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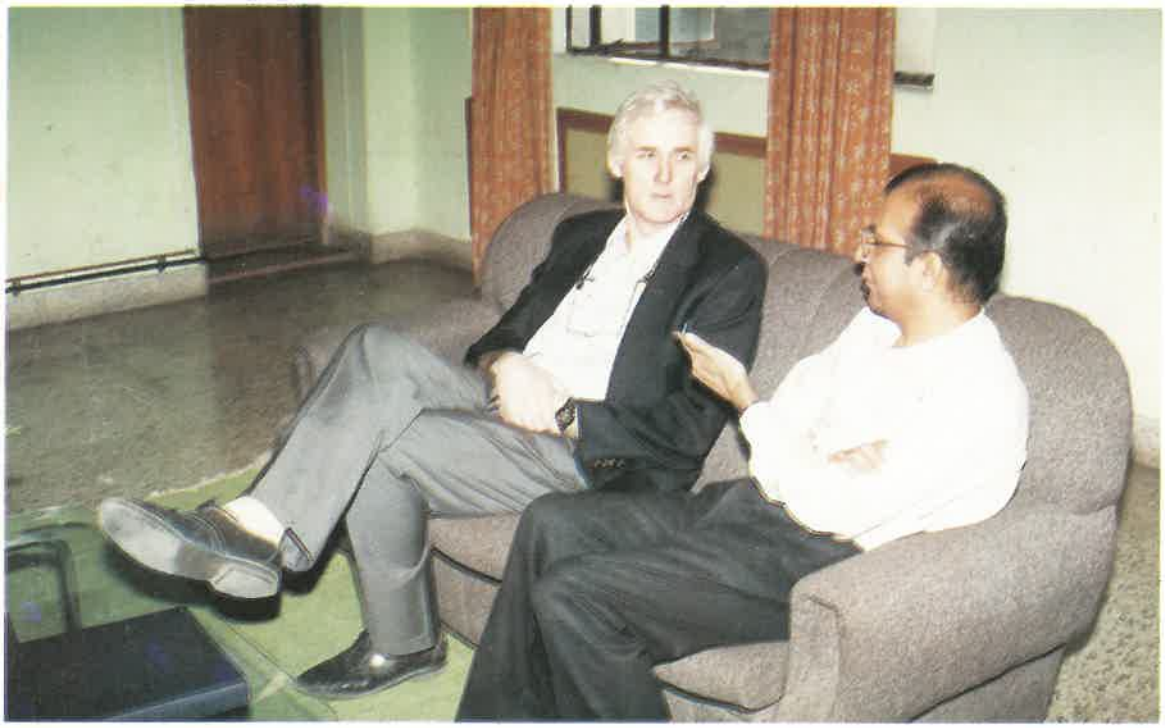
INDIAN INSTITUTE OF TROPICAL METEOROLOGY

ANNUAL REPORT 1996-97

A delegation of Russian Scientists visited the Institute under the Indo-Russian Working Group.



Prof. Julian Hunt, Chief Executive, Meteorological Office, U.K. had discussions with the Director during his visit to the institute under the IITM-Hadley Centre Collaborative Research Programme.

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ANNUAL REPORT
1996-97

INDIAN INSTITUTE OF
TROPICAL METEOROLOGY

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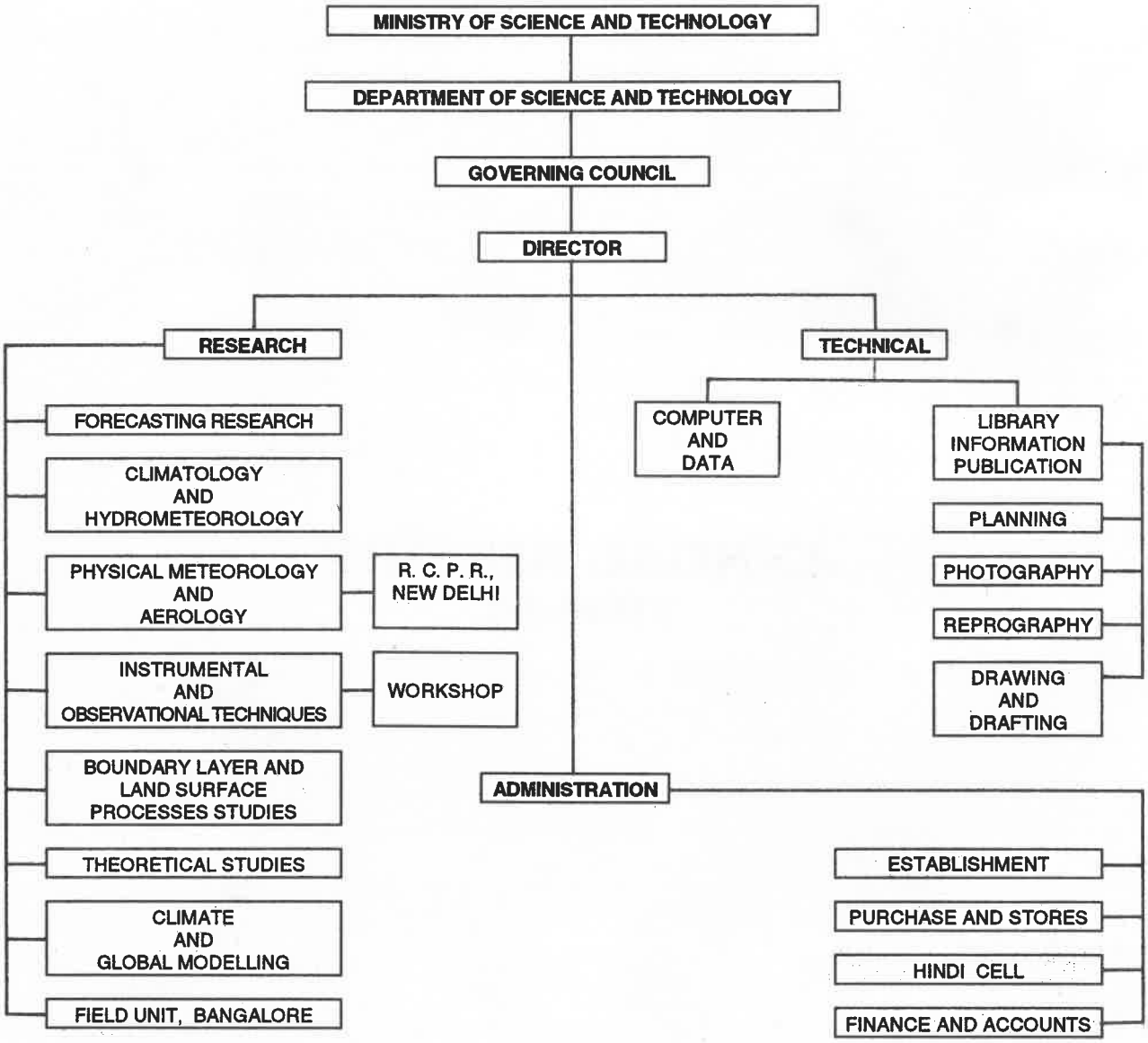

ORGANIZATIONAL PROFILE

CONTENTS

Foreword

1. Highlights 7
2. Overview 12
3. Publications 45
4. Participation in Symposia/Seminars/Conferences 52
5. Papers Presented at Symposia/Seminars/Conferences 57
6. Participation in Meetings 64
7. Seminars 66
8. Academic Activities 68
9. Deputation Abroad 76
10. Visitors 78

Audited Statements of Accounts ..... i-x

GOVERNING COUNCIL

Chairman (Ex-Officio)

Dr. N. Sen Roy,
Director General of Meteorology,
India Meteorological Department,
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New Delhi 110 003

Members

Dr.Y.S.Rajan,
Advisor,
Department of Science and Technology,
New Delhi 110 016
(Up to 31.7.1996)

Dr. R.K.Midha,
Joint Advisor,
Department of Science and Technology,
New Delhi 110 016
(from 1.8.1996)

Shri S.B.Krishnan,
Joint Secretary (Finance),
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(Up to 1.9.1996)

Shri Rahul Sarin,
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* Prof. (Smt.)Sulochana Gadgil,
Head, Centre for Atmospheric Sciences,
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(from 1.8.1996)

* Prof. G.C.Asnani,
Retd. Professor,
University of Nairobi,
Pune 411 007
(from 1.8.1996)

* Tenure : Two years

* Prof. B.H.Subbaraya,
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(Up to 31.7.1996)

* Prof.S.K.Dube,
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Dr.A.K.Kamra,
Deputy Director
Performing Current Duties of Director,
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Pune 411 008
(from 1.6.1996)

Non-Member Secretary

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

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Indian Institute of Tropical Meteorology,
Pune 411 008.

Dr. U.S. De
Additional Director General of Meteorology (Research),
India Meteorological Department,
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Tenure : No tenure for this Committee.

Dr. R.K. Midha,
Joint Adviser
Department of Science & Technology,
New Delhi 110 016.

Smt. Vimla Yadav,
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Department of Science & Technology,
New Delhi 110 016.

FOREWORD

The Indian Institute of Tropical Meteorology (IITM), Pune was established in 1962 to fulfill the need for research in the field of Meteorology and Atmospheric Sciences in India. The fundamental objective of the Institute is to pursue research programmes in Tropical Meteorology. True to its objectives, the Institute has been functioning, since its inception, as the National Centre for Basic and Applied Research in the field of Tropical Meteorology. The Institute is supported financially by the Government of India through its Department of Science and Technology, New Delhi.

A good mix of fundamental and applied research is kept in the Institute's programmes. The research programmes are balanced among theoretical studies, field experiments and laboratory work. The scientists of the Institute have made significant contributions in the challenging areas of the Atmospheric Sciences like Weather Forecasting, Climatology, Hydrometeorology, Monsoon Studies, Climate Modelling, Weather Modification, Cloud Physics, Atmospheric Chemistry, Atmospheric Electricity and Studies relating to Land-Surface Processes. During the year, the Institute's scientists continued to publish their research work in standard national and international journals and presented their work in the national and international symposia/seminars.

The Institute has enhanced its infrastructure to fulfill the present need. The modern high computing facilities, data acquisition systems, sophisticated laboratory equipment and a well equipped library facilitated the research work.

The Institute arranged field experiments of its own as well as through participation in the multi-agency missions. Institute's participation in the Antarctica scientific expedition and the INDOEX programme made the year eventful.

The Institute continued to participate in the collaborative research programmes. A DST-Sponsored Indo-Brazilian Joint Workshop on Climate Research was organised at the Institute to identify possibilities of research collaborations between the two countries in the field of Climate Research. The Institute has also entered in to a scientific collaborative programme with the Hadley Centre for Climate Prediction and Research, U.K. Under this programme, Prof.Julian Hunt, the Chief Executive of the Meteorological Office, U.K., visited the Institute. A delegation of Russian scientists visited the Institute under the Indo-Russian Working Group. Several dignitories from India and other countries also visited the Institute during the year and exchanged scientific experiences with the Institute's scientists.

Technical guidance, assistance and support to several scientific organisations, Government bodies and Service Agencies have been provided. The Institute's studies on hydrometeorological aspects of monsoon rain have found wide applications by the irrigation and flood control agencies. The Warm Cloud Modification Technique developed by the Institute for increasing rainfall has been utilized by several State Governments in their cloud seeding operations. Institute is also providing technical support to the ISRO for its Polar Orbiting Satellite Observational Programme by organising special lidar and radiometric observations.

One of the distinguished feature of the Institute's programmes is the promotion of scientific collaboration with the universities and other research organisations. Institute's scientists provided teaching and research support to the Universities in their M.Sc, M.Tech. Courses and Ph.D. Programmes in Atmospheric Sciences and also provided expertise to various scientific organisations and bodies in their man-power development programmes and other courses.

The Institute organised man power development programmes by arranging specialised training programmes in different areas of atmospheric sciences. The DST-sponsored Third SERC School on Advanced Geophysical Fluid Dynamics, Three-Day Orientation Course in Climatology and a Short-term Training Course on Agrometeorology were the major courses held at the Institute during the year.

The Institute will keep its productivity high and continue to enhance research by identifying, developing and providing advanced facilities and services to the scientific community.

A. K. KAMRA
Deputy Director
Performing Current Duties of Director

1. Highlights

The year 1996-97 was marked by several training programmes and bilateral research programmes organised at the Institute. Institute's participation in the multi-institutional programmes like Antarctica Expedition and INDOEX Programme also made the year eventful. Several distinguished scientists from India and abroad visited the Institute and had interactive discussions with the scientists of the Institute.

The Institute enhanced its infrastructural facilities by acquiring many specialised and sophisticated scientific equipment, data acquisition and storage systems and latest computational facilities. Institute acquired one more Indy Graphics Workstation specially for the Climate Modelling research work and also established the Secondary Data Utilization Centre (SDUC) to receive the satellite cloud imageries. Local Area Network (LAN) has already been established and launching of the INTERNET through VSAT was under progress.

Programmes for popularization of Meteorology amongst the common people and the students were arranged at the Institute through organisation of open-house scientific exhibitions, visits to laboratories and computers, scientific film shows, popular lectures and students-scientists interactions, on the occasion of National Science Day and World Meteorological Day Celebrations.

The Institute has undertaken many scientific research programmes of national and international significance. The important highlights are summarised below:

Relationship between the storm activity over North Indian Ocean and ENSO was revealed. During the La Nina or cold phase of ENSO, the frequency of cyclonic disturbances over North Indian Ocean tends to be more compared to that during the El Nino or warm phase of ENSO. However, within this broad feature of the relationship, there is a strong seasonal dependence also.

An empirical study showed that the El Nino related droughts over India are more severe than the non-El Nino related droughts. However, the non-La Nina related floods are more severe than the La Nina related floods.

A study between the northern hemisphere geopotential height at 50 hPa level showed that the March geopotentials over the Canadian (east Asian) sector has significant positive (negative) relationship with subsequent Indian monsoon rainfall. The difference of the geopotentials over the Canadian and the east Asian sector during March shows a correlation of 0.7 with subsequent Indian monsoon rainfall over the data period 1958-1990.

Using DMSP-SSM/I (Defense Meteorological Satellite Program-Special Sensor Microwave Imager) satellite data, day to day variations in integrated water vapour, surface wind speed, integrated cloud liquid water and precipitation rates were studied for the life cycle of monsoon depression that formed over the Bay of Bengal during 22-27 July 1992. Strengthening of surface winds (12-15 ms^{-1}) to the south of the low pressure area prior to the formation of depression, higher values of the integrated water vapour (60-70 kg m^{-2}) over central and head Bay throughout the life cycle of depression, and highest values of integrated cloud liquid water and precipitation rates (70 kg m^{-2} * 100, > 200 mm hr $^{-1}$ * 10) in Southwest sector of the depression were the salient features brought out in the study.

The apparent heat source (Q1) and the apparent moisture sink (Q2) were estimated for the summer monsoon 1979 over India using daily FGGE ECMWF level IIIb data. The Q1 and Q2 over the monsoon trough area varied coherently with the rainfall over central India. This indicated that the diabatic heating was largely contributed by the latent heat released by cumulus convection and rainfall. An anomalous intense diabatic heat source was developed over the western part of the monsoon trough area during the active phase and the monsoon activity evolved into weak/break phases subsequent to such events during monsoon 79. The work has been completed under the Indo-US collaborative programme on Climate Research.

A software for the coloured animated display of monsoon circulation by using zonal and meridional component of wind, temperature and relative humidity super-imposed with streamline analysis at different tropospheic levels over the Indian region has been developed in house by using the GrADS (Grid Analysis Display System). Simulation of the Indian monsoon of 1979 by using the zonal component of wind with the streamline analysis at 700 hPa level has been made available on display. Such a display is found to be useful for the study of monsoon circulation.

The long range forecast of the All-India rainfall for the southwest monsoon season (June-September) 1996 based on stepwise multiple linear regression

model was given to the India Meteorological Department. The model had estimated that the monsoon rainfall on All India scale would be 93.9% of the average during the training period 1965-1994.

In order to investigate the physics of monsoon clouds in detail, numerical simulation experiments were carried out using a two dimensional time dependent (2DTD) cloud model by using aerological data obtained from special radiosonde observations made at Pune as a part of the Warm Cloud Modification Experiment of the Institute. A comparison between the results of cloud model and the aircraft cloud physical observations suggested that the cloud model can beneficially be used for the prediction and study of the physical and dynamical characteristics of the monsoon clouds and to understand the effects of hygroscopic particle seeding of warm clouds.

A study of the wet and dry depositions, including their seasonal variations and fluxes was carried out using the long-term field observations collected at Pune during 1984-1995. The results of the study indicated that (i) the dry depositions were minimum during the summer monsoon season and maximum during the winter season, (ii) there was no significant difference in pH of rainwater during the summer monsoon and winter seasons, (iii) the wet deposition of all ionic components was higher than the dry deposition, (iv) the depositions of the ionic components from natural sources (soil and sea) were higher than those from anthropogenic sources, (v) the dry deposition velocities of the aerosols were found to be increased with the increase of their mass median diameter, (vi) the chemical composition of the dry deposition indicated maximum depositions of the alkaline substances, which are the main cause for the alkaline pH of rainwater. The low acidic depositions at most of the locations of the study indicated that the anthropogenic sources have not perturbed the atmospheric S and N cycles in the region.

The interannual variability in the global surface air temperature, sea surface temperature and pressure was investigated using the COADS (Comprehensive Ocean Atmosphere Data Set) for the 28-year period (1961-88). Continuous periodogram power spectral analysis technique was used for the analysis of the above data. The results of the study indicated that the power spectra of the meteorological parameters follow the universal inverse power law form of the statistical normal distribution which is identified as signature of self-organized criticality or non-local space-time correlations. The results of the study are in agreement with the results of a recently developed cell dynamical system model for prediction of atmospheric flows. Also, the study suggested that the universal spectrum for atmospheric interannual variability rules out linear secular trends in global surface air temperature, sea surface temperature and the surface pressure. It was shown that green house gas related global warming will result in intensification of fluctuations of all scales in time. Further, the results of the periodogram analysis showed that by and large periodicities up to 5.5 years contribute up to 50 per cent of the total variance of the power spectra. The results of the study have significant applications in developing techniques for weather and climate prediction.

The atmospheric electric field vector measurements during passsage of a dust devil over the observatory at Pune were taken and were analysed to study the electrical properties of the dust devil. The dust devil was theoretically simulated as a vertical cylinder of negative space charge moving close to ground. The experimental observations agreed with the theoretical simulation when the results are averaged over 1-minute interval. These observations demonstrate not only the capability and reliability of spherical field meter to measure the magnitude and direction of electric field vector but also the movement of small space charge pockets close to the surface which may cause the development of horizontal component of electric field.

The observational experiment under the DST funded project Land Surface Processes Studies commenced at Gujarat. The installation of 10 m towers was completed at Anand, Arnej, Derol, Sanand and Khandha, in addition to a 30 m tower installed earlier at Anand. The first set of observations were taken from 13 - 18 January 1997. Sonic anemometer was also installed at 4 m height at Anand and was operated from 16 - 25 January 1997. Subsequently, data were collected in the months of February and March. During the intensive observational periods, averaged data were acquired every minute from the towers while for the rest of the month, data were automatically logged into memory modules every five minutes. The data collected consisted of temperature, wind speed, humidity and wind direction at 1, 2, 4 and 8 m heights, soil temperature at surface, 5 cm, 20 cm, 40 cm and 100 cm depths, net radiation, short wave and long wave radiation (upward and downward), pressure and precipitation. Soil moisture up to 100 cm depth was also monitored twice daily at Anand. During the intensive observational periods of the experiment RS/RW and Pibals data were collected

through the RS/RW flights and pilot balloon flights conducted by the India Meteorological Department at Anand and at other grid stations respectively.

Data from the total solar eclipse field experiment conducted at Robertsgunj were analysed. It was observed that at the time of totality, the temperature showed a drop of six degrees, the soil temperature decreased by four degrees and the soil flux decreased by an amount of 10 w/m^2 while the relative humidity showed a sharp increase by about 50 - 60% .

Indigenously developed three dimensional energy package was applied to analyse basic and eddy energies, all kinds of energy conversions, generation, dissipation and boundary fluxes throughout in the troposphere during the development of a severe cyclonic storm in the Arabian Sea in June 1994. It was found that the transport of energies from the latitude band of 9° south of the critical latitude (16.5°N) takes place during the development of the cyclonic storm.

SST fields over north ocean (north of 30°S) for the period 1977 to 1991 was simulated successfully using two and half layer McCreary ocean model and compared with observations of NCEP-SST for the period 1982-1991. Results indicated trends of warming near east of Madagascar (55°-65°E) about six months prior (in December) to the bad monsoon years of 1979 and 1987. These findings are being analysed to determine possible teleconnections.

Seasonal forecasting of the summer monsoon of 1996 was attempted with the COLA T30 General Circulation Model (GCM) using Sea Surface Temperature (SST) forecasts in the Pacific ocean from Cane Zebiak (CZ) ocean model. Two sets of ensemble seasonal integrations were carried out with the GCM with climatological SST and SST anomalies from CZ superposed on the climatological SST. Each ensemble is a set of nine realizations based on nine different initial conditions. Thus a total number of 18 seasonal integrations were performed in this study. A comparison between the simulations with climatological and forecast SST fields showed a marginally stronger monsoon in 1996.

To study the interannual variability of the simulated climate, a four year long integration of the UKMO Unified Model was completed. The run was started using initial data of 1 June 1991 and continued till December 1994. Observed SSTs and sea ice data for 1991-1994 were used as boundary conditions. Though the model simulated a stronger than observed monsoon on the seasonal time scale, the interannual variability was reasonably well simulated. The simulated monsoon of 1994 was stronger than 1991 monsoon, which agrees with the observed behaviour of the monsoon of these years.

The impact of inclusion of convective downdrafts in the penetrative mass-flux cumulus parameterization scheme on the summer monsoon simulation by UKMO GCM was examined. The seasonal simulation without downdrafts in mass-flux scheme showed large amounts of precipitation over oceanic area, whereas with downdrafts there was an increase in rainfall over Indian land mass and a decrease over the oceans. The monsoon circulation improved and the northward advance of the monsoon was faster in the presence of downdrafts.

Establishment of SDU Centre

A Secondary Data Utilization Centre (SDUC) has been set up in the Forecasting Research Division of the Institute to receive daily cloud imageries from INSAT satellite and meteorological data broadcast by Insat Meteorological Data Processing System (IMDPS), India Meteorological Department, New Delhi. The satellite cloud imageries being received by this SDUC are used by the scientists for their research work.

Technical Assistance provided to the ISRO's IRS-P3 Polar Orbiting Satellite Observing Systems

The Institute provided technical support to the ISRO for its IRS-P3 Polar Orbiting Satellite Observational Programme by organising special lidar and radiometric observations of the distributions of aerosols in the atmosphere preceding and following the launching of the IRS-P3 on 20 March 1996. The observations collected are valuable for the validation of some of the data collected from the IRS-P3. Further experiments in this regard are being carried out in synchronisation with the satellite overhead passes over Pune. The special observations collected during the above experiment would serve as ground-truth for calibrating the satellite radiometers used for monitoring atmospheric aerosol distributions. The experiments are being carried out in collaboration with the Space Applications Centre, ISRO, Ahmedabad.

Collaborative Scientific Research Programme

The Institute had entered into a scientific collaborative programme with the Hadley Centre for Climate Prediction and Research, U.K., initially for a

period of three years commencing from September 1993. The theme of the programme is "Understanding of the monsoon climate change scenario through the U.K. Meteorological Office (UKMO)". Under this Collaborative Programme, so far, two scientists of the Institute visited the Hadlay Centre and four from the Hadley Centre, visited the Institute. The latest version (4.0) of the UKMO General Circulation model of climate studies and the User Friendly Interface have been installed in the computer systems of the Institute. Taking into account the progress during the past three years and the substantial benefits for both the Institutions the collaboration has been extended for another spell of three years. Prof. Julian Hunt, the Chief Executive of the Meteorological office, U.K. visited the Institute during 8-9 January 1997 and had discussions with the scientists.

Participation in Expeditions

The Institute participated in the XVI Indian Scientific Expedition to Antarctica during the period of 6 December 1996 to 15 March 1997. The scientist sponsored for the Expedition carried out measurements of atmospheric electric field, electric conductivity and aerosol size distribution, aboard the ship MV Polar Bird and at Antarctica. Special instruments required for the measurements of atmospheric electric field and conductivity at Antartica were designed and fabricated at the Institute.

Under the INDOEX, the Institute participated in the 120th Cruise of the ORV Sagarkanya for the period of 27 December 1996 - 1 February 1997. During the cruise period, measurements of atmospheric electricity were carried out on board the ship by the Institute's scientist sposored for the programme.

IITM Silver Jubilee Award

To commemorate the Silver Jubilee of the Institute, the Governing Council of the Institute has established, from the year 1988, an Annual Silver Jubilee Award for the best Research Contribution in the form of a published paper in the standard journal. The paper entitled "Study of Laser Scintillation in Different Atmospheric Conditions", by P.E. Raj, S.Sharma, P.C.S. Devara and G. Pandithurai, published in the Journal of Applied Meteorology, Vol. 32, No. 6, 1993, 1161-1167 received the 6th Silver Jubilee Award for the year 1993. The 7th Award for the year 1994 received by the paper, "Optical Scintillometer for Simultaneous Measurement of Atmospheric Cn^2 and Winds" by S.Sharma, P.C.S.Devara, P.E.Raj and G.Pandithurai published in the Journal of the IETE, Vol.40, No.2&3, 1994, 101-104. The paper "Universal Spectrum for Interannual Variability in COADS Global Air and Sea-Surface Temperature' by A.M. Selvam and R.R.Joshi published in the International Journal of Climatology, Vol.15, No.6, 1995, 613-623, received the 8th Award for the year 1995.

Honours

The Indian Meteorological Society, Pune Chapter awarded the IMS fellowship to Prof. P.R.Pisharoty, Prof. R.Ananthakrishnan, former Directors of the Institute and to Prof. G.C.Asnani, Retd. WMO Professor, at the hands of Shri Mohan Dharia, former Union Minister and the renowned Environmentalist, at a function specially organised on 22 July 1996 at the Varahamihir Hall of the Institute.

Visit of Russian Scientists

A delegation of three Russian scientists under the Indo-Russian Working Group visited the Institute on 18 April 1996. The scientists had discussions with Director and scientists of the Institute.

Ninth Five Year Plan Proposals

A document containing the Institute's proposals for the Ninth Five Year Plan (1997-2002) to the tune of Rs. 47.61 crores towards nineteen projects under six different areas was compiled and submitted to the Department of Science and Technology, New Delhi. For the preparation of these proposals the Institute had gone through a detailed exercise involving an independent Expert Committee consisting of eminent scientists in addition to those from the Institute.

Organisation of Meeting/Training/SERC School etc.

A meeting on Vision Document on Challenging Areas in Atmospheric Sciences was organised at the Institute on 20 May 1996 on behalf of the Department of Science and Technology (DST).

Under the DST sponsored five year cycle of SERC Schools on Advanced Geophysical Fluid Dynamics the third SERC School with special emphasis on Dynamics of Monsoon - Observations, Theory and Modelling was held at the Institute during 21 May-22 June 1996. Prof. R.Narasimha, Director, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore inaugurated the SERC School on 21 May 1996. Prof. V.R.Gowarikar, Vice Chancellor,

Secondary Data Utilization Centre (SDUC) established at the Institute to receive daily cloud imageries and meteorological data.

Indy Graphics Workstation for the Climate Modelling Research Work.

Multiwavelength Radiometer for monitoring atmospheric aerosols and ozone.

Atmospheric electrical and aerosol measurements at Maitri, Antarctica.

Inauguration of the DST sponsored Third SERC School on Advanced Geophysical Fluid Dynamics organised at the Institute.

Prof. R. Narasimha, Director, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore inaugurating the Third SERC School (left). Prof. V.R. Gowarikar, Vice Chancellor, University of Pune, Pune presiding over the inaugural function (right).

Director, IITM welcomes the audience at the inaugural function of the DST - sponsored Indo-Brazilian Joint Workshop on Climate Research.

Interaction of Indian and Brazilian scientists during the workshop.

University of Pune, presided over the inauguration function. Forty two trainees from different organisations/ universities including IITM participated in the SERC School. Experts in the field of Meteorology and Atmospheric Sciences delivered lectures to the participants. Two volumes of the Lecture Notes have been brought out.

Three days Orientation Course in Climatology was jointly organised by the Deccan Geographical Society and the Institute during 8-10 October 1996. Sixtyfive Professors/Lecturers of Geography from different educational Institutions in India participated in the Course.

A DST sponsored Indo-Brazilian Joint Workshop on Climate Research was organised at the Institute during 9-13 December 1996 to identify possibilities of research collaborations between the two countries in the field of climate research. Prof.G.C.Asnani, Retd. WMO Professor and IITM Hon. Fellow inaugurated the workshop. Research works related to climate research in India and Brazil were presented and research proposals in this field were proposed in the workshop.

A Mini Workshop on Monsoon - 1996 organised by the Indian Meteorological Society, Pune Chapter was held at the Institute on 18 December 1996.

A Meeting organised by the DST to finalise the equipment requirements of a project of the Indian Institute of Geomagnetism, Mumbai was held at the Institute on 20 December 1996.

A two week Short-term Training Course on Agrometeorology for the nodal scientists of the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi was organised during 23 December 1996 - 6 January 1997. Twentyone faculty members from Agricultural Universities and Institutes in India participated in the Training.

Participation in the Indian Science Congress

The Institute participated in the Science and Technology Exhibition organised at the 84th Session of the Indian Science Congress held at the University of Delhi, Delhi during 3-8 January 1997. The theme of the exhibition was 'Computer Networks in National Development.'

National Science Day

National Science Day celebrations were organised on 27 and 28 February 1997. On this occasion, an open-house exhibition highlighting the scientific activities of the Institute and scientific film shows for the public and the students were arranged. Prof. Pramod Kale, Retd. Director, Space Applications Centre, delivered talk on the theme 'India of Our Dreams'. A large number of public and students visited the exhibition, laboratories and computers of the Institute and had interactions with the scientists.

WMO Day

The World Meteorological Day was celebrated on 23 March 1997. The theme for this year's celebration was 'Weather and Water in the Cities'. An open-house exhibition depicting the scientific activities of the Institute and a popular talk on the theme by Dr.Nityanand Singh, Assistant Director of the Institute were organised on this occasion.

Publication of Books

A book entitled,'Climates of South Asia' dealing with the climatological characteristics and variability aspects of the countries of south Asian region, authored by Dr.G.B.Pant and Dr.K.Rupakumar of the Institute has been published by John Wiley & Sons Ltd., U.K. in March 1997.

Under the Wind Energy Survey project, the Field Research Unit of the Institute at Bangalore brought out in July 1996, 4th volume of the Book entitled, 'Wind Energy Resource Survey in India'. The volume contains comprehensive wind data collected from 39 wind monitoring stations in seven states and one Union Territory.

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2.1 FORECASTING RESEARCH DIVISION

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

* Development of numerical models for prediction of monsoons and tropical cyclones.

* Study of the characteristics of the monsoon trough planetary boundary layer using the meteorological data.

* Utilisation of OLR data from satellite (INSAT) for estimating divergent part for including in the analysed wind field and the development of variational analysis scheme for the adjustment of mass and wind fields.

* Interannual and longer-term variability of Indian monsoon rainfall (IMR) and the impact of El Nino/La Nina during the above and below normal epochal phases of the IMR and long-range forercast of AIMR.

* Diagnostics of frequency of Indian droughts and the low-frequency variability of ENSO and North Atlantic Oscillation.

* Organisation and fluctuation of enhanced convective activity within the near equatorial oceanic ITCZ in the global perspective.

2.1.1 Numerical Modelling and Model Diagnostics

Numerical simulation of tropical cyclone using limited area model (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 the integration reaching the minimum value 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 pressures. To investigate the effect of higher resolution on the evolution of tropical cyclone, the resolution was increased from 50 km to 20 km. It was found that with higher resolution, the evolution of tropical cyclone was faster with a minimum central pressure of 940 hPa and with a better structure.

Several numerical experiments were carried out with the LAM to see the impact of shallow convection (SC) on the performance of the model. Results revealed positive impact of SC on the forecast of low-level wind and also on precipitation.

A semi-Lagrangian semi-implicit LAM model adopted from the FSU model was integrated upto 48 hrs as a test run using the input of 12 GMT, 7 July 1979. The results are being verified with the ECMWF FGGE IIIb analysis.

The T80 global spectral model obtained from the NCMRWF was integrated. The results from test runs with data provided by the NCMRWF slightly differ from the corresponding forecast of the NCMRWF.

Momentum and sensible heat transport by zonal waves at 850 hPa for the period of 1 June - 31 August 1995 (92 days) were computed. The results indicated that there is convergence of fluxes around 15°N and divergence around the equator. There is significant increase in the convergence of momentum flux around 15°N during active phase of monsoon as compared to weak phases and a clear association between the performance of monsoon and momentum and sensible heat transport by wave number three.

During the intensive observation period of the monsoon trough boundary layer experiment (26 July - 10 August 1990) it was observed that the two extreme sectors of the trough, a dry convection on the west and moist convection on the east, received copious rainfall (about 60 mm/day), the former during 2-8 August and the latter during 26 July - 1 August as a result of moving low pressure systems. The detailed surface pressure structure during disturbed and undisturbed weather was studied. Surface heat fluxes tend to be higher on either of the sectors in undisturbed weather. Further, the surface heat fluxes responded to the cloud amount at the time of observation. Winds at the surface layer tend to become strong during disturbed weather on both the sectors.

The analyses of 15 years (1971-1985) mean diurnal "wind rose" diagrams for the synoptic hours 00, 06, 12 and 16 UTC for the month May, June and July over the monsoon trough region (15°- 30°N, 70°-90°E) were completed. These diagrams exhibited a systematic diurnal oscillation in both wind speed and direction. In general, the winds are strong and steady south-westerly over western India west of 77.5°E; weak and unsteady in the direction of 77.5°E to 82.5°E, and strong and steady southerly to south-

easterly, east of 82.5° (along east coast of India) during all the months. The wind field depicted two well defined trough systems - the one along the stretch of Gangetic valley (monsoon trough) and the other along the stretch of Indus valley (heat lows).

2.1.2 Objective Analysis including Satellite Input for NWP Models

The study on the impact of divergent part of the wind estimated from the INSAT OLR data on the NCMRWF global spectral model analysis and the forecast fields was completed. It was inferred that there has been positive impact on the analysis in general, when the divergent part is included and the impact is much more over data sparse oceanic region. There has been increase in the rainfall predicted for 24 hr and 48 hr. A preliminary report on the study was prepared and sent to the NCMRWF, New Delhi.

A study on the non-linear analysis of wind field has been taken up by developing an iterative method for non-linear equations. Using this method wind analyses for 850 and 200 hPa levels for 2-4 August 1988 were made and examined.

The study of modelling of observed correlation by the third order auto regressive (TOAR) function (which involved four unknown constants) for the statistical interpolation scheme of objective analysis was continued and the scheme was further tested for two more depression cases viz., 2-8 August 1988 and 26-31 July 1991. The results from this study, corroborate the earlier inferences.

The theoretical relationships between optimum interpolation and successive correlation methods of objective analysis and the convergence properties of latter method were investigated by Bratseth. It is an iterative method and always converges to the limit of the optimum interpolation scheme. The scheme was examined for the period 4 to 8 July 1979 at 700 hPa level over the Indian region. It was observed that the convergence takes place after 11 scans.

Using DMSP-SSM/I (Defense Meteorological Satellite Program-Special Sensor Microwave Imager) satellite data, day to day variations in integrated water vapour, surface wind speed, integrated cloud liquid water and precipitation rates were studied for the life cycle of monsoon depression that formed over the Bay of Bengal during 22-27 July, 1992. Strengthening of surface winds (12-15 ms^{-1}) to the south of the low pressure area prior to the formation of depression, higher values of the integrated water vapour (60-70 kg m^{-2}) over central and head Bay throughout the life cycle of depression, and highest values of integrated cloud liquid water and precipitation rates (70 kg m^{-2} * 100, > 200 mm hr^{-1} * 10) in Southwest sector of the depression were the salient features brought out in the study. (Fig. 1)

Mean composite structure of satellite-derived radiative energy budget parameters was studied for understanding the evolution of different phases of monsoon using TIROS-N and GOES (IO) satellite data obtained during 1979. From the results of the study it is inferred that characteristic features such as net radiative heating rates of the order of 0.2°c/day for pre-onset and onset phases, and 0.4°c/day for onset phase at upper tropospheric layer (100-200 hPa) with minimum radiative cooling between 500-700 hPa layer observed in case of satellite-derived radiative energy budget agree well with the characteristic features of the observational net radiative energy budget over the Indian region.

2.1.3 Extended Range Prediction

Recent hundred years of instrumentally recorded data of monsoon-index (viz. Indian summer monsoon rainfall) and the hemispheric sea surface temperatures (SSTs) have been used to investigate the decadal scale variability of the ocean-atmosphere-land interactive system. The fluctuations in SST anomaly difference between the SH and the NH oceans showed decadal scale periods of positive and negative anomalies and a general correspondence with the Indian monsoon rainfall fluctuations was also found. Decadal scale wet (dry) periods of monsoon activity appeared to be associated with negative (positive) anomalies in different (i.e. SH-NH) ocean SSTs.

The interannual and decadal scale variability in North Atlantic Oscillation (NAO) and its relationship with the Indian summer monsoon rainfall was investigated with 108 years (1881-1988) of data. The analysis was carried out with 500 hPa ridge in April at 75°E. The study revealed that there is a strong coupling between the strength of NAO and the position of the sub-tropical ridge at 500 hPa during summer. On the climatological scale, it was observed that the trend in the Northwest Indian summer monsoon rainfall and the trend in the NAO signal during winter are very much similar but in opposite phases.

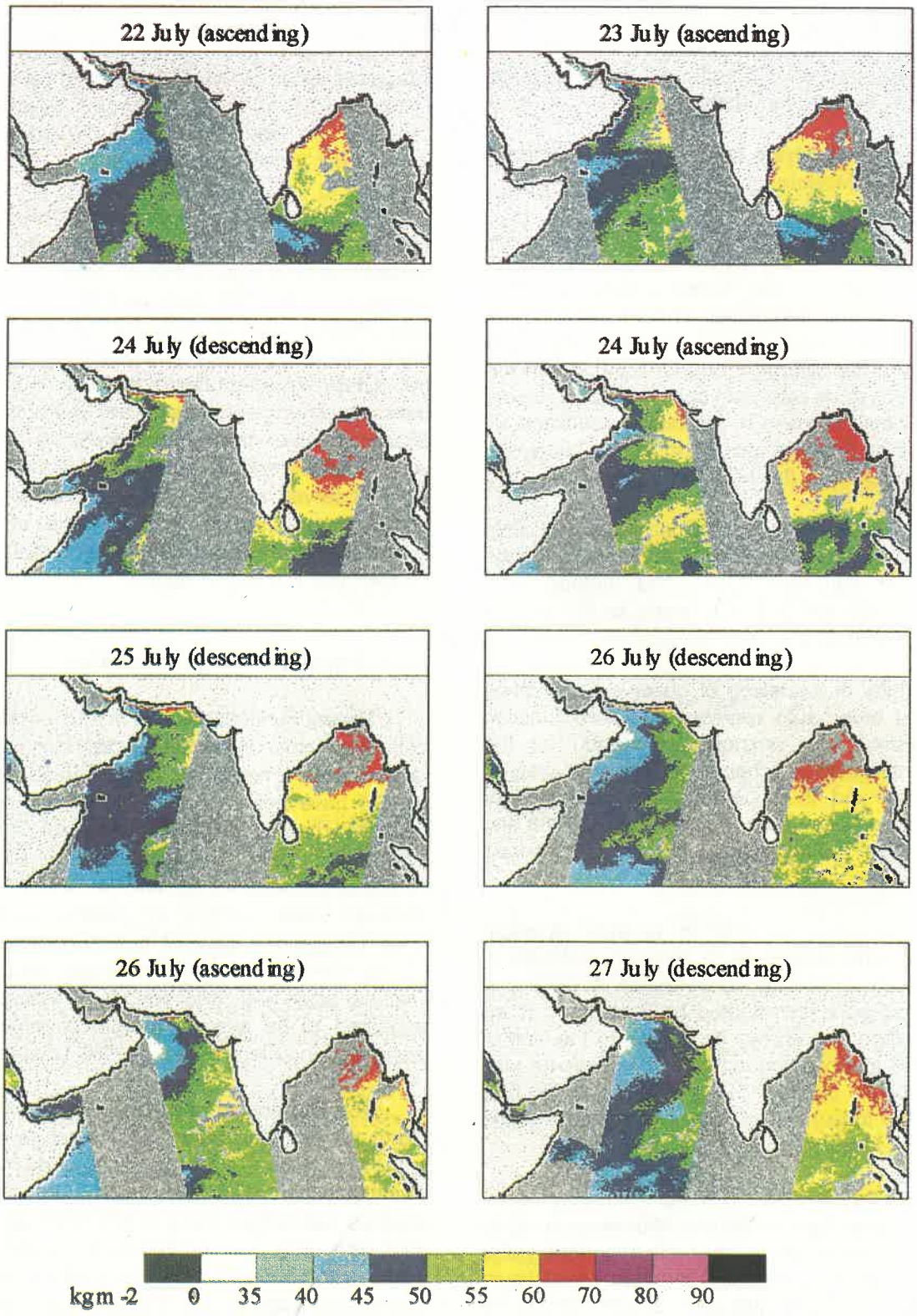


Fig. 1
DMSP-SSM/I derived integrated water vapour distribution associated with monsoon depression over the Bay of Bengal during 22-27 July 1992.

Analysis of the global surface air temperature of 30 year periods (1958 - 1988) and the Indian summer monsoon rainfall was carried out. Analysis was also carried out within the tropical belt i.e. 30°S - 30°N. The analysis revealed that there is a direct relationship between monsoon rainfall and global surface air winter time temperature, statistically significant at 1% level. There exists a strong inverse relationship between the monsoon activity and the tropical belt temperature after the monsoon . The relationship with the global temperature assumes special importance because of its predictive potential for long-range forecasting of summer monsoon rainfall.

Statistical analysis of the recent 40 years (1950-1989) of data revealed relationship between the storm activity over North Indian Ocean (NIO) and ENSO. During the La Nina or cold phase of ENSO the frequency of cyclonic disturbances over NIO tends to be more compared to that during the El Nino or warm phase of ENSO. However, within this broad feature of the relationship there is a strong seasonal dependence also.

The impacts of the El Nino and the non-El Nino related droughts over India were assessed using data for a 125 year period (1871-1995). Analysis revealed that the average standardised Indian Monsoon Rainfall (IMR) caused by El Nino forcing is -2.0, while for the Non-El Nino forcing it is -1.3. The difference between these means are statistically significant at 1% level, suggesting that the intensity of droughts over India is much more severe during the El Nino episodes than during the non-El Nino episodes. A similar analysis to examine the intensity of floods during the La Nina and the non-La Nina forcings revealed that floods are more severe during non-La Nina episodes than during the La Nina episodes.

A study was carried out to investigate the teleconnections between northern hemisphere (NH) lower stratospheric geopotentials and the IMR. Analysis revealed that there are domains over the NH where the variation of geopotential heights at 50 hPa level during the preceding months of the monsoon period influence the interannual behaviour of the IMR. During March high positive correlations were seen over the Canadian sector and high negative over the east Asian sector (Fig. 2). This dipole correlation structure reduces drastically once the ENSO cases are removed, suggesting that the teleconnection pattern is some manifestation of the ENSO cycle. The difference of the geopotential heights during March over the Canadian sector and the east Asian sector (north of Japan), signifying the strength of the dipole, shows a high correlation of 0.7 with IMR for the period 1958-1990 (Fig. 3).

The interannual variability of the IMR was analysed in relation to the OLR over tropical Asia (30°N to 30°S and 40°E to 100°E) using data of June 1974 - September 1993. The IMR seems to be most highly related to OLR variation over the west-central India. The correlation coefficient was found to be negative, which indicates that high convective activity

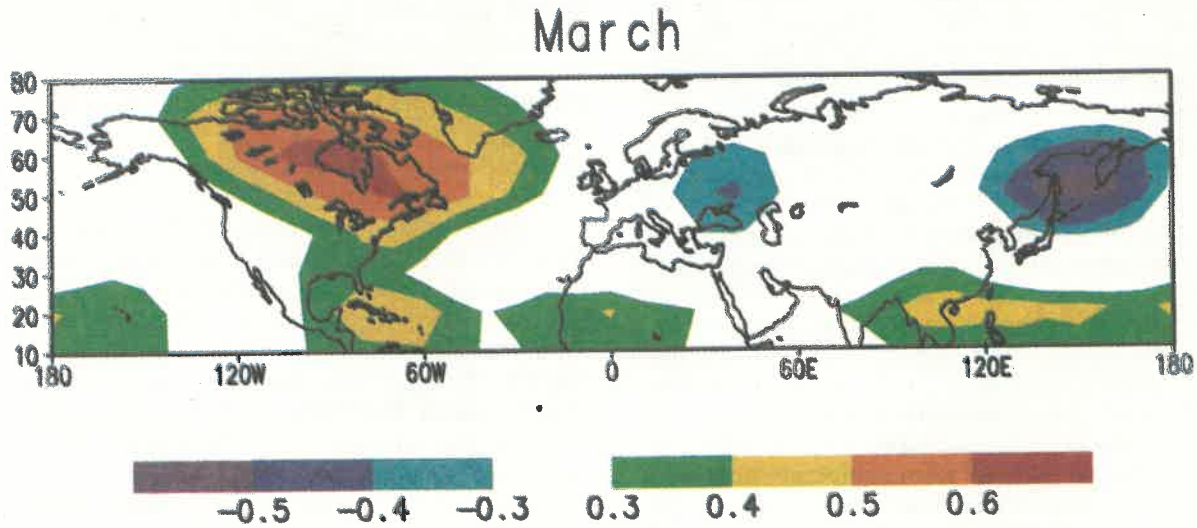


Fig. 2
Spatial distribution of the correlation coefficients of 50 hPa geopotential heights with Indian summer monsoon rainfall based on 1958-1990 data period.

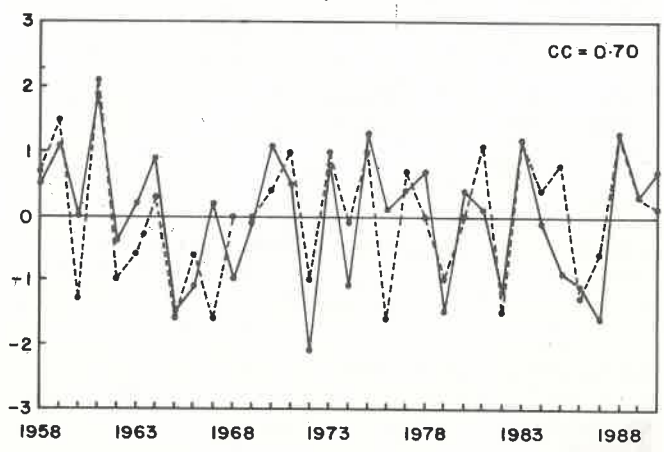


Fig. 3
Year-to-year standardised values of Indian summer monsoon rainfall (solid line) and the difference of the 50 hPa geopotential heights over the Canadian and the east Asian sector (dashed line), CC = Correlation Coefficient.

over this region is mainly responsible for the variability of monsoon rainfall over the country. The OLR for the monsoon period averaged over west-central India for the region between 20° - 25°N and 72.5° - 75°E showed correlation coefficient as high as -0.96 with the IMR.

The seventy years (1901-1970) data of pentad rainfall over 54 contiguous blocks (2.5 x 2.5 latitude/ longitude grid square) over India, were statistically analysed to characterise the climatic rainfall activity within southwest monsoon to delineate the homogeneous coherent zones and hence to identify the stochastic processes of univariate Box-Jenkins type. The analysis revealed that i) within the same meteorological subdivision, pentad rainfall of diversifying nature is observed, which may be described by Auto-regressive processes, and ii) low frequency oscillation with quasi-periodicity of Madden-Julian type as indicated by AR(2) processes is observed only for a few spatially coherent homogeneous zones of India.

A study of temporal and spatial variability in climatic components and their association on regional scale has been undertaken. The pre-monsoon (hot weather season) maximum temperature over heat low regions and monsoon rainfall observed on seasonal scale for the period 1901-87 were statistically analysed to test the hypothesis that increase of monsoon rainfall is linked with the pre-monsoon warming during recent short climatic temperature trends, in particular over arid and semi arid regions of India. It is revealed that except Gujarat, no subdivision in peninsular India shows the stability in mean rainfall during recent period. The monsoon rainfall over Madhya Maharashtra and Interior Karnataka (south) is found to be significantly correlated with pre-monsoon maximum temperature over central India.

2.1.4 Monsoon Studies and Forecasting

Spatial features of pentad rainfall over different subdivisions along west coast of India were derived from 30 years (1964 - 1993) of daily subdivisional rainfall data. First order discrete finite Markov Chain model was applied to describe the stochastic dependence among various spatial states of rainfall such as (i) no rain (ii) isolated (iii) scattered (iv) fairly widespread and (v) widespread. The stochastic matrix gives conditional probability of mutual (transition) and self (persistence) states. The potential of the stochastic matrix in predicting the qualitative behaviour of pentad rainfall over these subdivisions was evaluated by using independent data set.

The variation of onset and advance of monsoon using data of 48 well distributed stations over India were studied. The analysis clearly brought out the progress of monsoon over the country. The use of satellite derived OLR data was found to be useful in defining and monitoring the onset of monsoon and its northward progress. The OLR data were also capable of depiciting the rate of northward progress of monsoon and epochs of cloudiness and sunshine within the season over subdivisions of India.

The impact of rainfall activity on the yield of groundnut in Gujarat was studied. It was found that factors like onset date of monsoon rainfall and its subsequent spells of cloudiness or sunshine also play an important role in the growth of plants. Such information may be useful in pre-estimating the yield of groundnut or for other crops which is beneficial for the economic planning of the country.

Large-scale energetics of the Indian summer monsoon of 1987, an El-Nino Year was studied using NMC global monthly mean grid point values of zonal and meridional components of wind. One- dimenional Fourier analysis for the months of April through August 1987 at 700 and 300 hPa level was carried out. The study showed that (i)the convergence of momentum between the equator and 10°N leads to weaken the easterlies for June to August, (ii)waves 1 and 2 are dominant in the tropics between the latitudes 20°S and 20°N, in the zonal harmonics of zonal wind spectrum, (iii)in the meridional wind spectrum all the waves are contributing significantly to the total variance, (iv)in the latitudinal belt 5°S - 19.6°N, waves 1 - 4 are

sources of kinetic energy to the mean zonal flow via wave-zonal interactions and (v)waves 1 and 4 are sources of kinetic energy to other waves and waves 2,3,7 and 8 are sinks of kinetic energy to other waves via wave-wave interactions.

The apparent heat source (Q1) and the apparent moisture sink (Q2) have been estimated for the summer monsoon 1979 over India using daily FGGE ECMWF level IIIb data. The Q1 and Q2 over the monsoon trough area varied coherently with the rainfall over central India. This indicated that the diabatic heating was largely contributed by the latent heat released by cumulus convection and rainfall. The average heating rates over the trough area were found to be largest, as much as 8° to 10° K/day at mid tropospheric levels during the active periods, but much small and even negative during the break period.

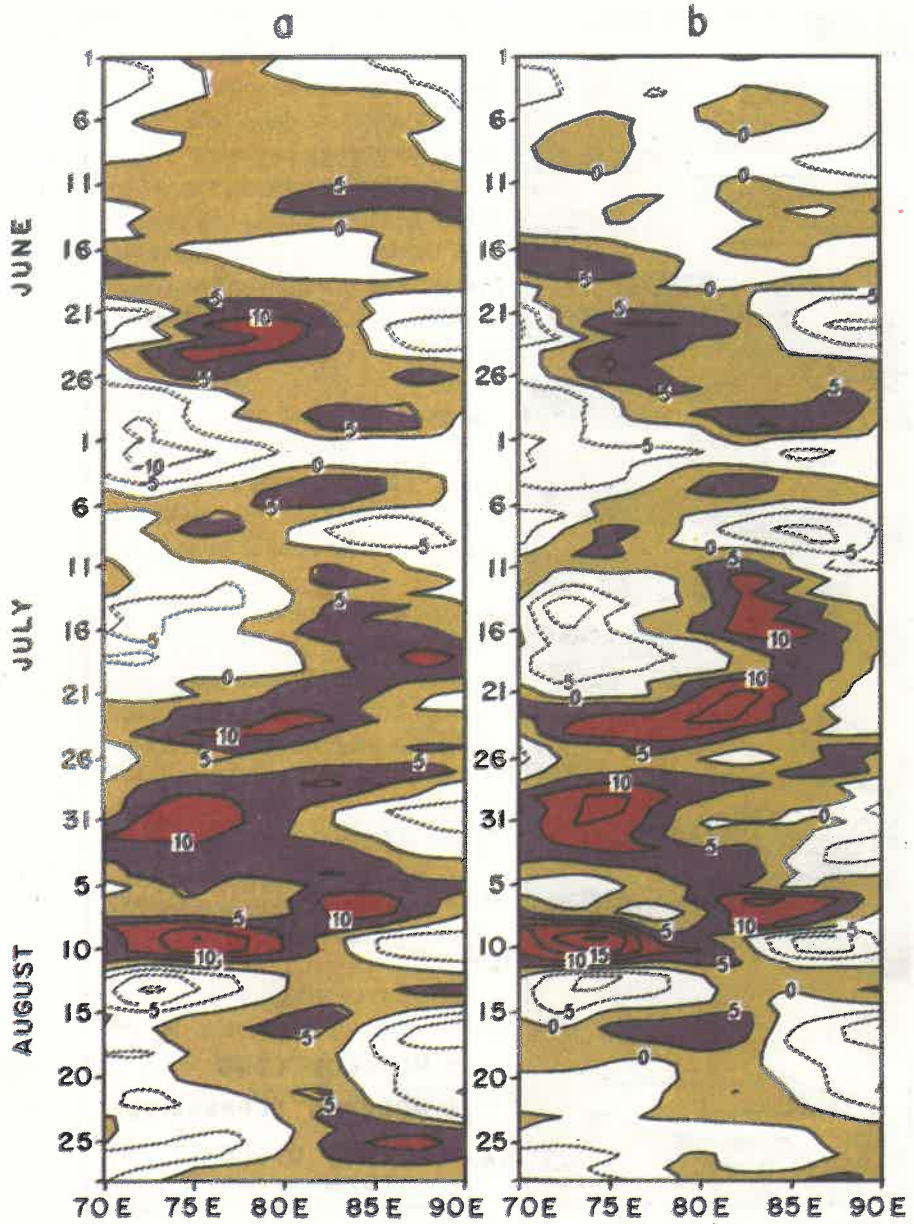


Fig. 4 :
Hovmoëller diagram of (a) heating rate Q_1/c_p and (b) drying rate Q_2/c_p at 500 hPa level along 22.15°N from 1 June to 31 August 1979. The contour intervals are 5°c day^{-1} for both the heating rate and the drying rate, with coloured part representing positive areas and dashed lines for negative contours.

Analysis of heating and drying rates at 500 hPa in the Hovmoëller diagram at 22.5°N, representing the monsoon trough area revealed that an intense heat source developed over the western part of the monsoon trough area during the active phase (Fig. 4 a and b). Such intense heating was found to be associated with transient synoptic scale disturbances and rainfall (Fig. 5a and b). The events were followed by negative heating rates during weak/break phases. This suggested that the anomalous intense diabatic heating over the western part of the monsoon trough area during the active phase might have led to the invasion of midlatitude westerlies over India during weak/break phases of monsoon 1979.

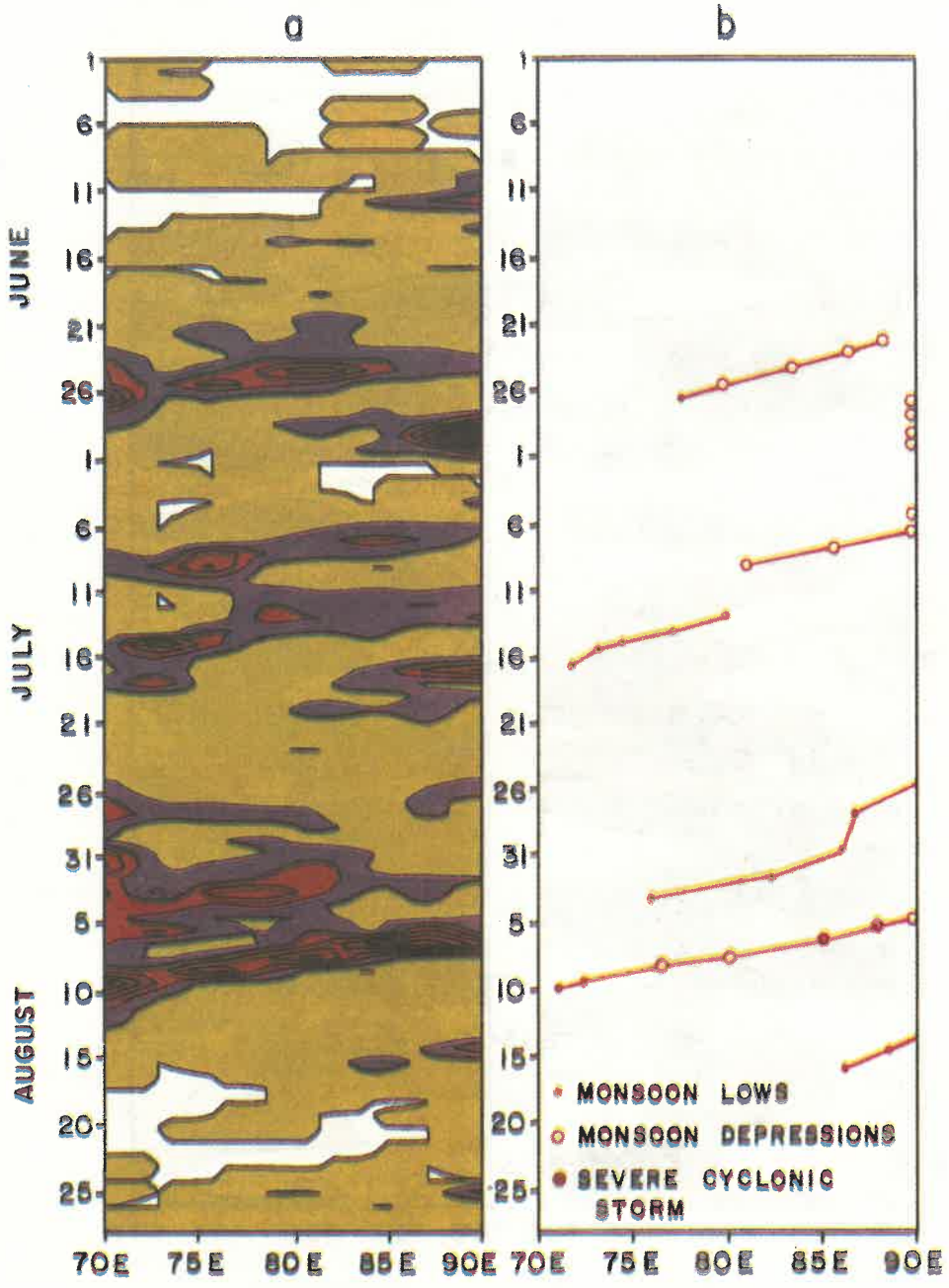


Fig. 5 :
Hovmoëller diagram of (a)mean rainfall for each 2.5° longitude belt and (b)longitudinal position of the centre of synoptic scale system between 70°-90°E longitude during 1 June to 31 August 1979. The coloured area represents rainfall and the contour interval is 10mm day^{-1}.

2.2 CLIMATOLOGY AND HYDROMETEOROLOGY DIVISION

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 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 the 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.

* 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.

2.2.1 Climate and Climatic Change

Ozone Minimum and Tropical Tropopause

Highest and coldest tropopause of the globe (Ozone minimum and tropical tropopause) appears over Indonesia and adjacent Pacific Ocean during the period October-April. Incidentally this happens to be the region and the period of minimum total ozone in the globe. This feature of the atmosphere migrates northward to south Asia in boreal summer. It is found that in the months of July and August the globe's highest and coldest tropopause with minimum total ozone appears over north-east India and the surrounding regions when the summer monsoon is active and thereafter this ozone minima shifts back again to the Indonesian region. The mechanism of this extraordinary feature was examined and it was seen that it may be due to (i) the convective overshoot from troposphere to stratosphere and (ii) the radioactive cooling through the reduction in heating rate by ozone absorption of the UV-radiation in the lower stratosphere as ozone concentration decreases in the region due to the convective overshoot.

Decadal Variability of Summer Monsoon Rainfall over India

On all India scale, the rainfall is known to have displayed distinct alternating sequences of multi-decadal periods characterised by wet and dry rainfall conditions over the country. These periods have been delineated as 1871-1900 (wet), 1901-1930 (dry), 1931-1960 (wet), 1961-1990 (dry), suggesting that the monsoon rainfall has long-term oscillations on time scales close to three decades. However, a closer examination of the decadal variations of monsoon rainfall on sub-divisional scale studied using a Gaussian low pass filter, shows widely varying temporal patterns. Surprisingly, the decadal variability pattern associated with the all India monsoon rainfall is not found in the same manner over any of the sub-divisions. For example, Orissa and East Madhya Pradesh had a prolonged wet spell (1881-1960) followed by continuous dry spell to the present, while the opposite feature is seen in the subdivision of coastal Andhra Pradesh which had a dry spell during 1871-1950 and wet

thereafter. However, the decadal rainfall variations on a macro-regional scale, particularly over the broad regions covering northwest India and west central India resemble those of all-India. The other macro regions, namely central northeast India, northeast India and peninsular India display large differences with the decadal variability pattern of all India. To understand the changes in the association between the all India summer monsoon rainfall (AISMR) and the rainfall over macro-regions on a low frequency mode, sliding correlations with 23 year window between AISMR and the monsoon rainfall of some regions delineated on the basis of homogeneous monsoon rainfall characteristics along with the 23 point smoothed curve of AISMR. (Fig. 6). All the macro-regions excepting the NE India are consistently and significantly correlated with the AISMR, with only a slightly varied strength, throughout the period 1871-1990. But, interestingly, the sliding correlation curve between the NE India monsoon rainfall and the AISMR closely follows the smooth rainfall curve of AISMR. This is more conspicuous in the case of dry epochs in AISMR. During the dry epochs of AISMR, the NE India rainfall is negatively correlated with AISMR and during the wet epochs it is positively correlated. This indicates that the well known out of phase relationship between NE Indian and all India monsoon rainfall is confined to dry epochs of all India rainfall.

For the purpose of seasonal prediction of Indian summer monsoon rainfall, several predictors representing regional and global teleconnections have been identified by several workers. However, almost all these predictors have shown secular variations in their relationships with AISMR. In general, a majority of the predictors have shown insignificant CCs with AISMR till 1950's and the CCs became significant thereafter. Examination of the role of ENSO on the secular variations of predictor-AISMR relationships on a 31 year sliding window (Fig. 7) revealed that most of the predictors have significant correlation with AISMR only when they are strongly correlated with the Darwin pressure tendency (taken as ENSO indicator). On smaller sliding window lengths (21 year and 11 year) the CCs between the Darwin pressure tendency and the predictors showed considerable decline in the

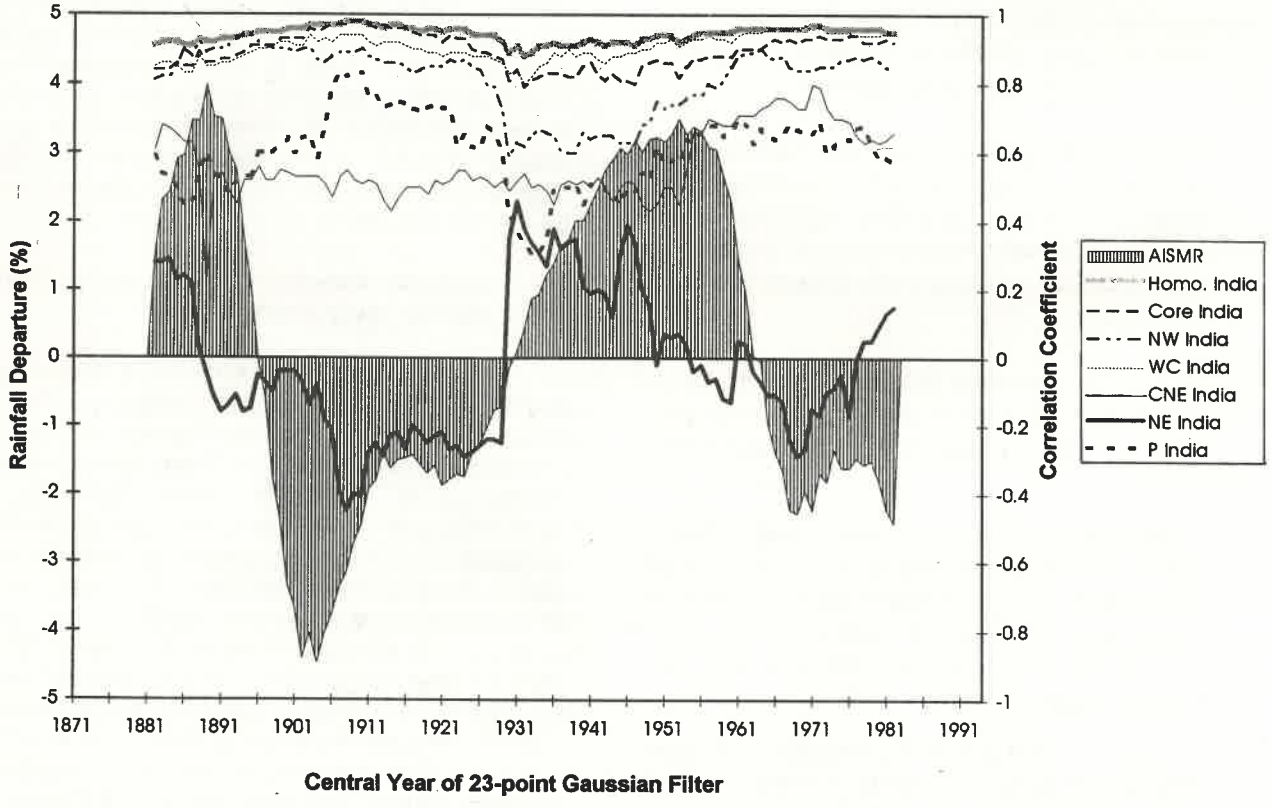


Fig. 6 :
Sliding correlation between AISMR and the monsoon rainfall of seven macro-regions in India over 23 years windows during 1871-1990. The curve with vertical bars indicates 23 point low parts filtered values of monsoon rainfall departures (%) of all India.

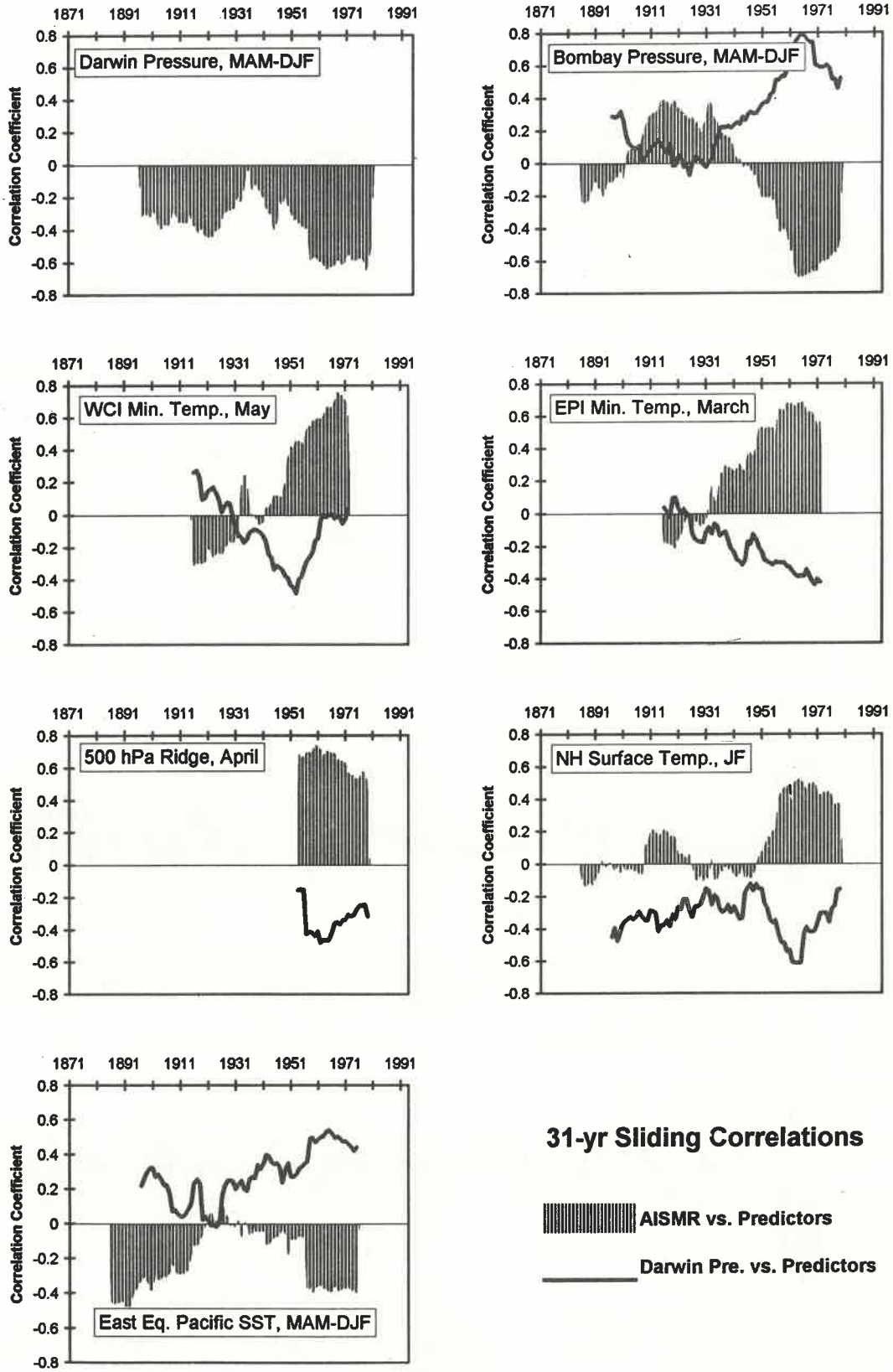


Fig. 7 :
Correlation Coefficients between Darwin pressure tendency and 6 predictor parameters over 31 year windows.

strength of CCs in the recent years. If this trend continues for a couple of decades we might enter into a regime where the predictor-AISMR relationship may become very weak (such as the period between 1920's and 1940's). In the past, such regime was characterised by low interannual variability in the monsoon as well as the ENSO phenomenon. These results suggested that the predictability of the monsoon itself may be having secular variation, and the predictability limits obtained for the monsoon rainfall by GCMs may need revision with more experiments conducted with a data set representative of the regimes chacterising weak monsoon-ENSO relationships.

Monsoon Rainfall Activity over India and Western Sahel

The analyses of the Indian summer monsoon and the May through September rainfall over western Sahel revealed that frequent occurrence of droughts over India and persistent rainfall deficit over western Sahel for the period 1970-1900 broadly coincide with an SST anomaly index based on the southern hemispheric and northern hemispheric ocean temperature. This relationship suggested that the global scale SST may be one of the forcing functions for the decadal scale variability over these regions.

Dendroclimatic Reconstruction of Shimla Temperature and Precipitation

Tree-ring index chronologies of *Picea Smithiana* from three different sites viz. Narkhanda (H.P.), Gahan (H.P.) and Dhanolti (U.P.Hills) have been prepared. These chronologies include 54 tree-ring samples and cover the time span of more than three centuries (1673-1989 A.D = 317 years). Various statistical tests indicated the high dendroclimatic potentiality of the species.

The response function analysis using the ring width data derived from these samples suggested that, the summer climatic conditions of the region have a strong influence on the tree growth. Therefore, these three chronologies are used to reconstruct the summer (March-April-May) temperature and precipitation of Shimla which is the nearest meteorological station to all the three sampling sites. The Figure 8 shows the reconstructed temperature

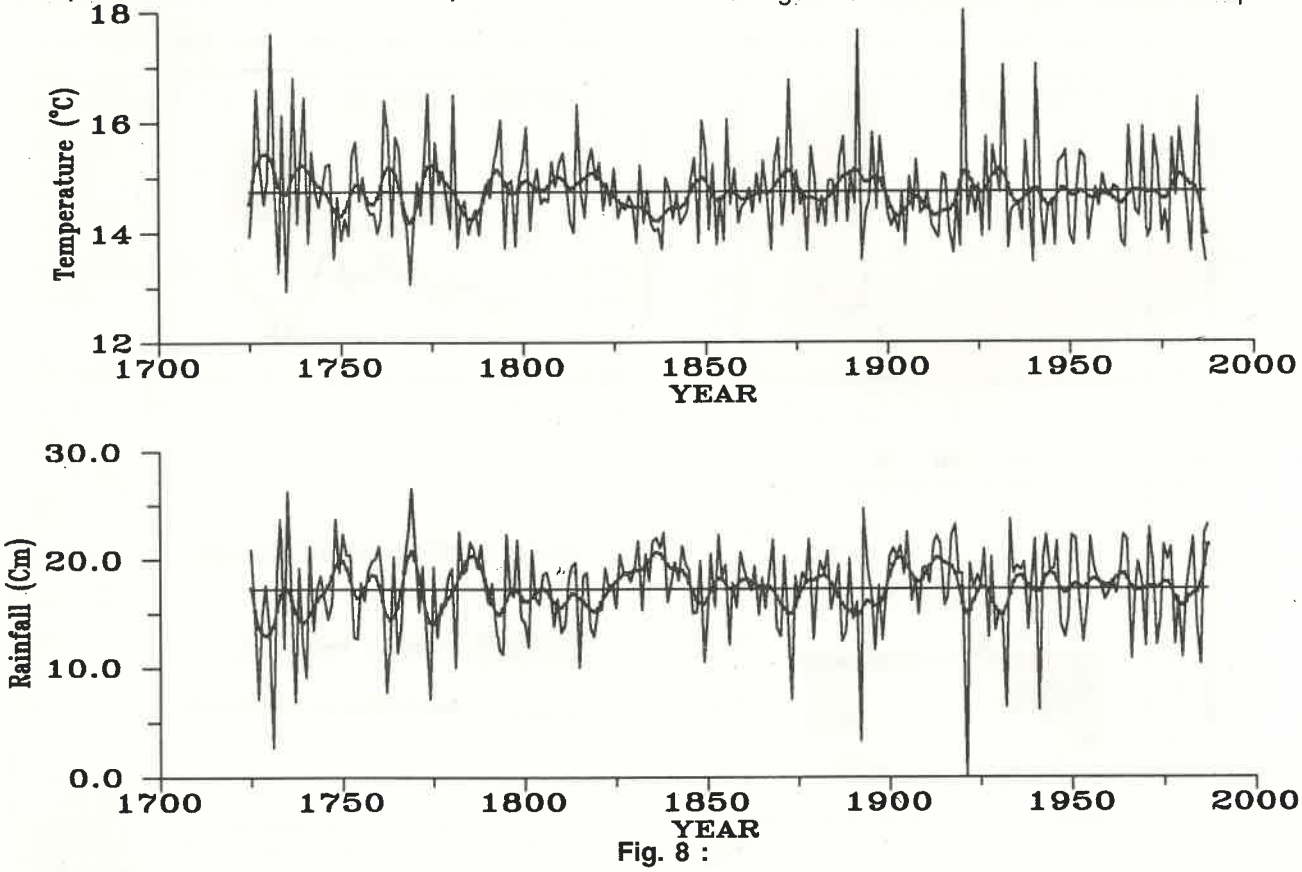


Fig. 8 : Reconstructed summer (MAM) temperature and precipitation of Shimla using three *Picea Smithiana* chronologies since A.D. 1725 to 1989 (dark smooth lines indicate low-frequency variations).

and precipitation of March-April-May season for Shimla since A.D.1725 using *Picea Smithiana* chronologies. The reconstructed series do not show any long-term trend in summer temperature or precipitation during the last 250 years. The low-frequency variations of temperature and precipitation are in opposite phase. Earlier reconstructions of the same parameters of Shimla based on *Cedrus deodara* chronologies have given similar pattern of summer temperature and precipitation as observed in the present reconstructions.

2.2.2 Hydrometeorological Studies

The design storm rainfall for different return periods and the Probable Maximum Precipitation (PMP) for different durations were made for the catchment above Srisailam dam on the Krishna river. The catchment covers an area of 206264 km^2 and the design storm estimates were made for a range of duration for 1 to 5 days. These estimates suggested that during the last 80 years the catchment as a whole experienced the highest rainfall of 6.3, 10.1, 12.6, 12.9 and 13.0 cm in 1, 2, 3, 4 and 5 days respectively. These values were scaled up to the level of PMP estimates by using proper maximisation factor. These design storm estimates are provided to the Central Water Commission, New Delhi for use in their planning purposes.

Severe rainstorms during the nonth-east monsoon season were analysed on the basis of daily rainfall data of several stations for their possible use in estimating the PMP for those areas which experience heavy rainfall during winter season. Preliminary analysis suggested that the rainstorm of 8-10 October 1943 centred to the west of Chennai contributed the highest areal raindepth for different durations.

2.3 PHYSICAL METEOROLOGY AND AEROLOGY DIVISION

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.
* Thermodynamics and dynamics 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.

2.3.1 Studies in Atmospheric Electricity

The possilbe association between the Indian summer monsoon activity and the thunderstorm activity was investigated. The monthly data of the number of thunderstorm days recorded at the network of 78 Indian stations over a period of 11 years from 1970 to 1980 were utilised for the study. The monthly time series of the thunderstorm data showed a bimodal variation with maxima in the months of May and September. It also revealed reduced thunderstorm activity during the three deficit monsoon years (1972, 1974, 1979). The deficit thunderstorm activity was most pronounced during the year 1972 which had maximum rainfall deficit among the three years.

2.3.2 Radar Study of Rain and Rain-Bearing Clouds

The size distributions of radar echoes obtained from the 16240 convective clouds in the Delhi region during the monsoon seasons of 1967 to 1972 were investigated. It was found that the size distribution of about 99 per cent of total echoes of clouds with diameter up to 35 km is well represented by the exponential distribution $N = a.\exp(-bD)$, where N is the number concentration per km^3 and D is the diameter of the echo in km. The exponential equation of the size distribution has been found to be $1.97 \times 10^{-2} e^{-0.19D}$ km^{-3}.

2.3.3 Warm Cloud Modification

In order to investigate the physics of monsoon clouds in detail, numerical simulation experiments were carried out by using a two-dimensional time dependent

(2DTD) cloud model. For these numerical experiments aerological data obtained from special radiosonde observations made at Pune as a part of the Warm Cloud Modification Experiment carried out by the Institute were used. Six days of aerological data, two each from the summer monsoon seasons of 1980, 1981 and 1982 representative of different weather conditions, e.g., weak, active and break-monsoon conditions were used for the cloud model computations.

As a part of the above warm cloud modification experiment, aircraft cloud physical observations consisting of the microphysical and dynamical parameters of monsoon clouds and the visible observations of the horizontal and vertical dimensions of clouds, precipitation development and other related observations were carried out. These observations were utilised to compare the results obtained from the cloud model computations. Also, in order to study the effects of cloud seeding, the hygroscopic particle seeding was simulated in the 2DTD cloud model by introducing sodium chloride (NaCl) particle concentration of one per litre, which is the average concentration of raindrops. It is assumed that these artificially introduced NaCl particles would grow to large size ($r \geq 20$ μm) cloud drops leading to acceleration of the collision-coalescence process vis-a-vis precipitation enhancement. The important results of the study are (i) the computed distributions of clouds in the model domain are in agreement with the observed distributions in the experimental region, (ii) there is agreement between the computed values of the cloud-base and cloud-top heights and the observed values, (iii) the computed vertical thickness of the clouds is in agreement with the observations, (iv) the computed values of the cloud liquid water content are in agreement with the observed values, (v) the computed values of the cloud-base vertical velocity are in close agreement with the observed values, (vi) the computed values of the raindepth are, by and large, in agreement with the observed rainfall, (vii) the vertical growth of the clouds and precipitation development are markedly influenced by the convergence at the cloud-base level, (viii) moderate convergence at the cloud-base level is essential for rain-formation, higher convergence can give rise to formation of tall convective clouds with higher values of cloud liquid water content (> 2 g/m^3) resulting in large size raindrops/high intensity rainfall, (ix) the cloud growth and precipitation development are, by and large, dependent on the circulation pattern at the cloud-base level during the early stages of the cloud development, (x) under favourable dynamical conditions (convergence and circulation pattern at the cloud-base level), seeding of the warm monsoon cloud with hygroscopic particles would accelerate the collision-coalescence process resulting in the enhancement of precipitation, (xi) seeding warm clouds with hygroscopic particles (1-10 particles of sodium chloride per litre of cloud air) results in the enhancement of rainfall (maximum up to 1-2 times in ideal cases).

A comparison between the results of cloud model and the aircraft cloud physical observations suggested that the cloud model can beneficially be used for the prediction and study of the physical and dynamical characteristics of the monsoon clouds and to understand the effects of hygroscopic particle seeding of warm clouds.

2.3.4 Studies of the Atmospheric Boundary Layer

A study has been carried out to examine association between the temperature stratification in the boundary layer and the power law. The temperature spectra constructed from the high resolution aircraft temperature observations carried out over the Deccan Plateau region during the summer monsoon seasons of 1980 and 1981 were utilised in the study. The results of the study suggested that when the temperature stratification deviates from dry adiabatic, the power law deviates from -5/3 slope. This is considered to be due to the buoyancy forces which cause leakage in the energy available for thermal dissipation.

A case study was carried out to examine the atmospheric boundary layer structure over the monsoon trough region using the aerological observations collected during 18 - 20 August 1990 over Calcutta and Jodhpur during MONTBLEX. Results of the study suggested that over Calcutta (deep moist convection), there was a possibility of updrafts in the cloud layer while over Jodhpur (dry convection) downdrafts were more predominant.

Clouds in the lower atmosphere influence the earth atmosphere radiation and hence play an important role in the studies relating to the thermodynamics of the Atmospheric Boundary Layer (ABL). Clouds also have significant influence on the fluxes of heat, water vapour and momentum in the ABL. Studies of the association among the distribution of the low clouds, synoptic conditions and the thermodynamical conditions of the ABL are important for advancing the knowledge of the monsoon variability

and climate system. A study was carried out using the concepts of saturation point and conserved variable plots utilising the aerological observations collected at Pune during the summer monsoon seasons of 1980 and 1981 to investigate the equilibrium structures in the ABL. The days were categorised according to the distribution of clouds vis-a-vis equilibrium structure of the ABL. The study suggested a close association between amount of clouds in the lower atmosphere and the thermodynamical conditions in the ABL.

2.3.5 Deterministic Chaos

The interannual variability in the global surface air temperature, sea surface temperature and pressure was investigated by analysing the COADS (Comprehensive Ocean Atmosphere Data Set) for the 28-year period 1961-88. Continuous periodogram power spectral analysis technique was used for the study. The results of the study indicated that the power spectra of the meteorological parameters follow the universal inverse power law form of the statistical normal distribution which is identified as signature of self-organized criticality or non-local space-time correlations. The results of the study are in agreement with the results of a recently developed cell dynamical system model for prediction of atmospheric flows. Also, the study suggested that the universal spectrum for atmospheric interannual variability rules out linear secular trends in global surface air temperature, sea surface temperature and the surface pressure. It was shown that green house gas related global warming will result in intensification of fluctuations of all scales in time. Further, the results of the periodogram analysis showed that by and large periodicities up to 5.5 years contribute up to 50 per cent of the total variance of the power spectra. The results of the above study would have significant applications in developing techniques for weather and climate prediction.

A study of the low frequency variability in the global mean sea level pressure was undertaken using the TOGA data for all the grid points (2.5 degree resolution) from 50°N to 50°S for the period January 1986-December 1990 (1800 days). Continuous periodogram power spectral analysis technique was used for the analysis of the above data. The power spectra of the global mean sea level pressure was found to follow the universal inverse power law form of the statistical normal distribution. Inverse power law form for the power spectra of temporal fluctuations imply long-range temporal correlations. Long-range spatiotemporal correlations were found to be ubiquitous to dynamical systems in nature and were recently identified as signatures of self-organized criticality. High frequency (less than 15 days periods) fluctuations in the daily surface pressure were more intense in the Southern Hemisphere as compared to the Northern Hemisphere and were attributed to enhanced turbulent mixing in the Atmospheric Boundary Layer.

A study of the association between the atmospheric pressure and geomagnetic activity was undertaken using the TOGA daily surface pressure time series data of all the grid points (2.5° resolution) from 50°N to 50°S for the five year period (1986-1990) and a major geomagnetic storm (A_P index more than 246). The study pointed out that there was an enhancement of high frequency (less than 15 days period) fluctuations in daily surface pressure following the major geomagnetic storm (A_P index = 246) on 13 March 1989. The study suggested that the above major geomagnetic storm is closely associated with the enhancement of high frequency fluctuations in the global surface pressure and the periodicities of 15 days or less contribute up to 50 per cent of the total variance at more than 60 per cent of the grid points.

A cell dynamical system model was developed which has application in weather and climate prediction. The model predicts quantumlike mechanics inherent to flow dynamics and atmospheric flows. It was shown that the overall flow structure follows a logarithmic spiral trajectory with the quasiperiodic Penrose tiling pattern for the internal structure. Atmospheric flows follow the Kepler's Third Law of planetary motion. The flow structure can be characterised in terms of the universal Feigenbaum's constants 'a' and 'd' as $2a^2 = \prod d$ where the fractional volume intermittency $\prod d$ of occurrence contributes to the total variance $2a^2$ of fractal structures. The model may form the basis for a "Theory of Everything" (TOE) which unifies microscopic world to macroscopic phenomena. The model computations indicated that the periodicities up to 5 years contribute up to 50 per cent of the total variance contributing to the internal variability. The observational evidence confirmed the above model results. The study suggested that the short term periodicities such as QBO and ENSO which are well documented could beneficially be used for weather and climate prediction.

2.3.6 Studies in Upper Atmosphere

A study was undertaken to examine the association between the Indian summer monsoon rainfall and temperatures of China. Data of monthly mean temperatures of two stations, viz., Atu-Zai

(22°00'N, 1060 m ASL) and Jinghong (21°52'N, 563 m ASL) at China during (December-February) and summer (June-August) seasons for the 5-year period (1960-1964) were used in the study. The results of the study indicated that during the winter season temperatures of China are associated with the summer monsoon activity over India.

A study to investigate the association between the tropospheric, stratospheric parameters vis-a-vis Indian summer monsoon rainfall was carried out using the Rocketsonde data of temperatures and winds at 25 km, 100 mb, 10 mb for Thumba and Balasore and the all-India summer monsoon rainfall for the period 1980-1992. The results of the study indicated a significant positive correlation between the winds at 25 km and the rainfall and negative correlation between the winds at the stratopause levels and the rainfall. The decrease in temperature at stratopause and tropopause levels was associated with the increase in positive departures of rainfall.

A study to investigate the association between volcanic eruptions and the Indian summer monsoon rainfall was carried out using the data of volcanic eruptions, oscillations of 500 hPa ridge during April at 75°E and the percentage departures of the all-India rainfall during the period 1959-1979. The volcanic eruptions having Volcanic Explosive Index (VEI) greater than 4 were considered and there were 9 such major eruptions during the period of study. Following major volcanic eruptions, gases and aerosols are injected into the stratosphere, and they would influence the dynamics of the middle atmosphere. Hence, the association between the oscillations of the 500 hPa ridge position at 75°E during the month of April within two years of major volcanic eruptions and the percentage departures of all-India summer monsoon rainfall was investigated. The study indicated that when the 500 hPa ridge oscillated between 11°N and 14°N, the percentage departures of the rainfall were negative and when the oscillations were between 14°N and 17°N, the percentage departures of the rainfall were positive. The results of the above study corroborate the hypothesis that major volcanic eruptions could influence the dynamics of the middle atmosphere vis-a-vis the rainfall reported by other investigators.

2.3.7 Studies in Air Pollution and Atmospheric Chemistry

The study of chemical composition of rain water collected at Delhi during the monsoon season of 1993 indicated that (i) the precipitation was alkaline with a mean pH of 6.0, (ii) the alkaline pH of rain water at Delhi is due to the presence of high concentration of Ca which is alkaline in nature and is able to neutralize the acidic effects generated by the presence of SO_4 and NO_3, (iii) the long term effects of pollutants such as SO_4 and NO_3 were observed in rain water at Delhi. However, these effects are slow compared with those observed in western countries and therefore, the anthropogenic pollutants have still not overpowered the ions released from natural sources such as oil and sea.

A study of the wet and dry depositions, including their seasonal variations and fluxes was carried out using the long term field observations collected at Pune during 1984-1995. The results of the study indicated that (i) the dry depositions were minimum during the summer monsoon season and maximum during the winter season, (ii) there was no significant difference in pH of rainwater during the summer monsoon and winter seasons, (iii) the wet deposition of all ionic components was found to be higher than the dry deposition, (iv) the depositions of the ionic components from natural sources (soil and sea) were found to be higher than those from anthropogenic sources, (v) the dry deposition velocities of the aerosols were found to be increased with the increase of their mass median diameter, (vi) the chemical composition of the dry deposition contains maximum depositions of the alkaline substances, which are the main cause for the alkaline pH of rainwater, and (vii) the acidic depositions at most of the locations of the study were low and the anthropogenic sources have not perturbed the atmospheric S and N cycles in the region. However, the scenario may change in the coming decades due to pressure on the atmospheric environment from the population growth, changing agricultural practices and the economic development, which will lead to an increase in anthropogenic contributions to the atmospheric budgets of reactive sulfur and nitrogen oxides.

Chemical analysis of 500 rainwater samples collected from Pune, Sinhagad, Nainital, Kullu, Alibag, Colaba, Kalyan and Thal during the monsoon season of 1995 was completed. Rainfall samples from Thal, Alibag, Colaba, Pune, Kullu and Nainital were in the alkaline range whereas at Kalyan the average pH was close to the CO_2 equilibrated value (pH > 5.65).

Samples of total suspended particulates (TSP) collected during 1992 were analysed for water and acid soluble components. The average concentration of TSP was found to be 485 μgm^{-3} and varied between 178 to 990 μgm^{-3}. The comparative study indicated that the concentration of TSP levels in Delhi region has increased by two times than for the year 1980.

Most of the TSP were associated with natural soil elements such as Fe, Al, Mn, Ca and K. Only a fraction of the mass of TSP comprised of elements from anthropogenic sources such as Pb, Ni, Cd, Sb, Cu and Zn. Thus the chemistry of aerosols in Delhi region was found to be potentially basic in nature even after one decade.

2.3.8 Lidar Probing of the Atmosphere

The dynamics of the nocturnal atmospheric boundary layer was studied from the simultaneous observations collected at the Institute using the lidar and Doppler sodar systems of the Institute. The time-height cross-sections of the mean, horizontal and vertical components of wind field derived from the sodar observations indicated that the wind is either easterly or northerly with its vertical component negative (downdraft). The interesting feature observed in this study is that the winds are either calm or relatively weaker in the night-time boundary layer as compared to the regions aloft. This feature was found more pronounced in the north-south direction in which the lidar and sodar equipment are located. Furthermore, the regions where stable/elevated layer formation is active were found to be associated with the smallest wind gradients leading to the accumulation of aerosol particles or larger temperature structure parameters. The time evolution of mixed-layer heights and the associated ventilation coefficients, determined from the combined lidar-aerosol and sodar-wind observations, were found to be useful to explain the transport and diffusion of pollutants across the elevated temperature inversions in the region of the study.

The possible influence of atmospheric aerosols on the atmospheric radiation budget vis-a-vis the Indian summer monsoon was investigated using the lidar-derived aerosol distributions and the summer monsoon rainfall for Pune using the data for the period 1987-1996. During this period, the data for the two contrasting monsoon years, 1987 (deficient monsoon year) and 1988 (good monsoon year) were also examined in detail. There appears to be a good correlation between the aerosol distributions and the summer monsoon rainfall during the period of study and it was attributed to the combined effects of atmospheric dynamics vis-a-vis the cloud microphysics in relation to the variations in the atmospheric aerosol distributions.

The Institute provided technical support to the ISRO for its IRS-P3 Polar Orbiting Satellite Observational Programme by organising special lidar and radiometric observations of the distributions of the aerosols in the atmosphere preceding and following the launching of the IRS-P3 on 20 March 1996. The observations collected are valuable for the validation of the data collected from the IRS-P3. Further experiments in this regard are being carried out in synchronisation with the satellite overhead passes over Pune. The special observations collected during the above experiment would serve as ground-truth for calibrating the satellite radiometers used for monitoring atmospheric aerosol distributions. The experiments are being carried out in collaboration with the Space Applications Centre, ISRO, Ahmedabad.

The space-time variations in the tropopause and refractivity turbulence structure parameter (C^2n) were studied by using the Indian MST radar data recorded at Gadanki, Tirupati over seven diurnal cycles on 17-18, 22-23, 24-25 November 1994, 26-27 September 1995, 4-5 January, 31 January - 1 February and 15-16 February 1996. The order of magnitude of C^2n was found to be in the range of 10^{-16} to 10^{-20} ($m^{-2/3}$) and the height of the tropopause is found to vary between 15 km and 18 km. The time-height variations in the tropopause and C^2n determined from the MST radar are compared with those obtained from the concurrent radiosonde measurements made at Madras and it was found that they agree fairly well. The height profiles of radar C^2n show sharp enhancement in the regions of tropopause. The diurnal variations of 'radar C^2n' and 'radar tropopuase height' exhibit periodic variations. Thus, the results indicated that the MST radar is a powerful tool to infer the tropopause and C^2n with good height and time resolutions as compared to the conventional radiosonde observations at synoptic hours.

The multi-wavelength radiometer developed at the Institute has been modified for measuring the solar radiation (direct plus diffuse) in the UV region. Ground-based spectral measurements of UV radiation levels, aerosols optical depth and total ozone column were performed at zenith angles from -80 to +80 degrees in the solar ascent and descent on about 100 days with clear sky conditions during November 1995 - May 1996 except during the summer monsoon months due to unfavourable sky conditions. It was found that the daytime diurnal variations in the UV radiation intensities at 317, 335, 371 and 382 nm wavelengths show broad maximum during the afternoon hours and exhibit a certain wavelength dependence according to the atmospheric optical extinction characteristics. The results also indicated an inverse relationship (Fig.9) between the aerosol optical depth and total columnar ozone, which is attributed to the gas-to-particle conversion processes.

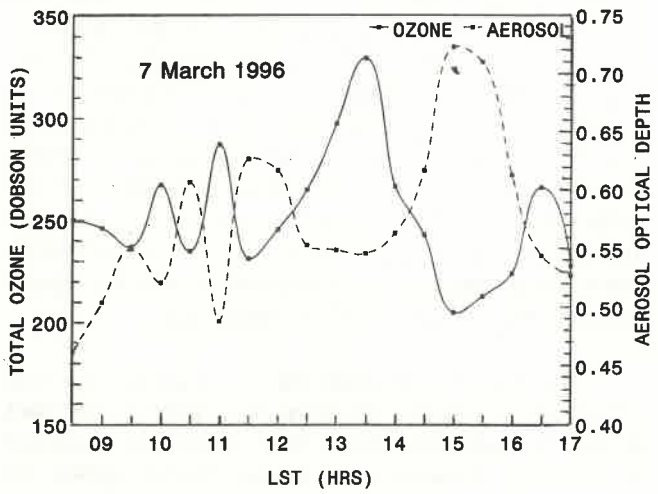


Fig. 9 :
Variations in the atmospheric aerosol optical depth at 400 nm wavelength and total columnar ozone.

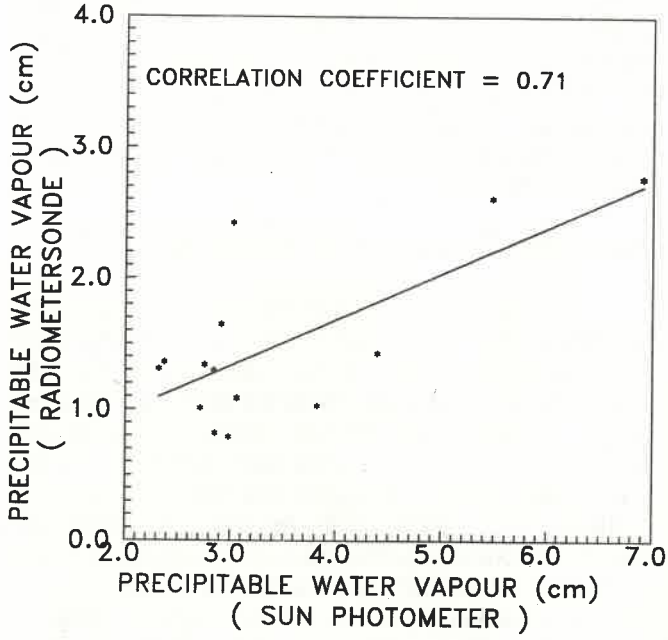


Fig. 10 :
Comparison of the column integrated precipitable water vapour data obtained from the Sun Photometer observations with those of the Radiometersonde observations

The columnar content of the atmospheric water vapour or column-integrated precipitable water vapour content was retrieved from the differential absorption measurements made at the near infrared (NIR) wavelengths, 940 and 1060 nm of the solar radiometer on about 175 cloud-free days during February 1993 - May 1996. The retrieved water vapour values were compared with those obtained from the radiometer sonde measurements of the India Meteorological Department, Pune on the days of the radiometer experiment, and they were found to be in good agreement. (Fig.10).The radiometer derived water vapour values were also compared with those computed from the standard empirical formulae and also with the radiometersonde derived water vapour mixing ratios and saturated with vapour pressures, and found that they agree fairly well.

2.3.9 Spectroscopic Measurements of Atmospheric Minor Constituents

A study of the variations in the atmospheric chemical composition resulting from the increasing concentrations of CO_2, N_2O, CH_4, CFCs and other trace gases was carried out by using an interactive two dimensional chemical model. The model which treats radiation, dynamics and chemistry interactively extends from surface to 85 km and from south to north pole with a resolution of 1 km in altitude and 5° in latitude. The model results indicated that there could be an increase in the concentration of water vapour (20%) and HNO_3 (50%) and a decrease in acetonitrile (15%) around 40 km by 2050 AD with the doubling of CO_2 and the present increasing trend of other greenhouse gases are considered. Most of the chemical composition perturbations calculated with the model exhibit an asymmetry between the two hemispheres. The total ionization density does not change appreciably by 2050 AD but distribution of individual ions show considerable variation up to about 100% throughout the middle atmosphere.

An algorithm that computes differential absorption cross-sections using second degree polynomial method for the analysis of different trace species like NO_2, O_3, O_4 etc. from spectrometric observations was developed.

A study of the photometric observations of the twilight sky intensities made at Pathardi, Ahmednagar District, Maharashtra during January 1993-December 1994 suggested that (i) the maximum concentrations of aerosols occur, on the average, at about 20 km and are associated with maxima on the logarithmic gradient of intensity, the lowest average height of about 12 km was found in July while the highest 30 km was found in March, (ii) the aerosol layer maxima showed downward drifting before cloudy days and upward drifting after cloudy days, and was found to be moving

downward with average speed of 6 km per month during advent of the monsoon season, and found to be moving upward with average speed of 2 km per month during the withdrawal phase of the monsoon, (iii) during monsoon season the increasing trend of aerosol loading in the upper troposphere, decreasing trend of aerosol loading at stratosphere and decreasing trend in troposphere could be attributed to the downward transport of aerosols from the stratosphere as well as upward transport of aerosol from lower level. (iv) the seasonal variability of the aerosol distributions in the lower stratosphere is remarkably similar to that observed in the upper troposphere and there is a significant increase in the upper tropospheric and lower stratospheric aerosol loading during the monsoon season, (v) the height of aerosol layer maxima and aerosol loading at the stratospheric level were found to be higher during 1993 as compared to that during 1994. This feature was attributed to the decay in the Mt. Pinatubo volcanic aerosol layer, (vi) the annual variation of aerosol number density is comparable with the annual variations derived by lidar method, (vii) the stratospheric aerosol sources and oceanic (tropospheric) aerosol sources may equally influence the cloud formation processes over the ocean as the oceanic and stratospheric aerosol concentrations are of the same order.

2.4 INSTRUMENTAL AND OBSERVATIONAL TECHNIQUES DIVISION

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

* Development of instruments/techniques to study the cloud electrification processes.

* Development of simulation techniques to study cloud physics under a controlled environment.

2.4.1 Instrumentation for Cloud Physics and Weather Modification Studies

The data on atmospheric electric field and conductivity collected near the gas well blow-out site at Pasarlapudi in Andhra Pradesh were analysed. It was concluded from the analysis that very low values of electric field observed during nighttime when winds are generally calm, may be due to the build up of negative space charge released by the flame. Rough estimates showed that the space charge released from the flame was enough to neutralize the fair-weather electric field in an area of about 3 km^2 around the flame in calm wind conditions.

Observations of electric field and Maxwell current density directly below thundercloud were taken on 23 April and 16 May 1996. Observations showed the presence of an inverted electric dipole in the thundercloud and a constant Maxwell current in-between two lightning discharges in active phase of the thundercloud. Further, the Maxwell current densities showed relatively larger variations in the dissipating stage than that in the active phase of the thundercloud.

To minimize the errors involved in the measurement of the electric field vector by the spherical field meter, the calibration set-up was modified and the revised values of distortion coefficients were found. The new calibration gives more realistic values of the horizontal electric field components and of the inclination of net electric field from the vertical in fair weather. The observations in fair weather can be explained due to the presence of space charge pockets present in the lower atmosphere. Further, the location of the charge centre before a lightning discharge in thunderstorms was found from the measurements made with the spherical field meter and a network of three microphones to record the associated acoustic signals. A comparison of the results with the two techniques showed reasonably good agreement.

Measurements of the electric field vector and space charge density during the passage of a dust devil over the observatory at Pune were taken and analysed to study the electrical properties of the dust devil. The dust devil is theoretically simulated as a vertical cylinder of negative space charge moving close to ground. The experimental observations agree with the theoretical simulation when the results are averaged over 1-minute interval. These observations demonstrate not only the capability and reliability of spherical field meter to measure the magnitude and direction of electric field vector but also that the movement of small space charge pockets close to the surface may cause the development of horizontal component of electric field.

A network of three microphones has been set up to study the acoustic characteristics of the lightning discharges. Simultaneous measurements of acoustic pressure signal received from three microphones and electric field vector with an a.c. spherical field meter were made on three thunderstorm days. The data are being analysed to study the location and path of a lightning discharge.

Vertical profiles of the atmospheric electric field and ion densities in the lower atmosphere were calculated considering the presence of aerosol particles, diffusion and vertical profiles of ionisation in cases of stratified and turbulent atmosphere. The profile showed the presence of negative space charge close to ground in a stratified atmosphere during low winds. The theoretical calculations support some of the observations made at this station during low wind profiles at the night time.

Aerosol-aerosol attachment coefficients for multiple charged and uncharged aerosol were computed. The theoretical calculations of electrical conductivity done earlier were revised for the realistic size distribution of aerosol particles.

The space charge measurements made with the filtration and Faraday cage methods were analysed for comparison of the two techniques and to study the space charge distribution near the Earth's surface.

Measurements of atmospheric electric conductivity and aerosol size distribution were taken aboard the ship MV Polar Bird and the Antartica during the Institute's participation in the XVI Indian Scientific Expedition to Antarctica. Instruments required for these measurements were designed and fabricated at the Institute. Three small field mills required to be installed in inverted position at a height from the ground surface, the associated electronic circuitry and a conductivity apparatus consisting of two Gerdien condensers were also fabricated at the Institute.

Measurements of the electric field and conductivity were also made aboard the ORV Sagarkanya during its 120th cruise under the INDOEX programme. Data collected during the cruise are being analysed.

To study the rate of evaporation of the charged and uncharged water drops suspended in a small vertical wind tunnel, large number of photographs of water drops were taken for different values of the drop diameter and the relative humidity of the atmosphere. These photographs are being analysed to study the effect of electric charge of the drops of different sizes for different times of their suspension in the wind tunnel.

The effect of the coagulation of aerosol particles on their size distribution in the atmosphere is being studied for larger time periods in a theoretical model.

The effect of the inclined electric force on the drag imparted to the air by precipitation in a mixed phase cloud is being studied.

2.5 BOUNDARY LAYER AND LAND SURFACE PROCESSES STUDIES DIVISION

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. The research programmes undertaken are:

* Development of instruments/techniques to study the structure of the atmospheric boundary layer.

* Carry out land surface processes and energy budget experiments over land with different vegetations.

* Analysis of the MONTBLEX observations.

2.5.1 Land Surface Experiment

The observational experiment under the DST funded project Land Surface Processes Studies commenced at Gujarat. Installation of 10 m towers was completed at the experimental sites viz. Anand, Arnej, Derol, Sanand and Khandha. Other requirements for the experiments were also completed which included (i) calibration of the 34 numbers each of temperature and wind speed sensors in the laboratory of the India Meteorological Department, Pune, (ii) setting and calibration of the 34 humidity sensors at the Institute by using four standard salt solutions (LiCl-12%, $Mg(NO_3)_2$–52%, $(NH_4)_2SO_4$-81% and K_2NO_3-93%), (iii) calibration of 16 numbers each of shortwave and longwave radiometers and 8 net radiometers, in the Institute and at all the sites of the experiment in Gujarat, (iv) checking of the sensors for the tower instrumentation at the Institute alongwith the testing of the data loggers and memory modules, (v) testing of the sonic anemometer probes and development of a program for the automatic recording of sonic data and on-line calculation of direction and magnitude of the wind, Monin Obukhov length, friction velocity and other turbulence parameters, (vi) testing and calibration of Neutron Probe and Capacitance Probe for soil moisture measurements, comparison with gravimetric method, and (vii) testing of the kytoon data acquisition system (ADAS) with four different payloads for checking of calibration shifts.

Data collected from the first, second and third sets of observations organised in the months of January, February and March 1997 respectively are being checked for errors and suitability for their analysis.

2.5.2 Boundary Layer Studies

A diagnostic model of the surface boundary layer was developed using the wind and temperature data at only two levels of 2 and 4 meters. The model could compute all the turbulent parameters. The model was tested with data from the International Experiments, viz. Kansas 1968, Minnesota 1973, ITCE 1976 and showed good agreement with the observed values.

As a part of the development of 1-D model for boundary layer using Land Surface properties, parameterisation scheme for computation of surface fluxes was included in the model. The computation scheme which provides values of surface temperature and himidity utilizing the evaporation values viz. direct evaporation, evaporation due to canopy and transpiration, was incorporated in the model.

An experiment was conducted at the Society for Applied Microwave Electronics Engineering and Research (SAMEER) with the Atmospheric Instrumentation Research (AIR) Inc. kytoon system available at IITM for validation of a doppler sodar which is under development at the SAMEER. The averaged winds and wind direction evaluated by doppler sodar matched well.

2.5.3 MONTBLEX Studies

Under the study of the spatial structure of turbulence at the production wave numbers, Orthonormal Wavelet techniques of Haar function were applied to five sets of sonic data of 10 minutes duration for 22 June 1990 at Kharagpur site (MONTBLEX 90). The characteristics of the turbulence analysed were (i) intermittency for structure of the flow, (ii) coefficient of variation in the scales of energy in the flow, (iii) flatness factors i.e. derivation of velocity flow from the normal, and (iv) ejection and sweep of momentum transport in wind velocity flow.

2.6 THEORETICAL STUDIES DIVISION

The Division has developed models for the study of monsoon and tropical circulation systems. The research programmes are undertaken for investigating the following:

* Role of barotropic, baroclinic and combined barotropic-baroclinic instability mechanisms in the formation and growth of monsoon disturbances.

* 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 and general circulation ocean models for understanding dynamics and physics of Indian ocean circulation.

* Development of simple couple ocean atmosphere model for understanding global circulation.

2.6.1 Barotropic and Baroclinic Instability of the Atmospheric Flow

An indigenously developed diagnostic model was used to understand the dynamics of the cyclonic storm that formed over east central Arabian Sea during 5 to 8 June 1994. Three dimensional vorticity budget from surface to 100 hPa at 50 hPa interval over 7.5° to 25.5°N and 51°-81°E was carried out using NCMRWF T80 model analysed wind and height fields. Observed local vorticity tendency was computed using cubic spline technique and compared with the computed tendency that arises due to large scale terms of the vorticity equation. As the storm moved westward almost parallel to 19.5°N, complete three dimensional day to day energetics (i.e. basic and eddy energies as well as all types of energy conversions, generation, dissipation and boundary flux terms for the maintenance of the system) was also obtained separately in the north and south zone of the storm track. Lat. 16.5°N was chosen for separation of the region from instability point of view. Computations showed that basic energies were dominated in the south zone but perturbation energies were more in the north zone. From the results, it can be inferred that for the maintenance of the severe cyclonic storm , energy generated in the south of the storm track was dissipated in the northern belt of the Arabian Sea.

To understand the movement of the system, vorticity budget package was applied at each of the four sectors of 900 sq. km surrounding the moving centre of the system for 5 to 8 June. Analysis is being carried out to identify the factor responsible for the westward motion of the system.

A numerical experiment using the six layer equatorial balance model with CISK and asymmetric equatorial boundary condition was carried out over EQ - 30°N latitudinal belt without basic zonal flow. The

most unstable mode obtained had a wavelength of 4000 km and growth rate 2.066 x 10^{-5}/sec. Wavelength of the most unstable mode of six layer model was half of that obtained for the three layer model but the growth rate of the unstable mode in both the cases were found to be almost same.

2.6.2 Simulation of Mean Monsoon Circulation and Predictability of the Monsoon system.

Atmospheric Modelling

Based on the NCMRWF model analysed Fourier coefficients of Ψ, χ and $\varnothing$ fields over the latitudinal belt 20°S - 30°N, the character of nonlinear transient eddy transfer processes during July 1995 were examined for 850 hPa and 200 hPa levels, as they were considered to be representative of lower and upper troposphere respectively. The tropical upper tropospheric circulation due to reduced activity is flanked by negative contributions from zonal available potential energy to zonal divergent kinetic energy exchange indicating an indirect thermal circulation. The results indicated that synoptic and sub-synoptic waves are mainly maintained by the zonal divergent KE to eddy rotational KE exchange due to vorticity and divergence. In the lower troposphere, ageostrophic effect plays an important role unlike the upper troposphere where loss of energy is noticed due to this effect for maintenance of synoptic scale rotational transient eddies. The results suggested that the tropical-middle latitude transient eddy transfer is very weak in the lower troposphere whereas transient motions in the upper troposphere appear to rely on the import and export of energy in this open system during the summer monsoon.

To understand the problem of maintenance of low frequency waves for tropical weather system, Fourier spectral formulae were derived by the use of cross spectral technique to determine nonlinear energy exchanges between divergent and rotational motions into individual triad interactions in the frequency domain.

A study to understand the intraseasonal variation of the global energetics in the troposphere and lower stratosphere during monsoon 1988 was taken up. For this purpose, daily grid point analyses of geopotential ($\varnothing$) and zonal (u) and meridional (v) wind components on 14 pressure surfaces from 1000 to 10 hPa for 92 days (1 June to 31 August) were used. To detect erroneous analyses, the climatological zonal means of u and v, as well as their standard deviations during mean monsoon season (Newell et al. 1972) were utilised. Observed global mean geopotential ($\varnothing$) and corresponding standard height (z) of the pressure surfaces, with + 5% deviation were utilised for quantitative check of $\varnothing$ field. In general, the data were free from spurious values. The grid point analyses were transformed into spectral coefficients with triangular truncation of 30. More than 85% of the observed variance was explained on transformation.

Ocean Modelling

The one and half layer reduced gravity model was used to simulate oceanic response to moving cyclone. The model was integrated for 12 days using the wind forcing arising from an idealised cyclone for an initial state of rest. Three different tracks were used in three different numerical experiments to understand the effect of coast line on the central upwelling region. These experiments were also carried out for an initial condition of April and May obtained from an earlier study. The preliminary analysis of the results suggested that different oceanic initial condition can lead variabilities of the order of 0.5 m in the simulated height anomalies.

The two and half layer ocean model was integrated for 15 years (1977 - 1991) to understand dynamical responses in upper layer circulation and SST of north Indian ocean to the interannual wind forcing. Climatological monthly mean surface heat fluxes derived from COADS were used as thermal forcing and interannually varying FSU wind stress was used as a body force in the 15 year simulation (Fig.11). The simulated SST fields showed interannual variabilities and the phases of the first three principal components were in good agreement with the observed variability. However, amplitudes of the model simulated variabilities were much smaller than the observed ones which bring out the greater influence of surface heat fluxes on the upper layer heat budget. The interannual simulation of SST in response to interannually varying surface wind was further analysed and compared with the observed NCEP-SST. The time series of both the models and the observed SSTs in a region east of Madagascar (55°-65°E) showed trends of warming prior to the bad monsoon year of 1979 and 1987 (Fig. 12). These findings are being further analysed for establishing a possible teleconnection.

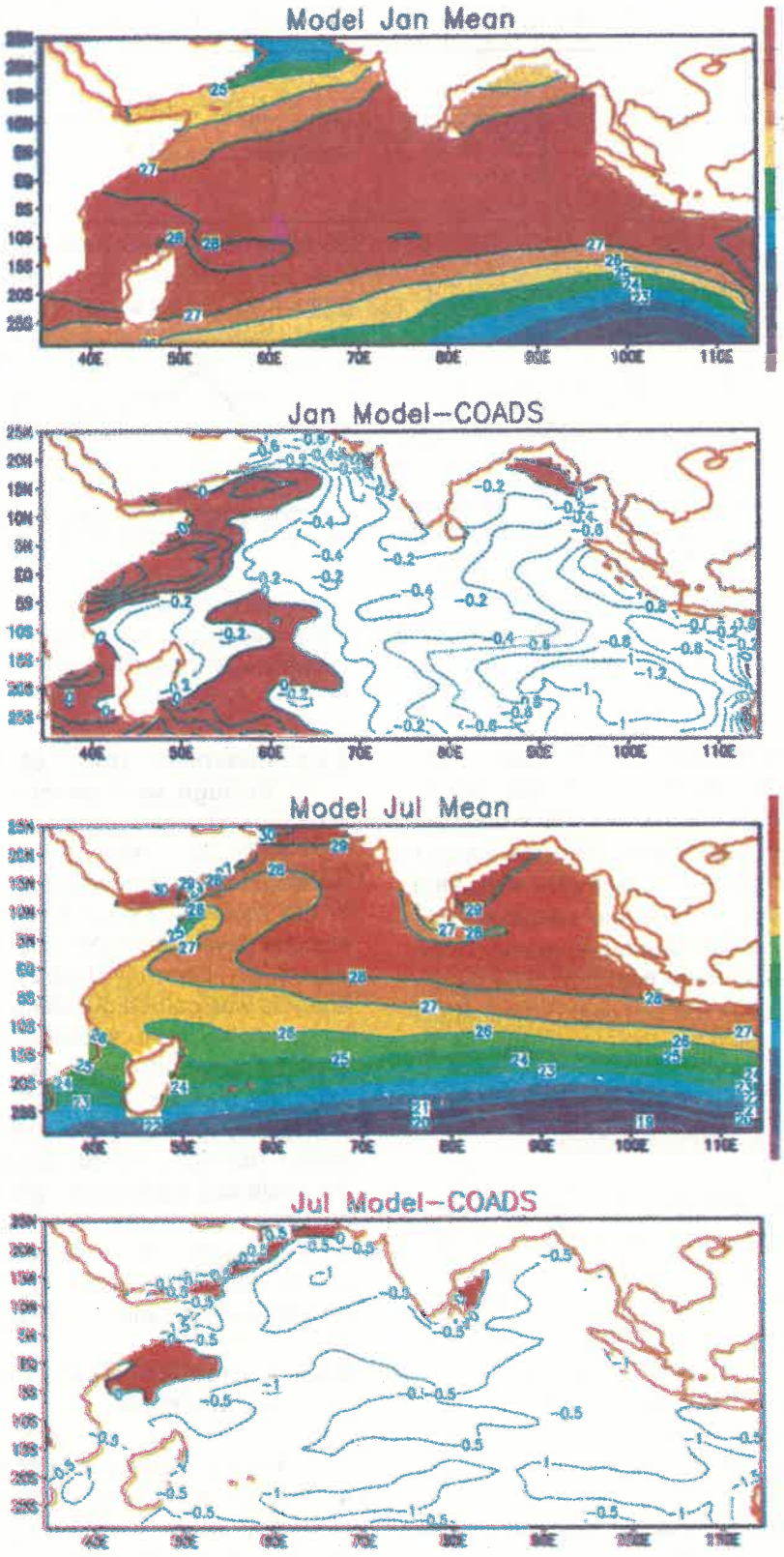


Fig. 11 :
Model climatology (15 year averaged) of January and July SST and the differences between the Model and COADS .climatology (positive values are shaded).

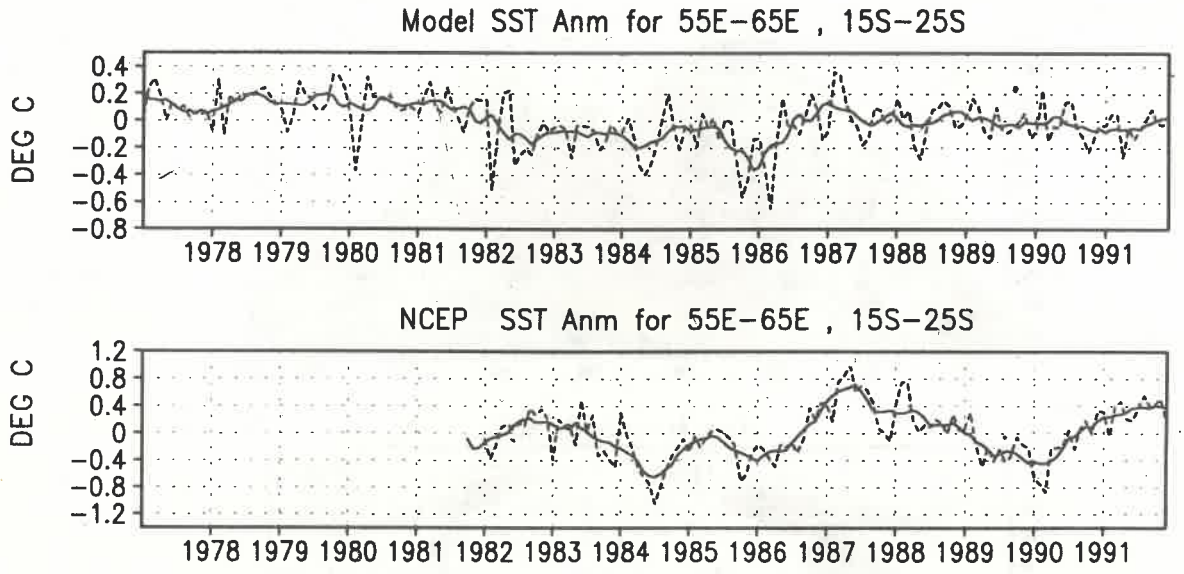


Fig. 12 :
Time series of SST anomalies (dashed lines) from the ocean model and observation. Superimposed is a 7 month running mean (solid lines).

Several sensitivity experiments were carried out to understand the sensitivity of the 2.5 layer ocean model in response to the changes in surface forcings. The surface forcings for the first year was increased or decreased in a 15 year model integration. The simulated SST anomalies suggested that there exists surface cooling (warming) with the increase (decrease) in the wind stress and decrease in the heat flux . The strong anomalies thus produced in the first year did not affect the anomalies of the following year over the Indian ocean.

2.6.3 Ocean models for climate studies

A recent version of the GFDL global ocean model (MOM 2) was integrated only for 20 days with idealised forcing condition and with 15 levels in vertical on the Power Challenge Computer. The model will be tested with realistic data and realistic geometry depending on the availability of required disc space. A three dimensional sigma coordinate, curvilinear grid, 15 level Princeton University Ocean Model (POM) was also tested for 20 days with idealised forcings and flat bottom ocean on the Power Challenge Computer. The model geometry is being modified to simulate coastal circulation , temperature and salinity at various depths with 12 km horizontal resolution to understand the physical and dynamical processes in the deeper layers of the north Indian ocean.

2.6.4 Instability study of tropical disturbances through semi-geostrophic approach

Role of non-geostrophic effects on the development of baroclinic unstable waves embedded in the mean monsoon flow were investigated using inhouse developed nonlinear, multi-level balance model based on Charney (1962) formulation. Instability analysis was carried out using an initial value approach for synoptic scale wavelength band. The preferred wave for adiabatic case was found to have wavelength 1800 km and the wavelength of the preferred mode slightly increases by the inclusion of Ekman friction and/or diabatic heating. Zonal plane distributions of the preferred wave were obtained for nongeostrophic as well as quasi-geostrophic cases. Wave amplitude in both the cases were almost same but the vertical phase distribution was significantly modified in the presence of diabatic heating.

2.6.5 Dynamical instability of the tropical stratosphere

A study of the baroclinic instability characteristics of the tropical lower stratospheric synoptic and planetary scale waves was undertaken. For this purpose, a quasi-geostrophic multilayer, linear model with unequal pressure interval from surface to 10 hPa was developed. Normal mode approach was adopted for the model formulation. Input to the model was

obtained using climatological wind and temperature field for the monsoon season over equator to 30°N and 30°-120°E.

2.6.6 Cumulus parameterisation scheme for Indian Monsoon Region

Using national MST radar facility, some experiments were conducted to measure u,v,w wind components inside the large scale clouds as well as convective clouds from 3.6 km to 20 km height levels during 4 -15 June 1996, to study the observed cyclonic storm which hit the Madras coast on 12 June 1996. Detailed analysis of the MST Radar data for the cyclonic storm and corresponding INSAT pictures suggested the occurences of layered clouds in the Indian Monsoon Region. Its relation to the dynamics of inertia-gravity waves are being investigated.

2.6.7 Manpower Development Programme

An expertise is developed on object oriented scientific computing using C++ language compiler available on the institute's HP workstation. Object oriented scientific tools can also be developed on the INTERNET using JAVA language which is the programming language of the internet. JAVA is acknowledged as "C++ on the internet". In view of the closeness of JAVA and C++, a study was made to compare the strength and limitations of JAVA and C++.

2.7 CLIMATE AND GLOBAL MODELLING DIVISION

Recognising the need for a sustained and long term scientific programme to understand the physical and dynamical processes in the climate system, the Institute has established the Climate and Global Modelling Division. The objectives of the division are :

* Comprehensive study of the physical and dynamical processes relating to global and monsoon climate and their variabilities on different time scales.

* Development and improvement of physical and mathematical models capable of simulating climate and climate change due to natural and anthropogenic factors and validation of the results of the climate models.

2.7.1 Long term integrations of the COLA GCM

A 13 year integration of the COLA GCM from 1982-1994 was carried out by using observed monthly sea surface temperature (SST) was carried out. The climatological features of the GCM for June - September and the observed climatology based on NCEP Reanalyses were compared. It was found that while the GCM simulated circulation features compare reasonably well with observations, the summer monsoon rainfall simulation by the GCM needs to be improved further.

2.7.2 Monsoon Seasonal Mean State and its fluctuations

Seasonal Forecasting of Summer Monsoon using GCM

Seasonal forecasting of the summer monsoon of 1996 was attempted with the COLA T30 GCM using SST forecasts in the Pacific ocean from Cane Zebiak (CZ) ocean model. Two sets of ensemble seasonal integrations were carried out with the GCM with climatological SST (CLIM) and CLIM + SST anomalies from CZ (REAL). Each ensemble is a set of nine realizations based on nine different initial conditions. Thus a total number of 18 seasonal integrations were performed in this study. A comparison between the simulations in CLIM and REAL showed a marginally stronger monsoon for 1996 (Figs. 13 and 14).

GCM Simulations of Active and Break Indian Summer Monsoons during El Nino and La Nina Phases

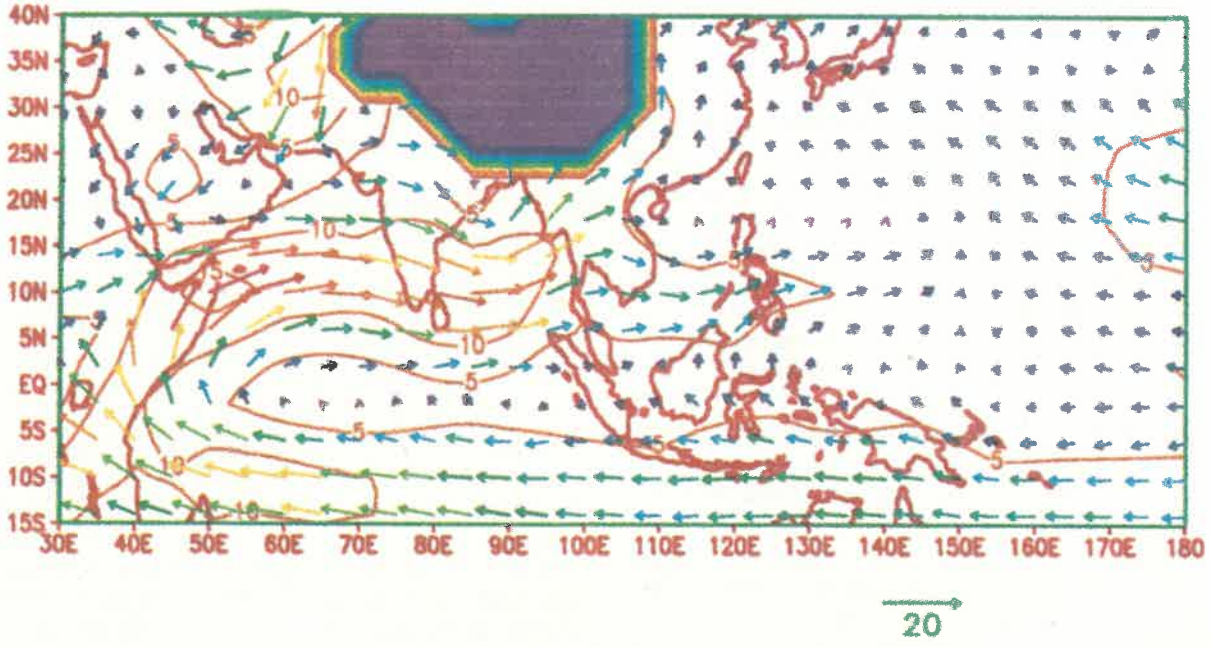
Ensemble seasonal integrations using the COLA GCM (V3.11) were carried out to examine the GCM simulations of summer monsoon during the El Nino and La Nina years of 1987 and 1988 respectively. The GCM simulations showed a reasonably realistic simulation of the weak (strong) seasonal mean monsoon during 1987 (1988). The simulations also revealed that the number of active (break) days of monsoon activity over the subcontinent was more (less) during 1988 (1987) respectively. It was found that the eastward propagating equatorial MJO was relatively stronger during 1987 as compared to 1988. However, the northward propagating monsoonal low frequency modes over the Indian subcontinent were stronger during 1988 as compared to 1987. Composites of rainfall, circulation and height fields during the active and break phases are realistically simulated by the GCM.

2.7.3 Studies of Monsoon Variability using GCM

Interannual variability studies

To study the interannual variability of the simulated climate, a four year long integration of the UKMO

a



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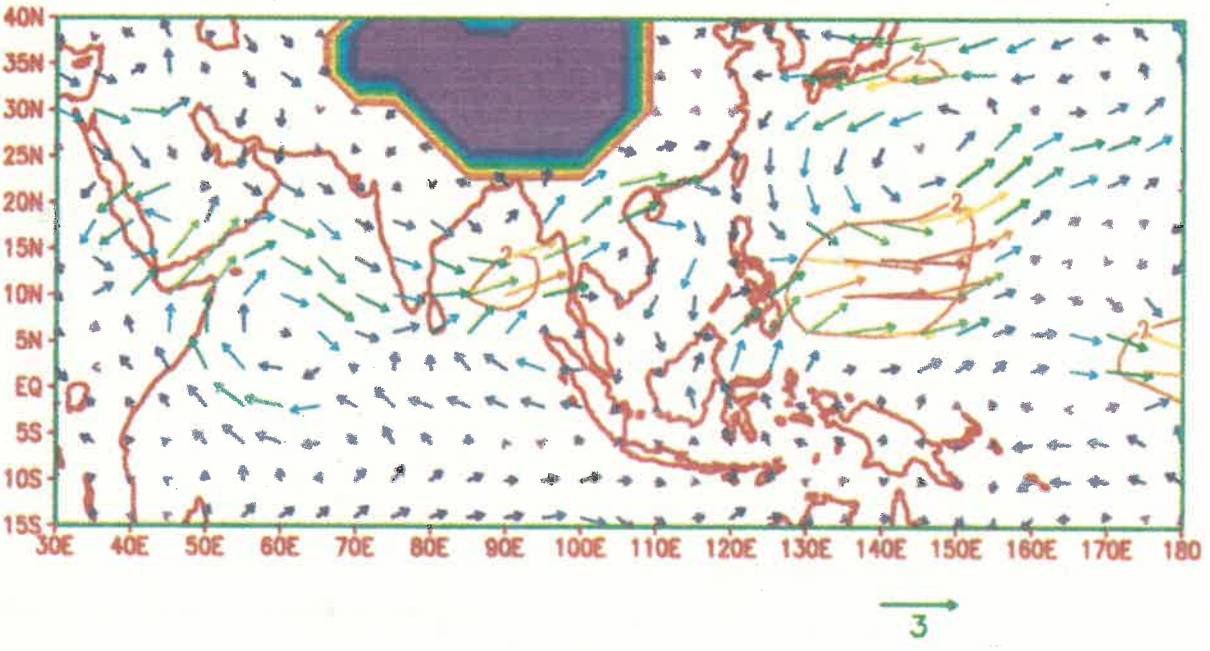

Fig. 13 :
Summer monsoon 850hPa wind simulation for 1996 by COLA T30L18 model.
(a) Winds(ms^{-1}) and (b) Wind Anomaly ((ms^{-1}) (Real minus Climatology)

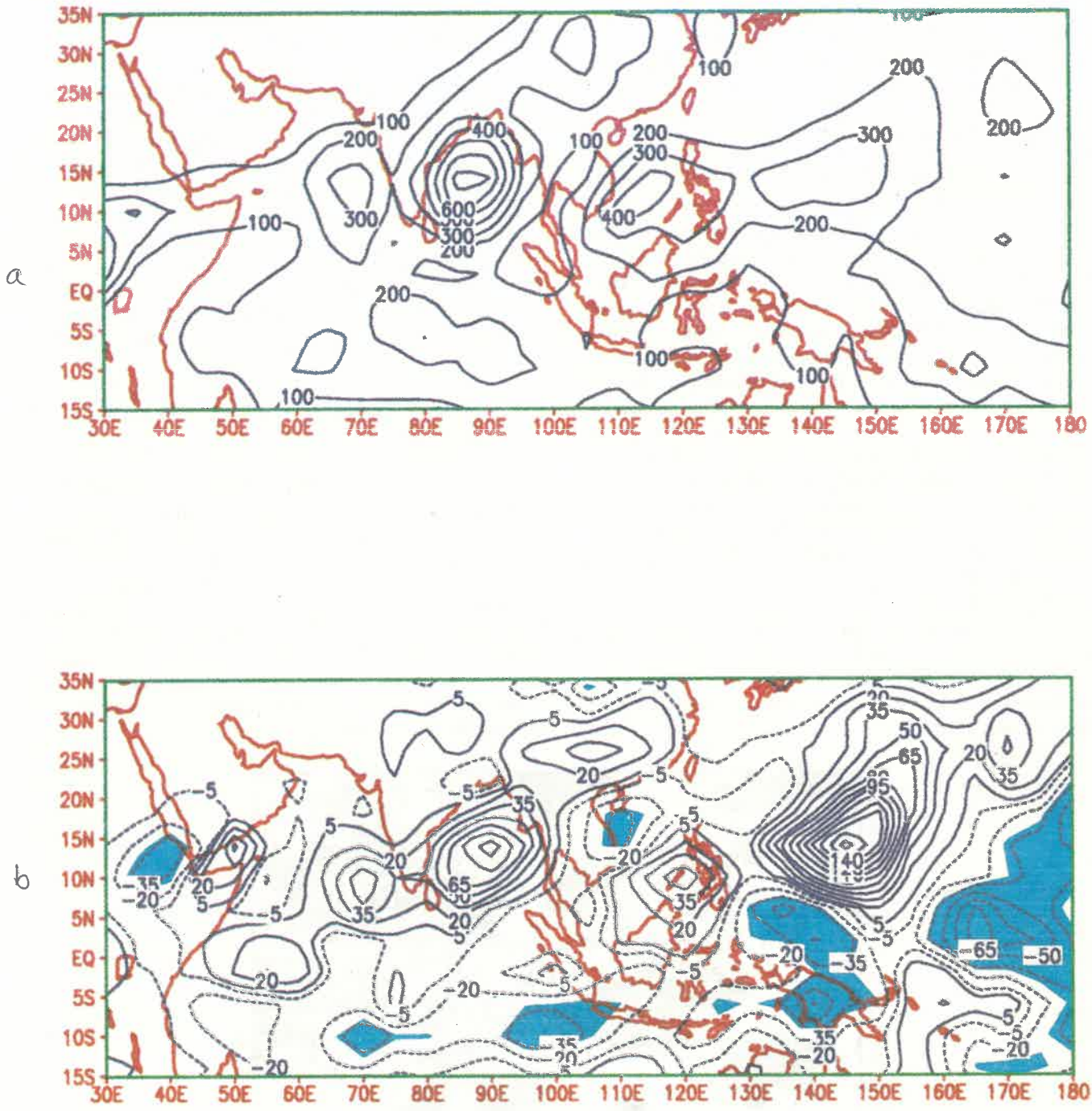

Fig. 14 :
Summer monsoon rainfall simulation for 1996 by COLA T30L18 model.
(a) Rainfall (mm) and (b) Rainfall Anomaly (mm) (Real minus Climatology)

Unified Model was completed. The run was started using initial data of 1 June 1991 and continued till December 1994. Observed SSTs and sea ice data for 1991-1994 were used as boundary conditions. Though the model simulated a stronger monsoon than the observed one, on the seasonal time scale, the interannual variability was reasonably well simulated. The simulated monsoon of 1994 was stronger than 1991 monsoon, which agrees with the observed behaviour of the monsoon of these years.

Sensitivity of Monsoon Simulation to SST of 1991 and 1994

The relationship between ENSO and rainfall over India is not always consistent. The monsoon rainfall of 1991 and 1994 were studied for the purpose. The Southern Oscillation Index was -1.3 during spring of both the years. The Indian monsoon rainfall for 1991 was 91.2 % of normal which was correctly forecast by the LRF models. For 1994 the LRF models predicted the rainfall below normal. However, India received 10% more than the normal rainfall. The difference between the two years was the spatial distribution of SSTs over the tropical Pacific. To examine the impact of SST forcing in the tropical Pacific ocean on the summer monsoon rainfall during these two years, two seasonal integrations of the UKMO GCM were carried out with the observed SSTs and initial conditions of 1991 and 1994. The model simulated a much stronger monsoon in 1994 as compared to 1991. It was seen that in 1994 the lower tropospheric monsoon westerlies were 5-7 m/s stronger and a marked increase was also seen in the rainfall over peninsular India and the adjoining sea areas.

2.7.4 Role of Convection and Downdrafts in GCM Simulations

Sensitivity of the Indian Summer Monsoon Simulation to Parameterization of Cumulus Convection

The impact of two well known cumulus convection schemes namely, Kuo (1974) and Relaxed Arakawa Schubert (RAS) of Moorti and Suarez (1992) on the simulation of Indian summer monsoon was examined by carrying out several seasonal integrations using the COLA T30 GCM. Results of this study indicated that the simulated monsoon was significantly stronger in RAS as compared to KUO. The seasonal land rainfall over India was significantly higher in RAS as compared to KUO. It was seen that the rainfall simulated by KUO was higher mainly in the equatorial Indian ocean.

Role of Convective Downdrafts in Monsoon Simulation

The impact of inclusion of convective downdrafts in the penetrative mass-flux cumulus parameterization scheme on the summer monsoon simulation by UKMO GCM was examined. The seasonal simulation without downdrafts in the mass-flux scheme showed large amounts of precipitation over oceanic area, whereas with downdrafts there was an increase in rainfall over Indian land mass and a decrease over the oceans. The monsoon circulation improved and the northward advance of the monsoon was faster in the presence of downdrafts (Fig. 15).

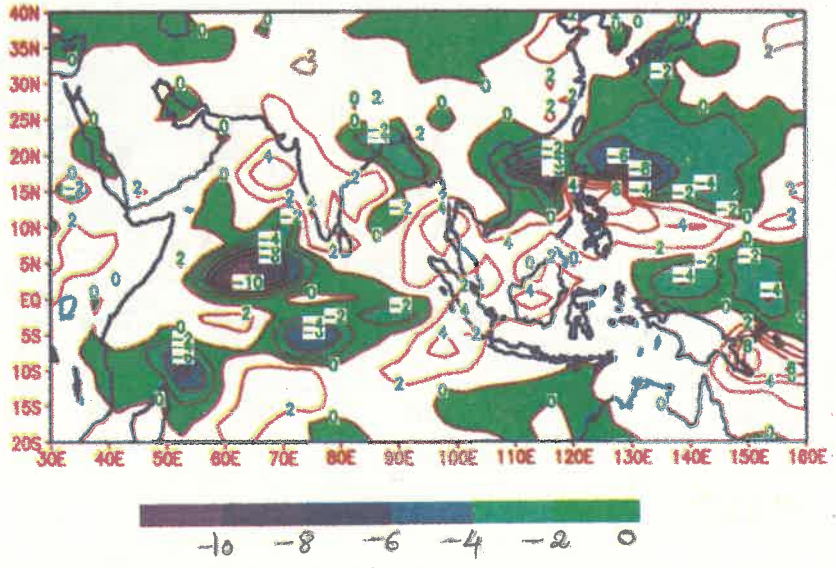

Fig. 15 :
Summer monsoon simulation for 1991 by UKMO GCM.
Difference in precipitation rates (mm/day) (downdraft minus downdraft).

2.7.5 Development of an Optimised Parallel Climate Model

A joint research project is ongoing between IIT, Delhi, IITM, Pune and C-DOT, Bangalore. The basic objective of the project is to develop a parallel climate model based on the current operational weather model of the NCMRWF and to implement the parallel model on 192 processors of CHiPPS computer installed at the IITM. Specifically, the objective is to parallelise the operational T80L18 weather prediction model in two dimensions (in the vertical as well as in the meridional direction) and then downscale the resolution to T42L18 for climate runs. The operational T80L18 model and initial data for model integration have been obtained from the NCMRWF and efforts are going on to implement the sequential code on a single processor of Silicon Graphics Power Challenge Machine.

2.7.6 Monsoon Studies using data

Dynamical Mechanisms of Premonsoon Signals over North India

A detailed diagnostic study based on the monthly NCEP/ NCAR Reanalysis (1982-1994) followed by a theoretical study was undertaken to examine the mechanisms of spring-time upper tropospheric signals over northern India and neighbourhood. Observations showed that the signals preceding strong (weak) monsoons are characterised by anticyclonic (cyclonic) upper tropospheric circulation anomalies and the warm (cold) thermal anomalies over northern India. The present study revealed that the premonsoon signals arise from land surface hydrological forcings over the Indian subcontinent as well as interannual variations of SST in the tropical Pacific and south Indian oceans. It is seen that the cyclonic anomalies prior to weak monsoon years are forced locally by upper level convergence over the Indian subcontinent and remotely by upper level divergence anomalies overlying the warm SST regions in the equatorial central and eastern Pacific and south Indian oceans. The regional scale response over north India and neighbourhood induced by the non-ENSO forcings appears to have larger amplitude as compared to that of the ENSO forcing. It is conjectured that the circulation anomalies preceding weak monsoons are maintained by the energy extraction from the mean flow by barotropic instability and the energy injection from the tropics into the subtropics by Rossby wave dispersion.

Study of variability of Indian summer monsoon rainfall using Wavelet Transforms

The spatio-temporal variability of the dominant modes in the summer monsoon rainfall was studied using data of 128 years from 1868-1995 of All India Summer Monsoon Rainfall (AISMR) and summer monsoon Rainfall of six homogeneous regions of India, viz.(i) North West (ii) North Central (iii) North East (iv) West Peninsular (v) East Peninsular and (vi) South Peninsular, were analysed for time-frequency localisation using Wavelet Transforms. The study revealed large climate oscillations with periodicities of 2, 4 and 64 years in the AISMR time-series. The 2 year mode showed 60% increase in activity in the 32 epoch (1964-1995) as compared to the earlier epochs. Also, it undergoes phase change about 7 times in each 32 year epoch. Wavelet analysis of SOI showed 2, 4 and 8 years dominant periodicities. Contribution of each mode to rainfall departure (from mean), in strong/weak monsoon years, was also studied. In ENSO years, in addition to 4 & 5 years modes, 2 year mode showed large climatic variability. For assessing the presence of mechanism of 2 year mode in UKMO GCM, monthly mean surface wind field in the AMIP period is being analysed.

2.8 COMPUTER AND DATA DIVISION

Scientific computing is vital for research in Atmospheric Sciences particularly connected with the modelling of atmosphere. Recognizing the importance of scientific computing for weather forecasting, the Institute has developed modern fast computing facilities for its research work.

The scientists are provided with the on-line access to the Numerical Algorithms Group (NAG) FORTRAN Library installed on the ND-560/CX computer system. The software facilities/requirements are being reviewed and additional facilities are planned and updated from time to time.

The ND-560/CX and RISC based HP-9000/735 workstation (with 40 MFLOPS, 112 MB RAM, 4.8 GB disc capacity) are being used extensively by the scientists of the Institute. An A-0 plotter, a line-printer and a Laser-Jet printer are connected to the workstation. Several Personal Computers, with various input/output media like floppy discs, cartridge tapes, CD-ROMs, digital audio tapes etc. are available. The C-DoT's High Performance Parallel Processing System (CHiPPs-192PE) is also being utilised for the Climate Research Project.

In addition to these, a very high end compute server, the Power Challenge XL of the Silicon Graphics Inc. consisting of 4 CPUs (R-8000, 75 MHz) each with a peak performance of 300 MFLOPS has been acquired for the Climate and Global Modelling work.

The configuration consists of 16 GB hard disk, a central memory of 512 MB and the INDY graphics workstation with very powerful software tools like IRIS showcase, Explorer and Indigo Magic for developing audio, video and graphics applications. The system is networked with HP-9000/735 workstation and any of the two can be accessed through several nodes in different divisions connected on the UTP network. The e-mail facility has also been made available to the Institute employees.

The Computer Division provides the technical services, viz., collection, archival and retrieval of the meteorological and other related data for the tropics on the regional and global scales to the scientists of the Institute. 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 holds voluminous data collected during the MONTBLEX Programme. The Division arranges special runs for the long and continuous uninterrupted computations during the nights and holidays depending on requirements of the scientists.

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.

The computing facilities of the Institute have further been enhanced by providing Pentium Pcs with WINDOWS 95 to all of its divisions. Most of the Pentiums and other Personal Computers in the divisions are connected to the Institute's LAN. Work for the installation of INTERNET facility through VSAT was under progress.

The Institute scientists also utilise the CRAY-XMP/14 Super Computer at the NCMRWF, New Delhi and VAX 4000/300 workstation at the IMD, Pune.

TOGA-I DATA Centre

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

DST-MONTBLEX Data Bank

The Institute has 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 user-scientists on request as per the guidelines issued by the DST.

Software Development for Accounts section

Application Softwares for the Institute's accounts work like Pay-Roll and its related statements have been developed. An object oriented programme using C++ is developed for calculation of Income-Tax along with Form-16 for filing Income-Tax returns. Computer programs for Provident Fund slips with interest, Budget estimates, MIS reports, abstracts & schedules for Institute's various categories of staff, etc. have been developed. Maintenance of the above softwares is done in accordance with Government orders, rules and regulations. Members of staff are trained from time to time to run the programs. A two-week training programme on MS-DOS and related topics was arranged for the benefit of Accounts and Administrative staff.

2.9 LIBRARY, INFORMATION AND PUBLICATIONS DIVISION

The Institute is a leading research centre in Tropical Meteorology and it has developed a comprehensive Information System. The Institute's Library, Information and Publications Division serves as Information System in Atmospheric Sciences 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.

The Library is now housed in its newly constructed, separate building. The Library has built a very good information base of about 25000 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. The library and information services are provided to the scientists of the Institute as well as to the research community working in the field of Atmospheric Sciences in different organisations. The Library has developed an informal resource sharing network with the libraries of different organisations within India and abroad and also strengthened its information base through the 'Gift and Exchange of Publications Programme' with the national and international organisations.

During the year 156 books and reports in Meteorology and allied subjects were added. 94 periodicals of national /international origin were subscribed to. Reprints of 34 papers authored by the Institute's scientists were also purchased. Several scientific and technical reports were received from the other National and 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 also 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 Scientific and Technical Libraries in Pune Metropolitan area (PUNE-NET). The computerised database for the collection of books has been made available for retrieval at the workstation of the PUNE-NET located at the Bioinformatics Centre of the University of Pune. Creation of database for reports and other publications is under progress.

The Division has 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. Scientific exhibitions depicting research activities of the Institute were organised on the occasion of important events, such as visits of distinguished visitors, National Science Day and World Meteorological Day celebrations etc.

2.10 MANAGEMENT STRUCTURE

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), New Delhi, Indian Institutes of Technology, Universities and other scientific organisations associated with the research work in Atmospheric Sciences and Oceanography.

2.11 ADMINISTRATION

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

2.11.1 Personnel Profile

The Institute has 300 scientific, technical and administrative staff. As on March 1997 the position of filled posts of different groups in different categories is as follows:

Group	Research	Scientific	Technical	Admin.	NTMS	Total
A	64	—	4	2	—	70
B	37	30	22	9	—	98
C	—	16	12	44	—	72
D	—	—	—	—	60	60
Total	101	46	38	55	60	300

2.11.2 Status of SC/ST/OBC Reservation :

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

Research		Scientific		Technical		Admin.		NTMS		Total	
SC	ST	SC	ST	SC	ST	SC	ST	SC	ST	SC	ST
9	3	6	1	7	—	10	4	19	2	51	10

Institute has completed the recruitment action for 9 reserved posts. Action to advertise 25 reserved posts has been initiated.

2.11.3 Staff Changes

Four persons joined and eight left the Institute during the year under different categories.

Prof.R.N.Keshavamurty, Director and Dr.B.Parthasarathy, Deputy Director retired on 31 May 1996, Shri R.N.Chatterjee, Deputy Director on 31 July 1996, Dr.P.R.Rakhecha, Deputy Director on 31 December 1996, Shri D.K.Paul, Senior Scientific Officer Gr.I on 30 November 1996, Shri D.S.Takawale, Laboratory Assistant on 31 March 1997 and Shri K.Singh, Watchman on 30 June 1996, all on attaining the age of superannuation. The resignation tendered by Shri H.B.Ade, Senior Scientific Assistant was accepted with effect from 12 April 1996 afternoon.

2.11.4 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 2.5 and 10 respectively.

2.11.5 Research Fellowships

As IITM Research Fellow shri D.R.Pattnaik joined the Institute on 17 June 1996 while S/Shri R.Ashrit and T.S.V.Vijaykumar joined on 21 June 1996. Shri T.S.Pranesha joined as IITM Research Associate on 20 August 1996.

Shri T.S.V.Vijaykumar, IITM Research Fellow was relieved on 11 December 1996. S/Shri M.A.Vittal and C.H.Kulkarni, Project Associates joined under the DST sponsored Land Surface Processes Project left the Institute on 23 October 1996 and 13 February 1997 respectively.

2.11.6 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 three meetings of Staff Council were held.

2.11.7 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. Two meetings of the council were held during the year.

2.11.8 Advisory Committee

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

2.11.9 Setting up of Review Committee, its Composition, Terms of Reference and Summary of Recommendations and Action Taken :

The Govt. of India, Ministry of Science and Technology constituted a Review Committee in 1988 under the Chairmanship of Prof. R. Narasimha to review the work of the Institute. The Committee submitted its report which was put up to the Governing Council of the Institute in its 50th meeting held on 17 January 1995. The comments of IITM on the report were submitted to the Governing Council at its 51st meeting held on 25 November 1995. The same was

also communicated to the Department of Science and Technology (DST), New Delhi.

2.12 FINANCE

2.12.1 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 1996-97 are as follows:

(Rs.in Lakhs)

	Budget Estimates	Revised Estimates	Grant Received	Actual Expenditure
Non-Plan	303.55	250.00	250.00	250.00
Plan	140.00	131.00	130.82	130.82

2.12.2 Action Taken/Note on Auditors' Report :

The replies/action taken for audit report for the year 1995-96 have been duly approved by the Governing Council of the Institute in its 53rd meeting held on 1 December 1996.

2.12.3 Internal Mobilisation of Resources :

i) The expertise developed by the Institute in the fields of Weather Modification, Hydrology and Long-range forecasting is being used in different projects of State Government and India Meteorological Department.

ii) Institute Scientists are participating in the development of teaching programmes undertaken by various universities.

2.12.4 Sponsored Projects

In addition to the ongoing research programmes the Institute undertakes sponsored projects for specific studies. Funds for these projects are provided by the respective sponsoring Departments. The details of the sponsored projects are given below:

Sr. No.	Title	Principal Investigator	Period	Grant (Rs.in lakhs)	Funding Depart-ment
1.	Climate Research (Global Modelling)	Prof. R.N. Keshavamurty/ Dr.V.Satyan	1994-99	198.32	DST
2.	Development of an Optimized Parallel Climate Model based on NCMRWF Operational Model (Jointly with IIT, New Delhi and C-DOT, Bangalore	Dr.V.Satyan	1996-98	2.00	DST
3.	Land Surface Processes Experiment over Sabarmati Region.	Prof.R.N. Keshavamurty/ Shri K.G. Vernekar	1994-97	75.00	DST
4.	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
5.	2D-chemical modelling of global changes induced perturbations in atmospheric minor constituents and ionizations of the lower and middle atmosphere	Dr.G.Beig	1996-99	6.00	CSIR
6.	One Dimensional model Atmospheric Boundary Layer using Land Surface Process	Dr.S.S.Parasnis	1996-98	0.97	DST

2.13 SCIENTIFIC EQUIPMENT

The Institute acquired during the year several scientific equipment,data acquisition and storage systems, accesories to the scientific equipment, office and library furniture items, personal computers, printers and enhancing systems to the existing infrastucture. The major items acquired for the research work are given below:

Sr.No.	Equipment
1.	Indy R 4600 PC Graphics Workstation
2.	Ground Receiving Equipment for SDUC Workstation
3.	Networking of PCs
4.	V-Sat (Very Small Aperture Terminal)
5.	Data Acquisition System suitable for Rotating Slit Scanner and Multichannel Average
6.	Polarised Rotator with Optical Thread Adaptor
7.	30 Meter Tower
8.	Class 'A' Pan Evaporimeters.
9.	Ultrasonic Sensor
10.	Coeliostat
11.	Grating with 12µm Blaze for spex model Double Monochrometer
12.	Eppley Precision Spectral Pyramometers with Infrared Radiometer.

2.14 OFFICIAL LANGUAGE IMPLEMENTATION

Hindi Cell is working under the Administrative wing of the Institute. It is engaged in the implementation of Official Language Policy as laid down by the Government of India through Official Language Act as well as other rules and directives received from time to time. All general circulars and office orders are being issued in bilingual format. Hindi Cell is looking after Hindi translation and arranging Hindi Training for Officers and Employees in different cadres. In this task the Official Language Committee is offering necessary assistance and guidelines.

The Institute sponsored one of its employees to undergo training arranged under the Hindi Teaching Scheme. The Hindi Cell has maintained a small collection of Hindi books on various subjects for the employees of the Institute to promote their Hindi knowledge.

The Institute celebrated the Hindi Day on 26 September 1996. On this occasion, competitions in elocution, poetry recitation and phrases and proverbs in Hindi were organised. Dr.S.K.Srivastava, Deputy Director General of Meteorology was the Chief Guest of the celebration. The prizes to the winners of the competitions were distributed by the Chief Guest.

2.15 IITM RECREATION CLUB

The Recreation Club continued to provide sports and library facilities to the members. 202 books were added to the Library. Badminton activity has been started in the Community Hall. Annual sports tournaments were organised on League basis and prizes to the winners and runners-up were distributed at the hands of the Director on 1 January 1997

On the Independence Day, the Club awarded prizes to the children of the Institute's employees who had obtained 80% or more marks in each of the S.S.C. and H.S.C. Examinations held in March 1996.

New Office Bearers for the period of April 1997 to March 1999 have been elected for the club.

2.16 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 (MNES), 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, exclusive wind data for the wind power projects, are collected by using 20/25 m tall guyed mast and microprocessor based data collection system. Under this programme total 257 stations have been commisioned in 14 States and 3 Union Territories. Additions to the list of stations are made from time-to-time, while some stations are closed down after collection of data.

Under the Wind Mapping Programme, wind data are collected primarily for studying the wind climatology of the country using a 5 m tall mast and simple instrumentation. So far, 595 stations in 20 States have been commissioned. Almost all of these stations have been closed down and presently the programme is in force only in Maharashtra. During the year 51 Wind Monitoring Stations and 8 Wind Mapping Stations were commissioned.

Thirty automatic data logging systems along with 140 anemometers and 145 windvanes have been imported from M/s. NRG Systems, USA for their use in the field stations.

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Miscellaneous

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4. PARTICIPATION IN SYMPOSIA/SEMINARS/CONFERENCES

Sr.No.	Symp./Conf./Sem.	Participant(s)
1.	Workshop on Meteorology, International Meteorological Institute, Stockholm, Sweden, 2-11 May 1996.	Shri A.G.Pillai
2.	International Conference on Tropical Climatology, Meteorology and Hydrology in Memorium of Bultot, The Royal Meterological Institute of Belgium, Brussels, Belgium, 22-24 May 1996.	Dr.P.N.Mahajan
3.	International Conference on Acid Deposition in East Asia, National Taiwan University, Taipei, Taiwan, 28-30 May 1996.	Shri P.S.P.Rao
4.	10th International Conference on Atmospheric Electricity, Osaka University, Osaka, Japan, 10-14 June 1996.	Dr.A.K.Kamra
5.	AVICENNE Workshop on Satellite Remote Sensing Applications, University of Bristol, U.K., 26-29 June 1996.	Dr.P.N.Mahajan
6.	International Workshop on El Nino, Southern Oscillation and Monsoon, International Centre for Theoretical Physics, Trieste, Italy, 15-26 July 1996.	Dr.K.Rupakumar, Dr.R.Krishnan, Shri K.K.Kumar, Shri S.Tiwari and Shri C.Venkatesan
7.	18th International Laser Radar Conference (ILRC), Free University, Berlin, Germany, 22-26 July 1996.	Dr.P.C.S.Devara
8.	Lecture Series on Meso-scale Modelling and Brain Storming Session, National Centre for Medium Range Weather Forecasting, New Delhi, 22-27 July 1996.	Shri P.S.Mukhopadhyay
9.	Brain Storming Session on Meso-scale Modelling, National Centre for Medium Range Weather Forecasting, New Delhi, 27 July 1996.	Dr.S.S.Singh
10.	Seminar on Understanding and Using INTERNET, Videsh Sanchar Nigam Limited, Pune, 27 July 1996.	Shri S.Sudarsanam
11.	International Conference on Instrumentation (ICI-1996), Indian Institute of Science, Bangalore, 8-10 August 1996.	Dr.P.C.S.Devara

S.No.	Symp./Conf./Sem.	Participant(s)
12.	Indian Ocean Experiment (INDOEX) Workshop, National Physical Laboratory, New Delhi, 19-21 August 1996.	Dr.A.K.Kamra, Dr.D.B.Jadhav and Dr.G.Beig
13.	National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.	Shri C.P.Kulkarni, Dr.(Smt.)I.Joshi, Shri P.V.Puranik, Shri S.M.Bawiskar, Smt.R.R.Joshi, Smt.N.V.Panchawagh, Shri S.S.Dugam, Shri Prem Singh, Shri S.D.Bansod, Shri S.D.Patil, Shri V.Sathiyamurty and Shri D.R.Pattnaik
14.	Workshop on The Role of Tibetan Plateau in Forcing Global Climatic Changes, Central Institute of Higher Tibetan Study, Dharamshala, 25-31 October 1996.	Dr.G.B.Pant
15.	31st Annual Convention of Computer Society of India, Bangalore, 28 October-3 November 1996.	Shri S.S.Aralikatti
16.	PUNE-NET Meet, Bioinformatics Centre, University of Pune, Pune, 29 October 1996.	Smt.A.A.Shiralkar
17.	Raman Memorial Conference (RMC-96), University of Pune, Pune, 7-8 November 1996.	Shri K.Ali, Shri R.S.Maheskumar and Shri D.R.Pattnaik
18.	Wind Flow Modelling Training Workshop, National Aerospace Laboratories, Bangalore, 14-17 November 1996.	Dr.S.Rangarajan
19.	A Special IAGA Symposium on Geomagnetism in Studies of the Earth's Interior and Electrodynamics of its Far Environment, Indian Institute of Geomagnetism, Mumbai, 18-20 November 1996.	Dr.(Smt).I.Joshi
20.	Second International Conference of the African Meteorological Society, Casablanca, Morocco, 25-28 November 1996.	Prof.G.C.Asnani

S.No.	Symp./Conf./Sem.	Participant(s)
21.	First SPARC (Stratospheric Processes and their Role in Climate) General Assembly, Council for Scientific and Indistrial Research Organisation, Melbourne, Australia, 2-6 December 1996.	Dr.L.S.Hingane, Dr.R.H.Kripalani and Dr.G.Beig
22.	International Workshop on Energy Applications, Indian National Science Academy, New Delhi, 3-7 December 1996.	Dr.S.Rangarajan
23.	National Symposium on Remote Sensing for Natural Resources with Special Emphasis on Water Management and Annual Convention of Indian Society of Remote Sensing, University of Pune and C-DAC, Pune, 4-6 December 1996.	Dr.P.C.S.Devara, Shri V.R.Mujumdar, Shri P.V.Puranik, Shri S.S.Dugam and Shri S.P.Ghanekar
24.	ISRO-DLR (German Aerospace Research Establishment) Workshop on MOS (Modular Optoelectronic Scanner) Data Utilization, Indian Space Research Organisation, Bangalore, 9-10 December 1996.	Dr.P.C.S.Devara
25.	Workshop on Fundamentals of Boundary Layer Physics and its Applications, Jawaharlal Nehru University, New Delhi, 9-28 December 1996.	Smt.S.B.Morwal
26.	DST Sponsored Training-cum-Field Workshop on Fluvial Geomorphology with Special Reference to Flood Hydraulics and Dynamics, University of Pune, Pune, 11-20 December 1996.	Dr.O.N.Dhar and Dr. (Kum.) S.S.Nandargi
27.	Two-day Workshop on Perspectives in Atmospheric Chemistry, Physical Research Laboratory, Ahmedabad, 26-27 December 1996.	Dr.P.C.S.Devara and Dr.G.Beig
28.	Third Winter School on Directional Data Analysis, Osmania University, Hyderabad, 27-31 December 1996.	Dr.S.K.Sinha
29.	International Workshop on Indian Ocean Experiment (INDOEX) National Physical Laboratory, New Delhi, 3-6 January 1997.	Dr.P.C.S.Devara, Dr.D.B.Jadhav and Dr.G.Beig

S.No.	Symp./Conf./Sem.	Participant(s)
30.	Science and Technology Exhibition at 84th Session of the Indian Science Congress, University of Delhi, Delhi, 3-8 January 1997.	Smt.R.R.Joshi and Shri P.W.Dixit
31.	Second Meeting on Current Trends in Optics (Optics-97), S.N.Bose National Centre for Basic Sciences, Calcutta, 14-17 January 1997.	Dr.P.C.S.Devara
32.	IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.	Dr.G.B.Pant, Smt.M.S.Naik, Shri C.P.Kulkarni, Dr.(Smt.) I.Joshi, Shri S.K.Jadhav, Shri A.A.Munot, Shri H.P.Borgaonkar, Shri B.D.Kulkarni, Smt.N.V.Panchawagh, Shri S.S.Dugam, Shri D.R.Kothawale, Shri S.D.Patil, Shri P.D.Safai and Shri R.S.Maheskumar
33.	IGBP Asia Pacific Network Workshop on Human Dimension of Global Change, National Physical Laboratory, New Delhi, 20-23 January 1997.	Dr. G.B.Pant,
34.	IASTA Seminar on Aerosols: Generation and Role in Medicine, Industry and Environment, Bhabha Atomic Research Centre, Mumbai, 22-24 January 1997.	Dr. P.C.S.Devara
35.	XXIV National Symposium of the Optical Society of India on Optics and Opto-Electronics, University of Calcutta, Calcutta, 30 January-1 February 1997.	Dr. P.C.S.Devara
36.	Conference on Climatology, Arts, Science andCommerce College, Chopda, Jalgaon, 2 February 1997.	Dr. H.N.Bhalme and Dr.A.K.Kulkarni

S.No.	Symp./Conf./Sem.	Participant(s)
37.	Third User Scientists Workshop on MST Radar Results, National MST Radar Facility, Gadanki, 6-7 February 1997.	Prof. G.C.Asnani, Dr. P.E.Raj, Dr. (Smt.)I.Joshi and Shri M.K.R.V.Raja
38.	National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.	Prof. G.C.Asnani, Dr. A.K.Kamra, Dr. G.B.Pant, Dr. S.N.Bavadekar, Dr. P.N.Mahajan, Shri D. R. Chakraborty, Shri M.Y.Totagi, Dr. S.K.Sinha, Dr. (Smt.)I.Joshi, Shri R.B.Sangam, Shri S.D.Dahale, Shri S.K.Jadhav, Smt.R.R.Joshi, Shri S.S.Dugam, Shri Prem Singh, Shri S.D.Bansod, Smt.S.B.Morwal, Shri O.Abraham, Shri S.D.Patil, Shri S.S.Sabade, Shri S.G.Narkhedkar, Shri S.P.Ghanekar, Shri P.D.Safai, Dr. (Kum.) S.S.Nandargi, Shri M.D.Chipade and Shri M.K.R.V.Raja
39.	National Seminar on Environmental Issues and Management, Pt.Ravi Shankar Shukla University, Raipur, 20-22 February 1997.	Shri B.N.Mandal
40.	First WMO International Workshop on Monsoon Studies, Denpasar, Bali Island, Indonesia, 24-28 February 1997.	Dr.H.N.Bhalme
41.	Symposium on Recent Advances in Management of Arid Eco-systems, Central Arid Zone Research Institute, Jodhpur, 3-5 March 1997.	Dr.N.Singh

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5. PAPERS PRESENTED AT SYMPOSIA/SEMINARS/CONFERENCES

1. Advances in atmospheric, hydrographic and vegetation remote sensing with lidar: Devara P.C.S., Raj P.E., Pandithurai G., Maheskumar R.S. and Dani K.K., National Symposium on Remote Sensing for Natural Resources with special emphasis on Water Management, University of Pune and C-DAC, Pune, 4-6 December 1996.

2. Aerosol climatology over Pune observed with collocated lidar and radiometer: Devara P.C.S., Maheskumar R.S., Raj P.E., Pandithurai G. and Dani K.K., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

3. Aerosols in meteorological studies (Invited talk): Devara P.C.S., IASTA Seminar on Aerosols: Generation and Role in Medicine, Industry and Environment, Bhabha Atomic Research Centre, Mumbai, 22-24 January 1997.

4. Application of satellite data in monitoring onset of Indian summer monsoon and agricultural yield: Mujumdar V.R., Puranik P.V., Ghanekar S.P. and Paul D.K., National Symposium on Remote Sensing for Natural Resources with special emphasis on Water Management, University of Pune and C-DAC, Pune, 4-6 December 1996.

5. Application of wavelet transform in the study of onset of Indian summer monsoon: Sathiyamurthy V. and Krishnan R., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

6. Association between solar activity, geomagnetic disturbances and ozone: Joshi I. and Tinmaker M.I.R., Special IAGA Symposium on Geomagnetism in Studies of the Earth's Interior and Electrodynamics of its far Environment, Indian Institute of Geomagnetism, Mumbai, 18-20 November 1996.

7. Association between tropospheric and stratospheric parameters with Indian summer monsoon rainfall: Joshi I. and Tinmaker M.I.R., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

8. Association of low pressure systems with Indian summer monsoon rainfall on weekly time scale: Jadhav S.K. and Bhalme H.N., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

9. Atmospheric monitoring using lidar and radiometric techniques: Maheskumar R.S., Raman Memorial Conference (RMC-96), University of Pune, Pune, 7-8 November 1996.

10. Blocking characteristics and their influence on the summer monsoon over India: Patil S.D., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

11. Chemical modelling of No_x and ozone: Beig G., Indian Ocean Experiment (INDOEX) Workshop, National Physical Laboratory, New Delhi, 19-21 August 1996.

12. Chemistry of wet depositions over different environments in India: Rao P.S.P., Momin G.A., Pillai A.G., Safai P.D. and Naik M.S., International Conference on Acid Deposition in East Asia, National Taiwan University, Taipei, Taiwan, 28-30 May 1996.

13. Climate modelling studies related to ISRO-GBP: Kasture S.V., Thomas B. and Satyan V., Second Workshop on ISRO-GBP Results, Indian Space Research Organisation, Bangalore, 1-2 August 1996.

14. Climate models: an overview in the Indian context: Satyan V., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorology, Pune, 9-13 December 1996.

15. Climate variability: Interannual to dacadal: Soman M.K., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorology, Pune, 9-13 December 1996.

16. Climate variability-interannual to decadal scales: Pant G.B., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorolgoy, Pune, 9-13 December 1996.

17. Climate variability on decadal to century scale: Rupa Kumar K., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorology, Pune, 9-13 December 1996.

18. Climate variations in weekly rainfall of summer monsoon over Indian region: Dahale S.D., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

19. Comparative study of chemical composition of monsoon rainfall over the manipulation zone and the core zone of Nilgiri Biosphere Reserve: Safai P.D., Momin G.A., Rao P.S.P., Pillai A.G., Naik M.S. and Tiwari S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

20. Comparative study of the results of different schemes of objective analysis over Indian region: Narkhedkar S.G. and Rajamani S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

21. Comparisons of winds and vertical motions of MST radar with winds and vertical motions of M-100 rocketsonde data: Joshi I. and Tinmaker M.I.R., Third Users Scientists Workshop on MST Radar Results, National MST Radar Facility, Gadanki, 6-7 February 1997.

22. Concentrations of major ions and their temporal changes in rain water at Delhi: Naik M.S., Momin G.A., Tiwari S., Pillai A.G., Rao P.S.P. and Safai P.D., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore,10-14 February 1997.

23. Decadal scale variability in the mid-tropospheric circulation and its relationship with North Atlantic Oscillation: Dugam S.S. and Verma R.K., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

24. Desertification: a disaster to mankind: Pattnaik D.R., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

25. Detection of low frequency mode in east and west Rajasthan rainfall during last four decades: Kulkarni C.P., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

26. Determination of cloud charge and location of charge center in a thundercloud from surface measurement of the electric field vector: Kamra A.K. and Ravichandran M., 10th International Conference on Atmospheric Electricity, Osaka University, Osaka, Japan, 10-14 June 1996.

27. Development of modern climatology (invited lecture): Bhalme H.N., Conference on Climatology, Arts, Science and Commerce College, Chopda, 2 February 1997.

28. Diagnostic study on upper tropospheric nonlinear energy interaction processes during summer monsoon 1995: Chakraborty D.R. and Agarwal N.K., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

29. Drought and desertification over northwest India in perspectives of earth system climate dynamics:Singh N. and Sontakke N.A., Symposium on Recent Advances in Management of Arid Ecosystems, Central Arid Zone Research Institute, Jodhpur, 3-5 March 1997.

30. Dynamical response of Indian ocean SST to interannually varying surface wind forcing: Behera S.K. and Salvekar P.S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

31. Dynamics of the coldest and highest tropopause in the subtropics: Hingane L.S., First SPARC (Stratospheric Processes and their Role in Climate) General Assembly, Council for Scientific and Industrial Research Organisation, Melbourne, Australia, 2-6 December 1996.

32. ENSO and monsoons: new prespectives: Kripalani R.H., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorology, Pune, 9-13 December 1996.

33. Environmental monitoring system for future development of megacities: Devara P.C.S., Gadgil A., Patwardhan B. and Tillu A.D., IASTA Seminar on Aerosols: Generation and Role in Medicine, Industry and Envioronment, Bhabha Atomic Research Centre, Mumbai, 22-24 January 1997.

34. Error characteristics of the estimated winds at different isobaric levels by using low level

observed winds at 850 hPa in the double Fourier Series surface filling technique : Bavadekar S. N. and Khaladkar R. M., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97). Indian Institute of Science, Bangalore, 10-14 February 1997.

35. Estimation of probable maximum precipitation over peninsular India by generalized approach: Kulkarni B.D. and Nandargi S.S., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

36. Extensive aerosol lidar observations for environmental and climatological studies at IITM, Pune: Devara P.C.S., Raj P.E., Pandithurai G., Maheskumar R.S. and Dani K.K., 18th International Laser Radar Conference (ILRC), Free University, Berlin, Germany, 22-26 July 1996.

37. Floods in India: Dhar O.N. and Nandargi S.S., DST Sponsored Training cum-Field Workshop on Fluvial Geomorphology with special reference to Flood Hydraulics and Dynamics, University of Pune, Pune, 11-20 December 1996.

38. Forcing of greenhouse gases on atmospheric composition and ionisation: Beig G., First SPARC (Stratospheric Processes and their Role in Climate) General Assembly, Council for Scientific and Industrial Research Organisation, Melbourne, Australia, 2-6 December 1996.

39. Fractal dimension of convective clouds in north India: Ali K., Raman Memorial Conference (RMC-96), University of Pune, Pune, 7-8 November 1996.

40. GCM simulations of active and break Indian summer monsoons during El Nino and La Nina phases: Krishnan R., International Workshop on El Nino, Southern Oscillation and Monsoon, International Centre for Theoretical Physics, Trieste, Italy, 15-26 July 1996.

41. GCM simulation of Indian summer monsoon-sensitivity to cumulus convection parameterisation: Vijaya Kumar T.S.V., Mujumdar M. and Krishnan R., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

42. Generation and dissipation of wave energy for the maintenance of the severe cyclonic storm during June 1994: Salvekar P.S., George L. and Singh P., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

43. Global temperature and monsoon activity: Dugam S.S. and Kakade S.B., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

44. Global warming and its impact on tropical cyclones: Dugam S.S., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

45. Identification of self-organised criticality in atmospheric low frequency variability: Joshi R.R. and Selvam A.M., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

46. Impact of convective downdrafts on simulation of summer monsoon: Naga Rathna K., Soman M.K. and Satyan V., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

47. Interannual variability of Indian summer monsoon rainfall in relation to the variability of rainfall over different regions of the global tropics, studied through satellite-derived precipitation estimates: Ghanekar S.P., Mujumdar V.R. and Paul D.K., National Symposium on Remote Sensing for Natural Resources with special emphasis on Water Management, University of Pune and C-DAC, Pune, 4-6 December 1996.

48. Interannual variability of the stratospheric circulation index: Joshi I. and Tinmaker M.I.R., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

49. Intraseasonal variability of rainfall during deficient summer monsoon over India: Sabade S.S. and Dahale S.D., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

50. Intraseasonal Variations of K.E. of lower tropospheric zonal waves during the Northern summer monsoon : Bawiskar S. M. Chipade M. D. and Singh S. S. National symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

51. Laser based network for monitoring of air pollution: Devara P.C.S., Raj P.E. and Tillu A.D., XXIV National Symposium of the Optical Society of India on Optics and Optoelectronics, University of Calcutta, Calcutta, 30 January - 1 February 1997.

52. Lasers and their applications to atmospheric studies (Invited talk): Devara P.C.S., Second Meeting on Current Trends in Optics (Optics-1997), S.N.Bose National Centre for Basic Sciences, Calcutta, 14-17 January 1997.

53. Layered clouds in Indian monsoon region: Asnani G.C., Raja M.K.R.V., Salvekar P.S. and Jain A.R., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

54. Lidar for environmental monitoring: Devara P.C.S., Raj P.E., Pandithurai G., Maheskumar R.S. and Dani K.K., International Conference on Instrumentation (ICI-1996), Indian Institute of Science, Bangalore, 8-10 August 1996.

55. Long-term climate trends: palaeoclimatic data and anthropogenic influences: Rupa Kumar K., Indo-Brazilian Joint Workshop on Climate Research, Indian Institute of Tropical Meteorology, Pune, Pune, 9-13 December 1996.

56. Long-term climate variability over western Himalaya derived from tree-ring analysis: Borgaonkar H.P. and Pant G.B., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

57. Momentum and sensible heat transport by zonal waves during weak and active phases of monsoon: Bawiskar S.M., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

58. Monsoon 1996: some features over India-China region: Kripalani R.H., Mini Workshop on Monsoon-1996, Indian Institute of Tropical Meteorology, Pune, 18 December 1996.

59. Monsoon predictions: Kumar K.K., International Workshop on El Nino, Southern Oscillation and Monsoon, Intrenational Centre for Theoretical Physics, Trieste, Italy, 15-26 July 1996.

60. Monsoon simulation in UKMO-Unified model: sensitivity of SST: Ashrit R., Mandke S.K. and Soman M.K., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

61. Objective analysis by Bratseth's successive correction method: Sinha S.K., Narkhedkar S.G. and Rajamani S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

62. On the annual variations of the tropopause over India: Patil S.D., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

63. On the predictability of Indian summer monsoon using the premonsoon thunderstorm activity over south peninsula: Ghanekar S.P., Puranik P.V., Bhide U.V. and Paul D.K., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

64. Past global changes (Invited lecture): Pant G.B., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

65. Past global changes research in India (Invited lecture): Pant G.B., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

66. Physico-chemical properties of atmospheric aerosols, trace gases in different environments in India: Devara P.C.S., Two day Workshop on Perspectives in Atmospheric Chemistry, Physical Research Laboratory, Ahmedabad, 26-27 December 1996.

67. Possible sources for sulphate in the forest and rural regions of India: Safai P.D., Momin G.A., Rao P.S.P., Pillai A.G., Naik M.S. and Ali K., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneshwar, 15-17 January 1997.

68. Precipitation chemistry study over an industrial region in Bombay: Naik M.S., Momin G.A., Pillai A.G., Rao P.S.P. and Safai P.D., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneshwar, 15-17 January 1997.

69. Predictability of five day rainfall spatial features during summer monsoon over west coast of India: Puranik P.V. Dahale S.D. and Ghanekar S.P., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

70. Prediction of Indian summer monsoon rainfall: a new methodology: Venkatesan C., International Workshop on El Nino, Southern Oscillation and Monsoon, International Centre for Theoretical Physics, Trieste, Italy, 15-26 July 1996.

71. Prediction of only drought years in a decadal time-scale by sunspot numbers as an indicator by superimposition method: Kulkarni C.P., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

72. Probability of occurrence of maximum rainfall in shorter durations at Bangalore: Kulkarni A.K., Mandal B.N. and Sangam R.B., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

73. Radiation budget over Asian monsoon region: ERBE observations and GCM simulations: Rajeevan M., Pai D.S. and Krishnan R., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

74. Relation between Indian summer monsoon and temperature at China: Joshi I. and Tinmaker M.I.R., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

75. Relationship between El Nino/La Nina and Indian summer monsoon rainfall on different spatial scale during 1871-1990: Parthasarathy B. and Rupa Kumar K., International Workshop on El Nino, Southern Oscillation and Monsoon, Intrenational Centre for Theoretical Physics, Trieste, Italy, 15-26 July 1996.

76. Relationship of Indian monsoon rainfall with sea surface temperature over eastern equatorial Pacific and southern oscillation index:Munot A.A. and Kothawale D.R., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

77. Role of circulation at 50 hPa level in the interannual behaviour of the Indian summer monsoon rainfall: Kripalani R.H., Kulkarni A.A. and Inamdar S.R., First SPARC (Stratospheric Processes and their Role in Climate) General Assembly, Council for Scientific and Industrial Research Organisation, Melbourne, Australia, 2-6 December 1996.

78. Satellite derived sea ice extent in northern hemisphere and ENSO: Dugam S.S. and Kakade S.B., National Symposium on Remote Sensing for Natural Resources with special emphasis on Water Management, University of Pune and C-DAC, Pune, 4-6 December 1996.

79. Satellite-observed wind forcing along east African coast during Indian summer monsoon: Mahajan P.N., Chintalu G.R. and Rajamani S., International Conference on Tropical Climatology, Meteorology and Hydrology in Memorium of Bultot, Brussels, Belgium, 22-24 May 1996.

80. Seasonal simulation of monsoon with GCMs using forcasted tropical SSTs as boundary forcing in the Annual Workshop as Monsoon-96: Soman M.K., Mini Workshop on Monsoon-1996, Indian Institute of Tropical Meteorology, Pune, 18 December 1996.

81. Severity of droughts (floods) in relation to their association with El Nino (La Nina): Kripalani R.H., Mini Workshop on Monsoon-1996, Indian Institute of Tropical Meteorology, Pune, 18 December 1996.

82. Signature of inertio-gravity waves in MST radar observations: Asnani G.C., Raja M.K.R.V. and Rao N.D., Third User Scientists Workshop on MST Radar Results, National MST Radar Facility, Gadanki, 6-7 February 1997.

83. Simulation of Madden-Julian oscillation in an aqua planet model: Thomas B., Kasture S.V. and Satyan V., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian

Institute of Science, Bangalore, 10-14 February 1997.

84. Some spectral statistics of tropospheric circulations during contrasting monsoon years over India using NMC data: Totagi M.Y., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

85. Space-time variability of radar C_n^2 and tropopause: Raj P.E., Devara P.C.S., Pandithurai G. and Dani K.K., Third User Scientists Workshop on MST Radar Results, National MST Radar Facility, Gadanki, 6-7 February 1997.

86. Spectral measurements of solar ultraviolet radiation and its relation to atmospheric aerosols and ozone: Devara P.C.S., Mahskumar R.S. and Dani K.K., XXIV National Symposium of the Optical Society of India on Optics and Opto-Electronics, University of Calcutta, Calcutta 30 January - 1 February 1997.

87. Spectral methods in numerical weather prediction (NWP): Pattnaik D.R., Raman Memorial Conference (RMC-96), University of Pune, Pune, 7-8 November 1996.

88. Stratospheric and tropospheric modelling: global change and changing atmospheric composition (Invited talk): Beig G., Two day Workshop on Perspectives in Atmospheric Chemistry, Physical Research Laboratory, Ahmedabad, 26-27 December 1996.

89. Stratospheric zonal wave and temperature in relation to monsoon rainfall over India: Bansod S.D., Prasad K.D. and Singh S.V., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

90. Study of atmospheric columnar water vapour content using multi-channel radiometer at Pune: Maheskumar R.S. and Devara P.C.S., XXIV National Symposium of the Optical Society of India on Optics and Optoelectronics, University of Calcutta, Calcutta, 30 January - 1 February 1997.

91. Study of cloudiness and rainfall through satellite derived data: Panchawagh N.V. and Singh S.V., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

92. Study of convective activity through satellite derived data: Panchawagh N.V. and Dahale S.D., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

93. Study of floods in the Ganga and its sub-basins: Dhar O.N. and Nandargi S.S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

94. Study of interannual and decadal variability of rainfall and temperature along east coast of India: Kothawale D.R., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

95. Study of rainfall frequency relationships for stations over west Madhya Pradesh: Kulkarni A.K., Mandal B.N. and Sangam R.B., National Seminar on Environmental Issues and Management, Pt.Ravi Shankar Shukla University, Raipur, 20-22 February 1997.

96. Study of winds in the coastal zone during contrasting monsoon years: Joshi I. and Tinmaker M.I.R., IGBP Symposium on Changes in Global Climate due to Natural and Human Activities, Regional Research Laboratory, Bhubaneswar, 15-17 January 1997.

97. Summer monsoon low pressure systems over Indian region and their relationship with the subdivisional rainfall: Jadhav S.K. and Bhalme H.N., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

98. Summer monsoon rainfall and outgoing long wave radiation over tropical Asia: a predictive implications: Prasad K.D. and Bansod S.D., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

99. Tree-growth climate relationship and the past climate of Himalayas: Pant G.B., Borgaonkar H.P. and Rupa Kumar K., Workshop on The Role of

Tibetan Plateau in Forcing Global Climatic Changes, Central Institute of Higher Tibetan Study, Dharamshala, 25-31 October 1996.

100. Tropopause over India during the anomalous monsoon situations: Patil S.D., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

101. Understanding the energetics in the north and south zones of severe cyclonic storm: Salvekar P.S., George L. and Singh P., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

102. Universal spectrum for atmospheric interannual variability in global COADS temperature time series: Joshi R.R. and Selvam A.M., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

103. Updraft/downdraft structure in the atmospheric boundary layer over the monsoon trough region: Morwal S.B. and Parasnis S.S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

104. Use of satellite data for radiative energy budget study of Indian summer monsoon: Mahajan P.N., Chintalu G.R. and Rajamani S., National Symposium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

105. Variability of rainfall during deficient summer monsoons over India : Sabade S. S. and Dahale S. D., National Sympusium on Monsoon, Climate and Agriculture (TROPMET-97), Indian Institute of Science, Bangalore, 10-14 February 1997.

106. Vorticity budget of the cyclonic storm during June 1994: George L., Salvekar P.S. and Singh P., National Seminar on Climate Variability and Predictability, Cochin University of Science and Technology, Kochi, 18-19 September 1996.

107. Water resources development (Invited lecture): Kulkarni A.K., Conference on Climatology, Arts, Science and Commerce College, Chopda, 2 February 1997.

108. Whether frequent large scale droughts in Indian monsoon during recent decades are manifestations of natural variability or irreversible climate change: Bhalme H.N., Patwardhan S.K. and Sikder A.B., First WMO International Workshop on Monsoon Studies, Denpasar, Bali Island, Indonesia, 24-28 February 1997.

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6. PARTICIPATION IN MEETINGS

Prof.R.N.Keshavamurty, Director

i) Meeting of the Indo-Russian Sub-Working Group on Meteorology, India Meteorological Department, New Delhi, 15-16 April 1996.

ii) Final Meeting of the Group of Experts on Ocean Atmosphere, Indian Space Research Organisation, Bangalore, 6-10 May 1996.

Dr. A.K. Kamra, Deputy Director, Performing the Current Duties of Director

i) Meeting of ILTP Advisory Committee in the area Theoretical and Applied Mechanics, National Aeronautical Laboratory, Bangalore, 8 July 1996.

ii) 26th Meeting of the Programme Advisory Committee on Atmospheric Sciences, Jawahar Lal Nehru Centre for Advanced Scientific Research, Bangalore, 25 July 1996.

iii) Final Meeting of the Experts on the Ocean Observing Systems and Services, National Aeronautical Laboratory, Bangalore, 7 August 1996.

iv) Meeting of Programme Advisory Committee (PAC) in Atmospheric Sciences, Indian Institute of Science, Bangalore, 14 February 1997.

v) Meeting of CMAS, India Meteorological Department, New Delhi, 2 September 1996 and 13 March 1997.

vi) Co-ordinators' Meeting of Higher Education Links convened by the British Council Division, British Deputy High Commission, Mumbai, 21-22 March 1997.

Dr.G.B.Pant, DD

i) Meeting of Indo-Russian Sub-Working Group on Meteorology, India Meteorological Department, New Delhi, 15-16 April 1996.

ii) Discussion Meeting on the proposed CLIMATSAT under IX plan, Indian Institute of Science/Indian Space Research Organisation, Bangalore, 3-4 June 1996.

iii) Meeting of the Programme Advisory Committee-MONTCLIM, Department of Science and Technolgy, New Delhi, 26 June 1996.

iv) Discussion Meeting - Indian Climate Research Programme, Indian Institute of Technology, New Delhi, 27-28 June 1996.

v) Meeting on Climate Component of Rice Productivity, Indian Institute of Science, Bangalore, 5-6 September 1996.

vi) Indian National Committee on IGBP Project Formulation Meeting on Past Global Change (PAGES), National Institute of Oceanography, Goa, 10-11 September 1996.

vii) NCMRWF Agromet Training Course - Coordinators Meeting, National Centre for Medium Range Weather Forecasting, New Delhi, 6 October 1996.

viii) CLIVAR Meeting, National Institute of Oceanography, Goa, 19—22 November 1996

ix) PAC Meeting of MONTCLIM, CMMACS, National Aeronautical Laboratory, Bangalore, 8 February 1997.

x) Meeting of the Implementation Committee of the Indian Climate Research, Indian Institute of Science, Bangalore, 9 February 1997.

Shri K.G.Vernekar, DD

i) Meeting to discuss IMD Participation in Land Surface Experiment, India Meteorological Department, New Delhi, 11 September 1996.

ii) Steering Committee Meeting of Land Surface Experiment, Department of Science and Technology, New Delhi, 12 September 1996.

iii) First Meeting of the RASS Review Committee, National MST Radar Facility, Tirupati, 26 February 1997.

Dr. S.S.Singh, DD

Meeting on Parallel Processing Computer System (PPS) in India, Department of Science and Technology, New Delhi, 14 May 1996.

Dr. S.Rajamani, DD

Editorial Committee Meeting, CMMACS, National Aeronautical Laboratory, Bangalore, 30 April-3 May 1996.

Dr. P.C.S.Devara, DD

Meeting on RH-200 Data Utilization, Indian Space Research Organisation, Bangalore, 26-27 November 1996.

Dr.V.Satyan, DD

i) Discussion Meeting on the ISRO-GBP Project, Physical Research Laboratory, Ahmedabad, 13-18 May 1996.

ii) Workshop on 9th Plan of DOD Project Proposals in the area of Ocean Dynamics and Modelling, CMMACS, National Aeronautical Laboratory, Bangalore, 28-29 October 1996.

Shri R.K.Verma, AD

Annual Monsoon Review (AMR) Meeting, India Meteorological Centre, Calcutta, 20 January 1997

Dr.(Smt.)P.S.Salvekar, AD

Meeting of Department of Ocean Development (DOD) Working Group on Numerical Weather Prediction Modelling, Centre for Atmospheric Sciences Indian Institute of Science, Bangalore, 30 April 1996.

Dr.D.B.Jadhav, AD

Meeting on DOD Expert Committee Working Group on Atmospheric Sciences and Aeronomy, Physical Research Laboratory, Ahmedabad, 29 January 1997.

Dr.S.S.Parasnis, AD

Meeting for the Planning of PU-ISRO interaction to discuss the interaction programme with the faculty members, University of Pune, Pune, 27 November 1997.

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7. SEMINARS

Sr. No.	Name	Topic	Date
1.	Shri D.R.Kothawale, SSA, IITM	Probabilities of excess and deficient southwest monsoon rainfall over different meteorological subdivisions of India.	3 April 1996
2.	Shri P.S.Mukhopadhyay, SSA, IITM	Basic principles of spectral techniques, method of simulation of non-linear differential equation using spherical harmonics (10 lectures)	8 April - 15 May 1996
3.	Dr.(Smt.)A.A.Kulkarni, JSO, IITM	Classification with Fuzzy C-means method : Rainfall pattern over India	8 May 1996
4.	Shri S.D.Pawar, JSO, IITM	Comparative measurements of the atmospheric electric space charge density made with the Filteration and Faraday Cage techniques	17 May 1996
5.	Shri V.Gopalakrishnan, JSO, IITM	Measurement of atmospheric electric field and conductivity in the gas well blowout	22 May 1996
6.	Shri S.Mahapatra, JSO, IITM	Spectral methods, fast fourier transformation and Gaussian quadrature (12 lectures)	28 May - 28 June 1996
7.	Shri R.Vijayakumar, AD, IITM	Structure of monsoon clouds	5 June 1996
8.	Dr.P.C.S.Devara, DD, IITM	Role of aerosols in monsoon clouds and rainfall : Observational evidence	18 June 1996
		Highlights of the 18th International Laser Radar Conference, Berlin, Germany, 22-26 July 1996.	30 September 1996
9.	Shri A.Bandyopadhyay, SSO II, IITM	Semi-Lagrangian semi-implicit schemes of time integration.	24 August and 4 September 1996.
10.	Dr.David Blaskovich, Sr.Director, Environmental Systems, Silicon Graphics Cray Research, USA	Supercomputers for environmental applications	17 September 1996

Sr. No.	Name	Topic	Date
11.	Dr.P.N.Mahajan, SSO I, IITM	Remote sensing and its application in climate study	10 October 1996
12.	Dr.S.K.Sinha, SSO II, IITM	Objective analysis over Indian region by Bratseth's successive correction method	29 October 1996
13.	Prof.R.Sadourny, Director, Laboratoire de Meteorologie Dynamique, Paris, France	Monsoon modelling at Laboratoire de Meteorologie Dynamique	13 November 1996
14.	Prof.Julian Hunt, Chief Executive, U.K.Meteorological Office, London, U.K.	Development in numerical prediction of weather and climate	9 January 1997
15.	Shri J.R.Kulkarni, SSO I, IITM	Studies of monsoon variability using wavelet transforms Part I: Interannual to climate scales	7 February 1997

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8. ACADEMIC ACTIVITIES

The Institute encourages its scientiists to collaborate with the Universities and other Institutions in promoting Academic Programmes. Following scientists delivered lectures for the students undergoing courses of M.Sc./M.Tech.(Atmospheric Sciences) at the University of Pune, Pune:

Scientist	Topic
Shri K.G.Vernekar, DD	Atmospheric boundary layer
Dr.S.Rajamani, DD	i) General circulation ii) NWP and Climate Modelling
Dr.(Smt.)P.S.Salvekar, AD	i) Advanced dynamic meteorology and numerical modelling ii) General circulation and laboratory simulation studies
Shri D.K.Paul, SSO I	Climatology
Dr.R.H.Kripalani, SSO I	Application of statistics to meteorology
Shri M. K. Tandon, SSO I	Principles of Programming Languages (C++)
Shri S.K.Behera, SSO I	i) Climate modelling ii) Ocean dynamics
Dr. (Kum.) P. L. Kulkarni, SSO II	Initialization
Smt.S.K.Mandke, JSO	Energy balance and radiative corrective models

The Institute also provides guidance, laboratory, computing and library facilities to the students of B.Sc., M.Sc., M.Tech., Ph.D. etc. of different universities for their research projects. The details of guidance provided during the year are given below :

Supervisor	Student	Course	University/College
Dr.S.S.Singh, DD	Kum.N.K.Gopal	M.Tech.	Cochin University of Science and Technology, Kochi
Dr.P.C.S.Devara, DD	Shri P.V.Subba Raju	M.Tech.	Andhra University, Visakhapatnam
	Kum.V.V.Vaidya	M.Sc.	University of Pune, Pune
	Kum.S.P.Joshi	M.Sc.	University of Pune, Pune
Dr.V.Satyan,DD	Shri K.Naga Rathna	M.Tech.	Andhra University, Visakhapatnam
	Shri K.Satheesan	M.Tech.	Andhra University, Visakhapatnam
Shri S.Sivaramakrishnan, AD	Shri S.Raghunath	M.Sc.	University of Pune, Pune
Dr.D.B.Jadhav, AD	Kum A.A.Kulkarni	M.Sc.	Fergusson College, Pune
	Shri S.H.Thigale	M.Sc.	Fergusson College, Pune
	Shri G.M.Prabhudesai	M.Sc.	Fergusson College, Pune

Supervisor	Student	Course	University/College
Dr.K.Rupa Kumar,AD	Smt.L.Umamaheswari	Ph.D.	Tamil Nadu Agricultural University, Coimbatore
Dr.M.K.Soman, AD	Shri R.Ashrit	M.Tech.	Andhra University, Visakhapatnam
Dr.R.Krishnan, AD	Shri T.S.V. Vijayakumar	M.Tech.	Andhra University, Visakhapatnam
Shri J.R.Kulkarni, SSO I	Shri R.S.Hooda	M.Sc.	Kurukshetra University, Kurukshetra
Shri C.P. Kulkarni, SSO II	Kum.S.C.Kulkarni	B.Sc.	Sir Parshuram Bhau College, Pune
Shri S.D.Pawar, JSO	Kum.V.Deshpande	B.Sc.	N.M.Wadia College, Pune

The Scientists of the Institute are encouraged to provide their expertise for the M.Sc., M.Tech. and Ph.D(Atmospheric Sciences) Degree examinations. The following scientists worked as External Examiners/ Paper Setters for different Universities and Institutions:

Scientist	Degree	University/Institution
Dr. A. K. Kamra, DD	M.Sc.	Cochin University of Science and echnology, Kochi
Dr.A.S.R.Murty, DD	M.Sc., Ph.D.	Andhra University, Visakhapatnam
Dr.S.Rajamani, DD	M.Tech.	Cochin University of Science and Technology, Kochi
Dr.(Smt.)A.M.Selvam, DD	M.Sc.	Andhra University, Visakhapatnam
Dr.P.C.S.Devara, DD	M.Sc.	University of Pune, Pune
Dr.V.Satyan, DD	Ph.D.	Shri Venkateshwara University, Tirupati
Dr.(Smt.)P.S.Salvekar, AD	M.Tech./M.Sc.	University of Pune, Pune
	M.Tech.	Cochin University of Science and Technology, Kochi
Dr.S.Sivaramakrishnan, AD	M.Tech/M.Sc.	University of Pune, Pune
Dr.D.B.Jadhav, AD	M.Sc.	University of Pune, Pune
Dr.K.Rupa Kumar, AD	Ph.D.	Tamil Nadu Agricultural University, Coimbatore
Shri R.Vijayakumar, AD	M.Sc.	University of Pune, Pune
Dr.S.S.Parasnis, AD	M.Tech.	University of Pune, Pune
Dr.R.H.Kripalani, SSO I	M.Tech.	University of Pune, Pune
Dr.P.N.Mahajan, SSO I	Phase 'A' Trainee Meteorologist, Gr.II	India Meteorological Department, Pune
Shri S.K.Behera, SSO I	M.Tech.	University of Pune, Pune
Dr. (Smt.) A.A.Kulkarni, JSO	M.Tech.	University of Pune, Pune

The Institute encourages its scientists to pursue higher studies in Atmospheric Sciences and allied subjects. The following scientists have completed their work of M.Sc. and Ph.D. Degrees in Physics and submitted their theses to the University of Pune, Pune :

Name	Research Guide	Degree	Thesis
Shri H.P. Borgaonkar, JSO	Dr.G.B.Pant, DD	Ph.D.	Tree growth - Climate relationship and long-term climate change over the western Himalaya : A dendroclimatic approach.
Shri S. Sivaramakrishnan, AD	Prof.R.N. Keshavamurty, Director	Ph.D.	Studies on the exchange processes in the convective atmospheric boundary layer in the monsoon trough region.
Shri J.K.Sahu, Air India Research Fellow	Dr.S.V.Singh, Ex- DD and Prof.G.C.Asnani Hon.Fellow	Ph.D.	Some thermodynamical and forecasting aspects of local severe storms over northwest India.
Smt.N.A.Sontakke, SSO II	Dr.G.B.Pant, DD	Ph.D.	Study of climatic variations and climate monitoring over India and neighbourhood.
*Kum.P.L.Kulkarni, SSO II	Dr.S.Rajamani, DD	Ph.D.	On the estimation of divergent wind from OLR data and its inclusion in objective analysis for Numerical Weather Prediction.
Smt.S.B.Morwal, JSO	Dr.S.S.Parasnis, AD	Ph.D.	Nature and some evolutionary aspects of the monsoon boundary layer.
Shri R.Vijayakumar, AD	Dr.A.S.R.Murty, DD	Ph.D.	Numerical simulation of the microphysical processes in monsoon clouds.
Shri P.S.P.Rao, SSO II	Dr.P.C.S. Devara, DD	Ph.D.	Some studies on the depositions of atmospheric pollutants in different environments in India.
*Kum.U.Iyer, SA.	Dr.S.S.Singh, DD	M.Sc.	Prediction experiments with a limited area model.
*Smt.J.V.Revadekar, SA.	Dr.G.B.Pant, DD	M.Sc.	A diagnostic study of GCM simulation of Indian monsoon and its interannual variability.

* Degree conferred.

Kum.S.S.Nandargi, SA has been awarded Ph.D. degree in Environmental Science by the University of Pune, Pune for her thesis entitled, 'Rainstorm studies for planning and development of water resources of the Indian region' under the guidance of Dr.O.N.Dhar, Emeritus Scientist, IITM and Dr.(Smt.) A.Gadgil, University of Pune, Pune.

Scientists of the Institute provide their expertise to various scientific committees. Following scientists have been nominated as members of different committees:

Scientists		Membership of
Dr.G.B.Pant, DD	i)	Scientific Steering Committee of the Past Global Changes (PAGES), a Core Project of IGBP.
	ii)	Steering Committee of START - SASCOM, a South Asian Regional Programme of START (a project of WCRP, IGBP, HDP).
	iii)	CLIMAT SAT (Climatological Satellite) Programme Definition Group, Indian Space Research Organisation.
	iv)	Project Advisory and Monitoring Committee, Monsoon and Tropical Climate (MONTCLIM), Department of Science and Technology.
	v)	Action Plan Committee for the Indian Climate Research Programme (ICRP), Department of Science and Technology.
Dr.P.C.S.Devara, DD	i)	Executive Committee of the International Commission on Cloud Physics (ICCP).
	ii)	Executive Council of the Optical Society of India (OSI).
	iii)	Indian Society of Remote Sensing (ISRS), Dehradun.
Shri M.K.Tandon, SSO I		Nomination Committee of the Pune Chapter of Computer Society of India.

Scientists of the Institute provide their expertise as faculties for different trainings, held at the Insitute and at other organisations/universities. On invitation, scientists delivered lectures for the following trainings:

Trainings	Scientists
Third SERC School on Advanced Geophysical Fluid Dynamics with special emphasis on Dynamics of Monsoon - Observations, Theory and Modelling, IITM, Pune, 21 May-22 June 1996.	Prof.G.C.Asnani, Hon.Fellow, Prof.R.N.Keshavamurty, Director, Dr.A.K.Kamra, DD, Dr.G.B.Pant, DD, Shri K.G.Vernekar, DD, Dr.S.S.Singh, DD, Dr.H.N.Bhalme, DD, Dr.S.Rajamani, DD, Dr.P.C.S.Devara, DD, Dr.P.R.Rakhecha, DD, Dr.V.Satyan, DD, Shri R.K.Verma, AD, Dr.(Smt.)P.S.Salvekar, AD, Dr.K.Rupakumar, AD, Shri R.Vijayakumar, AD, Dr.M.K.Soman, AD, Dr.R.Krishnan, AD, Dr.N.Singh, AD, Shri D.K.Paul, SSO I, Dr.R.H.Kripalani, SSO I, Smt.S.S.Vaidya, SSO I, Shri J.R.Kulkarni, SSO I Shri D.R.Chakraborty, SSO II, Shri K.K.Kumar, SSO II, Shri S.P.Gharge, STO II and Smt.M.K.Mandke, JSO

Trainings	Scientists
Orientation Course in Climatology (1996) for Geographers, jointly organised by the Deccan Geographical Society and the IITM, 8-10 October 1996.	Dr.G.B.Pant, DD, Dr.H.N.Bhalme, DD, Shri R.K.Verma, AD, Dr.K.Rupakumar, AD, Dr.N.Singh, AD, Dr.S.S.Parasnis, AD, Dr.P.N.Mahajan, SSO I and Shri K.K.Kumar, SSO II
Short-term Training Course on Agrometeorology for the Nodal Scientists of National Centre for Medium Range Weather Forecasting, IITM, Pune, 23 December 1996 - 6 January 1997.	Prof.G.C.Asnani, Hon.Fellow, Dr.G.B.Pant, DD, Shri R.K.Verma, AD, Dr.A.K.Kulkarni, AD, Dr.K.Rupakumar, AD, Dr.N.Singh, AD, Dr.R.H.Kripalani, SSO I and Shri J.R.Kulkarni, SSO I
UGC Refresher Course on Environmental Education, University of Pune, Pune, 4-29 January 1997.	Dr.G.B.Pant, DD and Dr.A.K.Kulkarni, AD
ICAR, CASM Refresher Course on Agrometeorology, College of Agriculture, Pune, 7 February 1997.	Dr.G.B.Pant, DD
Refresher Course on Operational Techniques on Agrometeorology, India Meteorological Department, Pune, 24 February-7 March 1997.	Dr.H.N.Bhalme, DD, Dr.A.K.Kulkarni, AD and Dr.K.Rupakumar, AD

The Institute encourages its scientists to undergo training in advanced research techniques. Under this programme following scientists participated in different training programmes:

Name	Training Programme
Smt.N.R.Deshpande, JSO, Smt.S.K.Patwardhan, JSO, Smt.S.R.Inamdar, SSA, Shri R.S.K.Singh, SSA, Smt.A.A.Deo, SSA, Shri S.De, SSA, Shri M.N.Patil, SA and Shri V.Sathiyamoorthy, Research Fellow	Third SERC School on Advanced Geophysical Fluid Dynamics with special emphasis on Dynamics of Monsoon- Observations, Theory and Modelling, IITM, Pune, 21 May-22 June 1996.
Shri O.Abraham, JTO	Object Oriented Programming Language using C++, Computer Society of India, 1 July -27 December 1996.

Name	Trainings
Shri M.N.Patil, SA, Shri S. Arul Raj, Project Associate, Shri M.A.Vittal, Project Associate and Shri C.H.Kulkarni, Project Associate	Training for Low Level Radiosonde Ascents, India Meteorological Department, New Delhi, 20-27 September 1996.
Shri R.M.Khaladkar, JSO	Advanced Refresher course on Aviation Meteorology, India Meteorological Department, Pune, 18-23 November 1996.
Shri S.B.Kakade, SSA	Intensive Course in Use of Statistical Methods in Weather Analysis and Prediction, Centre of Atmospheric Sciences, New Delhi, 2-21 December 1996.
Kum.P.L.Kulkarni, SSO II	Appraisal Course on Application of Remote Sensing, National Remote Sensing Agency, Hyderabad, 3-8 February 1997.
Shri S.Sudarsanam, STA	Intensive Course on Object Oriented Programming and Artificial Neural Networks, Physical Research Laboratory, Ahmedabad, 20-28 February 1997.

On invitation, following scientists delivered lectures on different topics of Atmospheric Sciences, at the other Organisations, Institutes and Universities:

Scientist	Topic	Date	Venue
Dr.(Smt.)P.S.Salvekar, AD	i) Basics of atmospheric science and its applications. (In English and Marathi)	19 April and 9 May 1996	Agharkar Research Institute, Pune
	ii) NWP models for meso-scale forecasting.	26 April 1996	India Meteorological Department, Pune
Dr.S.S.Singh, DD	Synoptic-mesoscale interaction CISK mechanism.	25 April 1996	India Meteorological Department, Pune
Shri A.Bandyopadhyay, SSO II	Boundary layer structure of tropical cyclone.	25 April 1996	India Meteorological Department, Pune
Dr.P.N.Mahajan, SSO I	i) Use of geostationary data for better depiction of monsoon circulation over the Indian region.	2 May 1996	Bristol University, U.K.
	ii) Application of satellite data for monsoon studies over the Indian region.	10 September 1996	Hadley Centre for Climate Prediction and Research, Bracknell, U.K.

Scientist	Topic	Date	Venue
Shri S.K.Behera, SSO I	Simulation of upper layer circulation in Indian Ocean and model simulated mixed layer response to a tropical cyclone.	10 May 1996	International Centre for Theoretical Physics, Italy
Dr.P.C.S.Devara, DD.	i) Lidar sounding of boundary-layer aerosol.	29 July 1996 1996	German Research Establishment (DLR), Wessling, Germany
	ii) Lidar activity in India.	30 July 1996	Meteorological Institute, Munich University (MIM), Germany
Dr.P.R.Rakhecha, DD	Hydrometeorology of south east Asian monsoon region including techniques for design rainfall.	1-28 September 1996	Department of Resources Engineering, Lund University, Sweden
Prof.G.C.Asnani, Hon.Fellow	Monsoon.	9 and 10 October 1996	Air Force Administrative College, Coimbatore
Dr.S.S.Parasnis, AD	Some aspects of convective boundary layer.	18 November 1996	Jadavpur University, Calcutta
	Saturation point analysis, concepts and formulations.	19 November 1996	
	Mixing line approaches for the studies of convective boundary layer.	19 November 1996	
	Dynamical aspects of convective boundary layer, Part I: conserved variable analysis.	20 November 1996	
	Dynamical aspects of convective boundary layer, Part 2:buoyancy consideration.	20 November 1996	
	Applications of SP analysis to different convective regimes.	21 November 1996	

Scientist	Topic	Date	Venue
	Responses of tropical convective boundary layer to different weather conditions.	21 November 1996	
	Marine boundary layer as revealed by monsoon experiments.	22 November 1996	
	Characteristics of convective boundary layer in monsoon trough regions.	22 November 1996	
	Atmospheric boundary layer modelling using land surface processes	20 February 1997	Indian Institute of Technology, New Delhi
Dr.A.K.Kulkarni, AD	Characteristics of Indian monsoon and India's water resources.	21 February 1997	Geography Department, Sir Parashuram Bhau College, Pune

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9. DEPUTATION ABROAD

Sr. No.	Name	Country	Period	Purpose
1.	Dr.P.N.Mahajan, SSO I	U.K.	15 March-14 September 1996	Participation in a training in Climate Change, University of Bristol.
2.	Shri S.K.Behera, SSO I and Shri J.V.Ratnam, IITM Research Fellow	Italy	22 April-10 May 1996	Participation in the Course on Geophysical Fluid Dynamics, Trieste.
3.	Shri A.G.Pillai, SSO I	Sweden	2-11 May 1996	Participation in the Workshop on Meteorology, Stockholm.
4.	Dr.H.N.Bhalme, DD	Switzerland	22-31 May 1996	Participation in the Meeting of Experts on CLIPS, 22-24 May 1996 and 2nd Session of WMO Commission on Climatology Working Group on Operational Use of Climatological Knowledge, 28-31 May 1996.
		Indonesia	24-28 February 1997	Participation in the First WMO International Workshop on Monsoon Studies, Bali Island.
5.	Shri P.S.P.Rao, SSO II	Taiwan	28-30 May 1996	Participation in the International Conference on Acid Deposition in East Asia, Taipei.
6.	Dr.A.K.Kamra, DD	Japan	10-14 June 1996	Participation in the 10th International Conference on Atmospheric Electricity, Osaka.
7.	Dr.K.Rupa Kumar, AD, Dr.R.Krishnan, AD, Shri K.K.Kumar, SSO II, Shri S.Tiwari, SA and Shri C. Venkatesan, IITM Research Fellow	Italy	15-26 July 1996	Participation in the Workshop on EL Nino Southern Oscillation and Monsoon, Trieste.

Sr. No.	Name	Country	Period	Purpose
8.	Dr.P.C.S.Devara, DD	Germany	22-30 July 1996	Participation in the 18th International Laser Radar Conference (ILRC), Berlin and visit to the Lidar laboratories at German Aerospace Research Establishment, Wessling and to the Meteorological Institute, University of Munich.
9.	Dr.P.R.Rakhecha, DD	Sweden	1-30 September 1996	As a Visiting Researcher to the Department of Water Resources Engineering, Lund University.
		Switzerland	1-4 October 1996	Exchange of research experiences in Hydrometeorology with the Department of Atmospheric Physics, ETH, Zurich.
10.	Dr.L.S.Hingane, AD, Dr.R.H.Kripalani, SSO I and Dr.G.Beig, SSO I	Australia	2-6 December 1996	Participation in the First SPARC (Stratospheric Processes and their role in Climate) General Assembly, Melbourne.
11.	Shri C.G. Deshpande, SSA	Antarctica	6 December 1996 - 15 March 1997	Participation in the XVI Indian Scientific Expeditiion to Antarctica.
12.	Dr.M.K.Soman, AD	U.K.	1 March- 31 August 1997	Visit to Hadley Centre under the IITM-Hadley centre HE Link Programme sponsored by the British Council.
13.	Dr.G.B.Pant, DD	Peoples Republic of China	5-7 March 1997	Participation as a Member of the Indian Delegation to China for Signing the Memorandum of Understanding between India and China on Co-operation in the Field of Meteorological Sciences and Technology.
		Republic of South Africa	14-17 March 1997	Participation in the Scientific Steering Committee Meeting of the Past Global Changes (PAGES) Programme, a Core Project of IGBP, Cape Town and Stellenbosch.

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10. VISITORS

Sr. No.	Visitor	Date(s)
	International	
1.	Three Russian scientists under Indo-Russian Working Group, Russia.	18 April 1996
2.	Dr.David Blaskovich, Senior Director, Environmental Systems, Silicon Graphics Cray Research, U.S.A.	17 September 1996
3.	Prof.R.Sadourny, Director, Laboratoire de Meteorologie Dynamique, Paris, France.	13 November 1996
4.	Prof.Julian Hunt, Chief Executive, U.K.Meteorological Office, London, U.K.	8-9 January 1997
5.	Dr.L. Granat, Associate Professor of Meteorology, Stockholm University, Sweden.	19-21 January 1997
6.	Dr.Edward R.Cook, Senior Research Scientist, Lamont-Doherty Earth Observatory, Columbia University, New York, U.S.A.	31 March - 2 April 1997
	National	
1.	Batch of Post Graduate Medical students, Department of Preventive and Social Medicine, B.J.Medical College, Pune.	2 May 1996
2.	Batch of Post Graduate students in Meteorology, Department of Atmospheric Sciences, Cochin University of Science and Technology, Kochi.	24 May 1996
3.	Shri S.Sethurathinam, Chief Engineer, Shri P.R.Datta Roy, Consultant and Shri S. Singal, Engineer, Water and Power Consultancy Services, New Delhi.	8 August 1996

Sr. No.	Visitor	Date(s)
4.	A batch of students, Rishi Valley School, Chittor.	13 September 1996.
5.	Prof.K.N.Iyer, Department of Physics, Saurashtra University, Rajkot.	27-28 September 1996
6.	Shri P.K.Dutta Roy, Consultant and Shri S.Singal, Engineer, Water and Power Consultancy Services, New Delhi.	1 October 1996
7.	Dr.M.B.Potdar, Dr.S.Manjul and Shri S.K.Sharma, Scientists, Space Application Centre, Ahmedabad.	20-22 October 1996
8.	A group of Naval Meteorological Observers (I Class) Sailors, School of Naval Oceanography and Meteorology, Kochi.	20 December 1996
9.	Dr.M.B.Potdar and Shri S.K.Sharma, Scientists, Space Application Centre, Ahmedabad.	30 December 1996- 1 January 1997
10.	Dr.S.Manjul and Shri S.K.Sharma, Scientists, Space Application Centre, Ahmedabad.	12-14 March 1997
11.	Prof.M.L.Sukhdeve and Prof.K.Thrideep Kumar, Reserve Bank of India, College of Agricultural Banking, Pune.	13 March 1997
12.	Team of Student Officers Air Force Administrative College Coimbature.	17 March 1997
13.	Team of Trainee Assistant Directors, Central Water and Power Research Station Pune.	21 March 1997

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AUDITED STATEMENTS OF ACCOUNTS

S. G. GUPTE
CHARTERED ACCOUNTANTS

Adhar Building 3rd Floor,
305,Narayan Peth, Opp.Vijay Talkies,
Off. Laxmi Road, PUNE 411 030.
Tel. No. - 451998

Date : 2.9.1997.

Director,
Indian Institute of Tropical Meteorology,
Pashan, Pune 411 008.

Sub. : Verification of Accounts for the financial year ended on 31st March, 1997.

Dear Sir,

We have verified the books of accounts of the Institute for the year ended on 31st March, 1997 and have to state that the enclosed Income & Expenditure Account for the year ended on 31st March, 1997 and Balance Sheet as on that date are in agreement with the books of accounts which were produced before us. Our comments and suggestions thereon are as under :

1. LAND DISPUTE WITH NATIONAL CHEMICAL LABORATORY, PUNE

It has been revealed from the records that National Chemical Laboratory , Pashan, Pune -8 has encroached on land of about 2.5 acres belonging to IITM, Pashan, which they personify that the said land belongs to them as the disputed land in question has already been accounted for in the books of IITM, Pashan, Pune-8.

2. ARBITRATION CASE

The work of the construction of A.B.C. type quarters (8 Nos each) including supply of water and sanitary provisions was assigned by CPWD to M/s Naidu & Company who has given up the work in the half-way stage. The CPWD has requested the Director, IITM, Pashan, Pune-8 to deposit a sum of Rs,3,48,345.03 to settle the above issue, vide their letter under no AB/Deposit/89/PCD/89 dated 26th May, 1992, and the said payment has been made on 31st March, 1992 to CPWD has informed the Director, IITM, Pashan, Pune- 411 008, that an arbitration case has been filed and amount if received from M/s Naidu & Co would returned to IITM Pashan, Pune-8. Follow-up with the CPWD authorities should be strengthened.

3. FIXED ASSETS

Physical verification report of the Committee, pertaining to the year 1995-96 was produced to us. A number of articles are reported as "Not available for verification/Missing". No reconciliation has yet been done . Report for the year 1996-97 is awaited.

4. STORES

(a) As was already pointed out in our report of the previous year, it is observed that the person who is in control of stores is also looking after purchase of stores. It is advisable to assign these two functions to two different individuals.

(b) Closing stock of stores include "Non-moving items". Few items are carried since last 8 to 10 years. The value has eroded due to various factors and is practically as good as scrap. Hence, it should be valued accordingly.

We are thankful to Dr.A.K.Kamra, Deputy Director (Performing Current duties of Director), Mr. B.Y.Gaikwad, Accounts Officer and members of the staff of the Institute for rendering us all possible co-operation in conduct of our audit.

We assure you of our best professional services at all time to come.

Yours faithfully,

Sd/-
(S.G.Gupte)

STATEMENT SHOWING INCOME & EXPENDITURE OF THE YEAR ENDED ON 31ST MARCH, 1997

Previous Year Rs. Ps.	Expenditure	Plan Rs. Ps.	Non-Plan Rs. Ps.	TOTAL Rs. Ps.	Previous Year Rs. Ps.	Income	Plan Rs. Ps.	Non-Plan Rs. Ps.	TOTAL Rs. Ps.
2,39,07,946.00	Payment & Provision for Employees'. Remuneration (Annexure 'C)	27,38,194.15	2,47,68,921.25	2,75,07,115.40	2,99,76,000.00	Maintenance Grant from Central Government.	71,62,000.00	2,50,00,000.00	3,21,62,000.00
					13,93,345.60	Interest (Annexure 'A')	—	9,25,456.61	9,25,456.61
43,77,403.91	Administrative Expenses (Annexure 'D')	36,37,091.88	60,000.00	36,97,091.88					
					1,37,302.05	Income from other Sources (Annexure 'B')	—	2,11,401.78	2,11,401.78
18,29,958.30	Repairs & Maintenance (Annexure 'E')	33,96,091.59		33,96,091.59					
						Income from sale of :			
39,294.11	Staff Welfare Expenses (Annexure 'F')	32,440.85		32,440.85	24,495.00	(i) Rainstorm Atlas	—	6,500.00	6,500.00
						(ii) PMP Atlas			
42,321.00	Honorarium (Annexure 'G')	8,800.00		8,800.00					
					—	Excess of Expenditure over Income	—	21,42,657.29	21,42,657.29
3,75,656.75	Consumption of Misc. Stores	8,06,475.96		8,06,475.96					
9,58,562.58	Excess of Income over Expenditure.	—	—	—					
3,15,31,142.65	**TOTAL**	**1,06,19,094.43**	**2,48,28,921.25**	**3,54,48,015.68**					
					3,15,31,142.65	**TOTAL**	**71,62,000.00**	**2,82,86,015.68**	**3,54,48,015.68**

For Indian Institute of Tropical Meteorology, Pune

Sd/-
Accounts Officer

Sd/-
Director

For S. G. Gupte Associates
Chartered Accountants

Sd/-
(S. G. Gupte)
Membership No. 30563

2 September 1997

Schedule to and forming part of Income and Expenditure A/C.

(Annexure 'A') : INTEREST

Sr. No.	Income Head	Plan	Non-Plan Rs.	Ps.	Total Rs.	Ps.
1.	Int. on advance paid to Staff	—	1,64,680.00		1,64,680.00	
2.	Penal Interest	—	529.00		529.00	
3.	Fixed Deposit with Bank	—	7,60,247.61		7,60,247.61	
	TOTAL	**—**	**9,25,456.61**		**9,25,456.61**	

(Annexure 'B') : INCOME FROM OTHER SOURCES

1.	Misc. Receipt	—	26,225.78		26,225.78	
2.	Licence Fees	—	1,33,738.00		1,33,738.00	
3.	Water Charges	—	33,906.00		33,906.00	
4.	Leave Salary Contribution	—	17,532.00		17,532.00	
	TOTAL	**—**	**2,11,401.78**		**2,11,401.78**	

(Annexure 'C') : DETAILS OF PAY & ALLOWANCES

Sr. No.	Expenditure Head	Plan Rs.	Ps.	Non-Plan Rs.	Ps.	Total Rs.	Ps.
1.	Pay	1,31,536.00		81,57,953.00		82,89,489.00	
2.	Dearness Allowance	1,99,145.00		1,20,11,625.00		1,22,10,770.00	
3.	City Comp. Allowance	4,101.00		2,72,634.00		2,76,735.00	
4.	House Rent Allowance	13,131.00		12,26,420.00		12,39,551.00	
5.	Bonus	—		3,02,833.00		3,02,833.00	
6.	Tuition Fees	—		20,758.00		20,758.00	
7.	Overtime Allowance	—		8,651.00		8,651.00	
8.	E.P.F. Contribution	—		37,248.00		37,248.00	
9.	Contribution to Pension Fund	—		5,68,941.00		5,68,941.00	
10.	L.T.C. Expenses	2,08,396.00		—		2,08,396.00	
11.	Medical Expenses	6,12,883.15		—		6,12,883.15	
12.	Research Fellowship	2,49,863.00		—		2,49,863.00	
13.	Expenditure on G. C. Meeting	24,394.00		—		24,394.00	
14.	Capitalised Value of Pension and D.C.R.G	12,23,665.00		—		12,23,665.00	
15.	Reimbursement of Deficit on G.P.F. A/c.	—		1,20,028.25		1,20,028.25	
16.	Contribution to Benevolent Fund	18,300.00		—		18,300.00	
17.	I.R. (I)	4,101.00		3,46,773.00		3,50,874.00	
18.	I.R. (II)	13,109.00		7,89,304.00		8,02,413.00	
19.	I.R. (III)	12,409.00		7,87,984.00		8,00,393.00	
20.	Research Asso.	20,238.00		—		20,238.00	
21.	Pension Contribution	2,923.00		—		2,923.00	
22.	Gratuity	—		1,17,769.00		1,17,769.00	
	TOTAL	**27,38,194.15**		**2,47,68,921.25**		**2,75,07,115.40**	

Schedule to and forming part of Income and Expenditure A/C.

(Annexure 'D') : ADMINISTRATIVE EXPENSES

Sr. No.	Expenditure Head	Plan Rs.	Plan Ps.	Non—Plan Rs.	Non—Plan Ps.	Total Rs.	Total Ps.
1.	Postage	87,010.00		—		87,010.00	
2.	Printing charges	1,24,127.65		—		1,24,127.65	
3.	Stationery charges	1,18,876.46		—		1,18,876.46	
4.	Entertainment Charges	18,449.75		—		18,449.75	
5.	Audit Fees	6,000.00		—		6,000.00	
6.	Advertisement Charges	13,305.00		—		13,305.00	
7.	Telephone Charges	3,00,998.85		—		3,00,998.85	
8.	Travelling & Conveyance	3,37,219.65		60,000.00		3,97,219.65	
9.	Misc. Expenses (including Washing Allowance)	92,251.83		—		92,251.83	
10.	Wages of Mazdoors.	1,54,478.40		—		1,54,478.40	
11.	Water Charges	9,429.00		—		9,429.00	
12.	Taxes	3,13,472.00		—		3,13,472.00	
13.	Security Arrangements	38,666.00		—		38,666.00	
14.	Contribution to Symposium	55,000.00		—		55,000.00	
15.	Horticultural Programme	1,38,689.40		—		1,38,689.40	
16.	Cost of Reprints	1,93,421.00		—		1,93,421.00	
17.	Cost of Journals	1,94,000.00		—		1,94,000.00	
18.	TA outside India	1,52,191.55		—		1,52,191.55	
19.	E—Mail Charges	1,00,000.00		—		1,00,000.00	
20.	Electricity Charges	10,78,997.84		—		10,78,997.84	
21.	Legal Charges	12,000.00		—		12,000.00	
22.	Antarctica Experiments	89,407.50		—		89,407.50	
23.	Data Charges	9,100.00		—		9,100.00	
	TOTAL	**36,37,091.88**		**60,000.00**		**36,97,091.88**	

(Annexure 'E') : REPAIRS & MAINTENANCE

Sr. No.	Expenditure Head	Plan Rs.	Plan Ps.	Non-Plan Rs.	Non-Plan Ps.	Total Rs.	Total Ps.
1.	Office Vehicle	52,286.00		—		52,286.00	
2.	Office Equipment	2,39,639.50		—		2,39,639.50	
3.	Minor Works & Repairs	8,02,433.00		—		8,02,433.00	
4.	Office Building : Civil	8,45,576.00		—		8,45,576.00	
5.	Maintenance of Computer	14,04,200.00		—		14,04,200.00	
6.	Petrol Charges	51,957.09		—		51,957.09	
	TOTAL	**33,96,091.59**		**—**		**33,96,091.59**	

(Annexure 'F') : STAFF WELFARE EXPENSES

1.	Liveries	27,865.85		—		27,865.85	
2.	Grant to staff Recreation Club.	4,575.00		—		4,575.00	
	TOTAL	**32,440.85**		**—**		**32,440.85**	

(Annexure 'G') : DETAILS OF HONORARIUM TO

1.	Out side experts	5,200.00		—		5,200.00	
2.	Part Time Obsevers	3,300.00		—		3,300.00	
3.	Visiting Scientists	300.00		—		300.00	
	TOTAL	**8,800.00**		**—**		**8,800.00**	

BALANCE SHEET AS ON 31ST MARCH, 1997

Previous Year Rs. Ps.	Funds and Liabilities	SCH No.	Rs. Ps.	Current Year Rs. Ps.
10,66,67,747.17	CAPITAL GRANT			11,17,42,673.38
	Balance as per last Balance Sheet		10,66,67,747.17	
	Add:			
	Received during the year		(+)42,38,000.00	—
	PLAN 42,38,000.00			
	NON-PLAN			
			11,09,05,747.17	—
	Add :			
	Transfer from unutilised Capital Grant		(+)8,36,926.21	—
96,55,189.86	OTHER GRANTS	I	—	66,81,118.86
36,62,567.69	INCOME & EXPENDITURE A/C			
	Balance as per last Balance Sheet		36,62,567.69	—
	Less :			
	Excess of Expenditure over Income		(-)21,42,657.29	—
				15,19,910.40
1,28,42,158.85	OTHER LIABILITIES			
	a) Unutilised Grants	II	—	1,20,12,192.64
14,675.00	b) Security Deposits	III		
	i) From Staff 1,000.00			
	ii) From others 13,675.00		14,675.00	14,675.00
798.00	c) Pay & Allowances			—
5,976.00	d) Overhead Charges		—	9,33,097.00
13,28,49,112.57	**TOTAL**			13,29,03,667.28

Previous Year Rs. Ps.	Assets	SCH No.	Rs. Ps.	Current Year Rs. Ps.
10,66,67,747.17	FIXED ASSETS	IV	—	11,17,42,673.38
	CURRENT ASSETS			
1,81,839.94	a) Stores in hand		1,55,254.31	—
	b) Advances To/For :	V		
18,45,267.20	i) Purchases/Journals		29,67,735.49	—
32,60,719.45	ii) Staff		27,56,576.00	—
61,44,531.28	iii) C.P.W.D., Pune		50,80,330.56	—
3,677.10	iv) C.P.W.D., N.Delhi		3,677.10	—
19,96,707.99	v) C.P.W.D., Bombay		12,32,253.99	—
54,130.00	c) Deposits	VI	60,130.00	—
4,43,600.00	d) Advances receivable in cash or in kind or for value to be received	VII	4,43,173.46	—
1,22,50,892.44	e) Fixed Deposit amount	VIII	79,18,500.00	
	f) Cash & Bank Balance		5,43,362.99	2,11,60,993.90
13,28,49,112.57	**TOTAL**			13,29,03,667.28

For Indian Institute of Tropical Meteorology, Pune

Sd/-
Accounts Officer

Sd/-
Director

For S. G. Gupte Associates
Chartered Accountants

Sd/-
(S. G. Gupte)
Membership No. 30563

2 September 1997

Schedule to and forming part of Balance Sheet

(Schedule 'I') : OTHER GRANTS

Sr. No.	Received from	Balance as on 1-4-1996 Rs.	Ps.	Amount Received Rs.	Ps.	Amount Utilised/ transferred Rs.	Ps.	Balance as on 31-3-1997 Rs.	Ps.
1.	1-D Modelling Project	25,000.00		—		16,634.00		8,366.00	
2.	Research Associate i) Shri S.Sharma	32,012.00		—		32,012.00		—	
3.	ii) Shri V.S.Murthy	364.75		80,350.00		38,245.00		42,469.75	
4.	Pages Brain Storming Session meeting held on 1.5.95	54,409.50		—		30,000.00		24,409.50	
5.	Indo U.S. Climate Research Programme	38,46,358.80		—		—		38,46,358.80	
6.	TOGA DATA Centre	24,463.40		74,000.00		82,175.00		16,288.40	
7.	DST. Montblex Data Bank Project	1,21,678.25		15,720.00		—		1,37,398.25	
8.	Training Course under Agrometeorology 21.12.95 to 5.1.96	5,732.10		9,267.90		15,000.00		—	
9.	IIIrd SERC School	5,79,469.00		—		5,61,464.75		18,004.25	
10.	Spectrometer	7,49,300.00		700.00		6,84,268.00		65,732.00	
11.	II SERC School on Agrometeorology, 27.11.95 to 16.12.95	1,63,132.60		—		1,63,132.60		—	
12.	Krishna Basin Project	2,29,649.50				11,699.00		2,17,950.50	
13.	Payable to Dr. S.V.Singh	6,580.00		—		6,580.00		—	
14.	Land Surface Processing Equipment.	21,93,169.28		53,593.10		21,47,355.91		99,406.47	
15.	Climate Res. Proj. (RNK)	16,23.870.68		20,00,000.00		17,98,357.40		18,25,513.28	
16.	Agromet Training Course 23,12 to 6.1.97			2,16,000.00		1,81,811.90		34,188.10	
17.	Air India Res.Fellow .		—	1,948.00		1,948.00			
18.	Agromet Training Course (GBPANT)		—	56,000.00		21,934.39		34,065.61	
19.	4th SERC (PC)			50,000.00		19,779.10		30,220.90	
20.	Chipps Project			1,30,000.00		736.50		1,29,263.50	
21.	Indo Brazil Work Shop			3,00,125.00		1,61,474.65		1,38,650.35	
22.	2 D Modeelling Programme			4,167.00				4,167.00	
23.	Indo-Brazil Printing			4,000.00				4,000.00	
24.	Payable to Max India Ltd.		—	4,666.20				4,666.20	
	TOTAL	**96,55,189.86**		**30,00,537.20**		**59,74,608.20**		**66,81,118.86**	

(Schedule 'II') : OTHER LIABILITIES

Sr. No.	Received from	Balance as on 1-4-1996 Rs.	Ps.	Amount Received Rs.	Ps.	Amount Paid/ transferred Rs.	Ps.	Balance as on 31-3-1997 Rs.	Ps.
1.	Unutilised Capital Grant	1,28,42,158.85		—		8,36,926.21		1,20,05,232.64	
2.	GPF Advance (PAO, IMD)	(-) 1,710.00		2,68,034.00		2,76,704.00		6,960.00	
	TOTAL	**1,28,42,158.85**		**2,68,034.00**		**11,13,630.21**		**1,20,12,192.64**	

(Schedule 'III') : SECURITY DEPOSITS

1.	From Staff: Shri R.B. Bhandari	1,000.00		—		—		1,000.00	
2.	M/s. Dynalab Weather Tech. Pvt. Ltd. Pune	4,675.00		—		—		4,675.00	
3.	CMC Ltd.	5,000.00		—		—		5,000.00	
4.	Canteen Contractor	4,000.00		—		—		4,000.00	
	TOTAL	**14,675.00**		**—**		**—**		**14,675.00**	

Schedule to and forming part of Balance Sheet

(Schedule 'IV') : FIXED ASSETS

Sr. No.	Description	Opening Balance as on 1-4-1996 Rs.	Ps.	Paid Rs.	Ps.	Recovered/ Adjusted Rs.	Ps.	Balance as on 31-3-1997 Rs.	Ps.
1.	Land	4,82,841.02		—		—		4,82,841.02	
2.	Office Buildings :								
	Ist Phase	41,10,361.04		—		—		41,10,361.04	
3.	IInd Phase	1,55,27,736.95		11,144.00		—		1,55,38,880.95	
4.	Construction of Library Building	1,08,30,913.76		7,37,472.00		—		1,15,68,385.76	
5.	Radar Building	46,769.95		—		—		46,769.95	
6.	Staff Quarters : Ist Phase	43,97,223.80		—		—		43,97,223.80	
7.	IInd Phase	37,40,601.93		—		—		37,40,601.93	
8.	Const of Director's Qtrs. Construction Work	4,77,021.46		—		—		4,77,021.46	
9.	Guest House	15,02,941.94		—		—		15,02,941.94	
10.	Hostel Building	21,18,745.94		—		—		21,18,745.94	
11.	Construction of Community Centre.	36,49,266.28		—		—		36,49,266.28	
12.	Work shop Building	2,41,287.07		—		—		2,41,287.07	
13.	Overhead Tank with under ground pump	20,02,877.00		—		—		20,02,877.00	
14.	Mini Bus Garage	4,10,717.00		—		—		4,10,717.00	
15.	Scooter Car Garage	3,80,988.60		—		—		3,80,988.60	
16.	Const.of Cloud Seeding Shed	4,59,349.60		2,16,172.00		—		6,75,521.60	
17.	Equipments (Plan)	1,12,44,730.99		30,87,064.00		—		1,43,31,794.99	
	(Non-Plan)	69,46.695.22		1,40,900.00		—		70,87,595.22	
18.	Furniture (Plan)	15,84,527.06		76,737.50		14,868.48		16,46,396.08	
	(Non-Plan)	13,81,775.17						13,81,775.17	
19.	Lib. Books (Plan)	47,946.80		—		—		47,946.80	
	(Non-Plan)	36,25,258.64		71,126.04		—		36,96,384.68	
20.	Plant & Machinery	4,06,903.50		—		—		4,06,903.50	
21.	Electrical fittings	76,448.40		—		—		76,448.40	
22.	Vehicles	9,50,155.16		—		—		9,50,155.16	
23.	IBM Computer 1620	77,506.44		—		—		77,506.44	
24.	500 KVA Power Sub Station	5,77,259.00		—		—		5,77,259.00	
25.	Approch Road to Kytoon Shade	91,988.00		—		—		91,988.00	

(Schedule 'IV') : FIXED ASSETS (Contd.)

Sr. No.	Description	Opening Balance as on 1-4-1996 Rs.	Ps.	Paid Rs.	Ps.	Recovered/ Adjusted Rs.	Ps.	Balance as on 31-3-1997 Rs.	Ps.
26.	Works & Repairs	47,486.61		—		—		47,486.61	
27.	Cap. Stores (Plan)	—		6,33,814.15		—		6,33,814.15	
	Cap. Stores (Non-Plan)	1,08,87,956.08		—		—		1,08,87,956.08	
28.	Providing premix carpeting to road to Hostel	25,879.84		—		—		25,879.84	
29.	Renovation of Canteen	12,673.00		—		—		12,673.00	
30.	Renovation & Elect. Inst.-Radar Building	33,948.00		—		—		33,948.00	
31.	Construction of Boundary Wall to Radar Building New Delhi.	50,425.00		—		—		50,425.00	
32.	Compound Wall for Director's Bungalow	1,37,560.82		—		—		1,37,560.82	
33.	Additional Septic tank of 500 users capacity	1,44,637.91		—		—		1,44,637.91	
34.	Residential Road to New Quarters	1,74,380.00		—		—		1,74,380.00	
35.	E.D.B. I & II of I & II nd floor.	32,238.00		—		—		32,238.00	
36.	Equipment acquired under Indo Japan programme.	1,80,871.23		—		—		1,80,871.23	
37.	ND 560 Computer	1,01,96,507.96		—		—		1,01,96,507.96	
38.	HCL Work Station	43,56,900.00		—		—		43,56,900.00	
39.	HCL Work Station Ist Upgradation	4,77,015.00		—		—		4,77,015.00	
40.	HCL Work Station IInd Upgradation	6,97,200.00		—		—		6,97,200.00	
41.	HCL Workstation IIIrd Upgradation	6,36,540.00		—		—		6,36,540.00	
42.	Silicon Graphic Computer (Inst. Cont)	11,84,690.00		—		—		11,84,690.00	
43.	Street light (Office)	—		1,15,365.00				1,15,365.00	
	TOTAL	**10,66,67,747.17**		**50,89,794.69**		**14,868.48**		**11,17,42,673.38**	

Schedule to and forming part of Balance Sheet

(Schedule 'V') : ADVANCES

Sr. No.	Received from	Opening Balance as on 1-4-1996 Rs. Ps.	Paid Rs. Ps.	Recovered Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
1.	Consumable and Non - Consumable	51,001.23	14,99,129.65	15,37,576.88	12,554.00
2.	Adv.for Journal	16,72,821.43	12,79,233.75	1,93,570.00	27,58,485.18
3.	Deposit with Custom Office	84,322.08	1,30,000.00	96,298.07	1,18,024.01
4.	Petrol	1,666.05	58,196.44	58,991.69	870.80
5.	Advance to Spectrometer	2,700.00	9,587.00	12,287.00	—
6.	Advance for Land Surface Meeting	31,316.41	2,81,019.55	2,49,887.46	62,448.50
7.	Advance for Reprints	1,440.00	10,933.00	1,440.00	10,933.00
8.	Advance for Books and Publication	—	4,420.00	—	4,420.00
9.	Advance to Indo Brazil Programme	—	10,125.00	10,125.00	—
10.	Advance to IV SERC School	—	3,600.00	3,600.00	—
	TOTAL (A)	**18,45,267.20**	**32,86,244.39**	**21,63,776.10**	**29,67,735.49**

(Schedule 'V') : ADVANCES (Contd.)

Sr. No.	Received from	Opening Balance as on 1-4-1996 Rs. Ps.	Paid Rs. Ps.	Recovered Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
	ADVANCE TO STAFF				
1.	Against Salary (Details Attached)	32,58,999.45	10,43,874.50	15,46,297.95	27,56,576.00
3.	Colony Welfare	10.00	14,747.00	14,757.00	—
	TOTAL (B)	**32,59,009.45**	**10,58,621.50**	**15,61,054.95**	**27,56,576.00**
	ADVANCES TO				
1.	CPWD Pune	61,44,531.28	16,79,331.28	27,43,532.00	50,80,330.56
2.	CPWD Bombay	19,96,707.99	41,425.00	8,05,879.00	12,32,253.99
3.	CPWD New Delhi	3,677.10	—	—	3,677.10
	TOTAL (C)	**81,44,916.37**	**17,20,756.28**	**35,49,411.00**	**63,16,261.65**

Schedule to and forming part of Balance Sheet

Enclosure to (Schedule 'V')

Sr. No.	Received from	Opening Balance as on 1-4-1996 Rs. Ps.	Paid Rs. Ps.	Recovered Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
1.	Festival	25,560.00	63,600.00	61,380.00	27,780.00
2.	Cycle	11,200.00	1,200.00	8,000.00	4,400.00
3.	Scooter	4,20,083.00	56,950.00	1,55,514.00	3,21,519.00
4.	House Building	27,61,980.00	1,74,600.00	6,00,140.00	23,36,440.00
5.	Travelling Allowance	297.00	2,76,282.00	2,26,758.00	49,821.00
6.	L.T.C	19,550.00	1,44,210.00	1,51,610.00	12,150.00
7.	Leave Salary	—	2,900.00	2,900.00	—
8.	Fan Advance	—	1,200.00	1,200.00	—
	Medical Advance to:				
8.	Poona Hos. Res. Centre	434.00	83,634.00	84,068.00	—
9.	Deendayal Hospital	9,643.00	48,933.00	58,099.00	477.00
10.	K.E.M. Hospital	4,164.00	90,715.00	94,879.00	—
11.	P.M.F. Hospital	4,862.00	31,750.00	32,623.00	3,989.00
12.	Hardikar Hospital	1,111.45	61,046.30	62,157.75	—
13.	N.M.Wadia Hospital	115.00	2,916.20	3,031.20	—
14.	Lokmanya Hospital	—	3,938.00	3,938.00	—
	TOTAL	**32,58,999.45**	**10,43,874.50**	**15,46,297.95**	**27,56,576.00**

(Schedule 'VI') : DEPOSIT

1.	T.I.F.R.	1,000.00	—	—	1,000.00
2.	SDE Cantonment works Kirkee	500.00	—	—	500.00
3.	Gas Company	730.00	—	—	730.00
4.	Pune Telephone	16,400.00	6,000.00	—	22,400.00
5.	M.S.E.B.	4,300.00	—	—	4,300.00
6.	Telephone Nigam N.Delhi	8,000.00	—	—	8,000.00
7.	Speciality Gas Co.	23,200.00	—	—	23,200.00
	TOTAL	**54,130.00**	**6,000.00**	**—**	**60,130.00**

(Schedule 'VII') :ADVANCES RECEIVABLE IN CASH OR IN KIND OR FOR VALUE TO BE RECEIVED

Sr. No.	Received from	Opening Balance as on 1-4-1996 Rs. Ps.	Paid Rs. Ps.	Recovered Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
1.	Research Associate Dr. K.K.Singh, C.S.I.R.	2,459.00	2,787.00	520.00	4,726.00
2.	Meeting Chairman A/c	8,297.35	—	8,297.35	—
3.	Receivable from DST	3,549.00	—	3,549.00	—
4.	Customs Dept. Bombay	1,016.00	—	—	1,016.00
5.	Receivable from Prof. R.N.Keshavamurthy	1,162.00	12,022.00	13,184.00	—
6.	Planning Committee Meeting 26-27/10.95	11,350.30	—	11,350.30	—
7.	Tropmet'94	16,855.36	—	—	16,855.36
8.	Receivable from Dr. G.B.Pant	7,706.00	72,143.00	79,849.00	—
9.	Receivable from Dr. P.C.S. Devara	8,628.00	6,740.00	15,368.00	—
10.	II SERC School	3,60,642.60	—	—	3,60,642.60
11.	IV SERC School A/c	—	6,037.60	—	6,037.60
12.	Receivable from DST	—	9,241.00	9,241.00	—
13.	Receivable from Dr. A.K.Kamra	—	21,385.00	17,741.00	3,644.00
14.	Receivable form Shri. V.S. Murty	—	2,845.00	2,845.00	—
15.	Air India	—	1,948.00	1,948.00	—
16.	Receivable from Shri.R.Vijaykumar	—	8,628.00	8,628.00	—
17.	Receivable from DST Meeting 20.5.95	—	9,440.00	—	9,440.00
18.	Receivable from Dr. S.Singh	—	17,256.00	17,256.00	—
19.	Receivable from G.E.C. Meeting A/c	—	40,311.90	—	40,311.90
20.	Court Attatechment	—	11,106.00	10,606.00	500.00
	TOTAL	**4,21,665.61**	**2,21,890.50**	**2,00,382.65**	**4,43,173.46**

Schedule to and forming part of Balance Sheet

(Schedule 'VIII') : CASH & BANK BALANCES

Sr. No.	Received from	Opening Balance as on 1-4-1996 Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
1.	**(A) with SBI in**		
	Security Deposit	1,000,00	1,000.00
	Current Account	37,97,470.25	4,77,362.99
	Fixed Deposit	84,38,002.39	79,17,500.00
	Margin Money	—	47,000.00
2.	**(B) Cash in Hand**		
	Petty Cash (Pune)	4,500.00	4,500.00
	Imprest (RCPR New Delhi)	1,500.00	1,500.00
	Imprest (RCPR New Delhi)	6,000.00	12,000.00
	Despatcher	1,000.00	1,000.00
	Undisbursed Cash with Cashier	1,419,80	—
	TOTAL	**1,22,50,892.44**	**84,61,862.99**

Sr. No.	Description	Opening Balance as on 1-4-1996 Rs. Ps.	Recovered Rs. Ps.	Remitted Rs. Ps.	Balance as on 31-3-1997 Rs. Ps.
1.	G.P.F	—	16,43,843.00	16,43,843.00	—
2.	E.P.F Subscription	—	76,456.00	76,456.00	—
3.	E.P.F Advance	—	42,297.00	42,297.00	—
4.	IITM G.P.F	—	18,34,112.00	18,34,112.00	—
5.	IITM G.P.F Advance	—	6,24,941.00	6,24,941.00	—
6.	IITM Benevolent Fund	—	56,066.00	56,066.00	—
7.	Income Tax	—	10,15,434.00	10,15,434.00	—
8.	Prof. Tax	—	2,04,600.00	2,04,600.00	—
9.	S.S.Scheme	—	3,48,583.80	3,48,583.80	—
10.	IITM Recreation Club	—	14,759.00	14,759.00	—
11.	IMD Society	—	28,96,020.00	28,96,020.00	—
12.	GPF ADVANCE (IMD)	—	18,48,912.00	18,48,912.00	—
13.	GPF Final Payment	—	5,52,691.00	5,52,691.00	—
14.	Death Cum Retirement Gratuity	—	23,48,112.00	23,48,112.00	—
	TOTAL	**—**	**1,35,06,826.80**	**1,35,06,826.80**	**—**

The Brazilian Scientists Dr. V.B. Rao, Instituto Nacional De Pesquisas Espaciais (left) and Dr. P.L. da Silva Dias, Universidade De Sao Paulo (right) presenting papers at the Indo-Brazilian Joint Workshop on Climate Research held at the Institute.

Prof. R. Sadourny, Director, laboratoire de Meteorologie Dynamique, Paris, France delivering a lecture during his visit to the Institute.

Prof. Pramod Kale, Retd. Director, Space Application Centre delivering a lecture on the occasion of National Science Day celebrations at the Institute.

High school students visiting the Dendroclimatology laboratory on the Open Day organised as a part of the National Science Day celebrations.

Open house Scientific Exhibition organised by the Institute on the World Meteorological Day.