Indian Institute of Tropical Meteorology

Pune 411 005 INDIA

ANNUAL REPORT 1984-85

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Cover Photo

Institute Building at Pashan, Pune

Prof. G.O.P. Obasi, Secretary General, W.M.O. addressing the scientists during his visit to the Institute on 15 February, 1985.

INTRODUCTION

INTRODUCTION

It is a pleasure for me to place in the hands of readers the Report of the Indian Institute of Tropical Meteorology for 1984-85 incorporating some of its important activities in the chapters to follow.

2. The Institute completed in 1982 two decades of its service to the nation. To commemorate this distinct landmark in its history, the Institute organised a symposium on "Current Trends in Tropical Meteorology" on 29 June 1984, which was inaugurated by Professor M.G.K. Menon, Member of the Planning Commission. Shri S.K. Das, Director General of Meteorology and Chairman of the Governing Council of the Institute, was the Chief Guest at the function. By a happy coincidence, the Symposium was followed by the Third Annual Convention of the Association of Hydrologists of India which was co-sponsored and hosted by the Institute. A publication embodying a conspectus of the contributions made by the Institute over a period of two decades was released on the occasion. The participation of a large number of distinguished scientists in these two events and deliberations thereat provided an opportunity for the Institute to take stock of the task that lay ahead of it.

3. A significant event during the year under report was the inspiring visit of Professor G.O.P. Obasi, Secretary General, World Meteorological Organisation, to the Institute on 15 February 1985. Professor Obasi evinced keen interest in the various research activities and was deeply impressed by the innovative ideas of the scientists of the Institute. He expressed his happiness at the progress made by the Institute during the past two decades and hoped that it would play a major role in the development of tropical meteorology at the global level in the future years. Concluding his visit Professor Obasi also addressed the scientists of the Institute.

4. The Institute has been actively participating in the Indian Middle Atmosphere Programme (IMAP). As part of the aerosol campaign an experiment was conducted at the Vikram Sarabhai Space Centre, Trivandrum during January-February 1984 for measurement of Aitken Nuclei, mass concentration and distribution of the total suspended particulates and ozone concentration in the atmosphere.

5. A meeting of the Working Group of the Department of Science and Technology on Cloud Physics and Weather Modification was held at the Institute on 1 July 1984 and considered the feasibility of setting up of a National Centre for Weather Modification. The Institute hopes that the proposed Centre would soon be a reality.

6. The Institute conducted aircraft-based experiments in weather modification for the ninth monsoon season during 1984 in the Pune region.

7. Under the Indo-US Monsoon Research Programme, a senior scientist of the Institute visited USA while one scientist is currently undergoing, under the UNDP Research Fellowship Programme, specialised training in the field of weather modification with emphasis on hail suppression. The services of an Assistant Director at the Institute were made available, at the request of the WMO, to the Tropical Ocean Global Atmosphere (TOGA) Project Office, Boulder, USA, for a period of two years.

8. Also, thirty two distinguished scientists, from within and outside India, visited the Institute and exchanged ideas with their counterparts at the Institute.

9. The Institute scientists participated in several national and international symposia/conferences and presented papers. Special mention of the following may be made:

i) XXV COSPAR meeting, held at Graz, Austria, (1-7 July 1984).
ii) IX International Cloud Physics Conference held at Tallinn, USSR, (21-28 August 1984).
iii) International Symposium on Middle Atmosphere, held at the Radio Atmospheric Science Centre, Kyoto University, Japan (26-30 November 1984).
iv) VI Indian Society for Theory of Probability and its Applications Conference held at Trivandrum (27-29 December 1984).
v) Indo-US Workshop on Inter-annual variability on Monsoon held at the India Meteorological Department (21-25 January 1985).
vi) National Seminar-cum-Workshop on Atmospheric Sciences and Engineering held at Jadavpur University (20-23 February 1985).

10. A Field Research Unit of the Institute is functioning at Bangalore. The Unit is funded by the Department of Non Conventional Energy Sources, Government of India. This unit is engaged in conducting surveys of wind energy for the states of Gujarat, Orissa, Tamil Nadu and Maharashtra and in the selection of suitable sites for the wind mapping stations.

11. At the request of the Ministry of Agriculture, Government of India, a Seminar on Meteorology was organised by the Institute from 11 to 19 December, 1984 for the State Government Agricultural Extension Functionaries.

12. Two members of the Institute were awarded Ph.D. degree by the University of Poona for their theses, while five more members submitted their theses during the year under report.

13. Members of the Institute published fortyeight research contributions in national/international journals and this activity is continuing on an ever-increasing scale. The details are furnished in the chapters to follow.

14. The year under report witnessed completion of the construction of sixtyfour staff quarters and their occupation by the members of the Institute, thus fulfilling a long-standing felt-need. Other constructional activities are also making steady progress on the Institute's campus at Pashan, Pune.

15. Ever since its conversion into an autonomous body in 1971, the Institute was under the administrative control of the Ministry of Tourism and Civil Aviation. Effective from 31 December 1984, it came to be transferred to the Ministry of Science and Technology (Department of Science and Technology).

16. The 7th Five-year Plan of the Institute proposes an outlay of Rs.5.05 crores. The plan envisages embarkation upon new areas of research and strengthening the base of the ongoing projects as well as addition to the existing infrastructure to help create an appropriate milieu for stepping up the research output of the Institute.

17. The Institute is making rapid progress in all directions, thanks to the valuable support received by it from the Government of India, and to the unstinted cooperation from the India Meteorological Department in particular, and from other scientific organisations in the country in general.

(Bh.V. Ramana Murty)
Director

1. RESEARCH HIGHLIGHTS

A south to north progressing wave with recurrence period of 40 days was identified in the Indian monsoon rainfall. This wave having a wave-length of 20° latitude was found to move across the country at the rate of 0.5° latitude/ day, explaining 25% variance of the spatio-temporal evolution of the weekly rainfall fields.

The relationship between the winter time surface air temperature of northern hemisphere and the following summer monsoon rainfall of India was found to remain stable and statistically significant during the past 3 decades.

Available Palaeoclimatic information for North West India for the past 10,000 years was examined. The analysis did not support Winstanley's hypothesis for extension of aridity in the region.

The one-day areal probable maximum precipitation (PMP) for areas of 1000 and 5000 sq. miles over the north Indian plains was found to range from 40-80 cm and 30-60 cm respectively.

The 1, 2 and 3-day probable maximum precipitation over the Karanja catchment situated in the Karnataka State and adjoining State of Andhra Pradesh was found to be 33.9 cm, 40.6 cm and 42.4 cm respectively.

The Stanford watershed model for conversion of rainfall to runoff was put on EC 1040 computer.

An Argon Ion Laser Radar System with wavelengths 4880 A° and 5145 A° was installed for remote sensing of aerosols in the lower atmosphere.

A meteorological rocket payload was designed using wire as sensor. Initial environmental tests and printed board layout were completed.

An instrument to measure electric charges on particles in three different size ranges (i) precipitation particles, (ii) cloud particles and (iii) aerosol particles was fabricated and put into use.

A barotropic-baroclinic-modified wave CISK instability model, with surface boundary layer - and cumulus friction, was developed and tested.

A 5-level global spectral model, was developed and successfully tested.

2. RESEARCH AND DEVELOPMENT

The Indian Institute of Tropical Meteorology functions as a National Centre for basic and applied research in Tropical Meteorology. Its primary functions are to promote, guide and conduct research in the field of Meteorology in all its aspects, including weather modification, with special reference to the tropics and the subtropics.

The programmes of work at the Institute are spread over **thirteen** areas of research and are carried out in its seven scientific divisions. The important results obtained in each of the areas are given below :

2.1 Forecasting Research Division - I

2.1.1. Numerical Weather Prediction

(a) Models

The five level primitive model, which had been developed earlier, was further tested for the case of monsoon depression of 7 July 1979. The comparative performance of Kuo's scheme of parameterization of cumulus convection and the scheme of moist convective adjustment was also investigated using this model. Both the schemes produced similar forecasts of circulation features.

The three level primitive model, which had also been developed earlier, was further tested by including higher orography with maximum height of 2 km using idealised flow fields. The model was also tested for the case of monsoon depression of 5 July 1973 by including in it low orography with maximum height of 1 km. The model produced improved low level circulation.

Quasi Lagrangian regional model, developed at NMC Washington, was made available to the Institute under Indo-US Collaborative programme. The model was suitably modified and integrated up to 48 hours on CYBER 205 Computer at NMC Washington using data of Indian region as input. The planetary scale systems were well predicted.

(b) Initialization

Numerical experiments were performed using the Buneman's Block cyclic reduction method and the Fourier Transform method for solving the elliptic equation in connection with the development of the bounded-derivative method of initialization.

(c) Objective analysis

Optimum interpolation scheme, which had been developed earlier, for analysis of wind field was tested for 1-12 July 1979 at 850 mb level. It was found that inclusion of mean random errors in the observation reduced the weighting factors.

In order to extend the univariate optimum interpolation scheme to that of multivariate, the autocorrelation functions and structure functions of wind field were computed using daily data of July month for the period 1976-1979.

2.1.2 Extended Range Prediction

(a) Intra-seasonal variation of monsoon circulation and rainfall

The contributions of low frequency bands centred around 15-day and 40-day periods towards the intra-seasonal **fluctuations of rainfall and 700 mb contour** height fields were studied by bandpass filtering. It was found that these two frequency bands contained respectively 15% and 8% variance of the daily rainfall and 15% and 12% variance of the daily 700 mb contour heights.

Extended empirical orthogonal function analysis was applied on 7-day rainfall and 5-day 700 mb contour heights to study the sequential evolution of these fields. The study pointed out that rainfall anomalies moved at the rate of 0.5° latitude per day from south to north up to about 20°N and to north-east thereafter.

Two-state (dry and wet) Markov chains of order 0, 1 and 2 were fitted to the pentad rainfall of 33 meteorological sub-divisions using 19 years of data (1955-1973). Three thresholds (viz. mean and mean ± one standard deviation) were used to define the dry and wet states. The results showed that the Markov chain of order 1 fitted the data of majority of the subdivisions. The mean order of the chain decreased with increase in the threshold value for the various sub-divisions. Further, 70 years of data (1901-1970) for the Konkan region was fitted through Markov chain model for the total span of the data, successively reducing the sample size by 10 years' period. The study showed that the order of Markov chain was independent of sample size for all the three thresholds.

The annual cycle in the monthly Indian rainfall and the stability of the monsoon rainfall patterns during the three climatic epochs (viz. 1901-1930, 1931-1960, 1961-1980) were investigated using eigen vector technique. It was found that the annual and semi-annual cycle explained 90% of the variance of the monthly rainfall. The first two eigen vectors were stable over the entire period (1901-1980) whereas the third one was stable over the recent epoch (1961-1980)

(b) Long range prediction and interannual variability

Data of surface air temperature of northern hemisphere for 80 years (1901-1980) were analysed to explore its importance for the long-range prediction of monsoon. The results were compared with those obtained by using other predictors, which were identified earlier, namely, pre-monsoon upper tropospheric thermal anomaly, upper tropospheric meridional component of wind and transport of angular momentum. The study revealed that northern hemispheric surface air temperature anomaly during January-February was the best predictor.

The 11 years' running correlation coefficients between winter-time surface air anomalies and following summer monsoon rainfall showed three distinct periods (1901-1925,1926-1950, 1951-1980). These periods more or less coincided with the observed short-term climatic epochs.

Spatial distribution of the correlation coefficients of the northern hemispheric winter-time surface air temperature anomalies with monsoon rainfall over various sub-divisions for the period 1901-1980 was analysed. The analysis delineates a contiguous west-central Indian region as a spatially homogeneous area.

A 30-year (1951-1980) data sample was utilised to test the usefulness of the positions of the sub-tropical ridge at 700 mb level over the west Pacific and at 500 mb over the Indian region during the pre-monsoon months in foreshadowing monsoon rainfall. Multiple regression equation developed explained 50% of the variance of the monsoon rainfall.

2.1.3. Monex Studies

Fluctuations of near equatorial oceanic ITCZ over the Indo-Pacific region during summer monsoon were studied utilising Monex-79 and ISMEX-73 data. The study showed that the intraseasonal fluctuations of Indian summer monsoon is dominantly controlled by two low frequency modes, namely, a quasi-bi-weekly and 30 to 50 day mode.

Quantitative estimates of mass and energy fluxes in the lower and middle troposphere of the Indian monsoon trough zone were made based on monthly mean radio-sonde/ radio wind data of June through August of 1979. They were also made for the monthly normals based on 20 years (1951-1970). The results showed an outflow of mass as well as sensible and latent heat in the middle troposphere during 1979 contrary to the inflow of these quantities obtained from the normals.

Time-composite satellite pictures of 5° latitude band (10°N-15°N) over the western Pacific ocean and Indian region (80°E 140°E) were examined in detail by comparing with the x, t diagram (Hovmoller diagram) of sea-level pressure for the period 1-17 July 1979 during summer Monex. Cloud clusters in the westward propagating wave disturbances were seen to be moving with a phase speed of $\sim$ 8 m sec^{-1}.

Northern summer tropical circulations during a bad monsoon year (1974) and a good monsoon year (1975) were studied by utilising NMC's global grid point mean monthly wind data for the months April through August for 700 mb and 300 mb levels. The study pointed out that during the bad monsoon year westerlies were weaker, northerlies were stronger and convergence of momentum was present at 300 mb between equator and 10°N.

The diurnal variation of various marine meteorological elements (viz. surface pressure, air-sea temperature, dew point temperature, wind speed and cloud cover) for the period 25 May - 3 June and 21-28 June 1979 for the Monex Ship were examined. The results showed, with the advance of monsoon, a decreasing tendency (2-3 units) in surface pressure, air-sea temperature and dew point temperature and an enormous increase (3-4 times) in wind speed and total cloud cover.

2.2. Forecasting Research Division (II)

(a) Short Range Prediction.

Adiabatic generation of kinetic energy was computed over India for the period 3-10 July 1979 which covered the life cycle of a monsoon depression. Vertical profiles of the generation from surface to 100 mb level were obtained. Strong generation was observed in the upper troposphere. Generation in the middle troposphere was weak. The vertically integrated area mean generation showed maximum on 8 July, when the depression was very intense.

Barotropic available potential energy over the monsoon region (as defined by Ramage) was computed for the six months period from May to October for poor monsoon year 1972 and good monsoon year 1975. The computations revealed that the available potential energy in the lower level (850-700 mb) was more in 1972 than in 1975, but in the upper level (300-100 mb) it was more in 1975 than in 1972.

2.3 Climatology Division

2.3.1. Studies on Climate and Climatic Change

(a) Floods and solar activity

The wetness index for the south-west monsoon was determined for the period 1891-1983. Power spectrum analysis of this time series showed periodicity of about 22 years. The analysis further suggested that flood events over India occurred in major but not in minor sunspot cycles.

(b) Antarctic temperatures and monsoon correlation

The relationship between the areal average monthly temperature anomalies of 16 stations between 65°S and 90°S and the Indian summer monsoon rainfall for the period 1957-1983 was studied. The highest (0.43 and most significant (5% level) correlation was found for the month of May, a month immediately preceding the monsoon season.

(c) Southern Oscillation, monsoon activity and Pacific sea surface temperature

The correlation between the Southern Oscillation Index (SOI), Sea Surface Temperature (SST) and monsoon activity indicated by Drought Area Index (DAI) and Flood Area Index (FAI) was studied. It was observed that SST anomalies in the eastern equatorial pacific ocean respond to the variations in SOI after one season.

(d) Upper air features during droughts and floods

Upper air zonal wind field and thermal field were studied for two drought years (1972 and 1979) and one flood year (1975). It was found that the areal spreading of easterlies over the tropics and the adjoining extra tropics was significantly more (by 10° latitude south of equator) during flood year than during drought year. The normal position of the easterly jet shifted to a higher level (from 14 km to 16 km) during flood year. The upper troposphere was significantly **colder (by 2°C) during drought year.**

(e) Vagaries of the Indian summer monsoon

A detailed examination was carried out of three spatial scales of the summer monsoon, namely, all India, 29 subdivisions and 306 individual stations. The correlation coefficients between all India summer monsoon rainfall and Southern Oscillation Index (SOI) for concurrent and succeeding seasons were positive and significant. Further, the all-India rainfall was inversely related with severity of El Nino events. Also, it was positively related with the Pacific high pressure for summer season and with northern hemispheric January surface temperature and negatively correlated with Aleutian low pressure for the preceding winter.

(f) Paleoclimatology

Samples being prepared in the Paleoclimatology laboratory for dendroclimatological analysis.

Winstanley's hypothesis was re-examined using longest available rainfall series of the Northwest India and other proxy climatic evidences collected by various workers for the holocene period. It was found **that the available evidences do not support** the extension or intensification of desert margins.

(g) Other Studies

Different aspects of the long-term variation of surface air temperature for whole India as well as different regions in the country were studied. Data from 73 stations for the period 1901 to 1982 were used in the analysis. The mean annual as well as seasonal temperature series were examined. It was observed that the mean annual temperature of India increased by 0.33°C during the above period. The increase was more conspicuous in winter and post-monsoon seasons. The temperature change during the monsoon season was not significant. The stations in the west coast, interior peninsula, north central and northeastern parts of the country were found to have predominantly contributed to the increase of temperature over the country.

Rainfall associated with cyclonic storms of the Bay of Bengal was examined for fitting a statistical model. Gamma probability model was found to be a good fit to the mean rainfall recorded within a distance of one degree on both sides of a point at which storm strikes the coast.

2.4 Hydrometeorology Division

2.4.1 Basin Rainfall Studies for Development of Water Resources

(a) Maximum and probable maximum precipitation (PMP)

Areal PMP for areas of 1000 and 5000 sq. miles for one-day duration were estimated using a combination of point PMP and depth-area model for stations in the north Indian plains. Two generalised charts depicting spatial patterns of 1-day PMP for these two areas were prepared. The PMP estimates of 1000 and 5000 sq. miles were found to lie between 40-80 cm and 30-60 cm respectively for 1-day duration. The estimates obtained by this method were compared with those derived from storm transposition and maximization method. The agreement was found to be good.

A study was conducted to determine the extent to which the estimatesof 1-day PMP at different stations lying north of lat. 20°N exceed their corresponding 1-day highest observed rainfall. A generalized chart showing the ratio between these two parameters indicated that 1-day PMP was of the order of 150 to 300% of the highest observed rainfall. A similar study made between 1-day PMP and the normal annual rainfall showed that the 1-day PMP could be 30 to 250% of the normal annual rainfall.

A detailed hydrometeorological study of the catchment up to the Karanja dam site was made to estimate the design storm depths of different return periods and the probable maximum rainfall likely to be experienced by the catchment using long rainfall data. It was observed that the catchment experienced maximum rainfall of 193 mm, 258 mm and 312 mm during 1,2 and 3 day periods respectively during the last 94 years of record. Severe rainstorms of September 1908 and July 1965, which occurred in a homogeneous region around the catchment, were transposed to estimate PMP. The values of PMP for 1, 2 and 3 day durations were found to be 339 mm, 406 mm and 424 mm respectively which were about 1.4 to 1.8 times the corresponding maximum raindepths experienced by the catchment.

b) Rainfall analysis of Narmada basin

Daily rainfall data from 1891 to 1980 for stations within the Narmada basin up to Sardar Sarovar dam site were used to determine the frequency of rainspells of different durations. A total of 260 rainspells of 1 to 7 day durations were experienced showing that the Narmada basin receives 3 heavy rainspells,on an average, in a year.

Three generalized charts showing the spatial distribution of 100-year return period values for 1, 2 and 3 day durations were constructed for Narmada basin using rainfall data of 105 stations. The values were found to vary from 20 cm to 40cm, 30 cm to 60 cm and 30 cm to 70 cm respectively.

The maximum basin raindepths up to Narmadasagar dam site were determined by transposing September 1926 rainstorm successively over the 3 sub-catchments. It was found that when the heavy rain centre of the transposed storm lay in the vicinity of the central sub-catchment, the basin experienced the maximum rainfall. The areal PMP estimates of 1,2 and 3-day durations were found to be 12.1 cm,24.0 cm and 33.8 cm respectively.

2.4.2 Analysis of Severe Rain Storms Including Development of Suitable Computer Techniques

(a) Severe storms

The areal rainfall associated with the severe rainstorms over Gangetic West Bengal and plains of North Bengal were analysed using past 90 years' rainfall data. A comparison between the severemost rainstorms of these two regions showed that storms over the Gangetic West Bengal were more severe than those over North Bengal for areas exceeding 3000 sq. km. despite the fact that the average annual rainfall of North Bengal plains was twice that over the Gangetic West Bengal.

The rainstorm of 28-30 August 1982 over the uncontrolled catchment of Mahanadi river which produced an unprecedented peak discharge of 44830 m^3/sec at Naraj was analysed. It was revealed that the rainstorm of August 1982 was not the severemost rainstorm in the catchment though it produced the maximum peak discharge. It was also found that the unprecedented peak discharge was due to antecedent wet conditions of the soil due to occurrence of a heavy rainstorm prior to this storm.

(b) Maximisation studies

A generalized chart showing the annual extreme dew point temperatures for the Indian region was prepared.

A study was conducted to determine the relationship between the rainfall and the available moisture content in the atmosphere for Narmada basin. It was found that during monsoon season, whereas the coefficient of variation of moisture ranged between 5 and 10%, that of rainfall ranged between 50 and 100%, on a daily basis.

(c) Rainfall variability studies

i) Using values of annual rainfall and Thornthwaite's moisture indices of 206 stations uniformly distributed over India, maps showing the probability of shift in the different climatic zones ranging from arid to per-humid in relation to rainfall were prepared. Knowing the average annual rainfall of any station, prevailing climatic conditions can be assessed from these maps.

ii) The correlation coefficients between mean and standard deviation of annual rainfall series of 460 stations of India revealed a linear relationship between the two parameters.

(d) Incidence of floods

Flood data of 16 years (1969 to 1984) at different gauge sites of major rivers of the country were analysed. The study showed that 42 major rivers recorded most severe floods on 798 occasions at 119 sites. The probability of getting such a flood in a year at a particular gauge site was found to be 0.43.

Rainfall data for the 1983 summer monsoon season, which was a good monsoon year, were examined. It was found that only 14 rivers of the country experienced severe floods inspite of the fact that 95% area of the country received normal or above normal rainfall. Rivers in the states of Assam and Uttar Pradesh were worst affected by floods.

(e) Computer applications to design storm and flood studies

Kentucky watershed model, a FORTRAN improvised version of Stanford watershed model, generates runoff from rainfall, evaporation and catchment characteristics. This model was modified to suit Indian tropical conditions. This modified version viz. OPSET was put on EC-1040 computer and its functioning was checked with the test data.

2.5 Physical Meteorology and Aerology Division

2.5.1 Cloud Physics and Weather Modification

a) Atmospheric electricity

i) Electrical conductivity in warm monsoon clouds was measured using a Gerdian type cylindrical condenser system which was fabricated earlier. The maximum value of the negative conductivity noticed in warm monsoon clouds was 8.64×10^{-12} mho. The variations in conductivity were found closely associated with those in liquid water content (correlation coefficient = 0.7 significant at less than 1% level).

ii) A warm cloud modification experiment is in progress in the Pune region since 1973. Observations were made of corona current, electrical conductivity and cloud droplet charge in seeded (target) and not-seeded (control) clouds during the period when the experiment was conducted in summer monsoon seasons of 1981-83. Analysis indicated that following seeding, corona current increased up to 16 times, electrical conductivity increased up to 5 times and cloud drop charge increased up to 3 times.

b) Radar studies

A study relating to the physics of precipitation formation in convective clouds forming within 100 km around Delhi was carried out using radar observations of 7,346 cloud cases obtained during the 16-year period (1960-1975). Results indicated that precipitation formation took place in 48% of the cases purely by coalescence process, in 11% of the cases by ice crystal process and in the remaining 41% cases by combination of both the processes.

c) Warm cloud modification experiment

The cloud seeding experiment, which has been in progress in the Pune region, was conducted on 12 pairs of days during the summer monsoon of 1984. Cloud physical observations were made in 10 pairs of randomly chosen seeded (target) and not-seeded (control) clouds.

Analysis was made of the rainfall data in the experimental area for all the 9 summer monsoon seasons (1973, 1974, 1976, 1979-84) during which the seeding experiment was conducted on 100 pairs of days. Results indicated increase in rainfall by 5% significant at 16% level. Analysis was also made stratifying the data according to nature of monsoon activity on the experimental days. Results showed increase in rainfall by 31% (significant at 17% level) on days with isolated to scattered rainfall activity. Rainfall decreased by 10% (significant at 40% level) on days with scattered to widespread rainfall activity.

Warm cloud responses to salt-seeding were studied using data of chemical composition of 140 samples of cloud/rain water collected from seeded and non-seeded clouds. Chloride and Sodium ion concentrations in seeded clouds were respectively higher by 273% and 305% than those in control clouds. In rainwater also, they were higher respectively by 238% and 133%. The differences in both the cases were significant at less than 5% level.

d) Lidar probing of the atmosphere

A LEXEL Model 95-4 Argon ion laser radar system, with two operating wavelengths 4880 A° and 5145 A°, was acquired. The laboratory facility required for the system was built and the radar was installed.

2.5.2 Environmental Physics

a) Atmospheric boundary layer

The dynamical characteristics of the atmospheric boundary layer (ABL) and monsoon clouds were studied using high resolution observations of vertical velocity and temperature data obtained from the aircraft measurements made as part of the Institute's cloud seeding experiment conducted during the summer monsoon seasons of 1982-83. The slopes of turbulence spectra in clear-air and cloud-air had limiting values of - 2 and - 3 respectively. The in-cloud spectral slopes increased with increase in liquid water content. Wind and temperature were normally distributed. A simple conceptual model for the eddy growth in the ABL was developed.

The thermodynamical structure of the atmospheric boundary layer over the Deccan Plateau region was studied using the aerological data for 1980 and 1981. The results indicated that on active monsoon days, the values of dry static stability were higher than those on weak monsoon days. Opposite trend was noticed in the case of moist static stability.

b) Upper atmosphere

Daily wind data in the 10-20 km region of Balasore (21.5°N, 86.9°E) for the months July and August 1979 (Monex period) were analysed. Results suggested presence of 4 to 5-day oscillation.

The synoptic data with regard to location of pressure system and temperature field obtained from stratalert messages from December 1983 to mid-March 1984 were analysed. Comparison of these results with those of the temperature and wind data obtained from the weekly launchings of M-100 rockets from Thumba (8.5°N, 76.9°E) revealed the presence of comparatively undisturbed winter in the high-latitude middle atmosphere up to the end of January 1984. However, a major warming occurred around 22-25 February 1984 and a final warming from 9 March 1984 was also noted. The study also suggested that no strong warming took place over tropics during the winter of 1983-84.

A study of interannual variability of the middle atmosphere during northern winter was carried out using the mean zonal wind and temperature data obtained from 8 stations for the six year period 1970-72 and 1974-76. The results indicated marked interannual variation in the zonal wind northward of 35°-40°N. In the stratosphere (25-45 km), the westerly zonal wind reached its maximum near 35°-40°N during 1970, 1971 and 1975 when the Indian summer monsoon was normal to strong. The zonal wind reached its maximum near 60°N (polar night jet) during 1972, 1974 and 1976 when the summer monsoon was weak to normal.

The possible linkage between daily rainfall and geomagnetic activity was investigated using daily rainfall data for 12 stations in the State of Tamil Nadu for the period 1961-70. It was noticed that geomagnetic activity during great storms and rainfall had a common 15-day periodicity significant at 1% level.

c) Air pollution

Analysis of trace elements in atmospheric aerosols at Delhi was carried out using measurements of total suspended particulates (TSP) made on 116 days during February-October 1980. The values of cross correlation of the TSP and its components were evaluated. High TSP (209 microgram m^{-3}) levels were found during the summer period when hot and dry weather conditions prevailed in the region. Low TSP (109 micrograms m^{-3}) were found during the southwest monsoon period. Most of the TSP mass was associated with natural soil elements, such as Fe, Al, Mn, Ca and K. Only a fraction of the mass of the TSP comprised of elements of anthropogenic origin i.e. Pb, Ni, Cd, Sb, Cu and Zn. The aerosols at Delhi are potentially basic in nature unlike those in the European countries which are acidic.

Conductivity and pH value of rain water samples being measured in the air-pollution laboratory.

A study of the nature and characteristics of trace elements and maritime aerosols over the sea regions around the Indian sub-continent was carried out using observations of TSP made on board the research vessel 'Gaveshani' during May 1983. The results indicated that the concentrations of elements of soil-origin (Al, Fe, Mn, and Ca) were maximum over the Arabian sea indicating presence of dust particles possibly transported to the sea region from the Arabian peninsula.

A study was made of the chemical composition of the TSP and of rain water and pH of rain water collected at different urban and non-urban stations in India. It was found that the pH of rainwater was influenced by the alkaline properties of soil-oriented elements (Ca, K and Mg). There was no conspicuous change in the alkaline property of rainwater at Delhi over the past two decades mainly because of the presence of high levels of alkaline dust in that region.

Round-the-clock measurements were made of trace gases viz. sulphur dioxide, nitrogen dioxide, ammonia and ozone in conjunction with Aitken nuclei in the surface air-layer at Delhi for a period of ten days during the winter season of 1983-84. The study showed that the value of ozone concentration was maximum during day and minimum during night. The trend was opposite for other trace gases. Variations in ozone and Aitken nuclei concentrations were similar.

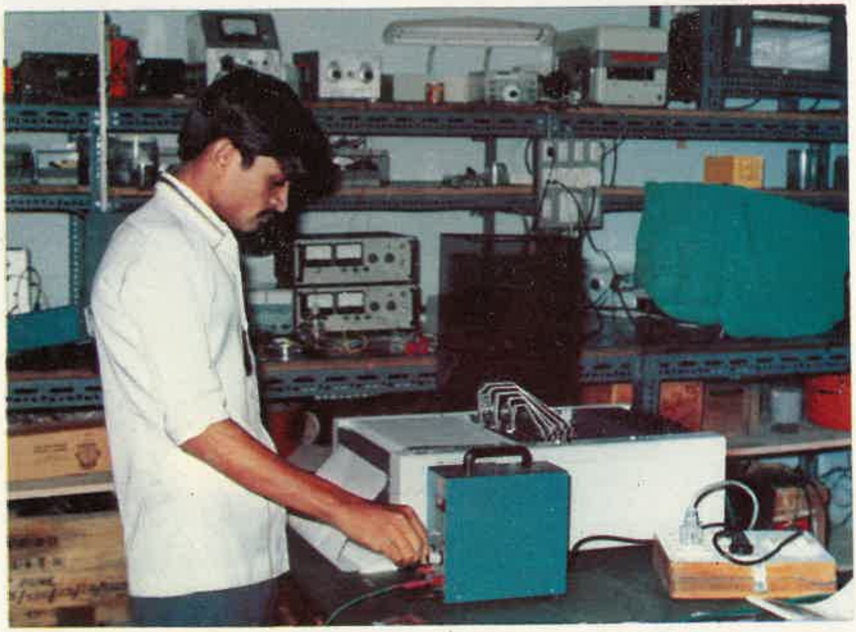
2.6 Instrumental and Observational Techniques Division

2.6.1. Development of Meteorological Payload for Rockets and Satellites

(a) Meteorological payload

Institute had developed earlier a meteorological payload using thermistor as sensor. An attempt was made to design a similar payload using wire (5 μ diameter) as sensor. The initial circuits required for this purpose were developed and the lay-out was finalized.

The radiation patterns of various reflecting cones of the payload developed earlier were re-examined at Vikram Sarabhai Spce Centre (VSSC), Trivandrum. A reflecting cone used for Judi-Dart type payload was selected for future use. A meteorological payload was launched from Thumba Equatorial Rocket Launching Station (TERLS) on 27 September 1984. The flight, however, did not yield data due probably to technical problems with the RH-200 rocket.



Micrometeorological instruments being tested and calibrated in the Instrumentation Laboratory of the Institute.

2.6.2. Development of Instruments for Boundary Layer Studies

(a) Boundary Layer Instruments

Cup anemometers of magnetic chopping type, designed and fabricated at the Institute, were calibrated.

Field instruments, a Gerdian tube, a space charge tube and a spherical field mill, are installed for obtaining atmospheric electricity measurements.

Preliminary work for designing a pressure sensor using CMOS (Complementary Metal Oxide Semi conductor) circuits and bellow was completed. The variation in the capacitance of the condenser system was measured in vacuum. A temperature display using LCD (Liquid Crystal Display) was fabricated. A cold junction compensated copper constantan thermocouple was used as sensor in the display.

The data collected earlier during the cruise of National Institute of Oceanography (NIO), Goa, research vessel "Gaveshani" in the Arabian sea and Bay of Bengal were analysed. The values of mean drag coefficient, sensible heat flux and momentum flux were computed for two days for which observations were available.

A study was made to determine sensible flux over a complex terrain (Pashan area, Pune) using a fine wire thermocouple a propellor anemometer exposed at 4.2 meters above ground during March 1985. A digital printer was used to record the data every hour for a duration of 10 minutes. A computer program was written to evaluate the sensible flux from the above input. The sensible flux evaluated was of the order of 50-100 watts/m^2.

2.6.3. Instrumentation for Cloud Physics and Weather Modification Studies

(a) Cloud electrification

An a.c. field mill for measuring atmospheric electric field, Gerdian tube for measurement of both polarities of atmospheric conductivity and an instrument for measurement of precipitation current and corona current, were fabricated.

Another apparatus which separates particles in three different sizes viz. i) precipitation particles; ii) cloud particles; and iii) aerosol particles was fabricated.

All the above instruments were exposed for measurement at the Institute building at Pashan, Pune.

The distortion of water droplets under the influence of high electric field was studied using vertical wind tunnel fabricated at the Institute.

2.7 Theoretical Studies Division.

2.7.1.Studies on Dynamic Instability

(a) Instability of summer monsoon flow

A numerical, quasi-geostrophic, combined barotropic-baroclinic, modified wave-CISK instability model was developed and tested. The cumulus and surface frictional effects were incorporated in the model. Computer routines were developed and tested for computing the generation of available potential energy by the boundary layer and cumulus frictions. The cumulus friction as incorporated in the model was due to the vertical transport of vorticity by cumulus convection. The relationship between the cloud mass flux and the large scale vertical velocity was found satisfactory and the same was used for computation of cloud mass flux for monsoon depression. The mean monsoon zonal wind distribution in the meridional plane was constructed. The results indicated that the combined barotropic-baroclinic unstable wave propagates in the westward direction. This was in agreement with the observed direction of propagation of monsoon depression.

The monsoonal upper (lower) level easterly (westerly) jet was analytically represented in two dimensions. The stream functions associated with the jets were computed by using the non-divergent condition. The stability characteristics and structure of the unstable waves associated with the jets were being investigated.

A primitive equation barotropic stability analysis of tropical easterly jet was performed. The study suggested that ageostrophic effect contributed to the growth of the disturbances and increase in their wave length.

In another study performed, it was found that mid-latitude westerly jets inhibited growth of disturbances in easterly jets.

The stability analysis of the mixed zonal and meridional monsoonal flow was done. It was found that vertical shear in the basic meridional wind enhanced the growth of the disturbances.

(b) Instability of zonal flow during MONEX

The cosine Fourier representations for meridional profiles of zonal winds, averaged between 80°E - 100°E were obtained for the region between equator and 30°N for July 1979. It was found that the low level westerly jet satisfied the necessary criterion for the combined barotropic-baroclinic instability of the zonal flow.

2.7.2. Simulation of Monsoon and Tropical Circulation Systems

(a) Models for Simulation

The computer code, which was developed earlier for the 5-level primitive equation global spectral model, was extensively revised in order to increase its computational efficiency. The model was successfully tested by simulating the propagation of Rossby wave of wavenumber 4

The linear quasi-geostrophic multi-level numerical model, which was developed earlier, was augmented. Computer routines were incorporated for computing available potential energy, energy conversions and the vertical velocity.

(b) Errors in numerical models

To determine the optimum vertical resolutions of the numerical models for predicting the development of monsoon depressions, a quasi-geostrophic, pure baroclinic, linear, numerical model was developed with unequal pressure intervals.

(c) Other studies

A computer programme was developed for interpolation of meteorological parameters in two dimensions by Bicubic spline method.

Control statements of the operating system of CYBER-170/730 were studied and a set containing 25 job streams for different types of jobs was prepared and made available to users.

Monthly Climatic Data (Surface) of 123 selected tropical stations for the period 1971-83 were collected and punched. Monthly Climatic Data (Upper Air) for ten standard levels in respect of the selected 80 tropical stations for the period 1977-81 were also collected and punched. Collection of data for the period 1982-83 was also completed.

3. PUBLICATIONS

3.1. Publications

3.1.1. Papers published in Journals

1. Ananthakrishnan R. and Parthasarathy B : Indian rainfall in relation to sunspot cycle : 1871-1978, Jr. of Climatology, 4, 2,March,1984, 149-169.

2. Awade S.T., Totagi M.Y., Bawiskar S.M. and Sikka D.R. : Dynamics of the large scale tropospheric circulation during summer monsoon and tropical droughts, Mausam,35, 3, July, 1984, 315-322.

3. Bhalme H.N. and Jadhav S.K. : Double (Hale) sunspot cycle and floods and droughts in India, Weather, 39, 4, April, 1984, 112-116.

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6. Chaudhuri S. : Technique of temperature measurement using wire sensor, Jr. of Indian Institute of Science, 65 (A), January, 1984, 21-26.

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9. Dhar O.N., Kulkarni A.K. and Mandal B.N. : Most severe rainstorm of India - a brief appraisal, Hydrological Sciences, Jr., 29, 2, June, 1984, 219-229.

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38. Raja Rao K.S., Awade S.T. and Nair M.V.H. : Dynamics of the stationary eddies in the lower stratosphere circulation in the wave number domain and monsoon activity, Proc. of Indian Academy of Sciences (Earth and Planetary Sc.), 93, 1, March, 1984, 1-16.

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48. Vernekar K.G., Brij Mohan and Saxena S. Preliminary results of a meteorological payload being developed by IITM, Advance in Space Research, 4, 6, 1984, 111-115.

3.1.2. Papers published in the Proceedings of Seminars/Symposia etc.

1. Devara P.C.S., Selvam A.M. and Ramana Murty Bh.V. : Behaviour of temperature structure parameters in cloud-and clear-air during the summer monsoon, IX Int. Cloud Physics Conf., Tallinn, USSR, 21-28 August 1984, 369-370.

2. Dhar O.N., Kulkarni A.K. and Mandal B.N. : Estimation of probable maximum point rainfall over plain areas of north India, Seminar on Hydrology, Hyderabad, 8-10 June 1983.

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5. Khemani L.T.. Naik M.S., Momin G.A., Kumar R., Chatterjee R.N., Singh G. and Ramana Murty Bh.V.: Chemical composition of atmospheric aerosols at Delhi, XI Int. Conf. on Atmospheric Aerosols, Condensation and Ice Nuclei, Budapest, Hungary, 2-7 September, 1984, 118-122.

6. Murty A.S.R., Selvam A.M., Devara P.C.S. and Ramana Murty Bh.V. : Ice nucleating characteristics of Chapparis Aphylla, an Indian herb., XI Int. Conf. on Atmospheric Aerosols, Condensation and Ice Nuclei, Budapest, Hungary, 2-7 September 1984, 122-126.

7. Murty A.S.R., Vijaykumar R., Sikka P., Selvam A.M. and Ramana Murty Bh.V Aircraft observations of cloud condensation nuclei in maritime and continental environments, XI Int. Conf. on Atmospheric Aerosols, Condensation and Ice Nuclei, Budapest, Hungary, 2-7 September 1984, 260-264.

8. Paul S.K., Pillai A.G., Selvam A.M., Murty A.S.R. and Ramana Murty Bh.V. : Cloud droplet spectra in warm monsoon clouds, IX Int. Cloud Physics Conf., Tallinn, USSR, 21-28 August 1984, 45-46.

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10. Selvam A.M., Devara P.C.S., Parasnis S.S., Paul S.K., Murty A.S.R. and Ramana Murty Bh.V. Characteristics of temperature spectra in warm monsoon clouds, IX Int. Cloud Physics Conf., Tallinn, USSR, 21-28 August 1984, 439-442.

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12. Selvam A.M., Murty A.S.R. and Ramana Murty Bh.V. : New Physical hypothesis for vertical mixing in clouds, IX Int. Cloud Physics Conf., Tallinn, USSR, 21-28 August, 1984, 383-386.

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3.2. Papers accepted for publication

3.2.1. Papers accepted for publication in journals

1. Ananthakrishnan R. & Soman M.K. : Evaluation of equivalent potential temperature from Radio-Sonde data, Current Science.

2. Chatterjee R.N. and Prem Prakash : Radar study of frequency of occurrence of cumulonimbus clouds around Delhi, Mausam.

3. Devara P.C.S. and Ramana Murty Bh.V. : VHF MST radar and its application to cloud physics, Indian Jr. of Radio and space physics.

4. Dhar O.N. : Rainfall organisation in India - need for a unified control, Indian Jr. of Power and River Valley Development.

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7. Hingane L.S., Rupa Kumar K. and Ramana Murty Bh.V. : Long-term trends of surface air temperature in India, Jr. of Climatology.

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11. Kamra A.K. and Ahire D.V. : Simple technique for simultaneous suspension of multiple drops in a small vertical wind tunnel, Jr. of Atmospheric and Oceanic Technology.

12. Kamra A.K., Sathe A.B. and Ahire D.V. Vertical wind tunnel for water drop studies, Mausam.

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14. Khemani L.T., Momin G.A., Naik M.S., Prakasa Rao P.S., Kumar R. and Ramana Murty Bh.V. Impact of alkaline particulates on pH of rainwater in India, Water, Air and Soil Pollution.

15. Khemani L.T., Momin G.A., Naik M.S., Prakasa Rao P.S., Kumar R. and Ramana Murty Bh.V. Role of chemical composition of rain-water and total suspended particulates on pH of rain water in India, Water, Air and Soil Pollution.

16. Kripalani R.H. and Singh S.V. : Rainfall probabilities and amounts associated with monsoon depressions over India, Mausam.

17. Mishra S.K. : On accelerating the FFT of Cooley and Tukey, Mausam.

18. Mishra S.K., Patwardhan M.D. and George L. : Primitive equation barotropic instability study of the monsoon onset vortex, 1979, Quarterly Jr. of Royal Meteorological Society.

19. Mukherjee B.K., Indira K., Reddy R.S. and Ramana Murty Bh.V. : Stratospheric/mesospheric warmings over tropics during winter and their implications for warming campaign of 1983-84, Indian Journal of Radio and Space Physics.

20. Pant G.B. and Borgaonkar H.P.: Growth rate of Chir pine (Pinus roxburghii) trees in Kumaon area in relation to regional climatology, Himalayan Research and Development.

21. Parthasarathy B. and Pant G.B. : Indian summer monsoon and Eurasian winter snow cover, Himalayan Research and Development.

22. Parthasarathy B. and Pant G.B. : Seasonal relationships between Indian summer monsoon rainfall and the southern oscillation, Jr. of Climatology.

23. Prasad K.D. and Verma R.K. : Large-scale features of satellite-derived out-going longwave radiation in relation to monsoon circulation over Indian region, Jr. of Climatology.

24. Rajamani S. : Energetics of the monsoon circulation over south Asia, Part - II - Energy terms and energy transformation terms, Mausam.

25. Rajamani S. and Kulkarni J.R. : On some energy aspects of the monsoon depressions during its life cycle, Mausam.

26. Rakhecha P.R. and Kennedy M.R. : Generalized technique for the estimation of probable maximum precipitation in India, Jr. of Hydrology.

27. Selvam A.M, Murty A.S.R., Sikka P. and Ramana Murty Bh.V. : Some physical and dynamical aspects of monsoon clouds and their modification, Archiv Fur Meteorologie, Geophysik und Bioklimatologie, Sr.A.

28. Singh S.S. and Sugi M. : Prediction of monsoon depression with a regional primitive equation model, Mausam.

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3.2.2 Papers accepted for publication in Proceedings of Seminars/Symposia

1. Mukherjee B.K., Indira K. and Ramana Murty B.V. : Inter-annual variability of middle atmosphere during northern winter, Int. Middle Atmosphere Programme, Kyoto, Japan, 22-30 November 1984.

2. Murty A.S.R., Chatterjee R.N., Selvam A.M., Mukherjee B.K., Khemani L.T. and Ramana Murty Bh.V. : Results of randomized warm cloud modification experiment conducted using aircraft in Maharashtra State, India during 9 summer monsoon seasons (1973, 74, 76, 1979-84), IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii , 12-14 August 1985.

3. Murty A.S.R., Chatterjee R.N., Mukherjee B.K., Reddy R.S., Khemani L.T., Kulkarni C.P. and Ramana Murty Bh.V. : Warm cloud responses to salt seeding under different synoptic conditions, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

4. Murty A.S.R., Khemani L.T., Momin G.A., Rao P.S., Naik M.S. and Ramana Murty Bh.V. : Warm cloud responses to salt seeding as evaluated from sodium and chloride ion concentrations in cloud/rain water, IV WMO Scientifc Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

5. Murty A.S.R., Paul S.K., Selvam A.M., Sharma S.K., Pillai A.G. and Ramana Murty Bh.V. : Warm cloud microphysical responses to salt seeding, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

6. Murty A.S.R., Selvam A.M., Manohar G.K., Devara P.C.S., Raj P.E., Kandalgaonakar S.S. and Ramana Murty Bh.V. : Warm cloud electrical and thermodynamical responses to salt seeding, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

7. Murty A.S.R., Selvam A.M., Parasnis S.S. and Ramana Murty Bh.V. : Warm cloud dynamical responses to salt seeding, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

8. Parasnis S.S., Bhosale C.S., Londhe A.L., Kulkarni C.P. and Ramana Murty Bh.V. : Statistical structure of the meteorological parameters in the atmospheric boundary layer, Nat. Sem./Workshop on Atmospheric Science and Engineering, Jadavpur Univ. Calcutta, 20-23, February 1985.

9. Prakash Rao P.S., Khemani L.T., Momin G.A. and Ramana Murty Bh.V. : State of marine aerosols over the sea region around Indian peninsula, Int. Symp. on Concepts and Techniques of Applied Climatology, Waltair, 18-21 March 1985.

10. Selvam A.M. and Murty A.S.R. : Application of ratio estimators in the numerical simulation of weather modification experiments, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

11. Selvam A.M. and Murty A.S.R. : Numerical simulation of warm rain process, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, 12-14 August 1985.

3.3. Research Report published in the series 'Contributions from the Indian Institute of Tropical Meteorology'

R. No.	Title	Author (s)
R-41	Long term variability of summer monsoon and climatic changes.	Verma R.K., Subramaniam K. and Dugam S.S.

4. PARTICIPATION IN SEMINARS/SYMPOSIA/MEETINGS

Prof. M.G.K. Menon, Member Planning Commission, delivering the inaugural address at the symposium on "Current Trends in Tropical Meteorology" organised by the Institute on 29 June, 1984.

Distinguished spekers at the inaugural session of the Symposium, from left to right, Dr. V.K. Gaur, Director, N.G.R.I., Shri S.K. Das, Director General of Meteorology, Chief Guest, Prof. M.G.K. Menon, Member of Planning Commission, Dr. P.R. Krishna Rao, Retd. D.G.M. and Dr. Bh.V. Ramana Murty, Director, I.I.T.M.

4.1 Participation in seminars/symposia

	Seminar/Symposium	Participant(s)
1.	Indo-US workshop on Ocean-atmosphere interaction, Indian Institute of Science (I.I.Sc.), Bangalore, 9-13 April 1984	Sikka D.R.
2.	Symp. on 'Current trends in Tropical Meteorology', Indian Institute of Tropical Meteorology, Pune, 29 June 1984.	41 Scientists
3.	Third Annual convention of the Association of Hydrologists, India (AHI), & Seminar on Hydrology, Pune, 29 June - 2 July 1984.	41 Scientists
4.	National Workshop on Numerical Prediction, India Meteorological Department (IMD), New Delhi, 2 July - 4 August 1984.	Khaladkar R.M. & Rajamani S.
5.	XXV COSPAR meeting, Graz, Austria, 1-7 July 1984.	Vernekar K.G.
6.	Indo-US workshop on Short Range Predictability of Monsoons, IMD, New Delhi, 6-10 August 1984.	Rajamani S. & Singh S.S
7.	IX Int. Cloud Physics Conf. Tallinn, Estonian, SSR, USSR, 21-28 August 1984.	Devara P.C.S.
8.	Seminar on Meteorology in India through the Ages, Ved Vidnyan Mandal, Pune, 22-24 September 1984.	Sikka D.R. & Bhalme H.N.
9.	Nat. Workshop on Long Term Variabihty of Monsoon, I.M.D., Pune, 27-29 September 1984.	Sikka D.R. Singh S.S. Verma R.K. Singh S.V. Bhalme H.N., Parthasarathy B. & Paul D.K.
10.	Int. Assn. of Seismology & Physics of the Earth's Interior (IASPEI) Regional Assembly, Hyderabad, 31 October - 7 November 1984.	Reddy R.S.
11.	First workshop on IMAP Results, Bangalore, 13-16 November 1984.	Vernekar K.G. Mukherjee B.K., Devara P.C.S. Reddy R.S. & Vijaykumar R.
12.	Int. Symp. on Middle Atmosphere, Radio Atmospheric Science Centre, Kyoto University, Uji, Japan, 26-30 November 1984.	Mukherjee B.K.
13.	Workshop on Gravity Waves and Turbulence in the Middle Atmosphere, Kyoto University, Uji, Japan, 3-4 November 1984.	Mukherjee B.K.
14.	Sem. on Meteorology for the State Agricultural Extension Functionaries I.I.T.M., Pune, 11-19 December 1984.	Vernekar K.G. Ramana Murty K.V., Pant G.B., Bhalme H.N., Singh S.V., Verma R.K., Sharma P.N., Paul D.K. & Rupa Kumar K.
15.	VI Indian Society for Theory of Probability & its Applications (ISTPA) Conf. Trivandrum 27-29 December 1984.	Kamte P.P., Kripalani R.H., Kulkarni P.L., Mahajan P.N., Deshpande V.R., Bansod S.D., Pathak S.S., Parasnis S.S. & Parathasarathy B.
16.	Indo-US Workshop on Interannual Variability of Monsoon, I.M.D., New Delhi, 21-25 January 1985.	Singh S.V., Verma R.K., Paul D.K., Pant G.B., Bhalme H.N. & Parthasarathy B.
17.	Nat. Sem.-cum Workshop on Atmospheric Sciences and Engineering, Jadavpur University, Calcutta, 20-23 February 1985.	Mukherjee B.K., Bavadekar S.N., Khemani L.T., Mandal B.N. & Totagi M.Y.
18.	Int. Workshop on Data Processing,Indian Institute of Geomagnetism (I.I.G.) Bombay, Organised under Interdivisional Commission of Developing Countries (IAGA) at University of Poona, Pune 25 February - 9 March, 1985.	Rupa Kumar K.

19. Annual Convention of Computer Society of India, New Delhi, 13-16 March 1985.	Subrahmanyam D.
20. Int. Symp. on Concepts and Techniques of Applied Climatology, Andhra University, Waltair, 18-21 March 1985.	Pant G.B., Reddy R.S., Prasad K.D., Rao P.G. & Parthasarathy B.

4.2. Participation in Meetings

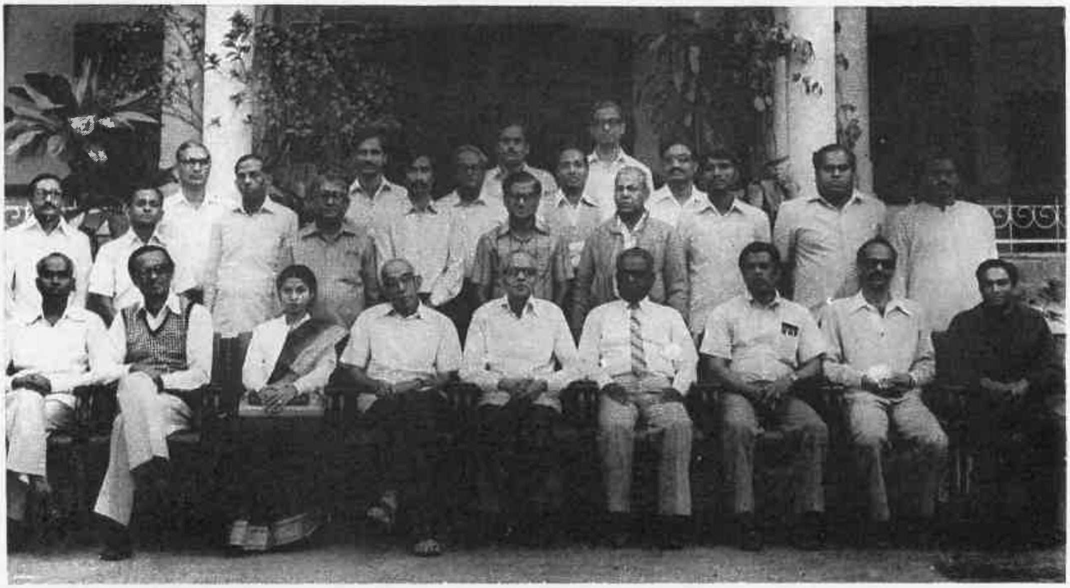
Meeting	Participant(s)
1. Possible programme of Indo-US Collaborations on Monsoon Variability in Relation to Ocean Atmosphere Coupling, Indian Institute of Science (I.I.Sc.), Bangalore; 8 April 1984.	Sikka D.R.
2. Advisory Committee Meeting of the Centre for Atmosphere and Fluid Sciences, Indian Institute of Technology (I.I.T.), New Delhi : 24 April 1984.	Ramana Murty Bh.V.
3. Meeting convened to discuss on the Indo-US Collaborative Programme on Monsoon Research, Department of Science & Technology (D.S.T.); New Delhi : 24 April 1984.	Singh S.S.
4. Meeting of the Indo-US Monsoon Research programme - Department of Science & Technology (D.S.T.), New Delhi : 21 May 1984.	Bhalme H.N.
5. First meeting of the Working Group of Theme-2 of ISRO — SCHCNE collaboration in Aeronomy and Space Meteorology, India Meteorological Department (I.M.D.), New Delhi : 30 May 1984.	Rajamani S.
6. Meeting of the Indian Middle Atmosphere Programme, Space Applications Centre, Ahmedabad, 7 June 1984.	Sikka D.R. & Mukherjee B.K.
7. Meeting of the Selection Committee, Centre of Atmospheric & Fluid Sciences, Indian Institute of Technology, New Delhi, 2 July 1984.	Ramana Murty Bh.V.
8. Co-ordination Committee meeting of Indo-US Monsoon Research, Task II-6, Birbal Sahni Institute of Palaeobotany, Lucknow, 7 July 1984.	Pant G.B.
9. Committee meeting on the IMAP Extension of Middle Atmosphere Programme, National Physical Laboratory, New Delhi, 9-10 July 1984.	Sikka D.R.
10. Second meeting of Organising Committee of Indo-US workshop on Programme I & II of Indo-US collaborative Programme on Monsoon Research, India Meteorological Department, New Delhi, 19 July 1984.	Singh S.S.
11. Working Group meeting on 'Priority Areas of Research' of the National Institute of Hydrology, Roorke, 20 July 1984.	Rakhecha P.R.
12. Meeting of the Indo-US Monsoon Research Programme, India Meteorological Department, New Delhi, 10-11 August 1984.	Ramana Murty Bh.V.
13. Second meeting of the National Review Committee to Recommend the Project Proposals under Indo-US Collaborative Programme on Monsoon Research, India Meteorological Department, New Delhi, 11 August 1984.	Singh S.S.
14. Council for Meteorology and Atmospheric Sciences (CMAS) meeting, India Meteorological Department, New Delhi, 13 August 1984.	Ramana Murty Bh.V.

15.	Meeting of the Indian Middle Atmosphere Programme, Physical Research Laboratory, Ahmedabad, 17 August 1984.	Sikka D.R.
16.	Seventh meeting of the Working Group on Rocket Payload, Bombay, 21 August 1984.	Kamra A.K., Vernekar K.G. & Brij Mohan
17.	First meeting of the Working Group of Theme-2 of ISRO-SCHCNE collaboration in Aeronomy and Space Meteorology, India Meteorological Department, New Delhi, 30 August 1984.	Rajamani S.
18.	Meeting of the Working Group for an Observational Programme on Ocean-Atmosphere Interaction, Indian Institute of Science, Bangalore, 3-4 September 1984.	Sikka D.R.
19.	Meeting of Review of DCP for INSAT-1B, Instruments Section, India Meteorological Department, Pune, 4 September 1984.	Vernekar K.G.
20.	Meeting of the Working Group on Meteorology, Min. of T. & C.A., New Delhi, 11 September 1984.	Ramana Murty Bh.V.
21	Discussion on the Guidelines in Accepting Scientific Payload for Rocket Experiments, Vikram Sarabhai Space Centre, Trivandrum, 26 September 1984.	Vernekar K.G.
22.	Data Requirement of Indian Scientists from USA under Indo-US Programme on Monsoon Research, India Meteorological Department, Pune, 26 September 1984.	Singh S.S.
23.	Organising Committee meeting of Indo-US Workshop on Long-Term Variability of Monsoon, Mausam Bhavan, New Delhi, 16 October 1984.	Pant G.B.
24.	Meeting of the Working Group of Theme-2 of ISRO -SCHCNE Collaborative Programme on Aeronomy and Space Meteorology, IMAP, Indian Space Research Organisation, Bangalore, 18 October & 21-22 December 1984.	Rajamani S.
25.	First meeting of National Committee on Palaeoclimatic Studies, Department of Science & Technology, New Delhi 19 October 1984.	Pant G.B.
26.	National meeting on Integrated Studies on Deep Sea Fans in the Bay of Bengal Department of Science & Technology, New Delhi, 26-27 October 1984.	Sikka D.R.
27.	Meeting of Advisory Committee of the Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi, 15-16 November & 31 December 1984.	Ramana Murty Bh.V.
28.	Meeting with Swedish and Danish Scientists in connection with the Wind Power Potential of India, Dept. of Non-conventional Energy Sources, Govt. of India, New Delhi, 30 November 1984.	Pant G.B.
29.	Meeting of the IMAP Working Group on Atmospheric Dynamics and Indo-USSR Protocol Theme-1, Physical Research Laboratory, Ahmedabad, 12 December 1984.	Vernekar K.G. & Mukherjee B.K.
30.	Meeting of CMAS, India Meteorological Department, New Delhi, 17 December 1984. & 25 March 1985.	Ramana Murty Bh.V.
31.	Meeting of the 7th Plan (1985-90) and Annual Plan (1985-86) of the Institute, Planning Commission, New Delhi, 10 January 1985.	Ramana Murty Bh.V.

32. Eighth meeting of the Working Group on Meteorological Rocket Payload, Indian Institute of Tropical Meteorology, Pune, 20 February 1985.	Kamra A.K. Vernekar K.G. & Brij Mohan
33. First meeting of DST Basic Physics of Monsoon Committee, Ahmedabad, 22-23 February 1985.	Mishra S.K.
34. Meeting of the Indian National for Solar Terrestrial Physics (INCOSTEP), Indian National Science Academy, New Delhi, 5 March 1985.	Bhalme H.N.

Operator at the IBM 1620 computer console

5. COLLABORATION WITH UNIVERSITIES AND OTHER SCIENTIFIC INSTITUTIONS/ORGANISATIONS



Participants in the seminars on Meteorology for the State Government agricultural Extension Functionaries.

5.1 Collaboration with Universities

Dr. G.B. Pant, gave two invited talks on 'Climate and Human Safety' and 'Studies in Climatic Change and Dendroclimatology at IITM' at the Department of Meteorology and Oceanography, Andhra University, Waltair on 23 March 1985.

Dr. A.K. Kamra, Dr. S.K. Mishra and Shri D.K. Paul participated in the teaching programme of M.Sc. course of University of Poona.

Facility to work at the Dendroclimatology laboratory of the Institute was extended to Mrs. Swarna Kumari, Research Scholar, Department of Meteorology and Oceanography, Andhra University, Waltair. Preliminary analysis of 50 samples of Teak trees collected by her from Andhra Pradesh was completed by her.

5.2 Collaboration with Institutions/Organisations

A nine day seminar on Meteorology for the State Government's Agricultural Extension Functionaries was conducted during 11-19 December 1984, at the request of Ministry of Agriculture, Government of India. Ten participants from West Bengal, Bihar, Gujarat, Maharashtra and Karnataka States attended the seminar.

As desired by the Department of Science and Technology, detailed planning documents for the proposed projects viz. (i) National Centre for Cloud Physics and Weather Modification Research Application (Revised) and (ii) National Hail research Experiment with respective budget estimates of Rs. 13.41 and Rs. 9.19 crores were prepared and forwarded to DST in November 1984 for consideration of their inclusion in the 7th plan project proposals of the DST.

At the request of the Executive Engineer, Ramiala Canals Division, Kamakhya Nagar, Orissa, estimation of probable maximum precipitation (PMP) for the Ramiala catchment was carried out. A brief note giving the estimation of PMP value of Ramiala catchment was forwarded to the concerned authorities.

At the request of the Chief Engineer, Tungabhadra project, Munirabad, estimation of PMP and PMF for the Karanja project in Karnataka state was taken up.

At the request of the Superintending Engineer, Central Design Organisation, Nasik, Government of Maharashtra, work on the development of Electronic Analogue Computer of flood forecasting for the river Godavari up to Nanded was taken up.

At the request of State Government of Karnataka (Karnataka Power Corporation), two scientists of the Institute were deputed to Bangalore for the period 11-17 September 1984 to provide technical assistance in their proposed cloud seeding operations in the Linganamakki catchment area.

Dr. Bh.V. Ramana Murty, Director was elected as a member of the Executive Council of the Association of Hydrologists of India, Waltair. Dr. O.N. Dhar, Emeritus Scientist was made an Honorary member of the Association.

Dr. G.B. Pant, was nominated as Institute's representative on the working group for National co-ordinated project on Palaeoclimatic studies, constituted by the Department of Science and Technology, Government of India, New Delhi.

Shri P.R. Rakhecha was entrusted the responsibilities of arrangements for convening the Third Annual Convention of Association of Hydrologists of India (AHI) and Seminar on 'Hydrology' at this Institute during 29 June -2 July 1984.

On invitation from India Meteorological Department, Pune, Dr. A.K. Kamra, delivered a lecture on 'Sink Mechanism' on 27 June 1984, in a training course on the 'Application of Meteorology to Air Pollution Control' for officers of the State Pollution Control Boards.

Dr. S. Rajamani, developed a lecture on 'On the current trends in objective analysis', at the Workshop on Numerical Weather prediction, IMD, New Delhi, held during 2-4 August 1984.

On invitation, Shri P.R. Rakhecha, delivered a lecture on 'Hydrometeorology' to trainee engineers at Staff Engineering College, Nasik on 18 September 1984.

Dr. K.V. Ramana Murty and Dr. O.N. Dhar delivered lectures on "Estimation of probable maximum flood (PMF)" and "Estimation of probable maximum precipitation(PMP) for water resources projects" respectively to the Trainee Officers of Water Resources Development Training Centre, Roorkee on 8th January, 1985.

Prof. S. Gregory, Department of Geography, University of Sheffield, U.K. recording in the visitors book impressions of his visit to the Institute during 18 February – 31 March, 1985.

6. Ph.D. PROGRAMME

6.1 Ph.D Awarded by University of Poona

Name	Thesis entitled
Shri S.V. Singh, Senior Scientific Officer, Gr. I	Prediction of summer monsoon circulation & rainfall over India.
Shri H.N. Bhalme, Senior Scientific Officer, Gr. I	Study of droughts/ floods in relation to atmospheric circulation.

6.2. Submission of Ph.D. Thesis to university of Poona.

Name	Thesis entitled
Shri J.M. Pathan, Jr.Scientific Officer	Studies on the rainfall of India.
Shri B.Parthasarathy, Senior Scientific Officer, Gr. II	Some aspects of large scale fluctuations in summer monsoon rainfall over India during 1871 to 1978
Shri L.T. Khemani, Senior Scientific Officer Gr. II	Characteristics of atmospheric gaseous & particulate pollutants & their influence on cloud microphysics & rain formation.
Shri S.N. Bavadekar, Senior Scientific Officer Gr. II	Some aspects of large scale atmospheric motion with special reference to typical Indian orography.
Smt. P.S. Salvekar, Senior Scientific Officer, Gr. II	On the development of monsoon disturbances through baroclinic instability & other physical processes.

7. MISCELLANEOUS

7.1 Visitors :

1. Dr. Mukut Mathur, Meteorologist, National Meteorological Centre, NOAA, U.S.A.
2. Shri N.K. Kapoor, Superintending Engineer, Office of the Chief Engineer (Planning & Monitoring), Govt. of M.P., Bhopal.
3. Shri Madanlal Navnithlal Gujarathi, Chopada, Dist. Jalgaon.
4. Shri M.S. Zaman, Asst. Professor, Irrigation Engineering, Water & Land Management Institute, Aurangabad.
5. Prof. M.P. Singh, Head, Centre for Atmospheric & Fluid Sciences, Indian Institute of Technology, New Delhi & Member G.C. IITM.
6. Prof. R.K. Parkale & Prof. M.C. Varshneya, Mahatma Phule Agricultural University, Rahuri.
7. S/Shri Rajendra Vinayak Shirgaokar, Jaganath Vasudeo Mantri and Jagadish Hari Kulkarni, M/s Ugar Sugar Works Ltd., Ugar Khurd, Karnataka State.
8. Dr. Roy Jenne, National Centre for Atmospheric Research, Boulder, Colorado, U.S.A.
9. Prof. Eric Smith, Colorado State University, Fort Collins, U.S.A.
10. Shri H. Chaudhary. Deputy Director, Deptt. of Meteorology, Bangla Desh.
11. Shri A.K. Sikka, Scientist 'C', National Institute of Hydrology, Roorkee.
12. A batch of M.Sc. (Meteorology) students, School of Marine Sciences, Cochin University, Cochin.
13. S/Shri Vasudeo Rao & M.A. Salim, Executive Engineer & Asstt. Engineer, Karanja Project, Irrigation Deptt. Bidar, Karnataka.
14. A batch of 15 trainee doctors and one medical officer, B.J. Medical College, Pune.
15. Shri D.D. Bidwai, Asstt. Engineer, Central Design Organisation, Nasik.
16. S/Shri M.H. Khan Chaudhary, Deputy Director, Bangla Desh Meteorological Service and Amin Ayiyal Hossain, AP of Bangla Desh Meteorological Service.
17. Miss Pratima Naidu, Executive Engineer, Central Design Organisation, Nasik.
18. Prof. Ding Yihui, Associate Professor & Deputy Director, Laboratory of Convective Weather & Tropical Meteorology, Prof. Zhang Guang Kun, Asstt. Professor & Director of the Division of Scientific Administration, Institute of Atmospheric Sciences, Chinese Academy of Sciences and Prof. Quan Yongfu, Associate Professor. Lazhou Institute of Plateau Atmospheric Physics of the Chinese Academy of Science.
19. Dr. R.M. Phatarford, Professor of Mathematics, Monash University, Australia.
20. Shri M.R. Dighe, Superintending Engineer, Central Design Organisation, Nasik.
21. Shri S.K. Joshi, Sub Divisional Officer, Central Design Organisation, Nasik.
22. Dr. Harry Van Loon, Chief, Empirical Research Group of NCAR, Boulder, Colorado, U.S.A.
23. Prof. K. Gambo, Professor of Meteorology, Geophysical Institute, Tokyo University, Japan.
24. Prof. G.O.P. Obasi, Secretary General, World Meteorological Organization, Geneva.
25. Prof. S. Gregory, Deptt. of Geography, University of Sheffield, U.K.
26. Dr. L.D. James, World Bank Expert & Director, Utah Water Research Laboratory, Utah, U S A &
    Dr. K.S. Rajagopalan, Senior Research Officer, CWPRS, Pune.
27. A batch of trainee Officers and one Instructor, Air Force Administrative College, Coimbatore

28. Dr. R. Gobinathan Reader in Physics, Crystal Growth Centre, Anna University, Madras.
29. Prof. K. Thangaraj, Faculty Improvement Programme Research Fellow, Crystal Growth Centre, Anna University, Madras.
30. Mr. Y. Valadon, Director, Mauritius Meteorological Department.

7.2 Extension of Service

The Government of India granted extension of service to Dr. Bh.V. Ramana Murty, Director for a period of one year from 1.10.1984.

7.3 Field Research Unit

The Field Research Unit, Bangalore rendered technical assistance and advice to the State Energy Development Agencies of Gujarat, Orissa, Tamil Nadu and Maharashtra for organising wind energy surveys and for the selection of suitable sites for wind mapping stations.

7.4 Construction of Institute's Buildings & Staff Quarters

Possession of A, B, C & Type III staff quarters and transit accommodation was taken over from the C.P.W.D. The quarters were allotted to the eligible staff members of the Institute.

The construction work of Guest House and Hostel Building was in progress.

Preliminary drawings/estimates for the second phase building programme were approved.

7.5 Facilities

7.5.1 . Library, Information and Publication

a) Library

During the year, 159 books in Meteorology and allied subjects were added. 117 useful scientific/technical reports were also added to the library.

7.5.2. Computer

The IBM 1620 computer worked during the year as follows :

	Hrs. Mts
Institute's Jobs	1282.05
Data Processing of India Meteorological Department	12.25
Breakdown/Maintenance	160.40
Paying Users	6.05

7.5.3. Lecture course

Under the auspices of the Theoretical Studies Division of the Institute a lecture course in Meteorology was conducted by Dr. R. Ananthakrishnan, Hon. Fellow for a period of 4 months from 2.1.1985 for the benefit of the Research and Scientific staff of the Institute. 29 staff members attended the lectures.

7.6 Official Language Implementation

The second workshop on Hindi noting and drafting for the benefit of the staff, who had already acquired working knowledge of Hindi, was held from December 1984 to February 1985.

A number of books such as the Legal Glossary and scientific books in Hindi were added to the Hindi library.

All standard forms were made bilingual.

Meetings of the Official Language Implementation Committee were held regularly. Periodical reports on implementation and progress of Hindi were forwarded to the Ministry.

Hindi versions of Institute's Annual Report (1983-84), Institute's contribution to the Ministry's Annual Report (1984-85), and Institute's Accounts/Audit Report (1983-84) were prepared and forwarded to the Ministry of Tourism & Civil Aviation.

'Hindi Day' celebration on 18 September, 1984

The Hindi Day was celebrated in the Institute on 18 September 1984. Prof. A.P. Dixit, Head of the Hindi Department, University of Poona , was the Chief Guest.

7.7 Horticultural Activities

About 400 Casuarina, Eucalyptus and flowering trees were planted during the year. All officers and staff members planted at least one tree at the new campus at Pashan. Prof. G.O.P. Obasi, Secretary General of W.M.O., Shri P. Rajendram, Director of W.M.O. Regional Offices for Asia and Shri S.K. Das, Director General of Meteorology, each planted one sapling at the Pashan Campus on 15.2.1985.

7.8 Staff Council

The Sixth Staff Council of the Indian Institute of Tropical Meteorology, Pune was constituted w.e.f. 1 December 1984 for a period of two years.

7.9 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 'D'	...	15
Group 'C'	...	1			

7.10 Budget, Accounts and Audit

The budget estimates and actual expenditure for the Institute for the period 1984-1985 were as given below :

(Rs. in lakhs)

	Budget Estimates	Revised Estimates	Actual Expenditure
Non-Plan	88.50	88.00	82.15
Plan	78.00	77.71	77.20

Prof. G.O.P. Obasi, Secretary General, World Meteorological Organisation;making happy gesture during discussions with Institute scientists. Shri S.K. Das, Director General of Meteorology, is sharing the joy.