



ANNUAL REPORT 1992-93



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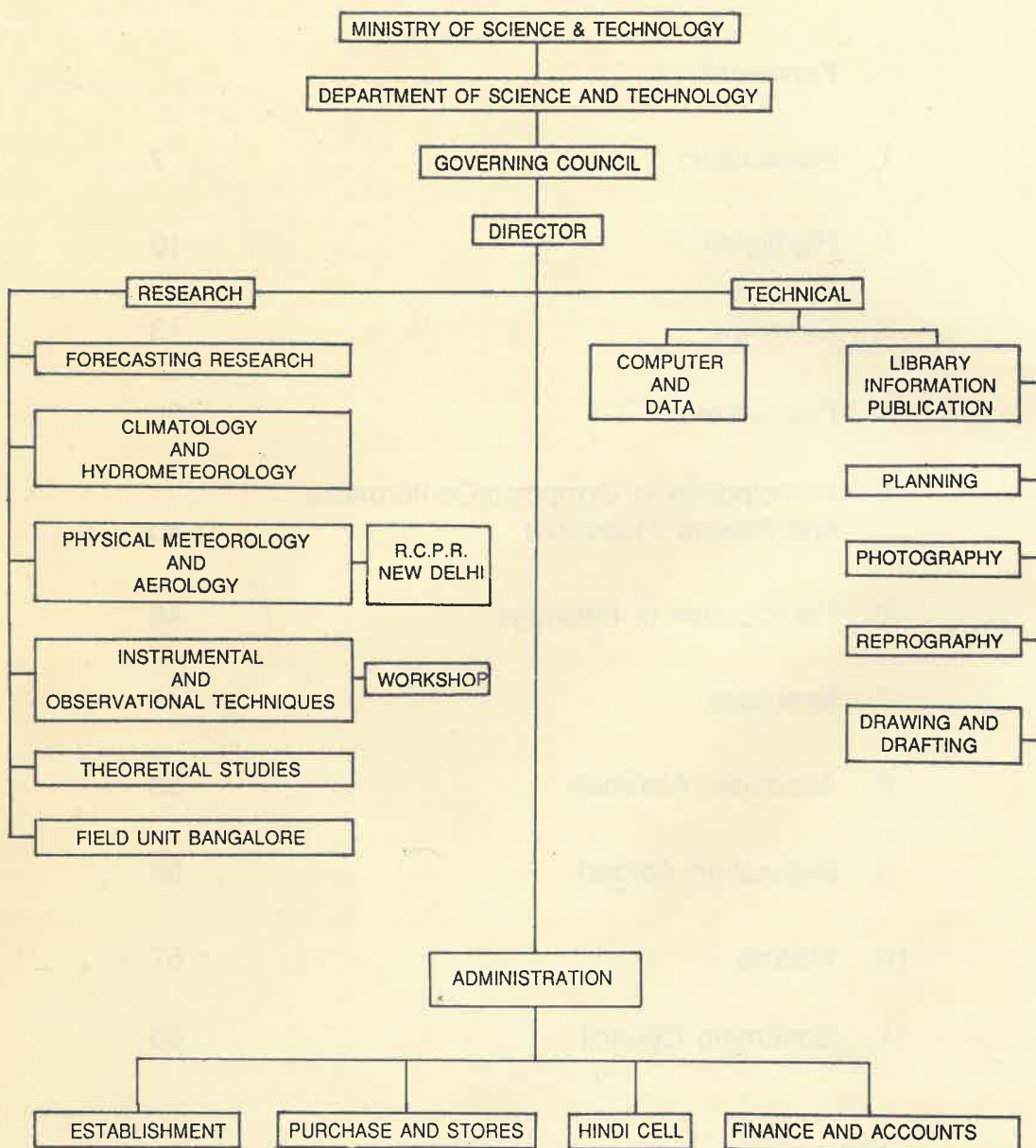
INDIAN INSTITUTE OF TROPICAL METEOROLOGY

CONTENTS

Foreword

1. Introduction	7
2. Highlights	10
3. Overview	13
4. Publications	33
5. Participation in Symposia/Conferences and Papers Presented	40
6. Participation in Meetings	46
7. Seminars	48
8. Academic Activities	53
9. Deputation Abroad	56
10. Visitors	57
11. Governing Council	60

INDIAN INSTITUTE OF TROPICAL METEOROLOGY



ORGANIZATIONAL PROFILE

FOREWORD

I have pleasure in presenting the Annual Report of the Institute for the year 1992-93.

The Institute could achieve considerable progress as evidenced by (i) a good publication record—173 papers published in standard national and international journals and presented in symposia/seminars; (ii) the Sixth SAARC award (1987) and the Dr. B. N. Desai award (1989-90) received by the scientists of the Institute and (iii) Ph.D. and M.Sc. Degrees obtained by eight scientists (and nine more submitted).

All the ongoing research programmes of the Institute were reviewed and the Eighth Plan projects were revised and finalised. Four research scholars were recruited and trained.

The scientific projects of the Institute cover most of the thrust areas in atmospheric sciences like—short-range weather forecasting using fine mesh limited area models, climate diagnostics, intra-seasonal and interannual variability of monsoon, seasonal prediction of monsoon, dendroclimatology, energetics of monsoon systems and global modelling. The other thrust areas are : cloud physics, atmospheric boundary layer studies, atmospheric chemistry, air pollution, geosphere-biosphere interactions, atmospheric aerosols and trace gas monitoring using lidars and spectrometers, deterministic chaos, atmospheric instrumentation for boundary layer measurements and atmospheric electricity.

Work on ocean modelling has also started. A new activity on climate modelling is starting soon. Research activities using MONTBLEX (Monsoon Trough Boundary Layer Experiment) data were also intensified and a Workshop was held during March 1993. In another meeting, thrust areas in Palaeoclimatology were identified. Collaborative programmes like the Indo-US Climate Research Programme were intensified. A collaborative programme with the Hadley Centre, UK has also started.

The Institute is now housed in a beautiful campus and the new library building is also coming up fast. The computing facilities of the Institute have been upgraded by the acquisition of a modern fast RISC-based Workstation with eight terminals and ancillary equipment. The Workstation was commissioned and is being used for theoretical and modelling studies, numerical weather prediction, climate studies and studies of physical meteorology.

The seminar activity of the Institute has been strengthened. We had several eminent visitors from India and abroad including Prof. T. N. Krishnamurti, USA and Dr. D. A. Bennetts, UK. We have maintained close interaction with the India Meteorological Department, the National Centre for Medium Range Weather Forecasting and the University of Poona.

The Institute is now poised for greater scientific achievements.

R. N. KESHAVAMURTY
Director

1. INTRODUCTION

1.1 Background

The Indian Institute of Tropical Meteorology (IITM) was established on 17 November 1962 by the Government of India. It is a leading Research Centre in Tropical Meteorology and its objectives are to undertake research aimed at advancing the present knowledge in Atmospheric Sciences by identifying, planning and conducting research programmes of national and international importance.

1.2 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 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 Governing Council are nominated by the DST. The Director General of Meteorology is the Ex-officio Chairman of the Institute's Governing Council. The Institute maintains close collaboration and interaction with other organisations working in the field of Meteorology, particularly with the India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), Indian Institutes of Technology, Universities and other scientific organisations associated with research work in Atmospheric Sciences and Oceanography.

1.3 Organisational Structure

The Scientific, Technical and Administrative work of the Institute is organised under the following eight divisions :

Division	Areas
1. Forecasting Research	i) Numerical Weather Prediction ii) Extended Range Prediction iii) Monsoon Studies and Forecasting
2. Climatology and Hydrometeorology	i) Climate and Climatic Change ii) Hydrometeorological Studies
3. Physical Meteorology and Aerology	i) Cloud Physics and Weather Modification ii) Environmental Physics
4. Instrumental and Observational Techniques	i) Development of Instruments for Boundary Layer Studies ii) Instrumentation for Cloud Physics and Weather Modification Studies
5. Theoretical Studies	i) Studies of Dynamic Instability ii) Simulation of Monsoons and Tropical Circulation Systems iii) Advanced Training in Atmospheric Sciences
6. Computer and Data	i) In-house Computer Facility ii) Data Acquisition and Services
7. Library, Information and Publications	i) Library and Information Services ii) Technical Services like Microfilming, Photography, Drawing, Reprography and Publications.
8. Administration	i) Administrative Services ii) Finance and Accounts iii) Purchase and Stores

1.4 Staff

The Institute has 245 scientists, technologists and administrators. As on March 1993 the staff position in different categories is as follows :

Category	Number
i) Scientific	148
ii) Technical	40
iii) Administrative	57
Total	245

1.5 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 1992-93 are as follows:

	(Rs. in Lakhs)			
	Budget Estimates	Revised Estimates	Grant Received	Actual Expenditure
Non-Plan	212.30	187.00	187.00	185.60
Plan	90.00	110.00	109.97	109.97

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.

1.6 Scientific Equipment

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

S. No.	Equipment
1.	RISC—based Workstation (Hewlett Packard HP 9000/720)
2.	Gould 6 channel recorder
3.	Ceiloostat
4.	Double monochrometer
5.	Stroboscope
6.	PC/AT 80286 (2 Nos)
7.	PC/AT 80386 (3 Nos)
8.	Roland A3/A4 size plotter
9.	Facsimile transreceiver
10.	EC VCR with remote control

1.7 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.	Interaction of Atmospheric Chemistry with Nilgiri Biosphere Reserve.	Dr. L. T. Khemani	1989-93	13.90	DEF
2.	Co-ordinated project on Boundary Layer Studies.	Shri K. G. Vernekar	1987-93	22.90	DST
3.	TOGA-I Data Centre.	Shri R. Suryanarayana	1991-96	6.50	DST
4.	DST-MONTBLEX Data Bank.	Shri R. Suryanarayana	1991-93	6.10	DST
5.	Energy Budget Studies in Spatial and Wave Number Domain.	Dr. S. K. Mishra	1992-93	0.30	DST

A major project on Climate Research funded by the DST is expected to start soon.

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2. HIGHLIGHTS

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

A limited area model with a 100 km horizontal resolution was used for prediction of the track of the tropical cyclone of 10 May 1979. In order to define the initial state, an artificial vortex was introduced in the large scale analysis. Results indicated that inclusion of the artificial vortex in the analysis improved the forecast.

Objective analysis of wind and geopotential fields at five standard levels over the Indian and adjoining regions for the period 4-8 July 1979 was carried out using Sasaki's numerical variational technique. The cross isobaric flows obtained from the variational technique were found to be much less than those obtained from the Univariate Optimum Interpolation technique.

A methodology was developed for the optimization of the rain gauges to construct a representative summer monsoon rainfall series based on averaging the ratio of actual and mean rainfall of 306 well distributed stations over the country. The rainfall series was constructed adopting three different schemes, viz., (i) random selection, (ii) multiple linear regression, (iii) objective subset of gauges based on forward selection scheme. The series prepared on the basis of scheme (iii) was found to be the most appropriate.

The long-range forecast of the monsoon rainfall for 1992 over the country as a whole and the broad sub-divisions of northwest India and peninsular India based on the results of three different multiple regression models was sent to the India Meteorological Department. The overall performance of the monsoon over India as a whole for the season was found to be in close agreement with the prediction.

Quantitative Precipitation Forecasting (QPF) models have been developed separately for each of the five subdivisions in the Narmada basin. The verification statistics suggested that the statistical dynamical QPF model has a better performance score as compared to the persistence and climatology.

A technique for the measurement of atmospheric turbulence from laser scintillation observations has been developed. A study based on the observations

made at Pune during 1990-91 indicated a systematic diurnal variation of the turbulence in the surface layer and its close association with cloud formation.

Field observations of surface ozone carried out in the Upper Kargudi and Bandipur stations located in the core zone of the Nilgiri Biosphere Reserve (NBR) indicated that the concentrations of surface ozone in the NBR were within the range of world background concentrations.

The dynamical characteristics of the Convective Boundary Layer (CBL) along the monsoon trough region were investigated using the special field observations carried out during MONTBLEX. The fluxes in the CBL and the related turbulence characteristics under different synoptic conditions were also studied.

A field experiment was carried out at Pashan during May 1992 and extensive high resolution observations of wind, temperature and soil temperature were obtained using different instruments. These observations were used to study the physical processes relating to the atmospheric boundary layer and the study of the land-surface processes. The studies indicated that (i) a rough balance was found to exist among the different terms of the surface energy balance equation on a time scale of about 24 hrs. (ii) the contribution of thermal bursts to the sensible heat flux was maximum during the afternoon hours.

A field experiment to study the effect of a pole on the distortion of fair weather electric field was conducted at Pashan during 14-16 December 1992 and continuous observations of the three components of the electric field and space charge were carried out.

Development and testing of a global linear spectral barotropic instability model for zonal asymmetric flow over the sphere was completed. Unstable modes for July mean flow at 200 hPa level were computed for different truncations of perturbation as well as the basic state. Unstable modes with periods of 4-6 days and 30-50 days as well as stationary modes were identified.

Computations of energetics for a monsoon onset vortex showed that eddy kinetic energy generated in the layer 850-600 hPa was transported away upwards and downwards.

2.1 Appointment of Director

Consequent upon the retirement of Shri D. R. Sikka, Director, Shri R. Suryanarayana, Deputy Director, was nominated by the Governing Council to perform the duties of Director with effect from 29 February 1992. On appointment as Director of the Institute Prof. R. N. Keshavamurty took over the charge with effect from 10 July 1992.

2.2 Awards

Dr. R. H. Kripalani, Senior Scientific Officer, Gr. I received the Sixth (1987) SAARC Regional Award from the Sri Lankan High Commissioner in India on 15 March 1993 at New Delhi for the paper entitled, "Application of extended empirical orthogonal function analysis of inter-relationships and sequential evolution of monsoon fields," by S. V. Singh and R. H. Kripalani, published in Monthly Weather Review, 1986.

Dr. S. Rajamani, Assistant Director received the Dr. B. N. Desai Award for the year 1989-90 on 17 March 1993 at the inaugural ceremony of the TROPMET-93 National Symposium on Meteorology and National Development, held at New Delhi for the paper entitled, "Some dynamical characteristics and thermal structure of monsoon depressions over the Bay of Bengal" by S. Rajamani and D. N. Sikder, published in Tellus, 1989.

2.3 National Seminars/Workshops/Meetings

A discussion meeting on "Global Modelling" was held at the Institute during 9-13 November 1992.

A meeting "To Identify the Thrust/Gap Areas in Palaeoclimatology" sponsored by the DST, was held at the Institute during 21-22 January 1993. Sixtyseven delegates from all over India participated in the meeting. A Panel of Experts of the meeting recommended training of manpower, and laid emphasis on studies of periods after late quaternary using high resolution quantitative data. They stressed the need for studies on aridity, coastal deposits and lake sediments. The Panel also recommended establishment of a National Facility for Dating.

The Seventeenth Meeting of the Programme Advisory Committee on Atmospheric Science of the DST was held at the Institute on 19 February 1993.

A Mini-Workshop on "Monsoon-92" was jointly organised at the Institute by the Indian Meteorological Society, Pune Chapter and the IITM on 24 February

1993. A number of scientists from the Institute and the India Meteorological Department participated in the Workshop.

The "Second Monitoring Workshop on MONTBLEX Research Results" sponsored by the Department of Science and Technology, New Delhi, was held at the Institute during 26-27 March 1993. Prof. R. Narasimha, Director, National Aeronautical Laboratory, Bangalore, inaugurated the Workshop. Sixtyfive delegates attended the Workshop and about thirtyfive scientific papers relating to studies of the atmospheric boundary layer were presented and discussed in the Workshop.

A radio talk on 'MONTBLEX' by Shri K. G. Vernekar, Deputy Director was broadcast by the All India Radio Station, Pune on 30 March 1993.

2.4 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 Technology exhibition organised at its 80th Session at National Institute of Oceanography, Goa during 3-8 January 1993. The theme of the session was "Science and Quality of Life."

2.5 National Science Day

The Institute celebrated the National Science Day by arranging an exhibition depicting its research activities during 24-26 February 1993. Special invited lectures on "National Science Day" by Prof. P. R. Pisharoty and Prof. R. Ananthakrishnan, Retired Directors were arranged on 26 February 1993.

2.6 WMO Day Celebrations

The Institute celebrated the 33rd World Meteorological Day on 23 March 1993. As a part of the celebrations, the Institute participated in the scientific exhibition arranged at the India Meteorological Department, Pune. In addition to this, the Institute arranged an open house scientific exhibition at its premises. On this occasion, the scientific divisions and laboratories were also kept open to the public. There was a very good response from the public at both the places.

A special programme in Marathi was broadcast by the All India Radio, Pune Station on 23 March 1993 on the occasion of the WMO Day. Dr. D. A. Mooley, Retd. Asst. Director, Dr. (Smt.) P. S. Salvekar

and Dr. S. S. Parasnis, Senior Scientific Officers of the Institute participated in this Programme.

A popular article by Smt. A. A. Shiralkar, Senior Technical Officer of the Institute on the theme of the WMO Day 'Meteorology and the Transfer of Technology' was published in two local English newspapers.

2.7 Consultancy Service

At the request of Government of Gujarat, information and assistance relating to their proposed cloud seeding operations were provided.

2.8 Participation in Cruise

The Institute participated in the 75th and 81st Cruises of ORV Sagarkanya during 8 July to 17 August 1992 and 14 January to 10 February 1993 respectively over the Western Arabian Sea and adjoining equatorial Indian Ocean for taking observations of atmospheric electric field and conductivity.

2.9 In-House Training

The Institute arranged an in-house Research Oriented Training Course in Meteorology for the Institute's scientists and Research Fellows for a period of eight months from 14 December 1992.

2.10 Acquisition of a Workstation

A RISC-based HCL-HP Workstation (Hewlett Packard HP 9000/720, 50 MHz, Hard Disk 840 MB, RAM 64 MB) with eight terminals (HCL-HP 386X/80386X, 25 MHz), and A0 size Multipen Plotter, 132 column, 600 lpm Line Printer, 6250/160 bpi, 125 ips

Streamer Spool Tape Drive and other ancillary equipment/software were acquired in March 1993. The Workstation was installed and commissioned under the supervision of a User Group consisting of 13 scientists of the Institute. A training programme was organised by the Hindustan Computers Limited (HCL). Several scientists of the Institute participated in the training programme and got familiarisation with the Hardware and Software aspects of the Workstation.

2.11 Felicitation

Dr. S. S. Singh, Deputy Director, was felicitated as Co-editor of the book 'Physical Processes in Atmospheric Models' by the Marathi Vidnyan Parishad, Pune and Wiley Eastern Pub. Ltd. on 20 July 1992.

2.12 Release of Book

A book entitled, 'Physics of Monsoons' by R. N. Keshavamurty and M. Sankar Rao was released at the hands of Prof. V. M. Bachal, Principal, Fergusson College, Pune at a function organised by the Indian Meteorological Society, Pune chapter on 4 January 1993.

2.13 Radio Talk

A radio talk on "Monsoon Variability" by Prof. R. N. Keshavamurty, Director, was broadcast by the All India Radio Station, Pune on 3 March 1993.

2.14 Honorary Fellowship

Prof. P. R. Pisharoty and Prof. G. C. Asnani have been conferred with the Honorary Fellowships by the Governing Council of the Institute. The Institute has been providing them with the Library and other facilities for the pursuit of their research work.

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3. OVERVIEW

3.1 FORECASTING RESEARCH DIVISION

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

- * Development of a regional model for track prediction of tropical cyclones with emphasis on the parameterization of land surface fluxes.
- * Study 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 relationships, 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 cycle.

3.1.1 Regional NWP Modelling and Model Diagnostics

Computation 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.

A limited area model with 100 km horizontal resolution was used for the prediction of the track of the tropical cyclone of 10 May 1979 in the Bay of Bengal. In order to define the initial state of the cyclone, an artificial vortex was introduced in the large-scale analysis. Results of the study indicated that inclusion of the artificial vortex in the analysis improved the forecast (Fig. 1).

A semi-empirical scheme was used to compute the surface fluxes of heat and momentum by using routine weather parameters measured at a level close to the ground surface. The scheme was tested for

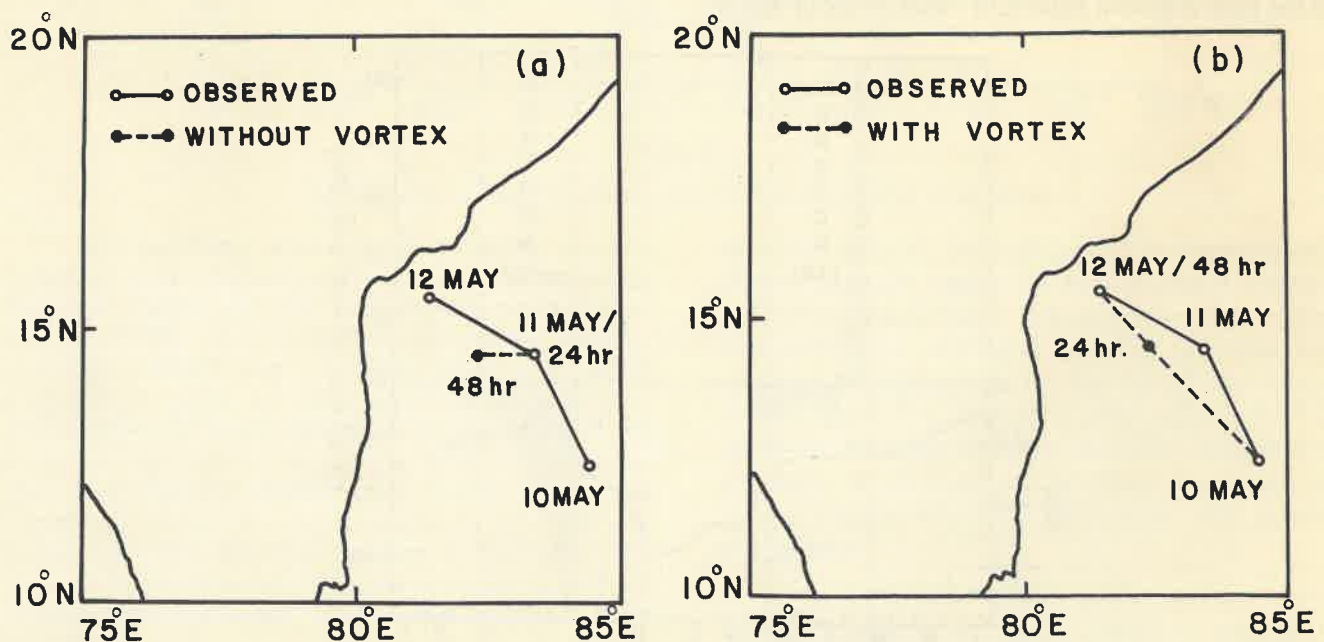


Figure 1 :

Model predicted track of the tropical cyclone of 10 May 1979 in the Bay of Bengal.

bare soil surface and dry grass (yellow) surface at the Agricultural Meteorological observatory, IMD, Pune for 17-26 May 1991 and (ii) IITM campus for 20 May 1992. The diurnal trend in the computed and observed fluxes were found to be similar at both the sites.

3.1.2 Objective Analysis Including Satellite Input for Regional Models

Objective analysis of wind and geopotential fields at five standard levels over India and adjoining regions for the period 4-8 July 1979 was carried out using Sasaki's numerical variational technique. The cross isobaric flows obtained from the variational technique were found to be much less than those obtained from the Univariate Optimum Interpolation technique.

Impact of the low level winds derived from the INSAT Satellite at 850 and 700 hPa was evaluated for a case of a depression formed over the Bay of Bengal during 19-21 September 1991. Results of the analysis which included satellite derived information on cyclonic circulation and the centre of depression were found to be more accurate as compared to the analysis which included only the conventional winds.

3.1.3 Extended Range Prediction

The temporal and spatial distributions of rainfall during Indian summer monsoons of 1991 and 1992, and the near-deficient departure value of about -8% in

their average seasonal rainfall could be broadly explained from the warm ENSO (El Nino - Southern Oscillation) episode of 1991-92. This ENSO cycle had two distinct characteristic features viz., (i) a very long life-span (about 17 months) and (ii) peaking in between the two monsoons (around February 1992). This configuration phase-locked the latter part of monsoon-91 with the evolving phase of the ENSO and the earlier part of monsoon-92 with the decaying phase of the ENSO resulting in the contrasting temporal variation in the rainfall activity during the two monsoons. Interestingly, the two contrasting temporal variations averaged to almost the same departure value -8% (Fig. 2).

Relationships between NAO (North Atlantic Oscillation) Index viz., pressure gradient between Azores high and Icelandic low, and the frequency of cyclonic disturbances over north Indian Ocean, on monthly, seasonal, annual and decadal scales, were investigated with the data for 98 years (1891-1988). The annual and summer monsoon season's frequency of disturbances showed statistically significant positive correlations with the strength of NAO in February and April while October showed still higher but negative correlations. On longer time-scales the 3-decadal frequency of disturbances was more when the intensity of NAO was more normal.

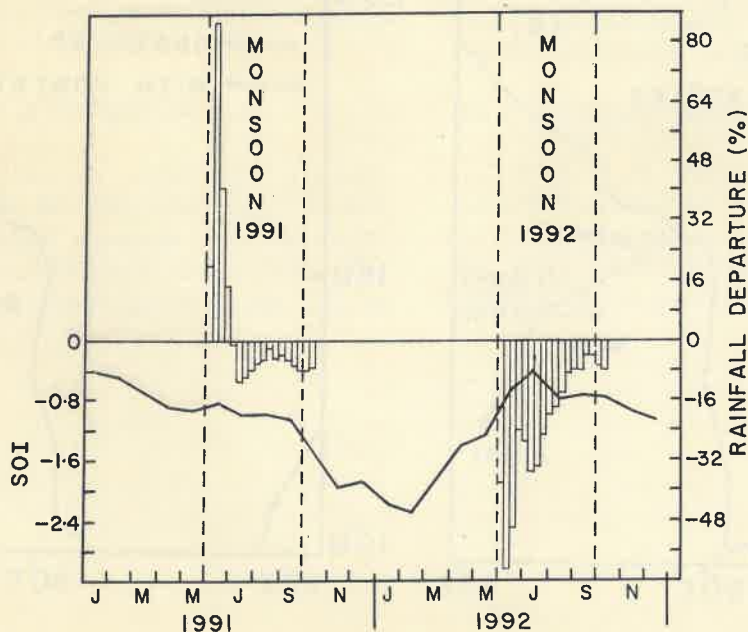


Figure 2 :

Phase-locking of monsoons of 1991 and 1992 with ENSO. The variations in the five month running mean of SOI (Southern Oscillation Index) and percentage departure of the weekly cumulative Indian rainfall from the normal.

Analysis of 20 years of upper tropospheric data showed that the ridge of high pressure over south-east Asia shifts equatorward during the pre-monsoon months in bad monsoon years as compared to good monsoon years—a result which may have some potential for long-range forecasting of monsoon rains.

Interesting results regarding rainfall variations over India and China were reported earlier. Towards further fulfilment of the above objective a study on the intraseasonal and interannual variability of the monsoon rainfall over Thailand was carried out. The results of the study indicated that the Madden-Julian oscillations of period 30-60 days were dominant over the Indian region and the quasi-biweekly oscillations were

dominant over Thailand. On the interannual time scale, the meteorological conditions over northwest Thailand seem to be associated with the rainfall variations over west-central India.

Interaction of the Indian summer monsoon with the Northern Hemisphere Midlatitude circulation on intraseasonal time scale was studied using the midlatitude geopotential heights and the Indian rainfall. The 500 hPa geopotential height in the three regions (i) the Manchurian region north of Korea (45°N 130°E); (ii) the Mediterranean region (30°N 0°E) and (iii) the Caspian Sea region (45°N 40°E) has significant positive relationship with rainfall over northern parts of India (Fig.3).

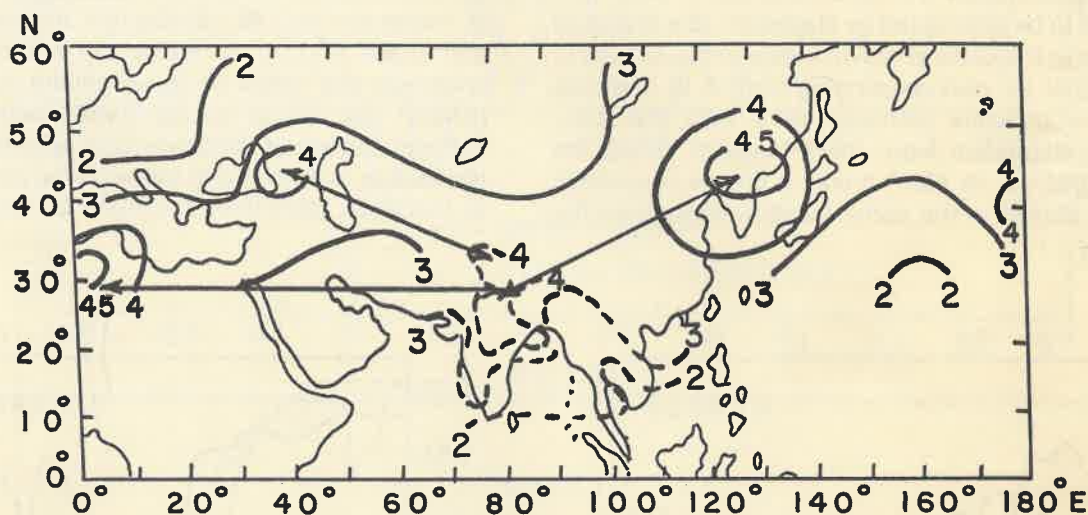


Figure 3 :

Midlatitude—Tropical interaction on intraseasonal time scale.

The possible association between surface pressure and temperature over the area bounded between $0-60^{\circ}\text{N}$, $30-100^{\circ}\text{E}$, during the pre-monsoon months—March, April, May and the Indian summer monsoon rainfall was examined using the recent thirtyseven years of data (1951-87). Significant correlations are found between the pressure in the month of April over the region lying around the Caspian Sea and monsoon rainfall. In the month of May the significant correlation region shifts to the heat low region i.e., over the Sind province of Pakistan. The regions of significant correlations of temperatures are located over north-west, west-central and east coast of India.

3.1.4 Monsoon Studies and Forecasting

Based on ECMWF FGGE Level IIIb data (u , v , T and RH) the apparent heat sources (Q_1) and the

apparent moisture sinks (Q_2) were computed over the Indian monsoon region for the monsoon season of 1979 (May-September). The analysis of the vertically integrated area averaged Q_1 and Q_2 time series revealed the dominance of the 30-50 day mode of oscillation over the monsoon trough region ($15-27.5^{\circ}\text{N}$, $70-95^{\circ}\text{E}$). An analysis of the vertically integrated time averages of Q_1 and Q_2 revealed the major heat source regions and their association with observed precipitation.

The ECMWF-FGGE Level-IIIb data for the monsoon season 1979 were utilised to compute the apparent heat sources (Q_1) and the apparent moisture sinks (Q_2) over the Indian monsoon region for all the standard levels (1000-100 hPa) for each day. The analysis of Q_1 and Q_2 in time and space revealed

that : (i) the time series analysis of the vertically integrated area averages Q1 and Q2 over the monsoon trough region (17.5-27.5°N, 70-95°E) shows good agreement in the variation of Q1 and Q2 with the monsoon cycle of 1979 and (ii) the analysis of the horizontal distribution of the vertically integrated time averages of Q1 and Q2 revealed the major heat source regions and their association during the entire monsoon cycle of 1979 viz., onset and advance-active-weak-break-revival-active phases.

The onset and advance of SW monsoon over India was studied based on 31 years (1961-91) of monsoon onset dates for Indian stations. The northward progress of monsoon along the west coast of India (along approximately 70-75°E longitudinal belt) was often seen to be interrupted by stagnation at a preferred location over the Gujarat region between the latitudinal belt 20-23°N for periods ranging from 2 to 6 weeks resulting in deficient monsoon rains over the state. Cases of stagnation were more frequent during the decade 1982-91. In 1991, it was a unique stagnation as it was stalled in the same location throughout the

country for over 30 days. The cause of such unique stagnation in 1991 was attributed to the excess latent heat release due to unprecedented heavy rainfall over the south peninsula during the onset phase of the monsoon in 1991 (4-10 June) in association with a synoptic scale disturbance. The excess latent heating of the middle troposphere seemed to have weakened the north-south gradient of convective heating and thereby stalling the further northward progress of ITCZ and its associated moisture laden monsoon westerlies leading to the stagnation of monsoon near 23°N.

Satellite data (OLR and cloud imageries) were analysed to study the year to year variability of the commencement of monsoon rain over a region (onset of monsoon) and its subsequent distribution in time and space (Fig. 4). In Indian agriculture the sowing operation and yields of some rainfed summer crops (Kharif) are found to be linked with the timely commencement of monsoon rain and its subsequent distribution. A relationship between the commencement of monsoon rains over the State of Gujarat and the

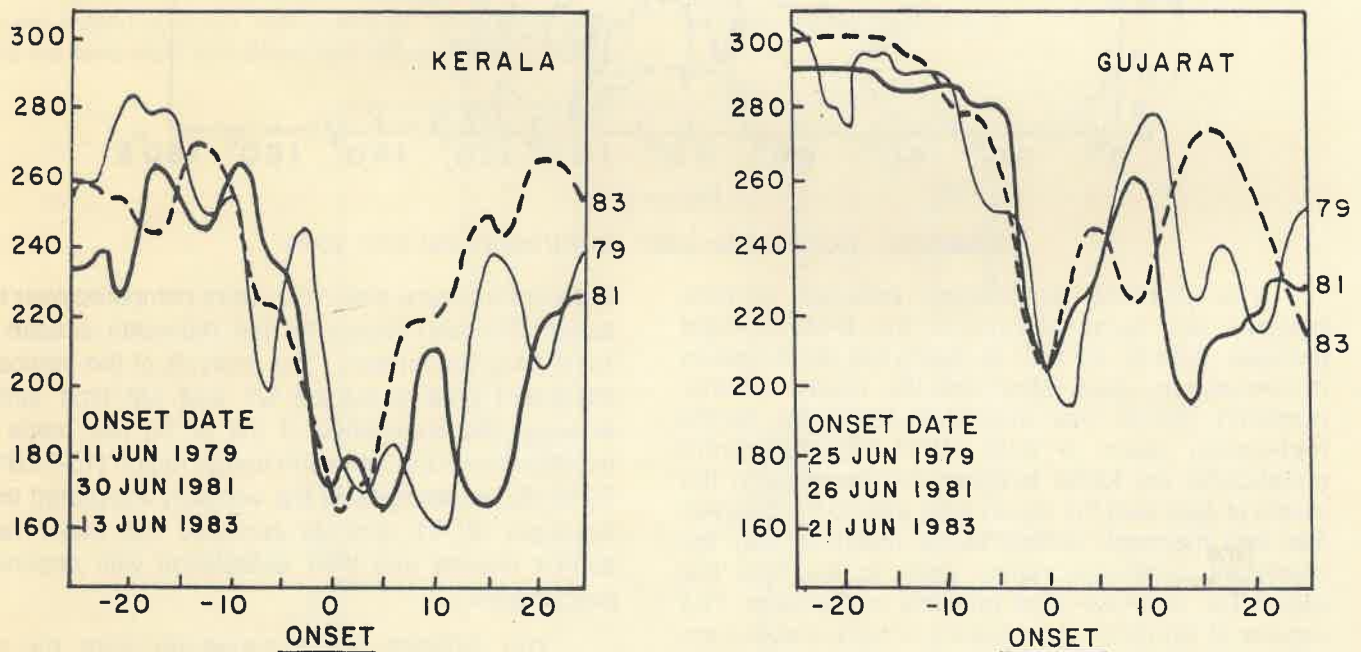


Figure 4 :

Variations in the satellite derived mean OLR data for Kerala and Gujarat regions in relation to the onset of monsoon during different years.

yields of groundnut over the region during 1965-1987 showed late commencement of rains resulting in poor yields (Fig. 5). Prior knowledge of the time of commencement of rain would thus help the Indian farmers to plan their sowing operation for better yields.

The study showed that satellite data can be applied to monitor the commencement of monsoon rain over a region as well as its subsequent distribution in time and space.

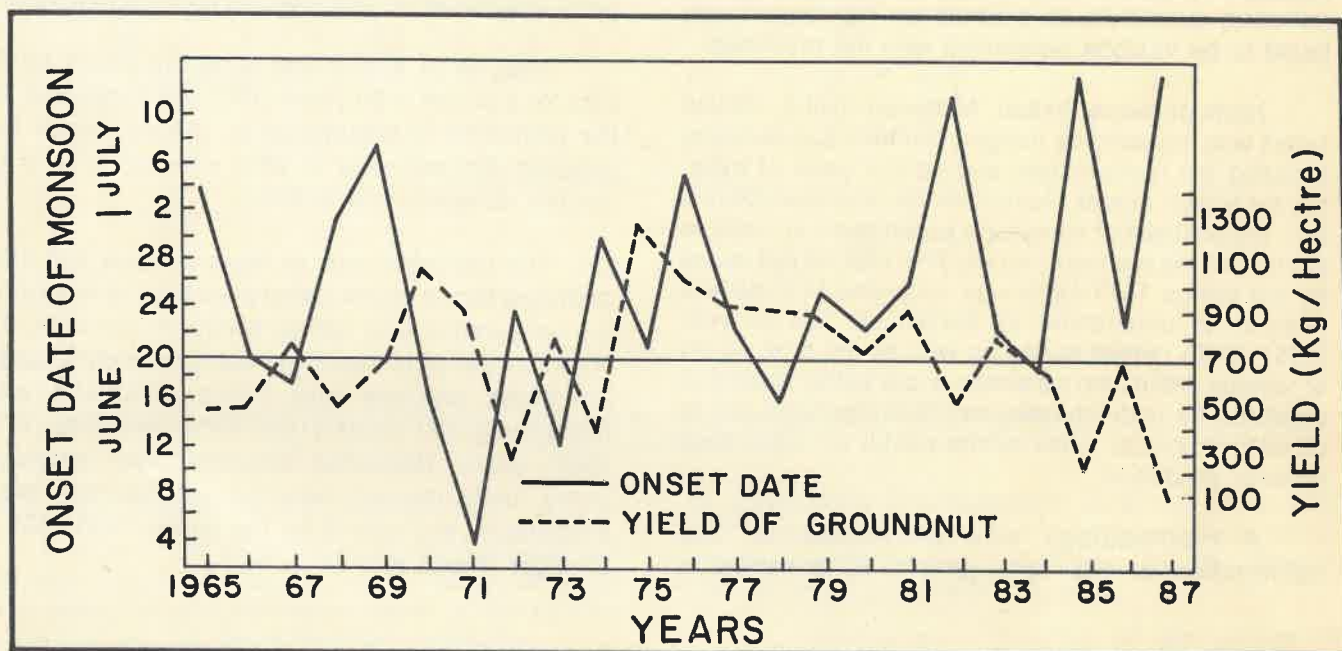


Figure 5 :

Time series of monsoon onset over Gujarat and yield of groundnut. The central line marks the normal onset date over Gujarat and the normal yield of groundnut.

3.2 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 the overall economy of the country. Currently there is an enhanced emphasis on the studies of global and regional climatic change. To assess the magnitude and impact of climatic variations and to develop predictive capabilities, a detailed analysis of the observed and proxy climatic records of the recent past is essential. Likewise, the analysis of long records of 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 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 Indian summer monsoon rainfall and identify its teleconnections with the global and regional atmospheric and oceanic parameters.
- * Hydrometeorological analysis of rainfall data of various river basins in the country for planning and design of water resources management projects.
- * Estimation of probable maximum precipitation, depth-area-duration analysis of severe rainstorms and development of quantitative precipitation forecast schemes.

3.2.1 Climate and Climatic Change

The long-range forecast of monsoon rainfall for 1992 over the country as a whole and two broad subdivisions of northwest India and peninsular India was sent to the Director General of Meteorology. The forecast was based on three different multiple regression models and the overall performance of the monsoon over India as a whole for the season was found to be in close agreement with the prediction.

Homogeneous Indian Monsoon (HIM) rainfall series was prepared by merging fourteen sub-divisions covering the northwestern and central parts of India, having similar rainfall characteristics and associations with regional/global circulation parameters in order to strengthen the monsoon signal. This HIM rainfall series for the period 1871-1990 was subjected to statistical analysis to understand its behaviour. The 30-year (1951-1980) rainfall series as well as the time series of various circulation parameters are being studied in detail for the understanding of teleconnections and to develop empirical relationships useful for long-range weather prediction.

A methodology was developed for the optimization of the rain gauges to construct a

representative summer monsoon rainfall series based on averaging the ratio of actual and mean rainfall of 306 well distributed stations over the country. The rainfall series was constructed adopting three different schemes, viz., (i) random selection, (ii) multiple linear regression, (iii) objective subset of gauges based on forward selection scheme. The series prepared on the basis of scheme (iii) was found to be most appropriate.

Analysis of ENSO and sunspots based on the data for a period of 90 years (1901-90) suggested that the probability of occurrence of El-Nino events in a negative sunspot-cycle is 68% whereas that in the positive sunspot cycle is 32%.

The ring width data of *Abies pindrow* and *Picea smithiana* from Kashmir valley were used to reconstruct the temperature and rainfall series for Srinagar. The maximum period of mean ring width index chronologies for *Abies pindrow* and *Picea smithiana* were respectively 371 years (1612-1982) and 208 (1775-1982) years. Response functions were developed using instrumental records of monthly mean temperature and rainfall for the period 1893-1982 for Srinagar (Figs.6 and 7).

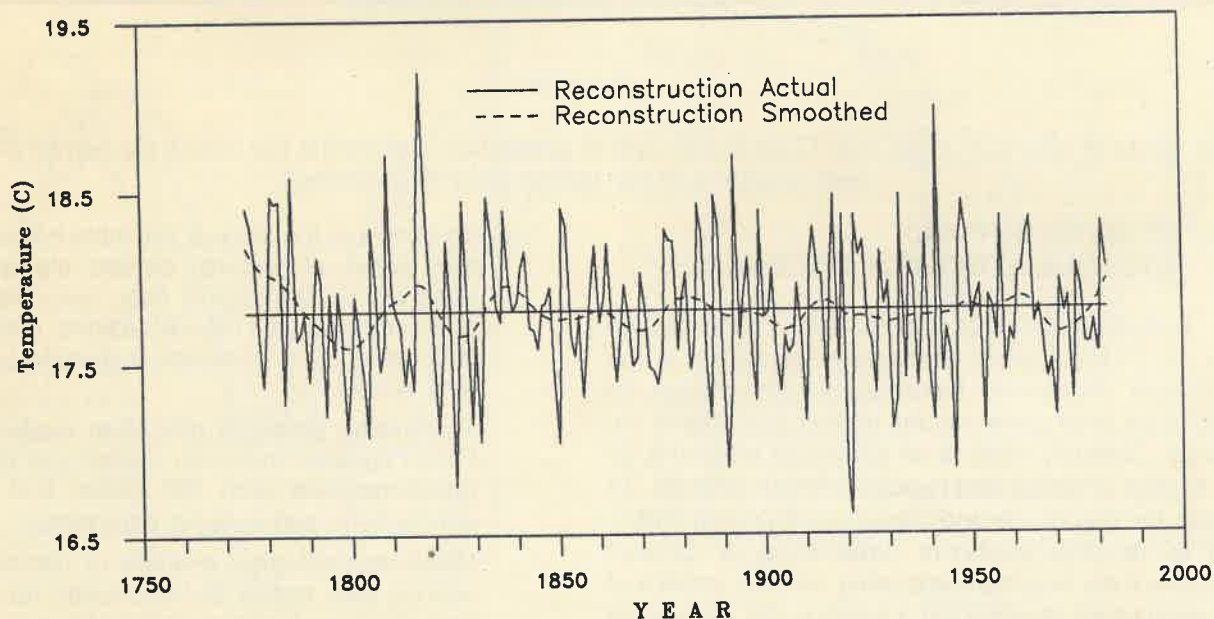


Figure 6 :

Reconstructed Summer (April-June) mean temperature at Shimla (HP) using *Cedrus deodara* chronologies.

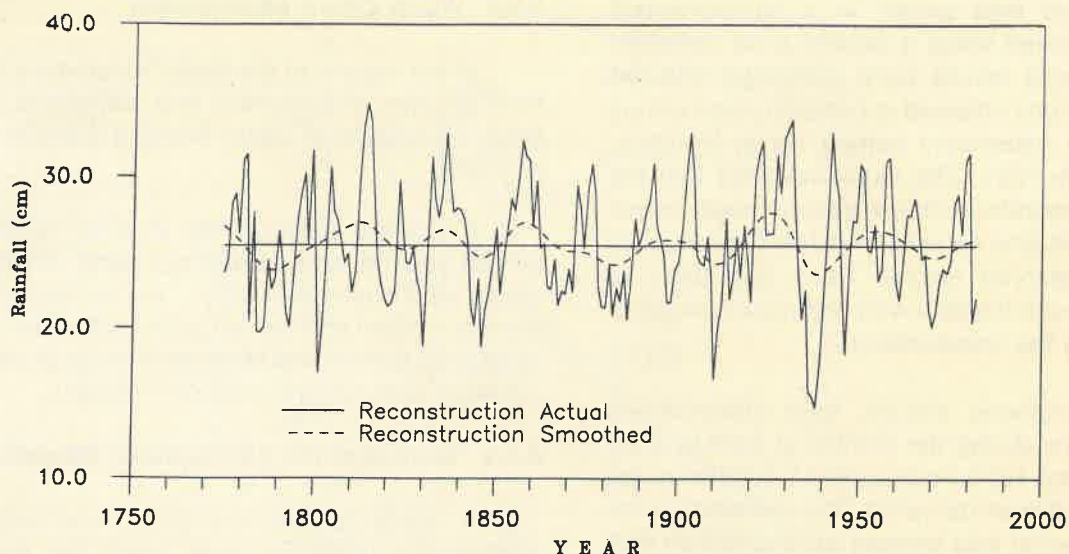


Figure 7 :

Reconstructed summer (May-September) precipitation at Srinagar (J&K) using *Picea smithiana* and *Abies pindrow* chronologies.

3.2.2 Hydrometeorological Studies

A rainstorm Atlas of India containing the analysis and other details of selected severe rainstorms which have occurred over different regions of the country during the last 100 years is under publication.

A generalised method was developed to estimate the areal probable maximum precipitation (PMP) for 1000, 5000 and 10000 km² for 1-day duration over Tamil Nadu State. Three generalized charts showing the variation of areal group for these three areas were prepared. The study showed that the respective values of the 1-day areal PMP for 1000, 5000 and 10000 km² were found to vary from 48-32 cm, 38-26 cm and 32-22 cm respectively.

A generalised chart showing the spatial distribution of two-day PMP was prepared using the rainfall data of 80-years (1901-1980) for 131 stations in the Indian Peninsula covering 8-20°N. The PMP estimates varied from 40 to 95 cm and the average ratio of the two day PMP to the highest observed two-day rainfall was found to be 1.76.

3.3 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 acid rain, greenhouse gases, ozone depletion, atmospheric aerosols and biogeochemical cycles, and evaluate the impact of pollutants on the climate.
- * To study the theory of deterministic chaos and its applications in atmospheric sciences particularly in Atmospheric and Climate modelling.

3.3.1 Studies in Atmospheric Electricity

The theory relating to electrification in layer clouds through the electrochemical mechanism was studied. The observed electrical structure of layer clouds could be explained when the ion-droplet interactions at various levels of the cloud height were simulated in the model. The study suggested that the unipolar to multipolar structures observed in the layer clouds could be explained through the above electrification mechanism.

The electric field growth in a cumulonimbus cloud was simulated using a parallel plate capacitor model. The model results were compared with the aircraft observations obtained in cumulonimbus clouds during the field experiment carried out in Montana, USA during July 1981. The study indicated that the results of the laboratory charge transfer experiments of ice-crystal-hailstone non-inductive mechanism could explain the observed electric fields and there is agreement between the observed and model predicted electric fields in the thunderstorms.

The atmospheric electric field observations recorded at Pune during the months of April to June of 1974, 1976 and 1977 were studied in relation to the onset of the southwest monsoon. The variations in the atmospheric electric field showed an association with the meteorological and synoptic conditions associated with the onset of the monsoon.

Computations of small ion mean life-times were carried out using the observations of small ions and Aitken nuclei obtained from different environments (oceanic, urban and rural). The study suggested that the mean life-times of small ions in the oceanic/rural environments are one order less as compared to those observed in the urban environments. The study suggested that the atmospheric electric parameters could be useful signatures of air pollution levels.

3.3.2 Radar Study of Rain and Rain Bearing Clouds

Heights of the radar echoes from convective clouds around Delhi, observed during winter, pre-monsoon, monsoon and post-monsoon seasons were analysed in order to investigate the growth mechanisms of such clouds in this region. Analysis of the radar observations collected during 1967-1972 showed that echo heights tended to follow log-normal distribution in each season confirming thereby that convective clouds grow according to the law of proportionate effect in this region.

Diurnal variation of rainfall in the Delhi region was investigated. It was found to be bimodal in the months of January, March, May, June, July and September and unimodal in the rest of the months. The time of occurrence of the maximum rainfall is mostly found to be in the afternoon.

3.3.3 Warm Cloud Modification

At the request of the State Government Agencies from Gujarat, Maharashtra and Karnataka technical guidance relating to Cloud Seeding Experiments was provided.

A detailed study of the evolution of the cloud droplet spectra was carried out using the numerical model of Fitzgerald (1972). The computed spectra were compared with the actual aircraft observations of cloud drop spectra and other microphysical parameters obtained from several monsoon clouds.

3.3.4 Studies of the Atmospheric Boundary Layer

A study of the fractional cloudiness in the atmospheric boundary layer using the concept of saturation point analysis was carried out using the aerological observations collected at Pune during 1980 and 1981. The results of the study suggested that 65% of the cloudiness was confined to 850-750 hPa levels.

Aerological observations collected during the summer monsoon seasons of 1980 and 1981 at Pune were used to study the average thermodynamic structure of the Convective Boundary Layer (CBL). The CBL consists of a typical three layer structure (sub-cloud, cloud and capping layer). The average CBL top during the summer monsoon season was found to be 650 hPa (Fig. 8a and 8b).

A study of the Atmospheric Boundary Layer (ABL) was carried out using the wind observations collected during active and weak monsoon conditions at Kharagpur as a part of MONTBELX-1990. The results of the study indicated pronounced diurnal variation in the ABL heights during weak monsoon conditions. ABL heights were found suppressed during active monsoon conditions.

The theory relating to a simple 2D-model of the convectively driven boundary layer was studied. The model simulates the mixed layer depth as a function of time and space, in which turbulence is mainly produced by penetrative convection. Predictions of depth averaged potential temperature and velocity, inversion strength and velocity jump across the inversion were also incorporated in this model. The software required for the theoretical computations was developed and the results are being verified.

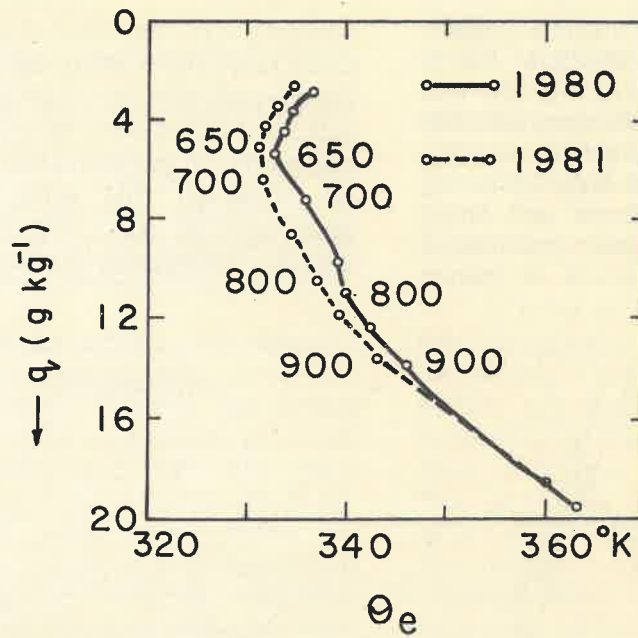


Figure 8(a)

Distribution of equivalent potential temperature (θ_e) against mixing ratio (q) at different heights in the convective boundary layer (CBL). The kinks at 650 hPa correspond to the top of the CBL.

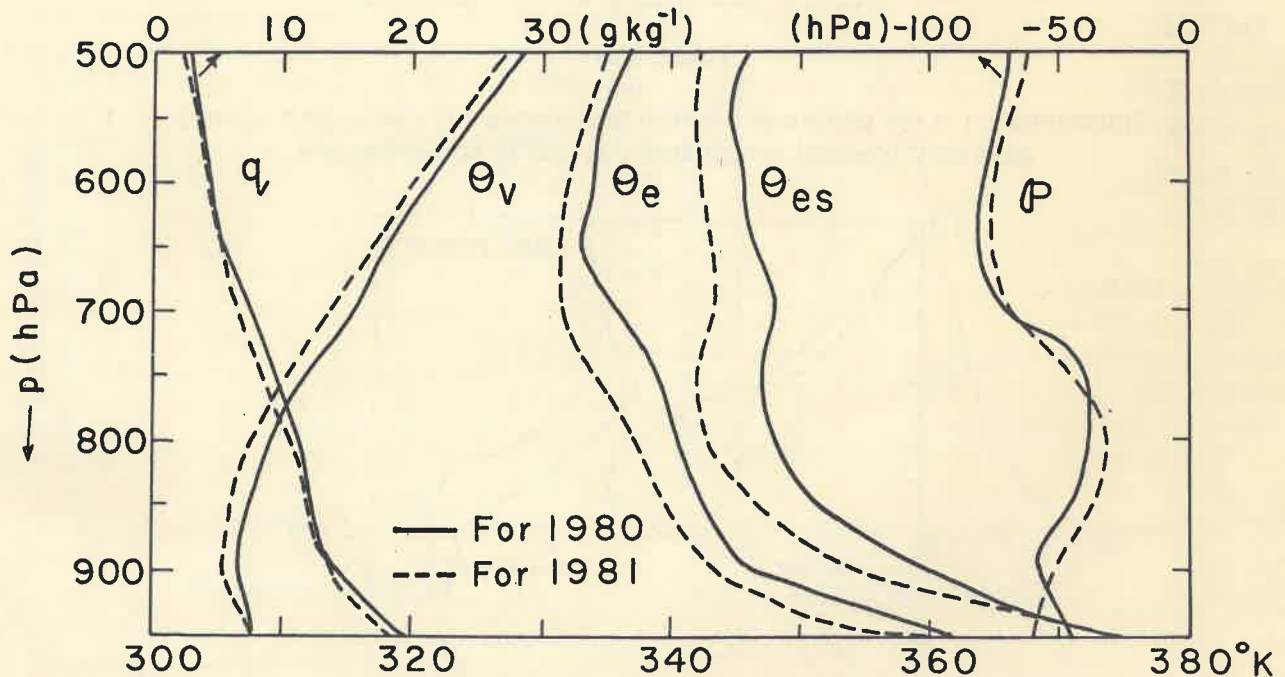


Figure 8(b)

Profiles of mixing ratio (q), virtual potential temperature (θ_v), equivalent potential temperature (θ_e), saturated equivalent potential temperature (θ_{es}) and saturation pressure difference (P). The hPa as seen from the minimum values of θ_e and P .

A case study of the thermodynamic transformation of boundary layer structure due to mesoscale processes such as convective rain was carried out using the aerological observations collected during MONSOON-77 over the Arabian sea. The characteristic well mixed sub-cloud layer preceding the rain was transformed by updrafts and falling precipitation to a new structure after precipitation (Figs. 9a and 9b). This new structure of marine

boundary layer consisted of warmer, more stable sub-cloud layer and a more well mixed cloud layer than the corresponding layers preceding the rain. Since the sub-cloud layers were nearly saturated, the effect of cooling due to evaporation of falling precipitation was not observed. The zonal wind maxima shifted downwards by about 500 m after the precipitation implying suppression of mixed layer.

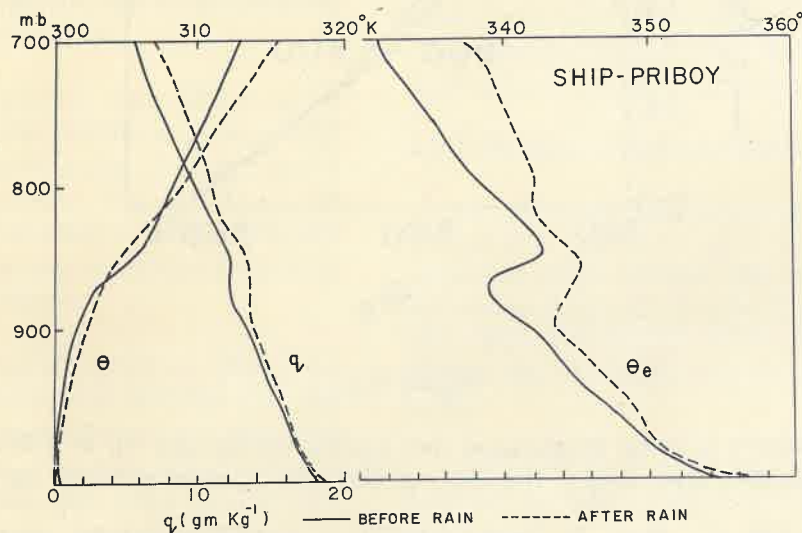


Figure 9(a)

Transformation in the profiles of potential temperature (θ), mixing ratio (q) and equivalent potential temperature (θ_e) due to convective rain.

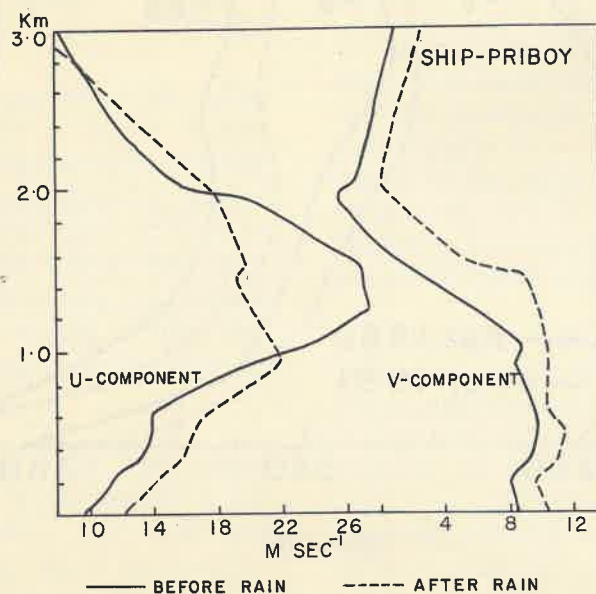


Figure 9(b)

Transformation in the profiles of U (zonal) and V (meridional) components of wind due to convective rain.

3.3.5 Deterministic Chaos

Continuous periodogram spectral analysis of daily temperature data (TOGA) for the period June to August 1988 for all grid points from 50°N to 50°S latitude showed that the power spectra by and large follow the universal inverse power law form of the statistical normal distribution. The results are in agreement with the results of the cell dynamical system model developed for prediction of atmospheric flows.

Continuous periodogram analysis of hemispheric annual mean surface temperature was carried out using the 125-years data covering the period 1866-1990. The computations were carried out using 5 data sets of 25 years (1866-1890, 1891-1915, 1916-1940, 1941-1965 and 1966-1990). The results of the study indicated that the power spectra follow the universal inverse power law form of the statistical normal distribution. Long-range temporal correlations (persistence) implicit in the universal power law form of the power spectra are found to be ubiquitous to real world dynamical systems and are recently identified

as signatures of self-organized criticality or deterministic chaos. The present study identifies and provides a unique quantification for self-organized criticality in the interannual variability of hemispheric surface temperature. Universal spectrum for interannual variability rules out the possibility of linear secular trends in hemispheric surface temperature.

3.3.6 Studies in Upper Atmosphere

In order to examine the nature of disturbance that may arise due to monsoon activity, the geopotential height data for five levels, 500, 300, 200, 100 and 50 hPa for Singapore (1.3°N, 103.0°E) during six contrasting summer monsoon years 1972, 1975, 1979, 1983, 1987 and 1988 were analysed applying the Discrete Fourier Transform (DFT) method. The results of the study suggested predominance of significant low frequency modes (31-72 days) during good monsoon years (1975, 1983 and 1988) and high frequency modes (3-6 days) during bad monsoon years (1972 and 1979) in the troposphere/stratosphere (Fig. 10).

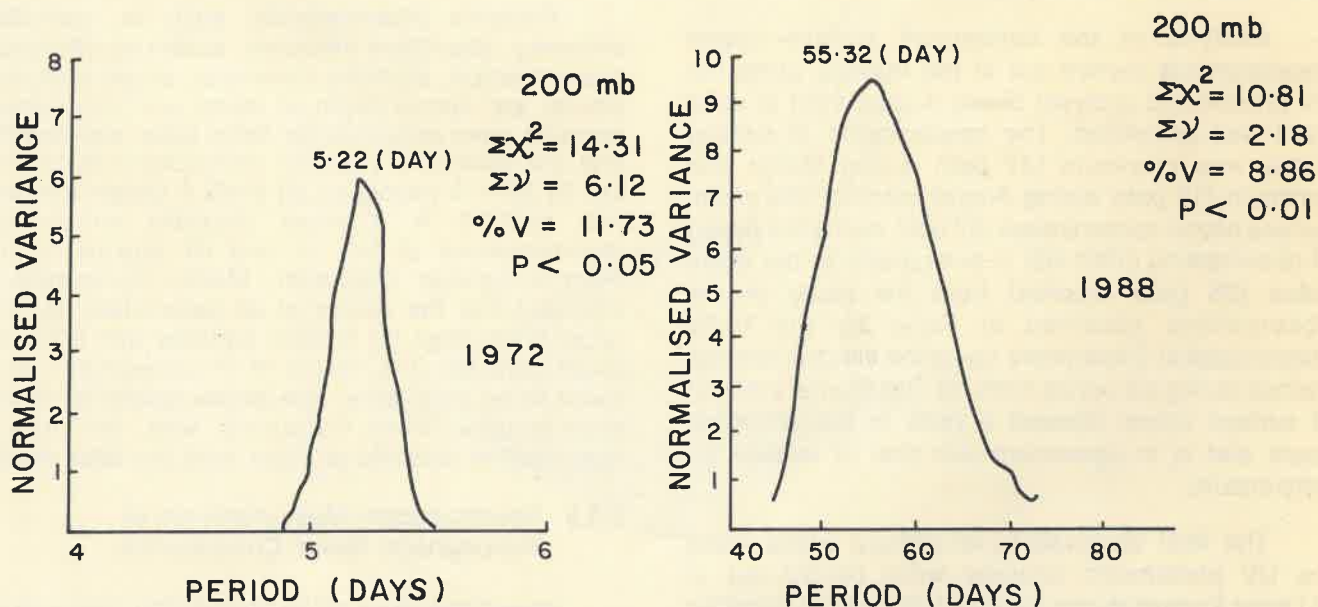


Figure 10

Periodogram showing significant high and low frequency modes in daily geopotential heights at 200 mb over Singapore during June-September for contrasting monsoon activity over India : 1972 (bad monsoon) and 1988 (good monsoon).

A study of the effect of Pinatubo Volcano eruption (Philippines, June 1991) on the low-latitude stratospheric temperature and total ozone was undertaken. For this study, daily zonal mean temperatures at 50 mb at 20°N (collected from published data by Labitzki) and the daily total ozone data for Pune for the period June to November 1991 were considered. This study indicated increase in the stratospheric temperature and decrease in the total ozone following the Pinatubo volcano eruption.

A study of the association between the north pole temperature during winter with summer monsoon rainfall over India during the following summer was carried out using the data of north pole temperature at 30 mb for the period 1957-1988. Significant periodicities were identified using the results of the harmonic analysis of the two data sets. The results of the study indicated QBO in the north pole temperature at 30 mb during December to March and the succeeding summer monsoon rainfall. Also, the north pole temperatures at 30 mb during December to January exhibited 8-11 year significant periodicity which may be associated with the 11-year solar cycle indicating solar influence on north pole temperatures at 30 mb.

3.3.7 Studies in Air Pollution

Analysis of the continuous surface ozone measurements carried out at the Institute using the UV photometric analyser during August 1991 to June 1992 was completed. The concentration of surface ozone was maximum (37 ppb) during March and minimum (12 ppb) during August months. The mean surface ozone concentration (27 ppb) during the period of observations (1991-92) is comparable to the mean value (25 ppb) reported from the study of the observations obtained at Pune by the India Meteorological Department using the electrochemical method during the period 1969-70. The diurnal variation of surface ozone showed a peak in the afternoon hours and is in agreement with that of surface air temperature.

The field observations of surface ozone using the UV photometric analyser were carried out at (i) Upper Kargudi during January 1992 and (ii) Bandipur during April 1992, the two field stations chosen for the study of the Nilgiri Biosphere Reserve. The mean concentrations of surface ozone at Upper Kargudi and Bandipur were respectively 13.5 ppb and 15.4 ppb. The above study indicated that the concentrations of surface ozone are within the range of world background concentrations.

The variations in the ionic composition and pH of rain water during convective showers were investigated. For this study rain water samples of equal volume were collected sequentially from eight convective showers at Pune during the monsoon seasons of 1988 and 1989 and their chemical composition and pH were determined. Sharp variations in the ionic concentrations with time during the shower were noticed. The pH varied from 4.8 to 7.0. The results indicated that the washout of soil particles rich in Ca is responsible for maintaining the pH of rain water in the alkaline range.

3.3.8 Lidar Probing of the Atmosphere

A technique for measurement of atmospheric turbulence from laser scintillation observations was developed. The turbulence characteristics of the surface layer over Pune were studied using the laser scintillation observations collected during 1990 and 1991. Atmospheric turbulence exhibited systematic diurnal variation with maximum during afternoon hours and minimum immediately after sunrise/sunset periods. A secondary maximum was also observed during midnight on days with strong inversion conditions. The observations indicated close association between the intensity of turbulence and cloud formation.

Radiative characteristics, such as, extinction efficiency, absorption efficiency, scattering efficiency, phase function, asymmetry parameter, single scattering albedo and optical depth of urban and tropospheric aerosols were computed for three laser wavelengths that are commonly used for atmospheric monitoring i.e., (i) 3371 Å (nitrogen), (ii) 5145 Å (Argon-ion) and (iii) 106000 Å (Carbon dioxide) which are representatives of UV, V and IR regions of the electromagnetic spectrum. Model computations indicated that the values of all parameters, by and large, were large for smaller particles and small for larger particles. The values of IR wavelengths were found to be vice versa. The model results for visible wavelengths were validated with the actual observations obtained at Pune from the laser radar.

3.3.9 Spectroscopic Measurements of Atmospheric Minor Constituents

Intercomparisons of the photometric observations of the total columnar density of atmospheric ozone were carried out at Pune by the scientists of the Institute and the Institute of Meteorology and Physics, University of Bodenkultur, Austria, during 11-12 February 1992. Two scientists Mr. Philip and Miss Isabel from Austria brought their photometers for the above intercomparison campaign.

Simultaneous special observations of atmospheric NO_2 , O_3 , H_2O and aerosols using spectrometers and a photometer were carried out at Pune since December 1992. These observations will be utilised to study the spatial and temporal distributions of the above parameters and for the inter-comparison of instruments and for checking the accuracy of measurements. As part of the above study, observations of atmospheric O_3 and H_2O using spectrometer technique were being organised at Kolhapur in collaboration with the Department of Physics, Shivaji University, Kolhapur.

3.4 INSTRUMENTAL AND OBSERVATIONAL TECHNIQUES DIVISION

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

- * The development of instruments/techniques to study the structure of the atmospheric boundary layer.
- * The development of instruments/techniques to study the cloud electrification processes.

- * The development of simulation techniques to study cloud physics under a controlled environment.

3.4.1 Development of Instruments for Boundary Layer Studies

Activities under the Atmospheric Boundary Layer (ABL) project comprise of development and field testing of sensors and probing the boundary layer using the state-of-art instruments like Doppler Sodar, Lidar, Kytoon and Instrumented Tower. Processing of the data collected during the MONTBLEX to study the structure of the ABL during the Indian summer monsoon also forms a part of the activity.

To study the energy budget at the earth atmosphere interface, an experiment was conducted during 5-22 May 1992 at the Institute. Hourly observations of (20 minutes sampling duration) temperature (surface and soil) and wind at 30, 60, and 160 cms were taken. Heat fluxes at the surface and 1 cm below the surface were measured using flux plates (Fig. 11). For turbulence studies, components

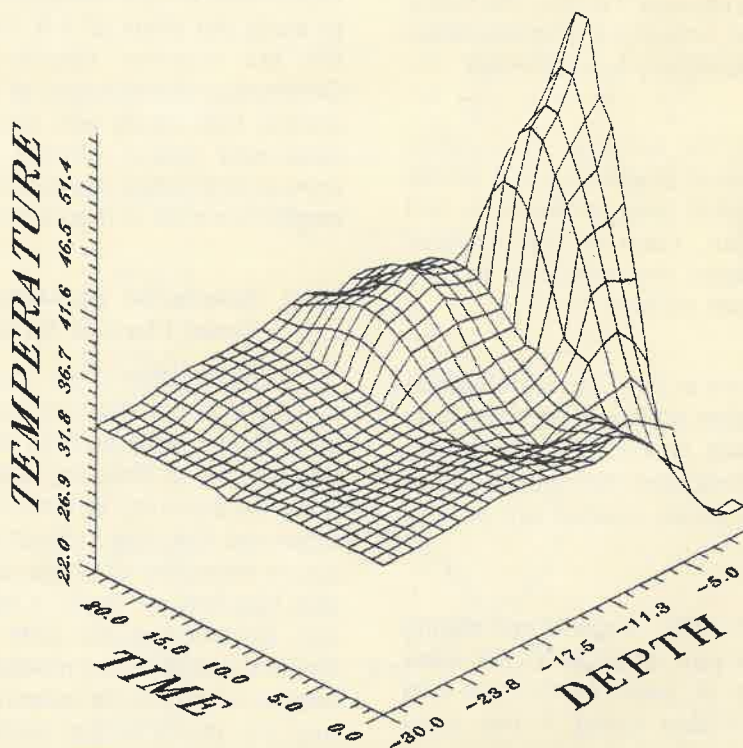


Figure 11

Three dimensional soil temperature profile.

of wind were measured using propeller anemometer (30 cm above ground) and sonic anemometer (4.5 metres height). Net radiometer sensors were used to measure solar radiation. These observations were used to study the physical processes relating to the atmospheric boundary layer and also the land-surface processes. The studies indicated that (i) energy balance at the surface was observed for time periods of about 24 hrs., (ii) contribution of the thermal bursts to the sensible heat flux was maximum during the afternoon hours.

A stepper motor driving circuit was developed and used in the field study at the Institute to measure the temperature at specified heights by moving a single sensor up and down. Observations showed that in the one metre thick surface layer close to ground, the temperature gradient varies as much as 5°C within a span of 1 hour during morning hours (0600-0700 hrs) and 6-7°C during afternoon hours (1200-1300 hrs.)

The dynamical characteristics of the Convective Boundary Layer (CBL) along the monsoon trough region were investigated using the special field observations carried out during MONTBLEX. The fluxes in the CBL and the related turbulence characteristics under different synoptic conditions were studied.

MONTBLEX data for the intensive observation period (1-12 July 1990) were analysed using profile technique. Fluxes of sensible heat, momentum and water vapour for Kharagpur, Varanasi and Jodhpur were computed and a report was prepared for the inter-comparison experiment initiated by DST.

Computations of fluxes in the CBL were carried out using the eddy correlation and the profile methods using the MONTBLEX data obtained at Kharagpur. The results of the study indicated that the values of peak flux obtained by the profile method are less by a factor of 2 to 3.

Data obtained from ORV Sagarkanya during 18-25 August 1990 as a part of MONTBLEX were analysed and the fluxes of heat, momentum and water vapour were estimated using a two level numerical model.

3.4.2 Instrumentation for Cloud Physics and Weather Modification Studies

Activities under the project comprise of development of instruments, conducting studies to understand the electrical properties of the clouds and atmosphere, and conducting simulation experiments to study the physics of clouds.

Scientists of the Institute participated in the 75th and 81st cruises of the ship ORV Sagarkanya of National Institute of Oceanography, Goa. Observations of electric field, conductivity and particle charges on three different categories of particles under rainshowers were carried out in the western Arabian sea and the adjoining equatorial Indian ocean. Analysis of the observations obtained during these and earlier cruises in the Bay of Bengal and Indian ocean showed a secular decrease in conductivity over sea and the influence of air pollution and its extension from the sea coast.

Studies on the horizontal electric fields that may exist close to the ground were continued. A field experiment for the measurement of electric field and to study the effect of a 5 metre pole on distortion of the fair weather electric field was conducted. Continuous observations of three components of the electric field along with the ambient vertical electric field and space charge were made for three consecutive days. Results confirm the existence of large horizontal components of electric field.

3.4.3 Simulation Techniques for Cloud Physics Studies

Investigation of the break-up and occurrence of corona in water drops suspended in a small vertical wind tunnel were carried out. Analysis of the movie photograph of breaking water drops depicts a new mode of break-up in horizontal electric fields. It was observed that the critical electric field required to cause instability of water drops is much lower than that required by Taylor's instability criterion and the one observed in the past experiments. The drops become unstable and produce corona when the drop's oscillation amplitude overshoots its equilibrium value and the plane of the oscillation coincides with the direction of electric field. The results of this experiment show that horizontal electric fields can not only modify the size distribution of cloud particles but also trigger a lightning flash in the bases of thunderclouds.

3.5 THEORETICAL STUDIES DIVISION

Atmospheric physical phenomena can be studied through numerical modelling. The Institute has developed models for the study of dynamic instability and for the simulation of monsoon and tropical circulation systems. The Institute has undertaken programmes for investigating the following :

- * Role of barotropic and baroclinic instability mechanisms in the growth of monsoon disturbances.
- * Hemispheric and global spectral P.E. barotropic model for simulation of summer monsoon circulation.
- * Diagnostic studies and numerical modelling of linear and nonlinear interactions among different spatial and temporal scales of monsoon flow.

3.5.1 Barotropic and Baroclinic Instability of Atmospheric Flow

A study of the monsoon onset vortex of 1979 showed that the vertical eddy energy flux due to eddy

pressure interaction was found to transport eddy kinetic energy away from the layer (850-600 hPa) where it is generated excessively by combined barotropic-baroclinic energy conversions (Fig.12). The time averaged boundary terms (vertically integrated) for eddy kinetic energy were found to be comparable to the contribution of the barotropic and baroclinic conversions put together. The generation rate of zonal available potential energy, eddy available potential energy and dissipation of eddy kinetic energy were also computed.

Global linear spectral barotropic instability model for zonal asymmetric flow over the sphere was developed and tested. Unstable modes for July mean flow at 200 hPa level were computed for different truncations of perturbation and basic state. Unstable modes for periods 4-6 days, 30-50 days and stationary modes were identified. The structure of a few unstable modes was computed and examined for a possible explanation of cyclogenesis and 30-50 day mode oscillation of the tropical easterly jet.

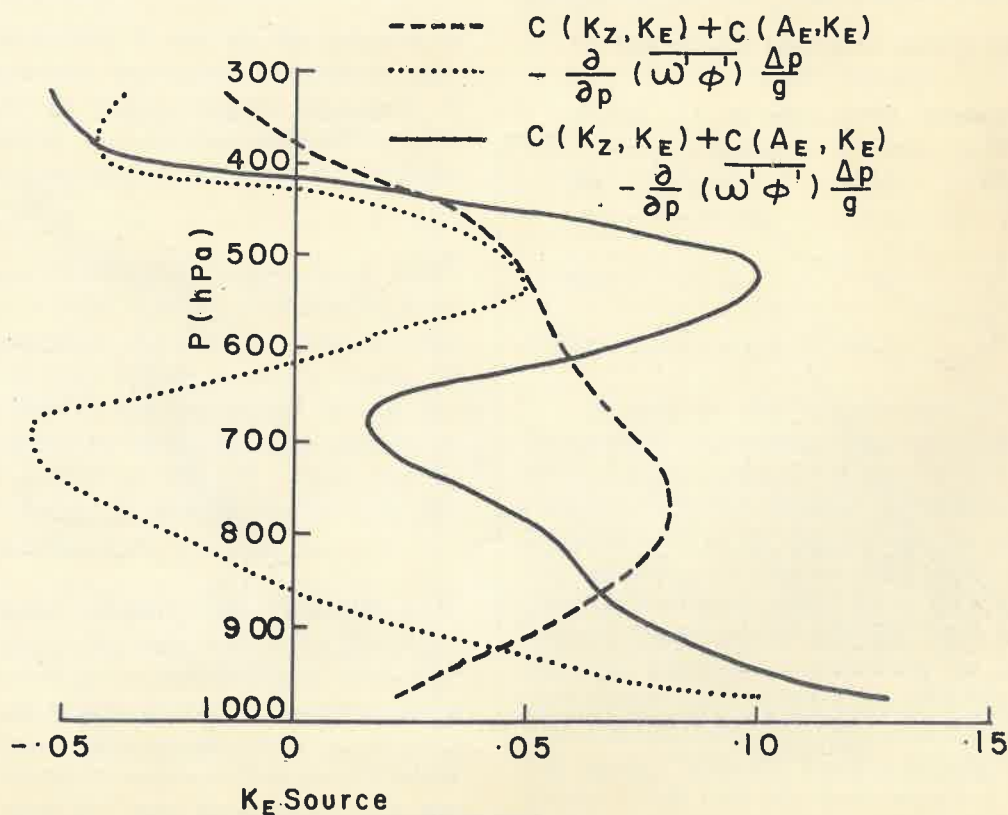


Figure 12

Vertical distribution of various area averaged energy conversions for eddy kinetic energy. Units : m^{-2} .

3.5.2 Simulation of mean Monsoon Circulation and Predictability of the Monsoon Systems

A reduced gravity transport model developed for the Indian ocean was integrated upto 90 days with an idealised westerly wind stress as forcing. The basin averaged kinetic energy showed a quasi-steady state after 30 days. The time variations in the zonal and meridional velocities and height fields along equator, 5°N and 5°S showed an initial eastward propagating Kelvin wave and then a continuously westward propagating Rossby wave. The model was modified to include radiation boundary condition to simulate an open boundary condition at eastern boundary. The experiment showed effective passing of equatorial Kelvin waves through the eastern boundary without any reflections. In another experiment with the model, the use of a damper, as a sponge boundary, showed unusually high model layer depth at that boundary. The model forced with a summer climatic wind stress simulated the Somali Current and the Southern Gyre. The spatial extent of the Southern Gyre is quite comparable with that of the vertical component of the wind stress curl, indicating its influence on the Somali Current and the Southern Gyre. The Somali Current

leaves the coast at 2-4°N which is in agreement with observational studies. The spatial extent of the vertical component of relative vorticity and divergence obtained from the circulation field are also comparable with the negative wind stress curl off the Somali coast. The model height field indicates upwelling all along the Somali coast. Comparison between model height variation from the initial prescribed height field with seasonal SST suggested that SST can be predicted approximately from the model height field through a simple linear relation (Fig. 13).

Spectral analysis of the lower tropospheric (1000-850 hPa) energy transfer due to nonlinear intractions in wave-number domain showed that the transient mode of synoptic scale waves is slightly stronger than that of planetary scale waves. Planetary, synoptic and sub-synoptic scale waves contribute towards the maintenance of zonal flows. The primary source of energy for the transient synoptic scale waves is the transient divergent rotational KE transfer whereas the interaction between the zonal stationary and the transient wave is likely to be a secondary source.

In a study relating to global energy and enstrophy distribution spectra in the troposphere during July

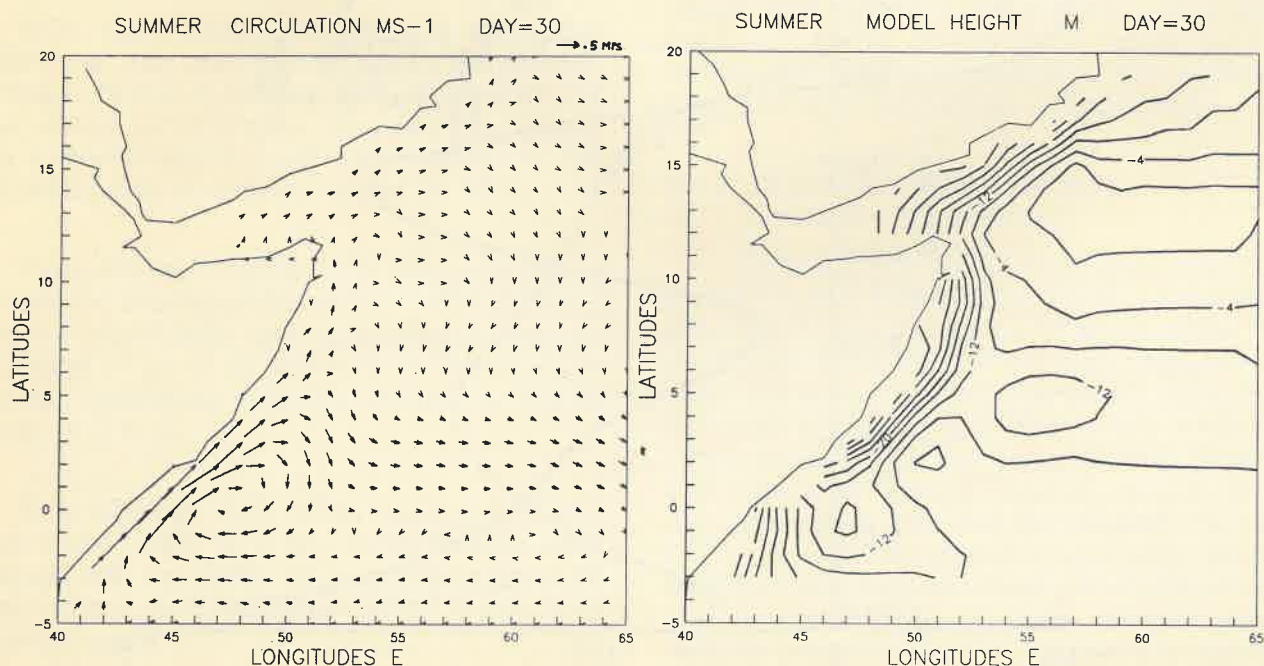


Figure 13

Model simulated Somali current and height field after 30-days of integration.

1979, the vertical distribution of slopes of the two-dimensional (n) transient kinetic energy, enstrophy and available potential energy in the inertial subrange, showed maximum slopes of -2.64, -0.80 and -2.80, respectively, against the theoretically expected values of -3, -1 and -3. Further, the vertical profiles of stationary and transient global averaged kinetic and available potential energy and enstrophy of the long, medium and short zonal wave categories showed that the long waves are basically stationary and contain a large portion of the stationary eddy kinetic and available potential energy. The medium waves are transient in nature and contain more than 64% and 52% of the transient eddy kinetic and available potential energy, respectively. The nonlinear interactions of kinetic energy and enstrophy for different zonal wave categories show that the medium waves lose both kinetic energy and enstrophy while the long and short waves as well as the zonal flow gain kinetic energy. Available potential energy is transferred from long waves to medium and short waves (down the scale) as a result of nonlinear interactions.

3.6 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 Institute has installed in 1988 a Super 32/60 (ND-560/CX, Norsk Data, Norway) Computer System with adequate peripherals. A PC-AT/386 with Cartridge tape drive and a laser printer is also available. In addition to the ND-560/CX Computing facility, the Institute's scientists are also provided access to (i) NEC S/1000 system at the NIC, Pune and (ii) CRAY-XMP/14 Super Computer System at the NCMRWF, New Delhi.

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 continuous uninterrupted computations during the nights and holidays depending on the requirements of the scientists.

The Division has acquired the Numerical Algorithms Group (NAG) Fortran Library and installed on the computer system. The Library contains a galaxy of complex software useful for the research work in Atmospheric Sciences. The scientists are provided with the on-line access for the NAG library and it has been found as an important addition to the Institute's computing facility. The software facilities/requirements are being reviewed by a group of active users 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 taking courses connected with the Atmospheric Sciences. The utilisation of the ND-560/CX system at the Institute during 1992-93 is shown in the following Table :

ND-560/CX Utilisation during 1992-93
(CPU Hours)

I.I.T.M. Hrs.	I.M.D. Hrs.	Others Hrs.	Breakdown/ Maintenance Hrs.
1384	5	6	33

TOGA-I Data Centre

Funded by the Department of Science and Technology, the Institute has taken up a project in which the data collected during the field phase of the "Tropical Ocean Global Atmosphere (TOGA)" Programme is to be archived for the convenience of the research scientists in India. Data received from the TOGA Project office on a CD-ROM (575 MB approx.) pertaining to different data sets from the various countries consisting of sea surface temperature, winds, wind stress, basic level III analysed data and supplementary fields data are being archived. The special software made available by the TOGA Project Office has also been installed. This software enables users to get a graphical view on a colour monitor of various parameters and areas selected. The menu-driven software is very simple and short.

There is also a provision for data extraction so that those desirous of utilizing the data for some other computations can do so. A PC/AT-386 with digitizer and laser printer was acquired in October 1992 for this project.

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 users on request.

3.7 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, drafting, drawing, 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 159 books in Meteorology and allied subjects were added and 67 periodicals of national/international repute were subscribed to. Reprints of 37 papers authored by the Institute's scientists were also purchased. Several scientific and technical reports were received from National and 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 Institute's library has become a member of the Resource Sharing Network of the Scientific and Technical Libraries of Pune. The library has also developed an informal network with the Scientific/Academic Institutions within the country engaged in research in Atmospheric Sciences.

The VIII Five Year Plan (1992-97) document (Revised) consisting of 14 schemes with a total outlay of Rs. 500 Lakhs was prepared for submission to the Governing Council of the Institute and the DST for their approval.

A number of reports were prepared and sent to the DST, India Meteorological Department, Universities and Research Institutes.

Technical facilities like photocopying, microfilming, photography, drafting, drawing, printing and binding were provided to the Institute's scientists.

3.8 ADMINISTRATION

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

3.8.1 Staff Changes

Dr. S. K. Mishra, Deputy Director was relieved of his duties at the Institute with effect from the afternoon of 27 January 1993 to take up his new assignment as Director, National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi.

3.8.2 Employment of Ex-servicemen

Reservation for the ex-servicemen is made at 10% in Group 'C' and 'D' posts of the Institute. The percentages of ex-servicemen working at the Institute vis -a- vis the total number of employees in Group 'C' and 'D' are 1.12 and 9.83 respectively.

3.8.3 Staff Council

The Staff Council is an elected body representing



A RISC-based Workstation with eight terminals and ancillary equipment was acquired and commissioned at the Institute for the research work in Atmospheric and Climate Modelling.



Library building under construction



Dr. D. A. Bennetts, Research Co-ordinator, Hadley Centre for Climate Prediction and Research, Bracknell, UK, visited the Institute during 12-19 December 1992 and delivered lectures on Climate Modelling.



Professor T. N. Krishnamurti, Florida State University, USA, visited the Institute during 21-23 January 1993 and delivered lectures on Tropical Meteorology.

employees of the Institute in different categories and acts as a forum for discussion on matters of common interests to the employees and for increasing efficiency. During the year, 4 meetings of the Staff Council were held.

3.8.4 Academic Council

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, 5 meetings of the Academic Council were held.

3.8.5 Advisory Committee

Advisory Committee consisting of the Heads of the Divisions and the Deputy Directors was constituted in July 1993 to consider policy matters of the Institute and 5 meetings were held thereafter.

3.8.6 Research Fellowship

- i) The tenures of the fellowships of Shri S. Bose, Air India Research Fellow and Shri. K. K. Singh, IITM Research Fellow were extended from 21.12.1992 to 20.12.1993 and from 7.3.1993 to 30.6.1993 respectively.
- ii) The tenures of Shri H. J. Savant and Kum. Sathi Devi, IITM Research Fellows were terminated with effect from 10.7.1992 and 17.7.1992 respectively.
- iii) S/shri J. Venkata Ratnam, C. Venkatesan, V. Vasudevan and R. R. Ramanan joined the Institute as IITM Research Fellows in the month of October 1992.

3.8.7 Official Language Implementation

The Institute recorded a steady 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.

Hindi week was celebrated during 16 to 21 September 1992. Competitions in Hindi essay writing, debating, poetry recitation, typing, noting and drafting

were organised and prizes were awarded. Cash award for using more than 20,000 words in Hindi in office work was awarded to Smt. Arati Ursekar. Shri. R. S. Sharma, Reader in Linguistics Department of Deccan College, Pune, the Chief Guest, distributed the prizes to the winners.

Hindi books worth Rs. 2,500/- especially on scientific subjects were added to the Hindi Library of the Institute.

Dr. Gorakhnath, Assistant Director and Shri. N. K. Arora, Senior Hindi Translator, Official Language Division, Department of Science & Technology, New Delhi visited the Institute on 2 February 1993 and inspected the work of Hindi implementation in the Institute. The efforts made for Official Language Implementation in the Institute were very much appreciated.

Official Language Workshop was organised during 26 February to 3 March 1993. The Workshop was inaugurated by Professor R. N. Keshavamurty, Director and attended by officials of the Rajbhasha Vibhag. Smt. A. A. Dunakhe, Assistant Director, Hindi Teaching Scheme, Pune was the Chief Guest. Certificates of earlier Hindi Examinations and Workshops were also distributed.

3.8.8 Capital Works

Possession of sixteen Type II quarters was taken and the construction of the Type IV quarters was completed. Construction work of the Library Building and the Community Hall was in progress.

3.8.9 IITM Recreation Club

The Recreation Club continued to provide sports and library facilities to the members. Two good quality carrom boards for the Sports Club and 79 books to the library were added.

Eighteen members of the Club participated in various sports events of the XXVI Annual Open Tournaments (High Power Tournaments) of the Central Government Offices for 1992-93. Dr. S. Rajamani, Assistant Director received the Runner-up prize in the Veteran's Men's Single Lawn Tennis Tournament.

Independence Day and Republic Day Tournaments were organised and prizes to the winners and runners were distributed by the Director.

A New Year Get Together of the members was arranged and Prof. P. R. Pisharoty, Former Director of the IITM, addressed the members.

The Club has constituted prizes for children of the employees of IITM who had obtained the maximum number of marks (1st, 2nd and 3rd ranks) in each of the SSC and HSC examinations held during 1992 and the prizes were distributed on the Independence Day.

The General Election of the office bearers of the Club was held on 5 February 1993 and the new Executive Committee was elected.

3.8.10 Field Research Unit

The Bangalore Field Research Unit organises and conducts wind energy surveys in the country under the Projects financed by the Ministry of Non-conventional Energy Sources, Government of India.

Ten additional wind monitoring stations were established during the year bringing the total number of stations in operation to 105 in 8 States and 2 Union Territories. While the older stations have 20 m tall instrumented masts with wind sensors at 10 m and 20 m levels, the new stations have 25 m tall instrumented masts, with sensors at 10 and 25 m levels. All the 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 for publication of Interim Reports from time to time.

"Wind Energy Resource Survey in India — II" was published during the year presenting wind speed, wind power and wind energy data collected during 1986-1991 at 50 stations in 6 States. The volume was formally released during the Wind Energy Seminar organised by the Tamil Nadu Energy Development Agency as part of "ENERGY -92" at Coimbatore in December 1992. A paper on "Wind Resource Assessment in India and Tamil Nadu" was presented during the Seminar by Dr. S. Rangarajan. He also presented a paper "Wind Energy Resource Assessment in India" during the 3-day Seminar on "Wind Energy Utilization" held at Madras and jointly organised by Max Mueller Bhavan, Anna University and the Tamil Nadu Energy Development Agency, in October 1992.

Under the wind mapping programme, 5 m tall masts were used for cup counter anemometers at 278 stations in 14 States. The supervision of the observational network in each State was done by the State Nodal Agencies and the wind data were scrutinized at Bangalore.

Eight Interim Reports of the wind energy resources survey conducted in the country using data from wind monitoring and 11 Interim Reports on wind climatology of the different States were prepared for the limited distribution among the concerned Nodal Agencies.

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List of Papers Published

Forecasting Research Division

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4. Initialization by variational adjustment of horizontal wind in a regional model : Rajagopal E. N. and Singh S. S., *Research Activities in Atmospheric and Oceanic Modelling*, G. J. Boer, Ed., WMO Report No. 17, 1992.
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13. Some experiments with multivariate objective analysis scheme of heights and winds using optimum interpolation : Sinha S. K., Narkhedkar S. G., Talwalkar D. R. and Rajamani S., *Advances in Atmospheric Sciences*, 9, 1992, 431-440.

Extended Range Prediction

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16. Impact of ENSO on monsoon rainfall : Verma R. K., *Proc. of Int. Conf. on Sustainable Development Strategies and Global/Regional/Local Impacts on Atmospheric Composition and Climate*, IIT, New Delhi, 25-30 January 1993, 156-158.

17. Indian ocean SST correlation with monsoon precipitation : Verma R. K., TOGA Notes, 10, 1992, 5-8.
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Proc. of Int. Conf. on Sustainable Development Strategies and Global/Regional/Local Impacts on Atmospheric Composition and Climate, IIT, New Delhi, 25-30 January 1993.

102. Wind and turbulence profiles in a simulated wind tunnel boundary layer : Sivaramakrishnan S. and Brij Mohan, Mausam, 43, 1992, 283-290.

Simulation Techniques for Cloud Physics Studies

103. Generation of condensation nuclei by natural ionization in the atmosphere : Kamra A. K. and Dhanorkar S., Proc. of the 9th Int. Conference on Atmospheric Electricity, St. Petersburg, USSR, 15-19 June 1992.
104. Short time variations in atmospheric electrical parameters : Deshpande C. G. and Kamra A. K., Journal of Atmospheric and Terrestrial Physics, 54, 1992, 1413-1420.

Theoretical Studies Division

Studies of Dynamic Instability

105. Simulation of north Indian ocean circulation using a simple barotropic model and some sensitivity studies ; Behara S. K., Sawant H. J. and Salvekar P. S., Mausam, 43, 1992, 353-360.

Simulation of Monsoon and Tropical Circulation Systems

106. Computer processing Evolution : Tandon M. K., Computer Society of India—Poona Chapter, Newsletter, August, 1992.
107. Fortran algorithm for divergent and rotational wind fields : Tandon M. K., Contributions from IITM, Research Report, RR 052.
108. Let us 'C' FORTRAN-90 : Tandon M. K., Computer Society of India—Poona Chapter, Newsletter, October, 1992.
109. Programming languages : Tandon M. K., Computer Society of India—Poona Chapter, Newsletter, May, 1992.
110. Some aspects of solar radiations : Tandon M. K., Contributions from IITM, Research Report, RR 054.

Computer and Data Division

111. File extract utility : Joshi R. R. and Dixit P. W., IITM Technical Report, TR 03.
112. File manager utility : Joshi R. R., IITM Technical Report TR 02.
113. Pay-role accounting system : Abraham O. and Sudarsanam S., IITM Technical Report, TR 04.
114. Sort merge utility : Joshi R. R., IITM Technical Report, TR 01.

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5. PARTICIPATION IN SYMPOSIA/CONFERENCES AND PAPERS PRESENTED

S. No.	Sem/Symp/Participant(s)	Paper(s)
1.	Seminar on Accountability in Scientific Research, INSA, New Delhi, 7 April 1992. — Dr.S.K.Mishra, DD.	—
2.	Seminar on Quality of Scientific Publications, INSA, New Delhi, 8 April 1992. — Dr.S.K.Mishra, DD.	—
3.	Short-term Intensive Programme on Abstracting and Indexing, National Institute of Small Industry Extension Training, Hyderabad, 13-24 July 1992. — Smt. A. A.Shiralkar,STO I.	—
4.	Annual Convention of Computer Society of India, Madras, 16-19 September 1992. — Kum. J. S. Pethkar, JSO.	—
5.	Second Int. Workshop on Composition and Acidity of Asian Precipitation (CAAP), BARC, Bombay, 29 September-2 October 1992. — Prof. R. N. Keshavamurty, Director (Inaugurated the Workshop) and Dr.L.T.Khemani, AD.	Acid rain problems in the Indian context: Khemani L. T.
6.	Int.Symp. on Torrential Rain and Flood, Huangshan, China, 5-9 October 1992. — Dr. R.H. Kripalani,SSOI and Shri K.K. Singh, Research Fellow.	i) Classification of 5-day monsoon precipitation fields over India and study of sub-regional precipitation extremes:Singh K.K. ii) Connection between India-China rainfall : Kripalani R. H.
7.	Fourth Annual Conf. on Indian Aerosol Science and Technology Association (IASTA), NIOH, Ahmedabad, 12-13 October 1992. — Smt. M. S. Naik, SSO II, Shri S. Tiwari, SSA,Shri K. Ali, SA and Shri S. Sharma, Research Fellow.	i) Chemistry of snow at Kalpa, Himachal Pradesh : Tiwari S., Kapoor R. K., Khemani L. T., Ali K., Singh G. and Prakash P. ii) On the radiative characteristics of urban atmospheric aerosols : Devara P.C.S., Pandithurai G., Raj P. E. and Sharma S. iii) Removal of SO ₄ , NO ₃ and alkaline particulates by wet processes: Naik M.S., Khemani L. T., Momin G. A., Rao P.S.P., Safai P. D. and Pillai A.G. iv) Role of aerosols in cloud development and precipitation: Ali K., Kapoor R.K. and Chatterjee R. N.

S. No.	Sem/Symp/Participant(s)	Paper(s)
8.	Eighth Congress of Asia and Pacific Regional Division of the Int. Association for Hydraulic Research, CWPRS, Pune, 20-23 October 1992. — Dr. P. R. Rakhecha, AD.	—
9.	SERC Conference, DST, New Delhi, 26-27 November 1992. — Prof. R. N. Keshavamurty, Director.	—
10.	Western Region Conference - 92 (WRC 92) on Emerging Trends in Information Technology, Computer Society of India, Pune, 4-5 December 1992. — Shri M.K.Tandon, SSO II.	—
11.	Winter School on Understanding the Present Climate and its Future Change over the Indian sub-continent due to Global Warming, IIT, New Delhi, 7-24 December 1992. — Shri M. Mujumdar, SSA.	—
12.	Workshop on Advanced Computing (with focus on Parallel Processing), C-DAC, Pune, 29-31 December 1992. — Shri M.K.Tandon, SSO II.	—
13.	80th Session of Indian Science Congress, NIO, Goa, 3-8 January 1993. — S/Shri.P. V. Puranik, JSO, A. A. Munot, JSO, B. S. Murthy, SSA and R. M. Soni, Sr. D'man.	—
14.	Geology of Maharashtra : Environmental and Geological aspects, Shivaji University, Solapur, 11-12 January 1993. — Dr. A. K. Kulkarni, SSO I.	Study of heavy rainfall of 8-10 June 1991 over some parts of Maharashtra : Kulkarni A.K., Mandal B. N. and Sangam R. B.
15.	Meeting to Identify Thrust/Gap Areas in Palaeoclimatology, IITM, Pune, 21-22 January 1993. — Prof. R. N. Keshavamurty, Director, Dr. G. B. Pant, DD, Dr. S. S. Singh, DD, Dr. H. N. Bhalme, DD, Dr. B. Parthasarathy, AD, Shri R. K. Verma, AD, Dr. P. R. Rakhecha, AD, Dr. L. S. Hingane, AD, Dr. Rupa Kumar, SSOI, Shri N. Singh, SSOI, Shri K. Krishna Kumar SSOI, Smt. N. A. Sontakke, JSO, and Shri H. P. Borgaonkar, JSO.	i) Dendroclimatic evidences of climatic variations over the western Himalaya : Rupa Kumar K. ii) General circulation models of palaeoclimate : Pant G. B. iii) Instrumental records of climatic change over India : Krishna Kumar K. iv) Variability of aridity over northern India and general circulation of the atmosphere : Singh N.

S. No.	Sem/Symp/Participant(s)	Paper(s)
16.	Int.Conference on Sustainable Development Strategies and Global/ Regional/Local Impacts on Atmospheric Composition and Climate, IIT, New Delhi, 25-30 January 1993. — S/Shri. K. G. Vernekar, DD, Dr. P. C. S. Devara, AD, R.K.Verma, AD, Dr. L. T. Khemani, AD, Dr., Dr. D. B. Jadhav, SSOI, S. Sivaramakrishnan, SSO I, Dr. S. S. Parasnis, SSOI, G. K.Manohar SSOI, Smt.S.G.Nagar, SSOII and P.S. P. Rao, JSO.	<p>i) Aerosol characteristics and their role in acidification of rain water in Chembur-Trombay region : Rao P. S. P., Khemani L. T., Momin G. A., Safai P.D. and Pillai A. G.</p> <p>ii) Aerosol composition over the forest regions in India : Momin G. A., Khemani L. T., Rao P. S. P., Pillai A. G. and Safai P. D.</p> <p>iii) Annual variation of NO₂ and O₃ observed over Pune using visible twilight spectroscopy : Jadhav D.B., Londhe A. L. and Bose S.</p> <p>iv) Assessment of fractional cloudiness in the boundary layer : Parasnis S. S. and Kulkarni M. K.</p> <p>v) Coupling between radiative cooling of sub-cloud layer and surface heat fluxes : Parasnis S. S.</p> <p>vi) Energy balance in the tropical circulation : Parasnis S.S. and Morwal S. B.</p> <p>vii) Impact of ENSO on monsoon rainfall : Verma R. K.</p> <p>viii) Impact of turbulence generated by wind shear on entrainment : Parasnis S. S.</p> <p>ix) Observations of NO₂ and O₃ during thunderstorms using visible spectroscopy : Jadhav D. B. and Bose S.</p> <p>x) On the energy balance at the earth atmosphere interface-a local perspective : Vernekar K. G., Saxena S., Pillai J. S. and Murthy B. S.</p> <p>xi) Parameterization of the surface fluxes from the routine meteorological surface weather data : Nagar S.G. and Seetaramayya P.</p> <p>xii) Preliminary results of annual thunderstorm activity over Indian region during 1970-1983 : Manohar G. K., Kandalgaonkar S.S., and Kulkarni M. K.</p> <p>xiii) Rain water and throughfall chemistry in the Silent Valley forest : Rao P. S. P., Momin G. A., Safai P.D., Pillai A. G. and Khemani L. T.</p> <p>xiv) Realtime monitoring of atmospheric aerosols and gases using a computer-controlled lidar: Devara P. C. S., Raj P. E., Sharma S. and Pandithurai G.</p>

S. No.	Sem/Symp/Participant(s)	Paper(s)
		xv) Study of surface ozone behaviour at urban and forested sites in India : Khemani L. T., Momin G. A., Rao P.S.P., Vijayakumar R. and Safai P. D.
		xvi) Surface potential gradient associated with monsoon onset at Pune: Kandalgaonkar S. S. and Manohar G. K.
		xvii) Turbulent diffusion in the convective boundary layer during monsoon : Sivaramakrishnan S.
		xviii) Variation of lateral dispersion parameter-sigma-(Y) with stability—a case study during monsoon 1989 : Saxena S. and Sivaramakrishnan S.
		xix) Variations in the ionic composition of convective showers: Naik M. S., Khemani L. T., Momin G. A., Rao P. S. P. and Safai P. D.
		xx) Vertical profile of atmospheric ozone using sun and sky visible spectroscopy : Jadhav D.B., Bose S., Londhe A. L. and Mehra P.
17.	XIV Indian Geographers' Meet, Madurai, 10-12 February 1993. S/Shri B.N.Mandal, SSO II, P.N. Mahajan SSOII and S.S. Dugam, SSA.	i) Short-term climatic fluctuations in North Atlantic oscillations and the frequency of cyclonic disturbances over north Indian ocean : Dugam S. S., Kakade S. B. and Verma R. K.
		ii) Use of satellite observed convective cloud data for long term rainfall estimates over the tropical Indian ocean:Mahajan P. N.
		iii) Utilisation of summer monsoon rainfall by representative dams in Maharashtra—a brief appraisal : Mandal B. N., Kulkarni A. K. and Sangam R. B.
18.	5th National Symposium on Hydrology, WALMI, Patna, 10-12 February 1993. — Dr. P. R. Rakhecha, AD	Return period analysis of annual maximum rainfall of 1-3 day duration over Bihar : Rakhecha P.R. and Soman M.K.
19.	Mini-workshop on Monsoon-92, IMS, Pune Chapter, 24 February 1993. — S/Shri R. K. Verma, AD, D. K. Paul, SSO I, Dr. A. K. Kulkarni, SSO I, Smt. U. V. Bhide, SSO II, P.V. Puranik, JSO and S. P. Ghanekar, SA.	i) Intra-seasonal fluctuation of monsoon rainfall during 1992 : Bhide U. V., Paul D. K., Puranik P. V. and Ghanekar S. P.
		ii) Monsoon-1992 and ENSO : Verma R.K
		iii) Severe rainstorms during monsoon-92 : Kulkarni A. K.

S. No.	Sem/Symp/Participant(s)	Paper(s)
20.	Tropmet-93 National Symp. on Meteorology and National Development, New Delhi, 17-19 March 1993. — Prof. R. N. Keshavamurty, Director, Dr. S. Rajamani, A. D., Kum. P. L. Kulkarni, SSOI, Shri P. V. Puranik, JSO, Shri A. A. Munot, JSO and Shri D. K. Trivedi, SSA.	i) Auto regression process in pentad rainfall over Indian region : Dahale S. D. and Puranik P. V. ii) Kinetic energy exchanges among transient, stationary and between transient and stationary waves during monsoon 1991 : Bawiskar S. M. Chipade M. D., Paul D. K. and Singh S. S. iii) Numerical prediction of tropical cyclone track in Indian seas : Trivedi D. K. and Singh S. S. iv) On the enhancement of initial divergence using OLR data in the wind analysis : Kulkarni P. L., Narkhedkar S. G., Nair S. and Rajamani S. v) Relationship between Indian summer monsoon rainfall and Kharif food grain production : Parthasarathy B., Rupa Kumar K. and Munot A. A.
21.	Indian Meteorological Society Seminar, SAC, Ahmedabad, 22 March 1993. — Prof. R. N. Keshavamurty, Director.	—
22.	Prof. K.R.Ramanathan Centenary Celebration Symposium on Futuristic Perspectives in Aeronomy and Atmospheric Science Research in India, PRL, Ahmedabad, 23-24 March 1993. — Prof. R. N. Keshavamurty, Director Shri R. K. Verma, AD and Shri K. Krishna Kumar, JSO.	i) Ocean-atmosphere interactions—significance for climate studies : Keshavamurty R. N. (invited talk)
23.	Second Monitoring Workshop on MONTBLEX Research Results, IITM, Pune, 26-27 March 1993 — Prof. R. N. Keshavamurty, Director, Shri R. Suryanarayana, DD, Dr. A. K. Kamra, DD, Dr. A. S. R. Murty, DD, Dr. G. B. Pant, DD, Shri K. G. Vernekar, DD, Dr. S. S. Singh, DD, Dr. (Mrs.) A. M. Selvam, AD, S. Sinha, AD, Shri L. K. Sadani, SSO I, Shri D. K. Paul, SSOI, Shri S. Sivaramakrishnan, SSOI, Shri S. S. Aralikatti, SSO I, Dr. S. S. Parasnis, SSO I, Shri Brij Mohan, SSOI, Smt. S. G. Nagar, SSOI, Smt. S. Saxena, JSO, Shri S. B. Debaje, SSA, Shri J. S. Pillai, SSA, Shri B. S. Murthy, SSA, Smt. S. B. Morwal, SSA, Smt. M. K. Kulkarni, SSA, Kum. M. Radhamani, SSA, Shri M. N. Patil, SSA and Smt. V. V. Sapre, STA.	i) Characteristic variation of mixed layer over the marine boundary layer : Parasnis S.S., Morwal S. B. and Kulkarni M. K. ii) Direct solution of the surface equation for estimating two-level data : Sinha S. iii) Estimation of nocturnal temperature profile using sodar inversion heights : Sadani L. K. and Murthy B. S. iv) Estimation of surface fluxes from simulated soil surface temperature : Pillai J. S., Saxena S. and Vernekar K.G. v) Fluxes of heat and momentum over sea surface during the passage of a depression in the north Bay of Bengal : Sivaramakrishnan S., Patil M. N. and Vernekar K. G.

S. No.	Sem/Symp/Participant(s)	Paper(s)
		vi) Fractal nature of MONTBLEX time series data: Selvam A. M. and Sapre V. V.
		vii) Micrometeorological observations using two level tower over head Bay during MONTBLEX-90 : Seetaramayya P., Debaje S. B., Nagar S. G. and Mullan A. H.
		viii) On the sea surface temperature (SST) variability of the head Bay in response to monsoon depression during MONTBLEX-90 : Seetaramayya P., Nagar S. G. and Mullan A. H.
		ix) On the thermodynamics of downdraft circulation in the monsoon trough region : Parasnis S. S., Kulkarni M. K. and Kunchur V. A.
		x) Study of forces in the monsoon boundary layer : Morwal S. B., Vernekar K. G., Aralikatti S.S. and Parasnis S. S.
		xi) Turbulence characteristics in ABL over Kharagpur : Murthy B. S., Patil M. N., Brij Mohan and Vernekar K. G.
		xii) Universal spectrum for turbulent fluxes of sensible heat and momentum from MONTBLEX-89 data sets : Radhamani M. and Selvam A. M.
		xiii) Wind and temperature profiles in the atmospheric boundary layer over Kharagpur during MONTBLEX-90 : Debaje S. B., Sivaramakrishanan S. and Vernekar K. G.
		xiv) Wind profile in the boundary layer over Kharagpur associated with synoptic scale systems : Paul D. K., Ghanekar S. P., Murthy B. S. and Vernekar K. G.

Total number of paper presented in Symposia/Seminars : 59

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6. PARTICIPATION IN MEETINGS

Prof. R. N. Keshavamurty, Director

Shri D. K. Paul, SSOI

- i) 15th Meeting of Programme Advisory Committee—Atmospheric Sciences (PAC-AS), Calcutta, 17 July 1992.
- ii) Inter Agency Co-ordination in Atmospheric Sciences Meeting DST, New Delhi, 20 July 1992.
- iii) Meeting of MONTBLEX Committee, NAL, Bangalore, 4 August 1992.
- iv) Assessment Committee Meeting of DRDO as Outside Expert. NAL, Bangalore, 31 August 1992.
- v) Programme Advisory Committee on ILTP, NAL, Bangalore, 1 September 1992.
- vi) Fifth and Final Steering Committee on DOD, Bangalore, 19 October 1992.
- vii) Meeting of the Scientific Advisory Committee of NCMRWF, New Delhi, 29 October 1992 and 24 November 1992.
- viii) Council for Meteorology and Atmospheric Sciences Meeting, New Delhi, 3 November 1992.
- ix) Programme Evaluation and Monitoring Committee of the DST Meeting, New Delhi, 5 November 1992.
- x) Brain Storming Session on Future Super Computer Strategy for Medium Range Weather Forecasting, DST, New Delhi, 23 November 1992.
- xi) Meeting of TOGA Monsoon Numerical Experiment Group (MONEG), IMD, New Delhi, 12-14 January 1993.

Forecasting Research Division

Dr. S. S. Singh, DD and
Shri J. R. Kulkarni, SSOI

Meeting of TOGA Monsoon Numerical Experiment Group (MONEG), IMD, New Delhi, 12-14 January 1993.

Fourth Annual Monsoon Review Meeting, IACS, Calcutta, 3 February 1993.

Climatology and Hydrometeorology Division

Dr. G. B. Pant, DD

- i) Discussion meeting regarding Past Global Changes (PAGES) Programme of IGBP, NPL, New Delhi, 6-7 April 1992.
- ii) Assessment Committee Meeting : External Expert in Meteorology, SAC, Ahmedabad, 17 June 1992.
- iii) Review of the research work of CSIR Research Fellow, Department of Meteorology and Oceanography, Andhra University, Visakhapatnam, 24-25 June 1992.
- iv) Organising Committee Meeting of National Symposium on IGBP, NPL, New Delhi, 3 August 1992.
- v) Meeting on Long Range Forecasting (LRF), its Uses and Dissemination, IMD, New Delhi, 5 January 1993.
- vi) Programme Advisory and Monitoring Committee (PAMC) Meeting on Agroclimatology, DST, New Delhi, 19 March 1993.

Dr. P. R. Rakhecha, AD

9th Meeting of Hydrometeorology Panel of Indian National Committee on Hydrology (INCOH), NIH, Roorkee, 12 October 1992.

Dr. K. Rupa Kumar, SSO I

Programme Advisory and Monitoring Committee-Environmental Science (PAMC-ES) Meeting, University of Kumaon, Nainital, 11 November 1992.

Physical Meteorology and Aerology Division

Dr. A. S. R. Murty, DD

Meeting in connection with the Cloud Seeding Programme in Gujarat State, DST, New Delhi, 18 August 1992.

Dr. L. T. Khemani, AD

International Geosphere Biosphere Programme
(IGBP) Meeting, NPL, New Delhi,
10 August 1992.

Instrumental and Observational Techniques Division

Shri K. G. Vernekar, DD

- i) MONTBLEX Monitoring Committee Meeting
NAL, Bangalore, 4 August 1992.
- ii) First Land-Surface Meeting, DST, New Delhi,
8-10 February 1993.

Theoretical Studies Division

Dr. S. K. Mishra, DD

- i) INSA Sectional Committee Meeting, New Delhi,
9-10 April 1992.
- ii) ILTP Project Advisory Committee Meeting, NAL,
Bangalore, 1 September 1992.

- iii) Brain Storming Session on Future Super
Computer Strategy for Medium Range
Weather Forecasting, DST, New Delhi,
23 November 1992.

- iv) Selection Committee Meeting (as Member) for
the post of Assistant Professor in the Centre
for Atmospheric Sciences, IISc., Bangalore,
7 December 1992.

- v) TOGA Monsoon Numerical Experimentation
Group, IMD, New Delhi, 12-14 January 1993.

Computer and Data Division

Shri R. Suryanarayana, DD (Performing duties of
Director)

- i) CMAS Meeting, New Delhi, 9 April 1992.
- ii) Project Advisory Committee Meeting, DST,
New Delhi, 20 April 1992.
- iii) Review Committee Meeting as an outside
expert, VSSC, Trivandrum, 29 April 1992.
- iv) Meeting of UNDP, New Delhi, 19 May 1992.

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7. SEMINARS

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

S. No.	Speaker	Topic	Date
1.	Dr. R.H.Kripalani, SSO I, IITM	i) Large-scale aspects of India-China summer monsoon rainfall.	3 April 1992
		ii) Interactions of the Indian summer monsoon with the Northern hemisphere mid-latitude circulation on intra-seasonal timescale.	28 September 1992
		iii) International Symposium on Torrential Rain and Flood in China.	26 November 1992
2.	Dr. K. D. Prasad, SSO I, IITM	i) Exploring the possibility of forecasting monthly 700 hPa geopotential fields over India.	11 April 1992
		ii) Relationship between El Nino/Southern oscillation and Indian monsoon rainfall using canonical correlation analysis.	19 April 1992
3.	Shri S. S. Dugam, SSA, IITM	Teleconnections between the pressure gradient between icelandic low and Azores high and Indian summer monsoon rainfall.	15 July 1992
4.	Smt.S.S.Desai, JSO, IITM	Global energy and enstrophy spectra and their spectral fluxes in the lower and upper troposphere during 1979.	20 July 1992
5.	Dr. G. Viswanathan, Project Director, M. S. T. Radar Facility, Tirupati	MST radar	27 July 1992
6.	Shri S. Sivaramakrishnan, SSO I, IITM	Some results of the analysis of MONTBLEX tower data.	29 July 1992
7.	Shri J. R. Kulkarni, SSO II, IITM	Modelling interannual variations of summer monsoons-review.	7 August 1992
8.	Shri B. S. Murthy, SSA, IITM	Doppler sodar derived winds during the nocturnal boundary layer formation over a complex terrain.	11 August 1992
9.	Shri A. Bandyopadhyay, JSO, IITM	Evaluation of forecast performance of an economical explicit time integration scheme.	12 August 1992
10.	Dr. L.Granat, Univ. of Stockholm, Sweden	i) Chemical composition of precipitation : when and where it is acidic.	20 August 1992

S. No.	Speaker	Topic	Date
		ii) Precipitation chemistry.	3 October 1992.
11.	Shri M. K. Tandon, SSO II, IITM	i) FORTRAN-90 : New era of scientific computing.	7 September 1992
		ii) Let us C FORTRAN-90.	22 September
12.	Prof. Kanji Takahashi, Kyoto, Univ., Japan	Characterisation and source apportionment of atmospheric aerosols.	11 September 1992
13.	Dr. Digvijay Singh, Former Union Minister for Environment, Gujarat	The Rio Earth Summit, June, 1992	18 September 1992
14.	Shri V. R. Deshpande, JSO, IITM	VII Summer School at University of Dundee, Scotland, Remote Sensing and Global Climate Change : A brief.	30 September 1992
15.	Dr. Kunhikrishnan, VSSC, Trivandrum	Atmospheric boundary layer studies at Thumba.	1 October 1992
16.	Dr. H. Rodhe, Stockholm University, Stockholm, Sweden.	Atmospheric modelling.	3 October 1992
17.	Dr. G. Ayers, Division of Atmospheric Research, CSIRO, Australia	International global atmospheric chemistry.	3 October 1992
18.	Dr. A. K. Kamra, DD, IITM	The onset of disintegration and corona in water drops falling at terminal velocity in horizontal electric field.	6 October 1992
19.	Shri R. Suryanarayana, DD, IITM	13th International CODATA Conference and General Assembly held at Beijing, China.	6 October 1992
20.	Dr. S. H. Damle, Microwave Division, SAMEER, Bombay	Conversion of Doppler Sodar to a Radio Acoustic Sounding System (RASS)	11 November 1992
21.	Dr. D. B. Rao, NMC, Washington D.C., USA	i) Development of marine products at NMC.	30 November 1992
		ii) Oceanic normal modes, tides and circulation.	1 December 1992

S. No.	Speaker	Topic	Date
22.	Dr. E. M. Rasmusson, University of Maryland, College Park, USA	i) An overview of the ENSO cycle.	2 December 1992
		ii) Secular variability of the ENSO cycle.	3 December 1992
23.	Shri S. D. Dahale, JSO, IITM	Persistence behaviour of rainfall over tropic during principal rainy season.	4 December 1992
24.	Shri M. D. Chipade, SA, IITM	Upper tropospheric energetics of standing and transient eddies in wave number domain during summer monsoon of 1991.	11 December 1992
25.	Dr. D. A. Bennetts, Hadley Centre for Climate Prediction and Research, U.K.	i) Transient climatic change experiments.	14 December 1992
		ii) Analysis of results and current area of uncertainty.	16 December 1992
26.	Shri J. Sanjay, SSA, IITM	Parameterization of land surface fluxes in a limited area model.	21 December 1992
27.	Shri K. G. Vernekar, DD, IITM	Land-surface processes-Local energy budget evaluation.	1 January 1993
28.	Shri Sarit Manna, University of Poona, Pune	Numerical experiments to study the impacts of moisture on monsoon circulation.	5 January 1993
29.	Dr. A. K. Ray, Fundamental Research Institute, Ottawa, Canada	Boundary layers in atmosphere, ocean and cryosphere.	8 January 1993
30.	Dr. Anandu Vernekar, University of Maryland, USA.	Effect of Eurasian spring snow cover on Indian summer monsoon.	18 January 1993
31.	Prof. T. N. Krishnamurti, Florida State University, USA	Some new results in tropical meteorology.	22 January 1993
32.	Shri M. Y. Totagi, SSOII, IITM	Power and cross spectra for the turbulent atmospheric motion and transports in the domain of wave number frequency space Part I : Theoretical aspects.	27 January 1993
33.	Dr. Gorakhnath, Assistant Director (Official Language), Department of Science and Technology, New Delhi	Implementation of Recommendations of the Parliamentary Official Language Committee (Hindi)	2 February 1993

S. No.	Speaker	Topic	Date
34.	Shri S. Dwivedi, Assistant Director, Hindi Teaching Scheme, Department of Official Language, Pune	Official Language in Administrative Correspondence (Hindi)	25 February 1993
35.	Dr. G. B. Pant, DD, IITM	Origin and use of Scientific terms in Hindi (Hindi)	26 February 1993
36.	Smt. V. M. Mudaliyar, Hindi Officer, IITM	i) Official Language Act ii) Official Language Rules and Scientific Writing in Hindi-guidance iii) Efforts to be made for implementation of Hindi iv) Different types of correspondence (All in Hindi)	26 February 1993 1 March 1993 2 March 1993 3 March 1993
37.	Shri P. N. Sharma, SSOI, IITM	Clouds : their various types and functions (Hindi)	1 March
38.	Prof. G. C. Asnani, Hon. Fellow, IITM	Some three problems of Nobel Prize Status in Tropical Meteorology.	4 March 1993
39.	Smt. A. A. Dunakhe, Assistant Director, Hindi Teaching Scheme, Department of Official Language, Pune	Origin of Numeral, Roman and Devnagari (Hindi)	25 March 1993

Lectures delivered outside the Institute

S. No.	Speaker	Topic	Date	Venue
1.	Dr. P. C. S. Devara, AD	Lasers and their Applications in Science and Engineering	24 April 1992	Vishwa Karma Institute of Technology, Pune.
2.	Dr. S. K. Mishra, DD	Energetics in Physical Space and Wavenumber domain of Atmosphere	17-21 August 1992	Andhra University, Waltair.
3.	Shri V. R. Deshpande, JSO	Remote Sensing and Global Climate Change-A brief	30 September 1992	University of Dundee, U.K.
4.	Shri S. Sivaramakrishnan, SSOI	Wind and Turbulence in Surface Boundary Layer	13 November 1992	Regional Meteoro- logical Centre, IMD, Madras.

S. No.	Speaker	Topic	Date	Venue
5.	Dr. G. B. Pant, DD	i) Weather forecasting and climatic change	20 November 1992	Symbiosis Institute of Journalism and Communications, Pune.
		ii) Past climatic changes on global and regional scales :	8 December 1992	Winter School on Climate Change, IIT, New Delhi.
		iii) Equilibrium climate models	9 December 1992	
		iv) Palaeoclimatology	8-10 March 1993	Phase 'C' Met II Training, IMD, Pune.
6.	Prof. R. N. Keshavamurty, Director	General circulation and Climate modelling	8 December 1992	Winter School on Climate Change, IIT, New Delhi.
7.	Dr. S. V. Singh, DD	Synoptic climatology	8-12 February 1993	Phase 'C' Met II Training, IMD, Pune.
8.	Dr. K. Rupa Kumar, SSOI	Applied climatology and biometeorology	22 February 2 March 1993	Phase 'C' Met II Training, IMD, Pune.
9.	Dr. P. R. Rakhecha, AD	Hydrometeorology in water management projects	10-11 March 1993	Water and Land Management Institute, Aurangabad.

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8. ACADEMIC ACTIVITIES

The Institute encourages its scientists to collaborate with the Universities and other Institutions in promoting Academic Programmes. Several scientists delivered lectures at the following Institutions :

Scientist	Topic	Academic Programme
Shri. K. G. Vernekar, DD	Atmospheric boundary layer	M. Tech., University of Poona.
Dr. S. Rajamani, AD	Objective analysis of meteorological fields	M.Sc./M.Tech., University of Poona.
Shri. D. K. Paul, SSOI	Synoptic meteorology	M.Sc., University of Poona.
	Solution of linear balance equation	M.Tech., University of Poona.
Shri. R. Vijayakumar, SSOI	Radiation	M.Sc., University of Poona.
Dr. A. K. Kulkarni, SSOI	Indian monsoon and rainstorm analysis methodology and results	M.Sc.(Agri. Met.), Centre for Advanced Studies in Agriculture Meteorology, College of Agriculture, Pune.
Shri. N. Singh, SSOI	Statistical methods in agricultural meteorology	M.Sc.(Agri. Met.), Centre for Advanced Studies in Agricultural Meteorology, College of Agriculture, Pune.
Shri. P. N. Mahajan, SSOII	Advances in satellite meteorology	M.Sc./M.Tech., University of Poona.
Shri. J. R. Kulkarni, SSOII	Dynamic meteorology	M.Sc., University of Poona.
Shri. D. R. Talwalkar, SSOII	Objective analysis of meteorological fields	M.Sc. / M. Tech., University of Poona.
Smt. N. A. Sontakke, JSO	Statistical analysis of climatological data	M.Sc. /Ph.D. (Geography), University of Poona.

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.

Name	Degree	Thesis	Research Guide
Smt. R. V. Bhalwankar, SA	M.Sc.	Wind tunnel studies of the break up of charged and uncharged water drops in horizontal electric field	Dr. A. K. Kamra, DD
*Smt. U. V. Bhide, SSOII	M.Sc.	Circulation features of southwest monsoon over southeast Asia	Dr. S. Rajamani, AD
Shri. C. S. Bhosale, JSO	M.Sc.	Middle atmospheric responses to ozone variability and to wave and monsoon activity	Dr. B. K. Mukherjee, AD

Name	Degree	Thesis	Research Guide
Shri. S. Bose, Research Fellow	Ph.D.	On studies of atmospheric nitrogen dioxide and ozone using visible spectrometer	Dr. D. B. Jadhav, SSO-I
Smt. S. S. Desai, JSO	M.Sc.	Spectral representation of various Meteorological parameters during monsoon	Dr. S. K. Mishra, DD
*Shri. C. G. Deshpande, SA	M.Sc.	The space charge distribution in the lower atmosphere	Dr. A. K. Kamra, DD
Smt. S. S. Dhanorkar, JSO	Ph.D.	Characteristics of atmospheric ions close to ground	Dr. A. K. Kamra, DD
Smt. L. George, SSO-II	M.Sc.	Energetics of the synoptic scale monsoon disturbances	Dr. S. K. Mishra, DD
*Smt. S. S. Kandalgaonkar JSO	M.Sc.	Possible urban effects on atmospheric electric field	Dr. A. S. R. Murty, DD
Shri. D. R. Kothawale, SSA	M.Sc.	Surface air temperature over India : A diagnostic study	Dr. G. B. Pant, DD
*Shri. R. H. Kripalani, SSO-I	Ph.D.	Intraseasonal fluctuations of monsoon circulation and rainfall and their prediction	Dr. S. V. Singh, DD
*Shri. B. D. Kulkarni, SSA	M.Sc.	Hydrometeorological studies of Maharashtra rainfall	Dr. O. N. Dhar, Emeritus Scientist
Shri. G. K. Manohar, SSO-I	Ph.D.	Some studies of surface atmospheric electricity parameters in different environments over Indian region	Dr. D. B. Jadhav, SSO-I
*Shri. S. G. Narkhedkar, SA	M.Sc.	On multivariate optimisation interpolation scheme of objective analysis and verification	Dr. S. Rajamani, AD
Shri. S. D. Patil, SSA	M.Sc.	Performance of summer monsoon over India and the anomalous features of the atmospheric general circulation	Dr. G. B. Pant, DD
*Shri. K. D. Prasad, SSO-I	Ph.D.	Large scale features and long range prediction of the Indian summer monsoon	Dr. S. V. Singh, DD

* Degree conferred

Shri. S. P. Ghanekar, SA obtained M.Sc. degree in Mathematics from University of Poona, as an External candidate.

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

S. No.	Supervisor	Student	Course/ Topic	University
1.	Dr. P.C.S. Devara, AD	Shri. Praveen Naresh	M.Tech.	Andhra University.
2.	Dr. G. B. Pant, DD	Shri. Shammi Raj	Ph.D.	Banaras Hindu University.
3.	Dr. S. S. Singh, DD	i) Shri. A.V.M. Subba Rao ii) Shri. Sanjib Kumar De iii) Kum. Priya	M.Tech. M.Tech. M.Tech.	Andhra University. Calcutta University. Cochin University.
4.	Dr. S. Rajamani, AD	Shri. T. Kunhikrishnan	M.Tech.	Cochin University.
5.	Dr. S. K. Mishra, DD	Shri. P. S. Josan	M.Tech.	Cochin University.
6.	Dr. D. Subrahmanyam, SSOI	i) Kum. Y. Anita ii) Kum. P. Leena	M.Tech. M.Tech.	Andhra University. Cochin University.

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

S.No.	Name	Degree	University
1.	Dr. A.S.R. Murty, DD	Ph.D. M.Sc. M.Tech.	Andhra University Andhra University Cochin University
2.	Dr. S. K. Mishra, DD	Ph.D.	IISc, Bangalore
3.	Dr. (Smt.) A. M. Selvam, AD	M.Tech.	Cochin University
4.	Dr. L. S. Hingane, AD	M.Tech.	University of Poona
5.	Dr. D. Subrahmanyam, SSOI	M.Sc.	Andhra University

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9. DEPUTATION ABROAD

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

S. No.	Name	Place/ Country	Period	Conf/Meeting/Inst.
1.	Shri H. P. Borgaonkar, JSO	U.S.A.	30 March- 26 May 1992	To visit the Laboratory of Tree Ring Research, University of Arizona, Tucson.
2.	Shri D. K. Paul, SSOI	U.S.A.	1-30 May 1992	To visit the IOWA State University uring 1-16 May and Saint Louis University during 16-29 May under the Project III of the Indo-US Climate Research Programme.
3.	Dr. S. V. Singh, DD	i) Canada	22-26 June 1992	To attend the Fifth Inter- national Meeting on Statistical Climatology at Toronto, Canada and visit Canadian Climate Centre to deliver an invited talk. He also chaired a session.
		ii) Germany	10 March- 9 September 1993	Post-Doctoral Fellowship, Max-Planck Institute for Meteorology, Hamburg.
4.	Shri V. R. Deshpande, JSO	U. K.	19 July-8 August 1992	To attend the VII Summer School on 'Remote Sensing and Global Climate Change' at the University of Dundee, Scotland.
5.	Dr. R. H. Kripalani, SSO I and Shri. K. K. Singh, Research Fellow	China	5-9 October 1992	To attend the International Symposium on Torrential Rain and Flood, Huangshan.
6.	Shri R. Suryanarayana, DD	China	19-24 October 1992	To participate in the 13th International CODATA Conference and General Assembly, Beijing, as an Indian Delegate nominated by INSA.

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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. L. Granat, University of Stockholm, Sweden.	18-23 August 1992 & 3 October 1992
2.	Prof. Kanji Takahashi Kyoto University, Kyoto, Japan	11 September 1992
3.	Dr. H. Rodhe, University of Stockholm, Sweden	3 October 1992
4.	Dr. D. B. Rao, National Meteorological Centre, Washington D. C., U.S.A.	29 November-2 December 1992
5.	Dr. E. M. Rasmusson, Senior Research Scientist, University of Maryland, U.S.A.	1-7 December 1992
6.	Dr. D. A. Bennetts, Research Coordinator, The Hadley Centre for Climate Prediction and Research, Bracknell, U.K.	12-19 December 1992
7.	Dr. A. K. Ray, Fundamental Research Institute, Ottawa, Canada	8 January 1993
8.	Dr. Anandu Vernekar, University of Maryland, U.S.A.	15-20 January 1993
9.	Prof. T. N. Krishnamurti, Florida State University, U.S.A.	21-23 January 1993
10.	Dr. C. M. Bhumralkar, NOAA, U.S.A.	8-9 March 1993

National

1. Shri. C. R. V. Raman,
Retd. Scientist, IMD. 1 April 1992
2. Post Graduate Medical
Students of B. J. Medical
College, Pune. 21 May 1992
3. A team of Directing
Staff and Student Officers
of Air Force Admin. College,
Coimbatore. 17-18 June 1992
4. Dr. S. H. Damle,
Society for Applied Microwave
Electronic Engineering Research
(SAMEER), Bombay. 6-7 July 1992
5. Shri. S. Tripathi,
Secretary, Urban
Development Deptt.,
Govt. of Maharashtra, Bombay. 17 July 1992
6. Dr. G. Viswanathan,
Project Director
M.S.T. Radar Facility,
Tirupati. 27 July 1992
7. Dr. Narayan Rao,
Tirupati University,
Tirupati. 27 July 1992
8. Dr. B. R. D. Gupta,
Banaras Hindu University,
Varanasi. 4 August 1992
9. Dr. R. P. Singh,
Department of Science
and Technology, New Delhi. 4 August 1992
10. Shri. S. Kale,
Commissioner,
Bombay Municipal Corporation,
Bombay. 6 August 1992
11. Shri. B. N. Kandarphale,
Executive Engineer,
Shri Godgarte,
Sub-Divisional Engineer,
Shri R. Tamture,
Member of Z. P.,
Shri. M. B. Shelke, Vice Chairman,
Panchayat Samitee,
Shri R. B. Swami and
Shri M. Kathi,
Representatives of Osmanabad District,
Maharashtra State. 12 August 1992

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| 12. | Dr. S. K. Pradhan,
Principal Scientific Officer,
Department of Science and Technology,
New Delhi. | 14 August 1992 |
| 13. | Prof. Khare,
Allahabad University,
Allahabad. | 17 August 1992 |
| 14. | Shri. S. Ambi,
Deputy Secretary (Finance),
Department of Science and Technology,
New Delhi. | 11 September 1992 |
| 15. | Dr. B. D. Acharya,
Director,
Department of Science and Technology,
New Delhi. | 17-18 September 1992 |
| 16. | Dr. V. Satyan,
Professor,
Physical Research Laboratory,
Ahmedabad. | 17-18 September 1992 |
| 17. | Dr. Digvijay Singh,
Former Union Minister
for Environment,
Wankaner, Gujarat. | 18 September 1992 |
| 18. | Shri. G. P. Naik,
Senior Project Officer,
British Council Division,
Bombay. | 30 September 1992 |
| 19. | Dr. Kunhikrishnan,
Vikram Sarabhai Space
Centre (VSSC),
Trivandrum. | 30 September-1 October 1992 |
| 20. | Dr. V. P. Bhatkar,
Executive Director,
C-DAC,
Pune. | 15 October 1992 |
| 21. | Shri. U. C. Kulshrestha and
Kum. Nandini Kumar,
Research Scholars,
Dayalbag Educational Institute, Agra. | 2-16 November 1992 |
| 22. | Dr. Subba Ramu,
Bhabha Atomic Research Centre.
Bombay. | 4 December 1992 |
| 23. | Ms. Manjula Rao,
Project Officer,
British Deputy High Commisioner,
Bombay. | 19 March 1993 |
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11. GOVERNING COUNCIL

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| 1. | Dr. S. M. Kulshrestha,
Director General of Meteorology,
India Meteorological Department,
Mausam Bhavan, Lodi Road,
New Delhi 110 003. | Chairman
(Ex-Officio)
Upto 30 April 1992 |
| 2. | Dr. N. Sen Roy,
Director General of Meteorology,
India Meteorological Department,
Mausam Bhavan, Lodi Road,
New Delhi 110 003. | Chairman
(Ex-officio)
From 1 May 1992 |
| 3. | Shri. S. B. Krishnan,
Joint Secretary (Finance),
Department of Science and Technology,
Technology Bhavan, New Mehrauli Road,
New Delhi 110 016. | Member |
| 4. | Shri. Y. S. Rajan,
Advisor,
Department of Science and Technology,
Technology Bhavan, New Mehrauli Road,
New Delhi 110 016. | Member |
| 5. | Prof. B. H. Subbaraya,
Physical Research Laboratory,
Navarangpura,
Ahmedabad 380 009. | Member |
| 6. | Prof. (Mrs.) Sulochana Gadgil,
Head, Centre for Atmospheric Sciences,
Indian Institute of Science,
Bangalore 560 012. | Member |
| 7. | Prof. S. K. Sinha,
Director,
Indian Agricultural Research Institute,
New Delhi 110 012. | Member |
| 8. | Prof. V.V.R. Varadachari,
Retd. Director, NIO, Goa,
Kala Nivas,
11/A Sagar Co-operative Housing Society,
Dona Paula, Goa 403 004. | Member |
| 9. | Dr. H. N. Srivastava,
Additional Director General of
Meteorology (Research),
India Meteorological Department,
Pune 411 005. | Member |

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| 10. | Shri. R. Suryanarayana,
Deputy Director,
Performing Duties of Director,
Indian Institute of Tropical Meteorology,
Pune 411 008. | Member
(Upto 9 July 1992) |
| 11. | Prof. R. N. Keshavamurty,
Director,
Indian Institute of Tropical Meteorology,
Pune 411 008. | Member
(from 10 July 1992) |
| 12. | Shri V. K. Asrani,
Administrative Officer,
Indian Institute of Tropical Meteorology,
Pune 411 008. | Non-Member
Secretary |

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Inauguration of the DST Meeting to Identify Thrust/Gap Areas in Palaeoclimatology held at the Institute during 21-22 January 1993.



Professor R. Narasimha, Director, National Aeronautical Laboratory, Bangalore, inaugurating the Second Monitoring Workshop on MONTBLEX Research Results held at the Institute during 26-27 March 1993.