ISSN 0250-6017

INDIAN INSTITUTE OF TROPICAL METEOROLOGY

ANNUAL REPORT 1993-94

Dr. N. Sen Roy, Chairman (Centre),
Shri S.B. Krishnan, Jt. Secretary (Finance), DST (Left)
and Prof. R.N. Keshavamurty, Director, IITM (Right)
at the 48th Meeting of the Governing Council held at
the Institute on 5 January 1994.

ISSN 0250-6017

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PUNE 411 008

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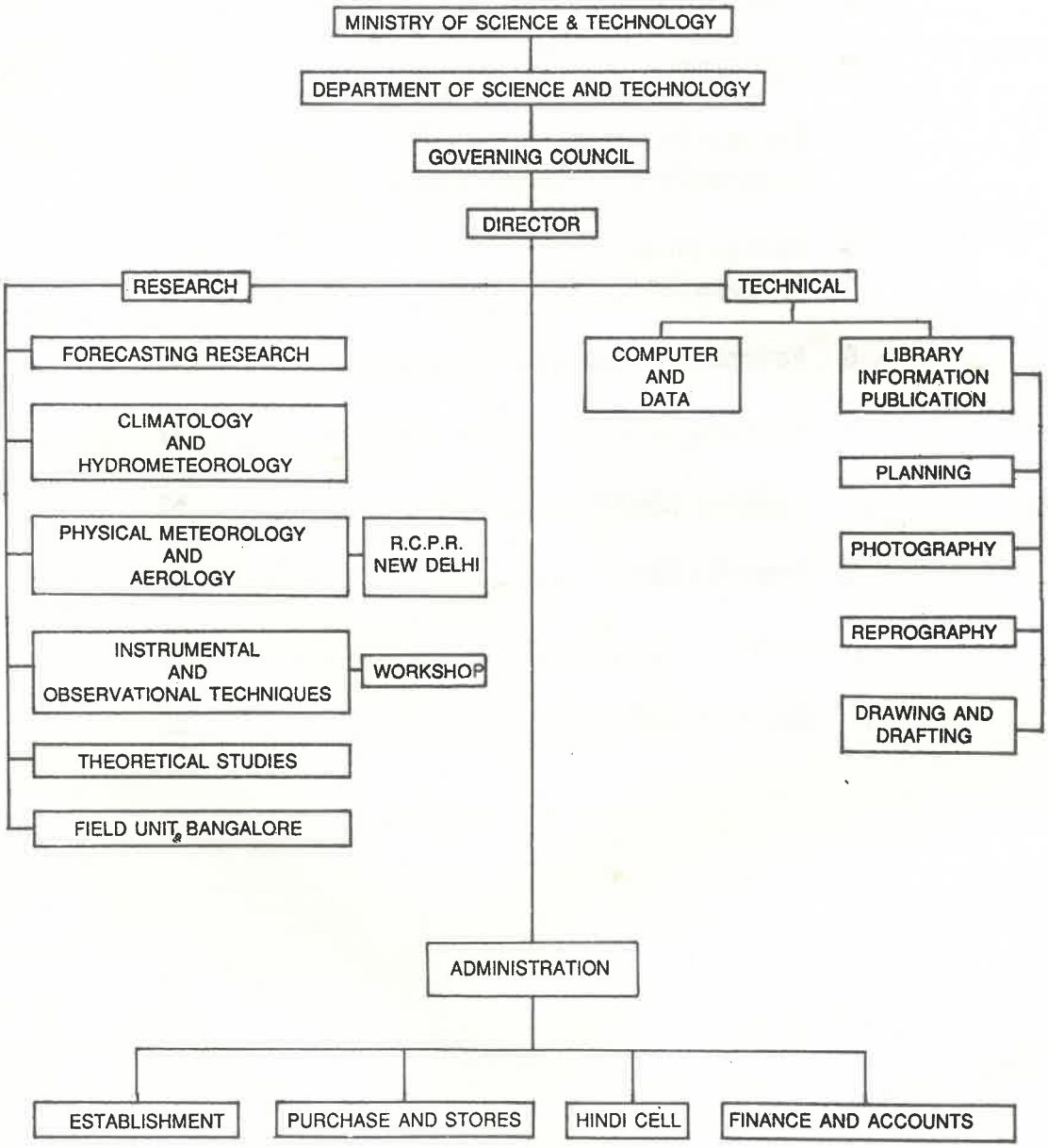
Institute's Building

INDIAN INSTITUTE OF TROPICAL METEOROLOGY



ORGANIZATIONAL PROFILE

FOREWORD

I have pleasure in presenting the Annual Report for the year 1993-94.

The Institute could achieve considerable progress in its research and academic activities in the Thrust Areas like Weather Forecasting, Climatology, Monsoon and Climate Modelling, Atmospheric Chemistry, Atmospheric Electricity, Theoretical Studies, Geosphere-Biosphere Interactions and Studies relating to Land-Surface Processes.

A National Symposium on **"Climate Variability (TROPMET-94)"** was hosted during 8-11 February 94, under the auspices of the Indian Meteorological Society. Two hundred and forty scientists from various Research Organisations and Universities participated and presented about 200 research papers. A meeting of the Indo-US Collaborative Climate Research Programme was held at the Institute and reviewed the progress of work of all the on-going research projects. Thirtytwo scientists including ten from USA participated in the above meeting.

The scientists of IITM have published 123 research papers in standard national and international journals and presented 103 papers in national and international symposia/ seminars. The Seventh SAARC Regional Award (1989) and the IITM Silver Jubilee Awards for 1991 and 1992 were received by our scientists. Four Ph.D. (Physics) degrees and Five M.Sc. (Physics) degrees were awarded and three scientists submitted their theses for the award of the M.Sc. degree.

A 'Global Modelling Group' has been formed for the study of monsoon variability on different time scales using Global Climate Models. Scientists of the Hadley Centre for Climate Prediction and Research, UK, visited the Institute under the Indo-UK Collaborative Programme and installed the UNIFIED UK Meteorological Office Climate Model on the Workstation at the Institute and research in Climate Modelling has been progressing well.

Fourteen scientists of the Institute have received training in USA/UK under different fellowship programmes including the UNDP Fellowship Programme. Ten scientists were deputed abroad for participation in Symposia/Seminars.

Several distinguished scientists from USA (including Dr.Mrs.Ruby Krishnamurti, Visiting Professor), U.K., Canada, Japan, Germany and Austria visited the Institute. We have close collaboration and co-operation with the India Meteorological Department, National Centre for Medium Range Weather Forecasting, New Delhi and Universities.

The diverse scientific, technical and academic activities summarised in this report emerged out of the hard work and enthusiasm of the scientists and staff of IITM. The national and international interactions which have been established, the scientific, technical and other infrastructural facilities created at the Institute bear witness to the exciting future for productive and quality research work in Atmospheric Sciences. I am confident that the Institute would continue to make significant contributions in the challenging areas in Atmospheric Sciences.

R. N. KESHAVAMURTY
Director

1. HIGHLIGHTS

The year 1993-94 was an eventful year for the Institute. It hosted the National Symposium on 'Climate Variability (TROPMET-94)' under the auspices of the Indian Meteorological Society. 240 delegates participated in the symposium and presented papers.

Several distinguished visitors from India and other countries visited the Institute. Prof. (Mrs.) Ruby Krishnamurti and Prof. T.N. Krishnamurti, both from Florida State University, U.S.A. visited the Institute and delivered a series of lectures.

The Institute has undertaken the DST sponsored Climate Research Project and has formed a 'Global Modelling Group' for the study of monsoon variability on different time scales using Global Climate Models.

A project entitled, 'Land-Surface Processes Experiment' sponsored by the DST has also been undertaken. A field experiment is planned in the Sabarmati region.

We have also undertaken many research programmes of National and International significance. The important highlights are summarised below :

Scientists working on long-range forecasting of monsoon rainfall have started work on forecasting for smaller areas. This has yielded encouraging results.

Computations of diabatic heating rates and of regional energetics (energy and energy conversion terms) were made for 2-7 August 1988 with and without including divergent part of the wind estimated from the OLR data in the analysis. Diabatic heating rates, energy values and energy conversion terms obtained with the inclusion of the divergent part of the wind were found to be higher and the heating field compared better with the satellite cloud pictures as compared to the results obtained without inclusion of the divergent part of the wind.

A limited area model has been used to study the comparative performance of two schemes of cumulus convection, viz, the Kuo scheme and the Betts scheme of convection. Analysis of the forecast results showed that the Betts scheme produced stronger wind circulations than those produced by the Kuo scheme. The rainfall rates and surface pressure patterns are better predicted by Betts scheme.

Decadal scale variability in the North Atlantic Oscillation (NAO) and the Indian Summer Monsoon rainfall and their relationships have been investigated with 108 years (1881-1988) of data. The analysis revealed that NAO Index during winter and spring has an inverse relationship with the summer monsoon rainfall over northwest India, peninsular India and whole of India - the highest correlation being with the winter NAO index. Trend analysis showed that both NAO and monsoon rainfall have almost similar epochs of short term climatic trends, but in opposing phase.

The role of the regional scale heat sources and the moisture sinks over the region of seasonal monsoon trough on the evolution of different phases of summer monsoon 1979 were studied using ECMWF-FGGE level III b data. Spatial and temporal variations of the apparent heating and drying rates (^{o}K/day) at the mid-tropospheric level (500 hPa) suggested that the re-distribution of heating and drying over northwest India due to westward passage of synoptic scale disturbances and the associated heavy rainfall over the western part of the trough zone could have led to the evolution of weak/break phases after an active monsoon spell during the monsoon 1979.

The long-range forecast of the all India rainfall for the Southwest monsoon 1993 based on three different multiple regression models was sent to the Director General of Meteorology. The model estimates suggested that the monsoon on All-India basis was likely to be normal, which was found to be in close agreement with the actual performance of the monsoon-1993.

Reconstructed temperature and precipitation series of western Himalayas for 250 years based on dendroclimatic approach showed that the prominent changes relating to the Little Ice Age period are not easily detectable over this region.

A "Severe Rainstorms of India" Atlas containing the analysis and other details of selected rainstorms which have occurred over different regions of the country during the last 100 years has been published.

A book entitled, "Climates of South Asia" authored by G.B.Pant and K.Rupa Kumar is under publication.

A computer algorithm for the parameterization of ozone heating in the stratosphere due to absorption of short-wave radiation has been developed. The space-time variations of the ozone heating rates could be

computed using the above algorithm and it is useful for 2-D and 3-D models.

A field programme to study the Geosphere-Biosphere interactions in the Himalayan ecosystems region has been formulated for collecting observations in collaboration with the G.B.Pant Institute of Himalayan Environment, Almora, U.P. Observations of atmospheric and precipitation chemistry are being collected from June 1993 at Almora.

A high power, pulsed, tunable CO_2 laser system has been acquired for aerosol measurements up to stratospheric altitudes required for the studies relating to the climate system.

A simple empirical scheme which gives estimates of heat and momentum fluxes during day-time has been tested to compare the observed values of the fluxes of heat and momentum with the estimated values. The observations obtained from a small scale land-surface experiment at Pune during 1992 are compared with the model computed values. There is good agreement between the observed and the estimated values of these fluxes.

Soil heat fluxes were computed using the observational data of soil temperatures at 10, 20 and 30 cm below the surface obtained at Kharagpur, Jodhpur, Varanasi and Delhi as a part of MONTBLEX-90. Computations of sensible heat flux were also carried out using the bulk aerodynamic method utilizing the simulated soil temperatures at the surface and the observed temperatures and winds at 1 m above the surface.

The scavenging of aerosol particles by the charged and uncharged water drops has been studied in the absence or presence of electric fields in a laboratory simulation experiment. The collection efficiency for various drops have been calculated. Washout coefficients, half-life and rainfall depth for different rainfalls have been calculated for the charged and uncharged cases. The results effectively show how the electrical forces can enhance the washout of aerosol particles in the atmosphere.

A reduced gravity ocean model with summer climate wind stress as a forcing simulated the Somali current and the associated southern gyre after 30 days of integration. The spatial extent of the southern gyre is comparable with that of the vertical component of the wind stress curl, indicating the importance of local wind stress.

1.1 Global Modelling Group

A Global Modelling Group has been formed in the Institute on 20 January 1994 with the objective to study monsoon and climate variability on different time scales using global climate models. The U.K. Meteorological Office UNIFIED Model acquired under the IITM-Hadley Centre Collaboration scheme, sponsored by the British Council has been installed on the Institute's HP 9000/735 Workstation.

1.2 Awards

The Seventh SAARC Regional Award for the year 1989 was conferred on Shri M.K. Tandon, Senior Scientific Officer, Grade II during the inaugural function of the SAARC Workshop-cum- Seminar on Aviation Meteorology, at the India Meteorological Department, Pune on 6 December 1993.

Shri P.N. Mahajan, Senior Scientific Officer, Grade II and Shri S.P. Ghanekar, Senior Scientific Assistant were awarded the IITM Silver Jubilee Award for the year 1991 for their paper entitled, 'Assessment of satellite observed HRC data for rainfall estimates over the tropical Indian Ocean', published in Mausam,1991.

The IITM Silver Jubilee Award for the year 1992 was won by Smt. S.S. Dhanorkar, Senior Scientific Officer, Grade II and Dr. A.K. Kamra, Deputy Director for their paper entitled,'Relation between electrical conductivity and small ions in the presence of intermediate and large ions in the lower atmosphere,' published in Journal of Geophysical Research, 1992.

The IITM Silver Jubilee Awards for 1991 and 1992 were presented by Dr. Vasant Gowariker,Former Scientific Advisor to the Prime Minister,at the inaugural function of the TROPMET-94 Symposium held on 8 February 1994.

1.3 Visiting Professorship

Prof. (Mrs.) Ruby Krishnamurti, under the Visiting Professorship Programme of the Institute and Prof. T.N. Krishnamurti, both from Florida State University, U.S.A. visited the Institute during 5-18 December 1993 and delivered a series of lectures on Monsoon, Tropical Cyclones, Cloud Modelling, GEWEX, Turbulent Convection and Geophysical Fluid Dynamics. In addition to the scientists of the IITM, Scientists from the National Centre for Medium Range Weather

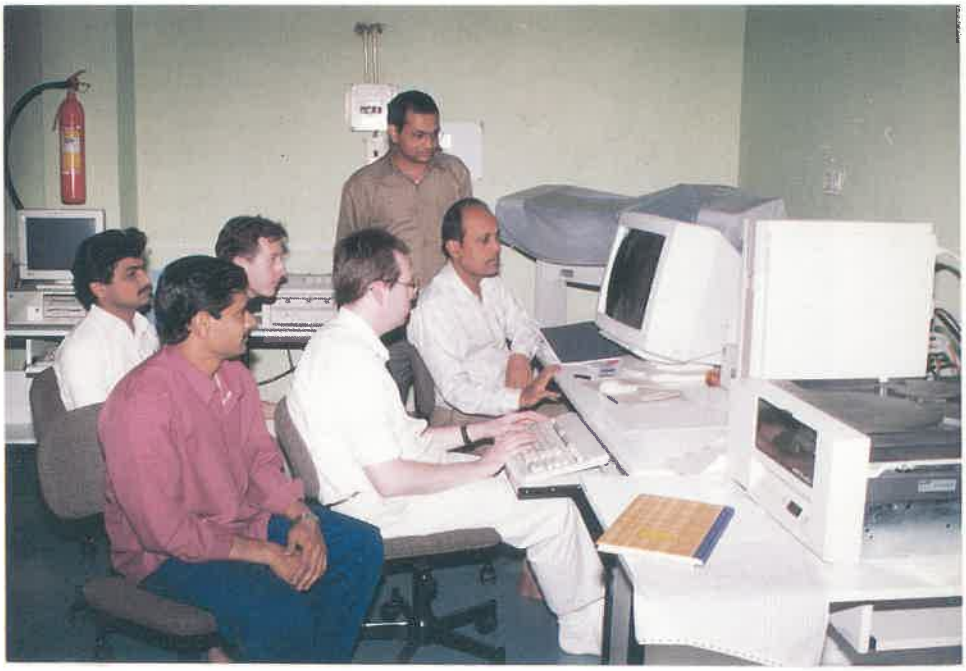
Dr. N. Sen Roy, Director General of Meteorology and President of the Indian Meteorological Society addressing the Inaugural Session of "TROPMET - 94".

Participants of TROPMET - 94.

Meeting of the Indo-US Collaborative Programme on Climate Research held at the Institute on 14-15 February 1994.

Participants in the Meeting of the Indo-US Collaborative Programme.

Prof. Ruby Krishnamurti, Florida State University, USA, delivered a series of lectures at the Institute during her visit under the Visiting Professorship Programme.



Scientists from the Hadley Centre for Climate Prediction and Research, U.K. visited the Institute under the IITM-Hadley Centre Collaborative Research Programme of Climate Modelling.

Field observations of atmospheric and precipitation chemistry carried out at the G.B. Pant Institute of Himalayan Environment, Almora, U.P.

Observations of soil temperature and radon carried out under the IITM-BARC Collaborative Field Programme.

Forecasting, India Meteorological Department, Physical Research Laboratory and University of Poona also attended these lectures and had extensive scientific discussions with Prof. (Mrs.) Ruby Krishnamurti and Prof. T.N. Krishnamurti.

1.4 National Seminars/Workshops/Meetings held at the Institute

A National Symposium on Climate Variability (TROPMET-94) was held during 8-11 February 1994 under the auspices of the Indian Meteorological Society. About 240 scientists from various organisations and Universities participated in the Symposium. About 100 contributed papers and 25 invited papers were presented in oral sessions and about 70 papers were presented in poster sessions.

An Expert Committee of the Department of Science and Technology met on 6 and 7 April 1993 and held discussions regarding the preparation of the Planning Document for the proposed 'Land Surface Processes Experiment'. Experts from the Institute, National Centre for Medium Range Weather Forecasting, New Delhi, Physical Research Laboratory, Ahmedabad, National Remote Sensing Agency, Hyderabad and Central Arid Zone Research Institute, Jodhpur participated in the meeting. Detailed presentations of the important research proposals to be undertaken as a part of the said experiment were made. A new layout of the grid point stations in the Sabarmati region for the Land Surface Processes Experiment was identified and accordingly the budget was reformulated in a meeting held on 12 October 1993.

A Brain Storming Session on Long-Range Forecasting of Summer Monsoon Rainfall for Higher Spatial and Temporal Resolutions organised by the Department of Science and Technology was held on 11 October 1993 to chalk out a co-ordinated plan of action for the development of long-range forecast system of monthly rainfall over smaller regions.

The 20th meeting of the Programme Advisory Committee on Atmospheric Sciences of the DST was held on 12 February 1994.

1.5 Bilateral Programme

A meeting of the Indo-US Collaborative Climate Research Programme was held on 14 and 15 February 1994 to review the progress of work of all the ongoing research projects and to consider new thrust areas of climate research such as Atmospheric and Climate modelling, and Atmospheric chemistry in relation to global climate change. Thirty two scientists including ten US scientists participated in the meeting.

1.6 In-House Training

An In-House Research Oriented Training Course in Meteorology for the Institute's scientists and Research Fellows was arranged for a period of eight months from 14 December 1992.

1.7 Participation in Cruise

The Institute participated in the 88th Cruise of ORV Sagarkanya over the Central Bay of Bengal (10-19°N, 81-94°E) during 11 October-9 November 1993 for taking observations of Marine Meteorology (sea surface temperature).

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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 model for prediction of the movement of tropical cyclones with emphasis on the parameterization of land surface fluxes.
* Study of the characteristics of the planetary boundary layer using the data collected during MONTBLEX.
* Development of objective analysis for NWP models including the use of satellite OLR and wind data.
* Diagnostics of ENSO-Monsoon relationship, intra-seasonal variations of rainfall and some new teleconnections of monsoon.
* Study of seasonal heat sources over monsoon trough region and its role in the evolution of monsoon cycles.

2.1.1 Regional NWP Modelling and Model Diagnostics

The limited area model was tested with different vertical levels in order to obtain a suitable vertical resolution that would give better forecast field in the upper as well as lower levels. It was found that a modified 10 level model gave better circulation features at 850 hPa level. Also, the error statistics showed improvement.

A limited area model was used to study the comparative performance of two schemes of cumulus convection, namely, the Kuo Scheme and the Betts Scheme. Analysis of the forecast results showed that Betts Scheme produced better circulation features, rainfall rates and surface pressure patterns than those produced by Kuo Scheme.

Computations of moisture fluxes over the land surface was modified by using a ground wetness parameter which was dependent on the past rainfall rate and other large scale surface parameters. It was found that the modified ground wetness parameter gave a better spatial distribution of the land-surface moisture fluxes. The forecast results obtained after 2-day integration of the limited area model with this modified method, showed improvement in predicted rainfall features.

Marine meteorological data collected on board ORV Sagarkanya during its two cruises over Arabian Sea(15 July to 15 August 1992) and the Bay of Bengal (10 October to 11 November 1993) were analysed. The analysis showed that Arabian sea was cooler by 1° C than normal during the period of cruise. The lowest SST was observed over Somali basin (9.2° N, 55.5° E) on 7 August 1992 and highest value over the east Arabian sea (4.0° N, 62.5° E) on 10 August 1992 with a gradient of 8.1° C between the two regions. The Somali basin was gaining energy (Q_N = 74 WM^{-2}), where as equatorial east Arabian sea was loosing energy (Q_N = -31 WM^{-2} to -200 WM^{-2}). Sensible and latent heat fluxes were negative over the Somali basin implying the transfer of heat from air to sea. Over Bay of Bengal the SST varied from 28.5° C to 29.5° C. The solar radiation varied from 90 WM^{-2} to 1040 WM^{-2} from overcast sky to clear sky.

A three-dimensional primitive equation model in sigma coordinate system was developed for the numerical simulation of tropical cyclones. The model contains all the necessary physics. The model input consists of a weak vortex in gradient wind balance. Preliminary results showed that the model is able to produce vortex of tropical cyclone intensity after 120 hrs of integration.

2.1.2 Objective Analysis Including Satellite Input for Regional Models

Computations of Diabatic heating rates and regional energetics (energy and energy conversion terms) were made for six days (2 - 7 August 1988) with and without including divergent part of the wind estimated from the OLR data in the analysis. Diabatic heating rates, energy values and energy conversion terms obtained with the inclusion of the divergent part of the wind were found to be higher and the heating field compared better with the satellite cloud pictures as compared to the results obtained without inclusion of the divergent part of the wind.

Geopotential heights computed from the satellite observed temperatures for the period from 27 to 31 July 1991 for a case of monsoon depression, over the region of the Indian Ocean, were used for Univariate Optimum Interpolation scheme of analysis and the results were compared with the analysis carried out excluding the satellite observations.

2.1.3 Extended Range Prediction

Global structure of the Madden-Julian Oscillations (MJOs) during 1987 (deficient monsoon) and 1988 (excess monsoon) revealed that the spatial distribution of these oscillations was more in 1987 than in 1988.

The most important features of the MJOs are the eastward propagation with periods of 30-60 days and the dominance of the planetary scale waves. Both these features appeared during 1987 and they were almost non-existent during 1988.

Climatology of the Indian summer monsoon and its response to equatorial Pacific SST anomalies, as simulated with the GFDL-GCM in a 15-year integration experiment were investigated. The seasonal changes and evolution of the Indian summer monsoon rainfall are simulated realistically but the rainfall amounts are underestimated and the standard deviation is large compared to observations. However, when the El Nino conditions are incorporated by varying the SST in the tropical Pacific realistically, the simulated monsoon rainfall comes closer to the observations.

2.1.4 Monsoon Studies and Forecasting

The thermal structure and diabatic heating over the Indian monsoon trough region were analysed with the FGGE-Level IIIb data of the European Centre for Medium Range Weather Forecasts for 1979. The apparent heat sources over the Indian monsoon trough zone varied in a fashion similar to rainfall over central India. The spatial and temporal variations of the vertically integrated apparent heat sources (Q1) and apparent moisture sinks (Q2) at 500 hPa level revealed a 30-50 day eastward propagation and a 10-20 day westward propagation of Q1 and Q2 along the monsoon trough area (Fig.1). The long period fluctuation is found to be a part of the oscillation of whole summer monsoon activity in 1979.

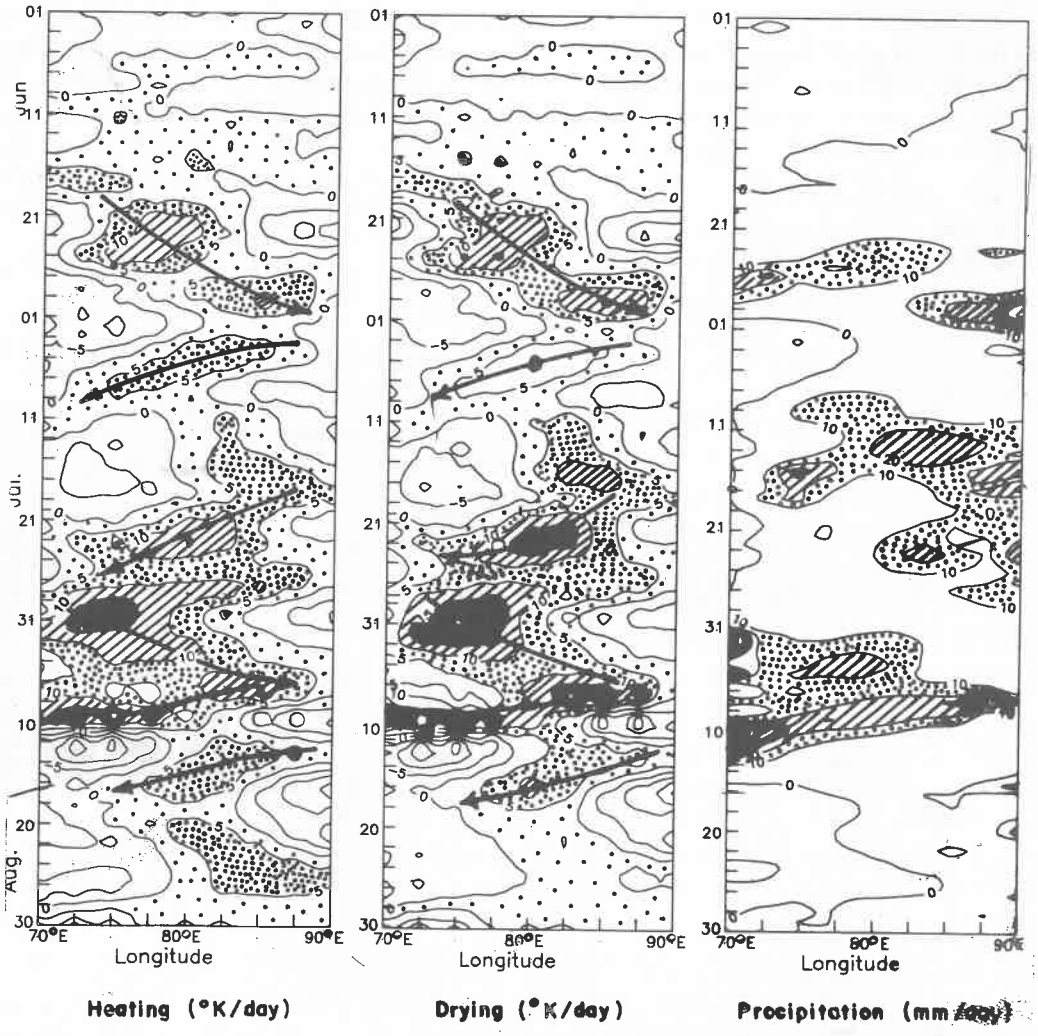
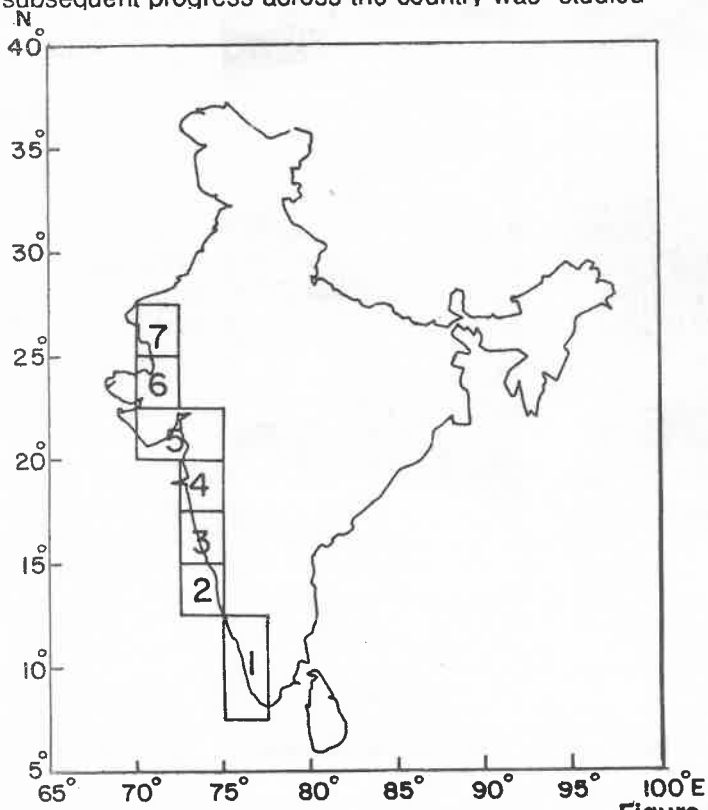


Figure 1 :
Relationship between eastward-westward propagating low frequency oscillations and the summer monsoon activity during 1979.

Standardised pentad anomalies of rainfall for the period 1901 to 1980 were analysed to study evolution of the monsoon from active to weak/break phases during June to September. The study showed definite mean patterns of evolution of the negative values of rainfall anomaly over India particularly over the central parts and the adjoining south peninsula during the subsequent 3 pentads, (K=1,2 and 3) following the initial pentad (K=0) having large positive rainfall anomaly values over a test block, bounded by 20° to 25°N and 70° to 72.5°E representing western part of the monsoon trough zone. This result supports the hypothesis based on the computations of the apparent heat source and apparent moisture sink over the monsoon trough zone for 1979 that a non-adiabatic heat source over the western part of the monsoon trough in association with intense rainfall activity on synoptic scale might lead to weak/break monsoon situation over India. The rainfall anomalies on the daily scale also showed similar evolutionary patterns for typical 'break' monsoon situations over India in the years 1965,1966, 1970, 1971, 1972 and 1973.

The onset of Indian summer monsoon and its subsequent progress across the country was studied based on outgoing longwave radiation (OLR) data for 15 years (1974-1990, barring 1978). The OLR data were found to give fairly realistic picture of the atmospheric convection and convective rains over a region. During the time of onset of monsoon well organised convective cloud clusters are seen to move northwards from the near equatorial region towards the continent of India through its southern part ushering the monsoon rains to different parts of the country. The study made an attempt to monitor the organisation and northward advance of such cloudiness over various regions through analysis of OLR data during the onset and the advance phases of monsoon. The analysis indicated a continuous lowering of the OLR values few days prior to the onset of monsoon over the region culminating to a lowest value near about the official onset date. A threshold values of OLR were identified for each region to determine the onset date. The onset over a region determined solely by the OLR criteria compared well with the official onset date (Fig.2). Satellite-derived OLR data can thus be used as an additional criterion in monitoring and determining the onset of the monsoon over a region and its further progress across the country as well as to predict the date of onset a few days ahead.



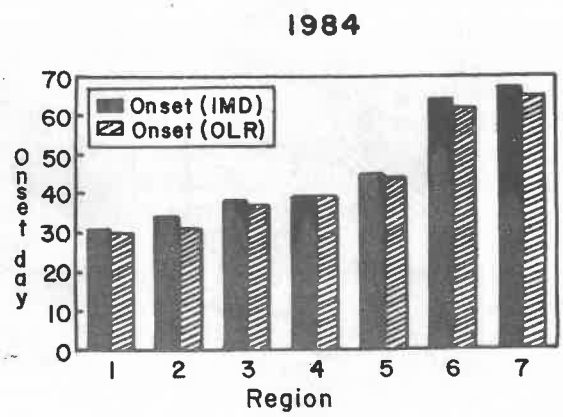


Figure 2 :
Onset of summer monsoon in different regions along the westcoast of India 1984 as determined by satellite derived OLR data.

Daily monsoon rainfall data of 364 Indian stations for 80 years (1901-1980) were analysed and classified into the zones of homogeneous weekly rainfall. Such zones are constructed by using tercile values of weekly rainfall intensity and weekly rainfall variability for a suitable statistical model to predict weekly rainfall over these zones.

Large-scale tropospheric circulations during the contrasting monsoon years over India were studied using NMC data at 300 hPa level for the monsoon months June through August. The study showed convergence of momentum between equator and 10° N in bad monsoon years and divergence in good monsoon years.It also showed that the momentum transport due to mean meridional circulation is quite significant between the latitudes 20°S and 20°N but no contrast is seen in good and bad monsoon years. Waves 1 and 2 are more prominent in the spectrum of the zonal component of wind in good monsoon years compared to bad monsoon years. However, waves 1 to 10 are prominent in the spectrum of the meridional component of the wind.

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

The long-range forecast of the All India rainfall for the Southwest monsoon 1993 based on three different multiple regression models was sent to the Director General of Meteorology. The overall performance of the monsoon over India as a whole for the season was found to be in close agreement with the prediction.

Detailed analyses of global monthly wind and geopotential height at 850 hPa and 200 hPa levels and the thickness field between these levels were undertaken for the months of April, May and July for the period 1980-92 based on the ECMWF analysis data. It was observed that the eastward displacements in the centers of action of tropical circulation and rainfall regimes normally brings below normal rainfall over India during the major ENSO warm episodes. The displacement of rainfall regimes to the east during the years of below normal monsoon over India is supported by satellite derived global precipitation data.

The ocean-atmosphere interactions are an important component of the observed climate variability on all time scales. The frequent occurrence of droughts over India during two epochs of 1901-20 and 1965-90 was investigated by analysing the SST anomalies of different ocean basins for the period 1871-1990 using the COADS and the UK Met Office data sets. These two epochs of frequent occurrence of droughts broadly correspond with warmer southern hemispheric oceans compared to the northern hemispheric oceans. The long intervening period between these two epochs with a few droughts in India is characterized by a colder southern hemispheric oceans than the northern hemispheric oceans.

One hundred tree core samples of coniferous trees from western Himalayan region were analyzed for dendroclimatic analysis. Four tree ring chronologies for Cedrus deodara and Pinus roxburghii trees for Simla-Manali (H.P.) and Tani, Kanasar (Uttar Pradesh) region were prepared. Tree growth-climate response model suggests that the summer temperatures of the region are most responsive and negatively correlated to tree growth. Reconstructed temperature and precipitation series for Mussorrie and Simla do not indicate a prominent Little Ice Age cooling.

A comprehensive study of the diurnal asymmetry of surface temperature trends over India suggested that the increase in the mean temperature over India during 1901-87 is almost solely contributed by the increase in maximum temperature (0.6°C/100 yr), with the minimum temperature remaining practically trendless on all India scale (Fig.3).

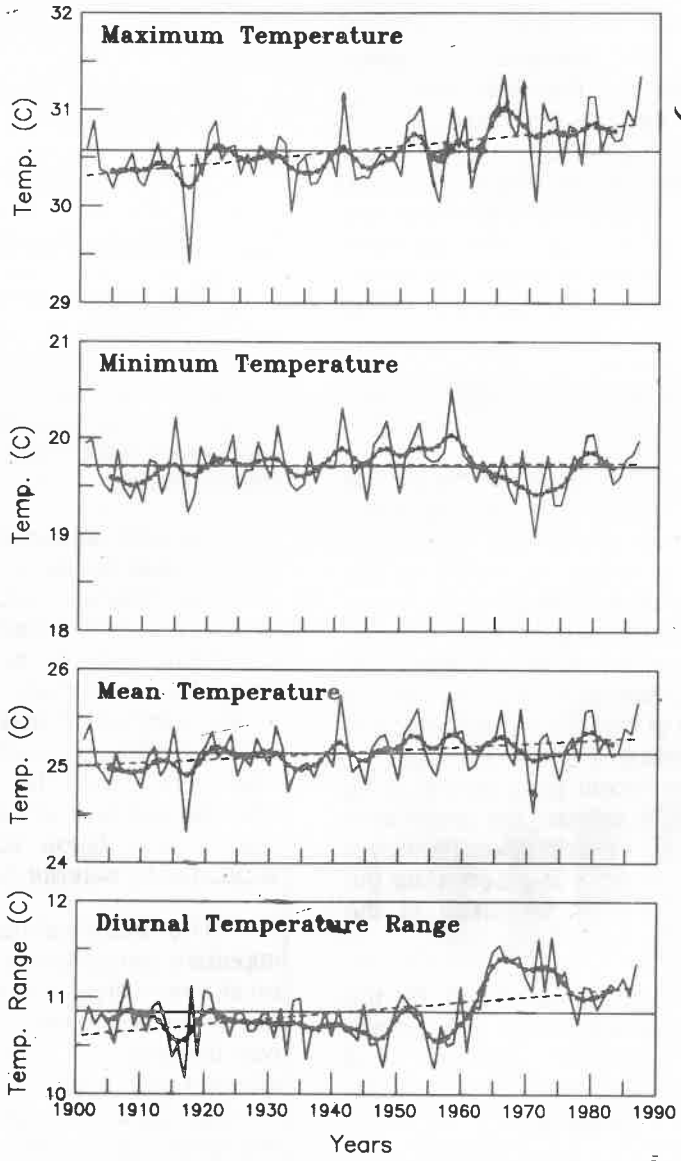


Figure 3

Variations of the all India average surface temperature and its diurnal range (Continuous lines)during 1901-87. Dotted lines : 9-point Gaussian lowpass filtered series; Dashed lines : linear trend.

The minimum temperature during the monsoon season showed a tendency to decrease in north India. Consequently there is a general increase in the diurnal range of temperature over India, unlike the trends over several other areas of the world. These trends do not show significant urban or altitude bias. The trends show some differences on smaller spatial and temporal scales, but the increase of maximum temperature is predominant over a major part of India (Fig.4), particularly in winter and post monsoon season.

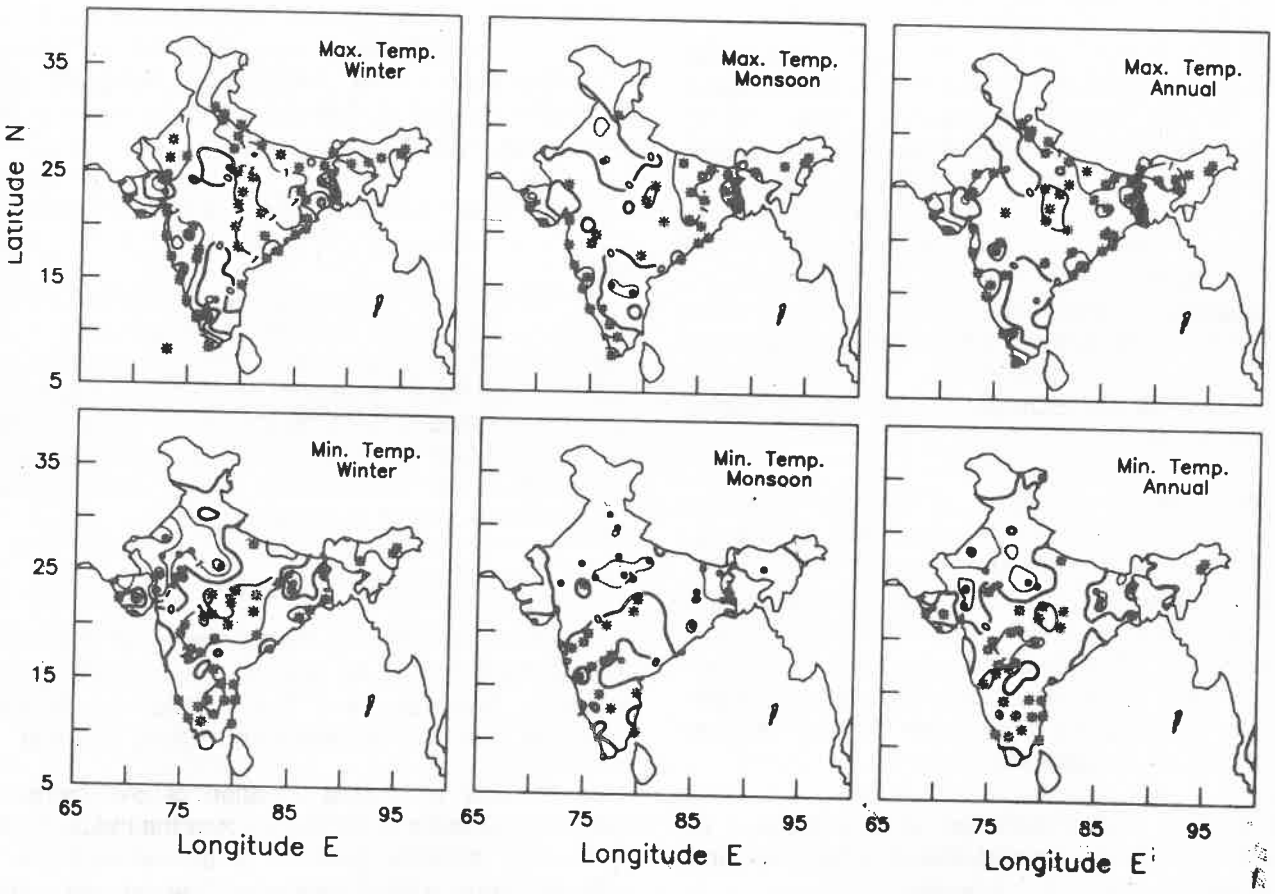


Figure 4

Spatial distributions of the linear trend in the surface temperatures. Stars indicate stations with significant warming/cooling.

2.2.2 Hydrometeorological Studies

The annual extreme rainfall series in the time scale of 1 to 3 day durations for 316 stations well distributed over the country were analysed from 80 year daily rainfall data from 1901 to 1980. It is found that the annual extreme rainfall records of most stations are entirely free from persistence and trend. However, a significant increasing trend was found in the extreme rainfall series at stations over the west coast and at a few places to the east of the western ghats while a decreasing trend was found at stations over the southern peninsula and the lower Gangetic valley. These trends in annual extreme rainfall events at a few places have implications in the hydrological studies and dam design projects.

At the request of Central Water Commission (CWC), New Delhi a detailed hydrometeorological study of the Tungabhadra catchment up to Tungabhadra dam site with an area of 27,000 km^2 was made using the data for 1901-85 to estimate the design storm depths of different return periods and the Probable Maximum Precipitation to be experienced by the catchment. It was found that the catchment experienced maximum rainfall of 11.5 cm, 17.6 cm and 23.0 cm during 1, 2 and 3 days period 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 and of 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 association between the frequency of lightning and the associated variations in the cloud-electrical parameters with respect to the onset of precipitation in the thunderstorms was studied using the observations collected during thunderstorms at Pune. The preliminary results of the study indicated intensification of precipitation following the lightning in the thunderstorms.

Analysis of the atmospheric electric field and meteorological observations collected at Pune during 1973-1977 suggested a close association between the magnitude of the electric field during the pre-monsoon months of April-June and the onset of the southwest monsoon in the region.

2.3.2 Radar Study of Rain and Rain Bearing Clouds

Based on the radar data of precipitation echoes within 100 km around Delhi collected during the period from 1966 to 1971, study of the variability of monsoon clouds vis-a-vis total amount of rainfall in this region was completed. The study showed that the number of precipitation echoes and their average aerial coverage were more during rainfall excess years compared to rainfall deficient years.

2.3.3 Warm Cloud Modification

At the request of the Agencies of the State Government of Haryana, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu, the Institute provided technical information on 'Cloud Seeding'.

A study of diurnal variation of SW monsoon rainfall at 33 stations distributed over the Indian region indicated different patterns of diurnal variation in different geographical locations. Coastal and inland stations showed enhanced rainfall from midnight to morning hours and below average rainfall during day time. Many inland stations showed rainfall maximum towards afternoon/evening hours. Some hill stations exhibited the same behaviour as inland stations. The heavy rainfall station of Cherrapunjee has maximum rainfall activity from mid-night to morning hours and least rainfall in the afternoon hours similar to coastal stations.

Harmonic analysis of 24-hourly SW monsoon rainfall data indicated that the first harmonic accounts for more than 50% of the variance of the rainfall series at (i) inland stations for which the maximum of the first harmonic is reached between 16 hours IST and midnight, and (ii) coastal/island stations for which the maximum is seen between 03 and 07 hours IST. At most of the coastal/island stations, the first harmonic alone accounts for 75% or more of the variance. For the heavy rainfall station of Cherrapunjee, the first harmonic which attains its maximum at 3.8 hours IST, is able to account for 96% of the variance of the rainfall series.

The rainspell parameters for 5 SW monsoon seasons of 1966-1970 for 15 stations representative of different rainfall regimes over India showed that the average daily rainfall per spell day is highest (50-60 mm) for the stations in the West Peninsular region and the lowest (about 30 mm) for the stations in the Central Peninsular region of the country. A maximum of 75-80% of the SW monsoon rainfall is received by high intensity rainspells (with rainfall 20 mm/day) at stations in the West Peninsular region and a minimum of 45-55% of the season's total is registered at stations in the East and Central Peninsular regions. The contribution of high intensity rainspells to the SW monsoon rainfall at stations in the other regions of the country ranges from 60 to 75% and the average rainfall per spell day is of the order of 35-50 mm.

2.3.4 Studies of the Atmospheric Boundary Layer

The characteristics of the mixed layer over the marine boundary layer over North and adjoining Central Bay of Bengal were studied using the observations collected from 'Sagarkanya' during 18 August-18 September 1990. The results of the study indicated that the mixed layer heights are dependent not only on the surface flux but also on the surface wind. Sea surface temperature values were low during strong wind conditions which is attributed to the increased evaporation (Fig. 5).

A simple one-dimensional model was developed to study the interactions between land-surface processes and the atmosphere. In this model surface temperature and humidity obtained from energy balance equation, were used to compute the surface fluxes.

A simple empirical scheme which gives estimates of heat and momentum fluxes during daytime was

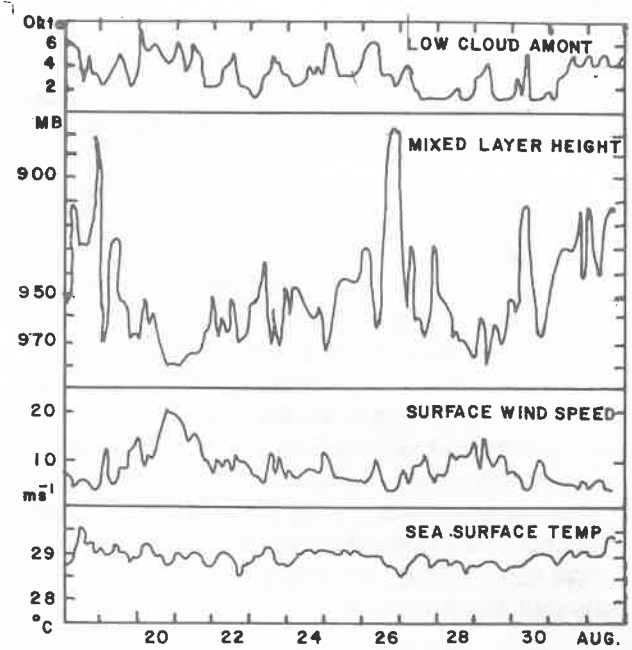


Figure 5 :
Association between Sea Surface Temperature (SST), Surface Wind Speed (V), Mixed Layer Height (W) and Low Cloud Amount over the Bay of Bengal (a) 18 August - 1 September 1990.

tested to compare the observed values of the fluxes of heat and momentum with the estimated values. In this scheme the sensible heat flux was obtained using surface radiation and energy budgets. The momentum flux was obtained with the help of surface roughness length applying Monin-Obukhov similarity theory. The observations obtained from small scale Land-Surface experiment at Pune during 1992 were compared with the model computed values. There was good agreement between the observed and estimated values of these fluxes.

2.3.5 Deterministic Chaos

Studies in non-linear dynamics indicated that the apparently chaotic fluctuations exhibited by the systems in nature have self-similar fractal geometry in space and time e.g., (i) global cloud cover patterns exhibit self-similar fractal geometry, (ii) power spectrum of temporal fluctuations of atmospheric variables exhibit inverse power law form etc. Self-similarity in space and time evolution implies long-range spatio-temporal correlations. Such non-local connections or persistence were recently identified as signatures of self-organized criticality. The theory relating to this was being studied in detail with the objective of advancing the present knowledge of self-organized criticality in

atmospheric flows and its quantification/applications in weather/climate prediction. A cell dynamical system model for universal quantification of deterministic chaos in dynamical systems (models) was developed.

2.3.6 Studies in Upper Atmosphere

The possible influence of Mt. Pinatubo eruptions in Philippines during June 1991 on the stratospheric temperatures and winds in the tropics was investigated using corresponding stratospheric rocket-sonde data for Thumba. The results of the study suggested increase in temperatures at 25 km up to 3.6^{o} following the volcano eruptions. Correspondingly, the easterly zonal winds increased up to 9 mps. The above changes were attributed to the modification of the stratospheric dynamical conditions by the volcano eruption-induced aerosols into the atmosphere.

Analysis of the daily data of the temperature and geopotential heights for the 30 and 50 hPa levels for Syowa (69°S, 40°E) for 10 years (1977-1982, 1984-1987) suggested that the above parameters have strong direct relationship indicating decrease in ozone in the polar vortex where contour heights at these levels attain minimum values in presence of cold Polar Stratospheric Cloud (PSC). The harmonic analysis of the daily temperature and geopotential heights for 50 mb suggested preponderance of waves with the periodicities of 15, 30 and 60 days. The waves with periodicity of 30 days were dominated in the Antarctic region during winter.

Spectral analysis of the daily data of the geopotential heights for 500, 200 and 100 hPa (troposphere) and for 50 hPa (lower stratosphere) for Singapore (1°22'N, 103°55'E) for 3 pairs of contrasting summer monsoons (1972-1975, 1979-1983, 1987-1988) suggested existence of waves in the geopotential heights at Singapore during summer monsoon (June-September) with significant periodicities 3-10 day (high frequency), 11-40 day (low frequency) and 41-72 day (very low frequency) during all the six years mentioned above. The study also broadly indicated shifting of wave disturbances in the geopotential heights towards lower frequency modes at Singapore, the gateway to cross-equatorial flow of maritime airmass, during strong monsoon years (1973, 1983 and 1988) in India. It was also noticed that the waves with various frequencies are present at Singapore during the strong monsoon years but it is not so in the case of weak monsoon years.

Stratalert messages obtained from Berlin through the WMO Telecommunication were analysed for the four months December 1993 to March 1994. Analyses of the polar diagrams for 10 hPa of the NH (Northern Hemisphere) indicated intense warmings during 20.12.1993 to 14.1.1994 and 9.2.1994 to 14.2.1994 and minor warming during 4.2.1994 to 8.2.1994 over northern Atlantic and Europe. A reversal in temperature gradient at 1.5 hPa between 60° N and the pole was shown on 15 Feburary. There was no major warming and wave activity was less during the winter of 1993-94.

2.3.7 Studies in Air Pollution

The ionic composition and pH of snow samples collected at Gulmarg during December 1986 to May 1987 were studied. The results of the study indicated higher concentrations of cations (K^{+}, Ca^{2+}, Mg^{2+}) as compared to the snow samples in other regions with similar environmental conditions. The higher concentrations of cations observed in the snow at Gulmarg were attributed to the transport of aerosols from the arid regions in the west and northwest during the period of the western disturbances.

Rain water samples were collected on rainy days during the monsoon season (July-September) of 1992 around Super Thermal Power Plant (U.P.) and trace gas measurements were made for a period of 10 days in September 1992. The study pointed out that the acidic depositions from the power plant are limited within a distance of 0.5 km and decrease with distance in the downwind and upwind of the power plant. The alkaline nature of aerosol is the main cause which does not allow the spread of acid rain in the regions.

A field observational programme was conducted at Kosi, Almora and Tungnath in U.P. during 5-12 October 1993. The results of the preliminary analysis suggested the following:

i) The concentrations of the trace gases (SO_2, NO_2 & NH_3) during the period of measurements were in the range of World background levels at Kosi, Almora.

ii) The average mass concentration of the atmospheric aerosols was 45 $\mu g\ m^{-3}$. The mass size distribution of aerosols showed bimodal distribution. The coarse particles contributed 70% and submicron particles 30% of the total mass of

aerosols. This distribution suggested that natural sources mainly, soil, dominated the anthropogenic sources.

iii) The total mineralisation in the rain water collected in both the areas i.e., Kosi and Tungnath were in the range of 4-6 mg/l which is in the range of background level (6-12 mg/l).

iv) Average pH of rain water at Kosi is 5.82 and the individual value varied between 4.9 and 7.1. Average pH of rain water at Tungnath is 5.68 which is around the CO_2 equilibrated value (pH=5.65). The above results suggest that rain water is not acidic at both the places.

2.3.8 Lidar Probing of the Atmosphere

A high power, pulsed, tunable CO_2 laser system has been acquired to extend the present lidar aerosol measurements up to stratospheric altitudes.

A high-resolution multiple wavelength solar radiometer was developed for the study of temporal-spectral characteristics of atmospheric aerosols and gas molecules. The radiometer consists of a heliostat for continuous tracking of the sun, a double monochromator for analysing the solar flux in the specified spectral range, and a data acquisition system for the real-time recording of the solar spectra. The radiometer was operated on 10 cloud-free days during April-June 1993 and observations were collected in the 200-720 nm wavelength region. Computer algorithms were developed for the estimation of atmospheric optical depths from the radiometer observations.

The aerosol climatology of Pune was studied using more than 350 vertical profiles of lidar-derived aerosol concentration obtained during the seven-year period from October 1986 to September 1993. The study indicated a direct relationship between the monsoon rainfall amount and the pre-monsoon to monsoon decrease in aerosol content, which is about 33%. The power spectral analysis of lidar-derived aerosol content and concurrent surface meteorological parameters (temperature, wind speed, relative humidity, rainfall and cloud amount) showed significant annual and semi-annual oscillations besides other shorter period oscillations.

The spectroradiometer observations of solar flux at 61 wavelengths covering spectral region from 490 nm to 700 nm at 5 nm interval were carried out on 10 days with clear sky conditions during winter (December - February) of 1993-94. These high-spectral resolution observations were utilised for the study of columnar size distribution of aerosols over Pune (Fig.6).

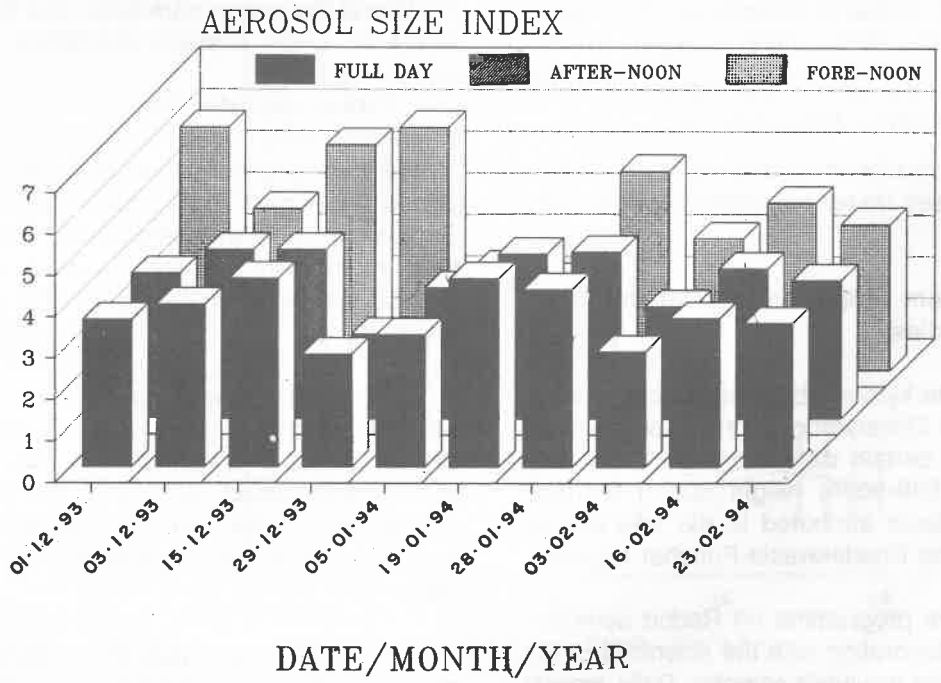


Figure 6 :
Variations in the Aerosol size index.

2.3.9 Spectroscopic Measurements of Atmospheric Minor Constituents

The observations of atmospheric NO_2 and O_3 were carried out using the UV-visible spectrometer on 10 days during July-November 1993. The spectrometric observations collected during April-May 1993 were analysed and slant column densities of NO_2 and O_3 were worked out. The analysis of the photometer data collected during January-February 1993 was completed and the vertical profiles of aerosols were obtained.

Observations of O_3 in Chappuis band were carried out for 15 days using a portable spectrometer.

The fabrication work of IR double monochromator was completed. The construction/fabrication of an amplifier required for spectrometer signal was completed.

2.4 INSTRUMENTAL AND OBSERVATIONAL TECHNIQUES DIVISION

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

* Development of instruments/techniques to study the structure of the atmospheric boundary layer.
* Development of instruments/techniques to study the cloud electrification processes.
* Development of simulation techniques to study cloud physical processes under controlled environment.

2.4.1 Development of Instruments for Boundary Layer Studies

Analysis of the kytoon observations collected at the Central Agrimet Observatory during February 1989 suggested that on certain days there is moisture advection in the 500-600m height during morning hours and it has been attributed to the lake-breeze penetration from the Khadakwasla-Panshet regions.

A collaborative programme on Radon detection was initiated in collaboration with the scientists of the BARC, Bombay at the Institute's complex. Daily, weekly and trimonthly observations were taken separately. Along with radon observations, soil temperature up to 60 cm depth, surface observations, temperature, winds and pressure were also noted daily.

Analysis of data collected with sonic anemometer during May 1992 at the Institute's complex (complex terrain) yielded the following conclusions :

i) The ratio of turbulence kinetic energy flux to that of mean kinetic energy flux was 0.07 under neutral conditions. With increasing instability, this ratio was found to be increased.

ii) The variance of wind components: u, v and w, under neutral conditions was nearly stable and showed a tendency to increase with increasing instability.

iii) The normalised spectra of u and w studied under different stability conditions showed that the eddy sizes corresponding to peak frequencies of u (0.05) and w (0.2) were 102 m and 2.6 m, respectively.

Using tower data from MONTBLEX-89 pilot experiment at Kharagpur, the angular displacement of wind vane was compared with the lateral wind component from the sonic anemometer. It was observed that they compare relatively well when the data sampled at 8.43 Hz rate were averaged over a non-overlapping interval of 2.4 seconds. In this case the lateral dispersion parameter was found to lie close to 0.4 w^* under unstable conditions.

Mini-radiosonde data of MONTBLEX-90 from Kharagpur were used to determine the nocturnal temperature profile.Further analysis of data for the period 26 August to 1 September 1990 and 8-19 September 1990 was carried out. Fluxes of sensible heat, momentum and water vapour were computed. Diurnal variations of fluxes were observed over the sea surface.

Sonic anemometer data of 26 and 27 June 1990 for Jodhpur and Kharagpur were analysed to study the turbulence characteristics. It was found that the wind spectra depict -2/3 law of the inertial subrange though with some scatter. The 4/3 ratio between transverse to longitudinal velocity spectra is nearly depicted.

Nocturnal temperature profile and stable boundary layer heights estimated from back scattered intensity of sodar data at Kharagpur were found to compare well with profiles of Anfossi and Surridge.

2.4.2 Instrumentation for Cloud Physics and Weather Modification Studies

The data of atmospheric electric field and conductivity obtained on four cruises of ORV Sagarkanya in the Bay of Bengal and the Indian ocean were analysed. It was studied with reference to the Global Electric Circuit and extension of land pollution over the ocean. In contrast to the generally observed unitary diurnal variation, the 40 days average electric field curve shows a maximum around 1000 UT and a minimum at 0000 UT with a small secondary peak at 1900 UT. Magnitudes of measured electric field and conductivity and the calculated values of air-earth current are comparatively much smaller than that reported earlier over oceans (Fig. 7). When considered with reference to the classical theory of the Global electric circuit, the observations indicate a tendency to accentuate the effect of strong thunderstorm activity over Asia-Australia and Africa-Europe and to attenuate the effects of far distant storms over America.

Observations of the electric field vector measured with a spherical field meter in the presence of a nearby convective cloud showed that the movement of electrical charges in a cloud can be effectively studied with such measurements.

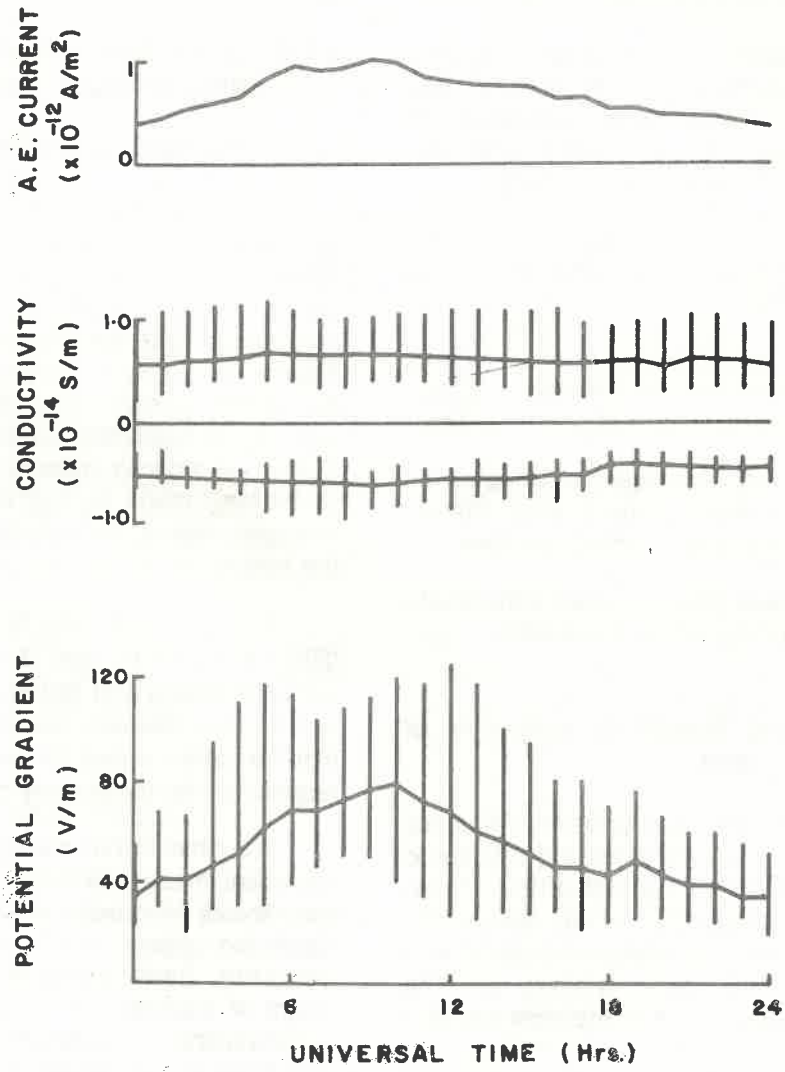


Figure 7 :
Diurnal variations in the atmospheric electrical parameters over Bay of Bengal, Indian Ocean and Arabian Sea regions.

2.4.3 Simulation Techniques for Cloud Physics Studies

The scavenging of aerosol particles by the charged and uncharged water drops was studied in the absence or presence of electric fields in a laboratory simulation experiment. The collection efficiencies for various drops were calculated. Washout coefficients, half-life and rainfall depth for different rainfalls were calculated for the charged and uncharged cases. The results effectively showed how the electrical forces can enhance the washout of aerosol particles in the atmosphere.

2.5 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 and 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.

2.5.1 Barotropic and Baroclinic Instability of Atmospheric Flows

Barotropic stability analysis of various easterly and westerly jet type profiles in the tropics(Equator to 25° N) was performed. It was found that both ß and divergence stabilize westerly jet, ß destabilises the easterly jet and divergence stabilizes easterly jet with a pronounced effect than that of westerly jet. The divergence plays a significant role for the most unstable mode.

A multilayer, numerical, linear, baroclinic instability model was developed using eigenvalue approach for the study of instability of zonal flow in stratosphere and mesosphere. The model performance was being tested with idealised wind profiles.

In order to study the meridional distribution of energetics for the evolution of monsoon depression during MONEX-79, an attempt was made to provide various energies and their conversions associated with the formative stage (4 July) and mature stage (7 July) of the depression. The computations over two different horizontal domains surrounding the deep depression centre of 7 July were carried out using reanalysed FGGE level- IIIb data from surface to 100 hPa. This study gave an insight for the minimum horizontal extent required for the generation and intensification of the system from the energy point of view.

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

(a) Atmospheric Modelling

For the study of energy budget in the wavenumber domain for the tropical belt 10° S to 30°N a computer package was developed which computes 13 categories of energy interactions viz., zonal-wave and wave-wave interactions of Kinetic Energy (K.E.) and Potential Energy (P.E.), K.E. dissipation, generation of P.E. by diabatic heating, wave-wave boundary fluxes of K.E. and P.E. etc. Further, in order to understand the predictability of 30 to 50 day mode in the lower troposphere of the monsoon region, formulation of energy exchange in the frequency domain was completed.

A numerical interface of Matsuno's finite difference scheme and a recursive frequency filter were developed and tested. This interface was found to be unconditionally stable. Strong damping of the high frequency waves by the filter was identified to be responsible for the stability of this numerical interface.

A 3-dimensional, non-linear, non-hydrostatic, P.E., numerical, mesoscale model in plane polar coordinates was developed in order to simulate mean atmospheric circulation pattern over a region surrounded by high mountains. Radial extent of the model is 500 km and height of mountains is considered to be 1 km. The model reached quasi steady state after 10 minutes of integration with idealised initial flow field. Preliminary qualitative results showed strong downward motion in the middle region and small upward motion near mountain walls.

(b) Ocean Modelling

A reduced gravity wind driven ocean circulation model was developed to study the interannual variability in the upper layer of the Indian ocean (24°S to 23°N and 35°E to 115 ^{o}E). The results showed that most of the observed features of the annual cycle of the upper layer are simulated satisfactorily when the model is forced with the ten year averaged monthly mean wind stress. The circulation features and the model upper layer thickness show considerable interannual variability in most parts of the basin, in particular the Somali current, basin wide southern hemisphere gyre the equatorial currents and the gyres in the Bay of Bengal. It was found that the variability in the Bay of Bengal is not due to local forcings but is due to remote forcing both in space and time i.e. from west equatorial Indian Ocean with a time lag of 2 to 3 months. Further investigation with a grid resolution of 55 km indicated the four stages of the circulation features in the Bay of Bengal viz. large anticyclonic gyre in the winter months (November to March) followed by two gyres (anticyclonic on the western side and cyclonic on the eastern side) in the early summer (April to May) (Fig.8). Then the gyre became cyclonic in June and July followed by again two gyre system (cyclonic in western side and anticyclonic in the eastern part) during late July to October (Fig.9). However, there exists considerable interannual variability in the position and intensity of these gyres.

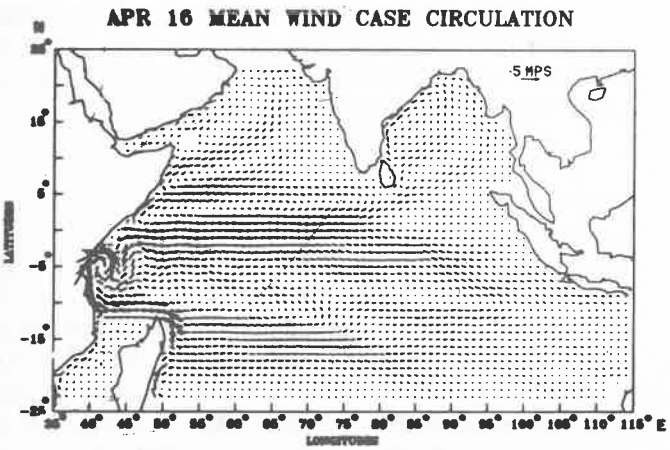


Figure 8 :
Results of the reduced gravity wind driven ocean circulation model for 16 April based on the average monthly mean wind stress data for 1977-86 as input data.

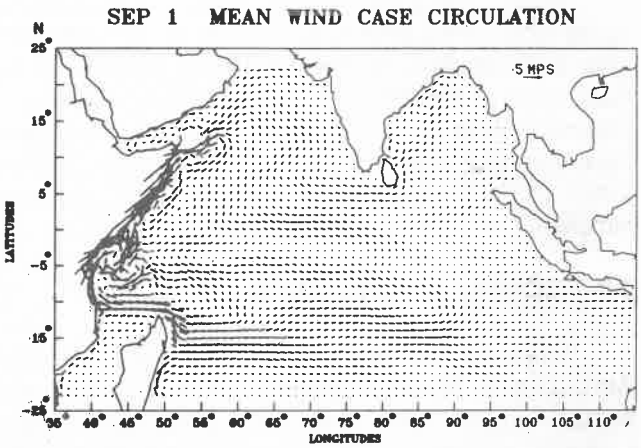


Figure 9 :
Results of the reduced gravity wind driven ocean circulation model for 1 September based on the average monthly mean wind stress data for 1977-86 as input data.

2.6 GLOBAL MODELLING GROUP

A Global Modelling Group has been formed with the objective of studying monsoon and climate variability on different time scales using global climate models.

The U.K. Meteorological Office UNIFIED MODEL has been acquired under the IITM-Hadley Centre Collaboration Scheme, sponsored by the British Council. The model has been installed on the HP 9000/735 Workstation of the Institute.

The equations used for the model were more accurate approximation to the equations of motion with full 3-D representation of earth's rotation. The equations were integrated in spherical polar coordinates using a 'Hybrid vertical coordinate'. A regular latitude-longitude grid was used in horizontal with variables arranged according to Arakawa 'B' grid. The split-explicit finite difference scheme was used. The parameters viz. land surface, boundary layer, large scale cloud and precipitation, convection, radiation, gravity wave drag, horizontal eddy diffusion, and vertical eddy diffusion were used in the model.

In the control experiment, the model was integrated for 30 days using initial conditions of 1 June 1991. This experiment has a resolution of 7.5 in X-direction (Longitude) and 5 in Y-direction (Latitude) and 19 levels in vertical. The results were being analysed.

During the deputation of one of the members of the Global Modelling Group at the Hadley Centre, the UNIFIED Model was integrated for 5 years to study the monsoon simulation and to test the sensitivity of the monsoon for SST boundary conditions. The results showed that the broad scale features of the monsoon circulation are simulated, the rainfall simulation (amount and distribution over India) requires improvement, and cooling of Arabian sea in July-August reduces the rainfall over India.

A five level global spectral model was integrated for 90 days on the CRAY-Supercomputer at NCMRWF, New Delhi to study the impact of SST anomaly in the East Central Pacific in the presence of Himalayan orography and in basic monsoon flow. The results indicated that stationary waves are formed to the West of Himalayas during winter and monsoon simulation was weak during summer.

2.7 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) and the FGGE level III-b data set acquired from the ECMWF, U.K. 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 Division also provides its facilities to other organisations like the India Meteorological Department, Universities, research scholars and M.Tech. students undergoing courses connected with the Atmospheric Sciences.

A RISC based HP-9000/720 workstation installed last year has been upgraded to HP-9000/735 with 40 MFLOPS. The RAM has been enhanced to 112 MB and the disc capacity to 4.8 GB. An A-0 size plotter, a line printer and a laserjet printer are also connected to the system. Several Personal Computers, with various input/output media like floppy discs, cartridge tapes, CD-ROM, digital audio tapes are also available.

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

The Institute has taken up a project funded by the Department of Science and Technology for the archival of the data collected during the field phase of the "Tropical Ocean Global Atmosphere (TOGA)" Programme. 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 are 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 is being used for the data archival and retrieval work.

DST-MONTBLEX Data Centre

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

2.8 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.

During the year 96 books in Meteorology and allied subjects were added and 79 periodicals of national / international origin 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 scientists of the Institute are kept abreast of the latest developments in their research areas through the Current Awareness and Selective Dissemination of Information Services. Photocopies of the articles/ information of interest are also supplied to the scientists.

The library of the Institute has continued to be a member of the Resource Sharing Network of the Scientific and Technical Libraries of Pune. The library is also benefitted by the informal network developed with the libraries/information centres of scientific/ academic Institutions engaged in research in Atmospheric Sciences, within the country.

The VIII Five Year Plan (1992-97) document (Revised) consisting of 14 schemes with a total outlay of Rs. 510.00 Lakhs was prepared for submission to the Governing Council of the Institute and to the DST for their approval.

A number of reports on the research activities 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.

2.8.1 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 81st session held at the University of Rajasthan, Jaipur during 3-11 January 1994. The theme of the session was 'Science in India: Excellence and Accountability'.

2.8.2 National Science Day Celebration

The Institute celebrated the National Science Day on 28 February 1994. On this occasion a scientific lecture was arranged. A scientific film show was also arranged by the Institute's Recreation Club.

2.8.3 WMO Day Celebration

The Institute celebrated the 34th World Meteorological Day on 23 March 1994 by arranging an Open House Scientific Exhibition at its premises. On this occasion, the scientific divisions and laboratories were also kept open to the public and a scientific film show was arranged for the visitors. A popular article by Smt.A.A.Shiralkar, Senior Technical Officer, Grade I was published on the theme of the WMO Day 'Observing Weather and Climate,' in a local English newspaper.

2.9 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.

2.10 ADMINISTRATION

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

2.10.1 Staff

The Institute has 302 scientific, technical and administrative staff. As on March 1994 the staff position in different categories is as follows:

	Category	Number
i)	Scientific	148
ii)	Technical	38
iii)	Administrative	56
iv)	Non-technical Maintenance	60
	Total	302

2.10.2 Staff changes

Two persons joined and five left the Institute during the year under different categories.

Smt. V. Mudaliyar, Hindi Officer, Shri Mohd. Ismail, Mechanic Grade I (Driver) and Shri R. Suryanarayana, Deputy Director, Computer and Data Division retired from service on attaining the age of superannuation on 30 June 1993, 30 November 1993 and 31 March 1994 respectively.

Shri V.B. Bambale, Office Attendant passed away on 7 September 1993.

Dr.(Smt.) P.S. Salvekar, Assistant Director joined the Institute on 26 June 1993 after completion of her deputation as Reader at the Department of Physics, University of Poona, Pune from 12 December 1991.

2.10.3 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.

2.10.4 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 1993-94 are as follows:

(Rs. in Lakhs)

	Budget Estimates	Revised Estimates	Grant Received	Actual Expenditure
Non-Plan	195.00	205.00	206.40	206.40
Plan	95.00	95.00	95.00	94.64

A regular review of the research projects of the Institute is carried out every year with a view to optimise the objectives of the research programmes.

2.10.5 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.S.K. Mishra (till 27.1.1993) Dr. (Smt.)P.S. Salvekar	1992-94	0.30	DST
4.	TOGA-1 Data Centre	Shri R. Suryanarayana/ Shri S.S. Aralikatti	1991-96	6.50	DST
5.	DST-MONTBLEX Data Centre	Shri R. Suryanarayana/ Shri S.S. Aralikatti	1991-94	6.10	DST

2.10.6 Staff Council

The Staff Council is an elected body representing employees of the Institute in different categories and acts as a forum for discussion on matters of common interest to the employees and for increasing efficiency. During the year six meetings of Staff Council were held.

2.10.7 Academic Council

The Academic Council is a body consisting of scientists in the grade of Senior Scientific Officer, Gr. I and above. It considers all the matters relating to scientific projects of the Institute and ensures team work and team spirit in the Institute for achieving its aims and objectives. During the year nine meetings of the Academic Council were held.

2.10.8 Advisory Committee

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

2.10.9 Research Fellowships

i) The tenure of Fellowships of Shri T.S.Pranesha, IITM Research Fellow and Shri Satyandra Sharma, Air India Research Fellow have been extended from 14.8.1993 to 30.6.1994 and from 28.2.1994 to 31.12.1994 respectively.

ii) The tenure of Shri S.Bose, Air India Research Fellow and that of Shri K.K.Singh, IITM Research Fellow expired on 20.12.1993 and 31.12.1993 respectively.

2.10.10 Scientific Equipment

The Institute has acquired during the year the following major equipments required for the research work:

S.No.	Equipment
1.	Electronic Digital Analytical Balance
2.	Neutralizer Radio-active Aerosol generator
3.	CO_2 Laser system
4.	Modem for E- Mail Service

2.10.11 Capital Works

Possesion of Type IV quarters was taken over from the CPWD. Construction work of the Library Building and the Community Hall was in progress.

2.10.12 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.

Parliamentary Official Language Implementation Committee visited the Institute on 5 and 6 July 1993 and inspected the work of Hindi Implementation in the Institute. The Committee expressed satisfaction with the use of Hindi in the Institute's work.

Hindi Week was celebrated during 14-21 September 1993. Competitions in Hindi essay writing, debating, poetry recitation, noting and drafting and simple Hindi writing quiz were organised. Dr. H.N. Srivastava, Additional Director General of Meteorology (Research), the Chief Guest of the Hindi Week Celebration, distributed the prizes to the winners of the competitions.

Bilingual software "Akshar" and "Devbase" have been purchased and installed in the personal computer for the use of Hindi in the Institute's work.

Hindi books worth Rs. 445/- were added to the collection of the Institute's Hindi Library.

2.11. 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 100 books for the club library were added.

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

Twenty three members of the club participated in the High Power Tournaments of the Central Government Offices. Volley ball and Cricket teams also participated in the High Power Tournaments.

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 1993.

On the occasion of the National Science Day on 28 February 1994 a film show "Man and Planet" was arranged by the Club.

2.12. Field Research Unit

The Bangalore Field Research Unit organises and conducts wind energy 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. wind monitoring and wind mapping, with the active assistance of the State Nodal Agencies. Eighteen additional wind monitoring stations were established during the year. The earlier stations have 20 m tall instrumented masts with wind sensors at 10 m and 20 m levels while the new ones have 25 m 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 in EPROM chips, and for checking the performance of the wind instruments and data loggers. The data collected were processed on computers and published.

Under the wind mapping programme, 403 stations were established in 19 states in the country. The supervision of the observational network in each state is carried out by the State Nodal Agencies and the wind data are scrutinised and processed at Bangalore.

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Forecasting Research Division

Regional NWP Modelling and Model Diagnostics

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Extended Range Prediction

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14. Methods for identification of quasi-periods: Singh S.V., WMO/IMD Training Course in Monsoon Meteorology, Pune, India, 7 January -1 February 1991, WMO TD 496, I, 59-71.

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16. Observed quasi-periodic fluctuations during summer monsoon: Verma R.K., WMO/IMD Training Course in Monsoon Meteorology, Pune, India, 7 January - 1 February 1991, WMO TD 496, II, 72-83.

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CLIMATOLOGY AND HYDROMETEOROLOGY DIVISION

Climate and Climatic Change

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Instrumental and Observational Techniques Division

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16. Dendroclimatic reconstruction of the climate over western Himalayas: Rupakumar K., Kumar K.K. and Pant G.B., National Symposium on the International Geosphere-Biosphere Programme, Madras, 21-24 April 1993.

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62. Pulsed CO_2 lidar sounding of the atmosphere: Climate implications: Devara P.C.S. and Raj P.E., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

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90. Sulphur dioxide concentration vis-a-vis meteorological conditions at Delhi: Kapoor R.K., Tiwari S. and Singh G., Conference on Aerosol Science and Technology, Bombay, 9-13 January 1994.

91. Summer monsoon climatology of weekly rainfall over spatially coherent zones of India: Puranik P.V. and Dahale S.D., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

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94. Trends in rainfall over west coast stations of India: Kothawale D.R. and Munot A.A., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

95. Trends of maximum and minimum temperatures over India during 1901-1987: Rupakumar K., Kumar K.K. and Pant G.B., National Symposium on the International Geosphere-Biosphere Programme, Madras, 21-24 April 1993.

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97. Universal spectrum for interannual variability in COADS temperature time series implications for global warmings: Selvam A.M. and Joshi R.R., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

98. Universal spectrum for intra-seasonal variability in TOGA temperature time series: Selvam A.M. and Radhamani M., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

99. Utilization of OLR data from satellite for estimating divergent part of the wind: Kulkarni P.L., Narkhedkar S.G., Nair S. and Rajamani S., IAMAP-IAHS 1993 Symposia, Japan, 11-19 July 1993.

100. Variability in the tropical convections as observed from OLR data and relations with monsoon rainfall: Prasad K.D., Kulkarni A.A. and Singh S.V., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

101. Variability of interannual oscillations of the Indian summer monsoon rainfall: Kulkarni J.R. and Vijayakumar R., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

102. Variation of the daily rainfall and the vertical distribution of thermodynamic parameters: Soman M.K., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

103. Variation of hourly rainfall of 5 recent intense one-day rainspell over Bhira: Kulkarni A.K., Mandal B.N. and Sangam R.B., TROPMET-94 National Symposium on Climate Variability, Pune, 8-11 February 1994.

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5. PARTICIPATION IN SYMPOSIA/SEMINARS/CONFERENCES

S.No.	Symp./Sem./Conf.	Participant(s)
1.	International Seminar on Hydrology with a Special Colloquium on Environmental Problems and Water Resource of the Himalayan Region, Nepal, 19-21 April 1993.	Dr.A.K. Kulkarni and Shri K.K.Singh
2.	Workshop on High Resolution Records of Past Climate from Monsoon Asia:The Last 2000 Years and Beyond, Taiwan, 21-23 April 1993.	Dr. G.B. Pant
3.	National Symposium on the International Geosphere-Biosphere Programme, Madras, 21-24 April 1993.	Prof. R.N. Keshavamurty and Dr.K.Rupakumar
4.	XVIII European Geophysical Assembly, Germany, 3-7 May 1993.	Dr.S.V. Singh
5.	IAMAP-IAHS 1993 Symposia, Japan, 11-19 July 1993.	Kum.P.L. Kulkarni and Dr. S.K. Sinha
6.	ENERGY-1993 Symposium, Madurai, 1 August 1993.	Dr.S. Rangarajan
7.	Seminar on Digital Signal Processing, Pune, 17-18 August 1993.	Shri C.G. Deshpande
8.	Workshop on Flood Hazards Mitigation, Bombay, 2-3 September 1993.	Dr.P.R.Rakhecha
9.	Minimax Workshop, USA, 27-30 September 1993.	Dr.S.V.Singh
10.	Asian Workshop-Cum-Training Course on Methane Emission Studies and the FASAS Seminar on Global Environmental Chemistry, New Delhi, 18 September- 1 October 1993.	Dr.L.T. Khemani and Shri P.D. Safai
11.	Annual Convention of Computer Society of India (CSI-93), Bombay, 3-6 November 1993.	Shri R. Suryanarayana
12.	Scientific Seminar Heralding 35 Years of Indo-US Cooperation in Science & Technology, New Delhi, 8 November 1993.	Dr.S.V.Singh
13.	International Symposium on HEIFE, Japan,8-11 November 1993.	Shri K.G. Vernekar and Dr S.S. Parasnis
14.	International Conference on Regional Environment and Climate Changes in East Asia,Taiwan, 30 November- 3 December 1993.	Dr. L.T.Khemani and Shri K.K. Kumar
15.	30th Annual Convention and Seminar on Space Application in Earth System Sciences, Hyderabad, 21-23 December 1993.	Shri R.B. Sangam
16.	Indian Science Congress, Jaipur, 3-11 January 1994.	Prof.R.N.Keshavamurty, Shri M.T.Goklaney, Shri S.D.Dahale and Shri K.K. Dani
17.	National Symposium on Instrumentation (NSI-18), Tirupati, 9-12 January 1994	Shri G.Pandithurai
18.	Conference on Aerosol Science and Technology, Bombay, 9-13 January 1994.	Dr.P.C.S.Devara, Dr.L.T.Khemani, Dr.D.B.Jadhav, Shri A.G.Pillai, Smt.M.S.Naik, Shri A.L.Londhe, Smt.S.S.Kandalgaonkar, Shri C.G.Deshpande and Shri S.Tiwari
19.	National Symposium on Microwave Remote Sensing and Users' Meet, Ahmedabad, 10-11 January 1994.	Shri D.K.Paul
20.	Workshop on Monsoon-1993, IMS, Pune Chapter and Department of Physics, University of Poona, Pune, 24 January 1994.	Prof.R.N.Keshavamurty, Dr.A.K.Kulkarni, Smt.U.V.Bhide and Shri J.R.Kulkarni
21.	First Annual Workshop on Numerical Weather Prediction in Tropics, New Delhi,31 January-4 February 1994.	Dr.S.S.Singh, Dr.S.Rajamani, Dr.(Smt)P.S.Salvekar, Kum.P.L.Kulkarni and Dr.S.K.Sinha

S.No.	Symp./Sem./Conf.	Participant(s)
22.	TROPMET-94, National Symposium on Climate Variability, Pune, 8-11 February 1994.	Dr.R.N.Keshavamurty, Shri R.Suryanarayana, Dr.A.K.Kamra, Dr.A.S.R.Murty, Dr.G.B.Pant, Shri K.G.Vernekar, Dr.S.S.Singh, Dr.H.N.Bhalme, Dr.S.V.Singh, Dr(Smt)A.M.Selvam, Dr.S.Rajamani, Dr.B.Parthasarathy, Dr.B.K.Mukherjee, Dr.P.C.S.Devara, Dr.R.K.Verma, Dr.P.R.Rakhecha, Dr.L.S.Hingane, Shri S.Sinha, Dr.L.T.Khemani, Dr(Smt)P.S.Salvekar, Shri L.K.Sadani, Dr.D.B.Jadhav, Dr.K.Rupakumar, Shri D.K.Paul, Shri S.Sivaramakrishnan, Shri R.Vijayakumar, Dr.A.K.Kulkarni, Shri N.Singh, Dr.K.D.Prasad, Dr.G.K.Manohar, Shri P.Seetaramayya, Dr.S.S.Parasnis, Smt.U.V.Bhide, Kum.P.L.Kulkarni, Dr.P.E.Raj, Shri M.K.Soman, Shri P.N.Mahajan, Shri J.R.Kulkarni, Shri S.K.Behera, Shri A.L.Londhe, Dr(Kum) K.Indira, Smt.S.G.Nagar, Shri K.K.Kumar, Smt.N.A.Sontakke,
	TROPMET-94, National Symposium on Climate Variability, Pune, 8-11 February 1994.	Shri V.R.Deshpande, Shri S.K.Jadhav, Shri V.R.Mujumdar, Shri P.V.Puranik, Shri A.A.Munot, Shri H.P.Borgaonkar, Smt.N.R.Deshpande, Smt.S.K.Patwardhan, Shri B.D.Kulkarni, Smt.N.V.Panchwagh, Shri A.B.Sikder, Shri S.S.Dugam, Dr(Smt)A.A.Kulkarni, Smt.R.R.Joshi, Shri J.S.Pillai, Shri V.Gopalkrishnan, Smt.S.B.Morwal, Smt.A.A.Deo, Kum.M.Radhamani, Shri D.R.Kothawale, Shri S.D.Patil, Shri S.S.Sabade, Shri S.P.Ghanekar, Shri S.B.Kakade, Shri M.N.Patil, Kum.S.S.Nandargi and Shri H.K.Trimbake
22.	XXI National Symposium on Optics, Madras, 10-12 February 1994.	Shri S.Sharma
23.	XV Annual Conference, Indian Geographers Meet, Raipur, 20-22 February 1994.	Shri P.N.Mahajan, Shri R.B.Sangam, Shri H.P.Borgaonkar, Shri B.D.Kulkarni, Shri S.S.Dugam and Shri D.R.Kothawale
24.	Seminar on Designing Enterprise Network, Pune, 28 February-2 March 1994.	Shri S.Sivaramakrishnan

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6. PARTICIPATION IN MEETINGS

Prof. R.N. Keshavamurty, Director

i) Special Board Meeting, Andhra University, Waltair, 28 April 1993.

ii) Meeting of the Expert Panel in Earth, Atmospheric and Marine Sciences, DST, New Delhi, 7 May 1993.

iii) Eighteenth Programme Advisory Committee on Atmospheric Sciences Meeting, DST, New Delhi, 10 May 1993.

iv) Group Monitoring- cum- Standing Committee Meeting, DST, New Delhi, 14 May 1993.

v) Brain Storming Discussion Meeting on Monsoon Dynamics Studies, DST, New Delhi, 9 June 1993.

vi) Brain Storming Session of DOD, New Delhi, 29 July 1993.

vii) Second Advisory Committee of the NCMRWF, New Delhi, 30 July 1993.

viii) Standing Advisory Committee of the Centre for Atmospheric Sciences, IIT, New Delhi, 15 September 1993.

ix) Assessment Board Meeting, DST, New Delhi, 6-7 October 1993.

x) Meeting on Indian Geosphere Biosphere, START Programme, NIO, Goa, 26 October 1993.

xi) Programme Advisory Committee Meeting, Cochin University, Cochin, 5 November 1993.

xii) Review Committee Meeting, Sriharikota, 2 December 1993.

xiii) Advisory Council Meeting for Monsoon and Tropical Climate, DST, New Delhi, 16 February 1994.

xiv) Advisory Committee Meeting on MONTCLIM, DST, New Delhi, 9 March 1994.

Forecasting Research Division

Dr. S.V. Singh, DD

Meeting of Expert Group on Long Range Forecasting, IMD, Pune, 25 March 1994.

Shri R.K. Verma, AD

Meeting of Expert Group on Long Range Forecasting, IMD, Pune, 25 March 1994.

Climatology and Hydrometeorology Division

Dr. G.B. Pant, DD

i) Fourth Meeting of PAMC Agrometeorology, DST, New Delhi, 10 October 1993.

ii) Annual Meeting of Scientific Steering Committee on IGBP-PAGES, Washington, DC, USA, 13-15 October 1993.

iii) Meeting on Indian Geosphere Biosphere, START Programme, NIO, Goa, 26 October 1993.

iv) Steering Committee of CASAM, University of Agriculture, Rahuri, 25 November 1993.

v) Regional Planning Meeting of START, Sri Lanka, 14-16 February 1994.

vi) Meeting of the Expert Group on Establishment of the National Climate Centre, IMD, Pune, 21 March 1994.

Dr. B. Parthasarathy, AD

i) Fifth Annual Monsoon Review Meeting, IMD, Madras, 1 February 1994.

ii) Meeting of Expert Group on Long Range Forecasting, IMD, Pune, 25 March 1994.

Physical Meteorology and Aerology Division

Dr. A.S.R. Murty, DD

i) Meeting on Artificial Rain, Government of Andhra Pradesh, Hyderabad, 25 August 1993.

ii) Meetings of the Expert Committee (Water Planning) of the Municipal Corporation of Greater Bombay, Bombay, 25 October, 27 November and 18 December 1993.

iii) Meeting of Experts on Cloud Seeding, Ministry of Agriculture, New Delhi, 17 December 1993.

Dr. L.T. Khemani, AD

IGBP Meeting, NPL, New Delhi, 10 December 1993.

Instrumental and Observational Techniques Division

Shri K.G. Vernekar, DD

i) Meeting for Identification of New Site for the Land Surface Processes Experiment, NCMRWF, New Delhi, 28 October 1993.

ii) Meeting to discuss Final Site for the Land Surface Processes Experiment, SAC, Ahmedabad, 25 November 1993 and Agricultural University, Anand, 26-27 November 1993.

iii) PAMC Meeting of MONTCLIM of DST, Goa, 7 December 1993.

iv) Advisory Board Meeting for MONTCLIM, DST, New Delhi, 9 March 1994.

v) Indo-US Meeting on Atmospheric Technology, IISc, Bangalore, 14-15 March 1994.

Theoretical Studies Division

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

i) Meeting of the Board of Studies(Mathematics), University of Poona, Pune, 27 September 1993.

ii) First Meeting of the Task Force for the Department of Space Sciences, University of Poona, Pune, 8 March 1994.

Computer and Data Division

Shri S.S. Aralikatti, SSOI

Group Discussion Meeting on MONTCLIM of DST, Goa, 6-7 December 1993.

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7. SEMINARS

S. No.	Name	Topic	Date
1.	Shri R.S.K. Singh, SSA,IITM	Ekman pumping velocity and depths of surface mixed layer of the north Indian ocean during southwest monsoon.	6 April 1993
2.	Kum. S.S. Nandargi, SA, IITM	The zones of severe rainstorm activity over India.	12 April 1993
3.	Shri R.M. Khaladkar, JSO, IITM	Estimation of winds at different isobaric levels based on observed winds at 850 hPa level using double Fourier series.	15 April 1993
4.	Shri M.K. Soman, SSOII, IITM	i) Long term changes in the extreme rainfall events of 1 to 3 day durations over India.	16 April 1993
		ii) Probable maximum precipitation for 2-day durations over north India.	
5.	Dr.K. Rupakumar, SSOI, IITM	Diurnal asymmetry of 20th Century surface warming over India.	7 May 1993
6.	Shri K.K. Kumar, SSOII, IITM	Pre-monsoon thermal field over India in relation to the Indian summer monsoon rainfall.	7 May 1993
7.	Shri S.K. Behera, SSOII, IITM	Simulation of summer and winter circulation for Arabian Sea.	12 May 1993
8.	Dr. A.K. Kulkarni, SSOI, IITM	i) Participation in the International Seminar on Hydrology, held at Kathmandu, Nepal, April 1993.	10 June 1993
		ii) Study of heavy rainfall of 8-10 June 1991 over Maharashtra.	26 November 1993
9.	Shri J.R. Kulkarni, SSOII, IITM	i) Review of the paper entitled, 'Estimating the fractal dimension and predictability of the atmosphere', by X. Zeng et al, Journal of Atmospheric Sciences ,1992.	17 June 1993
		ii) The variability of the interannual oscillations of the Indian summer monsoon rainfall.	12 July 1993

S. No.	Name	Topic	Date
10.	Shri M.K. Rama Varma Raja, University of Poona, Pune	Review of the paper entitled, 'Combined updraft-downdraft cumulus ensemble model', by M. Chang, Journal of Atmospheric Sciences, 1989.	22 & 28 June 1993
11.	Shri N.K. Agarwal, SSA, IITM	Equations governing energetics of the atmosphere.	23 & 26 July 1993
12.	Dr.M.K. Tiwari, Secretary, NC-IGBP,	International Geosphere-Biosphere Programme. ISRO HQ, Bangalore	21 July 1993
13.	Shri D.K. Paul, SSOI, IITM	The role of regional scale sources on the evolution of different phases of Indian summer monsoon 1979.	27 July 1993
14.	Shri C.S. Bhosale, JSO, IITM	Behaviour of temperatures and geopotential heights in the lower stratosphere at Antarctica during the period of ozone depletion and their harmonic analysis.	5 August 1993
15.	Shri V.R. Deshpande, JSO, IITM	Mid-season appraisal of monsoon 1993.	6 August 1993
16.	Smt. S.M. Naik, SSOII, IITM	Chemical composition of fresh snow over Gulmarg, North India.	19 August 1993
17.	Shri S.S. Dugam, JSO, IITM	Short term climatic fluctuations in North Atlantic oscillation and frequency of cyclonic disturbances over North Indian Ocean and North West Pacific.	25 August 1993
18.	Dr. P.C.S. Devara, AD, IITM	Paper entitled, 'Scientific investigations planned for Lidar In-Space Technology Experiment (LITE)', by M.P. McCormick et al, Bulletin of American Meteorological Society, 1993.	27 August 1993
19.	Dr. A.K. Kamra, DD, IITM	i) The global electric circuit ii) The secular change and the land-to-ocean extension of air pollution from atmospheric electricity measurements over ocean.	30 August 1993

S. No.	Name	Topic	Date
20.	Shri K.Ashok, Andhra University, Visakhapatnam	A numerical simulation experiment of Bay of Bengal cyclone.	17 September 1993
21.	Shri P.N. Mahajan, SSOII, IITM	Use of INSAT winds for the better depiction of monsoon depression over the Indian region.	27 September 1993
22.	Shri S. Sivaramakrishnan, SSOI, IITM	i) A case study of fluxes in the surface boundary layer during MONTBLEX.	23 September 1993
		ii) Design of Enterprise networking.	15 March 1994
		iii) Characteristics of turbulence and the balance of fluxes above a Pine forest canopy.	21 March 1994
23.	Shri M.K. Tandon, SSOII, IITM	Matsuno scheme with a recursive frequency filter.	30 September 1993
24.	Kum.P.L. Kulkarni, SSOII, IITM	An overview of the IAMAP-IAHS '93 Symposium.	5 October 1993
25.	Dr. L.S. Hingane, AD, IITM	Aftermath of the Maharashtra earthquake: A personal experience.	19 October 1993
26.	Shri Brij Mohan, SSOII, IITM	Penetration of lake breeze from an isolated lake-effect of orography and stability.	3 November 1993
27.	Prof.(Mrs.)Ruby Krishnamurti, Florida State University, USA	i) Momentum transport in turbulent convection.	6-17 December 1993
		ii) Generation of low frequency oscillations in turbulent convection.	
		iii) Fluid mechanics demonstrations.	
28.	Prof. T.N. Krishnamurti, Florida State University, USA	i) Monsoon and differential heating.	6-17 December 1993
		ii) Intraseasonal low frequency modes of the monsoon : observations and prediction over India, China and Australia.	

S. No.	Name	Topic	Date
		iii) Physical initialisation. iv) Tropical cyclone forecasting, formation, bogussing, recurvature (Andrew and Bangladesh storms). v) Cloud prediction (Implicit, explicit). vi) GEWEX. vii) Tropical troposheric ozone, biomass burning.	
29.	Dr. Taiichi Hayashi, Kyoto University, Japan	Gust and downward momentum transport in atmospheric surface layer.	23 December 1993
30.	Dr. Nobutaka Monji, University of Osaka, Japan	Flux measurements of green-house gases.	23 December 1993
31.	Prof. H. Horvath, Institute of Experimental Physics, Austria	Visibility and optical properties of atmospheric aerosols.	7 January 1994
32.	Dr. G.K. Manohar, SSOI, IITM	Estimation of electrical charges that are deposited to ground by cloud-ground lightning in thunderstorms at Pune.	18 January 1994
33.	Dr. W. Hollander, Fraunhofer Institute of Toxhologie and Aerosol Research, Germany	Diffusion and phorebic spectroscopy of aerosols.	21 January 1994
34.	Dr.S.V. Singh, DD, IITM	Experiences of working at Max Planck Institute for Meteorology, Hamburg Germany.	21 January 1994
35.	Prof. G.R. Freeman, University of Alberta, Canada	i) Kinetics of nonhomogeneous processes (KNP): A new general classification of kinetics. ii) KNP in human society: Unethical behaviour and societal chaos.	25 January 1994

S. No.	Name	Topic	Date
36.	Dr. David Gregory, Hadley Centre for Climate Prediction and Research, UK	i) UK Met Office UNIFIED Model - Structure and performance. ii) Developments in convective parameterization schemes.	1 February 1994
37.	Dr. Peter Inness, Hadley Centre for Climate Prediction and Research, UK	Aspects of the tropical circulation in the UKMO UNIFIED model.	4 February 1994
38.	Dr. P.R. Rakhecha, AD, IITM	Hydrometeorological study of Tungabhadra catchment for estimating design storm raindepths.	21 February 1994
39.	Shri N.Singh, SSOI, IITM	The TOPLATS Hydromodel.	25 February 1994
40.	Shri D.R. Chakraborty, SSOII, IITM	Energetics in wavenumber and frequency domain and their applications in the field of predictability of tropical weather systems.	28 February 1994
41.	Shri K.G. Vernekar, DD, IITM	Land surface processes.	3 March 1994
42.	Shri C. Venkatesan, Research Fellow, IITM	Adjoint model and its application to sensitivity analysis.	4 March 1994
43.	Dr. S.S. Parasnis, SSOI, IITM	International Symposium on 'HEIFE'.	11 March 1994
44.	Shri J.Venkata Ratnam, Research Fellow, IITM	Instability studies of monsoon disturbances using semigeostrophic approximation.	28 March 1994
45.	Shri C.P. Kulkarni, SSOII, IITM	QBO signal in winter north pole temperature at 30 mb and in southwest monsoon Indian rainfall.	29 March 1994

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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.Sc. and M.Tech. at the University of Poona, Pune :

Scientists	Topic	Academic Programme
Shri K.G. Vernekar, DD	Atmospheric boundary layer.	M.Tech.
Dr.S. Rajamani, AD	Objective analysis of meteorological fields.	M.Tech.
Dr.(Smt)P.S.Salvekar, AD	Dynamic meteorology, Numerical weather prediction and parameterisation of physical processes.	M.Tech.
Shri D.K. Paul, SSOI	i) Synoptic meteorology. ii) Solution of linear balance equation.	M.Sc. M.Tech.
Shri P.N. Mahajan, SSOII	Advances in satellite meteorology.	M.Tech.
Shri J.R. Kulkarni, SSOII	Dynamic meteorology.	M.Tech.
Shri S.K. Behera, SSOII	Dynamic meteorology, Dynamic oceanography, and Climate modelling.	M.Tech.
Shri D.R. Talwalkar, SSOII	Objective analysis of meteorological fields.	M.Tech.

Dr. G.B. Pant, DD and Shri K. Krishnakumar, SSOII delivered ten lectures from 16 -20 August 1993 to the Trainee Meteorologists, Grade II- 10th batch on the subjects "Applied Climatology, Biometeorology and Palaeoclimatology" at the India Meteorological Department, Pune.

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

Superviser	Student	Course	University
Prof. G.C. Asnani, Hon.Fellow	Mr.A.Owino, Common Wealth Research Fellow	Ph.D.	University of Poona, Pune
Dr.G.B. Pant, DD	Shri Shammi Raj	Ph.D.	Banaras Hindu University, Varanasi
Dr. S.S. Singh, DD	Smt.M. Priya	M.Tech.	Cochin University of Science and Technology, Cochin

Superviser	Student	Course	University
Dr. S.V. Singh, DD	Flt.Lt.J.K. Sahu, Met.Officer, Indian Air Force	Ph.D.	University of Poona, Pune
Dr. B. Parthasarathy, AD	Shri V. Sathyamurthy	M.Tech.	Cochin University of Science and Technology, Cochin
Dr.(Smt.) P.S. Salvekar, AD	i) Shri A.D. Datta	M.Tech.	Indian Institute of Technology, Kharagpur
	ii) Shri M.K. Rama Varma Raja	M.Tech.	University of Poona, Pune
Dr.D.Subrahmanyam, SSOI	Kum. P. Leena	M.Tech.	Cochin University of Science and Technology, Cochin
Shri L.K.Sadani, SSOI	Shri J.Sharma	M.Sc. (Agri.)	College of Agriculture, Pune
Dr.S.S. Parasnis, SSOI	Shri R.V.Kharul	M.Tech.	University of Poona, Pune

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

Name	Degree	University
Dr.A.K.Kamra, DD	Ph.D.	Kashmir University, Srinagar
Dr.A.S.R.Murty, DD	Ph.D., M.Sc. and M.Tech.	Andhra University Cochin University of Science and Technology, Cochin
Dr.G.B. Pant, DD	Ph.D.	Indian Institute of Technology, New Delhi
Dr.B. Parthasarthy, AD	M.Sc.and M.Tech.	Andhra University, Visakhapatnam
Dr.(Smt)A.M.Selvam, AD	M.Tech.	Cochin University of Science and Technology, Cochin
Dr.(Smt.)P.S.Salvekar, AD	M.Tech.	University of Poona, Pune and Cochin University of Science and Technology, Cochin

Name	Degree	University
Dr. D. Subrahmanyam, SSOI	M.Sc., M.Tech. and SRF Award	Andhra University, Visakhapatnam
Shri S.K. Behera, SSOII	M.Tech.	University of Poona, Pune and Cochin University of Science and Technology, Cochin

Dr. O.N. Dhar, Emeritus Scientist has been recognised as a Post Graduate Guide in 'Environmental Sciences' by the University of Poona, Pune in addition to being a Guide in 'Atmospheric Sciences'.

Prof. G.C. Asnani, Hon.Fellow assessed 13 scientific papers authored by Institute's scientists for the selection of best paper for the IITM Silver Jubilee Award for the year 1992. Prof.Asnani also assessed one paper from Bangala Desh forwarded by the Director General of Meteorology, New Delhi for the 11th SAARC Regional Award for the year 1993.

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

Name		Membership
Prof.R.N.Keshavamurty, Director	i)	Member, Standing Advisory Committee, Centre for Atmospheric Sciences, IIT, New Delhi
	ii)	Member, Council for Meteorology and Atmospheric Sciences (CMAS), India Meteorological Department, New Delhi
	iii)	Member, Programme Advisory Committee, Atmospheric Sciences, Department of Science and Technology, New Delhi
	iv)	Member, Advisory Council for Monsoon and Tropical Climate (MONTCLIM), Department of Science and Technology, New Delhi
	v)	Member, Editorial Board, Mausam, India Meteorological Department, New Delhi
	vi)	Member, Cruise Planning and Program Priorities Committee for Ocean Development, Department of Ocean Development, New Delhi
	vii)	Member, Expert Group Scientific Advisory Committee for NCMRWF, Department of Science and Technology, New Delhi
Prof.G.C. Asnani, Hon. Fellow		Referee for 'Mausam,' India Meteorological Department, New Delhi and 'Journal of African Meteorological Society', Nairobi, Kenya
Shri K.G. Vernekar, DD	i)	Executive Council of Indian Meteorological Society, New Delhi
	ii)	Project Advisory and Monitoring Committee for Monsoon and Tropical Climate
Dr.S.V.Singh, DD		Editorial Board of the International Journal of Climatology, Royal Meteorological Society, U.K.
Shri M. K. Tandon, SSOII		Scientific Application Division of Poona Chapter of the Computer Society of India.

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 S.Bose, IITM Research Fellow	Dr.D.B. Jadhav, SSOI	Ph.D.	On studies of Atmospheric nitrogen dioxide and ozone using visible spectrometer.
*Smt.R.V. Bhalwankar, SA	Dr.A.K.Kamra, DD	M.Sc.	Wind tunnel studies of the break up of the charged or uncharged water drops in horizontal electric field.
*Shri C.S.Bhosale, JSO	Dr.B.K.Mukherjee, AD	M.Sc.	Middle atmospheric responses to ozone variability and to wave and monsoon activity.
Shri M.D.Chipade, SA	Dr.S.V.Singh, DD	M.Sc.	Understanding of monsoon 1979 through energetics of transient and standing eddies.
*Smt.S.S.Desai, JSO.	Dr.S.K.Mishra, DD	M.Sc.	Special representation of various meteorological parameters during monsoon.
*Smt. L.George, SSO II	Dr.S.K.Mishra, DD	M.Sc.	Energetics of the synoptic scale monsoon disturbances.
Shri D.R.Kothawale, SSA	Dr.G.B. Pant, DD	M.Sc.	Surface air temperature over India: a diagnostic study.
*Shri G.K.Manohar, SSOI	Dr.D.B.Jadhav, SSOI	Ph.D.	Some studies of surface atmospheric electricity parameters in different environments over Indian region.
*Shri S.D.Patil, SSA	Dr.G.B.Pant, DD	M.Sc.	Performance of Summer monsoon over India and the anomalous features of the atmospheric general circulation.
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, A.D.	Ph.D.	Remote sensing of the atmosphere using the the lidar technique.
*Shri K.K.Singh, IITM Research Fellow	Dr.S.V.Singh, DD	Ph.D.	Principal modes of meteorological fields over monsoon region and their prediction.
Shri M.K.Soman, SSO II.	Dr.R.Ananthakrishnan, Hon. Fellow	Ph.D.	Studies on some aspects of the rainfall and upper air features associated with the Indian summer monsoon.

* Degree conferred.

Dr. S.K. Sinha, Senior Scientific Officer, Grade II has been awarded Ph.D. degree by the Jadavpur University, Calcutta for his thesis entitled, 'Objective analysis of meteorological parameters for numerical weather prediction model'.

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
Shri V.R. Deshpande, JSO	Course on Remote Sensing with emphasis on Digital Analysis Techniques, National Remote Sensing Agency, Hyderabad, 19 April-26 June 1993.
Shri N.G. Narkhedkar, SA	Lecture series on 'Analysis', National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi, 29 April- 7 May 1993.
Shri D.K.Trivedi, SSA, Shri Prem Singh, SSA and Shri M.Mujumdar, SA	Lecture Series on 'Familiarisation with T-80 model, physical initialisation', National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi, 3-8 June 1993.
Shri P.N. Mahajan, SSOII	Winter school on Remote Sensing of Crop Environment, IARI, New Delhi, 2-27 November 1993.

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9. DEPUTATION ABROAD

The Institute deputes its scientific and technical personnel 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 personnel were deputed abroad:

WMO/UNDP Fellowship Training

S. No.	Name	Country	Period	Field/Institute
1.	Shri P.S.P. Rao, SSOII	U.S.A.	1 May - 30 August 1993	Atmospheric Chemistry in relation to Biosphere Interaction, North Carolina State University, Raleigh
2.	Shri A. Bandyopadhyay, SSOII	U.S.A.	7 July- 6 December 1993	Physical processes in Atmospheric Models, National Meteorological Centre, Washington, D.C.
3.	Dr K. Rupakumar, SSOI	U.S.A.	15 July- 14 November 1993.	Climate Sensitivity and Agriculture, University of Illinois, Urbana
4.	Shri D.R. Chakraborty SSOII	U.S.A.	1 August- 30 November 1993	Predictability of Tropical Weather Systems, Florida State University, Tallahassee
5.	Shri R. Vijayakumar, SSOI	U.S.A.	1 September- 22 December 1993	Precipitation Enhancement Studies, School of Mines and Technology, South Dakota, and University of Chicago, Chicago
6.	Shri N. Singh, SSOI	U.S.A.	1 September- 31 December 1993	Hydrometeorological Modelling for Watersheds, Princeton University, Princeton
7.	Smt. N. A. Sontakke, JSO	U.S.A.	1 September- 31 December 1993	Meteorological Drought, National Center For Atmospheric Research (NCAR), Boulder, Colorado
8.	Smt. A. A. Shiralkar, STOI	U.S.A.	27 September- 31 December 1993	Library and Information Systems, National Oceanic and Atmospheric Administration (NOAA) Central Library, Silver Spring, Maryland
9.	Shri S. Sivaramakrishnan, SSOI	U.S.A.	4 October 1993- 4 February 1994	Atmospheric Turbulence and Diffusion Division, Air Resources Laboratory, Oak Ridge, Tennessee
10.	Dr. R.H. Kripalani, SSOI	U.S.A.	1 February -31 May 1994	Numerical Prediction, Florida State University, Tallahassee

Participation in Conferences/ Seminars/ Meetings/Training etc.

S. No.	Name	Country	Period	Conf./Meeting/Inst
1.	Dr. S.V. Singh, DD	Germany	10 March-9 September 1993	Post Doctoral Fellowship, Max Planck Institute for Meteorology, Hamburg
2.	Dr.A.K.Kulkarni, SSOI	Nepal	19-21 April 1993	International Seminar on Hydrology with a special Colloquium on Environmental Problems and Water Resources of the Himalayan Region, Kathmandu
3.	Dr. G.B.Pant, DD	i) Taiwan	21-23 April 1993	Workshop on High Resolution Records of Past Climate from Monsoon Asia : The last 2000 years and beyond, Taipei
		ii) U.S.A.	13-15 October 1993	Annual Meeting of the Scientific Steering Committee of IGBP-PAGES
		iii) Sri Lanka	14-16 February 1994	The Regional Planning Meeting of START (Systems for Analysis Research and Training), Colombo
4.	Kum.P.L. Kulkarni, SSOII	Japan	11-17 July 1993	IAMAP/IAHS 93 Symposia, Yokohama
5.	Dr. S.K. Sinha SSOII	Japan	13-19 July 1993	IAMAP/IAHS 93 Symposia, Yokohama
6.	Dr. H.N. Bhalme, DD	U.S.A.	1 August-4 September 1993	Project I(a) of Indo-US Climate Research Programme, University of Maryland, National Meteorological Centre, National Climate Data Centre, and Climate Monitoring and Diagnostics Laboratory
7.	Shri D.R. Talwalkar, SSOII	France	2-27 August 1993	International Summer School on Assimilation of Meteorological and Oceanographical Observations, Toulon

S. No.	Name	Country	Period	Conf./Meeting/Inst
8.	Shri J.R. Kulkarni, SSOII	U.K.	13 September - 17 December 1993	Study of the U.K. Meteorlogical Office General Circulation model under the collaborative programme of research between Hadley Centre and IITM in the area of Climate Change, Hadley Centre for Climate Prediction and Research
9.	Shri K.G. Vernekar, DD and Dr.S.S. Parasnis, SSOI	Japan	8-11 November 1993	International Symposium on HEIFE, (Sino-Japanese Co-operative Programme on Atmospheric Land Surface Processes in Heife river basin, 1989-1993), Kyoto and visit to University of Kyoto
10.	Dr.L.T. Khemani, AD and Shri K.K. Kumar, JSO	Taiwan	30 November-3 December 1993	International Conference on Regional Environmental and Climate Change in East Asia, Taipei
11.	Shri K.K.Kumar SSOII	U.S.A.	14 March-16 December 1994	Second International Training Course on Practical and Theoretical Aspects of Short Term Climate Prediction, Lamont Doherty Earth Observatory, Columbia University
12.	Shri M.K. Soman, SSOII	U.K.	28 March 1994-31 March 1995	British High Commission's Indo-British Technical Co-operation Training on Climate Change

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10. VISITORS

A number of distinguished scientists working in Atmospheric Sciences and allied disciplines from India and abroad visited the Institute:

S. No.	Visitor	Date(s)
	International	
1.	Dr. C.M. Bhumralkar, Director, Programme Development and Co-operation, NOAA, U.S.A.	8-9 November 1993
2.	Prof.(Mrs.) Ruby Krishnamurti and Prof. T.N. Krishnamurti, Florida State University, U.S.A.	5-18 December 1993
3.	Dr. Taiichi Hayashi, Kyoto University, Japan.	23 December 1993
4.	Dr. Nobutaka Monji, University of Osaka, Perfecture, Japan.	23 December 1993
5.	Prof. H.Horvath, Institute of Experimental Physics, Austria.	6-7 January 1994
6.	Dr.W.Hollander, Fraunhofer Institute of Toxkologie and Aerosol Research, Germany.	20-21 January 1994
7.	Prof.G.R.Freeman, Department of Chemistry, University of Alberta, Canada.	24-28 January 1994
8.	Dr. David Gregory, Hadley Centre for Climate Prediction and Research, U.K.	1 February 1994
9.	Dr. Peter Inness, Hadley Centre for Climate Prediction and Research, U.K.	4 February 1994

S. No.	Visitor	Date(s)
	National	
1.	Trainee Officers, Air Force Administrative College, Coimbatore.	5-7 July 1993
2.	Shri G.C.Dash, Deputy Director, Dam Dafety, Orissa.	19 July 1993
3.	Shri V.Rajagopal, Superintendent Engineer, Madras Metropolitan Water Supply & Sewerage Board, Govt. of Tamil Nadu, Madras.	29 July 1993
4.	Dr.A.B.Ghosh, Scientist, National Physical Laboratory, New Delhi.	13-17 September 1993
5.	Batch of 10 M.Sc. Students, Cochin University, Cochin.	15 September 1993
6.	Shri K.D.Sharma, Executive Engineer, Haryana State Electricity Board, Haryana.	23 Sepember 1993
7.	S/Shri R.V. Godbole and P.D.H.S.Rao, Directors, Central Water Commission, New Delhi.	14-16 February 1994

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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 110003.	Chairman (Ex-Officio)
2.	Shri S.B.Krishnan, Joint Secretary(Finance) Department Of Science and Technology, Technology Bhavan,New Mehrauli Road, New Delhi 110016.	Member
3.	Shri Ashok Harnal, Director(Administration), Ministry of Science and Technology, Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi 110016.	Member
4.	Prof. B.H. Subbaraya, Physical Research Laboratory, Navarangpura, Ahmedabad 380009.	Member
5.	Prof. (Smt.) Sulochana Gadgil, Head,Centre for Atmospheric Sciences, Indian Institute of Science, Malleswaram, Bangalore 560012.	Member
6.	Prof.S.K.Sinha, Director, Indian Agricultural Research Institute, New Delhi 110012.	Member (upto 8.9.1993)
7.	Prof. G.C. Asnani, Retd. Professor, University of Nairobi, 822, Sind Housing Society, Pune 411007.	Member (from 9.9.1993)
8.	Prof. V.V.R. Varadachari, Retd. Director, NIO, Goa, Kala Nivas, 11/A Sagar Co-Operative Housing Society, Dona Paula, Goa 403004.	Member (up to 8.9.1993)
9.	Prof. H.C. Khare, Retd. Professor, Allahabad University, 9, Jawaharlal Nehru Road, Allahabad 211002.	Member (from 9.9.1993)

10.	Dr. H.N. Srivastava, Additional Director General of Meteorology (Research), India Meteorological Department, Shivajinagar, Pune 411005.	Member
11.	Prof. R.N. Keshavamurty, Director, Indian Institute of Tropical Meteorology, Pune 411008.	Member
12.	Shri V.K. Asrani, Administrative Officer, Indian Institute of Tropical Meteorology, Pune 411008.	Non-Member Secretary

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