सत्यमेव जयते
Ministry of
Earth Sciences

सत्यमेव जयते
Department of Science
and Technology (DST)

Brain Storming Workshop on

"CLIMATE SERVICES : STAKE HOLDER PERSPECTIVE"

Organised by Indian Meteorological Society

and jointly supported by MoES, DST and IMD

22-23 March, 2019

DISCUSSION PAPERS

Compiled and Edited by

D. R. Pattanaik
S. K. Dash

INDIAN METEOROLOGICAL SOCIETY
NATIONAL COUNCIL
(2018-2020)

President	Prof. Sushil Kumar Dash Tel: 9818027563 (M); E-mail: skdash@cas.iitd.ac.in
Immediate Past President	AVM Dr. Ajit Tyagi Tel: 9818163666 (M); E-mail: ajit.tyagi@gmail.com
Vice- Presidents	Dr. Atul Kumar Sahai Tel.: 9423582314 (M); Email: sahai@tropmet.res.in
Sh. Anand Kumar Sharma	Tel: 9411575800 (M); Email: anand.sharma870@gmail.com
Secretary:	Dr. D. R. Pattanaik Tel.: 9868554029 (M); Email: drpattanaik@gmail.com
Jt. Secretary:	Dr. S. I. Laskar Tel.: 9013179961 (M); Email: drsebul@gmail.com
Treasurer:	Sh. Ashok Kumar Baxla Tel.: 9818429165 (M); Email: baxla.asc@gmail.com
Council Members:	Prof. U.C. Mohanty Tel.: 8763862775 (M) Dr. D. Rajan Tel.: 9818051053 (M) Sh. R. K. Giri Tel.: 9868901535 (M) Prof. R. Bhatla Tel.: 9415290782 (M) Sh. Sikandar M. Jamadar Tel.: 9922753294 (M) Ms. SamantiSarkar Tel.: 9868493443 (M) Dr. D. Ram Rajak Tel.: 9428499221 (M) Sh. Manas Kumar De Tel.: 9810790779 (M)

BRAIN STORMING WORKSHOP ON

"CLIMATE SERVICES : STAKE HOLDER PERSPECTIVES"

22-23 March 2019

INDIAN METEOROLOGICAL SOCIETY
Room No. 605, VI Floor, Satellite Meteorological Building,
Mausam Bhavan Complex, Lodi Road, New Delhi-110003.
Tel: 91-11-24653728, Email: imetsociety@gmail.com

Compiled and Edited by

D. R. Pattanaik
S. K. Dash

CONTENTS

सत्यमेव जयते

डॉ. एम. राजीवन
DR. M. RAJEEVAN

सचिव
भारत सरकार
पृथ्वी विज्ञान मंत्रालय
पृथ्वी भवन, लोदी रोड, नई दिल्ली-110 003
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
PRITHVI BHAVAN, LODHI ROAD, NEW DELHI-110003

MESSAGE

In the changing climate scenario, the demand for weather and climate services by the society has increased many folds. Climate change is going to have adverse impacts over many parts of the globe with developing country like India will be impacted more compared to other countries. In the warming climate, there will be changes in global climate system which includes warmer temperatures, rising sea levels, and potentially more frequent and severe extreme weather events such as tropical storms, monsoonal heavy rainfall, flood, drought, intense heat wave etc. Such extreme weather events are considered as most destructive both economically and socially accounting for about 90% of people affected by natural disasters. These pose significant risks to public safety and natural resources particularly for a country like India which has diverse climatic systems and economic strata of the people. Thus, there is an urgent need to enable better management of the risks arising out of climate variability and change by proving appropriate climate services to different stake holders.

Providing better climate services by sharing climate information, climate prediction, knowledge and best practices for the risks management will supports stakeholders at all levels. Policy and management guidance will increase resilience to the impacts of climate variability and climate change in these priority areas. Thus, there is a need to deliver climate services which includes the production, translation, transfer, and use of climate information purposefully designed to enable policymakers and decision-makers the address significant problems and create solutions. The priorities areas as identified in the Global Framework of Climate Services (GFCS) of World Meteorological Organization (WMO) are (i) Agriculture and Food Security, (ii) Disaster Risk Reduction, (iii) Energy, (iv) Water, and (v) Health.

I am happy to note that Indian Meteorological Society (IMS) is organizing a two-day "BRAIN STORMING WORKSHOP ON CLIMATE SERVICE: STAKE HOLDER PERSPECTIVES, during 22-23 March, 2019 to address the above issues, and efforts will be made to bring together climate change scientists, government bodies, disaster managers and stakeholders from all the above five priority areas to deliberate on these important issues.

I convey my best wishes for the success of this conference.

(M. Rajeevan)

Tel. : +91-11-24629771, 24629772 ❑ Fax : +91-11-24629777 ❑ E-mail : secretary@moes.gov.in

डॉ. के. जे. रमेश
मौसम विज्ञान विभाग के महानिदेशक
एवं
विश्व मौसम विज्ञान संगठन में भारत के स्थाई प्रतिनिधि
एवं कार्यकारी परिषद के सदस्य

Dr. K. J. Ramesh
Director General of Meteorology &
Permanent Representative of India with W.M.O.
and Member Executive Council of W.M.O.

भारत सरकार
पृथ्वी विज्ञान मंत्रालय
भारत मौसम विज्ञान विभाग
मौसम भवन, लोदी रोड
नई दिल्ली–110003

Government of India
Ministry of Earth Sciences
India Meteorological Department
Mausam Bhawan, Lodi Road
New Delhi - 110003

Message

It gives me immense pleasure to know that Indian Meteorological Society (IMS) is organizing **"BRAIN STORMING WORKSHOP ON CLIMATE SERVICES : STAKE HOLDER PERSPECTIVES, during 22-23 March 2019 at Mahika Hall, Prithvi** Bhawan, New Delhi.

Recently, India Meteorological Department (IMD), Ministry of Earth Sciences (MoES) has taken major steps in improving the weather, climate and hazards warning services capabilities in the country. With the improvement in observational and forecasting tools including augmentation of NWP Models, Radar network and satellite products, forecasting/warning services in respect of tropical cyclones, severe thunderstorms, now casting, flash/urban floods, urban climate, climate change, heavy rainfall, advisories to farmers, pilgrimage forecast, heat waves/cold wave etc has been further strengthened. Scientists of IMD in collaboration with other institutes of MoES are working strenuously in providing better weather and climate services to all users by further augmenting modeling and observational network.

The brain storming workshop organized by IMS is a very timely step which will provide an excellent opportunity for interaction among climate scientists, stake holders, Academicians and disaster managers to discuss the need and modalities of providing climates services to the vulnerable sectors. I am glad to note that the recommendations from this workshop will throw some light on the future direction in which the climate services will be undertaken in India for the benefit of the society.

I wish the event a grand success.

(K. J. Ramesh)

Phone : 91-11-24611842, Fax : 91-11-24611792, Resi. : 91-11-26257374
E-mail : kjramesh2607@gmail.com / dgmmet@gmail.com / kj.ramesh@nic.in / kj.ramesh@imd.gov.in

Background Materials

BRAIN STORMING WORKSHOP ON "CLIMATE SERVICES : STAKE HOLDER PERSPECTIVES", 22-23 March 2019

Venue - MAHIKA HALL, PRITIVI BHAVAN, Ministry of Earth Sciences, Lodhi Road, New Delhi – 110 003

Increasing scientific evidence confirms the fact that anthropogenic activities have lead to changes in global climate system which includes warmer temperatures, rising sea levels, and potentially more frequent and severe extreme weather events such as tropical storms, monsoonal heavy rainfall, flood, drought, etc. These pose significant risks to public safety and natural resources particularly for a country like India which has diverse climatic systems and economic strata of the people. Thus, there is an urgent need to enable better management of the risks arising out of climate variability and change by linking weather and climate services with the national development strategies. The five priority areas that may become vulnerable to climate change are:-

- Agriculture and Food Security,
- Disaster Risk management
- Energy availability and use
- Human Health impacts
- Water availability and use

Climate services framework is basically proposed to enable better management of the risks arising due to climate variability and change and appropriate adaptation strategy to climate change. This can happen with the incorporation of climate information and prediction into planning, policy and practice on country level. Providing better climate services by sharing climate information, climate prediction, knowledge and best practices for the risks management will supports stakeholders at all levels by providing policy and management guidance that increase resilience to the impacts of climate variability and climate change in these priority areas. Thus, there is a need to deliver climate services which includes the production, translation, transfer, and use of climate information purposefully designed to enable policymakers and decision-makers to address significant problems and create solutions.

The two-day brainstorming workshop is planned to address the above issues and efforts will be made to bring together climate change scientists, local government bodies, disaster managers and stakeholders from all the above five priority areas to deliberate on this important issue.

It will be joint event with the key national institutions such as the Ministry of Earth Sciences (MoES), Department of Science and Technology (DST), India Meteorological Department (IMD) and the Indian Meteorological Society (IMS) which are involved with weather and climate science. Eminent scientists from DST, MoES Institutions and the distinguished Fellows of IMS will be invited to participate in the workshop. In addition organisations such as, Indian Space Research Organisation (ISRO), Indian Council of Medical Research (ICMR), Indian Institute of Public Health (IIPH), Indian Council of Agricultural Research (ICAR), Indian Red Cross, National Research Development Corporation (NRDC), Central Water Commission (CWC) etc and interested private companies engaged in this science will be invited to participate and put forth their concerns.

It is expected that recommendations from this workshop will throw some light on the future direction in which the climate services will be undertaken in India for the benefit of the society.

Thanking you all

S K Dash
D R Pattanaik

Ministry of Earth Sciences

Department of Science and Technology (DST)

BRAIN STORMING WORKSHOP ON

"CLIMATE SERVICES: STAKE HOLDER PERSPECTIVES"

22-23 March, 2019

Organised by

Indian Meteorological Society

And Jointly Supported by MoES, DST and IMD

World Water Day – 22nd March, 2019
World Meteorological Day – 23rd March 2019

Venue : Mahika Hall, Prithvi Bhawan Lodhi Road, New Delhi

Technical Programmes

Time	Programme
0930-1000	**Arrival of guests and Registration**
1000-1110	**Inauguration** • Invitation to guests and lighting of lamps & Vandana • Welcome Dr. D. R. Pattanaik, Secretary, IMS • Address by Dr. S. K. Dash, President IMS • Address by Dr Akhilesh Gupta, DST • Address by Dr K. J. Ramesh, DG IMD • Release of Booklet and Vayu Mandal by Chief Guest, Dr. M. Rajeevan • Inaugural talk by Chief Guest: Dr M. Rajeevan, Secretary, MoES • Vote of thanks
1110-1130	**High Tea**
1130-1315 **Technical Session - I**	**Theme - Overview of Global & Regional Framework for Climate Services** **Chairman – Prof. S. K. Dube; Rapporteur - Dr. R. K. Giri** • Climate Services in India – **Dr. K. J. Ramesh, DG IMD** • Weather and Climate Modelling for Seamless Forecasting in Climate Services – **Dr. A. K. Sahai, IITM, Pune**

	• Satellite Observations for Climate Monitoring – **Dr. C. M. Kishtawal, SAC, ISRO** **(Discussion on session – I)**
1315 - 1415	**Lunch Break**
1415 - 1545 **Technical Session – II**	**Theme –Climate Services for Agriculture and Food Security** **Chairman – Prof. U. C. Mohanty, IIT Bhubaneswar ; Rapporteur - Dr. A. K Baxla** • Climate Services for Agriculture and Food Security – **Dr. P. K. Aggrawal, CCAFS** • Agromet Advisories and Agriculture Contingency Plans – **Dr. P. Vijaya Kumar, CRIDA** • Agromet Advisory Services and its Role in Enhancing Farm Productivity – **Dr. K. K. Singh,IMD** **(Discussion on session – II)**
1545-1615	**Tea Break**
1615-1800 **Technical Session – III**	**Theme – Climate Services for Water Sector** **Chairman – Dr G. B. Pant ; Rapporteur - Dr. Samanti Sarkar** • Hydrological modelling for flood management – **Dr. N. K. Goel, IIT Roorkee** • Flash Flood Forecasting - Climate Services to Water Sector – **Prof. A.K. Gosain, IITD** • Weather & Climate Forecast for Hydrological Application – **Dr. A. K. Mitra, NCMRWF** • Climate Services for Hydrological Risk Management – **Dr. Vimal Mishra, IIT Gandhinagar** **(Discussion on session – III)**
1800-1915	**IMS Meeting**
1930	**Dinner (India Habitat Centre; Jacaranda Hall)** **Courtesy : GIZ**
Day 2	**23 March, 2019** **World Meteorological Day theme for 2019 - The Sun, the Earth and the Weather**
(0930-1115) **Technical Session – IV**	**Theme –Climate Services for Disaster Risk Reduction (DRR)** **Chairman – Dr Ajit Tyagi ; Rapporteur - Dr. V. R. Durai** • Disaster Risk Management – Challenges and Opportunities – **Dr. Pavan Kumar Singh, NDMA** • Early Warning & Impact Based Forecast – **Dr. M. Mohapatra, IMD** • Ensemble Forecast based on GEFS for Extreme Weather' – **Dr. Medha Deshpande, IITM** • Capacity Building for Effective Disaster Management – • **Dr. Anil Gupta, NIDM** **(Discussion on session – IV)**

1115-1130	**Tea Break**
1130 - 1200	**World Meteorological Day – Lecture** Advancement and Immediate Priorities of the Earth System Modelling in India – **Dr. R. Krishnan, CCCR, IITM Pune.**
1200-1315 **Technical Session – V**	**Theme –Climate Services for Health Sector** **Chairman – Dr. Bhaskar Rao ; Rapporteur - Dr. D. Rajan** • Climate and Health – **Dr. R. C. Dhiman, ICMR** • Prospect of Application of Climate Forecast on Health -**Prof. Dileep Mavalankar/Dr. Pingle –** Public Health Foundation of India • Heat Wave Forecasting : Application of Extended Range Forecast on Health Sector - **Dr. D. R. Pattanaik, IMD** **(Discussion on session – V)**
1315-1400	**LUNCH**
1400-1500 **Technical Session – VI**	**Theme - Climate Services for Energy Sector** **Chairman – Dr R. K. Datta ; Rapporteur - Dr. S. I. Laskar** • Climate Change – Risk Management for Energy Sector – **(MNRE)** • High resolution model forecast for application in Energy Sector – **Dr. Raghavendra Ashrit, NCMRWF** • Application of Weather & Climate Forecast –in Power Sector – **Mr. Alok Kumar, Chief Engg. NRLDC, POSOCO, New Delhi** **(Discussion on session – VI)**
1500-1545 **Technical Session–VII**	**CLIMATE SERVICES – Capacity Building and Public Awareness (Role of institutions and NGOs); Chairman - Dr. P. C. Joshi** • Earth watch (Dr. Raghu Saxena) • Indian Red Cross (Dr. Rina Tripathy) • IIHMR (Dr. Nitish Dogra) • TARU (Dr. Manu Prakash) • GIZ India
1545-1715	**Panel Discussion & Valedictory Function** **Moderator (Prof. S. K. Dash, President, IMS)** **Theme - Country Preparedness Towards Effective Implementation of Climate Services – Way Forward** • Dr. K. J. Ramesh, DG IMD • Dr. Akhilesh Gupta, DST • Dr. J. R. Bhatt, MoEF • Dr. P. Vijaya Kumar, CRIDA (Agriculture) • Mr. KVS Baba, CMD, POSOCO (Energy Sector) • Ms. Swati Sulagna, NDMA
1715 onwards	**Closing (High Tea)**

Climate Services – An Overview

D R Pattanaik

(With input from WMO - https://www.wmo.int/gfcs/)

India Meteorological Department, New Delhi
E-mails : dr.pattanaik@imd.gov.in; drpattanaik@gmail.com

1. World Climate Congress (WCC) & Conceptualization of Climate Services

The **World Climate Conference**s are a series of international meetings, organized by the World Meteorological Organization (WMO), about global climate issues principally global warming in addition to climate research and forecasting.

The **First World Climate Conference** was held on 12-23 February 1979 in Geneva and sponsored by the WMO. It was one of the first major international meetings on climate change. Essentially a scientific conference, it was attended by scientists from a wide range of disciplines. In addition to the main plenary sessions, the conference organized four working groups to look into climate data, the identification of climate topics, integrated impact studies, and research on climate variability and change. The Conference led to the establishment of the World Climate Programme and the World Climate Research Programme (WCRP). It also led to the creation of the Intergovernmental Panel on Climate Change (IPCC) by WMO and UNEP in 1988.

The **Second Climate Conference** was held on 29 October to 7 November 1990, again in Geneva. It was an important step towards a global climate treaty and somewhat more political than the first conference. The main task of the conference was to review the WCP set up by the first conference. The IPCC first assessment report had been completed in time for this conference. The scientists and technology experts at the conference issued a strong statement highlighting the risk of climate change. Eventually, however, developments at the conference led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), of which the Kyoto Protocol is a part, and to the establishment of the Global Climate Observing System (GCOS), a global observing system of systems for climate and climate-related observations.

World Climate Conference-3 (WCC-3) was held in Geneva, Switzerland, 31 August - 4 September 2009. ***Its focus was on climate predictions and information for decision-making at the seasonal to multi-decadal timescales. The goal was to create a global framework that will link scientific advances in these climate predictions and the needs of their users for decision-making to better cope with changing conditions.*** Key users of climate predictions include food producers, water managers, energy developers and managers, public health workers, national planners, tourism managers and others, as well as society at large. Participants in WCC-3 included these users, as well as climate service providers and high-level policy-makers. The Conference also aimed to increase commitment to, and advancements in, climate observations and monitoring to better provide climate information and services worldwide that will improve public safety and well-being.

WCC-3 outcomes also intended to contribute to the achievement of the United Nations Millennium Development Goals and broader UN climate goals, including the Hyogo Framework for Action on Disaster Risk Reduction. The Conference theme complemented global work under way to help societies adapt to climate change in line with Bali Action Plan, especially the Nairobi Work Programme. The outcomes formed part of WMO input to the 2009 UNFCC COP-15 meeting for climate mitigation in Copenhagen in the December following WCC-3.

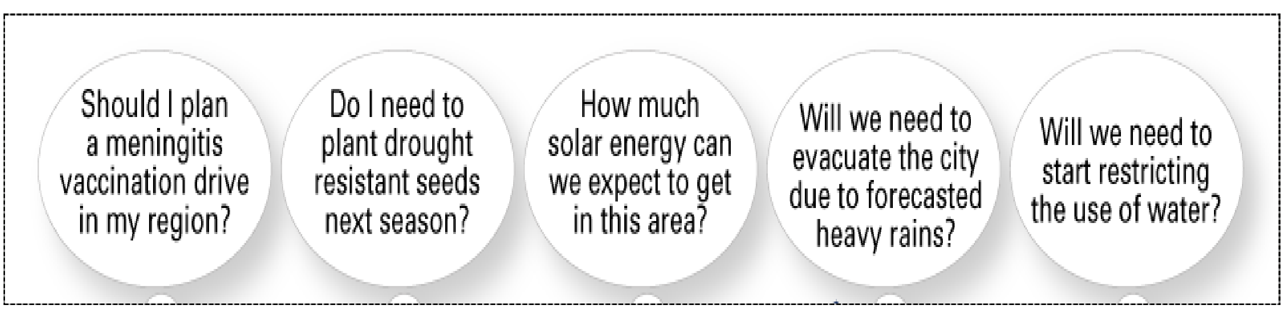
The theme of the Conference was ‘Climate Prediction and Information for Decision Making’ and its vision was for “An international framework for climate services that links science-based climate predictions and information with the management of climate-related risks and opportunities in support of adaptation to climate variability and change in both developed and developing countries”.

WMO and its partners convened WCC-3 to provide nations with the opportunity to jointly consider an appropriate global framework for climate services over the coming decades that would help ensure that every country and every climate-sensitive sector of society is well equipped to access and apply the growing array of climate prediction and information services made possible by recent and emerging developments in international climate science and technology.

On the basis of the three days of discussion and deliberations during the Expert Segment, ***the participants supported the development and implementation of the proposed Global Framework for Climate Services.***

2. Definition of Climate Services?

Climate services provide climate information to help individuals and organizations make climate smart decisions.



The climate services work by

- **National and international databases** provide high quality data on temperature, rainfall, wind, soil moisture and ocean conditions, as well as maps, risk and vulnerability analyses, assessments, and long-term projections and scenarios.

- **Socio-economic variables** and non-meteorological data such as agricultural production, health trends, human settlement in high-risk areas, road and infrastructure maps for the delivery of goods, may be combined, depending on user needs.

- The data and information collected is transformed into customized products such as **projections, trends, economic analysis and services** for different user communities.

- **Climate services** *equip decision makers in climate-sensitive sectors with better information to help society adapt to climate variability and change*

3. Global Framework of Climate Services - Vision

"To enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale."

The Global Framework for Climate Services (GFCS) accelerates and coordinates the technically and scientifically sound implementation of measures to improve climate-related outcomes at national, regional and global levels. As a framework with broad participation and reach, GFCS enables the development and application of climate services to assist decision-making at all levels in support of addressing climate-related risks.

The implementation of GFCS has five components:
(*http://www.wmo.int/gfcs/components-of-gfcs) viz.,*

- ***Observations and Monitoring :*** The essential infrastructure for generating the necessary climate data.

- ***Climate Services Information System :*** The production and distribution system for climate data and information products that address user needs.

- ***Research, Modelling and Prediction :*** To advance the science needed for improved climate services that meet user needs.

- ***User Interface Platform :*** Users can make their voices heard through the Platform and make sure climate services are relevant to their needs.

- ***Capacity Development :*** It will support the systematic development of the institutions, infrastructure and human resources needed for effective climate services.

4. Focus Areas of Climate Services

GFCS focuses on developing and delivering services in **five priority areas**, which address issues basic to the human condition and present the most immediate opportunities for bringing benefits to human safety and wellbeing:

(i) Agriculture and Food Security : Year-to-year, climate variability has a large influence on agriculture, which is heavily dependent on rainfall, sunshine and temperature. Human-induced climate change has introduced a new complicating factor into the food security equation, which is modifying natural climate variability. At higher latitudes, some producers may benefit from a longer growing season, while others in arid and semi-arid areas will experience increased water shortages. Scientists expect an increase in the frequency and intensity of extreme events such as floods and droughts that will ultimately impact crops and livestock.

Better understanding and management of climate variability will help cope with climate change. Decreasing the vulnerability of different sectors, such as forestry and agriculture, to natural climate variability through more informed policies, practices and technologies will, in many cases, reduce the long-term vulnerability of these systems to climate change.

(ii) Disaster Risk Reduction : Every year, natural hazards cause significant loss of life and erode gains in economic development. Nine in ten of the most commonly reported disasters are directly or indirectly related to weather or climate. Vulnerability to disasters is increasing as more people inhabit high risk areas. Since 1970, the world's population has grown by 87%. At the same time, the proportion of people living in flood-prone river basins increased by 114% and on cyclone-exposed coastlines by 192%. Rapid urbanization and the growth of megacities will increase exposure to natural hazards. Climate change is expected to increase the frequency and intensity of the most severe weather-related hazards in the decades to come.

Equipped with quantitative risk information, countries can develop risk management strategies using early warning systems to reduce casualties; medium and long-term sectoral planning (such as land zoning, infrastructure development, water resource management, and agricultural planning) to reduce economic losses and build livelihood resilience; and weather-indexed insurance and risk financing mechanisms to transfer the financial impact of disasters.

(iii) Energy: Energy systems are the engine of economic and social development. Energy generation and planning of operations are markedly affected by meteorological events and energy systems are increasingly exposed to the vagaries of weather and climate affecting both the availability and energy demand. By taking into account weather and climate information, energy systems can therefore considerably improve their resilience to weather extremes, climate variability and change, as well as their full chain of operations during their entire life-cycle. Under the current efforts to reduce greenhouse gas emissions within the context of a low-carbon development path, the share of renewable energy in the energy mix of countries is expected to increase dramatically. Energy is essential for the functioning of the four priority areas of the GFCS (agriculture and food security, water, health and disaster risk reduction), while at the same time energy efficiency and generation of renewable energy are sensitive to weather, climate, and water. Through appropriate partnerships and stakeholder engagement, the application of weather and climate information can provide useful support to energy management decisions and relevant policymaking to achieve optimal balancing of supply and demand as well as to drive behavioural changes in energy saving.

Focus Areas of Climate Services

(iv) Health : Weather and climate are inextricably linked to some of the most fundamental determinants of human health such as clean air and water, adequate food and shelter, and the distribution and occurrence of disease. Heat and cold waves, tropical cyclones, floods and droughts claim many lives and heighten the transmission of diseases each year. Factors indirectly related to weather and climate – food security and non-communicable diseases, such as cardiovascular and respiratory diseases resulting from exposure to poor air quality – also cause the death and illness of many people. Furthermore, the proliferation of communicable water-borne and vector-borne diseases, due to favorable conditions particularly triggered by climate variability, result in a huge cost to society and the economy.

Understanding the relationship between climate and health is fundamental when taking preventative action against climate related health risks. It is a challenge for the health community to access, recognize, understand, interpret and apply available climate information. Likewise, the climate services community often does not fully appreciate all public health concerns and needs, and the role climate services can play to support public health.

The Global Framework for Climate Services aims to help bridge these gaps. It will foster collaboration to develop reliable health and climate-related tools and services for various time scales – from months to seasons, decades and longer. These services will support health priorities such as improving disease surveillance, and extending the lead-time to prevent and prepare for climate related outbreaks and emergencies.

(v) Water : Water is fundamental to life. Population growth, urbanization, and soaring industrial and agricultural use have increased demand for this precious natural resource. At the most basic level, people need freshwater supplies for drinking, but such resources are increasingly strained in arid areas in parts of America, Africa and inland regions of Asia and Australia. Groundwater reserves are being depleted. Water scarcity is a major problem, affecting one in three people.

Climate data and information underpin the planning and management of surface water supplies and disaster risk reduction: calculations of the frequency and duration of heavy rainfall, the probable maximum precipitation, low-flow and flood forecasting, assessments of water resources, etc. Such data collected on weekly, seasonal and annual timescales and at national, regional and local levels are now more essential than ever to develop operational water management strategies, including flood and drought preparedness and response.

Need for Improved Climate Services in Agriculture and Food Security

Mannava V. K. Sivakumar

Senior Consultant, World Bank and WMO, Geneva, Switzerland
E-mail : mannavas@gmail.com

According to United Nations (2012), by 2050, the world population is projected to increase to 9.2 billion, with most of the increase in South Asia, the Middle East and Africa. Poverty and hunger are projected to persist and some of the most vulnerable and poorest economies will remain marginalized. In recent decades, changes in climate have caused impacts on natural and human systems on all continents and across the oceans. The number of hydrometeorological hazards in particular (such as droughts, floods, tropical storms and wild fires) which were measured on an average of 195 per year in 1987-1998 increased to 365 per year in 2000-2008 (WMO, 2014a).

Despite the impressive advances in agricultural technology over the last half a century, climate variability has a large influence on agriculture, which is heavily dependent on rainfall, sunshine and temperature. Of the total annual crop losses in world agriculture, many are due to direct weather and climatic effects such as droughts, flash floods, untimely rains, frost, hail, and severe storms. Adverse weather and climate conditions directly affect agricultural productivity, livelihoods, water security, land use, agricultural marketing systems, market instability, food prices, trade and economic policies; and small-holder farmers, fishers, livestock herders and forest dependent communities are often highly vulnerable to these impacts.

Climate change will exacerbate existing threats to food security and livelihoods from a combination of increasing frequency of climate hazards, diminishing agricultural production in vulnerable regions, expanding health risks, increasing water scarcity, and intensifying conflicts over scarce resources, which will likely lead to new humanitarian crises, as well as increasing displacement. Climate change is expected to affect allof the components that influence food security: availability, access, stability and utilization.

All countries are having difficulties in coping adequately with the increasing effects of hydrometeorological disasters, whether through a growth in the number of severe events, through increased exposure, heightened vulnerability, or all three. Efforts have to be directed towards strengthening capacities at national and local levels, with international support where necessary. Climate services develop and provide science-based and user-specific information relating to past, present and potential future climate and address all sectors affected by climate, at global, regional and local scale. They connect natural and socio-economic research with practice.

Climate services consist of the collection of climate data; generation and provision of a wide range of information on past, present and future climate; development of products that help improve the understanding of climate and its impacts on natural and human systems; and the application of these data, information and products for decision-making in all walks of life and at all levels in the society. The provision of more and better climate services will allow farmers to fine-tune their planting and marketing strategies based on seasonal climate forecasts.

Climate services contribute to Sustainable Development Goals (SDG) 2 and 15 to enhance agricultural productivity. In addressing SDG-2 entitled "*End hunger, achieve food security and improved nutrition and promote sustainable agriculture",* information on the start, end and quality of the rainy season will help improve food production, nutrition and food security. Climate services could strengthen the capacity of farmers for adaptation to climate change, extreme weather, drought, flooding and other disasters. For SDG-15 entitled "*Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*", climate services can ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands and combat desertification.

Climate services in agriculture extend to where it can help develop sustainable and economically viable agricultural systems, improve production and quality, reduce losses and risks, decrease costs, increase efficiency in the use of water, labour and energy, conserve natural resources and decrease pollution by agricultural chemicals or other agents that contribute to the degradation of the environment (WMO, 2014b). Available, accessible, comprehensive and useful weather and climate data can help agriculture and food security decision-makers improve their understanding of climate's impact on agricultural development and food systems, and their estimates of populations at risk (risk mapping). Weather and climate data can be particularly helpful to anticipate, prepare for and respond to agriculture or food security risks, on both short time scales to address problems triggered by climate extremes (i.e., droughts, thermal extremes) as well as longer term risks associated with climate change (e.g., increased frequency of cyclones, desertification etc.).

Intra- and inter-seasonal variability has a major impact on agriculture and food security. Seasonal climate outlooks can influence decisions on which varieties to plant and when, or the best timing for spraying where plant disease outbreaks are likely to occur, or perhaps estimate of the quantity of water needed for irrigation or whether to reduce livestock numbers if a drought is forecast. Farmers may be unprepared for expected weather conditions and make decisions based on an understanding of general climate patterns in their regions. Better climate predictions three to six months in advance can help shape appropriate decisions, reduce impact and take advantage of forecasted favourable conditions. Seasonal forecasts provide probability distribution for monthly to seasonal means of climate parameters such as rainfall and temperature, several months in advance that can be used for crop yield estimates. Yet, information about growing season weather beyond the seasonal average is also needed, such as growing degree days, chill days, and changes in the growing season (WMO, 2014b).

References

United Nations, 2012, Back to Our Common Future, Sustainable Development in the 21st century (SD21) project: Summary for policymakers. United Nations Department of Economic and Social Affairs, Division for Sustainable Development, New York, USA. 44pp.

WMO, 2014a, Disaster Risk Reduction Exemplar to the User Interface Platform of the Global Framework for Climate Services. World Meteorological Organization, Geneva, Switzerland. 47pp.

WMO, 2014b, Agriculture and Food Security Exemplar to the User Interface Platform of the Global Framework for Climate Services. World Meteorological Organization, Geneva, Switzerland. 35pp.

Enhancing Climate Services in South Asia – activities and plans of the Regional Multi-hazard Early-warning System (RIMES)

G. Srinivasan, Anshul Agarwal and Mitesh Sawant

RIMES, Pathumthani, Thailand
E-mail : srini@rimes.int

Daily weather services are required to make choices that are immediate, within periods of hours to days. Decisions made for beyond the period of days need information on climate time scales of months, years, or decades. Information beyond the period of days are broadly termed as “climate information” and are available as statistical aggregates associated with probabilities, rather than more exactly determinable outcomes. Hence the relevance of “climate information” is highly context dependent, making it imperative for a close liaison with users so that the information is appropriately interpreted to their specific situations. The Regional Integrated Multi-hazard Early-warning System for Asia and Africa (RIMES) was supported by the World Meteorological Organization (WMO) Programme to implement the Global Framework for Climate Services (GFCS) at the Regional and National Scales with funds provided by the Government of Canada through the Federal Department of the Environment. RIMES with collaborative support of the National Meteorological and Hydrological Services (NMHSs) of countries in South Asia facilitated user engagements at different levels to enhance climate services. These activities are currently being continued within the Asia Regional Resilience to Climate Change (ARRCC) Programme, in collaboration with the UK Met Office, funded by the UK Department for International Development (DFID).

Credible climate information is an important starting point for effective climate services and risk management decisions. Globally, the Global Producing Centers (GPCs) coordinated by WMO offer a large sub-set of climate predictions months in advance. The Regional Climate Centers (RCCs) help in contextualizing the global products for the region and also building capacities within the region to interpret such results from a national perspective. The implementation of the South Asian Climate Outlook Forum (SACOFs), at regional level and National Climate Outlook Forum (NCOFs)/Monsoon Forum, at National Level were two important tools used for establishment/strengthening user interface platforms in south Asia. Efforts to tailor weather and climate services to user needs begin with the consideration of recommendations, received through user interface platforms such as Monsoon Forums/NCOFs and SASCOFs, field level demonstration and Decision support systems (DSS) need to be developed in the countries of the region, for example a web-based platform. Feedback received at SASCOFs and NCOFs and in-country consultations facilitated by respective NMHSs with sector departments, guided the development of prototype DSSs to showcase climate services.

One such prototype evolved through a Co-development process was implemented for the water sector in Sri Lanka. In close collaboration with Department of Meteorology (DoM) and the Department of Irrigation (DoI) a pilot project was developed to showcase the use of weather and climate information in the water sector. The *KirindiOya* basin located at southern part of Sri Lanka was identified during a joint meeting on 30 May 2016. There is a strong connect with agriculture as the reservoir serves a command area of about 13,000 acres that benefits more than 7000 farmer family cultivating paddy. The flood and water logging problems in some downstream hamlets also provides a disaster risk reduction aspect. So, overall the pilot location identified was quite ideally suited to demonstrate the use of climate information in the water sector. The objective was to develop an integrated DSS to manage the operations at *Lunugumvehera* reservoir to ensure daily and hourly releases through downstream channel within the acceptable limits. With this objective, the prototype DSS for water sector was developed and deployed in Sept 2017. This is now being operationally tested during 2018-19.

For the health sector prototype development, the focus was on diseases like Malaria and Dengue that are prevalent in several districts of the southern Indian state of Tamil Nadu and have known climate linkages. Customized weather and climate information would be useful in preparedness for these disease outbreaks. The Public Health Department, State Government of Tamil Nadu identified both Malaria and Dengue as the diseases that are climate sensitive and are a cause of concern when favorable climate acts as a predisposing factor. Climate however is not the only factor that can cause outbreaks. Other factors like susceptible locations that are known to be congenial to vectors and availability of a critical numbers of infected people is equally, if not more, important factor. But the department did recognize that weather and climate information could be very useful for giving them lead-time for preparedness.

Based on earlier experience and data Malaria – Ramanathapuram (11 Blocks) and Dengue Tiruppur (13 Blocks) were identified. Preliminary disease incidence data were used for building DSS prototype and analysis is being carried out. It has been reported that the water storage adopted by the people may be providing ideal conditions for Dengue vectors to become prolific when seasonal climate becomes congenial. Based on available studies and information provided by the Public Health Department of Tamil Nadu a prototype DSS to flag hotspot locations at sub-district level for possible disease outbreaks was implemented and demonstrated. Initially the system was built to run on operational 3-day short range and 10-day medium range weather forecasts with features to ingest climate predictions at seasonal and sub-seasonal scales. The prototype system is being tested by the Public health department and also dynamic integration of epidemiological data is being explored for another pilot location. Availability of disease data at required temporal and spatial resolution limits precise identification of environmental thresholds. Nevertheless, the system was recognized a useful tool by the Public Health Department officials for collating proper and necessary information to guide their preparedness.

RIMES has also developed similar prototypes for agriculture and disaster management sectors. More examples of such DSSs need to be co-developed with the NMHSs and sector-users to ensure suitable products are designed that meet the needs. This is expected to enhance the use of seasonal forecast information (and eventually sub-seasonal) and help sustained improvements that meet evolving demands. The experience and lessons learnt must be self-sustaining; therefore, there is a need to convey the benefits of climate services to policy makers through a variety of modes.

Climate Services - Over India and South Asia

D R Pattanaik*

** With inputs from Colleagues at IMD Pune and IITM Pune*

India Meteorological Department, New Delhi
Emails : dr.pattanaik@imd.gov.in; drpattanaik@gmail.com

1. Introduction

Recently, India Meteorological Department (IMD), Ministry of Earth Sciences (MoES) has taken major steps in improving the weather, climate and hazards warning services capabilities in the country. With the improvement in observational and forecasting tools including augmentation of NWP Models, Radar network and satellite products, forecasting/warning services in respect of tropical cyclones, severe thunderstorms, now casting, flash/urban floods, urban climate, climate change, heavy rainfall, advisories to farmers, pilgrimage forecast, heat waves/cold wave etc has been further strengthened. Scientists of IMD in collaboration with other institutes of MoES are working strenuously in providing better weather and climate services to all users by further augmenting modeling and observational network.

National Climate Centre (NCC), Pune which was established in 1995 by IMD with an objective to provide various climate related services to the country (India). Since then, NCC has been carrying out many India specific climate related activities like Climate Monitoring and Analysis, Climate Prediction (Seasonal Forecasts), Climate Data Management, and Climate Research. In addition, the extended range forecast (forecast up to 4 weeks) is also another component of climate forecast where the forecast of rainfall, temperature and other derived products are being widely used for applications in various sectors such as Agriculture, Water Resources, Energy, Health and Disaster Risk Reduction (the five prime areas of Climate Services). IMD started this extended range forecast on experimental basis from the year 2008 and it is now operational with implementation of a coupled modelling system, which is run once in a week with the forecast length of four weeks.

1. Operational Activities for Long-range Forecasting in IMD

- Regional gridded Monthly and Seasonal Forecasts based on Monsoon Mission CFS (MMCFS) model

- Country Averaged Monthly Forecasts - Country averaged monthly rainfall and 2m temperature anomaly graphs for the all 8 south Asian countries. These products are updated every month.

- Forecasts of Global Sea Surface Temperatures and ENSO and IOD Indices - Monthly and seasonal forecast maps of global SST anomalies and forecast of El Nino –

Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) indices updated every month.

- Seasonal Climate Outlook for South Asia for rainfall and temperatures over south Asia for the next 2 moving 3 month seasons (total 4 months) with month update.

- ENSO Bulletin providing statement on the global SST forecast anomalies with emphasis on the ENSO and IOD conditions for the next 8 months prepared based with monthly update.

- South Asian Climate Outlook Forum (SASCOF) Activities from 2010 onwards

Under this activity, Regional Climate Centre (RCC), Pune provides technical support and takes lead role in the preparation and issuance of consensus forecast outlook for the rainfall/temperature over South Asia. The forum also facilitates the dialogue and promote the use of RCC Regional Climate Outlook Forum (RCC/RCOF) products by the climate sensitive user sectors, representatives of the user community are also invited for the Forum.

2. Operational Activities for Climate Monitoring

- *Preparation monthly and seasonal maps of climate variables like mean surface pressure, maximum and minimum temperatures, rainfall, outgoing long wave radiation, seas surface temperature etc. over south Asia. The maps are updated every month.*

- *Climate Monitoring and Analysis - Prepares and publishes monthly and seasonal climate diagnostic bulletins and annual climate summary for Indian region regularly. Detailed monsoon reports are also being published every year.*

- *Drought Monitoring – IMD also prepares the aridity index every fortnight for drought monitoring.*

3. Operational Data Services, to support operational LRF and climate monitoring

Climate Data Archive - IMD Pune has a long time series of various Climate Data meticulously preserved at National Data Centre (NDC), Pune. Climate Data services and data rescue are the important activities of the NDC. Under Data Rescue activity, the data set of Daily Maximum and Minimum Temperatures recorded during the period 1889 to 1930 (based on 8 AM observations) from India and 109 stations from south and West Asia have been recently digitised. The processing of data from 1930 to 1968 from monthly registers is in the final stages and will soon be added to NDC archives. The centre is now poised for upgrading its capabilities on similar lines with WMO's latest Climate Data Management Specifications.

4. Operational Extended Range Forecast Activities of IMD

Extended range forecast (ERF) in the tropics covering the time scale from one week to about a month is one of the most challenging tasks in atmospheric sciences. It fills the gap between medium-range weather forecasting and seasonal forecasting. The ERF time scale is certainly a difficult time range of weather forecasting, since the timescale is sufficiently long so that much of the memory of the atmospheric initial conditions is lost and on the other hand, monthly mean time average is not large enough for the atmospheric signal associated with the ocean anomalies to emerge over the atmospheric noise. Though the seasonal forecast of monsoon has its own relevance for the policy maker the forecast of monsoon in ERF time scale is critical for the optimization of planting and harvesting. Thus, the forecasting of active-break cycle of monsoon 2 to 4 weeks in advance is of great importance for agricultural planning (sowing, harvesting, etc.), which can enable tactical adjustments to the strategic decisions that are made based on the longer-lead seasonal forecasts, and also will help in timely review of the on-going monsoon conditions for providing outlooks to farmers. The real time ERF of rainfall during north east monsoon season and ERF of cyclogenesis potential is also very useful for different users such as farmers, disaster managers etc.

Like the utility of ERF of Indian monsoon rainfall, cyclogenesis, northeast monsoon, the ERF of surface air temperature (hereafter denoted as temperature) on two to four weeks has a wide range of applications in agriculture, energy, health, insurance, power, financial sector etc. In May 2003 the heat wave claimed over 1,600 lives throughout the country with some 1,200 individuals died in the state of Andhra Pradesh alone. Like in 2003, during 2005 also India was under the grip of severe heat wave towards the third week of June and about 200 people died in the eastern parts of the country covering the state of Orissa and neighbourhood. Recently the year 2015 also witnessed severe heat wave condition over Telengana, Odisha and other parts of the country with death reaching more than 2000.

In last few decades, many groups throughout the world are working in developing empirical models for predicting the MJO signals, which can be utilized for the intra-seasonal fluctuation of rainfall over India. In addition, there are many global modelling centers like European Centre for Medium Range Weather Forecasting (ECMWF), National Centre for Environment Prediction (NCEP), Japan Meteorological Agency (JMA) etc. are also running atmospheric General Circulation Model and coupled atmosphere-ocean models operationally. The latest generation coupled models are found to be very useful in providing skilful guidance of extended range forecast. IMD has started issuing ERF guidance since 2008 by using available products from statistical and dynamical model outputs from various centres in India and abroad. In the present article a brief review of the evolution of operational ERF system of IMD since its inception in 2008 along with prospects of its application in different sectors are presented. The different products that can be used for sectoral applications are also presented.

At present the ERF system at IMD is running operationally once in a week on every (Wednesday) and the forecast is generated for 4 weeks starting from subsequent Friday to Thursday and so on as shown in Fig. 1. The current operational ERF modelling system is a suite of models at different resolutions based on the CFSv2 coupled model adopted from NCEP. The oceanic component is the GFDL Modular Ocean Model V.4 (MOM4). The operational suite of models consists of (i) CFSv2 at T382 (≈38 km) (ii) CFSv2 at T126

(≈ 100 km) (iii) GFSbc (bias corrected SST from CFSv2) at T382 and (iv) GFSbc at T126 with 4 members each (Total 16 members).

This ERF system has the capability of predicting active-break cycle of monsoon, which can be used for various applications. The performance of Extended Range Forecast skills for 2017 monsoon, cyclogenesis, heat wave, cold wave etc for the entire year 2017 is also available in a report published by IMD (Pattanaik and Sahai 2018; http://nwp.imd.gov.in/ERF_Report_2017.pdf).

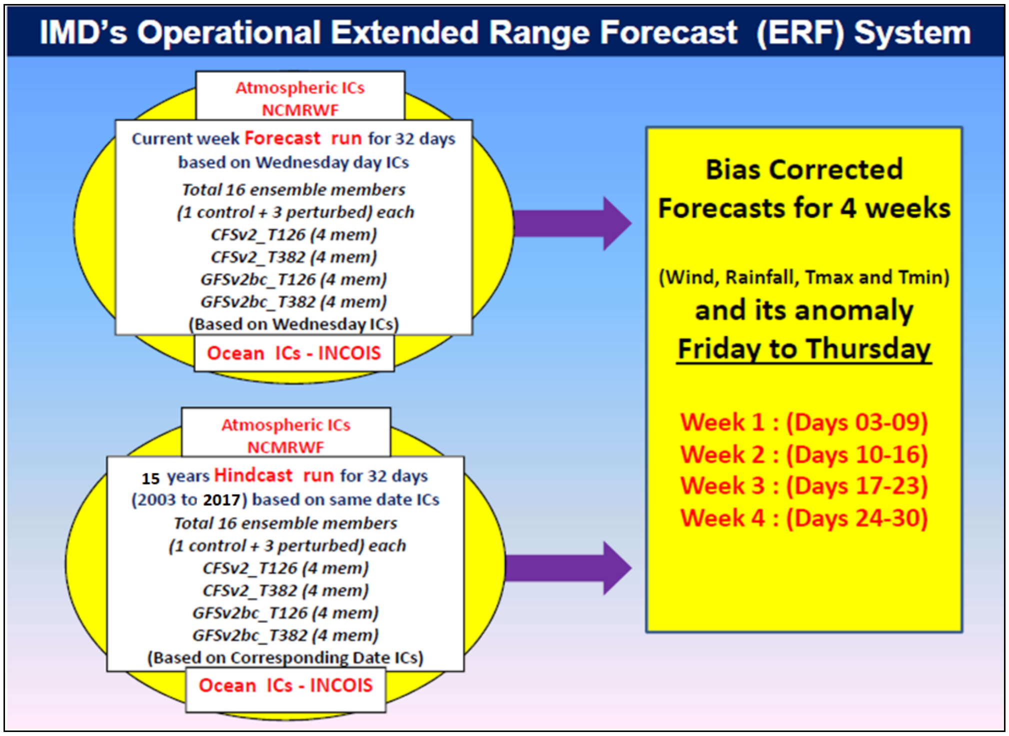


Fig. 1. Operational Extended Range Forecast System of IMD

4.1. Extended Range Forecast of Active & Break Cycle of Monsoon

The active-break cycle of monsoon is well predicted and is being used for preparing Agromet Advisory purposes. As seen from Fig. 2 the daily monsoon rainfall over core monsoon region during monsoon season 2018 indicating the transition from active phase to weak phase during last week of July –first week of August is very well predicted as seen in two weeks extended range forecast of monsoon rainfall based on 18 July, 2018 indicating the transition from above normal during week 1 (20-26 July 2018) to below normal in week 2 (July 27 -02 August 2018).

Like the transition from active-break monsoon transition the active phase of monsoon rainfall is also well predicted in the real time extended range forecast. During the last week of August 2017 (25-31 August) the monsoon condition indicated very active phase of monsoon with very heavy rainfall over Mumbai and adjoining Maharashtra and Gujarat states leading to floods conditions. The extended range forecast of this active phase of rainfall is very well predicted two to three weeks in advance, which can be seen from the forecast rainfall averaged over different meteorological sub-divisions of Maharashtra and Gujarat valid for the week from 25-31 August, 2017 with initial conditions of 23 Aug, 16 Aug, 09 Aug and 02 Aug, 2017 respectively (Fig. 3a). Similarly the spatial distribution of ERF rainfall valid for 25-31 Aug, 2017 indicating the active phase of monsoon is also very well captured in the forecast (Fig. 3b). This information can be used by the city or regional planners to give quantitative precipitation forecast for a city or a block. This rainfall forecast in different lead-times could be used for quantitative flood forecast based on hydrological models.

(a)

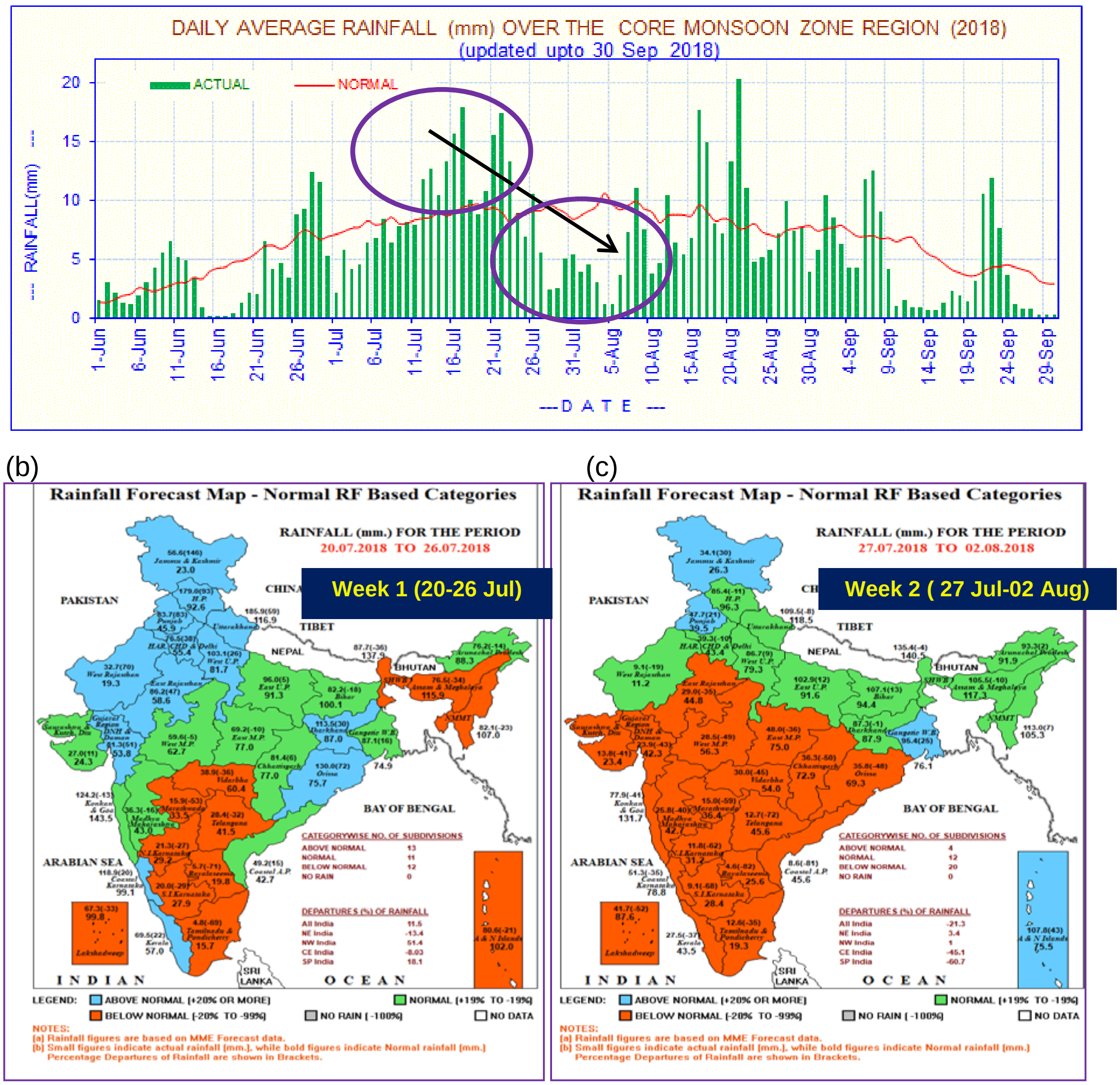
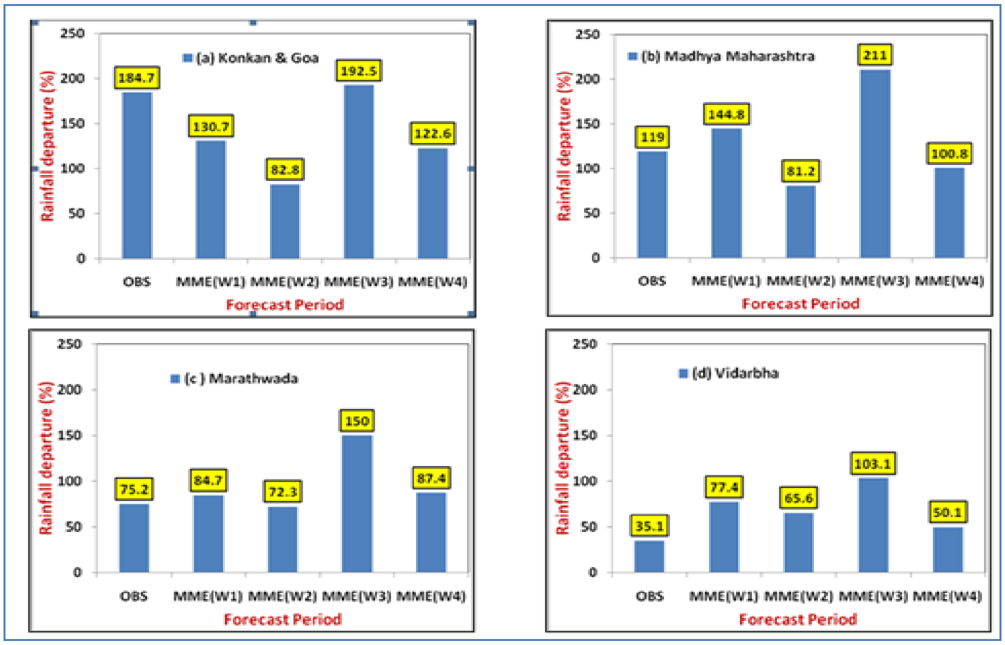


Fig. 2. (a) Daily monsoon rainfall over core monsoon region during monsoon season 2018 indicating the transition from active phase to weak phase. (b) Two weeks extended range forecast of monsoon rainfall based on 18 July, 2018 indicating the transition from above normal during week 1 to below normal in week 2.

Another product, that can be used for the hydro-meteorological application is the Standard Precipitation Index (SPI) to monitor the dry/wet condition. IMD has started preparing these products from the monsoon season of 2018 in the real time based on the extended range forecasts. The SPI outlook based on the 4 weeks extended range forecast of 11 July 2018 and valid for the period from 12 July to 8 August, 2018 is shown in Fig. 4.

(A)



(B)

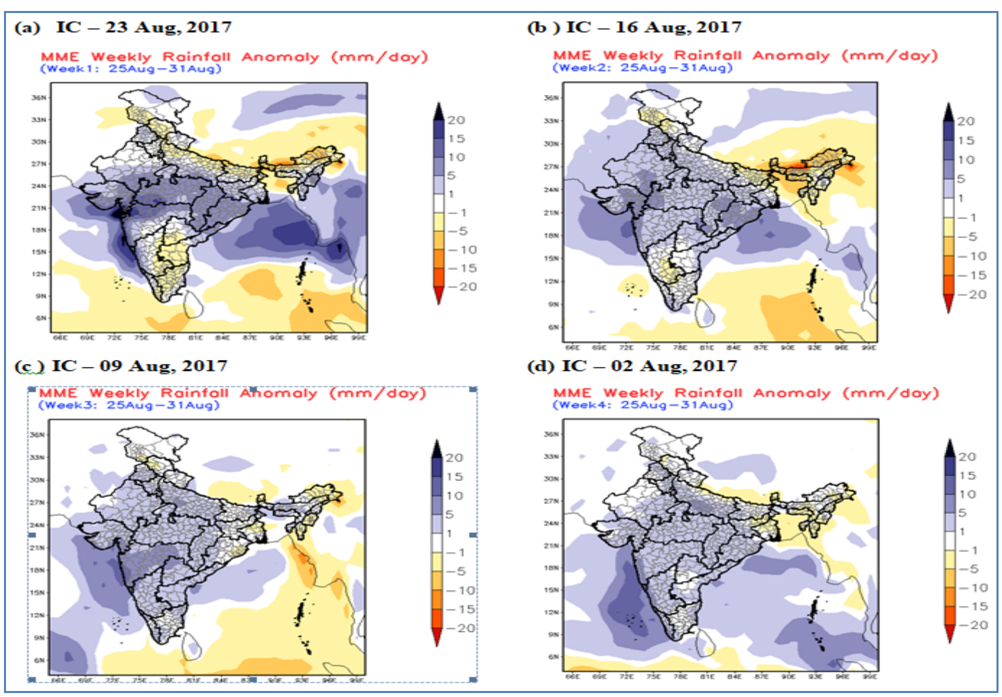


Fig. 3A. ERF forecast rainfall averaged over different meteorological sub-divisions of Maharashtra and Gujarat valid for the week from 25-31 August, 2017 with initial conditions of 23 Aug, 16 Aug, 09 Aug and 02 Aug, 2017. (B) Same as 'a' but for the forecast spatial rainfall anomaly.

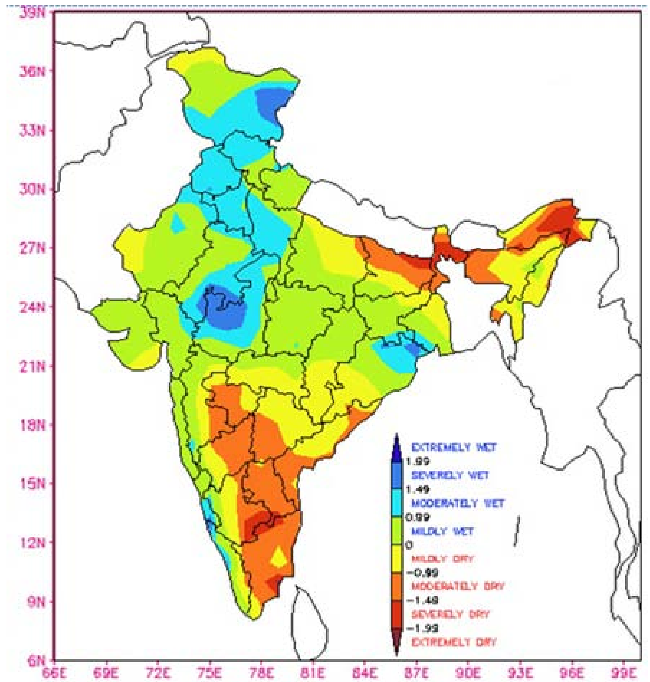


Fig. 4 : Standardized Precipitation Index (SPI) outlook based on the 4 weeks extended range forecast of 11 July, 2018 and valid for the period from 12 July to 8 August

4.2. Extended Range Forecast of Heat Wave

Climatologically March, April and May are the summer months in India**.** Hot winds known as "loo" are the marked feature of summer in northern India. Extremely hot weather is common in India during late spring preceding the onset of the monsoon season in June. During March the mean temperature is around 32°C, but in the western region, the Tmax can be far above the average. During April, the isotherm line greater than 38°C covers large parts of India with a small pocket of central India having temperature greater than 40°C. During May, the Tmax increases and exceeds 40°C over large parts of India covering north-western parts of the country extending towards the Indo-Gangetic plain. During June, though the monsoon currents cool the southern parts of the country, the *T*max remains more than 40°C in north-western parts of the country. During summer, most areas of India experience episodes of heat waves (HW).

Many studies have indicated except over northeast India and large parts of Peninsula (South of ~21°N & west of 80° E), most areas of the country have experienced on an average ≥ 2 HW days. Many areas of West Rajasthan, Punjab, Haryana, northern parts of East Rajasthan, Madhya Pradesh, Chhattisgarh, Vidarbha, western Uttaranchal, East Uttar Pradesh, western parts of Jharkhand & Bihar, Gangetic West Bengal, northern parts of Orissa, Telangana, Coastal Andhra Pradesh, eastern parts of Rayalaseema and north Tamil Nadu on an average have experienced≥ 8 HW Days. Fig. 5b is same as Fig. 5a but for average SHW days per season. It is seen that average SHW days of 1-3 days were mainly experienced over northwest, north and eastern parts of the country.

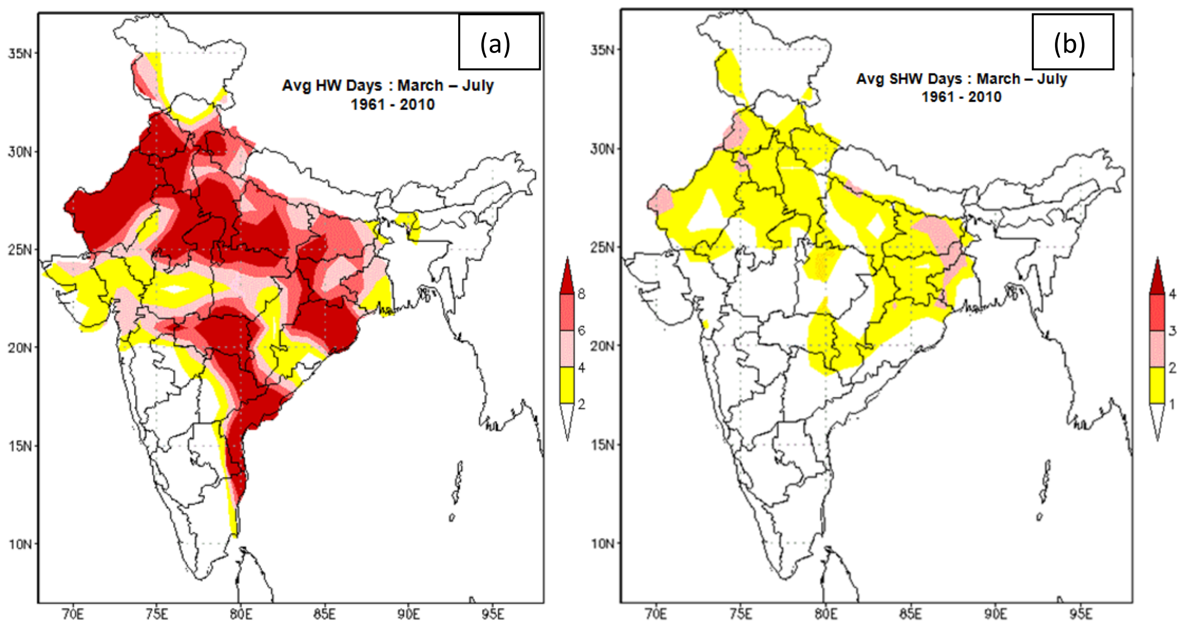


Fig. 5 (a). Seasonal climatology map of number of HW days during the hot weather season (March - July) over India. The climatology was computed by averaging the number of HW days for the period (1961-2010). (b) Same as 'a' but for number of SHW days. (*Source* : Pai et al., 2013; Mausam).

Almost every year many parts of India experience HW/SHW episodes causing sunstroke, dehydration and death. At times, extreme temperatures like heat wave can also cause enormous losses of standing crops, live stock and fisheries. Along with high temperature, the high humidity compounds the effect of heat wave and due to this, a quantity Heat Index (HI) is defined, which is a function of both temperature and humidity

IMD is constantly engaged in providing forecast products and early warning for hot weather conditions at different spatial and temporal scales. With regard to the early warning and services pertaining to heat wave, IMD has been providing various forecasts and outlook for the hot weather seasons as given below. The extended range prediction for the extreme heat conditions has been initiated and predictions are being given on weekly basis for 4 weeks based on the coupled models run at IMD**.** As shown by Pattanaik et al., (2016) published in Met. Atmos. Physics, the real time multi-model based (MME) extended range forecast (ERF) of maximum temperature could able to predict the 2015 May heat wave over eastern states of Odisha Andhra Pradesh and Telangana two to three weeks in advance. The forecast of Tmax for the period of 22-28 May, 2015 was well predicted by the model (Fig. 6a-b).

During 2017 most part of India was also under the grip of heat wave during 12 May to end of May. The MME ERF forecast of bias corrected Tmax and its anomaly for two weeks based on the initial condition of 10th May, 2017 and valid for the period 12-18 May and 19-25 May, 2017 (Figs. 7a-d) clearly demonstrated the expected high temperatures over India.

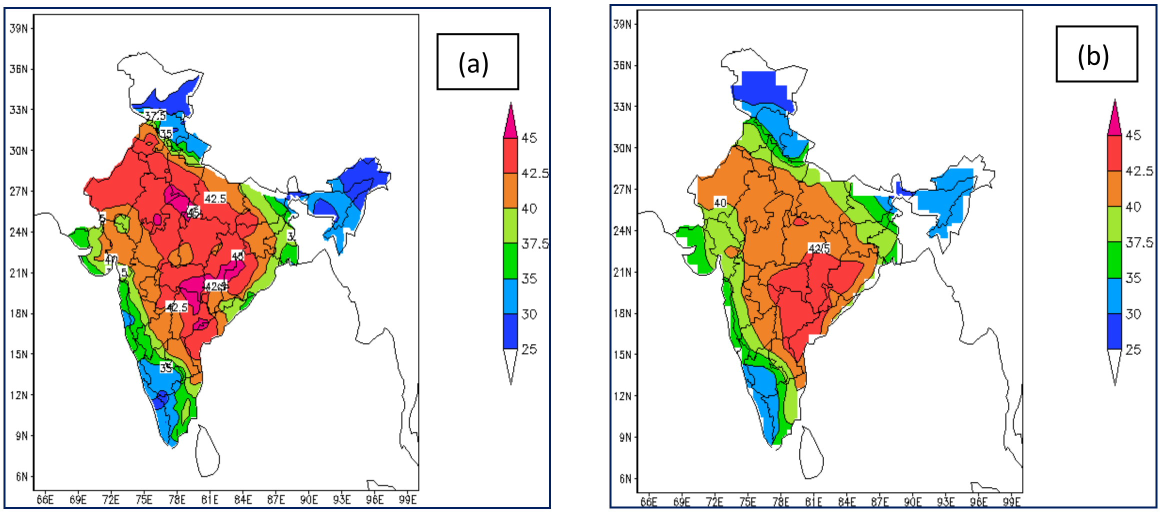


Fig. 6a. Observed maximum temperature during 22-28 May, 2015. (b) MME Extended Range Forecast of Tmax based on 6th May, 2015 and valid for 22-28 May, 2015.

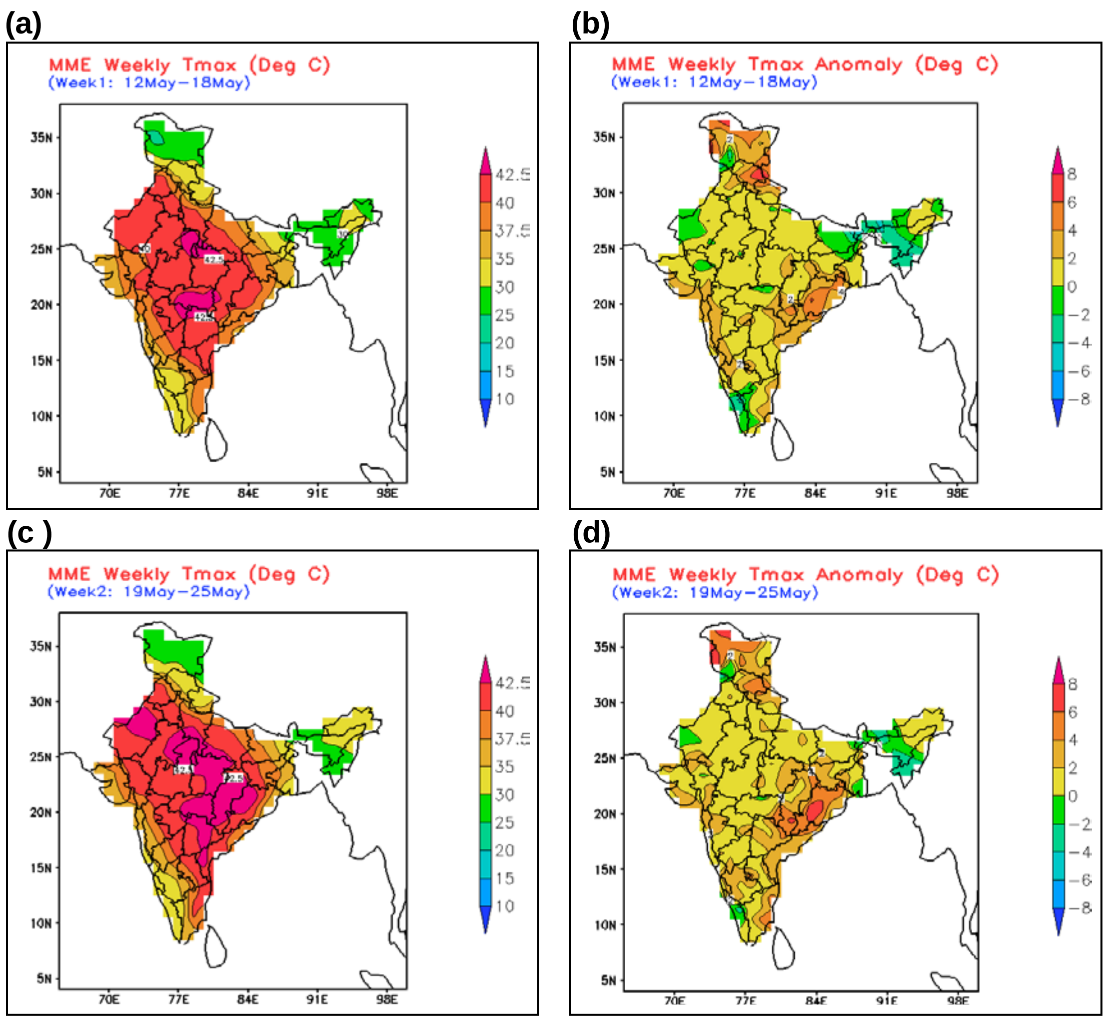


Fig. 7 : MME ERF forecast of bias corrected Tmax and its anomaly for three weeks based on the initial condition of 10th May, 2017 and valid for the period 12-18 May, 19-25 May and 26 May-01 Jun, 2017.

4.3. Experimental Climate Information Product for Health

Considering the favourable windows of temperature and humidity which helps in transmission of vector borne disease, IMD has started preparing the Climate Information products for Health experimentally based on extended range forecast. The temporal evolution of spatial distribution of transmission window for Vector borne disease, based on extended range weather forecast of 03rd October, 2019 and valid for subsequent four weeks are shown in Figs. 8a-d.

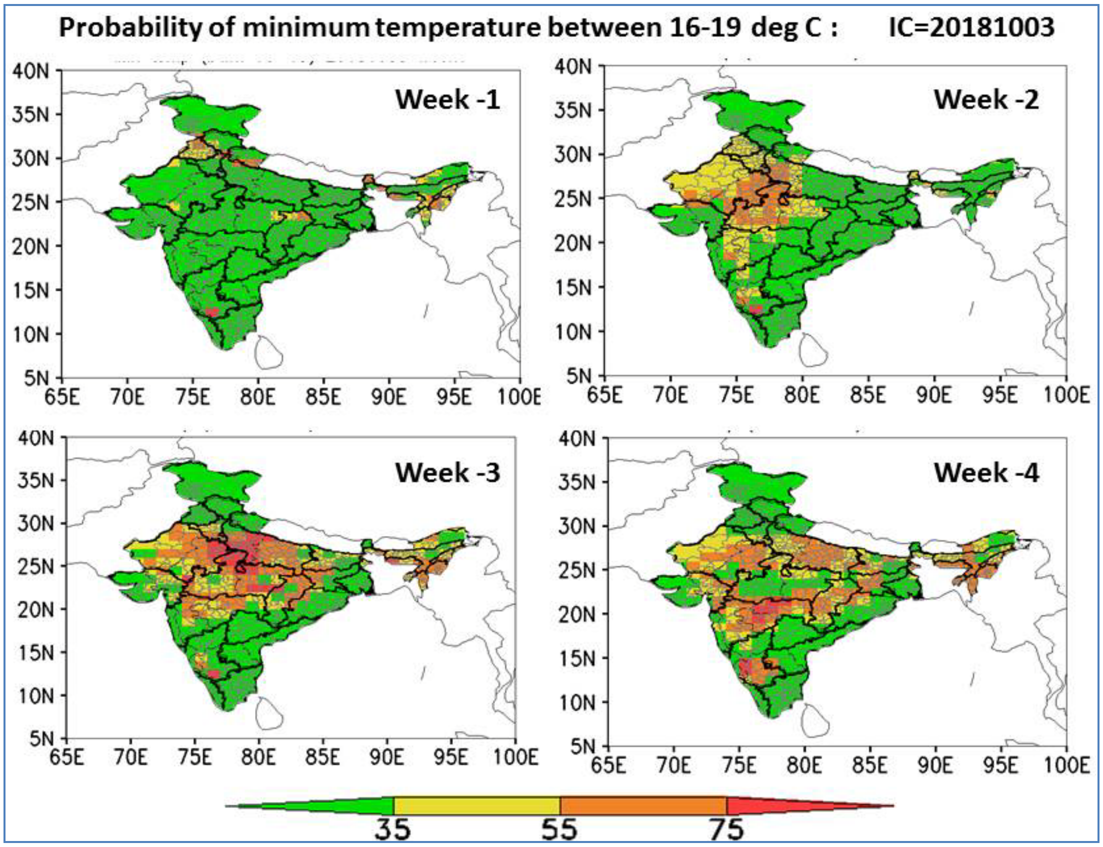


Fig. 8. Probability of minimum temperature between 16-19℃ for week 1-4 from 3rd October, 2018 initial condition

5. Climate Services for South Asian Countries

IMD has established as leader in the area of weather and climate services in the region of South Asia. It has been engaged in Human capacity building & Institute strengthening, participation in National Science events, Technology transfer, Joint R & D project to

i) Help the countries from south Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka) in providing various climate service activities such as Climate Monitoring and Analysis, Climate Prediction (Seasonal Forecasts), Climate Data Management, Climate Applications etc.

ii) To provide a platform for the stakeholders from south Asian countries under South Asian Climate Outlook forum (SASCOF) to prepare seasonal climate forecast outlooks in the national and regional levels, share and exchange experience and knowledge on summer monsoon and its prediction, and

iii) To initiate capacity building/human resource development activities in climate services for the South Asian region, particularly in seasonal prediction;

With an objective to expand climate service activity across south Asia, since May 2013, NCC has taken up additional responsibility of a WMO recognized Regional Climate Center (RCC) for the south Asia. For this purpose, efforts were made to build capacity to perform the mandatory RCC functions. RCC products described below are currently made available through a dedicated website (www.imdpune.gov/Clim_RCC_LRF/Index.html). In order to consolidate and further expand the climate services activities in the country and south Asia, the activities of NCC & RCC were brought under newly established Climate Services Division of IMD, Pune in 2015. The various activities under RCC are given below:

5.1 Capacity Building and use of climate products and services for South Asia

5.1.1 Training and Capacity Building:

The Meteorological Training Institute (MTI) of IMD at Pune is one of the WMO RMTCs. Regular training courses, refresher courses and specialized training courses for the IMD personnel as well as personnel from various national and international organizations are being conducted here in various branches of meteorology. The subjects include climate science and climate services.

The Meteorological Training Institute (MTI) of IMD at Pune is one of the WMO RTCs. Being a responsible RTC in the region, to fulfil it's national & international commitment, it regularly conducts routine training courses on different disciplines of Operational Meteorology, at different levels (ab-initio, carrier progression) with duration ranging from 4 to 12 months for Indian nationals (Including IMD personnel) as well as for foreign nationals (including personnel form South Asia). In all such training courses, Climate has occupied a very important place either as Climatology or as Climate Science. Besides Indian Climatology, the course content of such Climate modules contains basics of Climate Science, Climate Change, Climate prediction tool, climate information etc. Besides, RTC India organises many short term tailor made training courses on the themes of topical interest. Recently, RTC has also introduced a short term course on "Operational Climate Service".

5.1.2 SASCOF Training workshops

Associated with previous South Asian Climate Outlook Forums (SASCOFs) meetings, training workshops on seasonal prediction are also conducted. Centre designs and conducts the training workshops as per the regional requirement. Support of international experts is also used. The participating climate experts from the NMHS of the region are trained in using, interpreting and downscaling global seasonal prediction products and developing a consensus outlook (Fig. 9).

Fig. 9. Participants of SASCOF-4 forum meeting & training workshop conducted in April, 2014 at IMD, Pune.

5.1.3 Extended Range Forecast for Bhutan

An inception meeting on the development of climate services toolkit (CST) was held at Office of Climate Research & Services (CR&S) during 16-17 January 2018. One of the objectives of the meeting was to Develop Climate Services Toolkit in support of Decision Making by the Agriculture Sector in Bhutan. The primary objective of the meeting was to identify potential areas of support from India for developing a suitable Climate Services Toolkit for National Center for Hydrology and Meteorology (NCHM), Bhutan as a part of WMO's efforts for implementing effective Climate Services in Bhutan by developing capacities at NCHM through operationalization of the CST components designed to meet user requirements primarily in the sectors of Agriculture, Water resources, Health and Disaster Risk Reduction etc. This meeting was attended by two delegates from NCHM along with experts from WMO, IMD, IITM, and RIMES.

Following this meeting IMD scientist was deputed to National Center for Hydrology and Meteorology (NCHM),Bhutan to participate as an "Expert for capacity building on Extended Range Prediction(ERP)" during 19-21 March, 2018 (Fig. 10). Since then the extended range forecast products (Temperature and Rainfall) are being prepared regularly for Bhutan (Fig. 11).

Fig. 10. During the Capacity building training workshop on Extended Range Forecast at National Center for Hydrology and Meteorology (NCHM), Bhutan during 19-21 March, 2018.

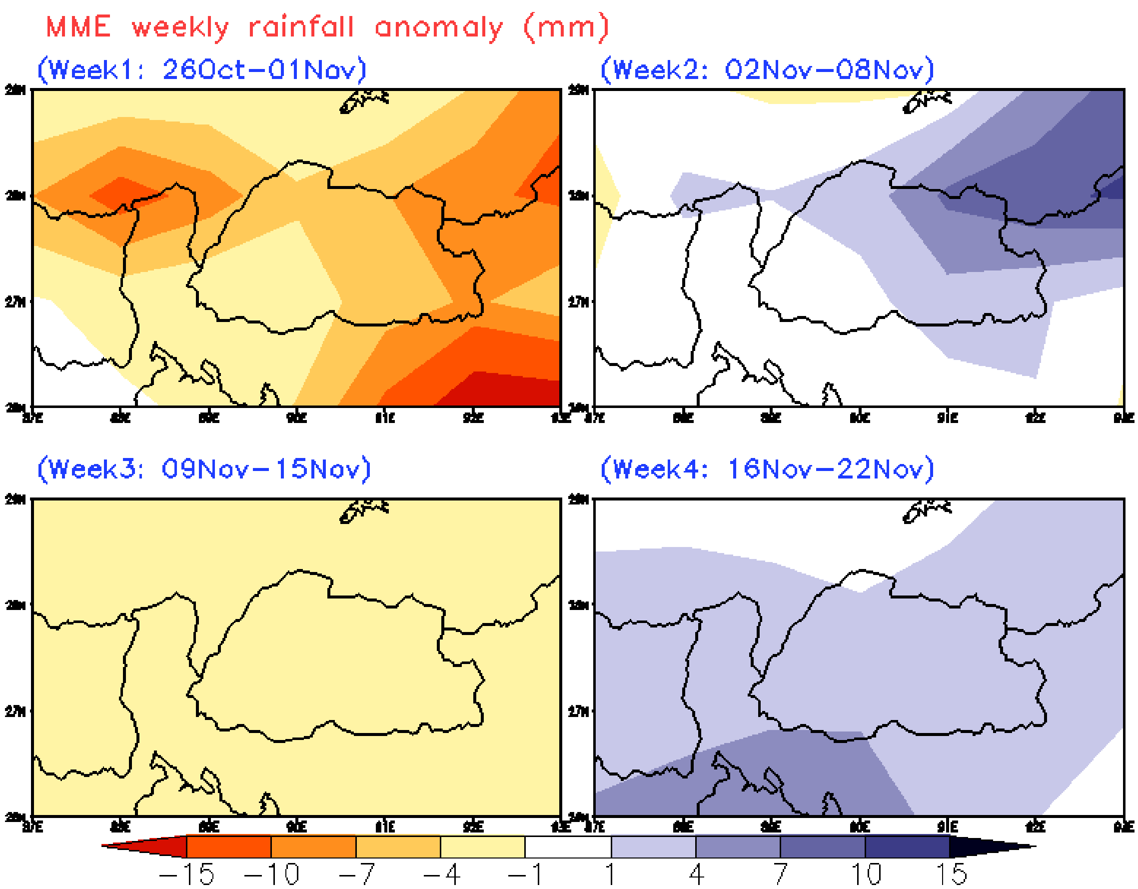


Fig. 11. Operational extended range forecast products prepared for Bhutan

Weather and Climate Modelling for seamless forecasting in Climate Services

A.K. Sahai

Indian Institute of Tropical Meteorology, Pune
E-mail: sahai@tropmet.res.in

The monsoon season over the Indian subcontinent during boreal summer provides 80% of the annual rainfall over most of the regions of India. It is characterized by a strong seasonal cycle and a marked interannual variability with rainfall having a standard deviation of~ ±10% of the seasonal mean. During any monsoon season, there is a prominent northward propagation of convection from Indian Ocean leading to several bursts of rainy spells with intensity varying from less than 5mm/day to over 200mm/day, and the duration of each spells varying from days to weeks. With improvements in the forecast in the subseasonal scale in the recent years, a coherent, seamless prediction in multiple spatial scales is slowly evolving. This leads to fulfil one of the mandates of Ministry of Earth Sciences, which is to produce and deliver science-based weather and climate information about future climate change and impacts and climate and weather forecast to improve decision-making in climate/ weather sensitive sectors.

The climate service has undergone a broad overhaul over India in the last few years owing to the induction of newer technologies and adoption of WMO Global Framework for climate services (GFCS). GFCS focuses on developing and delivering services in five priority areas, which address issues fundamental to the human living condition and present the most immediate opportunities for bringing benefits to social safety and wellbeing. Five essential application domains identified for GFCS climate service are, (a) agriculture and food security, (b) Disaster risk reduction, (c) Energy, (d) health and, (e) water. The forecast service forms an integral part of WMO-GFCS. The forecast service has two essential components: (a) Modelling and Research, and (b), operational applications for stakeholders.

The adoption of WMO Global Framework for climate services (GFCS) framework by Ministry of Earth Sciences and the operational agencies like IMD has provided a charter for application of climate forecast to various stakeholders. The weather and climate modelling activities of MoES are conducted through its two major programs - Centre for Climate Change and Research (CCCR) and Monsoon Mission (MM). These modelling activities are oriented to provide science-based seamless information on weather and climate (from short to seasonal and climate change) for various user communities.

CCCR aims to develop high resolution climate models or Earth System Models (ESM) to address scientific questions on attribution and projection of regional climate changeand to generate reliable climate inputs for impact assessments. A project is undertaken for development of multi-model ensemble projections of high resolution (50km) regional climate change scenarios for South Asia. Also,CCCR-IITM is developing a global high resolution (27km) atmospheric version of the IITM Earth System Model. The aim of these modelling frameworks is to reduce the hazard impacts with better estimates of projected risks in food security, water security, ecosystem vulnerability, etc. with increase in global surface temperature.

MM project in IITM aims to develop better prediction models of monsoon forecast in the seasonal to sub-seasonal scale. The S2S prediction is likely to be important in near future as the daily heavyrain rate shows increase while percentage of wet days shows decrease. The future active/break spells could be more intense and regionally extended. Enhanced propensity of active and long break spells Strong Monsoon years (Weak Monsoon) could be more wet (dry) in future due to the increment in longer active (break) spells. In such a scenario prediction of extreme events becomes challenging which affects management of water resources, agricultural yields, and infrastructure and in turn lives of millions over Indian subcontinent

Seasonal and extended range forecasts are essential for long-term policy makers. Based on this forecast, advisories for tactical decisions on agricultural operations are prepared; This forecast helps in preparedness well in advance for selection of crops / cultivars; choosing windows for sowing / harvesting; irrigation scheduling – optimal water use; mitigation from adverse weather events; nutrient management : fertilizer application,etc.

Similarly *extended to short range forecasts* are essential for regional stakeholders' especially agricultural and hydrological stakeholders. Agricultural stakeholders can use this forecast for preparatory activities, including land preparation and collection of plant material; Planting or seeding/ sowing; management of crops, fruit trees and vines; Application of fertilizer, irrigation; thinning, weeding; pest and disease control; management of grazing systems; Harvesting, on-farm post-harvest processing and transport of produce; Livestock production activities (for dairy enterprises, beef systems, lamb and other livestock systems). Hydrological forecaster can use this forecast for dam management, flood forecast, inundation risk, etc. Similarly, the forecast have great uses in health sector. Heat wave forecast and cold forecast (which are health hazards) could be intimately linked to meteorological forecast. Advance warning of meteorological conditions could potentially help district administration taking precautionary steps.

Thus multi-scale forecast strategy forms the backbone of forecast based risk maneuvering system. A strong collaboration (research and data exchange) is a pre-requisite in this direction. Notably, in the current era, preparing a stakeholder to get "*weather ready and climate smart*," the seamless multi-scale prediction is significant for the operational agencies and partner research institutions. Initial applications based on case studies using a strategy of using seamlessforecast information in health, agriculture, hydrology shows a great potential in this direction.

Satellite Observations for Climate Monitoring

C M Kishtawal

Space Applications Centre (ISRO), Ahmedabad
E-mail:cmk307@rediffmail.com

A better understanding of climate change and its impact is necessary for governments and decision makers to define and implement appropriate mitigation and adaptation policies, including investment policies for large infrastructure with long lifecycles. The demand for climate services has increased considerably over recent decades. Key public and private sector interests such as insurance, agriculture, public health, energy and transportation have a fundamental need for authoritative climate information and services upon which to base strategic plans, investments and day-to-day decisions. A strong observation and monitoring system is a critical foundation for climate services at the global, regional and national levels. The provision of more and higher quality observational data, together with advances in climate science, will improve the prediction of extreme events such as droughts, floods and tropical cyclones. Better predictions of, and preparation for, such events will save lives, protect property and improve economic resilience and public well-being and security. A significant part of the required observations can only be provided in a synoptic manner by satellite systems. The large Numerical Weather Prediction centres around the world already use up to 80 million satellite observations per day in the framework of the World Weather Watch. The climate predictions will require much more observations. Satellite observations provide unique advantage over the conventional observations in terms of coverage, accuracy, completeness and representativeness.

Since the launch of the first weather satellite in 1959, Earth observation satellites have proven to be vital tools for climate research. Satellites observations have helped us to discover how the human activities like deforestation, fossil fuel burning etc. are affecting the radiation budget of the earth atmosphere system and affecting the ozone layer. Satellite observations showed us how the large scale changes have occurred in the surface of the earth in the form of urbanization, vegetation cover, and snow cover during the recent decades, how the cloud climatology is changing, how the cyclones are now intensifying faster than they did few decades ago. The recent launch of Orbiting Carbon Observatory (OCO2) mission gave us the first global maps of carbon dioxide concentration around the world. Additionally, there are satellite missions that provide global distribution of trace gases that provide the glimpse of the influence of human activity on our environment. Pulling together data from the NASA, NOAA, ISRO, JMA, CMA, and elsewhere, there are 162 earth observation satellites that are either active or semi-operational. Many of these observation systems are optimized to support real-time weather monitoring and forecasting, but their scope is gradually expanding to provide a foundation for longstanding climate records of key atmospheric parameters. For example, the international geostationary network, currently maintained by seven satellite operators, will soon fly enhanced visible and infrared imagers, hyperspectral infrared sounders and lightning detectors. Towards the end of the decade, some series will include an additional payload for atmospheric composition. These satellites fall into two categories. Those in a geostationary orbit cruise at the very precise altitude of 35,786km, remaining above the same spot on earth. The second group are those with low-earth orbits, circling at a height of around 400-1400km above Earth's surface. The different orbits serve different purposes. A geostationary orbit allows satellites to continually monitor a particular region uninterrupted. Satellites in a low earth orbit can directly monitor the climate from their position within or just above the atmosphere, and can provide near-global coverage as they scan over different swathes of ground with each orbit.

Climate Services for Agriculture and Food Security : Agromet Advisories and Agriculture Contingency Plans

P Vijaya Kumar*, S K Bal and G Ravindra Chary

All India Coordinated Research Project on Agrometeorology
ICAR- Central Research Institute for Dryland Agriculture
E-mail* : pv.kumar@icar.gov.in

Climate change affects agriculture in a number of ways, with effects unevenly distributed across the world. Climate change will probably increase the risk of food insecurity for people and regions who are exposed to climatic hazards, rely on climate sensitive activities and having low adaptive capabilities. Globally, future climate scenarios predict an increase in the frequency of extreme weather events, together with an increase in average global temperature. The increasing trend in temperature and extremes of weather has already been observed over the past decades with implications for global food production.

These changes will greatly affect the health and productivity of crops, livestock, fish and forests and rural livelihoods. Recent studies indicate that each degree Celsius increase in the global mean temperature would, on an average, reduce global yields of wheat by 6%, rice by 3.2%, maize by 7.4% and soybean by 3.1%. Similarly, a temperature increase of 3–4 °C can cause crop yields to fall by 15–35% and 25–35% in Afro-Asia and Middle East, respectively. (Ortiz et al. 2008). In India, since agriculture contributes roughly 14% of India's GDP, a 4.5–9% negative impact on agricultural production due to climate change results in loss of roughly 1.5% of GDP per year (Venkateswarlu et al. 2013).

Need for climatic services

Timely onset of Southwest monsoon rains and their distribution governs entire gambit of the Agriculture in India, which in turn affects the economy of the country. On the other hand extreme events like heavy and unseasonal rainfall, flash floods, droughts, heat and cold waves, frost and hailstorms are causing consider able damage to the field and horticultural crops. At this juncture, there is a need to provide good weather forecast based crop and region specific agroadvisories, which can help the planners and farmers to take near real time cropmanagement practices. In addition, a timely Agromet advisory can save inputs (seeds, fertilizers, plant protection chemicals etc) as well as the crop (especially at maturity stage). Agromet Advisory Service (AAS) is a part of extension Agrometeorology and defined as "Agrometeorological and agro-climatological information that can be directly applied to improve and/or protect the livelihood of farmers".

Initiatives of ICAR

- **AICRP on Agrometeorology** (AICRPAM) was initiated by ICAR in 1983 with coordinating cell at CRIDA, Hyderabad and 25 cooperating centres across the country. The broader themes of the project are: Agroclimatic characterization, Crop-weather relationships, Crop-weather-pest-disease interaction, Crop modelling and Agro-advisory services. The agro-climatic onset of season, dry-spell situation, extreme events during the crop season are being regularly monitored and AAS bulletins are issued twice in a week, in vernacular languages. Besides this, the project is providing technical back stop to IMD by developing "*Dynamic Crop Weather Calendars*" for each district.

- **AICRP on Dryland agriculture** (AICRPDA) was established in 1971 to develop agro-ecology specific drought management practices to increase the productivity of rainfed crops. Since then, the network centres of the project are demonstrating real-time contingency measures based on the real-time weather to manage weather aberrations in the adopted villages.

- **District Agricultural Contingency Plans** (DACP) - CRIDA in collaboration with DAC&FW, MoA&FW, GoI, National Agricultural Research System (NARS) and state line departments prepared district agricultural contingency plans for 648 districts of the country. These contingency plans are being operationalized in many states based on seasonal and extended weather forecast.

- **KVKs of ICAR** are involved in issuing Agromet advisories through District Agro-Met Units (DAMUs).

- **NPCC & NICRA** - Network project on Climate Change (NPCC) of ICAR (2004) involving ICAR and SAUs including CRIDA was operated to understand climate change / variability and its impact on agriculture and allied sectors. This was followed by initiation of National Innovations in Climate Resilient Agriculture (NICRA) in 2011 with focus on developing and disseminating climate resilient techniques with multi-disciplinary and multi-institutional approaches with a goal to sustain agricultural food production.

Major stakeholders of Agromet-advisories

The main purpose of issuing agromet advisory is to improve the farmers' ability to cope with different climate/weather aberrations and maximizing natural resources for sustained crop productivity. The major stake holders of the advisories are as follows

- NITI Aayog - *Policy makers*
- Ministry of Agriculture & Farmers' Welfare - *Policy makers*

- India Meteorological Department (IMD) - *Service provider through District Agro-Met Units (DAMUs) established under the project GraminKrishiMausamSeva (GKMS)*
- State Agricultural Universities - *Information dissemination*
- Line departments - *On-field assessment of benefits*
- Farmers - *direct beneficiaries*

Impact of Agromet advisories: Lessons learnt

- Takes advantage of benevolent weather
- Minimizing the adverse impact of malevolent weather
- Saving input costs on irrigation, fertilizers, pesticides, weedicides etc.
- Minimizing environmental pollution
- Improving economic gain with higher income

Way forward

- **Improved Seasonal forecasts** to help planners at state/ district and block level for managing the required inputs and making them available to farmers on time to implement contingency plans for minimizing farm loss.

- Management of extreme weather events is very much needed to safe guard the field/ horticultural crops during sensitive growth stages and to protect harvested output. **Strengthening of Nowcasting and short range weather forecasts** at block level is required. Government support for establishment of infrastructure for Nowcasting is very much needed in management of these extreme weather events.

- Weather based pest and disease forewarning becomes a major factor in management under the changing climate scenario. Cross boundary pest problems is envisaged in future for different crops at different locations (for example mealy bug). **Timely and accurate weather forecasts at short and medium range** will help in generating pest incidence alerts for taking timely control measures by the farmers.

- **MicrolevelAgromet Advisories were developed at block level** and successfully tested in 50 selected villages in 25 districts of the country under NICRA-AICRPAM project. This may be extended to all the districts of the country. The experience and expertise of ICAR and IMD, in a collaborative mode can help in scaling up Agromet advisories for minimizing the adverse impacts of climate change/ variability in agriculture. The inclusion of **Dynamic Crop Weather Calendars** in automation of Agromet advisories for dissemination by DAMUs will help in improving the quality of agromet advisories.

Agromet Advisory Services and its role in enhancing farm productivity

Dr. K K Singh

Head AASD
E-mail: kksingh2022@gmail.com

India Meteorological Department (IMD), Ministry of Earth Sciences in active collaboration with ICAR, State Agricultural University and Other Institutes is rendering the weather forecast based Agromet Advisory Services (AAS) to the farmers at district level through a network of existing 130 Agro-Met Field Units (AMFUs) co-located with Agriculture Universities/ICAR/IITs in each Agro Climatic Zone (ACZ). Agromet Advisory Service (AAS) provides advance weather information along with crop specific agromet advisories to the farming community by using state of the art instruments and technology through efficient delivering mechanism of the information which ultimately enables farmers to take appropriate actions at farm level. Weather forecast of medium range forecast at district level is used to prepare advisory every Tuesday and Friday. The advisories are sent to the farming community by multi-channel dissemination system like print and electronic media, newspaper, Television, Radio, internet as well as through SMS. Currently **4.0 Crore** farmers are receiving SMS advisory on their mobile phones through mKisan portal. Efforts are also carried out with the help of state departments to enhance the no of farmers receiving the services. Economic impact assessment of the study carried out by National Council of Applied Economic Research (NCAER), an independent agency, during 2015 estimated that the economic benefit from the use of weather information as the product of the percentage of farmers receiving information. At present only 24 percent of the farmers are benefitting from the SMS services. The economic profit estimates Rs. 42,000 crore on 4 principal crops viz. paddy, wheat, sugarcane and cotton only. This service has the potential of generating net economic benefit up to Rs. 3.3 lakh crores at 2012-13 prices on the 22-principal crops when AAS is utilized by 95.4 million farming households.

In view of the need to provide the farming system, farm specific tailored information on weather and crop/ livestock etc. The present system of delivering the services at district level is underway to extend up to sub-district/ block level with dissemination up to village level to meet the end users requirements of customized advisory at sub district/block level with medium range block level weather forecast. The present network is under extension through establishing 530 District Agrometerological Units (DAMU) at district level in collaboration with ICAR by 2020 in phased manner. To facilitate the extension of network and preparation of advisor, fully fledged observation system (Agro-AWS) at district level, an agrometeorologists is provided by IMD at DAMU in KVK premises. The agrometeorologists, expert panel consisting of agromet experts at KVKs will generate the block level agromet advisory. Agriculture officers of district level and officers from state department of agriculture will also be the part of system for dynamic exchange of information.

The various components of GKMS service viz. observing weather, its monitoring and forecast; crop specific advisory bulletin generation; outreach and feedback are being digitized to support integration of all the components of information generated. Hence an automated Agromet-Decision Support System (Agromet-DSS) is being developed for automation of the services provided under GKMS. This includes a dynamic framework to link the existing knowledge base on crop weather calendar, contingency action plan of CRIDA etc. Mobile apps being developed by SAUs/ICAR are also used under GKMS for better outreach of services.

Role of Precipitation forecasts in Operational Inflow Forecasting System for Tehri Dam: Limitations and Future scope

Narendra Kumar Goel[1] and Niraj Kumar Agrawal[2]

[1]Department of Hydrology, Indian Institute of Technology Roorkee, Roorkee -247 667
[2]THDCIL, Rishikesh
E-mail : goelhy@gmail.com

An operational inflow forecasting has been developed for the Tehri dam. For this dam 6 hourly and 24 hourly inflow forecasts are being issued by IIT Roorkee since July 1, 2018. For 24 hourly inflow forecasts, the following type of precipitation forecasts are used in the model.

(i) 1 to 3day precipitation forecasts issued by National Centre of Medium Range Weather Forecasting;

(ii) 1 to 7day precipitation forecasts issued by India Meteorological Department using WRF, MME and GFS models for Bhagirathi basin.

The forecasts issued by both the agencies provide useful information. However, there are issues related to the accuracy of the forecasts and availability of past forecasts. A strong network of 11 automatic weather stations has been developed in the Tehri catchment. There is need to integrate these data in the forecast models used by IMD and NCMRWF. It is proposed to present the details of the Inflow forecasting system for the Tehri dam and then discuss how the results of rainfall forecasts could be improved and integrated in the inflow forecast models.

Water Information from Seamless Modelling System across Scales

Ashis K. Mitra*

** With inputs from Colleagues at NCMRWF and IMD*
NCMRWF, MoES,
A-50, Sec 62, Noida, UP, India 201309
E-mail: ashis.mitra@nic.in

In last one decade due to availability of enhanced computing resources, weather/ocean observed data and improved assimilation-forecast system, the skill of tropical wind and rainfall forecasts have improved in medium range time scale. High capacity computers are aiding ensemble forecasting systems at high resolutions and enhanced ensemble manners. This has helped us in dealing with uncertainties in water forecasting by issuing probabilistic forecasting from global and regional ensemble prediction systems. By inclusion of exclusive Ocean, Land-Surface, Sea-Ice and Bio-Geo-Chemistry into the prediction model, a complete Earth System Model is now possible for going beyond medium range to a season and even climate projects. Particularly for India where the monsoon rainfall information is the lifeline of people the water forecasted at sub-seasonal to seasonal scale is very important for agriculture and water management. Due to improved model skill, services at short-term climate scales (up to a season) have become possible. AT NCMRWF a seamless modeling system is implemented for providing weather/climate information across scales from hours to a season. The advantage of such seamless modeling systems is its fast development cycle. The field campaign data collected at local scales can be experimented with meso-scale and large-scale process studies in model to improve the model. While the models are gradually improving there is enhanced demand of rainfall forecast from various sectors of economy for a variety of applications. Keeping pace with the demand, developing and demonstrating applications for water sector is a challenge for weather/climate modeling community. The 'THORPEX Interactive Grand Global Ensemble' (TIGGE) is an implementation of ensemble forecasting for global weather forecasting and is part of THORPEX, an international research programme established in 2003 by the WMO/UN to accelerate improvements in the utility and accuracy of weather forecasts up to two weeks ahead. NCMRWF 12 km global model output is being shared with TIGGE. WMO's 'Sub-seasonal to Seasonal Scale (S2S) prediction project is working towards improving forecast skill and understanding on the S2S timescale with special emphasis on high-impact weather events. Mainly operational centers are involved if this S2S project. WMO's Global Frame Work on Climate Services (GFCS) will be approached through this S2S project. WMO coordinated seasonal forecasting has benefitted by data sharing from Global Producing centers (GPCs). Multi-model Seasonal forecast of rainfall for various regions are being tried under R&D projects. WMO coordinated South Asian Climate Outlook Forum (SASCOF) is another mechanism for India for getting engaged in short-term climate prediction. Translating ensemble model output to suitable user interface platforms and capacity development for the end users remain a challenge in India. NCMRWF seamless modeling products related to water sector will be discussed in the workshop.

Climate Services for Hydrometeorology

Vimal Mishra, PhD

Associate Professor, Civil Engineering, IIT Gandhinagar, Palaj, Gandhinagar, 382355
E-mail:vmishra@iitgn.ac.in

Extreme conditions like droughts and floods affect millions of lives in India. Rainfall, temperature and soil moisture condition forecast on short and extended range lead time is required for policy making, planning and water management for district level. A short, medium and extended range forecast monitoring system is required for India to assist policymakers, stakeholders, and water managers and to minimize the impacts of water and food scarcity. We show the observed condition of precipitation, maximum temperature, minimum temperature, mean temperature, runoff and soil moisture on a daily basis. We simulate runoff and soil moisture for 10 days lead time using Global Forecast System (GFS) on a daily basis and 32 days lead time forecast using Extended Range Forecast System (ERFS) product every week using Variable Infiltration Capacity (VIC) model. 1-month SSI and 1-month RSI for observed condition show the current drought condition in the country while 1-month SSI and 1-month RSI at the end of the 7th forecasted day for IMD GFS product and at the end of 4 weeks for IMD ERFS product shows short term and long term drought condition in India.

Observed Products

We use daily observed precipitation, maximum temperature, and minimum temperature from India meteorological department (IMD) regrided at 0.25 degree and wind data from NCEP-NCAR regrided at 0.25 degree from Tiwari and Mishra [2019] from 1951 to 2017. From 01st January 2018, we downloaded daily precipitation, maximum temperature, minimum temperature from IMD (http://imdpune.gov.in/Seasons/Temperature/temp.html) and wind data from NCEP-NCAR (https://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.pressure.html). We regrid these datasets to the 0.25º spatial resolution to make it consistent on a daily basis by using the same methods earlier explained for precipitation and temperature datasets.

Forecast products

The data from IMD GFS (Global Forecast System) and IMD Extended Range Forecast System (ERFS) is used on a weekly basis. The spatial resolution of IMD GFS and IMD ERFS products are of 12 km and 1 degree respectively. We re-gridded these forecasted datasets to 0.25-degree spatial resolution to make it consistent with the observed data. We made two sets of forcing data using observed data (Precipitation and temperature) from IMD and (Wind) from NCEP/NCAR and forecast data from 2 models (GFS and ERFS). We converted 3 hourly IMD GFS data to daily data for 10 days forecast. We took ensemble mean of 16 ensembles of IMD ERFS data which provides a forecast of 32 days lead on a weekly basis.

Potential applications

- We provide rainfall, max. Temperature, min. temperature, mean temperature, runoff and soil moisture for 10 forecast days using IMD GFS data. These products provide hydro-meteorological information at the short and medium range forecast time.
- We evaluate the change in soil moisture for 3rd, 5th and 7th forecasted day to see the soil moisture availability of the upcoming days of the week with respect to last observed day by using the IMD GFS simulated forecasted results. This anticipated soil moisture change shows the soil moisture condition for the upcoming week.
- We also evaluate 1-month Standardised Soil Moisture Index (SSI) from soil moisture and 1-month Standardized Runoff Index (SRI) from total runoff at the end of the observed day and at the end of the 7th forecasted day. With these products, we get to know the current and 1 week forecasted drought condition of the country.
- We evaluated the forecast skill using bias in 7th day forecasted 1-month SSI and 1-month SRI with observed 1-month SSI and 1-month SRI respectively. We find that our forecasted results show very less bias (less than 0.5) in these indices.
- We show the rainfall, max. Temperature, min. temperature, mean temperature, runoff and soil moisture for 32 forecast days using IMD ERFS data. These products are helpful for extended range planning and execution.
- From IMD ERFS products we evaluated the weekly rainfall, max. temperature, min. temperature, mean temperature, runoff and soil moisture for 4 forecasted weeks.
- We evaluated the anticipated change in weekly max. & min. temperature, weekly runoff and weekly soil moisture for 2 forecasted weeks with respect to the past observed week.
- Similar to IMD GFS 1-month SSI and 1-month SRI, we evaluated these products for IMD ERFS also at the end of 4 forecasted weeks. With 1 month lead time forecast, we can better plan for the Irrigation, water supply, and other hydropower projects.
- With observed daily conditions, we are able to tell the real-time precipitation, temperature, runoff and soil moisture condition of the country. This real-time situation information will help for better planning and decision making.
- With 2 forecast models available, we are able to forecast the runoff and soil moisture condition for short and medium range time. This forecast is very beneficial for farmers, policymakers, and stakeholders.

Early warning and Impact Based Forecasting

Mrutyunjay Mohapatra

India Meteorological Department
Lodi Road, New Delhi
E-mail : m.mohapatra@imd.gov.in

India experiences many types of natural disasters including cyclones, floods, droughts, earthquake, landslides, heat wave, cold wave, thunder squalls and tornadoes. Most of these natural disasters (about 80%) are hydro-meteorological in nature. The risk management of these natural disasters depends on several factors including (i) hazard analysis, (ii) vulnerability analysis, (iii) preparedness& planning, (iv) early warning, (v) prevention and mitigation. The early warning component includes (i) skill in monitoring and prediction of natural hazards, (ii) effective warning products generation and dissemination, (iii) coordination with emergency response units and (iv) public awareness and perception about the credibility of the official predictions and warnings.

Though there have been significant improvement in multi-hazard monitoring & early warning in recent years due to various initiatives of Ministry of Earth Sciences (MoES)/India Meteorological Department (IMD) and policy frame work of Govt of India, there is limited improvement in impact based forecasting and risk based early warning. There is also scope for improvement in terms of (i) improving the mesoscale hazard detection and monitoring, (ii) improving the spatial and temporal scale of forecasts through technological upgradation, (iii) warning products generation and dissemination to last mile and disaster managers through state of art technology, (iv) sectoral applications of early warning based on anticipated impact and risk due to different severe weather events, (v) developing synergized standard operation procedure among the early warning agencies and user agencies and (vi) upgrading and enhancing the link between early warning service provider, disaster managers and other stakeholders. Further to stress the importance of the above, World Conference on Disaster Risk reduction (WCDRR) during 2015 at Sendai has set a target to substantially increase the availability and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030. All these aspects will be presented and discussed with special emphasis on achievements in recent years, existing gap areas and future scope to shift from conventional early warning to impact based forecast and risk based early warning in India.

High Resolution Ensemble Forecast for Extreme Weather

Medha Deshpande*, Radhika Kanase, Snehlata Tirkey, Malay Ganai and P Mukhopadhyay

IITM, Pune 411008
E-mail : medha_d@tropmet.res.in

In view of the uncertainty in initial condition and model physics there was a need for high resolution ensemble based forecast system for region specific probabilistic prediction of weather over India.Considering this along with the existing Global Forecast System deterministic model (GFS T1534), the high resolution (12 km approximately) ensemble forecast system GEFS (T1534) with 20 members is implemented and is in operation since June 2018 for the probabilistic prediction. The operational GEFS is valuable in the probabilistic prediction of extreme weather events like: Thunderstorm, Heavy Rain, Tropical Cyclones, Heat and Cold wave. Some of the events/cases of extreme weather will be discussed in the meeting. Various indices are developed for thunderstorms and the genesis probability based of GPP is also developed for tropical cyclones. The prediction of wind gust, rainfall probability is significant in the flood management and issue of warning point of view. For the benefit of IMD forecasters, various new model diagnostics and products like rainfall probability for all the blocks, EPSGRAM, SKEW T log P diagram etc. have been developed and are available operationally.

Capacity Building for Climate Resilient – Disaster Safe Development

Anil K Gupta

Head – Environment, Climate Change and DRM Division,
National Institute of Disaster Management, New Delhi
Expert Team Member – WMO Climate Statement,
South Asia CG Member – IUCN-CEM
E-mail : anil.nidm@nic.in

Businesses, occupations and economies globally, at all levels, are witnessing increased risk of disasters, as evident over the recent decades. Climate change and climate variability together with increased uncertainties, is causing twofold impacts on the disaster processing system: (i) climate change aggravating hazards by altering the patterns and trends of weather systems and events, and (ii) increasing vulnerability of land, people and their resources, by diminishing their capacities, livelihoods, economics and demographics. The environment-disaster nexus, therefore, has become central in dealing with disaster safe sustainable development, in the wake of SDGs, Sendai Framework and Paris Agreement.

The climate disaster complex that has been a matter of scientific and policy interventions over time acquired key consideration in business continuity and resource governance across urban, rural and industrial domains, in addition to people's safety and habitat resilience. The interlinkages between science-policy-planning-practice, therefore, form core agenda of capacity building and research programmes pertaining to climate change – mitigation, adaptation and disaster resilience together. The Prime Minister of India, gave a 10 point Agenda on Disaster Risk Management while inaugurated the 7th Asian Ministerial Conference in 2016 that provides an easily understandable and achievable roadmap towards climate resilience and SDGs.

However, climate awareness and use of climatic projections and patterns in decision making is still rare in India, even within corporate and government systems. Information on weather forecasts also need to be translated to finer useful products for use by community, farmers and local vendors. Hence, the capacity building approach that existed over past two decades concerning climate change and disasters need to be revisited and revised accordingly. The new tools like Disaster Impact Assessment (DIA, as extension to EIA process), Disaster Safety Audit, climate adaptive & resilient business continuity system (CASBCS), Mitigation Analysis (MA) are the recent developments that need to be integrated into the project and business management practices.

Looking to the evergrowing challenge of climate disaster nexus and extreme events related risk to developmental settings and peoples actions, the capacity building need to include following modules at various levels:

- Climate adaptive – resilient development and business continuity
- Climate Adaptive and disaster safe industrial systems
- Climate Adaptive and Resilient Infrastructure Systems
- Role of climate data and projections in planning & actions for SDGs
- Climate actions and forewarning for disaster resilience and response

Weather based policy making and programming need to be a common agenda on political diasporas for developmental decisions and effective long – and middle term early warning, rather than only alert and handling emergencies. Popularization of climate knowledge in daily life and investments has to be a priority focus, to strengthen communities and governments, especially urban local bodies and village panchayats, besides small and medium businesses. The National Human Resource Plan (NHR Plan) for Disaster Management of India recognizes the need of institutional network and consortium approach involving institutions including Universities, NGOs and sub-national governments. The capacity building efforts across 8 missions (3 new added, so total 11 missions) need to be designed woven using the institutional network and keeping NDMA, NIDM, related Ministries like MOES, MOS&T, MOEFCC, MOAG, etc. as central players.

Climate Services in Health Sector: Vector Borne Diseases

Ramesh C Dhiman

ICMR-National Institute of Malaria Research
NEW DELHI
E-mail : dhiman.rc.nimr@gov.in

All the vector borne diseases (VBD) is climate sensitive as they are transmitted by cold-blooded arthropods, mainly insects. The relationship between climate and malaria has been studied the most. In India, rainfall along with few economic parameters has been used long back in Punjab in 1946 for providing forecasts of malaria. Since then ,there is no tangible effort to use climate services for forecast of malaria or other VBDs. There has been renewed interest in the thematic area and more and more studies highlighting the role of climatic parameters in early warning of malaria etc. have been undertaken in last 3-4 decades. Several tools like Cumulative rainfall, Normalized Difference Vegetation Index, Sea Surface Temperature, Temperature Condition Index and El Nino Southern Oscillation, which reflect relationship of malaria with rainfall or rainfall related parameters, have been identified for early warning of malaria. Though malaria or other VBDs have local and focal micro-niche responsible for endemicity or receptivity, early warning tools cannot be developed at village or sub-centre level and one tool will not be applicable in a similar way for whole state or country.

A tool, which is simple, accurate and easy to be adopted at district level, has chances of more acceptability. Rainfall based tools using critical thresholds for causing outbreaks in a district can be used for providing early warning alerts for outbreaks for malaria. Of course the incorporation of intervention measures and health seeking behavior of the concerned population will further refine the alerts. The climate services would play a significant role for such system. Studies on assessing the usefulness of climatic parameters in early warning of other VBDs are also warranted.

Heat Stress and Adaptation
Learning from Ahmedabad Heat Action Plan (HAP)

Shyam Pingle*, Priya Dutta, Dileep Mavalankar

Indian Institute of Public Health- Gandhinagar, Gujarat, India
E-mail* : shyampingle@iiphg.org

Heat waves and resultant heat illness and heatstroke deaths is a well-established fact globally. Increased mortality due to increasing heat waves is predicted to be a major burden on health due to climate change.

A heat wave is usually a prolonged period of abnormal high temperature, which occur frequently during summer season in the western part of India. Recurrent heat waves, already a concern in rapidly growing and urbanizing South Asia, will very likely worsen in a warming world. Coordinated adaptation efforts can reduce heat's adverse health impacts, however. To address this concern in Ahmedabad (Gujarat, India), a coalition has been formed to develop an evidence-based heat preparedness plan and early warning system.

In May 2010, Ahmedabad faced a deadly heat wave with peak temperatures of over 46°C causing a spike in illness and death. Over 4,462 (all-cause) deaths occurred in May 2010, comprising an excess of 1,344 (all-cause) deaths, an estimated 43.1% increase when compared to the average of the same month in 2009 & 2011[1]. The all-cause mortality rose almost three times on the peak heat day of 2010. This is the first time anyone has reported such gross increase in mortality during heat wave in tropical countries. There was no apparent reason for this great increase in mortality except heat wave.

Our finding led us to develop Heat Action Plan (HAP)[2]based on similar learnings from Europe and America. We partnered with national, international agencies and Ahmedabad Municipal Corporation launched Ahmedabad HAP in 2013. The May 2015 historic heat wave of India, which was responsible for over 2,000 deaths nationwide, the states of Telangana and Andhra Pradesh were most significantly affected by the tragic heat wave.

Our HAP evaluation findings on all-cause mortality data of summer 2014–2015 indicated that the maximum pre-HAP RR was 2.34 (95%CI 1.98–2.76) at 47°C (lag 0), and the maximum post- HAP RR was 1.25 (1.02–1.53) estimated at 47°C (lag 0). Thus, an estimated 1,190 (95%CI 162–2,218) average annualized deaths were avoided in the post-HAP period (2014-15).

The plan has shown positive impact on mortality during heat waves over last 5 years. Around 17 cities and 11 states have adopted or are developing heat action plans in India. Ahmedabad's HAP plan has served as a guide for other cities attempting to increase resilience to extreme heat.

References:

[1]Azhar, Gulrez Shah, et al. "Heat-related mortality in India: excess all-cause mortality associated with the 2010 Ahmedabad heat wave." PLoS One 9.3 (2014): e91831.
[2]Knowlton, Kim, et al. "Development and implementation of South Asia's first heat-health action plan in Ahmedabad (Gujarat, India)". International journal of environmental research and public health 11.4 (2014): 3473-3492.

Discussion Points:

- Understanding correlation between heat wave and all-cause mortality
- Necessity to develop a city specific Heat Action Plan
- Consequences of increasing heat wave and related impacts on human health.
- Importance of developing city level temperature threshold for developing early warning system.
- Setting up system to monitor implementation of Heat Action Plan and measure the impact on mortality rise / reduction during heat waves.

High resolution model forecast for application in Energy Sector – NCMRWF

Raghavendra Ashrit

NCMRWF Noida
E-mail : raghu@ncmrwf.gov.in

Efficient power-grid integration and load balancing chiefly depend on the accurate power forecasts. Currently the installed capacity of wind power is 35GW and solar power is 22GW. This is likely to be increased to 60GW and 100GW respectively, by 2022. In the wind and solar energy sectors, the wind/solar forecasts are crucial. The wind/solar forecasting methods, which are primarily based on statistical algorithms, use farm observations, and have insufficient accuracy beyond a few hours into the future. In the past the Numerical weather prediction (NWP) models played limited role in providing short range wind/solar power forecasts. These model products have had relatively coarse grid horizontal resolution without customization for wind/solar power applications.

High-resolution models with state of the art data assimilation methods are now used for farm-scale forecasts. The boundary-layer wind is one of the most difficult variables for NWP models to predict. This is especially true for complex terrain regions. SW radiation forecasts are used for solar power forecasting, which are dependent on accurate prediction of cloud cover, movement and duration. There is ongoing research for improving such NWP model forecasts for optimization of physical-process parameterizations, the development of more-effective methods for the assimilation of meteorological measurements from wind/solar farms, and the post-processing of model forecasts to remove errors. Furthermore, to quantify model-forecast uncertainties, high-resolution ensemble prediction systems are being used.

At NCMRWF, state of the art NWP modeling is used in real time seamless prediction. The forecasting at different scales (spatial and temporal) is carried out using 12km (large and synoptic scale), 4km and 1.5km (mesoscale) model configurations. The high resolution models allow for realistic representation of the local terrain and land use characteristics and their interaction with near surface wind flow. These forecast products are used for day-ahead, short (72hrs) and medium (7days) range energy and load forecasts. Further, these forecast products can also be directly use for load forecasting, depending on the evolving weather conditions (temperature, humidity and rainfall) in short and medium range, and energy trading.

Impact of Weather on Power System

Alok Kumar

Sr. Deputy General Manager
NRLDC, POSOCO, New Delhi

E-mail : alok.kumar@posoco.in

India operates one of the largest synchronous grid in the world. The total installed capacity of Indian grid is 349.28 GW as on Dec'2018. The electricity demand is highly dependent on weather conditions and its vide variation over the day and seasons poses a big challenge to system operator in terms of secure and reliable grid operation. Weather information on different time scales is essential both in day-to-day energy management and for the generation and distribution infrastructures The impact of High temperature and high humidity can be appreciated by the fact that there is a 30-40% increase in electricity demand in summer months compared to winter months in the country. Temperature and Humidity impacts heating and cooling loads of Residential and Commercial loads whereas Rainfall and Precipitation impacts Agricultural demand and cooling needs depending on the season.

Present Renewable energy Capacity is 72 GW (Wind 35 GW, Solar 24 GW, Rest biomass and Small Hydro). Integration of 175 GW of Renewable Energy (100,000 MW Solar, 60,000 MW Wind, 10,000 MW Biomass and 5000 MW Small Hydro) by 2022 is going to make it more complex and complicated. Power output from Solar Photo Voltaic (PV) plants are affected by, Global horizontal irradiance (GHI) , Ambient temperature, Aerosols, Water Vapour and Cloud Cover. These parameters are highly variable in space and time which makes them the crucial components in the atmosphere on available solar irradiance and forecasting. GHI is directly related to power production by a PV plant. Wind speed is extremely important for the amount of energy a wind turbine can convert to electricity. The Power output of a wind turbine varies with the cube (the third power) of the average wind speed i.e if wind speed doubles, the power output will increase 8 times. Power output of wind turbine is also related to the local air density, which is a function of altitude, pressure, and temperature. Dense air exerts more pressure on the rotors, which results in higher power output. Power changes due to rapid increase or decrease in wind speed, are most difficult to handle and to predict when they occur due to an increase in wind speed (around 25 m/s) in high wind conditions. The shutdown of all turbines in a farm or a cluster of farms may happen nearly synchronous for all turbines with potentially severe consequences on the security of the grid. Therefore, the integration of anticipated renewable power of 175 GW by 2022 in the grid which is highly dependent on weather, shall further increase the challenges for a system operator. To plan and manage the secure and reliable system operation, it is imperative to have an accurate understanding of this variability and its impact on the power system.

Extreme Weather conditions invariably affect both power system and its operation to a large extent. The Indian weather is primarily driven by the Asiatic Monsoon system. In addition, the great Himalayan range and the Thar Desert play a vital role to influence it. Diversity of weather conditions ranging from tropical wet to tropical dry and subtropical humid to dry contributes with a huge variation. During summer period, massive convective thunderstorms predominantly affect Northern India's weather. These weather conditions lead to sudden load crash in pockets due to abrupt drop in temperatures and tripping/opening of distribution feeders leading to high voltages in the Grid. However, within few hours load returns after short and temporary effects of thunderstorm.

Cyclones are particularly common in the northern reaches of the Indian Ocean in and around the Bay of Bengal. Cyclones cause heavy rains, large storm surges, and strong winds that often are responsible for major outages in power supply in the affected areas.

Under such extreme weather conditions, accurate anticipation of variations in weather conditions helps in advance operation planning, secure system operation and early restoration of the affected areas. With an aim to increase the resilience of the power grid against such onslaught of the weather phenomenon, Meteogram, Radar imagery & Satellite Images are being utilized by the Grid Operator which is proving extremely effective for Indian Power System.

IMD-POSOCO Collaboration on Weather Services:-

MOU signed on 18th May,2015 between India Meteorological Department(IMD) and Power System Operation Corporation(POSOCO)

- Workshops carried out by IMD in all the Regions (July 2015 to September 2015)
- Weather Portal for Power Sector was developed using readily available products of IMD (March to June 2017)
- Presentation on Weather Portal in OCC/RPC/Special meetings
- Hon’ble Minister of State (IC) for Power and New & Renewable Energy ShriPiyushGoyal launched POSOCO-IMD Weather Portal for Power Sector on 23rd June 2017
- Workshop on Meteorology for system operators held on 27th -28th September 2018
- Hon’ble Minister of State (IC) for Power and New & Renewable Energy released a reference document on “Weather Information Portal for Indian Power System” on 29th August 2018.

Eco Weather Watch & Conservation of Urban Blue and Green Spaces - a programme initiative on Citizen Science & Experiential Learning

Raghuvansh Saxena

CEO, Earthwatch Institute India

E-mail:rsaxena@earthwatch.org.in

India is a land of unique climatic regime due to several characteristic features, including (i) two monsoon seasons (southwest and north-east) leading to drought & flood condition, active and break cycle of monsoon and also heavy rainfall leading to flash flood and landslides, (ii) two cyclone seasons (pre- and post-monsoon cyclone seasons), (iii) hot weather season characterized by thunderstorms, dust storms and heat waves, (iv) cold weather season characterized by snow storms in the Himalayan regions, cold waves and fog.

Indian Meteorological Department (IMD) under the Ministry of Earth Science is continuously taking meteorological observations through various platforms (Surface, Upper Air, Satellite, Radar, Automatic Weather Station etc.), preparing the forecasts and warning about adverse weather and disseminating the same to various users through different communication tools like web-based, mobile, IVRS, radio, etc. The Indian Meteorological Society works closely with IMD.

Indian Meteorological Society (IMS) and Earthwatch Institute India (EWI) share a common vision of engaging people in scientific field research & education to promote the understanding in regard to weather and meteorology, application of meteorological science in pollution monitoring, climate & weather forecasts; agriculture and land use, conservation of biodiversity and natural resources.

Blue (water bodies) and Green (parks, urban forest etc.) help significantly in contribution towards ecosystem services and ecological balance. Green spaces provide much needed oxygen and fix carbon dioxide and thus rescue a city from becoming an urban heat island. Biodiversity of Blue and Green Spaces are important elements of the environment. Eco-Weather Watch initiative has focus on engaging people in scientific field research and education in regard to application of meteorological science in climate and weather studies.

Time and again, ‘Citizen Scientists’ - members of the public who voluntarily help scientific studies - have made a difference to research, for example by meticulously collecting data. With a well-planned scientific research project, a list of tasks suitable for general public, and a science leader who can ensure that volunteers are productive, citizen science can work.

As part of Eco Weather programme, bespoken facilitated learning sessions provide field based experiential learning to enhance the impact of citizen science programmes. These facilitated outdoor sessions enable participants to step out of their normal surroundings on to an experiential learning journey. Such programmes impact participants' hearts and minds – inspiring passion and commitment and turning ideas into plans for action. Transformational learning based on fieldwork is a subject that is gaining wider recognition amongst students, educators, scientists and young researchers.

The programmes span a wide spectrum of thematic areas such as: • Eco-Weather Watch and Climate Studies • Sustainable Agriculture, Pollinators and Ecosystem Services • Sustainable Forests • Water Conservation and Freshwater Ecosystem • Biodiversity and Habitat • Urban Ecology

Eco Weather Watch programme will: Engage students and teachers at selective freshwater bodies and urban forests and develop a programme on field research and experiential learning on Weather Watch and Micro-Climate in these locations. Provide a framework for catalysing innovative thinking among participants on the role they could play in providing solutions to sustainability challenges. At the core of the programme will be an empowering and unforgettable experience of being part of a team with weather & meteorology scientists and researchers.

Eco-Weather Watch Programme involves hands-on activities where citizens work with meteorologists to understand the basic science behind weather and meteorology data and the application of meteorological science.IMS and EWI have significant experience and knowledge pool to develop an interesting and engaging Eco Weather Watch programme. (Source – Eco Weather Watch flyer of IMS and EWI).

Climate Services for Health
Use of Social Media and ICT*

***Nitish Dogra and Manish Priyadarshi**

Faculty, International Institute of Health Management Research, New Delhi
E-mail: nitish.dogra@gmail.com

Introduction

Social media covers the entire gamut of interaction means in society where individuals and institutions create and/or exchange ideas and information in the virtual world. The social media universe globally and in India can be gauged by the two figures below.

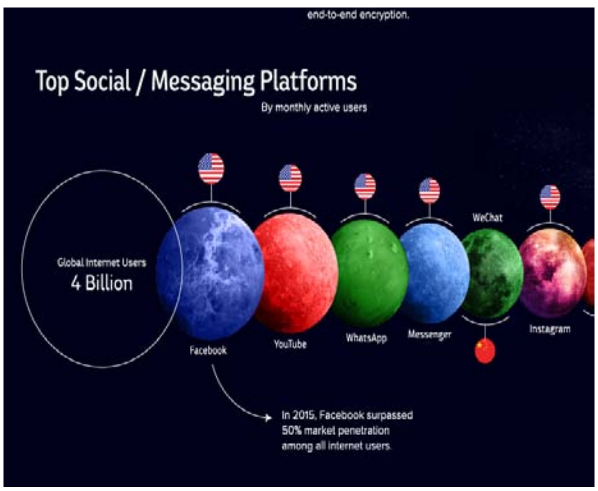


Fig. 1. *Global Social Media Universe (Univers mondial des médias sociaux)* Modified from Source: Visual Capitalist

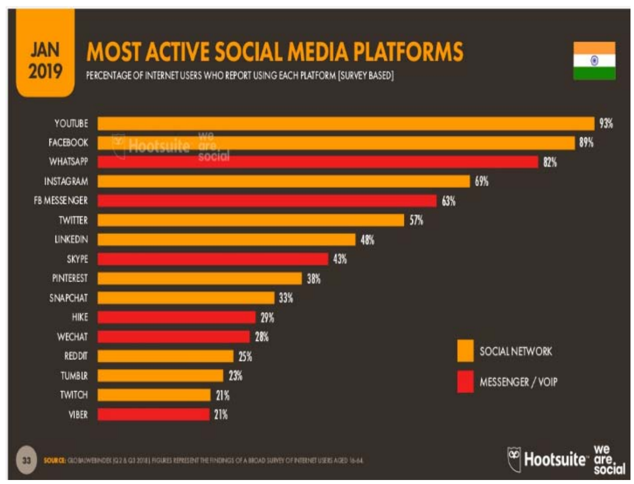


Fig. 2. *Indian Social Media Universe* (Indien univers des médias sociaux) Source: Digital 2019 India

The growing relevance of social media can be demonstrated by an examination of information and communication technology (ICT) access which facilitates the use of social media in climate services. These are radically altering the scope of communication possibilities and playing an increasingly important role in response to complex emergencies as well as natural disasters including climate change related disasters such as floods, cyclones, droughts and heat waves. These disasters can result in significant number of deaths, differing health impacts and possible displacement. As such, preparedness is crucial to deal with all the health related aspects such as housing, sanitation, security, reuniting families not just the obvious aspects related to medicines and human resources for health. Thus social media today augments traditional capacity related to all these aspects.

Besides the worldwide application of social media in disaster situations, in India too we have seen that social media has played a major role after events such as the Kedarnath, Chennai and Kerala floods. In fact it was the relative failure of ICT during the 2004 tsunami that prompted a thorough review of modern communication systems in crisis. These events had a direct bearing on India too (1).

Social Media Universe (in order of popularity in India)

The major purpose of the social media is to enhance the interaction between all stakeholders related to climate services including scientists, policy planners, program managers and general public. In this regard, the utility of popular social media platforms is described below (list is not exhaustive).

1) *Youtube:* Capacity building, awareness and communication both in preparedness and response
2) *Facebook:* Survival status, location sharing, real-time personal and news information exchange
3) *Whatsapp:* Crisis communication, broadcasting, location sharing, free audio/*video calling*
4) *Instagram:* Video and picture sharing
5) *Twitter:* Advocacy, influencing the @influencer (# communication), dissemination platform
6) *LinkedIn:* Professional communication, knowledge clearinghouse, emergency recruitment

Whatsapp and the Ahmedabad Heat Action Plan

The Ahmedabad Heat Action Plan is one of the first heat action plans in a developing country context. The plan has an integral early warning system built into it. The plan also involves continuous engagement with various stakeholders including the municipal officials, meteorology department, health department and the community amongst others. The Ahmedabad Municipality has now started using Whatsapp as a communication tool along with traditional methods such as text messaging (2).

Facebook and the Kerala Floods

Facebook as a social media platform assumes importance at the time of a disaster for the reasons mentioned above. During the Kerala floods, Facebook had activated Facebook Safety Check for the whole State. As the number of casualties rose, this was a vital means by which family/friends and the larger community could inquire about whereabouts and well-being. This is a tool that Facebook has built so that users can contact their family or friends in any disaster affected region to inquire about their whereabouts and well being. This feature also allows users in the affected areas for volunteering such as food, water, clothing and work using this platform. This feature is manually enabled by Facebook since it keeps a track of practically all situations around the world. This feature has been enabled earlier in India too such as the dust storms in 2018 (3).

Case Studies

Conclusion

Communicating climate services for various sectors such as health is critical since the best technology such as early warning will not be useful if this aspect is not assured. Considered the ubiquitous nature of the social media universe, the most significant elements should be exploited to the maximum extent possible.

References (relevant links)

1) http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN022464.pdf
2) https://www.nrdc.org/sites/default/files/ahmedabad-heat-action-plan-2016.pdf
3) https://www.bgr.in/news/facebook-activates-safety-check-for-people-affected-by-kerala-flash-floods/

INDIAN METEOROLOGICAL SOCIETY

Room No. 605, VI Floor, Satellite Meteorological Building,

Mausam Bhavan Complex, Lodi Road, New Delhi-110003.

Tel: 91-11-24653728, Email: imetsociety@gmail.com