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INDIAN INSTITUTE OF TROPICAL METEOROLOGY

ANNUAL REPORT 1994-95

Students-Scientists interaction through a 'Prashna Mancha' arranged at the Institute on the occasion of National Science Day on 28 February 1995.

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ANNUAL REPORT 1994-95

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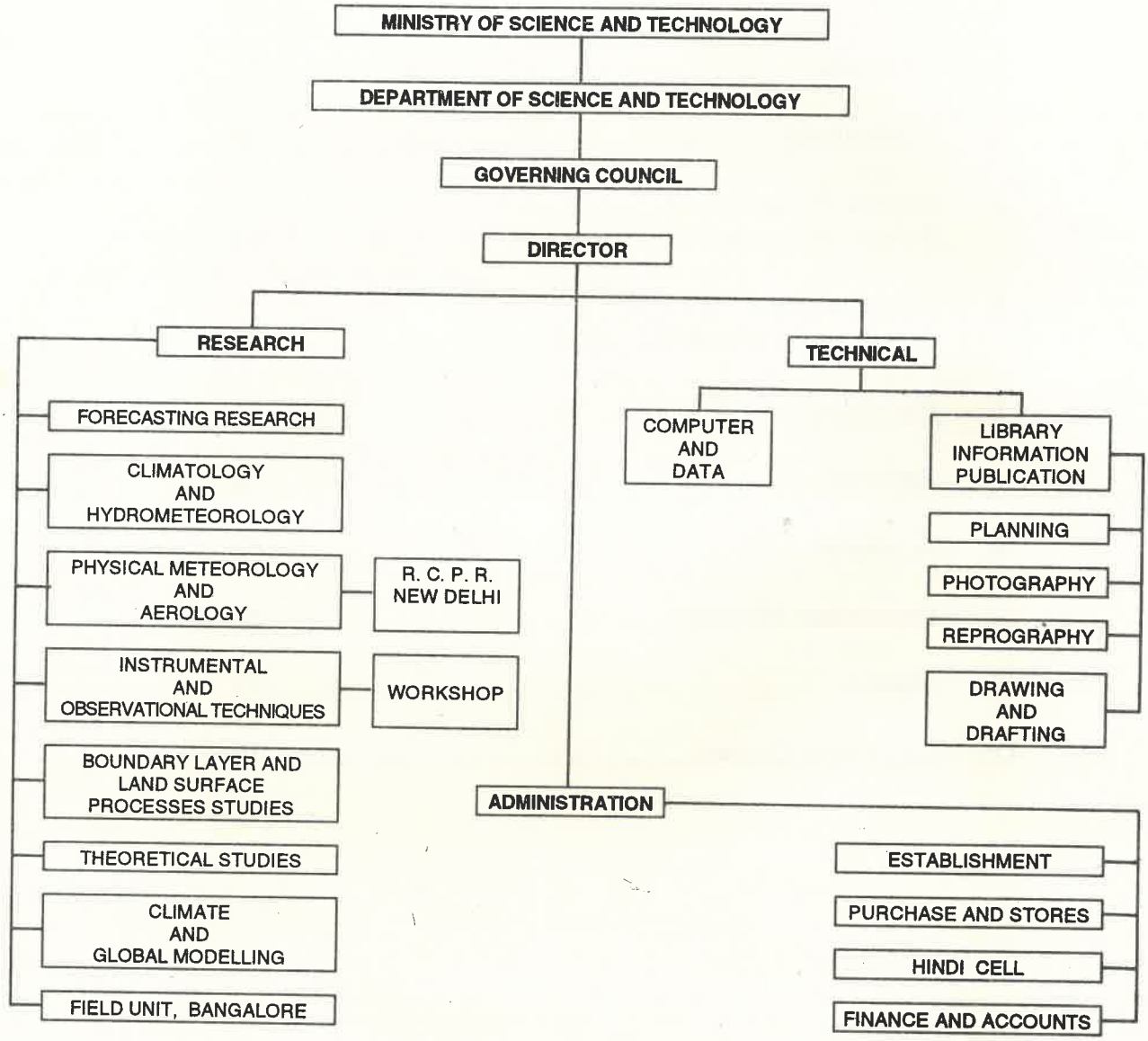
Institute's Building

INDIAN INSTITUTE OF TROPICAL METEOROLOGY



ORGANIZATIONAL PROFILE

FOREWORD

I have pleasure in presenting the Annual Report of the Institute for the year 1994-95.

Considerable progress was achieved in many of the thrust areas of Atmospheric Sciences like weather forecasting, climatology, monsoon and climate modelling and studies relating to land-surface processes, atmospheric chemistry and atmospheric electricity. Two new Scientific Divisions viz., (i) Climate and Global Modelling Division and (ii) Boundary Layer and Land Surface Processes Studies Division were formed to achieve better progress and understanding in these important areas.

We have enhanced our computing facilities by adding the CHiPPS-192 Parallel Processing System of C-DoT. We are upgrading our computer facility further. The Lidar and other laboratory facilities were also enhanced by acquiring modern equipment for the experimental research work.

The Institute has also organised some Field Observational Programmes for the study of atmospheric chemistry, atmospheric electricity and troposphere-stratosphere coupling and its dynamics.

The Institute hosted the DST sponsored SERC School on Advanced Geophysical Fluid Dynamics during 23 May-24 June 1994 with an objective to provide an excellent ground for high calibre research students/post-doctoral fellows in the field of Atmospheric Sciences. A Brain Storming Session on Long-range Weather Forecasting, a two-day Workshop on 'Optics of Aerosols' in co-operation with the Indian Aerosol Science and Technology Association (IASTA) and a DST-sponsored training programme on 'Agrometeorological Data Monitoring and Management' were also held at the Institute.

The research output of the Institute remained high and the scientific results summarised in this report have received recognition by the scientific community as evidenced by the awards, fellowships, memberships etc. received by the scientists. Scientists of the Institute have published 104 research papers in standard national and international journals, books, reports etc. and presented 91 papers in national and international symposia/seminars. Two scientists of the Institute have been jointly awarded the Tenth SAARC Regional Award for the year 1992. Six scientists of the Institute received Ph.D. (Physics)/M.Sc. (Atmospheric Sciences) degrees and four scientists submitted their theses.

Several distinguished scientists from USA and other countries visited the institute and delivered seminars on front-ranking topics in Atmospheric Sciences. Under the Visiting Professorship Programme, Dr. D.B.Rao of the National Meteorological Centre, USA visited the Institute and delivered a series of lectures on 'Basic Geophysical Fluid Dynamics'. Twenty-two scientists of the Institute were deputed abroad for participation in international symposia/seminars/training and for research work under collaborative programmes.

The Institute would continue to serve as a leading research centre in tropical meteorology and make significant contributions in the challenging areas in Atmospheric Sciences,

Director

1. HIGHLIGHTS

The year 1994-95 was a milestone in the annals of the Institute. We hosted the first ever DST sponsored SERC School on 'Basics of Geophysical Fluid Dynamics' during 23 May-24 June 1994. A Brain Storming Session on Long Range Forecasting was also held at the Institute under the Chairmanship of Dr.N.Sen Roy, Director General of Meteorology. Several distinguished visitors from India and abroad visited the Institute. An important highlight of the year was the formation of two new Scientific Divisions in the Institute viz. (i) Climate and Global Modelling Division and (ii) Boundary Layer and Land Surface Processes Studies Division. These Divisions are supported by DST sponsored projects.

The main objectives of the Climate amd Global Modelling Division are (i) Comprehensive study of the physical and dynamical processes relating to Global and Monsoon Climate and their variabilities on different time scales, (ii) Development/improvement of the physical mathematical models capable of simulating climate and climate change due to natural and anthropogenic activities and validation of the results of the climate models.

The Boundary Layer and Land-surface Processes Division has an objective to study the land-surface processes in the surface layer and the parameterization of various fluxes in relation to partition of solar energy at the land-surface interface. As a sequel to this, a field programme sponsored by the Department of Science and Technology has been taken up to study the land-surface processes in the Sabarmati river basin in Gujarat region. The data generated during the field programme will be used in validating one-dimensional regional models.

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

There seems to be teleconnection between ENSO (El Nino-Southern Oscillation) and sea-ice extent in the Northern Hemisphere. The investigation showed statistically significant inverse relationship of winter-time sea-ice extent with the ENSO. The result suggested that the warm phase of ENSO is associated with colder temperatures in higher latitudes/polar regions of Northern Hemisphere. This facilitates larger extent of sea-ice (and vice-versa).

The longitudinal asymmetry of the east-west oriented near equatorial ITCZ is reflected in the organisation of large scale enhanced convection and precipitation over some preferred regions within it during the northern summer. The most prominent regions are the Indo-Pacific (70^{O}-160^{O}E) monsoon region (IP) and the Eastern Pacific-Central American (120^{O}W-60^{O}W) region (EPCA). On the intra-seasonal time scale the convective episodes over the two regions oscillate in an opposite sense. This is contributed to mostly by the eastward propagating 30-50 day mode of oscillation. On the monthly and seasonal scales the out of phase relationship of organised convection and precipitation is found to be associated with the El Nino (1987)/La Nina (1988) events.

Rainfall variability over the Asian monsoon region and its interrelationship with Indian rainfall was investigated. One study dealing with Bangladesh and Nepal rainfall showed an increasing trend in rainfall of Bangladesh after 1963 and long period cycles in rainfall of Nepal like those observed in Indian rainfall. Further, rainfall over Bangladesh during May showed significant relationship with Indian summer monsoon rainfall.

Dynamics of monsoon clouds and the effects of seeding clouds with hygroscopic particles were investigated through simulation of the relevant dynamical and physical processes in a 2 dimensional time dependent cloud model using the aerological soundings of Bombay. The results suggested that the vertical growth of the cloud is markedly influenced by the magnitude of the convergence at the cloud base level. Moderate convergence is essential for rain formation. Vigorous convergence can give rise to formation of tall convective clouds with higher values of cloud liquid water content resulting in large size rain drops/high intensity rainfall. Seeding warm clouds with hygroscopic particles could result in acceleration of the collision-coalescence process leading to enhancement in rainfall.

Observations of atmospheric aerosols and trace gases carried out during the field observational programme at the Blow-out site of the ONGC Gas-well indicated that the smoke emitted from the burning gas-well has no adverse pollution effects on the air quality in the vicinity of the above site.

Surface measurements of the electric field vector measured near a Cumulus cloud with a spherical field meter showed that past estimates of cloud charge

from observations of only the vertical component of electric field may be an underestimate.

An increase in atmospheric electric conductivity with increase in relative humidity/sea surface temperature was observed from measurements made in the western equatorial Indian Ocean and the Arabian sea.

Under the Land Surface Processes Studies Programme, preparation for conducting the pilot experiment in Gujarat at Anand Agricultural University, was completed. The anemometers and the temperature sensors were calibrated. All the tower instrumentation along with the data logger were also tested.

The variations in the drag coefficient vis-a-vis wind speed and stability were studied using the special observations collected on board ORV Sagarkanya as a part of MONTBLEX-90. The above observations were used for obtaining mean values of drag coefficients for different wind speeds and stability conditions.

Study of dynamics of air flow surrounded by high mountains was completed by using the indigeneously developed 3-D nonlinear, nonhydrostatic, P.E. numerical, mesoscale model in polar coordinates. The results clearly indicated the effect of dynamic pressure for generating strong divergence in the region.

The C-DoT, CHiPPS-192 Parallel Processing System was transferred to IITM in September 1994 and has been put in use for studies relating to atmospheric/climate modelling by the scientists of the Institute.

Atmospheric General Circulation Models have been integrated to study the contrasting monsoons of 1987 and 1988. Studies relating to the applications of Artificial Neural Network (ANN) for long-range prediction of the Indian summer monsoon rainfall were also initiated utilising the rainfall data for the period 1939 to 1994.

1.1 Award

The paper entitled, 'Some aspects of daily rainfall distribution over India during SW monsoon seasons' by M.K.Soman and K.Krishna Kumar published in the International Journal of Climatology, 1990, received the Tenth SAARC Regional Award for the year 1992.

1.2 SERC School

A five year cycle of SERC Schools on Advanced Geophysical Fluid Dynamics is being organised under the sponsorship of the Department of science and Technology. The First SERC School on 'Basics of Geophysical Fluid Dynamics with special emphasis on Rotating Fluids' was held at the Institute during 23 May-24 June 1994. The objective of the SERC School is to provide an excellent ground for high calibre research students/post-doctoral fellows for taking up research work in priority areas such as atmospheric and oceanic modelling, numerical weather prediction, monsoon dynamics and climate dynamics including global climate change.

Fortynine trainees from different organisations/ universities including IITM participated in the SERC School. Experts from IITM, IMD, NCMRWF, IIT, Delhi, IISc, PRL, Delhi University and University of Poona delivered lectures.

The Second School in the series entitled, 'Advanced Geophysical Fluid Dynamics' was also planned to be held at the Institute. This School will cover all aspects of the general circulation of the atmosphere and oceans covering observations, theory, numerical modelling as also laboratory simulations.

A Meeting of the Planning Committee of Second SERC School on 'Geophysical Fluid Dynamics' was held at the Institute on 6 and 7 December 1994.

1.3 Bilateral Programme

Under the Project III of the Indo-US Climate Research Programme, Dr.G.V.Rao, Professor and Director, Meteorology, Associate Chair, Earth and Atmospheric Sciences, Saint Louis University, U.S.A. and Dr.Tsing-Chang Chen, Professor of Meteorology, Atmospheric Science Program, IOWA State University, U.S.A. visited the Institute during 3-9 January 1995 and 3-4 March 1995 respectively.

1.4 Visiting Professorship Programme

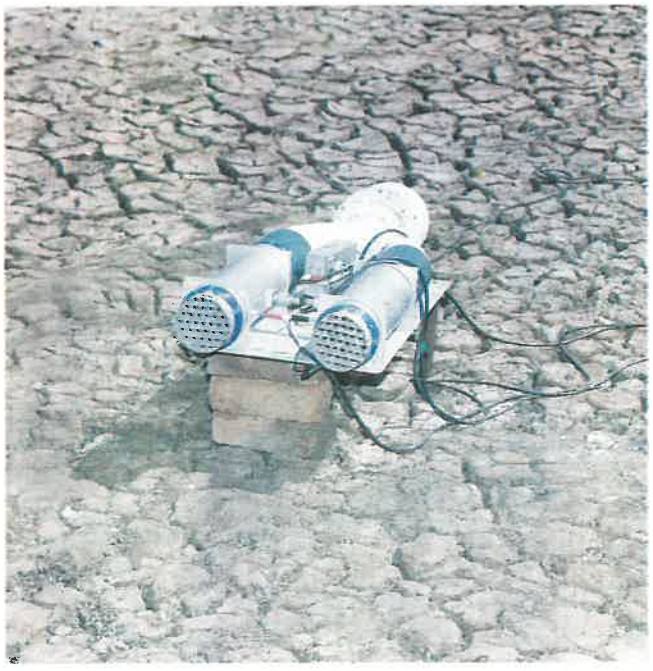
Dr.D.B.Rao, National Meteorological Centre, U.S.A. visited the Institute during 13-24 February 1995 under the Visiting Professorship Programme of the Institute for the year 1994-95. He delivered a series of lectures on 'Basic Geophysical Fluid Dynamics'.

Prof. P.R. Pisharoty, Founder Director of the Institute inaugurating the First SERC School on 'Basics of Geophysical Fluid Dynamics with Special Emphasis on Rotating Fluids' organised at the Institute during 23 May-24 June 1994.

Inauguration of the DST-sponsored Training Programme on 'Agrometeorological Data Monitoring and Management' held at the Instutite during 24 October-7 November 1994.

Inauguration of a Two-day Workshop on 'Optics of Aerosols' organised at the Institute in co-operation with the Indian Aerosol Science and Technology Association (IASTA) during 23-24 March 1995.

Visit of the participants of the Workshop on 'Optics of Aerosols' to the Laser Laboratory of the Institute.



Field Observations carried out for Studies relating to Atmospheric Electricity and Atmospheric Pollution in the vicinity of the 'Blow-out' site of the ONGC gas-well at Pasarlapudi, Andhra Pradesh.

C-DOT High Performance Parallel Processing System (CHiPPS) acquired recently is being used for the studies relating to atmospheric/climate modelling.

High power CO_2 Laser system acquired for the Remote Sensing of Aerosols and gases up to the stratosphere.

1.5 Project Proposals

The following two Research Proposals submitted to the National MST Radar Facility, have been approved for undertaking the experiments using the MST radar:

i) MST radar study of atmospheric stability during clear-cloudy-sky conditions

ii) Study of the wave activities in the middle atmosphere and tropospheric-stratospheric coupling processes

1.6 Organisation of Workshops/Meetings

A Brain Storming Session on Long-Range Weather Forecasting was organised in the Institute on 28 September 1994 under the chairmanship of Dr.N.Sen Roy. Thirty-two scientists from the concerned organisations took part in the Session and discussed various issues relating to Long-Range Forecasting of Summer Monsoon Rainfall over India.

A two-day Workshop on 'Optics of Aerosols' was organised at the Institute/University of Poona, Pune during 23-24 March 1995 in co-operation with the Indian Aerosol Science and Technology Association (IASTA). About 70 delegates from all over India including scientists of the Institute participated in the Workshop. Special lectures by the experts in the field and visits to Laser Laboratory of the Institute/Space Physics Laboratory, Department of Physics, University of Poona were arranged during the workshop.

A Mini Workshop on 'Monsoon -1994' organised by the Indian Meteorological Society, Pune Chapter was held at the Institute on 19 January 1995.

1.7 Organisation of Training

A training programme on 'Agrometeorological Data Monitoring and Management' sponsored by the Department of Science and Technology was held at the Institute during 24 October-7 November 1994. Twenty two scientists from Agricultural Universities over different parts of the country participated in the programme.

1.8 Field Experiments

A field experiment was carried out at Kosi, Almora, U.P. during 30 April-12 May 1994 to collect observations required for undertaking the studies relating to atmospheric chemistry, acid rain and biogeochemical cycles. The observations are being analysed to carry out related studies.

A field observational programme was carried out in the vicinity of the 'Blow-out' of the ONGC gas-well at Pasarlapudi, Amalapuram, Andhra Pradesh during 23 February to 3 March 1995. Observations were taken for the study of Atmospheric Electricity and Atmospheric Pollution in the vicinity of the Blow-out site.

A field experiment to study the dynamical interaction between the troposphere and the stratosphere was conducted using the National MST Radar facility at Gadanki, Andhra Pradesh during 17-25 November 1994. The special MST radar observations collected during the above experiment are being used to investigate the coupling between the troposphere and the stratosphere and the related atmospheric dynamical and circulation characteristics.

1.9 Publication

Volume III of the "Wind Energy Resource Survey in India" containing comprehensive statistics on wind data for 54 stations covering 2-5 years was published in August 1994 by the Field Research Unit of the Institute at Bangalore.

1.10 Reports

I. The following two reports on Design Storm Rainfall Studies of Krishna Project were sent to the Central Water Commission, New Delhi:

   i) Design storm study for upper Krishna River catchment above Almutti dam site

   ii) Design storm study of the upper Krishna River catchment above Miraj (Gauging Site-2).

II. A Review Paper on 'Warm Cloud Modification' containing the current status of the Physics and Chemistry of Clouds and Weather Modification Research was sent to the WMO. The report was prepared by Dr.A.S.R.Murty, Deputy Director who has been nominated as Member of the WMO-CAS Working Group Executive Council Panel of Experts on Physics and Chemistry of Clouds and Weather Modification Research. The paper will be published as an Annex to the WMO Report of the Executive Council Panel of Experts/CAS Working Group.

1.11 Scientific Communication through Public Media

A programme on 'Tropical Cyclones' presented by Prof.T.N.Krishnamurti, Florida State University, USA and Dr.(Smt)P.S.Salvekar, A.D. was telecast by Delhi Doordarshan on 13 April 1994 under the Countrywide Classroom Programme.

1.12 Review Meeting of UNDP Trainees

The UNDP trainees of the Institute who have completed training during 1993-94 under the UNDP supported project on 'Meteorological Applications in Agriculture'.participated in a one-day Review Meet organised by the DST at the India Meteorological Department, New Delhi on 29 March 1995. They also made brief presentations about their training.

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2.1 FORECASTING RESEARCH DIVISION

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

* Development of regional prediction model with emphasis on the parameterization of cumulus convection.
* Study of the characteristics of the monsoon trough planetary boundary layer using the agro-meteorological data.
* Development of objective analysis for NWP models including the use of satellite OLR and wind data.
* Diagnostics of ENSO-Monsoon relationship and development of canonical correlation model for forecasting seasonal monsoon rainfall on subdivisional scale.
* Organisation and low frequency oscillations of enhanced convective activity near equatorial ITCZ in the global perspective.

2.1.1 Regional NWP Modelling and Model Diagnostics

Three numerical experiments were carried out to study the sensitivity of the convective rainfall to the adjustment parameters used in the Betts - Miller Scheme of cumulus convection. The results of the experiments indicated that the convective rainfall has considerable sensitivity to saturation pressure departure value, whereas, the impact of the stability weight on the convective rainfall is marginal.

The power spectral analysis of marine meteorological data over Head Bay of Bengal (20°N, 89°E) during MONTBLEX-90 revealed three prominent peaks in time - scale of 120 hours (5 days), 12 - 15 hours and 2 - 5 hours in all the meteorological fields such as Sea-level pressure, sea-surface temperature, air temperature, total cloud cover, relative humidity and net effective long-wave radiation at the sea surface. The above three peaks are attributed to the presence of synoptic oscillation of monsoon trough and associated formation of low pressure systems in north-west Bay of Bengal, semi-diurnal pressure-wave and generation of localized mesoscale convective cloud systems respectively. The normalized co-spectra between total cloud cover and the net effective long-wave radiation showed strong negative correlation with a peak of 5 days and the phase angle between them is 180°.

The scheme suggested by Holtslag (1983) to compute the surface flux of radiation, sensible heat, latent heat and ground heat was followed for understanding the flux transfer processes in the region of unsaturated and deep moist zone of the normal monsoon trough during the pre-monsoon period. The surface temperature computed by the above method was tested with the observed soil temperature at 5 - 7.5 cm depth. The marginal difference between the computed surface temperature and the observed soil temperature is within the expected limit.

During oceanographic survey period (17 July - 14 August) of South-west monsoon 1992 (cruise No. 75 of ORV Sagarkanya) in the Southern Arabian Sea and equatorial Indian ocean, an interesting atmospheric and oceanic weather condition characterised by heavy rainfall (>38 mm), strong south-westerly wind (>25 knots) and low SST (~28°c) were observed in the vicinity of equator near 67°E on 23 and 24 July. The surface meteorological fields of wind, SST, air temperature and wet-bulb temperature, depression in the area bounded by 3°N - 3°S and 65°E 68°E, the measured rainfall, the radiosonde temperature profiles, the INSAT-1D derived cloud pictures and wind field at 850 hPa level during 21-24 July were analysed to highlight the above rare weather phenomenon. The analysis revealed that the low level convergence (850 hPa) at the upper level subsidence south of 1°S and low level divergence (850 hPa) close to the equator in the wake of an organised low-pressure area in the SHET (Southern Hemispheric Equatorial Trough) lying just south of the equator have contributed to the development of spontaneous intense convection ('HOT TOWER') at the equator giving rise to the above observed rainfall. At the same time a huge cloud cluster moving from south-west and crossing the equator near 67°E was also found to play an important role for the development of 'HOT-TOWER' at the equator.

2.1.2 Objective Analysis including Satellite input for Regional Models

The scheme for including the divergent part estimated from OLR (Outgoing Longwave Radiation) data in the wind analysis was further tested for a case of a monsoon low during the period of 6 to 12 August 1988 and also for a case of weak situation on

14 August 1988. Vertical velocity, velocity potential, diabatic heating etc. were computed for two cases, the first including divergent part estimated from OLR data and the second without the divergent part. In the comparison of two cases it was found that magnitudes of these computed parameters were higher when divergent part is included and also that magnitudes of these parameters decreased as the intensity of monsoon low decreased or the convective activity increased. The diabatic heating was also computed from rainfall estimated from OLR data following Arkin and found to be similar in magnitudes and in patterns to the computations from OLR data made in the present scheme.

The above scheme was also tested with the model available at NCMRWF, New Delhi for four days, 15 and 16 July 1993 representing active monsoon and 23 to 24 August 1993 representing the break condition. In this experiment the divergent part estimated using OLR data were added to the rotational part of the wind at the grid points and these were used as additional observations along with the conventional observations and analyses were made using NCMRWF SSI analysis scheme (experiment). Thus these analysed winds (experimental) were compared with those analyses made without the additional observations (control analyses) for the four days. Vertical velocity and diabatic heating computed with both the cases were examined. It was also inferred that vertical velocity, diabatic heating etc. increased in magnitude over the cloudy region in the experimental case. The differences in wind analyses at 850 hPa level suggest firstly that the meridional component increased over the cloudy region when the divergent part was added and secondly that the increase was more over oceanic regions compared to land region where observed data were available.

The height-height correlation of the observed anomalies is represented by the degenerated third order auto regressive (TOAR) function as suggested by Mitchel et. al. (1990) in the multivariate optimum interpolation scheme. Using this scheme analyses of height and wind fields were made at 850, 700 and 500 hPa levels. These analyses showed that this new scheme performs better than the earlier scheme using Gaussian functions.

The objective analysis of wind field using optimum interpolation (OI) scheme using non-divergent statistical model smoothens the divergent part of the wind which is very important in tropics specifically over the convective regions. To overcome this deficiency, the above OI scheme was used with modified statistical model of the wind forecast errors suitable for the Indian region so as to retain the divergent part of the wind during analysis procedure. Wind analysis made using this new scheme showed that the magnitudes of divergence are higher in this case than those found in earlier scheme.

Seasonal, monthly and daily convective activities in the region of SHET were examined through OLR anomalies, HRC frequencies and INSAT observed cloud imagery over the equatorial Indian ocean for the periods, 1974-83 (OLR anomalies), 1971-85 (HRC frequencies) and 1986-1993 (INSAT imageries) respectively. It was found that in good (bad) years more (less) HRC frequencies and negative (positive) OLR anomalies persist over the region of SHET indicating that SHET activity is more during the good monsoon years than during the bad monsoon years.

2.1.3 Extended Range Prediction

A canonical correlation model was developed for forecasting seasonal monsoon rainfall on subdivisional scale. Rainfall of 29 contiguous meteorological subdivisions was considered as the set of predictands in the model. The predictors considered are the 500 hPa ridge axis position over India during April, Darwin surface pressure tendency from January to April, the sea surface temperature of Central and East equatorial Pacific for five consecutive months preceding the monsoon season and the June rainfall over Kerala. The model was developed on 30 years of data (1939-58) and was tested on 16 independent years thereafter. The model showed positive skill scores for a large number of meteorological subdivisions, with higher values for the subdivisions in the west-central India. The skill of the model appeared to be marginally higher than that obtained through the multiple regression equations developed earlier.

A study to investigate and understand the interannual variability of summer monsoon rainfall over Bangladesh and Nepal was initiated. Preliminary analysis showed that the rainfall for Bangladesh shows random fluctuation up to the year 1963, rising values thereafter. The rainfall variations over Bangladesh are well related with rainfall variations over the northeastern region of India. It was also observed that May rainfall over Bangladesh is significantly related with June to September rainfall over India. Analysis of Nepal (Kathmandu) rainfall revealed that Nepal rainfall is well related with the rainfall variation over northern and central parts of India.

There seems to be a teleconnection between ENSO (El Nino Southern Oscillation) and sea-ice

extent in the Northern Hemisphere. The investigation carried out with the annual and winter time satellite derived sea-ice extent data in the NH (available since 1973 onwards) showed inverse relationship (significant at 1% level) with the ENSO. The result suggested that warm phase of ENSO (i.e. large negative Southern Oscillation Index) is associated with the colder temperature in the higher latitudes/polar regions of Northern Hemisphere to facilitate larger extent of sea-ice and vice-versa.

The low-frequency variability of ENSO was investigated by spectrum analysis performed on the long-time series of ENSO indices representing both oceanic and the atmospheric components of the phenomenon. Spectra of SOI (Southern Oscillation Index), east equatorial Pacific SST anomaly in Nino-3 region, 850 hPa zonal wind index in central equatorial Pacific and high cloud index near equatorial date-line revealed many time-scales embedded in the series, but two low-frequency variabilities which stand out markedly as a biennial mode and a lower frequency mode of 4-7 years. Some of the spectra also revealed significant seasonal and intraseasonal periodicities. The results suggested that ENSO may be termed as an aperiodic phenomenon of air-sea interactive system modulated by the seasonal and intraseasonal cycles.

2.1.4 Monsoon Studies and Forecasting

Long term global grid point data of Outgoing Longwave Radiation (OLR) for 1975-1990, satellite derived precipitation estimates produced by Global Precipitation Climate Project (GPCP) for 1986-1992 and monthly mean sea surface temperature (SST) for 1986-1990 obtained from TOGA were analysed for the global tropical belt of northern hemisphere to study the organisation of large scale convection and precipitation within the planetary scale intertropical convergence zone (ITCZ) during northern summer. Their oscillation in the intra-seasonal and interannual scale were also studied. The analysis showed that the east-west oriented ITCZ lies mostly over the warm sea surface and is the zone of organised convective and precipitation during northern summer. The longitudinal assymetry of the ITCZ can be seen from the organisation of enhanced convection over some preferred longitudinal belts within the planetary scale ITCZ, the most prominent among them being that over the Indo-Pacific (IP) monsoon belt (70°-160°E), Eastern Pacific - Central American (EPCA) belt (120°-60°W) and the West African (WA) monsoon belt (20°W-30°E) in the near equatorial region (5°-15°N) (Fig. 1). In the intra-seasonal scale the two regions of organised convections over the IP and EPCA are the centres of low frequency modes of 30-50 and 15-25 days oscillation with which the active-break cycle of Indian summer monsoon is associated. The most striking result of the study is the out of phase oscillation of large scale convective episodes in the planetary scale ITCZ between IP and EPCA regions, which has been contributed mostly by the eastward propagating intra-seasonal 30-50 day mode. In the inter-annual scale a seesawlike oscillation of organised convection and enhanced precipitation between IP and EPCA are found to be well associated with El Nino (1987) / La Nina (1988) events (Fig. 2).

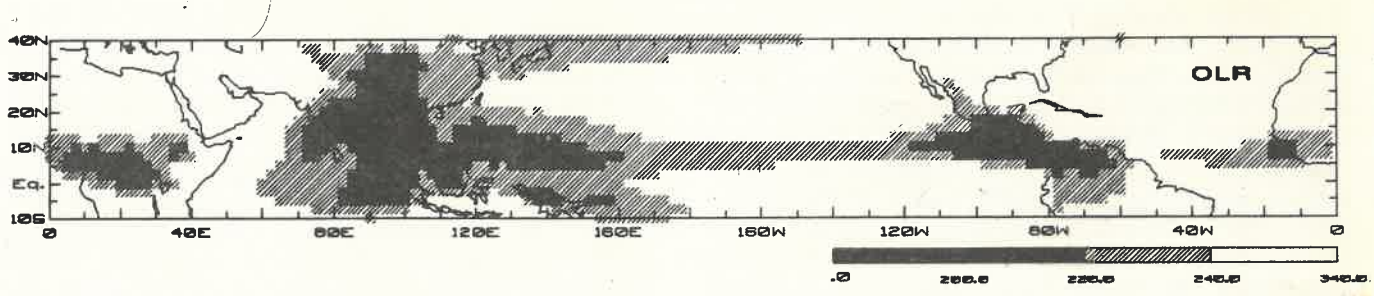

Figure 1 :
Analysis of long term seasonal (JJAS) mean OLR.

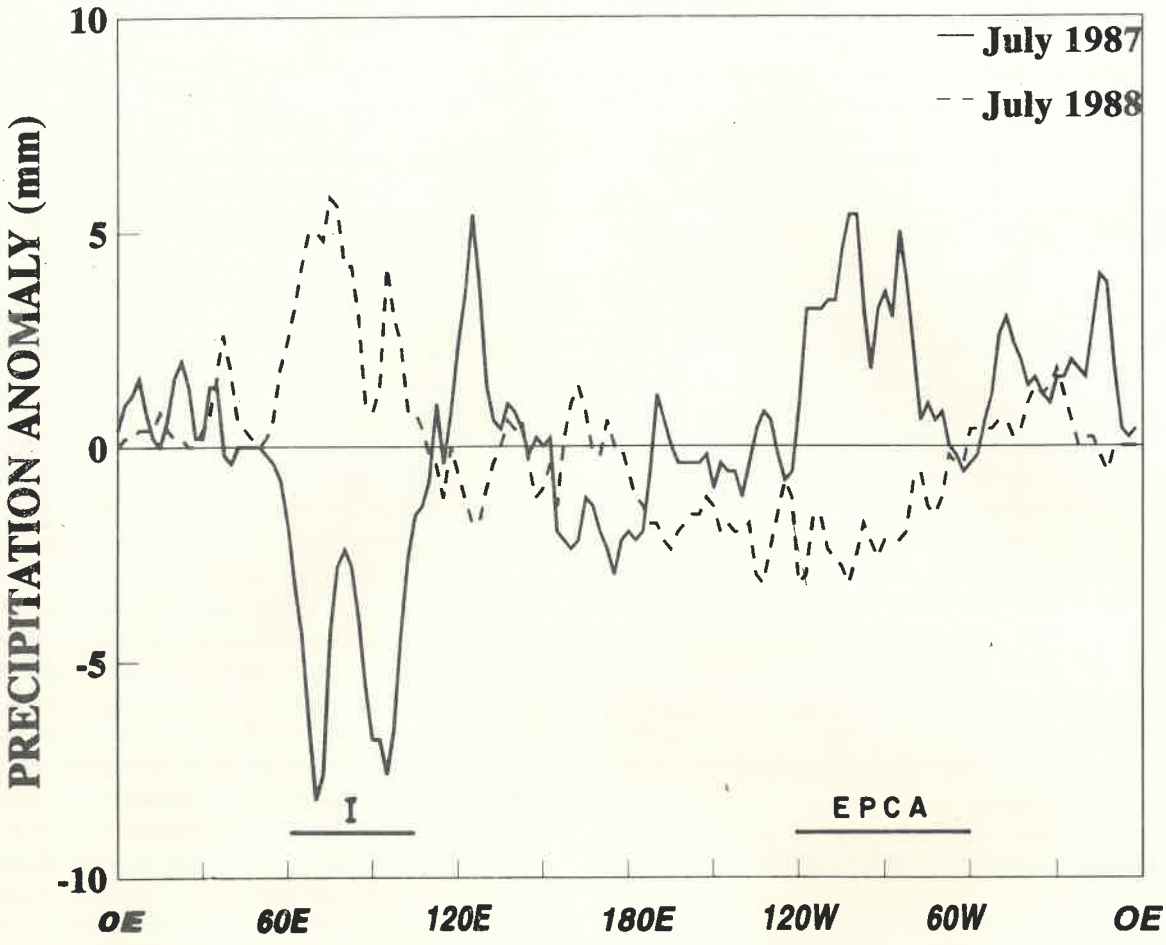

Figure 2 :
Monthly precipitation anomaly along 5° - 15° N for July 1987 and 1988.

Study with satellite derived OLR data indicated that the OLR data can be successfully used as an additional criterionin determining the onset of monsoon over a region and also in monitoring its subsequent distribution with time. The growth and ultimate yield of certain agricultural crops are found to be largely influenced by the timely commencement of rain (onset of monsoon) as well as its subsequent temporal distribution. An earlier study showed that timely (delayed) onset of monsoon over Gujarat and/or a proper (improper) distribution of rainfall/ cloudiness and sun shine resulted into a bumper (poor) yield of ground nut over Gujarat. Further study suggested that the annual production of tea in Assam and Sri Lanka can be estimated on the basis of satellite derived OLR data, as well as conventional weather data. The study showed that high (low) values of areal mean OLR, above (below) a threshold value of OLR (245 w/m. sq.), over the two regions, which signifies more sunshine (shade, due to large scale cloud coverage and rain) during the period, signals poor (better) growth of tea plants with poor (good) yield of tea leaves during the year (Fig. 3). In view of the importance of groundnut and tea in the national

economy, the Economists and Planners can make good use of the result of such study with satellite data in their decision making.

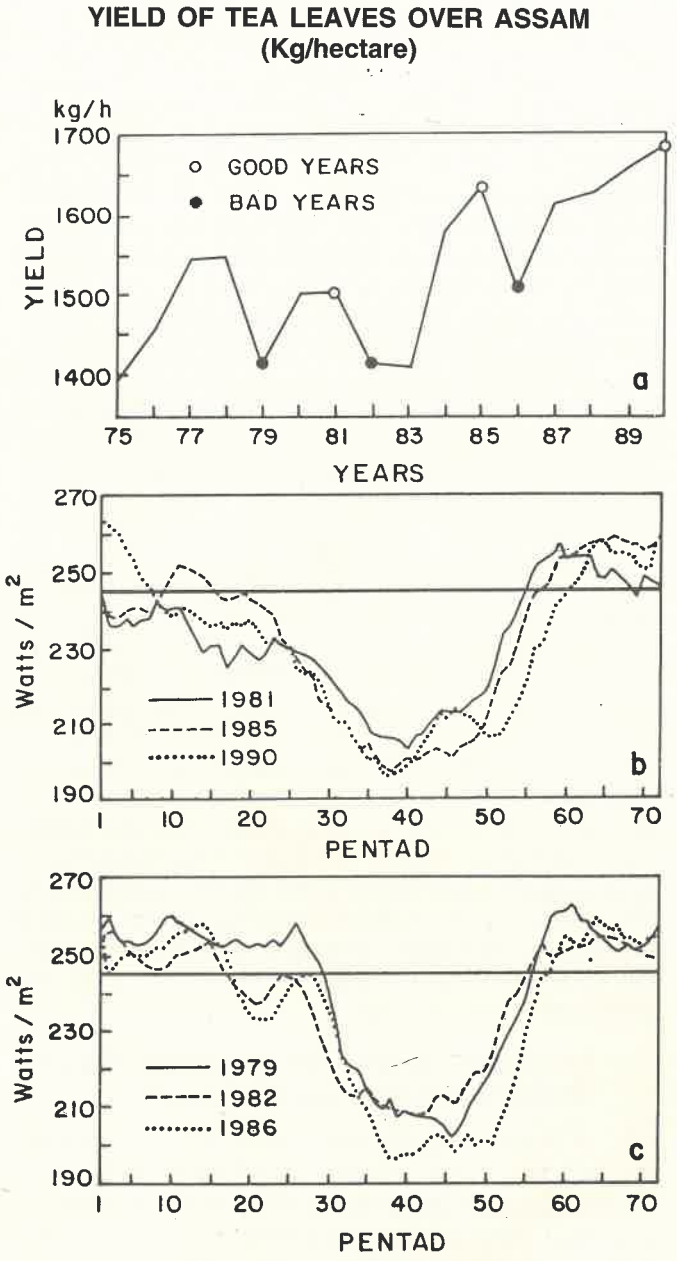

Figure 3 :
(a) Annual Yield (b) Mean OLR distribution for years of better yield (1981, 1985 and 1990) and (c) Mean OLR distribution for years of poor yield (1979, 1982 and 1986).

The break situation in monsoon 1993 were analysed using satellite cloud imageries from INSAT-2A and the weekly percentage departures of rainfall from normal for various subdivisions of India. The study showed that the rainfall activity was modulated by southward extensions of mid-latitude westerly troughs/ridges over India during the season. Such modulation was preceded by anomalous heavy rainfall activity over some of the subdivisions of northwest India, in association with synoptic scale monsoon disturbances. The development of an intense diabatic heat source due to release of latent heat of condensation over the western part of the monsoon trough zone, seemed to play an important role in modulating the circulation and rainfall over India during monsoon 1993.

The monsoon trough controls the moisture convergence and rainfall distribution of the country in space and time during peak monsoon months of July and August. Satellite derived OLR data and the satellite cloud imageries together with conventional pressure and wind analysis were utilised to delineate the location of the trough axis over the Indian longitudes. The intensity and the intraseasonal oscillation of monsoon trough axis for the past 20 years (1975-1994) were examined. Different types of trough oscillations were classified depending on the dominant seasonal location and oscillation of the trough axis during the season. Their year to year variability were examined. The seasonal rainfall distribution over the country in association with each type are studied. It is seen that the frequency of occurrences of an intense trough axis to the south of its mean location for 60 to 80 percent of days during the peak monsoon months of July and August, resulted into good monsoon activity during the seasons (e.g., 1988, 1991, 1994). Similarly dominant northward location of the trough axis for 40-60 per cent of occasion during the two months led to deficient seasonal rainfall (e.g. 1979, 1987).

The governing equations for the computation of power and cross-spectra for the atmospheric motion and transports in the wave number of frequency domain were derived. The spectra for the contribution of the nonlinear interactions of the atmospheric waves in velocity and temperature fields to the conversion of kinetic and potential energies and to the meridional transports of angular momentum and sensible heat in the atmosphere were obtained in the wave number frequency domain.

2.2 CLIMATOLOGY AND HYDROMETEOROLOGY DIVISION

Long-term changes and variability in the climate over the Indian region, particularly the activity of the southwest monsoon, have significant impact on agricultural production 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, 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 parts of the country have the following objectives :

* To construct the longest available homogeneous time series of regional climatic elements from observed meteorological data, historical records and dendroclimatic reconstructions, and to study their behaviour on interannual, decadal and longer time scales.
* To develop empirical prediction models for the seasonal total rainfall over the country as a whole and homogeneous subdivisions of the country. To make a comprehensive analysis of global and regional atmospheric and oceanic parameters and their teleconnections with the Indian summer monsoon rainfall, to understand the nature of these relationships.
* 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

Dendroclimatic Studies

About 120 tree-ring core samples of Cedrus deodara from Western Himalaya (from Manali in Himachal Pradesh through Kanasar in Uttar Pradesh), were analysed and four site chronologies of ring-width index were developed. All the four chronologies contain a significantly large common variance indicating good potential of the species for dendroclimatic studies. The tree-growth climate relationship using the above ring-width chronologies and instrumental record of meteorological data at Shimla showed a significant negative relationship of tree-growth with temperature and positive relationship with precipitation in the summer months. Based on these results, calibrations have been developed and appropriately verified using independent data to reconstruct the summer (MAM) temperature of Shimla. This reconstruction has helped to extend the summer temperature record of Shimla back to 18th century.

Canonical Correlation Analysis for Monsoon Prediction

In view of the high spatio-temporal variability of monsoon rainfall over the country, the forecasting of monsoon rainfall on smaller regional and temporal scales was attempted employing Canonical Correlation Analysis (CCA) involving both conventional meteorological data as well as coupled model forecast SSTs over the Pacific Ocean. The CCA analysis carried out with monsoon rainfall from 29 meteorological sub-divisions in India as the predictand data set and the global SSTs and minimum temperatures over India, in several combinations, as the predictor data set, during the period 1946-87 showed significant and useful skill for monsoon rainfall forecasting for the sub-divisions covering central, northern and western parts of India. The skill scores obtained by this method are found to be much higher and covered larger areas of the country compared to the similar skills obtained earlier using multiple regression technique. However, the skills are very low over the extreme southern parts of peninsula and northeast Indian regions.

Diagnostic Studies using Lamont Coupled Ocean-Atmosphere Model Outputs

A diagnotic study was carried out to understand the nature of rms. errors of SST forecasts from Lamont Coupled Ocean-Atmosphere model for different lead times and to examine their possible association with the monsoon rainfall, using forecasts for a 22 year (1972-93) period. The analysis indicated that the model rms. errors during September till next March in the equatorial Pacific, mainly east of the date line over a broad region are significantly related with the performance of monsoon rainfall over India prior to that period. Utilizing this relationship, when model forecasts from October till next March were corrected using the monsoon rainfall anomalies, the errors get

reduced by as much as 60% over central equatorial Pacific region where the model errors are also incidentally high. Similar association was also found between the rms. errors of Scripps hybrid coupled model forecast SSTs and the monsoon rainfall during the following fall and winter seasons.

Model Diagnostics using UGCM (UK)

The seasonal evolution and the intra-seasonal behaviour of the summer monsoon over India in the UK Universities Global Atmospheric Modelling Programme GCM (UGCM) were examined in relation to the Kuo and Betts-Miller Convective parameterisation schemes. The two convective schemes produced similar tropospheric circulation of the monsoon in the seasonal time scale. The onset phase of the monsoon is represented better by the Betts-Miller scheme. The Kuo scheme produced small amounts of continuous rainfall without any discernible intra-seasonal variation.

The major problem with both the integrations is the collapse of the monsoon pressure field in the beginning of August due to excessive cooling of the land surfaces. This was due to the surface parameterization used in the model, in which the deep soil temperatures are not allowed to vary from the prescribed climatological values. An integration with a modified surface parameterization with a no flux boundary condition in which the soil temperatures vary according to energy input, simulated stronger monsoon flow both in the lower and upper troposphere. The monsoon trough remained active up to the end of September and the continuous cooling of the surface did not occur (Fig.4). However, despite these improvements the simulated monsoon rainfall over India continued to be much less than the observed rainfall.

The impact of different elements of SST anomaly patterns in the tropical Pacific Ocean associated with El Nino/La Nina events on the Asian summer monsoon was examined by a series of seasonal integrations of UGCM. The experiments were designed in such a way as to enable separation of the influence of SST anomalies in the western and eastern Pacific on the evolution of the monsoon.

In both El Nino and La Nina years, the warm SST anomalies have greater impact on the monsoon than cold anomalies. The warm SST anomalies in the central and eastern equatorial Pacific weaken the

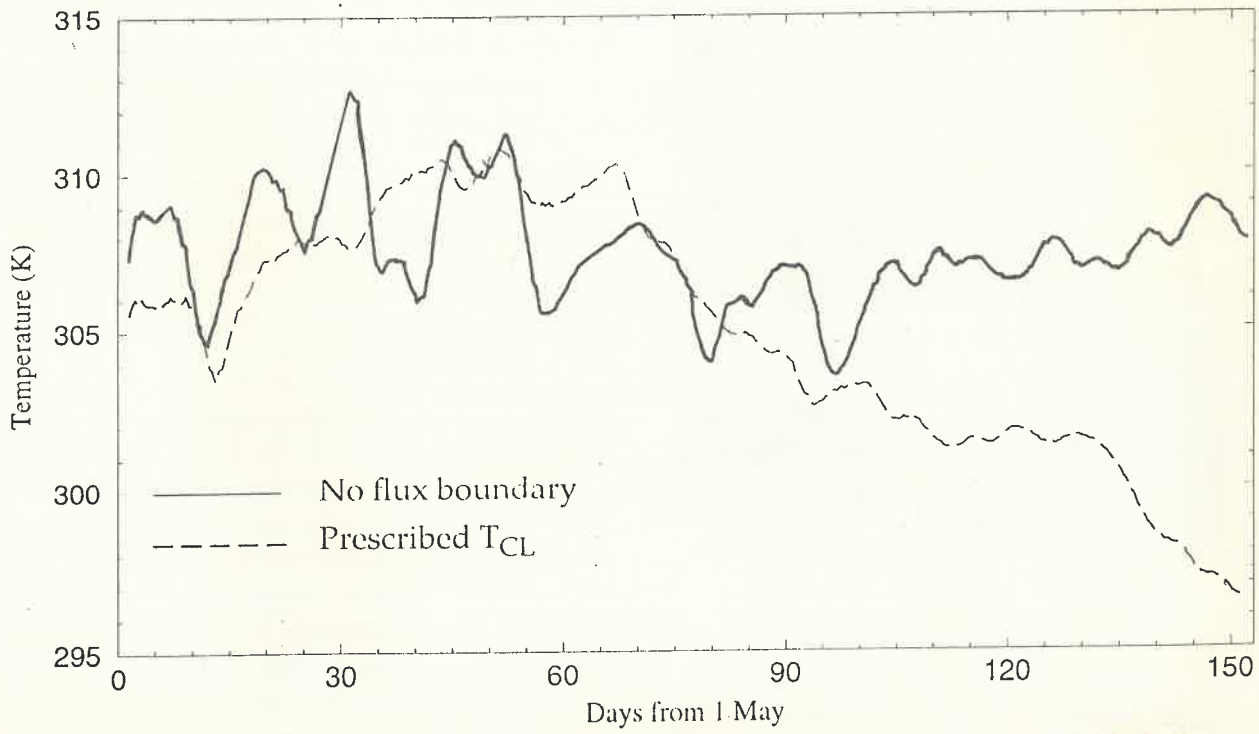

Figure 4 :
Time series of surface temperature (°K) over north India between Lat. 24-28°N and Long. 73° - 85°E from 1 May to 30 September simulated by the model (UGCM) with the old and new land surface parameterizations.

monsoon circulation substantially through the modification of planetary scale divergent circulations. However, when the warm anomalies are absent over this region as in Non-El Nino years, it is the western Pacific SST anomalies which has teleconnections with monsoon. In preceding spring these anomalies modulate the strength and northward movement of the ITCZ in West Pacific (Fig.5) which in turn modulate

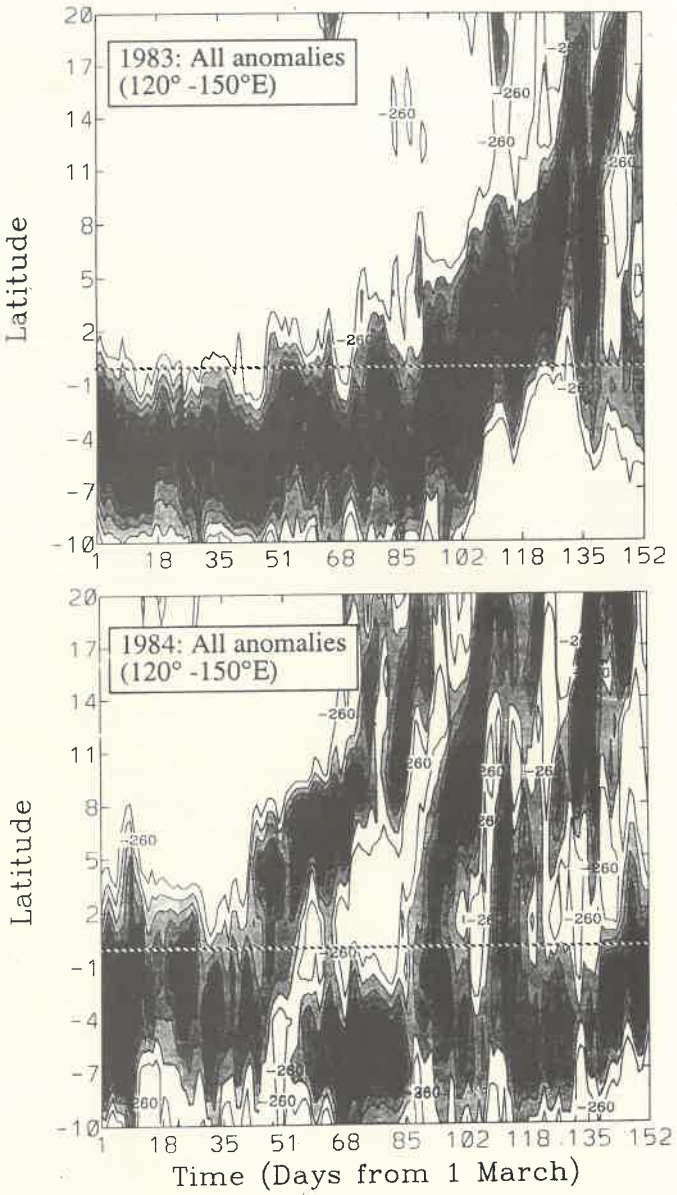

Figure 5 :
Hovmoller plots of OLR showing the northward march of ITCZ over Western Pacific Ocean from the model simulations with SSTs of 1983 and 1984. The contour intervals are 20Wm^{-2} and areas less than 240Wm^{-2} are shaded.

the developing phase of the Asian monsoon. In a number of seasonal integrations with different SST patterns and initial data, the UGCM consistently simulated late onset of monsoon over India when west Pacific was cooler than normal in spring. The integrations of the model with observed SSTs of 1991 and 1994 also showed that the location of SST anomalies in the tropical Pacific is the dominant factor in the interannual variation of the monsoon. As in reality, the model simulated stronger monsoon in 1994 compared to 1991 though the Southern Oscillation index in spring in both the years was negative and of nearly same magnitude.

Variability of Precipitation over South Asia

Annual cycle of precipitation over the Indian Subcontinent was documented to describe climatology and variability of precipitation on daily, monthly and seasonal basis. Daily data generally spanning 60-65 years from 1901 onwards of total 1656 stations over India, Pakistan, Bangladesh, Sri Lanka and Tibet were analysed for this purpose. Selected stations' plots include:

i) The annual unconditional probability of precipitation (UPP) and tabulated weekly UPPS, and weekly total precipitation.

ii) Daily annual median and sextile precipitation amounts using wet days, and tabulated monthly robust and Gaussian statistics.

iii) Histograms indicating the distribution of daily precipitation amounts.

Results depicted precipitation characteristics and contrasts from daily to seasonal scale over the continent (Fig.6-8). Very high UPPS (70% to 100%) were observed over hilly areas and west coast and low UPPS over Pakistan, Northwest India and western Tibet in SW monsoon. Double maxima are evident over Sri Lanka, Tamilnadu and Kerala showing both SW and NW monsoon active. During SW monsoon a relative minimum is observed in August at stations over Central and Northern India. Histograms of wet days showed highly positively skewed distribution of daily rainfall.

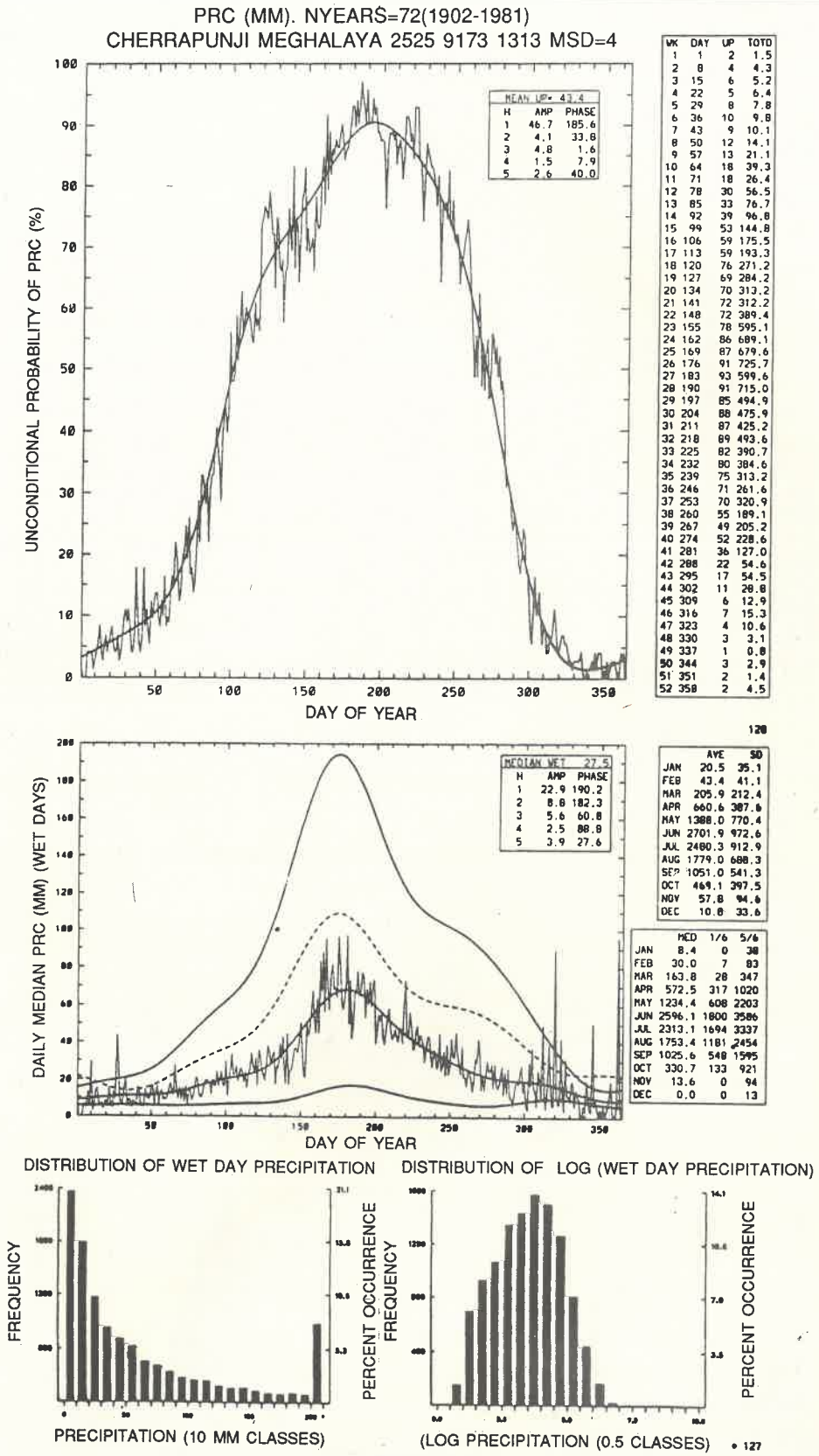

Figure 6 :
Daily UPP, wet day statistics and precipitation distribution for **Cherrapunji.**

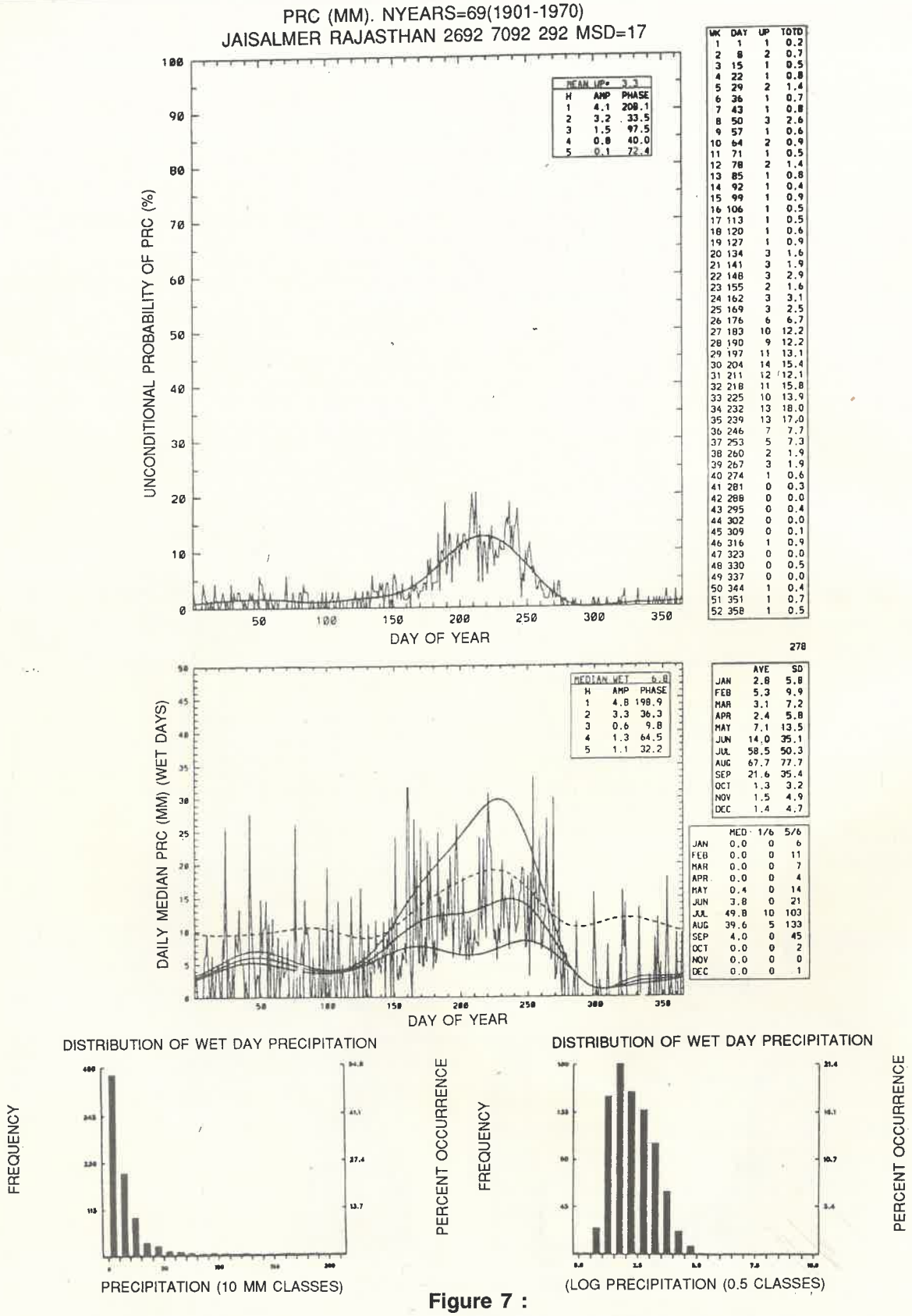

Figure 7 :

Daily UPP, wet day statistics and precipitation distribution for **Jaisalmer.**

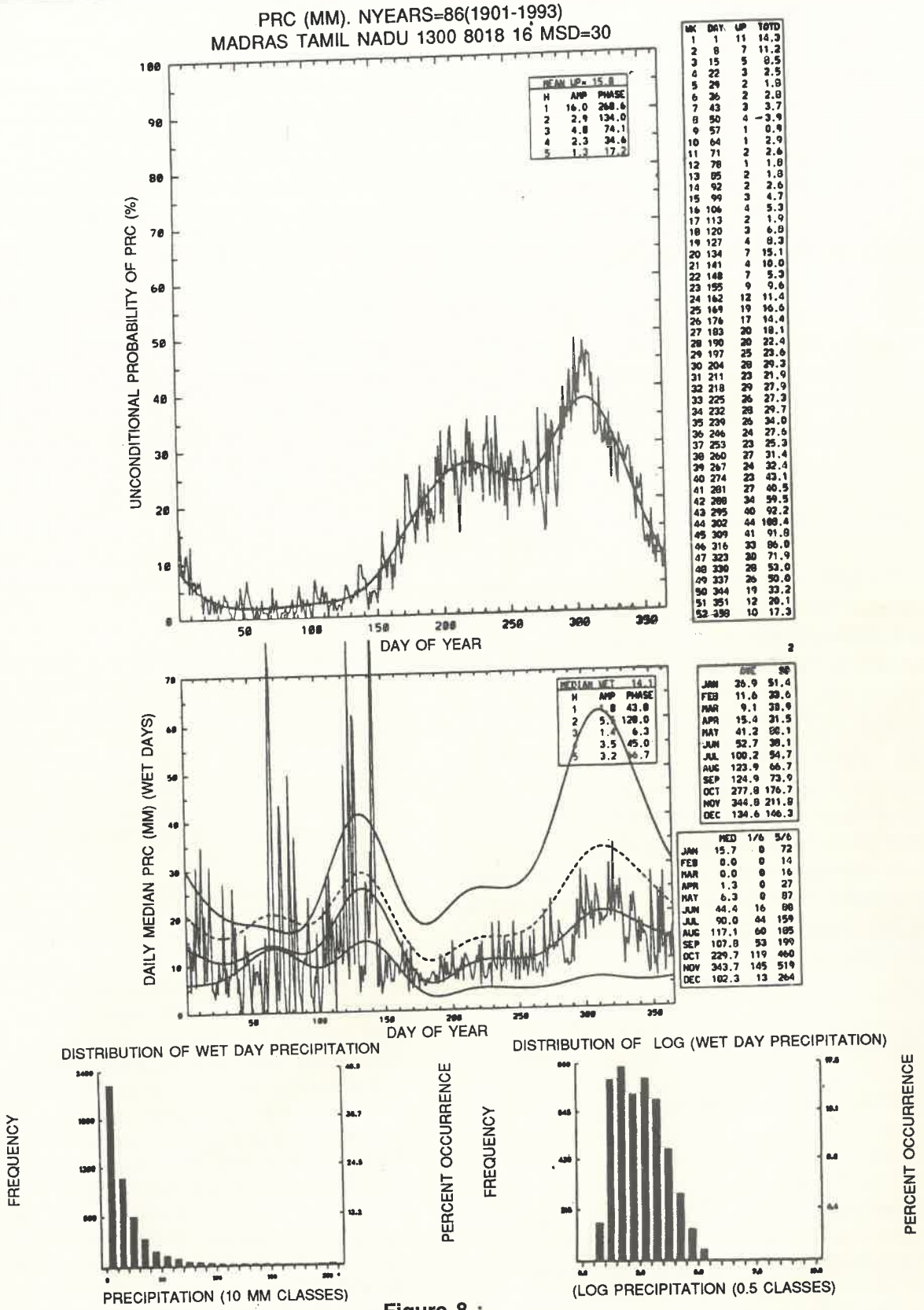

Figure 8 :

Daily UPP, wet day statistics and precipitation distribution for **Madras.**

Optimization of Raingauge Network for Climatological Purpose

An objective technique was developed similar to forward selection of independent variables in the multiple linear regression for optimizing the network of areally averaged climatological series useful for constructing time series with available stations. This attempt of constructing areally averaged climatological series by using limited number of selected stations enabled to construct longest instrumental all-India summer monsoon rainfall series and to from 1813 onwards update the series immediately with easily available stations. The technique was found to be theoretically sound.

Representative Areal Mean Rainfall over India

The areal representation of the all-India summer monsoon rainfall series was found to be limited due to large spatial variability. To develop an effective system of monitoring/prediction of summer monsoon rainfall variations over different regions six zones were delineated over the country. Fluctuation analysis, cluster analysis based on correlation coefficient and distance coefficient, and empirical orthogonal function (EOF) analysis of summer monsoon rainfall of 306 stations were carried out for this classification. The summer monsoon rainfall series for these six zones were prepared for longest instrumental period by using the objective optimization technique. The six zones and the series constructed from the year are as follows:

North West India (NWI)	:	1844
North Central India (NCI)	:	1842
North East India (NEI)	:	1848
West Peninsular India (WPI)	:	1817
East Peninsular India (EPI)	:	1848
South Peninsular India (SPI)	:	1813

2.2.2 Hydrometeorological Studies

Hydrometeorological Study of Tungabhadra and Krishna River Catchments

A detailed hydrometeorological study of the Tungabhadra catchment of 14189 km^2 area up to the gauging site number 27 was made to assess the design storm raindepths of different recurrence intervals and the Probable Maximum Precipitation to be experienced by the catchment. The daily rainfall data of 29 stations for the period 1901-1985 was used in the study. The analysis revealed that the individual stations in the catchment have recorded the highest rainfall in the range of 20 to 50 cm in 1-day, 25 to 80 cm in 2-day and 30 to 100 cm in 3-day durations. Majority of heavy rainstorms over the catchment occurred in the month of July. The catchment as a whole recorded the heaviest rainfall of 12 cm, 20 cm, 28 cm, 31 cm and 35 cm in 1,2,3,4 and 5-day respectively during July 1923. The areal PMP estimates of 1 to 5-days based on physical method are found to be 15 cm, 26 cm, 35 cm, 39 cm and 44 cm respectively.

A study was made for the upper Krishna river catchment up to gauging site-2 having an area of 8700 km^2 to determine the design storm rainfall of different return periods and the PMP likely to be experienced by the catchment using rainfall data for the period 1901-85. It was found that the catchment experienced maximum rainfalls of 14.7 cm, 21.7 cm, 31.2 cm, 38.1 cm and 40.3 cm during 1,2,3,4 and 5 days respectively. Severe rainstorms of July 1912 and August 1914 which occurred *in situ* were moisture maximized to estimate the PMP. The areal PMP estimates of 1,2 and 3-day durations were found to be 19.1 cm, 28.2 cm and 40.6 cm respectively. In the upper Krishna river the Almutti dam is the major water resource project with a storage reservoir capacity of 6425 million m^3 to spillway crest level. The design storm study was done for the catchment above the dam site. The design storm rainfalls of various return periods were compiled from a statistical analysis of point and areal time series of annual maximum rainfalls. While evaluating PMP the maximum observed rainfalls obtained by Duration-Depth (DD) method were maximized to incorporate the influence of the topography of western ghats over the catchment. It was found that the catchment experienced the highest rainfalls of 14.0 cm, 21.5 cm and 24.6 cm in 1,2 and 3-day durations respectively which are scaled up by a factor of 1,2 and 3 to obtain PMP estimates. The

PMP estimates for the Almutti dam were found to be 18.0 cm, 27.0 cm and 31.0 cm for 1,2 and 3-day durations with return periods as 10,000, 4,000 and 1,500 years respectively.

Generalized PMP Estimates

A generalized method of estimating the PMP was developed for the river catchments within India east of 80°E longitude by pooling together all the major rainstorms that have occurred in the region. The areal raindepths of these storms are normalized for the factors such as, storm dew point temperature, distance of the storm from the coast, topographic effects and any intervening mountain barriers between the storm area and the moisture source. The normalized values with appropriate adjustments were applied for the estimation of PMP for the Subarnarekha river catchment up to Chandil dam site having an area of 5663 km². The PMP estimates for 1, 2 and 3-days are found to be 33 cm, 78 cm and 98 cm respectively.

2.3 PHYSICAL METEOROLOGY AND AEROLOGY DIVISION

Investigations relating to the formation of clouds, precipitation mechanisms, atmospheric electricity, atmospheric boundary layer, atmospheric chemistry, middle atmospheric dynamics and its association with the Indian monsoon activity, deterministic chaos and its applications in Atmospheric Sciences particularly with respect to atmospheric modelling are some of the important programmes undertaken by the Division with the following major objectives :

* To improve the knowledge of the physics of monsoon clouds, precipitation mechanisms and atmospheric electrical processes.

* To study the dynamics of the middle atmosphere.

* To study the atmospheric boundary layer in relation to the tropical weather systems.

* To investigate the outstanding problems in atmospheric chemistry including the acid rain, greenhouse gases, ozone depletion, atmospheric aerosols and biogeochemical cycles and evaluate their impact on the climate.

* To study the theory of deterministic chaos and its applications in atmospheric sciences particularly to weather and climate modelling prediction.

2.3.1 Studies in Atmospheric Electricity

The variations noticed in the atmospheric electrical and meteorological parameters during the total solar eclipse of 16 February 1980 were investigated using the field observations collected at Raichur. The study suggested that there was decrease of surface air temperature (about 3°C) following the onset of the solar eclipse. Similar variations viz., decrease in the atmospheric electric field and increase in electrical conductivity were also observed following the onset of the solar eclipse.

The global distribution of Nitric Oxide (NO) production due to lightning was studied using 10° x 10° (latitude, longitude) grid data on lightning frequency for every four hours of a day during the two-year period (June 1978 - May 1980). The production of NO due to lightning was found to be maximum in the latitudinal belt of 0-10°N and the seasonal values showed large variations in the tropical latitudes (20°N - 20°S).

2.3.2 Radar Study of Rain and Rain-bearing Clouds

Nature of the frequency distribution of the spacings between neighbouring convective cloud pairs and their relationship with effective radii of such cloud pairs were investigated. Radar data of precipitation echoes of convective clouds within 100 km around Delhi observed during monsoon season of 1977 were considered for the study. The distributions of the spacings between the neighbouring clouds were found to be lognormal. The effective radii of clouds and their spacings are found to have linear relationship.

Based on radar data, frequency of occurrence of thunderstorms in four different regions of India namely, Bombay, Calcutta, Delhi and Gauhati as well as their height distributions during the hot weather and monsoon seasons were investigated. The study showed that in both the seasons, frequency of storm development varied markedly from place to place. In both the seasons, maximum frequency of storm occurrence was found in Calcutta region. However, minimum frequency of storm occurrence was found in Bombay region in hot weather season and in Gauhati in monsoon season. Study of the height distribution showed that in hot weather season thunderstorms

attain greater height in Bombay than in other regions, while in monsoon season they attain greater heights in Delhi. In hot weather season, mean height of the storm echo tops were found to be 11.1, 10.0, 9.2 and 9.2 km in Bombay, Calcutta, Delhi and Gauhati regions respectively. In monsoon season, mean height of the storm echo tops in the above four regions were found to be 9.7, 9.1, 10.4 and 8.6 km respectively.

2.3.3 Warm Cloud Modification

Dynamics of monsoon clouds and the effects of seeding warm clouds with hygroscopic particles were investigated through simulation of the relevant dynamical and physical processes in the cloud model. For this study a two dimensional time dependent cloud model and the aerological soundings of Bombay were used. The results of the study suggested that (i) the vertical growth of the clouds is markedly influenced by the magnitude of the convergence at the cloud-base level. 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 gm m^{-3}) resulting in large size rain drops/high intensity rainfall and (ii) seeding warm clouds with hygroscopic particles (1-10 particles of sodium chloride per litre of cloud air) could result in acceleration of the collision- coalescence process leading to higher rainfall (maximum up to 1-2 times in ideal cases).

Charts depicting the spatial distribution of wettest and driest hours of the day during the southwest monsoon season over the Indian region have been prepared. For this purpose the hourly rainfall values for 42 self-recording raingauge stations with data period of 5 to 9 SW monsoon seasons for different stations were utilised. The overall picture brought out by the charts indicates that the wettest period occurs in the afternoon hours over the main land region and in the night-hours over the coastal region. The delay in time brings out the differential response of the solar influence on precipitation formation mechanism over land and sea areas. The driest period of the day occurs in the forenoon hours over a large portion of the Indian region suggesting that there is no significant difference in the occurrence of driest period over the main land regions and over the coastal regions of India.

2.3.4 Studies of the Atmospheric Boundary Layer

Simulations of boundary layer parameters were carried out using the aerological observations over Pune collected during 1980 and 1981 and over the Arabian sea collected during MONSOON-77 experiment. The effect of turbulence was studied using the transilient turbulence theory. In case of potential temperature, after turbulent mixing, the profiles showed neutral/stable stratification which were unstable initially. Simulated profiles of moisture, showed upward transport after mixing.

The dynamical characteristics of the convectively driven monsoon trough boundary layer were investigated using the conserved-variable method of analysis. For the above study aerological observations collected during the Monsoon Trough Boundary Layer Experiment-1990 (MONTBLEX-90) were used. Thermodynamical parameters such as θ_e, θ_{es} were computed from the aerological observations and the mixed-layer heights obtained from SODAR were used in the study. The results of the study indicated the following:

(i) The mixed-layers which were unsaturated before the onset of the monsoon became saturated due to intrusion of moisture into the boundary layer.

(ii) The mixed-layer heights indicated a diurnal cycle, with a peak at 0.8-1.0 km between 1100-1300 hrs IST.

(iii) The thermodynamic conditions at Bhubaneswar and Calcutta, as seen from θ_e and θ_{es}, were favourable for deep convection whereas those at New Delhi and Jodhpur indicated suppression of convective activity.

The dynamical characteristics of downdrafts in the monsoon trough region were investigated using the aerological data collected during the MONTBLEX - 90. The "Saturation Point Analysis" technique was used to study the convective scale downdrafts driven by the evaporation of rain in the monsoon trough region during the passage of synoptic disturbances. The results of the study indicated a characteristic mixing line in the lower troposphere ahead of the synoptic disturbance and a distinct evaporation line structure following the passage of the disturbance.

2.3.5 Deterministic Chaos

A study of interannual variability was carried out using 28-years' (1961-1988) seasonal mean COADS global air and sea surface temperature data sets. Continuous periodogram analysis of the temperature time series suggested that the power spectra follow the universal inverse power law form of the statistical normal distribution. Inverse power law for power spectra of temporal fluctuations is identified as signature of the self-organized criticality and is explained on the theory of the cell dynamical system for atmospheric flows developed at the Institute. Universal spectrum for interannual variability rules out linear secular trends in global air and sea surface temperatures. The study indicated the potential applications of the chaos theory in atmospheric research and for the first time introduces quantum-like mechanics, fractals and self-organized criticality into Classical Climatology. The results are of significant importance in demonstrating how this relatively new approach can be integrated into and assist in the understanding of the apparent existence of global warming trends.

A study of the total ozone for 5 stations, Hobart (42° 49'S, 147° 30'E), Melbourne (37° 50'S, 144° 59'E), Tateno (36° 03'N, 140° 08'E), Reykjavik (64° 00'N, 21° 30'W) and Varanasi (25° 20'N, 83° 00'E) was carried out using 6 sets of twenty to twenty five daily averages of the data obtained from the Ozone Data for the World (1991). The broadband power spectra of total ozone time series was computed using the Jenkinson method of quasi-continuous form of classical periodogram analysis. The results of the study suggested that the spectra of temporal (days) fluctuations of atmospheric columnar total ozone content follow the universal and the unique inverse power law form of the statistical normal distribution. It was shown that the inverse power law form for the power spectra of temporal fluctuations is a signature of self-organized criticality in the non-linear variability of atmospheric columnar total ozone content and the self-organized criticality can be quantified in terms of the universal characteristics of the normal distribution. The cell dynamical system model for atmospheric flows developed earlier and the results of the periodogram analysis suggest that it is possible to predict the dominant cycles in the atmospheric columnar total ozone content.

The association of meteorological parameters, solar and lunar activity with the incidence of Acute Myocardial Infarction (AMI) was investigated using the cases of AMI recorded at a leading Institute of cardiology at Pune during June 1992 to May 1994. The above study was carried out by one of the medical students as a partial fulfilment of his M.D. (General Medicine) under the guidance of one of the scientists of the Institute. The results of the study indicated association between the incidence of AMI, surface pressure, cosmic ray index, solar flares and the lunar activity.

2.3.6 Studies in Upper Atmosphere

A study of the Quasi Biennial Oscillation (QBO) in the winter north-pole temperature at 30 hPa and its association with the Indian south-west monsoon rainfall was carried out using the temperature and rainfall data for 32 years (1957- 1988). Harmonic analysis of the temperature and rainfall data exhibited the QBO signal in north pole temperature as well as in the Indian summer monsoon rainfall. Also, it was suggested that the years of good summer monsoon rainfall over India were preceded by warm north pole temperatures at 30 hPa during winter and vice-versa.

A study of the variations in the temperatures and geopotential heights in the lower stratosphere over Antarctica during winter and their association with the ozone variability was carried out. For the above study the daily data of temperature and geopotential heights for 50 hPa and 30 hPa for Syowa (69°S, 40°E) for the 10-year period (1977-1982, 1984-1987) and the mean monthly Dobson total ozone data for south pole were utilised. Results of the Harmonic analysis of the data showed significant periodicities of 15, 30 and 60 days in temperature and geopotential height. The 30-day periodicity was found to be dominant. The variations in the total ozone during winter was found to be closely associated with the temperature and geopotential height at 50 and 30 hPa.

A study of the effect of Pinatubo volcano on the temperature stratification in the stratosphere/ troposphere in the low- and high-latitudes was undertaken using the related rocketsonde temperature and other aerological data for two winter seasons (1991-92 and 1992-93). Preliminary results of the study indicated that the aerosols released into the stratosphere during the Pinatubo volcano could alter the radiation balance resulting in the decrease in the planetary wave activity/stratospheric warmings.

2.3.7 Studies in Air Pollution and Atmospheric Chemistry

Study of chemical composition of aerosols collected at the Nilgiri Biosphere Reserve forest revealed the following:

i) The concentration of Pb, Cd and Ni in TSP and size separated aerosols were found to be below detection limits. This indicates the absence of long range transport of pollutants to the forest region. The concentration of Cu, Zn, Mn, Fe and Al are minimum during the monsoon season due to washout effects.

ii) All the heavy metals i.e. Cu, Zn, Mn, Fe and Al showed unimodal distribution with a peak in coarse mode in all the three seasons with variation in amplitude. The percentage contributions of coarse particles were found to be higher than those of fine particles of Al, Fe, Mn and Cu whereas, in the case of Zn, the percentage contribution of fine particles was slightly higher than that of coarse particles. This observation suggests that vegetation may be the source for Zn and soil is the source for Fe, Al and Mn.

The analysis of rain water samples collected at Sinhagad during the monsoon season of 1992 suggested that rain water is alkaline with pH values varying from 5.9 to 6.7. The ionic composition was alkaline and the concentration of Ca was highest among all the ions. The low concentrations of excess SO_4 and NO_3 (23.8 and 15.2μ eq/l respectively) observed indicated no effect of air pollutants of anthropogenic origin.

Wet and dry deposition samples collected at Pune during 1994 were analysed for Na, K, Ca and Mg. The pH value of Pune rain water collected during 1994, varied between 5.90 and 8.10 indicating that the rainwater at Pune continued to be in the alkaline range.

Ten samples each of coal and soil were collected around Singrauli Super Thermal Power Plant. Analysis of these samples for different ions (Fe, Cl, SO_4, No_3 NH_4, Mn, K, Ca and Mg) along with pH suggested that the concentration of SO_4 was found to be maximum (454.4 mg/kg) and that of K was minimum (20.0 mg/kg) in coal whereas in soil the concentration of Ca was found to be maximum (254.10 mg/kg) and that of Fe was minimum (46.0 mg/kg). The high concentration of sulphate observed in the coal used in the thermal power plant was found responsible for the presence of acid rain observed in the near vicinity of the coal fired plant on some occasions in the downwind regions.

An Ion Chromatograph (Model DX-100) of Dionex Corporation, USA has been installed for the study of detection of more inorganic and organic ions which were not analysed so far in rain/aerosol samples. Also, the analysis by Ion Chromatograph proves the accuracy of the analysis methods followed earlier.

2.3.8 Lidar Probing of the Atmosphere

Special observations of lidar aerosol vertical distribution were organised at the Institute during 7-18 September 1994 as a part of the world-wide Correlative Measurements Programme of the 'Lidar In-Space Technology Experiment (LITE)' launched aboard the U.S.Space Shuttle discovery on 9 September 1994 by the NASA, USA. These lidar observations were being analysed to study the tropospheric aerosol characteristics, night-time boundary layer and cloud parameters over Pune. The results will be used for the validation of the above space-based lidar performance over Pune during the mission period.

The effect of volcanic material on the satellite observed stratospheric aerosol size distributions was studied using the SAGE (Stratospheric Aerosol and Gas Experiment) data of aerosol extinction and optical depth, covering the latitude range, 75^oS - 75^oN during the volcanic eruptions of Alaid (50.8^oN, 155^oE) and Pagan (18.1^oN, 145.8^oE) during April-May 1981. The latitudinal variations showed higher aerosol optical depths in the equatorial and high-latitude regions while the average data showed 2 to 4- fold increase in the aerosol extinction due to the above eruptions. Using the ratio of aerosol extinctions at wavelengths, 0.45 μm, and 1.00 μm, the aerosol modal radius at different air layers was evaluated to examine the changes in size distributions due to eruption. it is found that the larger aerosol particles (with modal radius in the range, 0.06 0.12 μm) were found to be in abundance in the post-eruption period.

In order to study the dynamical interaction between the troposphere and stratosphere, a field experiment was carried out using the National MST Radar Facility at Gadanki during 17-25 November 1994. The preliminary analysis of the observations indicated (i) presence of stable layers in the 6-8 km

height region and around tropopause, (ii) unusually large meridional wind velocities of more than 20 m/s indicating the cyclonic activity, (iii) sharp gradients in both zonal and meridional winds around 7 km and (iv) radar signatures from hydrometeors around 5 km and large vertical wind velocities of more than 1 m/s around 12 km during the period of strong convective activity in the region.

The spatio-temporal variations in the water vapour optical depth in the lower troposphere and their association with the south-west (SW) monsoon activity were studied using the radiometersonde data of pressure and temperature profiles obtained at Pune during the years 1987 and 1989-1992. The results of the study indicated that (i) water vapour optical depths were found to increase from pre-monsoon to monsoon by about 58% and the maximum increase of 80% was observed in the 1465-2000 m layer, (ii) monthly variations in the vertical structure of optical depth showed a pronounced annual oscillation with the largest amplitude around 1465 m, and (iii) time-height cross-sections of water vapour optical depth showed early (March or April) vertical transport during the good monsoon year (1991) and delayed vertical transport of moisture, during the bad monsoon year (1987).

Multi-spectral observations of solar radiation using a Volz sunphotometer were carried out in the vicinity of the Blow-out of the ONGC gas-well at Pasarlapudi, Andhra Pradesh during 24 February-2 March 1995. These observations were used to derive the aerosol and gaseous optical depths. The preliminary analysis of the observations indicated significant variations in aerosol optical depth at different wavelengths (0.4, 0.6, 0.94, 1.06 and 1.63 μ). The wavelength dependence of aerosol optical depths revealed the Junge aerosol size exponent variation from 2.41 to 3.39 indicating the presence of coarse-mode smoke particles and it showed correspondence with the variations in relative humidity during the period of observations.

A high power, pulsed, tunable CO_2 laser system has been installed on to enlarge the scope of the lidar aerosol and trace gas observations up to stratospheric altitudes. The observations proposed to be undertaken would be valuable for better understanding of the climate system and its variability.

2.3.9 Spectroscopic Measurements of Atmospheric Minor Constituents

The UV-visible spectrometer was set for the observations in the wide spectral region 400-600 nm by mounting the bandpass filter LL-400 to KS 600 nm on the filter wheel. This system is calibrated for the wavelengths in visible region by using sodium and mercury sources. Further, slitwidth of the system is increased and NO_2 absorption cross-sections for the visible region were worked out with the help of NO_2 cell spectrum.

Photometric observations collected at Pathardi (Ahmednagar District) for the period April-December 1993 and January-May 1994 were analysed.

The analysis of spectroscopic observations of NO_2 and O_3 collected during the period October-December 1993 was completed. The slant column densities of NO_2 and O_3 were calculated to retrieve their vertical profiles.

2.4 INSTRUMENTATION AND OBSERVATIONAL TECHNIQUES DIVISION

The broad scope of this 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:

From an analysis of measurements of the electric field vector mode on the ground surface in the vicinity of a cumulus cloud with a spherical field meter, it is concluded that the past calculation of charge in a cloud which are based on the measurements of only the vertical component of electric field, may be in error. Further, it was proposed that for location of charge center in a cloud, measurements at only two instead of four stations are required, if the electric field vector instead of the vertical electric field is measured (Fig. 9).

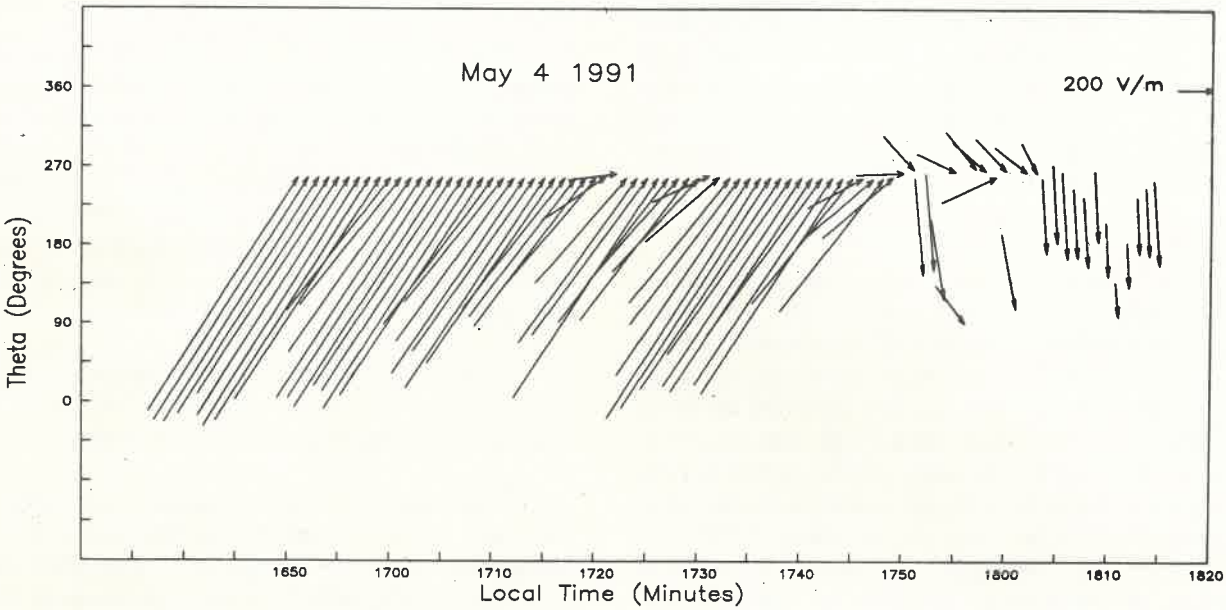

Figure 9 :
Measurements of atmospheric electric field vector at ground close to a cumulus cloud.

Analysis of atmospheric electric conductivity obtained in the western equatorial Indian Ocean and Arabian sea on board ORV Sagarkanya showed that the electrical conductivity increases with the increase in relative humidity/sea surface temperature. The electrical conductivity also shows an increase with geomagnitude latitude on both the sides of geomagnetic equator.

Theoretical computations of the electrical conductivity were made considering the effect of recombination of charged aerosols. In support of earlier measurements at Pune, the results showed an increase in polar conductivity with the increase in aerosol concentration when aerosol concentration is > 10^4-10^5/cc. For still higher concentration of aerosol, the conductivity settles down to some constant value.

Simultaneous observations of space charge using Faraday cage and direct filtration technique were taken for comparison of the two techniques of space charge measurements.

The Electrical Aerosol Size Analyser was installed and commissioned to measure aerosol size spectra in the sub-micron range. Arrangements to collect air samples at 1 meter height from the ground were made. A few samples of atmospheric aerosol size spectra were obtained and checked.

The data logger to record atmospheric electric parameters was installed and commissioned.

The instrument fabricated to measure charge and size of the raindrop was tested with data logger and the data obtained with it was checked to improve the design of the apparatus.

A field experiment was conducted at the gas well Blow-out site at Pasarlapudi, near Amalapuram, Andhra Pradesh during 23 February to 3 March 1995 to measure atmospheric electric field and conductivity.

2.4.2 Simulation Techniques for Cloud Physics Studies:

Results of a laboratory experiment on the scavenging of aerosol particles by water drops showed effects of distortion and oscillation of drops along with the effects of electrical forces on the scavenging of

rainfall. Results demonstrate that the rainfall from an electrified thundercloud may be more efficient in scavenging the aerosol particles in the atmosphere than the one from an unelectrified cloud. Computations of washout coefficient showed that a heavy rainfall over a short duration is more efficient in removing the particles < 2.2μm whereas a lower rainfall spread over a long duration is more effcient in removing particles > 2.2μm.

Photographic technique used to determine the size of the water drop suspended in a vertical wind tunnel was tested by taking several photographs against bright and dark backgrounds.

Results of a laboratory experiment on the effect of density of aerosol material on the collection efficiency of a large water drop collecting micron-size particles showed that the collection efficiency increases with increase of the density of aerosol material and size of the particles.

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.
* Analysis of the MONTBLEX Observations.

2.5.1. Development of Instruments for Boundary Layer Studies

The kytoon data obtained during 1989 field experiment was used to prepare humidity profiles to study the large scale advection effects of water bodies. The humidity profiles respond to this effect in the morning hours.

Turbulent statistics : w/u_*, u/u_*, v/u_* were computed using sonic anemometer data collected during 1992 Land Surface Field Experiment. The ratio of energy density of vertical wind and zonal wind was found to be around 1.33.

Using 1992 field experiment data, partitioning of total energy and wind effect on the soil flux were studied. On cloudy days with low winds the ratio of soil flux to total radiation is about 0.24 and it is 0.15 on clear sky days.

The correlation between soil temperature gradient and radon emanation concentration is found to be 0.50 in the month of August and radon emanation is inverserly proportional to soil surface temperature. Hence, during winter season more radon emanations are observed than those during summer and rainy season. The correlation between atmospheric pressure and radon emanation levels is 0.92. It was found that there is a close relationship between radon, thoron and their daughter product and surface meteorological parameters and soil surface temperature.

Studies on evaporative fluxes were carried out for May-December 1994 on atmospheric stability with Penman-Brutsaert potential evaporation model using mean hourly values of R_n, G, R_H, T_a and U of CAMO-IMD site. The fluxes for wet months were in good agreement with class A pan evaporimeter while they were over estimated for dry periods.

While testing the Digital Data Transmission System procured from Bangalore, a small shift in the time of onset of transmission was observed. This problem was being rectified using another circuit for time control being developed at the Institute. Further testing of the system was continued.

A new circuit was developed to use d.c. motor for the Bowen's ratio technique to be used in the forthcoming Land Surface Processes Experiment.

2.5.2 MONTBLEX Studies

The PBL height over Kharagpur was estimated using turbulent fluctuations of wind and temperature obtained during pilot MONTBLEX experiment (6 and 7 July, 1989). Two different methods were used to compute the PBL height. Some studies on large scale circulations over Kharagpur during MONTBLEX were in progress. Spectra of wind direction, speed, temperature and the flux spectra were estimated for the pilot experiment to study:

(i) the scales of eddies contributing to the turbulent boundary layer structure and

(ii) the performance of wind direction sensor (slow) w.r.t. sonic anemometer in order to determine the minimum averaging time required to compute the lateral dispersion coefficient.

The variation of drag coefficient (C_D) with wind speed and stability over sea surface were studied for the period 18 August to 19 September 1990 using

surface meteorological observations obtained on board ORV Sagarkanya during MONTBLEX-90. The results showed that the mean value of C_D = 1.5 x 10^3, for neutral conditions and that it increases exponentially with increasing instability. At low wind speeds (< 5 m/s), C_D decreases with increasing wind speed and is nearly constant for speeds 6 -10 m/s.

Vertical velocity in the Boundary Layer were computed using MONTBLEX-90 data for a few synoptic situations of monsoon in Kharagpur region.

Using Doppler Sodar, a low level nocturnal jet was observed around 2300-0200 hrs IST (11.6-17.6 m/s max. wind) at 330 m agl at Kharagpur during MONTBLEX-90. The jet is due to inertial oscillations with a period of 36 hrs. originating from sunset.

Mesoscale divergence was studied for some cases of MONTBLEX-90 data and the boundary layer characteristics were analysed.

2.6 THEORETICAL STUDIES DIVISION

Atmospheric physical phenomena can be studied through numerical modelling. 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 couple ocean atmosphere model for understanding global circulation.

2.6.1 Barotropic and Baroclinic Instability of the Atmospheric Flow

For the understanding of the existence of slow instabilities, a simple couple ocean model was formulated and necessary pre-requisites of the eigen value problem were completed.

Work was undertaken to investigate the instability characteristics of large scale low latitude disturbances using semi-geostrophic approach. Energetically consistant semi-geostrophic equations were formulated. Numerical version of the model was completed with suitable horizontal and vertical boundary conditions and using centred difference scheme for space derivatives.

In order to understand the role of (i) boundary flux terms of both zonal and eddy kinetic (K) and available potential(A) energies as well as (ii) dissipation (generation) of K_z and K_E (A_z and A_E), for the maintenance of monsoon systems, the computer routines for computing energy budget were modified successfully.

Energy budget of the monsoon system that formed in the beginning of June 1994 was completed using initial analysed grid point wind and height data from surface to 100 hPa at 1.5^o interval over 6^{o}S to 25.5^{o}N from coast of Africa to central India for the period 30 May to 10 June. Time averaged vertically integrated energies and conversions indicated that (i) Basic state KE (APE) is dominated in the upper (lower) troposphere but the eddy energies are comparable throughout in the vertical (ii) the system is maintained and enhanced due to generation of eddy available P.E.

2.6.2 Simulation of Mean Monsoon Circulation and Predictability of the Monsoon Systems

Atmospheric Modelling

Divergent-rotational KE conversions by zonal-wave and wave-wave interactions due to Coriolis force, vorticity and divergence effect for stationary, transient and observed flow at 200 hPa and 850 hPa over the global tropical belt (10^{o}S to 30^{o}N) for the month of July 1979 were investigated. Computations suggest that the Coriolis force is the primary contributor for all categories of stationary and transient wave.

Further, the computations of the nonlinear K.E. exchanges, into individual traid interactions, in the frequency domain for global tropical belt (20^{o}S to 30^{o}N) at 200 hPa using June-August 1988 TOGA data were completed. The results showed that high frequency transients gain K.E. from low frequency transients and low frequency triads are relatively stronger than high frequency triads.

Earlier developed 3-D nonlinear, non-hydrostatic, P.E., numerical, mesoscale model was modified with

unequal resolution in the vertical and azimuthal direction using sponge boundary condition in order to avoid boundary reflection. The model system conserves mass and energy. The model was applied to study the dynamics of air flow through a mountain gap over the Turkana Channel of East Africa. The results of quasi-steady state after 16 min. of integration with t = 10 sec. showed maximum downward motion at the centre of the channel which is comparable to the radial in flow and the magnitude of downward motion decreases at the narrow end and at azimuthal boundaries.

Ocean Modelling

In-house developed reduced gravity wind driven ocean circulation numerical model with horizontal resolution 28 km was used successfully to simulate intra-seasonal and interannual variability in the upper layer circulation of the North Indian Ocean (24^{o}S to 23^{o}N and 35^{o}E to 115^{o}E). The influence of local and remote forcings in the circulation of west coast of India and in the Bay of Bengal were investigated using closed and open eastern boundary in the model. Results of west coast circulation indicated that the northward flow along the west coast of India during winter months (November-February) is remotely forced by coastal Kelvin waves propagating from the Bay of Bengal and southward flow during summer months (May-September) arises due to local forcings by the Arabian Sea wind. However, circulation in the Bay of Bengal seems to be remotely driven by the equatorial waves throughout the year.

The model is also used to simulate surface circulation of the Arabian Sea and the Bay of Bengal for two cases of contrasting monsoon years (i.e. 1978-79 and 1982-83). Results indicated that during bad monsoon years there is relatively strong equatorial flow in early March and shallower upper layer thickness in the southern Arabian Sea in April. This in turn indicates cooler sea and therefore, not favourable for monsoon activity.

Daily rainfall SSM/I data for 1981 to 1986 were studied over the North Indian Ocean as well as west and central Pacific tropical ocean (i.e. from 25^{o}S to 25^{o}N and 30^{o}E to the Date line). Primary analysis of each 10^{o} belt of two cases of consecutive contrasting monsoon years (1981-82, 1985-86) indicated northward propagation of rainfall pattern during good monsoon years and southward propagation in bad monsoon years over Indian Ocean.

2.7 CLIMATE AND GLOBAL MODELLING DIVISION

The Climate and Global Modelling Division has been formed with the objective of studying monsoon and climate variability on different time scales using global climate models. The research programmes undertaken by the Division are:

* Study of atmospheric general circulation model by using different global climate models
* Long range prediction of Indian summer monsoon by Artificial Neural Network

2.7.1 Monsoon Studies with Climate Model

The study of the atmospheric circulation anomalies during the contrasting monsoon years viz. 1987 and 1988 using COLA Model was carried out. The COLA GCM with triangular truncation at zonal wave number 30 (T30) resolution was integrated for 90 days, starting from the National Meteorological Centre (NMC) analyses of the observed atmospheric initial state of 0000 UTC on 1 June 1987 and 1 June 1988. The study showed that the low level circulations over the Arabian Sea were strongly anticyclonic during 1987 and the speed of the Somali Jet as well as TEJ (Tropical Easterly Jet) was less in 1987 than in 1988. There was an eastward shift of upper tropospheric divergent field at 200 hPa in 1987 compared to 1988. The centre of divergence at 200 hPa in 1987 (mean of June, July and August) was located at 150^{o}E and that in 1988 at 130^{o}E. The other general circulation statistics such as transport of heat, momentum, various energy conversions, sources and sinks etc. are being estimated.

The Climate Model from the Hadley Centre (U.K. Met. Office) was integrated for 30 days on the HP 9000 workstation of the Institute. The model has horizontal resolution of 5^{o} x 7.5^{o} in latitudes and longitudes and 19 levels in the vertical. It has initial conditions from the U.K.Met. Office analysis of 1 June 1991. The different components of the model were being studied.

2.7.2 Climate Model on Parallel Processor

Climate Modelling requires computational powers of the order of Giga or Terra flops. Such a requirement can be fulfilled by the use of parallel processors. A project on development of an optimised parallel climate model code was taken up. The CHiPPS (C-DoT High Performance Parallel Processing System) acquired by

the Institute is being used for this purpose. The CHiPPS is based on Single Algorithm and Multiple Data (SAMD) architecture. It has three components, viz. (i) Main Controller (MC), (ii) Processing Elements (PE) and (iii) Global Memory Banks (GMB). A flexible Interconnection Network (ICN) interconnects all the components. The raw data for computation are written by the MC into the memory banks and the program is broadcast to the PEs through high speed serial links. The PEs are based on IMS T800 transputers with peak performance of 2.25 MFLOPS at 25 MHz. It has local memory of 4 Megabytes. The total number of PEs is 192.

In SAMD architecture, the spectral GCM has been parallelised in a straight forward way by identifying the parallelism inherent in the model. During each step of integration, there are three stages of computation, viz. grid point domain, spectral domain and back to grid point domain. In the grid point domain, the computations are done on each latitude pair which is independent of the computations on the other pair. The pair of latitudes consists of the northern latitude and its corresponding latitude in the southern hemisphere.

GCMs with the parallel code at resolution of T21, T42, T63 were installed on the CHiPPS. For T21 resolution, there are 32 latitudes from north to south and 64 grid points along each latitude. The computations on 32 latitudes were assigned to 16 PEs. 48 PEs were used for T 63. To get the understanding and familiarity with the parallel code, the models were integrated up to 30 days, with and without physics.

2.7.3 General Circulation Diagnostics

The Atmospheric Model Intercomparison Project (AMIP) is an international effort to determine the systematic climate errors of atmospheric general circulation models (GCMs) under realistic conditions and calls for simulation of the climate for the decade 1979-1988, using the observed monthly averaged distributions of sea surface temperature and sea ice as boundary conditions. The atmospheric circulation features simulated by the UNIFIED Climate Model of U.K. Met. Office were validated over the Indian region. The grid point model at 2.5^{o} x 3.75^{o} resolution in the horizontal and 13 levels in the vertical was integrated for 10 year AMIP period (1979-1988) with real SST data. The temperature at surface and divergence at 200 hPa level were compared with the observations. The study showed that the mean (JJA) temperature anomaly (model minus observed) varies from 6^{o}C over NW India to -2^{o}C over extreme north of India. Mean (JJA) divergence at 200 hPa was underestimated in the weak monsoon year.

2.7.4 Extended Range Forecast using Artificial Neural Network

The work of Long Range Prediction of Indian Summer Monsoon Rainfall by Artificial Neural Network (ANN) was undertaken. The use of ANN has been recognised recently as a promising way of making predictions on time series data. ANN is the parallel computational method of interconnected processors called neurons which resembles the functioning of brain. The structure of ANN consists of a group of neurons, the input layer, which are fed by external stimuli. These input neurons process the information, sending their output to intermediate units which form the hidden layer are inturn connected to the units in the output layer, which finally produce the response to the external stimuli. The interconnection among neurons-weights are chosen so that the network "learns" to relate inputs to desired outputs.

Indian Summer Monsoon Rainfall (ISMR) data from 1939 to 1994 were processed with 3 layer architecture consisting of input, hidden and output layer. The input parameters are 500 hPa April ridge position and Darwin sea level pressure tendency. The ANN has been designed to use 45 data points for learning the 11 data points for independent prediction. The root mean square error was found to be 48.00 mm.

2.8 COMPUTER AND DATA DIVISION

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

The Computer Division also provides other technical services to the scientists, viz., collection, archival and retrieval of the meteorological and other related data for the tropics on the regional and global scales. The major data bases archived include Comprehensive Ocean Atmosphere Data Set (COADS), the FGGE level III-b data set acquired from the ECMWF, U.K, and the Monthly Climate Upper Air Data and Radiosonde Data for different stations and

periods. The Division also holds voluminous data collected during the MONTBLEX Programme. The Division also arranges special runs for the long and continuos uninterrupted computations during the nights and holidays depending on the requirements of the scientists.

The scientists are provided with the on-line access for the Numerical Algorithms Group (NAG) Fortran Library installed on the Division's 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 the 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 size plotter, a line printer and a laserjet printer are connected to the workstation. Several Personal Computers, with various input/output media like floppy discs, cartridge tapes, CD-ROM, digital audio tapes are also available.

The Division provides its facilities to other organisations like the India Meteorological Department, Universities, and also to the research scholars and M.Tech. students undergoing courses connected with the Atmospheric Sciences. The C-DoT High Performance Parallel Processing System (CHiPPS) - 192 has been installed in the Institute and put in use for the Climate Research Project.

In addition to these facilities the Institute scientists are also provided access to NEC-S/1000 system at the NIC, Pune and CRAY-XMP/14 Super Computer at NCMRWF, New Delhi.

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 to be archived for the convenience of the research scientists in India. Data received from the TOGA Project office on a CD-ROM (575 MB approx.) pertaining to different data sets from the various countries consisting of sea surface temperature, winds, wind stress, basic level III analysed data and supplementary fields data were being archived with a special software made available by the TOGA Project Office. This software enables users to get a graphical view on a colour monitor of various parameters and areas selected with a provision for data extraction. A PC/AT-386 with digitizer and laser printer acquired for this project was being used for the 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 were being supplied to the users on request.

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 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 Institutes, organisations and universities in India and abroad.

The Library provides library and information services to the scientists of the Institute as well as to the research community working in the field of Atmospheric Sciences in different organisations. It has built a very good information base of about 25000 publications consisting of books, monographs, back volumes of journals, scientific/technical reports, 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. It has maintained well the 'Gift and Exchange of Publications Programme' with other national and international organisations.

During the year 155 books and reports in Meteorology and allied subjects were added and 82 national / international periodicals were subscribed to. Reprints of papers authored by the Institute's scientists were also purchased. Several scientific and technical reports were received from the National and the International Organisations against the Institute's Publications Exchange Programme.

The information base is continuously strengthened. The library also renders 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 Institute's Library and Information System has liaison with several National and International Organisations and serves 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 INSDOC's 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 library has developed informal resource sharing network with the libraries of different organisations within India. The automation of the library and information services has been introduced. Creation of data base for the whole collection of books has been completed by using the UNESCO - developed CDS/ISIS Software.

A number of reports on the research activities and plan schemes of the Institute were prepared and sent to the Department of Science and Technology, India Meteorological Department, Universities and Research Institutes.

Technical facilities like photocopying, microfilming, photography, drafting, drawing, printing and binding were also provided to the Institute's scientists. Scientific Exhibitions were organised for depicting research activities of the Institute on important events/ occasions..

2.9.1 Participation in the Indian Science Congress

The Institute continued its association with the Indian Science Congress, Calcutta as an Institutional Member and participated in the Science and Technololgy exhibition organised at its 82nd session held at the Jadavpur University, Calcutta during 3-8 January 1995. The theme of the session was 'Science, Technology & Industrial Development in India'.

2.9.2 National Science Day Celebration

Jointly with the Indian Meteorological Society, the Institute celebrated the National Science Day on 28 February 1995. On this occasion, Dr.S.M.S.Mody, Director, N.M. Wadia Institute of Cardiology, Pune gave a talk on 'Climate, Weather and Heart Attacks'. A 'Prashna Mancha' was also arranged for polularizing meteorology amongst the students through interaction with the scientists.

2.9.3 WMO Day Celebration

The Institute celebrated the 35th World Meteorological Day on 23 March 1995 by organising a polular talk by Dr.U.S.De, DDGM(WF), Pune on the theme 'Public Weather Services'. A Scientific Exhibition depicting the research activities of the Institute was also arranged on this occasion. As a part of the function, prizes were distributed to the winners of the 'Prashna Mancha' conducted on the National Science Day (28 February 1995). Prof. G.C.Asnani, Retd. Professor, University of Nairobi chaired the function.

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 Staff

The Institute has 309 scientific, technical and administrative staff. As on March 1995 the staff position in different categories is as follows:

	Category	Number
i)	Scientific	155
ii)	Technical	38
iii)	Administrative	56
iv)	Non-technical Maintenance	60
	Total	309

2.11.2 Staff changes

Fifteen persons joined and two left the Institute during the year.

Shri P.N.Sharma, Senior Scientific Officer Gr.I and Dr. B. K. Mukherjee, Deputy Director, both from Physical Meteorology and Aerology Division retired from service on attaining the age of superannuation on 31 July 1994 and 31 December 1994 respectively.

2.11.3 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.

2.11.4 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 1994-95 are as follows:

(Rs.in Lakhs)

	Budget Estimates	Revised Estimates	Grant Received	Actual Expenditure
Non-Plan	286.40	253.65	220.00	220.00
Plan	110.00	110.00	120.36	117.18

2.11.5 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 ten meetings of Staff Council were held.

2.11.6 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. During the year five meetings of the Academic Council were held.

2.11.7 Advisory Committee

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

2.11.8 Research Fellowship

i) Consequent upon their appointment as Junior Scientific Officers, the IITM Research Fellowship of Miss S. Amin and Shri V. Vasudevan was terminated on 25 April 1994 and 30 June 1994 respectively.

ii) Shri R.S.Maheskumar, Shri R.K.Bansal and Miss Sunitha Devi joined as IITM Research Fellows on 30 January 1995, 6 February 1995 and 14 February 1995 respectively.

2.11.9 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:

S No.	Title	Principal Investigator	Period	Grant (Rs.in lakhs)	Funding Department
1.	Climate Research. (Global Modelling)	Prof. R.N. Keshavamurty	1994-99	198.32	DST
2.	Land Surface Processes Experiment over Sabarmati Region.	Prof. R.N. Keshavamurty/ Shri K.G. Vernekar	1994-97	75.00	DST
3.	Energy Budget Studies in Spatial and Wave Number Domain.	Dr.(Smt.)P.S. Salvekar	1992-94	0.30	DST
4.	TOGA-1 Data Centre	Prof.R.N. Keshavamurty/ Shri S.S.Aralikatti	1991-96	6.50	DST
5.	DST-MONTBLEX Data Bank	Prof.R.N. Keshavamurty/ Shri S.S.Aralikatti	1991-94	6.10	DST

2.11.10 Scientific Equipment

The Institute has acquired during the year several scientific equipment, furniture items and computer accessories. The major equipment acquired for the research work are given below:

S.No.	Equipment
1.	CO_2 Analyzer
2.	Ion Chromotograph
3.	9 Meter Instrumentation Tower
4.	Tower Instrumentations Package consisting of 3 Cup Anemometers, Wind Valve, Air Temperature and Humidity Sensor etc.
5.	Neutron Soil Moisture Probe

2.11.11 Capital Works

Construction work of the Library Building and the Community Hall was in progress.

2.11.12 Official Language Implementation

The Institute recorded growth in the area of correspondence in official language, Hindi. Besides circulars, office memoranda and office orders, a good part of letters being sent to Scientific Institutions, Universities and Publishers in India were also sent bilingually.

Official Language Implementation Committee of the Institute met regularly to review and discuss the progress of Hindi implementation in official work.

Hindi Week was celebrated during 14-20 September 1994. Competitions in Hindi essay writing, debating, typing and recitation, were organised. Shri Shyam Agrawal, the renowned Hindi Journalist and Editor of a local Hindi Newspaper "Aaj Ka Anand", was the Chief Guest of the Celebration. The prizes to the winners of the competitions were distributed by the Chief Guest.

Hindi books worth Rs. 2,096/- were added in the collection of Institute's Hindi Library.

2.12. IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to the members. Tournaments quality carrom board for the sports club and 141 books for the club library were added.

On the Independence Day, the Club awarded prizes to the children of the Institute's employees who had obtained maximum marks (1st, 2nd and 3rd ranks) in each of the S.S.C. and H.S.C. Examinations held in March 1994.

Annual sports tournaments were organised on League basis and prizes to the winners and runners-up were distributed on the Republic Day.

Members of the General Body approved the Bye-Laws of the Club in its meeting held on 24 February 1995. The new Executive Committee for the year 1995-97 has been elected unopposed.

2.13 Field Research Unit

The Field Research Unit of the Institute at Bangalore organises and conducts wind energy resource surveys in 20 States and 2 Union Territories in the country under various projects financed by the Ministry of Non-Conventional Energy Sources, Government of India. The Unit conducts two programmes, viz. (i) Wind Monitoring and (ii) Wind Mapping, with the active assistance of the State Nodal Agencies. Under the former, fortyone additional wind monitoring stations were established during the year and eleven were closed down. The earlier stations have 20 m tall instrumented masts with wind sensors mounted at 10 m and 20 m levels, while the new stations have 25m tall instrumented masts with sensors at 10 m and 25 m levels. All the wind monitoring stations were periodically visited for collecting wind data (stored on EPROM chips) and for checking the performance of the wind instruments and data loggers. The data thus collected were processed on computers and published.

Under the Wind Mapping Programme, 469 stations were established in 20 states in the country. The supervision of the observational network in each state was carried out by the State Nodal Agencies and the wind data collected were scrutinised and processed at Bangalore.

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14. Extreme Indian monsoon rainfall in relation to global and Dutch Harbour temperature: Dugam S.S., XVI Indian Geographers Meet, Chandigarh, 12-14 February 1995.

15. Intraseasonal Madden Julian Oscillations (MJOs) during Indian summer monsoon: Kripalani R.H. and Singh S.V., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994, 27.

16. New predictor for long-range forecasting of Indian summer monsoon: Dugam S.S., Kakade S.B. and Verma R.K., Vatavaran, 15, 1993, 6-9.

17. Persistence in rainfall over Tropical South East Asia and Equatorial Pacific: Dahale S.D., Panchwagh N.V., Singh S.V., Ranatunge E.R.

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22. Fourier analysis techniques for large scale atmospheric energetics in the wave number domain and wave number frequency domain: Totagi M.Y., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

23. Frequency distribution of nearest neighbour spacings of convective clouds in Delhi region during monsoon season: Ali K., Prem Prakash, Kapoor R.K. and Chatterjee R.N., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

24. Global oscillation and variability in Indian monsoon rainfall: Dugam S.S., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

25. Impact of meteorological service through satellite derived data on the agroeconomical condition: Mujumdar V.R. and Paul D.K. Conference on Economical Benefits of Meteorological and Hydrological Services, Geneva, 19-23 September 1994.

26. INSAT cloud cover variations over Bay of Bengal and monsoon activity during two contrasting monsoons of 1987 and 1994: Sikder A.B. and Bhalme H.N., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

27. Instability characteristics of monsoon disturbances over Arabian Ocean: Salvekar P.S., Prem Singh and George L., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

28. Interaction of monsoon and southern oscillation: Keshavamurty R.N., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

29. Interannual variability in satellite derived OLR and Indian monsoon: implication for forecasting, Bhalme H.N., Patwardhan S.K. and Sikder A.B.,8th National Space Science Symposium, NSSS-94,VSSC,ISRO, Thiruvananthapuram, 20-24 December 1994.

30. Intraseasonal fluctuations in INSAT satellite visible cloud cover in relation to daily Indian monsoon rainfall: Sikder A.B., Jadhav S.K. and Bhalme H.N., 8th National Space Science Symposium, NSSS-94,VSSC,ISRO, Thiruvananthapuram, 20-24 December 1994.

31. Intraseasonal Madden-Julian oscillations during Indian summer monsoon season: Kripalani R.H. and Singh S.V., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

32. Investigation of Ekman pumping velocity and mixed layer depth in the Indian Ocean: Behera S.K., Ganer D.W. and Singh R.S.K., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

33. Land surface processes experiment over western India and its data management: Vernekar K.G., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

34. Large scale coherence between Indian summer monsoon rainfall and outgoing long wave

radiation on weekly time scale: Jadhav S.K. and Bhalme H.N., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

35. Latitudinal variation of transport of momentum flux due to MMC and standing eddies during contrasting monsoon years over India: Totagi M.Y., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

36. Lidar study of air quality in the atmospheric boundary layer: Devara P.C.S., Maheskumar S., Pandithurai G., Raj P.E. and Sharma S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

37. Long term variability of rainfall and temperature over Sri Lanka: Rupakumar K., Workshop on Climate Variability of South Asia and its Impact on Agriculture, IISc., Bangalore, 6-9 February 1995.

38. Mechanisms of precipitation initiation in clouds over north India: Prem Prakash, Ali K., Kapoor R.K. and Chatterjee R.N., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

39. Meteorological droughts over India: Space time distribution, Pant G.B, International Seminar on Disaster, Environment and Development, New Delhi, 9-12 December 1994.

40. Monsoon 1994: an acid test for long range forecasting: Verma R.K., Mini Workshop on Monsoon-94, IITM, Pune, 19 January 1995.

41. Monsoon variability : Keshavamurty R.N. (Invited talk), Fifth WMO Regional Workshop for Asian/ African Monsoon emphasising Training Aspects, IMD, New Delhi, 30 January-3, February 1995.

42. Monsoon variability over the Asia Pacific region in relation to ENSO events: Sikka D.R. and Paul D.K., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

43. Multivariate objective analysis of height and wind fields using revised correlation function: Sinha S.K., Narkhedkar S.G. and Rajamani S., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

44. Numerical simulation of ocean circulation over Arabian Sea: Behera S.K. and Salvekar P.S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

45. Numerical simulation of seasonal wind driven upper layer circulation in Bay of Bengal: Behera S.K. and Salvekar P.S., National Seminar on Conservation and Sustainable Development of Coastal Resources, Berhampur University, 14-17 December 1994.

46. Object oriented programming: Tandon M.K. (Invited talk), Computer Policy Planning (CPP-94), Meet of the Bank of Maharashtra, Pune, 7 December 1994.

47. Objective analysis of wind and height fields in the tropics: Sinha S.K., Narkhedkar S.G. and Rajamani S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

48. Ocean modelling: Salvekar P.S. (Invited talk), Symposium on New Dimensions in Atmospheric Sciences, University of Poona, Pune, 28 December 1994.

49. On climate coherent zones of weekly rainfall during summer monsoon over Indian region: Dahale S.D. and Puranik P.V., 31st Annual Convention and Seminar on Geosciences for Energy and Environment, IGU, Hyderabad, 20-22 December 1994.

50. Onset phase of monsoon 1994: Deshpande V.R. and Paul D.K., Mini-Workshop on Monsoon-94, IITM, Pune, 19 January 1995.

51. On the sea-surface temperature variability in response to monsoon depression over the Head Bay during MONTBLEX-90: Seetaramayya P., Workshop on the the Bay of Bengal and Monsoon, NIO, Goa, 21-22 September 1994.

52. Optimization of effective area of Indian summer monsoon signal for understanding of its variability, teleconnections and prediction: Parthasarathy B. and Munot A.A., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

53. Overview of lidar studies of the atmosphere at Pune, India: Devara P.C.S., 17th International Laser Radar Conference (ILRC), Japan, 25-29 July 1994.

54. Parallel processing: Tandon M.K. (Invited talk), Computer Policy Planning (CPP-94), Meet of the Bank of Maharashtra, Pune, 7 December 1994.

55. Point discharge current through a point raised above different types of surfaces: Bala S.S. and Kamra A.K., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

56. Precipitation chemistry in India: Dusty atmosphere and alkaline rain: Khemani L.T., Momin G.A., Safai P.D., Granat L. and Rodhe H., Joint 8th CACGP Conference and Second JGAC Conference, Fuji Yoshida, Japan, 5-9 September 1995.

57. Prediction of Indian summer monsoon rainfall using artificial neural network: Venkatesan C., Sanjay J., Tambe S.S., Kulkarni J.R., Kulkarni B.D. and Keshavamurty R.N., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

58. Proposed Land Surface Experiment over a semi arid region in India: Vernekar K.G. and Keshavamurty R.N., 9th International Symposium on Observations and Instrumentation, Charlotte, North Carolina, USA, 27-31 March 1995.

59. Radon emanation as revealed by soil temperature gradient: Debaje S.B., Vernekar K.G., Subba Ramu M.C., Shaikh A.N. and Ramachandran T.V., 8th National Space Science Symposium, NSSS-94,VSSC,ISRO, Thiruvananthapuram, 20-24 December 1994.

60. Rainfall variability over Bangaladesh and Nepal: Comparison and connection with features over India: Kripalani R.H. (Invited talk), Workshop on Climate Variability of South Asia and its Impact on Agriculture, IISc., Bangalore, 6-9 February 1995.

61. Reconstruction of low dimensional boundary layer dynamics by singular spectrum analysis: Kulkarni J.R., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

62. Relationship between mean wind speed and mean power density: Rangarajan S., Energy-94 Symposium, Salem, 10-15 August 1994.

63. Relationship of Indian summer monsoon with regional surface air temperature over the globe: Munot A.A., 31st Annual Convention and Seminar on Geosciences for Energy and Environment, NGRI, Hyderabad, 20-22 December 1994.

64. Ring width variation of Cedrus deodara and its climatic response over the Western Himalaya: Borgaonkar H.P., Pant G.B. and Rupakumar K., International Tree-ring Conference on Environment and Humanity, USA, 17-21 May 1994.

65. Role of regional scale heat sources on the evolution of different phases of the Indian summer monsoon in 1979: Bhide U.V., Mujumdar V.R., Ghanekar S.P. and Paul D.K., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

66. Satellite data application in the study of interannual variability of monsoon trough oscillation and associated rainfall distribution over India during summer monsoon: Puranik P.V., Mujumdar V.R. and Paul D.K., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

67. Satellite derived sea ice and ENSO: Dugam S.S. and Kakade S.B., 31st Annual Convention and Seminar on Geosciences for Energy and Environment, NGRI, Hyderabad, 20-22 December 1994.

68. Satellite perspective of monsoon variability over South Asia: Singh S.V. (Invited talk), Workshop on Climate Variability of South Asia and its Impact on Agriculture, IISc., Bangalore, 6-9 February 1995.

69. Satellite study on the relationship between fluctuations of organised convection over different regions in the planetary scale ITCZ: Paul D.K., Ghanekar S.P., Mujumdar V.R., Deshpande V.R. and Bhide U.V., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

70. Simple climate modelling and atmospheric chaos: Kulkarni J.R. (Invited talk), Symposium on New Dimensions in Atmospheric Sciences, University of Poona, Pune, 28 December 1994.

71. Simulation of interannual variability in the Indian Ocean: Behera S.K. and Salvekar P.S., International Conference on Monsoon Variability and Prediction, Trieste, Italy, 9-13 May 1994.

72. Some analytical solutions to atmospheric non-linear waves: Venkatesan C., Raman Memorial Mini Conference, Department of Physics, University of Poona, Pune, 23-24 November 1994.

73. Spectral oscillations of meteorological fields over Head Bay of Bengal (20^{o}N, 89^{o}E) during MONTBLEX-90: Seetaramayya P. and Nagar S.G., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

74. Spherical field meter measurements of the electric field vector near a cumulus cloud: Ravichandran M. and Kamra A.K., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

75. Spread of acid rain in India: Momin G.A., College of Atmospheric Boundary Layer and Air Pollution Modelling, Italy, 16 May-3 June 1994.

76. Stratospheric winds and Indian summer monsoon rainfall: statistical relationships, Parthasarathy B. and Munot A.A., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

77. Study of global warming using a simple energy balance climate model: Ratnam J.V. and Salvekar P.S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

78. Study of 100 years severe rainstorms over Vidarbha subdivision of Maharashtra State- a brief appraisal: Kulkarni B.D. and Nandargi S.S., 31st Annual Convention and Seminar on Geosciences for Energy and Environment, NGRI, Hyderabad, 20-22 December 1994.

79. Study of simulation of the atmospheric fields over the Indian region during AMIP period by UKUM model: Mujumdar M. and Kulkarni J.R., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

80. Surface air temperature and monsoon rainfall variations along 5^{o} longitudinal belt in India: Kothawale D.R., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

81. Teleconnections among ENSO, NAO and satellite derived sea-ice extent in northern hemisphere: Dugam S.S., Kakade S.B. and Verma R.K., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

82. Temporal variation of radon concentration with respect to soil temperature and its gradients: Debaje S.B., Vernekar K.G. and Ramchandran T.V., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

83. Thermodynamic structure of the atmosphere over the equatorial western Indian Ocean (EWIO:10^{o}N to 3^{o}S, 52^{o}E to 68^{o}E) during monsoon-88: Mullan A.H. and Seetaramayya P., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

84. Tropical cyclone prediction: Singh S.S., DST sponsored Brain-Storming Session on Tropical Cyclone and Storm Surge, IIT, New Delhi, 21-22 March 1995.

85. Two-dimension cloud model for warm based clouds: Vijayakumar R. and Orville H.D., Sixth WMO Scientific Conference on Weather Modification and Applied Cloud Physics, Italy, 30 May-4 June 1994.

86. Use of agrometeorological data in the parameterization of surface fluxes in the monsoon trough region: Nagar S.G., Seetaramayya P. and Singh S.S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

87. Utilization of satellite derived low level CMWS in 3-D wind analysis: Khaladkar R.M., Mahajan P.N., Bavadekar S.M. and Rajamani S., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

88. Validity of similarity theory for the wind spectra over MONTBLEX station: Murthy B.S. and Vernekar K.G., 8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

89. Variation of drag coefficient with stability over sea: Patil M.N. and Sivaramakrishnan S.,8th National Space Science Symposium, NSSS-94, VSSC, ISRO, Thiruvananthapuram, 20-24 December 1994.

90. Variations in precipitation chemistry with meteorological conditions: Rao P.S.P., Momin G.A., Pillai A.G., Safai P.D., Naik M.S. and Khemani L.T., TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.

91. Washout of alkaline components during the convective showers at Pune, India : Naik M.S., Momin G.A., Rao P.S.P., Safai P.D., Pillai A.G. and Khemani L.T., Joint 8th CACGP Symposium, Japan, 5-9 September 1994.

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5. PARTICIPATION IN SYMPOSIA/SEMINARS/CONFERENCES

S.No.	Symp./Conf./Sem.	Participant(s)
1.	International Speciality Conference on Global Climate Change, USA, 5-8 April 1994.	Dr.S.V. Singh
2.	11th Session of WMO Commission on Atmospheric Sciences (CAS), Switzerland, 5-14 April 1994.	Prof. R.N. Keshavamurty
3.	International Conference on Monsoon Variability and Prediction, Italy, 9-13 May 1994.	Prof. R.N. Keshavamurty, Dr.B. Parthasarathy, Dr.D. Subrahmanyam, Dr.R.H. Kripalani, and Shri S. Tiwari.
4.	College of Atmospheric Boundary Layer and Air Pollution Modelling, Italy, 16 May-3 June 1994.	Shri G.A. Momin
5.	International Tree-ring Conference on Environment and Humanity, USA, 17-21 May 1994.	Shri H.P. Borgaonkar
6.	Sixth WMO Scientific Conference on Weather Modification and Applied Cloud Physics, Italy, 30 May-4 June 1994.	Shri R. Vijayakumar
7.	Course on Parallel Programming, C-DAC, Pune, 13-17 June 1994.	Shri J.R. Kulkarni
8.	Indo-French Conference on Mathematical Methods for Partial Differential Equations, Bangalore, 27 June-1 July 1994.	Shri C. Venkateshan
9.	17th International Laser Radar Conference (ILRC), Japan, 25-29 July 1994.	Dr.P.C.S. Devara
10.	Workshop on Remote Sensing and its Applications, CDAC, Pune, 5 August 1994.	Shri S.N. Bavadekar, Shri D.K. Paul, Smt.S.G. Nagar, Shri P.N. Mahajan, Shri R.M. Khaladkar, Shri V.R. Mujumdar and Shri V.R. Deshpande
11.	Energy-94 Symposium, Salem, 10-15 August 1994.	Dr.S. Rangarajan
12.	Meeting of Commission on Climatology of the IGU, Czech Republic, BRNO, 15-20 August 1994.	Dr.S.V. Singh
13.	Third International Symposium on Tropospheric Profiling: Needs and Technologies, Germany, 30 August-2 September 1994.	Shri K.G. Vernekar
14.	Joint 8th CACGP Symposium, Japan, 5-9 September 1994.	Smt.M.S. Naik
15.	Brainstorming Session on Parameterization of PBL in Large-scale Models, New Delhi, 15-16 September 1994.	Shri K.G. Vernekar and Shri S. Sinha
16.	Conference on Economical Benefits of Meteorological and Hydrological Services, Geneva, 19-23 September 1994.	Shri V.R. Mujumdar
17.	Brainstorming Session on Coupled Phenomena in Geoenvironment, NPL, New Delhi, 21-22 September 1994.	Prof.R.N. Keshavamurty and P.C.S. Devara
18.	Workshop on the Bay of Bengal and Monsoon, NIO, Goa, 21-22 September 1994.	Shri P. Seetaramayya

S.No.	Symp./Conf./Sem.	Participant(s)
19.	Brainstorming Session on Long Range Weather Forecasting, IITM, Pune, 28 September 1994.	Prof.R.N. Keshavamurty, Dr.G.B. Pant, Dr.S.S. Singh, Dr.H.N. Bhalme, Dr.S.V. Singh, Dr.B. Parthasarathy, Shri R.K. Verma, Dr.(Smt.) P.S. Salvekar, Dr.K. Rupakumar, Dr.N. Singh, Dr.K.D. Prasad, Dr.R.H. Kripalani, Shri J.R. Kulkarni, Smt.N.A.Sontakke, Shri A.A. Munot, Smt.S.K. Patwardhan, Shri S.S. Dugam, Dr.(Smt.) A.A.Kulkarni and Shri C.Venkatesan
20.	Workshop on Multimedia and E-Mail, CSI, Pune, 6 October 1994.	Shri M.K. Tandon
21.	17th International Conference on Science and Technology, New Delhi, 10-11 November 1994.	Shri R.K. Kapoor
22.	Space Research in India-Accomplishments and Prospects; on the Occasion of the 75th Birth Anniversary of Dr.Vikram Sarabhai, PRL, Ahmedabad, 12-13 November 1994.	Shri K.G. Vernekar
23.	Teleconnections in Indian Monsoon Rainfall, Indian Instiute of Science, CAS, Bangalore, 16 November 1994.	Dr.R.H. Kripalani
24.	Intensive Course on Modelling of Oceanic and Atmospheric Processes, C-MMACS, Bangalore, 18 November 1994.	Prof.R.N. Keshavamurty
25.	Raman Memorial Mini Conference, Department of Physics, University of Poona, Pune, 23-24 November 1994.	Shri C. Venkatesan
26.	Winter School on Analysis of Directional Data, Indian Statistical Institute, Calcutta, 6-9 December 1994.	Shri N. Singh
27.	Computer Policy Planning (CPP-94), Meet of the Bank of Maharashtra, Pune, 7 December 1994.	Shri M.K.Tandon
28.	International Seminar on Disaster, Environment and Development, New Delhi, 9-12 December 1994.	Dr.G.B.Pant
29.	National Seminar on Conservation and Sustainable Development of Coastal Resources, Berhampur University, 14-17 December 1994.	Shri S.K.Behera
30.	XVI IASLIC Seminar on Networking of Libraries: Problems and Prospects, IIT, Bombay; 19-20 December 1994.	Smt.A.A.Shiralkar
31.	31st Annual Convention and Seminar on Geosciences for Energy and Environment, NGRI, Hyderabad, 20-22 December 1994.	Shri B.N. Mandal, Shri S.D. Dahale, Shri A.A. Munot, Shri B.D. Kulkarni and Shri S.B. Kakade
32.	8th National Space Science Symposium, NSSS-94, VSSC,ISRO, Thiruvananthapuram, 20-24 December 1994.	Dr.H.N. Bhalme, Dr.B. Parthasarathy, Shri P. Seetaramayya, Shri M.Y. Totagi, Dr.S.K. Sinha, Dr.(Smt.) I. Joshi, Shri V.R. Mujumdar, Shri A.B. Sikder, Shri S.S. Dugam, Shri S.B.Debaje, Shri J.S.Pillai, Shri B.S.Murthy, Shri D.R.Kothawale, Shri M.N.Patil and Shri P.D.Safai

S.No.	Symp./Conf./Sem.	Participant(s)
33.	XII Annual Convention and National Seminar on Hydrology, University of Poona, Pune, 22-24 December 1994.	Dr.A.K.Kulkarni
34.	Workshop on Design Storm Studies for Inflow Design flood at Hirakund, CWC, New Delhi, 26-27 December 1994.	Dr.P.R.Rakhecha
35.	Diamond Jubilee Conference of Indian Mathematical Society, University of Poona, Pune, 27-30 December 1994.	Dr.(Smt.)P.S. Salvekar and Shri M. Mujumdar
36.	Symposium on New Dimensions in Atmospheric Sciences, University of Poona, Pune, 28 December 1994.	Prof.R.N. Keshavamurty, Dr.(Smt.)P.S. Salvekar, Shri J.R.Kulkarni and Shri C. Venkatesan
37.	Indian Science Congress Exhibition, Calcutta, 3-8 January 1995.	Smt.N.A.Sontakke, Shri S.C. Rahalkar and Shri G.Pandithurai
38.	Workshop on Advanced Methods in Particle Measurement and Applications in Aerosol Science, University Department of Chemical Technology, Bombay, 6-7 January 1995.	Dr.P.C.S.Devara, Shri D.M.Chate and Shri C.G.Deshpande
39.	Course on Assimilation of Data in Atmospheric and Oceanic Model,National Aeronautical Laboratory, C-MMACS, Bangalore, 15 January-4 February 1995.	Dr.S.Rajamani and Dr.S.K.Sinha
40.	Mini-Workshop on Monsoon 1994, IITM, Pune, 9 January 1995.	Dr.S.S. Singh(Panelist), Shri R.K.Verma and Shri V.R.Deshpande
41.	Fifth WMO/IMD Sponsored Regional Workshop on Asian African Monsoon-emphasising Training Aspects,IMD, New Delhi, 30 January-3 February 1995.	Prof.R.N. Keshavamurty Dr.S.S.Singh and Shri J.R.Kulkarni
42.	Workshop on Climate Variability of South Asia and its Impact on Agriculture, IISc., Bangalore,6-9 February 1995.	Dr.G.B.Pant, Dr.S.V.Singh, Dr.K.Rupakumar, Dr.N.Singh, Dr.R.H.Kripalani and Smt.N.A.Sontakke
43.	4th National Symposium on Environment, Anna University, Madras, 7-10 February 1995.	Shri S. Tiwari
44.	TROPMET-95 National Symposium on Advanced Technologies in Meteorology, NRSA, Hyderabad, 8-11 February 1995.	Prof.G.C. Asnani, Prof.R.N. Keshavamurty, Dr.A.K. Kamra, Shri K.G. Vernekar, Dr.P.C.S. Devara, Shri L.K. Sadani, Shri P. Seetaramayya, Shri J.R. Kulkarni, Smt.U.V. Bhide, Shri Prem Prakash, Shri S.K. Behera, Shri M.Y. Totagi, Dr.(Smt) I. Joshi, Smt.S.G.Nagar, Shri P.S.P. Rao, Smt.A.H. Mullan, Shri R.M. Khaladkar, Shri S.K. Jadhav, Shri P.V. Puranik, Shri A.B. Sikder, Shri S.B. Debaje, Shri M. Ravichandran, Shri Prem Singh, Shri K. Ali, Shri S.G. Narkhedkar, Shri M.S. Mujumdar, Shri D.W. Ganer, Shri J.V. Ratnam, Shri C. Venkatesan
45.	Conference on Neural Network and Fuzzy Systems, Anna University, Madras, 16-18 March 1995.	Shri C. Venkatesan
46.	DST Sponsored Brain-Storming Session on Tropical Cyclone and Storm Surge, IIT, New Delhi, 21-22 March 1995.	Dr.S.S. Singh

S.No.	Symp./Conf./Sem.	Participant(s)
47.	IASTA Workshop on Aerosols, IITM, Pune, 23-24 March 1995.	Prof.G.C. Asnani, Dr.A.S.R. Murty, Dr.S.S. Singh, Dr.P.C.S. Devara, Dr(Smt.)P.S. Salvekar, Dr.G.K. Manohar, Dr.P.E. Raj, Shri A.G. Pillai, Smt.M.S. Naik, Shri A.L. Londhe, Shri P.S.P. Rao, Shri G.A. Momin, Shri G. Pandithurai, Shri A.L. Sagar, Dr.S. Sharma and Shri R.S. Maheskumar
48.	Ninth International Symposium on Observations and Instrumentation, USA, 27-31 March 1995.	Shri K.G.Vernekar

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6. PARTICIPATION IN MEETINGS

Prof. R.N.Keshavamurty, Director

i) Meeting of the Selection Committee, Department of Science and Technology, New Delhi, 24 June 1994.

ii) Meeting with Vice-Chanceller, Mangalore University, Mangalore, 7-8 July 1994.

iii) Meeting at the Centre of Development of Telecommunication, Bangalore, 9-10 July 1994.

iv) Meeting of the Expert Committee, National Centre for Medium Range Weather Forecasting, New Delhi, 15 July 1994.

v) Meeting of the Scientific Advisory Committee (SAC), National Centre for Medium Range Weather Forecasting, New Delhi, 16 July 1994.

vi) Meeting with the Meteorology Group, Physical Research Laboratory, Ahmedabad, 18 July 1994.

vii) Meeting with the Chief Engineer, Central Public Works Department, Bombay, 29 July 1994.

viii) Meeting of Programme Advisory Committee with the Chairman, Board of Studies in Mathematics and Physics from Univesities of Kerala, Karnataka and Goa States, Mangaolre University, Mangalore, 30 August 1994.

ix) Meeting of the Programme Advisory Committee on Atmospheric Sciences, Mangalore University, Mangalore, 31 August 1994.

x) First Meeting of the Committee for Development of National Coordinated Programme on Atmospheric Modelling in the Tropics, Indian Institute of Science, Bangalore, 24 October 1994.

xi) Meeting of the Selection Committee, Department of Science and Technology, New Delhi, 12-13 December 1994.

xii) Meeting for discussions at the C-DoT, Bangalore, 23-27 December 1994.

xiii) 42nd CMAS Meeting, India Meteorological Department, New Delhi, 29 December 1994.

xiv) Meeting of the Steering Committee, National Remote Sensing Agency, Hyderabad, 12 January 1995.

xv) Twenty Second Meeting of the Programme Advisory Committee on Atmospheric Sciences, Department of Science and Technology, New Delhi, 15 February 1995.

xvi) One day Review Meeting of UNDP Supported Project on Meteorological Applications in Agriculture, India Meteorological Department, New Delhi, 29 March 1995.

Forecasting Research Division

Dr. S. S. Singh, DD

Meeting on Parallel Processing System (PPS), Department of Science and Technology, New Delhi, 26 April 1994.

Shri R.K.Verma, AD

Annual Monsoon Review (AMR) Meeting, India Meteorological Department, Pune, 22 February 1995.

Shri D.K.Paul, SSO I

i) Eighth Working Group Meeting on Marine Application Remote Sensing Information System (MARSIS), Institute of Ocean Management, Madras, 17 August 1994.

ii) Tenth Working Group Meeting on Marine Application Remote Sensing Information System (MARSIS), National Institute of Oceanography, Goa, 20-21 March 1995.

Shri P.N.Mahajan, SSO I

i) Meeting of the Selection Committee for the post of Publication Officer, National Institute of Naturopathy, Pune, 22 March 1994.

ii) Meeting of the Selection Committee for the post of Senior Observer, India Meteorological Department, Pune, 27 May 1994.

Shri V.R.Deshpande, JSO

Meeting of the Departmental Promotion Committee for promotions of Office Attendant to Laboratory Attendant, India Meteorological Department, Pune, 14 November 1994.

Climatology and Hydrometeorology Division

Dr.G.B.Pant, DD

i) Meeting of the Organising Committee of the Workshop on Climate Variability and Agriculture, Indian Institute of Science, Bangalore, 26-27 April 1994 and 20 December 1994.

ii) Departmental Promotion Committee for Promotion from the grade Scientist D to Scientist E as an External Expert, Indian Space Research Organisation, Bangalore, 28 May 1994 and 17 December 1994.

iii) Meeting of the National Committee on IGBP, National Physical Laboratory, New Delhi, 16 September 1994.

iv) Twentieth Meeting of the Indian National Committee on Hydrology (INCOH), Central Water Commission, New Delhi, 29 December 1994.

v) Meeting of the South Asian Regional START Steering Committee and National Committee on IGBP, National Physical Laboratory, New Delhi, 11 February 1995.

Dr.P.R.Rakhecha, AD

First Meeting of Technical Advisory Review Committee (TAC) for guiding the preparation of generalized PMP Atlas by WAPCOS, Central Water Commission, New Delhi, 5-7 February 1995.

Physical Meteorology and Aerology Division

Dr.P.C.S.Devara, DD

Meeting of the Managing Committee of the Indian Aerosol Science and Technology Association (IASTA) Meeting, Bhabha Atomic Research Centre, Bombay, 8 June 1994.

Boundary Layer and Land Surface Processes Studies Division

Shri K.G.Vernekar, DD

Third Meeting of Programme Advisory and Monitoring Committee on Monsoon and Tropical Climate, National Institute of Oceanography, Goa, 23-24 September 1994.

Theoretical Studies Division

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

i) Second meeting of the Planning Committee for the Department of Space Science, University of Poona, Pune, 12 April 1994.

ii) Board of Studies (Maths) Meeting, University of Poona, Pune, 22 September 1994.

Honorary Fellow

Prof. G.C.Asnani

Meeting of the Selection Board for the post of Joint Director (Applications), National Centre for Medium Range Weather Forecasting, New Delhi, 21 February 1995.

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7. SEMINARS

Scientific Seminars are important for the progress of the research work and for creating an academic environment. Seminars on the latest topics are held frequently. The scientists of the Institute/invited experts are encouraged to participate in the seminar programme. The following seminars were held during the year.

Sr. No.	Name	Topic	Date
1.	Shri V.R. Mujumdar, JSO, IITM	i) Starbase subroutines and a graphic software for analysis of meteorological parameters and windvectors -Inhouse training course on familiarisation of workstation.	22 April 1994
		ii) Impact of meteorological service through satellite derived data on the Agro-economical conditions of the country.	15 September 1994
		iii) Socio-economic implicity of hydrometeorological services - The Geneva Conference, September 1994.	25 January 1995
2.	Shri M. Ravichandran, SSA, IITM	Surface measurements of the electric field vector in fair weather and in the vicinity of cumulus cloud.	20 May 1994
3.	Dr.S.K. Sinha, SSOII, IITM	i) Multivariate analysis of wind and height field in the tropics.	7 June 1994
		ii) Variational technique of data assimilation using adjoint equations in a barotropic model.	5 July 1994
4.	Shri L.K. Sadani, AD, IITM	'Parameterization schemes of land surface process for mesoscale atmospheric models' by Bougeault.	29-30 June 1994
5.	Shri S. Sivaramakrishnan, AD, IITM	i) 'Atmospheric parameterisation schemes for evaporation over land: Basic concepts and climate modelling aspects' by P.R.Rowntree.	5-6 July 1994
		ii) On some aspects of turbulence in the surface layer during monsoon 1989.	8 August 1994
6.	Shri R. Vijayakumar, AD, IITM	Cloud modelling including simulation of seeding effects.	6 July 1994
7.	Shri J.S. Pillai, SSA, IITM	'Efficient prediction of ground surface temperature and moisture with inclusion of a layer of vegetation' by J.W.Deardorff.	12-15 July 1994

Sr. No.	Name	Topic	Date
8.	Shri S.B. Debaje, JSO, IITM	'Land surface processes : Description, theoretical approaches and physical laws underlying their measurements' by A. Perrier and A. Tuzet.	19-20 July 1994
9.	Shri M. Rajeevan, Meteorologist -I, IMD, Pune	Climate forcings due to sulphate aerosols.	20 July 1994.
10.	Shri B.S. Murthy, SSA, IITM	'The budgets of turbulent kinetic energy and temperature variance in the atmospheric surface layer' by J.C.Wyngaard and O.R.Gote.	21 July 1994
11.	Smt.A.A. Deo, SSA, IITM	i) Slow instabilities in tropical ocean basin global atmosphere models-Basic formulation and development. Part I.	26 July 1994
		ii) Slow instabilities in tropical ocean basin global atmosphere models-Basic formulation and development. Part II.	18 January 1995
12.	Shri T.S. Pranesha, IITM Research Fellow	Scavenging of aerosol particles by large water drops, I: Neutral case II: The effect of electrical forces, III: Washout coefficients, half-lives and rainfall depths.	3 August 1994
13.	Shri V.R. Deshpande, JSO, IITM	Performance of monsoon during the first half of the season 1994.	4 August 1994
14.	Shri K.Ashok, JSO, IITM	i) Review of the paper, 'The Moist available potential energy of a conditionally unstable atmosphere and Part II: Further analysis of GATE data' - Wang and Randall, JAS, 1992 and 1994'.	5 August 1994
		ii) Intraseasonal variability of Indian summer monsoon in UKMO GCM.	1 March 1995
16.	Prof.J.Shukla, Institute of Global Environment and Society, Maryland, USA	Simulation and predictability of monsoons.	10 August 1994
17.	Shri S.S.Dugam, JSO, IITM	Interannual and long-term variability in North Atlantic oscillation and Indian summer monsoon rainfall.	19 August 1994

Sr. No.	Name	Topic	Date
18.	Shri P.R.Rakhecha, AD, IITM	Estimation of PMP for catchments in India east of the Long.80^{O}E by a generalised method	19 August 1994
19.	Shri V.Vasudevan, JSO, IITM	i) Review of the paper, 'Instability of planetary waves and zonal flows in two layer quasigeostropic models on a sphere' by J.S.Frederiksen, QJRMS,1978.	25 August 1994
		ii) A Review of Ph.D.thesis 'Stability analysis of Indian summer monsoon flow and mechanisms of the growth of monsoon depression - S.K.Dash'.	20 January 1995
20.	Prof.Sethu Raman, North Carolina State University, Raleigh, USA	Non-hydrostatic modelling of sea breeze circulation.	26 August 1995
21.	Shri N.K.Agarwal, SSA, IITM	Effects of Coriolis force, vorticity and divergence on non-linear energy conversions during different phases of July 1979 monsoon.	26 August 1994
22.	Shri G.Pandithurai, SSA, IITM	Aerosol size distribution and refractive index from bistatic lidar angular scattering measurement in the surface layer.	1 September 1994
23.	Dr.N.Singh, SSO I, IITM	Variability of moisture and thermal fields over India.	7 September 1994
24.	Dr.P.C.S.Devara, DD, IITM	Highlights of the 17th International Laser Radar Conference, Japan.	14 September 1994
25.	Smt. S.S.Vaidya, SSO II, IITM	Sensitivity of convective rainfall to the adjustment parameters in Betts-Miller Scheme of convection.	16 September 1994
26.	Shri J.R.Kulkarni, SSO I, IITM	i) Assessing climate model sensitivity to prescribing landscapes.	28 September 1994
		ii) Long-range prediction of the Indian summer monsoon rainfall by artificial neural network.	28 September 1994

Sr. No.	Name	Topic	Date
27.	Smt.N.A.Sontakke, JSO, IITM	Longest instrumental regional and All India summer monsoon rainfall series : Reconstruction and update.	30 September 1994
28.	Dr.L.S.Hingane, AD, IITM	Global ozone depletion.	19 October 1994
29.	Shri K.G.Vernekar, DD, IITM	Wind profilers: Needs and technologies.	8 November 1994
30.	Dr.A.K.Kulkarni, SSO I, IITM	Some recent heavy rainspells over Maharashtra.	23 November 1994
31.	Shri M.K.Soman, SSO I, IITM	Tropical SSTs and Asian summer monsoon : A GCM study.	2 December 1994
32.	Dr.D.Subrahmanyam, SSO I, IITM	Kelvin wave CISK theory for low frequency oscillation of tropical atmosphere.	5 December 1994
33.	Shri S.K.Behera, SSO II, IITM	i) Seasonal wind driven ocean circulation in the Bay of Bengal.	8 December 1994
		ii) Numerical simulation of ocean circulation around Indian coasts.	1 February 1995
34.	Dr. A.K. Kamra, DD, IITM	Effect of the SST an latitudinal variation of cosmic rays on the electrical conductivity of the marine air.	9 December 1994
35.	Dr. Mike Fennessy, COLA, Maryland, USA	Monsoon research at COLA.	9 December 1994
36.	Shri C.Venkatesan, IITM Research Fellow	Application of neural network in atmospheric sciences.	26 December 1994
37.	Shri D.K. Paul, SSO I, IITM	Fluctuation of organised convection and precipitation within the planetary scale ITCZ during northern summer : A global perspective.	4 January 1995
38.	Dr.G.V.Rao, St.Louis University, USA	Monsoon convection over the oceans.	6 January 1995
39.	Dr.G.K.Manohar, SSO I, IITM	Impact of the total solar eclipse on surface atmospheric electricity.	18 January 1995
40.	Prof.K.Shankar Rao, NOAA, USA	Atmospheric turbulence and diffusion.	30 January 1995

Sr. No.	Name	Topic	Date
41.	Shri Prem Singh, SSA, IITM	Instability characteristics of monsoon disturbances over Arabian Sea.	1 February 1995
42.	Shri D.W.Ganer, SA, IITM	Investigation of Ekman pumping velocity and mixed layer depth in the Indian Ocean.	1 February 1995
43.	Shri J.Venkatratnam, IITM Research Fellow	Study of global warming using a simple energy balance climate model.	1 February 1995
44.	Dr.D.B.Rao, NMC, Washington D.C., USA	i) Introduction to basic dynamical system of equations.	13 February 1995
		ii) Scale considerations.	14 February 1995
		iii) Linear motions in an atmosphere at rest.	14 February 1995
		iv) Non-hydrostatic gravity waves.	15 February 1995
		v) Inter-fatial waves.	15 February 1995
		vi Quasi-static gravity waves-homogeneous and two layers case.	16 February 1995
		vii) Vertical normal mode decomposition-layered and continuous stratification.	16 February 1995
		viii) Shallow-water waves homogeneous and stratified case.	17 February 1995
		ix) Equatorial waves.	20 February 1995
		x) Oscillations of a global ocean.	20 February 1995
		xi) Rossby adjustment problem.	21 February 1995
		xii) Baroclinic instability.	21 February 1995
		xiii) Barotropic instability.	22 February 1995
		xiv) Benard convection.	23 February 1995

Sr. No.	Name	Topic	Date
45.	Mr.Dirk Shaefer, University of Mainz, Germany	Studies on climate variability of South Asia conducted at the University of Mainz, Germany.	17 February 1995
46.	Dr.P.R.Rakhecha, AD, IITM	Design storm rainfall for the development of water resources in the upper Krishna river catchment.	22 February 1995
47.	Dr.R.H.Kripalani, SSO I, IITM	Rainfall variability over Bangaladesh and Nepal: Comparison and connection with features over India.	22 February 1995
48.	Dr.T.C.Chen, IOWA State University, USA	Role of Asian monsoon on the global hydrological cycle.	3 March 1995

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8. ACADEMIC ACTIVITIES

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

Scientists	Topic
Shri K.G.Vernekar, DD	Atmospheric boundary layer
Dr.S.Rajamani, DD	i) Objective analysis ii) Satellite meteorology
Dr.(Smt.) P.S.Salvekar, AD	i) Numerical modelling ii) Climate modelling iii) Advanced dynamic meteorology
Shri D.K.Paul, SSO I	Synoptic meteorology
Shri P.N.Mahajan, SSO I	i) Application of INSAT data for atmospheric studies ii) Satellite meteorology
Shri J.R.Kulkarni, SSO I	Dynamic meteorology
Shri S.K.Behera, SSO II	i) Dynamic oceanography ii) Climate modelling iii) Physical and dynamical oceanography
Miss S.Amin, JSO	Energy Balance Model and Rediative Convective Model.

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
Dr.S.Rajamani, DD	Smt. K.S.Acharya	M.Tech.	Andhra University, Waltair
Dr.B. Parthasarathy, DD	Shri V.Sathiyamoorthy	M.Tech.	Cochin University of Science and Technology, Cochin
Dr.P.C.S. Devara, DD	i) Shri R.S. Maheskumar	M.Tech.	Andhra University, Waltair
	ii) Sqn.Ldr.J.M. Joshi, Institute of Armament Technonogy (IAT), Pune	M.Tech.	University of Poona, Pune

Supervisor	Student	Course	University
Dr.L.S. Hingane, AD	Shri S.Savant	M.Sc.	University of Poona, Pune
Dr.(Smt.) P.S. Salvekar, AD	i) Shri M.D.Khandkar	M.Tech.	University of Poona, Pune
	ii) Shri R.Prakash	M.Tech	University of Poona, Pune
	iii) Miss Sunita Devi	M.Tech	Cochin University of Science and Technology, Cochin
	iv) Mr.Albert Owino, Common Wealth Fellow, Kenya Meteorology Department,Kenya	Ph.D.	University of Poona, Pune
	v) Shri M.K.Rama Varma Raja, UGC Fellow	Ph.D.	University of Poona, Pune
Shri L.K. Sadani, AD	Shri J.Sarma	M.Sc.	CASAM, College of Agriculture, Pune
Dr.S.S. Parasnis, SSO I	i) Miss G.Asharani	M.Tech.	Andhra University, Waltair
	ii) Shri A.V. Mavalkar	M.Sc. (Physics)	University of Poona, Pune
	iii) Smt.V.A.Kunchur	Ph.D.	University of Poona, Pune
	iv) Shri R.Kharul	Ph.D.	University of Poona, Pune
Shri P.N. Mahajan, SSO I	i) Miss V.Alsi	M.Tech.	University of Poona, Pune

Guidance was also provided for the research work of two M.B.B.S. Doctors for their M.D. Degrees by Dr. (Smt.) A.M.Selvam, DD.

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:

Name	Degree	University
Dr.A.S.R.Murty, DD	M.Sc.	Cochin University of Science and Technology, Cochin
	Ph.D.	Andhra University, Waltair
Dr.G.B.Pant, DD	Ph.D.	i) M.S.University of Baroda, Baroda ii) Berhampur University, Berhampur iii) Banaras Hindu University, Varanasi iv) Andhra University, Waltair v) Air Force Administrative College, Coimbatore vi) Indian Institute of Technology, New Delhi
Dr.(Smt.)A.M.Selvam, DD	M.Tech.	Cochin University of Science and Technology, Cochin
Dr.B.Parthasarathy, DD	Ph.D.	Andhra University, Waltair
Dr.P.C.S.Devara, DD	M.Tech.	Andhra University, Waltair
Dr.(Smt.)P.S.Salvekar, AD	M.Tech.	i) University of Poona, Pune ii) Cochin University of Science and Technology, Cochin
Shri M.K.Tandon, SSO I	M.Tech.	University of Poona, Pune
Shri J.R.Kulkarni, SSO I	M.Tech.	University of Poona, Pune
Shri S.K.Behera, SSO II	M.Tech.	University of Poona, Pune

Dr.(Smt.) P.S.Salvekar, AD worked as an External Expert in the Selection Committee for the admissions into the M.Tech (Atmospheric Sciences) course of the University of Poona, Pune.

The Institute encourages its scientists to pursue higher studies in Atmospheric Sciences and allied subjects. The following scientists have completed their work/obtained degrees of Ph.D. and M.Sc. (partly by papers and partly by research) in Physics from the University of Poona, Pune :

Name	Research Guide	Degree	Thesis
* Shri M.D. Chipade, SA	Dr. S.S. Singh, DD	M.Sc.	Understanding of monsoon 1979 through energetics of transient and standing eddies in wave number domain.
* Smt.S.S.Dhanorkar, SSO II	Dr.A.K.Kamra, DD	Ph.D.	Characteristics of atmospheric ions close to ground.
Smt.R.R.Joshi, JTO	Dr.(Smt.)A.M.Selvam DD	M.Sc.	Interannual variability of sea surface and air temperature using COADS data.
* Shri D.R. Kothawale, SSA	Dr.G.B. Pant, DD	M.Sc.	Surface air temperature over India: a diagnostic study.
Shri M.N.Patil, SA	Dr.S.V.Singh, DD	M.Sc.	Some characteristics of atmospheric boundary layer.
Shri T.S.Pranesha, Research Fellow	Dr.A.K.Kamra, DD	Ph.D.	Laboratory simulation of scavenging of micron sized aerosol particles by large water drops.
* Shri S.S.Sabade, SSA	Dr.S.V.Singh, DD	M.Sc.	Comparison of classification techniques for synoptical / climatological studies.
* Shri S.Sharma, Air India Research Fellow	Dr.P.C.S.Devara, AD	Ph.D.	Remote sensing of the atmosphere using the lidar technique.
Shri M.I.R.Tinmaker, SA	Dr.A.S.R.Murty, DD	M.Sc.	Physical aspects of the precipitation processes in monsoon clouds.

* Degree conferred.

Shri N.Singh, SSO I was awarded Ph.D. degree by the Banaras Hindu University, Varanasi for his thesis entitled, 'Variability of moisture and thermal fields over India.' Dr.G.B.Pant, DD provided guidance for the research work.

Mr.Albert Owino, Common Wealth Fellow, Kenya Meteorological Department submitted his thesis entitled, 'Dynamics of Air flow through mountain gap' to the University of Poona for the award of Ph.D. degree. Prof. G.C.Asnani, Hon. Fellow provided research guidance to Mr.Owino.

Institute's scientists also provide their expertise to various scientific committees. Following scientists have been nominated as members of different committees:

Scientist	Scientific Committee
Prof. R.N.Keshavamurty, Director	i) National Committee on Science and Technology in Developing Countries (CODATA) of Indian National Science Academy (INSA). ii) Committee on Development of National Co-ordinated Programme on Atmospheric Modelling in Tropics, DST, New Delhi. iii) Advisory Committee of monsoon and Tropical Climate (MONTCLIM), DST, New Delhi.

Scientist	Scientific Committee
Dr.A.S.R.Murty, DD	WMO/CAS Working Group/Executive Panel of Experts on Physics and Chemistry of Clouds and Weather Modification Research.
Dr.G.B.Pant, DD	i) National Committee for the International Geosphere Biosphere Programme of the Indian National Science Academy. ii) Indian National Committee on Hydrology (INCOH) constituted by the Ministry of Water Resources, Govt. of India.
Dr.S.V.Singh, DD	i) Editorial Advisor to an interdisciplinary Journal, 'Climate Research' published by Inter-Research, Germany. ii) Expert Group on Long-range Forecasting Council for Meteorology and Atmospheric Sciences.
Shri R.K.Verma, AD	Expert Group on Long-range Forecasting Council for Meteorology and Atmospheric Sciences.
Dr.P.R.Rakhecha, AD	Technical Advisory and Review Committee for the Preparation of Generalized PMP Atlas of India, Central Water Commission, New Delhi.
Shri S.Sinha, AD	Member of the Screening and Editing Committee appointed by the Department of Science and Technology for reviewing the papers presented at the Second Monitoring Workshop on MONTBLEX Research Results held at IITM during 26-27 March 1994.

The Institute encourages its scientists to undergo training in Atmospheric Sciences and related topics. Under this programme the scientists participated in different training programmes:

Name	Training Programme/Duration
Smt.N.R.Deshpande, JSO, Smt.S.K.Patwardhan,JSO, Shri K.Ashok, JSO, Miss S.Amin, JSO, Shri V.Vasudevan, JSO, Shri Prem Singh, SSA, Shri S.G.Narkhedkar, SSA, Smt.S.R.Inamdar, SSA, Shri M.S.Mujumdar, SA and Shri C.Venkatesan, Research Fellow	SERC School on Basics of Geophysical Fluid Dynamics (with special emphasis on Waves in Rotating Fluids), IITM, Pune, 23 May-24 June 1995.
Shri R.M.Khaladkar, JSO	Advanced Refresher Course on Satellite Radar Input for Cyclone Warning, India Meteorological Department, New Delhi, 12-23 September 1994.

Name	Training Programme/Duration
Shri S.Mahapatra, JSO and Shri P.S.Mukhopadhyay, SSA	Advanced Meteorology Training, India Meteorological Department, 12 September 1994 - 11 July 1995.
Shri M.Ravichandran, SSA	Short Term Course on PC-based Instrumentation, Indian Institute of Science, Bangalore, 20-30 September 1994.
Smt.V.V.Massey, JTO and Shri B.C.Morwal, STA	AACR/I/CCF, University of Poona, Pune, 17-22 October 1994.
Shri R.P.Mali, STA	Colour Photography Technology, Indian Institute of Remote Sensing, Dehradun, 6-25 November 1994.
Dr.S.K.Sinha, SSO II Shri J. Sanjay, JSO Miss S.Amin, JSO Smt.A.A.Deo, SSA Shri J.V.Ratnam, Research Fellow, Shri C.Venkatesan, Research Fellow and Shri M.K.Rama Verma Raja, Research Fellow	Intensive Course on Modelling of Oceanic and Atmospheric Processes, National Aeronautical Laboratory, C-MMACS, Bangalore, 7-19 November 1994.
Miss P.L.Kulkarni, SSO II Dr.S.K.Sinha, SSO II and Shri R.M.Khaladkar, JSO	Course on Assimilation of Data in Atmospheric and Oceanic Model, National Aeronautical Laboratory, C-MMACS, Bangalore, 15 January-4 February 1995.
Shri P.N.Mahajan, SSO I	Appraisal Course on Remote Sensing, National Remote Sensing Agency, Hyderabad, 16-20 January 1995.
Shri J.Sanjay, JSO, Shri K.Ashok, JSO and Shri C.Venkatesan, Research Fellow	Familiarisation Training of the NMC Global Spectral Model, NCMRWF, New Delhi, 6-13 March 1995.

LECTURES DELIVERED OUTSIDE THE INSTITUTE

Sr. No.	Scientist	Topic	Venue	Date
1.	Dr.P.C.S.Devara, DD	i) Lasers in remote sensing, meteorology and air pollution monitoring	Institute of Armament Technology, Pune	26 April 1994
		ii) Optical remote sensing of atmospheric aerosole	Bhabha Atomic Research Centre, Bombay	14 June 1994
2.	Prof.R.N.Keshavamurty, Director	i) Climate and monsoon dynamics	Mangalore University, Mangalore	30 August 1994
		ii) Climate dynamics and Monsoon dynamics	Air Force Administrative College, Coimbatore	16 and 17 November 1994
		iii) Climate modelling	C-MMACS, Bangalore	18 November 1994

Sr. No.	Scientist	Topic	Venue	Date
3.	Shri D.K.Paul, SSO I	Principles of synoptic meteorology -Training Programme on Agrometeorological Data Monitoring and Management	Department of Science and Technology, New Delhi	24 October-7 November 1994
4.	Shri K.G.Vernekar, DD	Boundary layer activities at IITM	Physical Research Laboratory, Ahmedabad	11 November 1994
5.	Dr.S.S.Parasnis, SSO I	i) Tropical boundary layer studies	Royal Netherland Meteorological Institute, De Bilt, The Netherlands	14 November 1994
		ii) Convective boundary layer	Hadley Centre for Climate Prediction Studies and Research, Bracknell, UK	12 January 1995
		iii) Thermodynamic stratification of boundary layer during summer monsoon	University of Wisconsin, Madison, USA	25 January 1995
		iv) Characteristics of convective boundary layer studies	North Carolina State University, Raleigh, USA	7 February 1995
6.	Dr.R.H.Kripalani, SSO I	Teleconnections in Indian monsoon rainfall	Indian Institute of Science, Bangalore	16 November 1994
7.	Shri M.K.Tandon, SSO I	i) Parallel processing	Bank of Maharashtra, Pune	7 December 1994
		ii) Object oriented programming		
8.	Dr.S.Rajamani, DD	Four dimensional data assimilation in tropics (4 lectures)	C-MMACS, Bangalore	27 January-4 February 1995
9.	Dr.S.K.Sinha, SSO II	Different schemes of objective analysis (6 lectures)	C-MMACS, Bangalore	28 January-1 February 1995
10.	Shri K.Ashok, JSO	Simulation of intraseasonal variation of Indian summer monsoon	Hadley Centre for Climate Prediction and Research, Bracknell, UK	9 February 1995

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9. DEPUTATION ABROAD

The Institute deputes its scientists abroad for training, attending the International Conferences/Symposia/ Meetings etc. with a view to create general awareness of the latest developments in Atmospheric Sciences. The following scientists of the Institute were deputed abroad:

Sr. No.	Name/Credential	Country	Period	Purpose
1.	Dr.S.V.Singh, DD	USA	5-8 April 1994	Participation in the International Speciality Conference on Global Climate Change: Science, Policy and Mitigation Strategies, Arizona.
		Czech Republic	15-20 August 1994	Participation in the International Geophysical Union Conference on Contemporary Climatology, BRNO.
2.	Prof.R.N.Keshavamurty, Director	Switzerland	5-14 April 1994	Participation as an Indian delegate in the 11th Session of WMO Commission on Atmospheric Sciences (CAS), WMO, Geneva.
		Thailand	6-10 March 1995	Participation in the Second International Study Conference on GEWEX (Global Energy and Water Cycle Experiment) in Asia and GAME (GEWEX Asian Monsoon Experiment), Pattaya.
3.	Dr.D.B.Jadhav, SSO I	Spain	6 May 1994 - 5 May 1995	Assignment on Atmospheric Research, Instituto Nacional De Technica Aerospacial.
4.	Prof.R.N.Keshavamurty, Director, Dr.B.Parthasarathy, DD, Dr.D.Subrahmanyam, SSO I and Shri S.Tiwari, SA	Italy	9-13 May 1994	Participation in the International Conference on Monsoon Variability and Prediction, Trieste, 9-13 May 1994.
5.	Shri G.A.Momin, JSO	Italy	16 May-3 June 1994	Participation in the College of Atmospheric Boundary Layer and Air Pollution Modelling, Trieste.
6.	Shri H.P.Borgaonkar, JSO	USA	17-21 May 1994	Participation in the International Conference on Tree-Ring, Environment and Humidity,Tucson.

Sr. No.	Name/Credential	Country	Period	Purpose
7.	Shri R.Vijayakumar, AD	Italy	30 May-4 June 1994	Participation in the Sixth WMO Scientific Conference on Weather Modification and Applied Cloud Physics, Paestum.
8.	Dr.B.Parthasarathy, DD	USA	13 June-20 July 1994	Working at University of Maryland, Goddard Space Flight Centre and Climate Analysis Centre under the Indo-US Climate Research Programme-ATM/I(a)/87.
9.	Shri C.M.Mohile, SSO II	UK	1 July-31 October 1994	Under the UNDP Fellowship Programme in the field of Data Processing in connection with Global Meteorology, University of East Anglia.
10.	Dr.P.C.S.Devara, DD	Japan	25-29 July 1994	Participation in the 17th International Laser Radar Conference (ILRC), Sendai.
11.	Shri K.G.Vernekar, DD	Germany	30 August-2 September 1994	Participation in the Third International Symposium on Tropospheric Profiling: Needs and Technologies, Hamburg.
		USA	23-31 March 1995	Participation in the 9th American Meteorological Observations and Instrumentation, Charlotte, North Carolina.
12.	Dr.(Smt.)A.A.Kulkarni, JSO	Germany	1 September-30 November 1994	Assignment at the Climate Dynamics Section of the Max Planck Institute for Meteorology, Hamburg.
13.	Smt.M.S.Naik, SSO II	Japan	5-9 September 1994	Participation in the Joint 8th GACGP (Global Atmospheric Chemistry and Global Pollution) Symposium and 2nd IGAC Conference, Fuji-Yoshida.
14.	Shri V.R.Mujumdar, JSO	Switzerland	19-23 September 1994	Participation in the Conference on Economical Benefits of Meteorological and Hydrological Services, WMO, Geneva.

Sr. No.	Name/Credential	Country	Period	Purpose
15.	Dr.S.S.Parasnis, SSO I	Netherlands, UK and USA	8 November 1994 - 10 January 1995	Visit to the Royal Netherland Meteorological Institute and participation in Seminar on Tropical Boundary Layer Studies: Validation of the 1-D Model for Boundary Layer.
		UK	11-12 January 1995	Visit to the Hadley Centre for Climate Prediction and Research and Participation in Seminar on Convective Boundary Layer Characteristics.
		USA	16-22 January 1995	Discussions with scientists on Modelling Studies, University of Maryland, Maryland.
			23-26 January 1995	Participation in Seminar on Thermodynamic Structure of the Boundary Layer, University of Wisconsin, Madison.
			4-7 February 1995	Participation in Seminar on Convective Boundary Layer Studies, North Carolina State University, North Carolina, Raleigh, and discussion with Prof. S. Sethu Raman and his research group.
16.	Shri K.Ashok, JSO	UK	15 November 1994 - 15 February 1995	Training on Climate Prediction and Research at Hadley Centre for Climate Prediction and Research under IITM-Hadley Centre Collaboration Scheme.
17.	Dr.H.N.Bhalme, DD	Mauritius	22 November - 2 December 1994	Participation in the Session of WMO Commission of Climatology Working Group on Operational Use of Climatological Knowledge and a Training Workshop on National Climate Application Programme, Vacoas.

Sr. No.	Name/Credential	Country	Period	Purpose
18.	Dr.P.E.Raj, SSO I	Italy	20 February - 10 March 1995	Participation in the Second Winter College on Optics, Trieste.
19.	Shri S.K.Behera, SSO II	UK	11 March- 7 July 1995	British Council Fellowship in the Technical Cooperation Training Programme and visit to Reading University and Hadley Centre for Climate Prediction and Research.

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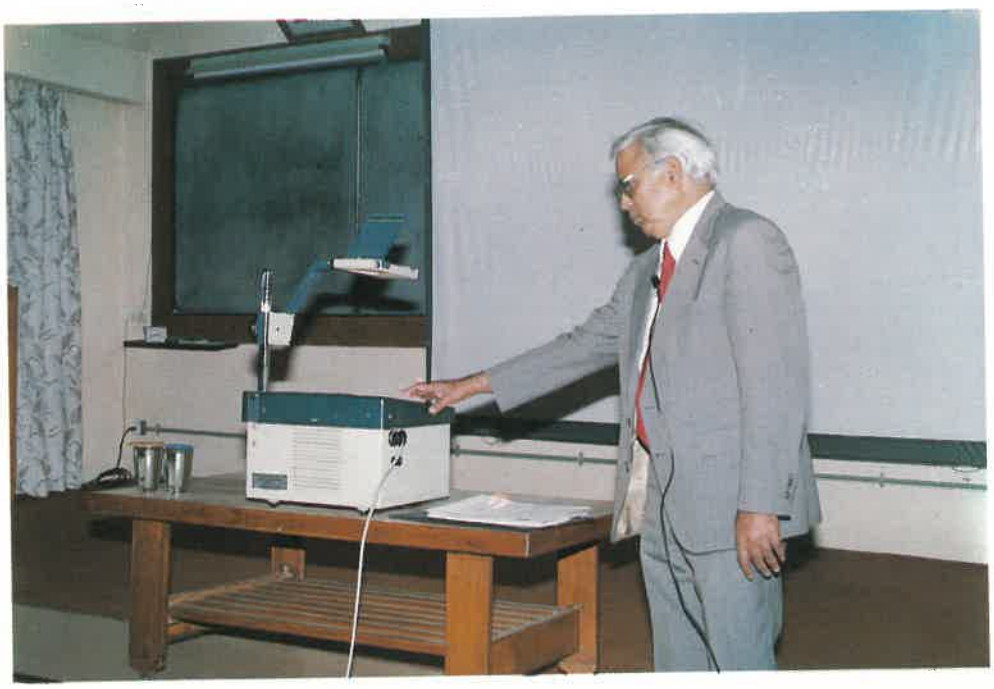
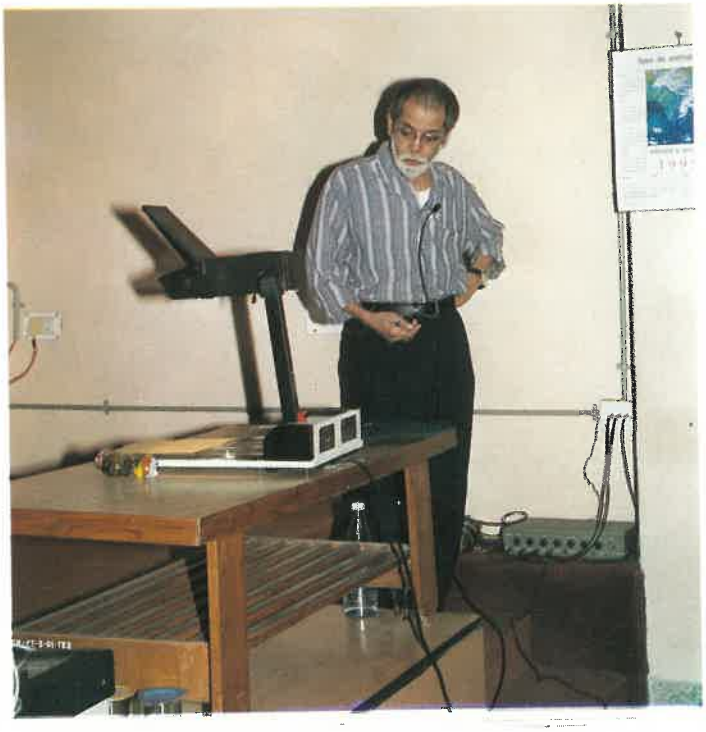
Prof. J. Shukla, Institute of Global Environment and Society, Maryland, USA had discussions with the Director during his visit to the institute on 10 August 1994.

Dr. Mike Fennessy, Centre for Ocean-Land Atmosphere (COLA) studies, Maryland, USA delivering a lecture on 'Monsoon Research at COLA' during his visit to the Institute.



Under the Indo-US Climate Research Programme Dr. G.V. Rao, Professor and Director, Earth and Atmospheric Sciences, Saint Louis University, USA visited the Institute during 3-9 January 1995 and delivered a lecture.



Dr. D.B. Rao, National Meteorological Centre, USA, delivered a series of lectures at the Institute during his visit under the Visiting Professorship Programme.

10. VISITORS

Sr. No.	Visitor	Date(s)
	International	
1.	Dr.J.Shukla, President, Institute of Global Environment and Society, Maryland, USA	10 August 1994
2.	Prof.Sethu Raman, North Carolina State University, North Carolina, Raleigh, USA	24 August 1994
3.	Dr.Mike Fennessy, Centre for Ocean-Land Atmosphere (COLA) Studies, Maryland, USA	8-14 December 1994
4.	Dr.G.V.Rao, Professor and Director, Meteorology, Associate Chair, Earth and Atmospheric Sciences, Saint Louis University, USA	3-9 January 1995
5.	Prof.K.Shankara Rao, National Oceanic and Atmospheric Administration (NOAA) USA	30 January 1995
6.	Dr.Dirk Shaefer, Institure of Geography, University of Mainz, Germany	11-17 February 1995
7.	Dr.D.B.Rao, National Meteorological Centre, USA	13-24 February 1995
8.	Dr.Tsing-Chang Chen, Professor of Meteorology, Atmospheric Science Program, IOWA State University, USA	3-4 March 1995
9.	Dr.(Ms)M.Lueck and Dr.(Ms)Laura Bautz, National Science Foundation, USA	15 March 1995

Sr. No.	Visitor	Date(s)
	National	
1.	Eight students of M.Tech. (Lasers and Electro-Optics) and Dr.J.P.Dudeja, Institute of Armament Technology, Pune.	13 May 1994
2.	S/Shri P.K.Misra, Superintending Engineer and S.Rath, Executive Engineer, Upper Indravati Hydroelectric Project, Government of Orissa, Orissa.	26 May 1994
3.	Dr.P.Rama Rao, Secretary, Department of Science and Technology, New Delhi.	8 June 1994
4.	Shri R.V.Godbole, Director, Central Water Commission, New Delhi.	9 June 1994
5.	Dr.A.P.Mitra, Bhatnagar Fellow (CSIR), National Physical Laboratory, New Delhi.	13 June 1994
7.	S/Shri Y.V.Dharma Rao, Chief Engineer and P.D.H.S.Rao, Director, Central Water Commission, New Delhi.	16-17 August 1994
8.	Trainee Naval Meteorological Observer (I Class) Sailors, School of Naval Oceanography and Meteorology, Cochin.	14 December 1994
9.	Trainee Officers, Department of Hydrology, University of Roorkee, Roorkee.	23 December 1994

Sr. No.	Visitor	Date(s)
10.	Students of M.Sc.(Tech.) Geophysics, and Dr.K.M.Srivastava, Teacher-in-Charge, Banaras Hindu University, Varanasi.	2-5 January 1995
11.	Dr.M.S.Narayanan and Dr.Pal, Space Application Centre, Ahmedabad.	23-24 January 1995
12.	Cadets and Officers, Department of Geography, Nature's Study Club, National Defence Academy, Pune.	15 February 1995
13.	Trainee Officers, Central Water Commission, Central Training Unit, Central Water and Power Research Station, Pune.	1 March 1995
14.	Officers and Directing Staff, Air Force Administrative College, Coimbatore.	30 March 1995

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11. GOVERNING COUNCIL

1.	Dr. N. Sen Roy, Director General of Meteorology, India Meteorological Department, Mausam Bhavan, Lodi Road, New Delhi 110 003.	Chairman (Ex-Officio)
2.	Dr.Y.S.Rajan, Advisor, Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi 110 016.	Member
3.	Shri S.B.Krishnan, Joint Secretary (Finance) Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi 110 016.	Member
4.	Prof. B.H.Subbaraya, Retd. Professor, Physical Research Laboratory, Navarangapura, Ahmedabad 380 009.	Member
5.	Prof.(Smt.)Sulochana Gadgil, Head, Centre for Atmospheric Sciences, Indian Institute of Science, Malleswaram, Bangalore 560 012.	Member
6.	Prof. G.C.Asnani, Retd. Professor, University of Nairobi, 822, Sind Housing Society, Aundh, Pune 411 007.	Member
7.	Prof. H.C. Khare, Retd. Professor, Allahabad University, 9, Jawaharlal Nehru Road, Allahabad 211 002.	Member
8.	Dr.H.N. Srivastava, Retd. Additional Director General of Meteorology (Research), India Meteorological Department, Pune 411 005.	Member (Up to 30 November 1994)
9.	Prof. R.N.Keshavamurty, Director, Indian Institute of Tropical Meteorology, Pune 411 008.	Member
10.	Shri V.K.Asrani, Administrative Officer, Indian Institute of Tropical Meteorology, Pune 411 008.	Non-Member Secretary

Participant of the 'Prashna Mancha' viewing the Palaeoclimatology Section of the Scientific Exhibition arranged as a part of the National Science Day Celebrations.