INTEGRATING MULTI-HAZARD EARLY WARNING SYSTEMS AND IMPACT ASSESSMENT TOOLS

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New Delhi
Inputs of climate information services to various stages of the climate resilient framework

Characteristic Lifetime of Event:
- 1 century
- 1 decade
- 1 year
- 1 month
- 1 day
- 1 hour
- 1 minute

Characteristic Size of Event (kilometers):
- 10 m
- 100 m
- 1 km
- 10 km
- 100 km
- 1,000 km
- 10,000 km
- 100,000 km

An operational framework for managing climate and disaster risk

PILLAR 2: Risk Reduction
Avoided creation of new risks and reduced risks in society through greater disaster and climate risk consideration in policy and investment

PILLAR 3: Preparedness
Improved capacity to manage crises through developing forecasting, early warning and contingency plans.

PILLAR 4: Financial Protection
Increased financial resilience of governments, private sector and households through financial protection strategies

PILLAR 5: Resilient Reconstruction
Quicker, more resilient recovery through support for reconstruction planning

PILLAR 1: Risk identification
Improved identification and understanding of disaster and climate risks through building capacity for assessments and analysis
Disaster risk is determined by the occurrence of a natural hazard (e.g., a cyclone), which may impact exposed populations and assets (e.g., houses located in the cyclone path). Vulnerability is the characteristic of the population or asset making it particularly susceptible to damaging effects (e.g., fragility of housing construction). Poorly planned development, poverty, environmental degradation and climate change are all drivers that can increase the magnitude of this interaction, leading to larger disasters.

Total loss and damage from hydro-meteorological disasters, by affected sector (1972-2013)

- **Economic Losses**
  - Total: 71%
  - 17% Social sectors
  - 5% Infrastructure sectors
  - 5% Productive sectors
  - 7% Cross-cutting sectors

- **Physical Damages**
  - Total: 32%
  - 32% Social sectors
  - 31% Infrastructure sectors
  - 5% Productive sectors
  - 5% Cross-cutting sectors
Major science themes/applications/services of the organisation

- Prediction of land, atmospheric and Oceanic states at different scales to provide weather and climate services in different spatial and temporal range
  - Nowcasting (up to 6 hours)
  - Short range (1-2 days)
  - Medium range (few days – week)
  - Extended Range (2 weeks)
  - Seasonal (Few months, e.g. Jun-Sep Monsoon)
  - Climate Scales

**Spatial range:** Location, Block, District, Meteorological Sub-division, River catchment, State and Homogeneous regions
Weather Forecast and Warning

- All India weather Inference - Updated 4 times a Day
- All India Weather Forecast - Updated 4 times a Day
- All India Weather Warning - Updated 4 times a Day
- Nowcast warning –Updated every 3 Hours
- FOG Forecast – Location specific during winters
- Regional Weather Forecast
- Regional Weather Warning
- Bay Bulletin: Sea Area Bulletin, Coastal Area Bulletin
- Pre Cyclone Watch, Cyclone Alert, Cyclone Warning
- Post Landfall outlook
- Port Warning

### 6 Days Rainfall Forecast:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>MET-SUBDIVISION</th>
<th>28 Aug</th>
<th>29 Aug</th>
<th>30 Aug</th>
<th>31 Aug</th>
<th>01 Sept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jammu &amp; Kashmir</td>
<td>ISOL</td>
<td>ISOL</td>
<td>ISOL</td>
<td>ISOL</td>
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<tr>
<td>2</td>
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<td>ISOL</td>
<td>SCT</td>
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<td>5</td>
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<td>FWS</td>
<td>FWS</td>
<td>ISOL</td>
<td>SCT</td>
<td>ISOL</td>
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<tr>
<td>6</td>
<td>West Uttar Pradesh</td>
<td>FWS</td>
<td>FWS</td>
<td>SCT</td>
<td>FWS</td>
<td>FWS</td>
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<tr>
<td>7</td>
<td>East Uttar Pradesh</td>
<td>FWS</td>
<td>FWS</td>
<td>FWS</td>
<td>FWS</td>
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<td>8</td>
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<td>ISOL</td>
<td>DRY</td>
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<td>DRY</td>
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<tr>
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<td>East Rajasthan</td>
<td>FWS</td>
<td>FWS</td>
<td>SCT</td>
<td>SCT</td>
<td>SCT</td>
</tr>
</tbody>
</table>

### Outlook for subsequent 2 days:
(from 0830 hrs IST of 2nd Sept 2018 to 0830 hrs IST of 04th Sept, 2018):

- Fairly widespread rainfall activity likely over Uttar Pradesh.
- Isolated to scattered rainfall activity in the rest of the region.

### Spatial Distribution (% of stations reporting)

<table>
<thead>
<tr>
<th>% Stations</th>
<th>Category</th>
<th>Term</th>
<th>Probability of Occurrence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>76-100</td>
<td>Widespread (W/S Most Places)</td>
<td>Unlikely</td>
<td>&lt;25</td>
</tr>
<tr>
<td>51-75</td>
<td>Fairly Widespread (W/S Many Places)</td>
<td>Likely</td>
<td>25 - 50</td>
</tr>
<tr>
<td>26-50</td>
<td>Scattered (SCT A Few Places)</td>
<td>Very Likely</td>
<td>50 - 75</td>
</tr>
<tr>
<td>1-25</td>
<td>Isolated (ISOL)</td>
<td>Most Likely</td>
<td>&gt;75</td>
</tr>
</tbody>
</table>
Major services of IMD

Core Services
Accelerated efforts to improve services
Support Services

Aviation
General Public
Disaster Mgt Support
Climate
Shipping
Agriculture
Sustainable Urban Development
Tourism
Defence
Met. Support For Floods
Petroleum

Environment
Power grid Mgt.
Highways
Non-conventional Energy
All India Summer Monsoon Rainfall Departure (1901-2017)

All-India Summer Monsoon Rainfall, 1871-2017
(Based on IITM Homogeneous Indian Monthly Rainfall Data Set)
Monsoon Mission Model Performance (Prediction Skill as well as inter-annual variance) is better than other models for Indian Monsoon.

Performance of Monsoon Mission Dynamical Model for Seasonal Monsoon Prediction.

Courtesy: IITM Pune
South Asian Climate Outlook Forum (SASCOF): Beginning & Objectives

• In a meeting convened by WMO, the Directors General of the National Meteorological and Hydrological Services (NMHSs) in South Asia and Permanent Representatives (PRs) of the respective countries with WMO, at the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy, on 6 August 2009, the PRs of south Asian nations with the WMO had unanimously agreed to establish a South Asian Climate Outlook Forum (SASCOF), to be implemented from 2010 onwards. The main objectives of SASCOF are the following.

• To review the progress made in understanding and long range prediction of summer monsoon both regionally and globally;
• To make available detailed information on climate variability in South Asia for dissemination along with the seasonal outlook;
• To provide a platform for the stakeholders of SASCOF to share and exchange experience and knowledge on summer monsoon and its prediction;
• To initiate capacity building/human resource development activities for the South Asian region, particularly in seasonal prediction;
• To build collaboration and partnerships among the members of SASCOF for mutual benefit;
• To identify needs of user sectors through a dialog among different groups.
SASCOF meetings so far

• This is one of the important LRF activities of the center. RCC, Pune has been providing technical support and taking lead role in the preparation and issuance of consensus forecast during all these forum meetings. SASCO is co-sponsored by WMO and coordinated by IMD, currently under the demonstration phase for a WMO RCC for South Asia and IITM at Pune.

• The first three (during 2010-2012) and fifth (during 2014) meetings of SASCOF were held in Pune, India.
• fourth session (in 2013) of the SASCOF was held at Kathmandu, Nepal
• sixth session (in 2015) was held at Dhaka, Bangladesh.
• Seventh session (2016), SASCOF for SW monsoon was held in Colombo, Sri Lanka
• 8th Session will be held in Thimpu, Bhutan (last week of April)
• After six sessions of SASCOF conducted each year during the period 2010-2015, first SASCOF that was focused on the NE monsoon season (October to December), was held in Chennai, India during 14-15 October 2015.
• Last year, looking into requirements of the member countries of the region, consensus forecasts were also prepared for the NDJ and DJF seasons through e-mail discussions. and
• SASCOF for NE monsoon during 2016 was held during Oct., 2016 in Nay Pyi Taw, Myanmar.
• SASCOF-10 for SW Monsoon during 2017 was held in Thimpu, Bhutan
• SASCOF-11 for NE monsoon during 2017 was held in Sept., 2017 in Male, Maldives
• SASCOF-12 for SW Monsoon during April 2018 was held in Pune, India
SASCOF-12 Forecast
Issued on 18th April 2018

Seasonal Rainfall Anomaly
1st June – 14th Sept. 2018
Extreme Weather associated with South Asian weather systems

ML: Monsoon low
MTC: Mid-tropospheric cyclone
C: Cyclone
TS: Thunderstorm
OV: Onset Vortex

Western Disturbance
Fog

Off-shore vortices
Easterly wave
Pre-monsoon (MAM) and Post monsoon Tropical Cyclone (OND);
1951-2014

Mar-May

Oct-Dec
Numerical Weather Prediction (NWP) Modeling: Backbone for Forecasting and Warning Services

Models in 2018

- Ensemble Prediction Systems
  - GEFS (12km), UMEPS (9Km)

- Global Models
  - GFS (T1534), Unified Model

- Regional Models
  - WRF, HWRF

- Nowcasting Tools
  - WDSSII, ARPS Model

Warnings Activities

- Multi-model ensemble (Extended Range), Single Model Ensemble, Grand Global Ensemble
- Global models
- Regional models
- Nowcasting

By 2019: 1-3 km Regional multi-model prediction system, ocean-atmosphere-land surface coupled severe weather pred. systems, Parametric models and Expert systems – severe weather Warning up to 5-7 days, Forecast outlook up to 10-15 days.
WRF (3 km) Forecast & IMD observed Rainfall Analysis at 03 UTC 15-08-2018

IMD MESOSCALE MODEL (03 Km) 24 HOURLY RAINFALL (mm) FORECAST (48 hr)
based on 00 UTC of 13-08-2018 valid for 03 UTC of 15-08-2018

IMD MESOSCALE MODEL (03 Km) 24 HOURLY RAINFALL (mm) FORECAST (72 hr)
based on 00 UTC of 12-08-2018 valid for 03 UTC of 15-08-2018

OBSERVED (0.25x0.25 Deg.) RAINFALL ANALYSIS (mm)
on 03 UTC of 15-08-2018

(Background does not depict political boundary)
OPERATIONAL ERF IMPLEMENTED IN IMD

- **Extended Range Forecast** – Coupled Atmospheric-Ocean General Circulation Models (CFSv2) at different resolutions CFSv2_T382, CFSv2_T126, GFSbc_T382, GFSbc_T126 (with 16 members) implemented in IMD in December 2016.

- The hindcast (2003-2017) and forecast is run once in a week (every Wednesday initial condition) for 32 days period and the forecast for mean and anomaly is prepared for 4 weeks on every Thursday. (TMAX, TMIN, RAIN, WIND, MJO, etc)

The operational products are prepared for use in India and abroad.

- The customised products in the form of met subdivision level forecast for two weeks are used for Agro advisory purpose.

- The products are also prepared for QATAR and adjoining country Bhutan
Extended Range forecast products available in IMD

Rainfall Anomaly (mm/day)
(Week1: 07Sep–13Sep)  
(Week2: 14Sep–20Sep)  
(Week3: 21Sep–27Sep)  
(Week4: 28Sep–04Oct)
Forecast products for QATAR

MME weekly rainfall anomaly (mm)

Week 1: 07Sep–13Sep

Week 2: 14Sep–20Sep

Week 3: 21Sep–27Sep

Week 4: 28Sep–04Oct

INDIA METEOROLOGICAL DEPARTMENT
Forecast products for Bhutan

MME weekly rainfall anomaly (mm)

(Week 1: 13 Apr – 19 Apr)

(Week 2: 20 Apr – 26 Apr)

(Week 3: 27 Apr – 03 May)

(Week 4: 04 May – 10 May)
Operational Nowcasting

- 378 stations covered so far in by March 2018
- Nowcasting for district level since 2017
- Nowcast Page is updated by Meteorological Centres
- Nowcast bulletins by SMS issued for severe weather for district level and transmitted through SMS and e-mail
- Target: location specific nowcast for 660 stations by 2019
- Based on Nowcast Guidance Bulletin, MC/RMC will issue round the clock Nowcast Bulletin.
- Pan India nowcast being issued for severe weather like heavy rain/snow, thunderstorm etc.
Deep Depression (07 September)

Warning issued on 03-09-2018

Warning issued on 04-09-2018

Warning issued on 05-09-2018

Warning issued on 06-09-2018

Warning issued on 07-09-2018
Severe Weather Forecast & Warnings skills

Noticeable improvements achieved in Skills of Heavy Rainfall Forecast (False Alarm Rate reduced from 46% to 11% & Probability of Detection increased from 49% to 67% from 2002-12 to 2013-15)

Lead time of warnings increased from 3 to 5 days in respect of Rainfall, heat wave, cold wave.

Introduced new Forecast bulletin Terminology

Target for 2019: Improvement of accuracy and skill by 20% up to 7 days
IMD has launched a website exclusively for RSMC, New Delhi. The data, forecast and products will be available to all the countries of the region through this website.
Cyclone Forecast: Achievements

- Genesis forecast with lead period for systems developing near coast
- Intensity forecast, specially rapid intensification and weakening
- Heavy rainfall warning - Location specific and river catchment wise

Target for 2024: Reduction in error and Improvement of skill by 20% up to 7 days

Target for 2024: Dynamical Impact based Forecast and Warning
Major Milestones accomplished (1): Cyclone Hazard Analysis

Cyclone hazard prone districts of India based on

1. Frequency of total cyclones,
2. Total severe cyclones,
3. Actual/estimated maximum wind strength,
4. PMSS
5. PMP
TYPES OF POTENTIAL DAMAGES ACCOMPANYING **TROPICAL CYCLONES**

- **CYCLONE**
  - LOCAL TIDES
    - STORM SURGE
      - LOCAL COASTAL CONFIGURATION
        - WIND
          - RAIN
            - Flooding of coastal areas
            - Erosion of beaches
            - Loss of soil fertility from saline intrusions
            - Damage to structures
            - Loss of power/communication
            - Injuries & loss of life
            - Destruction of crops, vegetation, live-stock
            - Contamination of water supply system
            - Land subsidence
            - Flooding of inland area
SWFDP – Bay of Bengal

Focus: Coastal communities and activities

- Bangladesh
- India
- Maldives
- Myanmar
- Sri Lanka
- Thailand
- Bhutan (later)
- Nepal (later)
- Afghanistan (later)
- Pakistan (later)

Severe Weather from TCs, severe thunderstorms and monsoon:
Heavy precipitation, Strong winds
Large waves / swell, Storm Surge

Improved severe weather forecasting, warning services to disaster management (PWS) and other sectoral applications
Severe Weather Forecast Demonstration Project

- Three tier cascading system (global, regional and national partners)
- Project will commence in pilot mode in 2 May 2016 for cyclone, heavy rain, wind and wave with RSMC, New Delhi as Regional Centre
- Global model products from NCEP, ECMWF, UKMO, JMA will be available for this domain
Sea Level Monitoring Stations

HF Radar-based Monitoring of Surface Current and Wave
Based on Forecast Issued by ESSO-IMD at 1300 IST of 12-10-2013

EXPECTED TIDE AT PARADEEP  -0.3M DURING LANDFALL

EXPECTED WIND SPEED  210 - 220 KMPH
MAX EXPECTED SURGE  2.6 M AT GANJAM, ORISSA
MAX EXPECTED INUNDATION EXTENT  3 KM THROUGH RIVER NEAR GANJAM, ORISSA
Multi-Hazard Vulnerability
Case Study

Composite Multi-hazard line and future shoreline overlaid on DEM

Building polygons are in hazard area (pink) and non-hazard area (green) are overlaid.
3D GIS

Main window shows 3D model of the Earth surface. The cities having 3D building models are marked by colored flags.
Allows to select any area of the Earth surface and zoom in on this area up to the highest resolution 60 cm (if a certain satellite imagery of the highest resolution is available)
Manipulation with realistic 3D models and textures of real buildings.
Inclusion of real object images (peoples, items, signs) in a 3D model.
The building brief (address, telephone, owner) appears in the pop-up information box.
The example of design a photographically exact 3D model. These real buildings are the buildings for public worship in Nagapattinam (India).

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT
Heat action plan

- Heat action plan is extended to seven cities across Central India.
- Letter written by HMoES to all chief Secretaries for preparing Heat Action Plan
- Daily Bulletin on Heat Wave issued during April to June
- Indian Medical association and power sector among other were provided forecast

<table>
<thead>
<tr>
<th>Temperature Forecast: Specific Range, Time duration and area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now casting: (Lead time/validity of 3 to 6 hours)</td>
</tr>
<tr>
<td>Short range: (Lead time/validity of 1 to 3 days)</td>
</tr>
<tr>
<td>Medium range: (Lead time/validity of 4 to 10 days)</td>
</tr>
<tr>
<td>Long/Extended range: (Lead beyond 10 days)</td>
</tr>
<tr>
<td>Local range: (Its intensity, frequency and time of occurrence is indicated)</td>
</tr>
</tbody>
</table>

3.3 Identification of Color Signals for Heat Alert:

<table>
<thead>
<tr>
<th>Alert Type</th>
<th>Day Description</th>
<th>Temperature Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Alert</td>
<td>Extreme Heat Alert for the Day</td>
<td>Normal Maximum Temp increase 6°C to more</td>
</tr>
<tr>
<td>Orange Alert</td>
<td>Heat Alert Day</td>
<td>Normal Maximum Temp increase 4°C to 5°C</td>
</tr>
<tr>
<td>Yellow Alert</td>
<td>Hot Day</td>
<td>Nearby Normal Maximum Temp.</td>
</tr>
<tr>
<td>White (Normal)</td>
<td>Normal Day</td>
<td>Below Normal Maximum Temp.</td>
</tr>
</tbody>
</table>

3 Ahmadabad Heat Action Plan 2015
Heat Wave defined in India

Heat wave considered when actual Max. temp. is 40°C or more for plains and 30°C or more for Hilly regions

a) Based on Departure from Normal
Heat Wave: Departure 4.5°C to 6.4°C
Severe Heat Wave: Departure >6.4°C

b) Based on Actual Maximum Temperature
Heat Wave: Maximum Temperature ≥ 45°C
Severe Heat Wave: Maximum Temperature ≥ 47°C

c) Criteria for describing Heat Wave for coastal stations
When Max Temp departure from normal is 4.5°C or more, provided actual maximum temperature is 37°C or more.
Long-term climatological summer (March-June) mean Tmax

Climatological mean number of days of summer (March–June) high (Tmax>37°C) days

Jaswal et al. (2015), J. Earth Syst. Sci
Heat waves over India

Average Frequency of Heat Wave Days

Trends in severe heat waves over India
Main Period of Heat Waves: April - June

April

May

June

(d) Normal Maximum Temperature for June
Based on period (1971–2000)
## Impact Based Forecasts as Per Thresholds Provided By The Users

10 CITIES IN 2016

<table>
<thead>
<tr>
<th>DATE</th>
<th>FC</th>
<th>Forecast in colour code</th>
<th>May-16 ACT</th>
<th>ACTUAL in COLOUR CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>42</td>
<td></td>
<td>43.1</td>
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</tr>
<tr>
<td>02</td>
<td>41</td>
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<td>43.3</td>
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</tr>
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<td>07</td>
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<td>08</td>
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<td>40.6</td>
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<td>09</td>
<td>43</td>
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<td>42.4</td>
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<td>10</td>
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<tr>
<td>31</td>
<td>41</td>
<td></td>
<td>41.5</td>
<td></td>
</tr>
</tbody>
</table>

### Temperature Thresholds

- **≤ 41 deg. Selsius**
- **41.1 to 43 Celcius**
- **43.1 to 44.9 Celcius**
- **> or eq. 45 deg Celcius**
### Example: T.Max for Andhra
(Forecast for 11.3.2018 to 13.3.2018)  
Dated 10/03/2018

<table>
<thead>
<tr>
<th>Districts</th>
<th>Total Mandals</th>
<th>Observed AWS Data 10.03.2018</th>
<th>Forecast for Next 24hr (Valid from 08.30am 11.03.2018 to 08.30am of 12.03.2018)</th>
<th>Forecast for Next 48hr (Valid from 08.30am 12.03.2018 to 08.30am of 13.03.2018)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very Hot</td>
<td>Hot</td>
<td>Warm</td>
</tr>
<tr>
<td>Srikakulam</td>
<td>38</td>
<td>0</td>
<td>7</td>
<td>26</td>
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<tr>
<td>Vizianagaram</td>
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<td>0</td>
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<tr>
<td><strong>Total</strong></td>
<td>670</td>
<td>0</td>
<td>51</td>
<td>231</td>
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</table>

* Based on Observed AWS data
* Based on WRF Model Simulations and using Temperature and Humidity Combination
Heat-Health service of IMD has resulted in significant reduction in number of deaths due to heat.

(Source: NDMA)
“JSW- The Times of India 8th Earth Care Awards 2018” in the category of “Leadership in Urban Climate Action” was jointly awarded to IMD, IIPH, Gandhinagar and Ahmedabad Municipal Corporation for Ahmedabad Heat Action Plan.

The Awards was given away by the Hon’ble Union Minister of Science & Technology, Earth Sciences, Environment, Forest and Climate Change Dr. Harsh Vardhan Ji in New Delhi on 17 April 2018.
Weather based farm management advisory

- Crop & Variety Selection
- Sowing & Harvesting Dates
- Intercultural operations
- Irrigation Management
- Fertilizer Application
- Plant Protection from Pest/Disease
- Post harvest management
- Livestock Management (Shelter, Health, Nutrition)
Automation of Advisory System (Agromet-DSS)

Observed Weather Data

WRF Model Forecast 3 days lead time (3 x 3 km)

GFS Model Forecast 4-10 days lead time (12.5 x 12.5 km)

IMD Agromet Decision Support System

Short SMS based on 5 days forecast information

10 Day Agro-met bulletin

Agriculture Information:
- District wise Major Crop and Cultivar information
- Dynamic crop weather Calendar and contingency plans
- Crop health and Soil wetness
- Crowd sourcing through network
Weather Information
- Observation
- Forecast
- Verification

Crop Information
- Crops, cultivars, sowing data
- Stage and stage of crops
- Dynamic crop Weather calendar and Contingency Plan

Agromet Advisory
- Broad advisory from Agromet-DSS
- Advisory for Irrigated and Rainfed agriculture.
- Vetting of advisory by Expert Panel

Dissemination
- Multi-mode dissemination to stakeholders
District Level Model Forecast and Value Addition

Value Addition of ANANTPUR (Andhra Pradesh)

<table>
<thead>
<tr>
<th>Date</th>
<th>Rainfall (mm)</th>
<th>Temp Max(°C)</th>
<th>Temp Min(°C)</th>
</tr>
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<tbody>
<tr>
<td>2018-09-13</td>
<td>20</td>
<td>36.6</td>
<td>36.6</td>
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<td>2018-09-14</td>
<td>5</td>
<td>35.9</td>
<td>35.9</td>
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<td>2018-09-15</td>
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<td>2018-09-16</td>
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<tr>
<td>2018-09-17</td>
<td>62</td>
<td>35.6</td>
<td>35.6</td>
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</tbody>
</table>
### Agromet DSS - Crop Weather Calendar

**View Crop Calendar**

Select State: Madhya Pradesh

Select District: Jabalpur

Crop Name: Paddy-Kranti

---

<table>
<thead>
<tr>
<th>Stage Name</th>
<th>Stage Start</th>
<th>Stage End</th>
<th>Ideal Conditions</th>
<th>Crop Activity</th>
</tr>
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<tbody>
<tr>
<td>NURSERY</td>
<td>20-Jun</td>
<td>4-Jul</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Max</th>
<th>Min</th>
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<tr>
<td>Rainfall</td>
<td>77</td>
<td>70</td>
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<tr>
<td>Temperature Max</td>
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<td>Temperature Min</td>
<td>41</td>
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<tr>
<td>Relative Humidity</td>
<td>30</td>
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</tr>
</tbody>
</table>
AGROMET-DSS MENU

Overview: Display of observed weather parameters on India map for 1-10 days

Outlook: District and Block level forecast and value addition

Crop Panel: Crop List, growth stages, crop calendar, rainfed and irrigated crop information

Crop Advisory Panel: Crop custom advisory

Data Panel: Information of receiver groups (e-mail group)

Analysis: Forecast analysis in graphical form & skill score

Logout
Dynamic Crop Calendar & District level contingency action for rain-fed agriculture (CRIDA)

- Advisories are prepared separately for rainfed and irrigated areas/crops in a district.
- Timing of Onset rain based sowing date for rainfed crops for each of the 660 districts in India.
- Crop calendar (CRIDA) dynamically linked with progress on sowing time to define crop cycle.
- Weather forecasts for 10 days- rain spell (3-day quantitative and 4-10 days outlook) – Updated and Verified on-line on Daily basis at MC level
- Contingency Actions in Advisories- Based on the rainfall scenario - need for supplementary or micro irrigation in dry land/ rainfed areas; re-sowing of short duration varieties etc.
- Early season/Mid-season/End season Deficiency of rainfall-linked with Contingency plans
Economic Impact Assessment Of AAS


- 95% of farmers experienced improved accuracy & reliability
- Incremental profit assessed to be 25% of net income.
- 24% farmers have access to AAS
- Annual Economic Profit on 4-principal crops (wheat, paddy, sugarcane and cotton), assessed as Rs. 38,463 crs in 2010 which raised to Rs. 42,000 crs in 2015.
- Service has the potential of generating net economic benefit up to Rs. 3.3 lakh crores on the 22-principal crops when AAS is utilized by all farming households in the country
District level Agro-meteorological Services during monsoon season

Preparation of value added medium range forecast at district level

From Composite State Level Bulletin, Agrimet Division, IMD preparing National AAS bulletin

Issuing District Level Bulletin

In all total 636 bulletins in 14 languages & uploading in the website of Agrimet Division (http://imdagrimet.gov.in)

Dissemination of Agromet Advisory through Multi-Channel

Kisan Sanchar
Reliance Foundation
Mahindra Samriddhi
Handygo

Organised different training programmes
Established feedback mechanism

Agromet Advisory

Value addition

Agromet Field Units (AMFUs)

Conducting Farmer Awareness Programme

Conducting State Level Meeting

NWP products

State Met Centre (SAMC) Issuing State Level Composite Bulletin

Tuesday

Friday

Parameters

Rainfall, Wind speed and direction, Maximum temperature, Relative humidity, Minimum temperature, Cloud cover

T1534

Conducting Farmer Awareness Programme

Also Brochures for Awareness were completed for 14 languages

Economic benefits from savings in farm inputs. Increased farm productivity

40.0 million farmers Receiving SMS

From Composite State Level Bulletin, Agrimet Division, IMD preparing National AAS bulletin

Also Brochures for Awareness were completed for 14 languages

Economic benefits from savings in farm inputs. Increased farm productivity

40.0 million farmers Receiving SMS
HYDROLOGICAL SERVICES

- **2016**: Preparation of Rainfall Statistics; daily, weekly & monthly. Commended by the President of India.
- Provides real-time rainfall information by means of GIS based rainfall products.

The district-wise and river basin-wise rainfall statistics is helpful to farmers for their agricultural activities and flood forecast/water management.

**2016**

- Quantitative precipitation forecast (QPF) to CWC for flood forecast purposes increased from 125 to 146 river sub-basins.
- QPF increased from 5 day to 7 days from flood season 2015.
- Sub catchment wise QPF from NWP models- GFS for 7 days in addition to WRF, MME for 3 days
- QPF for 4 new catchments Jhelum, Pennar, Torsa, Sankosh which involves 12 sub catchments.

**By 2019**: Develop a State-of-the-Art Hydrological Information System and Flood Warning Support for all the Major River Basins of the Country.

- Monitor the three dimensional variability of regional hydrological cycle and assess its expected changes and impacts in the future.
HYDROLOGICAL SERVICES

- Preparation of Rainfall Statistics; daily, weekly & monthly. Commended by the President of India.
- Provides real-time rainfall information by means of GIS based rainfall products.

District-wise and river basin-wise rainfall statistics is helpful to farmers for their agricultural activities and water management.
Analyzed Soil Hydrology Products
(Based on Variable Infiltration Capacity (VIC) Model: Joint Efforts of IIT Gandhinagar and IMD)

14-09-2018

![Maps showing precipitation, runoff, temperature, and soil moisture](image-url)
10-Day Simulated Soil Moisture (12km scale)
River Basin Scale Hydrological Response Assessment for Flood Warning
(Based on Soil and Water Assessment Tool (SWAT): Joint Efforts of IIT Delhi and IMD)

Flood Forecast for River Basins based on IMD Rainfall Forecast

- SWAT operates on a daily time step at basin scale and has been modified as per Indian Conditions.
- SWAT uses a two-level disaggregation scheme; a preliminary sub-basin identification is carried out based on topographic criteria, followed by further discretization using land use and soil type considerations.
- Areas with the same soil type and land use form a Hydrologic Response Unit (HRU), a basic computational unit assumed to be homogeneous in hydrologic response to land cover change.
SWAT Products – Mahanadi Basin

- SWAT hydrological model run parameters on Mahanadi basin calibrated using measured discharges.
- 3 days (observed, 2 days forecast using IMDGFS rainfall forecast)
South Asia – Regional Flash Flood Guidance System (SAsiaFFGS)

Under

Global Initiative Project for Flash Floods with MoU between various organisations like UN-WMO, HRC, USAID/ OFDA, NOAA and regional NMHS (IMD).

Implemented

By

भारत मौसम विज्ञान विभाग
India Meteorological Department
Introduction to SAsiaFFG Implementation Background

The South Asia Flash Flood Guidance System

- The primary mission of the South Asia (SAsiaFFG) System is to provide real-time informational guidance products pertaining to the imminence of potential small-scale flash flooding throughout the region of application.

- Ingests real-time satellite and gauge precipitation data on an hourly basis and, on the basis of available spatial databases, produces flash-flood-occurrence diagnostic indices over small basins in the region of interest.

- The diagnostic flash flood guidance index may then be used with nowcasts or forecast rainfall volumes of the appropriate durations to identify the likelihood of flash flooding at the outlet of specific small catchments.

- SAsiaFFG is not a predictive system in itself, rather it is a diagnostic system for flash floods that the forecaster can use with forecasts or nowcasts of precipitation to produce forecasts and ultimately warnings for flash floods.
Remotely-sensed precipitation estimates provide good spatial coverage and detail.
In situ observations (rain gauges) provide “ground truth” but often have sparse coverage.

Global Hydro-Estimator (GHE):
Rainfall rate based on Cloud Top Brightness Temperature (Infrared (IR) based).
This is an indirect measurement.
- ~ 4km resolution
- ** Short latency ** (< ½ hour)
FFGS Satellite Precipitation: MWGHE

HRC effort to combine IR-based GHE rainfall with MW-based CMORPH rainfall.

CMORPH Precipitation Estimates

CMORPH is based on microwave scattering from hydrometeors.

This is still an indirect measurement.

- ~ 8km resolution
- 18-26 hour latency in operations
Merged MAP is the best estimate of Mean Areal Precipitation over each small watershed. 1-, 3-, 6-, and 24-hour accumulations.
- Satellite
- Real-time gauges
* Includes bias adjustment
Potential for flash flooding is increased when \textit{PRECIPITATION} > \textit{FFG}.

\textit{Flash Flood Threat, FFT, defined:} \textit{FFT} = \textit{MAP} - \textit{FFG}

\textit{FFT provides indication of regions of potential concern. Color bar provides magnitude of FFT.}
Different FFT products are provided, based on observed or forecasted precipitation and timing.

- IFFT: imminent, based on observed precipitation that has fallen. *Flash flooding may be occurring!*

- PFFT: forecast of persistence – *IF* rainfall continues at current rate

- FFFT: based on forecast precipitation.
MAPSERVER visualises multiple outputs/forecasts of the micro level catchment areas at the same time which identifies flash flood prone zones.

Sacromental Soil Moisture Model (SSM)

Low FFG Values
High Risk of Flash Flood Potential

Verified by Mumbai Radar Data

28780 Micro watersheds

146 Sub Basins
The well marked low pressure area lay over southeast Arabian sea and adjoining east central Arabian Sea off north Kerala Karnataka coasts. Associated cyclonic circulation extends up to 7.6 km above mean sea level.
## Rainfall Observation on 30th May'18

### District: Dakshina Kannada

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### District: Udupi

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Mangaluru: Heavy downpour leaves city in a shambles

MANGALURU: Torrential rains that lashed that the city on Tuesday morning inundated most of the low lying areas in the city. The rains which started at 9am left the city in a shambles with the steady drizzle turning to a downpour by mid-afternoon. Many low lying areas in the city witnessed artificial flooding and water entered many compounds — making it difficult for residents to venture out or come in.

South west monsoon: Heavy rains lash Mangaluru, schools to be closed tomorrow

MANGALURU, MAY 29, 2018 14:34 IST

MANGALURU, MAY 29, 2018 16:32 IST

Mangalore Rain: The south-west monsoon had hit the Karnataka coast earlier than usual. Mangalore and areas around it have been receiving heavy rains since Monday night. Although there was a sigh of relief for the locals during the early hours of Tuesday, there has been unabated rainfall since 9:30 am, according to a report by The Hindu. Various low-lying areas including Kottara Chowki and Ballal Bagh experienced waterlogging on Day 1 of the season.

One Air India, one SpiceJet and one Air India Express was diverted from Karnataka's Mangalore airport due to rain and poor visibility. Air traffic control (ATC) says ‘it will improve soon’. Rescue operations are underway in Mangalore's Panambur as streets got water-logged following pre-monsoon rains.

The Mangaluru Central Railway Station and the adjacent Railway Mail Service office were completely inundated with rainwater and overflowing sewage.
Important Terminology
Weather Forecast andWarning
Meteogram
Radar Images
Satellite Image
RAPID
METAR
Experience so far

• Weather Portal For Power Sector
  http://amssdelhi.gov.in/NRLDC/index.html
Heat Wave: Heat wave is considered if maximum temperature of a station reaches at least 40°C or more for Plains, 37°C or more for coastal stations and at least 30°C or more for Hilly regions. Following criteria are used to declare heat wave:

**Based on Departure from Normal**
- Heat Wave: Departure from normal is 4.5°C to 6.4°C
- Severe Heat Wave: Departure from normal is >6.4°C

**Based on Actual Maximum Temperature (for plains only)**
- Heat Wave: When actual maximum temperature ≥ 45°C
- Severe Heat Wave: When actual maximum temperature ≥47°C

To declare heat wave, the above criteria should be met at least in 2 stations in a Meteorological sub-division for at least two consecutive days and it will be declared on the second day.
Meteogram

- Reference document discusses Meteogram
  - Meteogram is a plot of various Meteorological Variables
    - Rainfall, Cloud cover, Temperature, Humidity, Wind Speed, 
      Indices of Thunderstorm, Sea level pressure
    - Three hourly forecast for 10 days.
    - Updated twice daily
    - Available for 450 locations in India
Typical Meteogram Plot

- Relative Humidity
- Mean Sea Level Pressure
- Thunderstorm Indices
- Wind Speed & direction
- Temperature
- Relative Humidity at 2 Meter
- Clouds
- Rains
Radar Image Uses in System operation:
- Identifying distance and height of Clouds (Kms)
- Movement of clouds/Thunderstorm/Rains
- Location of Rainfall and its intensity in mm/h
  - (Assessment of the impact and advance control measures required to maintain the Grid Security)
- Total Rainfall in mm in the last 24 hours (mm)
  - Assessment of demand in next 24 hours
- Wind speed and direction at the Location of Radar (knots)
  - Load reduction due to factors, like, switching off of distribution lines to prevent collateral damage/distribution network outage

Reference document explains the details of various Radar Products:
- Plan Position Indicator (Max (Z)), Surface Rainfall intensity (mm/hr), Plan Position indicator
- (Mean velocity (m/s), Precipitation Accumulation (mm))
Satellite makes measurement indirectly by sensing electromagnetic radiations coming from the surface below. INSAT 3D is being used to monitor the Weather. Image is updated every 30 minutes.

The weather document explains different types of satellite Image with their colour coding for monitoring of Fog, Cloud Cover, sand, dust, snow, cyclone etc.
Fog will have a sharp/smooth boundary, while low clouds will have disbursed boundary. In animation, fog will remain stationary, while low clouds will show some movement.

Fog Coupled with Pollution leads to tripping of EHV lines.
RAPID—Real time Analysis of Products & Information Dissemination is a web based quick visualization and analysis tool for satellite data on a real time basis. Using RAPID one can interact like actual satellite workstation and may zoom to any actual resolution.
A METAR weather report is predominantly used by pilots in fulfilment of a part of a pre-flight weather briefing, and by meteorologists, who use aggregated METAR information to assist in weather forecasting. METAR is the scheduled observation taken at the end of each hour/half hour (important Airports).

A typical METAR contains data for the
- temperature,
- dew point,
- wind direction and speed,
- precipitation,
- cloud cover and heights,
- visibility and
- barometric pressure.

The visibility at an Airport can provide a good idea about status of FOG/SMOG.
• Meteogram, wind and rain forecast for 27/28/29-05-2017 helped in better load assessment of UP control area by U.P. State Load Despatch Centre.

• As anticipated, UP demand went down from 19000 MW to 17000 MW due to change in weather conditions.

• Accordingly, STOA & purchase from Power Exchange of the order of 2000 MW was reduced. i.e Backing down of approximately 13 MU of costly thermal generation.
Load Crash of around 450 MW

Timely MW Reduction by BSES

Benefit achieved by BSES
## Savings by BSES

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<td></td>
<td><strong>Total</strong></td>
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</table>
Thunderstorms:
- A likely phenomena during summers
- Leads to Load Crash
- Excursion in Voltage and Frequency

Rain/Thunderstorm Monitoring

Radar Image for Rain/Thunderstorm Monitoring

100 km Boundary

50 km Boundary
Radar Image for Rain/Thunderstorm Monitoring
Radar Image for Rain/Thunderstorm Monitoring
Near Real time Radar image helped in Timely Reduction of Generation in State Control area/ISGS Generation, RRAS (Reserves Regulation Ancillary Services) Regulation leading to better Load Generation balance in the Grid.
Activities Critical for Coastal Areas

- Observing Systems for Atmospheric and Oceanic Science & Services – multi-scale networks over **Land** (Doppler Weather Radars; Automatic Weather Stations/Rain Gauges; High Wind Speed Recorders etc.), **Sea** (moored and drifting buoys, Argo Floats, ADCP and Current Moorings etc.), in-situ airborne & ship borne platforms and **Satellite Based systems** (INSAT, Kalpana, OCEANSAT, Megha Tropique, NOAA, EUMETSAT etc.) for real time data transmission and reception
- 24X7 system of severe weather surveillance and forecasting (continuously scaling up) - **Cyclones; Tsunami and Storm Surges; all other severe weather systems**; River basin scale meteorological support for river flood warning system
- Continuously monitoring the pattern of sea level changes all along the Indian coastline with established 26 tide gauges.
- Vulnerability of the Coastal Zones – [3-Dimensional Geographical Information System (3D GIS) maps for the entire coastal stretch; mosaic with other available topographic and thematic high resolution maps at 1:100000; 1:25000; 1:5000 scale; shoreline change maps at 1:25000 scale] for effective emergency response, risk reduction, sustainable shoreline management and natural resource management
- Climate services information products viz. **spatial monthly scale anomalies of rainfall and temperature; minimum/maximum temperature; standardized Precipitation Index (SPI)** etc. along with severe weather events.
Future Plans for Coastal Areas

- Building multi-scale & multi-sensor networks for Long-term measurements of various environmental/terrestrial/marine/bio-geochemical/GHGs variables at large/regional/local/eco-system scales to capture vital signatures of the earth system response to climate variability and change

- Comprehensive multi-institutional Program for Changing Water Cycle; thermal expansion of Bay of Bengal and Arabian Sea; Sea Level Changes & coastal zone impacts; Engineering and Technical Solutions for Structural Safety of Coastal Investments

- Build Earth System Model (ESM) to treat comprehensively the coupling of various sub-systems (ocean-atmosphere; land-atmosphere; cryosphere-atmosphere; biogeo-chemical cycles over ocean and land; aerosols-GHGs-clouds-precipitation etc.) to improve our predictions of weather, climate, hazards, air quality and Environment

- Expanding services in support of four key climate-sensitive sectors, including agriculture, water, health, Energy and climate and disaster risk management for rendering customized services for societal, environmental or economic benefits

- Accelerating initiatives related to Capacity Building – for regular induction of skilled and specialized manpower
Activities to be augmented to the Multi-Hazard Early Warning Systems

❖ **Observational and Prediction Systems**
  - Hourly and 3-Hourly Telemetered Data (Land, Ocean and Space based observational systems)
  - Need for seamless data sharing/exchange of information amongst agencies
  - Build local scale severe weather forecast systems

❖ **Quantification of Impact**
  - Impact assessments to include likely spatial impacts on ground based on severe weather forecasts

❖ **Customization of Early warning system products**
  - Development of Decision Support Systems (DSS) for sectoral customization of Early warning system products
  - Need for developing decision making tools for effective response strategies at district and sub-district level
Local Scale Multi-Hazard Assessment Tools Development

- Adaptation of appropriate district scale models for storm surge/tsunami waves along coastal River/Delta systems [To generate storm surge/Tsunami inundation Maps]
- Development of appropriate regional scale models for Wind Damage Assessment, Heavy Precipitation and spatial inundation scenarios in coastal urban areas, Coastal SEZs/EPZs/Oil and Gas Installations and catchment scale coastal river hydrological models[To generate Wind Hazard Maps]
- Integrate the above information into a multi-hazard risk management and decision making tool for district level multi-hazard response planning
Quantified Information

- Population to be affected
- Densely populated villages
- Areas under threat
- Threat to Crops
- Damage to Structures
- Rail and Road network in the affected areas
- Vulnerable points
- Cyclone shelters
Thanks
Agencies dealing with various Hazards within the Ministry of Earth Sciences, Government of India

**HYDRO-METEOROLOGICAL HAZARDS – IMD, INCOIS**
Tropical Cyclones, Local Severe Storms, Winter Systems.
[Support for Floods, Drought Snow Avalanches]
Climate change impacts on severe weather events (IITM and IMD)

**GEOLOGICAL HAZARDS**
Earthquakes & Tsunamis (NCS and INCOIS)
[Support for Rain Induced Landslides/Mudslides (IMD; NCESS)]

**ENVIRONMENTAL IMPACTS**
- Air pollution & Haze, FOG, Smog (IMD)
- Coastal Zone Management (NCCR)
- Coastal Erosion (NCCR; NCESS)
- Eco-system monitoring/ modeling (IITM and IMD)