Indian Meteorological Society, Chennai Chapter
Newsletter Vol.15, Issue No.2, December 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.15, Issue 1). The focus of the chapter's activities during the last six months has been on the conduct of **International Tropical Meteorology (INTROMET) Symposium on Monsoons – Observations, Prediction and Simulation** slated for 21-25 February 2014 at SRM University, Kattankulathur (near Chennai) under the joint auspices of the Indian Meteorological Society and the SRM University. Arrangements for a grand conduct of this mega event are in full swing. Two Local Organising Committee meetings were held.

A half-a-day seminar on "***Monsoons 2013***" was conducted on 08th January 2014. As many as 6 lectures on various aspects of southwest and northeast monsoons 2013 were covered during this seminar. In addition to 3 IMD scientists, two civil administrators and a research scholar delivered lectures. Dr. T.S. Sridhar, I.A.S., Additional Chief Secretary & Commissioner of Revenue Administration, Govt. of Tamil Nadu, Chennai spoke on *Revenue administrative perspective of monsoons of 2013* and Dr. B. Chandra Mohan, I.A.S., Managing Director, Chennai Metropolitan Water Supply and Sewerage Board, Chennai spoke on the *Impact of monsoon 2013 on water supply to Chennai city*.

A Climate Calendar-2014 was prepared under the joint auspices of the Indian Meteorological Society, Chennai Chapter and the SRM University. Copies of the same have been sent to the other IMS Chapters and *Fellows* of IMS.

The 4th Local council meet of the chapter for the biennial term 2011-2013 (extended upto March 2014) was held on 30th January 2014. Elections for the Chennai chapter local council for the term 2014-2016 are being planned to be held in parallel with the elections for the National council to be held in March/April 2014 about which circulars have been and also being issued as and when information is received from the returning officer.

The next issue of Breeze is likely to be released by the new editorial board to be constituted by the incoming committee. Thank you for your cooperation for the current council till date.

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

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

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

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

THE IMPACT OF MONSOON 2013 ON THE WATER SUPPLY TO CHENNAI CITY BY CHENNAI METROPOLITAN WATER SUPPLY AND SEWERAGE BOARD

by

B. CHANDRA MOHAN, I.A.S.,

Chennai Metropolitan Water Supply and Sewerage Board, Chennai

Preamble

Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) is depending mainly on surface water, partly on groundwater and water from two desalination plants for its water supply to Chennai city. The main water sources for Chennai city are as follows:

1. Poondi, Cholavaram, Redhills and Chembarambakkam Reservoirs.
2. Krishna River water received in the Poondi reservoir through Kandaleru-Poondi Canal.
3. Veeranam Lake in Cuddalore District.
4. Desalination Plants at Kattupalli near Minjur (100 MLD) and Nemmeli near Mahabalipuram (100 MLD)
5. Ground water sources from Wellfields in the Araniyar-Koratalaiyar River Basin and from Neyveli aquifer.

The water storage in the reservoirs and recharge of groundwater are mainly depending on monsoon rains. The failure of Southwest monsoon this year combined with the failure of the Northeast monsoon during the year 2013 has its impact on water supply to the Chennai city after April 2014.

Impact of monsoon 2013

The average annual rainfall for the year 2013 in Chennai city is 1200 mm. But during the year 2013, the Chennai city has received only 1086 mm. Due to the poor monsoon, the water storage in the reservoirs and the groundwater level is comparatively less than the previous year.

Comparison of rainfall between Normal and Actual for the year 2013

Period	Normal Rainfall in mm.	Actual Rainfall in mm.	Deficit
Southwest Monsoon - 2013	450	616	+ 37%
Northeast Monsoon - 2013	750	437	- 41%
Total	1200	1086	- 10%

The CMWSSB has maintained daily water supply of 831 MLD up to 21.05.2013. Considering the storage position in reservoirs, CMWSS Board is now maintaining the same quantity (90 mld) as supplied prior to 21.05.2013 and without any changes in eight zones of newly added areas.

However, re-organization arrangements in respect of water supply distribution have made in the remaining seven zones of old Chennai City for providing alternate day supply with effect from 22.05.2013.

Comparison of water storage in the reservoirs between 2013 and 2014

Reservoir	Full Capacity in 'Mcft'	Storage as on 02.01.2013 in 'Mcft'	Storage as on 02.01.2014 in 'Mcft'	Storage difference in 'Mcft'
Poondi	3,231	1,523	138	-1,385
Cholavaram	881	471	169	-302
Redhills	3,300	2,166	2,160	-6
Chembarambakkam	3,645	1,241	870	-371
Total	**11,057**	5,401	3,337	-2,064
Veeranam	1,465	491	720	+229
Grand Total	**12,522**	**5,892**	**4,057**	**-1,835**

As on 02.01.2014, the storage in the reservoirs (Excluding Veeranam) is 3,337 mcft against the full capacity of 11,057 mcft and the storage as on the same day last year is 5,401 mcft i.e. present storage is 2,064 mcft less than last year's storage.

The present pattern of average drawal of water from various sources and distribution of water to City and Industries is as follows:

Sl.No.	Source of Drawal	Quantity in 'MLD'
1	Redhills Lake	55
2	Poondi Lake	15
3	Veeranam Lake	180
4	Desalination Plant (Minjur)	100
5	Desalination Plant (Nemmeli)	80
6	Well fields (Department wells only)	35
7	Chembarambakkam Lake	80
8	Added Areas (Own source)	30
	Total	**575**

Past experience

During earlier drought period in the years between 2001 and 2004 the reservoirs had gone completely dry. Then the water supply was managed by extracting more ground water from the well fields, by hiring agriculture bore wells, transporting about 25 MLD of groundwater from distant sources such as Chengleput, Neyveli, Gummidipoondi etc. through water tankers and by transporting average quantity of 2 MLD through railway wagons from Erode and Mettur.

Water Management strategies by CMWSSB to meet the present scenario

The CMWSSB has planned the following contingency measures to increase the water sources to meet and maintain the Chennai city's present water requirement after April 2014.

- By drilling additional 6 bore wells in the well fields and 10 bore wells in the Neyveli aquifer.
- By transporting 20 MLD of groundwater from distant sources through water tankers.

- By hiring agriculture wells in the well field area it has been proposed to by 40 MLD of groundwater.
- To request Andhra Pradesh Government to increase the discharge at Kandaleru Reservoir so that a minimum of 800 cusecs can be realized at Zero Point from Krishna water source after permanent restoration of the Kandaleru-Poondi Canal at Ubbalamadagu from January 2014 till June 2014.
- Action has to be initiated for more fillings in the Veeranam lake for maintaining the city supply after April 2014.

Conclusion

As CMWSSB has implemented the Hon'ble Chief Minister's long term perspective to commission of the New Veeranam Project in 2004 and commissioning of Desalination Plants (Kattupalli & Nemmeli) as a drought proof measure, the piped water supply will be continued with the additional groundwater extraction from the well field area, hiring of agri wells, transport of water from distant sources and additional quantity from Krishna water source.

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Weather wonders ….

9th January 2014: Partly frozen Niagara Falls (USA) (Courtesy: www.ibtimes.com)

MONSOONS - 2013

by

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Indian Summer Monsoon 2013 ended with positive departure of six percent above Long Period Average (LPA). Cyclonic Storm "Mahasen" (10-16May) that formed in Bay of Bengal helped in strengthening the cross equatorial flow. This led to the early onset on monsoon over Andaman & Nicobar Islands (3 days ahead of normal date of 20 May). The monsoon onset over Kerala was on 1 June (normal date). Due to the active phase of Madden Julian Oscillation and northward movement of east-west shear line, there was a rapid progress of monsoon. After onset over Kerala, monsoon rapidly covered the south peninsula and north east India by 9 June and covered the entire country by 15 June (one month ahead of the normal date). Strong cross equatorial flow prevailed during June and July. It weakened during second half. The second and third initial weeks had positive departures of 34 & 89 percent. The third week's seasonal total was 54 percent above normal. After this week, only four weeks during the rest of the season had meaningful positive departures and other weeks were either just normal or below normal. Yet the initial surge helped in maintaining the seasonal figure to be on the positive side of the LPA. The month wise performance was 132 percent of LPA and July was 106 percent. August recorded 98 percent and September 86 percent of LPA.

There are four homogenous regions and north east India alone had a negative figure of 72 percent of LPA. The other regions viz., northwest India recorded 109 percent, central India 123 and south peninsula 115 percent of LPA. A sub division wise analysis indicates that out of 36 meteorological sub divisions, 14 sub divisions (comprising 48 percent of total area of the country) recorded excess. 16 sub divisions (occupying 38 percent of the country's area) received normal rainfall and remaining 6 subdivisions (with areal spread of 14 percent of country's area) received deficient rainfall. Out of 641 districts, 100 districts had meteorological drought (26-50 percent deficit) and 39 recorded severe drought.

During this season Tamil Nadu / Puducherry subdivision recorded normal rainfall. It recorded a rainfall of 321.6 mm against a normal figure of 317.2 mm. All sub division's performance in the southern region is given in the following table.

Sub division	Actual (mm)	Normal (mm)	Departure (Percentage)
Telengana	949.7	755.2	+26
Coastal Andhra Pradesh	524.1	581.1	-10
Rayalaseema	420.3	398.3	+6
Coastal Karnataka	3620.8	3083.8	+17
North Interior Karnataka	533.1	506.0	+5
South Interior Karnataka	826.6	660.0	+25
Tamil Nadu/Puducherry	321.6	317.2	+1
Kerala	2562.5	2039.6	+26
Lakshadweep	1057.2	998.5	+6

During this season there were 2 monsoon depressions and 16 low pressure areas against a normal of 6 monsoon depressions and 6 monsoon lows.

Withdrawal was on 9 September (normal date is 1 September) over west Rajasthan. After 19 September withdrawal was stalled due to the formation of 2 low pressure areas and their westward movement towards central India.

The normal onset date for onset of easterlies is around 14 October. However due to the presence of VSCS "Phalin", it became clear that it would be delayed, Withdrawal from the entire counting on 21 October 2013. A low pressure , which formed on 20 October 2013 in central parts south bay off moved westwards and it could be located in the south bay off TN-SAP coast. This system heralded the monsoon. So, we had the withdrawal of Southwest monsoon over the entire country and the simultaneous commencement of Northeast monsoon 2013 over Tamil Nadu, Kerala and adjoining areas of Andhra Pradesh and Karnataka.

The well marked low pressure after crossing the AP coast was moving inside AP and weakened in to low on 26 October. Since it moved towards, TN came under the grip of westerlies again. The situation was reminiscent of south west monsoon period in Tamil Nadu. Receipt of good rainfall was restricted only on the day of commencement of Northeast monsoon rains. As it moved towards AP, all the three subdivisions of AP got good rains. The two subdivisions which matter in north east monsoon period viz., CAP and Rayalaseema had very good weekly departures of 100 &80 percent. As far as week ending 23/10/2013, Tamil Nadu/Puducherry, South Interior Karnataka & Kerala recorded departures of 25,52 and 79 percent respectively. The reason for Kerala getting good rains is due to bay system drawing Arabian Sea current.

After the initial week during the commencement of NEM rains, Tamil Nadu/Puducherry experienced less rainfall activity mainly due to the reversal of winds. Tamil Nadu had to wait for three more weeks to experience meaningful rainfall activity. A Tropical depression (named as "Wilma" by Pagasa). It formed in the Philippines Sea near Mindano islands on 04/11/2013, further moved westwards through South China Sea. It made landfall in Vietnam on 07/11/2013 and moved across Cambodia and emerged in Gulf of Thailand and adjoining Tenasserim coast on 08/11/2013 as a low pressure area. It further moved in a west north westerly direction and concentrated in to a depression on 13 November (700 Km east south east of Chennai). It continued to move westwards and ultimately made the landfall near Nagapattinam between 07 & 08 UTC of 16/11/2013.

TS "Podul" formed on 11 November 2013 and dissipated on 15 November 2013. When the system became a depression, it was 1175 Km south east of Koror, Palau. After making the landfall in Philippines moved across South China Sea and made landfall in Vietnam on 15 November and travelled across Cambodia and Thailand and remnant energy of TS "Podul" emerged in the Andaman Sea on 17 November. The system moved westwards and became a depression on 19 May (700 Km east north east of Chennai). It later intensified in to TC "Helen" on 20 November over West Central Bay. It made landfall close to Masulipatnam on 22 November. Since the system was drawing Arabian Sea currents the PDP of Kerala for the week ending 27/11/2013 was 102, South Interior Karnataka 34 and for CAP, it was 67 percent.

Close to the heels of formation of TS "Helen" another system formed. The system formed in the South China Sea, east of Malay Peninsula on 19/11/2013. Generally, when they form in this low latitude during late November, they would head towards TN coast. At the time of formation itself, the system showed that it had all the potential to become a strong system. The system rapidly strengthened and it was a very Severe Cyclonic Storm "Leher" on 25/11/2013. Afterwards, the system was moving towards AP coast and weakened in to depression before land fall due to strong wind shear aloft and colder Sea Surface Temperature. CAP received 58 percent more rain for the week ending 04/12/2013 and Kerala had 51 percent more rain due to this system and due to an upper circulation over Lakshadweep area.

A trough of low pressure could be located over South west Bay off Srilanka & Tamil Nadu coast on 1 December. On 3 December, the system became a well marked low pressure area. It concentrated in to depression on 6 December. It was situated between two Anti cyclones. The system gradually intensified in to Cyclonic Storm “Madi”. The system was steered to the north due the high pressure situated in the west. After moving pole ward, the system was weakened due to strong wind shear aloft. Later the high pressure, which was lying in the west, became the dominant steering force and the system started to move in a south westerly direction towards Tamil Nadu coast. The weakned system made the landfall over vedaranyam during evening of 12 December and reemerged in Palk Strait and finally made the landfall near Tondi during late night period. There were widespread rains over Tamil Nadu/Puducherry subdivision on that day and weekly departure figure (For week ending 18/12/2013) was 21 percent.

At the end of the season CAP was the only sub division with excess rainfall. This was mainly due to the good performance of well marked low pressure area during the initial days during the commencement of Northeast monsoon rains. Subsequent systems, which were heading towards AP coast also contributed for the good performance. As far as Tamil Nadu/Puducherry subdivision is concerned, the systems which were heading towards AP coast took the moisture away. Though two depressions made landfall in Tamil Nadu, they hardly stayed for a day. So Tamil Nadu/puducherry subdivision ended with deficit figures. Kerala ended with negative figures, but within the limits of normal rains. Rayalaseema and South Interior Karnataka ended with deficit figures, as no system passed through that region.

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CLIMATE CALENDAR OF INDIA 2014

by
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- A Climate Calendar of India – 2014 has been prepared with the joint efforts of the SRM University and the Indian Meteorological Society (IMS). This is an attempt to create awareness and popularize meteorology / climate among public in general and students in particular.

- This was released on 27 December 2013 during the DST INSPIRE camp held at SRMUniversity for ~ 200 bright HSC students of Tamil Nadu schools.

- With the Climate Change / Global Change controversies, the recently released 5th Report of the International Panel on Climate Change (IPCC) on Global Change and discussions thereon taking place so regularly in media, it was thought appropriate that we know first and foremost, our present climate – at least of our own country.

- This Table top Climate Calendar has a total of 26 pages. On the reverse of the cover page, some information about SRMUniversity and IMS are given, besides a short highlight of the calendar's contents.

- Two pagesare assigned for each calendarmonth. The front side, besides showing day – date has also

- Monthly maps of India depicting climatic contours of Temperature and Rainfall
- An INSAT image depicting the typical weather of the month eg.,

  (i) Widespread fog over north India during January
  (ii) Western Disturbance during February
  (iii) Norwesters in eastern India during March / April
  (iv) Various facets of southwest monsoon – onset, active, break etc. during June - September
  (v) Tropical Cyclone during November etc

This page also includes some significant climate Records and Events of interest.

- On the reverse side, a brief description is given of the weather event whose INSAT image is shown on the front side. It has a Table showing important Climatic information of 10 select stations of India (6 Metros + Pune, Ahmedabad + 2 Hill stations).

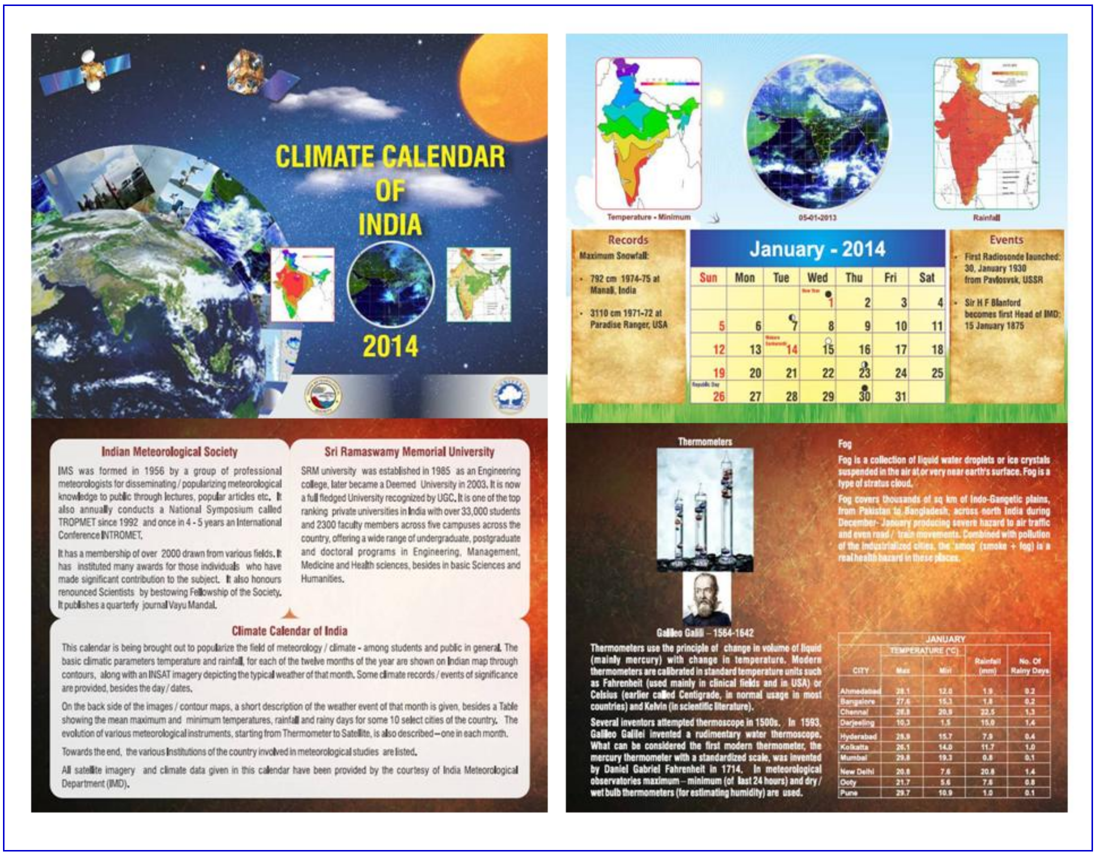
- Most importantly, in this reverse side we have described in short about the variousweather instruments (with photograph of their discoverers) that are used to measure / analyse weatherparameters routinely – vizThermometers, Barometers, Rain gauge, Surface observatory / AWS, Meteorological Tower, Meteorological Rockets, Weather Radar, Meteorological Satellites, Super Computers and Numerical Weather Prediction (NWP). At the end, we have included a list of important Indian Organisations / Institutions and Universities involved in Weather and Climate studies.

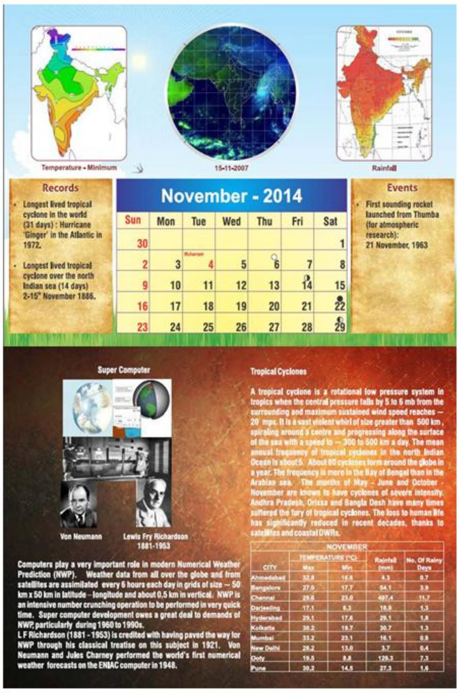
- The various data and maps included in the Calendar have been provided by the various units of the India Meteorological Department (IMD). Some information have also been taken from internet sources.

- This calendar is to be distributed to the delegates of the INTROMET conference to be held during February 21 – 25, 2014 at SRM University. Now it is being sent to
  - Some select Schools in Tamil Nadu, and
  - IMS Chapters, Fellows and Various Institutions involved in Met / Ocean / Climate Research in India.
- A photograph taken during the release ceremony, and a few sample pages of the calendar are included at the end of this article. The contents of the Calendar are provided in full at the URL link:

https://drive.google.com/folderview?id=0B0_CpHFxoErreExjRzNoTWVzdUk&usp=sharing

- We would highly appreciate receiving your critical comments and suggestions.

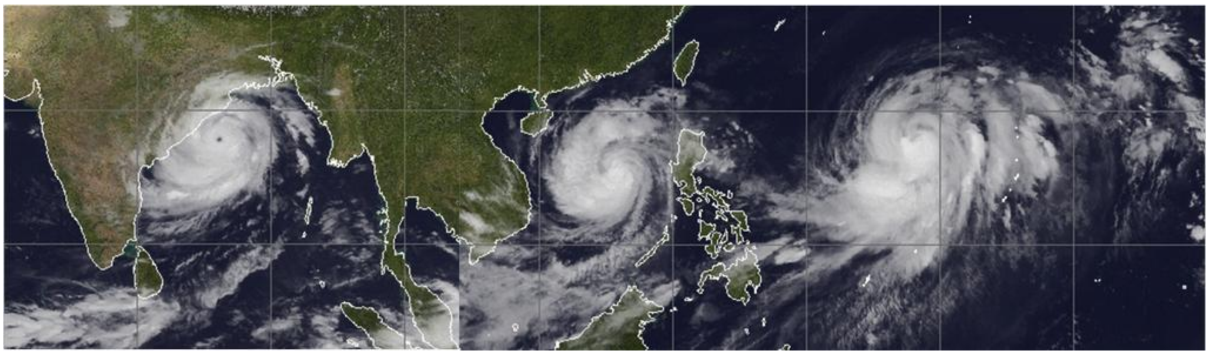




Prof. D.John Thiruvadigal (Head, Dept. of Physics SRM),
Dr.M.S. Narayanan (Former Director, MOG, SAC, Ahmedabad),
Prof.D.Narayana Rao (Director Research, SRM),
Dr. S.R.Ramanan (Director, ACWC, RMC, Chennai),
Dr.M.Ponnavikko(VC, SRM), Dr.S.R.Rao (Advisor, DBT, Govt. of India),
Dr.R.Suresh (Director, AMO, RMC, Chennai),
Dr.C.Muthamizhchelvan (Director Engg. & Tech, SRM) and
Dr. A. Karthigeyan(Assistant Professor,SRM)

Weather wonders ...

Devastating, yet, *Spectacular* Weather events on 12th October 2013 – Three Tropical Cyclones (*Phailin, Nari* and *Wipha*) heading for menacing Asia



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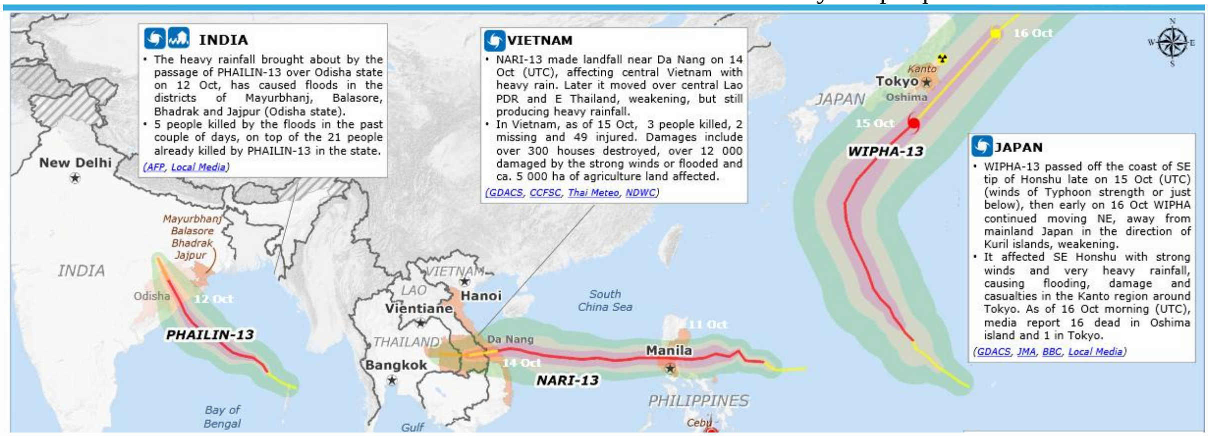

Source: ercportal.jrc.ec.europa.eu/

ELEVATION MEASUREMENTS USING DIFFERENTIAL GNSS TECHNOLOGY

by

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IMD network of AWS

Automation of the surface observational network is being implemented by India Meteorological Department (IMD) in a phased manner. As on 31.12.2013 there are 675 Automatic Weather Stations (AWS) and around 1150 Automatic Rain Gauges (ARG) installed in the entire length and breadth of the country. Technical information about the IMD network of AWS and ARGs has been provided by the author in earlier articles published in the newsletter Breeze (Details given under References). In any national meteorological service, a variety of challenges go hand-in-hand with the implementation phase of automation in any type of observational network. Diverse types of bottlenecks are experienced for which effective way out options need to be identified. The focus of this article is to emphasise one such area for which contemporary solutions have come to aid.

Sensors and measurement of atmospheric pressure

An AWS is configured to measure with the help of sensors interfaced in the system and report air temperature, hourly maximum and minimum temperatures, relative humidity, station level atmospheric pressure(SLP), hourly and the day's cumulative rainfall, wind speed and wind direction. The accuracy of the pressure sensor used by IMD in AWS is ±0.3 hPa. Its reliability and consistency in performance under field conditions is very good. The pressure sensor is mounted adjacent to the datalogger inside the NEMA enclosure of an AWS typically at a height of 1.5m above ground level. Hourly Mean Sea Level Pressure (MSLP) is generated at the Earth Station in Pune using the SLP, air temperature, vapour pressure, elevation of the site etc. The height above mean sea level (m.s.l) or in other words, elevation of all the AWS sites needs to be incorporated to a high degree of accuracy in the generic algorithms used to generate MSLP from the SLP of a station. AWS data is now assimilated into the NWP models and plotted in synoptic charts for operational weather forecasting. Accuracy in MSLP reported by a coastal station which has an AWS but does not have a conventional surface observatory is crucial while analysing the isobaric pattern in a synoptic chart, more so during the passage of cyclonic storms (CS). The likely place of landfall of the CS could be determined precisely based on the fall in MSLP of such coastal AWS.

Challenges in obtaining accurate elevation of sites

When 100 AWS of Sutron-make were installed all over India during 2006-07, one third of the AWS were collocated for validation purposes with conventional surface observatories for which elevation was known as they were predetermined using standard surveying techniques. For the other AWS sites the elevation was obtained from official / government records of the organisations in whose premises the AWS were installed. Obtaining accurate elevation details of a large number of sites through Survey of India is a costly and long drawn process. So, if details of elevation were not readily available, handheld digital modules like Garmin and Trimble using the satellites of the Global Positioning System (GPS) were used to determine the same. The geocoordinates like latitude and longitude obtained from these instruments were accurate and very much reliable. However, due to limitations in the positioning accuracy (of the order of 10 metres) of the GPS instruments procured, the elevation obtained was found to be incorrect in the case of a few sites which was inferred based on the erroneous MSLP reported by the station.

During data validation procedures digital pressure standards traceable to national standards are utilised to compare and check the measurement of SLP by pressure sensors on-site. Such an exercise in all AWS sites has led to the firm belief that SLP is correctly measured by the sensor within the tolerance limits specified by the World Meteorological Organisation. Hence it was affirmed that the elevation of the site needs to be known precisely to avoid errors in conversion of the SLP to MSL.

In the case of uneven natural terrain conditions and land-filled sites, the history of which is not known at first sight when a site is selected for installation of an AWS, a significant change in elevation of a few metres between two locations separated by even a short distance has been observed. So it is imperative to have authentic elevation measurements done exactly in the locations where AWS are planned to be installed rather than take the value available in records for granted.

GPS / GNSS technology

Understanding the importance of documenting and utilising the accurate elevation of AWS sites, modern online tools like Google Earth maps were also tried with limited success. As the density of the AWS located in geographically diverse and remote terrain is increasing manifold, obtaining the height above m.s.l of new sites accurately became an important pre-requisite component of the meta database while planning the augmentation of the observational network.

It was then decided to tap the options available from state-of-art satellite technology. The constellation of satellites of the Global Navigation Satellite System (GNSS) / GPS provides sub-metre accuracy positioning information including the height above m.s.l. of any geographic location. The Medium Earth Orbit (MEO) satellites have a circular orbit approximately at a height of around 20-25,000 km around the earth and their timings are very accurate, maintained by cesium / rubidium atomic clocks. The orbit ephemerides are clearly known. The satellites operate in L band (1-2 GHz) and in three particular frequencies viz., L1 (1575.42 MHz), L2 (1227.60 MHz) and L5 (1176.45 MHz) using code division multiple access technique. GPS satellites are operated by USA and its Russian equivalent is the GLONASS (Global Navigation Satelllite System). As of now, we in India depend on these satellite coverages and use their services to obtain accurate positioning information. GNSS is a commonly used acronym for GPS, GLONASS and other equivalents of China (Compass) and European Union (Galileo).

India through Indian Space Research Organisation (ISRO) with its self-reliant vision of having a Regional Navigation Satellite System has launched the first of its series of seven navigational satellite IRNSS-1A on 1st July 2013. It is geosynchronous at 55°E with an inclination of 29°. In addition we have GAGAN, an inter-operable GPS aided satellite based augmentation system (SBAS) helpful for air navigation.

Radio signals continuously transmitted by the GNSS satellites pass through different layers of the atmosphere and are received by numerous reference (base) stations whose position is known to the highest degree of accuracy using conventional surveying techniques. The user equipment (receiver and antenna) also receives the signals from multiple GNSS satellites. In differential GNSS, the base station determines ranges to GNSS satellites in view and for each satellite, recovers the information that was transmitted and determines the time of propagation viz., the time it takes for the signals to travel from the satellite to the receiver. This information and the difference in ranges between the satellites is communicated to other receivers which incorporate the corrections into their position calculations and then compute their position and time.

Omnistar-HP subscription services

Commercial SBAS like Omnistar-HP is used in India to have access to the corrections provided by their high performance range correcting systems. Omnistar uses dual frequency receivers and is able to provide accuracies of 6 to 10 cm in elevation. Differential positioning requires a data link between base stations and other receivers if corrections need to be applied in real-time. At least four GNSS satellites need to be in view at both the base station and the receivers. Positioning based on standalone GNSS service is accurate to within a few metres and the less number of satellites available with one GNSS service is not sufficient for us. On an average, there is a variation of 1 hPa for every 10 metres height difference in the vertical atmosphere and very high accuracy in elevation measurements are needed. Hence differential GNSS technique is used. The absolute accuracy of the receiver's computed position will depend on the absolute accuracy of the base station's position. One has to subscribe and obtain licence for the period (1 to 2 years as applicable) we require. Only then the receiver will be able to access and utilise the Omnistar services.

When used with NovAtel's GPS antennas, the Propak-V3 receiver provides superior tracking performance, positioning accuracy and reliability. The antenna is compatible with Omnistar-HP. Omnistar uses geostationary satellites in 8 regions covering most of the landmass of each inhabited continent on Earth. It uses 100 reference stations, 6 high performance satellites and two global network control centres for errror corrections.

IMD's procurement

Accordingly, during the year 2012, O/o Dy.Director General of Meteorology(Surface Instruments), Pune procured the following equipment viz., a) a GPS-702-GG-L1/L2 GNSS antenna (Fig.1a) offering combined GPS + GLONASS signal reception facility, b) a Propak V3 triple frequency GNSS receiver (Fig.1b), c) tripod stand(Fig.1c), d) power supply (12V/5 Ah), and e) a note pad computer containing NovAtel CDU software interface (Version 3.9.0.7, Build 6168) for communication with the receiver. A screen shot of the software while using it to track the satellites and obtain the correct geocoordinates and elevation of a site is shown in Fig.2.

Using these equipments survey of all AWS sites was initiated first in the state of Maharashtra. Remarkable improvement in accuracy levels with errors less than 0.3 hPa was evident in the conversion of SLP to MSLP of AWS in Maharashtra after incorporating in the Earth station software the elevations of sites obtained through the GNSS receiver equipment. Similar such survey was completed for Tamil Nadu (TN) and south Andhra Pradesh(AP) during the year 2013. The advantage is that the accurate elevation of the pressure sensor above m.s.l is known. Hence reduction of SLP to MSL is most accurately obtained. Shri. Anjit Anjan, Scientist-C from O/o DDGM(SI), IMD, Pune imparted training on operation of the sub-metre accuracy GNSS receiver equipments to officers and staff of RMC Chennai on 1.1.2013. After familiarisation, team members of Regional Instruments Maintenance Centre (RIMC) successfully completed survey of 64 sites (in TN and south AP) including surface observatories during 1.1.2013 to 8.5.2013.

1(a) (b) (c)

Fig.1(a) Pin wheel antenna b) Propak V3 receiver and c) Tripod stand used to mount the antenna

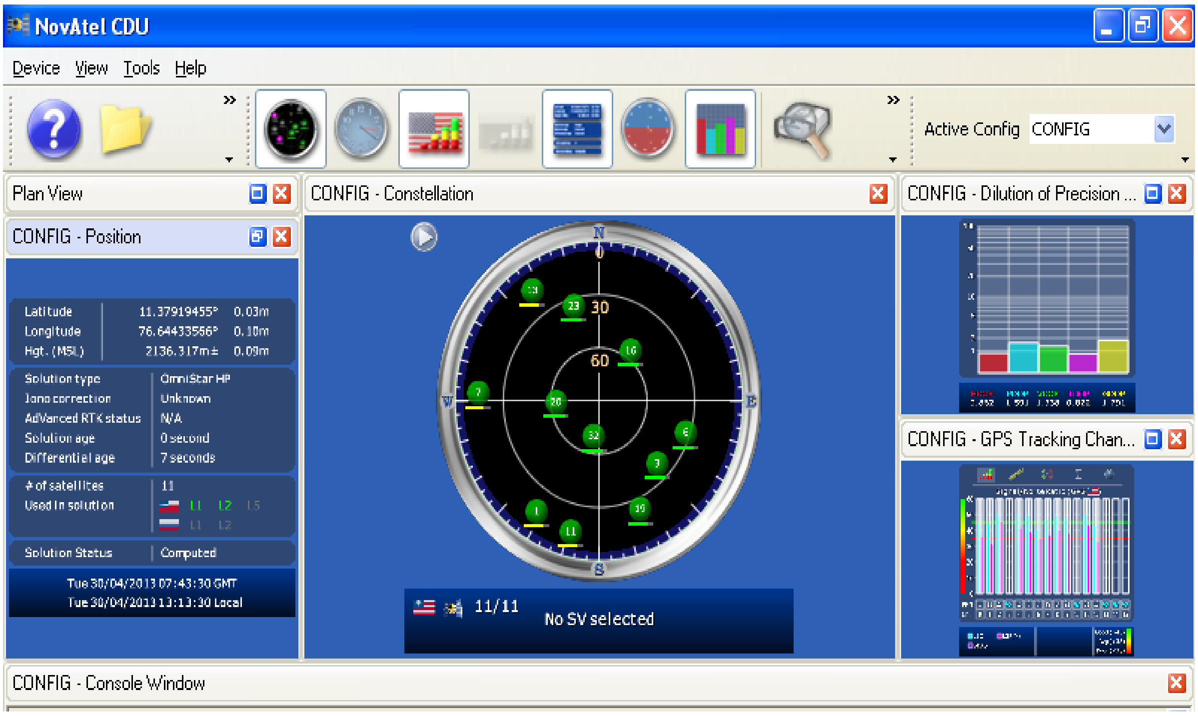

Fig.2 Screen shot of the tracking of satellites using NovAtel CDU GNSS receiver software

Table 1 provides the details of 45 stations and their elevations prior to and after the survey. It is clear from Table 1 that for a few stations there is a marked deviation between the elevations available prior to and after the survey. Others have negligible errors in elevation. This can be attributed to the comparatively uniform terrain in the coastal areas of TN and south AP and the gradual increase in elevations as one proceeds westwards due to the variability in topography under the influence of the western ghats. The same situation cannot be expected in other States when there is high region-specific variability in topopgrahy and hence the survey is crucial in such regions. Problems in reduction of slp to msl in few sites (like Vedasandur, Mailam, Kanchipuram, Vrinjipuram, Othakadai(Madurai), Periyakulam, Darsi, Kavali, where the accurate elevation was not known have been sorted out now.

Table 1 – Elevation details of AWS in Tamil Nadu and South Andhra Pradesh

No.	State	Station	Actual height of pressure sensor amsl (m) after survey	Elevation (m) of the site as per available records prior to survey	Error (actual-old) (m)
1	TN	Adirampattinam	6.1	4.3	1.8
2	TN	Aduthurai	20.4	19.0	1.4
3	TN	Ariyalur	74.7	78.0	-3.3
4	TN	Chidambaram	5.2	4.0	1.2
5	TN	Coimbatore	431.5	433	-1.5
6	TN	Coonoor	1773.4	1765	8.4
7	TN	Ennore_Port	10.6	5.0	5.6
8	TN	Erode	171.7	166.7	5.0
9	TN	Hosur	882.9	881.0	1.9
10	TN	Kalavai	137.9	138.0	-0.1
11	TN	Kanchipuram	84.1	69.7	14.4
12	TN	Karaikal	2.9	7.0	-4.1
13	TN	Kovilpatti	80.0	81.0	-1.0
14	TN	Madhavaram	6.8	8.0	-1.2
15	TN	Mailam	57.1	45.6	11.5
16	TN	Meenambakkam	16.5	15.0	1.5
17	TN	Namakkal	191.2	192	-0.8
18	TN	Natham	260.7	269.0	-8.3
19	TN	Neyveli	56.8	66.0	-9.2
20	TN	Neyyoor	51.7	47.0	4.7
21	TN	Nungambakkam	8.7	6.1	2.6
22	TN	Ooty	2136.3	750	1386.3
23	TN	Othakadai_Madurai	139.8	N/A	139.8
24	TN	Paiyur	468.6	469.0	-0.4
25	TN	Pechiparai	78.9	87.0	-8.1
26	TN	Perambalur	120.8	118.0	2.8
27	TN	Periyakulam	289.5	300.0	-10.5
28	TN	Puducherry&MO	38.4	38.2	0.2
29	TN	Thuvakudi	75.1	70.0	5.1
30	TN	Tiruchendur	4.2	2.0	2.2
31	TN	Tirunelveli	40.1	44.0	-3.9
32	TN	Tiruttani	88.8	88.1	0.7
33	TN	TuticorinPort	3.8	1.0	2.8
34	TN	Vedasandur	211.6	192.0	19.6
35	TN	Viringipuram	232.8	206.0	26.8
36	TN	Virudhunagar	94.6	94.0	0.6
37	TN	Yercaud	1400.5	1399.6	0.9
38	AP	Bapatla	7.7	6.0	1.7
39	AP	Darsi	125.9	101.0	24.9
40	AP	Kavali	24.3	13.1	11.2
41	AP	Nellore	14.4	20.0	-5.6
42	AP	Perumalapalli	188.8	191.0	-2.2
43	AP	Sriharikota	6.2	5	1.2
44	AP	Tirumala	837.8	845.0	-7.2
45	AP	Tirupati	191.8	193.0	-1.2

Field usage aspects

Measurements using the GPS/GNSS antenna and receivers are best done in clear sky conditions and with maximum number of satellites in the field of view while undertaking the survey. Ideally around 10 to 11 satellites (11 in Fig.2) give the maximum accuracy. A minimum of time of 30 minutes is required for the accuracy to reach ± 0.1m. Hence, as soon as one reaches the site, the GNSS equipment is set up for synchronisation to commence. A 12V/5 Ah battery is required for powering up the receiver. Sometimes under cloudy sky conditions the number of satellites in the field of view may be only 7 or 8 and the accuracy will also vary from ±0.2 to 0.4m. While in the site, during the 30 minutes time, three-four snap-shots of the image containing the lat/lon/elevation details are taken and the best with the least error is taken as representative of the site. A digital hand-held pressure standard (DPI-740) is also carried to sites to validate the data from the pressure sensor of AWS and to note deviations if any, for corrective action. The accurate geocoordinates for AWS in TN and south AP have been fed into the database of earth station. The MSLP conversion is now accurate and so the synop message generated is in consensus with the isobaric analysis while plotting and analyzing MSLP synoptic chart.

The survey of AWS sites in Kerala also has since been completed and is pending in north AP and Karnataka due to formalities in renewing the licence with Omnistar. Yearly calibration of pressure sensor of AWS added with accurate elevations of sites will generate correct MSLP.

Around 2000 AWS are envisaged in the next few years by IMD and site surveys using GNSS receivers for obtaining correct height above m.s.l are mandatory. Hence IMD has planned to procure more number of GNSS receivers. Each of the Regional Meteorological Centres needs to undertake this type of survey of the sites before finalising them for installation of AWS in their respective regions to ensure reliability in MSLP data.

It may be mentioned here that various other organisations install their own AWS and might require the use of this receiver procured by IMD for accurate reporting of atmospheric pressure above m.s.l. IMD will be able to provide assistance in this regard to such organisations.

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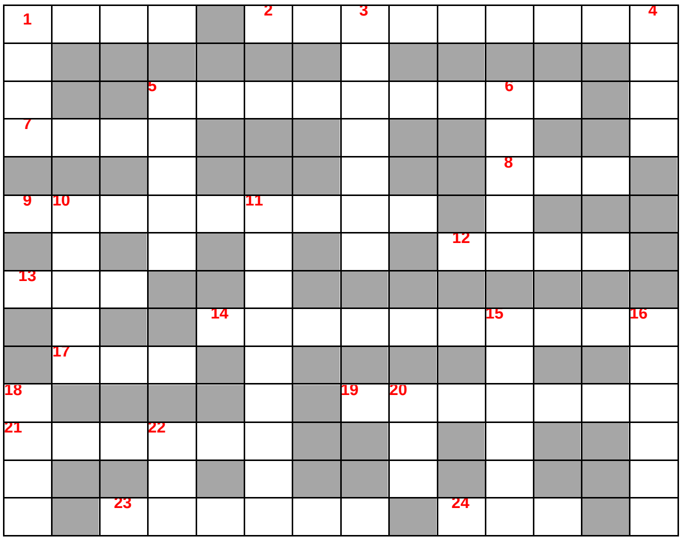
http://www.novatel.com/

Manual of Propak V3 receiver.

Instructions Note on usage of GPS /GNSS equipment prepared by RIMC Chennai, July 2013.

wXword



ACROSS:

1 : Water in Latin
2 : Action of drawing liquid into a tube or porous material
5 : Transfer of energy through vacuum
7 : Cloud Cover is measured in ----------.
8 : Term used for professional body of lawyers is a unit of measurement in Meteorology
9 : You call it a -----------process in an insulated system.
12 : Acronym for an agency held by Navy and Air Force in Pearl Harbour
13 : Acronym for procedure of shifting files from one host to another in internet
14 : State of the atmosphere when isotherm and isobar run parallel to each other
17 : German physicist known for his contribution to scattering
19 : Longest of the five notable latitudinal circles
21 : Hidden and it matters when change of state of substance occurs
23 : This programming language reminds us of measuring unit in Meteorology
24 : Geo physical entity distinct from earth and sky

DOWN:

1 : ------foresting is an integrated approach of using the interactive benefits by combining trees, shrubs with crops.
3 : Sapphire in Thai means second strongest ever cyclone to make landfall in India
4 : Directional antenna in synonym with typhoon that impacted Ryukyu islands in the year 2000
5 : Well-known palindrome in meteorology
6 : ---------- of a planet is typically elliptical
10 : Reference from which measurements are made
11 : One of shortest in the five notable latitudinal circles
15 : Synonym with impenetrable
16 : Father of thermodynamics
18 : Rate of flow of energy across unit area
20 : Acronym for zonal flow in tropical stratosphere
22 : Acronym of advent in flight schedule

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AN ANALYTICAL TOOL FOR DEPICTING RAINFALL CHARACTERISTICS OF TROPICAL CYCLONES OVER NORTH INDIAN OCEAN - *TCRAIN*

by
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India, having an extensive coastline is vulnerable to the destructive features of Tropical Cyclones (TCs) that form over the North Indian Ocean (NIO) basin comprising of the Bay of Bengal (BOB) and the Arabian Sea (AS). Torrential rains associated with landfalling TCs cause fresh water flooding and extensive damages to crops in the respective coastal areas so much so, that, rainfall prediction is a highly warranted aspect of TC forecasting. However, Quantitative Prediction Forecasts for TCs is a highly challenging aspect as precipitation distribution around a TC display complex asymmetric structure owing to TC translational speed, environmental wind shear and TC specific structural and dynamical aspects.

Characterisation of rainfall associated with TCs based on intensity stratification is an important step towards understanding the symmetry and/or asymmetry of TC rainfall distribution during the life cycle of the TC. Frequency distribution of rain rates would give valuable information on highly probable rain rates associated with different intensity stages of the TC; azimuthally averaged radial profiles of mean rain rates would provide information on rainfall variability at different radial distances from the TC centre; and quadrant-wise mean rain rates would depict the asymmetry in the radial rainfall structure.

TCRAIN is a Tropical Cyclone Rainfall Analytical tool that provides rainfall characteristics of 43 Tropical Cyclones that formed over North Indian Ocean during the period 2000-2010 in graphical / pictorial form through a menu-driven user interface. Three products, viz., the (i) Frequency distribution of rain rates within 500 km from the TC centre (ii) Azimuthally averaged radial profiles of mean rain rates within 500 km from the TC centre and (iv) Quadrant-wise mean rain rates within 200 km from the TC centre are presented for five different stages of intensity during the life cycle of each cyclone. The products are generated using 3-hourly Tropical Rainfall Measuring Mission (TRMM) rainfall data at a spatial resolution of 0.25^o x 0.25^o grid.

The rainfall analysis is carried out using the TRMM based precipitation data (3B42 V6) having a spatial coverage of 50^oS to 50^oN at 0.25^o x 0.25^o resolution at 3 hourly intervals. The 3B42 processing has been designed to maximise data quality and has been recommended for research work (http://disc.sci.gsfc.nasa.gov/).

According to India Meteorological Department's (IMD) classifications based on maximum sustained surface wind speeds, low pressure systems are categorised as Well marked low (<17 knots), Depression (**D**, 17-27 knots), Deep Depression (**DD**, 28-33 knots), Cyclonic Storms (**CS**, 34-47 knots), Severe Cyclonic Storms (**SCS**, 48-63), Very Severe Cyclonic Storm (**VSCS**, 64-119 knots), and Super Cyclonic Storm (**SuCS**, >120kts).

During the period 2000-2010, 43 TCs (CS and higher categories) have affected the NIO basin. Using the IMD's best track data of TCs which contain information on instantaneous position, intensity and direction of motion of the TC, the life cycle of a TC is stratified based on intensity during the growth and decay of the TC and grouped into 5 stages as follows: The **growing phase** of the life cycle of the TC is classified into **3 *intensification stages*** indicated by a prefix '***i***'; the intensity categories of **D, DD** are categorised as ***Stage-1*** (Intensification stage 1 and indicated as ***iD***); the category **CS** is categorised as ***Stage-2*** (Intensification stage 2 and indicated as ***iCS***); the categories of **SCS, VSCS** and **SuCS** are grouped under ***Stage-3*** (Intensification stage 3 & indicated as ***iSCS***) and the **decaying phase** (i.e., when the intensity category of the TC changes from the peak category to lower categories) of the TC is classified into ***two stages of weakening*** indicated by prefix '***w***'; the intensity category of **CS** during the decaying phase is classified under ***Stage-4*** (Weakening stage 1 and indicated as ***wCS***) and the categories of **DD** and **D** during the decaying phase as ***Stage-5*** (Weakening stage 2 and indicated as ***wD***).

Whereas the IMD's best track data are available at 3-hourly interval for 00, 03, 06, 09, 12, 15, 18 and 21 UTC, the precipitation data are centered at 0130, 0430, 0730, 1030, 1330, 1630, 1930 and 2230 UTC. Hence, the location and direction of movement of the TCs at TRMM Observation times are determined by interpolation from the IMD's Best Track dataset.

For the purpose of computations, a moving coordinate system with the TC centre as the origin and direction of motion of the TC as the reference direction is considered. For each instant of time, the centre of the coordinate system is first shifted to the centre of the TC at that instant and then the coordinate system is rotated such that the direction of motion of the TC at that specific instant of time coincides with the 0^{o} azimuth which is taken as the positive Y-direction for the purpose of plotting. For this purpose, every grid point in the world co-ordinate system (longitude, latitude) are represented in polar co-ordinates *(r,θ)*, in terms of radial distance from the TC centre *(r)* and oriented at an angle *(θ)* with reference to direction of motion of the TC [taken as the 0^{o} azimuth]. All 0.25^{o}x0.25^{o} rainfall data are then represented in terms of radial distance from the TC centre and with reference to the direction of motion of the TC.

For each stage of intensity of a TC, all three hourly rainfall data are grouped together and the composited mean rainfall characteristics are determined for that stage. FORTRAN programs developed for the purpose and GrADS software package are used for computations and plotting.

The methodology of computation is as follows:

(i) The percentage frequency distribution of rain rates is determined by considering all rain rates within 5^{o} radius (≈500 km from the TC centre) in respect of all the 3-hourly instances of observation grouped under the specific intensity category. For this purpose, the rain rates are classified into nine classes (including no rain category) as 0.0, 0.0-0.1, 0.1-0.2, 0.2-0.5, 0.5-1.0, 1.0-2.5, 2.5-5.0, 5.0-10.0 and >10.0 mm/hr and the frequency distribution in each class is determined and expressed in percentage.

(ii) Radial profile of mean rain rates is obtained by first azimuthally averaging rain rates within an annulus of very small thickness [0.1^{o} (≈10 km)] for a particular radial distance *r*, and then determining the same for all radial distances from the TC centre up to 5^{o} radius (≈500 km from the TC centre) for each instant of observation and then determining the mean of all the mean rain rates corresponding to each radial distance (annulus at that radius) in respect of all observations in the specific intensity category. For this purpose, for each observation, the origin is shifted to the TC centre. Then an area within 5^{o} radius (≈500 km) from the TC centre (origin) is taken and divided in to 50 annular rings of 0.1^{o}width (≈10 km). Each data point within 5^{o} radius from the TC centre is then expressed in terms of radial distance from the centre (*r*) and all rain rates within each annulus of radius *r* are considered for determining the azimuthally averaged rain rate at the radial distance *r* of the annulus from the TC centre. Fig.2 depicts the methodology of determining the azimuthally averaged radial profile schematically. Thus, as we go from the TC centre ($r=0^{o}$) to outer most radius of $r=5^{o}$ in steps of 0.1^{o}, a profile of 50 radial mean rates corresponding to 50 annuli are obtained. Similarly, instantaneous profiles are obtained for all observations grouped under a specific intensity stage from which the mean profile of azimuthally averaged mean rain rate for that intensity stage is determined. Similar profiles are obtained for all intensity stages during the life cycle of the TC.

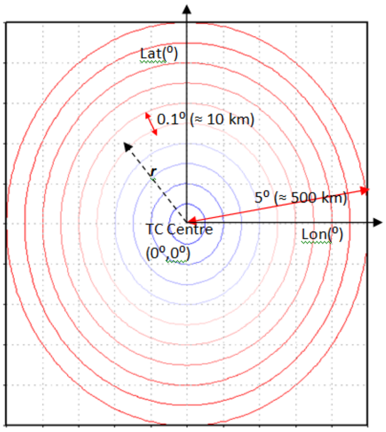

Fig.2 Schematic representation of steps for determination of azimuthally averaged radial profile of mean rain rate

(iii) The Quadrant-wise mean rain rates are obtained by averaging all rain rates within 2° radius (≈200 km) from the TC centre with the direction of motion of the TC as the reference direction for each instant of observation and then determining the mean rain rate in each quadrant in the specific intensity category of the TC. For this purpose, the co-ordinate system is rotated through an angle θ_1 which is the direction of TC movement measured clockwise from the reference direction (North, which is taken as 0° azimuth as per meteorological convention) such that the direction of movement of the TC is now oriented along 0° azimuth, the reference direction. Then, in the rotated configuration, the mean of all rain rates in the quadrant *0°-90°* (measured clockwise from the direction of movement of the TC) from the TC centre up to 2° radius is determined which gives the mean rain rate in the *Right Forward* quadrant. Similarly, mean of all rain rates in the quadrant *90°-180°* within 2° radius gives the mean rain rate in the *Right Rear* quadrant, that in quadrants *180°-270°* and *270°-360°* correspond to *Left Rear* and *Left Forward* quadrants respectively. Fig.3 depicts the steps schematically.

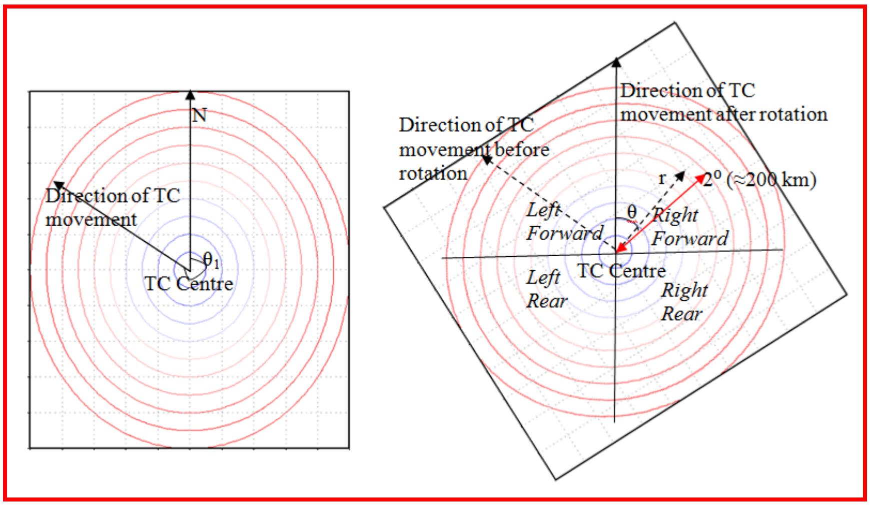

Fig.3 Schematic representation of steps for determination of quadrant-wise mean rainrates

The frequency distribution and azimuthally averaged radial profiles of mean rain rates are determined up to 500 km from the TC centre as the radial extent of the TCs, and hence its impact, normally extends up to a radial distance of 500 km. However, quadrant-wise mean rain rates, which provide information on the mean asymmetric characteristic of rainfall distribution, are computed up to 200 km only from the TC centre as generally, the most devastating torrential rains are realised within 200 km from the TC centre and beyond 200 km, the rain rates are generally not so alarmingly high.

Sample products obtained are depicted in Fig.4.

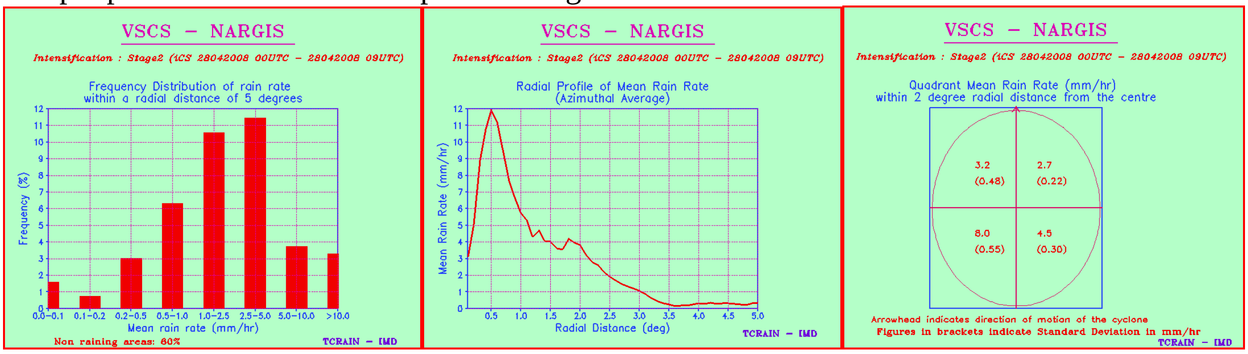

Fig.4 Sample products available in *TCRAIN*

The above products are hosted in the web at the URL: www.cwrcimdchennaitcrain.in and would provide valuable information on the characteristics of rainfall associated with various intensity stages of tropical cyclones over the North Indian Ocean basin and hence would provide key inputs for carrying out analytical studies on the dynamics of rainfall associated with cyclones of North Indian Ocean.

Solution to *wXword* in page17

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