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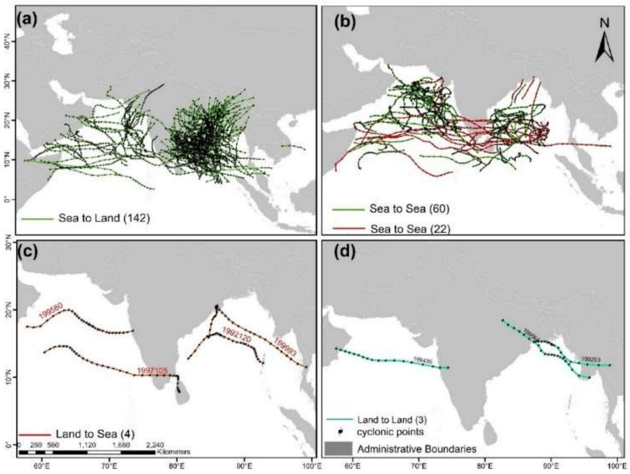
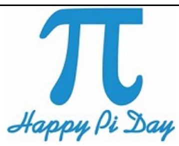


Various categories of Cyclone tracks over Indian region during 1974–2019

Some important concepts of Mathematics		
 **International Pi Day (March 14): International Day of Mathematics**	**Almost-Pythagorean Triples (APT) in Prime numbers:** $(a^2 + p^2) = (t^2 + 1)$	

Weather Satellites of India

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"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.

Contents:

Do we need to include the MJO information in the cyclone intensity prediction models?

M. M. Ali [1,2,3]

[1]Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL 32306, USA;

[2]Presently @ Andhra Pradesh State Disaster Management Authority, Andhra Pradesh, Kunchanapalli 522501, India

([3]E-mail: mmali110@gmail.com ; mmali@coaps.fsu.edu)

(Excerpt from Impact of the Madden–Julian Oscillation on North Indian Ocean Cyclone Intensity by MM Ali, UN Tanusha, C. Purna Chand, B. Himasri, M. A. Bourassa and Y. Zheng, Atmosphere, 2021, 12, 1554. https://doi.org/10.3390/atmos12121554)

Tropical cyclones are the deadliest and the most damaging natural disasters affecting people, livestock, agriculture, and the economics of the coastal areas. Storm surge is another aspect of the havoc that is created by cyclones in particular in the low-lying and flat surface areas. The severity of the storm surge depends upon the cyclone intensity, direction of the storm approaching the coast beside the topography of the place. Thus, predicting the cyclone intensity along with its track with a minimum uncertainty is of great benefit to the disaster management authorities to plan the evacuation and mitigation processes.

Most of the Indian Ocean depressions or cyclones originate in the ocean and dissipate either in the ocean itself or cross the land and then dissipate. Some of them even cross the landmass and enter the other basin. The cyclone tracks in terms of the above categories are shown in **Figure 1**.

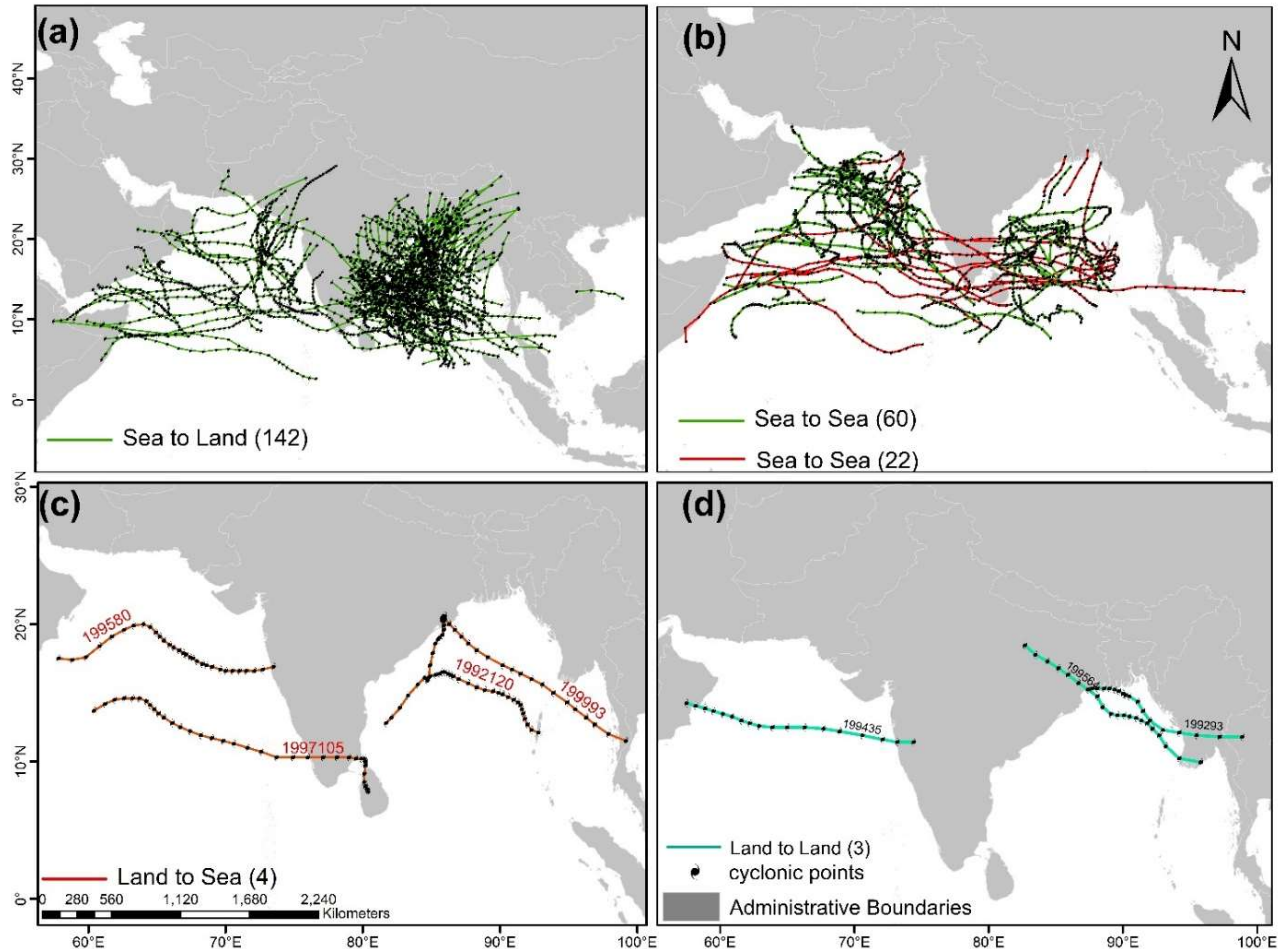

Figure 1 : Cyclone tracks that have (a) formed over the sea and dissipated over the land (no. of cyclones 142; green in colour); (b) formed over the sea and dissipated over the sea itself without crossing the land (no. of cyclones 60; green in colour), formed over the sea and dissipated over the sea after crossing the land (no. of cyclones 22; red in colour); (c) formed over land and dissipated over the sea (no. of cyclones 4; red in colour) and (d) formed over land and dissipated over land (no. of cyclones 3; green in colour).

Most of the cyclonic systems in the Indian Ocean form either from April to June with a peak in May or from September to December having a peak in November, as shown in **Figure 2**.

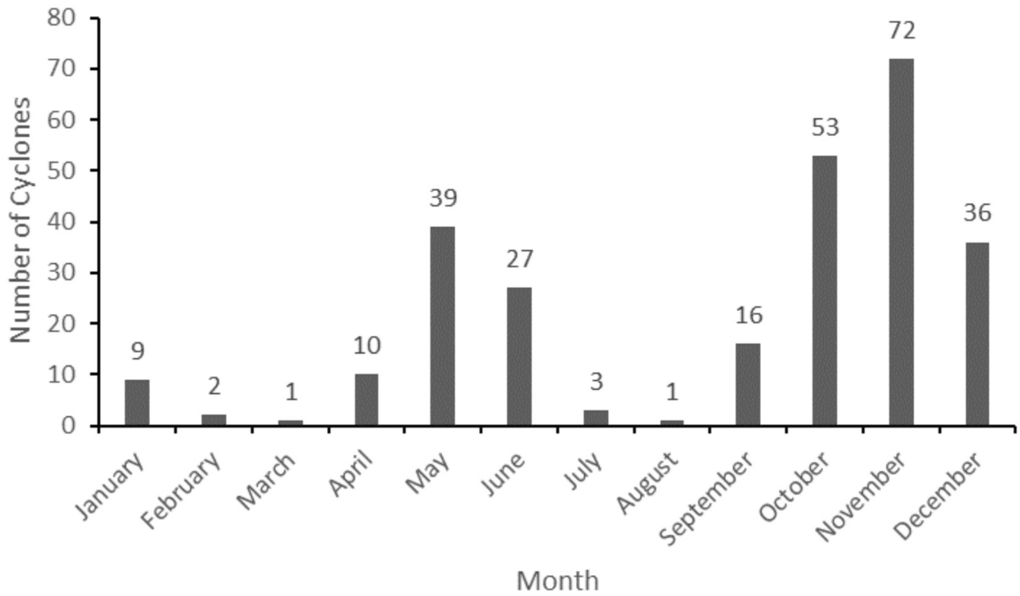

Figure 2: Number of cyclonic systems of all categories formed in different months during 1974–2019. The numbers on the bars indicate the number of systems in that month.

While sea surface temperature, ocean heat content, upper-level divergence, and many other atmospheric and oceanographic parameters and processes are known to influence cyclones, the impact of Madden-Julian Oscillation (referred to as M.J.O.) on the cyclone intensity is one of the least explored phenomena.

An M.J.O is the dominant sub-seasonal global tropical mode of variability in the tropics (Tian and Waliser, 2014). This has an area of relatively active convection that circles the globe (Zhang et al. 2020, Kikuchi et al. 2000). Thus, this phenomenon influences weather and climate variability on a global scale. In this context, Ali et al. (2021) explored the impact of M.J.O alone on cyclone intensity without considering the other factors. They used an Artificial Neural Network approach for this analysis. This approach is one of the powerful data mining or machine learning tools for computing input-output relationships. It is an information processing paradigm that works somewhat similar to a biological system in the human brain. Statistical analysis of their study revealed that M.J.O is another important phenomenon that needs to be considered for cyclone intensity predictions. The deviations between the wind speeds estimated using this approach and the actual observations are within -20 knots and +20 knots for 80% of the cases and for most of the cyclone categories (**Figure 3)**. In addition, they found that the influence of M.J.O on wind speed increases with increasing amplitude and has more impact on more intensity cyclones. They also observed that its impact is more when the activity is in the Indian Ocean and the two adjoining phases compared to the other four phases of M.J.O (**Table 1**).

Table 1: Influence of MJO amplitude on estimated wind speed scatter index (SI) for all the categories of the cyclonic systems for (i) all amplitudes, (ii) amplitudes ≥ 1, (iii) ≥ 1.5 and (iv) ≥ 2 separately for the validation dataset. The number of points for each category (D: Depression, DD: Deep Depression, CS: Cyclonic Storm, SCS: Severe Cyclonic Storm, and VSCS: Very Severe Cyclonic Storm) is also provided.

All Phases									
	Scatter Index (SI)				**Number of Points**				**Correlation Coefficient**
Category/ Phase	**All**	**≥1**	**≥1.5**	**≥2**	**All**	**≥1**	**≥1.5**	**≥2**	**All**
D	0.485	0.476	0.467	0.323	720	457	255	110	0.431
DD	0.428	0.428	0.383	0.278	505	328	189	84	0.423
CS	0.381	0.387	0.345	0.264	394	253	148	66	0.427
SCS	0.271	0.263	0.208	0.138	180	118	76	33	0.467
VSCS	0.183	0.152	0.149	0.085	94	63	40	21	0.638
Phases—1, 2, 3, 4									
	Scatter Index (SI)				**Number of Points**				**Correlation Coefficient**
Category/ Phase	**All**	**≥1**	**≥1.5**	**≥2**	**All**	**≥1**	**≥1.5**	**≥2**	**All**
D	0.473	0.463	0.447	0.430	432	291	170	77	0.435
DD	0.408	0.396	0.352	0.252	310	217	130	58	0.503
CS	0.370	0.342	0.310	0.248	240	166	102	43	0.478
SCS	0.255	0.259	0.206	0.134	110	74	50	21	0.605
VSCS	0.174	0.174	0.121	0.055	53	35	24	13	0.705

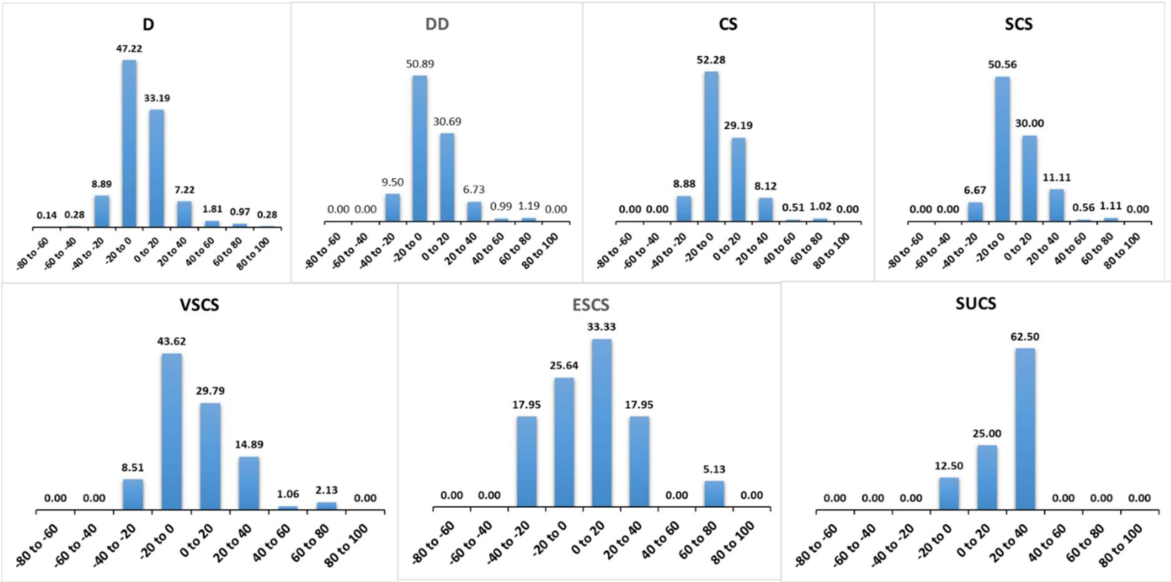

Figure 3: Percentage of Deviations for validation datasets divided into Categories of D, DD, CS, SCD, VSCS, ESCS and SUCS

This study is purely a statistical investigation. More detailed studies, particularly using dynamical models are required to come to a more physically-based conclusion and to answer whether incorporation of the M.J.O. information in the statistical and dynamical models will improve the cyclone predictability.

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Inaccurate Mathematical Constant Pi

Manoj Kumar Tandon[1, 2, 3]

[1]Scientist (Retired), IITM, Pashan Road, Pune.
[2]Former Secretary, Computer Society of India, Pune Chapter.
(**[3]E-Mail ID: mkbtandon@gmail.com**)

Mathematics is universally acknowledged and accepted as the mother of all computational sciences like Fluid Mechanics, Dynamic Meteorology and Theoretical Computer Science among others. The term mathematics is defined as "The science (a) of numbers and their operations and the relations between them and (b) of space configurations and their structure and measurement". In Euclidean geometry Pi is defined as the ratio between the circumference of a circle to its diameter. This ratio is same for all circles irrespective of their radii and is approximately equal to 3.14156. It is of great importance in mathematics not only in the measurement of circle but also in more advanced mathematics in connection with such topics as continued fractions, logarithm of imaginary numbers and periodic functions. Throughout the ages progressively more accurate values have been found for Pi. Its early value was Greek approximation, (22/7), which was found by considering the circle as the limit of a series of polygons with an increasing number of sides inscribed in a circle. **About the mid 19th century the value of Pi was figured to 707 decimal places and by the mid 20th century an electronic computer had calculated Pi to 100,000 decimal places**. Electronic computer took 8 hours for this calculation; however, it would have taken a person 30,000 years to make this calculation by working, without errors, 8 hours a day on a desk calculator. Although **Pi has now been calculated to more than 100,000,000 digits, the exact value of Pi cannot be calculated**. It was shown by German mathematicians JOHANN LAMBERT in 1770 that Pi is irrational and by FERDINAND LINDERMANN in 1882 that Pi is transcendental i.e. Pi cannot be the root of any algebraic equation with rational coefficients. **Pi is the sixteenth letter of the Greek lower case alphabet π and Greek upper case alphabet Π**. **Pi symbols (π, Π) are perhaps the most widely used symbols of mathematics.**

Around 4000 years ago, people discovered that the ratio of circumference of a circle to its diameter was about 3. In nature, people saw large and small circles and they realized that this ratio was an important tool. People have been fascinated by Pi, an irrational number, throughout history. Pi was calculated to different values with the passage of time. **At around 500B.C. value of Pi was at 3, at around 250B.C. it became 3.1463, around 450A.D. Pi was evaluated as 355/113, around 800A.D. Pi was 3.1416, in**

the year 1600 Pi was computed up to 35 places and in the year 1990 Pi was known up to 2 billion digits. However, many mathematicians have used Pi to make important contributions in the different studies of mathematics. **Widely used symbol of Pi came into existence in the year 1737**.No number has captured the attention and imagination of number fanatics and nerds throughout ages as much as the ratio of a circle's circumference to its diameter – a.k.a. Pi. **In September 1999, Dr. YASUMASA KANADA of University of Tokyo calculated 206,158, 430,000 (approximately 3 X $2^{36)}$ digits of Pi**. **However, again in September 2002, Dr. Kanada and his team broke their own world record by calculating 1.2411 trillion digits of Pi. Calculation of the value of Pi up to 1.2411 trillion digits took over 400 hours on Hitachi Supercomputer installed at the University of Tokyo**. This Hitachi Supercomputer is capable of performing 2 trillion calculations per second. Value of Pi expressed up to 1000 places of decimal is given below.

Value of Pi expressed up to 1000 decimal places

3.14159265358979323846264338327950288419716939
9375105820974944592307816406286208998628034825
34211706798214808651328230664709384460955058223
17253594081284811174502841027019385211055596446
22948954930381964428810975665933446128475648233
78678316527120190914564856692346034861045432664
82133936072602491412737245870066063155881748815
20920962829254091715364367892590360011330530548
82046652138414695194151160943305727036575959195
30921861173819326117931051185480744623799627495
67351885752724891227938183011949129833673362440
65664308602139494639522473719070217986094370277
05392171762931767523846748184676694051320005681
27145263560827785771342757789609173637178721468
44090122495343014654958537105079227968925892354
20199561121290219608640344181598136297747713099
60518707211349999998372978049951059731732816096
31859502445945534690830264252230825334468503526
19311881710100031378387528865875332083814206171
77669147303598253490428755468731159562863882353
78759375195778185778053217122680661300192787661
11959092164201989

Value of Pi has been calculated to many millions of decimal places to no readily apparent purpose. We should however remember that no perfect circles or spheres exist in nature since matter is composed of atoms and therefore lumpy and not smooth. Nature herself sometimes takes to rounding off the more extreme decimals of numbers when they get sufficiently small. However, a continued extension of Pi provides a harmless exercise of computer power which would otherwise may be misused by either playing games or surfing pointless Web sites. The computation of Pi is virtually the only topic from the most ancient stratum of mathematics that is circle and its diameter and this ratio evaluated to 3.1415… where ellipses (…) mean continue indefinitely.

Lower Case Pi Symbol	**Upper Case Pi Symbol**
π	Π

Pi defines the ratio of circumference of any circle and its diameter and it evaluates as 3.1415.This value shows that 3, 1 and 4 are the three most significant digits in the decimal representation of the value of Pi. For people who follow Month/Date format, first digit of the value of Pi represents 3rd month of the year, i.e. March, and the next two digits, 14, of this value represent day of the month i.e. “March 14”. Hence in the year 1988, **March 14** was recognized as “**International Pi Day**” by physicist **LARRY SHAW**. In 2019, **UNESCO’s General Conference** decided to observe “**Pi Day (14 Mach)**” as “**International Day of Mathematics**”.

International Pi Day (March 14)
is recognized as
International Day of Mathematics

We should however remember that **we can never know the accurate value of the circumference of any circle as the value of Pi can never be calculated accurately.**_Pi is one of the few concepts in mathematics whose mention evokes a response of recognition and interest in even those who are not concerned professionally with the subject of mathematics. Pi has been a part of human culture and the educated imagination for more than twenty five hundred years. Pi is a topic which provides mathematicians with examples of many current mathematical techniques as well as a palpable sense of their historical development. Probably no symbol in mathematics has evoked as much mystery, romanticism, misconception and human interest as the number Pi. The digits of Pi dance about so unpredictably that scientists and statisticians have long used them as a handy stand-in for randomly generated numbers in applications from designing clinical trials to performing numerical simulations. But surprisingly, mathematicians have been completely at sea when they try to prove that the digits of Pi are indeed randomly distributed. When a number's digits are randomly distributed, you have no information about what any given digit will be even when you know the previous one. Now, some mathematicians have taken up studies to prove Pi's randomness, perhaps opening the door to a solution of centuries-old conundrum. Problem of proving Pi's randomness is nearly 900 years old.

Following are some interesting features of mathematical constant Pi.

(1) Pi is ancient. Though it was not called Pi until the 18th century, numerical relationship between a circle's diameter and circumference has been pondered since antiquity. In the second millennium B.C., the Babylonians used 25/8 for Pi (equivalent to 3.125), the Egyptians are believed to have used 256/81 for Pi (equivalent to 3.160). **The Greek symbol π was used to denote the circumference-to-diameter ratio of a circle in 1706 by Welsh mathematician William Jones**. **But it did not catch on until Swiss mathematician Leonhard Euler adopted its use in 1730s**.

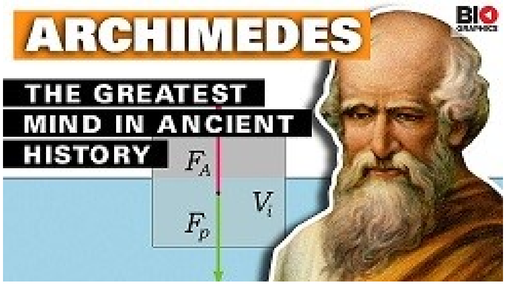
(2) In 2016, a Swiss scientist, Peter Trueb, used a computer with 24 hard drives and program called y-cruncher (Pi bench mark program) to calculate pi to more than 22 trillion digits – which is the current world record for the enumeration of pi. If you read one digit every second, it would take you just under 700,000 years to recite all those digits of pi. As on today, pi has been (informally) successfully computed to 31.4 trillion decimal places – 31,415,926,535,879 to be exact.

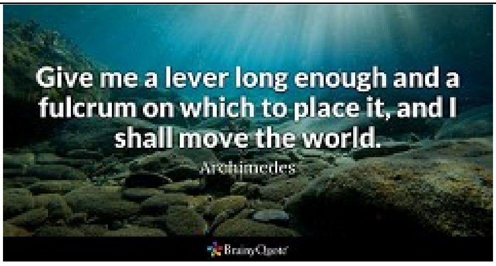
Some Details of Peter Trueb's y-cruncher (Pi bench mark program)	
Start Date	September 22, 2018, 06:49: 32 UTC
End Date	January 21, 2019, 09:40:50 UTC
Compilation Time	111.8 days
Total Start to End Time	121.1 Days
Total Disk I/O	9.02 PB read, 7.95 PB write

(3) Pi is the most famous number in mathematics.

(4) The fact that value of Pi never ends is a fascinating fact of Pi.

(5) Pi is also called **ARCHIMEDES CONSTANT** after a Greek mathematician, physicist, engineer, astronomer and inventor named Archimedes. Archimedes is regarded as one the leading scientist in classical antiquity.





(6) At least since 1970s, math geeks have competed informally to recite from memory as many digits of pi as possible. In 2015, Suresh Kumar Sharma, a vegetable vendor from Jaipur, India (he is now a memory coach) set a world record when successfully recited more than 17,000 digits of pi – a feat that took him 17 hours to complete.

(7) Aside from being **Pi Day, March 14, 1879 is also Albert Einstein's birthday. Physicist Stephan Hawking, considered as Albert Einstein's intellectual successor, died on, Pi Day, March 14, 2018**.

It is widely believed that this pearl of mathematics (number Pi) will keep on igniting the need and urge for its further explorations in the minds of mathematicians and physicists of future generations. **Mystery and magic of Pi keeps humans fascinated.**

++++++++++++++++++++++++++++++

"Almost Pythagorean Triples" in Prime numbers: A new concept

Somnath Mahapatra [1,2,3,4]

[1] Scientist-E, Indian Institute of Tropical Meteorology, Ministry of Earth Sciences, GoI
[2]Senior Scientist, International Monsoon Project Office (IMPO) at IITM Pune India
[3]Former Secretary, IMS Pune Chapter (2018-2020)

([4]E-mail : mahap@tropmet.res.in)

A Pythagorean triple (PT) consists of 3 natural numbers (i.e., positive integers) *a*, *b*, and *c*, which follow the mathematical relation: $(a^2 + b^2) = c^2$ **… (1)**, which may be called **PT relation**, and is commonly written as **(*a*, *b*, *c*)**. Some well-known examples are (3, 4, 5), (5,12,13), (8,15,17), etc. Thus, Pythagorean triples describe the three integer side lengths of a right triangle. However, right triangles with non-integer sides do not form Pythagorean triples, e. g., the triangle with sides a = b = 1 and c = √2 is a right triangle, since we have $(1^2 + 1^2) = (\sqrt{2})^2$, but (1, 1, √2) is not a Pythagorean triple because √2 is not an integer. Pythagorean triples have been known since ancient times (Robson, 2002; Sally and Sally, 2007; Romik, 2008; Kak and Prabhu, 2014; Wikipedia; etc.). Pythagorean triples were also known in India, the earliest Baudhāyana-Sulbasutra contains five such triples (Kak and Prabhu, 2014; Wikipedia).

A **primitive Pythagorean triple (PPT)** is a Pythagorean triple (a, b, c), in which **a, b and c are co-primes**, i.e., "highest common factor (HCF) or greatest common divisor (GCD) of a, b, and c is 1" (Long, 1972; Romik, 2008; Kak and Prabhu, 2014; Wikipedia), thus they do not have any common factor other than 1. The most common example of PPT is (3, 4, 5). Kak and Prabhu (2014) have discussed about Cryptographic applications of primitive Pythagorean triples (PPTs). They identified certain sequences and named those as "Baudhāyana sequences", after the name of Baudhāyana, the author of one of the earliest Sulbasutras (documents containing some of the earliest Indian mathematics), who used Pythagorean triples several centuries before Pythagoras (i.e., dating back to the sixth century before Christ).

There are 16 Primitive Pythagorean Triples (a, b, c) with c less than 100 (Wikipedia), which are shown in **Table-1**, where we find that $(a^2 + b^2) = c^2$.

Table-1: 16 Primitive Pythagorean Triples (a, b, c) with c <100
[which follow the relation: $(a^2 + b^2) = c^2$]

S. N.	Primitive Pythagorean Triple (a, b, c)	a^2	b^2	$a^2 + b^2$	c^2
1.	(3,4,5)	9	16	25	25
2.	(5,12,13)	25	144	169	169
3.	(8,15,17)	64	225	289	289
4.	(7,24,25)	49	576	625	625
5.	(20,21,29)	400	441	841	841
6.	(12,35,37)	144	1225	1369	1369
7.	(9,40,41)	81	1600	1681	1681
8.	(28,45,53)	784	2025	2809	2809
9.	(11,60,61)	121	3600	3721	3721
10.	(16,63,65)	256	3969	4225	4225
11.	(33,56,65)	1089	3136	4225	4225
12.	(48,55,73)	2304	3025	5329	5329
13.	(13,84,85)	169	7056	7225	7225
14.	(36,77,85)	1296	5929	7225	7225
15.	(39,80,89)	1521	6400	7921	7921
16.	(65,72,97)	4225	5184	9409	9409

Given a Primitive Pythagorean triple (a, b, c), its multiple (na, nb, nc) is also a Pythagorean triple, where n is a natural number, since $\{(na)^2 + (nb)^2\} = (nc)^2$. Thus, multiples of the PPT (3, 4, 5) e.g., (6, 8, 10), (9, 12, 15), (12, 16, 20), (15, 20,25), etc. are also Pythagorean triples.

Almost Pythagorean triples (APTs) in Prime numbers:

Orrin Frink (1987) found some new triples (x, y, z) of 3 natural numbers, which show the mathematical relation: $(x^2 + y^2) = (z^2+1)$, and named them as "Almost Pythagorean Triples", as the above relation is very close to the Pythagorean Triples (PT) relation (1). While squaring and adding terms of the sequence 5, 10, 15, 20, 25, 30, 35, …., he noticed that $(10^2 + 15^2) = (18^2 + 1)$; $(20^2 + 25^2) = (32^2 + 1)$; $(25^2 + 35^2) = (43^2 + 1)$, etc. So, he suggested solving the Diophantine equation: $(x^2 + y^2) = (z^2+1)$, and called its positive integer solutions (x, y, z) of the equation as "Almost Pythagorean Triples" (APT). The first six APTs, in increasing values of z, are found to be (5, 5, 7), (4,7, 8), (8, 9, 12), (7, 11, 13), (11, 13, 17) and (10, 15, 18).

A prime number is a natural number, which is divisible only by 1 and itself, e.g., 2, 3, 5, 7, 11, 13, etc. I was experimenting with several prime numbers and found that **several prime number triplets follow the above mathematical relation of APT** (**Mahapatra, 2021**). For extending the above new concept of APTs, (introduced by Orrin Frink), for special case of prime numbers only, let me represent these as (a, p, t) which follow the mathematical relation: $(a^2 + p^2) = t^2+1$ **… (2)**

Table-2 gives listing of such 12 APTs in prime numbers. The list can be extended anytime, if someone is interested in this. I wish to show that these Primitive APTs have very close relation with Pythagorean Triple (PT) relation. For this, let me find the Percentage of deviation of APT (a, p, t) from PT relation using the following formula: **Percentage of deviation (PD in %) from Pythagorean Triple (PT) relation**

$$= [\{(a^2 + p^2) - t^2\}/ t^2] *100 = [1/ t^2] *100 = [100/ t^2] \dots (3)$$

Table-2: Examples of 12 "Almost-Pythagorean Triples in Prime numbers" [which follow the relation $(a^2 + p^2) = (t^2+1)$]

S.N.	Almost - Pythagorean Triple in Prime numbers (a, p, t)	a^2	p^2	$a^2 + p^2$	t^2	PD * (in %)	t^2+1
1.	**(5,5,7)**	25	25	50	49	2.04	50
2.	**(7,11,13)**	49	121	170	169	0.59	170
3.	**(11,13,17)**	121	169	290	289	0.35	290
4.	**(13,19,23)**	169	361	530	529	0.19	530
5.	**(23,29,37)**	529	841	1370	1369	0.07	1370
6.	**(13,41,43)**	169	1681	1850	1849	0.05	1850
7.	**(29,37,47)**	841	1369	2210	2209	0.05	2210
8.	**(31,43,53)**	961	1849	2810	2809	0.04	2810
9.	**(41,53,67)**	1681	2809	4490	4489	0.02	4490
10.	**(43,59,73)**	1849	3481	5330	5329	0.02	5330
11.	**(43,71,83)**	1849	5041	6890	6889	0.01	6890
12.	**(61,83,103)**	3721	6889	10610	10609	0.01	10610
[*PD (in %), calculated correct up to second decimal place]							

As seen from Table-2, we find that APTs have very small Percentage of deviation from PT relation (1), less than 0.6% for most of the cases, and even less than 0.1% as numerical values of the numbers in APTs increase. The PD% decreases sharply as the numerical values of (a, p, t) increase, e.g., for APTs in Table-2, PD% decreases from 2.04% for APT (5,5,7) to ~0.01% for APT (61,83,103). The very small values in PD % can allow us to utilize APTs as approximate extension of Pythagorean Triples with very small error margin. Also, another interesting finding from Table-2 is that, the unit's digit of "t" (the third number of the APT) is either 7 or 3; and the unit's digits in the numerical values of ($a^2 + p^2$) and (t^2+1) are zero (0).

It may also be noted that when all the three numbers in the APT are prime numbers, they are co-prime also, as being prime numbers, they will have 1 as the only common divisor. Hence APTs in prime numbers are also Primitive Almost -Pythagorean Triples (a, p, t), following the formula: $\mathbf{(a^2 + p^2) = t^2+1}$

The finding of these Almost-Pythagorean Triples in Prime numbers is very relevant for the year 2021, as it is believed that **this year has been a year of prime numbers**, as the number 2021 is product of two consecutive prime numbers 43 and 47. My cousin Dinabandhu forwarded me a message which had a mathematical meaning: "For a mathematics lover, 2021 is product of two prime numbers, 43 and 47, (as 43*47 = 2021). Interestingly, it can also be expressed as the product (a-b)*(a +b), as 2021 is (45-2)*(45+2) = 43*47…So, **2021 appears to have a partner in Prime.** The number 2021 is both the concatenation of consecutive integers (20 & 21) and the product of two consecutive primes 43*47. Also, multiplication of 2021 by its reverse number 1202, is a palindrome (i.e., same, when read from both sides, front & opposite sides), as 2021*1202 = 2429242, which will be same 2429242 when read from the opposite side". Many Mathematics lovers may like the above message.

In my recent paper (Mahapatra, 2021), I have given some references about the utilization of the words like, "semi". "quasi", "almost" in science (including earth sciences/meteorology), which have provided some new concepts to begin with, and led to some new innovations later on. Some researchers may argue that approximate or almost relations will have some error component, but if the error (percentage deviation in this case) is very small, it can be useful. Numerical analysis provides various orders of approximation and orders of accuracy for approximating differentials with finite differences and has been extremely useful for numerical modelling, leading to its important application in dynamical modelling of present-day models of weather and climate having atmospheric, oceanic and coupled ocean-atmosphere systems. Therefore, I feel that some new innovative concepts can help science to progress further. For benefit of the new- generation researchers, I have shown some practical uses of APTs in mathematics through my paper and think that their uses can be extended to other branches of science and technology in near future.

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North East Monsoon performance with regard to precipitation over Tamil Nadu for the years 2005, 2015 & 2021

S. Sivakumar [1,2] and J. P. Selvan[1,2]

[1]IMS Member Madras - Chennai Chapter

([2]E-Mail: headshiva@gmail.com; selvanfun@gmail.com)

North East Monsoon ... or in short **NEM is so much captivating**, the moment you hear and more so when you experience it. The sheer beauty or the fascinating aspect of all the three much talked about, **Surplus/ Excess NE Monsoons of 2005, 2015 & 2021** have been, the way each has been different from the other. Yes, it is a known fact that no two monsoons, even with the same parameters / atmospheric conditions can be the same. Vagaries of weather, if one can call it that way.

Let us look into the **three North East Monsoons (of 2005, 2015 & 2021) which have caught the imagination of all weather-enthusiasts and people in general in recent years**.

The first one in 2005 NEM… Well, what a significant one in terms of the timing. Yes, after a miserable 2003/2004 in most parts of the monsoon region, all eyes were on how well 2005 would behave / perform to restore the grave situation we were in then. Thankfully nature was all ears to shower all its might, bestowed with us the bounty. The monsoon had an early onset, getting into top gear straightaway in October, maintaining the momentum in November and finally sustaining almost till the very end of December. The highlight was that the rain events were nicely spaced out so well, as though it was programmed / designed in a lab ensuring every drop of it mattered to us the most. The season overall ended in a majestic manner leaving no room for complaints purely from the dire need of improvement in water table.

Ten years later, we were almost in a similar situation when 2013 /2014 didn't deliver much and all eyes were on **how well 2015 NEM would respond to the needs**. Nature again had its task cut out and was geared up to hear our pleas. Well, **2015 NEM was all the more like a T20 big bash**... A late onset like a 7 pm start to the match. Hits n misses in the first few overs of the power play, before connecting all the mighty swings in a grand manner leaving the opponents (general-public) shell shocked, the mood turning / swinging wildly from ecstasy to agony within a month before delivering the final knock-out punch on December 1st leaving no room even for the mandatory stand up count and a recovery at least for a while.

Well, **the third one in 2021 NEM**, right from the beginning had other ideas and was eager to stamp its authority in saying " **I'll** (shall) **be entirely different to what you have seen or heard of me before**. I'm not here to pretend or pose that I can or can't be trusted upon ... I wanna (want to) be **more consistent rather than being too classical, methodical, (2005) or flashy (2015)** …I would rather be more workmanlike and be counted for every effort I put in ...".

Yes, 2005, 2015 & the ongoing 2021 have been unique in their own ways and for sure have left an indelible mark in the North East monsoon calendar history...

Also, we take this opportunity to share a **comparison in terms of the entire season, in terms of Rainfall, OLR, ENSO index etc. ...**

In the following **Table-1**, we have tabulated the rainfall amounts (in mm), departures of rainfall (in %) from the normal values & number of rainy days during October, November & December months of the 3 years: 2005, 2015 & 2021, along with NEM Seasonal rainfall (mm) and Annual rainfall (mm) for these 3 years over Madras of Tamil Nadu.

Table-1: Rainfall data of Madras, Nungambakkam (RMC); Data courtesy - IMD Nungambakkam.

Year	**October** **Rf (mm), Departure** & No. of Rainy days	**November** **Rf (mm), Departure** & No. of Rainy days	**December** **Rf (mm), Departure** & No. of Rainy days	**NEM Season Total Rainfall (mm)**	**Annual Total Rainfall (mm)**
2005	**1078 mm, + 242%,** 14 Rain days	**608 mm, + 62%,** 14 Rain days	**422 mm, +138%,** 12 Rain Days	**2108 mm**	**2556 mm**
2015	**211 mm, - 33%,** 12 Rain days	**1013.6 mm, +171%,** 18 Rain days	**438.4 mm, +147%,** 7 Rain Days	**1663 mm**	**2094.8 mm**
2021	**216.4 mm, - 31%,** 10 Rain days	**1044.3 mm, + 179%,** 23 Rain days	**224.1 mm, + 26%,** 2 Rain days	**1484.8 mm**	**2258.7 mm**

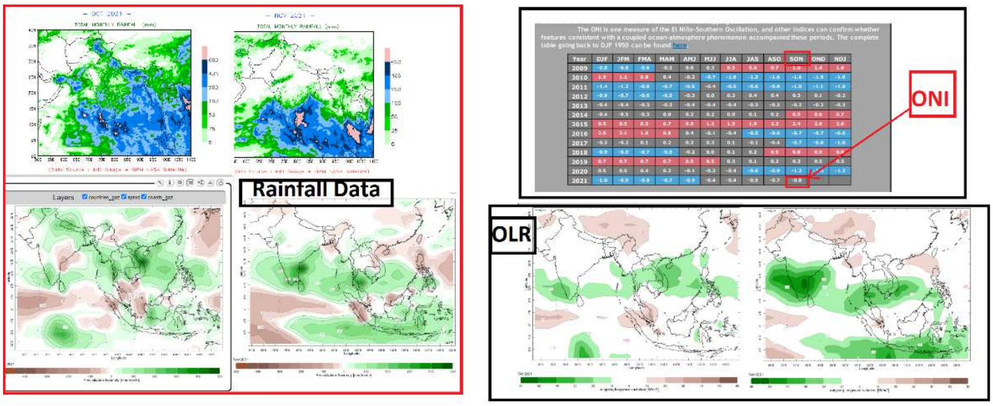
The Oceanic Niño Index (**ONI**) is NOAA's primary indicator for monitoring the ocean part of the seasonal climate pattern called the El Niño-Southern Oscillation, or "ENSO" for short. (The atmospheric part is monitored with the Southern Oscillation Index.) The ONI tracks the running 3-month average sea surface temperatures in the east-central tropical Pacific between 120°-170°W, near the International Dateline, and whether they are warmer or cooler than average. ONI Index values of +0.5 or higher in the Niño-3.4 region indicate El Niño, while ONI values of -0.5 or lower over that region indicate La Niña. [you may refer to the website : https://www.climate.gov/news-features/understanding-climate/climate-variability-oceanic- ni%C3%B1o-index# ...]. For North-East Monsoon, we consider ONI values for the 3-monthly quarters of September-October-November (SON), October-November-December (OND) and November-December-January (NDJ) and highlight (dark rectangle) SON, OND & NDJ values for the years 2005, 2015 and 2021(available for SON only) for comparison-sake.

Table-2: 3-monthly ONI values during 1996 - 2021

1999	-1.5	-1.3	-1.1	-1.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.7	
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	
2000	-1.7	-1.4	-1.1	-0.8	-0.7	-0.6	-0.6	-0.5	-0.5	-0.6	-0.7	-0.7	
2001	-0.7	-0.5	-0.4	-0.3	-0.3	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3	
2002	-0.1	0.0	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.2	1.3	1.1	
2003	0.9	0.6	0.4	0.0	-0.3	-0.2	0.1	0.2	0.3	0.3	0.4	0.4	
2004	0.4	0.3	0.2	0.2	0.2	0.3	0.5	0.6	0.7	0.7	0.7	0.7	
2005	0.6	0.6	0.4	0.4	0.3	0.1	-0.1	-0.1	-0.1	-0.3	-0.6	-0.8	weak la nina
2006	-0.9	-0.8	-0.6	-0.4	-0.1	0.0	0.1	0.3	0.5	0.8	0.9	0.9	
2007	0.7	0.2	-0.1	-0.3	-0.4	-0.5	-0.6	-0.8	-1.1	-1.3	-1.5	-1.6	
2008	-1.6	-1.5	-1.3	-1.0	-0.8	-0.6	-0.4	-0.2	-0.2	-0.4	-0.6	-0.7	
2009	-0.8	-0.8	-0.6	-0.3	0.0	0.3	0.5	0.6	0.7	1.0	1.4	1.6	
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	
2010	1.5	1.2	0.8	0.4	-0.2	-0.7	-1.0	-1.3	-1.6	-1.6	-1.6	-1.6	strong la nina
2011	-1.4	-1.2	-0.9	-0.7	-0.6	-0.4	-0.5	-0.6	-0.8	-1.0	-1.1	-1.0	
2012	-0.9	-0.7	-0.6	-0.5	-0.3	0.0	0.2	0.4	0.4	0.3	0.1	-0.2	
2013	-0.4	-0.4	-0.3	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3	
2014	-0.4	-0.5	-0.3	0.0	0.2	0.2	0.0	0.1	0.2	0.5	0.6	0.7	
2015	0.5	0.5	0.5	0.7	0.9	1.2	1.5	1.9	2.2	2.4	2.6	2.6	strong el nino
2016	2.5	2.1	1.6	0.9	0.4	-0.1	-0.4	-0.5	-0.6	-0.7	-0.7	-0.6	
2017	-0.3	-0.2	0.1	0.2	0.3	0.3	0.1	-0.1	-0.4	-0.7	-0.8	-1.0	
2018	-0.9	-0.9	-0.7	-0.5	-0.2	0.0	0.1	0.2	0.5	0.8	0.9	0.8	
2019	0.7	0.7	0.7	0.7	0.5	0.5	0.3	0.1	0.2	0.3	0.5	0.5	
Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	
2020	0.5	0.5	0.4	0.2	-0.1	-0.3	-0.4	-0.6	-0.9	-1.2	-1.3	-1.2	
2021	-1.0	-0.9	-0.8	-0.7	-0.5	-0.4	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0	strong la nina
2022	-1.0												

Table-2 shows **3-monthly ONI values during 1996 - 2021.** Let us focus on NEM seasons of 2005, 2015 and 2021. During the year **2005**, ONI values of **-0.3, -0.6, -0.8** during SON, OND, and NDJ indicated **gradually evolving La Niña conditions from weak La Niña**, while ONI values of **2.4, 2.6, 2.6** during SON, OND, and NDJ of **2015 indicated very strong El Niño conditions**. The ONI value of **-0.8, -1.0, -1.0** during SON, OND, and NDJ of **2021 indicated relatively strong La Niña conditions**. However, **for all these 3 years, NEM rainfall amounts have been above average in Madras region**, as shown in earlier data of rainfall values (**Table-1**) and their departures from normal values were mostly positive departures, showing higher than normal rainfall in these 3 years.

Figure-1 shows a comparative analysis of Total monthly rainfall (in mm) during October 2021& November 2021 over the Indian region, along with corresponding precipitation anomalies (mm/month), Outgoing Longwave Radiation (OLR) anomalies (in Wm^{-2}), and ONI values during recent years.



Rainfall (mm) & Precipitation Anomalies (mm/month)

ONI values and OLR Anomalies (in Wm^{-2})

Figure-1: Total monthly rainfall during October 2021& November 2021 over the Indian region, along with corresponding precipitation anomalies, OLR anomalies and ONI values during recent years.

Figure-2 shows analysis of SST anomalies (in deg. C), OLR anomalies (W/m^2), total energy content (W/m^2), 925 mb (lower level) wind anomalies (m/s) and 200 mb (higher level) wind anomalies (m/s) during November 2021 over Indian region. These show that weak SST warming persisted in the eastern Indian Ocean. Convection was enhanced over the eastern Indian Ocean, consistent with the negative Indian Ocean Dipole (-IOD) conditions.

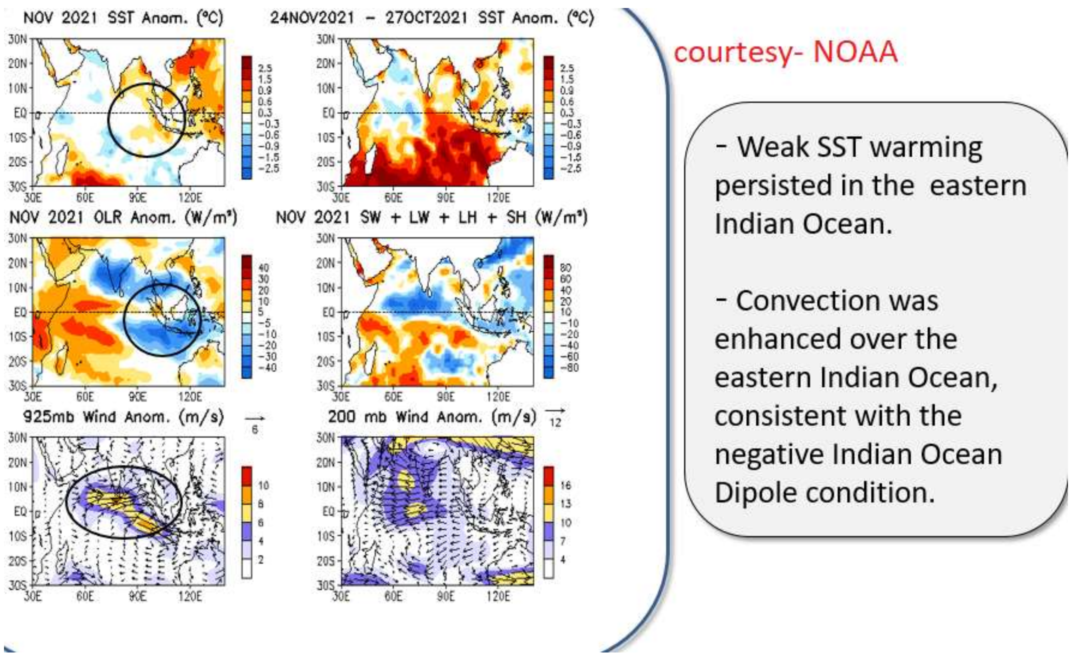


Figure-2: SST anomalies, OLR anomalies, total energy content, 925 mb (lower level) wind anomalies and 200 mb (higher level) wind anomalies during November 2021 over Indian region.

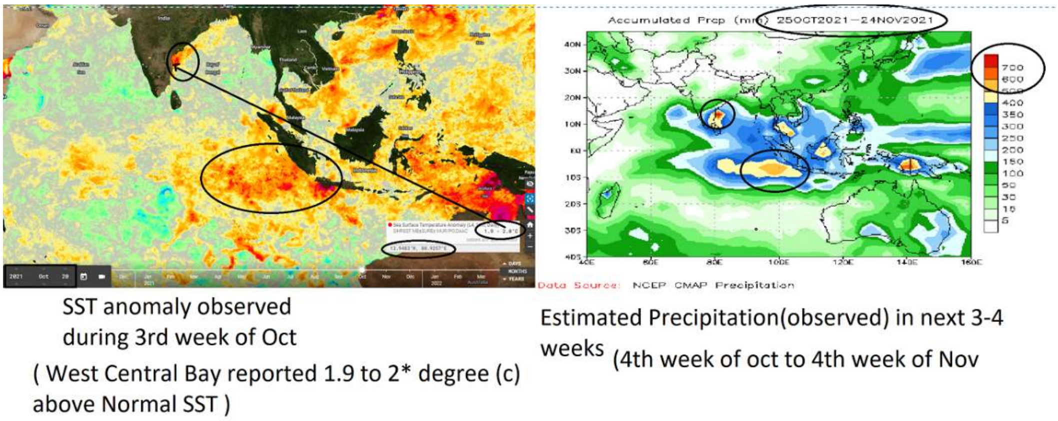


Figure-3: SST anomaly observed during third week of October 2021, and observed precipitation in next 4 weeks (during 25 October to 24 November 2021).

From observed SST anomaly during third week of October 2021 (**Figure-3**), it can be seen that the West-Central Bay of Bengal reported around 1.9 to 2 degree C above normal SST. This resulted in higher precipitation over that region in next 4 weeks (during 25 October to 24 November 2021), causing higher rainfall in Tamil Nadu region.

Figure-4 shows a comparative analysis of OLR anomalies of October, November and December months of 2005 and 2015. It may be noted that rainfall amount in October 2005 was much higher than that of October 2015, while rainfall amount in November 2005 was lower than that of November 2015 (as shown in Table-1).

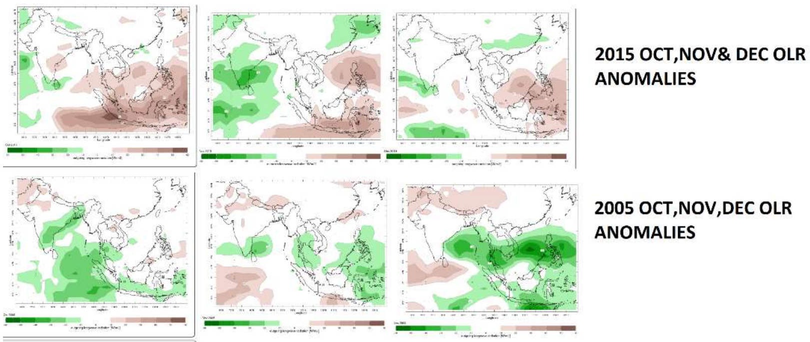


Figure-4: Comparative analysis of OLR anomalies of October, November and December months of 2005 and 2015.

Figure-5 shows a comparative analysis of Mean Sea Level Pressure (MSLP) and OLR anomalies of November 2005 and November 2021. It may be noted that rainfall amount in November 2021 was quite higher than that of November 2005 (as shown in Table-1).

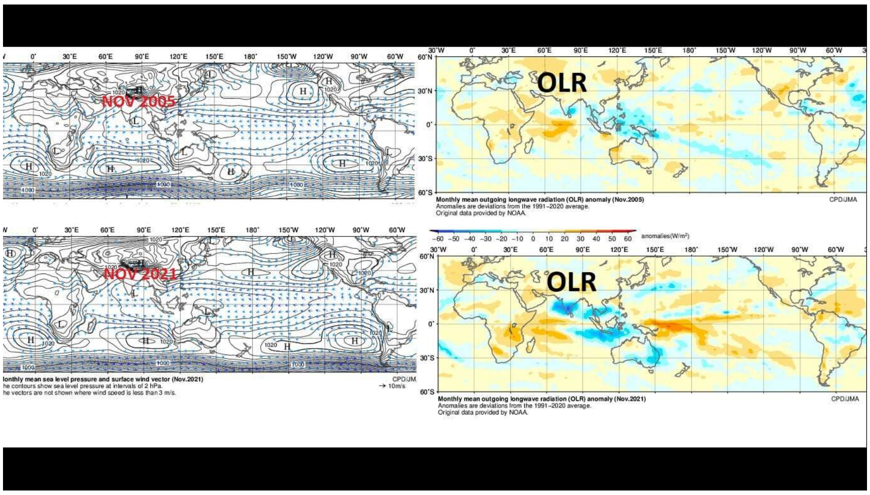


Figure-5: Mean Sea Level Pressure (MSLP) and OLR anomalies of November 2005 (upper panels) and November 2021 (lower panels).

Table-3: District-wise daily and NEM Seasonal rainfall distribution of Tamilnadu & Puduchery

GOVERNMENT OF INDIA, MINISTRY OF EARTH SCIENCES							
INDIA METEOROLOGICAL DEPARTMENT							
REGIONAL METEOROLOGICAL CENTRE, CHENNAI							
Districtwise daily / seasonal rainfall distribution for Tamil Nadu & Puducherry							
NE-MONSOON RAINFALL 2021		31.12.2021			From 01.10.2021 to 31.12.2021		
CODE	NAME	ACTUAL in mm	NORMAL in mm	PDN*	ACTUAL in mm	NORMAL in mm	PDN*
	STATES						
31	TAMIL NADU	9.8	0.9	992	711.6	448.0	59
	MET. SUBDIVISIONS						
31	TAMIL NADU & PUDUCHERRY						
534	ARIYALUR	14.3	1.4	921	933.0	578.3	61
687	CHENGALPATTU	47.9	1.8	2562	1238.4	702.6	76
461	CHENNAI	176.0	1.7	10252	1360.4	784.0	74
462	COIMBATORE	0.0	0.1	-100	678.6	343.8	97
463	CUDDALORE	25.2	2.1	1098	1184.7	704.6	68
464	DHARMAPURI	4.3	0.2	2037	476.8	327.6	46
465	DINDIGUL	5.4	0.7	671	588.6	470.2	25
466	ERODE	0.0	0.1	-100	521.9	308.4	69
688	KALLAKURICHI	5.1	0.7	629	818.2	471.4	74
467	KANCHEEPURAM	47.4	2.1	2157	995.2	591.4	68
468	KANYAKUMARI	0.0	0.7	-100	1076.8	523.9	106
636	KARAIKAL	18.9	1.7	1012	1491.7	1032.5	44
469	KARUR	0.8	0.2	295	496.7	309.7	60
470	KRISHNAGIRI	3.7	0.4	821	442.0	289.8	53
471	MADURAI	3.7	0.3	1138	484.6	418.8	16
695	MAYILADUTHURAI	70.1	2.7	2497	1155.8	886.0	30
472	NAGAPATTINAM	26.3	3.8	591	1219.3	987.4	23
473	NAMAKKAL	0.2	0.2	0	531.6	293.2	81
474	NILGIRIS	0.6	1.4	-54	635.0	477.2	33
475	PERAMBALUR	8.3	0.7	1084	850.7	467.7	82
476	PUDUCHERRY	13.3	1.1	1109	1491.4	882.0	69
477	PUDUKKOTTAI	6.7	1.5	349	629.3	410.5	53
478	RAMANATHAPURAM	6.9	1.8	284	593.2	523.1	13
689	RANIPET	33.2	0.8	4048	788.2	423.4	86
479	SALEM	0.5	0.5	7	481.4	359.0	34
480	SIVAGANGA	4.9	1.1	348	661.1	423.7	56
690	TENKASI	0.0	0.6	-100	717.9	448.6	60
481	THANJAVUR	8.9	1.7	421	867.3	593.7	46
482	THENI	3.4	0.3	1017	596.1	363.9	64
483	TIRUNELVELI	5.1	1.8	181	841.2	491.4	71
691	TIRUPATTUR	6.8	0.2	3279	576.2	268.5	115
535	TIRUPPUR	1.0	0.1	856	480.9	318.4	51
484	TIRUVALLUR	69.6	1.4	4869	1058.2	639.1	66
485	TIRUVANNAMALAI	16.0	0.6	2567	837.6	460.0	82
486	TIRUVARUR	8.1	2.4	238	1030.0	742.1	39
488	TOOTHUKUDI	0.0	1.3	-98	592.4	427.7	39
487	TRICHY	5.3	0.6	776	668.0	394.2	69
489	VELLORE	3.9	1.3	199	626.2	389.8	61
490	VILLUPURAM	13.8	1.0	1284	1211.4	554.3	119
491	VIRUDHUNAGAR	1.1	0.9	21	525.2	395.2	33
	SUBDIVISION RAINFALL	9.8	0.9	994	714.3	449.7	59
LEGEND	PDN*	Percentage Departure from Normal					
	**	Rainfall for the 24 hrs ending at 0830 hrs of date					

Table-3 shows District-wise daily (for 31.12.2021) and NEM Seasonal (for 1st October to 31st December 2021) rainfall distribution of Tamil Nadu and Puducherry. This has been obtained from Regional Meteorological Centre (RMC), Chennai of Ministry of Earth Sciences, Government of India.

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We are thankful to IMS Madras/Chennai Chapter, and Regional Meteorological Centre (RMC), Chennai for their kind support. We sincerely thank Prof. Sulochana Gadgil madam for her kind encouragements and Mr. Somnath Mahapatra for his kind support. We wish to thank all agencies for data sources and images, used in the article.

For Data-Sources, Credits go to

https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

And data from IMD PUNE, NOAA, IRI

IMS Madras/Chennai Chapter, Regional Meteorological Centre (RMC), Chennai.

Weather Satellites of India

M. R. Ramesh Kumar [1,2,3]

[1]Chief Scientist (Retd), Physical Oceanography Division,
National Institute of Oceanography, Dona Paula, Goa
[2]President, Goa Philately and Numismatic Society, PANJIM, Goa.

([3]E-mail: rameshkumar.mr@gmail.com)

Stamp collecting or Philately is a very interesting and relaxing hobby. There are several ways of collecting stamps. Such as country wise, theme wise, chronologically, unusual stamps etc. In the present article, the author has chosen the theme of weather satellites. There have been several stamps on weather satellites all over the world. But the author has narrowed it down to depict only the Indian Satellites only as the theme and topic is very vast. Postage stamps are unique in educating the public, almost on any theme, as there are plenty of stamps on each one of them.

Weather satellites can be broadly classified into two categories, Geostationary and Polar orbiting satellites. Geostationary satellites orbit with a period of 24 hours, viewing the earth below as if stationary. These satellites orbit over the equator at a height of 36,000 km. Polar Orbiting satellites orbit at a much lower altitude of 800-1200 km above the earth.

Geostationary Satellite

A geosynchronous satellite is a satellite whose orbital track on the Earth repeats regularly over points on the Earth over time. If such a satellite's orbit lies over the equator, it is called a geostationary satellite. The orbits of the satellites are known as the geosynchronous orbit and geostationary orbit. INSAT Series of Satellites are Geostationary Satellites

Polar Orbiting Satellite

Polar orbits are often used for Earth-mapping, Earth observation, capturing the Earth as time passes from one point, reconnaissance satellites, as well as for some weather satellites. Indian Remote Sensing Series are examples of Polar Orbiting Satellites.

Near-polar orbiting satellites commonly choose a Sun-synchronous orbit, meaning that each successive orbital pass occurs at the same local time of day. This can be particularly important for applications such as remote sensing atmospheric temperature, where the most important thing to see may well be changes over time which are not aliased onto changes in local time. To keep the same local time on a given pass, the time period of the orbit must be kept as short as possible, this is achieved by keeping the orbit lower around Earth. However, very low orbits of a few hundred kilo-meters rapidly decay due to drag from the atmosphere. Commonly used altitudes are between 700 and 800 km, producing an orbital period of about 100 minutes. The half-orbit on the Sun side then takes only 50 minutes, during which local time of day does not vary greatly.

We, at National Institute of Oceanography had carried out several Sea Truth Validation campaigns (Pathak et al, 1983; Viswambharan et al., 1984, Ramesh Kumar and Prasad, 1997; Muraleedharan, et al., 2004) for most of the Oceanographic and Meteorological Payloads onboard different satellites starting with the Bhaskara series of satellite in joint collaboration with the Meteorology and Oceanography Group (MOG) Space Application Centre, Ahemdabad. The next were for Oceansat sensors OCM and MSMR and then we also validated the Saral Altika satellite data and Megha Tropiques sensor data. Some of the ships which we had used for our sea truth Validation were Gaveshani and Sagar Kanya of the Institute.

Aryabhata Satellite

Named after the 5th century Indian astronomer and mathematician, Aryabhatta was the first satellite, built by ISRO, launched on 19th April 1975 from Kapustin Yar using a Kosmos-3M launch vehicle. An agreement was signed between India and the Soviet Union in 1972 which allowed the USSR to use Indian ports for tracking ships and launching vessels in return for launching Indian satellites. X-ray astronomy, aero-nomics, and solar physics experiments were conducted using the satellite.

Figure 1: This 25 paisa stamp has been issued by the Department of Posts, Govt. of India, way back in 1975.

Bhaskara I and II

Bhaskara-I and II were two satellites built by the Indian Space Research Organisation that formed India's first low-Earth orbit Earth observation satellite. They collected data on telemetry, oceanography and hydrology. Both satellites are **named after ancient Indian mathematicians Bhāskara I and Bhāskara II.**

Bhaskara-I, weighing 444 kg at launch, was launched on 7 June 1979 from Kapustin Yar aboard the Inter-cosmos launch vehicle. It was placed in an orbital Perigee and Apogee of 394 km and 399 km at an inclination of 50.7°. The satellite had a sensor called Satellite Microwave Radiometer (SAMIR) which operated in the 19 and 22 Ghz for studying the Ocean state, Water Vapour and liquid water content in the atmosphere.

Figure 2: A Special Cover on Bhakara II Satellite was released during the TANAPEX, Madras, on 24th December,1981.

Indian Remote Sensing Satellite – (IRS) 1A

IRS-1A, Indian Remote Sensing satellite-1A, the first of the series of indigenous state-of-art remote sensing satellites, was successfully launched into a polar Sun-synchronous orbit on 17 March 1988 from the Soviet Cosmodrome at Baikonur. IRS-1A carries two sensors, LISS-1 and LISS-2, with resolutions of 72 m (236 ft) and 36 m (118 ft) respectively with a swath width of about 140 km (87 mi) during each pass over the country. Undertaken by the Indian Space Research Organisation (ISRO). It was a part-operational, part-experimental mission to develop Indian expertise in satellite imagery.

Figure 3: A Block of 4 of Indian Remote Sensing Satellite IRS 1A stamps of value, Rs 6.50 which was issued by the Department of Posts, Govt. of India.

INSAT3

The ISRO-made Indian weather satellite INSAT-3DR, operated by the Indian National Satellite System provides meteorological services along with search and rescue information and message relay for terrestrial data collection platforms. The satellite was launched on 8th September on a Geosynchronous Satellite Launch Vehicle (GSLV Mk II) from the Satish Dhawan Space Centre. INSAT-3DR is an advanced version of the INSAT-3D with imaging System and an Atmospheric Sounder. It captures night time pictures of low clouds and fog, estimates Sea Surface Temperature (SST) with better accuracy and offers Higher Spatial Resolution in the Visible and Thermal Infrared bands. It also carries a Data Relay Transponder and a Search and Rescue Transponder.

Figure 4: A postally used 300 paisa-stamp of the INSAT in orbit, issued by the Department of Posts, Govt of India.

Oceansat-1 and II

OceanSat-1 or IRS-P4 was launched by ISRO's PSLV-C2 along with German DLR-Tubsat and South Korean KitSat 3 on 26th May 1999 specifically for oceanographic studies. It is a part of the Indian Remote Sensing satellite series and was mounted with Ocean Colour Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR). The OCM monitors the colour of the ocean to document chlorophyll concentration, phytoplankton blooms, atmospheric aerosols and particulate matter. It detects eight spectrums from 400 nm to 885 nm. The MSMR measures sea surface temperature, wind speed, cloud water content, and water vapour content. It completed its mission on 8th August 2010 after serving for 11 years and 2 months. **Oceansat-2** is the second Indian satellite built primarily for ocean applications. It was a part of the Indian Remote Sensing Programme satellite series. Oceansat-2 is an Indian satellite designed to provide service continuity for operational users of the Ocean Colour Monitor (OCM) instrument on Oceansat-1. It will also enhance the potential of applications in other areas.

Figure 5: A Rs 3 stamp on the Oceansat which was issued by the Department of Posts, Govt. of India.

Oceansat-2 carried three instruments for ocean-related studies, namely, Ocean Colour Monitor-2 (OCM-2), an OceanSat Scatterometer by Indian Space Research Organisation (ISRO), and an instrument called ROSA (Radio Occultation Sounder of the Atmosphere) developed by the Italian Space Agency (ASI). The major applications of data from Oceansat-2 are the identification of potential fishing zones, sea state forecasting, coastal zone studies, and inputs for weather forecasting and climatic studies.

The two satellites were developed jointly by Indian Space Research Organisation (ISRO) and the Centre National d'Etudes Space (CNES) of France.

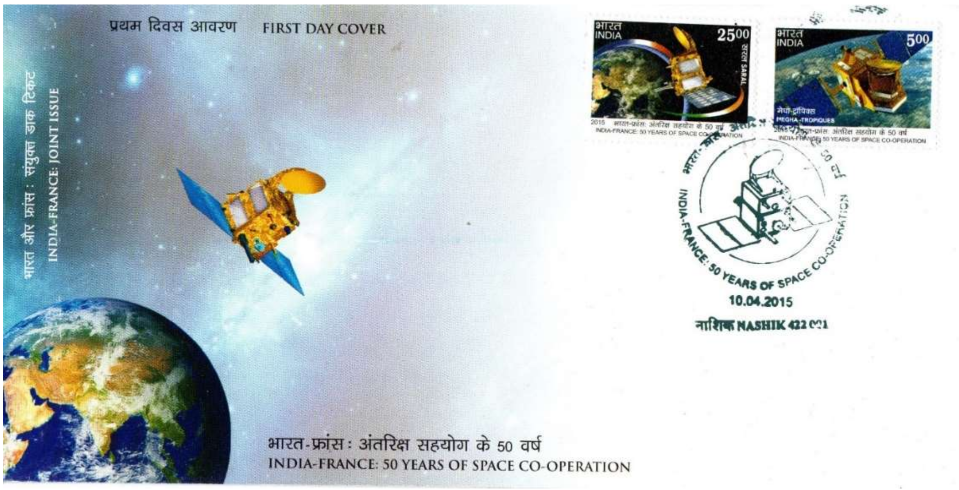

Figure 6: A First Day cover with the stamps contain the images of "Satellite with ARgos and ALtika" (SARAL) and Megha-Tropiques satellite, a joint venture of the Indian and French Collaboration in space.

The satellites Megha-Tropiques and SARAL were launched by the Indian PSLV-C18 in 2011 and PSLV-C20 in 2013 respectively. The data provided by these satellites is being utilised by ISRO and CNES and is being shared with other countries. The partnership between India and France in space started in 1964 when the two countries entered into a protocol agreement for cooperation in space research. The countries have since continued to work together for the advancement of peaceful uses of outer space.

Megha Tropiques

Megha-Tropiques is a satellite mission to study the water cycle in the tropical atmosphere in the context of climate change [2] A collaborative effort between Indian Space Research Organisation (**ISRO**) and French Centre National d'Etudes Spatiales (CNES), Megha-Tropiques was successfully deployed into orbit by a PSLV rocket in October 2011.

The Sensors onboard the Megha Tropiques are the following:

a) Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS) is a microwave imager, with conical scanning (incidence angle 56°), close from the SSM/I and TMI concepts. The main aim of the mission being the study of cloud systems, a frequency has been added (150 GHz) in order to study the high-level ice clouds associated with the convective systems, and to serve as a window channel relative to the sounding instrument at 183 GHz.

b) Sounder for Probing Vertical Profiles of Humidity (SAPHIR) is a sounding instrument with 6 channels near the absorption band of water vapor at 183 GHz. These channels provide relatively narrow weighting functions from the surface to about 10 km (6.2 mi), allowing retrieving water vapor profiles in the cloud free troposphere. The scanning is cross-track, up to an incidence angle of 50°. The resolution at nadir is of 10 km (6.2 mi).

c) Scanner for Radiation Budget (ScaRaB) is a scanning radiative budget instrument, which has already been launched twice on Russian satellites. The basic measurements of ScaRaB are the radiances in two wide channels, a solar channel (0.2 - 4 μm), and a total channel (0.2 - 200 μm), allowing to derive longwave radiances. The resolution at nadir will be 40 km (25 mi) from an orbit at 870 km (540 mi). The procedures of calibration and processing of the data in order to derive fluxes from the original radiances have been set up and tested by CNES and LMD.

d) Radio Occultation Sensor for Vertical Profiling of Temperature and Humidity (ROSA) procured from Italy for vertical profiling of temperature and humidity.

Saral Altika performs altimetric measurements designed to study ocean circulation and sea surface elevation and the data can be used for following applications:

a) Marine meteorology and sea state forecasting
b) Operational oceanography
c) Seasonal forecasting
d) Climate monitoring
e) Ocean, Earth system and climate research

Table 1: Details of the various satellites and their launch date, vehicle orbit type and their applications

Name	Launch Date	Launch Mass	Launch Vehicle	Orbit Type	Application
Bhaskara I	7th June, 1979	442 Kg	C-1 Intercosmos	LEO	Earth Observation, Experimental
Bhaskara II	20th November, 1981	444 Kg	C-1 Intercosmos	LEO	Earth Observation, Experimental
IRS – 1A	17th March, 1988	975 Kg	Vostok	SSPO	Earth Observation
Oceansat I (IRS-P4)	26th May, 1999	1050 Kg	PSLV-C2/IRS-P4	SSPO	Earth Observation
Oceansat II	23rd September, 2009	970 Kg	PSLV-C14	SSPO	Earth Observation
INSAT 3B	21st March, 2000	2070 Kg	Ariane – 5G	Geosychrnonous (83 E)	Communication and Meteorology
Megha - Tropiques	12th October, 2011	1000 Kg	PSLV-C18/Megha-Tropiques	SSPO	Climate & Environment, Earth Observation
SARAL	25th February, 2013	407 Kg	PSLV-C20/SARAL	SSPO	Climate & Environment, Earth Observation

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Undefined Infinity

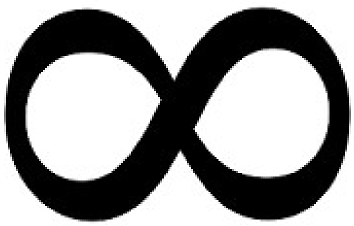
Manoj Kumar Tandon[1, 2, 3]

[1]Scientist (Retired), IITM, Pashan Road, Pune.
[2]Former Secretary, Computer Society of India, Pune Chapter.
([3]**E-Mail ID: mkbtandon@gmail.com**)

Sometime between 5th and 6th centuries B.C., the Greeks discovered infinity. The concept of infinity (**हिन्दी में अनंतता**) was so overwhelming, so bizarre, so contrary to every human intuition, that it confounded the philosophers and mathematicians who discovered it, causing pain and insanity. Of course, from the time people began to think about the world they lived in, questions about infinity arose. There were questions about time. Did the world come into existence at a particular instant or had it always existed? Would the world go on forever or will there be a finite end? Then there were questions about space. What happens if one keeps on travelling in a particular direction? Would one reach the end of the world or could one travel forever? Again, above the earth one could see stars, planets, the sun and moon, but was this space finite or does it go on forever? These questions are very fundamental and must have troubled thinkers long before recorded history. **Infinity symbol, ∞, is also sometimes called "Lazy Eight", evoking the image of "8" lying on its side**. **Infinity symbol, ∞, is named LEMNISCATE. In algebraic-geometry, a LEMNISCATE is any of the several figure-eight or ∞ shaped curves.**

Infinity Symbol

(Lazy Eight)



LEMNISCATE

There were more subtle questions about infinity, which were also asked at a stage when people began to think deeply about the world. What happens if one cuts a piece of wood into two pieces, then again cuts one of the pieces into two and continues to do this. Could one do this forever? We begin our account of infinity with the fifth-century philosopher Zeno of Elea. The early Greeks had come across the problem of infinity at an early stage in their development of mathematics and science. In their study of matter they realized the fundamental question: "Can one continue to divide matter into smaller and smaller pieces or will one reach a tiny piece which cannot be divided further". **Pythagoras (569 – 500 B.C.)** had argued that "all is number" and his universe was made up of finite natural numbers. Then there were Atomists who believed that matter was composed of an infinite number of indivisibles. Of course these paradoxes arise from the infinite. **Aristotle** did not seem to have fully appreciated the significance of Zeno's arguments but the infinite did worry him nevertheless. He introduced an idea, which dominated thinking for two thousand years and is still a persuasive argument to some people today. Aristotle argued against the actual infinite and, in its place, he considered the potential infinite. His idea was that we can never conceive of the natural numbers as a whole. However, they are potentially infinite in the sense that given any finite collection we can always find a larger finite collection. It was an attempt to bring infinity, as well as zero, into the number system. Of course, it does not work since if it were introduced then 0 times infinity must be equal to every number n, so all numbers are equal. **Thomas Aquinas**, the Christian theologian and philosopher, used the fact that there was not a number to represent infinity as an argument against the existence of the actual infinite. The concept of infinity has tantalized and sometimes troubled mankind. To a mathematician, the word 'infinity' means many different things depending on their context. There are many kinds of infinity. At the end of 19th century, the mathematician **Georg Cantor** devised a system for comparing infinities. For example; the infinity of integers is smaller than the infinity of real numbers. In fact, for any infinity you can name, there is another infinite quantity that's infinitely bigger. **Infinity is numerically undefined.** Infinity is of different kinds having different perceptions.

The symbol, ∞, which we use today for representing infinity was first used and introduced by an English mathematician John Wallis who used it in "De Sectionibus Conicis" in 1655 and again in "Arithmetica Infinitorum" in 1656. **John Wallis (1616-1703)** was one of the most original and accomplished English mathematician of his time. He chose this symbol to represent the fact that one could traverse the curve represented by this symbol infinitely often. Romans used the infinity symbol to represent 1000, a BIG number to them. The word infinity comes from the Latin word 'infinitas'. Infinity refers to different concepts in theology, philosophy, mathematics and everyday life. The earliest known documented knowledge of infinity was presented in ancient India in **'Yujur Veda' (1200-400 BC) – Hindu Mythology**, which states "if you remove a part from infinity or add a part to infinity, still what remains is infinity". **The Jaina mathematical text 'Surya Prajnapati' (400 BC)**, classifies infinite into 'Nearly Infinite', 'Truly Infinite' and 'Infinitely Infinite'. The Jaina was the first to discard the idea that all infinities were identical or same. They recognized different types of infinities. In common parlance, infinity is often used in a hyperbolic sense. For example: "The movie was infinitely boring, but we had to wait forever for tickets". Mathematics considers infinity as the useful concept of a process with no end. The terms infinity and infinite have a variety of related meanings in mathematics. The adjective finite means having an end, so infinity may be used to refer something having no end.

In mathematics, the infinity symbol ∞ means boundlessly large but not necessarily uncountable. In 1600s **Galileo** proposed that infinity should obey a different arithmetic than finite numbers. Few concepts in mathematics are more fascinating, tantalizing and confounding than infinity. The concept of infinity has tantalized and sometimes troubled mankind. Infinity is neither a fiction nor a figment of imagination. It is a part of reality, or a positive quantity or measurement, but it is too large to accommodate a count of dimension in it. In the state of infinity, there is no beginning, no mid-point, no end-point and no point of reference. However, unlike infinity which is a reality, zero is an abstract or imaginary quantity because in reality zero does not exist and is an abstract assumption. Infinity as a real physical thing is still often treated with skepticism. The definite nature of infinity is very much an unresolved mystery in both physics and mathematics. **Newton (1643 – 1727)** rejected indivisibles in favour of his fluxion, which was a measure of the instantaneous variation of a quantity. Of course, the infinite was not avoided by him since he still had to consider infinitely small increments. Newton's fluxions produced wonderful mathematical results but many were wary of his use of infinitely small increments. Newton believed that space is in fact infinite and not merely indefinitely large. He claimed that such infinity could be understood; particularly using geometrical arguments, but it could not be conceived. **Infinity is an abstract concept used to describe something that is endless or boundless**. Infinity has its own special symbol, ∞, which is called "**LEMNISCATE**". The word "infinity" comes from the Latin word "**infinitas**" which means boundless. An interesting example of infinity is the widely used mathematical constant Pi. Mathematicians use a symbol **(π)** for Pi because it is impossible to write the number down. Value of Pi consists of an infinite number of digits. It is impossible to write down last digit in the value of Pi represented by infinite collection of digits. **Value of Pi represents one kind of infinity**.

The problem of whether space and time are infinitely divisible continued to trouble mathematicians and scientists. Little progress was being made on the question of the actual infinite. The same arguments kept on appearing without any definite progress towards a better understanding. Perhaps one of the most significant events in the development of the concept of infinity was **Bernard Bolzano's "Paradoxes of the Infinite"** which was published in 1840. He argued that the infinite does exist and his argument involves the idea of a set, which he defined for the first time as "A collection where the order of its parts is irrelevant and where nothing essential is changed if only the order is changed". Why does defining a set make the actual infinite a reality? Once one thinks of integers as a set, then there is a single entity that must be actually infinite. Aristotle looked at the integers from the point of view that one can find arbitrarily large finite subsets. But once one has the set concept then these are seen as subsets of the set of integers which must itself be actually infinite. At this stage the mathematical study of infinity moved into set theory. Infinity as a physical thing is still often treated with skepticism. Infinity is neither big nor huge nor tremendously large. Infinity is simply endless. Infinity is the idea of something that has no end. Infinity does not grow. Infinity has been treated with a mixture of fascination and awe. Infinity is more than simply the largest ever number, and even this simple description has caused problems for mathematicians throughout the ages. **From the ancient Greeks to Newton, from Newton to present-day mathematicians, infinity has posed both practical and conceptual problems**.

John Wallis

Creator of infinity

Symbol ∞

John Wallis, English Mathematician, had the unique ability of doing mental calculations. He once calculated the square root of a 53-digit number and dedicated the 27-digit square root of the same number all in his head. **John Wallis invented and introduced, ∞, the symbol of infinity.** Philosophers and mathematicians have gone mad contemplating its nature and complexity. The definite nature of infinity is very much an unresolved mystery in both physics t ***described infinity as a floorless room without walls and ceiling.*** Desire to quantify the magnitude of infinity has always been triggering the imaginations and intelligence of mathematicians and scientists. Numerical representation of infinity is one of the profound unsolved problems and mysteries of computational mathematics. No other concept has ever moved so profoundly the spirit of man; no other idea has so fruitfully stimulated his intellect and no other concept stands in greater need of clarification than that of infinity. Once scientists virtually asked infinity – **"Who are you Infinity"**? Infinity replied – **"I am your curiosity"**. The concept of infinity has been a subject of speculation throughout the history of mankind. **Infinity is a mystery of science**.

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IMSP News:

Annual Monsoon E-Workshop (AMW 2021) & National E Symposium

Annual Monsoon E-Workshop (AMW 2021) & National E-Symposium on "Changing climate and extreme events: impacts, mitigation & Role of oceans" was successfully organized by Indian Meteorological Society, Pune Chapter (IMSP), in association with Ocean Society of India, Pune Chapter (OSIP) and with kind supports from IITM Pune, IMD Pune and DASS SPPU Pune, on online platform, during 21st – 23rd February 2022 (3 days: Monday - Wednesday).

The inaugural session of the event included welcome address by **Dr. C. Gnanaseelan**, IMSP Chairman; expert addresses by Chief Guest **Dr. M. Mohapatra**, DGM IMD & President IMS; and by Guests of honour **Dr. R. Krishnan**, Acting Director, IITM and **Mr. K. S. Hosalikar**, Head CR&S, IMD; followed by vote of thanks by **Dr. Madhu Chandra R. Kalapureddy**, Secretary IMSP.

Annual Monsoon E-Workshop (AMW 2021) included presentations for both SW Monsoon and NE Monsoon over Indian region during the year 2021. **National E-Symposium on "Changing climate and extreme events: impacts, mitigation & Role of oceans" covered five themes,** respectively on **(1) Climate change, (2) Extreme events, (3) Impact of Climate change, (4) Climate change Mitigation, and (5) Role of Oceans on changing Climate and Extremes**. For these **5 themes, 52 abstracts** were received from various parts of the country. In total, there were **8 sessions** during the E-Workshop and the E-Symposium. The event included **20 Expert talks and 52 Oral presentations**. IMSP **received 30 feedbacks** from workshop participants and senior life members of the society. **Dr. Prabhat Kumar** was specially **felicitated by IMSP**, in recognition of his great achievement of obtaining **AMS** (American Meteorological Society) **Award**. For encouraging young participants & organizers, several awards were distributed. There were **16 awardees**, 13 for presentations and 3 for significant contribution in organizations. **Presentation awards were received by 13 young participants**: (1) Ambuj Kumar Jha (2) Meenu R. Nair (3) Subroto Halder (4) Naresh G. Ganeshi (5) Shreyas Dhavale (6) Diya Das (7) Dipankar Sarma (8) Anila Sebastian (9) Sandeep Narayanasetti (10) Anupama K. Xavier (11) Nandini G. (12) Darshana Patekar, and (13) Priya Priyadarshini. Ms. Smarti Gupta received award for the best performance (especially for nicely anchoring the event). Mr. Padmakar Domtuwar received award for the best IT services (especially for online arrangements, done very nicely) while Ms. Rashmi Sahu received award for the best services from the IITM Library (especially for webpage management & uploading important information). This year, the **Pune Chapter of Ocean Society of India (OSIP) joined hands** with IMSP, IMD & SPPU in conducting the AMW-2021 E-Workshop cum E-Symposium, and there was a very good synergy of Ocean and Meteorological Societies for working together towards popularizing science to the society. Great efforts by the Executive Committee of IMSP and various Committees formed for organization resulted in great success of this important event.

More Details (about this event) are available at the website of IMS Pune Chapter (IMSP), https://imdpune.gov.in/Links/imsp/index.html

====== Compiled by Somnath Mahapatra, Ex-Officio Member, IMSP EC =============

BIMSP Managing Editor: Somnath Mahapatra, IITM Pune

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