BREEZE

Indian Meteorological Society, Chennai Chapter
Newsletter Vol.14, Issue No.2, December 2012

Contents

From the Chairman's Desk...

Dear members of IMS Chennai chapter and readers of Breeze,

At the outset, on behalf of IMS Chennai chapter, let me **wish you, your family, your team and their families a very happy and prosperous 2013**.

As you are aware, our chapter has been conducting every year a half-a-day seminar to review the performance of previous year's southwest and northeast monsoons during January / February. This year, a seminar on "Monsoons of 2012" has been conducted on the A/N of 10th January 2013 at the conference hall I of Regional Meteorological Centre, Chennai. Various aspects of synoptic, thermodynamic and dynamic features associated with both southwest and northeast monsoons of 2012, Doppler Weather Radar tracking of NILAM cyclone (29-31 October 2012) during northeast monsoon and effective utilization of operational forecasts issued during both monsoons by the Government machinery have been well covered by eminent speakers. In all, five papers have been presented in this seminar. I am happy to announce that abstracts of some of the papers presented in the seminar have been included in the current issue of ***Breeze*** (Vol. 14, Issue 2). The current issue of ***Breeze*** also contains some informative articles contributed by members of our chapter. ***Breeze*** is available online. Enjoy reading by browsing through http://www.imdchennai.gov.in/IMSWEB/imsframe.htm.

As has been mentioned in the foreword of previous issue of *Breeze* (Vol. 14, Issue 1), the first intimation pamphlet about the contemplated International Tropical Meteorology symposium (INTROMET-2013) on **Monsoons – Observations, Prediction and Sustainability** to be held during 27-30 August 2013 at SRM University, Kattankulathur (near Chennai) has been issued in the recently help TROPMET-2012 symposium at Dehradun on 20th November 2012. Although there had been some unavoidable delay, the electronic version of brochure of INTROMET-2013 will be made available during first /second week of January 2013 through web media and hard copies will be circulated by SRM University shortly. Members are once again requested to prepare high quality papers for presentation in the INTROMET-2013 symposium and submit their extended abstracts adhering to the dates specified in the brochure.

With best regards
R. Suresh
Chairman, IMS Chennai Chapter.
10 January 2013, Chennai

Membership details of IMS-Chennai Chapter (as on December 2012)
Life Members: 145; Ordinary Members: 15; Total : 160

Those who wish to become members of IMS, Chennai Chapter may please mail to
e-mail : **ims.chennai6@gmail.com**

Disclaimer : The Editor and IMS Chennai Chapter are not responsible for the views expressed by the authors.

NORTHEAST MONSOON 2012 – TIME SERIES CORRECTION OF RAINFALL, SEASONAL OUTLOOK AND ASSOCIATED GLOBAL FEATURES

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1. Introduction

The Northeast monsoon (NEM) which is a monsoon of smaller scale that affects the south eastern parts of Peninsular India during the period October to December. For a detailed review of this monsoon and its various features, reference may be made to publications such as IMD(1973), Raj (2011) and several other similar manuals / papers. In this note, we will present some of the features of NEM-2012 especially the correction in the time series of October-December NEM rainfall of Tamil Nadu (NRT) that has taken place in the year 2012. The seasonal outlook on NRT which is taken as the index of NEM activity prepared on experimental basis, its performance, some of the global features associated with NEM 2012 and a few aspects of the intra-seasonal variation also will be discussed.

2. Rainfall

The daily rainfall graph of NEM 2012 during the period 01.10.2012 to 31.12.2012 is presented in Fig.1. During the year 2012 the NEM set in over Tamil Nadu and the adjoining meteorological sub-divisions on 19.10.2012 and good monsoon activity subsequently prevailed for nearly 2 weeks. The formation of *Nilam* Tropical cyclone in the Bay of Bengal on 25 October and its crossing the TN coast near Kalpakkam on 31 October brought in good amount of rainfall over TN and later over Rayalaseema and Coastal Andhra. The rainfall received by TN for the period 1 October – 1 November 2012 was 299.7 mm with percentage departure from normal (PDN) of rainfall 60%.

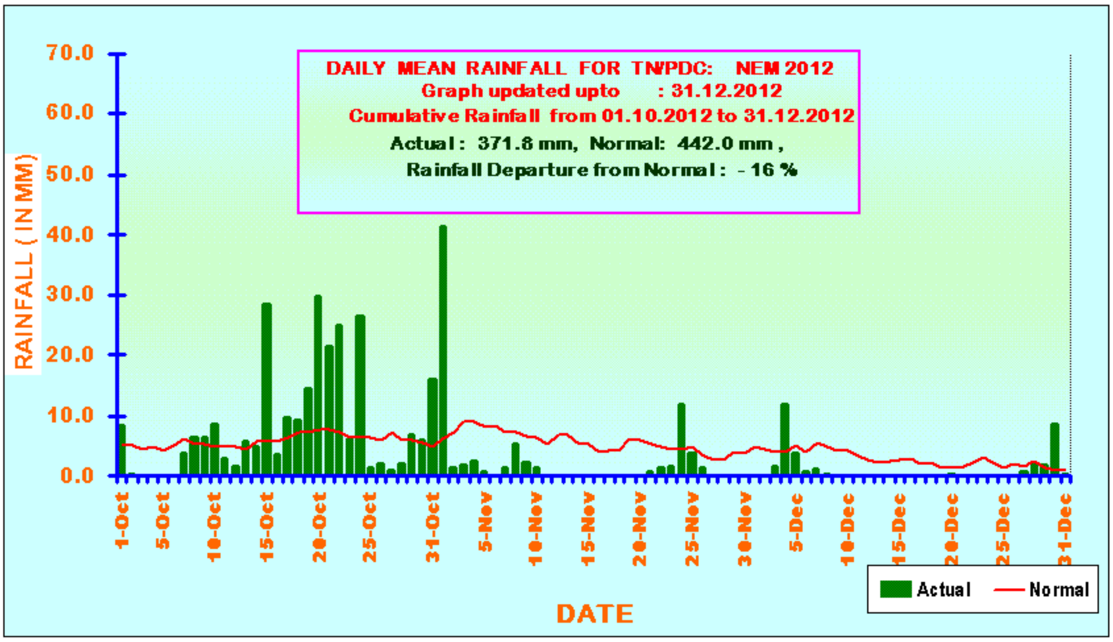

Fig.1. Daily rainfall over Tamil Nadu during 1 Oct-31 Dec 2012

However, thereafter the state of TN experienced a prolonged phase of subdued NEM. Complete dry weather prevailed over TN during 11-20 November, 27 November – 2 December and 8-26 December punctuated by light rain spells in between. The monsoon slightly revived towards the end of December during 27-30 December with one day of vigorous activity. The season ended with a deficit of 16% for TN which realised actual rainfall of 371.8 mm against the normal of 442.0 mm. Thus the state received only 72.1 mm rainfall since the crossing of TC *Nilam.* Out of the 34 districts of TN and Pondicherry, 20 districts realised rainfall PDN of less than -20% termed as deficient rainfall. The rainfall PDN of TN though falls within the category of normal range (i.e. PDN ±19%) can better be described as slight deficient rather than normal.

The 16% deficiency of NRT has been preceded by deficit rainfall in all the three earlier seasons of the year 2012 for Tamil Nadu. Table 1 presents the actual, normal and the PDN rainfall for all the four seasons and also for the entire year. As shown the PDN is -70% for January- February, -33% for March- May, -23% for June-September, -16% for October-December and -23% for the entire year January-December for which the realised rainfall and the normal rainfall are 713 mm and 923 mm respectively. Thus, over all, this year has been a deficient year for TN in hydrometeorological terms which has caused considerable amount of distress for the people of the state especially the farming community. Taken in the context of Tamil Nadu being basically a water stressed but densely populated state, the deficiency assumes ominous proportions.

Table 1
Seasonal and annual rainfall over Tamil Nadu in 2012

Season	**Actual** (mm)	**Normal** (mm)	**PDN %**
Winter (**Jan-Feb)**	9.5	31.4	-70
Pre- Monsoon (**Mar-May)**	86.1	127.8	-33
SW Monsoon (**Jun-Sep)**	246.0	321.4	-23
NE monsoon (**Oct-Dec)**	371.8	442.0	-16
Annual (**Jan-Dec)**	713.0	923.0	-23

PDN: rainfall % departure from normal

3. NRT time series during 2000-12

The NEM is an unstable monsoon with a high 27% co-efficient of variation of NRT. The time series of NRT as PDN during the period 2000-2012 is presented in Fig.2. As shown, NRT has reported negative departure during the period 2000 to 2003 with 2 deficit years (PDN < -20%) in 2000 and 2003 However, since 2004, NRT was above normal for all the years up to 2011. The excess during 2004 was only 1% of PDN but during all subsequent years excess rainfall was substantially high with as many as 5 years *viz*. 2005, 2007, 2009, 2010 and 2011 all registering rainfall in the excess category i.e. PDN $\geq$ 20. The occurrence of 8 years of positive PDN for NRT has been unprecedented in the history of NEM of TN for which, rainfall data are available since the year 1871. Thus the period 2004-2011 was a high NRT epoch of the state receiving bountiful rainfall.

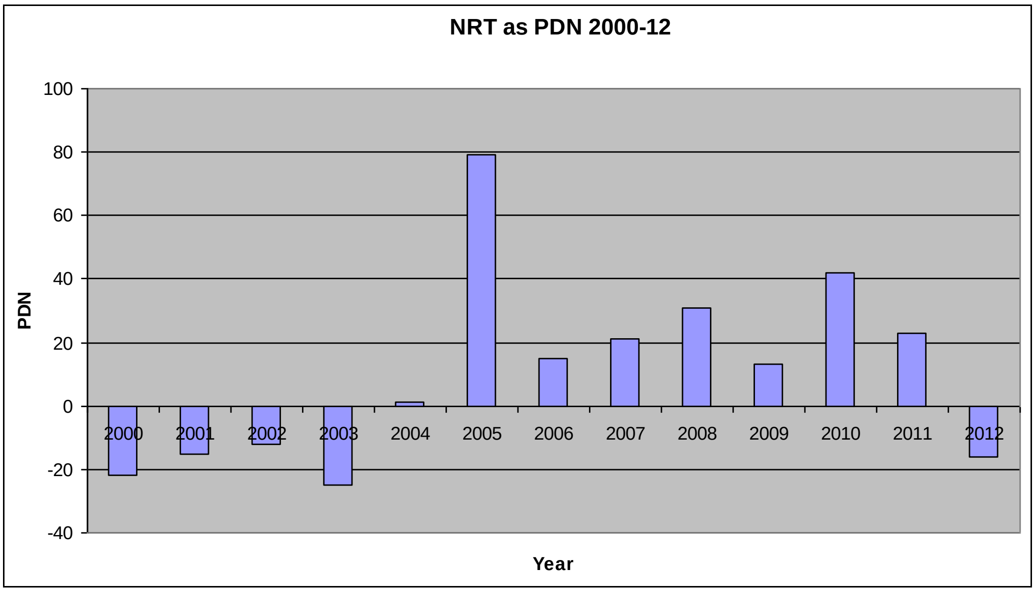

Fig.2. NEM (Oct-Dec) rainfall of TN as % departure from normal (PDN)

Similar epochs of lesser duration have occurred in the earlier years and also in the recent past. The 5 year period 1928-32 (13, 4, 47, 36 & 31% PDN respectively) and the 4 year period 1976-79 (0, 56, 33 & 32% PDN) have seen such high epochal behaviour. However the performance during 2004-2011 had no parallel and obviously such a run of positive events cannot continue indefinitely. The deficiency in 2012 has broken the run which could be called as the correction in the time series of NRT.

4. Seasonal outlook on NRT

Experimental seasonal outlook for NEM rainfall especially over TN has been prepared in RMC Chennai for more than 15 years and internally circulated. These are also sometimes communicated to a restricted set of users as advisories. The outlook on NRT prepared at RMC Chennai and available in the first week of October is based on 6 parameters some of them *Global* some of them *Regional*. These are : Upper tropospheric wind and temperature anomalies over India, performance of southwest monsoon (SWM) over India, strength of tropical easterly jet stream (TEJ) over southern Indian peninsula, Southern oscillation index (SOI), El-Nino Index and the strength of the Siberian high pressure cell. The values of the parameters are taken for the preceding season of SWM of June-September or in some cases even for the pre-monsoon season of March-May. For a detailed exposition on this particular topic, reference may be made to Raj (2011). For the year 2012, wind and temperature anomalies, TEJ and SWM performance provided favourable signals for normal to above normal NRT. Only Siberian high indicated below normal rainfall activity. The ECMWF global seasonal prediction model predicted slight negative departure. Considering that there has been a continuous run of 8 years of positive departures of NRT, the anticipated statistical correction in the time series owing to the law of averages led to expectation of below normal NRT. Taking all these factors into consideration the final outlook was kept as normal which was realised though in the negative category.

5. Intra seasonal variation

Another intriguing characteristic of the relationship between some of the global features and the NEM performance over southern Indian Peninsula is that the relationship itself changes within the season. Negative SOI and El-Nino occurring during June to September or in October favour good NEM, then the relation reverses to opposite viz., positive SOI and La-Nina favour NEM towards the end of December and in January. Though the normal rainfall during December and January is not very high and the intensity of reversed relationship is only modest, the reversal in itself is intriguing as well as interesting. A critical analysis of this type of relationship has been carried out in Raj and Geetha (2008) and the crucial role played by the transposition of sub-tropical ridge at 200 hpa level (STR 200), related location of equatorial trough (ET) at the lower levels of the atmosphere over peninsular India has been prised out. It has been shown that positive SOI/ El-Nino shift the STR 200 towards southern latitudes whereas negative SOI and La-Nina shift them towards north with reference to their normal positions. Now the STR and ET always are in transition during October to January moving from north to south synchronising with the movement of the sun and considering that the region of southern Indian Peninsula influenced by NEM by and large lies between the latitudinal belts of 8-17°N, the reason for reversal of the relation becomes obvious. The STR / ET moving south of the normal position favours good NEM in October / November whereas STR / ET moving northwards favour a good NEM in December or January.

6. Possible reasons for the prolonged dry spell during NEM 2012 of Tamil Nadu

As shown in Fig.1, NEM remained subdued after 1 November with long dry spells which continued in December also. That such long dry spells during NEM are not uncommon and last longer than those of SWM over Tamil Nadu is a fact mentioned in IMD (1973). Table 2 presents the monthly values of SOI and the SST anomalies over the Nino 3.4 area, which is taken as the El-Nino Index, for the period June-December 2012. The slight negative SOI which prevailed during June-August and the development of a moderate El-Nino in September were favourable factors for the Indian NEM in its initial phase. The prevalance of positive Nino 3.4 SST anomalies during November and the development of negative SOI in December have been unfavourable for good NEM activity in December (Fig.1).

Table 2

Monthly variation of SOI and Nino3.4 SST anomaly during June-December 2012

Month	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
SOI	-10.4	-1.7	-5.0	2.7	2.4	3.9	-7.4
SST anomaly (°C)	0.10	-.03	0.18	0.61	0.47	0.85	0.00

To explore this aspect a bit further we present in Fig.3, the SOI values during 2-31 December 2012 (source: www.longpaddock.2ld.govt.in – Queensland Government website). The figure shows substantial negative values of SOI during 7-19 December 2012 with SOI < -20 on 7 days and then reversal to positive SOI since 20 December. As shown in Table 2 the SST anomalies are significantly positive during September, October, November and dropped to zero in December. Thus it appears that SOI and El-Nino favoured NEM in its initial stages resulting in enhanced activity over the Peninsular region especially over Tamil Nadu in October. However the continuation of positive SST anomalies in November and also negative anomalies of SOI in December obviously did not help good NEM activity as elucidated in the previous section. The reversal of SOI during December was favourable for prolonged monsoon up to the end of December and possibly into the first half of January 2013. It has been shown in Raj and Geetha (2008) that late withdrawal incidences of NEM are frequently associated with positive SOI phase whereas prevalence of negative SOI in December is associated with abrupt NEM cessation.

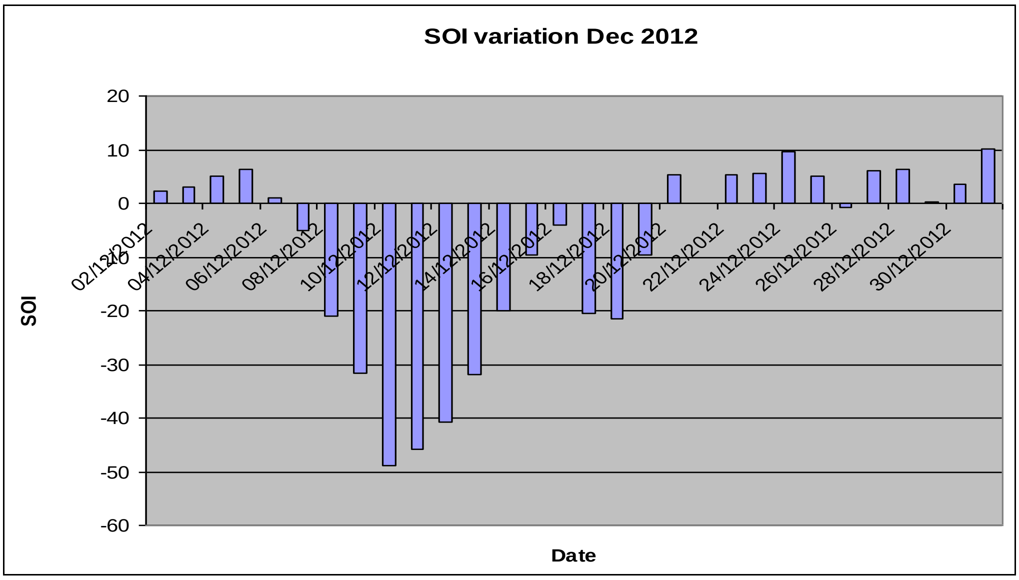

Fig.3 Variation of southern oscillation index, 2-31 Dec 2012

The monthly global October to December 2012 distribution of parameters such as OLR, divergence and precipitable water content are in conformity with the pattern of intra-seasonal variation of this year NEM. Over Southern Indian Peninsula, Upper air divergence was more in October than in November. OLR anomalies were negative in October and positive in November. In November and December the equatorial trough was aligned towards lower latitudes as revealed from the spatial distribution of OLR and precipitable water.

7.Concluding remarks

During the northeast monsoon season of 2012, Tamil Nadu registered 16% below normal rainfall thus ending the unprecedented positive run of above normal rainfall events realised every year for the period since 2004. The seasonal outlook which was experimentally prepared proved to be partially correct but obviously much more research work and development needs to be undertaken for issuing of authentic seasonal forecasts on NEM rainfall to the users on real time basis. The variation of two important global features namely SOI and El-Nino has thrown some light into the initial better performance of NEM, the subsequent very subdued activity and the mild revival towards the end of the season.

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NATIONAL DATA BUOY NETWORK AND ITS ROLE IN WEATHER FORECASTING

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The Data buoys provide reliable real-time meteorological and oceanographic data to forecasters and the general public. Moored data buoys in the northern Indian Ocean have repeatedly provided crucial upstream intelligence in support of forecast. Buoy data can be used for accurately to assess storm strength, wind speeds, and sea conditions before storms make landfall and permit forecasters to compare model prognoses to ground truth. The northern Indian Ocean (IO) is characterized by a strong annual cycle of surface winds associated with the Asian monsoon while the equatorial IO is characterized by a semiannual cycle. The special character of the surface winds in the IO is responsible for a mean sea surface temperature (SST) distribution. The important role of Sea surface temperature and near surface heat content on the evolution of monsoons and cyclones has been reported in many recent publications.

The National Institute of Ocean Technology under the Ministry of Earth Sciences have strengthened the ongoing moored buoy programme and this network was revived in 2011. There was a scientific need to augment the existing met – ocean buoys with underwater sensors to record vertical profiles of temperature, salinity and current in the Bay of Bengal and Arabian Sea.. This buoy system was augmented with subsurface sensors, Solar radiation and Rainfall sensor called as Ocean Moored buoy system for Northern Indian Ocean (OMNI). Eleven of these OMNI Buoys are transmitting data real-time in GTS in addition to existing 7 Met ocean buoy systems.

This next Generation Moored buoys were deployed having equipped with subsurface sensors to measure the vertical structure of temperature and salinity at discrete depths (5, 10, 15, 20, 30, 50, 75, 100, 200, 500 m) and current sensors to measure vertical profiles of currents at discrete depths (1.2, 10, 20, 30, 50 , and 100 m). Now these buoys have been providing valuable data for operational agencies and serve sea truth validations of satellite data. The OMNI data buoys serve as observatory, which provide all this surface marine, meteorological parameters that go into weather prediction models for improved forecasts. These OMNI buoy data would be very useful to predict the evolution of summer and winter monsoons, the life cycle of monsoon lows, depressions, deep depressions, cyclone and severe cyclones, which mostly originate over the Bay of Bengal. The subsurface measurements can be used to study the Kelvin and Rossby waves in the Indian Ocean. The availability of time series data on surface met-ocean parameters and near surface thermohaline structure provides unlimited opportunities for research scientists to describe and explain the variability on different time scale. Studies related to warm and cool pools and fresh water pool are being carried out to explain their genesis, evolution and decay in certain regions of the Arabian sea and the Bay of Bengal. This buoy net-work provides very valuable sea truth data to validate the satellite measurements and model prediction.

We know satellites can provide SST and estimates of surface wind, sea state, and sea-level where near- or onshore features do not interfere, and radars, ship-based systems, aircraft, and other serendipitous sources of environmental observations are sometimes available, weather forecasters nonetheless require data from buoy network. The main purpose of the network is to provide reliable, accurate, and cost-effective atmospheric and oceanic observations in support of weather forecasting.

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News from other chapters ....

The *Indian Meteorological Society, Pune Chapter*, proposes to organise a two a day workshop on "**Southwest monsoon 2012**" in second / third week of **February 2013** at Pune. The theme of the workshop is based on '**Understanding of summer monsoon over Indian sub continent**'. The organising committee has called for papers for oral presentation (15-20 minutes) from students working in related fields. The selected students will be provided with to and fro AC three tier (including Tatkal charges) train fare along with support for lodging and boarding. The event is fully sponsored by the Ministry of Earth Sciences, New Delhi. The exact date, time and venue would be communicated in due course.

The abstract of papers (not more than one page) has to be sent to the following office bearers latest by **25th January 2013** by e-mail:

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MONSOON LOW LEVEL INVERSION FROM METOP SATELLITE

by

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Monsoon low level temperature inversion over western Arabian sea was first detected from ship upsonde observations during International Indian Ocean Experiment (IIOE) by Colon (1964). It was detected from satellite observations, albeit the coarse vertical resolution (~ 2 km) of TIROS-N satellite sensors, during MONEX 1979 by Narayanan and Rao (1981). They had detected this feature using a simple differencing technique

$\Delta T = T\ (skin) - T\ (850\ mb)$

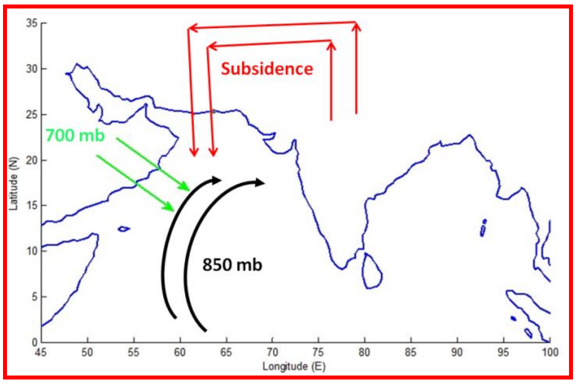
This was possible to be detected from satellites because of the relatively large spatio - temporal nature of monsoon inversion. Using a large number (around 150) of MONEX 1979 period ship upsonde and aircraft dropsonde profiles, concurrent with satellite data, Narayanan and Rao showed that $\Delta T < 2$ K in satellite temperature data are associated with temperature inversion over Arabian sea.

Some important features of monsoon inversion are that they are:

- commonly observed over western Arabian sea west of 65º E during southwest monsoon,
- decrease in strength and vertical extent as one goes from west to east,
- traps moisture below 850mb level
- extent oscillates from west to east longitudes with activity of monsoon.

The two suggested causes of inversion are (Fig.1a): (i) advection of warm air from Arabia at the level of around 700mb riding over cool maritime air flowing from south Indian Ocean at lower levels and (ii) subsidence of air over Arabian sea associated with convection over Indian land mass.

In the present study, we have used temperature and humidity profile data from Infrared Atmospheric Sounder Interferometer (IASI) instrument onboard METOP satellite (Fig.1b). This satellite was launched in 2006 by ESA in a sun synchronous orbit (as a complement to NOAA of USA). It has an orbital height of 817 km and has two passes per day over tropical latitudes with a nominal swath of ~ 2200 km. IASI measures the upwelling radiation from the earth – atmosphere system in 8461 narrow channels by a Fourier Transform Spectrometer in the 3.6 to 16.5 micron carbon dioxide and water vapour absorption bands. It has best vertical resolution among the contemporary satellite sounding instruments. The operational products (temperature and humidity) from IASI are available at 90 pressure levels up to stratospheric heights. They are available at vertical resolution of about 300 – 400 m from surface to about 600 mb, beyond which they are much degraded.



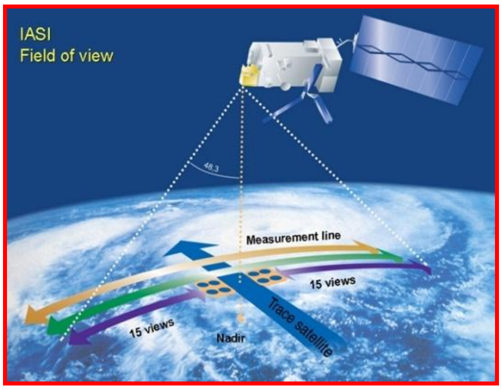


Fig 1(a) Fig 1(b)

Fig.1 (a) Schematic diagrams depicting causes of low level temperature inversion during monsoon (b) Field of view of Infrared Atmospheric Sounder Interferometer (IASI) onboard METOP satellite

In the present analysis, we have used a new parameter, atmospheric refractivity (N), which incorporates the effects of both temperature and humidity. The expression used for N at any level is

$$N = 77.6\left(\frac{P}{T}\right) + 3.73 \times 10^5\left(\frac{e}{T^2}\right)$$

where P is pressure, T is Temperature and e is vapour pressure. Following Narayanan and Rao (1981), we are using besides ΔT (< 2 K), a new index ΔN = N (1000 mb) - N (850 mb) for delineating inversion.

Figure 2(a) shows the longitudinal variation of atmospheric temperature over Arabian sea from IASI data at three different levels viz 1000 mb, 850 mb and 700 mb in the latitudinal belt 15 – 17 N. It can be assessed from this figure that the inversion region is confined between about 950 mb and 800 mb. Figure 2(b) shows the variation of ΔT and corresponding ΔN for a typical day., from which the opposing trend of the two parameters can be seen. Whereas ΔT ranges about 6º C in this longitudinal domain, ΔN varies by about 12 - 15 N units, showing that it has a better dynamic range to detect inversion. Figure 2(c) shows the longitudinal variation of midlevel moisture in the same domain, for an inversion and a non-inversion day (criterion ΔT < 2 K). It can be seen that moisture gets trapped at lower levels by about 20% at the western longitudes during inversion.

In Fig 3, we have shown the behavior of a new parameter MR (indicative of suppression of convection of moisture to higher levels), defined as ratio of total precipitable water to precipitable water in the middle levels (700 – 500 mb). The suppression of moisture to lower levels on an inversion day over the Arabian sea is well brought out (Fig 3 a) compared to a normal day (Fig 3 b).

Fig.4 shows the ΔT comparison for good (2011) and poor monsoon (2009) years over a selected grid of the western Arabian Sea. ΔT is observed to be lower by about 2 K during the season as a whole during the poor monsoon year vis – a – vis a good monsoon year, suggesting the possibility of an interannual variation of this parameter.

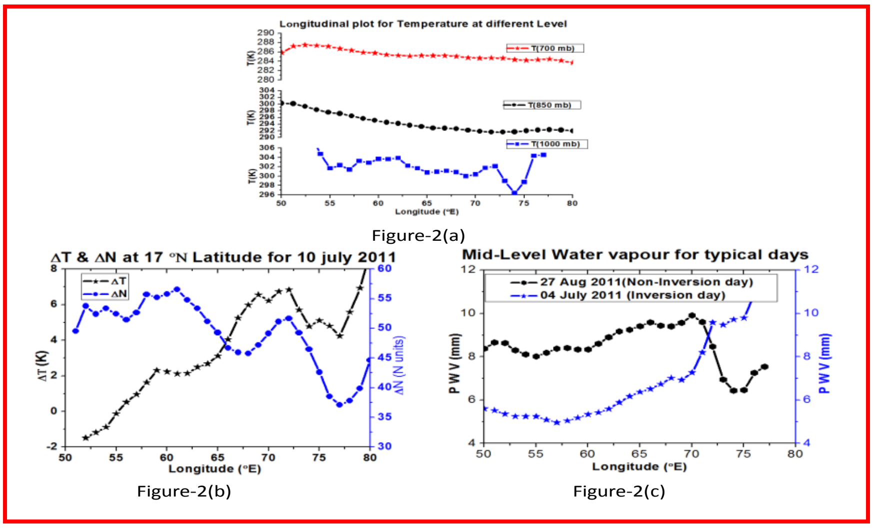


Fig 2: Longitudinal variation of some important parameters

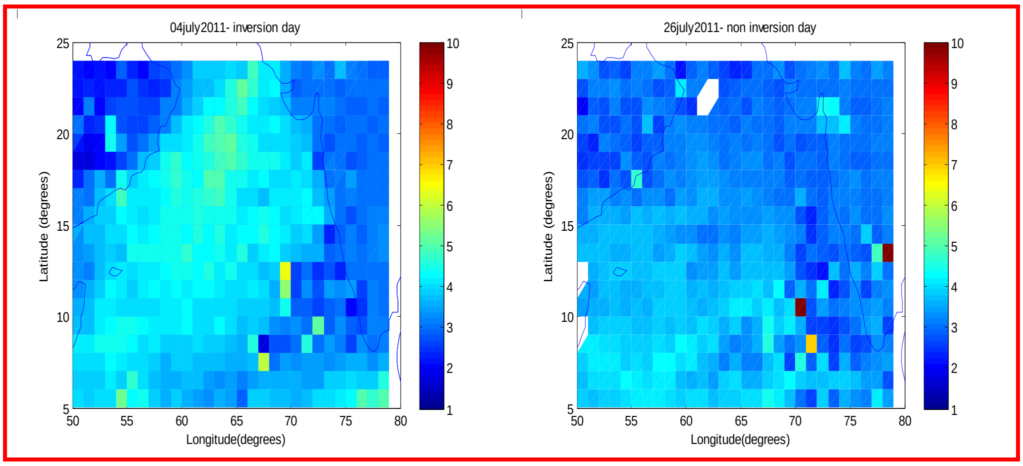


Fig 3(a) Fig 3(b)

Fig. 3 Ratio of total moisture to mid level moisture during an inversion and a normal day

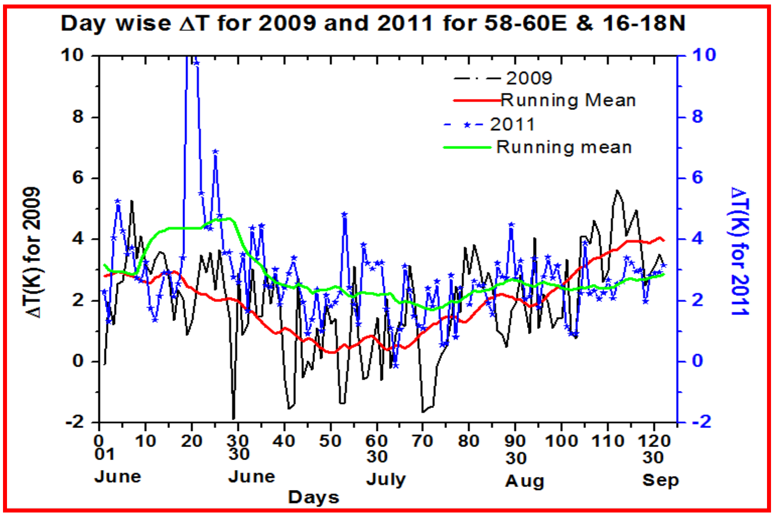


Fig.4 Intra-seasonal variation of ΔT during two contrasting monsoon years

Fig.5 shows a plot of ΔT and ΔN for active and break spells during the monsoon of 2009. We can see from ΔT map that during the break spell, a large part of Arabian sea is covered with inversion region up to ~ 68 E. Inversion is observed to be west of 65 E during the active spell; however, the ΔT map is patchy. Comparing corresponding ΔT and ΔN maps by pattern matching, we see that ΔN > 65 N can be additionally used for inversion delineation.

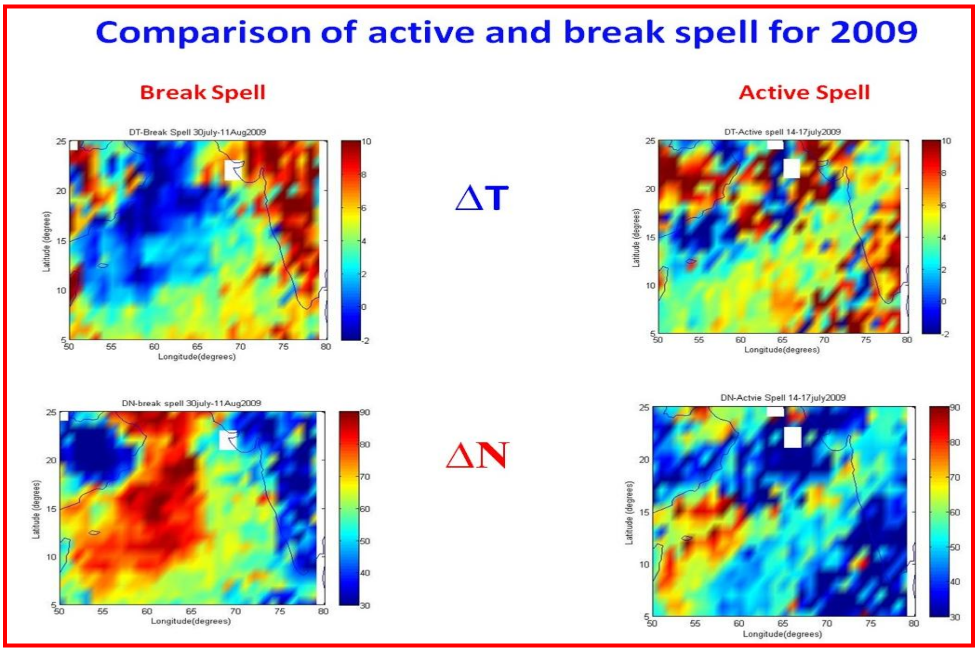


Fig.5 ΔT and ΔN variations over Arabian sea during an active and break spell

In conclusion, it is suggested from the analysis of the limited two years data, that regions with ΔN > 65 N units could be classified as inversion regions over the Arabian sea. ΔN is seen to delineating inversion regions in a better manner when ΔT maps are patchy. We are currently carrying out detailed analysis of IASI data for all available seven years (2006 – 2012) to study the interannual and intraseasonal aspects of monsoon inversion.

This work is part of the ISRO sponsored project for the study of Monsoon Inversion from INSAT – 3D satellite, to be launched in 2013.

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A REVIEW OF NORTHEAST MONSOON 2012

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After eight successful monsoon performances in succession, how it would perform in the ninth year? Perhaps Tamil Nadu/Puducherry (TN/PDC) subdivision had the best phase of positive epoch in terms of monsoon activity (Five years of excess and three years of normal rainfall). As far as seasonal forecast, only ECMWF showed rainfall activity on the negative side of the normal (of the order of 5 cm below normal) and all other models were on the contrary.

Southwest monsoon withdrew from the entire country on 18th October. A trough of low pressure formed in Andaman Sea and it drifted westwards and resulted in the commencement of Northeast monsoon on 19th October 2012 and TN/PDC subdivision experienced *Active/Vigorous* monsoon condition from 19th to 22nd October. This system further moved westwards in Arabian sea and gradually strengthened in to a Cyclonic Storm "*Murjan*". This system crossed Somali coast before dissipation.

On 25th October, a trough of low pressure formed in north Andaman Sea. It progressively strengthened in to a cyclonic storm. Cyclonic storm "*Nilam*" crossed close to Kalpakkam (Lat12^{0}27'N & Long 80^{0}09'E) on 31st October between 16.10-16.40 hrs IST. Active rainfall situation occurred in Coastal Tamil Nadu (CTN) / PDC on 29th October and in North TN (NTN) / PDC on 30th October and it was vigorous in NTN/PDC on 31st October and 1st November. The system, after making the landfall moved further north westward and weakened gradually. The entire rainfall belt shifted northwards and an east-west shear line could be located across Karnataka and Andhra Pradesh and it resulted in vigorous monsoon situation over Coastal Andhra Pradesh (CAP) till 3rd November. In the week ending 07/12/2012, CAP, Rayalaseema and South Interior Karnataka (SIK) exhibited a departure of 491,165 and 396 percent respectively. It is the only week during which SIK had positive performance.

The cyclonic disturbances were traversing in the low latitudes and relatively dry weather conditions prevailed in the peninsula during November and December. A trough of low pressure could be located in the southeast bay. The system moved towards higher latitudes and gradually strengthened to a Deep Depression level and it was located 950Km NNE of Chennai on 18th November, it gradually weakened and was steered by low level winds in south westerly direction towards South Andhra –North Tamilnadu coast and became a trough of low pressure on 23rd November. During its northerly sojourn, southern peninsula experienced practically dry weather. A typhoon named "*Baupho*" wreaked havoc in Philippines. It drew the moisture from bay side and saw to it that no system emerged from South China Sea in the bay. Thus November 2012 became a poor month in terms of monsoon performance.

A trough of low pressure, which formed on 25th November over north Andaman Sea, moved west and resulted in scattered rainfall activity in TN/PDC subdivision but performed well in south Coastal Andhra Pradesh & Rayalaseema. In the week ending 05/12/2012, CAP and Rayalaseema exhibited percentage departure of 144 & 175 respectively. Subsequently, most of the systems were traversing in the low latitudes and did not generate good rainfall activity in the peninsular region.

Regarding the performance of northeast monsoon over Tamil Nadu/Puducherry subdivision, practically the major contribution came during the two weeks with week endings on 17th and 24th October 2012. Even though the monsoon rains commenced around 19th October, a system in the Lakshadweep area generated good rains over Tamil Nadu. During these two weeks TN/PDC subdivision recorded a percentage departure of 48 and 167. In all other weeks, it was on the negative side of the normal or deficit or scanty.

As far as Kerala is concerned, only one week ending 14/11/2012 was in excess and two initial during onset phase recoded normal. In marked contrast, all other weeks recorded either deficit or scanty.

At the end of the season, though TN/PDC as well as Rayalaseema subdivisions, recorded normal rains, but on the negative side. Kerala and SIK subdivisions recorded deficit rains. Thanks to the remnant of CS "*Nilam*", CAP subdivision recorded excess.

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PERFORMANCE OF STATISTICAL PREDICTION MODEL ON SEASONAL CYCLONIC ACTIVITY OVER NORTH INDIAN OCEAN

by
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The Northeast monsoon season of October to December (OND) is the primary season of cyclonic activity over the North Indian Ocean (NIO). Reliable forecasts of seasonal cyclonic activity (CA) over the NIO would serve as important inputs for civic administrator and disaster managers. Balachandran and Geetha (2012) have developed a statistical model for predicting CA during OND over the NIO as a modest and maiden attempt towards generating forecasts of CA over the NIO which would serve as important inputs for preparatory and mitigation action plans for the ensuing cyclone season.

The model has been developed by identifying predictors from amongst well known climate indices and regional circulation features of the 30 year period of 1971-2000 and tested for an independent period of 2001-2009. Here, the CA is expressed as the number of days of cyclonic disturbances over the NIO that includes the stages of Depression (D), Deep Depression (DD), Cyclonic Storm CS), Severe Cyclonic Storm (SCS), Very Severe Cyclonic Storm (VSCS) and Super Cyclone(SuCS) and is generally referred as ***CD days***.

Based on a 30 year (1971-2000) mean (20 days) and standard deviation (8 days) of CA over NIO, the following classification is employed to express CA qualitatively:

No. of CD days less than 12: ***subdued CA***
No. of CD days between 12 and 16: ***below normal CA***
No. of CD days between 16 and 24: ***Normal CA***
No. of CD days greater than 24: ***above normal CA***

Prediction is based on significant correlations between the number of CD days and regional circulation features defined below as prediction parameters (***PR****) and depicted in Fig.1:

PR1: meridional wind at 200 hPa over 95-105˚E & 5˚S to 2˚N during August (v200)
PR2: zonal wind at 200 hPa over 30-42˚E & 7˚S to 5˚N during August (u200)
PR3: SST over 46-56˚E & 38-34˚S during July & August
PR4: zonal wind at 700 hPa over 73-80˚E & 5˚S to Equator during August (u700)

The above parameters refer to the same calendar year as the year for which prediction is made.

The statistical parameters of the predictors *PR1*, *PR2*, *PR3* and *PR*4 and their relationship (expressed as Correlation Coefficient, CC) with CA during OND over NIO, based on data of 1971-2000 are given in Table 1.

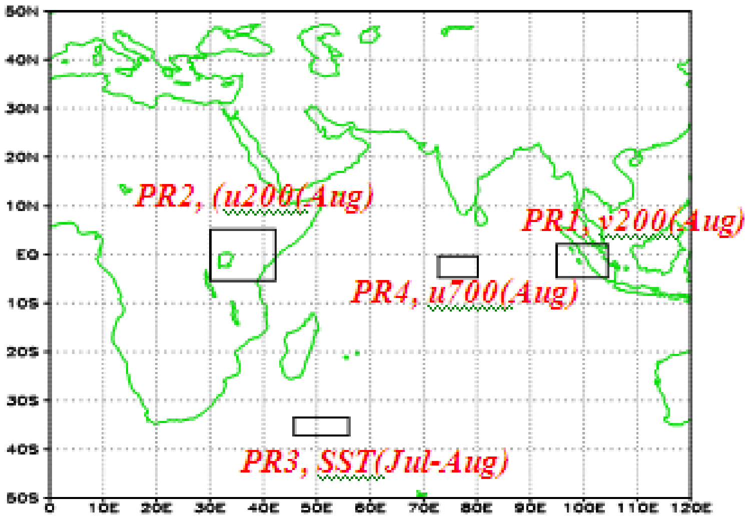

Fig.1 Locations of the predictors chosen

Table-1
Statistical parameters of the predictors

Parameter	Mean	Std. Deviation	CC with CD days /CA
PR1, *v200 (Aug)* *(95-105˚E & 5˚S to 2˚N)*	-7.31 m/s	1.35m/s	0.65**
PR2, *u200 (Aug)* *(30-42˚E & 7˚S to 5˚N)*	-7.98 m/s	2.61m/s	-0.59**
PR3, *SST (Jul-Aug)* *(46-56˚E & 38-34˚S)*	16.68˚C	0.29ºC	-0.57**
PR4, *u700 (Aug)* *(73-80˚E & 5˚S to Equator)*	4.74 m/s	1.84m/s	0.40*

**: significant at 1% level; *: significant at 5% level

Using the above prediction parameters, a qualitative outlook on seasonal cyclonic activity during OND over the NIO is prepared every year on experimental basis (in real-time; by September) to get an idea of CA during the ensuing cyclone season and the same is validated at the end of the season. The outlook is based on the following two schemes:

(i) **Conditional means of number of CD days for various intervals of the predicting parameters PR1,PR2,PR3 and PR4 .**

(ii) **Multiple regression equation with the same predictors PR1, PR2, PR3 and PR4**

A performance report of the model predictions during the years 2010-2012 are presented in Table 2.

Table-2
Evaluation of model predictions for the years 2010-12

Year	Predictor value and prediction of Seasonal cyclonic activity (No. of CD days) by the predictor				Prediction by MR equation	Final Outlook	Observed	Remarks on model prediction
	PR1	*PR2*	*PR3*	*PR4*				
2010	-5.3 m/s; Above normal	-7.0 m/s; Normal	16.8˚C; Below Normal	6.1 m/s; Normal	21 days; Normal	16-24 days; ***Normal***	15 days; ***Below Normal***	Not correct
2011	-7.1 m/s; Normal	-10m/s; Normal	16.3˚C; Above normal	1.2 m/s; Normal	22 days; higher side of Normal	16-24 days; ***Normal***	24 days; **higher side of *Normal***	Partly correct
2012	-9.7m/s; Below normal	-7.2m/s; Normal	16.8˚C; Below Normal	0.89 m/s; Below normal	11 days; Subdued	12-16 days; ***Below normal***	15 days; **Below normal**	Correct

For the purpose of evaluation, the observed number of CD days is determined from the best track data / published reports of India Meteorological Department (Annual Cyclone Review reports / Preliminary report on each cyclone etc.). Here, the days on which the cyclonic disturbance is very short-lived (i.e., at most for 3 hours) are excluded while determining the number of CD days.

From Table 2, it may be noted, the parameter ***PR3***, viz, ***SST over 46-56˚E & 38-34˚S during July & August,*** has predicted more correctly than the other parameters during all the three years. The **MR equation** is also able to give a good indication on the ensuing seasonal cyclonic activity.

Thus, despite the known limitations of statistical models such as secular variations of correlation, choice of optimum number of predictors, test period etc., predictions of the seasonal cyclonic activity over the North Indian Ocean every year based on the above model is encouraging to continue the exercise on real-time basis to get a likelihood scenario of the ensuing cyclone season until more precise and accurate dynamical models are developed for prediction of seasonal cyclonic activity over the NIO.

Reference

Balachandran S. and Geetha B., 2012, “Statistical prediction of seasonal cyclonic activity over the North Indian Ocean”, *Mausam*, **63**, 1, 17-28.

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SURFACE OZONE ANALYSER AT KODAIKANAL

by
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The catchy phrase "Ozone good up high, bad nearby" of the Environmental Protection Agency(EPA), United States of America(USA) highlights succinctly the background and keen interest evinced by scientists around the globe, in measuring and having a watchful eye on the amount of ozone in the surface level. Yes, of course, all of us are aware of the depleting ozone layer in the stratosphere and the ozone hole over Antarctica! Thanks to the global efforts in minimizing the emissions of ozone depleting substances(ODS), the thinning of the ozone layer has been controlled in the recent years.

India Meteorological Department (IMD) has a network of air pollution monitoring stations and a few of them have ozone analysers. Surface ozone analysers are installed at various locations all over India. In Tamil Nadu, Kodaikanal (10º14'N / 77º 28'E) located 2343 metres a.m.s.l is the only surface meteorological observatory which has the ozone analyser. The observatory is functional since 1891 within the premises of the subsequently established Indian Institute of Astrophysics(IIA) and surface ozone measurements are made here since the early 1970s. The Brewer Spectrophotometer was in use for a long period in Kodaikanal providing valuable ozone data though now it is not in use but preserved safely, nicely tucked in the "Brewer hut" in a picturesque hillock there. Then came the electrochemical conventional surface ozone anlayser which is operational even now in Kodaikanal.

As a modernization activity, state-of-art surface ozone analysers imported from M/s Ecotech, Australia, through Envirotech Instruments Pvt. Ltd., Hyderabad. have been installed by IMD in nine locations during the year 2012, viz., Guwahati, Kodaikanal, Nagpur, New Delhi, Port Blair, Pune, Ranichauri, Thiruvananthapuram and Varanasi. Surface Ozone Analyser is a Serinus Model No.10 Ozone analyser which is completely automated and requires minimum maintenance. However, calibration of the system is required to be performed once in a month, the process taking at least 6-8 hours of a day.

The author was part of the Site Acceptance Test conducted during 25-26 October 2012 by a three member Committee which comprised including her of Shri. Siddhartha Singh, Scientist-C, Environmental Monitoring and Research Centre (EMRC), New Delhi and Shri.V.Pandy, S.A. in-charge, Met.Unit, Kodaikanal. The motivation to write this article is to bring an awareness about ozone and its effects.

Ozone (O3) a word derived from the Greek "ozein", meaning "to smell") is a pungent gas present naturally in the atmosphere, 90 % of which is found in the stratosphere(16 to 50 km upward) and around 10 % is seen in the troposphere (ground level up to approximately 16 km). Stratospheric ozone is formed in chemical reactions involving ultraviolet(UV) radiation from sunlight and oxygen (O2) molecules which constitutes 21 % of the composition of the atmospheric air. Sunlight breaks one O2 molecule to produce two oxygen atoms (2 O). Each of these atoms combine with an O2 molecule and produce O3 molecule. These reactions continue in the presence of UV and O2. The presence of O3 in the stratosphere is good for us because it helps as a protective shield against harmful UV radiation reaching the ground level. Depletion is a matter of concern because of our susceptibility and exposure to harmful UV radiation.

Normal levels of O3 in the stratosphere are about 12,000 molecules for every billion air molecules (1 billion = 1000 million). In the troposphere, near the Earth's surface, O3 molecules in each billion air molecules typically vary between 20-200. In other words, 20-200 parts per billion (ppb) is the typical value of O3 in air. In less polluted air, the values hover in the lower range and in highly polluted industrial cities the values touch the higher range and go up to 80 or even 120 ppb, one such city being New Delhi where the suspended particulate matter and O3 are higher than the permitted levels in the environment.

In recent years, due to anthropogenic causes, the levels of O3 in the ground level are alarmingly increasing because of O3 forming in air polluted by steady emissions like Chloroflurocarbons (CFCs), oxides of Nitrogen (NOx), volatile organic compounds from cars, industries, air conditioners and such other modern gadgets. O3 has now become a major greenhouse gas apart from CO2, methane and water vapour. As we normally tend to think, O3 measurements are required in highly polluted areas to know the extent of generation of O3 at surface level as it is known to have adverse effects on health. Suppressed immunity responses, respiratory, eye problems, and worsening of pre-existing health conditions of the heart and lungs in human beings are some of them. Excessive exposure is harmful to green cover as well since crop yield and forest growth is reduced.

For the inquisitive mind, it is food for thought to know that a hilly station like Kodaikanal is considered most appropriate for ozone measurements since they are best suitable to understand the transport effect of pollutants. A comparison can then be made about the extent to which winds and other atmospheric factors play an important role in circulation of the air and the pollutants in it.

The Serinus ozone analyser sucks the air around through a pipe exposed to the atmosphere, combines microprocessor control with UV photometry to provide accurate measurements of ozone in the ambient air. The filter needs periodic cleaning or replacement for accuracy in the data. A dedicated broadband connection along with a static IP address are basic requirements for the Ozone analyser to facilitiate EMRC, New Delhi in downloading / retrieving the data daily. MU Kodaikanal had obtained the static IP address for the existing modem and upgraded the internet connection. TCP/IP port number of the analyser is assigned along with an IP allocated locally to the analyser.

Shri.Siddhartha trained the officials of MU Kodaikanal in the operation, maintenance of the analyser, calibration process, downloading the data(using the Serinus downloader software installed in the PC) and emailing it to Delhi in case of any problem in network connectivity etc. The representative of the firm M/s Envirotech was also present to sort out the problems in general and to ensure data retrieval from the analyser in particular. The SAT Committee members did the formal checks and signed the report. Verification about remote access and retrieval of data by EMRC officials at Delhi was made. On a daily basis data is downloaded by EMRC using a customized software.

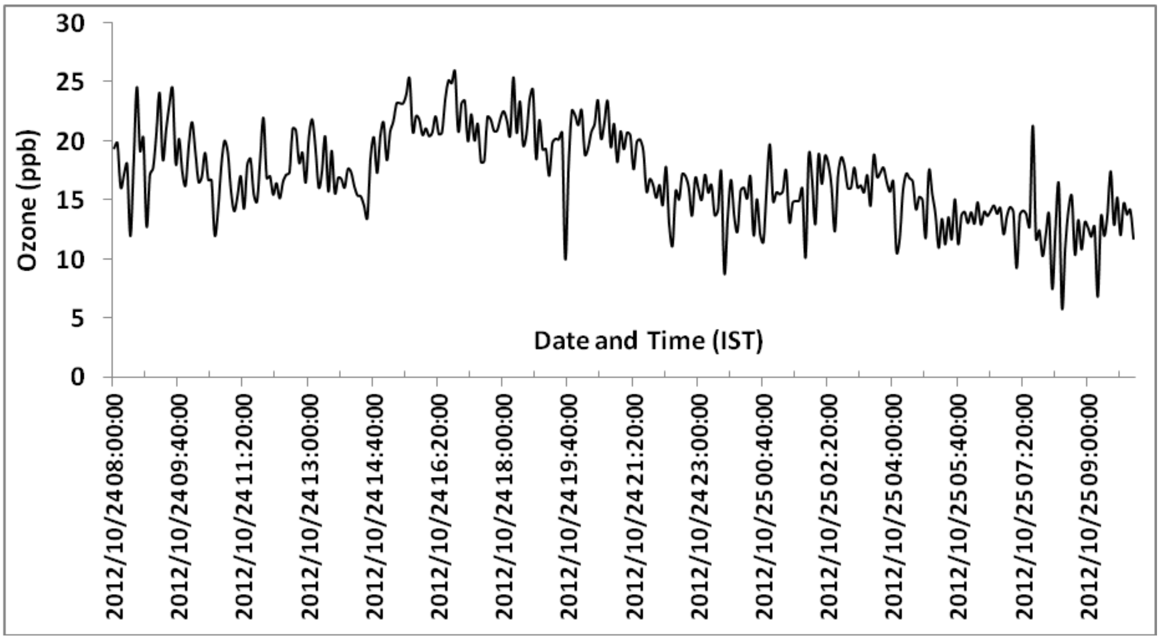

Fig.1 Ozone at the surface level in Kodaikanal during 24-25 October 2012

During the period of testing, the values of ozone in the air ranged from 20 to 30 ppb during 25-26 October 2012 (Fig.1) which appears to be very well within normal limits. A seasonwise analysis would provide plausible evidences of the ambient ozone in Kodaikanal. The values were compared and validated with the conventional type of ozone analyser and both were found to be equal. The staff of MU Kodaikanal were imparted training in calibration process so that they can independently take up the calibration work regularly once in a month. In the presence of the representative of the firm and the SAT members, the officials of Kodaikanal operated the equipment independently on their own to gain confidence in operating the system.

The presence of the Surface Ozone Analyser in Kodaikanal and continuous monitoring of ozone levels stands as a constant reminder to us in Tamil Nadu so that we can avoid, to the extent possible, being the cause for increasing the levels of O3 in the surface level. Any amount of increase is a cause of concern due to its detrimental but silent effects on health which manifest adversely in the long run.

The fresh air in Kodaikanal which gave new strength to the lungs, the excellent hospitality of Dr.Sundararaman, Director and Scientist-in-charge, IIA, his words of wisdom, homely warmth, wit, the silent and noble services done by him in popularising astronomy among students, a visit around the awesome facilities in the astronomical observatory, nostalgic memories of the facts leading to shifting of the Madras observatory (our own Nungambakkam astronomical observatory, formerly called "Nakshatra Bungalow" in view of its historical importance since 1792) to Kodaikanal and the establishment of the Solar Physics observatory there in 1899, and last but not the least, the unforgettable care and affection of our IMD colleagues in Kodaikanal surface meteorological observatory who perform their duties in such tough terrain and cold weather conditions, all made this visit personally for me, as one of the best and memorable official tours!

The International Day for preservation of Ozone layer is celebrated every year on 16 September, the day when Montreal Protocol came into being. Let us, as responsible individuals ensure that the atmosphere is not polluted by our insensitivity towards Mother Earth and more so, in particular, preserve the natural resources around us without abusing them for our selfish reasons.

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Met … Wit ….from Net (contributed by Johnson Lukose)

In America ….

It was autumn, and the Red Indians on a remote location asked their new Chief if the winter was going to be cold or mild. Since he was a Red Indian Chief in a modern society, he had never been taught the old secrets, and when he looked at the sky, he couldn't tell what the weather was going to be. Nevertheless, to be on the safe side, he replied to his tribe that the winter was indeed going to be cold and that the members of the village should collect wood to prepare for the cold winter.

But also being a practical leader, after several days he got an idea. He went to the phone booth, called the National Weather Service and asked "Is the coming winter going to be cold?"

"It looks like this winter is going to be quite cold indeed," the meteorologist at the weather service responded.

So the Chief went back to his people and told them to collect even more wood in order to be prepared. A week later, he called the National Weather Service again. "Is it going to be a very cold winter?"

"Yes," the man at National Weather Service again replied, "It's definitely going to be a very cold winter."

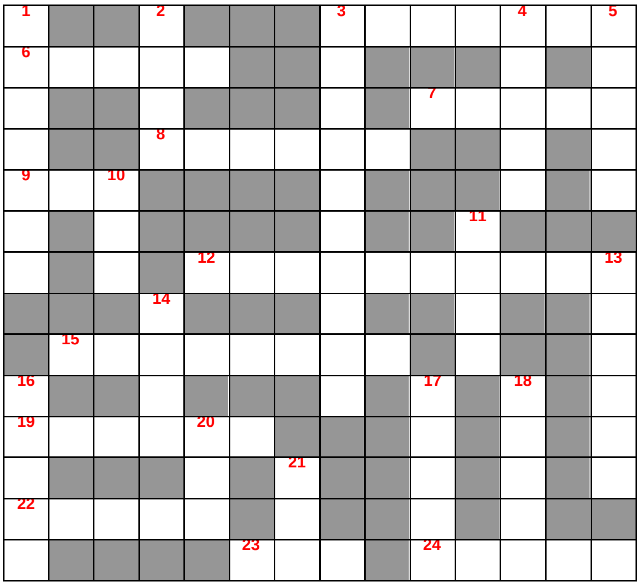
The Chief again went back to his people and ordered them to collect every scrap of wood they could find. Two weeks later, he called the National Weather Service again. "Are you absolutely sure that the winter is going to be very cold?"

"Absolutely," the man replied. "It's going to be one of the coldest winters ever."

"How can you be so sure?" the Chief asked.

The weatherman replied, "The Red Indians are collecting wood like crazy."

WEATHER PUZZLE



Across

3 – violent funnel
6 – co-ordinate system using angles
7 – bridge the higher elevation
8 – scientist who studied giant meanders in high altitude winds
9 – acronym for offices in aerodromes
12 – dot product indicates exit
15 – what is longest day for one half would be shortest for other half
19 – area where climatology would be first used while designing an airport
22 – one blade of pair of large scissors in synonym with forces which lead to deformation
23 – only stronger systems would have this
24 – indicates distance down or across

Down

1 – effect of buoyancy
2 – acronym for dry rate of decrease with height
3 – chaotic air flow
4 – what is SHAMAL in Middle East is----- in India
5 – stationary block
10 – acronym for synoptic chart
11 – transfer it through thermal interaction
13 – ability to work
14 – motion of fluid particles
16 – deposit solidly from vapour
17 – visible manifestation of thermodynamic process in the atmosphere
18 – acronym for the European satellite in operational meteorology
20 – if it moves, you feel it
21 – celestial sphere

S.R.RAMANAN

WOMEN OPTING FOR A CAREER IN METEOROLOGY - AN INDIAN SCENARIO

by

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An interesting and motivating feature in the career pattern of women since Independence is their increasing entry into non-traditional services and professions. Equality of opportunities for higher education and employment, changing social values, rapid industrial expansion, better economic development etc. have given immense opportunities for Indian women to take up employment in considerable numbers. The guarantee of women's rights envisaged in the Indian Constitution has enabled women of modern India to enter all walks of life and make their presence felt. There is no denying the fact that women have entered all the so-called male dominated professions including the military, administration, police service, aviation and business management. But next to teaching, which still continues to be the stronghold of women, women scientists are on the increase in many fields. One such field is Meteorology and Atmospheric Sciences. The very ancient and perhaps the oldest scientific organisation catering to the science of Meteorology and weather forecasting is the India Meteorological Department(IMD).

The first meteorological observations started in September 1793 at Madras(now Chennai) but the birth of the IMD took place only in 1875 and like any other government service the number of male employees in IMD was always higher than the number of women employees more so in the higher echelons. The male bastion was broken only with the entry of Miss. Anna Mani (1918 – 2001), from Kerala who joined as a Meteorologist in the Instruments Division of Pune in the late 1940s. This very first lady-meteorologist of IMD proved herself to be highly efficient and rose to the highest position of heading the Instruments Division of IMD. The upkeep, discipline and quality of the Instruments Division at Pune and Delhi bear testimony to her excellent administrative and technical capabilities. She made a mark for herself not only amongst the scientists of the Indian community but also in the international arena, particularly in the field of radiation and alternate energy sources like wind and solar energy. Her two monumental works on these topics are much acclaimed and are considered as valuable reference books for those who pursue research in those areas. She has also been a mentor for many aspiring researchers of IMD to obtain their Ph.D degree and even when nearing 80 years of age and in frail health, she pursued her research at Raman Institute, Bangalore. Her sense of commitment to Meteorology is outstanding and praiseworthy.

While Miss. Mani is the first woman who made a mark in the field of meteorological instrumentation, another officer to follow her was Dr. Mary Selvam. She was mainly a researcher who after her post-graduation, could pursue her doctorate study in cloud physics and atmospheric electricity only after joining the department in the same Instruments Division at Pune. She joined the Tropical Research Unit which was functioning as a separate unit which, later, was renamed as Indian Institute of Tropical Meteorology(IITM), Pune. Though it was initially under IMD, subsequently it became an autonomous institution and started functioning at Pune. Dr.Mary Selvam chose to get herself posted to that unit due to the non-transferable and non-operational nature of duties. Thus the credit of first woman researcher at IITM, Pune in the field of Tropical Meteorology goes to Dr. Mary Selvam. Though she was the first lady to join in the officer cadre at IITM, Pune and hold the high position of Asst. Director before her retirement, there are now many women researchers and senior scientists who work in IITM, Pune. When compared to IMD, the percentage of women scientists is more there mainly due to stability in their work place and the research work undertaken. Dr.Purva Salvekar (nee Katre), Scientist-G in IITM, Pune who won the WMO Young Scientist Award also proved to be a dedicated researcher on monsoon modelling studies and is a towering personality who is known for her devotion and passion for atmospheric sciences.

Till the late sixties, IMD had only one or two women officers mainly working in research divisions, instrumentation or astronomy. Though IMD's main mandate is weather forecasting, the entry of women in weather forecasting began with the entry of Dr. N. Jayanthi, the first author, in the early 1970s' when she became the first woman to be trained in Advanced Meteorology and was inducted as the first full-fledged weather forecaster of IMD. Though she worked as a Duty Aviation Forecaster at Bombay (now Mumbai) as a mandatory requirement of her training programme, her posting at Chennai (then Madras) also made her the first woman to enter into regular operational roster duties in non-aviation forecasting at the Area Cyclone Warning Centre.

Being a woman did not dampen her spirits to attend the night duties during cyclonic situations and on several occasions had to wade through knee-deep water without any transport facility to discharge her services as the duty weather forecaster. All her contributions to the field of Meteorology and Aviation were possible due to the unstinted support and encouragement of her family and her male superiors. She also worked in aviation forecasting for more than 14 years which is another milestone for women in weather service as she became the first woman to head an International Airport Meteorological Division, that too at Chennai. After that she was elevated as Dy.Director General of Meteorology (Training) and the World Meteorological Organisation (WMO) appointed her as an Expert Panel Member for Education and Training. She was also nominated as the WMO expert member of the Group on Accreditation and Certification for Aviation Meteorology. She was also selected for a key position in the International Civil Aviation Organisation (ICAO) in 2001 but due to other government formalities she could not join the same. She retired from IMD as Additional Director General of Meteorology(Research) which is a post second in hierarchy in IMD, next only to the Director General of Meteorology, who heads IMD.

Another efficient woman forecaster to follow was Dr.B.Shyamala of Mumbai who also had her initial stint as aviation forecaster at Mumbai and later handled the cyclone and monsoon forecasting division of the Mumbai region. She was also the first woman from India to be selected by WMO as panel member on tropical cyclones but due to frail health she could not accept the post. She later retired as Dy. Director General of Meteorology(Climatology) in Pune.

Significant contributions in the field of Agricultural Meteorology by Dr.Kambete of Pune and Mrs.Anjana Chowdry of Kolkata is worth mentioning. Incidentally, Mrs.Anjana Chowdry got the credit of being the first woman meteorologist to initially head the Positional Astronomical Centre (PAC) Kolkata which is mainly responsible for preparing tide tables, Rastriya Panchang etc. Though meteorology and hydrology are inseparable, the credit for exclusive research on hydrology and handling of hydrological issues goes to Dr.Surinder Kaur, now Dy.Director General of Meteorology(Hydrology), IMD New Delhi who joined IMD in the early eighties and won the SAARC Award in the year 1992, for her outstanding contributions to Meteorology. She is also the first woman meteorologist to head a Regional Meteorological Centre(RMC) and history preferred to etch the landmark for RMC Nagpur.

Though the 1990s' witnessed influx of a few more women officers joining the IMD, still the number of middle level and senior level officers in weather forecasting is abysmally poor. In the six regions of IMD classified for administrative reasons, female forecasters are only few contributing to less than 2% of the entire posts. As per the statistics taken during Jan 2009 (Fig.1), women in the post of Director constitute just 4% of the total workforce in IMD. Women in administrative posts constitute 1.6% of the total workforce of 6500 employees in IMD.

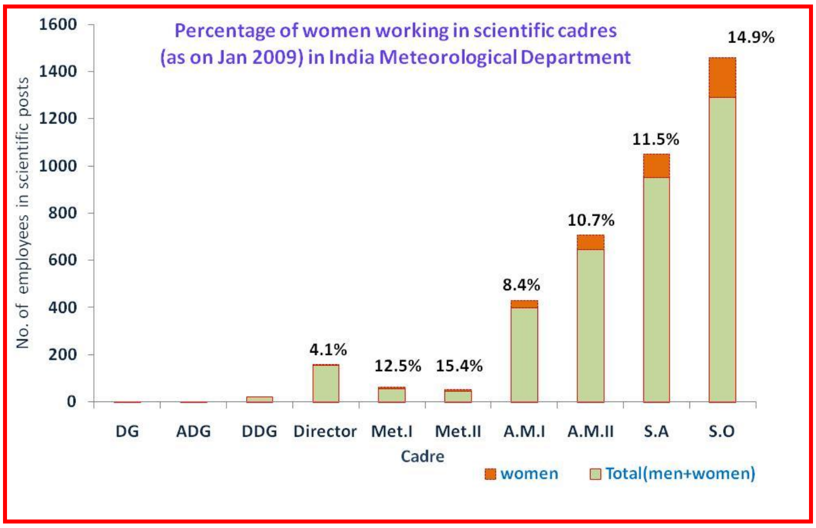

Fig.1 Percentage of women in scientific cadres in IMD

However, when compared to operational weather forecasters, women in research areas is quite encouraging. Dr.Begam of NCMRWF perhaps takes the credit of being the first woman forecaster who was mainly involved in cyclone modelling. It is indeed a moment of pride to note that Dr.Swati Basu, Scientist-G, a brilliant scientist and an expert in Numerical Weather Prediction and modelling heads the National Centre for Medium Range Weather Forecasting(NCMRWF) as its Director & Head now. Special mention must be made of Dr.Sulochana Gadgil who obtained her doctorate from the prestigious Harvard University and joined IITM, Pune to pursue her research on Indian monsoon. She is now Professor in Indian Institute of Science, Bengaluru guiding many aspiring atmospheric scientists. Similarly, Dr.Suman Goyal at Satellite Meteorology Division, IMD, New Delhi and Dr.Manju of IIT, Delhi were involved in research on atmospheric boundary layer problems. The Indian Institute of Astrophysics and Geomagnetism at Alibag, Mumbai was also part of IMD till early 1970s' which subsequently became an autonomous institution. The first lady members to be posted in Kodaikanal and Mumbai were Mrs.Nirupama Raghavan (nee Nirupama Subramaniam) and Dr. Nalini respectively during 1960s and 1970s.

In general, we can see that though the percentage of educated women in India is small, their contribution to science is significant. Nearly about 80% of them pursued higher education and qualified themselves by acquiring doctorate degrees, after taking up a career in IMD. The academic achievements of women are quite noteworthy when compared to their male counterparts where the percentage of men who got their doctorate degrees is abysmally poor being less than about 2%.

In the recent years of IMD, mention needs to be made of women meteorologists like Dr.Medha Khole who is the Dy.Director General of Meteorology(Weather Forecasting), Pune, Dr.Kamaljit Ray, heading the Meteorological Centre at Ahmedabad who is known for her depth of knowledge as a weather forecaster, Smt.Ranju Madan, Scientist-E another leading scientist who has made significant contributions in the field of upper air observations, and working in Upper Air Instruments division of IMD, New Delhi, Smt. P.G.Gore, Scientist-E at IMD, Pune with significant research publications on monsoons and droughts, Smt.S.Stella, Director, RMC Chennai, an aviation meteorologist who has the commendable achievement in her credit as the first woman meteorologist to go to Antarctica, Dr.Soma Sen Roy, Director, IMD New Delhi known for her contributions to Satellite Meteorology and currently working in NWP division, Smt. Sunitha Devi, Director at IMD, Pune a meticulous officer involved in preparation of the seasonal weather summaries for the journal "Mausam" in addition to her valuable contributions as a weather forecaster at IMD, Pune are some of them. Smt.Neetha Gopal at Aviation Centre, IMD New Delhi, scientists at Met.Centres like Dr.Geetha Agnihotri at Bengaluru, Dr.K.Nagaratna at Hyderabad, Smt.V.K.Mini in Met.Centre, Thiruvananthapuram, Smt. Manorama Mohanty at Ahmedabad, Smt.Shubhangi Bhute at RMC Mumbai and Smt. Samanti Sarkar at Telecom division, IMD Delhi are making their mark in their respective areas of strength.

The second author of this article strives for improving the quality and dependability of data from Automatic Weather Stations(AWS) in IMD since her initiation into the area in 2003 and she is also the first woman Project Director to be assigned the task of implementing the project of 550 AWS during year 2007. She holds in reverence Ms.Anna Mani whose extraordinary achievements were first mentioned to her by the first author of this article.

At this juncture, we fondly remember all our unsung women colleagues in IMD who untiringly perform their operational duties in fair and adverse weather situations without expecting any fame or recognition and their list is obviously endless!

The focus of the current article is to highlight the achievements of some of the women who have chosen Meteorology as their career and is meant to be a tribute to all the women scientists and to encourage many more such talents to join this very challenging field. It is our fondest hope that our tribe may increase in future! Certainly, this write-up is not exhaustive. It is our earnest request to the readers to let us know in case we have missed to mention any of them which is purely unintentional.

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Solutions to the Weather Puzzle on page 21

1 U			2 D				3 T	O	R	N	4 A	D	5 O
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D			L				R		7 R	I	D	G	E
R			8 R	O	S	S	B	Y			H		G
9 A	M	10 S					U				I		A
F		L					L			11 H			
T		P		12 D	I	V	E	R	G	E	N	C	13 E
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16 F			O				E		17 C		18 M		R
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VALIDATION OF LOCATION SPECIFIC WRF MODEL FORECASTS OF MAXIMUM TEMPERATURES OVER TAMIL NADU AND ANDHRA PRADESH - MAY 2012

by

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Introduction

Under the modernisation programme of India Meteorological Department (IMD), a High End Server has been installed and commissioned at Regional Meteorological Centre (RMC), Chennai with effect from October 2009. The Numerical Weather Prediction (NWP) unit at RMC Chennai has since been running Weather Research and Forecasting (WRF) model as a part of the regional modelling initiatives taken up by IMD in the recent years. The WRF model version 3.2 is run at a resolution of 15 km for the domain of 72˚-92˚E and 4˚-20˚N centred at 82˚E/12˚N and comprising of the region of southern peninsular India. The real-time model forecasts of lower, middle and upper tropospheric wind fields and rainfall for 24hr, 48 hr and 72 hr are generated daily and uploaded in the RMC Chennai website. Validation of model forecasts for areas of varying topography within the regional domain is an integral part of regional modelling exercise, as, model simulations are quite difficult in geographically heterogeneous regions and the role of regional modelling centres would therefore be to provide new insights into mesoscale meteorology than what would be possible at national centres alone.

Verification of WRF forecast of maximum temperature for May 2012

The model domain of RMC Chennai comprises of regions of varying topography such as the Southwest Bay of Bengal, eastern and western coastal belts up to 20˚N, the western and eastern ghats, the Deccan plateau region and coastal and interior plains. As a part of model verification exercise, WRF maximum temperature forecasts of 24hr (Day-1), 48 hr (Day-2) and 72 hr (Day-3), generated for the peak summer month of May for some locations (in Tamil Nadu and Andhra Pradesh) of varying topography are validated against the observed maximum temperature over these locations. Fig.1 presents the model domain and sample maximum temperature forecast product. The verification is carried out for some selected cities in the states of Tamil Nadu [Chennai (Nungambakkam), Vellore, Thiruchirapalli, Madurai and Coimbatore] and Andhra Pradesh [Nellore, Gannavaram, Kurnool, Rentachitala, Hyderabad, Nizamabad and Ramagundam].

Fig.2a & b present a comparison of forecasts generated for Day-1 (24 hr) and the observed maximum temperatures during May 2012 for the selected locations in Tamil Nadu and Andhra Pradesh respectively. The model forecasts match quite well with the observed values for interior stations of Thiruchirapalli (88m a.s.l), Madurai (136m a.s.l) and Ramagundam (179m a.s.l) located within 200m a.s.l. In case of coastal / near coastal stations of Chennai (6m a.s.l), Nellore (19m a.s.l) and Gannavaram (1m a.s.l), the forecast follows closely the pattern of the observed values but with positive bias in the cases of Chennai and Gannavaram and a negative bias in the case of Nellore.

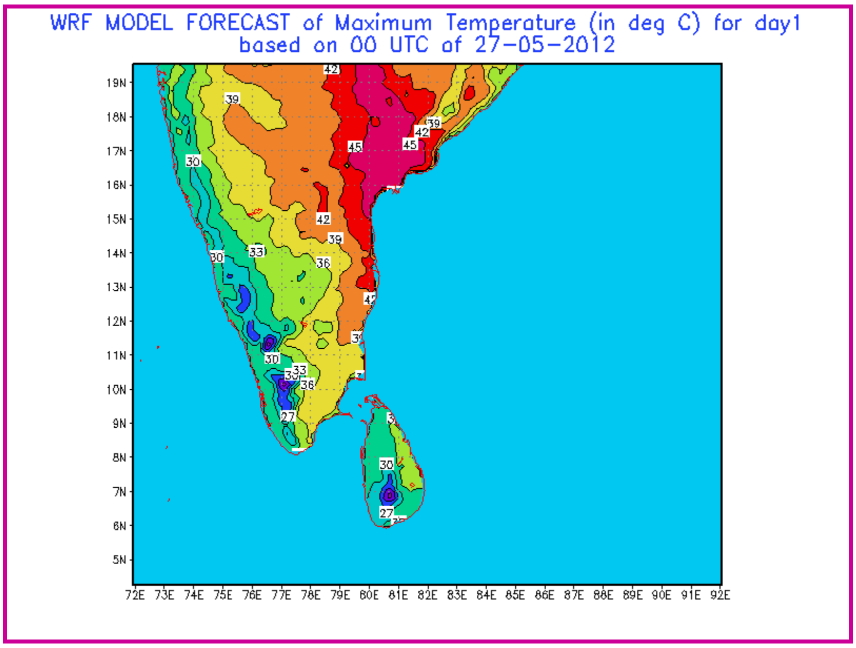

Fig.1 RMC Chennai domain and sample WRF Maximum temperature forecast product

In the case of interior stations located at slightly higher altitudes, namely, Vellore (725m a.s.l), Hyderabad (542m a.s.l), Nizamabad (395m a.s.l), the model forecasts follow the observed pattern but with greater error values of 2-4˚C. In the case of Coimbatore (409m a.s.l) where comparatively lower maximum temperatures are generally recorded and Rentachintala (104m a.s.l) where very high values of maximum temperatures are recorded, the model is able to capture the nature of daily variation but with very high forecast errors of nearly 4-6˚C.

The statistical parameters of the forecasts of Maximum Temperature for Day-1 (TX1), Day-2 (TX2) and Day-3(TX3) generated by WRF as compared to the actual observations, viz., (i) Mean Maximum Temperature forecast during May 2012 [Mean(F/c)] and the mean of actual Observation ([Mean)obs)], (ii) the corresponding standard deviations [SD(F/c) and SD(Obs)], (iii) root mean square error (RMSE) and the (iv) Mean Bias Error (MBE) are presented in Tables 1a&b for the selected cities in the states of Tamil Nadu and Andhra Pradesh respectively. The difference in the mean of the forecast and observed fields for all the locations varies within 1-2˚C for Day-1, Day-2 and Day-3.

The standard deviations of the forecast and observed fields match somewhat well (<0.5˚C) for Day-1 and Day-2 forecasts. The RMSE varies between 1-4˚C. RMSE is quite high for Coimbatore (inTamil Nadu) located in the foothills of Nilgiris mountainous region and also for Rentachitala, Nizamabad and Gannavaram in plateau regions of Andhra Pradesh.

Assimilation of high resolution data, higher resolution model run aimed at location specific forecasts and better definition of static fields generating the topography in the model could probably improve the forecasts generated by the model.

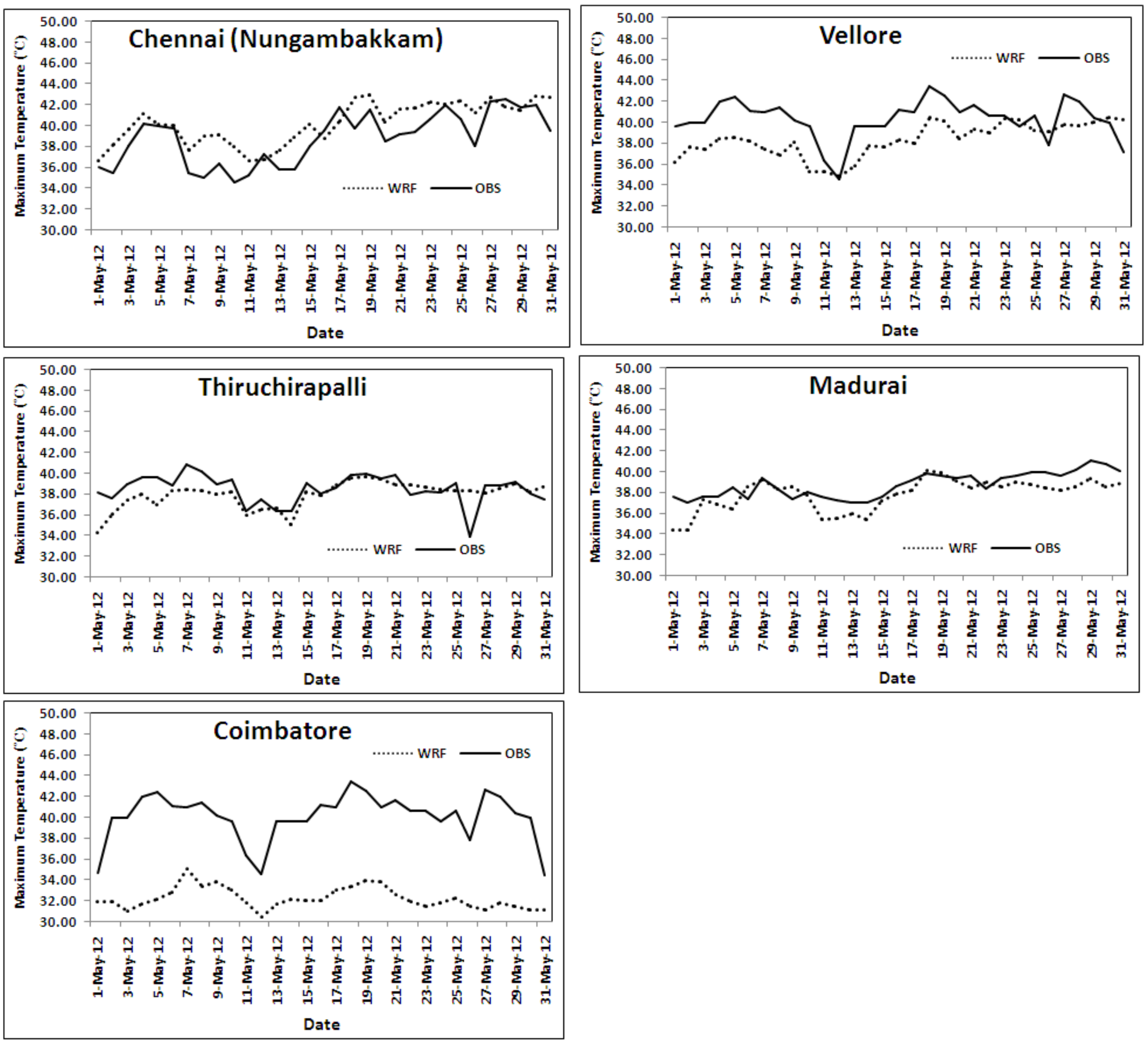

Fig.2a Maximum temperature forecast for Day-1 generated by WRF model and the observed maximum temperature over various locations in Tamil Nadu region

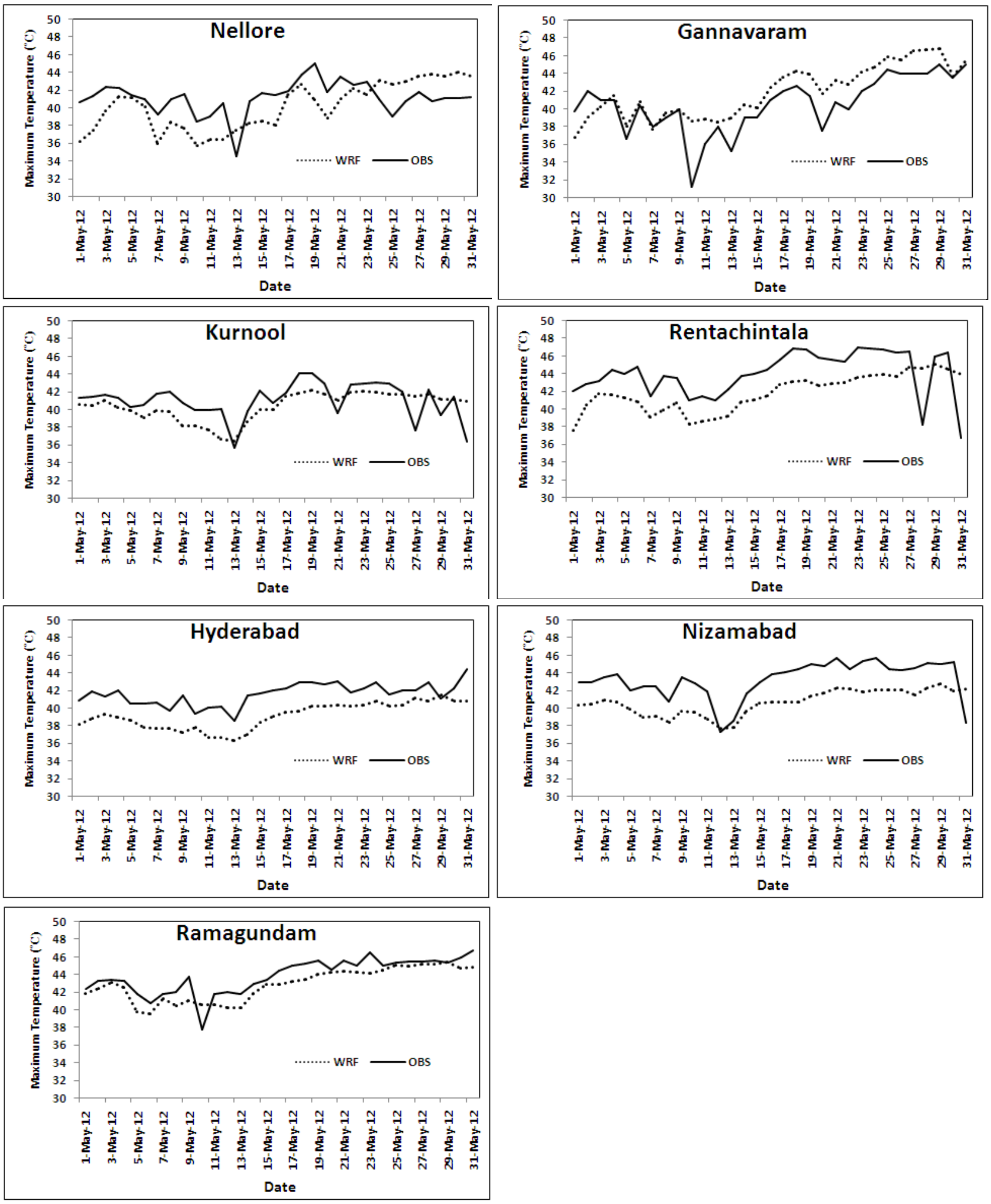

Fig.2b Maximum temperature forecast for Day-1 generated by WRF model and the observed maximum temperature over various locations in Andhra Pradesh region

Table -1a

Statistics of WRF Forecasts and Observed Maximum Temperatures in respect of Tamil Nadu region for the month of May 2012.

F/c verification parameter	Statistical parameter	Station				
		NBK	TRY	MDR	CBE	VLE
		(˚C)	(˚C)	(˚C)	(˚C)	(˚C)
TX1	Mean (Obs)	38.76	38.48	38.73	34.84	40.30
	Mean (F/c)	40.24	37.92	37.81	32.22	38.34
	SD (Obs)	2.51	1.40	1.22	0.93	1.86
	SD(F/c)	2.02	1.27	1.56	1.03	1.64
	RMSE	2.04	1.50	1.38	2.75	2.62
	MBE	1.47	-0.56	-0.92	-2.61	-1.96
TX2	Mean (Obs)	38.91	38.53	38.86	34.85	40.25
	Mean (F/c)	40.86	37.64	37.63	31.90	39.17
	SD (Obs)	2.48	1.42	1.32	0.93	1.90
	SD(F/c)	1.97	1.52	1.39	1.06	1.56
	RMSE	2.47	1.72	1.56	3.15	2.22
	MBE	1.95	-0.89	-1.23	-2.95	-1.07
TX3	Mean (Obs)	39.13	38.63	39.03	33.90	40.25
	Mean (F/c)	41.11	37.87	37.79	31.90	39.44
	SD (Obs)	2.47	1.47	1.39	3.23	1.90
	SD(F/c)	1.95	1.32	1.30	1.12	1.53
	RMSE	2.61	1.58	1.60	3.69	2.14
	MBE	1.98	-0.76	-1.24	-2.00	-0.80

Table -1b

Statistics of WRF Forecasts and Observed Maximum Temperatures in respect of Andhra Pradesh region for the month of May 2012.

F/c verification parameter	**Statistical parameter**	**NLE**	**GNV**	**KRN**	**RNT**	**HYD**	**NZB**	**RMD**
T max	Mean (Obs)	41.16	40.52	41.06	44.03	41.61	43.23	43.86
for Day-1	Mean (F/c)	40.16	41.96	40.36	41.84	39.15	40.68	42.88
	SD (Obs)	1.86	3.16	1.96	2.59	1.26	2.13	2.00
	SD(F/c)	2.72	2.99	1.62	2.12	1.51	1.43	1.88
	RMSE	2.75	2.39	1.82	3.30	2.65	2.94	1.36
	MBE	-1.00	**1.43**	-0.71	-2.19	-2.45	-2.55	**-0.97**
T max	Mean (Obs)	41.07	40.68	41.12	44.49	41.46	43.29	43.88
For Day-2	Mean (F/c)	41.27	43.79	40.68	42.71	39.58	41.03	43.34
	SD (Obs)	2.04	3.24	1.84	2.23	1.17	1.99	1.93
	SD(F/c)	2.65	2.69	1.42	1.94	1.53	1.41	1.68
	RMSE	2.71	3.73	1.74	2.57	2.22	2.70	1.08
	MBE	0.20	3.11	-0.43	-1.78	-1.88	-2.26	-0.54
T max	Mean (Obs)	41.10	40.74	41.11	44.58	41.41	43.23	43.85
For day-3	Mean (F/c)	41.72	44.18	40.84	43.02	39.89	41.27	43.64
	SD (Obs)	2.05	3.28	1.84	2.22	1.19	2.03	1.95
	SD(F/c)	2.69	2.72	1.38	1.86	1.26	1.08	1.43
	RMSE	2.78	3.94	1.77	2.42	1.85	2.61	1.15
	MBE	0.62	3.44	-0.26	-1.56	-1.51	-1.96	-0.20

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