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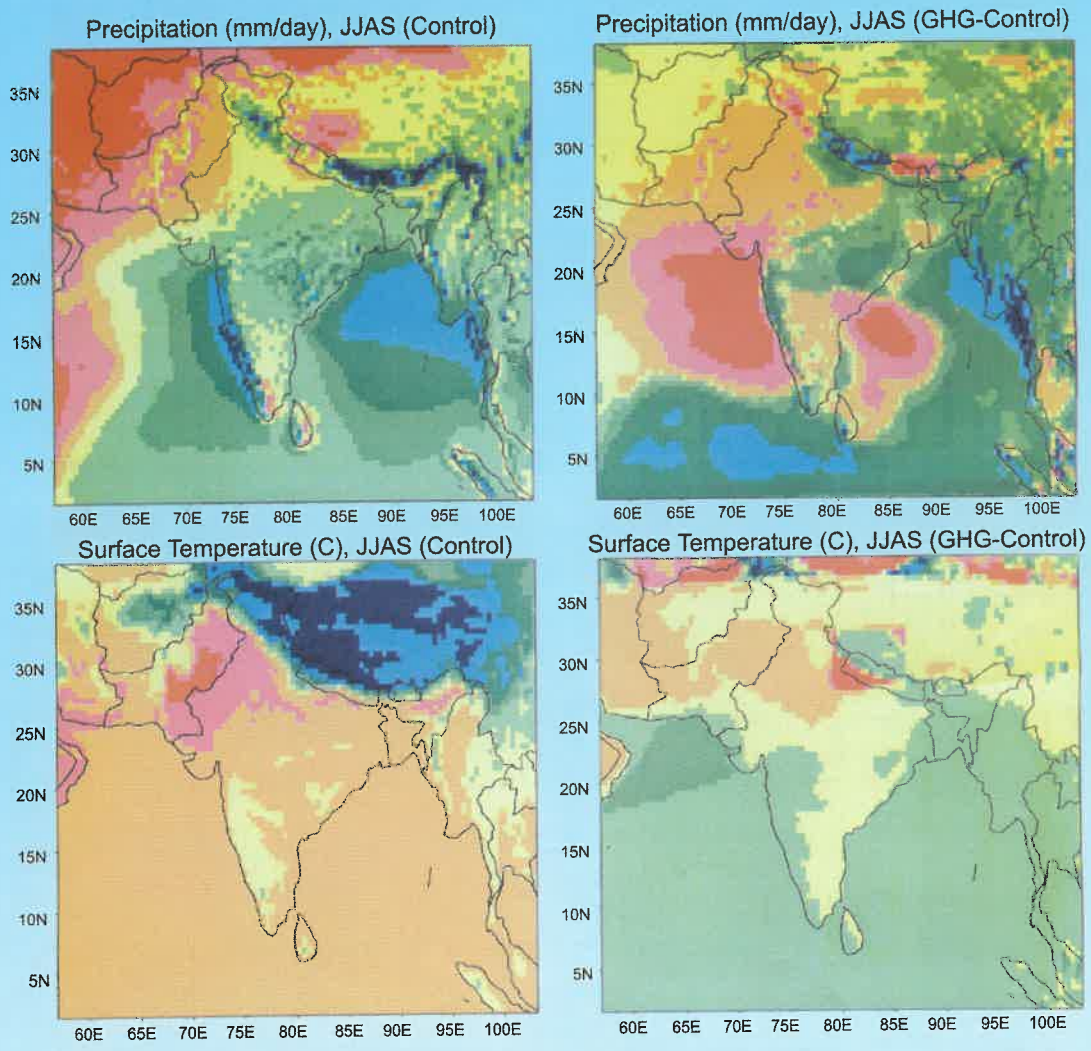
2001 - 02



INDIAN INSTITUTE OF TROPICAL METEOROLOGY
PUNE

Governing Council of the IITM

Finance Committee of the IITM

Visit of the National Commission for SC/ST

Annual Report
2001 - 02

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

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Tenure : Governing Council - Two Years,
Finance Committee - No Tenure

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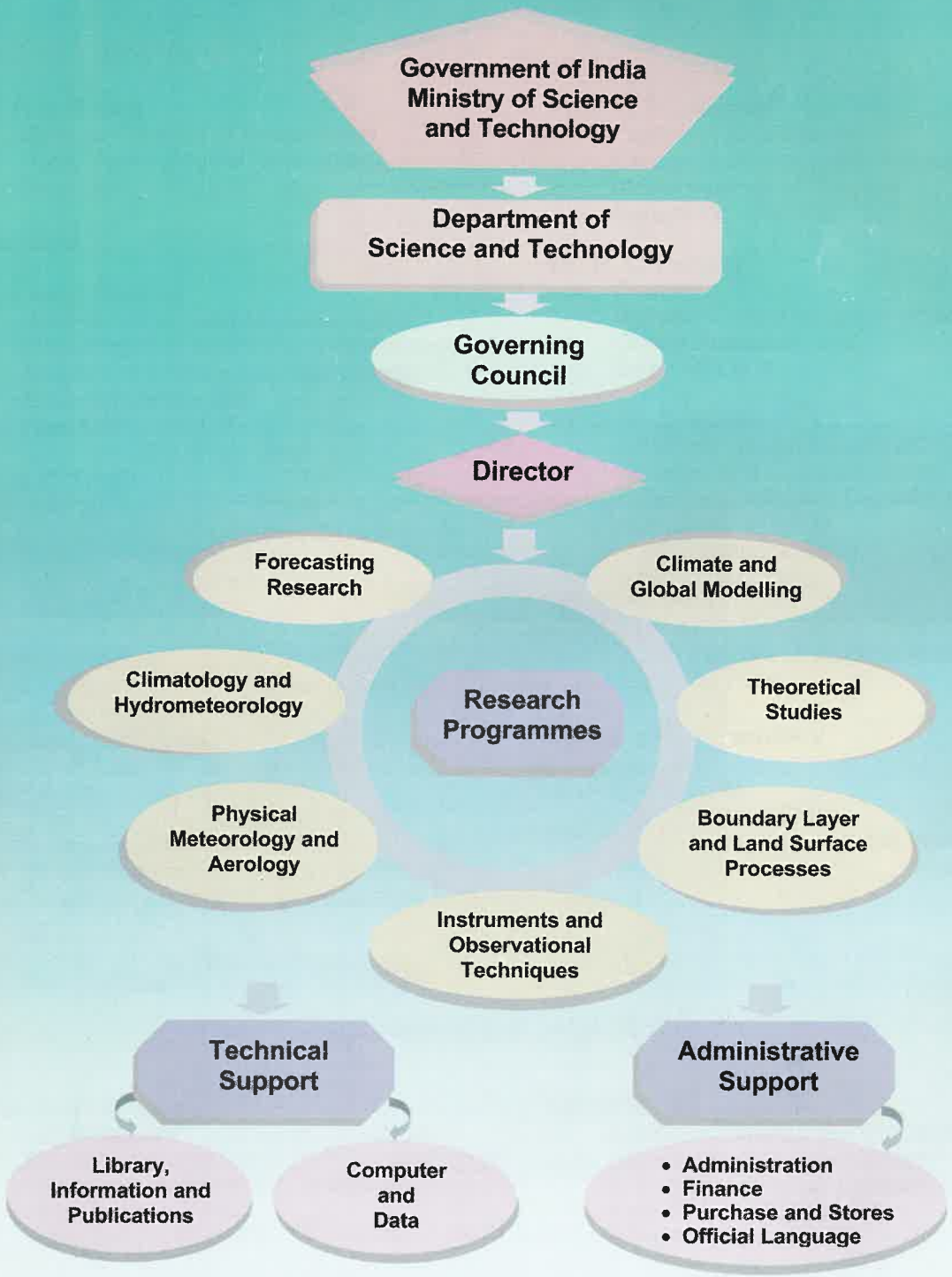
Front Cover : Summer monsoon rainfall and surface air temperature patterns as simulated by the HadRM2 regional climate model



Organisational Profile

Foreword

The year 2001-02 witnessed a number of important scientific, academic and administrative activities. Keeping pace with the developments in the new millennium, the Institute initiated several new research projects in the frontline thrust areas pertaining to various aspects of the meteorology and atmospheric sciences, of its own and also in collaboration with other organizations within and outside the country. The scientific research outputs have been published in peer reviewed journals and presented at the national and international scientific gatherings.

The Institute arranged manpower development programmes by organizing Training Workshops and Schools on specialized topics of meteorology and atmospheric sciences for the benefit of the young scientists and academicians all over the country. The Institute also supported such activities of other Institutes by co-sponsoring and providing its expertise and infrastructural facilities .

The Institute continued its collaboration with various Indian Universities in their post-graduate and Ph.D. programmes by providing its expertise and library /computer facilities to the students for their teaching and research work. Also, under the Memorandum of Understanding (MoU) with the University of Pune, The Institute is conducting M.Tech. course in Atmospheric Physics.

The year also witnessed a large number of exchange visits of scientists for meetings, seminars, workshops, brainstorming sessions and specialized research collaborations in the country and abroad.

The Institute took efforts to increase interaction of students and public with the scientists by arranging various science popularization programmes such as scientific popular lectures, film shows, exhibitions, open days and special tours to the laboratories and other facilities.

It is my pleasure to present the Annual Report of the Institute for the year 2001-02 highlighting these aspects. A general overview of the research results is presented in the opening pages of the report with a summary of significant highlights. A list of research publications during the year will serve the purpose of reference material for the exchange of research ideas amongst the scientific community.

I take this opportunity to thank the Department of Science and Technology, Government of India, and Governing Council and Finance Committee of the Institute for continued support and encouragement. I am also thankful to all the scientific and supporting staff of the Institute for their kind cooperation and devotion to work.

(G.B. Pant)
Director

40th FOUNDATION DAY CELEBRATIONS

Welcome address by
Dr. G.B. Pant, Director, IITM

Dr. R.R. Kelkar, Director General of Meteorology
is welcomed by Dr. G.B. Pant

Address by
Dr. R.R. Kelkar

Inauguration by the Chief Guest Dr. Ashok Kolaskar,
Vice Chancellor, University of Pune, Shri Dattatraya Gaikwad,
Mayor, Pune Muncipal Corporation was the Guest of Honour

Inaugural speech
by
Dr. Ashok Kolaskar

Foundation Day Lecture by
Dr. V.G.Bhide, Former Vice-Chancellor,
University of Pune, Pune

Presentation of IITM Silver Jubilee Award for the year 1999 to Dr. G.K.Manohar,
Dr.(Smt.) S.S.Kandalgaonkar and Shri M.J.R. Tinmaker (R-L)

Silver Jubilee Lecture by
Dr. G.K. Manohar

Presentation of IITM Excellent Performance Award for the year 2000 to
Smt. S.U. Athale, Smt. B.G. Wadikar and Shri. T.R.Waghmare (R-L)

Dr. R. R. Kelkar inaugurating the
Excimer Laser system of the IITM

Events

- PAGES (Past Global Changes) Training Workshop on Palaeoclimatic Methods was organized during 14-19 May 2001 for post graduate students and young scientist.
- The Second SERC School on "Cloud Physics and Atmospheric Electricity-Frontiers" sponsored by the Department of Science and Technology, New Delhi was organized during 7 June - 5 July 2001. Delegates from all over India participated in the school.
- Seminars on "Radio and Internet (RANET) for Diffusion of Agrometeorological Information" and "Monsoon Research in India" held on 30 and 31 July 2001 in conjunction with the 6th Session of Scientific Advisory Committee (SASCOM) of the African Centre of Meteorological Application for Development (ACMAD) were co-sponsored by the Institute.
- 40th Foundation day of the Institute was celebrated on 17 November 2001.

Research

- Forecast for seasonal monsoon rainfall for the year 2001 was prepared based on statistical and dynamical techniques and provided to the India Meteorological Department as an input in the preparation of their national forecast.
- The Advance regional Prediction System (ARPS) meso-scale model was integrated for the forecasting of heavy rainfall events.
- Examination of the decadal variability of the Indian monsoon rainfall indicated its de-linking with the global warming.
- Consistency and quality control analyses were made on the meteorological data for different periods for the study of surface climatology of Western Himalaya.
- Design storm studies were carried out for the construction of major hydroelectric projects over the Siang river basin in Northeast India undertaken by the National Hydroelectric Power Corporation. Design raindepths were also estimated over different river basins in India.
- Observations of submicron aerosol size made in Antarctica have shown that the total aerosol concentration increases by an order of magnitude whenever a low-pressure system passes over the station.
- Oceanic response to moving cyclones in the Indian Ocean was studied using the IITM Reduced Gravity Model. An idealized cyclonic vortex was generated to force the model. The model produced cooling and warming for this place were found to be closer to the observed ones.
- The monthly mean surface wind stresses as simulated by COLA Atmospheric General Circulation Model were used to drive the McCreary Ocean Model for simulation of SSTs over Indian Ocean region. The simulated SSTs show a better correspondence with the observed values.
- A methodology has been developed for making an optimal use of global sea surface temperatures for long lead prediction of Indian summer monsoon rainfall.

Collaborations / Field Observations

- The Institute has taken up two major research projects on "Climate Change Scenario Development and Impacts on Water Resources", as part of the joint Indo-UK collaborative programme on Indian Climate Change Impacts. A state-of-the art regional climate model has been installed at the Institute for this work.
- An Indo-French project on the "Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change" has been taken up.
- Under the programme on regional Air Pollution in Developing Countries the Institute has undertaken an Indo-Swedish collaborative project entitled, "Composition of Acid Deposition", with the Meteorological Institute of Stockholm University, Sweden.
- First phase of the IITM-SHAR collaborative project of "Establishment of Field Mill Network at SHAR for Thunderstorm Warning and Forecasting of the Warning Levels" has been completed.
- Special field observations were conducted in industrial and residential areas of major cities for the study of size distribution of aerosols, suspended particulates, Aitken nuclei, surface ozone, fog water and meteorological parameters.
- A joint field experiment was conducted with the Health and Safety Division of the Indira Gandhi Centre for Atomic Research, Kalpakkam for the study of the coastal atmospheric boundary layer characteristics.
- A new initiative has been taken up to carry out collaborative research with the India Meteorological Department with the recruitment of two research scholars to work at the Institute on long-range prediction.

SECOND SERC SCHOOL
on Cloud Physics and Atmospheric Electricity - Frontiers

Inauguration by Dr. Rajaram Nityananda, Director, National Centre for Radio Astrophysics, Pune (centre)

Release of Volumes of Lecture Notes by Dr. Rajaram Nityananda

Inaugural Lecture by Dr. Rajaram Nityananda

Dr. P.B. Rao, Visiting Professor, National MST Radar Facility, Tirupati presenting prizes to the Meritorious participants (R-L) Shri P.Murugavel, Sq. Leader Shri V.K. Mishra and Dr. C.G.Deshpande

Feedback from one of the participants

Participants and Faculties

PAGES TRAINING WORKSHOP

Welcome address by Dr. G.B.Pant, Director IITM

Inaugural address by Prof. B.L.K. Somayajulu, PRL, Ahmedabad

Forecasting Research

The research programmes of this Division are formulated 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 broad objectives:

- Study of meso-scale systems and meso-scale modelling.
- Study of planetary boundary layer characteristics using routine weather, LASPEX and BOBMEX data.
- Application of satellite data in objective analysis for NWP models.
- Teleconnections of monsoon variability over South and East Asia.
- Interannual and decadal scale summer monsoon variability over India and its association with El Nino Southern Oscillation, North Atlantic Oscillation and Eurasian snow cover, and their application in extended range predictions.
- Study of the intraseasonal variability of summer monsoons.

Numerical Weather Prediction Research and Meso-scale Modelling

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

The Advance Regional Prediction System (ARPS) meso-scale model was integrated for 24 hrs in nested grid mode using the data of 00UTC, 12 April 2001 as input when there was a heavy rainfall event over Kerala and South Karnataka region. The inner grid of 30 km resolution was one-way connected to the coarse-grid of 60 km. The results showed that the model could produce the observed heavy precipitation over the south-Karnataka region. Another numerical experiment was carried out with the same ARPS model to simulate a thunderstorm event occurred over Agartala station in the early hours of 2 May 1979. The results showed high values of maximum vertical velocity representing strong convection. The 3-hr model run produced considerably high rainfall over the station.

Numerical experiment for simulating the movement and associated rainfall of a slowly moving low pressure area during 28-31 July 1998 off the North Andhra- South Orissa coast, was carried out with Regional Atmospheric Modelling System (RAMS). The model was integrated for 72 hrs with horizontal resolution of 48 km. The model simulated the slow movement and associated rainfall fairly well.

The case studies in detecting meso-scale convective regions using 3 hourly-digitized IR data from INSAT were carried out and verified with available weather reports of the India Meteorological Department (IMD). A number of regions with meso-scale convective clouds were detected over North India, Central and Northeast India. Weather reports of the IMD suggested that these regions experienced severe weather in association with the detected convective region.

Extended Range Weather Prediction Research

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

Western Himalayan snow cover and Indian Monsoon Rainfall

Analysis of 15 years (1986-2000) of INSAT derived snow estimates revealed that the spring snow cover area has been declining and snow has been melting faster from winter to spring since 1993 (Figure 1).

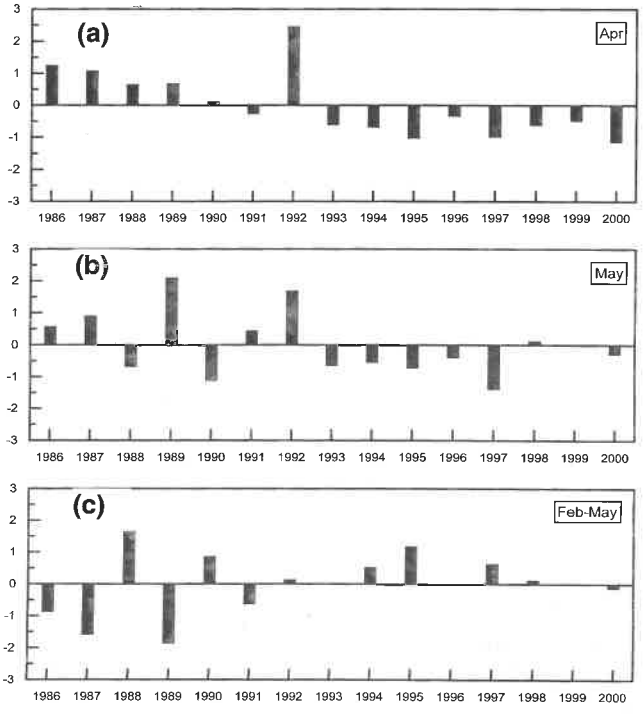


Fig. 1: Year–to-year variations of standardized snow cover areas for April and May, and snow melt during February-May depicting the interannual variability in snow estimates over Western Himalayas. (a) and (b) show the declining snow cover areas during spring and (c) shows 1990s, the warmest decade of the millennium due to faster snow melting from winter to spring.

Connections between snow cover estimates and IMR revealed that snow melt from winter to spring is better related with the Indian monsoon rainfall (IMR) than spring snow cover area. NCEP/NCAR data further showed that the heat low over northwest India and the monsoon circulation over the Indian sub-continent intensified (weakened) when the snow cover area was smaller (extensive) and snow melted faster (slower).

Indian monsoon variability in a global warming scenario

The climate model projections based on the IPCC (2001) report suggested an increase in the Asian monsoon variability and changes in the monsoon strength. In the light of the global warming scenario the inter-annual and decadal variability of IMR was examined by using observed data for the period 1871-2001. There is no clear evidence to suggest that the variability of IMR is affected by the global warming. Though the 1990s have been the warmest decade of the millennium the IMR variability reduced drastically. Connections between the ENSO phenomenon, NH temperature and the Eurasian snow revealed that the relationships are weakened and changed the signs in 1990s (Figure 2) suggesting that the IMR is de-linked not only with the Pacific but with the Eurasian continent also. The weak NH temperature / snow

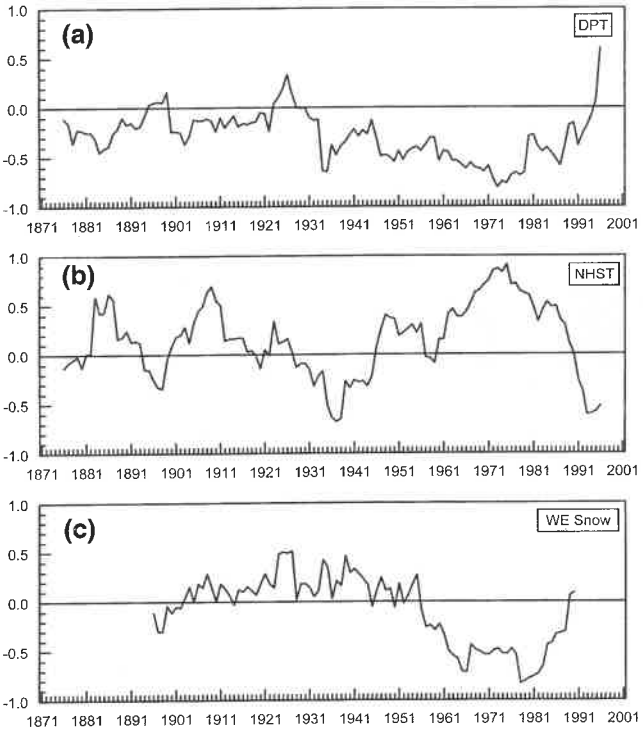


Fig. 2: 11-year sliding correlations of Indian monsoon rainfall with (a) Darwin Pressure Tendency (DPT: index of ENSO), (b) Northern Hemisphere Surface Temperature (NHST: Index of global warming) and (c) Western Eurasian Snow Depth (WE Snow : Index of global warming). The relationships have changed with time.

relationships with IMR in 1990s further suggested that global warming need not be a cause for the recent ENSO-Monsoon weakening.

Summer monsoon rainfall variability over South Korea

Seasonal rainfall patterns over South Korea were classified by a *k*-means clustering method using data for a 40-year period (1961-2000). Distinct dominant types were obtained. The contrasting circulation features associated with the types were related to the position, shape and strength of the North Pacific Subtropical High and the warm pool over the Western Pacific.

Characteristic features of the intra-seasonal Quasi–biweekly oscillations (10-20 days period) and Madden Julian oscillations (30-60 days period) were investigated by applying the Butter-worth band-pass filter to the 5-day rainfall data over South Korea using data for a 23-year period (1978-2000). The inter-annual variability suggested that the monsoon rainfall over South Korea is likely to be more when the Madden Julian oscillations are strong and the Quasi–biweekly oscillations are weak, in contrast to the behaviour over the Indian region.

Impact of North Atlantic Oscillation and Southern Oscillation on Indian monsoon variability

The simultaneous effect of North Atlantic Oscillation (NAO) and Southern Oscillation (SO) on the cyclonic activity over the North Indian Ocean was investigated. Below-normal pre-monsoon cyclonic activity was found to be associated with the positive phase of the Effective Strength Index (ESI) of both the phenomena and vice a versa. Winter ESI can serve as a useful guide for pre-monsoon cyclonic activity. In another study it was found that, there is a statistically significant direct relationship between ESI and 850 hPa zonal wind indices, over central equatorial Pacific Ocean. The study is useful to understand the mechanism of the Walker cell circulation in relation to NAO and SO (Figure 3).

The analysis of the duration of breaks (Number of break days) in SW monsoon in the month of July and August, with North Atlantic Oscillation indices (NAOI) was carried out for 109 years' data (1881-1988), on monthly, seasonal and decadal scale. It is observed that, during the strong phase of NAO there is either less duration of breaks or no breaks in the monsoon activity, while during weak phase of NAO the break monsoon condition prevails significantly.

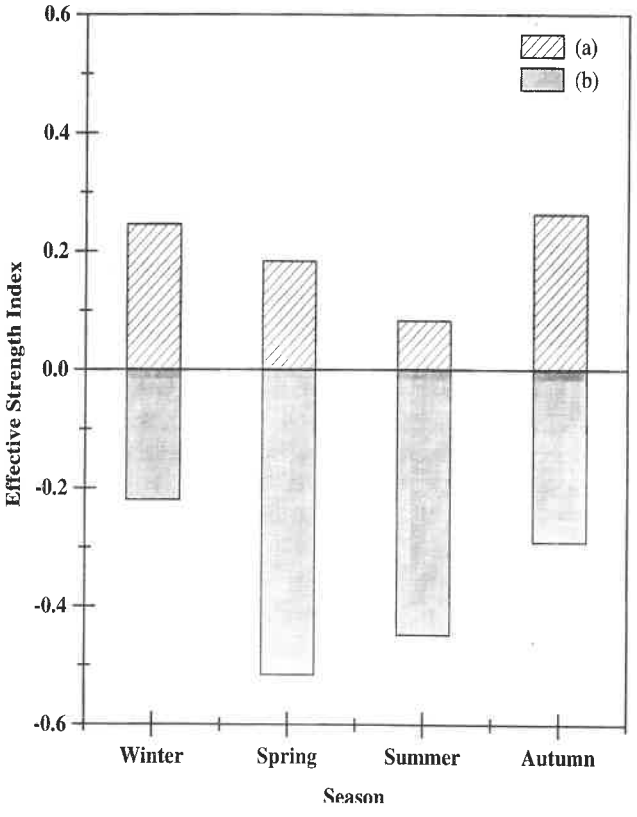


Fig. 3: Composite seasonal mean effective strength index for (a) 31 below-normal years and (b) 18 above-normal years of pre-monsoon cyclonic activity over North-Indian Ocean during 1951-1999.

Tibetan Plateau temperature and Indian Monsoon Rainfall

The temperature field over the Tibetan Plateau was examined in relation to the Indian Monsoon Rainfall (IMR) variability using data for the period 1957-1989. The January temperature anomaly of northeastern part of the plateau was found to have a significant negative relationship with the subsequent IMR. The relationship was consistent and stable during the period of analysis.

Spatio-temporal variability of convection over the Indian Ocean

The spatio-temporal variability of rainfall and cloud cover in relation to the sea surface temperature distribution over the Indian Ocean warm pool (10°N–15°S, 60°–100°E) was examined using NOAA OLR and GPCP precipitation data. The dipole mode of the summer OLR showed a strong positive loading between 5°–10°S, east of 90°E. This area coincides with the underlying cold water, while a reverse dipole mode was observed between 5°–10°N, 65°–75°E over the high warm waters.

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)

Energetics of monsoon circulation

Energetics of lower tropospheric zonal waves at 850 hPa during onset, as well as established and withdrawal phases of monsoon were studied for 1994, 1995 and 1996. The analysis showed that energetics of wave 0 over R1 (10°S-10°N), long waves, viz., wave numbers 1 and 2 over R2 (10°N-30°S) and short waves having wave numbers between 3 and 10 over R3 (30°- 50°N) influence the monsoon activity over India on intra-seasonal scale. Momentum transport of wave 0 over latitudinal belt L0 (12°S-3°N), wave 1 over the belt L1 (10°-15°N) and wave 2 over the belt L2 (33°-45°N) showed a significant correlation with all India rainfall on a weekly scale. Larger southward momentum transport of wave 0 over L0 and larger northward momentum transport of wave 1 over L1 and that of wave 2 over L2 enhance the monsoon activity over India.

Temporal variation of kinetic energy of wave number 1 was studied for three monsoon seasons of 1994, 1995 and 1996. A steep decrease was found in the kinetic energy prior to the formation of depressions/cyclonic storms in the Bay of Bengal. The kinetic energy of wave number 1 weakens (strengthens) when the depression/cyclonic storm in the Bay of Bengal strengthens (weakens). Wave to wave interaction L(n) showed that wave number 1 supplied kinetic energy during the formation/ intensification of depression/ cyclonic storm in the Bay of Bengal. After decay of the cyclonic system, wave number 1 received the kinetic energy (Figure 4). The study has been found to be helpful in getting prior signal about the formation of the depression/ cyclonic storm in the Bay of Bengal.

Transport of angular momentum (T_m) and sensible heat (T_h) were computed for 50 and 30 hPa levels for January and July representing winter and summer conditions at 30°N and 60°N latitudes for the years 1987 and 1988. At 30°N, T_m was found to be mainly northward at both the levels in these years. However, there was larger northward transport of momentum in 1987 than in 1988 in winter condition. At 60°N, more northward transport of momentum was present in winter for 1987, whereas T_m was southward in winter as well as in summer of 1988. Transport of sensible heat was found to be northward at 30°N in winter at both the levels for both the years. However, in summer it was southward in 1987 and northward in

1988. At 60°N, northward T_h was more in 1987 as compared to that in 1988. Whereas the transport of T_h was northward in 1987 and southward in 1988 in summer at 50 hPa level and it was southward at 30 hPa level for both the years.

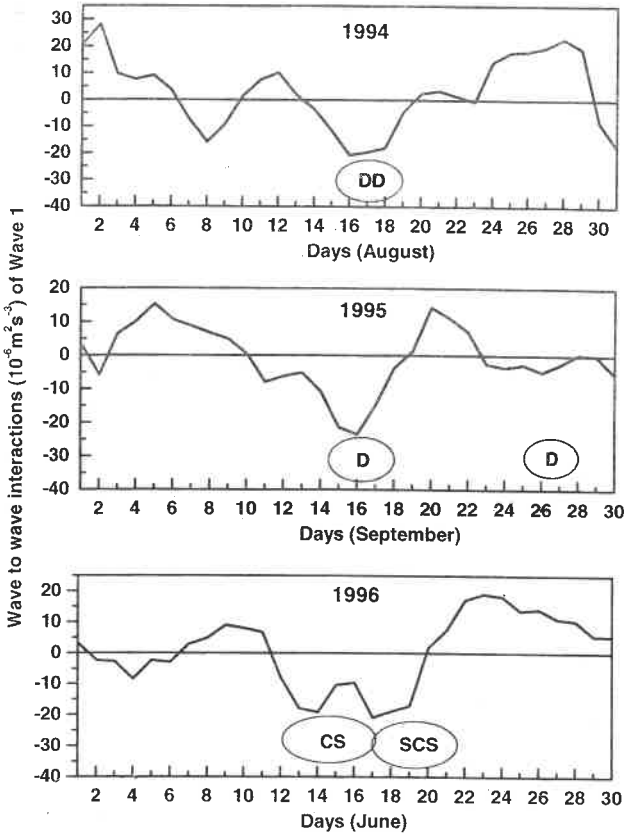


Fig. 4: Daily variation of wave to wave interactions (10^{-6} m^2/s^3) of wave 1 at 12° N at 850 hPa.

Results from analysis of BOBMEX-99 data

Surface meteorological parameters acquired during field phase of the Bay of Bengal Experiment (BOBMEX-99) for the stationary periods (SP I and II) of the ship ORV Sagar Kanya over Bay of Bengal were used to estimate the fluxes of sensible and latent heat and momentum at the air-sea interface. Active and weak monsoon conditions prevailed during these two periods respectively over India. At the air-sea interface, during SP I, the transfer of total heat energy was found to be dominated by the latent heat flux during epochs of stronger wind speed in association with the two depressions. Occasions of prominent fall in SST during typical rainfall events were observed. During these events, more contribution of sensible heat flux was observed under the influence of weaker synoptic systems such as a low pressure area in SP I and a cyclonic circulation in SP II when winds were weak.

The analysis of surface synoptic observations taken during the BOBMEX-99, at a stationary point over Bay of Bengal showed that, irrespective of the favourable SSTs, well-marked disturbances formed only during first phase of the experiment. Strong surface pressure gradient between Port Blair and ship location was observed with the formation of a system with an increasing trend few days prior to the formation. Very weak gradient was noticed during the second stationary phase of the experiment suggesting that in addition to oceanic support, suitable atmospheric conditions are also needed for the genesis of the systems. In view of the observations the mean sea level pressure gradient between Port Blair and Bhubaneshwar was computed for the months of July and August for the period 1997-2000. The mean pressure gradient prior to the formation of the system was found to vary between 5.8 to 10.2 hPa corresponding to intensities ranging from low pressure area to deep-depression. The results suggested a potential utility of such gradient to anticipate the formation of well-marked disturbances over Bay of Bengal in the months of July and August.

Archival of synoptic charts

Daily Limited Area Model stream line analysis at 925 and 850 hPa and winds at 850, 500 and 300 hPa levels, transmitted by IMD through Internet have been archived since May 2001 to study the synoptic conditions over India during different seasons.

Secondary Data Utilization Centre

Satellite images, CMVs and analysis of the satellite data products like OLR, QPE, etc. received daily at the Institute's Secondary Data Utilization Centre (SDUC) were displayed and archived. Specially transmitted hourly cloud images during the Arabian Sea cyclones of 19-23 May 2001 and 25-27 September 2001 were monitored and archived. Scientists of the institute consulted the archived images and monitored the transition of cloud pattern during onset phase of monsoon 2001. Typical digital images were also made available for the scientists for their use in research work.

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, Mata Mahakur)

Monitoring, analysis and depiction of various stages of very severe cyclonic storm formed over the Arabian Sea during 21-29 May 2001 were carried out by using satellite derived parameters obtained from NOAA, TRMM, IRS-P4, METEOSAT and INSAT Satellites. Cloud Motion Vectors (CMVs), Water Vapour Wind Vectors (WVWVs) obtained from

METEOSAT-5 satellite were used for finding dynamical variations in vorticity, convergence and divergence at 850 and 200 hPa during complete life cycle of the tropical cyclone. Intensification of sea surface winds from 14 to 18 m/s, sea surface temperature variations between 30 to 31°C, integrated water vapour from 6.5 to 7 gm/cm^2 (Figure 5) and cloud liquid water content from 4 to 4.5 gm/cm^2 were the special features observed during the development of severe cyclonic storm. Convergence at 850 hPa was properly maintained throughout the life period of cyclone. But, divergence at 200 hPa did not show proper adjustment after 24 May 2001. Development of non-divergence and some convergence area in the central dense overcast region from 25 May 2001 onwards gave a signal of weakening of severe cyclonic storm into depression and low pressure area on subsequent days. It dissipated from a very severe cyclonic storm to well marked low pressure area and then hit the Gujarat coast on 29 May 2001.

IRS P4 MSMR derived geophysical parameters such as sea surface wind speed, sea surface temperature, integrated water vapour and integrated cloud liquid water were studied for a unique monsoon depression that formed over the Bay of Bengal during 9-14 June 2001. Intensification of sea surface winds (12-19 m/s) to the south of low pressure area prior to the formation of depression, sea surface temperature ranging 27-30°C during the formation of depression, higher values of integrated water vapour (6-8 gm/cm^2) and higher values of cloud liquid water content (1-3 gm/cm^2) at the time of formation of the depression were the salient features of the study.

A satellite study of very severe cyclonic storm over the Arabian Sea during 16-22 May 1999 was made using NOAA daily OLR data, INSAT cloud imagery as well as cloud top temperature (computed from OLR data). OLR analysis provided information on northward movement, changes in intensity and turning features of the storm. Cloud top temperature analysis provided the information on cloud top height and subsequently organisation of clouds and axis of tallest clouds associated with the storm over the oceanic region.

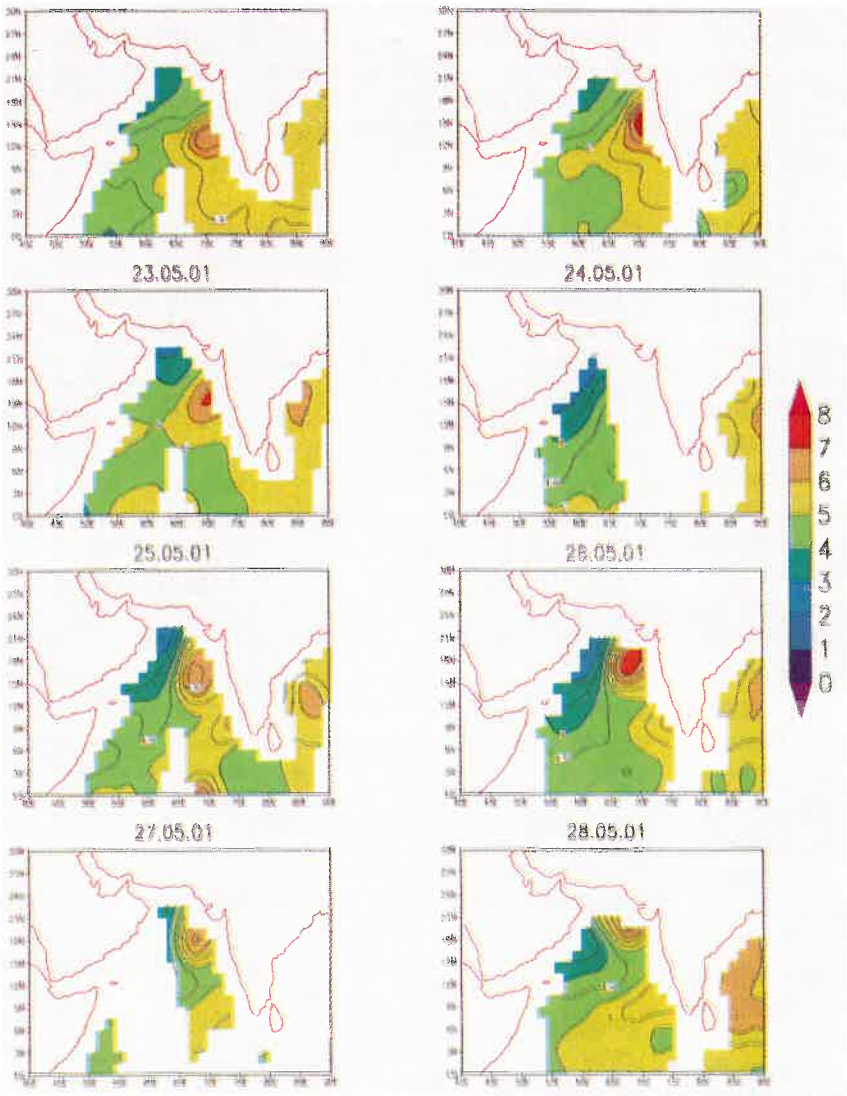


Fig. 5: IRS-P4 MSMIR Integrated Water Vapour (gm/cm^2) during complete life cycle of tropical cyclone.

Potential utility of satellite-derived winds was investigated for better depiction of circulation patterns over Indian region. Daily satellite derived upper tropospheric WVWV obtained from GMS-5 satellite over Port Blair at 151-250 and 251-350 hPa layers were compared with radiosonde (RS) winds of Port Blair (11.7°N, 92.7°E) for the year 1997 (00 and 12 UTC). Making use of this algorithm, upper tropospheric winds at 150, 200, 250, 300 and 350 hPa levels were generated for the complete life cycle of a tropical cyclone (14-21 May 1997) over the Bay of Bengal. Using the data an algorithm was developed to relate satellite derived moisture winds and Radiosonde winds. A highly significant correlation between satellite derived moisture winds and radiosonde winds was observed at 150, 175, 200, 250, 300 and 350 hPa levels for u and v components. Root mean square (rms) errors of satellite-derived winds were generally less than 6 mps as compared to Radiosonde data for all the levels. Impact of these winds on objective analysis was evaluated by using

Optimum Interpolation (OI) scheme during various stages of the tropical cyclone (TC). The analysed winds were compared with subjective and NCEP/NCAR reanalyses. It was found that there was a positive impact of WVWVs on wind speed, circulation and centre of anticyclone than NCEP/NCAR reanalyses and analyses with Radiosonde data only.

Objective analysis of meteorological data

Objective analysis of mean sea level pressure was carried out using multiquadric interpolation (MQI) scheme. The results of the application of this method were compared with the analysis from Gandin's Optimum Interpolation (OI) scheme. The MQI scheme produced superior analysis as compared to OI scheme and root mean square difference was reduced by around 50%.

Air-Sea Interactions in Tropical Monsoons

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

BOBMEX-98 pilot results

Charts of dynamic topographies at the surface, 15 m, 50 m and 100 m depth relative to 500 m depth (i.e. level of no motion/reference level) were prepared under the IITM-NIO collaboration programme to understand upper ocean circulation and the related temperature distribution near the BOBMEX Pilot-98 experimental site (6°-13°N, 85°-87°E) in the southern Bay of Bengal where cyclones usually originate/ pass through, by using the CTD (Conductivity–Temperature–Density) Sensors, temperature, salinity and density data during 29 October to 11 November 1998. The charts depicting the water circulation at the surface (0/500 m) and 50 m depth (50/500 m) are shown in Figures 6a and 6b respectively, while the corresponding charts of temperature at the above depth are shown in Figures 6c and 6d. The stations upon which the charts are based are shown in solid dots. In the former two figures the letters L- and H- represent low and high values of the dynamic height (cm.). The arrowheads show the direction of flow. It is interesting to note that the meridional flow at 6°N is deviated towards (from surface to 50 m depth) north between 7°-11°N and northwesterly north of 11°N. The centres of H- and L- values at 50 m coincide with the centres of warm (W) and cold (C) water pools at 50 m depths in Figure 6d, indicating the areas of downwelling and upwelling respectively. The values of dynamic topography varied from 108 cm to 132 cm at the surface. The pattern of dynamic height contours showed an east-west shear line (lower value) along 10°N separating southern and northern higher values. The shearline appears to coincide well with the shear line of NHET (Northern Hemisphere Equatorial Trough) along 10°N associated with high wind speed on either side. It is further interesting to note that the northerly flow of current keeps the colder waters (Figure 6a and 6b) to its left (west) and warmer waters to its right (east) and form a frontal line along 86°E from surface to 100 m depth. This type of frontal flow is conducive for the formation of mid-oceanic gyres of size 100-200 km. These gyres are potentially useful for the ocean flux transfer processes at the air-sea interface where the wind blows across these gyres from cold to warm waters and vice-versa. The cyclonic heat potential computed based on the above temperature data is of the order of 6x108 Jm^{-2} north of 10°N where two tropical cyclones formed during October-November 1998 near 13°N.

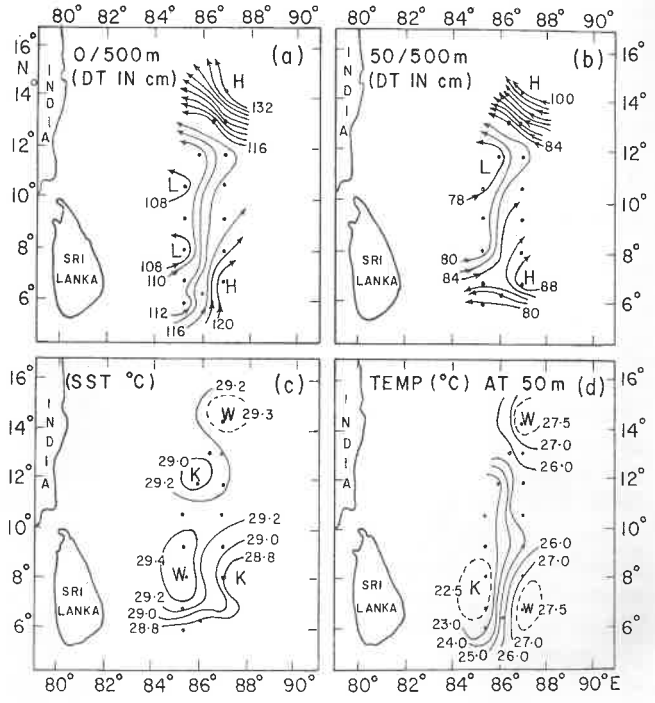


Fig. 6: Dynamic Topographies (in cm) relative to 500 m deep (level of no motion) at (a) the sea surface (0/500 m), (b) 50 m depth, in the Bay of Bengal (5°-13°N, 85°-87°E) from 29 October to 11 November 1998 near the BOBMEX-98 experimental site.

Response of Bay of Bengal to super cyclones

Impact of two tropical cyclones i.e. Gopalpur cyclone and Paradip cyclone formed over the Bay of Bengal during 15-31 October 1999 was examined using marine meteorological observations obtained from a buoy stationed at 13°N, 87°E. The response (SST before minus after the cyclone) of the Bay of Bengal due to Gopalpur cyclone was 0.7°C and that for Paradip cyclone was 0.9°C.

Climatology and Hydrometeorology

It is being increasingly recognized, globally as well as at regional levels, that climatic information plays a predominant role in socioeconomic activities and also in determining their future pathways. Therefore, an adequate understanding of the climate variability and the various processes involved in such variability is essential, particularly on regional aspects, in order to develop reliable predictive capabilities.

This is the underlying theme of the research programmes formulated by the Climatology and Hydrometeorology Division, with 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 derive projections of future climate scenarios for the Indian region.
- To make comprehensive analysis of the teleconnections of global and regional atmospheric and oceanic parameters with the Indian summer monsoon as well as northeast monsoon and to identify useful predictors for seasonal prediction of monsoon rainfall.
- To 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 long series of high resolution rainfall data over various river basins of the country for application in water resources management.
- To estimate the probable maximum precipitation, analyse depth-area-duration of severe rainstorms, and to provide inputs for the estimation of design parameters of hydrological projects.
- To study 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 climate change scenarios for India

As part of the project, 'Development of Indian Climate Change Scenarios for Impact Assessment' under the Joint Indo-UK Collaborative Research Programme on Climate Change Impacts in India, the second generation Regional Climate Model (RCM) of Hadley Center (HadRM3H) has been successfully installed on a Compaq Alpha workstation. HadRM3H would be run with the provision of extensive data at the boundaries from the global climate model (HadAM3H) run with different greenhouse gas scenarios. To generate fast-track climate change scenarios, HadRM2 model output generated by the Hadley Centre for the Indian subcontinent for control as well as two climate change scenarios have been obtained and are being analysed (Figure 7).

Development of teak (Tectona grandis) tree-ring width chronology from central India

Tree-ring analysis of teak (*Tectona grandis*) from the western ghats of India revealed the usefulness of the species in reconstructing the past vagaries of monsoon and drought/flood events. To extend the spatial coverage of teak tree-ring network in India, more than 300 tree core samples of teak were collected over 18 sites from central India. The region is strongly influenced by the summer monsoon rainfall where more than 75% of total annual precipitation is received during the monsoon months. Cross-dating between cores from the same tree and between different trees of the same sites is generally good. Detailed analyses were made to detect and resolve dating problems related to cross-matching, false rings, etc. More than 200 core samples were processed,

dated and ring widths were measured. A few of them go back to early 18th century. Measurements of ring width of the remaining samples and preparation of final site chronologies have been taken up for further dendroclimatic analysis.

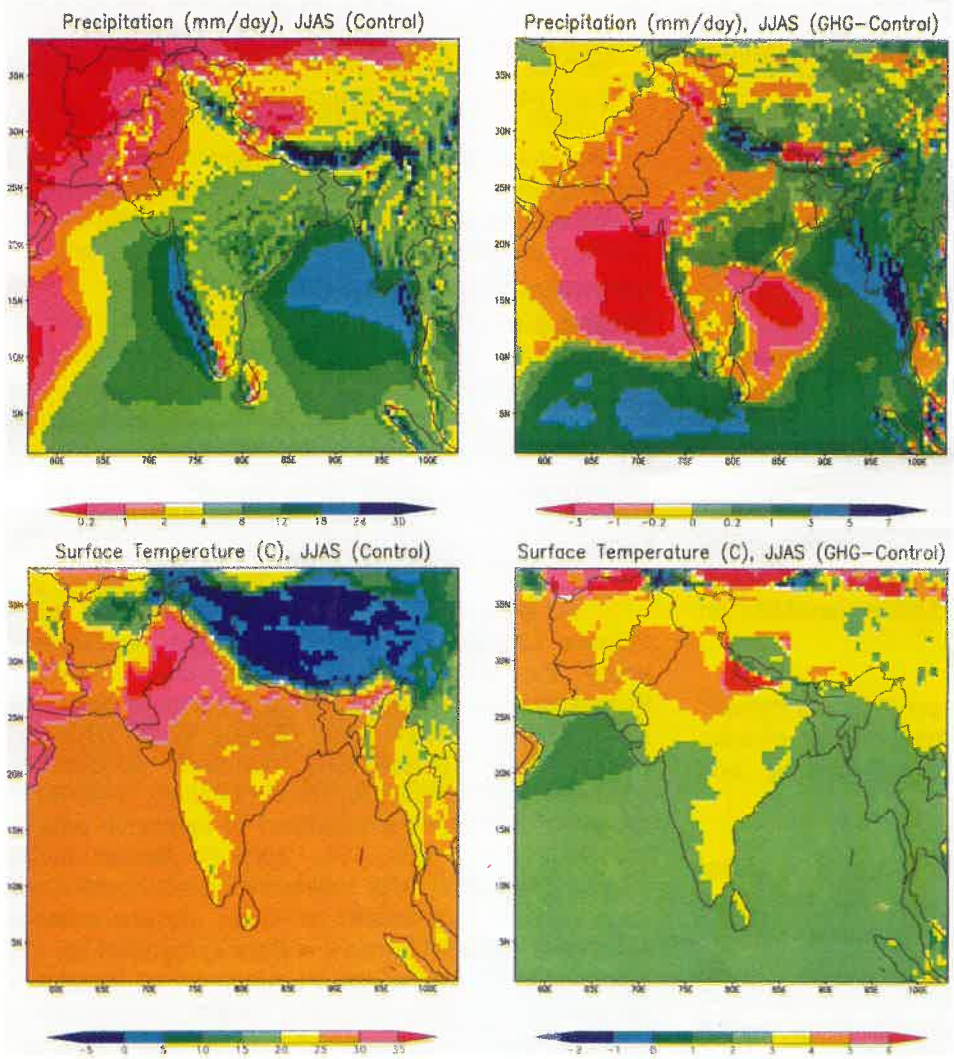


Fig. 7: Summer monsoon rainfall and surface air temperature patterns as simulated by the regional climate model, HadRM2. Control simulation was performed using a fixed greenhouse concentration of 1990 levels and the perturbed simulation (GHG) corresponds to the period 2041-60 which was performed with a 1% compounded increase of greenhouse gas concentrations from the present levels.

Collection of tree-ring samples in the Bori Reserve Forest, Madhya Pradesh.

Field expedition to teak forest for tree-ring sample collection

Scientists of the Institute and Drs. E.R. Cook and Paul Krusic, Senior Scientists from Tree-Ring Laboratory, Lamont-Doherty Earth Observatory, Columbia University, New York visited Bori Reserve Forest near Pachmarhi, Madhya Pradesh during 2-8 March 2002. More than 100 tree cores were collected from old living teak trees. This collection is a useful addition for dendroclimatic studies in the Institute.

Surface climatology of Western Himalaya

Meteorological data for November - April for different periods ranging from 1970 to 1997 in respect of 25 stations in the Western Himalayan region have been received from Snow and Avalanche Study Establishment (SASE), Chandigarh. The data contain following parameters:

- Maximum, Minimum, Dry bulb and Wet bulb temperatures, Wind direction and speed, Relative humidity, Pressure, Cloud amount and type, Present Weather, and Rainfall.
- Snow surface parameters like Amount, Duration, Density, Standing Snow, Surface temperature, Water equivalent, Appearance, Characteristics, Penetration, Crust-thickness, Penetration below.
- Sunshine, Insolation, Albedo and Net-radiation.

Consistency and quality control analyses were made on the data.

Indian tropospheric temperature variations and ENSO-monsoon linkages

To understand the role of regional tropospheric temperatures in ENSO-monsoon relationship, composites of all-India mean tropospheric (surface to 150 hPa levels) temperature anomalies of three seasons before and after the monsoon season during the El Nino / La-Nina years for the period 1971-2000 were examined. The El Nino (La Nina) composite anomalies of tropospheric temperature were found to be negative (positive) during three seasons before monsoon and positive (negative) during monsoon as well as all the subsequent seasons up to subsequent year's pre-monsoon season, at the surface and 850 hPa levels. The lag/lead correlations between JJA NINO3 SST and seasonal tropospheric temperatures were also studied. A pronounced negative relationship was seen between the lower tropospheric (surface-850hPa) temperature of three seasons prior to monsoon season and JJA NINO3 SST, and the relationship becomes positive from the monsoon season to the successive year's pre-monsoon season.

Secular variations in the relationship between Darwin sea-level pressure during pre-monsoon and monsoon seasons and Indian monsoon rainfall as well as temperature were examined by means of 15-year sliding correlations, using the data for the period 1951-2000. Darwin pre-monsoon pressure was found to be positively and significantly correlated with the Indian surface temperature during the monsoon season over most of the data period. Concurrently during the monsoon season, Darwin pressure and all-India mean surface temperatures were also positively correlated, but not statistically significant. There is a general indication that the relationship between Indian monsoon temperatures and Darwin pressures in spring as well as summer seasons has weakened in the recent period (1985 onwards). However, this feature is not as prominent as in the case of monsoon rainfall, for which the sliding correlations with Darwin pressure have rapidly weakened in the recent period.

Climate Applications Agriculture, Water Resources and Public Health

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

Diagnostics of AGCM simulations for understanding the variability of Asian monsoon and its global teleconnections

A six member ensemble Atmospheric General Circulation Model (AGCM) runs made with observed global sea surface temperatures (SSTs) during 1949-1997 were analysed to examine ability of the model to simulate various global climatic features such as the Indian summer monsoon, North Atlantic Oscillation (NAO) etc. and their interannual variability. These runs were made recently at the Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA), Tsukuba, Japan. Apart from the general climatological features, emphasis was given to examine in detail the Indian monsoon rainfall simulation in the model and its teleconnections with El Nino-Southern Oscillation (ENSO). The analyses showed several encouraging positive aspects of the model simulations while the inherent deficiencies brought out suggested the need for further improvements in the model physics and parameterizations. These highly computationally expensive 6 member ensemble runs were also utilized to study the predictability (internal vs SST forced variability) aspects of various global meteorological variables such as the precipitation, surface temperature, sea level pressure etc.

Indian Ocean SSTs and monsoon variability

Sliding correlations between the Indian summer monsoon rainfall (ISMR) and the SSTs in the Indian Ocean (IO-SST), (8°-22°N; 55°-72°E), showed a dramatic increase in long-lead correlations up to 3 seasons preceding the monsoon season, during the period after 1978. These correlations had been very low and insignificant during 1856-1978. Strengthening of the long-lead correlations between ISMR and IO-SST coincides with the recent weakening of concurrent correlation between ISMR and NINO3-SST (ENSO index), which is also unprecedented in recorded history. Further detailed analyses suggested that the IO-SSTs during summer and autumn seasons showed statistically significant correlations with the subsequent winter surface air-temperatures over a major part of the Eurasia in the recent period, while such relation was not seen prior to 1978. Summer and autumn IO-SSTs also showed enhanced correlations with the subsequent winter North Atlantic Oscillation (NAO) index, which is believed to have a strong relation with the recent Eurasian warming. In this context, the association between IO-SST variability in summer and autumn and the subsequent winter tropical rainfall over the equatorial Indian Ocean and the west Pacific Ocean was analysed. The results indicated a pattern that is typical of the tropical heat sources/sinks associated with the mid-latitude circulation over the continental Eurasia through remote Rossby-wave response. Thus, the interannual variations of IO-SSTs in summer and autumn appear to have some connection with winter circulation anomalies (anomalous anticyclonic flow in this case) over the Eurasian region, both through the NAO and through the tropical-mid latitude links, resulting in warmer than normal surface temperature conditions in the recent decades. Keeping in view the fact that the surface temperatures

over Eurasia in winter and spring play a dominant role in determining the strength of the monsoon over India, the enhanced Eurasian temperatures in recent decades, both as part of the general global warming and through IO-SST induced mid-latitude circulation response, might be a plausible mechanism for the recent long-lead correlations between IO-SSTs and ISMR.

Climate signal in malaria incidences in India

In connection with the Indo-UK project, 'Impact of Climate Change on Human Health', data on the incidence of Malaria during 1961-1995 were analysed to examine the possible climate signal, both regional and global, involving various meteorological data such as the monthly and seasonal rainfall and surface temperatures over India, global land-sea surface temperature data from Climate Research Unit, University of East Anglia, UK. Analysis showed statistically significant positive correlation between the detrended yearly all-India Malaria incidence data and the previous year October rainfall whereas a significant negative correlation was seen with the same year May rainfall on all-India scale (Figure 8).

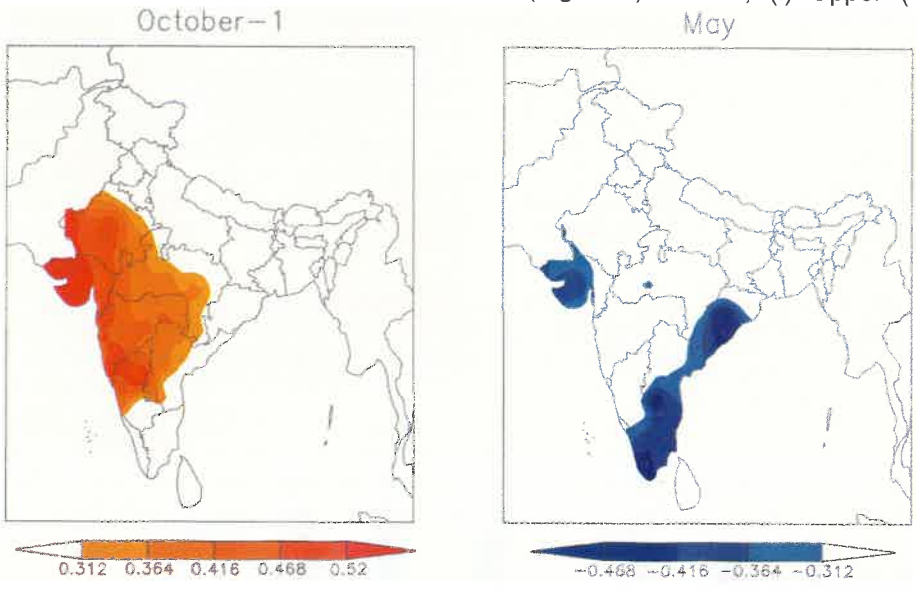


Fig. 8: Correlation between the incidence of Malaria (annual) and antecedent rainfall over India during 1961-1995.

The spatial patterns of correlations showed significant positive correlations in October to be over a wide region covering northwest and west central parts of India while the negative correlations in May were found to be generally confined to Gujarat and most parts of east coast of India. Most of El Nino/La Nina years have resulted in below/above normal incidences of Malaria respectively. Though general tendency for the Malaria incidences was found to be below/above normal during drought/flood monsoon seasonal rainfall years, the separation was not as good as that observed in case of El Nino/La Nina events. Malaria Incidences also showed significant positive correlation with the surface temperature (January) over most part of continental Eurasia and also significant negative correlations with the winter and spring sea surface temperatures over east Pacific Ocean (representative of El Nino condition). These long-lead teleconnections appear to be operating through their well-known connection with the Indian summer monsoon rainfall.

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 of the Siang basin in northeast India

Design storm studies in the form of 1, 2 and 3-day Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) over three sub-basins viz., (i) Upper (4675 km^2), (ii) Middle (3850 km^2), (iii) lower (7700 km^2) and the entire Siang basin (16225 km^2) in Northeast India, for use by the National Hydroelectric Power Corporation (NHPC) Ltd., were carried out. Five severe rainspells over three sub-basins and the entire basin were analysed by Depth-Duration (DD) method. DD analysis showed that 21-23 June 1978 rainstorm contributed envelope raindepths for 1 to 3 days durations over each of three sub-basins and the entire basin. SPS raindepths obtained by DD method were found to be 10.0 cm, 18.0 cm and 23.3 cm respectively over the entire basin. The SPS raindepths were maximised with a moisture maximization factor (MMF) of 1.22 to obtain PMP raindepths. PMP raindepths by DD method were estimated as 12.2 cm, 22.0 cm, and 28.4 cm over the entire basin for 1, 2 and 3-day durations respectively.

Depth-area-duration (DAD) analysis of 10 severe rainstorms occurred in the nearby region of the basin was carried out. Raindepths obtained from most severe rainstorm of 24-26 June 1931 were adjusted with proper elevation correction factor to obtain SPS raindepths over the basin. SPS raindepths over entire basin by DAD method were found to be 13.3 cm, 22.0 cm and 27.3 cm for 1, 2 and 3-day durations

respectively. Estimates of PMP were worked out by adjusting the SPS raindepths with a MMF of 1.35. PMP raindepths over three sub-basins and the entire basin by DAD method were found as 17.9 cm, 29.7 cm and 36.9 cm respectively during 1, 2 and 3-day durations.

Estimates of PMP by statistical method were also worked out by using point PMP values and found to be 28.7 cm, 39.6 cm and 54.5 cm over the entire basin. PMP estimates obtained by the statistical method were found to be to the higher side than obtained by DD and DAD methods as it is based on point PMP values.

Precipitation analysis to obtain mean, annual, seasonal, highest 1, 2 and 3-day precipitation and estimates of PMP by statistical method over the rainfed area of the Upper Siang basin in Tibet (32,675 km^2) was also carried out by using data of six stations for a period of 6 years (1994-1999) and NCEP/NCAR Reanalysis precipitation data of 42 years (1958-1999).

Analysis of heavy rainfall events during monsoon-2001

Highest 1-day rainfall amounts recorded at 44 representative observatory stations in India during 2001 monsoon season were compared with similar past heavy rainfall based on data up to 1980. It was seen that there were 21 stations which recorded 25 cm or more rainfall in 1-day during 2001 monsoon over India. However, the heaviest 1-day rainfall amount in monsoon-2001 at none of the stations exceeded the past heaviest recorded amount.

Four heavy rainspells viz. (i) 15-18 June over Konkan and neighbourhood, (ii) 4-7 July over Orissa, (iii) 15-17 July over U.P. and neighbourhood and (iv) 30 August - 3 September over Bihar and East U.P. affected the Indian region during 2001 monsoon season. Depth-Area-Duration (DAD) analysis of heaviest 1-day rainfall on 4 July over Orissa was carried out and it was found that this rainspell gave 15 cm rainfall over 50,000 sq. km. area in 1-day. Each of the 4 heavy rainspells of 2001 monsoon was compared with a past severe rainstorm from the affected region. The heavy rainspells of 2001 monsoon were found to be much weaker than the past severe rainstorms in the affected regions.

During 2001 monsoon season, the states of Orissa, Uttar Pradesh, Bihar and West Bengal (particularly Malda district) were severaly affected by floods. The Ganga, the Ghagra, the Rapti, the Kosi, the Baitarni, the Brahmini and the Mahanadi were the major rivers, which experienced floods in the north Indian region. There were a few incidences of floods over northeast India due to floods in the Brahmaputra river.

From hydrological point of view the 2001 monsoon was not that severe considering the heavy rainfall and associated floods.

Comparative flood frequency study of Ganga and Brahmaputra systems

Occurrence of floods in the two important river systems of north India, viz. the Brahmaputra and the Ganga, was studied at their respective terminal gauge/ discharge (G/D) sites, viz. Dhubri at Brahmaputra and Farakka at the Ganga using the flood data of the 14 year period 1986-1999. Both the rivers are located in the north India, north of lat. 22°N and are more or less affected by similar meteorological situations. It was seen that monsoon rainfall over the two basins in each year during the period varied considerably when compared to long period normal rainfall. In case of Brahmaputra basin monsoon rainfall varied from -30% (1986) to + 31% (1988) whereas in case of Ganga river basin, these values varied from - 20% (1987) to +12% (1994) (Figure 9). Frequency of floods at their respective terminal (G/D) sites was found to be more or less of the same order though their catchments are vastly of different sizes. Therefore, it appears that the size of the basin does not play a major role so far frequency of floods is concerned.

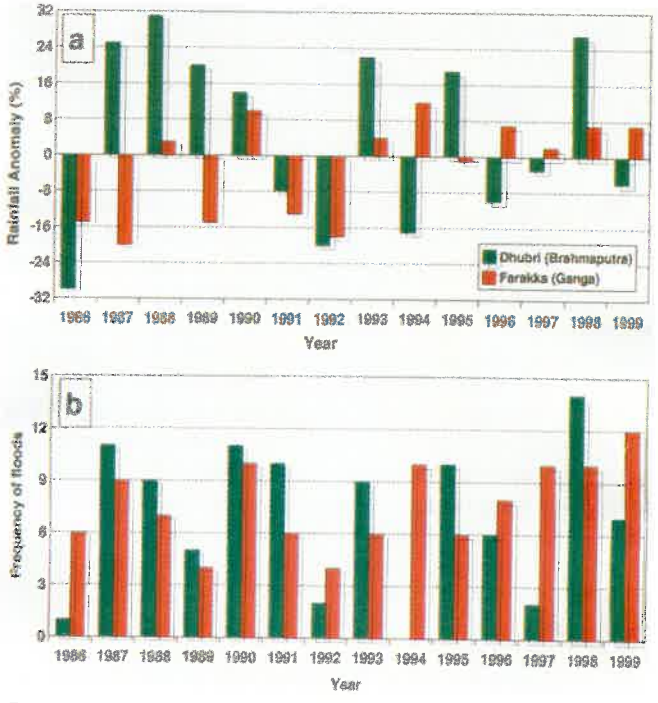


Fig. 9: Summer monsoon rainfall anomalies (a) and flood frequencies (b) over Brahmaputra and Ganga river basins during the period 1986-1999.

Estimation of design raindepths over the Wainganga basin

Estimation of design raindepths over the Wainganga basin up to the confluence of river Wardha (58,507 km^2) for durations of 1, 2 and 3-day were

made by hydrometeorological method using data of all the available long-period rainfall stations for about 100 years (1891-1990). Depth-Duration (DD) analysis of seven severe rainspells over the basin showed that 18-20 June 1918 rainstorm contributed envelope raindepths over the basin. Average raindepths for 1, 2 and 3-day durations obtained from this rainstorm were found to be 15.7cm, 24.8 cm and 30.3 cm respectively.

Probable Maximum Precipitation (PMP) was worked out by physical method by transposing the most severe rainstorm of 19-21 September 1926 from a nearby homogenous region of the basin and adjusting the transposed raindepths with an appropriate moisture maximization factor (MMF). PMP estimates over the Wainganga basin were found to be 23.7 cm, 40.3 cm and 57.3 cm for 1, 2 and 3-day durations respectively.

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)

Climatic fluctuations and environmental changes of the Indo-Gangetic plains

Paralleling the Southern Himalayan Province, the Indo-Gangetic Plains Region (IGPR) of India is very important for the food security of South Asia. An attempt has been made to document the instrumental-period fluctuations of important climatic parameters like rainfall amounts (1829-1999), severe rainstorms (1880-1996) and temperature (1876-1997) exclusively for the IGPR. From the long-term trends in summer monsoon rainfall over different parts of IGPR, it can be broadly inferred that there has been a westward shift in rainfall activities over the IGPR. Analysis suggested westward shift in the occurrence of severe rainstorms also. The spatial changes in rainfall activities may be due to regional changes in the Indian summer monsoon circulation, which appear to be linked with global warming (Figure 10) and associated changes in the general atmospheric circulation. The annual surface air temperature of the IGPR showed significant (at 1% level) rising trend at the rate of 0.53 °C / 100 yr during 1875-1958 and significant (at 5% level) decreasing trend at the rate of -0.93 °C / 100 yr during 1958-1997. The post-1958 period cooling of the IGPR is found to be opposite to the large-scale warming of India and the northern hemisphere, possibly due to expansion and intensification of agricultural activities and spreading of irrigation network in the region in the post-independence era of the country. Lateral shift in the river courses is an environmental hazard of serious concern in the IGPR. In the study it is suggested that meteorological factors like strength and direction of low level winds and spatial shift in rainfall/climatic belt also play a significant role along with tectonic disturbances and local sedimentological adjustments in the vagrancy of the river courses over the IGPR.

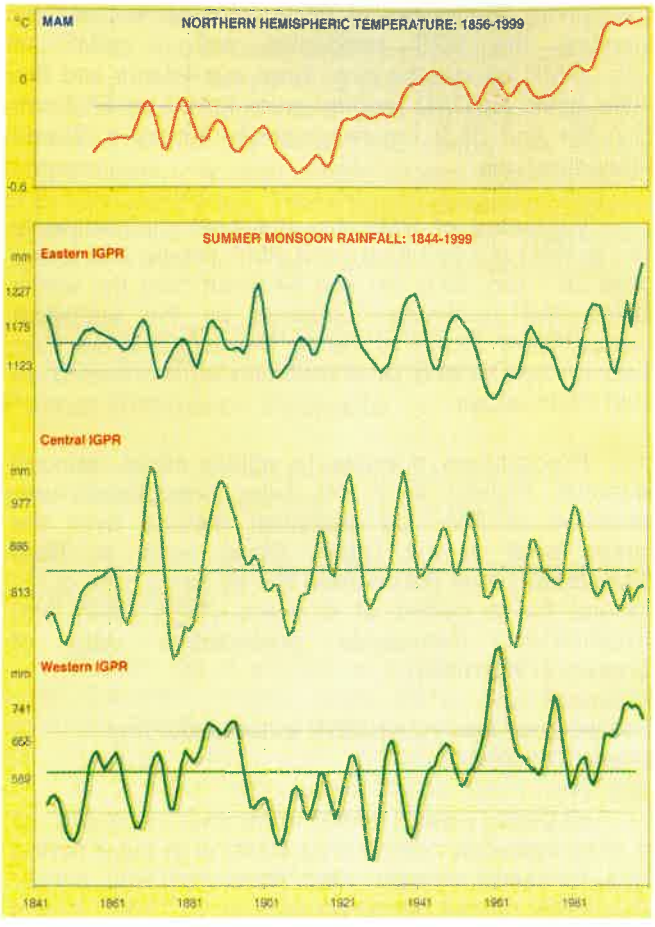


Fig. 10: The low frequency mode (9-point low-pass filtered values) fluctuations of the spring surface air temperature of the northern hemisphere (1856-1999; Parker et al., 1994) and that of the summer monsoon rainfall of each of the three zones of the Indo-Gangetic Plains region during 1844-1999.

Long-term rainfall fluctuations at Cherrapunji

Recent studies showed increasing trend in rainfall over Northwest India and decreasing trend over the Northeast. In a detailed rainfall analysis for the Northeast India (area of the country east of 84°E), however, declining trend was noticed at stations over northern parts of the region only and stationary or increasing trend over the southern parts. As a case study, Cherrapunji rainfall data were compiled for the period 1860-1999 for trend analysis. No long-term trend was observed in the annual total rainfall at Cherrapunji. On a seasonal scale, the winter and pre-monsoon rainfall also did not indicate any significant trend. However, the summer monsoon rainfall showed a decreasing trend of 8 mm/yr while the post-monsoon rainfall showed an increasing trend of 1.5 mm/yr, both marginally significant at 10% level. Like other places of the northeast region there appeared to be a definite effect of regional and global changes on the rainfall fluctuations at Cherrapunji. Decreasing trend in the number of monsoon storms/depressions over Bay of Bengal from about 12 during 1890s to less than 3 during 1990s is possibly one such aspect.

Physical Meteorology and Aerology

The Division has undertaken thrust area research programme which is 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.
- Chemistry/dynamics of the middle atmosphere vis-a-vis the troposphere–stratosphere coupling/ monsoon activity/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)

Simulation of precipitation processes from tropical clouds

A two-dimensional slab symmetric time dependent cloud model of Chen and Orville with grid interval of 200 m in the X and Z direction in domain of 19.2 km in depth and height was used to simulate the heavy precipitation formation in the warm cloud region of the tropical cyclone. The model can simulate the interaction between the environmental airflow, the cloud air motion, and the cloud microphysics, including water vapour, cloud water, rainwater, cloud ice and precipitating ice (hail). In an ideal experiment, the atmospheric sounding having characteristics of the tropical cyclone was used. The lower level convergence appropriate to the tropical cyclone was provided to the model. The model could simulate well the observed heavy rainfall rates.

Field mill network for thunderstorm warning

The Institute has undertaken a collaborative Project entitled "Development of Field Mill Network System at Sriharikota High Altitude Range (SHAR) for Thunderstorm Warning and to Study the Dynamical Properties of Thunderstorm for Forecasting the Warning Levels" with the SHAR of the Indian Space Research Organization (ISRO). It is envisaged to establish a field-mill network at SHAR for measuring the three components of electric field at different locations in SHAR. First phase of the project was completed and two stations were connected to the central processing unit. The data were collected for six months and analyzed. Second phase of the project has been started in which two additional stations would be installed to collect three vector electric field mill data.

A software was developed for processing the online data received from the field mill. It would handle data of 8 stations simultaneously and process the same. The communication is through the dedicated lines and 8 channel multiport card. Also, for analysing the archived data from the field mill a graphic software has been developed, which can be used for plotting and for embedding the final graphs directly in the word document.

Cylindrical Field Mill Network developed by IITM for installation at the Rocket Launching Station, SHAR, Sriharikota.

Statistical modelling of thunderstorm phenomenon

Markov Chain models of first, second and third orders were used to provide the probabilistic description of the thunderstorm phenomenon in the pre-monsoon and post-monsoon period at a tropical inland station, Pune (18°32'N, 73°51'E, 559 m asl). The analysis was based on the relevant data for 11-year period (1970-1980). Use of Akaike's Information Criterion (AIC) revealed that the Markov Chain of the first order is perhaps the model that best describes the phenomenon. The preliminary results of the study indicated appropriate period of 7 days for occurrence of thunderstorms over Pune. The theoretical values of the mean recurrence time for the thunderstorm and non-thunderstorm days hence obtained were in close agreement with the observed data.

Pentad rainfall analysis

A comprehensive study was undertaken to examine the mid-August rainfall minimum in five-degree zonal belts across India using the normalized rainfall of each pentad with respect to rainfall of pentad 46. The time variation of the average pentad rainfall ratios for 230 stations classified under a, b and c groups in different zonal belts is shown in Figure 11. The results of the study indicated that (i) The rainfall minimum occurs more frequently in pentads 45-46 for stations in the zonal belts 15°-20°N and 20°-25°N and in pentads 46-47 for stations north of 25°N. This suggests a progressive shift of rainfall minimum from pentad 45 in the south to pentad 47 in the north; and (ii) The interval between the two rainfall maxima on either side of the minimum corresponding to the northward and southward transits of the ITCZ over India during the advancing and retreating phases of the monsoon increases from 7 pentads at individual stations north of 25°N to 13 pentads for stations in the zonal belt 20°-15°N. This is in agreement with the observations. These findings are helpful in inferring the physical and dynamical properties of tropical clouds forming over the country.

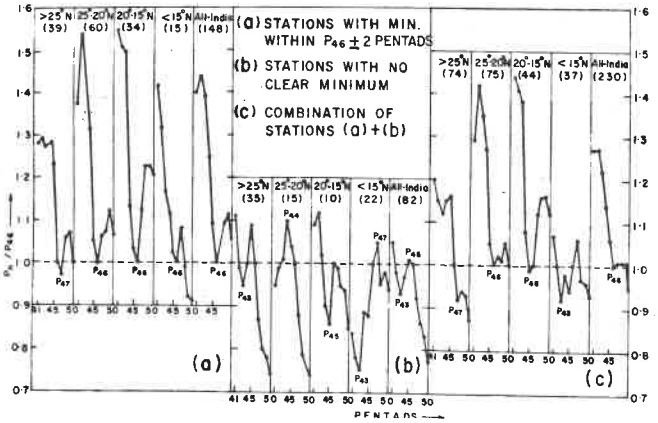


Fig. 11: Graphical presentation of the time variation of average P_n / P_{46} ratios for pentads 41 to 50 in five-degree zonal belts and for All-India. The number of stations of the a, b and c groups in respective zonal belts is given in the parentheses.

Thermodynamical characterization of planetary boundary layer

A study was carried out to explore the influence of the changing atmospheric conditions on the thermodynamic structure of the Convective Boundary Layer (CBL) over the region 80.79°– 87°E along 13°N of the Bay of Bengal. Radiosonde measurements made during the Phase II of the BOBMEX-99 i.e. 27–30 August 1999 onboard ORV Sagar Kanya were utilized to compute the average vertical profiles of different thermodynamic parameters. The study indicated that some components of the continental air mass (mostly warm and dry) appeared to move over the oceanic region (relatively cold and moist air mass) and get mixed up with the air mass in the open ocean. The fluctuations observed in the vertical profiles of mixing ratio (q), potential temperature (θ) and virtual potential temperature (θ_v) were minimum in oceanic region and maximum in continental region. The vertical profiles of above thermodynamical parameters approximately merged into one profile below 990 hPa and above 520 hPa. The vertical distribution of mean u and v components of wind showed the existence of southerly/southwesterly wind fields throughout the CBL over oceanic region, and in the coastal region winds are southwesterly in the lower CBL and southwesterly/ northwesterly in the upper CBL. The conserved variable diagrams in the oceanic regions were dominated by the convectively driven single mixing line structure whereas over coastal region double mixing line structure is found to be predominant. The mean vertical profiles of saturation pressure deficit (P*), equivalent potential temperature (θ_e) and saturated equivalent potential temperature (θ_{es}) indicated that CBL top varies from 710 to 590 hPa.

Influence of synoptic scale disturbances on convective boundary layer structure

A study was carried out to explore the influence of the synoptic scale disturbances on the thermodynamic structure of the CBL over land. Also, an attempt was made to examine the temporal and spatial variation in the thermodynamic parameters. For this purpose aerological observations collected during the BOBMEX-99 over the six coastal stations i.e. Kolkata, Bhubaneshwar, Visakhapatnam, Machilipatnam, Chennai and Karaikal for the period 12-14 August 1999 were utilized. A low pressure area (LPA) was observed over the northeast Uttar Pradesh and adjoining Bihar plains during 12-14 August 1999. The 6-hourly radiosonde observations were used to compute the thermodynamic parameters from surface to 400 hPa at an interval of 10 hPa. The stations were classified into two groups depending on their location with respect to the LPA, i.e. group A included the stations (Kolkata, Bhubaneshwar and Visakhapatnam) situated in the vicinity of the LPA and group B included the stations (Machilipatnam, Chennai and Karaikal) situated away from the LPA. The Group A stations were found to be associated with low surface pressure values where as group B stations showed an increasing trend. Also, surface air temperature values showed steady increasing trend from Group A to Group B stations. An opposite trend was observed in the surface mixing ratio values (Figure 12). The thermodynamic parameters viz. potential temperature, virtual potential temperature, equivalent potential temperature and saturated equivalent potential temperature showed diurnal variation for both the

groups. Group A stations were found to be associated with more convective instability in the lower layers, less mixed layer heights and CBL tops reaching up to higher levels as compared to Group B stations. Thus the spatial and temporal variation in thermodynamic parameters was clearly evident from the study carried out.

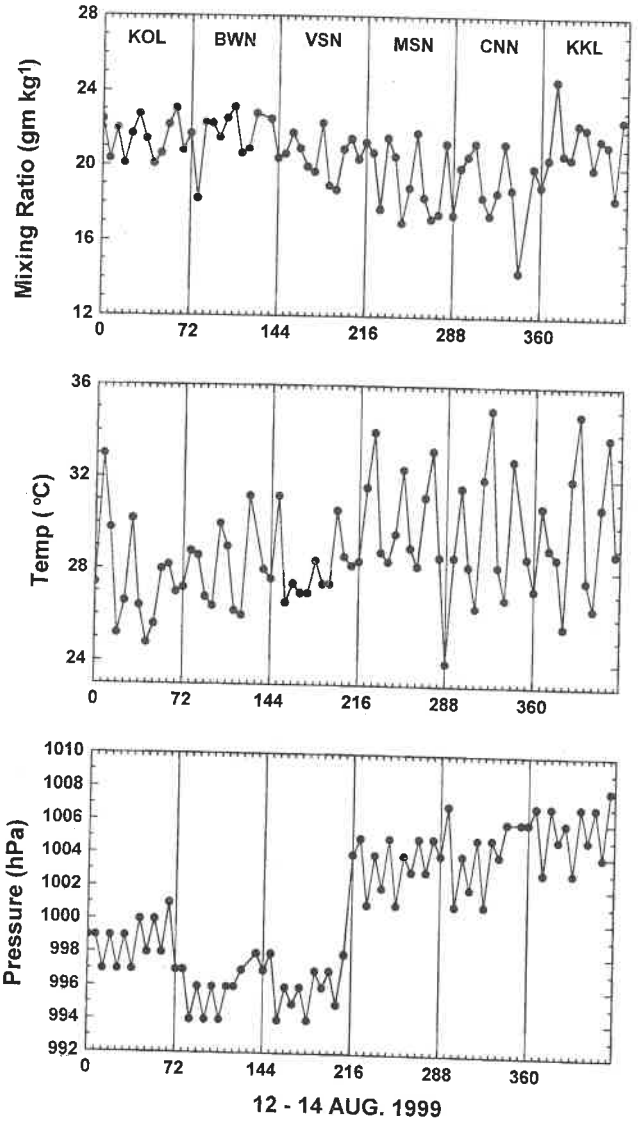


Fig. 12: Mean hourly variations of surface level pressure, temperature and mixing ratio over six coastal stations (Kolkata, Bhubaneshwar, Visakhapatnam, Machilipatnam, Chennai and Karaikal) during 12-14 August 1999 (BOBMEX-99).

Studies of Radiosonde profiles over Indian East Coast stations

Radiosonde observations from surface up to maximum available level up to 15 hPa at 00 and 12 GMT, collected during the BOBMEX-99 for the coastal stations were analyzed. The radiosonde ascents were undertaken during the period July-August 1999 for the Intensive Observation Period (IOP) over six coastal stations viz., Kolkata, Bhubaneshwar, Visakhapatnam, Machilipatnam, Chennai and Karaikal and also for the island station Port Blair. Based on the study a report entitled, "Indian East Coast Stations Radiosonde Profiles" containing prevailing weather conditions and synoptic charts depicting the profiles of thermodynamic parameters for each sounding for all the IOP for all the seven stations has been prepared.

Studies of air mass characteristics over Indian East coast stations

A study was carried out to examine the source of the airmasses over the six coastal stations i.e. Kolkata, Bhubaneshwar, Visakhapatnam, Machilipatnam, Chennai and Karaikal for the period 12-14 August 1999. For this purpose, wind observations from surface up to 400 hPa at 00, 06, 12 and 18 GMT hours, collected during the BOBMEX-99 were utilized. The average values of zonal (u, m/s) and meridional (v, m/s) components of wind for the period 12-14 August 1999, from surface up to 400 hPa at an interval of 50 hPa, for all the six stations were computed. The average vertical profiles of u and v showed that the westerly component was predominant at all the coastal stations in the Convective Boundary Layer. Over all the stations, the winds were found to be either southwesterly or northwesterly indicating the land originated air masses. By the end of July, southwest monsoon was well spread over all the Indian stations and thus the period under study was associated with the well established phase of southwest monsoon. This supports the prevailing land originated air masses. Also, it was observed that the wind maxima were at lower levels during morning and night hours as compared to those during afternoon and evening hours. The wind maximum at Machilipatnam was found to be highest as compared to that over other stations. This may be due to the fact that isobars at this location showed a trough on all the three days.

Remote Sensing of the Atmosphere using Lidar, Radiometric 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, Y.K. Tiwari)

Physico-optical characteristics of aerosols during dust-storm

Special radiometric observations of atmospheric aerosols were carried out during a dust-storm event occurred between 3 and 5 June 2000 over a metropolitan city, Delhi. The columnar aerosol optical

depth (AOD) measured at six wavelengths (380, 440, 500, 675, 870 and 1020 nm) and corresponding aerosol size distribution inverted from the above observations were examined to investigate significant changes in the aerosol optical and physical properties due to dust-storm activity. The salient results of the study indicated (i) Greater AOD (about 50%) on the dust-storm day as compared to the days before and after the event. (ii) Enhancement in AOD, on an average, was about 19% from the pre dust-storm period and decreased up to about 30% during post dust-storm period. (iii) Presence of larger particles (radius ≥ 1.0 μm) during the period of dust-storm as compared to the quiescent period (Figure 13).

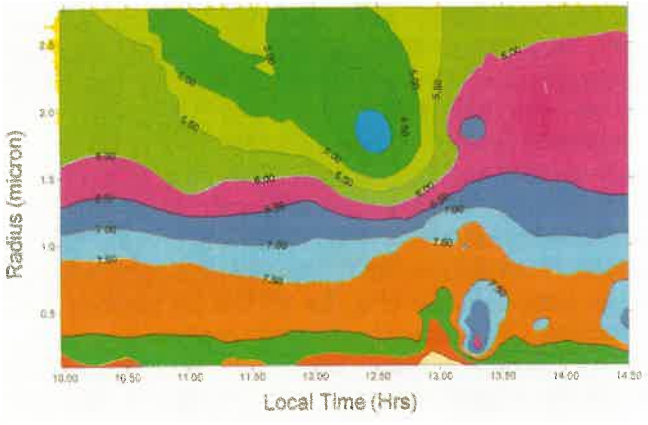


Fig. 13: Time-size cross-section of aerosols observed during dust-storm that occurred during 3-5 June 2000 over New Delhi. Presence of long (radius ≤ 1 μm) aerosol particles during the period of dust-storm is evident.

The lidar derived vertical distribution of aerosol number density obtained during the three-year period (1997-2000) were analyzed to study the contrast between aerosol properties during the pre- sunrise and post- sunset period over Pune. The results of the study revealed that (i) The monthly mean aerosol column content was found to be more in morning hours during December, January, February (winter months) and in the evening hours during March, April, May (pre-monsoon months). (ii) Aerosol column content was found to decrease from morning to evening in winter months and increase from morning to evening in post- monsoon months by about 10% during the period of observations. (iii) The aerosol column content showed minimum values on the days associated with precipitation.

Sky radiometric sounding of urban aerosols

The PREDE sky radiometer received from University of Maryland on loan for implementing the DST-NSF joint research project entitled "Aerosol Optical Characterization and Investigation of Aerosol Radiative Forcing at the Surface and Top of the Atmosphere" had been operated at IITM on about 200 clear-sky days during November 2000- March 2001. The direct solar and diffuse radiation data collected were analysed with a detailed radiative transfer model to retrieve aerosol optical depth, volume size distribution, single scattering albedo and phase function. Aerosol optical depth (AOD) and single scattering albedo (SSA) at different wavelengths viz. 400, 500, 675, 870 and 1020 nm were analysed at daily and monthly scales to study their day-to-day and monthly variability. Day-to-day variation in AOD and SSA showed large variability. The monthly mean AODs were found to be about equal at 500 nm wavelength (0.319 and 0.32) during winter and pre-monsoon. The spectral dependence of SSA showed decreasing trend with increasing wavelength during all months indicating the absorbing nature of aerosols prevailing over the experimental site. Seasonal variation in SSA suggested more contribution from absorbing aerosols during pre-monsoon season (0.78) as compared to winter season (0.85).

Observations of atmospheric aerosol optical depth, ozone, precipitable water vapour and single scattering albedo were carried out on 65 clear-sky/ hazy days using the hand-held multi-band solar radiometers and PREDE sky radiometer at the Institute. High spectral resolution radiometric observations of atmospheric aerosols in the wavelength region of 400-720 nm were organized at the Institute on 55 days during clear-sky conditions.

Excimer laser for ozone profiling

A Lambda Physik model EMG 102E Excimer Laser System equipped with Hydrogen filled Raman Gas cell acquired under a DST-ICRP sponsored project for vertical profiling of atmospheric ozone up to ~ 35 km using the DIAL (Differential Absorption Lidar) technique has been installed at the Institute. The laser line at fundamental wavelength of 308 nm as ON line and the first Raman shifted Stokes line at wavelength of 353 nm as OFF line have been used for determining differential absorption due to ozone. The interface between the transmitter, receiver and data acquisition system is being carried out for regular measurements of vertical profiles of ozone over Pune.

Excimer Laser and Control Systems with the multi–channel scaler / averager.

Solar flux studies in UV-B spectral region

A study of surface-reaching solar flux variations in the UV-B spectral region (305,312 and 320 nm) was carried out using the multi-spectral radiometric observations collected on clear-sky and hazy-sky days during the winter of 2000-01.The preliminary results of the study indicated (i) a systematic diurnal variation in solar flux with broad maximum during afternoon hours (when the air mass is minimum) in relation to the solar elevation angle, (ii) the variations in solar flux exhibit the wavy nature on the days associated with hazy sky conditions and (iii) the magnitude of diurnal variation in the solar flux observed at different spectral lines shows strong wave-length dependence.

Solar radiometric studies of columnar water vapour

Solar radiometric measurements of precipitable water content made at Pune since May 1998 were studied. The 936 nm channel located in a strong water vapour absorption band and the 1020 nm channel having minimum absorption had been employed. Data collected on 413 days of observation (about 2-30 observations daily) until September 2001 were used for the analysis. The over all monthly mean precipitable water content (PWC, in cm) showed low values during December–March and started increasing by April (Figure 14). Mainly two types of diurnal variation of PWC were noticed. During winter months higher values of PWC were observed both in the morning and evening hours with a minimum around noontime. During the pre-monsoon summer months PWC values were found to be low till noontime and increased by afternoon hours indicating the effect of convective activity. On an average, the clear-sky PWC (cloud amount = zero octa) value was found to be about 0.8 cm and this value doubled when cloud amount becomes 5 octa. The results of the study showed good relationship between radiometer derived PWC and surface relative humidity, radiosonde derived precipitable water content etc.

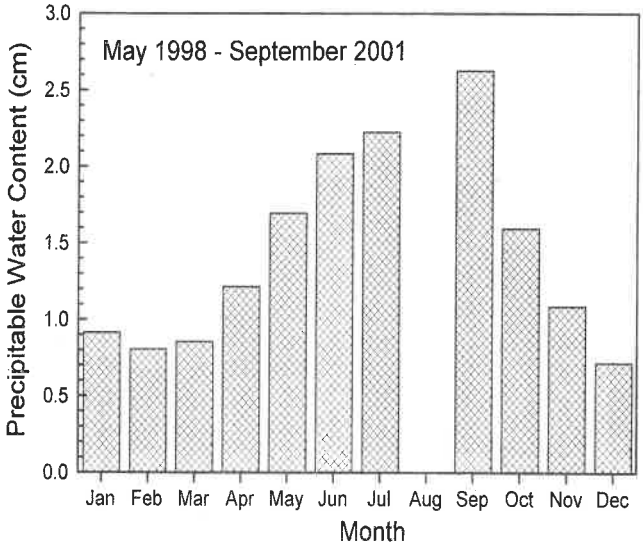


Fig. 14: Monthly mean variations in radiometer derived precipitable water content recorded over Pune during May 1998-September 2001 (The data gap during the month of August due to unfavourable sky conditions).

IRS-P4 satellite synchronous aerosol observations

Special observations of atmospheric aerosols, ozone and precipitable water content using hand-held solar radiometers were carried out on 37 days in synchronization with IRS-P4 satellite passes over Pune during the period of report. The clear-sky observations obtained on about 18 days during this period were utilized to calibrate the ATMRAD model for retrieving land-aerosol characteristics from IRS-P4 satellite data.

The results obtained from the database archived so far include (i) The time-size cross sections showed dominance of accumulation mode particles during hazy sky conditions, particularly during winter season. (ii) The day-time diurnal variation of spectral aerosol optical depth suggested higher forenoon depths and size exponents during winter months. (iii) Higher single scattering albedos during pre-monsoon season suggested the dominance of absorbing aerosols over the experimental station. (iv) The aerosol phase function at 500 nm showed significant dependency with optical depth. Higher optical depths were found to associate with forward scattering. (v) The aerosol refractive index retrieved from sky radiance measurements ranged between 1.45 and 1.6 with imaginary part around 0.005. These values corroborated earlier lidar retrievals at the experimental station. (vi) The time evolution of volume size distribution exhibited neutral extinction characteristics of aerosols on certain occasions of higher afternoon optical depths.

Studies of short wave and long wave radiative flux variations

The radiation sensors, obtained under a joint research programme with Centre for Environmental Remote Sensing (CEReS), Chiba University, Japan were operated and Short Wave (SW) and Long Wave (LW) radiation data acquired on about 45 days. The preliminary analysis of the data showed a systematic diurnal variation in SW and LW radiative flux with broad maximum during afternoon hours and slow-raising and falling trends during morning and evening hours on clear sky days. Significant variations in ground reaching SW as well as LW radiative flux were observed during cloudy days and they were found to be proportional to variations in cloud amount.

Studies in Air Pollution and Precipitation Chemistry

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

Diurnal variation of Aitken Nuclei at Pune and its association with meteorological parameters

Round-the-clock measurements of Aitken Nuclei (A.N.) (particles < 0.1μm radius) were carried out at Pune on 5 days during the months of May and June 2001 to study the diurnal variation of A.N. and its relationship with meteorological parameters i.e. wind speed, direction, temperature and relative humidity (R.H.). The study revealed that (i) A.N. showed high concentrations during daytime and low concentrations during nighttime. The higher concentrations during daytime could be attributed to photochemical reactions. the concentrations of A.N. were found to be low on a rainy day compared to those on a clear day due to the washout effect. The average concentration of A.N. was also found to be higher in the month of May (4680 / cm^3) than that in June (2515 / cm^3). The low concentrations of A.N. in June were due to the comparatively low temperatures and also due to the washout by rain (Figure 15). (ii) A.N. showed a direct relationship with temperature (r=0.66 at 1% significant level) and an inverse relationship with R.H. (r=0.45, 1% significant levels). At higher humidity, the Aitken particles grow into bigger size particles and hence their concentration would be low. The concentration of A.N. were high when the wind speeds were in-between 1 and 1.5 m/s. A.N. concentrations were found to be highest when the wind flow was from north/west and low when the wind flow was from South/Southwest (S/SW). The low concentrations of A.N. during S/SW winds can be attributed to the maritime air mass, which is relatively less polluted than the continental air mass.

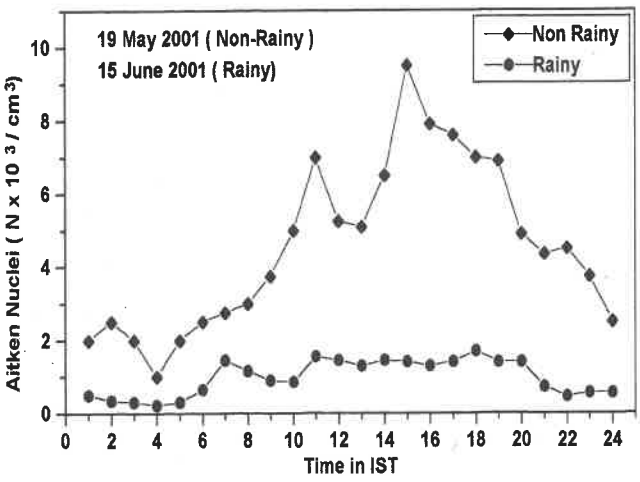


Fig. 15: Comparison of diurnal variation of Aitken Nuclei concentration on non-rainy and rainy days over Pune.

Chemical analysis of precipitation

More than 140 rain water samples were collected at Pune during the monsoon of 2001. The pH of these samples varied from 5.44 to 8.89 with an average value of 6.30. Gradual decrease was observed in average pH value i.e., in June, it was 6.97, in July 6.90, in August 6.85 and in September 5.95. Sixteen rain water samples of equal volume i.e. 100 ml (equivalent to 1.6 mm) collected at Pune on 19 September 2001 were analysed for pH. The initial sample was alkaline (pH 6.21) and thereafter the alkalinity decreased in subsequent samples, which could be due to the effect of washout of alkaline components in the few initial samples. However, again it turned to alkaline at the end. Also, wet and dry deposition samples have been collected at the Rain and Cloud Physics Research (RCPR) Centre, New Delhi. The pH of the samples varied between 5.43 to 8.02 with an average value of 7.50. The chemical analysis of 26 rain water samples collected at J.C.Bose Institute, Mayapuri, Darjeeling during 5 September- 20 November 2001 was carried out. The pH of the samples varied from 5.52 to 6.48, with an average value of 5.73, indicating slightly alkaline rain.

Model evaluation of cloud scavenging phenomenon

Slinn's model for determining washout coefficients of aerosol particles of different sizes has been modified and applied to the particle size distribution of pre-monsoon months of 1998-99 at Pune and Himalayan region. The effect of chemical nature of aerosol particles on washout coefficient and scavenging efficiency were also studied theoretically. Similarly, washout coefficient and scavenging efficiency were computed for hygroscopic particles [NaCl and $(NH_4)_2SO_4$]. The washout coefficients for Cl, Mg, sulphate and sea salt particles were found to be 2 to 3 orders higher than those of aerosol particles of unit density.

Field observations at Delhi and Darjeeling

A field observational programme has been undertaken at Darjeeling and New Delhi under the DST-supported project "Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments". The results revealed that (i) The average concentration of Aitken Nuclei was 3.73 x $10^4/cm^3$, 1.40 x $10^4/cm^3$ and 0.35 x $10^4/cm^3$ at Okhla, New Delhi and Darjeeling, respectively. These concentrations are one of the best indicators of anthropogenic activities at any location as they are mainly formed by man-made activities through, gas-to-particle conversion mechanism. (ii) The average concentrations of Total Suspended Particulate (TSP)

at Darjeeling, Delhi and Okhla (industrial area near New Delhi) were 68.1, 288.76 and 412.77 $\mu g / m^3$. The higher concentration of TSP observed at Okhla may be due to emissions from industrial sources in the area. Relatively lower concentration was observed at Darjeeling. This may be due to the fact that Darjeeling is a high altitude station, located away from urban and industrial pollution. The mass size distribution of atmospheric aerosols at Darjeeling, Delhi and Okhla showed bimodal distribution with one peak in fine mode (< 0.1 μm), contributing about 40% to the total concentration, and other in coarse mode contributing about 60%.

Instruments in operation for monitoring of Aitken Nuclei and wet/dry deposition at a high altitude location (2411 m) near Darjeeling in November 2001.

Atmospheric Chemistry, Modelling and Dynamics

(G. Beig, I. Joshi, C.P. Kulkarni, S.S. Fadnavis, N. Saraf)

3-D modelling studies of marine ozone and pollutants

A three-dimensional tropospheric-lower stratospheric model was used to evaluate the atmospheric ozone measurements and to study the vertical distribution of tropospheric ozone, secondary pollutants (NO_x, CO and CH_4) and their impact on climate. Figure 16 depicts the laboratory where the computation facility for running the model is installed. The model results were used to explain some of the observational features. Model extends from surface to 3 hPa (25 vertical levels) with a resolution of 2.8 x 2.8 degrees in latitude and longitude. The model reproduced most of the broad features such as low surface ozone values (~20 ppb), increase in concentration in the mid-troposphere in the range 40-60 ppb followed by steep gradient (~120 ppb) near the tropopause, observed in the ozonesonde measurements available from the ship observations during the IFP INDOEX 1999. The low value of O_3 was characterized by the low concentration of NO_x and CO in the deep ocean as simulated by the model. However, the marginal increase in the ozone concentration from the oceanic region towards the coastal region was not in conformity with the steady rise in the NO_x value which touches as high as 700 ppb near the continent (11°N, 75°E). The variation in CO from ocean to the continent was found to be more closely related to the O_3 variation. The specific latitudinal distribution pattern of ozone over the marine boundary layer shifts from north of the equator to its south in the deep ocean as the CO rich air from the continent spreads towards the deep ocean, thereby reflecting the inflow of pollutants to the pristine marine region during the dry winter season (Figure 16).

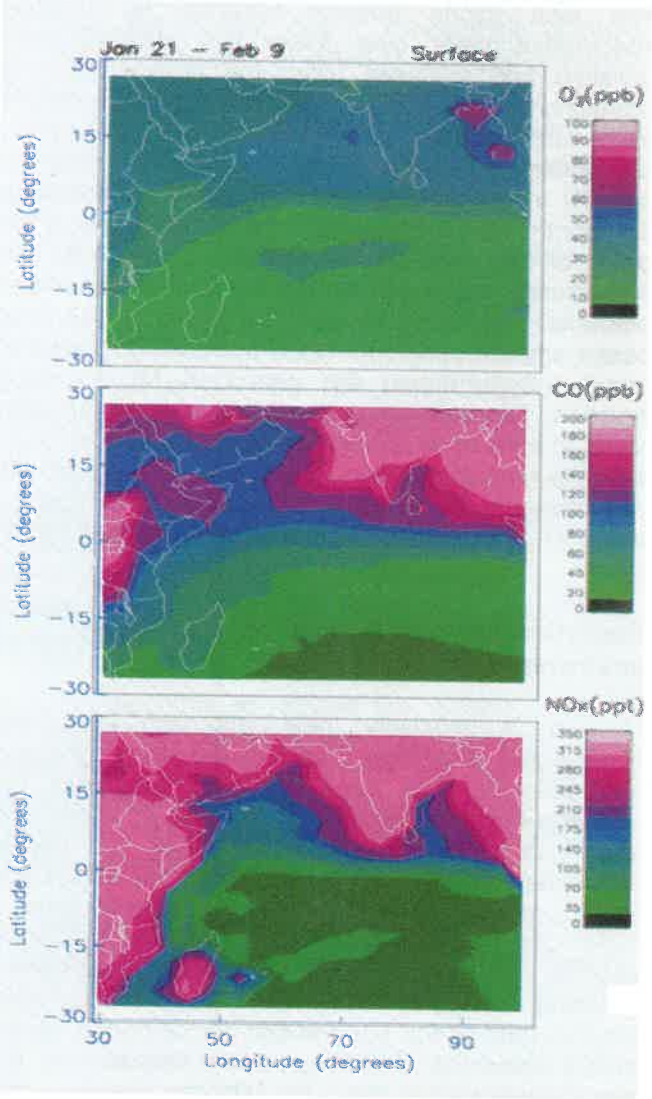


Fig. 16: Surface distributions of O_3 and its precursors (CO and NO_x) for Indian Ocean and sub-continent using the 3-D chemical transport model.

Impact of volcanic eruption on ozone over India

Three independent sets of experimental data for ozone obtained by balloon-borne ozonesondes and Dobson spectrophotometer during the period from 1979-1998 were analysed in search of volcanic signals after the Mt. Pinatubo eruption of 1991 over the tropical Indian region covering two stations viz., Delhi (28°N, 77°E) and Pune (18°N, 73.5°E). These data

sets were analysed using the state of the art regression model, which is based on multiple function regression theory and takes into account of several natural and anthropogenic signals in detecting and separating out the relatively smaller magnitude of sporadic effect. To study the volcanic effects in the vertical structure of ozone, Umkehr and ozonesonde data sets were independently analysed for 4 different vertical layers corresponding to predefined Umkehr layers covering the altitude range from 15 to 33 km. The total ozone amount obtained by Dobson spectrophotometer over these two stations were revisited and analysed using the above statistical regression model. An inter-comparison of the results from different data sets revealed reasonably good agreement. A maximum decrease of the order of 4-7 DU in the altitude range of 15-24 km following 3-4 months of eruption and a maximum increase of the order of 2-3 DU for the altitude range 24-33 km immediately after the eruption were observed in ozone amounts over these two tropical stations. The total ozone amount measurement indicated a decrease of about 5-6 % during the period of Mt. Pinatubo eruption. The decreasing trend in ozone content was found to exist up to a maximum of one and a half year from the time of eruption. The similarity of the results obtained from the 3 sets of data analyzed, affirms the effect of volcanic eruption over the tropical Indian region.

Reconstruction of atmospheric palaeo-environments

In a relatively new approach, the two dimensional interactive model of radiation, dynamics and chemistry has been used to reconstruct the annual vertical distribution of thermal structure and trace gas concentrations of the lower and middle atmosphere for the periods extending from last ice age to the present. For this purpose, ice core air data of the forcing parameters like CO_2, CH_4 and N_2O were used as input to the model for different time frames including Mounder Maximum, Roman maximum, pre-industrial period and the last glacial period. Model results show that the considerable reduction in the greenhouse gas content for the last ice age has resulted in cooling of troposphere and a warming by about 10°K to 15°K in the upper stratosphere as compared to present. The variation in temperature is closely related with the water vapor content. The percentage change in ozone concentration for the last glacial period is to a maximum of 50% near the poles in the upper stratosphere and about 10% in the tropics. A significant decrease in the hydroxyl content in the last ice age must have contributed in increasing the ozone content above 30 km. However, the total integrated ozone content appears to show marginal variations from last ice age to the present due to the fact that the deficit in tropospheric ozone and an increase in upper stratospheric ozone have nearly counterbalanced the total ozone content.

Long-term temperature trends in the middle atmosphere

A study relating to long-term temperature trends in the middle atmosphere vis-à-vis possible global change was undertaken utilizing radiosonde and M-100 rocketsonde data collected over Thumba (8°N) in the 20-80 km altitude region for the period 1971-1993. For the purpose, a multifunctional regression model has been developed by us which, accounts for several functions and filters out natural variations, change due to instrumental modifications and tidal effects. Results of the study indicated an annual negative temperature trend of 1 to 2.5 °K/decade from 20 to 45 km, 2 to 3°K/decade in the lower mesosphere and a rise in cooling up to 5°K/decade in the upper mesosphere. There appears to be a variation in trend pattern in different seasons. These experimental results are complemented with 2-D interactive model results simulated for the same duration and found to agree well. The model accounts for the actual measured growth rate of several greenhouse gases including CO_2, CH_4, N_2O and CFCs for this period.

Association between geomagnetic activity and tropospheric temperature / wind

From superposed epoch analysis of daily winds and temperatures during 1971-1987 for two seasons viz., summer (May-June) and winter (November-February) for 4 stations viz., Madras, Hyderabad, Kolkata and Thiruvananthapuram, increase in wind speed from -3.7 to +3.8 and increase in temperature from 23°C to 28.1°C in the troposphere following the geomagnetic storms were observed with a lag up to 3 days. Also, a 15-day periodicity and a high correlation between geomagnetic activity and temperatures/winds over a period of 15 days were observed from the spectral analysis of k-indices and temperatures/winds (daily values).

Influence of southern oscillation on total ozone variations

A study was undertaken to examine the relationship between total ozone and SOI (Southern Oscillation Index) during both the phases of QBO. For this study, total ozone data from 0 to 20°N latitude and 70° to 100°E longitude during 1950-1992 for three months (June-August) were considered. Also, SOI data for the same period were considered. It was observed that SOI-Ozone relationship depends on the QBO, i.e. decrease in total ozone was observed when the QBO and SOI are in phase.

Role of Quasi-biennial oscillation (QBO) in cyclonic storms

The relationship between the frequency of cyclonic storms, Genesis Potential (GP) and temperatures in the lower stratosphere at 60°N in the Easterly and Westerly phases of QBO for a 36-year period (1964-1998) was investigated. GP values were calculated by subtracting the values of relative vorticity values at 850 hPa from those at 200 hPa. To calculate GP values, radiosonde data at 00 and 12 GMT were utilized. It was observed that, GP is greater for developing synoptic scale disturbances in the westerly phase of QBO than in the easterly phase of QBO. Also, cold temperatures in the lower stratosphere at 60°N in the westerly phase of QBO were found to be associated with more number of cyclonic storms over Indian seas (Figure 17).

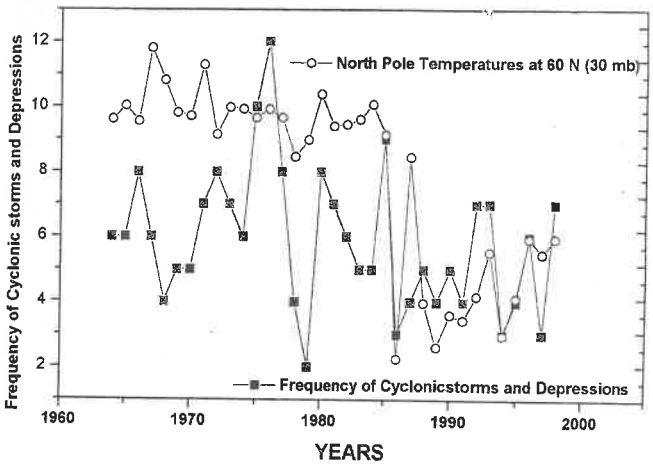


Fig. 17: Co-variations between north-pole temperatures and frequency of cyclonic storms and depressions during 1964-1998.

Analysis of stratalert messages

Analysis of stratalert messages obtained from Free University, Berlin revealed stratospheric warming during 17 December 2001–3 January 2002. Warming existed for about 18 days. Intense stratospheric warming occurred on 26 December and the temperature gradient reversed between 60°N and pole from 10 hPa to 1hPa.

Measurement and Monitoring of Atmospheric Minor Constituents

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

Documentation of volcanic eruption aerosols

Photometeric data collected over Karad (17°1'N, 74° 11'E) during the period October 1999- December 2000 were analysed to obtain the aerosol vertical profiles. Reduction in aerosol loading was clearly seen in 2000 as compared to that observed in 1993, the period of post-Mt. Pinatubo volcanic eruption.

Development of computer algorithm for vertical profiling of aerosols and minor constituents

A model was developed to compute theoretically the scattering intensity due to atmospheric aerosols and the air molecules at different altitudes or earth's shadow heights which in turn used to derive aerosol vertical profile. The theoretically obtained profile was found to be reasonably in good agreement with the guess profile.

A single scattering model was developed to study airmass factors for scattered light observations. Zenith sky air mass factors of NO_2 and O_3 were calculated for a 5 km thick homogeneous absorbing layer located at 0-5 km, 10-15 km, 20-25 km and 30-35 km for 400, 450, 479, 550 and 595 nm.

A new algorithm wherein reference spectra is derived from measured spectra was used for measurement of direct slant column density of NO_2 and O_3. The algorithm to retrieve the vertical profile of O_3 was developed and the results were found to be comparable to Umkher ozone profile at Pune.

An algorithm to retrieve the vertical profile of NO_2 and O_3 was developed which includes matrix form of air mass factors (AMF) used as the Radiative Transfer Model. This matrix was then solved to give the vertical distribution of NO_2 and O_3 with weighted Chahine iteration solution.

Influence of Quasi-biennial oscillation (QBO), solar and volcanic parameters on total ozone variations

Atmospheric ozone variations over four Indian stations (Delhi, Kodaikanal, Pune, Varanasi) and their association with QBO, solar and volcanic activities were studied using the total column ozone data for the period 1981-1998. The results indicated positive ozone anomalies for the period 1981-1990 and negative for 1991-1998 (Figure 18). No much variation was observed in the influence of QBO and solar activity on ozone variations during 1981-1990 and 1991-1998. A prominent relationship was observed between ozone amounts and volcanic activity. The lower values of ozone during 1990-98 can be ascribed to the effect of Mt. Pinatubo volcanic eruption and associated photochemical processes in 1991.

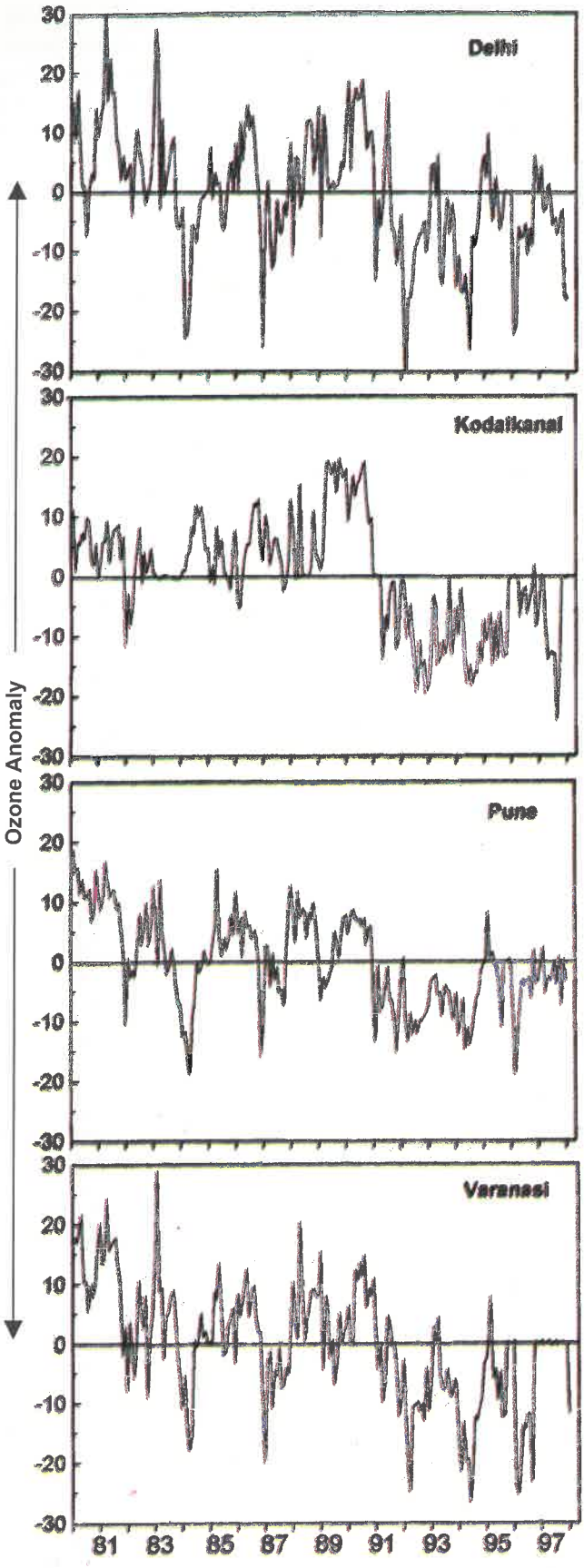


Fig. 18: Monthly ozone anomalies observed over 4 Indian stations with different environments during January 1981 to December 1998.

Development of online twilight photometer for aerosol profiling

The twilight photometer at the Institute was modified and improved its performance. The observations were commenced since 10 November 2001 over Pune. Simultaneously, the required computer algorithms for analyzing the data were developed. The vertical profiles of aerosol index up to 150 km altitude were acquired with the modified photometer.

Photometer and related interface units for the measurements of aerosol vertical profiles during twilight period.

Instruments and Observational Techniques

The broad scope of this Division is to design and develop instruments and techniques for observations and to carryout field and laboratory experiments. Topics identified for research are:

- The development of instruments / techniques to study the cloud electrification processes.
- The development of simulation techniques to study the microphysical processes in cloud physics under controlled environmental conditions.

Simulation Techniques in Cloud Physics

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

To study the effect of vertical electric field on the rate of evaporation of water drops, a laboratory experiment was conducted by suspending drops in a vertical wind tunnel under vertical electric field. Photographs of suspended drops were taken in different values of electric field for analysis. The data obtained during the experiments carried out earlier to study the variation of the rate of evaporation with

ventilation coefficients were further analysed to estimate the relaxation time for the charged and uncharged water drops. The rate of evaporation of charged drops was found to be slower than that of uncharged drops. The relaxation time required for a ventilated drop to reach its equilibrium temperature was found to increase with the drop size and it was higher for the charged drops than for the uncharged drops.

The effect of relative humidity on the scavenging of aerosols during the rain showers was studied theoretically. The computations showed change in the precipitation scavenging rate with height below the cloud base. To study the phenomenon of scavenging in a laboratory simulation experiment, a water drop generator was developed for the production of mono disperse droplets in micrometer size range.

Surface Observations of Atmospheric Electricity and Electric Properties of Clouds

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

Maxwell current density, electric field, precipitation current, space charge density and conductivity were measured below thunderclouds. Analysis of these measurements collected during the pre-monsoon and post-monsoon thunderstorm showers in 1997 and 1998 and study of the field recovery curves after lightning discharges were undertaken to learn about the electrical processes in thunderclouds and sub-cloud layers. The recovery curves of electric field after positive lightning were found to be different than the negative lightning when the value of pre-discharge electric field was very high.

The transfer of charge to the ground by raindrops was examined from the data collected at Pune. Analysis showed that in thunderstorm showers, excess positive charge is brought down to the ground if the ratio of the number of positively to negatively charged drops is more than one, and excess negative charge is brought down to the ground if this ratio is less than one. Exactly reverse is the situation in monsoon rain. The average charge on a raindrop in thunderstorm is one order of magnitude more than that of drops in monsoon rains. The relationship of rainfall rate with the size distribution of water drops was also studied. The size of raindrops increases with rainfall rate. However, the charge on the drop does not show any relation with the rainfall rate.

Observations of aerosol size distribution made during the 1996-1997 Indian Antarctic Expedition were analyzed. Vertical winds associated with the low pressure systems encircling the continent of Antarctica were examined for the period January-February 1997 to study the generation mechanism of the sub-micron aerosols associated with such systems. The total aerosol concentrations were normally observed between 800 and 1200 particles/cm^3 which are typical of the coastal stations at Antarctica in summer. The aerosol size distributions were found to be generally trimodal and open-ended with a peak between 75 and 133 nm and two minima at 42 and 420 nm. Size distributions remained almost similar for several hours or even days in absence of any meteorological disturbance. The total aerosol concentration increased by approximately an order of magnitude whenever a low pressure system passed over the station. Based on the evolution of aerosol size-distributions during such aerosol increases, three distinct types of cases were identified. The nucleation mode in all the cases was suggested to result from the photochemical conversion of dimethyl sulfide emissions transported either by marine air or by the air from the ice-melt regions around Maitri. The subsidence of mid-tropospheric air during the weakening of radiative inversion was also suggested in some cases as a possible source of the nucleation mode particles. Growth of the nucleation mode particles by coagulation and/or by cloud processes was found to be responsible for other modes in size distributions.

The model developed earlier to compute the vertical profiles of the atmospheric electrical parameters close to ground was further extended. Profiles of the atmospheric electrical parameters were computed for different values of mixing parameters and aerosol concentration close to the ground surface.

Five a.c. field-mills fabricated for the electric field measurements to be used in the project on Global Electric Circuit in collaboration with the Indian Institute of Geomagnetism, were calibrated. The electronic circuitry fabricated for five a.c. field mills and five conductivity apparatus required for the project were tested.

Considering coherent cyclotron resonance mechanism for the generation of ELF (Extremely Low Frequency) emissions, the resonance energy growth rate and magnetic field intensity at various frequencies of the emissions were computed for low latitude. It was observed that both resonance energy and growth rate decrease with increasing frequency as well as L-values. The computed magnetic field intensity of the low latitude ELF emissions in the equatorial plain increases with the frequency. A close agreement was found between the computed intensities and those observed on board satellite.

Boundary Layer and Land Surface Processes Studies

The broad scope of this Division is to design and develop instruments and techniques of observation and carry out field and laboratory experimental studies relating to the atmospheric boundary layer and land surface processes. The research programmes undertaken are:

- 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.

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

(S.S. Parasnis, S. Sinha, M.N. Patil, B.S. Murthy)

A coupled one-dimensional land surface–atmospheric boundary layer model was used to simulate surface fluxes for two days from the Lasnd Surface Processes Experiment (LASPEX 1997) data set and compared with observations. These two days represent pre-monsoon (May) and monsoon (July) conditions. For dry pre-monsoon conditions net radiation and sensible heat flux were well simulated by the model. But for wet soil conditions during monsoon net radiation as well as sensible, soil and latent heat fluxes were poorly simulated. The findings suggested that further work should focus on updates to the representation of land-surface processes in the model for the LASPEX region, specifically the parameterization of canopy conductance for tropical crops which appear to need improvement as well as the soil heat flux formulation. Annual simulations were made for the central site of Anand with the land-surface scheme only in an offline mode using hourly atmospheric and radiation forcing to drive the offline land-surface scheme. The performance of the land-surface scheme would be evaluated through the seasons. In the offline mode the land-surface processes and deficiencies can be isolated from complications associated with feedback when the land-surface is coupled with the boundary layer.

Experimental Study of Exchange Processes in the Atmospheric Boundary Layer

(S. Sivaramakrishnan, S. Sinha, T. Dharmaraj, B.S. Murthy, S.B. Debaje)

Land Surface Processes Studies

The LASPEX-97 data viz. surface layer wind and temperature at 1, 2, 4 and 8 m AGL were studied over an agriculture field from July-September at Anand (22°24' N, 72°36' E) and Khandha (22°02' N, 73°11' E) during the Indian summer monsoon 1997. Analysis showed that the hourly averaged winds during the monsoon were light to moderate at both the stations. Spectral analysis of the data revealed sharp peaks separated by 42 days at these stations which showed the intra-seasonal oscillation of wind speed, besides peaks of quasi-biweekly oscillation of the monsoon. Diurnal variation of air temperature showed stratified layers during day time. Variation of daily mean temperature of air near the crop (1 m AGL) and away from the crop (8 m AGL) did not show much difference. They showed spectral energy peaks of period 20-22 days and 10-12 days. Daily mean surface wind direction at 2 and 8 m AGL was fluctuating between S-SW-W showing the normal features of the southwest monsoon. Variation of relative humidity at 1 m AGL at Khandha showed the low frequency oscillation of period 40, 20,15 and 6-9 days.

Using the LASPEX-97 tower observations, estimation of surface fluxes by profile method for Anand, Sanand, Derol, Khandha and Arnej were completed. Variations of drag coefficient by using Sonic Anemometer (Metek) with wind speed and stability were carried out over Anand station (Figure 19).

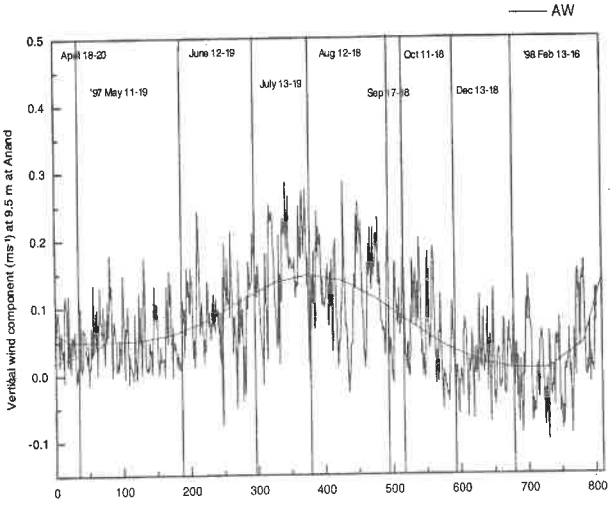


Fig. 19: Time series of hourly-mean vertical wind component (from Sonic) at Anand.

Studies on CABLE (Coastal Atmospheric Boundary Layer Experiment) data

Data collected during the joint field campaign at the Indira Gandhi Centre for Atomic Research

(IGCAR), Kalpakkam (June-July and November-December 2001) by IITM-IGCAR, were processed. Vertical structure of Thermal Internal Boundary Layer (TIBL) was studied using kytoon profiles of wind, temperature and relative humidity. Influence of sea breeze on surface layer wind, temperature and humidity and fluxes of heat and momentum was also studied.

Time series of solar radiation components at Kalpakkam for the month of December 2001 was carried out (Figure 20).

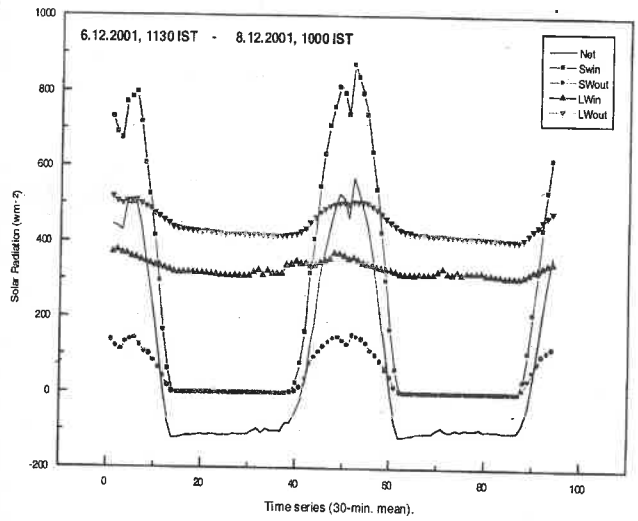


Fig. 20: Time series of solar radiation components at Kalpakkam in December 2001.

Studies on MONTBLEX data

The dependency of mixed layer height on the turbulent surface fluxes of heat and momentum were studied using MONTBLEX-90 data over Bay of Bengal (20° N, 80° E). The results suggested that the mixed layer height does not depend on the magnitude of sensible and latent heat flux but it moderately depends on the momentum flux. Variations were found to be more in the mixed layer height. For the higher momentum flux, the mixed layer height appeared to be constant between 920 and 900 hPa. Virtual potential temperature profiles obtained from the meteorological observations collected during MONTBLEX, in the vicinity of the depression/low pressure systems showed different characterizations. The meteorological parameters (SST, wind speed and pressure) showed diurnal variations of different scales. Empirical relation between the cloud base height and the surface meteorological observations as given by Betts and Ridgway (1989) was verified for its validity over the Bay of Bengal during monsoon conditions which agreed well. This suggested that cloud base height and mixed layer height could be treated as equal during the monsoon conditions over the Bay of Bengal. Cloud base height showed diurnal variation during undisturbed period when the cloud amounts were less. A simple relation based on surface air temperature, pressure and wind speed was suggested to estimate the cloud base height.

Studies on surface ozone

Surface ozone (O_3) measured at Porayar, a tropical coastal station in Tamilnadu, during the period May 1997-October 2000 was analysed. Preliminary results showed significant diurnal cycle of O_3 with a maximum concentration (25-40 ppb) in the afternoon and minimum (8-12 ppb) near Sunrise. A pronounced seasonal variation of O_3 was seen with maximum concentration during summer and minimum during NE monsoon season. The minimum concentration was observed in October and the maximum in April. In moderately polluted coastal air at Porayar diurnal cycle of surface ozone appeared to be regulated by the photochemical production of ozone. The annual average concentration of O_3 was found to be 20 ppb during the period. The surface ozone seen to be increased at the rate of 1-2 % per year for the period 1997-2000 at Porayar.

Survey of surface ozone over urban city

A survey of surface ozone (O_3) was conducted (Phase I: 26 November–12 December 2001 and Phase II: 12–29 December 2001) during winter season over Pune to understand the average (per day) ozone levels in different parts of the city. The survey was conducted by using passive sampler technique at 10 different locations which cover low and high traffic density of the vehicles in the city. The passive sampler (sensor) used here as a rubber strip of size 11 cm x 3 cm was hung for 10 days with 120 gm weight (stress) attached to the lower end. The sensor has been calibrated by using O_3 data measured by the India Meteorological Department, Pune. The results showed that the estimated average integrated ozone per day was in the range 3-16 ppbv/day. The ozone contour was plotted over Pune city in different locations. This revealed that some of the pockets of the city are in NO_x saturated environment. In such pockets, O_3 decreases as NO_x increases. This shows the nonlinear behaviour of O_3 production in Pune city.

Continuous measurements of O_3 by chemical method and incoming solar radiation by pyranometer were being carried out at the Institute campus. These measurements would be utilized to understand the complex behaviour of tropospheric chemistry of ozone. Preliminary results showed pronounced diurnal and seasonal variation of surface ozone in Pune.

Theoretical Studies

This Division conducts theoretical studies for understanding atmospheric and oceanic circulations with special reference to Southwest monsoon. Following research programmes are undertaken :

- 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 domain, 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 multilevel ocean model for understanding 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 academic programmes in Atmospheric Sciences

Studies on Dynamical Ocean Modelling

(P.S. Salvekar, A.A. Deo, D.W. Ganer,
C. Gnanaseelan, P. Singh)

SST simulation using 2½ layer thermodynamic model

The 2½ layer thermodynamic ocean model over the tropical Indian Ocean region 35°-115°E, 30°S-25°N was integrated for ten years to reach steady state using monthly mean climatology for the period 1983-1992 obtained by NCEP and COLA T30 L18 AGCM winds seperately. The model integration was further carried out with inter-annually varying monthly winds of NCEP and COLA. In both the experiments NCEP heat flux was used as a thermal forcing. The simulated SSTs in both the wind cases were in the range of 21°C to 30°C. The difference between the Reynolds SST and the model SST in NCEP case was found to be 0.5°C for all the months and are in agreement with those reported in the literature by others. The simulated SSTs for the year 1985 which was a bad monsoon year in both the cases differ less as to that of year 1986. Figure 21 shows the difference between the SSTs simulated in both the cases for the year 1986 at bimonthly interval.

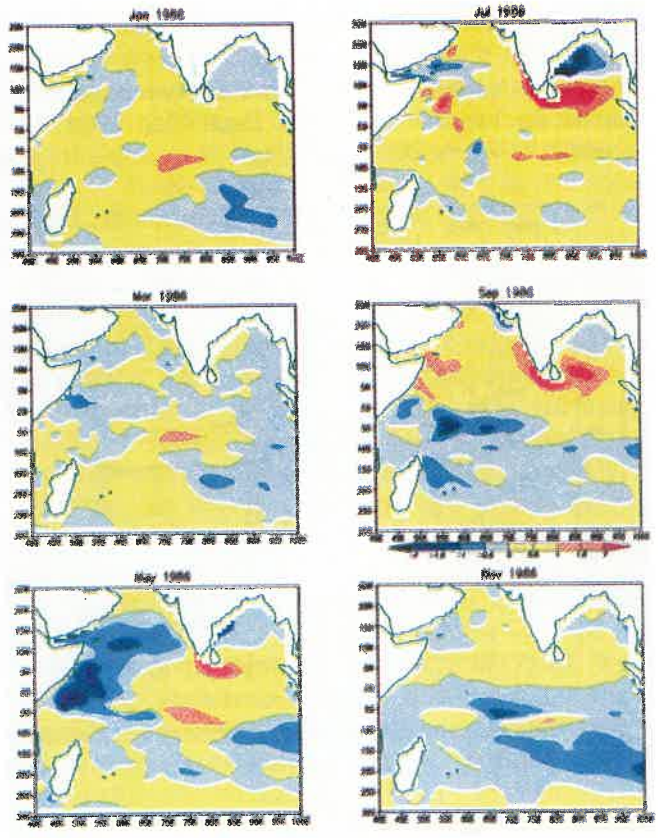


Fig. 21 : Difference between model SSTs using COLA and NCEP winds (COLA-NCEP).

Study of oceanic response to moving cyclone using IRG model

In order to study the SST changes during the passage of cyclone, the IRG model code comprising of momentum equations and continuity equation was modified so as to include the temperature equation in it. Four observed cyclone cases of 1994 (two cyclones each in northern and southern hemisphere) in the Indian Ocean were considered. An idealized cyclonic vortex suitable for all the four cases was generated to force the model. The model was integrated for a number of days of the life span of the cyclones for each case. Figure 22 shows temperature change of mixed layer from the initial temperature of 29°C and upper layer thickness deviation (ULTD) from initial value of 50 m, for all the four cyclone cases for different days. The results indicated, for the Track 1, that the maximum cooling of about 4°C occurs slightly to the right of the track for day 5, suggesting right bias in the temperature field. The isotherms exhibited an

oscillation with wavelength of ~600 km. The ULTD field also showed the right bias and the maximum upwelling was on the right of the storm track. The inertial wave in the wake of the cyclone was found to have a wavelength of about 400 km. The region of upwelling was surrounded by the region of downwelling. For all the tracks the number of inertial gravity waves in the ULTD field in the wake of the cyclone, was in correspondence with the number of waves in temperature field. The area of temperature change was widely spread as compared to that of upper layer thickness. Consequently, the lag between the storm position and the maximum cooling was less than that for the maximum upwelling. For the case of track 2 the ULTD and temperature field on the 5th day gave maximum upwelling and cooling on the left side of the track. This may be due to unusual southwestward movement of the storm in the northern hemisphere. For the Track 3 case, the model ULTD and temperature change for 6th day indicated that maximum cooling and maximum upwelling are to the south of the track, implying the ULTD and temperature field has left bias. The left bias in the southern hemispheric cyclone case was basically, due to the change in the sign of *f* (Coriolis parameter), in the southern hemisphere. Maximum cooling of the order of 4° C and maximum upwelling of the order of 12 m were found. For the Track 4 case, the model ULTD and temperature change is shown for 4th day in the figure 22. As the track is in southern hemisphere and towards south, the maximum cooling (5°C) and upwelling (18 m) were on the left of the storm tack. To improve this over estimated result, another experiment was carried out for which the model was forced with daily SSM/I surface winds after superimposing the bogus cyclone winds analytically generated by taking into account the real cyclone parameters such as size and intensity. The model produced cooling and warming in this new experiment was found to be closer to the observed one.

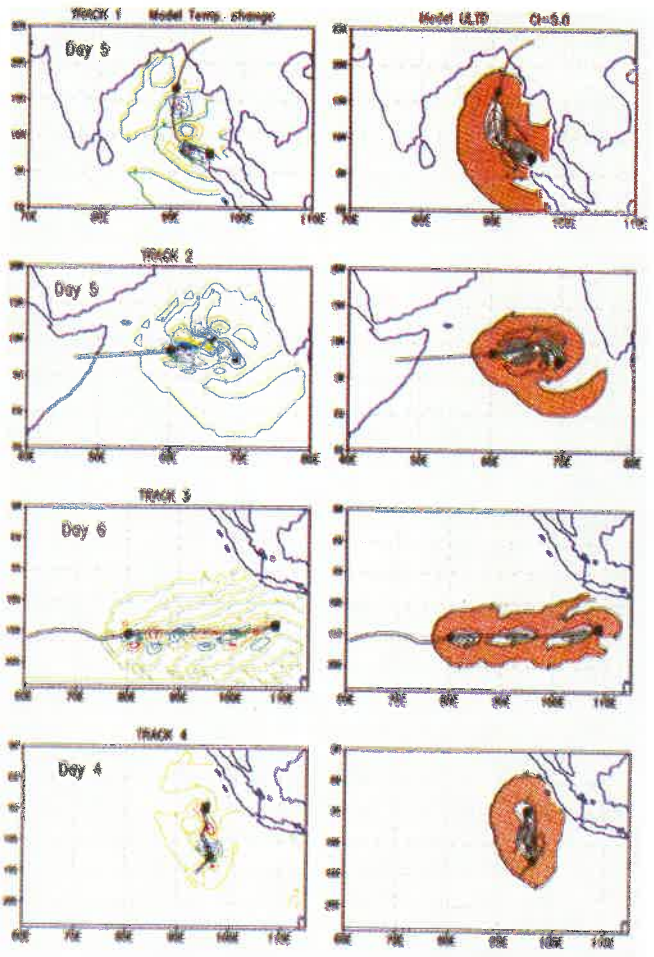


Fig. 22: Model temperature change and ULTD for different tracks ■ indicates initial position and ● indicates present position of the cyclone centre. The solid line indicates cyclone track.

Circulation study with IRG Model

The daily surface winds of NCEP analyses for the period of 1 January 1999 to 30 September 2001 were interpolated to model grid point (0.5°x 0.5°). The earlier climatology of daily winds from 1992-1998 was modified to new climatology using 1992 to 2000 daily surface winds. This was used to spin up the IRG model for 10 years of integration to reach the steady state. The model was then forced with inter-annual wind stress from 1992 to 2000 from the steady state condition. In order to study the ocean surface circulation during monsoon of 2001 the model was further integrated up to September 2001 and the circulation for 2001 was compared with model climatology as well as with model results for the year 2000. The circulation was found to be stronger in 2001 monsoon season than the model climatology. The model results for the years 2000 and 2001 were analysed in detail near the onset dates of two years. Figure 23 describes the wind stress and the model circulation for 25 and 30 May of the two years. The formation of weak anticyclonic gyre along Somali coast on 25 May 2001, in association with the strengthening of south-westerlies north of the equator was found to be related with the early onset of monsoon in 2001.

Application of OCEANSAT data in IRG model

IRS P4 MSMR (OCEANSAT) derived 6 hourly surface winds over North Indian Ocean were acquired for the mid monsoon months of years 2000 and 2001. The winds (1.5° x 1.5 °) were interpolated to IRG model resolution (0.5° x 0.5°). In order to analyze the impact of MSMR data on the daily surface circulation of North Indian Ocean, for the month of July, the steady state solution for June obtained by using climatological NCEP wind data (1992-2000) was taken as the initial state. Then the model was integrated for months of July 2000 and 2001. The results were compared with those obtained by NCEP climatology for July. The circulation for the month of July in both the years showed two-gyre

system along Somali coast with strong northward currents up to 3°N. The northern gyre was found to be weaker as compared to the climatological one. The circulation in the Bay of Bengal was well simulated in both the years. The basin wide gyre was divided into two gyres such that the dominant cyclonic gyre in the western part of the basin and the small anticyclonic gyre in the eastern part of the basin. The east India coastal current was southward in both the years, which was in close agreement with July climatology.

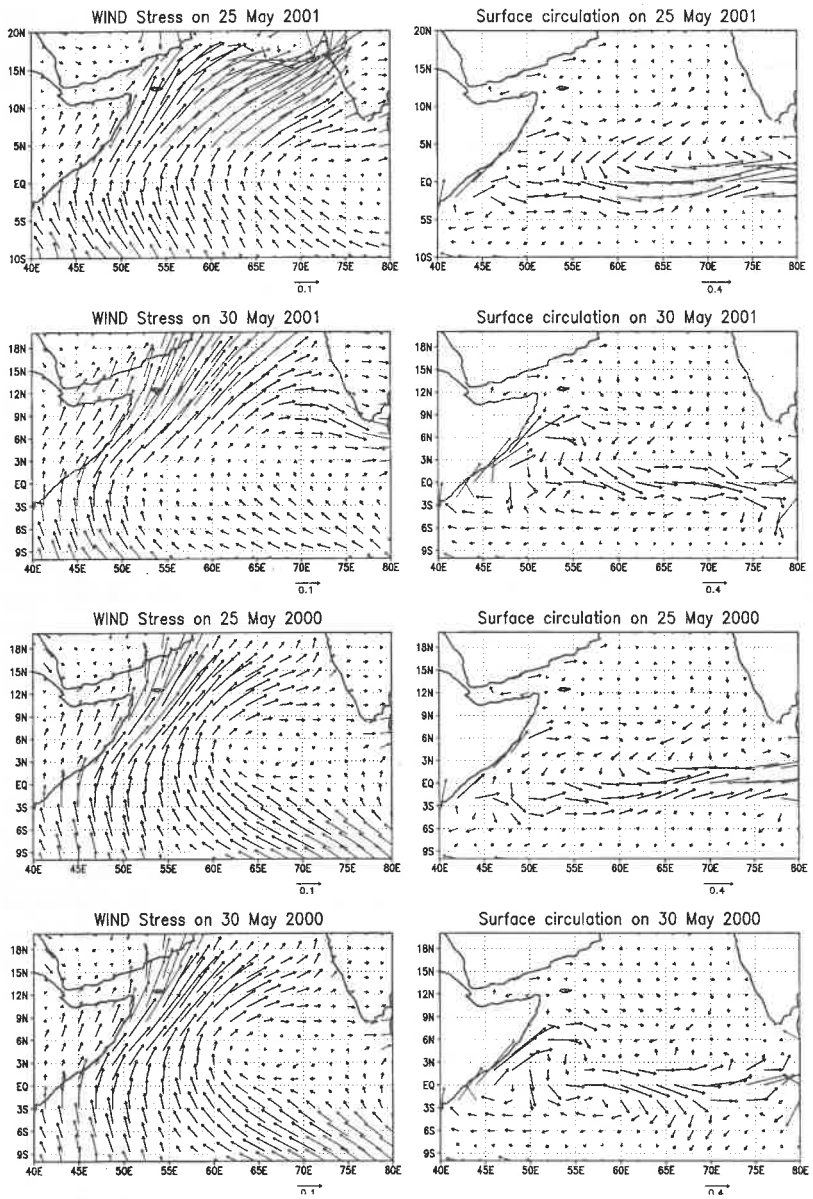


Fig. 23: Wind stress and surface circulation on 25 May and 30 May for the years 2001 and 2000.

Inter-decadal variability of surface circulation from IRG model

NCEP/NCAR monthly surface winds data pertaining to the model grid region (35°-115°E, 24°S-23°N) for the period 1949-2000 were acquired in order to determine the inter-decadal variability of North Indian Ocean circulations. The winds were used to prepare the climatology and were used as a forcing to spin up the 1½ layer Reduced Gravity ocean model from a state of rest. After ten years the model reached quasi-stable state, and the eleventh year of integration was considered as the model climatology. Then the model was run for thirty years i.e., from 1949 to 1978, using interannual forcings. The surface circulations for all the 12 months of the 30 years, were plotted. The analysis of the results was undertaken.

Study made with HRG (high resolution IRG) model

Detailed investigation of coastal circulation was carried out by successfully integrating High Resolution (0.085 x 0.085 i.e. 9 km x 9 km) Reduced Gravity (HRG) ocean model for the period 1 January 1992 – 31 December 1998. The mean surface circulation over Bay of Bengal for the monsoon months (May- September) was examined in detail. The currents along the east coast of India were found to be northward up to 18°N, which were in close agreement with the observations. The basin wide cyclonic gyre normally observed during monsoon season in the Bay of Bengal was found to be split at 18°N into two small gyres with reduced magnitude. The gyre north (south) of 18°N was cyclonic (anti cyclonic). This special feature was noticed for the first time, may be due to the fine resolution of the model. The currents along west coast of the Bay were found to be strong while currents in the central Bay were weak. Westward intensification of currents was thus prominently noticed in the model computations. The northward currents along the eastern rim of Bay were found to shift westward up to south central Bay from May to September.

Study with POM (Princeton Ocean Model)

Work was undertaken to understand the circulation and temperature in the North Indian Ocean at various depths from surface to thermocline. For this purpose, the POM model (Princeton Ocean Model), which is a 3 D model with σ coordinate in vertical and curvilinear orthogonal coordinates in the horizontal direction was studied. As a first step to understand the governing equations, the momentum and continuity equations were separately derived in curvilinear σ coordinate and verified with model equations. The model was tested for the 'seamount problem' over a rectangular basin using analytical input as the test case and run successfully for 10 days.

Diagnostic study

The surface fluxes over the North Indian Ocean (35°-115°E, 20°S –25°N) were simulated for the period 1982-2001 in a numerical Atmospheric Mixed Layer (AML) model. The computed heat fluxes were compared with NCEP fluxes. Further, the variability of the surface fluxes during two tropical cyclones (near Gopalpur and Paradip super cyclones during 15-31 October 1999) was studied and the latent heat flux was found to be higher over the Bay of Bengal region during the cyclone.

Studies on Atmospheric Energetics in Wave Number and Frequency Domain

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

Study of the onset phase: four dimensional energetics

Onset week of southwest monsoon is considered as first week of June. In order to understand the interannual variability of the dynamics of onset week, i.e. 1-8 June various dynamical and physical parameters (ξ, D, ω, Q_H & Q_L) were computed for each day surrounding the southwest coast region (5°-15° N and 65°-80°E) from surface to tropopause at every 50 hPa interval using NCEP reanalysed wind and temperature fields for three different years i.e. early onset (1999), normal onset (2000) and late onset (1997). Results of 1st June indicated that magnitudes of all the dynamical and physical parameters for 1997 were higher than that for the year 2000. The results for the case one week after the normal onset date i.e. for 8th June indicated that the magnitudes of the above parameters for the year, 1999 and 2000 were mainly confined in the lower troposphere up to 700 hPa but for the year 1997 the circulation and strong upward motion were found to be confined in the mid-troposphere. In order to explain these computations, day to day four dimensional energetics were computed for each year using the energy package, developed in-house, during 1 - 8 June. The analysis suggested that the contribution of basic and eddy energies due to meridional wind in the lower troposphere becomes significant and comparable to that of zonal wind as the onset date approaches.

Global energetics in the spectral domain

To understand the vertical, zonal and two-dimensional structure of the stationary atmospheric flow during monsoon months of June and July, and its interannual variation during the years 1988, 1990 and 1991 the 60 days mean (1 June to 31 July) of the daily spherical harmonic coefficients of stream function, velocity potential and temperature during each of the three years was considered. The vertical profiles of rotational (RKZ, RKE) and divergent kinetic energy (DKZ, DKE), enstrophy (ENZ, ENE) and available potential energy (AZ, AE) as well as the spectral representation of RKE, ENE and AE from surface to 10 hPa in terms of the zonal (m) and two-dimensional (n) wave numbers were obtained. The stationary eddy enstrophy was found to be an important parameter in the study of interannual variability of different zonal and two-dimensional scales. The results indicated that (i) The stationary eddy divergent kinetic energy is twice the corresponding zonal kinetic energy through out in the troposphere and stationary eddy enstrophy was approximately twice the zonal enstrophy in the lower troposphere. In the upper troposphere (500-100 hPa), the eddy and zonal enstrophy were comparable. (ii) The vertical profiles of stationary AZ and AE for the three years indicated significant inter-annual variation in the temperature field in the upper troposphere. (iii) From the spectral representation of RKE, ENE and AE in terms of zonal and two-dimensional wave number, the stationary long waves ($1 \leq m \leq 4$) were found to contain maximum energy and enstrophy in the lower troposphere (1000-750 hPa) and upper troposphere (400-100 hPa). In the interannual variation, however, the medium scale ($5 \leq m \leq 15$) and small scale ($16 \leq m \leq 30$) waves were found to be more active than the long wave.

Energetics in the wave number and in the Frequency Domain

A diagnostic modelling study was made to understand the development of low frequency oscillation on the Madden Julian time scale in the free atmosphere originating from the surface layer through PBL by examining the fluxes of heat, moisture and momentum in the frequency domain by using frequency co-spectra and frequency cross-bispectra technique. The procedure for calculation was based on the Monin-Obukhov similarity theory, Bulk Aerodynamics theory and K-theory. The entire computation of this study used one year daily forecast values of u, v, t and q based on one year numerical integration of the FSUCGSM (Florida State University Coupled Global Spectral Model) from April 1996 to March 1997 using global atmospheric analysis from ECMWF and global SST analysis from NCEP over the regions over the equatorial (11.2°N–11.2°S) regions at west Pacific (132.19°-151.88°E), Central Pacific (160.31°–180°W) and Indian Ocean (61.88°-109.69°E). The results of the study concluded a hypothesis that within the surface and planetary boundary layer fluxes, that invoke non-linearities, the Madden Julian Time Scale grows from such

interactions. In the frequency domain this contributes to the maintenance of the Madden Julian Time Scale in a coupled atmosphere-ocean system.

The study performed using the mathematical model developed earlier, to compute the convergence of wave kinetic energy advected by the mean flow, showed that the interaction between time-mean and time transient flows plays a significant role towards the convergence of wave kinetic energy. Further, it was concluded that the seasonal mean flow is the main source of kinetic energy for low frequency oscillations with periods 30-40 days during monsoon over the Indian region.

Nonlinear error energy budget of forecast model in global tropical region

Analysis of total, systematic and random error and their different components in growth rate budget of NCEP (MRF) model for global tropical region (30°S-30°N), in both spectral and physical domain, was carried out using analysis-forecast (up to 5 days) wind data at 850 hPa for the period 1 June - 5 July 2000. Results showed that (i) Tropical systematic error is mainly associated with wave numbers 1 & 2 and generated due to the inadequate formulation of cumulus parameterization processes. (ii) Tropical random error is associated with high wave numbers in comparison with that of systematic error and shows its maxima in wave number band 4-8 and is generated mainly due to the observational error caused by poor data density coverage and error due to the inaccurately describing the sensible heating process in the model over the region of study. (iii) The above two findings are also true for the different components like flux, conversion and generation terms associated with the systematic and random error growth rate budget respectively.

Human Resource Development and Training Programme in Atmospheric Sciences

(L. George, P.S. Salvekar, M.K. Tandon, D.R. Chakraborty, C. Gnanaseelan, A.A. Deo)

Keeping in view the highly specialized nature of atmospheric research, the Institute has signed a Memorandum of Understanding (MoU) with the University of Pune to develop human resources. This Division is actively involved in conducting M.Tech. (Atmospheric Physics) degree course of University of Pune in collaboration with its Department of Physics. During the year, facilities for internship and research guidance was provided to the students of 13th batch and about 200 lectures were delivered to the students of the 14th batch by the scientists of the Institute at the Division's seminar hall.

CLIMATE AND GLOBAL MODELLING

This 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.

Studies on Global and Regional Climate, Variability and Change Using General Circulation Models

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

Dynamical prediction of summer monsoon 2001 using AGCMs

Two atmospheric general circulation models (AGCMs) viz., COLA and HadAM2b were used to study and predict the monsoon-2001. COLA AGCM is a spectral model with T30 resolution in the horizontal and 18 levels in the vertical. The horizontal resolution is approximately equivalent to 3.75°lat. x 3.75°long. grid resolution on the earth surface. HadAM2b is a grid point model with horizontal resolution of 2.5°lat.x 3.75 °long. and 19 levels in the vertical.

Three monsoon-2001 prediction experiments, in the ensemble mode, were carried out using each of the two AGCMs. In the first experiment, April 2001 sea surface temperature (SST) anomalies were persisted over climatological SSTs and used as boundary conditions. The initial conditions were taken from daily NCEP analysis for the period 28 April–3 May 2001 in the COLA prediction experiment, while for the HadAM2b AGCM, model dumps corresponding to 1 April of the last six years of a 17-year integrations were used. The COLA AGCM prediction of the monsoon-2001 was -2.04 % departure from the model normal. HadAM2b prediction showed a departure of +17.68% from the normal.

In the second experiment, May-2001 SST anomalies were persisted over the climatological SSTs for the integration period May through September

2001. The initial conditions were taken from daily NCEP analysis for the period 26 May - 31 May 2001 in the COLA experiment. The revised COLA AGCM prediction of the monsoon 2001 rainfall was -21.03 % departure from the normal. The revised HadAM2b prediction was still on the positive side of the normal (+3 %), but much reduced in the magnitude compared with April SST experiment (Figure 24).

In the third experiment, real SSTs were used as the boundary conditions. The initial conditions from the second experiment were used in this experiment. The monsoon-2001 rainfall departures in this experiment were -10.6% and -1.7% by COLA and HadAM2b AGCMs respectively. In order to find out the causes of the negative departures of the rainfall, the diagnostic study of the monsoon-2001 circulation was carried out. It was observed that there was eastward shift in the 200 hPa divergence circulation pattern over Indian-west Pacific region. Also, there was an anomalous subsidence at 20° N latitude over the Indian region. In general, the monsoon circulation was weaker than normal.

AGCM Simulation of Monsoon Disturbances

To investigate whether a relatively low resolution AGCM such as HadAM2b is capable of simulating monsoon disturbances (lows, depressions and cyclones), frequency and structure of monsoon disturbances were studied in model simulation of summer monsoon 1997. 10-member ensemble integrations for 2-years (1996-1998), with weekly observed SSTs and initial conditions corresponding to 1 September of 10-years (1986-1995) taken from long term integrations of the same model, were used. The criteria adopted for the classification of monsoon depressions were as those of India Meteorological Department. Results showed that the majority of ensemble members simulated the frequency of lows and depressions reasonably well compared to observations. However, they differed from observations in simulation of frequency of intense systems such as deep depressions and cyclonic storms. Spatial distributions of mean sea level pressure, precipitation, and relative vorticity at

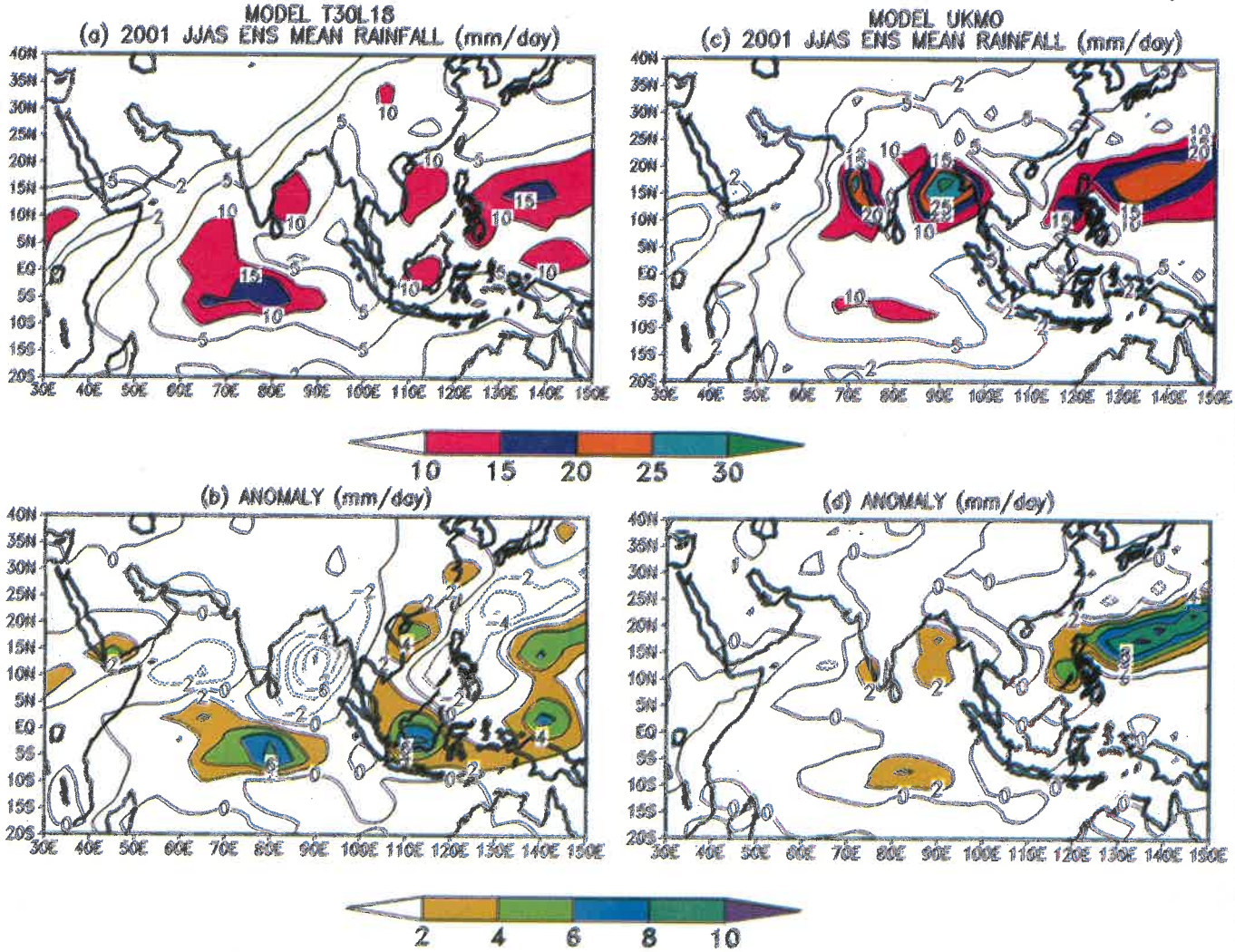


Fig. 24: Ensemble mean JJAS rainfall prediction for 2001 (a) Mean rainfall (b) Anomaly pattern predicted by COLA AGCM (c) Mean rainfall (d) Anomaly pattern predicted by UKMO AGCM.

850 hPa and 500 hPa, during cyclonic storm simulated by the model for the period 13-16 September showed that the cyclone moved from Bay of Bengal in northwest direction and the associated peak precipitation rate (~90 mm/day) and peak cyclonic vorticity (~10x10^{-5}/sec) were noticed on 14-15 September. The cyclonic circulation seemed to be significant at 500 hPa. Figure 25 shows spatial distribution of mean sea level pressure and precipitation rate on 14 September. It is seen from the figure that associated with strong cyclonic storm in Bay of Bengal on 14 September precipitation rate was 100 mm/day over Bay and 10-30 mm/day over peninsular India. Simultaneously a low-pressure area was noticed over Arabian Sea. Precipitation rate associated with this low-pressure area was 30-40 mm/day.

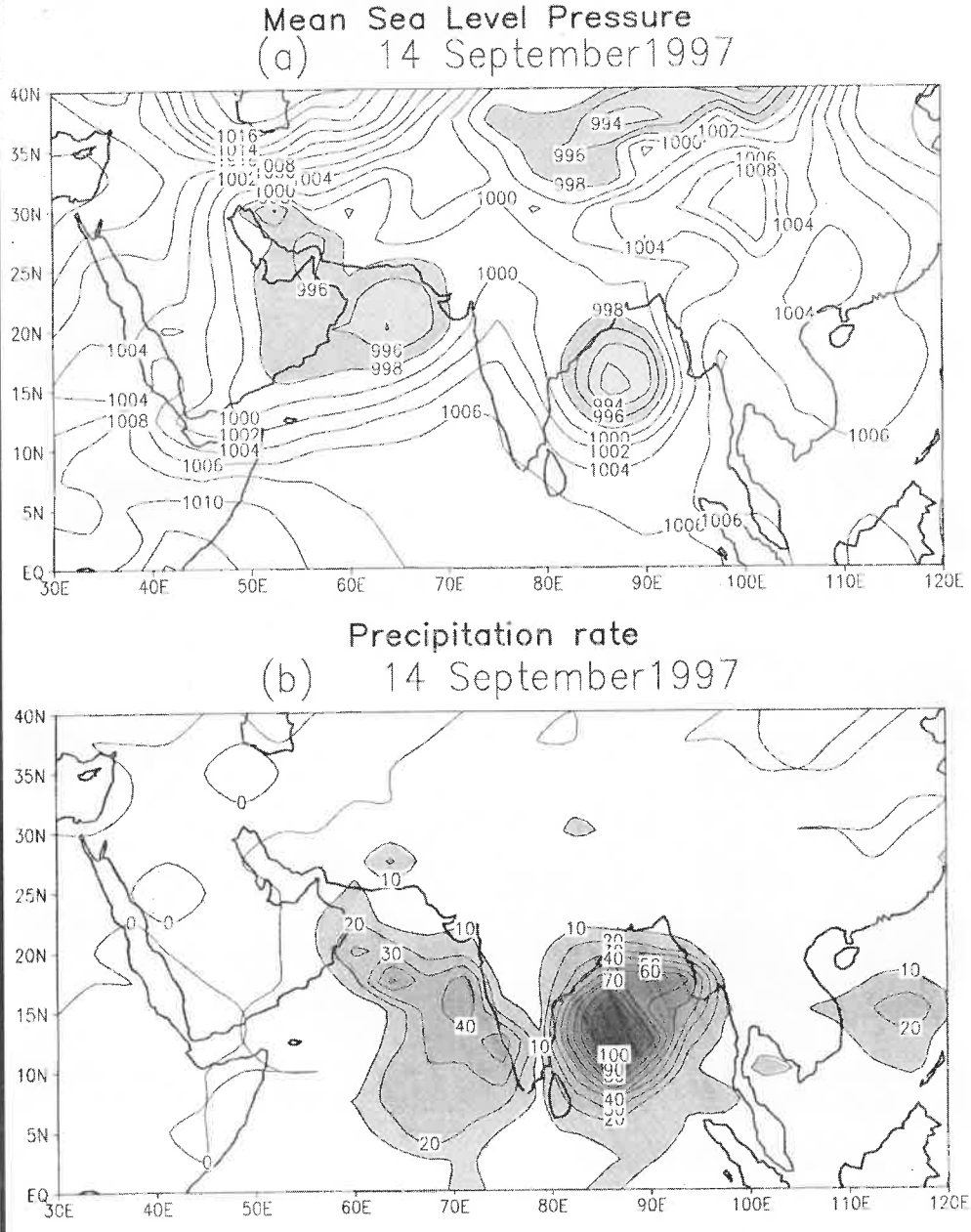


Fig. 25: Spatial distribution of (a) Mean sea level pressure (b) Precipitation rate, during cyclonic storm simulated by UKMO model.

Hadley Centre climate model - HadAM3b (version 4.5) along with User Interface has been obtained from Hadley Centre for Climate Prediction and Research, U.K. The User Interface has been installed on SUN workstation and the model installation was in progress.

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)

Simulations of monthly mean sea surface temperatures (SSTs) over Indian Ocean region using an ocean model driven by AGCM simulated wind stresses

The surface wind stresses from COLA Atmospheric General Circulation Model (AGCM) were used to drive McCreary Ocean model for simulation of SSTs over Indian Ocean region. The McCreary model has horizontal resolution of 0.50°latx 0.50° - long and two and half levels in the vertical. It is a basin scale model. The ocean model was integrated for 10-year period from January 1983 to December 1992 with COLA wind stresses over the region comprising of 25°S-25°N, 35°–115°E. The simulated SSTs were compared with the observed Reynold's SSTs over the Indian region. In general, the error in SST simulation lies between -2 to + 2°K. Over Arabian Sea, during the period January to May the maximum error of -2 to -2.5°K was observed. In the months of March and April, the errors reduced to -1.5°K During Monsoon season, there was an increase in the error. Over Bay of Bengal, the

maximum error of -1.5 was observed during January through May. The maximum error of -2°K was observed in the months June to August. The errors in the SST simulations may be attributed to errors in the wind stress simulations and the fact that SSTs provided by McCreary model are actually depth averaged temperatures of the first layer.

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)

Abnormal Indian Summer Monsoon of 2000

Diagnostic analysis of observations and a series of ensemble simulations using an AGCM were carried out with a view to examine the wide-spread suppression of the seasonal summer monsoon rainfall over the Indian subcontinent in 2000. During this period, the equatorial and southern tropical Indian Ocean was characterized by warmer than normal sea surface temperature (SST), increased atmospheric moisture convergence and enhanced precipitation. These abnormal conditions not only offered an ideal prototype of the regional convective anomalies over the subcontinent and Indian Ocean, but also provided a basis for investigating into the causes for

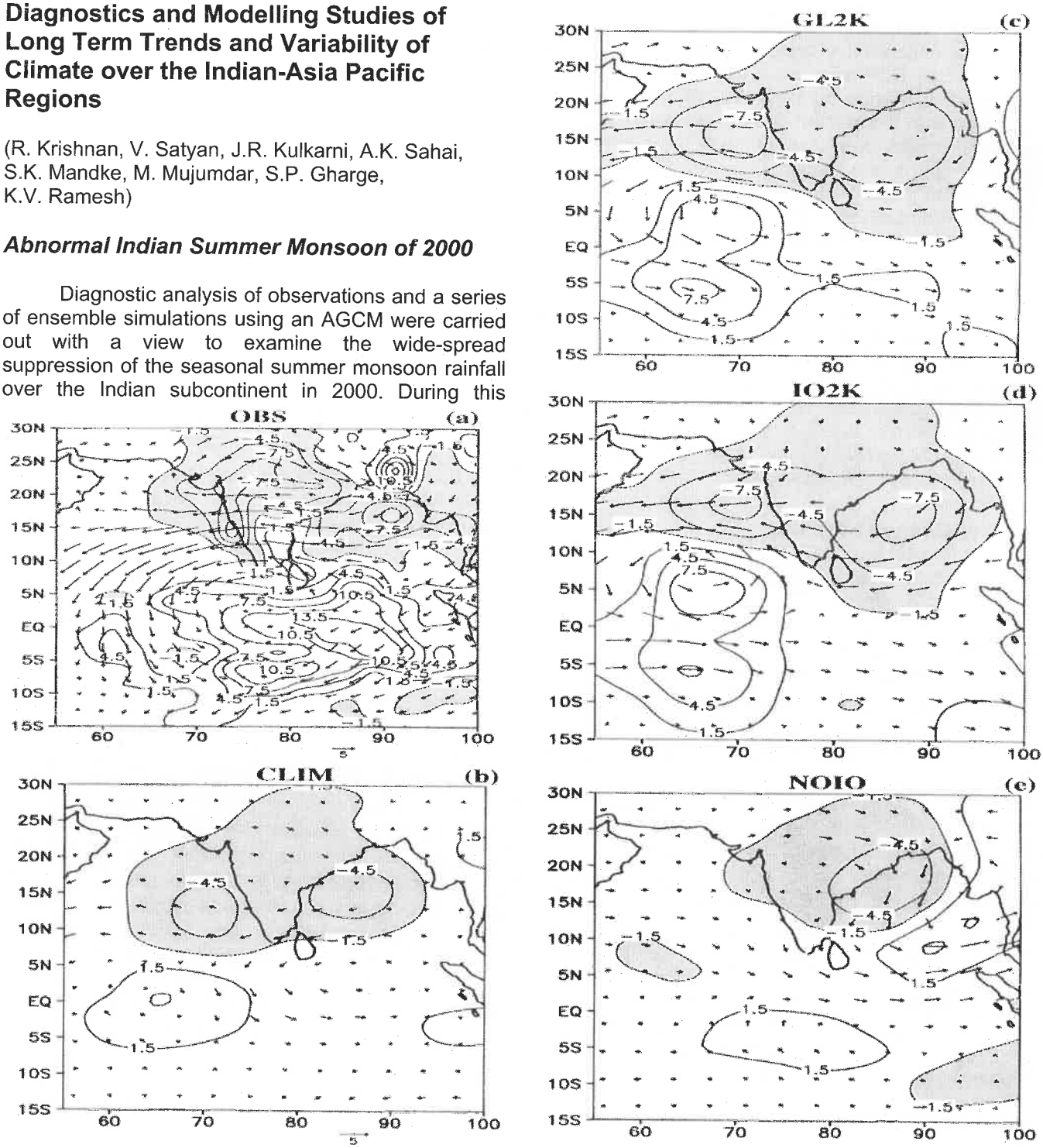


Fig. 26: (a) The composited rainfall (mm/day) anomaly pattern obtained by averaging the CMAP rainfall anomalies over those pentads coinciding with three major break spells of 2000, (b) The composited rainfall anomaly during breaks for the CLIM run, (c) Same as (b) except for GL2K experiment, (d) Same as (b) except for IO2K experiment, (e) Same as (b) except for NOIO experiment.

intensification and maintenance of the anomaly patterns. The findings of this study revealed that the strengthening of the convective activity over the region of the southern equatorial trough played a key role in inducing anomalous subsidence over the subcontinent and thereby weakened the monsoon Hadley cell. It was seen that the leading Empirical Orthogonal Function (EOF) component of the intraseasonal variability of observed rainfall was characterized by a north-south asymmetric pattern of negative anomaly over India and positive anomaly over the equatorial belt. This first EOF accounted for about 21% of the total rainfall variance during 2000. GCM simulations suggested that the pattern of rainfall anomaly during monsoon breaks tends to intensify and persist in presence of warm tropical Indian Ocean SST anomalies as in 2000. Figure 26a shows the pattern of observed rainfall and low-level wind anomalies associated with the monsoon breaks during 2000. The simulated anomalies are shown in Figure 26 (b-e). It was seen that the north-south pattern of decreased rainfall over India and increased rainfall over the equatorial Indian Ocean was reinforced in the presence of the warm Indian Ocean SST anomalies in the GL2K and IO2K experiments, which was qualitatively consistent with observations. On the other hand, in the absence of the Indian Ocean SST forcing (CLIM and NOIO), the break anomaly showed a relatively weak north-south pattern.

Climate Change Studies

Anthropogenic emissions over the Asian region have grown rapidly with increase in population and industrialization. Air pollutants from this region lead to a brownish haze over most of the North Indian Ocean and South Asia during winter and spring. The haze, with as much as 10-15% of black carbon (by mass), is known to reduce the surface solar insolation by about 10% (-15 W/m^2) and nearly double the lower atmospheric solar heating. To study the effects of absorbing aerosols with competing radiative forcing on the atmosphere and the surface, an analysis of observed surface-temperature variations over the Indian subcontinent was carried out. This analysis filters out effects of greenhouse gases and natural variability. The analysis revealed that the absorbing aerosols have led to a statistically significant cooling of about 0.3°C since 1970s. The seasonally asymmetric cooling, consistent with the seasonality of the South Asian aerosol forcing, raises the new possibility that the surface cooling underneath the polluted regions, is balanced by warming elsewhere.

Atmosphere-ocean interaction studies

A Global Ocean GCM developed at Los Alamos National Laboratory (LANL) under the Parallel Ocean Program (POP), was ported and successfully installed at the Institute. The POP-GCM is a descendant of the Bryan-Cox-Semtner (BCS) models and has been designed to run on massively parallel computers. The POP-GCM at the Institute has horizontal resolution of 1.87° x 1.41° and 32 levels in the vertical. The model primitive equations with the active thermohaline dynamics describe the evolution of currents, temperature, heat content, salinity etc. The preliminary runs have been made with this global ocean GCM on a single processor. The ocean GCM will be used in conjunction with the existing atmospheric GCMs to study problems related to air-sea interactions in the tropics.

General Circulation Model Systematic Error Corrections and Seasonal Predictions using Artificial Neural Network

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

A methodology was developed for making an optimal use of global sea surface temperatures (SST) for long lead prediction of Indian summer monsoon rainfall (ISMR), In the first step, correlation analysis was used to identify the regions and seasonal lag when SSTs in those regions are highly correlated with ISMR. From the first 9 Principal Components (PCs) of these regions historical relationship between ISMR and SST was seen to be consistent in recent years. In the second step, a strategy for selecting the best set of 18 predictors (hot spots of the global oceans) was investigated. Relative roles of different ocean basins to interannual and decadal variability of ISMR were studied. For the first time, the dominant role of the South Pacific and North Atlantic Ocean SSTs has been established. It was found that since mid seventies, south Pacific and North Atlantic SSTs had a dominating influence on ISMR while the influence of east Pacific SSTs has been weakening. It was also seen that when the relationship between ISMR and SST in one ocean weakens, the connection in another ocean strengthens. These changes seem to be a part of natural oscillations of climate system. Therefore, despite the weakening of El Nino Southern Oscillation- ISMR relationship in recent years, most of the variability of ISMR can still be attributed to the SST. In the third step, a consistent index (Total Ocean Index, TOI) for long lead prediction of ISMR was developed based on the 2 PCs of the SST of 18 hot spots over global oceans. This index explains about 80% of the variance of ISMR in model verification period. Thus a skillful long lead forecasting of ISMR is possible. A predictive scheme that is stable and therefore useful in a changing background climate, has been developed

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.	Atmospheric Aerosol Loading over Land from IRS-P3 MOS Sensors Data	Dr. P.C.S. Devara	1997-2002	5.54	Indian Space Research Organisation
2.	Variability of North Indian Ocean and its Impact on Global Ocean and Understanding the Mechanism of Coastal Circulation around India	Dr. (Smt.) P.S. Salvekar	1997-2002	34.25	Department of Ocean Development, Govt. of India
3.	Simulation of Surface Wind Stress on Monthly and Seasonal Time Scales using Coupled Atmospheric Ocean Model (CAOM) to Provide Forcing for Driving an Ocean General Circulation Model (OGCM)	Dr.V. Satyan	1997-2002	34.25	Department of Ocean Development, Govt. of India
4.	Studies on Mesoscale (Beta and Gamma) Systems over Indian Region using Regional Atmospheric Modelling Systems of Colorado State University (Indo-US Collaborative Project)	Dr.S.S. Singh	1999-2002	1.734	Department of Science and Technology/ National Science Foundation, USA
5.	Impact of Anthropogenic and Natural Activities on Atmospheric Chemistry and Climate Forcing Factors with their Variability	Dr.G. Beig	1999-2002	15.70	Department of Science and Technology, Govt. of India
6.	Investigations of the Signature of Land-Surface Processes in the Atmospheric Boundary Layer	Dr.S.S. Parasnis	1999-2003	4.60	Department of Science and Technology/ National Science Foundation
7.	Numerical Modelling of the Dynamics of North Indian Ocean Circulation	Dr.(Smt.)P.S. Salvekar	1999-2003	7.50	Space Application Centre
8.	Climate Modelling using PARAM-10000	Dr.V.Satyan	2000-2002	7.37	Department of Science and Technology, Govt. of India
9.	Management Perspectives to Seasonal Climate Forecast in Mixed Cropping System of Southern India's Semi Arid Field	Dr. K.Krishna Kumar	2000-2003	1.20	Global Change System for Analysis, Research and Training/ Asia Pacific Network

Sr. No.	Title	Principal Investigator	Period	Grant (Rs.in lakhs)	Funding Department
10.	Development of Regional Tree-ring Data Network to Study the Past Climate Variations on Decadal to Century Time Scale over Asia	Dr. K. Rupa Kumar	2000-2003	7.25	Indian Space Research Organisation (IGBP)
11.	Differential Absorption Lidar Sensing of Ozone	Dr.P.C.S. Devara	2000-2003	29.94	Department of Science and Technology, Govt. of India
12.	ENSO-Snow-Monsoon Interactions: Understanding and Predicting Monsoon Variability	Dr. R.H. Kripalani	2000-2003	7.38	Department of Science and Technology, Govt. of India
13.	Convective Boundary Layer during the Summer Monsoon over Bay of Bengal	Dr.(Smt.) S.B. Morwal	2000-2003	3.27	Department of Science and Technology, Govt. of India
14.	Development of Field Mill Network System at SHAR for Thunderstorm Warning and to Study the Dynamical Properties of Thunderstorm for Forecasting the Warning Levels	Dr. D.B. Jadhav	2000-2003	26.28	Indian Space Research Organisation
15.	Studies on Evolution of Atmospheric Boundary layer Through Land Surface Interactions at Anand	Dr.S.S. Parasnis	2000-2003	3.96	Department of Science and Technology, Govt. of India
16.	National Information Facility for Climate Research	Smt. A.A. Shiralkar	2000-2003	4.24	Department of Science and Technology, Govt. of India
17.	Experimental Study of Coastal Atmospheric Boundary Layer Structure at Kalpakkam	Dr.S. Sivarama-Krishnan	2001-2002	3.00	Safety Research Institute-Atomic Energy Regulatory Board, Department of Atomic Energy
18.	Surface Climatology of Western Himalaya (Work order of Defence Research and Development Organisation)	Dr.K.Rupa Kumar	2001-2003	9.90	Snow and Avalanche Studies Establishment
19.	Investigation of Features of Monsoon Depressions and Tropical Cyclones by IRS-P4 MSMR Data	Dr.P.N. Mahajan	2001-2003	9.09	Space Application Centre (ISRO)
20.	Aerosol Optical Characterization and Investigation of Aerosol Radiative Forcing at the Surface and Top of the Atmosphere	Dr. G. Pandithurai	2001-2003	3.62	Department of Science and Technology/National Science Foundation (USA)

Sr. No.	Title	Principal Investigator	Period	Grant (Rs.in lakhs)	Funding Department
21.	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	2001-2003	5.46	Department of Science and Technology, Govt. of India
22.	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, Transport and the Regions, Govt. of U.K.
23.	Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change	Dr. K. Rupa Kumar	2001-2004	6.20	Indo-French Centre
24.	Mesoscale Modelling for Monsoon Related Predictions (NMITLI Project)	Dr. S.S. Singh	2001-2004	26.25	Council for Scientific and Industrial Research
25.	Studies of Mesoscale System over Indian Region	Smt. S.S. Vaidya	2001-2004	15.32	Department of Science and Technology, Govt. of India
26.	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
27.	Heat Sources over India during South-West Monsoon Season	Smt. U.V. Bhide	2001-2004	4.30	Department of Science and Technology, Govt. of India
28.	Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber/ Frequency Domain	Shri D.R. Chakraborty	2001-2004	6.445	Department of Science and Technology, Govt. of India
29.	Numerical Modelling of the Upper Ocean Mixed Layer over Indian Ocean Region using Satellite Data	Dr. C. Gnanaseelan	2001-2004	6.972	Department of Science and Technology, Govt. of India
30.	Indian Climate Change Scenario for Impact Assessment	Dr. K. Rupa Kumar	2001–2004	48.50	Department of Energy, Transport and Region, Govt. of U.K./ Min. of Environment and Forests, Govt. of India
31.	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

Sr. No.	Title	Principal Investigator	Period	Grant (Rs.in lakhs)	Funding Department
32.	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)
33.	Observational Study of Aerosol Radiative Forcings 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
34.	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
35.	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
36.	Instrumentation for Atmospheric Boundary Layer Studies	Shri K.G. Vernekar	2001-2004	3.02	Department of Science and Technology, Govt. of India
37.	Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact	Dr. K. Rupa Kumar	2002	18.00	National Communication (NATCOM), Ministry of Environment and Forests, Govt. of India
38.	Composition of Acid Deposition (CAD)	Dr. P.S.P. Rao	2002-2004	0.90	Department of Meteorology, Stockholm University, Sweden
39.	Comparison of Aerosol Vertical Profiles Derived by Twilight Photometer and Lidar	Smt. B. Padmakumari	2002-2004	- -	National MST Radar Facility
40.	Measurement of Meteorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface	Dr. S. Sivarama-Krishnan	2002-2004	21.31	Department of Science and Technology, Govt. of India
41.	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
42.	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

Other Special Events and Activities

Seminars Co-Sponsored

The Institute co-sponsored seminars on (i) Radio and Internet (RANET) for diffusion of Agrometeorological Information and (ii) Monsoon Research in India, held on 30 and 31 July 2001 in conjunction with the 6th Session of Scientific Advisory Committee (SACOM) of the African Centre of Meteorological Application for Development (ACMAD) organised by the India Meteorological Department, Pune during 1-3 August 2001.

PAGES Workshop

A "PAGES Training Workshop on Palaeoclimatic Methods" was organised in the Institute during 14-19 May 2001. Prof. B.L.K. Somayajulu, Physical Research Laboratory, Ahmedabad inaugurated the Workshop. Post-graduate students and young scientists from different universities and research institutions participated in the Workshop. Senior scientists working in the field of palaeoclimatology from various institutions and universities of India were invited as faculty.

PAMC Meeting

10th Meeting of the Project Advisory and Monitoring Committee (PAMC) on the Monsoon and Tropical Climate (MONTCLIM) and the Indian Climate Research Programme (ICRP) was held at the Institute during 21-22 November 2001.

Monsoon Workshop

The Indian Meteorological Society, Pune Chapter and the Institute jointly organised the Annual Monsoon Workshop-2001 at the India Meteorological Department, Pune on 20 December 2001.

SERC School

Second SERC School on Cloud Physics and Atmospheric Electricity-Frontiers (second of the two-year cycle) was held in the Institute during 7 June -5 July 2001. The School was organized jointly by the Institute and the University of Pune and was sponsored by the Department of Science and Technology (DST), New Delhi. Thirty one participants selected from all over India participated in the School. Faculty for the School was identified from various research organizations/ Universities from all over the country. The School was inaugurated on 7 June 2001 by Dr. Rajaram Nityananda, Center Director, National Centre for Radio Astrophysics, Pune. On this occasion, Lecture Notes of the School were released. Eighty nine lectures were delivered by 33 faculty members from various Institutions like PRL, SPL, SAC, IMD, ISRO, IIG, BHU, NMRF, IITM, Air Force Headquarters etc. The valedictory function was held on 5 July 2001. Dr. P.B. Rao, Visiting Professor, National MST Radar Facility, Tirupati was the Chief Guest.

Shri P. Murugavel, IITM, Sq. Leader Shri V.K. Mishra, Air Force Administrative College, Coimbatore and Dr.C.G. Deshpande, IITM were awarded first, second and third prize respectively at the hands of the Chief Guest of the valedictory function for their seminar presentation at the SERC School.

Foundation Day of the Institute

The Institute celebrated its 40th Foundation Day on Saturday, the 17th November 2001 at its premises at Pashan. Dr. Ashok Kolaskar, Vice Chancellor of the University of Pune was the Chief Guest, Dr. R.R. Kelkar, Director General of Meteorology, New Delhi was the Chairman and Shri Dattatraya Gaikwad, Mayor of the Pune Municipal Corporation was the Guest of Honour of the function. The function also included presentation of Annual IITM Silver Jubilee Award for the scientific research paper, 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. Foundation Day Lecture by Prof. V.G. Bhide, Former Vice Chancellor, University of Pune, the Silver Jubilee Award Lecture and a popular lecture by Dr. Shirish Patwardhan were also arranged. 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. Messages of Greetings on this occasion were received from Dr.Murli Manohar Joshi, the Honourable Minister of Human Resource Development and Science & Technology and Ocean Development, Shri Bachi Singh Rawat, Minister of State for Science and Technology, and many other dignitaries.

On this occasion, a Lambda Physik model EMG 102E Excimer Laser System acquired under the DST-sponsored project, for vertical profiling of atmospheric ozone up to ~35 km using the DIAL (Differential Absorption Lidar) technique, was inaugurated by Dr. R.R. Kelkar.

Awards and Honours

The IITM Annual Silver Jubilee Award for the year 1999 was received by Dr. G.K. Monohar, Dr.(Smt.)S.S.Kandalgaonkar and Shri M.I.R. Tinmaker for their research paper entitled, "Thunderstorm activity over India and the Indian southwest monsoon", published in the Journal of Geophysical Research, 104, 1999, 4169-4188.

Dr. G.B. Pant, Director has been awarded Prof.K.R.Ramanathan Memorial Gold Medal for the year 2001 by the Indian Geophysical Union during its 38th Annual Convention held at Visakhapatnam on 19 December 2001.

Biographical sketch of Dr. G.B. Pant, Director has been published in a Compendium Volume entitled, "Uttarakhand ki Vibhutiya" under the chapter on eminent scientists, published by Uttara Prakashan, Rudrapur, Uttaranchal.

Dr. A.K. Kamra has been elected as a Fellow of the Indian Meteorological Society and as a Chairman of its Pune Chapter for the year 2001-2003.

Dr. O.N. Dhar, Emeritus Scientist has been elected as a Fellow of the Indian Meteorological Society.

Dr. K. Rupa Kumar has been nominated as a Senior Associate by the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy for a period of six years (2001-2006).

Dr. G. Beig has been bestowed with National Young Scientist Award in the Physical Sciences category by the Muslim Association for Advancement in Science and Centre for Studies on Science, Aligarh.

Shri S. Mahapatra has been awarded second prize for the seminar presentation and computer programming in the Second SERC School on NWP–Data Processing Assimilation and Initialization, Indian Institute of Technology, New Delhi.

Shri P. Murugvel and Dr. C.G. Deshpande were awarded First and Third Prizes respectively for their presentations in the SERC School on Cloud Physics and Atmospheric Electricity–Frontiers, Indian Institute of Tropical Meteorology, Pune, 5 June – 7 July 2001.

Smt. B.G. Wadikar, Smt. S.U. Athale and Shri T.R. Waghmare received the Excellent Performance Award for the year 2000 specially established by the Institute for the Administrative, Technical and Non-Technical Maintenance category respectively.

Dr. G.B.Pant, Dr. A.K.Kamra, Dr. P.C.S. Devara, Dr. (Smt.) P.S. Salvekar, Dr. K. Rupa Kumar, Dr. R. Vijayakumar, Dr. P.N.Mahajan, Shri J.R. Kulkarni, Smt. S.S.Vaidya, Dr.(Kum.) P.L.Kulkarni, Shri D.R. Talwalkar, Dr. C. Gnanaseelan and Dr. (Smt.) A.A. Kulkarni, have been bestowed with the title "Adjunct Professor", by the University of Pune, Pune for the academic year 2001-2002.

Indo-Japan Collaborative Research

A precision Infrared Radiometer, Pyranometer and Data Acquisition Unit have been received and installed under the project, 'Radiation Sensors and a Data Acquisition System' between the Centre for Environmental Remote Sensing (CEReS), Chiba University, Japan and the Institute. The short-wave and long-wave radiations data from the above sensors in conjunction with the PREDE Sky Radiometer would be used for computing the Direct Radiative Forcing due to aerosols. Regular observations of radiation, utilizing the above equipment at a tropical urban station like Pune have been commenced on 4 February 2002.

Indo-UK Collaborative Programme

The Institute has taken up two major research Projects on "Climate Change Scenario Development and Impacts on Water Resources" as part of the Joint Indo–UK collaborative programme on Indian Climate Change Impacts. A state-of-the-art regional climate model has been installed at the Institute for this work.

Indo-French Collaborative Programme

An Indo-French project on the "Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change" has been taken up. This project analyses the simulations of the CNRM (Centre National de Recherches Météorologiques of Météo France, Toulouse) coupled ocean-atmosphere climate model to evaluate its representation of the Indian summer monsoon of present-day conditions. The projected scenario of the monsoon associated with increased greenhouse gas and aerosol concentrations will also be examined. Additional time-slice experiments are proposed to be conducted to assess the sensitivity of the monsoon climate to the treatment of land surface in the GCMs.

Indo-Swedish Collaborative Programme

The Institute has taken up an Indo-Swedish Collaborative Project entitled "Composition of Acid Deposition (CAD)", under the programme on Regional Air Pollution in Developing Countries (RAPIDC) with the Meteorological Institute of Stockholm University (MISU), Stockholm, Sweden, for a period of three years from 2002. Under this project, a rural background site, Sinhagad (Pune) is selected for the measurements of aerosols and wet/dry deposition along with meteorological parameters.

IITM-SAC Collaborative Programme

Special observations of atmospheric aerosols, ozone and precipitable water vapour using the lidar and radiometric techniques were carried out at the Institute and at Mulshi and Khadadwasla dam sites in synchronization with observations of IRS-P3 satellite passes over Pune. In addition, high-resolution radiometric observations were also carried out at the Institute on 37 days in synchronization with the IRS-P4 satellite passes over Pune.

IITM-SHAR Collaborative Programme

The Institute and the Sriharikota High Altitude Range (SHAR) of the Indian Space Research Organization (ISRO) have undertaken a collaborative Project entitled "Development of Field Mill Network System at SHAR for Thunderstorm Warning and to Study the Dynamical Properties of Thunderstorm for Forecasting the Warning Levels". It is envisaged to establish field mill network at SHAR for measuring the three components of electric field at different locations in SHAR. First phase of the project was completed and two stations were connected to the central processing unit. The data were collected for six months and analysed. In the second phase two additional stations would be installed to collect three vector electric field mill data.

Technical guidance was provided in the maintenance of cylindrical field mills and for collecting electrical field data during PSLV Launch Campaign from 15 to 19 October 2001.

IITM-IIG Collaborative Programme

For atmospheric electric field measurements at Maitri, Antarctica, an a.c. field mill was fabricated and handed over to the personnel of the Indian Institute of Geomagnetism (IIG) going to Antarctica. The electronic circuit of this field mill was rewired and the field mill was recalibrated for Antarctica measurements.

IITM-IGCAR Joint Field Experiment

A joint field experiment to study the coastal atmospheric boundary layer characteristics was jointly conducted by the IITM and the Health and Safety Division of the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam during 18 June-8 July 2001 and 28 November - 13 December 2001. Observations on wind speed and direction, air temperature, humidity and atmospheric pressure were taken at different levels of height.

Inter-comparison Experiments

Correlative measurements employing the multi-filter solar radiometers available with the Institute and Bhabha Atomic Research Centre (BARC), Mumbai were made on 19 and 20 March 2002 with a view to utilise the results of these inter-comparison experiments in the proposed IITM-BARC joint research work on 'Aerosol Characterization over Urban versus Coastal Environments'.

Special Field Observational Programmes

The field observations were conducted in Delhi at two locations, Okhala (Industrial) and New Rajender Nagar (Residential) during 29 January – 10 February 2002, under the DST Project "Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments". Observations regarding mass size distribution of aerosols, total suspended particulates, Aitken nuclei, surface ozone, fog water and meteorological parameters such as temperature, humidity, wind and pressure were carried out during this period.

Under the above mentioned project observations were also taken at the High Altitude Research Centre at Mayapuri, Darjeeling of the Dr. J.C. Bose Institute, Kolkata. Precipitation samples were collected during 31 August-7 September 2001. Special observations of atmospheric aerosol, surface ozone and meteorological parameters such as wind, temperature, humidity and pressure were collected at this center during 9-24 November 2001.

A special experimental programmes on "Influence of atmospheric dynamics on aerosol characteristics" and "Stratosphere-troposphere coupling through aerosol as tracer", was conducted at the National MST Radar Facility (NMRF), Gadanki, Tirupati during 8-17 February 2002. Special observations of atmospheric aerosol distributions using multi-band solar radiometers/twilight photometer, in conjunction with MST radar and ND YAG lidar, atmospheric extinction profiles were carried out at NMRF.

Reports

The Institute carried out design storm studies required for the construction of a major hydroelectric project and submitted the following two project reports to the National Hydroelectric Power Corporation (NHPC) Ltd. :

- Hydrometeorological study of the Middle Siang basin for estimating design storm raindepths.
- Hydrometeorological study of lower and upper Siang basins of the Brahmaputra river for estimating design storm raindepths.

Science Popularisation Programmes

The Institute arranged scientific exhibition, special invited popular science lectures and open days for all to visit the Institute and see its laboratories, computers, library etc. on the occasions of celebration of National Technology Day on 11 May 2001, Institute's Foundation Day on 17 November 2001, National Science Week during 25-28 February 2002, and World Water Day and World Meteorological Day on 22 March 2002. The programmes of different events were well covered by the local newspapers, All India Radio and some of the TV channels. Regular visits of the students, teachers and trainees of various schools, colleges and Institutions from different parts of India were also arranged under the science popularization programme.

Computer and Data Archival Facility

Most of the projects of the Institute are computer based and realizing this, the Institute enhanced its computing power by acquiring a number of high end workstations. The present computing facilities available in the Institute consist of 9 Workstations and about 50 nodes of personal computers (PCs), connected to the Institute's Local Area Network.

A high speed Internet link of 512 KBPS has been established for e-mail, file transfer and internet browsing. In order to provide dedicated bandwidth with higher uptime availability, Institute's LAN has been revamped by installing high-speed backbone, switches, racks and jack-panels. The old V-SAT based connectivity of 9.6 KBPS provided by ERNET has been discontinued. A 2-KVA online UPS with 4-hour battery backup has been acquired for the Internet related activities of mail server and web server.

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 created/updated from time to time and linked to Institute's web page. The mail server on Linux platform has been functioning well with about 150 users.

In-house Computer Trainings

A computer training programme for the Institute's Administrative staff was conducted during 16-27 April 2001. The programme covered Computer Awareness and use of DOS, WINDOWS, Microsoft Word, Microsoft Excel, Internet Browsing and e-mail.

In order to promote the use of freeware viz. Star Office-the Office Automation Software, a 4-day online demonstration training programme on "Introduction to Star Office 5.2" was conducted during 30 October - 2 November 2001. More than 50 users from the Institute attended the training.

Software Development

The Computer Division has developed and modified Program for Pay-roll, Income-Tax, GPF and Budget (revised and anticipated). Software program packages have been developed for medical claims and up-to-date expenditure statements for different projects. Assistance was also provided in computerizing some of the activities of Purchase and Stores Unit like preparation of database for technical and non-technical (dead stock) items.

Data Archival

The Computer Division also provided other technical services to the scientists, such as procurement and installation of softwares, archival and retrieval of meteorological and other related data. The major databases archived include Comprehensive Ocean Atmosphere Data Set (COADS) and the FGGE level III-b data set acquired from the ECMWF. The Division also holds voluminous data collected during the MONTBLEX programme. Large amounts of NCEP reanalysis data (daily, weekly and monthly) of different parameters were downloaded up to date. The work of extraction and supply of TOGA, MONTBLEX, COADS, TOPEX, NCEP reanalysis data is carried out as per the requirement.

Library, Information and Publication

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 26,000 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 Meteorology and Atmospheric Sciences.

During the year 207 books and reports in Meteorology and allied subjects were added. 79 Periodicals of national/international origin were

subscribed to. Reprints of 58 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. The photocopies of the articles of interest were provided 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 has also been an active member-participant of the Resource Sharing Group and Network of Libraries in Pune Metropolitan area (PUNE-NET).

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 in India and abroad.

Technical services like photocopying, microfilming, photography, drafting, drawing, printing and binding were provided.

Programmes for popularisation of meteorology among students and public were arranged 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, National Technology Day, Engineers' Day, etc. The Division also co-ordinates regular visits of students from schools and colleges from various parts of the country to the Institute and arranges taking the visitors round the Institute to see its laboratories, computers and library.

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 (G.C.) 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 of the G.C. are nominated by the DST. The Director General of Meteorology is the Ex-officio Chairman of the Institute's Governing Council. 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 2002 the Institute had total 270 staff out of which 133 belong to Scientific, 36 to Technical, 52 to Administrative and 49 to Non-technical Maintenance category.

Staff changes

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

- **Retirement on Superannuation**

Shri Prem Prakash *Senior Scientific Officer Gr.I*	31 May 2001
Shri N.D.Bidkar *Laboratory Assistant*	31 May 2001
Shri J.K.Panchbudhe *Mechanical Assistant*	31 July 2001
Shri M.S.Dhende *Laboratory Assistant*	31 July 2001
Shri Gurumukh Singh *Senior Scientific Officer Gr.I*	31 August 2001
Shri K.V.S.Madhavan *Section Officer*	31 December 2001
Shri Brij Mohan *Assistant Director*	31 January 2002
Shri Ranjit Singh *Safaiwala*	31 March 2002

- **Voluntary retirement**

Shri S.Sudarsanam *Junior Technical Officer*	1 April 2001
Dr.K.D.Prasad *Assistant Director*	1 May 2001
Shri N.V.Kolhatkar *Security Inspector*	1 June 2001

- **Resignation**

Dr.K.Ashok *Senior Scientific Officer Gr. II*	11 May 2001
Shri A.Bhagwath Singh *Junior Scientific Officer*	19 October 2001
Shri B.Y.Gaikwad *Accounts Officer*	23 January 2002

Employment of Ex-servicemen

Reservation for the ex-servicemen is 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' is 2.

Status of SC/ST/OBC Reservations

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

	SC	ST	OBC	Total
Research	15	5	4	24
Scientific	2	1	3	7
Technical	6	2	1	9
Administrative	6	6	--	12
Non-Technical Maintenance	17	2	2	21
Total	**46**	**16**	**10**	**72**

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 Assistant Directors 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. Two meetings of the Council were held during the year.

Advisory Committee

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

Vigilance Awareness Programme

The Institute observed Vigilance Awareness Week during 31 October - 6 November 2001. The Week began with administration of pledge and reading of the messages from Honorable Home Minister Shri L.K. Advani, Leader of Opposition Smt. Sonia Gandhi, Central Vigilance Commissioner Shri N. Vittal and Vigilance Commissioner Shri V.S.Mathur. On this occasion, a lecture on "Vigilance Awareness" by Shri S.K. Agarwal, Deputy Commissioner, Central Excise, Pune Division was arranged in the Institute on 2 November 2001. A competition of a write-up on Rights and Role of Citizens to Fight Corruption was also arranged for the employees of the Institute. Prizes to the winners of the competition were given away at the hands of Shri Agarwal.

Armed Forces Flag Day

Armed Forces Flag Day was celebrated on 7 December 2001. Employees of the Institute contributed a sum of Rs. 5386/- on this occasion.

Finance

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 2001-2002 were as follows:

(Rs. in Lakhs)

	Grant Received	Actual Expenditure
• **Plan**	230.00	164.00
• **Non-Plan**	315.00	447.00*
• **Sponsored Projects**	171.25	100.22
• **Total**	**716.25**	**711.22**

* Excess expenditure over grant met from Plan and Sponsored Project Funds.

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. 67.29 lakhs
- Dead Stock : Rs. 02.82 lakhs
- Consumables : Rs 06.49 lakhs

Official Language Implementation

Hindi Cell is working under the Administrative Wing of the Institute as per rules and directives regarding Official Language Implementation. With the guidance of Official Language Implementation Committee, Hindi Cell is looking after the Hindi translation and arranging Hindi Training for officers and employees in different cadres. Five employees were nominated for "Pragnya" course held by Hindi Teaching Scheme during the year. All the five candidates successfully completed the course. All general circulars and office orders were issued in bilingual format. Major scientific reports on the activities of the Institute such as Annual Report, Monthly Summary for the Cabinet, Institute's contribution for the reports of the Department of Science and Technology, New Delhi were published in Hindi also.

Use of Hindi is being promoted in scientific work in addition to its regular use in administrative work. Scientists of the Institute presented their scientific work in Hindi at seminars and workshops in order to promote Hindi terminology, a word in English with its counter- word in Hindi is displayed daily on a board at the prominent place in the Institute.

The Institute celebrated Hindi Week during 13-17 September 2001. On this occasion, competitions in Hindi were organised. Dr. (Smt.) Archana Gautam, Hindi Officer, Film and Television Institute of India, Pune was the Chief Guest of the concluding function of the Hindi week celebration. The prizes to the winners of the competitions were given away by the Chief Guest. A lecture by Prof. Sambhaji Bhavsar, University of Pune, Pune was also arranged on this occasion. 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 the members. Annual Sports Tournaments were organised on League basis. Rangoli competition was arranged for ladies.

On 31 August 2001, the Recreation Club awarded prizes to the children of the Institute's employees who had exhibited excellent performance in S.S.C., H.S.C., Diploma, Graduation, Post-Graduation Examinations, Special courses and extra curricular activities, held in the Academic Year 2000-01, under different disciplines. The Recreation Club also arranged slide shows and lectures by eminent personalities. Three slide shows viz., (i) Amarnath Trek and Leh Safari, (ii) African Safari covering Total Solar Eclipse and (iii) China Tour were arranged on 20 June, 1 August 2001 and 1 January 2002 respectively and a lecture on Importance of Bicycle on 17 November 2001.

The Recreation Club started several new activities for the benefit of the Institute's employees. 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 40th Foundation Day Celebration.

International Women's Day was celebrated on 11 March 2002. A slogan writing competition on the topic "My views on International Women's Day" and a special lecture by Smt. Urmila Ukidawe, Director, Victory Association, Pune were arranged on this occasion. Prof. Shashi Gangal, University of Pune was special guest of the celebration. Prof. Gangal planted a sapling.

Garden Committee

The year 2001-02 has been a year of delightful environment to the visitors coming to the Institute complex. Garden Committee accepted the challenge of beautification of the Institute's premises with the development of garden area and maintenance of ecological balance throughout the year. The cultural motivation given to various plants brought out charming characteristics in respect of shape, size and beautification in various plants of the garden. All the employees of the Institute, number of visitors and various students coming from different schools are enjoying the pleasant atmosphere and delightful surrounding of the Institute with variety of seasonal flowers and number of ornamental plants at almost all the time of the year.



Hindi Week Celebrations (left to right) Prof. Sambhaji Bhavsar, University of Pune delivering invited talk, Prize distribution to the winners of the competitions in Hindi, Dr. (Smt.) Archana Gautam, Hindi Officer, Film and Television Institute of India, Pune delivering lecture as Chief Guest of the function

National Science Day Lecture by Shri Govind Kulkarni, Cognizant Technology Solutions, India Ltd., Pune

World Water Day and World Meteorological Day Lecture by Dr. B.D.Kulkarni, IITM


Dr. Shashi Gangal, Prof., University of Pune (left) and Smt. Urmila Ukidawe, Director, Victory Association, Pune (right) on the occasion of International Women's Day Celebrations

Lecture by Dr. Shirish Patwardhan, on Importance of Bicycle

Lecture by Shri. S.K. Agarwal, Deputy Commissioner, Central Excise, Pune Division under Vigilance Awareness Programme

Lecture by Dr. Vijaya Sathe, Nutrition Therapist

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Satyan V., Climate modelling, *Brain Storming Session on Mathematical Modelling of Atmosphere, Land and Ocean Systems, K. Banerjee Centre of Atmospheric and Ocean studies, University of Allahabad, Allahabad, 3-4 November 2001.*

Satyan V., Dynamical seasonal forecasting of monsoon at IITM, *Workshop on Extended Range Monsoon Prediction, Space Application Centre, Ahmedabad, 22 March 2002.*

Singh D.K. and Singh R.P., VLF hiss emission and Cerenkov radiation mechanism, *XII National Space Science Symposium (NSSS-2002), Barakatullah University, Bhopal, 25-28 February 2002.*

Singh N., Effect of global atmospheric thermal conditions on the monsoons of the Indian region, *International Workshop on East Asian Monsoon and Climate, Meteorological Research Institute/ KMA, Seoul, Korea, 25-26 February 2002.*

Singh N. and **Sontakke N.A.**, Impact of global warming on the rainfall pattern and hydrological regime changes over the Indo-Gangetic Plains, India, *First Korea-Russia Joint Workshop on Climate Change and Variability, Jeju, Korea, 17-20 December 2001.*

Sontakke N.A., Longest precipitation fluctuations over northwest India, its teleconnections and estimation, *Workshop on Flood Forecasting with Reference to Global Change, 6th Scientific Assembly of the International Association of Hydrological Sciences (IAHS), Maastricht, The Netherlands, 23-25 July 2001.*

Sontakke N.A. Meteorological problems that require GIS solution, *National Symposium on Recent Advances in Remote Sensing and GIS Technologies for Natural Resources Management, Indian Institute of Technology, Mumbai, 5-7 December 2001 (Invited Talk).*

Trivedi D.K., Tropical cyclones and their prediction over Indian Seas, *DAE Symposium on Cyclone Emergency Preparedness, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, 30-31 January 2002 (Invited Talk).*

Trivedi D.K., Tropical cyclones: genesis, dynamics and movements, *National Interactive Workshop on Cyclone Disaster Management, Tamilnadu Agricultural University, Coimbatore, 25-26 February 2002 (Invited Talk).*

Vijayakumar R., Sun and radiation, *Workshop on Quality Improvement Programme-2001of AICTE on Energy Conservation through Responsive Architecture, Bharati Vidyapeeth's College of Architecture, Pune, 17-22 December 2001.*

PAPERS PUBLISHED

Journals	:	**80**
Proceedings, Books, Reports etc.	:	**36**
PAPERS PRESENTED	:	**67**

Participation in Symposia, Seminars etc.

Brain Storming Session on Arabian Sea Monsoon Experiment (ARMEX) Science Plan, Jawaharlal Nehru Centre, Indian Institute of Sciences, Bangalore, 9 April 2001.
(Dr. G.B. Pant, Dr. S. Sivaramakrishnan and Dr. R.H. Kripalani)

PAGES Training Workshop on Palaeoclimatic Methods, IITM, Pune, 14-19 May 2001.
(Shri A.B. Sikder, Shri Somaru Ram and Smt. J.V. Revadekar)

Workshop on IRS P4 Utilisation, Space Application Centre, Ahmedabad, 29 May 2001.
(Dr. P.N. Mahajan)

Conference on Climate Variability and Land-Surface Processes: Physical Interactions and Regional Impacts, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 11-15 June 2001.
(Dr. K. Rupa Kumar and Dr. R.H. Kripalani)

Summer Colloquium on Physics of Weather and Climate, Workshop on Land-Atmosphere Interactions in Climate Model and Conference on Climate Variability and Land Surface Processes: Physical Interactions and Regional Impacts, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 28 May-15 June 2001.
(Kum, V, Vaidya)

Conference of Reliability Theory, Department of Statistics, University of Pune, 21-23 June 2001.
(Dr. (Smt.) A.A. Kulkarni)

Second International Workshop on Long Term Changes and Trends in the Atmosphere, Prague, Czech Republic, 2-6 July 2001.
(Dr. G. Beig) (Chaired a Session on Temperature Trends)

Workshop on Aerosols, Clouds and Climate, Centre of Atmospheric and Oceanic Sciences (CAOS), Indian Institute of Sciences, Bangalore, 9-13 July 2001.
(Dr. G. Pandithurai, Smt B. Padmakumari, Dr. R.S. Maheskumar)

IGBP Global Change Open Science Conference on Challenges of a Changing Earth, Amsterdam, The Netherlands, 10-13 July 2001.
(Dr. K. Rupa Kumar and Dr. G. Beig)

Second International Conference on Fog and Fog Collection, St. John's Newfoundland, Canada, 15-20 July 2001.
(Dr. K. Ali)

Sixth Scientific Assembly of the International Association of Hydrological Sciences (IAHS), Maastricht, The Netherlands, 23-25 July 2001.
(Dr. (Smt.) N.A. Sontakke)

Seminar on Radio and Internet (RANET) for Diffusion of Agrometeorological Information, India Meteorological Department, Pune, 30 July 2001.
(Dr. A.K. Kamra, Dr. R.H. Kripalani, Dr. K. Krishna Kumar and Smt S.K. Patwardhan)

One-day International Seminar on Monsoon Research in India, India Meteorological Department, Pune, 31 July 2001.
(Dr. S.S. Singh, Dr. R.H. Kripalani, Dr. K. Krishna Kumar and Smt S.K. Patwardhan)

General Assembly of International Association of Geomagnetism and Aeronomy (IAGA) 2001 and Symposium on Long Term Trends in the Mesosphere, Thermosphere and Ionosphere Systems, Hanoi, Vietnam, 19-31 August 2001.
(Dr. G. Beig) (Acted as Convener for two scientific sessions and chaired the Working Group Meeting of IAGA WG – 11F)

Brain Storming Meeting on Impacts of Climate Change on Human Health in India, National Physical Laboratory, New Delhi, 1 September 2001.
(Dr. K. Krishna Kumar)

Fourth American Dialogue on Water Management, Iguacu, Brazil, 2-6 September 2001.
(Dr. A.K. Sahai)

Brain Storming Session on Southern Ocean Atmospheric and Oceanographic Studies, National Centre for Antarctic and Ocean Research, Goa, 4 September 2001.
(Dr. A.K. Kamra)

Eighth National Conference of Women in Science, Agharkar Research Institute, Pune, 12-14 September 2001.
(Dr. (Smt.) A.A. Kulkarni)

Brain Storming Session of INDOEX, Indian Institute of Petroleum, Dehradun, 18-20 September 2001.
(Dr. G.B. Pant and Dr. P.C.S. Devara)

Conference of the Korean Earth Science Society, Taejon, South Korea, 21 September 2001.
(Dr. R.H. Kripalani)

Summer School on Physics of Equatorial Atmosphere, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, 24 September-5 October 2001.
(Dr. C.G. Deshpande)

Course on Inverse Methods in Atmospheric Science, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, 1-12 October 2001.
(Dr. R.S. Maheskumar and Shri Y.K. Tiwari)

Special Symposium on Global Aerosol Climatology and Database and American Association for Aerosols Research Annual Conference (AAAR-2001), Portland, Oregon, U.S.A., 13-19 October 2001.
(Dr. P.C.S. Devara)

Symposium on Role of Earth Sciences in Integrated Development Related Societal Issues, Geological Survey of India, Lucknow, 1-2 November 2001.
(Dr. G.B. Pant, delivered Key Note Address)

Brain Storming Session on Mathematical Modelling of Atmosphere, Land and Ocean Systems, K. Banerjee Centre of Atmospheric and Ocean Studies, University of Allahabad, Allahabad, 3-4 November 2001.
(Dr. G.B. Pant, Dr. V. Satyan and Shri D.R. Chakraborty)

Workshop on Reanalysis, European Centre for Medium Range Weather Forecasting, Reading. U.K., 5-9 November 2001.
(Dr. K.Rupa Kumar)

Workshop on Mountain Meteorology and Remote Sensing, Manali, 7–10 November 2001.
(Shri P. Mukhopadhyay)

Workshop on India's National Communication to United Nations Framework Convention on Climate Change (UNFCCC), Habitat Centre, New Delhi, 22-23 November 2001.
(Dr. G.B. Pant)

XVI National Convention on Multidimensional Impact of Physics in Agriculture, Amolakchand Mahavidyalaya, Yavatmal, 23-25 November 2001.
(Dr. P.N. Mahajan)

NATCOM Training Workshop on Greenhouse Gas Inventory Development, Indian Institute of Management, Ahmedabad, 3-5 December 2001.
(Dr. K. Rupa Kumar, Resource Person)

Seminar on Nowcasting and Mesoscale Disturbances, Indian Air Force, New Delhi, 5 December 2001.
(Dr. G.B. Pant)

National Symposium on Recent Advances in Remote Sensing and GIS Technologies for Natural Resources Management, Indian Institute of Technology, Mumbai, 5-7 December 2001.
(Dr. (Smt.) N.A. Sontakke)

NATCOM Training Workshop on Future Socio-Economic Scenario Generation and Emission Projections, Indian Institute of Management, Ahmedabad, 6-7 December 2001.
(Dr. K. Krishna Kumar, Resource Person)

NATCOM Training Workshop on Climate Change Impact Assessment: Vulnerability and Adaptation Strategy, Jadavpur University, Kolkata, 17-19 December 2001.
(Dr. K. Rupa Kumar (Resource Person), Dr. K. Krishna Kumar (Resource Person), Smt. S.K. Patwardhan and Smt. N.R. Deshpande)

First Korea-Russia Joint Workshop on Climate Change and Variability, Jeju, Korea, 17-20 December 2001.
(Dr. N. Singh)

Workshop on Quality Improvement Programme-2001 of AICTE on Energy Conservation through Responsive Architecture, Bharati Vidyapeeth's College of Architecture, Pune, 17-22 December 2001.
(Dr. R. Vijayakumar and Dr. K.Krishna Kumar)

38th Annual Convention on Natural Hazards and Disaster Management-Role of Earth System Scientists, Andhra University, Visakhapatnam, 18-20 December 2001.
(Dr. G.B. Pant and Dr. P.N. Mahajan)

DAE Symposium on Cyclone Emergency Preparedness, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, 30-31 January 2002.
(Shri D.K. Trivedi)

NATCOM Meeting on Vulnerability and Adaptability for Climate Change in the Forestry Sector, Indian Institute of Science, Bangalore, 7-8 February 2002.
(Dr. K. Rupa Kumar)

Indo-US Workshop on Weather and Climate Modelling, National Centre for Medium Range Forecasting, New Delhi, 7-9 February 2002.
(Dr. G.B. Pant, Dr. K. Krishna Kumar, Shri D.R. Chakraborty and Shri P.R. Reddy)

National Symposium and Workshop on Forecasting and Mitigation of Meteorological Disasters: Tropical Cyclones, Floods and Droughts (TROPMET-2002), Meteorological Centre, Bhubaneshwar, 11-14 February 2002.
(Dr. G.B. Pant, Dr. P.N. Mahajan, Dr. R.H. Kripalani, Dr. (Smt.) I.S. Joshi, Dr. C. Gnanaseelan, Shri S.D. Bansod, Smt. S.K. Mandke, Shri P.V. Puranik, Smt. A.A. Deo, Smt. S. Nair, Shri S.B. Kakade, Shri S.P. Ghanekar, Shri D.W. Ganer and Shri M.D. Chipade)

National Seminar on Human Resources Development, High Energy Material Research Laboratory, Pune, 19-20 February 2002.
(Smt. B.G. Wadikar and Smt. Y.K. Bhonde)

International Workshop on East Asian Monsoon and Climate, Meteorological Research Institute/KMA, Seoul, Korea, 25-26 February 2002.
(Dr. N. Singh)

National Interactive Workshop on Cyclone Disaster Management, Tamilnadu Agricultural University, Coimbatore, 25-26 February 2002.
(Shri D.K. Trivedi)

XII National Space Science Symposium (NSSS-2002), Barkatullah, University, Bhopal, 25-28 February 2002
(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.N. Mahajan, Dr. G. Beig, Dr. (Smt.) I.S.Joshi, Dr. (Smt.) M.S. Naik, Shri S.S. Dugam, Shri S.D. Patil, Smt. R. Latha, Dr. D.K. Singh and Kum. N. Saraf)

IASTA Workshop on Aerosol Characterization Techniques for Pollution Control Application, Bhabha Atomic Research Centre, Mumbai, 6-9 March 2002.
(Shri P.Siva Praveen)

International Conference on Quaternary Climate, Tectonics and Environment of Himalaya: Comparison with other Regions, Kumaon University, Nainital, 11-15 March 2002.
(Dr. H.P. Borgaonkar)

International Symposium on Equatorial Processes Including Coupling (EPIC), Kyoto University, Kyoto, Japan, 18-22 March 2002.
(Dr. G. Beig)

Workshop on Extended Range Monsoon Prediction, Space Applications Centre, Ahmedabad, 22 March 2002.
(Dr. V. Satyan)

Participation in Meetings

Dr. G.B. Pant

- Meeting of the Sub-group on Scientific Services, Department of Science and Technology, New Delhi, 10 April 2001.
- Meeting of Scientific Advisory Committee, National Centre for Medium Range Weather Forecasting, New Delhi, 16 -17 April 2001 and 11 September 2001.
- Second Session of the WMO/CSA Working Group on Tropical Meteorology Research Programme, Cairns, Australia, 28 May –1 June 2001.
- Naval Research Board Panel Meeting, National Institute of Ocean Technology, Chennai, 30 June 2001.
- Discussion Meeting on Doppler Weather Radar and its applications for rain measurements, Indian Space Research Organization, Bangalore, 3-4 July 2001.
- Meeting of Working Group on Ocean Atmosphere Field Experiments under ICRP, Regional Meteorological Centre, Mumbai, 6 August 2001.
- 54th Meeting of Commission for Meteorology and Atmospheric Sciences, Mausam Bhavan, New Delhi, 10 August 2001.
- Fifth Meeting of Program Advisory and Monitoring Committee on Himalayan Glaciology (PAMC-HG), Wadia Institute of Himalayan Geology, Dehradun, 20 and 21 August 2001.
- Annual Review of the activities of Space Physics Laboratory by Scientific Advisory Committee, Thiruvananthapuram, 27-28 August 2001.
- Third Meeting of the Project Monitoring Committee at Jai Vigyan Technology Mission Project on Natural Hazard Assessment in Himalaya, Department of Science and Technology, New Delhi, 12 September 2001.
- Second Meeting of the Ocean Environmental Panel of Naval Research Board, Qutab Institutional Area, New Delhi, 15 September 2001.
- First Meeting of the JSWG Megha - Tropiques, Indian Institute of Science, Bangalore, 30 November 2001.
- Meeting of the Eminent Scientists to discuss on the Assessment of Climate Change in India, World Wide Fund for Nature (WWF), India Secretariat, New Delhi, 18 December 2001.
- Meeting of the Progress Review Committee on the Wind Profiler RASS Project of the Department of Science and Technology, India Meteorological Department, New Delhi, 30 January- 1 February 2002.
- 55th Meeting of the Commission for Meteorology and Atmospheric Sciences, India Meteorological Department, New Delhi, 8 March 2002.
- 23rd Meeting of the Joint Scientific Committee of the World Climate Research Programme, Tasmania, Australia, 18-23 March 2002.

Dr. A.K. Kamra

- Meeting on Aerosol and Radiation Budget, Centre for Atmospheric Sciences, Indian Institute of Science, Bangalore, 19 April 2001.
- Second Meeting of the JSWG Megha - Tropiques, Indian Space Research Organisation, Bangalore, 21 May 2001.
- Meeting of a Select Group of Scientists about the Proposed Artificial Rain Operations at Mount Abu, Rajasthan, by a French Scientist, New Delhi, 29 May 2001.
- Mid-year Meeting, Indian Academy of Sciences, Bangalore, 20-21 July 2001.
- Selection Committee Meeting, Indian Academy of Sciences, Bangalore, 22 July 2001.
- Meeting of the National Executive Committee of the Indian Meteorological Society, Indian Institute of Tropical Meteorology, Pune, 3 August 2001.
- 38th Meeting of the Programme Advisory Committee on Atmospheric Sciences (PAC-AS), Department of Science and Technology, New Delhi, 23 August 2001.
- 67th Annual Meeting, Indian Academy of Sciences, S.V. University, Tirupati, 9-11 November 2001.
- Meeting of the Sectional Committee of Indian Academy of Sciences, S.V. University, Tirupati, 10 November 2001.
- 13th Session of the Commission for Atmospheric Sciences (CAS), Oslo, Norway, 12-20 February 2002.

Dr. S.S. Singh

- First Steering Committee Meeting of the NMITLI Project on Mesoscale Modelling on Monsoon Related Prediction, National Aerospace Laboratories, Bangalore, 8 June 2001.
- Expert Group of Scientific Advisory Committee of National Centre for Medium Range Weather Forecasting, New Delhi, 10 September 2001.
- Preparatory Meeting, Indo-US S&T Forum on Weather and Climate Modelling, National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi, 19 November 2001.
- Second Steering Committee Meeting and First Monitoring Committee Meeting of the NMITLI Project on Mesoscale Modelling on Monsoon Related Prediction, National Aerospace Laboratories, Bangalore, 24 and 25 January 2002 respectively.

Dr. P.C.S. Devara

- Meeting of the National Committee on Aerosol and Radiation Studies, Indian Institute of Science, Bangalore, 19 April 2001.
- Annual General Body Meeting, Indian Aerosol Science and Technology Association (IASTA), Bhabha Atomic Research Centre, Mumbai, 12 November 2001.

Dr. V. Satyan

- Second Ocean Environmental Panel Meeting, Naval Research Board, New Delhi, 15 September 2001.
- Meeting of the DOD / INDOMOD / SATCORE Steering Committee, Space Application Centre, Ahmedabad, 16 October 2001.
- Meeting of the Eminent Scientists to discuss the Assessment of climate change in India, World Wide Fund for Nature (WWF), India Secretariat, New Delhi, 18 December 2001.
- Indo-Russian Meeting on Atmospheric Science, C-DAC, Pune, 5 March 2002.

Dr. K.Rupa Kumar

- Meeting of Asian – Australian Monsoon Panel, University of Reading, U.K., 29-31 August 2001.
- Meeting of the ISRO-GBP Working Group-I (Climate Modelling and Palaeoclimatic Studies), Space Application Centre, Ahmedabad, 5 December 2001.
- Selection Board Meeting for the recruitment of Research Assistants, Central Water and Power Research Station, Pune, 12 December 2001.

Dr. (Smt.) P.S. Salvekar

- International Meeting of the ARGO Implementation Planning Committee, Hyderabad, 26-27 July 2001.
- Second Meeting of the Ocean Environmental Panel of Naval Research Board, Qutab Institutional Area, New Delhi, 15 September 2001.
- Review Meeting of IRS P4, Space Application Centre, Ahmedabad, 6 February 2002.
- Indo-Russian Meeting on Atmospheric Science, C-DAC, Pune, 5 March 2002.

Dr. R. Krishnan

- Indo-Russian Meeting on Atmospheric Science, C-DAC, Pune, 5 March 2002.

Dr. R.H. Kripalani

- Meeting of the Scientific Committee of African Centre for Meteorological Applications for Development, Hotel Pride, Pune, 30-31 July 2001.
- Annual Monsoon Review Meeting, Regional Meteorological Centre, Chennai, 17 January 2002.

Shri J.R. Kulkarni

- Meeting of the DOD / INDOMOD / SATCORE Steering Committee, Space Application Centre, Ahmedabad, 16 October 2001.
- Indo-Russian Meeting on Atmospheric Science, C-DAC, Pune, 5 March 2002.

Shri B.N. Mandal and **Dr. A.K. Kulkarni**

- Meeting on the project on Hydrometeorological study of the Subansiri and Siang basin of the Brahmaputra river, National Hydroelectric Power Corporation Ltd., Faridabad, 10 May 2001.

Dr. K. Krishna Kumar

- Meeting of the Scientific Committee of African Centre for Meteorological Applications for Development, Hotel Pride, Pune, 30-31 July 2001.
- Preparatory Meeting of the Indo-US Workshop on Weather and Climate Modeling, National Centre for Medium Range Weather Forecasting, New Delhi, 21 January 2002.
- Review Meeting for the Vulnerability Assessment and Adaptation Component of the NATCOM Projects, Winrock International India, New Delhi, 6 March 2002.

Dr. G. Beig

- Working Group Meeting of IAGA-IASPEI Joint Scientific Assembly on Trends in Mesosphere, Thermosphere and Ionosphere, Hanoi, Vietnam, 27 August 2001 (as Chairman).
- First Meeting of the Lead Conveners of Division II of IAGA for IUGG-2003, Kyoto University, Kyoto, Japan, 20 March 2002.

Dr. P.S.P. Rao

- Meeting of the Experts on Climate Related Environmental Monitoring (CREM), Department of Science and Technology, New Delhi, 16 October 2001.

Dr. H.P. Borgaonkar

- ISRO-GBP Meeting, WG-1 (Climate modelling and palaeoclimatic studies), Space Application Centre, Ahmedabad, 5 December 2001.

Dr. M.N. Patil

- Meeting, Departmental Promotion Committee for the Post of Mechanic Grade I and Grade II, India Meteorological Department, Pune, 28 December 2001.

Shri S.D. Patil

- Departmental Screening Committee (DSC) Meeting, India Meteorological Department, Pune, 29 August 2001.

Shri M. Mujumdar

- Meeting of the Scientific Committee of African Centre for Meteorological Applications for Development, Hotel Pride, Pune, 30-31 July 2001.

Smt. S.K. Patwardhan

- Meeting of the Scientific Committee of African Centre for Meteorological Applications for Development, Hotel Pride, Pune, 30-31 July 2001.
- Meeting on Assessment of Climate Change in India, World Wide Fund for Nature, New Delhi, 28 February - 1 March 2002

Dr. B.D. Kulkarni

- Meeting on Assessment of Climate Change in India, World Wide Fund for Nature, New Delhi, 28 February - 1 March 2002

By Visitors

Ms.Joanna Syroka, Department of Physics, Imperial College, U.K.

- South Asian monsoon and stratospheric water vapour
  (16 April 2001)

Dr. S.V. Singh, National Centre for Medium Range Weather Forecasting, New Delhi

- Medium range weather forecast at NCMRWF
  (24 April 2001)

Dr. P.K. Kunhikrishnan, Vikram Sarabhai Space Centre, Thiruvananthapuram

- Lower atmospheric wind profiler- A tool for atmospheric boundary layer studies
  (3 May 2001)

Dr. A. K. Bohra, National Centre for Medium Range Weather Forecasting, New Delhi

- New computing facility at NCMRWF
  (8 May 2001)

Dr. Sharad L. Joshi, Chairman, Computer Society of India, Pune Chapter, Pune

- Current trends in Information Technology
  (11 May 2001) (National Technology Day Lecture)

Dr. P. Goswami, Centre for Mathematical Modelling and Advanced Computing Simulation, Bangalore

- Variable resolution GCM: A strategy for high-resolution monsoon forecast
  (25 May 2001)

Prof. K.P.R. Vitthal Murthy, Department of Meteorology and Oceanography, Andhra University, Visakhapatnam

- Analysis and results of Micromet Tower data at Pantanal, Brazil
  (10 August 2001)

Dr. David Hassell, Hadley Centre for Climate Prediction and Research, U.K. Meteorological Office, U.K.

- Regional climate modelling: Concepts, development and a case study
  (14 August 2001)

Prof. G.V. Gruza, Institute for Global Climate and Ecology, Russian Academy of Sciences, Russia

- Outlook of studies of climate variability and forecasting
  (7 November 2001)

Dr. M. Bardin, Institute for Global Climate and Ecology, Russian Academy of Sciences, Russia

- Observed climate change in regions of Russia in 20th century
  (8 November 2001)

Dr. T. Sahay, Inter University Centre for Astronomy & Astrophysics, Pune

- Present scenario of R & D in India
  (28 November 2001)

Dr. Andrew Gettelman, National Center for Atmospheric Research, USA

- Information divide in climate sciences : A discussion
  (1 February 2002)

Shri Govind Kulkarni, Cognizant Technology Solutions India Ltd., Pune

- Current and future Information Technology trends (National Science Day Lecture)
  (28 February 2002)

Dr. Edward R. Cook, Tree-Ring Laboratory, Lamont-Doherty Earth Observatory, Columbia University, USA

- Dendroclimatic signals in long tree-ring chronologies from the Himalayas of Nepal
  (1 March 2002)

Smt. Urmila Ukidawe, Victory Association, Pune

- BACH Flower Remedy – A holistic approach of treatment,
  (International Women's Day Lecture)
  (11 March 2002)

By Institute Scientists

Kum. V. Vaidya

- Anomalous conditions over the summer monsoon regions during 2000: data diagnostics and GCM simulations
  (17 May 2001)

Shri Y.K. Tiwari

- Tropical urban aerosol distributions as inferred from lidar during pre-sunrise and post-sunset period
  (17 May 2001)

Shri J. Sanjay

- Meso-scale modeling-Introduction
  (8 June 2001)
- Meso-scale modeling systems over Indian region
  (11 June 2001)

Shri K. Ali

- Chemical composition of fog water at Delhi, North India
  (19 June 2001)

Dr. G. Beig

- Overview of the middle atmospheric temperature trend assessment
  (20 June 2001)
- Ozone in the marine boundary layer over the tropical Indian Ocean
  (20 June 2001)
- Long-term trends in temperature and composition of the middle atmosphere-model simulations
  (10 August 2001)
- 2nd International Workshop on Long-term Changes and Trends in the Atmosphere
  2-6 July 2001
- Radiative forcing of greenhouse gases in the middle atmosphere
  (5 March 2002)
- Trends in the mesosphere
  (5 March 2002)

Dr. K. Rupa Kumar

- Changes in Indian summer monsoon rainfall and its link with the ENSO in greenhouse-warming scenario
  (21 June 2001)
- Monsoon simulation for global warming scenarios
  (17 August 2001)
- CLIVAR initiatives in monsoon research
  (17 August 2001)
- Interannual variability and teleconnections of Indian summer monsoon in reanalyses
  (24 October 2001)

Dr. R.S. Maheskumar

- Results of aerosol measurements using IITM lidar and radiometers during different INDOEX field phases
  (22 June 2001)

Dr. (Smt,) N.A. Sontakke

- Longest precipitation fluctuations over Northeast India, Its teleconnections and estimation
  (26 June 2001)

Dr. R.H. Kripalani

- Climate variations and teleconnections over South and East Asia
  (27 June 2001)

Dr. S. Tiwari

- Chemical characteristics of urban precipitation at Delhi, India
  (6 July 2001)

Shri S.S. Dugam

- Relationship between NAO and SO during onset and active phase of Indian summer monsoon
  (13 July 2001)

Shri S.P. Ghanekar

- Forecasting the onset of monsoon over Kerala using the peak in pre-monsoon convective activities over South peninsular India
  (24 July 2001)

Kum. N. Saraf

- Tropospheric distribution of ozone and its precursors over the tropical Indian Ocean
  (14 August 2001)

Dr. G. Pandithurai

- Characterization of tropospheric aerosols over oceans with SeaWIFS: Preliminary results
  (12 September 2001)
- Aerosol optical characteristics over Pune during the APEX-E2 period
  (12 September 2001)

Shri D.R. Chakraborty,

- Air-sea nonlinear interaction on the Madden-Julian time scale
  (24 September 2001)

Dr. S. Sivaramakrishnan

- Oscillation of wind, temperature and humidity in the surface layer over agriculture field during the Indian summer monsoon
  (3 October 2001)

Dr. P.C .S. Devera

- Aerosol climatology over a tropical urban station established with collocated ground-based lidar and radiometers,
  (4 October 2001)
- Optical remote sounding of tropical atmospheric aerosols: Indian scenario
  (4 October 2001)

Dr. B.S. Murthy

- Role of ABL observations in meso-scale modelling (Real time applications)
  (10 October 2001)

Shri P. Mukhopadhyay

- Microphysical processes in meso-scale modelling
  (9June 2001)
- Explicit representation of microphysical processes
  (11 June 2001)
- Meso-scale modelling-approaches and case studies
  (30 October 2001)
- Sensitivity study and precipitation skill score using Eta model
  (6 March 2002)

Smt. S.S. Vaidya

- Approach to detect mesoscale convective activity using satellite data
  (28 November 2001)

Shri J.R. Kulkarni

- Artificial neural network: theory and applications to modify the dynamical monsoon seasonal forecast (Part-I)
  (11 January 2002)
- Artificial neural network: theory and applications to modify the dynamical monsoon seasonal forecast (Part-II)
  (18 January 2002)
- Artificial neural network: theory and applications to modify the dynamical monsoon seasonal forecast (Part-III)
  (25 January 2002)

Dr. B.D. Kulkarni

- Indian rainfall from the hydrological consideration and impact of climate change on water resources (World Water Day and World Meteorological Day Lecture)
  (22 March 2002)

Guidance to Students / Trainees for Research Projects

Dr. S.S. Singh

Kum. M.A. Thomas, *Research Fellow, Cochin University of Science and Technology, Kochi (Familiarization Training)*

Kum. P. Bhaskar, *M.Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi*

Dr. P.C.S. Devara

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

Kum. R.T. Madhu Priya, *M.Tech. (Atmospheric Science), Shri Venkateswara University, Tirupati*

Dr. D.B. Jadhav

Shri D.M. Bhor, *M.Sc. (Instrumentation), University of Pune, Pune*

Kum. H.G. Nagar, *B.Sc. (Physics), Fergusson College, Pune*

Dr. K. Rupa Kumar

Shri H. Chaudhury, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri K. Vani, *M.Tech. (Atmospheric Science), Shri Venkateswara University, Tirupati*

Dr. (Smt.) P.S. Salvekar

Shri M. Mishra, *B.Sc. (Physics), Fergusson College, Pune*

Shri Prem Singh and Shri N.K. Agarwal, *Advanced Meteorological Training Course, India Meteorological Department, Pune*

Dr. R. Vijayakumar

Kum. Sireesha, *M.Tech. (Atmospheric Science), Shri Venkateswara University, Tirupati*

Dr. R. Krishnan

Shri K.V. Ramesh, *Ph.D. (Physics), University of Pune, Pune*

Dr.P.N.Mahajan

Kum. N. Jyothi, *M.Tech. (Atmospheric Science), Shri Venkateswara University, Tirupati*

Shri C.Y. Barge, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri J.S. Chawdhary, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri R.R. Raut, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri T. Pattanaik, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri M.P. Agnihotri, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Shri J.R. Kulkarni

Kum. C. Sukumaran, *M.Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi*

Shri S. Polade, *M.Sc. (Space Science), University of Pune, Pune*

Dr. R.H. Kripalani

Asst. Comdt. R. Yadhav and Shri S.S. Sabade, *Advanced Meteorolgoical Training Course, India Meteorological Department, Pune*

Dr. G. Beig

Shri N.V. Sheode, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Dr. P.S.P. Rao

Shri Gouri Sankar, *M.Sc. (Meteorology and Oceanography), Andhra University, Visakhapatnam*

Dr. (Smt.) I. Joshi

Kum. D. Neelima, *M.Sc. (Meteorology and Oceanography), Andhra University, Visakhapatnam*

Smt P. Paul, *Ph.D. (Physics), University of Pune, Pune*

Dr. (Smt.) N.A. Sontakke

Shri R.T. Waghmare, *B.Sc. (Physics), University of Pune, Pune*

Kum. A.J. Bidkar, *B.Sc. (Physics), University of Pune, Pune*

Kum. Y. Inamdar, *B.Sc. (Physics), University of Pune, Pune*

Shri D.R. Chakraborty

Kum. B. Jacob, *M.Tech. (Atmospheric Sciences), Cochin University of Science and Technology, Kochi*

Shri T. Dharmaraj

Kum. B. Vyapari, *B.E. (Instrumentation and Control), D.Y. Patil Women's College of Engineering, Pune*

Kum. S. Sikchi, *B.E. (Instrumentation and Control), D.Y. Patil Women's College of Engineering, Pune*

Kum. V. Pawar, B.E. (Instrumentation and Control), D.Y. Patil Women's College of Engineering, Pune

Dr.H.P. Borgaonkar

Lt. R. Dwivedi, *Advanced Meteorological Training Course, India Meteorological Department, Pune*

Dr. C. Gnanaseelan

Kum. R. Mahajan, *M.Tech. (Atmospheric Physics), University of Pune, Pune*

Dr. S.B. Debaje

Kum. A.S. Nagare, *M.Sc. (Physics), Fergusson College, Pune*

Kum. A. Narsale, *M.Sc. (Physics), University of Pune, Pune*

Nominations as External Examiner / Paper Setter/ Member of the Selection Committee etc.

Dr. G.B. Pant

Ph.D., Banaras Hindu University, Varanasi

Ph.D., Andhra University, Visakhapatnam

Ph.D., Indian Institute of Science, Bangalore

Dr. P.C.S. Devara

Ph.D., Andhra University, Visakhapatnam

Ph.D., Banaras Hindu University, Varanasi

M.Tech. (Applied Physics), Institute of Armament Technology, Pune

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

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

Dr. K. Rupa Kumar

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

Dr. (Smt.) P.S. Salvekar

Ph.D., Utkal University, Bhubaneshwar

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

M.Sc. (Engineering), Indian Institute of Science, Bangalore

Dr. R. Vijayakumar

M.Tech. (Atmospheric Science), Cochin University of Science and Technology, Kochi

M.Sc. (Physics), Cochin University of Science and Technology, Kochi

Dr. P.N. Mahajan

Advanced Meteorological Training Course, India Meteorological Department, Pune

Shri J.R. Kulkarni

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

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

M.Sc. (Physics), Aligarh Muslim University, Aligarh

Dr. G. Beig

M.Phil. (Physics), Aligarh Muslim University, Aligarh

M.Sc. (Physics), Aligarh Muslim University, Aligarh

Dr. (Smt.) I. Joshi

Ph.D. (Physics), Osmania University, Hyderabad

Dr. C. Gnanaseelan

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

Smt. S.K. Mandke

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

Smt. A.A. Deo

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

Expertise Provided as Faculties

Dr. G.B. Pant, Dr. K. Rupa Kumar, Shri J.R. Kulkarni and **Dr. H.P. Borgaonkar**

PAGES Training Workshop on Palaeoclimatic Methods, Indian Institute of Tropical Meteorology, Pune, 14-19 May 2001

Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. R. Vijaya Kumar, Dr. G. Beig, Dr. (Smt.) S.S. Dhanorkar, Shri J. Sanjay, Dr.C.G.Deshpande and **Shri P. Mukhopadhyay**

Second SERC School on Cloud Physics and Atmospheric Electricity-Frontiers, Indian Institute of Tropical Meteorology, Pune, 7 June – 5 July 2001

Dr. V. Satyan

DST-SERC School on Mathematical Modelling of Atmospheric Pollution, Department of Mathematics, University of Bangalore, Bangalore, 5-6 June 2001

Dr. P.N. Mahajan

Training Course on RS-GIS Application in Water Resources Development and Management, Sponsored by Indian Space Research Organisation, Bangalore (Part of the Training Course was conducted at the Indian Institute of Tropical Meteorology, Pune on 29 January 2002)

Dr. K. Krishna Kumar

Quality Improvement Programme-2001, AICTE Bharati Vidyapeeth's College of Architecture, Pune, 19 December 2001

Smt. S.K. Patwardhan and **Smt. N.R. Deshpande**

Training Course on Crop Modelling, Centre of Advanced Studies in Agricultural Meteorology (CASAM), Pune, 8 March 2002

Memberships of Scientific Committees

Dr. G.B. Pant

- Member, Joint Scientific Committee of the World Climate Research Programme (WMO/ICSU/IOC)
- Member, Editorial Board, Mausam, India Meteorological Department, New Delhi
- Member, Program Advisory and Monitoring Committee, Indian Climate Research Programme and Glaciology Programme, Department of Science and Technology, New Delhi
- Member, WMO Commission for Atmospheric Sciences working on Tropical Meteorology Research
- Member, Commission on Meteorology and Atmospheric Sciences (CMAS), Government of India
- Member, Executive Committee and Life Member, Indian Science News Association, Kolkata
- Member, Editorial Board, Bulletin of the Indian Meteorological Society (Vayu Mandal)
- Member, National Executive Committee of the Indian Meteorological Society
- Member, Ocean Environment Panel of the Naval Research Board, Ministry of Defence, Government of India
- Member, Programme Definition Group, Climatological Satellite, Indian Space Research Organization (ISRO), Bangalore
- Member, CODATA National Committee of the Indian National Science Academy, New Delhi

- Member, Organising Committee of Conference on Quaternary Climate, Tectonics and Environment of the Himalaya: Comparison with other regions, Department of Geology, Kumaon University, Nainital
- Member, Committee of the Planning Commission, Government of India on National Natural Resources Management System: Meteorology
- Member, ISRO-IGBP Working Group on Climate Modeling and Palaeoclimate Studies
- Member, Editorial Advisory Committee, Association of Agrometeorologists, Anand
- Member, Scientific Advisory Committee
  (i) National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi
  (ii) Space Physics Laboratory (SPL, ISRO), Thiruvananthpuram
  (iii) Monsoon Study Centre, Department of Atmospheric Sciences, University of Cochin, Kochi

Dr. A.K. Kamra

- Member, Programme Advisory Committee in Atmospheric Sciences (PAC-AS), Science and Engineering Research Council (SERC), Department of Science and Technology, New Delhi
- Member, WMO Commission for Atmospheric Sciences, Geneva, Switzerland

Dr. P.C.S. Devara

- Vice-President, Managing Committee of the Indian Aerosol Science and Technology Association (IASTA), Mumbai
- Member, Editorial Board, Indian Journal of Radio and Space Physics, Bangalore
- Member, Editorial Committee, Indian Meteorological Society, Pune Chapter
- Secretary, Indian Meteorological Society, Pune Chapter
- Member, Governing Council, Instrument Society of India, Bangalore
- Member, National Committee on Aerosol and Radiation Studies, ISRO, Bangalore
- Life Member, Laser and Spectroscopy Society of India

Dr. K. Rupa Kumar

- Member, Australian-Asian Monsoon Panel of the International Research Programme, CLIVAR
- Member, Scientific Steering Committee for the IPCC Workshop on Changes in Extreme Weather and Climate Events, Beijing, China

Dr. R. Vijayakumar

- Secretary, Indian Meteorological Society, Pune Chapter

Shri J.R. Kulkarni

- Member, Stream Sub-committee in Atmospheric Sciences, University of Pune, Pune

Dr. R.H. Kripalani

- Member, Editorial Board of the Korean Journal of Atmospheric Sciences
- Member, Editorial Board of the Journal of the Korean Earth Science Society.

Shri M.K. Tandon

- Honorary Secretary, Pune Chapter of Computer Society of India

Dr. G. Beig

- Chairman, MTTA (Mesospheric Temperature Trend Assessment) Panel constituted jointly under the auspices of IAGA, ICMA and SCOSTEP (PS-MOS) Working Group on Trends
- Member, International Committee of Young Scientists of International Association of Geomagnetism and Aeronomy (IAGA) on Future of Association and its Scientific Priorities over the following 20 years called 'IAGA 2020 Vision'
- Lead Convener, Union Symposium on Challenges of Global Change in Forcing from Below and Above, as a part of the General Assembly of International Union of Geodesy and Geophysics (IUGG), Saporoo, Japan, 2003
- Member, International Scientific Programme Committee of the Second International Workshop on Long-term Changes and Trends in the Atmosphere held at Prague, Czech Republic, 2-6 July 2001

Dr. P.S.P. Rao

- Member, Managing Committee, Indian Aerosol Science and Technology Association, Mumbai
- Associate Editor Journal of Current Sciences, S.K. University, Dumka (Jharkhand)

K. Krishna Kumar

- Member, Scientific Steering Committee for the IPCC Workshop on Changes in Extreme Weather and Climate Events, Isla de Margarita, Venezuela, 11-13 June 2002

Shri M. Mujumdar

- Executive Member, Indian Academy of Industrial and Applicable Mathematics

Lectures Delivered Outside

Dr. G.B. Pant

- Application of botanical knowledge in deciphering palaeoclimate, Birbal Sahni Institute of Palaeobotany, Lucknow, 7 October 2001
- Dr. K.R. Ramanathan Memorial Lecture, Indian Geophysical Union, Visakhapatnam, 19 December 2001

Dr. P.C.S. Devara

- Lidar and radiometric studies of aerosols : A review and future needs, Meeting of National Committee on Aerosol and Radiation Studies, Indian Institute of Science, Bangalore, 19 April 2001
- Remote sensing of atmospheric aerosols, Andhra University, Visakhapatnam, 21 July 2001
- Lidar probing of the atmosphere, Department of Physics, Banaras Hindu University, Varanasi, 31 August 2001

Dr. V. Satyan

- Climate modelling at IITM: An overview, Centre for Mathematical Modelling and Computer Simulation (CMMACS), Bangalore, 5-10 December 2001
- Climate change scenarios, World Wide Fund for Nature, India Secretariat, Lodi Estate, New Delhi, 18 December 2001

Dr. (Smt.) P.S. Salvekar

- Ocean modelling activity at IITM, Indian Institute of Science, Bangalore, 12 December 2001

Dr. S. Sivaramakrishnan

- Atmospheric boundary layer measurements, Indira Gandhi Centre for Atmospheric Research (IGCAR), Kalpakkam, 2 July 2001

Dr. N. Singh

- On the relationship between climate fluctuations and environmental changes over the Indo-Gangetic plains, Centre for Studies Resource Engineering, Indian Institute of Technology, Mumbai, 21 June 2001.

Dr. K. Krishna Kumar

- Sensitivity of Indian summer monsoon to Indo-pacific SST patterns: Observational and model simulation results, Meteorological Research Institute, Tsukuba, Japan, 20 April 2001
- Sensitivity of Indian summer monsoon to Indo-pacific SST patterns: Observational and model simulation results, Institute for Global Change Research, Tokyo, Japan, 18 May 2001

Dr. P.S.P. Rao

- On-going studies related to atmospheric gases and aerosols and future plans, Meeting of Experts on Climate Related Environmental Monitoring (CREM), Department of Science and Technology, New Delhi, 16 October 2001

Shri. D.R. Chakraborty

- Estimation of nonlinear energy exchanges in the frequency domain by use of frequency cross-bispectra technique, Department of Meteorology (Ocean-Atmosphere Modeling Unit), Florida State University, U.S.A., 21 June 2001

Smt. S.K. Patwardhan

- Climate change and desertification: issues over Indian region, World Wide Fund for Nature, India Secretariat, New Delhi, 28 February 2002

Shri B.D. Kulkarni

- Hydrometeorological analysis of Indian rainfall – impact of climate change on water resources, Assessment of Climate change in India, World Wide Fund for Nature, India Secretariat, New Delhi, 28 February 2002

Dr. (Smt.) A.A. Kulkarni

- Inferences from General Insurance Data, National Insurance Academy, Pune, 9 June and 23 November 2001, and 21 March 2002
- Application of statistics in atmospheric research, Department of Statistics, University of Pune, Pune, 19 January 2002

Dr. G. Pandithurai

- Aerosol radiative forcing, Centre for Environmental Remote Sensing, Chiba University, Japan, 9 May 2001
- Aerosol optical characterization and radiative forcing, Kinki University, Osaka, Japan, 11 June 2001

Shri P. Mukhopadhyay

- Meso-scale modelling: approaches and case studies, Snow and Avalanche Studies Establishment, Manali, 8 November 2001

Shri Y.K. Tiwari

- Lidar study of aerosols during pre-sunrise and post-sunset period over Pune, Abdus Salam International Centre for Theoretical Physics, Trieste, Italy, 10 October 2001

Training Undergone

Shri S. Mahaptra and **Shri D.K. Trivedi**

- Second SERC School on Numerical Weather Prediction –Data Processing, Assimilation and Initialisation, Indian Institute of Technology, New Delhi, 12 March – 7 April 2001

Shri S.D. Pawar, Shri V. Gopalakrishnan, Shri C.G. Deshpande, Shri P. Murugvel, Smt. R. Latha, Smt. M.N. Kulkarni, Smt. R.V. Bhalwankar, Dr. D.K. Singh, Smt. M.K. Kulkarni and **Shri Y.K. Tiwari**

- Second SERC School on Cloud Physics and Atmospheric Electricity-Frontiers, Indian Institute of Tropical Meteorology, Pune. 6 June - 5 July 2001

Smt. U. Iyer, Smt J.V. Revadekar and Smt. S.S. Naik

- Condensed Basic Training Course followed by Advanced Meteorological Training Course, India Meteorological Department, Pune September 2001 – August 2002

Smt. S. Nair

- Advanced Meteorological Training Course, India Meteorological Department, Pune 11 February 2002

Smt. V.V. Sapre

- Network Security Training Course on Information Warfare 2002, S.K. International, Pune, 19-20 February 2002

Smt. V.V. Massey and **Smt. M.S. Jadhar**

- Course on WINISIS, BAIF-Dr. Manibhai Desai Management Training Centre, Pune, 19-23 March 2002

Ph.D. and Post-Graduate Programme

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

Shri M.N. Patil

Characteristics of atmospheric boundary layer in the monsoon trough region
(Guide : Dr. S.S. Parasnis)

Shri B.S. Murthy

Atmospheric boundary layer studies using sodar and micro-meteorological Tower
(Guide : Dr.S.S.Parasnis)

Shri B.D. Kulkarni

On some climatological and hydrometeorological aspects of Godavari basin for the optimum development of the water resources project
(Guide : Dr. G.B. Pant)

Shri C.G. Deshpande

Atmospheric electrical and aerosol measurements over the Indian Ocean and at the Antarctica
(Guide : Dr. A.K. Kamra)

Shri R.G.Ashrit

Climate change and variability over India: observations, model simulations and agricultural impacts
(Guide: Dr. K. Rupa Kumar)

Shri D.R. Pattanaik, Meteorologist Gr.II,
India Meteorological Department, Pune

Modelling of the moist convection over the monsoon region
(Guides : Dr. V. Satyan and Dr. R. Krishnan)

Award of Ph.D. / M.Tech. Degrees by other Universities

Shri K. Ali
Ph.D.

Radar studies of convective clouds in North India
(Guide: Prof. B.R.D Gupta, Banaras Hindu University and Dr. P.C.S. Devara, IITM)

Awarded by : Banaras Hindu University, Varanasi

Shri R.M. Khaladkar
M. Tech.

Comparison of satellite derived sea surface winds with NWP model analysis and forecast
(Guides ; Dr. P.N. Mahajan, IITM and Dr. P.K. Pal, Space Application Centre, Ahmedabad)

Awarded by : Andhra University, Visakhapatnam

Thesis Submitted to University of Pune, Pune

Shri S.M. Bawiskar
Ph.D.

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

Smt. S.S. Naik
M.Sc.

Dynamics of rain bearing systems during onset phase of southwest monsoon in the Indian coastal region
(Guide : Dr. (Smt.) P.S. Salvekar)

Teaching and Research Support to University of Pune, Pune

Lectures delivered for M.Sc. / M.Tech. students

Dr. P.C.S. Devara

- Modern observational techniques, M.Tech. (Atmospheric Physics)
- Lasers and electro-optics, M.Tech. (Applied Physics), Institute of Armament Technology, Pune

Dr. (Smt.) P.S. Salvekar

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

Dr. R. Vijayakumar

Cloud physics and atmospheric thermodynamics, M.Sc. (Space Science) and M.Tech. (Atmospheic Physics

Dr. S. Sivaramakrishnan

- Atmospheric dynamics, Atmospheric boundary layer and turbulence, M.Sc. (Space Science)

Dr. P.N. Mahajan

- Satellite meteorology, M.Tech. (Atmospheric Physics)

Shri J.R. Kulkarni

- Advanced dynamic meteorology, M.Tech. (Atmospheric Physics)
- Fluid mechanics, M.Tech. (Atmospheric Physics)
- Climate modelling, M.Tech. (Atmospheric Physics)
- Monsoon meteorology, M.Tech. (Atmospheric Physics)
- General Turbulence Theory, M.Tech. (Atmospheric Physics)
- Monsoon, M.Tech. (Atmospheric Physics)
- Non linear dynamics, M.Tech. (Atmospheric Physics)
- Atmospheric Physical Processes, M.Tech. (Atmospheric Physics)
- Mathematical Methods and Techniques, M.Sc. (Space Science)
- Dynamic meteorology, M.Sc. (Space Science)
- Cloud physics, M.Sc. (Space Science)

Dr. P.S.P. Rao

- Air pollution, M.Sc. (Environmental Science)

Shri D.R. Chakraborty

- Energetics of atmosphere, M.Tech. (Atmospheric Physics)

Dr. C. Gnanaseelan

- Mathematics and numerical methods, M.Tech. (Atmospheric Physics)

Smt. S.K. Mandke

- Sensitivity experiments with energy balance model, M.Tech. (Atmospheric Physics, Practicals)

Shri S. Mahapatra

- Introduction to spectral methods and spectral models, M.Tech. (Atmospheric Physics)
- Fast Fourier transformations, M.Tech. (Atmospheric Physics)
- Gaussian quadrature formula, M.Tech. (Atmospheric Physics)
- Global spectral models, M.Tech. (Atmospheric Physics)

Dr. (Smt.) A.A. Kulkarni

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

Smt. A.A. Deo

- Physical and Dynamical oceanography, M.Tech. (Atmospheric Physics)

Shri D.R. Talwalkar

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

Deputation Abroad

Dr. G.B. Pant

- Second Session of the WMO Commission for Atmospheric Sciences (CAS) Working Group on Tropical Meteorology Research Meeting, Cairns, **Australia**
  (26 May-4 June 2001)

- Twenty third Meeting of the Joint Scientific Committee for World Climate Research Programme (WCRP), Hobart, Tasmania and visit to the Bureau of Meteorology Research Centre, Melbourne, **Australia**
  (14-31 March 2002)

Dr. A.K. Kamra

- Thirteenth Session of the Commission for Atmospheric Sciences (CAS), Oslo, **Norway**
  (10-22 February 2002)

Dr. P.C.S. Devara

- Special Symposium on Global Aerosol Climatology and Database, and American Association for Aerosol Research (AAAR 2001) Conference, Portland, Oregon, **U.S.A.** and visit to the Department of Meteorology, University of Maryland, **U.S.A.**
  (11-27 October 2001)

Dr. K. Rupa Kumar

- Conference on Climate Variability and Land-Surface Processes: Physical Interactions and Regional Impacts, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, **Italy**
  (9-17 June 2001)

- IGBP Global Change Open Science Conference on Challenges of a Changing Earth, Amsterdam, **The Netherlands**
  (8-15 July 2001)

- Meeting of Asian-Australian Monsoon Panel, University of Reading, Reading, **U.K.**
  (27 August - 3 September 2001)

- ECMWF Workshop on Reanalysis, European Centre for Medium Range Weather Forecasting, Reading. **U.K.**
  (4-11 November 2001)

Dr. N. Singh

- Work on a project 'Research of Hydrometeorological Prediction over India and South Korea with the Change of Regional and Global Environment, Meteorological Research Institute, Seoul, **South Korea**
  (10 December 2001-11 June 2002)

Dr. R. Krishnan

- Collaborate and Write a Scientific Assessment Report with Prof. V. Ramanathan, Centre for Clouds, Chemistry and Climate, Scripps Institute of Oceanography, University of California, San Diego, **USA**
  (22 February-19 July 2001)

Dr. R.H. Kripalani

- Conference on Climate Variability and Land-Surface Processes: Physical Interactions and Regional Impacts, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, **Italy**
  (9-17 June 2001)

- Foreign Expert in the field of Asian Monsoon and work on the project, "Development of Changma (Rainy season in Korea) Index", Department of Earth Sciences, Chosun University, Kwangju, **South Korea**
  (2 August – 2 October 2001)

Dr. G. Beig

- Second International Workshop on Long Term Changes and Trends in the Atmosphere, Prague, **Czech Republic**
  (30 June-6 July 2001)

- IGBP Global Change Open Science Conference on Challenges of a Changing Earth, Amsterdam, **The Netherlands**
  (8-15 July 2001)

- Joint Scientific Assembly of IAGA-IASPEI 2001 and Symposium on Long Term Trends in the Mesosphere, Thermosphere and Ionosphere Systems, Hanoi, **Vietnam**
  (19 August – 3 September 2001)

- International Symposium on Equatorial Processes Including Coupling (EPIC), Kyoto University, Kyoto, **Japan**
  (16-24 March 2002)

Dr. A.K. Sahai

- Collaborative work of the Department of Physics, Federal University of Parana, Curitiba, **Brazil**
  (31 January 2001-1 February 2003)

Dr. K. Krishna Kumar

- STA (Science and Technology Agency) Fellowship awarded by Japan Science and Technology Corporation, Government of Japan, Meteorological Research Institute, Tsukuba, **Japan**
  (25 March – 25 June 2001)

Dr. (Smt.) N.A. Sontakke

- Sixth Scientific Assembly of the International Association of Hydrological Sciences (IAHS), Maastricht, **The Netherlands**
  (21-27 July 2001)

Shri D.R. Chakraborty

- As a Visiting Scientist to work on a project "Energetics of coupled climate model", Florida State University, **USA**
  (30 March –1 August 2001)

Dr. K. Ashok

- Frontier Research Program for Global Change, Institute for Global Change Research, Tokyo, **Japan**
  (31 January 2000 – 30 January 2002)

Shri J. Sanjay

- Visiting Scientist, Department of Meteorology, Florida State University (FSU), **U.S.A.**
  (1 September 2001 - 31 August 2002)

Dr. G. Pandithurai

- Joint Research Work on "Aerosol Retrieval from Space and Ground", Institute of Earth Environmental System, Kinki University, Higashi-Osaka, **Japan**
  (1 May-2 July 2001)

Shri K. Ali

- Second International Conference on Fog and Fog Collection, St. John's Newfoundland, **Canada**
  (12-23 July 2001)

Dr. C.G. Deshpande

- Summer School on Physics of Equatorial Atmosphere, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, **Italy**
  (23 September-9 October 2001)

Dr. R.S. Maheskumar and **Shri Y.K. Tiwari**

- 2001 Course on Inverse Methods in Atmospheric Science, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, **Italy**
  (1-12 October 2001)

Kum. V. Vaidya

- Summer Colloquium on Physics of Weather and Climate, Workshop on Land-Atmosphere Interactions and Climate Model and Conference on Climate Variability and Land Surface Processes: Physical Interactions and Regional Impacts, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, **Italy**
  (25 May-17 June 2001)

International

Dr.Ralf Toumi and **Ms.Joanna Syroka**
Department of Physics,
Imperial College, London, **U.K.**,
14-18 April 2001

Dr. Mohammed Sadek Boulahya
Director General, African Centre of Meteorological Application for Development (ACMAD), Niamey, **Niger**,
3 August 2001

Prof. Abdelkrim Ben Mohamed
University of Abdou, Moumouni, Niamey, **Niger**,
3 August 2001

Dr. Abdallah Mokssit
Chef du Centre National de Recherche Meteorologique, **Morocco**, 3 August 2001

Mrs. Yanna Djellouli and **Dr. M.V.K. Sivakumar**
WMO, Geneva, **Switzerland**, 3 August 2001

Dr. Steve Palmer
Technical Co-ordination Manager,
Meteorological Office, London, **U.K.**,
3 August 2001

Dr.David Hassel
Hadley Centre for Climate Prediction and Research, Meteorological Office, London, **U.K.**,
13-18 August 2001

Mr. Bakuretsion Kassahun
General Manager, Ethiopian Meteorological Service, Addis Ababa, **Ethiopia**,
7 September 2001

Dr. Moti Mittal
Sr. Scientist, Ohio Supercomputer Center,
Columbus, **U.S.A.**, 24-25 October 2001

Prof. Georgii V. Gruza and **Dr.Mikhail Bardin**
Institute for Global Climate and Ecology,
Russian Academy of Science, Moscow, **Russia**,
5-13 November 2001

Dr. Ebrahim Haji Zedah
First Secretary and Director, Science and Education Section, Embassy of Islamic Republic of Iran, **Iran**, 15 January 2002

Dr. Andrew Gettlelman
National Centre for Atmospheric Research, Collorado, **U.S.A.**, 1 February 2002

Dr. Edward R. Cook and **Dr. Paul Krusic**
Tree-Ring Laboratory, Lamont Doherty Earth Observatory, Columbia University, New York, **U.S.A.**, 17 February–10 March 2002

National

Dr. P.K. Kunhikrishnan
Space Physics Laboratory,
Vikram Sarabhai Space Centre,
Thiruvananthapuram, 3 May 2001

Dr. A.K. Bohra
National Centre for Medium Range Weather Forecasting, New Delhi, 8 May 2001

Dr. P. Goswami
Centre for Mathematical Modelling and Advanced Computing Simulations, Bangalore, 25 May 2001

Shri N.N. Pande
National Hydroelectric Power Corporation Ltd., Devrukh, 28 May 2001

Trainee Assistant Directors
Central Water Engineering Services, Central Training Unit, Central Water Commission, Pune,
8 June 2001

Mr. Kevin Smith, Shri S.S. Udgirkar
Shri S.R. Shete and **Shri U.K. Apte**
Engineers, Minor Irrigation Programme,
Maharashtra Rural Development and Water Conservation Department,
Pune, 27 June 2001

Prof. K.P.R. Vitthal Murthy
Department of Meteorology and Oceanography,
Andhra University, Visakhapatnam,
10 August 2001

Shri Sandeep Kansal
National Hydroelectric Power Corporation (NHPC) Ltd., Faridabad,
23-24 August 2001

Dr. M.B. Potdar
Space Applications Centre, Ahmedabad,
25-27 September 2001 and 26-28 February 2002

Dr. V.J. Daoo
Bhabha Atomic Research Certre, Mumbai,
27-28 September 2001

Shri C. Challappan,
Honourable Member,
National Commission for SC/ST, New Delhi,
7 November 2001

Dr. A. Ganju
Snow and Avalanche Study Establishment,
Chandigarh,
20 November 2001

Trainee Officers
National Water Academy, Central Training Unit,
Central Water Commission, Pune,
11 December 2001

Vigilance Committee
Department of Science and Technology,
New Delhi,
18–19 December 2001

Smt. Rashpal Kaur
Snow and Avalanche Study Establishment,
Chandigarh,
9-11 January 2002

Shri Appa Rao and **Shri Ram Mohan**
Sriharikota High Altitude Range (SHAR),
Sriharikota,
3 February 2002

Trainee Officers
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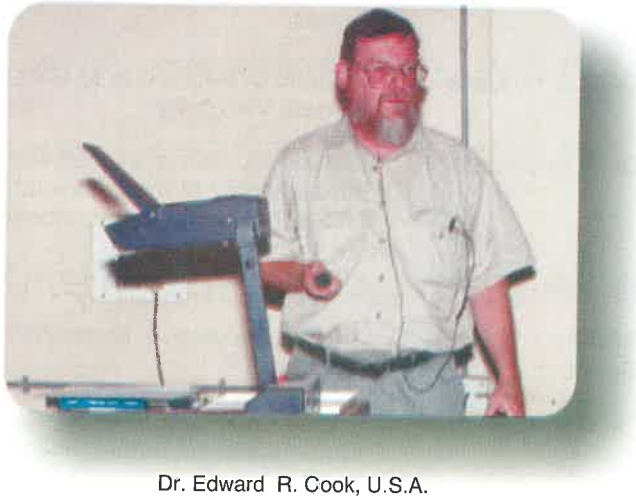
Agricultural Meteorology (CASAM),
College of Agriculture, Pune,
11 March 2002

Prof. Georgii V. Gruza, Russia

Dr. Mikhail Bardin, Russia

Visit of Members of the Scientific Committee of African Centre for Meteorological Applications for Development



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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 R.C. Reddy	Variability of North Indian Ocean and its Impact on Global Ocean and Understanding the Mechanism of Coastal Circulation around India
Shri K. Annapurnaiah	Numerical Modelling of the Dynamics of North Indian Ocean Circulation
Shri Pankaj Kumar	IMD-IITM Collaborative Scheme on Long-range Forecasting
Shri Ramaesh Kumar Yadav	IMD-IITM Collaborative Scheme on Long-range Forecasting
Shri Jagdish K.	Development of Regional Tree-ring Data Network to Study the Past Climate Variations on Decadal to Century Time Scale over Asia
Shri Akhilesh Kumar Mishra	Numerical Modeling of the Upper Ocean Mixed Layer Over Indian Ocean Region Using Satellite Data
Shri Mrinal Kanti Biswas	Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber / Frequency Domain
Shir Umesh Kumar Singh	Studies of Mesoscale System over Indian Region
Shri P. Siva Praveen	Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments
Dr. Pankaj Kumar Mishra	Indian Climate Change Scenario for Impact Assessment
Shri Atul Kumar Shrivastava	Study of Coupling between Lidar / Radiometer Measured Aerosol and Radar Sensed Winds
Kum. Cini Sukumaran	Measurement of Meteorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface
Kum. T. Rajitha Madhu Priya	Measurement of Meteorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface
Shri. Vinay Kumar	Simulation of Surface Wind Stress on Monthly and Seasonal Time Scales using Coupled Atmospheric Ocean Model (CAOM) to Provide Forcing for Driving an Ocean General Circulation Model (OGCM)

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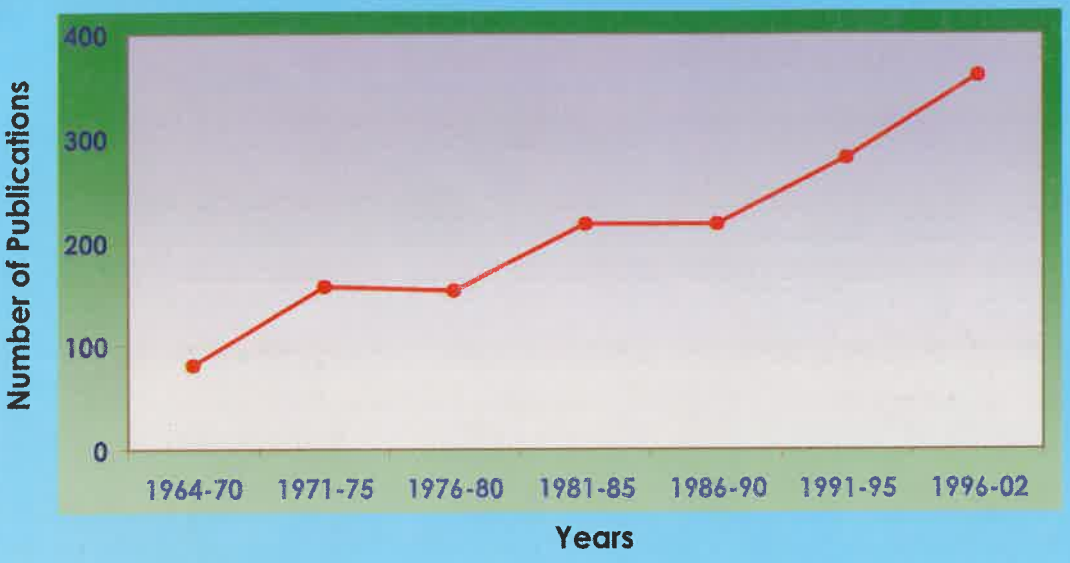
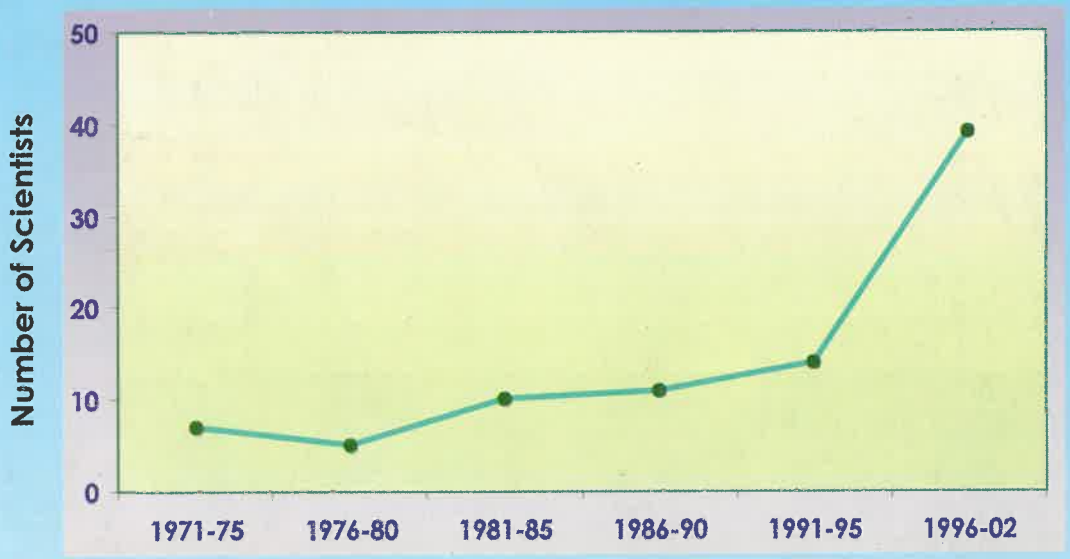
SCIENCE POPULARISATION PROGRAMME

Research and Academic Profile

Research Publications in Journals



Ph. D. Awards



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