Science in the Indian Institute of Tropical Meteorology
A 25 Year Profile

(1962 -1987)

SCIENCE IN THE INDIAN INSTITUTE OF TROPICAL METEOROLOGY

A 25-YEAR PROFILE

CHAPTER 1

1. BRIEF HISTORY

1.1 Establishment of the Institute

The Indian Institute of Tropical Meteorology (IITM), known at its inception as the Institute of Tropical Meteorology (ITM), was established at Pune, as a distinct unit of the India Meteorological Department (IMD), on 17 November 1962, when its first Director took over charge. The establishment of the Institute was an important land-mark in the growth of meteorology in India. Till then meteorological research in India, was pursued by the officers of the IMD on their own initiative, in addition to their normal service functions, following the traditions set up by the early pioneers of Indian Meteorology. Soon after Independence, the tempo of all-round national developmental activities began to accelerate and the IMD had to concentrate its attention on the problems of modernising the weather service to meet the challenging and increasing demands. Faced with such a situation, the IMD soon recognized the need for the setting up of an exclusive research unit, supported by adequate infra-structure, with the objective of pursuing research in Physical and Dynamical understanding of the atmospheric processes. It was an opportune time for meteorology, as the Science had entered into a new phase of rapid development within a decade of the Second World War. Numerical Weather Prediction (NWP) with the use of fast computers had become a reality in the 1950's. The introduction of weather satellites towards the end of the 1950's imparted a new dimension to global meteorology. Internationally, it was realised that an understanding of the meteorological processes in the tropics was very vital

for the development of the forecasting techniques. In 1959, the Third Congress of the World Meteorological Organisation (WMO) took an important step in recommending the establishment of Meteorological Research Centres in the countries situated in the tropical belt to tackle the problems peculiar to the region.

It is with the above background, that the Director General of Observatories initiated a proposal in 1959 for the establishment of a National Institute of Meteorology under the wings of the IMD. The primary objective was to provide an academic environment for the atmospheric scientists "Where scientific advances in tune with the needs of the times are made in the fast developing field of Meteorology". The IMD therefore, submitted a scheme in June 1961 to the Government of India for the establishment of the Institute under its Third Five-Year plan proposal. The proposal was approved by the Government in February 1962. It was decided to locate the Institute at Pune, where a number of technical and scientific units of the IMD were already functioning. To begin with, the Institute was established as a Special Fund Project of the United Nations Development Programme (UNDP). With this, India took a major stride in the matter of organised research in Tropical Meteorology.

The Institute was conceived to meet the National requirements for research in Tropical Meteorology in general, and Monsoons in particular. It was also emphasised that the Institute would "Serve Regional and International requirements as well" through imparting training, exchange of information and visiting scientist programmes.

The perspectives and the scientific activities of the Institute were oriented towards achieving fundamental understanding of the atmospheric processes in the tropical region, which are distinct from those in the higher latitudes. Over the years, the Institute has strived to fulfil these objectives

by organising inter-disciplinary research towards understanding the fundamental atmospheric processes controlling the weather and climate with orientation towards practical application for service to the public. It has also made continuous effort to provide a stimulating environment where the freedom of the individual researcher is also preserved within the framework of the research Institute.

1.2 Major Developments in the IITM during 1962-70

1.2.1 Establishment of Divisions

The establishment of the Institute coincided with the beginning of a major International effort under the International Indian Ocean Expedition (IIOE) Programme aimed at gaining more complete information about the meteorological and oceanographic processes of the Indian Ocean, which has been the least explored. India played a host to the meteorology programme of the IIOE, when the International Meteorological Centre (IMC) was set up at Bombay on 1st January 1963. IMC functioned as a special division of the Institute during its existence over the period 1963-66.

Six divisions of the Institute were established at Pune in a phased manner as follows :

S.No.	Division	Year in which established
1.	Forecasting Research	1964
2.	Climatology and Hydrometeorology	1964
3.	Physical Meteorology and Aerology	1966
4.	Instruments and Observational Techniques	1966
5.	Training	1968
6.	Library, Information and Publication	1968

In 1967, the Rain and Cloud Physics Research Centre (RCPRC) of the National Physical Laboratory, New Delhi, which

had been functioning since 1955, was transferred by the Council of Scientific and Industrial Research (CSIR) to the Institute. The scientific activities of the RCPR Centre were in the area of Cloud Physics and Weather Modification. As such, these activities were merged with the functions of the Physical Meteorology & Aerology Division of the Institute.

During the first 5 years of the establishment of the Institute, it received substantial financial support from the UNDP. Several scientists of the Institute were sent abroad for familiarisation in the developing disciplines of atmospheric research. Also several foreign experts visited the Institute for extended periods of time.

1.2.2 Field Observational Programme

The Institute also started a tradition of organising field experimental programmes aimed at tackling the specific research problems with the help of an array of advanced experimental facilities. The following field experiments were carried out during the period :

1. Meso-Meteorological experiment around Pune (May-July 1963)
2. Participation in research aircraft facilities under the IIOE programme (1963-65)
3. Effect of Palghat gap on the monsoon wind flow (September-October 1966)
4. Measurement of environmental physical parameters on the western ghats (1969).

1.2.3 Highlights of Scientific Activities During 1963-70

The Institute had started functioning in a building known as Ramdurg House, which is in the neighbourhood of the Meteorological Offices, Pune. Foreseeing the rapid growth of the

Institute, the then Director of the Institute, Professor P.R. Pisharoty, took early steps to acquire land for the permanent buildings of the Institute. Government of Maharashtra readily agreed to the request of the Institute and allocated in 1965 over 81 acres of land at Pashan in the neighbourhood of the National Chemical Laboratory.

During this initial period the Institute acquired trained scientific personnel, established research facilities and mobilised requisite infrastructures. Its scientific achievements were also substantial and its scientific publications numbered about 100. Three of its scientists received National awards and five scientists obtained their Ph.D. degree. It also acquired the first electronic computer, IBM-1620, in 1963 and could thus launch its activities in data processing and applications of Computers to meteorology in India. It also, for the first time in the country, organised research in Numerical Weather Prediction for which the Computer facilities available at the Tata Institute of Fundamental Research (TIFR) were used. An important piece of work accomplished with the Computer related to the development of dynamical model for the orographic rainfall of the Bombay-Pune region in the Western Ghats.

The above mentioned few developments indicate that the Institute had passed through the take-off stage and had received a recognition from the scientific community on the National Research Scene. It was thus ready to enter into the next phase of development.

1.3 Institute as an Autonomous Body and its Objectives

Following the recommendations of the Committee for the Organisation of Scientific Research (COSAR), appointed by the Prime Minister, the Institute went through a major organisational change on 1st April 1971, when it was converted into an autonomous body. The Institute was then re-designated as the Indian Institute of Tropical Meteorology.

The following objectives were set forth by the Government of India while granting autonomous status to the Institute :

OBJECTIVES

1. to promote, guide and conduct research in the field of Meteorology in all its aspects, including Weather Modification, with special reference to the tropics and sub-tropics.

2. to establish, maintain and manage laboratories, workshops and/or other units to assist scientific research in Meteorology.

3. to conduct field experiments connected with the activities of the Institute.

4. to undertake the design, development and construction of special meteorological instruments for research.

5. to organise training facilities for advanced study and research in Meteorology, and arrange lectures, seminars and symposia in pursuance of the academic work of the Institute and for the diffusion of scientific knowledge.

6. to invite scientists from India and abroad, who are actively engaged in research in Meteorology, to deliver lectures and participate in the research activities of the Institute.

7. to institute and award fellowships, scholarships prizes and medals.

8. to co-operate and collaborate with other national and/or foreign institutions and international organisations in the field of Meteorology and allied sciences.

9. to publish the results of research conducted in the Institute.

10. to disseminate information on matters concerning the activities of the Institute.

11. to take over the present works and functions of the Institute of Tropical Meteorology, Poona including those of the Rain and Cloud Physics Research Unit, at New Delhi, and acquire all their assets and liabilities, rights and obligations and duties and functions.

12. to acquire by gift, purchase, exchange, lease, hire or otherwise howsoever any property, movable and/or immovable and to construct, improve, alter, demolish or repair buildings, works and constructions as may be necessary or convenient for carrying on the activities of the Institute.

The Institute was registered as a Society under the Socities Registration Act, and as a Public trust under the Bombay Public Trusts Act, 1950.

As a result of autonomy certain changes were introduced in the Institute which are briefly discussed below.

1.3.1 Governing Council of the Institute

To administer and manage the Institute at the apex level, the Governing Council was constituted. The Council now consists of the following members :

1.	Director General of Meteorology	Ex-officio Chairman
2.	Addl. Director General of Meteorology	Member
3.	Representative of the Administrative Ministry	Member
4.	Financial Adviser attached to the Administrative Ministry	Member

5-8	Four Scientist members to be nominated by the Central Government in consultation with the Director	Members
9.	Director, Indian Institute of Tropical Meteorology.	Ex-officio Member

The Council is reconstituted biannually.

Since 1971 the Chairmanship of the Council, which is ex-officio, has been held by five eminent scientists who have headed the IMD.

1.3.2 Academic Council

In 1972 the Governing Council of the Institute approved formation of the Academic Council consisting of the Director as Chairman, all Assistant Directors and the Senior Scientific Officers Gr.I as members. The functions of the Academic Council are :

1. To advise the Director on all matters relating to scientific projects of the Institute and

2. to ensure team work and team spirit inside the Institute for achieving its aims and objectives.

Since its inception the Academic Council held 115 meetings till September 1988. It has been meeting regularly once a month since 1987.

1.3.3 Staff Council

In 1972 the Governing Council of the Institute also constituted the Staff Council, consisting of two elected members from amongst each of the four categories of employees with Director as its ex-officio Chairman. The objectives of the Staff Council are :

1. To promote harmonious relations and

2. to secure greatest measure of co-operation between the Institute in its capacity as employer and the general body of its employees in matters of common concern and increasing efficiency.

The term of Staff Council is for a period of two years and it is re-elected thereafter. Since 1987 the 7th staff council is ~~presently~~ functioning and has been holding a meeting once every month.

1.4 Organisational Changes Following Autonomy

1.4.1 Conversion of Training Division to Theoretical Studies Division

Soon after autonomy in 1971 the Governing Council converted the Division of Training into the Division of Theoretical Studies. This change no doubt gave a fillip to the advancement of theoretical meteorology in the Institute. However, it did affect its promised role to act as a body involved in promoting higher education in atmospheric sciences in the country. It also affected the training of its own scientific manpower as the focus on training got diluted. The Institute has, however, over the years, established close contacts with the Universities and other Academic Institutions through exchange visits of scientists, exchange of data and other information and provision for experimental support.

During the last few years several Universities have approached the Institute for providing teaching support for their M.Sc. and M.Tech. courses. Also, the Institute has felt the need for human resource development programme to meet its own requirements for trained scientific manpower and to extend the support at the National level to other Universities and Academic Institutions. For this purpose, a scheme is being proposed under the 8th Five year plan to create a unit for "Human Resource Development, Training and Planning".

1.4.2 Introduction of Research areas and Projects

In 1976 the Institute chalked out well defined research programmes within the areas of each of its scientific division as a long-term plan of investigations into different aspects of atmospheric sciences. The areas of research presently being pursued in different divisions are :

Area	Division
Numerical Weather Prediction	Forecasting Research
Extended Range Prediction	Forecasting Research
MONEX Studies	Forecasting Research
Climate and Climatic Change	Climatology and Hydrometeorology
Hydrometeorological Studies	Climatology and Hydrometeorology
Cloud Physics and Weather Modification	Physical Meteorology and and Aerology
Environmental Physics	Physical Meteorology and Aerology
Development of Meteorological Payloads for Rockets	Instruments and Observational Teachniques
Development of Instruments for Boundary Layer Studies	Instruments and Observational Techniques
Development of Instruments for Atmospheric Electricity	Instruments and Observational Techniques
Studies of Dynamic Instability	Theoretical Studies
Simulation of Monsoons and Tropical Circulation Systems	Theoretical Studies.

The research projects in each area are listed in Enclosure-I.

1.4.3 Changes in Organisational Structure

With the autonomy it also became necessary for the Institute to have adequate Management support for running the administrative and financial functions of the Institute. For this purpose Administrative Section, Accounts Section and a Purchase and Stores Unit have been created.

Till the end of 1984 the Institute functioned under the Ministry of Tourism & Civil Aviation. It was transferred to the Department of Science & Technology with effect from 31st December 1984. This change has been beneficial to the scientific growth of the Institute as since then it has been involved with the developments of major national programmes in Atmospheric Sciences. The Institute has been identified as an S&T Institute by the Science Advisory Committee to the Cabinet. In 1987, with the acquisition of a ND-560 Computer System and also to meet the demands of data acquisition, processing and storage, the earlier computer unit has been upgraded into the "Computer and Data Division".

A field research Unit, of the Institute under Prof. Anna Mani, as Scientist-in-charge, has been functioning at Bangalore since 1979. The present organisational structure of the Institute is shown in Enclosure-II.

1.4.4 Implementation of the Institute's Buildings Programme

Even though the land for the permanent buildings was acquired in 1965 no progress could be made in the direction due to paucity of funds. In the Sixth five-year plan the Institute made a significant progress in this direction, when in 1979, the foundation stone of the Institute's office building was laid. The first phase of the building was ready in 1982 and four of its divisions viz., Forecasting Research, Physical Meteorology

and Aerology, Instruments and Observational Techniques and the Library, Information and Publication started functioning in the Pashan complex of the Institute. Also 64 residential quarters have been constructed and allotted to the staff members of different grades. The second phase of the Institute's building began under the seventh Five-year plan scheme and has been making progress. It is hoped that the Building Programme of the Institute would be completed in the 8th Five-year Plan period.

CHAPTER 2

2. ASSESSMENT OF THE INSTITUTE'S RESEARCH TOWARDS FULFILLMENT OF ITS OBJECTIVES

2.1 Research Work

As already mentioned, the research work of the Institute is carried out within its scientific divisions and is organised under broad areas as a part of the Institute's long-term scientific plan of work. Each of the area has one or more than one project. Table 1 gives the summary of the application oriented research carried out under different areas during 1976-1987. These research results are being presented at the meetings of the Research Applications Group, jointly constituted by the IMD and the IITM.

Table 1

Application oriented research carried out in different areas

S.No. (1)	Area (2)	Application Oriented Results (3)
1.	Numerical Weather Prediction (NWP)	i) A forecast system based on NWP consisting of objective analysis schemes, barotropic and multilevel P.E. regional forecast models developed and tested.
2.	Extended Range Prediction	i) Regression equation models for medium range forecasting of rainfall on subdivisional basis developed. This technique was tested in operations;
		ii) Stochastic models for prediction of rainfall developed;
		iii) Synoptic climatology for forecasting based on pattern correlations developed;

Table 1 Contd.

(1)	(2)	(3)
		iv) Predictors for long range forecasting (LRF) identified and regression equations for LRF developed. Forecasts based on this method are being supplied to IMD since 1979;
		v) Planetary and regional scale connections for explaining inter-annual variability of monsoon identified.
3.	Monex Studies	i) Identification of 30-50 day mode of oscillation in the monsoon and its exploration for the potential for prediction of major epochs in monsoon activity;
		ii) Categorisation of weather charts for monsoon forecasting on the basis of synoptic analogues. The technique was tested in operations and found useful by the IMD.
4.	Short Range Prediction	i) Energetics of monsoon disturbances have been studied for understanding the mechanisms of energy conversion.
5.	Climate and Climatic Change	i) Preparation of homogeneous series of monsoon rainfall on sub-divisional and district-wise basis;
		ii) Drought Area Index (DAI) and Flood Area Index (FAI) series for India made. Flood area events are found to occur in the 22-year double (Hale) sunspot cycle;
		iii) Teleconnections of the Indian monsoon with EL NINO events in the Pacific and southern oscillations documented;

Table 1 Contd.

(1)	(2)	(3)
		iv) Use of upper tropospheric and stratospheric circulations based predictors in long range forecasting of monsoon suggested.
6.	Studies in Palaeo-climatology	i) Signatures of climate fluctuations in growth of tree rings identified using samples collected from different forest belts of India;
		ii) Impact of large scale droughts on the Indian economy quantified;
		iii) Chronology of drought years over India for the past 200 years built from historical records.
7.	Hydrometeorological Studies	i) Results of a large number of investigations of this project have been extensively used by dam design/irrigation/World Bank engineers. A few of them are listed below for illustration purpose. a) Systematic design rain storm studies conducted for river basins in India and depth area duration for major storms computed; b) Probable maximum precipitation (PMP) values for large number of Indian stations (about 2000) computed. Generalised PMP charts for different parts of India prepared; c) Highest 1-day observed rainfall for different stations determined.
		ii) Technical guidance for the estimation of design storm rain depth provided to several State Governments and agencies.
8.	Cloud Physics and Weather Modification	i) Warm cloud modification technique for increasing rainfall has been developed. Its efficacy has been established through cloud physical measurements.

Table 1 Contd.

(1)	(2)	(3)
		ii) A new numerical simulation technique for identifying regions suitable for conducting weather modification experiments developed and tested;
		iii) Assistance rendered to several state Governments in their cloud seeding operations;
		iv) Dynamic effect of salt seeding in warm clouds identified;
		v) New observations on the micro-physical and dynamical characteristics of monsoon clouds from extensive aircraft measurements obtained. New-Charge generation mechanism in monsoon clouds also identified from aircraft observations.
9.	Environmental Physics	i) Stratospheric warming events in tropics during winter and summer identified for the first time. They may have applications in understanding stratospheric dynamics and association with the performance of seasonal monsoon
		ii) Association of QBO in the stratospheric zonal wind with the performance of monsoon rains suggested;
		iii) Extensive precipitation chemistry measurements suggest no evidence of acid rain in India on a large scale This is due to the presence of atmospheric particulates of alkalin nature, which neutralise the acidic particles resulting from industrial effluents;
		iv) Urban effects on weather and climate documented.

Table 1 Contd.

(1)	(2)	(3)
10.	Development of meteorological payload for rockets and satellites	i) Different versions of rocket payload for measurement of temperature in the upper atmosphere developed, integrated with the launch operations and tested.
11.	Development of instruments for boundary layer studies	i) Special instruments for making heat, measurements of fluxes of ~~temperature,~~ moisture and momentum in the atmospheric boundary layer were developed and used for measurements under different environmental conditions.
12.	Instrumentation for cloud physics and weather modification	i) Instruments for measurements of atmospheric electric parameters designed and used for observations; ii) Inorganic/organic materials may be introduced to the atmosphere by electrical atomization of rain water dripping from the tree leaves. This phenomenon has several facets; iii) Theoretical model for thunderstorm electrification developed.
13.	Studies on Dynamic Instability	i) Barotropic and baroclinic instability mechanisms for the growth of monsoon disturbances in the lower and upper troposphere identified;
14.	Simulation of Monsoon and Tropical Circulation Systems	i) Interaction between regional meridional (Hadley) and zonal (Walker) circulations during summer monsoon investigated and their role defined in active/break monsoon and in good/bad monsoon years; ii) Hemispheric and global spectral P.E. barotropic model developed. Work on the development of multi-level P.E. global spectral model with parameterisation of physical processes is nearing completion. The model would become an important tool for monsoon simulation and for its prediction.

A review of the research projects was carried out in 1987 which provided an opportunity to re-orient some of projects and fix sharper objectives. The review showed that the Institute has made substantial contributions to the advancement of knowledge in tropical Meteorology with special reference to monsoon meteorology and warm cloud modification. The research work of the Institute has received National and International recognition. Some of the important results of research are :

* Development and testing of forecast system based on numerical weather prediction. Models consisting of objective analysis scheme, barotropic and multi-level P.E. regional forecast models tested

* Theoretical understanding of the growth of monsoon disturbances through barotropic and baroclinic instability mechanisms.

* Interaction between regional meridional (Hadley) and Zonal (Walker) circulation during summer monsoon and their role in the active, break-monsoon and good/bad monsoon years.

* Development of 2 D models for the numerical simulation of summer monsoon.

* Development of Global Spectral P.E. barotropic model.

* Identification of suitable regional and global predictors and development of suitable regression equations for the long range forecasting of the summer monsoon rainfall over India.

* Determination of analogues for weather prediction on short-medium- and long range scales for the summer monsoon season.

* Identification of a 5-day westward moving wave number one in the global tropics.

* Identification of a 30-50 day mode of oscillation in the summer monsoon based on satellite cloud imagery, tropospheric winds and rainfall data.

* Study of the energetics of the monsoon disturbances for the understanding of the mechanisms for energy conversion and their association with monsoon activity on a seasonal scale.

* Preparation of a long homogeneos series of monsoon rainfall on the sub-divisional and district basis This series has formed the basic-data set for research on monsoon variability in India and abroad.

* Preparation of Drought Area Index (DAI) and Flood Area Index (FAI) for India and the association of FAI with the 22 year double (Hale) sunspot cycle.

* Documentation, for the first time, of the teleconnections of the Indian rainfall with El Nino events.

* Extensive studies on the interannual variability of the summer monsoon rainfall and its relation with the southern oscillation.

* Determination of signatures of climate fluctuation in the growth of tree rings using samples collected from different forest belts of India.

* Preparation of a catalogue of historic droughts for the past 200 years and related studies about their impact on Indian economy.

* Role baroclinic disturbances in the South Indian Ocean on the onset and oscillations in the Indian summer monsoon.

* Extensive work on the systematic design rain-storm studies, for different river basins in India, and determination of the highest one-day rainfall for different stations.

* Preparation of generalised probable maximum precipitation (PMP) charts for different parts of India.

* Identification for the first time of stratospheric warming events in the tropics during winter and summer.

* Association of QBO in the stratospheric zonal winds in the performance of monsoon rains in India.

* Identification of urban effects on rainfall and cloud physical parameters.

* Laboratory investigations on new ice nucleants which can be used for seeding cold clouds.

* Development of warm cloud modification technique for rainfall enhancement on local scales under suitable cloud conditions.

* Documentation of microphysical and dynamical characteristics of monsoon clouds from extensive measurements and identification of a new electric charge mechanism in monsoon clouds.

* Extensive measurements on cloud water and precipitation chemistry which have shown the non-existence of acid rain in India on a large scale.

* Development of different versions of a rocket payload for measurement of temperature.

* Development of special instruments for the measurements of fluxes of ~~temperature~~ heat and momentum in the atmospheric boundary layer.

* Modelling the effect of external electric fields on the growth of cloud particles and identification of their effects on the microphysics and dynamics of thunder clouds.

* Identification of the phenomenon of the electrical atomisation of the water drops dripping from plant leaves and from melting hail stones.

Among the above list there are several discovery-oriented results, theory-based ones for deeper analysis of natural phenomena and also many related to now measurements, analysis and interpretation of data. True to its objectives the Institute has indeed kept a good mix of fundamental and applied research in its programmes.

2.2 Research Publications and Awards

The Institute disseminates its research results through the following media :

a) Publications in the National/International Scientific Journals.

b) Presentation/Publications in the Proceedings of the National/International Symposia, Conferences, Workshops.

c) Institute's Research Reports.

The year-wise breakup of research publications of the Institute is given in Table 2.

Table - 2

Details of Research Publications-Number of Papers

Year	Journals	Proc. of Symp./ Conf.	Research Reports	Total
1964	5	-	-	5
1965	4	3	-	7
1966	3	1	-	4
1967	15	2	-	17
1968	14	3	-	17
1969	14	-	-	14
1970	25	11	-	36
1971	27	10	5	42
1972	41	4	2	47
1973	37	3	6	46
1974	19	17	4	40
1975	30	5	2	37
1976	37	33	2	72
1977	21	14	-	35
1978	33	7	4	44
1979	18	14	-	32
1980	36	19	1	56
1981	46	34	9	89
1982	39	44	-	83
1983	29	6	4	39
1984	50	17	1	68
1985	50	26	-	76
1986	53	12	-	65
1987	32	32	-	64
Pre-Autonomy period: 1963-70 :	80	20	-	100
Post-Autonomy period: 1971-87 :	598	297	40	935

As can be seen from Table 2, the Institute has maintained impressive publication record. It is worth mentioning that over 50 per cent of the Institute's research papers published in Journals have appeared in the Journals published in India. The strength of the Institute's research output is also well reflected in the references, which its publications have received, in the papers published by other authors in the National and International journals. It is encouraging that inspite of the fact that several trained and experienced senior scientists left the Institute following the autonomy, the scientific output in fact steadily improved. Thus, inspite of this handicap the Institute was able to make good scientific progress towards fulfilment of its objectives. This speaks well about the dynamism of its scientific community.

Institute scientists have made important new findings, which have received attention of the national and International scientific community. Several of its scientists have won important awards and fellowships, in recognition of their scientific work as given in Table 3.

Table - 3

(a) Awards Won by the Institute's Scientists

S.No.	Award/Prize	Recipient	Year
(1)	Dr. B.N. Desai Award	Shri R.N.Keshavamurty	1968
(2)	Indian Journal of Meteorology & Geophysics Award	Shri R.V.Godbole & Shri R.R. Kelkar	1969
(3)	WMO Research Award for encouragement of Young Scientists	Shri B.M. Mishra	1974
(4)	WMO Research Award for encouragement of Young Scientists	Dr. A.K. Kamra	1976

Table 3 Contd.

S.No.	Award/Prize	Recipient	Year
(5)	Shri Hari Om Ashram Prerit Dr. Vikram Sarabhai Research Award	Dr. A.S.R. Murty	1976
(6)	Third prize (Students' Technical Session) The Institution of Engineers (India)	Shri S.K. Sharma	1977
(7)	Second prize (Students' Technical Session) The Institution of Engineers (India)	Shri S.K. Sharma	1980
(8)	Young Scientist Award by the Andhra Pradesh Academy of Sciences, Hyderabad	Dr. P.C.S. Devara	1980
(9)	WMO Research Award for encouragement of young Scientists	Shri S.K. Mishra & Smt. P.S. Salvekar	1981
(10)	Dr. B.N. Desai Award	Shri D.R. Sikka	1981
(11)	Prof. P.T. Rao Shastiabadhipoorthy Prize in Physics Andhra University, Waltair	Dr. P.E. Raj	1983
(12)	B.P. Kapadia Memorial Prize Eighth All India Students Seminar, The Institution of Engineers (India)	Shri S.K. Sharma	1984
(13)	Best Paper Award of the National Space Science Symposium, Ahmedabad, 1987.	Shri R.K. Verma	1987
(14)	Second South Asia Association for Regional Co-operation (SAARC) Regional Award.	Dr S.K. Mishra Smt. M.D. Patwardhan & Smt. L. George	1988

(b) Fellowship of the Science Academy

S.No.	Name of the Fellow	Academy	Year of election
(1)	Shri D.R. Sikka	Indian Academy of Sciences, Bangalore	1984
(2)	Dr. S.K. Mishra	Indian Academy of Sciences, Bangalore.	1987

It is gratifying to note that, some of the scientists who worked at the Institute for some time in the past, hold very important positions at present in their respective disciplines in India and in the U.S.A.

2.2.1 Membership of International Scientific Bodies Commissions and Editorial Boards of Journals

The following scientists have either served or are serving on international scientific bodies, WMO Experts and Editorial Boards of Journals as given in Table 4.

Table - 4

Membership of International Scientific Bodies, Commissions, and Editorial Boards of Journal

S.No.	Name	Membership
(1)	Dr. R. Ananthakrishnan	Editorial Board, Indian Journal of Meteorology and Geophysics (1971)
(2)	Dr. K.R. Saha	Indian Journal of Meteorology and Geophysics, (1975-77)

S.No.	Name	Membership
(3)	Dr. G.C. Asnani	WMO Expert, University of Nairobi, Nairobi, (1975-77)
(4)	Dr. Bh.V. Ramana Murty	International Commission on Cloud Physics (1972-80)
(5)	Shri D. R. Sikka	International Radiation Commission of IAMAP IUGG, (1979-83)
(6)	Dr. Bh.V. Ramana Murty	Editorial Board, Mausam (1981-86)
(7)	Shri R.N.Chatterjee	International Commission on cloud physics, (1980-88)
(8)	Dr. Mrs. A. Mary Selvam	Sub-Commission - V of the International Commission on Atmospheric Electricity (1980-88)
(9)	Shri D.R. Sikka	Editorial Board, Proc. Indian Academy of Sciences (1982-86)
(10)	Shri D.R. Sikka	International TOGA Project Office, Boulder, Colorado, USA (1984-86)
(11)	Shri D.R. Sikka	JSC/CCCO TOGA Scientific Steering Group (1987-
(12)	Shri D.R. Sikka	Editorial Board, Mausam (1987-
(13)	Shri R.Suryanarayana	Advisory Working Group of the WMO Commission for Atmospheric Sciences (1986-90)
(14)	Dr. A.S.R. Murty	International Advisory Committee 12th International Conference on Atmospheric Aerosols and Nucleation, Vienna, Australia, 21-28 August 1988
(15)	Dr. G.B. Pant	Editorial Board, Journal of Climatology, U.K. (1987-90)
(16)	Dr. G.B. Pant	Secretary, INSA Committee on World Climate Research Programme (1988-91)

Scientists of the Institute also serve on several important national Committees connected with Atmospheric Sciences.

2.3 Other Academic Activities

The field research unit of the Institute at Bangalore has also carried out user-oriented projects on solar radiation and wind energy under the sponsorship of the Department of Science and Technology and the Department of Non-conventional Energy Sources. The following user-oriented publications have been brought out :

* Handbook of Solar Radiation, Data for India - 1980
* Solar Radiation over India - 1982
* Wind Energy Data for India - 1983

The Institute is recognised by several Universities as a Centre of Advanced research for carrying out work leading to the award of M.Sc. and Ph.D. degrees. It has encouraged post-graduate and doctoral scientific education of its own staff members. About 25 Scientists of the Institute are recognised guides by several Universities in India. Since its inception 7 Scientists of the Institute have obtained M.Sc. degrees and 36 scientists have obtained Ph.D. degrees. At present 24 scientists are registered for the M.Sc. degrees and 6 scientists for the Ph.D. degrees.

One of the distinguishing features of the Institute's programmes has been the promotion of scientific collaboration with the Universities and other research organisations. Under this programme the Institute has encouraged its scientists to provide teaching and research support to the Universities in their M.Sc. and M.Tech. courses in Atmospheric Physics. This programme would be further encouraged to promote excellence in education and research as well as to forge a sense of collaboration and partnership between the Institute and Universities. Its scientists have also been involved in teaching advanced courses at the IMD Training School, Pune.

2.4 Field Experiments

The Institute has been vigorously pursuing its Field Experimental Programme to collect special observations for the understanding of physical processes of the atmosphere. As already stated, the Institute's establishment coincided with the beginning of the IIOE - a major international programme for the understanding of the large scale meteorological and oceanographic processes in the Indian Ocean region. The Institute has actively participated in the International experiments and also carried out its own special field programmes as follows :

(i) Large-scale Monsoon Experiments :

* IIOE - Monsoon Programme (1963-66)
* Indo-Soviet Monsoon Experiment (ISMEX) - 1973
* Monsoon - 1977
* Summer Monsoon Experiment (S-MONEX) - 1979
* Indian Middle Atmosphere Programme (1982-87)

(ii) Warm Cloud Modification :

* 11 year scientific experiment in Maharashtra State (1973-74, 1976, 1979-86)

* Operational cloud seeding programmes in different States of India :

S.No.	State Government		Years
1.	Uttar Pradesh	...	1973, 1974
2.	Haryana	...	1973, 1974
3.	Karnataka	...	1975, 1981-82
4.	Tamil Nadu	...	1983
5.	Gujarat	...	1972-81, 1987
6.	Kerala	...	1987

(iii) Atmospheric Boundary Layer :

* Effect of Palghat gap on the monsoon wind flow (1966)
* Boundary layer experiment in and around Pune (1977-80)
* Marine Boundary Layer Studies along the Indian Coast (1983, 1985, 1988)
* Monsoon Trough Boundary Layer Experiment pilot studies (1988)

(iv) Air Pollution, Cloud Physics and Atmospheric Electricity :

* Air pollution monitoring around thermal power plants (1978, 1981, 1982, 1988)
* Atmospheric electricity and aerosols, cloud ~~microphysical~~ microphysical measurements and precipitation chemistry (1969, 1970, 1971, 1973, 1975, 1977, 1983)
* Atmospheric ozone and aerosols (1983, 1984,
* Solar eclipse - 1980
* Himalayan snow chemistry - 1987, - ~~1987~~, 1988
* Trace gases and suspended Particulates in Niligiri-Biosphere reserve - 1988
* The field programmes have sustained research into a variety of meteorological, geophysical and atmospheric chemistry problems.

2.5 Technical Facilities

2.5.1 Laboratories

Well equipped laboratory facilities play an important role in stimulating the scientists to carry out experiments on natural phenomena, simulate the phenomena and analyse the samples collected during field experiments. The Institute has strived hard to build modern laboratory facilities within the overall budgetary constraints of a growing organisation. Since the Institute became an autonomous organisation (1971) the following laboratory facilities have been progressively built up :

* Aircraft instrumentation for cloud physics and weather modification (1973)
* Atmospheric Electricity (1971)
* Atmospheric Chemistry (1978)
* Instrumentation for Atmospheric Boundary Layer Studies (1980)
* Laboratory for simulation of Boundary Layer phenomena and Cloud microphysics (1980)
* Laboratory for Dendroclimatological studies (1981)
* LIDARS for the measurement of atmospheric aerosols (1984)
* Spectrometers for the measurement of atmospheric minor constituents (1985)

The above laboratories are progressively being upgraded through the addition of sophisticated equipments.

2.5.2 Computers

High speed computers are essential for the progress of work on atmospheric modelling. The Institute acquired its first computer, IBM-1620 in 1964. As this Computer was not adequate to meet the requirements of the numerical weather prediction work, the Institute began to utilise the facilities of the more powerful computer systems of the TIFR Bombay. The Institute also made use of the EC-1040 Computer system of the Meteorological offices, Pune from 1977. The computing resources available to the Institute scientists have been considerably enhanced in 1988 by the acquisition of a ND-560 computer system with an enhanced memory of 11 MB and having 8 interactive terminals. The Institute also avails of more powerful computer facilities of the National Informatics Centre (NEC-S-1000/10), Pune and of the Tata Institute of Fundamental Research, (CYBER - 170/730), Bombay.

2.5.3 Workshop :

A moderately equipped workshop exists in the Institute for fabrication of specialised scientific instruments required for observational studies.

2.5.4 Library and Information

The Library of the Institute has acquired a large collection (about 10,000) of books, journals and scientific reports relating to meteorology and allied fields. Currently about 90 journals are being subscribed. The budget allocation for the Library has been steadily increasing.

A "Current Awareness" service is also functioning in the Library to assist the scientists of the Institute. Recently the Institute has provided special bibiliographical services to the Universities and the research organisations. During the next few years the Institute is planning to organise information services on atmospheric sciences to meet the needs of the growing scientific community in the country.

Information about the Institute's publications, contributions etc. is regularly made available to the following to help dissemination :

* Information and Referral System of UNDP, New Delhi
* National Technical Information Service (NTIS), USA
* INFOTERRA REFRAL SYSTEM OF UNEP.
* Reprography etc.

Adequate reprography, photography and drafting facilities are also available at the Institute.

2.6 Symposia and Seminars

The Institute has promoted scientific research through the organisation and co-sponsoring of the International and National Symposia on different aspects of atmospheric sciences.

International Symposia :

* The Scientific Results of the IIOE, Bombay - (1966)
* Tropical Monsoons, IITM, Pune - (1976)
* Numerical Weather Forecasting, IIT, New Delhi (1977)
* Monsoons, IIT, New Delhi (1977)
* Monsoon Dynamics, IIT, New Delhi (1977)
* International Symposium on concepts & Techniques of Applied Climatology, Waltair (1985)
* Micrometeorology and Air pollution, IIT, Delhi (1985)
* Monsoon Understanding and Prediction, IITM, Pune (1988)

National Symposia :

* Recent Advances in Computer Techniques in Meteorology, Biomechanics and Applied Systems, IIT, Delhi (1980)
* Early Results of Monsoon Experiments, IMD, New Delhi, (1981)
* Environment Physics and Atmospheric Boundary Layer, IITM, Pune (1981)

* Local Severe Storms, I. Met. Soc., Calcutta (1982)

* Hydrological Investigations during the last 25 years in India, Association of Hydrologists of India, Waltair (1982)

* Space Science Symposium, University of Poona, Pune (1983)

* "Meteorology in India through the Ages" Ved Vidnyan Mandal, Pune (1984)

* Tropical Cyclones and Disaster Preparedness, I. Met. Society, Bhubaneswar (1984)

* Current Trends in Tropical Meteorology, IITM, Pune (1984)

* Annual Conventions of the Association of Hydrologists, India and Seminars on Hydrology, Association of Hydrologists of India (1983, 1984, 1985 and 1986)

* Optics and Opto-Electronics held at Pune by Optical Society of India (1987)

Besides this the Institute has been sponsoring its scientists to participate in the National and International Conferences and Symposia.

Seminars and lectures on scientific topics form an integral activity of the Institute for the promotion of research and creation of proper academic environment. Visiting Scientists from India and abroad and the Institute scientists regularly deliver lectures under this programme.

To commemorate the completion of 25 years of the Institute a special Silver Jubilee Seminar series was organised during 1987-88. Several scientists of this Institute and distinguished scientists from other organisations in the country delivered lectures under this series.

2.7 Other Scheme

2.7.1 Emeritus Scientists Scheme :

The Institute has a scheme under which scientists on retirement from the Institute or from the IMD can pursue their research work under the grants-in-aid from the Institute and other sponsoring organisations like the CSIR, ISRO, IMD, DST etc. So far 4 Scientists have availed of this scheme.

2.7.2 Research scholars :

The Institute has a scheme for granting scholarships for the pursuit of research leading to the award of Ph.D. degree in Atmospheric Physics. Under this scheme 11 fellowships are funded by the Institute and 2 fellowships are funded by Air India tenable at the Institute.

2.7.3 Visiting Scientists Programme

Visits of distinguished scientists are an important element of the scientific activities of the IITM. Short-term visits of Scientists from India or abroad, who come for only a day or a few days, help develop interactions with the scientists of the Institute.

Recently the IITM has instituted a Visiting Professhorship scheme under which reknowened scientists from abroad spend an extended period of time for giving lectures on advanced topics and developing research programmes. Under this programme the following scientists have visited the Institute :

	Name	Specialisation	Year
*	Prof. R.L. Pfeffer Deptt. of Meteorology, Florida State University, USA.	Atmospheric Dynamics	1986-87
*	Dr. Chandran Kaimal Environmental Research Laboratories, NOAA, Boulder, Colorado, USA.	Atmospheric Boundary Layer	1987-88
*	Dr. Kamal Puri Australian Numerical Meteorology Research Centre, Melbourne, Australia.	Atmospheric Modelling	1988-89

2.8 National and International Collaboration

2.8.1 National :

Having started as a distinct wing of the IMD, the IITM has continued to maintain very close links and contacts with the parent Department even after autonomy. It continues to get full support of the Department in its activities and, on its part, the Institute gives its full co-operation to the Department.

The Institute has also maintained close contacts with several other scientific organisations in the country. Being a grant-in-aid Institute, the IITM has special relationship with DST and as such it is actively involved in the development of different research programmes under the aegis of the DST.

2.8.2 International :

As stated in Chapter 1, the Institute was established as a special Fund Project of the UNDP. It continuous to maintain international Scientific contacts not only by exchange of publications but also through visits of its scientists to scientific organisations in other countries and by hosting visits of scientists from abroad. Scientists from several countries such as USA, USSR, Japan, U.K., France, West Germany, Bangla Desh, Sri Lanka, Afghanistan, Kenya, Phillipnes, Ethopia, Egypt, Canada, Brazil, Australia, New Zealand etc. have visited the Institute. Presently the Institute is participating in the following major bilateral programmes :

* Indo-US Programme on Monsoon Research under the Science and Technology Initiative.

* Indo-USSR Programme of Co-operation in Science and Technology

* Indo-USSR Programme of Co-operation on Space Meteorology and Aeronomy under the ISRO-SCHENE Programme.

Participation of the Institute in the following bilateral programmes is under active consideration :

* Indo-US Programme on Atmospheric Sciences under the Indo-US Sub-Commission on Science and Technology.

* Indo-USSR Integrated Programme of Co-operation in Science and Technology.

CHAPTER - 3

3. HIGHLIGHTS OF THE RESEARCH PROGRAMMES IN THE LAST FIVE YEARS

An account of the research achievements of Institute since its inception, including those in the last five years, has been given in Chapter-2. Herein are described the major research programmes which have been pursued or initiated since 1983.

3.1 Research Programme Pursued

Salient features of the important research results of different divisions in the last 5 years are given below :

(a) Forecasting Research Division :

* Development of a number of regional dynamical prediction models including the objective analysis system based on successive correlation method and the optimal interpolation scheme. Two multi-level P.E. models and different versions of barotropic P.E. model were tested with the data obtained during Monex-79. The impact of satellite data as well as data from non-conventional observing systems on the forecasts was also examined. Dynamic and dynamic normal modes initialisation schemes were also formulated and tested for the regional models.

* A regional model was developed to study the impact of orography on the monsoon circulation which could simulate several features of the monsoon circulation by using the idealised and real topography.

* Relationships of a number of oceanic/atmospheric regional and global parameters with seasonal monsoon rainfall were examined and different statistical predictive

relationships were developed. The forecasts based on these relationships were passed on to IMD for their use in decision making purpose for the issue of long-range monsoon forecast.

* The structure and inter-annual variation of the 30-50 day oscillation in monsoon circulation cloudiness and rainfall were studied. Their potential in forecasting 5 and 10 day rainfall was assessed. Utilising the special data collected during the ISMEX-73 and MONEX-79, the interaction between the westward propogating 10-20 day wave and northward propogating 30-50 day wave was studied and its role on the active break cycle of the monsoon was also examined. Also alternating episodes of active and weak convections over the Indo-West Pacific and the Eastern Pacific-Central American regions were investigated in the light of super-synoptic scale organisation of tropical cyclogenesis. It was hypothesised that the air-sea interactions on the super-synoptic scale, associated with intense tropical cyclogenesis events, may play a key role in the dynamics of the 30-50 day oscillation.

* Multiple regression equations were developed for forecasting 7-day rainfall during the monsoon season over 7 sub-divisions in West Central India by screening the 700 mb data over the Asian region. These equations were tested in experimental forecast and transferred to IMD in 1985 for preparation of guidance forecast of weekly rainfall. Based on statistical analysis, the potential predictability of seasonal circulation and rainfall were monsoon also examined.

(b) Climatology and Hydrometeorology Division

* Extensive studies were carried out to examine the relationship between the monsoon and ENSO. For this purpose the parameters examined were (i) SST on the central and eastern pacific and (ii) indices of southern oscillation. Winter to spring tendencies of the following parameters have been found to be suitable for long-range prediction : (i) Surface Pressure over Bombay (ii) Pressure at Darwin (iii) Pressure gradient between Agalega and Nouville islands in South Indian Ocean. (iv) Surface temperature and Pressure over India and the Indian Ocean region.

* Relationship of the double sunspot cycle with occurrence of major flood years over India was established. Also it was determined that 10 mb stratospheric zonal wind at Balboa (Central America) in January has predictive value for the ensuing season monsoon rainfall over the country.

* An overall increasing trend in rainfall and decreasing trend in surface temperature during monsoon season over N.W. India is detected, which has been ascribed to a change in surface boundary condition over the area brought about due to large scale irrigation and cultivation. At the upper tropospheric level a decreasing trend has been noticed over several Indian radiosonde stations based on 30 years data.

* An equation has been developed to estimate the total annual food grain production in the country based on monsoon season rainfall.

* Studies on the stable isotope ratio of Carbon and Hydrogen in growth ring cellulose of tropical teak trees were conducted in collaboration with Scientists of the PRL, Ahmedabad. It was shown that tropical teak trees could be used for the reconstruction of fluctuations of past monsoon climate.

* Based on the extensive studies carried out in PMP estimates, an atlas of the one day PMP estimates for each state of the country is under publication.

* A generalised technique for estimating areal PMP for the Indian region has been developed. This technique has been included in the Manual on Estimation of PMP, published by the WMO.

(c) Physical Meteorology and Aerology Division

* A warm cloud weather modification experiment, which was conducted over the 11 year period (1973-74, 1976, 1979-86) near Pune (Maharashtra State) was concluded. The results of this experiment have been evaluated and found to show about 24 % increase in rainfall when the 'area seeding technique' is used. The results were presented in September 1987 before a Committee of Scientists under the Chairmanship of the Secretary, DST. A proposal to extend the warm cloud modification, on operational basis to a few States, has been submitted for consideration of the DST. Based on the cloud microphysical measurements obtained during aircraft weather modification experiments, a new charge generation mechanism was proposed. Assistance to a few State Governments for their Weather Modification programmes was provided.

* Results of precipitation measurements in different environmental conditions showed no evidence of acid rain in India on a large scale. This was ascribed to the presence of alkaline aerosols of soil-origin in the atmosphere.

* Quasi-Biennial oscillation in the stratospheric zonal winds were linked with the monsoon activity over India. Also the occurrence of major volanic eruptions showed some relationship with the rainfall of Sri Lanka.

* The Institute contributed significantly to the implementation of the Indian Middle Atmosphere Programme (IMAP) during 1983-88. Towards this end, a STRATWARM campaign was organised during January-March 1986 and special observations were taken for different ozone and aerosol campaigns.

(d) Instruments and Observational Techniques Division

* A new phenomena of electrical atomization of water drops dripping from plant leaves and from melting hail storm has been discovered. Possible significance of these processes in nature has been studied.

* A vertical wind tunnel was fabricated. Using the same, the distortion of water droplets under the influence of high electric field was studied.

* A particle charge measuring apparatus was fabricated and measurements were made of charges on different categories of particles, precipitation current and corona current during rain showers.

* Several instruments for the study of surface fluxes of momentum, sensible heat, latent heat and radiative heating in the atmospheric boundary layer were fabricated and field tested. A pilot study for the measurement of surface fluxes was conducted at IIT Khargpur in August 1987, as part of the national MONTBLEX programme, in collaboration with the Scientists of Centre for Atmospheric Sciences, I.I.Sc Bangalore.

* A new version of the rocket payload was fabricated and qualifying laboratory tests were conducted.

(e) Theoretical Studies Division

* A numerical, quasi-geostrophic combined ~~barotropic~~-barotropic - baroclinic and wave and CISK instability model, incorporating cumulus and surface friction effects, was developed and tested.

* A primitive Equation - barotropic instability analysis of the Tropical Easterly Jet Stream of the Summer Monsoon System was performed and it was shown that ageostrophic effect contributed to the growth of disturbances. Barotropic-baroclinic instability of the mean lower tropospheric monsoon westerly jet was studied using 20 - layer quasi-geostrophic model. The wave length of preferred unstable wave was found to be 2750 km. Other dynamical characteristics of the model-wave were also found to be in fair agreement with observations.

* A 5-level global spectral model was developed incorporating several sub-grid scale processes. The model would be used as an important research tool for investigating the dynamics and predictability of monsoon flow.

* Propogation of initial errors on different spatial and temporal scales and their contribution to the predictability of synoptic scale monsoon disturbances was determined.

3.2 New Programmes

Several new research programmes have been initiated in the last few years which would help in meeting the new scientific and technological challenges emerging in the Atmospheric sciences. These programmes with their potential are discussed below :

* Monsoon Trough Boundary Layer Experiment (MONTBLEX)

This is a multi-agency national programme, sponsored by the DST, in which the Institute has taken a leading role in preparing the scientific plan, fabrication and acquisition of sophisticated equipments and in conducting pilot study for the measurement of surface fluxes of momentum, sensible heat and latent heat at the field station installed at IIT, Kharagpur. The programme is aimed at understanding the role of boundary layer processes in the monsoon and studying the interactions between the moist part of the trough (Gangetic West Bengal) and the dry western part of the trough (Rajasthan).

* Precipitation Chemistry in Nilgiri-Biosphere Reserve and Contribution to the National Component of the Geosphere-Biosphere Programme

In order to study the biogeochemical cycle a programme on atmospheric chemistry measurements ~~have~~ has been commenced in the Nilgiri-Biosphere Reserve in collaboration with the Centre for Ecological Studies, I.I.Sc., Bangalore. The scope of these measurements will be extended as part of the Institute's contribution to the national programme under the International Geosphere-Biosphere Programme, to cover other ecosystems in the country such as Western Ghats, Deccan Plateau and the Himalayan region.

* Measurement of Minor Atmospheric Constituents and Aerosols

Minor atmospheric constituents (methane, ozone, oxides of nitrogen etc.) and aerosols of natural and anthrophogenic origin have important role in the climate system. A phased programme was launched in 1985 to develop technology for remote sensing of these constituents. Two laser low-powered systems (Argon-ion and Helium-Neon) have been installed at the Institute and a spectrometer has been built. This programme will be further intensified during the 8th Five Year Plan under which mobile ground-based and air-borne systems will be acquired/developed for measurements of the minor constituents in different environmental conditions. The programme is also expected to contribute to the international efforts planned under the Global Tropospheric Chemistry Programme and the Global Change Programme for the study of Earth System Science.

One dimensional numerical model for atmospheric ozone studies is under development. Modelling work will be extended with multi-dimensional approach to cover other minor constituents.

* Extended Range Prediction

The country witnessed one of its worst droughts in the 20th century. Understanding the interannual variability of the monsoon rains and their long range prediction have become very important as the economy of the country is adversely affected in a drought year. The Government of India, at the highest level, is very much concerned about the efficacy of long-range forecast. The Institute was involved in the two meetings with the Prime Minister of India during November 1987 and May 1988 in which the developments in meteorology of the country and the long range monsoon forecast for the 1988 season, based on a new parametric model were discussed. These developments have led to a new joint initiative between the IMD and the IITM for a concerted effort in long-range monsoon prediction. A special group has been formed

International Research Programme under the WCRP such as the on-going (1985-94) Tropical Ocean Global Atmosphere (TOGA) and the World Ocean Circulation Experiment (WOCE), planned for 1990-95 and others are focussed towards understanding and predicting the state of the climate system on the sub-seasonal/interannual to decadal scales. Also ICSU is planning a major programme under the Global Energy and Water Cycle Experiment (GEWEX), which would integrate the effect of land surface and hydrological processes in the atmospheric and coupled atmosphere-ocean models. GEWEX would foster the developments in satellite and ground-based systems observing data management techniques and data assimiliation systems. These developments have great operational applications to long-range weather forecasting, hydrology and climate prediction. With the availability of super-computing power in the country well within sight, the Institute is preparing to launch research on Dynamical Extended Range Prediction, involving atmospheric global circulation models and the coupled atmosphere-ocean models. For this purpose, collaborative arrangements would be worked out with National Centre for Medium Range Weather Forecasting, New Delhi and other major research groups in India and abroad.

* Quantitative Precipitation Forecasting and Precipitation Network Design

Floods in different river basins of the country cause great havoc during the monsoon season. A special study has been recently (1988) launched for the quantitative forecasting of rainfall over the catchment areas of a few selected river basins.

At the request of the High Level Technical Committee for Hydrology of the Government of India, work was initiated based on objective techniques for determing precipitation design network, for different river basins. This is a long-term project and shall be conducted on basin by basin approach basis.

* Extension of Teaching/Research Facilities-Support to Universities and Other Organisations

A conscious effort is being made to forge a partnership between the University sector and the IITM towards improving standards of meteorological education and research at the M.Sc., M. Tech., and Ph.D. level programmes. This effort, it is hoped, will plough the resources of the IITM, which is a national organisation, to the Universities and encourage discovery-oriented research. The Institute has also started to provide specialised bibliographical service to Universities/research organisations in the country. To intensify this useful service, it has plans to start a National Centre for Information on Atmospheric Sciences during its 8th Five Year Plan.

* Enhancement of Computational Power

Recognising that the availability of fast and large computational power plays a crucial role in promoting atmospheric modelling work and training of scientists in the emerging areas, the Institute has installed an in-house ND-560 Computer System in 1988. It has also made arrangements with the National Centre for Information Sciences to use their Pune-based powerful NEC-S-1000/10 system through an entry terminal located at the Institute. The Institute has plans to acquire a more powerful Computer System in the middle of the 8th Five year plan period (1992-93) which could be used as a National facility for atmospheric and oceanic modelling work.

* Cooperation for the Establishment of the National Centre for Medium Range Forecasting (NCMRWF)

Government of India has approved a mission-mode scheme for the establishment of NCMRWF and extension of Agro-meteorological services in different Agro-climatological zones of the country. This is a major scheme, involving large financial outlay and high technological resources. The Institute has been actively involved with the DST and IMD in the implementation of this project with regard to the (i) preparation of the Detailed Project Report for the NCMRWF, (ii) Carrying out some special research projects on NWP which could be useful for the Centre, conducting scientific exercises for the availability of data needed for the Centre, and (iii) the recruitment and training of manpower for the Centre and (iv) the permanent location of the Centre.

CHAPTER - 4

4. A VISITION OF THE THRUST AREAS

4.1 New Opportunities in Atmospheric Sciences

The Institute has been making steady progress during the last 25 years. It has kept a good balance in its research programmes between the application-oriented and fundamental aspects of atmospheric sciences. It has witnessed tremendous scientific and technological advances over these years and has adjusted its programmes accordingly. This includes use of :

* Fast computers for atmospheric theory, modelling and prediction and climate research;
* Mass spectrograph for studies on dendroclimatological work;
* Research aircraft for work on physics of warm clouds and their modification for enhancement of rainfall;
* Data from weather satellites for understanding the regional and planetary scales weather and climate phenomena;
* LIDAR systems for studies of atmospheric aerosols;
* Spectrometers for measurements of minor constituents of the atmosphere and analysis of samples for air pollution studies;
* Sophisticated instruments for the measurements of surface fluxes of meteorological quantities for atmospheric boundary layer studies;
* Rockets for study of middle atmospheric phenomena; and
* Advanced devices for the studies on atmospheric electricity.

Its studies on hydrometeorological aspects of monsoon rains have found wide applications by the irrigation and flood control engineers.

Currently the Institute is passing through exciting times in the development of atmospheric sciences, which provide opportunities for undertaking advanced scientific programmes with a promise of making new contributions to society. These range from improvements in short, medium- and long-range weather prediction and monitoring of Global Change. These opportunities are being stimulated by the intellactual progress and sense of accomplishment witnessed in the last decade and by the existing and the emerging atmospheric technology. The thrust on climate research, with the objectives of ultimate prediction of climatic fluctuations on sub-seasonal and inter-annual scales, has integrated several disciplines like physics, biology, chemistry and computer science. The boundaries between different disciplines are expected to further blur in the next decade as we progress in our effort to understand the earth's climate system and the Global Change.

Earth's climate is also influenced by its chemical composition as the chemical constituents are critically involved in the absorption and emission of short wave solar radiation and long wave earth's radiation. Research in Atmospheric Chemistry, in the last two decades, has added a new dimension to climate research. Several minor interacting species, with sources and sinks in the earth's surface and atmosphere, man-made or of biospheric origin, have been discovered. There is a growing societal concern that man is no longer an innocent user of the earth's climate as his natural heritage, but if unchecked, he has acquired the capability to adversely affect this resource on global scale. Increase of atmospheric carbon dioxide, methane and chlorofluro methanes as well as the recent discovery of the abrupt decrease in the winter-time Antarctic Ozone

Layer (Antarctic Ozone Hole) portend changes with possible serious implication in the next few decades. Understanding and prediction of Global Change has therefore, become of paramount importance. This necessitates intense and strong multi-disciplinary research in atmosphere, ocean, land-surface processes, terrestrial biosphere and biogeochemical processes. Observations will be necessary for the development of models. Improved observations of the atmosphere and terrestrial phenomena will be matched by improvements in computing power.

There are also exciting challenges in understanding the severe weather phenomena like the tropical cyclones, severe local storms (dust storms, tornadoes, norwesters etc.) and meso-scale convective developments. The parameterization of convective phenomena and other sub-grid scale processes into large-scale numerical models and the understanding of interaction of dynamics and thermodynamics of moist convection, are of paramount importance for extending the practical predictability of weather systems on the extended range scale. Studies of inter-annual fluctuation of monsoons linked with Monsoon-El-Nino-Southern Oscillation phenomena are no longer considered to be of local but of global interest. They are found to be related to the dynamical coupling between the Tropical Oceans and Global Atmosphere - the subject which is of great importance to the World Climate Research Programme (WCRP) under its TOGA Programme.

More and diverse observations on the global scale will also need special arrangements for data management. Therefore, improvements in archival, retrieval and dissemination system for geophysical data are called for to provide high quality global data to researchers to facilitate data analysis and quantitative modelling for laying the basis for further research in the coming decades.

IITM cannot afford to miss exciting opportunities on the horizon in contributing its intellectual resources to the national and international efforts for research in the emerging thrust areas in atmospheric sciences which have immense consequences on the society and civilization. India has emerged as an important industrial country and must share the responsibility with the rest of the world in promoting research on the Global Change.

4.2 Nationally recognised Thrust Areas in Atmospheric Sciences

In a recent meeting of the Programme Review Committee for Atmospheric Sciences of the DST, the following national thrust areas for the coming decade were recognised :

* Atmospheric and Oceanic Modelling, which includes meso-scale models for severe local storm prediction, regional models for short range prediction, global models for medium and long-range prediction and climate models for sensitivity studies of the climate system.

* Monsoon studies, which includes monsoon prediction, rain-producing monsoon disturbances, sub-seasonal scale variability, interannual variability and teleconnections with other global circulation regimes etc.

* Theoretical Monsoon Studies with emphasis on instability of the symmetric and asymmetric flows, instability of the coupled atmosphere-ocean system, simulation of monsoon etc.

* Regional and global climate studies including climatic fluctuations, impact of atmospheric minor constituents on the climate, simulation and prediction of climate using coupled ocean-atmosphere models.

* Near-Earth Space Environment including Middle Atmospheric Dynamics, which includes studies on stratospheric waves, application of MST/ST radar techniques for tropospheric stratospheric mixing, role of global ozone variations on monsoon activity, studies on chemistry, dynamics and climatology of minor constituents, coordinated measurements of temperature, wind and minor constituents using ground-based, air-borne, balloon-borne, rocket-borne and satellite-borne sensors.

* Certain aspects of Agricultural Meteorology which includes development of physical and mathematical models of energy and mass exchange in the boundary layer of the agro-ecosystem, response function models of crop-weather relationship, indices for agricultural droughts and large-scale climatic stress on crop and forest zones.

* Severe Local Storms which includes climatology of severe storms in different parts of India, observations and theory of development of severe convection and radar observations of severe storms.

* Atmospheric chemistry and Air Pollution, which includes development of remote sensing techniques such as lidars, spectrometers, photometers and radiometers for measurement of chemical and physical composition of the atmosphere, monitoring of gaseous and particulate pollutants in urban and rural environments, study of source and sink mechanisms for atmospheric minor constituents and precipitation chemistry.

* Cloud Physics and Atmospheric Electricity, which includes space and time variation of cloud microphysical and electrical parameters and their interactions, laboratory experiments, radar studies on growth of clouds and precipitation and modification of clouds for rain enhancement.

* Global Electric Circuit, which includes measurements of Maxwell current below thunderstorms, location of lightning discharges and study of ionospheric potential in tropical regions.

* Atmospheric Boundary Layer, which includes role of boundary layer processes on the synoptic weather systems, response of the boundary layer to external and surface forcings, measurement and modelling of fluxes of meteorological variabiles in the surface layer and parameterisation of boundary layer processes in dynamical models.

* Tropical Cyclones, which include studies on physical and dynamical nature of the cyclones, their genesis and structure, numerical simulation and prediction.

* Satellite Meteorology, which includes studies on the development of techniques for the construction of data sets on wind, moisture and SST fields, rainfall estimates, and satellite in-puts to numerical weather prediction.

* Planetary Atmospheres, which includes studies on observed features and dynamics of the atmosphere of Venus, Mars and Jupiter and the complexities of the Earth's atmosphere.

The above mentioned studies would require large resources of scientific manpower, fast and large memory computers, use of global data-bases, collaboration between several national organisations engaged in atmospheric research and even bilateral and international collaboration in certain areas.

4.3 Internationally Recognised New Programmes

4.3.1 The WMO Research and Development Programme

At the International level the WMO has also chalked out a 10-year WMO Research and Development Programme (1988-97) with a

view to promote research on the applied side of meteorology, which covers the following themes :

* Programme on Short and Medium Range Weather Prediction with three tasks consisting of (i) phenomenalogical studies for the prediction of significant weather elements and severe weather phenomena, (ii) development of limited area weather prediction models and (iii) development of very short-range forecasting.

* Programme in Long-Range Forecasting Research (i) to develop and introduce methods for long-range forecasting by encouraging appropriate research and coordinating international activities in this area, (ii) to transfer among Members scientific knowledge on long-range forecasting and development of operational prediction models and techniques based on both dynamical and empirical metnods and (iii) to provide guidance to all members on the rationale underlying all aspect of long-range forecasting.

* Tropical Meteorology Research Programme which covers (i) understanding the behaviour and physical processes of tropical systems and to improve forecasts by assisting Members in strengthening their research in important areas of tropical meteorology, (ii) improving knowledge of tropical phenomena and developing prediction techniques relating to (a) monsoons (b) tropical cyclones (c) tropical droughts and semi-arid zone meteorology, (d) rain-producing tropical system (e) interaction between tropical and mid-latitude weather systems (f) tropical limited area modelling and (g) operational use of numerical products for tropical forecasting, and (iii) transferring scientific knowledge on methodologies and their operational applications among Members to ensure the full exploitation of scientific advances to meet the economic needs of tropical countries.

* Environmental Pollution Monitoring and Research Programme with long-term objectives (i) to determine global and regional levels long-term trends of atmospheric constituents, both natural and man-made which affect the environment, for forecasting future stresses in the environment, (ii) to further the understanding of the chemistry and physics of the environment and climate-related atmospheric constituents and properties, (iii) to ensure the application of meteorology and hydrology to the study of problems arising from the impact of man's activities on chemical and physical properties of the atmosphere and (iv) to provide leadership and guidance in international effort towards the protection and management of environment.

* Cloud Physics and Weather Modification Research Programme whose main long-term objectives are (i) to promote sound scientific foundation for weather modification based on cloud physics and other relevant investigations and (ii) to provide the rationale underlying all aspects of weather modification.

4.3.2 ICSU related and other Research Initiatives

The International Scientific Community under the ICSU and other organisations are also promoting several exciting research-oriented programmes of fundamental nature to meet the challenges of future with potential applications. Some of these programmes are listed below :

* WCRP with its several components such as Tropical Ocean and Global Atmosphere (TOGA), World Ocean Circulation Experiment (WOCE), International Satellite Cloud Climatology Project (ISCCP) etc.

* Global Energy and Water Cycle Experiment (GEWEX)
* International Geosphere-Biosphere Programme (IGBP)
* Global Change
* Global Tropospheric Chemistry Programme
* Meso-scale Meteorology Programme
* Coupling of Energetics and Dynamics of the Atmospheric Regions.

4.4 IITM's Programme under the 8th Five year plan

Keeping into consideration the visionary nature of the above mentioned National thrust areas, the recommended programmes under WMO Research and Development Programme and research initiatives under the ICSU and other sponsorships, the IITM's research community, after integrating the major objectives of the above programmes and in the light of its own resources and strength, has included the following research areas in its 8th Five Year Plan (1990-95) proposals :

* Study of the Regional Weather Systems and Dynamical Extended Range Prediction, which covers understanding and prediction of weather systems in the Indian region including tropical cyclones and global circulations diagnostics and dynamical extended range prediction.
* Physic of clouds and precipitation, which includes studies on monsoon clouds and their modification and applied atmospheric electricity.
* Environmental Meteorology which covers studies on (a) dynamics of the monsoon boundary layer - observations and theory, (b) environmental aspects of atmospheric aerosols, (c) atmospheric minor constituents and climate and (d) atmosphere-biosphere interactions.

* Human Resources Development for Atmospheric Sciences which includes (a) manpower development, training and planning and (b) establishment of Information Centre for Atmospheric Sciences in the country.

* Strengthening of Infrastructures.

* Creation of Facilities at National Level which includes (a) establishment of a computing centre for atmospheric research and (b) creation of Research Flight Facility Division.

The objectives of the above new schemes cover the scope of several visionary initiatives discussed in this profile of the IITM. The new schemes have been projected taking into account (i) the infrastructure and scientific manpower presently available at the Institute (ii) the ability of the Institute to build and absorb new infrastructure and to create a new generation of competent scientific manpower in the country (iii) to keep a balance between the application-oriented and fundamental aspects of atmospheric sciences and to catch up with the emerging areas of research, and (iv) to meet the scientific imperatives and service demands for a rapidly expanding national economy in need of better inputs from atmospheric sciences community. It is obvious that the accomplishments of these scientific visions by the Institute and its meeting the challenge of new scientific opportunities would also depend on the availability of additional funds.

The Institute looks at the future developments with great optimism. With the encouragement, which it has been receiving from its Governing Council and the support provided by the Department of Science and Technology, it would continue to strive hard to build excellence in its research programmes.