

RAMAKRISHNA IYER ANANTHAKRISHNAN

(11 April 1911 – 21 August 1998)

Biog. Mem. Fell. INSA, N. Delhi 31 53-74 (2007)





Ramkrishna



RAMAKRISHNA IYER ANANTHAKRISHNAN

(1911-1998)

Elected Fellow 1961

RAMAKRISHNA IYER ANANTHAKRISHNAN was one of the builders of Post-Independence Meteorology in India and inspired many students and associates to tread on the path of excellence, along which he had travelled for over 60 years of his professional life. Besides being a physicist and a meteorologist, he was a great human being, a person of great integrity, uprightness, infinite kindness, erudition and highly independent. He was religious, meticulous and dignified in his official functions – a great disciplinarian and yet easily approachable by his juniors without any fear or awe. I had been fortunate to start my professional career under his care in February 1955 at a modest position when he was Director, Regional Meteorological Centre, Nagpur. I derived the benefit of his scholarship and personality over the next four decades. He treated me with the same affection and care when I occupied a modest position and when I rose in my professional career. I was fortunate to share some of his memories and thoughts about his early days and later professional life on rare occasions when he could become nostalgic. He belonged to Professor CV Raman school at the Indian Institute of Science (IISc), Bangalore and carried very respectful memories of working with the Indian Noble Laureate in Physics. He was a research scholar during 1933-1937. During one of our visits to the Institute in 1970s, he showed me, with great excitement, the room where he had worked as a student of Professor Raman and mentioned to me the guidance and affection he enjoyed from the esteemed Professor. He exhibited throughout his professional career the qualities he had imbibed from Professor Raman for hard work, perseverance and dedication to the subject of study and a dignified but humane approach towards students and juniors. These qualities, imbibed in early years as a research student, remained the corner stone of his professional career till the end of his life.

FAMILY BACKGROUND AND EARLY EDUCATION

Ananthakrishnan was born on 11 April 1911 at village Koovapadi of Palghat district in Kerala. He was the third child and the only son of his parents, Shri A Ramakrishna Iyer and Srimati Lakshmi Ammal and had two elder sisters. He remained attached to one of his sisters till 1980s and used to meet her once a year at Varanasi where she spent her last years of life. He belonged to a lower middle class family as his father was an employee of the erstwhile Travancore state with modest income. His mother managed the household with the modest means of the family very well to bring up her children. His childhood was spent under stressful financial



circumstances and hence frugal living but upright and lofty thinking, enriched by the traditional culture and wisdom of the Indian society of the bygone era, had shaped his early life. He had realized from his early days the value of leading a simple life combined with devotion to studies and perseverance against odds. Occasionally he used to remember those days and shared with me with great pride the hardship he had faced early in his life and in spite of that he made an illustrious scientific career for himself. Dr Ananthkrishnan finished his primary education between 1916 and 1920 in a village school with little facilities compared to the present day standards in big cities of India. He completed his high school education in a town in Kerala between 1924 and 1927 obtaining first class with Physics, Chemistry and Mathematics. Being a brilliant student, showing great promise, his parents sent him for higher college education in science at the Maharaja College of Science, Trivandrum which was then affiliated to Madras University. He was given a merit scholarship for college studies and passed his Intermediate examination in 1929 in First Class. He joined St. Joseph College, Trichinopoly, then affiliated to the Madras University and secured BA (Hons) degree in Physics, also with first class, in 1932. He later secured MA (Physics) degree in 1936. Soon after passing BA (Hons) degree in 1932, he joined the Department of Physics, Indian Institute of Science, Bangalore as a post-graduate research scholar under the guidance of Professor Sir CV Raman whose fame had already spread all over the scientific world as a great teacher, guide and scholar. Ananthkrishnan wrote his first scientific paper in 1934. He was awarded D Sc Degree in Physics by the Madras University in 1937 for his thesis entitled "Investigations on Molecular Scattering of Light and Raman Effect". By then he had already published 25 scientific papers in prestigious journals including *Nature*. The contributions which he had made during the pursuit of D Sc Degree had great scientific merit and he was elected Fellow of the Indian Academy of Sciences, Bangalore in the very next year (1938) of his acquiring the D Sc degree. Those were difficult days for following an academic career and hence on the advice and recommendation of Professor Raman, he joined the India Meteorological Department (IMD), then one of the major scientific organizations in the country, as Assistant Meteorologist.

He was married into a prestigious family of Kerala and had three children (one son and two daughters). His son, Sahadev Ananthkrishnan took his Ph D degree in Aeronomy under the guidance of Professor KR Ramanathan at the Physical Research Laboratory, Ahmedabad and is settled in Brazil. Both his daughters (Mrs Seetha and Mrs Revathi) are married and settled in USA. Dr Ananthkrishnan's scientific work and functional responsibilities in IMD did not allow him much time to be with his family. He remained immersed in his scientific pursuits and achieved greater recognition for his work during the four decades from 1960s to 1990s. In 1961, he was elected Fellow of the Indian National Science Academy (INSA) which was a great recognition for his scientific achievements.



PROFESSIONAL CAREER AND SCIENTIFIC CONTRIBUTIONS

1937-1945 - Work on Upper Air Climatology and Weather Forecasting

After being selected for the IMD, Dr Ananthakrishnan joined the Headquarters of the department, then at Pune, on 3 August 1937. His very first posting was to Upper Air Section where he was to supervise the quality control of pilot balloon data, processing of meteograph data and the publication of the data. He also became conversant with the work of Weather Central, Pune which issued daily weather forecasts on the basis of synoptic analysis and was also responsible for the publication of All India Daily Weather Report – a prestigious publication of the IMD in those days. He meticulously scrutinized and issued daily without any delay. Those were the days when officers of the IMD learnt their profession by working on different jobs. There was no formal training and yet the officers acquired knowledge by following the instructions and guidance of their superiors. Research was done in the spare time in the office or by working up to late hours after completing the operational functions. The department had the tradition to provide the key of the Pune Meteorological office library to its officers so that at night they could acquire knowledge by reading books and scientific journals. After about a year at Pune, Dr Ananthakrishnan was transferred to the Meteorological office, Alipore (Kolkata) which was another important office of the IMD which was responsible for the work connected with tropical storms in the Bay of Bengal. This posting exposed Dr Ananthakrishnan to the forecasting of two very hazardous weather phenomena viz.; severe thunderstorms, commonly known as Kal Baisakhi and the tropical cyclones, both of which have tremendous societal implications as they cause enormous destruction of property and loss of human life. He was again brought back to Pune in 1940 and posted to Upper Air Section. Dr CWB Normand was then the Director General of Observatories, who attached great importance to the use of upper air temperature and moisture profiles in forecasting convective weather. Upper air soundings were becoming available in India and there was a need to plot these soundings on aerological diagrams to analyse the thermodynamic structure of the upper atmosphere. Dr Ananthakrishnan, with his background of thermodynamics, took up the work of designing an aerological diagram for India. The Tephigram, then prepared by Dr Ananthakrishnan for the Indian climatic conditions, remains still in use at the IMD. To scientifically explain the diagram and its use, he later in 1947, authored a technical note with his colleague in the upper air section, Shri S Yegnanarayanan. During this period of 1942 to 1947, Dr Ananthakrishnan remained occupied with the analyses of upper air data obtained from Aeroplane Meteorological Flights undertaken by the Royal Air Force at Peshawar and Quetta between 1927 and 1936. He was also engaged in probing the radiative equilibrium of the atmosphere, thermal structure of the troposphere at Agra, (which was the major station for regular sounding of the atmosphere in those days) and understanding the



conservation of entropy and reversible processes along the saturation adiabats. The deep understanding which he showed with regard to processes which moist air undergoes while ascending along the saturation adiabat (latent heat release in condensation of water vapour and the heat of fusion when the ice particles melt into liquid water) were noteworthy. Some of the modern ideas about Convective Available Potential Energy (CAPE) and Convective Inhibitive Energy (CINE) existed in the form of positive and negative areas in the discussions on the principles on which construction of Tephigram is based. While working at the Upper Air Section, Pune, Dr Ananthkrishnan came under the inspiring scientific leadership of Professor KR Ramanathan. He held Professor Ramanathan in his great esteem right through his last days.

Dr Ananthkrishnan was promoted as Meteorologist in 1943. During the Second World War years he worked as a forecaster at several important stations of the Royal Air Force such as Barakpore (Kolkata), Trichinopoly and Mauripur (Karachi).

1946-1954: Work on Solar Physics

Dr Ananthkrishnan's career underwent a major change when in 1946 he was posted to the Solar Physics Observatory at Kodaikanal as its Assistant Director and he remained in this position till 1954. His work was experimental astrophysics and he immensely enjoyed this work. Besides, he also devoted himself to the analyses of vast amount of data available at Kodaikanal on solar prominences and sunspots. An interesting result which emanated from this research was the remarkable progression of prominences from the equatorial to polar latitudes during the transition of sunspots from maximum to minimum. Dr Ananthkrishnan had also an opportunity to work on astrophysics during his short stay for a period of six months in 1960 at the Dominion Astrophysics Observatory at Ottawa (Canada).

IMD had plans to establish an astrophysical observatory in the high Himalayas and a multi-disciplinary team of scientists was set up by the Government of India to select a suitable site for the purpose. Dr Ananthkrishnan was a member of the team which visited several places in Badrinath, Jammu and Sikkim areas. For different reasons it took another 25 years to set up such an observatory in Ladakh under the Indian Institute of Astrophysics, Bangalore after the Solar Physics Observatory, Kodaikanal had become an autonomous institute under this name.

1954-1959: Director of the Regional Meteorological Centre, Nagpur, New Delhi and Bombay

Dr Ananthkrishnan had to leave astrophysics and Kodaikanal as he was promoted to the position of Director in IMD in 1954 and posted as in-charge of the Regional Meteorological Centre, Nagpur. It is there in February 1955 that I had the good fortune to work under his direct supervision for nearly two years when he gave me



the charge of the First Class Surface Observatory and Pilot Balloon Station at Nagpur. He trained me in the maintenance of scientific instruments as he wanted that the self recording instruments, the Pan Evaporimeter and other instruments functioning at the station should not only be in spic and span condition but also provide reliable high quality data. He always emphasized the importance of quality of observations, which ultimately resulted in understanding and prediction of weather phenomena. As photography was his hobby, he established a dark room and would develop and enlarge photographs with his own hands. I shared several hours working as his photographic assistant. I could recall several events of his extraordinary enthusiasm for scientific pursuits, quick decision making capabilities as an administrator and great visionary approach for organizational work. He believed in high quality scientific data and with a view to inculcate this quality in his observatory staff he toured and personally inspected all the surface and upper air observatories in Nagpur region, carrying with him all the inspecting equipments, including regional standard barometer for comparing the observatory barometer. For this purpose, he undertook arduous train and bus journeys with Shri MT Jaisinghani who was then the inspector of observatories of Nagpur region. In 1957, I was transferred to Jodhpur, which is under the RMC, New Delhi. Dr Ananthakrishnan was also shifted from RMC Nagpur to RMC, New Delhi towards the end of 1957 and I met him at Jodhpur when he came there to inspect the station. He was transferred as Director, RMC, Bombay in 1959. It is somewhat rare that an officer of the IMD functioned as Director at three of the then 5 RMCs in a period of just about 5 years. While functioning as Director, RMC, Nagpur and New Delhi he wrote several scientific papers with his colleagues. His paper with KL Bhatia on "Tracks of Monsoon Depressions and their Recurvature towards Kashmir", which he presented at the International Symposium on 'Monsoons of the World' held at New Delhi in 1957, is one of his most cited papers.

1959-1971: Deputy Director General (Climatology and Geophysics) and Weather Forecasting, Pune and Director Institute of Tropical Meteorology, Pune

In 1959, Dr Ananthakrishnan was promoted as Dy. Director General of Observatories and posted as in-charge of Climatology and Geophysics (DDGC) at the Meteorological Office, Pune. As his early research interest in meteorology was in understanding the thermal structure of the upper air over India, he organized a programme of launching four radiosonde ascents per day for four typical months for studying the diurnal variability of the upper air temperatures and winds over five representative stations – New Delhi, Calcutta (now Kolkata), Hyderabad, Nagpur, Bombay (now Mumbai) and Madras (now Chennai). In 1960, he moved to the position of Dy. Director General Weather Forecasting (DDGF), Pune and remained in that position for nearly 9 years. In this period, besides performing the important



job of coordinating and guiding the work of the many Weather Forecasting offices in India, he plunged himself deeply with his colleagues to pursue scientific research on the weather and climate of India including their year-to-year variability. His group produced nearly 40 research papers which were published in journals, international symposia and also as Forecasting Manual Reports. As weather forecasting is one of the primary functions of the IMD and the records connected with the forecasting work were spread in many papers, Dr Ananthakrishnan felt the need to consolidate information and knowledge about weather forecasting and through his persuasion with the headquarters of IMD, New Delhi, the Government of India sanctioned a special project for preparing "Forecasting Manuals" at the office of DDGF, Pune. A series of Forecasting Manual Reports appeared in the next 10 to 15 years which have till today retained their importance and quoted in many papers since then. The very first FMU Report "On the Criteria for Declaring the Onset of Monsoon over Kerala" under the authorship of Ananthakrishnan, UR Acharya and AR Ramakrishnan, appeared in 1967. This Report not only became a trendsetter for the high scientific quality of the series, but also diagnosed with great scientific depth an important problem faced by the operational meteorologists every year. While working as DDGC and DDGF at Pune, Dr Ananthakrishnan could find time to guide students for Ph D Degree. The first student who successfully completed the degree under his guidance, is Dr RY Mokashi, who then worked in the Upper Air Section of DDGC office.

As DDGF he was a regular visitor to the Weather Central, Pune at the time of issuance of the All India Daily Weather Forecast by the Chief Forecaster. He participated in weekly map discussions every Thursday in which detailed discussions were conducted and the younger scientists like myself were allowed to raise questions about changes and developments of weather over the country during the week. He organized Forecasting Officers' Conference once every 2-3 years during his tenure as DDGF and presided over the Conference with great dignity and authority giving a chance to the operational forecasters to raise issues and helped them in finding solutions to the complex problems they faced in their professional work.

Another important work which Dr Ananthakrishnan organized as DDGF was the preparation of "Storm Track Atlas of the North Indian Ocean (1877-1960)", which was published in 1961 showing not only the statistics about the cyclonic storms and depressions but also portrayed their individual tracks for each year. This work has remained a standard reference on the subject since then and the style followed in that work has been followed in subsequent two versions of the Atlas. As DDGF, Dr Ananthakrishnan also contributed to international meteorology through his participation in the meetings of World Meteorological Organisation (WMO) and International Civil Aviation Organisation (ICAO) as well as in several international scientific symposia which he attended. His preference for publishing his scientific



researches in *Current Science*, *Journal of the Indian Academy of Sciences*, *Nature* and the *Indian Journal of Meteorology and Geophysics* (now *Mausam*) continued throughout this period. The richness of his investigating intellect on a variety of subjects dealing with variability of weather and climate of India, upper air wind, thermal and moisture structures over India and a variety of other subjects is evident from a large number of papers by him jointly with his co-workers and students.

During the Second World War years, IMD had introduced operational radio-sounding system at several stations in India to determine the geopotentials, temperatures and moisture profiles in the atmosphere. Two types of indigenously manufactured radiosondes one at the Pune Workshop (Fan-Type Sonde) and the other at New Delhi Workshop (Clock-Type Sonde) were functioning in the department. While Dr Ananthakrishnan was Director, RMC, Nagpur, in 1956, IMD had organized the inter-comparison of these two types of radiosondes. This was with a view to determine the compatibility of data provided by the two sonde systems. He showed great interest in this inter-comparison campaign. He with his colleagues between 1966 to 1967 authored several papers on the performance characteristics of the radiosonde data and brought to light the problems with the data from both types of radiosondes. As a result of his relentless pursuit, the IMD designed a new type of radiosonde, after the US design and introduced it uniformly over its entire network in India in 1971. Though the uniformity of the sensing instrument was established in 1971 but after a few years the quality again began to deteriorate. Dr Ananthakrishnan continued to pursue the problem of quality of the radiosonde data till 1980s. The improvement of data quality of the Indian radiosonde system still confronts the IMD inspite of different designs introduced by them in the last 3 decades.

To Dr Ananthakrishnan's credit as DDGF is also the work on the "Climatology of the Himalayas, Tibet and Adjoining Areas (Parts I & II)" which he undertook, with several of his colleagues at the Meteorological Office, Pune, on top priority basis in 1963 and completed the massive work in just about 4 months. The work was published by the Ministry of Defence and distributed to various service units as the basic information (reference material) on the climatology of the hazardous high mountain forward areas and as mentioned by the then Scientific Advisor to the Defence Ministry, "to which our defence activities are intimately concerned".

Period 1969-1993: Director, Institute of Tropical Meteorology, Pune and Honorary Fellow of the Indian Institute of Tropical Meteorology, Pune

Till about 1960, meteorological research in India was mainly pursued at the IMD as the two universities viz. Andhra University, Visakhapatnam and Banaras Hindu University, Varanasi were still in their formative years. Officers of the IMD, on their own initiative, engaged themselves in research studies in addition to their service



functions, following the traditions set by early pioneers of the Indian Meteorology since its inception in 1875. After India's Independence the tempo of all round national developmental activities had begun to increase during the first two Five Year Plans (1951-61). IMD was rapidly expanding and had to concentrate its attention on the immediate problems of modernizing the weather and climate services to meet national and international requirements. Meanwhile the need for research had also increased in proportion to the quantity, quality and complexity of fresh service demands. Post-War and Post-Independence developments in meteorology in India were phenomenal and the service demands of the IMD had become manifold and exacting. Faced with this situation, the IMD had recognized that without proper long-term sustained effort, supported by adequate infrastructure, further significant advances in the physical and dynamical understanding of the atmospheric processes in the tropics were hard to achieve. IMD in November 1962 took a major step since its inception, to establish the Institute of Tropical Meteorology (ITM) in Pune as a distinct part of the department where scientists could devote themselves exclusively to important research goals, untrammelled by the day-to-day demands of a modern weather service. Before the researchers for different divisions of the Institute could be recruited, IMD had asked volunteers from its existing staff to offer their services for the Institute for the initial few years. Dr Ananthakrishnan was so enthusiastic that he offered his services for the Institute in any capacity which the Director General of IMD might deem fit. This was a unique gesture by a person in the top hierarchy of the department.

Professor PR Pisharoty was selected for the post of Director, ITM and he became the founder Director when he took charge on 12 November 1962 as a single scientific staff. Soon others joined from the IMD before the first batch of directly recruited scientists could join the Institute in 1964. The initial years of the ITM were full of new vigour. Dr Ananthakrishnan took this as an opportunity to ignite a spirit of research in the IMD, as he wanted to show that good research could be still pursued at IMD. In those days he used to advise IMD personnel "Publish or Perish". The period 1966-68 was the planning of the World Weather Watch (WWW) by the World Meteorological Organisation (WMO) - a new concept to provide data for regional and global dynamical weather analysis and prediction systems which had been introduced in Europe and USA after the successful research phase of Numerical Weather Prediction (NWP) during 1950s. Dr Ananthakrishnan as DDGF, was responsible for implementation of the WWW in India on behalf of IMD. Being the senior-most serving officer in the IMD, the Govt. of India offered him in 1966 to take over the position of the Director-General of Observatories, the top post in IMD. Dr Ananthakrishnan, being attached to pursuit of research in an academic environment of the Meteorological office, Pune was averse to the hurly-burly of administrative environment of the Headquarter office in New Delhi. He resisted the temptation of the high position and politely declined the offer. Meanwhile, the position of Director,



ITM fell vacant on the retirement of Professor PR Pisharoty and Dr Ananthakrishnan was appointed as Director, ITM in September 1968. The Government of India honoured him with the award of Padma Shri in January 1969. Dr Ananthakrishnan served as Director, ITM upto April 1971 when he reached the age of 60. The period 1969-71 was a period of good progress in ITM as new fields such as Numerical Weather Prediction (NWP), Climate Research, Weather Modification, Development of Rocket Pay Load, Atmospheric Boundary Layer Studies and Theoretical Studies were added. After taking up the stewardship of the Institute, Dr Ananthakrishnan with his research student and Air India research scholar, Shri BM Mishra, undertook experimental work of photographing the clouds and for the first time the team actually determined by theodolite measurements the height of the bases of tropical clouds at Pune. During this phase, Dr Ananthakrishnan asked Shri Mishra to examine data on the large scale pressure changes in the tropics. This was to revive the work of Sir John Eliot, done towards the end of the 19th Century in India, in which he had pointed to the periodic variation of pressure tendencies simultaneously over wide regions of the tropics. The research results of Ananthakrishnan and Mishra were revealing and a 4-5 day pressure oscillation, not only in the tropics but even in mid-latitudes was established.

IMD also showed high regard to various recommendations made by Dr Ananthakrishnan aimed at the progress of the ITM. Just before his retirement, ITM was given the status of an autonomous research Institute on 1 April 1971 on the recommendations of a committee appointed by the Government of India under the chairmanship of Professor S Bhagavantam. Thus with the retirement of Dr Ananthakrishnan, the ITM had entered a new phase with a new name Indian Institute of Tropical Meteorology (IITM). The Governing Council of the IITM conferred on Dr Ananthakrishnan Honorary Fellowship of the Institute and he was to continue his research at the Institute which he did till his last days. His association with the Institute lasted for 3 decades, from 1969 to 1998, and the Institute was proud of this fruitful relationship. As a Fellow of the Institute, he occupied a modest office in an old bungalow called 'Gharpure House' which housed the Institute's Theoretical Studies Division, very close to the main building of the Institute "Ramdurg House" next to the IMD complex at Pune. With his modest retirement benefits he had purchased a flat within about 1 Km distance of the IITM, Ramdurg House - Gharpure House Complex so that he could walk to the Institute for pursuing research and teaching. While working as Director of the Institute, Dr Ananthakrishnan respected the opinions of working scientists and allowed them opportunities to express themselves freely which promoted the academic life at the Institute. Besides pursuing his own research at the Institute for nearly 30 years he guided research for Ph D degrees of different Universities in India and several scientists of IITM and IMD like BM Misra, RN Keshvamurty, SK Mishra, PV Joseph,



M Pathan, CK Rajan and MK Soman acquired their doctoral degrees under his guidance.

Dr Ananthkrishnan, being a true scientist, was much attached to teaching. Even as DDGF in IMD while performing his complex official functions, he used to take a course on Atmospheric Thermodynamics in the Meteorological Training School, Pune. He kept this practice in IITM too even as an Honorary Fellow and gave many lectures covering Atmospheric Dynamics and Thermodynamics, Atmospheric General Circulation and Statistics. A course of lectures given by him on the "Theory of Tidal Oscillation" was very interesting. He remained also a student even in his advanced years as he himself attended courses conducted at the Institute on computer programming and other areas. He used to write his own programs by punching them on Hollerith Cards to be fed into the IBM 1620 computer. He was fascinated, with child-like excitement to see the results of his computer programs and would check them with hand calculation before he would process the full data. He used to attend the special lecture series, organized by Professor GC Asnani, Head of the Theoretical Studies Division, to review all path-breaking papers on Atmospheric Dynamics, NWP and Climate Simulation. Dr Ananthkrishnan was a master in the critical analysis of observational scientific data but regretted in several personal conversations with me that in his young days in the IMD there was no formal training which exposed its scientists to theoretical studies. Dr Ananthkrishnan although a great teacher-philosopher and guide to young scientists, remained a student of science till his last days. I remember his being much excited acquiring new insight into atmospheric dynamical properties when he first read the book on "Introduction to Dynamic Meteorology by JR Holton", which according to him, helped him in appreciating the theoretical aspects of the behaviour of atmospheric processes.

After his formal retirement from the IITM, Dr Ananthkrishnan took to teaching meteorology at the newly established Department of Atmospheric Sciences in Cochin University and functioned as Professor for seven years (1975-1982). He would take the long train journey between Pune and Cochin, three to four times a year, stay in the modest hostel of the University of Cochin for a month or so each time, impart courses to M Sc students and return to Pune. Meticulous as he was, soon after his return to IITM, he would plan his next trip and make railway reservations well in time. In fact he was the builder of the Department of Atmospheric Sciences of Cochin University and the good progress which the department has kept over the years is a great legacy of Dr Ananthkrishnan. Professor Sulochana Gadgil and her colleagues at the IISc, Bangalore invited him frequently to visit the Centre for Atmospheric Sciences to deliver lectures. She remembers him as "He was a source of inspiration to me and young scientists at the Centre". A visit to IISc always reminded him of his old research scholar days. He was also associated with the launching of a scheme of M.Tech. courses in



Atmospheric Science by the University Grants Commission and gave a strong thrust to the M.Tech. Programme at the University of Poona by teaching and Meteorology to students of University of Poona from 1984 to 1990. Professor Ananthakrishnan, at the instance of Madras Science Foundation, published a book entitled "An Introduction to Meteorology" which explains in lucid style the fundamentals of meteorology. He enjoyed the gift of writing in English language in clear style with great depth of understanding of any subject on which he wrote, be it an official communication or a scientific paper. Perfectionist, as he was, he would sit with his associates to personally examine the facts presented by the data and also explained in detail the size of the diagrams were their lettering to the draughtsman so that the diagrams are effectively presented when published in papers for quick readability and grasp. He was unable to tolerate mediocrity but was kind at heart to help his associates and students. Though he was calm and in control, he would not be happy when a shoddy work was done or indiscipline was shown by his juniors.

MEMBERSHIP OF INTERNATIONAL TECHNICAL COMMISSIONS

Dr Ananthakrishnan, during his professional career in the IMD functioned on several WMO Technical Commissions like the Commission for Atmospheric Science (CAS) and its working group on 'Accuracy Requirements in Aerological Soundings', Commission for Synoptic Meteorology (CSM) and its Working Group on "Synoptic Use of Satellite Meteorological Data", Commission for Climatology (CCI) and its Working Group on Regional Climatic Atlases, Chairman of the Regional Association (RA-II) Working Group on Regional Requirements for Basic Meteorological Data (Processed and unprocessed) from inside and outside the region. He also served as a Member of the WMO Executive Committee Panel of Experts on Tropical Meteorology". The subjects dealt by these Commissions Working Groups and the Panel of Experts were very close to his heart and he could make important contributions to these deliberations by virtue of his long experience and expertise.

FELLOWSHIPS OF SCIENTIFIC/ ACADEMIC / SOCIETIES AND AWARDS

As mentioned earlier Dr Ananthakrishnan was elected Fellow of the Indian Academy of Sciences, Bangalore at a young age of 27 years in 1938 and remained a life Member of the Academy. He was elected Fellow of the Indian National Science Academy in 1961 and remained its life member. He was the founder member of the Indian Meteorological Society which was formed in 1957 and remained its life member. He was also a Fellow of the Indian Geophysical Union. He also served as a member of the Council for Indian Academy of Sciences (1962-1964) and on its Committee for the Election of Fellows. He was associated with the Editorial Boards of several scientific journals like *Mausam*, *Journal of the Indian Academy of Sciences*



(Earth and Planetary Sciences), *Current Science* and the *International Journal of Climatology*. All these honours did not touch him and he remained a modest and unassuming person in spite of his great achievements.

LAST DAYS AND APPRECIATION OF HIS PERSONALITY

Till his last days Dr Ananthkrishnan enjoyed good health and continued to visit the IITM regularly. I used to frequently go to his residence to exchange ideas and take benefit of his rich wisdom and advice. Dr ASR Murty, a senior scientist of the IITM also provided him company and support, particularly in his last few years when he had become frail. Even when he was in hospital, after suffering a fall in his home, he remained cheerful and he did not bear an iota of resentment against anyone as he had led a sublime life showering affections on everyone around him.

Dr Ananthkrishnan had led a life of complete dedication to science. He led a simple life but remained dedicated to high thinking. His needs were few. He was averse to spending money for outward personal show but was moved easily by the requirements of the needy around him and supported them financially – a philanthropist who saved to donate for good causes. Success and honours came to him for his scientific achievements but like a *Karmyogi* he remained unattached. He was religious and believed in the eternal philosophy of Bhagvad Gita and also derived strength from the writings of J Krishnamurti and Shri Ramana Maharishi. He had given me a framed photograph of Shri Ramana Maharishi with the advice to concentrate on the great saint philosopher.

Professor Ananthkrishnan was an Atmospheric Scientist par excellence and an affectionate and able teacher. Development of well trained manpower in atmospheric sciences in India remained his passion in the last 20 years of his life. It was a pleasure to work under his inspiring leadership. Several of his students carry fond memories of his great leadership. One of his students, PV Joseph, recalls with gratitude how Professor Ananthkrishnan urged him to join Cochin University of Science and Technology as a Visiting Professor in 1989 to support the teaching and research programmes at their Department of Atmospheric Science. However, due to various reasons Dr Joseph took up this position only in 1995 and is continuing in this position till today as a Professor Emeritus. Professor TN Krishnamurti of Florida State University, one of the greatest authorities in Tropical Meteorology, has recalled his association with him as "Dr R Ananthkrishnan was indeed a great observational scientist on the monsoon behaviour. He showed a kind of maturity on monsoon observations and their interpretations that was rarely seen. He followed the traditions of Professor KR Ramanathan. Both Professor Ramanathan and Professor Ananthkrishnan grasped the essence of monsoon phenomenon quickly and provided the wise decisions we all sought. I enjoyed knowing him as a scientist and as a warm and humble human being". Dr Ananthkrishnan's student, Dr BM Misra,



who held several important positions in different laboratories in USA and is currently at the MIT Lincoln Laboratory, in his tribute to his mentor said the following words "Dr Ananthakrishnan was in the tradition of eternal experimentalists for whom the means are always more important than the goals. An honour to the scholarship of Professor Ananthakrishnan is an honour to the path we walk. He would say "observe". Professor Ananthakrishnan epitomized rich tradition of Indian scholarship, had savant-like qualities, remained calm, composed, and highly organized in his long professional life during which he earned several scientific achievements". We meteorologists in India salute the memory of Dr Ramakrishnan Iyer Ananthakrishnan and pray that his soul enjoys eternal peace.

ACKNOWLEDGEMENTS

The author is deeply indebted to INSA for giving him the opportunity to write this biographical memoir. He is thankful to Mrs AA Shiralkar, Head, Library and Publication Division of the IITM, Pune, who provided him with some material on Dr Ananthakrishnan's life and achievements which was used in this write up. He also acknowledges the background material provided to him by Shri SK Sahni, Executive Secretary of INSA, which helped the author in organizing this biographical memoir.

DR SIKKA

40 Mausam Vihar

New Delhi-110 051

E-mail: drsikka@yahoo.com

BIBLIOGRAPHY

Astrophysics

- 1934 The Molecular Scattering of Light in Binary Gaseous Mixtures *Ind Jour Physics* **8** 555
- Photoelectric photometry of Light Scattering in Fluids *Proc Ind Acad Sci* **1** 201
- On the convergence of error in depolarization measurements *Proc Ind Acad Sci* **2** 133
- 1935 Redetermination of the depolarization of light scattering in gases and vapours *Proc Ind Acad Sci* **2** 1953
- On the Convergence Error in Depolarisation Measurements *Proc Ind Acad Sci* **2** 133
- Raman Spectrum of Heavy Water *Nature* **136** 551
- Raman Spectrum of Heavy Water *Proc Ind Acad Sci* **291** 1935
- Some New Features in the Raman Spectra of Carbon and Silicon Tetrachlorides *Proc Ind Acad Sci* **2** 452
- 1936 Raman Spectra of some Organic Liquids under High Dispersion and Resolving Power *Proc Ind Acad Sci* **3** 52
- 1936 Polarization of the Raman Bands of Water and Deuterium oxide *Proc Ind Acad Sci* **3** 201
- Effect of Temperature on the Raman Spectrum of CCl_4 *Curr Sci* **4** 868



- 1936 The Raman Spectra of Propylene and Iso-butane *Proc Ind Acad Sci* **3** 527
- The Raman Spectra of Some Boron Compounds *Proc Ind Acad Sci* **4** 74
- The Raman Spectrum of Cyclopropane *Nature* **138** 123
- The Raman Spectra of Cyclopropane and Ethylene Oxide *Proc Ind Acad Sci* **4** 82
- The Raman Spectra of Tri-methyl-Amine and Some Compounds of Hydroxylamine and Hydrazine *Proc Ind Acad Sci* **4** 204
- Constitution of phosphorous Acid and the Phosphites *Nature* **138** 803
- A New Technique of Complementary Filters for Photographing the Raman Spectra of Crystal Powders *Curr Sci* **5** 131
- 1937 The Raman Spectra of some simple Molecules Dimethyl Ether, A Phosgene, n-Butane, Ethylene Diamine, Ethylene Glycol, Ethylene Dichloride, Ethylene Dibromide, Acetylene Tetrachloride, Acetylene Tetrabromide and Hexachloroethane *Proc Ind Acad Sci* **5** 265
- The Raman Spectra of Crystal Powders-I The Halides and Sulphate of Ammonium *Proc Ind Acad Sci* **5** 76
- The Raman Spectra of Crystal Powders - II The Chlorides and Sulphate of Hydroxylamine and Hydrozine *Proc Ind Acad Sci* **5** 87
- The Raman Spectra of Crystal Powders - III Exchange Reactions NH_4Cl and D_2O *Proc Ind Acad Sci* **5** 175
- The Raman Spectra of Crystal Powders - IV Some Organic and Inorganic Compounds *Proc Ind Acad Sci* **5** 200
- Raman Spectrum and Constitution of the NO_3^- Ion *Curr Sci* **5** 421
- The Raman Spectra of Crystal Powders - V Inorganic Nitrates Water of Crystallisation *Proc Ind Acad Sci* **5** 447
- Effect of Temperature on the Raman Spectrum of liquid CCl_4 - Some preliminary Considerations *Proc Ind Acad Sci*
- 1947 (With SETHUMADHAVAN K and DAS AK) Sunspot Activity during the Current Cycle - A Review *Jour Sci & Ind Res* **6** 9
- 1949 (With DAS AK) Existe-The Working Group-IV of the ERMP-il une correlation entre les protuberances a disparition brusque et les perturbations geomagnetiques *L'Astronomie* 177-179
- 1951 (With DAS AK) A Recording Photoelectric Photometer *Ind Jour Met & Geophys* **2** 157
- Intensity Variation in Sunspots *Nature* **168** 291
- 1952 Prominence activity and the sunspot cycle *Nature* **170** 156-158
- 1953 Geomagnetic Activity and the Sunspot Cycle *Nature* **172** 854
- Spectrophotometric Study of Sunspots *Proc Ind Acad Sci* **37** 268
- 1954 Prominence Activity (1905-1952) *Proc Ind Acad Sci* **40** 72
- 1954 A Note on the Observations of Sunspots Recorded at Kodaikanal from 1903 to 1950 *Kod Obsy Bull No* **133**



- 1954 (MADHAVAN NAYAR P) Discussion of the Results of Observation of Solar Prominences made at Kodaikanal from 1904 to 1950 *Kod Obsy Bull No 137*
- 1955 The East-West Asymmetry of Hydrological-Alpha Dark Markings Symp on High Alt Res Gulmarg
- 1959 (With VENKATESHWARAN SP) Formation of rainbows in a vertically projected search-light beam *Indian Journal of Meteorology and Geophysics 10* 456-459
- 1960 Light Curves of Meteors *Nature 187* 675
- 1961 Anomalies in the Light Curves of Meteors Resulting from Fragmentation *Nature 190* 896
- Distribution of heights of prominences *Astrophysical Journal 133* 969-972
- 1965 Light and Ionisation Curves of Meteors *Curr Sci 34* 421-424
- 1966 Meteor Luminosity and Meteor Ionisation *Nature 210* 402-403

Meteorology

- 1942 Discussions of the Upper Air Data obtained from Aeroplane Meteorological Flights over Peshawar and Quetta during the years 1927-36 *Meteorological Notes Ind Met Dept 29* Part-2
- 1945 Radiation Equilibrium of the Atmosphere and the Thermal Structure of the Troposphere over Agra *Curr Sci 14* 298
- 1946 Evidence for the Existence of the "Emission layer" in the Atmosphere *Proc Ind Acad Sci 24* 393
- On Fluctuations of Pressure and Temperatures in the Atmosphere *Proc Ind Acad Sci 24* 393
- 1947 (With YEGNANARAYANA S) On the Construction Properties and uses of the Tephigram *India Met Dept Tech Note No 26*
- 1948 On the Thermal Structure of the Atmosphere over Agra *Mem Ind Met Dept 27* part 4
- 1950 On the Changes in the Thermal Structure of the Atmosphere over Agra associated with the passage of a Western Disturbance in Winter *Ind Jour Met & Geophys 1* 45
- 1951 (With SANKAR NARAYAN PV) Conservations of Some Meteorological Phenomena from the Kodaikanal Observatory *Proc Ind Acad Sci 2* 265
- 1956 (With RAJAGOPALAN KSV) Two Spells of Rainfall of unusually high intensity in Nagpur in June 1954 *Ind Jour Met & Geophys 7* 153
- 1957 Appearance of Hazes and Clouds through a Polaroid *Ind Jour Met & Geophys 8* 122
- 1958 (With BHATIA KL) Tracks of Monsoon Depressions and their Recurvature towards Kashmir Monsoons of the World 157-172 1958
- 1959 (With VENKATESHWARAN SP) Formation of Rainbows in a vertically projected search-light Beam *Proc Ind Acad Sci 10* 456
- 1961 (With KRISHNAN A and PANT PS) Variability of Upper Winds Over India *Ind Jour Met and Geophys 12* 431
- 1961 (With RAMA SASTRY AA) Meteorology and Oceanography in Relation to Marine Navigation Shipping and Shipbuilding Conference held at Bombay in Dec 1961
- 1962 (With RAO KV) Microbarograph Records of Indian Observatories in association with the large Nuclear Explosion of 30 October 1961 *Ind Jour Met & Geophys 13* 383



- 1962 (With KRISHNAN AK) Upper Air Changes over India and Neighbourhood associated with the Southwest Monsoon *Curr Sci* **31** 133
- 1963 (With RANGARAJAN S) Inversions and Stable Layers in the Free Atmosphere over India *Ind Jour Met & Geophys J Meteor Geophys* **14** 173
- (With RAMAKRISHNAN AR) Perturbations of the General Circulation Over India and Neighbourhood Proceedings of the WMO/IUGG Symposium on Tropical Meteorology Rotorua New Zealand
- (With RAO KV) Diurnal variation of Low Level Circulation over India Proceedings of the WMO/IUGG Symposium on Tropical Meteorology Rotorua New Zealand
- (With RANGARAJAN S) Some Features of the Thermal Structure of the atmosphere over India and Neighbourhood Proceedings of the WMO/IUGG Symposium on Tropical Meteorology Rotorua New Zealand
- (With RAJAGOPALACHARI PJ) Pattern of Monsoon rainfall distribution over India and neighbourhood *Proceedings of the WMO/IUGG Symposium on Tropical Meteorology Rotorua New Zealand*
- 1964 The role of Meteorology in Transport and Communications *The Economic Times Bombay* June 29 1964
- Recent Progress in Meteorology *Geophysics in India Bull No 1*
- (With CHELLAPPA R and MARY SELVAM) Dew Point and Humidity Mixing Ratio at the Surface and Precipitable Water Vapour in the Atmosphere *Met Res Paper No 13* (DDGF's Office)
- (With CHELLAPPA R, PILLAI PV and SRINIVASAN TV) Tables of humidity mixing ratio *Met Res Paper No 14* (DDGF's Office)
- (With RAMAKRISHNAN R) Vertical Variation of the Constancy of Upper Winds over India *Ind Jour Met & Geophys* **15** 359
- (With RAMAKRISHNAN AR) Changes in the Zonal Circulation over India accompanying the Onset and withdrawl of the Southwest Monsoon *Curr Sci* **33** 543
- (With RAMAKRISHNAN AR and MARY SELVAM) Changes in Meridional Circulation over India accompanying the Onset and withdrawl of the Southwest Monsoon *Curr Sci* **33** 672
- (With RAMAKRISHNAN AR) The Role of Meteorology in Transport and Communications *The Economic Times Bombay* 29 June 1964
- Atlas of tracks of storms and depressions in the Bay of Bengal and the Arabian Sea 1877-1960 India Meteorological Department, New Delhi
- (With CHELLAPPA R and SELVAM MM) Precipitable water vapour in the atmosphere over India Meteorological Research Paper No 12 DDGF-MR India Meteorological Department August 1964
- 1964 (With CHELLAPPA R and SELVAM MM) Dew point and humidity mixing ratio at the surface and precipitable water vapour in the atmosphere *Meteorological Research Paper No 13* DDGF-India Meteorological Department August 1964
- 1965 Light and ionization curves of meteors *Curr Sci* **34** 421-424



- 1965 (With RAMAKRISHNAN AR, SELVAM MM and RAJAGOPALACHARI PJ) Seasonal variations in the zonal and meridional circulation over India *Curr Sci* **34** 272-277
- (With SELVAM MM and CHELLAPPA R) Seasonal variation of precipitable water vapour in the Atmosphere over India *Indian Journal of Meteorology and Geophysics* **18(B)** 371-384
- (With THIRUVENGADATHAN A) Vertical structure of the high level easterlies over Trivandrum and Minicoy during southwest monsoon season of 1963 *Indian Journal of Meteorology and Geophysics* **16** 139-140
- (With CHELAM EV, RAMAKRISHNAN AR and THIRUVENGIDATHAN A) Some dynamical aspects of the zonal and meridional circulations over India and neighbourhood *Proc IAMAP/WMO Int Symp on Dynamics of large scale processes in the Atmosphere (Moscow)* 424
- (With THIRUVENGADATHAN A) Relation between Wind and Pressure at Low Latitudes *Nature* **205** 166-167
- (With RAMAKRISHNAN AR) Upper tropospheric zonal and meridional circulation over India and neighbourhood in relation to the southwest monsoon *Proc Ind Acad Sci Int Symp on Meteorological Results of the IIOE Bombay June 1965*
- General circulation of the atmosphere over the Indian ocean and adjoining areas *Proc Symp on Meteorological Results of the IIOE (Bombay)* 105
- (With RAMAKRISHNAN AR and THIRUVENGIDATHAN A) Inter-relation between the lower tropospheric westerlies and upper tropospheric easterlies during the southwest monsoon *Ibid* 141
- (With THIRUVENGIDATHAN A) Comparison between the actual and geotrophic winds over the Indian Tropics during the summer and winter monsoon months *Ibid* 384
- 1966 (With MOKASHI AY and RAMAKRISHNAN AR) On the Performance Characteristics of the C and F type Radiosondes I Systematic C/F Differences *Ind Jour Met Dept Sci Rep No 21*
- (With RAMAMURTHI KK) Effects of reduction of pressure to mean sea level on surface synoptic weather charts *Ind Met Dept Sci Rep No 50*
- (With THIRUVENGIDATHAN A) Thermal changes in the troposphere associated with seasonal transitions over India *Curr Sci* **37** 184
- Meteor luminosity and meteor ionization *Nature* **210** 402-403
- (With THIRUVENGIDATHAN A) Biennial oscillation in the equatorial troposphere *Nature* **212** 144
- (With MOKASHI AY and RAMAKRISHNAN AR) On the Performance Characteristics of the C and F type Radiosondes II Random Errors of F-type Radiosondes Aerological Data of Trivandrum and Ernakulam *Ind Jour Met Dept Sci Rep No 22*
- 1966 (With THIRUVENGIDATHAN A) Biennial oscillation in the equatorial troposphere *Nature* **212** 1443
- 1967 (With RAMAMURTHY K) On the Performance Characteristics of the C and F type Radiosondes III Random Errors of F-type Radiosondes Aerological Data of Trivandrum Bangalore, Madras and Nagpur *Ind Jour Met Dept Sci Rep No 23*
- (With RAMAKRISHNAN AR) On the Performance Characteristics of the C and F type Radiosondes IV Random Errors of C-type Radiosondes Aerological Data of Jodhpur and Allahabad *Ind Jour Met Dept Sci Rep No 24*



- 1967 (With RAMAKRISHNAN AR) On the Performance Characteristics of the C and F type Radiosondes V Variability of Upper Air Temperatures recorded by Radiosondes operating around India *Ind Jour Met Dept Sci Rep No 25*
- (With RAMAKRISHNAN AR) On the Performance Characteristics of the C and F type Radiosondes VI Comparison of the Monthly Mean Upper Air Temperatures over Indian Stations with Data of the Tropical Stations *Ind Jour Met Dept Sci Rep No 26*
- (With ACHARYA UR and RAMAKRISHNAN AR) On the Criteria for Declaring the Onset of the Southwest Monsoon over Kerala India *Met Dept FMU Rep No 1*
- Some dynamical aspects of the zonal and meridional circulations over India and neighbourhood *Proc Symposium on Dynamics of Large Scale Processes in the Atmosphere Moscow USSR 23-30 June 1965 424-449*
- 1968 (With SRINIVASAN V, RAMAKRISHNAN AR and JAMBUNATHAN R) Synoptic features associated with onset of southwest monsoon over Kerala *Forecasting Manual Vol IV-18 2 India Meteorological Department Pune*
- 1969 (With RAMAKRISHNAN AR) Fluctuations in the upper tropospheric easterlies over India during the southwest monsoon season *IITM Scientific Report No 102*
- Weather Service for Agriculture *Economic and Political Weekly 4 14*
- 1970 Reversal of pressure gradients and wind circulation across India and the southwest monsoon *Quarterly Journal of Royal Meteorological Society 96 539-542*
- Seasonal march of surface pressure gradients across India and the southwest monsoon *Current Science 39 248-251*
- Some salient features of the space-time variations of rainfall over India and the neighbourhood *Curr Sci 39 101-105*
- (With KESHAVAMURTY RN) On some aspects of the fluctuations in the pressure and wind fields over India during the summer and winter monsoon season *Proc Symposium on Tropical Meteorology University of Hawaii Honolulu 2-11 June 1970*
- (With MISHRA BM) Atmospheric oscillations of 4-5 day period *Curr Sci 39 386-387*
- (With MISHRA BM) Photogrammetric study of post-monsoon clouds over Poona *Proc Symposium on Tropical Meteorology University of Hawaii Honolulu 2-11 June 1970*
- (With MISHRA BM) Quasi-periodic oscillations in the pressure tendencies over the Asian monsoon region *Proc Symposium on Tropical Meteorology University of Hawaii Honolulu 2-11 June 1970*
- 1970 (With PATHAN JM) North-South oscillations of the equatorial trough and seasonal variations of rainfall in the tropics *Proc Symposium on Tropical Meteorology University of Hawaii Honolulu 2-11 June 1970*
- (With PATHAN JM) On some features of the space-time variations of rainfall over India and neighbourhood *Ind Met Dept Sci Rep No 118*
- 1971 The Oceans and the Atmosphere Int Symp on Indian Ocean and Adjacent Areas their Origin Science and Resources (Cochin)
- 1971 (With SIKKA DR) Some aspects of the reversal of circulation over the Indian monsoon area and the day-to-day variations in convective activity during the southwest monsoon ISRO/IMD/IRS Symp on Trop Met (Thumba)



- 1971 Mean monthly zonal and meridional winds over India and adjacent seas *Ind Met Dept Sci Rep No 148*
- (With PATHAN JM) Rainfall patterns over India and adjacent seas *India Meteorological Department Scientific Rep No 144*
- (With PATHAN JM) Pentad rainfall charts and space-time variations of rainfall over India and adjoining areas *IITM Res Rep No 036*
- (With SOMAN MK and KRISHNAKUMAR K) Inter-annual variability of the data of onset of the southwest monsoon over Kerala and the variability of monsoon rainfall *Proc Workshop on variability of tropical oceans and atmosphere* (Centre for Atmospheric Sciences Bangalore) 5-23
- 1972 (With KESHAVAMURTY RN) Fluctuations of surface pressure patterns and upper air circulation features during strong and weak monsoon situations *Symp on Droughts in Asian Monsoon Region* (Pune)
- (With KESHAVAMURTY RN) Some new features of the vertical distribution of temperature and humidity over Bombay during the southwest monsoon season *Journal of Marine Biological Association of India* **14** 732-742
- 1973 (With KESHAVAMURTY RN) Preliminary study of the adiabatic generation and dissipation of kinetic energy by meridional and zonal winds over India and neighbourhood during the winter season *Indian Journal of Meteorology and Geophysics* **24** 235-244
- 1974 (With KESHAVAMURTY RN) Vorticity equation *Indian Journal of Meteorology and Geophysics* **25** 81-82
- (With SURYANARAYANA R and SIKKA DR) On the diurnal variation of the zonal and meridional circulation in the troposphere and lower stratosphere Preprint Vol Pt I International Tropical Meteorology Meeting Nairobi Kenya 31 January - 7 February 1974 105-108
- (With SIKKA DR) On the influence of synoptic scale patterns in controlling convective activity during the southwest monsoon Preprint Vol Pt I International Tropical Meteorology Meeting Nairobi Kenya 31 January - 7 February 1974 115-120
- 1976 Some aspects of the variability of daily, monthly and annual rainfall at neighbouring pairs of stations and the nature of monsoon rainfall at individual stations *Proc Symposium on Tropical Meteorology Indian Institute of Tropical Meteorology Pune* 8-10 September 1976 354-364
- 1977 Some aspects of the monsoon circulation and monsoon rainfall *Pure and Applied Geophysics* **115** 1209-1249
- 1979 (With PARTHASARATHY B and PATHAN JM) Meteorology of Kerala *Jour Mar Sci* (Univ of Cochin) 60-125
- Some features of the southwest monsoon rainfall along the west coast of India *Proc Indian Academy of Sciences* (Earth and Planetary Sciences) **88** 11 177-199
- (With PATHAN JM) Meteorology of Kerala. Commemoration volume on the occasion of Sixtieth Birthday of Prof CV Kurian Head of the Department of Marine Science Univ of Cochin
- 1981 (With PATHAN JM and ARALIKATTI SS) On the northward advance of the ITCZ and the onset of the southwest monsoon rains over the southwest Bay of Bengal *Journal of Climatology* **1** 153-165
- 1981 (With RAJAN CK and VALSALA P) Some aspects of the rainfall of Kerala and adjoining areas. The southwest monsoon rainfall of Cochin *Bull Dept Mar Sci* (Univ of Cochin) **12** 65



- 1981 (With PATHAN JM) Harmonic analysis of pentad normal rainfall of Indian stations *IITM Res Rep No 035*
- 1982 (With RAJAN CK and VALSALA P) Some aspects of the rainfall of Kerala and adjoining areas The northeast and pre-southwest monsoon rainfall of Cochin *Bull Dept Mar Sci (Univ of Cochin) 13 96*
- 1983 (With PATHAN JM and ARALIKATTI SS) Onset phase of the southwest monsoon *Curr Sci 52 155-164*
- 1984 (With ARALIKATTI SS and MALIEKAL JA) Atmospheric tidal oscillations Part 1 Historical development *Curr Sci 53 945-951*
- (With ARALIKATTI SS and MALIEKAL JA) Atmospheric tidal oscillations Part 2 Diurnal variation of pressure over India *Curr Sci 53 1007-1016*
- (With PARTHASARATHY S) Indian rainfall in relation to sunspot cycle 1871-1978 *Journal of Climatology 4 149-169*
- 1985 (With SOMAN MK) Evaluation of equivalent potential temperature (EPT) from radiosonde data *Curr Sci 54 314-317*
- 1987 (With SOMAN MK) Some observational aspects of variability of the summer monsoon circulation and rainfall over India during 1978-1979 and 1980 *Vayu Mandal, 17 75-86*
- (With SOMAN MK) Superposed epoch study of rainfall of Kerala during the onset phase of the southwest monsoon *Curr Sci 56 1-8*
- (With RAJAN CK) Some features of southwest monsoon rainfall of Cochin and Minicoy *Journal of Climatology 7 355-372*
- 1988 (With SOMAN MK) On the association between the amount and frequency of daily rainfall distribution at Indian stations *Curr Sci 57 877-882*
- (With SOMAN MK) Onset of southwest monsoon over Kerala 1901-1980 *Journal of Climatology 8 283-296*
- 1989 (With SOMAN MK) Anomalies in aerological data of Mangalore and Ahmedabad *Mausam 40 279-282*
- (With SOMAN MK) Further examination of the anomaly in the radiosonde data of Ahmedabad *Mausam 40 202-206*
- (With SOMAN MK) Onset dates of the southwest monsoon over Kerala for the period 1890-1900 *International Journal of Climatology 9 321-322*
- 1989 (With SOMAN MK) Statistical distribution of daily rainfall and its association with the coefficient of variation of rainfall series *International Journal of Climatology 9 485-500*
- 1991 (With PATHAN JM) Climatological singularity around mid-August in the summer monsoon rainfall of India *Curr Sci 60 439-445*
- (With SOMAN MK) Onset of southwest monsoon in 1990 *Curr Sci 61 447-453*
- 1991 Time Calendar and Climate (Lecture given at the UGC sponsored Workshop on "Fundamentals in Atmospheric Sciences" at the Centre for Atmospheric Sciences Indian Institute of Science Bangalore *Sci Rep No 91 AS2 1-40*)
- 1992 (With SOMAN MK) Inconsistencies in the mean fields of temperature geopotential heights and winds over the Indian aerological network during July-August *Mausam Vol 43 199-204*

