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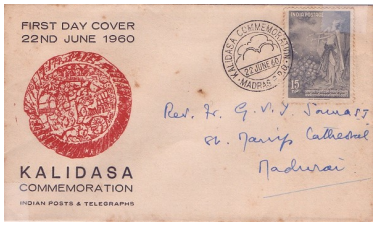

Weather and Climate: a Philatelic Journey (by Dr. M. R. Ramesh Kumar)

Special issue of CLIVAR Exchanges (CE-79) on "India's Monsoon Mission"

[Guest Editor: Dr. M. N. Rajeevan]

Indian Meteorological Society

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The Indian Meteorological Society was established in 1956 and was registered on 26 May 1972 under the societies Registration act of 1860 as amended by Punjab Amendment Act 1957 applicable to Delhi. Registration No. of the society is 5403. The Society's headquarter is located at Delhi and its local chapters are functional at various places of India. The Society is a non-profit making organization and none of its income or assets accrues to the benefit of its members.

Objectives of the Society

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

Any person, who is interested in above objectives of the society, is eligible to become a Life member.
The Life membership fee is Rs. 3000/- for Scientists from India + Admission fee of Rs. 50/- only.

"Bulletin of IMSP" is generally published quarterly. Correspondence and contributions to the bulletin may be sent to Editorial Board (**jrksup@tropmet.res.in** OR **mahap@tropmet.res.in)**_ with copy (**Cc**) to the Chairman (**seelan@tropmet.res.in**) OR **pune_ims@rediffmail.com**. The manuscript should be typed at 1.15 space using Times New Roman font size 12, in MS-Word file. The author's name should be typed on the line below the title, the affiliation and email ID should follow on next line.

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Contents:

Weather and Climate: a Philatelic Journey

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About the Author: Dr. M. R. Ramesh Kumar is a retired Chief Scientist, Physical Oceanography Division at the National Institute of Oceanography, Dona Paula, Goa. His research interests are air sea interaction, monsoons, remote sensing, cyclones, climate change, etc. He has participated in several oceanographic expeditions, including the Arabian Sea Monsoon Experiment. His most important voyage was the 6th Indian Scientific expedition to Antarctica, way back in 1986-1987. **He contributed for the formation of IMS Goa Chapter. He had been President of IMS GOA Chapter and continues to be in close association with it.**

Some brief introduction to Philately:

Philately has a deeper meaning of researching about various kinds of stamps, as to when these stamps are born, what are the reasons that led to their birth, who designed the stamp, what a particular stamp depicts and how many perforations are there, etc.

Stamps can be classified into two types a) used and b) mint (unused) stamps. Further, they are categorized as:

Definitive stamps: These stamps are a part of the regular issue and are available for using postage services for an extended period. They are designed to serve the everyday postal needs of the country.

Commemorative stamps: A commemorative stamp is often issued on a significant date such as an anniversary, to honour or commemorate a place, event, person, or object. The subject of the commemorative stamp is usually spelt out in print. Numerous commemorative stamps were issued by India to honour notable personalities like freedom fighters, politicians etc. Many other stamps to celebrate special events related to sports, space, science and technology, defence, arts and crafts etc. showcase the reflections of a vibrant India.

Miniature sheets: A miniature sheet is a small group of stamps that are still attached to the sheet on which they are printed. They could be regular issues of commemorative ones as well.

First Day Cover: Envelops bearing stamps on the first day of the issue

Special covers: To commemorate a special occasion, special covers are released either by the Department of Posts or Institutions or organizations.

Unusual Stamps: These are special stamps, which have a different shape, size or even different material used while making them, such as Wood, ceramic, Cloth etc. Some of the stamps also have smell of various scents, also there are stamps which are 3 Dimensional and some stamps can be used as Compact Disc for playing Music or Hologram image etc. Some of the stamps are edible too.

Special cancellation: In addition to the above, at times, the department of posts also introduces special cancellation to mark an occasion or an event.

Introduction:

Weather, climate and water have attracted the interest of the mankind from time immemorial, thus many surviving records of ancient civilizations contain references to these fields, which today come under the purview of the World Meteorological Organisation (WMO).

Benjamin Franklin (1706-1790), a notable scientist and inventor of the lightning rod, was also between 1775 and 1776 Post Master General of 13 American Colonies that became the United States of America in 1776. He plotted the course of the Gulf Stream to facilitate the shipboard mail distribution. In an early example of fruitful collaboration between postal and meteorological services.

It is estimated that more than 1000 stamps have been issued to illustrate meteorology related events, in addition to cancellations, souvenir sheets, aerogrammes, stationary cards and other philatelic material.

The basic source of all weather-phenomena has been the solar energy. There would be no life on earth without the sun. The sun provides practically all the energy which the earth needs for life and weather systems. Rain, which has played a significant role in a man's history, and many other meteorological elements has been depicted as gods.

Abnormal behaviour by animals and plants is often taken to mean a change in weather. The basis for this these "forecasts" lies in the animal's sensitivity to pressure and humidity changes, that human beings do not necessarily recognise.

Weather observations made by cargo (merchant) and research ships have long tradition in world oceans. Weather observations are made all over the world, from pole to pole. There being no land around the north pole, Arctic Expeditions, in addition to a few northern islands, have provided valuable weather information.

The World Meteorological Organisation coordinates, standardises and promotes meteorological activities throughout the world and covers all meteorology related issues. Its headquarters is in Geneva, Switzerland. The first WMO Day was celebrated in 1961 and has since then been celebrated every year annually on 23rd March. Particular attention has been given to the contribution of Meteorology for various aspects of economic development.

Flooding can be disastrous in low lying areas or rivers. Monitoring water levels is one of the duties of most national Meteorological services, which regularly collect information on water cycle components,

like precipitation, evaporation and runoff. Flooding is caused by a mixture of factors and conditions, including large amounts of precipitation and altitude differences and land use and land change patterns etc. Emergency mail deliveries are sometimes necessary because of floods.

In the past, the gods were believed to explain the weather phenomena. The Sun, the centre of the universe, has been adored by man for many civilizations. In this article of mine, I have tried incorporate, the various weather gods depicted by different countries including India, weather instruments, weather phenomena and also National Weather services as well as International Collaboration in weather related activities.

Weather Gods:

Given below is the **Greek Supreme God, Zeus**, he is also called the God of the skies. The stamp shows the **100th Anniversary of World Meteorological Organisation** (WMO) along with an image of **Radarscope,** a modern Meteorological equipment which measures the clouds, etc. and this **stamp was issued by Grenada.**

Konark, Sun temple is dedicated to the Hindu God, Surya. The term Konark, is derived from a combination of Sanskrit words, Kona (meaning corner or angle) and Arka meaning Sun or Surya. The term Konark, likely refers to the corner direction in which the temple was aligned to face the sunrise. The Se-tenant stamp given below depicts the **Konark Sun temple along with the Chariot wheel**. This **stamp was issued by Department of Posts, Government of India**.

The Greek Sun God "Helios" is depicted in the stamp given below. It clearly depicts the role of Sun in the formation of various seasons and equinoxes are depicted in a stamp issued by Grenada during the **100th Anniversary of the World Meteorological Organisation.**

The sunrise of the new Millennium (1-1-2000) is depicted on a **First day cover (FDC) issued by Department of Posts, Government of India**. **Katchal – the sunrise island** as it is called now, is a tiny island which belongs to the Andaman and Nicobar group of islands in the Bay of Bengal. The First Day cover is given along with the 1-1-2000 cancellation of the Ernakulam Post office.

Meteorological Instruments:

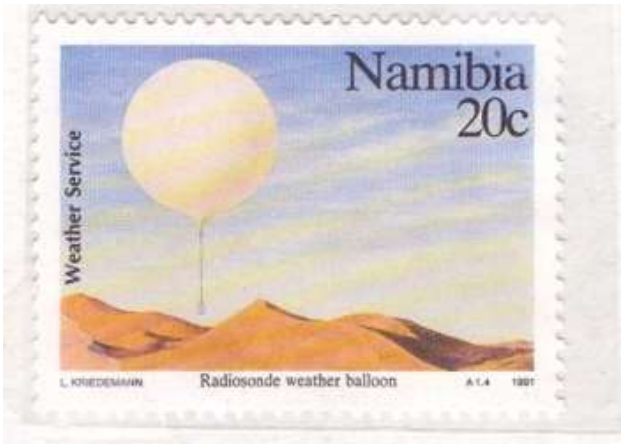
There are different meteorological parameters which are needed to measure periodically, the various meteorological weather elements, most important being the atmospheric pressure Given below is stamp of an **Aneroid Barometer, issued by the Australian Antarctic Territory**. The atmospheric pressure varies significantly over Antarctica and hence is a very valuable tool for understanding the weather phenomena over there.

:

Wind is another important parameter as far weather is concerned, the stamp below depicts, the **cup anemometer** (which measures the wind speed) **along with the wind vane** (which gives the wind direction), This stamp is **issued by the Kingdom of Saudi Arabia**.

Another important instrument used for weather studies is the duration of Sunshine over different regions. The amount of sunshine duration determines the weather over that region. The stamp issued by Namibia shows a **Sunshine Recorder of the Namibian Weather Service**, this will give a clear idea of the amount of solar radiation received by each place and thus play an important role in the energy budget of each individual area/region.

The atmosphere surrounding the Earth is three dimensional in nature, the bottom most layer is called, Troposphere and next is the Stratosphere and so on. The most abundant gases in the atmosphere are Nitrogen (78%) and Oxygen (21%) and other gases in small or variable amounts. The **stamp issued by Namibia shows a radiosonde** which measures the temperature, humidity and pressure at various levels from surface up-to a height of about 30 km. The name comes from a combination of radio (transmission) and sonde (sounding)

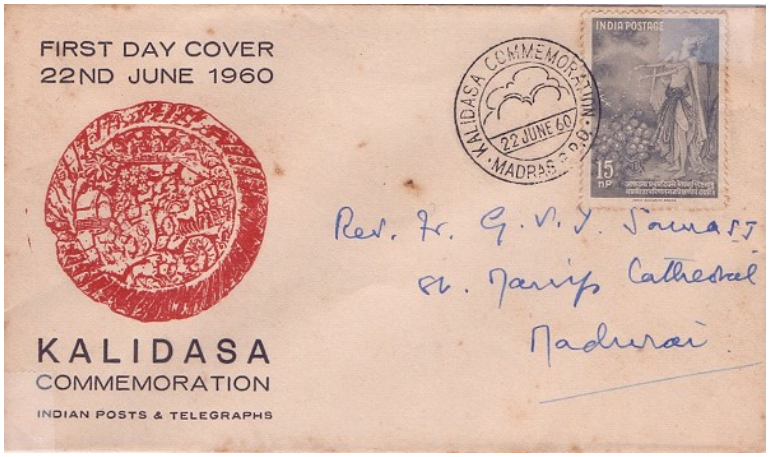


According to the World Meteorological Organisation (WMO), the **temperature measurements** are usually made in different types of wooden screens which are 0.25 m to 2 m above the surface. They are usually called **Stevenson screen**. They have **two thermometers** at the back, one measures the dry bulb, the other one measures the wet bulb, it also has a hygristor which measures the humidity. This **stamp is issued by Namibian Weather Service**.

A weather station is a facility which is either situated on land or sea or ocean and is equipped with several meteorological instruments for measuring the various weather parameters. The **stamp below depicts the picture of a weather station issued by Namibian Weather Service**.

Skies – Clouds:

One of the most important **visual observation of meteorology is clouds**. The sun's energy is reflected from the atmosphere, depending upon the amount and form of cloud. The cloud classification system, based on Latin names, groups clouds into one or more of the following criteria a) Appearance b) Height and c) processes. The **Maxicard shown below is that of a Cirrus cloud which is feathery in nature and issued by Swedish Meteorological Services**.



"Megha Dhoot" in Sanskrit means Cloud Messenger, and it is a **Sanskrit play** written **by one of the greatest Indian poets of all times, Kalidasa**. The **First Day Cover was issued on 22nd June, 1960 by Indian Posts shows Clouds.**

Weather Phenomena:

There are different types of weather phenomena which occur in nature. One of the most interesting and important is **thunder and lightning**. Lightning is caused by the difference in the electrical charges between surface and cloud, it is usually of the order of 10,000 volts, and it is seen as a flash of light. Thunder is the sound caused by the rapid expansion of the gases in a lightning caused within the cumulonimbus cloud.

The **FDC** (First Day Cover) given below **depicts the different types of lightning** and the **FDC was issued by Germany**.

Another weather phenomena, which affects lots of people as well as causes extensive damage is called **Cyclone**. It is called by **different names in different oceans, in Indian Ocean, it is called a Cyclone, in Pacific Ocean it is called Typhoon and in Atlantic Ocean it is called Hurricane**. These are usually monitored by satellites, which give the genesis regions as well as the track followed by the convective systems. The World Weather Watch, which monitors these systems, gives **pictures of two such systems, off the east coast of U.S.A**. The **stamps were issued by United Nations and it has a cancellation of World Weather Watch.**

Tracks of the various Hurricanes formed over the Atlantic Ocean is displayed in the stamp released by Cuba and is given below:

Another interesting fact is the **availability of different types of weather stations all over the world**, these weather station measure a variety of parameters such as air temperature, wind speed, direction, humidity, rainfall etc.

A satellite measures various weather conditions both over the land and the Ocean. **A stamp released by erstwhile, East Germany (DDR) on hundred years of the International Meteorological Meeting held at Leipzig** (1872-1972) is depicted in the miniature sheet, with **a Berlin Cancellation**, which was the capital of the east Germany at that point of time. Bonn was the capital of West Germany.

The weather of a country is influenced by the conditions within and outside its borders, Regular observations of these conditions both at surface, ocean, satellite and upper air form the 'back bone ' of Meteorology. The **World Weather Watch (WWW)** supplies and sends these observations to the whole world through telecommunications networks with information send to the whole world.

The **WWW is an operational arm of the World Meteorological Organisation**. This is a good internal cooperation in Meteorlogy. The **2 FDCs issued by United Nations** are given below

Climate Change and Greenhouse gases:

The climate is changing continuously, but many changes form part of the natural climatic variability determined by climatological statics. The Greenhouse effect was first discussed Svante Arrhenius, who showed that anthropogenic sources of carbon dioxide such as burning coal. Are intensifying the natural greenhouse effect and may lead to atmospheric warming. Many environmental are caused by the use of fossil fuels, which have been widely used since 1900s around the world.

Another interesting phenomenon in the atmosphere has been discovered in 1980s, it is called **OZONE HOLE**. The ozone is found everywhere in the atmosphere from surface to different parts of the atmosphere, with **maximum amount in the stratosphere from 25-30 km in the stratosphere**. The **maximum depletion of Ozone has occurred over Antarctica**. Every year, 16th of September is celebrated as **World Ozone Day**.

There are several other atmospheric processes and stamps, miniature sheets and First Day Covers associated with weather and climate phenomena. I have only displayed a few of them and hope you liked and you can also start collection under this new theme. All the items displayed in this article are from my collection.

Byte: Binary Tuple

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A 'BYTE' (**pronounced as "bite"**) is a unit of measurement of a computer's data storage and is most often considered as a collection of 8 bits. Historically bytes have ranged from 5 to 12 bits but the use of a byte to mean a collection of 8 bits has become nearly ubiquitous. Byte is also one of the built-in data types in some computer programming languages like FORTRAN-90 and JAVA. **Dr. WERNER BUCHHOLZ** coined the term '**BYTE**' in June'1956 during the early phase of 'IBM -7030 Stretch' computer. Name '**BYTE**' is derived from '**B**INAR**Y** TUPL**E**'. Byte representing a collection of 8 bits is also sometimes called as 'Tuple of 8 bits'. **CLAUDE ELWOOD SHANNON**, an American Electrical Engineer and Mathematician, coined the term '**BIT**' in 1948. Name '**BIT**' is derived from '**BI**NARY DIGI**T**'. Claude Elwood Shannon is regarded as the father of 'Information Theory'. Information theory also uses a natural digit called either a 'nit' or 'nat'. Quantum computing uses the terms '**qubit**' – **qu**antum **bit**; and '**qubyte**' - **qu**antum **byte**. Different names came for collections of different number of bits. Some of these names along with the size of collection of bits represented by them are tabulated below.

Number of bits in the collection	Name of the collection of bits.
2	CRUMB or TYDIT or TAYSTE or QUAD
4	NYBBLE or NIBBLE
5	NYCKLE or NICKEL
8	BYTE or OCTECT
10	DECKLE
16	PLAYTE
18	CHAWMP
32	DYNNER
48	GAWBLE

Different units used for representing computer storage of different sizes, in terms of number of bytes, are tabulated below.

Name	Symbol	Number of Bytes
1 KILO Bytes	KB	1024 (2^{10})
1 MEGA Bytes	MB	1,048,576 (2^{20})
1 GIGA Bytes	GB	1,073,741,824 (2^{30})
1 TERA Bytes	TB	1,099,511,627,776 (2^{40})
1 PETA Bytes	PB	1,125,899,906,842,624 (2^{50})
1 EXA Bytes	EB	1,152,921,504,606,846,976 (2^{60})
1 ZETTA Bytes	ZB	1,180,591,620,717,411,303,424 (2^{70})
1 YOTTA Bytes	YB	1,208,925,819,614,629,174,706,176 (2^{80})

There is some lack of standardization on these terms when applied to memory and disk capacity. Memory specifications tend to adhere to the above definitions where as disk capacity specifications tend to simplify things to the 10^{th} power definitions like Kilo = 10^3, Mega = 10^6 and Giga = 10^9 etc.; in order to produce even numbers. When 64-Bit CPUs will become available, memory will start to be spoken about in TB, PB and EB. Above storage units of binary domain are sometimes also called by their synonyms from the decimal domain, and these are tabulated below.

Binary Domain Name	Decimal Domain Synonym
1 KILO Byte	1 Thousand Bytes
1 MEGA Byte	1 Million Bytes
1 GIGA Byte	1 Billion Bytes
1TERA Byte	1 Trillion Bytes
1 PETA Byte	1 Quadrillion Bytes
1 EXA Byte	1 Quintillion Bytes
1 ZETTA Byte	1 Sextillion Bytes
1YOTTA Byte	1 Septillion Bytes

The prefixes used for memory specifications and disk capacities represent slightly different values with former representing higher one. Memory specifications are based on powers of 1024 (**2^{10} – Binary Kilo**), a convenient binary number whereas disk capacities are based on powers of 1000 (**10^3 – Decimal Kilo**), a convenient decimal number. Binary kilo is larger than decimal kilo. The following table illustrates the aforesaid difference.

Prefix	Name	Disk Capacity	Memory Specification	Size Difference
K	KILO	$10^3 = 1000^1$	$2^{10} = 1024^1$	02.40 %
M	MEGA	$10^6 = 1000^2$	$2^{20} = 1024^2$	04.86 %
G	GIGA	$10^9 = 1000^3$	$2^{30} = 1024^3$	07.37 %
T	TERA	$10^{12} = 1000^4$	$2^{40} = 1024^4$	09.95 %
P	PETA	$10^{15} = 1000^5$	$2^{50} = 1024^5$	12.59 %
E	EXA	$10^{18} = 1000^6$	$2^{60} = 1024^6$	15.29 %
Z	ZETTA	$10^{21} = 1000^7$	$2^{70} = 1024^7$	18.05 %
Y	YOTTA	$10^{24} = 1000^8$	$2^{80} = 1024^8$	20.89 %

The most common area where bits are used instead of bytes is in measuring bandwidth (in bits per second). In computers, byte is also defined as the "Addressable unit of data storage large enough to hold any member of the basic character set of the execution environment". Some implementations of ANSI 'C' and C++ computer programming languages support a byte representing a collection of either 8 or 9 or 16 or 32 or 36 bits. Actual number of bits in any such implantation of 'C' and C++ language is documented as CHAR_BIT as implemented in the computer's header file <limits.h>. ANSI FORTRAN-90 supports one byte INTEGER variables and constants. ANSI FORTRAN-90 has built-in features for printing value of an INTEGER variable and constant in binary representation. ANSI FORTRAN-90 has built-in library function BIT_SIZE which gives size of memory of an INTEGER type variable of any KIND in bits. The above-described digital information can be quite useful and handy for quantifying the storage related complexities of any software and the exact amount of memory supported by a computer system. We should however remember that unlike humans who perform computations in decimal notation (radix 10); computers perform computations in binary notation (radix 2). Besides using binary notation (radix 2), computers also use two other relatively compact notations viz. hexadecimal notation (radix 16) and octal notation (radix 8).

A need was felt to use different symbols for representing figures which are powers of 1000 (Decimal Kilo) and figures which are powers of 1024 (Binary Kilo). It was therefore in December 1998 when the International Electro-technical Commission (IEC) introduced new symbols for expressing computer storage which is expressed as powers of 1024 which is the 10^{th} power of 2. IEC suggested different

abbreviations for bytes and bits. Figure of 1024 bytes was abbreviated as 'Kibibyte' – a contraction for 'Kilo binary bytes'; while a figure of 1024 bits was abbreviated as 'kibibit' – a contraction of 'kilo binary bits'. Uppercase first alphabet is conventionally used for bytes while lowercase first alphabet is conventionally used for bits. Following tables give IEC suggested names for collections of bytes and bits of different sizes.

Symbol	Number of bytes	Meaning of Symbol
Kibibyte	1024^1	**Ki**lo **bi**nary **byte**s
Mebibyte	1024^2	**Me**ga **bi**nary **byte**s
Gibibyte	1024^3	**Gi**ga **bi**nary **byte**s
Tebibyte	1024^4	**Te**ra **bi**nary **byte**s
Pebibyte	1024^5	**Pe**ta **bi**nary **byte**s
Exbibyte	1024^6	**Ex**a **bi**nary **byte**s
Zebibyte	1024^7	**Ze**tta **bi**nary **byte**s
Yobibyte	1024^8	**Yo**tta **bi**nary **byte**s

Symbol	Number of bits	Meaning of Symbol
kibibit	1024^1	**ki**lo **bi**nary **bit**s
mebibit	1024^2	**me**ga **bi**nary **bit**s
gibibit	1024^3	**gi**ga **bi**nary **bit**s
tebibit	1024^4	**te**ra **bi**nary **bit**s
pebibit	1024^5	**pe**ta **bi**nary **bit**s
exbibit	1024^6	**ex**a **bi**nary **bit**s
zebibit	1024^7	**ze**tta **bi**nary **bit**s
yobibit	1024^8	**yo**tta **bi**nary **bit**s

Unfortunately, the aforesaid symbols suggested by the international standardizing organization IEC for different amounts of computer storage were not widely used by the computer fraternity thereby restricting the popularity of use of these standard symbols. As of 2018, there are no approved standard sizes for anything bigger than a **Yotta Byte (YB)**. However, two new proposed standards are **Hella Byte – HB** (**2^{90} bytes**) and **Bronto Byte – BB** (**2^{90} bytes**).

India's "Monsoon Mission": great success through combined and coordinated efforts

Compiled by

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India, our great country, is blessed with a **Monsoon system** which provides necessary rainfall for our water requirements and may be considered as a natural public distribution system of water to all of its inhabitants including citizens, animals and plants. Agricultural productivity and economy of our country largely depends on the performance of Indian monsoon rainfall. Therefore, prediction of total quantum of Indian summer monsoon rainfall (ISMR) during the months of June to September (also called the "seasonal rainfall", which produces about 80% annual rainfall over the country), its intra-seasonal variability & inter-annual variability and knowledge of extreme rainfall conditions are very much useful for planning and management of agriculture, water resources and disaster management, leading to great benefit to the society and citizens of the country. Although the year-to-year variation of ISMR is only about 10% of the mean (~86 cm), it has a strong link with the food production and even the gross domestic product (GDP) of our country. Hence, predicting ISMR & its variability is of great socio-economic importance. Statistical models had been used for operational long-range forecasts for the ISMR over the years. In the recent decades, weather and climate predictions by dynamical numerical models have considerably improved in different time scales, viz., short range forecast (up to 3 to 8 days in advance) to medium range forecast (up to 2 weeks in advance), extended range prediction (up to 4 weeks in advance) and long-range forecast (LRF) or the seasonal prediction (for June –September ISMR). ISMR has a global teleconnection and strong relation with El Nino/Southern Oscillation (ENSO) Sea Surface Temperature (SST) over East Pacific-ocean. Most of the state-of-the-art global coupled models have good prediction skill of ENSO SST with six months lead time. The hindcast skill of seasonal mean rainfall, one season in advance, over the central Pacific is also very good. These provide prior indications for model predictions of ISMR with reasonable skill.

Keeping in view the importance of a dynamical prediction framework, the Earth System Science Organization (ESSO) of the **Ministry of Earth Sciences (MoES) launched an ambitious project named "Monsoon Mission" in 2012, to develop a dynamical prediction system (modelling framework) for improving monsoon prediction skill in different time scales, over the Indian region.** Details of this Mission can be found in the **"Science and Implementation Plan of the Monsoon Mission"**, available in the following web-link of the Monsoon Mission website:

https://www.tropmet.res.in/monsoon/assets/files/Monson_Mission_Science_Plan.pdf .

❖ Objectives and achievements of the Monsoon Mission (MM), Phase-1:

The first phase of "Monsoon Mission" (**MM-I**) project was launched by ESSO, Ministry of Earth Sciences (**MoES**), Government of India in 2012, with **focus on two major objectives: (1) To build a working partnership between the Academic and Research & Development Organizations, both national and international, and the MoES to improve the monsoon forecast skill over the country and (2) To setup a state of the art dynamical modelling framework for improving prediction skill of (a) Seasonal and Extended range predictions and (b) Short and Medium range (up to two weeks) prediction.** The above objectives of **MM-I** project were fulfilled successfully during its **tenure of 5 years** (**2012-2017**) and details of **Major achievements of MM Phase-1** can be found at the following **web-link: https://www.tropmet.res.in/monsoon/assets/files/Achievements_MM1.pdf**

Some of the salient features are discussed below.

❖ Coordination and building of working partnerships:

The Indian Institute of Tropical Meteorology (**IITM**), Pune has been coordinating the Monsoon Mission program since 2012. Four MoES institutes of ESSO (**IITM, NCMRWF, IMD and INCOIS**) have partnered actively in this important and ambitious program to realize the proposed objectives. The international collaborations of MoES with NCEP-NOAA, USA; UKMO, UK and NERC, UK had been very useful during implementation of this project. Monsoon Mission (MM) effectively worked to build a working partnership between the Academic and R&D Organizations, both national and international and the MoES organizations (IITM, IMD, NCMRWF & INCOIS), through in house model developments and funding of national and international projects, to improve the monsoon forecast skill over the country. Monsoon Mission funded several National (Indian) and International (foreign) projects for Research & Development on Indian Monsoon and related issues. The administration and management for this was coordinated by IITM, with Director IITM as the Mission Director, who has been well supported by Associate Mission Director & Project Directors of MM and a Monsoon Mission Directorate (MMD). MMD is comprised of a Project Manager and few staff (e.g., a computer application person and two UDCs) to coordinate & implement administrative, financial & other aspects of the Monsoon Mission projects. For funding appropriate projects, Monsoon Mission uses to invite project proposals globally. For inviting national and international project-proposals on MM objectives, MMD puts advertisement and suitable formats for the project-proposals to apply till a scheduled last date. The received project-proposals are then reviewed by a high-level committee named "Scientific Review & Monitoring Committee" (SRMC) of MM periodically during SRMC meetings. During these high-level meetings,

Principal Investigators (PIs) of the project proposals are invited to present their proposals in presence of the SRMC experts. After review, SRMC recommends the appropriate project proposals (in the line of main objectives of MM) to the Scientific Steering Committee (SSC) of MM at the Ministry of Earth Sciences (MoES), Government of India for necessary approval and sanction for funding those projects. From MoES side, a Programme Director coordinates the above procedure. The funded projects make working partnerships with MoES organizations on scientific matters and interact frequently with those, through MMD, for any requirements. MMD uses to organize the SRMC and SSC meetings periodically and takes necessary actions after approval & sanction of the particular projects for funding through Monsoon Mission, with kind support from IITM administration. A total of about 40 projects (including National and International projects) have been funded by MoES, through MM during its first phase. Out of these, 20 International projects (from different countries, like USA, UK, Australia, Canada, France, Japan & UAE) have been funded, mainly for modelling aspects for prediction and data assimilation. The national projects were from various Indian Universities and academic/professional organizations (like, IISc. Bangalore; University of Allahabad; Andhra University, Visakhapatnam; CDAC Pune & CDAC Bengaluru; CUSAT, Kerala; University of Calcutta, Kolkata; IIT Bhubaneshwar; TERI, New Delhi; NAL, Bangalore; IIT Madras; CSIR, Visakhapatnam; TIFR, Hyderabad etc.). Some of these projects were linked with NERC (UK) - MoES (India) initiative. Some of the important outcomes from these projects include coupled data assimilation based on LETKF, model development activities to improve dynamical predictions system, downscaling the model forecasts at higher resolution, better understanding of model behaviour and suggestions for further improvement, etc.

❖ **Development of Dynamical Prediction System and Improving Prediction Skill:**

The main target of MM was to develop dynamical modelling framework on different time scales with improved skill for predicting Indian monsoon weather and climate, through combined efforts. The **ocean-atmosphere coupled dynamical model** "**Climate Forecast System, Version-2**" (**CFSv2**, adopted from NCEP, USA) was chosen as the base model for extended range (predictions up to 4 weeks in advance) to seasonal (for the SW monsoon season of June to September) prediction of monsoon. IITM developed a seasonal prediction system of very high horizontal resolution (of ~38 km), named **MMCFS model**, with considerably good prediction skill for predicting Indian summer Monsoon rainfall (ISMR), as well as **an extended range prediction system** (up to 4 weeks in advance) of very high accuracy. Due to these dedicated efforts of the scientists, there has been significant improvement in prediction skill of the dynamical models (which was very low in the last decade). IITM Scientists have carried out developmental activities in the direction of improving convective parameterization, cloud microphysics, parameterization of land surface processes, etc. as well as increasing horizontal resolution of the model. **IITM transferred these modelling systems to IMD for providing operational prediction (Long and extended range forecasts) to the nation**. IITM also worked on improving short range prediction system (up to 8 days in advance) using **Global Forecast system** (**GFS**, the atmospheric model of **CFSv2**) of very high resolution (of ~12 km) in association with NCMRWF and IMD. Infrastructure required for these developmental activities was made available at IITM and NCMRWF as part of Monsoon Mission by procuring and installing High performance computing (HPC) facility. NCMRWF worked on improving short to medium range forecasts using **Unified Model (UM)** of UK Met. Office (UKMO) for

short to medium range weather forecast (prediction up to 10 days in advance) and contributed for implementation & operationalization of the atmospheric data assimilation system for both UM and GFS models. Ocean data assimilation system was set up at INCOIS (in close association with IITM) and was involved in providing initial conditions of ocean data for different forecasts using GODAS. For building a working partnership between the Academic and R&D Organizations and the MoES organizations, several national and international projects were funded through Monsoon Mission. The above targets set through the above objectives have been achieved successfully during the first phase of Monsoon Mission program (2012-2017), in close association of IITM, NCMRWF, IMD and INCOIS. **Some of the important achievements made during the MM phase-I include:**

- Development of dynamical seasonal prediction system (MMCFS) of very high resolution (of ~38 km) with considerably good prediction skill for predicting Indian summer Monsoon rainfall (ISMR), using a modified version of CFSv2 T382 model by IITM. The model was transferred to IMD for operational forecasts to the nation from 2017 onwards. At present, this model is referred as "Monsoon Mission CFS" (MMCFS) Model.
- Development of dynamical extended range prediction system (up to 4 weeks in advance) of very high accuracy by IITM and it was made operational by IMD since 2017.
- Significant improvement in prediction skill of the dynamical models (which was very low in the last decade) through well-coordinated model developmental activities.
- Development of Data Assimilation systems, using WCDA (Weakly Coupled Data Assimilation) CFS-LETKF (Local Ensemble Transform Kalman Filter) for CFSv2.

The details are available in the **very useful research paper by Rao et. al. (2019**), published in the Bulletin of American Meteorological Society (**BAMS**). This paper has nicely highlighted improvement of prediction skills of coupled dynamical models for prediction of Indian monsoon rainfall on different time scales (seasonal, extended range, short range, etc.) through MM Phase-1 (MM-I) program.

❖ **Human Resource Development & capacity building:**

Through Monsoon Mission, there have been several high-level national & international training workshops, brainstorming meetings, discussion meetings, etc. for relevant-scientists and young researchers. Some young scientists of MoES organizations (IITM, NCMRWF & INCOIS) were deputed abroad to work with International Project Investigators (PIs) of International Projects of Monsoon Mission. Some young researchers completed their Ph. D. works, in association with Project Investigators of National projects of the Monsoon Mission. Useful data had been provided to researchers and Postgraduate students for carrying out their project works. These activities led to considerable amount of capacity building and preparing suitable scientists in this field for model development works towards improvement of models to obtain better skill & reduced bias. Project scientists & young researchers of national projects were often given necessary training by senior scientists of IITM and other MoES organizations and MMD also helped them for any administrative requirements. Overall, Monsoon Mission elevated the status of Indian science, particularly in the field of Atmospheric & Ocean sciences, in the International-forum.

❖ **International Collaborations:**

The international Collaborations of the MoES with NCEP/NOAA USA and UK Met-Office (UKMO) have been very useful for adopting CFSv2 model of NCEP and Unified Model of UKMO as the base models for MM. Some scientists of those organizations have also contributed for some international training workshops. "Monsoon Desk" was formed in USA to provide any necessary support for technical issues for model development works with CSv2 model. Some international projects had collaboration with MoES organizations, e.g., scientists of IITM and INCOIS worked with expert scientists of an international project of University of Maryland, USA for development of ocean-atmosphere coupled data assimilation system. MoES had international collaboration with NERC, UK for work in 3 important international collaborative projects namely, "Monsoon dynamics and thermodynamics from land surface, through convection to the continental-scale (INCOMPASS)", "South West Asian Aerosol Monsoon interaction (SWAAMI)", and "Impact of ocean-atmosphere processes in the Bay of Bengal on the South Asian monsoon (BOBBLE)". Other international projects of MM collaborated with MoES organizations and other Indian Institutes/Universities. Details are available in the achievement report of MM-I.

❖ **High Performance Computing (HPC) infrastructure:**

Monsoon Mission helped for infrastructural and computational development, like procurement of High-Performance Computers (HPC) at MoES organizations. During MM-I, infrastructure required for model developmental activities was made available, at IITM and NCMRWF, as part of MM, by procuring and installation of High-performance computing system (HPCS) facility with combined performance of 1.2 Peta Flops. Later-on, in the second phase of MM, HPCS of another 6.8 Peta Flops (4 Peta Flops at IITM and 2.8 Peta Flops at NCMRWF) were added. Trained & expert scientists and technical personnel are working in these facilities continuously for support to model development and innovative research works.

Monsoon Mission Phase-II (2017-2020) - Objectives and achievements:

After the successful completion of Phase-I (2012-2017), the Ministry of Earth Sciences (**MoES**) **launched the Monsoon Mission Phase-II (2017-2020) in September 2017, with emphasis on predicting extremes and development of climatic applications based on monsoon forecasts, especially in the field of agriculture, hydrology and power/energy sector, while continuing model development activities.**

Monsoon mission Phase-II (MM-II) was focused on the below two major Objectives:

❖ To build a working partnership between the Academic and R & D Organizations, both national and international, and the MoES to improve the operational monsoon forecast skill
over the country and develop relevant climate applications for agriculture, hydrology and power sectors.
❖ To develop and improve a state-of-the-art dynamical modelling frame work for improving prediction skill of (a) Seasonal and Extended range predictions and (b) Short and Medium range (up to two weeks) prediction. [**Details** are available **at https://www.tropmet.res.in/monsoon/index_2.php**]

The MM-II project has intensively worked for (1) Model developmental activities and model diagnostics; (2) operationalization of next version of monsoon mission CFS (MMCFS) model by carrying out hindcasts and integration of all developmental activities and (3) development of Climatic applications for hydrology, agriculture, power sector, etc. In this context, MM-II achieved important contributions from its 3 major parts: **(a)** Model development for monthly and Seasonal prediction of rainfall and temperature & for short range prediction of thunderstorms/lightning; Coupled Ocean-Atmosphere Data Assimilation systems (for better monsoon predictions) and development of Climate applications for agriculture, hydrology & power sectors; **(b)** Extended Range Prediction of Active/break Spells (ERPAS) of monsoon & prediction of weather extremes; and **(c)** High Resolution Short-range forecast (for general & extreme weather conditions), which included High Resolution (12km) global ensemble forecast system (NITI Aayog identified activity).

To address an important objective of MM-II to develop a prediction system for extreme weather conditions, **a dynamical prediction system for thunderstorms forecast was developed at IITM Pune** (**in association with IMD**). For this, a thunderstorm/lightning modelling team was identified with objectives to develop "a system for thunderstorm/ lightning prediction" using high resolution regional model (such as WRF) and Improvement of extreme monsoon forecast using coupled GCM and dynamical downscaling (under "MM–Phase II" project of MoES) at IITM Pune.

The cyclone prediction by IMD has been excellent in recent times with a very large lead time of more than one week. This enabled central and state governments as well as NDRF/SDRF teams and armed forces to get sufficient preparation time for their operations like evacuation of human & other living beings and other important measures for considerable decrease in loss of life due to cyclone impacts. In association with IITM, IMD has started giving prediction of heat waves, cold waves and other severe conditions at a very high skill. In this regard, IITM has been supporting IMD in all aspects. Also, IITM initiated the work for climatic applications in agriculture and hydrology in collaboration with IMD, ICRISAT, etc.

Through Monsoon Mission, a very high resolution (horizontal resolution of ~12km) **short range forecast system,** Global Ensemble Prediction System (**EPS**) with 21 ensemble members for short range forecast system **based on GEFS T1534**) was developed at IITM (in association with IMD & NCMRWF) **in June 2018 and the system was transferred to IMD** for its operational use. Subsequently the latest version 14 of GEFS has been implemented for operational forecast in IMD. The forecasts based on GEFS T1534 and GFS T1534 are being continued by IMD operationally. In addition, the probabilistic forecast for all the river basins of India, have been developed at IITM and shared with the IMD, Hydrology division, New Delhi. It has been utilized by IMD's Flood Monitoring Office (FMOs) at different places.

There have been significant works in Data Assimilation system using WCDA (Weakly Coupled Data Assimilation) CFS-LETKF (Local Ensemble Transform Kalman Filter) at IITM (in association with INCOIS and University of Maryland, USA). IITM scientists successfully assimilated the high resolution satellite derived SST data in CFS LETKF WCDA system, which was installed on HPC Pratyush.

Strongly coupled LETKF Ocean atmospheric coupled data assimilation system for CFSv2 has been implemented on HPC Aaditya.

Major achievements of Monsoon Mission Phase-II (2017-2020) are as follows:

- Setting up of an **advanced prediction system** for Seasonal prediction; Extended range prediction and Very high-resolution Short-range prediction.
- Development of a very high resolution (~12 km) Global Ensemble Prediction System (EPS) with 21 ensemble members for short range forecast system based on GEFS (T1534), put in place by IITM and handed over to IMD for operational implementation since June 2018.
- Commissioning of a Global Ensemble Forecast System (GEFS) for short and medium range prediction at 12 km.
- A remarkable improvement in the skill of the forecast especially in the short to medium range has been noticed.
- The Cyclone track and intensity prediction has also shown a steady improvement over the last three years.
- The operationalization of Monsoon Mission dynamical model (MMCFS) to prepare operational seasonal forecast of monsoon rainfall and temperatures during the hot and cold weather seasons over India.
- Use of MMCFS and extended range prediction system for preparing regional seasonal forecast outlook for south Asia under WMO recognised Regional Climate Center and South Asia Seasonal Climate Outlook Forum (SASCOF) activities.
- Major modification to the existing Cloud Microphysics scheme in the CFSv2 model, in conjunction with modified convective scheme and using CAIPEEX data, has been done to improve the seasonal mean Indian Summer Monsoon Rainfall (ISMR).
- Development of the "Modelling framework for thunderstorm/ lightning prediction" based on new approaches using 'dynamical lightning parameterization' in WRF, for operational use. Development of 1 km thunderstorm/lightening prediction system.
- Based on observed data of ice nuclei (IN) number, availed from Spectrometer for Ice Nuclei (SPIN installed at HACPL site), a new IN parameterization formulation has been derived and implemented in WRF and CFSv2.
- The multilayer snow scheme implemented in IITM CFSv2 shows promising results in the simulation of snow as well as Indian summer monsoon rainfall.
- The Stochastic Multi-Cloud Model (SMCM) has been implemented in CFS coupled model to improve the convection with Stochastic Multi-cloud model & the deep convection by changing the cloud parameters (thus to mimic super-parameterization). The same has been implemented in the seasonal forecast and the skill has improved from 0.41 to 0.61.
- A Weakly coupled CFSv2-LETKF ocean atmospheric coupled Data Assimilation system has been developed under the Monsoon Mission program.
- Development of an algorithm to monitor and predict the Monsoon Intra-seasonal Oscillations (MISO) on the extended range.
- Development of a method to monitor and predict the Madden-Julian Oscillation (MJO) on the extended range.

- Development of a criterion to monitor and predict the Heat Waves on the extended range.
- In association with IITM and NCMRWF, IMD has started giving prediction of heat waves, cold waves and other severe weather conditions at a very high skill.
- Development of an index to predict the genesis and evolution of tropical cyclones and other cyclonic disturbances over the north Indian Ocean.
- The cyclone prediction by IMD has been excellent in recent times with a very long lead time and great accuracy.
- The Extended range prediction system as well as the customized forecast products are used for operational purposes, which are being used for generating the agricultural and health bulletins every week.
- Implementation of globally highest resolution EPS system based on GEFS (at spectral resolution T1534) at 12.5 km horizontal resolution with 21 members to issue 10 days forecast. These forecast outputs have also been shared with global platforms such as TIGGE along with other global NWP Centres.
- Probabilistic Quantitative Precipitation Forecast over all the Indian river basin have been operationally implemented.
- Probabilistic (percentile based) forecast for extreme wind, precipitation have been established.
- Significant development in convection and cloud microphysics parameterization for CFS/GFS.
- Stochastic Multi Cloud parameterization in CFS.
- GFS/GEFS forecasts have been extensively used to provide guidance to Forest fire possibility and also to Renewable Energy Sectors namely, Wind and solar.
- IMDAA Reanalysis Product at very high resolution of 12 km.
- Work for climatic applications in agriculture and hydrology is in progress by IITM, in collaboration with IMD, ICRISAT, etc.
- Monsoon Mission is providing high frequency model predictions of weather parameters and related data to various energy/power sectors, as per their requirements.
- All information and predictions are given for the whole country and thus, this Monsoon Mission program has shown its National-behaviour in true sense.
- A large number of research papers (>200) were published by scientists (working in this project) in high impact journals.
- The achievements have been in the lines of the targets set for the Mission, still more improvements are necessary for which scientists are working continuously.
- Several national and international projects were funded (including 10 international projects during MM-II: 8 from USA, 1 from UK and 1 from Australia).
- Several personnel have been trained for modelling & forecast through Monsoon Mission Program and capacity building activities have been done through targeted trainings.

It may be noted that Models developed under Monsoon Mission (MM) were successful on majority occasions in the last 3 years.

- On Seasonal timescale (seasonal mean) the model developed under MM was successful in predicting seasonal rainfall accurately in 2 years out of 3 years, with 2 to 3 months lead time. The models developed under MM surpasses the skill of empirical models for the same period.

- On short and medium time scales (up to 10 days) the model forecasts were successful in predicting the cyclones and extreme rainfall events with at-least 3 to 5 days lead time.
- In the extended range prediction (beyond 10 days) the model developed under MM could capture all major events of active/break spells over Indian region and also could capture heat/cold waves in summer/winter seasons with 2 to 3 weeks lead time.

There are many more achievements of Monsoon Mission, whose details are available in several research papers, published in high impact factor journals. **Recognizing the broader interest of the Monsoon Mission activities to the World Climate Research Programme (WCRP) community**, the **CLIVAR/GEWEX Monsoons Panel** of WCRP coordinated a **Special issue of CLIVAR Exchanges** on "**India's Monsoon Mission" (CE-79)**. **Dr. M. N. Rajeevan, Ex- Secretary MoES, Government of India, has kindly contributed as the Guest Editor of this special issue, with necessary supports from ICMPO** at IITM Pune, India **and ICPO**, China. **This issue showcases 12 articles highlighting the results achieved so far under Monsoon Mission**.

Monsoon Mission has been highly appreciated by an Independent Review Committee (IRC), constituted by the Ministry of Earth Sciences (MoES) in this regard**. IRC noticed** a **remarkable improvement in the skill of the forecast on different time scales** (especially in the short to medium range) and found that the **Cyclone track and intensity prediction has shown a steady improvement** over the last 3 years. The Committee appreciated various achievements, like setting up of an advanced prediction system for Seasonal prediction; Extended-range prediction & Very high-resolution Short-range prediction; Operationalization of Monsoon Mission dynamical model (MMCFS),which has been useful to prepare operational seasonal forecast of monsoon rainfall and temperatures during the hot and cold weather seasons over India. In addition, there was Commissioning of a Global Ensemble Forecast System (GEFS) for short and medium range prediction at a very high resolution of ~12 km. Monsoon Mission showed the importance of monsoon prediction for socio-economic applications and public benefits. Third party evaluation of the **Impact assessment and Economic Benefits** of the services rendered by the Ministry of Earth Sciences has been carried out by the **National Council for Applied Economic Research** (**NCAER**). The NCAER study has clearly brought out the improvement in skill of the forecasts, its acceptability and its importance in various sectors.

In its recent Report, **NCAER has mentioned that Monsoon Mission**, augmented with HPC expenses, **produced economic benefits to the country of more than Rupees 50000 Crore, which is an economic return of more than 50 times the investment on this program by Govt. of India. Honourable Union Minister of Earth Sciences**, while inaugurating the report, **appreciated the efforts by scientists** for implementing objectives of this Mission and **mentioned that investment on it was really worth**. **Monsoon Mission has significantly contributed for National Development Plans of Government of India and benefitted several Ministries /Departments of Government of India, National Disaster Management, various important sectors, farmers, fishermen & various stakeholders and the common public of the country in general.**

Considering the importance of monsoon prediction for the society, some of the future targets may include (i) Development of a seamless prediction system using monsoon mission model, on different time scales, like Seasonal (for whole Monsoon season), Extended range (up-to 4 weeks), and Short range prediction at a very high resolution; (ii) Use of artificial intelligence and machine learning (AI/ML) for prediction purposes (iii) Initiation & coordination of further working partnerships between Indian and foreign institutes to develop system for prediction of extremes and climate applications; (iv) Development and implementation of systems for climate applications having social impacts (such as agriculture, flood forecast, extreme events forecast, wind energy, etc.); (v) Advanced data assimilation system for preparing high quality data for model predictions, (vi) Support for targeted observations over land & sea, etc.

Some Important References:

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Major achievements of MM Phase-1 (MM-I), available at the web-link: **https://www.tropmet.res.in/monsoon/assets/files/Achievements_MM1.pdf**

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Mathematics Crossword

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For Clues Across and Clues Down of this Crossword, please see the next page

Clues Across

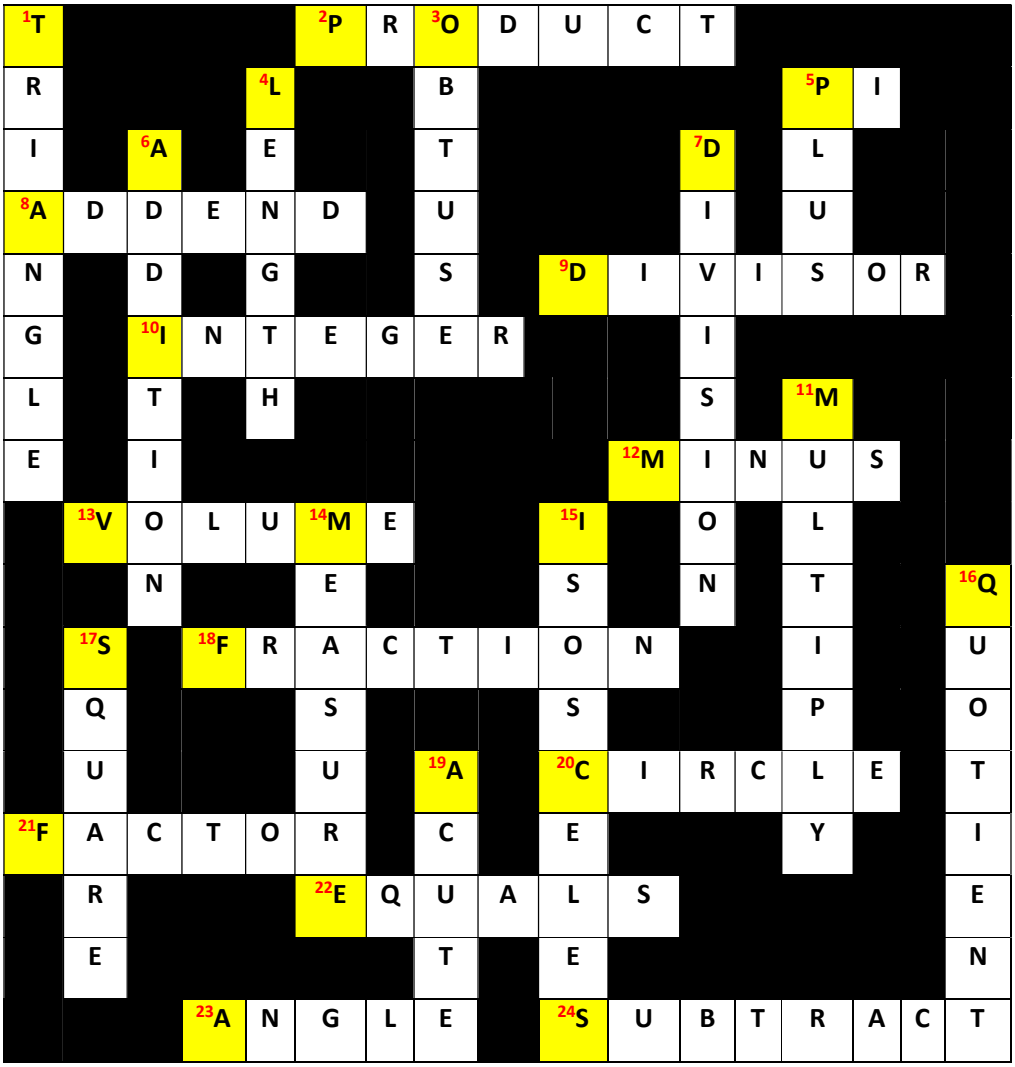
2 Wholesome-increase
5 Mathematical-constant
8 Number added to another number
9 Denominator
10 Number having no fraction
12 To reduce
13 Three-dimensional-space
18 Part of one
20 Figure having no end
21 Integral part
22 Similar
23 Inclination
24 To reduce

Clues Down

1 Three-sided figure
3 More than ninety degrees
4 Extent
5 To increase
6 Operation of increasing
7 To split
11 To increase in multiples
14 Estimate
15 Triangle with two equal sides
16 Result of division
17 Multiple of itself
19 Shortage

For solution of this Mathematics Crossword, please see the next page

Solved Mathematics Crossword



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IMSP News: Activities of IMSP during January-June 2021 and MoES Awards of 2021

(Compiled by Mr. Somnath Mahapatra, Ex-Officio Member, IMS Pune Chapter)

Indian Meteorological Society, Pune Chapter (IMSP) organized **1-day Monsoon E-workshop** on "**Monsoon 2020**" **on 18th January 2021**, followed by **2 days' National E-Symposium** on "**Cloud and Precipitation Processes**", during **19-20 January, 2021**. As a regular activity, IMSP conducts 'Annual Monsoon Workshop' every year. This year **MOES, IMD, IMS, IITM**, **NCMRWF & SPPU, Pune joined hands with IMSP** to organize the above online event. The first day (18th January 2021) was dedicated to an online **Brainstorming Workshop on Monsoon-2020**, hosted by India Meteorological Society, Pune Chapter with kind support from IITM, Pune. It was followed by **2-days National E-Symposium on "Cloud and Precipitation Processes"**, held during **19-20 January, 2021** and included **abstracts (both oral & poster) from both AMW-2019** (postponed last year due to Covid-19 pandemic) **and AMW- 2020** together. During this National E-Symposium, **Dr. P. Pradeep Kumar**, **former Head of DASS, SPPU**, **was felicitated** for his significant contribution on cloud & precipitation processes, atmospheric electricity and his important contributions to IMSP and teaching Atmospheric Sciences at Savitribai Phule Pune University (SPPU), Pune for a very long period.

Indian Meteorological Society, Pune Chapter (IMSP) organized **2-days webinar series** by eminent meteorologists **during 25-26 March 2021**, **to honour and felicitate Dr. A. K. Sahai**, **Vice President, IMS National Council and Scientist-G & Project Director, Monsoon Mission (Phase-II), IITM Pune** for his significant contributions in Monsoon variability, predictions and climate services, **on the eve of his superannuation on 31st March 2021**.

IMS Pune chapter (IMSP) organized an **online Workshop for Journalists on "Recent advances in Meteorology and Climate Services",** during **17-19 June 2021**. This was attended by a large number of journalists from different parts of the country. Eminent meteorologists from IMD and IITM delivered lectures during this online workshop.

MoES National Awards conferred to IMSP Life members (of IITM & IMD) on the occasion of 15th MoES Foundation-day 2021 on 27th July 2021:

National Award for Atmospheric Science & Technology was awarded to Dr. R. Krishnan, Scientist-G and **Executive Director**, **Centre for Climate Change Research** (CCCR), Indian Institute of Tropical Meteorology (IITM), Pune. His research interests are mainly in the areas of **Global Climate Change & Variability, Climate Dynamics pertaining to the Indian region and Dynamics & Variability of the Indian / Asian Monsoon**. He is **one of the lead authors in the IPCC Assessment Report 6** (AR-6) and **member of the Joint Scientific Committee** (JSC) **of World Climate Research Program** (WCRP).

Anna Mani Award for Woman Scientist was awarded to Dr. Thara Prabhakaran, Scientist-F, Indian Institute of Tropical Meteorology, Pune**.** Her expertise lies in the areas of **Meso and microscale modelling and simulation, Boundary Layer Meteorology and Cloud microphysics**. She is Program Director of the **CAIPEEX airborne observational campaign** conducted by IITM and a **member of the WMO Expert Team on Weather Modification**.

Certificate of Merit Awards were awarded to (1) Dr. Supriyo Chakraborty, Scientist-F, Indian Institute of Tropical Meteorology (IITM) Pune, for his dedicated research works in the field of **Paleoclimatology, Paleo-oceanography & GHGs dynamics**, and **(2) Dr. O. P. Sreejith, Scientist-E, CRS Pune (Climate Monitoring and Analysis group), Climate Research & Services, IMD,** Shivajinagar, Pune.

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