Indian Institute of Tropical Meteorology

Pune 411 005 INDIA

ANNUAL REPORT
1985-86

GOVERNING COUNCIL

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10. Shri D.W. Kshirsagar, Administrative Officer, Indian Institute of Tropical Meteorology, Pune 411 005.	Non-Member Secretary

CONTENTS

INTRODUCTION

I have pleasure in presenting the Annual Report of the Indian Institute of Tropical Meteorology, Pune for the year 1985-86.

Dr. Bh.V. Ramana Murty who headed the Institute from 19 October 1978 retired from service on 30 September 1985, after handing over charge to the Chairman of the Governing Council pending appointment of a new Director. Action to fill up the vacant post of Director was initiated.

On the organisational and administrative side one of the achievements during Dr. Ramana Murty's tenure as Director was the construction of the office building for the Institute (first phase) and also a number of residential quarters for staff members on the land that had been acquired for this purpose at Pashan, close to the National Chemical Laboratory. Dr. Ramana Murty also imparted momentum to the research activities of the Institute by encouraging publications and presentation of papers at scientific meetings, seminars and symposia within and outside the country, by the scientists of the Institute.

A brief presentation of some of the highlights of the scientific work of the Institute during the year under review is given in the following paragraphs. Detailed report of the activities of the various Divisions is contained in the subsequent sections of the Report.

Scientists of the Institute participated in the Indo-US Co-operative Programme of Monsoon Research. This has two main components: (i) development of numerical models for simulation of monsoon and short-range weather prediction; (ii) development of capability for long-range prediction of monsoon variability. Under the first item one of the scientists of the Institute visited the USA. In connection with the second item visits by a few scientists of the Institute to the USA are planned in the near future.

The Forecasting Research Division of the Institute continued work on the development of numerical models suitable for short-range prediction of weather over India and neighbourhood. Recent studies in the Institute and elsewhere have brought to light a quasi-periodicity of 30 to 50 days in the circulation and weather parameters over the Asian monsoon region. Weekly rainfall anomalies over India predicted on this basis were tested using empirical orthogonal functions.

The Theoretical Studies Division has successfully developed a global spectral model for numerical studies on the general circulation of the atmosphere. The model was refined by incorporating the physics of relevant small scale processes.Studies on the instability process leading to the formation of monsoon depressions - the most important synoptic weather producing systems of the southwest monsoon season have led to a satisfactory explanation and understanding of the conditions leading to the formation.

Much interest centres round the possibility of artificial increase of rainfall by cloud seeding over regions where the rainfall is marginal and erratic. Experiments directed towards this consist in introducing artificial nuclei of appropriate materials into the clouds utilising aircraft. Such studies utilising finely powdered common salt as the seeding material have been conducted by the Physical Meteorology Division of the Institute over a selected area in the Maharashtra State close to Pune during the past ten summer monsoon seasons. Analysis of the results has furnished evidence for increase of rainfall over the seeded area.

The physical processes in the lowest layer of the atmosphere (known as the Planetary Boundary Layer) are of prime importance in the dispersal of atmospheric pollution and transport of heat water vapour etc. to the upper layers of the atmosphere. Simulation studies of the vertical profiles of wind velocity and turbulence in the boundary layer for an atmosphere with neutral stratification over a rural terrain were carried out in a wind tunnel. Measurements of the atmospheric electric field over different locations and studies on the shape changes of charged rain drops in an electric field were carried out. These studies formed part of the activities of the Division of the Instruments and Observational Techniques.

Information relating to Probable maximum precipitation (PMP) computed by scientists of the Hydrometeorology Division was supplied on request, in connection with world bank funded river valley projects.

Recent studies in India and elsewhere have shown significant association between the summer monsoon rainfall of India and global circulation features such as the sea surface temperature changes over the Eastern Pacific (El Nino), surface temperature anomalies over the northern hemisphere, Antarctic temperatures, Himalayan snow cover etc. Utilising these parameters, a multiple regression equation has been developed for forecasting the seasonal rainfall of the Indian summer monsoon a month in advance. Other studies in the Climatology Division have evolved indices for large scale droughts and floods over India (known as Drought Area Index DAI, and Flood Area Index FAI). The methodology for deriving these indices has been adopted by some other tropical countries.

Studies in the newly established Palaeo-climatic Laboratory have shown a significant correlation between rainfall and the isotope ratio (C12/C13) change in tropical teak-tree samples.

Established in 1962 to fulfil a keenly felt need to catch up with the phenomenal advances and developments in the field of Meteorology and Atmospheric Sciences, it is gratifying that the Institute has now become a recognised centre of advanced learning and research in this field, well known

both in India and abroad. Scientists who have had their start at the Institute are now occupying prominent scientific positions not only in the country but also outside. The Institute is also attracting Visiting Scientists from advanced countries like Japan, UK, USA, USSR, etc. Starting with a nucleus of staff originally drawn from the India Meteorological Department, the Institute today has a large number of bright and young scientists with devotion and dedication to work. During the coming years I look forward to an era of fruitful cooperative work between the young Institute and the old India Meteorological Department that will add new dimensions to Tropical Meteorology in general and Indian Meteorology in particular.

R.P. SARKER
Chairman, Governing Council
Indian Institute of Tropical Meteorology

2. RESEARCH AND DEVELOPMENT

2.1 Forecasting Research - I

2.1.1 Numerical Weather Prediction

a) Regional Models

An adiabatic version of six level primitive equation model in sigma coordinate system has been developed and tested using input data of 8 August 1979. Preliminary analysis indicates that the numerical simulation of the model is acceptable and the 24 hour predicted flow fields are found reasonably good.

Towards the formulation and testing of a regional P.E. model under Indo-US collaborative programme on monsoon research, all the computer programs connected with the model have been matured and installed on the CYBER computer. The initial input using data of 28 May 1979 has been prepared. The integration of the model is being attempted.

The regional five level P.E. model (in x, y, p, t system) developed earlier was made interhemispheric by extending the domain towards south of the equator upto 10°S. The modified version of the model has been tested for three cases.

A three level P.E. model developed earlier was integrated upto 84 hours for orography with a maximum height of 2 km embedded in 10 m s^{-1} uniform westerlies. The flow field indicated that the windward ridge lies to the east along the northern boundary and the leeward trough to the west along the southern boundary of the orographic barriers.

(b) Initialization

The elliptic equation in the bounded derivative method of initialization was solved by the Buneman's Block cyclic reduction method. It was found that the error in the solution for the height field was large in the neighbourhood of the grid point where the orography was very steep. Numerical experiments were designed to determine the optimum slope of orography suitable for the model.

c) Objective Analysis

In order to develop the multi-variate optimum interpolation scheme, the climatological characteristics are used to compute the weighting functions. The autocorrelation and the structure functions for the months of June, August and September and also for the season as a whole have been computed.

For the analysis of geopotential height, the cross-correlations between u- and v-components of winds and between geopotential height and u- and v-components are computed for month of July.

The auto-correlation functions and structure functions for mixing ratios at 850 mb level were computed to construct the necessary weighting functions. Using these weighting functions, analyses of mixing ratio for ten cases were done.

2.1 2 Extended Range Prediction

a) Intra-seasonal variations

Sixty-years (1901-60) of pentad rainfall data of 8 representative stations were analysed for persistence of dry and wet periods during monsoon season. The extent of dependence in sequences of wet and dry pentads is examined by comparing the observed integrated frequencies of runs of like pentads with the values calculated through geometrical probability distribution. The results indicate that the wet periods have a tendency to prolong, if they have lasted for 2 to 3 pentads. No such tendency is observed for the dry periods.

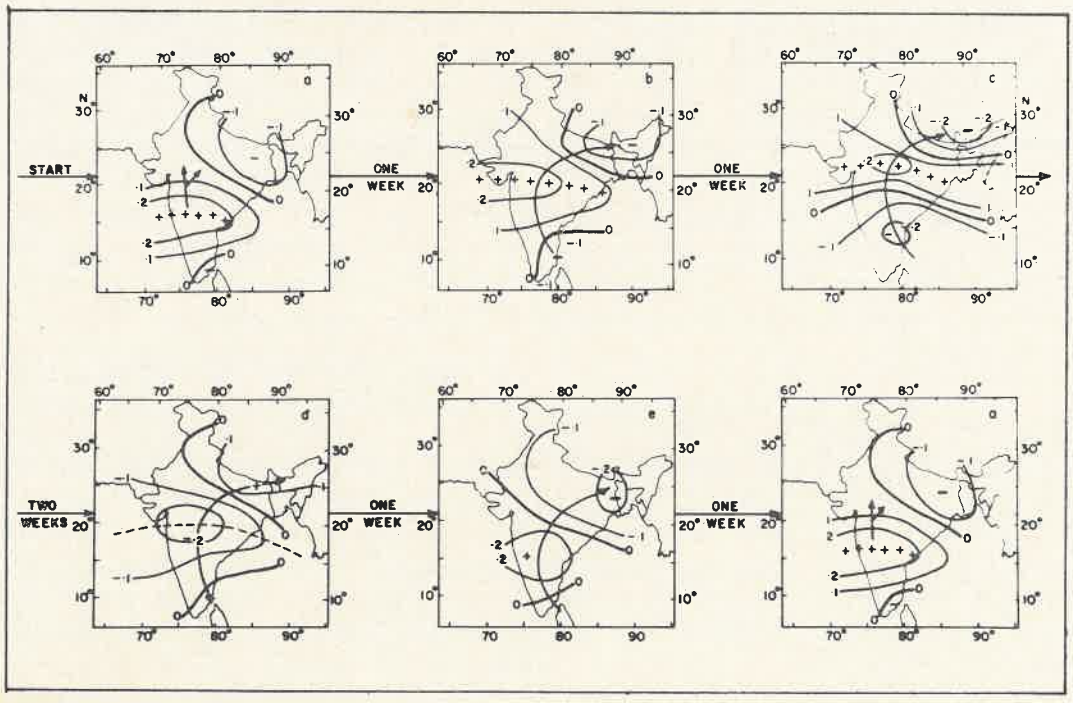
b) Inter-annual variability and long-range forecasting.

Lag relationships of some large scale parameters, viz. (i) Arctic region surface air temperature, (ii) Antarctic region surface air temperature, (iii) Indonesian-North Australian region sea-surface temperature and (iv) upper level oceanic thermal anomaly over the

equatorial pacific, with the all India monsoon rainfall were investigated. The relationship of the Arctic temperature with the monsoon rainfall is found to be similar as in case of the northern hemispheric surface air temperature, studied earlier. The Antarctic temperature in previous year-July, Indonesian region SST in January of same year and the upper surface oceanic thermal anomalies in the previous year-November showed significant correlation with monsoon rainfall. These new relationships have potential for providing a higher lead time for forecasting of monsoon rainfall.

below normal value of rainfall was predicted and the observed value was found to be quite close to the predicted value.

The monthly mean satellite derived outgoing long wave radiation data for the period June 1974 to May 1981 are studied for annual and interannual fluctuations by using EOF analysis (Empirical Orthogonal Function) The first three EOFs explained 93% of the total variance. The first EOF represents the annual cycle with a pronounced variation over the belt 10°N-20°N. This is indicative of major areas of cloudiness associated with the intertropical



Sequential evolution of weekly rainfall anomaly patterns as obtained through EEOF analysis depicting 40 days circle based on 1963-82 data.

The long range forecast of the 1985 monsoon season was prepared by utilising the relationship developed earlier between winter season northern hemispheric surface air temperature and the monsoon rainfall. A

convergence zone. The second EOF shows an out of phase relation between north India and the equatorial region and a pronounced semi-annual oscillation. The third EOF exhibits characteristic features of the northeast

monsoon over the southeast peninsular India. The inter-annual variation of the outgoing longwave radiation showed close association with the Indian monsoon rainfall.

c) Monex studies and application of satellite data in forecasting

The examination of the satellite derived low level winds indicated that the first burst of monsoon rainfall along the west coast of India in 1979 was preceded by abrupt increase in the intensity of low level jet and the associated cross equatorial flow over the western Indian ocean.

Excitation of low level cross-equatorial flow due to the passage of the cold fronts in the southern hemisphere has been investigated during the period 16 May to 7 July 1979. It is found that the northward propagation of cold fronts near 30°S - 40°S is favourable for intensification of the low level cross equatorial flow.

The moist static energy in the troposphere, expressed in terms of equivalent potential temperature Θ_e, is examined in relation to the convective activity over the stationary USSR ship polygon during 2 to 14 June 1979. The daily average Θ_e values are found to increase at all levels during the passage of synoptic scale disturbances across the polygon. Highest Θ_e values are observed, particularly in the layer between 800 and 500 mb levels, whenever cumulonimbus clouds covered extensive area over the polygon region.

A study of the formation and intensification of two simultaneous monsoon depressions over Arabian sea and Bay of Bengal showed that the low level westerly jet shifted northeastwards to Peninsular India at the region of highest cyclonic vorticity lying northward of the belt of maximum westerlies.

Formation of onset vortices is examined in relation to the sea surface temperature prevailing over the Arabian sea during the two weeks periods preceding the onset of monsoons in the years 1980-85. It is observed that during 1980, 84, and 85 the onset vortices originated over a warm sea (30-32°C) and no onset vortices formed during 1981-83 when the sea surface was relatively cold. ($\prec$ 29°C)

Northern summer tropical circulations during a bad monsoon year (1968) and a good monsoon year (1970) are studied by utilising NMC global tropical (48°S-48°N) mean monthly wind data for 300 mb levels during the periods April through August. The study revealed that in both the years only the long waves (wave number 1 to 4) are dominant in the zonal component of the wind but the waves 1 to 10 are important in the meridional component of wind. Weaker easterlies, stronger northerlies and convergence of momentum at 300 mb level are observed in the belt 0-10°N during the bad monsoon year. For both the years, the long waves 1, 3 and 4 are the sources and the wave 2 is the sink of the kinetic energy to all other waves in the belt 5°S to 19.6°N. However, all the waves 1-4 are the source to the mean zonal flow.

2.2 Forecasting Research (II)

The barotropic contributions of the monsoon region (APEM) and Indian region (APEI) to the global available potential energy, were computed for six months May through October for six years period 72 through 77. The main findings are (1) The vertical time section shows maximum of APEM in the month of August and in the layer 500-300 mb, (2) Maximum of APEI occurs in the month of May and in the layer 850-700 mb, (3) The lowest APEI occurs in the months of July and August and in the layer 850-700 mb, (4) Contributions of APEI and APEM are more in good monsoon years than those in bad monsoon years (5) Monthly variation is small in APEM than in APEI. Similarly the baroclinic contributions of the monsoon region and Indian region were computed for the same period. The baroclinic contributions are one order of magnitude less than the barotropic contributions.

2.3 Climatology & Hydrometeorology

2.3.1 Studies of large-scale droughts over India

a) Stratospheric wind and droughts/floods over India.

In an attempt at applicability of stratospheric wind in forecasting of extreme climatic events such as large-scale drought/flood during the monsoon over India, tropical stratospheric monthly zonal wind anomalies at Kwajalein (8° 44′ N, 167° 44′ E) were examined in relation to the Indian monsoon rainfall for the 20 year period (1959-78). The highest correlation coefficient 0.70 (significant at 0.1% level) between Indian monsoon rainfall and monthly zonal wind anomalies of 30 km at Kwajalein is found for January. Winds at 30 km for January at Kwajalein thus seem to indicate some potential for forecasting of occurrence of drought/flood over India.

b) Global General Circulation and Indian Summer Monsoon

Global sea-level pressure distribution has been analysed for the months, April and July for 5 years (deficient rainfall years, 1972 and 1974, excess rainfall year, 1975 and normal rainfall years 1970 & 1973) using data of 400 stations. It is found that during April of poor monsoon year the anomalies in global pressure pattern are minimum; however, eastward shifting of high pressure areas, which are normally centered over USSR and North Pacific, is well marked. During good monsoon years, a breakaway cell of Icelandic low goes deep south and the high pressure areas centered over south Indian ocean and Australia are stronger and are more eastward in both the months i.e. April and July.

A study of the relation between the global tropical upper tropospheric wind and thermal field with the behaviour of Indian summer monsoon is being done for the period 1960-85. Preliminary results show a good relation between global spreading and speed of easterly wind and speed of westerlies over Australia during May and June with the All-India monsoon rainfall.

2.3.2 Vagaries of the Indian Summer Monsoon

a) Analysis of All-India summer monsoon rainfall

There is an increase of two percent of summer monsoon rainfall from first half (1871-1924) to the second half (1925-1978). This increase in the monsoon rainfall of the country as a whole is not statistically significant; however, there are two epochs noticed with frequent deficient/drought years (1891-1920 and 1965 to 1985) separated by an epoch of almost near normal rainfall.

b) A probability model for areal extent of drought/flood over India during the summer monsoon season.

Drought/flood over a district has been identified by two criteria :

(i) Percentage departure of the summer monsoon rainfall from normal being $\leq -25\%$ for drought and $\geq 25\%$ for floods. (ii) The monsoon rainfall in standard units $(R_i - R)/S$ being < -1.28 for droughts and ≥ 1.28 for floods. The time series of drought/flood area over India expressed as percentage area of country have been obtained for the 108-year period 1871-1978. It is observed that the positively-skewed Gamma distribution is a good fit to these series and this distribution can be used to obtain the probabilities of different values of drought/flood areas being exceeded.

c) Low frequency signals of long term monsoon variability

Time series analysis of 100 years of data of the Indian summer monsoon rainfall, number of oneset and break monsoon days, indicies of the southern oscillation anomalies of temperature in the northern hemisphere and the SST in the Pacific was carried out. The results indicated a low frequency signal associated among the above events and the monsoon activity.

d) Rainfall variability studies

i) Normal distribution has been fitted to the actual, the square-root, the cube root and the log transformed values of the annual rainfall data of 26 stations of Rajasthan. The data after transforming to square-root and the cube-root values has been found to be normally distributed for stations in east and west Rajasthan respectively. Rainfall probabilities as estimated from the most suitable transformed normal distribution were found to be in close argeement with those obtained from gamma function.

ii) The trend analysis of the rainfall over upper Narmada catchment was carried out using daily rainfall data of about 40 stations from 1901 to 1980. The analysis showed that there was significant increase in rainfall during 1901 to 1945 however, during the last three decades there was no significant change in rainfall over the upper Narmada catchment.

iii) The usefulness of coefficient of variation (C.V.) in determining rainfall probabilities in the humid region has been examined using monthly, seasonal and annual rainfall data from 1901 to 70 for 80 rainfall stations well distributed in Kerala. Variation in four selected rainfall probabilities, e.g. probability of occurrence of no-rain, equal to or less than one-half mean, equal to or less than mean and equal to or less than one-and-a-half mean separately, with changing coefficient of variability, is studied.

2.3.3 Studies in Palaeoclimatology

The δ_D, δ_C^{13} of nitrated Cellulose prepared from 42 individual rings (1920-1961 AD) of a teak tree from Murbad range in Thane forest division have been determined using the mass spectrograph and stable isotope analysis facilities at PRL, Ahmedabad. An increasing trend in the total annual rainfall at Bombay is closely followed by the increasing trend in the tree cellulose-isotope ratio. A stepwise multiple regression analysis of the yearly δ_D, δ_C^{13} data with available instrumental climatic parameters revealed that δ_D of tree cellulose is positively correlated to mean maximum temperature and the total annual rainfall.

2.3.4 Long term variations of surface and upper air temperature over India.

a) Variation of air temperature at the surface and at 850, 700, 500 and 200 mb levels over India has been studied using the data at 10 stations, for 30 to 41 years during 1944-1984. Surface temperatures do not show appreciable trend during the last 3 decades and the upper air temperatures show a trend reversal, from warming to cooling, around 1958. During the period 1958-1984, the north Indian stations have shown cooling trend while the southern stations have not shown any significant trend. The rate of cooling increases with height, particularly at the northern stations.

2.3.5 Basin rainfall studies for the development of water resources

a) Maximum and probable maximum precipitation (PMP) studies

Generalised charts of 1-day probable maximum point precipitation (PMP), as percentage of (i) 100-year one-day rainfall and (ii) mean annual rainfall have been prepared for the Indian region using data of about 1000 stations. The ratios of 1-day PMP to 100-year rainfall were found to vary from 175% to 350% and one-day PMP to mean annual rainfall ranged from 20% to 250%.

The estimates of areal probable maximum precipitation (PMP) for 1000 and 5000 sq. miles for 1-day duration over different locations in the northwestern Indian region were found to vary between 60 to 102 cm and 40 to 70 cm respectively.

Generalised charts of highest observed one day rainfall, maximum rainfall of 50 and 100 year return periods and probable maximum precipitation (PMP) for one day duration were prepared for Himalayan regions of Uttar Pradesh. The study showed that the mean annual precipitation varies from 100 to 250 cm, 1-day highest rainfall from 15

to 50 cm, and 1-day probable maximum precipitation from 50 to 70 cm.

b) Study on precipitation climatology of Nepal Himalayas describing meteorological causes of heavy precipitation, rainfall distribution during 'breaks' in monsoon, its variation with elevation and highest one-day rainfall ever recorded was carried out. The highest one day rainfall in this region varies from 15 to 41 cm which constitutes about 9 to 32 % of the mean annual rainfall.

2.3.6 Analysis of rainstorms

a) Average areal rain depths for the Godavari basin upstream of Nanded (9842 sq. km) were worked out for the heavy rain spells which occurred during the period 1913 to 1983 The June, 1914 rainstorm was found to be most severe rainstorm which gave 327 mm of rainfall on 27 June 1914 and 476 mm on 26-27 June 1914 over the catchment 100-year return period values for 1 and 2-day durations have been estimated as 200 mm and 276 mm respectively.

b) The rainstorm of 3-5 October, 1955 which caused the highest areal raindepths over Punjab region with an efficiency (E) of 22%, is considered to be the 3rd highest among the most severe rainstorms of north Indian plains.

c) Rainstorms which occurred over the Bihar state during 1891 to 1978 were analysed by Depth-Area-Duration (DAD) technique. The analysis revealed that the storms of (i) 17-19 June 1898,(ii) 31 July - 2 August 1917 and (iii) 1-3 October 1961 were found to be most severe rainstorms (almost of equal magnitude) which occurred in south Bihar region.

2.3.7 short duration rainfall analysis

Hourly rainfalls of six most intense 1-day rains recorded at Bidar station located in Karanja catchment,Karnataka, were analysed to determine the temporal pattern of design rainfall for use in conversion of probable maximum precipitation to probable maximum flood. The analysis showed that during 1-hour period as much as 56 % and in two hours 73 % of total one-day rianfall can occur. Further, the general occurrence of greatest inter-hourly intensity seems to be during periods from 17 to 24 hours.

Frequency distribution of annual maximum 1,2,3,6,12, 24,36, and 48-hr rainfall recorded at Colaba observatory, Bombay from 1924 to '84 is studied using Gumbel and Gamma distributions, both have been fitted by moments as well as maximum likelihood methods separately. Gumbel distribution fitted with method of moments is found most suitable as indicated by minimum value of absolute relative deviation and quadratic deviation.

2.3.8 Development of Analogue computer for flood routing and forecast

An Analogue computer is under development for flood routing and forecasting of river Godavari up to Nanded.

2.4 Physical Meteorology & Aerology

2.4.1 Cloud Physics and Weather Modification

a) Studies in Atmospheric Electricity

i) Special oceanic observations of the three components of the atmospheric electric field using the cylindrical field mill developed at the Institute, were undertaken on board the ORV 'Sagar Kanya' during its cruise from 7 October to 17 November 1985, in the Bay of Bengal, Indian ocean and the Arabian sea regions. The magnitude of the atmospheric electric field in the above oceanic regions is found to be three orders less than the average electric field value observed over land during the same period.

(ii) An analysis of the atmospheric electric field and selected meteorological data for Bombay (Colaba) for the period 1936-66 in dicated significant increases in the above parameters during the later half of the above period (1951-66) when the industrial growth in the region was substantial. The increases

noticed in the electric field, temperature and rainfall were respectively 33%, 4% and 12%.

(iii) A portable cylindrical field mill with integrated circuits, which can measure three components of the atmospheric electric field has been designed and got fabricated through a local commercial firm. The instrument can be used for airborne as well as surface measurements. The instrument has been field tested and the performance has been found to be very good. The cost of the instrument is an order of magnitude less than that of the one manufactured in USA.

b) Radar Study of rain and rain-bearing clouds

Analysis of the radar observations of 598 severe thunder-storms which occurred within 100 km around Delhi during the summer monsoon seasons of the 20 year period (1959-78) indicated that in 50% of the cases the height of the cloud-top was above the tropopause level. Also, it was noticed that the thunderstorm cells, by and large, have a tendency to organise themselves along the squall lines.

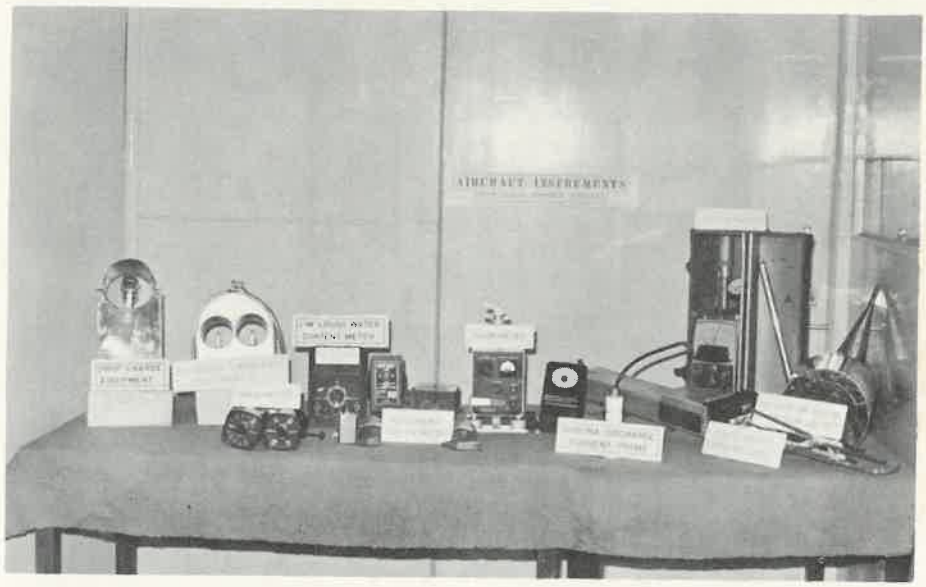
c) Studies in cloud microphysics and investigations of the feasibility of increasing rainfall by cloud seeding

Institute's cloud seeding experiment in the Baramati and Sirur regions of Maharashtra State for the 1985 monsoon season commenced on 5 July 1985 and ended on 30 August 1985. The experiment was conducted on 25 days using about 60 hours of aircraft flying time. Extensive cloud physical observations were carried out in randomly chosen seeded and not-seeded clouds. Also, cross-country observations were made during the ferry flights from Bombay to Pune on 30.6.1985 and Pune to Bombay on 30.8.1985.

d) Lidar Probing of the Atmosphere

i) A 25 cm Newtonian type telescope required for the laser-radar system for remote sensing of the atmospheric aerosols was installed on the terrace of the Institute's building at Pashan and commissioned.

(ii) Preliminary observations of the atmospheric aerosols in the atmospheric boundary layer using the Helium-Neon laser have been made. Theoretical computations



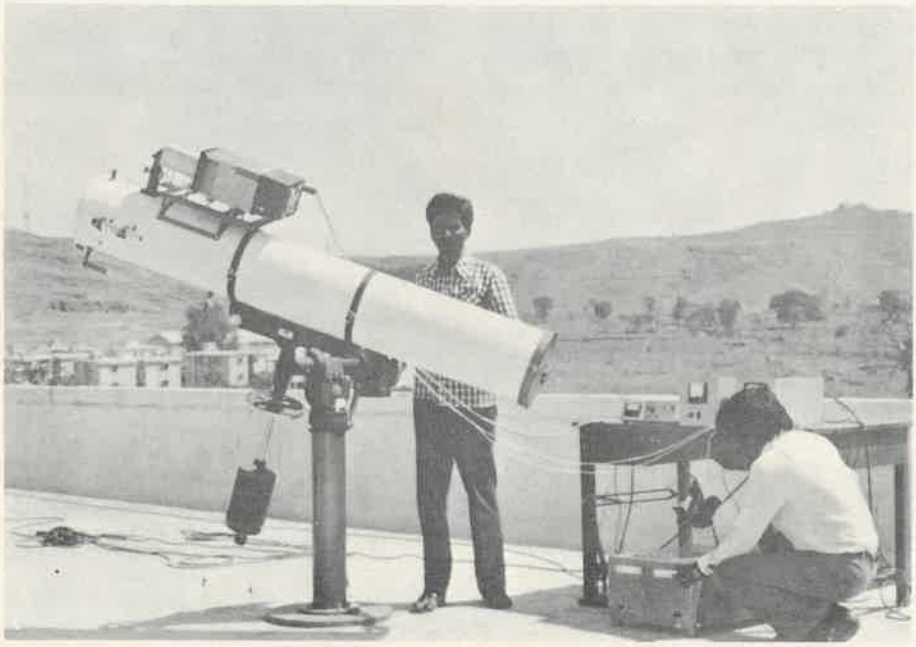
Instruments used for measurement of aerosols, cloud physical and electrical parameters during cloud seeding experiments at Pune

relating to the estimation of the common scattering volume observed by the transmitter and receiver of the laser radar system at different scattering angles were carried out.

(iii) Photometric observations in the visible (4000 A° - 7000 A°) and near infrared wavelength (7000 A° - 10000 A°) of Halley's comet were made using the telescope.

spectral slopes increased with increase in liquid water content. The distributions of wind and temperature were found to be normal. A simple conceptual model for the eddy growth in the ABL was developed.

Analysis of the high resolution temperature and wind data relating to the onset period of the SW monsoon obtained



Telescope of the LASER RADAR in operation

2.4.2 Environmental Physics

a) Studies of the 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 during the summer monsoon seasons of 1982-83. The slopes of the turbulence spectra in clear air and cloud-air had limiting values of -2 and -3 respectively. The in-cloud

from the NOAA-P3 aircraft during MONEX-79 in the Arabian sea region was completed. The results indicated the following : (i) The mixing ratio profiles, as expected, showed a decreasing trend with height from surface to 1200m The values of mixing ratio in the region near the Arabian coast were higher than those obeserved near the Bombay coast. Above 1200 m, atmosphere in the region of the Arabian coast was found to be drier as compared to that near the Bombay coast. The mixing ratio profiles near the Bombay coast were steeper as compared to those near the Arabian coast.

The turbulent spectra of wind, temperature and mixing ratio obtained from the level flight at 500 mb covering a distance of 950 km between the Arabian coast and the Bombay coast suggested a marked peak in the spectra of the mixing ratio at the wavelength of 430 m near Bombay coast which indicates upward transport of moisture by convective process. The spectrum near the Arabian coast was found to be smoother without any marked peaks indicating absence of active convective processes in the region. The spectral characteristics are consistent with the observed clouding near the Bombay coast and absence of clouding near the Arabian coast during the period of the aircraft observations.

b) Studies in Upper Atmosphere

A study of the rainfall variations of the Indian sub-continent and the quasi-biennial oscillation (QBO) in the normal winds of lower equatorial stratosphere at Balboa (9°N, 80°W) pointed out that about 15% of the rainfall variability over India during the summer monsoon is associated with the phases of the QBO in the zonal wind in the lower stratosphere.

A study of the interannual variabilities of the high-latitude middle atmosphere vis-a-vis summer monsoon activities over India during 1970-72 and 1974-76 has pointed out that the strong polar night jet during January has been associated with the ensuing weak to normal monsoon activity and weak or diffused polar night jet with the ensuing normal to strong monsoon activity over India.

c) Studies in Air Pollution

The study of the chemical composition of rain water in most of the places in India has shown that pH is influenced by the alkaline properties of soil-originated elements (Ca, K and Mg) present in high concentration in rain water. the effect of the anthropogenic pollutants (SO_4 and NO_3) is neutralised by the alkaline components. However, low pH values in the rain water in India might be restricted to localised regions in highly industrialised sites like Chembur in Bombay from where acid rain has been reported.

Analysis of the special oceanic observations of atmospheric aerosols carried out on board the RV 'Gaveshani' during its cruise from 8-20 May 1983 indicated that the aerosols are rich in Al, Fe, Na and Ca which are of soil origin. These observations indicated the transport of aerosols of soil origin from the Arabian coast towards the west coast of India.

2.5 Instrumental & Observational techniques

2.5.1 Development of meteorological payload for rockets and satellites

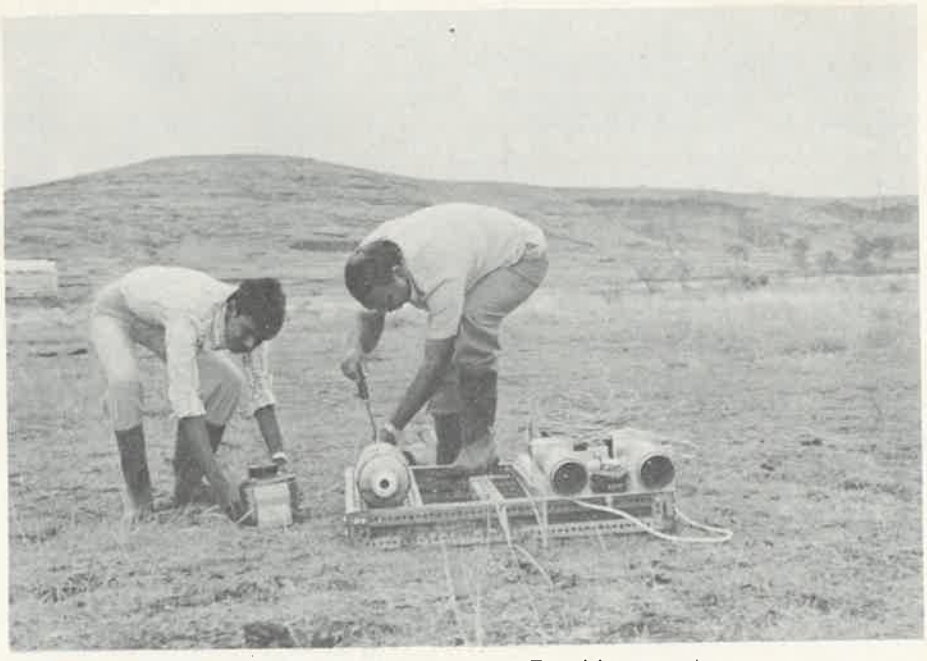
Towards the fulfilment of the GATE tests laid down by Vikram Sarabhai Space Centre, Trivandrum, three payloads were subjected to 96 hours burning test, 8 hours bake test, vibration test, vacuum and shock test at VSSC Trivandrum. Active and passive components required by the payload were screened at VSSC Trivandrum and M/s Keltron, Trivandrum. Actions have been taken to replace the tube version of the 1680 mhz transmitter by a transistorized version.

2.5.2 Development of instruments for boundary layer studies

A wind tunnel experiment was conducted to simulate the mean wind and turbulence profiles of the adiabatic atmospheric boundary layer, in a low speed wind tunnel at Central Water & Power Research Station, Pune. Profiles of longitudinal turbulence intensity, mean wind velocity and Reynolds stress were measured over rough floor downstream of a honeycomb flat plate system. Power spectra and microscale of turbulence was also studied at selected spots.

Vortex thermometer with fine wire thermocouple as sensor was put in operation during cloud seeding experiments. Hourly values of sensible heat flux over a complex terrain at IITM Pashan site, were computed from data collected from a vertical wind sensor and temperature sensor mounted on a

Instrumented towers used in the field experiment conducted near the Institute, to study flux profile relationships on the undulated terrain



Measurement of Surface Atmospheric Electricity parameters

4 meter tower during March 1985, using an eddy correlation programme. Mean flux during day time based on 9 days observation is estimated as 75 Watt/m^2.

Study of direct and indirect solar radiation was carried out using an occultation technique on the terrace of IITM building. Also, NO_2 concentration study was made using a NO2 detector on the terrace of IITM building. Direct and diffuse solar radiations for 15 days and NO_2 concentration for 10 days were recorded.

2.5.3 Instrumentation for cloud physics and weather modification studies

Field measurements were made at the Institute's Pashan complex to measure atmospheric electric field, space charge and conductivity using a d.c. field mill, space tube and Gerdian tube respectively. Space charge measurements were made in open atmosphere, inside a Faraday cage and underneath a tree to study the effect of atmospheric electric field on space charge distribution close to the ground.

To study the movement of space charge pockets in the atmosphere, measurements on the horizontal components of electric field in fair weather were made using a spherical field mill.

To study the effect of vertical propagation of thermal inversion on the space charge density distribution close to the ground, space charge was measured at three different locations at different heights viz., near ground level, terrace of IITM building and atop an adjoining hill.

2.5.4 Development of simulation techniques for cloud physics studies

Drops under electrical stress were photographed and analysed. Preliminary analysis showed that while the shape of uncharged drops is not much influenced in the presence or absence of electric fields, usually existing in thunderstorms, that of charged drops is significantly modified.

2.6 Theoretical Studies

2.6.1 Studies on Dynamic Instability

a) Barotropic and baroclinic instability of the atmospheric flow.

The barotropic-baroclinic instability of mean monsoon westerly jet was studied by using a 20-layer quasi-geostrophic model. It was found that the preferred wave of wavelength 2750 km propagates westward, has an equatorward tilt with height and its maximum amplitude at the surface is located in the vicinity of 18°N. These characteristics of the model wave agree better with the observed features of monsoon depression than pure baroclinic wave. It was also seen that orographic effect contributes to the westward propagation of the wave.

The influence of northern and southern hemispheric westerly jets on the wave disturbances along tropical easterly jet was studied using a linear global barotropic spectral model. The northern jet is found to stabilise the disturbances more than the southern jet. This was explained in terms of wave over-reflection from the critical latitudes.

The stability analysis of monsoonal zonal flow in meridional plane was performed with an equatorial balance model with Ekman CISK. The growth rates, phase speed and the two-dimensional structure agree with the earlier results obtained with pure baroclinic models. The individual contribution of the monsoon westerly and the easterly jets to the instability is being examined.

A numerical model for the study of barotropic instability of zonally asymmetric monsoon flow over Bay of Bengal was formulated. The computer code for the model is being developed.

Sensitivity studies of baroclinic modified wave CISK instability of mean monsoon zonal flow to cumulus heating have indicated that downward shift of maximum cumulus heating increases the growth rate of depression scale waves in the model.

b) Barotropic and baroclinic instability of the atmospheric flow in the summer monsoon (MONEX Studies).

In order to identify the mechanism for formation of the depression of 7th July 1979 in Bay of Bengal, daily MONEX data were analysed for the period 4-7 July 79 over the area of formation. The meridional and vertical eddy transports of sensible heat and momentum and the barotropic and baroclinic energy conversions were computed for 4 July. It was found that the depression gained kinetic energy due to baroclinic energy conversion during its formative stage.

2.6.2 Simulation of mean monsoon and tropical circulation system

a) Models for simulation

In order to make the global spectral model, developed earlier, suitable for monsoon circulation studies, the conservation of moisture equation was incorporated in the model. The computer routines were also developed for the following physical processes : (i) vertical transfer of momentum, heat and moisture from surface to boundary layer and then to free atmosphere, (ii) dry convection, (iii) effect of smooth orography, (iv) large scale condensation and evaporation and (v) integration of the prognostic equation for ground temperature.

b) Study of error characteristics in numerical models simulation and their relation to atmospheric predictability.

A study on the propagation of initial error in a primitive equation barotropic limited area model and its consequence on the predictability of monsoon system was undertaken. A program was developed to solve Poisson's equation, based on direct block cyclic reduction technique to obtain the initial data for the model.

A view of the reading room in the Institute's Library hall.

3. PUBLICATIONS

3.1 Papers Published

3.1.1 Papers published in Journals

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14. Long-term trends of surface air temperature in India : Hingane L.S., Rupakumar K. & Ramana Murty Bh.V., Jr. of Climatology, 5,5, Sep.-Oct., 1985, 521-528.

15. Modification of some microphysical properties in the highly electrified regions of thunderclouds : Kamra A.K., Archiv fur Meteorologie, Geophysik und Bioklimatologie, Sr.A., 34, 1, 1985, 37-50.

16. Observations of Aitken nuclei and gases in different environments in India : Khemani L.T., Momin G.A., Naik M.S., Kumar R.& Ramana Murty Bh.V., Water, Air & Soil Pollution, 24, 1985, 131-140.

17. On accelerating the FFT of Cooley & Tukey : Mishra S.K., Mausam, 36, 2, Apr, 1985, 167-172.

18. On some energy aspects of the monsoon depression during its life cycle Rajamani S. & Kulkarni J.R. , Mausam, 37, 1, Jan., 1986, 9-16.

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35. Subseasonal scale fluctuations of ITCZ over Indo-Pacific region during summer monsoon Pt. I - Fluctuations over Indian region : Sikka D.R., Paul D.K., Deshpande V.R., Mujumdar V.R. & Puranik P.V., Proc. of Indian Academy of Sciences (Earth & Planetary Sc.), 95, 1, Mar, 1986, 47-53.

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1. Application of ratio estimators in the numerical simulation of weather modification experiments : Selvam A.M. & Murty A.S.R., IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, USA, 12-14 August 1985, 507-512.

2. Brief appraisal of the most severe rainstorm of Punjab : Dhar O.N., Kulkarni A.K. & Mandal B.N., Nat. Sem. on Estimation of Runoff for Surface and Sub-surface Drainage, New Delhi, 9-10 December 1985, III DKM-1-III DKM-6.

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7. Feasibility of rain enhancement during south-west monsoon over north India : Kapoor R.K., Singh G. & Prem Prakash, IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, U.S.A., 12-14 August 1985, 425-428.

8. Height variation of diurnal and semi-diurnal tidal fields in the meteor zone : Devara P.C.S., Chandrasekhar G. & Ahmed M.I., First GLOBMET Symp., Dushanbe, USSR, 19-24 August 1985, 19.

9. Impact of orography on barotropic prediction : Bandyopadhyay A., Vaidya S.S. & Singh S.S., Nat. Sem. cum Workshop on Atmospheric Science & Engineering, Jadavpur Univ., Calcutta, 20-23 February 1985, 6-12.

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11. Northern summer tropical circulations during 1979, a drought year : Totagi M.Y., Bawiskar S.M. & Sikka D.R., Nat. Sem. cum Workshop on Atmospheric Science & Engineering, Jadavpur Univ., Calcutta, 20-23 February 1985, 168-178.

12. Numerical simulation of warm cloud process : Selvam A.M. & Murty A.S.R., IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, USA, 12-14 August 1985, 503-506.

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15. Raindepths associated with most severe rainstorms of the Indian region : Dhar O.N., Rakhecha P.R., Kulkarni A.K. & Mandal B.N., 6th Conf. on Hydrometeorology, 29 October - 1 November 1985, Indiana Polis, USA, 17-21.

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17. Report on rainfall studies of India (Status Report) : Dhar O.N., Nat. Sem. cum Workshop on Atmospheric Science and Engineering, Jadavpur Univ., Calcutta, 20-23 February 1985, 87-113 (Special volume).

18. Results of randomized warm cloud modification experiment conducted using aircraft in Maharashtra state, India, during nine summer monsoon seasons (1973-74, 1976, 1979-84): Murty A.S.R., Chatterjee R.N., Selvam A.M., Mukherjee B.K., Khemani L.T. & Ramana Murty Bh.V., IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, USA, 12-14 August 1985, 477-482.

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22. Warm cloud microphysical responses to salt seeding : Murty A.S.R., Paul S.K. , Selvam A.M., Sharma S.K., Pillai A.G. & Ramana Murty Bh. V., IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, USA, 12-14 August 1985, 485-488.

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24. Warm cloud responses to salt seeding under different synoptic conditions : Murty A.S.R., Chatterjee R.N., Mukherjee B.K., Reddy R.S., Khemani L.T., Kulkarni C.P. & Ramana Murty Bh. V., IV WMO Scientific Conf. on Weather Modification, Honolulu, Hawaii, USA, 12-14 August 1985, 497-502.

3.2 Papers Accepted for Publication

3.2.1 Papers accepted for publication in Journals

1. Aeronomic reactions of ozone in the stratosphere and troposphere : Hingane L.S., Archiv fur Meteorologie, Geophysik und Bioklimatologie, Sr. B.

2. Aircraft observations of condensation and ice nuclei at a tropical station : Paul S.K., Sharma S.K., Selvam A.M. and Murty A.S.R., Jr. de Recherches Atmospheriques.

3. Analysis of presistence in daily monsoon rainfall over India : Singh S.V. & Kripalani R.H., Jr. of Climatology.

4. Application of EEOF analysis to inter-relationships and sequential evolution of monsoon fields : Singh S.V. & Kripalani R.H., Monthly Weather Review.

5. Baroclinic energetics and zonal plane distribution of monsoon disturbances : Salvekar P.S. & Mishra S.K., Pure and Applied Geophysics.

6. Burst of Indian summer monsoon as revealed by GOES satellite during Monex-79; Mahajan P.N., Mujumdar V.R. & Ghanekar S.P., Advances in Atmospheric Sciences.

7. Characteristics of cloud-drop spectra in tropical warm clouds : Paul S.K., Pillai A.G., Selvam A.M. & Murty A.S.R., Pure & Applied Geophysics.

8. Effect of Ekman boundary layer friction on the baroclinic growth of monsoon depression : Salvekar P.S. & Mishra S.K., Mausam.

9. Estimates of heat and moisture over the Indian monsoon trough zone during monsoon 1979 : Kulkarni P.L., Mausam.

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11. Extension of equational easterlies at 150 mb level towards India in relation to the southwest monsoon : Patil S.D., Hingane L.S. & Rupakumar K., Mausam.

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13. Forecasting of monsoon performance over India : Bhalme H.N., Jadhav S.K., Mooley D.A. & Ramana Murty Bh.V., Jr. of Climatology.

14. Further analysis of persistence in daily monsoon rainfall over India : Singh S.V. & Kripalani R.H., Jr. of Climatology.

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17. Interannual variability of middle atmosphere and Indian summer monsoon : Mukherjee B.K., Indira K. & Ramana Murty Bh.V., Archiv fur Meteorologie, Geophysik und Bioklimatologie Sr.A.

18. Investigation of heaviest rainfalls over coastal Andhra Pradesh of India during

October : Reddy R.S., Mukherjee B.K., Indira K. & Ramana Murty Bh.V., Monthly Weather Review.

19. Large scale features of the summer monsoon during 1979 : Awade S.T., Totagi M.Y. & Bawiskar S.M., Mausam.

20. Low level wind shear and baroclinic growth of monsoon depression scale waves : Salvekar P.S., George L. and Mishra S.K., Archiv fur Meteorologie, Geophysik Und Bioklimatologie, Sr.A.

21. Measurement of atmospheric total ozone by filter photometric method : Sikka P., Vijaykumar R. & Selvam A.M., Jr. of Atmospheric Chemistry.

22. Meteorological and climatological studies carried out in high Himalayas of Nepal by Japanese scientists : Dhar O.N. & Rakhecha P.R., Jr. of Himalayan Research Group (Special issue on 'Nepal Himalayas').

23. Meteorological effects on sulphur dioxide : Kapoor R.K., Chatterjee R.N.and Singh G., Vayu Mandal

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28. Pocket of heavy rainfall in the Nepal Himalayas - a brief appraisal : Dhar O.N. & Mandal B.N., Jr. of Himalayan Research Group (Special issue on 'Nepal Himalayas').

29. Potential predictability of lower tropospheric monsoon circulation and rainfall : Singh S.V. & Kripalani R.H., Monthly Weather Review.

30. Precipitation climatology of Nepal Himalayas : Dhar O.N. & Rakhecha P.R., Jr. of Himalayan Research Group (Special issue on 'Nepal Himalayas').

31. Relationship between 500 mb ridge axis position over the Indian summer and the west Pacific region and the Indian summer monsoon : Singh S.V., Inamdar S.R., Kripalani R.H. & Prasad K.D., Advances in Atmospheric Sciences.

32. Relationship between Indian summer monsoon rainfall and location of ridge at 500 mb level along 75°E : Mooley D.A., Parthasarathy B. & Pant G.B., Jr. of Climate and Applied Meteorology.

33. Satellite derived cloud motion vectors for monitoring lower and upper tropospheric monsoon circulation during summer Monex 1979 : Mahajan P.N. & Deshpande V.R., Vayu Mandal.

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35. Some aspects of large scale Lee-waves due to westerly flow over peninsular India : Bavadekar S.N. & Khaladkar R.M., Mausam.

36. Some aspects of rainfall associated with cyclonic storms of the Bay of Bengal : Mooley D.A. & Mohile C.M., Jr. of Climatology.

37. Some facts about monsoon onset dates over Kerala and Bombay : Deshpande V.R., Kripalani R.H. & Paul D.K., Mausam.

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44. Vertical wind tunnel for water drop studies : Kamra A.K., Sathe A.B. & Ahire D.V., Mausam.

45. Wind variations in the lower thermosphere at a high mid-latitude station : Devara P.C.S., Current Science.

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3. Prediction of All India Summer Monsoon rainfall with regression model : Parthasarathy B. & Singh S.V., I WMO Workshop on Diagnosis and seasonal atmospheric variation over globe, USA, 29 July - 2 August 1985.

4. Predictive relationship between northern hemispheric surface temperature and Indian Summer monsoon : Verma R.K., I WMO Workshop on Diagnosis and seasonal atmospheric variation over globe, USA, 29 July - 2 August 1985.

5. Specification of monthly monsoon rainfall from regional circulation fields : Singh S.V. & Kripalani R.H., I WMO Workshop on Diagnosis and seasonal atmospheric variation over globe, USA, 29 July - 2 August 1985.

6. Variation in trace gases at Delhi : Kapoor R.K., Singh C. & Prem Prakash, IV Annual Conv. & Sem. on Hydrology, Haryana Agricultural Univ. Hissar, 14-16 June 1985.

4. PARTICIPATION IN SEMINARS/SYMPOSIA/MEETINGS AND CONFERENCES

4.1 Participation in Symposia/Seminars

Sr. No.	Name of the Symp.	Participant(s)	Papers presented, if any.
1.	4th Annual convention and seminar on Hydrology, Haryana Agriculture University, Hissar, 13-16 June 1985.	Kapoor R.K. & Krishna Kumar K.	i) Appraisal of heavy rainfall distribution over the intermediate catchment between Narmada Sagar and Sardar Sarover dams – Dhar O.N., Rakhecha P.R. & Mulye S.S. ii) Brief appraisal of major floods of 1984 monsoon season – Dhar O.N., Mandal B.N. & Rakhecha P.R. iii) Comparison of 1-day PMP estimates of stations in India with their respective 100-years and mean annual rainfalls – Dhar O.N., Kulkarni A.K. & Mandal B.N. iv) Estimation of areal maximum possible rainfall for different frequencies from point maximum rainfall – Rakhecha P.R. v) Exercise in rainstorm transposition over the Narmada Basin up to Narmada Sagar dam site in Madhya Pradesh - Dhar O.N., Kulkarni A.K., & Sangam R.B. vi) Ten day average evaporation values and their variability - Ramana Murty K.V. & Krishna Kumar K. vii) Variation in trace gases at Delhi – Kapoor R.K., Singh G. and Prem Prakash.
2.	First WMO Workshop on 'Diagnosis and prediction of monthly and seasonal atmospheric variation over the globe', University of Maryland USA, 29 July - 2 August 1985	Parthasarathy B.	i) Prediction of All-India summer monsoon rainfall with regression model - Mooley D.A., Parthasarathy B. & Singh S.V. ii) Relationship between All-India summer monsoon rainfall and ENSO during last one century – Parthasarathy B. & Mooley D.A.

			iii) Summer monsoon rainfall over different regions of India and circulation features during 1981-84 - Parthasarathy B. & Pant G.B.
3.	Workshop on Monsoon, Indian Institute of Technology, Kanpur, 19-23 August 1985.	Bhalme H.N. & Mishra S.K.	Interannual variability of Indian monsoon in global context of El Nino/Southern Oscillation – Bhalme H.N.
4.	Indo-Soviet programme of co-operation in Science and Technology for 1984-87 in the field of Meteorology, Deptt. of Science & Technology, New Delhi, 20 September 1985.	Chatterjee R.N.	———
5.	Seminar on Floods and Drought control in Bihar, Patna University, Patna, 22-23 September 1985.	Mandal B.N.	i) Most severe rainstorms of Bihar state - Dhar O.N., Kulkarni A.K. & Mandal B.N. ii) Rainfall & flood study of Bihar – Dhar O.N., Mandal B.N. & Mulye S.S.
6.	Indo-US-STI Workshop on Interannual variability of monsoons, DST, New Delhi, 30 September-4 October 1985.	Pant G.B., Bhalme H.N., Singh S.V., Verma R.K. & Parthasarathy B.	i) To analyse GCM experiments for studying the influence of hemispherical surface air temperature anomalies on monsoon – Verma R.K. ii) 40-60 day oscillation - interaction with intraseasonal and seasonal cycles - Singh S.V. iii) Indian rainfall fluctuations in relation to ENSO - Bhalme H.N. iv) Linking regional features with global circulation - Parthasarathy B v) Long term proxy records for monsoon research (Tree-rings) – Pant G.B.
7.	S.K. Mitra Commemoration seminar, Calcutta, 5-7 November 1985.	Indira K.	———
8.	WMO Regional Workshop on Asian Summer monsoon, India Met. Deptt., New Delhi, 5-6 November 1985.	Murty A.S.R. & Singh S.S.	Cloud & Precipitation mechanisms in the monsoon – Murty A.S.R. (invited talk).

9. National Sem. on Estimation of runoff for surface and sub-surface drainage, N.Delhi, 9-10 December 1985.	Rakhecha P.R.	i) Brief appraisal of the most severe rainstorm of Punjab - Dhar O.N., Kulkarni A.K. & Mandal B.N. ii) Estimation of probable maximum precipitation (PMP) over north-western India – Rakhecha P.R. & Sangam R.B. iii) Estimation of probable maximum rainfall over urban areas of Punjab & Haryana - Dhar O.N., Kulkarni A.K. & Mandal B.N.
10. U.S. FGGE National Conference, A.M.S., Miami, 13-17 January 1986.	Sikka D.R.	Subseasonal fluctuations of summer monsoon over Indo-Pacific region based on data of monsoon experiments - Sikka D.R.
11. Workshop on Effect of Air-Sea interaction on monsoon prediction, Physical Research Laboratory, Ahmedabad, 24-28 February 1986.	Bhalme H.N. & Parthasarathy B.	i) Effect of air sea interaction on monsoon prediction - Parthasarathy B. ii) Identification of key regions of global oceanic heat supply having prediction skill for monsoon and development of forecast models - Bhalme H.N.
12. Second Indian Agro-meteorological Congress on Environmental impact on Agriculture and advanced agromet techniques for rural development, Deptt. of Agri. Met., Gujarat Agricultural University, Anand, 10-12 March 1986.	Kamte P.P.	Persistency of precipitation over India - Kamte P.P.

4.2 Participation in Meetings

Sr.No.	Meeting	Participant
1.	Advisory Committee on Space Science (ADCOS), 21 April 1985	Vernekar K.G.
2.	Rohini Sounding Rockets (RSR) Review meeting, Vikram Sarabhai Space Centre, Trivandrum, 22 April 1985	Vernekar K.G.

3.	10th Working Group Meeting on 'Atmospheric Dynamics of IMAP, National Remote Sensing Agency, Hyderabad, 16-19 June 1985.	Mukherjee B.K.
4.	Second Meeting of DST-Basic Monsoon Physics Committee, IITM, Pune, 2-3 July 1985.	Mishra S.K. & Singh S.S.
5.	Second meeting of the Research Applications Group (RAG) of IITM, IITM, Pune, 12 July 1985.	Ramana Murty Bh.V., Mishra S.K. & Singh S.S.
6.	Meeting for imparting familiarisation of a regional model to IMD Personnel, India Meteorological Department (I.M.D.), New Delhi, 15-19 July 1985.	Singh S.S.
7.	Second meeting of the National Committee on Palaeoclimatic Studies, Department of Science & Technology (D.S.T.) New Delhi, 17 July 1985.	Pant G.B.
8.	R & D Projects Committee Meeting, DST, New Delhi, 22 July 1985.	Ramana Murty Bh.V.
9.	Council for Meteorology & Atmospheric Sciences Meeting, IMD, New Delhi, 23 & 24 July 1985.	Ramana Murty Bh.V.
10.	Combined meeting of Programme Management Board (PMB) and Scientific Advisory Committee (SAC) of IMAP, Ahmedabad, 27-30 August 1985.	Mukherjee B.K.
11.	First Meeting of the Hydrometeorology Panel of the High Level Technical Committee on Hydrology, New Delhi, 9 September 1985.	Ramana Murty K.V.
12.	Centre for Atmospheric Sciences Meeting, Indian Institute of Technology, New Delhi, 10 September 1985.	Ramana Murty Bh.V.
13.	10th Meeting of 'Sizing by methods other than sieving sub committee' Building Division Council (BDC) 19:2 of the Indian Standards Institution, New Delhi, 19 September 1985.	Kapoor R.K.

14.	Indo-Soviet Programme of Co-operation in Science and Technology for 1984-87 in the field of Meteorology, IMD, New Delhi, 20 September 1985.	Chatterjee R.N.
15.	DST Meeting for presentation of research work of the Institutions aided by the DST, India International Centre, New Delhi, 24 & 25 September 1985.	Ramana Murty Bh.V. Mishra S.K. & Murty A.S.R.
16.	First meeting of the task force on 'Cyclone probing aircraft and cyclone research and training of the DST, D.S.T., New Delhi, 27 December 1985.	Murty A.S.R.
17.	Expert Committee meeting for examining the requirement of equipment by the Centre for Atmospheric Sciences, IIT, New Delhi, 12-15 January 1986.	Vernekar K.G.
18.	43rd meeting of Planning and Co-ordination, Central Water Commission, New Delhi, 21 January 1986.	Dhar O.N.
19.	Meeting of the National Committee on 'World Climate Research Programme' Indian National Science Academy (INSA), New Delhi, 24 January 1986.	Pant G.B.
20.	DST meeting on Indo-US Collaborative Programme on 'Effect of Air Sea Interaction on Monson Prediction', Physical Research Laboratory (P.R.L.), Ahmedabad, 24-28 February 1986.	Vernekar K.G., Bhalme H.N. & Parthasarathy B.
21.	Meeting of Working Group on Meteorological Rocket Payload, IITM, Pune, 12 March 1986.	Kamra A.K., Vernekar K.G. & Brij Mohan
22.	Meeting with Dr. V. Trivedi, Director (STI), DST, on air-sea interaction & monsoon prediction, Tata Research & Development Centre, Pune, 18-21 March 1986.	Bhalme H.N. & Parthasarathy B.
23	Meeting to identify a transistorised version of transmitter for use on the meteorological rocket payload, IMAP office, Bangalore, 19-22 March 1986.	Vernekar K.G.

5. COLLABORATION WITH UNIVERSITIES AND OTHER SCIENTIFIC INSTITUTIONS

5.1 Collaboration with Universities

Dr. Bh. V. Ramana Murty, Director, conducted viva voce examination of a Ph.D. candidate at the Andhra University, Waltair on 23 April 1985.

Dr. G.B. Pant, A.D. conducted viva-voce examination of a Ph.D. (Physics) candidate of Gujarat University at Physical Research Laboratory, Ahmedabad on 8 July 1985.

Dr. A.K. Kamra, A.D. visited the University of Kashmir, Srinagar and the University of Roorkee to conduct viva voce examinations for M.Phil and Ph.D. degrees during 4-8 November 1985 and 6-11 February 1986 respectively.

Dr. A.K. Kamra, A.D., Dr. S.K. Mishra, A.D., Dr. S.N. Bavadekar, SSO-II, Shri D.K. Paul, SSO-II, Shri R. Vijaykumar, SSO-II and Dr. (Mrs) P.S. Salvekar, SSO-II participted in the teaching programme of M.Sc (Physics) course of Univeristy of Poona , Pune.

Dr. O.N. Dhar, Emeritus Scientist was appointed by the Andhra University as an examiner for 'Meteorology' for the year 1985.

Dr. O.N. Dhar, Emeritus Scientist and Shri P.R. Rakhecha, SSO-II reviewed a monograph on 'Water balance and its application' by Prof. V.P. Subramanyam which was published in the 'Transactions of the Indian Geographers', Vol.7, No.1, published by University of Poona, Pune.

5.1.1 Ph.D awarded by University of Poona

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

5.1.2 Submission of a Ph.D. Thesis to University of Poona

Name	Thesis
Shri Parasnis S.S., Junior Scientific Officer.	Some studies on atmospheric boundary layer.

5.1.3 M.Sc. degree (by research) awarded by University of Poona

Name	Thesis
Smt. Naik M.S., Junior Scientific Officer.	Chemical characteristics of monsoon rainfall.
Smt. Mullan A.H., Senior Scientific Assistant.	Some aspects of Indian summer monsoon.
Kum. Pethkar J.S. Senior Scientific Assistant.	Variations in rainfall and surface temperature at some urban and non-urban stations in India.

5.2 Collaboration with Institutions/Organisations

At the request of the India Meteorological Department, Dr. S.S. Singh, A.D. visited I.M.D, New Delhi during 15-19 July 1985 to impart familiarisation of the regional primitive equation model developed and tested at National Meteorological Centre (NMC), Washington, USA under Indo-US collaborative programme on monsoon research. Dr. Singh handed over a version of the model to the I.M.D. personnel (Shri R.K. Datta, Director, NWP) for installation at New Delhi computer.

A research proposal entitled, 'Climatic reconstruction for the past 1000 years over the western and central Himalayan regions of India using Dendroclimatic techniques' was submitted to Deptt. of Science & Technology, New Delhi.

A project proposal on 'Hydrological analysis of arid and semi-arid regions' was submitted to the Secretary, Department of Science & Technology, New Delhi.

Dr. A.S.R. Murty, A.D. has been nominated for two years as a member of the Programme Advisory Committee (PAC) of the Science and Engineering Research Council (SERC) set up by the Department of Science and Technology.

Dr. L.T. Khemani, SSO-II received an invitation from Dr. H.W. Ellsaesser, Chairman, Committee VII of the XV Inter. Conf. on the Unity of the Sciences (ICUSXV) to participate in the Conference to be held during 27-30 November 1986 at Washington D.C., USA and to present a review of the work done at IITM covering the paper, 'Role of particulates on pH of rain and implication for control of acid-rain' published in Water Air and Soil Pollution, Vol.25, 1985. The organisation committee agreed to pay the full expenses for the deputation of Dr. L.T. Khemani to U.S.A.

At the request of the State Government of Karnataka, (Karnataka Power Corporation) one senior scientist of the Institute was deputed to Bangalore during the period 29 July - 4 August 1985, to provide technical assistance in their proposed cloud seeding operations in the Linganamakki catchment area.

On request from 'The Madras Science Foundation', Prof. R. Ananthakrishnan, Hon. Fellow wrote the manuscript of a book on 'Meteorology' to be published by the Foundation.

At the request of DST-Basic Physics Monsoon Committee, Dr. S.K. Mishra, A.D. prepared three status reports, viz. (i) Instability of three dimensional flows over the sphere, (ii) Equilibrium states of the atmosphere and (iii) Critical layer interaction.

Dr. S.K. Mishra, A.D. had preliminary discussions with scientists of I.I.T., N. Delhi during September 1985 for possible collaboration with them in the field of general circulation studies.

Dr. G.B. Pant, A.D. was nominated as a member of the 'Indian National Committee for World Climate Research Programme' of the Indian National Science Academy, New Delhi for the period 1985-1988.

Dr. O.N. Dhar, Emeritus Scientist was requested by the Association of Hydrologists of India, Waltair, A.P. to prepare state-of-the art report on 'Flood Forecasting'. He was also requested by the Central Institute of Budhist Studies at Leh and Ladakh to become a member of the Advisory Board of their journal and contribute a paper on rainfall and snowfall distribution over Ladakh region.

Dr. R.R. Yadav, JSO, Birbal Sahni Institute of Palaeobotany, Lucknow joined the Institute on 6 Jan. 1986 for familiarisation training in Dendroclimatology with Dr. G.B. Pant, A.D. for a period of 40 days.

6. VISITORS

Mr. Workineh Degefu,
General Manager Ethiopian Meteorological Services and President of RA-I (Africa)
signing the Visitor's book

Mr. Degefu in the Theoretical Studies Division of the Institute

A

Sr. No.	Visitor-Credentials	Date of visit
1.	Dr. R.D. McPherson Chief, Short Range Branch, National Meteorological Centre, Washington.	9-11 April 1985
2.	Prof. A. Bronger, Geography Deptt Univ. of Keil W. Germany and Dr. R.K. Pant, Fellow, Physical Research Laboratory, Ahmedabad.	25 October 1985
3.	Dr. A.F.E. Zangi, World Bank Expert on Hydrology, Regional World Bank Office, New Delhi.	7 November and 10 December 1985
4.	Mr Workineh Degefu, General Manager, Ethiopian Meteorological Services and President of RA-I (Africa)	14 February 1986
5.	Mr.Mansell Moulin, Consulting Hydrologist of World Bank, U.K.	28 February 1986
6.	Dr. I.J. Jackson, Associate Professor, Deptt. of Geography, Univ. of New England, Australia.	13,14 March 1986
7.	Mr. Tokukiyo Hirai, Resident Representative, Japan International Co-operation Agency (JICA), New Delhi.	17 March 1986

B

Sr. No.	Visitor-Credentials	Date of Visit
1.	Shri S. Sheshadri, Chief Engineer, (Planning & Monitoring) Irrigation Deptt, Govt. of M.P. alongwith two Executive Engineers	2 April 1985
2.	Shri M.R. Dighe, Superintending Engineer, Central Design Organisation, Nasik.	21 June 1985
3.	S/Shri V. Sreenivasa Murty, Chief Engineer, (Electrical Design), Karnataka Power Corporation Ltd. (KPCL),Bangalore and S.A. Aleem Project Engineer (Electrical Design) Karnataka Power Corporation Ltd., Bangalore.	24 and 26 July 1985

4. S/Shri R.K. Jain, Chief Engineer, U.P. Laxminarain, Research Officer, A.N. Bhargava, Assistant Research Officer, and R.C. Bhatia, Assistant Research Officer, (All from Irrigation Research Institute, Roorkee, U.P.) — 12 August 1985

5. Shri S.V. Markale, Executive Engineer, Govt. of Maharashtra. — 7 November 1985.

6. Shri Raghavendra Rao, Manager, TERLS, Vikram Sarabhai Space Centre (VSSC) and Shri M.D. Bhaskar Head, Ground Support Division, TERLS, VSSC, Trivandrum — 7 January 1986.

7. Shri K.S. Appu Project Scientist, Vikram Sarabhai Space Centre, Trivandrum. — 16 January 1986.

8. Trainee Officers and an Instructor, Air Force Administrative College, Coimbatore — 17,18 & 19 March 1986

7. GENERAL

Farewell to Dr. Bh.V. Ramana Murty, Director on his retirement

7. General

7.1 Retirement of Director

Dr. Bh. V. Ramana Murty, Director retired from the service of the Institute with effect from 30 September 1985. He handed over charge of the post of Director of the Institute to Shri S.K. Das, Director General of Meteorology and Chairman, Governing Council, IITM on the afternoon of 30.9.1985.

7.2 The Governing Council

The administration and management of the Institute is vested in a Governing Council which consists of 9 members including the Director of the Institute.

The council held two meetings during the year at India Meteorological Department, New Delhi on 6 September 1985 and 24 March 1986 respectively.

Dr. R.P. Sarker, Additional Director General of Meteorology, India Meteorological Department, took over as Chairman of the Governing Council of the Institute on 21 February 1986.

7.3 Facilities

7.3.1. Library, Information and Publications

During the year, 118 books in Meteorology and allied subjects were added and 78 periodicals of national and international repute were subscribed to. A number of useful scientific/technical reports were also added to the library.

7.3.2 Computer

The IBM 1620 computer worked during the year as follows :

	Hrs.	Mts
Institute's jobs	1048	55
Data processing of India Meteorological Department	37	50
Break down/Maintenance	163	35
Paying Users	00	15

Monthly Climatic Data (surface) for the selected 113 tropical stations for the period 1971-84 were collected, punched and transferred to tapes for the use of scientists.

Collection of Monthly Climatic Data (Upper Air) for the ten standard levels in respect of the selected 40 tropical stations for the year 1984 was completed. The data for 40 stations for the year 1982 were punched.

A Five-week course in Fortran programming was conducted for the Institute members during Aug-Sept. 1985.

Governing Council allocated Rs.100 lakhs for the procurement of a 4th generation computer. In this connection, a feasibility report for the acquisition of a high speed computer by the Institute was sent to the Department of Electronics, Govt. of India for necessary clearance. The Commission while clearing the proposal recommended to purchase a ND-500 Super Mini computer.

7.4 U.N.D.P. Training

Shri R.N. Chatterjee, Senior Scientific Officer Grade I resumed his duty at the Institute (Rain and Cloud Physics Research Centre, New Delhi) with effect from 2 July 1985 after completion of U.N.D.P. training at Switzerland in the field of Weather Modification (radar detection of hail and its suppression techniques) for a period of six months.

7.5 Deputation/visits abroad

Dr. S. Rajamani, Senior Scientific Officer, Grade I was deputed by the Department of Science and Technology to visit National Meteorological Centre, Washington, U.S.A. from 1-28 July 1985 under the Indo-US Monsoon Research Programme, to study "Familiarisation of Optimum Interpolation Scheme (O.I.Scheme)" of objective analysis.

Dr. B. Parthasarathy, Senior Scientific Officer, Grade I was deputed to attend 'WMO Workshop on diagnosis and prediction of monthly and seasonal atmospheric variations over the globe' organised at the University of

Maryland, USA from 29 July to 2 August 85. He also visited the US Met. Offices/NOAA/ NWS/CAC, Washington DC and discussed with the scientists, the monsoon problem and the ongoing work in the field of climatology from 3 to 11 August 1985.

Dr. L.T. Khemani, Senior Scientific Officer, Grade II was deputed to the Commonwealth Scientific and Industrial Research Organisation, Australia for a period of 15 days from 6-20 September 1985 to undergo a specialised training in the field of cold cloud seeding by using silver iodide to increase rainfall.

Under the bilateral programme of co-operation between India and USSR in Science and Technology (Meteorology), Shri D.K. Paul, Senior Scientific Officer, Grade II was deputed to A.I. Veikol Main Geophysical Observatory, Leningrad, Moscow, USSR for a period of 10 days from 9 October 1985.

Dr. R.S. Reddy, Senior Scientific Officer, Grade II proceeded on a visiting fellowship offered by the Canadian Atmospheric Environment Service in the field of "Solar Terrestrial Physics and Meteorology" for a period of one year commencing from 18 November 1985.

7.6 Field Research Unit, Bangalore.

Consequent to the sanctioning of wind energy survey projects in four States, Tamilnadu, Gujarat, Orissa and Maharashtra by the Department of Non-Conventional Energy Sources, Ministry of Energy, New Delhi, the Field Research Unit of IITM was requested to co-ordinate the activities of the Nodal Agencies in the four States and to render appropriate technical services to them in the implementation of the project, taking NAL as their consultant.

The Scientist-in-Charge of Field Research Unit attended the International Conference on Solar and Wind Energy Applications held at Beijing from 1.8.1985 to 8.8.1985 and presented a paper on "Solar and Wind Energy Measurements in India".

7.7 Emeritus Scientist

The term of Dr. O.N. Dhar as Emeritus Scientist at the Institute was extended for a period of two years with effect from 12 May 1985.

7.8 Research Fellowship

S/Shri R. Alagaraj and H.K. Chaturvedi joined the Institute as Air India Research Fellows with effect from 8 and 9 April 1985 respectively.

S/Shri E.N. Rajagopal and B.B. Rao joined the Institute as IITM Research Fellows with effect from 12 August and 9 September 1985 respectively.

7.9 Institutional Seminars

S.No.	Speaker	Topic	Date
1.	Dr. R.D. McPherson National Meteorological Center, Washington, USA.	Recent research activities at the U.S. National Meteorological Centre in Extended Range Forecasting and New Observing Systems.	10 April 1985.
2.	Dr. B.K. Mukherjee SSO-I	International Symposium on the Middle Atmosphere Programme, Kyoto (Japan), November 1984.	12 April 1985

3. Shri R.B. Marathe, ARDE, Pune.	Maya in modern science.	22 May 1985
4. Dr. K.V. Ramana Murty, A.D.	New areas of research in Hydrometeorology.	14 June 1985
5. Shri M.K. Tandon, J.S.O	Research work being carried out in Theoretical Meteorology in the Institute.	20 September 1985
6. Dr. A.K. Mukherjee, ADGM, New Delhi.	How cold is our valley ?	15 October 1985
7. Dr. Ananthakrishnan R. Hon. Fellow, IITM	Some characteristics of the southwest monsoon rainfall.	13 December 1985
8. Shri D.R. Sikka, A.D. (currently on deputation to TOGA Project Office, USA)	Monsoon Meteorology in TOGA.	17 February 1986
9. Shri R.M. Khade, Scientist/Engineer 'SE' National Information Centre (NIC), Western region, Pune.	NEC system 1000 to be installed in NIC, Pune-7.	4 March 1986
10. Dr. Iam J. Jackson, The University of New England, Australia.	i) Some aspects of short period tropical rainfall characteristics.	13 March 1986
	ii) Traditional forecasting of tropical rainy season.	14 March 1986

7.10 Official Language Implementation

Substantial progress has been achieved in the implementation of the official language - Hindi, during the year thanks to the dynamism, initiative and involvement of the Hindi Officer.

A workshop was conducted for the benefit of the staff, who had working knowledge of Hindi. The participants gained experience in office procedures, noting and drafting of various letters/circulars in Hindi following the Rules and Regulations of the Government of India. Essay contest and debates were organised in Hindi so as to develop confidence in the correct usage of the language. Prizes/Certificates of merit were distributed on Hindi Day in September 1985.

A note-worthy feature of the Hindi-Day celebration of this year was staging of a Hindi drama, produced, directed and acted entirely by non-Hindi speaking staff. The Chief Guest Prof. (Ms). Durga Dixit, Head of the Department of Hindi, Poona University has praised the function as a step towards national integration.

A large number of circulars were issued bilingually, besides 48 letters in Hindi to different destinations. Staff members were helped and encouraged to correspond in Hindi. Monthly and annual progress reports were translated into Hindi. Audit reports and a few legal documents (e.g. Agreements, notices etc.) were also translated. The total material translated exceeds 600 pages.

Regular meetings of the official language implementation committee, were held every quarter and the reports were sent to the Department of Science and Technology.

7.11 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'	...15

7.12 Budget

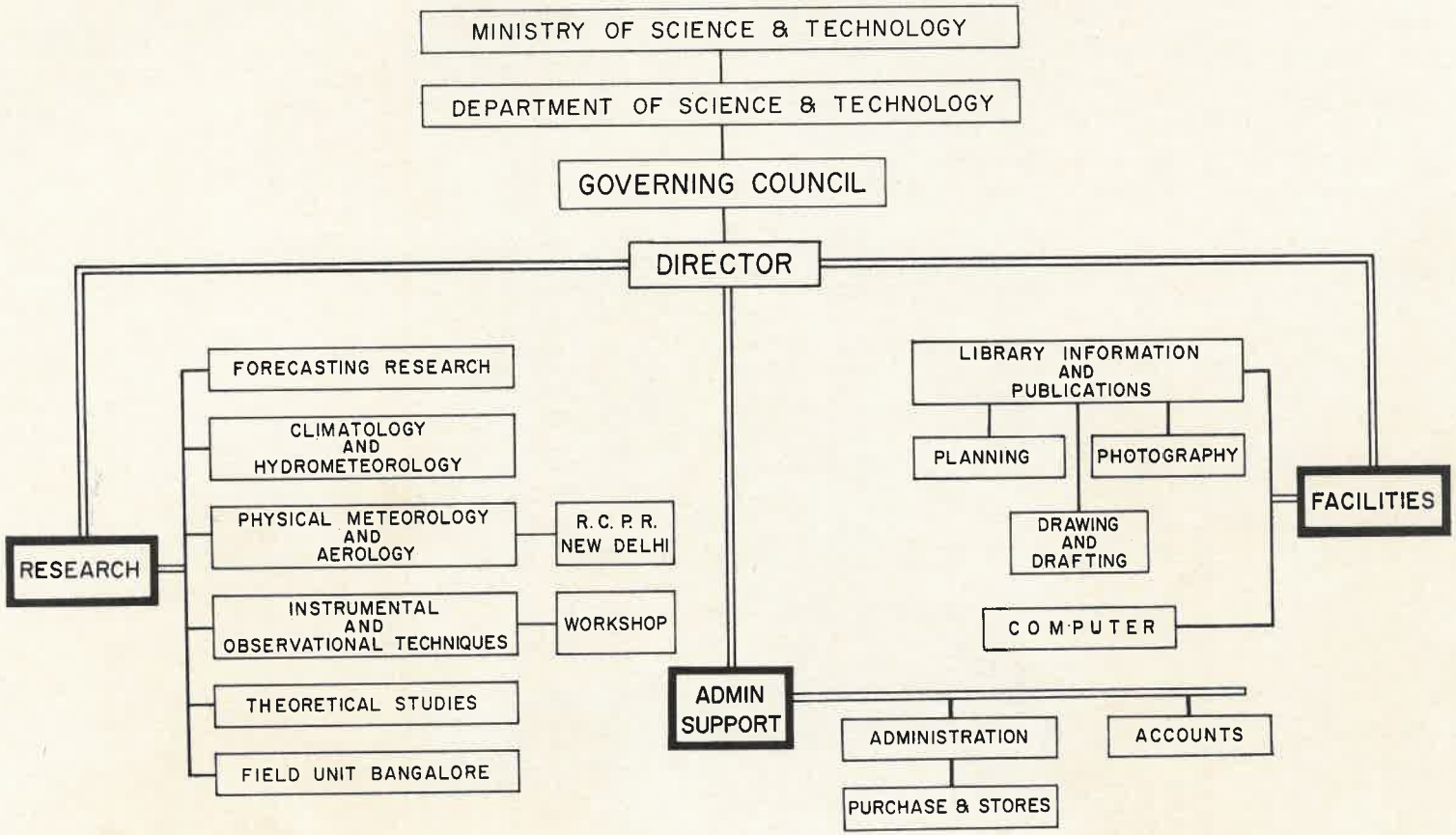
The budget estimates and actual expenditure for the Institute for the period 1985-86 were as given below :

(Rs. in lakhs)

	Budget Estimates	Revised Estimates	Actual Expenditure
Non-Plan	119.00	118.00	93.79
Plan	60.00	60.00	58.04

INDIAN INSTITUTE OF TROPICAL METEOROLOGY

(ORGANIZATIONAL PROFILE)



Prize distribution on Hindi day

Institute Building at Pashan, Pune.

Printed By Parshuram Process, Pune 4