INDIAN METEOROLOGICAL SOCIETY
AHMEDABAD CHAPTER

Monsoon Issue | e-MEGHA | 2016

Contents

From Chairman's Desk

Raj Kumar
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I extend my warm greetings to all the members of IMSA through this issue of e-Megha. After the new executive committee has taken over, it has resolved to bring out e-Megha regularly. I congratulate the e-Megha editorial committee for bringing out this issue with many informative articles and columns. This is the time when we are in the midst of monsoon with some area of the country experiencing heavy rain and flooding whereas many other areas are reeling under deficient rain, especially Gujarat. We can hope for a good amount of monsoon rains stored for next two months. We can recall monsoon of 2002 when up to July month the countrywide rain deficiency was reported to historically low at 51%, but we saw a remarkable recovery in the subsequent months.

India has a long history of weather and climate research and their applications for societal benefits. The first record of such history can be traced back to Upanishads (~3000 BC) which discuss about formation of clouds, rainfall, seasonal cycle, etc. The systematic record of weather observations in early period can be found in Arthshastra by Kautilya (Chanakya), who wrote about scientific measurement of rain and its application to revenue and relief work. The Indian space program contributed immensely towards weather observations through its many past and present satellite missions. Very shortly, we will be witnessing the launch of SCATSAT and INSAT-3DR missions. While SCATSAT will be carrying a Ku-band scatterometer for measuring wind vector over data sparse global oceans, the INSAT-3DR is a repeat mission of INSAT-3D which will augment services provided by INSAT-3D. I am looking forward towards the meteorological community to reap the full advantage of the availability of the unique observations from these missions for societal benefit.

We, the IMSA members, make our society very vibrant with series of new initiatives including planning for International Tropmet in 2017. Recently we conducted a successful "MET AWARE-2016" Program on 16 July 2016 in Anand and Vallabh Vidyalaya to nurture young students and researchers.

I wish all the IMSA members a good reading of this "Monsoon Issue" of e-Megha.

Secretary's Report

D Ram Rajak
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On behalf of the newly elected Indian Meteorological Society Ahmedabad (IMSA) Chapter executive committee (EC), I thank IMSA members for active participation in the activities conducted by the Society. The current EC was elected unanimously during the Annual General Body meeting held on 19 April, 2016. Over the years IMSA has emerged as a very active chapter by conducting various programs for researchers, educators and, most importantly, for students and the public. The strength of any society is its member and IMSA has efficiently used the expertise of its members in the field of satellite meteorology and climatology. IMSA is also actively participating with various other local scientific societies like ISRS, INCA, ISG, and SSME and thereby, is benefitted in conducting various activities where scientific and technical cooperation is required. We would like to continue this process and utilize the expertise available from other Societies /Chapters for the maximum benefit to researchers and students.

A joint meeting of outgoing and incoming ECs held in May 2016 and set an agenda for the new committee to attempt during its tenure. IMSA has constituted separate funds for the various activities such as students outreach activity, to encourage IMSA researchers and to execute various lectures and events. We would like to efficiently utilize these resources for planned activity with the help and support from our members. Five applications for IMSA Life Membership and five for IMSA Annual Membership are received in 3 months.

IMSA started its awareness program by organizing the first program of this year, "MET-Aware-2016" on 16 July 2016 at Anand and Vallabh Vidyanagar. This program was organized jointly by IMSA and N.V. Patel College of Pure and Applied Sciences (NVPAS), Vallabh Vidyanagar. The second program i.e. SIMPLE-2016 (Student Involvement in Meteorological Parameter Learning) of Metkit distribution to 40 schools of Ahmedabad district is co-organized with DIET – Ahmedabad (Rural) on August 10, 2016 at Vikram Sarabhai Space Exhibition (VSSE), Ahmedabad. Chairman – ISRO, Shri A. S. Kiran Kumar presented the prizes to the winner students of IMSA Essay Competition held last year.

IMSA has planned many activities during this year. This includes conducting Prof Satish Dhawan Lecture 2016; conducting Monsoon Lecture at the end of monsoon 2016; Weather discussions with the village farmers to understand their traditional ways of weather prediction that they have developed over generations. One major event that IMSA is going to host in 2017 is INTROMET-2017. This is an international conference organized by Indian Meteorological Society every four years.

I am sure IMSA members would actively participate in various planned activities to fulfil the goals and objectives of the Society.

Stills From IMSA's "MET-AWARE-2016" Program


Snippets on Weather and Climate News and Research

There is a gradual shrinkage of Indus river, which has been attributed to the cooler and cloudier summers which are slowing the snow-melt in the Himalayas. (Study published in Nature, 2016)

From the Chief Editor's Desk

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At the outset, let me extend my warm greetings, on behalf of all members of the newly constituted Editorial Board, to all IMSA members and the widespread reader community of our newsletter: **e-Megha**. My heartfelt greetings to the newly constituted Executive Council (EC) of IMSA and good wishes for an eventful tenure in office. As a principal mouthpiece and outreach medium for showcasing IMSA activities, it will be our sincere endeavour to continue to apprise our readers of the whole series of activities that IMSA engages in, as and when they happen, and, also those that are planned in near future. As has been the convention with earlier issues, e-Megha in its forthcoming editions, shall seek to consolidate on the whole gamut of news items pertaining to significant weather events. In keeping with the time of the year and the enthusiasm this season evokes, the current edition of the newsletter features a substantive column on MONSOON - its progress and status across the country, and especially, in the state of Gujarat. Accordingly, we have chosen to call all future issues for the quarter ending August – the Monsoon issue. This will be followed by the post-Monsoon issue for the quarter ending November, the Winter issue in February quarter end and the fourth Summer issue in May. Weather events causing catastrophic damage to life and property, as we have witnessed in recent occurrences of extreme rain events of Uttarakhand and Madhya Pradesh, are adequately covered in this issue, in terms of their meteorological indicators. This issue gives a wide coverage to ISRO's soon-to-be-launched SCATSAT mission for marine surface vector winds in terms of its system configuration and possible applications. The novel concept of GNSS-Reflectometry for ocean winds, global status and the initiatives taken at SAC are highlighted in this issue. We are also bringing for the first time a new column on eminent meteorologist/scientist in the field of atmospheric and oceanic sciences in each of the quarterly issues, especially for our younger readers. In this issue, we are profoundly privileged in presenting an anecdote of Dr. T N Krishnamurti, eminent world tropical meteorologist based in U.S.A.

The "Met Awareness" trip conducted successfully by IMSA, as an outreach activity for the young and uninitiated students, researchers and weather enthusiasts, is an important highlight of this issue. Besides, a host of other legacy item-heads from our earlier issues are chipped in to preserve the overall balance of the newsletter.

We appreciate feedback from our readers with regard to content and outlook of the newsletter and any other matter related to improving the readability of the newsletter. Contents (articles/news-items/graphics/interesting cartoons etc.) for the next ("Post-Monsoon" issue) issue of e-Megha are highly welcome from our readers. Please e-mail all your contents with name and affiliation, if any, and IMSA membership number to our newly created official e-mail imsa.emegha@gmail.com.

On this note, I wish you all happy reading!

Progress of Monsoon 2016

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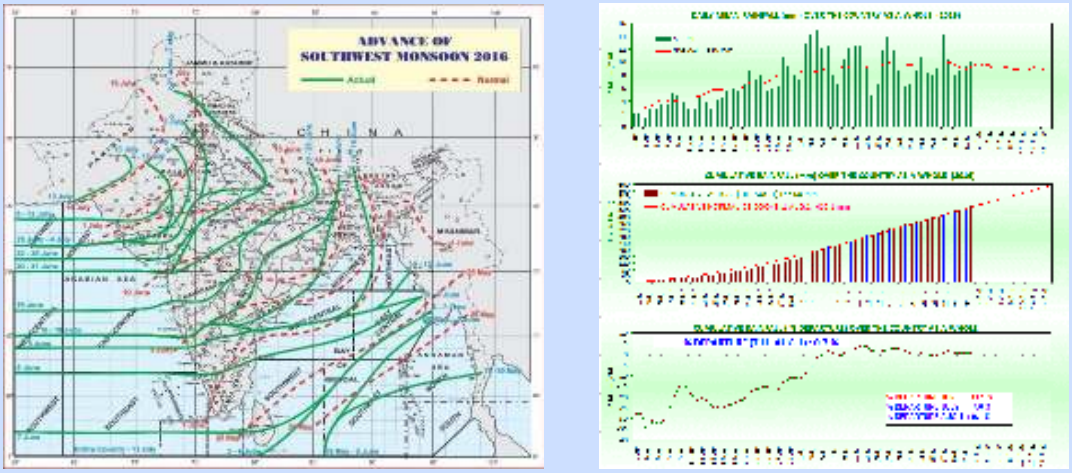
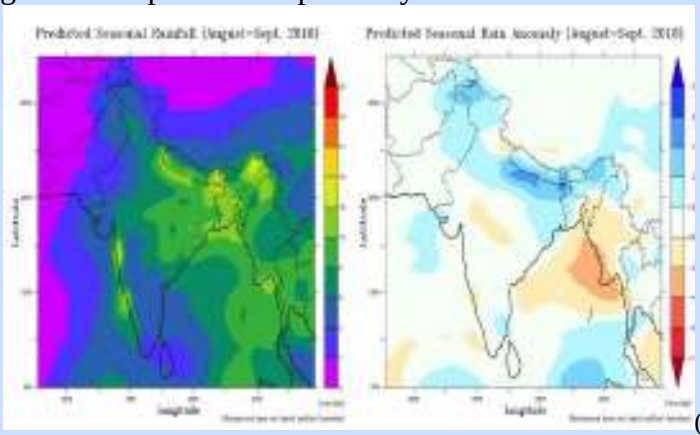
After two consecutive drought years viz. 2014 and 2015, IMD and other forecasting agencies predicted excess or above normal rainfall for the year 2016 for June through September over the Indian landmass. SAC Ahmedabad also made the experimental forecast of the All-India Rainfall (AIR) for the Monsoon Season of 2016 using dynamical model of ensemble prediction system. It is predicted to be 91.6 cm which is 104% of the long-term model mean (87.8 cm). The monthly predicted AIRs are 19.7 cm (109%) and 29.7 cm (108%) for the months of June and July. However, late arrival of monsoon (Onset as declared by IMD, June 7, 2016) resulted below normal rainfall during June (89% of long term normal) received by the country. Above normal rainfall received during July (107% of long term normal) revive the All-India rainfall for the first half of the season (100% of long term normal till 31st July).



(Courtesy: IMD)

After the late arrival of monsoon to the Kerala coast on June 7, it took a month to cover the entire country by 5th July. Sitting over the southern part and south-west coast of India during June 10 to 18 resulted the below normal rainfall received during June over the country as a whole. However, by the end of June, the monsoon has covered by the entire country and resulted above normal rainfall during July. Prediction for the second half of monsoon season by IMD is 107% of long term normal. SAC Ahmedabad also update its experimental forecast. The prediction for the second half of seasonal average rainfall distribution can be seen in the figure below. Quantitatively, the country is expected to receive 111% (46.9 cm) of the long-term model mean (42.2 cm) during the second half of the season. The monthly predicted AIRs are 28.3 cm (114%) and 18.6 cm (108%) for the months of August and September respectively.



(Courtesy:MOSDAC)

Soil Wetness Index characterizing the progress of Monsoon 2016

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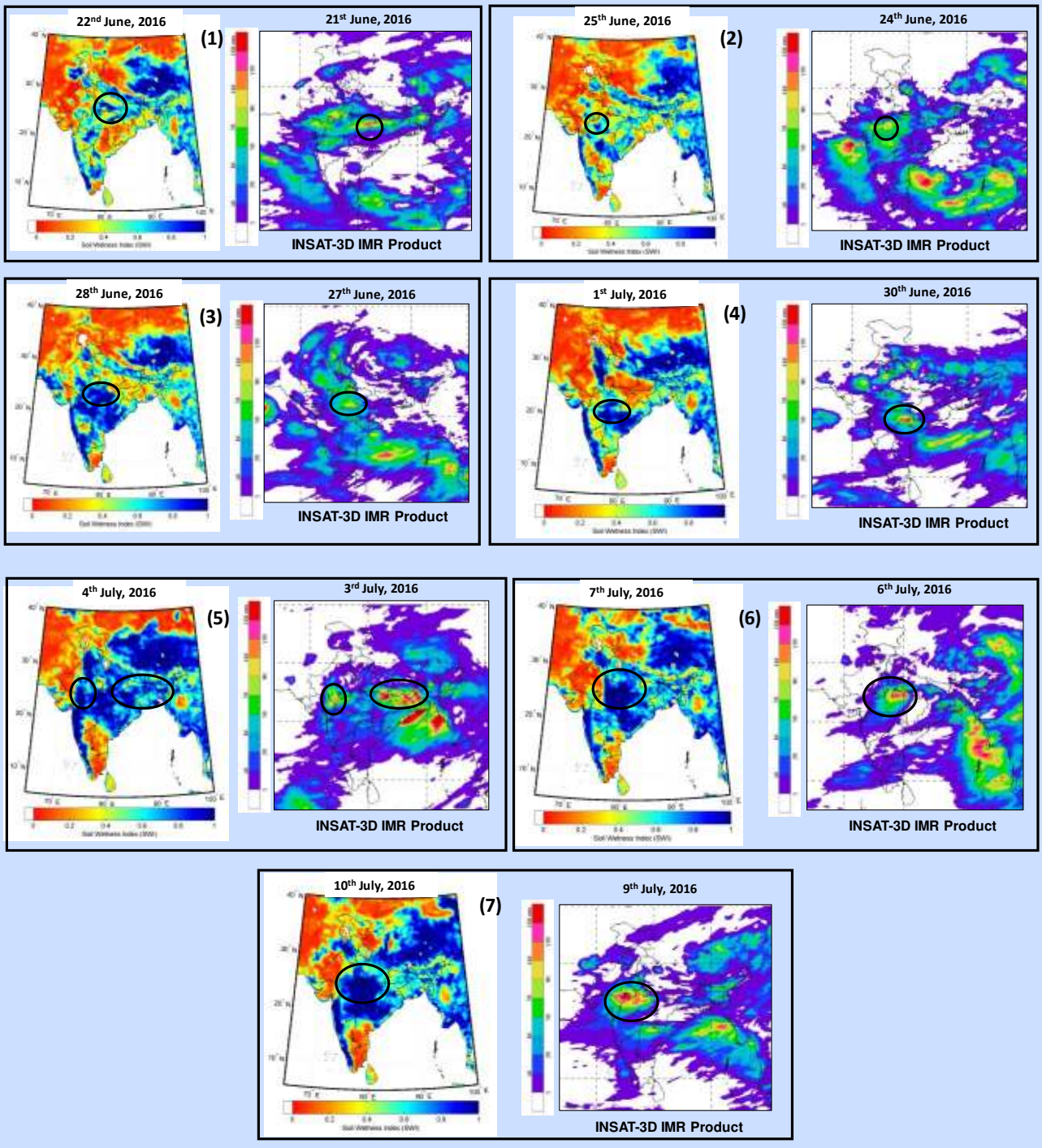
The progress of monsoon has also been captured by the Soil Wetness Index generated using time series based methodology from SMAP L-band radiometer data. Torrential rain over central India, caused severe flood condition and number of districts of Madhya Pradesh (Bhopal, Vidisha, Satna etc.) were severely affected during end of June, 2016 onwards. Several parts of Maharashtra also experienced flood like situation due to incessant rains for several days. Nasik, Kolhapur, parts of Konkan, Marathwada and Vidarbha region are worst affected by this. INSAT-3D IMR (INSAT Multispectral Rainfall) shows heavy rainfall during this period.



Satellite based analysis of some intense rainfall events over India-2016

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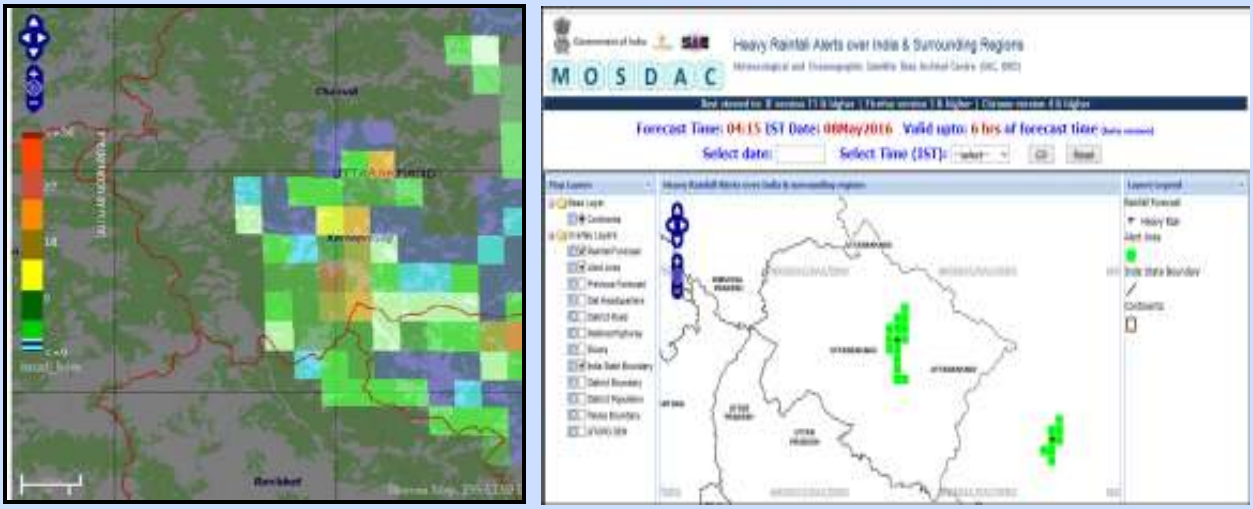
The last few decades have seen a rapid increase in extreme rainfall events (ERE). To name a few, the flash floods over Mumbai in July 2005, Leh cloudburst in August 2010, Uttarakhand extreme rainfall of 2013, Chennai Rainfall and floods in 2015; all caused massive loss to life and property. To monitor and predict such events, satellites play a major role by providing high resolution observations, which help in tracking the changes in a convective system. Also, the Space Applications Centre has developed an automatic satellite based nowcasting method which provides heavy rainfall alerts over India and surrounding regions on MOSDAC website (www.mosdac.gov.in). Two of the intense rainfall episodes of 2016 are discussed here:

Cloudbursts/ Heavy rainfall in Uttarakhand (08 May 2016)

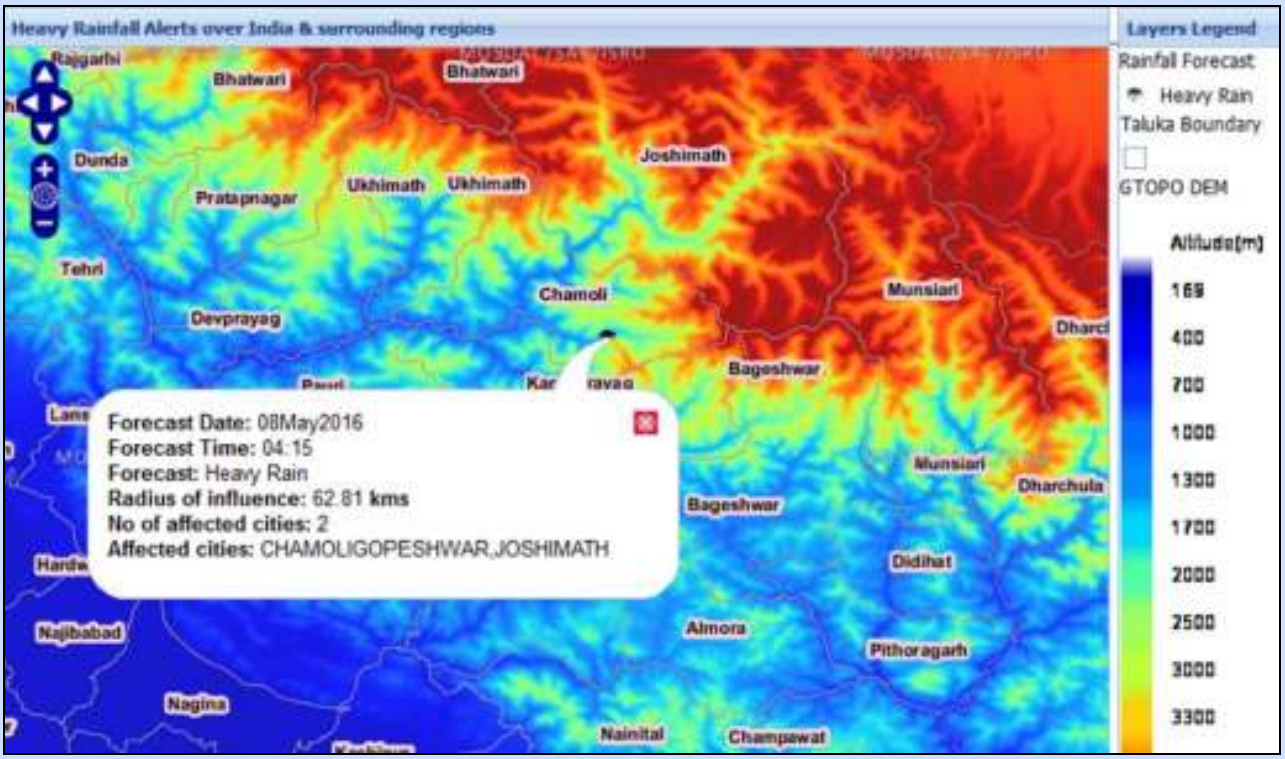


A cloudburst struck around 5.30 am (IST) in Uttarakhand's Chamoli district on 08 May 2016. The affected places were Karnaprayag, Tharali, Chamoligopeshwar, Joshimath, Tanakpur and Lohaghat. The same is seen in the adjacent figure of INSAT-3D Hydro-Estimator (HE) rainfall product (05:30 IST, 08 May 2016). In topographically fragile regions like Uttarakhand, the impact of extreme rain events attains a menacing proportion due to large scale landslides and flash floods triggered by these events. Timely alert of such events thus have a huge societal impact. Although cloudbursts are highly localized events, and this particular one was a pre-monsoon one, the satellite based prediction of the same was highly accurate.

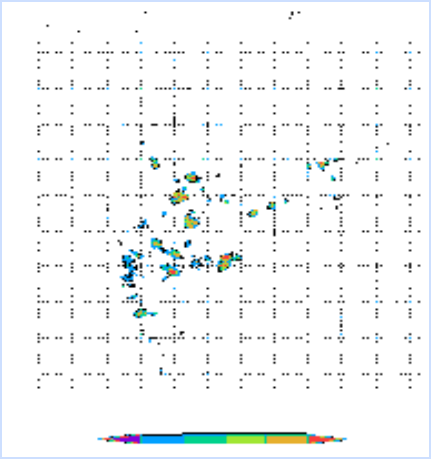
The alert displayed on GUI superimposed over Digital Elevation Map in the next figure (top of the next page) shows most affected region at the juncture of deep valley and high hills. It is interesting to note that the SAC-Nowcast model gave accurate alerts of heavy rain events and these alerts were disseminated in real-time through MOSDAC portal www.mosdac.gov.in.

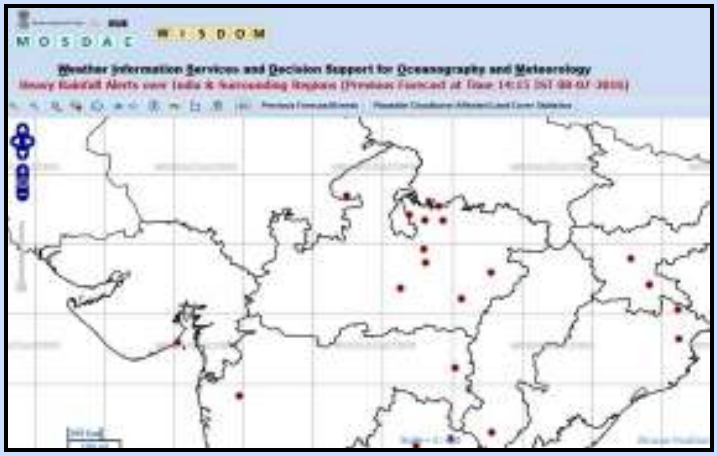
Heavy rainfall in Madhya-Pradesh (08 July 2016)

On 8th July 2016, within a span of few hours, the northern and central Madhya Pradesh (MP) received massive amount of rainfall. Cities such as Satna (245mm), Panchmarhi (103 mm), Damoh (86 mm), Sagar (51 mm) were most affected. The vigorous monsoon activity, which was was witnessed in the region could be attributed to the well-marked low pressure area over East Uttar Pradesh, which had moved towards Southwest Uttar Pradesh and adjoining areas. The associated upper air cyclonic circulation extended up to 7.6 km. In the INSAT-3D HE rainfall, the heavy rain



is well captured. The alerts for the heavy rainfall were again provided in real time as can be seen by a cluster of red markers over MP in the right hand side figure below.





Apart from these events, there were many spells of intense rainfall in other parts of the country like Maharashtra, Assam, Orrisa and more than 5 major cloud burst incidences over Western Himalayan region. It is hoped that the insights provided by satellite based observations will give an impetus to the monitoring and forewarning of extreme rainfall events bringing about a significant societal impact.

Snippets on Weather and Climate News and Research

Recent study suggests that rapid warming in the Indian Ocean is playing an important role in weakening the monsoon circulation 2016.

(Study published in Nature, 2016)

ISRO's Scatsat Mission: System and Applications

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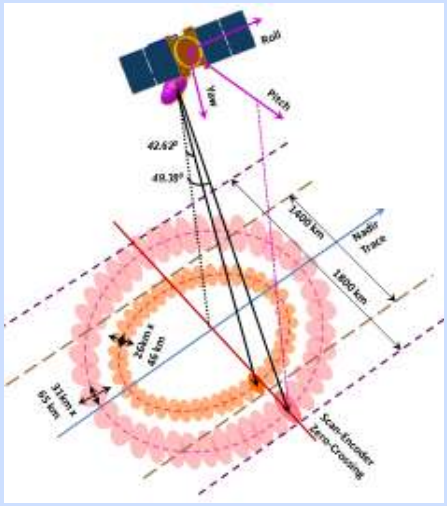
Ocean surface wind is an important parameter for various oceanographic applications and a key forcing parameter for ocean models. Thus, it is an important parameter to be monitored. Unfortunately, there are a few in-situ buoy observations of this parameter. Scatterometers, on the other hand, are active space-borne instruments operating in microwave region of electro-magnetic spectra and are used to estimate surface wind vectors over oceans, found to be thinly populated by buoys. Apart from the wind observations, scatterometers are also used for ice mapping, monitoring of polar ice and tropical vegetation. This capability was first demonstrated by SEASAT-A Satellite Scatterometer (SASS). The efforts in this field continued with European Remote Sensing Satellite ERS-1and ERS-2 along with NASA's NSCAT mission. As a follow up to NSCAT mission, SeaWinds scatterometer onboard QuikSCAT was launched on 19th June 1999. In 2008, European Space Agency (ESA) launched yet another scatterometer, viz. ASCAT, operating in C-band (5.3 GHz), for measuring ocean surface winds. Recent Oceansat-2 mission of Indian Space Research Organization (ISRO) is one more dedicated scatterometer mission for estimating ocean surface wind. Oceansat-2 was launched in 2009 and was placed in a sun-synchronous orbit at an altitude of 720 Km. It carried three payloads, which are the radar scatterometer OSCAT and the ocean color monitor (OCM) and a radio occultation payload- ROSA. OSCAT operates in Ku-band at a nominal frequency of 13.51GHz. It has a wide swath of 1800 km. It was a pencil beam scatterometer with dual polarization beams at look angles of 42.66° (HH) and 49.33° (VV). The incidence angles at surface for inner and outer beams of OSCAT are 49° and 57 ° respectively. Unfortunately, this dedicated mission came to an end in February 2014.

The ScatSat-1, which is India's second scatterometer mission, is scheduled to be launched in September 2016 and will carry an indigenously devised scatterometer similar to OSCAT. The scatterometer will have a wide swath of 1800 km, thus providing a global coverage with 2 days of repeativity. The basic product to be made available is the sigma-0. The sigma-0 will be calibrated using the other available sigma-0 from contemporary tandem mission and converted into meaningful met information i.e. the surface wind using the developed Geophysical Model Function (GMF). The wind will be available at 25 km resolution. The wind retrieval will be followed by extensive validation exercise and fine tuning of GMF. Final wind products hence prepared are to be made available to users after this calibration, retrieval and validation chain through NRSC.

Spacecraft Altitude: 720 Km (Nominal)
Orbit: Non-Sun Synchronous at launch ; To be arrested within 3-6 months from launch. Tentative local pass time: 8am/8pm. More than 90% Global coverage in a single day.
Platform: IMS-II
Frequency: 13.515625 GHz
Polarization: HH for inner and VV for Outer beams
Swath: 1400 Km (both HH and VV beams available)
1400-1800 km (only VV beam available)
Wind Speed Range: 3-30ms/s
Wind Direction Range: 0° to 360°
Wind Speed Accuracy: 1.8 m/s rms or 10% whichever is higher
Wind Direction Accuracy: 20^{o} rms
Wind Vector Cell (grid) Size: 25 Km x 25 Km and 50 km X 50 km swath Grid. Better sensitivity envisaged over OSCAT due to 32 bit processing and 4k FFT



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Scatsat-1 data applications will be mainly in four fields: Atmosphere, Ocean, Land and Polar regions. While the first two will make use of retrieved ocean surface vector winds, the last two will utilize sigma-0 data products. The Atmospheric Applications will be towards assimilation of scatterometer observations of sigma-0 as well as ocean surface winds in the atmospheric global circulation models for analysis and predictions, Monsoon onset, cyclogenesis, track prediction, its intensification, convection parameterization studies, and operational use in short range forecast. The Oceanic applications consist of ocean surface waves, surface currents, ocean circulations, oceanic mixed layer, air-sea interactions, sea ice, fisheries, primary productivity and suspended particles. The land applications will address large-scale soil moisture estimation, long-term land surface assessment, vegetation classifications and their growth assessment. As demonstrated in the case of OSCAT, the application for polar region will be for sea ice dynamics, assessment of surface melting, analyzing the ice calving events in addition to generation of sea-ice type and extent products. In addition to the listed applications, other novel products / applications (only with Scatsat or/and by merging the data with other sensors) may also be attempted.

Eminent Meteorologist: Dr. T N Krishnamurti

Dr. Tiruvalum N. Krishnamurti (famously known to many in meteorology as TNK) is a renowned world tropical meteorologist based in the U.S.A. He is currently professor emeritus at Florida State University, where prior to his retirement he was holding the prestigious chair as "Lawton Distinguished Professor of Meteorology". He has Pioneered scientific research in numerical weather prediction, his research interests include high-resolution forecasting of hurricane tracks, landfall, and intensities; short- and long-range monsoon predict--ion; and inter-seasonal and inter-annual variability of the tropical atmosphere. He has made enormous contribution toward hurricane forecast through Real-Time Hurricane Forecast Center (RTHFC). The RTHFC developed a new forecasting method called the Superensemble which has shown enormous potential in accurately predicting hurricanes, droughts, and floods. Notably, Dr. Krishnamurti has contributed to NASA's Tropical Rainfall Measuring Mission (TRMM), Global Precipitation Mission (GPM) and NASA's Laser Atmospheric Wind Sounder (LAWS). In addition to his research pursuits, Dr. Krishnamurti's interests in meteorological phenomena include hurricanes, monsoons, jet streams, and the meteorology of arid zones. To his credit, his Tropical Meteorology Laboratory, during the last 50 years, has had more than 100 researchers from India.

He is the recipient of several awards of excellence in his field including the most prestigious award in meteorology – the International Meteorological Organization Prize (in 1996) from the World Meteorological Organization, the Carl Gustav-Rossby Research Medal (1985) and the Charney Medal (1974) of the American Meteorological Society, the Sir Gilbert Walker Gold Medal (2012) of the Indian Meteorological Society. A symposium in his honor was held in 2012 as part of the American Meteorological Society annual meeting in New Orleans. He has authored 3 text books entitled, "An Introduction to Tropical Meteorology" 2014, Springer; "An Introduction to Global Spectral Modeling", Second Edition, Springer, 2006 (with H. S. Bedi, V. M. Hardiker and L. Ramaswamy), and "An Introduction to Numerical Weather Prediction Techniques" (with L Bounoua), 1995, CRC Press.

Dr. Krishnamurti holds a B.Sc. Honours degree in physics from Delhi University and an M.Sc. degree in meteorology from Andhra University, Visakhapatnam. In addition to his tenure at Florida State University, Dr. Krishnamurti previously served for five years on the faculty at the University of California – Los Angeles (UCLA). He earned his Ph.D. in Meteorology from the University of Chicago in 1959.

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Dr. Krishnamurti's interest in hurricanes began during his early years as a student. Professor Herbert Riehl, a pioneer on hurricane research at the University of Chicago, was his primary instructor in the late 1950's and 1960's. Dr. Krishnamurti participated in early exploratory flights into hurricanes and typhoons from West Palm Beach and Guam during those years. Currently he has flown hurricanes on numerous NASA DC8 hurricane flight missions with his special interest in the Coherent Wind Lidar that provides winds in the troposphere from backscattering of Doppler shifted motion of aerosols.

A kaleidoscope of Dr. Krishnamurti's journey…. (Adapted from his biography)

















Snippets on Weather and Climate News and Research

INSAT-3D and Scatsat, the forthcoming satellites to be launched by ISRO, will open new avenues for better atmosphere and ocean applications. Data from these missions will be *provided from ISRO's MOSDAC, VEDAS and NRSC web sites.*

Global Space-based Inter-Calibration System (GSICS)

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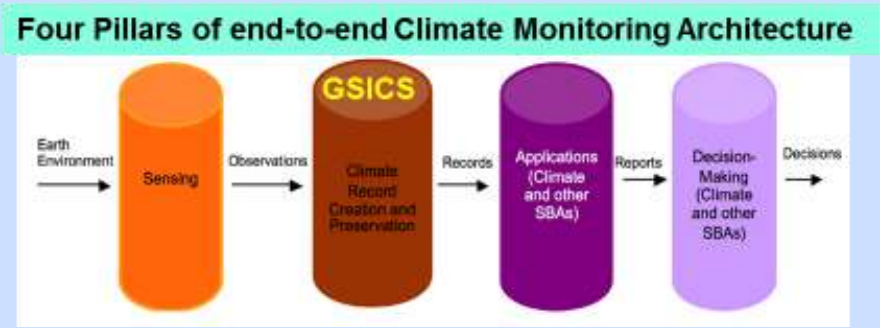
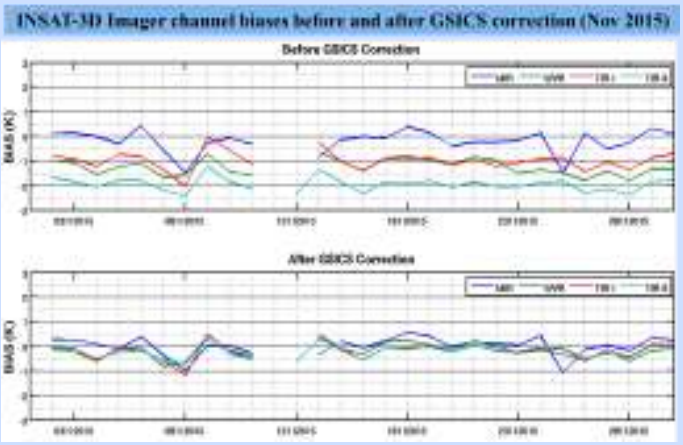
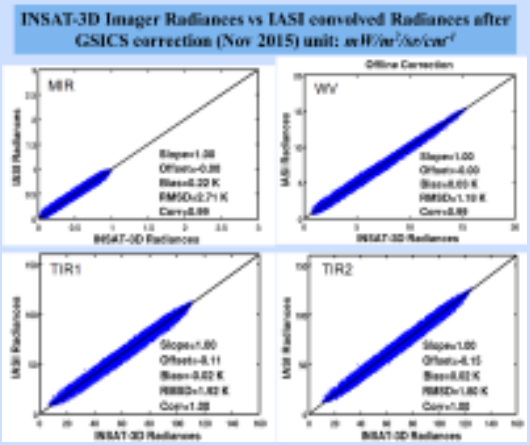
The Global Space-based Inter-Calibration System (GSICS) is an international collaborative effort initiated in 2005 by World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS). Objective of the GSICS is to deliver calibration corrections for integrating multiple observing systems and ensuring consistent observations for climate monitoring, weather forecasting, and environmental applications. The basic premise of inter-calibration is that two instruments should make identical measurements when they view the same target at the same time, with the same spatial and spectral responses with similar viewing geometry. Satellite inter-calibration of a monitored instrument is achieved by collocating and transforming its observations to that of the common standard references instrument. GSICS activity includes: (i) Monitoring instrument performance, (ii) Operational inter-calibration of satellite instruments for weather forecasting, (iii) tying the measurements to absolute reference and standards, and (iv) re-calibration of the archived satellite data leading to stable Climate Data Records (CDR).



ISRO as a member organisation of the GSICS has contributed by providing inter-calibration of IR sensors onboard Indian geostationary satellites, Kalpana/INSAT-3A/3D, using state-of-the-art hyperspectral sounding measurements from MetOp-IASI and Aqua-AIRS as reference instruments. IASI is an excellent inter-calibration reference for infrared sensors because its calibration has proven to be stable in-orbit and consistent with standard uncertainties of ~0.1 K. It is highly desirable to use an inter-calibration reference which is traceable to the International System of Units (SI). So far AIRS or IASI that are used as the reference instruments does not provide SI traceability. However, the GSICS framework will facilitate such traceability once a suitable standard becomes available in orbit, such as the Climate Absolute Radiance and Refractivity Observatory mission (CLARREO) in near future.





GNSS-Reflectometry for Ocean Surface Winds

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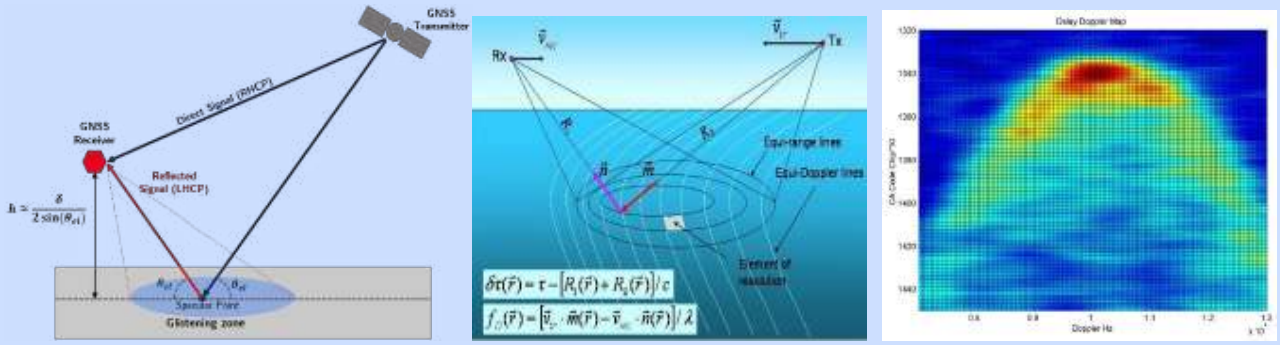
The technique of GNSS- Reflectometry (GNSS-R) makes use of any of the existing signals of opportunity, continuously broadcasted by GNSS constellation at L-band. Reflected signals from ocean surface are received by the down-looking antenna of space GNSS receiver in low earth orbit (fig.1a). An additional antenna for direct signal reception is required for precise orbit determination and identification of GNSS satellite associated with each one of the received signal. The L-band signals are adequate for sensing ocean surface roughness due to longer wavelength and can provide significant measurement of ocean wind speed and wave height. The technique can also provide sea ice coverage and thickness, assist in real-time monitoring of ship routes and retrieval of soil moisture and terrain features over land.



(a) (b) (c)

Figure 1. (a) A schematic of GNSS-R measurement geometry, (b) concept of iso-range and iso-Doppler lines and, (c) the Delay Doppler Map (DDM) of reflected power at the receiver (UK-DMC data).

It is note-worthy that the transmitted power at L-band is normally weak, and gets further weakened after ocean reflection. For useful measurements and data collection, only a small area (called the Glistening zone; blue patch in fig.1a) around the specular point contributes to the total power collected at the receiver. The specular point is fixed at the point on the surface where the Fresnel law of reflection holds true. This is the point where the time delay and Doppler shift are at minimum. Points radially away from the specular point have higher delay and Doppler but lower power contribution to the total power at the receiver from the footprint around the specular point. As seen in figure 1a, the reflected signal at the receiver undergo a change of polarization from RHCP (on the direct GNSS signal) to LHCP. At the specular point, the angle of incidence is equal to the angle of reflection. The power received at the receiver is the average total power from the glistening zone which includes the varying contributions from different sections of the zone (fig. 1b). For the purpose of splitting up the distinct contributions of different sections of the glistening zone, each footprint is divided into a number of concentric ellipses around the specular point, intersected by a family of parabolas (fig.1b). The intersected area element between any two concentric ellipses and two parabolic curves gives the element of resolution contributing to the total average power. The concentric ellipses are the locus of equi-range (or, equi-delay) lines; the family of parabolas corresponds to equi-Doppler lines. Figure.1b depicts this concept in vivid detail. An element closer to the specular point contributes higher reflected power than the one farther from the specular point. The analysis of the average total power distribution in terms of the Delay-Doppler elements inside the glistening zone is done through the processing of the reflected signal and its correlation properties which results in the generation of Delay-Doppler Maps (DDM) (fig.1c). The DDM is the first processed output of the remotely sensed ocean roughness signatures from which geophysical parameters such as wind speed and wave height can be derived.

(cont.)

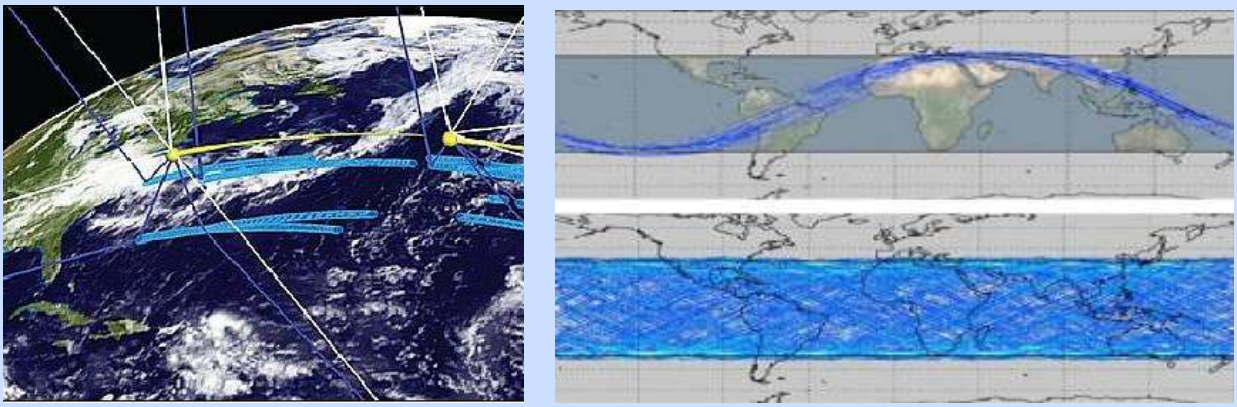


Figure 2. In-orbit measurement of reflection by NASA's CYGNSS constellation (left) and its simulated ground trace depicting coverage in 90 min. (top) and 24hrs. (bottom). (courtesy: NASA)

The current significance of this emerging branch of remote sensing technology and underlying science benefits is behind the upcoming NASA's CYGNSS constellation mission (fig.2), to be launched in late 2016 for wind speed retrieval in the inner core of tropical cyclones, currently not possible with polar-orbiting conventional surface wind imagers or scatterometers, which is severely affected by saturation of backscattering coefficient (sigma_0) under cyclonic wind conditions. Currently, TechDemoSat-1 (UK mission) measures the reflected signal of GNSS from LEO, and is the second such mission from space after proof-of-concept UK-DMC mission.

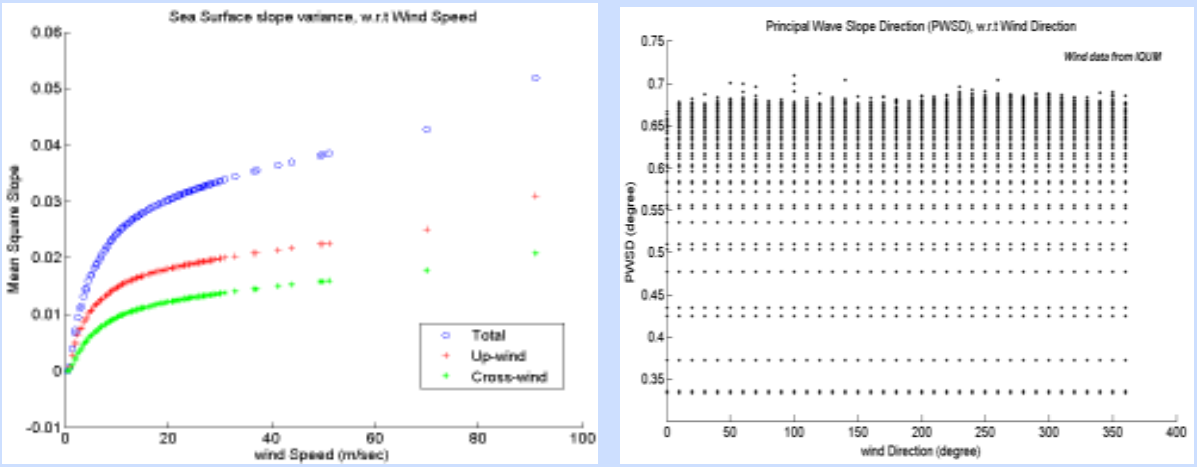


Figure 3. Variation of Directional mean square slope (left) and Principal wave slope direction (right) as a function of surface wind speed and wind direction (GRD/EPSA/SAC/ISRO).

At SAC/ISRO, preparation for an experimental ground based reflectometry measurement for surface wind speed using GPS as well as IRNSS signals is in good progress, despite numerous challenges in realization of the receiver system. Simultaneously, a geophysical model function (GMF) for deriving wind speed from DDM data is established for the full range of surface roughness conditions expressed in terms of mean square slope (MSS). The behavior of MSS for various wind regimes is established for GNSS-R geometry, as depicted in fig.3 (left). principal wave slope direction (PWSD) as a function of wind direction is shown on the right. The achieved theoretical accuracy for wind speed is up to 0.5 m/s (or, 5%) compared to the in-situ buoy wind data. Due to lack of dominant trend in PWSD vs wind direction, directional retrieval is not feasible for the bistatic GNSS-R geometry without additional information.

Obituary

Prof. G.S. Asnani (1922-2016), a leading figure in Tropical Meteorology passed away on 15 March 2016 at the age of 95 years in Pune. IMSA expresses its heartfelt condolences on the sad demise of Prof. Asnani. May his soul rest in peace.

Met-Aware-2016: A Meteorological Awareness Program

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A meteorological awareness program, Met-Aware-2016, aimed to create public awareness towards different aspects of weather and climate was held on July 16, 2016 at Anand and VallabhVidyanagar (VV). First part of the program i.e. a Scientists-Students interactive session along with 2 lectures by experts in the field of weather/climate/satellite meteorology was arranged at G.H. Patel College of Engineering & Technology (GCET) auditorium and co-organized with NV Patel College of Pure & Applied Sciences (NVPAS), Sardar Patel University (SPU), VV. This event was attended by around 340 participants including students and faculty members from SPU. The Chief Guest of the event, Shri Rajeev Jyoti, Deputy Director, Space Applications Centre (SAC – ISRO), Ahmedabad, and the Guest of Honor, Prof. S. G. Patel, Honorary Secretary, Charotar Vidya Mandal (CVM) honoured the event by their presence and addressed the participants. Two popular lectures full of information on general meteorology and satellite meteorology were delivered by Dr. C. M. Kishtawal, Group Director (AOSG), SAC and Dr. Manorama Mohanty, Senior Meteorologist, IMD Ahmedabad. The most vibrant and interactive session of the event i.e. ‘’Open House’’ received huge response from the students. The Panel of Experts consisting of Shri Rajeev Jyoti, Dr. P.K. Pal, Dr. Raj Kumar, Dr. C.M. Kishtawal, Dr. Vyas Pandey, Dr. A. S. Rajawat, Dr. Manorama Mohanty, Dr. S. M. Bhandari and Dr. R.P. Singh answered the questions asked by the participants. They solved a number of thought provoking queries from diversified field raised by the students. The students continued their interaction with the scientists during the lunch time till the end of this session.The program was supported by Dr. Basudeb Bakshi (Principal – NVPAS), Dr. Himanshu J Trivedi (HOD, Physics department, NVPAS), and volunteered by Dr. Mehul Pandya (SAC).

The second part of the program comprised of a visit to weather observatory and museum at Anand Agriculture University (AAU) followed by an educational visit of IMSA members and their family members to Amul Dairy (Anand). Participants saw various instruments used to collect different meteorological parameters at AAU weather observatory. Dr. Vyas Pandey, HoD (Agro-meteorology, AAU) and Dr. Manoj Lunagaria comprehensively explained the working of the instruments and importance of the in-situ observations of the weather parameters. The participants enjoyed the visit to the museum and gathered vast information on agricultural tools, techniques, practices, and many crop varieties and grain/seeds before high-tea provided by AAU. At Amul Dairy the participants saw working of a milk processing unit, production of different milk products along with a visit to the picture gallery/ museum/ audio-video documentary to see the evolution of White Flood Revolution in India.

IMSA Members and their family members visited AMUL, Anand

(under Met-Aware-2016 on July 16, 2016)

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The Amul Model of dairy development is a three-tiered structure with the dairy cooperative societies at the village level federated under a milk union at the district level and a federation of member unions at the state level.

The "Amul Visit'' was among one of the fascinating event of attraction for IMSA programme during 1-day meteorological awareness program, Met-Aware-2016 organised on July 16, 2016. The IMSA participants reached Amul, Anand factory by 1430 hrs. The Members were welcomed by Shri S. S. Sundaran (Amul - OSD). He briefed about the total programme at AMUL. The total visit was comprised of Museum/Photo Gallery, a Short Film and the Factory visits.

In the museum, participants were welcomed by Ms Smruti. There were old photographs in the museum depicting the various stages of formation and development of the cooperative movement AMUL. She explained that, in 1946, under the inspiration of Sardar Patel, and the guidance of leaders like Morarji Desai and Tribhuvandas Patel, the Kaira District Co-operative Milk Producers Union Ltd. began with just two village dairy co-operative societies and 247 litres of milk and is today better known as Amul Dairy. She also explained how the suffering farmers fought all odds to make the AMUL in the present form. Amul grew to new heights under the leadership of Tribhuvandas Patel, the founder Chairman and the committed professionalism of Dr Verghese Kurien, the father of White Revolution, who was entrusted the task of running the dairy from 1950. Members were overwhelmed by the site of historical photographs at the Museum. The photographs included the visit of Pandit Jawaharlal Nehru, Sardar Patel, Shri. Lal Bahadur Shastri, Indira Gandhi and so many renowned persons. One of the interesting photograph was that of a garage and its model where Dr. Kurien stayed in his initial years of stay in Anand, after denial for getting a proper accommodation, and lead the noble cause.This was followed by a documentary film where the history as well as the present scenario of Amulwere shown. From North to South and from West to East Amul has been an inspiring taste to many. Documentary also described the glances of avoiding Polson, the middle man and the British Empire to form the cooperative movement. After the documentary, the members were offered flavoured AMUL milk.

The last and the most interesting part of this visit was the factory visit. Mr. Richard took us to the factory. He explained the various products of Amul, the plants in India and abroad and systematically explained the various stages of dairy activities from collection of milk from farmers to the end product generation through practical demonstration at various stages. The fall of big cylindrical butter, packaging of butter cubes, milk powder etc. were really interesting. Members were excited and cleared their innumerable doubts on all aspects of milk processing. Overall, it was an interesting and memorable visit.

News Potpourri

Jason-3 launched on January 17 2016: "Jason-3 will take the pulse of our changing planet by gathering environmental intelligence from the world's oceans," said Stephen Volz, assistant administrator for NOAA's Satellite and Information Service. Jason-3 will contribute building a long time record of the measurements from altimetric missions starting with the TOPEX/Poseidon. The mission will improve weather, climate and ocean forecasts, including helping NOAA's National Weather Service and other global weather and environmental forecast agencies more accurately forecast the strength of tropical cyclones. (courtesy: JPL News)

NASA Maps Thawed Areas Under Greenland Ice Sheet:

NASA researchers have helped produce the first map showing what parts of the bottom of the massive Greenland Ice Sheet are thawed -- key information in better predicting how the ice sheet will react to a warming climate. Greenland's thick ice sheet insulates the bedrock below from the cold temperatures at the surface, so the bottom of the ice is often tens of degrees warmer than the top, because the ice bottom is slowly warmed by heat coming from Earth's depths. Knowing whether Greenland's ice lies on wet, slippery ground or is anchored to dry, frozen bedrock is essential for predicting how this ice will flow in the future. To carry out the study, first, they examined results from eight recent computer models of the ice sheet, which predict bottom temperatures. Second, they studied the layers that compose the ice sheet itself, which are detected by radars onboard NASA's Operation IceBridge aircraft and suggest where the bottom of the ice is melting rapidly. Third, they looked at where the ice surface speed measured by satellites exceeds its "speed limit," the maximum velocity at which the ice could flow and still be frozen to the rock beneath it. Fourth, they studied imagery from the Moderate Resolution Imaging Spectroradiometers on the NASA Terra and Aqua satellites, looking for rugged surface terrain that is usually indicative of ice sliding over a thawed bed. (courtesy: JPL News).

Rainfall situation during first half (June-July) of 2016 Monsoon season.

This year during June 2016, Southwest monsoon rainfall was 11% below the Long Period Average (LPA). However, July rainfall has been 7% above the LPA. A north-south belt comprising of the States and Meteorological sub divisions such as west Uttar Pradesh, Madhya Pradesh, east Rajasthan, Vidarbha, Marathawada, Madhya Maharashtra, north-interior Karnataka, Rayalaseema and Tamil Nadu have received wide spread and excess rainfall during July 2016. It has completely wiped out the 11% deficiency of June rainfall as the cumulative rainfall for the first half of the monsoon season (June-July) is normal with0% departure from the LPA. The rainfall statistics are given in the following.

Regions	01 June-30 June	01 July-31 July	01 June-31 July
	% Dep. From LPA	% Dep. From LPA	% Dep. From LPA
Country as a whole	-11	7%	0%
Northwest India	-7%	9%	6%
Central India	-17%	18%	6%
South Peninsula	26%	-12%	4%
East & Northeast India	-28%	-2%	-13%

(courtesy: IMD)

News Potpourri

The Results of Earth's 'Annual Physical' Are A Scary Dose of Deja Vu (huffingtonpost.com)

The State of the Climate report for year 2015, led by the National Oceanic and Atmospheric Administration and described as Earth's "annual physical," finds that the health of the planet has, once again, fallen into uncharted territory. It "shows not only that the temperature of the planet is increasing, but all the related symptoms that you might expect to see with a rising temperature are also current," Thomas Karl, director of NOAA's National Centers for Environmental Information, said of the report during a media briefing Tuesday. In 2015, greenhouse gas concentrations, global surface temperatures, sea surface temperature, global upper ocean heat content and global sea levels all toppled previous record highs. (courtesy: JPL News)

NASA Study Solves Two Mysteries About Wobbling Earth

Using satellite data on how water moves around Earth, NASA scientists have solved two mysteries about wobbles in the planet's rotation -- one new and one more than a century old. The research may help improve our knowledge of past and future climate. Although a desktop globe always spins smoothly around the axis running through its north and south poles, a real planet wobbles. Earth's spin axis drifts slowly around the poles; the farthest away it has wobbled since observations began is 37 feet (12 meters). These wobbles don't affect our daily life, but they must be taken into account to get accurate results from GPS, Earth-observing satellites and observatories on the ground. In a paper published today in Science Advances, Surendra Adhikari and Erik Ivins of NASA's Jet Propulsion Laboratory, Pasadena, California, researched how the movement of water around the world contributes to Earth's rotational wobbles.

Around the year 2000, Earth's spin axis took an abrupt turn toward the east and is now drifting almost twice as fast as before, at a rate of almost 7 inches (17 centimeters) a year. "It's no longer moving toward Hudson Bay, but instead toward the British Isles," said Adhikari. "That's a massive swing." Adhikari and Ivins set out to explain this unexpected change using Gravity Recovery and Climate Experiment (GRACE) satellites, which provide a monthly record of changes in mass around Earth. Those changes are largely caused by movements of water through everyday processes such as accumulating snowpack and groundwater depletion. They calculated how much mass was involved in water cycling between Earth's land areas and its oceans from 2003 to 2015, and the extent to which the mass losses and gains pulled and pushed on the spin axis.

Adhikari and Ivins' calculations showed that the changes in Greenland alone do not generate the gigantic amount of energy needed to pull the spin axis as far as it has shifted. In the Southern Hemisphere, ice mass loss from West Antarctica is pulling, and ice mass gain in East Antarctica is pushing, Earth's spin axis in the same direction that Greenland is pulling it from the north, but the combined effect is still not enough to explain the speedup and new direction. Something east of Greenland has to be exerting an additional pull. The researchers found the answer in Eurasia. "The bulk of the answer is a deficit of water in Eurasia: the Indian subcontinent and the Caspian Sea area," Adhikari said. The finding was a surprise. This region has lost water mass due to depletion of aquifers and drought, but the loss is nowhere near as great as the change in the ice sheets. So why did the smaller loss have such a strong effect? The researchers say it's because the spin axis is very sensitive to changes occurring around 45 degrees latitude, both north and south. "This is well explained in the theory of rotating objects," Adhikari explained. "That's why changes in the Indian subcontinent, for example, are so important." In the process of solving this recent mystery, the researchers unexpectedly came up with a promising new solution to a very old problem, as well. One particular wobble in Earth's rotation has perplexed scientists since observations began in 1899. Every six to 14 years, the spin axis wobbles about 20 to 60 inches (0.5 to 1.5 meters) either east or west of its general direction of drift. "Despite tremendous theoretical and modeling efforts, no plausible mechanism has been put forward that could explain this enigmatic oscillation," Adhikari said.

(courtesy: JPL News)

IMSA Executive Council Members: 2016-2018

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Awards and Recognitions

- Dr. A S Kiran Kumar took over as Chairman, ISRO and Secretary, DOS in 2015.
- Shri. Tapan Misra took over as Director, Space Applications Centre(SAC) in 2015.
- Dr P K Pal received ISRO Performance Excellence Award-2014 (announced in 2015).
- Shri D R M Samudariayah received ISRO Performance Excellence Award- 2012 (announced in 2015).
- Drs. Atul K Varma, R M Gairola and P K Pal received the NASA-Global Precipitation Measurement (GPM) Group Achievement Award-2015.
- Dr. Atul K Varma received ASI-ISRO Award-2013 in the area of "Space Science and Applications" (announced in 2015).
- Shri K N Mankad received ISRO Merit Award for year 2012 (announced in 2015).
- Many IMSA members received ISRO Team Awards for 2012, 2013 and 2014.
- Dr. R Ramakrishnan received Excellence Award for RAPID & IMDPS from IMD (MoES/GoI) in 2015.

e-Megha – Editorial Board (2016-2018)

N.B. For any correspondence on e-Megha, please communicate on our newly created official e-Megha e-mail: imsa.emegha@gmail.com

Readers are invited to share their valuable feedbacks as well as contents for the next issue of e-Megha (Post-Monsoon issue in November), either as articles (1-2Pgs), news items and pictures of interest to IMSA members on the official e-mail.

Concluding Page