Indian Meteorological Society, Chennai Chapter
Newsletter Vol.15, Issue No.1, June 2013

Contents

From the Chairman'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.14, Issue 2).

The Annual General Body (AGB) meeting of the chapter was held on 29th April 2013. It has been unanimously approved in the AGB meet that the present local council may continue their term upto March/April 2014, albeit the current term of the council was only upto March 2013, so that chapter elections could be held parallel to the elections of the National council which is likely to be held in March/April 2014.

The focus of the chapter's activities during the last six months has been the International Tropical Meteorology (INTROMET) Symposium on **Monsoons – Observations, Prediction and Simulation,** to be held during 27-30 August 2013 at SRM University, Kattankulathur (near Chennai) under the joint auspices of the Indian Meteorological Society and the SRM University. It is hoped that this mega event will be conducted in a grand manner.

A scientific lecture on "Aerosol forcings on the Radiation budget" was delivered by Dr. B.V. Krishnamurthy, visiting professor, SRM University on 21.06.2013. A gist of that lecture is included in the current issue of BREEZE for the benefit of the members who could not attend the lecture on 21st June. I hope that the material published in this issue will quench the scientific thirst of the readers.

As part of news from IMS Hq, action has been initiated for IMS National Awards for 2011-12.

With best regards
R. Suresh
Chairman, IMS Chennai Chapter, Chennai.
03.07.2013.

Membership details of IMS-Chennai Chapter (as on June 2013)
Life Members: 145; Ordinary Members: 4; Total : 149

Those who wish to become members of IMS, Chennai Chapter may please mail to
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ATMOSPHERIC AEROSOLS - IMPACT ON RADIATION BUDGET

by

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Atmospheric aerosols are liquid or solid particles suspended in air. The sizes of aerosols cover a wide range from 10^{-3} µm to 10^{2} µm. The atmospheric effects of aerosols depend upon the size range as listed below.

Atmospheric electricity …………….. ~ 10^{-3} µm
Cloud Physics…………………………~ 10^{-2} µm
Radiation ……………………………..~0.1 to 10 µm
Atmospheric chemistry ………………~ 0.1 to 10 µm.

In the present article the emphasis is on aerosols affecting the Earth-Atmosphere radiation budget.

Production and Loss Processes of Aerosols

1. Gas to particle conversion

Atmospheric trace gases (of natural and anthropogenic origin) can undergo chemical reactions to produce reaction products with low vapour pressures. As more and more of these products are formed, a state of super saturation will be reached with respect to these molecules. The degree of super saturation will determine the degree of nucleation /condensation. The nucleation/condensation processes are i) homogeneous homomolecular nucleation= involves formation of new ultra fine (in size) particles from a gas phase consisting of only a single species, ii) homogeneous heteromolecular nucleation-involves formation gas phase consisting of two or more species and iii) heterogeneous heteromolecular nucleation- involves condensation of gaseous species on preexisting nuclei. Thermodynamically the third process is the most efficient of the three as it does not involve formation of a new surface for condensation.

2. Mechanical processes

Soil erosion by wind causes small soil particles to become airborne. Another process is the breaking/bursting of air bubbles on oceans and these aerosols are called sea salt spray aerosols. These two are major contributors to the global aerosol production.

3. Condensation/Evaporation

Condensation of water vapour on aerosols (mainly hygroscopic) occurs when the relative Humidity (RH) is high and evaporation of water present (on aerosol) occurs at low RH.

4. Coagulation

This is caused by random movements (induced by Brownian motion) and subsequent collision and coalescence of small aerosol particles to form larger particles.

Condensation/Evaporation and coagulation are only size transforming processes and production of new particle is not involved.

5. Gravitational sedimentation

This is a loss process and is significant only for large particles (<20 µm).

6. Transport

This is a process which involves horizontal transport of aerosols by wind. By this process aerosols can be transported thousands of kms. Aerosols can also be transported by eddy diffusion mainly vertically.

7. Wet removal

This is the most significant loss process especially in the troposphere. Wet removal can be by rain out and wash out. In rain out, aerosol particles constitute the cloud nuclei and fall out as rain. In wash out rain drops sweep the aerosols on their way when falling.

Types of Aerosols

Sea salt aerosols - bursting of bubbles on ocean surface.

Non sea salt sulfate aerosols—gas to particle conversion of sulfur bearing gases= Di Methyl Supplied (from sea phytoplankton), SO2. H2S. DMS released by the sea phytoplankton gets oxidized and is converted to sulphate aerosols on condensation forming cloud condensation nuclei. The clouds reduce the ocean surface reaching solar radiation which in turn reduces the photosynthesis action of the phytoplankton and hence release of DMS. So a type of negative feedback system comes into play.

Nitrates- gas to particle conversion

Mineral dust- mixture of quartz and clay (from windblown dust).

Organic aerosols- gas to particle conversion of organics

Soot/black carbon- incomplete combustion of fossil fuels and biofuels.
Of these soot/Black Carbon (BC) is highly absorbing followed by mineral dust whereas sulphates/nitrates are mainly non absorbing and only scatter the incident radiation.

Anthropogenic aerosols constitute ~11% of the total average global aerosol burden whereas natural aerosols contribute ~89%. However regionally and episodically or in some periods anthropogenic component can be high, even more than the natural component. The tropospheric life times of aerosols are of the order of a few days 7-10 days. The short life times and a wide variety of sources (both natural and anthropogenic) make aerosols highly heterogeneous temporally and spatially.

Impact on Radiation Budget

The impact of aerosols on radiation is mainly in the short wave region. Aerosols affect the incoming solar radiation and the reflected radiation from the surface by scattering and absorption. The aerosol radiative forcing is defined as the difference between the solar flux without aerosols and with aerosols. As presence of scattering aerosols (sulphates) in the atmosphere increases the overall albedo due to their scattering, their presence will cause a reduction in the surface reaching radiation and hence cooling. On the other hand presence of Black Carbon aerosols in the atmosphere causes heating in the atmosphere while reducing the surfacing radiation and cooling the surface. Thus the presence of absorbing aerosols can induce temperature inversion (low level).

In the presence of a cloud in the atmosphere the effect of aerosols depends on the position of the aerosol layer with respect to that of the cloud. If the aerosol layer is situated below the cloud, it will be exposed to reduced solar radiation because of cloud albedo whereas if it is above the cloud, it will be exposed to cloud reflected radiation in addition to the direct solar radiation. So the effect of aerosol layer on radiation will be more if it is above the cloud than below.

From the Indian Ocean Experiment (INDOEX), it has been estimated that the aerosol radiative forcing regionally (over the Indian Ocean in January-February) is comparable to that due to the increased forcing of Greenhouse Gases from Pre Industrial time to 1999. It is significant on annual mean global basis too.

Thus, it is necessary to carry out aerosol observation at different locations in order to be able to assess their impact on radiation in a realistic manner. Keeping this in mind, the Indian Space Research Organization has started a nationwide project on Aerosol Radiative Forcing over India (ARFI). As a part of this programme, regular observations of Black Carbon concentration and Aerosol Optical Depth are being carried out at the SRM University Campus at Kattankulathoor, Chennai since March 2010 to study and establish the aerosol characteristics over the Chennai region.

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CLIMATE CHANGE RELATED HAZARDS AND VULNERABILITY ASSESSMENT IN THE COASTAL ECOSYSTEMS IN INDIA

by

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Indicators of coastal vulnerabilities

Coastal planning and management are constrained largely by a lack of information, data and analysis about the interaction between development activities and the coastal environment. Development activities are agents of change. Development status and disaster risk are closely linked. Disasters triggered by natural hazards put developmental gains at risk. The extent of impact of these activities at the ecosystem level will depend on the kind of pressure imposed and the extant health of the ecosystem. Knowledge relating to the health of such systems and the kind of development stressor active will enable more careful planning of development activities. This article reports on a framework of indicators of potential vulnerability developed at the socio-economic and ecosystem level for coastal India. Such an assessment can help improve future coastal management through targeted interventions aimed at stressors and stressed systems.

The concern with coastal vulnerability is really a concern for the negative outcomes that may result from the combination of development pressures and stressed ecosystems. Stressed ecosystems will in turn, impinge on the socio-economic and health status of people residing or dependent on the coast India does not have a specific coastal focus for its development policies. There is an attempt to provide a coastal focus through the use of coastal zoning in order to spatially separate incompatible uses and protect fragile ecosystems. It has on the one hand, policies and plans for sectoral development and on the other, environmental policies and legislation to protect the environment from such development. Some of these are incompatible. So coastal development takes place with no or little management. There is today an attempt at introducing a notion of integrated coastal management, but the meaning of integration is still unclear. There is an urgent need for integrated coastal management in the Indian context with the new development push that globalization forces have created. After 1991, a set of processes was set in motion by which production and consumption activities gradually shifted from the local or national scale to the global.

As India globalizes, the impacts of development are increasingly felt in the coastal states through increased multilateral investment, new industry, increased rural urban migration, and other societal forces. This is already evident in increased levels of investment in the country, and especially in the coastal states of India, and more policy decisions to gear up the economy to open up and out. The coast has come to assume a special significance, for its logistic advantages, more developed infrastructure, potential for accommodating global tourism, and also supporting export industries such as aquaculture. In this study, we identify and examine the drivers of change on local coastal ecosystems as a first step towards contributing to more integrated thinking on coastal management issues. A number of different frameworks have been proposed to measure links between development and the environment. Pressures have been defined more broadly through the inclusion of factors, human and non-human. Second, pressures have been divided into three sub-categories: underlying, indirect, and direct pressures.

Underlying pressures include social and demographic forces, technological change, and policies that stimulate economic activities. Indirect pressures include human activities (mostly but not exclusively economic activities) intended to benefit human welfare, as well as some natural processes and forces, such as nutrient cycles, volcanic eruptions, earthquakes, and meteorological events and cycles. Direct pressures include actual biophysical stresses on the environment, such as pollutant releases, resource extraction, and exotic species introductions.

Ecosystem approaches which are based on assessing the performance of a sector according to ecological, economic, and social dimensions and use four criteria for sustainability: productivity, resilience, stability, and equity.

The process of developing the indicators of the coastal vulnerability is summarized in Figure 1.

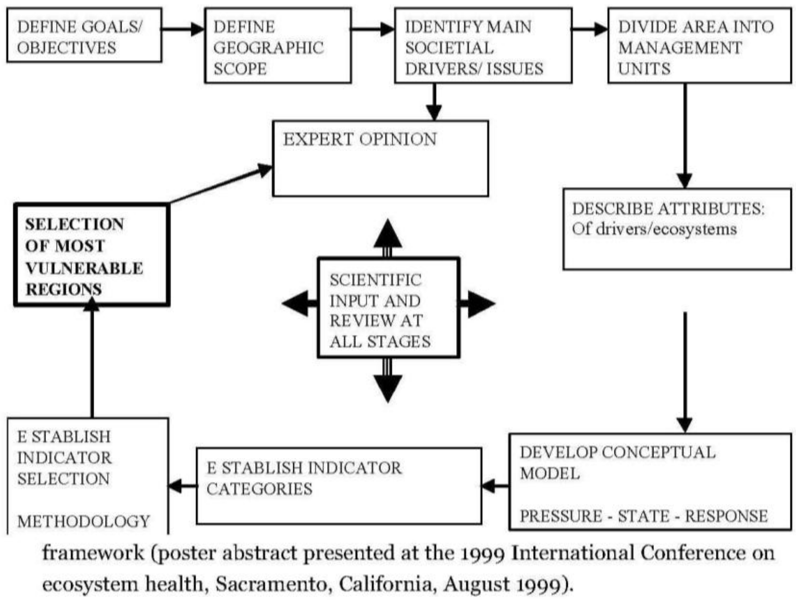

Fig.1 Process for developing indicators of coastal vulnerability (Adapted and modified from: CALFED Bay – DELTA ERP indicator)

The following are the main drivers of change in coastal India: Urbanization, Industrial activity, Intensive aquaculture/agriculture, Tourism and Port activity. The main pressures for the ecosystems from urbanization arise from the growth of population whether due to migration or natural growth and the consequent increase in demand for water, land, sewerage and other infrastructure. Coastal areas in India are particularly vulnerable to pressures from urbanization, as 25% of its one billion people live along the coast and the migration to coastal areas occurs all the time.

The ecosystems considered here are mangroves and dune vegetation, coastal aquifers and near shore coastal water. These are also typically the ecosystems that are stressed by anthropogenic activity in Indian coastal areas6 (Voices for the Ocean 1996). Mangroves are generally found in the littoral zones of tropical and subtropical sheltered coastlines. Quite apart from their role as coastal stabilizers and buffer zones, these ecosystems are very highly productive, which enables them to support large artisanal and commercial fisheries. Very recent studies have estimated a mangrove cover of approximately 3,15,000 ha in the country of which almost 80% occurs long the northeastern (Orissa and West Bengal) coast and in the Andaman and Nicobar group of islands. Approximately over 80% (2,67,000 ha) of the total Indian mangrove cover, exists in the deltaic regions, of which 78% occurs in the Ganges (Sunderbans) delta alone. The Gulf of Kuchchh and Gulf of Khambat and Kerala coasts have most degraded mangroves. Sand dune vegetation has been classified into the pioneer zone, midshore zone and the backshore zone. The pioneer zone is closest to the sea and the backshore zone is the farthest. The three zones together form a vegetation slope, which acts as a block to the movement of wind and sand. Plants on dune systems flourish with the organic matter brought by high waves during storms or heavy winds. The berm swells due to the aeolian import of sand. Dune vegetation traps sands and thereby increases the amount of sand in the dunes. Sand dunes play a vital role in protecting the coast from erosion and flooding. One of the important factors in dune stability is the cover it provides. The number of dune vegetation species on India's west coast is almost double that on the east coast.

The key characteristics for each of the ecosystems of our study are given in the chart below.

Characteristics of ecosystems:

Ecosystem	Characteristic/attribute
Coastal water	Water quality
Groundwater	Water quality and quantity
Mangrove vegetation	Area covered, trends in composition and Abundance

The state indicators are based on the characteristics of the ecosystems or surrogates that provide information on the condition of the ecosystems. The following were used for this study:

- *Coastal water*: (physical, chemical, biological parameters)
- *Coastal aquifers*: (physical, chemical, biological parameters)
- *Mangroves/dune vegetation*: (basal area covered, number of species, canopy cover) To assess the state of ecosystems (groundwater, mangroves, coastal waters) in the coastal districts, the following indicators were used to grade coastal ecosystem health:
- *Coastal water*: levels of DO, BOD, pH, colour and odour, floating matter, turbidity, suspended solids, oil and grease, heavy metals (Hg, Pb, Cd), dissolved iron, manganese, faecal coliform and following the use classification suggested by the CPCB (SW1 to SW5).
- *Ground water*: levels of pH value, coliform count, TDS (ppm), nitrate (ppm), specific conductivity (micro seimen/cm), hardness (ppm), percentage of sodium, boron (ppm), depth to WT (m), total groundwater draft (%), rainfall recharge (%) and aquifer type.
- *Mangrove vegetation*: Area covered by forest, number of species, luxuriance of the forest

Indicators of the health of coastal ecosystems within each district were placed in grades from 1-5. The grades/categories used to indicate the quality of each ecosystem are: Good - 1, moderately affected - 2, affected – 3, highly affected – 4, and severely affected - 5. Using the indicators described above, these grades were assigned to each ecosystem within each district based on the experts' (scientists working with the each of the relevant ecosystem) opinion. These five levels are taken as scores of each state indicator (from 1 - 5). The scores were summed for all three ecosystems and the district, with the highest score for state indicators, was assigned the highest rank indicating that the ecosystems here were the most affected.

Figure 2 presented below summarize the hypothesized links between driver and ecosystem. Coastal districts most threatened or vulnerable to development activities were those ranked high for both drivers and for stressed ecosystems. The Venn diagram (Figure 3) below illustrates this.

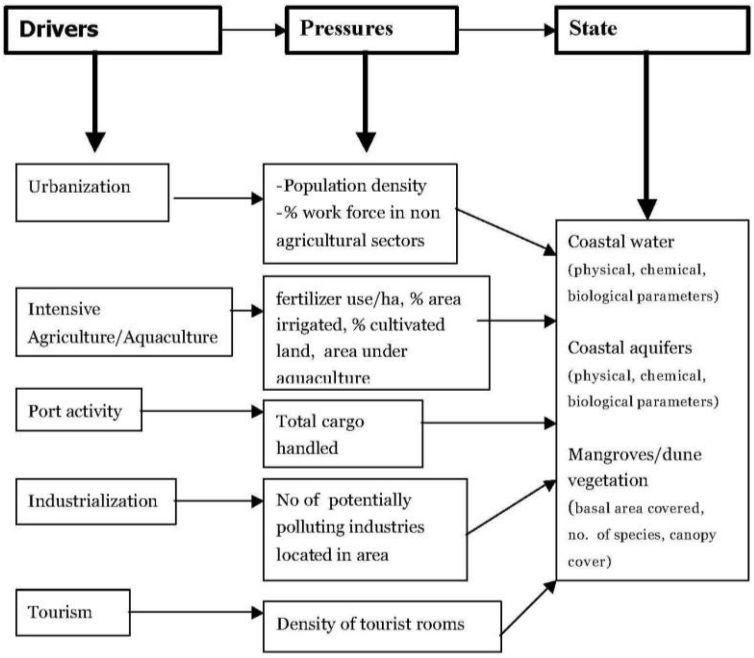

Fig.2 The Driver-Pressure-State indicator framework

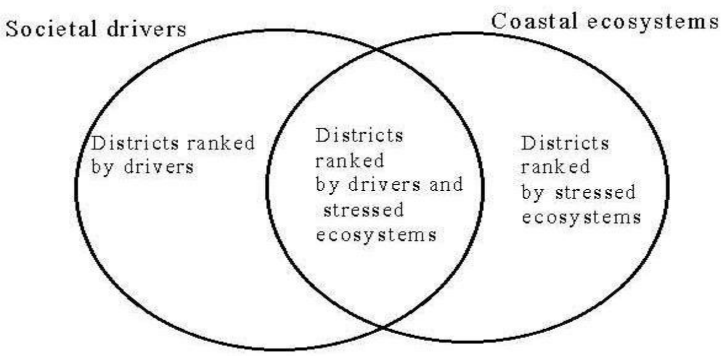

Fig.3 Potentially vulnerable Coastal districts

If these districts are examined for (1) pressures from the various drivers, and (2) ecosystem stress, we get:

- *Urbanization driver*: Of the 15 districts potentially threatened by urbanization pressures, only six can be said to have affected ecosystems. These are Mumbai, Chennai, Ernakulam, Trivandrum, Quilon, and Thane.
- *Industrial activity*: Of the 15 districts potentially threatened by heavy industrial activity, only four districts can be termed affected: Mumbai, Chennai, Thane, and Visakapatnam.
- *Intensive aquaculture/agriculture driver*: Mednipur, Ernakulam and East Godavari emerge as districts most representative of intense agricultural activities. Among these, East Godavari has the highest aquacultural activities. These also have affected ecosystems.

- *Port activity*: Of the 15 districts potentially threatened by port activity, only seven districts can be said to have affected ecosystems. Mumbai, Chennai, Vishakhapatanam, Dakshin Kannad, Ernakulam, Jamnagar, and East Godavari.
- *Tourism activity*: The districts of Mumbai, Chennai, North Goa, South Goa, Ernakulam, Trivendrum and Visakhapatnam emerge as potentially vulnerable districts.

Coastal districts short-listed by heavy pressures from drivers and with affected Ecosystems are given in Table-1.

Table-1
Coastal districts short-listed by heavy pressures from drivers and with affected Ecosystems

Districts/ Driver listed By ranks	Urbanization	Industrialization	Aquaculture/ Agriculture	Port Activities	Tourism	Stressed Ecosystem
1	Mumbai	Mumbai	Kheda	Mumbai	Chennai	Mumbai
2	Chennai	Thane	Tanjore	Chennai	Mumbai	Chennai
3	Mahe	Ahmedabad	West Godavari	Kachch	North Goa	Dakshin Kannada
4	24 Paragnas North	Raigad	24 Paragnas North	Visakhap atnam	South Goa	Visakhap atnam
5	Ernakulam	Chennai	Krishna	24 Paragnas North	Ernakulam	Ernakulam

The coastal districts whose ecosystems are vulnerable to development drivers are given in Fig.4.

Coastal Bio-Shields and their role in climate related hazards

Even six years after the Indian Ocean tsunami, one of the most widely debated topics has been the role of coastal vegetation in mitigating impacts of the tsunami. Following the aftermath, several publications, both in scientific journals and popular media, staked claims on the positive and protective role coastal vegetation provided in the event of such large scale natural disasters. Piloted and supported by this, huge amounts of money was spent in creating bio-shields along coastal stretches to act as natural defenses against events like the tsunami. While these modifications to coastal stretches were being implemented, a few studies indicated that coastal vegetation had very little or no protective role to play in the events like the tsunami and suggest that the role of other coastal features like topography, near shore bathymetry, distance to continental shelf, etc. need to be considered as variables that explain the observed inundation distances.

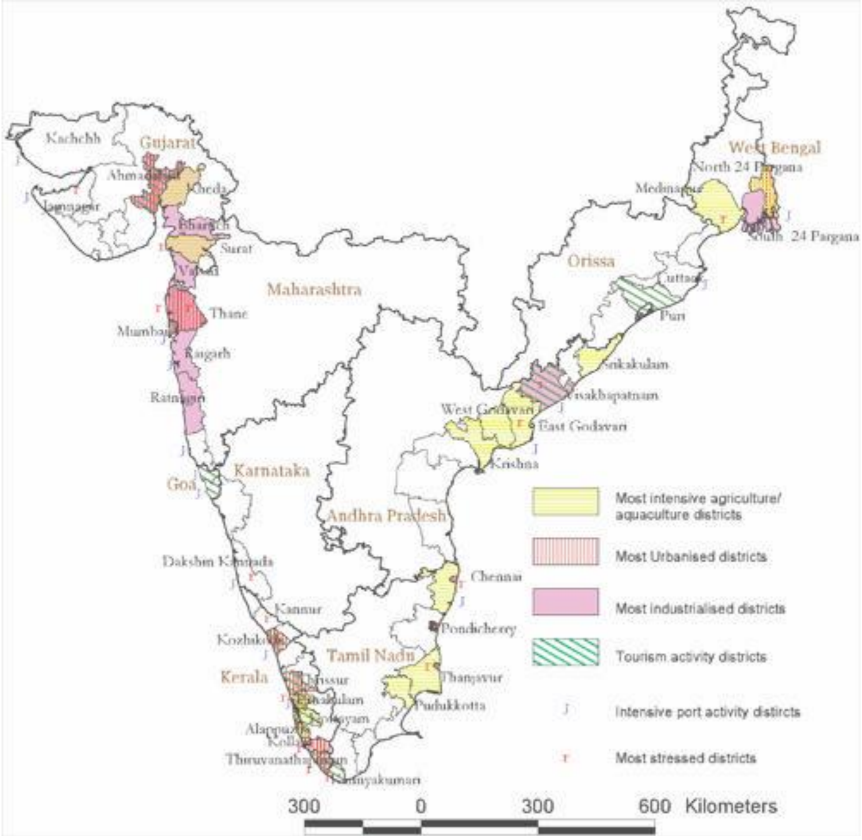

Fig.4 Coastal districts defined by drivers and stressed ecosystems

The role coastal forests and plantations play in providing livelihood opportunities, timber and fuel wood, etc. to coastal populations cannot be dismissed, but it would be naive to believe that they alone served the purpose of coastal protection against tsunamis. Such a notion will only serve to instill a false sense of security and hope among people who continue to reside in these vulnerable zones. Resolution to this disagreement is imperative and will help in minimizing loss of life and property in the event of such large scale natural calamities by adopting measures which will mitigate or reduce risks that populations are exposed to along the coast. Other factors that are correlated across space that also arrest wave inundation includes distance from shore, elevation, topographic complexity, history of land use, near-shore bathymetry, etc..

Conclusions

This article is based on a presentation on a framework of indicators of potential vulnerability developed for the coastal regions of India. Arriving at vulnerable coastal districts by ranking those with heavy development pressures and stressed ecosystems, using pressure and state indicators enables us to suggest that any further development in a `business as usual' scenario will put these districts at risk and result in negative outcomes for the people and activities located there. So there is need to put in place a coastal monitoring and managing system, which takes into account the ecosystems in each district that are particularly stressed by a particular driver. The ecosystem level indicators can also help regulatory regimes to be more sensitive to location specificities and vulnerability and also to stress from multiple uses. The framework has a number of limitations but also a number of strengths.

The analysis clearly highlights that simplistic models with single parameters are insufficient to explain the observed inundation distances and that more than a single variable contributes towards explaining the observed effects. The results also indicate that other than coastal slope, no single variable is good enough to explain the observed inundation and that vegetation plays a role only when combined with elevation slopes. From our results we conclude that vegetation alone did not play a significant role in preventing inundation due to the tsunami and physical variables such as topography and bathymetry do play a more important role than vegetation. While vegetation and near shore bathymetry did contribute, in the final model, their role is important only in combination with topographic relief.

Coastal vegetation does not provide adequate protection during events like the 2004 tsunami. Some have argued that because there may be a risk to life in future tsunamis if mangroves and reefs are not rehabilitated the normal standards of statistical proof should not apply to their research. The closest scientific evidence for the buffering function of mangroves comes from socio-economic and ethno biological surveys that focus on the services of mangrove forests. However, the only statements by villagers in support of mitigation presented in this paper refer to the protective function of mangroves against cyclone generated waves, which are an entirely different beast to a tsunami.

Even as the mitigation hypothesis was drawing attention, the action plan that was drawn up during the National Workshop on Formulation of Science Plan for Coastal Hazard Preparedness (2005) clearly acknowledges that vegetation alone will not be effective in the event of a tsunami "Vegetation such as mangroves is known to help mitigate the effects of storm surges and tsunami. It is, however, necessary to quantify the protection such natural buffer zones, now called bio-shields, provide to coastal habitation. Although such sound scientific recommendations and steps were taken immediately after the tsunami, a sizable amount of money was spent on creating bioshields all along the coast, while the same could have been spent on strengthening existing disaster preparedness through various education, training and awareness programs for communities living along the coast to deal such emergencies. While we make this conclusion on the role of coastal vegetation in events like the tsunami we do acknowledge the role coastal forests and plantations play in providing livelihood opportunities, timber and fuel wood, etc. to coastal populations. As vegetation might not protect people from disaster like the tsunami, the efforts to restore degraded coastal habitats should continue for ecological reasons and not on the false premise of coastal protection.

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SOLAR HALO AT CHENNAI

by

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Religious mythologies portray divine figures with a bright Halo around their heads. In reality only the Sun (The Sun of course has a permanent and spectacularly bright ring around it, the corona which can be seen during a total solar eclipse) and the moon are seen sometimes with haloes around them. Maybe these beautiful haloes inspired the concept of haloes around gods.

Halo at Chennai

These pictures (Fig.1) are of a beautiful Halo around the Sun which was seen at about 1130 hrs on 8 March 2013. The Sun was at a high elevation because of the time of day. The halo was a complete circle with red and yellow on the inside. By its side there was a long line of wavy cloud extending on both sides in a roughly east-west direction. It was the remnant of a contrail. By the time the pictures were taken, a part of the circle was clouded over and the contrail was more diffuse. The complete circle could not be photographed as there was no means of filtering out the sun at its centre. Hence the pictures were taken by shielding the camera behind some obstructions. By about 1200 hrs the Halo had mostly dissipated.

Fig.1 Photographs of Halo around the Sun at about 1130 hrs on 8 March 2013

Weather

The sky was a beautiful blue with a very few patches of clouds. Visibility was very good. It is rare to see a blue sky in our cities nowadays. The high pollution levels often result in a grey sky. However there was light rain over Chennai in the previous few days resulting in washing down of pollutants.

Haloes and allied optical phenomena are caused by *refraction* of sunlight by ice crystals. In the 22 ° halo shown in the Fig.2, the inner edge is red. A little yellow can also be seen outside the red. The rest of the ring is white. The diagram at the top left in the figure below shows the refraction as sunlight passes through the hexagonal cross section of very small columnar crystals that are tumbling through the air, resulting in the 22° halo. A uniform distribution of randomly oriented crystals is necessary to ensure that there are crystals oriented in every possible direction. Random distribution is possible only if the crystals tumble and only small crystals will do so. The light responsible for the halo is that which deviates least from the original direction. The angle of minimum deviation is 22°.

The other diagrams show the mechanism of formation of the other phenomena mentioned there. All these are more common at higher latitudes. Complete circle being seen is also rare.

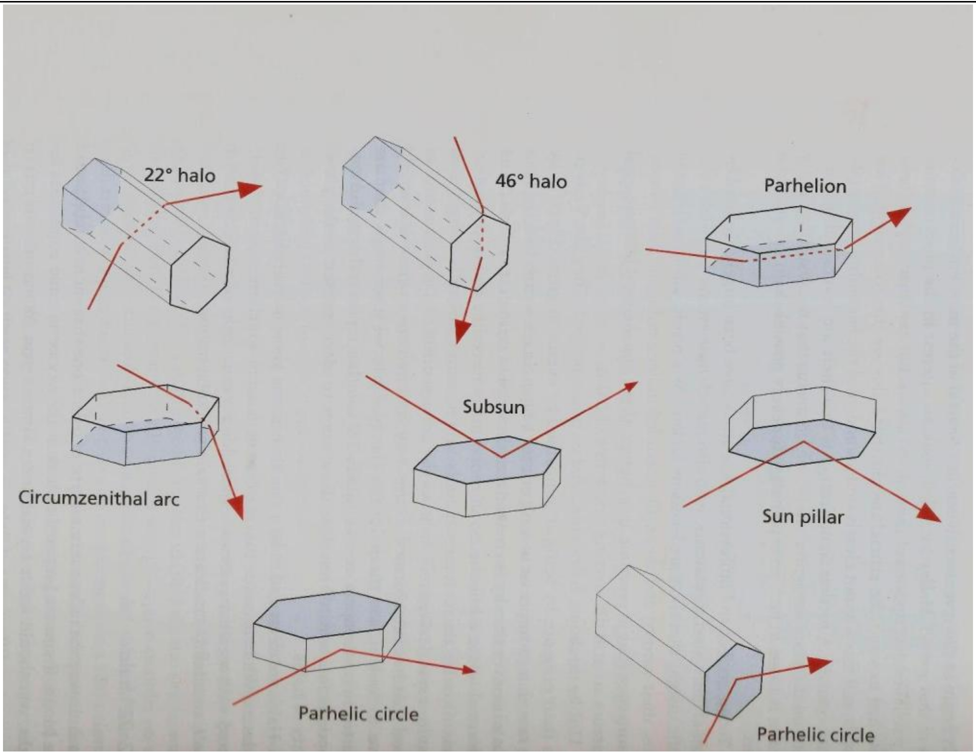

Fig.2 Figures depicting haloes and allied optical phenomena caused by *refraction* of sunlight by ice crystals
(Source: "*Out of the blue*" by John Naylor, Cambridge University Press, 2002, ISBN 0 521 80925 8)

The belief that a halo is a precursor of rain does not seem to have any sound basis.

It can be said that no one else besides the present writer has seen this halo because it is said that no two persons see the same halo just as no two persons see the same rainbow!

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EL-NIÑO –MODOKI

by
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The term El- Niño is quite familiar not only in the scientific community but also amongst the public at large. Though the traditional El-Nino is defined as the periodic warming of the eastern Pacific along the west coast of south America during the southern hemispheric summer, over period of time the meaning has changed and El-Nino is said to occur if 5 months of SST anomalies in the Nino 3.4 region (5˚N-5˚S:120-170˚W) exceed 0.4˚C in six months or more.

In the last two decades scientists have noticed that El-Nino warming is stronger in the Central Pacific rather than over the eastern side. In this non traditional El-Nino, the regions Nino1 and 2 are not affected but an anomaly arises in the Nino3.4 region. This phenomenon is called *Central Pacific(CP) El-Nino,* '*date line El-Nino*' as the anomaly arises near the date line and also known as *ElNino- Modoki*. The term *El-Nino Modoki* was first coined by Prof.Yamagata. "*Modoki*" is a Japanese term for "*Similar but different*"

It is characterized by anomalous warming of central equatorial Pacific flanked by anomalous cooler region on either side (east and west). Such zonal SST gradient results in two cell Walker circulations over the tropical Pacific with a wet region in the central Pacific. Its teleconnections are different from that of the conventional El-Nino that this new phenomenon has gained interest especially amongst the climatologists. The two phenomena also have different temporal features, While El-Nino is an inter annual variability, Modoki has a large decadal background.

With data sets now available for over 4 decades on EMI (El-Nino Modoki Index), several studies have emanated linking EMI and global weather. Recent studies link it to global warming, more hurricanes in the Atlantic, Arabian Sea etc. Still lot more needs to be done in understanding this phenomenon and its global impact.

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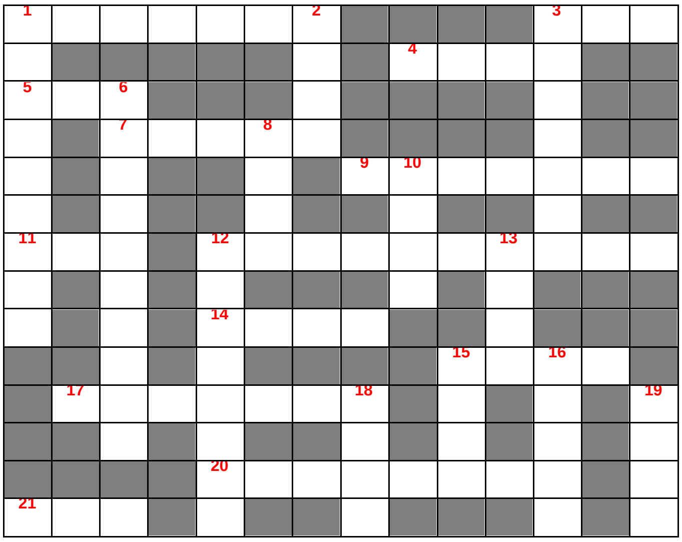
wXword



ACROSS

1- Effect discovered by an Austrian physicist for relative motion between a source and an observer
3- Acronym for prognosis of Aerodrome Weather
4- Source of data in data sparse ocean
5- Acronym for next generation mesoscale numerical weather prediction system
7- Difference of two extrema
9- Snow eaters in Canadian prairies
11- Acronym for real vapourisation of water
12- This implies heating under high pressure
14- Noble gas glows in advertising signs
15- How many bits make a character?
17- Originally METSAT later renamed
20- Longer λ than visible
21- Terrestrial radiation in short

DOWN

1- Air current synonym with bearish trend
2- Deposit of frosty film
3- For Shakesphere, it is tempest, for Pacific Ocean community, it means what?
6- This force helps us from slipping during walk
8- Strongest tropical cyclone on record in Arabian Sea
10- To salute or greet
12- Gist of happenings in the atmosphere at a particular time
13- Part of fluid temporarily maintaining its own identity
15- He related the absorption of radiation to properties through which its travels.
16- Primarily low level winds characterised by great consistency of direction
18- Regular valley wind in Lake Garda (Italy), synonym of luminous radiance surrounding a person
19- Unconsolidated mineral in earth's surface

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2012 - KERALA'S WORST EVER LOWEST ANNUAL RAINFALL SINCE 1901 LEADING TO POWER AND WATER SCARCITY

by

R.LAKSHMINARAYANAN

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Kerala receives a normal rainfall of 2.3 cm in winter(Jan-Feb), 37.8 cm in summer season (March – May), 205.1cm in the southwest monsoon season(June – September) and 47.7 cm in northeast monsoon season(Oct – Dec) thus totaling an annual rainfall of 292.8 cm as per the latest normal of Kerala based on 1951-2000. Thus the rainfall in Jan-Feb is 1%, summer rainfall is 13%, southwest monsoon rainfall is 70% and northeast monsoon rainfall is 16% of annual rainfall. The total rainfall of Kerala varies from 365 cm in the north to 175 cm in the south. The coefficient of variation of annual rainfall of Kerala is less than 15 % in the north and less than 20 % in the south.

Meteorologically *drought* over an area or place may be defined as a situation when annual rainfall over the area or place is less than 75% of the normal. It is further classified as "*moderate drought*" if the rainfall deficit is between 25% and 50% and "*severe drought* " when the deficit more than 50%.

During the period 1901-1950, Kerala as a whole did not experience any drought condition though Alleppey, Ernakulam, Palghat,Trichur and Thiruvananthapuram districts experienced moderate drought conditions - Allepey in 1905, Ernakulam in 1905,1918,1928 and 1934; Palghat in 1928; Trichur in 1921; and Thiruvanananthapuram district in1917,1934,1937,1938 based on 1901-1950 rainfall normals. The probability of occurrence of annual rainfall less than 75% of the normal is about 8% ie. about once in 12 years over the district in the long run. The probability of occurrence of excessive rainfall in the state as a whole is about 4% ie. once in 25 years in the long run. (Ref. "*Climate of Kerala State*" published by India meteorological Department in 1985.)

During the period 1901-2000 there have been ten years of deficient annual rainfall based on the earlier annual normal of 310.7 cm over Kerala and the years were 1934(-20%), 1951 (- 23%), 1952 (-23%), 1965(-23 %),1972 (-20%),1976(-28%),1982(-24%), 1986(-27%), 1987(-25%), and 2000 (-21%). It can be noticed that the second half of 20th century nine years of deficient rainfall, while the first half of 20th century had only one year of deficient rainfall. The years 1976,1986 and 1987 may be considered as years of moderate drought for Kerala the worst being 1976.It may be interesting to note that the decade 1981-1990 had three years of deficient rainfall out of which two years 1986 and 1987 were of moderate drought years. It may be mentioned that during the period 1901-2000, out of the ten years of deficient annual rainfall the southwest monsoon was deficient in seven years and in the year (in 2000) it was -18% and the other two years it was positive. In the recent decade 2001-2010, the two years 2002 and 2003, the southwest monsoon was deficient by 35% and 26%. But in 2002 the summer and northeast monsoon rainfall was excess and it made up and brought the annual rainfall of Kerala to 241.8 cm, with a deficiency of 18 %. In meteorological parlance - 19 % to + 19 % is considered as normal. In the year 2003 the annual rainfall of Kerala was 237.0 cm. as against the present annual normal of 292.8 cm which is 23% deficient.

For over a century Kerala has seen a declining trend in the southwest monsoon rainfall while the opposite was noticeable with northeast monsoon. The decrease in rainfall in southwest monsoon is just 1.2 cm per decade, while the northeast monsoon has 7.3 mm more rain per decade since 1871. While the declining rainfall per decade in southwest monsoon 1.2 cm per decade is significant the increase in northeast monsoon 7.3 mm per decade is not that significant as stated by Dr.Y.E.A.Raj, Deputy Director General of Meteorology, Regional Meteorological Centre, Chennai in a recent seminar on “Variability of monsoons in Kerala “. In a paper published in 1988 by late M.K.Soman and his colleagues of Indian Institute of Tropical Meteorology, Pune, mentioned that “significant declining trends in the southwest monsoon rainfall affecting the middle and high land areas of Southern Kerala as well as highlands of Northern Kerala over an 80 year period from 1901.”

The annual rainfall in some of the places showed significant decrease in the annual rainfall of the 20th century and some of the stations are given below.

Station	Annual rainfall in mm 1901-1950	Annual rainfall in mm 1951-2000	Difference in mm.
Kottayam	3261.5	2858.0	- 403.5
Punalur	3159.4	2760.6	- 398.9
Tiruvalla	3093.0	2732.2	- 360.8
Peermedu	5164.8	4427.7	- 737.1
Munnar	3815.9	3744.3	- 71.6
Alappuzha	3274.8	3006.1	- 268.7
Kollam	2398.1	2357.8	- 40.3

As far as southern Kerala is concerned there is normally heavy rain spell occurs at the onset phase of the southwest monsoon. If there is a failure of heavy rains at the onset phase of the southwest monsoon it is seen that generally it becomes difficult for the southwest monsoon to make up. This is what has happened in the year southwest monsoon season of 2012.

Kerala received a rainfall of 155.1cm as against a normal of 205.4 cm in 2012’s southwest monsoon season with a deficiency of 24%. Only three northern districts Kasargode, (-9 %),Kannur (- 13%) and Kozhikode (- 8 %) received normal rainfall (as -19 % to + 19 % is considered as normal in meteorological parlance)while all other districts received deficient rainfall the highest deficiency being in Wynad district with 49 %. All the 8 Southern districts received deficient rainfall the highest deficiency being in Thiruvananathapuram district with 43 %. When the districts of southern Kerala alone is considered South Kerala received a rainfall of 124.0 cm as against a normal of 176.3 cm with a deficiency of 30% in this year’s southwest monsoon season, while northern Kerala received a rainfall of 193.1 cm as against a normal of 242.4 cm with a deficiency of 20 %.

On the whole Kerala received a deficient rainfall of 24% in this year southwest monsoon season. It may be mentioned that that the normal for the southwest monsoon has been changed in 2011 from 214.3 cm to 205.1 cm. But for this change in the normal the deficiency which is 24 % in 2012 would have gone up by another 4%. Districtwise weekly weather report were started from 1976 by Meteorological Centre Thiruvananthapuram. It may be mentioned that in this year 2012 Idukki district received the third lowest southwest monsoon rainfall of 180.4 cm after 1976(162.9 cm)and 1987(166.4cm) since commissioning of Idukki dam in 1976. Pathanamthitta district received the second lowest southwest monsoon rainfall of 104.0 cm (-39% deficiency) after 1979with 76.5 cm (-59%deficiency)) since 1979 in this year’s southwest monsoon season.

A perusal of annual rainfall of Kerala from 1976 till 2011 shows that the years 1976,1982,1986,1987,2000,2002 and 2003 had deficient southwest monsoon rainfall and the annual rainfall had also ended up deficient in majority of the years. However, though the years 1982 and 2000 had normal southwest monsoon rainfall, the annual rainfall of 1982and 2000 ended up deficient, because of deficient rainfall in the summer and northeast monsoon season. The following table-1 gives details of southwest monsoon rainfall deficiency, annual rainfall received in South and north Kerala, annual rainfall of Kerala and departure from normal as per earlier annual rainfall normal of 310.7 cm and also departure from the present annual normal of Kerala 292.8 cm (based on 1951-2000).

Table-1
Details of deficient southwest monsoon rainfall

Year	Southwest monsoon r/f (PDN)	South Kerala Annual r/f in cm.	North Kerala Annual r/f in cm	Annual r/f of Kerala in cm	Annual r/f PDN (based on earlier annual normal: 310.7 cm)	Annual r/f PDN (based on present annual normal: 292.8 cm)
1976	- 33	211.7	240.5	225.0	-28 %	- 24%
1982	- 16	222.3	244.1	232.4	- 25%	- 21%
1986	- 23	225.4	238.9	231.2	- 26%	- 21%
1987	- 31	244.9	213.9	231.7	- 25%	- 21%
2000	- 18	248.7	249.5	249.0	- 20%	- 15%
2002	- 35	253.0	250.0	251.7	- 19%	- 14%
2003	- 26	240.6	233.8	237.0	- 24%	- 19%
2008	- 22	247.9	256.7	252.3	- 19%	- 14%
2012	- 24	201.5	235.6	217.1	- 29%	- 25 %

PDN: Percentage Departure from Normal

It can be easily seen from the above table that the annual rainfall of Kerala received in the year 2012 (excluding the rainfall of Jan-Feb which has only a normal of 2.3 cm) with 30.9 cm in summer, 155.1 cm in southwest monsoon season and 31.1 cm in the northeast monsoon thus making a total of 217.1 cm. Assuming that the normal rainfall of 2.3 cm has occurred in Jan-Feb in Kerala the total amount of rainfall for 2012 for Kerala will be 219.4 cm. As such Kerala recorded the worst ever lowest annual rainfall in the year 2012 leading to a moderate drought situation by recording the lowest ever annual rainfall since 1901.It may be interesting to note that the highest annual rainfall of 357.1cm was recorded in the year 2007 between 1976 and 2012. The following Table-2 gives district wise highest and lowest rainfall recorded in Kerala along with the year and amount of rainfall during the period 1976 to 2012.

Table-2
District-wise highest and lowest rainfall figures for Kerala during 1976-2012

District	Highest annual rainfall in cm .	year	Lowest annual Rainfall in cm.	Year
Kasargode	483.3	1978	246.7	1987
Kozhikode	469.4	1978	227.5	2003
Kannur	418.4	1994	234.2	1986
Mallapuram	353.5	2007	146.0	1982
Palghat	326.6	2007	169.8	2012
Wynad	385.7	1984	184.2	1987
Thiruvananthapuram	239.8	1992	110.4	2012
Kollam	296.7	1995	162.1	2012
Pathanamthitta	352.4 (since1979)	2010	124.5	1979
Alleppey	330.8	2007	182.9	2012
Kottayam	367.1	2010	219.9	1976
Idukki	565.3	2005	245.6	1987
Ernakulam	395.4	1978	246.5	1990
Trichur	544.6	1978	207.3	2000

It may be interesting to note that Thiruvananthapuram, Kollam, Alleppey and Palghat districts have recorded the lowest annual rainfall in this year 2012. It may be mentioned that Idukki and Kottayam districts recorded the second lowest annual rainfall in 2012.
It may be mentioned that the lowest annual rainfall of Kerala during the period 1976 to 2012 is 217.1cm plus 2.3 cm (winter rainfall) i.e 219.4 cm. As such the year 2012 recorded the lowest ever annual rainfall of Kerala since 1901 with 219.4 cm with a deficiency of 25 % leading to moderate drought conditions.

According to Central Water Commission the storage level in 16 of the 30 major reservoirs in South India was lower than 40 % of capacity and this was the lowest in a decade. Kerala reservoirs had 44% below compared with normal storage as on December. .The storage level in all the six reservoirs of Kerala is below 60%. Kerala used to get copious rainfall in the southwest monsoon normally. But in this year 2012 the southwest monsoon rainfall was deficient by 24%and also the summer and northeast monsoon rainfall was also deficient leading to poor storage levels. As such 2012 has become a nightmare year for Kerala in the water and power fronts.

ENSO RELATED CLOUD RADIATIVE FORCING AND TROPICAL CYCLONE ACTIVITY OVER NORTH INDIAN OCEAN

by

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Clouds are important elements of the climate system as they have a big impact on the Earth's energy balance. The Earth-Atmosphere system is in thermal equilibrium at the top of the atmosphere as the net incoming Short Wave (SW) radiation is equal to the outgoing Long Wave (LW) radiation. In both the SW and LW regions of the electro-magnetic spectrum, clouds induce significant impact by reflecting, absorbing, and emitting significant amounts of radiation. The role of clouds in the climate system is generally discussed by means of cloud radiative forcing (CRF).

Cloud radiative forcing is the difference between the radiation budget components for average cloud conditions and cloud-free conditions. CRF at the top of the atmosphere is defined as the difference between the radiative fluxes with and without clouds.
Shortwave cloud radiative forcing (SWCRF) is defined as

$$\text{SWCRF} = S\,(a_{\text{clr}} - a)\ldots(1)$$

where S is the monthly incoming solar flux at the top of the atmosphere and a is the total sky albedo of the earth–atmosphere system. Here a_{clr} is the clear-sky albedo of the earth atmosphere system. SWCRF is usually negative.
Longwave cloud radiative forcing (LWCRF) is defined as

$$\text{LWCRF} = F_{\text{clr}} - F\ \ldots.(2)$$

where$F$ is the longwaveradiative flux at the top of the atmosphere. The subscript 'clr' indicates the value of F for a clear scene. LWCRF is usually positive.
The net cloud radiative forcing is defined as the sum of SWCRF and LWCRF (i.e.)

$$\text{NETCRF} = \text{SWCRF} + \text{LWCRF}\ \ldots.(3)$$

and its sign depends upon the relative values of LWCRF and SWCRF. The SWCRF, LWCRF and NETCRF can be defined for top of the atmosphere (TOA) and for atmosphere (A).The variations in cloud radiative forcing are strongly correlated with changes in high cloud amount but weakly correlated with changes in low or middle clouds. It has been shown that the net cloud forcing at the top of the atmosphere can be large in July in the Indian Ocean when the amount of high clouds exceeds 50%. As such, the SWCRF, LWCRF and the NETCRF vary continuously in both space and time. Variations in time domain can be in daily, monthly and seasonal scales. Variations also occur in association with climatic oscillations / parameters.

India, having an extensive coast line, is vulnerable to destructive features of Tropical Cyclones (TCs) that form over the North Indian Ocean (NIO). It would be interesting to note the variations in CRF over the NIO associated with climatic oscillations such as ENSO during the chief cyclone months of November and May. It is well known that development of El-Nino matures and attains its peak in November-December and El-Nino conditions continue to exist for about an year or two. The present work is a pilot study on the CRF at the surface over the NIO region under El-Nino and La-Nina conditions during the chief cyclone month of November and the pre-monsoon cyclone month of May following the occurrence of peak El-Nino / La-Nina event during November-December of the previous year.

Monthly means of SWCRF and LWCRF at surface were taken from the NCEP reanalysis dataset for the month of November during the El-Nino years of 1972, 1977, 1982, 1987, 1991, 1994, 1997 and 2002 and La-Nina years of 1970, 1973, 1975, 1988, 1998 and 2000; and for the month of May following the El-Nino / La-Nina years (i.e), 1973, 1978, 1983, 1988, 1992, 1995, 1998 and 2003) / 1971, 1974, 1976, 1989, 1999 and 2001.

The spatial pattern of surface SWCRF, LWCRF and NETCRF during November for (La-Nina – El-Nino) year composites are shown in Figs.1(a),(b)&(c).

The following points are noted from the spatial patterns of composited surface SWCRF, LWCRF and NETCRF during November for El-Nino, La-Nina and (La-Nina – El-Nino):

(i) The surface SWCRF is negative over the BOB and AS during both El-Nino and La-Nina years indicating cooling effect. However, there is variation in the cooling effects during El-Nino and La-Nina years as is evident from the SWCRF(La-Nina – El-Nino) plot (Fig.1a).

(ii) Over parts of BOB (east of 85°E and North of 8°N), the difference in SWRCF between La-Nina and El-Nino years is of the order of -9 to -12 W/m^2 indicating greater cooling over this region during La-Nina years. During the month of November, Tropical Cyclone (TC) activity is the major synoptic scale feature associated with extensive cloud formation.

Hence variation in cooling effect of SWCRF is analysed with respect to TC activity over the NIO during El Nino and La-Nina years in November. Tracks of TCs over the NIO region during El-Nino / La-Nina years in the month of November are presented in Fig.2(a&b). Hence, excess cooling during La-Nina years could be associated with northward movement of TCs (Fig.4b) during these years. However, over parts of the AS (12-21°N and 65-75°E), greater cooling is associated with El-Nino years (difference in SWRCF between La-Nina and El-Nino years is of the order of 6 to 15 W/m^2). It may be noted from Fig.2(a&b) that there has been moderate TC activity over the AS during El-Nino years when compared to meager activity during La-Nina years.

Regarding LWCRF, generally its effect is seen more in the atmosphere than at the surface. Still warming is observed over both BOB and AS during El-Nino and La-Nina years but without much significant variations.

The NETCRF displays similar features noted in spatial pattern of SWCRF but with change in magnitudes. Over parts of AS, (12-21°N and 65-75°E), the difference in NETCRF between La-Nina and El-Nino years is of the order of 6 to 9 W/m^2 indicating greater cooling during El-Nino years which had moderate TC activity. Over parts of BOB, east of 85°E and north of 8°N, the difference is of the order of -6 to -12 W/m^2 indicating greater cooling during La-Nina years which are associated with northward movement of TCs.

The area averaged NETCRF over the box (10-20°N , 65-75°E) in the AS during El-Nino and La-Nina years are -35 W/m^2 and -29 W/m^2 respectively. The area averaged NETCRF over the box (15-25°N, 85-95°E) in the BOB during El-Nino and La-Nina years are -31 W/m^2 and -36 W/m^2 respectively. These are consistent with the expectations of more cooling during events of greater TC activity and associated cloud systems.

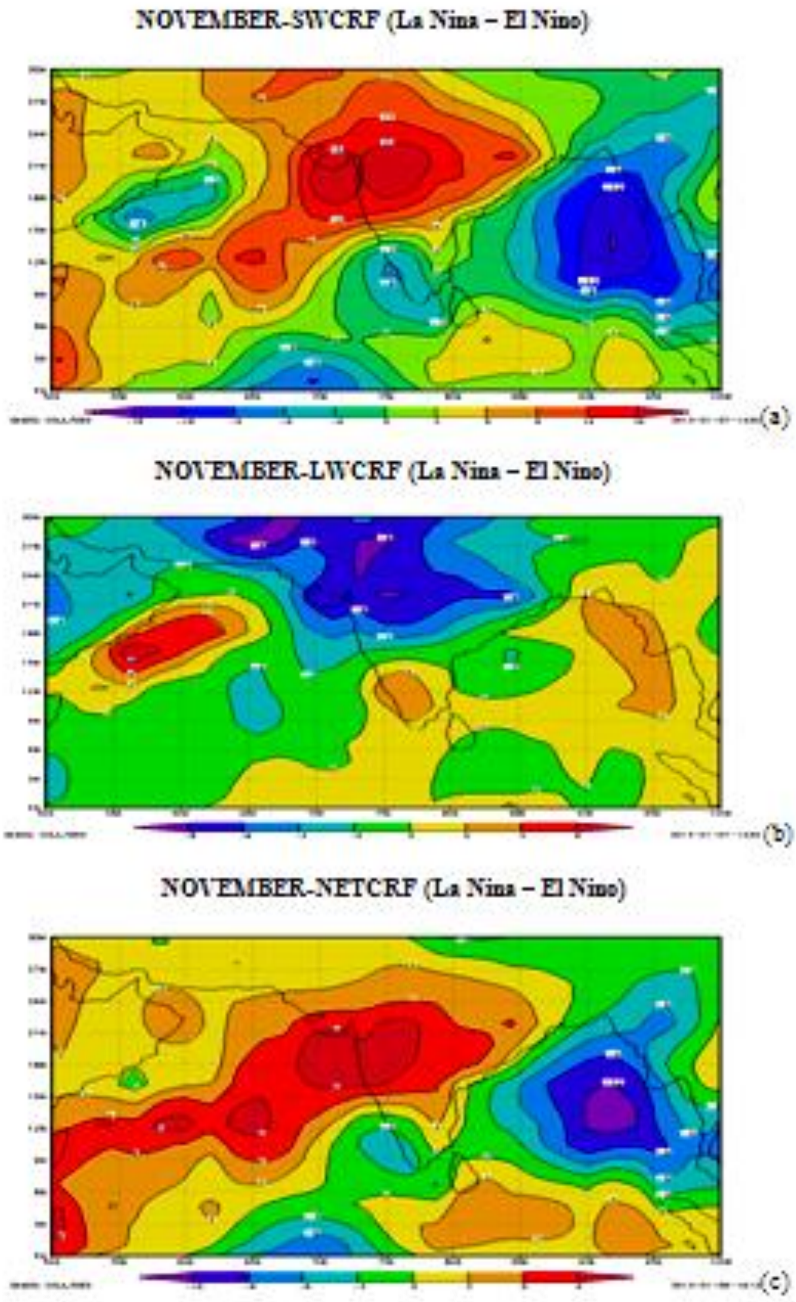
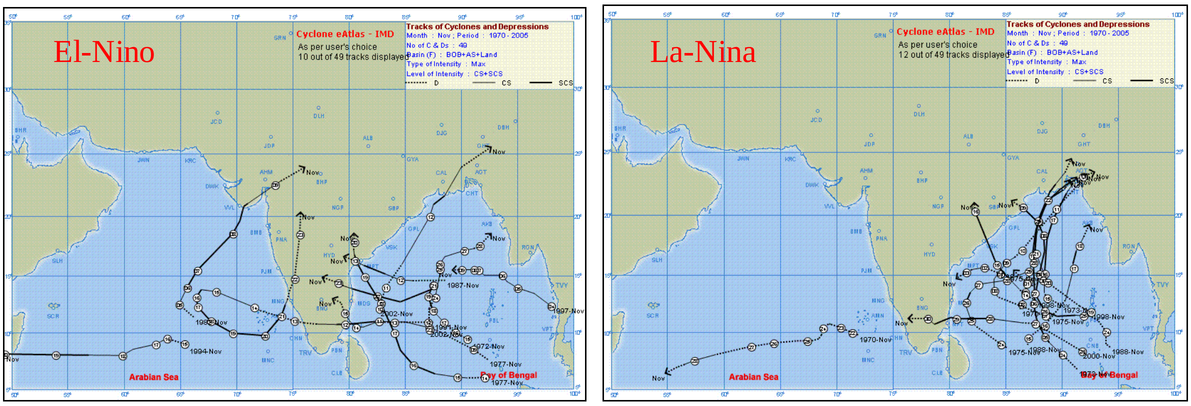


Fig.1(a-c) Surface SWCRF, LWCRF and NETCRF during November for (La-Nina – El-Nino) years



(a) (b)

Fig.2a&b Tropical Cyclone track composites for the month of November over NIO basin during (a) El-Nino (b) La-Nina years (Period: 1970-2005)

The spatial pattern of surface SWCRF, LWCRF and NETCRF for pre-monsoon cyclone month of May during the year following a peak El-Nino / La-Nina event during November/December for (La-Nina – El-Nino) year composites are shown in Figs.3a,b&c).

The surface SWCRF is negative over the BOB and AS during both El-Nino and La-Nina years indicating cooling effect. However, there is variation in the extent of cooling during the El-Nino and La-Nina years over the BOB and AS as is evident from the La-Nina – El-Nino plot (Fig.3c). Over the AS, the SWCRF varies by -5 to -25 W/m^2 indicating greater cooling effect during La-Nina years. By and large, over the BOB, between 8-18^{o}N and to the east of 85^{o}E, the SWCRF varies by -5 to -15 W/m2 during La-Nina years indicating greater cooling effect. But, TC track composites indicate lesser TC activity during La-Nina years than during El-Nino years (Fig.4a&b). As such, despite lesser TC activity, greater cooling is realised over BOB during La-Nina years than during El-Nino years.

In this connection, it may be mentioned that during the month of May, onset of Southwest monsoon takes place over the BOB and the associated cloud radiative forcing could override the signals from TC activity and play a more significant role in this variation in SWCRF during El-Nino and La-Nina years over the BOB. It may be noted that the plots refer to monthly scale variations of SWCRF while TC life time would be of the order of 6 to 7 days. Further, as the sample sizes are not uniform (8 El-Nino years against 6 La-Nina years) interpretations are from a qualitative sense only.

The spatial pattern of composite of surface LWCRF during the following May for (La- Nina – El-Nino) years are shown in Fig.3b. It may be noted that warming is observed over both BOB and AS during El-Nino and La-Nina years (LWCRF 10-20 W/m^2) with slightly greater warming during the La-Nina years (difference in LWCRF is of the order of 2-8 W/m^2).

The spatial pattern of composite of surface NETCRF during the following May for El- Nino, La-Nina and (La-Nina – El-Nino) are shown in 3c. This displays similar features noted in spatial pattern of SWCRF but with change in magnitudes. Over the AS, the difference in NETCRF between La-Nina and El-Nino years is of the order of -6 to -18 W/m^2 and over the BOB, east of 85°E, the difference is of the order of -3 to -12 W/m^2.

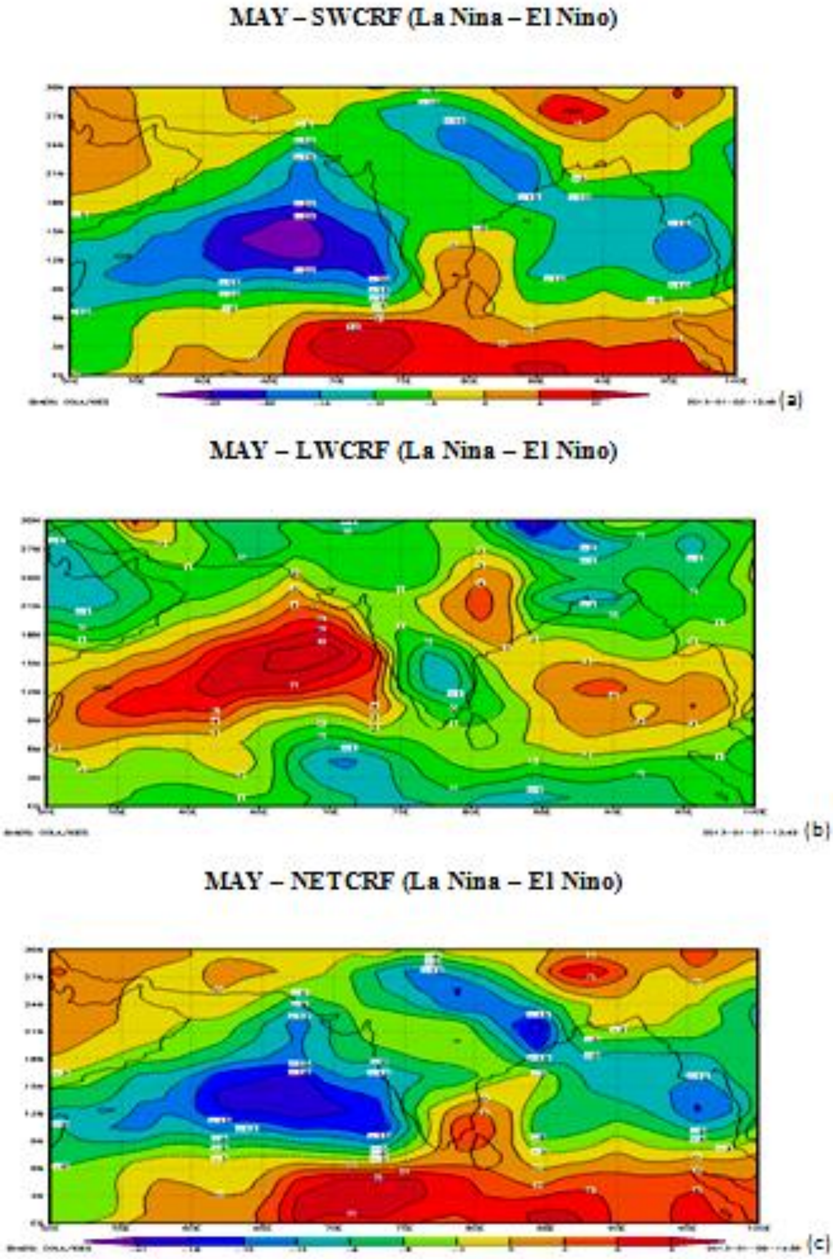
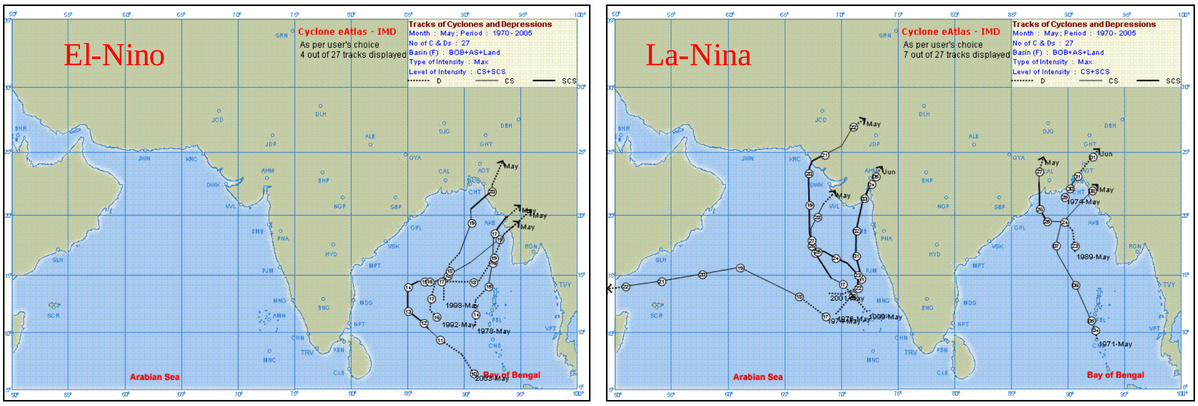


Fig.3(a-c) Surface SWCRF, LWCRF and NETCRF during May (La-Nina – El-Nino) years

The areal average of NETCRF over the AS region 10-20°N , 65-75°E during El-Nino and La-Nina are -50 W/m^2 and -65 W/m^2. This is consistent with expectation of more cooling during events with more TCs and associated cloud systems. However, on the other hand, the areal average of NETCRF over the BOB region 15-25°N, 85-95°E (where TC tracks differ considerably) is -68 W/m^2 and -77 W/m^2 during El-Nino and La-Nina years respectively. As mentioned above the areal averaged values are contrary to the expected variation which indicates the influence of systems other than TCs (such as onset of monsoon) modifying the signals from TCs.



(a) (b)

Fig.4a&b Tracks of TCs over the NIO composited for the month of May following (a) El-Nino and (b) La-Nina years (Period: 1970-2005).

Here, the CRF at surface alone is considered for analysis. Basically the impact of SWCRF is noted at the surface while the impact of LWCRF is seen in the atmosphere. Computations for CRF at the top of atmosphere, at the surface and in the atmosphere together will give complete picture about the radiative impact of clouds over the surface and the atmospheric column over it. If the NETCRF over the surface and the atmospheric column over it is zero implying cancellation of surface CRF and atmospheric CRF over the region under consideration, then it means that impact of clouds on the changes in radiational source over the region is nil ; otherwise it could lead to changes in the radiational balance over the region which would lead to dynamical implications due to the imposed conditions.

Solution to *wXword* in page 16

[1]D	O	P	P	L	E	[2]R					[3]T	A	F
O						I		[4]B	U	O	Y		
[5]W	R	[6]F				M					P		
N		[7]R	A	N	[8]G	E					H		
D		I			O		[9]C	[10]H	I	N	O	O	K
R		C			N			A			O		
[11]A	E	T		[12]S	U	B	S	I	D	[13]E	N	C	E
F		I		Y				L		D			
T		O		[14]N	E	O	N			D			
		N		O					[15]B	Y	[16]T	E	
	[17]K	A	L	P	A	N	[18]A		E		R		[19]S
		L		T			U		E		A		O
				[20]I	N	F	R	A	R	E	D		I
[21]O	L	R		C			A				E		L

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