Indian Meteorological Society, Chennai Chapter
Newsletter Vol.16, Issue No.1, June 2015

Contents

From the Chair-Person's Desk . . .

Dear Members of IMS Chennai Chapter and Readers of Breeze,

It is my privilege to update you on the activities of the chapter, since the release of the previous issue of BREEZE (Vol. No. 15, Issue No. 2, December 2013). In spite of our sincere efforts no issue could be released in the year 2014 and the present issue (Vol. No. 16, Issue No.1, June 2015) with seven informative articles from various authors.

Two talks were organized since December 2013. The first talk by ShriS.Rraghavan, DDGM (Retd.) on Interaction of Physics and Meteorology with the Social Sciences was on 20th August 2014. The second talk was arranged on 24th September 2014. On this occasion Dr. A.K. Ghosh, Manager,MET., R.O and Dr. M. Rajasekhar, Scientist from SDSC, Sriharikota deliveredtwo lectures. Dr. A.K. Ghosh delivered a lecture on topic related to Space Launch Operations and Dr. M. Rajasekhar on " Dynamical Weather Forecasts for Space Launch Operations" .

Two colloquium talks were also arranged on 18th November 2014. Dr. Y.E.A.Raj, DDGM (Retd.) talked about the "Project on Synergised SOP for coastal multi hazard EWS-A new initiative by WMO Panel on TCs" and Ms. B. Amudha, Scientist 'D', RMC Chennaigave a talk on "Characteristics of movement of low level clouds associated with onset/wet spells of Northeast Monsoon of Indian sub-continent as derived fromhigh resolution INSAT OLR data". Apart from these the annual seminar on Monsoon 2014 was arranged on 19th February, 2015.

The Annual General Body Meeting was arranged on 7th April 2014 in which the new office bearers of the biennial year 2014-2016 were elected. The first Local Executive Council meeting was held on 18th June 2014. New Treasurer Shri N. Ramamurthy was elected during the LEC meet and Dr. D. NarayanaRao, SRM University and Dr. SelviRajan, Sceintist, SERC were co-opted as Council Members. The editorial board of the BREEZE was also finalized.

I thank all of them, who were instrumental in bringing out this issue of BREEZE. The next issue of BREEZE is planned to be release before the end of 2015. Hence I request all of you to send your valuable contribution to BREEZE.

With Best Regards
N. Jayanthi,
Chair-Person, IMS Chennai Chapter.

Membership details of IMS Chennai chapter (as on December 2013)
Life Members 145: Ordinary members : 4 Total : 149
Those who wish to become members of IMS Chennai Chapter may please mail to ims.chennai6@gmail.com
Disclaimer: The Editor and IMS Chennai Chapter are not responsible for the views expressed by the authors.

The election for the biennial term 2014-16 was conducted by the Shri Augustine Sundar Singh, returning officer appointed for the purpose. The following members were as office bearers for the term 2014-2016:

Post	Elected member
Chair-person	Dr. N. Jayanthi
Immediate Past Chairman	Dr. R. Suresh
Secretary	Dr. S. Ramanan
Joint Secretary	Shri K.V. Balasubramanian
Treasurer	Shri N. Ramamurthy
Executive members: (1)	Dr. N. Sivagnanam
(2)	Shri S. Raghavan
(3)	Shri R. Nallaswamy
(4)	Shri S.B. Thampi
(5)	Shri Y.E.A. Raj
(6)	Dr. Asokan
(7)	Ms. B. Amudha
(8)	Dr. D. NarayanaRao
(9)	Dr. SelviRajan

Interaction of Physics and Meteorology with the Social Sciences[1]

By
S. Raghavan

1. Science and Humanities

Until recently,higher education in this country was strictly compartmentalised into Science and Technology on the one hand and the Humanities on the other with little or no scope for interaction between the two. This was based on the classical British model. The European and American models seem to provide more inter-disciplinary interaction. C.P. Snow the British scientist and author, in his famous lecture *Two Cultures* (1959) said that the intellectual life of the whole of western society was split into the titular two cultures — namely the *sciences* and the *humanities* — and that this was a major hindrance to solving the world's problems. He said that highly educated non-scientists looked blank when he referred to the Second Law of Thermodynamics.

It is not that there were no scientists or non-scientists interested in each other's fields. But general realisation of the need for inter-disciplinary interaction and its incorporation into our educational curriculum came rather late. Now we have humanities courses in IITs, for example. One early perception of this was in the essay *"The Unreasonable Effectiveness of Mathematics in the Natural Sciences,"* by the 1963 Physics Nobel Laureate, Eugene Wigner (1960). He said *"The enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it".*

Knowledge of the usefulness of mathematics in other sciences was there long before Wigner. Mahaveera,a scholar of the ninth century is quoted as saying,
"Laukikevaidikevaapitathaasaamaayikepi yah
Vyaapaarastatrasarvatrasamkhyaanamupayujyate"
"In all those transactions which relate to Vedic or (other) similarly religious affairs, calculation is of use" (SitaSundar Ram, 2012)

But Wigner did not stop there. He referred to the application of Mathematics to **non-science** subjects too. He gave an anecdote *"A statistician working on population trends explained his work to a former classmate.The latter asked "And what is this*

[1]Presentation at the Indian Meteorological Society, Chennai Chapter, August 2014
S. Raghavan Email: raglaksh@gmail.com

symbol here?" "Oh," said the statistician, "this is π*" "What is that?" "The ratio of the circumference of the circle to its diameter." "Well, now you are pushing your joke too far," said the classmate, "surely the population has nothing to do with the circumference of the circle."* He also cited the example of complex numbers which provide a particularly striking example for the foregoing. Certainly, nothing in our experience suggests the introduction of these quantities. But mathematical models have been extensively used in economics and sociology.

2. Application of Physics to other fields.

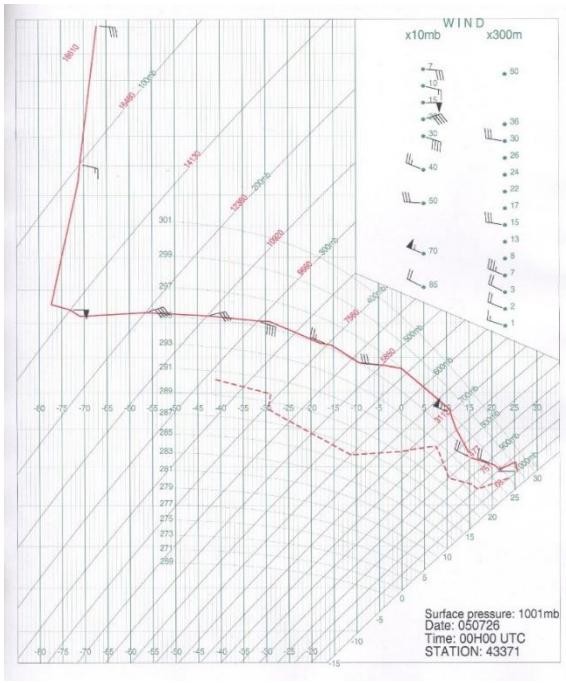
What about Physics? Many Physicists like to think that everything follows natural laws. Erwin Schrödinger, the Austrian Physicist in his 1944 essay "*What is Life*" said

"*I**n a world governed by the second law of thermodynamics, all isolated systems are expected to approach a state of maximum disorder. Since life approaches and maintains a highly ordered state –some argue that this seems to violate the aforementioned Second Law implicating a paradox. However, since life is not an isolated system, there is no paradox. The increase of order inside an organism is more than paid for by an increase in disorder outside this organism. By this mechanism,the Second Law is obeyed, and life maintains a highly ordered state, which it sustains by causing a net increase in disorder in the Universe. In order to increase the complexity on Earth - as life does - energy is needed".*

The Second Law of Thermodynamics leads to the concept of Entropy[2], a much misunderstood one.

2nd Law: Energy spontaneously disperses from being localised to becoming spread out if it is not hindered. **Entropy** measures the spontaneous dispersal of energy–as a function of temperature, $\delta Q/T$

[2]I did not think much of Entropy when I studied it at college. One day I went to a science exhibition at the College of Engineering Guindy, Chennai. At the India Meteorological Department stall I saw a radiosonde and a tephigram for the first time and realised the utility of the concept of Entropy.

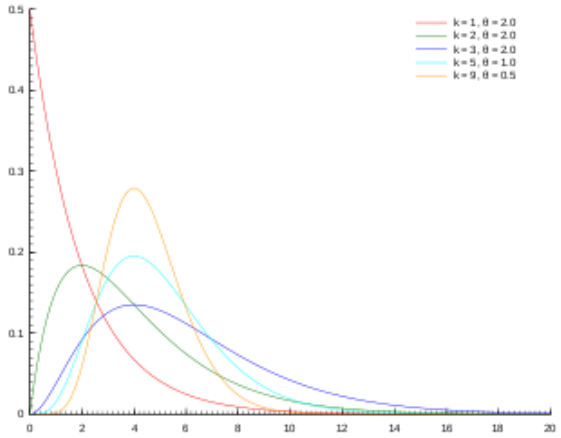


←Tephigram of a radiosonde ascent at Thiruvanathapuram 26 July 2005 00 UTC Temperature on X-axis, entropy or potential temperature on the Y-axis

Entropy has been interpreted as disorder by many authors who have tried to apply it to other fields. There is a book titled "*Entropy- A new world View*"(Rifkin and Howard, 1981) which tries to explain everything in economics and sociology on the basis of Entropy. Even Schrödinger (1944) seems to treat it that way. Some Physicists do not agree. They have pointed out that Entropy is not "disorder"; it is a measure of the dispersal of energy.

Physicists' interest in the social sciences is not new and can be traced to Daniel Bernoulli (18th century). But the term "**Econophysics**" was coined in the 1990s to mean the application to Economics of probabilistic and statistical methods taken from statistical physics(See the interview with Prof. Eugene Stanley who coined the name, at (http://www.saha.ac.in/cmp/camcs/Stanley-interview.pdf). It is interesting that Physics can be applied to economics but one has to be cautious as the latter deals with human behaviour and not natural laws.

Let us consider the kinetic theory of gases. All the molecules in a gas do not have the same energy. The energy distribution is a gamma distribution.



Probability density function of a gamma distribution

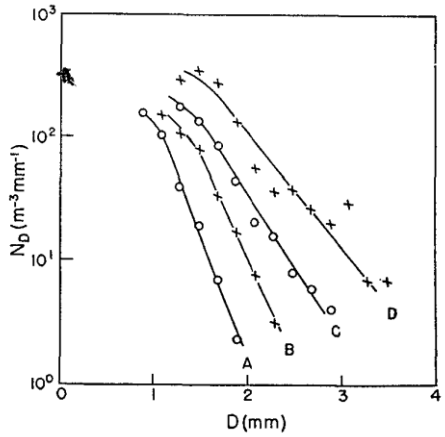
A large number of molecules have low energies and fewer have high energies.

Maxwell (19th century) postulated a "demon" (so named not by Maxwell but by Kelvin). Maxwell's Demon is supposed to selectively move faster molecules to one chamber and the slower molecules to another. Since molecular velocity means temperature the first chamber will rise in temperature and the second one will record a fall. This would result in a*decrease* in entropy of the system. (The difference in temperature can probably be used to drive a heat engine!). This violates the 2nd law. The process of selection of the molecules will involve energy and increase of entropy; so the demon is impractical.[3]

3. Meteorological analogies

Meteorology is a fascinating subject because it has relevance to every human activity.Let us examine Meteorological phenomena. Marshall and Palmer (1948) found that the distribution of rain drop sizes was **exponential** (except for drops with very small diameters).

[3]Lu et al (2014) describe a thought experiment conceiving an autonomous device able to convert thermal energy into work to raise a mass against gravity by writing information to a physical memory register



←From Marshall and Palmer (1948)

N_D= Number of drops of diameter D to $D+\delta D$is given by

$$N_D = N_0 e^{-\Lambda D},$$

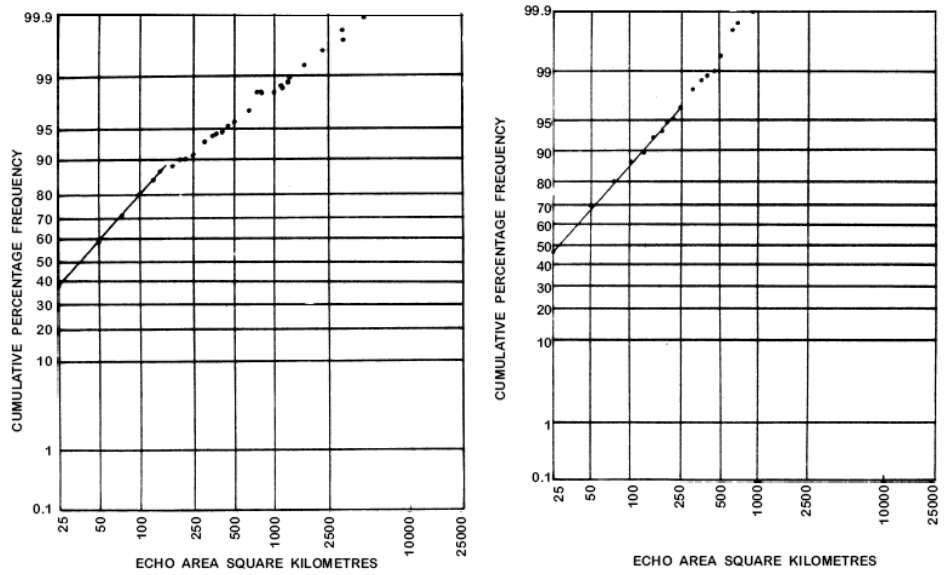
Later,scientists found that the distribution is better represented by a gamma distribution with one more parameter added. The exponential distribution is a special case of the 3-parameter gamma distribution

$$N_D = N_0 D^m \exp\left(\frac{-3.67 + m}{D_0} \cdot D\right)$$

The smaller drops are more numerous and the big drops fewer.

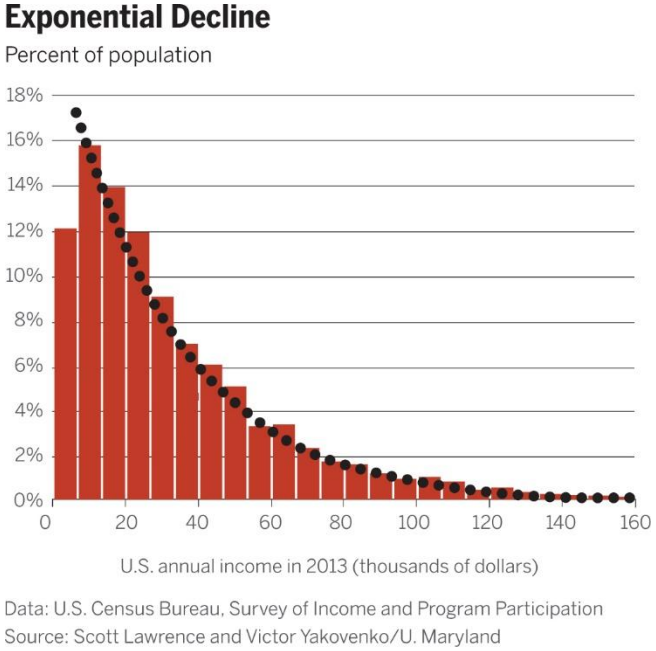
Let us consider another example from Meteorology. Convective clouds generally form in a random manner in an areafavourable for convection, because of the large scale airflowand appropriate thermodynamic conditions. Assuming that an initial cloud element grows further in size while entraining environmental air in some proportion, López (1976, 1977) showed that this process would result in a **log-normal distribution** of the sizes of the cells. [A log-normal distribution is a continuous probability distribution of a random variable whose logarithm is normally distributed]. In addition to the growth of an individual cumulus, clouds can grow by merger into larger elements and that also leads to a log-normal distribution.

If the cumulative percentage frequency of the areas (or heights) of radar echoes is plotted on logarithmic probability paper, a straight line should result. It has been found that this indeed is the case except for departures which have been explained [Houze and Cheng (1977), Raghavan et al (1983) Chatterjee et al (1991, 1992)]. These two figures (from Raghavan et al. 1983) show the distribution of radar echo sizes around Chennai in the southwest and northeast monsoon seasons respectively. There are departures (in opposite directions during the two seasons) from the lognormal, at the larger sizes, which have been explained by the authors in terms of the growth mechanisms. The point to note is that the small sizes are numerous and larger sizes fewer.



4. Socio-Economic Inequalities

Similarly, it is argued that the distribution of incomes in the USA is such that a large number of people have low incomes and fewer have high incomes and an exponential distribution can be fitted in (Cho 2014). Similar results have been obtained in respect of several other countries, though to different degrees.



Exponential decline
Y-axis - Percent of population
X-axis U.S. annual income in 2013 (thousands of dollars)

Data: U.S. Census Bureau, Survey of Income and Program Participation
Source: Scott Lawrence and Victor Yakovenko/U. Maryland

A common index has been formulated, called the *Gini coefficient*, of income inequalityranging from 0, in which everyone makesthe same income, to 1, in which a single richperson would get a country's entire income[4]. The Gini coefficient for the

[4]Economic equality or inequality alone do not measure the well-being of people or nations. Other measures such as Gross National Happiness (GNP) instead of GDP (Gross Domestic Product) and SPI (Social Progress Index) have been proposed. These are beyond the scope of the present paper.

USA is said to be 0.40, for China 0.55 and for India 0.30 or 0.52 depending on which survey you want to believe (Hvistendahl, 2014**)**. And inequality is said to be increasing in most countries (increase of entropy?).
Just as the molecules in the Kinetic theory, people can be considered to be an assembly with a distribution of "energies" i.e. that is wealth which is exponential. On the lines of the kinetic theory of gasesa "Kinetic exchange models of markets" has been developed. This, points to distributions of different types at the low and high end of income or wealth.

Not all people accept this analogy. An exponential distribution predicts fewer superrich people than are found in most economies; but such departures have been found in the case of the sizes of rain drops and the convective cells as well, as we have seen above.

The analogy about inequality can be seen from another example from Meteorology. Water vapour condenses on nuclei of various sizes to form clouds. If all drops are equal in size there can be no rain. However since saturated vapour pressure over a drop depends on drop curvature, water from the smaller drops evaporates and is deposited on the bigger drops. *In effect the bigger ones devour the smaller ones.* When they can be no longer supported by the air they fall as rain. While coming down, the terminal velocity of bigger drops is greater than that of the smaller ones. Hence the bigger ones sweep up the smaller ones.

[The bigger drops have higher terminal velocity. But did not Galileo prove that falling bodies come down at the same time irrespective of mass and size? Yes, that is true in a vacuum and in air too for massive bodies. Because of air drag opposing the gravitational force a constant terminal velocity is reached in the case of a rain drop and that is lucky for us].

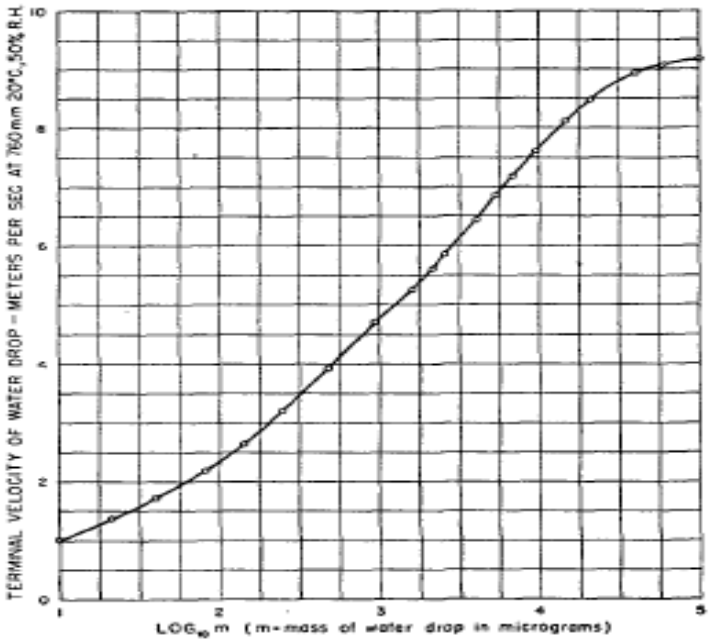


FIG. 2. Terminal velocity of distilled water droplets in stagnant air at 76 cm pressure, 20 degrees centigrade, and 50 per cent relative humidity, as function of the mass.

Terminal velocity vs Mass of water drops in the Laboratory - From Gunn and Kinzer (1949).

This process of big ones devouring the small is true in many fields and is called MATSYA-NYAYA, "the Law of the Fishes", which I have mentioned in my book,*Radar Meteorology* (2003). I came across this term in my Senior Cambridge History textbook in the context of bigger Kings of old who grabbed the kingdoms of smaller ones. This has a sociological angle in the sense of disadvantaged people being exploited by others. Rifkin and Howard, (1981) say "class division, exploitation, privilege are all determined by how a society's energy flow is set up". And this is true in biology too. Among baboons in the savannah there is a strict hierarchy and "pecking order" (Sapolsky 2004) and thus inequality is a characteristic of the animal world too.

Some have used the concept of Maxwell's demon as a metaphor for socio-economic inequality. If the demon can transfer more poor people into the chamber of the rich, inequality can be decreased! But in practice that would require resource inputs. Inequality has also been seen as necessary to provide incentives for entrepreneurship and progress. The analogy with Physics is that if you have an equilibrium state without temperature differences you cannot run a heat engine. In Meteorology also if an equilibrium state prevails there will be no weather. In the cloud growth example given above the stronger convective cloud develops a stratiform anvil thus "encroaching" over a larger area, leading to the departure from log-normal distribution.

These arguments foster the idea that *inequality is a natural law*and may be used by some to justify unfair treatment of the poor. The opposite view that Inequality leads to lower growth and less efficiency is also held by some leading economists (Stiglitz, 2012).

5. Socioeconomic benefits of Meteorology

There are other Physics analogies which can be cited. *But, of what relevance are these to Meteorologists?*

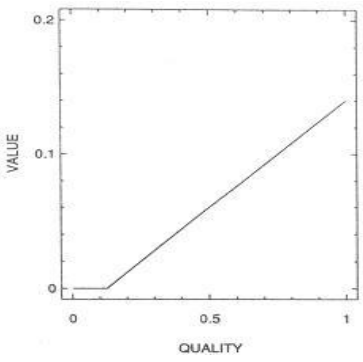
There was a time when Sciencewas supposed to be pursued purely as an effort to understand nature. However scientific research is increasingly viewed in terms of its benefit to Society. Indeed most scientific activities are funded by governments and therefore there is a need to justify the expenditure. [There is an anecdote that when Michael Faraday discovered electromagnetic induction, the then British Prime Minister asked him "Of what use is all this, Mr. Faraday?". Faraday replied "I am sure that one day you will be able to tax it"]. In Meteorology in particular, the socio-economic impact of meteorological information (data and forecasts) is of great importance. The benefits to society from meteorological information can be listed as (Raghavan 2007),

(i) Mitigation of loss of life and property due to severe weather,
(ii) Mitigation of adverse effects of human activities,
(iii) Economic benefits due to application of meteorological information for improving operations e.g. in agriculture, aviation, defence, health, industry, energy, transport, water resources management.
(iv)Social awareness, and psychologicalimpact (e.g. build-up of confidence)
(v) Establishment of knowledge base, data base and trained human power,
(vi)Development of new concepts and techniques,
(vii) Prospective export of products and techniques

The World Meteorological Organization (WMO) has been organizing events and publications relating to socio-economic issues dating back to the 1960s. Major international conferences on Economic and Social Benefits of Meteorological and Hydrological Services were held in 1990,1994 and 2007. Prior to the first of these conferences a questionnaire (drafted by me) was sent to WMO Member-countries to ascertain the status of awareness and action taken by them in this regard. Several studies have been made in some countries on this topic (e.g. Katz and Murphy, 1997; Anaman et al, 1998; Bedritsky and Khandozko, 2001, Buizza R., 2001, Cornford, 1996, 1997, Frei 2009,von Gruenigen et al., 2014,Met. Office 2007). These have analysed the positive benefits in economic terms of meteorological information in

various sectors of human activity as well as savings in losses in the context of extreme weather events.

In India there has been traditionally only a forecast verification by comparison to actual weather. But this only attempts to judge the accuracy of the forecast. The forecast,however accurate, may not have a **value**. Information can be accurate but useless. Let us say, aballoonist has a problem with his balloon and comes down in a field. This was before the advent of the Global Positioning System.He does not know where he is. He asks a passerby "Where am I"? The latter replies "You are in a balloon". 100% correct answer but of no use.



Curve in Figure is the relation between the two in a "static" case i.e. for a single event not influenced by previous ones. The value is zerotill a threshold level of quality is reached and later it increaseswith quality. In reality a "dynamic" situationexists i.e. the relation is linked to previous events and the curve usually has increasing slope.

- (Figure from Katz and Murphy, 1997)

Similarly if you forecast fair weather day after day in, say, October in Delhi, the forecast would be correct but of no value. Only when a western disturbance comes along and changes the scenario, the forecast, if correct, will have great value.
In the case of forecasts QUALITY isdefined as the degree of correspondence between the forecast and the actual weather experienced. The economic VALUEof meteorological information is defined as the saving or benefit the user gets from applying the information (data or forecasts).

The information produces a benefit only if it *reaches the users in time, is assimilated by them and they act upon it.*If the action saves lives or contributes to well-being it has a great social value. If it saves the user money, the information will result in an economic value. The value may be different for different people.For instance in aviation wind forecasts have been used for fuel-saving by re-routing aircraft (Anaman et al., 1998; von Gruenigen et al., 2014).In the energy sector wind power companies can regulate operations using wind forecasts (http://www.rap.ucar.edu/wsap/themes/renew_energy.php) and farmers and water resource managers have made significant gains from weather forecasts (NCMRWF 1999). Air pollution is a field where a proper understanding of meteorology can help solve many problems.

The India Meteorological Department did realise the need for outreach to users of its cyclone warnings and set up, around 1969, Disaster Mitigation Committees in coastal states to organise preparatory and relief action around 1969[5].

To my knowledge, the first quantitative assessment of the benefits of meteorological information in India was carried out by the National Centre for Medium Range Weather Forecasting (NCMRWF, 1999) in respect of Agrometeorological Advisory Services. There have also been specific case studies by some Agricultural Universities and other organisations (e.g. COLA/CARE Reports 1 to 6 by Sikka and Kulshrestha). Around the year 2000 the Finance Ministry advised ISRO to make a cost-benefit study of the Indian Space Programme. A "Techno-Economic Analysis" was carried out by the Madras School of Economics. The part relating to Meteorology was done by me after consultations with several organisations and individuals and covered various applications such as agriculture, aviation, tropical cyclones, floods etc. (Raghavan, 2007). Note that this was a "techno-economic" analysis and did not quantify intangible social benefits.

An expression for the Effectiveness **E** of disseminated meteorological information was formulated as the product of three factors **S, C,** and **R** (Raghavan, 1996, Raghavan and SenSarma, 2000)

$$\mathbf{E} = \mathbf{S} \times \mathbf{C} \times \mathbf{R}, \qquad (1)$$

Where**S** represents Science and Skill i.e. the contribution of the meteorologist,**C** represents Communication and is itself the sum of two parts, $\mathbf{C_1}$the timely and efficient dissemination of information *and*$\mathbf{C_2}$its INTERPRETATION and ASSIMILATION by the recipients, and **R** represents the RESPONSE i.e. the action taken by the recipients. In the case of extreme weather events this consists of action taken *before* the event (preparedness), *during* the event and *after* the event.

The factors $\mathbf{C_2}$**and R,**are critical in determiningthe Effectiveness**.** These depend on how the recipients **perceive** the implications of the information and how they **act**. Whether and how one acts on the information one receives depends on one's **perception** of what that information means to him/her. Perception of the recipient can differ vastly from what the sender intended to convey. Apart from distortions in translation or media-reporting, data or messages can be interpreted in surprisingly different ways. Dismissing these perceptions as wrong will not serve any purpose.

[5]In 1972 we set up a new radar at Chennai which tracked a cyclone for a long period for the first time in India The result was an accurate forecast saving many lives and much property. That was when I realised that I was serving the Society.

Unless we understand and tackle these perceptions we cannot maximise the effectiveness of the information we put out.

In a recent study (Budescu*et al.* 2014), 10,000 adults across 25 countries gave their numerical interpretation of probability terms (*very unlikely*, *unlikely*, *likely*, or *very likely*) used in Intergovernmental Panel on Climate Change (IPCC) statements. With only words, people interpreted unlikely events to be more likely than the IPCC intended, and vice versa. When the experimenters used both words and numerical ranges, however, the respondents estimated probabilities more accurately.

Another study (Shao et al., 2014) concludes that individuals' socio-demographic backgrounds and political orientations affect public perceptions of global warming. Another finding (Borick et al. 2014) is that actual weather conditions shape the process by which individuals arrive at their conclusions regarding the existence of global warming.

To give more extreme examples, a recent study in the USA found that a hurricane with a female name is associated in the public mind as more destructive than one with a male name! Or again there was a report some time back that salt producers in Toothukudi find BBC weather forecasts more useful than IMD forecasts. I found that BBC forecasts for this area were no better than IMD forecasts in accuracy. But BBC weather *presentations* are more professional, have good graphics and seem to make an impression.

The Long Range Forecast of the Monsoon by IMD influences the stock market and is often used or misused in the economic sphere.

Some years ago some farmers in southern Maharashtra had apprehensions that the wind mills were "driving away the clouds" and causing drought. Some political parties blew it up for their own ends. A committee headed by the Director of Indian Institute of Tropical Meteorology (IITM), Pune found no evidence for this. In fact that region experienced heavy rains subsequently for a few consecutive years (M. Rajeevan, personal communication). A US study (Baidya Roy et. al. 2004) found later that wind farms do have effects on the *local* circulation. The authors were immediately branded as lobbyists for the petroleum industry!

There are also issues such as people occupying vulnerable areas or being reluctant to leave a storm-threatened area because of socio-economic compulsions. There are also meteorological expectations based on traditional experience (folklore) or even astrology. The former needs to be investigated.

Efforts to improve the effectiveness and value of meteorological information have therefore to be **inter-disciplinary** involving not only Meteorologists and those from allied scientific and technical disciplines but also Social Scientists. Bringing in their Physics and Meteorology background, Meteorologists should be able to contribute more effectively to Society by such interaction.

Social sciences, include but are not limited to, anthropology, communication science, economics, geography, political science, psychology, and sociology (American Meteorological Society, 2013).Recognising this the American Meteorological Society started a separate (quarterly) Journal called "*Weather, Climate and Society*" five years ago.

Social Sciences come inhere, in two ways.

1. to understand how individuals and society interact with weather and climate. The term $\mathbf{C_2}$ in the above equation.
2. to develop and implement measures for maximising economic benefits and minimizing losses while involving people in decision-making. These will also involve preparedness plans which may include engineering, social, political, economic, regulatory and legal measures. This is part of **R** in the equation.

I had studied the Impact of cyclones hitting Andhra Pradesh over a period of 30 years (Raghavan and Rajesh, 2003). The damage figures in monetary terms were increasing over the years. But when normalised to take account of economic and demographic factors (i.e. inflation, increase in population and increase in economic activity in the area concerned (See Table). the trend of increasing impact largely disappears.

NORMALISATION (TO YEAR 1990-91) OF CYCLONE DAMAGE FOR INFLATION, GROWTH IN PER CAPITA INCOME AND [illegible]			
S. No	Cyclone	Damage Rs crore E	Normalised Damage Rscrore C
1	Nov. 19, 1977	172	1040
2	May 12, 1979	243	1203
3	Nov. 14, 1984	155	397.7
4	Oct.-Nov. 1987 (3 weak cyclones)	126	224.3
5	Nov. 8, 1989	41	50.1
6	May 9, 1990	2137	2137
7	Nov. 6, 1996	6129	2618
8	Nov. 15, 1998	306	99.4
9	*2001-2002 (Hypothetical Cyclone)*	*10009*	*2137*

Similar results were found in the USA and in Latin America (PielkeandLandsea, 1998, Pielke et al., 2003). That the increasing Impact is due to socio-economic factors and not due to increase in frequency or intensity of cyclones is now generally accepted [e.g. Association of British Insurers (ABI), 2005]. This is also recognised by a recent Report of the National Research Council (2014) of the USA on reducing coastal risks.

Similar conclusions were arrived at in the USA about floods (Pielke and Downton, 2000). In India no such comprehensive study is available but the 2013 Uttarakhand flood, the 2005 floods in Mumbai and Tamil Nadu and the landslide near Pune in July 2014 show that the impact is largely human-made and not due to any unprecedented meteorological event. Droughts are also often human-made.

When we speak of economic activity it includes unwise land use such as destruction of vegetation (coastal wetlands, forests), indiscriminate construction blocking natural water flow, excessive depletion of ground water, destruction of water storagesand occupation of vulnerable areas.

The social impact of such events are more on the poor, and on less developed countries although I have not seen any systematic study of income vs impact.

Hence the behaviour of people (or organisations or governments) is the important and often unpredictable factor involved. For example, the IPCC (2014) visualises various scenarios of socio-economic activity while assessing the impact of climate change. It says *"Future risks related to climate change varysubstantially across plausible alternative development pathways, and the relative importance of development and climate change varies by sector, region, and time period (high confidence). Scenarios are useful tools for characterizing possible future socioeconomic pathways, climate change and its risks, and policy implications".* Thus, while the IPCC may be able to assess the effect of a given level of CO_2 it is more difficult to estimate the level of CO_2 which will occur in a given year such as 2050 or 2100 because that depends on socio-economic behaviour which is difficult to predict (In any case such prediction cannot be verified!).

This is true of not just meteorology but many other scientific and technical fields. For example, Sovacool (2014) has pointed out that most of the research and funding in the energy sector is focused on *technology* of energy production, transmission and distribution systems, but very little research is devoted to sociological aspects such as energy behaviour and demand, energy saving behaviour, the perceptions of energy users, the needs of people affected by energy production and prevailing customs, traditions and behaviours.

Economists and Meteorologists are the only people who try regularly to predict the future (apart from Astrologers). But though the USA has most of the Nobel Laureates in Economics, they failed to predict the recession in 2008. After the event they wrote a lot about it. Meteorologists have done better apparently because Economics is based on human behaviour while Meteorology is based on natural laws. Meteorological prediction however has limitations. See Reeves R.W., 2014, "Edward Lorenz revisiting the limits of predictability and their implications:an interview from 2007", *Bull. Amer. Meteor. Soc*., 95, 681-687.

Economic theory assumes that people will do whatever they see to be in their best interest. This is how various financial or investment schemes are framed. But people often do not do what is in their best interest or even what they know to be in their best interest. The same is true of most sociological matters. Moreover the interests of different sections of society are different. Action taken by individuals or governments may aggravate the impact of a meteorological event for others. Problems

created by human actions are often (deliberately) branded as due to climate change or "act of god" or something else beyond our control.

6. Conclusions

Therefore **inter-disciplinary studies** on how meteorological information should be disseminated and how it will be applied by the people and how they can be persuaded to avoid negative actions, derive maximum benefits from the information and adapt to a future scenario are essential. It is also necessary to reach out to administrators, politicians, media and the public to make them appreciate the issues involved.

This is a narrow view. The interaction of Physics and Meteorology with the Social Sciences is a much wider subject meriting further study.

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Northeast Monsoon 2014

By
S.R. Ramanan[6]

After a good phase of monsoon lasting eight years from 2004-2011, the sub division of Tamilnadu / Puducherry witnessed dismal performance during 2012 & 2013. NE monsoon percentage rainfall departure figures for 2012 and 2013 remained 16 and 33 percent respectively. The subdivision experiences either normal /excess monsoon during El-Niño years. The prospects of a slight warming raised the expectations of a better northeast monsoon during 2014. This expectation was buttressed with favourable seasonal forecasts from various agencies.

The normal date for the onset of easterlies is 14 October. During 2013, VSCS "Phailin" formed prior to the onset of easterlies. Like last year prospects for formation of cyclonic storm was present from 06 October. Under the influence of an upper-air cyclonic circulation a low pressure area formed over Tenasserim coast and adjoining North Andaman Sea on October 6 and intensified into a cyclonic storm which was named Hudhud. Hudhud intensified into a cyclonic storm on October 8 and as a Severe Cyclonic Storm on October 9. Hudhud underwent rapid intensification in the following days and was classified as a Very Severe Cyclonic Storm. Shortly before landfall near Visakhapatnam, Andhra Pradesh, on October 12, Hudhud reached its peak strength with wind speeds of about 100 Knots and a minimum central pressure of 950 hPa. The system then drifted northwards towards Uttar Pradesh, causing widespread rains over that region. This system did not delay the commencement of norteast monsoon rains. On 16 October a trough of low-pressure formed in the south Andaman Sea and it was expected to herald the north east monsoon. On 17 October south west monsoon withdrew from Telengana and North interior Karnataka. The trough moved to south west bay off Tamilnadu -Srilanka coast on 18 October. South west monsoon withdrew from the region and the country and north east monsoon rains commenced over Tamilnadu, Kerala and in the adjoining areas of south interior Karnataka, Rayalaseema and coastal Andhra Pradesh on 18 October. The normal commencement day of the north east monsoon is 20 October.

During last monsoon Bay of Bengal was active with many cyclones and the sub division of Tamilnadu/Puducherry ended with deficit figure. The percentage departure was thirty three on the negative side. During the year 2005, many trough of low pressure systems came in succession and gave very good rain to Tamilnadu. Infact Tamilnadu ended with a figure of seventy nine percent departure on the positive side.

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So it can be inferred that troughs of low pressure coming in succession would generate more rain over peninsular India.

An east west oriented dumb bell shaped pressure field is the hall mark of northeast monsoon. Under the influence of an upper circulation a trough of low pressure formed and it was extending from Lakshadweep area to east central Arabian Sea on 18 October. This resulted in the formation of a dumb bell shaped pressure field and good monsoon activity could be witnessed in Tamilnadu and Kerala right from the commencement of North east monsoon rains from 18 October to 28 October.

The trough of low pressure became a low pressure area on 21 October off Lakshadweep area and adjoining east central area and later became more marked. It further concentrated in to a depression and intensified in to a deep depression on 26 October. It ultimately became cyclonic storm "Nilofar" later. Whenever a system forms in Arabian Sea, it draws the moisture from bay across Tamilnadu, Rayalseema and interior Karnataka. This is the time, when interior areas of Tamilnadu use to get the rain. The Arabian Sea system led to the vigorous/active rainfall in south interior Karnataka from 25 to 28 October and during 26 & 28 in Rayalaseema.

South coastal Andhra Pradesh would receive rain only if the trough extends up to west central bay and northern most coastal districts of Tamilnadu also receive rain only in that situation. Interior districts receive more rains only if the trough moves across the state. This year one peculiar aspect is during November and December, systems were moving in low latitudes. The systems could be located in equatorial Indian Ocean and the adjoining bay. The trough extending from these systems gave good rainfall to delta districts of Tamilnadu and south coastal Tamilnadu.

As already stated, the dumb bell shaped pressure field with trough in the bay and cyclonic disturbance in Arabian Sea after the commencement of the north east monsoon resulted good rainfall activity during the second fortnight of October in the Tamilnadu/Puducherry and Kerala subdivision. The week ending 22/10/2014 & 29/10/2014 saw the former getting weekly departures of 125 & 78 percent and the latter recording 60 & 48 percent respectively.

The Cyclonic disturbance in Arabian Sea during last week of October drew moisture from bay across peninsula and it resulted in good activity in the subdivisions of South Interior Karnataka and Rayalaseema and Coastal Andhra Pradesh. So in practical terms the best rainfall activity was confined to month of October. The subdivisions of coastal Andhra Pradesh, Rayalaseema and South Interior Karnataka

recorded positive departures from LPA for the week ending 29/10/2014 and the figures were 42, 178 and 156 percent respectively.

During November and December on most of the occasions Systems were traversing in low latitudes (equatorial Indian Ocean and adjoining bay) and the trough extending from the systems benefitted mainly the southern coastal districts of Tamilnadu. The districts of Ramanathapuram, Tirunelveli and Thoothukudi recorded excess rainfall. They have recorded seasonal percentage departures of 24, 81 and 37 percent respectively.

Last year Coastal Andhra Pradesh recorded excess due many systems entered that subdivision. This year the low latitude systems never had the trough extending up to west central bay. Hence this sub division recorded deficit figures.

During November and December, troughs seldom traversed through the peninsula. Hence Rayalaseema recorded deficit rainfall. Though rainfall for South Interior Karnataka remained normal figures they were on negative side. Kerala After a good performance during October, had subdued activity during November and December. In short the sub divisions of Tamilnadu/Puducherry and Kerala had a relatively dismal performance during November and December. The rainfall was coming in trickles and ultimately these two sub divisions slowly inched towards normal.

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Technological Revolution in Weather Information at sea A Mariner's Perspective

By
Captain S. Nandakumar[7]

Weather affects all aspects of life on land as well as at sea. But surprisingly knowledge and awareness of Climate and Weather among common people does not seem to be a priority especially so among the people of Tropical countries when compared to people in countries of Middle and Higher latitudes.This is probably because the Weather is perhaps rather monotonous in Tropical regions but for some slight variations only or he has more than a fleeting interest in the case of a Depression,Cyclone or Tropical storm developing in their area of habitat which could be a threat to his/her well being! Awareness of even the simple semi-diurnal pattern of air movements by way of Land and Sea breezes is also absent leave alone knowledge of Monsoons or El Nino or La Nina! To explain briefly the difference between Climate and Weather a well known adage goes "Climate is what you expect and weather is what you get "!

To put it briefly the Weather in Tropical regions is rather simple dependent practically if not mainly on two air masses only viz. Continental-Tropical and Maritime-Tropical (hence not much of fun?) whereas weather in Middle or Higher latitudes is complicated and dependent on various kinds of air masses viz. Arctic and Maritime or Continental Polar forming complex frontal systems consisting of Warm and Cold air masses (hence lot of fun?).

We Mariners get to experience all kinds of weather in a single voyage duration of even 15 to 20 days only! The worst as well as the best of weathers in such a short span of time! So it is important for us to understand the vagaries of the weather and climatology to make optimum utilization of prevailing conditions for operational economy; our life depends on how the Captain handles the ship in the prevailing conditions.

Previously there was no substitute for Meteorological surface observations received from Voluntary Observing Ships. Officers on board diligently used to observe weather around their ships and transmit Weather observations at Synoptic hours to Coast Radio Stations (CRS) using Morse codes.These CRS in turn would relay such reports to designated Meteorological Observation collection stations who collate information received from ships and other sources,prepare Surface Analysis

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and Prognosis charts for a wider area for ships to receive them by Facsimile. This then would be put to effective use for preparing appropriate routing and passage plans.

The art of observing weather at sea is slowly dwindling as Technological advances like Meteorological satellites,Ocean Data Acquisition buoys,Satellite and high-speed communications using fibre optics and Internet are now making valuable contribution to global Weather and Climate observing systems updating Data bases real time thus obviating the need for ships to make and send observations. Nevertheless Mariners benefit immensely from Weather data obtained from various sources or for free over the Internet.

Fig 1: Shipping operations

Fig 2: Anemometer

Fig 3: Mariner's Compass

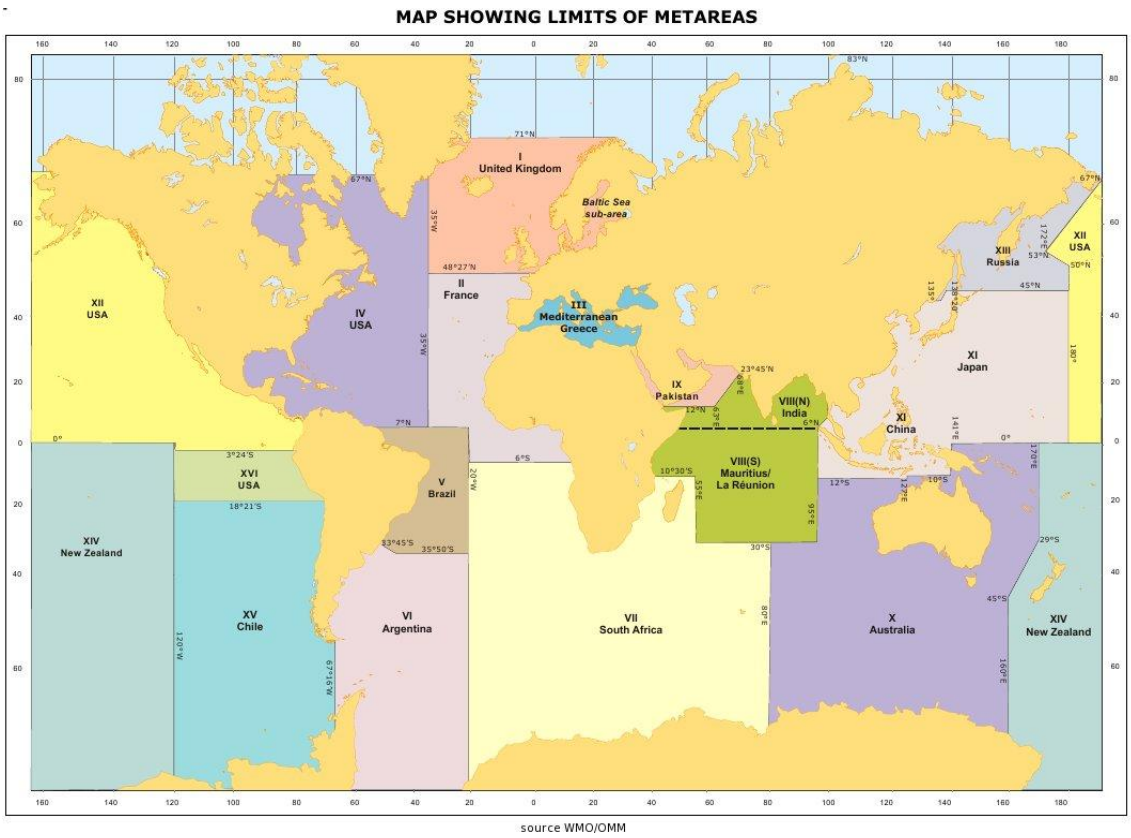

Fig 4: Map showing Meteorological Service Areas

The World Meteorological Organization (WMO) has established a global service for the transmission of high-seas weather warnings and routine weather bulletins, through the Enhanced Group Calling International SafetyNET Service a Satellite based communication system as part of METeorological service AREAS (METAREAS) within the World-Wide Navigational Warning Service (WWNWS). Each METAREA (Fig 4) has a designated National Meteorological Service responsible for issuing high seas weather warnings and bulletins. The designated authorities are not necessarily in the same country as the NAVAREA co-ordinators.

Most ships nowadays are routed by Meteorological Service providers (Weather News International, Applied Weather Technology, Fleet wood to name a few) who collate/analyse information on real time basis obtained from data bases of Meteorological departments worldwide and Forecast/Predict weather for next several days; they carry out something called Numerical Forecasting by applying mathematical equations expressing the basic physical laws governing the motion of the atmosphere and send us accurate predictions and recommend optimum routes.They even monitor our Passage on a daily basis and provide Performance analysis at the end of the voyage for Owners/Charterers of ships.

Going a step further some Shipowners or Management companies or Charterers have introduced-on board-weather information and Route optimisation systems which makes it possible for them to take full advantage of detailed on board weather information and route optimisation utilities (software).When calculating routes,predicted weather and the performance of ships at sea are accounted for.

Fig 5: On board-weather information and Route optimisation system

The benefits of such software are :
- minimising operational costs by eliminating expensive meteorologists
- avoid or foresee operational delays
- reduction in encountering adverse weather, in voyage times on ocean crossings and in risk of damage to ship & cargo
- automatic daily (email) reports on voyage performance and backup information for disputes and claims
- world-wide meteorological support without the weather facsimile with reliable high quality charts which are easy to use and low budget application

Awesome technological revolution this in Marine Meteorology!

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Automation of Radiation Tabulation at RS/RW Observatory, Minicoy

By
AshwinRaju D K[8]

Crystal blue water, Unadulterated air, amazing Sunset, pacifying nature, innocent people…….what more?. Yes, I am talking about the beautiful southernmost atoll of the archipelago of Lakshadweep, the Minicoy. It is quite different from other islands of Lakshadweep. In fact, the culture here is similar to Maldives. Mahal is the local language. Minicoy is known as Maliku in Mahal. The ancient name of Minicoy was Mahiladu meaning women's island and it is a female-dominant island till date.

In the center of the island one can find an old building, may be of British Raj, our own RS/RW Observatory. When I came to Minicoy wearing Basic formals and Woodland shoes to join as a new recruit, on being posted to this office, only one question echoed throughout 360 degrees around my mind by the sight of the office and its ambience..…. "Is this the office where I am going to work?!!!" It is common thoughtfor a person who had been in Minicoy and who has seen the offices of the Regional Meteorological Centre (RMC) and Airport Meteorological Office (AMO) atChennai. But this feeling disappeared after a few days. The island and its breeze here have such an impact. Trust me….if we are tense for some reason, normally, we go to seashore and stand there for half an hour. The breeze sure makes a difference and we return relaxed and fresh.

The RS/RW Minicoy has 6 units viz., PBO/Surface, RS/RW, Seismology, Air Pollution, AWS and the Radiation units. Among all the units, the Radiation unit was the one which I shuddered the most and the reason is quite simple, "One and Half hours of manual computation works".

By seeing the workload I never asked anyone about what they do in that section until one day my colleague (new recruit) was posted in there.(*If I know what they are doing, then I may have to work there right. That is why I never asked*). As I stepped in to the section my friend was sitting there at that moment and I knew he would not put me in trouble. What I came to know was that, they were doing hourly computations of Global, Diffuse, UV-A and Terrestrial radiation data manually. Actually they were doing 1296 arithmetic operations daily for tabulation. The first thing I asked my friend was "why can't we do it in computer? This casual talk was the basis of the development of an automation software.

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In Minicoy, there is a non-working Automatic Radiation Station (ARS)with Astra datalogger. The problem with the ARS was, recorded values were all wrong when connected to a satellite-based transmitter. Technically, this may be due to the "Loading Effect". And thus started nearly half a decade old history of manual computation in front of sophisticated Sutrondatalogger*(Sutron data logger was supplied as an alternative).*

We could get data from the data logger through PCMCIA card. But, how to read the data from the card? We require a PCMCIA card reader which was not available there. I was somewhat afraid about the logger at that time because I wasnot yet trained. I did not have any idea of this logger. Hence I could not proceed further at that moment. Believe me or not….within a week or two, I got the news of AWS Training at Pune and Minicoy has one AWS unit which sometimes gets the problem of data inaccuracy mainly due to the corrosion. I had not yet got IMTC Training and wished to undergo at least one training quickly. The then Officer in-Charge (Acting) Shri. KRSreedharan Nair suggested my name for AWS Training.

These 5 days of AWS Training at AWS Lab, Pune was the turning point. Because I could understand what data loggersare, how many makes of different manufacturers are used by IMD, what their features were etc. Back to my station, I was confident about the loggers and drafted a letter along with the Officer in-Charge Shri. Yadukulesha S., regarding a plan to computerise the tabulation work and sent to RMC Chennai.

Meanwhile the 3rd batch of IMTC was about to commence and my name was in that list. So, I proceeded to Chennai for undergoing training. Hence four month hiatus happened in the further development of software. In RMC Chennai, I came in contact with Miss. Amudha B Scientist D, Officer-in-charge of the network of Automatic Weather Stations(AWS)and Rain Gauge Stations under RMC Chennai, who is conversant with the technical issues of Sutron AWS. She was one of our teachers in the training programme and taught us about AWS and radiation instrumentation. When I sought for an alternate, easier method of retrieving data from the logger, she said that PCMCIA card and its card reader were needed to download the data from the radiation data logger. Since PCMCIA is an outdated technology now, the card readers were not available in the market, including in USA. The next generation of Sutron data loggers now have USB and MicroSD facilities. And then, she assured that an alternative solution would be provided before I leave for Minicoy again.

During the end of training, Amudha Madam suggested the use of an RS-232 cable with the XTerm software of Sutron logger as the only solution left for retrieving the data from the data logger. Although we have been trained in AWS Pune about XTerm, I wished an isolated solution like PCMCIA card in which datalogger and the computer can be completelyindependent from each other. But at that point of time, RS-232 cable as interface seemed to be the only solution left out, though it left me thinking of other possibilities.

Radiation Lab, Pune uses a software for tabulation. The software is customizable and has been supplied to all the radiation stations. The problem with the software with reference to Minicoy was data incompatibility. The software uses formatted data which is readily available in the web site *(www.imdaws.com)* where the link to radiation data was available. Since Minicoy had the facility of only logging the data with no facility for automatic transmission to the central server *(transfer of data was through SIM card technology, which many other radiation stations in the mainland have)*, our data is not available in the web site. But we have only raw-data. The raw data is actually unformatted one and has many junk values *(default values)* for the sensors which have not been installed. So we could not use the raw data directly.

Initially, I thought of formatting the raw data using Microsoft Excel. But, it required a lot of procedures. I felt that I may be able to do it but in my absence at the station this mayturn out to be a big problem for others. (Because earlier when I forgot to write an user manual, colleagues in the station while trying to use excel based autographic chart entry found it difficult to take print-out, as they were new to the software and they rolled back to the traditional paper work. It took great effort to convince and reintroduce excel based data entry in Minicoy.) So I thought, if I write a program which does all the formatting in a click of a button, it would facilitate others without my manual presence. Thus was sown the seed and I wrote a Java program called **"Radiation Data Formatter"** to convert the raw data into the required format and the effort proved successful.

Now we are able generate the monthly tabulation of Radiation data within five minutes. In fact, we can generate the tabulation for 6 months within 15 minutes. The main advantage of the **"Radiation Data Formatter"** is its ability for customization. It can be customized to any Radiation station and can be used for formatting of data obtained directly from the logger in case of failure of the ARS.

This whole thing would not have been completed without the co-operation of Mrs. Swati Bhagwat AM-II, Radiation Lab, Pune who supplied the tabulation

software and Miss. Amudha B Scientist-D, RMC Chennai for her words of encouragement.

There are some areas in IMD where we, the younger generation, can contribute significantly like satellite image processing, Radar, data encryption before transmission through third party networks (if not done earlier), improving the existing NWP models etc. If we get the right exposure and training, we would definitely contribute. As "Engaging Youth" is this year's (2014) theme of World Meteorological Day celebrated on 23rd March, I wish IMD engages us the most.

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Bad weather and aircraft accidents

By
K.V. Balasubramanian[9]

Introduction

Weather plays an important role in the field of aviation. Inclement weather is attributed as a cause of many aircraft accidents. Hence it is of great significance to identify and clarify the circumstances and causes of any aircraft accident which will help avoid similar accidents in the future. Even in our country besides attribution of various aircraft accidents to avionic causes, bad weather is one important prime cause for accidents of many aircraft and helicopters. Aircraft accidents occur due to various weather types, e.g. low visibility, presence of low clouds, wind shear, squalls, etc. Let us see how efficient use of newly available technology in meteorological services may help mitigate accidents to some extent.

During 2000–2012, two major aircraft accidents occurred in India. On 27 July 2000 the 'Alliance Air flight CD-7412'crashed at Patna airport, killing 60 passengers and on 22 May 2010, 'Air India Express Flight 812' crashed at Mangalore (Bajpe) airport, killing 158 passengers. In the above mentioned accidents weather was not the cause of the accident. There have been a number of other aircraft accidents/incidents from the non-scheduled category in India. These are either civil or defense aircraft mostly operated as non-scheduled for a specific purpose, and are smaller private aircraft and helicopters. Aircraft accidents have been reported from the North Eastern hills, Western Himalayan hills, north Indian region and the Eastern Ghats. At least 66 persons have been killed in air crashes in the North East during the past one decade. Of the 66 killed, at least 47 were in Arunachal Pradesh alone during the past ten years. The aircraft accident which occurred on 25 May 2011 near Delhi shows a case of aircraft accident over the plains, where visual flight navigation remains a challenge. During investigation of all of these aircraft accidents, attribution was made to avionic causes and bad weather. Hence weather is an important factor for safe operation of aircraft and helicopters over India.

Various studies that have been undertaken outside India show how weather is regarded as one of the main causes of aircraft accidents and incidents. Among different weather hazards, thunderstorms, microburst, mountain wave turbulence, clear air turbulence (CAT), wind shear, poor visibility and fog are the major causes of aircraft accidents and incidents. R.K. Jenamani and Ashokumar (Current Science, Vol.

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104, No. 3, 10 February 2013) have collected data on various aircraft accidents as available in annual Aircraft Accident Reports (1992–2008) published by the Director General Civil Aviation (DGCA). These data have been used by them to find year-wise variation of total number of aircraft accidents followed by number of weather related and nonweather related aircraft accidents. They have calculated the percentages of total aircraft accidents related to bad weather. They have further studied it based on aircraft operation types, e.g. airlines operation, training and private event.

Effect of various weather events on safe flight operation

Weather plays a dominant role at each stage of aircraft operation covering taxing stage at the runway, take-off stage at that airport, cruising stage in the skies, etc. including the landing stage at its destination airport. Among major weather events which affect aviation, convective weather such as thunderstorm (TS) with severe turbulence, intense updrafts and downdrafts, microburst, macro-burst, lightning, hail, heavy precipitation, icing, wind shear, strong low level winds, squalls, gusty winds and tornadoes have impacted flight operations the most. Low visibility and low level clouds are other major causes, especially for flights which operate in the Visual Flight Rule (VFR). Other weather conditions which are hazardous to aviation are Clear Air Turbulence (CAT), aircraft in-flight icing and ground de-icing conditions.

Federal Aviation Administration (FAA) in USA elaborately defines the role of various convective-related weather conditions for safe flight operations and safeguards, including dos and don'ts during such weather conditions. It states '***A thunderstorm packs just about every weather hazard known to aviation into one vicious bundle***', e.g. squall lines, tornadoes, turbulence, icing, hail, low visibility and ceiling, effect on altimeters, lightening and engine water ingestion. Among these, the effect on altimeter setting is most dangerous for an air- craft. Pressure usually falls rapidly with the approach of a thunderstorm and then rises sharply with the onset of the first gust and arrival of the cold downdraft and heavy rain, falling back to normal as the storm moves on. This cycle of pressure change may occur in 15 min. If the pilot does not receive a corrected altimeter setting, the altimeter may be more than 100 feet in error. With regard to ingestion of water during TS, turbine engines have a limit on the amount of water they can ingest. Updrafts are present in many thunderstorms, particularly those in the developing stages. If the updraft velocity in the thunderstorm approaches or exceeds the terminal velocity of the falling raindrops, high concentrations of water may occur. It is possible that these concentrations can be in excess of the quantity of water that turbine engines are designed to ingest. Therefore,

severe thunderstorms may contain areas of high water concentration which could result in flameout and/or structural failure of one or more engines.

The other important atmospheric event that severely affects aircraft operation is turbulence. It occurs at any stage during a flight, and causes a bumpy ride immediately, similar to a car on a rough road. This experience can be traumatizing and terrifying for some people and may develop into a phobia for flying. Turbulence is created by irregular and random air motion. It may be due to the result of different masses of air moving at different speeds and colliding with each other, or of the same air mass behaving in an irregular fashion (turbulent flow) as a result of certain other factors. Turbulence can shake any aircraft no matter how big it may be. It should be noted that aircraft turbulence occurs in cloudy atmosphere as much as it does in clear skies (atmosphere devoid of visible hydrometeors or water droplets). The latter case is often referred to as Clear Air Turbulence (CAT).

The International Civil Aviation Organization (ICAO) classifies turbulence as slight, severe and extreme. There are several kinds of turbulence caused by different kinds of weather pattern. They are:

i. *Turbulence from thermals*. Perhaps one of the most common forms of turbulence aircrafts experience is called thermal turbulence. This is the turbulence that aircrafts feel during the midday when they are flying near the surface during late winter season, summer and early south west monsoon season and is usually not protected by AIRMET Tango. The heating of the day causes convective thermals to rise, and pilots fly into these parcels of air which causes the planes to bump around. The turbulence is not typically caused by the rising thermals alone. It is the interaction between the thermals and the prevailing winds aloft that really make the bumps. These thermals act as obstructions to the normal air flow similar to mountainous terrain. The prevailing wind must deviate around the convective thermals resulting in turbulent eddies. These turbulent eddies are then carried downwind some distance before dissipating. The turbulent eddies are what we feel as bumps. Therefore, the intensity of the turbulence is related to the intensity of the thermals and the wind velocity. Light prevailing winds generally result in light thermal turbulence. Stronger prevailing winds mean that you should tighten your seat belt.
ii. *Turbulence from thunderstorms*. The cloud system responsible for thunderstorms is the Cumulonimbus (CB) clouds. From aircraft window it appears like a mountain of clouds. Thunder- storms can cause a myriad of problems. For instance, they can suck in air from the surrounding into the system (entrainment), or vertically from below the cloud base (updrafts) and discharge large bursts of wind downward (downdrafts or downbursts), all of which can create, from slight turbulence, when flying near them to

moderate, severe or even extreme turbulence when flying through their core and depending on how well developed they are.

iii. *Turbulence from wind shear.* This means a large change in wind speed and/or direction over a short distance. This can occur both in the horizontal and vertical directions. While considering horizontal flow, certain regions known as COL regions (between two lows and two highs) are typical wind shear zones and may create slight to moderate turbulence.

iv. Turbulence due to *Jet streams*. At the ground level warmer air from lower latitudes moves pole-ward and at some point a boundary is formed with colder air from the Polar Regions moves back to tropic. This triggers some dynamical forces that create strong currents (stream) of wind, sometimes speed reaching or even exceeding 400kmph, high above the ground. They usually move from west to east and are called jet in westerly. Winds progress in strength from the outer part until they reach a maximum at the middle or core. These wind changes over relatively short distances can cause slight to moderate turbulence for aircrafts. Although turbulence is an annoying part of flying, it is often an unavoidable part as well.

To increase air-safety, many attempts have been made by India Meteorological Department (IMD) to automate and integrate all the components of aviation weather services with ATC and pilot on-board the aircraft. These include all of its observing systems, e.g. current weather parameters of runway ends and airports, upper air wind flow, etc. and their now-casting and forecasting products updated by 3 hours in advance. Provision has also been made to send these data through on-line dissemination system to users in a user-friendly format, especially to pilots both during pre-flight planning and on-board through ATC or satellite communication or internet. Efforts are being made to make the observing systems to have capability to get a complete 3D scan of various weather events covering whole airport areas and along the flight routes. The presently available integrated aviation weather observing instruments at runways, cloud and wind scans by DWR and satellite, radiometer for vertical moisture contents, GPS sounding and upper air wind shear by Terminal DWR, lower level wind shear by anemometer array, wind conditions at flight path by Wind-Tracer, etc. if integrated with a robust forecasting system over the airport, will help in reducing the weather-related aircraft accidents.

IMD's activities towards modernization of the department can be seen more clearly in their document at http://www.imd.gov.in/doc/IMD_recent.pdf. However it should be mentioned that, pilots also should record the weather experienced by them and intimate the same to the Met Office concerned to help the Department issue better forecasts. Let us all strive for **accident/incident free air service** in our country.

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Mumbai Monsoon magic- My story

By

Shiva.kumar. S[10]

Mumbai mega city is famous for many wonderful things and in my opinion nothing can come close to the monsoon (SWM) magic which unfolds every year there. Life will be incomplete if one does not experience the monsoon magic of Mumbai at least once.

I would like to share the unforgettable Navi Mumbai Deluge of July 26, 2005 when I was a resident of Navi Mumbai then and also how Mumbai can fight back against all odds to overcome any grim situation and to have a wonderful and bountiful monsoon in its way.

26 July-2005 - Navi Mumbai

I was a resident of Navi Mumbai then and was working at Kalamboli area till 1.30 pm when out of nowhere, huge thunder and frightening lightning started and in no time it started raining. Normally you don't get to see and hear Lightning and thunder during mid monsoon period. One gets to see and hear those only during the time monsoon sets in over Mumbai (around June 8th) and the day it says Good bye to the season (around Sep 30). Even at that point I had plans to go to my office @ MahimWest and took a ST (State Transport) bus ticket to Dadar. Mid way between Nerul and Jui Nagar area, the rains started getting heavier and I decided to forego my office trip and got down at Jui Nagar Railway Station bus stop and took another bus towards Thane Belapur Road as I had to get down at Ghansoli area. What a sensible decision it was and probably the best one I have made thus far. It just poured with the same intensity right from the start till it ended at about 4 am I think..Fortunately, my area Cidco Colony in Ghansoli near MukambikaMandir is not a low lying area and many may not believe that there was no water stagnation at all in my locality and the surrounding area of my colony. The water canal separating MukambikaMandir and our colony was flooded and that was the only sign of heavy rain in that place. Power supply went off by 5 pm as the rains were in full fury by then. I was stuck at home since 2.30 pm and just ventured out to see the canal by around 5 pm. One had to experience the intensity and fury of the rainfall to believe it. It was mayhem to put it mildly. By 7pm when it was still pouring without any let up in the intensity levels and

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that is where I started fearing the worst as news about rains devastating other low lying areas of Mumbai started trickling in. No facebook, whatsapp and other channels of communication then, Phone lines were dead by 6pm. Nothing could be heard or seen as there was a expected power cut from 5 pm on wards..After a candle light dinner by 9.30 pm (courtesy Power cut) I had to hit the bed as nothing was left to do as it was pitch dark inside and outside..Fewpoint of lights were seen here and there. Got up in the middle of the night (2 am) to find out the same pounding the area was taking. At that point of time I understood how nature can dictate terms to the humanity. When I woke up at about 7am, it was pin drop silence everywhere as the rains had relented mercifully and people started to realize what really stuck them. People were forced to scramble for essential things first up in the morning and there was chaos in getting them.

Tail piece:The general forecast for the day was--Generally cloudy with few spells of scattered showers here and there. I came to know that few scattered spells amounted to about 90 to 100 cms in most part of Northern, North east, west Mumbai and North Suburbs. Colaba observatory recorded a mere 7 cms rain fall when areas not far away from the city recorded anything between 60 to 100 cms. One helluva day that was..

I have always loved Mumbai Monsoon and would eagerly wait for it to unfold during my tenure there.. This year 2014 was one of those rare years when SWM did not live up to its reputation to start with. I mean, Mumbai not getting any meaningful rains in the month of June as it happened in June 1995 where the quantum of rains recorded in both Colaba and Santa Cruz were well below 100 mm. The pace was so sluggish and much talked about El Nino event on the cards did put me in some sort of bother. Will monsoon fail this time around!? Lot of thoughts were lingering in my mind. How will Mumbai respond to a poor monsoon well below average? How will the city cope up with the drinking water needs? I was really apprehensive till June end this year. At the same time I always had this gut feeling that monsoon would makes its presence well and truly in the months of July and August.

Reflecting on how Colaba has covered the miserable June deficit in style.Honestly, this is nothing new when it comes to the city of Bombay to fight against all odds come what may. I have mentioned this before many times that I have hardly seen Bombay failing to get its average share irrespective of the conditions prevailing elsewhere.(at least during my tenure in that great city).Though it had a horrible June to start off, I was hopeful of the city making a comeback as July and August to some extent has always been the happening month compared to June and September..Had put a figure of 850 mm for Colaba in the July contest hoping it would

cover up lost ground as it has done several times before.Never I could fathom a figure of 1400mm or about for the month of July.The fighting spirit of this mega city is folklore now.This amazing city has again shown lot of character-tenacity to make a comeback be it any sphere of life.Weather(Rains), cricket, Violence (Bomb Blasts) you name it. The city will show its fighting spirit to make a comeback against all odds.I still remember the words I got to hear regularly,when I was new to this magical city in 1988 June. I was told "Man may fail, Machine may fail, Mantralaya (Secretariat) may fail, Met dept may fail.... Mumbai monsoon will never fail".

Now Irealise as to why they were so proud of the city's monsoon rains. I dearly miss Mumbai Monsoon Magic.

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Adapting to the rise

By

Saleem Khan. A.[11]

Climate change induced Sea Level Rise (SLR) is one of the greatest threats that humanity will face in the 21st century. Low lying coastal plain regions are more vulnerable to the impact of SLR. In addition, the effects of SLR on coasts are not uniform, but vary considerably from region to region and over a range of temporal scales. There is an increasing speculation that coastal cities and coastal natural resources may be threatened for their survival by inundation and coastal population may also find themselves trapped in a downward spiral of degradation in terms of their livelihood and life security.

However, the impacts of SLR have been assessed for many industrial nations, but much less are known about the potential effect on developing countries. Further, the regional and local implications of climate change induced SLR are vast and it is at this level that assessment of environmental change and society's response and adaptation to change are crucial. In particular, downscaling the projections of SLR at different scenarios, assessing the impact and vulnerability of the coastal system (both natural and social systems) to SLR and identifying appropriate coastal adaptation strategies to SLR, are the major focus areas of climate change induced SLR research, which are little explored, particularly in the developing countries like India.

India has a coastline of about 7500 km., of which about 5400 km. belong to the peninsular India and the rest to the Andaman, Nicobar and Lakshadweep islands. Tamil Nadu is one of the major states with the coastal length of 1076 km. along with valuable coastal ecosystems and one third of the population in the state depends upon the coastal resources for livelihood. Despite the ecological richness and the contribution to socio-economic activities, the coastal areas are under severe stress. Impact of climate change induced SLR poses one of the serious and major threats to the coasts of Tamil Nadu. Strengthening the resilience capacity of coastal systems and its dependent social communities to help them cope with this threat from climate change induced SLR calls for immediate action.

As an initiative for the first time in the country, the Centre for Climate Change and Adaptation Research (CCC & AR) at Anna University has estimated SLR projection for Bay of Bengal region of Tamil Nadu coast ranging from 0.19 m to a maximum of 0.73 m by the end of this century under different socio-economic scenario of IPCC AR4 (Inter governmental Panel of Climate Change – Assessment Report 4). The projections are primarily based on construction of multi-model ensemble with inputs from different Globl Circulation Models (GCMs). Pattern scaling principle has been employed to project SLR at local from global projection. This provides hands on information to policy planners and

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decision makers to plan time-based adaptation strategies to rising sea level. On the other hand, this type of information also urges to create awareness to build capacity at community level. CCC & AR is in the next phase of projecting SLR, based on IPCC AR5 for improved scientific understanding to meet uncertainties and also developing guidelines for informed decision making to frame anticipatory adaptation strategies to rising sea level.

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