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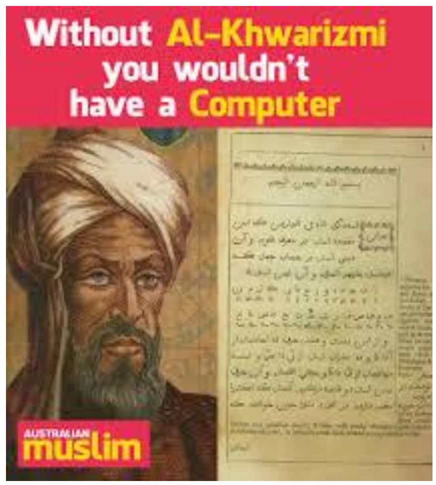
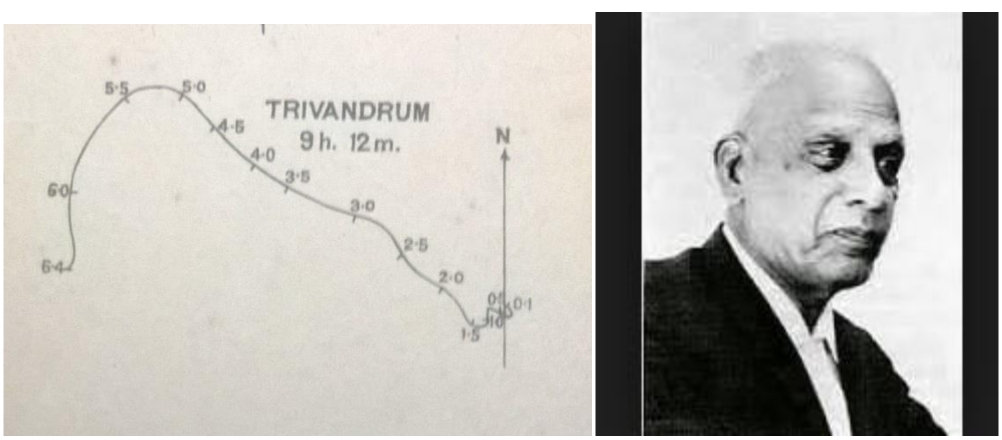


Software Quality of Algorithms



Remembering a great Meteorologist Prof. K. R. Ramanathan (1893-1984)

Indian Meteorological Society

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The Society is a non-profit making organization and none of its income or assets accrues to the benefit of its members.

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1. Advancement of Meteorological and allied sciences in all their aspects
2. Dissemination of the knowledge of such sciences both among the scientific workers and among the public and
3. Promotion of application of Meteorology and allied sciences to various constructive human activities

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The annual subscription of membership is Rs. 500/- for scientists from India +Admission fee, Rs. 50/-.
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"Bulletin of IMSP" is published monthly. Correspondence and contributions to the bulletin may be sent to **pune_ims@rediffmail.com**. The manuscript should be typed at 1.5 space using Times New Roman font size 12. The author's name should be typed on the line below the title, the affiliation and email ID should follow on next line.

The Editor and the society are not responsible for the views expressed by any author in his contributions published in Bulletin of IMSP.

Bulletin of IMSP

May 2019, Vol. 18, No. 5

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Software Quality of Algorithms

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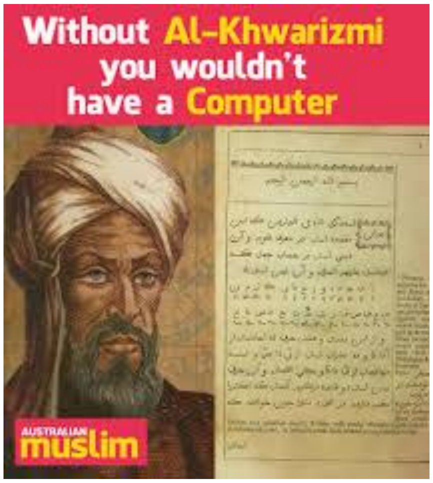
In 825AD (9th Century), a Persian astronomer, geographer and mathematician named "**Abu Ja'far Mahammed ibn Musa al Khwarizmi**" wrote a textbook on Mathematics. He is regarded as "Father of Algebra and Algorithms". Translation of '**al Khwarizmi**' part of his name from Persian to English means '**Algorithm**'.



Study of algorithms is called '**Algorithmics**'. In simplest terms, an algorithm can be defined as 'A method of solving a problem'. Before attempting to design any algorithm for solving a problem, we must first ensure that the problem is a solvable problem because there are problems which are unsolvable. A problem is said to be a solvable problem if it is a well posed problem. A problem is said to be a well posed problem if it satisfies the following criterion.

(a) It should be possible for us to unambiguously describe all inherent (built in) details of the problem.

(b) During the process of problem solving, it should be possible for us to know as to when we have obtained solution to the problem.

(c) Problem should not change during its attempted solution.

In the context of a well posed problem and a device on which its algorithm is to be implemented, an algorithm is defined as "**A precise characterization of a method of solving the problem presented in a computer programming language suitable to the device**". The language will be some computer programming language and the device will be a computer. We associate an integer value with every problem and this integer value represents size of the problem. Larger the size more is the time required to solve the problem and vice-versa. Solution to the factorial problem, FACT, of size N, i.e. FACT (N), is mathematically defined as under:

FACT (N) = 1 * 2 * 3 * … * (N – 1) * N

Similarly, solution to the factorial problem, FACT, of size (N – 1), i.e. FACT (N - 1), can be defined as:

FACT (N - 1) = 1 * 2 * 3 * … * (N – 1)

From the above definitions of factorial problem of two successive sizes N and N-1, we can analytically relate factorial problem, FACT, of sizes N and (N – 1) as:

FACT (N) = FACT (N – 1) * N

This factorial recurrence relation shows that factorial problem of size (N – 1) becomes a sub problem of factorial problem of size N. Recursive problem contains itself within itself. **A problem is said to be recursive, if it becomes the sub problem of itself**. Inner version of the recursive problem is of smaller size than the outer version of the problem. Recursive problems have a smallest threshold size for which its solution is known and it is at this size, recursive problem stops containing itself within itself. Process in which a problem contains itself within itself is called '**Recursion**'. Process of recursion stops as and when the inner version of problem is of smallest threshold size specified for the problem. Such smallest threshold size for factorial problem is zero. Factorial problem of size less than zero is undefined. A recursive problem becomes undefined for sizes less than the smallest threshold size specified for the problem. **Problem is said to be iterative if it does not become a sub problem of itself**.

Factorial algorithm for problem of size N is iteratively defined as under.

$$FACT (N) = 1 * 2 * 3 * \ldots * (N - 1) * N.$$

Factorial algorithm for problem of size (N – 1) is iteratively defined as under.

$$FACT (N - 1) = 1 * 2 * 3 * \ldots * (N - 1)$$

From the above two iterative definitions we conclude that algorithm for solving factorial problem of size N is [Algorithm for solving factorial problem of size (N – 1)] * N. Algorithm for solving a factorial problem of smaller size becomes a part of the algorithm for solving factorial problem of larger size i.e. algorithm for solving a recursive factorial problem is also recursive. An algorithm is said to be recursive, if it uses itself for evaluating itself. An algorithm is said to be iterative, if it does not use itself for evaluating itself. Recursion of computer science is same as recurrence relation of mathematics.

Following aspects of an algorithm are studied in algorithmics.

- **(a)** How to describe an algorithm?
- **(b)** How to design an algorithm as the code of some computer programming language?
- **(c)** How to validate the correctness of the design of an algorithm?
- **(d)** How to compare merits and demerits of different designs of same description of an algorithm?
- **(e)** How to study the software quality of the design (code) of an algorithm?

Software quality of an algorithm is studied by studying following resource requirements of the code of the algorithm during its execution.

- **(a)** How much space (Computer's memory in bytes) of the device (Computer) does the code of an algorithm require during its execution?
- **(b)** For how long (Execution time), algorithm retains this space (Memory) of device (Computer)?

Space related resource requirement defines the space component of the software quality of the algorithm and is called '**Space Complexity**' of the algorithm. Space complexity is bad if space requirement is more and space complexity is good if space requirement is less. It's a function describing the amount of memory an algorithm takes in terms of the size of input to the algorithm. We often speak of "extra" memory needed, not counting the memory needed to store the input itself. Again, we use natural (but fixed-length) units to measure this. Space complexity is sometimes ignored because the space used is minimal and sometimes it becomes as important issue as time. Time related resource requirement defines the time component of the software quality of the algorithm and is called '**Time Complexity**' of the algorithm. Time complexity is bad if time requirement is more and time complexity is good if time requirement is less. It's a function describing the amount of time required to run an algorithm in terms of the size of the input. "Time" can mean the number of memory accesses performed, the number of comparisons between integers, the number of times some inner loop is executed, or some other natural unit related to the amount of real time the algorithm will take. Time complexity of an algorithm depends on the instruction set, processor speed, disk I/O speed, etc. Both time and space complexities of the algorithm are mathematical functions whose argument is size of the problem. Different types of notations are used to represent the time complexity of an algorithm. Following notations are universally used to study the time complexity of an algorithm.

Notation Symbol : **O** – Pronounced as **Big Oh**
Notation Symbol : **Ω** − Pronounced as **Big Omega**
Notation Symbol : **θ** − Pronounced as **Big Theta**
Notation Symbol : **o** − Pronounced as **Little Oh**
Notation Symbol : **ω** − Pronounced as **Little Omega**

Combination of space complexity and time complexity of an algorithm is called '**Algorithm Complexity**' of the algorithm. Algorithm complexity defines 'Software Quality' of an algorithm. An understanding of algorithmic complexity provides programmers with insight into the efficiency of their codes. Algorithmic complexity is important in several areas of theoretical computer science including Data Structures and Complexity Theory. There are well defined methods for studying the design and analysis of complexity of algorithms viz. (1) Dynamic Programming, (2) Backtracking, (3) Greedy Method, (4) Branch and Bound and (5) Divide and Conquer.

Knowing the complexity of algorithms allows us to answer the following questions.

(a) How long will an algorithm run on any given input?

(b) How much space (computer's memory) algorithm will require during its execution?

Space and time related resource requirements can take two extreme values (1) minimum and (2) maximum l4ading to their four different combinations of resurce requirements and complexities. We can express the above complexity and resource related conclusions in the following tabular form.

Resource Requirement		**CASE**	**Related Complexity**	
Space	**Time**		**Space**	**Time**
Minimum	Minimum	1	Best	Best
Minimum	Maximum	2	Best	Worst
Maximum	Minimum	3	Worst	Best
Maximum	Maximum	4	Worst	Worst

We may be unable to achieve case (1) and would not like to achieve case (4).

An algorithm needs space of the computer for storing current values of variables used in its design. We can improve space complexity of an algorithm by using ‘Dynamic Variable’. A variable is said to be dynamic if it is bound to the address of a computer’s memory block which is obtained dynamically during execution of the code of algorithm using the tools of ‘Dynamic Memory Management’. Fortran-90 also supports dynamic variables and dynamic memory management. Name of dynamic variable does not appear in the source code. Fortran-90 introduced dynamic variable in scientific computing. Dynamic variable is an un-named variable or ‘Anonymous Variable’. Pointer variable was introduced in ‘C’ language to take the address of the memory block of a dynamic (anonymous) variable as its value. Pointer variable itself is not anonymous variable but its value is the address of the memory block which is dynamically allotted for an anonymous (dynamic) variable. There is a difference in implementation of dynamic variables in ‘C’ language and FORTRAN-90. Computer programming languages derived from ‘C’ language viz. C++, JAVA and C#, and all post-90 versions of Fortran viz. Fortran-95, Fortran-2003, Fortran-2008 and Fortran-2015, support dynamical allocation and release of computer's memory blocks using built in library functions. In 'C' language dynamical allocation and release of computer's memory block is implemented through built in intrinsic functions 'malloc' and 'free' where as in Fortran-90 it is implemented through library functions 'ALLOCATE and 'DEALLOCATE'. 'C' language and its derivative languages support only scalar dynamic variables whereas all post-77 versions of FORTRAN support both scalar and DIMENSION dynamic variables. Space complexity of algorithms designed (coded) in any post-77 version of FORTRAN has better scope of improvement than the algorithm designed either in 'C' language or in any of its derivative languages. Using dynamic variables we hold space (Memory) blocks for lesser durations of time. Space complexity (Quality) of an iterative algorithm is better than its recursive version. An algorithm needs time of the computer for completing the execution of the operations represented by various operators used in the design of the algorithm. Besides this, system also executes a number of machine instructions during the execution of an algorithm for making the functionality of the algorithm operational and this time is more than the time taken by the system for the complete execution of operations of different operators used in the design of the algorithm. We improve time complexity of an algorithm by performing '**Frequency Analysis**' of design of the algorithm. Time complexity of an iterative algorithm is better than that of its recursive version. There is always a trade-off between the space and time complexities of any algorithm. An improvement in one kind of complexity deteriorates the other kind of complexity. Space complexity always lives under the shadow of time complexity. Improvement in time complexity is given more importance over the improvement in space complexity.

In frequency analysis of an algorithm, we analyse the design (code) of the algorithm and identify those operations whose frequency is more than one viz. loops. Accessing any member of an array collection by indexing the array is a computational overhead. Array is a collection whose members do not have name and are identified by their positions in the array collection, and positions do not get addresses. Process of accessing members of an array collection by indexing the array (DIMENSION Variable of FORTRAN) leads to the execution of certain hidden calculations during execution of the algorithm and adversely affects the time complexity and software quality of the algorithm. We can improve software quality of an algorithm by performing its frequency analysis and designing it as an iterative algorithm. Algorithms are unambiguous specifications for performing calculations, data processing, automated reasoning and other tasks. The concept of algorithms has existed for centuries. Algorithms are the heart of computer science and the subject has countless practical applications as well as intellectual depth. In today's era of artificial intelligence, computer scientists are exploring the concept of '**Algorithmic Intelligence**'. Ever since man invented the idea of a machine which could perform basic mathematical operations, the study of what can be computed and how it can be computed well was launched. This study, inspired by computer, has led to the discovery of many important and clever algorithms. The discipline called 'Computer Science' has embraced the study of algorithms as its own. "Algorithm" is a fundamental concept of computer science. "Algorithm" has a special significance in computer science. Good understanding and knowledge of the design and computational complexity analysis of algorithms needs sound working knowledge of implementations of various data structures in some procedural or object oriented computer programming language. "**Computational Complexity Analysis of Algorithms**" is currently one of the most energetic areas of computer science research. If we try to identify those contributions of computer science which will be long lasting, surely one of those will be the refinement of the concept called 'Algorithm'.

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"India's New Policy for Scientific Social Responsibility"

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India is going to be possibly the first country in the world to implement a Scientific Social Responsibility (SSR) Policy on the lines of Corporate Social Responsibility (CSR) to encourage S&T institutions and individual scientists in the country to proactively engage in science outreach activities for bridging the science-society divide.

The Policy aims to harness the voluntary potential lying latent in the Indian scientific community for strengthening the linkages between science and society, and for making S&T ecosystem in the country more vibrant. The Policy is directed toward developing a mechanism for ensuring easy access to scientific knowledge and resources, transferring the benefits of science to meet the existing and emerging societal needs, creating an enabling environment for sharing ideas and resources within the knowledge ecosystem, promoting collaborations to identify problems and develop solutions, and inculcating social responsibility among S&T institutions and individual scientists.

A draft of the new SSR Policy 2019 is made available by the Government of India through Department of Science and Technology (DST) website (www.dst.gov.in) for public comments by 08 October 2019.

This new policy carries the traditions of the earlier science policies of India (Scientific Policy Resolution 1958, Technology Policy Statement 1983, Science and Technology Policy 2003 and Science Technology and Innovation Policy 2013) while having more interesting, pragmatic and practical provisions to make S&T institutions and individual scientists or knowledge workers socially more responsible and relevant for society.

The draft policy requires individual scientists or knowledge workers to devote at least 10 person-days of SSR per year for exchanging scientific knowledge to society. It also recognizes the need to adequately incentivize individual and institutional SSR/outreach activities with necessary budgetary support. It also proposes to give due credit to knowledge workers/scientists for individual SSR activities in their annual performance appraisal and evaluation.

An important aspect of this policy is that no institution would be allowed to outsource or sub-contract their SSR activities and projects. This means that all the knowledge institutions would be expected to develop in-house capabilities to implement their SSR activities and projects.

When almost all the S&T research in India is being done by using taxpayers' money, the scientific establishment has an ethical obligation of "giving back" to the society and other stakeholders. "SSR is not only about scientific impact upon society but also about the social impact upon science. SSR would therefore strengthen the knowledge ecosystem and bring efficiencies in harnessing science for the benefit of society", says the draft policy document in its preamble.

What is Scientific Social Responsibility (SSR)? The Policy document defines SSR as "The ethical obligation of knowledge workers in all fields of science and technology to voluntarily contribute their knowledge and resources to the widest spectrum of stakeholders in society, in a spirit of service and conscious reciprocity". Here, knowledge workers mean anyone who participates in the knowledge economy in the areas of the human, social, natural, physical, biological, medical, mathematical and computer/data sciences and their associated technologies.

The draft policy states that a central and nodal body/agency will be set-up at DST to supervise, monitor and implement the SSR activities in the country. Once formalized, the policy requires all the Central Government Ministries, State Governments and S&T institutions to make their own plans to implement SSR as per their mandate. Each S&T institution would be required to sensitise their knowledge workers about their ethical social responsibility toward society, to have an SSR monitoring system to assess institutional projects and individual activities, and to publish an annual SSR report. Appropriate indicators would be developed for monitoring SSR activities at both institutional and individual levels, while measuring their impact on short-term, medium-term and long-term bases.

To effectively implement the Policy, a national digital portal will be set-up to capture societal needs requiring scientific interventions and as a platform for implementers and for reporting SSR activities. It also requires the funding agencies to support SSR through: a) funding individual SSR projects, b) fixing a certain percentage of every project for SSR, c) recommending appropriate SSR requirements for any given project received for funding.

If implemented properly and efficiently, the Policy, while strengthening the existing efforts in science outreach, would play a transformative role in bringing scientific and innovative solutions to societal problems, uplifting the life standard of marginalised sections of society through capacity-building, skill development, facilitating rural innovations, empowering women and weaker sections, helping industries and start-ups, etc. It will also contribute in achieving sustainable development goals (SDGs), environmental goals and Technology Vision 2035.

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Remembering a great Meteorologist Professor K. R. Ramanathan

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Long back, in the second half of 1910's, an young college teacher, more accurately, a demonstrator in the Physics department of Maharajah's college (present University college) Thiruvananthapuram walked into the local Meteorological observatory. The reason was, the Relative Humidity calculated by his students daily were different from that published by the Meteorological observatory Thiruvananthapuram. The young teacher noted that observers at Meteorological observatory were not using the proper hygrometric table for calculating Relative Humidity of atmosphere. (Different tables are used for readings of Dry bulb and wet bulb from Stevenson screen, Whirling psychrometer and Assmann Psyhrometer.)

As a reward for pointing out the mistake then Director of Meteorological observatory, Dr. Stephenson, asked the young teacher to hold the post of Director of Meteorological observatory in addition to the teaching job. A planetary scale magnanimity showered on a subordinate! But how this young teacher became a demonstrator in Maharajah's college itself is another interesting story. The principal of Maharajah's college and head of the department of physics, Professor Stephenson(also the Director of Meteorological observatory), was one of his examiners for B.A Physics (Hons) in the famous Presidency college, Madras . Impressed by the students' performance in the examination, the principal offered him the post of a demonstrator in physics department with unfettered freedom to use the physics laboratory and library even during non working hours to quench his scientific thirst. A demonstrator (then a gazetted post) becoming director of a Meteorological observatory by overnight may be a big surprise, but his mentor's insight and prognostic acumen was very accurate , as *this Director* later on became an internationally known Meteorologist and was the Director of Physical Research Laboratories(PRL), Ahmedabad for 18 years after his retirement from India Meteorological department (IMD) in 1948. He is **Padma Vibhushan Kalpathi Ramakrishna Ramanathan**, **M.A., D.Sc., internationally Known as "Mr. Ozone" .**

Kalpathi Ramakrishna Ramanathan, FNA, FASc, FIAS, Hon.FRMetS

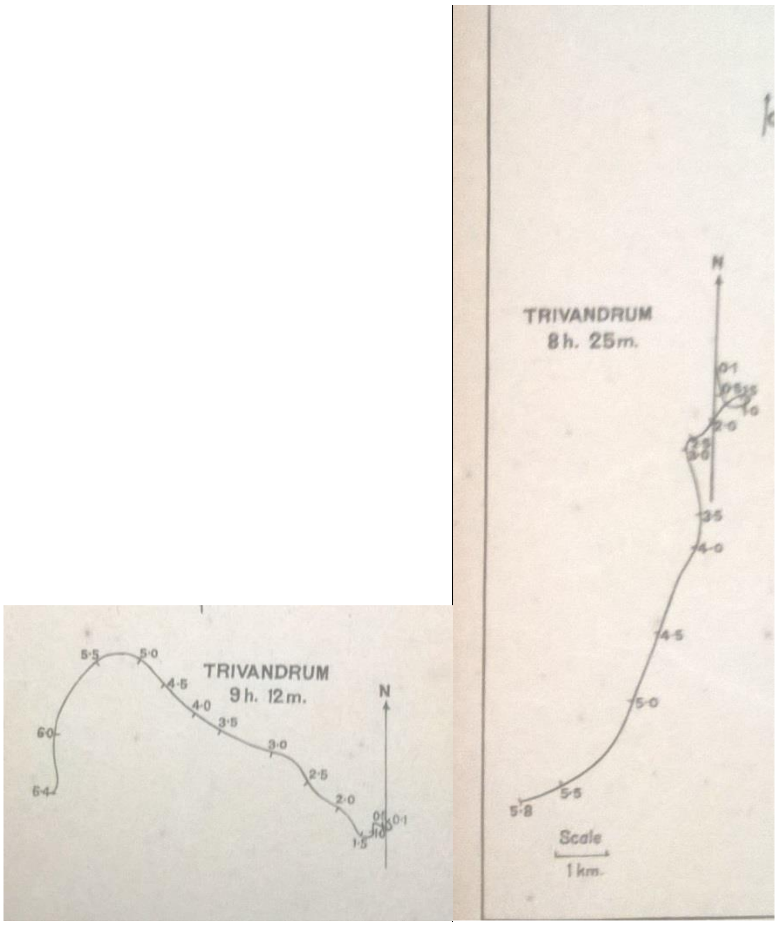
[**Born** on 28th February 1893 ; **Died** on 31st December 1984 (aged 91)]

Soon after preparing the rainfall map of Travancore state (a laborious job undertaken by making extensive tour to state-rain gauge stations and to the plantations which had rain gauges) and publishing his first research paper 'On thunderstorms over Trivandrum', Ramanathan who was well acquainted with the work of Prof. C .V. Raman joined him at Calcutta at the end of 1921.

Another one year was a rigorous scientific accomplishment for Ramanathan under Prof. C. V Raman and came up with ten outstanding papers on molecular scattering, x -ray diffraction, etc for which Madras university conferred the first ever D.Sc to him. Pecuniary consideration, forced him to take up the job of Assistant Professor in University of Rangoon. Nevertheless during his vacations he visited Raman's lab in Calcutta, and it was on one such visit, Dr. Ramanathan while studying the molecular diffraction of light by water observed a weak *fluorescence in the scattered light which he attributed to impurity in the liquid*. But Prof. C.V Raman was not satisfied with the explanation and after a series of painstaking experiments, *Raman deduced it as characteristic of the substance, associated with a change in frequency equal to the molecular vibrational frequency of the substance*. This is the famous **Raman effect** (1928) observed by Dr. K.R. Ramanathan in 1923 but wrongly interpreted. For Dr. Ramanathan it was a miss by a micron to be associated with the greatest invention ever made in India, due to a misinterpretation.

His interest in geophysics outweighed all other considerations and he left the teaching job in Rangoon and joined India Meteorological department (IMD) on invitation in 1925.During his service in IMD there is hardly any important branch of atmospheric science he has not researched upon; also contributed to geomagnetism, solar physics and seismology.

His researches were mainly based on observations. Accurate observational data provided by observers of his era were the mainstay of his research work. The pilot balloon trajectories (appended below) of 07-01-1929/0825UTC and 09-1-1929/0912UTC of Thiruvananthapuram which captured the atmospheric flow over Thiruvananthapuram and neighbourhood in minute detail, used in his research paper *'The structure of the Madras storm of January 1929'* are ample proof of integrity and sincerity of meteorological observers of his time, probably they were well motivated to be so.



[The pilot balloon trajectories of 07-01-1929/0825UTC and 09-1-1929/0912UTC of Trivandrum (Thiruvananthapuram), Kerala, utilized by Professor K. R. Ramanathan for his research paper]

Meteorological observers may be fascinated to know that it was Prof. K. R Ramanathan who compared Indian Meteographs with Meteographs taken by European scientists and showed that stratosphere is above 16 Km over India, at a higher level than over middle latitude . From the invaluable sounding balloon data obtained from upper air stations in India and from a few stations abroad Prof. Ramanathan published, the ever famous diagram showing the distribution of upper air temperature over the world up to a height of twenty five Km in summer and winter. In spite of voluminous upper air data now available from various modes of observation ,his diagram has not lost its sheen, for it had the indication of subtropical jet stream(STJ), if one applied the thermal wind equation to the diagram

After an illustrious service of twenty three years this "quiet, modest, wise, tolerant, understanding, happy and serene gentleman" as described by Prof.P.R Pisharoty, another renowned Indian Meteorologist and father of Indian Remote sensing , retired from IMD in 1948 at the age of 55 ,only to have another scintillating scientific career spanning over 36 years, out of which, first half as Director of PRL and as Professor Emeritus at PRL from second half to till his last breath on the night of 31 December 1984. Ramanathan's research work at the PRL was mainly concerned with studies of atmospheric Ozone, night airglow, ionospheric and space physics, and solar and galactic influences on the ionosphere.

He mentored many scientists, one among them was the celebrated women *meteorologist* of India Miss Anna Mani .It is worth mentioning here some of the contribution of Dr. Ramanathan , articulated by Miss Anna Mani, while delivery the first Professor K. R. Ramanathan Medal lecture (1987) under the auspicious of Indian National Science Academy .They are (1) Dr. Ramanathan's memoir on the general circulation of the atmosphere over India and neighbourhood is the first clear and comprehensive study of the subject. (2) After establishing network of Dobson Ozone spectrometer stations in India, he demonstrated that the Ozone maximum occurs at much higher level, 25-27 Km over the tropics than over mid latitude.(3) he proved that in tropics ,unlike in other places, the vertical distribution of Ozone does not change with season (4) the important relationship between atmospheric Ozone and general circulation (5) from the data gathered during international geophysical year (IGY) and International Geophysical Cooperation(IGC),Prof. Ramanathan pointed out the pronounced longitudinal difference in Ozone distribution that exist and showed that the spring rise in Ozone in high and middle latitude was associated with the break-up and warming of the polar stratospheric vortex.(6) His Discovery of the quasi biennial oscillation of total Ozone in the tropics. He was the world's leading authority on Ozone then and aptly called as "Mr. Ozone".

The Membership in learned societies and honours Prof. Ramanathan received asserts his eminence in the fields he had treaded. They are too many to mention, important among them are: he was President of (1) International Association for Meteorology (1951-54), (2) Inter-national Union of Geodesy and Geophysics (1954-57) ,(3) International Ozone Commission (1960-67). These positions also proclaim his international recognition. Various Scientific organizations took his advice and guidance during their formative stage. He was Foundation Fellow, Indian National Science Academy (1935) and was chairman, Board of Nuclear Sciences, Department of Atomic Energy (1961-68).

Let us pay tribute to the great scientist of India on the occasion of his 35th death anniversary on **31st December 2019**

References:

1. Biographical Memoirs Kalpathy Ramakrishna Rupanathan, by Prof. Pisharoty

2. Kalpathi Ramakrishna Ramanathan Medal Lecture (1987) by Anna Modayil Mani, FNA.

3. IMD scientific notes, Vol. III, No.18

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IMSP News:

Scientific Lecture by Dr. Jeevanprakash R. Kulkarni on 1st May 2019 at IITM Pune

IMS Pune Chapter (IMSP) organized a popular scientific lecture by **Dr. Jeevanprakash R. Kulkarni**, (Chairman IMSP, Ex WMO Expert and Retired Scientist, IITM Pune) on 1st May 2019 (Wednesday) at Varahamihira Hall of IITM Pune. Title of his lecture was "Meteorological aspects of current hot weather conditions in India".

The lecture highlighted very hot weather conditions over India during April 2019. He mentioned that several cities in Maharashtra and Rajasthan recorded maximum temperatures over 45 °C during April 2019. The lecture was attended by more than 125 persons.

IMSP

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Pune Chapter

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