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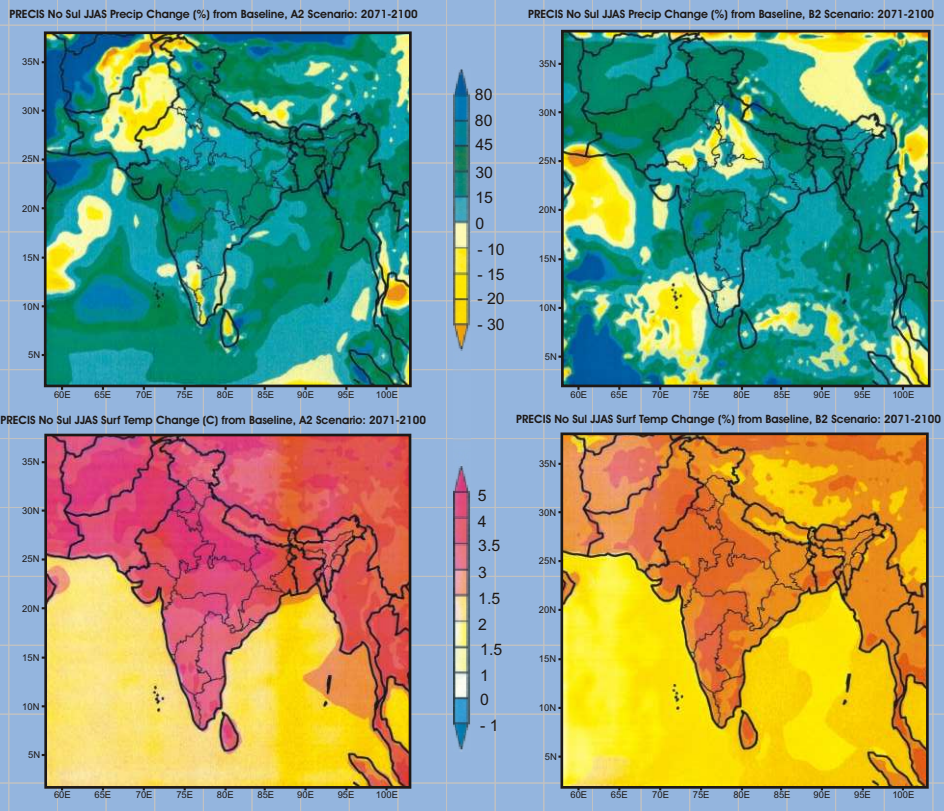
2003-04



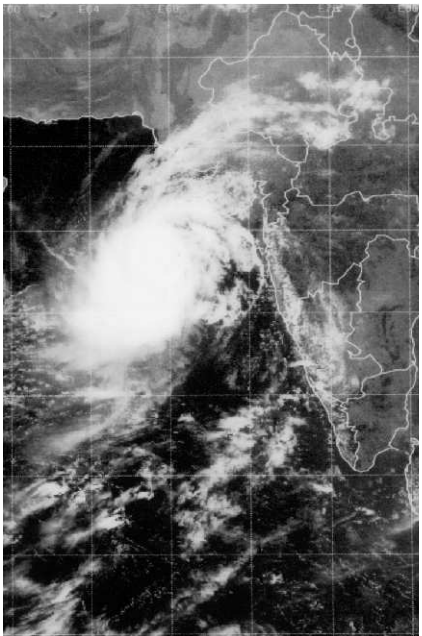
INDIAN INSTITUTE OF TROPICAL METEOROLOGY
PUNE

ANNUAL REPORT 2003-04

Governing Council

ANNUAL REPORT

2003-04



INDIAN INSTITUTE OF TROPICAL METEOROLOGY

(An Autonomous Institute of the Ministry of Science and Technology, Govt. of India)

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Cover : Simulation of future climate change

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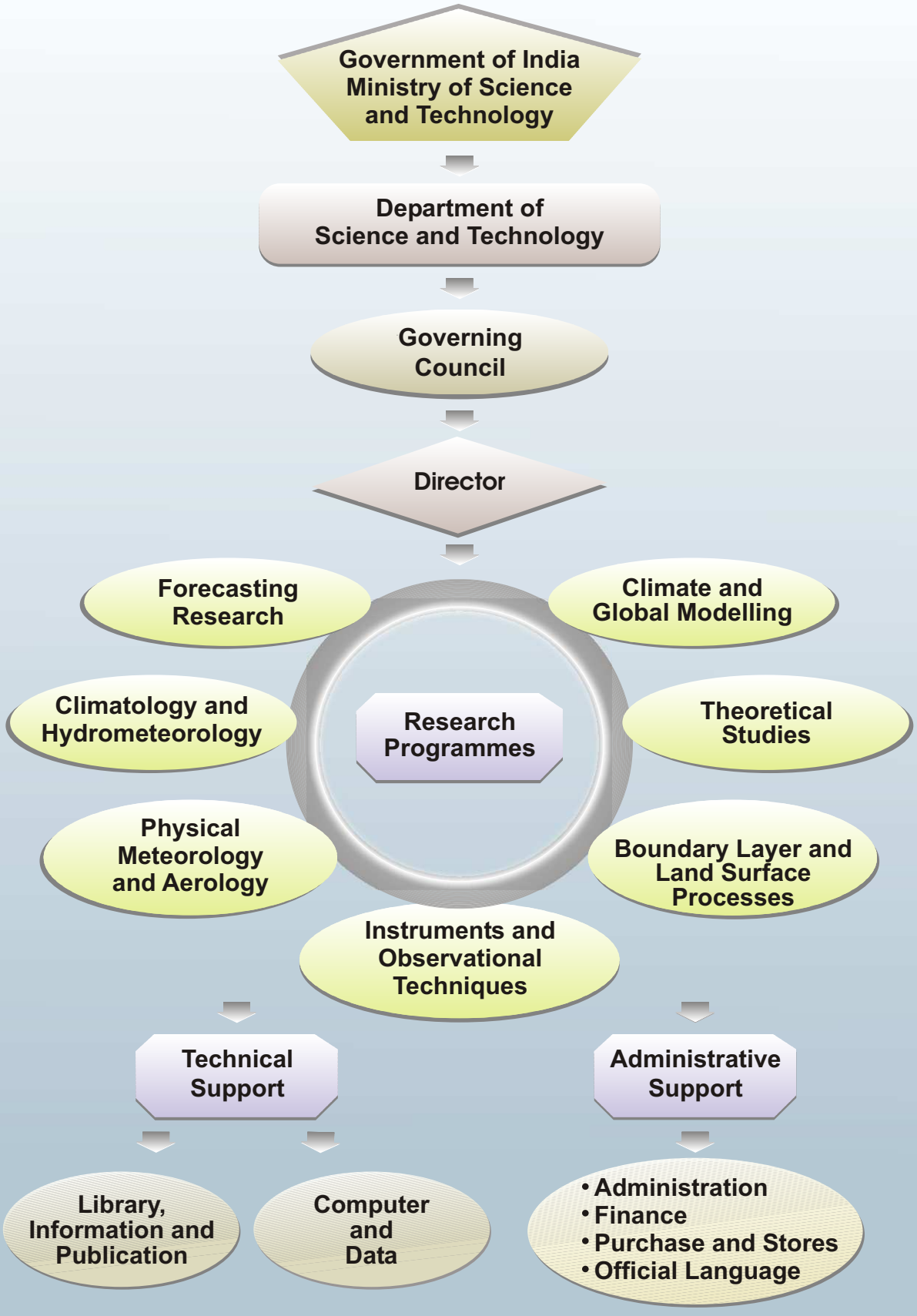
IITM Branch, New Delhi



Organisational Profile

Foreword

It is my pleasure to present the Annual Report of the Indian Institute of Tropical Meteorology (IITM), Pune for the year 2003-04 highlighting its research, academic and other activities in the field of Meteorology and Atmospheric Sciences.

The year 2003-04 was a glorious year which witnessed several significant events and programmes. The IITM organized and hosted many national and international scientific meetings, workshops, brainstorming sessions, trainings and panel discussions covering a wide range of topics in the field of Meteorology and Atmospheric Sciences. Several distinguished scientists and personalities from India and abroad visited us and shared their experiences. Our scientists received awards and honours in recognition of their research contribution. Many of the scientists participated in observational programmes of international repute and collected valuable data for continuing research activities. IITM has enhanced its infrastructural facilities to meet the present research need of its scientists. Several new research projects on the thrust areas of Meteorology sponsored by national and international agencies and departments have been taken up. Many young scientists have been recruited under such sponsored projects and also under its own academic programmes to support the new research activities. IITM continued to provide expertise and technical support to many of the universities and institutions in the country in their academic, observational and operational research programmes. Guidance and technical support in warm cloud seeding operations of many state governments, various hydrometeorological studies for the irrigation and water management authorities, special observational programmes for the Indian Space Research Organisation and multi-institutional nation-wide campaign for studying the atmospheric pollution have contributed the research work of the Institute. Special field observational programmes in different geographical and environmental conditions were also organized from time to time for the study of various aspects of the weather and climate studies.

The IITM scientists continued their participation in the proceedings of the world-wide programmes such as IPCC, UNFCCC, IGBP, WCRP, CLIVAR, PAGES, IUGG as well as that of Government of India's Ministries and Departments such as Ministry of Environment and Forests, Department of Science and Technology, Department of Ocean Development, Department of Atomic Energy, Department of Space, and the Defence Research and Development Organisation.

This Annual Report gives a summary of significant highlights followed by a general overview of the research results including a list of research publications, and other activities of the IITM during the year 2003-04. The diverse scientific, technical and academic activities summarised in the report have emerged out of the hard work and enthusiasm of the scientists and supporting staff of the IITM. The growing national and international interactions, modernized infrastructural facilities and the promising atmosphere at the campus of the IITM bear witness to the exciting future for productive and quality work. I am confident that the IITM would continue to make significant contributions in the challenging areas of Meteorology and Atmospheric Sciences.

I am thankful to the Department of Science and Technology, Government of India and the Governing Council and Finance Committee of the IITM for continued support and encouragement. I am also thankful to all the scientific and supporting staff for their devotion and cooperation.

(G. B. Pant)
Director

Highlights

Research

- High-resolution (~50 x 50 km) climate change scenarios were developed for India towards the end of the 21st century, using the state-of-art regional climate model PRECIS provided by the Hadley Centre for Climate Prediction and Research, UK. PRECIS was installed and run at the Institute on an array of 10 computers, to produce scenario data products for time slices of 31 years each under different baseline and future scenario experiments. Two types of socio-economic scenarios (A2 and B2) of the IPCC Special Report on Emission Scenarios (SRES) were used; both A2 and B2 represent regionally oriented socio-economic development, but A2 has a relatively higher priority to economic issues while B2 has a higher priority to environmental issues. PRECIS is driven by the lateral boundary conditions taken from global coupled model simulations supplied by the Hadley Centre.
- Based on detailed diagnostics of a large number of hindcast experiments using global models, it was shown that the use of uncoupled atmospheric models for seasonal forecasting of the Indian summer monsoon could be a major cause for the lack of prediction skills. Using the hindcast results of a global model with forced as well as coupled experimental design strategies, it was demonstrated that there is a surge in the skills for the Indian monsoon variability under a coupled ocean-atmosphere design.
- Vertical profiles of backscatter and depolarization ratios, obtained from the Nd:YAG polarization lidar observations carried out at National MST Radar Facility (NMRF), Gadanki revealed that cirrus clouds near the tropical tropopause are composed of ice/water droplets and mixed phase composition.
- An Excimer-Raman laser-based Differential Absorption Lidar (DIAL) ozone system was installed, for the first time in the country, at the Institute. The lidar was operated and vertical profiles of ozone number density were retrieved on 56 days during October, 2003 - March 2004. The lidar-derived ozone distributions were found to be in good agreement with other independent observations.
- Precipitation samples collected over Arabian Sea during ARMEX campaign aboard ORV Sagar Kanya revealed alkaline rain due to transport of Ca and SO_4 in the presence of strong southwesterly winds at surface level.
- Mesospheric temperature inversions over the Indian tropical region were studied using Halogen Occultation Experiment (HALOE) Satellite temperature data for the period 1991-2001. Frequency of occurrence of inversion in the 70-85 km altitude region was found to be 67% over this period, and showed a strong semiannual oscillation, with maximum strength occurring one month after equinoxes. Amplitude of inversion was found to be as high as 40°K.
- Simultaneous observations of twilight photometer and lidar were carried out at NMRF, Gadanki and the vertical profiles of atmospheric extinction deduced by both the techniques were found to be comparable.
- Evolution of lightning and the behaviour of recovery curves after a lightning discharge in thunderclouds were investigated from the surface measurements of electric field and Maxwell currents. Observations suggested a tripole structure in thunderclouds. Lower positive charge pocket was found to play a dominant role in initiating / triggering an intracloud / cloud-to-ground lightning discharge.
- Ship-borne measurements of different categories of atmospheric ions along with that of the atmospheric electric conductivity were made for the first time during the ARMEX. A strong relationship was revealed between the onset of the southwest monsoon and large ion concentration/conductivity over the sea.
- Airborne measurements of submicron aerosols made for the first time in India during the ARMEX period showed one to three orders of magnitude higher aerosol concentrations at 5-6 km altitude over sea when

the airmass is transported from the central Arabian Sea or Arabian deserts compared to that when it is advected up from the deserts of northwest India.

- A study of the onset phase of southwest monsoon for different cases revealed that the horizontal extent of cyclonic circulation and upward motion are generally of the synoptic scale but for the drought year (2002), the zones of convergence, divergence, upward and downward motion are found to be very small, i.e., of meso-scale nature.
- East Indian Ocean SST over the Region 5°S - 5°N, 85° - 95°E has been identified as a new predictor for both all India summer monsoon rainfall and annual rainfall, April SST over the region helps to predict the annual rainfall and June SST is useful in the monsoon rainfall prediction.
- Interactions between the oceanic mixed layer and the underlying thermocline were examined for the Northern Indian Ocean by analysing observed datasets from multiple sources (including the recently deployed ARGO floats), particularly focusing on understanding the mixed layer and thermocline responses of the Arabian Sea to forcing from the southwest monsoon circulation.
- Experimental seasonal forecasting of the Indian summer monsoon in 2003 was attempted in real-time using atmospheric general circulation models as well as empirical approaches. The results have been passed on to the India Meteorological Department as inputs for the operational seasonal forecasting.

Awards and Honours

- Dr. G.B. Pant has been elected a Fellow of the Maharashtra Academy of Sciences and the Indian Meteorological Society.
- Dr. A.K. Kamra has been elected a Fellow of the Indian National Science Academy (INSA), New Delhi.
- Dr. R.G. Ashrit, Dr. K. Rupa Kumar and Dr. K. Krishna Kumar received the 14th IITM Annual Silver Jubilee Award for the year 2001 for their research paper 'ENSO-monsoon relationships in a greenhouse warming scenario' published in the journal 'Geophysical Research Letters'.
- Shri J. Sanjay, Shri P. Mukhopadhyay and Dr. S.S. Singh received the 15th IITM Annual Silver Jubilee Award for the year 2002 for their research paper 'Impact of nonlocal boundary layer diffusion scheme on forecast over India' published in the journal 'Meteorology and Atmospheric Physics'.

Events

- Institute organised a workshop on 'Seasonal Climate and Crop Forecasting Methods for South Indian Rainfed Agriculture' jointly with the International Research Institute for Climate Prediction, New York, USA during 12-16 May, 2003.
- Institute organised a one-day workshop on 'National Lightning Information System' in collaboration with the India Meteorological Department on 18 July, 2003.
- Institute organised a training programme on 'Tree-ring sample collection procedure' at the Snow and Avalanche Study Establishment (SASE), Chandigarh for the field staff of SASE camping at high altitude areas of western Himalayas during 4-11 October, 2003.
- Institute celebrated its 42nd Foundation Day on 17 November, 2003.

- Institute organised meetings of the CLIVAR-Asian-Australian Monsoon Panel (AAMP) and the CLIVAR/ IOC Indian Ocean Panel (IOP) during 18-20 February, 2004.
- Institute organised an International workshop on 'Role of Indian Ocean in Climate Variability (INDOCLIM)' during 23-27 February, 2004.

Collaboration

- Two Indo-UK and one Indo-French collaborative research programmes on Climate Change issues are in operation at the Institute.
- The Institute has signed a Memorandum of Understanding (MoU) with the International Research Institute for Climate Prediction, University of Columbia, USA for collaborative research.
- A Research Programme 'Aerosol Optical Characterization and Investigations of Aerosol Radiative Forcing at the Surface and at the Top-of-the-Atmosphere' jointly sponsored by the Department of Science and Technology, Government of India and National Science Foundation, USA is under operation.
- Under the Indo-Bulgarian Programme of Co-operation in Science and Technology a research project on 'Optical Remote Sensing Studies of the Atmospheric Boundary Layer Characteristics using Laser Radar' is in progress.

Field Observational Programmes

- Field tour to Himachal Pradesh was arranged for collection of Tree-ring samples from forests around Simla, Kinnour, Kullu-Manali, Chamba and Kerala.
- Under the II Phase of Arabian Sea Monsoon Experiment (ARMEX-II) marine observations of aerosols, ion concentration and atmospheric electrical conductivity were taken on board Ocean Research Vessel Sagar Kanya and also air-sea boundary layer observations on land at the National Centre for Antarctica and Ocean Research, Goa.
- Institute participated in the Phase II and III of the Pilot expedition to Southern Ocean organized by the National Centre for Antarctica and Ocean Research, Goa for the measurements of aerosols in the Southern Hemisphere.
- Extensive measurements of aerosols, trace gases and meteorological parameters were taken at 20 locations between Pune and Hyderabad under ISRO-GBP land campaign.

Consultancy

- Institute provided guidance in respect of scientific aspects of weather modification experiments conducted by the State Government of Andhra Pradesh, Karnataka and Maharashtra during the monsoon season and post monsoon period of 2003.
- Institute provided estimates of standard project storms (SPS), probable maximum precipitation (PMP) and time distribution of hourly rainfall over Bhagirathi and Dhauliganga catchments in Uttaranchal for the National Thermal Power Corporation Ltd.
- Institute received a major project on the preparation of PMP atlas for the Krishna and Indus river basins from the Central Water Commission.

Inauguration of Varahamihira Seminar Hall

Prof. J. Shukla inaugurates

Inner view of Varahamihira Seminar Hall

Inauguration Lecture

Inauguration of INDOCLIM Workshop

Dr. S. K. Srivastav

Prof. Julia Slingo

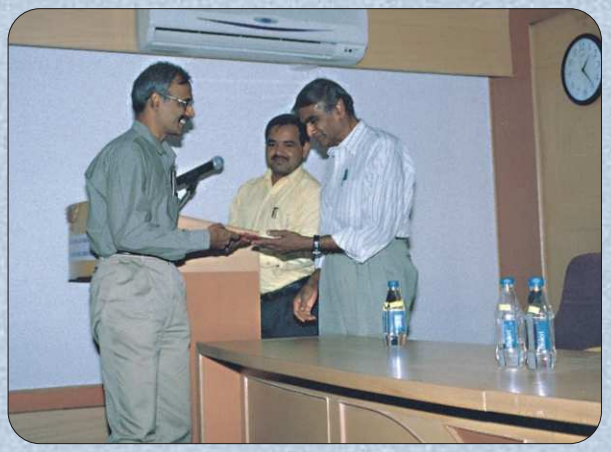
Dr. V. Satyan

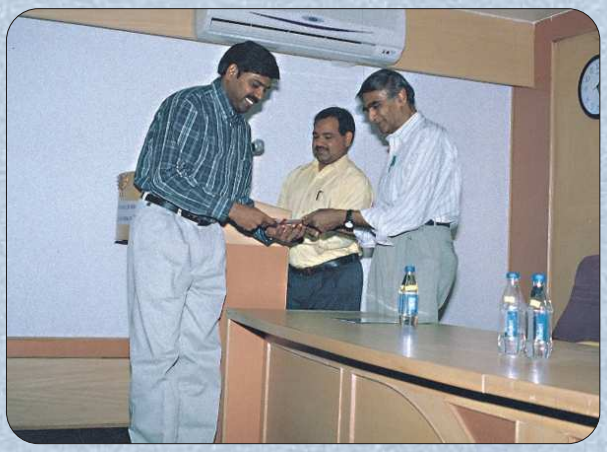
Dr. G. B. Pant

Inaugural lecture by
Dr. S. K. Srivastav

Dr. K. Rupa Kumar

Presentation of Awards





Dr. K. Rupa Kumar (left) and Dr. K. Krishna Kumar (right) receiving IITM Annual Silver Jubilee Award for the year 2001 at the hands of Prof. T. N. Krishnamurti

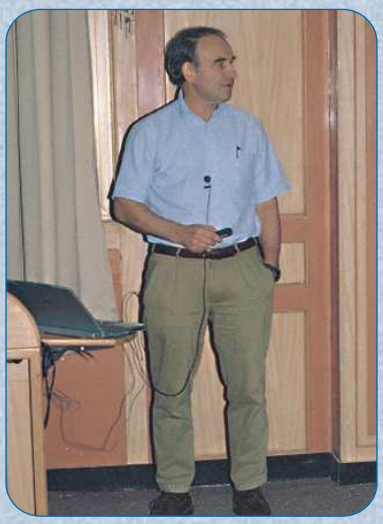
Shri. J. Sanjay (left) and Shri. P. Mukhopadhyay (right) receiving IITM Annual Silver Jubilee Award for the year 2002 at the hands of Prof. T. N. Krishnamurti

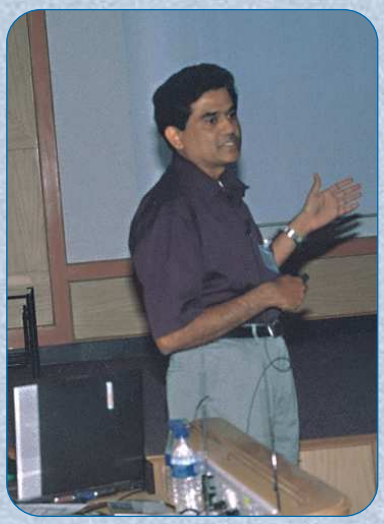
Prof. T. N. Krishnamurti, Florida State University, U. S. A. (left) receiving the Mausam Award for the year 2000-2001 at the hands of Dr. S.K. Srivastav (right)

INDOCLIM Workshop : Keynote Addresses

INDOCLIM Workshop : Presentation of Papers



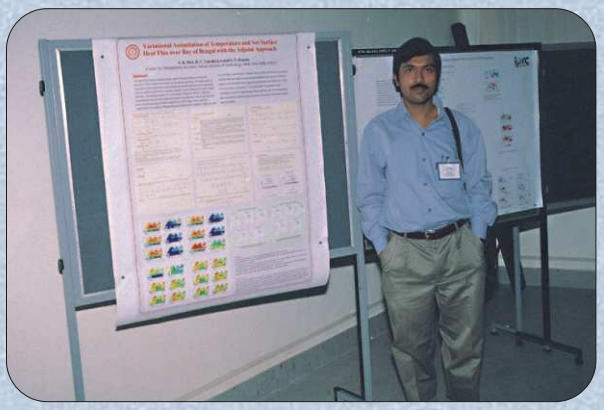


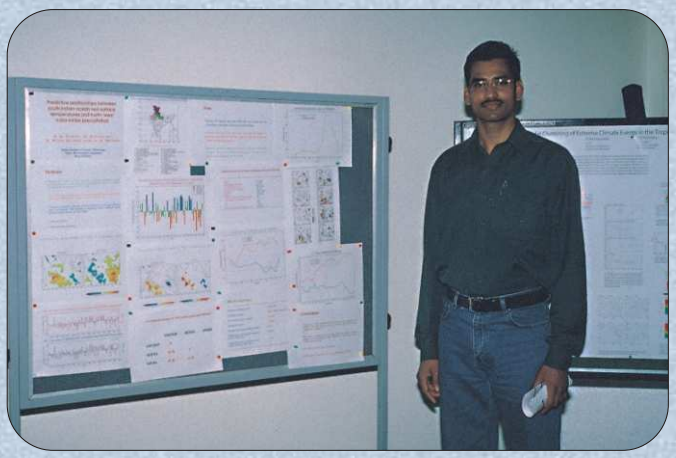






INDOCLIM Workshop : Poster Session





Tree Plantation on the occasion of INDOCLIM Workshop

Dr. G. Meyers

Prof. P. J. Webster

Prof. Julia Slingo

Dr. S. K. Srivastav

Dr. T. N. Krishnamurti

Prof. J. Shukla

Shri. D. R. Sikka

Forecasting Research

Forecasting Research Division has formulated its research programmes for understanding and prediction of the monsoon rainfall on short, medium- and long-range time scales and also for understanding and prediction of meso-scale systems including tropical cyclones. Following are the objectives of the Division :

- Study of meso-scale systems and meso-scale modelling.
- Study of planetary boundary layer characteristics using LASPEX and BOBMEX data.
- Application of satellite data in weather forecasting.
- Tele-connections of monsoon variability over South and East Asia.
- Inter-annual and decadal scale summer monsoon variability over India and its association with El Nino Southern Oscillation, North Atlantic Oscillation, Eurasian / Himalayan snow cover and Indian Ocean Dipole.
- Study of energetics of waves and wave to wave interaction.
- Study of secondary heat sources.

Numerical Weather Prediction Research and Meso-scale Modelling

(S.S. Singh, S.S. Vaidya, A. Bandyopadhyay, S. Mahapatra, J. Sanjay, D.K. Trivedi, P. Mukhopadhyay)

Regional Atmospheric Modelling System (RAMS) was integrated for 72 hrs with a horizontal resolution of 48 km to study the impact of surface meteorological parameters on simulation of a monsoon depression during 13-15 June, 1998. In one of the experiments RAMS was initialized with GAME (GEWEX Asian Monsoon Experiment) gridded data of 0000 UTC, 13 June, 1998 and run in nudging mode for first 12 hours till 1200 UTC. Thereafter, the model was run in forecast mode for the remaining 60 hrs. In the other experiment, the GAME analysis was enhanced by incorporating surface observations collected by India Meteorolgical Department at 1200 UTC, 13 June, 1998 and model was nudged for 12 hours followed by run in forecast mode. The results of both the experiments were compared. It was found that incorporation of surface data in the initial condition, in general, improved the forecast fields like mean-sea level pressure, wind-fields, geopotential heights and rainfall with the observation, skill scores namely 'equitable threat score' and bias were calculated. The positive impact of surface data on precipitation forecast was found from the improved skill-scores for all the rainfall categories (Fig. 01).

The real data simulation of a thunderstorm reported on 14 July, 1998 at 1200 UTC at Kolkata was carried out using the GAME analyses. RAMS was used with a two way interactive nested grids of resolution 16 km with grid points 68 x 68 (Grid-I) and 4 km with grid points 58 x 58 (Grid-II) in the east-west and north-south direction. Grid I covered a region 83.34° - 93.42°E along east-west and 17.78° - 27.28°N in the north-south direction. The inner nested domain (gird-II) covered a region 87.29°- 89.49°E in the east-west and 21.57°-23.59°N in the north-south direction. The grids were centered at 22.6°N, 88.4°E, the location of Alipore Observatory of Kolkata. Japan Meteorological Agency, as a part of the GAME 98, came out with six hourly gridded analyses for Asia-Pacific region (version 1.1) covering 80°-130°E and 30°S-80°N with horizontal resolution of 0.5°lat. x 0.5° long. at 17 vertical levels. For the simulation of 14 July, 1998, the gridded analyses of 0000, 0600, 1200 and 1800 UTC were used along with the upper air (RS/RW) data of three stations viz., Ranchi (23.43°N, 85.40°E), Patna (25.60°N, 85.10°E) and Calcutta (Kolkata) (22.53°N, 88.33°E). The RS/RW data were merged with gridded analyses to enhance the initial analyses. In one of the simulation experiments (Exp-1), only GAME gridded analyses were used and in the other (Exp-2), upper air data were incorporated to enhance the initial analyses.

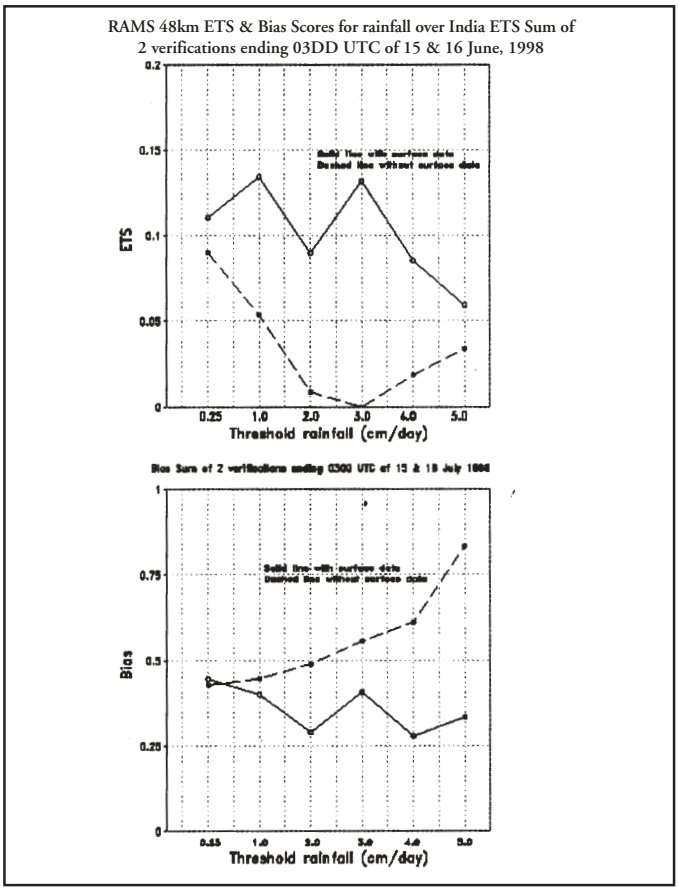


Fig. 01: Equitable threat score (ETS) (upper panel) for five selected threshold rainfall categories with and without surface data and taking rainfall forecast of 15 and 16 June together. Bias (lower panel) computed for five threshold rainfall categories with and without surface data for same days rainfall forecast for the 13-15 June 1998 Monsoon Depression

Exp-1 could simulate the storm with limited accuracy as compared to the time and location of observation. However, Exp-2 showed remarkable improvement in the simulation of different fields and was able to simulate temporal and spatial structure of the storm with significant accuracy in time and location. The growth, maturity and dissipation of the storm in Exp-2 as reflected by the forecast plots of one hourly streamline, total cloud condensate, vertical cross section of u, w and precipitation were found to be remarkably improved by finer grid as compared to either the coarse grid or by the corresponding plots of Exp-1. Exp-2 could better predict the spatial distribution and magnitude of the rainfall (3-4 cm) in and around Kolkata as compared to Expt-1. The rainfall reported by the station on 14 July was 4.7 cm (Fig. 2).

A severe Nor'wester, the first one in pre-monsoon season of 2003, struck Kolkata and surrounding region on 12 March, 2003. The storm was initially diagnosed with the help of hourly Doppler Radar images at Kolkata and also with hourly satellite images. The periods of genesis, maturity and decay of the storm were documented in detail with the radar and

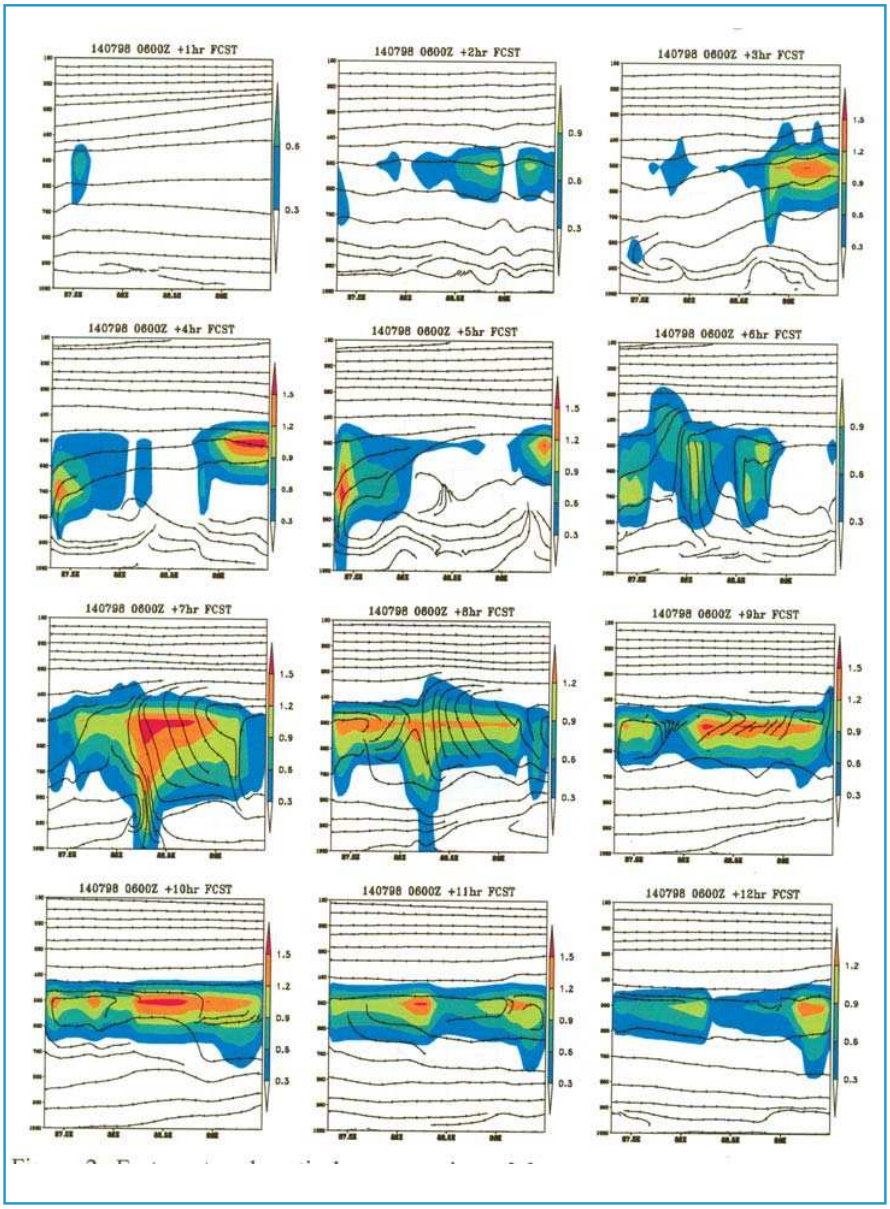


Fig. 2 : East-west and vertical cross section of forecast total cloud condensate and streamline (u component and vertical velocity) of 14 July, 1998 thunderstorm over Kolkata. Model initialized with enhanced GAME analysis and nudged for initial 6 hour. RAMS resolution 16 km

satellite images. Further, a sequence of radar and satellite images were used to determine the location and height of the Cb clouds associated with the storm as well as the precipitable water, and the speed and direction of movement of the storm. Subsequently, the system was simulated by two sets of experiments using RAMS. In the first experiment (Exp-1), the system was simulated using NCEP/NCAR daily six hourly reanalyses data only whereas in the second experiment (Exp-2), a mesoscale analysis was carried out by blending the RS / RW data of three stations (Kolkata, Ranchi and Patna). The available surface data from nearby stations were also used in the coarse large scale analysis. RAMS was used with a two way interactive nested domain of resolution 16 and

4-km. For both the experiments, the model was initialized with 0000 UTC analysis of 12 March, 2003 and run in four dimensional data assimilation (nudging) mode until 0600 UTC. The model was further run in a forecast mode for 12 hours ending at 1800 UTC of 12 March, 2003. Exp-1 could be able to simulate a weak storm, which reflected in lesser humidity value (0.08g/kg) of total condensate. The storm could not be simulated properly in terms of time and location. The 12 hr forecast accumulated rainfall was found to be of the order of 5 mm as against 50 mm observed. Exp-2 could show a significant improvement in simulating the growth, maturity and dissipation of the storm, producing a better forecast of the storm. This has reflected in the predictive parameters, namely, one hourly streamline pattern, total condensate, and vertical cross section of u, w and precipitation. The nested domain of fine grid resolution (4-km) consistently showed a better forecast than the outer domain of coarse grid resolution (16 - km) (Fig. 3).

Experiments with high resolution mesoscale model (MM5) were conducted to study the sensitivity of cumulus parameterization schemes on the simulation of super cyclone of Orissa (1999). The input for the model was taken from the NCEP reanalysis of 00 UTC on 26 October, 1999 when the system was reported as deep depression stage. The system track and intensity showed considerable sensitivity with Kuo producing better track and Kain-Fritsch scheme with better intensity development.

Two versions of recursive digital filtering initialization scheme (RDFI) and recursive adiabatic digital filtering initialization scheme (RADFI) were implemented in a limited area model. These schemes were found to effectively suppress the high frequency noise due to gravity-inertial waves from the meteorological data taken over Indian region. The reduction of noise level was more prominent in the early hours of the model integration. This was evident from the time evolution graphs of mean absolute surface pressure tendency (MASPT) over the model domain and time evolution graphs of surface pressure and vertical velocity fields over certain grid points, plotted for 12 hours of model integration.

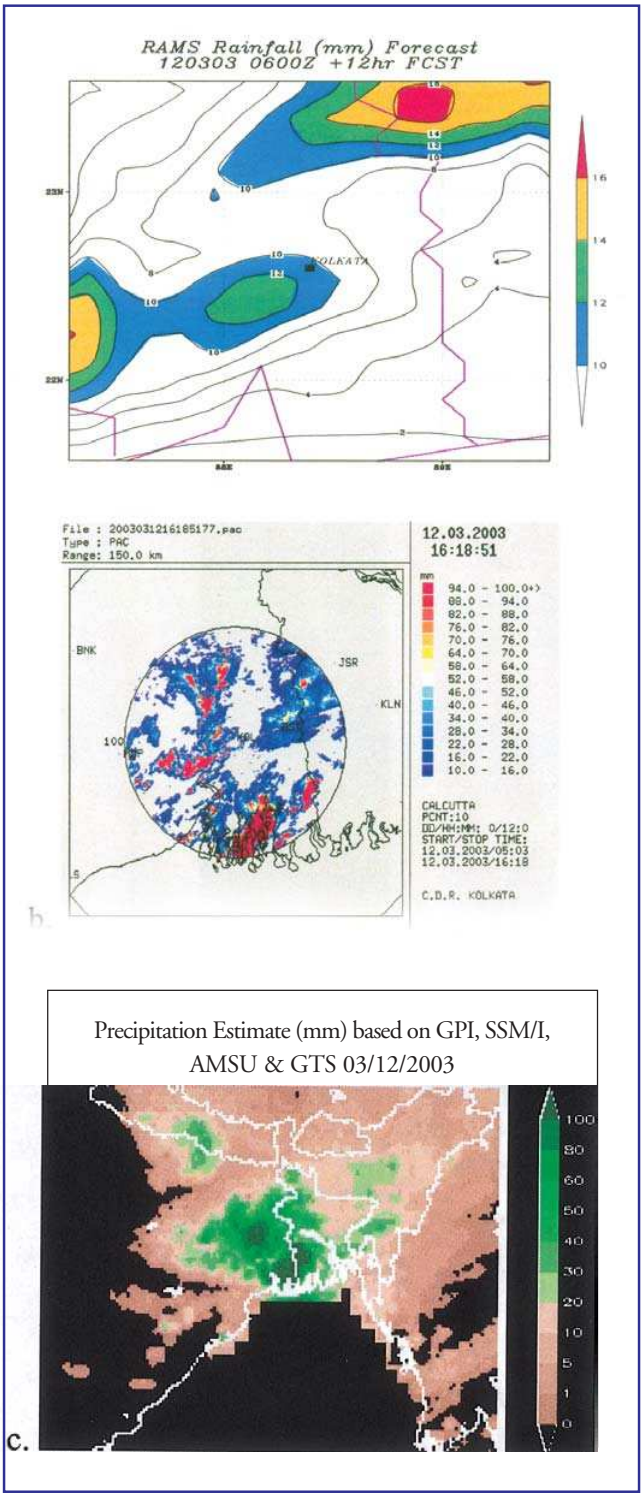


Fig. 3 : Comparison of 12 hour accumulated rainfall (mm) forecast by RAMS 16 km grid domain (a) with Doppler radar estimated 11 hour accumulated rain (b) CPC estimated rain (c) associated with the 12 March 2003 Nor'wester over Kolkata

Detection of thunderstorms were attempted using three stability indices viz., K-Index, TT-index and SWEAT index for various Indian stations and also using scatter-plot diagrams over a particular station, Kolkata (Dumdum Air Port). The index values fall within certain category indicating probability of thunderstorm occurrences. These were compared with the available weather information for validation purpose. It was found that most of the cases match well. This indicates that stability indices are the useful tools for thunderstorm detection and can be utilized for probabilistic forecast of thunderstorm occurrences.

Extended Range Weather Prediction Research

(R.H. Kripalani, S.S. Dugam, S.D. Bansod, A.A. Kulkarni, N.V. Panchawagh, S.B. Kakade, S.S. Sabade, S.R. Inamdar)

Role of intra-seasonal oscillations in seasonal monsoon strength : Indian monsoons of 2002 and 2003

The June through September summer monsoon rainfall for India as a whole was 81 (102)% during 2002 (2003) of its long period average. While the southwest monsoon of 2002 was a severe drought, monsoon 2003 was marked by near-normal rainfall over the country. During the last 5 monsoons (1999-2003), 2002 (2003) was the worst (best) monsoon in terms of the quantum of rainfall. The monsoon variability was found to be partly due to the external surface boundary forcings and partly due to its internal dynamics. The intra-seasonal oscillations dominant during the monsoon season constituted the internal dynamics. The technique of Band-pass filter and wavelet analysis were applied to daily rainfall time series to examine the role of the northward propagating 30-60 days mode, and westward propagating 10-20 days mode in monsoon variability during 2002 and 2003.

Figure 4 shows the daily rainfall anomalies, the filtered 10-20 days and 30-60 days time series super-imposed on the same diagram. The time series for 2002 (2003) are displayed in top (bottom) panel. Amplitude of 10-20 days oscillation was enhanced during monsoon 2003, and suppressed during monsoon 2002. On the other hand, amplitude of 30-60 days oscillation was found to be enhanced during 2002 and suppressed during 2003. Further, the active (break) monsoon spells were found to be strengthened when the positive (negative) phases of both the oscillations appeared simultaneously i.e. these were phase-locked, around 10 August, 2002 and 21 June, 2003 (July, 2002 and around 15 September, 2003).

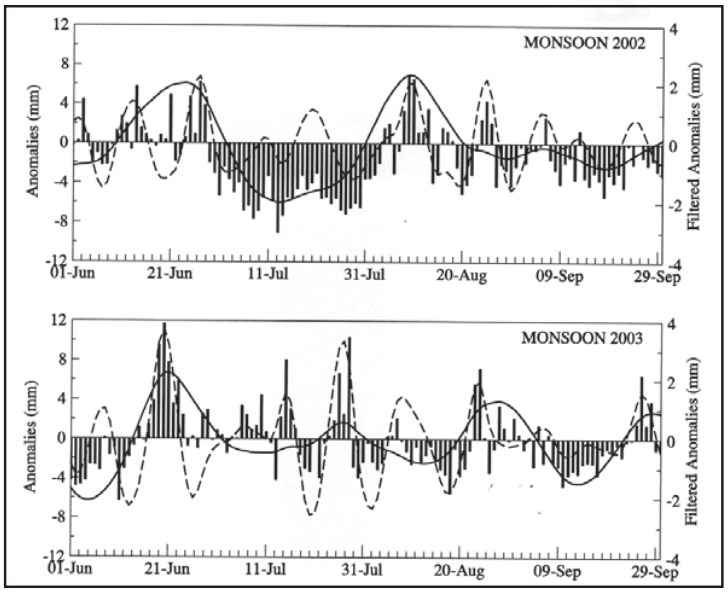


Fig. 4 : Time series of daily precipitation, filtered 10-20 days (dashed line) and 30 - 60 days filtered (solid line) for monsoon 2002 (upper panel) and for monsoon 2003 (lower panel)

The technique of wavelet analysis was used to examine change in the intensity of the mode during the season and whether one mode changes to another. The wavelet spectrum for monsoon 2002 (Fig. 5 upper panel) revealed that during June the maximum variance (red colour) was centered in periods less than 20 days, in particular the last week of June. The period of oscillation increased to around 60 days in July. Thereafter, the period of oscillation monotonically decreased. Thus, the severe drought during July, 2002 was due to the dominance of this longer period mode. The wavelet spectrum for monsoon 2003 is shown in Fig. 5 (lower panel). At the beginning of June the maximum variance is centered around 30-60 days periodicity,

thereafter in general over the season the maximum variance is centered in periods less than 20 days. In summary, the monsoon 2002 (2003) was dominated by the slower (faster) 30-60 (10-20) days mode.

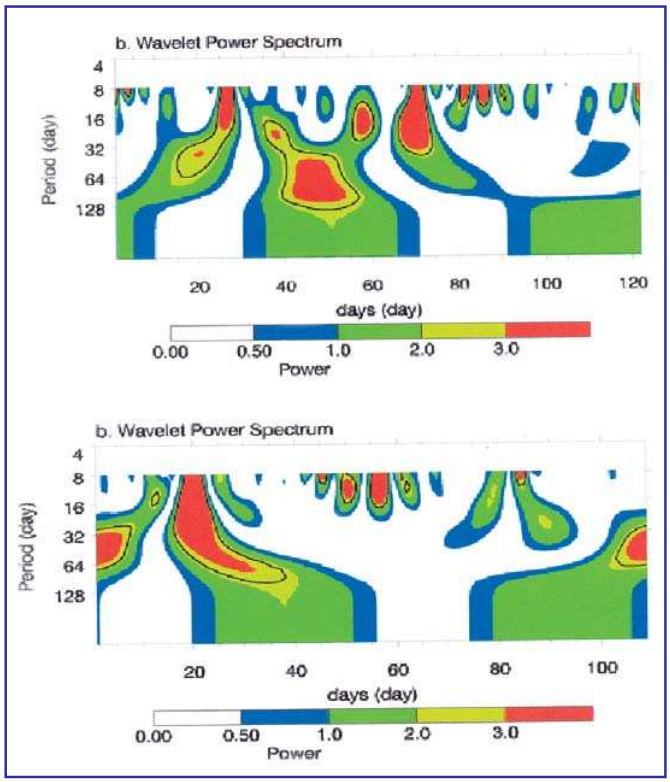


Fig. 5 : Wavelet spectrum computed from daily rainfall for monsoon 2002 (top panel) and monsoon 2003 (bottom panel). For the wavelet spectrum, x-axis denotes days from 1 June to 30 September and y-axis the period in powers of 2

Northeast monsoon rainfall variability over south Peninsular India vis-a-vis Indian Ocean dipole mode

While the June through September southwest summer monsoon season over the Indian sub-continent has been the main focus of research, the October through December northeast monsoon season over the south peninsular India has received less attention. Recently, the Indian Ocean dipole mode (IODM) exhibiting warm (cool) waters over the equatorial western (southeastern) Indian Ocean has been identified. This mode is quantified by the sea surface temperature difference over the equatorial western and southeast Indian Ocean. Since the southern part of India is situated approximately near the center of this mode, and mode peaks in September-November period, and rainfall peaks in October-December period, ie. both peak during boreal autumn with a lag of one month, the influence of this dipole mode on Northeast monsoon rainfall (NEMR) variability was examined.

The relationship was determined by comparing the circulation features associated with the extreme dipole and extreme monsoon phases using the NCEP /NCAR Reanalysis data. Fig. 6 (upper panel) shows the anomalous flow pattern associated with the positive IODM (warm west and cool east) and Fig. 6 (lower panel) the anomalous pattern for the excess monsoons. A comparison of these panels revealed that the winds converge over south India resulting in moisture transport over this region and enhancing the monsoon activity. Thus, the positive phase was found to be favourable for excess monsoons.

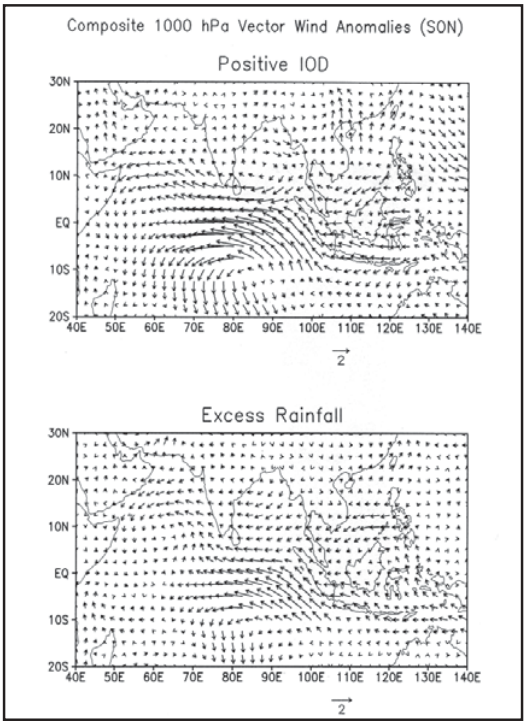


Fig. 6 : Composite seasonal 1000 hPa vector wind anomalies in m/s for autumn during the positive phase of IODM (upper panel) and the excess monsoons (lower panel)

On the other hand the flow pattern associated with the negative dipole mode (cool west and warm east) and deficient monsoon showed winds diverging away from south India and converging and transporting moisture towards Sumatra, away from the southern parts

of India. Thus, the negative phase of the dipole phenomenon inhibits the rainfall activity (Fig. 7).

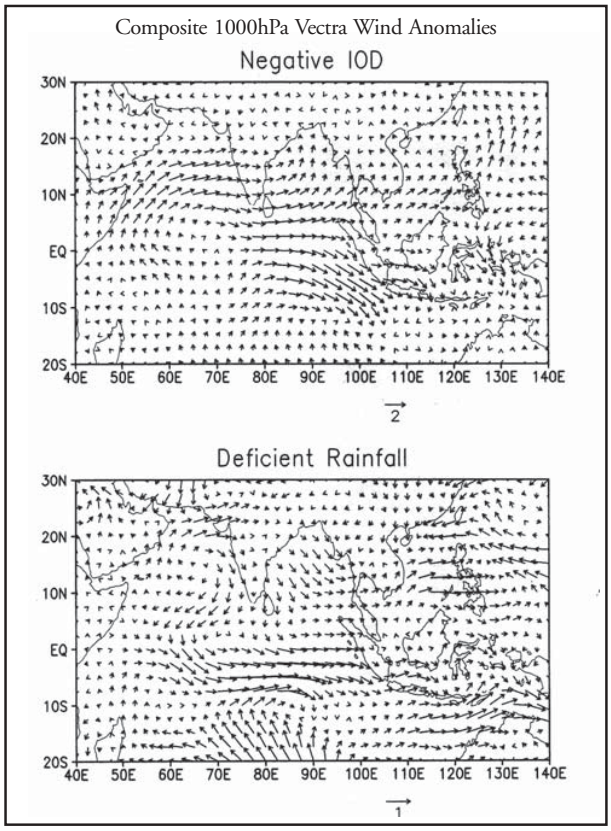


Fig. 7 : Composite seasonal 1000 hPa vector wind anomalies in m/s for autumn during the negative phase of the IODM (upper panel) and the deficient monsoons (lower panel)

The short term decadal climatic fluctuations in the IODM and NEMR were studied by applying Cramer's test for the 11-year running means using data for the period 1871-2001. The 11-year Cramer's t-statistics are presented in Fig. 8. The most striking feature for NEMR (Fig. 8 upper panel) was found to be the epochs of above and below normal rainfall. The epochs tend to last for about a decade or two, which is less than for the southwest monsoon rainfall, where the epochs tend to last for about 3 decades. Generally, the rainfall epochal regimes closer to the equatorial belt tend to last for a decade. While the variability during the earlier decades (1880-1920) and recent decades (1980-2000) appears to be large, the variability during the in between period appears to be small. The decadal variability for IODM (Fig. 8 lower panel) revealed that during the period prior to 1920, the mode was on the negative side, but on the positive side during the recent 40-year period, after 1960. The mode appeared to be inactive during the period 1920-1950. Thus, the NEMR rainfall variability appeared to be enhanced during the decades when the dipole was active and suppressed during the decades when the dipole was inactive.

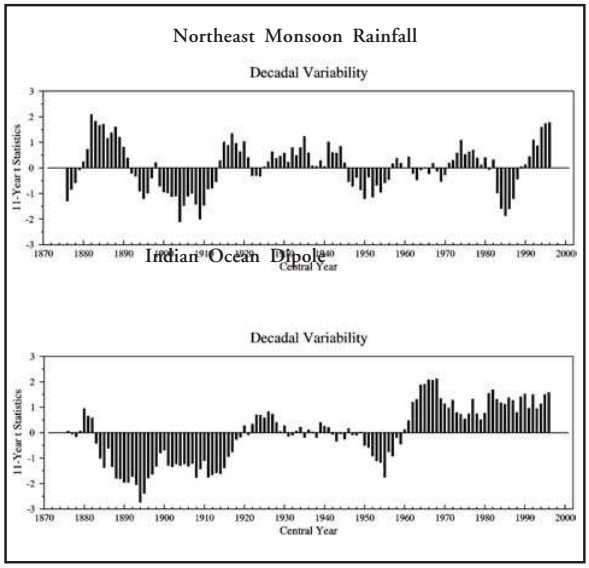


Fig. 8 : Values of the Cramer's t-statistics for the 11-year running means of NEMR (top panel) and autumn IODM (bottom panel) depicting decadal variability and the epochs of above and below normal. Values are plotted at the center of the 11-year period

Weather insurance with respect to rainfall

In a collaborative project with National Insurance Academy, as a pilot project the crop insurance scheme was developed for some selected crops like Paddy, Groundnut, Jowar, Bajra and Maize for some selected districts of Andhra Pradesh, Uttar Pradesh, Rajasthan and Karnataka. Five insurance products were developed based on seasonal rainfall, agronomic index, monthly weighted rainfall index, sowing failure index and catastrophic rainfall.

Sea-ice extent and SST in relation to Indian monsoon rainfall

Wavelet analysis of satellite derived sea-ice in southern Indian Ocean was carried out using monthly mean sea ice extent anomaly over southern Indian Ocean for 22 years (1979-2000). 2 to 4 and 6 to 8 mode in winter time sea-ice was found to be highly dominant and significant in the recent major

El-Nino events of 1987 and 1997 (Fig. 9a). The study was found to be useful for prediction of ENSO signal well in advance. Antarctica sea-ice analysis showed the similar results (Fig. 9b).

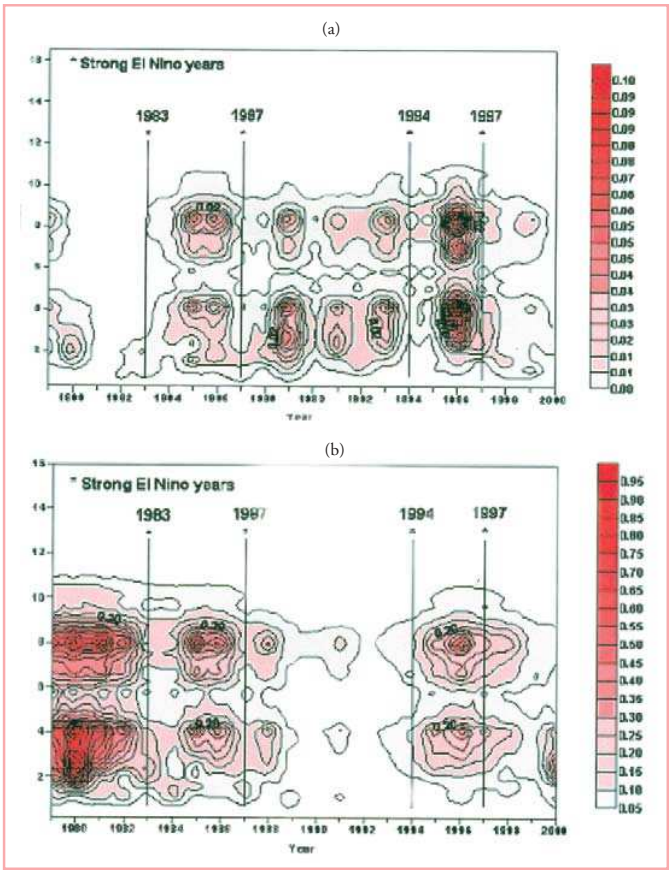


Fig. 9 : Wavelet analysis of sea-ice anomaly for 1979-2000, over Indian Ocean (upper panel) and over Antarctica (lower panel)

Indian Ocean SST (30°S-30°N; 46°-100°E) and all India summer monsoon rainfall (AISMR) for June-September were analysed on climatological and sub-climatological time scale by using the data of 129 years (1871-1999). The decadal variability of Indian Ocean SST in winter and summer seasons showed a highly significant, inverse association with summer monsoon rainfall over homogeneous regions of India and India as a whole (Fig. 10). The study was found to be useful for understanding the long-term variability of AISMR with Indian Ocean SST.

Antarctic sea ice extent and Indian summer monsoon variability over the various homogeneous regions of India were analysed for a period of 22 years (1979-2000). A significant relationship was revealed for West Central India and North West India only. The preceding winter (December-January-February) sea ice anomaly was found to have an inverse association with the performance of the following monsoon. This relationship may be used for the Long Range Forecasting (LRF) of monsoon rainfall over these regions of India.

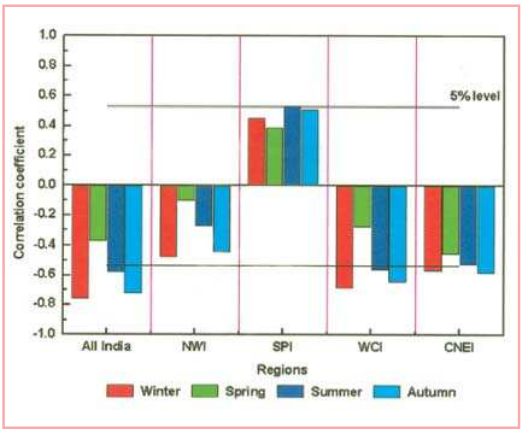


Fig. 10 : Relationship of monsoon rainfall over India and its homogeneous regions with seasonal SST over Indian Ocean for 1871-1999, on decadal scale

Studies on Monsoons and Tropical Weather Systems

(U.V. Bhide, M.Y. Totagi, A.A. Kulkarni, V.R. Mujumdar, P.V. Puranik, S.M. Bawiskar, S.P. Ghanekar, M.D. Chipade)

Forecast of All India Monsoon Rainfall 2003

Momentum transport of wave zero averaged over 21°S - 5°N at 850 hPa was computed by using NCEP data for the month of March, 2002 and used for a forecast of All India Monsoon Rainfall (AIMR) 2003. The estimated AIMR was 105% (893.89 mm) of the long term normal (852 mm).

Monsoon onset forecast for 2003

The onset of monsoon over Kerala for the year 2003 was predicted as 5 June using regression technique, based on information of pre-monsoon thunderstorm activities over selected stations of south peninsula in the month of April. The onset occurred over Kerala on 8 June, 2003.

Secondary heat sources for contrasting monsoon seasons

Estimation of the apparent heat source (Q1) and apparent moisture sink (Q2) was carried out for Indian region using NCEP grid point data for the southwest monsoon 2002. The results showed development of intense secondary heat source around 20° - 25°N and west of 80°E due to intense rainfall in association with the movement of a well marked low pressure area from north Bay of Bengal. Following this period, monsoon evolved into a break-like situation in July, 2002. Monsoon revived over India around 15 August, but not a single depression or storm was formed in the season. The y-t section of vertical velocity for regions east and west of 80°E (fig. 11) at 500 hPa level showed that increased subsidence over monsoon trough region affected monsoon activity adversely in the season. Increased activity of disturbances in mid-latitude westerlies caused increased subsidence and drying of the troposphere over India particularly in July, 2002 when a large deficiency in rainfall of -51% from normal was observed which was the unique feature of Monsoon 2002. A number of low pressure areas were formed over the North Bay region but none of them intensified into a depression or storm during the season. A similar analysis for southwest monsoon 1997 showed no such adverse effect of mid-latitude westerlies. Monsoon 1997 was normal while monsoon 2002 resulted into a drought year for India.

Comparative study of monsoon 1997 and 2002

Daily and weekly variations of the energetics of wave number one based on global NCEP data for June-September indicated that as long as momentum transport or kinetic energy of wave number one around 10°N is strong, the Indian monsoon rainfall is better and vice-versa. The amplitude of wave number one was almost half during 2002 as compared to that during 1997, which resulted into less transport of momentum and meager supply

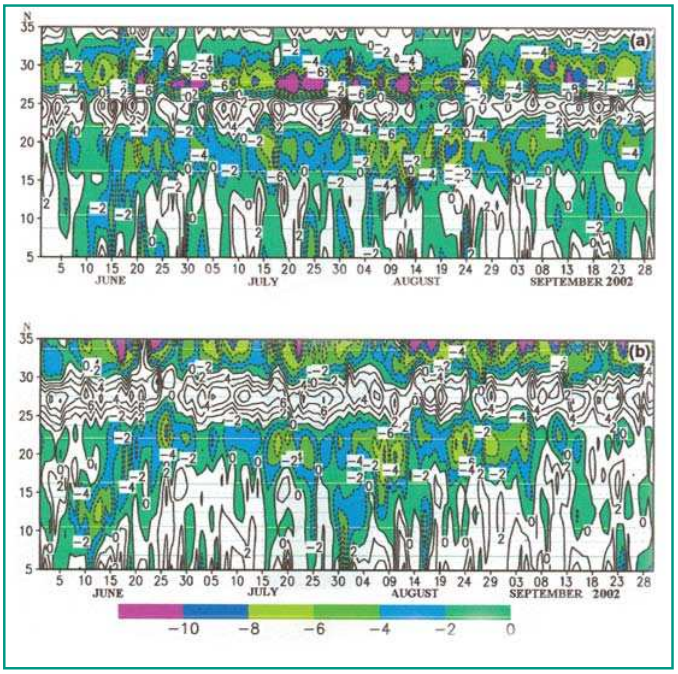


Fig. 11 : Daily variation of averaged vertical velocity (hPa/hr) at 500 hPa level for a) East region (80°-90°E), b) West region (70°-80°E) during monsoon 2002

of kinetic energy throughout the monsoon season of 2002. Significant release of kinetic energy by wave number one during 1997 might have led to the formation of four deep depressions, one depression and one cyclonic storm in the Bay of Bengal during monsoon 1997 whereas the weak supply of kinetic energy might have failed to trigger a single system in the Bay during monsoon 2002.

Comparative study of two monsoon systems of 1989

A comparative study of two monsoon weather systems of 1989 viz., a cyclonic storm formed on 22 July (CS-J) and a deep depression formed on 17 August (DD-A) was taken up using daily NCEP data for Indian region at 850 hPa. After formation over Bay of Bengal during their movement over land, the track of CS-J remained southward than normal and its intensity was maintained as a deep depression even after moving west of 75°E. However, DD-A, moved in a west-northwesterly direction and weakened to a low pressure area around 75°E. Strong average cyclonic vorticity and convergence prevailed in the southwest sector of CS-J where rainfall was also found to be intense. The prominent rainfall activity for August system prevailed in the northwest sector. The estimation of moisture flux showed higher moisture flux for CS-J as compared to DD-A during its life cycle. The difference in the behaviour of the two

systems may be linked with the difference in the latitudinal position of these systems and strong moisture flux from Bay of Bengal and Arabian Sea.

Kinetic energy of extra tropical waves and Indian monsoon rainfall

Kinetic energy of extra tropical waves and their effect on the Indian monsoon rainfall was studied by using Fourier technique. For this purpose daily kinetic energy of waves 0 - 10 for the monsoon season (1 June - 30 September) of 1994, 1995 and 1996 were computed using global NCMRWF wind data at 500 hPa. Weekly variation of kinetic energy of wave 0 and effective kinetic energy of waves 3-10 over extra tropics have significant negative correlation with weekly all India monsoon rainfall. The intensification (weakening) of waves 3-10 was found to be associated with weak (active) spells of rainfall over India. The figure 12 presents daily variation of kinetic energy of waves 3-10 during active phase of week ending 26 July, 1995 and break phases during 12-15 August, 1995 and 1-5 July, 1996. It can be seen from the figure that about ten days prior to weak (active) spells of rainfall, there was a gradual southward (northward) propagation (retrogression) of kinetic energy of waves 3-10. The study is found to be useful in getting prior signal about subdued or good rainfall activity over India.

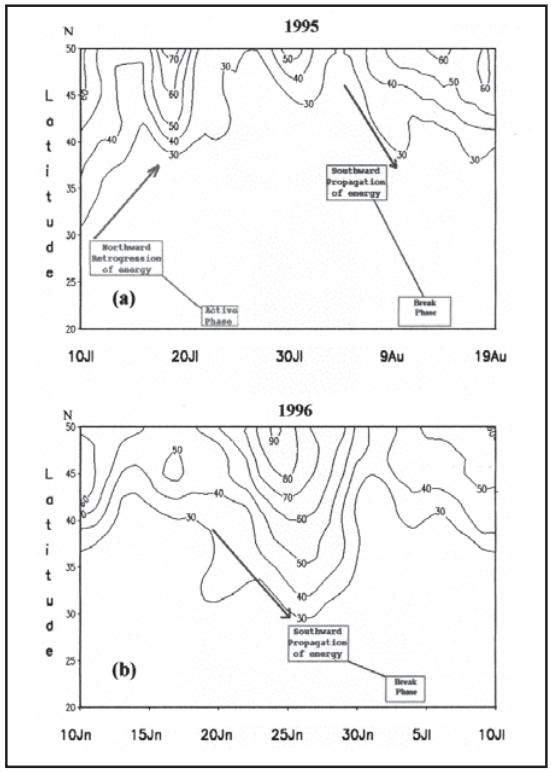


Fig.12 : Daily variation of kinetic energy (m^2/s^2) for the period a) 10 July – 19 August 1995 and b) 10 June – 10 July 1996

Energetics of wave number domain

Wave to wave and wave to zonal mean flow kinetic energy interactions were computed for four latitudinal belts at 300 hPa level during pre-monsoon period (April and May) and monsoon period (June through August) for six good monsoon years (1969, 1970, 1971, 1973, 1975, 1976) and four bad monsoon years (1968, 1972, 1974, 1979) in the wave number domain using NCEP's global monthly mean u and v components of wind. The four latitudinal belts considered were (i) Southern hemisphere belt (37.2°-9.9°S), (ii) Tropical belt (5°S-19.6°N), (iii) Sub-tropical belt (24.2°-37.2°N) and (iv) Total belt (37.2°S-37.2°N). In the tropical belt, the planetary scale waves 1 to 4 were found to be larger source of kinetic energy to mean zonal flow via wave-zonal interaction in good monsoon years as compared to bad monsoon years at 300 hPa level during monsoon period. This type of energy transfer generally leads to strengthening of zonal westerlies in the middle latitudes and consequently zonal easterlies in the tropics. The planetary scale waves 1 to 4 were found to be larger source of kinetic energy to other waves via wave-wave interactions in good monsoon years than in bad monsoon years at 300 hPa level during monsoon months.

Analysis of BOBMEX-99 data

Time-series observations of surface and upper air meteorological parameters were analysed during Phase I and Phase II of BOBMEX-99 when the ship ORV Sagar Kanya was stationary at 17.5°N, 89.0°E. India experienced active and weak monsoon conditions during Phase I and II respectively. The results showed warm and humid lower and middle troposphere during active phase (Phase I) when three intense monsoon disturbances were

formed. While it was relatively cool and dry during weak monsoon phase (Phase II) when no well-marked disturbance was formed over the Bay. There was strong north-south pressure gradient over Bay of Bengal along Sagar Kanya longitude in active phase of the experiment. While higher surface pressure and weak pressure gradient prevailed over Bay of Bengal during the weak phase. Vertical velocity computed at 850 and 500 hPa levels using daily NCEP data over the Bay region showed increased subsidence near the ship location during Phase II, which seemed to be responsible for transition of the monsoon activity from active to weak phase of BOBMEX-99.

Time-series data of surface meteorological parameters, and temperature and salinity profiles in the upper 100 m layer of ocean at stationary position of ORV Sagar Kanya ship (17.5°N, 89.0°E) during the two phases of BOBMEX-99 were analysed. In addition to this, the sea surface height anomalies data from the TOPEX/ POSEIDON, the surface winds from ERS-1 scatterometer and the Sea Surface Temperature (SST) data from NOAA/ AVHRR were also analysed. During Phase I, warmer temperatures were maintained in the upper 40 m ocean layer, while an overall cooling in this layer was observed during Phase II. Below 40 m depth, cooling was evident in Phase I and warming in Phase II. During Phase I, the depth of the mixed layer (estimated from the density criterion) was observed to be large initially and dropped to lower value as the core of freshwater plume arrived in the stationary ship location. Overall heat loss was observed at the sea surface during Phase I while a sizable heat gain was observed in Phase II. The Heat Content in upper 0-20 m layer of ocean was found to be relatively high in Phase I and low in Phase II, but in 0-100 m layer it was low in Phase I and large in Phase II. Heat Content variation in the 0-100 m suggested intense oscillation of the thermocline between Phase I and Phase II. The wind stress curl showed positive curl over the ship location in the northern Bay during 26 July-2 August in Phase I and negative curl during 16-23 August in Phase II. The curl field thus showed intra-seasonal variation over the northern Bay. The associated Ekman pumping was found to be upward leading to upwelling of cold sub-surface waters in Phase I and downwelling in Phase II.

Secondary Data Utilization Center

The onset and advance of monsoon 2003 was monitored and cloud images were archived and used for the presentation. One cyclonic storm formed on 11 May over Bay of Bengal and two monsoon depressions during 22-30 July and 25-30 August were monitored and a large number of cloud images were archived.

A nearly stationary organized cloud distribution over Kashmir and adjoining North Pakistan, associated with the western disturbances was noticed almost during entire month of March.

Satellite Meteorology and Application of Satellite data in Weather Forecasting

(P.N. Mahajan, P.L. Kulkarni, D.R. Talwalkar, S.K. Sinha, R.M. Khaladkar, S. Nair, S.G. Narkhedkar, M. Mahakur)

Complete life cycle of tropical cyclone formed over the Bay of Bengal during 13-21 October, 2000 was studied with integrated approach of INSAT, METEOSAT, IRS-P4 and TRMM Satellites. Strengthening of sea surface winds (12-14 mps) was observed during the development stage of tropical cyclone and the intensity of wind gradually decreased (6-8 mps) during the dissipating stage of cyclone. Maximum integrated water vapour (7-8 gm/cm^2) and maximum cloud liquid water content (45 mg/cm^2) were noticed during developing stage, which drastically decreased to (3-5 mg/cm^2) during the dissipating stage of cyclone. Vorticity, convergence and divergence computed through input of CMVs and WVWVs of METEOSAT-5 satellite by objective analysis of the wind field at 850 and 200 hPa showed a proper consistency with prevailing convective activity in the cyclone region (Fig. 13).

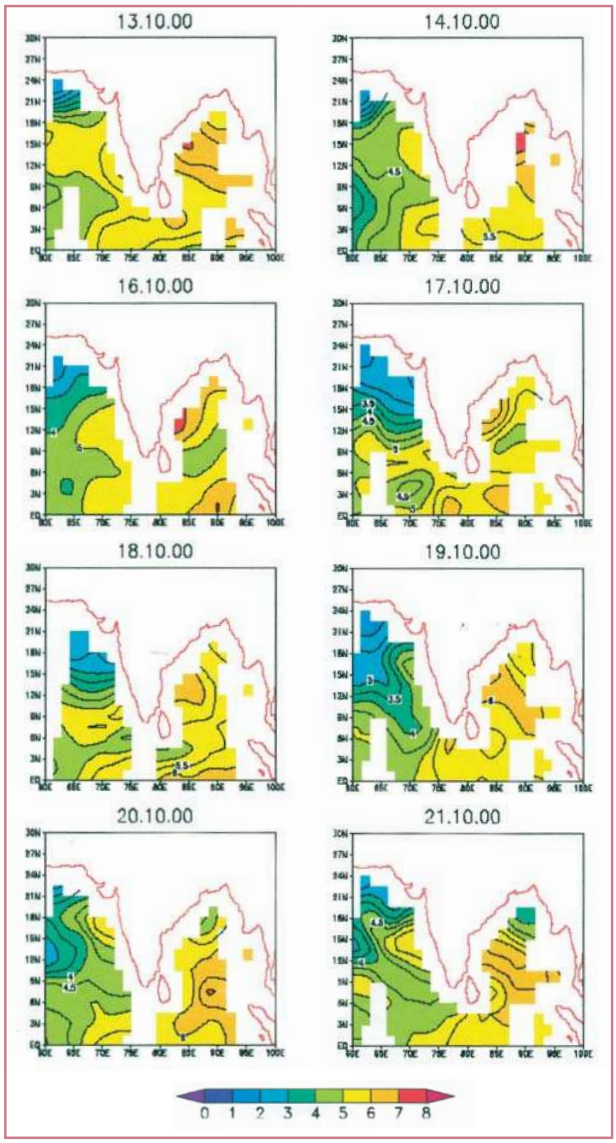


Fig. 13 : IRS-P4 MSMR derived integrated water vapour (gm/cm^2) for complete life period of tropical cyclone

A study was undertaken to examine the impact of correction factors on the analyses of sea surface temperature (SST) values derived from Indian polar orbiting satellite (IRS-P4). Some validating studies had indicated that certain correction factors need to be incorporated in IRS-P4 SST data as compared to INS Sagardhwani research vessel and buoy observations. These correction factors for day time (-1.4°C) and night time (+0.6°C) were applied to the satellite data and a case of Bay of Bengal tropical cyclone (25-30 November, 2000) was studied. The IRS-P4 SST data showed that the analysis is consistent with synoptic situation after incorporation of correction factors. Reduction of SST by 1-2°C over the oceanic area after the passage of cyclone was noticed due to turbulent mixing strong winds etc.

3-D numerical variational analysis, multiquadric analysis and cumulative semivariogram analyses schemes developed over India and adjoining region were found to be producing analyses which are comparable with the actual synoptic situations. These schemes were rested with the conventional data and satellite derived data viz. CMVs, WVWVWs, cloud top temperature and SST.

Using 10 years (1990-1999) NOAA OLR data for the months June to September, over the domain 10°S-35°N and 50°-110°E, interannual variability of OLR (convective activity) in relation to monsoon rainfall using CPC Merged Analysis of Precipitation (CAMP-rain) over India was studied. Percentage departures of OLR were calculated at each grid point (2.5° lat. x 2.5° long.) for each month and for all the years. Analysis of the results for the year 1991 showed –ve OLR anomalies (-3 to -0.5 Watts/m2) over the region of maximum convective activity/high rainfall (30 mm to 12 mm). Changes in the magnitude of OLR anomaly and rainfall were found to be consistent with the intensity of monsoon activity.

Air-Sea Interactions in Tropical Monsoons

(P. Seetaramayya, T. Venugopal, S.G. Nagar, A.H. Mullan, G.R. Chinthalu, U. Iyer)

Air-sea interface processes over Somali basin during monsoons 1988 and 1991

Variability in the surface fluxes over the Somali Basin was examined using MONSOON-88 and MONSOON-91 surface marine meteorological data collected under Joint INDO-USSR Monsoon Experiment. The area of the experiment was same (2°S-15°N, 52°-68°E) during both the years but the observation periods were slightly different (3 August - 12 September in 1988 and 19 August - 18 September in 1991). Figure 14 shows the composite of SST distribution over the study region during night (00 UTC) and day (09 UTC) time. It is seen from the figure that the 28°C isotherm which runs along a line joining 0°, 53°E to 12°N, 60°E

separates cold water (~23-24°C) over the Great Whirl* (i.e. at 8.1°N, 56.2°E in 1988 and at 8.7°N, 55.9°E in 1991) in the west and warm water pool (~29-30°C) in the east (0-4°N, 62-68°E). These two locations were characterized by strong winds (10-12 m/s, at Great Whirl) and comparatively weak winds (~2 m/s over warm water pool) during both the years. The SST over the Great Whirl differed by 2°C (25.0°C and 22.8°C in 1988 and 1991 respectively). Large gradients of SST were observed across the eastern edge of the Great Whirl and the gradients were stronger during 1991. It was interesting to note that there was nocturnal cooling and daytime warming over the region with a variation of 0.5°C to 1°C from day to night and vice-versa. *(The Great Whirl is defined as a systematically rotating anticyclonic warm water (~24° C) gyre/eddy which is seen in the summer monsoon (prominent during July to September) off the east African coast with its centre at around 8°N, 56°E).

Figure 15 shows the variability in wind and moisture fields across the eastern wedge of the Great Whirl (along the slanted line joining the grid points 8.5°N, 55°E and 2°N, 62°E) during these two years. The wind field was stronger during 1988 (210°/12.9 m/s) than in 1991 (230°/10.3 m/s). There was a substantial decrease in wind speed within 120 nautical miles around 56-58°E which is a characteristic feature over the Great Whirl. The specific humidity difference (q_{sst}-q_a) also reduced abruptly. These sudden changes in wind and moisture fields were reflected in fluxes of sensible heat (Q_H) and latent heat (Q_E). The values of Q_H were more or less same (varying between -25 to 25 W/m^2) during both the years, whereas, large values of Q_E were observed during 1988 than in 1991. Negative values of Q_H showed stability of the atmosphere over the Great Whirl region.

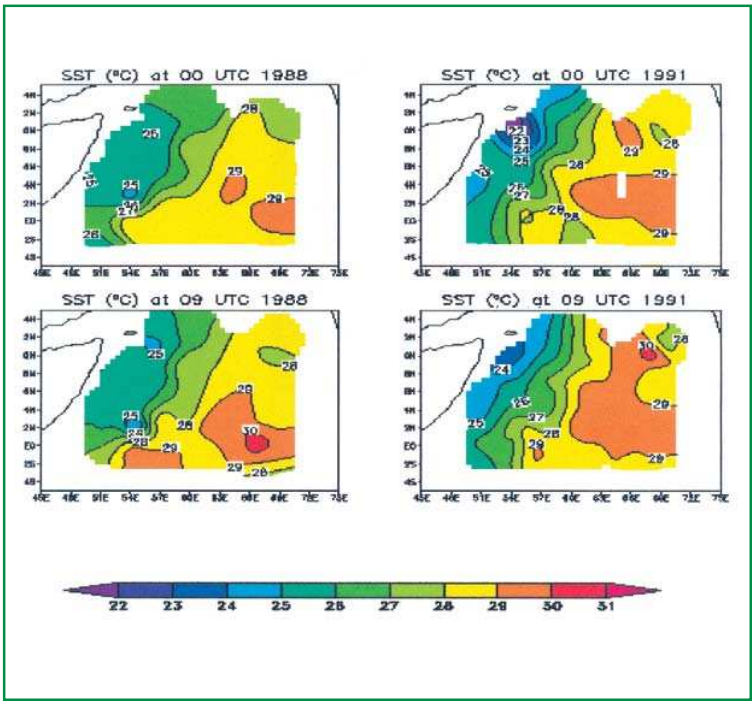


Fig. 14 : SST distribution over the Somali Basin

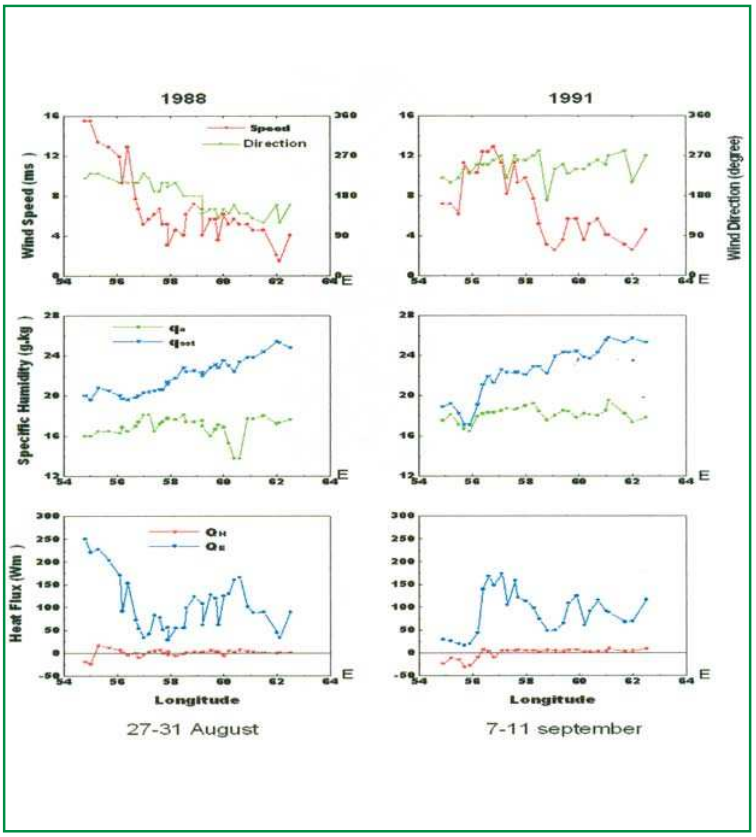


Fig. 15 : Flux transfer process across the Eastern wedge of the Great Whirl

Climatology and Hydrometeorology

Climatology and Hydrometeorology Division has formulated its research programmes with broadly addressing the following targeted objectives :

- To construct long homogenous time series of regional climatic elements from observed meteorological data, and to study their interannual and decadal variability on different space scales.
- To extend the observed climatic record back to the pre-instrumental era, using high-resolution proxy sources such as historical documents, tree rings, etc. and study the regional climate variability on centennial scales.
- To bring out the regional aspects of global climatic change, in terms of seasonal / annual mean climatic patterns as well as the severe climatic and weather events.
- To assess the numerical simulations of global climate with particular reference to the simulation of the Indian summer monsoon by means of model output diagnostics and to apply appropriate empirical/dynamical downscaling techniques to develop high-resolution future climate scenarios for the Indian region.
- To bring out regional/global teleconnections and develop empirical techniques for the prediction of seasonal / monthly climatic anomalies over the country as a whole and homogenous subdivisions of the country.
- To assess the impact of climate variability in various socioeconomic sectors like agriculture, water resources, human health, etc. and to develop methodologies for an optimal utilization of climatic information in these sectors.
- To carry out hydrometeorological analysis of short-duration rainfall data over various river basins of the country for application in water resources management.
- To carry out estimation of probable maximum precipitation analysis of the depth-area-duration of severe rainstorms and to provide inputs for the estimation of design parameters of hydrological projects.
- To understand the changes in rainfall patterns and hydrologic regimes and their possible association with global warming.

Regional Aspects of Global Climate Change and Variability

(K. Rupa Kumar, L.S. Hingane, H.P. Borgaonkar, A.B. Sikder, S.K. Jadhav, D.R. Kothawale, J.V. Revadekar, S. Ram)

Development of high-resolution climate change scenarios for India

High-resolution climate change simulations were performed using the latest version of the Hadley Centre regional climate model, for different socio-economic scenarios towards the end of the present century. This is a PC-based version called PRECIS (**P**roviding **RE**gional **C**limates for **I**mpacts **S**tudies), which has been installed at the Institute on an array of PCs for simultaneous experiments with different scenarios over the Indian region. PRECIS was run with a horizontal resolution of 0.44° longitude by 0.44° latitude (~50 x 50 km). The spatial domain chosen was 55.0°-104.72°E, 0.004°S-40.0°N. The model was run for an ensemble of three experiments of baseline climate representing the period 1960-90, and the SRES (IPCC Special Report on Emission Scenarios) scenarios A2 and B2 with and without sulphur for the time slice 2070-2100. The lateral boundary conditions were taken from the global model simulations using HadCM3 / HadAM3H performed by the Hadley Centre. The A2 scenario assumes a higher population growth rate than the B2 scenario, and slower per capita economic growth rates and technological change. As a result, the A2 scenario had a larger growth rate and higher emissions of CO_2, as well as larger emissions of methane, nitrous oxides and HFCs (hydro-fluoro carbons). PRECIS was run simultaneously on an array of high-end PCs to develop the scenarios within a relatively shorter time frame. To evaluate the model, the ECMWF reanalysis data were also used as lateral boundary conditions for the period 1979-1993. The scenarios covered the baseline period of 1961-1990 and the future period of 2071-2100 and were developed for A2 and B2 marker scenarios for the IPCC. The work was carried out as part of the Indo-UK collaborative programme on climate change impacts in India (Fig. 16).

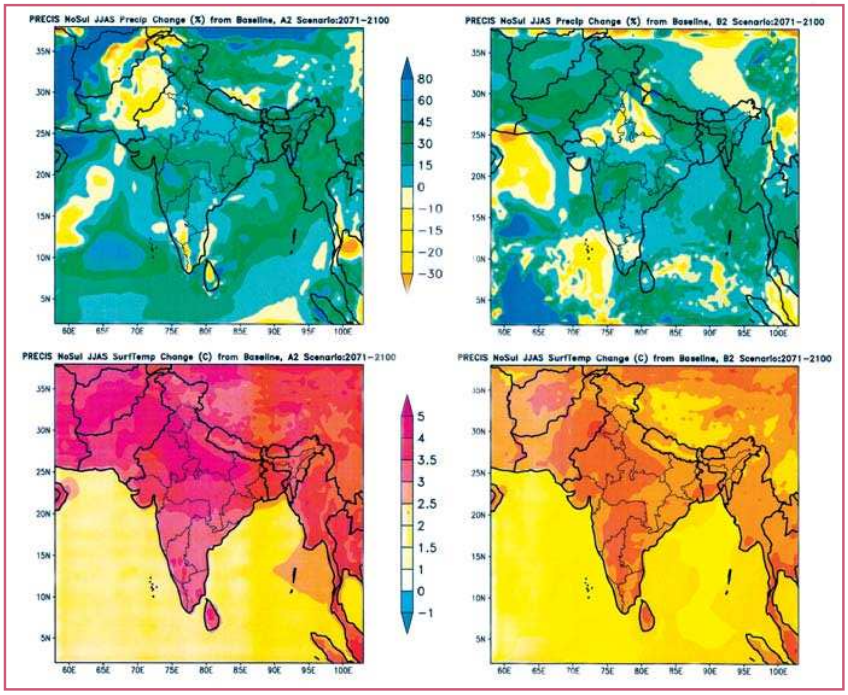


Fig. 16 : High-resolution climate change scenarios for rainfall and temperature during 2071-2100, using the regional climate model PRECIS

Future projections of extremes in rainfall and temperature

Simulated daily rainfall and temperature data generated from the regional model of Hadley Centre (HadRM2) were analysed for both control (greenhouse gas forcing fixed at 1990 level) and transient greenhouse gas (GHG) increase (IS92a, applicable for the period 2041-60) experiments. The number of rainy days, intensity per rainy day and extreme rainfall values were extracted from both the simulated and observed rainfall series for validation of the model simulations. Analyses of extreme temperatures (both maximum and minimum) were also carried out. In an increasing GHG scenario, an increase in extreme temperatures was indicated. Decreasing tendency was observed in the number of rainy days but the intensity of rainfall showed increasing tendency, in a greenhouse warming scenario.

Sensitivity of the Indian summer monsoon to enhanced greenhouse effect

A two-member ensemble of transient climate change simulations was analysed with a focus on the Indian summer monsoon and ENSO-monsoon teleconnection. The CNRM (Meteo France) ocean-atmosphere coupled model was integrated for the period 1950-2099 and driven by changes in concentrations of greenhouse gases and sulfate aerosols. The simulated monsoon climate was first validated against available observations and NCEP/NCAR reanalyses over the second half of the 20th century. The model captured main features of the Indian monsoon climate and the main mode of variability found in the tropical regions, namely the ENSO, reasonably well. During the second half of the 21st century, both the scenarios indicated a significant increase in the annual mean surface air temperature (about 2°C) and in monsoon precipitation (less than 10%) over India, relative to the 1950-1999 climatology. However, the model did not show a clear strengthening of the monsoon circulation, rather a northward shift of the westerly monsoon flow. The increase in monsoon precipitation was thus partly due to a 'non-dynamical' response to global warming, namely a large increase in precipitable water over India. While the transient response of the model showed a qualitative agreement with the surface warming observed over recent decades, neither the observations nor the model indicated significant trends in All India monsoon rainfall in the late 20th century. A long-term increase in simulated monsoon precipitation appeared from 1950 to 2099, but was superimposed onto relatively large multi-decadal fluctuations. The simulated ENSO - monsoon teleconnection showed a strong modulation on multi-decadal time scales, but no systematic change with increasing amounts of greenhouse gases. This work was carried out as part of an Indo-French collaborative research project.

Variability and prediction of northwest India winter precipitation

Northwestern parts of India receive considerable precipitation during the winter months (December - March), mainly associated with eastward moving sequence of mid-latitude synoptic systems known as western disturbances. Compared to summer monsoon rainfall very few studies have been attempted to understand the variability of winter precipitation over northwest India. In this context, an area-weighted mean northwest India winter precipitation (NWIWP) time series, based on the meteorological subdivisions having similar characteristics was developed for the period 1942-2003 (Fig 17). To understand the nature and mechanisms of the dominant modes of variability as well as the regional and global teleconnections having predictive potential, linear correlation and composite anomaly techniques were applied on different global datasets with NWIWP series. The NWIWP anomaly was found to be strongly related to the ENSO and NAO. Further, predictive relationships were identified over the south equatorial Indian Ocean during the preceding monsoon season, and with the Pacific / North America pattern (PNA) and the NAO during the previous spring season.

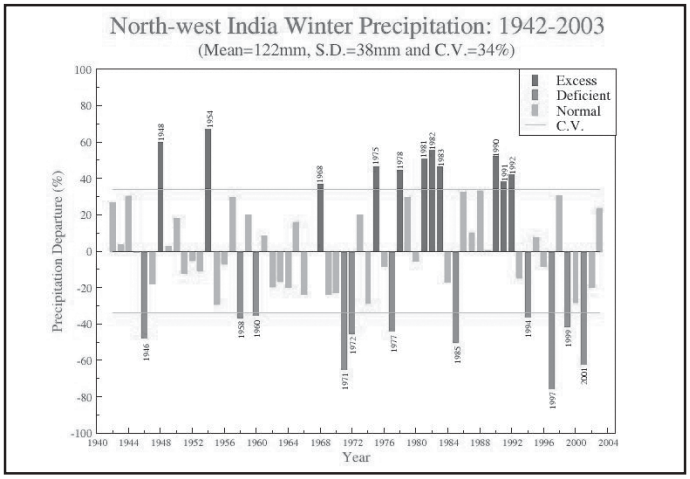


Fig. 17 : Interannual variability of winter precipitation over north-west India during 1942-2003

Northeast monsoon rainfall variability over India - Teleconnections and long range prediction

The southeast peninsular Indian region critically depends on the northeast monsoon to supplement the inadequate summer monsoon rainfall. A study of the role of Indian Ocean Dipole Mode (IODM) on the interannual and decadal variability of the northeast monsoon rainfall over south

peninsular India was carried out using long data series for the period 1871-2001. Observed rainfall data were used to determine the intensity of the northeast monsoon, GISST data to define the IODM strength, and the NCEP-NCAR data to understand the dynamics of the NEMR-IODM relationship. Enhancement of northeast monsoon rainfall by the positive dipole phase was noticed to be due to anomalously warm sea surface temperatures (SSTs) in the western Indian Ocean (IO), cool SSTs in the eastern IO and the associated large-scale convergence extending towards south India. On the other hand, the suppression of the northeast monsoon rainfall by the negative phase was found to be due to the anomalously cold SSTs in the western IO, and warm in the eastern IO and the associated divergent circulation and transport of moisture towards Sumatra, away from south peninsular India. These results showed the direct influence of the IODM phenomenon on the northeast monsoon rainfall variability during the boreal fall, the main rainfall season and the season with the strongest IODM intensity (Fig 18).

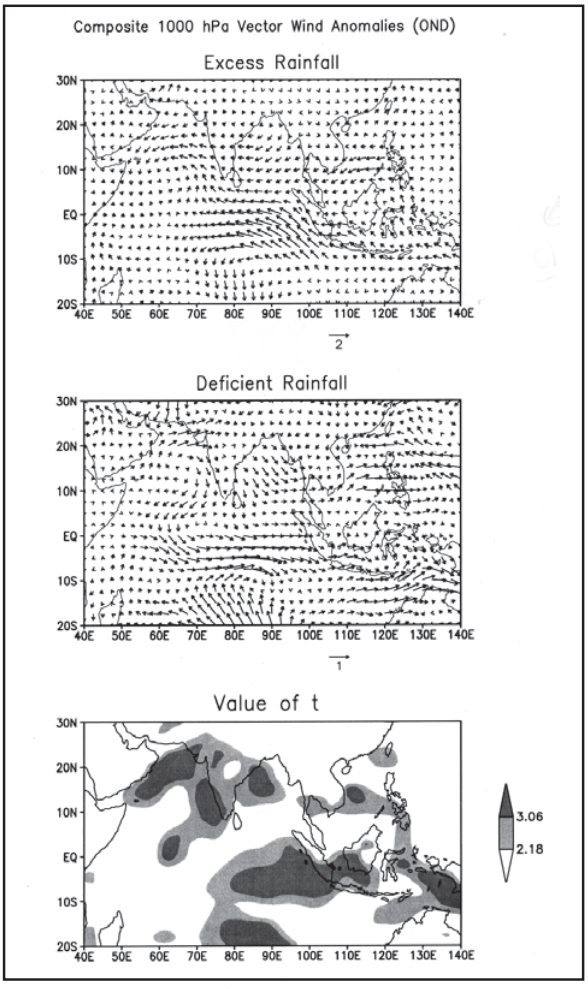


Fig. 18 : Composition of seasonal 1000 hPa wind anomalies (m/s) for excess and deficient rainfall during October through December, along with t- test of their differences

The relationship between northeast monsoon rainfall and the ENSO was investigated using a long time series of rainfall data. The relationship between the northeast monsoon rainfall over India and ENSO exhibited large secular variations. While the inverse relationship between southwest monsoon rainfall and the ENSO weakened during the recent years, the positive relationship between north monsoon rainfall and ENSO was strengthened and became statistically significant after mid 1970s.

Study of land-climate interactions

Two models viz., the Integrated Biosphere Simulator (IBIS) and Hydrological Routing Algorithm (HYDRA), developed by the Centre for Sustainability and Global Environment (SAGE), USA, were installed and successfully tested. An atmospheric general circulation model (CCM3) dynamically coupled to IBIS was also installed successfully. Experimental runs with IBIS and HYDRA were performed for the Indian region using the observed monthly data for the period 1901-1996. This suite of models would be extremely useful to study the climate-land interactions on a regional scale.

Analysis of heat wave conditions over Andhra Pradesh - 2003

Andhra Pradesh experienced severe heat wave conditions during May - June, 2003 and caused 1421 deaths. In view of this a detailed study was carried out to examine the trend, if any, in the maximum temperature and frequency of occurrence of heat

wave conditions in different parts of Andhra Pradesh in the recent decades. Monthly maximum temperature data for the months March - June at 10 well spread stations with data ranging for 94 to 102 years during 1901 - 2002 and daily maximum temperature data for the same months at four stations (Machilipatnam, Visakhapatnam, Hyderabad and Kurnool) for the period 1970-2002 were utilized. For the current year heat wave conditions, March - June maximum temperature data at 16 stations were analysed to identify heat wave spells and its severity over different parts of Andhra Pradesh. During the recent three decades, no significant warming trend was observed in March - June temperature of Andhra Pradesh. On a local scale, the station Machilipatnam seemed to be experiencing relatively more frequent heat wave conditions; however, no perceptible change in the heat wave conditions was observed over the past three decades at this station. On the whole, it may be concluded that the unprecedented heat wave conditions over Andhra Pradesh in 2003 resulted out of anomalous synoptic scale circulation features rather than being a part of a long-term regional temperature change.

Dendroglaciological studies of high altitude glacier sites of Western Himalaya

Preliminary results of ongoing project entitled 'Dendroglaciological studies of high altitude glacier sites of Western Himalaya' indicated that high altitude tree-ring chronologies far away from each other showed common signal of wide-scale climate effect (e.g. increasing temperature, glacier fluctuations). Two high altitudes near glacier tree-ring chronologies from Kothi and Sangla, (Himachal Pradesh) showed very similar patterns of increasing growth after 1920s. The chronologies did not show any other such significant episode of higher growth prior to 1920s. This may be explained as a possible effect of winter warmth. Over Western Himalaya, winter (December-February) temperature showed increasing trend. Particularly after 1940 significant increasing trend was observed with more positive anomalies. A few studies reported that during last few decades many Himalayan glaciers are shrinking. Particularly Gangotri glacier is retreating fast since 1935. This matches with the significant increase in winter temperature over Western Himalaya since 1940 and abrupt increasing trend in growth pattern of trees located far away from each other (Fig. 19 and 20).

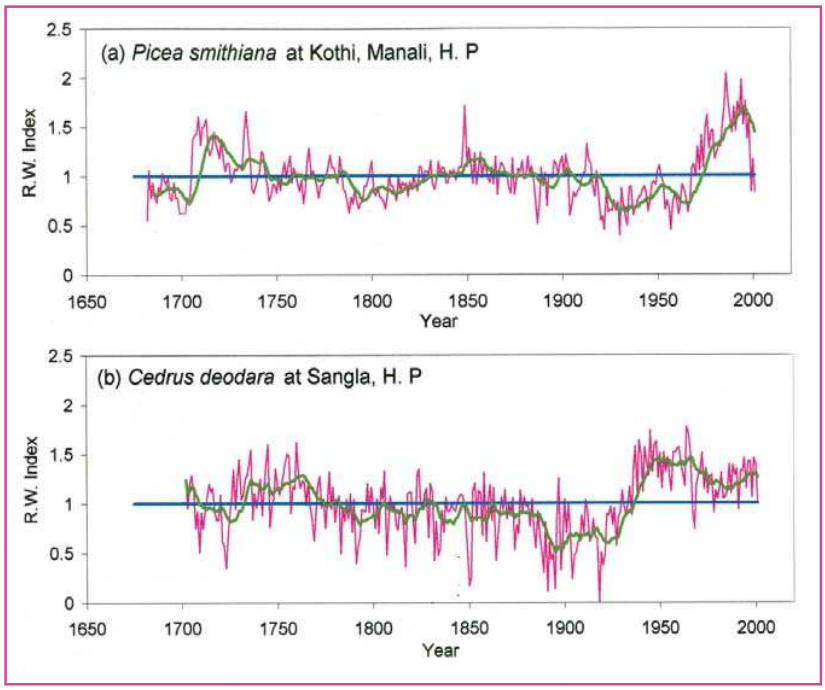


Fig. 19 : Tree-ring index chronology of a) Pices smithiana at Kothi, Manali, Himachal Pradesh (Alt. 2800 m amsl) and b) Cedrus deodara at Sangla, Himachal Pradesh (Alt. 3200 m amsl)

Reconstruction of past changes in monsoon precipitation by developing a regional network of tree-ring records over south Asia

Under the ISRO-GBP project, a field tour was organized to collect tree-ring samples from different parts of Kerala, during the period 29 December, 2003 to 25 January, 2004. About 225 samples were collected during the period. The preliminary analysis of the samples showed a high correlation with the pre-monsoon rainfall.

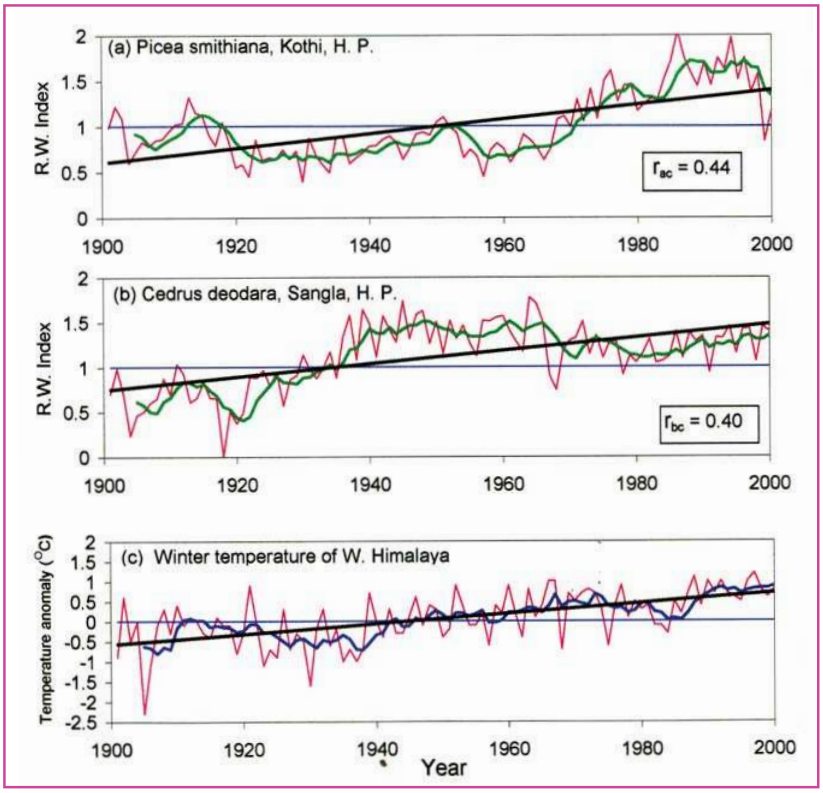
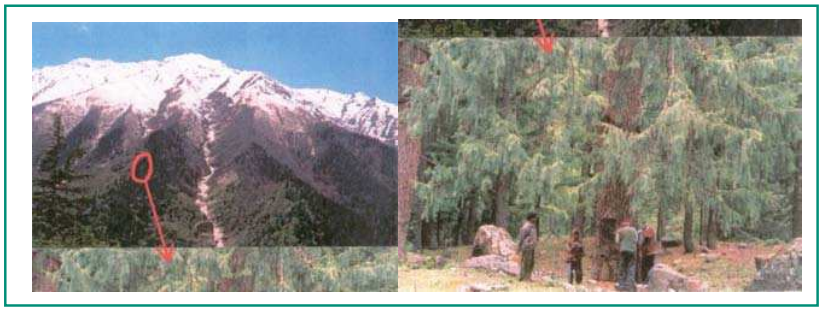


Fig. 20 : Tree-ring index chronology at a) Kothi b) Sangla c) Winter temperature anomalies of Western Himalaya rac and rbc are serial correlation of Kothi and Sangla chronologies respectively with winter temperature of Western Himalaya



Tree-ring sampling site near glacier at Sangla, Himachal Pradesh (Alt. 3200 m amsl)

Climate Applications in Agriculture, Water Resources and Public Health

(K. Krishna Kumar, C.M. Mohile, A.A. Munot, S.K. Patwardhan, S.D. Patil)

Annual cycle shifts in Indian rainfall

Utilizing more than a century long sub-divisional monthly rainfall data over India, shifts in the annual cycle were examined during well known above and below normal monsoon rainfall epochs (1891-1920, 1921-1950, 1951-1980, 1981-2000). The analysis was performed using frequency domain technique, Multi Taper Method-Singular Value Decomposition (MTM-SVD). This method isolates spatially coherent patterns (amplitude and phase) at different frequencies. These patterns for the annual cycle frequency were estimated for the four epochs and the shifts in annual cycle calculated for the recent two decades (1981-2000) relative to the earlier epochs. The recent two decades exhibited significant annual cycle shifts (of about 15-20 days earlier) relative to prior epochs over much of North and Central India (Fig. 21 a, b, c). Similar analyses were performed on the monthly rainfall data from high-resolution climate change scenario corresponding to a future time-slice of 2041-2060 developed using Hadley Center Regional Climate Model (HadRM2) with lateral boundary forcing from Hadley Center's coupled model (HadCM2). These results showed even stronger annual cycle shifts (of about 15-30 days earlier) in the enhanced greenhouse gas (GHG) scenario compared to the control simulations (Fig. 21 d). The striking similarity of observed annual cycle shifts in recent decades and future climate change scenarios hints for a tantalizing possibility of global warming to be a causal factor.

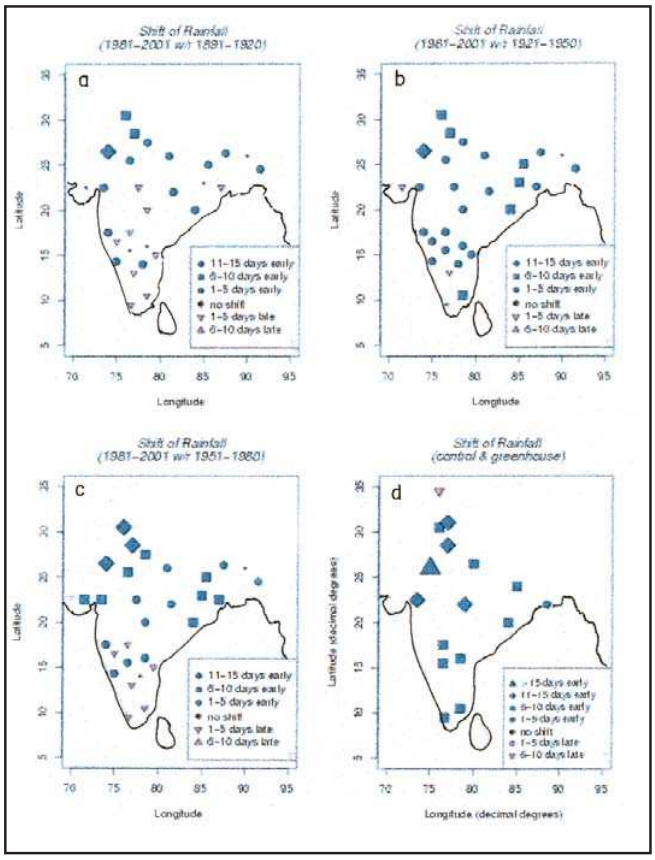


Fig. 21 : Annual cycle shifts (in days) during 1981-2001 period compared to three earlier ecpochs of a) 1891-1920, b) 1921-1950 and c) 1951-1980. The last panel shows such shifts in greenhouse gases (GHG) scenario rainfall (2041-2060) compared to the fixed GHG control simulation from Hadley Center regional climate model (HadRM2)

Dynamical Indian Monsoon Simulation Skills

Skills of Indian monsoon rainfall simulations were examined in a suite of 10 atmospheric general circulation models (AGCMs) run with prescribed observed sea surface temperatures (SSTs) during a 50 year period starting from 1950. Several ensemble runs (112 in all) were made for each of the models with different atmospheric initial conditions. Theoretical 'Perfect-Model' skills were computed by correlating time series of seasonal monsoon rainfall as simulated in one run with all other runs in each model resulting in more than 1000 such correlations. A probability density function (PDF) of such correlations is shown in Figure 22 (red curve). A high median correlation of 0.7 indicated a strong run-to-run reproducibility and potential high predictability. Paradoxically, the actual correlation skills between model simulated ensemble mean monsoon rainfall and observed rainfall (blue curve in Figure 22) proved to be woefully inadequate, falling far below Perfect-Model skills. From the large separation of the PDFs in Figure 22, it was evident that the high theoretical skill scores were not being realized for the Indian monsoon region in these AGCM simulations. The skill was shown to be materially

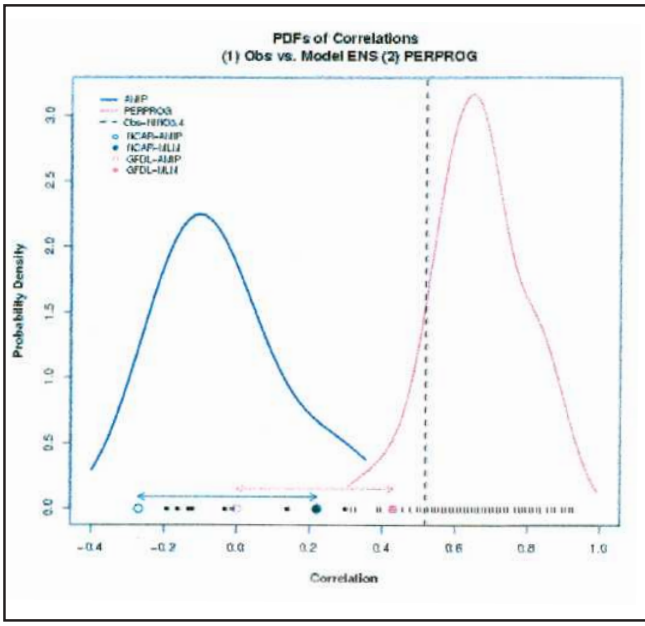


Fig. 22 : . Probability distribution functions (PDFs) of correlation skill of June-September Indian monsoon rainfall based on a theoretical perfect-model analysis (red curve), and based on the actual skill compared to observed all Indian monsoon rain (blue curve). Analysis is based on 10 AGCMs forced with specified global SSTs of 1950-1999. Tick marks denote the correlation between individual model realizations on the 1950-1999 Indian monsoon rain time series. Circles denote the correlation between ensemble GCM and observed Indian monsoon rain times series. Closed, colored circles denote the skill of two of the AGCM coupled to a mixed layer model. Arrows denote the change in skill between pairs of uncoupled (AMIP) and coupled (MLM) GCM simulations

increased by treating the year-to-year swings in Indian monsoon rain as a coupled ocean-atmosphere problem. Such interactions were not represented in AGCMs where in the two-tiered design (predicting SSTs first and using them as boundary forcing in AGCMs) presupposes Indian monsoon variations to be described as a purely forcing-response system. Enhancement in monsoon simulation skills could be visualized through the red and dark green circles and arrows in Figure 22 when two AGCMs (NCAR-CCM3 and GFDL-R30) were run with observed SSTs in the eastern Pacific, but the SSTs elsewhere in the world oceans evolved freely according to coupled air-sea interactions with a mixed layer ocean model. This has implications not only for India but may also lead to improved seasonal forecasting skills of other parts of the world.

Sensitivity of the Indian monsoon climate to different convective parameterization schemes in MM5

The Pennsylvania State University - National Center for Atmospheric Research (PSU-NCAR) model MM5 (version 3.5.2) was used to simulate the Indian summer monsoon rainfall during two contrasting years viz. 1987 and 1988. Three different cumulus convection parameterization schemes, Betts-Miller-Janjic, Kain-Fritsch and Grell were used to study the sensitivity of monsoon to cumulus heating. The model was integrated for a period of six months, starting from 1 May of each year. Six hourly NCEP-NCAR reanalysis data were used to provide the lateral boundary conditions and the observed weekly sea surface temperature, linearly interpolated to six hours, was used as the lower boundary. All the three cumulus schemes were able to simulate the general features of interannual and intraseasonal variabilities in the two contrasting monsoon seasons with reasonable accuracy. However, the spatial distribution of the rainfall and its quantity were different in all the schemes. The Grell scheme underestimated the rainfall in both the years. The simulated rainfall during the peak monsoon months of July and August in 1988 were very similar to observations in the Kain-Fritsch scheme, the remaining two months of 1988 and all the months in 1987, however, were overestimated with this scheme. On the other hand, the Betts-Miller-Janjic scheme simulated less rainfall in the drought year of 1987 and overestimated the rainfall in June and July of 1988. However, the circulation patterns as measured by the Webster-Yang Index (zonal wind index) and Monsoonal Hadley Circulation Index (meridional wind index) were simulated realistically in Betts-Miller-Janjic and Kain-Fritsch schemes. Sensitivity of cumulus schemes was also examined for the rainfall variabilities on smaller spatio-temporal scales and the results were verified using daily rainfall data from different parts of India.

Climate change impacts on irrigated rice production in southern peninsular India

Dynamic crop simulation model was used to investigate the potential impacts of climate change on intensive rice based cropping systems in southern India. Climate change scenarios were developed by two methods (i) simple adjustments to daily climate records (fixed climate change scenario) and (ii) daily outputs of a Regional Climate Models (HadRM2, Hadley Centre, U.K). The crop model was validated and parameterized for current management practices adopted by the farmers at case study locations for impact analysis. The simulated climate by HadRM2 for the future (2041-2060) with 1990 GHG emission (CTL) would be cooler by 0.85°C compared to the current observed climate (base line). The simulated annual rainfall under CTL was found to be consistently lower by 16.8% compared to current observed rainfall. The difference in rainfall might be unimportant for irrigated rice crop performance. The future climate change scenario (GHG) of HadRM2 showed increase in solar radiation, maximum temperature, and minimum temperature by 0.35 MJ/m^2, 3.4°C and 3.6°C, respectively and decline in rainfall by 9.5% compared to control (CTL) in a future time slice of 2041-2060. The rice yield was simulated using validated rice model (CERES-Rice) for 7 locations in the region, using the observed weather data and simulated weather by HadRM2. Rice based cropping systems of southern India exhibited greater probability of yield reduction under future climate change scenario with fixed temperature and CO_2 increments and HadRM2 model projections under IS92a GHG scenario. The average decline in rice yield was estimated to be -8.4% and -7.6% for the first (June-September) and second season

rice (October – January / February) of double crop systems, while the average reduction for single crop rice (September – December /January) system was lower with -3.7%. Delay in planting of first season rice by a month (July planting) reduced the rate of yield decline. However, delayed planting of first rice by a month would have greater overlap with the subsequent seasons, making adaptation options very difficult. Concerted research efforts for high temperature tolerant and drought resistant rice varieties might be the better adaptation option.

Use of Indian Ocean SST as a predictor for Indian summer monsoon rainfall

Because of its close proximity to the Indian sub-continent and the associated features of land-sea heating contrast, the Indian Ocean plays an important role in Indian monsoon rainfall variability. To understand the influence of the Indian Ocean SST over all-India summer monsoon rainfall, a detailed analysis of the Indian Ocean SST was carried out. Monthly mean SST of the Indian Ocean (55°-72°E, 8°-22°N) varied from lowest 25.8°C in January to highest 29.4°C in May. A significant increasing trend was observed in the Indian Ocean SST for all the months of the year. The Indian Ocean SST was found increasing at the minimum rate of 0.2°C/100 yr in February to maximum of 0.8°C/100 yr in October whereas annual mean Indian Ocean SST was increasing at the rate of 0.5°C/100 yr. Detrended Indian Ocean SST for June-July-August (JJA) season of the preceding year, with a lead time of about 10-12 months was found to be positively related (significant at 1% level) with all-India summer monsoon rainfall and could be used as a long-lead predictor for Indian summer monsoon rainfall. A simple linear regression equation to predict all-India summer monsoon rainfall using the Indian Ocean SST for JJA of the preceding year as a predictor explains about 35% of the variance.

Hydrometeorological Studies of River Basins for Applications in Water and Power Resource Projects

(B.N. Mandal, R.B. Sangam, N.R. Deshpande, J.S. Pethkar, S.S. Nandargi, S.S. Mulye)

Design storm studies over the Bhagirathi and the Dhauliganga catchments in Uttaranchal State

Design storm studies were carried out over the two catchments in Garhwal Himalayan region viz. the Bhagirathi up to Loharinag Pala (area 3316 km^2) and the Dhauliganga up to Tapovan Vishnugad (area 3100 km^2), using rainfall data of about 73 stations around the study region for their available period from 1901. Standard Project Storms (SPS) and Probable Maximum Precipitation (PMP) raindepths were estimated by physical and statistical methods. Analysis of 7 severe rainstorms viz. (i) 18-19 September, 1914, (ii) 28-29 September, 1924, (iii) 15-16 September, 1963, (iv) 2-3 October, 1910, (v) 24-25 June, 1921, (vi) 8-9 October, 1956 and (vii) 25-26 July, 1966 by Depth-Duration (DD) method revealed that, the envelope raindepths of 12.5 cm and 17.9 cm were contributed by the rainstorm of 15-16 September, 1963 (Fig. 23) for 1 and 2-days durations over the Bhagirathi Catchment while the rainstorm of 27-28 September, 1924 (Fig. 24) contributed envelope raindepths of 11.3 cm and 19.8 cm over the Dhauliganga catchment. PMP raindepths by physical method were obtained by maximizing the Standard Project Storms (SPS) raindepths over the two catchments with appropriate moisture maximisation factors (MMFs). The MMFs were found to be 1.41 and 1.40 for the rainstorms of September, 1963 and September, 1924 respectively. The PMP raindepths thus obtained were found to be 17.6 cm and 25.2 cm over the Bhagirathi, and 15.8 cm and 27.7 cm over Dhauliganga for maximum 1 and 2-day duration. The PMP raindepths by statistical method were found to be 16.2 cm, 25.0 cm over Bhagirathi and 19.0 cm and 29.5 cm over Dhauliganga catchment for 1 and 2 day durations. Time distribution analysis was also carried out using hourly rainfall data of nearby self recording rain gauge stations (SRRG).

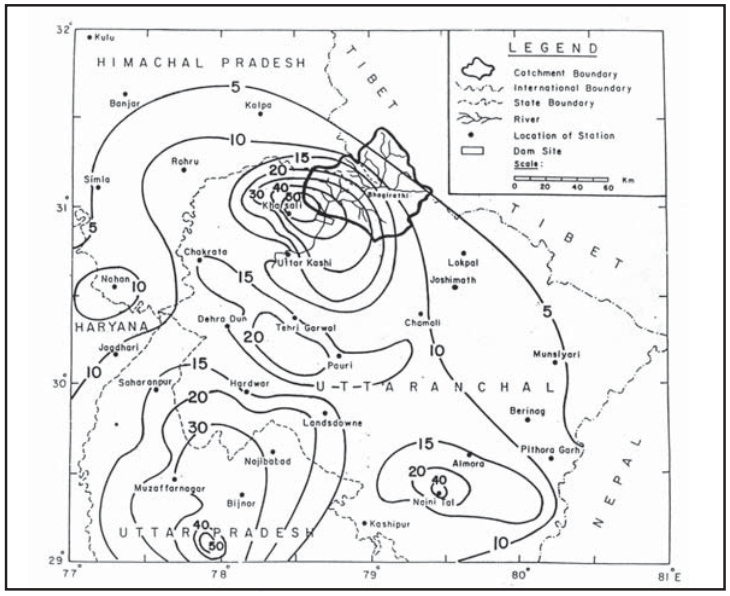


Fig. 23 : 2-day isohytal pattern of 15-16 September 1963 rainstorm over and near the Bhagirathi catchment (in cm)

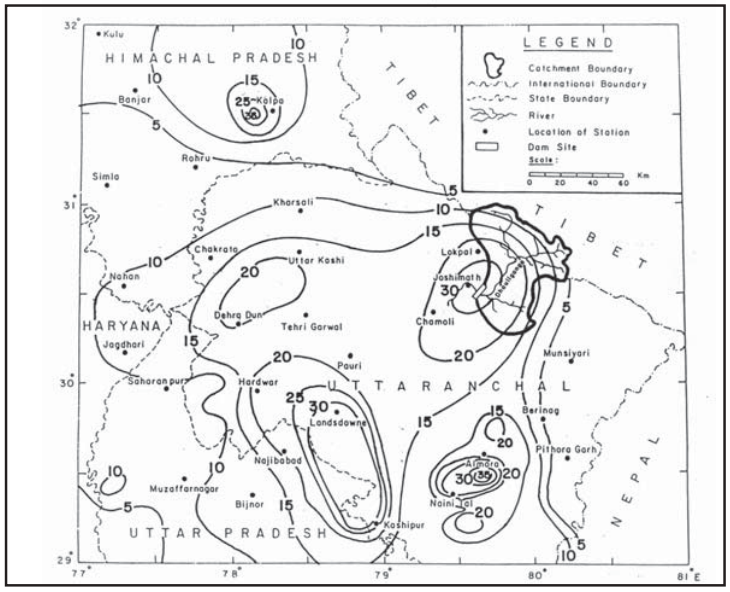


Fig. 24 : 2-day isohytal pattern of 27-28 September 1924 rainstorm over and near the Dhauliganga catchment (in cm)

Water Potential of the Wardha and the Penganga river catchments of the Godavari

Hydrometeorological analysis was carried out over Wardha and Penganga rivers and its sub - catchments of the Godavari basin. DAD analysis showed that the rainstorms of 12 July, 1994, 2-3 July, 1930 and 1-3 July, 1930 were severe and contributed raindepths of 18.2 cm, 20.6 cm and 28.2 cm respectively for 1, 2 and 3-day durations for an area of 50,000 km^2. Analysis on availability of water potential over 15 minor catchments of Wardha and Penganga rivers showed that on an average 0.74 to 1.07 million cubic meter of water per sq. km were recorded during southwest monsoon months (June-September). It was also found that there were 16 excess and 17 deficient rainy years during the period 1901-1990. The year 1959 was the wettest year, during which the catchment received 133.1 cm rainfall, 153% of the normal value, while the year 1920 was deficient year as catchment recorded 45.4 cm rainfall, i.e., 52.1% of normal rainfall.

Analysis of heavy rainspell of 26-28 June, 2002 over Saurashtra, Gujarat and adjoining north Konkan

During 26-28 June, 2002 heavy to very heavy rainfall were reported by many stations over the Saurashtra, Gujarat and adjoining north Konkan region (Fig. 25), in association with the passage of a low pressure system, combined with mid-tropospheric circulation and off-shore trough along the west coast. The heavy rainfall episode of 26-28 June, 2002 was analysed by Depth-Area-Duration (DAD) method for 1-3 day durations by considering daily rainfall data of about 200 stations. It was observed that the heavy rainspell had two distinct separate cells, one over the Saurashtra and Kutch region with centre at Palitana in Bhavnagar district and another over the north Konkan with centre at Pardi in Valsad district. Pardi recorded 62 cm of rain on 26 June and 94 cm during 26-28 June, while Palitana recorded 49 cm of rain during 26-28 June. DAD analyses were carried out for both the cells and raindepths over standard size of areas were estimated. It was found that for 50,000 km^2 area, cell in Saurashtra and Kutch gave 21.5 cm raindepth while cell over south Gujarat and north Konkan gave

34.5 cm for 3-day duration. Comparison of these DAD values with other severe rainstorms of the region revealed that areal raindepths of 26-28 June, 2002 were not of unprecedented in nature. However, this rainspell was the severemost in the monsoon season of the year 2002.

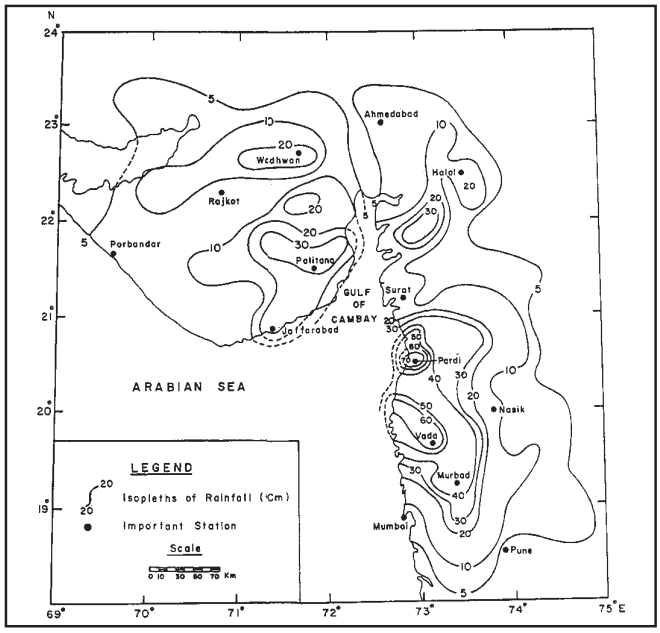


Fig. 25 : 2-day isohytal pattern of 26-28 June, 2002 rainstorm over Saurashtra, South Gujarat and North Konkan

Preparation of generalized PMP maps over Saurashtra and Kutch

A generalized approach of estimating areal Probable Maximum Precipitation (PMP) by physical method for the Saurashtra and Kutch region was developed. The DAD raindepths for different size areas and durations from the major rainstorms occurred over the region during 1891-2002 were obtained and moisture maximised at its original location of occurrence and then transposed at different grid points after identifying transposition limits of major rainstorms. After applying various corrections, PMP values at different grid points were estimated. Generalized PMP estimates at different locations were obtained with the help of these estimated PMP values and generalized PMP maps for 1000, 5000 and 10000 km^2 areas were prepared.

Water availability studies for major river basins in India

A case study was carried out to assess the surface water availability in the Krishna river basin in the past years. Monthly discharge data (m^3 /sec) at 17 selected gauging sites in the Krishna basin were considered for the available period of 24 years (1972-1995) and long period discharge data for 95 years (1901-1995) at Vijayawada. Monthly and seasonal mean discharge values at various sites were estimated to study the temporal and spatial changes in the water availability year to year variations were considered to see the presence of any trend in the data series. Series of minimum monthly discharge data per year were constructed for all the sites and fitted with 2 parameter weibull distribution (ie (b,c)). Parameters of the distribution were estimated by least square method. Using the inverse transformation of the cumulative distribution function and estimated parameters of the distribution, 80 % reliable monthly surface flow was estimated for each site. This measure, defined in terms of low flow estimation with some reliability was used in the study as the indicator of water availability at a location.

Analyses of monthly discharge data of the Ganga river basin at Farakka (1949-1973), the Godavari basin at Polavaram (1901-1979) and the Krishna basin at Vijaywada (1901-1979) were carried out in order to study variability in streamflow and their relationships with monthly basin rainfall for different time lags. For all the three sites empirical relationships were established and found to be statistically significant at time lag of 1 month (Fig. 26).

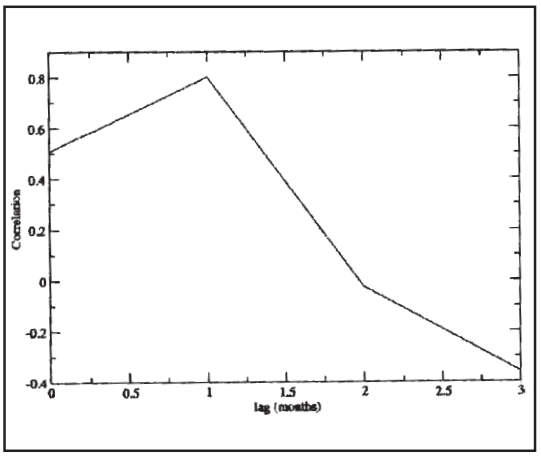


Fig. 26 : Correlation of monthly rainfall vs discharge for monsoon months at Farakka

Extreme rainfall features over the western Himalayan region

Daily precipitation data of 29 recording western Himalayan stations, well distributed over the region of southern parts of Jammu and Kashmir, Himachal Pradesh and some parts of west Uttaranchal were analysed for the extreme precipitation analysis. As the winter season is the chief rainy season for this region, data period considered was from November to April only and the data length was at least 5 years covering the period from 1971-2001. The spatial patterns of extreme observed precipitation for 1-day, 2 and 3 consecutive days' durations were made. General decreasing trend of extreme precipitation was noticed from west to east i.e. high values were observed over south-west part of Jammu and Kashmir. Decrease in extreme precipitation was observed towards the eastern parts of the study region. The range of highest observed precipitation for 1 day duration was 6 cm to 35 cm, for 2-day duration 7 cm to 68 cm and for 3-day duration it ranged from 8 cm to 68 cm respectively. Three stations viz., Sonemarg, Solang and North Portal recorded highest precipitation (>25 cm during 24 hours).

Hourly rainfall analysis over the Upper Krishna basin

Using hourly rainfall data of 6 SRRG stations in the Upper Krishna basin, some characteristic features of hourly rainfall for the rainy months (May-October) were studied. Maximum observed rainfall for 1, 3, 6, ..., 24 hours were computed for all the 6 stations. Highest as well as average percentage ratios of these durations to that of 24-hour rainfall were determined so as to study the time distribution of rainfall within heavy rainspells. Comparison between any maximum 24-hour rainfall and maximum observational-day rainfall using the heavy rainspell data was made. The diurnal variation of rainfall was studied for the months May - October (Fig. 27).

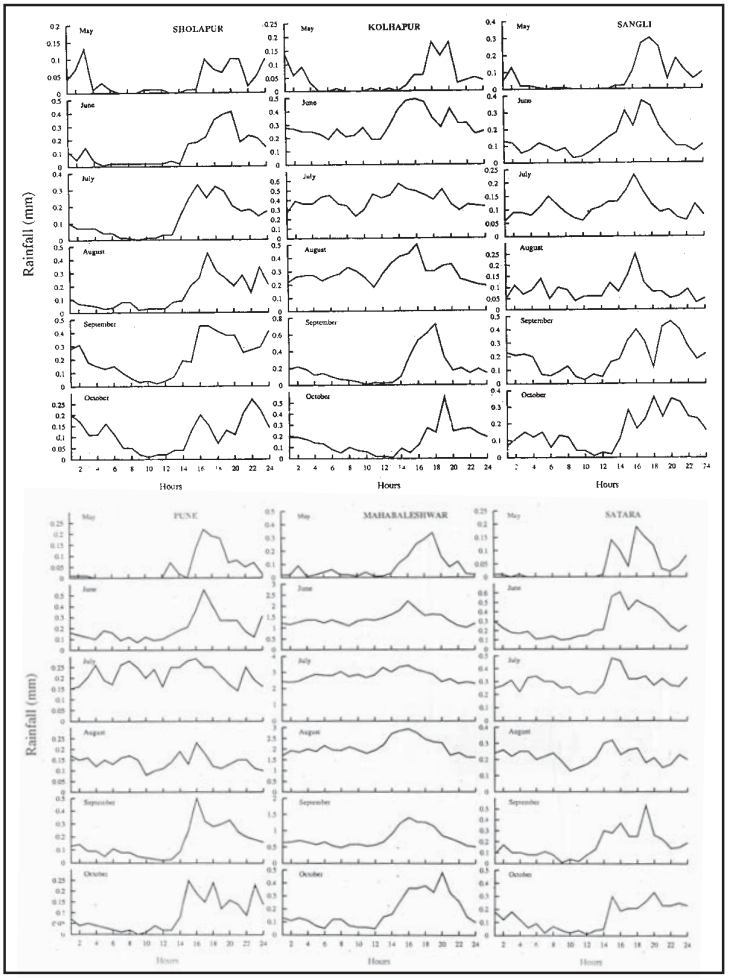


Fig. 27 : Diurnal variation of rainfall over 6 Self Recording Rain Guage (SRRG) stations in the upper Krishna basin

Rainfall distribution over Arunachal Pradesh Himalayas

Mean annual rainfall data of 67 stations in and around Arunachal Pradesh for varying periods of 5 to 70 years showed a heavy rainfall zone of 300-500 cm in the foot hill Himalayas to the north of the river Brahmaputra, north of which the rainfall decreases rapidly. The region as a whole receives rainfall of about 200 - 500 cm annually and there are pockets of heavy rainfall at some individual stations. A tongue of low rainfall less than 200 cm runs southwestwards from Rotung station. Pasighat station near the foot hills of the Himalayas has a mean annual rainfall of 445 cm and has recorded highest one-day rainfall of the order of 47 cm, whereas other stations have recorded highest one-day rainfall totals varying from 15 to 30 cm.

Water quality analysis of some selected stations in Krishna river basin

The quality of water in different water systems is an index of certain parameters, such as pH, conductivity, hardness, etc. dissolved in water flowing through different terrain. The Krishna river is perennial and one of the best harnessed rivers in the southern peninsula. The river and its tributaries flow through different terrain having varied soil conditions, vegetation and agricultural practices. In view of this, 17 different water quality parameters were selected. The mean monthly analysis of these parameters for 19 stations, well distributed in the 4 sub-catchments of the Krishna river for the period 1972-1996 was carried out for their temporal variation. In addition, daily rainfall data and discharge data at these sites were also collected for further analysis and study of relationship between them. This analysis would be useful to study the impacts of climate change on water quality of Krishna and its sub-basins.

Changes in Rainfall Pattern and Hydrologic Regimes over India and their Relationship to Global Warming

(N. Singh, N.A. Sontakke, B.D. Kulkarni, H.N. Singh)

Due to rising trend in the lower atmospheric temperature considerable spatial changes in the global rainfall distribution pattern are expected by the end of 21st century. Based on past instrumental data of ~150 years influence of large-scale temperature fluctuation on the spatial variation of rainfall pattern over India was investigated. In order to assess likely implication of global warming on the annual rainfall is studied by examining variation in the area under specified rainfall condition, delimiting the moisture regions - arid (rainfall < 560 mm), semiarid (561-1040 mm), dry subhumid (1041-1420 mm), moist subhumid (1421-1630 mm), humid (1631-2450 mm) and perhumid (> 2451 mm). On the mean annual rainfall chart 11.75% area of the country is under arid condition, 36.58% semiarid, 27.74% dry subhumid, 9.53% moist subhumid, 8.86% humid and 5.54% perhumid (Fig. 28).

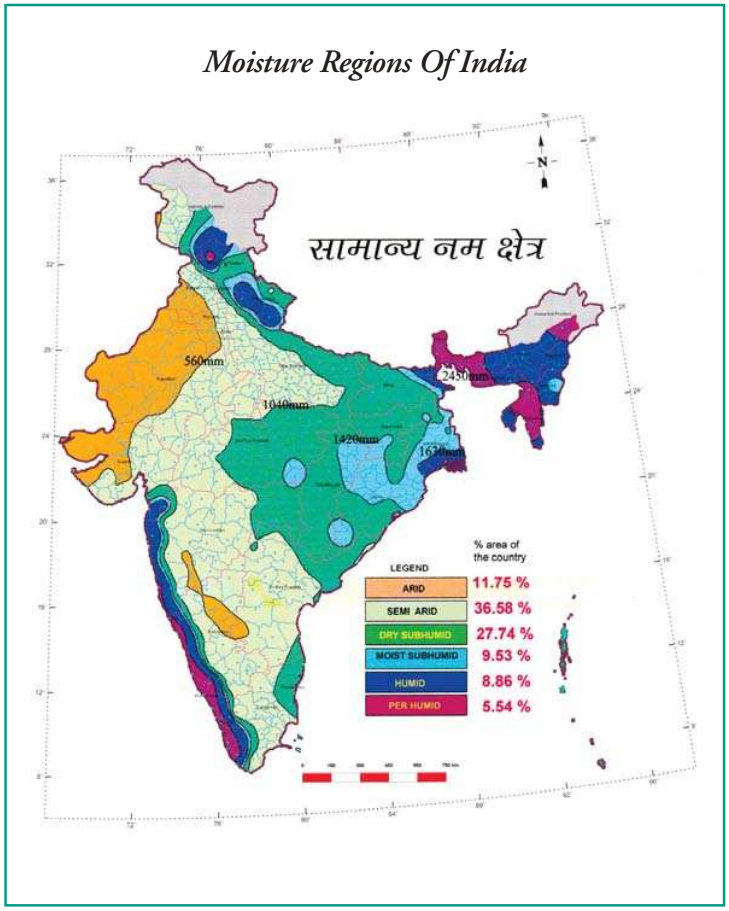


Fig. 28 : Moisture region delineated using GeoMedia GIS on the normal annual rainfall chart of India

Considering data from well spread 316 locations year-wise (period 1871-2001) area under different moisture conditions was obtained using GeoMedia Professional 5.1 GIS software package. Different moisture regions displayed large variation from one year to another. Some regularity was seen in the low frequency mode fluctuations (9-point Gaussian low-pass filtered values). The notable features are the spreading

tendency in semiarid and dry subhumid areas from about early 1940s, and shrinking in arid, moist subhumid, humid and perhumid areas (Fig. 29).

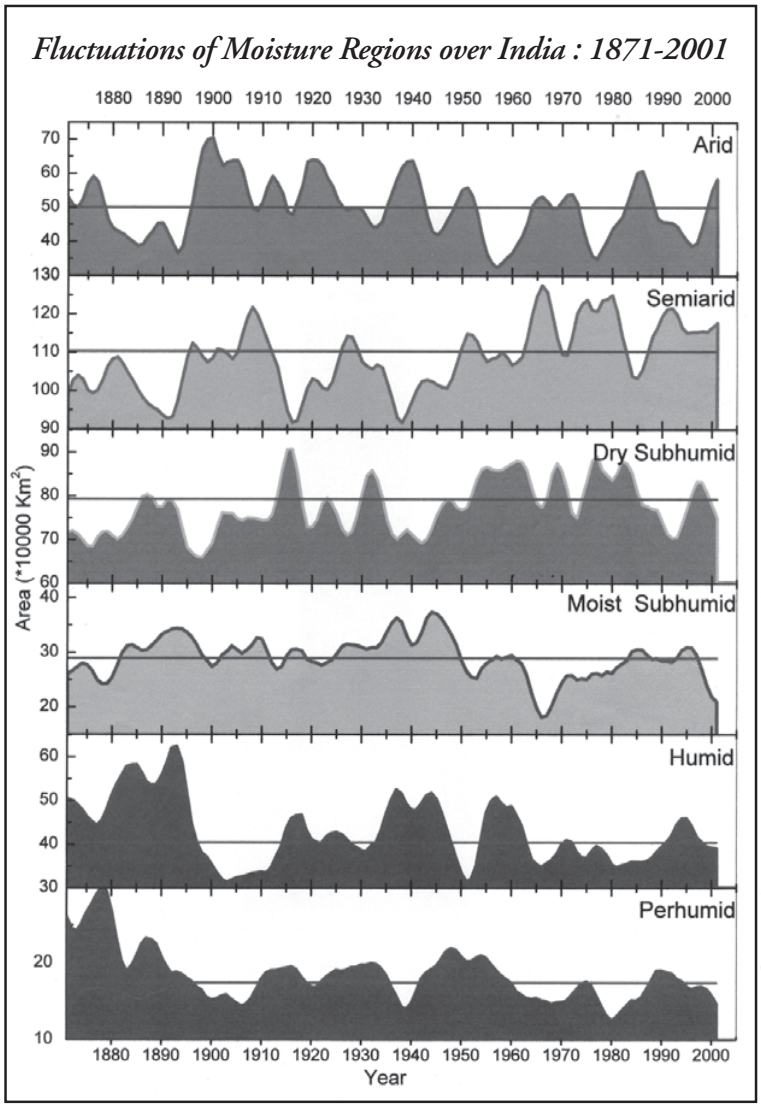


Fig. 29 : Low-frequency mode (9-point Gaussian filtered) fluctuations of different moisture regions of India

Spatial variability of seasonal rainfall was studied by examining variation in the area under very dry, dry, wet and very wet conditions. On the normal isohyetal chart three isohyets were carefully chosen dividing the country into four equal parts, designated as very dry, dry, wet and very wet areas. The low frequency mode fluctuations indicating tendency of long term changes in seasonal rainfall are :

Winter	Spreading tendency in very dry and contracting in wet and very wet areas
Summer	Spreading tendency in dry and very wet areas and contracting in very dry area
Summer	monsoon Spreading tendency in dry and wet areas and contracting in very wet area
Post-monsoon	Contracting tendency in very dry and spreading in dry, wet and very wet areas.

Regional rainfall analysis indicated rising trend in summer monsoon rainfall over northern west coast Gujarat, Rajasthan, Punjab, Haryana, and Jammu and Kashmir states in the east, and declining trend in the Central Highlands (most sharp falling trend is shown by Chhattisgarh rainfall fluctuation). Due to global warming a westward shift was observed in summer monsoon circulation and associated rainfall activities. Because of warming of the Eurasian land mass and intensification of continental low, a complimentary cooling of the lower atmosphere over northwestern Pacific region and intensification of the subtropical ridge was observed. Cold air incursion from extra-tropical to tropical region on the eastern side of the north western Pacific Subtropical Ridge was producing cooling effect over Indonesian warm pool. Due to the impact of cooling the number of remnants of the typhoons of the Pacific origin, entering in to the Bay of Bengal and intensifying into monsoon storms/ depressions, has declined from about 12 in the beginning of the 20th century to less than 3 in the end.

Physical Meteorology and Aerology

Physical Meteorology and Aerology Division has undertaken thrust area research programmes which are aimed at promoting better understanding of the atmospheric physical and chemical phenomena relating to the following topics :

- Physics of tropical monsoon clouds, precipitation mechanisms and atmospheric electrical / boundary layer processes.
- Active and passive remote sensing of the atmospheric aerosols and trace gases, and radiation budget.
- Precipitation chemistry, acid rain, atmospheric aerosols and tropospheric chemistry.
- Atmospheric Chemistry, dynamics of the middle atmosphere vis-à-vis the troposphere-stratosphere coupling, monsoon activity and climate change.
- Spectroscopic measurements of atmospheric minor constituents and climatic effects.

Physics and Dynamics of Tropical Clouds

(R. Vijayakumar, J.M. Pathan, S.S. Kandalgaonkar, S.B. Morwal, M.K. Kulkarni, A.S. Nath, M.I.R. Tinmaker)

NO_x contribution by lightning over the Indian region

NO_x contribution by lightning over the Indian region (8°-33°N, 73°-86°E) was assessed by using satellite lightning measurement from the Lightning Imaging Sensor (LIS). The lightning data from LIS for a period 1998-2001 were analysed and partitioned based on the latitude to obtain the differential count [Intra-cloud (IC) and Cloud to ground (CG) flashes]. The total lightning activity during the period was found to be 1.12×10^7 including 9.4×10^6 IC flashes and 1.8×10^6 CG flashes respectively over the Indian region. The total as well as the differential count was further utilized to estimate total and seasonal NO_x contribution. The lightning NO_x contribution was found to be 0.18 Tg N/yr over this latitudinal region using the representative contribution value of 6.7×10^{26} NO molecules for each CG and IC flash respectively. Seasonal analysis of NO_x contribution suggested that the maximum contribution of NO_x occurred in the premonsoon and monsoon months (i.e. 0.084 and 0.088 Tg N/yr respectively). Among the IC and CG flashes, NO_x yield from IC flashes was significantly higher than the CG flashes contributing nearly 83% and 17% to total NO_x contribution.

Diurnal variation of lightning activity over the Indian region

Satellite (LIS) based lightning flash grid (0.5° x 0.5°) data for the Indian land mass region 8°-33°N, 73°-86°E for a period (1998-2001) were used to examine the diurnal variation with one hour time resolution. A strong diurnal cycle (Fig. 30) was found to exist in the lightning activity with a prominent peak around 1000 UTC.

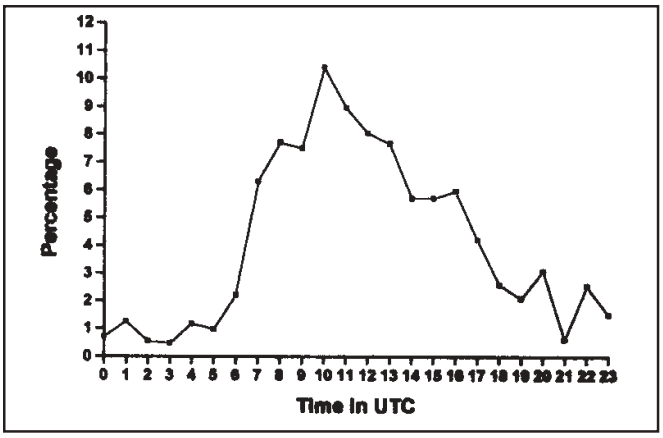


Fig. 30 : Diurnal variation of lightning activity over Indian region

The higher activity occurred during 0800-1559 UTC and the lower one during 0000-0759 UTC. Seasonal diurnal variation showed that the lightning activity was highest in premonsoon and lowest in the postmonsoon season. The results of monthly electrical conditions suggested that the activity in premonsoon season is 1.4 / 4.8 times higher than the monsoon/ postmonsoon season.

Convective boundary layer during disturbed weather conditions

In order to examine the boundary layer characteristics during the formation of cyclonic systems over the Bay of Bengal region the aerological observations collected on 10 (11°30'N, 91°54'E), 11 (13°12'N, 90°E), 15 (17°48'N, 89°E) and 17 (17°24'N, 87°30'E) June, 1996 at 12 UTC were used. The thermodynamic parameters revealed that the whole atmosphere had become warmer and moister during cyclonic storm period (11 - 15 June) than that of the period before and after the system was formed. The lower layers were found to be associated with neutral stratification before and after the system whereas these layers became stable during the formative stage of the cyclonic storm.

To understand response of the convective boundary layer (CBL) to different phases of convection and associated changes in the vertical stability of the CBL, a study was carried out to differentiate the CBL characteristics during extreme phases of convection i.e. weak (WPC) and active (APC) phases of convection by using high-resolution aerological observations for both convective and clear sky conditions during BOBMEX-99 over the Bay of Bengal region during the summer monsoon season. Active or more convective period

was found to be associated with substantial rainfall (total rainfall associated with the convective event more than 50 mm) whereas the weak period was associated with clear sky conditions and heating of the ocean. Break in monsoon was associated with the period of weak phase of convection. Lifting Condensation Level (LCL) was observed at 982 hPa and 962.3 hPa levels respectively during APC and WPC periods. In general, the atmosphere was found to be cool during APC at all the levels from surface up to 400 hPa as compared to WPC. However, cooling was more in the layer below 950 hPa (1-2 K) and in the layer 800 to 550 hPa (<1 K). Warming was observed above 550 hPa during APC. The moisture content (q profiles) was more during APC as compared to WPC from surface up to 400 hPa. More cooling and drying in the layer below 950 hPa may possibly be due to downdrafts during APC. The θ_e vertical profiles indicated more moist convective activity (above 950 hPa) and less dry convection (below 500 hPa) during APC period. In the surface layers (up to 950 hPa) the convective instability is more during weak phase as compared to active phase. In the higher layers the convection was less during the WPC period. The soundings during WPC period were found to be associated with suppressed convection whereas those during APC period were associated with deep convection. The CBL top was observed at 620 hPa in case of APC, associated with the minimum values of θ_e and P*. In case of WPC period the CBL top was observed at 710 hPa and coincided with P* and θ_e minima and flat θ_{es} maxima. The conserved variable diagrams (θ_e-q) indicated that the CBL is representative of single mixing line structure from surface up to CBL top (710 hPa) for WPC period and double mixing line structures for APC period (CBL top at 620 hPa). Thus the active phase of convection was found to be represented by cool, moist air, more moist convective activity and deep convection with deep cloud layer at higher levels.

Thermodynamic characteristics during a tropical cyclone

A tropical cyclonic storm formed during the period 12-16 June, 1996 over the southwest Bay of Bengal and moved in north-northeasterly direction. The thermodynamic characteristics of this system were investigated utilizing the surface and upper air observations collected onboard ORV Sagar Kanya over the Bay of Bengal region. The study showed that (i) whole atmosphere from surface to 500 hPa became warm and moist during the cyclonic storm period as compared to before and after the formation of this system, (ii) lower layer of the atmosphere became stable during the formative stage of the cyclonic storm and (iii) strong horizontal wind shears on 11 June acted as an initial triggering mechanism for the formation of the system.

ABL features during ARMEX-2002

A study was carried out to explore the salient features of the atmospheric boundary layer (ABL) over the eastern Arabian Sea regions during the summer monsoon season of 2002. For this purpose the aerological observations and surface meteorological observations collected onboard ORV Sagar Kanya during the Phase-I of ARMEX-2002 for the two stationary positions (30 June - 10 July and 22 July - 5 August, 2002) were utilized. The vertical structure of the ABL and the temporal variation of different surface parameters were investigated. The results showed prominent diurnal variation in different surface meteorological parameters. No influence of the offshore trough was revealed on the vertical structure of the ABL. The ABL showed multi-layered structure with shallow sub cloud layer, deep cloud layer, weak stable layer and the ABL extending up to higher levels in the presence of the cyclonic circulation (2-4 August, 2002), whereas the ABL was associated with deep sub cloud layer, shallow cloud layer, strong stable layer (inversion layer) and shallow ABL depth under the influence of weak offshore trough observed along the west coast of India (Fig. 31). Inversion layer was observed in all the radiosonde ascents around 800 hPa levels except during the period associated with cyclonic circulation. The conserved variable analysis showed double mixing line structure on most of the occasions. The low-level stability analysis showed that the soundings at both the stationary positions were associated with the inversion soundings except those during disturbed weather conditions, associated with deep convection.

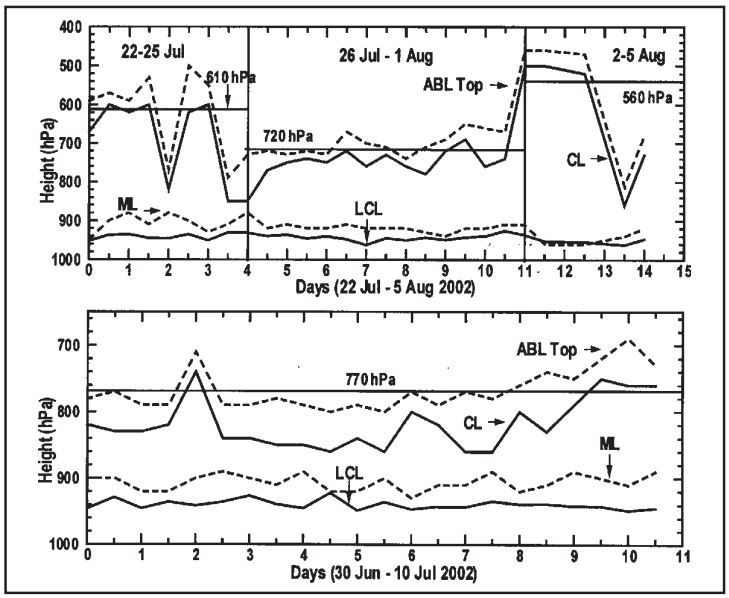


Fig. 31 : Height of different sub layers, namely LCL (Lifting Condensation Level), ML (Mixed Layer), CL (Cloud Layer) on the top of the ABL at two stationary positions (30 June – 10 July) and (22 July – 5 August 2002) in the east Arabian Sea during ARMEX 2002

Remote Sensing of the Atmosphere Using Lidar and Other Ground Based Techniques

(P.C.S. Devara, P. E. Raj, Y. Jaya Rao, G. Pandithurai, K.K. Dani, S.K. Saha, S.M. Sonbawne, R.S. Maheskumar, A.K. Srivastava, R. Bhawar)

Aerosol observations at coastal, island stations and over the Southeast Arabian Sea

Multi-channel radiometric measurements of aerosols, ozone and precipitable water were made as part of ARMEX Phase-II at a coastal station (Kochi), an island station (Minicoy, Lakshadweep) and also over the Southeast Arabian Sea (onboard a passenger ship) during the premonsoon period 24 March - 24 April, 2003. About 1120 sets of column aerosol optical depth (AOD) measurements were obtained at six wavelengths (340, 470, 500, 675, 870 and 1020 nm). The mean AOD at all the wavelengths were found to be smaller over the sea region. Kochi being an urban location showed a higher percentage variation. Day-to-day variations in AOD, and their association with columnar ozone and precipitable water content were investigated.

Aerosol radiative forcing studies

The aerosol radiative forcing was estimated from simultaneous and collocated measurements of aerosol optical characteristics and surface radiative fluxes; and from combination of observations and computations from a radiative transfer model. Spectral aerosol optical depth, single scattering albedo, asymmetry parameter, precipitable water content and total column ozone retrieved from sun / sky radiance data were integrated with a discrete-ordinate radiative transfer model to estimate aerosol forcing on clear sky days. Daily average of short-wave aerosol forcing at the surface on clear sky days ranged from -18 to - 48 W/m^2 for the range of AOD from 0.2 to 0.6 at 500 nm. Estimated aerosol forcing efficiency at the surface over Pune was found to be -72 W/m^2. The mean aerosol forcing values were -27, 3 and 30 W/m^2, at the surface, top of the atmosphere and in the atmosphere respectively during the years 2001 and 2002.

Columnar ozone studies at Pune

The sun photometer derived columnar ozone data collected on about 576 days during the period May, 1998 - May, 2003 at Pune were analysed to examine seasonal variation, relationship with TOMS derived columnar ozone and association with solar activity. The overall average total ozone at Pune was found to be 254.25 DU with a standard deviation of 18.9, with a small coefficient of variation (~7.4%). Monthly mean values showed maximum ozone during April-June and minimum during December-January. Ozonometer derived columnar ozone compared well with the TOMS reported values of ozone.

Study of long-wave aerosol radiative forcing

Long-wave aerosol radiative forcing over Pune (an urban station) was studied using skyradiometer-retrieved aerosol properties coupled with a radiative transfer

model. Diurnal mean down-welling and up-welling long-wave radiative fluxes in the spectral region from 3.5 to 50 µm were computed with and without aerosols for 17 clear sky days during February-March, 2002. Long-wave aerosol forcing values computed on individual days were correlated with daily mean aerosol optical depth values to estimate the forcing efficiency values. Increase in down-welling long-wave radiative fluxes at the surface was found to be by 19 W/m^2 per unit.

Radiometric observations of aerosols, ozone, water vapour over Gadanki

Aerosol measurements carried out at National MST Radar Facility, Gadanki during 28 February – 15 March, 2002 using a portable and compact solar radiometer, MICROTOPS consisting of Sun Photometer and ozone monitor providing instantaneous measurements of Aerosol Optical Depth (AOD), columnar ozone and water vapour were analysed. Sun photometer provides AOD at 380, 440, 500, 675, 870 nm whereas ozone monitor provides columnar ozone and water vapour by making use of differential absorption technique and also AOD at 1020 nm. The MICROTOPS was operated also at the Department of Physics, Sri Venkateswara University, Tirupati to study the influence of anthropogenic activity on aerosol characteristics. Results clearly showed considerable day-to-day variation of AOD. Higher magnitude of AOD for a few days clearly indicated the presence of haze, optically thin and sub-visible clouds during the period of observations. Spectral distributions of AOD were used to derive the Aerosol Size Distribution (ASD). ASDs for different days showed, by and large, mono-modal distribution except on 11 March, 2002, when bi-modal distribution was observed. AOD measurements for Tirupati showed higher magnitude as compared to the Gadanki measurements, suggesting the influence of anthropogenic activity.

The temporal variations of columnar ozone and water vapour during the period of observations showed considerable day-to-day variations in both the parameters. The magnitude of ozone was found to be less for Tirupati and consistent through out the period of observation (12 March, 2002) as compared to the previous day observations at Gadanki. Water vapour showed higher magnitude for Tirupati as compared to that of Gadanki measurements.

Relationship between UV-index and sun photometer derived total ozone

Daily Erythemal Dose (KJ/m^2) data were collected from internet for the Pune latitude/longitude for the period May, 1998 - May, 2003 and compared with sun photometer derived total ozone observed during the same period (Fig. 32). Erythemal dose values were found to be maximum during the pre-monsoon month of April and minimum during the winter month of December. The time series of monthly means of both the parameters showed a lag of 2-3 months in their co-variation. The winter season (December-February) total ozone values were found to be negatively correlated with the erythemal dose values of the immediately following pre-monsoon season (March-May), implying that any decrease / reduction in ozone content in the atmosphere during winter months can significantly enhance the harmful UV-B radiation reaching the surface during immediately following months of March, April and May. Such studies are important in view of the fact that excessive exposure to UV radiation can result in increased rates of skin cancer, eye cataracts, immense suppression, reduction in agricultural productivity etc.

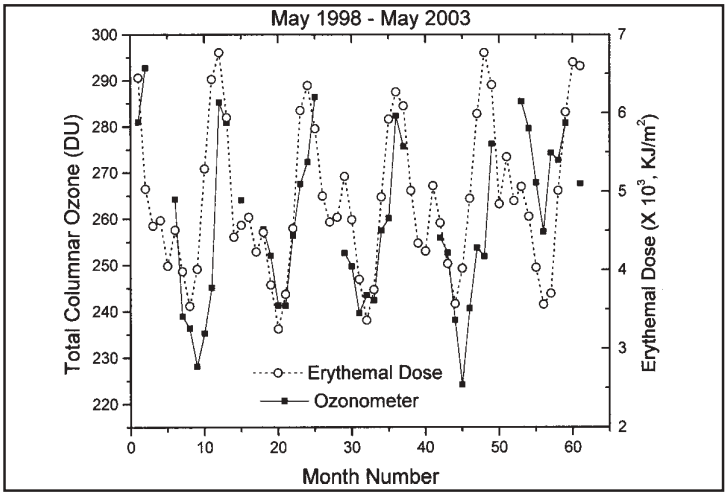


Fig. 32 : Association between daily erythemal dose and total column ozone observed over Pune during May 1998 – May 2003

Polarization lidar sensing of clouds

The Nd:YAG polarization lidar observations carried out at National MST Radar Facility, Gadanki during the year 2000 were utilized to characterize the lidar back-scattering signatures recorded during cloudy-and clear-sky conditions. From the data recorded in P (co-polarized) and S (cross-polarized) channels of the lidar, the altitude profiles of back-scatter (R_S) and depolarization (δ) ratios were computed for each experimental day. The monthly mean profiles and time height cross-sections deduced from special data sets containing series of profiles within nights were also studied. Profiles with $R_S \leq 1.5$ only were found to be due to clear-air scattering. On cloudy days, it was observed, most of the time, that R_S for S-channel dominated P-channel, and δ increased with altitude. During such occasions, clouds with δ values exceeding 0.1 were considered to be embedded with ice crystals and those with $\delta \leq 0.1$ were attributed to water clouds. On some occasions, when R_S values for P-channel dominated the S-channel, δ decreased initially with increase in altitude, reaching near-zero and thereafter increasing. Such clouds were considered to be mixed-phase clouds containing both water droplets and ice crystals. The vertical distributions of depolarization ratio, illustrating the lidar signatures during clear-sky [A], mixed phase clouds containing both water and ice [B], cloudy-sky associated with water clouds [C] and ice clouds [D] near the tropopause region are presented in Figure 33. Another interesting feature noticed in this study is that the integrated back-scattering coefficient of the sub-cloud to the cloud air layers varied for different types of clouds.

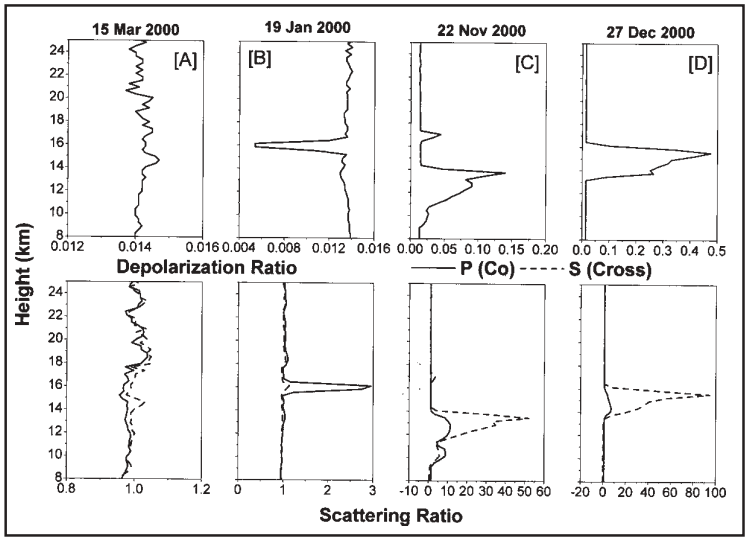


Fig. 33 : Vertical distribution of polarization and scattering ratios estimated from ND:YAG lidar observations during A) clear sky B)mixed phase clouds C) clouds with water content D) clouds with ice content over Gadanki, a tropical remote station

Solar radiometric observations of aerosols and precursors gases

Special observations of total column aerosol, ozone and precipitable water content using hand-held, multi-filter solar radiometers were carried out over a high-altitude remote station (Sinhagad) on 23 December, 2003.

Multi-filter solar radiometers (sunphoto-meter and ozonometer) were acquired and installed at the Institute for measurements of column integrated aerosol optical depth, size distribution, ozone and precipitable water content. Inter-comparison experiments utilizing this instrument and the similar one that has been in operation at the Institute for the past more than five years, in conjunction with other radiation equipment were carried out on 76 days during April, 2003 - March, 2004.

Aerosol heating rate estimates using aerosol observations and a radiative-transfer model

The heating by aerosols is expressed as a tendency in atmospheric temperature per day considering just the effects of solar absorption. Optical, radiative characteristics and vertical distribution of aerosols derived respectively from sun/skyradiometer and lidar at the Institute were used in a radiative-transfer model to simulate the vertical profiles of fluxes in the short- wave (0.3 - 3.0 μm) and long-wave (3.5 – 50.0 μm) spectral regions. From the flux divergence, net radiative heating rates were computed for pre-monsoon and winter seasons and found to be 0.93 K/day and 0.61 K/day, respectively, in the lower atmosphere (up to 7 km). Higher aerosol heating rate in the pre-monsoon season was found to be mainly associated with abundance of absorbing aerosols.

Wavelet analysis of aerosol observations over Pune

The time series of monthly mean aerosol distributions in the boundary layer as well as at different altitudes, derived from lidar (1986-2000) and solar radiometeric (1998-2003) data for the wavelengths at 380, 500 and 1020 nm, archived at the Institute were subjected to wavelet transform analysis to investigate different characteristic waves present in the data. The results exhibited 11-15 months (annual) and 22-25 months (quasi-biennial) periodicities at the statistically significant level and their absolute power was found to match well with the global wavelet spectra after smoothing, which further confirmed the existence of such longer periodicities in the data. Figures 34 and 35 show near-annual and quasi-biennial oscillations (QBO), their level of significance and global spectra for the lidar and radiometric data respectively.

It is evident from the figures that longer periodicities propagate upwards with increasing energy implying long-range transport of varying air mass rather than their local anthropogenic sources which are mostly confined to the surface layer, and the amplitude of QBO increases with AOD at smaller wavelengths, indicating that accumulation particles play greater role as compared to sub-micron and coarse-mode aerosol particles in the generation of QBO at the experimental station. The implication of environmental parameters such as transport, population and industrialization on the long term trends in the lidar observations was also studied.

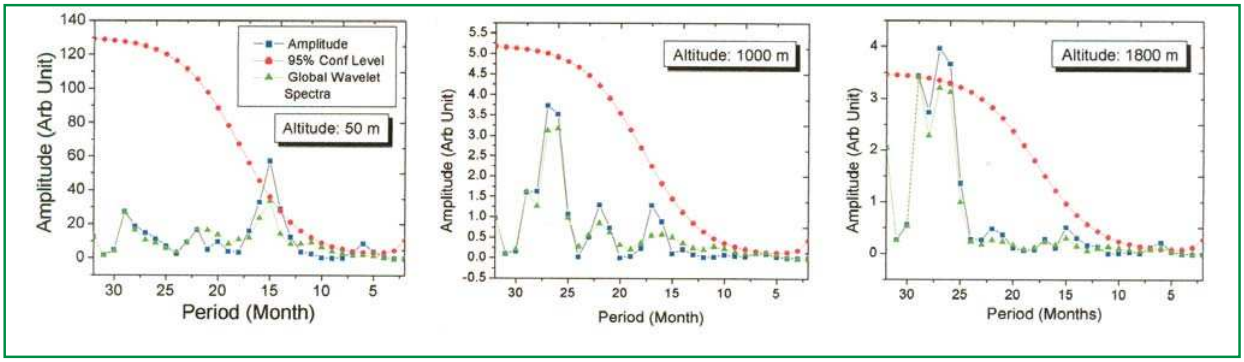


Fig. 34 : Spectra of different periodicities, their level of significance and global wavelet spectra matching for lidar-derived aerosol concentration at 50, 1000 and 1800 m at Pune

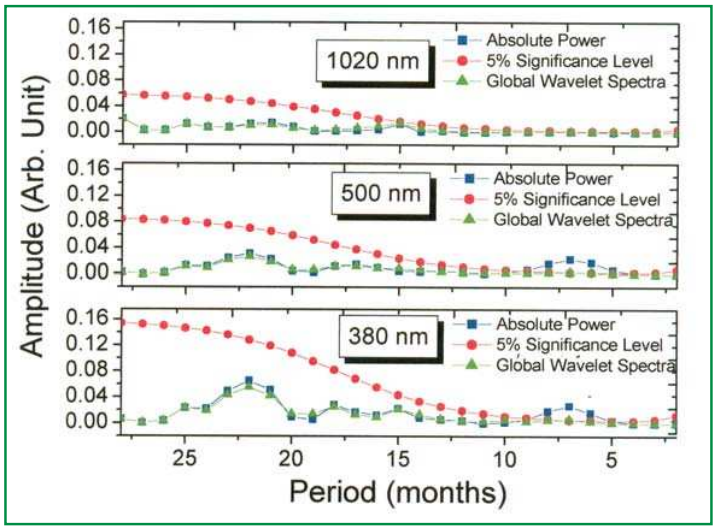


Fig. 35 : Spectra of different periodicities, their level of significance and global wavelet spectra matching for sunphotometric derived aerosol optical depth observed at 380, 500 and 1020 nm wave lengths

UV lidar for atmospheric ozone profiling

An ultra-violet (UV) rare-gas halide XeCl Excimer-Raman laser-based ozone lidar system has been developed, for the first time in the country, at the Institute (18°43'N, 73°51'E, 559 m amsl). The system essentially operates in the Differential-absorption-lidar (DIAL) mode with the laser emission at 308 nm (ON) wavelength as well as reference (OFF) wavelength of 353 nm generated by stimulated Raman shifting (SRS) the 308 nm radiation in hydrogen. The receiving system consists of a large diameter telescope tailored with a signal

detection and data acquisition/processing system with 5 ns - 10.5 ms multi-channel scaler/averager. The differential absorption observed at ON and OFF wavelengths was used for the retrieval of ozone vertical distributions. The lidar system was operated on 17 days in October, 22 days in November, 13 days in December, 2003 and 4 days during January-March, 2004 for obtaining vertical distributions of ozone number density. The retrieved ozone concentrations were found to vary between 10^{11} and 10^{13} molecules / cm^3. They were found to be in well agreement with the reference ozone atmosphere reported in the literature and also with ozonesonde profiles of India Meteorological Department on the days of lidar observations. The total column ozone (TCO) values determined from lidar were also found to agree with those obtained from collocated MICROTOPS Ozonometer and TOMS satellite data within the experimental limitations as depicted in figure 36. The higher TCO values noticed in the case of lidar were due to horizontal transport of ozone at different altitudes in the atmosphere.

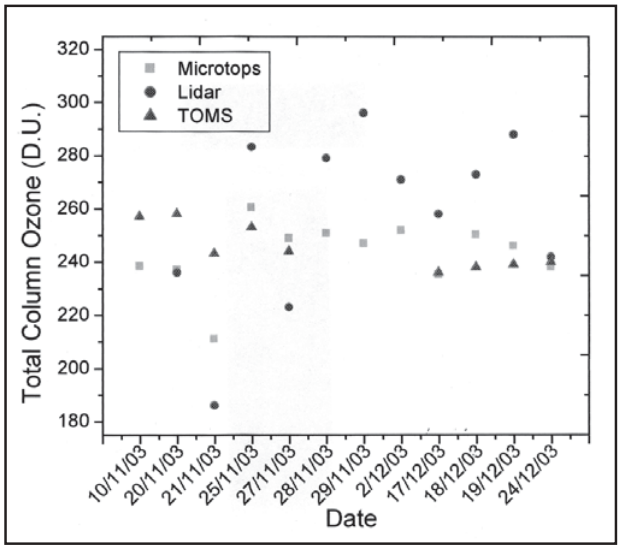


Fig. 36 : Comparison between Total Column Ozone (TCO) determined from MICROTOPS, Lidar and TOMS

Lidar and radiometric observations of aerosols and precursor gases at Pune

The vertical distributions of atmospheric aerosol number density up to 7 km amsl were obtained on 23 days using the bistatic Argon ion lidar. Special observations of polarization angle distribution of aerosol scattered intensity were also carried out on 15 March, 2004 to investigate the isotropy nature of aerosol particles over the experimental station. Observations of columnar aerosol optical depth, total column ozone and precipitable water content using MICROTOPS-II were carried out during clear sky conditions on 188 days at Pune during April, 2003 - March, 2004.

Studies in Air Pollution and Precipitation Chemistry

(P.S.P. Rao, D.M. Chate, G.A. Momin, K. Ali, P.D. Safai, S. Tiwari, P. Siva Praveen)

Comparative study of chemical composition of rain water at an urban (Pune) and a rural (Sinhagad) locations in India

Chemical composition of rain water collected at Sinhagad during August - October, 2002 and at Pune during April - September, 2002 was studied. It was found that on an average the chemical nature of rain water at both the places was alkaline, with slightly higher pH (pH = 6.50) at Pune than that at Sinhagad (pH = 6.25). Among the cations, Ca^{2+} showed highest concentration varying between 16.5 and 145 µeq/l with an average of 69 µeq/l at Sinhagad and from 31.5 to 496.5 µeq/l with an average of 134.7 µeq/l at Pune. Among the anions, Cl^- was maximum at both the places. A special feature observed at Sinhagad was that, on 11 October, 2002 fraction of chloride was found to be advected from the locations other than sea, and pH value of rain sample on that day was acidic (pH=5.18). This was mainly because of the absence of sufficient neutralizing cations and incursion of pollutants from nearby urban areas like Pune. During the month of April high concentrations of SO_4^{2-}, NO_3, Ca^{2+} and Mg^{2+} at Pune were due to a small amount of rain and the prevailing convective activity.

Transport of Ca and SO_4 aerosols from north African and Gulf countries towards India

Precipitation samples, collected over Arabian Sea during Arabian Sea Monsoon Experiment (ARMEX) campaign (June - August, 2002) onboard Ocean Research Vessel Sagar Kanya, were analysed for major ionic components. The pH of

rain water was found to be alkaline. The rain water data were interpreted in terms of long range transport and back ground pollution. Sea salt components dominated in rain water (~90%). Significant amounts of non-sea salt Ca, SO_4 and trace amounts of NO_3, NH_4 were found in precipitation samples, whereas no non-sea salt fraction was observed in case of K and Mg indicating that these were totally originated from the sea. During the observational period, the presence of strong southwesterly winds at surface level led to high sea salt aerosols in rain water. Radiosonde data indicated the presence of northwesterly winds at higher levels i.e. ≥1000 m. Back trajectories also showed that the air masses originated over North African and Gulf continents, carrying Ca and SO_4 aerosols travelled towards observational point. Hence, the excess Ca and SO_4 in rain water may be due to long-range transport of aerosols from North African and Gulf countries.

Chemical composition of aerosols at different locations

Chemical composition of aerosol samples collected at four different locations, i.e. Okhla (Industrial) and New Rajinder Nagar (Residential) in Delhi, Pune (Urban) and Darjeeling (High altitude rural) during winter season of 2002-2003 were investigated and plotted (Fig. 37). In contrast to the expectation, the concentrations of Cl, SO_4 and NH_4 were higher at New Rajinder Nagar than those at Okhla. However, all other ionic components were higher at Okhla than those at New Rajinder, Nagar. Higher concentrations of Cl and SO_4 at New Rajindar Nagar may be due to more anthropogenic activity such as biomass burning, tyre burning etc. The higher NH_4 concentrations may be due to more open garbage, animal excretion and open toilets. Among the metallic cations, next to Ca, the concentration of either Na or Mg was found higher. However, at

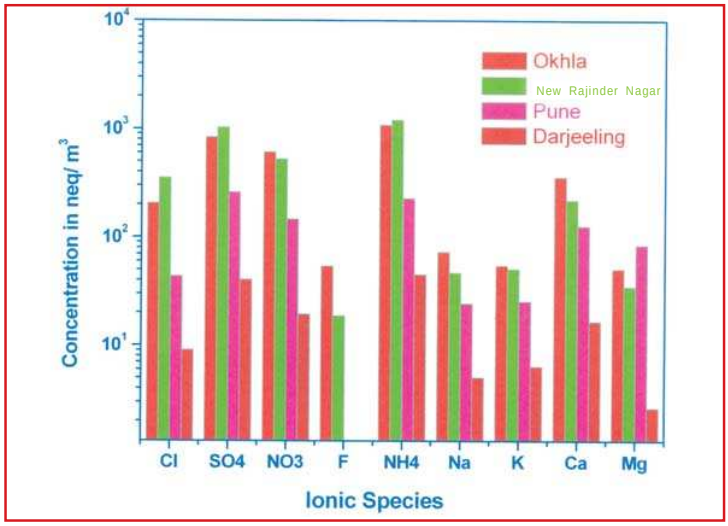


Fig. 37 : Chemical composition of aerosols observed in different environments during winter, 2002/2003

Darjeeling, potassium showed the second highest concentration among the metallic cations. This may be due to the emission of K by plants such as tea gardens.

Trends in the chemical composition of rain water over Pune

The chemical analysis of bulk rain water samples, collected at Pashan, Pune since 1984 was carried out. Significant trends in pH and other radicals are shown in figure 38. The decreasing trend in pH may be due to the increasing trends in concentrations of acidic constituents such as SO_4 and NO_3, and decreasing trend in major alkaline constituent Ca and its neutralizing potential.

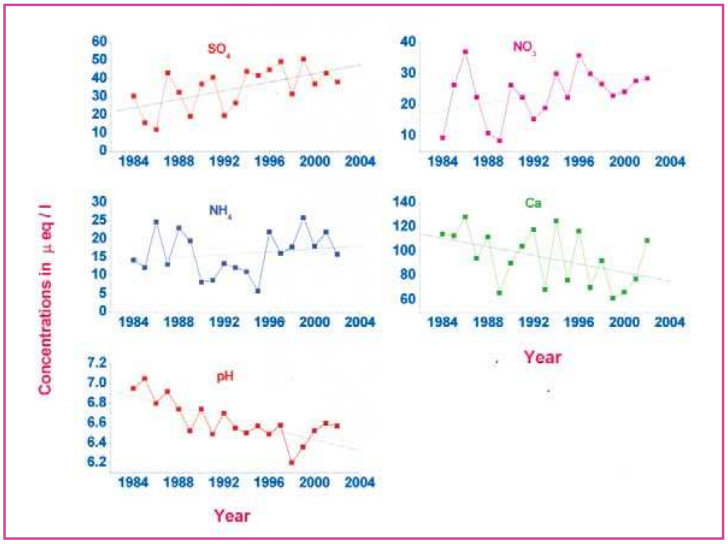


Fig. 38 : : Long - term trends in pH, SO_4, NO_3, NH_4 and Ca in rain water at Pune

For assessing the possible sources of chemical constituents of rainwater, certain techniques such as Enrichment Factor analysis and computation of Sea-salt Component using standard marine ratios, were carried out. About 99% NO_3 and 71% of total SO_4 were found to be contributed by anthropogenic sources, 21% was from marine and 8% from soil source. In case of K, about 30% was from sea and the remaining from soil and vegetation. Both sea and soil contributed equally for Mg.

Atmospheric Chemistry, Modelling and Dynamics

(G. Beig, I.S. Joshi, S.S. Fadnavis, S. Gunthe, A.R. Deshpande)

Long-term trends in the tropospheric and stratospheric ozone over the Indian tropical region

The long-term trends in ozonesonde vertical profiles in the lower stratosphere for the period 1972-2001 over the three stations of tropical India were studied using multi-functional statistical regression model. A systematic latitudinal variation in trend pattern was noticed. The magnitude of decreasing trend in ozone was found to be maximum over Delhi (28°N), which became insignificant over the equatorial station, Thiruvananthapuram (8°N). An annually averaged mean negative trend varying from 7% to 11% per decade (95% confidence level), particularly for the altitude range of 20-40 hPa was observed over Pune (18°N) and Delhi. The temperature trend obtained from reanalysed NCEP data sets over the same stations and for the same period was found to be statistically significant in the altitude range corresponding to 20-40 hPa, concomitant with a decrease in ozone.

An analysis of tropospheric column ozone (TCO) data derived from ozonesonde and Nimbus 7 / Earth Probe - Total Ozone Mapping Spectrometer (TOMS) during the period 1979-2002 was also done. No statistically significant trend was found over Thiruvananthapuram (8°N) but significant positive trend (within 2-sigma error bars) was found to occur in the lower troposphere over Pune (18°N) and throughout the entire troposphere over a heavily air-polluted urban center, Delhi (28°N). However, over the last decade, variations in tropospheric ozone have become statistically insignificant even over Delhi in spite of increasing surface NO_x concentrations. The TCO obtained by ozonesonde as well as TOMS data over Thiruvananthapuram did not reveal any statistically significant trend.

Monitoring of surface ozone, NOx, CO, and hydrocarbons

Continuous monitoring of surface ozone (O_3) and its precursors, namely, oxides of nitrogen (NO_x), carbon mono-oxide (CO) and hydrocarbons (CH_4-NMHCs) was made by regular observations at one hour interval. Three-dimensional atmospheric chemistry model was used to simulate the geographical distribution of NO_x (ppt) at the surface. Such distributions in different seasons over the Indian region are shown in figure 39. The concentration of NO_x showed its maximum around 25° latitude in all the seasons.

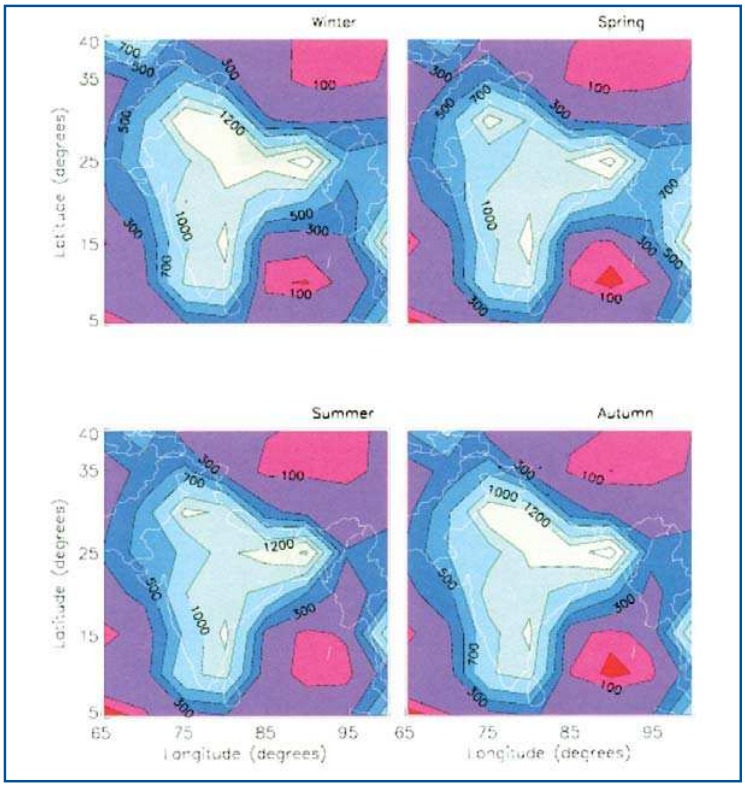


Fig. 39 : Geographical distribution of NOx (ppt) at the surface over Indian region in different seasons assimilated from 3-D atmospheric chemistry transport model

Mesospheric temperature inversions over the Indian tropical region

To study the mesospheric temperature inversion, daily temperature profiles for the period (1991 – 2001) from HALOE satellite for length 34 km - 86 km, with vertical resolution of 2.3 km, for a decade, over Indian tropical region (0°-30°N, 60°-100°E) were analysed. Frequency of inversion occurrence was found to be 67% over this period, thus showing strong semiannual oscillation, with maximum amplitude occurring one month after equinoxes (May and November). Variation of monthly mean top and bottom heights along with amplitude of inversions also showed the semiannual cycle. Amplitude of inversion was found as high as 40°K. Inversion layer was detected most frequently in the altitude range 70-85 km, however, the peak of inversion layer was observed in the height ranges of 80-83 km and bottom to the height ranges of 72-74 km. Monthly percentage frequency of occurrence and monthly peak height variation over low latitude Indian region (0°-15°N, 60°-100°E) were compared with results over low latitude Indian station Gadanki (13.5°N, 72.9°E), which showed similar nature. Seasonal variation of amplitude and frequency of occurrence of inversion layer showed good correlation with seasonal variation in the altitude (70-86 km) of average ozone.

Relation between monsoon rainfall and geomagnetic field over Pune

In order to examine the relation between monsoon rainfall and geomagnetic field variability, daily data for the period May - July, 2003 of geomagnetic field (nT) variations obtained with Proton Precision Magnetometer (PPM) were studied. Increase in geomagnetic field was found to be associated with an increase in monsoon rainfall over Pune.

Stratospheric and tropospheric temperature response to solar activity changes

The response of thermal structures in the troposphere and stratosphere to solar activity changes was examined using the temperature data of 0°-30°N collected from monthly climatic data for the world. Temperatures of May during 1978-1995 (18 years) at 500 hPa and 50 hPa were used for this purpose. Solar flares, the carrier of the component of solar variability that affects weather and climate were collected from Solar Geophysical Data for the same period. An out of phase relation was observed between stratospheric temperatures and solar flares (r=-0.3). A very good positive relation was also observed between stratospheric temperatures and 500 hPa temperature (r=+0.83) during May. Correlation between 500 hPa temperatures and solar flares was found to be -0.2, significant at <10% level. Thus the study suggested that increase in number of solar flares causes decrease in the stratospheric and tropospheric temperatures at 0°- 30°N.

Satellite derived tropospheric column ozone variations over different oceanic environments

An analysis of tropical tropospheric column ozone (TCO) data from the Nimbus 7 and Earth Probe - Total Ozone Mapping Spectrometer (TOMS) for the period 1979 -2002 over tropics (12.5°S -12.5°N), over different oceanic regions and surrounding continents clearly demonstrated the increasing role played by continental pollutants and advective processes in influencing tropospheric ozone concentration over oceans. The TCO trend over Pacific Ocean was found to be the maximum as it is surrounded from both the sides by continental boundaries where biomass-burning activities and emissions of secondary pollutants like NO_x are reported to be at large scale. The trend in TCO over Atlantic Ocean, which is mainly influenced by easterly convection from South African region, North America and Europe, was found to be relatively less in magnitude. It implied that the loading of average emissions on long-term basis over this region has been relatively in check. During recent times, the emissions of secondary pollutants over South and South East region have increased to levels much beyond that over North America and Europe. The TCO trend over Indian Ocean was found to be moderately increasing but the continental flow from Indian subcontinent and part of South Asia has increased potential to enhance the TCO amount. Variation in ozone trend from winter to summer was found to be substantial. It is quite possible that recently obtained significant and consistent trend over tropics in TCO may be a result of rapid increase in emission rates of secondary pollutants in recent times.

Analysis of Stratalert messages during the winter 2003-2004

Analysis of daily Stratalert messages, received from Free University of Berlin, Germany during the winter period, December, 2003 - March, 2004) revealed an intense major stratospheric warming on 3 January, 2004 at 10 hPa with temperature gradient reversed from pole to 60°N as displayed in figure 40.

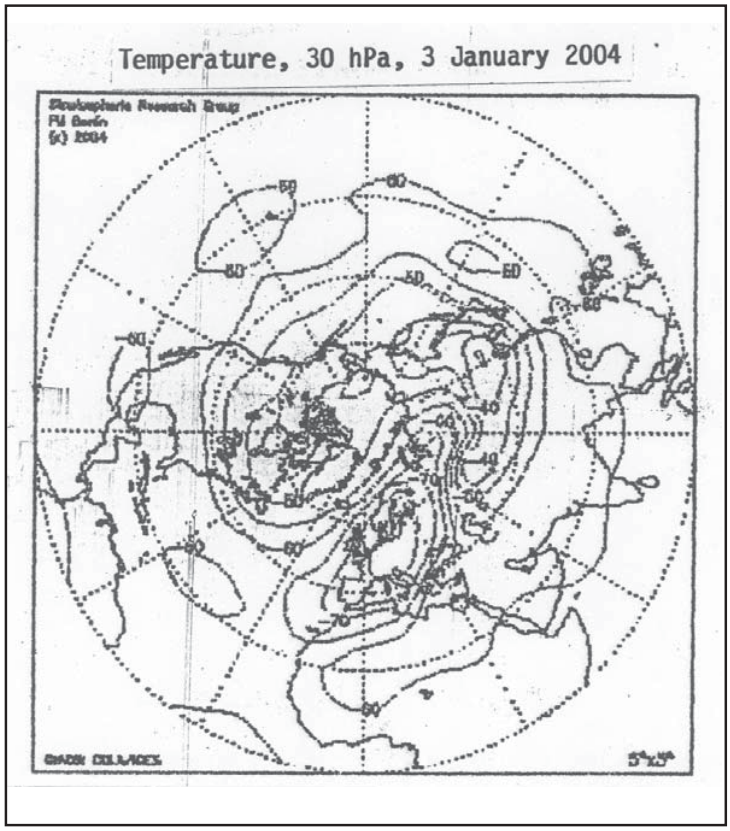


Fig. 40 : Isotherms at 30 hPa indicating major stratospheric warming on 3 January, 2004

Measurement and Monitoring of Atmospheric Minor Constituents

(D.B. Jadhav, A.L. Londhe, C.S. Bhosale, G.S. Meena, B. Padma Kumari)

Spectroscopic measurements of NO_2, O_3, H_2O and O_4

Total column density (TCD) of NO_2 and O_3 were compared with the earlier results obtained during May, 1988 - February, 1989 at Pune and at Ahmedabad during December, 1989 - January, 1990. Earlier spectroscopic studies at Pune showed that the TCDs of NO_2 and O_3 varied between 1.3 x 10^{16} - 0.6 x 10^{16} mole/cm^2 and 285-239 DU respectively during May, 1988 - February, 1989. During December, 2000 - January, 2001 (winter), 1.4 x 10^{15} mole/cm^2 (morning average) and 2.8 x 10^{15} mole/cm^2 (evening average) of NO_2 were observed in the vertical column. In May, 2001 (summer), average TCD of NO_2 was observed as 4.6 x 10^{15} mole/cm^2 and 7.8 x 10^{15} mole/cm^2 in the morning and evening twilight hours respectively at Pune. Similarly average morning TCD of NO_2 was 4.9 x 10^{15} mole/cm^2 and average evening value was 7.9 x 10^{15} mole/cm^2 in May, 2000. Average of morning and evening TCDs of NO_2 were 2.1 x 10^{15} mole/cm^2 in December, 2000 - January, 2001, 6.2 x 10^{15} mole/cm^2 in May 2001 and 6.4 x 10^{15} mole/cm^2 in May, 2000. The ratio of summer to winter densities of NO_2 was 2.95 and for O_3 it was 1.21. TCDs of NO_2 at Ahmedabad were noticed between 0.5 - 2.5 x 10^{15} mole/cm^2 (average 1.5 x 10^{15} mole/cm^2) during December, 1989 - January, 1990 (winter), which was lower than the present winter value 2.1 x 10^{15} mole/cm^2 at Pune. The (PM/AM) ratio of NO_2 was found to be 1.25, maximum in December and then it had a decreasing trend at Ahmedabad. At Pune the ratio was 2.0 in December and decreased up to 1.7 in May, 2001. Thus the similar trend in ratio values was observed at Ahmedabad and Pune.

The diurnal variations of vertical column densities of NO_2, O_3, H_2O and O_4 were derived from the UV-visible spectrometer observations carried out during November - December, 2003 for clear and cloudy sky days. In thick clouds NO_2 and O_3 absorption enhancements were observed up to a factor of 2 while in case of tropospheric gases O_4 and H_2O enhancements were observed up to a factor of 4 due to multiple Mie-scattering of light by clouds.

Intra-seasonal variability of total column ozone over Indian region

Monthly and intra-seasonal variability of daily total column ozone (TCO) over 13 Indian stations was studied, using TOMS daily data of May - September for the period (1998-2002). On monthly scale, the TCO values were found less over most of the north Indian stations in the deficient ISMR year (2002) compared to the normal ISMR year (1998). The power spectrum analysis of daily TCO data showed three dominant modes of periods viz., 3-7 days, 15-20 days and 30-40 days similar to that found in the ISMR as shown in figure 41. Mean spatial distribution of the activities of these intra-seasonal modes over Indian region and their changes with ISMR activity were studied.

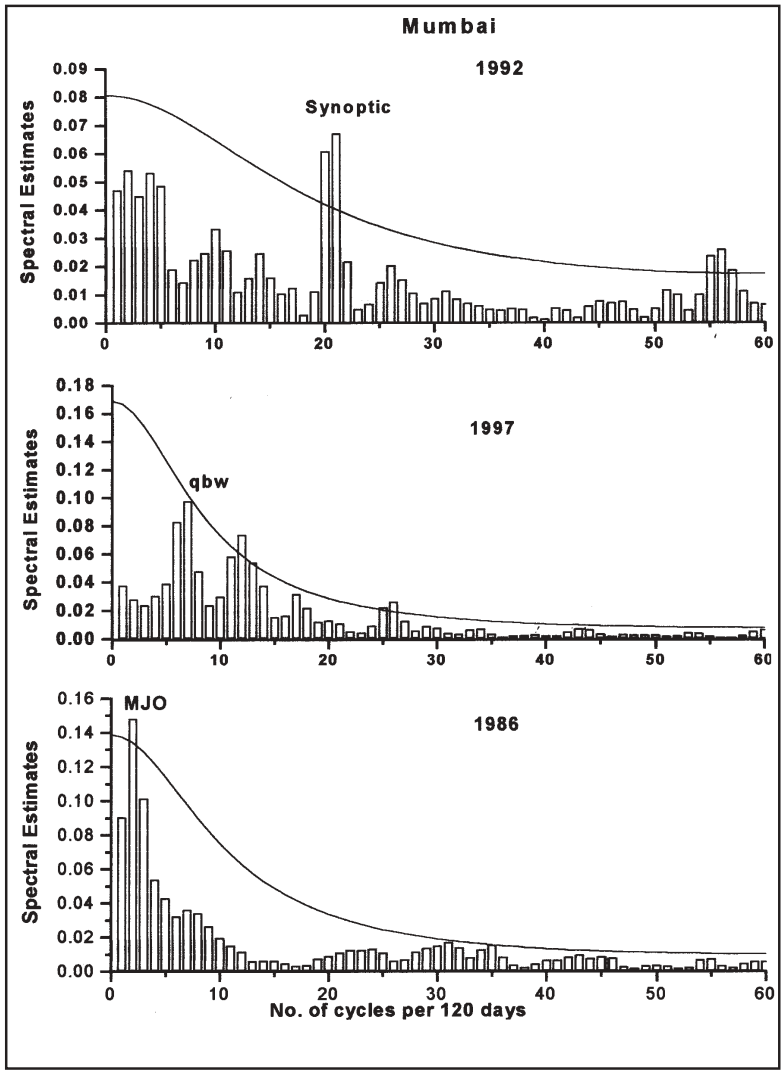


Fig. 41 : Intra-seasonal modes, namely, synoptic (3-10 days, quasi-bi weekly (15-20 days) and Madden Julian Oscillation (30-60 days) in Total Column Ozone variability during Indian summer monsoon (June-September) The curves represent 5% significant level

Ozone variation over Indian region

Monthly mean total column ozone variations were studied for the period 1981-1998 over Indian region. During the period 1981-1990 no much year to year variability was found in ozone, whereas it was found during the period 1991–1998. The ozone anomalies showed positive anomaly for 1981-1990 and negative anomaly for the period 1991-1998. Though there was not much difference in QBO and solar cycle for the two different periods, the total of 1981-1990 and 1991-1998 column ozone for the latter period was found to be less. The lower ozone amounts may be attributed to Mt. Pinatubo volcanic eruption.

Comparison of aerosol vertical profiles derived by passive and active remote sensing techniques

Simultaneous observations of the twilight photometer at the Institute and NMRF Lidar were carried out at Gadanki (13.45° N, 79.18° E) during March, 2003. Comparison of the profiles deduced by both the techniques is shown in figure 42. Reasonable agreement within the experimental limitations was seen. The results showed evidence of the presence of high cirrus clouds with base height ranging from 11 to 14 km and stratospheric aerosol layer, or Junge layer (17-23 km) in the profiles derived by both the techniques. The comparison made with those of balloon-borne and HALOE satellite derived aerosol extinction profiles was also encouraging.

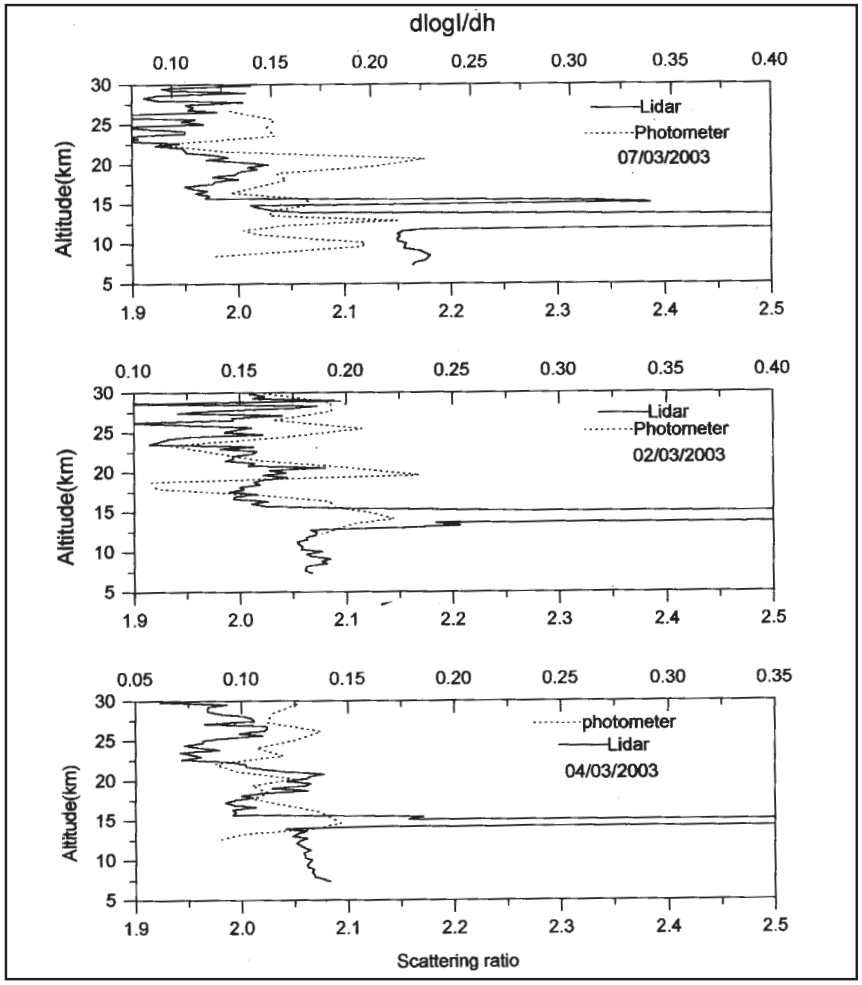


Fig. 42 : Comparison between vertical profiles of atmospheric extinction observed simultaneously by twilight photometer and lidar at National MST Radar Facility (NMRF), Gadanki

Variations of O_3, NO_2 and O_4 densities in association with NAO at Reykjavik

The study of the atmospheric trace constituents like O_3, NO_2 and O_4 was made in the visible spectral region (550-595 nm) using the data at the sub-Arctic station Reykjavik (64° N, 22.6° W) for the months December-April (winter/spring) of 1993/1994 and 1994/1995. The Differential Optical Absorption Spectroscopy (DOAS) technique was used to obtain slant column density (SCD) of O_3, NO_2 and O_4 from the above light intensity. Vertical column densities (VCDs) of O_3 and NO_2 were obtained at solar zenith angle (SZA) 90°. The results of the above analyses showed existence of a predominant daily variation in the VCDs of O_3 and NO_2, with one oscillation within the daily variations of O_3 and NO_2. This oscillation was confined to the same period of 3-10 days. These periodic oscillations were found to have coincided with the oscillation of the stratospheric warm and cold episodes during the period of observations. The variations in the VCD of O_3 and NO_2 were associated with the North Atlantic Oscillation (NAO) index. But VCDs of NO_2 seldom showed any relationship with NAO index. Also, the daily variations in SCDs of O_4 were studied in connection with the different types of clouds prevailing at the Arctic station during winter/spring of 1993/1994 and 1994/1995. A strong variability of O_4 was observed with variations of the type of clouds.

Instruments and Observational Techniques

Instruments and Observational Techniques Division designs and develops instruments and techniques for observations and carries out field and laboratory experiments. The Division conducts its research with the following objectives :

- To measure the atmospheric electrical, meteorological parameters and aerosols over land, ocean and in clean environments to study the global electric circuit.
- To reconstruct lightning channels using acoustic signals.
- To develop instruments for the measurements of atmospheric electrical parameters at Antarctica.
- To study the micro-physical processes such as evaporation, distortion, oscillation, collision and coalescence of millimeter size water drops in a vertical wind tunnel in presence and absence of vertical and/or horizontal electric fields.
- To study the scavenging of aerosol particles by charged and uncharged water drops.

Simulation Techniques for Cloud Physics Studies

(A.K. Kamra. A.B. Sathe, R.V. Bhalawankar)

The photographic data obtained with a 16-mm movie camera in a wind tunnel experiment in presence or absence of electric field were analysed to study the distortion and oscillation of a drop. Observations showed that the horizontal and vertical electrical forces acting on the surface of a drop elongate it along the direction of electric field. The changes were studied in terms of change in the distortion ratio of the drop with its diameter. The deviation in axis ratio in horizontal and vertical electric field from its mean position was calculated from the movie photographs.

Surface Observations of Atmospheric Electricity and Electric Properties of Clouds

(S.S. Dhanorkar, A.K. Kamra, S.D. Pawar, V. Gopalakrishnan, R. Latha, C.G. Deshpande, P. Murugavel, M.N. Kulkarni, D.K. Singh, K.P. Johare, V. Pant)

Participation in ARMEX and data analysis

Airborne measurements

The data obtained from the aircraft measurements during the phase I of ARMEX for size distribution of aerosol particles and electrical conductivity were studied with reference to the prevailing meteorological conditions in the atmospheric boundary layer (Fig.43). The aerosol concentrations at 0.9 km altitude were found to be larger if the mixing layer depth is more than this height. Further, values of aerosol concentration at 5.1-6 kms altitude were one to three orders of magnitude higher if the air mass is being advected from the central Arabian Sea or the Arabian deserts in comparison to the values when the air mass is being advected up from the deserts of the northwest India. Aerosol size distributions at 0.9 km level were bimodal or trimodal with a maximum at 133 nm in accumulation mode and the minima at 75 and 480 nm. Aerosol concentrations generally kept increasing at both the ends of the size distribution indicating the presence of Aitken and coarse modes. Size distributions tend to become log-normal at 5.1 - 6 km altitudes. Observations also showed higher concentrations in all the size ranges of aerosols over land than over sea. Further, smaller particles can extend over sea to longer distances from the coastline while larger particles settle down under gravity comparatively closer to the coastline. Results suggested that the processes of aerosol coagulation and gravitational

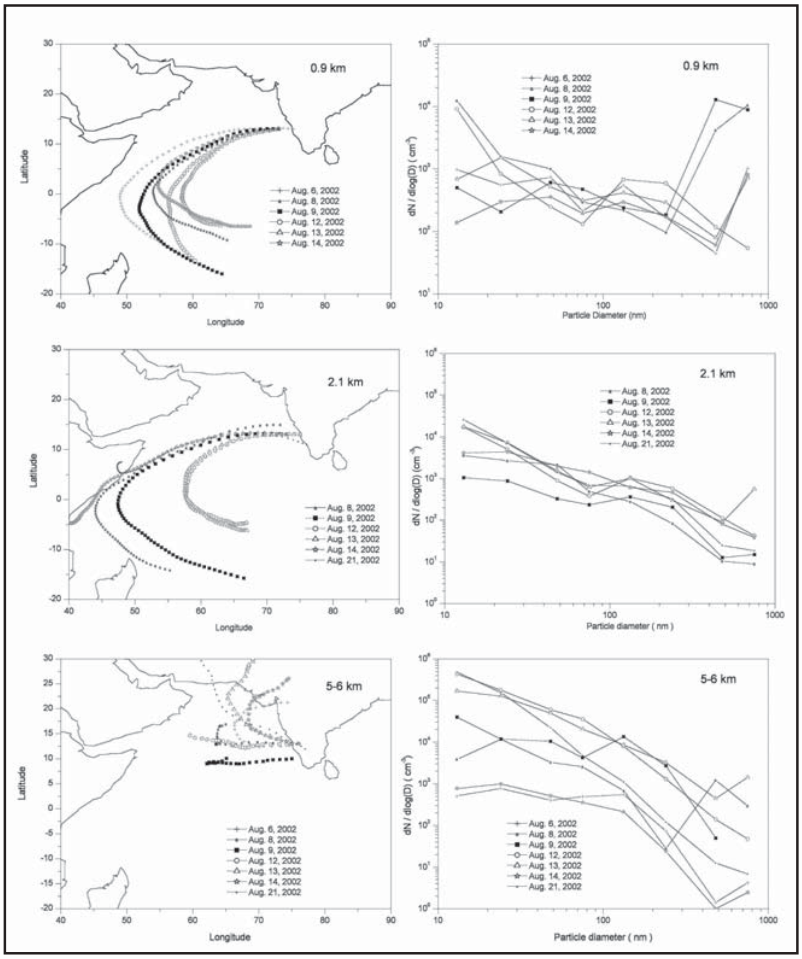


Fig. 43 : The 5-days back trajectories (obtained from NOAA-HYSPLIT model) and the aerosol size distributions observed at 0.9, 2.1 and 5.1 - 6 km altitude on different days

settling mainly determine the evolution of modal nature of size distributions observed at lower altitudes over sea. However, generation of particles by processes such as the wave-breaking over the sea surface during the periods of high wind, the passage of air-mass over land surface or the downward transport of fine aerosols from the free troposphere may modify the size distributions observed at different altitudes.

Shipborne measurements

Measurements of ion concentrations, atmospheric electric conductivity and electric field were made at sea surface over the Arabian Sea aboard ORV Sagar Kanya during the Phase I and Phase II of ARMEX. The value of conductivity was found to be low when the air-mass was transported from the desert region of northwest India or Arabian Sea, compared to when it was transported from southern hemisphere. The variations of conductivity in monsoon months followed the variation in the large / intermediate ions than that of small ions.

Scanning mobility particle sizer (upper) and Aerodynamic particle sizer (lower) installed onboard ORV Sagar Kanya during Pilot Expedition to Southern Ocean

Evolution of lightning in a thunderstorm

Evolution of lightning and the shape of recovery curves after multiple discharge flashes in a thundercloud were studied from the surface measurements of electric field and Maxwell current near a tropical thundercloud. Observations suggested a tripole structure of the cloud, with its lower positive charge center (LPCC) playing a dominant role in initiating / triggering an intracloud (IC) or cloud-to-ground (CG) lightning discharge. IC discharges in the initial state of thundercloud were found to be followed by CG discharges from the LPCC and then by two distinct groups of multiple-discharge flashes. Each flash in the first group consisted of an IC discharge triggered by a CG discharge and in the second group a CG discharge triggered by an IC discharge. Flashes in each group were bunched together for about 15 – 20 minutes and occurred with almost a regular periodicity of 1- 1.5 minutes. The Maxwell current during every such flash in both the groups had a tripolar transient and a positive overshoot which subsequently relaxed back to its pre-discharge value. Magnitudes of overshoot for the flashes in the first group were found to be much lower than that for the flashes in the second group. From a small portion in recovery curves of such multiple-discharge flashes it can be concluded that the rate of charge build-up in the main negative charge center is higher than that in the LPCC.

Antarctica measurements

A new field-mill for the round-the-year measurement of atmospheric electric field at Antarctica was fabricated. A Gerdien's apparatus and an electric field mill were calibrated and handed over to the Indian Institute of Geomagnetism, Mumbai for carrying out the measurements of conductivity and electric field at Antarctica during the summer of 2004.

The electrical conductivity data obtained during 16th Indian Scientific Expedition to Antarctica showed latitudinal variations of electrical conductivity along the cruise track with a minimum at 28°S. Variations in conductivity in the 10°N – 20°S and 60°–70°E latitudinal belts showed opposite trends. The results can be explained on the basis of the well-known northward shift of the subsidence leg of the southern Hadley cell and the position of the Intertropical Convergence Zone during the months of March – April in this region.

Determination of eddy diffusion coefficient

A new technique for the determination of eddy diffusion coefficient from atmospheric electricity measurements was worked out. The values of eddy diffusion coefficients obtained from this technique reasonably agreed with those obtained from the bulk aerodynamic and other methods.

VLF emissions studies

Parallel resonance energy and wave growth / damping of electrons in the Earth's magnetosphere at various frequencies for different L-value were computed for whistler mode wave in the presence of thermal velocity and parallel electric field. The resonance energy of the electron was found to decrease with wave frequency and L-value. The energy was also evaluated for normal and disturbed magnetospheric conditions. The wave growth / damping were found to depend upon the nature of dc electric field present in the Earth's magnetosphere.

Boundary Layer and Land Surface Processes Studies

Boundary layer and Land Surface Processes Studies Division designs and develops instruments and techniques for observations and carries out field and laboratory experimental studies relating to the atmospheric boundary layer and land surface processes. Following are the research programmes undertaken by the Division:

- Development of instruments / observational techniques to study the structure of the atmospheric boundary layer and related studies.
- Land surface processes studies to estimate the energy budget over different vegetation and soil conditions.
- Study of the dynamics of the atmosphere over land and ocean surfaces.

Investigation and Modelling of Land Surface Processes in the Atmospheric Boundary Layer

(S. Sinha, M.N. Patil)

Studies on LASPEX and ARMEX

Marine boundary layer features were studied using the observations collected during the ARMEX-2002. Mixed layer heights were estimated using radiosonde observations. The boundary layer was found to undergo weak / small diurnal changes during monsoon conditions. The height of mixed layer found to be varied from 200-1000 m depending on the synoptic weather conditions and location. Mixed layer potential temperature, a constant temperature in the mixed layer, changed within the range of approximately 2°K in a day (24 hrs). When the mixed layer temperature increased, the convective boundary layer was found to grow rapidly. Spatial distribution of mixed layer height suggested the boundary layer to be shallow near the coastal regions of southern Arabian Sea. The mixed layer heights were increased towards the northern coast. In some cases, a double mixed layer structure (first the ground based and other one elevated) was observed as shown in figure 44. The virtual potential temperature was constant up to the height of about 500 m. Above this, an increase was observed for about next 400-500 m and then another mixed layer (constant θ_V region) of 300-400 m width was noticed. The ground based mixed layer was found to be associated with the upward transport of convective fluxes. Another mixed layer was found to be associated with high wind speed and the decrease in humidity. Stable layer was associated with higher relative humidity (> 94%). Top and bottom of the mixed layer as well as stable layer was marked with negative wind gradient. The top of the elevated mixed layer was marked with the influence of low level jet. The ground based mixed layer showed change in wind direction but above this layer, there was a wind from uniform direction. On the top of the elevated mixed layer, there was decrease in wind speed due to the effect of low level jet. The observations revealed that the elevated mixed layer was a dry residual layer in between two clouds with nearly zero turbulence but neutrally buoyant.

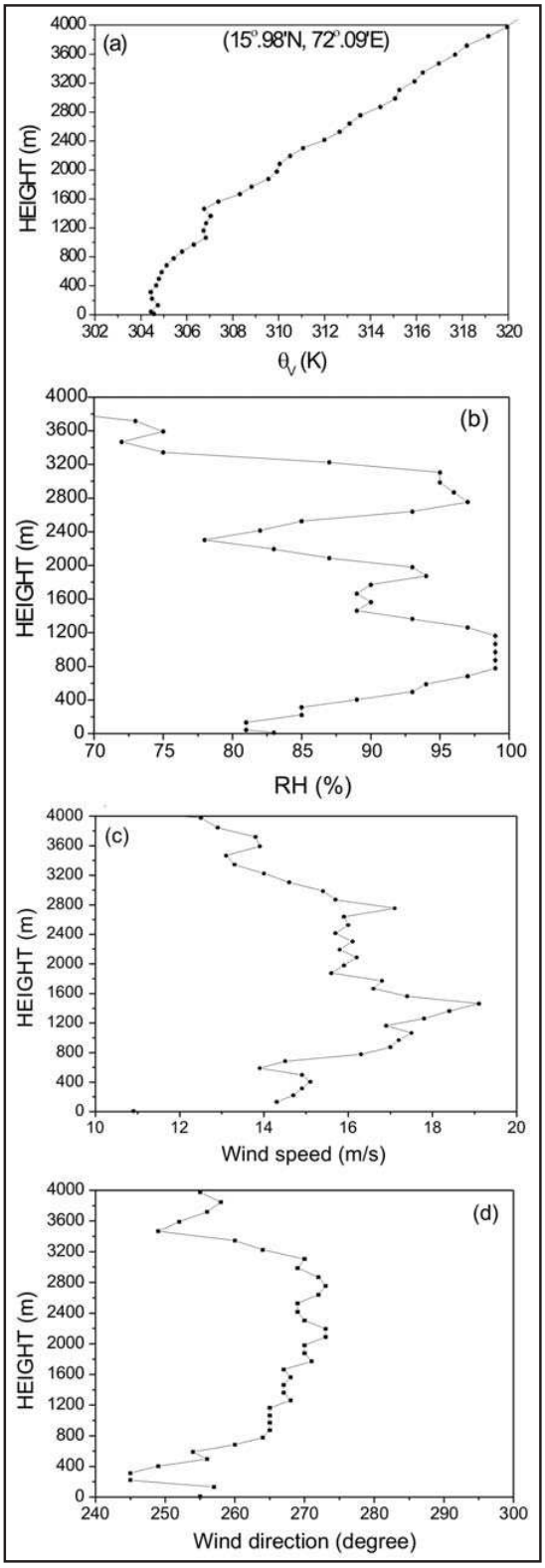


Fig. 44 : Vertical profiles of (a) virtual potential temperature (b) relative humidity (c) wind speed and (d) wind direction over Arabian Sea in August 2002

Experimental Study of Exchange Processes in the Atmospheric Boundary Layer over Continental and Marine Environment

(S. Sivaramakrishnan, T. Dharmaraj B.S. Murthy, S.B. Debaje, C. Sukumaran, T. Rajitha, Madhu Priya)

Studies on ARMEX

Mesoscale convergence/divergence over Goa coast was estimated using Bellamy Technique from ORV Sagar Kanya, Goa and Mangalore using upper air data (RS/RW). Moist convective instability over the Arabian Sea during ARMEX (Arabian Sea Monsoon Experiment) 2002 was studied in terms of CAPE (Convective Available Potential Energy) and mean lapse rate variability. At times steep fall in CAPE was associated with intense rainfall. During monsoon 2003 also CAPE for surface air parcels as obtained from NOAA website showed same order of magnitude, concluding that the Arabian Sea is characteristically a low CAPE region as compared to the Bay of Bengal irrespective of good or bad monsoon. Radiosonde data over Arabian Sea, Goa and tower data of wind speed and direction, temperature, humidity, surface fluxes, rainfall and CO_2 and H_2O at the National Centre for Antarctica and Ocean Research, Goa from ARMEX were analysed for the period 20-24 July, 2002 (Fig. 45).

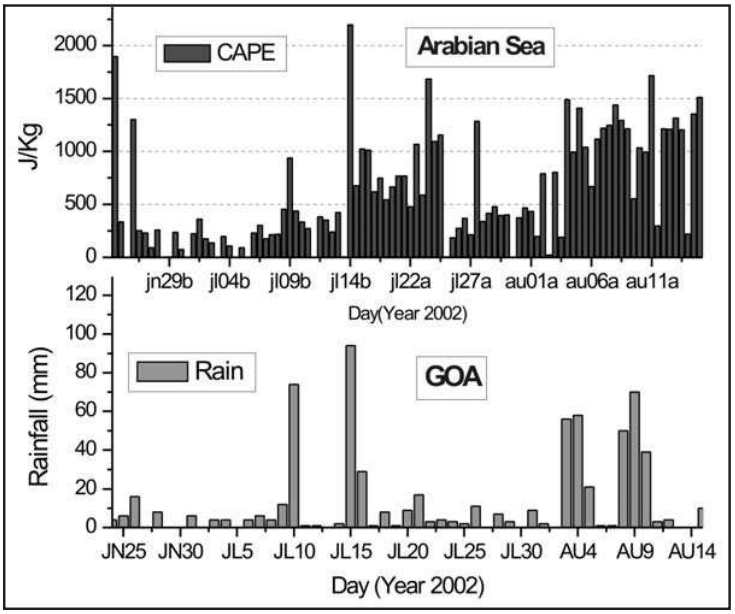


Fig. 45 : Convective available potential energy (CAPE) in relation with rainfall over Arabian Sea and Goa during June- August 2002

The PBL showed divergence over the Goa coast during 10 - 24 July, 2002. CAPE was ~1000 Jouls/kg during June- August, 2002 over Arabian Sea. The depth of mixed layer over Goa and offshore was about 1 km during July, 2002. A capping inversion layer of 500 m thickness was present over the Arabian Sea on some occasions. The first 200 m was showing super adiabatic lapse rate over Goa. The marine atmospheric boundary layer appeared to be well-mixed in the first 1 km. The vertical temperature gradient above 1 km was very steep over the Arabian Sea as compared to that over the west coast at Goa. The mean relative humidity (RH) in the layer 0-2 km was observed to be ~80% and ~75% over the Sea and Goa respectively. Above 2 km there was a sharp decrease in RH to about 40% over Goa indicating the presence of dry layer. There were significant fluctuations in RH in the range 40-90% above 2 km over the Arabian Sea which may possibly be due to the presence of clouds. Correlation coefficients for heat and momentum flux scaled well with Momin-Obukhov stability parameter. Sensible heat flux during July, 2002 was observed to be in the range -50 to 150 W/m^2. Many a times an inverse phase relationship was observed in the variation of CO_2 and H_2O concentrations (Fig. 46).

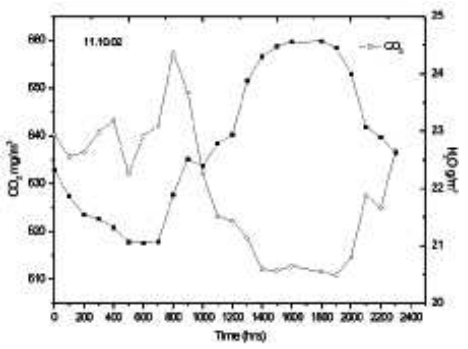


Fig. 46 : Variation of CO_2 and H_2O during ARMEX on 11 October 2002 at NCAOR, Goa

Since there exists an internal boundary layer (IBL) extending up to about 4 m from surface the fluxes measured directly above this height at 5 m level on the tower would represent surface layer fluxes very close to the coast.

Turbulence statistics of wind, temperature, heat and momentum followed the universal similarity relations of the atmospheric surface layer. Prominent energy peaks (period 4-5 sec.) in the spectrum (sampling time: 7 min.) of temperature, water vapour and vertical velocity in unstable conditions showed intermittency in turbulence due to buoyancy. The inertial sub-range in the spectra of wind, temperature and water vapour was found to depict -2/3 law of Kolmogorov. The daily rainfall and sensible heat flux were found to be inversely related. An analysis of a precipitation (10 mm) event during noon time that lasted for a few minutes showed rapid changes in short wave solar radiation, surface wind, air temperature and relative humidity thus emphasizing the sensitivity of the surface layer to external forcing.

The Sonic anemometer (USA, METEK) of the Indira Gandhi Centre for Atmospheric Research, Kalpakkam was installed on 9 m micrometeorological tower at 5 m AGL at the National Centre for Antarctic and Ocean Research, Goa. Measurements of turbulence on wind components and virtual temperature were taken using Sonic anemometer and that of CO_2 and H_2O were taken using CO_2 / H_2O analyser. All the measurements were taken at 5 m AGL.

Data collected during phase I of ARMEX were analysed to study the time variation of moist convective instability and its relation to rainfall during monsoon 2002. It was observed that on many occasions mixed layer height was observed to be less than LCL (Lifting condensation level) indicating that large-scale triggering is required to lift the parcel to LFC (Level of free convection) for the deep convection to occur. LFCs were on the order of 800-1000 m. LNBs (Level of neutral buoyancy) were observed to vary significantly during the period. Steep fall in CAPE associated with moderate and heavy precipitation were analysed in two cases, using the radiosonde data at Hansa-Goa. It was observed that vertical gradients in temperature and moisture reduced considerably following precipitation. Mixed layer was found to collapse following intense rainfall and a stable layer developed near the surface. Surface layer turbulence characteristics and fluxes during phase I and phase II of ARMEX were studied from the perspective of intra-seasonal variability of Monsoon 2002.

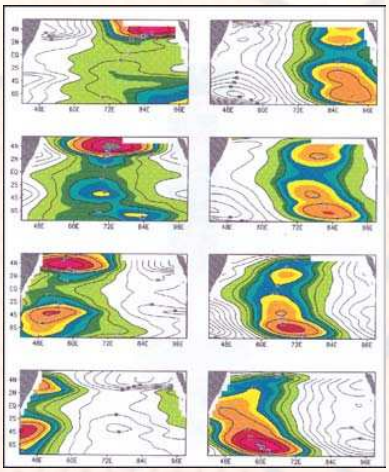
Experimental set-up at NCAOR, Goa using Sonic anemometer and CO_2 / H_2O analyzer systems during ARMEX Phase II

Surface ozone studies

Variation of surface ozone in coastal and urban regions and their relation with meteorological processes were studied by analysis of ozone data. Measurements of surface ozone, solar radiation, relative humidity and cloud cover were carried out in the campus of the Institute to understand the ozone formation in the surface layer.

Theoretical Studies

Theoretical Studies Division conducts theoretical studies for understanding atmospheric and oceanic circulations with special reference to southwest monsoon. Following are the research programmes undertaken by this Division :



- Development of diagnostic models for the study of (i) Regional energetics in the grid point domain (ii) Tropical belt energetics in the wave number and frequency domains and (iii) Global energetics in the spectral domain.
- Development of numerical models to diagnose the linear and nonlinear interactions among different spatial and temporal scales of monsoon flow.
- Development of simple reduced gravity as well as thermodynamic ocean circulation models for understanding dynamics and physics of Indian Ocean circulation and SST variability.
- Development of simple coupled ocean atmosphere model for understanding global circulation.
- Development of regional three dimensional multi-level ocean model for understanding surface and sub-surface temperature and circulation of Indian Ocean.
- Application of numerical ocean model for studying oceanic response to moving cyclones in the tropical Indian Ocean.
- To promote post graduate academic programmes in Atmospheric Sciences.

Studies on Dynamical Ocean Modelling

(P.S. Salvekar, C. Gnanaseelan, Prem Singh, A.A. Deo, D.W. Ganer, P.R.C. Reddy, B. Thompson, A.K. Mishra, J.S. Chowdary, B.H. Vaid)

Studies made using 1½ layer IRG ocean model

a) Simulation studies and applications

A reduced-gravity (1½-layer) model forced by daily climatological winds (experiments were carried out with NCEP and NCMRWF winds) simulated twin, anti-cyclonic meso-scale gyres, propagating westward on either side of the equator. The gyres were formed at the beginning of both the southwest and the northeast monsoon in the equatorial eastern Indian Ocean, and subsequently propagated across the basin. When inter annual winds were used as forcing, the equatorial meso-scale gyres were obtained with some inter annual variability. The existence of gyres was supported by velocity observations taken during WOCE in 1995 and by TOPEX / Poseidon sea-level observations during 1993 (Fig. 47). The gyres were also present in the ECCO model/data product, formed at the front of a Rossby-wave packet generated by the reflection of the equatorial jet (EJ) from the eastern boundary of the basin.

The model has the ability to simulate circulations of different scales depending on the scale of input. When seasonal and monthly forcings are used as input, large scale features like the equatorial jet and the Somali gyres are well simulated, but to simulate meso-scale features like the twin gyres, daily data played a very crucial role. To understand

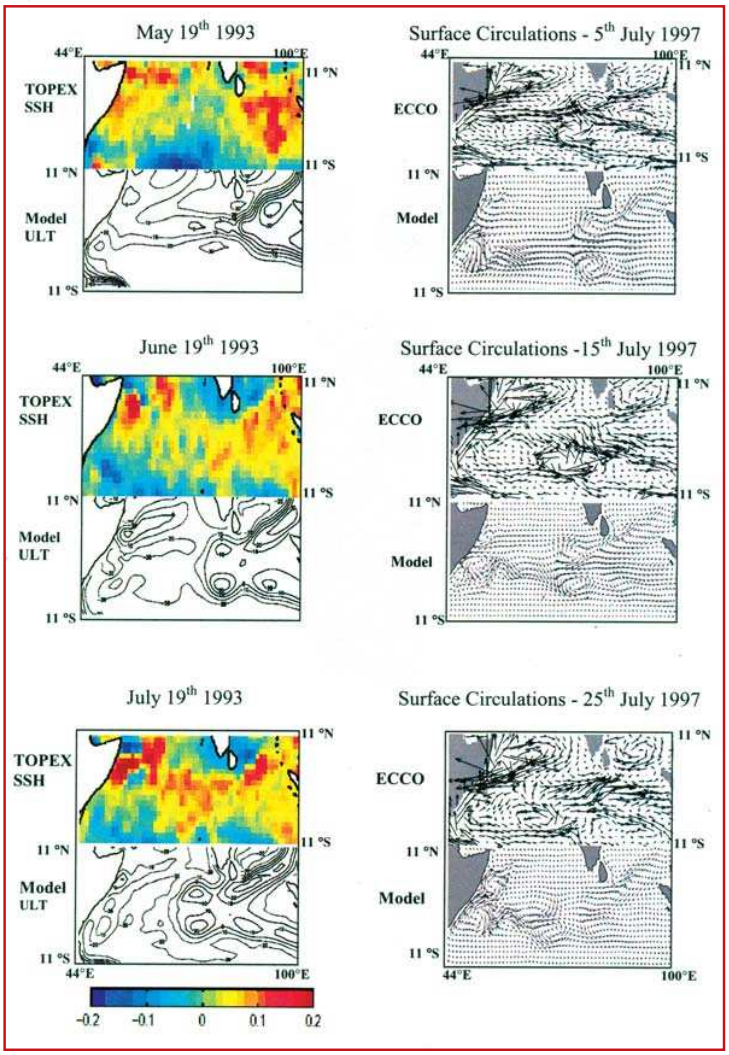


Fig. 47 : Left panels compare TOPEX SSH with ULT deviation from the annual mean from the daily solution. Right panels compare the ECCO reanalysis product with the daily solution. The latitudinal extent of each plot is from 11°S-11°N

this fact the data spectrum was proposed in relation with space and time scale. The gyre structure in the surface circulation was not stationary. It was found to have a continuous westward movement. The meso-scale transient feature was found to vanish when relatively large-scale circulation was obtained.

As a consequence of the discovery of the twin gyres, the grid region of 5°S-5°N, 85°-95°E was identified as a sensitive region in which the initial formation of twin gyres takes place. Hence the grid was chosen to look for a possible correlation between SST over this region and the Indian monsoon rainfall. A negative correlation was found between June SSTs over the region 0-5°S, 85°-95°E and the Indian southwest monsoon rainfall. The correlation was found to be – 0.24 for a period of

70 years (1932-2001) corresponding to a statistically significant level of 95%. Further, a strong positive correlation was found to exist between April SST over the region 0°-5°N, 85°-95°E and the all India annual rainfall. The correlation was found to be as good as 0.48 for a period of 25 years (1977-2001) corresponding to a significance level of 99%. It can be inferred that warmer the SSTs in the grid, more the rainfall in that year and vice versa. Twenty one year sliding correlation as well as spatial distribution of correlations coefficients were also studied to examine the utility of these indices for long-range forecasting of the all India annual rainfall and the Indian southwest monsoon rainfall.

b) Oceanic response to Indian Ocean cyclone

In order to study the impact of different model resolutions on the upper ocean response to Indian Ocean cyclone, the 1½ layer reduced gravity ocean model (½° x ½°), developed earlier, was suitably modified to $^1/_8$° x $^1/_8$° and $^1/_{12}$° x $^1/_{12}$°. The numerical experiments were performed by considering two storm tracks viz. northward in the Bay of Bengal and westward in the Arabian Sea. As the resolution increased, the cooling increased from 4°C to 8°C. The magnitude of down welling also increased with the resolution (Fig. 48). The model temperature change in the case of high resolution ($^1/_{12}$° x $^1/_{12}$°) model was unrealistically high. In order to get the realistic temperature field the vertical gradient (used for temperature parameterization) was reduced. The model results then showed less cooling, which was close to the observed one. Further, the sensitivity experiments with $^1/_8$° x $^1/_8$° resolution were carried out by changing radius of eye wall. The model temperature field showed increase in maximum cooling and decrease in maximum warming with decrease in the eye radius.

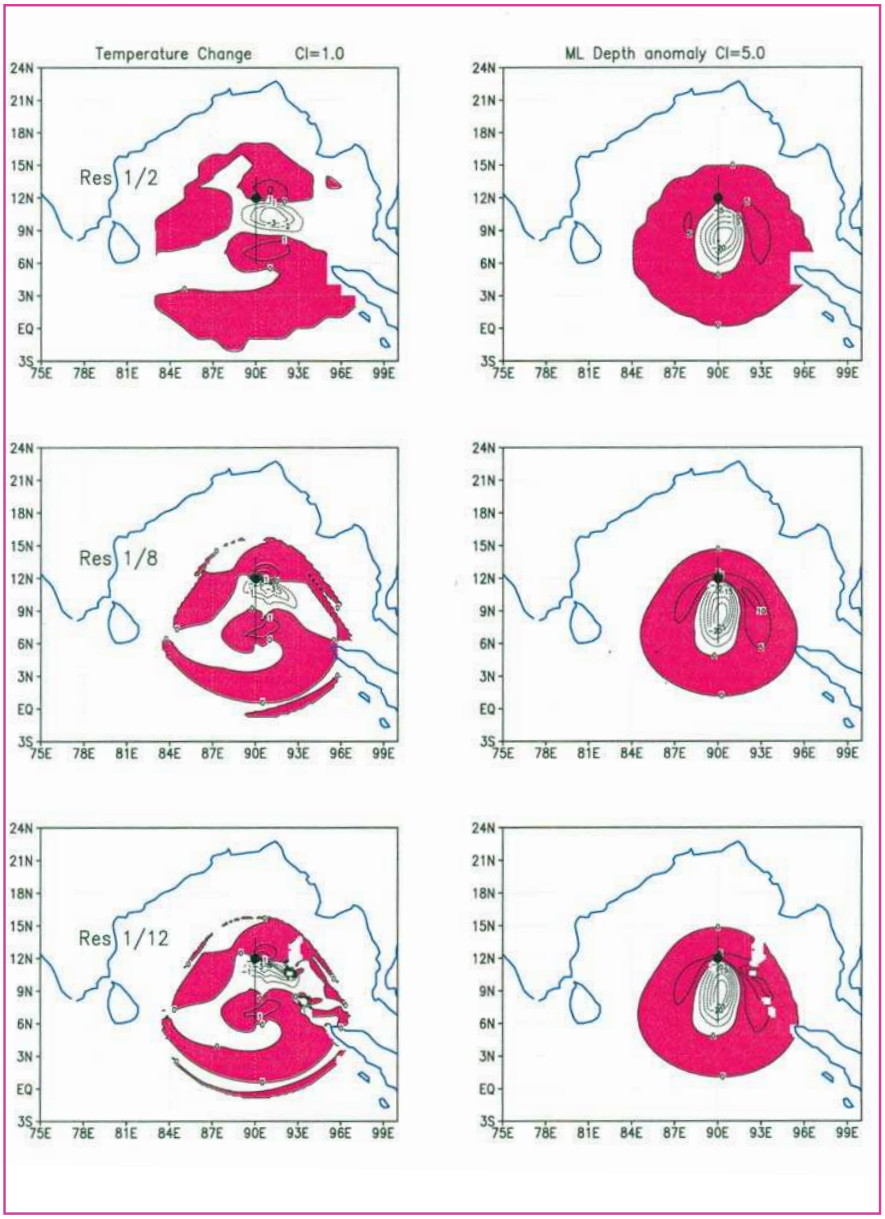


Fig. 48 : Model temperature change and mixed layer depth anomaly on third day for different resolution. Dot represents the position of the storm center.

Numerical experiments were performed to examine the effect of asymmetric cyclone moving along different directions. The cyclonic vortex having right and left asymmetric winds was considered. The model temperature showed reduction in cooling (~ 3°C) for left asymmetric cyclone and increase in cooling (~ 6°C) for right asymmetric cyclone as compared to that in the symmetric case (~ 4°C). The right bias was found to increase in the right asymmetric case. Mixed layer depth increased on the side of the asymmetric winds. Further, the model simulations for the numerical experiments were carried out for the mirror image of these asymmetric cyclonic cases in the southern hemisphere. The oceanic response to the right (left) asymmetric cyclonic winds in the northern hemisphere was same as that for the left (right) asymmetric winds in southern hemisphere quantitatively since they were symmetric about equator.

Studies made using 2½ layer thermodynamic ocean model

The simulated positive Indian Ocean dipole (IOD) events during 1994 and 1997 SST anomalies over Indian Ocean suggested existence of a strong east west gradient in SST anomalies over equatorial Indian Ocean with the maximum of 1°C. The gradient seemed to be independent of ENSO and may be natural oscillation of Indian Ocean. The warm SST anomalies over western Indian Ocean were found to be a result of weak cross equatorial flow associated with Somali Jet and evaporation. The cold SST anomalies over eastern Indian Ocean were due to coastal upwelling along Sumatra and advection of cold SST anomalies from the eastern sides. The positive IOD events might have a significant impact on Indian Ocean climate variability.

Three dimensional ocean model studies

The three dimensional σ coordinate POM ocean model with horizontal resolution 1° X 1° and 21 levels from surface to deep ocean, was used to simulate surface and subsurface temperature, currents, salinity and sea surface elevation in the model region (35°-115°E, 20°S-25°N). This model was used in the simulation of thermodynamic features and interannually varying currents.

For simulation of thermodynamic features Hellermen and Rosentine wind stress, and SOC surface heat fluxes were used to spin up the model and the model reached steady state after 20 years integration. For the interannual simulations NCEP monthly mean winds for the years 1982 - 2001 were used. Corresponding surface heat fluxes were computed from OLR, ISCCP clouds and NCEP surface temperature. The model simulated SST anomalies for the years 1982 - 2001 were well comparable with the Had SST (GISST) anomalies and NCEP/NCAR OIV2 SST anomalies. The model subsurface temperature anomalies were comparable with the corresponding SODA (Simple Ocean Data Assimilation) products. The model successfully simulated the positive and negative Indian Ocean Dipole (IOD) of the recent years. The model sea surface elevation anomaly patterns were found to be comparable with the TOPEX/Poseidon SSH anomaly pattern.

Using daily Quicksat wind data and earlier computed heat fluxes the model was integrated to simulate Arabian Sea warm pool for the years 2002 and 2003. Surface heat flux and fresh water transport from Bay of Bengal were found to be the main features responsible for evolution of the warm pool. The strong monsoon winds and currents were found to be responsible for the warm pool collapse.

For simulation of interannually varying currents the ECMWF monthly mean climatological surface forcings and Levitus climatology for internal forcings were used to spin up the model. The model reached steady state after 16 years of integration. The model was further intergrated for interannual runs for the period 1980 - 1989. Interannually varying surface currents were examined. The currents for the month of April for all the years and a climatology are shown in Fig. 49. A large interannual variability was observed in the south equatorial current. Seasonal migration of Somali gyre had less variability. However, considerable interannual variability was noticed in the south west Indian Ocean between equator and 10°S.

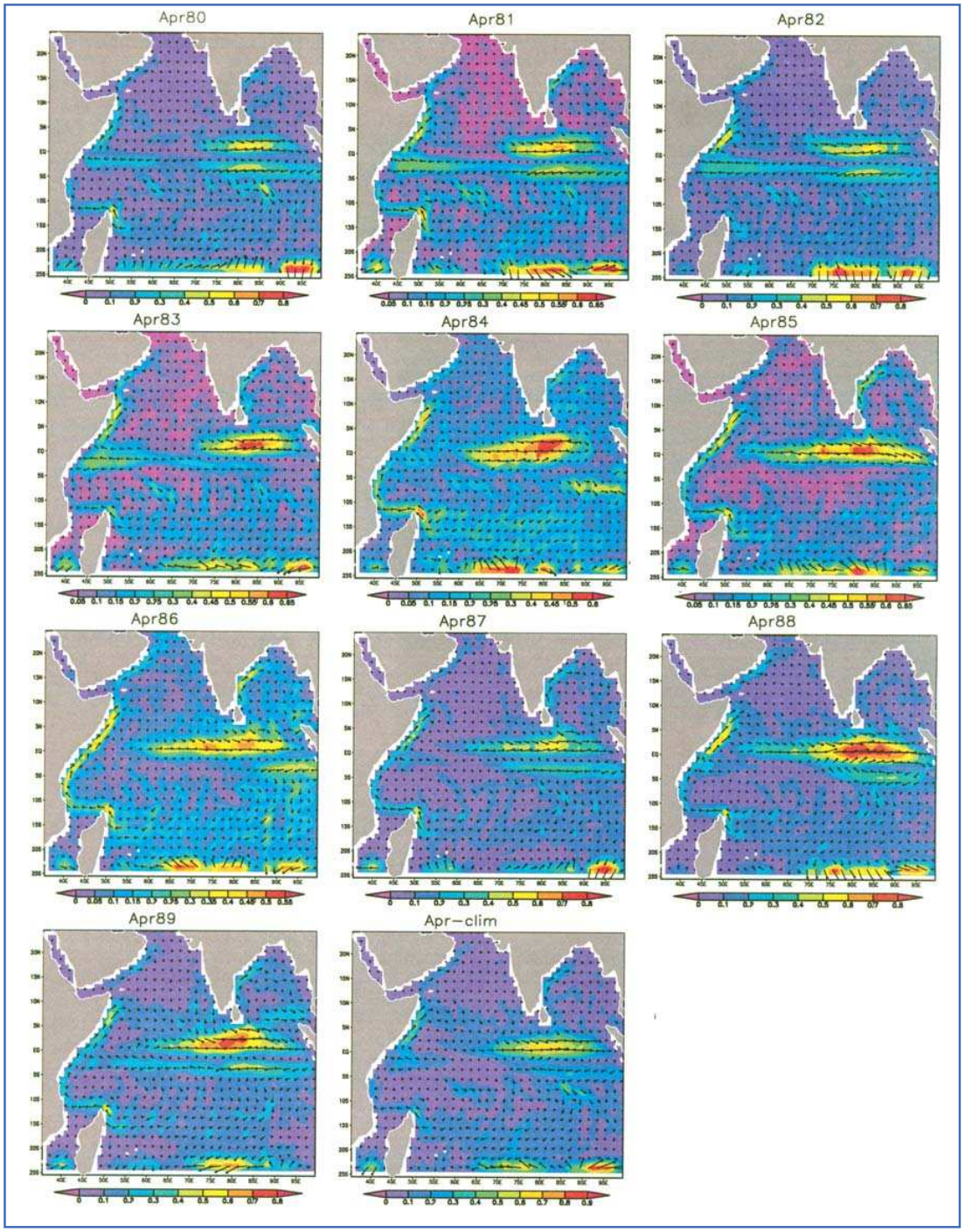


Fig. 49 : Interannually varying surface circulation for the month of April during 1980 - 1989 and model climatology

Studies made using mixed layer models

A two-dimensional mixed layer model developed in-house was used to simulate the mixed layer depth for the period 1992 - 2001 in the north Indian Ocean (35°-115°E, 20°S-25°N). The model climatology was well comparable with the Levitus and U.S. Navy climatology except in the Somali coast and near 15°S. The 1-D mixed layer model (PWP) was modified to simulate the SST and MLD during monsoon season at 15.5°N, 61.5°E.

Diagnostic studies using in situ and satellite observations

The ARGO (Array for Real - time Geostrophic Oceanography) float observations in the Arabian Sea during 2002 and 2003 were objectively interpolated using Baren's method and utilized to understand the oceanic processes during two contrasting monsoons. It was observed that the Arabian Sea was warmer in 2003 than 2002 during the southwest monsoon period. It was also observed that the 2003 warming extended up to the thermocline making the thermocline warmer in 2003 monsoon than 2002. The available CTD and XBT observations over the equatorial Indian Ocean during 1992 - 2001 were objectively analysed to understand the interannual variability in the surface and subsurface temperature. The eastern cooling and western warming for the years 1994 and 1997 were very clearly seen in the analysis.

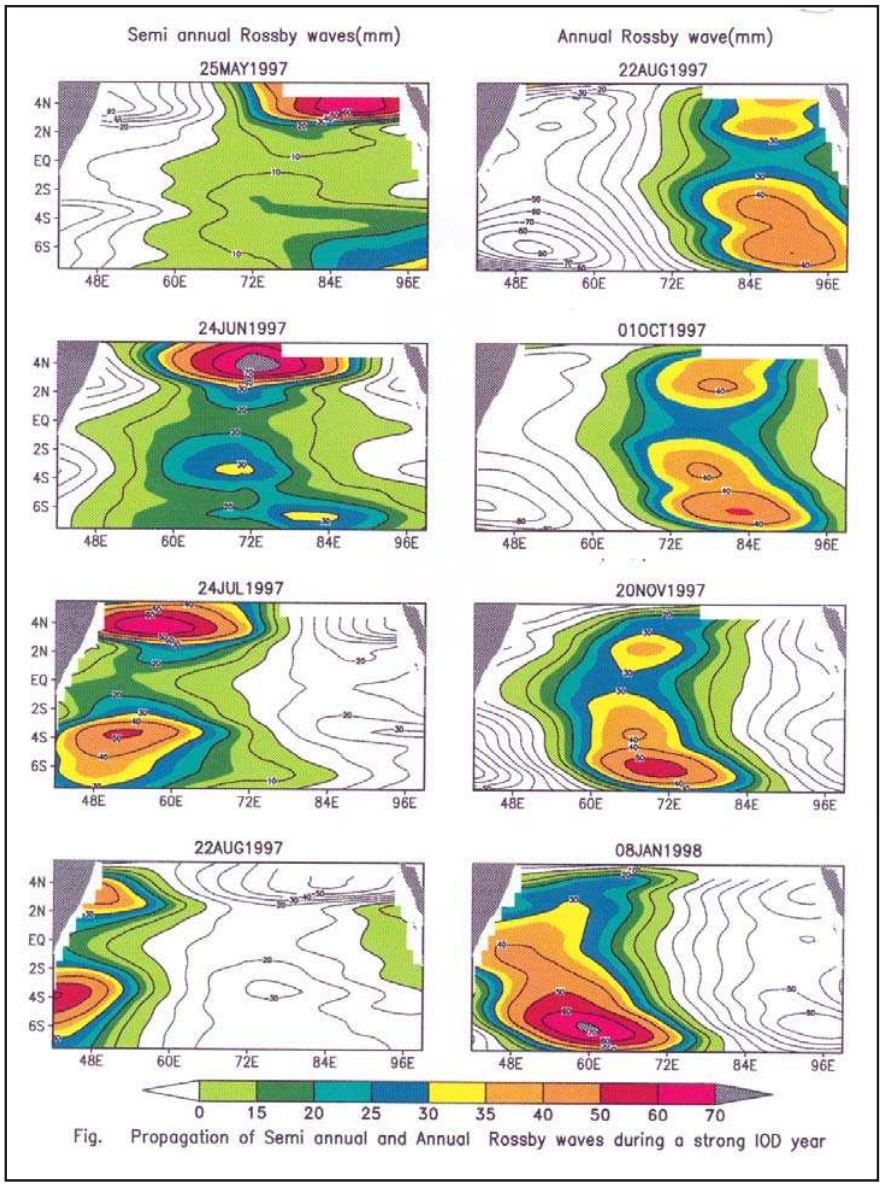


Fig. 50 : Propagation of Semi-annual and Annual Rossby waves during a strong IOD year

The TOPEX/Poseidon SSHA during 1993 - 2002 were filtered into several spectral wave components such as Rossby waves (semi-annual, annual and biannual etc.), Kelvin waves, tropical instability waves, meso-scale eddies etc. using finite impulsive response (FIR) band pass filters. The interannual variability in the Kelvin and Rossby wave components were studied. The semi-annual and annual Rossby wave signals were found to be westward propagating twin gyres (Fig. 50). The annual Rossby wave components were found to be travelling very slowly from 80°E onwards during the positive IOD years 1994 and 1997, reaching the western boundary in January, 1995 and 1998 respectively. Whereas in case of the other years, it reached the western boundary in July/August of the same year. The Kelvin wave signals were found maximum along the equator whereas maximum Rossby wave signals were found along 3-4° latitudes in both the hemispheres. Anomalous biannual signals of 2-3 cms were observed in the IOD years 1994 and 1997.

In order to understand the surface meso-scale eddies in the north Indian Ocean the surface currents were diagnostically derived from TOPEX altimetry data and Quickscat winds during 1999 to 2001.

Studies on Atmospheric Energetics in Wavenumber and Frequency Domain

(P.S. Salvekar, D.R. Chakraborty, L. George, S.S. Desai, N.K. Agarwal, S. De, S.S. Naik, R.S.K. Singh, M.K. Biswas)

Intraseasonal transients in kinetic energy exchanges

The mathematical modelling designed earlier to investigate the interactive dynamical and physical processes of seasonal mean monsoon circulation and low frequency oscillation on Madden Julian time scale through nonlinear triad and quasi linear energy interactions was applied on the two contrasting monsoon seasons 2001 and 2002 over the Indian region (EQ-30°N, 40°-120°E). The seasonal mean flow was found to be the main source of kinetic energy for the maintenance of low frequency transients on MJO time scale during the good monsoon 2001 in the lower troposphere while during bad monsoon year 2002, the energy exchange took place in the opposite direction, thus showing that in bad monsoon year 2002 the intra-seasonal oscillations on Madden Julian Oscillation (MJO) time scale could not be well established. During good monsoon year 2001, strong nonlinear energy interactions on the time scale of 20-60 days were found to be associated with planetary scale wave numbers 1 and 2 in upper troposphere whereas the same remained almost unnoticed during the bad monsoon year 2002.

Atmospheric modelling : Global energetics in the spectral domain

A study of the intraseasonal and interannual variability in the transient global spectral kinetic energy (K), enstrophy (EN) and available potential energy (A), and their nonlinear exchanges during early monsoon months of June and July of the years 1988, 1990 and 1991 was carried out and examined i) the tropospheric vertical profiles of transient global averaged zonal (KZ, AZ) and eddy (KE, AE) energies, ii) spectral distribution of the vertically integrated eddy energy and their nonlinear interaction in the lower troposphere (LT, 1000 - 500 hPa), upper troposphere (UT, 500 - 150 hPa), and lower stratosphere (LS, 150-10 hPa) in terms of the zonal (m) and two-dimensional (n) wave number and iii) the verical-time sections of the daily zonal and eddy K and A during the selected period of the three years (1988, 1990 and 1991).

In general, the intra-seasonal and the interannual variations in the transient eddies were found to be more in June compared to July during the three years. The interannual variation of KZ and KE was found to be prominent in the upper troposphere (UT) than in the lower troposphere (LT) and lower stratosphere (LS). The interannual variation in the zonal and eddy available potential energy was found to be of non-uniform nature at different tropospheric levels. The planetary ($1< m < 3$) and synoptic scale waves ($4 < m < 9$) showed interannual variability of transient KE in the LT and UT. In LS, the variation was observed only in the planetary scale waves. The interannual variation of AE was observed only in the planetary scale waves. The daily transient kinetic energy and also its intra-seasonal variation was found to be maximum at 250 hPa level. The tropospheric transient KE and AE energies reached their maximum during first week of June i.e. just at the onset of monsoon over India and neighbourhood. It seems, therefore, that the global averaged transient eddy KE reflects the Asian monsoonal activity. Zonal waves with $m<12$ indicated interannual variation in the nonlinear exchanges of KE and AE in the tropospheric region. In the LS, zonal waves with $m<4$ ($m<9$) were active in the nonlinear exchanges of KE/AE (EN) and their interannual variation. In a large region of wave number domain up to $m<23$, the zonal waves actively took part in the nonlinear exchanges of tropospheric enstrophy. The interannual variation in the enstrophy parameter was remarkable throughout the wave number domain.

Nonlinear error energy budget of a forecast model in medium range tropical weather forecasts

In order to determine error estimation of the forecast wind fields up to 7 - day of NCEP (MRF) model over the tropical region (30^0S - 30^0N) to explore the intrinsic dynamics of nonlinear barotropic error characteristics, systematic and random error and the different terms in their growth rate equations were evaluated for winter (DJF, 2000-2001) and summer (JJA, 2001)

months in physical as well as in spectral domains. The epitome of the study is that in physical domain, summer and winter systematic error clearly exhibited shifting of the maximum error band from south to north of the equator in accordance with the seasonal oscillation of ITCZ (fig. 51). Winter random error showed its biasness to southern hemisphere whereas summer part covered the whole region of the study (fig. 52). The growth rate of both the errors appeared with larger magnitudes at winter time in comparison to their summer counter part to that region where the respective error predominated. Summer and winter fluxes of both the errors showed strong convergence on the prevalent erroneous zone. For the conversion term, systematic error was converted largely to random error

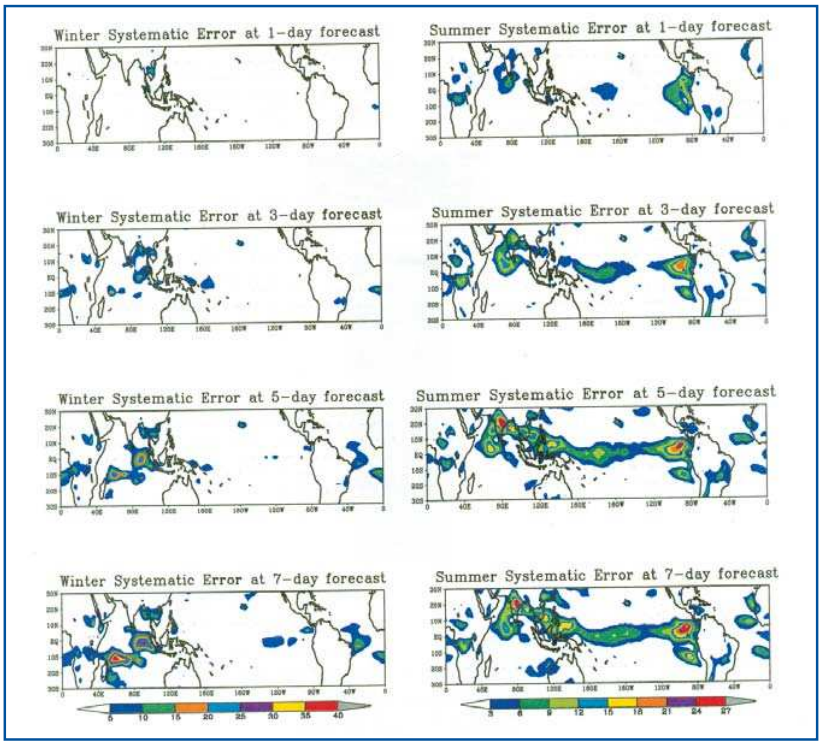


Fig. 51 : Spatial distribution of systematic error variance of 850 hPa wind for winter (DJF, 2000-01) and summer (JJA, 2001) of NCEP (MRF) model in m^2/sec^2 at different forecast time

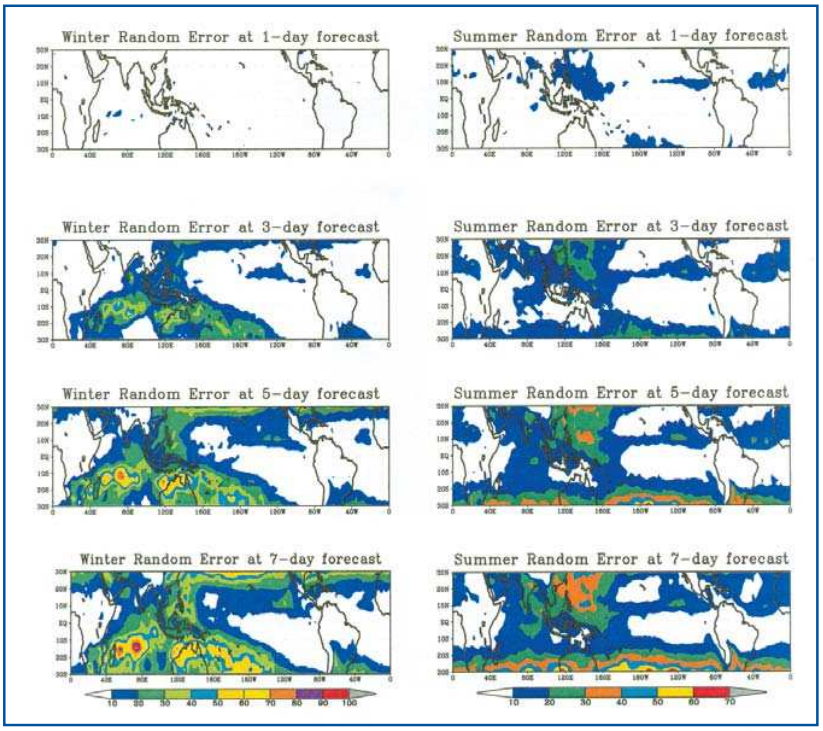


Fig. 52 : Spatial distribution of random error variance of 850 hPa wind for winter (DJF, 2000-01) and summer (JJA, 2001) of NCEP (MRF) model in m^2/sec^2 at different forecast time

in summer showing the opposite feature in winter. In wave number domain, systematic error and its growth rate showed maximum value at wave number 1 during both the seasons for most of the forecast days whereas random error and its growth rate were associated with the wave number band 3-7 or 4-8 at initial forecast time.

Diagnostic study for understanding the onset phase of southwest monsoon

To understand three-dimensional structure of the onset phase of southwest monsoon four different cases viz. early onset, normal onset, late onset and drought year were considered over the region EQ-25°N, 50°-90°E. All the dynamical and physical parameters were computed for

about two weeks from the mean onset date by using NCEP reanalysed daily data. For the year 1997, 1999 and 2000, the vertical extension of z and w were seen throughout in the troposphere from surface to 200 hPa and maximum intensity was seen near 700 hPa whereas for the year 2002, the vertical extension of cyclonic circulation was found to be shallow (not beyond 500 hPa) with a maximum at 850 hPa (Fig. 53). The horizontal extent of cyclonic circulation and upward

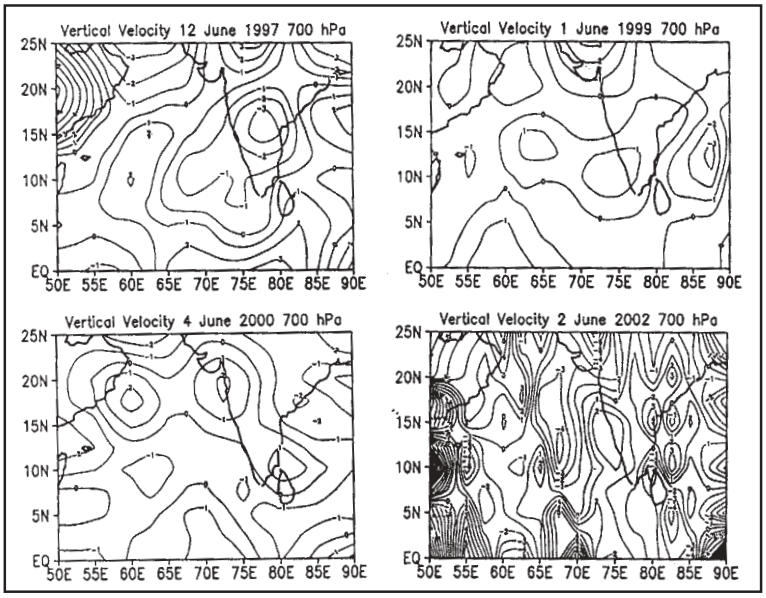


Fig. 53 : Computed vertical velocity ù (10^-3 hPa / s) maximum at 700 hPa over Indian peninsula and neighbouring seas on the near onset date

motion for all the years were of the synoptic scale but for the year 2002, the zones of convergence, divergence, upward and downward motion were found to be very small i.e. of meso-scale nature. Further, three dimensional structure of all the dynamical (z, D, w) and physical (Q_H & Q_L) parameters were critically examined for 1st June, the climatological onset date. The weak magnitudes of z, w, Q_H etc. for the year 1997 explained the late arrival of monsoon, whereas all the parameters (especially w, Q_H) were found to be over estimated during 1999, may be because of the early onset case.

Human Resource Development and Training Programme in Atmospheric Sciences

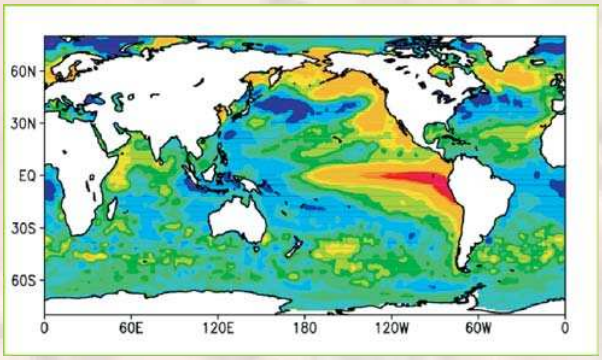
P. S. Salvekar, Prem Singh, C. Gnanaseelan, A. A. Deo.

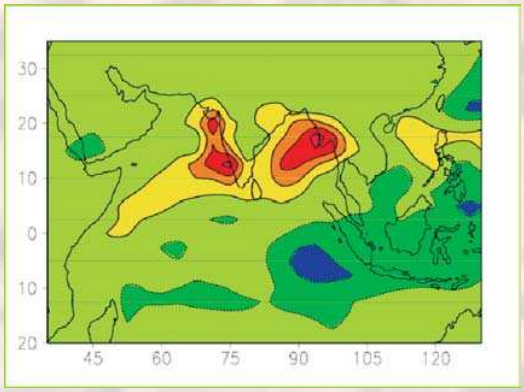
The Institute has been conducting M.Tech. (Atmospheric Physics) degree course of the University of Pune in collaboration with its Department of Physics under the MoU with the University. Courses for the 16th batch have been started and facilities for internship and research guidance are being provided to the students of 15th batch. The Institute has also provided research facilities to M.Sc. and M.Tech. Students of other universities. An Academic Cell has been formed in the Institute to coordinate the academic activities of the Post-graduate, Ph.D. and Post-Doctoral students from various Indian Universities. Dr. (Smt.) P.S. Salvekar has been nominated as a Coordinator of the Academic Cell.

Visit of a Committee headed by Prof. U. R. Rao in connection with feasibility of formation of 'Space Science University' in Pune

Climate and Global Modelling

Climate and Global Modelling Division conducts global modelling studies to understand the physical and dynamical processes in the climate system. The current research programmes are focused at the following objectives :





- Comprehensive study of the physical and dynamical processes relating to global and monsoon climate and their variabilities and change on different time scales.
- Development and improvement of physical and mathematical models capable of simulating climate, its variability and change due to natural and anthropogenic factors and validation of the results of the climate models.
- Application of general circulation models for seasonal forecasting of monsoon rainfall.

Climate Modelling Studies including Parallel Processing Techniques

(J.R. Kulkarni, V. Satyan, R. Krishnan, A.K. Sahai, S.K. Mandke, M. Mujumdar, S.P. Gharge)

Multimodel scheme for prediction of monthly rainfall over India

A multimodel scheme for the prediction of monthly rainfall over India has been developed. It is a linear combination of three different nonlinear time series models, viz. EBP (based on error back propagation algorithm of Artificial Neural Networks ANN), aiNet (based on probabilistic neural network theory) and SVR (based on Support Vector Machine theory). Separate schemes were developed for all India and seven macro-climatic zones (homogeneous, core, northwest, west central, central northeast, northeast and peninsular) of India. Monthly rainfall data of these regions for the period 1871-1990 were used for training and those for the period 1991-2001 were used for testing. The data were pre-processed by applying principle component analysis to overcome multi-co-linearity problem and dimensionality reduction. The models showed capability of simulating the monthly rainfall variability over all the regions quite well. The performance of the models was found to vary from month to month and region to region. Figure 54 shows predicted and observed monthly rainfall for (i) all India (August) (ii) homogeneous India (August) (iii) central North East India (August) and (iv) Peninsular India (November). The performance of the models in predicting monthly rainfall was tested by computing the skill scores. The highest skill score achieved was 0.31. Taken all the 8 regions together, the multi-model approach showed skills in the monthly predictions in 54%, 46%, 63% and 50% of months in the winter, pre-monsoon, monsoon and post-monsoon season, respectively. Though low, skill scores were found to be positive in 56% of cases.

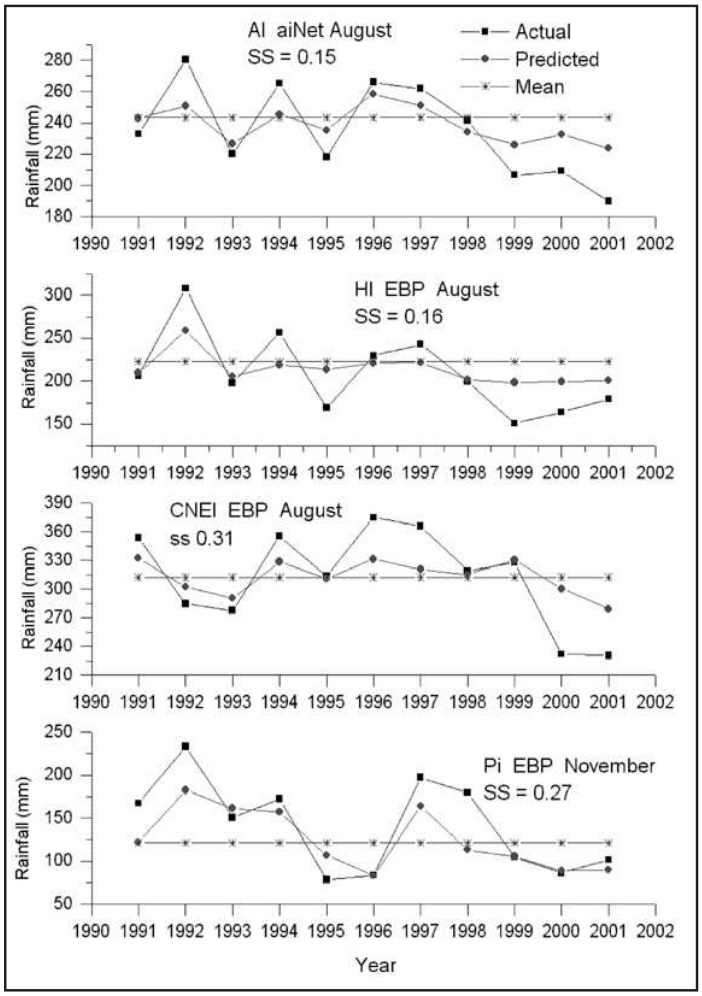


Fig. 54 : Predicted and observed monthly rainfall (i) All India (August) (ii) Homogeneous India (August) (iii) Central North East India (August) and (iv) Peninsular India (November).

Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate over the Indian – Asia Pacific Regions

(R. Krishnan, V. Satyan, J.R. Kulkarni, A.K. Sahai, S.K. Mandke, M. Mujumdar S.P. Gharge, K.V. Ramesh)

ENSO variability from long numerical simulation experiments of a global OGCM

A major contributor to the natural variability of the global climate system is the El Nino / Southern Oscillation

phenomenon. Evolution of oceanic features associated with El Nino and La Nina events in the tropical Pacific Ocean were examined by performing three sets of 43-year (1958-2000) numerical simulation experiments by integrating a global Ocean General Circulation Model (OGCM). In the first experiment (EXP1), the OGCM was forced using observed monthly wind-stress and heat fluxes from NCEP reanalysis for the period. In the second experiment (EXP2), the OGCM was forced with climatological monthly heat fluxes and interannually varying wind-stress field. In the third experiment (EXP3), the OGCM was forced with climatological monthly varying wind-stress and interannually varying heat fluxes. The El Nino and La Nina events simulated by the OGCM were validated with observed datasets. The variability of sea surface temperature (SST) in the Pacific Ocean from the model simulation experiments (Fig. 55) showed the major El Nino/ La Nina events during (1958-2000). The spatial distribution of SST and sub-surface temperature anomalies in the EXP1 simulation captured several features of the observed anomaly patterns (Fig. 56 and Fig. 57). Comparison of the ENSO simulation in the three experiments indicated that the SST variability was affected by interannual variations both in the wind-stress and heat fluxes. In the absence of the wind-stress variability, the OGCM simulation was found to be unable to capture the thermocline changes during ENSO events. The subsurface temperature variability in the Pacific Ocean associated with the El Nino and La Nina events highlight the significance of ocean dynamical processes in providing long-term memory to the coupled ocean-atmosphere variabilities in the tropics.

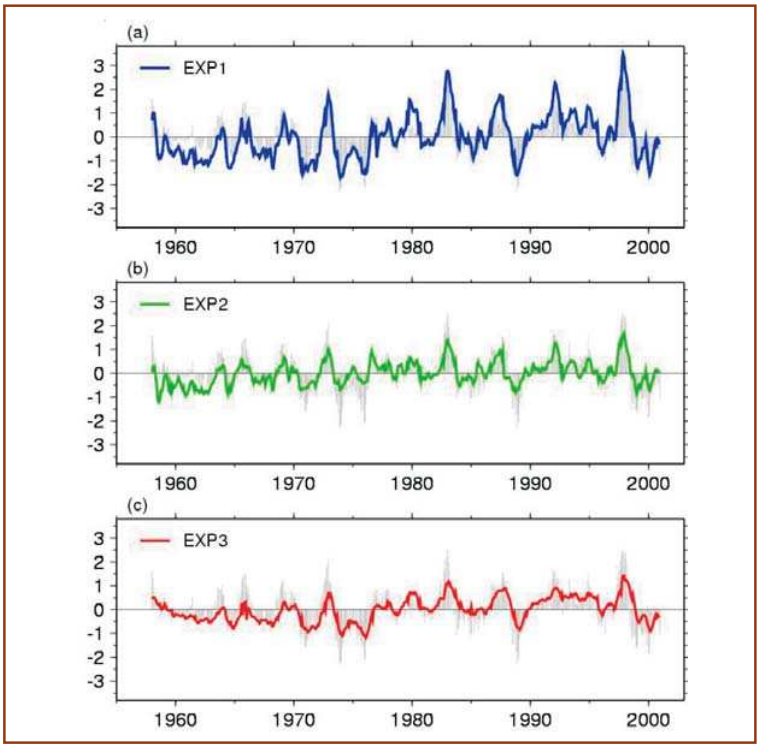


Fig. 55 : Monthly SST variation (°C) for the NINO3.4 region (170° – 120° W; 5° S – 5° N) in the equatorial central-eastern Pacific Ocean during the period (1958 - 2000) as simulated by the OGCM (a) EXP1 (b) EXP2 (c) EXP3. The observed SST variations based on the GISST2.3b dataset are shown in each panel by the grey shading.

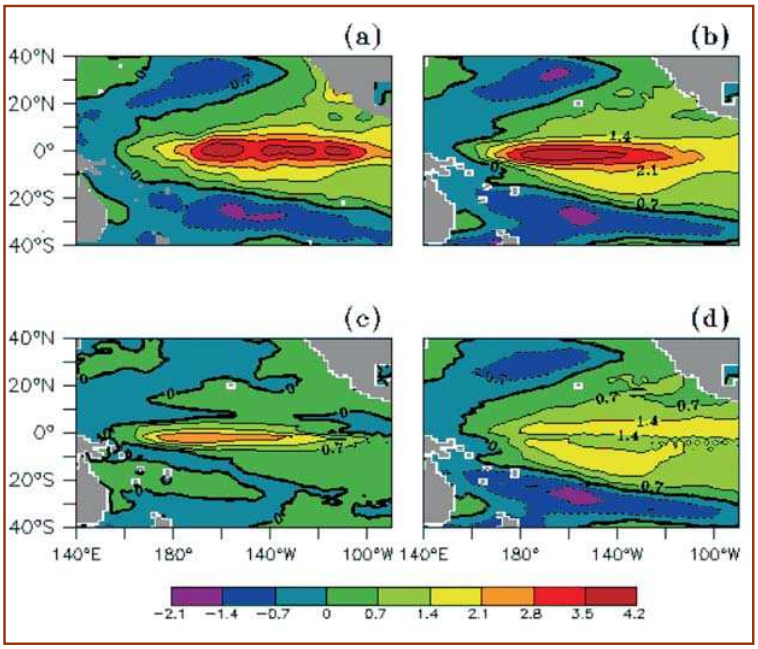


Fig. 56 : Warm minus cold (WMC) composite of SST anomalies (°C) based on 7 El Nino and 7 La Nina events during (1958 - 2000) for (a) GISST2.3b dataset (b) EXP1 (c) EXP2 (d) EXP3.

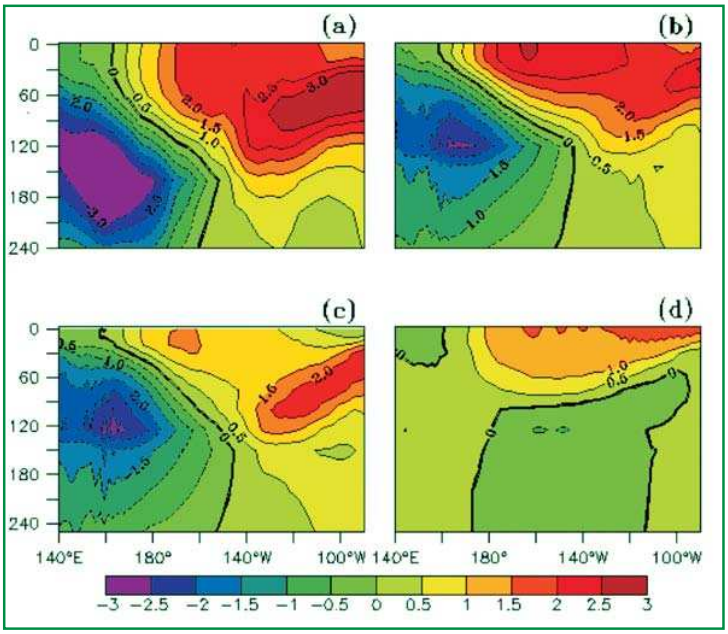


Fig. 57 : Longitude-depth section of warm minus cold (WMC) composite of potential temperature anomalies (°C) in the equatorial region (5°S– 5° N) based on 7 El Nino and 7 La Nina events during (1958 - 2000) for (a) Joint Environmental Data Analysis Center (JEDAC) dataset (b) EXP1 (c) EXP2 (d) EXP3

Ocean mixed layer and thermocline interactions associated with the monsoonal forcing over the Arabian Sea

Dynamical interactions between the oceanic mixed layer and the underlying thermocline provide vital information about the mechanisms of heat storage. Such interactions were examined for the Northern Indian Ocean by analysing observed datasets from multiple sources (including the recently deployed ARGO floats). The present study particularly focused on understanding the mixed layer and thermocline responses of the Arabian Sea to forcing from the southwest monsoon circulation. The climatological surface cooling of the Arabian Sea in the southwest monsoon months was found to be accompanied by significant warming of the thermocline. The vertical profiles of temperature (°C) for the southwest monsoon season and the rest of the year (all months excluding the southwest monsoon season) are shown in figure 58a. The latitude-depth section of (T_{JJAS} - T_{REST}) difference zonally averaged across 50°–70° E is shown in figure 58b. The seasonal cooling of the mixed-layer and warming of the thermocline in the Arabian Sea during the Southwest monsoon season can be clearly noted. The seasonal warming of the thermocline in the south-central Arabian Sea during the southwest monsoon season is as much as 1.2°C relative to other months. The profiles of vertical diffusivity of heat computed for the Arabian Sea indicated that the vertical mixing of heat is

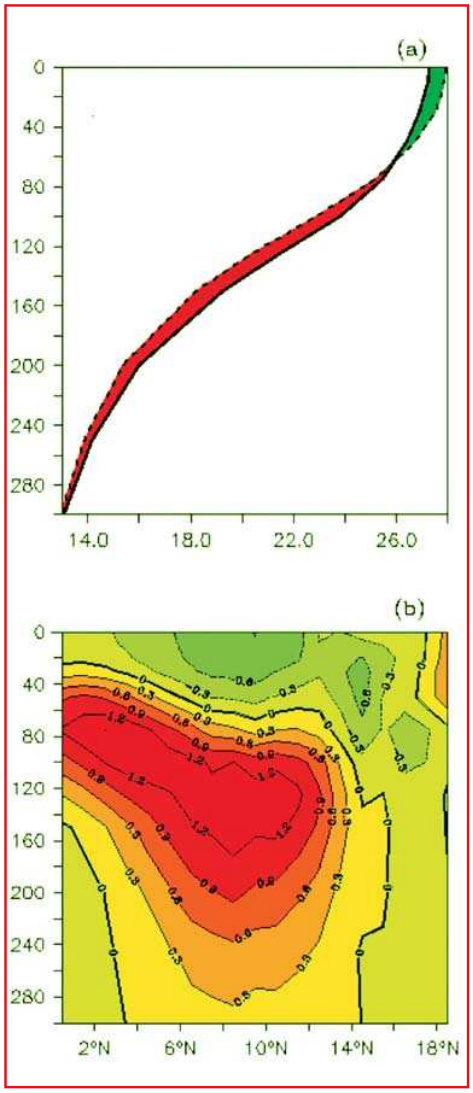


Fig. 58 (a) Vertical profile of temperature (°C) averaged in the Arabian Sea region (50° E –70° E; 0°–15°N) based on the WOA2001 climatological dataset. The solid line (T_{JJAS}) corresponds to the profile of the Southwest monsoon season (June to September). The dashed line (T_{REST}) is the profile for rest of the year (all months excluding the Southwest monsoon season). The green shading shows the area for T_{JJAS} is less than T_{REST}. The red shading denotes the area for which T_{JJAS} is more than T_{REST} (b) Latitude-depth section of (T_{JJAS} - T_{REST}) difference zonally averaged across (50° E – 70° E)

much stronger and deeper during the southwest monsoon season as compared to other months. The signatures of this

phenomenon were clearly evident from the observed response of the Arabian Sea during the contrasting summer monsoons of 2002 and 2003. The southwest monsoon of 2002 was very weak, while the monsoon of 2003 was normal. The difference in the surface winds between July, 2003 and July, 2002 (Fig. 59a) showed the circulation changes associated with the monsoon variability during these two years. Analysis of subsurface temperature variability during these two years using the ARGO float observations clearly revealed the impact of monsoon interannual variability on the upper ocean response. By contrasting the ocean response associated with the monsoons of 2003 and 2002, it was seen that the pattern of mixed-layer cooling and thermocline warming was enhanced during 2003 as compared to 2002 (Fig. 59b).

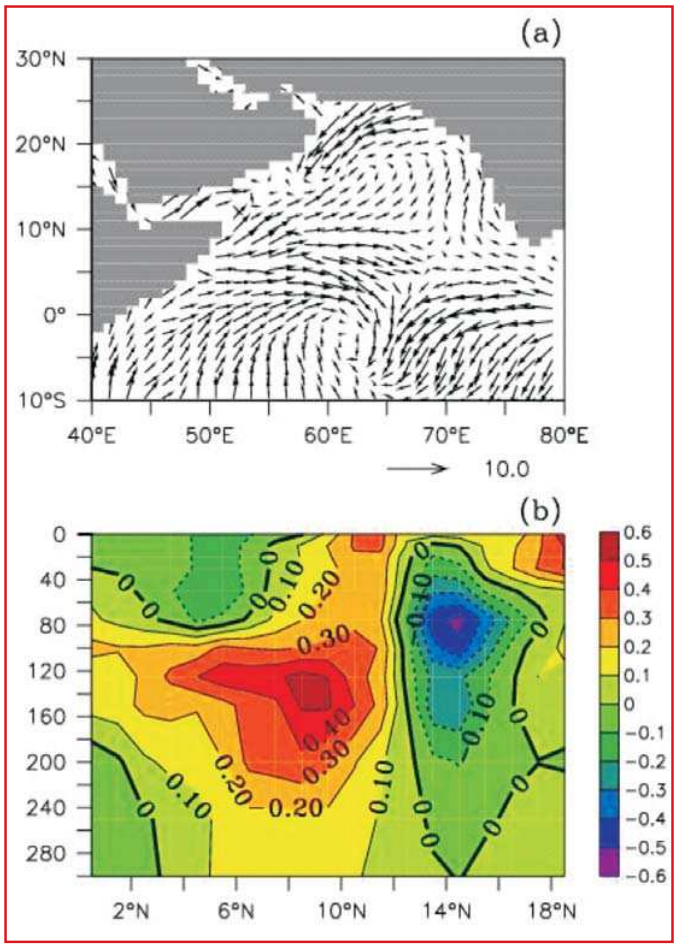


Fig. 59 : (a) Surface wind difference (July 2003 minus July 2002) in based on the QuikSCAT dataset m/s (b) Latitude-depth section of temperature difference (July 2003 minus July 2002) zonally averaged across (50°E – 70° E)

While the mixed-layer was relatively cooler in 2003 as compared to 2002, the thermocline warming was higher in 2003 by as much as 0.5°C relative to 2002. Due to enhancement of coastal upwelling during 2003, the subsurface temperatures to the north of 13°N were cooler during 2003 relative to 2002. In short, the temperature changes between 2002 and 2003 consistently manifested the response of Arabian Sea to forcing associated with interannual variability of the Southwest monsoon.

Dynamical seasonal prediction of Monsoon – 2003

As a part of the long-range forecasting (LRF) activity, seasonal forecasting experiments of Monsoon 2003 were carried out using two atmospheric general circulation models viz., COLA T30L18 GCM and Hadley Centre Climate Model (HadAM2b). Using the COLA GCM, two sets of 5-member ensemble integrations were carried out. The 5-ensemble members in both the sets were initiated from 5 different atmospheric initial conditions corresponding to (26-30 April, 2003) obtained from NCEP reanalysis. In the first set (CLIM), monthly climatological SST was used as boundary condition. In the second set (E2K3), the model integrations were carried out with the observed SST anomalies of April, 2003 superposed on the monthly climatological SST and persisted during the course of the GCM integration (until early October, 2003). The impact of persisting the April, 2003 SST anomaly on the summer monsoon was examined by comparing the 5-member ensemble simulations in the two cases. The mean of the ensembles showed that the monsoon precipitation averaged over the Indian region (10°-30° N, 75°-95° E) during the June-September months was deficient in the E2K3 experiment as compared to the CLIM experiment. The percentage departure

of the monsoon rainfall in the E2K3 experiment with respect to the CLIM experiment was found to be -9.4%. The dynamical features showed a weakening of the monsoon circulation in the E2K3 experiment relative to the CLIM experiment. Similar experiments were attempted with the HadAM2b model. In this case, the impact of persisting the May, 2003 SST anomalies on the monthly climatological SST was examined. SST anomalies of May 2003 provided the latest available SST information for the prediction experiments. Six-member ensemble integrations were carried out in this case. The ensemble mean percentage departure of the June - September rainfall over India, relative to the model climatology was found to be +2.46%.

Role of Indian and Pacific Ocean SST on Indian summer monsoon simulation of 1997

El Nino of 1997 was one of the strongest events in the recent history and has been widely studied. Another notable feature of global tropical SST pattern during 1997 was presence of Indian Ocean Dipole characterized by cold anomalies in the eastern equatorial Indian Ocean and warm anomalies in the western Indian Ocean. Relative roles of the Pacific and Indian Ocean SST on Indian summer monsoon of 1997 were examined by carrying out numerical simulation experiments using a global AGCM. The GCM simulations suggested that the SST anomaly patterns in the Indian Ocean played a significant role in altering the regional circulation and rainfall pattern over the Indian Ocean and monsoon region during 1997.

General Circulation Model Systematic Error Correction and Seasonal Prediction Using Artificial Neural Network

(A.K. Sahai, V. Satyan, J.R. Kulkarni, M.A. Shinde)

Empirical seasonal prediction of the Indian summer monsoon rainfall-2003

Experimental forecast of the seasonal (June - September) Indian summer monsoon rainfall (ISMR) for the country as a whole, for the year 2003 was obtained. The correlation analysis was used to identify the regions and seasonal lags for which seasonal SST anomaly or tendency in seasonal SST anomaly were highly correlated with the ISMR for the period 1876-1989. A strategy for selecting the best predictors was investigated. 18 predictors (hot spots of the global oceans) were selected. Seasonal mean and seasonal mean tendencies of SST were calculated for each selected region in the given lag. Then the time series (1876-2003) of each region was standardized with mean and standard deviation for the period 1960-1990. In the next step previous 5 year mean was subtracted from each value so that the resulting time series were from 1881-2003. The EOF analysis was performed on these 18 series using data from 1881-1989 and finally principal components were calculated up to 2003. First two principal components were used to develop a regression model for each 25-year running window and prediction was done for one year forward. This predictive scheme was found to be stable and useful in a changing background climate.

Empirical forecasts from this method can be obtained one season in advance using the predictors selected only from sea surface temperature (SST) field. The hindcasts in the verification period (1990-2001) showed a good skill (root mean square error = 2.7% and correlation coefficient = 0.91). The forecast for the ISMR 2002 was 88.5% of long-term mean (the observed one was 81%). The forecast for the year 2003 ISMR was obtained as 112.9%.

Sponsored Research Projects

In addition to the on-going research programmes the Institute undertakes sponsored projects for specific studies. The details of the sponsored projects operational during the year are given below:

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
1.	Impact of Anthropogenic and Natural Activities on Atmospheric Chemistry and Climate Forcing Factors with their variability.	Dr. G. Beig	1999-2004	16.77	Department of Science and Technology Govt. of India
2.	Management Perspectives to Seasonal Climate Forecast in Mixed Cropping System of Southern India's Semi Arid Field	Dr. Krishna Kumar	2000-2004	1.20	Global Change System for Analysis, Research and Training, Asia Pacific Network
3.	Aerosol Optical Characterization and Investigation of Aerosol Radiative Forcing at the Surface and Top of the Atmosphere	Dr. G. Pandithurai	2001-2004	3.62	Department of Science and Technology, Govt. of India / National Science Foundation, USA
4.	Study of Vertical Velocity in the Troposphere and Stratosphere Using Indian MST Radar and Lower Atmospheric Wind Profiler (Fast Track Scheme for Young Scientists)	Dr. Y. Jaya Rao	2001-2004	5.46	Department of Science and Technology, Govt. of India
5.	Impact of Climate Change on Water Resources	Dr. G.B. Pant	2001-2004	29.50	Ministry of Environment & Forests, Govt. of India / Dept. of Environment, Food and Rural Affairs, Govt. of U.K.
6.	Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change	Dr. K. Rupa Kumar	2001-2004	6.20	Indo-French Centre
7.	Mesoscale Modelling for Monsoon Related Predictions (NMITLI Project)	Dr. S.S. Singh	2001-2004	26.25	Council for Scientific and Industrial Research (CSIR)
8.	Studies of Mesoscale System over Indian Region	Smt. S.S. Vaidya	2001-2004	15.32	Department of Science and Technology, Govt. of India
9.	Monsoon Variability in Relation to NAO and ENSO and its Use for Predicting Monsoon Rainfall over Smaller Spatial and Temporal Scale	Shri. S.S. Dugam	2001-2004	4.56	Department of Science and Technology, Govt. of India

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
10.	Heat Sources over India during South-West Monsoon Season	Smt. U.V. Bhide	2001-2004	4.23	Department of Science and Technology, Govt. of India
11.	Non-linear Scale Interactions in the Energetics of Monsoon in Wave number / Frequency Domain	Shri D.R. Chakraborty	2001-2004	7.85	Department of Science and Technology, Govt. of India
12.	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data	Dr. C. Gnanaseelan	2001-2004	7.764	Department of Science and Technology, Govt. of India
13.	Indian Climate Change Scenario for Impact Assessment	Dr. K. Rupa Kumar	2001– 2004	48.50	Min. of Environment and Forests, Govt. of India / Department of Environment, Food and Rural Affairs, Govt. of U.K.
14.	Atlas of Spatial Features of Moisture Regimes and Rainfall of India during 19th and 20th Centuries	Dr. N. Singh	2001-2004	20.71	Department of Science and Technology, Govt. of India
15.	Study of Coupling between Lidar/ Radiometer Measured Aerosol and Radar Sensed Winds	Dr. Y. Jaya Rao	2001-2004	6.35	Indian Space Research Organisation (ISRO), Govt. of India
16.	An Observational Study of Direct Radiative Forcing of Atmospheric Aerosols on the Surface Reaching Solar Flux (Fast Track Scheme for Young Scientists)	Dr. R.S. Maheskumar	2001-2004	9.36	Department of Science and Technology, Govt. of India
17.	Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments	Dr. P.S.P. Rao	2001-2004	16.57	Department of Science and Technology, Govt. of India
18.	Experimental and Theoretical Studies of Secondary Pollutants and Ozone for Chemical Forecasting	Dr. D.B. Jadhav	2001-2004	29.65	Department of Science and Technology, Govt. of India
19.	Instrumentation for Atmospheric Boundary Layer Studies	Shri K.G. Vernekar	2001-2004	3.02	Department of Science and Technology, Govt. of India
20.	Surface Climatology of Western Himalaya	Dr. K. Rupa Kumar	2001-2004	9.90	Snow and Avalanche Study Establishment, Defence Research and Development Organisation, Govt. of India

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
21.	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact	Dr. K. Rupa Kumar	2002-2004	18.00	National Communication (NATCOM), Ministry of Environment and Forests, Govt. of India
22.	Dendroglaciological Studies of High Altitude Glacier Sites of Western Himalaya	Dr. H.P. Borgaonkar	2002-2004	4.92	Snow and Avalanche Study Establishment, Defence Research and Development Organisation, Govt. of India
23.	Composition of Acid Deposition (CAD)	Dr. P.S.P. Rao	2002-2004	0.90	Department of Meteorology, Stockholm University, Sweden
24.	Comparison of Aerosol Vertical Profiles Derived by Twilight Photometer and Lidar	Smt. B. Padmakumari	2002-2004	--	National MST Radar Facility, Gadanki.
25.	Measurement of Micro-meteorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment (ARMEX)	Dr. S. Sivarama-krishnan	2002-2004	24.916	Department of Science and Technology, Govt. of India
26.	Studies of Lightning Discharges During Pre-monsoon and Post- Monsoon Thunderstorms over Pune	Dr. (Smt.) S.S Kandalgaonkar	2002-2005	6.36	Department of Science and Technology, Govt. of India
27.	Lidar Sounding of Aerosols in the Lower Atmosphere and their Impact on Local Climate and Environment (Fast Track Scheme for Young Scientists)	Dr. G. Pandithurai	2002-2005	7.44	Department of Science and Technology, Govt. of India
28.	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System	Dr. G.B. Pant	2002-2005	22.43	Department of Science and Technology, Govt. of India
29.	Influence of Columnar Aerosol, Ozone and Water Vapour on the Evolution of Warm Pool over the Southern Arabian Sea	Dr. P.E. Raj	2003-2004	10.08	Department of Science and Technology, Govt. of India
30.	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling	Dr. G. Beig	2003-2004	11.46	Ministry of Environment and Forest, Govt. of India.

Sr. No.	Title	Principal Investigator	Period	Grant (Rs. in lakhs)	Funding Department
31.	Monitoring of Pollutant Species in Rain Water / Dust Fall in Different Environments around the National Capital Region of Delhi	Dr. S. Tiwari	2003-2005	11.16	Department of Science and Technology, Govt. of India
32.	Air-Sea Interactions in the Indian Ocean Region (DOD / INDOMOD 10th plan programme)	Dr. R. Krishnan	2002-2007	106.80	Department of Ocean Development, Govt. of India
33.	Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD / INDOMOD 10th plan programme)	Dr. C. Gnaneseelan	2002-2007	41.75	Department of Ocean Development, Govt. of India
34.	Estimation of Standard Project Storm (SPS), Probable Maximum Precipitation (PMP) and Time Distribution over the Bhagirathi Catchment up to Loharinagpala & Dhauliganga Catchment up to Tapovan	Shri B.N. Mandal	2003	3.00	National Thermal Power Corporation (NTPC), Noida
35.	Application of Satellite Data to Climate Research	Dr. G.B. Pant	2003-2005	15.50	Indian Space Research Organisation (ISRO), Govt. of India
36.	Optical Remote Sensing Studies of the Atmospheric Boundary Layer Characteristics Using Laser Radar	Dr. P.C.S. Devara	2003-2005	1.31	DST (Indo-Bulgarian Inter-Governmental Program of Co-operation in Science and Technology)
37.	Role of Aerosols and Black Carbon in Atmospheric Radiation Budget Studies	Dr. P.D. Safai	2003-2006	33.94	Indian Space Research Organisation (ISRO), Govt. of India
38.	Modelling of Tropical Aerosol Radiative Forcing Using Satellite, Lidar and Radiometric Aerosol Database and Surface Radiation Measurements	Dr. G. Pandithurai	2003-2006	9.62	Indian Space Research Organisation (ISRO), Govt. of India
39.	Multi-Site Characterization of Tropical Aerosol Direct Radiative Forcing Using Measurements	Dr. P.C.S. Devara	2003-2006	42.40	Indian Space Research Organisation (ISRO), Govt. of India
40.	Atmospheric Boundary Layer over the Arabian Sea during ARMEX : Thermodynamic Aspects	Dr. (Smt.) S.B. Morwal	2003-2005	2.88	Department of Science and Technology, Govt. of India

42nd Foundation Day Celebration

Welcome address by
Dr. A.K. Kamra

Dignitories on the dais

Inauguration by the
Chief Guest Shri Mohan Dharia

Inaugural speech of Shri Mohan Dharia

Address by the Guest of Honour
Dr.Vijay Bhatkar

Address by Dr. S. K. Dixit
ADGM (Research)

Dr. R.K. Gupta,
IITM Ex-employee
sharing memories

Presentation of Excellent Performance Award to
Smt. R.A.Desai, Shri S. P. Gharge and Shri U. R. Kashid (r to l)

Foundation Day Lecture by
Dr. V. G. Bhide

Foundation Day Celebration : Cultural Programme















Other Special Events and Activities

Workshops / Meetings / Seminars / Brain Storming Sessions

International

A Workshop on Seasonal Climate and Crop Forecasting Methods for South Indian Rainfed Agriculture was organised by the Institute jointly with International Research Institute for Climate Prediction (IRI), New York, USA during 12-16 May, 2003. The Workshop was followed by a Strategic Planning Meeting for a Multi-Partner Initiative to Develop Seasonal Rainfall Prediction to Enhance Smallholder Farmer Livelihoods, during 19-20, May, 2003. A concept paper was prepared to take up a major international project on seasonal forecasting applications for small farmers in India, with IITM as the coordinating agency.

Sixth Session of the CLIVAR Asian-Australian Monsoon Panel (AAMP) and the inaugural session of the newly constituted CLIVAR / IOC Indian Ocean Panel (IOP) were organised at the Institute during 18–20 February, 2004. Leading experts and Panel members from India and abroad attended the meetings. The CLIVAR/IOC Panel meetings were followed by an International Workshop on Role of Indian Ocean in Climate Variability (INDOCLIM) held during 23-27 February, 2004. Dr. S.K. Srivastava, Director General of Meteorology inaugurated the Workshop on 23 February, 2004. On this occasion, Institute's Varahamihira Hall, renovated with modern seminar facilities, was inaugurated by Prof. J. Shukla, Director, Center for Ocean–Land–Atmosphere (COLA) Studies, USA and Mausam Award of the India Meteorological Department was presented to Prof. T.N. Krishnamurti, Florida State University, USA. Prof. Julia Slingo, University of Reading, U.K. and Chairperson of INDOCLIM Scientific Steering Committee, and Dr. V. Satyan, Director (Climate Modelling), World Climate Research Programme of the World Meteorological Organisation, Switzerland also spoke on this occasion. The inaugural function was followed by a keynote talk by Prof. J. Shukla on 'Coupled ocean–atmosphere variability in the Indian Ocean with and without tropical Pacific variability'. About 150 delegates from various countries, including 41 from the Institute participated in the workshop and presented their research papers. The workshop was concluded on 27 February, 2004.

National

Second Subject Expert Committee Meeting under the Women Scientists Scheme of Department of Science and Technology, Government of India was held at the Institute during 30-31 May, 2003.

A one-day Workshop on National Lightning Information System was organized at the Institute in collaboration with the India Meteorological Department on 18 July, 2003. About 25 scientists from various research organizations and universities attended the workshop and discussed several aspects of the proposed facility.

A discussion meeting was organized at the Institute with the representatives of the IFFCO-TOKIO General Insurance Co., Gurgaon, Haryana, on various aspects of Monsoon Variability and Prediction in connection with the Weather Linked Insurance Cover for the Indian Farmers on 30 July, 2003.

A training programme on 'Tree-ring sample collection procedure' was arranged by the Institute at the Snow and Avalanche Study Establishment (SASE), Chandigarh for the field staff of SASE Camping at high altitude areas of Western Himalaya, during 4-11 October, 2003. A field programme was arranged to Kufri in Simla forest on 8 October, 2003 as a part of the training for the tree-ring sample collection.

Second meeting of the Programme Advisory and Monitoring Committee of the Weather and Climate Research Programme (PAMC-WCRP), Department of Science and Technology, New Delhi was held at the Institute on 10 October, 2003 to review

the progress of the Project, 'Wind Profiler / Radio Acoustic Sounding System (WP/ RASS)'. The meeting was held under the Chairmanship of Dr. R.R. Kelkar, Director General of Meteorology.

A meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects was organized at the Institute on 13 October, 2003. Scientists from various research organizations attended the meeting and discussed several aspects of the topic. Subsequently a Brain Storming Session on Water Resources, Rainfall, Evaporation, Water Conservation, Cloud Seeding vis-a vis Meteorological Aspects was organized at the Institute in collaboration with Indian Water Resources Society, Pune Local Chapter on 14 November, 2003. About 22 scientists from various research organizations attended the Session and discussed several aspects of the water resources.

A Brain Storming Session on Meso-scale systems and Modelling was organized at the Institute on 20 December, 2003. About 23 Scientists from various Indian organizations including IITM participated in the session.

A meeting regarding establishment of an International Centre for Capacity Building for Climate Change, organized by the Department of Science and Technology was held at the Institute on 28 October, 2003. Dr. Amitabha Pandey, Joint Secretary; Shri Shambhu Singh, Director; Dr. G. Srinivasan, Scientist from the Department of Science and Technology, New Delhi and Dr. Anand Patwardhan, Indian Institute of Technology, Mumbai attended the meeting.

Fourth meeting of the Programme Advisory and Monitoring Committee (PAMC) on Himalayan Glaciology Programme sponsored by the Department of Science and Technology, New Delhi was organized at the Institute on 28 January, 2004. About 20 PAMC-HG members, Principal Investigators and special invitees participated in the Meeting.

Monsoon-2003 Workshop was organized in collaboration with the Indian Meteorological Society, Pune Chapter (IMSP) on 29 January, 2004. Dr. G.B. Pant, Director inaugurated the Workshop and released a special issue of "Leeward News"- a newsletter of the IMSP.

Co-Sponsoring of Seminar

The Institute co-sponsored the following events :

- International Seminar on Watershed Development, Department of Geophysics, Andhra University, Visakhapatnam, 16-18 October, 2003.
- National Symposium on Development in Geophysical Sciences in India, Banaras Hindu University, Varanasi, 6-8 November, 2003.
- 40th Annual Convention and Meeting on Recent Advances and Future Strategies in Geoscientific Exploration, Department of Geology, Madras University, Chennai, 16-18 December, 2003.
- Annual Monsoon Workshop – Monsoon 2003, Indian Meteorological Society, Pune Chapter, India Meteorological Department, Pune, 29 January, 2004.

Foundation Day Celebrations

The Institute celebrated its 42nd Foundation Day on 17 November, 2003 at its premises at Pashan. Shri Mohan Dharia, a renowned environmentalist, was the Chief Guest and Prof. V.G. Bhide, Former Vice Chancellor, University of Pune was the Chairman of the function. Dr. Vijay Bhatkar, Chairman, Education to Home (ETH) was the Guest of Honour. The function included presentation of the Excellent Performance Award specially established by the Institute for its Administrative, Technical and Non-Technical Maintenance staff, and Annual Sports Awards to the employees. A book entitled, 'Instrumentation for Atmospheric Boundary Layer Studies' by Shri K.G. Verneker, Deputy Director (Retd.) of this Institute was released at the hands of Dr. Vijay Bhatkar. The lecture on "Renewable energy in this millennium" by Prof. Bhide was also arranged on this occasion. In addition to the main function, an exhibition was arranged on scientific activities of the Institute and important events in the Institute. Heads of various local Institutions, important dignitaries and ex-employees of the Institute participated in the function. The function was concluded by a cultural programme in the evening.

Honours

Dr. G.B. Pant has been elected as a Fellow of the Maharashtra Academy of Sciences and Indian Meteorological Society.

Dr. A.K. Kamra has been elected as a Fellow of the Indian National Science Academy, New Delhi.

Dr. (Smt.) P.S. Salvekar has been nominated as a Member of Subject Experts Committee (Earth and Atmospheric Sciences) for Technical Evaluation of Proposals under the Women Scientists Scheme of the Department of Science and Technology, Government of India, New Delhi.

Dr. K. Krishna Kumar has been nominated as Associate Member by Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy for the period 2003-2008.

Dr. G. Beig acted as a Convener of the Symposium JSA09 entitled, 'Challenges of Global Change in Forcing from Below and Above' during the General Assembly of International Union of Geodesy and Geophysics (IUGG) on 10 July, 2003 at Sapporo, Japan. Dr. Beig has been nominated as a Vice-Chairman of the Joint Working Group of International Association of Geomagnetism and Aeronomy (IAGA), and International Commission for the Middle Atmosphere (ICMA) on Long Term Trends in The Mesosphere, Thermosphere and Ionosphere for the period of four years (2003-2007). He has been re-elected as a Member of the Scientific Steering Committee of the ICMA of IUGG for the period 2003-2007. He was nominated as a Member of International Scientific Program Committee of the 3rd International Workshop on Long Term Changes and Trends in the Atmosphere to be held at Sozopol, Bulgaria during 9-14 June, 2004. He was also nominated as Chairman of the Mesospheric Temperature Trend Assessment (MTTA) panel.

Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. (Smt.) P.S. Salvekar, Shri J.R. Kulkarni, Dr. P.N. Mahajan, Dr. P.S.P. Rao, Dr. G. Beig, Dr. C. Gnanaseelan, Dr. (Smt.) A.A. Kulkarni and Smt. A.A. Deo were bestowed with the title 'Adjunct Professor' of the Department of Physics, University of Pune, Pune for the Academic Year 2003-2004.

Awards

Silver Jubilee Awards

The paper entitled 'ENSO-monsoon relationship in a green-house warming scenario' by R.G. Ashrit, K. Rupa Kumar and K. Krishna Kumar, published in Geophysical Research Letters, Vol. 28, 2001, 1727-1730 and the paper entitled 'Impact of non-local boundary layer diffusion scheme on forecasts over Indian region' by J. Sanjay, P. Mukhopadhyay and S.S. Singh, published in Meteorology and Atmospheric Science, Vol. 80, 2002, 207-216 received the Institute's Annual Silver Jubilee Award for the year 2001 and 2002 respectively. The Awards were presented on 27 February, 2004 at the hands of Prof. T.N. Krishnamurti, Florida State University, USA, on the occasion of the valedictory session of the International Workshop on Role of Indian Ocean in Climate Variability (INDOCLIM) held at the Institute.

Excellent Performance Awards

The Excellent Performance Award for the year 2002 was received by Smt. R.A. Desai, Senior Assistant for Administrative Category, Shri S.P. Gharge, Senior Technical Officer – Gr. II for Technical Category and Shri U.R. Kashid, Office Attendant for the Non-Technical Maintenance Category. The awards were presented on the occasion of the 42nd Foundation Day of the Institute on 17 November, 2003.

Artist of the Year Award

Shri S.G. Purandhare was awarded 'Artist of the Year' for the outstanding performance in photography of Kashmir by the Central Government Employees' Welfare Co-ordination Committee, Pune on the occasion of its 31st Cultural Festival 2004 held on 1 March, 2004.

Inauguration of Ozone Pollution Laboratory

The Ozone Pollution Laboratory, equipped with up to date and highly sensitive analysers to monitor the ambient concentration of ozone (O_3), and several ozone

precursors namely, oxides of nitrogen ($NO+NO_2=NO_x$), Carbon mono-oxide (CO) and Methane-Non-methane Hydrocarbons (CH_4-NMHCs) was inaugurated on 10 October, 2003 at the hands of Shri D.R. Sikka, Former Director, IITM and Chairman, Programme Advisory and Monitoring Committee of the Weather and Climate Research Programme (PAMC-WCRP), Department of Science and Technology, New Delhi. Dr. R.R. Kelkar, Director General of Meteorology and Members of the PAMC-WCRP were also present on the occasion.

Bilateral Programmes

IITM-SAGE

In collaboration with the Centre for Sustainability and Global Environment (SAGE), University of Wisconsin, Madison, USA, the models Integrated Biosphere Simulator (IBIS) and Hydrological Routing Algorithm (HYDRA) have been installed at the Institute. These models help in studying the role of land and vegetation in climate variability.

IITM-IRI

The Institute has signed a Memorandum of Understanding with the International Research Institute for Climate Prediction (IRI), University of Columbia, USA, for collaborative research on problems of mutual interest.

Collaborative Programmes

IITM-SAC

Under the IITM-SAC collaborative project "Atmospheric aerosol loading over land using IRS-P3/P4 data", special observations of columnar atmospheric aerosols, ozone, precipitable water content and concurrent surface level meteorological parameters were carried out along the Pune-Daund-Pune stretch in synchronisation with IRS-P4/1C/1D satellite overhead passes over the region during 16 April, and 14 and 30 May 2003, 25 January, 18 February and 13 March, 2004, employing the multi-channel solar radiometer (MICROTOPS II) and weather monitor. Valuable observations of columnar aerosol optical depth, ozone, precipitable water vapour and near-surface meteorological parameters were carried out. Near-similar MICROTOPS II was also operated at the Institute, representing the urban environment, and obtained the above aerosol optical and pre-cursor gaseous optical depths for comparison with those obtained over the satellite overhead pass regions.

IITM-NMRF

Special observations of atmospheric aerosols, clouds and stability using the multi-filter radiometer, twilight photometer, lidar and MST radar have been carried out at the NMRF, Gadanki during 28 February-10 March, 2003. Simultaneous solar radiation measurements were also carried out using a short wave pyranometer.

IITM-IMD

Dr. O.P. Singh, Director, India Meteorological Department, New Delhi worked at the Institute on climate change problem with Dr. K. Rupa Kumar under the IITM-IMD Collaborative Work Programme.

ARMEX (ARabian Sea Monsoon EXperiment) Programme

Under the Arabian Sea Monsoon Experiment (ARMEX) programme, marine observations of aerosols and their mass size distribution of ion concentrations, the atmospheric electric conductivity and electric field at sea surface over the Arabian Sea were carried out onboard ORV Sagar Kanya since 14 March, 2003.

Aerosol sampling using high volume air sampler over the Arabian Sea onboard ORV Sagar Kanya during ARMEX

ISRO-GBP Land Campaign Programme

Institute scientists participated in an ISRO-GBP-organized Nationwide Road Campaign for studying the atmospheric pollution as a national programme on a research mode. Extensive observations of atmospheric aerosols, trace gases, radiation and meteorological parameters, employing an instrumented mobile vehicle, were carried out along the stretch from Pune to Hyderabad and back over a total of about 20 experimental sites covering different geographical locations and associated with a variety of environments during 10-27 February, 2004. A number of special observational sets during morning and evening periods, and round-the-clock observations of columnar aerosol optical depth, ozone, water vapour, near-surface ozone, Aitken nuclei concentration, aerosol mass-size distribution and NO_x (NO_2 + NO) were collected. The photograph shows one of the experimental sites (Bagalkot), where the column-integrated aerosol optical depth, total column ozone and precipitable water content measurements were carried out using the MICROTOPS II radiometer. Additionally inter-comparison experiments involving different experimental facilities used were conducted at the National Remote Sensing Agency, Shadnagar, Hyderabad during 16-21 February, 2004, in collaboration with other scientific organizations participated in the programme.

Measurements using Microtops-II radiometer at Bagalkot during the Nation wide land campaign programme organised under ISRO-GBP by Department of Space (DOS) during February, 2004

Consultancy

Institute provided guidance in respect of scientific aspects of weather modification experiment conducted by the state governments of Andhra Pradesh, Karnataka and Maharashtra during the monsoon season and post monsoon period of 2003. Shri J.R. Kulkarni participated in a discussion on 'Cloud Seeding' along with Dr. Vasant Gowarikar, Former Vice Chancellor, University of Pune and Shri H.Y. Kolawale, Chief Engineer (Hydrology), Maharashtra State Government. The programme was broadcast by All India Radio, Pune station on 20 September, 2003.

A report on "Heat wave conditions over Andhra Pradesh during May and June, 2003 and causative factors of the severe heat wave conditions" was submitted to a committee constituted by the Govt. of Andhra Pradesh for making an in-depth study for the severity of the heat wave conditions. Dr. G.B. Pant acted as an expert member in the committee.

Special Field Observational Programmes

A field experiment was organized for collection of tree-ring samples around Simla, Kinnour, Kullu-Manali, Chamba and other sites in Himachal Pradesh, and also from different parts of Kerala.

Field programmes were arranged to collect passive samples, dry deposition samples and running aerosol samples at Sinhagad, Pune, under the Indo-Swedish Collaborative Project.

Under the DST sponsored project measurements of TSP, mass size distribution of aerosols, Aitken nuclei, surface NO_X, O_3 and meteorological parameters were made at Darjeeling.

Current Weather Discussions

A forum of Institute scientists has been formed to discuss the current weather. The forum met every Tuesday during 3 June to 30 September, 2003. Scientists made presentations and discussed week-by-week features of Monsoon – 2003. Dr. R.H. Kripalani coordinated this activity.

Science Popularisation Programmes

The Institute celebrated National Science Day on 27 February, 2004 at the Institute's premises in a befitting manner. On this occasion a lecture on 'Monsoon variability' by Dr. (Smt.) S. Gadgil, Indian Institute of Science, Bangalore, was arranged.

The Institute celebrated World Water Day on 22 March, 2004 and the World Meteorological Day on 23 March, 2004 at the Institute's premises. Two lectures viz., "Inter-Linking of Rivers Programme (ILRP) of India in World Context" by Dr. C.D. Thatte, Chairman, International Commission on Large Dams (ICOLD) and Former Secretary General, International Commission on Irrigation and Drainage (ICID) on 22 March, 2004 and "Global Warming Affecting Rainfall Pattern of India: GIS Application in Evaluating Rainfall Spatial Changes" by Dr. Nityananda Singh, from the Institute, on 23 March, 2004, were arranged as part of the World Water Day and World Meteorological Day, respectively. On these occasions an Open-House exhibition highlighting the scientific activities of the Institute was arranged. The Institute was kept open for all to visit its laboratories, computers, and library. A film show of scientific films was also arranged on 23rd March, 2004 for students and general public visiting the Institute, and for the Institute's employees. A large number of students, academicians, and scientists from schools, colleges and universities and general public visited the Institute and observed the Institute's research activities and had interactions with the scientists. The event was also covered by the local news papers.

Vigilance Awareness Week

The Institute observed Vigilance Awareness Week during 3-7 November, 2003. The programme began with the administration of pledge. On this occasion, a lecture on "Citizen's role in good governance" by Shri Arun Bhatia, Retd. I.A.S. Officer was arranged in the Institute on 7 November, 2003. A competition on 'Role of vigilance officer to fight corruption in democratic set-up' was also arranged for the employees of the Institute. The prizes to the winners were given away at the hands of Shri Arun Bhatia.

Armed Forces Flag Day

Armed Forces Flag Day was celebrated on 7 December, 2003.

Health Check up Camp

A General Health Check up Camp for the Institute's Employees and members of their family was arranged in the Institute on 27 and 28 May, 2003 by the Inlaks and Budhrani Hospital, Pune. The camp received very good response.

Computer and Data Archival Facility

Computing Facilities

Most of the projects of the Institute are computer based and realizing this, the Institute has enhanced its computing power by acquiring a number of high end workstations for the computational needs. The present computational facilities available in the Institute are 140 PCs, 16 Servers/Workstations and a few Laptops. All the PCs and Workstations are connected to the Institute's Local Area Network, round the clock high speed Internet connectivity and E-mail facility with web server. The high speed Internet link of 512 KBPS is being used for e-mail, file transfer and browsing by the Institute's employees.

Red Hat Linux based web-server has been set up for the Institute's website which gives brief summary of the Institute and other information including current research activities and events like SERC Schools, Symposia etc. Web pages on various activities of the Institute such as Fellowships, job opportunities, tenders, new research activities, publications etc. have been updated from time to time and linked to Institute's web page. The mail server on Linux platform has also been functioning well.

Software Development

Software maintenance was carried out for applications developed for pay-roll, Income- Tax, GPF and EPF. Income Tax system was modified for Form-16 output. A program was developed for generating reimbursement of tuition fees, TA/ medical claims for directly crediting to Bank for all the employees. Assistance was provided in computerising some of the activities of Purchase and Stores Unit like updating of database for technical items, dead stock items and write-off items. Reports were generated using dBase III.

Trainings organized

A Computer awareness training programme for the Administrative staff of the Institute was conducted during 1-11 July, 2003 on the topics such as Windows XP, Microsoft word, Microsoft excel, UNIX, Internet browsing and e-mail. The training was attended by 19 participants. A training programme in C-programming language was also conducted for the scientists and research fellows of the Institute during 1-16 October, 2003. About 50 participants including scientific staff and research fellows attended the training.

Data Archival

Data sets from NECP reanalyzed monthly/daily 6 hourly and IO SST OLR monthly data were extracted and provided to the users by programming in a suitable format as per the requirements. Data sets of daily radiosonde for September-October, 1998, monthly sub-divisional rainfall 2002 and some missing rainfall data from the available data sets were acquired from the India Meteorological Department.

Under the project, 'Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System', observations for wind and temperature were generated from the wind profiler from May, 2003. Data were processed through offline software to calculate u, v, ws and wd from raw data, and stored on 40 x 6 GB DAT as well as on CDs.

Library, Information and Publications

The Institute has developed a comprehensive Information System in Meteorology and Atmospheric Sciences. The Institute's Library, Information and Publications Division serves as the Information System with the following objectives :

- Collection, organisation and dissemination of information pertinent to the present and anticipated research needs of the Institute.
- Providing technical services like library, documentation, information, publications, drawing, drafting, micrography and photography to scientists of the Institute.
- Providing facilities for the retrieval and use of information resources.
- Preparing, publishing and presenting various scientific research reports and allied material on the activities of the Institute and keeping liaison with other scientific organisations and universities in India and abroad.
- Development of informal resource sharing network with libraries in India and abroad.

The Library has built an information base of about 27,000 publications consisting of books, monographs, back volumes of journals, scientific/technical reports, seminars/symposia proceedings, reprints, abstracts, bibliographies, global meteorological data, geophysical data, maps, atlases, theses etc. and national / international current journals covering a wide range of subjects in Atmospheric Sciences.

During the year, 166 books and reports in Meteorology and allied subjects were added. 92 Periodicals of national/ international origin were subscribed to. Reprints of 63 papers authored by the Institute's scientists were also acquired. Several scientific and technical reports were received from other National and International Organisations on complimentary and exchange basis.

The scientists of the Institute were kept abreast of the latest development in their research areas by rendering Information Dissemination Services on different ongoing research projects of the Institute. Photocopies of the articles of interest were provided to scientists of the Institute and other organisations under the Resource Sharing Services.

The library has been listed in the Directory of Special and Research Libraries in India, World Guide to Libraries and the Union Catalogue of Serials and Periodicals. The Library is also an active member- participant of the Resource Sharing Group and Network of Libraries in Pune Metropolitan area (PUNE-NET). The computerised databases for the collection of books and journals have been made available for retrieval at the workstation of the PUNE-NET at the Bioinformatics Centre, University of Pune. Computerised databases for books, back volumes of journals, reports and other publications have been created.

The Division maintained liaison with Institutions, Universities and Ministries. A number of reports on the research activities and plan schemes of the Institute were prepared and sent to the Department of Science and Technology, India Meteorological Department, Universities and Research Institutes. Various queries on the Institute's activities and facilities were answered through e-mails and letters.

Visits of Students and trainee's to the Institute under their study tour programmes were arranged.

Technical services like photocopying, microfilming, photography, drafting, drawing, printing and binding were provided to the scientists of the Institute.

Programmes for popularisation of meteorology among students and public by organising open day and scientific exhibitions depicting research activities of the Institute on the occasion of important events, such as visit of Scientific Committees, celebration of the National Science Day, World Water Day, World Meteorological Day, Institute's Foundation Day, etc. were arranged.

Management

The Institute functions as an autonomous organisation under the Department of Science and Technology (DST), Government of India. The management of the Institute vests with its Governing Council at the apex level. The Governing Council is constituted by the DST every two years and consists of five ex-officio members and four scientist members. The scientist members are nominated by the DST. The Director General of Meteorology is the Ex-officio Chairman of the Council. The Governing Council held its meetings at the Institute on 19 July, 2003 and 26 December, 2003. The Institute maintains close collaboration and interaction with other organisations working in the field of Meteorology, particularly with the India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), Indian Space Research Organisation (ISRO), Indian Institutes of Technology, Universities and other scientific organisations associated with the research work in Atmospheric and Oceanic Sciences.

Administration

The Administration provides support for the personnel management, finance, purchase, stores, capital works and maintenance of buildings and campus.

Personnel Profile

As on 31 March, 2004 the Institute had its staff under different categories as shown below:

Research I	79
Research I- A	45
Technical	33
Administrative	47
Non-Technical Maintenance	43
Total	**247**

Staff changes

Seventeen employees under different categories left the Institute during the year as shown below:

Retirement on Superannuation

Shri R.M. Soni Senior Draughtsman	31 May, 2003
Shri R.D. Salunke Mechanical Assistant	31 May, 2003
Smt. L. George Scientist C	30 June, 2003
Dr. S.S. Singh Scientist E	31 July, 2003
Shri C.P. Kulkarni Scientist C	31 July, 2003
Dr. S.S. Parasnis Scientist E	31 October, 2003
Shri A.B. Sathe Scientist C	31 January, 2004
Dr. J.M. Pathan Scientist C	31 January, 2004
Shri C.H. Khan Laboratory Assistant	28 February, 2004
Shri D. Bhattacharya Senior Technical Officer Gr. I	31 March, 2004

Voluntary Retirement

Smt. R.P. Bhagwat Section Officer	1 April, 2003
Shri A.P. Chavan Watchman	11 May, 2003
Shri P.S. Chavan Watchman	27 October, 2003
Shri L.S. Khandave Office Assistant	1 January, 2004
Dr. (Smt.) S.S. Dhanorkar Scientist E	3 February, 2004

Smt. M.S. Jadhar, Technical Assistant resigned on 12 June, 2003 and Service of Shri I.S. Kolekar, Gardener was terminated on 10 May, 2003.

Status of SC / ST / OBC Reservations

The status of filled positions for SC/ ST/ OBC was as follows :

	SC	ST	OBC	Total
Research I	10	3	2	15
Research I-A	8	5	5	18
Scientific	-	-	-	-
Technical	6	1	1	8
Administrative	6	6	-	12
Non-Technical Maintenance	12	2	2	16
Total	**42**	**17**	**10**	**69**

Employment of Ex-servicemen

Reservation for the ex-servicemen was made at 10% in Group 'C' and 'D' posts of the Institute. The percentage of ex-servicemen at the Institute vis-a-vis total number of employees in Group 'D' was 2.3%.

Staff Council

The Staff Council is an elected body representing employees of the Institute in different categories and acts as a forum for discussion on matters of common interest to the employees and for increasing efficiency. During the year four meetings of the Staff Council were held.

Academic Council

The Academic Council is a body consisting of scientists in the grade of Scientist-D and above. It considers all the matters relating to scientific projects of the Institute and ensures team work and team spirit in the Institute for achieving its aims and objectives. Four meetings of the council were held during the year.

Advisory Committee

The Advisory Committee consisting of the Heads of the Divisions considers policy matters of the Institute. During the year five meetings of the Committee were held.

Finance

The Finance Committee of the Institute constituted by Governing Council met on 12 September, 2003.

Budget

The main funding agency for the Institute is the Department of Science and Technology. The budget estimates and the actual expenditure for the period 2003-2004 are as follows:

(Rs. in Lakhs)

	Grant Received	Actual Expenditure
• **Plan**	**618.00**	**489.00**
• **Non-Plan**	**324.00**	**324.00**
• **Sponsored Projects**	**327.00**	**212.62**
Total	**1269.00**	**1025.62**

The Auditors, appointed by the Governing Council, M/s M.S. Godbole and Associates, Chartered Accountants, Pune conducted the audit for the year 2003-2004. The abstract of the report is enclosed at the end of this report.

Purchase and Stores

The Institute acquired scientific equipment and accessories, data acquisition and storage systems, personal computers, work stations, enhancing systems and accessories to the existing computer systems, and office furniture items.

During the period the following purchases were made:

- Equipment : Rs. 208.50 lakhs
- Dead Stock : Rs. 8.61 lakhs
- Consumables : Rs. 7.72 lakhs

Official Language Implementation

Hindi Cell works under the Administrative Wing of the Institute as per rules and directives regarding Official Language Implementation. All general circulars and office orders were issued in bilingual format. With the guidance of Official Language Implementation Committee, Hindi Cell looks after Hindi translation and arranging Hindi Training for officers and employees in different cadres. Four employees were nominated for "Prabodh" and "Pragnya" course held by Hindi Teaching Scheme during the year. All the four candidates successfully completed the course.

In addition to the regular use in administrative work, the use of Hindi is being promoted in scientific work. Scientists of the Institute presented their scientific work in Hindi at various seminars and workshops. They also attended the seminars/ workshops held in Hindi.

The Institute celebrated Hindi Week during 15-19 September, 2003. On this occasion, competitions in Hindi were organised. Dr. Durgadutt Oza from Jodhpur was the Chief Guest. The prizes to the winners of the competitions were given away by the Chief Guest. Dr. G. B. Pant, Director of the Institute presided over the function.

IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to its members, which include the employees, research assistants, research scholars and project personnel of the Institute.

The Club awarded prizes to the children of the Institute employees who had exhibited excellent performance in S.S.C., H.S.C., Diploma, Graduation, Post-Graduation and other qualifying Examinations held in the Academic Year 2002-2003 under different disciplines. Prizes were also given to the Institute's employees who acquired higher academic qualifications during the year.

A few lectures by the eminent personalities were arranged during the year. Annual Sports Tournaments were conducted. The Institute's employees participated in various tournaments organised by the Central Government Employees Welfare Co-ordination Committee, Pune and won prizes and honours. They were felicitated on the occasion of the Institute's 42nd Foundation Day Celebration held on 17th November, 2003. The club organised cultural programme of children of the Institute employees and of a few professional artists on the occasion of the Institute's Foundation Day. The Recreation Club arranged coaching for cricket and football for the children of the Institute employees.

Garden Committee

The horticulture activities of the Institute were on full swing throughout the year. Garden Committee gave emphasis to beautification and development of the garden. Special consideration was given to maintaining ecological balance and scenic integrity of the campus by planting various plants and trees. The exotic plant grown during each season shows off their colours and is a feast to the eyes of the employees as well as visitors to the Institute. People are happy to see the uniqueness and majesty of the premises. The vibrant ambience created by the large greenery to concrete ratio is rejuvenating to everyone in the campus. The Garden Committee organised special Tree Plantation Programmes by the Institute's employees on Independence Day and by the significant dignitaries on the occasion of Institute's Foundation Day celebration, INDOCLIM Workshop and International Women's Day celebration.

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Publications

Papers Published in Journals

Numerical Weather Prediction Research and Mesoscale Modelling

Krishnamurti T.N. and **Sanjay J.**, New approach to the Cumulus parameterization issue, Tellus, 55A, 2003, 275-300.

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Mukhopadhyay P., Sanjay J. and **Singh S. S.**, Objective forecast of thundery/ non-thundery days using conventional indices over three north-east Indian stations, Mausam, 54, 2003, 867-880.

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Bansod S.D., Yin Z., Lin Z.Y. and Zhang X., Thermal field over Tibetan plateau and Indian summer monsoon rainfall, International Journal of Climatology, 23, 2003, 1589-1605.

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Kakade S.B. and **Dugam S.S.**, North Atlantic oscillation and warming/cooling of equatorial Pacific Ocean, Vatavaran, 25, 2001, 45-54.

Kripalani R.H., Kulkarni A.A., Sabade S.S. and **Khandekar M.L.**, Indian monsoon variability in a global warming scenario, Natural Hazards, 29, 2003, 189-206.

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Bhide U.V., Puranik P.V., Mujumdar V.R., Kulkarni A.A. and **Kripalani R.H.**, Development of monsoon breaks due to heat source over northwest India, Mausam, 54, 2003, 377-384.

Ghanekar S.P., Mujumdar V.R., Seetaramayya P. and **Bhide U.V.**, Ocean– atmosphere interaction and synoptic weather conditions in association with the two contrasting phases of monsoon during BOBMEX–1999, Proc. Indian Academy of Sciences (Earth and Planetary Sciences), 112, 2003, 283-293.

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Narkhedkar S.G., Mahajan P.N., Khaladkar S.G., Nair S., Joshi P.C. and Pal P.K., Orissa super cyclone of October, 1999 as revealed by IRS-P4 satellite data, Indian Journal of Radio and Space Physics, 33, 2004, 35-42.

Narkhedkar S.G., Mahakur M., Sinha S.K. and **Mahajan P.N.**, Impact of satellite data on the Objective Analysis of wind field, Journal of Indian Geophysical Union, 7, 2003, 71-85.

Sinha, S.K., Narkhedkar S.G., Mahakur M. and **Mahajan P.N.**, Meteorological objective analysis using three dimensional numerical variational technique, Atmosfera, 16, 2003, 173-191.

Sinha S.K., Narkhedkar S.G., Talwalkar D.R. and **Mahajan P.N.**, Cumulative semivariogram technique for objective analysis of height field over India and adjoining region, Journal of Indian Geophysical Union, 7, 2003, 87-95.

Talwalkar D.R., Sinha S.K., Narkhedkar S.G., Nair S. and **Mahajan P.N.**, On some aspects of objective analysis using SATEM height data by optimum interpolation method, Vatavaran, 27, 2003, 1-10.

Regional Aspects of Global Climate Change and Variability

Ashrit R.G., Douville H. and **Rupa Kumar K.**, Response of the Indian monsoon and ENSO-monsoon teleconnection in enhanced greenhouse effect in the NRM coupled model, Journal of Meteorological Society of Japan, 8, 2003, 779-803.

Hydrometeorological Studies of River Basins for Applications in Water and Power Resource Projects

Deshpande N.R., Nandargi S.S. and **Dhar O.N.**, Some characteristic features of hourly rainfall over the Upper Krishna basin in Maharashtra, Indian Journal of Power and River Valley Development, 53, 2003, 47-53, 62.

Kulkarni B.D. and **Mulye S.S.**, Estimation of maximum one-day rainfall for different return periods for the Godavari basin, Indian Journal of Power and River Valley Development, 53, 2003, 117-123.

Kulkarni B.D., Mulye S.S. and **Mandal B.N.**, Brief appraisal of water potential of the Wainganga catchment for the optimum development of its water resources, Indian Journal of Power and River Valley Development, 53, 2003, 101-108.

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Tiwari S., Momin G.A., Rao P.S.P., Safai P.D., Ali K. and **Chate D.M.,** Contribution of alkaline and acidic sources to precipitation rainfall at Delhi, National Conference on Advances in Environmental Science and Engineering, Indian Institute of Technology, Mumbai, 8-9 December, 2003.

Trivedi D.K., Impact of cumulus parameterization on simulation of super cyclonic storm of Orissa (1999), International Symposium on Natural Hazards (INTROMET-2004), Hyderabad, 24-27 February, 2004.

Trivedi, D.K., Numerical simulation of super cyclonic storm of Orissa (1999) with vortex initialization, National Symposium on Development in Geophysical Sciences in India, Banaras Hindu University, Varanasi, 6-8 November, 2003.

Vaid B.H., Gnanaseelan C., Chowdary J.S. and **Salvekar P.S.**, Interannual variability in the TOPEX/POSEIDON sea surface height anomalies over Indian Ocean, IX Raman Memorial Conference, University of Pune, Pune, 26-27 February, 2004.

Vaid B.H., Gnanaseelan C., Mishra A.K. and **Salvekar P.S.**, Rossby waves in Indian Ocean, 12th National Scientific Hindi Workshop, Department of Ocean Development, New Delhi, 24 November, 2003.

Vaid B.H., Gnanaseelan C., Polito P. and **Salvekar P.S.**, Interannual variability of mesoscale eddies in the Arabian Sea, International Workshop on Role of Indian Ocean in Climate Variability over India, Indian Institute of Tropical Meteorology, Pune, 23-27 February, 2004.

Vaidya V.V. and **Devara P.C.S.**, Direct radiative forcing due to aerosols in ultraviolet, visible and infrared spectral regions, General Assembly of International Union of Geodesy and Geophysics (IUGG – 2003), Sapporo, Japan, 3-14 July, 2003.

Vijayakumar R., Past cloud seeding experiment in India with special emphasis on Pune experiments, Weather Modification Workshop, National Institute of Advanced Studies, Indian Institute of Science, Bangalore, 15 October, 2003.

Vinaykumar, Indian monsoon drought of 2002: diagnostic analysis and GCM simulations, International Conference on Scale Interaction and Variability of Monsoon, Munnar, Kochi, 6-10 October, 2003.

Yadav R.K., Rajeevan M., **Rupa Kumar K.** and **Munot A.A.**, Predictive relationships between south Indian Ocean sea surface temperatures and north-west India winter precipitation, International Workshop on Role of Indian Ocean in Climate Variability over India (INDOCLIM), Indian Institute of Tropical Meteorology, Pune, 23-27 February, 2004.

PAPERS PUBLISHED		
Journals	:	**69**
Proceedings, Books, Reports etc.	:	**39**
PAPERS PRESENTED	:	**155**

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Participation in Symposia, Seminars etc.

Eighth WMO Scientific Conference on Weather Modification, Casablanca, Morocco, 7-12 April, 2003
(Dr. A.K. Kamra)

21st Annual Convention and Conference of Society for Information Science on New Challenges in Information Management and E-learning in the Age of Globalisation, Issues and Opportunities, Indian Institute of Technology, Roorkee, 9-11 April, 2003
(Smt. A.A. Shiralkar)

42nd Meeting of PAC-AS and Group Monitoring Workshop and a Brain Storming Session on Thunderstorms, Indian Institute of Technology, Kharagpur, 16-18 April, 2003
(Dr. A.K. Kamra)

Scientific Coordination Meeting of the Indo-UK Project on Climate Change Impacts, New Delhi, 21 April, 2003
(Dr. K. Rupa Kumar)

National Level Brain Storming Meet on Specific Compaigns Related to Aerosols, Minor Constituents and Radiation, Department of Space, Indian Space Research Organisation, Bangalore, 22 April, 2003
(Dr. A.K. Kamra, Dr. P.C.S. Devara)

Advance Level Training Programme on Web Designing and Data Base Management, Centre for Environment Education (CEE), Pune, 22-25 April, 2003
(Shri M. M. Kokate, Kum. S. Oommen)

Third Conference on Maharashtra State Federation of Education Laboratory Staff Organization, Satara, 24 April, 2003
(Dr. D.B. Jadhav)

22nd Spring Conference of the Korean Meteorological Society, Kyungpok National University, Taegu, South Korea, 25-26 April, 2003
(Dr. N. Singh)

The APEX-RIHN International Workshop on Atmospheric Aerosols and Clouds, Awaji, Japan, 25-27 June, 2003
(Dr. P.C.S. Devara, Dr. G. Pandithurai)

General Assembly of International Union of Geodesy and Geophysics (IUGG–2003), Sapporo, Japan, 3 – 14 July, 2003
(Dr. P.C.S. Devara, Dr. G. Beig, Dr. G. Pandithurai)

Gordon Research Conference on Solar Radiation and Climate, Cathy Sawyer College, New Hampshire, USA, 13 – 18 July, 2003
(Dr. R. S. Maheskumar)

Two-day Workshop on MOM-4 Users and Ocean Modelling Group Meeting, CMMACS, Bangalore, 21 – 22 July, 2003
(Dr. R. Krishnan)

NATCOM – V&A Workshop on Scenarios and Future Emissions, Indian Institute of Management, Ahmedabad, 22 July, 2003
(Dr. K. Krishna Kumar, Shri V. Prasanna, Kum. Kamala)

European Aerosol Conference (EAC-2003), Facultad de Medicina, Universidad Compluteine de Madrid, Madrid, Spain, 31 August - 5 September, 2003
(Shri S. Saha)

National Hindi Workshop on Ocean Services, Indian National Centre for Ocean Information Services, Hyderabad, 1 September, 2003
(Shri A.K. Mishra)

Seminar on Silicon Graphics Technology Tour, Hotel Blue Diamond, Pune, 10 September, 2003
(Smt. S.U. Athale, Shri. O. Abraham, Smt. V.V. Sapre)

6th International Symposium on Tropospheric Profiling Needs and Technologies (ISTP-2003), University of Leipzig, Leipzig, Germany, 14 – 20 September, 2003
(Dr. P.C.S. Devara)

International Conference on Earth System Modelling, Max Planck Institute for Meteorology, University of Hamburg, Hamburg, Germany, 15–19 September, 2003
(Shri S.M. Sonbawane)

Workshop / Brainstorming Meeting of Climate and Weather of the Sun – Earth System (CAWSES), Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, 29-30 September, 2003
(Dr. G.B. Pant, Dr. R. Krishnan, Dr. G. Beig)

International Conference on Scale Interaction and Variability of Monsoon (SIVOM), Munnar, Kochi, 6-10 October, 2003
(Dr. R. Krishnan, Smt. S.S. Desai, Shri Vinaykumar)

Weather Modification Workshop, National Institute of Advanced Studies, Indian Institute of Science, Bangalore, 15 October, 2003
(Dr. R. Vijayakumar, Shri J.R. Kulkarni, Shri K.K. Dani)

International Seminar on Watershed Development, Department of Geophysics, Andhra University, Visakhapatnam, 16-18 October, 2003
(Dr. B.D. Kulkarni, Shri S.S. Mulye)

National Seminar on Antarctic Geoscience Ocean Atmosphere Interaction and Palaeoclimatology, National Centre for Antarctica and Ocean Research, Goa, 2-5 November, 2003
(Dr. G.B. Pant)

National Symposium on Development in Geophysical Sciences in India, Banaras Hindu University, Varanasi, 6-8 November, 2003
(Dr. P.N. Mahajan, Dr. A.L. Londhe, Dr. A.A. Munot, Dr. B.D. Kulkarni, Shri S.S. Dugam, Shri Prem Singh, Shri S.D. Bansod, Shri N.K. Agarwal, Shri S. Mahapatra, Shri R.M. Khaladkar, Shri S.K. Jadhav, Shri D.K. Trivedi, Shri D.R. Kothawale, Shri G.S. Meena, Shri S.B. Kakade, Shri Somaru Ram, Shri A.K. Mishra, Shri U.K. Singh)

Training cum Performance Evaluation Workshop, ENVIS Secretariat of the Ministry of Environment and Forest, Bhubaneshwar, 6 – 8 November, 2003
(Dr. G. Beig)

INDO-US Workshop on Modelling the Transport of Pollutants, National Environmental Engineering Research Institute (NEERI), Nagpur, 11-13 November, 2003
(Dr. G. Beig)

First ARGO Science Workshop, Tokyo, Japan, 12-14 November, 2003
(Dr. R. Krishnan)

XII National Scientific Hindi Workshop, Department of Ocean Development, New Delhi, 24 November, 2003
(Shri B.H. Vaid)

Group Monitoring Workshop – 2003 (GMW-2003) on Weather and Climate Research Programme, Jadavpur University, Kolkata, 8-9 December, 2003
(Dr. G.B. Pant, Dr. P.C.S. Devara, Dr. N. Singh, Dr. R.H. Kripalani, Smt. S.S. Vaidya, Dr. G. Beig, Dr. P.S.P. Rao, Shri S.S. Dugam, Shri S.M. Bawiskar, Dr. C. Gnanaseelan)

Annual Convention Meet of Computer Society of India, New Delhi, 9-11 December, 2003
(Shri O. Abraham)

International Conference on Water and Environment–2003, Regional Research Laboratory of CSIR, Bhopal, 15-18 December, 2003
(Shri B.N. Mandal, Dr. B.D. Kulkarni, Smt. N.R. Deshpande, Shri S. Bhandare)

40th Annual Convention and Meeting on Recent Advances and Future Strategies in Geoscientific Exploration, Madras University, Chennai, 16-18 December, 2003
(Dr. D.K. Singh, Shri G.R. Chinthalu)

Brain Storming Session on Meso-scale System and Modelling, Indian Institute of Tropical Meteorology, Pune, 20 December, 2003

(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. R. Krishnan, Shri P. Seetaramayya, Smt. S.S. Vaidya, Dr. A.K. Sahai, Shri S. Mahapatra, Shri J. Sanjay, Shri D.K. Trivedi, Shri P. Mukhopadhyay, Shri U.K. Singh)

ARMEX Workshop on Data Analysis and Initial Scientific Results, National Institute of Ocean Technology, Chennai, 22-23 December, 2003
(Dr. A.K. Kamra, Dr. S. Sivaramakrishnan, Dr. P.S.P. Rao, Dr. (Smt.) S.B. Morwal, Shri T. Dharmaraj, Dr. M.N. Patil, Dr. C. Gnanaseelan, Shri G.R. Chinthalu, Shri V. Gopalkrishnan, Shri P. Murugvel, Dr. D.K. Singh, Kum. C. Sukumaran, Kum. T. Rajita Madhu Priya, Shri A.K. Mishra)

National Conference on Hydraulics and Water Resources – HYDRO-2003, Central Water and Power Research Station, Pune, 26-27 December, 2003
(Dr. C. Gnanaseelan)

Brain Storming Session on Ocean-IGBP Projects of Surface Ocean-Lower Atmosphere Study (SOLAS) and Integrated Marine Biogeochemistry and Ecosystems Research (IMBER), National Chemical Laboratory Pune 28-29 December, 2003
(Dr. A.K. Kamra, Dr. P.C.S. Devara)

91st session of the Indian Science Congress, Punjab University, Chandigarh, 3-7 January, 2004
(Dr. K. Rupa Kumar)

Sixth Training Programme on Applications of RS-GIS Techniques in Water Resources Development and Management, National Water Academy (NWA), Pune, 6-16 January, 2004.
(Smt. N.R. Deshpande,Dr. (Kum.) S.S. Nandargi)

Fourth Winter School on Indian MST Radar, National MST Radar Facility, Gadanki, Tirupati, 21-30 January, 2004.
(Dr. Y. Jaya Rao, Shri S.M. Sonbawne and Shri A.K. Shrivastava)

Seminar on Natural Disasters and Catastrophic Losses, National Insurance Academy, Pune, 23-24 January, 2004
(Dr. P.N. Mahajan)

Annual Monsoon Workshop – Monsoon 2003, Indian Meteorological Society, Pune Chapter, India Meteorological Department, Pune, 29 January, 2004
(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. (Smt.) P.S. Salvekar, Dr. R.H. Kripalani, Dr. A.K. Sahai)

Workshop on Atmospheric Brown Cloud, Tata Energy Research Institute, New Delhi, 2-3 February, 2004
(Dr. R. Krishnan)

MODIS Data Utilization Workshop, National Remote Sensing Agency, Hyderabad, 11-12 February, 2004
(Dr. P.N. Mahajan, Kum. R. Bhawar)

International Asian Monsoon Symposium, Honolulu, Hawaii, U.S.A., 16-24 February, 2004
(Dr. R.H. Kripalani)

National Space Science Symposium (NSSS-2004), Mahatma Gandhi University, Kottayam, 17-20 February, 2004
(Dr. (Smt.) I. Joshi, Dr. A.L. Londhe, Shri S.S. Dugam, Smt. S.S. Naik, Shri A. K. Shrivastava, Shri S. Gunthe, Shri B. Thompson)

International Workshop on Role of Indian Ocean in Climate Variability over India (INDOCLIM), Indian Institute of Tropical Meteorology, Pune, 23-27 February, 2004
(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. (Smt.) P.S. Salvekar, Shri. S. Sinha, Dr. R. Vijayakumar, Dr. S. Sivaramakrishnan, Dr. R. Krishnan, Dr. P. Seetaramayya, Dr. P.N. Mahajan, Dr. R.H. Kripalani, Dr. G. Beig, Dr. A.K. Sahai, Dr. K. Krishnakumar, Smt. U.V. Bhide, Dr. Smt. S.G. Nagar, Dr. A.A. Munot, DR. H.P. Borgaonkar, (Smt.) S.K. Patwardhan, Shri S.S. Dugam, Shri. V. Gopalkrishnan, Dr. C. Gnanaseelan, Smt. S.K. Mandke, Dr. (Smt.) A.A. Kulkarni, Shri S.K. Jadhav, Smt. A.A. Deo,

Shri D.R. Kothawale, Shri. S.D. Patil, Shri S.B. Kakade, Shri. S.P. Ghanekar, Shri. D.W. Ganer, Smt. S.R. Inamdar, Shri. P. Mukhopadhyay, Smt. J.V. Revdekar, Shri. J.S. Chowdary, Shri. P.R.C. Reddy, Shri. P.K. Shrivastava, Shri. B.H. Vaid, Shri. R.K. Yadav

International Symposium on Natural Hazards – INTROMET-2004, Hyderabad, 24-27 February, 2004
(Dr. G.B. Pant, Shri V.R. Mujumdar, Shri D.K. Trivedi)

IX Raman Memorial Conference, University of Pune, Pune, 26-27 February, 2004
(Dr. (Smt.) P.S. Salvekar, Shri B.H. Vaid, Kum. R. Deepa)

Hindi Workshop, National Institute of Virology, Pune, 26-27 February, 2004
(Dr. K. Ali)

Workshop on Adaptation to Climate Change in Mountain Ecosystem: Bridging Research and Policy, Kathmandu, Nepal, 3-5 March, 2004.
(Dr. A.K. Sahai)

National Workshop on Extended Range Monsoon Prediction (ERMP), Space Applications Centre, Ahmedabad, 16-17 March, 2004
(Dr. G.B. Pant, Dr. K. Rupa Kumar, Dr. A.K. Sahai)

International Conference on High-Impact Weather and Climate: Understanding, Prediction and Socio-economic Consequences (ICHWC-2004), Seoul, South Korea, 20-28 March, 2004
(Dr. R.H. Kripalani)

Workshop on Tropical Atmospheric Chemistry and Aerosols, Physical Research Laboratory, Ahmedabad, 25-26 March, 2004
(Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. R. Krishnan, Dr. G. Beig)

National Workshop on India's Initial National Communication (NATCOM) to United Nations Framework Convention on Climate Change, India Habitat Centre, New Delhi, 26 March, 2004
(Dr. G.B. Pant)

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Participation in Meetings

Dr. G.B. Pant

- CLIMSAT Meeting, ISRO Headquarters, Indian Space Research Organisation, Bangalore, 22 July, 2003.
- Meeting of the State Level Committee for making an In-depth Study for the Severity of Heat Wave Conditions Prevailed in the State of Andhra Pradesh, Hyderabad, 26 July, 2003.
- Working Group Meeting for Technical Discussions, Department of Science and Technology, New Delhi, 1 August, 2003.
- Scientific Advisory Committee Meeting of the Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, 11-12 August, 2003.
- Review Meeting of the Meteorology and Oceanography Programme of ISRO/DOS, Space Applications Centre, Ahmedabad, 18 August, 2003.
- 57th Meeting of Council for Meteorology and Atmospheric Sciences (CMAS), Mausam Bhavan, New Delhi, 19 August, 2003.
- Meeting convened by the Irrigation Department, Maharashtra State, on Cloud Seeding Experiments in Drought Areas of Maharashtra, Mantralaya, Mumbai, 13 and 22 August, 2003.
- Third Meeting of the Programme Advisory and Monitoring Committee (PAMC) on Himalayan Glaciology, Indian Institute of Technology, Mumbai, 22-23 August, 2003.
- 4th Meeting of the PAMC on Weather and Climate Research Programme, National Centre for Antarctic and Ocean Research, Goa, 26-27 August, 2003.
- Meeting for the Establishment of an International Centre for S & T Capacity Building in Climate Change for Developing Countries, Department of Science and Technology, New Delhi, 9 September, 2003.
- Selection Committee Meeting for the Selection of Scientist D, Centre for Wind Energy Technology, Chennai, 17 September, 2003.
- ISRO – Climate Mission Meeting, India Meteorological Department, New Delhi, 19 September, 2003.
- Meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects, Indian Institute of Tropical Meteorology, Pune, 13 October, 2003.
- INDO-US Meeting, National Centre for Medium Range Weather Forecasting, New Delhi, 10 November, 2003.
- Joint CLIVAR/PAGES/IPCC Meeting on Drought, University of Arizona, Tucson, U.S.A., 18-21 November, 2003.
- DST Expert Committee Meeting, Bose Institute, Darjeeling, 6 December, 2003.
- 5th Meeting of the PAMC on Weather and Climate Research Programme, Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, 30 January, 2004.
- Status Meeting of ISRO-GBP Project on Monsoon Variability Studies with Regional Climate Models using Satellite derived Surface Parameters, Space Application Center, Ahmedabad, 14 February, 2004.

Dr. A.K. Kamra

- 42nd and 43rd Meetings of the Programme Advisory Committee on Atmospheric Sciences of the DST, Indian Institute of Technology, Kharagpur, 16-18 April, 2003 and Tirupati, 10-11 November, 2003 respectively.
- Screening Committee Meeting, Indian Institute of Geomagnetism, New Mumbai, 22 August, 2003.
- Meeting on Pilot Cruise to Southern Ocean on board ORV Sagar Kanya, National Centre for Antarctic and Ocean Research, Goa, 26 August, 2003.
- Meeting on Cloud-bursts and Land-slides, Department of Science and Technology, New Delhi, 1 October, 2003.

- Meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects, Indian Institute of Tropical Meteorology, Pune, 13 October, 2003.
- ISRO-GBP Planning Meeting for Road Experiment, Physical Research Laboratory, Ahmedabad, 29 October, 2003.
- 69th Meeting of the Indian Academy of Sciences, Guwahati, 21-23 November, 2003.
- 69th Annual General meeting of the Indian National Science Academy, National Chemical Laboratory, Pune, 27 and 28 December, 2003.
- Meeting on SOLAS IMBER of IGBP, National Chemical Laboratory, Pune, 28-29 December, 2003.
- WG-IGBP Meeting of ISRO on Atmospheric Chemistry, Aerosols and Global Change, ISRO HQ, 7 – 10 January, 2004.
- PAMC Meeting on Himalayan Glaciology Programme of DST, Indian Institute of Tropical Meteorology, Pune, 28 January, 2004.
- Meeting on Land Campaign for ISRO-GBP Programme, Physical Research Laboratory, Ahmedabad, 24 March 2004.

Dr. P.C.S. Devara

- Meeting of the Executive Committee, ICCP, Sapporo, Japan, 1 July, 2003.
- Meeting on Atmospheric Brown Cloud (ABC), Sapporo, Japan, 2 July, 2003.
- Selection Committee Meeting for the appointment of a Project Assistant for a research project in the School of Environmental Sciences, University of Pune, Pune, 17 July, 2003.
- High-power Committee Meeting on Proposed Cloud Seeding Operations in Ananthapur District by the Andhra Pradesh Government, A.P. State Government Secretariat Office, Hyderabad, 14 August, 2003.
- Management Committee Meeting of IASTA, Bhabha Atomic Research Centre, Mumbai, 25 September, 2003 and 11 March, 2004.
- 2nd Advisory Committee Meeting on Wind Profiler and Radio Acoustic Sounding System (WP-RASS), Indian Institute of Tropical Meteorology, Pune, 10 October, 2003.
- ISRO-GBP Meeting on Road Campaign Measurements of Aerosols and Gases, Physical Research Laboratory, Ahmedabad, 29 October, 2003 and 24 March, 2004.
- Meeting of the Instrument Society of India, Pune Chapter (ISOI-P), Pune Institute of Engineering and Technology, Pune, 26 March, 2004.

Dr. D.B. Jadhav

- Selection Committee Meeting for the appointment of a Project Assistant for a research project in the School of Environmental Sciences, University of Pune, Pune, 17 July, 2003.
- Meeting of the Instrument Society of India, Pune Chapter (ISOI-P), Pune Institute of Engineering and Technology, Pune, 26 March 2004.

Dr. K. Rupa Kumar

- The Scientific Coordination Meeting of the Indo-UK Project on Climate Change Impacts, Environmental Resources Management (ERM), New Delhi, 21 April, 2003.
- Meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects, Indian Institute of Tropical Meteorology, Pune, 13 October, 2003.
- Review Meeting of the Indo-UK Projects, New Delhi, 5 February, 2004.

Dr. R. Vijayakumar

- Meeting on Cloud Seeding Operation in Karnataka State on project mode/ experimental basis, Bangalore, 23 May, 2003.
- Meeting in connection with proposed cloud seeding operations over Maharashtra, Mantralaya, Mumbai, 13 August, 2003.
- First Meeting of the Monitoring Committee on Aerial Cloud Seeding Operations in Anantapur District - Andhra Pradesh, Hyderabad, 15 September, 2003.

- Second Meeting of the Seeding Aircraft Modification Committee, SWDC Building, Ananda Rao Circle, Bangalore, 19 September, 2003.
- Third and Fourth Meetings of Cloud Seeding Monitoring Committee of Karnataka, Vidhan Soudha, Bangalore, 19 and 30 September, 2003.
- Meeting to review the cloud seeding activity in the three districts viz., Cuddapah, Chittor and Anantpur, Andhra Pradesh State Government Secretariat Office, Hyderabad, 10 November, 2003.
- Meeting of Drought Monitoring Cell of Government of Karnataka, Bangalore, 18 November, 2003.
- Meeting convened by Minister of Major Irrigation, for Future Course of Action for Cloud Seeding, Bangalore, 19 November, 2003.
- Final Meeting of Cloud Seeding Monitoring Committee of Karnataka, Vidhan Soudha, Bangalore, 21 November, 2003.

Dr. N. Singh

- Meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects, Indian Institute of Tropical Meteorology, Pune, 13 October, 2003.

Dr. R. Krishnan

- Meeting of the Peer-review Committee of the C-MMACS project proposal entitled, 'Integrated multi-scale forecast for the monsoon region', Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore, 5 May 2003.
- INDOMOD/DOD Meeting, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, 21 April, 2003.

Dr. P.N. Mahajan

- Selection Committee Meeting for the Recruitment of Junior Research Fellow, University of Pune, Pune, 12 May, 2003.
- First Meeting of Expert Committee to Review INSAT-3D Sounder, Space Applications Centre, Ahmedabad, 15 December, 2003.
- Second Meeting of Expert Committee to Review INSAT-3D Sounder, Space Applications Centre, Ahmedabad, 31 March, 2004.

Shri J.R. Kulkarni

- Meeting on Extended Range Prediction, Ministry of Agriculture, New Delhi, 27-28 November, 2003.
- THORPEX Meeting, National Centre for Medium Range Weather Forecasting, New Delhi, 1-4 February, 2004.

Smt. S.S. Vaidya

- Steering Committee Meeting of CSIR projects, National Aerospace Laboratory, Bangalore, 23 August, 2003.

Dr. R.H. Kripalani

- Annual Monsoon Review Meeting, India Meteorological Department, Kolkata, 18-20 January, 2004.

Shri. B.N. Mandal

- Meeting on Water Resources Conservation, Rainfall, Water Management vis-à-vis Meteorological Aspects, Indian Institute of Tropical Meteorology, Pune, 13 October, 2003.

Shri B.N. Mandal, Smt. N.R. Deshpande, Dr. B.D. Kulkarni, Shri R.B. Sangam, Shri S.S. Mulye, Dr. (Kum.) S.S. Nandargi

- Meeting regarding data requirement for the NTPC sponsored project on 'Estimation of SPS and PMP at Loharinag Pala and Tapovan Vishnugad', Central Water and Power Research Station, Pune, 24 July, 2003.

Dr. K. Krishna Kumar

- The Scientific Coordination Meeting of the Indo-UK Project on Climate Change Impacts, Environmental Resources Management (ERM), New Delhi, 21 April, 2003.

Dr. G. Beig

- Meeting of the Working Group on Long Term Trends in the Mesosphere, Thermosphere and Ionosphere, IUGG-2003, Sapporo, Japan, 7 July, 2003.
- Advisory Committee Meeting of International Commission for Middle Atmosphere (ICMA), IUGG-2003, Sapporo, Japan, 8 July, 2003.
- 1st and 2nd Meetings of the Technical Evaluation Committee for Procurement of Instruments for Monitoring GHGs, India Meteorological Department, New Delhi, 29 January, and 14 February, 2004.
- 1st Meeting of the Technical Evaluation Committee for Procurement of Instruments for Monitoring NO_x and SO_2, India Meteorological Department, New Delhi, 20 February, 2004.

Dr. P.S.P. Rao

- Management Committee Meeting of IASTA, Bhabha Atomic Research Centre, Mumbai, 25 September, 2003.
- 1st Meeting of the Technical Evaluation Committee for Procurement of Instruments for Monitoring GHGs, India Meteorological Department, New Delhi, 29 January, 2004.

Dr. Y. Jaya Rao

- RESPOND Review Committee Meeting for Space Science, Physical Research Laboratory, Ahmedabad, 5-6 September, 2003.

Dr. M.N. Patil

- Selection Committee Meeting for the interview of Apprentices, India Meteorological Department, Pune, 25-29 August, 2003.

Dr. (Smt.) S.B. Morwal

- Third Meeting of the PAMC on Weather and Climate Programmes, Centre for Monsoon Studies, Cochin University of Science and Technology, Kochi, 13-14 May, 2003.

Dr. G. Pandithurai

- DST-FT GMW Fast Track Project Meeting, Physical Research Laboratory, Ahmedabad, 16-17 January, 2004.

Shri J. Sanjay

- Status Meeting of ISRO-GBP Project on Monsoon Variability Studies with Regional Climate Models using Satellite derived Surface Parameters, Space Applications Centre, Ahmedabad, 14 February, 2004.

Dr. K. Ali

- Nagar Raj Bhasha Karyanvayan Samiti Meeting, National Chemical Laboratory, Pune, 19 December, 2003.

Shri S.D. Patil

- Selection Committee Meeting for the Departmental Promotion of LDC and UDC, India Meteorological Department, Pune, 30 January, 2004.

Dr. C.G. Deshpande

- Meeting in connection with Pilot Expedition to Southern Ocean, National Centre for Antarctica and Ocean Research, Goa, 10 January, 2004.

Shri M. Mahakur

- Departmental Promotion Committee Meeting for the Group C and D employees, India Meteorological Department, Pune, 17 July, 2003.

Shri S. Saha

- 14th Annual General Meeting of The Aerosol Society, University of Reading, Reading, U.K., 31 March-5 April, 2003.

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Meetings organised at the Institute

Strategic Planning meeting for a Multi-partner Initiative to Develop Seasonal Rainfall prediction to Enhance Small holder Farmers Livelihood, 19 - 20 May, 2003

Meeting of the PAMC-WCRP, Department of Science and Technology, New Delhi to review the WP-RASS Project, 10 October, 2003

Brain Storming Session on Water Resources, Rainfall, Evaporation, Water Conservation, Cloud Seeding vis-a-vis Meteorological Aspects, 14 November, 2003

PAMC meeting on Himalayan Glaciology Programme, 28 January, 2004

Meetings of the CLIVAR Asian-Australian Monsoon Panel (AAMP) and the CLIVAR / IOC Indian Ocean Panel (IOP), 18-20 February, 2004

Seminars and Special Lectures

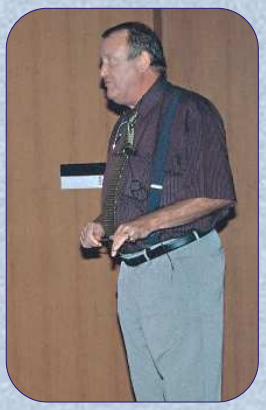
Prof. F. T. M. Nieuwstadt,
The Netherlands

Dr. K. A. Rao,
U.S.A.

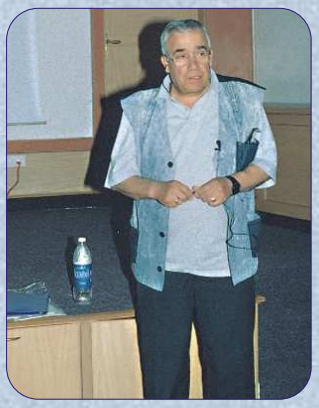
Prof. Brian Launder,
U.K.

Prof. Dirk Offermann,
Germany

Dr. Lennart Granat,
Sweden

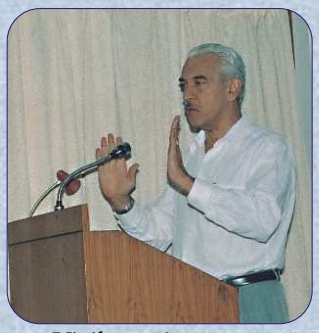


Dr. C. J. Stigter,
The Netherlands



Prof. I. Kolev,
Bulgaria

Hindi week Celebration
lecture by
Dr. Durgadutt Oza

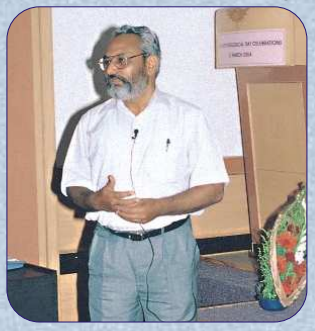


Vigilance Awareness
lecture by
Shri Arun Bhatia

National Science Day
lecture by
Dr. (Smt.) Sulochana Gadgil

International Women's Day
lecture by
Prof. (Smt.) Tanuja Marathe

World Water Day
lecture by
Dr. C. D. Thatte



World Meteorological Day
lecture by
Dr. Nityanand Singh

Seminars

Visitors

Dr. M. Dileep Kumar, National Institute of Oeanography, Goa.

- CSIR Network Project : ocean-atmosphere time series measurements, 24 April, 2003.

Prof. R.T. Pinker, Department of Meteorology, University of Maryland, Maryland, USA.

- Remotely sensed radiation budgets: progress and challenges, 13 June, 2003.

Prof. F.T.M. Nieuwstadt, Delft University of Technology, The Netherlands

- Dynamics of stable boundary layer, 1 August, 2003.

Dr. K. A. Rao, Lawrence Livermore National Laboratory, USA.

- Ozone warming signals from climate models, 29 October, 2003.

Dr. C. Venkatesan, Analytical Services and Materials Inc., (Radiation and Aerosol Branch), NASA Langley Research Centre, Hampton, Virginia, USA.

- Cloud climatology of the SHEBA derived from an automated Arctic cloud mask, 4 December, 2003.

Prof. A. Chandrasekar, Department of Physics, Indian Institute of Technology, Kharagpur.

- Studies on evaluation of mesoscale meteorological models, 11 December, 2003.

Prof. Dirk Offermann, Physik, Bergische Universität Wuppertal, Germany, Chief Scientist and Mission Coordinator of the German CRISTA Satellite on NASA Space Shuttle.

- Trace gases in the upper troposphere / lower stratosphere, 6 January, 2004.

Dr. Jagdish Bahadur, Retd. Joint Advisor, Department of Science and Technology, Govt. of India, New Delhi.

- Role of Himalayan snow and ice in meteorology, 9 January, 2004.

Dr. Lennart Granat, Stockholm University, Sweden

- Atmospheric deposition with special reference to acidification – importance of measurements, 3 February, 2004.

Dr. Manohar Lal, Reader, Equatorial Geophysical Research Laboratory, Indian Institute of Geomagnetism, Tirunelveli.

- Study of geomagnetic storm induced surface wave at equatorial latitude, 12 February, 2004.

Dr. Ivan Kolev, Laser Research Laboratory, Institute of Electronics, Bulgaria.

- Lidar observations of the aerosol structure in the planetary boundary layer, 4 March 2004.

Prof. (Smt.) Tanuja Marathe, Fergusson College, Pune

- World of Gems, 12 March, 2004 (International Women's Day Lecture).

Dr. C.D. Thatte, Secretary General, International Commission on Irrigation and Drainage (ICID), Chairman, International Commission on Large Dams (ICOLD).

- Inter-Linking of Rivers Programme (ILRP) of India in world context, 22 March, 2004 (World Water Day Lecture).

Institute Scientists

Dr. A.K. Kamra

- Effect of the horizontal electric field on the distortion of water drops suspended in a wind tunnel, 3 April, 2003.

- Some new opportunities for research in meteorology, 30 April, 2003.

- Vertical profile of submicron aerosols over the Arabian Sea in the southwest monsoon season, 18 December, 2003.

Dr. P.C.S. Devara

- Multi-year aerosol characterization experiments using lidar and solar radiometric techniques at a tropical station in India, 20 June, 2003.

- Characterization of aerosol, ozone and precipitable water content over Pune, an Indian urban station, 20 June, 2003.
- Direct radiative forcing due to aerosols in UV, visible and IR spectral regions, 20 June, 2003.
- Differential absorption lidar system for vertical profiling of atmospheric ozone, 20 June, 2003.
- Profiling of aerosol, ozone and water vapour using a mobile radiometer over a tropical rural station in India, 1 September, 2003.
- Excimer-Raman dial probing of atmospheric ozone over an urban station: first results, 31 March, 2004.

Dr. G. Pandithurai

- Aerosol radiation forcing over an urban station in India and its comparison with INDOEX estimates, 20 June, 2003.
- Characteristic aerosol properties of a tropical urban region, 20 June, 2003.

Dr. G. Beig

- Variation in lower stratospheric ozone: solar influence, 26 June, 2003.

Shri S.K. Saha

- Variations in aerosol optical depth ozone and precipitable water obtained from identical sunphotometers, 22 August, 2003.

Shri S.M. Sonbawne

- Solar zenith angle dependence of aerosol optical depth during different seasons over a tropical urban station, Pune, India, 28 August, 2003.

Dr. R.H. Kripalani

- Monsoon variability 2003: a comparison with monsoon 2002, 10 October, 2003.
- Indian Ocean dipole and its influence on Asian monsoon variability: observational and modelling aspects, 10 February, 2004.

Dr. P.N. Mahajan

- Integrated approach of multiple satellites for better depiction of monsoon depressions over the Indian region, 14 October, 2003.
- Multiple satellite analysis of monsoon depressions for better monsoon variability, 19 February, 2004.

Shri S.S. Dugam

- Monsoon variability over the smaller spatial scale in relation to regional pressure variation, 14 October, 2003.
- Satellite derived sea-ice extent in Indian Ocean and its impact on monsoon variability, 27 January, 2004.
- Impact of Indian Ocean SST and sea-ice extent on monsoon variability, 12 February, 2004.

Shri S.D. Bansod

- Indian Ocean dipole in sea surface temperature over the Indian Ocean and the sub-divisional summer monsoon rainfall over India, 14 October, 2003.

Dr. A.A. Munot

- Intraseasonal and interannual variability of summer monsoon rainfall over India, 15 October, 2003.
- Some aspects of Indian Ocean SST and its relationship with all-India summer monsoon rainfall, 16 February, 2004.

Dr. B.D. Kulkarni

- Hydrometeorological study of extreme rainfall over Saurashtra and Kutch - A brief appraisal, 15 October, 2003.
- Water potential of the Wardha and the Wainganga river catchments for the optimum development of their water resources-a brief appraisal, 10 December, 2003.

Shri S.K. Jadhav

- Daily rainfall distribution in association with the low pressure systems over the Indian region, 15 October, 2003.
- Decrease in cyclonic disturbances during summer monsoon season for recent years, 16 February, 2004.

Shri D.R. Kothawale

- Heat waves over Andhra Pradesh- a case study of 2003, 15 October, 2003.

- Temperature variability over north Indian Ocean and relationship with Indian summer monsoon rainfall, 16 February, 2004.

Shri S.D. Patil

- Spatio-temporal variation of the cloud radiative forcing over Indian region during El Nino event, 15 October, 2003.
- Cloud radiative forcing in relation to the energy balance and its anomalous features over the Indian monsoon region, 16 February, 2004.

Dr. A.L. Londhe

- Ozone variation over Indian region during La Nina / El Nino events, 17 October, 2003.
- Monsoon circulation induced variability in total column ozone over India, 11 February, 2004.
- Seasonal variability of stratospheric aerosol layer as observed by ground based and satellite remote sending techniques, 11 February, 2004.

Shri S. Mahapatra

- Application of digital filter for initialization of meteorological data over Indian region, 17 October, 2003.

Shri R.M. Khaladkar

- Application of IRS-P4 satellite data for cyclone study – effect of correction factors on the analyses of geophysical parameters, 17 October, 2003.

Shri S.B. Kakade

- Intraseasonal variability of Indian summer monsoon rainfall in relation to the tendency of simultaneous impact of NAO and SO, 17 October, 2003.
- Frequency of cyclonic disturbances in north-Indian Ocean in relation to the simultaneous impact of NAO and SO, 12 February, 2004.

Shri G.S. Meena

- Effects of clouds on the spectroscopic measurements of the trace gases over Pune, India, 17 October, 2003.

Shri Somaru Ram

- Long term climate variability over Western Himalaya deduced from instrumental and tree-rings, 17 October, 2003.

Shri D.K. Trivedi

- Numerical simulation of super cyclonic storm of Orissa (1999) with vortex initialization, 20 October, 2003.
- Numerical simulation of tropical cyclones using mesoscale models in Brain storming session on Mesoscale systems and mesoscale modeling, 20 December, 2003.
- Impact of cumulus parameterization schemes on simulation of super cyclonic storm, Orissa (1999), 19 February, 2004.

Shri Prem Singh

- Simulation of tropical Indian Ocean circulation using a free surface sigma coordinate model, 22 October, 2003.

Shri N.K. Agarwal

- Intraseasonal transients in kinetic enetgy exchanges during Indian summer monsoon 1996, 22 October, 2003.

Dr. R. Krishnan

- Structure and variability of the Indian Ocean as revealed from ARGO observations, 7 November, 2003.

Shri J.R. Kulkarni

- Multimodal scheme for prediction of monthly rainfall over India, 25 November, 2003.

Dr. (Smt.) I. Joshi

- Association between geomagnetic field variations and monsoon rainfall over Pune, 4 December, 2003.
- Study of tropospheric parameters during two contrasting summer monsoons 2002 and 2003, 11 February, 2004.

Shri B.N. Mandal

- Design storm studies over the Bhagirathi and the Dhauliganga river basins in Uttaranchal State, 10 December, 2003.

Smt. N.R. Deshpande

- Future rainfall projection over major river basins in India, 10 December, 2003.

Shri G.R. Chintalu

- Role of heat, moisture and momentum transport across the air-sea interface in the off-shore trough over the Eastern Arabian Sea during (IOP 22 July – 4 August) ARMEX 2002, 11 December, 2003.
- Air-sea interaction properties in the Eastern Arabian Sea during active phase of off-shore trough (IOP 7-9 August ARMEX 2002), 11 December, 2003.

Dr. S. Sivaramakrishnan

- Mesoscale divergence / convergence, surface flux and rainfall over the west coast during ARMEX-I: a case study, 16 December, 2003.
- Observational study of carbon-dioxide and water vapour at Goa on west coast of India during ARMEX 2002-2003, 17 February, 2004.

Dr. M.N. Patil

- Characteristics of mixed layer over Arabian Sea during summer monsoon 2002, 16 December, 2003.

Dr. B.S. Murthy

- Moist convective instability over the Arabian Sea during monsoon 2002, 16 December, 2003.
- Surface fluxes at Goa during ARMEX (phase I and II), 16 December, 2003.

Shri T. Dharmaraj

- Thermodynamic structure of ABL during ARMEX phase I and phase II over Goa, 17 December, 2003.

Dr. P.S.P. Rao

- Physical and chemical characteristics of aerosols over Arabian Sea during ARMEX 2002-2003, 18 December, 2003.

Dr. (Smt.) S.B. Morwal

- Atmospheric boundary layer during ARMEX 2002 at stationary position: comparative study, 18 December, 2003.

Shri V. Gopalkrishnan

- Change in the submicron aerosol characteristics with the change in air mass, 17 December, 2003.
- Climatology of the atmospheric ions over sea in the monsoon and pre-monsoon seasons along the west coast of India, 19 February, 2004.

Shri P. Murugvel

- Airborne measurements of the submicron aerosol size distributions during ARMEX 2002-03, 17 December, 2003.

Dr. C. Gnanaseelan

- Dynamics and mechanism of Indian Ocean warm pool, 19 December, 2003.
- Effect of open ocean circulation on coastal sea level over the west coast of India, 19 December, 2003.
- Interannual variability in the tropical Indian Ocean with a special emphasis on Indian Ocean dipole, 17 February, 2004.

Shri J. Sanjay

- Stochastic-Dynamic approaches for mesoscale modeling, 20 December, 2003.
- Unified planetary boundary layer formulation in FSU global spectral model, 16 January, 2004.

Shri P. Mukhopadhyay

- Mesoscale modeling activities and related issues, 20 December, 2003.

Shri S.B. Debaje

- Monitoring of surface ozone in the Institute, 6 February, 2004.

Dr. (Mrs.) A.A. Kulkarni

- Indian monsoon variability: role of Indian Ocean dipole mode, 10 February, 2004.

Smt. S.S. Naik

- Understanding the dynamics and physics of onset phase of southwest monsoon during the Indian region, 11 February, 2004.

Dr. Y. Jaya Rao

- Radiometric observations of columnar aerosol optical depth, ozone and water vapour at Gadanki, 13 February, 2004.

Shri A.K. Srivastava

- ND-YAG lidar observations of aerosols in the vicinity of tropical tropopause, 13 February, 2004.

Dr. H.P. Borgaonkar

- Climatic variations over India : Evidence from tree-ring records during past three centuries, 17 February, 2004.

Smt. S.K. Patwardhan

- Cyclonic disturbances as simulated by PRECIS and comparison with the observed disturbances over Indian region, 17 February, 2004.

Smt. S.K. Mandke

- Influence of SST anomalies over Indian Ocean and Pacific Ocean on Indian summer monsoon of 1997, 17 February, 2004.

Smt. A.A. Deo

- Oceanic mixed layer variations during the movement of the Indian Ocean cyclone: sensitivity to model resolution and hemisphere, 17 February, 2004.

Shri D.W. Ganer

- Numerical simulations of surface and subsurface dipole in the Indian Ocean using 2½ layer thermodynamic ocean model, 17 February, 2004.

Smt. S.S. Inamdar

- Intraseasonal variations of post monsoon rainfall, 17 February, 2004.

Smt. J.V. Revadekar

- Intraseasonal variability of southwest monsoon over India : Comparison of monsoon 2002 and 2003, 17 February, 2004.

Smt. U.V. Bhide

- Intraseasonal variability of southwest monsoon over India for 1997 and 2002, 19 February, 2004.

Dr. (Smt.) S.G. Nagar

- Flux transfer processes over Somali basin during monsoons 1988 and 1991, 19 February, 2004.

Shri V.R. Mujumdar

- Study of secondary heat sources in relation to 2002 drought, 19 February, 2004.

Shri S.P. Ghanekar

- Assessment of the monsoon conditions over Bay of Bengal during the stationary periods of BOBMEX-1999, 19 February, 2004.

Dr. N. Singh

- Global warming affecting rainfall pattern of India: GIS application in evaluating rainfall spatial changes, 23 March, 2004
(World Meteorological Day Lecture).

Research Fellows / Project Personnel

Dr. R.S. Maheskumar

- Study of direct short wave aerosol radiative forcing, 8 July, 2003.

Shri U.K. Singh

- Approach to study stages of super cyclonic storm of Orissa (1999) using INSAT IR data, 20 October, 2003.

Shri. A.K. Mishra

- Simulation of the diurnal variation in the mixed layer depth and SST in the central Arabian Sea, 22 October, 2003.

- Mixed layer response of southeast Arabian Sea during 2003 warming phase, 19 December, 2003.

Shri R.K. Yadav

- Predictive relationships between south Indian Ocean sea surface temperatures and north-west India winter precipitation, 5 December, 2003.

Kum. C. Sukumaran

- Variation of water vapour and CO_2 during ARMEX phase I and phase II at Goa, 17 December, 2003.

Shri B. Thompson

- Variability of synoptic features over north Indian Ocean during two contrasting monsoons, 11 February, 2004.

Kum. T. Rajita Madhu Priya

- Observational study of carbon dioxide and water vapour at Goa on the west coast of India during ARMEX 2002-03, 16 February, 2004.

M.Sc. / M.Tech. Students

Shri B.H. Vaid, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Rossby waves in Indian Ocean, 21 November, 2003.
- Planetary waves and its variability in the Indian Ocean from TOPEX/Poseidon altimetry data, 21 January, 2004.
- Interannual variability of meso-scale eddies in the Arabian Sea, 17 February, 2004.

Shri S. Pal, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- LIRAD sounding of the atmospheric aerosols and pre-cursor gases over Pune, India, 5 January, 2004.

Shri Vijay Kanawade, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Ground-based remote sensing technique for measurements of vertical distributions of atmospheric aerosols, 16 January, 2004.

Smt. Ashwini Deshpande, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Utility of satellite microwave radiometry data for better depiction of monsoon depression, 16 January, 2004.

Shri Sahidul Islam, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Detection of thunderstorms over various Indian stations by stability indices and numerical simulation of thunderstorm by a mesoscale model, 21 January, 2004.

Shri U.P. Shinde, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Experimental studies in thunderstorm electrification, 23 January, 2004.

Shri Vinod Kumar, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Study of vertical wind variability in the troposphere using Indian MST radar, 23 January, 2004.

Shri S. Gunthe

- Diurnal variation of surface ozone and its precursors over the urban site at Pune, 5 February, 2004.

Shri R. Reddy, M.Tech. (Atmospheric Physics) student, University of Pune, Pune.

- Intercomparison of palaeoclimate model simulations over south Asia rainfall and temperature changes since mid-Holocene, 10 February, 2004.

Shri Vinaykumar

- Model studies on droughts in the tropics and sub-tropics, 13 February, 2004.

Shri J.S. Chowdary

- Seasonal heat storage in the Arabian Sea from ARGO observations during two contrasting monsoons, 17 February, 2004.

Shri Pankaj Kumar

- Northeast monsoon rainfall variability over India and its teleconnections with sea surface temperatures, 17 February, 2004.

Dr. P.K. Mishra

- Pattern scaling : an examination of the technique for scenario development, 19 March, 2004.

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Academic Activities

Guidance to Students for Research Projects

Dr. P.C.S. Devara

- Shri S.V. Kulkarni, M.Sc. (Physics), Fergusson College, Pune.
- Shri Anil Gite, M.Sc. (Physics), Fergusson College, Pune.
- Shri S. Pal, M. Tech. (Atmospheric Physics), University of Pune, Pune.

Dr. D.B. Jadhav

- Shri V. Kanawade, M.Tech. (Atmospheric Physics), University of Pune, Pune.
- Shri. S. Bhattacharya, M.Sc. (Instrumentation), University of Pune, Pune.
- Shri. J. Patil, M.Sc. (Instrumentation), University of Pune, Pune.

Shri P. Seetaramayya

- Kum. Deepa R., M.Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi.

Dr. P.E. Raj

- Shri V. Balakrishna, M.Sc. (Space Science), Andhra University, Visakhapatnam.

Dr. P.N. Mahajan

- Shri B.S. Gugale, Ph.D. (Physics), University of Pune, Pune.
- Kum. A.R. Deshpande, M.Tech. (Atmospheric Physics), University of Pune, Pune.
- Smt. S. Nair, M.Sc. (Atmospheric Science), University of Pune, Pune.

Shri J.R. Kulkarni

- Shri S.T. Bhutia, M.Sc. (Space Science), University of Pune, Pune.

Dr. P.S.P. Rao

- Shri S.R.Bargude, M.Sc.(Physics), Fergusson College, Pune.

Dr. (Smt.) I. Joshi

- Kum. K. Vasudha., M.Sc. (Space Science), Andhra University, Visakhapatnam.
- Shri R. More, M.Sc. (Physics), University of Pune, Pune.
- Shri R.P. Pande, M.Sc. (Physics), University of Pune, Pune.

Dr. (Smt.) S.S. Dhanorkar and **Dr. D.K. Singh**

- Kum M. Kale, B.E., University of Pune, Pune.
- Kum S.R. Kulkarni, B.E., University of Pune, Pune.
- Kum S.B. Kulkarni,, B.E., University of Pune, Pune.

Dr. (Smt.) S.S. Kandalgaonkar

- Kum. D. Sawarkar, M.Sc. (Environmental Science), University of Pune, Pune.
- Smt. M.K. Kulkarni, M.Sc. (Environmental Science), University of Pune, Pune.

Shri T. Dharmaraj

- Shri V.K. Patel, M.Sc. (Space Science), University of Pune, Pune.

Dr. Y. Jaya Rao

- Shri P.S. Vinod Kumar, M.Tech. (Atmospheric Physics), University of Pune, Pune.
- Shri R.S. Bidwai, M.Sc. (Physics), University of Pune, Pune.
- Smt. M. Bose, M.Sc. (Physics, Space Science), University of Pune, Pune.
- Shri K. Mathur, M.Sc. (Physics, Space Science), University of Pune, Pune.

Shri S.D. Pawar

- Kum S. Raut, M.Sc. (Physics), University of Pune, Pune.
- Kum R. Patole, M.Sc. (Physics), University of Pune, Pune.
- Kum A. Thakre, M.Sc. (Physics), University of Pune, Pune.

Shri V. Gopalakrishnan

- Shri P.S. Avatare, M.Sc. (Physics), University of Pune, Pune.

Dr. C. Gnanaseelan

- Shri B.H. Vaid, M.Tech. (Atmospheric Physics), University of Pune, Pune.

Dr. G. Pandithurai

- Shri S.S.S. Chauhan, M.Sc. (Space Science), University of Pune, Pune.

Shri S. Mahapatra

- Shri S.Islam, M.Tech. (Atmospheric Physics), University of Pune, Pune.
- Shri R. Hiwale, M.Sc. (Space and Atmospheric Science), University of Pune, Pune.

Smt. R. Latha

- Kum U.D. Bombe, M.Sc. (Physics), University of Pune, Pune.

Shri P. Murugvel

- Kum H.M. Rajopadhyay, M.Sc. (Physics), University of Pune, Pune.

Expertise Provided

Dr. P.C.S. Devara

- Short-term Training Programme, Government College of Engineering, Pune, 9-21 June, 2003.

Dr. R. Krishnan, Dr. A.K. Sahai, Dr. K. Krishna Kumar and Shri S. Mahapatra

- Fourth SERC School on Numerical Weather Prediction in Tropics : Process Modelling, Indian Institute of Technology, New Delhi, 14 April – 10 May 2003.

Dr. P.N. Mahajan

- Continuous Education Programme (CEP) on Artillery Rockets, Armament Research and Development Establishment, Pune, 19 December, 2003.

Shri J.R. Kulkarni

- Winter School on Mathematical Modelling of Engineering Systems, D.Y.Patil College of Engineering, Pune, 22 December, 2003.

Dr. R.H. Kripalani

- Advanced Meteorological and Met. Gr.II Training Course, India Meteorological Department, Pune, June, 2003 – June, 2004.

Dr. A.K. Sahai

- Training Course on Application of Stutgart Neural Network Simulation (SNNS) for Retrieval and Quantification of Precipitation from Satellite Data and also for Non-linear Principal Component Analysis, Indian Institute of Tropical Meteorology, Pune, 30 December, 2003 – 6 January, 2004.

Smt. U.V. Bhide

- Advanced Meteorological Training Course, India Meteorological Department, Pune, June, 2003 – June, 2004.

Dr. K. Krishna Kumar

- 15th Batch of Met. Gr.II Training Course, India Meteorological Department, Pune, July-August, 2003.

Dr. H.P. Borgaonkar

- 15th Batch of Met. Gr.II Training Course, India Meteorological Department, Pune, July-August, 2003.
- Training programme on 'Tree-ring sample collection procedure', Snow and Avalanche Study Establishment (SASE), Chandigarh, 4-11 October, 2003.

Shri A.B. Sikder

- Training programme on 'Tree-ring sample collection procedure', Snow and Avalanche Study Establishment (SASE), Chandigarh, 4-11 October, 2003.

Shri S. Mahapatra

- Fourth SERC School on Numerical Weather Prediction in Tropics : Process Modelling, Indian Institute of Technology, New Delhi, 14 April – 10 May, 2003.

Lectures Delivered Outside

Dr. A.K. Kamra

- Ozone layer depletion and its causes, Institute of Engineers, Pune, 13 June, 2003.

Dr. P.C.S. Devara

- Atmospheric aerosol characterization using remote sensing techniques, Max Plank Institute for Biogeochemistry (MPIB), Jena, Germany, 22 September, 2003.
- Atmospheric aerosols research activity at IITM, Pune, India, Department of Meteorology, University of Maryland, Maryland, USA, 3 February, 2004.

Dr. K. Rupa Kumar

- Climate over India in a changing world, Centre for Sustainability and Global Environment, University of Wisconsin, Madison, USA, 17 September, 2003.

Dr. N. Singh

- Fluctuations of moisture regions and rainfall of India during 1813-2001, National Geophysical Research Institute, Hyderabad, 2 January, 2004.
- Utility of satellite remote sensing of better monitoring of monsoon system over the Indian region, National Water Academy, Pune, 13 January, 2004.
- Application of RS-GIS in weather/rainfall analysis and prediction, National Insurance Academy, Pune, 17 January, 2004.
- Understanding characterisation of rainfall across India, National Insurance Academy, Pune, 24 January, 2004.

Dr. R. Krishnan

- Structure and variability of the Indian Ocean as revealed from ARGO observations, Frontier Research System for Global Change, Yokohama, Japan, 20 November, 2003.

Dr. S.S. Parasnis

- Land surface experiment, Vikram Sarabhai Space Centre, Thiruvananthapuram, 17 June, 2003.
- Atmospheric boundary layer modelling using land surface processes, Vikram Sarabhai Space Centre, Thiruvananthapuram, 18 June, 2003.

Dr. P.N. Mahajan

- Proper depiction of atmospheric systems through satellite remote sensing over Indian region, National Centre for Antarctic and Ocean Research, Goa, 22 December, 2003.

Shri J.R. Kulkarni

- Artificial neural network and its applications to weather modelling, S.K.Banerjee Centre for Atmospheric and Oceanic Sciences, Allahabad, 2-5 December, 2003.
- Artificial rain, Padmavati Pratishthan, Fergusson College, Pune, 28 December, 2003.
- Rain and rainfall processes, Water and Land Management Institute, Aurangabad, 21 January, 2004.
- Wavelet regression for intraseasonal prediction of monsoon rainfall, National Centre for Medium Range Weather Forecasting, New Delhi, 11 March, 2004.
- Multimodal scheme for prediction of monthly rainfall over India, National Centre for Medium Range Weather Forecasting, New Delhi, 11 March, 2004.

Dr. (Smt.) N.A. Sontakke

- Rainfall fluctuations across India since early 19th century and global warming, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 24 July, 2003.

Dr. G. Pandithurai

- Aerosol optical characterization and radiative forcing, Department of Meteorology, University of Maryland, Maryland, USA, 3 February, 2004.
- Aerosol radiative forcing and heating rates from sky radiometers and lidar observations, Climate Monitoring and Diagnostics Laboratory, National Oceanic and Atmospheric Administration (NOAA), Boulder, Colorado, USA, 5 February, 2004.

Training Undergone

Smt. A.A. Shiralkar

- Pre-conference Tutorials on Internet Information Resources and Building of Digital Libraries organized by the Society for Information Science, Indian Institute of Technology, Roorkee, 7-8 April, 2003.

Shri M.M. Kokate and Kum. Suby Oommen

- Advance level Training Program on Web Designing and Database Management, Centre for Environment Education (CEE), Pune, 22-25 April 2003.

Shri S. Mahapatra

- Fourth SERC School on Numerical Weather Prediction in Tropics: Process Modelling, Indian Institute of Technology, New Delhi, 14 April – 10 May 2003 (Participated as a participant cum Resources Person).

Dr. D.K. Singh

- Fifth SERC School on Solar Terrestrial Environment– Space Weather, Department of Physics, Banaras Hindu University, Varanasi, 1-20 September, 2003.

Shri S. Bhandare

- First hand Training of Soil and Water Assessment Tool (SWAT), Indian Institute of Technology, New Delhi, 8-15 September, 2003.

Smt. U. Iyer

- Advanced Meteorological Training, India Meteorological Department, Pune, November, 2003 – September, 2004.

Smt. N.R. Deshpande and Dr. (Kum.) S.S. Nandargi

- Sixth training Programme on Applications of RS-GIS Techniques in Water Resources Development and Management, National Water Academy (NWA), Pune, 6-16 January, 2004.

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Ph.D. and Post-Graduate Programme

Award of Ph.D. Degree by the University of Pune, Pune

Smt. S.G . Nagar

- Some aspects of the boundary layer characteristics over Indian region (Guide : Dr. S.S. Singh)

Shri S.M. Bawiskar

- Energetics of zonal waves and performance of Indian summer monsoon rainfall (Guide : Dr. S.S. Singh)

Smt. T. Priscilla Pilli

- Geomagnetic effect in the meteorological parameters of the lower middle and upper atmosphere (Guide : Dr. (Smt.) I. Joshi)

Shri P.R. Patil

- Vertical profiles of aerosols with twilight method (Guide : Dr. D.B. Jadhav)

Kum. N. Saraf

- Role of natural and anthropogenic activities on the tropical chemical climate of troposphere and stratosphere (Guide : Dr. G. Beig)

Award of M. Sc. Degree by the University of Pune, Pune

- Shri A.B. Sikder and Smt. M.K. Kulkarni have been awarded M.Sc. (Environmental Sciences) degree by the University of Pune, Pune

Thesis Submitted for Ph.D. Degree to University of Pune, Pune

Shri P.R.C. Reddy

- Role of satellite data in understanding the circulation and the SST field over the Indian seas (Guide : Dr. (Smt.) P.S. Salvekar

Recognition as Ph.D. Guide

- Dr.H.P. Borgaonkar and Dr. C. Gnanaseelan have been recognized as guides for Ph.D. (Space Science) by the University of Pune, Pune

Teaching and Research Support to University of Pune

Lectures delivered for M.Sc./M.Tech. Students, University of Pune, Pune

Dr. P.C.S. Devara

- Observational techniques and data processing, M.Tech. (Atmospheric Physics)
- Lidar, sodar and RASS, M.Sc. (Space Science)

Dr. (Smt.) P.S. Salvekar

- Advanced dynamic meteorology, M.Tech. (Atmospheric Physics)

Shri J.R. Kulkarni

- Climate modelling, M.Tech. (Atmospheric Physics).
- Advanced fluid mechanics and monsoon meteorology, M.Tech. (Atmospheric Physics)

Dr. P.S.P. Rao

- Air pollution, M.Tech. (Atmospheric Physics)
- Measurement of trace gases, M.Tech. (Atmospheric Physics)
- Air pollution and atmospheric chemistry, M.Tech. (Atmospheric Physics)

Shri D.R. Talwalkar

- Objective analysis, M.Tech. (Atmospheric Physics) - Practicals

Dr. C. Gnanaseelan

- Data processing and numerical methods, M.Tech. (Atmospheric Physics)
- Mathematics–bridge course, M.Tech. (Atmospheric Physics)

Smt. S.K. Mandke

- Sensitivity of Energy Balance Model to Different Parameterizations, M.Tech. (Atmospheric Physics) – Practicals

Shri S. Mahapatra

- Spectral methods, spectral techniques and spectral models, M.Tech. (Atmospheric Physics)

Dr. (Smt.) A.A. Kulkarni

- Statistical theory, M.Tech. (Atmospheric Physics)

Smt A.A. Deo

- Physical oceanography, M.Tech. (Atmospheric Physics)
- Dynamic oceanography, M.Tech. (Atmospheric Physics)

Shri Prem Singh

- Finite difference techniques, M.Tech. (Atmospheric Physics)
- Numerical methods, M. Tech. (Atmospheric Physics)

Shri M. Mahakur

- Computation of apparent heat sources, M.Tech. (Atmospheric Physics) (Practicals)

Dr. P.C.S. Devara Lidar Probing of Atmosphere and Hydrosphere to M.Tech. (Laser and Electro-optics), Institute of Armament Technology, Pune

Nomination as External Examiner / Paper Setter / Member of the Selection Committee

Dr. G.B. Pant

- Ph.D., Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi

Dr. A.K. Kamra

- M.Sc. (Engg.), Indian Institute of Science, Bangalore

Dr. P.C.S. Devara

- M. Tech. (Atmospheric Science), Andhra University, Visakhapatnam
- M.Tech. (Atmospheric Physics) of Department of Physics, University of Pune, Pune

Dr. (Smt.) P.S. Salvekar

- M.Tech. (Atmospheric Physics), University of Pune, Pune.

Dr. S. Sivaramakrishnan

- M.Sc. / M.Tech, Cochin University of Science and Technology, Kochi

Dr. P.E. Raj

- M.Sc. (Space Science), University of Pune, Pune

Dr. P.N. Mahajan

- Ph.D., Goa University, Taleigo Plateau, Goa
- M.Sc. (Space Science), University of Pune, Pune

Shri J.R. Kulkarni

- M.Sc. (Space Science), University of Pune, Pune
- M.Tech. (Atmospheric Physics), University of Pune, Pune
- M.Tech. (Modelling and Simulation), Institute of Armament Technology, Pune

Dr. P.S.P. Rao

- M.Tech. (Atmospheric Physics) University of Pune, Pune

Dr. G. Beig

- Ph. D., Saurashtra University, Rajkot
- M. Phil., Aligarh Muslim University, Aligarh

Dr. (Smt.) I. Joshi

- M. Sc. (Space Science), University of Pune, Pune

Smt. U.V. Bhide

- Old Advanced Meteorological Training Course, India Meteorology Department, Pune

Dr. Y. Jaya Rao

- M.Sc. (Physics), University of Pune, Pune
- M.Sc. (Space Science), University of Pune, Pune

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- M.Tech. (Atmospheric Physics) University of Pune, Pune

Dr. (Smt.) A.A. Kulkarni

- M.Tech. (Atmospheric Physics) University of Pune, Pune

Dr. G. Pandithurai

- M.Sc. (Space Science), University of Pune, Pune

Smt. S.K. Mandke

- M.Tech. (Atmospheric Physics), University of Pune, Pune. (Practicals)

Shri S. Mahapatra

- M.Tech. (Atmospheric Physics), University of Pune, Pune

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Deputation Abroad

Dr. G.B. Pant

- Participation in the First Scoping Meeting of the IPCC Fourth Assessment Report, Marrakech, **Morocco** (12–19 April, 2003)
- Participation in the CLIVAR SSG Meeting, Victoria, **Canada** (2–15 May, 2003)
- Participation in the Second Scoping Meeting of the IPCC Fourth Assessment Report, Postdam, **Germany** (29 August – 5 September, 2003)
- Participation in the Joint CLIVAR/ PAGES/IPCC Meeting on Drought, University of Arizona, Tucson and to visit Laboratory of Tree Ring Research, **U.S.A.** (16 November – 2 December, 2003)
- Participation in the 25th Session of the Joint Scientific Committee for the World Climate Research Programme (WCRP), Russian Academy of Sciences, Moscow, **Russia** (1–6 March, 2004)

Dr. A.K. Kamra

- Participation in the 8th Scientific Conference on Weather Modification, Casablanca, **Morocco** (5–14 April, 2003)

Dr. P.C.S. Devara

- Participation in the Sixth Atmospheric Particulate Environment Change Experiment–Research Institute for Humanity and Nature, APEX-RHIN Joint International Workshop on Atmospheric Aerosols and Clouds, Awaji Yumebutai, Visit to the Centre for Environmental Remote Sensing (CERES), Chiba and Participation in the General Assembly of International Union of Geodesy and Geophysics (IUGG – 2003), Sapporo, **Japan** (23 June – 11 July, 2003)
- Participation in the 6th International Symposium on Tropospheric Profiling : Needs and Technologies (ISTP), University of Leipzig, Leipzig, and Visit Max Planck Institute for Biogeochemistry, Jena, **Germany** (13 – 24 September, 2003)
- Under the DST-NSF sponsored project 'Aerosol optical characterization and investigation of aerosol radiative forcing at the surface and top of the atmosphere', Department of Meteorology, University of Maryland, **U.S.A.** (20 January – 6 February, 2004)

Dr. K. Rupa Kumar

- Visit to the Center for Sustainability and Global Environment (SAGE), University of Wisconsin, Madison and as a START (global change System Analysis Research Training) Visiting Scientist, **U.S.A.** (20 July –2 October, 2003)
- Under the Joint Indo–French Collaborative Project on Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change, National Centre for Meteorological Research, Toulouse, **France** (23 March –22 April, 2004)

Dr. R. Krishnan

- Participation in the First ARGO Science Workshop, Tokyo, and Visit to Frontier Research System for Global Change, Yokohama, **Japan** (9–24 November, 2003)

Dr. R.H. Kripalani

- Participation in the International Symposium on Asian Monsoon, Honolulu, Hawaii, **U.S.A.** (16–24 February, 2004)
- Participation in the International Conference on High–Impact Weather and Climate: Understanding, Prediction and Socio-Economic Consequences (ICHWC 2004), Seoul, **South Korea** (20–28 March, 2004)

Dr. A.K. Sahai

- Participation in the Workshop on Adaptation to Climate Change in Mountain Eco-system: Bridging Research and Policy, Kathmandu, **Nepal** (1–5 March, 2004)
- Under the Joint Indo-French Collaborative Project on Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change, National Centre for Meteorological Research, Toulouse, **France** (23 March – 22 April, 2004)

Dr. G. Beig

- Participation in the General Assembly of International Union of Geodesy and Geophysics (IUGG–2003), Sapporo, **Japan**
  (30 June – 14 July, 2003)

Dr. K. Krishna Kumar

- Research Associate, Cooperative Institute for Research in the Environmental Sciences, University of Colorado, Boulder, **U.S.A.**
  (29 September, 2003 – 28 September, 2004)

Dr. (Smt.) N.A. Sontakke

- Senior Associate, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy**
  (5 July –17 August, 2003)

Shri D.R. Chakraborty

- Visiting Research Associate, Florida State University, **USA**
  (16 June, 2003 – 14 June, 2004)

Dr. G. Pandithurai

- Participation in the Sixth Atmospheric Particulate Environment Change Experiment–Research Institute for Humanity and Nature (APEX-RHIN) Joint International Workshop on Atmospheric Aerosols and Clouds, Awaji Yumebutai, Visit to the Centre for Environmental Remote Sensing (CERES), Chiba and Participation in the General Assembly of International Union of Geodesy and Geophysics (IUGG–2003), Sapporo, **Japan**
  (23 June – 11 July, 2003)

- Under the DST-NSF sponsored project 'Aerosol optical characterization and investigation of aerosol radiative forcing at the surface and top of the atmosphere', Department of Meteorology, University of Maryland, Maryland and training at NOAA, Boulder, **U.S.A.**
  (20 January – 20 February, 2004)

Shri S.S. Mulye

- Training in Methods of Dendrochronology, Lamont Doherty Earth Observatory (Tree-Ring Laboratory), Columbia University, **U.S.A.**
  (5 March – 4 June, 2004)

Shri J. Sanjay

- To work with Prof. T.N.Krishnamurti, Florida State University, Tallahasee, Florida **U.S.A.**
  (29 February – 30 April, 2004)

Dr. C.G. Deshpande

- To participate in the Pilot Expedition to Southern Ocean onboard ORV Sagar Kanya, **Mauritius**
  (19 January – 12 March, 2004)

Shri S.M. Sonbawane

- Participation in the International Conference on Earth System Modelling, Hamburg, **Germany**
  (10 – 21 September, 2003)

Shri S.K. Saha

- Participation in the 14th Annual General Meeting of The Aerosol Society, University of Reading, Reading, **U.K.**
  (31 March – 5 April, 2003)

- Participation in the European Aerosol Conference, Universidad Complutense de Madrid, Madrid, **Spain**
  (31 August – 7 September, 2003)

Dr. R.S. Maheskumar

- Participation in the Gordon Research Conference on Solar Radiation and Climate, Cathy Sawyer College, New Hampshire, **U.S.A.**
  (12 – 20 July, 2003)

Shri V. Pant

- To participate in the Pilot Expedition to Southern Ocean onboard ORV Sagar Kanya, **Mauritius**
  (19 January – 31 March, 2004)

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Visitors

International

Prof. Rachel T. Pinker
Department of Meteorology
University of Maryland
U.S.A.
11-16 June, 2003

Prof. F.T.M. Nieuwstadt
Delft University of Technology
The Netherlands
1 August, 2003

Dr. Colin Clerk
Director
Charldon Hill Research Station
Bruton
U.K.
8 December, 2003

Shri Lochan Prasad Devkota
Tribhuvan University
Kathmandu
Nepal
16-25 December, 2003

Prof. Brian Launder
Regional Assistant Director
Tyndall Center for Climate Change Research (North)
University of Manchester
U.K.
3 January, 2004

Prof. Dirk Offermann
Director
Physik, Bergische Universitat Wuppertal, and Chief Mission Coordinator CRISTA (CRyogenic Infrared Spectrometers and Telescopes for the Atmosphere) Satellite on NASA
Germany
5-6 January, 2004

Dr. Lennart Granat
Retired Professor
Stockholm University
Sweden
28 January – 4 February, 2004

Dr. Ivan Kolev
Scientist
Laser Research Laboratory
Institute of Electronics, Sofia
Bulgaria
18 February – 6 March, 2004

National

Dr. M.B. Potdar
Space Applications Centre
Ahmedabad
15-17 April, 13-16 May,1-5 December, 2003 and 12-13 March, 2004

Smt. R. Rege
Space Applications Centre
Ahmedabad
13-16 May, 1-5 December 2003, 18 February and 12-13 March, 2004

Prof. N.H. Ravindranath and **Shri N.V. Joshi,**
Centre for Ecological Sciences
Indian Institute of Science
Bangalore
30 June, 2003

Dr. Edward Peters
Water Resource Management Group
Regional Research Laboratory
Bhopal
10 July, 2003

Dr. S.C.Garg and **Dr. S.L. Jain**
National Physical Laboratory
New Delhi
20-21 July, 2003

Dr. Varun Joshi
G.B. Pant Institute of
Himalayan Environment and Development
Garhwal
5 August, 2003

Dr. A. Muzumdar
Reader
Space Shuttle
Department of Water Resources Engineering
Jadavpur University
Jadavpur
5-6 August, 2003

Shri V.R. Sastry
Chief Engineer and
Shri D.S. Madaan
Deputy Director (Hyd.)
Central Water Commission,
New Delhi
19 August, 2003

Shri S.N. Huddar
Chief Engineer and Joint Secretary
Irrigation Department
Government of Maharashtra and
Shri H.Y. Kolawale
Chief Engineer (Hydrology)
Jalvidyan Bhavan,
Nasik
21 August, 2003

Shri Shambhu Singh
Director, and
Shri G. Srinivasan
Scientist
Department of Science and Technology
New Delhi
25 – 26 September, 2003

Post-graduate Medical Students
Department of Preventive and
Social Medicine
B.J. Medical College
Pune
10 October, 2003

Shri. S.M. Khare
Deputy General Manager
National Thermal Power Corporation (NTPC)
Noida
21 October, 2003 and 25 March, 2004

Officers
Institute of Armament Technology
Pune
22 October, 2003

Shri Amitabh Pande
Joint Secretary
Shri Shambhu Singh
Director, and
Shri G. Srinivasan
Scientist
Department of Science and Technology
New Delhi
28 October, 2003

Dr. Anand Patwardhan
Indian Institute of Technology,
Mumbai
28 October, 2003

Shri M. Rajavel and **Shri R. Balasubramanian**
Meteorologist Gr. II
India Meteorological Department
Pune
29 October, 2003

Dr. M.B. Potdar and **Shri Rajendra Rege**
Space Applications Centre
Ahmedabad
1-5 December, 2003

B.Sc. Students
Banguranagar Arts, Science and Commerce College
Dandeli
24 December, 2003

Dr. Prakash

Director
Drought Monitoring Cell
Bangalore
29-31 December, 2003

Dr. K.S. Zalpuri
National Physical Laboratory
New Delhi
30 December, 2003

Prof. A.W. Date
Department of Mechanical Engineering Indian Institute of Technology,
Mumbai
3 January, 2004

Shri R.K. Gupta
Director,
Hydrology (South) Directorate
Central Water Commission,
New Delhi
22 January and 9 March, 2004

Dr. Manohar Lal
Reader
Equatorial Geophysical Research Laboratory,
Indian Institute of Geomagnetism
Tirunelveli
12 February, 2004

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Academic Faculty

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. G.B. Pant	Climate, Climatic Change, Palaeoclimatology, Monsoon Variability and Prediction	gbpant@tropmet.res.in	M.Sc., Ph.D.
Dr. A.K. Kamra	Cloud Physics, Atmospheric Electricity, Aerosol Physics	kamra@tropmet.res.in	M.Sc., Ph.D.
Dr. P.C.S. Devara	Atmospheric Optics, Remote Sensing of Atmospheric Aerosols and Trace Gases, Aerosol-Climate Interactions	devara@tropmet.res.in	M.Sc., Ph.D.
Dr. D.B. Jadhav	Spectrometric Techniques for Atmospheric Chemistry, Radiation, Atmospheric Electricity	dbj@tropmet.res.in	M.Sc., Ph.D.
Dr. K. Rupa Kumar	Climate Change, Monsoon Variability and Prediction, Dendroclimatology, Climate Impact Studies	kolli@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) P.S. Salvekar	Monsoon Disturbances, Simulation of Atmospheric and Oceanic Circulation, Human Resource Development for Atmospheric Sciences	pss@tropmet.res.in	M.A., Ph.D.
Dr. V. Satyan	Climate Modelling	satyan@tropmet.res.in	M.Sc., Ph.D.
Shri S. Sinha	Theoretical and Experimental Atmospheric Boundary Layer Studies	ssinha@tropmet.res.in	M.Sc.
Dr. R. Vijayakumar	Cloud Physics, Numerical Modelling of Clouds	vijay@tropmet.res.in	M.Sc., Ph.D.
Dr. S. Sivaramakrishnan	Atmospheric Boundary Layer, Wind Tunnel Simulations	siva@tropmet.res.in	M.Sc., Ph.D.
Dr. Nityanand Singh	Hydrometeorological Studies, Rainfall Prediction on Shorter Spatial and Temporal Scales	nsingh@tropmet.res.in	M.Sc., Ph.D.
Dr. R. Krishnan	Climate Modelling	krish@tropmet.res.in	M.Sc., Ph.D.
Shri P. Seetaramayya	Marine Boundary-Layer Studies	seetar@tropmet.res.in	M.Sc. (Tech.)
Dr. P.E. Raj	Optical and Radio Remote Sensing of the Atmosphere, Environmental Studies, Aerosol-Climate Interactions	ernest@tropmet.res.in	M.Sc., Ph.D.
Dr. P.N. Mahajan	Satellite Data Applications for Weather Forecasting	mahajan@tropmet.res.in	M.Sc., Ph.D.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri J.R. Kulkarni	Monsoon Variability and Prediction, Nonlinear Dynamics and Chaos, Climate Modelling	jrksup@tropmetores.in	M.Sc.
Dr. L.S. Hingane	Climate Change Studies	hingane@tropmet.res.in	M.Sc., Ph.D.
Smt. S.S. Vaidya	Numerical Weather Prediction with Special Emphasis on the Physical Processes	ssvady@tropmet.res.in	M.Sc.
Dr. R. H. Kripalani	Asian Monsoon and Climate Variability	krip@tropmet.res.in	M.Sc., Ph.D.
Shri B.N. Mandal	Hydrometeorological Studies for Different River Basins and Regions	mandal@tropmet.res.in	B.Sc.
Dr. G. Beig	Atmospheric Chemistry, Ozone Pollution, Greenhouse Gases-3D Chemical – Climate Modelling	beig@tropmet.res.in	M.Sc., Ph.D.
Dr. A.K. Sahai	Climate Variability	aksahai@tropmet.res.in	M.Sc., Ph.D.
Dr. P.S.P. Rao	Air Pollution, Precipitation Chemistry	psprao@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) I.S. Joshi	Upper Atmosphere, Ionosphere and Environmental Sciences	indira@tropmet.res.in	M.Sc., Ph.D.
Dr. K. Krishna Kumar	Monsoon Variability and Prediction, Global Teleconnections and Climate Application	krishna@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) N.A. Sontakke	Climate Variability and Prediction with Special Reference to Indian Monsoon	sontakke@tropmet.res.in	M.Sc., Ph.D.
Shri M.K. Tandon	Development of Scientific Computing Techniques for Atmospheric Sciences	tandon@tropmet.res.in	M.Sc.
Dr. T. Venugopal	Numerical Weather Prediction, Planetary Boundary-Layer Studies	tvgopal@tropmet.res.in	M.Sc., Ph.D.
Dr. S.K. Sinha	Objective Analysis including Satellite Input for NWP	sinha@tropmet.res.in	M.Sc., Ph.D. Ph.D.
Smt. U.V. Bhide	Studies on Monsoon and Tropical Weather System	bhide@tropmet.res.in	M.Sc.
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Dr. (Smt.) S.G. Nagar	Atmospheric Boundary-Layer over Land and Ocean	nagar@tropmet.res.in	M.Sc., Ph.D.
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Dr. A.L. Londhe	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	londhe@tropmet.res.in	M.Sc., Ph.D.
Shri. C.S. Bhosale	Monitoring of Atmospheric Constituents, Twilight Spectroscopy	bhosale@tropmet.res.in	M.Sc.
Dr. (Smt.) S.S. Kandalgaokar	Thunderstorm Climatology and Related Meteorological Parameters	sskandal@tropmet.res.in	M.Sc., Ph.D.
Shri T. Dharmaraj	Atmospheric Boundary-Layer, Instrumentation and Related Studies	dharam@tropmet.res.in	B.E.
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Dr. H.P. Borgaonkar	Long-term Climate Variability over Monsoon Asia, Dendroclimatology, Palaeoclimatology	hemant@tropmet.res.in	M.Sc., Ph.D.
Smt. N.R. Deshpande	Hydrometeorological Studies for Different River Basins and Regions	nrdesh@tropmet.res.in	M.Sc., M.Phil.
Smt. S.K. Patwardhan	Climate Change, Monsoon Variability and Teleconnections	patwar@tropmet.res.in	M.Sc.
Dr. B.D. Kulkarni	Hydrometeorological Studies for Different River Basins and Regions	bdkul@tropmet.res.in	M.Sc., Ph.D.
Shri R.B. Sangam	Hydrometeorological Studies for Different River Basins and Regions	sangam@tropmet.res.in	B.Sc.
Smt. A.H. Mullan	Air-Sea Interaction, Marine Boundary Layer Studies	mullan@tropmet.res.in	M.Sc.
Dr. Y. Jaya Rao	Optical and Radio Remote Sensing of the Atmosphere	jrao@tropmet.res.in	M.Sc., M.Tech., Ph.D.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri S.D. Pawar	Aerosol Physics, Atmospheric Electricity	pawar@tropmet.res.in	M.Sc.
Dr. M.N. Patil	Land Surface-Atmosphere Interactions	patil@tropmet.res.in	M.Sc., Ph.D.
Dr. B.S. Murthy	Theoretical and Observational Studies of Atmospheric Boundary Layer	murthy@tropmet.res.in	M.Sc., Ph.D.
Dr. (Smt.) S.B. Morwal	Atmospheric BoundaryLayer	morwal@tropmet.res.in	M.Sc., Ph.D.
Shri A.B. Sikder	Long-term Climate Variability over Monsoon Asia, Dendroclimatology, Palaeoclimatology	sikder@tropmet.res.in	B.A, M.Sc.
Shri D.M. Chate	Air Pollution Studies	chate@tropmet.res.in	M.Sc.
Shri S.S. Dugam	Monsoon Variability and Prediction with NAO and ENSO	dugam@tropmet.res.in	M.Sc.
Shri V. Gopalakrishnan	Cloud Physics, Atmospheric Electricity	gopal@tropmet.res.in	M.Sc.
Shri Prem Singh	Ocean Modelling and Simulation Studies	psg@tropmet.res.in	M.Sc., M.Phil.
Shri S.D. Bansod	Monsoon Variability and Teleconnection	erp@tropmet.res.in	M.Sc.
Dr. C. Gnanaseelan	Ocean Modelling and Data Assimilation	seelan@tropmet.res.in	M.Sc., M.Tech., Ph.D.
Smt. S.K. Mandke	Climate Modelling	amin@tropmet.res.in	M.Sc., M.Tech.
Shri N.K. Agarwal	Atmospheric Energetics in Wavenumber Frequency Domain	nka@tropmet.res.in	M.Sc., M.Phil., PGDCA
Dr.(Smt.) A.A. Kulkarni	Monsoon Variability and Teleconnections	ashwini@tropmet.res.in	M.Sc., Ph.D.(Stats)
Dr. S.B. Debaje	Studies on Surface Ozone and Atmospheric Chemistry	debaje@tropmet.res.in	M.Sc., Ph.D.
Shri J. Sanjay	Numerical Weather Prediction with Special Emphasis to Mesoscale Modelling and Boundary Layer Processes	sanjay@tropmet.res.in	M.Sc.
Dr. G. Pandithurai	Atmospheric Aerosols and Remote Sensing	pandit@tropmet.res.in	M.Sc., PGDCA, Ph.D.
Shri S.S. Mulye	Hydrometeorological Studies for Different River Basins and Regions	mulye@tropmet.res.in	B.Sc.
Shri S. Mahapatra	Numerical Weather Prediction, Regional and Mesoscale Modelling, Initialization Techniques	mahap@tropmet.res.in	M.Sc. (Tech.), M.Tech.
Shri. G.A. Momin	Air Pollution Studies	momin@tropmet.res.in	M.Sc.
Smt. A.A.Kulkarni	Monsoon Studies and Forecasting	aakulkarni@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Shri R.M. Khaladkar	Satellite Meteorology, Weather Forecasting	khaldkr@tropmet.res.in	M.Sc., M.Tech. PGD
Dr. (Kum.) J.S. Pethkar	Hydrometeorological Studies for Different River Basins and Regions	pethkar@tropmet.res.in	M.Sc., Ph.D.
Smt. S.S. Desai	Atmospheric Dynamics, Global Spectral Energetics	ssd@tropmet.res.in	M.Sc.
Shri V.R. Mujumdar	Indian Monsoon	vrmujumdar@hotmail.com	B.Sc.
Shri P.V. Puranik	Studies of Monsoons and Tropical Weather Systems	monsoon@tropmet.res.in	B.Sc.
Dr. S.M. Bawiskar	Extended Range Prediction	monsoon@tropmet.res.in	M.Sc., Ph.D.
Shri S.K. Jadhav	Studies on Low PressureSystems over the Indian Region	skj@tropmet.res.in	B.Sc.
Smt. N.V. Panchawagh	Extended Range Prediction	panchwag@tropmet.res.in	M.Sc.
Shri D.K. Trivedi	Numerical Weather Prediction, Tropical Cyclone Modelling	trivedi@tropmet.re.in	M.Sc.
Smt. A.A. Deo	Application of Ocean modeling, Studies of Upper Oceanic Processes in Different Time and Space Series	aad@tropmet.res.in	M.Sc., M.Phil.
Dr. K. Ali	Cloud Physics and Radar Meteorology, Air Pollution Studies	kaushar@tropmet.res.in	M.Sc. (Tech.), Ph.D.
Shri D.R. Kothawale	Climate Change, Monsoon Variability and Prediction	kotha@tropmet.res.in	M.Sc.
Shri S.D. Patil	Climate and Climatic Change, Ozone Variability	patilsd@tropmet.res.in	M.Sc.
Smt. M.K. Kulkarni	Atmospheric Electricity	mkk@tropmet.res.in	M.Sc.
Smt. Latha R.	Atmospheric Electricity	latha@tropmet.res.in	B.Tech.
Shri G.S. Meena	Atmospheric Minor Constituents	gsm@tropmet.res.in	M.Sc.
Shri S.B. Kakade	Monsoon Variability and Prediction with NAO and ENSO	kakade@tropmet.res.in	M.Sc.
Shri S.P. Ghanekar	Extended Range Prediction	ghanekar@tropmet.res.in	M.Sc.
Shri S.G. Narkhedkar	Objective Analysis, Including Satellite Data in Weather Forecasting	narkhed@tropmet.res.in	M.Sc.
Shri S.S. Sabade	Monsoon Variability and Teleconnections	sabade@tropmet.res.in	M.Sc.

Name	Specialisation	E-mail Address	Academic Qualifications
Dr. C. G. Deshpande	Aerosol Physics, Atmospheric Electricity	cgdesh@tropmet.res.in	M.Sc., Ph.D.
Smt. Sathy Nair	Satellite Meteorology and Applications of Satellite Data in Weather Forecasting	Sathy1957@hotmail.com	B.Sc.
Dr. P.D. Safai	Surface Ozone, Atmospheric Aerosols and Precipitation Chemistry	safai@tropmet.res.in	M.Sc., Ph.D.
Dr. M.S. Mujumdar	Climate Modelling	mujum@tropmet.res.in	M.Sc., Ph.D.
Shri. K.K. Dani	Remote Sensing of Atmospheric Aerosols and Trace Gases	kundan@tropmet.res.in	B.Sc.

Managerial and Technical Support

Administration, Finance and Purchase Support

Shri V.K. Asrani, Administrative Officer

Ms. N.S. Girija, Accounts Officer

Shri A. Girijavallabhan, P.A. to Director

Shri S.R. Nirgude

Shri V.G. Bathija

Shri V.S. Kulkarni

Shri S.N. Prasad

Shri M.H. Gangawane

Computer and Data Archival

Smt. S.U. Athale, Head of the Division

Shri S.P. Gharge

Shri O. Abraham

Smt. A.R. Sheshagiri

Dr. (Smt.) R.R. Joshi

Smt. V.V. Sapre

Shri P.W. Dixit

Library, Information and Publications

Smt. A.A. Shiralkar, Head of the Division

Smt. V.V. Massey

Shri P.G. Bhegade

Shri A.L. Sagar

Shri R.P. Mali

Shri B.C. Morwal

Shri S.C. Rahalkar

Shri V.V. Deodhar

Shri T.A. Disale

Shri V.H. Sasane

Workshop

Shri S.B. Jaunjale

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Research Fellows and Project Personnel

Name	Project (Funding Agency)
IITM Research Fellows	
Shri K.V. Ramesh	Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate over the Indian-Asia Pacific Regions.
Kum. Neetu Saraf	Impact of Anthropogenic and Natural Activities on Atmospheric Chemistry and Climate Forcing Factors with their Variability.
Shri P. Rahul Chanda Reddy	Studies on Dynamical Ocean Modelling
Kum. Rohini Bhawar	Remote Sensing of the Atmosphere Using Lidar and Other Ground Based Techniques.
Shri Vimalesh Pant	Surface Observations of Atmospheric Electricity and Electric Properties of Clouds.
Kum. Suchitra Sundaram	Diagnostics and Modelling Studies of Long Term Trends and Variability of Climate over the Indian-Asia Pacific Regions.
Kum. Nattala Jyothi	Regional Aspects of Global Climate Change and Variability.
Project Personnel	
Dr. S.H. Damale (Consultant)	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, Govt. of India).
Dr. R.S. Maheskumar	An Observational Study of Direct Radiative Forcing of Atmospheric Aerosols on the Surface Reaching Solar Flux (Department of Science and Technology, Govt. of India).
Shri Dipayan Roy	Meso-scale Modelling for Monsoon Related Prediction (Council for Scientific and Industrial Research, New Delhi).
Shri Hemantkumar Chaudhari	Meso-scale Modelling for Monsoon Related Prediction (Council for Scientific and Industrial Research, New Delhi).
Shri Umesh Kumar Singh	Studies of Meso-scale System over Indian Region (Department of Science and Technology, Govt. of India).
Shri Pankaj Kumar	IMD-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department).
Shri Ramesh Kumar Yadav	IMD-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department).
Shri K. Jagdish	Development of Regional Tree-ring Data Network to Study the Past Climate Variations on Decadal to Century Time Scale over Asia (Indian Space Research Organisation).

Name	Project (Funding Agency)
Shri V. Prasanna	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact (National Communication (NATCOM), Ministry of Environment and Forests, New Delhi)
Dr. Pankaj Kumar Mishra	Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.)
Kum. K. Kamala	Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.)
Shri Sachin Bhandare	Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.)
Shri Vasu Rajyam	Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.)
Kum. Preethi Bhaskar	Management Perspectives to Seasonal Climate Forecast in Mixed Cropping System of Southern India's Semi Arid Field (Global Change System for Analysis, Research and Training, Asia Pacific Network)
Shri Amit Kumar Pandey	Atlas of Spatial Features of Moisture Regimes and Rainfall of India during 19th and 20th Centuries (Department of Science and Technology, Govt. of India)
Shri Atul Kumar Shrivastava	Study of Coupling between Lidar / Radiometer Measured Aerosol and Radar Sensed Winds (Indian Space Research Organisation)
Shri P. Siva Praveen	Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments (Department of Science and Technology, Govt. of India)
Shri Shaiju Augustin	Monitoring of Pollutant Species in Rain Water / Dust Fall in Different Environments around the National Capital Region of Delhi (Department of Science and Technology, Govt. of India)
Shri Manish M. Kokate	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling (Ministry of Environment and Forests, Govt. of India)
Kum. Suby Oommen	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling (Ministry of Environment and Forests, Govt. of India)
Kum. Ashwini R. Deshpande	Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling (Ministry of Environment and Forests, Govt. of India)

Name	Project (Funding Agency)
Shri Sachin Gunthe	Experimental and Theoretical Studies of Secondary Pollutants and Ozone for Chemical Forecasting (Department of Science and Technology, Govt of India).
Kum. Cini Sukumaran	Measurement of Micrometeorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment (ARMEX) (Department of Science and Technology, Govt. of India).
Kum. T. Rajitha Madhu Priya	Measurement of Micrometeorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment (ARMEX) (Department of Science and Technology, Govt. of India).
Shri Akhilesh Kumar Mishra	Numerical Modelling of the Upper Ocean Mixed Layer Over Indian Ocean Region Using Satellite Data (Department of Science and Technology, Govt. of India).
Shri B.H. Vaid	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data (Department of Science and Technology, Govt. of India).
Shri Jasti Sriranga Chowdary	Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD / INDOMOD 10th plan programme) (Department of Ocean Development, Govt. of India).
Shri Mrinal Kanti Biswas	Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber/ Frequency Domain (Department of Science and Technology, Govt. of India).
Shri. Vinaykumar	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th plan programme) Department of Ocean Development, Govt. of India).
Shri Basant Kumar Samala	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th plan programme) (Department of Ocean Development, Govt. of India).
Smt. P. Swapna	Air-Sea Interactions in the Indian Ocean Region (DOD/ INDOMOD 10th plan programme) (Department of Ocean Development, Govt. of India).
Shri Sachin Deshpande	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, Govt. of India).
Shri Narendra Singh	Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, Govt. of India).
Shri Mohd Shahabuddin	Information Technology Assistance in Library, Information and Publication Services.

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M/s M. S. Godbole & Associates

CHARTERED ACCOUNTANTS

67 / 2, 4, Uberoi House, Nal Stop, Karve Road, Pune 411 004
Phone : 2543 35 40, E-mail : mgodbole@vsnl.com

To
The Members,
Indian Institute of Tropical Meteorology,
Homi Bhabha Road,
Pashan,
Pune-411 008.

Sub : Audit Report for the Financial Year ended 31st March 2004

Sirs,

We have audited the attached Balance Sheet of the Indian Institute of Tropical Meteorology as on 31st March, 2004 and the Income & Expenditure account as on that date annexed thereto. These financial statements are the responsibility of the management. Our responsibility is to express an opinion on these financial statements based on our audit.

We have concluded our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statements presentation. We believe that our audit provides reasonable basis for our opinion.

a) We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

b) The Balance Sheet and Income & Expenditure Account dealt with by the report are in agreement with the books of accounts.

c) We invite your attention to the following:

   i) In respect of funds received for earmarked projects, no separate investment / bank accounts are made. As informed this is due to large number of projects. Hence interest income earned on these funds are not credited to respective projects but is shown as consolidated figures in Income & Expenditure Account.

d) In our opinion and to the best our information and according to the explanations given to us, the said Balance Sheet and Income & Expenditure Account read together with significant Accounting Policies followed and other observations give a True and Fair view:

   i) In the case of Balance Sheet, of the state of affairs as at 31st March 2004 .

   ii) In case of Income & Expenditure Account, of the excess of Income over expenditure for the year ended on that date.

For **M. S. Godbole & Associates**
Chartered Accountants

sd/-

(Mohan S. Godbole)
Partner

Date : 25 August, 2004
Place : Pune

Auditor's Report

Following are our observations based on books, records, and documents produced before us and information and explanation given by the officials of the Institute :

A. **Maintenance of Fixed Assets Register :** To have proper control over the assets, it is recommended that the entries in the said register should be made as soon as the entries are made in the store records.

B. **Physical Verification Report of Dead Stock :** Physical verification report for the year ended 31st March, 2003 is on record. Preparation of the physical report for the year ended 2004 is still in progress.

C. **Claims Receivable :** (Schedule 6 to Balance Sheet)

Claims receivable amounting to Rs. 3,60,352/- pertains to excess expenditure on some projects. The above said amount is receivable from the concerned sponsors of the projects and advances given to employees.

D. **Land Dispute with National Chemical Laboratory (NCL), Pune** : We have been informed that a high level discussion with NCL officials had taken place regarding encroachment of the land belonging to IITM. It has been explained that NCL is getting the land surveyed. However efforts are in progress to get the land in question from NCL as per the demarcation of land shown by the city survey office.

E. **Arbitration Case :** As per the request letter from CPWD, the Institute has deposited Rs. 3,45,000/- with CPWD to settle the case with M/s. Naidu & Co. which has given up the work of construction of A, B, C type quarters including water supply and sanitary provisions half way. The case went against CPWD and the amount of deposit is still recoverable from CPWD.

This amount is due since 1992 and inspite of follow-up for recovery by the Institute, no recovery has been possible till date. We are of the opinion that, given the nature of advance and the time since which it is outstanding, the advance seems to be irrecoverable.

F. **Assets Written Off :** During the year fixed assets to the extent of Rs. 3,316.90 have been written off as per the resolution passed by the governing council.

For **M. S. Godbole & Associates**
Chartered Accountants
sd/-
(Mohan S. Godbole)
Partner

Date : 25 August, 2004
Place : Pune

Compliance to Audit Observations

A. **Maintenance of Fixed Assets Register.**	The concerned Division has taken note of it and are complying with the process.
B. **Physical Verification Report of Dead Stock.**	A committee for the purpose has been constituted and the report with compliance would be furnished to audit as soon as it is ready.
C. **Claims Receivable**	They pertain to advances paid to staff and which are receivable. The present status of the claims is enclosed.
D. **Land Dispute with National Chemical Laboratory (NCL), Pune**	It is understood that the City Survey Office have surveyed the NCL land and as per the report, the land belongs to IITM. The NCL authorities have been requested to settle the dispute.
E. **Arbitration Case**	The case is pending for a long period. The Chief Engineer, CPWD, Nagpur has been requested to settle the matter by refunding amount of Rs.3,45,000. But no reply has been received in spite of continued follow up.
F. **Assets Written Off**	No comments.

SIGNIFICANT ACCOUNTING POLICIES

A. BASIS OF ACCOUNTING :

The financial statements are prepared by the institute on the basis of historical cost convention, unless otherwise stated and on accrual method of accounting.

B. FIXED ASSETS

Fixed assets stated in the Balance Sheet are at their cost of acquisition inclusive of freight, octroi and other direct and indirect costs in respect thereof less depreciation. Assets acquired for sponsored projects are written off as project cost.

C. Depreciation

Depreciation is provided on the straight line method at the following rates.

Sr. No.	Particulars	Rate
1.	Building Tube wells & Overhead Water Tank	1.63%
2.	Furniture & Fixtures	6.33%
3.	Plant & Machinery, Scientific Equipment Office Equipment	4.75%
4.	Computers, Workstations	16.21%
5.	Vehicle	9.5%
6.	Books	100%

D. GOVERNMENT GRANTS :

a. Government grants of the nature of contribution towards capital cost are shown as capital grants in the Balance Sheet.

b. Grants in respect of specific fixed assets acquired are shown as a deduction from the cost of the related assets.

c. Government grants are accounted on realization basis.

E. RETIREMENT BENEFITS :

1. Retirement benefits to the employees comprise of payments to gratuity, superannuation and provident fund under the approved schemes of the society. Contribution to pension fund for payment of gratuity is made on ad-hoc basis and not on the basis of actuarial valuation. No provision is made for encashment of leave entitlements of employees and same is provided on cash basis.

F. CONTINGENT LIABILITY :

Commitments given towards purchase of Scientific Equipments Rs. 86,94,220/-.

G. Previous year figures have been regrouped wherever necessary.

For **M. S. Godbole & Associates**
Chartered Accountants
sd/-
(Mohan S. Godbole)
Partner

Date : 25 August, 2004
Place : Pune

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31.03.2004

	Schedule	Current Year	Previous Year
INCOME			
Income from Sales / Services			
Grants / Subsidies	7	6,76,40,634.03	7,86,17,739.01
Fees / Subscriptions	—	0.00	0.00
Income from Investments (Income on Invest from earmarked / endow. Funds transferred to Funds)	—	0.00	0.00
Income from Royalty Publication etc.	8	0.00	0.00
Interest Earned	9	16,76,672.00	12,75,079.77
Other Income	10	9,42,332.16	5,33,825.00
Increase / (decrease) in stock of Finished goods and works-in-progress	—	—	0.00
TOTAL (A)		**7,02,59,638.19**	**8,04,26,643.78**
EXPENDITURE			
Establishment Expenses	11	5,16,77,069.32	4,80,17,338.04
Other Administrative Expenses etc.	12	1,41,76,518.54	1,18,70,326.91
Expenditure on Grants Subsidies etc.	13	0.00	30,000.00
Interest	—	0.00	0.00
Depreciation during the year	—	40,23,518.00	27,60,623.00
TOTAL (B)		**6,98,77,105.86**	**6,26,78,287.95**
Balance being excess of Income over Expenditure (A-B)	—	3,82,532.33	1,77,48,355.83
Transfer to Special Reserve (Specify each)	—	0.00	0.00
Transfer to / from General Reserve	—		
Previous years depreciation	—	28,708.00	5,39,06,641.76
BALANCE BEING SURPLUS / (DEFICIT) CARRIED TO CORPUS / CAPITAL FUND	—	3,53,824.33	-3,61,58,285.93
Significant Accounting Policies contingent Liabilities and Notes on Accounts	14		

Date : 25 August, 2004
Place : Pune

For **M. S. Godbole & Associates**
Chartered Accountants

sd/-
Director
Indian Institute of Tropical Meteorology
Pune - 411 008

sd/-
Accounts Officer
Indian Institute of Tropical Meteorology
Pune - 411 008

sd/-
(Mohan S. Godbole)
Partner

Note : Schedules are not enclosed

BALANCE SHEET AS AT 31.03.2004

CORPUS / CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS / CAPITAL FUND	1	8,21,91,504.96	6,68,36,523.42
RESERVES AND SURPLUS	2	2,11,68,677.25	2,04,73,662.29
EARMARKED / ENDOWMENT FUNDS	3	1,14,58,024.74	1,01,22,576.25
SECURED LOANS AND BORROWINGS	—	0.00	0.00
UNSECURED LOANS AND BORROWINGS	—	0.00	0.00
DEFERRED CREDIT LIABILITIES	—	0.00	0.00
CURRENT LIABILITIES AND PROVISIONS	4	24,09,724.95	23,18,488.73
TOTAL		**11,72,27,931.90**	**9,97,51,250.69**
ASSETS			
FIXED ASSETS	5	7,32,72,453.52	6,23,23,522.31
INVESTMENTS - FROM EARMARKED / ENDOWMENT FUNDS	—	0.00	0.00
INVESTMENTS - OTHERS	—	0.00	0.00
CURRENT ASSETS LOANS ADVANCES ETC.	6	4,39,55,478.38	3,74,27,728.38
MISCELLANEOUS EXPENDITURE (TO THE EXTENT NOT WRITTEN OFF OR ADJUSTED)	—	—	—
TOTAL		**11,72,27,931.90**	**9,97,51,250.69**
SIGNIFICANT ACCOUNTING POLICIES	14		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	—		

Date : 25 August, 2004
Place : Pune

For **M. S. Godbole & Associates**
Chartered Accountants

sd/-
Director
Indian Institute of Tropical Meteorology
Pune - 411 008

sd/-
Accounts Officer
Indian Institute of Tropical Meteorology
Pune - 411 008

sd/-
(Mohan S. Godbole)
Partner

Note : Schedules are not enclosed

इण्डोक्लिम कार्यशाला के अवसर पर सांस्कृतिक कार्यक्रम

भारतीय उष्णदेशीय मौसमविज्ञान संस्थान

(भारत सरकार, विज्ञान और प्रौद्योगिकी मंत्रालय का एक स्वायत्त संस्थान)

डॉ. होमी भाभा मार्ग, पाषाण, पुणे - **411 008,** महाराष्ट्र, भारत

ई-मेल : lip@tropmet.res.in दूरभाष : **91-020-25893600**

वेब : http://www.tropmet.res.in फॅक्स : **91-020-25893825**