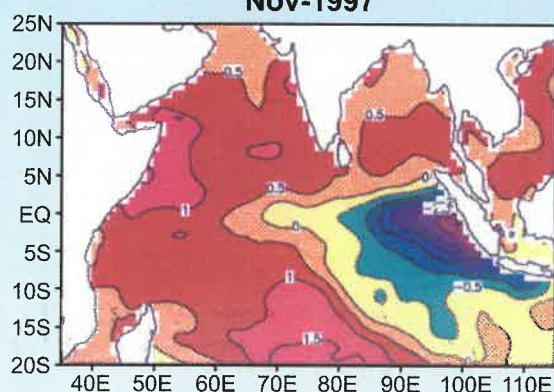


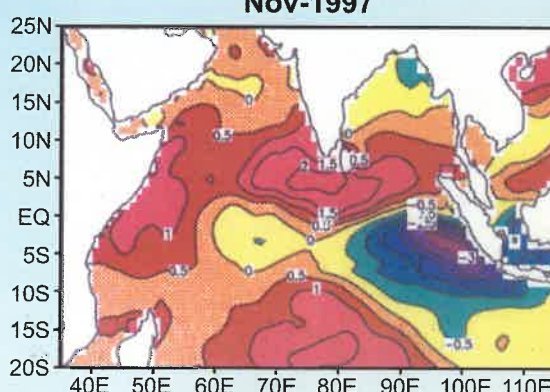
ANNUAL REPORT 2002 - 03

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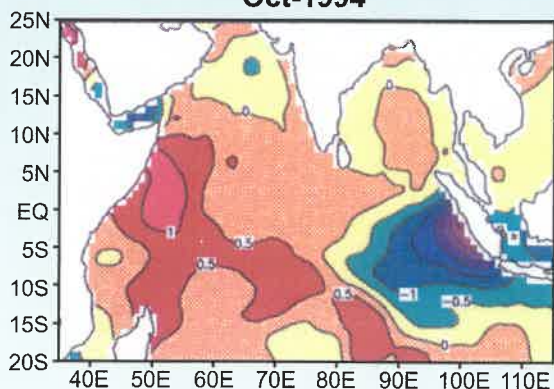
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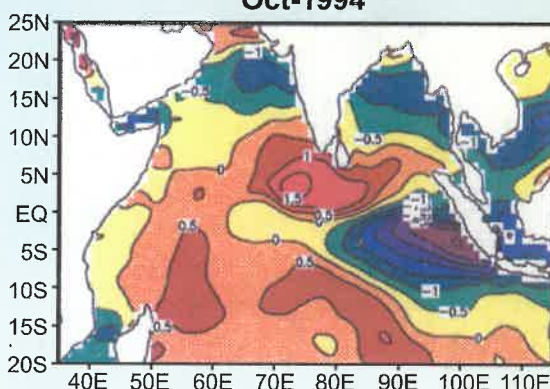
MODEL
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Oct-1994



Oct-1994



**INDIAN INSTITUTE OF TROPICAL METEOROLOGY
PUNE**

Homage



अन्तवन्त इमे देहा
नित्यस्योत्ता शरीरिणः

*The body is transient;
The spirit is permanent*

Prof P.R. Pisharoty, Former Director of the Institute passed away on 24th September 2002, at Pune. He was 93 years of age when he passed away. He was born on 10th February 1909 in Kollengoda, Palghat District of Kerala. Prof. Pisharoty was educated in Chennai (Madras), Bagalore and Los Angeles. He began his career as a Lecturer in Loyola College, Chennai in 1935. His urge for scientific research was so great that he used to spent his summer vacations to work with Nobel Laureate Sir C.V. Raman, at the Indian Institute of Science, Bangalore during 1936-41. He joined the India Meteorological Services in 1942 as a Senior Officer. While on deputation to USA to familiarize with modern methods of weather forecasting he obtained his Masters Degree in Meteorology in 1953 from the University of California, Los Angeles. From the same University he obtained Ph.D. Degree in 1954 in record short time. At the University of California Prof. Pisharoty came in close contact with world renowned meteorologists like

Prof. J. Bjerkenes, Prof. Holmboe, Prof. Jule Charney, Prof. Neilburger, Prof. Yale Mintz and Prof. Wurtele. Prof. Pisharoty returned to India in 1954 and started playing a prominent role in development of meteorology in India. He worked as the Director of Colaba Observatory, Mumbai (Bombay) during 1959-1962 and also Director of the International Indian Ocean Expedition (IIOE) operated from India with its Headquarters at Colaba during 1961-62.

Prof. Pisharoty became the first Director of the IITM on 17 November 1962, then known as the Institute of Tropical Meteorology, a distinct part of the India Meteorological Department. The founding of the IITM is considered to be a mile stone in the Indian Meteorology. Prof. Pisharoty made significant contribution in nurturing the Institute in its initial formative years. Because of his great vision for the future of the Institute and meticulous planning of the infrastructural requirements the Institute has been able to pursue its excellence in meteorological research and get the recognition as a premier Institute of Research in the field of Meteorology.

Prof. Pisharoty retired from the Institute on 9th February 1967 on attaining the age of superannuation. After the retirement, on invitation, Prof. Pisharoty joined the Physical Research Laboratory, Ahmedabad as Professor of Aeronomy to work in collaboration with Prof. K.R. Ramanathan and Dr. Vikram Sarabhai. He was in Ahmedabad for 15 years and was active in the starting stage of Indian Space Research Organisation (ISRO) and establishment of its branches at various places in India. The establishment of National Centre for Medium Range Weather Forecasting (NCMRWF) at New Delhi was also out of his personal interest in providing a national weather forecasting service for the agricultural purposes in India.

Prof. Pisharoty contributed a good number of research papers in national and international journals and wrote a number of books on Indian Monsoon and related Meteorological topics. He was awarded several prizes and honours including Padmashree of the Government of India in 1970 and IMO Prize of the World Meteorological Organisation in 1989. He received honours to work on several national and international organizations and committees in the field of meteorology, space science, geomagnetism, remote sensing, atomic energy etc. He was inspiration for many young meteorologists. Prof. Pisharoty will be fondly remembered for his inimitable style of inauguration of scientific meetings, seminars and symposia with invocation of relevant Sanskrit verses and explaining their meaning very carefully.

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Indian Institute of Tropical Meteorology

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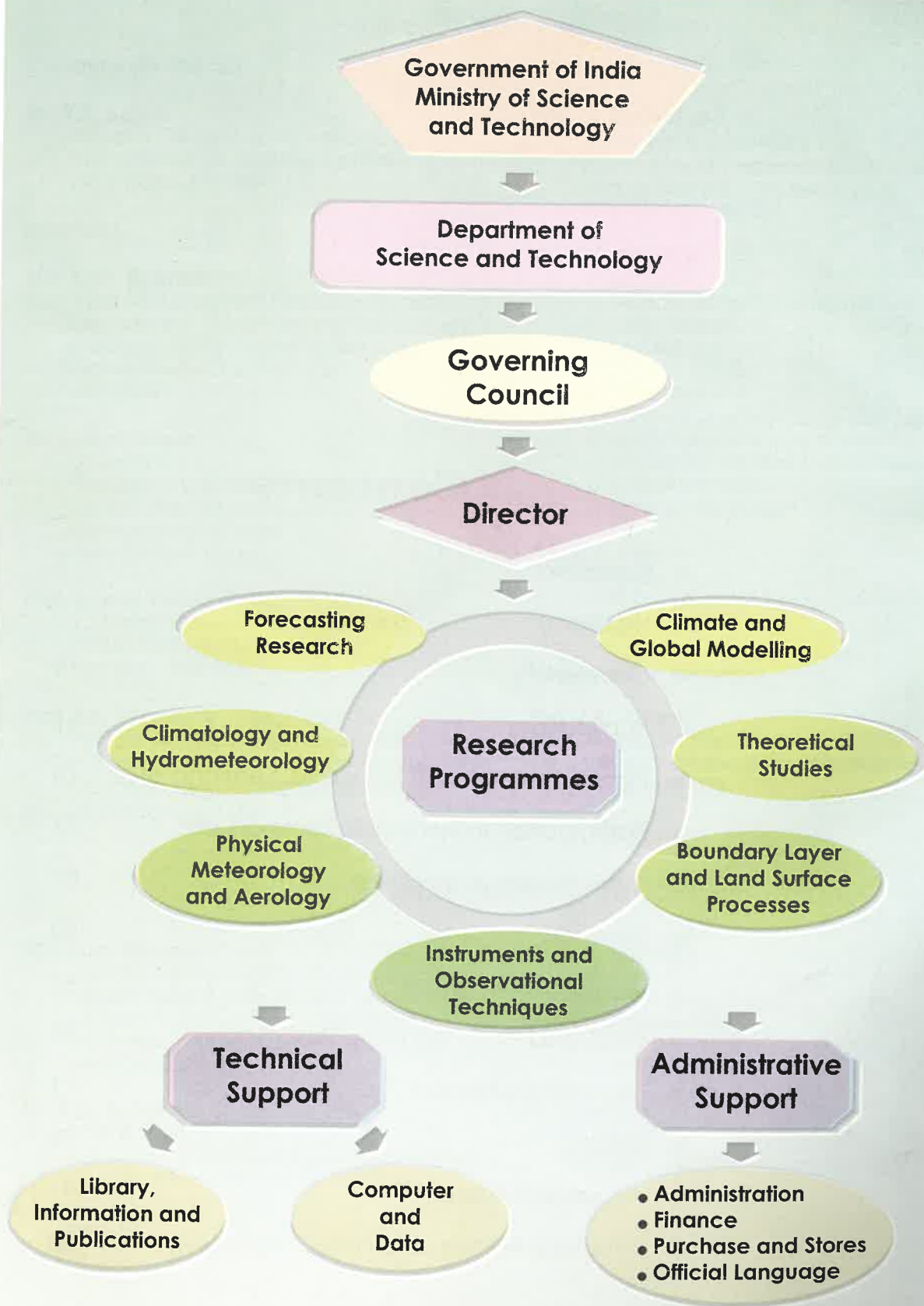
Dr. G.B. Pant

Director
Indian Institute of Tropical Meteorology
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Tenure : Governing Council - Two Years,
Finance Committee - No Tenure

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Organisational Profile



The Institute was formally established under the UNDP's Special Fund Project as the Institute of Tropical Meteorology (ITM) at Pune on 17 November 1962 as a distinct part of the India Meteorological Department (IMD). Subsequently, the ITM was transformed into an autonomous research organization and redesignated as the Indian Institute of Tropical Meteorology (IITM) on 1st April 1971. The Institute has, since then, grown into a leading research centre of international repute in all the relevant aspects of atmospheric sciences, particularly those concerning monsoons and tropical climate. The work at the Institute, over the years, has been marked by significant achievements in research as well as physical development of the infrastructure including its campus. The research programmes of the Institute are balanced among theoretical studies, field experiments and laboratory work. The IITM has achieved considerable progress in its research and academic activities in the thrust areas of Atmospheric Sciences like Weather Forecasting, Climatology, Monsoon Studies, Climate Modelling, Hydrometeorology, Weather Modification, Atmospheric Chemistry, Atmospheric Electricity, Cloud Physics, Instrumentation for observational studies, Theoretical Studies and studies relating to Land-Surface-Processes. Currently, the Institute functions under the Department of Science and Technology, Government of India.

The year 2002-03 witnessed a number of important scientific, academic and administrative activities. The Institute evaluated and revised its on-going research projects and initiated several new ones in the frontline thrust areas pertaining to various aspects of the meteorology and atmospheric sciences. 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 scientific research outputs have been published in peer reviewed journals and presented at the national and international scientific events and programmes.

During the year scientists represented the Institute on several International bodies for their world-wide programmes such as IPCC, UNFCCC, IGBP, WCRP, CLIVAR, PAGES, IUGG and participated in meetings, conferences, workshops organized at international organizations in various countries. Institute was also involved in several bilateral research programmes with Institutes from USA, UK, France, Germany, Sweden and some Asian countries.

During the year the Institute also continued its participation in national research programmes of various organizations and Ministries and Departments of the Government of India such as MOEF, DST, DOD, DAE, ISRO, TERI, etc. The Institute was part of the ARMEX - national multi-institutional observational experiments under the Indian Climate Research Programme (ICRP) of the DST. Observations were arranged in different environmental conditions through instrumented research vessel, towers and aircrafts.


The Institute continued its collaboration with various Indian Universities in their postgraduate and Ph.D. programmes by providing its expertise and library/computer facilities to the students for their course work. The Institute has been conducting the M.Tech. course in Atmospheric Physics under the Memorandum of Understanding (MoU) with the University of Pune.

During the year the Institute arranged various science popularization programmes for increasing interaction of students and public with the scientists.

The Institute experienced an irrecoverable loss in Indian Meteorology on passing away of its first Director Prof. P.R. Pisharoty on 24 September 2002. Prof. Pisharoty built a strong base for this Institute and put it on a firm foundation of international recognition in the field of meteorology. I am confident that the Institute will continue to contribute its intellectual resources to Prof. Pisharoty's vision about its future role in national and international scientific research programmes in meteorology and allied fields. On behalf of all the members of this Institute I dedicate the Annual Report of the Institute for the year 2002-03 to late Prof. Pisharoty. A state of the art Conference Hall has been built in the Institute and named after him.

The Report will give a general overview of the research results presented in the beginning with a summary of significant highlights. A list of research publications will serve the purpose of reference material for the exchange of research ideas amongst the scientific community.

I thank the Department of Science and Technology, Government of India, and Institute's Governing Council and Finance Committee 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

Events

- ♦ Dr. P.C.S. Devara elected a Fellow of the Royal Meteorological Society, U.K. in recognition of his contribution in the field of Tropical Meteorology.
- ♦ Scientists of the Institute participated in and provided input for the International Conference on Science and Technology Capacity Building for Climate Change followed by the Eighth Conference of the Parties (COP-8) to the UNFCCC held in India.
- ♦ Institute co-sponsored seven national and international seminars and symposia.
- ♦ Institute participated in Swadeshi Mela at Mumbai by organizing a Scientific Exhibition on the research activities.
- ♦ Institute celebrated its 41st Foundation Day on 17 November 2002.

Research

- ♦ Forecast for seasonal monsoon rainfall for the year 2002 was prepared based on statistical and dynamical techniques and provided to India Meteorological Department as an input in the preparation of national forecast.
- ♦ The cyclonic storms which moved across Bay of Bengal during November 2002 were monitored. The advancement, establishment and withdrawal of monsoon 2002 were monitored utilising the cloud imageries of METEOSAT-5. Signal of dissipation of very severe cyclonic storm 2-3 days before its hitting the Gujarat coast over the Arabian Sea during May 2001 was observed through multiple satellite approach (INSAT, METEOSAT, IRS-P4 and TRMM) for further studies.
- ♦ The relationship of the Indian Ocean Dipole with monsoon variability over South and East Asia has been established. The relationship is found to be stronger and consistent over remote East Asian region (Korea, Japan) than that over the near South Asian (India) region.
- ♦ Time series of cyclonic disturbances affecting the Kachchh district of Gujarat region showed decreasing trend during the last century. Climate change scenarios developed based on 8 coupled models indicate 2-4°C increase in the annual surface temperature in all the models and 5 out of 8 models show slight increase in the monsoon seasonal rainfall over this region after 2040s.
- ♦ The influence of global warming on the cyclonic storms forming in the Bay of Bengal, the Arabian Sea and the Indian Ocean and passing the Indian sub-continent has been examined using simulations of a high resolution regional climate model (HadRM2). The analysis indicates no significant change in the frequency of storms in the Bay of Bengal, but the mean intensity of the storms appears to have increased significantly in the greenhouse gas (GHG) simulations compared to control (CTL) simulations. The frequency of storms in the Arabian Sea, however, shows some decrease in the GHG simulations.
- ♦ Generalized charts for different standard areas of 100 to 10,000 sq. km for 1-day durations were prepared using rain depths of severe rainstorms occurred over the Indian region during the period 1880 to 2000. These charts are useful for obtaining preliminary estimates for design storm for small and medium size river basins in India having areas less than 10,000 sq. km.
- ♦ The climatological trends and direct radiative forcing of atmospheric aerosols on the surface reaching solar flux have been studied using the lidar and solar radiometric data acquired at the Institute.
- ♦ The precipitation and Total Suspended Particulate (TSP) samples collected at a high altitude remote station (Darjeeling) have been analyzed to examine their physical and chemical characteristics. The analysis showed a very good balance between cations and anions and neutralization of acidic components of rain water by the presence of calcium, sodium and potassium, and that of aerosols by ammonium.
- ♦ Analysis of the data obtained during the INDOEX indicated that in addition to the aerosols carried from the continent, the haze layer observed over the northern Indian Ocean during the northeast monsoon is also caused by the aerosols transported down from free troposphere to the marine boundary layer.

- ♦ The recovery curves of the surface electric field following a lightning discharge between the lower positive charge center and the upper main negative charge in thunderstorms showed an additional step of much lower rate of build-up of the electric field. This novel feature of the recovery curves is due to corona charge in the sub-cloud layer and is not reported earlier.
- ♦ One and half layer model simulated currents obtained by using daily forcings over tropical Indian Ocean have been validated with WOCE Cruise observations.
- ♦ Two-dimensional mixed layer model simulated upper layer temperature over tropical Indian ocean during 1997 to 2001 indicated that warming over western Indian Ocean during the dipole years (1994 & 1997) is mainly caused by the wind and heat flux anomalies.
- ♦ Four-D energetics of the Bay of Bengal depression (9-12 November 2001) was analysed using MM5 model simulated winds and temperature and the results indicated that the baroclinic mechanism is responsible for the maintenance of the depression.
- ♦ Monsoon drought of 2002 was studied through hind cast experiments using spectral and grid point AGCMs.
- ♦ A coherent inverse relationship between the decadal oscillations of the Pacific Ocean SST and the Indian monsoon was established through a diagnostic analysis of multi-source datasets.

Consultancy

- ♦ Hydrometeorological proposals such as estimation of probable maximum precipitation (PMP) and standard project storms (SPS), preparation of PMP atlases and isohyetal maps of monsoon rainfall over different river basins of India have been taken up on consultancy basis for various organizations of the Government of India and State Governments.
- ♦ Technical assistance was provided to Indian Space Research Organisation, Department of Space, in the development of a field mill network at SHAR, Shriharikota for thunderstorm warning and for forecasting the warning level.
- ♦ Technical guidance was provided to the Ministry for Irrigation of Karnataka Government, Bangalore in the proposed cloud seeding operations in Karnataka State.

Collaborations/Field Observations

- ♦ Institute participated in the ARMEX (ARabian Sea Monsoon EXperiment), a national field experimental programme conducted under the Indian Climate Research Programme (ICRP) of the Department of Science and Technology, Government of India. Observations on meteorological parameters, Aitken nuclei, atmospheric aerosols, trace gases and electric conductivity were taken in different environments. Observations were arranged at the National Centre for Atmospheric and Oceanic Research, Goa, on board ORV Sagar Kanya during the cruise in Arabian Sea and on an instrumented aircraft.
- ♦ Institute conducted a field experiment to study the coastal atmospheric boundary layer characteristics jointly with the Health and Safety Division (HASD), Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam to probe the growth of thermal internal boundary layer at the observational site.
- ♦ Under the Indo-Swedish collaborative project of the programme on Regional Air Pollution in Developing Countries the Institute installed instruments and collected samples of wet and dry deposits, and trace gases from rural areas near Pune.
- ♦ Spectral observations were arranged for atmospheric aerosols and clouds at the National MST Radar facility, Gadanki.
- ♦ Institute continued its collaboration with SAC by conducting special observations of atmospheric aerosols, ozone and water vapour on the days in synchronization with IRS-P4 satellite passes over Pune.
- ♦ Special field expeditions were conducted in forests for collection of tree-ring samples for the dendroclimatological studies.
- ♦ Observations were conducted in industrial and residential areas of major cities and also at high altitudinal stations in the country for the study of atmospheric aerosols, trace gases and precipitation chemistry.

41st Foundation Day Celebration



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



Inauguration by the Chief Guest Dr. P. K. Das,
Former Director General of Meteorology



Address by Dr. R. R. Kelkar,
Director General of Meteorology



Inaugural speech by
Dr. P. K. Das



Address by Prof. G. C. Asnani,
Former WMO Professor



Presentation of IITM Silver Jubilee Award
for the year 2000 to Dr. G. Beig



Silver Jubilee lecture by
Dr. G. Beig



Audience

Forecasting Research



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

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

Numerical Weather Prediction Research and Meso-scale Modelling

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

Two cases of heavy precipitation events during 14-16 May 1998 and 27-29 June 1998 were simulated using MM5 model. The model simulated some of the localized heavy precipitation zones over Kerala. The model was initialized with GAME analysis and run on FDDA nudging mode for the first 24 hours and then run on free forecast mode for the next 24 hours. For June case, the model was integrated for 48 hours.

The Advance Regional Prediction system (ARPS) model was used for the simulation of monsoon depression of 13 June 1998 and tropical cyclone of 18 May 1998 over the Indian region. The GAME data interpolated at 50 km resolution and enhanced by RS/RW data were used as input to the model. The results showed that the inclusion of RS/RW data improved the mean sea level pressure and rainfall prediction. The simulation of the tropical cyclone with 25 km resolution simulated some sub-synoptic features.

Three cases of thunderstorm, one over Kolkata on 14 July 1998, and two over Ranchi on 25 May 1998 and 5 June 1998 respectively were chosen for model simulation using Regional Atmospheric Modelling System (RAMS) model to see the impact of horizontal resolution on model simulation. The RAMS was run with 5 km as well as with 1 km resolution with 30 levels in vertical. The model was initialised with 0600 UTC RS/RW data over the stations and the initial thermal field was perturbed with 5°C and the total water mixing ratio by 25 percent to trigger the convection. Subsequently, the model was integrated for 12 hours. It was seen that 1 km run of the model could simulate a strong thunderstorm compared to 5 km run. The precipitation forecast for 1 km run was much closer to the observed one than that of 5 km run.

Three monsoon systems viz. a deep depression over Head Bay of Bengal during 13-16 June 1998, a low pressure area off Orissa-Andhra coast during 28-31 July 1998, and a land depression over West Madhya Pradesh during 13-16 September 1998 were simulated using GAME analysis for 72 hours and by using the model RAMS. The objective was to examine the capability of RAMS to simulate the different tropical systems and associated heavy rainfall. The model could satisfactorily simulate the systems and the results agreed well with the observations.

Extended Range Weather Prediction Research

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

Indian Ocean Dipole (IOD) and monsoon variability over South and East Asia

The influence of the IOD on summer monsoon rainfall over South Asia (India) and East Asia (China, Korea, Japan, Mongolia) was investigated. Long period rainfall data varying from 1869 to 2000 were used applying statistical techniques of correlation and composite analysis. While the observed rainfall data were used as a measure of rainfall activity, the NCEP-NCAR reanalysis data (1958-1998) were used to examine the circulation features associated with the extreme dipole and monsoon phases over the Indian subcontinent, the East Asian-North Pacific sector and over Eurasia.

The positive phase of the dipole was found to be favourable for rainfall activity of the following year over India, China and Mongolia, but unfavorable over Korea and Japan. The relationships were found to be more consistent and stronger for the remote regions of Korea and Japan, rather than the near Indian Ocean region (Fig.1).

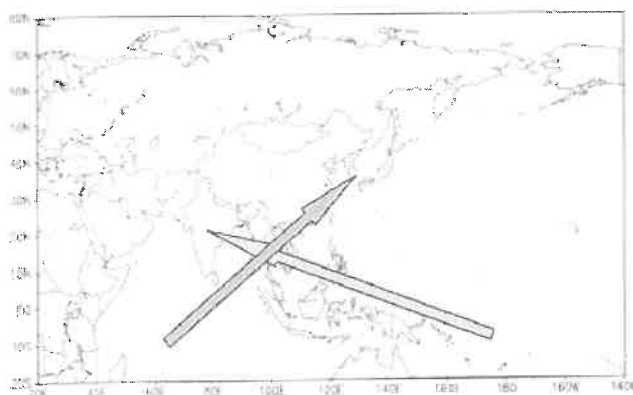


Fig. 1 : Schematic representation showing the connections between monsoon variability over South Asia with the Pacific Ocean and over East Asia with the Indian Ocean : Cross Diagonal Effect

Tendency of ESI and monsoon Rainfall

The tendency of Effective Strength Index (ESI), which means the joint effect of North Atlantic Oscillation (NAO) and Southern Oscillation (SO), from January through April was analysed and its relationship with Indian summer monsoon rainfall (ISMR) on various homogeneous regions of the

country was examined. The analysis was carried out for the recent 30 years (1961-1990). An inverse association of tendency of ESI from January through April was found with rainfall over India as a whole and some of its homogeneous regions. The relationship was statistically significant at 1% level. The study has been found to be useful for the prediction of monsoon rainfall over various parts of India and India as a whole.

Regional pressure index and monsoon variability

For the long range forecasting and long-term prediction of Indian Summer Monsoon Rainfall (ISMR) the Regional Pressure Index (RPI) was constructed over Indian region (20°-40°N, 70°-85°E) for a period of 101 years (1899-1999) on monthly scale. This region was considered because, the heat low and dynamic low play a significant role for monsoon variability over this region. The relationship of these indices was carried out with ISMR over the various homogeneous regions, for all the time scales. The RPI in the month of May was found to be significantly associated with ISMR over various regions on all the scales. The relationship was statistically significant at 1% level.

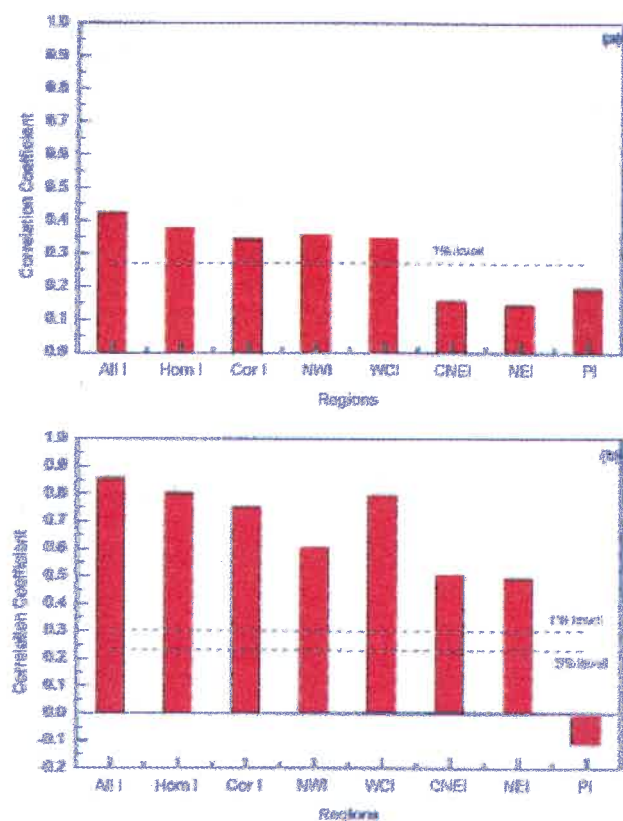


Fig. 2 : Correlation coefficients of monsoon rainfall over different homogeneous regions of India and regional pressure index in the month of May for 1990-99 on (a) decadal and (b) climatological scale

The study revealed that RPI in the month of May and January would be a new precursor for the long range forecasting of ISMR on the smaller spatial scale. On decadal and climatological scale, winter and spring time RPI showed a significant inverse relationship with the rainfall over the Peninsular India (PI) and North West India (NWI), while the association was found to be direct with Central North East India (CNEI) and North East India (NEI). The relationship was significant at 0.1 and 1% level respectively. The long term relationships of monsoon rainfall over different homogeneous regions of India and RPI in the month of May are shown in Fig. 2.

Wavelet analysis of NAO and monsoon rainfall

The relationship between the NAO and ISMR on various homogeneous regions through the wavelet analysis approach was carried out by using data of 108 years (1881-1988). In 72% occasions, 2 to 4 modes, in the NAO, during winter season were quite dominant and significant during the excess monsoon years, while in the deficient monsoon years they were either absent or insignificant (Fig.3).

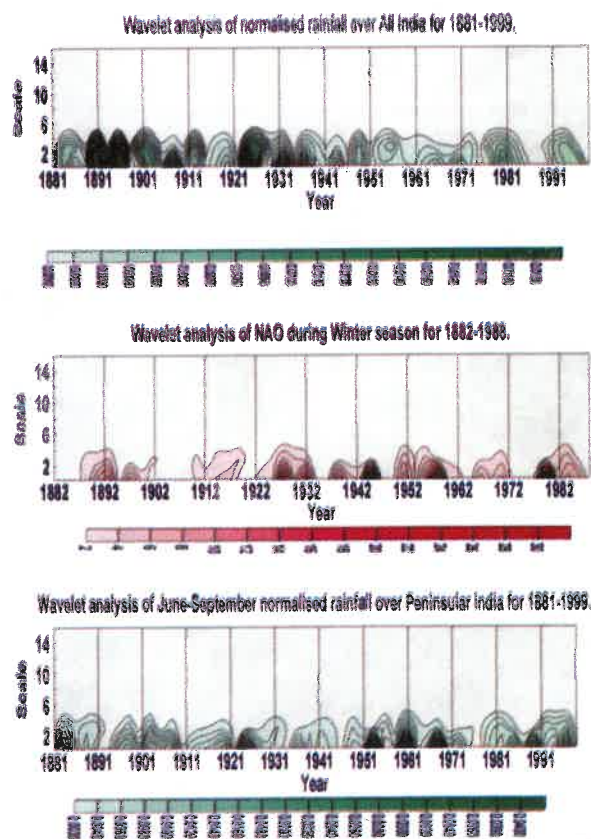


Fig. 3 : Wavelet analysis of NAO and monsoon rainfall over All India (top panel), NAO during winter season (centre panel) and normalized monsoon rainfall over Peninsular India (bottom panel)

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)

Intraseasonal variability of rainfall and heat sources over India

A synoptic climatological analysis of pentad rainfall anomalies for 52 blocks over India for southwest monsoon season for the years 1901 - 1980 was carried out to identify events of anomalous heavy rainfall over the western part of the monsoon trough area (TA). An event of positive pentad rainfall anomaly (SA) for a test area TA on the western part of the monsoon trough was considered as a basic synoptic event. SA was categorised into five classes (C1 - C5) having ranges between -1 and 9. The mean patterns of rainfall anomalies for the different classes indicated that an event of heavy/very heavy rainfall over TA is followed by development of a weak/break of phase

over India during the period of study. An analysis of time series of daily latitudinal anomaly (DLA) of the axis of the monsoon trough at 75°E and 85°E for selected cases of C4 and C5 showed that the development of a secondary diabatic heat source over TA due to convective heavy rainfall caused northward movement of the monsoon trough at 75°E. A simultaneous northward movement of the monsoon trough at 75°E and 85°E particularly during August 1979 resulted into a break situation over India.

The southwest monsoon during the year 2002 had three unusual features viz., i) a delay in advance of monsoon over westernmost parts of India by one month, ii) absence of depression/storms over Bay of Bengal and Arabian Sea and iii) -51% departure of all India rainfall in the month of July which resulted in to a drought year (AIMR departure was -19% of the normal). The monthly tropospheric circulation showed an evolution of a break-like situation over India for July. Prior to this event, during June, very large positive weekly rainfall departures were observed for subdivisions like Vidarbha, Madhya Maharashtra, Gujarat etc. in association with

formation of a well marked low pressure area over North Bay of Bengal on 20 June and its subsequent movement in a westward direction and this led to 6 percent above normal rainfall for the country in the month of June. Hence an estimation of the apparent heat source (Q_1) and apparent moisture sinks (Q_2) over India were carried out using daily NCEP grid point data over India for June -July 2002 to study the role of diabatic heat sources developed due to organized cumulus convection in relation to the evolution of a break-like situation in July. On monthly scale a coincidence of centres of large positive vertically integrated heat source $\langle Q_1 \rangle$ and moisture sink $\langle Q_2 \rangle$ around 20°N over Indian land and North Bay of Bengal for June was remarkable (Fig.4). However, for July $\langle Q_1 \rangle$ and $\langle Q_2 \rangle$ were not coincident and $\langle Q_2 \rangle$ reflected the deficient rainfall activity over the country. Pentad average southwest wind along 15°N for the longitudinal belt 40°- 130°E indicated strong southwest winds > 10 mps, observed in May and June (Fig.5) which seem to be associated with the onset of monsoon over South China Sea and India respectively. Moderate southwest winds were observed over the planetary scale monsoon region from July

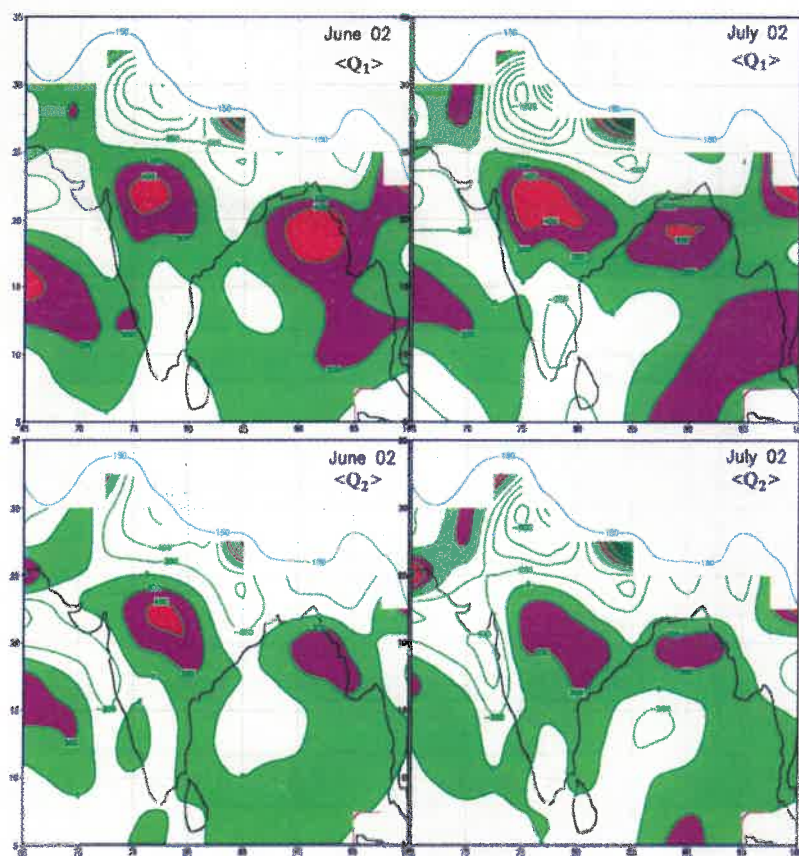


Fig. 4 : Vertically integrated apparent heat source $\langle Q_1 \rangle$ W/m^2 and apparent moisture sink $\langle Q_2 \rangle$ W/m^2 for June and July 2002

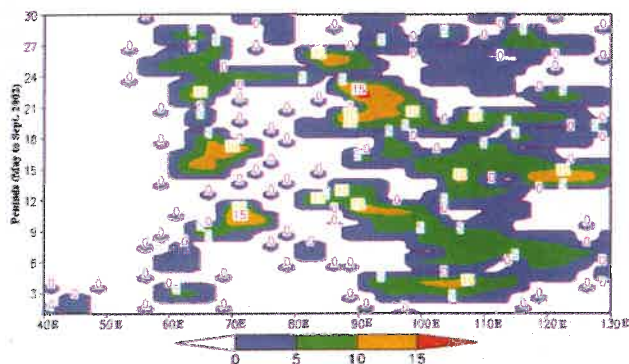


Fig. 5 : Longitude-time section at 15°N of 5-day mean southwesterly vector wind speed (m/sec) at 850 hPa for May to September 2002

onwards, which reflected in the absence of depressions/ storms over Bay of Bengal. This suggested that the monsoon circulation evolved into a break-like situation in July due to development of an intense diabatic heat source over India in a southward location around 20°N by the end of June and associated southward development of an anticyclone at 200 hPa over the monsoon trough.

Energetics of zonal waves during summer monsoon

Daily global NCEP data of 1 May - 31 August for the years 1997 and 2002 at 850 hPa were subjected to Fourier analysis to study intraseasonal variability of global circulation in the monsoon season. The momentum transport and kinetic energy at 850 hPa were very large during active phases of monsoon. The energetics of wave number 1 influenced the ISMR on seasonal and intra-seasonal scale. Intensification of wave number 1 around 10°N was found to be favourable to monsoon rainfall activity over India. The significant supply of kinetic energy by wave number 1 during 1997 resulted in the formation of six cyclonic systems (five depressions and one cyclonic storm) in the Bay of Bengal (Fig.6).

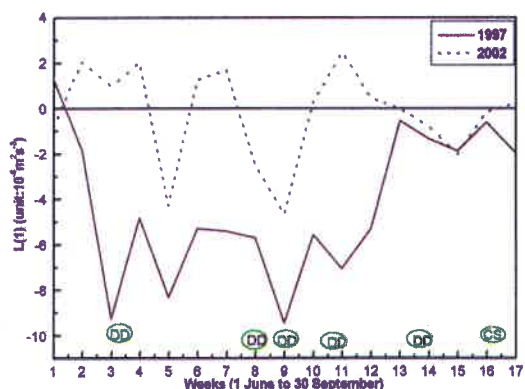


Fig. 6 : Exchange of kinetic energy due to wave no. 1

The supply of kinetic energy by wave number 1 was moderate and depression or cyclonic storm did not form during 2002.

The meridional transport of monthly momentum flux due to standing eddies was computed in the wave number domain at 300 hPa level. For this purpose NCEP global grid point data of meridional and zonal components during pre-monsoon months (April-May) and monsoon months (June through September) for ten years of contrasting monsoon activity over India during 1968-1976 and 1979, were subjected to one dimensional Fourier analysis by fitting sixteen waves. The study revealed that the northward transport of momentum flux due to standing eddies across 30°N was more in good monsoon years during premonsoon as well as monsoon months. The planetary scale waves 1 to 4 were found to be the major contributors to the total momentum flux. The contribution by the short waves was less as compared to the planetary scale waves.

Analysis of BOBMEX-99 data

The temperature and salinity profile data for upper 100 m ocean layer at 17.5°N, 89°E over Bay of Bengal during stationary periods of Sagar Kanya in Phase I (27 July - 5 August 1999) and Phase II (13-22 August 1999) of BOBMEX-99 were analysed. At air-sea interface, a net heat loss (heat gain) was observed during Phase I (Phase II). During Phase I, the isothermal layer was quite stable and warm when the sea level pressure was quite low and three well-marked systems formed during 27 July-5 August. Isothermal layer showed increased depth with the lowest pressure observed during the phase. During Phase II the isothermal layer was fluctuating and less deep. The sea level pressure during this period was observed to be appreciably high. Rapid fluctuations were observed around 17-18 August when the monsoon trough was located around the ship location. The salinity of the upper 40 m layer showed a decreasing (increasing) trend during Phase I (Phase II). Two prominent rainfall epochs were observed around 31 July -1 August in Phase I and 15-16 August in Phase II when decrease in temperature and salinity was noticed in the upper 40 m layer.

Secondary Data Utilization Centre

Satellite imageries of METSAT-1 (Kalpana 1) retransmitted by the India Meteorological Department, New Delhi were received and archived daily. The cyclonic storms which moved across Bay of Bengal from 14° to 22°N during 11 and 12 November and 10°-16°N during 23-27 November 2002 were monitored and the special cloud imageries

received were archived. The advance, establishment and withdrawal of monsoon 2002 were monitored utilising the cloud imageries of METEOSAT-5 and cloud images were archived. Scientists of the Institute monitored the progress and variability of the cloud systems.

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)

Monsoon depressions and tropical cyclones through IRS-P4 MSMR

Daily gradual intensification of surface wind speed to the south of low pressure area was detected by IRS-P4 MSMR data before formation of monsoon depression over Bay of Bengal during 17-24 August 2000 (Fig. 7). This gave a signal of generation of more cyclonic vorticity indicating the development of more convergence in the lower troposphere for the formation of depression. In order to justify this indication, NCEP wind analysis at 850 and 200 hPa were further analysed by objective analysis (optimum interpolation scheme) of the wind field with the inclusion of CMVs (Cloud Motion Vectors) and WVVVs (Water Vapour Wind Vectors) obtained from METEOSAT-5 on daily basis for the complete life cycle of monsoon depression that formed over the Bay of Bengal during the above period. Maximum values of convergence ($-2.5 \times 10^{-5}/\text{sec}$) at 850 hPa and maximum values of divergence ($2.5 \times 10^{-5}/\text{sec}$) at 200 hPa were observed just one day before the formation of monsoon depression indicating a prior signal of intensification of low into depression.

The case of super cyclone, which formed during 24-31 October 1999 over Bay of Bengal was studied. It was the most intense cyclone in last 114 years for the Orissa state. It produced fierce and

very strong winds along with huge storm surge and catastrophic floods causing severe damage in the districts of Orissa and West Bengal. The system was studied with the help of satellite imageries of INSAT, surface weather chart analyses (subjective), objective analyses of METEOSAT-5 (water vapour winds) using NCEP/NCAR data as first guess field. The geophysical parameters derived from IRS-P4 were used for better understanding the genesis, and movement of the storm in a qualitative and quantitative manner. The increase in wind speed as system intensified from low pressure to super cyclone stage was noticed when values of sea surface winds were observed to change from

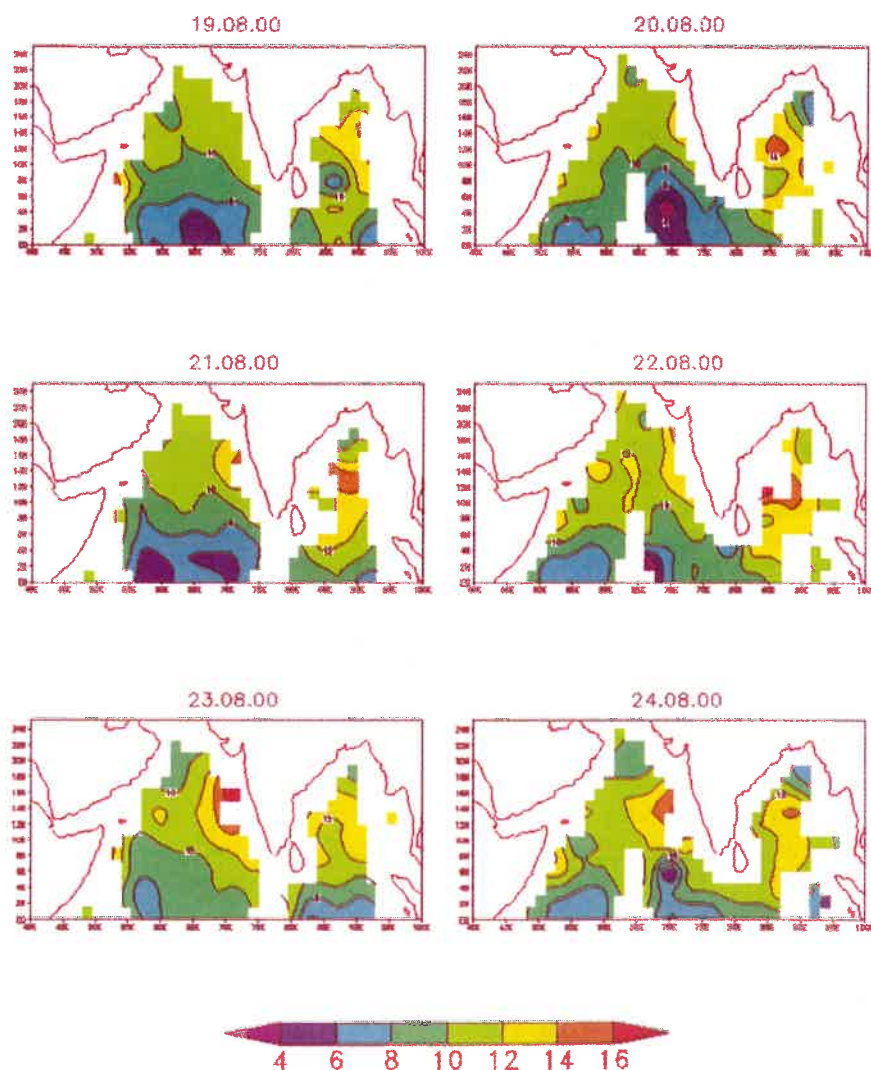


Fig. 7: IRS-P4 MSMR sea surface winds (m/s) for the complete life cycle of monsoon depression

4 m/sec to 24 m/sec. The values of SSTs were between 26°C and 30°C throughout system period and over the areal coverage of about 1200 km to 1400 km. Integrated water vapour was ranging between 4 gm/cm² to 8-gm/cm² and the values of cloud liquid water content were between 20 mg/cm² to 45 mg/cm².

Energy aspects of the depression with NOAA inputs

In order to study the role of work done by the mean meridional circulation and release of latent heat during the life cycle of a monsoon depression over northwest Bay of Bengal over a monsoon cell (10°- 28°N, averaged over 70°-90°E) and changes in intensity of deep convection were studied for a case of deep depression during 27-29 July 1999. For the above study NCEP/NCAR reanalyses and NOAA OLR data were utilised. The cumulus convection was important when upper level circulation became stronger and became a major source of energy for the maintenance of the disturbance. Intensification of the system from depression stage to deep depression was associated with maximum intensity of deep convective activity. Also this system was maintained till the kinetic energy produced by mean meridional circulation was positive in the monsoon trough (1.2×10^4 kJ/m/sec on 28 July, deep depression and 0.114×10^4 kJ/m/sec on 30 July, well marked low pressure area) region. During this period Hadley type circulation prevailed and generated zonal kinetic energy from zonal available potential energy. Due to passage of western disturbance to the north of India, southerlies occupied the upper troposphere of Indian monsoon region. This led to consumption of kinetic energy to the south of 20°N, resulting in reduction of the intensity of convection and zonal kinetic energy, and weakening of the system.

GTS SATEM heights and depiction of Mascarene high

Inputs of SATEM heights obtained through GTS were included in objective analysis (optimum interpolation scheme) of height field at 850 and 700 hPa during 27-31 July 1991 at 00 UTC. Depiction of synoptic features was better over oceanic region when satellite data were included in the analyses. Intensity of Mascarene high was properly depicted as 1600 gpm at 850 hPa on 27 July 1991 00 UTC with the inclusion of SATEM data.

Air-Sea Interactions in Tropical Monsoons

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

Water vapour characteristics over the Eastern Arabian Sea during ARMEX-2002

The water vapour characteristics of the marine atmospheric boundary layer (MABL) over the eastern Arabian Sea were examined by computing the sea-air interface humidity difference (DQ=saturation specific humidity at the SST-actual specific humidity of air at dew point), Relative humidity (RH), Latent heat flux (Q_E) and the height of the lifting condensation level (HCL) with the three hourly marine surface meteorological data (winds, air, dew point and sea water temperature, mean sea level pressure) collected on board ORV Sagar Kanya at a stationary location 15°04'N, 72°02'E during Arabian Sea Monsoon Experiment (ARMEX-2002) during 22 July-4 August 2002. Fig. 8 shows the temporal variability of the above parameters,

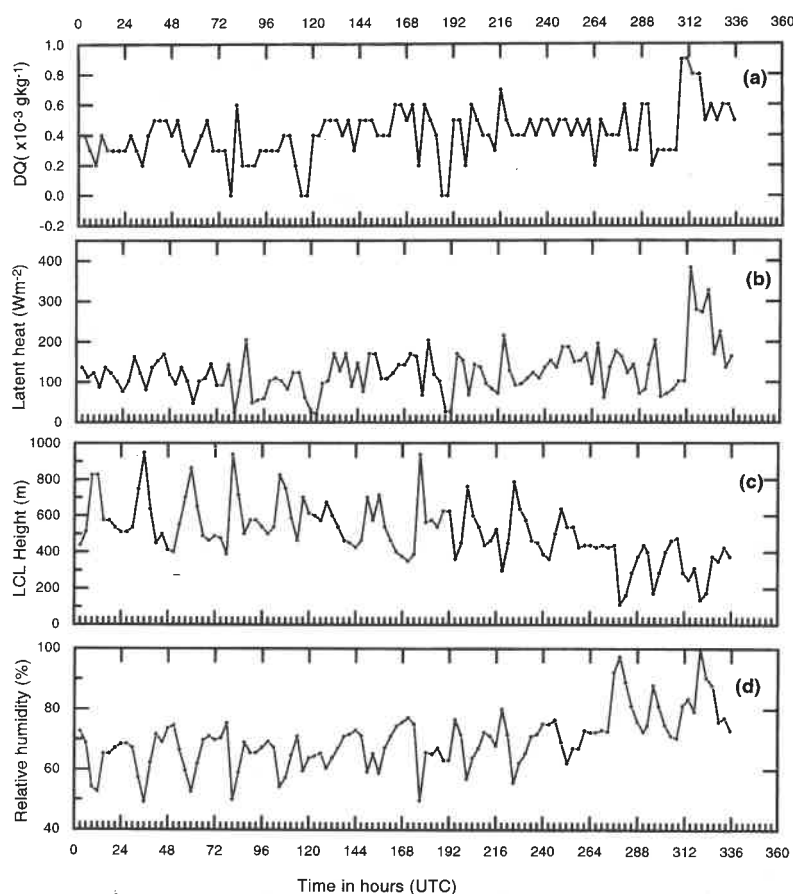


Fig. 8 : Time series distribution of (a) DQ, (b) Q_E , (c) HCL and (d) RH for the period 22 July to 4 August 2002, ARMEX Phase-I, Sagar Kanya cruise no. 179 (location : 15°04'N, 72°02'E)

DQ (Fig. 8a), Q_e (Fig. 8b), HCL (Fig. 8c) and RH (Fig. 8d). It is interesting to note that in spite of a few occasions of highly fluctuating moist spells (6g/kg), the marine environment over the eastern Arabian Sea was mostly dry ($DQ < 4$ g/kg) between 22 and 26 July, fairly moist ($DQ=4-6$ g/kg) between 27 July and 1 August and moist ($DQ=5-9$ g/kg) during 2-4 August. The above three periods mostly signify low latent heat flux ($Q_e < 100$ W/m²), medium latent heat flux ($Q_e=100-200$ W/m²) and high latent heat flux ($Q_e=150-350$ W/m²) respectively. The distribution of the HCL and RH showed trends directly opposite to each other, implying that the height of the lifting condensation level seems to be quite sensitive to the relative humidity of the environment. The periods of low RH appeared to be periods of high HCL and vice-versa. During periods of high RH (RH > 70%) during 2-4 August, the HCL came down to less than 400 m and varied between 50-400 m. During completely dry periods, the HCL rose to as high as 990 m on 23, 25 and 29 July.

Flux transfer processes at air-sea interface over the Somali basin during Monsoon-91

Marine meteorological data for 31 days of Sagar Kanya 1991 cruise for the period 19 August - 18 September 1991 at 3 hours interval were analysed. The experimental study area covered was between 13°N to 3°S and 52° to 70°E. The marine meteorological parameters analysed were air temperature, dew point temperature, sea surface temperature and pressure. The data were used to compute the fluxes of momentum, sensible heat and latent heat. The analysis showed that i) the SST varied between 22.8 and 29.2°C, the former was observed over the Somali prime eddy region at 8.7°N, 55.9°E and the latter at the equator, 68°E. The water temperature along the equator decreased from east to west from 68°E (SST=29.2°C) to 52°E (SST=26.6°C), ii) the air temperature was found to vary from 24.8°C (8.7°N, 55.9°E) to 30.0°C (3.6°N, 62.6°E). The former value corresponds to an area of low SST over the Somali basin prime eddy, and iii) the latent heat showed large variations over the study area with a low value of 7 W/m² (2°N, 52°E) and a high value of 312 W/m² (2.1°N, 54.3°E). The reason for the lowest value of latent heat at the above point was observed to be due to the high saturated atmosphere over a relatively cool (24.8°C) water surface.

Flux transfer processes at air-sea interface over Arabian Sea and Bay of Bengal

Flux-transfer processes at air-sea interface over Arabian Sea and Bay of Bengal were studied using the surface meteorological data, i.e. SST,

air-temperature, wind field and mean sea surface pressure (1013.25 hPa) for the period (i) 16 October 1994- 15 October 1995 (Arabian Sea) and (ii) 27 July - 5 August 1999 (BOBMEX-99, Bay of Bengal). The results revealed that i) the flux transfer processes were efficient in Arabian Sea (15.5°N, 61.6°E) as compared to Bay of Bengal (17.5°N, 89°E), ii) in the Bay of Bengal SST and air temperature were found to be higher than the counter part in the Arabian Sea, iii) however, the wind speed was stronger in the Arabian Sea than in Bay of Bengal and iv) all the meteorological parameters on both the ocean basins exhibited a strong seasonal variability with high synoptic and diurnal fluctuations embedded in it during the height of the monsoons over India. These diurnal and synoptic fluctuations were still higher during the monsoon months of July and August over Bay of Bengal. The synoptic fluctuations were absent in climatological data.

Climatology and Hydrometeorology



Climatology and Hydrometeorology Division has formulated its research programmes 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 develop high-resolution future climate scenarios for the Indian region.
- ❖ To bring out regional/global teleconnections and develop empirical techniques for the prediction of seasonal / monthly climatic anomalies over the country as a whole and homogenous subdivisions of the country.
- ❖ To assess the impact of climate variability in various socioeconomic sectors like agriculture, water resources, human health, etc. and to develop methodologies for an optimal utilization of climatic information in these sectors.
- ❖ To carry out hydrometeorological analysis of short-duration rainfall data over various river basins of the country for application in water resources management.
- ❖ To carry out estimation of probable maximum precipitation analysis of the depth-area-duration of severe rainstorms, and to provide inputs for the estimation of design parameters of hydrological projects.
- ❖ To understand the changes in rainfall patterns and hydrologic regimes, and their possible association with global warming.

Regional Aspects of Global Climate Change and Variability

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

Installation of a PC-based regional climate model

The Hadley Centre regional climate modelling system, known as PRECIS (Providing Regional Climates for Impacts Studies which is a PC-based version of the regional climate model HadRM3) has been successfully installed at the Institute as part of the Joint Indo-UK collaborative project on the development of high-resolution climate change scenarios for India. PRECIS runs on Linux operating system and is computationally identical to HadRM3 which is also available at the Institute on a Compaq workstation. Some sample runs were made using PRECIS. It is proposed to run PRECIS simultaneously on several PCs, to accelerate the development of climate change scenarios required for the project.

Coupled model simulations with IS92a GHG forcing

The climate simulations made by eight coupled atmosphere-ocean general circulation

models (AOGCMs) were analysed to develop climate change scenarios for India using IS92a greenhouse gas forcing. The AOGCMs used include, (i) CCC (Canada), (ii) CCSR (Japan), (iii) CSIRO (Australia), (iv) DKRZ (Germany), (v) GFDL (USA), (vi) HadCM3 (UK), (vii) MPI (Germany) and (viii) NCAR (USA). Long integration of control simulations (about 200 years in most cases) with constant climate forcing were used to evaluate the model simulated surface air temperature and rainfall with the observations on global and regional scales. Most models simulated the migration of tropical rain belts between winter and summer hemispheres reasonably well. However, large differences were noted between models in simulating monsoon rainfall over the Indian region, while the annual cycle in rainfall and temperature were quite realistically simulated in most models. Model simulations with GHG forcing in the 21st century when compared with present day climate (1961-1990) showed remarkable consensus on an increasing trend in the temperature (increasing trend in all) into the future (Fig.9) while the likely changes in monsoon rainfall over India varied from one model to the other (Fig.10).

All India Climate Change Scenarios of Temperature with IS92a Scenario

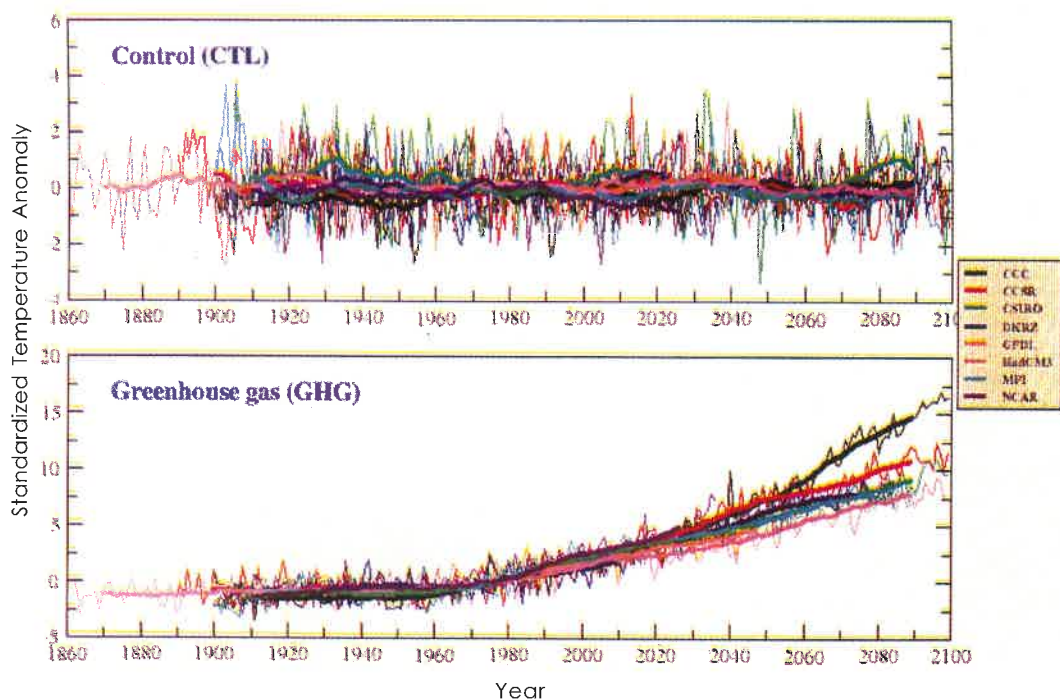


Fig 9 : Time series of simulated All-India mean annual surface air temperature (standardized anomalies with respect to the common period 1961-90) by eight AOGCMs for control and increasing greenhouse gas (IS92a) scenarios. The mean annual temperature ranges from 17°C to 25°C and standard deviation from 0.25°C to 0.76°C among the different AOGCMs.

All India Climate Change Scenarios of Rainfall with IS92a Scenario

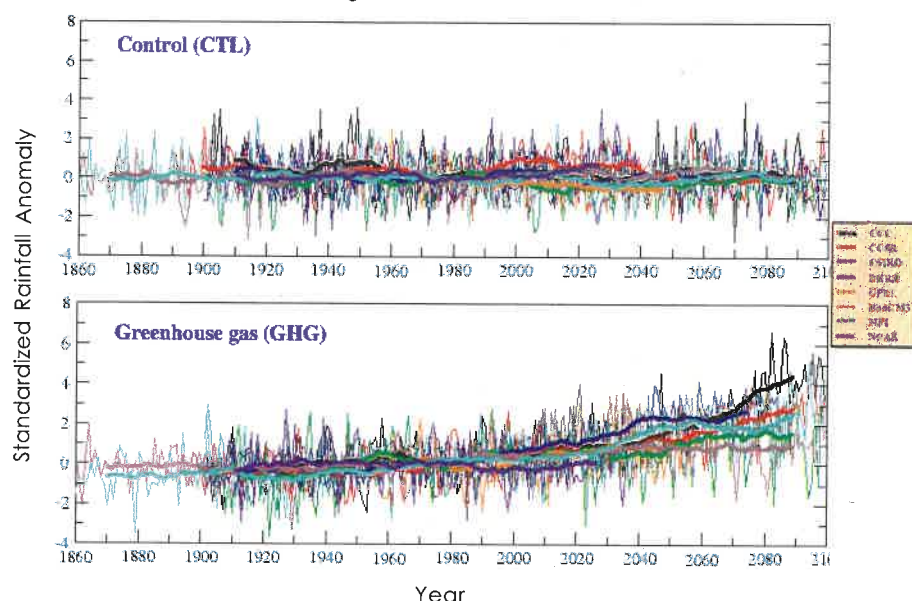


Fig 10 : Time series of simulated All-India summer monsoon rainfall (standardized anomalies with respect to the common period 1961-90) by eight AOGCMs for control and increasing greenhouse gas (IS92a) scenarios. The mean rainfall ranges from 5 to 8 mm/day and standard deviation from 0.5 to 1.6 mm/day, among the different AOGCMs.

Dendroclimatological analysis of Teak (*Tectona Grandis*)

Teak tree-core samples recently collected from Dhamni, Pune District and Machkot Forest near Jagdalpur, Chattisgarh were analysed. Tree-ring width chronology of Dhamni goes back about 250 years. The preliminary results indicated the association of narrow patches with lack of water condition (drought). The Jagdalpur teak chronology spans about 340 years i.e. A.D. 1662-2001 (Fig.11). Initial statistical analysis showed moderately high sensitivity to the regional climate.



Giant teak (*Tectona grandis*) tree from Jagdalpur forest, Madhya Pradesh

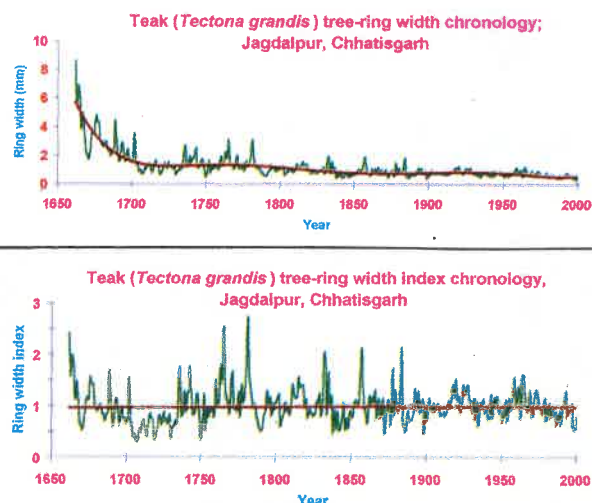


Fig. 11 : Tree-ring width and width index chronology

Climate Applications in Agriculture, Water Resources and Public Health

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

Study of vulnerability characteristics of Kachchh District, Gujarat

A project entitled, 'Study of Vulnerability Characteristics of Kachchh District, Gujarat' has been undertaken for the National Council for Cement and Building Material (NCB), New Delhi as

part of their National Communication (NATCOM) project to provide a comprehensive analysis on the climatological features, long term trends and future scenarios. As the deficient rainfall over the region puts serious strain on the regional economy, an attempt was made to compute the probability of one or more deficient years in a five year period. The analysis indicated that the summer monsoon rainfall over Saurashtra and Kuchchh region was homogeneous, Gaussian distributed with no trend. The probabilities of 1, 2 and 3 or more deficient rainfall years in a five year period estimated using Poisson distribution were found to be 0.35, 0.12 and 0.03 respectively. The analysis also showed that if June + July rainfall is deficient the probability of summer monsoon rainfall to be deficient is 58%. It was observed that over Saurashtra and Kuchchh region, MAM and JJAS seasons show significant increasing trend in temperature of the order of 0.9°C and 0.6°C per hundred years respectively. Time series of cyclonic disturbances affecting the region during the last century showed a decreasing trend. The greenhouse gas forced (IS92a scenarios) climate simulations made using 8 coupled models suggested 2-4°C increase in the annual surface air temperature over the Saurashtra and Kachchh region by the late 21st century. Five out of eight models showed slight increase in the monsoon seasonal rainfall over this region after 2040s. However, none of the models showed any decrease in the rainfall. Most of the models showed increase in the year-to-year variability in the seasonal rainfall after 2040s indicating a possibility for the extremes (droughts/floods) to increase.

Impact of climate change on cyclonic storms in Indian seas

The influence of global warming on the cyclonic storms forming in the Bay of Bengal, the Arabian Sea and the Indian Ocean and passing the Indian sub-continent was examined using simulations of a high resolution regional climate model. The control (CTL) and greenhouse gas (GHG) forced simulations of Hadley Center coupled ocean-atmosphere model (HadCM2) were used to drive the Hadley Center regional climate model (HadRM2) at a resolution of 0.44° x 0.44° during the period 2041-2060. Atmospheric CO₂ was held constant in the CTL simulations at the present day value. The GHG simulations observed increase in CO₂ from 1860-1990 and there after with a compound increase of 1% per year. The cyclonic storms and depressions were identified, in both the CTL and GHG simulations, based on the daily sea level pressure anomaly and low-level wind fields during different seasons. A systematic bias was observed in the monsoon depression tracks and the intensity as simulated in the regional model. The monsoon depression tracks in the model were found to be south of the observed tracks in both CTL and GHG run and the mean intensity of storms appeared to be generally stronger than observed. The analysis indicated no significant change in the frequency of storms in the Bay of Bengal, the mean intensity of the storms increased significantly in the GHG simulations as compared to CTL simulations. The frequency of storms in the Arabian Sea however, showed some decrease in the GHG simulations compared to the CTL simulations (Fig.12).

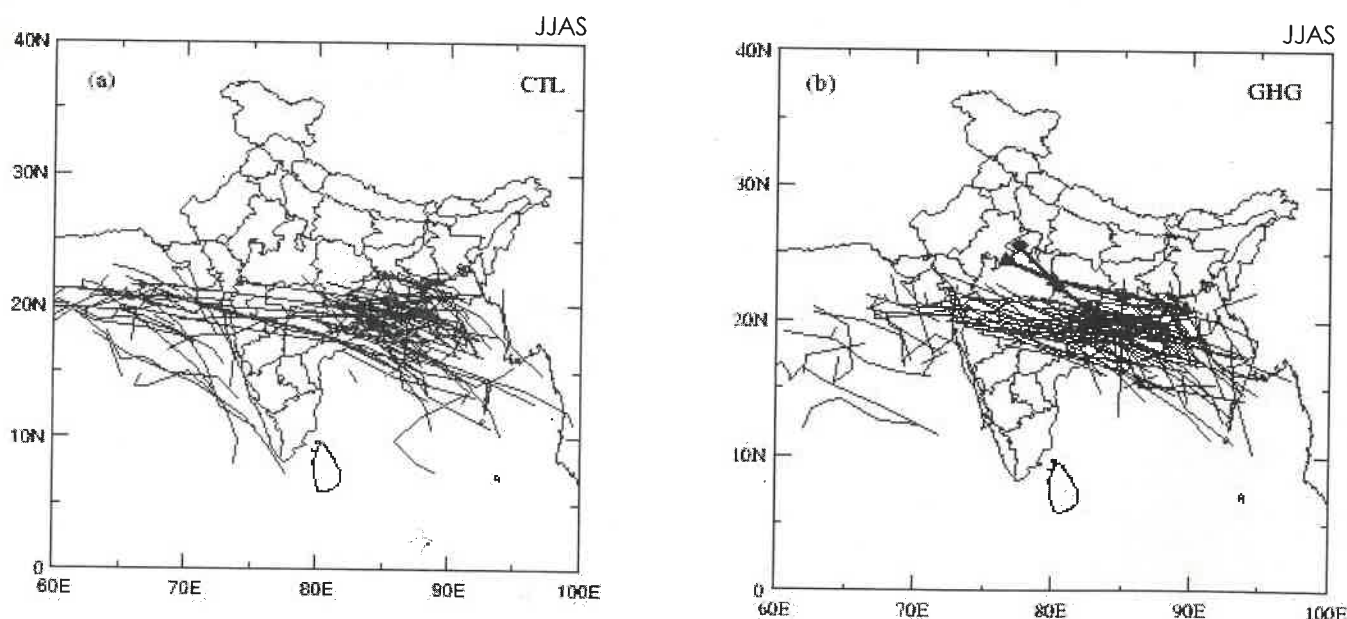


Fig. 12 : Monsoon storm tracks as simulated by HadRM2 for the period 2041-2060

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)

Estimation of PMP for the Sabarmati river basin

Estimation of probable maximum precipitation (PMP) raindepths for the Sabarmati river basin having an area of 21674 km² was made by physical method using all available long period rainfall stations. Analysis of severe rainstorms which occurred over and near the basin revealed that the rainstorms of 26-28 July 1927 with centre at Dakor in Kaira district and 24-26 June 1997 with centre at Visnagar in Mehsana district of Gujarat were severe ones. Isohyetal patterns of these two rainstorms were transposed over the basin to obtain the potential highest raindepths. Suitable moisture maximization factors (MMFs) were applied to the highest transposed basin raindepths to obtain PMP over the basin. PMP raindepths by physical method over the basin were estimated as 30.3 cm, 60.8 cm and 75.2 cm in 1, 2 and 3-day durations respectively.

Generalized charts of areal raindepths over India

Emphasis has been laid on the study of areal distribution of raindepths of severe rainstorms that occurred over the Indian region during the period 1880 - 2000. The results have been presented in the form of generalized charts for different standard areas of 100 to 10,000 sq. kms. for 1-day duration. These raindepth charts can be utilized for obtaining preliminary estimates for design storm for small and medium size river basins in India having areas less than 10,000 sq. kms.

Estimation of design storm for the Manjra catchment

Hydrometeorological analysis over the Manjra catchment up to its confluence with the river Godavari having an area of 30,844 sq. km was carried out using data of 35 rainfall stations (state raingauges / IMD observatory) for the period 1901-1986. Mean monsoon rainfall over the catchment was estimated as 75 cm which is about 82 % of the annual total. Highest observed point rainfall over the catchment was found to range from 10 cm to 40 cm in 1-day. Analysis of severe rainstorms which occurred in and around the catchment during 1901-1986 showed that 13-15 July 1965 rainstorm with centre at Nizamsagar was the most severe one. Isohyetal patterns of this rainstorm were transposed over the catchment so as to obtain the highest raindepths. PMP raindepths by

physical method over the catchment were estimated as 15 cm, 20 cm and 22 cm respectively for 1, 2 and 3-day durations after adjusting the transposed raindepths with a moisture maximisation factor of 1.15.

Precipitation distribution around the Annapurna range of Nepal Himalaya

Precipitation analysis was carried out around the Annapurna range of the Nepal Himalayas using precipitation data of about 100 stations varying from 10 to 50 years both to the south as well as to the north of this 7 to 8 km high Himalayan range. It was seen that in this sector of the Himalayas, moist winds on crossing the range from south to north lose about 95% of their moisture which appears to be the highest for any section of the Himalaya.

Spatio-temporal variability over major river basins in India

Rainfall analysis was carried out to bring out rainfall characteristics such as seasonal, annual, variability of rainfall (C.V.) and extreme 1, 2 and 3-day rainfall over different major river basins in India falling in the six zones as per the Khosla classifications.

Daily rainfall data for about 1135 stations falling within the six zones for the data period 1901 - 1992 were used for the analysis. Three major river basins namely the Krishna, the Godavari and the Ganga were selected for further detailed rainfall analysis to assess the climate change impacts on water resources over these basins. Areal mean annual rainfall over the Ganga and the Godavari basins were found to be of the order of 105 cm each while that of the Krishna basin was 91 cm with variability ranging between 13 to 17 % over these basins. Southwest monsoon contributes 75-85 % of the annual rainfall over the Godavari and the Krishna river basins while for the Ganga basin it was 90%. July and August were the heavy rainy months over these basins contributing about 50 % to the annual total with less variability compared to other months. Trend analysis of seasonal / annual mean rainfall over Ganga and Godavari basins indicated a slight decreasing tendency, but not statistically significant. However, in case of the Krishna river basin significant increasing trends at 5% level of significance were observed in the south-west monsoon season (16 cm/100years) and in the annual rainfall series (19 cm/100 years) (Fig. 13). For all the three river basins, an increasing tendency was observed in extreme rainfall series of 1-3 day durations, but these changes were not found to be statistically significant at 5% level of significance.

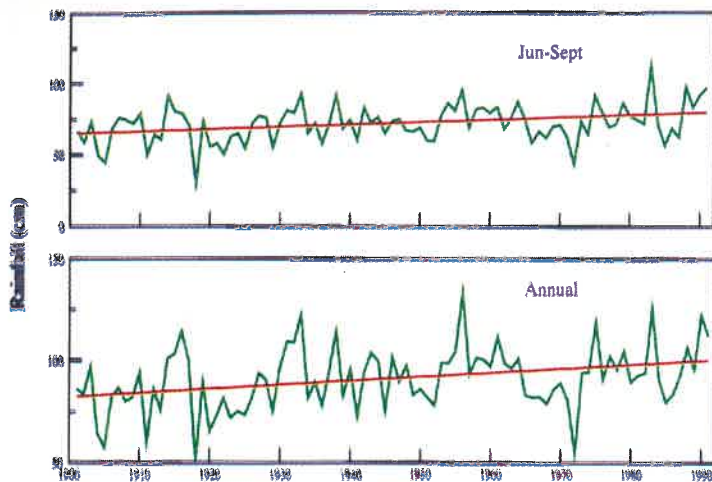


Fig. 13 : South-West monsoon and annual rainfall (cm) over the Krishna river basin

Water quality analysis for the Krishna river basin

The quality of water in different water systems is an index of certain parameters, like pH, conductivity, hardness, etc. These parameters reflect the type of terrain through which water traverses. The Krishna river is perennial and one of the best harnessed rivers in the southern peninsula. The river and its tributaries flow through different terrain having varied soil conditions, vegetation and

agricultural practices. In view of this, as a case study, on the basis of five hydrological observation stations, analysis for different water quality parameters was carried out using data for the period of 11 years (1987 - 1998).

All the samples of water of the Krishna basin were found to be distinctly alkaline (pH ranged between 7.5 and 8.8) in nature except for a very few samples of upper reaches of Tungabhadra and Malaprabha which showed slightly acidic in nature (Fig. 14 a and 15 a). In the Krishna basin salinity values in general varied from moderate to high (Fig. 14 c and 15 c). Annual variation of hardness in the Krishna river (Fig. 14 d) showed an increase in the hardness of water during the last 11-year period (1987-1998). The seasonal variation showed that the (Fig. 14 e and f) cationic / anionic concentration goes on reducing with the advance of monsoon and again increases with the withdrawal phase of the monsoon. From the analysis of discharge data at these five selected stations it was seen that total average runoff is more during the monsoon months of August and September and up to certain extent in October (see Fig. 14 b). The annual discharge data (Fig.15b) showed that during the good monsoon years of 1988, 1992, 1994 discharge was comparatively on the higher side.

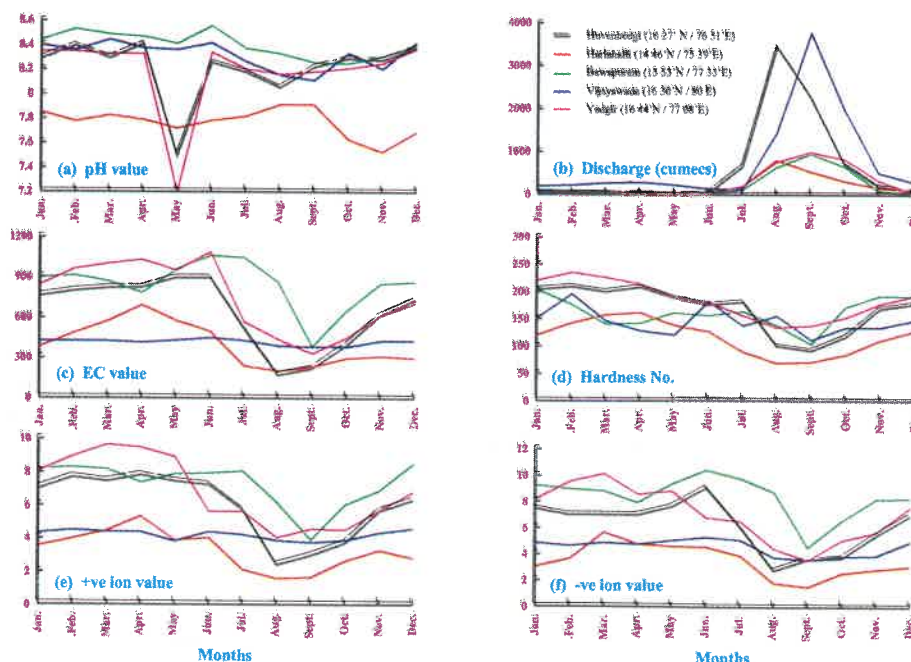


Fig. 14 : Monthly variation of different water quality parameters for selected stations in the Krishna basin (1987-88 to 1997-98)

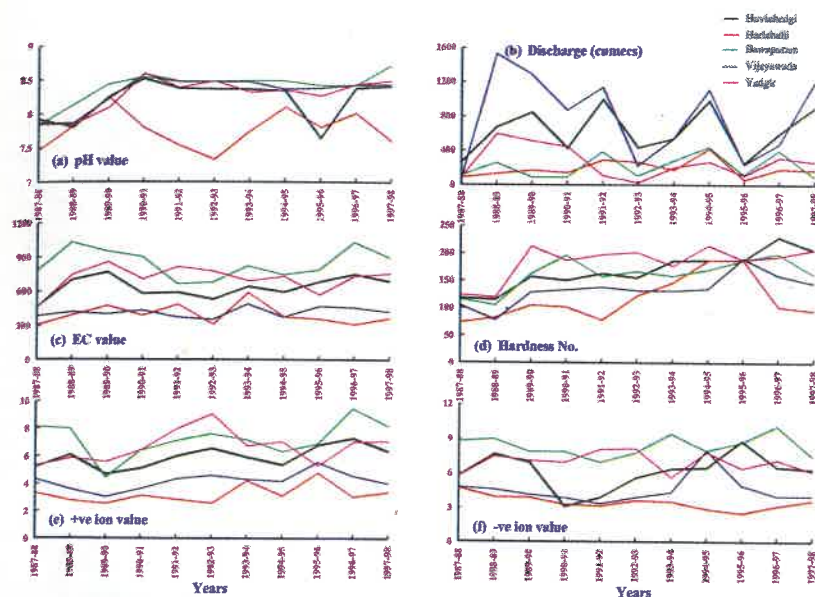


Fig. 15 : Yearly variation of different water quality parameters for selected stations in the Krishna basin (1987-88 to 1997-98)

Analysis of HadRM2 simulated precipitation data to assess the impact of climate change scenarios in 2050s over the three major river basins

Daily rainfall simulated by the regional climate model HadRM2 was analysed for both control (CTL) and greenhouse gas increase (GHG) experiments using a data of 20 years for each experiment. The control simulations represent climate of 1990 and the increase GHG simulations represent the scenarios for 2050s. To assess the model skills in representing the daily rainfall variations over three major river basins viz. the Ganga, the Krishna and the Godavari, seasonal and annual rainfall patterns

from model simulations (control group) were compared with that of observed patterns of rainfall for corresponding seasons over each of the basins. It was observed that for all the three basins, model generated well the seasonality in the rainfall series. However, in the Ganga basin for the months of May-September, rainfall was underestimated while for the Godavari and the Krishna basins, model overestimated the rainfall for the months June - December. 1-day extreme rainfall patterns of observed, control and GHG. Figure 16 showed that model underestimated the extreme rainfall to the north of 20°N. GHG experiments showed that there is likely to be increase in extreme rainfall in 2050s.

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)

Atlas of spatial features of moisture regions and rainfall of India during 19th and 20th centuries

For the DST sponsored project entitled, 'Atlas of Spatial Features of Moisture Regimes and Rainfall of India during 19th and 20th Centuries', the monthly rainfall data of 316 raingauge stations for the period 1985-2000 were collected from the records of the India Meteorological Department, Pune. There is

considerable number of missing observations for different stations. Nearest available station has been identified to get an estimate of each of the missing observations. The processed data constituted an update to the existing rainfall data bank up to 1984 forming the core data set to be used to develop the atlas. GeoMedia based Customized GIS Software Package has been installed for use in the development of the atlas.

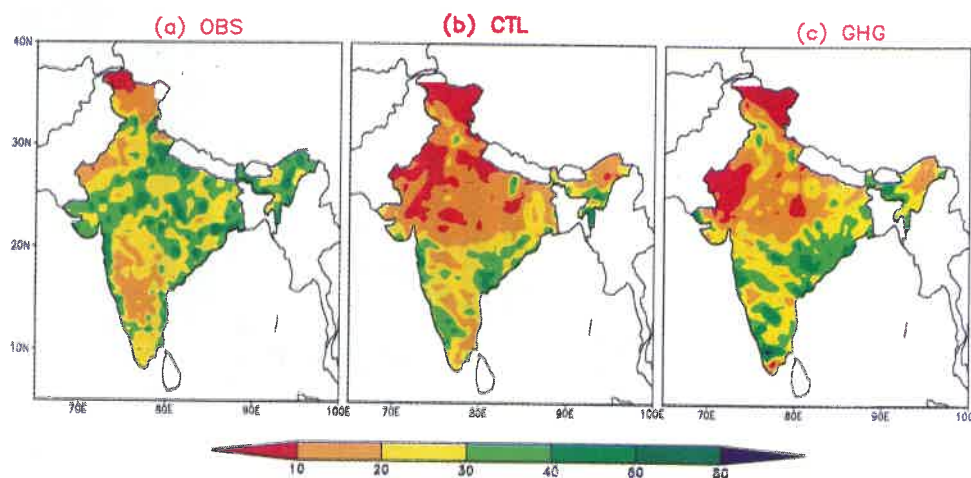


Fig. 16 : One day extreme rainfall (cm)

Influence of global warming and regional circulation changes on rainfall fluctuations and land use / cover changes over northwest India

It is widely accepted that global warming and changes in regional circulation features would considerably affect on the climatic variations of the Indian region. The influences were investigated using longest available instrumental records for northwest India, climatically the most sensitive area of the country. The impact of rainfall/climatic fluctuations on land use/cover changes (LUCC) over Rajasthan has also been documented.

Top panel of the fig. 17 shows 9-point Gaussian low-pass filtered values of the spring surface air temperature of the northern hemisphere (NH) for the period 1856-2001. Two broad epochs can be identified in the temperature fluctuation, cooling trend up to about 1910 and warming trend there after. The second panel shows 9-point filtered values of the annual rainfall over northwest India (north of 21°N and west of 80°E) for the period 1844-2001. Increasing trend in the northwest Indian (NWI) rainfall in association with NH temperature can be seen up to mid - 1970s. Thereafter, while NH temperature showed rising trend, NWI rainfall started showing decreasing trend. The third panel shows fluctuations (9-point filtered values) in the area under arid environment (annual rainfall less than 560 mm) over northern India (north of 20°N) for the period 1871-2001. Negative relationship between the NWI rainfall and the north Indian arid area can be seen throughout, which is understandable. Trend analysis of recent rainfall fluctuation (since 1974) over different river basins indicated increasing trends over basins in eastern parts of the country and decreasing over western parts. Increased convective activities as indicated with higher SST over western Pacific, Indonesian and Philippines Seas and Bay of Bengal appeared to be the main cause of increased rainfall

activities over eastern parts of the country.

The bottom most panel shows land use changes in Rajasthan in seven categories (arable, built-up, forest, intermittent woods, grasses, desert and wet lands) over the period 1860-1980. The most notable feature of the diagram is the shrinking tendency in the area under desert condition since 1890. Study revealed that shrinking in desert area is due to expansion of agricultural activities over the culturable desert wastelands owing to improved rainfall conditions.

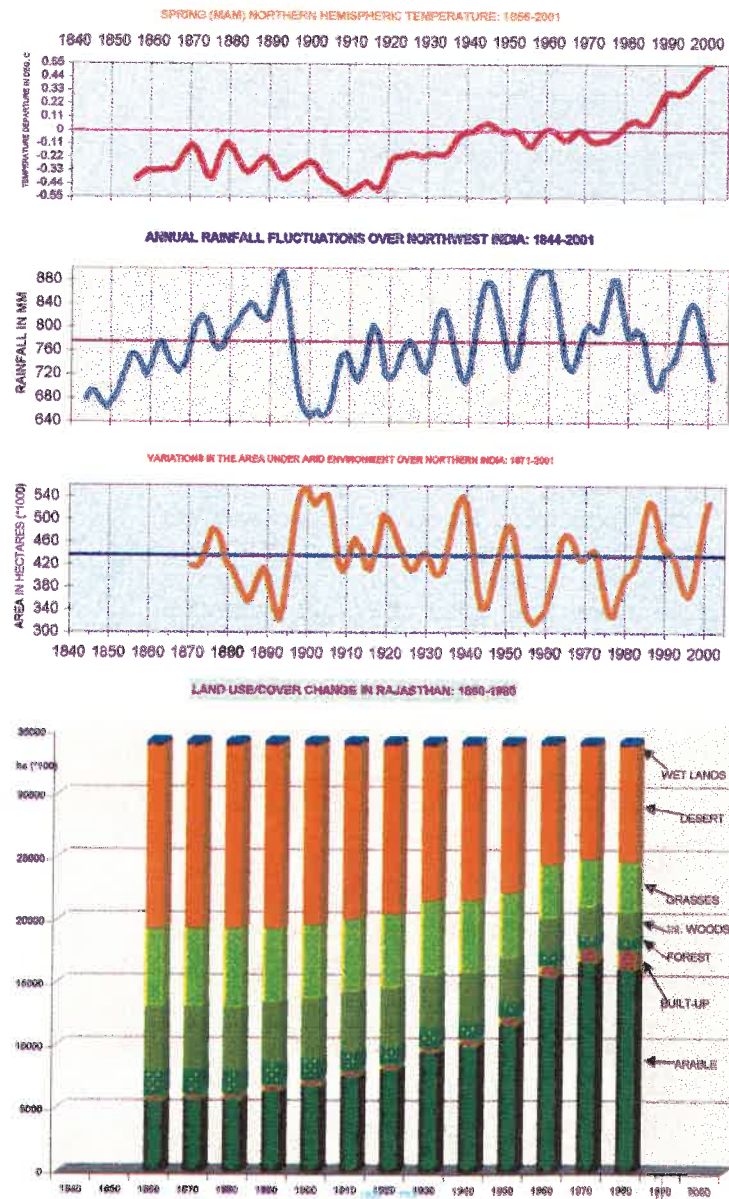


Fig. 17 : Influence of global warming and regional circulation changes on rainfall fluctuation and land use / cover changes over Northwest India

Physical Meteorology and Aerology



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

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

Association between thunderstorm and rainfall activity

Thirty years (1951-1980) mean monthly thunderstorm days (TS) and rainfall (RF) amounts for 260 Indian observatories spread uniformly over the country were used to obtain their monthly, seasonal and zonal percentage occurrences from all India totals. The study revealed that the percentage occurrence of thunderstorms exhibited bi-modal oscillation and that of rainfall exhibited unimodal oscillation over the Indian region. There was a time lag of one month in the occurrence of first maximum of thunderstorms and rainfall. Seasonal analysis of these two parameters suggested that postmonsoon season thunderstorm seems to tend to increase the rainfall over the Indian region.

India has been subdivided into six homogeneous regions based on rainfall. The zonal monthly mean percentage occurrences of thunderstorms and rainfall were prepared for these zones. The analysis of thunderstorms and rainfall in 6 different zones suggested that there exists a wide range of variations in both the parameters month after month. But the mean percentage occurrence of 30 years seemed to be more or less equal in magnitude of the percentages in each zone as shown in the Fig. 18.

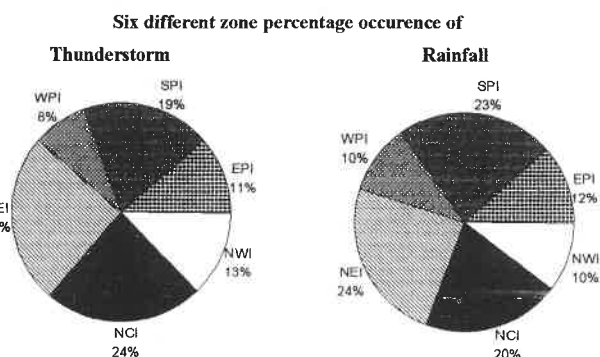


Fig. 18 : Percentage occurrence of thunderstorm and rainfall in six different zones (NWI : North West India, NEI : North East India, WPI : West Peninsular India, SPI : South Peninsular India, EPI : East Peninsular India)

Thermodynamic features of convective boundary layer

The thermodynamic features of the Convective Boundary Layer (CBL) during the summer monsoon season of 1999 were examined over the Indian east coastal stations with respect to the prevailing synoptic scale weather disturbances. For

this purpose, high resolution aerological observations specially collected during the Bay of Bengal Monsoon Experiment-99 (BOBMEX-99) for the Intensive Observing Periods (IOPs) for the six east coastal stations and an island station were considered. Out of the five available IOPs observations during two IOPs, one during July and another during August 1999, were used to explore the differences in the CBL characteristics. The coastal stations were categorised into two groups based on the location of the stations with respect to the prevailing weather disturbance (depression or low pressure area) viz. Group A (stations located in the vicinity of the disturbance) and Group B (stations situated away from the disturbance). The daily distribution of different thermodynamic parameters at the surface indicated more convective activity at the surface during August. The mean vertical profiles revealed more convective activity for Group A stations as compared to Group B stations during both July and August indicating the influence of the existing disturbance. However, convective activity was found to be more during July as compared to August, except in the surface layer, for both the groups. For both the groups, the CBL tops varied in the range 700-500 hPa. Over the island station, the CBL tops were observed at higher levels during July as compared to August (Fig. 19).

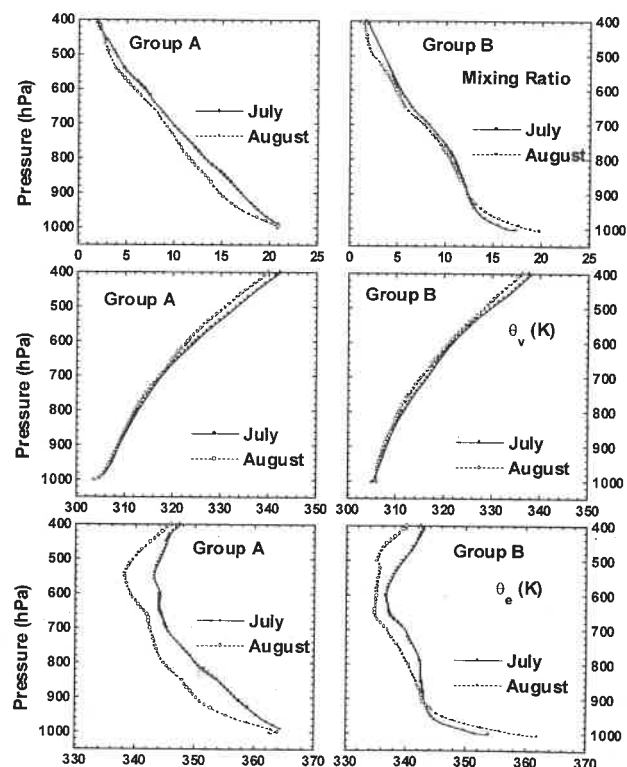


Fig. 19 : Averaged vertical profiles of mixing ratio q_v (Virtual potential temperature) and q_e (Equivalent potential temperature) during July and August for Group A and Group B stations during BOBMEX-99

Field mill network at SHAR for thunderstorm warning

Under a collaborative project with the SHAR of ISRO the field mill network developed in IITM has been tested and installed at SHAR during 7- 23 May 2002.

Two softwares have been developed. One is for processing the online data received from the field mill, and to handle and process the data of 8 stations simultaneously. The another one is for analyzing the archived data from the field mill. A graphic software has also been developed to plot and embed the final graphs directly on the word document.

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

(P.C.S. Devara, P.E. Raj, Y. Jaya Rao, G. Pandithurai, K.K. Dani, S.K. Saha, S.M. Sonbawne, R.S. Mahes Kumar, A.K. Shrivastava)

IRS satellite synchronous observations of aerosols, ozone and water vapour

Special observations of atmospheric aerosols, ozone and water vapour were carried out over water bodies (Khadakwasala and Mulshi dams) and vegetation zone (Pune-Daund-Pune stretch) using multifilter solar radiometers on 22 days in synchronization with IRS-P4 / ID satellite passes over Pune.

Study of the climatological trends in total column aerosol optical depth, ozone and precipitable water content

From the multi-filter solar radiometric observations of aerosols and trace gases carried out during the years 1998-2001, the inter-annual, intra-seasonal and monthly data of columnar aerosol optical depth (AOD), aerosol size distribution (ASD), ozone (TCO) and precipitable water content (PWC) were examined. The results indicated significant inter-annual variability with greater monthly average AOD, TCO and PWC values in 1999 than those observed in 1998, 2000 and 2001. All the parameters were found to show a decreasing trend with varying magnitude. The Angstrom wavelength exponent which is an index of particle size distribution, showed lower values, indicating abundance of coarse particle contribution from May to October in all the four years of observations.

Lidar - Radar observations of aerosols and clouds

To monitor the characteristics of upper tropospheric and stratospheric aerosol including the

influence of winds and atmospheric stable layers such as tropopause on aerosol characteristics, experiments were carried out using Nd:YAG lidar system, (operating at 532 nm) available at National MST Radar Facility, Gadanki. Simultaneous observations of atmospheric stable layers and 3-dimensional vector winds were carried out using MST radar during 11-20 February 2002. In addition to these experiments, lidar and MST radar data archived by NMRF for the period 1998-2000 were also analysed. Scattering and depolarization ratios were derived from the lidar data. Lidar derived scattering ratio clearly showed enhancement wherever the depolarisation ratio was minimum at different height levels in the height region of 18-25 km i.e. in the lower stratosphere suggesting multiple layer structures. Results also showed strong enhancement in scattering ratio as large as >2 just below the tropopause with strong enhancement in depolarization ratio suggesting the presence of cirrus clouds just below the tropopause. Occasionally cirrus clouds have also been observed both below and above the tropopause. These results were found to play an important role in understanding of radiative properties of cirrus clouds and their influence on tropopause thereby stratosphere - troposphere interaction (Fig 20).

Observational study of direct radiative forcing of atmospheric aerosols on the surface reaching solar flux

The aerosol forcing on short wave radiation was investigated based on the concurrent observations of downwelling global short wave radiation flux using a pyranometer and aerosol optical depth using a sun / sky radiometer. The results of the analysis of observations collected using the above instruments on clear sky days during 2001 indicated that (i) the estimated land aerosol radiative forcing of efficiency in the broad band short wave was about -72 W/m^2 at the surface which agrees well with INDOEX measurements, (ii) decrease of spectral dependence of single scattering albedo showed decrease with increasing wavelength and agreement with the urban/ industrial aerosol model results reported in the literature, (iii) lower values of single scattering albedo suggesting a portion of aerosols over the experimental station to be of absorbing type and (iv) higher values of single scattering albedo during winter months as compared to pre-monsoon months revealing the abundance of scattering type aerosols.

Atmospheric aerosols are significant source of direct and indirect global climate forcing. Aerosols can scatter the solar radiation back to space and

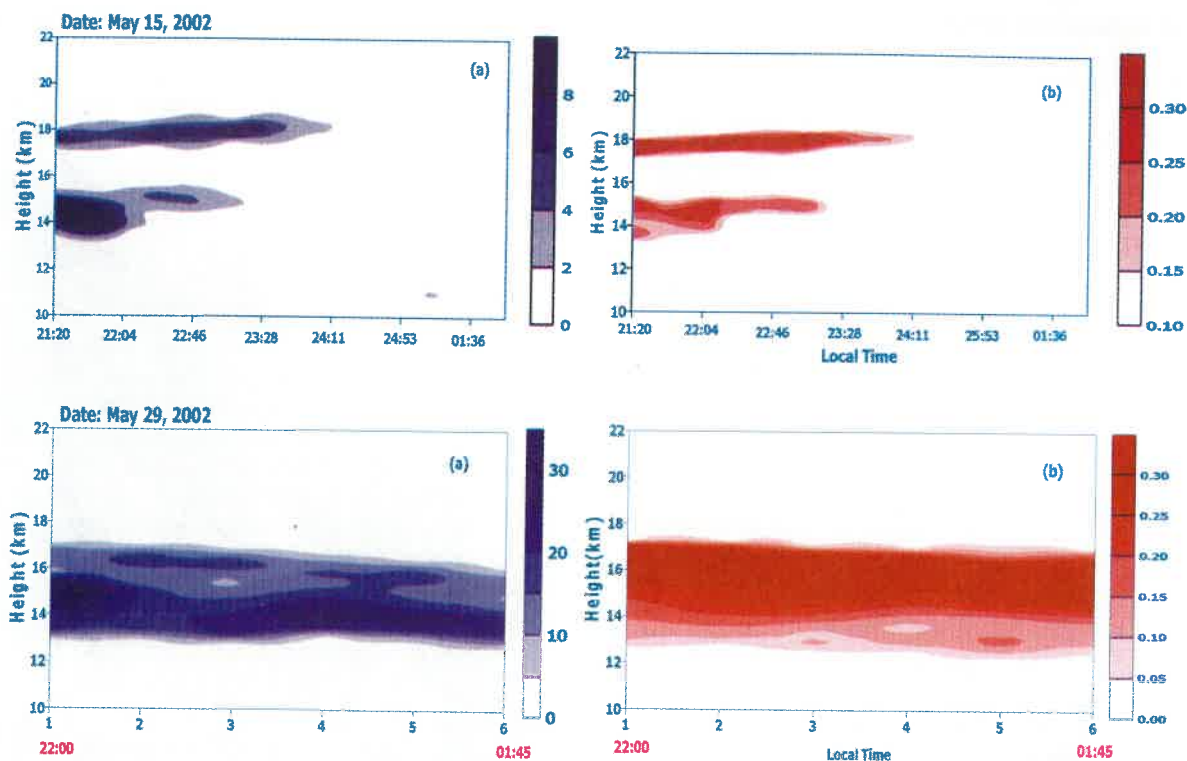


Fig. 20 : Lidar Observation of cirrus clouds around the tropical tropopause. Panels (a) and (b) show scattering and depolarization ratios respectively

enhance the albedo, thus causing a negative radiative forcing (cooling) depending upon their chemical composition. An observational study of aerosol radiative forcing was undertaken at the Institute using a co-located and simultaneously operated sunphotometer and a short-wave pyranometer which measure aerosol extinction and incoming global radiation flux, respectively. The analysis of the observations carried out during the period December 2002 - January 2003 revealed (i) day-to-day variability in the incoming short-wave flux depending upon the different aerosol loading conditions, (ii) direct aerosol radiative forcing (at 500 nm) of -233 W/m^2 per unit optical depth increase on a typical day, and (iii) larger forcing over urban environment (-233 W/m^2) when compared with rural environment (-45 W/m^2). Also, the experimentally determined flux changes due to aerosols at the surface were compared with the SBDART model derived fluxes on different experimental days and they showed a very good agreement (Fig. 21).

Aerosol radiative forcing estimated over an urban station, Pune, by integrating sun/sky radiometric observations with radiative transfer model yielded -33 W/m^2 , 8 W/m^2 and 41 W/m^2 at the surface, top of the atmosphere (TOA) and

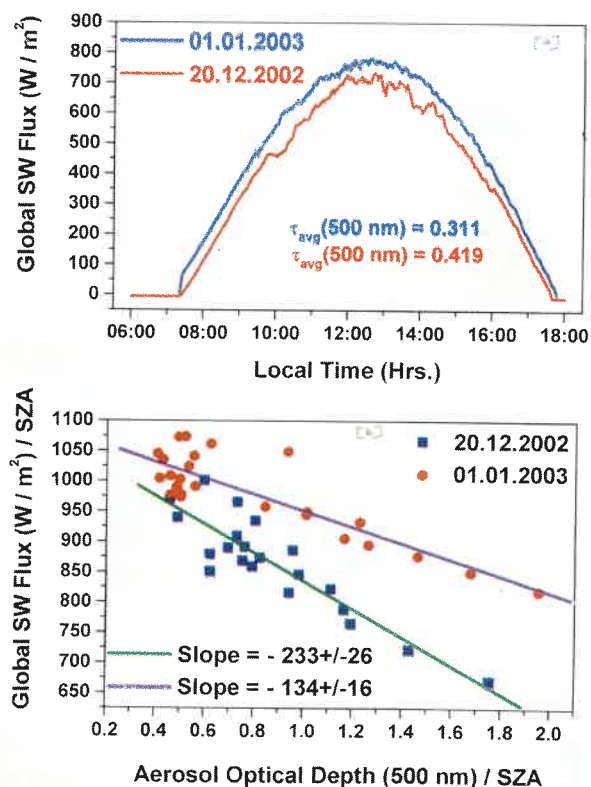


Fig. 21 : Temporal variation of global SW flux (WM^2/SZA) on 20 December 2002 and 01 January 2003 (a) and corresponding aerosol radiative forcing (b)

atmosphere respectively. The values were compared with the marine aerosols estimated from the INDOEX observations (Fig. 22). The forcing at the TOA was found to be positive over land and negative over ocean.

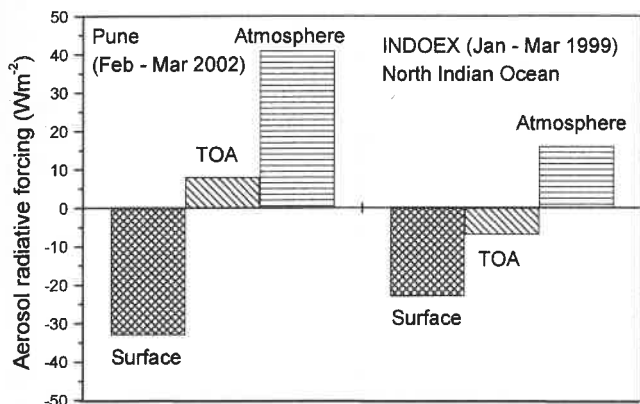


Fig. 22 : Comparison between urban and marine aerosol radiative forcings

Solar radiometric characterization of aerosols and pre-cursor gases

The short-scale fluctuations in the aerosol and related pre-cursor gases utilizing, high-resolution observations (3-5 minute interval) of total column aerosol optical depth, ozone and precipitable water content were investigated during clear sky conditions on 23, 30 November, and 1, 7, 8 and 29 December 2002. Co-located simultaneous observations of surface-level temperature, wind and relative humidity were also measured on the above days.

The preliminary analysis of the aerosol and meteorological observations carried out on 16 December 2002 over a high-altitude (~1313 m AGL) remote (rural) station, Sinhgad indicated smaller temporal variations in column aerosol optical depth (AOD) as compared to those observed over the urban stations suggesting the aerosols over the station to be of natural origin, and conversion of smaller size spectrum of accumulation-mode aerosol particles into sub-micron size particles. The simultaneously measured relative humidity and precipitable water content also supported this event, and besides following the wavelength dependence of AOD, coarse-mode particles were found to show diurnal variation different from those of accumulation particles indicating hydrophilic nature and aerosol growth processes over the experimental site.

Solar radiometric observations of total column aerosol optical depth and precipitable water

content were carried out at the Institute during 1 January 2002- 28 February 2003. Simultaneous surface level meteorological parameters were also collected. The analysis of the above observations indicated (i) higher AOD and PWC during hazy-days in contrast to clear-sky days, (ii) greater value of alpha suggested abundance of smaller aerosol particles during hazy days and relatively larger particles during clear sky days, (iii) higher beta values depicted higher aerosol loading on hazy days as compared to clear sky days, (iv) mean AOD at 500 nm and PWC was highest on hazy day and lowest on clear sky day, (v) close relationship between AOD and PWC suggested increase in optical depth during occasions of high precipitable water content, (vi) high positive correlation between relative humidity, wind speed and AOD at 500 nm on all days, (vii) significant correlation between AOD at 500 nm and columnar PWC suggesting that they follow each other and increase in aerosol extinction with increase in PWC and vice versa and (viii) most of the size distribution curves showed bimodal and power-law type of distribution.

Solar radiometric and lidar observations were carried out at National MST Radar Facility, Gadanki during 28 February - 15 March 2003. Radiometric observations involving sunphotometer and SW pyranometer to understand the environmental influence on the aerosol radiative forcing over a rural station (Gadanki) were carried out during 26 February - 7 March 2003.

Studies in Air Pollution and Precipitation Chemistry

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

Precipitation chemistry studies in Mumbai region

The rain water samples collected at Kalyan (downwind location of a large industrial belt) and at Alibag and Colaba (upwind locations) during the southwest monsoon seasons of 1994 and 1995 were analysed for their chemical composition and compared with similar data of 1973-1974. The analysis revealed that pH of rainwater at Kalyan which was alkaline 20 years ago, became acidic due to long-term effect of pollutants. A decreasing trend in excess SO₄ was observed at Colaba and Kalyan, which can be attributed to the pollution control measures adopted by industries and switching over from coal to natural gas as fuel which contains low sulphur. Whereas the increasing trend in NO_x observed at Kalyan and Colaba, was attributable to the increased automobile emissions.

Fog and precipitation chemistry at Delhi

Fog water samples were collected during three consecutive winters of the years 2000 to 2003 and their chemical compositions were studied. It was found that all the samples were alkaline in nature in comparison to atmospheric CO_2 equilibrated pure water neutrality. Neutralization of fog acidity by cations occurred in order as $\text{NH}_4^+ > \text{Ca} > \text{Mg}$. Comparison of the chemical composition of fog water and that of rain water, which were collected during the same period, indicated that nearly all the chemical constituents were higher in fog water than those in rain water except for one case of rain water which occurred on 25 December 2002. Concentration of nitrate both in fog and temporally nearest rain water samples was nearly same except for the rain sample of 25 December 2002. This indicates that while fog water drags only the lower tropospheric NO_3^- , rain water collects an appreciable amount of NO_3^- by both the rainout and washout mechanisms. Major contribution to the total lower tropospheric NH_4^+ ions may be from human and animal excretion during winter season. Finally, natural source of cations (Ca, K and Mg) dominated over the anthropogenically produced acidic anions (SO_4^{2-} and NO_3^-).

Observation on rainwater and aerosols at a high altitude station

The chemical analysis of rain water and total suspended particulate samples collected at Darjeeling during 12-20 November 2001 showed that (i) the anion/cation ratio for rain water was 0.96 whereas, that for aerosols i.e. TSP was 0.94, indicating a very good balance between cations and anions, (ii) the average pH of rain water was 5.71 which is close to the CO_2 equivalent value for neutral rain i.e. 5.65, (iii) even though, the aerosol as well as rain water composition showed slightly alkaline nature, the concentrations of acidic components such as sulphates and nitrates were significantly more and (iv) calcium, sodium and potassium were the major neutralising components in rain water whereas, in aerosols, ammonium played a major role in neutralising the acidity.

Chemical constituents of sequential samples during a shower

The chemical analysis of 7 sequential samples collected during a shower on 11 June 2001 revealed that (i) the pH gradually decreased from 7.07 at the beginning of the shower to 6.20 at the end, (ii) the conductivity also showed the similar trend with values falling from 56.3 to 16.3 $\mu\text{S}/\text{cm}$, (iii) all the major chemical constituents showed a decreasing

trend during the course of shower indicating the washout effect and (iv) although the decreasing trend was observed for both cations and anions, the washout effect was found to be comparatively more for cations than the anions resulting in the decreasing trend in pH.

Observations over the Arabian Sea

Under the ARabian Sea Monsoon EXperiment (ARMEX) Phase-I, cruise observations were undertaken on board ORV Sagar Kanya during 24 June - 16 August 2002. Surface ozone was monitored with the help of UV photometric ozone analyser at 254 nm wavelength. Concentration of O_3 varied from 4 to 24 ppb with an average of 11 ppb. Hourly analysis showed no prominent diurnal variation of surface O_3 over the ocean. Also, mass size distribution of aerosols was studied using Andersen low volume sampler. Bimodal distribution of aerosols was observed with a small peak in fine size (0.65 μm) and a major peak in coarse (4.7 μm). Fine size particles contributed 30% and coarse size particles contributed 70% to the total aerosol load, indicating dominance of coarse size seasalt particles. The results indicated less anthropogenic influence over the sea.

Indo-Swedish collaborative programme on wet / dry deposition

Under the Indo-Swedish collaborative project on 'Regional Air Pollution in Developing Countries', 37 wet only and bulk samples were collected at Sinhagad during August and September 2002. The pH values of the samples varied from 5.86 to 7.19 indicating alkaline rain.

Rainwater composition over Pune during monsoon 2002

During the monsoon season of 2002, about 56 rain water samples (including showers) were collected at Pashan, Pune. The average pH value was 6.68 with minimum 5.54 and maximum 7.60. Only 4% samples were acidic (pH < 5.60). Cl among the anions and Ca among the cations showed maximum concentrations. Average electrical conductivity was 36.2 μS .

Atmospheric Chemistry, Modelling and Dynamics

(G. Beig, I.S. Joshi, C.P. Kulkarni, S.S. Fadnavis, N. Saraf, S. Gunthe, M. Kokate, A. Ayare)

A multiple function regression analysis of the Rocketsonde data collected over the equatorial station Thumba (8°N, 76°E), India extended for about two solar cycle period, which also takes into

account successive instrumental modifications and tidal effects, was carried out. Results apparently showed a significant solar cycle component in the mesospheric temperature, magnitude of which increased with the height. A negative correlation in the entire stratosphere and a positive correlation in the mesosphere existed over Thumba. Solar coefficients were found to fall off with the height above 70 km and value was as high as $4^{\circ}\text{K}/100^{\circ}\text{F}$ at 75 km where rocketsonde measurements were marred by several biases, hard to account in total but dealt firmly in the present analysis. The high value ($3\text{--}4^{\circ}\text{K}/100^{\circ}\text{F}$) of solar signal above 70 km as obtained in this work might have biased the trend estimate calculations made by earlier workers for Thumba where unusually high negative trend coefficient ($5\text{--}10^{\circ}\text{K}/\text{decade}$) as well as high solar coefficient were reported. Present trend estimates including that of upper mesosphere were found to be very well in agreement with majority of other estimates obtained by other workers in recent literature for this region.

Solar response of ozone and temperature

A study to determine the solar dependency of ozone and temperature over the Indian tropical region on a decadal scale was made. For the purpose, the data obtained by ozonesonde and Umkehr methods for the vertical distribution of lower stratospheric ozone and that of total ozone amount from Dobson spectrophotometer during the period 1979-1999 were analysed using the multi-functional regression model, which takes the account of all the known natural and anthropogenic signals. The NCEP and MSU- satellite data for the temperature over this region were used.

Human Influence on Marine Environment

The model simulated results of ozone and its precursors (CO , NO_x etc.) using a 3-D chemistry transport model were used to study the effect of human influence on the marine pristine environments of different oceans (Indian Ocean, Atlantic Ocean and Pacific Ocean). The study clearly depicted that the increasing anthropogenic activities due to increasing biomass burning, fossil fuel emissions etc. result in tremendous enhancement of pollutants like CO , NO_x etc. These pollutants get transported to marine regions during different time of the year, thereby affecting the otherwise clean environment.

Simultaneous monitoring of surface ozone and its precursors

A laboratory has been set up for continuous monitoring of surface ozone (O_3) and its precursors

namely oxides of nitrogen (NO_x), carbon monoxide (CO) and hydrocarbons (CH_4 - NMHCs) at the Institute (IITM). Regular observations are taken at the IITM premises from a site where fresh air flow (free from any closer source of pollution) has been ensured. Data are being collected on hourly basis.



A number of new features have been observed. From the first glimpse of the data it appeared that the level of NO_x concentration goes up in the morning and evening hours which coincides with the beginning and closing hours of the offices/business establishments located in the vicinity. Such features were not observed on holidays and also this peak was not observed in CO concentration as it has longer life time than that of NO_x . The raw data (without the quality control check) are being directly plotted on-line on a newly established web site of the Environment Information System (ENVIS) node at the IITM.

Numerical study of atmospheric dynamical problems

A numerical study for realistic simulation of dynamical systems was taken up. Finite precision computations using digital computers involved inherent errors such as (i) round-off error of finite precision computations, (ii) binary computer arithmetic precludes exact number representation of traditional decimal system used in data input stage to the computer. The results suggested that although the round-off error is as small as 10^{-7} (single precision) in the beginning, it can enter the mainstream computation within 50 iterations in iterative computations, such as that used in numerical integration schemes, for example, the commonly used fourth order Runge-Kutta method.

Comparative study of vertical structure of temperature trends over the Indian region

HALogen Occultation Experiment (HALOE) temperature data (satellite based) collected over

the Indian region (0° - 30° N, 60° - 100° E) for the period 1991-2001, radiosonde (1983-1993) and rocketsonde (1971-1993) temperature data over the equatorial station Thumba (8.32° N, 76.5° E) were used for the study of vertical structures in temperature trends. Vertical trend distributions in all the data sets were obtained by using multiple regression model. Radiosonde, rocketsonde and satellite (HALOE) trend profiles showed similar variations indicating cooling of -1.6° K/decade in the lower stratosphere and negative trend of 2° - 3.5° K/decade in the upper mesosphere. Positive (warming) temperature trend was obtained in the upper troposphere. Vertical trend profiles of rocketsonde and HALOE temperature data showed similar valley like feature at 45 km (Fig. 23).

Evidence of anthropogenic signals in satellite data of tropospheric ozone over tropics

An analysis of tropical tropospheric column ozone (TCO) data derived by Nimbus-7 and earth Probe -total ozone mapping spectrometer (TOMS) during the period 1979-2002 over the tropics (12.5° S- 12.5° N), revealed statistically significant linear trends widely believed to be of anthropogenic origin. Present results revealed an increase in TCO by 23 (± 10) % in the past two decades indicating that a radiative forcing of climate

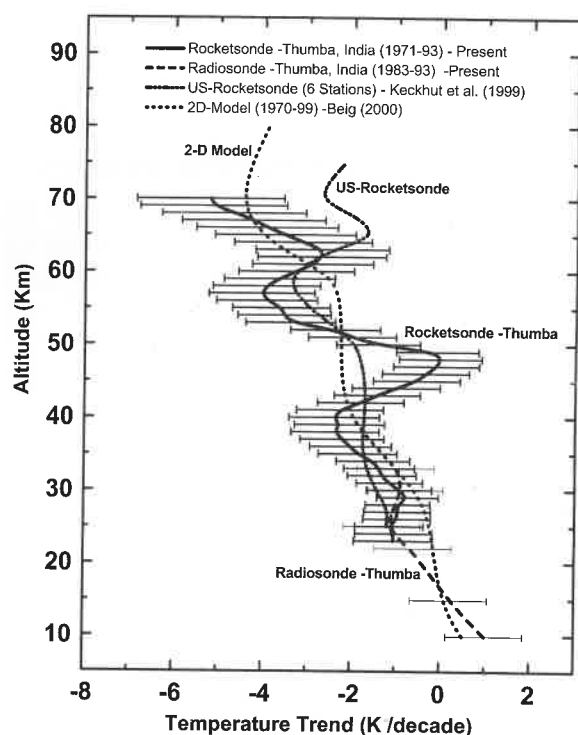


Fig. 23 : Temperature trends deduced from experiments. Observations and model results over low latitude

may be up by about 0.3 W/m^2 , which is substantial. If sustained, it will have serious climatic implications. The trend results were qualitatively consistent with model results that link the trend to the growth in surface emissions of NO_x and hydrocarbons. It also revealed a marginally significant out-of-phase solar response in TCO. The solar coefficient was found to be around $-1.3 \text{ DU/100 F } 10.7 \text{ solar flux}$, significant only at 90% confidence level.

Stratospheric warming during January- March 2003

Analysis of stratalert messages of Free University, Berlin during the period 14 December 2002 - 19 March 2003 revealed (i) intense stratospheric warming started on 12 January 2003, intensified into major warming on 18 January 2003, and turned into a major warming and continued till 15 March 2003, (ii) there was no PSC formation, (iii) a strong anticyclone over eastern Siberia from 30 hPa upwards, spreading westwards in the upper stratosphere, and (iv) an intense warm region was located over Siberia in the lower and middle stratosphere resulting in reversed temperature gradient between 60° N and the pole from 10 hPa upwards (Fig. 24).

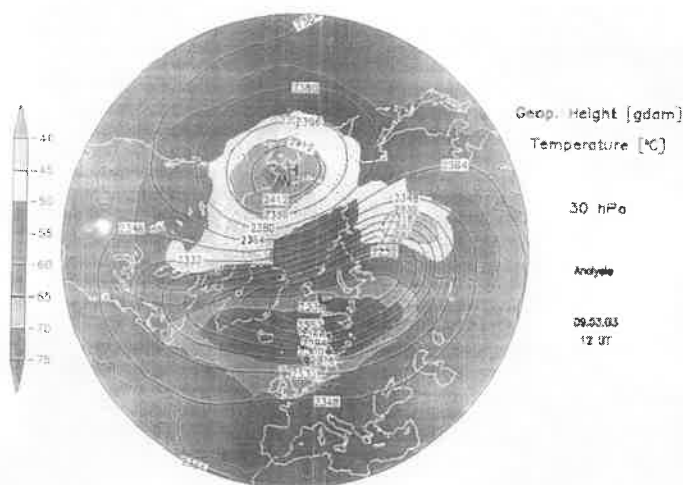


Fig. 24 : 30-hPa geopotential height (gpdm) and temperature (°C) over the northern hemisphere from 30° - 90° N on 9 March 2003

Measurement and Monitoring of Atmospheric Minor Constituents

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

The twilight photometer ($\lambda = 600 \text{ nm}$) and lidar ($\lambda = 532 \text{ nm}$) data collected simultaneously at National MST Radar Facility, Gadanki, during February 2002 were analysed. The observed deviations between the profiles derived by both the techniques were considered to be due to the

difference in probing the wavelength and sensing the area covered by individual techniques.

Daily total columnar densities of NO_2 and O_3 were computed at 90° Solar zenith angle, for the Sub-Arctic Icelandic station, Reykjavik, from the morning / evening data for the period of two consecutive winters of the years 1993-1994 and 1994-1995.

Observations were made for comparison of cloudy sky optical paths and clear sky optical paths for the study of trace gases in cloudy sky. The ring effect contribution was calculated in zenith sky absorption spectra, because the ring effect reduces the apparent depths of the structured molecular absorption region, thereby leading to under estimation in the measured column densities of stratospheric trace gases such as O_3 , NO_2 , H_2O and O_4 etc.

Multiple regression analysis of Total Column Ozone (TCO) for the period 1981-1998 for four Indian stations, New Delhi, Varanasi, Pune and Kodaikanal was carried out. The contributions of QBO in 30 hPa zonal wind and solar cycle to the ozone variations were worked out. The regression model fit and observed ozone showed good agreement with correlation coefficient, 0.6 significant at 99 percent level.

Spatio-temporal variability of TCO was examined with fast Fourier transform and singular spectrum analysis. The results revealed that about 50% TCO variability can be explained by the annual cycle and significant part of the remaining variability is due to QBO and solar cycle. The normalised TCO residual series obtained by filtering the annual, QBO and solar cycle showed decreases of 19, 12, 14 and 10 DU at the end of 1991 at New Delhi, Varanasi, Pune and Kodaikanal respectively, which may be attributed to Mt. Pinatubo volcanic eruption (Fig. 25).

Diurnal and seasonal variations in column NO_2 and O_3

The daily morning and evening twilight total abundance of NO_2 and O_3 was computed from the spectrometric observations carried out during May 2000 - May 2001. The results showed strong seasonal and diurnal variations of NO_2 with maxima in the summer at sunset time and minima in the winter at sunrise. The seasonal pattern was, thus, mainly caused by changing length of the night with season. The seasonal and diurnal patterns were found to be caused by the changing partitioning between NO_2 and N_2O_5 . Ozone was found to have

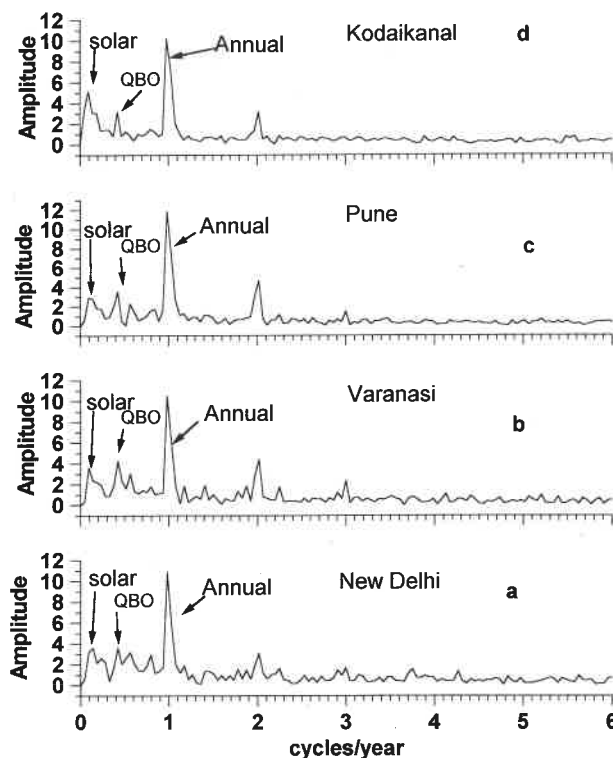


Fig. 25 : FFT of mean monthly total column ozone time series (1981-1998) for a) New Delhi, b) Varanasi, c) Pune and d) Kodaikanal

a strong seasonal variation but weak diurnal variation, maximum in the summer and minimum in the winter.

The total column density of O_3 was derived by different methods using calculated air mass factors from single scattering radiative transfer model, which were in good agreement with Dobson spectrophotometer observations. The variations in daily twilight measurements of NO_2 and O_3 at Pune, ($8^\circ 32'\text{N}$) for the period 4 May 2000- 31 May 2001 revealed that maximum values occur in summer and minimum values in winter, in addition, the sunset values were found to be dominated by photochemistry and reflected the changing positioning between NO_2 and N_2O_5 . Evening NO_2 was observed to be higher than morning due to day time air pollution and photochemical effects.

Twilight photometer observations were made during the Leonid meteor shower on 18 November 2002 and Geminid meteor shower on 12 December 2002. The data were analysed. After the shower period, a peak was observed at about 20-30 km. This feature persisted for a short period and later disappeared. Similar feature was also observed during the Leonid meteor shower of November 2001.

Instruments and Observational Techniques



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

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

Simulation Techniques in Cloud Physics

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

The precipitation scavenging rate for aerosol particles estimated from the computed values showed that the change in the size of the raindrops due to evaporation leads to significant change in the precipitation scavenging rate with height. Results showed that for the rainfall rate of 10 mm/hr and relative humidity 95%, the scavenging of aerosols takes place mainly near the base of the cloud.

The effect of electrical forces on the shape and distortion of water drops was studied in vertical electric fields. The photographic data collected on mass loss of water drops in presence of horizontal and vertical electric fields were analysed.

Surface Observations of Atmospheric Electricity and Electric Properties of Clouds

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

An atmospheric ion counter was designed, fabricated and tested at the Institute for measurements of the small-, intermediate-, and large-ion concentrations. This ion counter has been installed on Sagar Kanya. Measurements of ion concentrations of three categories, atmospheric electric conductivity and electric field were carried out at sea surface over the Arabian Sea. The measurements of size distribution of sub-micron sized aerosol particles and electrical conductivity were also made on an IAF AN-32 aircraft over the Arabian Sea for 35 hours spread over 8 sorties. The vertical profiles of the aerosol particle concentration and size-distributions were also measured between 3000 - 7000 feet perpendicular to and parallel to the coastline of India in two of these sorties. Analysis and study of the data obtained during ARMEX have been taken up with respect to the prevailing meteorological conditions.



Ion counter and conductivity measuring apparatus on board ORV Sagar Kanya during ARMEX

The modal parameters for Aitken and accumulation modes of aerosols measured in different latitudinal belts during the onward and return cruises of Antarctic Expedition and during INDOEX-99 cruise were computed.

Effect of fog on atmospheric electric conductivity and aerosol size distribution was studied by using the data obtained during the 16th Scientific Expedition to Antarctica. The Antarctic data of the atmospheric electric field, conductivity and Maxwell current measured in the summer season of 2000 and 2001 were analysed in collaboration with the scientists from the Indian Institute of Geomagnetism, Colaba.

The atmospheric electric field and Maxwell current density measured below a thundercloud on 3 May 2002 were being analysed to study the behaviour recovery curves of lightning discharges in the storm. Observations showed a dominant role of the lower positive charge centre in initiating and triggering of the intra-cloud and cloud-to-ground discharges.

Use of atmospheric charge density as a tracer of atmospheric mixing and the division of charge between small and large ions were investigated. Attempts to find out eddy diffusion coefficient from the atmospheric electric method were made. Development of a model involving surface electric field, space charge and the aerosol concentration at the surface was under progress.

Whistler triggered emissions recorded at low latitudes were analysed. The characteristic features of very low frequency hiss emissions during quiet and disturbed conditions observed at ground stations and onboard satellites were summarized. The increased intensity of hiss emissions during magnetic storm period can be explained by considering the enhanced flux of energetic electrons during magnetic storm period.



Air Inlet on IAF Aircraft AN - 32 for measurements of sub-micron aerosol particles during ARMEX.

Boundary Layer and Land Surface Processes Studies



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

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

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

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

A study was carried out to determine the minimum scale of the low level wind, represented by LASPEX (Land Surface Processes EXperiment) low level wind observations, which can be treated as the large scale wind representative of the area. For this purpose, the wind components were represented by a trigonometrical function of wavelength and distance from the centre of the four observing stations. The mean divergence values were computed for each wavelength, from the divergence values at each station. The Yanai's method of computing the large scale divergence over the LASPEX area, was used to compute the mean divergences for the same wavelengths. The ratio of the two was above 0.9, greater than 2830 kms, which represented the minimum wavelength that can be treated as being representative of the area. The development of a technique to compute winds and eddy diffusivities at different heights in the Planetary Boundary Layer, from the winds and temperature at heights of 2 m and 4 m respectively was continued. Tests conducted with Wangara data showed encouraging results.

Studying the coupled land-atmosphere system on local scales (e.g. mesoscale or finer) involves proper understanding of land-surface and atmospheric boundary layer (ABL) processes. The LASPEX data set was taken in western India (Gujarat state) which has a semi-arid tropical monsoon climate in a region of agricultural crops. A study carried out using the observations in the contrasting monsoon conditions namely pre-monsoon and monsoon conditions to investigate response of the coupled land-atmosphere system using an interactive land-surface/atmospheric boundary layer model (OSU Coupled ABL Plant Soil, or CAPS model,) helped to assess model performance in a tropical region (agricultural crops in a semi-arid monsoon region). The current model formulation for the canopy conductance has one universal set of vegetation parameters for agricultural crops, regardless of the geographic region. Since the canopy conductance to a large degree determines the surface evaporation (mostly transpiration for surfaces with a large vegetation fraction), a detailed study of the response of the canopy conductance is needed to assess the performance of the current model formulation for canopy conductance (for agricultural crops in the case). Certainly there may be some difference between tropical and extratropical agricultural crops. Judging from the

modelled versus observed latent heat fluxes, the current canopy conductance formulation may be adequate, while during the monsoon conditions it may not, suggesting that the generality of the canopy conductance formulation should be examined further.

Based on the observations of LASPEX, over semi-arid station, Anand (22°24'N, 72°36'E), turbulence parameters collected by fast response sonic anemometer at 10 m height were studied. The drag coefficient (C_D) in different seasons (viz. summer, monsoon and winter) was investigated with respect to wind speed. Fig. 26 (a-d) shows the variation of C_D with the wind speed observed over Anand in different seasons. In all the seasons, C_D was found to decrease with increase in wind speed but showed great variability in magnitude with seasons. This variability in C_D values in different seasons can be attributed to the change in soil wetness (soil moisture) and vegetation parameters which are changing from season to season. High magnitude of C_D corresponding to lower wind speed (< 1 m/s) was

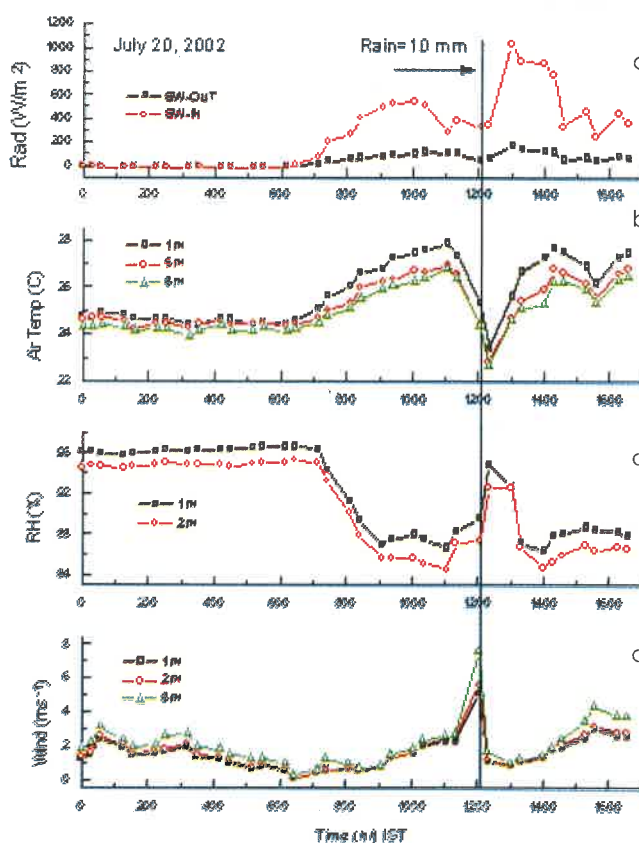


Fig. 26 : Response of meteorological parameters to precipitation (10 mm) on 20 July 2002

observed in all the seasons. Higher values were observed in summer and monsoon seasons. In winter, C_D values were decreased to nearly half. It was also noticed that, the rate of decrease of C_D with increase in wind speed was higher in the low wind speed region (< 2 m/s). But this phenomenon was not observed in winter season. Magnitude of C_D was greater in unstable stratification and low in stable stratification. Despite decrease in C_D with increase in wind speed, temperature increased with increase in wind speed in summer and monsoon season up to 3-5 m/s. But in winter season (Fig 26c), temperature decreased with increase in wind speed right from the beginning up to 5 m/s (highest wind speed recorded).

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

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

Studies on ARMEX

Data collected from sonic anemometer and IR Hygrometer at Goa were processed for estimating the fluxes during ARMEX. Surface fluxes of sensible and latent heat and other turbulent statistics were computed from sonic anemometer and IR Hygrometer data during the period 13-28 July 2002 and found to depict diurnal variation. Similarity hypothesis was tested and found to be obeying. The internal boundary layer (IBL) development over the terrain due to step change in surface roughness was observed to be within 4 m from AGL. Hence the fluxes of heat, momentum and water vapour measured directly by eddy correlation technique at 5 m above the surface represented the values over the coast almost free from local terrain interference which may serve as input for surfaces fluxes in meso-scale modelling.

The slow data measured at 1, 2, 5 and 8 m on the tower showed characteristic diurnal variation. The variation of solar radiation, air temperature, humidity and wind speed is presented in Fig. 27. Precipitation (10 mm) has been observed

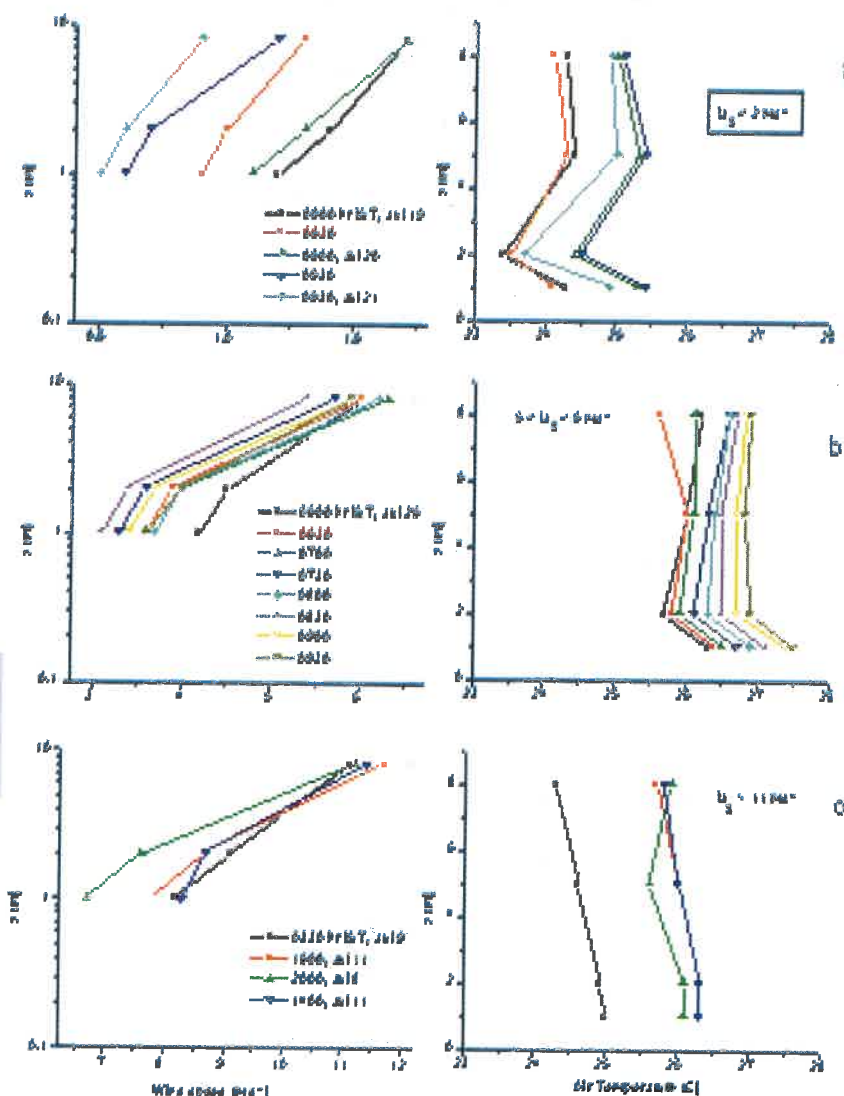


Fig. 27 : Profiles of wind and temperature at 25 m away from the coast at NCAOR, Vasco, Goa

to associate with sudden increase in wind speed at 1200 hrs. Air temperature, relative humidity and solar radiation increased just after precipitation.

The characteristic kinks in the wind profiles were observed when the wind flow was from smooth to rough surface at Goa. A tendency of the kinks in wind profiles to reduce gradually as the wind speed increases from very low (2 m/s), moderate (6-7 m/s) to very high values (>11 m/s) was observed (Fig. 28). This indicated that strong synoptic winds overcome the effect of small-scale irregularities at the surface like roughness change. Air temperature profiles also showed similar kinks at the same height and also the tendency of smoothing with increase in wind speed. However, humidity profile did not show this tendency.

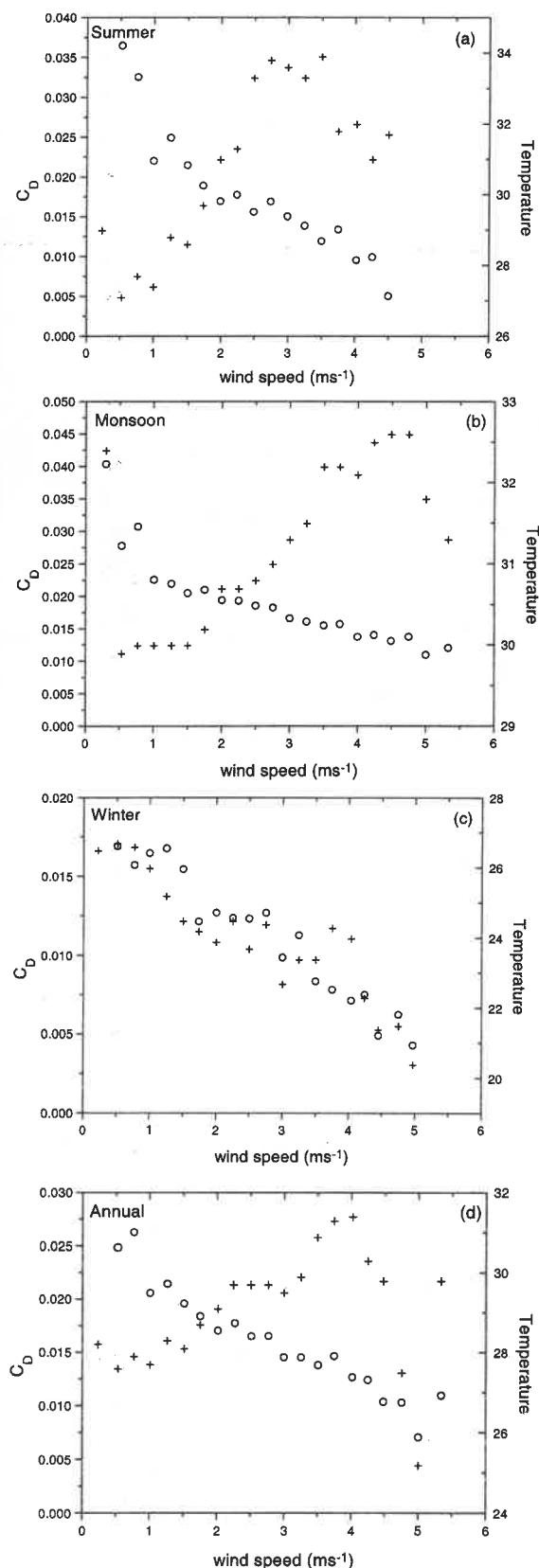


Fig. 28 : Variation of C_D at Anand

Surface ozone studies

Surface ozone (O_3) and incoming solar radiation have been monitored continuously in the Institute's campus. A relationship was seen between surface ozone and solar radiation. The maximum ozone concentration (32 ppbv) occurred around noon hours and minimum (about 10 ppbv) during the sunrise. The winter high O_3 concentration showed that surface temperature inversion may play an important role in controlling the O_3 level in the environment in addition to its precursors. This suggested that there is a need to monitor ABL stability and surface ozone simultaneously to understand the complex behaviour of the O_3 . Preliminary analysis of the coastal O_3 data received from the Tranquebar Bishop Manickam Lutheran (TBML) college, Porayar (Tamil Nadu), for the period May 1997-October 2000 showed low concentration of O_3 (10-35 ppbv) in winter as compared to O_3 observed at Pune (8-49 ppbv) and Ahmedabad (18-60 ppbv) Fig. 29.

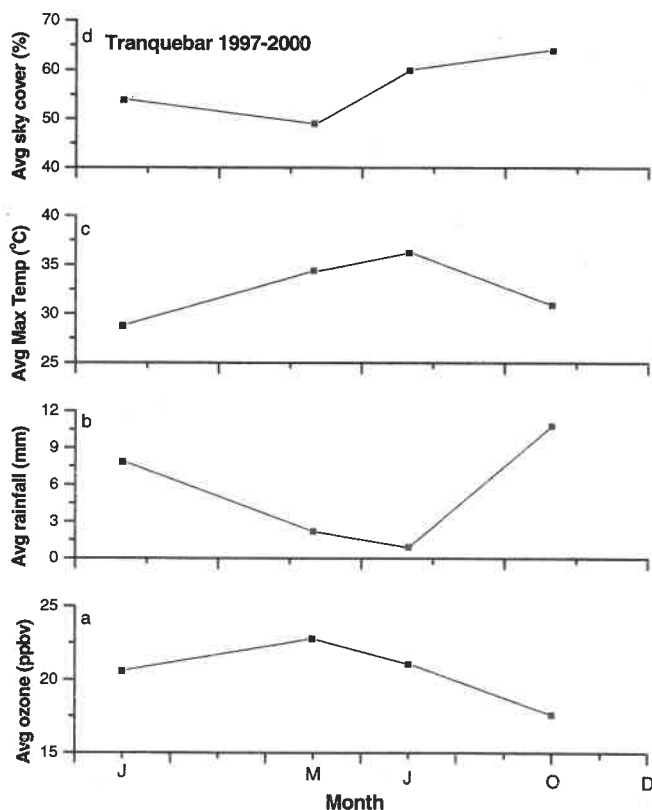


Fig. 29 : Average variation of O_3 for the month of January, May, July and October (a), rainfall (b), maximum surface air temperature (c) and sky cover (d) observed at Tranquebar

Theoretical Studies



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

- ❖ Development of diagnostic models for the study of (i) Regional Energetics in the grid point domain (ii) Tropical belt energetics in the wave number and frequency 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 multi-level 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, C. Gnanaseelan, P. Singh, A.A. Deo, D.W. Ganer,)

Studies carried out using 1½ layer IRG model

1½ layer IRG model simulated surface currents, obtained by using daily NCEP surface forcings were validated over 19 different positions of tropical Indian Ocean viz., over Somali region, west equatorial region, central tropical region, east equatorial region and south Bay of Bengal. For this purpose observations of WOCE (World Ocean Circulation Experiment) from six cruises (Knorr and Meteor Research Vessels) during January to October 1995 were used. The model simulated currents were found to be in qualitative agreement with the observations, but the magnitudes of model currents were 30% to 40% underestimated because the observed currents were at about 25 to 35 meter depth whereas the model simulated currents were the depth averaged upper layer (100 m) currents. This study clearly indicated that model simulated surface currents can be treated as observations in the data sparse region (Fig 30).

Oceanic response to moving cyclone

Best track estimates of the cyclones in the Indian Ocean from JTWC site were downloaded for eight years up to 2002 for both the northern and southern Indian Ocean. The tracks were examined in order to choose the different idealized cyclonic tracks symmetric about the equator in both the hemispheric Indian Ocean. Three different tracks in the north of equator were selected, i.e. northward, westward and northwestward. The mirror images of these tracks in the southern Indian Ocean were considered. The idealized cyclone of radius 400 km was allowed to pass along all these six tracks for 5 days in the separate experiments using IRG model. The upper ocean response in terms of currents, temperature and mixed layer depth was examined. Preliminary analysis showed that the model field had right (left) bias for the north and northwest track in the northern (southern) hemisphere. Also, experiments were carried out to examine the sensitivity of initial latitudinal position. The cooling of the order of 4°C occurred in the wake of the cyclone for the due north moving track having initial position at about 6°N. The magnitude of cooling reduced from 4°C to 2°C as the initial position of

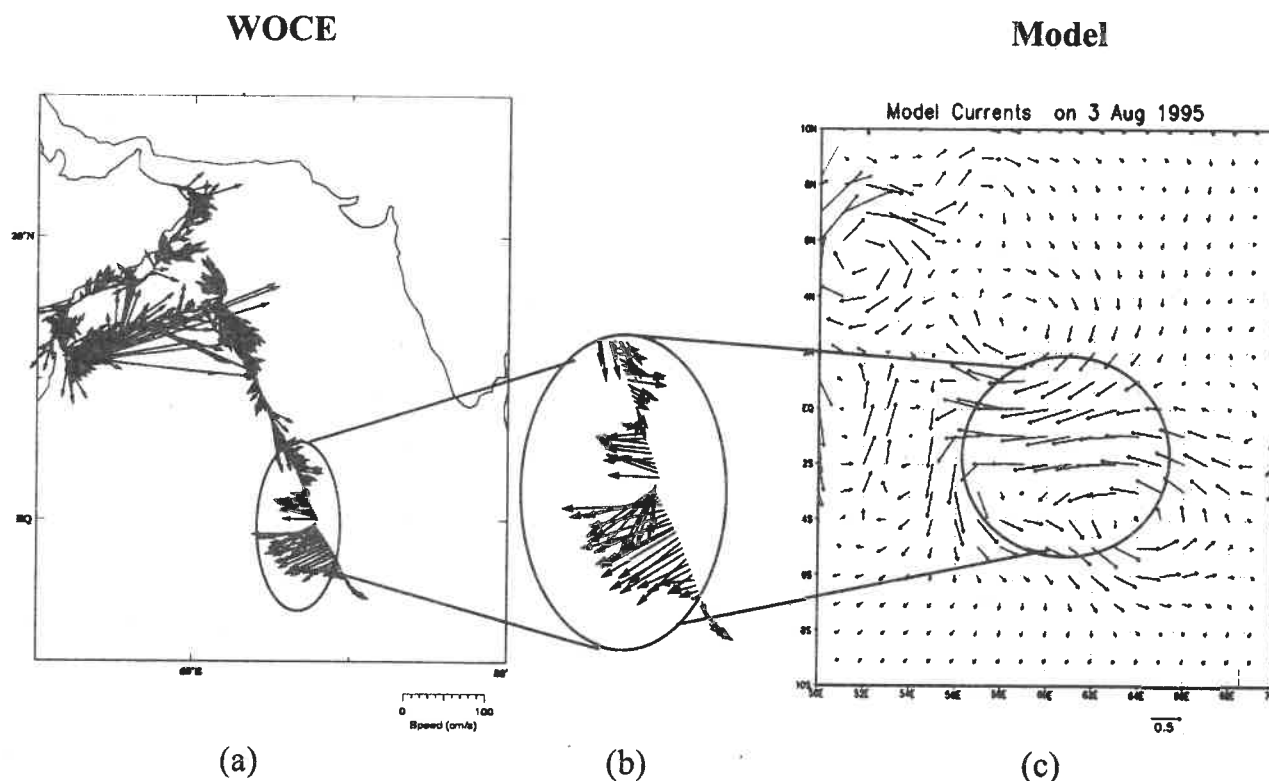


Fig. 30 : Validation of WOCE surface current with the model surface currents a) vector plots of surface circulations (25 m to 35 m) from the WOCE along 50°-80°E, 10°S-30°N during 7th July -26 August 1995 b) a closer view (65°-70°E, Eq-5°N) from 1st to 3rd August 1995 c) the model simulated surface currents along 64°-70°E, Eq-5°N for 3rd August 1995

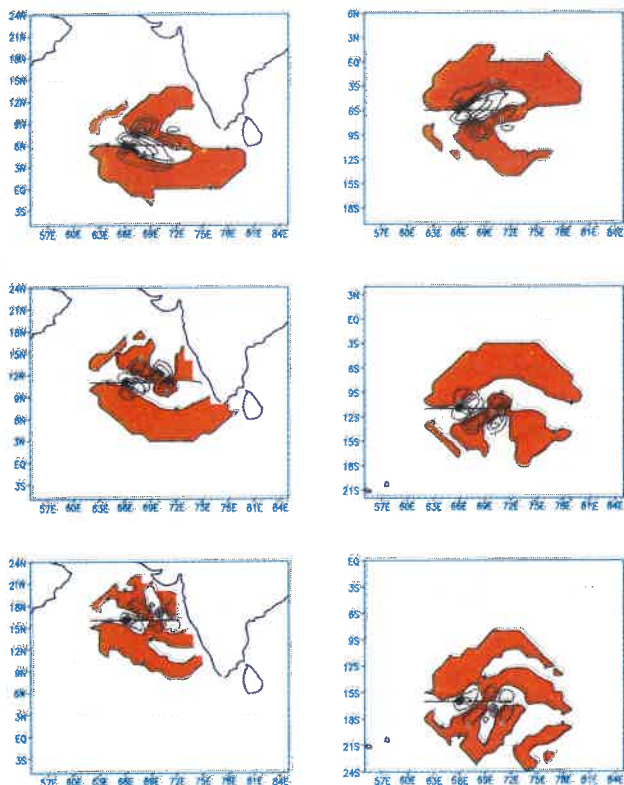


Fig. 31 : Model temperature change for westward moving cyclone along different latitude in NH and SH Indian Ocean

the cyclone changed from 6°N to 16°N (Fig. 31). The magnitude of cooling increased when the cyclone movement contained westward component and the cooling was found to be maximum for due west track. Similar results were seen for the southern hemispheric tracks. Trough and ridge axis of inertia gravity wave as seen from the temperature field was inclined at NW-SE (NE-SW) direction for northern (southern) hemispheric cyclone whereas mixed layer depth showed trough axis exactly along the track in the wake of the cyclone. The temperature anomalies in the wake of the cyclone approach from the NE (SE) direction in the case of northern (southern) hemispheric cyclone. This shows that the mixed layer is cooled more on the right (left) side, but upwelling is exactly symmetric in the wake of the cyclone for northern and southern hemispheric cyclones.

2½ layer Thermodynamic ocean model

A 2½ layer thermodynamic ocean model was integrated further for 5 years from 1 January 1997 to 31 December 2001 using interannually varying daily NCEP surface winds and heat fluxes. Surface

and sub-surface temperature anomalies were examined. The positive Indian Ocean dipole (IOD) event was well simulated in the year 1997. Further detailed analyses of the model results showed that the response of this event was not only confined to the equatorial region but also found in other parts of tropical Indian Ocean. The upwelling coastal Kelvin wave during the IOD events (1994, 1997) influenced the circulation in the Bay of Bengal (Fig. 32). The strong propagating Kelvin wave along the perimeter of the Bay sets up southward currents along the eastern boundary of the Bay and reflected Rossby wave sets northward currents along the western boundary of the Bay forming an anti-cyclonic circulation in the Bay. The sub-surface temperature during the dipole events 1994 and 1997 was also analysed. The sub-surface dipole during 1994 was well simulated by model. However, during 1997, it was to the southward of its surface dipole position. The surface dipole mode was found to be stronger in 1994 than in 1997. The surface and sub-surface dipole were almost of the same order during 1994 but the sub-surface dipole was weak as compared to the surface one in 1997.

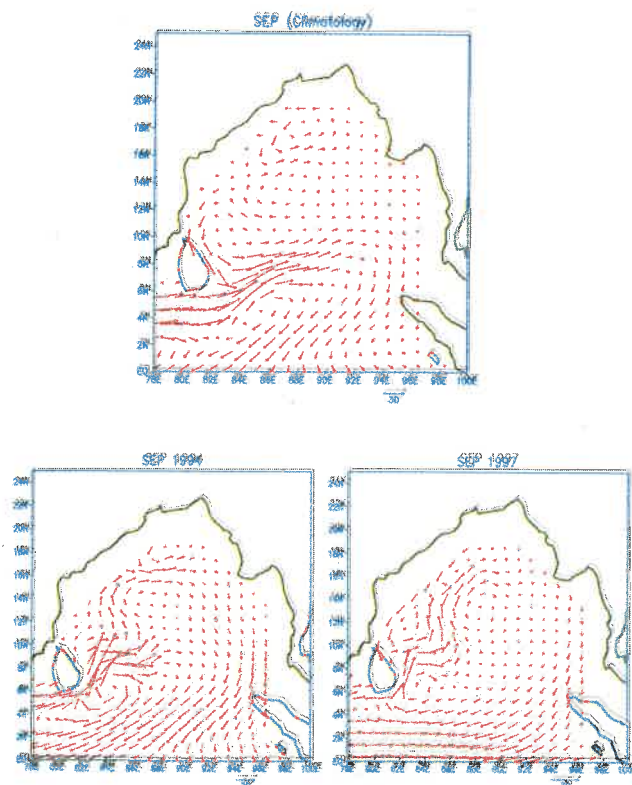


Fig. 32 : Surface circulation in the Bay of Bengal during IOD events

Studies with multilevel ocean model

To understand surface and sub-surface circulation in the Indian Sea and tropical Indian Ocean, the free surface sigma coordinate multilevel ocean model commonly known as POM (Princeton University Ocean Model) was used in the domain (25.5°S - 24.5°N and 35.5° - 99.5°E). The horizontal resolution was 1° lat X 1° long and 21 sigma levels in the vertical. For bottom topography actual bathymetry at the interval of 5 minutes was considered. Input to the model at every grid point was chosen as (i) seven year Climatological Monthly Mean Surface Wind Stress for the year 1980-1986 from ECMWF as surface forcing and (ii) vertical profile of monthly mean temperature and salinity from Levitus climatology as internal forcing.

The model was integrated successfully for 10 years to reach quasi steady state by using semi implicit time integration scheme, with the internal time step of half hour (1800 sec) and external time

step of 1 minute (60 seconds). The model could simulate the mean surface features satisfactorily e.g. reversal of Somali current in summer and winter season, East India Coastal Circulation (EICC) during monsoon season, Seasonal variation of EC (Equatorial Current) and SECC (South Equatorial Counter Current).

Studies using mixed layer models

A two-dimensional mixed layer model developed in-house was used to simulate the mixed layer temperature (MLT) during 1992 - 2001 and interannual variability in the MLT was studied. The simple model could simulate the observed dipole events of 1994 and 1997 reasonably well (Fig. 33). It was found that the cooling observed in the south eastern equatorial Indian Ocean during the dipole years was mainly due to reduced heat flux in the form of latent heat flux, however, the western warming during the dipole years was mainly caused by the wind and latent heat flux anomalies.

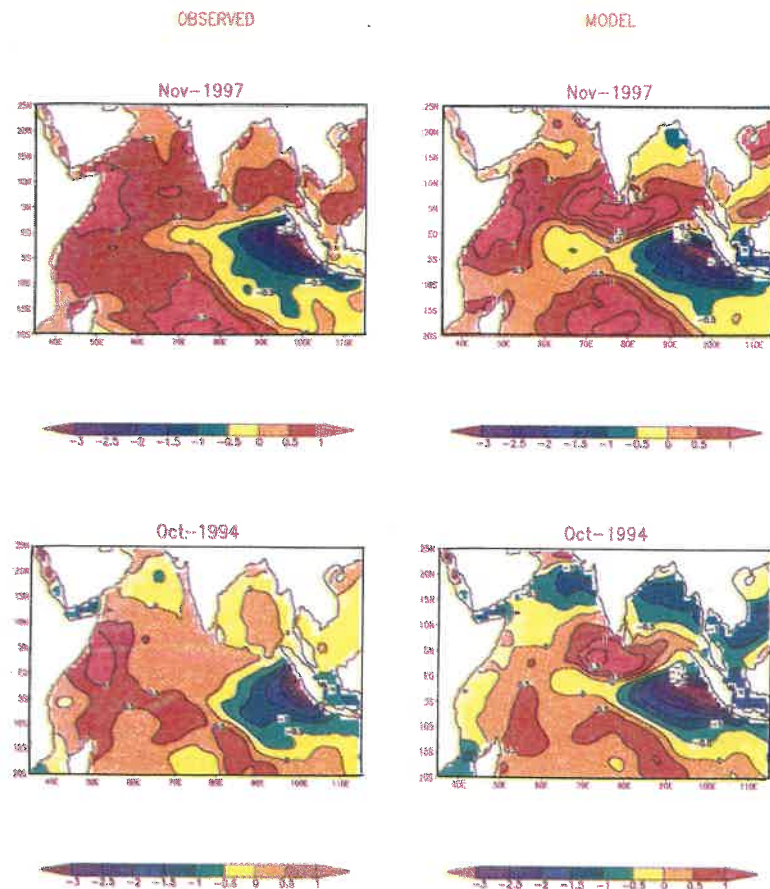


Fig. 33 : Indian Ocean dipole model as simulated by inhouse developed mixed layer model

Two 1-D mixed layer models viz. PWP (Price, Weller and Pinkel) and MY (Mellor and Yamada) were used to simulate the SST and MLD at two locations in the Arabian Sea (15.5° N, 61.5° E during 16 October 1994 - 19 October 1995 and 15.3°N, 69.3°E during 1 February - 31 December 1998). The SST over the region was found to be mainly controlled by the surface net heat flux except during the monsoon season. During the SW monsoon season the SST reduced by 4°C, mainly due to the entrainment cooling caused by wind shear and partly due to advection.

Diagnostic studies over the north Indian Ocean

The North Indian Ocean (20°S - 25°N, 35° - 115°E) monthly surface currents were estimated diagnostically using TOPEX / POSEIDON sea surface height anomalies and NCEP surface winds for the period 1993 - 2000. Observed meso-scale and large-scale features were retained in the computed currents. Climatology of the computed currents for the period 1993 - 2000 was found to be in good agreement with the observed one. Interannual variability in the computed monthly currents was found to be insignificant.

Studies on Atmospheric Energetics in Wave Number and Frequency Domain

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

Regional energetics in the frequency domain

Study based on the mathematical modelling designed earlier to investigate the interactive dynamical and physical processes of seasonal mean monsoon circulation and intraseasonal oscillations (ISO) on Madden Julian time scale associated with rotational and divergent transients during monsoon (June - September 1996) over Indian region (0° - 30° N, 40° - 120° E) through divergent-rotational KE exchanges in the frequency domain revealed that (i) at 850 hPa, seasonal cycle was found to be very much interactive due to the effect of both vorticity and divergence in building up rotational component of transient ISO. The existence of strong rotational 30-40 day oscillation at 850 hPa indicated the presence of the Rossby mode which is highly non divergent. Further, the transient flow was found to be barotropically unstable to rotational transient low frequency disturbances due to divergence over the region 15° - 25° N (Fig. 34) (ii) at 200 hPa the signature of ISO on Madden Julian time scale was captured prominently in the divergent component of the transient flow. The coupling between the divergent component of the seasonal cycle and 30-60 day regional scale ISO was found to be very important for good monsoon over India.

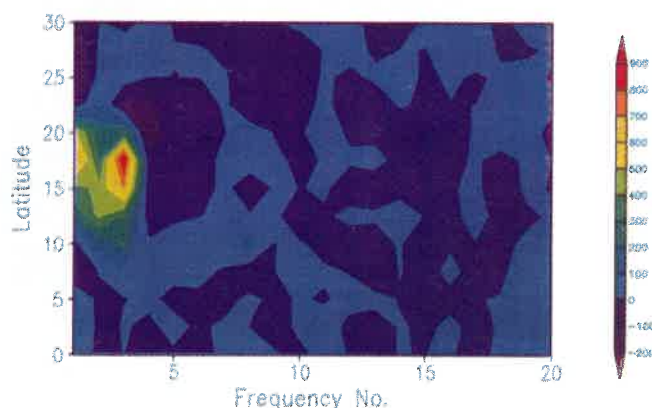


Fig. 34 : A latitude-frequency plot of intrafrequency nonlinear KE exchanges between divergent and rotational flows due to divergence at 850 hPa. Unit : 10^{**7} W/kg

The study was applied to understand the behavior of monsoon 2002 using NCEP/NCAR reanalysis ψ and χ fields. The effect of intra frequency time mean transient interactions on the reduction of energy can be considered as an important dynamical mechanism for bad monsoon year 2002.

Nonlinear error energy budget of medium range tropical weather forecast

In-house developed mathematical model was used to determine nonlinear barotropic forecast error, its systematic and random components of horizontal wind field of NCEP-MRF model at 850 hPa over the tropical belt 30° S - 30° N in the physical and spectral domain. The most significant features of the study of June 2000 up to 5-day forecasts, were that large amount of systematic error appeared on India and adjoining areas within 10° - 20° N latitudinal belt indicating a crucial role played by the cumulus parameterization process in the generation of tropical systematic error. Random error was mainly generated due to the sparse observational networks over tropical region showing large error in both the continental and oceanic area (Fig. 35). In spectral domain, systematic error was associated with wave numbers 1 and 2 whereas the random error was found to be associated with higher spectral band of wave numbers 4-7. The study was extended for consecutive winter (DJF, 2000-2001) and summer (JJA, 2001) months for 7-days forecasts. It was found that in the physical domain, the forecast error and its systematic and random components in winter appeared in larger magnitude with their bias in southern hemisphere in comparison to their summer counterparts. Winter and summer systematic error variance exhibited clearly the shifting of maximum error band from south to north of the equator in accordance with the seasonal oscillation of ITCZ. In the wave number distribution, for both winter and summer seasons, systematic error showed the largest spectrum at wave number 1 for maximum number of forecast days, whereas random error accumulated at the wave number band 3-7.

Grid point energetics in the regional domain

To study the impact of different cumulus parameterisation schemes on the simulation of a depression formed in the Bay of Bengal during 9-12 November 2001, MM5 model was integrated with four different schemes viz., Grell, Kain-Fritsch, Betts-Miller and Anthes Kuo. Model simulated winds and temperature from surface to 200 hPa over the region (equator- 25° N, 65° - 95° E) at 50 km horizontal resolution were used to analyse four dimensional energetics (zonal and eddy energies, their conversions, generation and dissipation) of the system. Results showed that the Betts-Miller and Kain-Fritsch, schemes generated more convective heating as compared to the analysis. The Grell scheme was able to produce the energies comparable to the analysis. The energy conversions of all the schemes showed that the baroclinic mechanism is responsible for the maintenance of the disturbance.

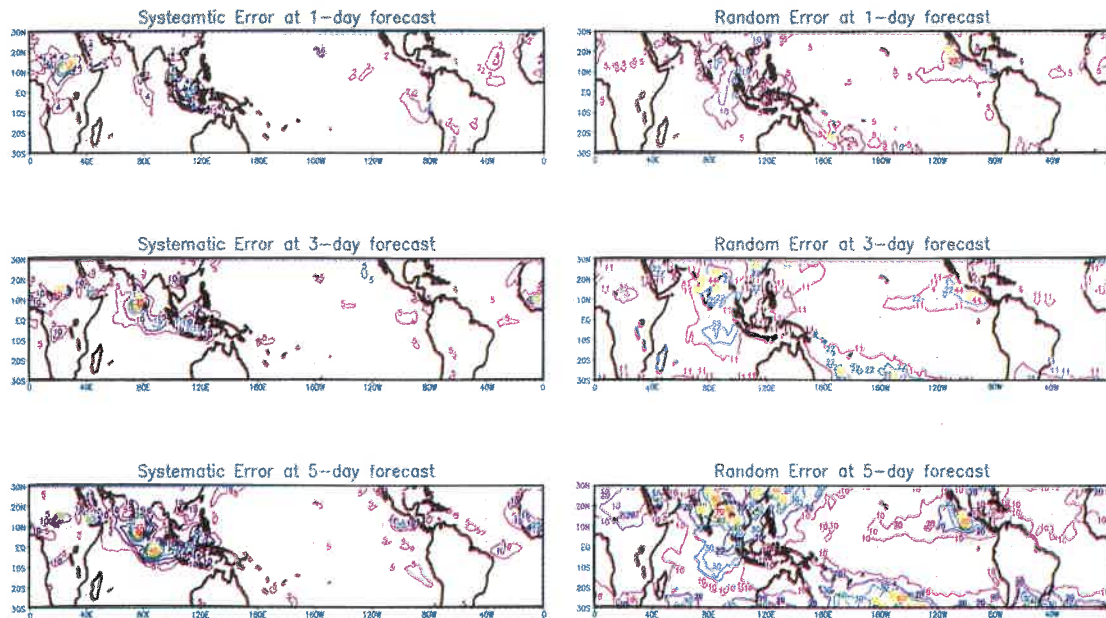


Fig. 35 : Spatial distribution of systematic and random error variance of 850 hPa wind for June 2000 of NCEP (MRF) model in $m^2/sec.^2$ different forecast times

Global energetics in spectral domain

The nonlinear exchanges of global lower tropospheric (LT), upper tropospheric (UT) and lower stratospheric (LS) kinetic energy (KE), enstrophy (ENE) and available potential energy (AE) among two-dimensional waves ($n = 1$ to 30) during June and July months of 1988, 1990 and 1991 were examined. The main findings were (i) the magnitude of transient nonlinear exchanges is higher by one order than the stationary exchanges. Further, the tropospheric exchanges are more by an order of magnitude than the stratospheric exchanges, (ii) maximum stationary KE and AE transfer is by wave number 2 in the LT and UT with negligible transfer at truncation value $n = 30$. The enstrophy transfer, however, is minimum at $n = 2$ and maximum at $n = 30$, (iii) the lower and upper

transient waves in the regime $11 < n < 23$ transfer KE and ENE to remaining waves with more KE (less ENE) going to smaller scales ($24 \leq n \leq 30$) and (iv) the transient wave with $n=2$ seems to be the source of AE to waves $3 < n < 20$ in LT and UT (Fig. 36).

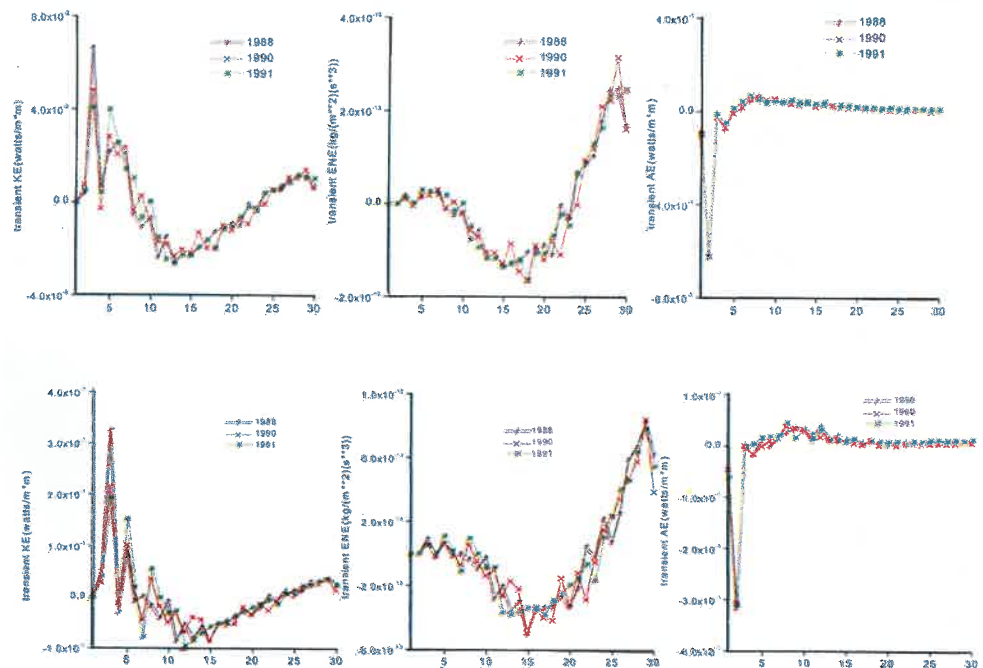


Fig. 36 : Wave-wave interaction against two-dimensional wave number (n) for June and July. Lower troposphere (top), Upper troposphere (bottom)

Air sea interaction

The study concerned with the parameterization and estimation of air-sea fluxes of heat, moisture and momentum in the frequency domain considering the temporal variability of stability dependent exchange coefficient for the development of MJO suggested that the high frequency transients from the extra-tropics associated with wind field propagating and coming down to the Indian and tropical Pacific Oceans interact nonlinearly with the synoptic scale disturbances arising out of tropical instability and MJO signal in moisture already built up through enhanced SST from surface layer physics for further strengthening of MJO in latent heat flux at the top of planetary boundary layer.

Human Resource Development and Training Programme in Atmospheric Sciences

(L. George, P.S. Salvekar, Prem Singh, C. Gnanaseelan, A.A. Deo)

Keeping in view the highly specialized nature of atmospheric research, the Institute has signed an Memorandum of Understanding (MoU) with the University of Pune, to develop human resources. The Theoretical Studies Division has been actively involved in conducting M. Tech. (Atmospheric Physics) degree course of the University of Pune in collaboration with its Department of Physics. During the year, facilities for internship and research guidance were provided to the students of 14th batch and about 200 lectures were delivered to the students of the 15th batch by the scientists of the Institute.



M. Tech. (Atmospheric Physics) Course conducted at the Institute

CLIMATE AND GLOBAL MODELLING



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

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

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)

Numerical Simulation of Monsoon - 2002

In order to study the monsoon drought during 2002, hindcast experiments were conducted using two atmospheric general circulation models (AGCMs), viz., a global spectral model (COLA T30L18) and a grid-point model (HadAM2b). Both the models were forced with observed SST boundary conditions. An ensemble of integrations was carried out starting from different initial conditions using the two models. The COLA GCM simulation showed a major weakening of the monsoon circulation and rainfall reduction during the summer 2002. In particular, the rainfall decrease associated with the prolonged monsoon break condition in July 2002 was brought out well in the COLA GCM simulation (Fig. 37). The model simulation showed large anomaly patterns over the tropical Indian and Pacific Oceans. The HadAM2b GCM indicated a decrease in monsoon rainfall mainly over peninsular India.

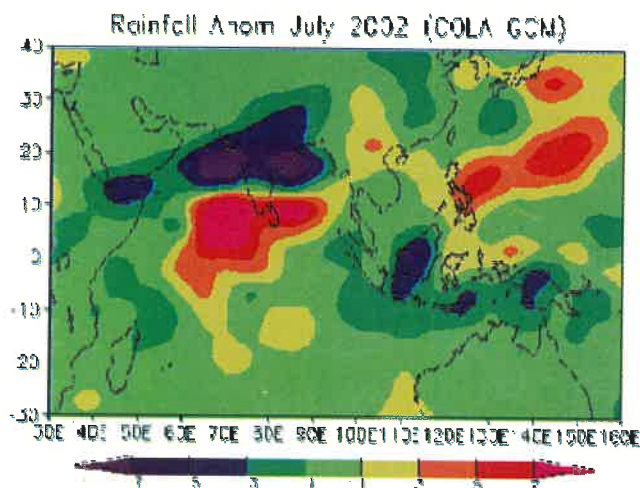


Fig. 37 : The spatial distribution of monsoon rainfall anomaly for July 2002, simulated by the global spectral AGCM. The rainfall anomalies are expressed in mm / day. The negative anomalies over central and northern India correspond to a significant decrease in the monsoon precipitation during July 2002

Dynamical seasonal prediction of Monsoon - 2002

As a part of the long range forecasting activity, the COLA and HadAM2b AGCMs were used to obtain experimental predictions for the monsoon season of 2002. The model integrations were carried out with observed SST anomalies of 2002 superposed

on the monthly climatological SST. In the first set of ensemble experiments, the SST anomalies of April 2002 were superposed on the climatological SST and persisted all through the seasonal (June-September) integration. There were six realisations in the ensemble integrations. The six member integrations were initiated from six different observed atmospheric initial conditions corresponding to 1-6 May 2002 derived from the NCEP reanalysis. This experiment indicated normal summer monsoon rainfall over India for 2002. The ensemble mean precipitation averaged over the Indian monsoon region (5°-30°N, 60°-95°E) simulated by the COLA model for the period June-September 2002 was found to exceed the model climatological rainfall by about +5.9%. The monsoon rainfall simulated by the HadAM2b GCM showed a positive departure of +6.5% from normal.

The SST boundary condition for the second set of ensemble experiments was based on the anomalies of May 2002 superposed on the climatological SST. Similar to the first experiment, the second set also included six member ensemble integrations starting from 26-31 May 2002 respectively. The six member ensemble mean percentage departure of the area averaged rainfall for 2002 summer monsoon season was found to be -14.2% in the COLA GCM simulation.

Climate Modelling Studies including Parallel Processing Techniques

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

Wind stress curl variability over Indian Ocean region

In order to simulate the atmospheric variability on the time scales of a month and longer period, AGCMs are required to be coupled with the ocean general circulation models (OGCMs). The surface wind stress is one of the important components in the coupling of the two systems. In the earlier studies, detailed analyses of wind stresses simulated by COLA and NCEP AGCMs were carried out. The study had been extended to the analysis of wind stress curl distribution. The wind-stress-curl is a major forcing component of the vertically integrated mass transport of the mean ocean circulation. Mean monthly variation of wind-stress-curl over the Indian region was studied by using COLA simulated and NCEP produced monthly data for the period 1982-1994. The distribution of mean wind-stress-curl values showed that during the winter months (December, January, February,) negative values were observed over north, west Arabian Sea, north Bay of Bengal and Indian Ocean south of 10°S. The

positive values were observed over south Arabian Sea, Bay of Bengal and equatorial Indian Ocean. During the pre-monsoon months (March, April, May) the area covered by positive curl values reduced considerably. During the monsoon season, there was reversal in the distribution of curl values compared to the distribution in the winter season. Large negative values were observed over south Arabian Sea and equatorial Indian Ocean. During the post monsoon month, low values of curl were observed over the Arabian Sea, Bay of Bengal and Indian Ocean. Monthly wind-stress-curl distribution simulated by COLA AGCM has been found to agree with the NCEP produced distribution.

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)

43-year numerical simulation of a global ocean GCM

A 43-year long (1958-2000) integration of a global OGCM was performed by forcing the model with observed surface wind-stress and heat-fluxes.

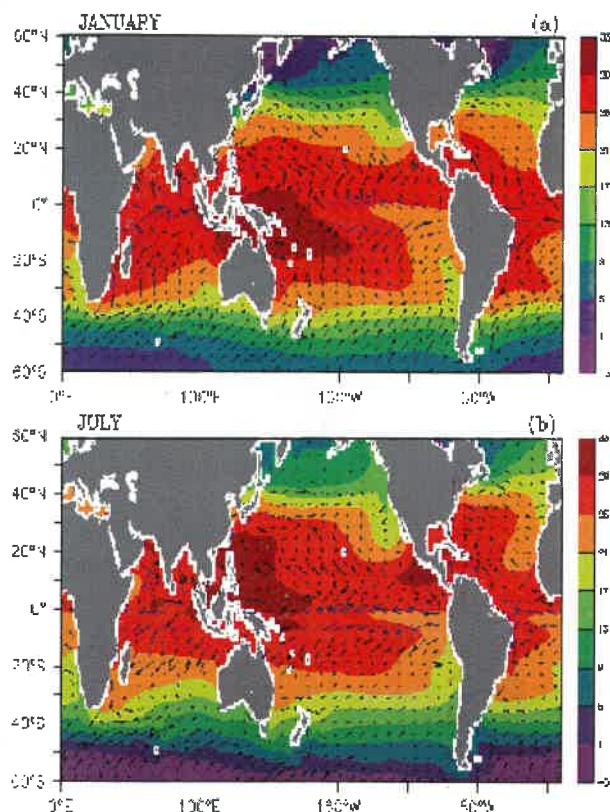


Fig. 38 : Time-mean (1958-2000) SST ($^{\circ}\text{C}$) and surface currents (cm/s) simulated by the global OGCM (a) January (b) July

Analysis of the OGCM simulation showed that several features of the time-mean oceanic circulation were captured well by the model. The mean SST and surface currents simulated by the OGCM are shown in fig. 38. In addition, the observed interannual variability in the tropical oceans was found to be simulated quite realistically by the OGCM. The major El Nino and La Nina events in the 43-year model simulation are shown in fig. 39. Further, the life cycle of the El Nino / Southern Oscillation (ENSO) evolution simulated by the OGCM was found to resemble with that of the observed ENSO.

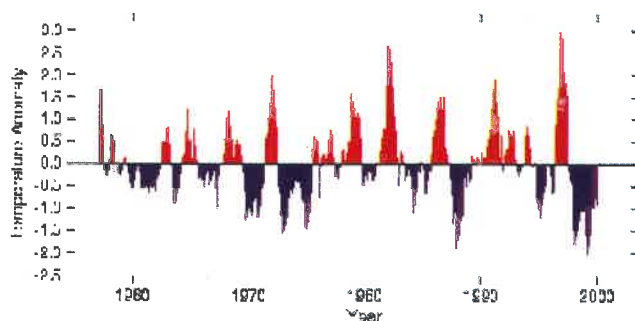


Fig. 39 : Time series of SST variations in NINO3.4 (170° - 120°W - 5°S - 5°N) region simulated by OGCM. The red (blue) peaks (troughs) correspond to major El Nino (La Nina) events during 1958-2000

Pacific Decadal Oscillation and its relationship with the Indian Monsoon

Recent studies have furnished evidence for ENSO-like interdecadal variability in the tropical Pacific Ocean. The importance of this phenomenon in causing persistent anomalies over different regions of the globe has drawn considerable attention in view of its relevance in climate assessment. This study examines multi-source climate records and shows the influence of the Pacific decadal variability on the Indian summer monsoon. The findings indicated a coherent inverse relationship between the decadal fluctuations of Pacific Ocean sea surface temperature and Indian monsoon rainfall during the last century. The Indian monsoon was found to be more vulnerable to drought situations, when El Nino events occur during warm phases of the Pacific interdecadal variability. Conversely, wet monsoons are more likely to prevail when La Nina events coincide during cold phases of the Pacific interdecadal variability.

Decadal variability of storm frequency over Bay of Bengal

Examination of decadal variability of storm frequency and SST over Bay of Bengal during monsoon season by using data for the period 1958-1998 revealed that the storm frequency has

decreased since 1980s in spite of increasing SSTs. An attempt has been made to study if such a decrease in storm frequency is reflected in atmospheric circulation changes over Bay of Bengal on decadal scale. Using monthly mean NCEP/NCAR reanalysis data for the period 1958-1998, the decadal variation of SST, relative vorticity at 850 hPa, horizontal and vertical shear of zonal wind averaged over Bay of Bengal during monsoon season were studied. The anomalies of these parameters were found to be of opposite signs for the period prior to and after 1980. Latitude-time section of 11-year running mean of u and v at 850 hPa averaged over 80° - 100° E during the monsoon season are shown in fig. 40a and 40b respectively. These figures show that the u and v at 850 hPa in the monsoon season decreased over latitudinal belt from 9° N to 30° N from 1980 onwards. Zone of strong westerly winds in the lower troposphere was found to be associated with active monsoon conditions over India. The same figure shows that the zone of strong winds also became weaker in epoch 2 (1981-1998) compared to epoch 1 (1958-1980). Fig. 40 c and 40d show the temporal changes of anomalies of u and v components of wind at 850 hPa. The anomalies were remarkably positive during epoch1 while negative during epoch 2 and reflected the decrease of u and v , noticed in fig. 40a and 40b, suggesting that the monsoon circulation on decadal scale became weak in the lower and middle troposphere.

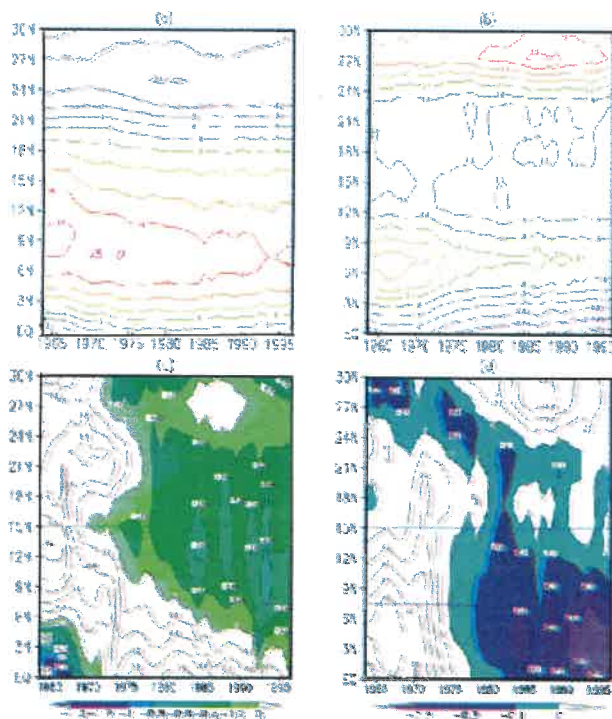


Fig. 40 : 11-year running mean of wind at 850 hPa (a) u wind (b) v wind (c) Anomaly of u wind (d) Anomaly of v wind.

Results suggested that the changes in all the atmospheric parameters from epoch 1 to epoch 2 are related to decreasing storm frequency inspite of favourable SSTs.

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

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

Empirical seasonal prediction of the Indian monsoon

Prediction model for ISMR was developed. Additionally, the changing ENSO-monsoon relationship in recent years was discussed and an attempt made to understand whether these changes are due to decadal and longer term natural climate variability or due to longer term trends related to anthropogenic- induced global warming climate changes.

A methodology has been presented for making optimal use of global sea surface temperatures (SST) for long lead prediction of ISMR. The first step was to identify regions of which seasonal SST anomalies or tendencies in anomalies are significantly correlated with ISMR and in the next step to select best among them. The lag was considered from one season (3 months) prior to the start of monsoon season up to five years. Using two principal components of the selected 18 predictors (hot spots of the global oceans) (Fig.41), multiple

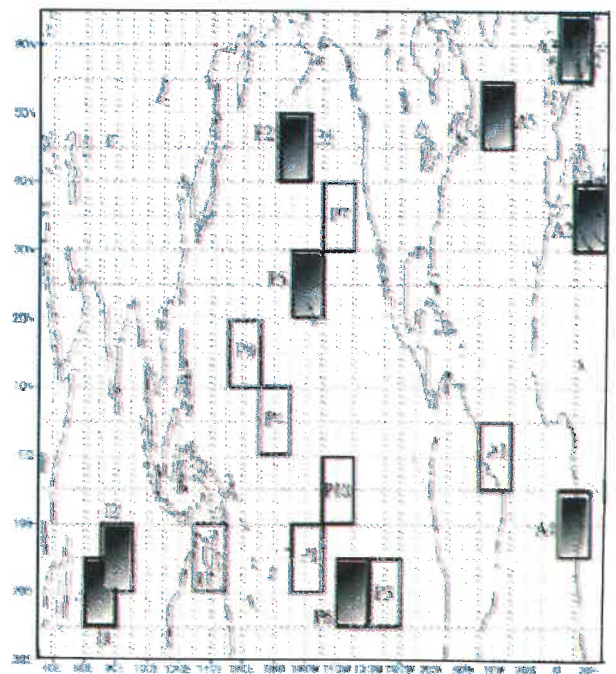


Fig. 41. : Location of 18 hot-spots of global ocean.

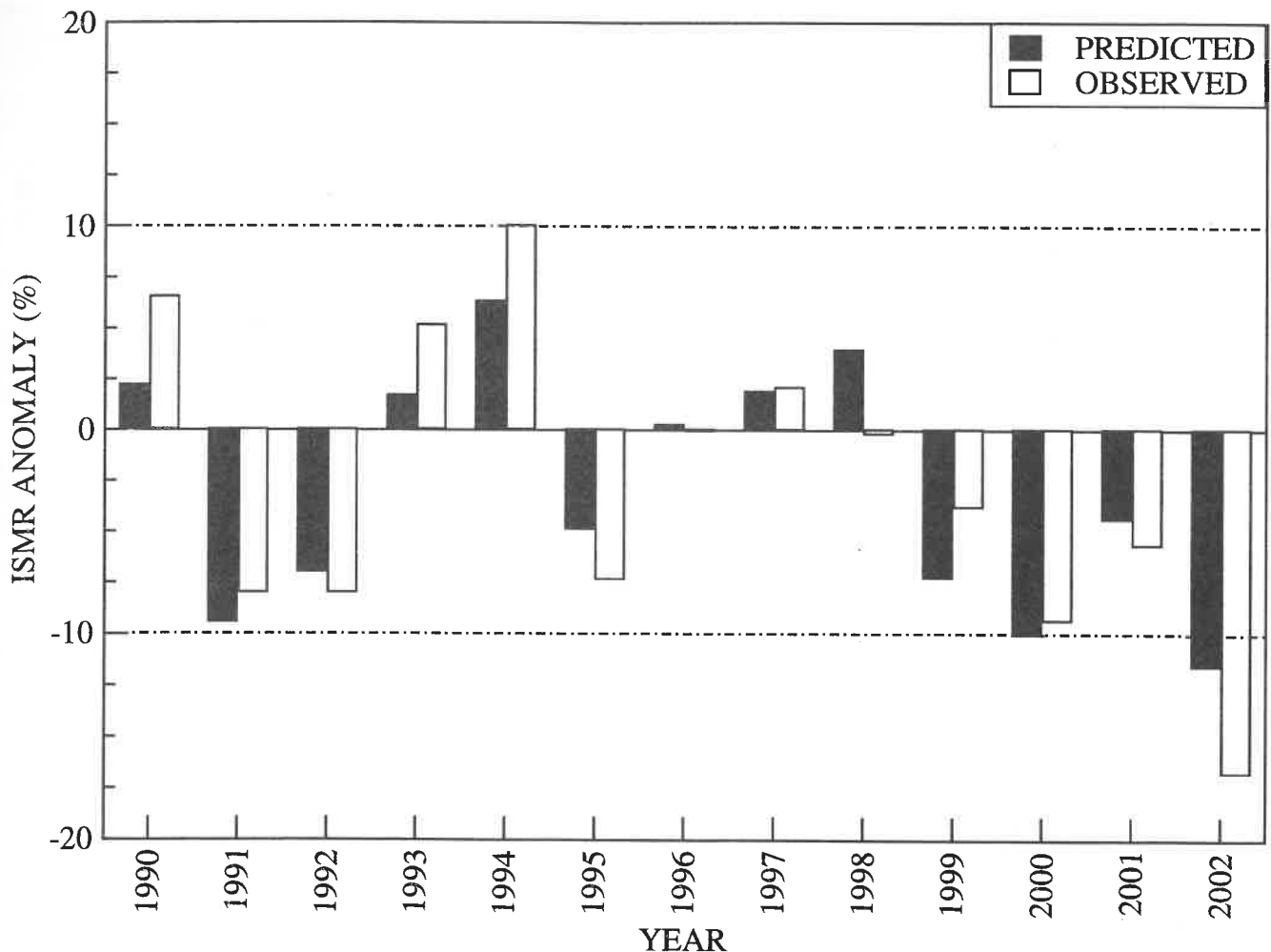


Fig. 42 : Predicted and observed ISMR anomalies for the model verification period, when regression equation was derived using previous 25 years and prediction is done one year in future. The prediction in this case is done using first two principal components of 18 selected predictors.

regression model was developed for each 25-year running window and prediction was done for one year forward (Fig. 42). The prediction for ISMR 2002 was obtained as 89% of long-term mean. To achieve further long lead in the forecast, lag from three seasons (9 months) prior to ISMR season up to four years was considered. Using 14 selected predictors, it has been shown that such a long-lead forecast is possible from SST anomalies, and the forecast for ISMR 2002 was obtained as 102%. The observed ISMR was 81%. Thus, the 3-month lead forecast was close to the observed one, and the 9 month long lead forecast was not good.

In a different study, three indices over different regions of the globe viz., at the surface, middle and upper tropospheric levels of the atmosphere were used in the neural network model to predict ISMR

for the period of 43 years (1958-2000). The indices used were i) an upper tropospheric index represented by the 200 hPa geo-potential height over the Asian land mass during May, ii) a middle tropospheric index represented by the 500 hPa geo-potential height over the Caribbean region during May, and iii) a surface index represented by the tendency of the SOI (March to May - December to February). The climate shift around 1976, observed by various researchers, is evident in the relationship between predictors and ISMR. In order to know whether the improvement in prediction is due to the new predictors or due to the ANN model, the results of the ANN prediction model were compared with the multiple regression model. The achievement of skilful prediction of ISMR was found to be due to the new predictors as well as to the ANN.

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. | 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 | 1997-2003 | 34.25 | Department of Ocean Development, Govt. of India |
| 2. | Simulation of Surface Wind Stress on using Monthly and Seasonal Time Scales Coupled Atmospheric Ocean Model (CAOM) to Provide Forcing for Driving an Ocean General Circulation Model (OGCM) | Dr. V. Satyan | 1998-2003 | 34.25 | Department of Ocean Development, Govt. of India |
| 3. | Numerical Modelling of the Dynamics of North Indian Ocean Circulation | Dr. (Smt.) P.S. Salvekar | 1999-2003 | 8.25 | Space Application Centre |
| 4. | 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 |
| 5. | 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) |
| 6. | Differential Absorption Lidar Sensing of Ozone | Dr. P.C.S. Devara | 2000-2003 | 29.94 | Department of Science and Technology, Govt. of India |
| 7. | 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 |
| 8. | 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 |
| 9. | 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 |
| 10. | National Information Facility for Climate Research | Smt. A.A. Shiralkar | 2000-2003 | 4.24 | Department of Science and Technology, Govt. of India |

| Sr. No. | Title | Principal Investigator | Period | Grant (Rs. in lakhs) | Funding Department |
|---------|--|------------------------|-----------|----------------------|--|
| 11. | 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 |
| 12. | Investigation of Features of Monsoon Depressions and Tropical Cyclones by IRS-P4 MSMR Data | Dr. P.N. Mahajan | 2001-2003 | 5.50 | Space Application Centre (ISRO) |
| 13. | 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) |
| 14. | 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 |
| 15. | Impact of Climate Change on Water Resources | Dr. G.B. Pant | 2001-2004 | 29.50 | Ministry of Environment & Forests, Govt. of India/ Dept. of Environment, Food and Rural Affairs, Govt. of U.K. |
| 16. | Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change | Dr. K. Rupa Kumar | 2001-2004 | 6.20 | Indo-French Centre |
| 17. | Mesoscale Modelling for Monsoon Related Predictions (NMITLI Project) | Dr. S.S. Singh | 2001-2004 | 26.25 | Council for Scientific and Industrial Research |
| 18. | Studies of Mesoscale System over Indian Region | Smt. S.S. Vaidya | 2001-2004 | 15.32 | Department of Science and Technology, Govt. of India |
| 19. | 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 |
| 20. | Heat Sources over India during South-West Monsoon Season | Smt. U.V. Bhide | 2001-2004 | 4.23 | Department of Science and Technology, Govt. of India |
| 21. | Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber / Frequency Domain | Shri D.R. Chakraborty | 2001-2004 | 6.99 | Department of Science and Technology, Govt. of India |
| 22. | 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 |

| Sr. No. | Title | Principal Investigator | Period | Grant (Rs. in lakhs) | Funding Department |
|---------|---|------------------------|-----------|----------------------|--|
| 23. | Indian Climate Change Scenario for Impact Assessment | Dr. K. Rupa Kumar | 2001-2004 | 48.50 | Min. of Environment and Forests, Govt. of India / Department of Environment, Food and Rural Affairs, Govt. of U.K. |
| 24. | Atlas of Spatial Features of Moisture Regimes and Rainfall of India during 19 th and 20 th Centuries | Dr. N. Singh | 2001-2004 | 20.71 | Department of Science and Technology, Govt. of India |
| 25. | 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) |
| 26. | 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 |
| 27. | 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 |
| 28. | 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 |
| 29. | Instrumentation for Atmospheric Boundary Layer Studies | Shri K.G. Vernekar | 2001-2004 | 3.02 | Department of Science and Technology, Govt. of India |
| 30. | 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 |
| 31. | ENSO-Snow-Monsoon Interactions: Understanding and Predicting Monsoon Variability | Dr. R.H. Kripalani | 2002-2003 | 7.38 | Department of Science and Technology, Government of India |
| 32. | Dendroglaciological Studies of High Altitude Glacier Sites of Western Himalaya | Dr. H.P. Borgaonkar | 2002-2004 | 4.92 | Snow and Avalanche Study Establishment |
| 33. | Composition of Acid Deposition (CAD) | Dr. P.S.P. Rao | 2002-2004 | 0.90 | Department of Meteorology, Stockholm University, Sweden |
| 34. | Comparison of Aerosol Vertical Profiles Derived by Twilight Photometer and Lidar | Smt. B. Padmakumari | 2002-2004 | -- | National MST Radar Facility |

| Sr. No. | Title | Principal Investigator | Period | Grant (Rs. in lakhs) | Funding Department |
|---------|---|------------------------------|-----------|----------------------|--|
| 35. | Measurement of Micro-meteorological Parameters over a Coastal Station and the Atmospheric Constituents and Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment | Dr. S. SivaramaKrishnan | 2002-2004 | 21.31 | Department of Science and Technology, Govt. of India |
| 36. | Establishment of wind profiler data archival and utilization centre at IITM for wind profiler / Radio Acoustic sounding system | Dr. G. B. Pant | 2002-2005 | 22.43 | Department of Science and Technology, Govt. of India |
| 37. | 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 |
| 38. | 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 |
| 39. | Air-Sea Interactions in the Indian Ocean Region (DOD/INDOMOD 10 th Plan Programme) | Dr. R. Krishnan | 2002-2007 | 106.80 | Department of Ocean Development, Govt. of India |
| 40. | Data Assimilative Sigma Coordinate Numerical Model for the North Indian Ocean (DOD/INDOMOD 10 th Plan Programme) | Dr. C. Gnanaseelan | 2002-2007 | 41.75 | Department of Ocean Development, Govt. of India |
| 41. | Acid Rain and Atmospheric Pollutants Modelling | Dr. G. Beig | 2003 | 6.15 | Ministry of Environment and Forest, Government of India. |
| 42. | Influence of columnar Aerosol, Ozone and Water Vapour on the Evolution of Warm Pool over the Southern Arabian Sea | Dr. P.E. Raj | 2003-2004 | 10.08 | Department of Science and Technology, Govt. of India |
| 43. | Monitoring of Pollutant Species in Rain Water / Dust Fall in Different Environments around the National Capital Region of Delhi | Dr. S.Tiwari | 2003-2005 | 11.16 | Department of Science and Technology, Govt. of India |

Other Special Events and Activities

Foundation Day

The Institute celebrated its 41st Foundation Day on 17 November 2002 at its premises at Pashan. Dr. P.K. Das, Former Director General of Meteorology was the Chief Guest and Dr. R.R. Kelkar, Director General of Meteorology was the Chairman of the function. The function included presentation of Annual IITM Silver Jubilee Award for the scientific research paper, the Excellent Performance Awards specially established by the Institute for its Administrative, Technical and Non-Technical Maintenance staff, and the Annual Sports Awards to the employees and release of a book entitled, 'Advances in Atmospheric Chemistry'. The Silver Jubilee Award lecture and the Vasundhara Trust sponsored programme on Children's Science Movement were also arranged on this occasion. Under this programme a lecture on 'Monsoon' by Dr. R.R. Kelkar and prize distribution for the winners of the Essay Competition on 'Monsoon' arranged by the Vasundhara Trust for Students were organized. In addition to the main function, an exhibition was arranged on scientific activities and important events of the Institute. Heads of various local Institutions, important dignitaries and ex-employees of the Institute participated in the function. The function was concluded by a cultural programme in the evening.

Participation in International and National Programmes

By considering the increasing scientific evidence of human interference with the climate system coupled with growing public concern over global environmental issues the Institute has undertaken several research programmes relating to Climate Change and allied topics. The Institute has been participating in various international programmes such as Intergovernmental Programmes of Climate Change (IPCC), Climate Variability and Predictability (CLIVAR), World Climate Research Programme (WCRP), International Geosphere Biosphere Programme (IGBP), United Nations Framework Convention on Climate Change (UNFCCC), etc. The Institute has been part of several collaborative research programmes such as Indo-UK programme on impact of climate change on water resources, Indo-France programme for the study of sensitivity of the Indian summer monsoon to anthropogenic climate change, Indo-US (DST-NSF) projects on aerosols

studies, Asia-Pacific Network (APN) for global change research etc. Institute's scientists have attended meetings, workshops, conferences and contributed their research findings to these programmes. The Institute has also been part of many national research and observational programmes such as Indian Climate Research Programme (ICRP) of the Department of Science and Technology, Indian Ocean Modelling (INDOMOD) programme of the Department of Ocean Development, IRSP4 Applications programme of the Indian Space Research Organisation, Environmental Information System (ENVIS) of Ministry of Environment and Forests, Climate Change projects of the Tata Energy Resources Institute (TERI) etc. Considering the dynamic role of the atmospheric aerosols and trace gases in the earth's climate system, the Institute has participated in multi-organisational field observational programmes. The recent ones are the Indian Ocean Expedition (INDOEX), Bay of Bengal Monsoon Experiment (BOBMEX) and Arabian Sea Monsoon Experiment (ARMEX). Observations on aerosols, trace gases, electrical conductivity and meteorological parameters have been made in different environmental conditions such as on board research vessels during cruise, coastal and high latitudinal stations and forests, and air borne measurements by specially instrumented aircrafts. Data collected during these experiments are being analysed and shared with other organizations and National and International bodies dealing with global change issues.

Group Monitoring Meeting, Workshop etc.

Fifth meeting of the Working Group on "Ocean Atmosphere Field Experiments" under the Indian Climate Research Programme (ICRP) of the Department of Science and Technology, New Delhi was held at the Institute on 13 May 2002.

The DST sponsored three-day Group Monitoring Workshop on MONTCLIM and ICRP Projects (GMW 2002) was organized at the Institute during 9-11 October 2002.

Participation in Indian Science Congress

Dr. G.B. Pant, Director was a panelist of a Session on Climate and Weather System and made a presentation on Problems of Modelling South Asian Climate. The Session was organized at the Jnana Bharati Campus of the Bangalore University on 5 January 2003 as a part of the Indian Science Programmes.

Participation in Exhibition at Swadeshi Mela

The Institute arranged a scientific exhibition depicting its research activities at the Swadeshi Mela organized by the Centre for Bharatiya Marketing Development during 28 January to 4 February 2003 at Somaiya Trust Ground, Mumbai. The exhibition was arranged under the pavilion of the Department of Science and Technology, Government of India, New Delhi. Shri V.R.Mujumdar, Shri K.K.Dani, Shri V.H.Sasane and Shri C.T.Jadhav organized the exhibition of the Institute.

Co-Sponsoring of Seminars/Conferences etc.

Institute co-sponsored the following events:

- National Workshop on Recent Trends in Drought Assessment: Monitoring and Management organised by the Centre of Studies in Resources Engineering, Indian Institute of Technology, Mumbai during 28-30 June 2002.
- IASTA Conference on Aerosol Remote Sensing in Global Change and Atmospheric Pollution, Bhabha Atomic Research Centre, Mumbai and Vikram Sarabhai Space Centre, Thiruvananthapuram during 18-20 September 2002. Dr. P.C.S. Devara, Vice President, IASTA was involved in organization of the conference.
- International Conference on Developments in Hydrology-the Current Status Along With a Colloquium on Water Resources Management, Indian Journal of River Valley Development, Kolkata, 24-25 October 2002.
- National Symposium on Advances in Frontier Areas of Meteorology at the turn of the Millennium, Department of Meteorology and Oceanography, Andhra University, Visakhapatnam, 29-31 October 2002.
- Fifth International Meeting of Global Continental Palaeohydrology, Geological Society of India, Pune, 2-4 December 2002.
- Annual Monsoon Workshop-2002, Indian Meteorological Society, Pune Chapter, Pune, 16 December 2002
- Raman Memorial Conference, Department of Physics, University of Pune, Pune, 22 February 2003

Honour

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

Dr. P.C.S. Devara has been elected a Fellow of the Royal Meteorological Society, UK in recognition

of his research contributions in the field of Tropical Meteorology. Dr. Devara was felicitated for this prestigious award at the Meeting of the Academic Council on 21 June 2002 and Indian Meteorological Society, Pune Chapter on 27 June 2002.

Dr. (Smt.) P.S. Salvekar has been nominated by the Department of Science and Technology, New Delhi as a member of Subject Expert Committee (Earth and Atmospheric Sciences) for Technical Evaluation of the proposals under the Women Scientists Scheme.

Dr. G. B. Pant, Dr. A. K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. (Smt.) P. S. Salvekar, Dr. P. N. Mahajan, Shri J. R. Kulkarni, Dr. (Smt.) A. A. Kulkarni and Dr. C. Gnanaseelan have been bestowed with the title 'Adjunct Professor', by the University of Pune, Pune for the academic year 2002-2003.

Shri J.R. Kulkarni was the chief guest of a function of National Science Day programme at the Md. Siddique Naik High School, Ratnagiri and Prize Distribution function of Scientific Essay competition organized by Ratnagiri District Science Teachers Association, Ratnagiri on 2 March 2003.

Awards

The 13th IITM Annual Silver Jubilee Award for the year 2000 was received by Dr. G. Beig for his research paper entitled "Relative Importance of Solar Activity and Anthropogenic Influences on the Ion Composition, Temperature and Associated Neutrals of the Middle Atmosphere" published in the Journal of Geophysical Research, Vol. 105, 2000, 19841-19856.

Dr. G. Beig also received the Muslim Association for Advancement in Science (MAAS)-National Young Scientist Award for the year 1999-2000, in the Physical Sciences category at the hands of Honourable Chief Minister, West Bengal at the Proclamation Ceremony held in Kolkata on 22 December 2002.

Shri S. Mahapatra, has been awarded the First Prize for the Best Performance amongst all the participants of the Third SERC School on Numerical Weather Prediction - Parameterization of Physical Processes held at the Indian Institute of Technology, New Delhi during 8 April - 5 May 2002.

Release of Book / Monograph

The Proceedings of the DST approved "National Workshop on Atmospheric Chemistry (NWAC-99)" in the form of a book entitled "Advances in Atmospheric Chemistry", edited by Dr. P.C.S. Devara, and Dr. P. E. Raj, was released at the hands of

Prof. G.C. Asnani, Former WMO Professor, at the IITM Foundation Day Celebration on 17 November 2002.

A Monograph entitled, "Radiosonde profiles along Indian east coast stations of Bay of Bengal during BOBMEX-99" by Dr. (Smt.) S.B. Morwal and Dr. R. Vijayakumar was released on the occasion of IMS Mini Workshop, organized by the Indian Meteorological Society, Pune Chapter on 16 January 2003.

Contribution to Book

Institute's Scientists made a major contribution in the book entitled "Climate Change and India, Issues, Concerns and Opportunities", edited by P.R. Shukla, S.K. Sharma and P. Venkata Ramana, published by Tata McGraw-Hill Publishing Company Limited, New Delhi. The book contains research work presented and discussed in the National Seminar on Climate Change: Issues, Concerns and Opportunities, organized by the Ministry of Environment and Forests, Government of India on 23 November 2001.

Consultancy

Following two proposals on consultancy basis have been submitted by the Institute :

- Preparation of generalized PMP Atlas for the Krishna, Ganga, Brahmaputra and Barak, and the Indus, submitted to the Central Water Commission (CWC), New Delhi.
- Estimation of Standard Project Storm (SPS) and Probable Maximum Precipitation (PMP) and time distribution for two small basins, located in the Dhaole-Ganga river and Bhagirathi river respectively in the Uttaranchal region, submitted to the Central Water and Power Research Station (CWPRS), Pune.

As requested, the isohyetal maps of mean annual, south-west monsoon and north-east monsoon rainfall over the Cauvery river basin were prepared and supplied to the Water Resources Development Organisation, Government of Karnataka.

Technical assistance was provided to ISRO, Department of Space in the development of a field mill network at SHAR, Shriharikotta for the thunderstorm warning and for the study of dynamical properties of thunderstorm for forecasting the warning level.

Technical guidance was provided to the Ministry for Irrigation of Karnataka Government, Bangalore in the proposed cloud seeding operations in Karnataka State.

ENVIS Website

The Ministry of Environment and Forests, Government of India has selected the Indian Institute of Tropical Meteorology (IITM), Pune for the establishment of Environmental Information System (ENVIS) node on the subject "Acid Rain and Atmospheric Pollutant Modelling" from February 2003. This ENVIS node has a responsibility to disseminate information relevant to the air pollution and acid rain. The ENVIS node at the IITM will help in building up an inventory of information material on the subject area, disseminate information / data electronically and provide interactive web page for it. A Web site has been developed and maintained by the IITM for this ENVIS node (URL : <http://envis.tropmet.res.in>). The web site provides the details on ENVIS, acid rain, atmospheric pollutants and their impacts on the environment, global change in atmosphere, newsletters and links to some of the other related sites, books/journals, kid's corner, etc. Graphical online view about the variation of some of the species (NO_x , CO , O_3 , CH_4 etc.) which are being monitored continuously from the Institute's ozone pollution laboratory are also available at this site.

Indo-Swedish Collaborative Project

As a part of the Indo-Swedish collaborative project entitled, 'Composition of Asian Deposition (CAD)', with the Stockholm University, Sweden, wet-only and bulk collectors, aerosol and gas samplers and meteorological sensors for wind direction, pressure, temperature and humidity have been installed at Sinhgad. Wet and dry deposition samples and passive sampling of trace gases were collected.

IITM-NMRF Collaborative Studies

Special observations of atmospheric aerosols, clouds and stability by using the multi-filter radiometer, twilight photometer, lidar and MST radar were carried out at the National MST Radar Facility, Gadanki during 28 February - 10 March 2003.

IITM-SAC Collaborative Project

As a part of the IITM-SAC collaborative project entitled "Atmospheric aerosol loading over land from IRS-P3 MOS sensors data", special observations of atmospheric aerosols, ozone and water vapour were carried out using multi-filter solar radiometers on 22 days in synchronization with observations of IRS-P4 satellite passes over Pune. In addition, observations of atmospheric aerosols, ozone, precipitable water content and surface meteorological parameters were carried out along

the Pune-Daund-Pune stretch in synchronization with the IRS-P3/P4/1-C/1-D satellite passes over the region on 6 days.

ARMEX (Arabian Sea Monsoon Experiment) Programme

Under the ARMEX, a national field experiment programme, study of the air-sea fluxes over the Arabian Sea during monsoon season (June-September) of 2002 was carried out at the National Centre for Antarctic and Ocean Research (NCAOR), Goa. Observations on wind speed (1, 2 and 8 m AGL) and direction (1 and 8 m AGL), air temperature (1, 2, 4 and 8 m AGL), relative humidity (1, 2, 4 and 8 m AGL) were taken on a 9 m micro-meteorological tower. Short wave and long wave incoming and outgoing radiation were measured at 2 m height. Turbulence measurements on wind components and virtual temperature were taken using sonic anemometer (Applied Sonic) at 5 m AGL and measurements of CO₂ and H₂O were taken using CO₂ / H₂O analyzer at 5 m AGL.

Under the ARMEX Programme observations of total suspended particulates, Aitken nuclei, mass size distribution of aerosols, surface ozone and wet/dry deposition were also carried out on board ORV Sagar Kanya in Arabian Sea during the First cruise (21 June - 14 July 2002) and the Second cruise (15 July -16 August 2002).

Air-borne measurements of sub-micron aerosol size distribution and the atmospheric electric conductivity on an AN - 32 aircraft of the Indian Air Force have been arranged by the Institute under the ARMEX Programme. For this purpose, two scientists were stationed at IBRD, Kanpur to instrument the aircraft for the measurements. The instrumented aircraft was finally positioned at IAF station, Yelahanka, Bangalore. Seven flights were undertaken over the Arabian Sea in different modes finalised under the ARMEX. A few more flights in step-mode have been planned over the Arabian Sea and coastal area.

IITM-IGCAR Joint Field Experiment

A joint field experiment to study the coastal atmospheric boundary layer characteristics was conducted by the IITM and the Health and Safety Division, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam during October 2002. The kytoon (tethered balloon system with payload) system was used to probe the growth of thermal internal boundary layer at Anupuram. Turbulence measurements on wind components and virtual temperature were taken using Sonic Anemometer at 10 and 30 m AGL.

Special Field Observational Programmes

Institute Scientists collected tree-ring samples of teak from the Teak Forest of Dhamni, Ambegaon (Pune District) on 13 June 2002 for the dendroclimatic studies.

As a part of the DST-sponsored project entitled, "Studies of atmospheric aerosols, trace gases and precipitation chemistry in different environments", a field observational programme was conducted in Delhi at two locations, viz., Okhala (Industrial) and New Rajender Nagar (Residential) during 8-27 January 2003. Special observations of mass size distribution of aerosols, total suspended particulates and meteorological parameters were carried out during this period.

Special solar radiometric, total solar flux and meteorological observations of column aerosol optical depth, ozone and precipitable water content were carried out at a high-altitude station, Sinhgad on 16 December 2002 and, 3 and 21 January 2003. Vertical profile measurements of these parameters were also acquired by employing a mobile vehicle equipped with radiometers and meteorological sensors.

Field observations of total suspended particulates, mass size distribution of aerosols, Aitken nuclei and meteorological parameters such as wind, temperature and pressure were taken at the Bose Institute, Mayapuri, Darjeeling during 12-18 November 2002, under the field observational programme for high altitude stations.

Installation of Rain Water Sampling Gadget

In order to study the impact of industrial pollution on precipitation chemistry, rain water sampling gadget has been installed at Marivanios Convent School at Pimple Gurav which is located nearer to the Industrial belt in Pimpri-Chinchwad region of Pune. Rain water samples were collected and analysed for various ionic components.

Reports submitted

A report entitled "Indian East Coast Stations-Radiosonde Profiles" by S.B. Morwal and R. Vijayakumar was submitted to DST under the DST-ICRP supported project entitled "Convective Boundary Layer during the Summer Monsoon Season Over the Bay of Bengal".

A report entitled "Ultra-Violet Lidar System for Vertical Profiling of Atmospheric Ozone" by P.C.S. Devara, P. E. Raj, G. Pandithurai and K.K. Dani was submitted to DST as part of the activity under the DST-ICRP supported project entitled "Differential Absorption Lidar Sensing of Ozone".

At the request of Dr. G. Viswanathan, Program Director, INDOEX-India Program, ISRO, a comprehensive report covering the highlights of the results obtained from the measurements made during First Field Phase (FFP-98) and Intensive Field Phase (IFP-99) by the Institute scientists was sent in connection with continuation of INDOEX-India Programme.

An interim report on "Climate Change Projections for India and Assessment of the Associated Agricultural and Human Health Impacts" was submitted under NATCOM Project.

A report entitled, "Coastal Atmospheric Boundary Layer Experiment (CABLE-2001) at Kalpakkam" was submitted to Safety Research Institute (SRI)/ Atomic Energy Regulatory Board (AERB), Mumbai.

The final report on "Study of Vulnerability Characteristics of Kachch District, Gujarat" was submitted under the project "National Council for Cement and Building Materials" (NCCBM), New Delhi.

The following four interim reports were submitted under joint Indo-UK programme on Impacts on Climate Change in India:

- High resolution climate change scenarios for India : A preliminary report
- Baseline precipitation analysis
- Spatio-temporal variability over major river basins, past changes in water availability and quality
- Precipitation climatology of selected river basins and validation of climate model simulations of precipitation

Science popularization Programmes

The Institute arranged scientific exhibitions, 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 2002, Institute's Foundation Day on 17 November 2002, National Science Day on 28 February 2003, and World Meteorological Day on 24 March 2003. 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.

Vigilance Awareness Programme

The Institute observed the Vigilance Awareness Week during 31 October- 6 November 2002. The programme began with the administration of pledge. On this occasion, a lecture on "Vigilance awareness" by Smt. Vinita Deshmukh, Deputy Resident Editor, Indian Express, Pune was arranged in the Institute on 1 November 2002. A competition of a write up on 'How to get relief from cancer of corruption in Indian democracy' was also arranged for the employees of the Institute. The prizes were given away at the hands of Smt. Deshmukh.

Armed Forces Flag Day

Armed Forces Flag Day was celebrated on 7 December 2002. Employees of the Institute contributed a sum of Rs. 3645/- on this occasion.

Computer and Data Archival Facility

Computing Facilities

Most of the projects of the Institute are computer based and realizing this, the Institute has been enhanced its computing power by acquiring a number of high end workstations for the computational needs. The present computational facilities available in the Institute are 84 PCs, 14 Servers/Workstations connected to the Institute's Local Area Network, round the clock high speed Internet connectivity and E-mail facility with web server. The high speed Internet link of 512 KBPS is being used for e-mail, file transfer and browsing by the Institute's employees.

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

Software Development

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

Data Archival

The NCEP reanalyzed monthly and daily data (6-hourly) of pressure and non-pressure fields for the recent years were downloaded and stored in suitable format. OI SST monthly and OLR monthly data of NCEP were updated.

Library, Information and Publications

The Institute's Library, Information and Publications Division serves as the Information System in Meteorology and Atmospheric Sciences.

The Library has an information base of about 26,500 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 83 books and reports in Meteorology and allied subjects were added. 88 Periodicals of national/international origin were subscribed to. Reprints of 75 papers authored by the Institute's scientists were also acquired. Several scientific and technical reports were received from the 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 is also 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.

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 Indian Science Congress, National Technology Day, National Science Day, World Meteorological Day etc. The Division also co-ordinated regular visit of students from schools and colleges from various parts of the country to the Institute and arranged to take 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 Institute of Technology, New Delhi, Indian Institute of Science, Bangalore, 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 2003 the Institute had its staff under different categories as shown below :

| | |
|---------------------------|------------|
| Research I | 79 |
| Research I-A | 50 |
| Technical | 36 |
| Administrative | 49 |
| Non Technical Maintenance | 47 |
| Total | 261 |

Staff changes

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

Retirement on Superannuation

| | |
|--|-------------------|
| Shri S.S. Aralikatti Scientist D | 31 July 2002 |
| Shri K. Subramanian Senior Scientific Assistant | 30 September 2002 |
| Dr. (Smt.) M.S. Naik Scientist C | 31 October 2002 |
| Shri R. B. Bhandari Upper Division Clerk | 31 October 2002 |

Voluntary Retirement

| | |
|--|-----------------|
| Smt. S. Saxena Scientist C | 7 May 2002 |
| Smt. U.L. Bhandari Senior Assistant | 1 January 2003 |
| Shri A.S. Salvi Watchman | 20 January 2003 |

Obituary



Shri M.K. Bhise, Assistant expired on 25 February 2003. He was born on 14 July 1947. Shri Bhise joined the Institute on 12 July 1967 as a peon and then has risen to the level of Assistant in the Administration Category with effect from 4 June 1992. Late Shri Bhise was friendly to all.

He was very honest and sincere in the work and liked by all the staff of the Institute owing to his cheerful nature. He will ever be remembered by the Institute for the services he had rendered and cooperation given to the employees of the Institute.

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 2.1.

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. Three meetings of the council were held during the year.

Advisory Committee

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

Status of SC / ST / OBC Reservations

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

| Category | SC | ST | OBC | Total |
|---------------------------|-----------|-----------|-----------|-----------|
| Research I | 11 | 4 | 2 | 17 |
| Research I-A | 6 | 2 | 5 | 13 |
| Scientific | - | - | - | - |
| Technical | 6 | 2 | 1 | 9 |
| Administrative | 6 | 6 | - | 12 |
| Non-Technical Maintenance | 14 | 2 | 2 | 18 |
| Total | 43 | 16 | 10 | 69 |

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 2002-2003 are as follows:

| (Rs. in Lakhs) | | |
|--------------------|----------------|--------------------|
| | Grant Received | Actual Expenditure |
| Plan | 500.00 | 444.18 |
| Non-Plan | 318.00 | 318.00 |
| Sponsored Projects | 102.02 | 126.54* |
| Total | 920.02 | 888.72 |

* Excess expenditure over grant met from carried forward balance of previous year's grant.

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 year purchases were made as shown below :

| | | |
|---------------|---|-----------------|
| ● Equipment | : | Rs. 91.70 lakhs |
| ● Dead Stock | : | Rs. 04.32 lakhs |
| ● Consumables | : | Rs. 17.14 lakhs |

Official Language Implementation

Hindi Cell is working under 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 Hindi translation and arranging Hindi Training for officers and employees in different cadres. Three employees were nominated for "Pragnya" course held by Hindi Teaching Scheme during the year. All the three candidates successfully completed the course. All general circulars and office orders are being 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.

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

The Institute celebrated Hindi Week from 16 to 19 September 2002. On this occasion, various competitions in Hindi were organised. Dr. Sabhajit Singh, Chief Scientific Officer, Indian Agriculture Research Institute, Pune was the Chief Guest and Dr. Shrikant Upadhyay, Reader (Retired), Hindi Department, National Defence Academy, Pune was the Main Speaker of the concluding function of the Hindi week. The prizes to the winners of the competitions were given away by the Chief Guest. Dr. G.B. Pant, Director of the Institute presided over the function.

IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to the members. Annual Sports Tournaments were organised on League basis. Rangoli competition was arranged for ladies.

On 14 August 2002, the 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 and Post-Graduation Examinations held in the Academic Year 2001-02 under different disciplines. A few lectures and slide shows on popular topics by eminent personalities were arranged during the year.

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 Foundation Day Celebration.

Garden Committee

The year 2002-03 has been a year of pleasant horticultural surroundings in the Institute complex. Garden Committee took efforts to motivate the proper cultivation of ornamental plants, irrespective of less monsoon rainfall and adverse atmospheric conditions during the year. On the occasion of the Independence Day, number of employees of the Institute took part in the programme of plantation of various trees for ecological balance and better outlook of the premises. Number of students from various schools, visitors from different organizations, scientists of national and international levels and staff members are enjoying the beauty of the office complex throughout the year.





Governing Council of IITM



Director, IITM at the Fifth Meeting of the Indo-Russian Subworking Group on Meteorology, Russia



Director, IITM at the Meeting of Joint Scientific Committee of WCRP with Chairman (Dr. P. Lemke) and Vice Chairman (Dr. B.J. Hoskins)



Working Group Meeting of the ICRP



Workshop co-sponsored by the IITM



Dr. Vijay Gupta, USA



Dr. V. Krishnamurthy, USA

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(Dr. P.C.S. Devara)
- Conference on Aerosol Remote Sensing in Global Change and Atmospheric Pollution (IASTA-2002), Space Physics Laboratorys, Vikram Sarabhai Space Centre, Thiruvananthapuram, 18-20 September 2002
(Dr. P.C.S. Devara, Dr Y. Jaya Rao, Dr. G. Pandithurai, Dr. K. Ali, Dr. C.G. Deshpande, Smt. B. Padmakumari, Dr. P.D. Safai, Shri S. Tiwari, Shri S. M. Sonbawne, Dr. R. S. Mahes Kumar, Shri A.K. Shrivastava)
- Joint IGAC and CACGP International Symposium on Atmospheric Chemistry within the Earth System from Regional Pollution to Global Change, Heraklion, Crete, Greece, 18-25 September 2002
(Kum. N. Saraf)
- Conference on Application of Seasonal Climate Forecast in Agriculture, Tamil Nadu Agricultural University, Coimbatore, 24-26 September 2002
(Dr. G.B. Pant)

- Media Workshop in connection with the COP-8 UNFCCC Meeting, Ministry of Environment and Forests, New Delhi, 27 September 2002
(Dr. K. Rupa Kumar)
- Indian Geophysical Union 39th Annual Convention and Meeting on Sustainability Science and Environmental Geophysics, National Environmental Engineering Research Institute, Nagpur, 4-6 October 2002
(Dr. P.N. Mahajan, Dr. (Smt.) I. Joshi, Shri D.R. Chakraborty, Shri R.M. Khaladkar, Shri. S.G. Narkhedkar, Smt S.K. Mandke, Shri J.S. Chowdary)
- International Conference on Science and Technology Capacity Building for Climate Change, Federation of Indian Chamber of Commerce and Industry (FICCI), New Delhi, 20-22 October 2002
(Dr. G.B. Pant, Dr. R. Krishnan, Dr. K. Krishna Kumar)
- Eighth Conference of the Parties (COP-8) to the UN Framework Convention on Climate Change, United Nation Framework Convention on Climate Change (UNFCCC) and Government of India, New Delhi, 23 October - 1 November 2002
(Dr. G.B. Pant, Dr. K. Krishna Kumar)
- International Conference on Developments in Hydrology-the Current Status alongwith a Colloquium on Water Resources Management, Kolkata, 24-25 October 2002
(Shri B.N. Mandal, Dr. B.D. Kulkarni, Shri S.S. Mulye, Shri D.R. Kothawale)
- National Symposium on Advances in Frontier Areas of Meteorology at the turn of the Millennium, Andhra University, Visakhapatnam, 29-31 October 2002
(Dr. P.C.S. Devara, Dr. D.B. Jadhav, Dr. (Smt.) I. Joshi, Shri D.R. Chakraborty, Shri A.K. Mishra, Shri P.S. Praveen)
- Workshop on Sediment Disposal Techniques, Central Water and Power Research Station, Pune, 19-20 November 2002
(Dr. C. Gnanaseelan)
- Group Monitoring Workshop on Atmospheric Science Programme, Department of Physics, Andhra University, Visakhapatnam, 21-22 November 2002
(Dr. A.K. Kamra, Dr. D.B. Jadhav, Shri D.R. Chakraborty, Dr.C.Gnanaseelan)
- First Workshop on Composition of Asian Deposition (CAD), Malaysian Meteorological Service, Kuala Lumpur, Malaysia, 21-23 November 2002
(Dr. P.S.P. Rao)
- Brain Storming Session on Monsoon 2002, Indian Institute of Science, Bangalore, 28-29 November 2002
(Dr. G.B. Pant, Dr. K. Rupa Kumar, Dr. R. Krishnan, Smt. U.V. Bhide, Dr. A.A. Munot, Shri S.M. Bawiskar, Dr. M. Mujumdar)
- Fifth International Meeting on Global Continental Palaeohydrology, University of Pune, Pune, 2-7 December 2002
(Dr. H.P. Borgaonkar)
- SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SAARC Meteorological Research Centre, Dhaka, Bangladesh, 10-12 December 2002
(Dr. K. Rupa Kumar, Dr.(Smt.) A.A. Kulkarni)
- US-India Earth-Atmospheric Science Workshop in Support of Recently Extended Memorandum of Understanding (MoU) for Science Co-operation, NASA/NOAA-USA, Department of Space and Department of Science and Technology, Government of India, Centre for Ocean Land Atmosphere (COLA) Studies, Maryland, USA, 16-18 December 2002
(Dr. (Smt.) P.S. Salvekar)
- SAARC Training Seminar on Summer Monsoon and Prediction Techniques, Department of Hydrology and Meteorology, Government of Nepal, Kathmandu, Nepal, 17-20 December 2002
(Smt. S.K. Patwardhan)
- International Conference on Hydrology and Watershed Management, Department of Water Resources, Jawaharlal Nehru Technological University, Hyderabad, 18-20 December 2002
(Smt. N.R. Deshpande)
- One Day Workshop on Asian Brown Cloud, Tata Energy Research Institute, New Delhi, 20 December 2002
(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. K. Rupa Kumar, Dr. R. Krishnan)
- Indian Science Congress, Bangalore University, Bangalore, 4-6 January 2003
(Dr. G.B. Pant)

Workshop on Water Resources in South Asia : an Assessment of Climate Change Associated Vulnerabilities and Coping Mechanisms, Kathmandu, Nepal, 7-9 January 2003
(Dr. K. Rupa Kumar)

Seminar on Clean Development Mechanism as a Business Opportunity, Maharashtra Energy Development Agency, Pune, 30 January 2003
(Dr. A.K. Kamra)

Third DGS International Conference on Environment, Ecology and Remote Sensing, International Centre, Goa, 6-8 February 2003
(Dr. P.N. Mahajan)

South Asian PAGES Workshop-cum-Training (EILQUEC and POLTRAIN 2003), French Institute of Pondichery, Pondichery, 10-15 February 2003
(Dr. K. Rupa Kumar, Shri K. Jagadeesh)

National Seminar and Exhibition on Cement Industry, Environment and Sustainable Development, Cement Manufacturers' Association and National Council for Cement and Building Materials, Mumbai, 11-12 February 2003
(Dr. K. Krishna Kumar, Dr. A.A. Munot)

National Conference on Radio and Atmospheric Sciences, National Physical Laboratory, New Delhi, 16-18 February 2003
(Dr. G.B. Pant) (as a Chief Guest)

International Workshop on Biogeochemical Processes in the Northern Indian Ocean, National Institute of Oceanography, Goa, 24-25 February 2003
(Dr. P.N. Mahajan)

Sixth User Scientists Workshop, National MST Radar Facility, Gadanki, 26-27 February 2003
(Dr. P.C.S. Devara, Dr. Y. Jaya Rao, Smt. Padma Kumari)

First All India Official Language Conference on Scientific and Technical Terms and Official Language Policy, Vigyan Kendra, Council of Scientific and Industrial Research, New Delhi, 6-7 March 2003
(Dr. K. Ali)

Brainstorming Session on Mountain Environment and Climatic Changes, Shimla, 14-15 March 2003
(Dr. G. Beig, Shri C. M. Mohile)

Second National Conference on Applicable Mathematics in Wave Mechanics and Vibrations (WMVC-2003), A.C.College of Commerce, Mathematics and Statistics Section, Jalpaiguri, 15-16 March 2003
(Shri D. R. Chakraborty, Shri S. S. Dugam)

Conference on Monsoon Environments: Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change, Abdus Salam Centre for Theoretical Physics, Trieste, Italy, 24-28 March 2003
(Dr. K. Rupa Kumar, Dr. R. Krishnan, Dr. K. Krishna Kumar, Shri S.B. Kakade, Shri Pankaj Kumar)

National Symposium on Prediction of Meteorological Events—a Mathematical Approach, Birla Institute of Technology, MESRA, Ranchi, 25-26 March 2003
(Shri S.S. Dugam, Shri D.R. Kothawale, Shri S.K. Jadhav, Shri P. Mukhopadhyay, Shri U.K. Singh, Shri M.K. Biswas, Dr. P.K. Mishra)

Two Day BIMST-EC (Bangladesh-India-Myanmar-Sri Lanka-Thailand, Economic Co-operation) Workshop on Monitoring Prediction and Warning of Tropical Cyclones and Monsoon, National Centre for Medium Range Weather Forecasting, New Delhi, 25-27 March 2003
(Dr. G.B. Pant)

Workshop on Gangotri Glacier Geological Survey of India, Lucknow, 26-28 March 2003
(Mohile C.M.)

Workshop on Synthesis of NATCOM V and Studies and Future Climate Change Research Needs, India International centre, New Delhi, 28 March 2003
(Dr. G.B. Pant)



Participation in Meetings

Dr. G.B. Pani

- National Advisory Committee Meeting, (IASTA - 2002), Indian Space Research Organisation, Bangalore, 29 April 2002
- First Meeting of NNMRS Standing Committee on Meteorology, Lokmanya Bhavan, DOS Branch Secretariat, New Delhi, 9 May 2002
- PROMISE European Meeting, Paris, France, 13-15 May 2002
- First Meeting of the Programme Advisory and Monitoring Committee (PAMC), Himalayan Glaciology, Guwahati University, Guwahati, 25-26 June 2002
- National Communication (NATCOM) Ministry Meeting on Climate Change, Chennai, 13 July 2002
- Meeting of the Scientific Advisory Committee, Space Physics Laboratory, Thiruvananthapuram, 8-9 August 2002
- 56th Meeting of the Council for Meteorology and Atmospheric Sciences, Mausam Bhavan, New Delhi, 23 August 2002
- First Meeting of PAMC on Weather and Climate Research, Indian Institute of Technology, New Delhi, 28 August 2002
- Meeting of Expert Committee on South Asian Brown Cloud, Mausam Bhavan, New Delhi, 9 September and 26 November 2002
- Meeting convened by the Chief Minister of Karnataka State, Bangalore, 14 September 2002
- Meeting on Ocean Environmental Panel of Naval Research Board, National Physical and Ocean Laboratory, Kochi, 28 September 2002
- Meeting of the Intergovernmental Programme on Climate Change (IPCC), New Delhi, 29-30 October 2002
- Fifth International Meeting on Global Continental Palaeohydrology, University of Pune, Pune, 2-7 December 2002
- Preparatory Meeting on Climate Change, Central Water Commission, New Delhi, 21 December 2002
- Meeting of the Sub-working Group on Climate Observations and Modelling, Space Applications Centre, Ahmedabad, 9-12 January 2003

- ISRO-IGBP Meeting, Space Applications Centre, Ahmedabad, 13-14 January 2003
- Meeting of the Working Group on ARMEX- Phase II, National Institute of Oceanography, Goa, 13-14 February 2003
- First Meeting of the Inter-Departmental Consultative Committee for Indian Climate Research Programme, Department of Science and Technology, New Delhi, 5 March 2003
- Meeting of the PAMC in the area of the Environmental Management under the Shastri Applied Research Project, New Delhi, 23 March 2003

Dr. A.K. Kamra

- Meeting of the Programme Advisory Committee – Atmospheric Sciences (PAC-AS) and the Group Monitoring Workshop, RBS College, Agra, 16-17 August 2002
- 68th Annual Meeting of the Indian Academy of Sciences, Punjab University, Chandigarh, 8-11 November 2002
- 41st Meeting of PAC-AS and Group Monitoring Workshop (GMW), Andhra University, Visakhapatnam, 21-22 November 2002
- Meeting of the Working Group II : Atmospheric Chemistry, Aerosols and Global Change, Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, 29-30 November 2002
- Meeting of the Working Group on ARMEX-Phase II, National Institute of Oceanography, Goa, 12-15 February 2003

Dr. S.S. Singh

- Second Steering Committee Meeting of New Millennium Indian Technology Leadership Initiative (NMITLI) Project on Mesoscale Modelling for Monsoon Related prediction, National Aeronautical Laboratories, Bangalore, 3 April 2002
- Third Steering Committee Meeting of NMITLI Project on Mesoscale Modeling for Monsoon Related prediction, National Aeronautical Laboratories, Bangalore, 13 April 2002
- Fourth Steering Committee Meeting of NMITLI Project on Mesoscale Modelling for Monsoon Related prediction, National Aeronautical Laboratories, Bangalore, 19 July 2002

- Third Monitoring Committee Meeting of NMITLI Project on Mesoscale Modelling for Monsoon Related prediction, National Aeronautical Laboratories, Bangalore, 20 July 2002

Dr. P.C.S. Devara

- Meeting of Specification Committee for Procurement of Instruments Needed for Monitoring Greenhouse Gases and Aerosols, India Meteorological Department, New Delhi, 18 October 2002
- International Aerosol Research Assembly (IARA) Board Meeting, International Convention Centre, Taipei, Taiwan, 10 September 2002
- Meeting of the Managing Committee of the Indian Aerosol Science and Technology Association (IASTA), Vikram Sarabhai Space Centre, Thiruvananthapuram, 20 September 2002

Dr. K. Rupa Kumar

- Discussion Meeting on the APN Project on Water in South Asia, National Physical Laboratory, New Delhi, 6 June 2002
- Meeting of the ISRO-GBP Sub-Working Group (SWG), Physical Research Laboratory, Ahmedabad, 23 January 2003
- Mid-term review Meeting of Indo-French Project, National Institute of Advanced Studies, Bangalore, 30 October 2002
- Fifth Meeting of Asian Australian Monsoon Panel of CLIVAR, Atlanta, U.S.A., 25-27 February 2003

Dr. (Smt.) P.S. Salvekar

- Meetings regarding M. Tech. (Atmospheric Physics) Examination, University of Pune, Pune, 5 April and 8 May 2002
- Board of Studies (Space Science) Meeting, University of Pune, Pune, 17 April and 21 August 2002
- Meeting on INDOMOD - Tenth Plan Mission on Ocean-Atmosphere System and the Indian Sea, Space Application Centre, Ahmedabad, 20-21 September 2002
- First Meeting of the Subject Experts of Women Scientists Scheme of the Department of Science and Technology, Council of Scientific and Industrial Research, New Delhi, 28-30 March 2003

Dr. R. Vijayakumar

- Meeting regarding the possibility of cloud seeding operations in Karnataka State with the Minister for Irrigation, Karnataka Government, Bangalore, 16-19 September 2002

Dr. S. Sivaramakrishnan

- Technical Evaluation Committee Meeting, India Meteorological Department, Pune, 20 November 2002
- ARMEX Data Management Group Meeting, Indian Institute of Technology, New Delhi, 12-13 December 2002
- ISRO - University of Pune Project Review Committee Meeting, University of Pune, Pune, 18 December 2002

Dr. N. Singh

- XI Annual Review Meeting of the DST Project "Medium Range Weather Forecasting and Experimental Agrometeorological Advisory Services", Kerala Agricultural University, Thrissur, 28-30 November 2002
- Meeting of the ISRO-GBP on Regional Climate Modelling Studies, Indian Space Research Organisation Headquarters, Bangalore, 18-19 February 2003

Dr. R. Krishnan

- INDOMOD / DOD Meeting, Indian National Centre for Ocean Information Studies, Hyderabad, 2-5 September 2002

Dr. P.E. Raj

- Second Meeting of the PAMC on Weather and Climate Programmes, Department of Science and Technology, New Delhi, 13 December 2002

Dr. P.N. Mahajan

- Geomatic Measurement and Control, Pride Hotel, Pune, 27 August 2002

Smt. S.S. Vaidya

- Fifth Steering Committee Meeting of NMITLI Project on Mesoscale Modelling for Monsoon Related prediction, National Aeronautical Laboratories, Bangalore, 9 November 2002

Dr. R.H. Kripalani

- Second Meeting of Asian Monsoon Variability, Mt. Jiri, Korea, 25-27 September 2002

Shri B.N. Mandal

- Departmental Promotion Committee (DPC) Meeting, India Meteorological Department, Pune, 9 April, 20 June 2002 and 20 March 2003

Dr. P.S.P. Rao

- Meeting of the Working Group on 'Ocean-Atmosphere Field Experiments' under Indian Climate Research Programme (ICRP), National Institute of Oceanography, Goa, 13-14 February 2003.
- Technical Evaluation Committee (TEC) Meeting, India Meteorological Department, Pune, 11 March 2003

Dr. (Smt.) I. Joshi

- Project Guides Meeting for Space Sciences, Department of Space Sciences, University of Pune, Pune, 1 January 2003.

Smt. U.V. Bhide

- Annual Monsoon Review Meeting, India Meteorological Department, Mumbai, 21 January 2003

Dr. Y. Jaya Rao

- Convection Campaign Meeting, National MST Radar Facility (NMRF), Gadanki, 19 April 2002
- Discussion Meeting on Doppler Weather Radar and its Meteorological Applications, Sriharikota High Altitude Range (SHAR) Centre, Sriharikota, 18-19 July 2002
- Respond Review Meeting for Space Sciences, Physical Research Laboratory, Ahmedabad, 16-17 August 2002
- Project Guides Meeting for Space Sciences, Department of Space Sciences, University of Pune, Pune, 1 January 2003
- Group Monitoring Workshop for Fast Track Scheme for Young Scientists in the Area of Mathematical and Earth Sciences, National Institute of Oceanography, Goa, 11-12 January 2003

Dr. B.S. Murthy

- ARMEX Working Committee Meeting, National Institute of Oceanography, Goa, 13-14 February 2003

Dr. C. Gnanaseelan

- Meeting on INDOMOD-X plan mission on Ocean-Atmosphere system and the Indian Sea, Space Application Centre, Ahmedabad, 20-21 September 2002

Dr. G. Pandithurai

- Project Guides Meeting for Space Sciences, Department of Space Sciences, University of Pune, Pune, 1 January 2003

Shri P.S. Mukhopadhyay

- ISRO-GBP Meeting on Regional Climate Modelling Studies, Indian Space Research Organisation Headquarters, Bangalore, 18-19 February 2003

Dr. R.S. Maheskumar

- Group Monitoring Workshop for Fast Track Scheme for Young Scientists in the Area of Mathematical and Earth Sciences, National Institute of Oceanography, Goa, 11-12 January 2003

Shri A. K. Srivastava

- Convection Campaign Meeting, National MST Radar Facility (NMRF), Gadanki, 19 April 2002

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By Visitors

Dr. P.C. Pandey, Director, National Center for Antarctic and Ocean Research, Goa

- Indian Antarctic Research Programme (26 April 2002)

Prof. (Mrs.) S.K. Kulkarni, Department of Physics, University of Pune, Pune

- Emerging trends in nanotechnology (National Technology Day Lecture) (10 May 2002)

Dr. Navin Ramankutty, Centre for Sustainability and Global Environment (SAGE), University of Wisconsin, Madison, USA

- Land use and land cover change : Observations and consequences (21 June 2002)

Dr. (Smt.) S. Gadgil, Indian Institute of Sciences, Bangalore

- Physics of monsoon (17 July 2002)

Prof. Vijay Gupta, Co-operative Institute for Research in Environmental Sciences (CIRES), Boulder, Colorado, USA

- Statistical scaling in a dynamical model of tropical oceanic convection (7 August 2002)

Dr. Akio Kitoh, Climate Research Department, Meteorological Research Institute (MRI), Tsukuba, Japan

- Effect of orography on the climate system (24 December 2002)

Shri Prakash Khare, Geophysical Fluid Dynamics Laboratory, Princeton University, USA

- Adaptive observations for improved numerical weather prediction (14 January 2003)

Prof. Tsutomu Takahashi, Obirin University, Tokyo, Japan

- Rain accumulations and lightning activities of east-Asian monsoon rain-rainvideosonde observation (11 February 2003)

Dr. Ravindra Tewari, Scientist, National Chemical Laboratory, Pune

- DNA: The blueprint of life (National Science Day Lecture) (28 February 2003)

Dr. V. Krishnamurthy, Center for Ocean-Land-Atmosphere Studies, Institute of Global Environment and Society, USA

- Variability of the Indian Ocean: Relation to ENSO and monsoon (11 March 2003)

Dr. U.S. De, Additional Director General of Meteorology (Retd.), India Meteorological Department

- WMO – Its role and achievements (WMO Day Lecture) (24 March 2003)

By Institute Scientists

Shri Y.K. Tiwari

- Tropical urban aerosol distributions during pre-sunrise and post-sunset period as observed with lidar and solar radiometer at Pune, India (3 April 2002)

Shri J. Sanjay

- Unified cumulus convection parameterization scheme based on precipitation super ensemble (10 April 2002)

Smt. A.A. Deo

- Oceanic response to moving cyclones in Indian Ocean (15 May 2002)

Dr. P.C.S. Devara

- Climate modification by atmospheric aerosols: Inferences from long-term lidar and radiometric measurements at Pune, India (18 June 2002)
- Lidar and radiometric studies of aerosol, ozone and precipitable water content distributions over land and sea regions from measurements during INDOEX field phases (18 June 2002)
- Four-year climatology of total column urban aerosol, ozone and water vapour distributions over Pune, India (29 August 2002)
- Study of free tropospheric aerosols using combined active and passive remote sensing techniques (29 August 2002)

Smt. U.V. Bhide

- Evolution of breaks due to heat sources over northwest India (13 July 2002)

Shri S.S. Dugam

- NAO, regional pressure index and monsoon variability (21 August 2002)

Kum. Neeju Saraf

- Behaviour of tropospheric ozone and its precursors over oceanic environments (26 August 2002)

Shri S.Mahapatra

- Bhukamp (in Hindi) (17 September 2002)

Dr. P.S.P. Rao

- Chemical composition of wet and dry deposition at urban and rural locations in India (15 November 2002)

Shri A.K. Srivastava

- Observations of aerosols over Gadanki (6 December 2002)

Dr. G.B. Pant

- The climate agenda (1 January 2003)

Dr. Pankaj Kumar

- Interannual variability of northeast monsoon rainfall over south peninsular India : Teleconnections and long range prediction (7 March 2003)

Shri S.K. Saha

- Aerosol optical depth and precipitable water content variations during different atmospheric conditions (20 March 2003)

Dr. K. Rupa Kumar

- Empirical approach and seasonal forecasting of Indian summer monsoon: problems and prospects (21 March 2003)

Dr. R. Krishnan

- Role of Indian Ocean SST forcing on the interannual variability of the south Asian monsoon (21 March 2003)

Dr. K. Krishna Kumar

- Climatic impacts on Indian agriculture (21 March 2003)

Shri. S.B. Kakade

- Use of the tendency of simultaneous impact on NAO and SO for monsoon rainfall prediction (21 March 2003)



Academic Activities

Guidance to Students of Research Projects

Dr. P.C.S. Devara

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

Dr. K. Rupa Kumar

- Kum. N. Jyoti, M.Tech. (Atmospheric Science), Sri Venkateswara University, Tirupati
- Shri D. Srikanth, M. Tech. (Atmospheric Sciences), Andhra University, Visakhapatnam

Dr. (Smt.) P.S. Salvekar

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

Shri S. Sinha

- Shri V. Chaugule, M. Sc., Nowrosjee Wadia College, Pune

Dr. S. Sivaramakrishnan

- Shri R. Iyer, M. Sc., Nowrosjee Wadia College, Pune

Shri P. Seetaramayya

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

Shri J.R. Kulkarni

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

Dr. P.S.P. Rao

- Kum. S. Shailli, M. Sc. (Environmental Science), University of Pune, Pune

Dr. (Smt.) I. Joshi

- Smt. T. Priscilli Pilli, Ph. D., University of Pune, Pune

Dr. K. Krishna Kumar

- Kum. K.Kamala, M.Tech. (Atmospheric Science), Andhra University, Visakhapatnam
- Shri P.K. Pradhan, M. Tech. (Atmospheric Sciences), Andhra University, Visakhapatnam

Shri D.R. Chakraborty

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

Dr. H.P. Borgaonkar

- Shri A.B. Sikder, M. Sc. (Environmental Science), University of Pune, Pune

Dr. B.D. Kulkarni

- Shri T. Krishnamurthy, M. Tech. (Atmospheric Sciences), Sri Venkateswara University, Tirupati

Dr. Y. Jaya Rao

- Shri S.S.C. Bhardwaj, M. Tech. (Space Technology and Applications), Sri Venkateswara University, Tirupati
- Shri R.R. Raut, M. Tech. (Atmospheric Sciences), University of Pune, Pune
- Smt. M. Bose, M.Sc. (Astrophysics), University of Pune, Pune

Dr. C. Gnanaseelan

- Shri Yellamanda, M.Tech. (Atmospheric Science), Andhra University, Visakhapatnam
- Shri J.S. Chowdary, M. Tech. (Atmospheric Physics), University of Pune, Pune
- Shri P. Pattanaik, M. Tech. (Atmospheric Physics), University of Pune, Pune

Dr. S.B. Debaje

- Kum. Kharche, M. Sc., Fergusson College, Pune
- Kum. Upare, M. Sc., Fergusson College, Pune

Expertise Provided

Dr.G.B. Pant

- Third Post-Graduate Course in Satellite Meteorology and Global Change (SATMET-III), Space Applications Centre, Ahmedabad, 13-14 January 2003

Dr. A.K. Kamra

- Refresher Course sponsored by UGS on Cloud Physics and Atmospheric Electricity, Department of Atmospheric Sciences, Cochin University of Science and Technology, Kochi, 20-26 May 2002
- SERC School on Aviation Meteorology, Air Force Administrative College, Coimbatore, 28-29 December 2002

Dr. K. Rupa Kumar

- NATCOM Training Programme, Indian Institute of Technology, Mumbai, 23-27 April 2002

- Third Post-Graduate Course in Satellite Meteorology and Global Climate (SATMET-III), Space Application Centre, Ahmedabad, 25-27 November 2002

Dr. R. Vijayakumar

- Refresher Course sponsored by UGC on Cloud Physics and Atmospheric Electricity, Department of Atmospheric Sciences, Cochin University of Science and Technology, Kochi, 20-26 May 2002
- Third SERC School on Numerical Weather Prediction-Parameterization of Physical Processes, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, 8 April – 4 May 2002

Dr. S.S. Parasnis

- Third SERC School on Numerical Weather Prediction-Parameterization of Physical Processes, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, 8 April – 4 May 2002
- SERC School on Aviation Meteorology, Air Force Administrative College, Coimbatore, 28-29 December 2002

Dr. P. N. Mahajan

- Utility of Satellite Remote Sensing for Better Monitoring of Monsoon Systems over the Indian Region, RS-GIS Application in Water Resources Development, National Water Academy, Pune, 18 February 2003

Shri J.R. Kulkarni

- Course on Advanced Modelling Technology: Emerging Trends, Institute of Armament Technology, Pune, 26 September 2002

Dr. R.H. Kripalani

- Advanced Meteorological Training Course (Examination), India Meteorological Department, Pune

Dr. (Smt.) N.A. Sontakke

- Refreshers course on the Watershed and Disaster Management, Department of Geology, University of Pune, Pune, 26 December 2002

Shri B.N. Mandal, Smt. N.R. Deshpande and Dr. B.D. Kulkarni

- Senior Level Refresher Course on Hydrology, India Meteorology Department Training Centre, Pune, 8-9 October 2002

Dr. C.G. Deshpande

- Examination of Scientific Projects for National Children Science Congress-2002,
 - i) Pune City Level, Jnana Probodhini School, Pune, 23-24 November 2002
 - ii) Maharashtra State Level, Amrut College Sangamner, 29 November - 1 December 2002

Nomination / Membership

Dr. G.B. Pant

- Member, Executive Council, Indian Science News Association
- Member, Editorial Advisory Committee, Association of Agrometeorologists, Anand, Gujarat
- Member, Editorial Board, Mausum, India Meteorological Department, New Delhi
- Member, Editorial Board, Vayu Mandal, Indian Meteorological Society, New Delhi
- Member, Joint Scientific Committee (JSC) of WCRP, The World Climate Research Programme (WMO/ICSU/IOC)
- Member, WMO Commission of Atmospheric Sciences Working Group on Tropical Meteorology Research
- Member, Committee National Natural Resource Management System, Planning Commission, Government of India

Dr. P.C.S. Devara

- Member, Governing Council of the Instrument Society of India, Bangalore
- Member, National Organizing Committee of the IASTA 2002 Conference, Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, 18-20 September 2002.
- Member, Specification Committee for Procurement of Instruments needed for Monitoring Greenhouse Gases and Aerosols constituted by the Director General of Meteorology, India Meteorological Department, New Delhi
- Member, Editorial Board, Aerosol and Air Quality Research

Dr. K. Rupa Kumar

- Member, Organising Committee of the International Conference on Developments in Hydrology—the Current Status, and Colloquium on Water Resources Management, organised by the Indian Journal of Power and River Valley Development, Kolkata, 24-25 October 2002

Dr. (Smt.) P.S. Salvekar

- Member, Subject Experts Committee (Earth and Atmospheric Sciences), Technical evaluation of proposals under Women Scientists Scheme of the Department of Science and Technology, New Delhi

Dr. R.H. Kripalani

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

Shri B.N. Mandal

- Member, Organising Committee of the International Conference on Developments in Hydrology—the Current Status, and Colloquium on Water Resources Management, organised by the Indian Journal of Power and River Valley Development, Kolkata, 24-25 October 2002

Dr. P.S.P. Rao

- Associate Editor, Journal of Current Sciences, Dumka

Shri S. Mahapatra

- Member, Executive Committee, Indian Meteorological Society, Pune Chapter for 2003-2005

Lectures Delivered Outside**Dr. G.B. Pant**

- Problems of modelling South Asian Climate, Indian Science Congress, Bangalore University, Bangalore, 5 January 2003

Dr. P.C.S. Devara

- Atmospheric studies using lidar, Institute of Armament Technology, Pune, 12 February 2003

Dr. K. Rupa Kumar

- Monsoon-2002, Ahmedabad Centre of the Indian Meteorological Society, Ahmedabad, 3 December 2002

Dr. N. Singh

- Impact of climatic fluctuations and land use/land cover changes (LUCC) on the Indo-Gangetic Plains, India, National Bureau of Soil Survey and Land Use Planning (NBSS and LUP), Nagpur, 4 January 2003

Dr. R. Krishnan

- Abnormal Indian summer monsoon of 2000, Indian Institute of Science, Bangalore, 27 November 2002
- Preliminary results of ocean GCM response to the south Asian haze, TATA Energy Research Institute, New Delhi, 20 December 2002

Dr. P.N. Mahajan

- Satellite aani hawaman (in Marathi), Sane Guruji Vachanalaya, Hadapsar, Pune, 23 December 2002

Shri J.R. Kulkarni

- Uses of chaos theory in atmospheric science—advanced modelling technology, emerging trends, Institute of Armament Technology, Girinagar, Pune, 26 September 2002

Dr. R.H. Kripalani

- Indian monsoon variability in a global warming scenario, Mt. Jiri, Korea, 26 September 2002
- Indian Ocean dipole and monsoon variability over south and east Asia, Pukyong National University, Busan, South Korea, 17 December 2002
- Indian Ocean dipole, Climate Research Laboratory, Meteorological Research Institute, Korea Meteorological Administration, Seoul, South Korea, 7 January 2003

Dr. G. Beig

- Global change and atmospheric environment, Kolkata, 22 December 2002

Smt. U.V. Bhide

- Development of monsoon breaks due to heat source over Northwest India, Indian Meteorological Society, Pune, 11 July 2002

Shri S. Mahapatra

- Interaction of cumulus cloud ensemble with large-scale environment, Indian Institute of Technology, New Delhi, 29 April 2002

Dr. G. Pandithurai

- Aerosol monitoring using lidar and radiometric techniques : activities at IITM, Pune, National Center for Environmental Prediction, National Oceanic and Atmospheric Administration, Washington D.C., USA, 23 April 2002

Shri M. Mujumdar

- Role of initial and boundary conditions in simulating monsoon variability, Indian Academy of Industrial and Applicable Mathematics, Pune Chapter, Pune, 10 November 2002

Shri Y.K. Tiwari

- Tropical urban aerosol distributions during pre-sunrise and post-sunset period as observed with LIDAR and Solar radiometer at Pune, Max-Planck Institute for Bio-geochemistry, Jena, Germany, 10 April 2002

Training Undergone

- Shri S.D. Patil completed the Post Graduate Diploma Course in Satellite Meteorology and Global Climate conducted by the Centre for Space Science and Technology Education in Asia and Pacific (CSSTE-AP), Space Application Centre, Ahmedabad
- Smt. S. Nair and Smt. J.V. Revadekar completed the Advance Meteorological Training Course conducted by the India Meteorological Department, Pune
- Shri. D.W. Ganer has been deputed for the Advance Meteorological Training Course being conducted by the India Meteorological Department, Pune



Ph.D. and Post-Graduate Programme

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

Shri M. Mujumdar

Studies on initial and boundary conditions in climate models using spectral techniques: applications to Asian monsoon
(Guide : Dr. R. Krishnan)

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

Smt. S.S. Naik

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

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

Smt. S.G. Nagar

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

Smt. T. Priscilla Pilli

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

Shri P.R. Patil

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

Recognition as Ph.D. Guide

Dr. P.E. Raj, has been recognized by the University of Pune, Pune as a research guide for Ph. D. in Physics, Faculty of Science

Teaching and Research Support to University of Pune, Pune

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

Dr. P.C.S. Devara

- Floating instrument platform (FLIP) , M. Tech. (Atmospheric Physics)
- Thermal infrared multi-spectral scanner (TIMS), M. Tech. (Atmospheric Physics)
- Modern observational techniques, M. Tech. (Atmospheric Physics)

Dr. (Smt.) P.S. Salvekar

- Satellite Meteorology, M. Tech. (Atmospheric 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

- Monsoon, M.Sc. (Space Science)
- Climate Modelling, M.Tech. (Atmospheric Science), M.Sc. (Space Science)
- Fluid Mechanics, M.Tech. (Atmospheric Science), M.Sc. (Space Science)
- Monsoon Meteorology, M.Tech. (Atmospheric Science)
- Non-Linear Dynamics, M.Tech. (Atmospheric Science), M.Sc. (Space Science)
- Chaos, M.Tech. (Atmospheric Science)
- Cloud Physics, M.Sc. (Space Science)

Dr. P.S.P. Rao

- Air Pollution, M.Sc. (Environmental Sciences)

Shri D.R. Talwalkar

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

Shri D.R. Chakraborty

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

Shri Prem Singh

- Finite differences and numerical integration methods, M.Tech. (Atmospheric Physics)

Dr. C. Gnanaseelan

- Data Processing and Numerical Methods, M. Tech. (Atmospheric Physics)
- Mathematics-Bridge Course, M.Tech. (Atmospheric Physics)

Smt. S.K. Mandke

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

Shri S. Mahapatra

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

Dr. (Smt.) A.A. Kulkarni

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

Shri M. Mujumdar

- Data Diagnostics, M.Sc.(Space Science)

Smt. A.A. Deo

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

Dr. K. Ali

- Air Pollution, M.Sc. (Environmental Sciences)

Dr. P.D. Safai

- Air Pollution, M.Sc. (Environmental Sciences)

Shri M. Mahakur

- Time integrations of non-divergent barotropic vorticity equation, M.Tech. (Atmospheric Physics - Practicals)

Nominations as External Examiner/Paper Setter/Member of the Selection Committee etc.**Dr. G.B. Pant**

- Ph.D., Indian Institute of Science, Bangalore
- Ph.D., Berhampur University, Berhampur
- Ph.D., Banaras Hindu University, Varanasi
- Ph.D., Indian Institute of Technology, New Delhi
- Ph.D., Devi Ahilya Vishwavidhyalaya, Indore

Dr. P.C.S. Devara

- Ph.D., M. L. Sukhadia University, Udaipur

Dr. D.B. Jadhav

- Ph.D., Udaipur University, Udaipur

Dr. (Smt.) P.S. Salvekar

- M.Tech., (Atmospheric Physics), University of Pune, Pune
- Ph.D., Indian Institute of Sciences, Bangalore
- Ph.D., Utkal University, Bhubaneswar
- Ph.D., Andhra University, Visakhapatnam
- Ph.D., University of Pune, Pune

Dr. S. Sivaramakrishnan

- Ph. D., University of Mumbai, Mumbai

Dr. R. Krishnan

- Ph. D., University of Delhi, Delhi
- M. Sc. (Engineering), Indian Institute of Science, Bangalore

Dr. P.E. Raj

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

Dr. P.N. Mahajan

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

Shri J.R. Kulkarni

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

Dr. G. Beig

- Ph.D., Saurashtra University, Rajkot

Dr. (Smt.) I. Joshi

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

Dr. Y. Jaya Rao

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

Dr. (Smt.) A.A. Kulkarni

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

Dr. G. Pandithurai

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



Deputation Abroad

Dr. G.B. Pant

- Participation in the PROMISE European Meeting, Paris and visit to the Centre National de Recherches Meteorologique (CNRM), Toulouse in connection with the project entitled, 'Sensitivity of the Indian Summer Monsoon to Anthropogenic Climate Change', **France** (12-27 May 2002)
- Participation as an Indian delegate in the 5th Meeting of the Indo-Russian Sub Working Group on Meteorology, Moscow, **Russia** (11-18 October 2002)
- Participation in the 24th Session of Joint Scientific Committee (JSC) for World Climate Research Programme (WCRP), Reading, **U.K.** (13-24 March 2003)

Dr. P.C.S. Devara

- Participation in the 21st International Laser Radar Conference, Quebec City, **Canada** (5-15 July 2002)
- Participation in the 6th International Aerosol Conference (IAC-2002), Taipei, and International Aerosol Research Assembly (IARA), International Convention Centre, Taipei, **Taiwan** (6-15 September 2002)

Dr. V. Satyan

- Appointment as Director for Climate Modelling with the Joint Planning Staff for the World Climate Research Programme, World Meteorological Organisation, Geneva, **Switzerland** (11 October 2002 - 10 October 2004)

Dr. K. Rupa Kumar

- Participation as a Member of the Scientific Steering Committee, in the IPCC Workshop on Changes in Extreme Weather and Climate Events, Beijing, **China** (9 -16 June 2002)
- Participation in the SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SAARC Meteorological Research Centre, Dhaka, **Bangladesh** (9-14 December 2002)
- Participation in the Workshop on Water Resources in South Asia : an Assessment of Climate Change Associated Vulnerabilities and Coping Mechanisms, Kathmandu, **Nepal** (6-13 January 2003)
- Participation in the 5th Meeting of the Asian-

Australian Monsoon Panel (AAMP) of CLIVAR, Atlanta, **USA**
(24 February – 3 March 2003)

- Participation in the Conference on Mountain Environments : Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change , Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (22-30 March 2003)

Dr. (Smt.) P.S. Salvekar

- Participation in the US-India Earth-Atmospheric Science Workshop in Support of Recently Extended Memorandum of Understanding (MoU) for Science Co-operation, NASA/NOAA-USA, Department of Space and Department of Science and Technology, Government of India, Centre for Ocean Land Atmosphere (COLA) Studies, Maryland, **USA** (13-26 December 2002)

Dr. R. Krishnan

- Participation in the Conference on Mountain Environments : Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change , Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (22-30 March 2003)

Dr. S.S. Parasnis

- Research Work in connection with DST-NSF project entitled, 'Investigations of processes in Atmospheric Boundary Layer', Oregon State University and University of Cincinnati, **USA** (16 August - 22 September 2002)

Dr. R.H. Kripalani

- Visiting Professor, Climate Modelling Research Laboratory, Department of Environmental Atmospheric Sciences, Pukyong National University, Busan, **South Korea** (22 July 2002 – 21 January 2003)

Dr. G. Beig

- Participation in the Heracus Seminar on Trends in the Upper Atmosphere, Kuhlungsborn, **Germany** (10-18 May 2002)

Dr. A.K. Sahai

- Collaborative research work at Department of Physics, Federal University of Parana, Curitiba, **Brazil** (1 February 2001 - 1 February 2003)

Dr. P.S.P. Rao

- Participation in the First Workshop on Composition of Asian Deposition (CAD), Malaysian Meteorological Service, Kuala Lumpur, **Malaysia** (19-25 November 2002)
- Research Work in connection with Indo-Swedish Collaborative Project, 'Composition of Asian Precipitation (CAD)', Stockholm University, **Sweden** (4-18 December 2002)

Dr. K. Krishna Kumar

- Participation in the Inaugural Meeting for the project, 'Applying Climate Information to Enhance the Resilience of Farming System Exposed to Climate Risk in South and Southeast Asia', Bangkok, **Thailand** (21-25 May 2002)
- Participation in the Workshop and Conference on El-Nino and Tropical Ocean Atmosphere Interaction, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (31 May -16 June 2002)

Research Work in connection with ongoing APN Project 'Applying Climate Information to Enhance the Resilience of Farming System Exposed to Climatic Risk in South and Southeast Asia, International Research Institute for Climate Prediction (IRI), New York, **USA** (16-29 November 2002)

- Research Work in connection with the ongoing collaboration on the project, 'Climate Change Scenario Development Work', Hadley Centre for Climate Prediction and Research, Reading **U.K.** (30 November - 9 December 2002)
- Participation in the Conference on Mountain Environments : Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change , Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (22 - 30 March 2003)

Dr. A.L. Londhe

- Participation in the Cruise of Sagar Kanya, **Mauritius** (10 October - 10 November 2002)

Smt. S.K. Patwardhan

- Participation in SAARC Training Seminar on Summer Monsoon Techniques, Department of

Hydrology and Meteorology, Government of Nepal, Kathmandu, **Nepal** (17 - 20 December 2002)

Shri A.B. Sikder

- To work at the Tree-Ring Laboratory, Lamont Doherty Earth Observatory, Columbia University, New York, **USA** (10 June - 12 July 2002)

Dr. (Smt.) A.A. Kulkarni

- Participation in the SAARC Seminar on Climate Variability in the South Asian Region and its Impacts, SAARC Meteorological Research Centre, Dhaka, **Bangladesh** (9 - 14 December 2002)

Shri J. Sanjay

- Visiting Scientist, Department of Meteorology, Florida State University, **USA** (1 September 2002 - 31 August 2003)

Smt. A.A. Deo

- Participation in the Workshop and Conference on El-Nino and Tropical Ocean Atmosphere Interaction, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (1 - 16 June 2002)

Dr. G. Pandithurai

- Research Work in connection with the DST-NSF Joint Research Project entitled, 'Aerosol Optical Characterization and Investigation of Aerosol Radiative Forcing at the Surface and Top of the Atmosphere', Department of Meteorology, University of Maryland, **USA** (1 - 30 April 2002)

Shri S.B. Kakade

- Participation in the Conference on Monsoon Environments : Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (22 - 30 March 2003)

Shri P. Mukhopadhyay

- Participation in the Spring Colloquium on the Physics of Weather and Climate : Regional Weather Prediction, Modelling and Predictability, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy** (6 - 21 April 2002)

Dr. M. Mujumdar

- Research Scientist, Department of Earth and Planetary Sciences, University of Tokyo, Tokyo, **Japan**
(12 December 2002-11 December 2003)

Shri Y.K. Tiwari

- Visit to Max-Planck Institute for Bio-geochemistry (MPI-B), Jena, **Germany**
(8-14 April 2002)

Shri K.V. Ramesh

- Participation in the Workshop and Conference on El Nino and Tropical Ocean Atmosphere Interaction, Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy**
(31 May -16 June 2002)

Kum. Nitu Saraf

- Participation in the Joint IGAC and CACGP International Symposium on Atmospheric Chemistry within the Earth System : from Regional Pollution to Global Change, Heraklion, Crete, **Greece**
(18-27 September 2002)

Shri Pankaj Kumar

- Participation in the Conference on Mountain Environments : Agricultural and Hydrological Impacts of Seasonal Variability and Climate Change , Abdus Salam International Centre for Theoretical Physics, Trieste, **Italy**
(22-30 March 2003)



International

Dr. L. Granat

Associate Professor
Department of Meteorology
Stockholm University, Stockholm, **Sweden**
15 May - 1 June 2002

Mr. Lochan Prasad Devkota

Tribhuvan University, Kathmandu
Mr. Saraju Kumar Baidya
Meteorologist
Department of Hydrology and Meteorology
Kathmandu, **Nepal**
17-30 June 2002

Mr. Navin Ramankutty

Assistant Scientist
Centre for Sustainability
and Global Environment (SAGE)
University of Wisconsin
Madison, **U.S.A.**
19-21 June 2002

Dr. Vijay Gupta

Co-operative Institute for
Research in Environmental Sciences
Boulder, Colorado, **U.S.A.**
7 August 2002

Dr. James Hansen

International Research Institute
for Climate Prediction
New York, **U.S.A.**
28-29 September 2002

Prof. J. Shukla

Scientist
Centre for Ocean Land
Atmosphere (COLA) Studies,
Maryland, **U.S.A.**
27 October 2002

Dr. Richard Jones

Hadley Centre for Climate Prediction
UK Meteorological Office, **U.K.**
1 November 2002

Dr. Akio Kitoh

Meteorological Research Institute (MRI)
Japan Meteorological Agency
Tsukuba, **Japan**
21-25 December 2002.

Prof. Tsutomu Takahashi

Obirin University
Tokyo, **Japan**
9-11 February 2003

Dr. V. Krishnamurthy

Center for Ocean Land
Atmosphere (COLA) Studies
Maryland, **U.S.A.**
11 March 2003

National

Ms. S. Bhadwal and Ms. A. Paul

Tata Energy Research Institute
New Delhi
14-16 April 2002

Dr. M.B. Potdar

Space Applications Centre
Ahmedabad
16-18 April, 24-28 September,
25-27 October and 18-23 November 2002
22-25 February and 24-26 March 2003

Dr. Anand Patwardhan

Associate Professor
Indian Institute of Technology
Mumbai
16 April 2002

Dr. A. Ganju

Deputy Director
Snow and Avalanche Study Establishment,
Chandigarh
17 May 2002

Shri A. Singh

Research Scientist
S.J.M. School of Management
Indian Institute of Technology
Mumbai
27-31 May 2002

Dr. M. Swamy

Scientist
Central Leather Research Institute
Chennai
10 June 2002

Shri P.K. Chanda

Executive Editor
Indian Journal of Power and
River Valley Development
Kolkata
12 June 2002

Shri M.S. Bhagwat

Group Manager (ENV)
National Council for Cement
and Building Materials (NCCBM)
Haryana
16-17 July 2002

Dr. (Smt.) S. Bhattacharya

Expert Consultant
NATCOM
New Delhi
26-28 August 2002

Assistant Directors

Central Water Commission
National Water Academy
Khadakwasla
Pune
4 September 2002

Met. Observers, Sailors

School of Naval Oceanology
and Meteorology
INS Garuda, Kochi
4 September 2002

Dr. B.K. Purandare

Scientist
National Institute of Hydrology
Belgaum
21 November 2002

Trainees

Centre for Advanced studies
in Agricultural Meteorology
College of Agriculture
Pune
13 December 2002, 28 January 2003

Shri D.S. Madaan,

Deputy Director (Hyd)
Central Water Commission
New Delhi
3 January 2003

Mr. Guy Honore

German Project Coordinator

Ms Indrani Phukan

Project Officer
Indo-German Bilateral Project on
Water Shade Management (IGBP)
New Delhi
6 February 2003

Dr. S. Bose

Project Consultant
ERM, India Pvt. Ltd.
New Delhi
13 February 2003

Dr. N. Ghose

Additional Director

Shri S. Govindam

Joint Director

Dr. M.M. Kshirsagar

Research Officer
Central Water and Power Research Station
Pune
14 February 2003

Shri S.R. Kulkarni

Vice-President

Shri V.B. Agashe

Chief Engineer
BSES Ltd., Mumbai
4 March 2003

Shri A.N. Dave

General Manager (PE-Civil and Hydro)

Shri S.M. Khare

Deputy Manager

Shri M. Chatterjee

National Thermal Power Corporation

Shri S. Govindan

Joint Director
Central Water and Power
Research Station
Pune
20 March 2003

Trainee Officers,

Air Force Administrative College
Coimbatore
20 March 2003



National Technology Day Lecture by Prof. (Smt.) S. K. Kulkarni



National Science Day Lecture by Dr. Ravindra Tewari



World Meteorological Day Lecture by Dr. U. S. De



Visit of Students to laboratories on Open Day



Students interacting with Director, IITM



Institute's participation in Swadeshi Mela, Mumbai



Hindi Week Celebration - Welcome Address by Dr. Nityanand Singh, (R to L) Dr. Shrikant Upadhyay and Dr. Sabhajit Singh, Chief Guests, Dr. G.B. Pant, Director, IITM



Vigilance Awareness Programme lecture by Smt. Vinita Deshmukh, Deputy Resident Editor, Indian Express

Academic Faculty

| Name | Specialisation | E-mail Address | Academic Qualifications |
|--------------------------|--|-----------------------|-------------------------|
| Dr. G.B. Pant | Climate, Climatic Change, Palaeoclimatology, Monsoon Variability and Prediction | gbpant@tropmet.res.in | M.Sc., Ph.D. |
| Dr. A.K. Kamra | Cloud Physics, Atmospheric Electricity, Aerosol Physics | kamra@tropmet.res.in | M.Sc., Ph.D. |
| Dr. S.S. Singh | Numerical Weather Prediction | sssing@tropmet.res.in | M.Sc., Ph.D. |
| Dr. P.C.S. Devara | Atmospheric Optics, Remote Sensing of Atmospheric Aerosols and Trace Gases, Aerosol-Climate Interactions | devara@tropmet.res.in | M.Sc., Ph.D. |
| Dr. V. Satyan | Climate Modelling, Ocean-Atmosphere Interaction, Climate Variability, Dynamical Seasonal Monsoon Forecasting | satyan@tropmet.res.in | M.Sc., Ph.D. |
| Dr. D.B. Jadhav | Spectrometric Techniques for Atmospheric Chemistry, Radiation, Atmospheric Electricity | dbj@tropmet.res.in | M.Sc., Ph.D. |
| Dr. K. Rupa Kumar | Climate Change, Monsoon Variability and Prediction, Dendroclimatology, Climate Impact Studies | kolli@tropmet.res.in | M.Sc., Ph.D. |
| Dr. (Smt.) P.S. Salvekar | Monsoon Disturbances, Simulation of Atmospheric and Oceanic Circulation, Human Resource Development for Atmospheric Sciences | pss@tropmet.res.in | M.A., Ph.D. |
| Shri S. Sinha | Theoretical and Experimental Atmospheric Boundary Layer Studies | ssinha@tropmet.res.in | M.Sc. |
| Dr. R. Vijayakumar | Cloud Physics, Numerical Modelling of Clouds | vijay@tropmet.res.in | M.Sc., Ph.D. |
| Dr. S. Sivaramakrishnan | Atmospheric Boundary Layer, Wind Tunnel Simulations | siva@tropmet.res.in | M.Sc., Ph.D. |
| Dr. Nityanand Singh | Hydrometeorological Studies, Rainfall Prediction on Shorter Spatial and Temporal Scales | nsingh@tropmet.res.in | M.Sc., Ph.D. |
| Dr. R. Krishnan | Climate Modelling, Interannual and Intraseasonal Monsoon Variability, Ocean-Atmosphere Interaction, Monsoon Diagnostics | krish@tropmet.res.in | M.Sc., Ph.D. |
| Dr. S.S. Parasnis | Atmospheric Boundary-Layer Modelling | paras@tropmet.res.in | M.Sc., Ph.D. |
| Shri P. Seetaramayya | Air-Sea Interaction, Marine Boundary Layer Studies | seetar@tropmet.res.in | M.Sc. Tech. |

| Name | Specialisation | E-mail Address | Academic Qualifications |
|---------------------------|--|-------------------------|-------------------------|
| Dr. P.E. Raj | Optical and Radio Remote Sensing of the Atmosphere, Environmental Studies, Aerosol-Climate Interactions | ernest@tropmet.res.in | M.Sc., Ph.D. |
| Dr. P.N. Mahajan | Satellite Data Applications for Weather Forecasting | mahajan@tropmet.res.in | M.Sc., Ph.D. |
| Shri J.R. Kulkarni | Physical Processes in Atmospheric and Oceanic Global Circulation Models, Monsoon Variability and Prediction, Non-linear Dynamics and Chaos | jrksup@tropmet.res.in | M.Sc. |
| Dr. R. H. Kripalani | Asian Monsoon and Climate Variability | krip@tropmet.res.in | M.Sc., Ph.D. |
| Smt. S.S. Vaidya | Numerical Weather Prediction with Special Emphasis on the Physical Processes | ssvady@tropmet.res.in | M.Sc. |
| Shri B.N. Mandal | Hydrometeorological Studies for Different River Basins and Regions | mandal@tropmet.res.in | B.Sc. |
| Shri M.K. Tandon | Development of Scientific Computing Techniques for Atmospheric Sciences | tandon@tropmet.res.in | M.Sc. |
| Dr. G. Beig | Atmospheric Chemistry, Greenhouse Gases-Analysis and Modelling | beig@tropmet.res.in | M.Sc., Ph.D. |
| Dr. T. Venugopal | Numerical Weather Prediction, Planetary Boundary-Layer Studies | tvgopal@tropmet.res.in | M.Sc., Ph.D. |
| Dr. A.K. Sahai | Climate Change, Neural Network Technique in Meteorology, Statistical and Dynamical Forecasting of Monsoon | sahai@tropmet.res.in | M.Sc., Ph.D. |
| Dr. P.S.P. Rao | Air Pollution, Precipitation Chemistry | psprao@tropmet.res.in | M.Sc., Ph.D. |
| Dr. (Smt.) I.S. Joshi | Studies in Upper/Middle Atmosphere and Ionosphere | indira@tropmet.res.in | M.Sc., Ph.D. |
| Dr. (Smt.) S.S. Dhanorkar | Atmospheric Electricity, Aerosol Physics | savita@tropmet.res.in | M.Sc., Ph.D. |
| Dr. K. Krishna Kumar | Monsoon Variability and Prediction, Global Teleconnections and Climate Application | krishna@tropmet.res.in | M.Sc., Ph.D. |
| Dr. (Smt.) N.A. Sontakke | Climate Variability and Prediction with Special Reference to Indian Monsoon | sontakke@tropmet.res.in | M.Sc., Ph.D. |
| Dr. S.K. Sinha | Objective Analysis including Satellite Input for NWP | sinha@tropmet.res.in | M.Sc., Ph.D. Ph.D. |
| Smt. U.V. Bhide | Monsoon Studies and Forecasting | bhide@tropmet.res.in | M.Sc. |

| Name | Specialisation | E-mail Address | Academic Qualifications |
|-------------------------------|--|-------------------------|-------------------------|
| Shri C.M. Mohile | Climate Change, Frequency of Tropical Cyclones, Climate Database Management | mohile@tropmet.res.in | M.Sc. |
| Dr. (Kum.) P.L. Kulkarni | Objective Analysis including Satellite Input for NWP | plk@tropmet.res.in | M.Sc., Ph.D. |
| Dr. J.M. Pathan | Rainfall Climatology of India, Pentad Rainfall Analysis | jmpathan@tropmet.res.in | M.Sc., Ph.D. |
| Shri C.P. Kulkarni | Sun-weather Relationships | cpk@tropmet.res.in | M.Sc. |
| Smt. Leela George | Atmospheric Dynamics, Four Dimensional Regional Energetics for Synoptic Scale Disturbances | lge1@tropmet.res.in | M.Sc. |
| Shri D.R. Talwalkar | Objective Analysis including Satellite Input for NWP | drt@tropmet.res.in | M.Sc. |
| Shri M.Y. Totagi | Monsoon Energetics | frdmail@tropmet.res.in | M.Sc. |
| Smt. S.G. Nagar | Atmospheric Boundary-Layer over Land and Ocean | nagar@tropmet.res.in | M.Sc. |
| Shri D.R. Chakraborty | Atmospheric Energetics in the Wavenumber and Frequency Domain | drc@tropmet.res.in | M.Sc. |
| Shri A. Bandyopadhyay | NWP Modelling and Model Diagnostics | bandop@tropmet.res.in | M.Sc., DIIT |
| Shri A.B. Sathe | Simulation Techniques in Cloud Physics | sathe@tropmet.res.in | B.Sc. |
| Dr. A.L. Londhe | Monitoring of Atmospheric Constituents, Twilight Spectroscopy | londhe@tropmet.res.in | M.Sc., Ph.D. |
| Shri C.S. Bhosale | Monitoring of Atmospheric Constituents, Twilight Spectroscopy | bhosale@tropmet.res.in | M.Sc. |
| Dr. (Smt.) S.S. Khandalgaokar | Thunderstorm Climatology and Related Meteorological Parameters | sskandal@tropmet.res.in | M.Sc., Ph.D. |
| Shri T. Dharmaraj | Atmospheric Boundary-Layer, Instrumentation, and related studies | dharma@tropmet.res.in | B.E. (Electronics) |
| Dr. A.A. Munot | Monsoon Rainfall Variability, Teleconnection and Prediction | munot@tropmet.res.in | M.Sc., Ph.D. |
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 Shri S.R. Nirgude
 Shri V.S. Kulkarni
 Shri V.G. Bathija
 Shri S.N. Prasad
 Smt. R.P. Bhagwat
 Shri N.S. Ramakrishnan

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 Smt. V.V. Massey
 Shri P.G. Bhegade
 Shri A.L. Sagar
 Shri R.R. Mali
 Shri B.C. Morwal
 Shri R.M. Soni
 Shri S.C. Rahalkar
 Shri V.V. Deodhar

Workshop

Shri S.B. Jaunjale

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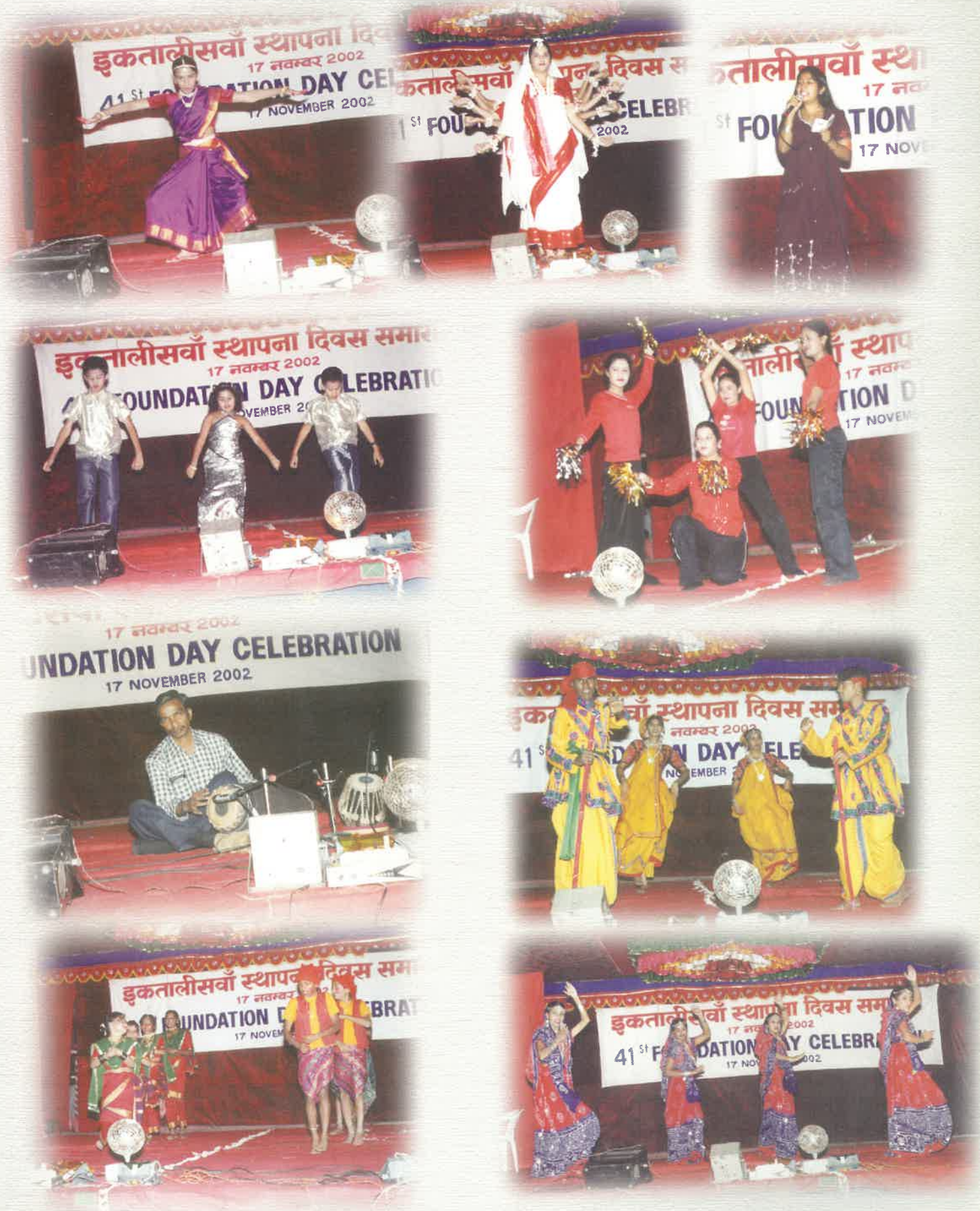
Research Fellows and Project Personnel

| Name | Project (Funding Agency) |
|----------------------------|---|
| Dr. R.S. Maheskumar | Observational Study of Direct Radiative Forcing of Atmospheric Aerosols on the Surface Reaching Solar Flux (Department of Science and Technology, New Delhi) |
| Shri Manish M. Kokate | Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling (Ministry of Environment and Forests, New Delhi) |
| Shri Atul Ayare | Environmental Information System (ENVIS) Node on Acid Rain and Atmospheric Pollutants Modelling (Ministry of Environment and Forests, New Delhi) |
| Shri Y.K. Tiwari | Remote Sensing of the Atmosphere Using Lidar, Radiometric and Other Ground Based Techniques |
| 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 | Numerical Modelling of the Dynamics of North Indian Ocean Circulation (Space Application Centre, Ahmedabad) |
| Shri K. Annapurnaiah | Variability of North Indian Ocean and its Impact on Global Ocean and Understanding the Mechanism of Coastal Circulation around India (Department of Ocean Development, New Delhi) |
| Shri Pankaj Kumar | IMD-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department) |
| Shri Ramaesh Kumar Yadav | IMD-IITM Collaborative Scheme on Development of Long-range Forecasting (India Meteorological Department) |
| Shri K. Jagdish | Development of Regional Tree-ring Data Network to Study the Past Climate Variations on Decadal to Century Time Scale over Asia (Indian Space Research Organisation, Thiruvananthapuram) |
| Shri V. Prasanna | Climate Change Projection for India and Assessment of the Associated Agricultural and Human Health Impact (National Communication (NATCOM), Ministry of Environment and Forests, New Delhi) |
| Kum. Preethi Bhaskar | Management Perspectives to Seasonal Climate Forecast in Mixed Cropping System of Southern India's Semi Arid Field (Global Change System for Analysis, Research and Training / Asia Pacific Network) |
| Shri Akhilesh Kumar Mishra | Numerical Modelling of the Upper Ocean Mixed Layer Over Indian Ocean Region Using Satellite Data (Department of Science and Technology, New Delhi) |
| Shri Mrinal Kanti Biswas | Non-linear Scale Interactions in the Energetics of Monsoon in Wavenumber/Frequency Domain (Department of Science and Technology, New Delhi) |
| Shri Umesh Kumar Singh | Studies of Mesoscale System over Indian Region (Department of Science and Technology, New Delhi) |
| Shri Dipayan Roy | Mesoscale Modelling for Monsoon related Prediction (Council for Scientific and Industrial Research, New Delhi) |

| Name | Project (Funding Agency) |
|-----------------------------|--|
| Shri P. Siva Praveen | Studies of Atmospheric Aerosols, Trace Gases and Precipitation Chemistry in Different Environments (Department of Science and Technology, New Delhi) |
| Dr. Pankaj Kumar Mishra | Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.) |
| Dr. Y.N. Jani | Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.) |
| Shri Sachin Bhandare | Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.) |
| Kum.K.Kamala | Indian Climate Change Scenario for Impact Assessment (Ministry of Environment and Forests, Government of India/Department of Environment, Food and Rural Affairs, Government of U.K.) |
| Shri Amit Kumar Pandey | Atlas of Spatial Features of Moisture Regions and Rainfall of India during 19 th and 20 th Centuries (Department of Science and Technology, New Delhi) |
| Shri Atul Kumar Shrivastava | Study of Coupling between Lidar / Radiometer Measured Aerosol and Radar Sensed Winds (Indian Space Research Organisation, Thiruvananthapuram) |
| Kum. Cini Sukumaran | Measurement of Micrometeorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment (Department of Science and Technology, New Delhi) |
| Kum. T. Rajitha Madhu Priya | Measurement of Micrometeorological Parameters over a Coastal Station and the Atmospheric Constituents and Atmospheric Electrical Parameters over Sea Surface during the Arabian Sea Monsoon Experiment (Department of Science and Technology, New Delhi) |
| Shri Sachin Gunthe | Experimental and Theoretical Studies of Secondary Pollutants and Ozone for Chemical Forecasting (Department of Science and Technology, New Delhi) |
| 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) (Department of Ocean Development, New Delhi) |
| Shri Sachin Deshpande | Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, New Delhi) |
| Shri Narendra Singh | Establishment of Wind Profiler Data Archival and Utilization Centre at IITM for Wind Profiler/Radio Acoustic Sounding System (Department of Science and Technology, New Delhi) |

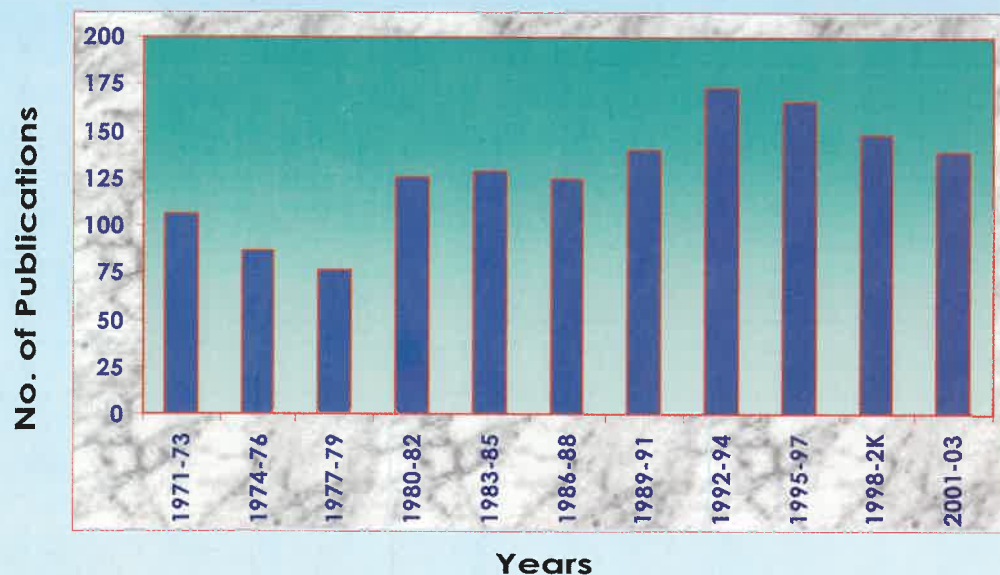


Cultural Programme on Foundation Day Celebration

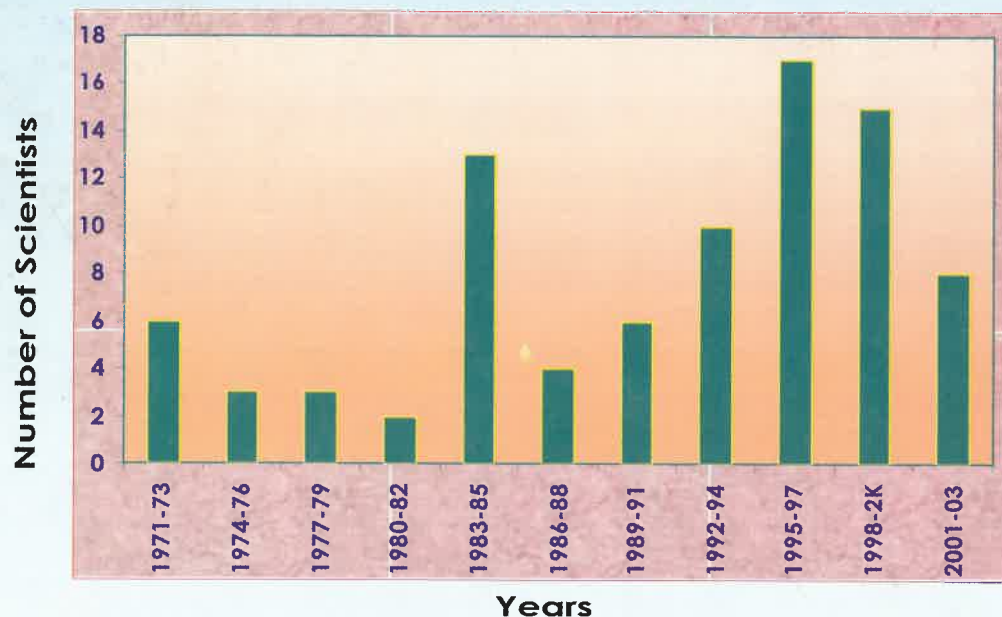


Research and Academic Profile

Research Publications in Journals



Ph.D. Awards



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