



Indian Institute of Tropical Meteorology
Pune 411 005 INDIA

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Director greeting the Sub-Committee (2) of the Committee of Parliament on
Official Language

Cover page photograph

Measurement of atmospheric trace gases and particulates at Masingudi, Kamataka
as a part of the Nilgiri Biosphere Reserve Programme for the study of global
climatic change

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INTRODUCTION

The Institute was set up by the Government of India to fulfil the long-felt need for research to keep pace with the phenomenal growth and rapid development in the field of meteorology and atmospheric sciences. On the scientific plane, the perspectives of the Institute are oriented towards achieving a fundamental understanding of the atmospheric processes in the tropical region, which are distinct from those in the higher latitudes. True to its objectives, the Institute has been functioning since inception in 1962 as the National Centre for basic and applied research in the field of tropical meteorology. The period of twenty-five years is not a span long enough to assess the impact of a research Institute on the frontiers of knowledge. However, the Institute has continued to emphasise on achieving excellence in its research goals. Over the years, it has strived to fulfil its objectives through well-conceived research projects, aimed at understanding the fundamental atmospheric processes controlling the weather and oriented towards its practical applications.

While for management purposes the scientific personnel are placed in different divisions and much of the research is being carried out in scientific divisions on specified projects, there is no rigid compartmentalisation. Scientists in different groups are encouraged to work on inter-divisional and multi-agency collaborative programmes.

The Institute stepped into its Silver Jubilee last year. It is celebrating the important occasion in its life through organising a Silver Jubilee Lecture Series at the Institute delivered by eminent scientists in India and abroad. To commemorate this significant landmark, an International Symposium on 'Monsoon-Understanding and Prediction' has also been planned to be organised at the Institute during November 1988.

The Institute continued its association with the Indian Science Congress, Calcutta, as an Institutional Member and participated in the Science and Technology Exhibitions organised from 7-20 January 1988 in the campus of the University of Poona during the Platinum Jubilee Session of the Indian Science Congress. The National Science Day was celebrated at the Institute on 29 February 1988. The Institute also took part in the WMO day celebrations on 23 March 1988 organised at the India Meteorological Department, Pune.

The Institute is actively taking part in several bilateral scientific programmes with the U.S.A. and the U.S.S.R. Under the Indo-US Science and Technology Initiative (STI) programme, a senior scientist was deputed to Geophysical Fluid Dynamics Laboratory (GFDL), Princeton, USA to study the inter-annual variability of monsoon. Under the Indo-US Sub-Commission on Science and Technology (Atmospheric and Marine Sciences) programme, the Institute has proposed five scientific projects in different thrust areas involving ten senior scientists, and it is hopefully looking forward towards the fulfilment of the programme. Its collaboration with US Scientists also continued under the Indo-US STI Programme. The Institute is also having fruitful collaboration with the USSR in the field of meteorology and atmospheric sciences. Four scientists were deputed to USSR last year under the Indo-USSR Programme of Co-operation in Science and Technology (Meteorology and Environmental Protection). Two delegations of Soviet Scientists also visited the Institute during the year for scientific discussions. Participation of the Institute in the Indo-USSR Integrated Long Term Programme of Cooperation in Science and Technology is also on the anvil.

As a contribution to the Geosphere-Biosphere studies, the Institute is collaborating with the Centre for Ecological Studies, Indian Institute of Science, Bangalore for investigations of

climate-vegetation interaction in the Nilgiri Biosphere Reserve. A field observational station was set up last year by the Institute's scientists at Masingudi, Karnataka. The Institute is also actively associated with the Indian Middle Atmosphere Programme (IMAP).

Within the ambit of the National Programme for Atmospheric Boundary Layer Research, the Institute proposed a process study entitled, "The Monsoon Trough Boundary Layer Experiment (MONTBLEX)" under the sponsorship of the Department of Science and Technology (DST). A specially designed experimental programme is proposed to be conducted for the purpose by the scientists of the Institute during the current year in collaboration with other national agencies involved in the programme. The Institute also continued to associate itself with the DST towards setting up the National Centre for Medium Range Weather Forecasting (NCMRWF).

The Institute had conducted a 'Warm Cloud Modification Experiment in Maharashtra State' for 11 summer seasons during 1973-86. The scientific results of the experiment were presented before a review committee under the chairmanship of the Secretary, DST. Based on this review a detailed Project Report, incorporating the results of the experiments, was prepared and submitted to the DST towards undertaking warm cloud seeding on operational basis for enhancement of rainfall in different states. The proposal is under consideration of the DST. The Institute also provided technical assistance during the year to the states of Gujarat and Kerala in their cloud seeding operations.

In the field of water resources management, the Institute provided technical guidance on the estimation of probable maximum storm for the Koyna catchment in Maharashtra and on the estimation of Probable Maximum Precipitation (PMP) for the Indravati Project in Orissa. One day PMP Atlases for the different states of India have been prepared and are proposed to be published by the Institute for the benefit of hydrologists and engineers for design of hydraulic structures.

The Institute continued to extend active cooperation to the University of Poona in its programme of offering an optional course on Atmospheric Physics in the M.Sc. (Physics) curriculum. It also provided academic support to the Mahatma Phule Agricultural University, Rahuri for teaching courses on General Meteorology and Climatology, introduced during the year, at the Centre of Advanced Studies in Agricultural Meteorology at the College of Agriculture, Pune. The University Grants Commission (UGC) has been considering introduction of post-M.Sc., M.Tech Courses in Atmospheric Sciences in different Universities in India for the purpose of providing adequately trained man-power to meet the growing need of atmospheric sciences in the country. The Institute co-sponsored the 'Summer School in Atmospheric Sciences', organised in this regard by the UGC at the University of Poona, in May-June 1987. A number of Universities viz. the University of Poona, the University of Calcutta and the Andhra University have approached the Institute for academic support towards their proposed M. Tech courses, indicating their recognition of the scientific potential of the Institute. The Institute has favourably responded to their needs and has started providing support to their programmes.

Scientists of the Institute continued to have their active collaboration with the national and international organisations of repute in the field of meteorology and atmospheric sciences. The Director was nominated by the Organising Committee of the World Climate Research Programme (WCRP) to serve as a member of the JSC/CCCCO Scientific Steering Group for the Tropical Ocean Global Atmosphere (TOGA) project under the WCRP. He visited a few

premier scientific research laboratories in China and Canada during the year and participated in different scientific programmes organised there-at.

Several distinguished visitors, delegations of scientists from the USA and the USSR and a team of Experts from the World Bank Mission on Hydrology visited the Institute during the year and exchanged ideas with the scientists of the Institute. Such visits have been profitable for the scientific pursuits of the Institute.

The Institute's Field Research Unit at Bangalore has undertaken wind energy survey projects sponsored by the Department of Non-conventional Energy Sources. In addition to the on-going wind mapping projects, a number of wind monitoring stations were established in different states whose data could be useful in establishing wind energy farms.

Significant progress was achieved during the year in the field of infrastructure development. The ND-560 computer system of Norsk Data of Norway, with an enhanced memory of 11 MB, was installed and operationalised after conducting successful test runs. This has helped in meeting the long felt need of increased computational power for modelling and diagnostic research groups in the Institute. A 500 KVA power sub-station was also commissioned on the campus.

Construction work of the 2nd phase of the Institute's office building has been making good progress and on its completion adequate space will be available to house different laboratories and research groups under one roof. This is needed to provide academic campus environment for research growth.

Sub-Committee (2) of the Committee of Parliament on Official Language visited the Institute in October last year and reviewed the progress made in the policy of official language implementation. The Institute is implementing a plan to promote progressive use of Hindi in its working.

Staff welfare is very important to the growth of the Institute. During the year, Group Insurance Scheme of the LIC was introduced in the Institute. Steps were also initiated for the introduction of Pension Scheme for the Institute's staff who are at present covered by the Contributory Provident Fund Scheme.

Scientists of the Institute contributed 38 papers to scientific journals of national and international standing. 37 research papers authored by the Institute's scientists were also published during the year in the Proceedings of national/international seminars/symposia on varied scientific topics.

The Institute continued its research in thirteen major areas. Attention was also focussed on a few emerging thrust areas of research viz. Atmospheric Chemistry-Ozone Studies, Laser Remote Sensing of the Atmosphere for Trace Gases and Minor Constituents, Air Pollution and the Acid Rain Phenomenon, Cloud Physics and Boundary Layer Studies, Monsoon Variability, Climate Fluctuations and Tree-ring Studies, Weather Modification and Management of Water Resources.

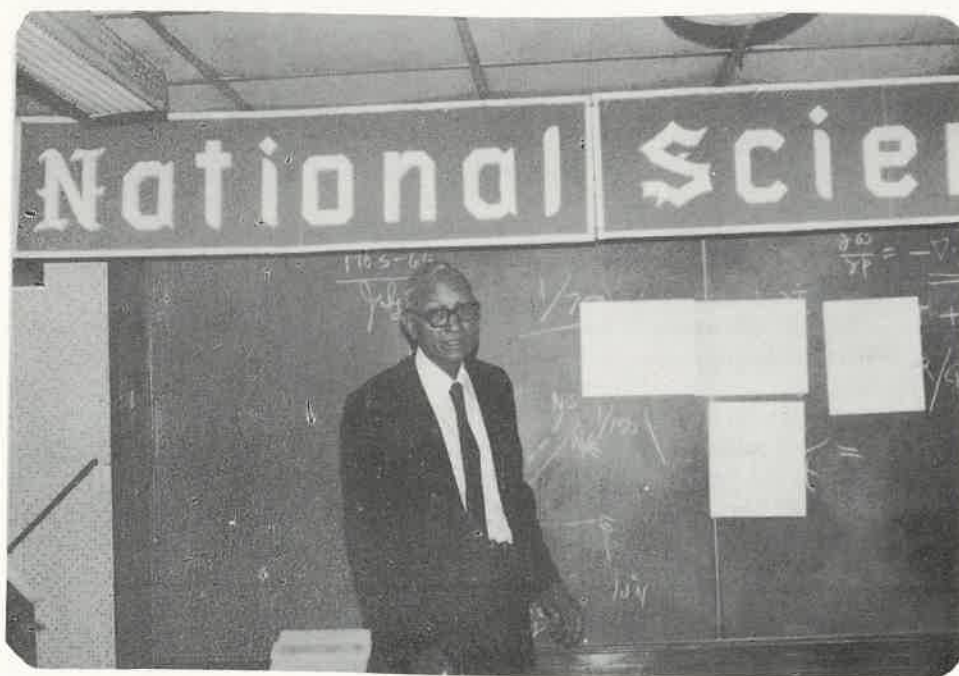
The following pages contain detailed descriptions of the various activities of the Institute and listing of its research publications in the year 1987-88.

Pune
September 1988

D. R. SIKKA
Director



Dr. P. R. Pisharoty, Dr. R. Ananthkrishnan, Dr. K. R. Saha and Dr. Bh. V. Ramana Murty, former Directors of the Institute along with the Director on the occasion of the National Science Day



Dr. K. R. Saha, former Director delivering a lecture on the National Science Day

RESEARCH HIGHLIGHTS

A numerical linear barotropic spectral model for a limited region was developed. The model takes into account the asymmetric nature of monsoon flow. Further work on the development of two multi-level regional primitive equation models with parameterised physics made steady progress.

Teleconnection between the Northern Hemisphere winter temperature abnormalities over the extra-tropical regions of North America and Eurasia and the ensuing Indian summer monsoon seasonal rainfall has been shown in the global analysis. Abnormally cooler winter, particularly over Eurasia, triggered from excessive December snow cover, is found to be unfavourable for the monsoon and vice-versa.

Further study on the low-frequency intra-seasonal oscillation of the summer monsoon showed the existence of 30-50 day periodicity in the rainfall data too. Trends in the rainfall of Kerala have been so and further work is continuing in this area.

The rainstorm of 12-14 August 1986, which occurred over the lower Godavari river basin, has been found to be a notable one. The areal rain-depths associated with this rainstorm have exceeded the areal rain-depths of past rainstorms for 1 to 3 days duration. A Depth-Area-Duration (DAD) model for rainstorms of southern India has been developed for 1 day duration. The model is useful for converting storm centre rainfall depth to mean areal rainfall.

Precipitation Concentration Index (PCI) has been developed for the upper Narmada river catchment upto the Indira Sagar Dam site for assessment of severity of floods and droughts over the catchment.

The utility of tropical teak trees as climatic indicators for reconstruction of past climate has been established using stable isotope

ratio analysis of annual growth ring cellulose.

Technical assistance was provided to (i) the Government of Gujarat in their warm cloud seeding operations and (ii) the Government of Kerala in their mountain top Silver Iodide Seeding operations.

Studies relating to the phenomenon of acid rain in different parts of India have been extended. Under this programme, it is proposed to organise sampling of rain water at (i) Nagpur, Khopoli and Sinhagad in Maharashtra, (ii) Trivandrum in Kerala, (iii) Masingudi in Karnataka, (iv) Visakhapatnam in Andhra Pradesh and (v) Madras in Tamil Nadu.

In order to evaluate the long-term effect of pollutants on the pH of rain water, data in the past collected at Agra and Delhi during the monsoon seasons of 1963 and 1965 and again in 1984 were examined. The pH values at Agra and Delhi decreased by 2.8 and 0.9 units respectively after a period of two decades but were still in the alkaline range. Reduction in pH could be ascribed to the increase in the anthropogenic components (SO_4 and NO_3) by 88% and the decrease in the soil oriented components (Ca, K) by 44% in the chemical composition of rain water samples.

Towards the development of meteorological payload for rockets and satellites, the solid state rocket payloads that were put to test, successfully crossed the GATE tests.

Opposite polarity of charges on rain drops and the other categories of particles may be reverse in case of drizzle and heavy rain. Measurements of charge on different categories of particles, with Particle Charge Measuring apparatus, revealed that the charges on raindrops may mostly be of a single polarity for a few minutes in the beginning and end of a shower, and of both polarities in between.

2. RESEARCH

2.1 Forecasting Research

2.1.1 Numerical Weather Prediction (NWP)

Work on the development and testing of short-range NWP models for regional forecasting and the objective analysis and initialisation schemes continued to be pursued vigorously. The progress made during the year is briefly described below :

a) Regional models

A dynamic normal mode initialisation scheme was formulated and applied for obtaining the initial balance input to the six level primitive equation (P. E.) model. An envelope orography was created and included in the model. The model was integrated upto 72 hrs with envelope and normal orography for two cases of monsoon depression. The forecast results were found to be satisfactory. No significant difference could be noticed for the envelope and normal orography.

A new version of P.E. barotropic model was developed by using Arakawa-B-grid difference scheme and fixed lateral boundary conditions. The model predicted the tracks of 1979 depressions in a way better than those predicted by the earlier versions of the model.

Influence of orography of the Eastern Africa, Arabia and India on the summer monsoon flow was examined by integrating upto 48-hr, a limited area (28°S – 40°N , 24°E – 102°E) 5 level primitive equation model with mean zonal flow as the initial conditions. It was found that the orography of the East African continent is important for simulation of the cross equatorial flow and development of the low level high wind speed/jet off the Somali coast. Also, the orography of the peninsular India was found to be important for evolution of low level flow over the Indian region.

b) Objective Analysis

Mean sea level surface pressure, relative humidity and 700 hPa contour height fields over the Indian region were objectively analysed for 5 test cases by using univariate optimum interpolation scheme developed earlier. The r.m.s. errors of these fields were found to be 1.1 hPa, 7.4% and 11.8 gpm respectively. The autocorrelation and structure functions required for carrying out univariate optimum interpolation of the relative humidity fields during July at 900, 850, 700, 600 and 500 hPa surfaces, were computed by using daily data of four July months. Similarly, necessary cross correlation functions between 700 hPa height and u and v components of wind were computed by carrying out multivariate optimum interpolation scheme. This scheme was then applied for simultaneous objective analysis of these parameters on 3 test cases.

The univariate optimum interpolation scheme developed earlier for 700 hPa wind field was modified to have different weighting functions for different regions to take into consideration the curved flows and the nonisotropic conditions. This scheme was also tested for 3 cases.

c) Numerical Modelling and study of the planetary boundary layer

The sea-surface temperature data were collected for the period 1 July to 31 August 1977, over the Bay of Bengal and 10-day mean charts of SST were constructed. The temporal changes of temperature in relation to the monsoon activity is being studied.

2.1.2 Extended Range Prediction

a) Statistical-dynamical prediction

The main thrust of these studies were on the two-frequency variability of the sub-seasonal and inter-annual fluctuations of the summer monsoon.

The interannual variability of the intensity of the 30-50 day oscillations in monsoon rainfall was studied by using 80 years of data. It was found that the intensity of these oscillations has no relationship with the phases of the ENSO phenomenon or the overall performance of the monsoon season. Thus, it seems unlikely that the intensity and phases of these oscillations can be foreshadowed in the beginning of the monsoon season. The potential of these oscillations in prediction of 5-day rainfall over India was also explored. It was found that the oscillations can explain about 16% of the variance of the pentad rainfall over the west central parts of the country covering the states of Gujarat, Maharashtra and West Madhya Pradesh.

Relationships between the Monsoon onset dates over Kerala and the rainfall over various parts of India during first 10, 20 and 30 days of June and during the entire monsoon season were investigated by using 80 years of data. Rainfall during the first 10 days of June over Orissa, Gangetic West Bengal, Vidarbha, Telengana and part of West Coast showed significant correlations with the onset date over Kerala. The area of significant correlation reduces considerably as the time period of rainfall is increased from 10 days to a season such that no significant correlations are found with the seasonal rainfall.

A Monte Carlo study was conducted to estimate the probability of occurrence of 4 and 10 year periods with extreme characteristics as judged by comparison with the standard deviation (σ) of rainfall, similar to those of the years observed in the recent past. These simulations reveal that the return periods for the recurrence of (i) 3 consecutive years each having deficiency of at least $.885\sigma$ (ii) 4 successive years having cumulation deficiency of 457σ and (iii) occurrence of 5 extreme years (drought or flood) in a 10 years period with deviation of at least 1.24σ are respectively 400, 300 and 200 years.

b) Synoptic-climatological studies and long-range prediction

These studies were primarily related to the investigation of regional and global meteorological parameters, in the seasons antecedent to the summer monsoon (June-September), which could be used for foreshadowing the summer monsoon rains over India.

Investigation of relationship between the Indian summer monsoon rainfall and the global sea surface temperature (SST) suggested some predictability of the Indian summer monsoon in response to tropical SST anomalies. The study also suggested a feedback from the monsoon to the SSTs over the Indian Seas and the El Nino region such that, following a deficit monsoon season, the SSTs tend to be warmer over these regions.

Spatial analysis of the relationship between the All India Summer Monsoon rainfall and the Northern Hemisphere surface air temperatures, with different time-lags, revealed that the abnormally cooler winter over the extratropical regions of North America and Eurasia is unfavourable for the ensuing summer monsoon rains and vice-versa.

It is found that the satellite-derived continental snow cover can be used for climate/monsoon monitoring. Eurasian snow cover dominates the inter-annual variability on hemispheric scale, which reveals a decreasing trend since late 1970s. December-Eurasian snow cover anomaly tends to persist through January and February and shows statistically significant relationship with the ensuing summer monsoon rainfall. Larger snow cover may lead to drier monsoon and vice-versa.

The failure of the monsoon in 1987 was studied in some detail. Analysis of regional/global scale anomalies associated with the large scale failure of monsoon-1987 over

India revealed two main factors : (i) The prevalence of ENSO (EL Nino-Southern Oscillation) reaching episodic proportion towards the end of 1986 and intensifying further till summer of 1987. This shifted eastwards the region of large-scale convection of monsoon trough zone, resulting anomalous subsidence over the region inhibited convection/rainfall; (ii) Excessive snow cover during December 1986 over Eurasia resulting in cooler than normal winter/spring in the region and the associated blocking highs over the region. This restricted the normal northward progression of the monsoon meridional circulation and weakened its intensity.

2.1.3 Monsoon studies and forecasting

Surface pressure data over the Indian and adjoining West Pacific region during the summer monsoon seasons of 1973 and 1979 were analysed for quasi-periodicities by power spectrum analysis. The pressure data of 7 stations over India covering various latitudes from Port Blair to Calcutta and those of grid points along 20°N over the west Pacific (120°–140°E) were considered. Dominant periods of 30-50 day over the Indian region and those of 10-15 day over the west Pacific were noted.

Day-to-day change of radiation budget properties, viz. outgoing long wave radiation, albedo, net radiation over the Indian and adjoining region during the onset phase (11-20 June) of summer monsoon 1979 were studied by using GOES (I. O.) data. The study revealed, (i) the northward propagation of broad zone of large radiative heat input to the earth atmosphere system and (ii) persistence of radiation heat source over the north and adjoining Arabian sea and the heat sink over the interior of Saudi Arabia during the study period.

Linear regression equation was developed for estimation of the surface specific humidity from the total precipitable water by using data

of ISMEX-73. The equation showed r.m.s. error of 1 gm/kg in estimation of specific humidity from the precipitable water, when validated on the data for MONEX-1979. This relationship may be useful in estimation of surface specific humidity over the data-void regions from the satellite estimation of total precipitable water.

2.2 Climatology and Hydrometeorology

2.2.1 Climate and Climatic Change

- a) Global and regional anomalies and important features of Monsoon 1987.

In order to understand the response of large-scale climatological features to the conditions resulting into droughts over India, the regional and global scale atmospheric and oceanic anomalies were investigated in relation to the drought year 1987. Following are the noteworthy features of the monsoon 1987 :

- 1) The monsoon onset over Kerala was timely but its advance and arrival over the east Uttar Pradesh were unusually delayed (delayed by about 3 weeks);
- 2) All India monsoon rainfall of 1987 was a departure from the normal by about –22%, thus, qualifying the year as one of the major drought years in the recorded history with a prolonged poor rainfall activity during the period 10 July to 5 August. During this period, the strength of the monsoon current as revealed by the surface pressure gradient over the peninsular India, was markedly weak;
- 3) Abnormally large positive surface pressure departures (~ 5 mb) were observed over the northwest and central parts of India in the month of May, immediately preceding the monsoon season. Positive pressure departures of large to moderate magnitude persisted over central parts of the country almost throughout the monsoon season.

4) The frequency of monsoon depressions was much below normal (a frequency of 4 during the season against a normal of about 9). All the depressions, except the one in June, formed on land and none formed over the Bay of Bengal;

5) The frequency of storms/ typhoons over the north Pacific during the monsoon season was slightly below normal (13 as against a normal of 16.2), however, with their unusual northerly tracks;

6) Since about August 1986, the Southern Oscillation Index (Tahiti—Darwin sea level pressure) was negative and reached minimum by about June 1987 with rising trend thereafter. This condition is unfavourable for the good monsoon activity. In the month of February 1988, the indications were that the SOI was close to zero (January value was -0.3), which is a favourable condition for a good monsoon in the year 1988;

7) SST off the Peru coast remained between 1° and 2°C above normal from March to October 1987 indicating an unfavourable condition for good monsoon in 1987. SST off the Peru coast turned close to normal with a value of 0.4°C in January 1988. There were indications in February that SST anomaly might be negative before the start of monsoon of 1988, which may also be a favourable factor for good monsoon in 1988;

8) Zonal wind anomaly at 10 hPa in January 1987 at Balboa (9°N , 80°W) was easterly (3 mps), an unfavourable factor for the good monsoon in 1987. Large-scale flood never occurred during the easterly anomalies, and drought conditions in India never occurred during the western anomalies.

b) El Nino and Indian monsoon

Temporal evolution of El Nino in relation to the performance of the Indian summer

monsoon rainfall was re-examined for the period 1875-1987. No two El Nino events nor their effects are alike. In a year of El Nino event, monsoon rainfall has never been excess suggesting that the excess monsoon rainfall is exclusively associated with the Non-El Nino event. Of the 27 El Nino events, 11 were associated with drought over India and in 16 years the rainfall was normal. In 6 years, monsoon drought occurred without an El Nino event. There seems to be a greater chance that the Indian monsoon rainfall occurs first and then the signal may be transmitted to other areas of the globe and such an area lies in the eastern Pacific. In case the oceanic part of the Central and Eastern Pacific is ready to respond to this signal, the full cycle of El Nino is completed. This may occur within six months, October to March, following the monsoon season (June to September), as it occurred during the events of 1965-66, 1972-73, 1982-83 and 1986-87 since the peak warming in the SST of the eastern equatorial Pacific is locked up with the southern hemisphere summer.

c) Studies on the characteristics of Monsoon rainfall

Linear trend in the monthly precipitation for 306 uniformly distributed rainfall stations of the country was computed month-wise. The areas delineating the statistically significant increasing/decreasing trends for the period 1871-1984 were demarcated.

d) Studies on the All-India Monsoon rainfall and wind Indices over the Pacific Ocean

A statistical examination of the association between the All-India monsoon rainfall and 850 hPa and 250 hPa wind indices over different regions of the Pacific Ocean for the period 1974-86 was made. The 850 hPa zonal wind index averaged over the Pacific Ocean region from 5°N — 5°S and 135° — 125°W for the DJF season, two seasons prior to monsoon rains, showed

significant high correlation (0.82). A regression equation developed between these two parameters indicated a good estimate of the All-India monsoon rainfall. For the 250 hPa zonal wind indices, the CCs are negative and significant for DJF and MAM seasons. It can be inferred that good monsoon conditions over the Indian sub-continent are preceded during DJF/MAM by weaker 850 hPa trends (westerly anomalies) and weaker 250 hPa westerlies (easterly anomalies) over the eastern equatorial Pacific, i.e., a weak Walker circulation. Further, a weak Walker circulation during DJF/MAM evolves into a strong Walker circulation during JJA/SON.

- e) Studies on the stable isotope ratio of teak tree annual rings and regional climate

On the basis of stable isotope ratio (δD in tree ring cellulose) of teak trees from the western ghat region of Maharashtra, it was found that the tropical teak trees which thrive on (monsoon) precipitation whose δD is not systematically related to air temperature or amount of rainfall, do show a significant correlation of δD of cellulose with amount of rainfall and mean maximum (diameter) growing season temperature, similar to coniferous trees from temperate regions. Thus, it is established that long sequences of teak tree rings from the Peninsular India could be useful to reconstruct the past monsoon variability for a few centuries back in time.

- f) Design and Development of one dimensional photochemical diffusion model for the study of ozone in the homosphere

A new one-dimensional photochemical diffusion model was designed and developed for the study of ozone in the atmosphere. The model was governed by input parameters such as solar fluxes, photo-absorption cross sections of different gases, chemical reaction scheme and reaction rate

coefficients and transport parameters (e.g. eddy and molecular diffusion coefficients). The model was designed with its upper boundary at 100 km whereas, the lower boundary is taken at the earth's surface. An efficient numerical scheme was developed for the solution of the set of simultaneous non-linear partial differential equations.

2.2.2 Hydrometeorological Studies

- a) Maximum and probable maximum precipitation (PMP)

- i) Estimates of Probable Maximum Precipitation (PMP) for 1 and 2 days durations were made for 3 river catchments namely Indravati, Indravati containing Palagad, and Kapur containing Muran having catchment areas of about 445, 595 and 420 mi^2 respectively in the State of Orissa. The PMP estimation for catchments of Indravati, Palagad and Kapur containing Muran for 1-day duration were found to be about 53, 51 and 55 cm respectively and for 2-day duration 84, 83 and 86 cm respectively.

- ii) Yearly observed 1-day maximum rainfall for about 40 long period stations in Jammu and Kashmir and about 60 long period stations in Assam were used to estimate the magnitudes of point extreme rainfall. The 1-day extreme rainfall for Jammu and Kashmir was found to range between 15 cm to 65 cm and for the State of Assam from 35 cm to 105 cm.

- iii) The highest recorded 24 hours rainfall data upto the period 1982 for about 300 stations in India were updated. The information on the spatial distribution of highest 24-hour rainfall was applied to demarcate the homogeneous rainfall zones of heavy rainfall. It was found that there existed a densely gauged area in the leeward side of the western ghats lying between latitudes 8° to 21°N within which greater than 20 cm of rain in 24 hours have never been recorded. Further, the rainfall potential

for mountaneous areas and flat areas was found to be more or less the same for 24 hours.

b) Analysis of rainstorms

i) The occurrence of severe rainstorms in the lower Godavari river basin was investigated for updating the storm climatology of the catchment. The recent severe rainstorm of 12-14 August, 1986 which occurred over the lower catchment was analysed by DAD method. Areal average raindepths obtained in this rainstorm for different durations were compared with the raindepths obtained in the past for the rainstorms which occurred over this region. It was found that the areal raindepths recorded during 1 to 3 days duration for the August 1986 storm exceeded the areal raindepths of past rainstorms.

ii) A Depth-Area-Duration (DAD) model for the Southern Indian rainstorms was developed by using DAD statistics of 18 rainstorms over the region. A model was developed to relate the mean depth of rainfall (\bar{R}) over a given area (A) to the storm centre rainfall depth (R) for 1-day duration. This model ($\bar{R} = R \cdot e^{0.0028 A^{0.749}}$) can be used to convert the storm centre rainfall amount to the mean rainfall in areas upto 10,000 km² for 1-day duration.

c) Short duration rainfall analysis

An analysis of maximum hourly rainfall records at Bangalore, Madras and Trivandrum stations during each year of the period 1969 to 1984 showed that Bangalore, Madras and Trivandrum recorded 60 mm, 87 mm and 77 mm respectively in 1-hour duration. The hourly annual maximum series for each station was also subjected to extreme value analysis and estimates of maximum 1-hour rainfall for return periods of 2 to 25 years were determined. The maximum 1-hour rainfall of 87 mm recorded at Madras was found to have about 40 years return period.

d) Rainfall variability

The periods of shortest possible durations contributing specified percentages of annual total rainfall were determined for each year of the period 1901 to 1980 for south and north Kerala separately with a view to identify the periods of reliable rainfall and their inter annual and long term fluctuations, if any. The analysis showed that 50, 70 and 90% of the annual rainfall was realised in 51, 93 and 166 days respectively over north Kerala with a standard deviation of 95 days. Further, no long term trends in durations of these periods were detected.

e) Analysis of stream flow data

On the basis of the stream flow data of Karanja catchment for the period 1964 to 1984, unit hydrographs for seven rainstorms were determined and an average unit hydrograph for the catchment was then obtained. Regression analysis was used to define relations between the rainfall and runoff for different months as well as for the year as a whole.

f) Analysis of floods and droughts

The incidence of hydrological floods and droughts in the upper Narmada river catchment upto the Indira Sagar dam site was investigated for the period 1901-1980. For this purpose, appropriate precipitation concentration index (PCI) was developed and for each year precipitation indices were computed using triad rainfall of the period May to October. The analysis indicated that the catchment experienced three severe floods in the years 1939, 1972 and 1973 and one severe drought in the year 1951.

2.3 Physical Meteorology and Aerology

2.3.1 Cloud Physics and Weather Modification

a) Studies in Atmospheric Electricity

Detailed analysis of the continuous recordings of atmospheric electric field

obtained at Pashan, Pune during the period October 1986–October 1987 was completed. The diurnal curve of fair weather electric field during the pre-monsoon, post-monsoon and winter seasons showed a bi-modal variation with peaks at 1100 hrs and 1700 hrs IST. During the monsoon season, the diurnal curve was mono-modal with the peak at 1300 hrs. The values of electric field varied between 65 and 500 Vm^{-1} . The magnitude and the diurnal variations in the atmospheric electric field were attributed to the airmass characteristics. These results are in agreement with those recorded at the Agrimet building of the Meteorological Office, Pune.

b) Radar study in rain and rain-bearing clouds

Radar data of precipitation echoes over Delhi from the convective clouds collected during the summer and monsoon seasons of the three-year period (1960-62) were analysed in order to study the echo-intensities of this type of echoes of different heights. Analysis of 1429 convective echoes showed that the low-level radar reflectivity factor exceeded 50 dbz in 55% cases when the echo top heights were 12 km or more. In case of echoes having echo-top heights less than 12 km, such high echo intensity was observed in 26% cases only.

c) Warm cloud modification

The Institute provided technical assistance to (i) Gujarat state in their aircraft salt seeding operations and (ii) Kerala state in the mountain-top Silver Iodide seeding operations. The details are given below :

i) Gujarat State

Cloud seeding operations were carried out during 38 aircraft flights undertaken during the period 25 July – 17 September 1987. Out of the 38 occasions, 20 days were found to be seedable according to the criteria adopted in the IITM experiment in the Pune region. Out

of these 20 days, rainfall was actually recorded on 18 days in the seeded areas. Cloud physical observations were carried out on 26 out of 38 aircraft flights. The liquid water content of clouds in 19 out of 26 days was found to be greater than 0.5 gm/m^3 , a condition found to be favourable for obtaining positive responses from the seeded clouds. The cloud depth (vertical thickness) in 19 out of 38 days was found to be in the range of 2000-6000 ft. which was also one of the favourable conditions for obtaining positive responses from seeded clouds.

ii) Idukki Catchment Area (Kerala State)

Mountain-top silver iodide burner seeding operations were carried out on 29 days during the period 17 September – 6 November 1987 using the special equipment obtained on loan by the IITM from CSIRO, Australia. An amount of 10.63 kg of silver iodide and 2.63 kg of Ammonium iodide and 732 litre of acetone were utilised in the operations. An examination of the rainfall data in the downwind region indicated that the measurable rainfall was recorded on 23 out of 29 seedable days. Also, the inflow on seeded days varied from 1.946 to 12.409 MCM as compared to that from 1.27 to 6.86 MCM on not-seeded days during the period of operation. The reservoir level during the period of operations increased from 2307.22 ft. to 2323.62 ft. AMSL.

2.3.2 Environmental Physics

a) Studies of the Atmospheric Boundary Layer

Computation of thermodynamic parameters over the regions of the Arabian Sea, Indian Ocean and the Bay of Bengal for the stationary period of the Russian ships during Monex-77 were carried out. Analysis of the thermodynamic parameters from the surface up to 500 hPa showed the following :

i) The regions of downward heat flux by and large coincided with the zonal wind

maxima and (ii) the meridional component of wind varied with the monsoon activity. There was a northerly transport of water vapour upto 600 hPa during the active monsoon conditions, whereas an opposite trend was observed during the weak monsoon conditions.

A study of the variations of the thermodynamic characteristics of the atmospheric boundary layer during the contrasting synoptic weather conditions was carried out using the aerological soundings at Pune. The two periods were chosen on the basis of the positions of monsoon trough, cyclonic circulation and other synoptic conditions. The results of the study suggest that during the break monsoon conditions, the subsidence dominated the boundary layer parameters resulting into the formation of an inversion layer at 750 hPa level. During the active monsoon conditions, pumping of the moisture upto the higher levels was reflected in the moisture profiles.

b) Studies in Upper Atmosphere

A study of the modulating effect of the low latitude QBO in the stratospheric zonal wind at 30 hPa on the frequency of the cyclonic storms and depressions was undertaken, using the 35 years' data for the frequency of occurrences of cyclones and depressions in the Bay of Bengal and the Arabian Sea (Indian sea) and the zonal wind at 30 hPa for Balboa (9°N, 80°W) during the post monsoon period (October-December) for 1951-1985.

The results of the study pointed out that there was an in-phase relationship in 21 out of 35 years (i.e. 60 per cent occasions) between the phases of the QBO in the zonal wind of the equatorial stratosphere at 30 hPa, and the cyclones as well as the depressions forming in the Indian seas during the post-monsoon season October-December. During the period of a distinct in-phase relationship, the frequency of cyclonic

storms and depressions in the Indian seas per season (October-December) was 7.2 in the westerly phase ($+2.2 \text{ m s}^{-1}$) and 4.5 in the easterly phase (-18.6 m s^{-1}) of the QBO, which compared well with the results of the study of the hurricanes in the Atlantic basin conducted by Prof. William Gray in USA. In the present study, the mean wind speed in the westerly phase was $+2.2 \text{ m s}^{-1}$ and that in the easterly was -18.6 m s^{-1} respectively. 10 occasions of out-of-phase relationship noticed herein could be indicative of lack of QBO modulation of the cyclones and depressions in the basins of the Indian seas than in the Atlantic basin.

The behaviour of the summer monsoon over India during June-September for the 8-year period 1980-87 has been erratic. The study of the monthly mean rocketsonde wind and temperature data for December (1979-86) and January (1980-87) for Thumba (8.5°N, 76.9°E) obtained during the period of Indian Middle Atmosphere Programme (IMAP) revealed that the drought years were preceded by weak westerly to strong easterly, and above normal monsoon rainfall years by strong westerly at 25 km during December and January. The good monsoon activity during 1983 was also preceded by strong easterly at 60 km during January of that year. Similar features were noticed at 50 km. At 25 km, during January, the very cold temperature was linked with the forthcoming severe drought years and the intense warm temperature with the only one very good monsoon year (1983) in the country during the above 8-year period. The cold temperature anomaly noticed at 25 km even extended up to 50 km during 1987.

The variations of large-scale poleward heat flux in the middle stratosphere during the northern winters were studied. The mean poleward transport of energy during the winter months (December-February), for the period 1971-83, was computed over the area north of latitude 50°N, utilizing the zonally averaged temperatures and meridional winds at 30-mb level. The variation in the energy

flux in relation to the westerly and early phases of the equatorial QBO was also examined. The study suggested a large interannual variability in the transport of energy. The variation in the flux was of a quasi-biennial nature. The amplitude of the biennial oscillation was large during the period 1971-78 and small during the period 1978-82. The stronger (weaker) flux during the westerly (easterly) phase of the equatorial QBO indicates a linkage between the low-and high-latitude circulation features.

Sun-Weather-Relations

The variations in middle stratospheric temperatures over the North pole during the winters for the period 1955-84 in relation to solar activity were examined with particular reference to the major stratospheric warmings and the equatorial quasi-biennial oscillation (QBO). The analysis revealed that the temperatures showed a large interannual variability with evidence of a stratospheric quasi-biennial oscillation (SQBO). The study confirmed a strong relationship between the temperatures and the solar activity when the data are stratified in accordance with the phases of the equatorial QBO. The temperatures varied in an in-phase manner with the solar activity during the westerly phase and in an anti-phase manner during the easterly phase of the equatorial QBO. The study highlighted the frequent occurrence of major warmings during the easterly phase of the equatorial QBO, most especially at the Sunspot minima. It also identified that the relatively few major warmings that occurred during the westerly phase of the equatorial QBO did so at the Sunspot maxima.

A study was undertaken to examine critically the relationship between the solar cycle and the Indian monsoon rainfall, for the period 1871-1984 and to search for the significant periodicities, by utilizing the maximum entropy spectral technique. The results of the study showed a significant 11-year cycle in solar activity and rainfall.

Also, a significant 7.33-year cycle in rainfall was observed. The double (Hale) sunspot cycle was not discernible either in sunspot number or in rainfall. The cross-spectral analysis between the sunspot number and rainfall confirmed the existence of reasonable correlation over a 11-year cycle with a relative phase lag of 0.16 year (sun lead).

c) Studies in Air Pollution

Under the extended programme of research relating to acid rain in India, rain water sampling was organised during the summer monsoon season of 1987 in the vicinity of the Koradi thermal power plant (Nagpur) and at the Trivandrum Airport. The chemical analysis of the 31 rain water samples collected at Koradi and 29 samples collected at Trivandrum was taken up. The pH values of rain water at Koradi and Trivandrum were found to be 6.4 and 5.8 respectively. 31 snow samples collected at Gulmarg during the winter period from December 1986 to May 1987 were analysed for various ionic compositions. The average total mineralisation in the snow samples was 3.78 mg/litre which is about 2 to 3 times lower than that in the rain water/fog water. Calcium and Sulphate were found to be dominant ions in the cations and anions respectively. The measured acidity in the snow samples was 7.1 pH, whereas the calculated estimate of the original acidity present in the atmosphere was 4.3 pH. Hence, the estimates of the original acidity is $1\frac{1}{2}$ orders of magnitude greater than the measured acidity, reflecting the importance of the alkaline components present in the atmosphere over Gulmarg.

In order to evaluate the long term effect of pollutants on the pH of rain water, samples for rain water were collected at Agra and Delhi during the monsoon seasons of 1963 and 1965 respectively and also after a period of two decades, in 1984. Chemical composition of rain water samples was determined along with the pH values.

The PH values at Agra and Delhi were found to be decreased by 2.8 and 0.9 units respectively after a period of two decades but were still in the alkaline range. The reduction in pH could be ascribed to the increase in the anthropogenic components (SO_4 and NO_3) by 88% and the decrease of the soil oriented components (Ca, K) by 44% in the chemical composition of rain water samples.

d) Studies in Remote Sensing of the Atmosphere

Theoretical computations of scattering cross-section for the atmospheric aerosols were taken up by using the Mie scattering algorithms. The Mie scattering cross-sections which are being estimated considering the different laser probing wavelengths, states of polarization and the size and refractive indices were used in the retrieval of atmospheric aerosol size distribution and refractive index from the lidar observations.

Observations of atmospheric aerosols collected during clear nights, using the Argon ion lidar system at the Institute for the 1-year period (October 1986-September 1987), were analysed and the monthly mean vertical aerosol profiles (up to 3000 m agl) were estimated.

Path-integrated or average column content (over a path length of about 7 km) measurements of atmospheric NO_2 concentration was carried out using the Argon ion lidar system. Differential Absorption Lidar (DIAL) technique was adopted for the above observations. 496.5 nm (absorption coefft. $= 1.11 \times 10^3 \text{ ppm}^{-1} \text{ m}^{-1}$) and 501.7 nm (absorption coefft. $0.543 \times 10^3 \text{ ppm}^{-1} \text{ m}^{-1}$) wavelengths of the Argon ion laser system were used. Preliminary observations, at an interval of 30 minutes were carried out on 24/25 April 1987 (between 2030-0535 hrs LT) to study the diurnal variation of atmospheric NO_2 concentration.

Analysis of the special spectrometric observations for the study of diurnal

variations in the atmospheric NO_2 were carried out on 18 and 21 December 1987.

2.4 Instrumental and Observational Techniques

2.4.1 Development of meteorological payload for rockets and satellites

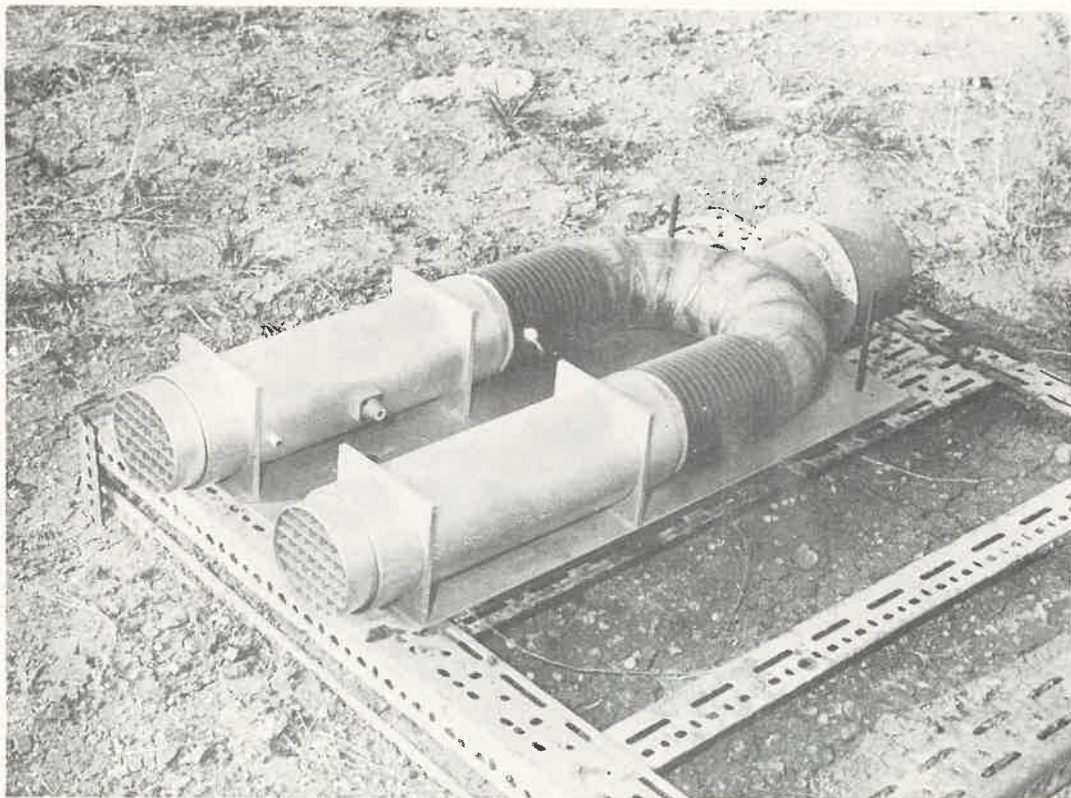
2.4.1.1 Development of rocket payload for upper atmospheric research and to carry out related physical studies

Five solid state 1680 MHz transmitters and modulating circuits were tested and necessary changes were made in the modulating circuit. To evaluate the battery drainage, a vigorous 7 hr line test was carried out. Antenna alignment was done. Two payloads were tested at TERLS, VSSC, Trivandrum for monitoring the frequency and radiation. Power pack was changed to a Ni-Cd rechargeable battery. Five payloads were subjected to 'GATE' tests at ARDE, Pune for sinusoidal and random vibrations. The payloads withstood the tests. The payloads were then put to 96 hr burn test at 70°C , 8 hrs bake test at 70°C , and 10 hr cold soak test at 10°C . Seven thermistor temperature sensor (Mylar film) mounts were prepared using imported silver paint.

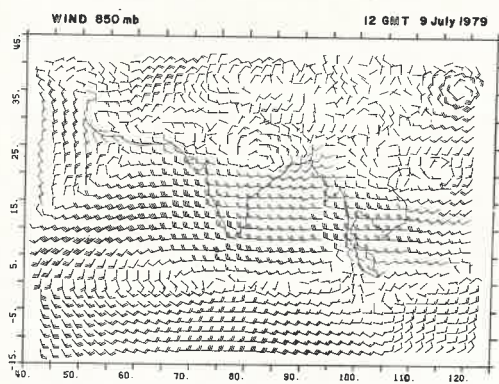
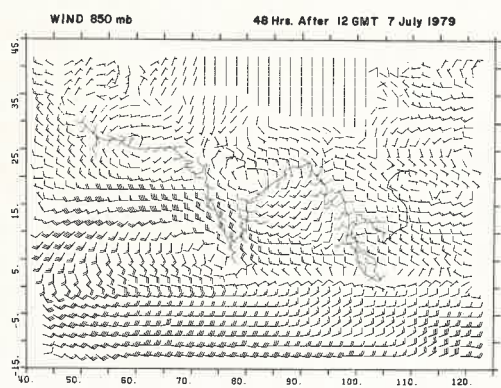
2.4.2 Development of instruments for boundary layer studies

2.4.2.1 Development of instruments for the fluxes and profiles measurements in the atmospheric boundary layer and to carry out related studies

Temperature sensors (bead type thermistors and thermocouples-6 each) with associated circuitry were fabricated and checked with 60 m cables in the laboratory, for temperature profile measurements. A thermocouple temperature sensor to measure +ve and -ve temperature and a modified radiosonde baroswitch were fabricated and calibrated for use on the Lyman α balloon borne payload. A water jacket to house the Lyman α and hygrometer circuitry was fabricated.



A Gerdien's tube for measurement of atmospheric electrical conductivity of both polarities



Six level P. E. model forecast and verification wind charts at 850 mb

Thermocouple temperature probe was field tested with and without radiation shields. The performance of the sensor without shield was found to be better and its frequency response was 2-3 Hz. Two high frequency response temperature probes similar to Kaimal probe were fabricated using 2 micron platinum wire.

Cup anemometers with infrared chopping system were designed, fabricated and tested in the laboratory. The anemometers and temperature sensors were fitted to a 23.2 m mast for wind and temperature profile studies in the surface boundary layer. The system was tested in the laboratory with 200 ft interfacing cable. The loading effect of cables was evaluated as about 3 mV in 800-1000 mV.

A three channel radiometer system to measure the direct, diffuse and total solar radiation was modified and put in operation along with a thermopile type radiometer of the IMD, for comparison. Global radiation value from both the radiometers agreed within 3-4% in noon period when both the radiometers were looking directly into the Sun. Using a sample data, the Angstrom turbidity was estimated.

Momentum flux at a point in a complex terrain (IITM, Pashan) was computed by an eddy correlation program using samples of wind data (u and w components) collected using the Gill propellor anemometers during 7-9 April 1986. The fractional error in flux due to the tilt on u-w plane of sensors w.r.t. orthogonal axis of wind was computed and studied. The study revealed that at 4 m height when the wind speed exceeds 4 m/s, the error per degree tilt of the sensor exceeds 25%. The diurnal progression of momentum flux was relatively smooth during the period. Mean momentum flux was estimated as 2.1 N/m^2 under convective conditions in light winds. Using the temperature data obtained during the period, standard deviations of temperature, wind components normalised with the mean wind speed and

their space correlation coefficients were computed and studied as a function of the mean wind speed.

The instruments required for wind and temperature profile measurements were developed and fitted to a 3.2 m mast for surface boundary layer studies. Electronic analog circuits (sum, difference, multiplication, squaring, averaging and integration over 5 min) were designed and fabricated and tested in the laboratory for eddy correlation studies.

2.4.3 Instrumentation for cloud physics and weather modification studies

2.4.3.1 Development of instruments and observational techniques for cloud electrification studies

A field experiment was conducted to study the effect of air pollutants on atmospheric space charge near the ground. Space charge was measured simultaneously under low, moderate and heavy air pollution conditions. Measurements of charge on different categories of particles with Particle Charge Measuring apparatus and of the precipitation current and corona current were made below rain showers. The particle charge measuring apparatus provided systematic data.

An A.C. field mill to measure atmospheric electric field was developed and calibrated. Data on vector electric field measured with a spherical field meter in fair weather conditions were analysed and studied. Continuous measurements of electric field, conductivity of both polarities and space charge were made on and around the day of solar eclipse on 18 March 1988. The parameters showed distinct variations during the eclipse period. A space charge tube was fabricated for measuring the atmospheric space charge in cloudy weather and was being tested. It is felt that the opposite polarity of charges observed with the particle charge measuring apparatus on raindrops

and the other two small categories may be reverse in case of drizzle and heavy rain. Charges on raindrops may mostly be of a single polarity for a few minutes in the beginning and end of a shower and of both polarities in between.

2.4.3.2 Development of simulation techniques for cloud physics

A vertical tube of 12 m length and 15 cm diameter was installed from terrace to the ground floor of the Institute building at Pashan, Pune to study the behaviour of water drops falling at their terminal velocity. The tube was fitted with electrodes to apply high electric fields on the drops. A clean and dry air supply unit for monodisperse aerosol generator was fabricated. Experiments to collect all the fragmenting water droplets on break-up of large drops suspended in vertical wind tunnel, were carried out.

2.5 Theoretical Studies

2.5.1 Studies on Dynamic Instability

2.5.1.1 Barotropic and Baroclinic Instability of the Atmospheric Flow

The role of diffusion and wave-wave interactions in the non-linear development of barotropic unstable waves in the vicinity of tropical easterly jet was further investigated using the barotropic spectral model developed earlier. The results obtained from the time integration of the model indicated that the interaction of the largest synoptic wave dominates over all other waves and diffusion was found to weaken strongly the wave-wave interactions. The problem of wave-wave exchange of enstrophy for non-divergent barotropic flow was mathematically formulated. The dissipation of kinetic energy due to the diffusion was computed in the spectral model for the study of the steady state kinetic energy and the enstrophy spectra.

A numerical linear barotropic spectral model for a limited region was developed. The model takes into account the asymmetric nature of monsoon flow. The model will be used to understand the reason for the preferred region of formation of monsoon depressions.

Efforts were continued to modify the linear equatorial balance model developed earlier for the study of instability of monsoon zonal flow.

The data obtained from ECMWF (height; wind and temperature) for the period 4-8 July 1979 and for the region 20.6°S-43°N and 30°E-120°E were scrutinised in order to identify the possible bad data. For this purpose, the data were subjected to isoline analysis by using a computer routine. The bad data were replaced by the interpolated data using the cubic spline technique horizontally and vertically.

2.5.2 Simulation of Monsoon and Tropical Circulation Systems

2.5.2.1 Simulation of Mean Monsoon Circulation and Predictability of Monsoon Systems

In order to provide the inputs to the 5-level global spectral model developed earlier, computer routines were developed for interpolation of data from pressure to sigma levels and for computation of the spherical harmonic coefficients. The spherical harmonic coefficients for streamfunction, velocity potential, geopotential and temperature were obtained using the FGGE III b level global data at 850 mb for 30 June 1979. The rhomboidal truncation at 45 is able to explain more than 95% of the observed variance. The computer routines were also developed for the presentation of model outputs. These routines compute the grid point values from the spectral coefficients and subject them to isoline analysis. A code for the dynamic normal mode initialisation was developed for the primitive equation barotropic spectral model.

The problem on longwave radiation parameterisation for H_2O and CO_2 , in troposphere was formulated, for use in the Spectral model. The radiative fluxes, infrared cooling/heating rates in different (vertical) layers were computed using the above formulation with test input data and were found to be consistent with the known values. Transmission function of CO_2 is assumed to be independent of temperature.

The expressions for kinetic energy transfer due to (i) advection, (ii) diffusion, (iii) bi-harmonic diffusion of vorticity and (iv) orography were derived in the zonal wavenumber domain for the non-divergent barotropic atmosphere. The energy transfer computations were carried out by using FGGE III b level data in the region $0-25^\circ N$ and $75^\circ E-105^\circ E$ at 850 mb for 4 July 1979. The results showed that due to the wave-wave interactions the zonal waves 2-8 provide kinetic energy to all other waves. The dissipation due to the diffusion and generation of kinetic energy due to orography was significant for waves 4-8.

2.6 Computer

The Institute acquired a new computer system ND-560 with 7 terminals, during the year. The system was made operational.

The packed binary global FGGE level III B data were transferred to the magnetic tape (9 track, 6250 bps) in a formatted manner in ASCII code by using NEC-S-1000 computer system. The printout of the data for two levels, viz., 850 mb and 200 mb (30 June 1979, 00 GMT) in the region latitudes $30^\circ S$ to $41.25^\circ N$ and longitude $60^\circ E$ to $120^\circ E$ were taken and analysed. Six files of the data for the period 11-16 May 1979 were transferred on a magnetic tape in a formatted form.

The work of transferring data collected during the IIOE period from cards to magnetic tape was in progress.

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A view of the Institute's ND-560 Computer System

3. COLLABORATION WITH UNIVERSITIES AND OTHER SCIENTIFIC INSTITUTIONS

The Institute maintains contacts with the Universities and other Scientific Institutions in India and abroad. It has also collaborative research arrangements with different organisations. Highlights of these activities during the year are given below :

3.1 Collaboration with Universities

The Institute continued to collaborate with the University of Poona in teaching a course on Atmospheric Physics in the second year of M.Sc. (Physics) degree course. It also co-sponsored the 'Summer School in the Atmospheric Science' held at the University of Poona during 4 May-12 June 1987. The Summer School was organised by the University Grants Commission with a view to promote post M.Sc. courses in Atmospheric Sciences in the Indian Universities. Several Scientists of the Institute delivered invited lectures on their areas of specialisation.

On request from the Vice-Chancellor, Mahatma Phule Agricultural University, Rahuri, the Institute has agreed to provide academic support to the teaching of meteorology at the Centre of Advanced Studies in Agricultural Meteorology at the College of Agriculture, Pune. The centre has been established under the UNDP/FAO, Govt. of India and Govt. of Maharashtra arrangements. Dr. G. B. Pant, A.D. delivered lectures for the semester course on General Meteorology and Climatology, as an invited faculty member of the University. Institute is also providing library facilities to their faculty members and students.

Shri R. Suryanarayana, A.D., participated in an invited Panel Discussion arranged by the University of Calcutta on 24 Feb. 1988 regarding 'Teaching curriculum in Atmospheric Science to make available properly

trained manpower towards the development of numerical models for medium range weather forecasting'.

Dr. S. S. Singh, A.D. delivered six lectures at the Workshop on 'Numerical Weather Prediction and Computer Software' at Andhra University, Waltair, during 30 December 1987 to 5 January 1988.

Dr. K. Rupakumar, SSO-II conducted viva-voce examination for M.Sc. Thesis at Haryana Agricultural University, Hissar.

Under the guidance of Dr. (Mrs) P. S. Salvekar, SSO II, two students of Univ. of Poona, Deptt. of Physics, submitted their dissertations as project work for their M.Sc. degree.

Award of Ph.D. degree

Shri D. V. Ahire, an ex-research scholar of the Institute was awarded Ph.D. degree in Physics by the University of Poona for his thesis entitled, 'The behaviour of charged and uncharged water drops under different electrical stresses'. He worked under the guidance of Dr. A. K. Kamra, A.D.

University of Poona has awarded Ph.D. degree in Physics to Shri Ishwar Datta for his thesis entitled, 'Risk based seismic response analysis of structures—a stochastic approach'. Shri Datt is working at the Central Water and Power Research Station, Pune and carried out his research under the guidance of Dr. A. S. R. Murty, A.D.

Award of M.Sc. Degree

Miss S. S. Goyal, SA was awarded M.Sc. degree in Physics by the University of Poona for her thesis entitled, "Some physical and thermodynamical aspects of Atmospheric Boundary Layer and Clouds". Dr. A. S. R. Murty, A.D. was her Research Guide.

3.2 Collaboration with Institutions/ Organisations

1. Bilateral Scientific Programmes

1.1 Indo-US Programme under the STI

Shri R. K. Verma, Senior Scientific Officer, Grade I was deputed to Geophysical Fluid Dynamics Laboratory (GFDL) Princeton, USA to study the interannual variability of monsoon under the Indo-US STI Programme for monsoon research from 12 April to 22 May 1987. During his visit, he gave a seminar talk on 'Interannual and long-term variability of the Indian Monsoon in relation to global climate variability' at GFDL on 1 May 1987. The research projects on numerical weather prediction under the STI programme made further progress.

1.2 Formulation of Programme under the Indo-US Sub-Commission

A 'get-together' of the scientists from

different organisations engaged in monsoon research was organised by DST at the Institute from 24-26 Aug. 1987 to develop new collaborative research projects under the Indo-US Sub-Commission. The projects proposed by the US Scientists were discussed in detail. Several projects were finalised for collaborative research. Scientific visits by the scientists of both countries are envisaged in the project. DST is taking necessary action for getting clearance from the Govt. of India for these projects. The projects and the Institute's scientists who would participate in these projects are given in the Table.

These projects were discussed in the 9th meeting of the Indo-US Sub-Commission on Science and Technology (Atmospheric and Marine Science) meeting held at New Delhi during 3-5 November 1987. Director IITM participated in this meeting as a member of the Indian side.

Sr. No.	Project Title	Participants of the Institute
1.	Large-Scale Ocean-Atmosphere Climate Interaction-Diagnosis, Theory and Prediction of Climate episodes in the global monsoon system.	Dr. B. Parthasarathy Dr. H. N. Bhalme Shri R. K. Verma Shri K. D. Prasad Shri R. Suryanarayana
2.	Data Preparation and Management	Shri R. Suryanarayana Shri S. S. Aralikatti
3.	Role of Planetary and Regional Scale Processes in Active-Break cycle of the Indian Summer monsoon.	Shri D. K. Paul Shri R. Suryanarayana
4.	Diagnostic studies of Global Atmospheric and Oceanic Fields for understanding the Interannual variability of the Indian Monsoon.	Dr. S. V. Singh Shri R. H. Kripalani
5.	Dynamics of ITCZ	Shri D. R. Sikka

1.3 Indo-USSR Programme

The following scientists were deputed to

USSR under the Indo-USSR programme of Co-operation in Science and Technology (Meteorology and Environmental Protection) :

Name of the Scientist	Period of deputation
i) Dr. P. C. S. Devara, SSO-I	18 days from 20 May 1987
ii) Shri D. K. Paul, SSO-II	One month from 20 May 1987
iii) Dr. K. Rupa Kumar Kolli, SSO-II	18 days from 20 May 1987
iv) Shri P. N. Mahajan, JSO	18 days from 20 May 1987

1.4 Participation in ISRO-SCHCNE Collaboration Programme

Shri R. Vijayakumar, SSO II participated in the IMAP-C Ozone Campaign-1987 which was held at the TERLS, VSSC, Trivandrum during 15 Nov. to 15 Dec. 1987 under ISRO-SCHCNE Collaboration. He made measurements of atmospheric total ozone using the IITM photometer.

2. Participation of the Institute in Scientific Programmes of National Importance

2.1 Nilgiri Biosphere Reserve Programme

The scientific committee meeting of the Nilgiri Biosphere Reserve Programme was held at Bangalore during 11-12 January 1988 under the chairmanship of Prof. Madhav Gadgil of I.I.Sc., Bangalore. Director and Dr. L. T. Khemani SSO II participated in the meeting and had discussions regarding the planning and execution of the programme. It was decided to undertake field observational programmes at Masingudi (Karnataka) and Silent Valley (Kerala) in collaboration with I.I.Sc., Bangalore and the Centre for Water Resources Development and Management (CWRDM), Calicut.

The Institute scientists have set up a field observational station at Masingudi (240 km from Bangalore) in collaboration with the scientists of the Centre for Environmental Studies, I.I.Sc., Bangalore. As a part of the first phase of the observational programme regular collection of rain samples was carried out which would be utilised for studying the chemistry and pH of rain water and their influence on climate vegetation interaction in Nilgiri Biosphere Reserve.

2.2 National Centre for Medium Range Weather Forecasting

The Institute continued to extend support to the DST in connection with the setting up of the National Centre for Medium Range Weather Forecasting, a Mission Mode Project under the 7th Five Year Plan. Towards this end, the Institute scientists participated in workshops and meetings organised by the DST at New Delhi.

3. Warm Cloud Modification Experiments

A high-level meeting was held on 20 September 1987 under the chairmanship of the Secretary, DST for reviewing the work of the project, 'Warm Cloud Modification Experiment in Maharashtra State' conducted by the Institute during the past 11 summer seasons (1973, 1974, 1976, 1979-1986). The participants included Chairman, G.C., Senior officers from DST and IMD, experts from Andhra University, Waltair and IIT, Kharagpur. Dr. A. S. R. Murty, A.D. made a detailed presentation of the results of the 'Warm Cloud Modification Experiments' carried out by the Institute before the high-level committee.

As per the decision taken at the meeting, a Detailed Project Report (DPR) for the formation of Cloud Seeding Programme (CSP) was prepared and submitted to DST. It is envisaged to undertake cloud seeding on operational basis initially in a few states.

4. Technical assistance to State Governments :

4.1 Assistance to State Governments for rain enhancement :

Gujarat :

At the request of the Govt. of Gujarat, the Institute provided technical assistance in their aircraft salt seeding operations by deputing scientists of the Institute. The field programme was executed during July-September 1987.

Kerala :

On request from the Chief Engineer, Kerala State Electricity Board, the Institute extended technical/scientific help during August to October 1987 in their mountain top Silver Iodide Seeding Operations.

4.2 Technical assistance on estimation of PMP

Koyna Catchment :

Technical guidance on the estimation of probable maximum storm for the Koyna catchment was provided to two Research Assistants, deputed by the Koyna Dam

Maintenance Division, Alore, Govt. of Maharashtra.

Indravati Project

Technical guidance and assistance on the estimation of PMP for Indravati project was provided to the Assistant Engineers deputed by the Upper Indravati Project, Govt. of Orissa.

One day PMP maps for the different states of India have been prepared with a view to publish these maps in an Atlas form for the use of hydrologists and design engineers.

Information on Severe rainstorms that have occurred in and around the Panchanad Dam Project near Etawah (UP) was supplied to the Directorate of Hydrology, IMD, New Delhi.

4.3 Collaboration with Bhabha Atomic Research Centre (BARC)

The RCPR Centre of the Institute, New Delhi has been providing facilities to BARC for collecting observations for their following studies :

- i) Monitoring of atmospheric pressure variations continuously with a micro-barograph,
- ii) Monitoring of ground vibrations with a seismometer and
- iii) Monitoring of radio-active fall out.

4.4 Collaboration with Birbal Sahni Institute of Palaeobotany

In collaboration with the Birbal Sahni Institute of Palaeobotany, Lucknow, a field trip to the forest sites of Karnataka and Tamil Nadu was organised from 2 to 14 December 1987 for dendroclimatological studies.

5. Exhibitions

The Institute participated in the Science and Technology Exhibitions, organised from 7-20 January 1988, during the Platinum Jubilee Session of the Indian Science Congress held at the University of Poona. It also participated in the celebration of 'Water Resources Day' organised by The Institution of Engineers (India), Pune Chapter. Dr. G. B. Pant, A. D. worked as a member of the organising committee. Exhibits in various meteorological aspects of Water Resources of Maharashtra were displayed by the

Institute during the exhibition at the Institution of Engineers, Pune on 15 and 16 April, 1987.

6. Memberships

6.1 Shri D. R. Sikka, Director has been nominated by the Organising Committee of the World Climate Research Programme (WCRP) to serve as a member of the JSC/CCCO Scientific Steering Group for the International Tropical Ocean Global Atmosphere (TOGA) programme, a project under the WCRP.

6.2 Dr. O. N. Dhar, Emeritus Scientist has been appointed as one of the members of the panel for upper Krishna Project, reconstituted by the Govt. of Karnataka.

6.3 Shri K. G. Vernekar, A.D. has accepted the membership of the Study-cum-Task Team for Promotion of Instrument Design, Development and Use for Atmospheric Research on Meteorology constituted by the Advisory Committee for Space Research.

6.4 Dr. H. N. Bhalme, A.D. worked as co-chairman for the working group in 'Drought Prediction and Early Warning'.

7. Review of proposals

Several research proposals submitted to DST for funding under their Atmospheric Research programme were reviewed by the scientists of the Institute.

8. Invitation from Editor, Environmental Central Technology

Dr. L. T. Khemani, SSO II received an invitation from Dr. Paul N. Cheremisinoff, Editor, Environmental Central Technology, New Jersey, USA to contribute a Review Paper on 'Atmospheric Aerosol' which will be published under the section on 'Sea Salt Aerosol' in the Encyclopaedia containing comprehensive information covering all aspects of Pollution Control and Environmental sciences.

9. Election as a Fellow

Miss K. Indira, JSO has been elected as Fellow of the Indian Physical Society, Calcutta.

4. PARTICIPATION IN SYMPOSIA/CONFERENCES ETC.

Forecasting Research

- a) Seminar on 'Hydrology' with colloquium on 'Urban Water Supply', Association of Hydrologists in India, Madras, 28-30 August 1987— V. R. Mujumdar, S. S. Dugam, M. W. Sonawane and S. D. Bansod.
- i) Impact on rainfall distribution over Gujarat and Rajasthan subsequent to stagnation of monsoon of 1985 : V. R. Deshpande and V. R. Mujumdar
- ii) Long term variability of the summer monsoon rainfall over different regions of India during 1971-1986 : K. D. Prasad, M. W. Sonawane and S. V. Singh.
- iii) Relationship between onset of monsoon and subsequent rainfall over various regions of India : S. D. Bansod and S. V. Singh
- iv) Quasi-biennial oscillation (QBO) in the Indian summer monsoon rainfall : S. S. Dugam, K. Subramaniam, S. B. Kakade and R. K. Verma
- b. National Space Science Symposium, Physical Research Laboratory, Ahmedabad, 21-24 December, 1987 : R. K. Verma
- i) Satellite monitoring of continental snowcover for climate studies : R.K.Verma
- ii) Satellite-observed radiation budget characteristics during the onset phase of summer monsoon 1979 : P. N. Mahajan, V. R. Mujumdar and S. P. Ghanekar
- c. Int. Agency workshop for Finalising Cruise Plans, National Institute of Oceanography, (NIO), Goa, 4-5 February 1988 : P. Seetaramayya.

Climatology and Hydrometeorology

- a. National seminar on 'Hydrology', Madras, 28-30 August 1987 : P. R. Rakhecha and A. K. Kulkarni.
- i) Appraisal of heavy rainfall and the highest floods of Bihar : O. N. Dhar, B. N. Mandal and A. K. Kulkarni.
- ii) Brief appraisal of water resources of Tamilnadu : P. R. Rakhecha and N. R. Deshpande.
- iii) Estimation of PMP for Kallada basin located in the Western Ghat of south India : O. N. Dhar, S. S. Nandargi and A. K. Kulkarni.
- iv) New method for estimating extreme rainfall for river catchments : P. R. Rakhecha and N. R. Deshpande.
- v) Review of recent hydrometeorological studies on Indian rainfall : O. N. Dhar, A. K. Kulkarni and B. N. Mandal.
- vi) Was the lower Godavari basin rainstorm of August 1986 unprecedented? : O. N. Dhar, S. S. Mulye and S. S. Nandargi.
- b. National symp. on 'Hydrology', Roorkee, 16-18 December 1987 : P. R. Rakhecha.
- i) Interannual and long-term fluctuations of hydroclimatic conditions of upper Narmada catchments : N. Singh, M. K. Soman and K. K. Kumar.
- ii) Use of 24-hour maximum point rainfall for demarcating homogeneous zones in India : P. R. Rakhecha, A. K. Kulkarni, B. N. Mandal and N. R. Deshpande.
- c. National space science symp., Physical Research Laboratory, Ahmedabad. 21-24 December 1987 : S. D. Patil.

Thermal and kinematic structure at tropopause level over India during the years 1965-1985 : S. D. Patil.

- d. 4th Nat. Symp. on Mass Spectrometry, I.I.Sc., Bangalore, 4-6 January 1988.

Climatic significance of D/H ratios in teak trees from Maharashtra : R. Ramesh, R. A. Jani, S. K. Bhattacharya and G. B. Pant.

Physical Meteorology and Aerology

- a. 15th National Optical Society of India Symp. on Opto-electronics, University of Poona, Pune, 29 June-1 July 1987 : A. S. R. Murty, P. C. S. Devara, D. B. Jadhav, S. S. Parasnis, P. E. Raj and A. L. Londhe.

P. C. S. Devara, SSO I chaired a session on 'Techniques for Remote Sensing' at the symposium.

- i) Design of infra-red (IR) grille spectrometer for atmospheric studies : D. B. Jadhav and S. S. Parasnis.
- ii) Development and application of spectral scanning polarimeter : S. R. Dhande, A. J. Kamatgi, D. B. Jadhav and A. D. Tillu.
- iii) Effect of size parameter and refractive index on atmospheric aerosol profiles retrieved from bistatic lidar measurements : P. C. S. Devara, P. E. Raj and A. L. Londhe.
- iv) Grating spectrometers for atmospheric studies (Review) : D. B. Jadhav and A. D. Tillu.
- v) Laser remote sounding of the atmosphere (Review) : P. C. S. Devara.
- vi) New three-channel twin photometer for atmospheric studies : S. R. Dhande, J. N. Shelke, M. R. Thade, D. B. Jadhav and A. D. Tillu.

- vii) Vertical distribution of atmospheric aerosols and its variation with time : P. C. S. Devara, P. E. Raj and A. L. Londhe.

- b. Int. colloquium on Atmospheric Sciences and Nat. Conf. on Manpower assessment and teaching strategies for post-M.Sc. programme on Atmospheric Sc., Jadavpur University and Saha Institute of Nuclear Physics, Calcutta, 14-22 and 23-25 September 1987 : K. Indira

- c. National Space Science Symp., Physical Research Laboratory, Ahmedabad, 21-24 December 1987 : D. B. Jadhav.

- i) Laser radar monitoring of tropospheric aerosols : P. C. S. Devara, P. E. Raj and A. L. Londhe.

- ii) Satellite imagery for major, minor and trace gases by high resolution spectroscopy : D. B. Jadhav.

- d. National Sem. on Power Generation and Environment, Lucknow, 11 Feb. 1988 : G. K. Manohar.

Electric properties of fly-ash particles as inferred from surface atmospheric electric measurements near a thermal power station : G. K. Manohar, S. S. Kandalgaonkar and S. M. Sholapurkar.

- e. Int. Conf. on Tropical Micrometeorology and Air Pollution, Indian Institute of Technology, New Delhi, 15-19 February 1988 : R. K. Kapoor, P. C. S. Devara, L. T. Khemani, D. B. Jadhav and S. S. Parasnis.

- i) Aircraft observations of temperature stratification of the sub-cloud layer : S. S. Parasnis, K. G. Vernekar and Brij Mohan.

- ii) Certain features of sub-micron aerosols in east Antarctica : R. K. Kapoor and M. Lal.

- iii) Chemical characteristics of rain water in non-urban region of India : M. S. Naik, G. A. Momin, P. S. P. Rao and L. T. Khemani.
 - iv) Determination of atmospheric NO₂ concentration in the surface layer using the Argon ion lidar system at Pune : P. C. S. Devara, P. E. Raj and A. L. Londhe.
 - v) Effect of wind, temperature and humidity on lidar derived aerosols at different heights in the lower atmosphere : P. C. S. Devara, P. E. Raj and A. L. Londhe.
 - vi) Long-term effects of pollutants on the pH of rain water in north India : L. T. Khemani, G. A. Momin, P. S. P. Rao, P. D. Safai, G. Singh, R. N. Chatterjee and Prem Prakash.
 - vii) Month-to-month variations in the height distribution of atmospheric aerosols inferred from laser radar measurements : P. E. Raj, P. C. S. Devara and A. L. Londhe.
 - viii) Remote sensing of atmospheric pollutants using high resolution spectroscopy : D. B. Jadhav.
 - ix) Spread of acid rain over India : L. T. Khemani, G. A. Momin, P. S. P. Rao, P. D. Safai, G. Singh and R. K. Kapoor.
 - x) Statistical distributions of the meteorological parameters in atmospheric boundary layer : S. S. Parasnis.
 - xi) Study of gaseous and particulate pollutants around thermal power plant : G. A. Momin, L. T. Khemani and M. S. Naik.
 - xii) Temporal changes in aerosol concentration at 30 m AGL and its relationship with surface wind and temperatures : P. C. S. Devara, P. E. Raj and A. L. Londhe.
 - xiii) Variations of the thermodynamic characteristics of the boundary layer during contrasting synoptic weather conditions : S. S. Parasnis and S. S. Goyal.
 - xiv) Will atmospheric electric field be a pollution problem of future? : D. B. Jadhav.
- Instrumental and Observational Techniques*
- a. Int. Conf. on 'Tropical Micrometeorology and Air Pollution', Indian Institute of Technology, New Delhi, February 1988 : A. K. Kamra and L. K. Sadani.
 - i) Complete micrometeorological lower instrumentation system for study of surface boundary layer : K. G. Vernekar, L. K. Sadani, S. Sivaramkrishnan, Brij Mohan and S. Saxena.
 - ii) Momentum flux over complex terrain- an experimental study in the surface boundary layer S. Sivaramkrishnan, Brij Mohan, S. Saxena and K. G. Vernekar.
 - iii) Observations of some atmospheric electrical parameter in the surface layer : S. S. Dhanorkar, C. G. Deshpande and A. K. Kamra.
 - iv) On the identification of convection regimes using flux gradient relationship : L. K. Sadani.
 - v) Three channel radiometer system with an automatic sun tracker to measure components of solar radiation : S. Saxena, Brij Mohan, R. Vijaykumar and K. G. Vernekar.
 - b. Workshop on Microwave and Millimeter Wave Propagation problems in

Atmospheric Boundary Layer, ISI, Calcutta, 23-25 February 1988 : S. Sivaramakrishnan.

Instrumentation and experimental studies in the atmospheric boundary layer at IITM : K. G. Vernekar, S. Sivaramakrishnan, L. K. Sadani, Brij Mohan and S. Saxena.

Theoretical Studies

- a. Symp. on Advances in Planetary Physics, Banaras Hindu University, Varanasi, 14-19 December 1987 : D. Subrahmanyam.

Dynamics of moon's rotation and its linkage to its revolution around earth : D. Subrahmanyam.

- b. National workshop on Numerical modelling, weather prediction and computer software, Andhra Univ., Waltair, 1-4 January 1988 : S. K. Mishra.

Spectral methods and primitive equation barotropic spectral model : S. K. Mishra.

Library, Information and Publications

Regional seminar on Management and Applications of Micrographics, Pune, 29-30 April 1987 : A. A. Shiralkar.

Director's Participation in Conferences/Symposia

Shri D. R. Sikka, Director, participated in the following conferences/symposia.

- a. National Workshop on Ozone, Indian National Science Academy (INSA), N Delhi, 13-15 April 1987.

- b. Third P. R. C.—U. S. Workshop on Monsoon, Kuming, China, 16-22 June 1987.

Episodic nature of planetary scale tropical cloudiness : D. R. Sikka.

- c. VI session of the scientific steering group of TOGA of the World Climate Research Programme, Institute of Oceanic Sciences, Sidney, B. C. Canada, 3-7 Aug. 1987.

- d. Symposia under Int. Association for meteorology and atmospheric physics of the XIX general assembly of the Int. Union of Geodesy and Geophysics (IUGG), 10-13 August 1987.

- e. Int. Conf. on Micrometeorology and Air Pollution, Indian Institute of Technology (IIT), N. Delhi, 15-19 February 1988.

5. PARTICIPATION IN MEETINGS

Forecasting Research

Dr. S. S. Singh, A. D.

- i) Indian Institute of Technology, New Delhi, 29 June 1987 for discussions on the proposed project 'Development of NWP models for MRWF and Agromet Services.'
- ii) Indian Institute of Tropical Meteorology, Pune, 10-15 March 1988 for discussions regarding Indo-USSR co-operative programme.

Dr. S. V. Singh, A. D., and Shri R. K. Verma, SSO I

Meeting of Indo-US-Sub-Commission on Science and Technology (Atmospheric Sciences), IITM, 24-26 August 1987.

Shri R. K. Verma, SSO I

Meeting of Committee to study the scientific aspects of monsoon-87, Pune, 20 October 1987.

Shri D. K. Paul, SSO II

Indo-USSR Co-operation Programme in Science and Technology, IMD, N. Delhi, 2-3 April 1987.

Shri J. R. Kulkarni, JSO

Meeting of Theme-2 under ISRO-SCHCNE collaboration, N. Delhi, 10 February 1988.

Climatology and Hydrometeorology

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

Expert Committee meetings on Palaeo-climatic and Environmental Research :

- a) Dept. of Sc. and Tech., N. Delhi, 1 June 1987.

- b) Birbal Sahni Inst. of Palaeobotany, Lucknow, 16-19 July 1987.

- c) IITM, Pune, 24-26 November 1987 and

- d) Dept. of Geology, Univ. of Delhi, 23-24 Dec. 1987.

Dr. G. B. Pant and Dr. H. N. Bhalme, A. D.

Indo-US Sub-Commission meeting, IITM, 24-26 August 1987.

Shri P. R. Rakhecha, SSO I

- i) 2nd meeting of the INCOLD sub-committee on 'Design Floods', CBI & P, N. Delhi, 11 Dec. 1987.
- ii) Directorate of Hydrometeorology, I.Met.D., N. Delhi, 14-15 December 1987.
- iii) 3rd meeting of HILTECH panel on 'Hydrometeorology', National Inst. of Hydrology, Roorkee, 17 Dec. 1987.

Physical Meteorology and Aerology

Dr. A. S. R. Murty, A. D.

- i) 5th meeting of the Programme Advisory Committee of the DST, N. Delhi, 30 April 1987.
- ii) DST Committee meeting for the approval of Detailed Project Report on the proposed 'Cloud Seeding Programme, N. Delhi, 16 February 1988.

Dr. B. K. Mukherjee, SSO I

IMAP meeting, Ahmedabad, 18-22 April 1987.

Dr. L. T. Khemani, SSO II

Scientific Committee meeting on Nilgiri Biosphere Reserve, Bangalore, 9-13 January 1988.

Instrumental and Observational Techniques

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

Meeting called by the Vice-Chancellor of Univ. of Poona, in connection with matters on Indian Science Congress, January 1988—25 November 1987.

Shri K. G. Vernekar, A. D.

Meeting on Monsoon Trough Boundary Layer Experiment, IITM, Pune, 29-30 May 1987.

Site Selection Committee meeting for MONTBLEX, and 3rd meeting of the Experts Committee of Atmospheric Boundary Layer, N. Delhi, 25 January 1988.

Theoretical Studies

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

- i) Parallel processing for weather prediction, Centre for Development of Telemetry, Bangalore, 24-25 June 1987.
- ii) Development of models for medium range weather forecasts and agrometeorological services, Indian Institute of Technology, N. Delhi, 29 June 1987.
- iii) Expert Group meeting on NWP, DST, N. Delhi, 27-28 August 1987 and 16-17 March 1988.
- iv) Meeting in connection with the setting up of the National Centre for Medium Range Weather Forecasts, DST, N. Delhi, 9 September 1987.
- v) Annual meeting of Indian Academy of Sciences, Regional Research Laboratory, Hyderabad, 7-9 November 1987.

Shri D. R. Sikka, Director

- i) Second meeting of the Expert Group

on Atmospheric Boundary Layer Studies, DST, N. Delhi, 18 May 1987.

- ii) Meeting of the Review Committee, Shar Centre, Sriharikota, 22 May, 1987.
- iii) Meeting on Monsoon Trough Boundary Layer Experiment, IITM, Pune, 29-30 May, 1987.
- iv) TOGA working group, DST, N. Delhi, 7 July, 1987.
- v) First meeting of Project Execution and Monitoring Committee of Atmospheric Sciences, DST, N. Delhi, 8 July, 1987.
- vi) Second meeting of National Organizing Committee for the National Space Science Symposium, PRL, Ahmedabad, 14 July, 1987.
- vii) 9th Advisory Committee for the Centre of Atmospheric Sciences, IIT, N. Delhi, 14 July, 1987.
- viii) Meeting concerning Indo-US Sub-Commission on Science and Technology, DST, New Delhi, 8 September, 1987.
- ix) Meeting in connection with the setting up of the National Centre for Medium Range Weather Forecasts, DST, N. Delhi, 9 September, 1987.
- x) Annual Budget meeting in the DST and the Expert Group meeting for formulation of the National Programme of severe local storm study, N. Delhi, 9-14 October, 1987.
- xi) Meeting of committee to study the scientific aspects of Monsoon-1987 constituted by the DGM, Pune, 20 October, 1987.

- xii) Meeting for review of work of the project on Atmospheric Physics in the Deptt. of Physics, IIT, Kanpur, 16-18 December, 1987.
- xiii) INSAT programme meeting at Planning Commission, N. Delhi and Meteorological Office, N. Delhi, 20 December, 1987.
- xiv) Scientific Committee meeting on Nilgiri Biosphere Reserve, IISc., Bangalore, 11 and 12 January, 1988.
- xv) Meeting for establishment of Centre for Medium Range Weather Forecasting, DST, N. Delhi, 15 February, 1988.
- xvi) Meeting for establishment of Centre for Norwester Studies and Cloud Seeding Centre Committee meeting, DST, N. Delhi, 16 February, 1988.
- xvii) The second meeting of PEMC on Atmospheric Sciences, DST, New Delhi and 10th meeting of the Advisory Committee of the Centre for Atmospheric Sc., New Delhi, 21-23 February, 1988.
- xviii) Council for Meteorology and Atmospheric Sciences meeting, India Meteorological Department, New Delhi, 29 March, 1988.



Dr. J. C. Kaimal, Chief, Atmospheric Wave Propagation Laboratory, Environmental Research Laboratory, NOAA, USA signing the Visitors' Book at the end of his visit to the Institute as a Visiting Professor

6. INSTITUTIONAL SEMINARS

The following seminars were organised under the Institute's seminar series :

Sr. No.	Speaker	Topic	Date
1.	Shri D. R. Sikka, Director, IITM	Climatic effect of ozone variation	10 April 1987
2.	Dr. E. S. Lakshminarayan, Pool Officer, IITM	Asymptotic behaviour of a solution to a degenerated system in atmospheric and oceanic dynamics	1 May 1987
3.	Shri M. K. Tandon, SSO II, IITM	Deterministic medium range weather forecast	27 May 1987
4.	Dr. D. B. Jadhav, SSO II, IITM	High Tech. spectroscopy for monitoring atmospheric constituents.	5 June 1987
5.	*Prof. P. R. Pisharoty, Emeritus Scientist, PRL, Ahmedabad.	Evolution of Meteorological Research in India	9 June 1987
6.	Dr. D. Subramanyam, SSO (I), IITM	Forcing of moon's rotation by its revolution.	12 June 1987
7.	Shri D. R. Sikka, Director, IITM	Some observations of Meteorological education and research in China.	10 July 1987
8.	Dr. K. Kessler, Scientist, NCAR, USA	Continuity of water substance.	27 July 1987
9.	Dr. R. Ananthakrishnan, Hon. Fellow, IITM	Further investigation of the anomaly in the aerological data of Ahmedabad	31 July 1987
10.	*Dr. G. C. Asnani, Former Professor, Univ. of Nairobi	Meridional circulation near the equator	21 August 1987
11.	*Shri R. K. Gupta, Scientist, National Remote Sensing Agency, Hyderabad	Satellite Remote Sensing and its Meteorological Applications (Silver Jubilee lecture Series)	26 August 1987
12.	Dr. B. S. Venkatchala, Director, RSIP, Lucknow	Origin and antiquity of life	2 September 1987

13.	*Prof. P. Koteswaram Former Director General, IMD, Pune	Monsoon Depresion	21 September 1987
14.	*Dr. S. T. Awade, Retd. Scientist, IITM	Large-scale circulation features and monsoon activity	25 September 1987
15.	Shri R. K. Verma, SSO, I and Shri D. K. Paul, SSO, II, IITM	'Aftercast' of monsoon 1987, a quick look of some large- anomalies.	16 October 1987
16.	Dr. D. Subramanyam, SSO I, IITM	Trapping of rotory motions of satellite planet due to solid bulges on their surface.	20 November 1987
17.	Prof. G. G. Schchukin Dy. Dir. Main Geo-physical Observatory, Leningrad, USSR	Indo-USSR Scientific collabo- ration in the field of meteorology	25 November 1987
18.	*Dr. P. C. S. Devara, SSO I, IITM	Laser remote sensing of the atmosphere—Some results obtained with IITM Laser Lidar System	11 December 1987
19.	Dr. B. S. Chuckkalov Chief of World Weather Analysis Div. of Hydrome- teorological Centre of USSR, Moscow.	Some results on the study of Indian monsoon conducted in USSR.	24 December 1987
20.	*Prof. R. Ananthakrishnan, Hon. Fellow, IITM	Some statistical aspects of the daily rainfall distribution of Indian stations.	5 February 1988
21.	*Prof. P. R. Pisharoty, Emeritus Scientist, PRL, Ahmedabad	Ocean bottom bathymetry with SEASAT, sea surface altimeter data.	8 February 1988
22.	*Prof. C. R. V. Raman, Ex-Jawaharlal Nehru Fellow	Northern pressure anomaly and its impact on monsoon 1987.	11 February 1988
23.	Prof. V. A. Baker, Arizona University, USA	Palaeoflood Hydrology	17 February 1988

24.	Dr. E. V. Chelam, Retired Scientist, IMD	Hydrostatic and normal mode features of some unbounded atmospheric models.	25 February 1988
25.	Dr. J. C. Kaimal, Wave Propagation Laboratory, NOAA, USA.	Recent Advances in ground based remote sensing.	26 February 1988
26.	*Dr. K. R. Saha, Ex-Director, IITM	Time-mean atmospheric circulation and diabatic heating over the Arabian sea during July.	29 February 1988
27.	*Dr. K. R. Saha, Ex-Director, IITM	Vertical circulations and heat and moisture budgets in the time-mean atmosphere over India and Bay of Bengal.	1 March 1988 Morning
28.	*Dr. K. R. Saha, Ex-Director, IITM	Structure and properties of the mean monsoon trough over S. China Sea.	1 March 1988 Afternoon
29.	*Dr. K. R. Saha, Ex-Director, IITM	Structure and development of a Bay of Bengal monsoon depression during MONEX-79.	2 March 1988
30.	*Dr. K. R. Saha, Ex-Director, IITM	An overview of monsoon circulation over Asia.	3 March 1988
31.	Prof. V. Zalesny, Scientist, Department of Numerical Mathematics, USSR.	Some aspects of numerical modelling of dynamics of ocean.	11 March 1988
32.	Prof. V. Perov, Department of Numerical Mathematics, USSR Prof. V. Lykossov, Department of Numerical Mathematics, USSR.	Mixed layers models atmospheric and oceanic PBL and Some problems of planetary boundary layer modelling.	14 March 1988
33.	*Mrs. P. S. Salvekar, SSO II, IITM	Dynamic Instability of atmospheric flow—a recent development.	25 March 1988

*These seminars were arranged under the Institute's programme of 'Silver Jubilee Celebration'.

6A. LECTURES DELIVERED OUTSIDE THE INSTITUTE

Forecasting Research

Dr. S. S. Singh, A.D.

- i) Two lectures on Numerical Weather Prediction at IIT, New Delhi during 6-9 April, 1987.
- ii) Six lectures at the Workshop on 'Numerical Weather Prediction and Computer Software' at Andhra University, Waltair, During 30 December, 1987 – 5 January, 1988.

Dr. S. V. Singh, A. D.

4 lectures on Synoptic Climatology to the I.M.D. trainees in Advanced Meteorology.

Shri R. K. Verma, SSO I

Interannual and longer-term variability of the Indian Summer Monsoon in relation to global climate variability at Geophysical Fluid Dynamics Laboratory, Princeton University, Princeton, USA on 1 May, 1987.

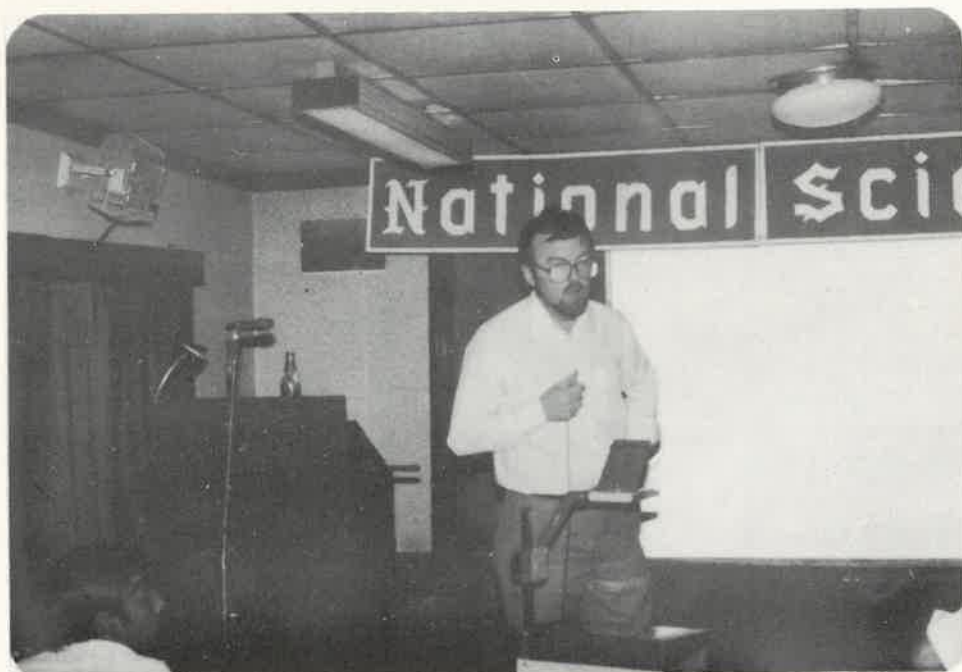
Physical Meteorology & Aerology

Dr. A. S. R. Murty, A. D.

Physics of monsoon clouds and their modification for rain enhancement (invited Review talk) at the Seminar on Artificial rain and aerial seeding organised by the Department of Forest, Govt. of Andhra Pradesh, Hyderabad, 19 March, 1988.

Dr. B. K. Mukherjee, SSO I

- i) Troposphere Middle Atmosphere Coupling at the Institute of Radiophysics and Electronics, University of Calcutta, Calcutta, 26 and 27 May, 1987.
- ii) Upper Atmosphere and satellite meteorology at Cochin University, Cochin, 21 February and 2 March, 1988.
- iii) The role of planetary waves in the middle atmosphere (invited lecture) at Cochin University, Cochin on 26 February, 1988.



Dr. J. E. Harries, Scientist, Rutherford Appleton Laboratory, Oxford, giving a Seminar

7. VISITORS

List of distinguished scientists and officials who visited the Institute during the year is given below :

A) National

Sr. No.	Visitors-Credentials	Date of Visit	Sr. No.	Visitors-Credentials	Date of Visit
1.	Dr. M. L. Modi, Scientist E., Defence Science Centre, New Delhi.	24 June 1987	7.	Shri B. Mohanty, Asst. Engineer, Irrigation Deptt., Govt. of Orissa, Bhubaneswar.	20 July 1987
2.	Dr. B. S. Venkatchala, Director and Dr. A. Bhattacharya, Scientist, Birbal Sahani Inst. of Palaeobotany, Lucknow.	24 and 25 June 1987	8.	Prof. (Dr.) N. Ahmed, Principal and Dr. Rais, Geological Deptt., Aligarh Muslim University, Aligarh.	11 and 12 August 1987
3.	Dr. R. N. Sachdev, Scientific Officer (SF), Bhaba Atomic Research Centre, Bombay.	1 July 1987	9.	Captain R. N. Dogra, Aviation Advisor, Govt. of Gujarat, Ahmedabad.	3 January 1988
4.	Shri S. G. Oke, Joint Director of Agriculture (Extension), Maharashtra State, Pune.	16 July 1987	10.	Dr. R. Ramesh, Scientist D., Physical Research Laboratory, Ahmedabad.	11 and 12 January 1988
5.	Shri M. P. Shende, Cotton Development Officer, Directorate of Agriculture, Maharashtra State, Pune.	16 July 1987	11.	S/Shri V. B. Tapale and M. N. Khaire, Agricultural Officer, Directorate of Agriculture, Maharashtra State, Pune.	23 February 1988
6.	Shri S. W. Inamdar, Executive Engineer, Koyna Dam Maintenance Division, Govt. of Maharashtra, Alore.	17 July 1987	12.	Prof. S. V. Khandge, Associate Professor of Aerobiometeorology, Centre of Advanced Studies in Agricultural Meteorology, College of Agriculture, Pune.	23 February 1988
			13.	Shri S. N. Bakhale, Chief Statistician, Deptt., of Agriculture, Maharashtra State, Pune.	24 February 1988

B) International

1. Mr. J. F. Cunningham, 14 April 1987
Mr. G. W. Fauss,
Dr. D. James
& Dr. J. A. H. Brown,
Members, World Bank
Mission on Hydrology for
India, alongwith other
experts.
2. Dr. Edwin Kessler, 27 July 1987
Scientist, NCAR, USA.
3. Dr. Joseph Fletcher, 27 October
Asstt. Administrator, 1987
Office of Oceanic and
Atmospheric Research,
NOAA, USA.
and
Dr. Chandrakant M. 27 October
Bhumbralkar, Director, 1987
Office of Oceanic and
Atmospheric Research,
NOAA, USA.
4. A delegation of Six 23-26
Russian Scientists under November 1987
Indo-USSR Co-operation
programme in Science
and Technology
(Meteorology).
5. Dr. J. Chandran Kaimal, 14-27
Chief, Atmospheric Wave January 1988
Propagation Laboratory,
Environmental Research
Laboratory, NOAA,
Boulder, Colorado, USA.
6. Dr. J. E. Harries, 29 February
Scientist, Rutherford 1 March 1988
Appleton Laboratory,
Oxford.
7. Prof. V. R. Baker, 17 February
Deptt. of Geo Sciences, 1988
University of Arizona,
Tucson, USA.
8. Dr. V. Zalesny, 10-15 March
Dr. V. Lykoshev 1988
and
Dr. V. Perov
Soviet Scientists.



Dr. Edwin Kessler, Scientist, NCAR, USA during his visit to the Institute

8. GENERAL

The Governing Council

The administration and management of the Institute is vested in its Governing Council which consists of 9 members including the Director of the Institute. The Council was reconstituted during the year. It held two meetings during the year at Pune and New Delhi on 4 December 1987 and 22 March 1988 respectively.

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. During the year, ten meetings of the Staff Council were held.

Meetings of Heads of Divisions

The Heads of Divisions of the Institute meet once in a month or more frequently, if so required, to take a review of all aspects of the work. 15 such meetings were held in 1987-88.

Academic Council

The Academic Council consisting of the research officers in the grade of Senior Scientific Officer, Gr. I and above, considers all matters relating to scientific projects of the Institute and ensures team work for achieving its aims and objectives.

The Academic Council meets normally once in a month to review the scientific activities of the Institute. 12 such meetings were held during the year. Some of the important matters discussed by the Council are as follows :

Indo-US Sub-Commission, Atmospheric Sciences (Monsoon) Collaborative Programme,

Indo-USSR research programme on Mathematical Modelling,

Monsoon Trough Boundary Layer Experiment (MONTBLEX);

Proposal on Atmospheric Chemistry for Nilgiri Biosphere Programme,

Holding an international symposium 'Monsoon—Understanding and Prediction' at IITM to make the completion of 25 years of IITM and 25th Anniversary of the International Indian Ocean Expeditions,

Organizing a workshop on "Parameterization of Sub-grid scale processes in Dynamical Models for Medium-range prediction and global climate circulation",

Formulating 8th Five-year plan (1990-95) of the Institute,

Proposals for purchase of scientific equipments costing more than Rs. one lakh.

Inauguration of the New Computer System

The ND-560 computer system acquired by the Institute under its 7th Five Year Plan was inaugurated by Dr. R. P. Sarker, Director General of Meteorology and Chairman, Governing Council of IITM on 4 December 1987. The 32-bit computer system is configured with a line printer, two tape transports, two winchester disk drives, seven terminals and a main memory of 3MB. The main memory of the ND-560/CX Computer system was enhanced from 3MB to 11MB by adding two additional memory boards of 4MB each. FORTRAN, ASSEMBLER, Screen handling system, Sort-Merge & Program Editor are some of the Languages/packages available on the system. Acceptance tests for the system were successfully conducted for one week during December 1987.

Silver Jubilee Lecture Series

The Institute is in the midst of its Silver Jubilee year. In order to celebrate the

occasion, a Silver Jubilee Lecture Series has been organised under which eminent scientists in India and abroad and scientists who have worked in the Institute and are working in the Institute are invited to give lectures in their respective area of specialisation. The first lecture under the series was delivered on 9 June 1987 by Prof. P. R. Pisharoty, who was the first Director of the Institute. 15 Lectures have been given so far under the series.

Welfare Schemes

A group Insurance Scheme of the LIC of India was introduced for the benefit of the Institute employees with effect from 5 May 1987.

Introduction of the Pension Scheme for the post-autonomy employees of the Institute, on the lines of the Central Govt. Pension Scheme, was approved by the Governing Council of the Institute and the Department of Science and Technology. Its implementation is being processed.

De-registration of the Institute as Public Trust

On an application made by the Institute, the Joint Charity Commissioner, Pune region, de-registered the Institute as a Public Trust under the Bombay Public Trusts Act in May 1987.

Capital Works Programme

Construction work of the Hostel was completed and it has been taken over by the Institute. Construction of the Director's quarters, Guest House, and the office building (2nd phase) was in progress.

A 500 KVA Power sub-station on the Institute's campus at Pashan, Pune was commissioned on 2 June 1987.

Deputations

Director was on deputation to China from 16-24 June 1987 and to Canada from 1-16 August 1987 to participate in (i) Third P.R.C. U.S. Workshop on Monsoon, (ii) 6th Session

of the JSC/CCCCO/TOGA scientific steering Group and (iii) XIX General Assembly of the Int. Union of Geodesy & Geophysics (IUGG).

Under the Indo-USSR co-operative programme in the field of Science & Technology, Dr. P.C.S. Devara, SSO I, Shri D. K. Paul, SSO. II, Dr. K. Rupakumar, SSO. II and Shri P. N. Mahajan, JSO were deputed to USSR during May and June 1987.

Shri R. K. Verma, SSO. I was on deputation to Geophysical Fluid Dynamics Laboratory (GFDL), Princeton University, Princeton, USA for 6 weeks under the Indo-US Science & Technology Initiative (STI) Programme for Monsoon Research from 12 April to 22 May 1987. He worked there with Dr. A. H. Oort, Head of Diagnostic Studies Division, on the project, 'To study the interannual variability of monsoon with special reference to Northern Hemisphere surface air temperature variations'

Training

As a part of Advanced Meteorology Training Course, Dr. V. N. R. Mukku, SSO. II and Shri P. V. Puranik, SSA attended the familiarisation course at the Meteorological office, Santa Cruz from 12.8.1987.

Shri S. S. Mulye, SSA and Smt. S. Nair, S. A. attended the Intermediate 'A' Phase Training Course from 7.9.1987 to 11.3.1988 at India Meteorological Department, Pune. Shri S. S. Mulye is also attending the Intermediate 'B' Phase Training with effect from 11.3.1988 at the India Meteorological Department, Pune.

Dr. S. V. Singh, A.D. attended a training course in 'Future forecast and perspective planning' organised by Department of Science & Technology during 21-25 March 1988 at Pune.

Shri V. R. Deshpande, SSA underwent two weeks training course on 'Satellite Oceanography' conducted by the Space



Dr. R. P. Sarker, D. G. M., & Chairman, Institute's Governing Council visiting the Institute's library



A view of the Exhibition arranged during the visit of the Sub-Committee (2) of the Committee of Parliament on Official Language.

Applications Centre, Ahmedabad during 7-18 September 1987.

Several scientists of the Institute attended the following computer training courses during November-December 1987 :

- i) 5-day ND-560 Computer Operator's Training Course, IITM, Pune;
- ii) One day course on CAD/CAM Software, NIC, Pune;
- iii) 6-day SINTRAN Supervisor Training on ND-560 Computer System, ECIL, Hyderabad; and
- iv) Two-week course on SINTRAN Operating System conducted by ECIL at the Institute.

Celebration of National Science Day

The Institute celebrated National Science Day on 29 February 1988 with a special lecture by Dr. K. R. Saha, Ex-Director of the Institute. On that occasion, the Institute was happy to have the presence of all the Directors of the Institute since inception.

Library, Information and Publications

To help the scientists in their pursuit of research, the Division of Library, Information and Publications renders necessary scientific and technical services by way of :

- i) Procuring books/journals, data etc. for the Institute's library;
- ii) Rendering necessary timely facilities viz. preparation of drawings, tracings, diagrams, charts, photoprints, slides, micro-films, ammonia prints etc;
- iii) Dissemination of appropriate scientific information;
- iv) Documentation and current awareness services; and
- v) Preparation, publication and presentation of various scientific/research

reports and allied materials projecting the activities of the Institute.

Formulation of various plan documents and monitoring of the on-going plan projects are also dealt with by this Division.

a) Library

During the year, 140 books in Meteorology and allied subjects were added and 72 periodicals of national and international repute were subscribed to.

A number of scientific/technical reports were also added to the Library. Reprints of papers authored by the Institute's scientists and published in different scientific journals of national and international standing were procured. Inter-library loan facilities arranged through the courtesy and co-operation of a large number of research libraries in the country, were availed.

Information Service

A number of periodical research reports and special reports were sent to the Department of Science & Technology, India Meteorological Department, Universities and Research Institutes.

Field Research Unit

The field research unit of the Institute headed by the Scientist-in-charge, Prof. A. Mani, is located in Bangalore. The unit undertakes sponsored research projects from various departments of the Government of India and the State Governments.

Wind mapping projects in eight States, Viz. Gujarat, Orissa, West Bengal, Uttar Pradesh, Bihar, Himachal Pradesh, Tripura and Kerala were being implemented by the Field Research Unit at Bangalore, in addition to the on-going projects in 4 states in Tamilnadu, Andhra Pradesh, Karnataka and Madhya Pradesh.

30 stations will be established in each State for measuring wind speeds at 5 synoptic hours from 0830 to 2030 IST, to begin with, and will be extended to 8 such hours. It is proposed to collect wind speed data for periods of 3 years at each of the stations.

The Field Research Unit is also responsible for establishing wind monitoring stations in six States, Tamilnadu, Gujarat, Orissa, Maharashtra, Andhra Pradesh and Rajasthan. 36 wind monitoring stations have been established in 5 states using 20 metre tall instrumented masts with sensors at 2 levels, 10 m and 20 m. Data collected on EPROM chips every two months from these stations are processed on computer and supplied to the Department of Non-Conventional Energy Sources and to the nodal energy development agencies concerned. Based on the data collected, 20 MW wind farms are shortly to be established in Tamil Nadu and Gujarat.

Appointment of Research Fellows

The following persons have joined as IITM Research Fellows at this Institute :

Sr. No.	Name	Date of appointment
1.	Smt. N. Swarna Kumari	21 July 1987
2.	Shri G. R. Iyengar	24 July 1987
3.	Shri T. S. Pranesh	14 August 1987
4.	Shri Keshav Kumar	7 September 1987

Employment of Ex-Servicemen

Reservation for ex-servicemen is made as per rules, in the case of groups 'C' and 'D' posts of the Institute. The percentage of ex-servicemen vis-a-vis total number of employees in groups 'B', 'C' and 'D' at the Institute was as follows :

Group 'B' — 3

Group 'C' — 1

Group 'D' — 14

Official Language Implementation

Sub-Committee (2) of the Committee of Parliament on Official Language visited the Institute on 8 October, 1987. The Committee reviewed the progress in Official Language implementation in the Institute and gave suggestions for the progressive use of Hindi. On the occasion, scientific exhibition was organised in the Institute to project the use of Hindi in the scientific activities of the Institute. The Committee was informed that 98% of the Institute's employees (except Grade IV) have acquired working knowledge of Hindi. About 5% of these employees possess proficiency in Hindi having studied through the medium of Hindi or having Hindi as one of the subjects at the graduate level.

As per suggestions given by the Parliamentary Official Language Committee, 80% of the forms and standard drafts in use in the Institute were made bilingual. This has resulted in more usage of Hindi for official purposes. Rubber Stamps which were earlier made separately in English and Hindi for correspondence in these two languages were also made bilingual.

The Institute's Official Language Implementation Committee which used to meet quarterly in previous years, met 8 times during the current year.

The Hindi week was celebrated in September 1987 with debates, poetry-recitation, essay & noting-drafting competitions etc. Prizes & Certificates were awarded at a special function organized on the final day. The prizes were given away by the Chief guest, Dr. G. P. Srivastava, retired Deputy Director General of Meteorology, Pune.

During the year, sixty circulars were issued bilingually (Hindi & English). 40 letters drafted in Hindi were sent to the Hindi speaking states in the 'A' area and 25 letters to the states in the 'B' area.

The Institute's Annual Report, Audit Report, Monthly progress reports and the minutes of the Staff Council meetings were produced in bilingual form.

A bilingual electronic typewriter was purchased in view of the increased use of bilingual forms and drafts in the Institute. Hindi-English & English-Hindi dictionaries were provided to all Divisions/Sections etc. to help the employees write in Hindi with ease.

Two non-Hindi speaking employees passed Pragma and one typist passed Hindi typing examination, all with distinction and cash awards.

Budget

The budget estimates and actual expenditure for the Institute for the period 1987-88 are given below :

	Rs. in lakhs				
	Budget Estimates 1987-88	Revised Estimates 1987-88	Grants including opening balance received from DST	Actual Expendi- ture	Shortfall in Expenditure over Grant-in-aid received
Non-Plan	140.00	143.40	143.37	142.70	0.67
Plan	115.00	58.60	58.58	55.52	3.06

Audit of the accounts of the Institute for the financial year 1987-88 was conducted by M/s. G. D. Apte and Co., Chartered Accountants, Pune.

9. PUBLICATIONS

9.1 List of Papers Published

Forecasting Research

Extended Range Prediction

1. Kutzback EOF of summer monsoon circulation and rainfall fields over India : Kamte P. P., Singh S. V. and Kripalani R. H., Proc. of the 3rd Int. Conf. on Statistical Climatology, Vienna, Austria, 23-27 June 1986, 489-492.
2. Potential predictability of 700 mb height and rainfall fields over the Indian and adjoining regions during summer monsoon season : Kripalani R. H., Kamte P. P. and Singh S. V., Proc. of the 3rd Int. Conf. on Statistical Climatology, Vienna, Austria, 23-27 June 1986, 499-501.
3. Relationship of southern oscillation and other large scale features with Bay of Bengal cyclones during the post monsoon season : Singh S. V., Mohile C. M. and Inamdar S. R., Advances in Atmospheric Sciences, 3, 2, 1987, 169-174.
4. Reply to comments on 'Potential predictability of lower tropospheric monsoon circulation and rainfall over India : Singh S. V. & Kripalani R. H., Monthly Weather Review, 115, 1987, 1460-1461.
5. Short-term climatic fluctuations and monsoon : Verma R. K., Subramanian K., Dugam S. S. & Kakade S. B., Proc. of the Sem. on Geophysics and Environment, NGRI, Hyderabad, December 1987, 73-77.

Numerical Weather Prediction

1. Comparative performance of two schemes of parameterization in monsoon prediction : Singh S. S.,

Bandyopadhyay A. & Vaidya S. S., WMO, WPRP Research Activities in Atmospheric and Oceanic Modelling Report No. 10, October 1987.

2. Impact of convective transfer of heat and moisture on the prediction of monsoon depression : Singh S. S., Bandyopadhyay A. & Vaidya S. S. Mausam, 39, 1, January, 1988, 19-26.
3. Monsoon prediction with six level primitive equation Model : Singh S. S. & Vaidya S. S., WMO-WPRP Research activities in Atmospheric Oceanic modelling Report No. 10, October 1987.
4. On some aspects of objective analysis of humidity over Indian region by the Optimum interpolation method : Sinha S. K., Talwalkar D. R. & Rajamani S., Advances in Atmospheric Sciences, 4, 3, 1987, 332-342.

Monex Studies

1. Climatic effects of Ozone variation. Sikka, D. R. National Workshop' on Ozone, INSA, New Delhi, April 1987.
2. Coherence of satellite infrared temperatures with monsoon rainfall at preferred frequencies and the triplex behaviour of the Indian summer monsoon : Smith E. A. and Sikka D. R., Meteorology and Atmospheric Physics, 37, 1987, 219-236.
3. Comparison of low level satellite winds and surface winds observed by research ships during summer Monex-79 : Mahajan P. N. & Nagar S. G., Mausam, 38, 4, October, 1987, 445-448.
4. ENSO and the summer monsoon of India; Sikka D. R., WMO/TD No. 199, WCP-141, October 1987.

5. Episodic nature of planetary scale tropical cloudiness; Sikka D. R., PRC-US Workshop on Monsoon. Kuming, China, June, 1987.
6. Organization of large-scale clouds over the Indian Ocean as revealed by TIROS-N satellite during June 1979 : Mahajan P. N., Mausam, 38, 3, July 1987, 309-312.
7. Performance of Monsoon—1987 and the regional and global factors affecting it: Sikka D. R. Invited Lecture delivered at Satellite Applications Centre, Ahmedabad Oct. 1987.
8. Satellite derived cloud motion vectors for monitoring lower and upper tropospheric monsoon circulation during summer Monex-79 : Mahajan P. N. & Deshpande V. R., Vayu Mandal, 16, 3 & 4, 1987, 6-9.
9. Sensitivity experiment about the influence of simultaneous SST anomalies of the opposite sign in the ITCZ of the eastern Pacific central American Sector and the Western Pacific Bay of Bengal sector on regional summer monsoon circulation : Sikka D. R. and Pfeffer R. L., Jacob Bierkenes Symposium on Air-Sea Interactions, Ame. Met. Soc. California, USA, January, 1988.
- Kothawale D. R., Jr. of Climatology, 7, 1987, 57-70.
3. El-Nino/SST of Puerto Chicama and Indian Summer monsoon rainfall-statistical relationships : Parthasarathy B. & Sontakke N. A., Geofisica International, 27, 1, January, 1988, 37-59.
4. Heating rate due to UV-absorption by O₃ over India : Hingane L. S., Mausam, 39, 1, January, 1988, 110.
5. Indian summer monsoon and Eurasian winter snow-cover : Parthasarathy B. & Pant G. B., Western Himalayas, 1987, 61-71.
6. Long-term variations in rainfall over upper-Narmada catchment : Ramana Murthy K. V., Soman M. K. & Mulye S. S., Mausam, 38, 3, July, 1987, 313-318.
7. Relationships between Pacific ocean zonal wind indices and Indian monsoon rainfall : Parthasarathy B., Poly G. M. & Welckman K. M., Tropical Ocean Atmospheric Newsletter, 41, September, 1987, 3-7.
8. Superposed epoch study of rainfall of Kerala during the onset phase of the southwest monsoon : Ananthakrishnan R. & Soman M. K., Current Science, 56, 17, 1987, 1-8.

Climatology & Hydrometeorology

Climate & Climatic Change

1. Crop-Weather relationships of sugarcane under different manurial treatments : Rupa Kumar K., Mausam, 38, 2, April, 1987, 223-226.
2. Droughts/floods in summer monsoon season over different meteorological sub-divisions of India for the period 1871-1980 : Parthasarathy B., Sontakke N. A., Munot A. A. and
9. Tropical quasi-biennial oscillation of the 10-mb wind and Indian monsoon rainfall-implications for forecasting : Bhalme H. N., Rahalkar S. S. & Sikder A. B., Jr. of Climatology, 7, 1987, 345-353.
10. Use of co-efficient of variation in determining rainfall probabilities in a humid region. Singh N., Soman M. K. & Kumar K. K., Mausam, 38, 2, 1987, 261-264.

11. Variation of tropospheric temperature over Indian during 1944-1984 : Rupa Kumar K., Hingane L. S. & Ramana Murty Bh. V., Jr. of Climate and Applied Meteorology, 26, 2, February, 1987, 304-314.
12. ENSO-Monsoon connections — a reappraisal : Sikka D. R. and Bhalme H. N., Jacob Bierkenes Symp. on Air-Sea Interactions, Ame. Met. Soc. California, USA, January 1988.
6. Decreasing trend in the rainfall of Kerala : Soman M. K., Kumar K. K. & Singh N., Current Science, 57, 1, 1988, 7-12.
7. Generalized 100-year point rainfall charts for the upper Narmada basin for planning and design of medium size hydraulic structures : Dhar O. N., Kulkarni A. K., & Sangam R. B., Proc. of the Colloquium on Precipitation analysis and flood forecasting, IITM, Pune, 30 June 1984, 1-5.

Hydrometeorological Studies

1. Appraisal of the heavy rainfall and the highest floods in Bihar : Dhar O. N., Mandal B. N. & Kulkarni A. K., Indian Jr. of Power & River Valley Development, 37, 11 & 12, November-December, 1987, 302-308.
2. Brief appraisal of precipitation climatology of Ladakh region : Dhar O. N. & Mulye S. S., Western Himalayas, 1987, 87-98.
3. Brief appraisal of severe rainstorms of Madhya Pradesh region for the optimum development of its water resources : Dhar O. N., Mandal B. N., & Mulye S. S., Indian Jr. of Power & River Valley Development, 37, 3 & 4, March & April, 1987, 88-93.
4. Comparison of Penman and Thornthwaite method of estimating potential evapotranspiration for Indian conditions : Kumar K. K., Rupa Kumar K., Rakhecha P. R., Theoretical & Applied Climatology, 38, 3, 1987, 140-146.
5. Correlation analysis of southwest and northeast monsoon rainfall over Kerala State : Dhar O. N., Soman M. K. & Saseendran S. A., Proc. of the Colloquium on Precipitation analysis and flood forecasting, IITM, Pune, 30 June 1984, 49-53.
8. Generalized maps of point PMP as percentages of mean annual rainfall and 100-years rainfall for peninsular India : Kulkarni A. K., Mandal B. N. & Dhar O. N., Proc. of the Seminar on geophysics and Environment, Indian Geophysics Union, Hyderabad, January 1987, 78-81.
9. Highest ever recorded floods in the major Indian rivers—a brief appraisal : Dhar O. N., Mulye S. S. and Mandal B. N., Transactions of Institute of Indian Geographers, 8, 1, January, 1986.
10. Probability distribution of summer monsoon rainfall and delineating rainfall zones in India : Singh N., Kumar K. K. & Mali R. R., Proc. of the Colloquium on Precipitation analysis and flood forecasting, IITM, Pune, 30 June 1984, 23-29.
11. Review of hydrometeorological activities and rainfall studies in India : Dhar O. N., Proc. of the first National Water Convention, New Delhi, 12-15 November 1987, 11-14.
12. Secular changes of rainfall along the east coast of India : Rao P. G., Proc. of the Seminar on Geophysics and Environment, Indian Geophysical Union, Hyderabad, 21-22 January 1987, 82-88.

13. Some facts about precipitation distribution over the Himalayan region of Uttar Pradesh : Dhar O. N., Mandal B. N. & Kulkarni A. K., *Western Himalayas (Environment)*, 1, 1987.
14. Study of the variability of ten-day average evaporation values in India : Ramana Murty K. V. & Kumar K. K., *Indian Jr. of Power and River Valley Development*, 37, 1, 1987, 20-22.
15. Was the lower Godavari basin rainstorm of August 1986 unprecedented ? : Dhar O. N., Mulye S. S. & Nandargi S. S., *Aquaworld*, 11, 12, December, 1987, 384-390.
16. Use of 24-hr. maximum point rainfall for demarcating homogeneous zones in India : Rakhecha P. R., Kulkarni A. K., Mandal B. N. & Deshpande N. R., *Proc. of Symp. on Hydrology*, Roorkee, 16-18 December 1987, 44-53.
4. Dynamics of organised chaos in subatomic astrophysical phenomena : Selvam A. M., *Proc. of XI Int. Conf. on Particles and Nuclei (PANIC)*, Kyoto, Japan, 20-24 April 1987.
5. Physical basis for self similarity and evolution of mesoscale cloud clusters (MCC) in the atmospheric boundary layer : Selvam A. M., *Proc. of 17th AMS Conf. on Hurricanes and Tropical Meteorology*, Miami, Florida, 7-10 April 1987.
6. Role of noise as an essential precursor to signal in physical systems : Selvam A. M., *Proc. of 9th Int. Conf. on Noise in Physical Systems*, Univ. of Montreal, Canada, 25-29 May 1987.
7. Self similarity in atmospheric processes and applications to climate prediction : Selvam A. M., *Proc. of AMS Conf. on Applied Climatology*, Maryland, 9-13 March 1987.

Physical Meteorology & Aerology,

Cloud Physics and Weather

Modification :

1. Dynamics of deterministic chaos and applications to modelling of severe local storms : Selvam A. M., *Proc. of the 15th A.M.S. Conf. on Local severe storms*, Baltimore, Maryland, 22-26 February, 1988.
2. Dynamics of deterministic chaos in atmospheric mesoscale models : Selvam A. M., *Proc. of the Second Int. American Meteorological Congress and CONGREMET V.*, Buenos Aires, Argentina, 30 November—4 December 1987.
3. Dynamics of deterministic chaos in numerical weather prediction models : Selvam A. M., *Proc. of the 8th A.M.S. Conf. on Numerical Weather Prediction*, Baltimore, Maryland, 22-26 February 1988.
1. Application of phase-modulator-demodulator IC chip to radio wave direction finding systems : Rao V. L., Devara P.C.S. & Ahmed M. I., Jr. of *Instrument Society of India*, 17, 4, 1987, 356-366.
2. Bistatic lidar for aerosol studies : Devara P.C.S. & Raj P. E., *Institution of Electronics and Telecommunication Engineers (IETE) Technical Review*, 4, 11, 1987, 412-415.
3. Dynamics of chaos in optics : Selvam A. M., *Proc. of 14th Congress of the Int. Commission for optics*, Canada, 24-28 August 1987.
4. Dynamics of deterministic chaos in single mode optical fibre laser transmission : Selvam A. M., *Proc. of National Aerospace and Electronics Conf.*, Ohio, USA, 18-22 May 1987.

Environmental Physics :

5. Dynamics of non-linear effects in optical processes : Selvam A. M., Int. Conf. on Luminescence 87, Beijing, China, 17-21 August 1987.
6. Dynamics of non-linear ionospheric rf wave propagation : Selvam A. M., Proc. of 7th American Physical Society Tropical Conf. on applications of Radio Frequency power to plasma, Florida, 4-6 May 1987.
7. Effect of neutral wind on the latitudinal variations of nighttime F-layer vertical movements : Raj P. E. and Devara P.C.S., Proc. of 8th ESA Symp. on European Rocket and Balloon Programmes and Related Research, Sunny, Sweden, 17-23 May 1987, 267-269.
8. Influence of alkaline particulates on the Chemistry of fog water at Delhi, north India : Khemani L. T., Momin G. A., Prakasa Rao P. S., Safai P. D. & Prem Prakash, Water Air & Soil Pollution, 34, 1987, 183-189.
9. Influences of alkaline particulates on pH of cloud and rain water in India : Khemani L. T., Momin G. A., Naik M. S., Rao P.S.P., Safai P. D. & Murty A.S.R., Atmospheric Environment, 21, 5, 1987, 1137-1145.
10. Influence of atmospheric pollutants on cloud microphysics and rainfall : Khemani L. T., Momin G. A. & Naik M. S., Boundary Layer Meteorology, 41, 1-4, 1987, 367-379.
11. Large-scale poleward heat flux in the middle stratosphere during the northern winters : Reddy R. S. & Godson W. L., Proc. of the Int. Union of Geodesy & Geophysics (IUGG), XIX General Assembly, Vancouver, Canada, 9-12 August 1987, Vol. 3.
12. Measurement of pH and chemical analysis of rain water in rural area in India : Naik M. S., Khemani L. T., Momin G. A. & Rao P.S.P., Acta Meteorologica Sinica, 2-1, 1988, 91-100.
13. Micro-processor controlled three colour twilight photometer : Jadhav D. B. & Trimbake H. K., Jr. of the Instrument Society of India, 17, 3, 1987, 274-279.
14. On the variation of temperature structure parameter in cloud and clear-air during the summer monsoon season : Devara P.C.S., Vernekar K. G. & Murty Bh.V.R., Pure & Applied Geophysics, 125, 1987, 121-129.
15. Opto-electronics system for the study of comet Halley : Devara P.C.S. & Raj P.E., Jr. of the Instrument Society of India, 17, 3, 1987, 252-260.
16. Remote sensing of geomagnetic field and applications to climate prediction : Selvam A.M., Proc. of Int. Geoscience and Remote sensing Symp. (IGARSS '87) Univ. of Michigan, USA, 18-21 May 1987.
17. Some ground-based optical observations of comet Halley during its post-perihelion passage : Devara P.C.S. & Raj P. E., Proc. of 8th ESA Symp. on European Rocket and Balloon programme and related research, Sunny, Sweden, 17-23 May 1987, 351-355.
18. Variations in trace gas concentrations in different environments in India : Khemani L. T., Momin G. A. and Singh G., Pure & Applied Geophysics, 125, 1987, 167-181.

Instrumental & Observational Techniques

Development of Instruments for Boundary Layer Studies :

1. Estimation of fluxes from wind and temperature profiles in the marine

atmospheric surface boundary layer :
Vernekar K. G., Sivaramakrishnan S.,
Brij Mohan and Saxena S., *Mausam*,
38, 2, April, 1987, 157-162.

2. On the variation of temperature structure parameter in cloud and clear air during the summer monsoon season : Devara P. C. S., Vernekar K. G. & Ramana Murty Bh. V., *Pure & Applied Geophysics*, 125, 1, 1987, 121-129.
3. Wind profile analysis near the ground : Sadani L. K., *Mausam*, 38, 4, October, 1987, 445-448.

Theoretical Studies.

Robert's recursive frequency filter—a reexamination : Tandon M. K., *Meteorology and Atmospheric Physics*, 37, 1987, 48-59.

9.2 List of Papers Accepted for Publication

Forecasting Research

Extended Range Prediction

1. Large-scale features of the Indian summer monsoon rainfall and their association with atmospheric variables : Prasad K. D. & Singh S. V., *Advances in Atmospheric Sciences*.
2. Monsoon rainfall and southern oscillation responses in the North Indian ocean : Prasad K. D. and Singh S. V., *Advances in Atmospheric Sciences*.

Climatology & Hydrometeorology

Climate & Climatic change

1. Climate and climatic change with special reference to India : Pant G. B. &

Sikka D. R., *Science Encyclopaedia (Gujarathi)*, Gujarat Bisvakosh Trust, Ahmedabad.

2. Climatic changes in and around the Rajasthan desert during the 20th century : Pant G. B. & Hingane L. S., Jr. *of Climatology*.
3. Long-term variability of the Indian summer monsoon and related parameters : Pant G. B., Rupa Kumar K., Parthasarthy B. & Borgaonkar H. P., *Advances in Atmospheric Sciences*.
4. Onset of southwest monsoon over Kerala 1901-1980 : Ananthakrishnan R. & Soman M. K., Jr. *of Climatology*.
5. Statistical model of climate reconstruction using tree-ring data : Pant G. B., Rupa Kumar K. & Borgaonkar H. P., *Proc. of Indian National Science Academy*.

Hydrometeorological Studies

1. Flood routing for the Dhalegaon—Babli reach of river Godavari : Rao P. G. & Ramana Murty K. V., *Mausam*.
2. Some hydrologic characteristics and modelling aspects of a small catchment in southern India : Rao P. G., *Mausam*.

Physical Meteorology & Aerology

Cloud Physics & Weather Modification

1. Applications of deterministic chaos in meteorology and atmospheric electric field : Selvam A. M., *Asia-Pacific Physics, News*, 1988.
2. Atmospheric electric field observations in the maritime environment along the coast of peninsular India : Manohar G. K., Kandalgaonkar S. S., Selvam A.M. & Murty A.S.R., *Proc. of XII*

General Assembly of European Geophysical Society, Strasbourg, France, 9-14 April 1987.

Dynamics of deterministic chaos in atmospheric electricity : Selvam A. M., Proc. of 8th Int. Conf. on Atmospheric Electricity, Uppasala, Sweden, 13-16 June 1988.

Dynamics of deterministic chaos in the atmospheric boundary layer and applications to universal cloud model : Selvam A. M., Proc. of 10th Int. Cloud Physics Conf., FRG, 15-20 August 1988.

Physical hypothesis for the observed scale invariant characteristics of atmospheric phenomena : Selvam A. M., Textbook on Scaling, Fractals and Non-linear variability in Geophysics, S. Lovejoy Ed., D. Reidel Pub., 1988.

Possible solar influence on atmospheric electric field : Mehra P., Selvam A. M. & Murty A.S.R., Advances in Atmospheric Sciences.

Precipitation initiation mechanisms in clouds over north India : Chatterjee R. N., Prem Prakash, Singh G. & Kapoor R. K., Proc. of 10th Int. Cloud Physics Conf., Bad Hamburg, FRG, 15-20 August 1988.

Three stage model of cloud electrification : Mukku V.N.R., Proc. of 8th Int. Conf. on Atmospheric Electricity, Uppasala, Sweden, 13-16 June 1988

Environmental Physics

1. Multiwavelength lidar measurements of aerosols in the lower atmosphere : Devara P.C.S., Raj P.E. & Londhe A.L., Proc. of 12th Int. Conf. on Atmospheric Aerosols and Nucleation, Vienna, Austria, 22-27 August 1988.
2. Physical and chemical characteristics of atmospheric aerosols : Khemani L. T., Library of Environment Control Technology, Gulf Pub., USA.
3. Remote sounding of aerosols in the lower atmosphere using a bistatic, CW Helium—Neon lidar : Devara P.C.S. & Raj P.E., Jr. of Aerosol Science.
4. Some results of photometric observations of comet Halley : Devara P.C.S. & Raj P.E., Jr. of Optics.

Instrumental and Observational Techniques

Development of Instruments for Boundary Layer Studies :

1. Experimental determination of sensible heat flux over a complex terrain by eddy correlation programme : Sivaramakrishnan S., Vernekar K. G. & Brij Mohan, Jr. of Indian Institute of Science.
2. Measurements of charges on three different categories of particles : Kamra A. K., Dhanorkar S. S. & Deshpande C. G., Proc. of 8th Int. Conf. on Atmospheric Electricity, Uppasala, Sweden, June 1988.

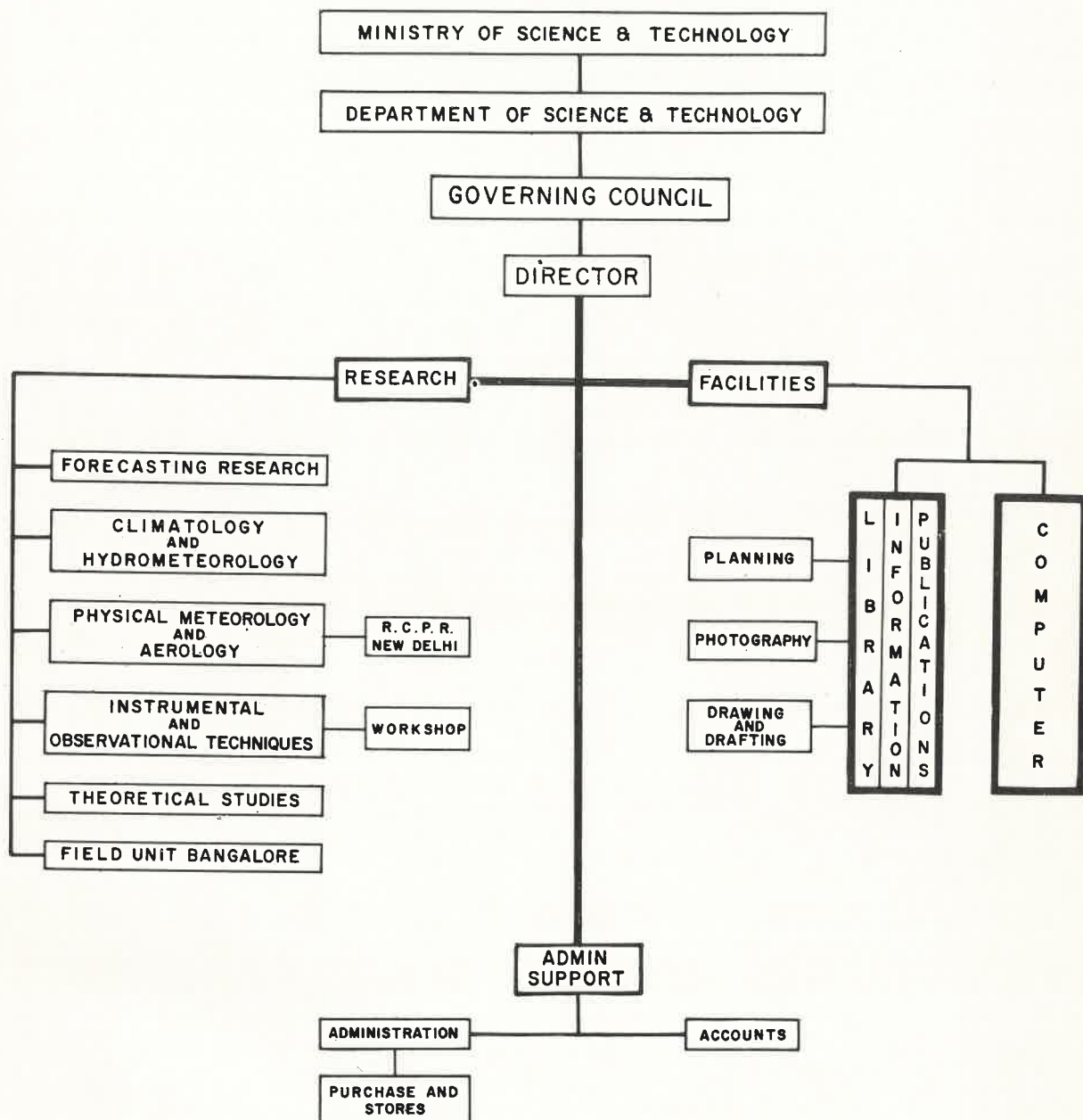
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Appendix I

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INDIAN INSTITUTE OF TROPICAL METEOROLOGY

(ORGANIZATIONAL PROFILE)





Signing of the Interim Report between the Indian and the USSR Scientists at Pune under the Indo-USSR Programme of Co-Operation in Science and Technology (Meteorology)



Dr. Joseph Fletcher, Assistant Administrator, NOAA, Dr. C. M. Bhumralkar, Scientist from NOAA, USA and Dr. R. V. Madala, Scientist, Naval Research Laboratory, Washington during their visit to the Institute



Shri R. Suryanarayana, Assistant Director, Computer explaining a point to
Dr. R. P. Sarker, Director General of Meteorology and Chairman, Governing
Council, on the occasion of the inauguration of the Institute's new ND-560
Computer System