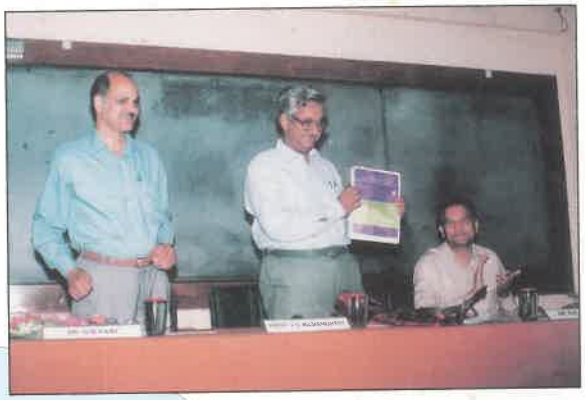
Indian Institute of Tropical Meteorology

ANNUAL REPORT
1998-99

Visit of Prof. V.S. Ramamurthy, Secretary, Department of Science and Technology, Government of India to Indian Institute of Tropical Meteorology

Inauguration of the IITM/IMD Workshop on Forecast Oriented Research Application

Releasing of "Lecture Notes on the Short Term Training Course on Agrometeorological Data Monitoring and Management -1997"



17 August 1998

Prof. V.S. Ramamurthy planting saplings

Dr. R.R. Kelkar, Director General of Meteorology planting saplings

Cover Illustrations

- Institute's Building (Full view).
- Institute's Building (Partial view).
- Library Building.

Indian Institute of Tropical Meteorology
Dr. Homi Bhabha Road , Pashan,
Pune 411 008, India
Phone : 91-020-5893600
Fax : 91-020-5893825
E-mail : siralkar@tropmet.ernet.in

Published by
Director
Indian Institute of Tropical Meteorology
Pune 411 008

Compiled, Edited and Layout by
Library, Information and Publications Division
Indian Institute of Tropical Meteorology
Pune 411 008

ISSN 0250-6017

Annual Report
1998-99

INDIAN INSTITUTE OF TROPICAL METEOROLOGY

GOVERNING COUNCIL

Chairman (Ex-Officio)

Dr.R.R.Kelkar,
Looking after Current Duties of the
Director General of Meteorology,
India Meteorological Department,
New Delhi 110 003

Members

Shri Rahul Sarin,
Joint Secretary and Financial Advisor,
Department of Science and Technology,
New Delhi 110 016

Shri R.K.Midha,
Joint Advisor, Earth System Science Division,
Department of Science and Technology,
New Delhi 110 016

Prof. G.C.Asnani,
Retd. WMO Professor,
University of Nairobi,
Pune 411 007

Prof. (Smt.) Sulochana Gadgil,
Centre for Atmospheric Sciences,
Indian Institute of Science,
Bangalore 560 012

Prof.S.K.Dube,
Centre for Atmospheric Sciences,
Indian Institute of Technology,
New Delhi 110 001

Dr.Pranav S.Desai,
Head, Meteorology and Oceanography
Division, Space Application Centre,
Ahmedabad 380 053

Dr.U.S.De,
Additional Director General of Meteorology
(Research), India Meteorological Department,
Pune 411 005

Dr.G.B.Pant,
Director
Indian Institute of Tropical Meteorology,
Pune 411 008

Non-Member Secretary

Shri V.K.Asrani,
Administrative Officer,
Indian Institute of Tropical Meteorology,
Pune 411 008

Tenure : Two years

FINANCE COMMITTEE

Director,
Indian Institute of Tropical Meteorology,
Pune 411 008

Dr.U.S.De,
Additional Director General of Meteorology
(Research), India Meteorological Department,
Pune 411 005

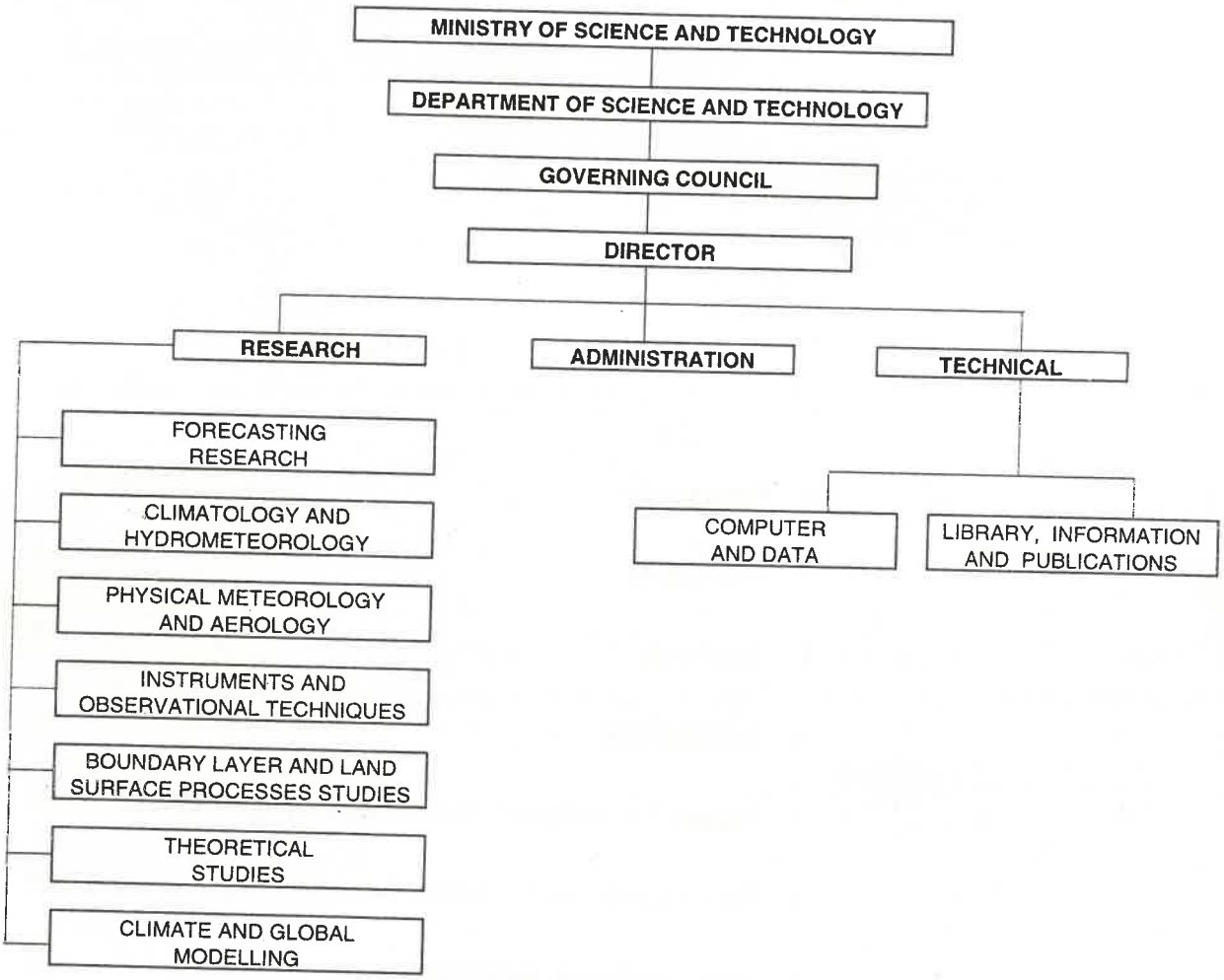
Shri R.K.Midha,
Joint Advisor, Earth System Science Division,
Department of Science and Technology,
New Delhi 110 016

Smt.Vimla Yadav,
Director (Finance),
Department of Science and Technology,
New Delhi 110 016

Tenure : No tenure

Contents

INDIAN INSTITUTE OF TROPICAL METEOROLOGY
PUNE - 411 008



ORGANIZATIONAL PROFILE

Foreword

It is my great pleasure to present the Annual Report of the Institute for the year 1998-99. This report provides a concise description of the various activities of the Institute. A general overview of the research results is presented in the beginning with a summary of highlights so that it serves the purpose of a reference material with complete list of research publications during the year. Collaboration with other scientific and academic institutions has been very active both nationally and internationally. Many scientific contributions of the Institute have brought awards and recognitions to individual scientists. A high standard of research publications and presentation in symposia and seminars is maintained. Several of the Institute scientists and Research Fellows working under the guidance of Institute faculty have been awarded research degrees. High quality of infrastructural support such as library, computer, internet, accommodation, administration, finance, purchase, recreation and canteen has been provided and maintained. We have maintained close interaction with the India Meteorological Department, National Centre for Medium Range Weather Forecasting, Space Applications Centre (ISRO), MST Radar Facility, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, Centre for Atmospheric and Oceanic Sciences, Indian Institute of Science, Bangalore and the Universities of Pune, Andhra, Banaras and Cochin.

The Institute participated in the implementation/ formulation of many collaborative research programmes during the year. At international level collaborations in the field of Atmospheric Sciences with China, Russia, USA, UK and Japan are at different levels of implementation. Several dignitaries and eminent scientists from India and abroad visited the Institute during the year. Many Institute scientists visited the centres of studies in Atmospheric Sciences in different countries of the world as members of important committees/ delegations as well as to present research papers or to work on the projects of relevance to the Institute. Technical guidance, assistance and support to several scientific organisations have been provided.

One of the important features of the Institute's programmes is the promotion of scientific collaboration as a part of its activity to provide expertise to academic institutions, scientific organisations and universities. Teaching and research support is provided to universities in their M.Sc., M.Tech. and Ph.D. programmes.

The Institute continues to play an important role in the proceedings of Inter Governmental Panel on Climate Change (IPCC), International Geosphere Biosphere Programme (IGBP) and Indian Climate Research Programme (ICRP) to ensure national and international coordination of the relevant research programmes. Institute has been actively involved in the research programme involving field observations under INDOEX, BOBMEX and LASPEX. One of the most significant event of the year has been the organisation of an International Workshop on "Long Term Changes and Trends in the Atmosphere" held at the Institute.

I express my sincere thanks to the Governing Council of the Institute for its guidance and support, and to all my colleagues for maintaining the high sense of duty and dedication. I express my thanks to all Heads of Divisions for providing necessary inputs to this report and to Smt. A.A. Shiralkar, Head, Library, Information and Publications Division and her staff for editorial efforts.

G. B. Pant
Director

Visitors from Abroad

Prof. Perov, Central Aerological Observatory, Moscow hydrological service, Moscow, Russia

Dr. Mike Hulme, climate Research Unit, University of East Anglia, UK

Prof. Janet Finch, vice Chancellor, Keele and Dr. Robert Monro, Head, Higher Education Links, B.C. Manchester, UK

Dr. Muthuvel Chellian, National Climate and Environmental Programme (NCEP), Washington, D.C., USA

The Institute is engaged in several scientific research programmes of national and international importance in the area of Meteorology and Atmospheric Sciences. The highlights of the significant achievements of the year are summarised below :

Forecast models based on statistical techniques were developed for the seasonal monsoon rainfall for the year 1998. The forecast input was sent to the India Meteorological Department in the month of May 1998. All the models indicated the rainfall on positive side of the normal. The 106% of the normal rainfall which occurred during June-September 1998 supported the estimates obtained from the studies.

A correlation analysis performed between all India rainfall and momentum transport process of lower tropospheric zonal waves for summer monsoon seasons of 1994, 1995 and 1996 indicated that (i) the transport of momentum by planetary waves influences the all India rainfall, (ii) transport by mean meridional circulation (MMC) has significant correlation with the all India rainfall and (iii) there is consistency in spatial and temporal variations of transport processes of MMC and planetary waves.

The April North Atlantic Oscillation (NAO) index is found to be a useful predictor for the long-range forecasting on smaller spatial scales and showed a significant relationship with monsoon rainfall over south peninsular India, North-west India and West-Central India.

A new nonlocal atmospheric boundary layer diffusion scheme in which the boundary layer height is expressed in terms of a bulk Richardson number in a global spectral model has been found to be more accurate in forecasting the locations of intense precipitation.

Analysis of daily rainfall activity over India during monsoon 1998 showed two important features of intraseasonal variability, viz., a short period stagnation of monsoon across Gujarat and a break during the second fortnight of July. Development of an anomalous heat source in the western part of the monsoon trough area due to convective rainfall and associated latent heat release might have led to the observed stagnation and break phase.

The cloud conditions over India and neighbourhood were monitored on daily basis during pre-onset and onset phase of monsoon 1998 by using the INSAT cloud imageries received through the Secondary Data Utilization Centre (SDUC). The major cyclonic systems over Bay of Bengal during third week of May and over Arabian Sea which hit the Gujarat coast were observed through the hourly cloud imageries. The significant imageries of the system were archived separately for further reference along with the usual archival of the cloud imageries. Particularly during monsoon season daily cloud imageries were provided to Institute scientists and displayed.

Under the Indo-Japanese collaborative project "Dendroclimatological reconstruction and estimation of global environmental changes in monsoon Asia", a study of climatic response of tree ring density variation in *cedrus deodera* over the western Himalaya was carried out. The study revealed the importance of early wood density in the tree ring and climatic relationships, which is quite different from the results of similar studies in other regions.

The nature of monsoon simulation (mean as well as variability) was examined in two coupled atmosphere-ocean general circulation models (HADCM2 and ECHAM4) by applying empirical downscaling techniques. Regional climatic changes due to anthropogenic influence are being estimated.

A new method named extrapography, which involves time series modelling and one step ahead extrapolation, has been developed for the prediction of winter, summer, June, July+August, September and Post-monsoon rainfalls in sequential manner over relatively plain and contiguous India.

The data on atmospheric electric field, conductivity and size distribution of aerosol particles obtained during the XVI Expedition to Antarctica and the INDOEX cruises were studied. The preliminary analysis showed that the phase and amplitude of the observed diurnal variation of electric field were different from the universal diurnal variation observed earlier over oceans and in the Antarctic region. Unusually large concentrations of sub-micron aerosol particles were found to exist in the Intertropical Convergence Zone.

Synoptic data (Agrimet Observatory) of the Land Surface Processes Experiment-97 (LASPEX-97) stations viz. Arnej, Derol, Khanda and Sanand for the year 1997 were analysed. It was seen that more than 50% of the loss of soil moisture by evaporation was compensated by precipitation for all the LASPEX sites, hence the region hardly falls under semi-arid category. The RS/RW (slow rising balloon) data of LASPEX-97 at Anand were also analysed to find the mixed layer height. The 'Mixed layer' height, found by the non-local parcel movement method of Stull, was about 3 km during March - June, 1.5 km during July - September and 2 km during October-February.

Study of day time surface layer (1.30 m) characteristics during monsoon 1989-90 using MONTBLEX data of Kharagpur revealed dynamic instability in the (1-15 m) layer. Wind and temperature time series at 8 m agl revealed short period (2-3 min.) waves arising probably from steepening and eventual breaking-on of meso-scale wave fronts into mini Kelvin-Helmholtz billows. Phase angles of vertical wind components with temperature and the horizontal wind component corroborate the existence of waves.

Day to day three dimensional energetics of west coast and east Arabian sea during the onset phase (first week of June) of 1994 and 1996 monsoon suggests a significant enhancement in basic kinetic energy (KZ) and eddy available potential energy (AE) in the lower troposphere during 1994 .

In a study, "Response of ocean to asymmetric idealised cyclone", it was found that, 30% asymmetry in the wind stress field on the left side of the track acts as the threshold value, to nullify any bias in the model upper layer thickness deviation field.

Oceanic response to a symmetric idealised moving cyclone was studied for three observed tracks in the Arabian sea. The right bias in the model currents is seen in all the cases, whereas the right bias in the upper layer thickness deviation field is noticed only for the cases having northward component in the track of the cyclone.

The DST sponsored Climate Research Project has completed its first phase on 31 March 1999. The project has helped in setting up a high speed computational facility in the Institute. Several interesting studies on monsoon seasonal mean state and its variability have been carried out using the atmospheric global circulation models installed on this computer.

On invitation from the 'WCRP/CLIVAR/Asian Australian Monsoon GCM Intercomparison Panel' to participate in the project, long runs and ensemble integrations of the UKMO AGCM were conducted, to understand the normal behaviour of 1997 monsoon, which is significant due to very strong El Nino during the year.

Awards

SAARC Young Scientist Award

Dr. Nityanand Singh, Assistant Director has been awarded the 13th SAARC Young Scientist Award for the year 1993-1994 for his paper entitled 'Optimizing a network of rain-gauges over India to monitor summer monsoon rainfall variations', International Journal of Climatology, Vol.14, 1994, 61-70.

J.Das Gupta Award

The paper entitled "A high spectral resolution radiometer for atmospheric monitoring" by P.C.S. Devara, P.E. Raj, G. Pandithurai and S. Sharma, Journal of the Instrument Society of India, Vol. 25, 1995, 142-154 won the J. Das Gupta Award of the Indian Meteorological Society for the year 1995-96. The Award was presented on 16 February 1999 at the inaugural function of the TROPMET-99 at Regional Meteorological Centre, Chennai.

IITM Silver Jubilee Awards

The 9th IITM Silver Jubilee Award for the year 1996 for the paper entitled, 'Ring-width variations in *Cedrus deodara* and its climatic response over the western Himalayas' by H.P. Borgaonkar, G.B. Pant and K. Rupakumar, International Journal of Climatology, Vol.16, 1996, 1409-1422 was presented to the scientists by Prof. V.S. Ramamurthy, Secretary to the Government of India, Department of Science and Technology, New Delhi at a function organised at the Institute on 17 August 1998.

The 10th Silver Jubilee Award for the year 1997 was given to the paper entitled "Rainfall variability over SE Asia - connections with Indian Monsoon and ENSO Extremes : New Perspectives", R.H. Kripalani and Ashwini Kulkarni, International Journal of Climatology, Vol. 17, 1997, 1155-1168. The award was presented on 16 February 1999 at the inaugural function of the First International Workshop on Long - Term Trends and Changes in the Atmosphere organised by the Institute.

Workshops

International workshop

The First International Workshop on "Long-Term Changes and Trends in the Atmosphere" was hosted and organised by the Institute during 16-19 February 1999. The Workshop brought together various frontier groups of scientists from all over the world on a common platform to discuss and address how the long term analysis of atmospheric data and model simulations may throw light on the basic issues of climate change and changing atmospheric composition and the ionosphere. About 97 researchers from twenty countries participated in the Workshop.

The Workshop was inaugurated by Prof. R.R. Daniel, Former Chairman of the Committee on Space Research (COSPAR). Dr. Guy P. Brasseur, National Centre for Atmospheric Research, Boulder, Colorado, USA delivered key note talk on Global Changes in the Atmosphere. Dr. A.P. Mitra, FRS, National Physical Laboratory, New Delhi presided over the function. On this occasion a publication entitled, 'Research Publications in Journals' containing a brief write-up about the Institute and a bibliography of papers published by Institute's scientists was released, and the 10th Annual IITM Silver Jubilee Award for the year 1997 was presented.

National workshops

The Indian Institute of Tropical Meteorology (IITM) and the India Meteorological Department (IMD) jointly organised a Workshop on Forecast-Oriented Research Applications during 17-21 August 1998. Prof. V.S. Ramamurthy, Secretary to the Government of India, Department of Science and Technology, New Delhi inaugurated the Workshop. The Directors/ Senior Meteorologists of the India Meteorological Department and its Regional Centres and Observatories participated in the Workshop. Institute's scientists provided their expertise as faculties for the training.

Annual Monsoon Workshop-1998 organised by the Indian Meteorological Society, Pune Chapter and co-sponsored by the Institute was held on 22 December 1998.

Meeting

Third Meeting of the Project Advisory and Monitoring Committee for Monsoon and Tropical Climate (MONTCLIM) and Indian Climate Research Programme (ICRP), organised by the Department of Science and Technology, was held at the Institute during 6-7 October 1998.

Brainstorming Session

Under the collaborative Research Programme of ISRO - IITM - University of Pune, a Brainstorming Session on Atmospheric Sciences and Modelling was organised at the Institute by the Department of Space Physics, University of Pune on 13 October 1998. The objective of the Session was to identify the research areas in Atmospheric Sciences under the Space Physics.

Honour

The Biographical data of Dr. P.C.S. Devara, Deputy Director, Dr. S. Sivaramakrishnan, Assistant Director and Dr.(Smt.) N.A. Sontakke, Junior Scientific Officer have been included in the 17th Edition of 'Marquis Who's Who in the World 2000', 16th Edition of 'Marquis Who's Who in the World 1999 ' and in the 'Outstanding People of the 20th Century' of the International Biographical Centre, Cambridge, UK, respectively.

Biographical data of Dr. A.K. Sahai, Senior Scientific Officer Gr.I have been selected for inclusion in the 5th Edition of the 'Marquis Who's Who in Science and Engineering'. Biographical data of Dr. P.N. Mahajan, Senior Scientific Officer, Gr-I have

also been selected for inclusion in the 4th Edition of the 'Who's Who in Asia and Pacific Nations', 28th Edition of the 'Directory of International Biography' and 5th Edition of the 'Marquis Who's Who in Science and Engineering'. Editorial and Advisory Boards of the International Biographical Centre of Cambridge, UK have confirmed the nomination of Dr. P.N. Mahajan as an 'International Man of the Millennium'.

Participation in International Meetings

Dr. G.B. Pant, Director attended as a Member of the Scientific Steering Committee of a Workshop on Rapid Nonlinear Climate Change and participated in the meeting organised by the IPCC at Noordwijkerhout, The Netherlands during 31 March to 2 April 1998.

Bilateral Research Programmes

International Programmes

An Indo-Japanese collaborative project entitled, "Dendroclimatological reconstruction and estimation of global environmental changes in monsoon Asia" has been initiated between the Institute and Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Japan. Dr. G.B. Pant, Director visited Japan under this programme during 13 September-17 October 1998. Dr. Takeshi Fujiwara, Dr. Naoki Okada and Dr.(Ms.) Kana Yamashita, from FFPRI visited the Institute during November 1998-January 1999. Under the project field programmes were organised in the tropical forest sites of western and eastern Maharashtra state and several tree-ring samples were collected.

Dr.(Mrs.) Helene Cachier and Dr. Patrick Chazette of Laboratory of Sciences, Climate and Environment (LSCE), France visited the Institute during 20-21 October 1998 under Indo-French Joint Experiments during the Intensive Field Programme of the INDOEX-1999.

Under the IITM-Hadley Centre HE Link (HEL) Programme sponsored by the British Council, a HEL Mission Team comprising of Prof. J. Finch, Vice Chancellor of Keel University, U.K., Mr. R. Munro, Head, HEL Programme, U.K., and Mrs. Manjula Rao and Ms. Emily Thomas of British Council, Division of British Deputy High Commission, Mumbai visited the Institute on 8 December 1998 and had discussions with the Institute's scientists.

As a part of the Institute's on-going INDO-US NSF Research Project 'Investigations of Atmospheric Chemistry - Aerosols - Climate Interactions', Dr. V. Ramaswamy of GFDL/NOAA, USA visited the Institute during 11-18 February 1999 and had discussions with the Institute's scientists involved in the project. The immediate work plan and preparation of data products from the experimental facilities (lidar, radiometers and spectrometer) available with the Institute, to suit to the radiative transfer models of GFDL were finalised during the discussion.

National Programmes

As a part of the Institute's participation in the INDOEX-India Programme, a Rotating slit Scanning Spectrometer has been installed at the University of Mauritius, Mauritius on 16 September 1998 for monitoring of atmospheric columnar NO_2 and O_3 and regular observations are being carried out. Special observations of atmospheric aerosols and trace gases have also been carried out on 101 days using ground-based direct and remote sensing techniques at the Institute, during the First Field Phase Programme of the Indian Ocean Experiment (INDOEX).

Scientists of the Institute participated in the cruise of Sagar Kanya under the INDOEX IFP-99 programme during 20 January to 12 March 1999 and collected observational data of concentration and size distribution of atmospheric aerosols, Aitken nuclei, atmospheric electric field and conductivity over the marine environment of Indian Ocean and Arabian Sea regions. One scientist of the team also participated in the cruise of the American ship "Ron Brown" from Mauritius to Maldives.

As a part of the INDOEX-India Programme a field observational site for making measurements of Aerosol Characterisation and Black Carbon particle concentration was set up at the Physics Department, Dharwar University, Dharwar. The programme was organised by the Institute in collaboration with the scientists of Dharwar University and two scientists from France.

Participation in BOBMEX

The Institute participated in the Bay of Bengal MONSOON Experiment (BOBMEX) Pilot Cruise on board ORV Sagar Kanya, Cruise No.138C conducted over Bay of Bengal over the area 7°-13°N and 85° - 87°E during the period 23 October-12 November 1998. Surface meteorological, aerological and Conductivity Temperature Depth (CTD) data were collected in co-operation with the scientists of National Institute of Oceanography, Goa.

IITM-SAC Collaborative Programme on

Special observations of atmospheric aerosols using the lidar and radiometric techniques were carried out at the IITM and at the Mulshi dam sites during Jan-Apr 99. on 1 and 25 January, 18 February, 14 March and 7 April 1999 and also at the Khadadwasla dam site on 6 and 30 January, 23 February, 19 March and 12 April 1999 in synchronization with overpasses of ISRO's IRS-P3 polar orbiting satellite over Pune.

Collaboration with BARC, Mumbai

At the request of the Bhabha Atomic Research Centre (BARC), Mumbai, intercomparison experiments, in a campaign mode, involving aerosol and radiation instrumental facilities available with the Institute and BARC were conducted at the Institute, during 28 December 1998 - 01 January 1999. This observational programme was primarily aimed at the validation of radiative transfer model available with the BARC. The preliminary results of aerosol number-mass-size distributions obtained from different complimentary equipment showed good agreement within the experimental limitations and were found consistent during the above observational period.

Release of a Scientific Publication

A scientific publication entitled, "Lecture Notes of the DST/NCMRWF/IITM Short Term Training Course on Agrometeorological Data, Monitoring and Management - 1997" edited by G. B. Pant, Nityanand Singh and N. A. Sontakke was released by Prof. V.S. Ramamurthy, Secretary to the Government of India, Department of Science and Technology, New Delhi at a function organised at the Institute on 17 August 1998.

Publication of Atlas

'SHIVA Atlas - Climatology of the Asian Summer Monsoon : 1979 - 95' by H. Annamalai, J. Slingo, K. Hodges, K.Rupa Kumar and P.Tschuck has been published by SHIVA Project, Department of Meteorology, University of Reading, U.K. in which Dr. K. Rupa Kumar of the Institute contributed during his one year deputation to France to work in the project.

Participation in Exhibition

The Institute participated in the following Science and Technology Exhibitions :

- India's Science Vision Exhibition, AGRASAR, "Achievements of Science and Technology Since Independence and Vision for the Future" organised by the Ministry of Science and Technology to commemorate 50 Years of Independence held at India Gate, New Delhi during 3-16 August 1998.
- Interschool Science Exhibition held at Saraswati Vidyalaya Union High School, Pune on 28 November 1998.
- 86th Annual Session of the Indian Science Congress held at the Anna University, Chennai during 3-8 January 1999.

Donation of Publications to Institute Library

Library of the Institute received donation of valuable publications from Ms. Seetha, daughter of Late Prof. R. Ananthakrishnan, Director (Retd.) and Honorary Fellow of the Institute, Dr. S.M. Kulshresta, Director General of Meteorology (Retd.), Dr. D.A. Mooley, Assistant Director (Retd.) and Dr.(Smt.) A.M. Selvam, Deputy Director (Retd.). The publications consist of books, journals, reprints of selected classic papers and scientific/technical reports on different topics of Meteorology and Atmospheric Sciences.

National Science Day

The Institute organised the National Science Day Celebrations spanning over a period of one week beginning on 22 February 1999. On this occasion, an open-house exhibition depicting the research activities of the Institute and visit of public and students to laboratories, computers and library of the Institute and their interaction with the scientists were arranged. A popular lecture on "Information Technology: Futuristic Implications" by Dr. Ashok Kolaskar, Director, Bioinformatics Centre, Department of Biotechnology, University of Pune, Pune was organised at the Institute on 22 February 1999. The response of visitors and the media personnel to the celebration was overwhelming.

Dr. Umashankar Upadhyay, Prof. and Head, Dept. of Hindi, University of Pune delivering a lecture as the Guest of the Hindi Week Celebrations

Dr. Ashok Kolaskar, Director, Bioinformatics Centre, University of Pune delivering a special lecture on National Science Day

WMO Day

The Institute organised the celebration of World Meteorological Day on 23 March 1999. The celebration was highlighted by an open-house exhibition, visit of general public and students, academicians and scientists from schools, colleges and universities, and a special popular lecture on the theme ' Weather, Climate and Health ' by Smt. A. A. Shiralkar, of the Institute. A report on the celebrations by Smt. A.A. Shiralkar was broadcast by the All India Radio, Pune station on 23 March 1999 at 8:25 pm and also published in local Newspapers.

Shri R. M. Khaladkar, IITM was awarded the Post Graduate Diploma in Satellite Meteorology and Global Climate by Dr. K Kasturirangan, Chairman ISRO

Smt. A. A. Shiralkar, IITM delivering a popular lecture as a part of the WMO Day Celebrations

***

Forecasting Research

The research programmes of the Forecasting Research Division are formulated for understanding and prediction of monsoon on short-, medium- and long- range scales, with the following objectives :

- Study of sensitivity of the global and regional model forecasts to the different physical processes
- Study of planetary boundary layer characteristics
- Incorporation of satellite data in the objective analysis of meteorological parameters for numerical weather prediction (NWP) models
- Interannual and long-term variability of Indian summer monsoon rainfall (IMR) and to establish relations with new predictors
- Study of the variability in ENSO and North-Atlantic Oscillations (NAO) on decadal scale
- Study of heat sources and moisture sinks over India due to convective rainfall and its relationship with monsoon variability.

NWP Modelling and Model Diagnostics

A nonlocal atmospheric boundary layer (ABL) diffusion scheme in which the ABL height is expressed in terms of a bulk Richardson number was incorporated in a global spectral model at T80L18 resolution. The ABL response to the surface heating and moisture availability with this new ABL scheme was examined by carrying out three day forecast experiments for pre-monsoon, monsoon and post-monsoon condition. Results showed that the formulation of ABL height used in this scheme is able to bring out realistic features of temporal and spatial variability of ABL over Indian region. The impact of this scheme to the model forecasts is assessed by computing the precipitation skill-scores in a set of three consecutive forecasts and comparing with a local diffusion scheme presently used in the model. The equitable threat score (ETS) computed for different thresholds of precipitation indicates that the model run with nonlocal ABL scheme produces, as an average, a higher ETS than the local ABL scheme, run for heavier precipitation categories suggesting that the new ABL scheme is more accurate in forecasting the intense precipitation locations.

The revised Betts-Miller scheme with variable moisture profile suggested by Janjic (1994) was incorporated in the limited area model (LAM). The model was integrated for 72 hrs with the input of five depression cases using six different sets of adjustment parameters. All these experiments were repeated with the original version of the Betts-Miller scheme also. The revised version was found to produce superior forecast results as compared to the original one.

Numerical simulation of tropical cyclone intensity and structure using LAM was carried out. The model was integrated for 10 days with a horizontal resolution of 50 km on a f-plane. The model successfully simulated the pressure and wind profile of a tropical cyclone. It was seen that the central pressure decreases slowly in the first two days and then rapidly after 7 days of integration reaching minimum of 955 hPa giving the typical pressure profile of a tropical cyclone. The evolution of surface wind was also found to be consistent with the surface pressure. To investigate the effect of higher resolution on the evolution of tropical cyclone, the resolution was increased from 50 to 20 km. It was found that with the higher resolution, the evolution of tropical cyclone was faster with a minimum central pressure of 940 hPa and with a better structure. The experiments were also carried out to study the sensitivity of tropical cyclone intensity to sea surface temperature (SST) and radiation. It was found that with lower SST, growth rate of cyclone was slow in terms of drop in surface pressure and the maximum intensity reached was also less. In case of no radiation, the time evolution of surface-pressure showed delayed intensification but maximum intensity reached was same as in the case with radiation.

The Pre-convective atmosphere of the pre-monsoon season (March to June) has been studied using the Radio-sonde (RS)/Rawindsonde (RW) data of Calcutta for 00 UTC and 12 UTC for the year 1980.

Codes for calculating different thermodynamic indices and parameters were developed. The buoyant nature of the atmosphere was studied by calculating convective available potential energy (CAPE) and normalised CAPE. Parameters and indices are being tested with skill-scores to estimate the success in forecasting thundery days and non-thundery days.

A correlation analysis between all India rainfall and momentum transport processes of lower tropospheric zonal waves was performed for summer monsoon seasons of 1994, 1995 and 1996. The results indicated that (i) the transport of momentum by Planetary transport by mean meridional circulation (MMC) has significant correlation with the all India rainfall, (ii) transport by mean meridional circulation (MMC) has significant correlation with the all India rainfall and (iii) there is consistency in spatial and temporal variations of transport processes of MMC and planetary waves.

Data collected during BOBMEX (Bay of Bengal Monsoon Experiment) Pilot Cruise, onboard ORV Sagar Kanya, cruise No. SK 138C, viz. Surface Marine Meteorological data for SST, dry bulb - and wet bulb-temperatures, wind speed, wind direction, mean sea level (MSL) pressure and total cloud cover for the period 23 October-11 November 1998 over the Arabian sea (en-route) and the field site (7°-13°N; 85°-87°E) in the Bay of Bengal, were analysed (Fig.1). Salient features of the results of the analysis are (i) in the Arabian sea, the SST was low (28°C) at 15°N, 73.1°E. It progressively increased toward south and attained a high value (28.9°C) at 9.2°N, 75°E and then decreased to 28.3°C toward south at 5.4°N, 76.3°E in the Indian ocean, (ii) the Bay of Bengal was comparatively warmer (28.9-29.5°C) than the Arabian sea. An abnormal high value of SST (30.4°C) was recorded at 10°N, 87°E at 1330 IST (08 UTC) on 3 November 1998. This value of SST coincided with a maximum global solar radiation (1064 Wm^{-2}) at the same time on that day, (iii) the wind field was quite variable over both the seas and mostly controlled by both the high pressure and low pressure system which moved across the study area, (iv) two zones of wind speed maxima (5-8 ms^{-1}) were noticed at 10°N, 75°E and 6.7°N, 75.7°E respectively, (v) the two zones had pressure field 1013.4 hPa at the same hour (03 UTC) on two consecutive days (25 and 26 October), (vi) over the Bay of Bengal, low wind speeds (2-4 ms^{-1}) were noticed with two low pressure areas across 7°N, 87°E and 10°N, 87°E and high wind speeds (5-12 ms^{-1}) at 13°N, 87°E, (vii) the MSL pressure exhibited a pronounced semidiurnal oscillation (Fig.2) with an amplitude of 2-3 hPa. The wind field followed this oscillation whereas the other elements viz., SST, air temperature and cloud cover showed a diurnal oscillation, and (viii) the cloud clusters moved across the study area and gave copious rainfall (10-30 mm) over the ship on some occasions along 87°E.

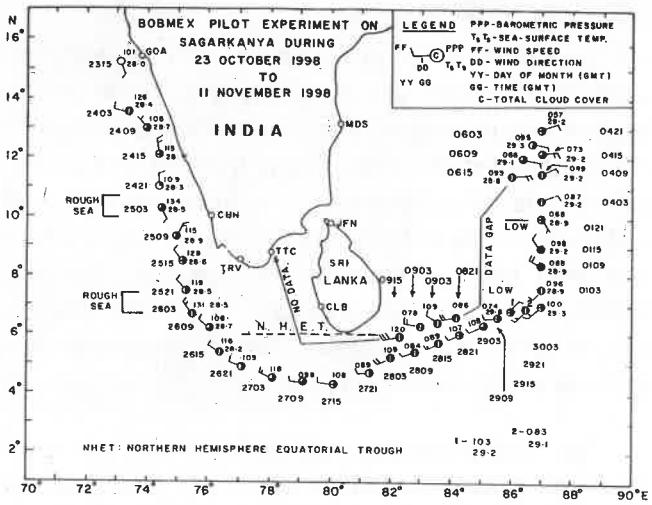


Fig. 1 ; BOBMEX Pilot Experiment onboard ORV Sagar Kanya (cruise No. 138C) : en-route routine weather at six hourly interval (DDFF, PPP, TsTs and YYGG)

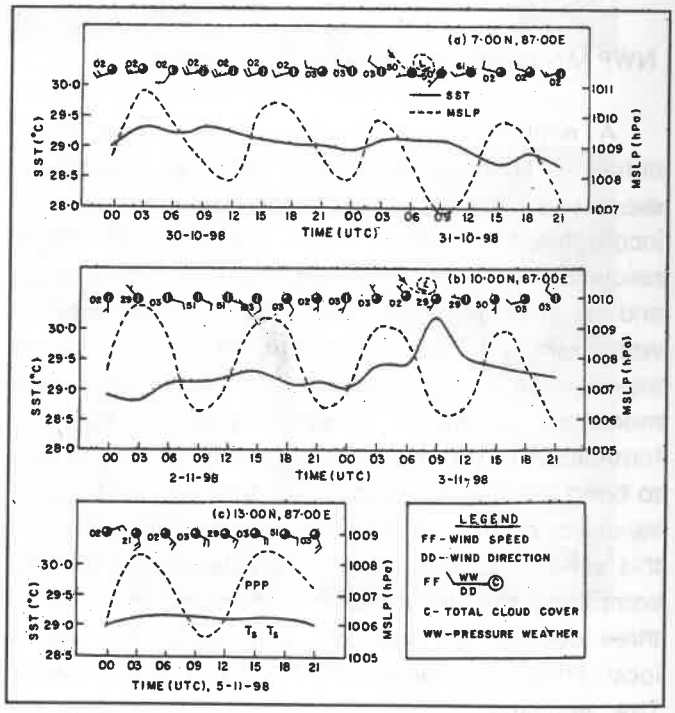


Fig. 2 : Diurnal variation of meteorological parameters (YYGG, NDDFF, PPP,TsTs, WW) at (a) 7°N, 87°E (b) 10°N, 87°E and (c) 13°N,87°E

Three hourly (00 UTC to 12 UTC) Radiosonde / Radiowind (Slow Rising Balloons) data and one hourly multi-level Tower observations taken during Land Surface Process Experiment (LASPEX-97) at Anand (22° 35'N, 72° 55'E, 45.1 m asml) in northwest India, for five consecutive days viz. 13th to 17th each in the months of May (Pre-monsoon) and July (monsoon) 1997 were analysed. The results of profiles of temperature and humidity in vertical at 10 hPa interval showed a pronounced dryness in May and pronounced wetness in July from 1000 to 600 hPa. High values of humidity 10 gm/kg in May and 25 gm/kg in July are confined to the surface. The θ_u, θ_e and θ_s profiles showed a mean convective mixed layer height of about 3.5 km during dry and warm month of May and 1.5 km during wet and relatively cold month of July. During May the profiles showed diurnal variation of surface stable boundary layer (1000-950 hPa) while the residual boundary layer (850-650 hPa) seldom showed any diurnal variation. However, the intermediate layer (950-850 hPa) between the surface stable layer and the residual layer undulates vertically depending on the warming and cooling of the surface stable boundary layer with the marching of the sun during the daytime (Fig. 3a). In contrast to the month of May, θ_v, θ_e and θ_{es} profiles show a different structure in July. The surface stable layer always exists between 1000-950 hPa throughout the day due to enhanced moisture and related surface cooling, whereas the residual boundary layer splits up into three layers such as subcloud layer (950-900 hPa), the cloud, the cloud layer (900-750 hPa) and the cloud top inversion layer (750-720 hPa). However, there exists a diurnal and temporal oscillation in the above three layers. These features are elaborately shown in Fig. 3b.

A one dimensional model, which requires only the surface synoptic weather data as an input, was run by using the tower data at 9.5 m level wind field and 1 m level temperatures to compute the surface fluxes of radiation (incoming, outgoing and net), sensible heat, latent heat and momentum, soil surface temperature, and planetary boundary layer height (convective mixed layer). A comparison of these results with those observed at Anand by the Radiosonde and Tower showed more or less similar results with an average error of 5 to 15%.

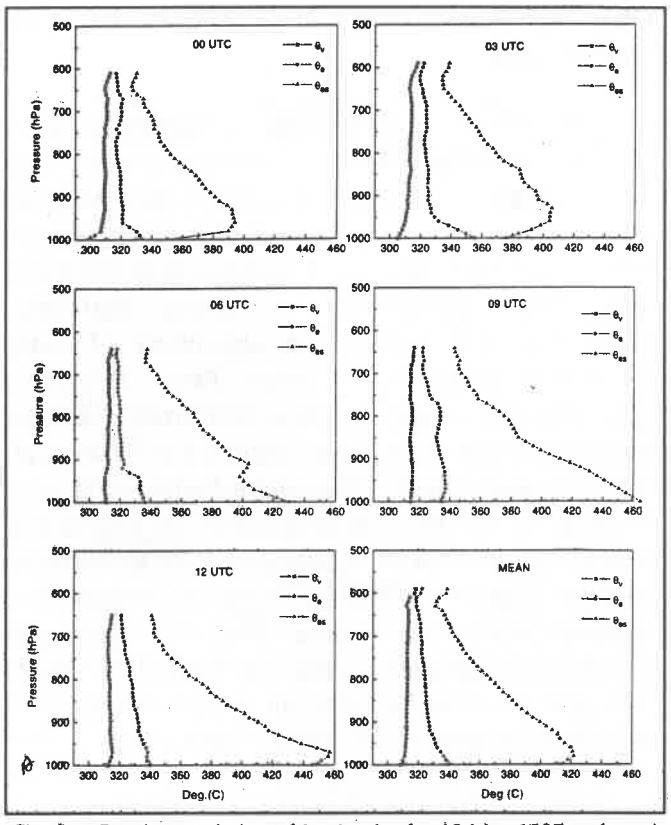


Fig. 3a ; Daytime variation of θ_v, θ_e, θ_{es} for 16 May 1997 at Anand

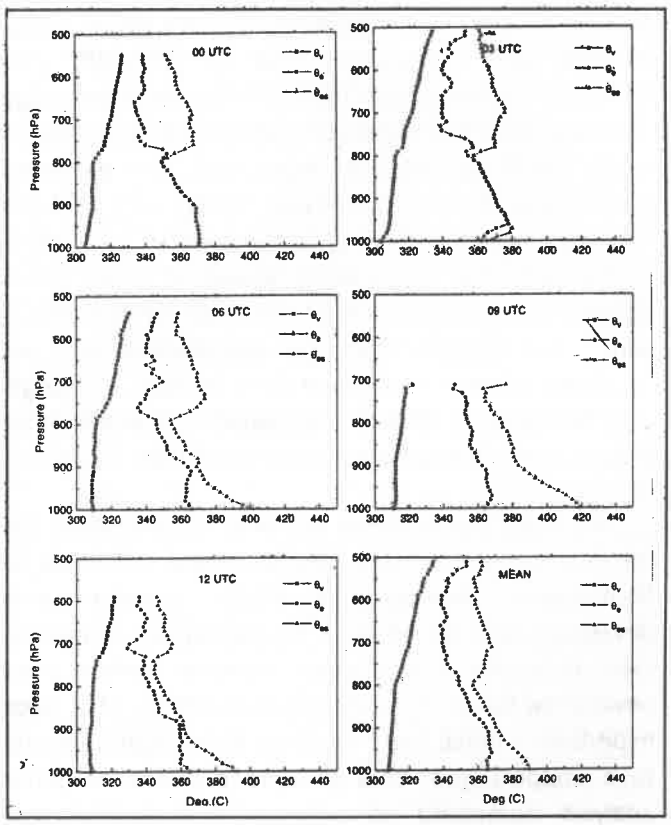


Fig. 3b ; Daytime variation of θ_v, θ_e, θ_{es} for 17 July 1997 at Anand

Objective Analysis Including Satellite Input for NWP Models

Intercomparison of the algorithms developed by various researchers in the recent years was made using satellite microwave radiometry data obtained from DMSP-SSM/I and radiosonde data obtained from Minicoy and Port Blair island stations, over the Indian seas. After comparing rms errors, correlation coefficients and biases, the algorithms of Petty, 1993a (for surface wind speed), Petty, 1993b (for integrated water vapour), Weng and Grody, 1994 (for integrated cloud liquid water content) and Smith et al., 1996 (for precipitation rates) were found to be most accurate for the retrieval of geophysical parameters. These algorithms were further assessed for different weather phenomena during monsoon periods. It is inferred from the results that the estimated geophysical parameters obtained from DMSP-SSM/I data are of potential use for better depiction of monsoon systems over the Indian seas.

Structural features of eastward propagating super cloud clusters over the equatorial Indian Ocean were studied during monsoon seasons using INSAT cloud imagery and reanalysis data of ECMWF and NCMRWF for the period 1987-98. Results of the study revealed that the observed hierarchical structure of super cloud clusters was associated with eastward propagating Kelvin wave-type mode and it was dominant within 10°N and 10°S mainly in zonal wind component. The propagating speed of super cloud clusters was found to be of the order of 5-7°/day. It was also found that genesis/development of monsoon system took place over the Bay of Bengal after 3-4 days with the first appearance of super cloud cluster over the southwest equatorial Indian Ocean.

An objective analysis scheme for analysing the mean sea level pressure field using the technique of Multiquadric Interpolation (MQI) scheme was developed and tested for a few synoptic situations. Like optimum interpolation scheme which uses covariance function as the basis function, MQI uses hyperboloid radial basis function to fit scattered data to a uniform grid. This scheme produces superior analysis compared to optimum interpolation and Bratseth's analysis.

Lower tropospheric vertical velocity field provided by the National Centre for Environmental Prediction (NCEP/NCAR reanalysis data, ω_{NCEP}) over Indian region was compared with the vertical velocity fields (ω with OLR and ω without OLR) computed by kinematic method from the analysed fields using optimum interpolation scheme for three cases of monsoon depression over Bay of Bengal (i) 2-7 August 1988, (ii) 28-30 July 1991 and (iii) 18 and 23 July 1993. Results showed that (i) the vertical velocity pattern and magnitude from reanalysis are similar to that computed from the analysed field without including divergent part from OLR data, however, ω_{NCEP} represents clouding over the Indian ocean better than ω without OLR and (ii) depiction of the system is better when the analysed field contains divergent part of the wind from OLR data. This ω field is in better agreement with satellite cloud imagery than ω_{NCEP}.

Extended Range Prediction

Monsoon Outlook For 1998

The impact of El Nino/La Nina on Indian Monsoon Rainfall (IMR) was examined during the below and the above normal rainfall epochs, the study indicated a forecast of seasonal monsoon rainfall on positive side of the normal (or even excess). Since there were indications that the eastern equatorial Pacific would enter into a La Nina phase sometime during August-September 1998, the outlook for monsoon 1998 had also suggested that this would be conducive for good monsoon activity over India during August-September 1998. The cumulative area weighted IMR up to 5 August 1998 was 98.7% of the normal, however, by the end of the season i.e. up to 30 September 1998, it was 106% of the normal thus supporting the above outlook.

Teleconnections : Soviet Snow Depth and Indian Monsoon Rainfall

Until recently the ground truth snow depth data were not available. However, under the bilateral data exchange agreement between United States of America and the former Union of Soviet Socialist Republics, Soviet snow depth data set has been developed. The data are for 284 stations for periods

varying from 1881 to 1985. Lag and lead correlation coefficients between snow depth and IMR revealed that the winter-time snow depth over western Eurasia surrounding Moscow (eastern Eurasia in Central Siberia) shows significant negative (positive) relationship with subsequent IMR. Following the monsoon the signs of the relationship reverse over both the regions (Fig. 4). This correlation structure is indicative of a midlatitude longwave pattern with an anomalous ridge (trough) over Asia during the winter prior to a strong (weak) monsoon. As time progresses from winter to spring, the coherent areas of significant relationship show southeastward propagation. Empirical orthogonal function analysis of the snow depth reveal that the first mode describes a dipole-type structure with one centre around Moscow and the other over central Siberia, depicting similar pattern as the spatial correlation structure. The decadal-scale IMR variations seem to be more associated with the Northern Hemisphere midlatitude snow depth variations rather than with the tropical ENSO (El Nino Southern Oscillation) variability.

The negative correlations to the west and positive to the east indicate low snow depth to the west and high snow depth to the east before a strong monsoon, and vice versa for the winter after a strong monsoon. This implies an anomalous anticyclonic circulation or a strong ridge over Asia before a strong monsoon (Fig. 4, top panel) with warm air advected from the south on the west side of the high to reduce snow depth, and cold air from the north on the east side of the high to preserve deep snow, and vice versa after a strong monsoon (Fig. 4, bottom panel) with an anomalous trough over Asia and cold southward flow on the west side of the trough associated with deep snow (positive correlations), and warm southerly flow on the east side of the trough and thinner snow cover (negative correlations). A schematic representation of these processes is shown in Fig. 5.

The OLR data from NOAA polar orbiting satellite for the period 1974 to 1996 have been analysed for detailed study of its relationship with the Indian monsoon rainfall (IMR). The study revealed that OLR near 30°S and 97.5°E over the south Indian Ocean

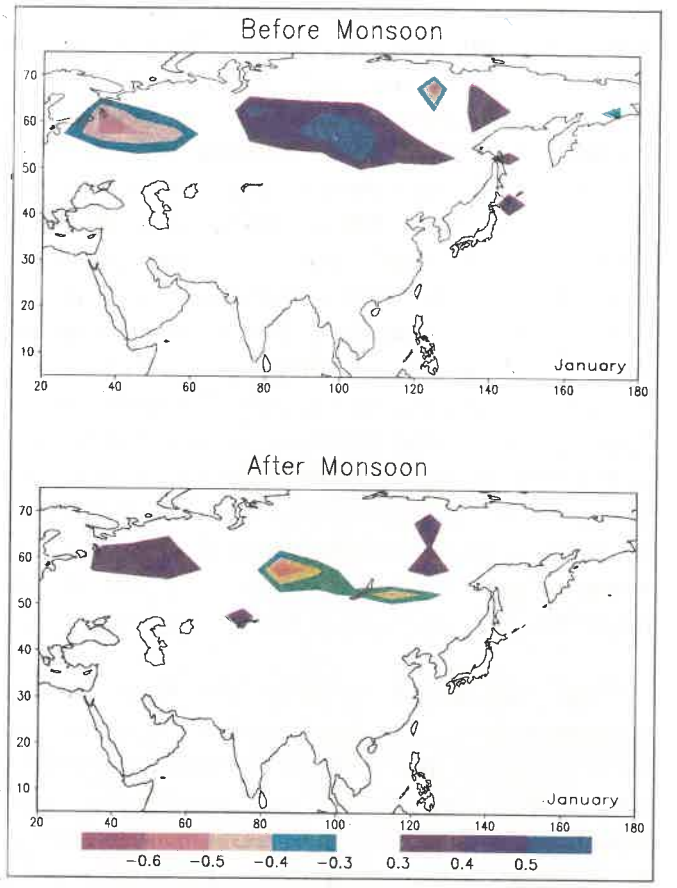


Fig. 4 : Teleconnections between Soviet snow depth and Indian monsoon rainfall

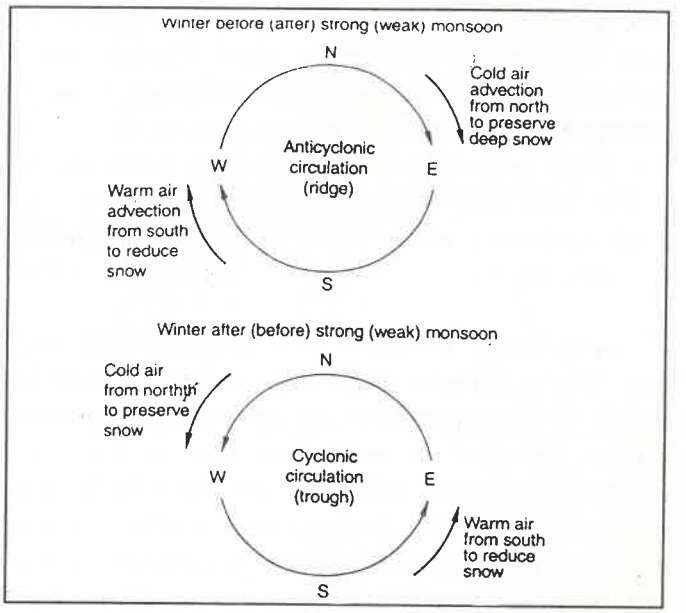


Fig. 5 : Schematic representation depicting a ridge (trough) over the Russian region during winter prior to a strong (weak) monsoon and a reversal of the processes during the winter following the monsoon (N, north, S, south, W, west, E, east)

during April has strong positive association with the IMR. Also, premonsoon month (May) OLR near 22.5°N and 92.5°E over the Head Bay of Bengal is found to have significant negative association with the IMR. The *indices* of OLR of these two regions are found to be independent to each other and their relationship with the IMR is also found to be stable. These two *indices* seem to have significant association with the monsoon rainfall of meteorological subdivisions of peninsular India and west central India respectively and they also seem to be better associated with the all-India rainfall of July as compared to other monsoon months. The forecast of the IMR through multiple regression model using these two *indices* seems to perform quite satisfactory. Also the performance of forecast for the monsoon rainfall of west central India and all India rainfall for July was found to be encouraging.

The relationship between the North Atlantic Oscillation (NAO) and the Southern Oscillation (SO) for 108 years of data (1881-1998) was investigated. It was found that these two oscillations show statistically significant inverse relationship (significant at 1% level). The cross spectral analysis shows that the phase angle between these two oscillations is almost 90 degree. The relationship between the NAO and rainfall over the five homogeneous regions of India (viz., North-West India, West Central India, Central North East India and South peninsular India) is investigated. The analysis showed that the April NAO is a useful parameter for the long range prediction of rainfall over the three homogeneous regions (viz. South peninsular India, North West India and West Central India).

Long Range Forecast for monsoon 1998 was given by a multiple regression equation which is based on the parameters viz. Northern hemisphere surface temperature anomalies and transport of angular momentum anomalies at 200 hPa in the month of May. The forecast was (+6%) on the positive side of the normal. The forecast based on the new parameters viz. NAO (North Atlantic Oscillation), NPO (North Pacific Oscillation) and the De Bilt temperature anomaly in the month of January 1998 gave almost the same result.

Analysis of 5-day Spatial Coverage Rainfall for Medium Range Prediction Study

In order to make diagnostic as well as prognostic studies of rainfall qualitatively on 5-day scale over subdivisions of India, spatial coverage rainfall features derived from those daily observed were statistically analysed. The objective of the studies was to understand the time evolution of the weather events on medium range scale. Therefore, the persistence behaviour of the features on synoptic scale were examined through the application of multi-state simple stochastic models of Markov chain type. A wealth of climatic information about 5-day rainfall coverage characteristics, useful for the operational forecasters to predict areal rainfall features over medium to extended range scale, was obtained.

Analysis of Weekly Rainfall for Climate Variation Study

The weekly rainfall intensity over small areal regions of India (blocks of 2.5° x 2.5° grid square), as a measure of flood intensity within summer monsoon was compared statistically over two consecutive short climatic epochs of 40 years. The objective of the study was to examine the climatic variation in the flood severity over recent climatic epochs. The weekly rainfall normals were examined over the North east India, the flood prone region. Flood prone periods over the north Indian subdivisions were also identified. The analysis showed that over western Assam the probability of severe floods during mid-July has been significantly increased in recent epoch.

Monsoon Studies and Forecasting

Onset of monsoon 1998 over south peninsula took place in association with a depression that formed over east central Arabian Sea on 4 June and struck the Gujarat coast on 9 June as severe cyclonic storm with hurricane winds. The system further moved towards east Rajasthan on 10 June. Examination of the storm tracks over Arabian sea during the onset of monsoon for the last 50 years revealed that only on one occasion i.e. during onset of monsoon 1976 a similar kind of system developed on 29 May and struck Gujarat coast on 3 June. Its track was eastward by 1° to 3° of

longitude as compared to that of 1998 system. The initial analysis of OLR field revealed that the northward movement of eastwest oriented convective cloud zone along the west coast and adjacent land area during 1976 caused rapid progress of monsoon along the west coast and wide spread rainfall over peninsular India. This was observed to be followed by a prolong stagnation across Gujarat in the progress of monsoon. During 1998 the convective zone was narrow and remained away from the west coast. Thus, even though during 1998 the system struck Saurashtra coast on 9 June, onset of monsoon over Mumbai took place on 14 June when the second pulse of convective zone moved northward along the central parts of the peninsula.

Daily OLR data from NOAA Polar orbiting satellite, of 2.5°X2.5° grid area, over Indian region for the years 1975 to 1986 (except 1978) and 1998, were used to determine onset of Southwest monsoon over India. Taking the maps of onset of southwest monsoon produced by the India Meteorological Department (IMD) as standard, the onset dates for 2.5°X2.5° grid area over Indian region (5°-30°N and 70°-95°E) were determined. A criterion based on OLR data was developed to fix the onset dates over different parts of the country. Utilising this criterion onset dates of monsoon for all the years under study were re-determined and compared with those obtained from the IMD maps. Over most of the parts of India the onset dates determined by OLR data are found to be in good agreement with those of the IMD. Thus, It is suggested that the satellite derived OLR data may prove to be the additional parameter in fixing the onset dates over India.

Governing equations for the study of large-scale atmospheric energetics in the wave number frequency domain were derived using fundamental equations. The relative merits and demerits of wave number domain and frequency domain were studied using Fourier analysis techniques. Basically they differ only in Fourier transform pairs. The analysis revealed that the most general way of studying the atmospheric turbulence and transport process is to analyse the motion in the wave number frequency domain. The primary advantage of this method is that it permits analysis of the transient waves in terms of their length scale, phase speed and direction of motion. Using these equations the relative importance of forward and backward moving waves is being studied using daily grid point data (u, v components) for monsoon season of 1991.

Time spectrum analysis of kinetic energy of zonal wave at 850 hPa during monsoon 1991 indicated that wave number 1 is dominated by 30-45 day and the bi-weekly oscillation, while shortwaves are dominated by weekly and bi-weekly oscillations. Short period oscillations of wave number 1 might be one of the factors causing weekly and bi-weekly oscillations in the kinetic energy of short waves.

Analysis of pre-monsoon thunderstorm data for the months March-June over the Indian stations lying within the belt of 8-12°N for the selected years 1979, 1983,1987,1988 and 1991, showed a characteristic peak in thunderstorm activity in a preferred pentad (about 8-12 pentads prior to the onset of monsoon over Kerala). Analysis of pentad mean OLR data obtained from the NOAA satellite for the years 1979, 1983 1987, 1988 and from the INSAT for 1991 over the same region also showed a characteristic fall in OLR value below a threshold value (<250 wm^{-2}). This exactly matched with the thunderstorm peak. It was further seen that the cumulative frequency of occurrences of thunderstorms over the region, subsequent to the characteristic peak for next successive five pentads were found to be subdued in deficient, frequent in excess and moderate in normal monsoon years. This study is found to be useful to give qualitative forecast of the performance of Indian Summer Monsoon.

Daily Pre-monsoon thunderstorm activities for selected stations of south peninsular India were analysed for the months March-June for the period 1961-1992. A characteristic peak in the cumulative thunderstorm frequencies for the stations was seen to occur about 6 weeks prior to the onset of monsoon almost every year. Such a peak may be followed by subsequent peak (peaks) in activities. Analysis of satellite derived OLR data over the region also showed a characteristic fall below a threshold value which coincides with such peaks. A regression equation was fitted to predict onset of summer monsoon over Kerala (using the information of the characteristic peak) well in advance (about 6 weeks). The relationship is significant at 99% level.

Climatology and Hydrometeorology

Climate is a natural resource that is vital for the availability and quality of food, water, shelter and lifestyle. Climate is also a potential hazard which manifests itself particularly through climate extremes. Therefore, knowledge of climate is necessary to mitigate the consequences of climate hazards, such as droughts and floods and also in making an optimum use of available resources.

Variability in the climate over the Indian region on different spatio-temporal scales, particularly the activity of the southwest monsoon, has significant impact on agricultural production, water resources management and overall economy of the country. Currently there is an enhanced emphasis on the studies of global and regional climatic change, subject to natural variations on all time scales, with possible alterations by human activities. To assess the magnitude and impact of climatic variations and to develop predictive capabilities, a detailed analysis of the climatic records of the recent past, observed as well as proxy, and development of appropriate statistical and dynamical models is essential. Likewise, the analysis of long records of short-duration precipitation data over different river basins of the country is essential for the planning and utilization of water resources of the country.

The research programmes formulated by the Climatology and Hydrometeorology Division for the study of regional climate and climatic change on different time scales and hydrometeorological problems of various regions of the country have the following objectives :

- To construct the longest available homogeneous time series of regional climatic elements from observed meteorological data, historical records and dendroclimatic reconstructions, and to study their behaviour on interannual, decadal and longer time scales

- To develop empirical prediction models for the seasonal total rainfall over the country as a whole and homogeneous subdivisions of the country

- To make comprehensive analyses and model the global and regional atmospheric and oceanic parameters and their teleconnections with the Indian summer monsoon rainfall, to understand the nature of these relationships and their predictive capabilities

- 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 for application in developing projections of future climatic scenarios and their impacts

- Hydrometeorological analysis of sufficiently long series of rainfall data on different time scales over various river basins of the country for planning and design of the water resources management projects

- Estimation of probable maximum precipitation, depth-area-duration analysis of severe rainstorms and development of quantitative precipitation forecast schemes

Climate and Climatic Change

Dendroclimatic Study

Densitometric analysis has been carried out for several tree-ring cores of *Cedrus deodara* from two different sites of Western Himalaya namely Kufri and Kanasar. Chronologies of various parameters viz. earlywood, latewood, minimum, maximum and mean densities and total ring width were prepared. Most of the parameters except latewood and maximum density showed moderately high values of common variance. Signal to noise ratios of the series were also large compared to those of maximum and latewood density chronologies, suggesting usefulness of density parameters of the species in dendroclimatic studies. Response function analysis based on monthly and seasonal climate parameters (temperature and precipitation) of the region and various density parameters of tree-ring indicated a significant relationship between pre-monsoon (March-April-May) summer climate and earlywood density parameters as well as total ring width. Based on the relationship derived from response function analysis, attempts were made to reconstruct the pre-monsoon climate of the region (Fig. 6).

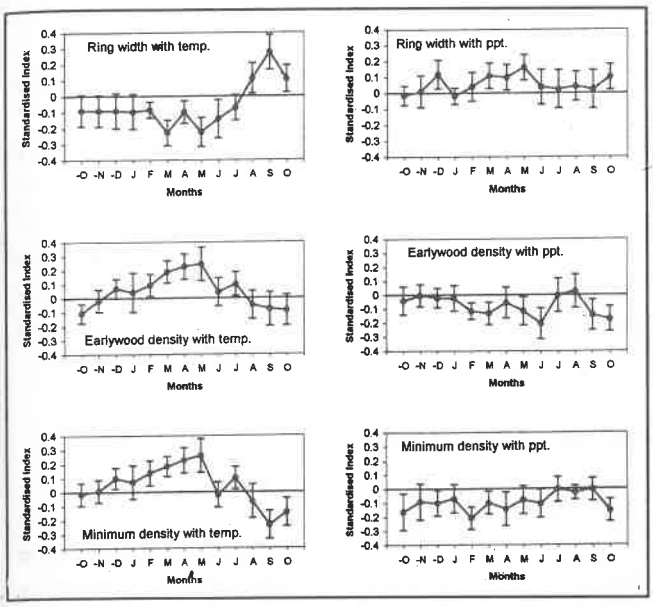


Fig. 6 : Response function analysis using ring width, earlywood and minimum density of Cedrus deodara from Kufri site (Himachal Pradesh) in relation to monthly mean temperature and precipitation at Shimla. Vertical bars indicated 95% confidence interval : response where the bars do not cross the zero line are significant

Objective Technique for Rainfall Prediction

A new method named extrapography, which involves time series modelling and one step ahead extrapolation, has been developed for the prediction of winter, summer, June, July+August, September and post-monsoon rainfalls in sequential manner over relatively plain and contiguous (RPAC) India. The time series of the period 1848-1997 with rainfall of the above seasons kept in sequential order is utilized in the study. Considering a long portion of the actual series $\{X_{N-m}\}$ (N is the record length and m can be ~30) and after substituting mean at its one-step-ahead term to be extrapolated, the full series $\{X_{N-m}\}$ is subjected to the Fourier or harmonic decomposition. Later dominant harmonics are combined to regenerate the value at the (N-m+1)th term. Using the series of successively longer length the generated values were obtained for sufficiently large number (m) of cases. The number of selected harmonics was adjusted so that the highest correlation is obtained between the generated values and the corresponding actual values. The correlation provides a measure of predictability. Overall the correlation was highest for July+August rainfall (~0.90), followed by September, post-monsoon, June and summer rainfall in the same order. The least correlation was found for winter rainfall.

A prediction reliability index is defined as, (=1-rmse/s)*100, where rmse is the root mean square error of the predictions and s is the standard deviation of the interannual series, to asses the skill of the present method of prediction. The prediction is categorized as excellent, very good, good, fair, poor and unpredictable for the PRI value between 100% and 80%, 80% and 60%, 60% and 40%, 40% and 20%, 20% and 0% and less than 0% respectively. Based on 10-year independent samples, 1988-1997, prediction of June, July+August, September and post-monsoon rainfalls was found very good to fair over the six zones and the RPAC India, prediction of summer rainfall over Northeast India was very good while over South Peninsular India it was good. In general, winter rainfall is unpredictable. A sketch of different computational steps off the technique is shown in figure 7, and comparision of actual and predicted rainfall for ten years (1988-1997) is given in figure 8.

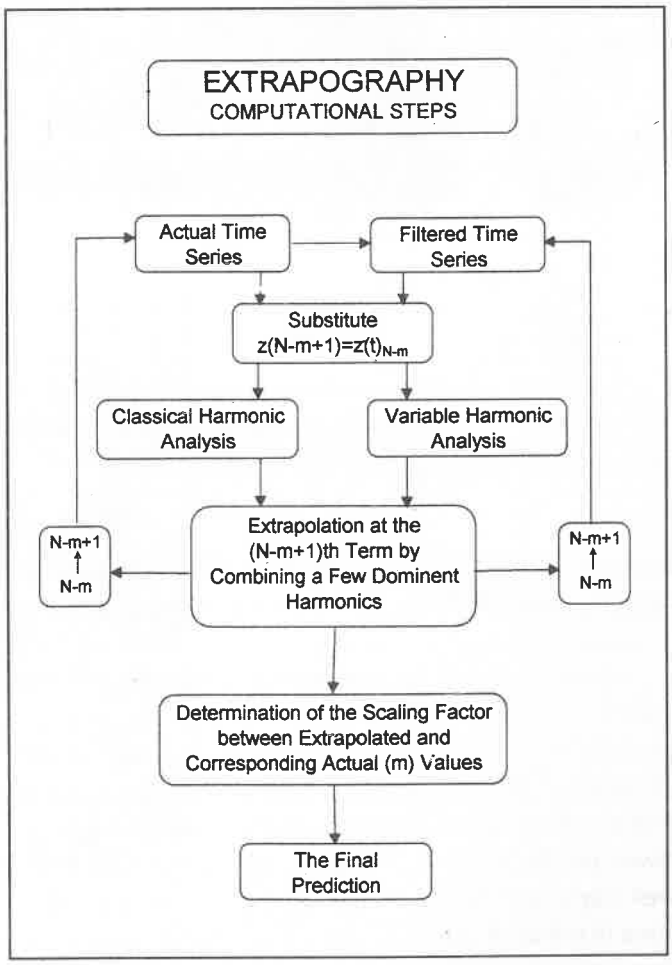


Fig. 7 : Computational steps of the newly developed technique extrapography for long range rainfall prediction across India

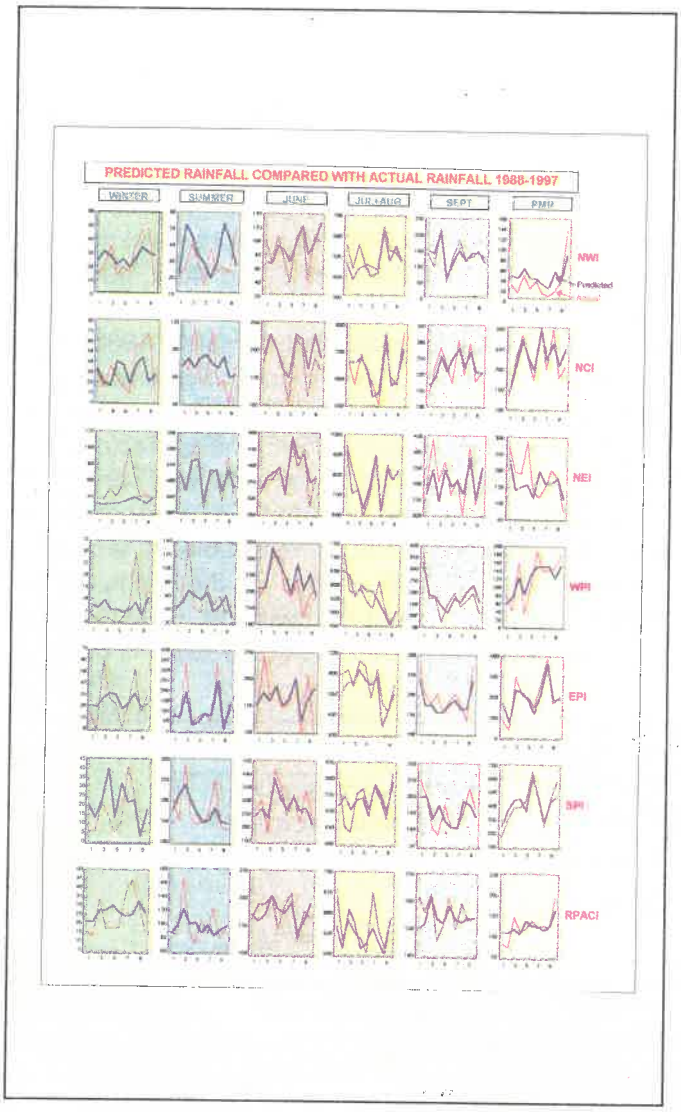


Fig. 8 : Predicted rainfall using the method of extrapography compared with the actual rainfall for the period 1988 - 1997. The ordinate is in mm.

Summer Monsoon Variability and Teleconnections from Reanalysis Data

The nature of the interannual variability of the Indian summer monsoon rainfall in the recently available NCEP/NCAR Reanalysis Data was examined, in comparison with observed data. It is seen that the monsoon rainfall as represented in the reanalysis has lower absolute mean but its variability is reasonably well captured. Some of the well-known teleconnections like that of the El Nino/Southern Oscillation were also well-reflected in the reanalysis data.

Tropical Ozone Variation

Long-term analysis of the Total Ozone Mapping Satellite (TOMS) data was carried out for the study of ozone variations. The analysis revealed that there is no depletion in the amount of ozone over equator, though the depletion is continued in the polar region. The monthly mean distribution of the ozone along the latitude circle over equator showed that one maximum located near zero longitude and one minimum near 180° longitude are common to all the seasons.

Short Term Rainfall Variability

Dependence of the seasonal rainfall amount on that of the monthly rainfall was obtained from the long homogeneous series of seasonal and monthly scale rainfall data for 124 years (1871-1994). From the probability analysis, it is seen that there is a rare possibility of occurrence of seasonal rainfall to be excess/deficient when monthly rainfall of any month (June to September) is deficient/excess.

Influence of low pressure system on Rainfall Variability

Influence of low pressure system (LPS) over India was studied for the period 1891-1990. Study showed that during the presence of LPS, areal average of rainfall along the monsoon trough is above normal whereas over the north-east India and the south-east peninsular area it is always below normal. Further, it is seen that LPS days during the last two decades are on increasing scale.

Hydrometeorological Studies

A generalized method for estimation of areal Probable Maximum Precipitation (PMP) for plain areas of Maharashtra State has been developed. In this method maximum average raindepths for different area sizes and durations from major rainstorms over plain areas of Maharashtra and its neighbourhood were considered using 100 years rainfall (1896-1995). By considering persisting dew point temperatures, these average raindepths were maximised. In order to get normalised maximised values to represent

Field work to collect tropical tree-ring samples under the Indo-Japanese Collaborative Programme in Dendroclimatology of Monsoon Asia

Dahanu, Maharashtra

Allapali, Maharashtra

Anderson aerosol sampler, Aitken Nuclei Counter and High Volume Sampler used in the field observation at Kullu in the Himalayan region

Handheld (MICROTOPS II) radiometers used for the measurements of aerosol optical depth, total column ozone and water vapour

Instruments for Research Activities

14-Channel Solar Radiometer used for the measurement of atmospheric aerosol optical depth on board ORV Sagar Kanya Cruise No. 141 during INDOEX-IFP99

Automatic visible spectrometer installed at Mauritius for the measurement of column density of atmospheric NO_2 and O_3

rainfall values to flat land close to the sea-coast, distance, moisture, topography and intervening mountain barrier corrections were applied. Using these normalized precipitation values by applying reverse corrections, areal PMP values at different grid points were obtained. By using this method generalized areal PMP estimates for 1000, 5000 and 10,000 km^2 areas at different locations in relatively plain areas of Maharashtra were obtained and accordingly generalized charts have been prepared. These maps of PMP for different size areas will be very useful for estimating design storm of PMP magnitude for catchment falling in the range of 1000 to 10,000 km^2 size. The analysis revealed that estimates of 1-day PMP over areas of 1000, 5000 and 10,000 km ranges from 25-70, 20-60 and 20-45 cm respectively.

Based on the analysis of 231 severe rainstorms affected Indian region it has been observed that under favourable synoptic conditions more than one rainstorm can be obtained especially when the movement of a low latitude west-moving disturbance is in phase with east-moving westerly troughs or western disturbances in mid latitudes. The second rainstorm normally occurs in northwest India and if it happens towards the fag end of the monsoon season, severe floods occur in the rivers of the northwest India.

Physical Meteorology and Aerology

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

- Physics of monsoon clouds, precipitation mechanisms and atmospheric electrical processes
- Dynamics and Thermodynamics of the tropical atmospheric boundary layer
- Theory of deterministic chaos and its applications in atmospheric sciences/atmospheric modelling
- Dynamics of the middle atmosphere vis-a-vis the troposphere - stratosphere coupling / monsoon activity
- Precipitation chemistry, acid rain, atmospheric aerosols and tropospheric chemistry
- Remote sensing of atmospheric aerosols and trace gases using lidar and spectrometric techniques.

Studies in Atmospheric Electricity

In order to study the mean cloud electrical conditions of the thunderstorms forming during the pre-monsoon and monsoon seasons, observations of the Point Discharge Current (PDC), recorded during the 30 thunderstorms each during the pre-monsoon and monsoon seasons of 6 years (1972-77) at Pune were analysed. The results of the study suggested that the mean maximum magnitude of the PDC in the pre-monsoon season was nearly three times higher (2.8μA) than that observed during the monsoon season (0.8μA). The magnitude of the PDC decreased by 46% during the month of June following the advent of the monsoon. During the months of July and August it decreased by 71%. Although the number of thunderstorms occurred during the pre-monsoon and monsoon seasons is the same, their contribution to the global electric circuit was found to be different. The study suggested that the main contribution to the global electric circuit comes from the thunderstorms forming during the pre-monsoon season.

The point discharge current (PDC) data recorded at Pune on 65 thunderstorm days during April - October spread over the period from 1972 to 1977 were analysed to study the temporal variations in PDC. The results showed (i) maximum PDC during late afternoon hours (1730-1930 hrs LMT) and minimum during early morning hours (0000-0230 hrs LMT), (ii) Seasonal variation with maximum PDC values during April - May and minimum during July - August, and (iii) the net charge received by the Earth was negative.

Radar Study of Rain and Rain-Bearing Clouds

Radar data of precipitation echoes collected from convective clouds in the Delhi region during the monsoon season of 1977 were analysed mainly to study the distribution of the spacings of the nearest

neighbouring cloud pairs, commonly referred to as nearest neighbour spacings (NNS) and their relationship with the effective cloud radii. Frequency distribution of the nearest neighour spacings tended to be normally distributed. Nearest neighbour spacings have been found to be linearly dependent on the effective cloud radii, suggesting thereby that small clouds tend to come closer to one another and form cloud clusters.

Clouds exhibit fractal structure over wide range of scales. The fractal structure of the clouds forming in the Delhi region was investigated using the radar observations of 2568 convective clouds collected during the monsoon season of 1977. The study suggested that the relationship between the perimeter (P) and the area (A) of the clouds could be represented by $P \sim A^{D+2}$ where D is described as the fractal dimension of the cloud echo perimeter. It was found that the value for D is 1.34 for cloud echoes having areas up to 600 km^2 and D = 1.19 for echoes having area greater than 600 km^2.

Frequency of thunderstorm development in Delhi region during the monsoon season and some of their general characteristics were studied using the radar observations of convective clouds within 100 km around Delhi made during the monsoon seasons of the 8-year period from 1965 to 1972. For this purpose convective clouds whose radar echo tops reached or extended beyond 8 km were considered as thunder clouds. The study revealed that about 34 per cent of the convective clouds, forming in and around Delhi, develop into thunderstorms. Monthwise percentage frequency distribution of the heights revealed that the frequency of occurrence of such storms was maximum in September (69.7 per cent) and minimum in July (55.3 per cent). Also, out of the total number of storm cells studied, only 3.2 per cent grew beyond tropopause i.e., 16 km, Occurrence of such a deep convection was found to be maximum in July (4.0 per cent), and minimum in August (1.6 per cent). Maximum height of echo tops observed was 20 km. Spatial distribution of such storm cells showed that maximum thunderstorm development appeared to occur in west-northwest sector (270° to 315°) and minimum in east-northeast sector (45° to 90°).

Studies of the Atmospheric Boundary Layer

A study was carried out to investigate the thermodynamic structure of the Atmospheric Boundary Layer (ABL) in the vicinity of the Equator (2°N - 2°S, 76- 80°E). For this the aerological observations obtained from MONSOON-77 during the period 25-31 July 1977 by former USSR research vessels viz. Shirshov (0°N, 80°E). Shokalsky (0°N, 76°E), Priboy (2°S, 78°E) and Okean (2°N, 78°E) were used. The low-level stability analysis revealed that all the soundings over all the locations are associated with deep convection. No difference was observed in the ABL characteristics over the two ships situated at the Equator. However, the ABL was found to be more saturated over the ship Priboy located at 2°S as compared to the ship Okean at 2°N. The values of the vertical velocities computed using the vertical profiles of u and v over the four ships indicated that the region west of 78°E is associated with ascending motions, whereas the region east of 78°E is dominated by descending motions.

A study has been carried out to simulate the boundary layer parameters and their interaction with soil hydrology using a numerical one-dimensional model coupled with a two-layer model of soil hydrology and thermodynamics. This model approximates the growth of the daytime mixed layer and considers the surface heat flux during the transition between the stable and unstable atmospheric conditions.

Studies in Upper Atmosphere

The influence of solar activity on geomagnetic field has been investigated using the daily observations of the geomagnetic field collected using the proton precision magnetometer at the Spicer College, Pune during May and June 1998. Preliminary results of the study suggested increase in the geomagnetic field with increase in the solar activity and rapid decrease in geomagnetic field during the period of strong convective activity.

A study was undertaken to investigate the association between daily values of zonal winds in the

lower stratosphere and upper troposphere vis-a-vis solar activity, using the MST Radar special observations of winds collected at Gadanki (13.5°N, 79.2°E) during 14 May -14 June 1995. The solar geophysical data consisting of the daily values of solar flux, sunspot numbers and observations of solar magnetic field variations were utilised for the study. The daily values of zonal winds were subjected to 1-2-1 smoothing and correlation coefficients between zonal winds and solar flux, sunspot numbers and solar magnetic field variations were computed. The study suggested that the day-to-day variations in the zonal winds in the upper troposphere or lower stratosphere were not correlated with the sunspot number peak values or 10.7 cm solar flux. But zonal winds in the stratosphere are having good positive correlation with solar magnetic field variation (correlation coefficient being +0.39 significant at less than five per cent level).

The variations in the total ozone, and characteristics of the winds and wave activity in the region extending from the lower troposphere up to the middle atmosphere during the occurrence of high latitude stratospheric warmings were investigated using the following data : (i) occurrence of stratospheric warmings in the high latitudes (ii) rocketsonde wind and temperature data for the period 1970-1992 (iii) total ozone data for the 1° - 67°N latitude belts for the period 1970-1997. The study suggested that during the period of major high latitude stratospheric warmings the total ozone was found to be increased in the high latitudes (around 60°N) and decreased in the equatorial regions. Cooling in the tropical mesospheric and tropospheric regions followed by wind reversal from easterly to weak westerly was also observed.

Studies in Air Pollution and Atmospheric Chemistry

Total Suspended Particulates (TSP) and mass size distribution of aerosols were monitored by using a high-volume air Sampler and a low-volume 9-stage Andersen Sampler, respectively during March-April 1998 at Pune and during 5-9 January 1998 at Tiruvananthapuram. All these samples were extracted for water- and acid- soluble components using standard extraction method. The water-soluble extracts were analysed for Cl, SO_4, NO_3, NH_4, Na, K, Ca and Mg and acid-soluble extracts for Al, Fe, Mn, Cu, Zn, Pb, Cd, Ni and Sb. The concentration of TSP varied from 67 to 185 $\mu g/m^3$ with an average of 122 $\mu g/m^8$ at Pune and from 35 to 73 $\mu g/m^3$ with an average of 57 $\mu g/m^3$ at Tiruvananthapuram. The mass size distribution of aerosols showed bimodal distribution having one peak in coarse mode and the other in fine mode at both the locations.

As a part of the Indian Ocean Experiment (INDOEX) programme, ground based measurements of trace gases (SO_2, NO_2, NH_3 and O_3) and Aitken Nuclei (AN) were carried out at Pune during March-April 1998. Also, measurements of surface ozone and Aitken Nuclei were made during 5-10 January 1998, during the intercomparison campaign of various instruments at Tiruvananthapuram. The mean concentrations of SO_2, NO_2, NH_3 and O_3 at Pune were 3.75, 5.81, 3.21 and 57.8 $\mu g/m^3$ respectively and that of O_3 at Tiruvananthapuram was 44 $\mu g/m^3$. The average concentration of AN was about five times higher at Pune (19000/cm^3) than that at Tiruvananthapuram (4,400/cm^3) indicating more pollution at Pune than at Tiruvananthapuram. The diurnal variation of surface ozone showed high concentrations during day time and low concentrations during night time at both the locations. Diurnal variation of AN at Pune showed daytime maximum and nighttime minimum. Whereas at Tiruvananthapuram night time values were higher than the daytime values which can be attributed to the influence of land and sea breeze.

Special field observations of aerosols, Aitken Nuclei and trace gases were carried out at Kullu and Manali regions of the Himalayan Ecosystem during May 1998. The results of the analysis of the observations indicated that (i) the average concentration of TSP (165 $\mu g/m^3$) at Kullu was found to be higher than that observed at the same site in 1996, (ii) the mass size distribution of aerosols showed bimodal with dominant coarse mode, (iii) chemical composition of aerosols showed higher SO_4 concentrations at Manali as compared to that at Kullu, and (iv) the average concentration of Aitken Nuclei at Kullu was found to be 5818 cm^{-3}.

Twenty one rainwater samples were collected at the Institute's Rain and Cloud Physics Research (RCPR) Centre, New Delhi during monsoon period of 1998. pH value of these samples were measured and found in the range of 5.68 to 8.94. Sixty four rainwater samples were collected at Kanpur from three different locations during monsoon period of 1998. pH values of these samples were found in the range of 6.11 to 7.68.

Lidar Probing of the Atmosphere

Special observations of atmospheric aerosols using the lidar and radiometric techniques have been carried out at the Institute and at Mulshi Dam on 17 April, 11 May 1998, 1 and 25 January, 18 February and 14 March 1999 and also at the Khadakwasla Dam on 22 April and 16 May 1998, 6 and 30 January, 23 February and 19 March 1999 in synchronisation with overpasses of IRS-P3 satellite over Pune. Handheld (Microtops II) radiometers were used for the measurement of columnar aerosol optical depth, ozone and precipitable water vapour over the Mulshi and Khadadwasla water reservoirs on the above experimental days.

A study of the low frequency oscillations in lower atmosphere (100m - 2 km) was carried out using the special lidar observations carried out at 15 minute intervals during the night of 23-24 December 1992. The results of the study indicated 130-140, 160-190, 220-250 minutes oscillations in the lidar data. Further investigations of the high-resolution meteorological observations are being carried out to study the relationship between the observed low-frequency oscillations in the lidar backscatter data and the meteorological parameters.

Special observations of atmospheric aerosols using the Argon-ion lidar were carried out on 25 days during the First Field Programme (17 February - 31 March 1998) as a part of the INDOEX-India. Some of the important results relating to the aerosol vertical distribution suggested that (i) the concentration of aerosols varied from 9000 to 74 cm^{-3} in the 50 m to 6.8 km layer of the atmosphere, (ii) large negative gradients were observed in the surface layer (200 m) and thereafter the concentration decreased exponentially with altitude, (iii) the mixed layer height was found to be 375 m and stable layers around 900 to 1500 m, and (iv) ventilation coefficient (index of air pollution) was found to be 1613 m^2 sec^{-1}.

Simultaneous observations were carried out at Pune (continental) and in the Arabian Sea/Indian Ocean regions (maritime) during the cruise (# 133) of the Sagar Kanya as a part of the First Field Phase of the Indian Ocean Experiment (INDOEX) during 17 February - 31 March 1998 to study of the possible association between the continental and maritime aerosols. The aerosol distributions at Pune were obtained using the Argon-ion lidar and the observations in the maritime environment were carried out on board the Sagar Kanya using the sunphotometer and High-Volume aerosol samplers. The results of the analysis of observations at Pune have indicated (i) variation in aerosol concentration from 9000 to 74 cm^{-3} between the altitudes 50 m and 6.8 km, (ii) large negative height gradients in aerosol concentration up to about 200 m and thereafter exponential decay with increase in altitude, (iii) increasing trend of about 20 per cent in daily variation of aerosol columnar content, and (iv) average height of mixed layer around 375 m and that of stable layer around 900 m, and mean ventilation coefficient around 1613 m^2 s^{-1}.

Spectral aerosol optical depth measurements using multi-channel radiometer (sunphotometer) and spectroradiometer were made at Pune as part of the INDOEX-FFP98 during 17 February to 31 March 1998. The data collected on 21 cloud-free days were analysed to study the optical and physical properties of continental aerosols and also to examine their relationship with concurrent marine aerosol characteristics for detailed understanding of the optical state of aerosols in the ITCZ. The results indicated close agreement between the sunphotometer and spectroradiometer-derived forenoon, afternoon and full day aerosol optical depths and the corresponding bimodal size distributions, and an increasing trend in aerosol optical depth at 0.5 μm during the study period. Comparison of these observations with those obtained over Tiruvananthapuram suggests that there

is a higher aerosol optical depth and abundance of coarse-mode aerosol particle concentration over Pune (urban) as compared to that over Tiruvananthapuram (coastal).

To investigate the optical and physical properties of haze and smoke aerosols and their relationship with atmospheric ozone and water vapour in winter at Pune, observations of direct solar radiation collected using sunphotometer, ozone monitor and spectro-radiometer on 57 cloud-free days during the winter (November-February) of 1998-99 were taken. The results of the study indicated (i) greater aerosol optical depths (more than double) on the days associated with haze and smoke as compared to the clear stable days, (ii) a close one-to-one relationship between the variations in columnar aerosol optical depth, precipitable water vapour and an opposite relationship between aerosol optical depth and total ozone (Figure 9), (iii) aerosol size spectra on both hazy and smoky days exhibit bimodal distribution with predominant smaller particles on smoky days and larger particles on hazy days, and (iv) aerosols during the winter season at Pune, substantially reduced the solar radiation reaching the ground and visibility.

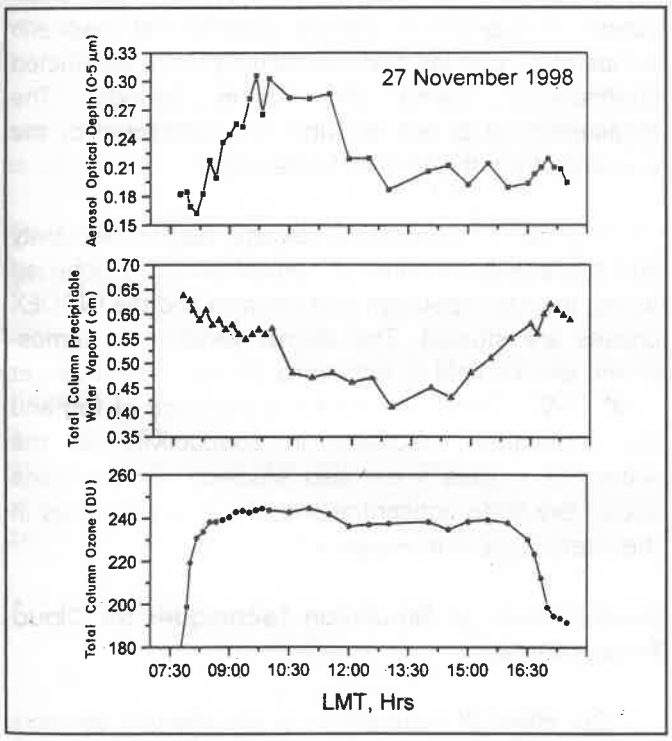


Fig. 9 : Co-variations between aerosol optical depth, total column precipitable water vapour and ozone observed radiometers.

Spectroscopic Measurements of Atmospheric Minor Constituents

The analysis of the rotating slit-scanning spectrometer observations during January-April 1998 was completed for the trace species NO_2 and O_3. The vertical profile of NO_2 was derived from the algorithm developed at the Institute. The profile showed exponential decay of NO_2 concentration with increase in altitude and the results were found to be consistent with other estimates for the tropics.

Spectrometer observations collected at Leeland station (Reykjavik) during winter season of 1994-95 were analysed and slant column densities of NO_2, O_3 and O_4 were computed and vertical profiles of NO_2 and O_3 were derived. The contour maps of NO_2 and O_3 columnar densities of Iceland station were prepared. The contour map of O_3 shows peak concentration around 22 km. The variations observed in all layers showed almost similar trend. Layerwise contributions of NO_2 total column density were worked out. The tropospheric layers showed larger variations on polluted days. The layer density variations of NO_2 are clearly seen in the contour map of NO_2. The vertical profiles of O_3 and NO_2 suggest that the stratospheric variations of NO_2 and O_3 are found to be in phase with each other and show good correlation.

An automatic visible spectrometer developed at the Institute has been installed at the University of Mauritius, Reduit, Mauritius on 16 September 1998 for the monitoring of distributions of NO_2 and O_3 in the atmosphere as a part of the Indian Ocean Experiment-India (INDOEX-India) Programme. The spectrometer has been developed indigenously based on the Czerny-Turner type spectrometer. The zenith sky radiations were collected by quartz lens and collimated through a proper optical arrangement for making measurement of absorption in different wavelengths by the atmospheric chemical species using visible spectrometer. The spectrometer has a data acquisition system and an online personal computer for real time data archival and analysis.

An improved algorithm was developed for deriving vertical profiles of aerosol number density from the rate of change of zenith sky intensity

variations during the twilight period. This algorithm has been successfully utilised for the retrieval of aerosol distributions in the upper troposphere and lower stratosphere from the twilight observations collected at Pathardi during 1993-94.

A study was carried out to examine the long-term changes and trends in the atmospheric thermal structure, neutral and ionized composition using a two-dimensional Eulerian residual circulation model that treats radiation, dynamics and chemistry interactively. The model results indicated (i) both the ionized and the neutral atmospheric composition undergo a significant variation with solar activity and anthropogenic activity, (ii) cooling by 10° K in the mesosphere and 0°-14°K in the stratosphere by 2050 AD (iii) maximum increase in NO^+ and O_2^+ ion concentration and negligible change in total ionization/electron density by 2050 A.D. and (iv) several neutral species are predicted to undergo significant changes by 2050 A.D. when Business As Usual (BAU) scenario is considered. The percentage change in the concentrations of NO, O, O_2, H_2O, CH_3CN for BAU scenario with respect to 1998 A.D. is plotted in Figure 10.

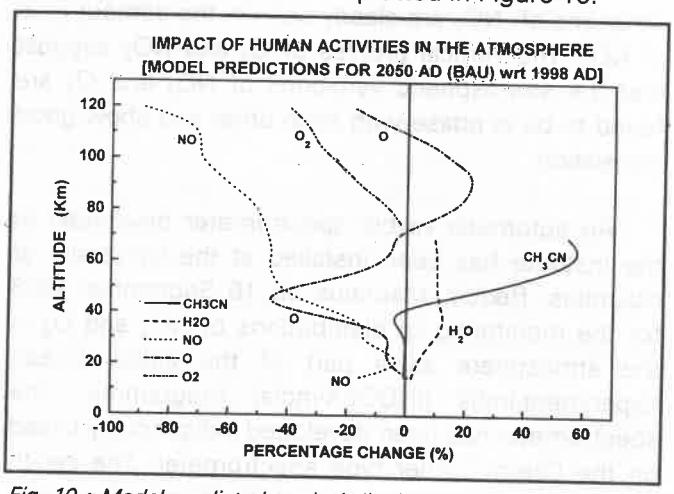


Fig. 10 : Model predicted vertical distribution of neutral species up to thermospheric levels

To examine the effect of global change induced perturbations in several alkaline neutral compounds and consequently on the distribution of ionization for the troposphere, a first steady state ion composition model has been developed indigenously and tested at the Power Challenge-SG-Computer at the Institute. It is envisaged to use this model for studying various problems related to tropospheric phenomena and global electric circuit.

Instruments and Observational Techniques

The broad scope of the Instruments and Observational Techniques division is to design and develop instruments and techniques for observations and to carry out field and laboratory experiments. Topics identified for the research are:

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

Development of Instruments and Observational Techniques for Cloud Electrification Studies

A comprehensive experiment to understand the atmospheric electrical state of the atmosphere close to ground was conducted from 20-27 April 1998 and 24-29 December 1998 at the Institute. Measurements of atmospheric electric field, conductivity, space charge, air-earth current, ion concentration, size distribution of sub-micron aerosol particles, atmospheric temperature profiles and radioactivity were conducted continuously during the above periods. The measurements of radioactivity were conducted by the scientists from the Mysore University.

The data of atmospheric electric field, conductivity and the size-distribution of aerosol particles obtained during the XVI expedition to Antarctica and the INDOEX cruises are studied. The diurnal variation of atmospheric electric field at Antarctica shows a maximum at 1300 GMT. Two cases of the occurrence of fog and the consequent decrease in conductivity on the Antarctica cruises were also studied. Observations show very large concentrations of aerosol particles in the Intertropical Convergence Zone.

Development of Simulation Techniques for Cloud Physics Studies

The effect of coagulation of the charged aerosols on the asymmetric charging of aerosol particles has been studied by solving the ion-aerosol balance equations numerically. The results show a decrease in

the asymmetry in the charge distribution of aerosol particles when the effect of coagulation is included. Change in particle charge distribution of positive and negative ions with aerosol concentration is also examined.

An a.c. field-mill and the Gerdien's condenser are being fabricated for the use of the scientists of Mysore University under their DST-sponsored project.

The data collected earlier on the size and charge of raindrops and electric field are being analysed to study the existence of mirror-image effect and other related phenomenon.

Photographs of the evaporating charged and uncharged water drops suspended in vertical wind tunnel are taken at different values of relative humidity. These and earlier photographs have been analysed to study the effect of ventilation on the evaporation of water drops. The results show that the effect of ventilation is stronger on the evaporation of uncharged drops than that of charged drops. Further, the calculations showed that at the cloud base, a charged drop is required to be smaller in size as compared to an uncharged drop in order to reach the Earth's surface with the same size.

A laboratory experiment to study the effect of electric charges on the terminal velocity of water drops is conducted in the vertical free-fall tube.

Boundary Layer and Land Surface Processes Studies

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

- Development of instruments / Observational techniques to study the structure of the atmospheric boundary layer and related studies
- Land surface processes studies to estimate the energy budget over different vegetation and soil conditions

Land Surface Processes Studies

The mixed layer height, estimated from the RS/RW (slow rising balloon) data of Land Surface Processes Experiment (LASPEX-97) by the non-local parcel movement method was about 3 km during March - June, 1.5 km during July - September and 2 km during October - February (Fig.11).

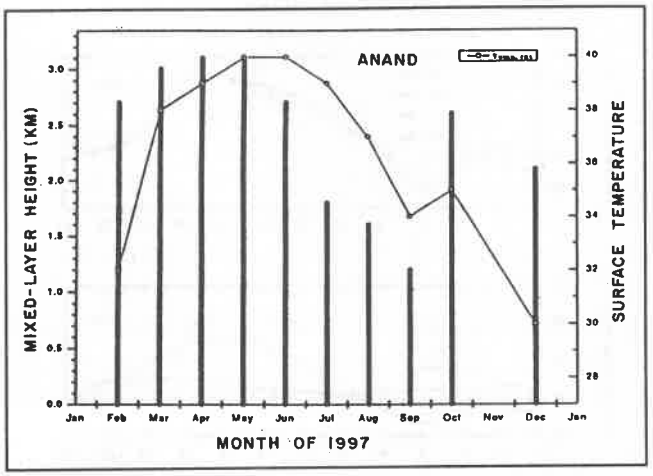


Fig. 11 : Mean Mixed-layer height at Anand

The land surface processes experiment (LASPEX) was conducted during January 1997 - March 1999. A large amount of surface and upper air data have been collected for 2 years at five experimental sites in the Sabarmati river basin of Gujarat. The raw data were processed systematically for the months of May, July, September and December 1997 and were distributed to participating institutions.

The diurnal variation of air and soil temperature with respect to solar radiation was studied in two selected periods, one in summer (April) (Fig.12) and the other during monsoon (July). It was observed that during summer, there was a considerable lag in the temperature maxima with respect to solar radiation, as compared to the monsoon period. Also, in summer, when there was an increase in wind speed from near zero values in the early morning hours, the soil surface as well as the air temperature minima were increased in magnitude.

Synoptic data of LASPEX-97 for Arnej, Derol, Khandha and Sanand for the year 1997 were analysed. The moisture index was found to be 0.45

for Arnej and 0.77 for Khandha. In all the stations monsoon season rainfall accounts for 96% of the annual rainfall. The Maximum potential evaporation per day was 18.5 mm for Arnej and 11.3 mm for Khandha. More than 50% of the loss of soil moisture by evaporation was compensated by precipitation for all the LASPEX sites for the year 1997.

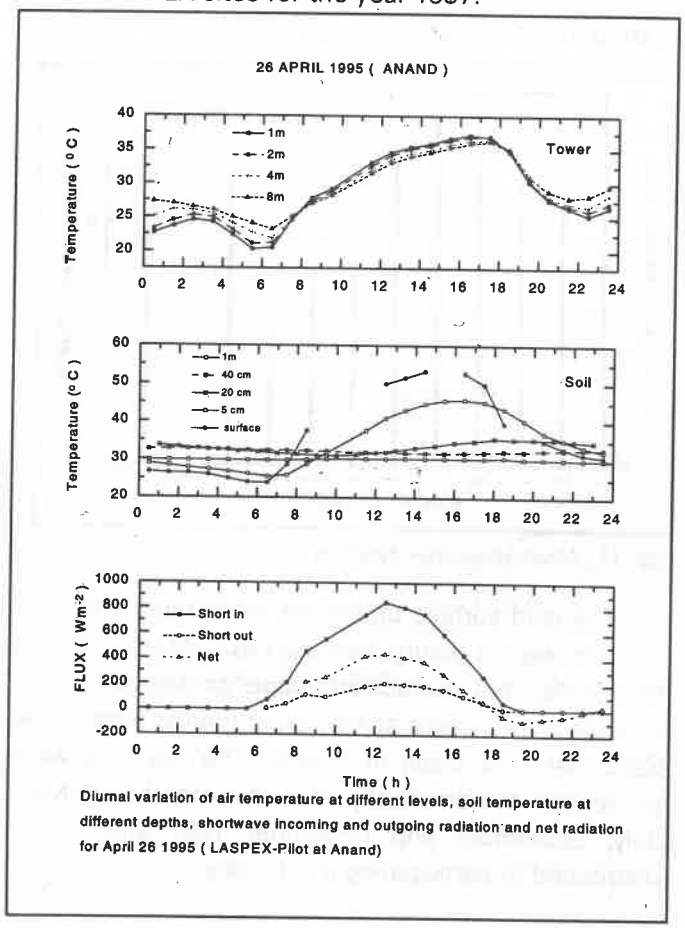


Fig. 12 : Dirunal variation of air temperature at different levels, soil temperature at different depths, shortwave incoming and outgoing radiation and net radiation for 26 April 1995 (LASPEX-Pilot at Anand)

MONTBLEX Studies

Stability characteristics in the surface layer were studied using the tower observations at Kharagpur, Varanasi and Jodhpur during MONTBLEX-90. The results showed that the stability characteristics in different sub-layers of the surface layer over three different convective zones were different. Variation of exchange coefficients of momentum(C_D), heat (C_H) and moisture (C_E) with wind speed and stability was studied. The result showed that magnitudes of C_D, C_H and C_E are decreasing with increasing stability over all the three convection zones of the monsoon trough. They show decreasing trend with increasing wind speed over the dry and alternate deep moist/ unsaturated convection zones while opposite trend is shown in the moist convection zone. The observed magnitudes of C_D, C_H and C_E generally agree with those obtained elsewhere in the northern hemisphere. C_H is nearly equal to C_E but C_D has less magnitude over all the three convection zones.

Theoretical Studies

The Division conducts theoretical studies and develops models for the study of monsoon and tropical circulation systems. The research programmes are undertaken to investigate the following :

- Role of barotropic, baroclinic and combined barotropic-baroclinic instability mechanisms in the formation and growth of monsoon disturbance
- Global spectral P.E. model for simulation of summer monsoon circulation and determining global energetics in different vertical and time domains
- Diagnostic studies and numerical modelling of the linear and non-linear 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 efficient object oriented models for meteorological computing

Barotropic and Baroclinic Instability of the Atmospheric Flow

A pure baroclinic 16 layer quasi-geostrophic numerical model was used to determine the baroclinic structure of the severe cyclonic storm formed during June 1994. It was found that the

baroclinic structure of preferred wavelength was comparable to that of the observed structure of the cyclonic storm. Further, it was seen that by inclusion of surface friction, the perturbation field is slightly enhanced but the vertical extention remains unchanged. Though the advected phase velocity is eastward, the phase velocity due to divergence term alone indicates the westward motion of the system.

A diagnostic study was carried out to compare the three dimensional energetics of the monsoon during the onset phase of east Arabian sea and surrounding region from surface to 200 hPa during 1-7 June of each of the years 1994 and 1996. The onset phase of 1994 was associated with a severe cyclonic storm whereas in 1996, it was a pure onset phase. Day to day energetics and conversions were computed at 50 hPa interval. In 1994, barotropic conversion was found dominant beyond 3 June which may be due to the presence of severe cyclonic storm. In 1996, beyond 3 June baroclinic conversion was enhanced throughout in the vertical column which implied that once the monsoon onset takes place, baroclinic mechanism plays an important role.

Simulation of Mean Monsoon Circulation and Predictability of the Monsoon System

Atmospheric Modelling

The results from the study dealing with the computation and analysis of Fourier spectral energetics in the frequency domain at 850 hPa and 200 hPa for the summer and winter months of 1994, 1995 and 1996 over tropics (20°S-20°N) and extratropics (20°N-60°N) revealed that the tropical convection plays an important role for the maintenance of intraseasonal oscillation during northern summer. In contrast to the summer circulation, instead of a down scale de-cascade, as in the case of the extratropics, kinetic energy is transferred in an opposite sense, namely from transients of shorter to those of longer time scales in the tropics during winter. The results suggested that there exists a possible link between Pacific North American (PNA) pattern and intraseasonal variability during northern winter.

A computational model was designed to understand the dynamical mechanism of low frequency monsoonal transients that result from nonlinear energy conversions due to the effects of coriolis force, vorticity and divergence. The results showed two distinct spectral peaks of periods 30-45 day and 18-25 day in the energy conversion from the transient divergent motions to rotational motion. Due to the latitudinal variation of earth's rotational effects, the conversions from the transient divergent motions to rotational motions on 30-45 day time scale are more pronounced to the north of 15°N while they are weaker in the mean equatorial latitudes. The contribution of the stationary waves to the maintenance of the low frequency rotational flow of the periods 30-45 and 18-25 day due to the effect of divergence through barotropic instability is significant at the upper troposphere.

The problem of phase locking related to monsoon circulation by examining the triad energy exchanges among the intraseasonal and interannual time series was mathematically formulated in terms of phases and amplitudes of the three oscillations involved.

Stratospheric global energetics and their space-time variability during the active monsoon month of August 1990 were studied. Stationary and transient spectra of global rotational kinetic and available potential energy and their nonlinear exchanges were obtained on six stratospheric pressure surfaces between 150 hPa to 10 hPa. Results showed that the stationary component of the energetics dominates the stratospheric circulation. The stratospheric circulation is found to be mainly governed by scales of motion having wavenumber less than 8. Therefore, for studies on stratospheric dynamics, truncation up to wavenumber 15 seems to be sufficient. The preferred scale of global stratospheric circulation is represented by wavenumber two.

Ocean Modelling

A two and half layer thermodynamic numerical ocean model was integrated for 15 years to simulate interannual variability in the thermodynamic characteristic of the upper north Indian Ocean. For this integration monthly climatology of surface heat flux derived from COADS and momentum flux derived from interannually varying monthly mean FSU pseudo stress data for the period 1977-1991 were used as the input. The spatial and temporal variabilities of the summer cooling in the Arabian Sea region were analysed by considering latitude-time cross section of SST anomalies along the longitude 55°E and north of equator. The cross section of model simulated SST anomalies (Fig. 13) for the period 1977-1991 and the corresponding NCEP SST anomalies (Fig.14) during the period 1982-1991 showed the northward advection of cold anomalies during 1984 and 1985, and advection of warm anomalies during 1982, 1983 and 1987. However, the cold advection in 1986 found in NCEP SST anomalies was not well simulated.

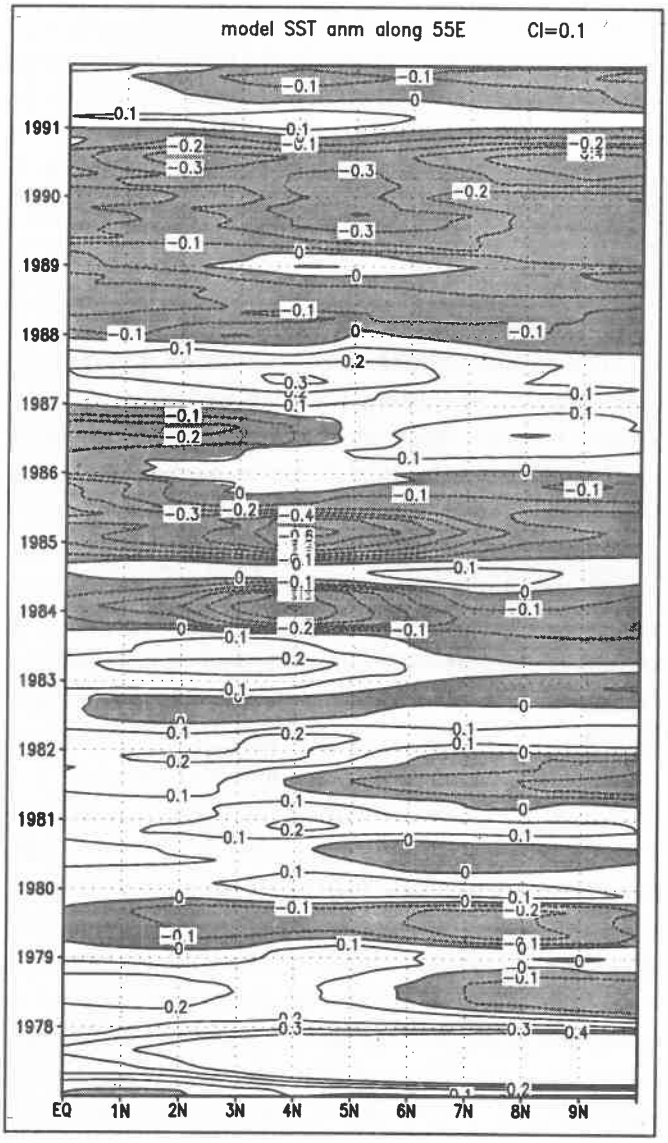


Fig. 13 : Latitude - time plot of SST anomalies along 55° E for the period 1977-1991. A seven month running mean is applied on the anomalies.

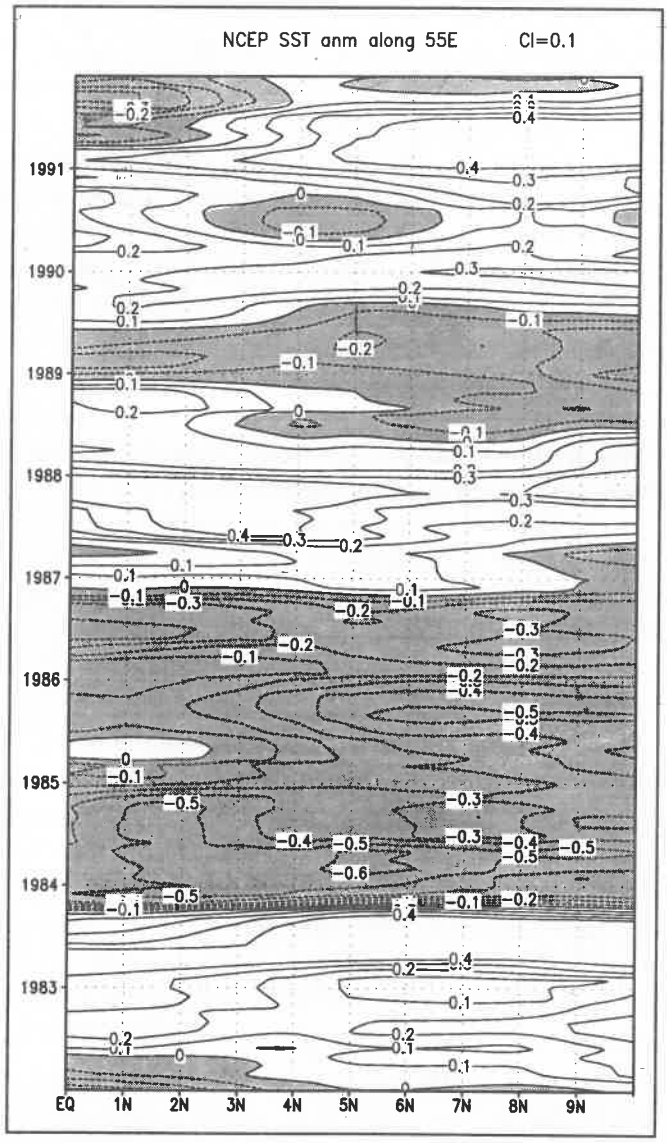


Fig. 14 : Latitude - time plot of SST anomalies along 55° E for the period 1982-1991. A seven month running mean is applied on the anomalies.

One and half layer IRG (IITM Reduced Gravity) model was used to determine the response of upper layer of ocean to an idealised, asymmetric cyclone in the Bay of Bengal, moving towards NW. 50% asymmetry in the cyclonic wind stress to the right of the track significantly enhances the right bias in upper layer thickness deviation. Whereas 50% asymmetry on the left of the track shows very little response to the left side of the track. 30% asymmetry on the left side of the track acts as a threshold value which removes bias in the model fields mainly in the upper layer thickness deviation field. The case of asymmetry ahead of the cyclone behaves similar to that of right asymmetric case. But the cooling, seen in the wake of cyclone, is relatively less than that of right asymmetric case. The case of asymmetry behind the cyclone centre shows reduction in the right bias of model upper layer thickness devation (ULTD) field but right bias in the model current field is still present.

A study was carried out to understand the wave propagation in the direction of (i.e along the track) and perpendicular (cross the track) to the symmetric cyclone movement. It was found that there is a wave propagation along the track in the direction of the cyclone movement with a period of 1.5 day and a phase speed of 5.4 m/s. Along the cross track direction the oscillation was found to be stationary. For the case of asymmetry ahead of the cyclone centre, it was found that the cross track oscillation also has phase propagation towards the left side of the track. No other case of the asymmetric cyclone showed phase propagation of the cross track oscillation.

Mixed layer response of ocean to Arabian Sea cyclone using IRG model was also studied considering three observed tracks in the Arabian Sea. The right bias in the model current was present in all the cases but the right bias in the ULTD field was present only for the tracks having northward component (Fig. 15). Reduction in the time step from 30 minutes to 15 minutes does not show any change in the currents and ULTD fields.

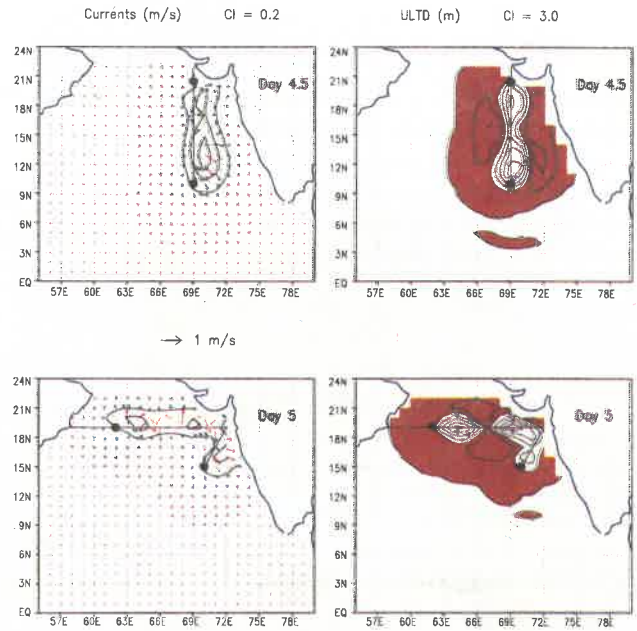


Fig 15: Model Currents and ULTD fields (positive values are shaded) for the case of northward moving cyclone after 4.5 days (Top) and for the case of westward moving cyclone after 5 days (Bottom)

Development of Advanced Computing Techniques

For the process of developing a library of efficient object oriented modules for meteorological computing, complex number theory has been successfully implemented as a C++ class. C++ features like Function Overloading, Operator Overloading, References and Friend Functions were extensively used in the design and development of this class. All implemented features were found working correctly. Besides a large number of primitive complex functions, the C++ implemented features include (i) complex roots of quadratic, cubic and quartic algebraic equations of non-complex coefficients, (ii) complex roots of quadratic equation of complex coefficients, (iii) evaluation of a complex determinant and (iv) inversion of a complex matrix. Formulation of the problem of development of a comprehensive C++ package for the non-complex and complex matrix eigen value problem is being worked out.

Climate and Global Modelling

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

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

CLIVAR Asian-Australian GCM Intercomparison Project

IITM participated in the CLIVAR Intercomparison of Monsoon Climatology and variability by the use of Atmospheric GCMs. This is a co-ordinated activity organized by the WCRP/CLIVAR Asian Australian Monsoon Panel. The main aim of the project is the GCM intercomparison of 1997-98 El Nino effect on monsoon based on 10-member ensemble integrations. India, China, Japan, Korea, Russia, USA and Taiwan participated in this project.

As part of the intercomparison project two sets of long integrations were carried out for 18 year period (1979-1996) with observed SST and sea ice as boundary forcing, in one case and climatological values of SST and sea-ice in the other case. The SST and sea-ice data used were the same prepared by Programme for Climate Model Diagnosis (PCMDI) for Atmosphere Model Intercomparison Project (AMIP II) integrations. The UKMO Unified Model (HadAM2b) was used for the intercomparison project.

To study the impact of recent 1997-98 El Nino on Asian Australian Monsoon, 10 ensemble runs of the model were carried out for the period 1 September 1996 to 9 September 1998 using observed weekly SST and sea-ice fields as boundary conditions. The initial conditions for these integrations were taken from the long integration with observed SSTs. The initial conditions correspond to 1 September 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994 and 1995.

The model outputs will be used to compute the long-term simulation statistics based on monthly data, annual cycle with 5-day mean, interannual and intra-seasonal variability of the Asian and Australian monsoon. The model precipitation climatology for the summer monsoon season (JJAS) based on observed SST integration is shown in Fig.16. The corresponding circulation features at 850 hPa and 200 hPa are given in Fig.17. The ensemble experiments are expected to provide insight into the unusual relationship between Indian monsoon and the ENSO of 1997-1998. The model output from these long integrations and ensemble integrations will be used for many other studies of the simulation of the summer and winter monsoons.

The monthly precipitation and wind at 850 and 200 hPa from the long integrations and the daily precipitation and wind at 850 and 200 hPa from the ensemble integrations have been sent to the project co-ordinator and exchanged with the participants.

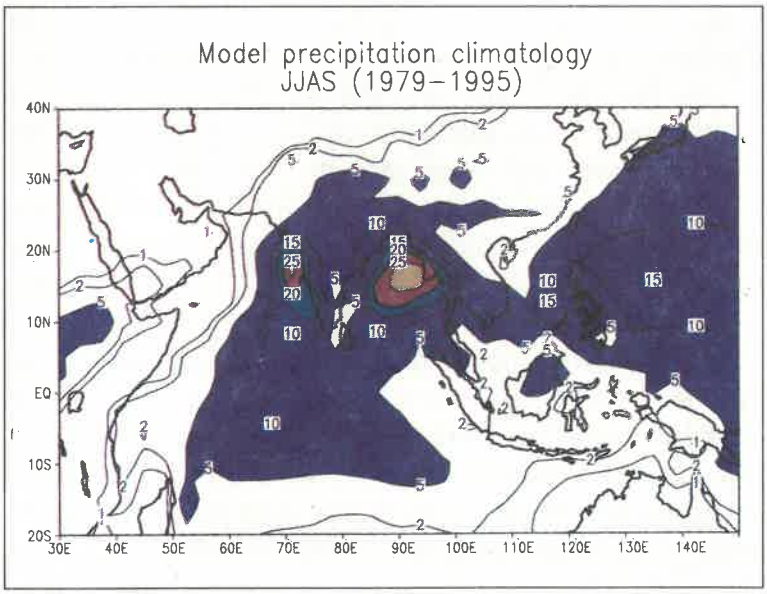


Fig. 16 : UKMO Unified Model precipitation climatology for the summer monsoon season (JJAS) based on observed SST integration for the period 1979-1995

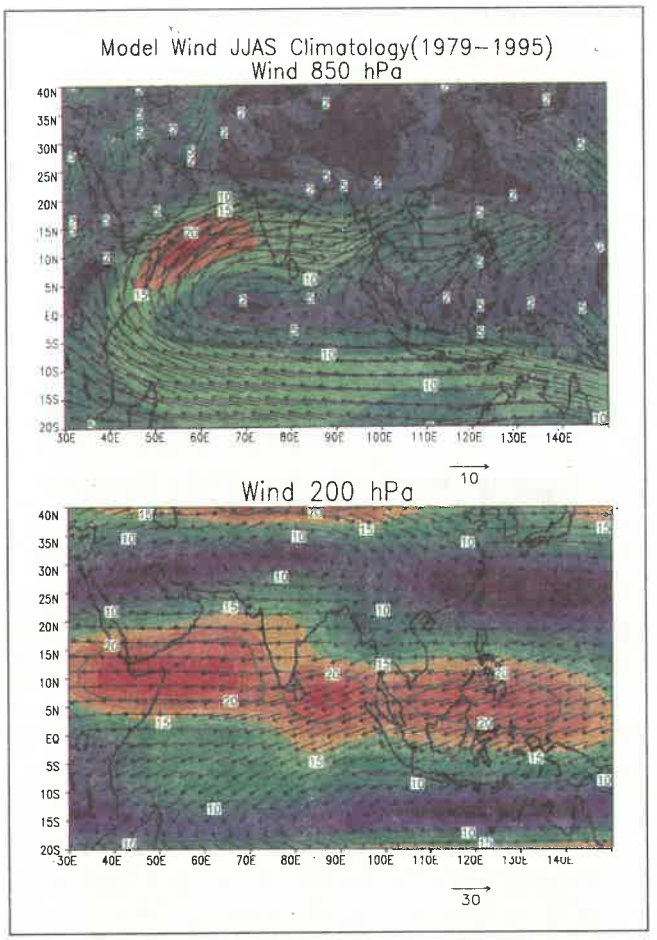


Fig. 17 : UKMO Unified Model wind climatology at 850 and 200 hPa for the summer monsoon season (JJAS) based on observed SST integration for the period 1979-1995

Role of Indian Ocean SST Anomalies in Mean Monsoon and its Variability

Sea Surface Temperature (SST) climatology has been used to study the interannual and intraseasonal variability in Indian Ocean SSTs. It is found that interannual variability in the monthly mean SSTs is typically around 0.5°C, whereas the intraseasonal variability is much higher, nearer 1°C. Motivated by these studies, several sensitivity experiments with the UKMO model (HadAM3) have been conducted to understand the role of Indian Ocean SST anomalies on monsoon mean state and its variability. It is found that the UKMO model is sensitive to Indian ocean SST anomalies monsoon mean state and its variability. It is further seen that the seasonal mean monsoon circulation and precipitation are sensitive to the location, strength and sign of the SST anomalies. It appears that warm SST anomalies in the North Indian Ocean tend to enhance intraseasonal variability. Thus, the study has shown the importance of Indian Ocean SSTs on the mean monsoon and its intraseasonal variability (Fig.18).

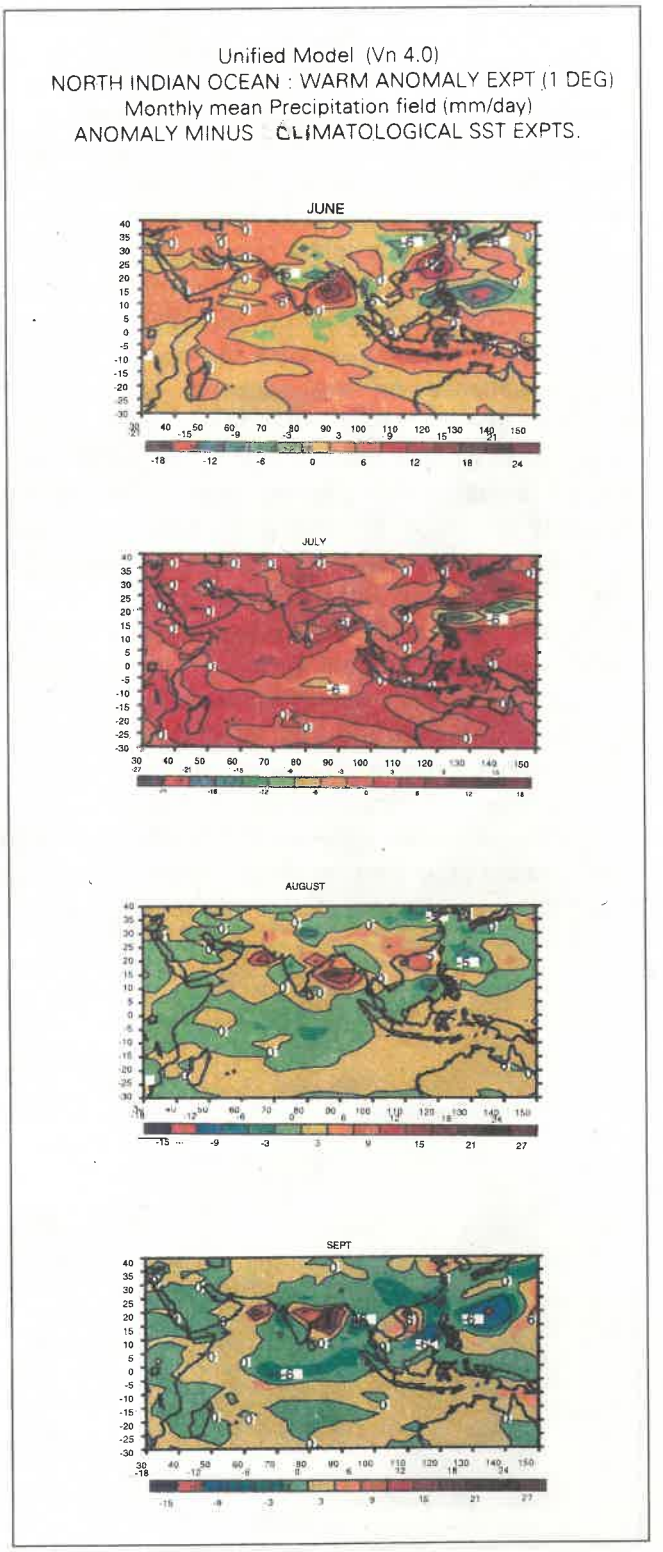


Fig. 18 : Monthly difference in precipitation between warm SST simulation and climatological SST simulation

Internally and Externally Forced Monsoon Variability

The contributions from internal and external forcings to the total interannual variability of All India Summer Monsoon Rainfall were quantified. COLA model at T30L18 resolution was integrated for four summer monsoon seasons (June through September), with observed sea surface boundary conditions. The ensemble integrations with 10 different atmospheric initial conditions from 1 May-10 May were carried out for four summer monsoon seasons. The study showed that the contribution from external variance is twice the contribution from internal variance on the seasonal scale. On the monthly scale the contributions from external variance dominates for the first three month period (Fig.19). Based on cumulative rainfall variance analysis the contributions of external and internal variances to the total variance were 60% and 40% respectively. The sensitivity of intraseasonal modes to initial conditions was studied by decomposing the time series into constituent modes using wavelet transform. The Haar orthogonal wavelet function was used to decompose the total variance into variances of 7 dyadic scales. It was observed that the intraseasonal modes are very much sensitive to initial conditions. However, the variability of the intraseasonal modes in terms of intensity and location (within the time series) is not related to the seasonal rainfall.

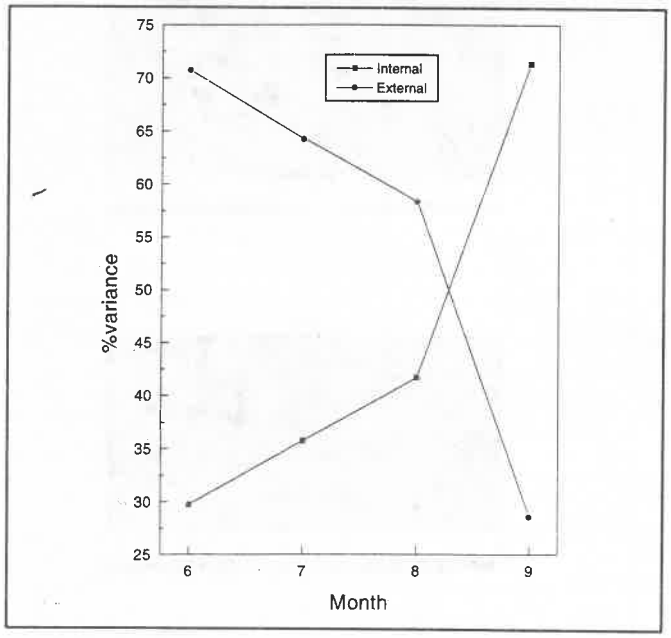


Fig. 19 : Monthly contributions from internal and external variabilities to all India summer monsoon rainfall

Seasonal Prediction of Summer Monsoon Rainfall using GCMs

Experimental seasonal prediction of summer monsoon rainfall over Indian region was attempted using both UKMO Unified Model and COLA model. SST anomalies of April/May 1998 were persisted on the climatological SSTs of monsoon season for using as boundary conditions. The SSTs used are OI SST data obtained through internet.

Seasonal Monsoon Prediction using UKMO Model

An ensemble of three model runs was carried out with April 1998 anomalies in the month of May and further three integrations with May 1998 SST anomalies, in the month of June. In the absence of real initial conditions for 1998, the initial conditions used were from long term integrations of model started from 23 May 1980. The restart dumps of 1 March of the years 1981, 1982 and 1983 were used as initial conditions for the present runs. The June to September rainfall over India (5-30°N, 65-95°E) from the ensemble runs and the ensemble mean were compared with the model climatology based on 15 year, 9 ensemble runs of the model (PROVOST runs). The April SST anomaly integrations indicated below average rainfall over both land only and land + ocean areas. However, when May SST anomalies were persisted over climatology, the simulated rainfall was above average over land areas and below average when land and ocean areas are considered together.

The forecasts were updated using SSTs of June, July and August months as and when they became available. As done earlier, three integrations were carried out using real SSTs upto current month and persisting the SST anomalies of the current month until the end of the season. The ensemble mean rainfall simulated with April, May, June, July and August persisted SST runs and real SSTs for whole monsoon season of 1998 were -2.6%, +2.9%, +12%, +7.6% and +8.4% and +11.9% respectively compared to long term model climatology. The percentage departures over Indian region (land only and land+ocean) with different months SST anomalies is shown in Fig. 20.

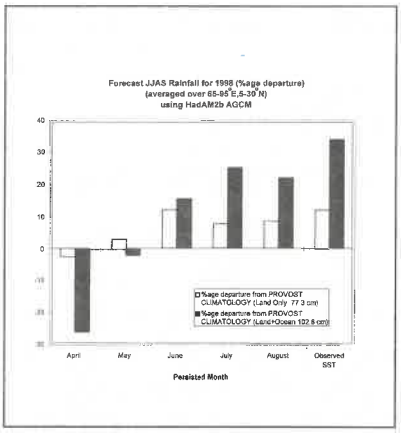


Fig. 20 : Forecast of percentage departures JJAS rainfall over Indian region (land only and land+ocean) with different months SST anomalies persisted for the rest of the season

Seasonal Prediction using COLA Model

COLA Model was integrated for the monsoon season of 1998. In the absence of real initial conditions for May 1998, the initial conditions were obtained from a long integration of the model started from 2 May 1996. The model was integrated for 24 months using OI-SST up to April 1998. The restart dump of 1 May 1998 was used as the initial conditions for running model for monsoon season 1998. The JJAS rainfall over India (5 - 30°N, 60 - 95°E) from the two sets of runs were compared with the model climatology based on 13 year runs. The JJAS mean rainfall produced by the April SST anomaly was found to be below model climatological mean rainfall over both land only and land + ocean areas. The seasonal integration using May 1998 SST anomalies showed below normal rainfall over land area and above normal rainfall over land + ocean region.

The COLA GCM was integrated for 130 days starting from the NCEP reanalysis of the observed atmospheric initial state of 00Z on 20, 24, 28, 29, 30 and 31 May 1998. The SSTs used were from the persistence of May 1998 SST anomalies, over the climatological SSTs of June to September. The JJAS mean rainfall over Indian region (5-30°N and 60-90°E) from the mean of the above 6 ensembles was compared with the model climatology based on 13 year runs and was found to be +4.4% above normal. The JJAS rainfall anomaly pattern for each initial condition pattern is shown in Fig. 21 and the ensemble mean 850 hPa wind anomaly and precipitation anomaly are shown in the Fig. 22.

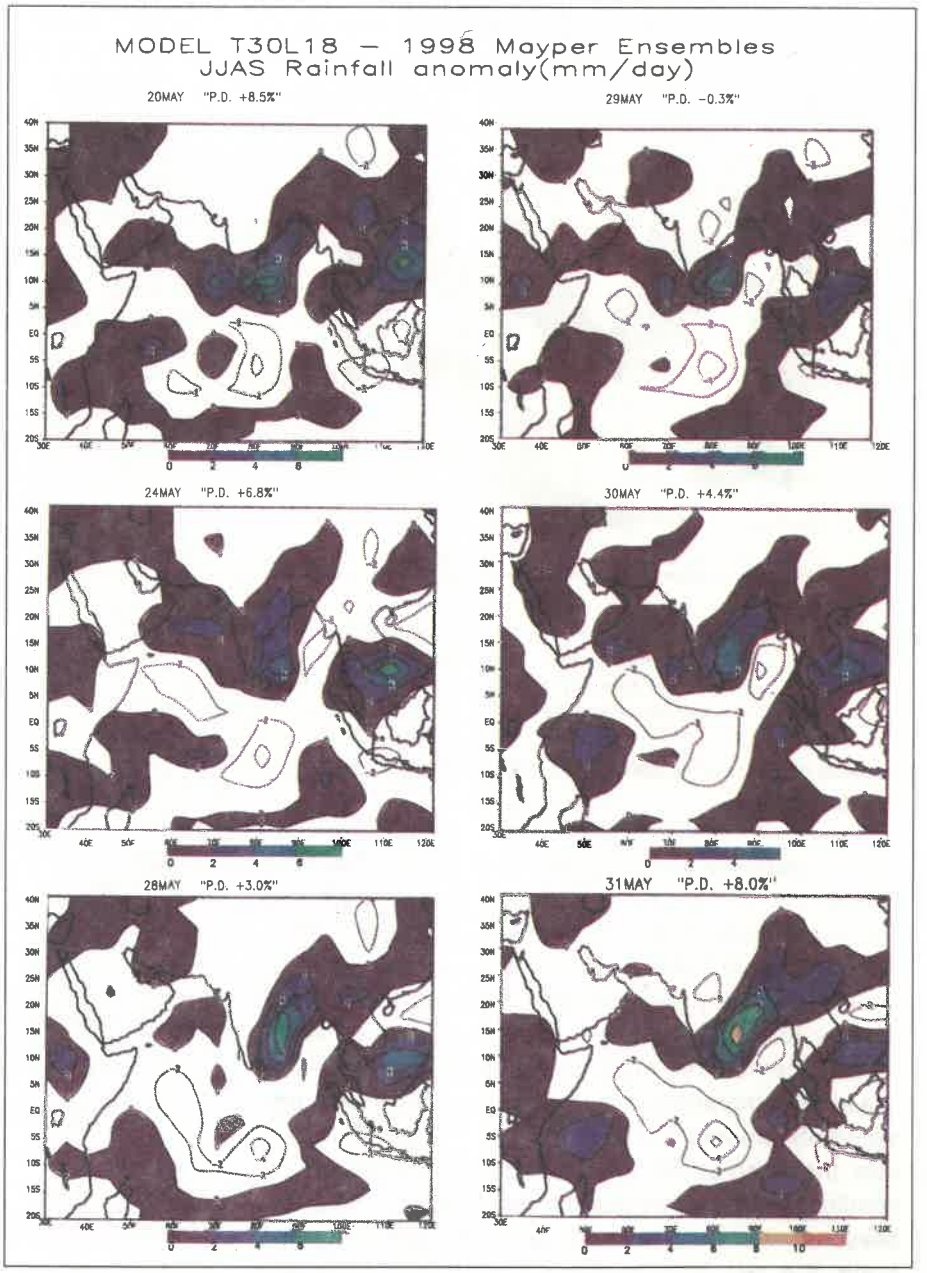


Fig. 21 : The JJAS rainfall anomaly pattern simulated by COLA GCM for monsoon 1998 with different initial conditions and persisted SST anomaly of May 1998

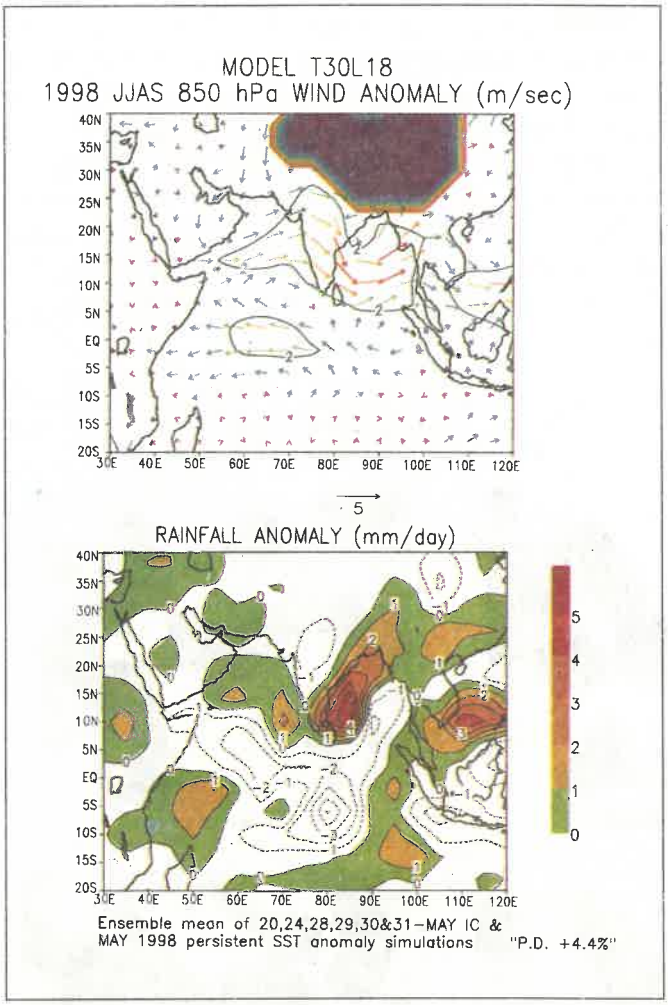


Fig. 22 : Ensemble mean 850 hPa wind anomaly and precipitation anomaly for JJAS 1998 with persisted SST anomaly of May 1998

Assessment of Persistent SST Method for Seasonal Predictions

For seasonal prediction of monsoon rainfall using GCMs, the SST boundary forcing for the whole season is required. In the absence of predicted monthly SSTs of global oceans, the SST anomalies of latest available monthly SST are persisted over the climatology for forcing the model. To examine the suitability of this method for monsoon prediction, a series of seasonal integrations using observed SSTs and persisted SST anomalies of May are carried out. For each year the integrations are started from 23 May initial conditions. The integrations for 1980 to 1993 (14 seasons) were completed. On the seasonal time scale, the two simulations with observed SSTs and the persisted SSTs showed similarity in many years and significant difference in some years. Large differences were seen in years where the SSTs changed rapidly at the beginning of the monsoon season. The June rainfall with both the integrations showed good agreement when May SST anomalies are persisted.

The Prediction by Using Artificial Neural Networks Technique

An Artificial Neural Network (ANN) technique with error-back-propogation algorithm was used to provide prediction (hindcast) of ISMR on monthly and seasonal scales. The ANN technique was employed on the 5 time-series of June, July, August, September and seasonal (JJAS) rainfall from 1871 to 1994. Previous 5 years values from all the 5 time-series were used to predict for the next year. The performance of the models was examined and it was found that they could be used as a forecasting tool not only at seasonal scale but also on monthly scales. The actual and predicted rainfall time series for June, July, August, September and season as a whole for the independent test period 1961-1994 are shown in Fig. 23.

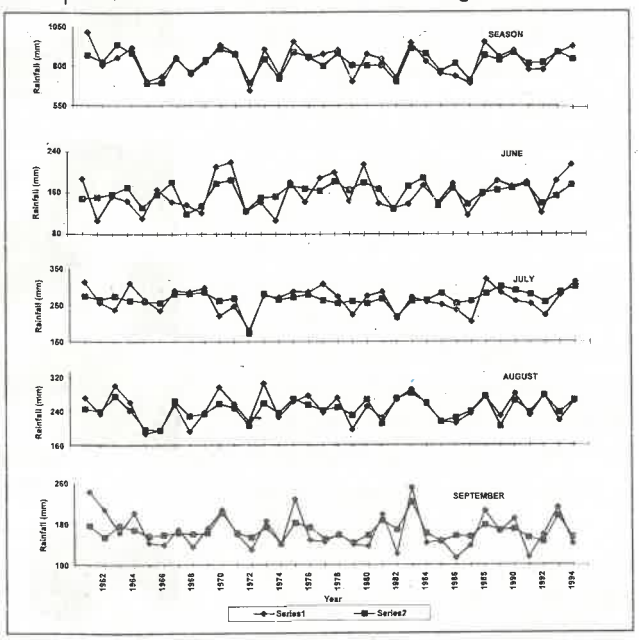


Fig. 23 : Observed (series 1) and predicted (series 2) seasonal and monthly all India Summer monsoon rainfall for test set in Neural Network Model

It is observed by various research workers that the relationships between various predictors and Indian monsoon are changing with time, leading to changes in predictability of monsoon rainfall. This aspect was examined and it has been found that the monsoon system inherently has a decadal scale predictability variation.

Sponsored Projects

In addition to the ongoing 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.	Climate Research. (Global Modelling)	Dr.V.Satyan	1994-99	198.32	DST
2.	Rotating Slit Scanning(Automatic) High Light Gathering Power UV-Visible Spectrometer (RSH IS) for Atmospheric Studies	Dr.D.B.Jadhav	1996-99	9.41	DST
3.	Synoptic Evolution of Weather over LASPEX Area and Role of Land Surface Parameters in Modulating Synoptic Developments	Shri.D.K.Paul	1997-1999	2.89	DST
4.	2D-Chemical Modelling of Global Changes Induced Perturbations in Atmospheric Minor Constituents and Ionizations of the Lower and Middle Atmosphere	Dr.G.Beig	1997-2000	6.00	CSIR
5.	U.S.India Co-operative Research: Investigation of Atmospheric Chemistry : Aerosols-Climate Interactions	Dr.P.C.S.Devara	1997-2000	4.00	NSF, USA
6.	Atmospheric Aerosol Loading Over Land from IRS-P3 MOS Sensors Data	Dr.P.C.S.Devara	1997-2000	5.54	ISRO
7.	Simulation of Surface Wind Stress on Monthly and Seasonal Time Scales using Coupled Atmospheric Ocean Model (CAOM) to Provide Forcing for Driving an Ocean General Circulation Model (OGCM)	Dr.V.Satyan	1997-2002	34.25	DOD
8.	Variability of North Indian Ocean and its Impact on Global Ocean and Understanding the Mechanism of Coastal Circulation Around India	Dr.(Smt.) P.S. Salvekar	1997-2002	34.25	DOD
9.	Numerical Modelling of the Dynamics of the Ocean Circulation	Dr.(Smt.) P.S. Salvekar	1999-2001	7.50	SAC

Field Research Unit

The Field Research Unit of the Institute at Bangalore is involved in carrying out a country-wide Wind Energy Resource Survey Programme since 1986 under a Project financed by the Ministry of Non-Conventional Energy Sources, New Delhi. Under this project, two programmes are being carried out, viz., (i) Wind Monitoring Programme and (ii) Wind Mapping Programme.

Under the Wind Monitoring Programme, comprehensive wind resource data from selected stations were collected by using 20/25 m tall guyed mast and microprocessor based automatic data collection system. The data were analysed and the results were made available to entrepreneurs in the planning and development of wind electric power to augment conventional electric power. So far, wind data were collected from 300 stations in 17 States and 3 Union Territories. The stations are being closed down after collection of data for 1-2 years and newer stations to be commissioned at other locations.

Under the Wind Mapping Programme, forty four stations were installed, 53 stations are dismantled and 96 are in position. To study the variations of wind speed in the lowest 50 m of the atmosphere, five 50 m tall masts with accessories are to be imported from U.S.A. After a trial, installation of one such mast (already imported from U.S.A.) in the compound of NAL, Bangalore, about 3 months continuous data on winds at 5 different levels were collected using automatic data loggers. This mast has now been erected on a suitable plot at Vajrakarur in Andhra Pradesh. The data acquisition will be carried out for a period of 1 year. Three or four more similar instrumented masts will be installed subsequently in other states to study the behaviour of the power law index in different climatic regimes.

In collaboration with the Ministry of Non-Conventional Energy Sources, Government of India a work to carry out the "Micro Surveys" around selected wind monitoring stations using the Wind Atlas Analysis and Application Programme was in operation. The analysis was being got done by 5 consultants and co-ordinated and supervised by the Field Research Unit.

A comprehensive programme for determining the wind resource in the northeast Indian states was being organised by the Field Research Unit under a special project funded by the Ministry of Non-Conventional Energy Sources. Two consultants have been engaged to carry out an in-depth study of the wind resource over the region.

Computer and Data

Scientific computing is vital for research in Atmospheric Sciences particularly connected with atmosphere modelling. Recognizing the importance of scientific computing for weather forecasting, the Institute has developed modern fast computing facilities for its research work. The software facilities/ requirements are being reviewed and additional facilities are planned and updated from time to time.

A very high end compute server, the Silicon Graphic's Power Challenge consisting of 4 CPUs (R 8000) each with a peak performance of 300 MFLOPS, with 512MB RAM, 32GB Harddisk, 3 INDY graphics workstations and RISC based HP-9000/735 workstation (with 40 MFLOPS, 112 MB RAM) constitute the Institute's computing infrastructure. Most of the Pentiums and other Personal Computers in the divisions are connected to the LAN. Powerful softwares like IRIS showcase, Explorer and Indigo Magic are available for developing audio, video and graphics applications. An efficient International Mathematical and Statistical FORTRAN Library is available. Internet facilities through VSAT have also been provided for web-browsing, file transfer, e-mail etc.

The Computer Division also provides other technical services such as collection, archival and retrieval of the meteorological and other related data for the tropics on the regional and global scales. The major databases archived include Comprehensive Ocean Atmosphere Data Set (COADS), the FGGE level III-b data set acquired from the ECMWF, U.K, and the Monthly Climatic Upper Air Data and Radiosonde Data for different stations and periods. The Division also holds voluminous data collected during the MONTBLEX Programme. Special arrangements for the long and continuous uninterrupted computations during the nights and holidays are also arranged depending on the requirements.

The Division provides its facilities to other organisations like India Meteorological Department, Universities and also to the research scholars and M.Tech. students undergoing courses connected with atmospheric sciences.

TOGA-I DATA Centre

Funded by the Department of Science and Technology, the Institute had taken up a project in which the data collected during the field phase of the 'Tropical Ocean and Global Atmosphere (TOGA)' Programme were archived for the convenience of the research scientists in India. Data received from the TOGA Project office on CD-ROMs (each with 575 MB approx.) pertaining to different data sets from various countries consisting of sea surface temperature, winds, wind stress, basic level III analysed data and supplementary fields data were archived with a special software made available by the TOGA Project Office. This software enables users to graphically view on a colour monitor, various parameters for selected areas with a provision for data extraction. A PC/AT-386 and laser printer acquired for this project were being used for the data archival and retrieval work.

DST-MONTBLEX Data Bank

The Institute had also taken up a project funded by the Department of Science and Technology for archiving data collected by various scientific organisations which participated in the Monsoon Trough Boundary Layer Experiment (MONTBLEX). The MONTBLEX data are being supplied to the users on request.

Software Development for Accounts and Management

Application Software Development for Accounts Section in its routine work like Pay Roll and its related statements, MIS reports, abstracts and schedules for Institute's various categories of staff was carried out. The output-data derived from Pay Roll were used for estimation of Income Tax and calculation of Income Tax along with Form-16 for filing the Income Tax returns. Programs have been developed in FORTRAN and C languages in addition to the interpreter languages like AWK under UNIX and dBASE-III+ on Personal Computers. The programs and data are interoperatable with heterogeneous computer platforms and software running under them. The staff of the Accounts Section were trained to run these programs and obtain print outs. Maintenance of these programs were done from time to time in accordance with the Government orders, rules and regulations.

Library, Information and Publications

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

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

The Library has built an information base of about 25,000 publications consisting of books, monographs, back volumes of journals, scientific/technical reports, seminars/symposia proceedings, reprints, abstracts, bibliographies, global meteorological data, geophysical data, maps, atlases, theses etc. and national/international current journals covering a wide range of subjects in Atmospheric Sciences.

During the year 86 books and reports in Meteorology and allied subjects were added. 96 Periodicals of national/international origin were subscribed to. Reprints of 36 papers authored by the Institute's scientists were also purchased. Several scientific and technical reports were received from the other National and the International Organisations on complimentary and exchange basis.

The scientists of the Institute are kept abreast of the latest development in their research areas by rendering regularly Information Dissemination Services through the Selective Dissemination of Information (SDI), Current Awareness (CA) and preparation of Documentation lists and Bibliographies (both current as well as retrospective) on different ongoing research projects of the Institute. The photocopies of the articles of interest are provided under the SDI and Resource Sharing Services. On demand, Citation Indexes for the research papers of the Institute's scientists are also prepared.

The Library and Information System has served as resource for literature on Meteorology and its allied subjects. The library is listed in the Directory of Special and Research Libraries in India and the Union Catalogue of Serials and Periodicals. The Library is also an active member- participant of the Resource Sharing Group and Network of Libraries in Pune Metropolitan area (PUNE-NET). The computerised databases for the collection of books and journals have been made available for retrieval at the workstation of the PUNE-NET located at the Bioinformatics Centre of the University of Pune. Computerised databases for reports and other publications have also been created.

The Division maintained liaison with Institutions, Universities and Ministries. A number of reports on the research activities and plan schemes of the Institute were prepared and sent to the Department of Science and Technology, India Meteorological Department, Universities and Research Institutes.

The Division also provided other technical services like photocopying, microfilming, photography, drafting, drawing, printing and binding to the scientists of the Institute. Programmes for popularisation of meteorology among students and public by organising open day and scientific exhibitions depicting research activities of the Institute on the occasion of important events, such as visitors, celebration of the National Science Day, the World Meteorological Day etc. were arranged.

Management

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

Administration

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

Personnel Profile

As on March 1999 the Institute had total 297 staff out of which 145 belong to Scientific, 39 to Technical, 57 to Administrative and 56 to Non-technical Maintenance category.

Staff changes

Twelve persons joined and fifteen left the Institute during the year under different categories.

Shri M.T.Goklaney, Senior Technical Officer Gr.II retired on 31 July 1998, Shri K.G. Vernekar, Deputy Director, Dr. D. Subrahmanyam, Senior Scientific

Officer Gr.I and Shri S.G. Nawadkar, Watchman, on 31 August 1998, Dr. H.N.Bhalme, Deputy Director and Dr.(Smt.) A.M.Selvam, Deputy Director on 28 February 1999, all on attaining the age of superannuation.

Shri S.R. Pandiyan, Watchman expired on 3 January 1999.

Shri S.S. Keshwani, Mechanic Gr.I and Shri K.Vijayaraghavan, Laboratory Attendent retired voluntarily with effect from 1 April 1998 and 1 August 1998 respectively.

Resignations tendered by Dr.(Smt.)P.Mehra, Senior Scientific Officer Gr.II, Kum. Sunitha Devi, Research Fellow and Shri D.R. Pattnaik, Research Fellow, were accepted with effect from 15 May 1998, 19 June 1998 and 22 June 1998 respectively. Tenure of IITM Research Fellowship of Shri C. Venkatesan was completed on 12 March 1998.

Services of Shri P.R. Kadam, Watchman, Shri J.E. Walke, Upper Divisional Clerk and Shri M.N. Bende, Watchman were terminated with effect from 10 July 1998, 21 August 1998 and 26 November 1998 respectively.

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 'C' and 'D' are 3.4 and 3.5 respectively.

Status of SC / ST / OBC Reservations

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

	SC	ST	OBC	Total
Research	13	5	3	21
Scientific	5	-	1	6
Technical	7	2	1	10
Admin	9	6	-	15
NTM	18	2	2	22
Total	52	15	7	74

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 Senior Scientific Officer, Gr. I 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 and Deputy Directors considers policy matters of the Institute. During the year six meetings of the Committee were held.

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 1998-99 are as follows:

(Rs. in Lakhs)

	Plan	Non-Plan
• **Budget Estimates**	145.00	263.00
• **Revised Estimates**	145.00	569.00
• **Grant Received**	272.04	255.34
• **Actual Expenditure**	272.04	255.34

Purchase and Stores

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

Official Language Implementation

Hindi Cell is working as per rules and directives regarding Official Language Implementation. The correspondence and regular reports to the Department of Science and Technology, Department of Official Language and other offices are made in bilingual format. Special attention has been paid towards Hindi Training of the Institute's employees as well as promoting the use of Hindi in the working of the Institute. Three employees completed the Hindi Training sponsored under the Hindi Teaching Scheme. A special library comprising of over 450 books in Hindi on various subjects is available to the Institute's employees to enrich their Hindi knowledge.

The Institute celebrated Hindi Week during 7-11 September 1998. Competitions in Elocution, Poetry recitation, Idioms and Phrases and Speech, and Antakshri all in Hindi, were organised on the occasion. Dr. Umashankar Upadhyay, Professor and Head, Department of Hindi, University of Pune, was the Chief Guest of the function. The Chief Guest delivered an invited lecture and distributed prizes to the participants of the competitions.

IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to the members. 80 books on different topics were added to the club's library. Annual Sports Tournaments were organised on League basis.

The Club celebrated its Foundation Day on 1 January 1999 with a Lecture and Slide Show by Dr.Chandrashekhar Desai on his tour to Europe on bicycle. On this ocassion prizes to the winners and runners-up of the annual sports tournament were distributed at the hands of the Director. On the occasion of the Independence Day function, 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 1997-98 under different disciplines. Two more special Guest Lectures and Slide Shows on adventurous expeditions viz., Environmental aspects of the Valley of Flowers by Dr.(Smt.)Radhika Behere and Mt. Everest Expedition by Shri Surendra Chavan and two special Film Shows on Lokmanya Bal Gangadhar Tilak and Veer Savarkar were arranged during the year. The Recreation Club started several new activities for the benefit of the Institute's employees.

***

Special Activities of the Recreation Club

Prof.(Smt.) Radhika Behere delivering lecture on "Environmental aspects of the Valley of Flowers"

Shri Prem Vaidya delivering lecture on "Lokmanya Tilak and Veer Savarkar", followed by Film Show

Mountaineer Shri Surendra Chavan delivering lecture on "Expedition to Mt. Everest", followed by Slide Show

Dr. Chandrashekhar Desai delivering lecture on "Tour to Europian Countries on Bicycle with his daughter Kum. Nupur", followed by Slide Show

Shri S.M.Bawiskar, IITM receiving a special trophy for his outstanding performance at the Annual Tournaments organised by IITM Recreation Club

Institute's exhibition at the Indian Science Congress, Anna University, Chennai

Students Participating in the Institute's National Science Day Celebrations

Participants of the Personality Development Camp, Loyola School, Pune watching the Institute's Supercomputers

PAPERS PUBLISHED IN JOURNALS

NWP Modelling

Bawiskar S.M., Chipade M.D. and **Singh S.S.**, Intraseasonal variations of kinetic energy of lower tropospheric zonal waves during northern summer monsoon, *Proc. of Indian Academy of Sciences (Earth and Planetary Sciences), 107, 1998, 121-126.*

Sanjay J. and Singh S.S., Impact of modified physics in limited area model forecasts, *Proc. of Indian Academy of Sciences (Earth and Planetary Sciences), 107, 1998, 187-201.*

Objective Analysis

Kulkarni P.L., Kunhikrishnan T., **Narkhedkar S.G., Nair S.** and **Rajamani S.**, Optimal nonlinear wind analysis over the Indian region by iterative correction scheme, *Indian Journal of Radio and Space Physics, 27, 1998, 156-167.*

Sinha S.K., Narkhedkar S.G. and **Rajamani S.**, Application of Sasaki's numerical variational technique to the analysis of height and wind fields over Indian region, *Mausam, 49, 1998, 1-10.*

Sinha S.K., Narkhedkar S.G. and **Nair S.**, Some experiments with univariate statistical objective analysis of relative humidity over Indian region, *Vatavaran, 21,1997, 1-3.*

Extended Range Prediction

Kulkarni A.A. and **Kripalani R.H.**, Rainfall patterns over India-Classification with Fuzzy C-means method, *Theoretical and Applied Climatology, 59, 1998, 137-146.*

Climate and Climatic Change

Kothawale D.R. and **Munot A.A.**, Probabilities of excess and deficient southwest monsoon rainfall over different meteorological sub-divisions of India, *Proc. of Indian Academy of Sciences (Earth and Planetary Sciences), 107, 1998, 107-119.*

Pant G.B., Borgaonkar H.P. and **Rupakumar K.**, Climatic signals for tree-rings: a dendroclimatic investigation of Himalayan spruce (Picea Smithiana), *Himalayan Geology, 19, 1998, 65-73.*

Hydrometeorology

Dhar O. N. and **Nandargi S.**, Rainfall magnitudes that have not been exceeded in India, *Weather, 53, 1998, 145-151.*

Kulkarni B.D., Probable maximum precipitation over plain areas of Maharashtra: a generalised approach, *Vayu Mandal, 27, 1997, 20-25.*

Nandargi S.S. and **Dhar O.N.**, Appraisal of succesive tropical disturbances and their associated severe rainstorms during monsoon months, *Journal of Meteorology, 23, 1998, 221-228.*

Nandargi S. S. and **Dhar O. N.**, Study of floods in the Ganga and its sub-basins, *Indian Journal of Power and River Valley Development, XLVIII, 1998, 85-90.*

Atmospheric Electricity

Manohar G.K., Kandalgaonkar S. S. and **Tinmaker M.I.R.**, Thunderstorm activity over India and the Indian southwest monsoon, *Journal of Geophysical Research, 104, 1999, 4169-4188.*

Radar Study of Rain and Rainbearing Clouds

Ali K., Spatial distribution of convective clouds in north India, *Atmospheric Research, 49, 1998, 1-10.*

Warm Cloud Modification

Paul S.K., Velocities of water drops falling in oil media and the wake effect, *Indian Journal of Radio and Space Physics, 28, 1999, 15-21.*

Deterministic Chaos

Selvam A.M., Cantorian fractal space-time and information in neural network of the human brain, *Chaos, Solitons and Fractals, 10, 1999, 25-29.*

Selvam A.M. and **Fadnavis S.S.**, Cantorian fractal space-time quanturm-like chaos and scale relativity in atmospheric flows, *Chaos, Solitons and Fractals, 10, 1999, 1577-1582.*

Selvam A.M. and **Fadnavis S.S.**, Cell dynamical system model for cantorian fractal, space-time and quantum gravity, *Fractalia, 7, 1998, 4-6.*

Selvam A.M. and **Fadnavis S.S.**, Signatures of a universal spectrum for atmospheric interannual variability in some disperate climatic regions, *Meteorology and Atmospheric Physics, 66, 1998, 87-112.*

Selvam A.M. and **Fadnavis S.S.**, Superstrings, cantorian-fractal space-time and quantum-like chaos in atmospheric flows, *Chaos, Solitons and Fractals, 10, 1999, 1321-1334.*

Lidar Probing of the Atmosphere

Devara P.C.S., Remote sensing of atmospheric aerosols from active and passive optical techniques, *International Journal of Remote Sensing, 19, 1998, 3271-3288.*

Devara P.C.S., Pandithurai G., Raj P.E., Maheskumar R. S. and **Dani K. K.**, Atmospheric aerosol-cloud-stability relationship as observed with optical and radio remote sensing techniques, *Atmospheric Research, 49, 1998, 65-76.*

Devara P.C.S. and **Raj P.E.**, Lidar study of atmospheric aerosols during two contrasting monsoon seasons, *Atmosfera, 11, 1998, 199-204.*

Devara P.C.S., Raj P.E., Gadgil A.S., Patwardhan B. and Tillu A.D., Optical network for monitoring of environmental pollution, *Journal of Optics, 27, 1998, 111-119.*

Devara P.C.S., Raj P.E., Pandithurai G., Maheskumar R.S., and **Dani K.K.**, Advances in atmospheric hydrographic and vegetation remote sensing with lidar, *Journal of the Indian Society of Remote Sensing, 25, 1997, 225-238.*

Pandithurai G., Devara P.C.S., Maheskumar R.S., Raj P.E. and **Dani K.K.**, Investigations of QBO in lidar-observed boundary layer aerosols over an Indian urban station, *Journal of Aerosol Science, 29, Suppl. I, 1998, S673- S674.*

Simulation Techniques for Cloud Physics

Dhanorkar S. S. and **Kamra A. K.**, Effect of coagulation on the aerosol charge distribution, *Journal of Aerosol Science, 29, 1998, S 973-974.*

Boundary Layer and Land Surface Processes

Debaje S.B., Jadhav D.B. and **Vernekar K.G.**, Estimation of nighttime NO_3 concentrations and its role in surface ozone formation, *Indian Journal of Environmental Protection, 18, 1998, 568-572.*

Debaje S.B., Jadhav D.B. and **Vernekar K.G.**, Tropospheric ozone: vulnerability of environmental health, *Indian Journal of Environmental Protection, 18, 1998, 10-14.*

Pillai J.S., Saxena S. and **Vernekar K.G.**, Diurnal variation of meteorological parameters in the land surface interface, *Boundary Layer Meteorology, 89, 1998, 197-209.*

Climate and Global Modelling

Ashok K., Satyan V. and **Soman M.K.**, Simulation of monsoon transient disturbances in UKMO General Circulation Model, *Journal of Applied Hydrology, XI, 1998, 25-34.*

Krishnan R. and **Mujumdar M.**, Remotely and regionally forced pre-monsoon signals over northern India and neighbourhood, Quarterly *Journal of Royal Meteorological Society, 125, 1999, 55-78.*

Kulkarni J.R., Sadani L.K. and **Murthy B.S.**, Wavelet analysis of intermittent turbulent transport in the atmospheric surface layer over a monsoon trough region, *Boundary Layer Meteorology, 90, 1999, 217-239.*

Sahai A.K., Climate change: a case study over India, *Theoretical and Applied Climatology, 61, 1998, 9-18.*

Sahai A.K., Thermosolutal convection in the presence of both vertical and horizontal temperature gradients, *Journal of Applied Mechanics, 66, 1999, 181-196.*

PAPERS PUBLISHED IN PROCEEDINGS / BOOKS / REPORTS ETC.

NWP Modelling

Dugam S.S., Sanjay J. and **Singh S.S.**, Role of North Atlantic oscillation in Rossby wave propagation and its impact on Indian monsoon activity, *Proc. the Rossby-100 Symposium, Stockholm, Sweden, 8-12 June 1998, Vol.I, 98-100.*

Objective Analysis

Mahajan P.N., Estimation of geophysical parameters over the Indian seas using DMSP-SSM/I satellite data, *Proc. Current Trends in Ocean Prediction with Special Reference to Indian Seas, National Physical Oceanography Laboratory, Kochi, 22-23 December 1998, 29-33.*

Extended Range Prediction

Kripalani R.H. and **Kulkarni A.A.**, Climate change and extreme hydrological events over India, *Proc. Second International Conference on Climate and Water, Espoo, Finland, 17-20 August 1998, Vol.3, 1340-1344.*

Kripalani R.H. and **Kulkarni A.A.**, Heat waves and floods across Asia: Was El Nino then La Nina the cause?, *Drought Network News, 11, 1999, 18-20.*

Kripalani R.H. and **Kulkarni A.A.**, No drought over India following very strong El-Nino episodes, *Drought Network News, 10, 1998, 14.*

Kripalani R.H. and **Kulkarni A.A.**, Why India did not experience drought during 1997 El Nino episode? *IMSP Newsletter, 3, 1998, 6-9.*

Kripalani R.H., Kulkarni A.A. and **Sabade S.S.**, Comparison of NCEP/NCAR reanalyses, Nimbus-7 SMMR and historical Soviet snow depth data sets vis-a-vis Indian monsoon rainfall variability, *Proc. of First WCRP International Conference on Reanalysis, WCRP-104, WMO/TD-NO.876, 1998, 262-265.*

Kulkarni A.A., Medium and long- range forecasting pertaining to monsoon 1998, *IMSP Newsletter, 3, 1998,7.*

Climate and Climatic Change

Patil S.D., Teleconnection between the middle and upper tropospheric thermal ridge over Tibetan plateau and the Indian summer monsoon rainfall: a synoptic approach, *Proc. Intenational Symposium on Environmental Management in Mountainous Regions (Mountain Meet '98), Govt. P.G.College, Rishikesh, 4-7 October 1998, 52-53.*

Rupakumar K. and **Ashrit R.G.**, Indian summer monsoon variability and teleconnections as seen in NCEP Reanalyses : Potential for seasonal prediction, *Proc. First WCRP International Conference on Reanalyses, WCRP-104, WMO/TD-No.876, 1998, 349-352.*

Hydrometeorology

Dhar O.N. and **Nandargi S.**, Floods in Indian rivers and their meteorological aspects, Flood Studies in India, Memoir 41, *Geological Society of India, Bangalore, 1998, 1-25.*

Kulkarni A.K., Mandal B.N. and **Sangam R.B.**, Some facts about heavy rainfall distribution over the Konkan region, *Proc. Workshop on Scientific aspects of water Management, Nasik, 24-25 April 1998, 13-28.*

Atmospheric Electricity

Manohar G.K., Kandalgaonkar S.S. and **Tinmaker M.I.R.**, Seasonal thunderstorm frequencies and sea surface temperatures at Port Blair and Minicoy Island stations and along the east and west coasts of India, *Newsletter on Atmospheric Electricity, 9, 1998, 10.*

Atmosperic Boundary Layer

Morwal S.B., Nature and some evolutionary aspects of the monsoon boundary layer, *Proc. Conference on the Role of Topography in Modelling Weather and Climate, International Centre for Theoretical Physics, Trieste, Italy, 27-28 June 1998, 1-4.*

Deterministic Chaos

Selvam A.M., Radhamani M., Fadnavis S.S. and **Tinmaker M.I.R.**, Universal spectrum for intra-seasonal variability in TOGA temperature time series, *Contributions from IITM, Research Report No. RR-077.*

Selvam A.M. and **Sapre V.V.**, Fractal nature of TOGA temperature time series, *Contributions from IITM, Research Report No. RR-081.*

Selvam A.M., Sen D. and Mody S.M.S., Self-organised criticality in daily incidence of acute myocardial infarction, *Contributions from IITM, Research Report No. RR-083.*

Studies in Upper Atmosphere

Joshi I. and **Tinmaker M.I.R.**, Study of winds during convective storm using MST radar, *Solar Terrestrial Energy Programme (STEP) Handbook on MST8 Workshop, USA, July 1998, 174-175.*

Lidar Probing of the Atmosphere

Devara P.C.S., Aerosols in meteorological studies, Aerosols: *Generation and Role in Medicine, Industry and Environment, K.S.V. Nambi, B.K.Sapra, Ed., Allied Publishers Ltd., New Delhi, 1998, 225-239.*

Devara P.C.S., Lidar for atmospheric aerosol measurements: an Indian perspective, *SASCOM Scientific Report No. 11, 1998, 20-23.*

Devara P.C.S., Maheskumar R.S., Pandithurai G., Raj P.E. and **Dani K.K.**, Lidar and radiometric observations of aerosols in a tropical environment, *NASA report No. L-17738A NASA LARC, 1998, 123-126.*

Devara P.C.S., Pandithurai G.,Raj P.E. and **Dani K.K.**, Indian MST radar study of atmospheric turbulence around the tropical tropopause, *Solar Terrestrial Energy Programme (STEP), 1998, 107-110.*

Devara P.C.S., Raj P.E., Pandithurai G. and **Dani K.K.**, Study of atmospheric stability and wind characteristics during clear and cloudy sky conditions as inferred from Indian MST radar observations, *Solar Terrestrial Energy Programme (STEP), 1998, 176-179.*

Jain A.R., Mydhili N.S. and **Rao Y.J.**, Height-time structures of VHF back scattered echoes from atmospheric turbulence and stable layers at tropical latitudes, *Solar Terrestrial Energy Programme (STEP), 1998, 17-20.*

Jain A.R., **Rao Y.J.**, Patra A.K., Rao P.B., Viswanathan G. and Subramanian S.K., VHF radar observations during passage of tropical convection events, *Solar Terrestrial Energy Programme (STEP),1998, 247-250.*

Parameshwaran K., Murthy K.K., Nair P.R., Rajan R., **Devara P.C.S., Kamra A.K., Pillai A.G., Ali K., Dani K.K., Rao Y.J., Maheskumar R.S., Momin G.A., Murugvel P., Naik M.S., Pandithurai G., Raj P.E., Rao P.S.P., Safai P.D.**, Zalpuri K.S., Gupta P.K., Jayaraman A., Acharya Y.B., Lal S., Naja M. and Modh K.S., Results of the INDOEX Pre-Cruise Inter-Comparison Campaign on Aerosols and Minor Constituents (PICAM) at Trivandrum, *Scientific Report No. SPL SR-002-98, 1998, 41.*

Potdar M.B., Sharma S.A., **Devara P.C.S., Raj P.E., Pandithurai G., Maheskumar R.S.** and **Dani K.K.**, ATMRAD model calibration retrieval of aerosol optical thickness and atmospheric correction factors from IRS-P3 MOS data, *Scientific Report No. SAC/RSA/RSAG/SN/05/98, 1998, 42.*

Rao Y.J., Jain A.R., Anandan V.K. and Lethika S., Oscillation of tropical tropopause during the passage of atmospheric waves, *Solar Terrestrial Energy Programme (STEP), 1998, 243-246.*

Simulation Techniques for Cloud Physics

Kamra A.K., Importance of atmospheric electricity measurements made at high altitude observatories, *Science at High Altitudes, S. Raha, P.K.Ray and B.Sinha, Ed., Allied Publishers Limited, New Delhi, 1998, 43-51*

Boundary Layer and Land Surface Processes

Parasnis S.S., Evolution of convective boundary layer over the Deccan plateau during summer monsoon, *Contributions from IITM, Research Report No. RR-082.*

Parasnis S.S., Kulkarni M.K., Arulraj S. and **Vernekar K.G.,** One-dimensional model of atmospheric boundary layer, *Contributions from IITM, Research Report No.RR-078.*

Sinha S., Computation of thermal properties of surface soil from energy balance equation using force-restore method, *Contributions from IITM, Research Report No. RR-080.*

Sinha S., Diagnostic model of the surface boundary layer: a new approach, *Contributions from IITM, Research Report No. RR-079.*

Simulation of Mean Monsoon Circulation and Predictability of the Monsoon Systems

Behera S.K., Salvekar P.S. and Yamagata T., Simulation of interannual SST variability in north Indian Ocean, *International WOCE Newsletter No. 33, 1998, 7-9.*

Krishnamurty T.N., Bachiochi D., LaRow T.E., Jha B., Tewari M., **Chakraborty D.R.,** Correa-Torres R. and Oosterhof D., Coupled atmosphere-ocean modelling of El Nino of 1997-98, *FSU Report No. 98-08, 1998.*

Krishnamurti T.N., Tewari M., **Chakraborty D.R.,** Marengo J.A., Pedro L., Dias S. and Satyamurthy P., Downstream amplification: a possible precursor to major freeze events over southeastern Brazil, *FSU Report No. 98-03, 1998.*

Tandon M.K., JAVA : Write once run anywhere, *Newsletter of Pune Chapter of Computer Society of India, 1999, 2-3.*

Climate and Global Modelling

Ashok K., Soman M.K. and **Satyan V.,** Simulation of monsoon transient disturbances in a GCM, *Contributions from IITM, Research Report No. RR-076.*

Ashrit R., Mandke S.K. and **Soman M.K.,** Monsoon simulation of 1991 and 1994 by GCM: Sensitivity to SST distribution, *Contributions from IITM, Research Report No. RR-084.*

Library, Information and Publications

Shiralkar A.A., Management of library and information system at the Indian Institute of Tropical Meteorology, *In Search of Excellence In Librarianship, D.N. Phadke Ed., Multi Tech. Publishing Co., Mumbai, 1998, 103-117.*

Hindi Cell

Singh N., Collaboration between Research Centres and Universities in the area of Defence Research and Development, *Proc. Seminar on Self Reliance in the Field of Defence-Efforts and Impacts, Armament Research and Development Establishment, Pune, 19 March 1999 (in Hindi).*

Singh N., Revolutionary changes in meteorological research due to advent of information technology, *Proc. Seminar and Workshop on Information Technology and Technological Co-ordination, High Energy Materials Research Laboratory, Pune, 16-17 March 1999 (in Hindi).*

Ursekar A.A., Progress in science and technology in India during last fifty years, *Proc. Seminar on Self Reliance in the Field of Defence-Efforts and Impacts, Armament Research and Development Establishment, Pune, 19 March 1999 (in Hindi).*

***

Papers Presented in Symposia, Seminars etc.

Asnani G.C., New visions emerging in meteorology, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999 (Invited lecture).*

Asnani G.C., El Nino of 1997-98, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Asnani G.C., Raja M.K.R.V. and **Salvekar P.S.**, New insight into the micro-structure of atmospheric layer near the tropopause, *Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Bandyopadhyay A., Iyer U. and **Singh S.S.**, Study on the impact of digital filtering initialisation on short-range prediction over Indian region, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998*

Bansod S.D. and **Dahale S.D.**, Association between cyclonic disturbances over Bay of Bengal and the consequent floods over north-east India, *International Conference on Disaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Bawiskar S.M., Momentum of lower tropospheric zonal wave and performance of Indian summer monsoon, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Behera S.K., Ganer D.W. and **Salvekar P.S.**, Sensivity of the surface forcings to the north Indian Ocean SST, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Behera S.K., Salvekar P.S. and Yamagata T., Variability in the Indian Ocean, *WOCE Indian Ocean Workshop, USA, 22-25 September 1998.*

Beig G., Atmospheric chemical response to forcing of green house gases through ice ages to industrial period, *Joint Symposium of IGAC- CACGP on Global Atmospheric Chemistry, Seattle, USA, 19-24 August 1998.*

Beig G., Long-term forcing of green house gases and natural events on atmospheric chemical composition, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 February 1999 (Invited talk).*

Bhide U.V., Forecasting significance of observed rainfall over India, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Bhide U.V., Variability of monsoon 1998, *Annual Monsoon Workshop, Indian Institute of Tropical Meteorology, Pune, 22 December 1998.*

Chakraborty D.R., Aspects of low frequency oscillation during the northern winter as inferred from nonlinear energy interactions, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Chakraborty D.R. and **Agarwal N.K.**, Effects of coriolis force, vorticity and divergence on frequency distribution of nonlinear energy interaction during summer monsoon, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Dahale S.D., On climatic variations in the summer monsoon floods over Assam and adjoining Indian region, *International Conference on Diaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Desai S.S. and **Salvekar P.S.**, Stratospheric global energetics and their space time variability during active monsoon of 1990, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Deshpande C.G., Gopalakrishnan V., Murugwel P. and **Kamra A.K.**, Secular changes in the background air pollution over the Indian oceans, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Devara P.C.S., Advances in remote sensing of atmospheric aerosols and gaps in the Indian aerosol research, *Special Half-a-day IASTA Seminar, Bhabha Atomic Research Centre, Mumbai, 30 November 1998 (Invited Talk).*

Devara P.C.S., Details of experiments conducted during the INDOEX first field phase (FFP), *International INDOEX Workshop, Institute for Marine and Atmospheric Research, Utrecht (IMARU), The Netherlands, 21-23 June 1998.*

Devara P.C.S., Lidar and radiometric observations of aerosls in a tropical urban environment, *19th International Laser Radar Conference (ILRC), Annapolis, MD, USA, 6-10 July 1998.*

Devara P.C.S., Overview of trends in aerosol and related parameters in India, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 February 1999 (Invited Talk).*

Devara P.C.S., Maheskumar R.S., Raj P.E., Dani K.K., Pandithurai G. and **Rao Y.J.**, Correlative measurements of aerosols optical depth and site distribution around INDOEX FFP-98 from multispectral solar radiometers, *National Workshop on Indian INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Devara P.C.S., Raj P.E., Maheskumar R.S., Dani K.K. and **Pandithurai G.**, Ground-based lidar study of aerosol and boundary layer characteristics during INDOEX first field phase, *National Workshop on Indian INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Dugam S.S., Global warming and frequency of natural calamities, *International Conference on Disaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Dugam S.S., Interactive mechanism between ENSO and NAO and its relationship with Indian summer monsoon variability, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Dugam S.S., Long-term trend in the north Atlantic oscillation and a major climate anomalies over the India-China region, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

George L., Singh P. and **Salvekar P.S.**, Three dimensional energetics of the onset phase of monsoon 1996, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Gopalkrishnan V. and **Kamra A.K.**, Measurements of the atmospheric electric field and conductivity made over Indian Ocean during December 96-January 1997, *National Workshop on Indian-INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Jadhav D.B., Londhe A.L., Meena G.S., Bhosale C.S., Nighut D.N. and Oree S., Long term changes in aerosol layer variations over tropics, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Jadhav S.K. and **Bhalme H.N.**, Decadal analysis of the duration of the low pressure systems over the Indian region, *35th Annual Convention and Meeting of Continental Margins of India - Evolution, Processes and Potential, National Institute of Oceanography, Goa, 18-20 November 1998.*

Joshi I. and **Tinmaker M.I.R.**, Association between tropical middle atmospheric parameters and El Nino, Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.

Joshi I. and **Tinmaker M.I.R.**, Association between tropospheric and stratospheric winds and solar activity, 35th Annual Convention and Meeting on Continental Margins of India-Evolution, Processes and Potentials, National Institute of Oceanography, Goa, 18-20 November 1998.

Joshi I. and **Tinmaker M.I.R.**, Impact of El Nino on cyclonic storms over Indian seas, *International Symposium on Environmental Management in Mountainous Regions, Mountain Meet 98, Government Post Graduate College, Rishikesh, 4-7 October 1998.*

Joshi I., Tinmaker M.I.R. and **Mukherjee B.K.**, Connections between the variability of the stratosphere-troposphere systems and weather/ climate, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Kakade S.B. and **Dugam S.S.**, Spatial variability in the dependence of Indian summer monsoon rainfall on thermal field, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Kothawale D.R., Thermal field over Indian region and its influence on Indian summer monsoon rainfall, *35th Annual Convention and Meeting on Continental Margins of India- Evolution, Processes and Potentials, National Institute of Oceanography, Goa, 18-20 November 1998.*

Kowahira K., Takatori S. and **Hingane L.S.**, Dynamical characteristics of ozone amounts over equatorial region, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Kripalani R.H., Climate change and extreme hydrological events over India, *Second International Conference on Climate and Water, Espoo, Finland, 17-20 August 1998*

Krishnan R., Rossby wave dynamics relevant to evolution of breaks in Indian summer monsoon, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Kulkarni A.A., Medium and long-range forecasting of monsoon 1998, *Annual Monsoon Workshop-1998, Indian Institute of Tropical Meteorology, Pune, 22 December 1998.*

Kulkarni A.K., **Mandal B.N.** and **Sangam R.B.**, Unprecedented rainfall associated with 24-26 June 1997 rainstorm over north Gujarat, *XIX Annual Conference of Institute of Indian Geographers (IIG), University of Pune, Pune, 14-16 March 1998.*

Kulkarni B.D., Estimation of maximum one-day point rainfall for different return periods in Godavari basin, *35th Annual Convention and Meeting on Continental Margins of India- Evolution, Processes and Potentials, National Institute of Oceanography, Goa, 18-20 November 1998.*

Kulkarni C.P., Wave characteristics of northern hemisphere land plus marine temperature series during the period 1867-1986 i.e. 120 years, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Kulkarni J.R., Some aspects of an association between southern oscillation and Indian summer monsoon as revealed through wavelet analysis, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Kulkarni P.L. and **Nair S.**, Comparison of vertical velocity from reanalysis (NCEP) and regional analysis over Indian region, *Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Mahajan P.N., Better understanding of cyclonic system over the Indian region through DMSP-SSM/1 satellite data, *International Conference on Disaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Mahajan P.N., Satellite observed eastward propagating super cloud clusters over the equatorial Indian Ocean, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Mahajan P.N., Use of satellite microwave radiometric data for hydrological studies over the Indian region, *XIX Annual Conference of Institute of Indian Geographers (IIG), University of Pune, Pune, 14-16 March 1998.*

Mandke S.K., **Ashok K.**, **Soman M.K.** and **Satyan V.**, Prediction of monsoon 1998 with a grid point climate model, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Mohanty M., **Salvekar P.S.** and Kumar P.P., Sensitivity of stream function field to zonal and meridional wave numbers in a global spectral model, *Symposium on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Momin G.A., **Rao P.S.P.**, **Safai P.D.**, **Ali K.**, **Naik M.S.** and **Pillai A.G.**, Atmospheric aerosol characteristics studies at Pune and Thiruvananthapuram during INDOEX programme 1998, *National Workshop on Indian INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Morwal S.B., Nature and some evolutionary aspects of the monsoon boundary layer, Summer Colloquium on the Physics of Weather and Climate the Effect of Topography on the Atmospheric Circulation and Conference on the Role of Topography in Modelling Regional Weather and Climate, *International Centre for Theoretical Physics (ICTP), Italy, 8-26 June 1998.*

Mujumdar M. and **Kulkarni J.R.**, Contributions from internal and external variabilities to the interannual variability of all India summer monsoon rainfall, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Mujumdar M., Satyan V. and **Krishnan R.**, Seasonal forecasting of monsoon 1998 using spectral T30L18 , GCM, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Mujumdar V.R., Prospects of satellite data for monitoring onset and advance of Indian summer monsoon, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Mukhopadhyay P. and **Singh S.S.**, Results of ETA model run over Indian region, *Summer Colloquium on the Physics of Weather and Climate the Effect of Topography on the Atmospheric Circulation and Conference on the Role of Topography in Modelling Regional Weather and Climate, International Centre for Theoretical Physics (ICTP), Italy, 8-26 June 1998.*

Mukhopadhyay P., Vaidya S.S., Sanjay S. and **Singh S.S.**, Study on heavy rainfall zone over coastal Kerala with ETA model, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Munot A.A., Interannual variability of summer monsoon rainfall over all India and homogeneous regions of India (1871-1990), *International Conference on Environment and Agriculture (INCEA-98), Tribhuvan University, Kathmandu, Nepal, 1-3 November 1998.*

Munot A.A., Some aspects of summer monsoon rainfall over homogeneous regions of India, *XIX Annual Conference of Institute of Indian Geographers (IIG), University of Pune, Pune, 14-16 March 1998.*

Murugavel P. and **Kamra A.K.**, Changes in the concentration and size-distribution of the sub-micron particles associated with the sea and land breezes at a costal station, *National Workshop on Indian-INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Murugavel P. and **Kamra A.K.**, Size distribution of the sub-micron aerosol particles over the Indian Ocean in February-March 1998, National Workshop on Indian-INDOEX Programme, *National Physical Laboratory, New Delhi, 16-18 November 1998.*

Naik M.S., Chemical composition of precipitation in India and Nepal, a preliminary report on an Indo-Swedish project on atmospheric chemistry, *International Workshop on Composition and Acidity of Asian Precipitation (CAAP), Bangkok, Thailand, 9-12 November 1998.*

Pant G.B., Climate of western Himalayas as reconstituted from the study of tree-rings, *Workshop on Palaeoclimatic Records of Arid and Semi-arid Regions during the Late Quaternary, Deccan College, Pune, 8-11 December 1998 (Invited talk).*

Pant G.B., Tree-rings and atmospheric processes, *DST Awareness Workshop on AMS and its Applications to Earth and Planetary Sciences, Bhubaneshwar, 12 August 1998 (Invited talk).*

Parasnis S.S., Air quality modelling using boundary layer characteristics, *Annual Conference of the American Association for Aerosol Research (AAAR), Cincinnati, Ohio, USA, 21-26 June 1998.*

Parasnis S.S., Some aspects of boundary layer modelling using land-surface processes, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Patil M.N. and **Parasnis S.S.**, Variation in drag,heat exchange and moisture exchange coefficients over the monsoon trough region, *First International Workshop on Long-Term Changes and Trends in the Atmosphere, Indian Institute of Tropical Meteorology, Pune, 16-19 Feburary 1999.*

Patil S.D., Teleconnections between the middle and upper tropospheric thermal ridge over Tibetan Plateau and the Indian summer monsoon rainfall, a synoptic approach, *International Symposium on Environmental Management in Mountainous Regions, Mountain Meet 98, Government Post Graduate College, Rishikesh, 4-7 October 1998.*

Patil S.D., Upper tropospheric circulation features during drought/flood monsoon situations over India, *International Conference on Disaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Pattnaik D.R. and **Satyan V.**, Role of different convective parameters used in cumulus parameterisation on the simulated Indian summer monsoon in AGCM, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Pillai A.G., Momin G.A., Naik M.S., Rao P.S.P., Safai P.D. and **Ali K.**, Studies of atmospheric aerosols and ozone in different environments, *Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Pranesha T.S., **Chate D.M., Deshpande C.G.** and **Kamra A.K.**, Measurements of submicron aerosol particle distribution in the lowest 1-m of the atmosphere, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Puranik P.V. and **Dahale S.D.**, Association between fairly widespread/widespread pentad rainfall and floods over north-east India, *International Conference on Diaster Management, Guwahati University, Guwahati, 23-26 April 1998.*

Raja M.K.R.V., Asnani G.C. and **Salvekar P.S.**, Inertio-gravity waves in the tropical atmosphere, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Rangarajan S., Wind energy resource assessment in India, *National Seminar on Renewable Energy, Thiruvananthapuram, 11-12 February 1999.*

Rangarajan S., Wind energy resource assessment programme in India and the results obtained, *SAARC Expert Meeting on the Utilisation of Wind Energy, Dhaka, Bangladesh, 13-15 December 1998.*

Rao D.N., Singh H.R., **Kulkarni J.R.**, Rao B. and Chandrika A.Y., Vertical variations of Madden-Julian oscillations in the normal monsoon season as revealed through MST radar wind data, *Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Rao P.S.P., Momin G.A., Safai P.D., Ali K., Naik M.S. and **Pillai A.G.**, Studies of trace gases and aitken nuclei at inland and coastal stations- a part of INDOEX programme, *National Workshop on Indian INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998.*

Rao Y.J., Jain A.R.and Anandan V.K., Oscillations of tropical tropopause during passage of atmospheric waves, *Seminar on Stratosphere - Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Rao Y.J., Jain A.R., Anandan V.K. and Rao P.B., VHF radar observations of weakening of stable layer structures near the tropical tropopause, *Seminar on Stratosphere -Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998.*

Safai P.D., Momin G.A., Rao P.S.P., Pillai A.G. and **Naik M.S.**, Studies on aitken nuclei and size distribution of aerosols at a rural Himalayan location, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Sahai A.K., Soman M.K. and **Satyan V.**, Prediction of all India summer monsoon rainfall on monthly and seasonal scale, a neural network approach, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Sanjay J. and **Singh S.S.**, Impact of new boundary layer scheme on the skill of a global spectral model precipitation forecast over India, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Sanjay J. and **Singh S.S.**, Simulated boundary layer structures over Indian region in a forecast model, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Sanjay J. and **Singh S.S.**, Thermodynamic adjustment parameters in Betts-Miller scheme of convection parameterisation with variable moisture profile, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Shiralkar A.A. and **Salvekar P.S.**, Meteorology in ancient India, *Seminar on Science and Technology in Ancient India, Institute for Oriental Study, Thane, 25-26 April 1998.*

Sikder A.B. and **Bhalme H.N.**, Does El Nino and the typhoon activity increased the Indian summer monsoon rainfall?, *International Conference on Environment and Agriculture (INCEA-98), Tribhuvan University, Kathmandu, Nepal, 1-3 November 1998.*

Singh N., Collaboration between Research Centres and Universities in the area of Defence Research and Development, *Seminar on Self Reliance in the Field of Defence - Efforts and Impacts, Armament Research and Development Establishment, Pune, 19 March 1999 (in Hindi).*

Singh N., Revolutionary changes in Meteorological Research due to advent of information technology, *Seminar and Workshop on Information Technology and Technological Co-ordination, High Energy Materials Research Laboratory, Pune, 16-17 March 1999 (in Hindi).*

Singh N., Surface hydrological processes, *Indo-US Workshop on Co-operations in Earth and Atmospheric Sciences, India Meteorological Department, New Delhi, 10-12 February 1998.*

Singh N., Variations in the arid region and drylands of India since 1871, *Workshop on Palaeoclimatic Records of Arid and Semi Arid Regions during the Late Quaternary, Deccan College, Pune, 8-11 December 1998.*

Singh P., **George L.** and **Salvekar P.S.**, Three dimensional structure of a cyclonic storm, a numerical study, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Sinha S.K., **Narkhedkar S.G.** and **Nair S.**, Objective analysis of mean sea level pressure over Indian region by multiquadric interpolation scheme, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Sivaramakrishnan S., Dynamic instability in the day-time surface layer during Indian summer monsoon, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Soman M.K., **Mandke S.K.** and **Satyan V.**, SST boundary forcing for long-lead dynamic forecast, how good is the persistent anomaly method?, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Sontakke N.A. and **Singh N.**, Near-two-century seasonal and annual rainfall variations across India, reconstructed instrumental past and predicted ten years feature, *Workshop on Palaeoclimatic Records of Arid and Semi-Arid Regions during the Late Quaternary, Deccan College, Pune, 8-11 December 1998.*

Trivedi D.K. and **Singh S.S.**, Numerical prediction of tropical cyclones over Indian seas, *International Summer School in Meteorology, Krivaja, Yugoslavia, 24 August- 4 September 1998.*

Trivedi D.K. and **Singh S.S.**, Numerical simulation of tropical cyclone using a 3-dimensional model, *National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999.*

Ursekar A.A., Progress in Science and Technology in India during last fifty years, *Seminar on Self Reliance in the Field of Defence- Efforts and Impacts, Armament Research and Development Establishment, Pune, 19 March 1999 (In Hindi).*

Vaidya S.S. and **Singh S.S.**, Thermodynamic adjustment parameters in Betts-Miller scheme of convection parameterisation with variable moisture profile, *National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998.*

Paper Published		
Journals	:	35
Proceedings, Books, Reports etc.	:	43
Paper Presented	:	100

***

International Conference on Disaster Management, Guwahati University, Guwahati, 23-26 April 1998
(Shri S.D. Dahale, Shri P.V. Puranik, Shri S.S. Dugam, Shri S.D. Bansod and Shri S.D. Patil)

Seminar on Science and Technology in Ancient India, Institute for Oriental Study, Thane, 25-26 April 1998
(Smt. A.A. Shiralkar)

Summer Colloquim on the Physics of Weather and Climate, the Effect of Topography on the Atmospheric Circulation and Conference on the Role of Topography in Modelling Regional Weather and Climate, International Centre for Theoretical Physics, Italy, 8-26 June 1998
(Dr.(Smt.) S.B. Morwal and Shri P.Mukhopadhyay)

Seminar on Technology Based Training Solutions for Tomorrow, National Institute of Information Technology, Pune, 13 June 1998
(Shri M.K. Tandon)

International INDOEX Workshop, Institute for Marine and Atmospheric Research, Utrecht, Netherlands, 21-23 June 1998
(Dr.P.C.S. Devara)

Seminar on Palaeoclimate in the Mediterranean Region, Milan, Italy, 22 June 1998
(Dr. G.B. Pant)

Annual Conference of the American Association for Aerosol Research, Cincinnati, Ohio, U.S.A., 21-26 June 1998
(Dr. S.S. Parasnis)

Workshop on Processing, Analysis and Utilization of XBT Data, National Institute of Oceanography, Goa, 23-26 June 1998
(Shri P. Seetaramayya)

19th International Laser Radar Conference (ILRC), Annapolis, USA, 6-10 July 1998
(Dr. P.C.S. Devara)

First Global Convention on "CAE '98-CAD/CAM", Pune Chapter of Computer Society of India, Pune, 28-30 July 1998
(Shri M.K. Tandon, chaired two sessions)

Seminar on Climate Change, its Dimensions and Implications for Planning in India, New Delhi, 31 July 1998
(Dr. G.B. Pant)

India's Science Vision Exhibition 'AGRASAR' Achievements of Science and Technology since Independence and Vision for the Future, New Delhi, 3-16 August 1998
(Dr. G. Beig, Shri Prem Prakash, Shri G. Singh and Shri A.B. Sikder)

9th Group Monitoring Workshop on Atmospheric Sciences (GMW-AS), Ludhiana, 5-6 August 1998
(Dr. D.B. Jadhav)

DST Awareness Workshop on AMS and its Applications to Earth and Planetary Sciences, Bhubaneswar, 12 August 1998
(Dr. G.B. Pant)

Second International Conference on Climate and Water, Espoo, Finland, 17-20 August 1998
(Dr. R.H. Kripalani)

Joint International Symposium of IGAC-CACGP on Global Atmospheric Chemistry, Seattle, USA, 19-24 August 1998
(Dr. G. Beig)

Fifth International Summer School in Meteorology 98, Krivaja, Yogoslavia, 24 August- 4 September 1998
(Shri D.R. Trivedi)

Workshop on Data Warehousing, Pune Chapter of Computer Society of India, Pune, 14 September 1998
(Shri M.K. Tandon)

WOCE Indian Ocean Workshop, New Orleans, USA, 22-25 September 1998
(Dr. S.K. Behera)

National Seminar on Librarianship and Publishing Industry - Some Pertinent Issues, University of Pune, Pune, 23-25 September 1998
(Smt. A.A. Shiralkar)

Second GKSS School on Environmental Research, Lauenburg, Germany, 23-30 September 1998
(Dr.(Smt.) A.A. Kulkarni)

International Symposium on Environmental Management in Mountainous Region: Mountain Meet 98, Government Post Graduate College, Rishikesh, 4-7 October 1998
(Dr.(Smt.) I. Joshi and Shri S.D. Patil)

Brain Storming Session on Atmospheric Sciences and Modelling, Indian Institute of Tropical Meteorology, Pune, 13 October 1998
(Dr. A.K. Kamra and Dr. P.C.S. Devara)

Third Group Monitoring Workshop of PAC in Atmospheric Sciences, Visakhapatnam, 1 November 1998
(Dr. G.B. Pant)

International Conference on Environment and Agriculture (INCEA-98), Tribhuvan University, Kathmandu, Nepal, 1-3 November 1998
(Shri A.A. Munot and Shri A.B. Sikder)

Workshop on Tropical Oceans and Climate, Indian Institute of Science, Bangalore, 3-6 November 1998
(Dr. M.K. Soman)

International Workshop on Composition and Acidity of Asian Precipitation (CAAP), Bangkok, Thailand, 9-12 November 1998
(Smt. M.S. Naik)

Workshop on Large Databases, Data Innings, Data Visualisation and Image Processing, Inter University Centre for Astronomy and Astrophysics, Pune, 15-24 November 1998
(Smt. R.R. Joshi, Shri O. Abraham, Shri S. Sudarsanam and Smt. S.S. Fadnavis)

National Workshop on Indian INDOEX Programme, National Physical Laboratory, New Delhi, 16-18 November 1998
(Dr. G.B. Pant, Dr. A.K. Kamra, Dr. P.C.S. Devara, Dr. P.S.P. Rao, Shri V. Gopalakrishnan, Shri P.D. Safai and Shri P. Murugavel) (Dr. A.K. Kamra chaired a Session)

35th Annual Convention and Meeting on Continental Margins of India - Evolution, Processes and Potentials, National Institute of Oceanography, Goa, 18-20 November 1998
(Dr.(Smt.) I.Joshi, Shri B.D. Kulkarni, Shri S.K. Jadhav and Shri D.R. Kothawale)

Workshop on Climate Change, Indian Agricultural Research Institute, New Delhi, 20-21 November 1998
(Dr. G.B. Pant)

Training Course on Application of Regional Climate Modelling for Asia, START Regional Centre for Temperate East Asia, Beijing, China, 23 November - 2 December 1998
(Dr.(Smt.) S.B. Morwal)

Seminar on Stratosphere-Troposphere Interactions, Cochin University of Science and Technology, Kochi, 24-26 November 1998
(Prof.G.C.Asnani, Shri A.G.Pillai, Shri J.R.Kulkarni, Dr.(Smt.)I.Joshi, Dr.Y.J.Rao and Smt.S.Nair)

Seminar on Managing IT (Information Technology) Professionals, Symbiosis Institute of Computer Studies and Research, Pune, 27 November 1998
(Shri M.K. Tandon)

Special IASTA Seminar on Aerosols, Bhabha Atomic Research Centre, Mumbai, 30 November 1998
(Dr. P.C.S. Devara)

National Seminar on Numerical Weather Prediction with Emphasis on Boundary Layer Modelling and Mesoscale Modelling, Jadavpur University, Calcutta, 3-5 December 1998
(Dr. S.S. Parasnis, Smt. S.S. Vaidya, Shri A.Bandyopadhyay, Dr. S.K. Sinha, Shri J. Sanjay and Shri P.S. Mukhopadhyay)

National Convention on Grand ERP'98, Pune Chapter of Computer Society of India, Pune, 7-10 December 1998
(Shri M.K. Tandon, Acted as the Co-Chairman of the Conference Management Committee)

Workshop on Satellite Oceanography: Methods and Applications, Space Application Centre, Ahmedabad, 8-11 December 1998
(Dr. P.N. Mahajan and Shri D.W. Ganer)

Third Workshop of IGCP-349 (Palaeomonsoons and Desert Margins) and First Workshop of IGCP-413 (Understanding Future Dryland Environmental Changes from Dynamics) on Palaeoclimatic Records of Arid and Semi-Arid Regions during the Late Quaternary, Deccan College, Pune, 8-11 December 1998
(Dr.(Smt.) N.A. Sontakke)

Seminar on Global Climate Change and Indian Agriculture, Indian Agriculture Research Institute, New Delhi, 3-7 March 1999
(Dr. G.B. Pant)

One day Seminar on VISIONET-2001, Institute of Management Education, Research and Training, Pune, 17 January 1999
(Shri M.K. Tandon)

One Day Seminar on Application Development Trends in the New Millennium, Pune Chapter of Computer Society of India, Pune, 18 January 1999
(Shri M.K. Tandon)

National Seminar on Renewable Energy, Agency for Non-conventional Energy Resources and Technology, Thiruvananthapuram, 11-12 February 1999
(Dr. S. Rangarajan)

National Symposium on Meteorology beyond 2000 (TROPMET-99), Regional Meteorological Centre, Chennai, 16-19 February 1999 *(Prof. G.C. Asnani, Dr. P.C.S. Devara, Dr. S. Sivaramakrishnan, Dr. P.N. Mahajan, Shri J.R. Kulkarni, Dr. A.K. Sahai, Smt. U.V. Bhide, Shri D.R. Chakraborty, Smt. S.S. Desai, Shri D.M. Chate, Shri V.R. Mujumdar, Shri S.M. Bawiskar, Shri Prem Singh, Smt. S.S. Mandke, Shri N.K. Agarwal, Shri J. Sanjay, Shri D.K. Trivedi, Shri S.B. Kakade, Shri M. Mujumdar and Shri P.D. Safai)* (*Dr. S. Sivaramakrishnan* chaired a session on New observational techniques - I (Ground based))

Seminar on Science and Media, Inter-University Centre for Astronomy and Astrophysics, Pune, 1-2 March 1999
(Smt. A.A. Shiralkar)

Brain Storming Meeting on Bio-Geo Data Base and Ecological Modelling for Himalayas, India International Centre, New Delhi, 4-5 March 1999
(Dr. G.B. Pant and Dr. P.C.S. Devara)

One Day Seminar on COMSEM99, University of Pune, Pune, 14 March 1999
(Shri M.K. Tandon)

One day Seminar on Data Warehousing, Pune Chapter of Computer Society of India, Pune, 16 March 1999
(Shri M.K. Tandon)

Seminar and Workshop on Information Technology and Technological Co-ordination, High Energy Materials Research Laboratory, Pune, 16-17 March 1999 (in Hindi).
(Dr. N. Singh)

Seminar on Self Reliance in the Field of Defence-Efforts and Impacts, Armament Research and Development Establishment, Pune, 19 March 1999 (in Hindi).
(Dr. N. Singh and Smt. A.A. Ursekar)

***

Dr. G.B. Pant,

- Meeting of the Selection Committee, Indian Institute of Science , Bangalore, 23 April 1998.
- 29th Meeting of Programme Advisory Committee on Atmospheric Sciences, National Geophysical Research Institute, Hyderabad, 30 April 1998.
- 49th Meeting of CMAS, Mausam Bhavan, New Delhi, 29 May 1998.
- 3rd Meeting of the National Steering Committee of INDOEX, ISRO Telemetry Tracking and Command Network, Bangalore, 9 June 1998.
- Meeting of Scientific Steering Committee of the IGBP (PAGES), Pallanza, Italy, 19-22 June 1998.
- First Meeting of the QRT on Agrometeorology, Krishi Bhavan, New Delhi, 20 July 1998.
- First Meeting of Reconstituted PAMC-Himalayan Glaciology (HG), Department of Science and Technology, New Delhi, 26-27 October 1998.
- 31st meeting of Programme Advisory Committee on Atmospheric Sciences (PAC-AS), Visakhapatnam, 2-3 November 1998.
- Joint Science Working Group meeting of CLIMATSAT TROPIQUES Mission , Indian Space Research Organisation (ISRO), Bangalore, 26 November 1998.
- Meeting of QRT finalisation, Indian Agricultural Research Institute, New Delhi, 27-28 November 1998.
- 50th meeting of Council for Meteorology and Atmospheric Studies, Mausam Bhavan, New Delhi, 12 January 1999.
- 24th Meeting of Indian National Committee on Hydrology, Sewa Bhavan, New Delhi, 19 March 1999.
- Indo-US Meeting , Mausam Bhavan, New Delhi, 24-25 March 1999.

Dr. A.K. Kamra

- Meeting of National Steering Committee of INDOEX, Indian Space Research Organisation (ISRO), Bangalore, 13 April 1998.
- Ninth Mid-year Meeting, Indian Academy of Sciences, Bangalore, 16-19 July 1998.
- 64th Annual Meeting of the Indian Academy of Sciences, Kottayam, 31 October 1998.
- Meeting of National Steering Committee and of the Working Group on Aerosols and Trace Gases of the INDOEX, National Physical Laboratory, New Delhi, 17 November 1998.

Dr. S.S. Singh

- Meeting of Technical Evaluation Committee on Digitization of Analysed Charts, India Meteorology Department, Pune, 8-9 October 1998.

Dr. P.C.S. Devara

- Meeting of the INDOEX-India Working Group-I on Aerosols and Chemistry, ISTRAC, Indian Space Research Organisation (ISRO), Bangalore. 15 September 1998.
- Meeting of Managing Committee and General Body of the Indian Aerosol Science and Technology Association (IASTA), Bhabha Atomic Research Centre, Mumbai , 30 November 1998.
- Technical Evaluation Committee (TEC) Meetings in connection with Modernisation and Augmentation of Air Pollution Laboratory of India Meteorological Department, Pune, 25 January and 8 February 1999.
- Project Advisory and Monitoring Committee (PAMC) Meeting , Department of Science and Technology, New Delhi, 11 February 1999.
- Review Meeting of IGBP WG-IV MOS/WiFS Data Utilisation for Global Change Studies, Space Applications Centre, Ahmedabad, 16 March 1999.

Dr. V. Satyan

- Planning Committee meeting for the Fifth SERC School, National Geophysical Research Institute, Hyderabad, 29 June 1998.
- Meeting of ISRO-IGBP, Space Application Centre, Ahmedabad, 28 July-1 August 1998.

- Meeting of Inter Departmental Committee for Indian Climate Research Programme (ICRP), Department of Science and Technology, New Delhi, 30-31 August 1998.

- Meeting of Resource Persons for the Fifth SERC School, National Geophysical Research Institute, Hyderabad, 12 August 1998.

- Indian Ocean Modelling and Dynamics (INDOMOD) and Satellite Coastal and Oceanographic Research (SATCORE) meeting, Department of Ocean Development, New Delhi, 15-18 December 1998.

Dr.(Smt.) P.S. Salvekar

- First Meeting of the Group of Committees on Indian Ocean Modelling and Dynamics (INDOMOD) and Satellite Coastal and Oceanographic Research (SATCORE), Department of Ocean Development, New Delhi, 29 April 1998.

Shri S. Sinha

- 3rd Meeting of Project Advisory Monitoring Committee for MONTCLIM and ICRP organised by DST, Indian Institute of Tropical Meteorology, Pune, 6-7 October 1998.

Dr. S.S. Parasnis

- 3rd Meeting of Project Advisory Monitoring Committee for MONTCLIM and ICRP organised by DST, Indian Institute of Tropical Meteorology, Pune, 6-7 October 1998.

Dr. R.H. Kripalani

- Annual Monsoon Review Meeting, Chennai, 22 February 1999.

Dr. P.N. Mahajan

- Meeting for the Evaluation of the Project proposed by Squadron Leader (Retd.) D.M. Puranik, Department of Physics, University of Pune, Pune, 5 December 1998.

Shri M.K. Tandon

- Meetings of the Managing Committee of the Pune Chapter of Computer Society of India, Pune, July 1998 - March 1999.

- Meeting for Finalising the New Syllabus for the Master in Computer Management (M.C.M.) degree course of the University of Pune, Pune, 25 July 1998.

Dr. Y.J. Rao

- Convection Campaign Meeting, National MST Radar Facility, Gadanki, Tirupati, 14 April 1998.

Shri A.B. Sikder

- Meetings of the Departmental Committee for the posts of Mechanic Grade I and II, Carpenter Group I, Scientific Assistant and Met Attendent, India Meteorological Department, 15 December 1998.

- Meetings for Confirmation of the Employees of Group D, Senior observers, Upper Division Clerks, Lower Division Clerks, Mechanic Grade II, Peons, Mazdoors etc., India Meteorological Department, 3 April 1998 and 23 February 1999.

- Meeting for Termination of Probation of the Employees in the posts of Senior Observers, Upper Division Clerks, Lower Clerks, Mechanic Grade II, Carpenter II, Peons, Mazdoors etc., India Meteorological Department, 23 February 1999.

Shri C.G. Deshpande

- Meeting for debriefing of XVI Indian Scientific Expedition team to Antarctica, Department of Ocean Development, New Delhi, 25 May 1998.

Dr. S. Rangarajan

- SAARC Expert Meeting on the Utilization of Wind Energy, Bangladesh Ministry of Science and Technology, Dhaka, 13-15 December 1998.

Smt A.A. Shiralkar

- Meetings of the PUNENET- a network of Libraries and Information Centres in Pune Metropolitan area, Bioinformatics Centre, University of Pune, Pune, 23 June, 9 September 1998, 9 March 1999.

***

By Visitors

Prof. S. Perov, Central Aerological Observatory, Moscow Hydrometeorological Service, Russia

- *Ozone layer problem (24 April 1998).*

Dr. (Smt.) Radhika Behere, Fergusson College, Pune

- *Environmental aspects of the valley of flowers (13 July 1998).*

Dr. Muthuvel Chelliah, National Climate Environmental Programme, USA

- *NCEP/NCAR reanalysis project : past, present and future (15 July 1998).*
- *Trends in reanalysis (NCEP / NCAR, ECMWF and NASA) tropospheric temperature data sets and surface data sets. Do they disagree? (17 July 1998).*

Prof. M. Ramamurthy, University of Illinois, USA

- *Ensemble prediction of hurricane Opal's track and intensity (12 August 1998).*

Dr. P.V. Joseph, (Retd.) Director, India Meteorological Department, Pune

- *Rossby waves in May in relation to monsoon (1 September 1998).*

Prof. R. Nityanand, Raman Research Institute, Bangalore

- *Tidal forces in astronomy (17 September 1998).*

Dr. B.D. Becker, University of Reading, U.K.

- *Preliminary results on monsoon variability from ensemble simulations of global atmosphere model, forced with observed and climatological SSTs (8 October 1998).*
- *SHIVA project: European initiative into investigation of Asian monsoon (9 October 1998).*

Dr. A.S. Kolaskar, Director, Bioinformatics Centre, University of Pune, Pune

- *Information technology : Futuristic implications (22 February 1999).*

By Institute Scientists

Dr. K. Krishna Kumar

- *Epochal changes in Indian monsoon-ENSO precursors and some possible mechanisms (21 April 1998).*
- *Weakening monsoon- ENSO relationship-Is global warming a player? (4 January 1999).*

Shri D.R. Pattnaik

- *Role of cumulus convection schemes in GCM simulation of summer monsoon (3 June 1998).*

Shri D.R. Chakraborty

- *Barotropic triad and baroclinic scale energy transfer processes in the frequency domain during summer monsoon (3 July 1998).*
- *Aspects of low frequency oscillation during the northern winter as inferred from nonlinear energy interactions (5 February 1999).*

Shri P.S. Mukhopadhyay

- *Step-mountain ETA model (20 July 1998).*

Shri M. Mujumdar

- *Simulation of the Indian summer monsoon of 1997 and 1998 with COLA T30 L18 GCM (9 September 1998).*
- *Seasonal forecasting of monsoon 1998 using spectral T30L 18 GCM (20 January 1999).*

Shri J.R. Kulkarni

- *Some aspects of an association between southern oscillation and Indian summer monsoon as revealed through wavelet analysis (20 January 1999).*
- *Contributions from internal and external variability to the interannual variability of all India summer monsoon rainfall (20 January 1999).*

Shri R.M. Khaladkar

- *Overview of CSSTE-AP course on satellite meteorology and global climate, conducted at SAC, Ahmedabad during 1 March-30 November 1998,(22 January 1999).*

Dr. P.N. Mahajan

- *Satellite-observed eastward propagation of super cloud clusters over the equatorial Indian Ocean (27 January 1999).*

Shri J. Sanjay

- *Impact of new boundary layer scheme on the skill of a global spectral model precipitation forecast over India (27 January 1999).*

Shri S.M. Bawiskar

- *Momentum transport of lower tropospheric zonal waves and the performance of Indian summer monsoon (27 January 1999).*

Shri S.B. Kakade

- *The spatial variability in the dependance of Indian summer monsoon rainfall on thermal field (27 January 1999).*

Smt. U.V. Bhide

- *Forecasting significance of observed rainfall over India (28 January 1999).*

Dr. (Kum.) P.L. Kulkarni

- *Distributed supercomputing for NWP via satellite (28 January 1999).*

Shri S.S. Dugam

- *Interactive mechanism between ENSO and NAO and its relationship with Indian summer monsoon variability (28 January 1999).*

Shri V.R. Mujumdar

- *Prospects of satellite data for monitoring onset and advancement of Indian summer monsoon (28 January 1999).*

Dr. S. Sivaramakrishnan

- *Dynamic instability in the day time surface layer during Indian summer monsoon (3 February 1999).*

Dr. A.K. Sahai

- *Prediction of all India summer monsoon rainfall on monthly and seasonal scale: a neural network approach (5 February 1999).*

Dr. N. Singh

- *Extrapography-Heuristic empirical approach to long range rainfall prediction across India (5 February 1999).*

- *A new tool to prediction by modelling and extrapolating natural regularity in atmospheric, oceanic and solar parameters (5 February 1999).*

Smt. S.K. Mandke

- *SST boundary forcing for long-lead dynamic forecast: how good is the persistent anomaly method? (5 February 1999).*

- *Prediction of monsoon 1998 with a grid point climate model (5 February 1999).*

Shri N.K. Agarwal

- *Effects of coriolis force, vorticity and divergence on frequency distribution of nonlinear energy interaction during summer monsoon (5 February 1999).*

Smt. S.S. Desai

- *Stratospheric global energetics and their space time variability during active monsoon of 1990 (10 February 1999).*

Shri P. Singh

- *Three dimensional energetics of the onset phase of monsoon 1996 (10 February 1999).*

- *Three dimensional structure of a cyclonic storm: a numerical study (10 February 1999).*

Shri P.D. Safai

- *Studies on Aitken nuclei and size distribution of aerosols at a rural Himalayan locations (10 February 1999).*

Smt. A.A. Shiralkar

- *Weather , climate and health (23 March 1999).*

***

Teaching and Research Support

Lectures delivered for M. Sc. / M. Tech.(Atmospheric Sciences), D.C.M., M.C.A., M.C.S., M.C.M. etc. at the University of Pune

Dr. P.C.S. Devara
- Atmospheric aerosols and trace gases

Dr. (Smt.) P.S. Salvekar
- Fundamentals and advanced dynamic meteorology
- Instability of atmospheric disturbances
- Mathematics for atmospheric sciences
- Climate and numerical modelling

Dr. D.B. Jadhav
- Absorption spectroscopy

Dr. R. Vijayakumar
- Thermodynamics

Shri M.K. Tandon
- Programming languages and Principles-I (C and FORTRAN)
- Programming languages and Principles-II (C++, PROLOG, LISP)
- Overview of JAVA and C++
- Design and analysis of algorithms

Dr. P.N. Mahajan
- Satellite meteorology

Dr. (Smt.) I. Joshi
- Atmospheric structure and stratospheric warmings

Dr. (Kum.) P.L. Kulkarni
- Objective analysis and initialization

Smt. S.K. Mandke
- Energy balance models

Smt. A.A. Deo
- Dynamical oceanography
- Physical oceanography

Guidance to Students for Research Projects

Dr. P.C.S. Devara
Kum. V.V. Vaidya and Kum. R. Mahajan
M.Sc., University of Pune, Pune

Kum. S. Sharma
B.Sc., University of Pune, Pune

Shri R. Ranganathan
M.Tech., Cochin University of Science and Technology, Kochi

Dr. (Smt.) P.S. Salvekar
Shri S. Bist and Kum. M. Mohanty
M.Tech., University of Pune, Pune

Shri K.N. Rao
M.Tech., Andhra University, Visakhapatnam

Dr. D.B. Jadhav
Shri D.N. Nighut
Ph.D., University of Pune, Pune

Shri M. Bhujabal and Shri A. Patil
M.Sc., University of Pune, Pune

Dr. R. Vijayakumar
Kum. M.J. Godkhindi
B.Sc., University of Pune, Pune

Shri R. Loganathan
M.C.A., Nehru Memorial College, Trichy

Dr. S.S. Parasnis
Shri J.A. Jain, Shri A.K. Padki, Shri D.S. Sacbar, Shri R.V. Sankla, Shri S.S. Shinde, Shri S.R. Shinde, Shri M.K. Thakkar, Shri V.V. Pate, Shri A.B. Shinde, Shri P.P. Raut, Shri Kalekar and Shri M. Shah, Diploma in Civil Engineering, Sou Venutai Chavan Polytechnic, Pune

Shri A.G. Pillai
Shri K. Maheshkumar
M.Tech., Cochin University of Science and Technology, Kochi

Shri K.V. Ramesh
M.Tech., Andhra University, Visakhapatnam

Dr. P.N. Mahajan
Shri Anil Kumar, Shri M. Shinde and Kum. V. Vaidya
M.Tech, University of Pune, Pune

Kum. B.S. Vaidya,
M.Sc., University of Pune, Pune

Dr. A.K. Sahai
Shri R. Narayana
M. Tech., Andhra University, Visakhapatnam

Dr. M.K. Soman
Kum. K. Rupa
M. Tech., Andhra University, Visakhapatnam

Shri J.R. Kulkarni
Shri M. Rahalkar, Shri G.K. Sawaisarje,
Shri S.S. Domse and Shri M.K. Kulkarni
M.Sc., University of Pune, Pune

Shri J.S. Pillai
Kum. M.P. Arude, Kum. A.A. Dani and
Kum. S.S. Gupte,
B.E., Cummins College of Engineering for Women, Pune

Nominations as External Examiners / Paper setters

Prof. G.C. Asnani
M.Phil., Bharathiar University, Coimbatore

Shri K.G. Vernekar
M.Tech., University of Pune, Pune

Dr. P.C.S. Devara
Ph.D., Indian Institute of Technology, Mumbai
Ph.D., Gujarat University, Ahmedabad

Dr. V. Satyan
Ph.D., Physical Research Laboratory, Ahmedabad

Dr. (Smt.) P.S. Salvekar
M.Tech., University of Pune, Pune
M.Tech., Cochin University of Science and Technology, Kochi
Ph.D., Indian Institute of Technology, New Delhi

Dr. S. Sivaramakrishnan
M.Tech., University of Pune, Pune

Dr. S.S. Parasnis
M.Tech., University of Pune, Pune

Dr. D. Subrahmanyam
M.Tech., Andhra University, Visakhapatnam

Shri M.K. Tandon
D.C.M., M.C.S., M.C.A.and M.C.M.,
University of Pune, Pune

Shri J.R. Kulkarni
M.Tech. and M.Sc., University of Pune, Pune

Expertise Provided as Faculties

- *IITM/IMD Workshop on Forecast Oriented Research Applications, India Meteorology Department, Pune, 17-21 August 1998*

  Dr. A.K. Kamra, Dr. A.S.R. Murty, Dr. S.S. Singh, Dr. H.N. Bhalme, Dr. P.C.S. Devara, Dr.V. Satyan, Dr. (Smt.) P.S. Salvekar, Dr. A.K. Kulkarni, Dr. K. Rupakumar, Dr. M.K. Soman, Dr. P.N. Mahajan, Shri A.G. Pillai, Shri J.R. Kulkarni, Smt. U.V. Bhide, Dr. (Smt.) S.S. Dhanorkar and Dr. (Smt.) A.A. Kulkarni,

- *Refresher Course on Space Mathematics, University of Pune, Pune, 25-28 August 1998*

  Shri J.R. Kulkarni

- *Second Refresher Course in Space Physics, Department of Space Sciences, University of Pune, Pune, 24 November-22 December 1998.*

  Dr. P.C.S. Devara, Dr. D.B. Jadhav and
  Dr. R. Vijayakumar

- *4th batch of Hydromet's Supervisor's Course, India Meteorological Department, Pune, 10 February 1999.*

  Prof. G.C. Asnani (Inagurated the Course)

Memberships of Scientific Committees

Dr. G.B. Pant

- Member, Editorial Committee of the research journal "Mausam" for 1999-2001.

- Member, Core Group on Global Warming/ Climate Change constituted by the Planning Commission, Government of India.

Dr.A.K.Kamra

- Member, Sectional Committee on the Earth and Planetary Sciences of the Indian Academy of Sciences.

Dr. S.S. Singh

- Member, National Committee on GEWEX Asian Monsoon Experiment (GAME)

- Member, Expert Group of Scientific Advisory Committee of the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi.

Dr. P.C.S. Devara

- Member, ISRO-GBP Working Group-II on Atmospheric Minor Constituents and aerosols. Convenors to the Conference (MCO5) entitled "Land-Falling of Tropical Cyclones of International Union of Geodesy and Geophysics (IUGG-99)", Bermingham, UK during 18-30 July 1999.

- Vice-President, Managing Committee of the Indian Aerosol Science and Technology Association (IASTA), Mumbai.

Dr. D.B. Jadhav

- Member, Managing Committee of the Indian Aerosol Science and Technology Association (IASTA), Mumbai for the period 1998-2001.

Shri M.K. Tandon

- Director, Scientific Applications of the Pune Chapter of the Computer Society of India for the year 1998-99.

- Member, Conference Management Committee of the First Global Convention on "CAE"-98 - CAD/CAM" organised by the Pune Chapter of Computer Society of India during 28-30 July 1998.

Lectures Delivered Outside

Prof. G.C. Asnani

- *Monsoon in north, central and south America,* Pune Chapter of Indian Meteorological Society, Pune, 17 June 1998

- *El Nino of 1997-98,* Pune Chapter of Indian Meteorological Society, Pune, 28 July 1998

- *How we in meteorology deal with non-linearity and chaos,* Rani Durgavati University, Jabalpur, 10 November 1998

- *Recent studies on cirrus clouds,* Pune Chapter of Indian Meteorological Society, Pune, 9 February 1999

Dr. G.B. Pant

- *Space Physics,* University of Pune, Pune, 7 September 1998

- *Green house effects and global warming,* Seminar cum Workshop on Recent Trends in Environmental Education, Walchand College of Arts and Science, Solapur, 29 January 1999

- *Global and regional climate change,* Prof. P.R. Pisharoty lecture series instituted by the Indian Society of Remote Sensing, Space Application Centre, Ahmedabad, 26 March 1999

Dr. A.K. Kamra

- *Cloud electrification,* Indian Academy of Sciences, Bangalore, 17 July 1998

- *Thunderstorm electrification,* Inter University Centre for Astronomy and Astrophysics, Pune, 21 September 1998

Dr. V. Satyan

- *Monsoon seasonal forecasting using GCMs,* India Meteorological Department, Pune, 5 November 1998

Dr. (Smt.) P.S. Salvekar

- *Fundamentals of atmospheric dynamics and instability of atmospheric disturbances,* Department of Space Science, University of Pune, Pune, 11 and 18 December 1998

Dr. N. Singh

- *Statistical methods used in crop,* Centre for Advanced Studies in Agricultural Meteorology (CASAM), College of Agriculture, Pune, 17 and 18 September 1998

Dr. S.S. Parasnis

- *Aerosol transport modelling using transilient turbulance theory*, Aerosol and Air Quality Research Laboratory, University of Cincinnati, Cincinnati, USA, 25 June 1998

Dr. R.H. Kripalani

- *Climatology and climatic change over the Asia- Pacific region* (5 lectures), United Nations Affiliated Course on SATMET and Climate Change, Space Applications Centre, Ahmedabad, 13-17 April 1998

Shri M.K. Tandon

- *Overview of JAVA and C++*, Neville Wadia Institute of Management Studies and Research, Pune, 22 April 1998
- *Parallel processing in Banking industries*, Prin. N.K. Naralkar Institute of Career Development and Research, Pune, 27 February 1999

Shri J.R. Kulkarni

- *Advanced dynamic meteorology and turbulence theory Dynamic meteorology*, Shri Venkateshwara University, Tirupati, 19-27 September 1998
- *Monsoon*, Kendriya Vidyalaya, Khadaki, Pune, 18 October 1998
- *Seasonal prediction of Indian summer monsoon rainfall using GCM*, Indira Gandhi Centre for Atomic Research, Kalpakkam, 15 February 1999

Dr. Y.J. Rao

- *Study of Atmospheric stable layers using Indian MST Radar*, National MST Radar Facility, Gadanki, 10 November 1998
- *Atmospheric turbulence and stability using Indian MST Radar*, 11 November 1998
- *Atmospheric aerosols*, 12 November 1998

Shri S. Mahapatra

- *Some studies on recent monsoon depressions*, National Centre for Medium Range Weather Forecasting, New Delhi, 4 September 1998

Dr. K. Ashok

- *Numerical weather prediction*, Shri Venkateshwara University, Tirupati, 23-29 August 1998

Shri M.Mujumdar

- *Seasonal forecasting in real perspective by T30L 18 GCM*, Indira Gandhi Centre for Atomic Research, Kalppakam, 15 February 1999

Award for Ph.D. Degree

Shri G. Pandithurai

Lidar and radiometric studies of aerosol and trace gas distributions in the tropical atmosphere, (University of Pune, Pune),
(Guide : Dr. P.C.S. Devara)

Smt. R.R. Joshi

Study of atmospheric intraseasonal variability using global TOGA (Tropical Ocean and Global Atmosphere) temperature time series, (University of Pune, Pune),
(Guide : Dr. (Smt.) A.M Selvam)

Shri S.K. Behera

Mathematical modelling of the Indian Ocean and sensitivity studies on dynamics, variability and air-sea interactions (Berhampur University, Berhampur),
(Guide : Dr.(Smt.)P.S.Salvekar)

Shri Y. Jaya Rao

Study of atmospheric stable layer in the tropical atmosphere using Indian MST Radar (Shri Venkateshwara University, Tirupati.),
(Guide : Dr. A.R .Jain and Prof. D. Narayana Rao)

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

Shri A.L. Londhe

Determination of the vertical structure of atmospheric constituents by visible spectroscopy
(Guide : Dr. D.B. Jadhav)

Shri S.B. Debaje

Tropospheric studies of some important atmospheric species over tropics
(Guide : Dr. D.B. Jadhav)

Shri M. Ravichandran

Study of the atmospheric electric field vector close to the ground

(Guide : Dr. A.K. Kamra)

Kum. J.S. Pethkar

Study of atmospheric interannual variability using global COADS surface pressure time series

(Guide : Dr. (Smt.) A.M. Selvam)

Shri A.A. Munot

Tropical general circulations and its association with Indian summer monsoon

(Guide : Dr. G.B. Pant)

Smt. S.S. Kandalgaonkar

Some studies of surface atmospheric electricity parameters : fair and distributed weather conditions

(Guide : Dr. D.B. Jadhav)

Shri R.S. Maheskumar

Atmospheric aerosol and air quality studies using lidar and in-situ techniques

(Guide : Dr. P.C.S. Devara)

Training Undergone

Shri R.M. Khaladkar

Post Graduate Diploma in 'Satellite Meteorology and Global Climate',

Space Application Centre (SAC), Ahmedabad

1 March-30 November 1998.

Shri S.B. Kakade, Shri S.G. Narkhedkar and Shri S.P. Ghanekar

Condensed Basic Training Course followed by Advanced Meteorological Training Course,

India Meteorological Department, Pune

8 September 1997 to 7 September 1998

Shri G.R. Chintalu

Condensed Basic Training Course followed by Advanced Meteorological Training Course,

India Meteorological Department, Pune

8 September 1998 to 7 September 1999

***

Dr. G.B. Pant

- Participation in the Workshop on Rapid Non-linear Climate Change, IPCC (WMO/UNEP), Noordwijkerhout, **The Netherlands**
  (30 March-4 April 1998)

- Participation in the Scientific Steering Committee Meeting of IGBP, Pallanza and a One Day Seminar on Palaeoclimate in the Mediterranean Region, Milan, **Italy**
  (17-24 June 1998)

- A scientific assignment in the Wood Quality Laboratory, Forestry and Forest Products Research Institute, Ibaraki under the Japanese Government Research Award, **Japan**
  (12 September-19 October 1998)

Dr. P.C.S. Devara

- Participation in the International INDOEX Workshop, Utrecht, **The Netherlands**
  (19-25 June 1998)

- Participation in the 19th International Laser Radar Conference (ILRC), Annapolis, **USA**
  (3-14 July 1998)

Dr. V. Satyan

- Research Work at the Hadley Centre under the IITM-Hadley HE Link Programme, **U.K.**
  (1 September 1997-30 April 1998)

Dr.D.B.Jadhav

- Installation of a Rotating Slit scanning UV-visible spectrometer, University of Mauritius, **Mauritius**
  (13-28 September 1998)

Dr. K. Rupakumar and Dr. H.P. Borgaonkar

- Participation in the Indo-Japanese Collaborative Research Project on Dendroclimatology, Forestry and Food Products Research Institute, Tsukuba, **Japan**
  (23 February-10 March 1999)

Dr. R. Krishnan

- Participation as a Researcher in the Frontier Research Programme for Global Change, Japan Marine Science and Technology Centre, Tsukuba, **Japan**,
  (1 May 1998-31 March 1999)

Dr. S.S. Parasnis

- Participation in the Conference of American Aerosol Association and Research (AAAR) and visit to the laboratories of University of Cincinnati, **USA**
  (19 June-16 July 1998)

Dr. R.H. Kripalani

- Participation in the Second International Conference on Climate and Water, Espoo, **Finland**
  (15-22 August 1998)

Dr. G. Beig

- Participation in the Joint International Symposium of IGAC-CACGP on Global Atmospheric Chemistry, Seattle, **USA**
  (17-28 August 1998)

- For familiarisation with the Atmospheric Chemical Modelling as a part of the INDOEX Programme, National Centre for Atmospheric Research, Boulder, **USA**
  (20 October - 27 November 1998)

Shri S.K. Behera

- Participation as Researcher in the Frontier Research Programme for Global Change, Japan Marine Science and Technology Centre, Tokyo, **Japan**
  (16 February 1998-15 February 2000)

Smt. M.S. Naik

- Participation in the International Workshop on Composition and Acidity of Asian Precipitation (CAAP), Bangkok, **Thailand**
  (7-18 November 1998)

Dr. K. Krishna Kumar

- Post Doctoral Research Fellowship at International Research Institute for Climate Prediction, Lamont-Doherty Earth Observatory, Palisades, **USA**
  (9 July 1998-8 July 1999)

Shri A.A. Munot and **Shri A.B. Sikder**

- Participatation in the International Confernce on Environment and Agriculture (INCEA-98), Kathmandu, **Nepal**
  (28 October-10 November 1998)

Smt. N.R. Deshpande

- Participation in the Training Session on Agricultural Application of Climate Forecasts, Toowoomba, Queensland, **Australia**
  (30 January-21 February 1999)

Dr. H.P. Borgaonkar

- Participation in the Training in Dendro-climatological Studies at Laboratory of Tree Ring Research, University of Arizona, Tucson and visit to the Tree Ring Laboratory at Lamont Doherty Earth Observatory, Columbia University, New York, **USA**
  (18 March - 21 July 1998)

- Participation in the Dendro Field Week-99, Chiang Mai, **Thailand**
  (9-18 January 1999)

Dr. V.Jaya Rao, Shri S.D.Pawar and **Shri P. Murugavel**

- Participation in the INDOEX IFP 99 Programme of Cruise Sagar Kanya from Goa, **Mauritius**
  (17 January - 7 March 1999)
  Shri P. Murugavel also participated in Cruise Ron Brown from Mauritius to Maldives,
  (8 March - 4 April 1999.)

Dr. (Smt.) S.B. Morwal

- Participation in the Training Course on Application of Regional Climate Modelling for Asia, START Regional Centre for Temperate East Asia, Beijing, **China**
  (21 November - 2 December 1998)

Dr. (Smt.) S.B. Morwal and **Shri P. Mukhopadhyay**

- Participation in the Summer Colloquium on the Physics of Weather and Climate, the Effect of Topography on the Atmospheric Circulation and Conference on Role of Topography in Modelling Weather and Climate, International Centre for Theoretical Physics,Trieste, **Italy**
  (6-28 June 1998)

Dr.(Smt.) A.A. Kulkarni

- Participation in the Second GKSS School on Environmental Research, Lauenburg, **Germany**,
  (22 September-1 October 1998)

Shri D.K. Trivedi

- Participation in the International Summer School on Meteorology 98, Krivaja, **Yogoslavia**
  (20 August - 7 September 1998)

Dr. G. Pandithurai

- As Faculty Research Assistant made by the University of Maryland, Maryland, **USA**
  (9 July 1998-8 July 1999)

Dr. S. Rangarajan

- Participation in the SAARC Expert Meeting on the Utilization of Wind Energy, Bangladesh Ministry of Science and Technology, Dhaka, **Bangladesh**
  (13-15 December, 1998)

***

International

Prof. S. Perov,
Central Aerological Observatory,
Moscow Hydrometeorological Service, Moscow,
Russia
18-25 April 1998

Dr. Muthuvel Chelliah ,
National Climate Environmental Programme,
Washington D.C., **USA**
14-18 July 1998

Dr. Suraj Kothari,
IOWA State University, Iowa City, **USA**
3 August 1998

Dr. B.D. Becker,
Department of Meteorology,
University of Reading, **U.K**
6-8 October 1998

Dr. (Mrs.) Helene Cachier and **Dr. Patrick Chazette,**
Laboratory of Sciences,
Climate and Environment (LSCE), **France**
20-21 October 1998

Dr. Takeshi Fujiwara,
Forestry and Forest Products Research Institute,
Tsukuba, **Japan**
15 November-8 December 1998

Prof. Janet Finch,
Vice Chancellor, Keele, **U.K.** and
Dr. Robert Monro,
Head, Higher Education Link,
B.C. Manchester, **U.K.**
8 December 1998

Dr. Takeshi Fujiwara, Dr. Naoki Okada and
Dr. (Ms.) Kana Yamashita
Forestry and Forest Products Research Institute,
Tsukuba, **Japan**
10-26 January 1999

Dr. V. Rama Swamy,
Geophysical Fluid Dynamics Laboratory,
U.S.Department of Commerce, NOAA,
Princeton, New Jersey, **USA**
11-18 February 1999

Dr. Mike Hulme,
Climate Research Unit,
University of East Anglia, **U.K.**
22-23 March 1999

National

Students, Vacation Camp on Personality Development,
Loyola High School,
Pune
24 April 1998

Prof. B.S.N. Prasad, Shri. J. Sannappa, Shri. N.V. Raju and **Shri. Nagaraja,**
Depatment of Physics, Mysore University,
Mysore
20-27 April and 24-29 December 1998

Naval Meteorological Observers-I Sailors,
School of Naval Oceanology and Meteorology,
INS Garuda,
Kochi
29 July 1998

Prof. V.S. Ramamurthy,
Secretary, Govt. of India,
Department of Science and Technology,
New Delhi
17 August 1998

Dr. R.R. Kelkar,
Director General of Meteorology,
India Meteorological Department,
New Delhi
and Chairman, IITM Governing Council
17 August 1998

Dr. S.M. Kulshrestha,
Director General of Meteorology (Retd.),
India Meteorological Department,
New Delhi
26 August 1998

Prof. Mohan Joshi,
Department of Mathematics,
Indian Institute of Technology,
Mumbai
24-27 August 1998

Dr. P.V. Joseph,
Director (Retd.),
India Meteorological Department,
Pune
1 September 1998

Participants, Refresher Course on Space Mathematics,
Department of Space Science and
Department of Mathematics,
University of Pune, Pune
4 September 1998

Trainees, Short-term Training Course on 'Crop Modelling',
Centre for Advanced Studies in Agricultural Meteorology, College of Agriculture,
Pune
24 September 1998

Dr. Vimla Yadav,
Director,
Department of Science and Technology,
New Delhi
24-26 November 1998

Dr. A.P. Mitra, FRS,
Honorary Scientist of Eminence and
Senior Homi Bhabha Fellow,
National Physical Laboratory,
New Delhi
2 December 1998

Mrs. Manjula Rao and **Emily Thomas,**
Award Officers,
British Council Division,
Mumbai
8 December 1998

M.Sc. Students,
Department of Geophysics,
Banaras Hindu University,
Varanasi
10-11 December1998

Mrs. Faby Sunny and **Mrs. B.K. Sapra,**
Environmental Assessment Division,
Bhabha Atomic Research Centre,
Mumbai
28 December 1998 -1 January 1999

Students, Deparment of Geography,
Shri Annadaneshwar Arts, Science and Commerce College,
Naregal
12 January 1999

M.B.B.S. Students of Medical College,
Bharati Vidyapeeth,
Pune
1 and 3 March1999

Post Graduate Students,
Department of Atmospheric Sciences,
Cochin University of Science and Technology,
Kochi
11 March 1999

Dr. N.C. Deb,
Electronics and Communication Sciences Unit,
Indian Statistical Institute,
Calcutta
23-27 March 1999

Trainee Officers,
Institute of Armament Technology,
Pune
26 March 1999

***

Academic Faculty of IITM

Name	Specialisation	Academic Qualification
Dr. G.B. Pant	Climate, Climatic Change, Palaeoclimatology , Monsoon variability and Prediction.	M.Sc., Ph.D.
Dr. A.K. Kamra	Cloud Physics, Atmospheric Electricity, Aerosol Physics.	M.Sc., Ph.D.
Dr. A.S.R. Murty	Cloud Physics, Weather Modification.	M.Sc., Ph.D.
Dr. S.S. Singh	Numerical Weather Prediction.	M.Sc., Ph.D.
Shri K.G. Vernekar	Atmospheric Boundary Layer Studies.	M.Sc.
Dr. H.N. Bhalme	Large-scale Droughts and Floods, Seasonal Rainfall Prediction, Sun-Weather Relationship.	M.Sc., Ph.D.
Dr.(Smt.) A.M. Selvam	Deterministic Chaos.	M.A., Ph.D.
Dr. P.C.S. Devara	Atmospheric Optics, Remote Sensing of Atmospheric Aerosols and Trace Gases, Aerosol-Climate Interactions.	M.Sc., Ph.D.
Dr. V. Satyan	Climate Modelling, Ocean-Atmosphere Interaction, Climate Variability, Dynamical Seasonal Monsoon Forecasting.	M.Sc., Ph.D.
Dr.(Smt.) P.S. Salvekar	Monsoon Disturbances, Simulation of Atmospheric and Oceanic Circulation, Human Resource Development for Atmospheric Sciences.	M.A., Ph.D.
Dr. L.S. Hingane	Climatic Changes due to Green house Gases, Climate Variability.	M.Sc., Ph.D.
Shri S. Sinha	Theoretical and Experimental Atmospheric Boundary Layer Studies.	M.Sc.
Dr. D.B. Jadhav	Spectrometric Techniques for Atmospheric Chemistry, Radiation, Atmospheric Electricity.	M.Sc., Ph.D.
Dr. K. Rupa Kumar	Climate Change, Monsoon Variability and Prediction, Dendroclimatology, Climate Impact Studies.	M.Sc., Ph.D.
Shri L.K. Sadani	Instrumental Study of Parameters of Atmospheric Boundary Layer.	M.Sc.
Dr. S. Sivaramakrishnan	Atmospheric Boundary Layer, Wind Tunnel Simulations.	M.Sc., Ph.D.
Dr. R. Vijayakumar	Cloud Physics, Numerical Modelling of Clouds.	M.Sc., Ph.D.
Dr. A.K. Kulkarni	Hydrometeorological Studies for different River Basins and Regions.	M.Sc., Ph.D.
Dr. Nityanand Singh	Hydrometeorological Studies, Rainfall Prediction on Shorter Spatial and Temporal Scales.	M.Sc., Ph.D.
Dr. K.D. Prasad	Monsoon Variability and Long-Range Forecasting.	M.Sc., Ph.D.
Dr. M.K. Soman	Climate Modelling, Land Surface Processes Parameterisation, Dynamical Seasonal Monsoon Forecasting, Monsoon Diagnostics.	M.Sc., Ph.D.

Name	Specialisation	Academic Qualification
Dr. R. Krishnan	Climate Modelling, Interannual and Intraseasonal Monsoon Variability, Ocean-Atmosphere Interaction, Monsoon Diagnostics.	M.Sc., Ph.D.
Shri P. Seetaramayya	Air-Sea Interaction, Marine Boundary Layer Studies.	M.Sc.
Dr. S.S. Parasnis	Atmospheric Boundary Layer Modelling.	M.Sc., Ph.D.
Dr. D. Subramanyam	Dynamic Instability of Atmospheric Flow.	M.Sc., Ph.D.
Shri S.S. Aralikatti	Computer and Data Management.	B.Sc.
Dr. G.K. Manohar	Atmospheric Electricity.	M.Sc., Ph.D.
Dr. R.H. Kripalani	Asian Monsoon and Climate Variability.	M.Sc., Ph.D.
Shri B.N. Mandal	Hydrometeorological Studies for Different River Basins and Regions.	B.Sc.
Dr. P.E. Raj	Optical and Radio Remote Sensing of the Atmosphere, Environmental Studies, Aerosol-Climate Interactions.	M.Sc., Ph.D.
Shri M.K. Tandon	Development of Scientific Computing Techniques for Atmospheric Sciences.	M.Sc.
Shri S.K. Paul	Cloud Physics, Atmospheric Aerosols, Atmospheric Chemistry.	B.Sc.
Shri A.G. Pillai	Air Pollution, Precipitation Chemistry.	M.Sc.
Dr. P.N. Mahajan	Satellite Data Applications for Weather Forecasting.	M.Sc., Ph.D.
Shri Brij Mohan	Field Experimentation for Atmospheric Boundary Layer.	B.Sc.
Shri J.R. Kulkarni	Physical Processes in Atmospheric and Oceanic Global Circulation Models, Monsoon Variability and Prediction, Non-Linear Dynamics and Chaos	M.Sc.
Smt. S.S. Vaidya	Numerical Weather Prediction with Special Emphasis on the Physical Processes	M.Sc.
Dr. G. Beig	Atmospheric Chemistry, Green house Gases, Analysis and Modelling.	M.Sc., Ph.D.
Dr. T. Venugopal	Numerical Weather Prediction, Planetary Boundary Layer Studies.	M.Sc., Ph.D.
Dr. S.K. Behera	Ocean Modelling.	M.Sc., Ph.D.
Dr. A.K. Sahai	Climate Change, Neural Network Technique in Meteorology, Statistical and Dynamical Forecasting of Monsoon.	M.Sc., Ph.D.
Dr. (Smt.) I.S. Joshi	Studies in Upper/Middle Atmosphere and Ionosphere.	M.Sc., Ph.D.

***

Indian Institute of Tropical Meteorology
(An Autonomous Institute of the Ministry of Science and Technology, Govt. of India)
Dr. Homi Bhabha Road, Pashan, Pune 411 008, Maharashtra, India
E-mail : siralkar@tropmet.ernet.in Fax : 91-020-5893825
Web : http://www.tropmet.ernet.in Telephone : 91-020-5893600

First International Workshop on Long-Term Changes and Trends in the Atmosphere (LT-ACT)

Inauguration by Prof. R.R.Daniel (centre), Dr. A.P.Mitra, FRS, (second from left) and Dr. G.P.Brasseur, USA (second from right)

Scientific session in progress

16-19 February 1999

Audience at the Inaugural function

Dr. A.P.Mitra, FRS presiding over the concluding session

Governing Council

Guest House ▲

Community Hall ▼

Indian Institute of Tropical Meteorology

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

Dr. Homi Bhabha Road, Pashan, Pune 411 008, Maharashtra, India

E-mail : siralkar@tropmet.ernet.in *Fax : 91-020-5893825*

Web : http://www.tropmet.ernet.in *Telephone : 91-020-5893600*

Printed at Kirloskar Brothers Limited, Printing Division, Pune 411 037.