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Indian Institute of Tropical Meteorology
Pune 411 008 INDIA

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Dr. Vasant Gowariker, Secretary, DST inaugurating the Indo-US Seminar held at the Institute during 6-10 August 1990.

Professor P.R. Pisharoty felicitating Professor R. Ananthakrishnan on his 80th birthday at the Indo-US Seminar.

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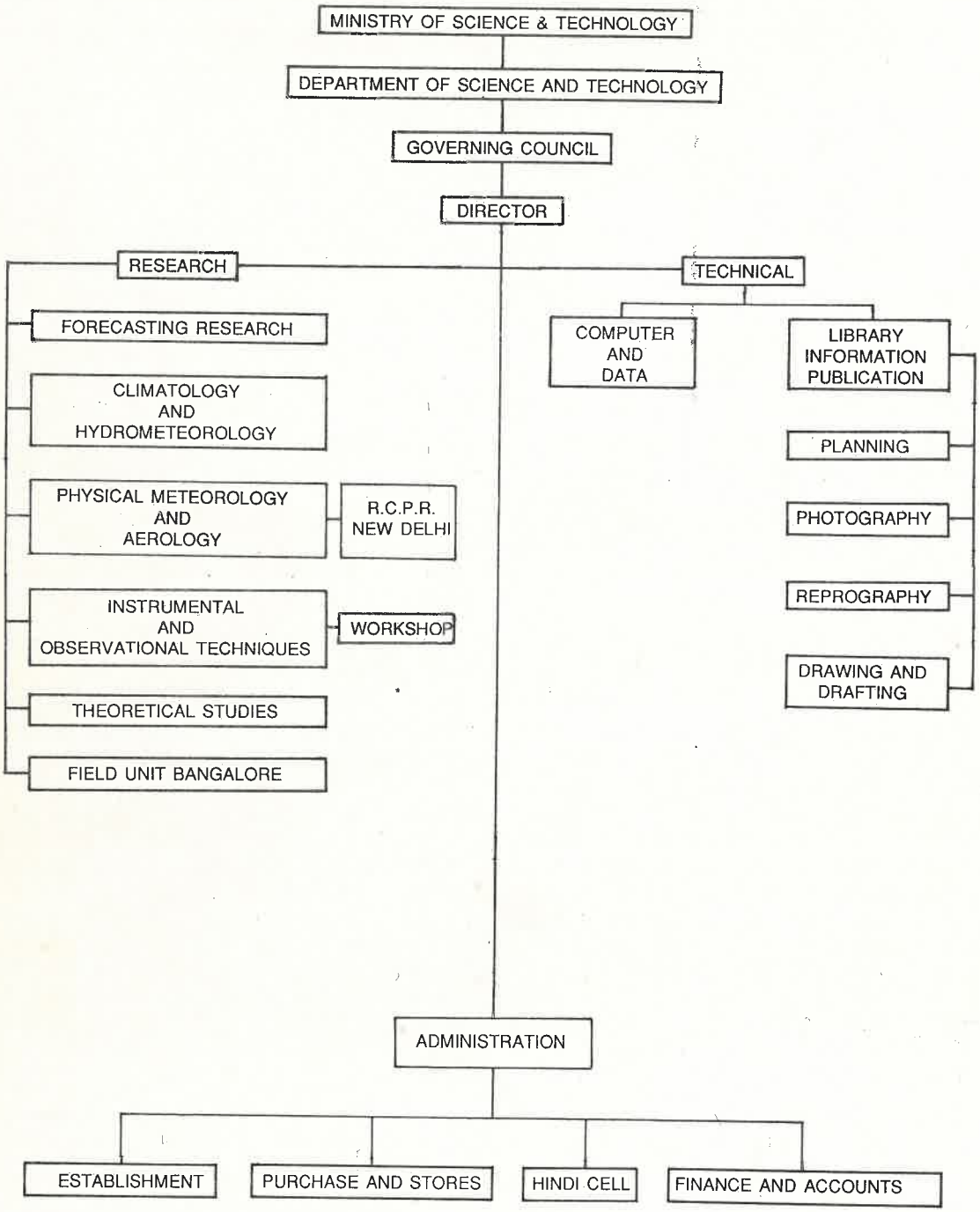
Cover Page Photograph
Institutes' new building at Pashan, Pune

INDIAN INSTITUTE OF TROPICAL METEOROLOGY



ORGANIZATIONAL PROFILE

FOREWORD

The Institute, as a National Centre of research in Tropical Meteorology, continues to make progress. During the year 1990-1991 it actively participated in many National and International Programmes particularly in the areas of Long-Range Weather Forecasting, Atmospheric Boundary Layer, Geosphere-Biosphere Interactions, Climate and Climatic Change, and Atmospheric Chemistry. The Institute maintained close association and collaboration with the India Meteorological Department and the National Centre for Medium Range Weather Forecasting Centre, New Delhi in their research and operational efforts to improve Short-, Medium- and Long-Range Weather Forecasting capabilities.

A national field programme 'Monsoon Trough Boundary Layer Experiment (MONTBLEX)' was organised and the Institute played a major role in it. A treasure of data required for the study and modelling of the atmospheric boundary layer in the monsoon trough region was collected during this experiment. The Institute also organised extensive field observations in the core zone of the Silent Valley in the Nilgiri Biosphere Reserve to study the Geo-biochemical cycles in this reserve.

With a view to promote studies in different areas of its activities the Institute played host to a number of national and international seminars/workshops. An Indo-US Seminar on Parameterization of Sub-Grid Scale Processes in Dynamical Models of Medium-Range Prediction and Global Climate was organised during 6-10 August 1990. A number of distinguished scientists from the USA and India participated in the Seminar and discussed the recent advances in various aspects of this important area. The Third World Meteorological Organisation (WMO) Workshop on Asian/African Monsoon Emphasising Training Aspects was held at the Institute during 4-8 February 1991 under the auspices of the WMO/IMD. The above Workshop was preceded by a four week training course on Monsoon Meteorology. A large number of delegates from India and abroad participated in the training course and the Workshop. At the national level the First Group Monitoring Workshop was held during 17-20 December 1990 under the auspices of the Department of Science and Technology and a large number of scientists from different organisations in the country participated in the workshop. A mini-workshop on "Monsoon-1990" was also held on 28 December 1990 under the Indian Meteorological Society, Pune Chapter. In March 1991, the Institute shifted its administrative set-up to its new complex at Pashan where its scientific and technical divisions had been shifted to the new complex in the earlier years. With this, the Institute started functioning from its own building complex at Pashan. For building this complex, efforts were initiated in November 1964, soon after the very setting up of the Institute, by its founding Director, Professor P.R. Pisharoty when he acquired a large plot of land at Pashan in the vicinity of the National Chemical Laboratory. Over the past three decades, due to the enthusiastic advocacy by the Directors of the Institute, strong and generous support from the Director Generals of Meteorology and the Governing Council of the Institute, adequate funding by the Government of India the Institute has been able to build in stages the necessary scientific, technical and housing facilities. We fondly hope that the Institute's Scientific, Technical and Administrative staff would continue to respond enthusiastically to meet the emerging challenges in research in Atmospheric Sciences.

D. R. SIKKA
Director

June 1991

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

1.3 Organisational Structure

The Research, Technical and Administrative work of the Institute is organised by 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) Scientific Computing ii) Collection and Archival of Meteorological Data
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 about 240 highly qualified scientists, technologists and administrators. As on March 1991 the staff position in eifferent categories is as follows :

	Category	Number
i)	Research	89
ii)	Scientific	59
iii)	Technical	39
iv)	Administrative	57
v)	Non-Technical Maintenance	61
	Total	305

The non-technical maintenance staff provide the support required for the maintenance of the buildings and gardening.

1.5 Budget

The Institute prepares every year budget estimates to meet the expenditure of various non-plan and plan projects sanctioned by the Governing Council and submits the budget estimates to the DST. The DST provides the funds as grant-in-aid to the Institute.

The budget estimates and the actual expenditure for the period 1990-91 are given below :

(Rs. in Lakhs)

	Budget Estimate 1990-91	**Revised Estimate 1990-91**	**Grant Received**	**Actual Expenditure**
Non-Plan	172.00	172.00	172.00	171.80
Plan	86.00	43.00	43.00	43.00

A regular review of the research projects of the Institute is carried out every year internally by an Expert Committee to optimise the objectives of the research programmes. The Institute has been following the zero-based budget system since 1989-90.

1.6 Scientific Equipment

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

Sr. No.	Equipment
1.	PH Meter
2.	UV-Photometric Ozone Analyser
3.	High Voltage Power Supply
4.	Digital Data Transmitter
5.	Three Axis Sonic Anemometer
6.	Honda Portable A.C. Generator
7.	Voltas Room Air Conditioners (4 Nos.)
8.	Wipro PC/AT Genius -386 with Epson EX-1000 dot matrix printer and HP laser jet IIP printer
9.	20 MHz Oscilloscope
10.	Beckman CO_2 Analyser

1.7 UNDP-CP IV Project Proposal

The Institute has formulated a project proposal jointly with the India Meteorological Department and the National Centre for Medium Range Weather Forecasting, New Delhi and submitted to the Department of Science and Technology seeking for the UNDP assistance under the CP-IV Programme (1991-1995). The project proposal entitled 'Meteorological Application in Agriculture' intends to develop a strong group of scientists in specified fields relating to Meteorology with applications to Agriculture.

1.8 Sponsored Projects

The Institute in addition to the on-going research programmes undertakes sponsored projects for specific studies and 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 Depart-ment
1.	Climate reconstruction for the past 1000 years over the western and central Himalayan regions using dendroclimatic approach	Dr. G.B.Pant	1988-91	6.85	DST
2.	Interaction of atmospheric chemistry with the Nilgiri Biosphere Reserve	Dr. L.T. Khemani	1989-92	13.2	DOE
3.	Modelling of the monsoon circulation	Dr. S.K Mishra	1990-91	1.00	DST
4.	Studies on the inter-annual and intraseasonal variation of the weather and climate of India	Dr. R. Ananthakrishnan	1987-92	0.75	IMD
5.	Medium range weather forecasting	Dr. S.K. Mishra	1988-91	4.96	DST
6.	Co-ordinated project on boundary layer studies	K.G.Vernekar	1987-92	22.90	DST

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2. HIGHLIGHTS

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

Long-range forecast of the southwest monsoon rainfall for 1990 based on different techniques developed at the Institute over the years was provided to the India Meteorological Department. An overall indication of normal monsoon for the year 1990 in the month of May was found to be in close agreement with the observed monsoon performance by the end of the season.

Prediction experiments with three types of lateral boundary conditions, namely (a) time invariant boundary conditions, (b) tendency modification scheme of Perkey and Kreitzberg (1976) and (c) time varying boundary conditions based on the analysis of real data were performed. The regional model was integrated up to 48 hrs using input of 17 June 1979 and 7 July 1979. The forecast results of the tendency modification scheme of Perkey and Kreitzberg (1976) incorporating the real data tendency were found to be the best. The computations of the above model were carried out at the NCMRWF, New Delhi.

Sea surface temperature (SST) data of the Comprehensive Ocean Atmosphere Data Set (COADS) obtained from the USA for the period 1950-1979 were used for investigating the relationship between the Indian summer monsoon rainfall and the Pacific ocean SSTs. Statistically significant negative correlations were noticed with the central and the east equatorial Pacific SST. This relationship keeps strengthening from the months preceding the monsoon season through December.

Organised convection in the Inter Tropical Convergence Zone (ITCZ), monsoon trough and south Pacific convergence zone was investigated using the daily positions of the maximum cloudiness zone picked at 10° longitude intervals from the satellite pictures for the years 1973 to 1984. The results indicated that the cloudiness zone is continuous from 50° E to 120° W during the non El Nino years but splits into 2 parts during the El Nino years. Gradual eastward shift of the cloudiness from 160° E - 100° W on monthly scale was also noticed during the El Nino years.

A field programme was organised to collect the tree ring samples from the forest regions near Gahan and Narkanda areas of the Himachal Pradesh. Tree core samples numbering 250 from old trees ranging in age up to 300 years were collected. Analysis of the samples collected from the Jammu and Kashmir region during the earlier expedition indicated that the summer temperature trend during the last 200 years has been practically the same as shown by the instrumental records. There was no evidence of any cooling associated with the last phase of the Little Ice Age over the region.

An examination of the model simulated doubling CO_2 scenario from the outputs of NCAR, GFDL and GISS models on the regional scale over India suggested a warming of 2-3°C in winter and 1-2°C in summer with increased summer precipitation mostly in the northern latitudes. The results of different models showed large variations.

Depth Area Duration (DAD) analysis of the severe rainstorms of durations 1 to 3 days which occurred over different river catchments of the country during the past hundred years was carried out for inclusion in the Rainstorm Atlas which is being published by the Institute.

Field observations were collected in the core zone of the Silent Valley in the Nilgiri Biosphere Reserve in Kerala during 1988-1989. The analysis of the observations of trace gases (SO_2, NO_2 and NH_3) suggested that the Silent Valley is free from long range transport of gaseous pollutants and the concentrations of trace gases were in

the range of world background values. The forest of the Silent Valley is a major source of sub-micron particles which were released from the vegetation.

Extensive studies of acid rain were carried out in different regions in India and the pH of rain water samples collected at various locations indicated that in south and northeast India, the pH is near the CO_2 equilibrated value of 5.65.

Measurements made with an ion counter, fabricated and developed at the Institute, showed that the contributions of intermediate and large ions to the conductivity of the atmosphere become significant when their concentrations are very high.

Experiments carried out to study the break-up of water drops in electric fields showed that break-up of drops occurs more readily in the presence of horizontal electric fields. Also, the drops breaking in the presence of horizontal electric fields produce corona which may be analogous to the triggering of lightning flashes in thunderstorms.

Primitive equation barotropic global spectral model developed in the Institute was integrated for 5 days with and without orography for the case of a sub-tropical anticyclonic centre at the 200 mb level. The forecast with orography appears to be in better agreement with the observations.

A linear stability analysis of monsoon circulation with an equatorial balance model indicated that major instability modes of the monsoon circulation could be obtained by a combination of the instability modes of its basic state components viz., monsoon westerly jet, easterly jet and CISK.

2.1 Participation in Bilateral Programmes

The Institute is participating in the following two Bilateral Programmes :

i) Climate Research Programme under the INDO-US Sub-Commission on Science and Technology for Atmospheric Sciences.

The Institute is the nodal agency for implementation of the Indo-US Programme on Climate Research. Under this Programme six projects have been formulated in which the Institute of Tropical Meteorology, India Meteorological Department, Indian Institute of Sciences, Bangalore, Space Applications Centre, Indian Space Research Organisation, Ahmedabad, National Institute of Oceanography, Goa are the participating Organisations from India. The projects were approved and the necessary funds have been sanctioned. Necessary action for their implementation has been initiated.

The Indo-US Sub-Commission on Science and Technology for Atmospheric Sciences in its meeting held at New Delhi during 3-5 November 1987 recommended holding an Indo-US Seminar on Parameterization of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate. The above Seminar was organised at the Institute during 6-10 August 1990. Experts working in different areas of parameterization of physical processes from India and USA participated in the Seminar and about 50 papers were presented. The papers are being edited for bringing out a special publication.

MR. William Clark, US Ambassador to India and MR. John J. Eddy, US Consul General at Bombay visited the Institute on 6 July 1990 and held general discussions with the Director regarding the scientific collaboration between India and USA in the area of Atmospheric Sciences.

ii) Indo-USSR Long Term Programme

Under the Indo-USSR Long Term Programme (ILTP) three scientists, Dr. A.L. Brekhovskikh, Professor A.A. Kordzadze and Dr. Yu. N. Skiba, who had come to the Institute in December 1989, continued their collaborative research work in atmospheric modelling for different periods ranging from 4 to 11 months. They delivered several lectures on atmospheric modelling at the Institute and four scientific reports containing the collaborative research work were published by the Institute during 1990.

Visit of Mr. William Clark, U.S. Ambassador to India,
Mr. John J. Eddy, U.S. Consul General at Bombay
to the Institute on 6 July, 1990.

Concluding Session of the Indo-US Seminar held at
the Institute on 10 August, 1990.

Dr. H. Kondo of the World Meteorological Organisation addressing the Third WMO/IMD Regional Workshop held at the Institute during 4-8 February, 1991.

Participants in the WMO/IMD Training Course on Monsoon Meteorology held at the Institute during 7 January—1 February, 1991.

2.2 International Seminars/Workshops

An Indo-US Seminar on 'Parameterisation of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate' was held at the Institute during 6-10 August 1990. The seminar was sponsored by the Department of Science and Technology, Government of India and the National Science Foundation, USA. The seminar was inaugurated by Dr.Vasant Gowariker, Secretary, Department of Science and Technology. Twentv two scientists from India and twenty four scientists from USA presented papers in the seminar. A large number of scientists from different Scientific Organisations and Universities participated in the Seminar.

Third World Meteorological Organisation Regional Workshop on Asian/ African Monsoon Emphasising Training Aspects was held at the Institute during 4-8 February 1991 under the auspices of the WMO/IMD. The prominent international participants include Dr. H. Kondo (WMO), Dr. G. Holland (Australia), Dr. M. J. Manton (Australia), Dr. K. Puri (Australia), Dr. M. Murakami (Japan), Dr. A.C.M.Beljaars (ECMWF) and Dr. B.K. Cheang (Malaysia). The above Workshop was preceded by a four week training course on Monsoon Meteorology. The Workshop was attended by 86 delegates of which 30 were from foreign countries. The workshop was inaugurated by Dr.Vasant Gowariker, Secretary, Department of Science and Technology, Government of India.

2.3 National Seminars/Workshops/ Meetings

Eighth meeting of the Programme Advisory Committee (PAC) of the DST was held at the Institute on 3 August 1990.

First Group Monitoring Workshop on Atmospheric Sciences and Meeting of the PAC of the DST was held at the Institute during 17-20 December 1990.

A Mini Workshop on Monsoon-90 of the Indian Meteorological Society, Pune Chapter was held at the Institute on 28 December 1990.

2.4 Field Experiment

The Institute was one of the major participants in the national Field Programme MONTBLEX which was completed in mid-September 1990. Its major instrumental facilities acquired/fabricated for the study of the atmospheric boundary layer were deployed at the IIT, Kharagpur and several scientists from different organisations participated in the programme. Two scientists from the Institute also participated in the ORV Sagarkanya cruise which was specially undertaken to collect the atmospheric and oceanographic observations from the ship stationed at 20°N, 89°E in the head Bay of Bengal during the period 5 August - 26 September 1990 as a part of the MONTBLEX-90.

2.5 Participation in the Indian Science Congress, Indore

The Institute participated in the exhibition arranged at the 78th Session of the Indian Science Congress held at Indore during 3-8 January 1991. The theme was 'Coping with Natural Disasters : An Integrated Approach'. Shri D.R.Sikka, Director presented an invited paper 'Weather and climate related natural disasters' on 6 January 1991 and three other scientists of the Institute participated in the exhibition.

2.6 Awards

Dr. S.V. Singh, A.D. and Shri K.D.Prasad, SSO-I were awarded the Silver Jubilee Prize consisting of Rs.5,000/- (shared equally by them) for their paper entitled, 'Large scale features of the Indian summer monsoon rainfall and their association with some oceanic and atmospheric variables'. The award was presented by Prof. P. R. Pisharoty, on 6 August 1990 during the Indo-US Seminar on Parameterisation of Sub-Grid Scale Processes in Dynamical Models of Medium Range Predication and Global Climate held at the Institute.

Dr. (Miss) K. Indira, JSO, received an award of young scientists for the best presentation of her paper entitled, 'Changes in dynamical parameters of the middle atmosphere associated with storm activity' at the Seminar on 'Geophysics in National Development' held at the Banaras Hindu University, Varanasi, during 29-31 August 1990.

The paper entitled, 'Estimation of fluxes from the wind and temperature profiles in the marine atmospheric surface boundary layer' by K.G. Vernekar, S. Sivaramakrishnan, Brij Mohan and S.Saxena was awarded the J. Das Gupta Award for 1987-1988, instituted by the Indian Meteorological Society. The award was presented by the Secretary, DST, on 4 February 1991 during the WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects held at the Institute.

Dr. P.C.S. Devara, A.D. has been awarded membership of the Institution of Electronics and Telecommunication Engineers (IETE) in recognition of his research contributions in Atmospheric Sciences.

2.7 Consultancy Services

At the request of the Government of Gujarat, the Institute provided technical assistance in their cloud seeding operations carried out in the Kutch and Saurashtra regions during August 1990. A report on the above operations was submitted to the Government of Gujarat in November 1990. The outcome of the cloud seeding operations appears to be promising. The Government of Gujarat paid Rs.41,323/- as consultancy charges to the Institute for providing the technical assistance in their cloud seeding operations.

At the request of the Rashtriya Chemicals and Fertilizers (RCF), Bombay, the Institute organised an extensive field observational programme to investigate the spread of acid rain in the Chembur-Trombay regions during the summer monsoon season of 1990. The results of the study provided a new observational evidence.

At the request of the Bombay Suburban Electric Supply (BSES) Ltd., Bombay, the Institute provided technical guidance to them for obtaining the site clearance from the environmental angle for their proposed 500 MW thermal power plant at Dahanu from the State and Central Government authorities.

Hydrometeorological advice and assistance was provided to the Civil Engineers of the Irrigation Department, Government of Tamil Nadu to carry out the Probable Maximum Precipitation (PMP) estimates of Sathanur dam project on Ponnaiyar river.

2.8 Hindi Workshop

An in-house workshop on implementation of Hindi as an official language was organised at the Institute during 14-31 January 1991.

2.9 National Science Day

The Institute celebrated the National Science Day on 28 February 1991 befitting with this year's theme 'Learning and doing science can be full of fun and joy'. Several popular science lectures by the senior scientists and film shows relating to the above theme and to remind about the achievements of the eminent scientists like Sir C.V. Raman and Dr.S. Ramanujan were arranged on the occasion.

2.10 Children Meet Scientists

'Children Meet Scientists' programme was organised at the Institute on 28 February 1991. The National Council for Educational Research and Technology (NCERT), New Delhi has recognised the Institute as the Centre in Pune for the celebration of the 'Children Meet Scientists' programme every year and the necessary funds were also provided by the NCERT for the purpose. About 100 children studying in Higher Secondary Schools in Pune were invited and popular scientific film shows were arranged. The children took great interest in the scientific programme. Refreshments were also arranged for the participants.

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3. OVERVIEW

3.1 FORECASTING RESEARCH DIVISION

The economy of the country is largely dependent on agricultural production vis-a-vis the monsoon activity. Recognizing the importance of the monsoon understanding and prediction, the Division has undertaken research programmes relating to short-, medium-, and long-range weather prediction with the following objectives :

* Development of regional NWP models
* Parameterisation of physical processes and improved boundary conditions and their validation
* Development of objective analysis for NWP models including the use of satellite OLR and wind data
* Intra-seasonal and inter-annual variability of monsoon rainfall including studies of teleconnections for long-range forecasting
* Diagnostic studies of the atmospheric dynamical and physical processes on regional and planetary scales

Considerable progress has been made in weather forecasting due to the research carried out by the centres of weather forecasting like the European Centre for Medium Range Weather Forecasting (ECMWF), U.K. and the National Meteorological Centre (NMC), USA. In order to develop models for weather forecasting in tropics, a National Centre for Medium Range Weather Forecasting (NCMRWF) was established by the Department of Science and Technology at New Delhi in 1989. The Institute is interacting with the NCMRWF in its research work leading to improved weather forecasting capabilities.

3.1.1 Regional NWP Modelling

Prediction experiments with three types of lateral boundary conditions, namely, (a) time invariant boundary conditions, (b) tendency modification scheme of Perkey and Kreitzberg (1976) and (c) time varying boundary conditions based on the analysis of real data were performed. The regional model was integrated upto 48 hrs using inputs of 17 June 1979 and 7 July 1979. The forecast results of the tendency modification scheme of Perkey and Kreitzberg incorporating the real data tendency were found best. Computations for the studies were carried out at the NCMRWF, New Delhi using the CRAY X-MP-14 super computer.

A radiation package to parameterize radiative heating/cooling due to long- and short-wave radiation was developed and incorporated in the six level primitive equation model. The model was integrated up to 48 hrs using the input data of 12 GMT, 7 July 1979. The forecast results with radiation physics of the test run showed marginal changes when compared with the results obtained without radiation.

The P.E. barotropic model was integrated up to 48 hrs with three different sets of input data, viz., FGGE data set, forecast data set and persistency data set. The results showed that for both zonal (u) and meridional (v) wind fields of the 24 hr and 48 hr r.m.s. errors in case of FGGE data set are smaller than those obtained in the other two sets for both 220 km and 100 km grid resolutions and for all the three synoptic cases.

Under the Indo-USSR ILTP Programme, a three dimensional primitive equation model based on splitting up method suggested by Prof. G.I. Marchuk was developed for north-Indian ocean. The model geometry includes 46°E-99°E and 1° N-26° N and has 31 levels (up to 6000 m). Preliminary results obtained after 70 days of integration were compared with the results of the 15-level model. Results obtained after 150 days of integration of the model also showed similar features. This programme is being jointly carried out with the Theoretical Studies Division of the Institute.

Analysis of the surface meteorological data collected in the head Bay region

(20°N, 89°E) from the ORV Sagarkanya during 17 August to 1 September and 8 to 19 September 1990 as a part of MONTBLEX-90 field programme indicated that the net heat flux received at the sea surface is always positive even during the bad weather conditions. The transfer of latent heat, sensible heat and momentum fluxes increased very rapidly following the development of a depression. The transfer of the energy at the air-sea interface was rather weak during the initial stages but increased rapidly following the displacement of the low pressure centre westward. The sea level pressure variations, which were closely associated with the development of the low pressure system, showed a cycle of 5-6 days.

3.1.2 Objective Analysis Including Satellite Input

In connection with the development of an objective analysis scheme for the mean sea level pressure field, the structure functions and autocorrelation functions were computed using the daily data (mean sea level pressure) of 10 July-months. Three different types of candidate correlation functions were fitted to the autocorrelation functions. They are (i) Gaussian function (ii) second order autoregressive function and (iii) damped cosine exponential function. It was found that the damped cosine exponential function is slightly better than the second order autoregressive function which, in turn, was found to be better than the Gaussian function. Regression relations were developed between low and high level GOES cloud motion vectors and the daily radiosonde winds obtained from the research ships. These relationships were used to construct the vertical profiles of winds. Inclusion of these constructed wind profiles in the analysis resulted in better depiction of the geometry of the monsoon systems over the data sparse oceanic regions. In another method the winds at different vertical levels were obtained by fitting polynomial surfaces to the ratio of the winds at the desired level to that at 850 hPa level. These polynomial surfaces were then used to reconstruct winds at the desired level. This method also provides reasonable statistics of the analysed winds.

3.1.3 Extended Range Prediction

The SST data of the COADS (Comprehensive Ocean Atmosphere Data Set) for the period 1950-79 were used to investigate the phase relationship between the Indian summer monsoon rainfall and the El Nino region SST anomalies. Maps of the correlation between monsoon rainfall and the SST anomalies in the tropical Pacific at different time lags were prepared. The analysis revealed statistically significant negative correlation between the Indian summer monsoon rainfall and the east equatorial pacific SST. The noteworthy point of this relationship revealed through these maps, is that the correlation values though statistically significant, are smaller during the months preceding the monsoon but become successively greater through December after the monsoon. This is suggestive of a positive feedback between the ENSO and monsoon.

The prediction of the Indian summer monsoon rainfall based on the deterministic chaos approach was attempted. The results showed that the approach has 83% probability of correctly predicting the change in the Indian summer monsoon rainfall from the preceding year to the current year.

The relationships between the winter time temperature of De Bilt, Netherlands and the Indian summer monsoon rainfall for all India, northwest India and Peninsular India were investigated using the data for the period 1957 to 1990. January temperature anomalies of the De Bilt showed significant positive correlation with the Indian rainfall. The regression equations were developed to estimate the rainfall of all the three regions by using this parameter.

A statistical model incorporating the January-February Northern hemispheric surface air temperature anomaly and the 200 hPa angular momentum transport anomaly over northwest India during May was used to forecast the rainfall of the monsoon season in 1990. The forecast was estimated to be 106% of the normal. The observed rainfall of the monsoon 1990 was also about the same.

Canonical correlation technique was used to study the relationship amongst three ENSO parameters and of these parameters with the Indian rainfall using monthly data for 80 years. The ENSO parameters considered were the (i) Darwin MSL pressure, (ii) central and east equatorial Pacific SST and (iii) Line Island rainfall. The Indian rainfall is found to be significantly related with these parameters, the best association being with the SST. The relationships between these parameters and the rainfall strengthen as one progresses from pre-monsoon months to the post-monsoon months.

Interannual variability of the spatial patterns of the seasonal rainfall was studied by objectively classifying the maps of percentage departures from the normal for 120 years (1871-1990). Three objective procedures, viz., (i) map to map correlation method, (ii) k-means clustering method and (iii) empirical orthogonal function analysis were employed. The results show that the most dominant patterns are ENSO related. It was also seen that large areas may experience deficiency or excess rainfall of ± 25% even in the years of normal all India rainfall.

Evolution of the 5-day Outgoing Longwave Radiation (OLR) anomalies over the Indo-Pacific region was studied by constructing the Hovemoller diagrams in the north-south and east-west directions and by the extended Empricial Orthogonal Function (EOF) analysis. It was found that the frequency of the northward progressions decreases and the southward progression increases as we move eastward from the Indian region to the central Pacific. It was also found that the eastward progressions dominate in the equatorial latitudes and the westward progressions in the subtropical latitudes.

3.1.4 Monsoon Studies and Forecasting

The onset of southwest monsoon over Kerala occurred early on 20 May during 1990. Causes of this early onset were investigated by analysing monthly mean upper air data over the Indian region for May 1990. One of the causes appeared to be the warmer middle and upper tropospheric temperatures which in turn can be attributed to changes in mid-latitude circulation features (Figure 1) and organised convective activity and latent heat released due to a severe cyclonic storm formed during 5-10 May over the Bay of Bengal.

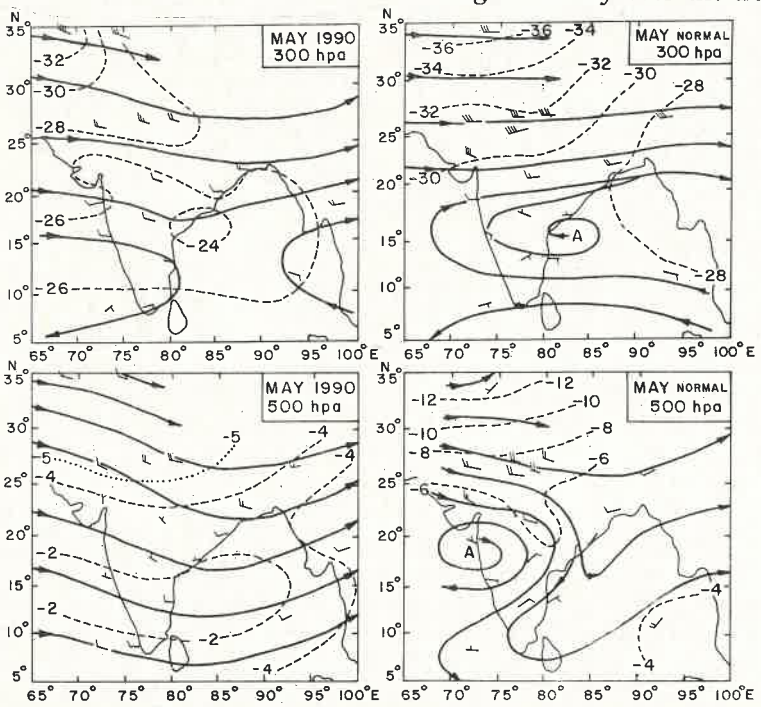


Figure 1 :
Winds and temperature patterns over India for May 1990 compared to long term normal patterns. (Upper panel : 300 hPa, Lower panel : 500 hPa)

Variations of weekly SST over the Arabian sea of southwest coast of India during (May-August) were studied in relation to the organised convection by using the data for 12 years (1979-1990). Cooling of the sea surface was observed to occur over this region a few days after the onset of monsoon over Kerala and progresses in steps with short spells of warm episodes within it. A relationship between this warm-cold episode of the Arabian sea and the fluctuation of large scale organised convection over the region has been observed (Figure 2). The cooling can be attributed to (i) increased sensible and latent heat flux, (ii) increased evaporation due to strengthening of surface winds and (iii) reduction of net radiation at the sea surface due to the organised convection over the Arabian sea with warmer SSTs.

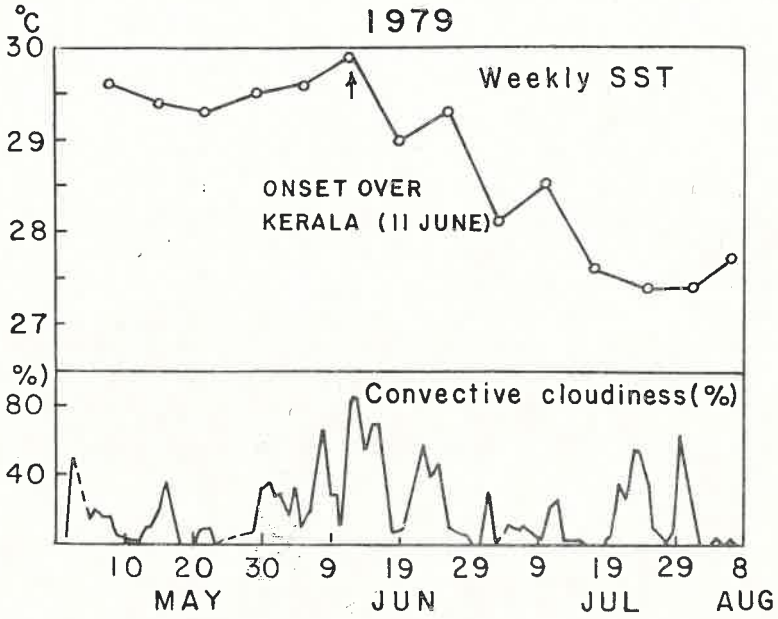


Figure 2 :
Weekly average sea surface temperature and daily percentage coverage of convective cloudiness over southeast Arabian sea (Eq.-12.5° N, 60°-77.5°E) for the period from May to July, 1990.

Organised convection in the ITCZ, monsoon trough and south Pacific convergence zone was studied by using the daily positions of the maximum cloudiness zone picked at 10° longitude intervals from satellite pictures for the years 1973-1984. The results showed that the cloudiness zone is continuous from 50°E to 120°W during the years but splits into 2 parts during the El Nino years. Gradual eastward shift of the cloudiness from 160°E to 100°W on monthly scale was also noted during the El Nino years.

The energetics of the 200 hPa level circulation between 25°N-5°S zone was studied for contrasting monsoon years using the NMC wind data for June through August. It was found that the total wave to wave interaction leads to positive imbalance of the kinetic energy during the normal monsoon years (1970,1971) and the negative imbalance during the drought years (1972,1979).

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 has significant impact on the agricultural production and overall economy of the country. There is a global concern about the increasing human activities resulting into the enhancement of concentrations of certain greenhouse gases and their impact on global climate. To assess the magnitude and impact of these

climatic changes a knowledge of the regional climate and weather fluctuations is essential. The Division has formulated research programmes for the study of the regional climate and related changes including the hydrometeorological aspects. The programmes have the following objectives :

* Improving the understanding of the physical and dynamical factors associated with abnormalities in the behaviour of the monsoon on intra-seasonal, inter-annual, decadal and longer time scales. To estimate the probable trends of future climate of India over the period of many decades
* To develop statistical multiple regression models using appropriate parameters to obtain the quantitative estimates of the seasonal monsoon rainfall. For this purpose a variety of meteorological parameters on the regional and global scales are examined to study their relationship with the southwest monsoon
* Hydrometeorological analysis of a sufficiently long series of rainfall data on different time scales for various river basins of the country for the planning and design of the water resource management projects
* Estimation of Probable Maximum Precipitation, Depth-Area-Duration Analysis of severe rainstorms and development of quantitative precipitation forecast models for flood forecasting

3.2.1 Climate and Climatic Change

(a) Diagnostic Studies Relating to the Long Range Forecast of the Summer Monsoon Rainfall

A comprehensive analysis was carried out on the space time variability of the 500 hPa ridge axis locations over India during the pre-monsoon season and its influence on the monsoon rainfall using data on the daily ridge locations from 1 March to 31 May for the period 1967-1990. The analysis indicated a negative association throughout March and early April and positive later on. The negative peak Correlation Coefficient (CC) was found between the mean ridge location of the period 12 March to 1 April and the All-India monsoon rainfall (-0.47) while the positive peak CC (0.63) was found for the period 17 April to 7 May. The negative relationship of the March ridge was more dominant with the monsoon rainfall of the southern sub-divisions while the positive relationship of April ridge is more dominant with the monsoon rainfall of the northern sub-divisions (Figure 3 and 4).

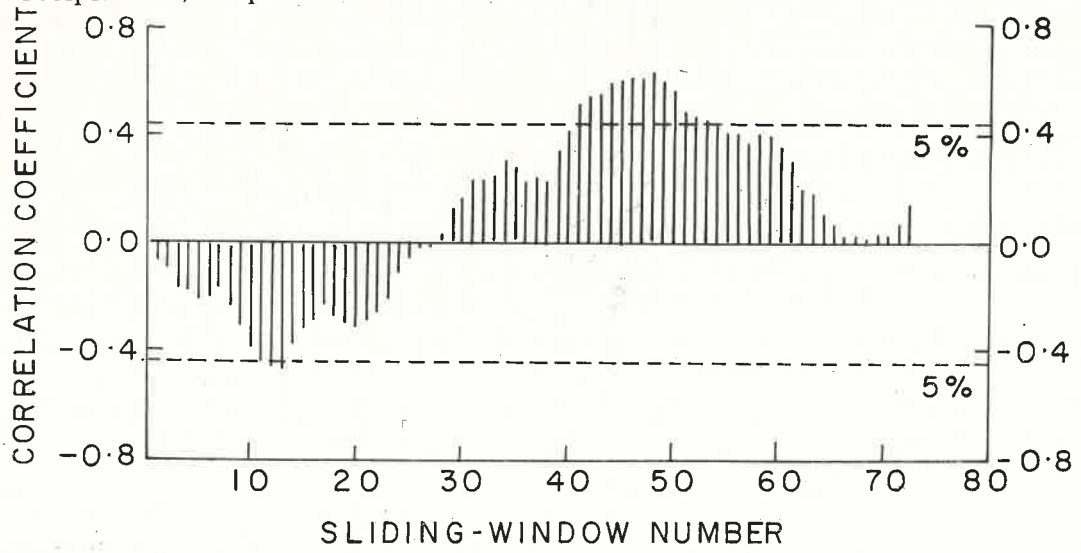


Figure 3 :
CCs between all-India summer monsoon rainfall and runing means of ridge location (0530 IST) over 21-day window.

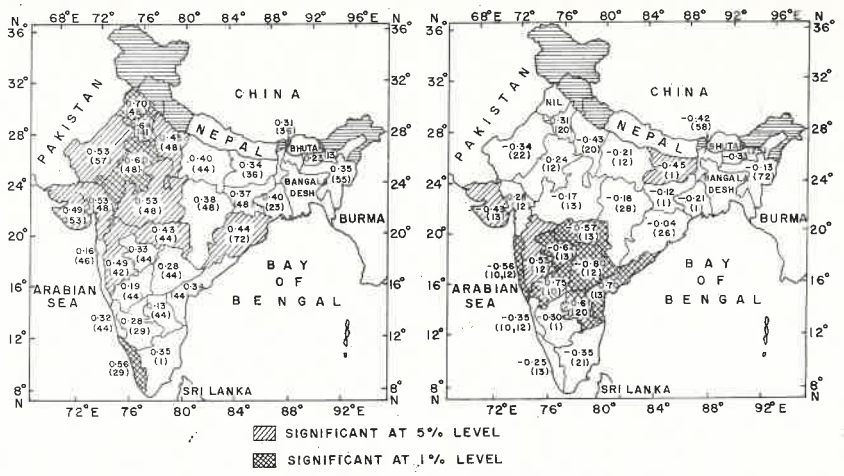


Figure 4 :
Distribution of peak CCs between the sub-divisional monsoon rainfall and the 21-day ridge locations. Numbers in parantheses indicate the corresponding 21-day running mean window numbers. (a) Positive CCs; (b) Negative CCs.

Surface pressure during the spring season (MAM) and its seasonal tendency from winter to spring (MAM-DJF) throughout India was found to be negatively correlated with the subsequent all-India monsoon rainfall. The CCs were significant with the pressures over central and northwestern regions. The spatial average of the msl pressure at six stations over West Central India (WCI), viz., Jodhpur, Ahmedabad, Bombay, Indore, Sagar and Akola showed a highly significant and consistent CC of -0.63 for MAM and 0.56 for MAM-DJF during the period 1951-1980.

(b) Long-Range Forecast of Monsoon 1990

Long-range monsoon season rainfall forecast for 1990 based on different techniques developed at the Institute over the years were passed on to the India Meteorological Department. All the techniques gave an overall indication of a normal monsoon for the year. The results were found to be in close agreement with the observed monsoon performance by the end of the season.

(c) Long-term Climate Variability

All-India summer monsoon rainfall series for the 178-years (1813-1990) based on a progressively increasing station density from 1813-1870 and then fixing the uniformly distributed station number to 36 from 1871 to 1990 was constructed. The statistical scheme takes care of the variance due to increasing network of stations during the period 1813-1870. Analysis of the series suggested that the basic characteristics of the rainfall have been found to be stable (Figure 5). Limited number of easily available observatory stations selected to construct this long time series would be useful for updating the series every year.

An examination of the results relating to the simulated doubling of atmospheric CO_2 on a regional scale over India obtained from the NCAR, GFDL and GISS General Circulation Models indicated a general warming of 2-3°C in winter and 1-2°C in summer with increased summer precipitation mostly in the northern latitudes. However, there were large variations in the magnitudes of temperatures predicted by different models.

A field programme was organised to collect tree ring samples from the forest regions near Gahan and Narkanda areas of the Himachal Pradesh. Tree core samples numbering 250 from old trees ranging in age up to 300 years were collected. Analysis

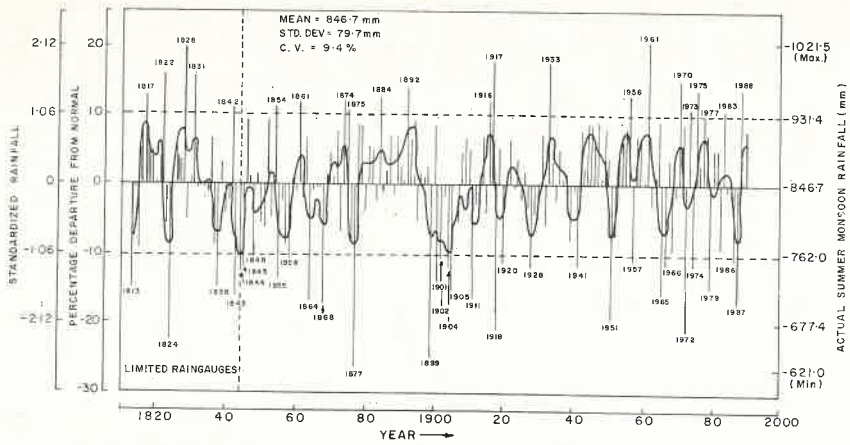


Figure 5 :
All-India summer monsoon rainfall series for the period 1813-1990. The curve indicates 5-point binomial low pass filter.

of the samples collected from the Jammu and Kashmir region during the earlier expedition indicated that the summer temperature trends during the summer seasons of the past 200 years were practically the same as shown by the instrumental records. Though the period of reconstruction covers the last phase of the Little Ice Age, there was no evidence of the associated cooling generally over the region.

All-India summer monsoon rainfall series prepared by averaging the estimated non-exceedance gamma probability of the station rainfall amount was found to be the most representative and could explain the maximum variance observed among the rainfall series of different stations.

(b) Studies on Atmospheric Ozone and Other Trace Gases

The extreme ozone minimum over the regions of Antarctica, Southeast Asia and west Pacific was investigated in association with the important meteorological features over the region. The changes in the tropopause heights over these regions and 100 hPa temperatures were found to be associated with the variations in total ozone. These associations could be explained in terms of the thermal and dynamical processes of the atmosphere over the region.

3.2.2 Hydrometeorological Studies

Quantitative Precipitation Forecasting (QPF) for Narmada catchment was carried out by the method of stepwise regression analysis. Daily upper air data for the southwest monsoon season of the year 1979 were used to determine various dynamical parameters such as vorticity, divergence, vertical velocity etc. The dynamical parameters and catchment antecedent rainfall which have got a high degree of correlation with the catchment rainfall were used in the development of multiple regression equations.

At the request of the Irrigation Department, Government of Tamil Nadu, studies relating to the Probable Maximum Precipitation (PMP) for Ponniar river catchment up to Sathanur dam site (area 11000 km^2) were carried out. The isohyetal pattern of May 1943 rainstorm, which was identified as the most severe one, was transposed over the catchment to achieve the maximum average raindepths over the catchment. The transposed raindepths up to the dam site for 1-day and 2-day durations were found to be 21.2 cm and 28.6 cm respectively. These estimates after maximization will be used in the revision of the spillway capacity of the existing dam.

Daily rainfall data for the period 1901-1970 were examined to determine maximum

rainfall values for 1 to 5 days durations for each year of their record for about 400 stations. These data will further be utilized for estimating the rainfall for durations ranging from 2 to 5 days.

The annual maximum rainfall series for the period 1901-1980 for 200 stations distributed in different river basins of Maharashtra were analysed with a view to predict 1-day maximum rainfall events for varying recurrence intervals ranging from 2 to 100 years. The maximum 1-day rainfall for river basins of Maharashtra were found to be about 8-25 cm, 10-30 cm, 12-40 cm and 15-50 cm for the 2,10,50 and 100 years recurrence intervals respectively.

The analysis of the rainstorm which occurred during 23-25 July 1989 in the Marathwada region causing very severe flooding in almost all the major rivers in the Maharashtra was carried out. The rainstorm was unique in the sense that it gave two distinct zones of maximum rainfall with their centres at Bhira and Bhir located at windward side of the western ghats and the interior region of Maharashtra respectively. The station, Bhir recorded 34.6, 38.0 and 39.2 cm while Bhira recorded 71.3, 74.9 and 95.7 cm during the 1-, 2-, and 3-days duration respectively. The maximum 1-day rain amount at Bhir approached the corresponding 1-day PMP of 35 cm. The rainstorms analysis for 1-, 2-, and 3-days was carried out by DAD method. It was found that with storm centre at Bhira, the maximum depths of rainfall recorded over an area of 30,000 km^2 during the 1-and 2-days were 25 cm and 51 cm respectively.

Depth-Area-Duration (DAD) analysis of severe rainstorms of durations ranging from 1 to 3 days which occurred over different river catchments of India during the last 100 years was carried out and an Atlas containing these maps and a detailed description of the synoptic situations is being published by the Institute.

3.3 PHYSICAL METEOROLOGY AND AEROLOGY DIVISION

The physical processes relating to the formation of clouds and precipitation, atmospheric electricity, upper atmosphere and atmospheric chemistry are the important areas of research undertaken by the Division. The objectives of the programmes are the following :

* Documentation of the dynamical, microphysical and electrical characteristics of monsoon clouds
* Precipitation mechanisms in monsoon clouds
* Warm cloud modification experiments/ operations for increasing the rainfall
* Atmospheric boundary layer studies
* Deterministic chaos and its applications in atmospheric sciences
* Middle atmospheric dynamics and its association with the Indian summer monsoon rainfall
* Atmosphere-Biosphere interactions/acid rain
* Lidar and Spectrometric measurements of atmospheric aerosols/trace gases

The Institute has placed great emphasis on the studies relating to Atmosphere-Biosphere Interactions and made significant contributions to the International Geosphere Biosphere Programme (IGBP) which was formulated with a focus on a set of key research questions of critical unknowns relating to the global environmental change.

3.3.1 Studies in Atmospheric Electricity

A theoretical study of the electric field inside the cumulonimbus cloud was investigated simulating the ice crystal-hailstone inductive mechanism and the model results were validated using the field observations.

Analysis of the observations of the atmospheric electric field, Aitken nuclei, gaseous pollutants (SO_2, NO_2 and NH_3) obtained from different environments, viz., urban, non-urban and marine indicated significant correlations between the atmospheric electric field and Aitken nuclei concentrations. The electric field appears to be associated with gaseous pollutants. The investigations suggested that

atmospheric electric parameters could be used as signatures of the particulates and gaseous pollutants. The mean variations in the atmospheric electric field, Aitken nuclei obtained from the observations recorded at Pune, during 1981-1987 are shown in Figure 6.

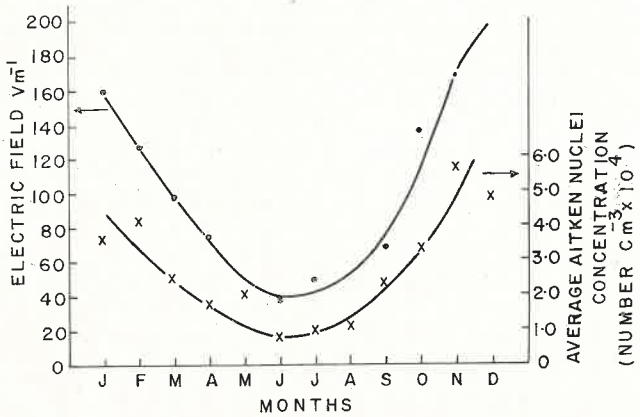


Figure 6 :
Variations in the fair weather electric field and Aitken nuclei concentration at Pune during the period 1981-1987.

3.3.2 Radar Study of Rain and Rain-bearing Clouds

Frequency of occurrence of rainfall and its spatial distribution in the Delhi region were studied using the rainfall data obtained from the dense network of 21 raingauge stations located within 25 Km around the Rain and Cloud Physics Research Centre, New Delhi. The analysis of the rainfall data suggested that the rainfall occurred on 33% of the days in a year on the average. Out of this, the mean rainfall of the individual days was found to be between 0.1 mm and 5 mm in 70% of the days and only in 5% cases the mean rainfall per day exceeded 25 mm. Seasonwise analysis indicated that the rainfall occurred on about 18, 31, 68 and 9% of the days during the winter, hot-weather, monsoon and post-monsoon seasons respectively. It exceeded 25 mm during the hot weather and monsoon seasons only and the percentages of such rainy days were found to be 1.9 and 8.3 respectively during the above two seasons. During the post-monsoon the mean rainfall per day did not exceed 25 mm and during the winter it did not exceed 15 mm. Study of the spatial distribution of the rainfall in this region indicated that the rainfall was non-uniformly distributed in all the seasons.

3.3.3 Warm Cloud Modification

The Institute, at the request of Government of Gujarat, provided the technical assistance in their cloud seeding operations carried out in the Kutch and Saurashtra regions during August 1990. The Institute deputed two of its senior scientists to Ahmedabad for the above purpose. The cloud seeding operations were carried out utilising the seeding criteria evolved from the 11-year scientific experiment carried out by the Institute in Maharashtra State. A report containing the analysis of the observations collected during the above cloud seeding operations was submitted to the Government of Gujarat and the outcome of the cloud seeding operations appears to be promising. The Government of Gujarat has paid Rs. 41,323/- as consultancy charges to the Institute for providing the necessary technical assistance in the cloud seeding operations.

3.3.4 Studies of the Atmospheric Boundary Layer

Preliminary analysis of the MONTBLEX observations of the atmospheric boundary layer (ABL) heights collected at Kharagpur during 2-14 June 1990 showed diurnal variation. Mixed layer heights showed a peak at 0.8-1.2 km during the afternoon hours (1200-1400 hrs IST). The ABL was found to be unstable during the day time and neutral during evening and night time.

Analysis of the Aerological observations collected during the MONSOON-77 was carried out to investigate the reversal in mixing ratio profile (q-reversal) over the Arabian sea. The results indicated that the q-reversals were dominant over the western Arabian sea (West of 65°), and they were absent over the region east of 65°. The study indicated that the ABL over the eastern Arabian sea was, by and large, associated with deep convection and over the western Arabian sea with either suppressed convection or inversion conditions (Figure 7).

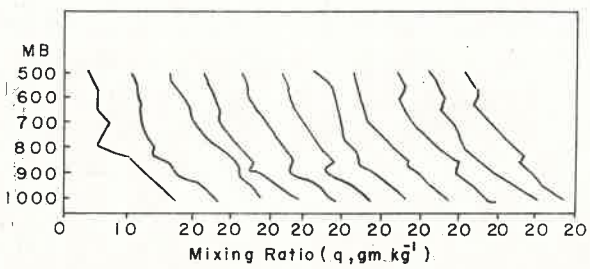


Figure 7 :
Vertical profiles of q in the region west of 65° during 13-16 July, 1977.

3.3.5 Deterministic Chaos

Finite precision computer realizations of calculus based non-linear mathematical models of dynamical systems in particular atmospheric flows become unstable and unpredictable because of the exponential growth of model uncertainties coupled with inherent roundoff errors of floating-point arithmetic. The resulting model solutions are chaotic, sensitively dependent on the initial conditions. Such sensitive dependence on the initial conditions, i.e., long-range spatio-temporal correlations exhibited by the computer realizations of non-linear mathematical models of dynamical systems is also exhibited by the real world dynamical systems and has recently (1988) been identified as the signatures of self-organised criticality. Self-organised criticality or deterministic chaos is manifested in real world atmospheric flows as the observed fractal geometry to the global cloud cover pattern concomitant with inverse power law form for the atmospheric eddy energy spectrum. The following theoretical investigations relating to deterministic chaos or self-organised criticality in real world and model atmospheric flows were undertaken.

A non-deterministic cell dynamical system model for the turbulent atmospheric flows was developed which enables quantification of the observed atmospheric flow structure characteristics by means of simple algebraic (analytical) governing equations which do not require long-term numerical integration schemes thereby avoiding deterministic chaos in model solutions.

The important result of the theoretical investigations is the prediction of quantum-like mechanics for atmospheric flows with inherent long-range spatio-temporal correlations, i.e., self-organised criticality or deterministic chaos. The above result is shown to have applications in the predictability of the non-linear variability in the evolution of solar-geophysical parameters. For this purpose, power spectrum analysis of fourteen different solar-geophysical parameters of different time scales and time period was carried out. The results indicated that the spectra of all the

geophysical parameters follow the universal inverse power law form of the statistical normal distribution (Figure 8). The cumulative percentage contribution to the total variance is equal to the eddy probability density corresponding to the normalised standard deviation t equal to (log λ/log λ_{50}) where λ is the period in appropriate time units and λ_{50} represents the period up to which the cumulative percentage contribution to total variance is equal to 50. The crosses in the Figure refer to the cumulative normal probability density distribution. The short horizontal line in the lower part of each spectrum indicates the lower limit above which the spectrum is the same as the cumulative normal probability distribution at the 95% confidence level as determined by the Chi-square test for "goodness of fit". The important conclusion of the present study is the unique quantification for the total pattern of non-linear variability of the solar-geophysical parameters i.e., predictability of the total pattern of fluctuations.

inverse power law form of the statistical normal distribution. Power spectrum analysis of the Lorenz attractor of the computable chaotic orbits of Bernoulli shifts, cat maps and pseudorandom number generators are in agreement with the model predictions. The important result of the above theoretical studies is the universal and unique quantification of the deterministic chaos or self-organization in real world and model atmospheric flows.

3.3.6 Studies in Upper Atmosphere

In the recent years the scientists all over the world are studying the consequences of ozone hole and its impact on earth's environment. The Institute has undertaken the study of ozone depletion over the tropics. For this study the monthly Umkher ozone data for three levels (250 and 200 mb, 125-62.5 mb, 62.5-31.2 mb) for 13 stations located in the tropics were analysed. The results of the study

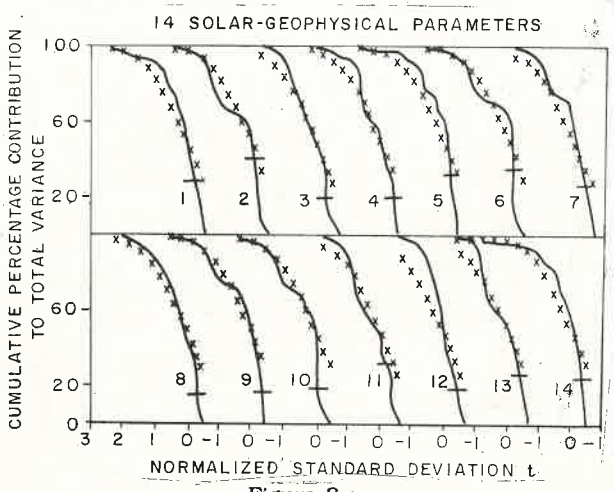


Figure 8 :

Continuous periodogram analysis of the 14 solar-geophysical parameters listed in the text. The crosses refer to the cumulative normal probability density distribution. The horizontal short lines indicate the lower limit above which the spectrum is the same as the cumulative normal probability density distribution at 95% confidence level.

A cell dynamical system model for deterministic chaos in model dynamical systems has been developed as an extension of the non-deterministic cell dynamical system model for turbulence in atmospheric flows developed earlier. The model results showed that the power spectra of chaotic dynamical systems follow the universal

indicated 40% to 80% reduction in the ozone from summer to winter in the layer 125-62.5 mb over tropics. The analysis of winter season total ozone suggested a declining trend in the ozone from mid-70s at some tropical stations (Figures 9 and 10). A depletion of 50% and 60% in ozone at 10° and 20° latitudes, respectively, can

be explained through the dynamical mechanism based on the available average value of the diabatic heating rate (0.5°K per day at 10° and 0.2°K per day at 20°).

In another study the association between the days favourable for the formation of the Polar Stratospheric Clouds (PSC) as inferred from the variations in the temperatures of the lower stratosphere and the atmospheric total ozone observations recorded at the Antarctic station Syowa (69°S) was investigated using the data for the 15-year period (1974-1988). The results indicated an inverse relationship between the two parameters.

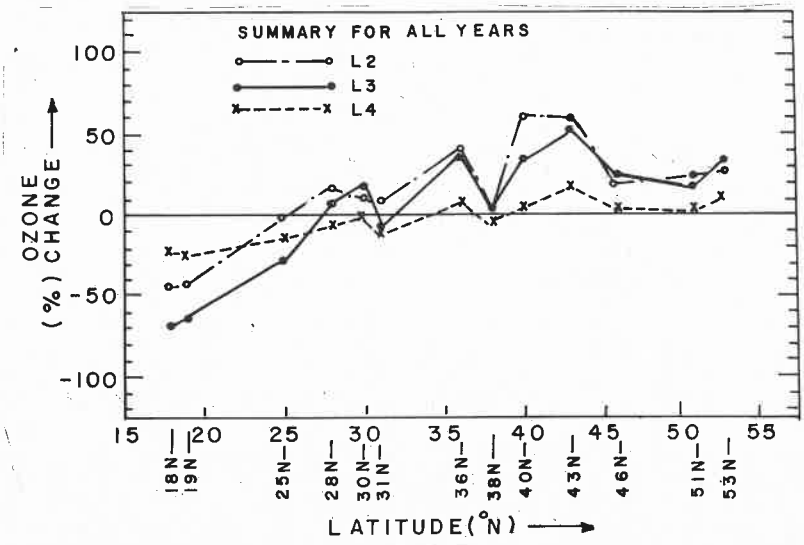


Figure 9 :
Percentage of change in Ozone content in three different Umkher layers from summer to winter.

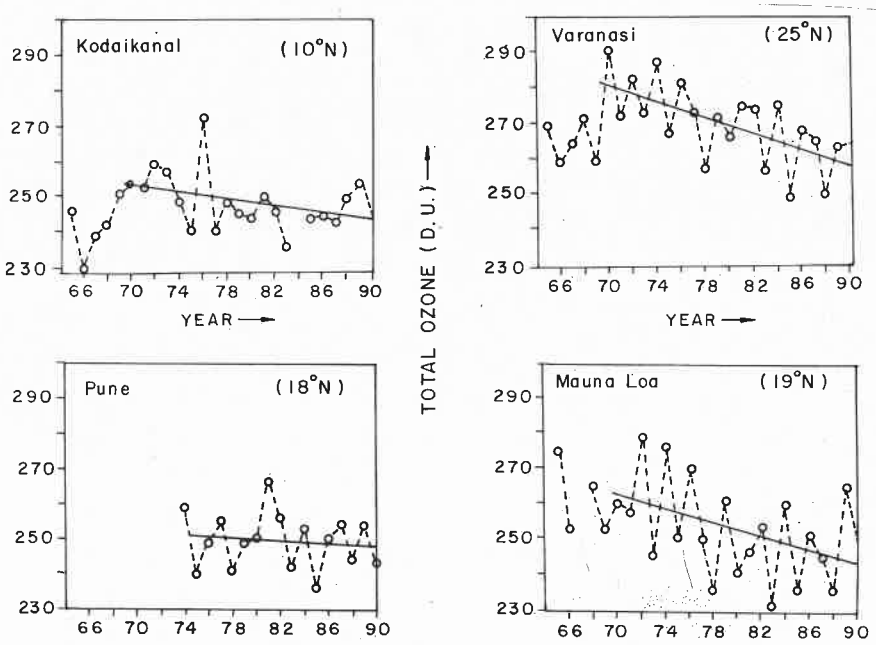


Figure 10 :
Secular variation in winter total ozone at some tropical stations.

3.3.7 Studies in Air Pollution

The world industrial activity has increased twenty fold since 1900 and is now profoundly affecting the environment. Increasing atmospheric concentrations of greenhouse gases may significantly alter our climate. In order to organise inter-disciplinary research focused on a set of key questions relating to the global environmental change, an International Programme entitled "The International Geosphere Biosphere Programme (IGBP)" has been initiated. The Institute is engaged in studies relevant to the IGBP through field observations in the Nilgiri Biosphere Reserve and acid rain studies in different regions in India.

Field observations were organised in the core zone of the Silent Valley in the Nilgiri Biosphere Reserve in Kerala during 1988-1989. The analysis of the observations of trace gases (SO_2, NO_2 and NH_3) suggested that the Silent Valley is free from long range transport of gaseous pollutants. The concentrations of trace gases were in the range of the world background values and the forest of the Silent Valley is a major source of sub-micron particles which are released from the vegetation.

Further field observations in the other core regions of the Nilgiri Biosphere Reserve (Tamil Nadu/Karnataka States) are being organised for confirmation of the results obtained from the field observations in the Silent Valley.

On the basis of the pH values reported from various parts of the world, a schematic diagram is prepared for different environments (Figure 11). It is seen that in the environments where the soil is protected against wind erosion by soil moisture and vegetation and also when the sea salt contribution is small or normal, the pH of rain water should be acidic. The pH of rain water will be alkaline when the contribution due to alkaline aerosols from soil and sea salt is substantial.

Extensive studies of acid rain carried out in different regions in India and the pH of water samples collected at various locations indicated that in the south and north-east India, the pH is near the CO_2 equilibrated value of 5.65.

The pH of rain water is in the alkaline range in the north-west and central India where the influence of alkaline soil dust on the pH of rain water is dominant. The results of acid rain study corroborate the physical concept shown in the schematic diagram.

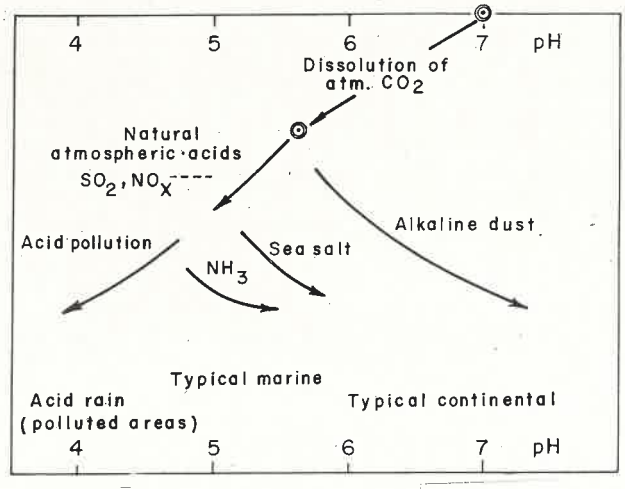


Figure 11 :
Schematic diagram showing the pH of precipitation in different environments and its dependence on various atmospheric trace constituents.

At the request of the Rashtriya Chemicals and Fertilizers (RCF) Bombay, extensive field observations were organised during the summer monsoon season of 1990 in the Chembur-Trombay regions to investigate the spread of acid rain in the region. The acid rain reported earlier in Chembur was highly localized and the present observations indicate alkaline pH of rain water. This variation from the acid to alkaline pH of rain water in the region was found to be due to the change in the fuel used by the RCF and the Tata Thermal Power Plant from coal to the natural gas.

3.3.8 Lidar Probing of the Atmosphere

Clouds and aerosols play a significant role in the expected climate change and the physical processes by which they affect the climate are not yet understood. The concentrations of many of the relevant atmospheric constituents and their interactions, represented by the physical, chemical, optical and electrical processes within the atmosphere, vary in time and space. To characterise this system, constituents must be measured for the studies relating to the interaction between them. In this context remote sensing techniques have been found vital for obtaining the observations of atmospheric aerosols and trace gases. The lidar has been found very useful for obtaining the distributions of atmospheric aerosols and trace gases. The Institute has developed the lidar technique for the remote sensing of atmospheric aerosols and trace gases.

The lidar derived vertical distributions of aerosols in the lower troposphere were computed using the observations collected during the period October 1986-August 1990 and the variations in the distributions were studied in relation to the meteorological conditions, 10.7 cm solar flux, sunspot number and the dynamical parameters of the lower atmosphere. The variations in the distribution of the atmospheric aerosols appear to be associated with the meteorological parameters, particularly, the temperature. The atmospheric aerosol distributions seem to influence the dynamical conditions in the atmosphere.

Monthly mean variations in the 10.7 cm solar flux (S_F), sunspot number (R_Z), lidar-derived aerosol content (N) and meteorological parameters, temperature range (T_R), rainfall (R), relative humidity (RH) observed during October 1986-August 1990 are shown in Figure 12.

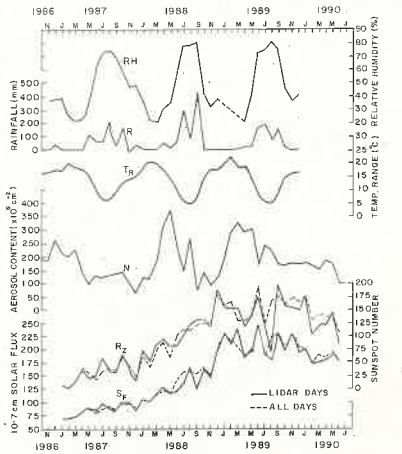


Figure 12 :

Variations in the lidar derived atmospheric aerosol content (N) for the period October 1986–August 1990. Variations in relative humidity (RH), rainfall (R), temperature range (T_R), sunspot number (R_Z) and 10.7 cm solar flux (S_F).

3.3.9 Spectroscopic Measurements of Atmospheric Minor Constituents

Remote sensing of atmospheric trace gases using the visible spectroscopy technique has been found to be very promising particularly in the context of the current scenario of global warming due to the greenhouse gases and the resulting climatic change. The Institute has developed visible and U-V spectrometers for the measurement of atmospheric trace gases (Figure 13). Regular observations have been carried out using the above spectrometers since 1987. The theory relating to the computation of the vertical profiles of the NO_2 and O_3 has been developed. Spectrometric observations were carried out on 100 days during the period of this report. The residual absorption spectrum in the wavelength region of 546 to 623 nanometers is shown in the Figure 14.

Field observations carried out in the Core zone of the Silent Valley, Nilgiri-Biosphere Reserve during September-October 1990.

Spectrometric Laboratory for the monitoring of atmospheric minor constituents.

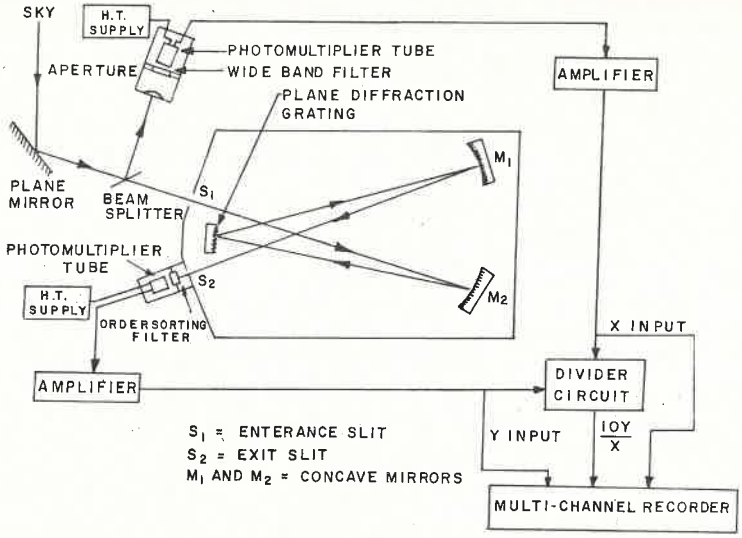


Figure 13 :
Spectrometer for the measurement of atmospheric trace gases.

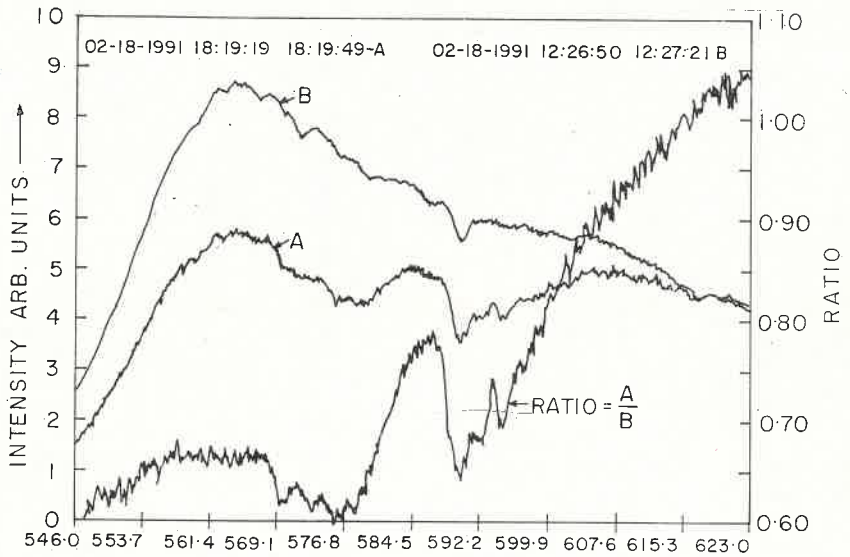


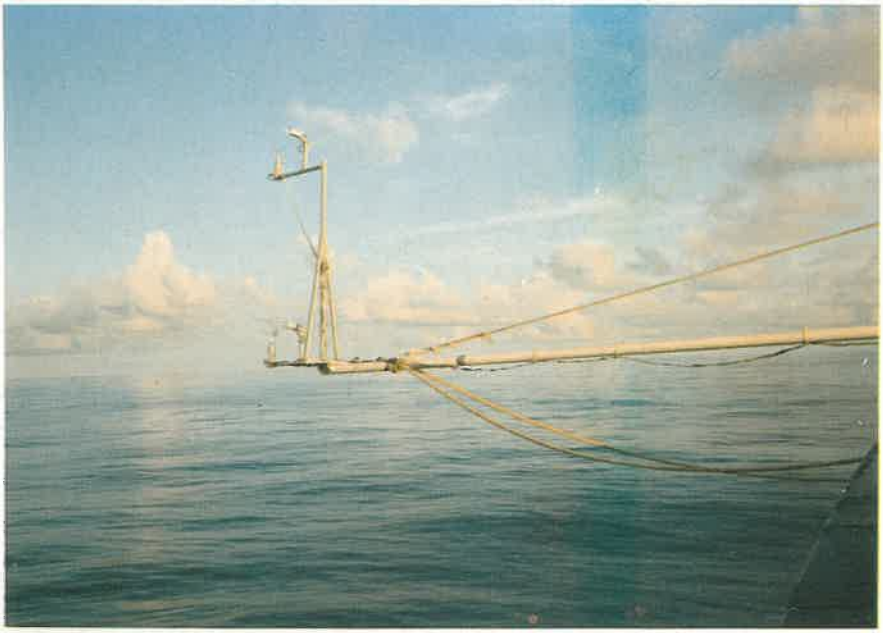
Figure 14 :
Solar spectrum observed during evening time (A), noon time (B) and their ratio spectrum (A/B) on 18 February, 1991.

3.4 INSTRUMENTAL AND OBSERVATIONAL TECHNIQUES DIVISION

Recent advances in technology have made it possible to obtain accurate observations of atmospheric parameters. Specialised instruments are required to be developed for collecting observations during the field programmes planned and organised for the study of specific state-of-art topics in Atmospheric Sciences. The Division has undertaken programmes with the following objectives:

* Design and develop instruments and observational techniques for the studies in cloud physics, atmospheric electricity and atmospheric boundary layer

High resolution meteorological instruments installed on a 30-m tower at the I.I.T., Kharagpur, as a part of MONTBLEX-90 programme.



High resolution meteorological instruments installed on a mast on the ORV Sagarkanya for collection of special observations during MONTBLEX-90.

3.4.1 Development of Instruments for Boundary Layer Studies

The Institute has in the recent past carried out a major national field experiment called Monsoon Trough Boundary Layer Experiment (MONTBLEX), in collaboration with the India Meteorological Department (IMD), Indian Institute of Science (IISc), Bangalore, Indian Institute of Technology (IIT), Kharagpur, the National Institute of Oceanography (NIO), Panjim, Goa and the Central Arid Zone Research Institute (CAZRI), Jodhpur. The Department of Science and Technology (DST), New Delhi has provided a special grant for the project. The main objectives of the MONTBLEX are to investigate the following:

* Dynamics of the ABL over the monsoon trough region
* Energetics of the monsoon trough
* Role of eddy fluxes in the maintenance of monsoon trough
* Modelling of the ABL and validation of model results

As a part of the MONTBLEX, 30 m instrumented towers were erected at three sites, Kharagpur, Varanasi and Jodhpur that lie along the axis of monsoon trough. A pilot experiment was conducted in July 1989 at the IIT, Kharagpur. The main phase of the experiment was conducted during the summer monsoon season (June-September) of 1990. A monostatic Doppler sodar was installed at the IIT, Kharagpur and observations of wind were taken. Also, observations of wind, temperature, humidity and pressure up to a height of 700 m in ABL were obtained using the kytoon. Forty five minisondes were released and the temperature profiles up to a height of 1.5 - 2.0 km were obtained. A large volume of data were collected during the MONTBLEX and these are being used for various studies.

Observations of the sea surface temperature and wind at two levels above the sea surface were carried out onboard ORV Sagarkanya as part of MONTBLEX-90. Wind and temperature sensors were developed at the Institute's laboratory and fitted at two levels on a mast projecting out of the vessel for measurements.

High resolution observations of wind and temperature obtained during 6-8 July 1989 using the Sonic anemometer installed at 8 m height on a 30 m micro-meteorological tower at the IIT, Kharagpur, were analysed. Fluxes of sensible heat and momentum were estimated using the eddy correlation technique. The day time heat flux showed systematic variations and the maximum value was observed around 14.30 hrs. IST. The heat flux during the night showed both positive and negative values. The atmosphere was found to be unstable or near neutral during the day time. During the night time, when the winds were moderate stable conditions prevailed. Fluctuations in wind and temperature and the correlation coefficients were found to follow the Monin-Obukov similarity scaling.

Evolution and growth of the atmospheric boundary layer and its thermodynamical properties were studied using the wind and temperature data obtained from the kytoon flights during February-March 1989 in the Central Agrometeorological Observatory, Pune. The study revealed that a nocturnal inversion exists in early morning hours up to 0900 hrs (IST) and starts eroding around 1000 hrs (IST). During the stable conditions (0600-1000 hrs) the sensible heat flux was estimated to be about 105 watt/sq.m. The variation in the mixing ratio with height was found to be nearly constant during stable conditions, whereas it decreased during the neutral conditions.

Observations on wind profiles were carried out using monostatic Doppler acoustic sounder during July 1989 at the IITM Pashan site which has a complex topography. The study of the echograms revealed that the stability of the atmosphere changed from the neutral to stable condition just after sunset. The wind shear in the layer between the surface and the 400 m level was found to be higher up to 10-20 minutes after the sunset.

3.4.2 Instruments for Cloud Physics and Weather Modification Studies

Atmospheric electrical observations were carried out in the marine environment onboard the ORV Sagarkanya in the Arabian sea, Indian ocean and the Bay of Bengal regions during 3 August-23 September 1990.

Atmospheric electrical observations and the meteorological observations were carried out using the high response sensors/instruments installed at the atmospheric electricity observatory at the Institute's building at Pashan. Analysis of the observations of atmospheric ions suggested that the contributions of intermediate and large ions to the polar conductivity were comparable to that of small ions when their concentrations were higher by atleast two and four orders of magnitude respectively.

The space charge variations observed during the night time were representative of those present in a horizontally stratified atmosphere whereas the day time variations were typically of the well mixed turbulent atmosphere. Short time variations in the potential gradient and conductivity showed tendency to obey the Ohm's law.

3.4.3 Simulation Techniques for Cloud Physics Studies

Laboratory experiments were conducted to investigate the electric charge transferred to a target surface when a water drop splashes on it at its terminal velocity. Analysis of the observations carried out with different targets and drop sizes showed that the transfer of the electric charge to the target surface increased with the hardness of the surface and the size of the drop. Results of experiments carried out to investigate the break-up of water drops suspended in a vertical wind tunnel under external horizontal electric fields suggested that the break-up of water drops takes place more readily in the presence of horizontal external electric fields. It was observed that breaking of drops in the presence of external electric fields produces corona which may be analogous to the triggering of lightning flashes in thunderstorms.

3.5 THEORETICAL STUDIES DIVISION

The atmospheric physical phenomena can be studied through numerical modelling. The Institute has developed models for the study of the dynamic instability, simulation of monsoon and tropical circulation systems. In the recent past scientists have developed coupled ocean-atmosphere general circulation model (GCM) to study the problems in global climate sensitivity. The Institute has undertaken programmes for investigating the following:

* Role of barotropic and baroclinic instability mechanics in the growth of monsoon disturbances
* Simulation of the interactions between the meridional (Hadley) and zonal (Walker) circulations during the summer monsoon
* Hemispheric and global spectral P.E. barotropic model for simulation of summer monsoon circulation

3.5.1 Studies on Dynamic Instability

A study of the daily energetics of the monsoon onset vortex undertaken using the data of 1000-300 mb levels over the area 22.5°N and 55°E-85°E for the period 10-14 June 1979 (Figure 15) suggested the following:

(i) K_z (zonal kinetic energy) of $\bar{u}$ motion is around 10 times to that of $\bar{v}$ motion

(ii) Sudden increase of K_z observed on 13th June 1979 was attributed to the strengthening of $\bar{u}$, and to the sudden increase in the meridional shear of $\bar{u}$

(iii) the transient part of the eddy motion associated with the vortex was found to be weak as compared to that of the stationary part of the monsoon motion during the formative stage

(iv) the baroclinic conversion was twice to that of the barotropic conversion

(v) the K_z was maintained partially by the conversion from A_z (zonal available potential energy)

(vi) the generation by the diabatic heating was essential to maintain the observed A_E (eddy A.P.E) as its loss to K_E was twice to its gain from A_z

(vii) K_E was transported away from the region. Further, the growth rates which were computed from the barotropic energy conversion at 700 mb were found to be in good agreement with the values obtained earlier from the barotropic instability study.

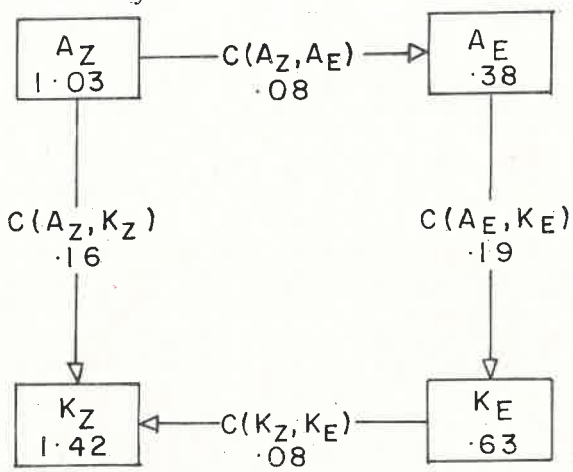


Figure 15 :
Energy cycle for monsoon onset vortex, 1979 during formative stage (10-14 June). Units of energy (10^5 J m^{-2}) and conversion (W m^{-2}).

CISK, barotropic, baroclinic and barotropic-baroclinic-CISK instability characteristics of the monsoonal (i) westerly jet, (ii) easterly jet and (iii) both the jets (total monsoonal flow) together were obtained using the 3 level equatorial balance model with 12 zones in the meridional direction. The westerly jet showed a growth rate maximum (1.7 x $10^{-6}s^{-1}$) around 3000 km, with the wave moving eastward with a phase speed of 5 ms^{-1}. The easterly jet showed a growth rate peak one around 4000 km and a broad peak around 10000 km with growth rates around 2 x 10^{-6} s^{-1}. Pure CISK showed a growth rate peak (2 x 10^{-6} s^{-1}) around a wavelength of 9000 km with a westward phase speed of 10 to 15 m s^{-1}. This wave resembled Yanai-Maruyama wave in its vertical structure and other characteristics. A comparison of the instability characteristics obtained for the above cases with the instability characteristics of the total monsoon circulation showed that its major instability modes may be obtained by a combination of the individual instability zones of the different basic state components of the circulation.

3.5.2 Simulation of Monsoon and Tropical Circulation Systems

The problem of parameterization of long wave (LW) and short wave (SW) radiation in NWP models was formulated and tested using the analytical vertical profiles of water vapour and carbon dioxide. The effects due to saturated and unsaturated clouds on LWR in addition to H_2O and CO_2 were also incorporated. Expressions for computing solar zenith angle and Rayleigh scattering were incorporated to take care of the SWR variation. Test results indicated maximum LWR cooling in a cloud layer. The LWR cooling (heating) due to H_2O (CO_2) was found to increase (decrease) with layer thickness. Maximum value of LWR (SWR) cooling (heating) was found to be -3.4 (+2.3)°C per day. A net (LWR+SWR) cooling was noticed in all layers. Maximum (LWR) cooling was always observed in the cloud layer. With the reduction in the cloud amount maximum cooling was observed in the cloud-free layer.

A study relating to the solar radiative dynamics was formulated and the duration and intensity of solar radiation on the top of the atmosphere at different places on the globe were computed. A symmetrical distribution of the radiation w.r.t. equator was noted, with the maximum values at 32° latitude in each of the hemispheres and the minimum values at the two poles. The magnitude of the winter hemisphere maximum was found to be more compared to that of the summer hemisphere maximum which is due to the differences in the heliocentric distances of the two hemispheres from the Sun.

The global average spectra of the kinetic energy (KE), enstropy (EN) and available potential energy (APE) and their wave-wave interactions and fluxes at 15 pressure levels for each day during July 1979 were computed in terms of the zonal as well as the two-dimensional wave number (Figure 16). The spectra were further decomposed into stationary and transient parts. Triangular truncation at 42 was used for the computations. FGGE IIIb data

set was used in this study. It is seen that in the troposphere, stationary KE has reached a maximum value at 200 mb while the transient KE has reached its maximum at 250 mb. This observed fact provides a justification for choosing 200 mb as the representative level for the studies of global monsoon. Also, KE and EN were nearly equally partitioned between the planetary scales, intermediate scales and the synoptic scales. This distribution was in contrast with that of the APE which is mostly confined to planetary scales. Further the KE, EN and APE spectra have the mean slopes of -3.1, -1.4 and -3.3 respectively in the spectral range $14 < n < 25$ while the theoretically expected values of the slopes are -3, -1 and -3 respectively.

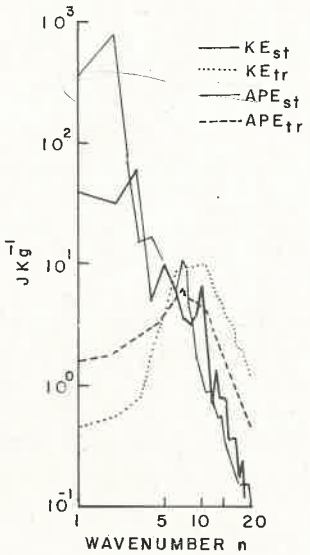


Figure 16 :
Global average kinetic energy (KE) and available potential energy (APE) spectra for the stationary (st) and transient (tr) components in the troposphere for July 1979.

The primitive equation barotropic global spectral model was integrated up to 5 days with and without the orography for the case of a subtropical anticyclonic centre. The initial input was the spherical harmonic coefficients of the stream function at the 200 mb level of 25 June 1979 with triangular truncation at 42. It was seen that results with orography were found to be in better agreement with the observations.

3.6 COMPUTER AND DATA DIVISION

Scientific computing is very vital for research in Atmospheric Sciences particularly connected with atmospheric modelling. Numerical simulation of monsoon and tropical circulation systems are important for advancing the present knowledge of weather forecasting which has important ramifications for the agricultural production and the economy of the country. 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 Computer (ND-560/CX, Norsk Data, Norway) System with the following technical specifications:

System	:	Super 32/60 32-BIT CPU
Main Memory	:	11 MB
Cache Memory	:	16 KB
Speed	:	2.1 MIPS
Floppy Drives	:	2 x 1.2 MB DSHD
Winchester Disk Drives	:	2 x 450 MB
Magnetic Tape Transport	:	2 x 1600/6250 BPI, 125 IPS
Terminals	:	14 (21 Lines/80 CHAR)
Line Printer	:	1 (600 LPM, 6/8 Lines/Inch)
Mathematical Fortran Library	:	NAG

The configuration of the computer system at the Institute is shown in the Figure 17.

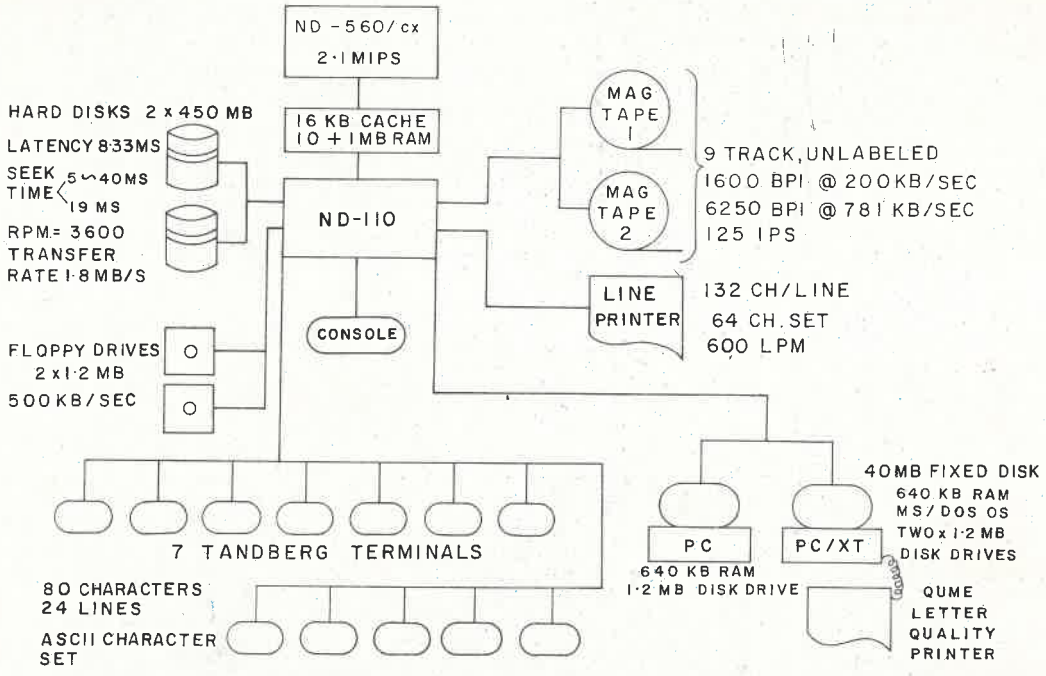


Figure 17 : ND-560/CX SYSTEM CONFIGURATION AT THE IITM.

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, (ii) Cyber 170/730 at the TIFR, Bombay and (iii) CRAY X-MP/14 Super Computer System at the NCMRWF, New Delhi.

The Computer division also provides other technical services to the scientists, viz., collection, archival, retrieval of meteorological and other related data for the tropics on the regional and global scales. The major data bases archived by the Division include Comprehensive Ocean Atmosphere Data Set (COADS) acquired from the NOAA, USA, and the FGGE Level III-b data set acquired from the ECMWF, U.K. 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 recently 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 Computer Division organizes/arranges training programmes of hardware and software for the employees of the Institute. Under this programme twenty staff members consisting of research/scientific/ technical/administrative cadres were trained at the IITM, NIC, Pune and ECIL, Hyderabad.

The division updates its hardware depending on the availability of funds. Under this programme (i) PC/AT Genius-386 (64KB Cache Memory, 2MB RAM, 40 MB Hard Disk) with 80387 co-processor, (ii) Epson EX-1000 dot matrix printer and (iii) HP-Laserjet II-P Printer were acquired during the year 1990. Efforts are on to

ND-560/CX Norsk Data Computer System.

Journals Section in the Library.

acquire an advanced Workstation containing the CD-ROM for the processing/retrieval of the data collected during the field programmes like TOGA and MONTBLEX.

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 1990-1991 is shown in the following Table :

ND-560/CX Utilisation during 1990-1991
(CPU hours)

I.I.T.M. Hrs	I.M.D. Hrs	Others Hrs	Breakdown Hrs
1787	16	1	62

3.7 LIBRARY INFORMATION AND PUBLICATIONS DIVISION

The research in Atmospheric Sciences would involve the study of a large number of disciplines and subjects and require a comprehensive Information System for quick dissemination of the information. The Institute is a leading research centre in Tropical Meteorology and it has developed a comprehensive Information System for Atmospheric Sciences. The Institute's Library, Information and Publications Division has the following objectives:

* collecting, organizing and disseminating 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

The Institute has over a period of 25 years, built a very good Information base consisting of books, monographs, journals, periodicals, scientific/technological research reports, conference/seminar proceedings, bibliographies, reprints, abstracts and meteorological/climatological/solar/ geophysical data. At present it has 5500 books, 2500 bound volumes of journals/ periodicals, 750 publications of the World Meteorological Organisation and 6000 scientific/technical reports. The Institute subscribes to more than 90 international journals which cover a wide range of subjects in Atmospheric Sciences. The information base is being continuously strengthened. This involves regular collection, collation and storage of scientific and technical information on Atmospheric Sciences.

The Library, Information and Publications Division of the Institute has also over the years developed a variety of technical facilities for reprography, microfilming and photography, drafting of scientific diagrams, preparation of charts, exhibits, maps and photocopying, printing and binding.

The Institute's Library has liaison with the International Organisations like (i) United Nations Environmental Programme (UNEP) for the International Referral System (ii) United Nations Development Programme (UNDP) for Information Referral Service (INRES-SOUTH) under agreement for the Technical Co-operation among the Developing Countries (TCDC), (iii) R.R. Bowker and Co., N.Y., USA for publication of titles of Institute's scientific publications in the Ulrich's International Directory for Periodicals and (iv) NTIS, USA for publication of the titles of Institute's publications.

The Institute's Library has also liaison with the national organisations like the Indian Association for Special Libraries and Information Centres (IASLIC), Calcutta, National Information System for Science and Technology (NISSAT) and Indian National Scientific Documentation Centre (INSDOC), New Delhi and many other important Information Centres. The IITM's library is listed in the Directory of Special

and Research Libraries in India, the INSDOC's Union Catalogue of Serials and Periodicals and the World Guide to Libraries, Germany.

Library, Information and Publications Division has initiated computerisation of information system for Atmospheric Sciences. Subjectwise bibliographies of different research topics were prepared. On the occasion of the WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects held at the Institute during 4-8 February 1991 a bibliography of papers relating to "MONSOON" published by the Institute's scientists was prepared. Computer printout copies were made available to the participants of the Workshop for the benefit of quick reference.

During the year 180 books and publications in Atmospheric Sciences and related subjects were acquired and 81 journals were subscribed. 3000 publications were issued. 160 reprint requests of scientific papers published by the Institute's scientists were received from the scientists in India and abroad and they were supplied to them.

A number of scientific and technical reports relating to the research programmes of the Institute were prepared and sent to the Department of Science and Technology, India Meteorological Department, Universities and Research Institutes. Reports to the Governing Council meetings and the quarterly and annual progress reports in English and Hindi were prepared and issued.

The Division organised Institute's participation in the celebration of the WMO Day on 23 March 1991. Smt. A.A. Shiralkar and Shri B.C. Morwal of the Division published popular articles on the theme in local newspapers and a talk by Smt. Shiralkar was broadcast on the All India Radio, Pune.

3.8 ADMINISTRATION

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

3.8.1 Staff Changes

Shri D. W. Kshirsagar, Administrative Officer retired from service on 31 July 1990.

Shri P. P. Kamte, Senior Scientific Officer, Grade I retired from service on 28 February 1991

Eight persons joined the staff of the Institute under different categories and eight left the Institute during the year.

Shri Y.K. Chavan, Watchman expired on 11 June 1990.

3.8.2 Special Recruitment Drive for Scheduled Caste/Scheduled Tribe

Action was taken to fill the vacant posts at the Institute reserved for Scheduled Caste / Scheduled Tribe candidates. 7 candidates have been appointed for various posts.

3.8.3 Employment of Ex-Servicemen

The percentages of ex-servicemen working at the Institute vis—a-vis total number of employees in Groups 'B', 'C', and 'D' are 2, 1 and 15 respectively.

3.8.4 Staff Council

The Staff Council is an elected body representing all 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, 13 meetings of the staff council were held. The Council could resolve several problems relating to welfare of the employees.

3.8.5 Staff Welfare

(a) Pension Scheme

The Pension Scheme for post-autonomy employees of the Institute was

Hindi Week Celebration at the Institute during 14-21 September 1990.

Participants in the sports events organised by the Recreation Club. Prizes were distributed by the Director on the Republic Day.

implemented after obtaining the necessary approval from the Department of Science and Technology.

(b) Benovalent Fund Scheme

The Institute has introduced the staff Benovalent Fund Scheme for its employees. The Scheme provides immediate financial assistance and relief to the families of the employees in the event of his/her death or distress.

3.8.6 Cadre Review Scheme for Administrative and Non-Technical Maintenance Staff

Two Expert Committees constituted by the Governing Council of the Institute completed their work on the Cadre Review for its Administrative and Non-Technical Maintenance staff. The recommendations of the Expert Committees were approved by the Governing Council and the scheme was implemented.

3.8.7 Meetings of the Heads of Divisions

Meetings of the Heads of the Divisions are held periodically to discuss on various policy matters of the Institute. Three such meetings were held during the year.

3.8.8 Academic Council

The Academic Council (A.C.) consists of the Senior Scientific Officers Grade-I and above. The A.C. meets once in a month and considers all matters relating to the scientific programmes of the Institute.

3.8.9 New Building at Pashan

The construction of the Institute's second phase office building has been completed. The Institute has shifted all its Scientific, Technical and Administrative divisions to the new building at Pashan and vacated the Ramdurg House by the end of March 1991.

3.8.10 Official Language Implementation

Special efforts were made to encourage officers and staff to write letters, notes and applications in Hindi. The total number of Hindi letters and applications made during 1990-1991 was 2,023 which was more than double of that during 1989-1990.

An inhouse Hindi Workshop was organised for training Technical/Scientific officers and staff in the usage of Hindi in official correspondence. Hindi week was celebrated from 14 to 21 September 1990 with competitions in essay-writing, speech contest, poetry recitation etc. Dr.Krishnaji Bhingarkar, Head of the Hindi Department, SNDT College, Pune was invited for the Hindi week celebrations and prizes were distributed to the employees who participated in the competitions. Four members of the staff received Hindi training and passed the Pragya examination and one of them bagged the merit prize for securing the highest marks.

Mrs. Sunanda Nagar, JSO and Shri P.G. Bhegade, STA were awarded merit certificates for their performance at the All-India Hindi Essay Competition. Hindi books of science and high literacy merit were added to the Hindi library.

Mrs. V. M. Mudaliyar, Hindi Officer attended a seminar on 'Rocket propulsion and project report writing' conducted in Hindi at the Explosives Research and Development Laboratory, Pune during 26-27 February 1991.

3.8.11 Capital Works Programme

The construction work of the second phase consisting of the office building and residential quarters was in progress. The new building has been taken over from the CPWD. An amount of Rs.20.5 lakhs was deposited with CPWD towards the construction of the Library building.

3.8.12 IITM Recreation Club

The elections for the post of various office-bearers of the Recreation Club were

held on 14 December 1990. The new Committee started a vigorous effort for increasing the membership and the activities of the club. There are 286 members as on 31 March 1991. The winter tournaments were held during January 1991 covering 14 events, in which a large number of members participated. Prizes were distributed by the Director at the Republic Day function held on 26 January 1991 at the Institute.

A hall in the new office building was allotted to the club and was inaugurated by the Director on 8 March 1991. A total of 99 books (Hindi-44, Marathi-38 and English-17) were purchased for the club library.

Many members of the Recreation Club participated in the tournaments of Tennis, Badminton and Cricket conducted by the High Power Committee for Central Government Employees in December 1990 and January 1991. The employees had performed very well in the above tournaments.

3.9 FIELD RESEARCH UNIT

A Field Research Unit of the Institute functions at Bangalore. This Unit is headed by Professor A. Mani. The Unit has undertaken projects on Wind Monitoring and Wind Mapping.

Under the Wind Monitoring Project 78 wind monitoring stations have been functioning for the past few years in eight states viz., Gujarat, Orissa, West Bengal, Uttar Pradesh, Bihar, Himachal Pradesh, Tripura, Kerala and one Union Territory.

During the year, five 20 m tall instrumented masts were installed, four at Ponmadi, Kundaly, Tolanar and Kottamale in Kerala and one in Kukma in Gujarat. Six instrumented masts installed in 1986 at Puri, Gopalpur, Marine-Drive, Chandipur, Chatrapur and Paradevip in Orissa were dismantled after completion of three years of measurements.

The results of the three years of wind energy resource assessment for 21 stations in Tamil Nadu, Gujarat, Orissa and Maharashtra were analysed and they were published in 'Wind Energy Resource Survey in India-I'. The volume was formally released at the National Symposium on Wind Power Development held at Madurai on 3 October 1990.

Under the Wind Mapping Project data from 275 wind mapping stations in 11 States were received and checked regularly.

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4. PUBLICATIONS

List of papers published

Forecasting Research

Regional NWP Modelling

FR 1. Application of a quasi-Lagrangian regional model for monsoon prediction : Singh S.S. and Bandyopadhyay A., Contributions from I.I.T.M. - Research Report No.RR-044, July 1990.

FR 2. Regional model for monsoon prediction : Singh S.S., Vaidya S.S. and Rajagopal E.N., Mausam, 41, 1990, 265-268.

Objective Analysis Including Satellite Input for Regional Models

FR 3. Estimation of vertical distribution of relative humidity using satellite data : Mahajan P.N., Acta Meteorologica Sinica, 4, 1990, 232-238.

FR 4. Estimation of upper air relative humidity for objective analysis : Kulkarni P.L., Sinha S.K., Talwalkar D.R., Narkhedkar S.G., Nair S. and Rajamani S., Mausam, 42, 1991, 41-46.

FR 5. Structure of vertical wind profile using satellite derived cloud motion vectors and its impact on objective analysis : Mahajan P.N., Talwalkar D.R., Nair S. and Rajamani S., Proc.of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 62-65.

FR 6. Use of surface observations to estimate upper air humidity for the objective analysis of relative humidity over Indian region : Sinha S.K., Talwalkar D.R., Kulkarni P.L., Narkhedkar S.G., Nair S. and Rajamani S., Advances in Atmospheric Sciences, 7, 1990, 491-501.

Extended Range Prediction

FR 7. Deterministic chaos and long range prediction of Indian summer monsoon rainfall : Kulkarni J.R., and Verma R.K., Proc. of the ICTP/ WMO International Technical Conference on Long Range Weather Forecasting Research, WMO/TD No.395, 147-150.

FR 8. Global annual mean surface air temperature anomalies and their link with Indian summer monsoon failures : Dugam S.S., Kakade S.B. and Verma R.K., Advances in Atmosospheric Sciences, 7, 1990, 245-248.

FR 9. Low frequency intraseasonal oscillations in Indian rainfall and outgoing longwave radiation : Singh S.V. and Kripalani R.H., Mausam, 41, 1990, 217-222.

FR 10. Recent monsoon variability in the global climate perspective : Verma R.K., Mausam, 41, 1990, 315-320.

Monsoon Studies and Forecasting

FR 11. Fluctuations of regional scale atmospheric features in relation to monsoon activities : Paul D.K., Mujumdar V.R., Puranik P.V., Ghanekar S.P., Deshpande V.R. and Sikka D.R., Mausam, 41, 1990,309-314.

FR 12. On the variability of monsoon onset and withdrawal dates over Indian region during 1970-1989 : Deshpande V.R., Mujumdar V.R., Puranik P.V. and Paul D.K., Proc. of Symposium on Global Changes, NGRI, Hyderabad, 15-17 March 1990.

Climatology and Hydrometeorology

Climate and Climatic Change

CH 1. Coupling between the El-Nino and planetary scale waves and their linkage with the Indian monsoon : Bhalme H.N., Sikder A.B. and Jadhav S.K., Meteorology and Atmospheric Physics, 44, 1990, 293-305.

CH 2. Estimation of all-India summer monsoon rainfall with limited raingauges : Sontakke N.A., Parthasarathy B. and Singh N., Proc. of the Third Symposium on Hydrology, CWPRS, Pune, 5-7 July 1990, 227-233.

CH 3. EVI distribution for modelling extreme rain events at Bombay : Singh N., Kumar K.K. and Abraham O., Mausam, 41, 1990, 427-432.

CH 4. Indian summer monsoon rainfall and 200-mbar meridional wind index :

: Parthasarathy B., Rupakumar K. and Deshpande V.R., Int. Jr. of Climatology, 10, 1991, 165-176.

CH 5. Long-range prediction of Indian monsoon rainfall for decision making in agricultural production : Parthasarathy B., Rupa Kumar K. and Munot A.A., Tropical Meteorology Research Programme Report Series No. 36 (WMO T.D. No. 353), 1990, 139-145.

CH 6. Low latitude volcanic eruption signal in Indian surface air temperature : Hingane L.S., Rupa Kumar K. and Patil S.D., Int. Jr. of Climatology, 10, 1990, 703-709.

CH 7. Ozone valley along the subtropics : Hingane L.S., J. Atmos. Sci., 47, 1990, 1814-1816.

CH 8. Rainfall fluctuations over upper Narmada catchment 1844-1988: Singh N., Sontakke N.A. and Mulye S.S., Proc. of the Third Symposium on Hydrology, CWPRS, Pune, 5-7 July 1990, 206-216.

CH 9. Rainfall index for hydrological floods/ droughts over India : Singh N., Kumar K.K. and Kripalani R.H., Mausam, 41, 1990, 469-474.

CH 10. Relationships between planetary scale waves, Indian monsoon rainfall and ENSO : Bhalme H.N., Sikder A.B. and Jadhav S.K., Mausam, 41, 1990, 279-284.

CH 11. Some aspects of daily rainfall distribution over India during southwest monsoon season : Soman M.K. and Kumar K.K., Int. Jr. of Climatology, 10, 1990, 299-311.

CH 12. Surface and upper air temperatures over India in relation to monsoon rainfall : Parthasarathy B., Rupakumar K. and Sontakke N.A., Theoretical and Applied Climatology, 42, 1990, 93-110.

CH 13. Vagaries of Indian monsoon rainfall and its relationships with regional/ global circulation: Parthasarathy B., Sontakke N.A., Munot A.A. and Kothawale D.R., Mausam, 41, 1990, 301-308.

CH 14. Some aspects of hydroclimatic fluctuations in Kerala, India : Singh N. and Soman M.K., Indian Jr. of Power and River Valley Development, 40, 1990, 75-84.

Hydrometeorological Studies

CH 15. Appraisal of snow and glacier observations in Nepal Himalayas : Dhar O.N., Indian Jr. of Power and River Valley Development, 40, 1990, 108-111.

CH 16. Brief appraisal of rainfall distribution in the two regions of Jammu and Kashmir state : Dhar O.N., Mandal B. N. and Kulkarni B. D., Transactions of Institute of Indian Geographers, 12, 1990, 1-11.

CH 17. Homogeneous zones of heavy rainfall of 1-day duration over India : Rakhecha P.R.., Kulkarni A.K., Mandal B.N. and Deshpande N.R., Theoretical and Applied Climatology, 41, 1990, 213-219.

CH 18. Hydrometeorological studies of Maharashtra rainfall : A brief appraisal : Dhar O.N., Kulkarni B.D. and Nandargi S., Proc. of the Third Symposium on Hydrology, CWPRS, Pune, 5-7 July 1990, 217-226.

CH 19. Rainfall and floods of 1989 monsoon season over contiguous India : Dhar O.N. and Nandargi S.S., Proc. of the Third Symposium on Hydrology, CWPRS, Pune, 5-7 July 1990, 197-205.

Physical Meteorology and Aerology

Atmospheric Electricity

PM 1. Off-shore sea surface electric field investigations around the Indian sub-continent during 19-20 May 1983 : Manohar G.K., Sholapurkar S.M. and Kandalgaonkar S.S., Advances in Atmospheric Sciences, 7, 1990, 453-462.

PM 2. Some characteristics of point discharge current during two pre-monsoon seasons' thunderstorms at Pune : Manohar G.K., Kandalgaonkar S.S. and Sholapurkar S.M., Current Science, 59, 1990, 367-370.

Radar Study of Rain and Rain-bearing Clouds

PM 3. Radar study of thunderstorms around Delhi during monsoon season : Chatterjee R.N. and Prem Prakash, Mausam, 41, 1990, 161-165.

PM 4. Some aspects of convective clouds around Delhi : Chatterjee R.N. and Prem Prakash, Mausam, 41, 1990, 475-482.

Weather Modification

PM 5. Cloud seeding operations in Gujarat State - August 1990 : PM & A Division, IITM Report, 1991, 65 pp.

PM 6. Electrical, microphysical and dynamical observations in summer monsoon clouds : Selvam A.M.,

Vijayakumar R., Manohar G.K. and Murty A.S.R., Atmospheric Research, 25, 1991, 19-32.

PM 7. Some physical aspects of summer monsoon clouds : Selvam A.M., Vijayakumar R. and Murty A.S.R., Advances in Atmospheric Sciences, 8, 1991, 111-124.

Atmospheric Boundary Layer

PM 8. Convective boundary layer over the Deccan Plateau, India during the summer monsoon : Parasnis S.S. and Morwal S.B., Boundary Layer Meteorology, 54, 1991, 59-68.

PM 9. Mixing processes in the atmospheric boundary layer during the summer monsoon : Parasnis S.S. and Morwal S.B., Acta Meteorologica Sinica, 5, 1991, 259-263.

PM 10. Stability of sub-cloud layer during the summer monsoon : Parasnis S.S., Boundary Layer Meteorology, 42, 1990, 69-73.

PM 11. Thermodynamical features of the atmospheric boundary layer during the summer monsoon : Parasnis S.S. and Goyal S.S., Atmospheric Environment, 24, 1990, 743-752.

PM 12. Wind characteristics in the lowest 340 m of the atmospheric boundary layer at Pune, India : Parasnis S.S., Boundary Layer Meteorology, 54, 1991, 277-286.

Deterministic Chaos

PM 13. Atmospheric low frequency variability -A signature of deterministic chaos in atmospheric flows : Selvam A.M., Proc. of International TOGA Scientific Conference, Honolulu, Hawaii, 16-19 July 1990.

PM 14. Cell dynamical system model for diffusion in condensed media : Selvam A.M., Proc. of International Conference on Rate Processes in Dissipative Systems - 50 years after Kramers, Germany, 10-13 September 1990.

PM 15. Cell dynamical system model for turbulent shear flows in the planetary atmospheric boundary layer : Selvam A.M., Proc. of 9th Symposium on Turbulence and Diffusion, Denmark,30 April-3 May 1990.

PM 16. Deterministic chaos in atmospheric flows as a model for neural networks : Selvam A.M., Proc. of NAECON-90, IEEE, USA, 21-25 May 1990.

PM 17. Deterministic chaos, fractals and quantum like mechanics in atmospheric flows : Selvam A.M., Canadian Jr. of Physics,9, 1990, 831-841.

PM 18. Fractal geometry of winter monsoon clouds over the Indian region : Jayanti A., Gupta A. and Selvam A.M., Mausam, 41, 1990, 579-582.

PM 19. Quantum-mechanical reality underlying fluid flows -a cell dynamical system model : Selvam A.M., Proc. of 8th EPS General Conference on Trends in Physics, Netherlands, 4-8 September 1990.

PM 20. Signature of quantum-like mechanics and deterministic chaos in geophysical parameters : Selvam A.M., Pethkar J.S. and Sholapurkar S.M., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 431-433.

PM 21. Universal algorithm for deterministic chaos in digital computer realisations of non-linear mathematical models of physical systems : Selvam A.M., Proc. of First Latin American Seminar on Application of Mathematics and Computer Science to Biology, Cuba, 31 October - 3 November 1990.

PM 22. Universal algorithm governing deterministic chaos in non-linear mathematical models of physical systems : Selvam A.M., Proc. of CP-90 Europhysics Conference on Computational Physics, Amsterdam, 10-13 September 1990.

Upper Atmosphere

PM 23. Association between 10.7 cm solar flux and ozone : Indira K., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 428-430.

PM 24. Four decades of Indian middle atmosphere studies : Mukherjee B.K. and Sikka D.R., Vayu Mandal, 20, 1990, 7-11.

PM 25. Middle atmosphere dynamics and monsoon variability : Mukherjee B.K., Mausam, 41, 1990, 203-208.

PM 26. Ozone during stratospheric warmings at Uccle : Mukku V.N.R. and Bhosale C.S., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 524-529.

PM 27. Stratwarm phenomenon at lower latitudes-current status and future prospects : Mukherjee B.K., Indian

Jr. of Radio and Space Physics, 19, 1990, 193-202.

Air Pollution and Atmospheric Chemistry

PM 28. Biogeochemical studies in the Nilgiri Biosphere Reserve : Khemani L.T., Momin G.A., Rao P.S.P., Safai P.D. and Pillai A.G., Proc. of Asian Workshop on the International Geosphere Biosphere Programme A study of Global Change, NPL, New Delhi, 11-15 February 1991.

PM 29. Composition of acidity in Indian precipitation, Khemani L.T., Proc. of IGAC-CAAP Planning Workshop, National University, Singapore, Singapore, 21-24 August 1990, 109-111.

PM 30. Dispersion of pollutants in the vicinity of elevated sources : Naik M.S., Proc. of the SAARC Countries Conference on Environment Management in Developing Countries, Rae-Bareli, 23-24 February 1991.

PM 31. Impact of Ca and SO_4 on pH of rain water in rural environments in India : Rao P.S.P., Momin G.A., Safai P.D., Indian Jr. of Environmental Protection, 10, 1990, 941-943.

PM 32. Nitrogen dioxide and oxidant in an urban region of Delhi, India : Kapoor R.K., Tiwari S. and Ali K., Journal of Energy and Building, 14, 1990, 683-689.

PM 33. Research in Atmospheric Sciences in India, Khemani L.T., Proc. IGAC-CAAP Planning Workshop, National University of Singapore, Singapore, 21-24 August 1990, 39-41.

Lidar Probing of the Atmosphere

PM 34. Laser radar applications to air pollution potential measurements during post-sunset period : Raj P.E. and Devara P.C.S., Proc. of 19th Optical Society of India Symposium on Optics and National Development, Lucknow University, Lucknow, 8-10 March 1991.

PM 35. Laser scintillation experiment for the study of atmospheric turbulence : Sharma S., Raj P.E. and Devara P.C.S., Proc. of National Symposium on Instrumentation (NSI-15), CLRI, Madras, 22-24 January 1991.

PM 36. Lidar aerosol measurements during lunar eclipse : Devara P.C.S. and Raj P.E., Jr. of Optics, 18, 989, 25.

PM 37. Lidar-derived mixing depths over a tropical station, Pune, India : Raj P.E. and Devara P.C.S., Book entitled "Aerosols : Science, Industry, Health and Environment", Eds. S. Masuda and K. Takahashi, Pergamon Press, UK, vol. 1, 1990, 311-314.

PM 38. Lidar measurements of cloud-base heights over Pune, India : Raj P.E. and Devara P.C.S., Proc. of 15th International Laser Radar Conference, USSR, 23-27 July 1990, 396-399.

PM 39. Lidar monitoring of urban aerosol layer structure : Devara P.C.S. and Raj P.E., Indian Jr. of Environmental Protection, 10, 1990, 907-913.

PM 40. Lidar sensing of aerosol layer variations for environmental studies : Raj P.E. and Devara P.C.S., Jr. of the Instrument Society of India, 19, 1989, 335-339.

PM 41. Lidar sounding of atmospheric aerosols during two contrasting SW monsoon seasons : Devara P.C.S. and Raj P.E., Proc. of 15th International Laser Radar Conference, USSR, 23-27 July 1990, 222-225.

PM 42. Optical remote sensing of atmospheric refractivity using laser beam scintillations, preliminary results : Devara P.C.S., Raj P.E. and Sharma S., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 19-22.

PM 43. Remote probing of transverse wind across a laser beam path : Devara P.C.S., Raj P.E. and Sharma S., Proc. of National Symposium on Instrumentation (NSI-15), CLRI, Madras, 22-24 January 1991.

PM 44. Some aspects of Rayleigh and Mie scattering in the atmosphere over Pune : Devara P.C.S. and Raj P.E., Special Issue of the Kodaikanal Observatory Bulletin, 15, 1990.

PM 45. Study of atmospheric aerosols in a terrain-induced nocturnal boundary layer using bistatic lidar : Devara P.C.S. and Raj P.E., Atmospheric Environment, 25A, 1991, 655-660.

PM 46. Three-year lidar observations of the tropospheric aerosols at Pune, a low-latitude station : Devara P.C.S. and Raj P.E., Book entitled "Aerosols : Science, Industry, Health and Environment", Eds. S. Masuda and K. Takahashi, Pergamon Press, UK, vol. 2, 1990, 1070-1073.

PM 47. Vertical gradients of lidar derived aerosol concentrations in the lower atmosphere over Pune : Raj P.E. and

Devara P.C.S., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 16-18.

PM 48. Wind measurements from radars at micrometer-meter wavelengths : Devara P.C.S., Proc. of National Workshop on Development of radars in India and present state-of-art, Amravati, 4-5 January 1991.

Spectrometric Measurements of Atmospheric Minor Constituents

PM 49. Algorithm to derive vertical profiles of atmospheric gases using solar spectra : Mehra P. and Jadhav D.B., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 13-15.

PM 50. Automated spectrometer for atmospheric studies : Jadhav D.B. and Bose S., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 8-12.

PM 51. High spectral resolution systems for advanced remote sensing from space : Jadhav D.B., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 56-59.

PM 52. On the possibility of monitoring different atmospheric constituents in near ultra violet, visible and near IR regions : Jadhav D.B. and Raju R., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 564-566.

PM 53. Portable spectrometer for atmospheric studies in visible region : Londhe A.L., Jadhav D.B. and Trimbake H.K., Jr. of the Instrument Society of India, 20, 1990, 41-57.

PM 54. Portable spectrometer with source intensity variation compensation for visible twilight spectroscopy : Jadhav D.B. and Londhe A.L., Proc. of International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990, 434-436.

Instrumental and Observational Techniques

Development of Instruments for Boundary Layer Studies

I&OT 1. Monsoon Trough Boundary Layer Experiment-Preliminary results : Prabhu A. and Vernekar K.G., Mausam, 41, 1990, 209-212.

I&OT 2. MONTBLEX programme and its role in the International Geosphere Biosphere Programme : Vernekar K.G., Proc. of Asian Workshop on International Geosphere Biosphere Programme - A study of Global Change, NPL, New Delhi, 11-15 February 1991.

Simulation Techniques for Cloud Physics Studies

I&OT 3. Potential of the ionosphere : Kamra A.K., Vayu Mandal, 20, 1990, 12-15.

I&OT 4. Recent advances in the study of the influence of air ions on plant growth: Kamra A.K., Ravichandran M., Gnanasekharan K.S.A. and Rajasekar S.R., Bulletin of Electrochemistry, 6, 1990, 326-328.

Theoretical Studies

TS 1. Barotropic spectral modelling of nonlinear interaction for transient waves in tropical easterly jet : Mishra S.K., Mausam, 41, 1990, 241-250.

Other Publications

DR 1. Assessment of ENSO-monsoon connection : Sikka D.R., Proc. International TOGA Scientific Conference, Honolulu, Hawaii, USA, 16-20 July 1990.

DR 2. Global Climatic change - regional scenario over India : Sikka D.R. and Pant G.B., Proc. Indo-US Workshop on Global Climate Change New Delhi, 8-12 January 1991.

DR 3. Monsoon and ENSO : Sikka D.R., Proc. WMO/IMD Regional Workshop on Asian/African Monsoon Pune, 4-8 February 1991.

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5. PARTICIPATION IN SYMPOSIA/CONFERENCES AND PAPERS PRESENTED

* Participant(s), - Paper(s) presented

Forecasting Research Division

a) Workshop on Atmospheric Boundary Layer and Turbulence, Bangalore, 25 April - 2 May 1990.
Nagar* S.G.

b) International TOGA Scientific Conference, Honolulu, Hawaii, USA, 16-20 July 1990.
Verma* R.K.

i) - Some observational and modelling aspects of ENSO - Monsoon linkage
Verma R.K.

c) Indo-US Seminar on Parameterization of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate, IITM, Pune, 6-10 August 1990.
Singh* S.S., Vaidya* S.S. and Behera* S.K.

i) - Envelope orography in a regional model for monsoon prediction
Singh S.S. and Rajagopal E.N.

ii) - Numerical model for dynamics of baroclinic ocean experiment for north Indian ocean
Kordzadze A.A., Behera S.K. and Sawant H.J.

iii) - Study of kuo type parameterization of cumulus convection in monsoon prediction
Rajagopal E.N., Vaidya S.S. and Singh S.S.

d) National Seminar on Geophysics in National Development, BHU, Varanasi, 29-31 August 1990.
Mahajan* P.N.
- Construction of divergent wind field over the oceanic region using satellite derived OLR data
Mahajan P.N., Khaladkar R.M. and Chintalu G.R.

e) WMO Training Workshop on Diagnosis and Prediction of Monthly and Seasonal Atmospheric Variations, Nanjing, China, 8-19 October 1990.
Singh* S.V.

i) - Monsoon variability and precipitation
Singh S.V.

ii) - Diagnosis and prediction of large scale weather regimes in the tropics.
Singh S.V.

f) International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990.
Talwalkar* D.R.

i) - Construction of vertical wind profile using satellite derived cloud motion vectors and its impact on objective analysis
Mahajan P.N., Talwalkar D.R., Nair S. and Rajamani S.

g) Interagency Workshop, NIO., Goa, 27-28 November 1990
Singh* S.S.

i) -IITM's participation in the cruises of ORV Sagarkanya,
Singh S.S.

h) Mini-workshop on Monsoon 1990, Indian Meteorological Society, Pune, 28 December 1990.
Verma* R.K. and Bhide* U.V.

i) - Some large scale features of monsoon 1990
Verma R.K.

ii) - Anomalous circulation features over India during May-90 in relation to the early onset of southwest monsoon
Bhide U.V., Paul D.K., Bawiskar S.M., Puranik P.V., Mujumdar V.R. and Deshpande V.R.

i) 78th Session of Indian Science Congress, Indore, 3-8 January 1991.
Mujumdar* V.R.

j) International Symposium on Oceanography of Indian Ocean, NIO., Goa, 14-16 January 1991.
Behera* S.K. and Ghanekar* S.P.

i) - Mathematical modelling of the dynamics of the north Indian ocean
Marchuk G.I., Kordzadze A.A., Behera S.K., Sawant H.J. and Salvekar P.S.

ii) - Variability of sea-surface convection over Indian region during summer monsoon
Paul D.K., Bhide U.V., Ghanekar S.P. and Sikka D.R.

k) WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects, IITM, Pune, 4-8 February 1991.
Singh* S.S., Singh* S.V., Rajamani* S., Verma* R.K., Paul* D.K., Mahajan* P.N., Vaidya* S.S., Behera* S.K. and Bawiskar* S.M.

i) - Medium-range forecasting of monsoon
Singh S.V.

Climatology and Hydrometeorology Division

a) Workshop on Crop Yield Forecasting, IMD, Pune, 30 April 1990.
Bhalme* H.N. and Parthasarathy* B.

b) Third National Symposium on Hydrology, CWPRS, Pune, 5-7 July 1990.
Dhar* O.N., Singh* N., Mandal* B.N., Sontakke* N.A. and Kulkarni* B.D.

i) -Estimation of all-India summer monsoon rainfall with limited raingauges
Sontakke N.A., Parthasarathy B. and Singh N.

ii) - Hydrometeorological studies of Maharashtra rainfall : a brief appraisal
Dhar O.N., Kulkarni B.D. and Nandargi S.S.

iii) - Probability of 1-day rainfall events over different river basins of Maharashtra
Rakhecha P.R., Kulkarni A.K., Mandal B.N. and Deshpande N.R.

iv) - Rainfall and floods of 1989 monsoon over contiguous India
Dhar O.N. and Nandargi S.S.

v) - Rainfall fluctuations over upper Narmada catchment during 1844-1988
Singh N., Sontakke N.A. and Mulye S.S.

c) National Seminar on Geophysics in National Development, BHU, Varanasi, 29-31 August 1990.
Parthasarathy* B.
- Surface pressure and summer monsoon rainfall over India
Parthasarathy B., Rupa Kumar K. and Munot A.A.

d) Symposium on Cyclones in Andhra Pradesh and Disaster Management, Hyderabad, 4-5 September 1990.
Pant* G.B.
- Some aspects of the climatology of cyclonic storms striking the Andhra coast during the last 111 years
Pant G.B. and Kumar K.K.

e) Workshop on IRS-1 Satellite, its Instruments, Characteristics and Applications in Oceanography, Climatology, Agricultural Forestry and Geology, NRSA, Hyderabad, 12-16 November 1990.
Kumar* K.K.

f) First Group Monitoring Workshop on DST Funded Projects in Atmospheric Sciences, IITM, Pune 17-19 December 1990.
Pant* G.B. and Rupa Kumar* K.

g) 78th Session of the Indian Science Congress, Indore, 3-8 January 1991.
Borgaonkar* H.P.

h) WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects, IITM, Pune, 4-8 February 1991.
Bhalme* H.N. and Parthasarathy* B.

- Interannual monsoon variability
Bhalme H.N., Sikder A.B. and Jadhav S.K.

- Indian monsoon variability
Parthasarathy B.

Physical Meteorology and Aerology Division

a) IGAC-CAAP Planning Workshop, National University of Singapore, Singapore, 21-24 August 1990.
Khemani* L.T.

- Research in Atmospheric Sciences in India
Khemani L.T.

- Composition of acidity in Indian precipitation
Khemani L.T.

b) National Seminar on Geophysics in National Development BHU., Varanasi, 29-31 August 1990.
Indira* K. and Ali* K.

- Changes in dynamical parameters of the middle atmosphere with storm activity
Indira K

- Mesoscale study of rainfall over Delhi
Chatterjee R.N. and Ali K.

c) International Symposium on Optical and Radio Remote Sensing of the Atmospheric Environment, NPL, New Delhi, 24-26 October 1990.
Jadhav* D.B., Raj* P.E. and Bose* S.

i) -Algorithm to derive vertical profiles of atmospheric gases using solar spectra
Mehra P. and Jadhav D.B.

ii) -Association between 10.7 cm solar flux and ozone
Indira K.

iii) -Automated spectrometer for atmospheric studies
Jadhav D.B. and Bose S.

iv) -High spectral resolution systems for advanced remote sensing from space
Jadhav D.B.

v) -On the possibility of monitoring different atmospheric constituents in near ultraviolet, visible and near IR region
Jadhav D.B. and Raju R.

vi) -Optical remote sensing of atmospheric refractivity using laser beam scintillations : preliminary results
Devara P.C.S., Raj P.E. and Sharma S.

vii) -Ozone during stratospheric warmings at Uccle
Mukku V.N.R. and Bhosale C.S.

viii) -Portable spectrometer with source intensity variation compensation for visible twilight spectroscopy
Jadhav D.B. and Londhe A.L.

ix) -Signatures of quantum-like mechanics and deterministic chaos in geophysical parameters
Selvam A.M., Pethkar J.S. and Sholapurkar S.M.

x) -Vertical gradients of lidar-derived aerosol concentrations in the lower atmosphere over Pune
Raj P.E. and Devara P.C.S.

d) National Workshop on Development of Radars in India and Present State-of-Art, Amravati, 4-5 January 1991.
Devara* P.C.S.
Wind measurements from radars at micrometer-meter wavelengths
Devara P.C.S.

e) Asian Workshop on International Geosphere Biosphere Programme - A Study of Global Change, NPL, New Delhi, 11-15 February 1991.
Khemani* L.T.
Biogeochemical studies in Nilgiri Biosphere Reserve
Khemani L.T., Momin G.A., Rao P.S.P., Safai P.D. and Pillai A.G.

Instrumental and Observational Techniques Division

a) Symposium on 30 Years of Scientific Ballooning in India, TIFR, Hyderabad, 21-24 October 1990.
Vernekar* K.G.

i) - Structure and growth of atmospheric boundary layer as observed by a tethered balloon payload
Vernekar K.G., Sadani L.K., Brij Mohan, Saxena S., Debaje S.B., Pillai S., Murthy B.S. and Patil M.N.

b) Asian Workshop on International Geosphere Biosphere Programme A study of Global Change, NPL, New Delhi, 11-15 February 1991.
Vernekar* K.G.

i) -MONTBLEX programme and its role in Geosphere-Biosphere programme
Vernekar K.G.

Theoretical Studies Division

a) Intensive Course on Atmospheric Boundary Layer and Turbulence at Center for Atmospheric Sciences, IISc, Bangalore, 25 April-3 May 1990
Agarwal* N.K.

b) Indo-US Seminar on Parameterization of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate, IITM, Pune, 6-10 August 1990.
Mishra* S.K. and Tandon* M.K.

i) - Non-linear effects of orography
Mishra S.K.

ii) - Tropospheric long and short wave radiation parameterisation
Tandon M.K.

c) International Symposium on Oceanography of Indian Ocean, NIO, Goa, 14-16 January 1991.
Salvekar* P.S. and Sawant* H.J.

i) - Study on the seasonal variation of north Indian ocean using a barotropic ocean circulation model
Behera S.K., Sawant H.J. and Kordzadze A.A.

d) WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects, IITM, Pune, 4-8 February 1991.
Mishra* S.K.
Monsoon depression : a baroclinic system
Mishra S.K.

Library, Information and Publications Division

a) 78th Session of the Indian Science Congress, Indore, 3-8 January 1991.
Goklaney* M.T.

Director's Participation in Conferences/ Symposia

a) Indo-US Preparatory Seminar on Parameterization of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate, NCMRWF, New Delhi, 14-15 June 1990.

b) International TOGA Scientific Conference, Honolulu, Hawaii, USA, 16-20 July 1990.
Assessment of ENSO-monsoon connection
Sikka D.R.

c) Second World Climate Conference, Geneva, Switzerland, 27 October - 4 November 1990.

d) Indo-US Workshop on Global Climate Change : Plant Productivity and Photosynthesis, New Delhi, 3 January 1991.
Global Climatic Change : Regional Scenario over India
Sikka D.R. and Pant G.B.

e) 78th Session of the Indian Science Congress, Indore, 3-8 January 1991.
Weather and climate related natural disasters.
Sikka D.R.

f) WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects, IITM, Pune, 4-8 February 1991.
Monsoon and ENSO
Sikka D.R.

g) Asian Workshop on International Geosphere Biosphere Programme A Study of the Global Change, NPL, New Delhi, 11-15 February 1991.

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6. PARTICIPATION IN MEETINGS

Forecasting Research Division

R.K. Verma, A.D.

i) Annual Monsoon Review Meeting on Local Forecasts, IMD, New Delhi, 11-12 December 1990.

D.K. Paul, SSO-I

i) First meeting of the Working Group of National Ocean Information System NIO, Goa, 21 August 1990.

ii) Second Meeting of the Working Group of National Ocean Information System, NRSA, Hyderabad, 27 November 1990.

Climatology and Hydrometeorology Division

Dr. G.B. Pant, D.D.

i) Project Advisory and Monitoring Committee on Agrometeorology, Haryana Agricultural University, Hissar, 18 May 1990.

ii) Programme Advisory Committee on Palaeoclimate and Palaeoenvironmental Research, BSIP, Lucknow, 28 June 1990.

Dr. P.R. Rakhecha, A.D.

i) 5th Meeting of the Hydrometeorology Panel of the Indian National Committee of Hydrology (INCOH), NIH, Roorkee, 29 August 1990.

Physical Meteorology and Aerology Division

R.K. Kapoor, A.D.

i) IGBP Meeting, DST, New Delhi, 3 August 1990.

Dr. L.T. Khemani, SSO-I

i) Commonwealth Science Committee Meeting on Chemical Research and Environmental Needs (CREN), CSIR, New Delhi, 29 January 1991.

Dr. P.C.S. Devara, A.D.

i) Laser Atmospheric Studies Working Group Meeting, DST, New Delhi, 13 February 1991.

Instrumental and Observational Techniques Division

Dr. A.K. Kamra, D.D.

i) Third Meeting of the National Steering Committee on Global Electric Circuit, IIG, Bombay, 17 September 1990.

K.G. Vernekar, D.D.

i) Monitoring Committee Meeting of MONTBLEX, DST, New Delhi, 24-26 September 1990.

Theoretical Studies Division

Dr. S.K. Mishra, D.D.

i) Meeting of National Working Group on GFDL, IITM, Pune, 20-21 June 1990

ii) Indo-USSR (ILTP) Project Review Meeting, NAL, Bangalore, 20 August 1990, 13 March 1991

iii) Meeting of DST Working Group on GFDL, IIA, Bangalore, 4-5 September 1990.

iv) 56th Annual meeting of Indian Academy of Sciences, Bhubaneshwar, 8-11 November 1990.

Dr.(Mrs) P.S. Salvekar, SSO-I

i) Board of Studies (Mathematics), University of Poona, Pune, 26 February and 21 March 1991

Computer and Data Division

S.S. Aralikatti, SSO-I

i) First meeting of the ND Users, Hyderabad, 20 April 1990.

R. Suryanarayana, D.D

i) Meeting with the Department of Telecommunication regarding the site clearance for the 5 cm Doppler Weather Radar, New Delhi, 27 June 1990.

ii) Meeting with the scientists of the ISRO regarding the site clearance for the 5 cm Doppler weather radar, Sriharikota, 28 August 1990.

C.M. Mohile, SSO-II

i) Annual convention of computer society of India, Calcutta, 31 October-3 November 1990.

D.R. Sikka, Director

i) Meeting of the MONTBLEX Monitoring Committee DST, New Delhi, 12 April 1990 and 25 September 1990.

ii) Meeting at the Department of Environment, New Delhi, 24 May 1990

iii) Meeting at the Department of Ocean Development, New Delhi, 25 May 1990.

iv) TOGA Advisory Committee meeting, DST, New Delhi., 11-16 November 1990.

v) UGC Meeting for reviewing the M.Tech. Programme of Atmospheric Sciences, Calcutta, 21 November 1990.

vi) Council for Meteorology and Atmospheric Sciences meeting, IMD, New Delhi, 22 November 1990.

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7. SEMINARS

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

Sr. No.	Speaker	Topic	Date
1.	Dr.Mans Joachim Fucks Germany	Project concept on climatic factors on tea productivity of tea in NE India	3 April 1990
2.	Dr.S.S.Bala IITM electrification	Change in precipitation drag due to thunderstorm	10 April 1990
3.	S.D. Bansod IITM	Relationship of monsoon onset with subsequent rainfall over India	11 April 1990
4.	Prof. R. Ananthakrishnan IITM	Fields of temperature geopotential and humidity at isobaric levels across India during the southwest monsoon and major longstanding anomalies in the aerological data	18 April 1990
5.	Dr. Yu. N. Skiba USSR	The qualitative study of nonlinear differential equations	19 April 1990
6.	Dr. Yu. N. Skiba USSR	On the global asymptotic stability of the vorticity equation solutions	3 May 1990
7.	Dr. Yu. N. Skiba USSR	On the dynamics of perturbations of Rossby-Haurwitz waves	17 May 1990
8.	R.Suryanarayana IITM	On the 10th Session of the WMO Commission for Atmospheric Sciences	29 May 1990
9.	Dr. L.S. Hingane IITM	Tropospheric ozone along the longest belt of the largest population density	5 June 1990
10.	Prof. S.D. Verma Dept. of Physics and Space Science, Gujarat University, Ahmedabad	Solar terrestrial relationships	8 June 1990
11.	Dr. Yu. N. Skiba USSR	A criterion of stable interaction of Rossby-Haurwitz waves and a modon on a sphere part-I	19 June 1990
12.	K.Krishna Kumar IITM	Characteristics of the daily 500 mb ridge axis location over India during pre-monsoon season and its relationship with monsoon rainfall	20 June 1990

Sr. No.	Speaker	Topic	Date
13.	Dr. S.S. Parasnis IITM	Convective boundary layer in the vicinity of the monsoon trough during the summer monsoon using conserved variable method	22 June 1990
14.	S.S. Bala IITM	Role of lightning in atmospheric chemistry	27 June 1990
15.	Dr. Yu. N. Skiba USSR	On the stability of zonal flows	1 July 1990
16.	Dr. Yu. N. Skiba USSR	A criterion of stable interaction of Rossby-Haurwitz waves and a modon on a sphere part-II	5 July 1990
17.	Dr. P.R. Rakhecha IITM	Predicting one day maximum rainfall events over different river basins of Maharashtra	12 July 1990
18.	S.K. Behera IITM	Splitting-up method used in solving the baroclinic ocean dynamics problem on the basis of primitive equations and the numerical schemes	12 and 23 July 1990
19.	S.M. Bawiskar IITM	Upper tropospheric energetics of standing eddies in wave number domain during contrasting monsoon activity over India part-I	20 July 1990
20.	N. Singh IITM	Climate variability of the Rajaputana desert and its association with NH surface temperature/General circulation of the atmosphere	23 July 1990
21.	N. Singh IITM	On the relationship of the rainfall variability and distribution with mean rainfall over India	23 July 1990
22.	Dr. A.K. Betts USA	Boundary layer budget studies over land (from FIFE)	25 July 1990
23.	Satyendra Sharma IITM	A study of the optical C_n^2 using laser beam scintillations	26July 1990
24.	S.M. Bawiskar IITM	Upper tropospheric energetics of standing eddies in wave number domain during contrasting monsoon activity over India part-II	27 July 1990

Sr. No.	Speaker	Topic	Date
25.	V.R. Deshpande IITM	On monitoring the monsoon onset phase during 1990	20 August 1990
26.	S. Sivaramakrishnan IITM	Participation in the college on atmospheric boundary layer physics, Trieste, Italy, during 21 May to 15 June 1990.	30August 1990
27.	Dr. P.R.Rakhecha IITM	Research activity in Hydrometeorology in IITM	3 September 1990
28.	Dr. G.B. Pant IITM	Climatology of cyclonic storms affecting Andhra Pradesh	5 September 1990
29.	D.R. Chakraborty IITM	Current research works in the Theoretical Studies Division	7 September 1990
30.	R.H. Kripalani IITM	Large scale features of rainfall and OLR over India and adjoining regions	9 September 1990
31.	Dr. J.M. Pathan IITM	Seasonal oscillatios of the ITCZ and bimodal characteristics of Indian summer monsoon rainfall with a lull around mid-August	11 September 1990
32.	D.R. Chakraborty IITM	On energy interaction	14 and 25 September 1990
33.	Mrs. S. Dhanorkar IITM	Measurement of mobility spectrum and concentration of all atmospheric ions with a single apparatus	19 September 1990
34.	D.R. Sikka Director, IITM	Environmental pollution	23 September 1990
35.	Dr. V.N.R. Mukku IITM	A study of cloud electrification	11 October 1990
36.	Mrs. Poonam Mehra IITM	An algorithm to derive vertical profiles of atmospheric gases using solar spectra	12 October 1990
37.	A.L. Londhe IITM	Portable spectrometer source intensity variation compensation for visible twilight spectroscopy	12 October 1990
38.	Dr. D.B. Jadhav IITM	On the possibility of monitoring different atmospheric constituents in near ultra-violet, visible and near IR spectra region	16 October 1990
39.	Dr. D.B. Jadhav IITM	High spectral resolution systems for advanced remote sensing	16 October 1990

Sr. No.	Speaker	Topic	Date
40.	Dr. D.B. Jadhav IITM	Automated spectrometer for atmospheric studies	16 October 1990
41.	G.K. Manohar IITM	Meteorological and electrical conditions associated with positive cloud to ground lightning	22 October 1990
42.	Mrs. M.S.Naik IITM	Dispersion of pollutants in the vicinity of elevated sources	22 October 1990
43.	M.K. Tandon IITM	Three dimensional filtering	30 October 1990
44.	Prof. M.S. Kallistratova and Dr. I.V. Petenko USSR	Acoustic sounding of the atmosphere	7 November 1990
45.	D.R. Sikka Director, IITM	Participation in the Second World Climate Conference, Geneva, Switzerland	9 November 1990
46.	Dr.V.N.R. Mukku IITM	Frequency of PSC favourable temperatures and total ozone at Syowa	13 November 1990
47.	M.K. Tandon IITM	Solar radiative dynamics	16 November 1990
48.	Dr(Miss) K. Indira IITM	Changes in the dynamical parameters of the middle atmosphere associated with the storm activity over the Bay of Bengal	20 November 1990
49.	Mrs. S.B. Morwal IITM	Variations in the boundary layer thermodynamical parameters during contrasting weather conditions	21 November 1990
50.	Dr.S.V. Singh IITM	Participation in the WMO Training Workshop on Diagnosis and Prediction of Monthly and Seasonal Atmospheric Variations, Nanjing, China, October 1990.	26 November 1990
51.	A.K. Kulkarni IITM	Analysis of 23-25 July 1989 rainstorm over northern half of the Indian Peninsula	26 November 1990
52.	R. Vijayakumar IITM	Chaos in computer arithmetic and its implications in atmospheric modelling	6 December 1990
53.	Miss S. Nandargi IITM	Study of exceptionally heavy rainspell of September 1988 over northwest India	10 December 1990
54.	M.K. Tandon IITM	FORTRAN algorithm for 2-dimensional harmonic analysis	11 December 1990

Sr. No.	Speaker	Topic	Date
55.	E.N. Rajagopal IITM	Regional model for monsoon prediction - sensivity studies	17 December 1990
56.	S.Sivaramakrishnan IITM	Characteristics of turbulent fluxes of sensible heat and momentum in the atmospheric boundary layer during Indian summer monsoon	19 December 1990
57.	Mrs. N.A. Sontakke IITM	Objective technique of optimising the number of stations for representative all India and sub-divisional rainfall series	24 December 1990
58.	R.Rama Mohan Rao University of Poona	Semi-Lagrangian methods in numerical modelling	26 December 1990
59.	Dr. H.V. Storch West Germany	POP prediction of the tropical 30-60 day oscillation	1 January 1991
60.	Dr. J.S. Xu West Germany	Relationship of QBO and ENSO	2 January 1991
61.	H.J. Sawant IITM	The component by component splitting up method for non-stationary problems-formulation, stability and accuracy of the method	2 January 1991
62.	K.G. Vernekar IITM	Characteristics of atmospheric boundary layer over a tropical station as evidenced by tethered balloon observations	4 January 1991
63.	Prof. E.S. Posmentier USA	Deterministic chaos in climate dynamics	9 January 1991
64.	Prof. S. Panchev Bulgaria	Dynamics of the tropical atmosphere-some problems	17 January 1991
65.	Miss P.L. Kulkarni IITM	On the use of OLR data in incorporating the divergent part of the wind in analysis	17 January 1991
66.	Dr. D. Syrakov Bulgaria	Application of statistical methods in meteorology	18 January 1991
67.	P.N. Mahajan IITM	Comparative study of construction of divergence of wind field based on OLR data obtained from polar orbiting and geostationary satellite	24 January 1991
68.	V.R. Mujumdar IITM	Variability of sea surface temperature and formation of onset vortex over eastern Arabian sea in different years (1980-83)	25 January 1991
69.	Mrs. A.A. Kulkarni IITM	Classification of summer monsoon rainfall patterns over India	13 February 1991

Sr. No.	Speaker	Topic	Date
70.	Dr. L.S. Hingane IITM	Some analogous meteorological features associated with the ozone minimum over Antarctica, west Pacific and southeast Asia	15 February 1991
71.	Dr. L.S. Hingane IITM	Ozone problem of India	15 February 1991
72.	M.K. Tandon IITM	A FORTRAN-77 algorithm for variance dependent filter	19 February 1991
73.	Prof. R. Ananthakrishnan IITM	Pursuit of science	28 February 1991
74.	Dr. S.K. Mishra IITM	Contribution of meteorology to the classical physics	28 February 1991
75.	Dr. D.B. Jadhav IITM	Man's impact on biological cycles	28 February 1991
76.	Dr. S.S.Parasnis IITM	Environmental Pollution	28 February 1991
77.	Prof. Sulochana M. Gadgil Bangalore	Systematic bias in NOAA OLR data set	4 March 1991
78.	A.K. Kulkarni IITM	Design storm estimation of Ponnaiyar river catchment above Sathnur dam site	8 March 1991
79.	Dr. B. Parthasarathy IITM	Forecast of Kharif foodgrain production based on monsoon rainfall	13 March 1991
80.	Dr. B. Parthasarathy IITM	Surface pressure and summer monsoon rainfall over India	13 March 1991
81.	Dr. S.N. Bavadekar IITM	A note on the polynomial surface fitting method for estimation of winds at different isobaric levels using observed wind at 850 mb level	14 March 1991
82.	Dr.(Mrs.) A. Mary Selvam, IITM	Deterministic chaos, fractals and quantum like mechanics in atmospherie flows	15 March 1991
83.	M. Mujumdar IITM	Dynamics of tropical low frequency waves	22, 23 and 26 March 1991
84.	S.P. Ghanekar IITM	Variability of sea surface temperature over the Arabian sea and organised convection over the India region during summer monsoon	26 March 1991

8. ACADEMIC ACTIVITIES

The Institute encourages its scientists to collaborate with the Universities and other Institutions in promoting academic programmes. Several scientists participated in the different academic programmes:

S. No.	Scientist	Topic	Academic Programme/ University
1.	Dr. S.V. Singh, A.D.	Weather Forecasting in Tropics (one lecture)	Trainees of the Refresher Course for College/ University Teachers held at the University of Poona in August 1990.
2.	Dr. S.V.Singh, A.D.	Synoptic Climatology (10 lectures)	Advanced Meteorological Training Course, IMD, Pune.
3.	Dr. S. Rajamani, A.D.	Objective Analysis (10 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
4.	D.K. Paul, SSO-I	Synoptic Meteorology (20 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
5.	P.N. Mahajan, SSO-II	Satellite Meteorology (10 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
6.	J.R. Kulkarni, SSO-II	Dynamic Meteorology (10 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
7.	Mrs. S.S. Vaidya, SSO-II	Numerical Weather Prediction (one lecture)	Advanced Meteorological Training Course, IMD, Pune
8.	Dr. G.B. Pant, D.D.	Climatology of Cyclonic Storms Affecting Andhra Pradesh (one lecture)	Senior Officers of the South Central Railway, Secunderabad.
9.	Dr. P.C.S. Devara, A.D.	Lidar Applications in Atmospheric Studies (two lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
10.	R. Vijayakumar, SSO-I	Thermodynamic/ Solar Radiation (11 lectures)	M.Sc. course in Physics, University of Poona.
11.	K.G. Vernekar, D.D.	Satellite Instrumentation/ Atmospheric Boundary Layer (18 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.
12.	Dr(Mrs.) P.S. Salvekar, SSO-I	Numerical Modelling/ Dynamic Meteorology (27 lectures)	M.Tech. course in Atmospheric Physics, University of Poona.

The scientists of the Institute participated in the WMO/IMD Training Course on Monsoon Meteorology held at the IITM, Pune during 7 January - 1 February 1991 and delivered the following lectures:

Sr.No	Name	Topic
1.	D.R. Sikka, Director	Developments in Monsoon Meteorology
2.	D.K. Paul, SSO-I	Interaction between tropical and extra tropical systems during monsoon
3.	P.N. Mahajan, SSO-II	Mid-latitude forcing of southern hemisphere and enhancement of tropical disturbances
4.	Dr. S.S. Singh, D.D	Introduction to numerical weather prediction
5.	M.K. Tandon, SSO-II	Parameterization of radiation
6.	Mrs. S.S.Vaidya, SSO-II	Parameterization of cumulus convection and PBL
7.	Dr. S.V. Singh, A.D	Methods for identification of quasi-periods
8.	R.K. Verma, A.D	Observed quasi-periodic fluctuations
9.	Dr. H.N. Bhalme, A.D	Onset, evolution and decay of ENSO
10.	Dr. B.Parthasarathy, A.D	Relationship between ENSO and summer monsoon rainfall
11.	Dr. S.Rajamani, A.D	Energetics of monsoon circulation
12.	Dr. S.K. Mishra, D.D	Energetics of monsoon circulation in wave number domain
13.	Dr. K. Rupa Kumar, SSO-I	Simple climate models
14.	Dr. G.B. Pant, D.D	Climate models - GCM
15.	Dr. S.V. Singh, A.D	Intraseasonal monsoon variability
16.	N. Singh, SSO-I	Intra seasonal variability of the Indian summer monsoon rainfall-practical aspects
17.	Dr. H.N. Bhalme, A.D	Processes responsible for interannual variability of monsoon
18.	N. Singh, SSO-I	Interannual variability of the Indian summer monsoon rainfall and general circulation of the atmosphere

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 projects. The details of guidance provided during the year are given below:

S.No	Supervisor	Student	Course/Topic	University
1.	Dr.S.S.Singh, D.D	S.M. Das	M.Tech. in Atmospheric Physics/ (Numerical Weather Prdiction)	Cochin University of Science and Technology
2.	D.K. Paul, SSO-I	C. Shaji	M.Tech. in Atmospheric Physics (Ocean-Atmosphere Interaction)	University of Poona
3.	A.K. Kulkarni, SSO-I	S.G. Gopalakrishnan	M.Tech. in Atmospheric Physics (Hydrometeorology)	University of Poona
4.	Dr. L.T. Khemani, SSO-I	i) V. Vinod	B.Sc.(Physics) (Atmospheric Aerosols)	University of Poona
		ii) Miss Jyutika Bhide	B.Sc.(Physics) (Acid Rain)	University of Poona
		iii) Miss Smita Shelke	B.Sc.(Physics) (Microbial Activity in Biosphere Reserve)	University of Poona

5.	Dr.D.B.Jadhav, SSO-I	D.V. Joshi	M.Sc.(Physics) (Atmospheric Electricity)	University of Poona
6.	Dr.V.N.R.Mukku, SSO-II	Miss Tara Prabha	M.Tech. in Atmospheric Physics (Stratospheric Ozone)	University of Poona
7.	Dr.S.K.Mishra, D.D	Miss K. Sati Devi	M.Tech. in Atmospheric Sciences (Cumulus Parameterisation)	Cochin University of Science and Technology

The Institute's scientists are encouraged to guide students for the Ph.D. (Physics) degrees. During the year the following scientist has been recognised as the post-graduate teacher in Physics:

S.No	Name	Subject	University
1.	Dr. S.V. Singh, A.D.	Physics	University of Amravati

The Institute's scientists are encouraged to provide their expertise for the M.Sc., M.Tech. and Ph.D. (Physics) degree examinations. The follo-wing scientists worked as external Examiners/Paper setters for different Universities.

S.No	Name	Degree		University
1.	D.R. Sikka, Director	Ph.D.	i)	Andhra University, Waltair
		Ph.D.	ii)	Indian Institute of Science, Bangalore
2.	D.K. Paul, SSO-I	M. Tech.		University of Poona, Pune
3.	Dr. B. Parthasarathy, A.D.	M.Sc. M. Tech.		Andhra University, Waltair Andhra University, Waltair
4.	Dr. A.S.R. Murty, D.D.	M.Sc.	i) ii)	Andhra University, Waltair Cochin University of Science and Technology, Cochin
5.	Dr. B.K. Mukherjee, A.D.	M.Sc.		Andhra University, Waltair
6.	Dr. D. Subramanyam, SSO-I	M.Sc. M. Tech. M. Tech.		Andhra University, Waltair University of Poona, Pune Andhra University, Waltair
7.	Dr (Mrs.) P.S. Salvekar, SSO-I	M. Tech.		University of Poona, Pune

The Institute encourages its scientists to pursue higher studies in Atmospheric Sciences and allied subjects. The following scientists have completed their work/obtained degrees of Ph.D. and M.Sc. (Partly by paper and partly by research) in Physics during the year :

S.No	Name	Degree	Research Guide	University
1.	E.N. Rajagopal, Research Fellow	Ph.D.(Physics) (thesis submitted)	Dr.S.S.Singh, D.D.	University of Poona
2.	Ms Poonam Sikka JSO	Ph.D.(Physics) (thesis submitted)	Dr.A.S.R.Murty, D.D.	University of Poona
3.	A.K. Kulkarni, SSO-I	Ph.D.(Physics) (thesis submitted)	Dr. O.N. Dhar, Emeritus Scientist	University of Poona
4.	K.K. Singh, Research Fellow	M.Phil.(Physics)	Dr. S.V. Singh, A.D.	University of Poona
5.	Mrs. S.G. Nagar, JSO	M.Sc.(Physics)	Dr. S.V.Singh, A.D.	University of Poona
6.	S.M. Bawiskar, SSA	M.Sc.(Physics)	Dr. S.S.Singh, D.D.	University of Poona
7.	G.A. Momin, JSO	M.Sc.(Physics)	Dr. B.K. Mukherjee, A.D.	University of Poona
8.	P.D. Safai, SA	M.Sc.(Physics)	Dr. B.K.Mukherjee, A.D.	University of Poona
9.	A.L. Londhe, JSO	M.Sc.(Physics) (thesis sub-mitted)	Dr. D.B.Jadhav, SSO-I	University of Poona
10.	C.G.Deshpande, SA	M.Sc.(Physics) (thesis sub-mitted)	Dr.A.K.Kamra, D.D.	University of Poona

The Institute scientists also provide their expertise for the academic work connected with various scientific committees. The following scientists have been nominated as members of different committees :

S.No	Name	Membership
1.	D.R. Sikka, Director	National:
		i) Chairman, R&D Projects Approval and Monitoring Committee, NCMRWF, DST, New Delhi
		ii) Indian Geophysical Union, Hyderabad
		iii) National TOGA Advisory Council, DST, New Delhi
		iv) Chairman, Scientific Advisory Committee on MONTBLEX, DST, New Delhi
		v) Monitoring Committee MONTBLEX, DST, New Delhi
		vi) Working Group, IGBP, INSA, New Delhi
		vii) Expert Advisory Committee, on Global Environmental Issues, Ministry of Environment and Forestry, New Delhi
		viii) Vice-President, Indian Meteorological Society, New Delhi

S.No	Name	Membership
		ix) Scientific Advisory Committee (SAC), Centre for Atmospheric Sciences, IIT, New Delhi
		x) Programme Execution and Monitoring Committee, DST, New Delhi
		xi) Programme Advisory Committee (PAC) on Atmospheric Sciences DST, New Delhi
		xii) Board of Studies in Geophysics, Banaras Hindi University, Varanasi
		xiii) Advisory Committee for Atmospheric and Oceanic Sciences, Kurukshetra University, Kurukshetra
		xiv) Faculty of Marine Sciences, Cochin University of Science and Technology, Cochin
		xv) Committee of Experts on Agrometeorological Advisories of NCMRWF, DST, New Delhi
		xvi) Earth, Marine, Atmospheric and Environmental Science and Environmental Technology Research Committee, CSIR, New Delhi
		xvii) Working Group for Formulation of Eighth Five Year Plan (1990-1995) for Meteorology Section, Government of India, Planning Commission, New Delhi
		xviii) Working Group on International Geosphere-Biosphere Programme, Indian National Science Academy, New Delhi
		xix) Committee on Global Warming on Sea Level Rise, Department of Ocean Development, New Delhi.
		xx) Committee of Experts on Communication Network for Dissimination of Agrometeorological Advisories of NCMRWF to Farmars, DST, New Delhi
		xxi) Mausam Award Committee India Meteorological Department, New Delhi
		xxii) Committee for Monitoring and Modelling of Sea Level Variations, Department of Ocean Development, New Delhi
		xxiii) National Steering Committee on Global Circuit, DST, New Delhi
		xxiv) Selection Committee, Indian Academy of Sciences, Bangalore
		xxv) Committee to Review Organisational Structure and Functions of the IMD at Group B,C and D levels, India Meteorological Department, New Delhi
		xxvi) Council for Meteorology and Atmospheric Sciences, India Meteorological Department, New Delhi
		xxvii) Committee on Research and Development of Resources for Forecasting and Management of Natural Calamities, DST, New Delhi

S.No	Name		Membership
		xxviii)	Working Group on Ocean Modelling, Department of Ocean Development, New Delhi
			International:
		i)	Scientific Steering Committee, TOGA, WMO, Geneva
		ii)	WMO-CAS Working Group on Tropical Mid-Latitude Interaction, WMO, Geneva
		iii)	Intergovernmental Panel on Climate Change (IPCC), UNEP, Bangkok, Thailand
2.	Dr. A.S.R. Murty, D.D.		DST-SERC Lectureship for delivering a series of lectures in Atmospheric Sciences at the academic/research institutions in the country.
3.	Dr. S.K. Mishra, D.D.	i)	Council of INSA Sectional Committee on Earth Sciences 1991-1993.
		ii)	Co-ordinator from Indian side for the areas of Atmospheric Sciences and Oceanography under the programme of Scientific Co-operation between the INSA and USSR Academy of Sciences.
4.	K.G. Vernekar, D.D.	i)	Committee on Anthropogenic and natural factors in environmental degradation due to atmospheric pollution and climate variability constituted by the ISRO in ISRO-SCHENE collaboration in the field of meteorology and upper atmospheric research.
		ii)	Expert Committee on Instruments/Equipment for the all India Co-ordinated Programme on Himalayan Glaciology.
5.	Dr. S.V. Singh, A.D.		Steering Committee of the international meetings on statistical climatology.
6.	Dr (Mrs.) P.S. Salvekar, SSO-I		Board of Studies (Mathematics) University of Poona, Pune.

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

S.No.	Name	Training Programme/Duration
1.	Dr. P.C.S. Devara, A.D.	Radar Meteorology Training, IMD, New Delhi, 15-26 October 1990
2.	K. Krishna Kumar, JSO	WMO/IMD Training Course on Monsoon Meteorology, IITM, Pune, 7 January - 1 February 1991
3.	S.M. Bawiskar, SSA	WMO/IMD Training Course on Monsoon Meteorology, IITM, Pune, 7 January - 1 February 1991
4.	Mrs. U.V. Bhide, SSO-II	Advanced Refresher Course on Cyclone Warning, IMD, Pune, 14-16 January 1991
5.	P.N. Mahajan, SSO-II	Advanced Refresher Course on Cyclone Warning, IMD, Pune, 14-16 January 1991
6.	S.S. Dugam, SSA	Advanced Meteorological Training, IMD, Pune, 1989-1990
7.	Mrs. R.R. Joshi, STA	Advanced Meteorological Training, IMD, Pune, 1989-1990
8.	R.M. Khaladkar, JSO	Advanced Meteorological Training, IMD, Pune, 1990-1991

9. DEPUTATION ABROAD

The Institute deputes its scientists to the International Conferences/Symposia/Meetings with a view to create general awareness of the latest developments in Atmospheric Sciences. The following scientists participated in different International Meetings :

S.No.	Name	Place/Country	Period	Conference/Meeting/ Institution
1.	D.R. Sikka, Director	Honolulu, Hawaii, USA	16-20 July 1990	International TOGA Scientific Conference
			23-25 July 1990	Ninth Session of the TOGA Scientific Steering Group
		Geneva, Switzerland	27 October - 4 November 1990	Second World Climate Conference
2.	R. Suryanarayana, D.D.	Offenbach, Germany	17-28 April 1990	i) 10th Session of the Commission for Atmospheric Sciences of the WMO
			30 April 1990	ii) Max Plank Institute of Chemistry, Mainz
				iii) Institute of Geography, University of Mainz
3.	Dr. S.V. Singh, A.D.	Nanjing, China	8-19 October 1990	i) WMO Training Workshop on Diagnosis and Prediction of and Monthly Seasonal Atmospheric Variations
			20 October 1990	ii) State Meteorological Administration, Beijing
4.	R.K. Verma, A.D.	Honolulu, Hawaii, USA	16-20 July 1990	International TOGA Scientific Conference
5.	Dr. L.T. Khemani, SSO-I	Singapore	21-24 August 1990	Composition and Acidity of Asian Precipitation (CAAP) Experiment Planning Workshop
6.	S. Sivaramakrishnan, SSO-I	Trieste, Italy	21May- 15 June 1990	Training Course in Atmospheric Boundary Layer
7.	Dr. S.K. Sinha, JSO	Trieste, Italy	15 October - 3 November 1990	Workshop on Atmospheric Limited Area Modelling

10. VISITORS

(a) **National**

Sr.No	Visitor(s)	Date(s)
1.	Post-Graduate Doctors, Department of Preventive and Social Medicine, B.J. Medical College, Pune	25 April 1990
2.	Prof. M. Mukunda Rao, Department of Electrical Engineering, Indian Institute of Technology, Madras	8 May 1990
3.	Prof. S.D. Verma, Department of Physics and Space Science, Gujarat University, Ahmedabad	8 June 1990
4.	Dr. Debasis Sengupta, National Centre for Medium Range Weather Forecasting, New Delhi	18 June-4 July 1990
5.	Dr. Harendu Prakash, National Centre for Medium Range Weather Forecasting, New Delhi	25 June-4 July 1990
6.	Dr. H. Chandra, Dr. A. Jayaraman, Scientists, Physical Research Laboratory, Ahmedabad	26 June 1990
7.	Dr. J.P.S. Chatha, Senior Scientist, Environmental Assessment Section, Bhabha Atomic Research Centre, Bombay	13 July 1990
8.	Dr. P.C. Pandey, Dr. M. Mohan, Space Applications Centre, ISRO, Ahmedabad	9 August 1990
9.	Mr. M. Prithivi, Mr. L.M. Pandiyan, Asstt. Engineers, Irrigation Department, Govt. of Tamil Nadu, Madras	9-13 August 1990
10.	M.Sc. (Tech.) Students, Banaras Hindu University Varanasi	12 October 1990
11.	Prof. R. Arulmozhi, College of Engineering, Anna University, Madras	23-26 October 1990
12.	Trainee Officers, School of Naval Oceanography and Meteorology, Cochin	21 November 1990
13.	Officers and Cadets, National Defence Academy, Pune	6 February 1991
14.	Dr. V.N. Saxena, Dr. J.P. Dudeja, Institute of Armament Technology, Pune	20 February 1991

15.	Prof. M.R. Khadilkar, Principal, Prof. S.M. Umrani, Head, Electronics Department, Vishwakarma Institute of Technology, Pune	13 March 1991
16.	M.Sc. Geology Students, Ravishankar University Raipur	13 March 1991
17.	Trainee Officers, Air Force Administrative College Coimbatore	13 March 1991

(b) **International**

1.	DR. Mans-Joachim Fuchs, Germany	3 April 1990
2.	MR. William Clark, U.S. Ambassador to India and MR. John J. Eddy, U.S. Consul General at Bombay	6 July 1990
3.	DR. T. Wodajo, Agrometeorologist, National Meteorological Service Agency, Ethiopia	7 August 1990
4.	DR. B. Haile, Head of Agricultural Development, Ministry of Agriculture Ethopia	7 August 1990
5.	DR. Gelan Negash, Ministry of Coffee and Tea Development, Ethopia	7 August 1990
6.	DR. M.A. Kallistratova, USSR	4-9 November 1990
7.	DR. I.V.B. Petenko, USSR	4-9 November 1990
8.	DR. Tran Van An, Director General of the Hydrometerological Service, Socialist Republic of Vietnam, Vietnam	12-13 November 1990
9.	Prof. A.S. Sarkisyan, USSR	23-25 November 1990
10.	DR. H.V. Storch, DR. J.S. Xu, Max Planck Institute Fur Meteorology, Hamburg, Germany	29 December 1990- 4 January 1991
11.	Prof. E.S. Posmentier USA	9 January 1991
12.	Prof. S. Panchev, DR. D. Syrakov, Bulgarian Academy of Sciences, Bulgaria	17-18 January 1991

(c) Several International scientists visited the Institute during the Indo-US Seminar and the WMO/ IMD Workshop held at the Institute and their names are given below:

(i) U.S. Participants in the Indo-US Seminar on Parameterisation of Sub-Grid Scale Processes in Dynamical Models of Medium Range Prediction and Global Climate, held at the Institute during 6-10 August 1990.

S.No.	Name	Affiliation
1.	Prof. Akio Arakawa	UCLA, California
2.	Dr. Alan K. Betts	Middlebury, VT
3.	Dr. Chris Bretherton	UW, Seattle
4.	Dr. Dale Durran	UW, Seattle
5.	Prof. Leo Donner	UC, Chicago
6.	Dr. Georg Grell	NCAR, Boulder
7.	Dr. Sethu Raman	NCSU, North Carolina
8.	Dr. Hau Lu Pan	NMC, Washington
9.	Dr. Eugenia Kalnav	NMC, Washington
10.	Dr. S. Nigam	UM, Maryland
11.	Dr. A. Vernekar	UM, Maryland
12.	Prof. Grame Stephens	CSU, Fort Collins
13.	Dr. David A. Randall	CSU, Fort Collins
14.	Prof. Roger Pielke	CSU, Fort Collins
15.	Dr. Steve Krueger	UU, Utah
16.	Prof. Harshvardhan	PU, W. Lafayette
17.	Prof. T.N. Krishnamurti	FSU, Florida
18.	Dr. P. Sardeshmukh	UC, Boulder
19.	Dr. R.V. Madala	NRL, Washington
20.	Dr. Joseph Sirutis	GFDL, Princeton
21.	Dr. Y.C. Sud	NASA, Maryland
22.	Dr. Piers J. Sellers	NASA, Maryland
23.	Dr. Sanjay Dixit	PSU, Pennsylvania

(ii) Foregin Participants in the WMO/IMD Regional Workshop on Asian/African Monsoon Emphasising Training Aspects, held at the Institute during 4-8 February 1991.

S.No.	Name	Country
1.	A.A.A. Al-Sulaiti	Qatar
2.	Ms. E.K. Anyamba	Kenya
3.	Dr. A.C.M. Beljaars	U.K.
4.	Bisimana Athanase	Rwande
5.	Dr. B.K. Cheang	Malaysia
6.	M.B. Fulakeza	Malawi
7.	Dr. Greg Holland	Australia
8.	Ms. S.A.G.M. Gunasekara	Sri Lanka
9.	A.Y. Haji Osman	Somalia
10.	Ms. Jamphon Chalalai	Thailand
11.	Koh Teck Cheong	Malaysia
12.	Dr. H. Kondo,	WMO, Geneva
13.	N.S. Kuwese	Tanzania
14.	Mrs. Mandira Rajbhak	Nepal
15.	Dr. M.J. Manton	Australia
16.	Muhammad Abdul Mumin	Pakistan
17.	Z.L.S. Mumba	Zambia
18.	Dr. M. Murakami	Japan
19.	Ms. Nguyen Thi Bich Hop	Vietnam
20.	R.E. Okoola	Kenya
21.	J.A. Paramena	Sudan
22.	P. Pieng Pannha	Lao P.D.R.
23.	Dr. K. Puri	Australia
24.	A.M. Ramiz	Maldives
25.	Rong Guengxun	China
26.	S.A. Said Abdulla	Oman
27.	Shanko Dula	Ethiopia
28.	M.S. Sultan Yarub	Oman
29.	T.C. Temba	Zimbabwe
30.	P.A. Winarso	Indonesia

11. GOVERNING COUNCIL

1.	Dr. S.M. Kulshrestha, Director General of Meteorology India Meteorological Department, Mausam Bhavan, Lodi Road, New Delhi 110 003	Chairman (Ex-Officio)
2.	Shri B.K. Chaturvedi, Joint Secretary and Financial Adviser, Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi 110 016	Member
3.	Dr. Harsh K. Gupta, Adviser (ESS), Department of Science and Technology, Technology Bhavan, New Mehrauli Road, New Delhi 110 016	Member
4.	Dr. N. Sen Roy, Additional Director General of Meterology (Services), India Meteorological Department, Mausam Bhavan, Lodi Road, New Delhi 110 003	Member
5.	Prof. R.N. Keshavmurty, Physical Research Laboratory, Navarangapura, Ahmedabad 380 009	Member
6.	Prof. Madhav Gadgil, Head, Centre for Ecological Sciences, Indian Institute of Science, Malleswaram, Bangalore 560 012	Member
7.	Dr. V.V.R. Varadachari, Emeritus Scientist, National Institute of Oceanography, Dona Paula, Goa 403 004	Member
8.	Prof. S.K. Sinha, Prof. of Eminence, Plant Physiology, Water Technology Centre, Indian Agricultural Research Institute, New Delhi 110 012	Member
9.	Shri D.R. Sikka, Director, Indian Institute of Tropical Meteorology, Pune 411 008	Member
10.	Shri V.K. Asrani, Administrative Officer, Indian Institute of Tropical Meteorology, Pune 411 008	Non-Member Secretary

Children Meet Scientists Programme held at the Institute on 28 February, 1991.

Higher Secondary School Children, Teachers and Scientists who participated in the Children Meet Scientists Programme.

Visit of Dr. Vasant Gowariker, Secretary, DST to the Institute's Scientific Exhibition arranged at the Indian Science Congress, Indore, 3-8 January, 1991.

National Science Day Celebration on 28 February, 1991.

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