INDIAN INSTITUTE

OF

TROPICAL METEOROLOGY

ANNUAL REPORT

1977-78

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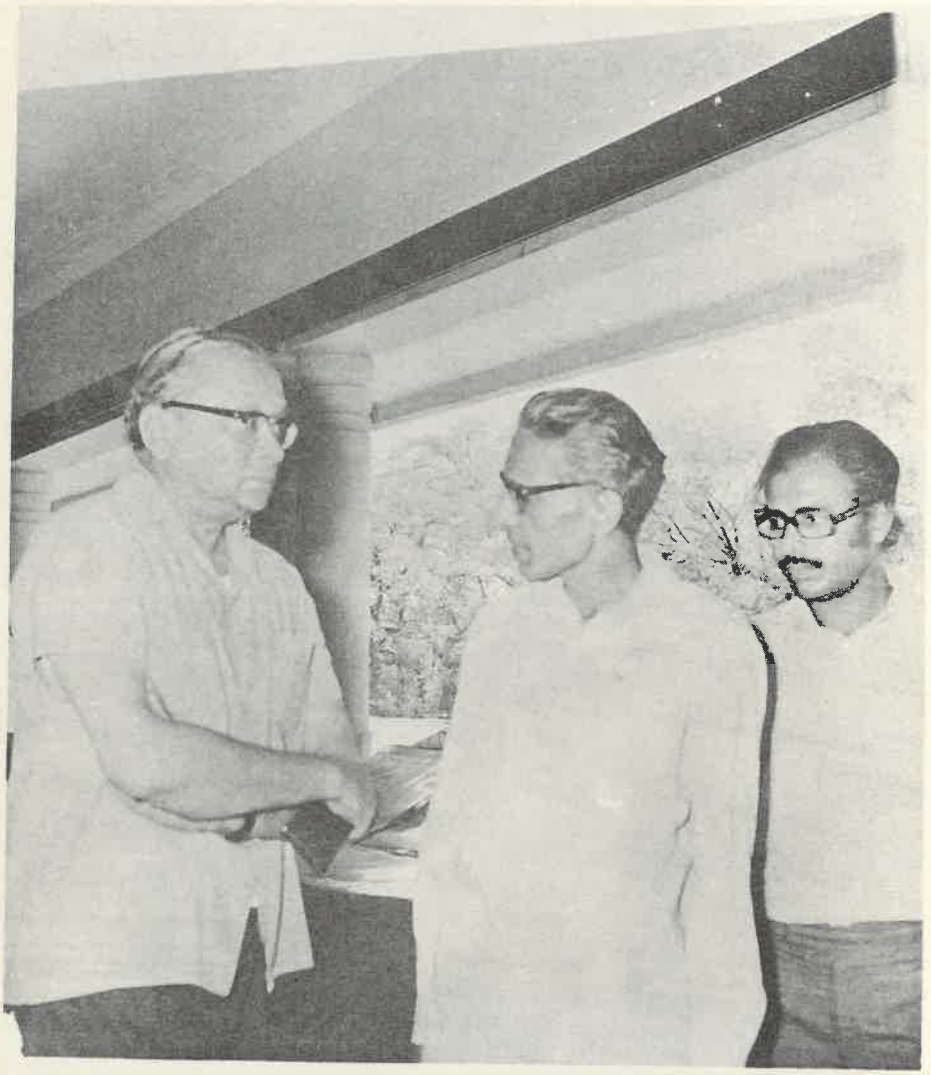


Shri R.P. Naik, Secretary Min. of
T. & C.A. in the exhibition-hall

C O N T E N T S

1. INTRODUCTION

The Indian Institute of Tropical Meteorology, which was part of the India Meteorological Department, was constituted as an autonomous research institution on 1st April, 1971 with the object of conducting research in all aspects of Meteorology with particular reference to the tropics. The research work in the Institute is organised under five research Divisions :

(1) Forecasting Research

(2) Climatology and Hydrometeorology

(3) Physical Meteorology and Aerology

(4) Instrumental and Observational Techniques, and

(5) Theoretical Studies.

Ancillary units to provide facilities for research, such as, Library, Information, Publication, and IBM 1620 electronic Computer, a Workshop and well-equipped laboratories are also available.

Research at the Institute is aimed at improving the knowledge of the terrestrial atmosphere and the cause and effect relationship of various meteorological phenomena taking place in the environment. One of the objectives is to improve the accuracy of weather forecasts by evolving criteria for prognosticating the fluctuations involved therein. Another important objective is to conduct experiments towards modifying the weather, particularly precipitation enhancement. Attempts are being made for developing techniques for predicting weather 1-3 days in advance (short range forecasting) as well as 5-20 days in advance (extended range forecasting). Studies are being

undertaken to develop the water resources potential of the country as well as to examine the feasibility of increasing rainfall in deficient and drought-prone areas by artificial cloud-seeding techniques. The research work is also oriented towards the study of climatic variation leading to droughts and floods in different parts of the country. With a view to establishing the paleo-climatology of nature, it is proposed to study ancient literature and to decipher the records left by nature, like tree rings. Investigation on the role of cloud electrification in precipitation has been taken up. Studies in air pollution are also in progress. Instruments for collecting data through weather satellites/rockets are being developed.

Research work is mainly concerned with eleven areas : (1) Numerical Weather Prediction, (2) Extended Range Prediction, (3) Climate and Climatic Change, (4) Hydrometeorological Studies, (5) Cloud Physics and Weather Modification, (6) Environmental Physics, (7) Development of Meteorological Payload for rockets and satellites, (8) Boundary Layer Studies, (9) Cloud Physics and Weather Modification Studies, (10) Studies on Dynamic Instability and (11) Simulation of the monsoon and tropical circulation.

Important achievements in research are briefly outlined below :

i) A rainfall analysis of cloud seeding experiments conducted over Poona during 1976 was completed. Out of a total of thirty-nine pairs during 1973, 1974 and 1976, the result was positive on twenty pairs, negative on eleven pairs and inconclusive on eight pairs of days.

ii) A numerical cloud-seeding experiment was conducted for Poona to determine the length of time for which experiments have to be conducted to detect the seeding effect at given levels of significance. The results of the preliminary study for Maharashtra suggested that 15 and 20 percent increases in rainfall due to seeding could be detected at 5 percent level of significance with 80 percent or more probability of detection, in 8 and 5 years respectively.

iii) A study of the characteristics of the atmospheric pollutants at Poona and their possible role on local rainfall was completed. It was found that sulphur-dioxide, ammonia, total ammonium and proportions of total chloride could be associated with rainfall.

iv) Work on the development of a multi-layer numerical prediction model using primitive equations was carried out. Efforts were made to include the effects of frictional dissipation and diabatic heating in a parameterized form.

v) Several studies connected with the understanding of the monsoon systems and its important fluctuations were undertaken. Development of a synoptic-climatological model of the thermal field for the SW monsoon region was completed.

vi) On the basis of water balance, a pilot study was undertaken for finding suitable criteria for large-scale droughts over India. Monthly rainfall and temperature data for the Indian region for a period of about 70 years was processed and suitable statistical parameters were computed.

vii) Probable maximum precipitation for some of the river basins of peninsular India were evaluated. Studies of maximum rainfall of different probabilities were made and generalised charts were prepared for some river basins.

viii) With a view to determining various hydrometeorological parameters for the development of water resources of India, detailed rainfall studies of a number of river basins of our country were undertaken.

ix) One payload developed at the Institute was flight-tested at Thumba.

x) M-100 Rocket data were analysed. A few interesting features relating to stratosphere were found and reported.

xi) A low level temperature sonde was developed.

xii) The possibility of instability in the tropical atmosphere, especially over India, was investigated.

xiii) A barotropic primitive equation spectral model was integrated up to 30 days. The performance was satisfactory in simulating amplitude and phase velocity of a propagating Rossby waves within an error of 10%. During 30-day integration the principles of conservation of total energy and entropy were satisfied.

Research work on these subjects will be continued. Some of the new schemes for 1978-79

are given below :

1) Studies utilising the data collected during MONEX.

2) Inclusion of subrigid scale processes for Numerical Weather Prediction Models.

3) Delineation of Severe rain-storms.

4) Objective Techniques for tropical cyclone prediction.

5) Silver Iodide generators and flares.

6) Development of instruments for the atmospheric boundary layer.

7) Development of instruments for weather modification.

Sixteen research papers were published in well known meteorological journals. Thirteen papers were accepted for publication in journals and twenty two were presented at national and international seminars, symposia and conferences.

In addition to the research work mentioned above, scientists of the Institute were actively participating in the analysis and related work in the 'Monsoon Experiment 1977'.

The budget estimates and actual expenditure for the Institute for 1977-78 are as given below :

Figures - Rs. in lakhs

	Budget Estimates	Approved Revised Estimates	Actual Expenditure	Shortfall
Non Plan	38.00	30.00	27.49	(-) 10.51
Plan	26.00	11.42	6.91	(-) 19.09

The shortfall in expenditure was mainly due to : (i) non-availability of a suitable aircraft at reasonable rates for conducting aerial cloud seeding experiments at Pune, (ii) delay in finalising the procedural formalities connected with the construction of the Institute buildings and (iii) delay in recruitment of staff sanctioned for the projects.

The Institute is yet to have a building of its own and is at present functioning in a number of rented houses scattered at different places. Rs.35 lakhs have been approved towards the proposed construction of the Institute building and staff quarters. An amount of Rs. 3.0 lakhs has been deposited with the C.P.W.D. to initiate necessary action in this regard.

An important event during the year was the visit of Shri R.P. Naik, Secretary to the Government of India, Ministry of Tourism and Civil Aviation on 4th June, 1977. An exhibition explaining the activities of the Institute through models and charts prepared by different divisions was arranged.

Meritorious achievements by the scientists of the Institute in their individual capacity are given below :

1) Shri K. Krishna, S.S.O.I., was awarded Ph.D. degree in Physics by the Poona University for his thesis entitled, "Studies of the Turbulent Exchange Between the Atmospheric Boundary Layer and the underlying surface".

2) A silver medal, a citation and two books were awarded to Shri S.K. Sharma, Mech. Gr.I for the paper which was adjudged as the third best in the students' technical session at the 57th Annual Convention of The Institution of Engineers (India), 8-12 April, 1977.

3) Dr. A.S.R. Murty, S.S.O.II, who was selected for Shri Hari Om Ashram Prerit Dr. Vikram Sarabhai Research Award for 1976, received the award consisting of cash prize of Rs. 4000/- and a medal in person on August 12, 1977 at the Physical Research Laboratory, Ahmedabad. Dr. Murty delivered a lecture entitled, "Some microphysical aspects of clouds and the physical basis for their modification" on the occasion.

The Institute submitted its Five Year Plan (1978-83) proposals involving an outlay of Rs. 166.44 lakhs to the Planning Commission. An amount of Rs. 100.00 lakhs has been approved for the purpose.

2. RESEARCH AND DEVELOPMENT

2.1 Rainfall Studies

The influence of mean annual rainfall on design storm estimates for 3 river basins, viz, Mahi, Betwa and Subarnarekha, lying in different regimes of North India was studied. This study revealed that the design storm of a basin was not influenced by the rainfall regime of the region in which a basin was located. A basin located in a region of high rainfall could have a design storm of low value and vice versa.

Rainfall and frequency of cyclonic disturbances traversing the India region during the monsoon periods of 1901 to 1960 revealed that the occurrence of more cyclonic disturbances in a particular year has no positive correlation with the incidence of more rainfall over the country.

A study of the characteristics of the atmospheric pollutants at Poona and their possible role on local rainfall was completed. It was found that sulphur dioxide, ammonium and proportions of total chloride might be associated with rainfall.

2.2 Forecasting Research

2.2.1 Numerical Weather Prediction

A primitive equation model for forecasting over the monsoon region was continued. Moisture and frictional dissipation were included into the model. The integration was carried out up to 24 hours with the initial data having a monsoon depression. The results of integration showed that the forecast movement and the flow patterns around the depression were satisfactory. However,

the vertical velocity pattern did not show much improvement over the patterns obtained with the dry model. Inclusion of diabatic heating due to cumulus convection, large scale convection and air-sea interaction were included in the model. The evolution of heating due to cumulus convection showed some distortion in certain parts of the domain after 6-hours of integration. These distortions were caused by unrealistically large temperature lapse rates, and the use of non-divergent part of the wind in the initial data. Dynamic initialisation procedures were being studied for preparing the input for the model.

The effects of orography were examined by a three level primitive equation model. For this purpose, analytical data for an elliptic orographic barrier were used in the model with the maximum height of barrier equal to 1 km at the centre of the region. The results were under examination.

Dynamic initialisation, using an averaging method, was applied to a barotropic primitive equation model. The model was integrated upto 72 hours with the initial data obtained from a balance equation, The hourly values of the mass-divergence were computed for each case. It was found that the dynamic initialisation brought about a better degree of balance between the mass and the wind fields.

Wind data at different pressure levels over the Indian stations were subjected to statistical analysis. Structure functions and auto-correlation functions of U and V components of wind at 850 mb level for the monsoon period (June to September) and at 850 mb, 700 mb and 500 mb for the month of July were computed. These computations showed that the area of influence for analysis of wind components was elliptical with the semi major axis oriented along the latitude for the

U-component and along the longitude for the V-component. Incorporating this feature, Cressman's method has been modified to get the objective analysis of the wind field for a number of situations. The results of wind analysis by the modified version were compared with those obtained by Cressman's method. The modified version was found to give a more realistic objective analysis of the wind field.

An optimum interpolation scheme was developed for wind analysis with the help of structure functions and auto-correlation functions. More data are being included to compute stable statistical parameters required for the optimum interpolation technique.

2.3 Extended Range Prediction

2.3.1 Synoptic Studies

To study the behaviour of the main synoptic systems on a scale of 3 to 7 days and to link it with the distribution of rainfall over India, 700 mb contours were used as the basic parameter. For this purpose, the analysis of 700 mb charts, as well as relevant statistics, were updated to 1976 for the southwest monsoon season.

With the object of linking up the anomalies in different parameters with monsoon activity, ten year (1967-1976) monthly mean data for height, wind and temperature at about 80 stations of India and neighbouring regions at standard levels upto 30 mb, were collected and their anomalous fields are being analysed.

Spherical harmonics (wave numbers 1 to 16) were used to compute the northern hemispheric meridional transport of sensible heat at 500 mb by standing eddies during a strong monsoon year (1967), a weak monsoon year (1972) and during the period of normal data (1951-60) for five months from April to August. The results showed that :

i) The northward transport of sensible heat is significantly more at subtropical latitude (30°N) in a weak monsoon year than during strong monsoon;

ii) Wave numbers 1 and 2 are prominent and showed contrasting features in these years;

iii) The transport of sensible heat during 1967, 1972 and normal year indicates similar features.

A harmonic analysis was made of monthly temperature data at standard levels for 120 radiosonde stations over the northern hemisphere. Two main features emerged : (i) over the tropics at an individual station, a double maxima is noticed, one in the lowest level and the other at about 300 mb, and (ii) the amplitudes of the annual oscillation are large over tropics and subtropics, with a maximum appearing over the Asiatic monsoon region. There is phase lag varying between 30 to 45 days between the two tropospheric maxima-the upper tropospheric one occurring later and towards the end ofJuly. The contribution of latent heat into the high amplitudes in the upper tropospheric maximum over monsoon region is emphasised. A schematic model for the tropospheric heating over the Asiatic summer monsoon region is suggested.

2.3.2 Statistical Studies

Regression equations developed earlier for prediction of 5-day rainfall during the south-west monsoon over different subdivisions of India were used for experimental prediction on real time basis during 1977. The evaluation did not indicate satisfactory results. A revised set of regression equations have been developed and its performance will be tested during 1978.

A stochastic process based on a simple Markov chain was used for estimating frequencies and durations of heavy precipitation in 24 hours for a month. This principle was applied to 19 year records of daily rainfall over the Konkan region for the four monsoon months of India from June to September. The probability of one-day rainfall exceeding 20, 30, 14 and 10 cm for the months of June, July, August and September respectively was evaluated. The model is being developed for the prediction of rainfall for 1 to 5 days during the monsoon.

2.3.3 Climatology and Hydrometeorology

Probable maximum precipitation (PMP) studies were taken up for peninsular India, with a view to preparing generalized charts of maximum and probable maximum rainfall of different durations. To work out the PMP, annual maximum rainfall data for about 240 long-period (1891-1960) stations in Tamil Nadu have been collected and analysed. Data of about 50 stations in Kerala have also been collected for a period of 70 years.

Rainstorm data of severe storms over Upper Krishna basin were collected for the period 1891-1968 and the data were analysed for working out design storm estimates for the Upper Krishna basin.

Influence of mean annual rainfall on design storm estimates in respect of 3 river basins viz. Mahi, Betwa and Subarnarekha, lying in the different rainfall regions of north Indian plains, was studied.

Design storm studies in respect of Mahi, Betwa and Subarnarekha revealed that the design storm of a basin was not influenced by the rainfall of the region in which a basin was located. It was found that a basin located in a region of high rainfall might have a design storm of low value and vice versa.

The distribution of rainfall in the different subdivisions of India during the wettest and driest years of 1917 and 1918 was studied. It was found that the north west sub-divisions of India, which normally receive comparatively less rainfall, received an abnormally high rainfall during the wettest year of 1917 and deficient to scanty rainfall during the driest year of 1918. It was also found that in the driest year 1918, all sub-divisions to the west of 85°E received deficient to scanty rainfall and only those sub-divisions lying to the east of 85°E received normal to excess rainfall.

Hydrometeorological aspects of heavy rainfall (i.e. incidence of severemost rainstorms, maximum point rainfall of different return periods and probable maximum precipitation) over the principal arid zone of Rajasthan were studied using the continuous rainfall records of the past 70-80 years.

A study was made to determine whether the frequency of cyclonic disturbances traversing the Indian region during the monsoon has any influence on the monsoon rainfall. It was revealed that the occurrence of more cyclonic disturbances in a particular year did not have any positive correlation with the incidence of more rainfall over the country.

2.4 Climate and Climatic Change

2.4.1 Droughts and precipitation extremes

Palmer's drought index is based on water balance and takes into consideration rainfall, temperatures and soil moisture. However, when this index was applied to a few selected districts in semi-arid and dry sub-humid areas of India, it was found that the index did not reflect the drought conditions realistically. Work for suitably modifying Palmer's index has been taken up. In evolving the modified drought index it is presumed that the amount of precipitation for near-normal operation of the established economy of the area during any period depends on the climate of the area, as well as the current and antecedent weather. A modified index based on a different drought severity equation has been evolved, taking into account rainfall, evapotranspiration and soil moisture. This has been applied to some selected semi-arid and sub-humid districts of India for the period 1901-1970. The modified drought index is found to bring out the drought conditions in a more realistic manner.

A long series of southwest monsoon rainfall of India was constructed for the period 1866 to 1970 by utilising the rainfall data of a large number of rain-gauge stations. The series

has been found to be homogeneous and Gaussian-distributed. The series does not exhibit any long-term trend. The years 1877, 1899, 1918, 1920, 1951 and 1965 were very bad monsoon years when the monsoon rainfall was below the 5th percentile. The mean monsoon rainfall for 1931-60 is significantly higher than the overall mean for the period 1865-70 at 5 percent level. While the decade mean was generally steady during the period 1870-1920, it rose from 1921 onwards and attained the maximum value for the decade 1941-50. Thereafter, it declined, the highest decline of 4.41 cm being from 1951-60 to 1961-70. The power spectrum analysis indicates the presence of Quasi-Biennial Oscillation (QBO) in southwest monsoon rainfall. There does not appear to be any significant relationship between the Indian monsoon rainfall and the solar activity.

A statistical model based on time series was developed for monsoon depressions during each year from 1891-1970. On the basis of the observed parallelism between the sunspot series and monsoon depressions it was assumed that the decreasing trend in the frequency of monsoon depressions was arrested around 1970, and the rate of increase after 1970 was approximately equal to the rate of decrease prior to 1970. The first three harmonic components of the monsoon depression series account for 39 percent of the variance. These components were superimposed on the assumed linear increasing trend in monsoon depressions during the period 1970-2000 to estimate a time series of monsoon depressions upto the year 2000. According to this estimate, the period 1975-85 may experience an above-normal frequency of monsoon depression and the period 1986-2000, below normal.

2.4.2 Palaeo-climatology

Recent adverse changes in some parts of the globe have created anxiety in the minds of people about changes in climate. Paleo-climatology has been taken up as a project to analyse this question.

Current literature in the field has been surveyed and a bibliography has been prepared. Radio-carbon dating techniques and archaeological methods have been studied.

It is proposed to confine the study to historical and archaeological studies of Indian region. It is also proposed to extend recorded weather data to a few hundred years using tree-rings and documented records of floods and famines.

2.5 Physical Meteorology and Aerology

2.5.1 Cloud Physics

Cloud electrification mechanisms were studied with the help of electric field, raindrop charge and rain intensity. These parameters were measured simultaneously during the pre-monsoon, monsoon and post-monsoon seasons. The characteristics of the raindrop charge, and the associated electric field, were found to be different during the three seasons. The differences were explained taking into consideration the process of electrification in different types of clouds.

Diurnal and seasonal variations of space charge, electric field and aerosols in the lowest layer of the atmosphere were studied, along with their association with meteorological conditions. The variations in space charge and the electric field were found to be closely associated with thermal stratification, and the physical and chemical characteristics of particulates in the boundary layer. The values of space charge and electric field were on the higher side during cold wave conditions in winter.

A study of the influence of the electric field on collision and coalescence efficiencies of water drops in warm clouds was undertaken, using the data obtained from the earlier laboratory experiments. The preliminary results of the study suggested the following :

i) The collision frequency for cloud and drizzle drops is independent of the external electric field for certain limiting initial conditions. These conditions specify the lateral and vertical separations between pairs of drops;

ii) There was no coalescence of drops in the absence of an electric field. The coalescence frequency increased with the electric field, and attained 100 percent at lower values of the field for cloud drops than for drizzle drops;

iii) The collection efficiency was zero in the absence of an external electric field. The ramifications of the above results on rainforming mechanisms in warm monsoon clouds were discussed, taking into consideration the aircraft-in-cloud measurements

of the electric field, cloud droplet charge and cloud droplet size distributions.

In order to help explain the previously noticed precipitation anomaly in and east of Bombay, a study of the electrical, microphysical and dynamical conditions in clouds in maritime and urban environments was undertaken with the help of aircraft observations in the Bombay region. The results showed the difference in electrical, microphysical and dynamical characteristics of clouds forming in maritime and urban environments. The results of the study were in agreement with the findings derived from METROMEX studies of - St. Louis, USA.

Electrical, micro-physical and dynamical conditions in clouds during the summer monsoon were studied with the help of field observations undertaken during August 1977. The study helped understand the physical processes of the electrifications and rain-formation mechanisms in monsoon clouds.

2.5.2 Radar Study of Rain and rain bearing clouds

Mock cloud seeding experiments and simultaneous radar observations were carried out at Delhi during the winter. Evaluation of such experiments using radar and rainfall data collected during the period 1957-68 and 1976-77 was in progress.

Detailed study of the percentage frequency of occurrence of convective type of radar echoes of different vertical extent at Delhi was undertaken after completing a preliminary study of these echoes.

2.5.3 Studies in cloud micro-physics

In collaboration with the U.S. scientists, investigation on the mechanism of ice-crystal production in Florida cumuli was undertaken using the in-cloud microphysical data collected by an Institute scientist, while on deputation to USA, during the Florida Area Cumulus Experiment, 1975. The result of a simple analytical model suggested that aerodynamic capture of secondary ice particles by the supercooled raindrops and the subsequent transformation of the raindrop to the new splinter producing graupel might be the main mechanism responsible for the observed rapid increase in the graupel concentrations.

A numerical methodology for the evaluation of cloud seeding experiments was developed. The results of the preliminary study for the Maharashtra region suggested that 15 and 20 percent increases in rainfall due to seeding could be detected at 5 percent level of significance, with 80 percent or more probability of detection, in 5 years.

Bayesian statistical analysis and other classical statistical tests were applied to the existing cloud seeding experimental data. To a high level of statistical significance, the positive results of cloud seeding experiments conducted at the Delhi-Agra-Jodhpur region, reported earlier, were confirmed. Further studies on the application of 'Decision Analysis' and Bayesian statistics were in progress to optimize the future experimental strategy and data collection.

A radar study of the effect of massive salt-seeding on warm maritime cumulus clouds was completed with the help of observations made over the Bombay region as a part of the cloud seeding

experiment undertaken during the 1974 monsoon. The evaluation of the results was based on the radar observations consisting of aerial echo coverage, echo intensity and the height of the echo top. The observations made in the 4 target clouds were compared with those in the control clouds. Following seeding, the aerial echo coverage showed remarkable increase in two of the four target clouds. The echo intensity increased in three out of the four cases and the height of the echo top increased in all the four. The electrical and microphysical measurements made in the target clouds support the above results.

Ground-based cloud seeding experiments were conducted from June to December 1977 at Cloud Seeding Centre, Tiruvallur, Tamil Nadu.

2.6 Environmental Physics

2.6.1 Studies of atmospheric boundary layer

A two-layer model was developed for the study of a steady state baroclinic boundary layer. The lower layer is the surface boundary layer in which the wind profiles are derived by using the similarity theory and the upper layer is the Ekman layer in which the steady state Ekman equation with a height-dependent pressure gradient is applied. Winds and gradients were matched at the interface of the two layers. An analytical solution using a Green's function was developed for the non-homogeneous Ekman equation. The model incorporated the effect of surface roughness (Z_o) and density stratification through the lower layer (surface layer) and the effect of latitude and baroclinicity, through the equation of motion.

The theoretical wind profile obtained from the model was verified from the wind profiles derived from the observations of the 'Atlantic Tropical Experiment' (ATEX), 1969. A method was developed for obtaining the gradients of scalers given at the ends of an equilateral triangle and was used to obtain the profile of the pressure gradient over the ATEX triangle. The result of the comparison was satisfactory.

The variation of cross isobaric angle α_o and surface stress τ_o, with the angle of the thermal wind β was studied, varying one at a time, the following four parameters: (i) strength of the thermal wind, (ii) latitude of the place, (iii) surface heat flux and (iv) surface roughness z_o. It was found that variations of α_o and τ_o were sinusoidal waves with a phase difference of about 90°. Several other features of those variations were also noted. Observational support was given wherever suitable observations were available.

The study of pressure gradient profiles over different latitudes revealed that they varied non-linearly with the height. The model described above was used to study the shapes of wind profiles when the pressure gradient varied non-linearly with the height.

Studies in upper atmosphere

Investigation of the phenomenon of stratospheric warmings and changes in upper level winds and temperatures, for their possible association with the variation in monsoon activity over India was in progress.

Investigation of calender singularities in Indian rainfall and their association with terrestrial and/or extra-terrestrial phenomenon was in progress.

2.7 Studies in air pollution

To investigate the influence of the atmospheric pollutants on the physical processes governing cloud development and rain-formation, measurement of the concentration of atmospheric gaseous and particulate pollutants at Poona was in progress. Collection of cloud-water and rain-water samples at different places in the neighbourhood of Poona and analysis of the relevant data were also in progress.

Background air pollution measurements were made in February and March 1978 at Tuticorin around the thermal power plant, scheduled for commission in December 1978. The gaseous pollutants comprising of SO_2, NH_3, NO_3 and O_3 and particulate pollutants comprising of Cl, SO_4, NO_3, NH_4, Na, K, Ca and Si were measured. The total dust load in the atmosphere which was also measured, was of the order of about 110 $\mu g/m^3$. The analysis of data was in progress.

2.8 Instruments and Observational Techniques

2.8.1 Meteorological payload for rockets and satellites

A rocket payload using chip circuit as sensing element was fabricated. Results of M-100

rocket flight data were presented in the Space Science Symposium 1978, at Waltair.

It is proposed to test the payload in Menaka II rocket, for routine observations of temperature and wind.

2.8.2 Instruments for boundary layer studies

Two low level sondes were flight-tested. Four 401 MHz transmitters were flight-tested with SR 150 balloons and the signals received. Field tests were made on temperature and wind sensors for scaling their out puts to go with the data acquisition system.

Wind tunnel for simulation of the atmospheric boundary layer

An experiment was conducted to determine the height of the developing boundary layer inside the wind tunnel available at the India Meteorological Department, Pune.

The test section of the model wind tunnel was modified to facilitate velocity profile measurements.

A closed circuit prototype wind tunnel was designed to realise velocity profiles and turbulence intensities for simulation studies of the atmospheric boundary layer. Fabrication of this tunnel is in progress.

2.8.3 Instrumentation for cloud physics and weather modification

Two field mills of alternating and direct current respectively were designed and fabricated. Electronic circuitry for the two field mills is being developed.

Some implications of inductive charge generation process in thunderstorms were identified.

It was found that the inclined electric field in thunder clouds introduced a new source of leakage current.

It was also found that the combined action of the convective and precipitative processes could produce very large electric fields in thunderclouds. However, the electrical forces acting on the charged cloud and precipitation particles cannot be ignored.

It is proposed to develop Instrumentation for measurements of the electrical activity inside clouds. Tethered and free balloons will be used to carry these intruments into the clouds. The studies will be directed towards better understanding of the cause and nature of the cloud electrification.

A vertical wind tunnel to suspend water drops was designed, and was under fabrication. A water droplet generator has been fabricated.

It is proposed to develop simulation techniques to study the microphysical processes occurring in the clouds.

2.9 Theoretical Studies

2.9.1 Studies of Dynamic Instability

a) Combined (barotropic-baroclinic) instability of zonal flow

A quasi-geostrophic model, which allows both vertical and lateral variations of the basic zonal wind and spatial and temporal variations of static stability, was formulated and a multi-layer numerical version of the model was prepared. The results obtained by the model, namely, the wavelength spectrum of unstable disturbances and the structure of unstable disturbances, are being studied.

In order to offset the inherent shortcoming in the eigenvalue method, i.e. the inability of the method to accept and respond to different initial structures of the disturbance, the instability problem was reformulated by an initial value approach. The preliminary experiment performed with a 20-layer pure baroclinic quasi-geostrophic version of the model has shown unstable short waves (wavelengths around 2000 km) with a doubling time of 2.2 days, and long waves (wavelengths around 6000 km) with a doubling time around 1.5 days. The vertical structure of these disturbances has shown an amplitude maximum at the surface in the former case, and a more uniform amplitude distribution in the vertical with a double maxima (one in the lower and the other in the upper tropospheres) in the latter case. Further, the response to the short wave initial perturbation located in the lower troposphere and a longwave initial perturbation located in the upper troposphere were most favourable for the growth of these disturbances. The short wave disturbances did not show vertical

penetration beyond the mid-troposphere, while the long wave disturbances did indicate penetration into the upper troposphere.

It is proposed to test the adiabatic and non-geostrophic instability model with the tropical zonal data. Further development of the model to incorporate non-adiabatic effects under the eigen-value approach will be carried out.

(b) Non-linear barotropic instability of a Rossby wave :

With a view to explaining the periodic nature of the jet and Rossby wave, the non-linear barotropic instability of the propagating Rossby wave in the β -plane was studied by the numerical interaction of the barotropic vorticity equation. It was found that the growth rate of the unstable wave exhibited an oscillation in time. The period of this oscillation is inversely related to the ratio of initial kinetic energy of the perturbation and the basic flow. The period of oscillation was found to be 8.3 days when the above ratio was 1:4, and the amplitude of oscillation 0.605 per day. In this experiment, a westerly jet stream was also observed to form and exhibit the oscillation in time, such that the jet attained the maximum amplitude when the amplitude of the basic Rossby wave was minimum and vice-versa.

A few experiments are planned to determine the role of the surface friction, vertical variation of static stability and the structure of the initial perturbation on the growth of the unstable waves.

2.9.2 Study of dynamic instability of synoptic scale systems in tropic

Cellular cloud patterns with variable eddies have been studied. The results show that different width to height ratios can be achieved as an effect of this variability, and the minimum Rayleigh number, which was obtained as 225, is found to be close to the value 200.

Same eddy concept is introduced in the planetary boundary layer. Thus, the wind velocities are computed which agree fairly well with the experimental data obtained by Dobson.

With the help of the above findings, a scheme of parameterization of mesoscale cellular convection is being developed.

Scattering of smoke in a turbulent atmosphere is on the process of investigation.

2.9.3 Simulation of monsoon and tropical circulations

A barotropic parimitive equation spectral model was integrated for a period of 30 days by using a time step of 60 minutes. The performance of the model was satisfactory for simulating the amplitude and phase velocity of a propagating Rossby-Haurwitz wave of wave number 4. The model was found to have conserved (to a high degree) total energy, enstrophy and angular momentum. Two versions of the model have been developed and compared. The stream-function, velocity potential and geopotential are the basic inputs in the first version, while the three physical parameters-absolute vorticity, divergence and geopotential are in the second. The second one is found to be

computationally more efficient compared to the first.

A numerical experiment was performed to understand the generation and maintenance of the upper tropospheric easterly and the mid-latitude westerly jet stream. It was noted that the Rossby wave of the mid-latitudes was able to generate an easterly jet at 10°N and a westerly jet at 30°N of magnitude approximately 25 m/sec in 5 days time. The simulation of the easterly and westerly jet streams is not completely satisfactory. Further work is in progress.

3.0 New Schemes for Research

Tropical cyclones

Frictional dissipation of kinetic energy, and the generation of 'Available Potential Energy' (APE), by sensible heating in the layer surface to 850 mb were computed for a tropical cyclone in the Arabian sea during 6 to 8 June, 1973. The results showed that the generation and distribution of APE occurred in the eastern and western sectors of the storm respectively. The average generation of APE within the volume of storm was found to be lesser than the dissipation of kinetic energy by friction.

A review of the various objective methods in use, e.g., synoptic-climatological, statistical and dynamical for forecasting the movement of tropical cyclones in the different oceanic basins was prepared. A critical assessment of the performance of different methods for operational use was also made.

Monex Studies

Work was continued to study the formation of depressions in the Bay of Bengal and Arabian sea during the monsoon season. The following preliminary studies are being pursued from the data collected during Indo-Soviet monsoon experiments 1973 (ISMEX-73) and Monsoon-77 :

i) The inter-compatibility of data obtained by the Indian radiosonde stations and the Russian vessels was examined. A study of the moisture field showed the characteristic features of the building up of a moist layer as the monsoon current approaches the Indian coast. Deep moist layer up to 500 mb was found to be established under the influence of synoptic scale disturbances;

ii) The data collected by the Russian research vessels were used to study the convergence of relative vorticity and vertical motion at the centre of the polygon formed by the ships in the first two phases of the experiment. It was seen that in the near equatorial region the convergence, and upward vertical motion in the lower troposphere, were found to occur with negative relative vorticity at several occasions under cloud cluster conditions. However, on these occasions positive relative vorticity was usually found between 800-600 mb. The vertical variation of divergence was also found to change sign more than once in the troposphere. Long wave radiative cooling pattern as computed by a numerical model were also studied in relation to disturbed and undisturbed conditions.

Energetics of southwest monsoon

Study of the energy aspects of the summer monsoon circulation over south Asia was continued

using the daily radiosonde data of July 1963. In this study, the monsoon trough and the monsoon depressions or lows have been considered as standing and transient eddies respectively. The energy terms of the mean flow, the standing eddies and the transient eddies, their conversion terms and the energy flux across the boundary were computed. The generation of available potential energy and the dissipation of kinetic energy were also computed.

The results indicate that there has been positive generation of both zonal and standing eddy available potential energy. This generation has been more than the dissipation of kinetic energy plus the energy advected out of the region under study. It is inferred that this excess energy helps in the maintenance of the monsoon circulation.

3. PUBLICATIONS

3.1 Papers Published in Journals :

Sr. No.	Title	Author(s)	Journal
1.	Available potential energy generation due to sensible heating and frictional dissipation of kinetic energy in an Arabian sea cyclone.	K.D.Prasad and G.B. Pant	Archiv. Fur Met. Geophys. Bioklimat, Sr. A 1978
2.	Airborne electrical and microphysical measurements in clouds in maritime and urban environments.	A.M.Selvam, A.S.R.Murty, S.K. Paul, R.Vijaykumar and Bh.V. Ramana Murty	Atmos. Environment, Vol.11, 1977
3.	Numerical experiment with primitive equation barotropic model using quasi-Lagrangian advective scheme to predict the movement of monsoon depression and tropical cyclone.	S.S. Singh and K.R. Saha	Ind.J.Met. Hydro. Geophys. Jan-April, 1978
4.	Estimation of design storm for Subarnarekha basin upto Chandil and Ghatsila dam sites.	O.N. Dhar, P.R.Rakhecha and B.N. Mandal	Ind.Jour. of Pow. & Riv. Val. Dev., Vol. 27, No.9, Sept. 1977

Sr. No.	Title	Author(s)	Journal
5.	Estimated temperature correction for Menaka II Meteorological Rocket Payload.	K.G.Vernekar and Brij Mohan	Ind.J.Radio & Space Physics Vol.6, Dec. 1977
6.	Relationships between central rainfall and its areal extent for severemost rainstorms of north Indian plains.	O.N. Dhar & B.K. Bhatta-charya	Irri. & Pow. Vol. 34, No.2, April, 1977
7.	Effect of inclination of the electric field on the inductive charging mechanism in thunderclouds.	A.K. Kamra	J. of Atmos.Sc. Vol.34, No.4, April, 1977
8.	On the vorticity budget and vertical velocity distribution associated with the life cycle of monsoon depression.	S.M.Daggupathy and D.R.Sikka	J. of Atmos Sc. Vol.34, No.5, May, 1977
9.	Comments on 'Calculations of electric field growth within a cloud of finite dimensions'.	A.K. Kamra	J. of Atmos. Sc. Vol.34, No.5, May, 1977

Sr. No.	T i t l e	Author(s)	Journal
10.	Characteristics of rain-drop charge and associated electric field in different types of rain.	A.M.Selvam, G.K.Manohar, L.T.Khemani and Bh. V. Ramana Murty	J. of Atmos. Sc. Vol.34, No.11, Nov. 1977
11.	'Reply' to C.P.R. Saunders.	A.K. Kamra	J. of Atmos. Sc. Vol.35, No.1, Jan. 1978
12.	Radar evaluation of the effect of salt seeding on warm maritime cumulus clouds.	R.N.Chatterjee, A.S.R. Murty, K. Krishna and Bh. V. Ramana Murty	J. of Weather Modification, Vol.10, 1978
13.	Some aspects of the life history, structure and movement of monsoon depression.	D.R. Sikka	Pure and Applied Geophysics, Vol.115, 1977
14.	Climatology of five days upper level summer monsoon flow over India and its relationship with rainfall.	S.V. Singh, K.D. Prasad, and D.A. Mooley	Rivista Italiana Di Geopisica E. Science Affini, Vol.4, No.5/6, 1977

Sr. No.	Title	Author(s)	Journal
15.	Scientific and Technological safeguards against air pollution for a happy future - in Hindi. सुखद भविष्य के लिए वैज्ञानिक सावधानियाँ	G.B. Pant and P.N. Sharma	Vaigyanik, a BARC Hindi Quarterly Publication, Vol.9, No.4, 1977

3.2 Papers accepted for Publication in Journals

Sr. No.	Title	Author(s)	Journal
1.	Prediction of 10-day summer monsoon rainfall over India.	S.V. Singh, D.A. Mooley and K.D. Prasad	Archiv. Fur Met. Geophys. Biklimat. 1978
2.	Reply to comments by Prof. Stanley A. Changnon on the paper "Electrical, microphysical measurements in clouds in maritime and urban environments".	A.M. Selvam, A.S.R. Murty, S.K. Paul, R. Vijaykumar and Bh. V. Ramana Murty	Atmos. Environment, Vol.12, 1978
3.	Rainfall distribution over Indian subdivisions during the wettest and driest monsoons of the period 1901 to 1960.	O.N. Dhar, A.K. Kulkarni and G.C. Ghose	Hydro. Sc. Bull. 1978
4.	An analytical study on the barotropic energy conversion in the lower tropospheric monsoonal flow.	S.K. Mishra	Ind.J. Met. Hydro. Geophysics, 1978
5.	Major climatological discontinuities in the monthly monsoon activity in the neighbourhood of the western Ghats.	D.A. Mooley	Ind. J. Met. Hydro. and Geophysics

Sr. No.	T i t l e	Author(s)	Journal
6.	Heavy rainfall stations of India - a brief appraisal.	O.N. Dhar, B.N. Mandal and G.C. Ghose	Ind. Jour. of Pow. & Riv. Val. Dev.
7.	An estimate of spillway design rainstorm for the Betwa basin upto Rajghat dam site.	O.N. Dhar, P.R.Rakhecha and A.K. Kulkarni	J. of Ind. Asso. of Hydrologists, Vol.2, No.1, 1978
8.	Synoptic climatology of the daily 700-mb summer monsoon flow pattern over India.	S.V. Singh, D.A. Mooley and R. H. Kripalani	Monthly Weather Review, 1978
9.	Some features of a long homogeneous series of Indian summer monsoon rainfall.	B. Parthasarathy and D.A. Mooley	Monthly Weather Review, 1978
10.	Climatology of five-day upper level summer monsoon flow over India and its relationship with rainfall.	S.V. Singh, K.D. Prasad and D.A. Mooley	Rivista Italiana Di Geopisica E. Science Affini.

Sr. No.	Title	Author(s)	Journal
11.	Conquest of Kanchanjunga and weather in relation to mountaineering in the Himalayas.	O. N. Dhar	Vayu Mandal.
12.	Cherrapunji breaks the world rainfall record for 4-day duration and a list of heavy rainfall stations of India.	O. N. Dhar	Vayu Mandal.
13.	Summer monsoon rain in India and cyclonic disturbances.	O. N. Dhar	Weather, 1978

4. PARTICIPATION IN SEMINARS/ SYMPOSIA/MEETINGS AND CONTRIBUTION OF PAPERS

4.1 Scientists of the Institute participated in the following Seminars/Symposia/Meetings

Sr. No.	Seminar/Symposium/Meeting	Participant(s)
1.	57th Annual convention (Students' Technical Session) of the Institution of Engineers (India), Chandigarh, April, 8-12, 1977.	Shri S.K. Sharma
2.	Meeting of the Scientific Advisory Committee (SAC) for MONEX-79, Meteorological Office New Delhi, July 1977.	Shri D.R. Sikka
3.	Indo-Soviet symposium on preliminary results of Monsoon-77, Calcutta, August 23, 1977.	Shri D.R. Sikka Dr. D.A. Mooley and Shri R. Suryanarayana
4.	Ninth International Conference on Atmospheric Aerosol, Condensation and Ice Nuclei Ireland, Sept. 21-27, 1977.	Shri L.T.Khemani
5.	Meeting of the Scientific Advisory Committee (SAC) for MONEX-79, Meteorological Office, New Delhi, Oct. 13, 1977.	Shri D.R. Sikka
6.	Meeting of the Scientific Advisory Committee (SAC) for MONEX-79, Meteorological Office, New Delhi, Nov. 4-26, 1977.	Shri D. R. Sikka

Sr. No.	Seminar/Symposium/Meeting	Participant(s)
7.	Seminar on Atmospheric Ozone and Radiation, Pune, Nov. 23-24, 1977.	Dr. G.B. Pant and Shri P.N. Sharma
8.	Ist meeting of 'Committee for Weather Modification Experiments' Meteorological Office, New Delhi, Nov. 28, 1977.	Dr. Bh. V. Ramana Murty
9.	IUTAM/IUGG Symposium on 'Monsoon Dynamics' Indian Institute of Technology, New Delhi, Dec. 5-9, 1977.	S/Shri K. Krishna, D. R. Sikka R. K. Verma S. N. Bavadekar and P.R. Rakhecha
10.	Space Sciences Symposium, Andhra University, Waltair, Jan. 9-12, 1978.	Dr. D.Subrahmanyam and Shri R.K.Gupta
11.	58th Annual Convention (Students' Technical Session) The Institution of Engineers (India), Gauhati, Jan. 13-15, 1978.	Shri S.K. Sharma
12.	8th Conference of Forecasting Officers, India Meteorological Department, Pune, Jan. 16-23, 1978.	S/Shri D.R.Sikka S. S. Singh, S. V. Singh and H. N. Bhalme
13.	Seminar on Weather Forecasting, India Meteorological Society, Bombay, Jan. 24, 1978.	S/Shri D.R. Sikka and S.S. Singh

Sr. No.	Seminar/Symposium/Meeting	Participant(s)
14.	Meeting on the utilisation of oceanographic research vessels for non-living resources, National Institute of Oceanography, Panaji, Feb. 1978.	Shri D. R. Sikka
15.	Probability and Statistical Inference, University of Poona, Feb. 6-9, 1978.	S/Shri R.K.Kapoor S. V. Singh P. N. Sharma H. N. Bhalme P. P. Kamte and K. D. Prasad
16.	13th Annual Convention of the Computer Society of India, Calcutta, Feb. 5-8, 1978.	Shri R. Suryanarayana
17.	International symposium on Arid Zone Research and Development, Jodhpur, Feb. 14-18, 1978.	Shri P.R. Rakhecha
18.	Environmental modelling of physical oceanographic features as applied to Indian ocean, Naval Physical and Oceanographic Laboratory, Cochin, Feb. 23-24, 1978.	Dr. G. B. Pant
19.	Seventh Session of Commission for Atmospheric Sciences (CAS), Manila Philippines, Feb. 27 - March 10, 1978.	Dr. Bh.V. Ramana Murty
20.	Second, Third and Fourth meetings of the Scientific Advisory Committee (MONEX) Delhi, July 5, 1977, Nov.16, 1977 and March 28, 1978 respectively.	Dr. Bh.V. Ramana Murty

4.2 Papers contributed to Seminars/Symposia/ Meetings

(A) 57th Annual convention (Students' Technical Session) of The Institution of Engineers (India), held at Chandigarh, April 8-12, 1977 :

i) Multi-slide coating gadget for measurement of cloud droplet - S. K. Sharma

(B) Symposium on Preliminary Results obtained during Monsoon-77 Experiment held at Calcutta, August 23, 1977.

i) Pressure Gradient - Wind Relationship in Low Latitudes - D. A. Mooley and M. C. Sharma

ii) Computation of Energy Flux and Evaluation of Aerodynamic constant using Monsoon-77 data - R. Suryanarayana

iii) Divergence, vertical motion, vorticity and long wave radiative flux computations over the Arabian sea during phase I and II of Monsoon-77 - D.R. Sikka

iv) A preliminary examination of upper air temperature and humidity data over the Arabian sea along and off the west coast of India during phase II of Monsoon-77 - D.R. Sikka and R. Ananthakrishnan

(C) 9th International Conference on Atmospheric Aerosol, Condensation and Ice nuclei, held at Galway, Ireland, September 21-27, 1977 :

i) Characteristics of atmospheric aerosols and their role in warm rain process - L.T. Khemani, G.A. Momin and Bh.V. Ramana Murty

ii) Chemical composition of cloud water at a hill station - L. T. Khemani, G.A. Momin and Bh.V. Ramana Murty

(D) Seminar on 'Atmospheric Ozone and Radiation' held at Pune, November 23-24, 1977 :

i) Parameterization of longwave radiation in general circulation models : A comparision - G.B. Pant and P.N. Sharma

(E) Symposium on Monsoon Dynamics, held at New Delhi, December 5-9, 1977 :

i) Some aspects of the annual oscillation in the tropospheric temperature in the northern hemisphere - R. K. Verma and D. R. Sikka

ii) Use of the equation of continuity of water vapour for computation of average precipitation over peninsular India during summer monsoon - S.N. Bavadekar and D.A. Mooley

iii) Effect of elevation on monsoon rainfall distribution in the central Himalayas - O. N. Dhar and P. R. Rakhecha

iv) The use of empirical orthogonal functions for rainfall estimates - P.R. Rakhecha and B.N. Mandal

(F) Space Sciences Symposium held at Andhra University, Waltair, January 9-12, 1978 :

i) Dynamics of Tropopause, near a jet-stream - D. Subrahmanyam

(G) 58th Annual Convention of The Institution of Engineers (India), held at Gauhati, January 13-15, 1978 :

i) Design of a photometer for measuring the total precipitable water vapour in the atmosphere - S.K. Sharma

(H) 8th Conference of forecasting officers held at Pune, January 16-23, 1978 :

i) Future long term behaviour of monsoon depressions - H. N. Bhalme

(I) Seminar on 'Probability and statistical inference' held at University of Poona, February 6-9, 1978 :

i) On the statistical design and evaluation techniques of randomized cumulus cloud seeding experiments for rain enhancement - R.K. Kapoor and P.N. Sharma

ii) On the estimation of future monsoon cyclonic activity - H.N. Bhalme

iii) Probability estimates of the extreme rainfall based on stochastic model over Indian region - P. P. Kamte and K.D. Prasad

iv) Prediction of 5-day summer monsoon rainfall over India - some preliminary results - S.V. Singh, D. A. Mooley and K.D. Prasad

(J) International symposium on Arid Zone Research and Development held at Jodhpur, February 14-18, 1978 :

i) On some hydrometeorological aspects of heavy rainfall distribution over the principal arid zone of Rajasthan - P.R. Rakhecha and O.N. Dhar

(K) Symposium on 'Environmental modelling of Physical oceanographic features as applied to Indian Ocean' held at Naval Physical and Oceanographic Laboratory, Cochin, February 23-24, 1978 :

i) Available Potential Energy generation due to sensible heating and frictional dissipation of kinetic energy in an Arabian Sea Cyclone - K. D. Prasad and G. B. Pant

(L) Conference on Meteorology over tropical oceans to be held by the Royal Meteorological Society, London :

i) Barotropic stationary wave instability in the tropics - S. K. Mishra

5. COLLABORATION WITH UNIVERSITIES AND OTHER SCIENTIFIC INSTITUTIONS

5.1 Collaboration with Universities :

(a) The Institute continued to be recognised by the University of Poona as an approved Institution for research in atmospheric sciences, leading to the award of M.Sc. and Ph.D. degrees. It also continued to be recognised as a centre for advanced research in Physics (Meteorology) by the following Universities :

i) Banaras Hindu University, Varanasi,

ii) Nagpur University, Nagpur,

iii) Bombay University, Bombay,

iv) Andhra University, Waltair,

v) Bangalore University, Bangalore,

vi) Kerala University, Trivandrum,

vii) Maharaja Sayajirao University, Baroda.

(b) Shri K. Krishna, S.S.O. (I), was awarded Ph.D. degree in Physics by the Poona University for his thesis entitled, "Studies of the Turbulent Exchange Between the Atmospheric Boundary Layer and the underlying surface".

(c) Prof. M.R. Bhide, Head of the Department of Physics and Prof. V. Gananathan, Head of the Department of Geography, University of Poona, Chairman and Member respectively, of the Recognition Committee (Local Enquiry Committee) appointed by the University of Poona, visited the Institute on August 30.

(d) Three M.Sc. students sponsored by the Statistics and Biometry Department of the Poona University were given practical training in the application of statistics to meteorological problems from 16 May to 15 June.

(e) The following scientists submitted their thesis for the award of Ph.D. degree :

i) Shri S.S. Singh - "Some aspects of prognostic and diagnostic studies of the Indian summer monsoon" submitted to Banaras Hindu University.

ii) Shri S. Rajamani - "Some energy aspects of Indian southwest monsoon" submitted to University of Poona.

5.2 Collaboration with other scientific Institutions:

(a) On invitation from the Indian Institute of Science, Bangalore, Shri D.R. Sikka, S.S.O.I. visited the Centre for Theoretical Studies, in September 1977 to participate in their research programme on southwest monsoon.

(b) On invitation from the India Meteorological Department, Pune, Shri D.R. Sikka, S.S.O.I. delivered a lecture on 'Tropical Wave Disturbances' for the advanced refresher course on tropical waves conducted at Pune during February 1978.

(c) On invitation from the India Meteorological Department, Pune, Shri D.R. Sikka delivered a series of lectures on synoptic meteorology for a period of about 5 months for the advanced training course in meteorology.

Kumari P.G. Kulkarni and Shri B.K. Bandopadhyay, Air India Research Fellows, continued their research study in the Institute.

7. VISITORS

Sr. No.	Particulars	Date of visit
1.	A batch of 18 trainee officers attending the 15th International Post Graduate Course in Hydrology, School of Hydrology, University of Roorkee.	April 2, 1977
2.	Shri C.V.V.S. Rao, Hydrometeorologist, Central Ground Water Board, Sholapur.	April 7
3.	Dr. Harold P. Grout and Dr. Albert Gibbs, World Bank experts in Hydrology.	May 2, 4, 5
4.	Shri Y.P. Rao, D.G.O., Chairman, Governing Council, IITM.	May 23, 24 August 1, 2 November 21, 23 January 17, 1978 March 22
5.	Shri R.P. Naik, Secretary, Ministry of Tourism and Civil Aviation, Government of India/Secretary, Department of Official Languages and Hindi Adviser to the Government of India.	June 4, 1977
6.	S/Shri N.P. Salvi and P.K. Gore, Engineers from the office of the Additional Chief Engineers Irrigation Department, Pune.	July 14, 15

Sr. No.	Particulars	Date of visit
7.	Prof. R. Narasimha, Department of Aeronautical Engineering, Indian Institute of Science, Bangalore and Member G.C., IITM., Pune.	July 19, 22
8.	Prof. M.R. Bhide, Head of the Department of Physics, University of Poona and Prof. V. Gananathan, Head of the Department of Geography, University of Poona.	August 30
9.	A group of Higher Secondary students from Kendriya Vidyalaya, Southern Command, Pune.	September 7
10.	Shri K. Kalyanaraman, Systems Engineer, National Remote Sensing Agency, Secunderabad.	November 19
11.	Dr. Albert E. Gibbs and Dr. George T. Finlinson, Consultant Hydrologic Engineers, World Bank.	December 3
12.	Prof. Takio Murakami, University of Hawaii at Manoa, Honolulu, U.S.A.	December 8

Sr. No.	Particulars	Date of visit
13.	Dr. S.S. Srivastava, Director, Scientific Evaluation (R. and D. Head Quarters), Ministry of Defence and Member, MONEX Committee.	December 15
14.	Dr. D. Cadet, Laboratories de Meteorologie Dynamique, Paris, France.	December 16
15.	Dr. Ray Jeane of the National Centre of Atmospheric Research, Boulder, U.S.A.	December 16
16.	Shri M.K. Tiwari, Indian Space Research Organization, Bangalore.	December 27
17.	A group of M.Sc. (Tech) Geophysics Students accompanied by Prof. Dr. Awadh of the Banaras Hindu University, Varanasi.	December 28
18.	Mr. John O. Adebimpe, Meteorologist, from Nigerian Meteorological Service.	December 29, 30
19.	Dr. K.G. Vohra, Head, Division of Radiological Protection, Bhabha Atomic Research Centre, Bombay.	January 17, 1978

Sr. No.	Particulars	Date of visit
20.	Prof. M.P. Singh, Professor and Head, Department of Mathematics, Indian Institute of Technology, New Delhi.	January 19
21.	Shri S. Babington, Chief Engineer, (Irrigation) Manipur.	February 10
22.	Mr. J. Kastelein, Head, Aeronautical Division, Netherlands Meteorological Service.	March 1
23.	A batch of Nine Officers and one Instructor from Administrative College, Coimbatore.	March 3,4,6,7
24.	Two batches of trainee officers from participants in the 6th International Post-Graduate course in Hydrology, University of Roorkee.	March 9, 17
25.	Dr. P.K. Das, Deputy Director General of Observatories (Scientific Services and Administration), New Delhi.	March 19-20

8. GENERAL

8.1 The Governing Council

The Management of the Institute is vested in a Governing Council which consists of nine members including the Director of the Institute. List of members is given in Appendix I.

From January 1, 1977, the duties and functions of the Director are being performed temporarily by the Chairman, Governing Council, Indian Institute of Tropical Meteorology, on retirement on superannuation of Dr. K.R. Saha, Director.

8.2 Facilities

8.2.1 Library, Information and Publication

This Division has been responsible for rendering necessary supporting facilities like dissemination of information, preparation of photo-copies of documents/journals, publication of Research Reports and allied materials, preparation of necessary tracings, diagrams, charts, etc. to help the Institute employees in their pursuit of research. With the introduction of "Current Awareness Service" as a first step towards documentation, the scientific staff were always kept abreast of the latest developments in their respective fields through literature surveys. Proven techniques of Information Science were applied to the "Information Cell" in the Institute Library. While 218 books of current interest in the meteorological and allied fields were added, fifty journals of national and international standing were subscribed to.

In an effort to cater to the dynamic and growing needs of the research staff for the latest literature in their respective fields which may not be readily available in the Institute, inter-library loans were arranged through the courtesy and co-operation of a number of research libraries in and

around Pune.

The following institutions/organisations extended a helping hand in rendering inter-library loan facilities :

i) University of Poona,

ii) National Chemical Laboratory, Pune,

iii) India Meteorological Department, Pune,

iv) Gokhale Institute of Economics and Politics, Pune,

v) Deccan College, Pune,

vi) Maharashtra Association for Cultivation of Sciences, Pune and

vii) Central Water and Power Research Station, Pune.

Apart from those named above, the Institute continued to have exchange facilities with the libraries of the following research organisations :

i) Tata Institute of Fundamental Research, Bombay,

ii) Indian Institute of Geomagnetion, Bombay, and

iii) Indian Institute of Science, Bangalore.

Proceedings of the "Symposium on Tropical Monsoons, Pune, September 8-12, 1976" brought out last year as a priced publication by the Institute, received good response and wide appreciation from the interested scientists in India and abroad. While 99 copies were sold, 42 copies were distributed to different parties as complimentary ones.

The Division continued to maintain liaison with the other research organisations/universities o for exploring areas of mutual interest. The Division extended its whole-hearted support and co-operation to national/international projects in building up comprehensive data banks for the use of scientists and scientific workers all over the World

Collected reprint volumes for 1975 and 1976 containing papers published by the Institute Scientists in different journals were compiled and distributed as per the standing Mailing list. Members of the scientific staff were rendered necessary assistance in getting themselves registered for admission to M.Sc. and Ph.D. courses (by research) of different Indian Universities.

There has been a major overhaul in the procedures so far being followed in the library in respect of issue of books, journals and other publications, annual physical stock verification/procurement of books/journals etc. on payment as well as on exchange basis and display of reading materials. While the objective is to provide as much help and assistance to the scientific staff as is feasible, in order to improve upon the existing facilities, it is envisaged to undertake the following projects in the near future.

i) Compilation and publication of an uptodate revised edition of "Papers published by Institute Scientists";

ii) Publication of pending Research Reports;

iii) Classification, catalogueing and indexing;

iv) Publication of monthly 'News Index' containing news about current research going on in India and abroad in meteorological and allied fields;

v) Documentation and information;

vi) Translation facilities.

8.2.2 The IBM 1620 Computer worked during the years as follows :

	Hrs.	Mts.
Internal Data Processing	2079	50
Data Processing of I.M.D.	992	25
Break Down/Maintenance	149	55
Paying Users	125	50

Twelve special night-runs of computer were arranged during the year for urgent processing of data from the Deputy Director General of Observatories (Climatology & Geo-Physics), Pune.

The IBM 1620 Computer is being run in a single shift with effect from March 1.

8.2.3 Training

8.2.3.1 Kum. A.H. Master and Shri T.K. Saha, Senior Scientific Assistants completed the Advanced Training Course in Meteorology conducted by the India Meteorological Department, Pune.

Shri P.D. Ubale, Smt. U.V. Bhide and Shri U.P. Raibole, Senior Scientific Assistants have been deputed to undergo Intermediate/Advanced Training Courses in Meteorology at the India Meteorological Department, Pune.

8.2.3.2

(a) Dr. A.K. Kamra, SSO-I, visited the National Balloon Facility, TIFR Hyderabad, from 14-18 June 1977.

(b) Shri L.K. Sadani, JSO, was on tour to Mahabaleshwar from 22-30 August, 1977 for field studies.

(c) Shri K.G. Vernekar, SSO-I, visited the National Balloon Facility, TIFR Hyderabad, during 2-4 February, 1978.

(d) Shri R. Suryanarayana, SSO-I, was on tour to New Delhi from 24-28 October and from 3-28 December in connection with the data processing work of the "MONSOON-77" project.

(e) Dr. D.A. Mooley, Assistant Director was on tour to "Monsoon-77 Experiment Centre, New Delhi" for a total period of 5 months from May 77 to February 78 for analysis of charts prepared during the experiment period and for preliminary study of some problems utilising the data collected during the experiment.

8.3 Awards

8.3.1 A silver medal, a citation and two books were awarded to Shri S.K. Sharma, Mechanic Gr.I for his paper "Multi-slide coating gadget for measurement of cloud droplet" which was adjudged as the third best in the students' technical session at the 57th Annual Convention of The Institution of Engineers, (India) 8-12 April, 1977.

8.4 Important staff changes

8.4.1 Appointments and promotions

8.4.1.1 Appointments

(a) Dr. G.B. Pant, assumed charge as Senior Scientific Officer, Grade I, with effect from May 11, 1977.

(b) Shri A.B. Mazumdar, assumed charge as Junior Scientific Officer with effect from July 23, 1977.

8.4.1.2 Promotions

(a) Shri V.T. Ranpise, Mechanic Grade I and Shri A.S. Gade, Draughtsman were promoted to the grade of Mechanical Assistant and Senior Draughtsman with effect from June 10, 1977 and August 1, 1977 respectively.

(b) Smt. S.J. Mane, Lower Division Clerk was promoted to the grade of Upper Division Clerk with effect from December 6, 1977 (F/N).

8.4.1.3 Deputation

Dr. G.C. Asnani, Assistant Director was on deputation on WMO assignment in the University of Nairobi, Kenya upto December 31, 1977.

8.4.2 Pool Officers of the C.S.I.R.

(a) Dr. N. Ramanathan, was attached as a Pool Officer from July 14, 1977 to February 4, 1978.

(b) Dr. Murari Lal, was attached as a Pool Officer from September 13 to December 12, 1977.

8.4.3 Apprentice trainees

Under the Apprenticeship Scheme, four apprentices in commercial trade were engaged at the Institute during the year. Two apprentices were already undergoing training in the Institute. Out of the total strength of six, three apprentices continued to be trained.

8.4.4 Shri C. Muthuvel, Institute Research Fellow, continued his research study in the Institute.

8.4.5 Relief

8.4.5.1 Officers' Relief

a) Shri T.K. Kamble, Junior Scientific Officer was relieved on August 1, 1977 (F/N),

b) Shri A.B. Mazumdar, Junior Scientific Officer was relieved on October 15, 1977 (F/N),

c) Shri A.T. Desai, Purchase and Stores Officer was allowed to revert to his parent department, Central Water and Power Research Station, Pune, on completion of his two-year period of foreign service at the Institute on March 10, 1978 (F/N).

8.4.5.2 Voluntary Retirement

Shri K. Raghavan, Senior Scientific Assistant and Dr. G.C. Asnani, Assistant Director were allowed to proceed on voluntary retirement from the service of the Institute with effect from August 24 and December 31 respectively.

8.5 Important Meetings

a) Dr. Bh.V. Ramana Murty, Assistant Director participated in the discussion on connection with the formulation of the First Five Year Plan (under the rolling plan concept) of the Institute, held at New Delhi from October 11-16, 1977.

b) The Chairman, Governing Council, attended the meeting of the working group on Meteorology, at the Ministry of Tourism and Civil Aviation, New Delhi, held on October 24, 1977 for discussions pertaining to the Institute's Five Year Plan (1978-83).

c) Chairman, Governing Council, attended the meeting of the Planning Commission, New Delhi, on November 26, 1977, for discussion on the Institute's Annual Plan Proposals (1978-79).

d) The Fourteenth Meeting of the Governing Council of the Institute was held at New Delhi on December, 28, 1977, in the Office of the Director General of Observatories, New Delhi.

e) Dr. Bh. V. Ramana Murty, Assistant Director was the Indian delegate to attend the 7th Session of the W.M.O. Commission for Atmospheric Sciences held in Manila (Philippines) from February 27 to March 10, 1978.

8.6.1 Budget, Accounts and Audit

The Institute received from Government of India grants totalling Rs. 39,77,614/- including the unspent balance of the previous year, other receipts like computer charges, interest on fixed deposit, interest on Advance etc. Out of this, an amount of Rs. 34,43,531/- approximately was spent during the year 1977-78.

Audit of the Institute's accounts for the year 1976-77 was conducted by M/s Kirtane and Pandit, Pune.

8.6.2 Building Construction

The Institute, at present, is housed in five different buildings which are separated from each other at considerable distances. The space of 26134 Sq. ft. available in all five buildings is totally inadequate to meet the requirements of even the existing staff.

The Government of India had approved in 1972 the proposal for the construction of office buildings and staff quarters for the Institute. The Fifth Plan provided for an allocation of Rs. 35/- lakhs for the Institute's building (Functional Laboratories). This provision was found to be inadequate as the estimates of cost prepared by the Central Public Works Department in 1977-78 were to the tune of Rs. 51/- lakhs.

It is proposed to provide Rs. 55/- lakhs during Plan period (1978-83) for office buildings on the Institute land at Pashan, Pune. This provision is expected to meet the minimum space requirements of the Institute to the tune of 35628 Sq. ft.

It is also proposed to construct a total of 194 quarters of Types I to V spread over two phases. The total expenditure on staff quarter during the 2 phases is estimated at Rs. 80/- lakhs.

An amount of Rs. 30/- lakhs has been deposited with the C.P.W.D. as the first instalment.

8.7 Celebration of W.M.O. day

Dr. D.A. Mooley, Assistant Director gave a talk in Marathi on "Meteorology and Research for future" from A.I.R. Pune on 22 March and wrote an article in Marathi on "Meteorology and research for future". The article was published in "Sakal", a local Marathi daily.

8.8 Staff welfare

The first meeting of the Board of Trustees, Indian Institute of Tropical Meteorology Employees' Provident Fund was held on 23rd November 1977. The Employees' Provident Fund was established with effect from 23rd November, 1977.

APPENDIX-I

Names and Addresses of Members of Governing Council, Indian Institute of Tropical Meteorology, Pune.

1. Shri Y. P. Rao, Director General of Observatories, C/o The Observatory, Lodi Road, New Delhi-110 003. — Chairman (Ex-officio)

2. Dr. P. K. Das, Deputy Director General of Observatories, (S.S. and A.), C/o The Observatory, Lodi Road, New Delhi-110 003. — Member

3. Prof. R. Narasimha, Indian Institute of Science, Department of Aeronautical Engineering, Bangalore-560 003. — Member

4. Shri P.R. Krishna Rao, Retired D.G.O., No.70, Gayatri Devi Park Extension, Bangalore-560 003. — Member

5. Shri C.M. Chaturvedi, Joint Secretary, Min. of Tourism and Civil Aviation, Sardar Patel Bhavan, Parliament Street, New Delhi-110001. — Member

6. Dr. Hari Narain, Director, National Geophysical Research Institute, Hyderabad-7. — Member

7. Dr. D. Lal, Director, Physical Research Laboratory, Ahmedabad-380 009. — Member

8. Shri C.K. Vohra, Under Secretary (Finance), Ministry of Finance, C/o The Observatory, Lodi Road, New Delhi-110003. — Member

APPENDIX-II

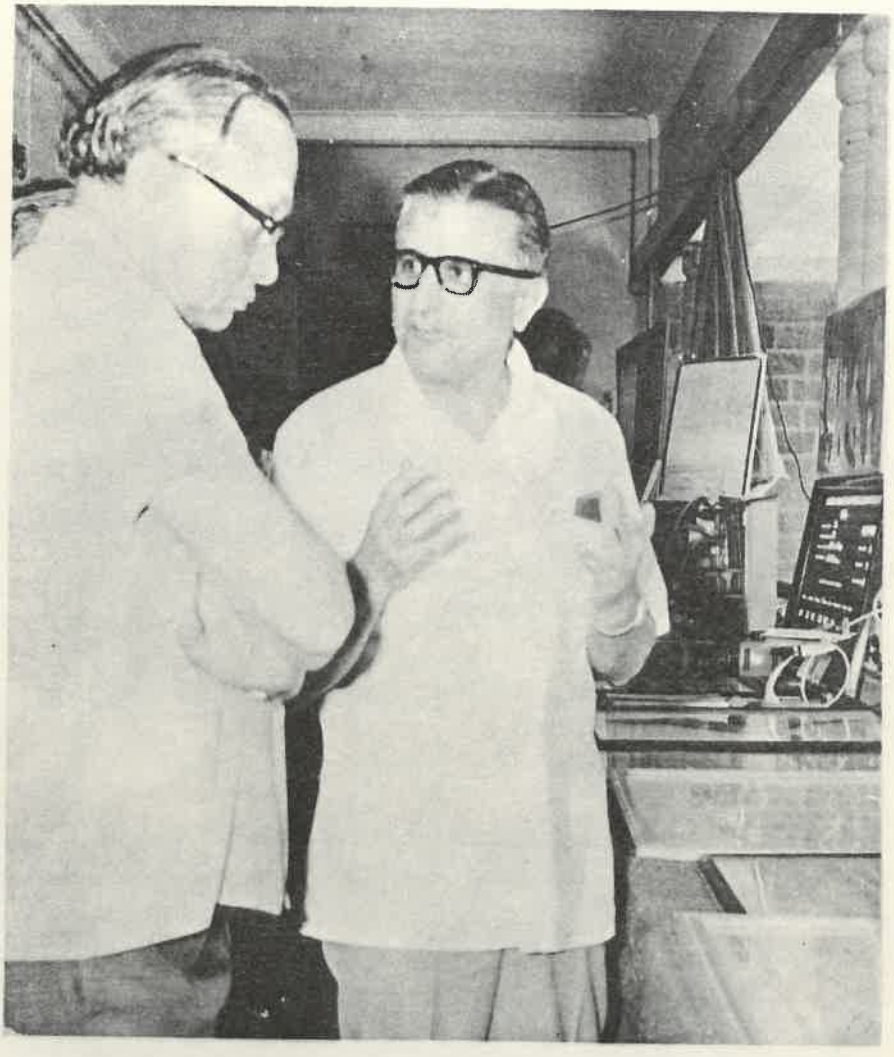
(a) Research Scientists as on 31st March, 1978 :

Assistant Directors:		Dr. Bh.V. Ramana Murty, M.Sc., Ph.D. Dr. O.N. Dhar, M.Sc., Ph.D. Dr. D.A. Mooley, M.Sc., Ph.D.
Senior Scientific Officers, Grade I	:	Shri R. Suryanarayana, M.Sc. Shri D.R. Sikka, M.Sc. Shri R.K. Kapoor, M.A. (Maths) Dr. K.Krishna, M.A. (Econ.), M.A. (Maths), Ph.D. Dr. A.K. Kamra, M.Sc., Ph.D. Shri S.K. Mishra, M.Sc. Dr.(Miss) Durga Ray, M.Sc., Ph.D. Shri K.G. Vernekar, M.Sc. Shri S.S. Singh, M.Sc. Dr. R.V. Godbole, M.Sc., M.S., Ph.D.
Senior Technical Officer, Grade I	:	Shri D. Bhattacharya, B.Sc. (Hons), B.C.E.
Senior Scientific Officers, Grade II	:	Dr. A.S.R. Murty, M.Sc. (Tech)., Ph.D. Shri R.N. Chatterjee, M.Sc. (Tech.) Shri S. Sinha, M.Sc. Shri H.N. Bhalme, M.Sc. Shri Shyamvir Singh, M.Sc. Shri P.N. Sharma, M.A.Grad. I.T.E. Dr. (Mrs.) A.M. Selvam, M.Sc., Ph.D. Shri S. Rajamani, M.Sc. Shri R.K. Verma, M.Sc. Dr. D. Subrahmanyam, M.Sc.(Tech.), Ph.D.

Junior Scientific Officers	:	Shri R.K. Gupta, M.Sc. Shri S. Sivaramakrishnan, M.Sc. Shri L.K. Sadani, M.Sc. Shri B. Parthasarathy, M.Sc. (Tech.) Shri S.N. Bavadekar, M.Sc. Shri P.P. Kamte, M.Sc. Dr. A.C. Mahanti, M.Sc., D.I.I.T., Ph.D. Shri D.K. Paul, M.Sc. Shri R.N. Sengupta, M.Tech. Shri P.R. Rakhecha, M.Sc. Shri S.T. Awade, M.Sc. Shri L.T. Khemani, M.Sc. Shri S. Chaudhari, M. Tech.

(b) Administrative Officers :

Administrative Officer	:	Shri D.W. Kshirsagar, M.A., M.Com. LL.B.
Accounts Officer	:	Shri A.N. Limaye, M.A.
Purchase and Stores Officer	:	Shri A.T. Desai, D.C.E. Upto March 10, 1978



Dr. O.N. Dhar, Assistant Director,
explaining an exhibit.