



Early Warnings Capabilities of INDIA & Status of Operational Flash Flood Forecasting

by

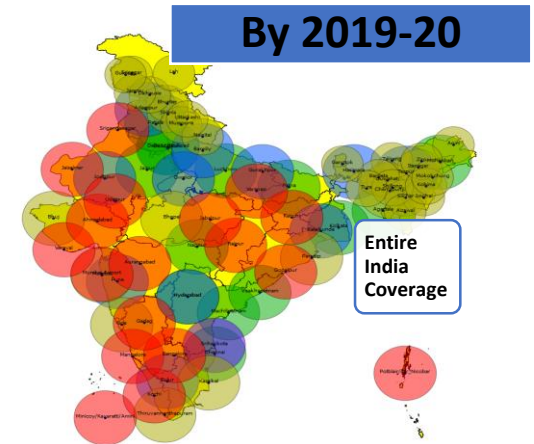
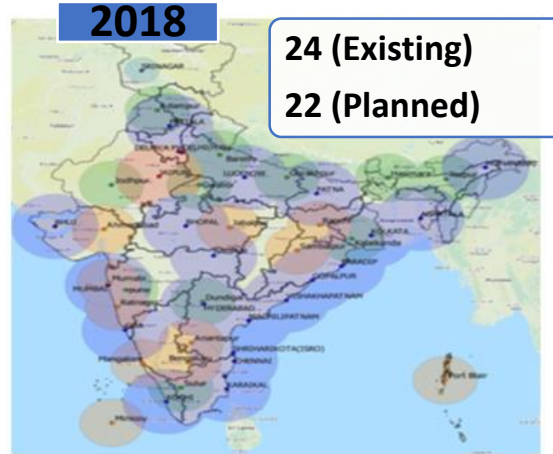
S K Asok Raja

Scientist

IMD



DWR Network Expansion



- ✓ Doppler Weather Radars (DWR) installed at Kochi and Gopalpur.
- ✓ 22 Radars are planned by IAF and IMD for the plain areas; Exclusive DWR networks are under implementation for Himalayas and under approval for NE States.
- ✓ MoU signed between IMD and DRDO for development of Laser based sensor for meteorological applications for measurement of clouds.
- ✓ RFP and site selection under finalization for commissioning of 11 C-Band DWRs.

Mumbai	Bengaluru	Mangalore	Lakshadweep	Andaman Islands (Port Blair)
Anantapur	Sambhalpur	Sri Ganganagar/ Jabalpur	Ranchi	Ratnagiri and Ahmedabad

- ✓ 10 X-Band DWRs. Most of DWR sites have been selected.

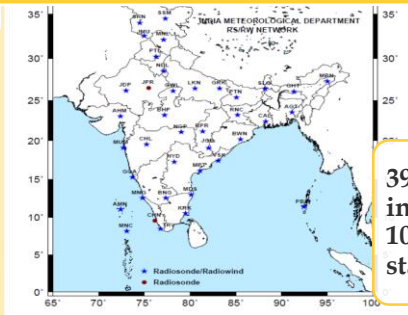


Shimla	Jammu	Missouri / Dehradun	Nainital	Uttarkashi
Bhuntar	Dalhousie	Leh	Gulmarg	Baltal



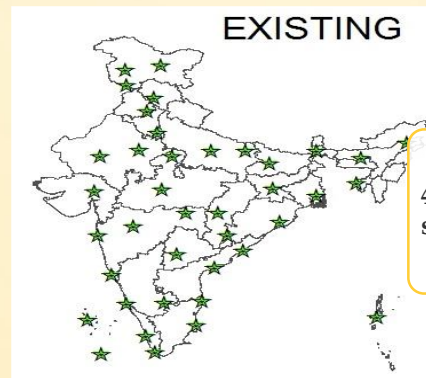
Upper Air & Surface Network Expansion

2012



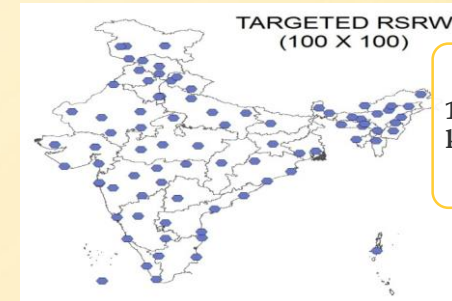
39 stations including 10 GPS stations

2016



43 GPS stations

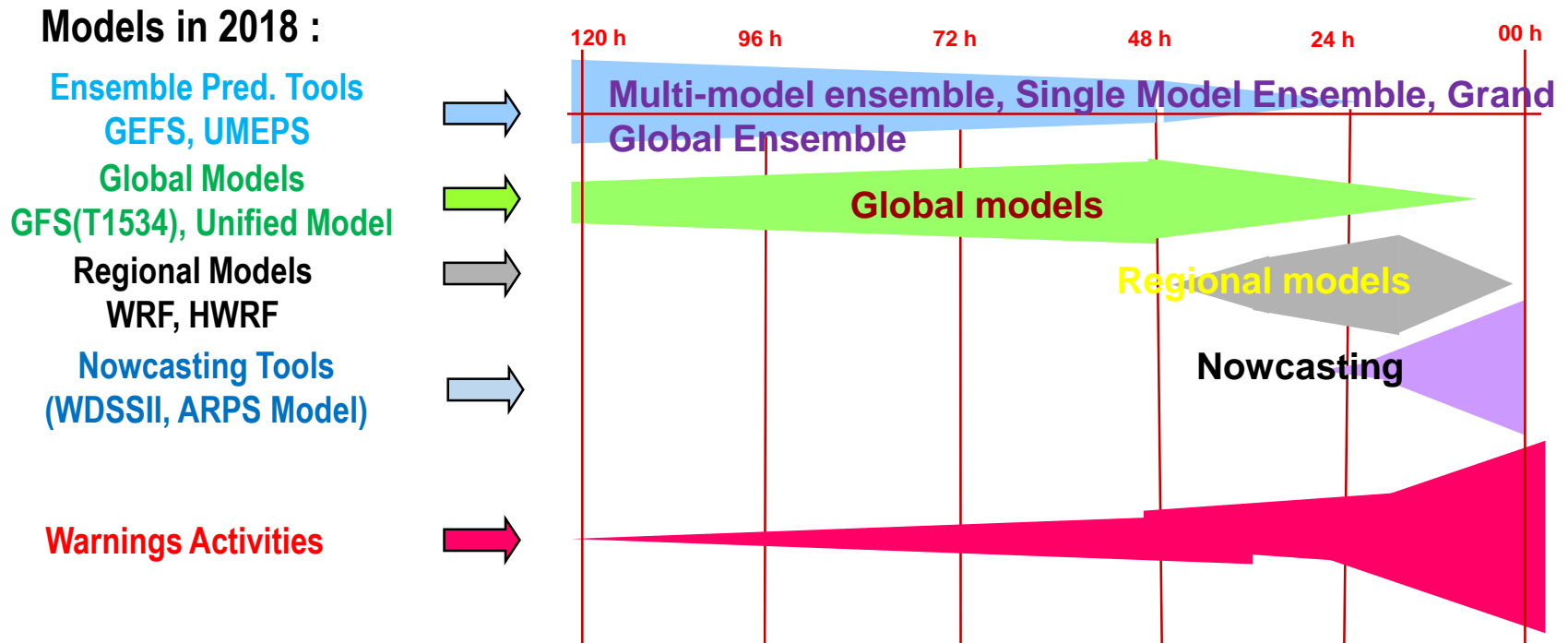
2019-20 (57 GPS)
2020-24 (~120 GPS)



100x100 km

- To improve the upper air observations, S.O. placed for procurement of 5000 radiosondes and 43 GPS radiosondes.
- For strong surface observations, 300 AWS data logger, 1000 ARG's, 200 Digital Station Barometers (DSB), 45 UV-B Radiometers, 10 Solar trackers, 20 Pyranometers to be commissioned shortly.
- Established the network of "Multi-wavelength Nephelometer (12 stations), Black Carbon Monitoring Network (16 stations) and Electronic Sunshine recorders installed at 12 World Radiation Data Centre (WRDC) network stations.

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



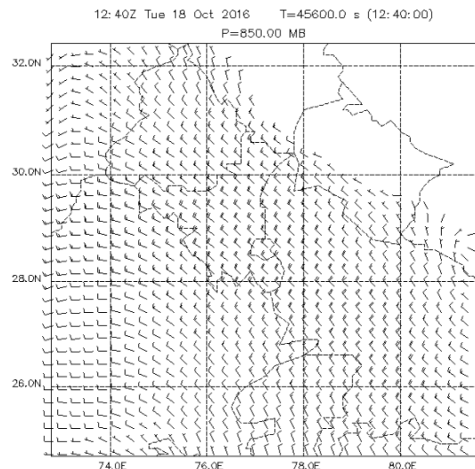
❖ By 2019 : 12 km Global Model Ensemble prediction system, 1-3 km Regional multi-model prediction system, ocean-atmosphere coupled severe weather pred. systems, Parametric models and Expert systems – severe weather Warning up to 5-7 days, Forecast outlook up to 10-15 days.

❖ Improvement in forecasting skills & warning by introduction of Probabilistic high resolution (12Km) Global Ensemble Weather Forecasting System (GEFS) .

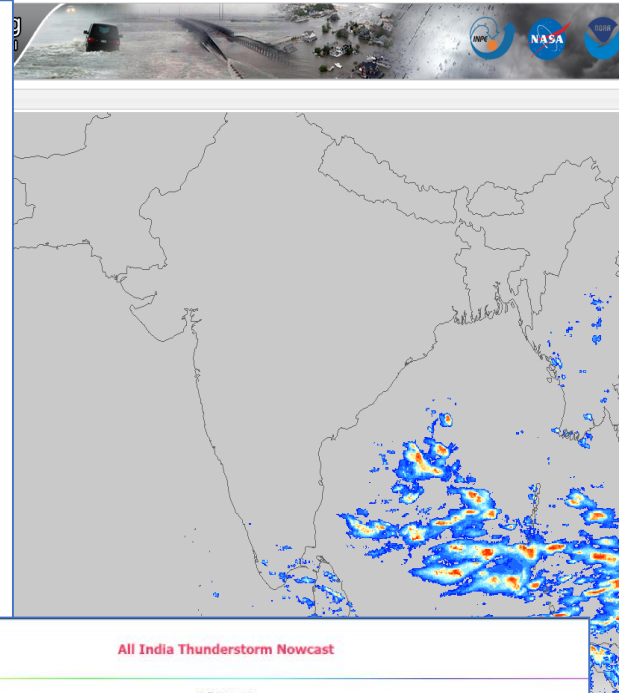
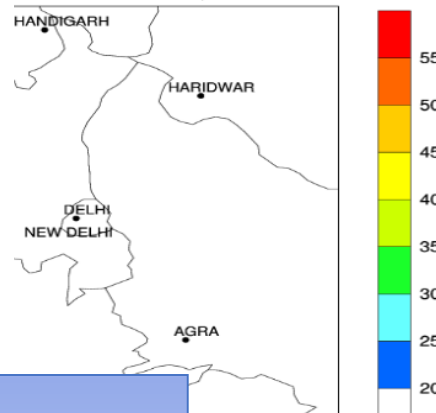
Guidance products and Nowcast Services

ADVANCED REGIONAL PREDICTION SYSTEM (ARPS) ACTIVITY FORECAST FOR DELHI AND NEIGHBOURHOOD

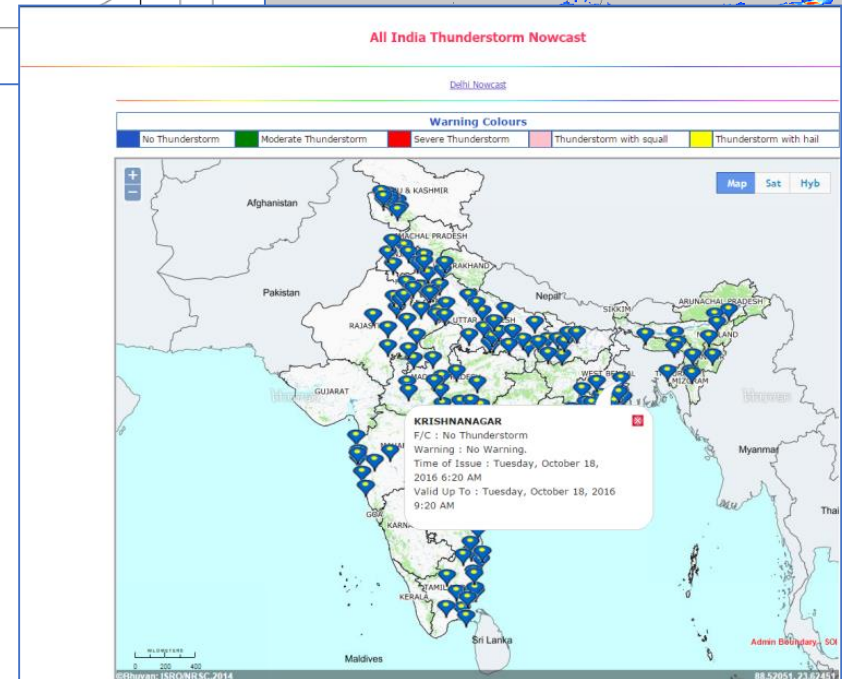
REFLECTIVITY & WIND (850 hPa)



Reflectivity Forecast for Delhi and Neighbourhood on 20161018 AT 1547 hrs IST
Adopted from NSSL,USA
based on DELHI Radar Data)



- Nowcast for about 300 cities.
- ARPS model-NW India
- Scope Nowcasting through SWFDP-BOB
- Nowcast Guidance Bulletin from 5 October 2016 once a day from monsoon season 2017 twice a day.
- Based on Nowcast Guidance Bulletin, MC/RMC are issuing around the clock
- Nowcast Bulletin at district level.
- Implementation of SWIRL software is in progress



Hydro-meteorological services

- 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.

2012

- Conventional Quantitative precipitation forecast (QPF) to CWC for flood forecast purposes for 125 river basins

2018

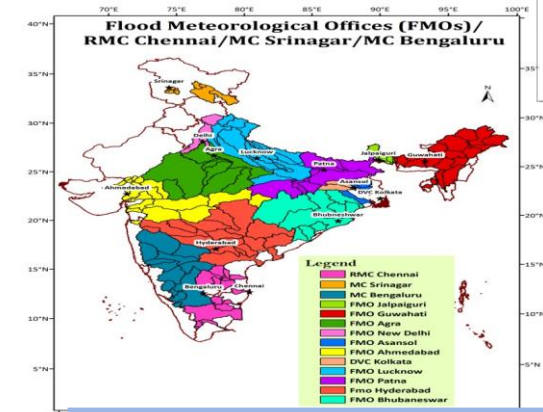
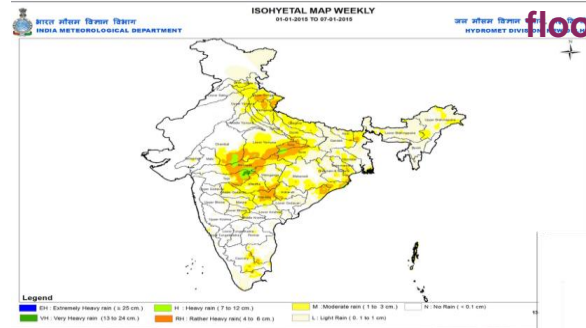
Quantitative precipitation forecast (QPF) to CWC for flood forecast purposes increased from 125 to 146 river sub-basins.

- MoU signed between IIT Delhi and IMD for sub-basin hydro-meteorological services using SWAT model for all 146 sub basins covering entire country.

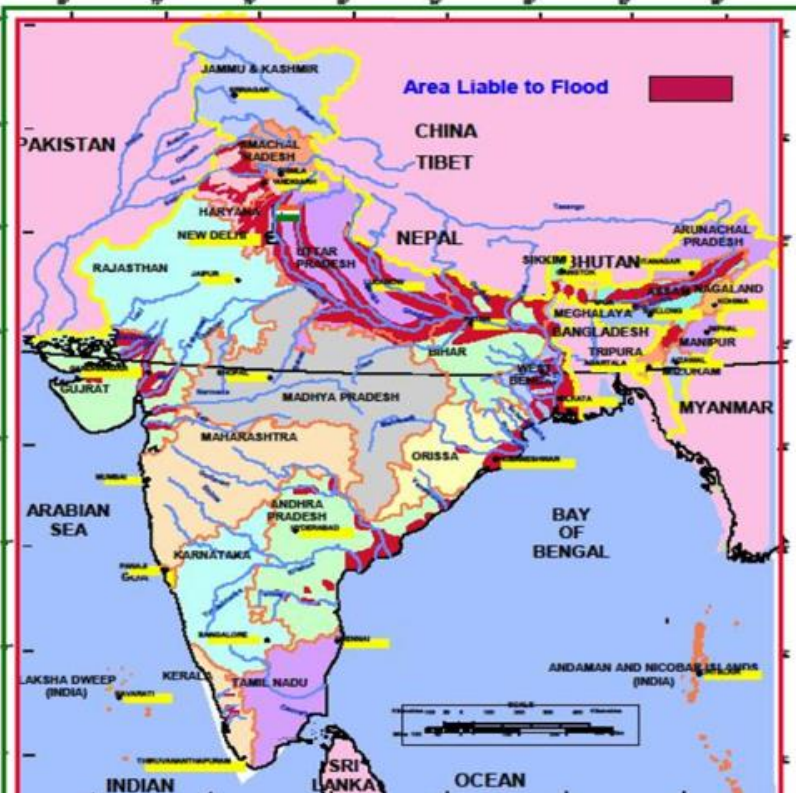
- SAsiaFFGS will be implemented shortly with the help of WMO providing Flash flood guidance at urban areas.

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.

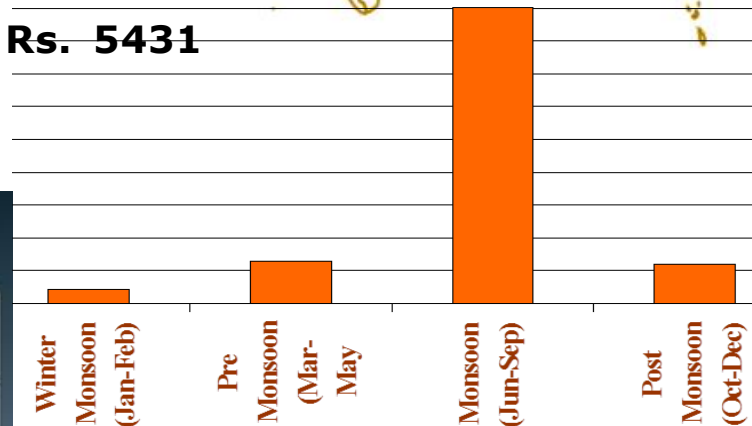


AREA LIABLE TO FLOODS



Average annual Flood Damage

- 7.19 mha area affected
- 31.88 m population affected
- 3.92 mha crop area affected
- Damage of Rs. 5431 cr approx.



Central Water Commission
Flood Forecast

HOME | SITE MAP | ABOUT US | CONTACT US

DATA FLOW/WP BASED | LIST BASED EXPLORATION | FLOOD CATEGORYWISE ABSTRACT | CURRENT STATUS OF FLOOD FORECAST | HYDROGRAPH VIEW

Legends for various Tabs in CWC Flood Forecast Information :

This is a website for Central Water Commission's Flood Monitoring and Forecast dissemination. This can be explored using map based exploration or list based exploration.

Map can be used as a tool to find information of 176 CWC Flood Forecasting Station. The Colour of any point signifies the basic Characteristics of the Station. Blue is for Inflow Forecast station basically a dam/reservoir/barrage/weir etc.

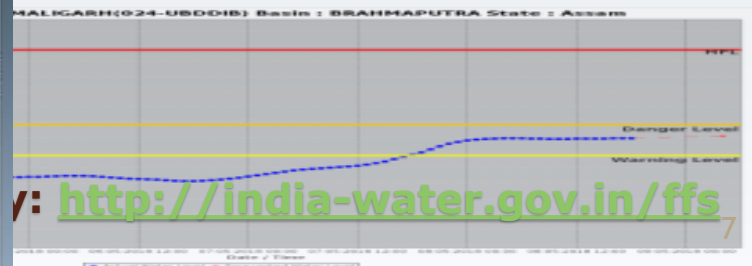
These colours will be dynamically changing for Flood Level Forecast Stations as per the river water level with respect to Warning Level (WL), Danger Level (DL), Highest Flood Level (HFL). Normally latest dynamic information is available during flood period 1st May/1st June to 31st October/31st December every year.

Blinking "Yellow" when the river level is flowing at a level which is equal to the warning level to a level which is below 0.5 m of HFL. (Low Flood when river level is between WL and DL, Moderate Flood (When river level is between DL and 0.5 m below HFL)

Blinking "Orange" when the river level is flowing within 0.5 m of HFL and below HFL (High Flood).

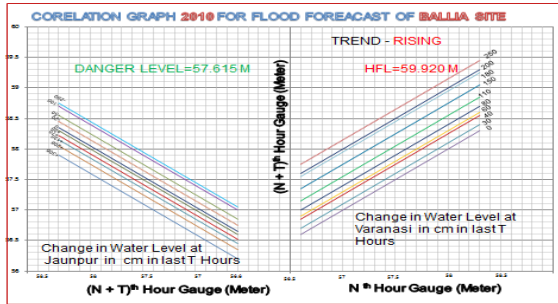
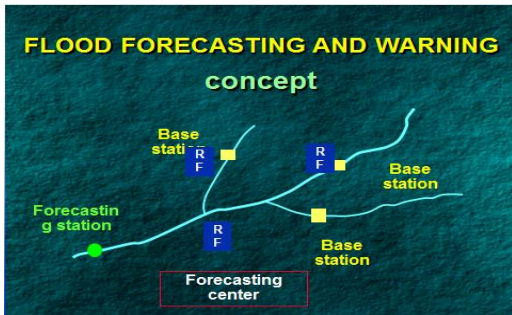
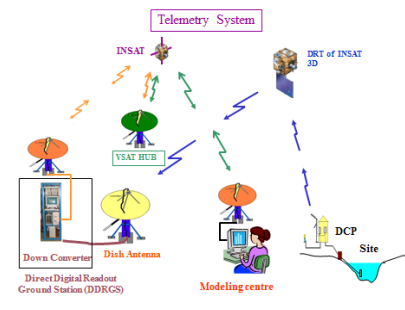
Special Message: No Special Report today.

Logged as Guest

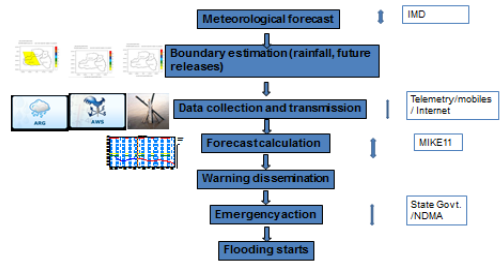


FLOOD FORECASTING

- **Data collection – Manually, Sensors**
- **Transmission (Site to Modelling Centre) – Wireless, Telephone, Mobiles, Telemetry**
- **Forecast formulation - Statistical Correlations using gauge to gauge, Gauge - discharge data - Multiple coaxial correlations using gauge, rainfall, API data**
- **Mathematical Models like MIKE, Rainfall Runoff module, Hydrodynamic module, Flood Forecast module**
- **Dissemination**



Rainfall-Runoff Modelling



Central Water Commission Flood Forecast

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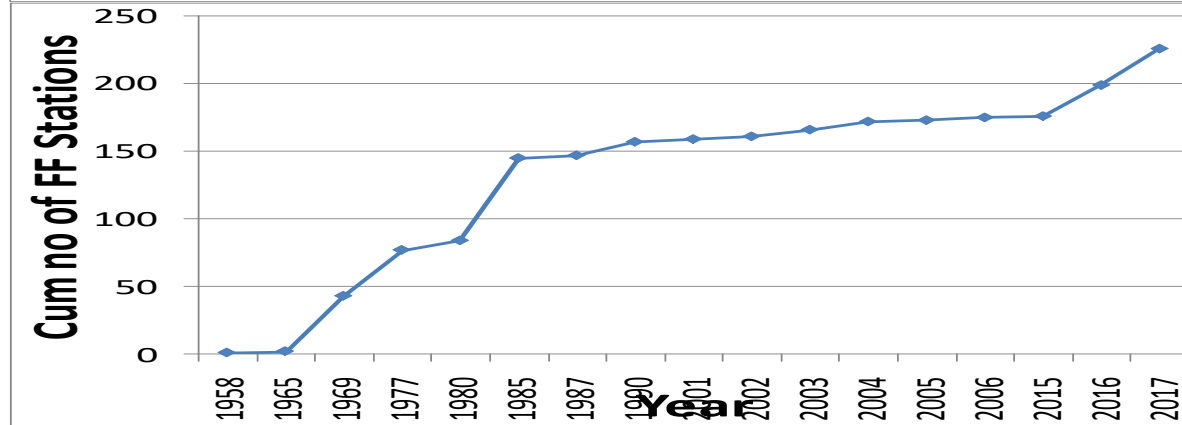
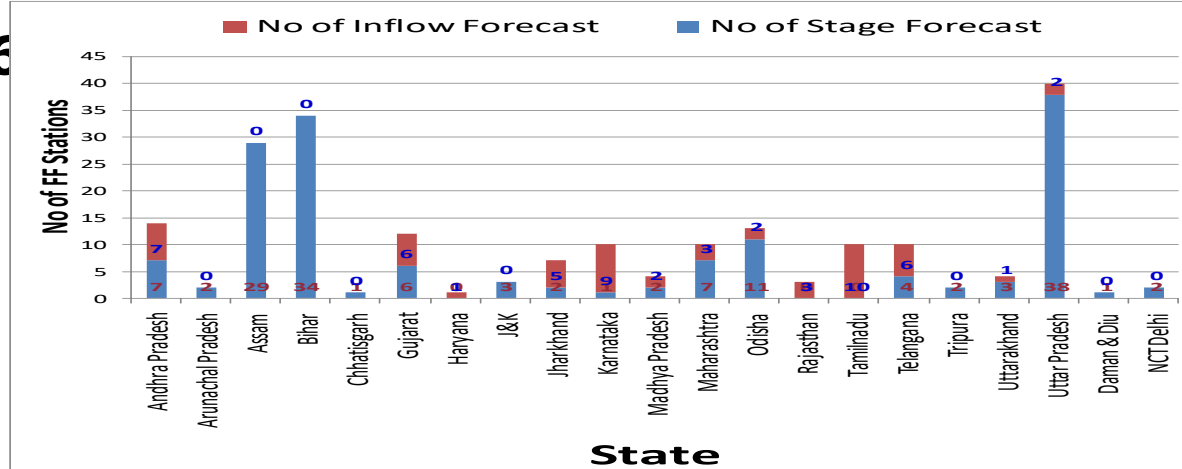
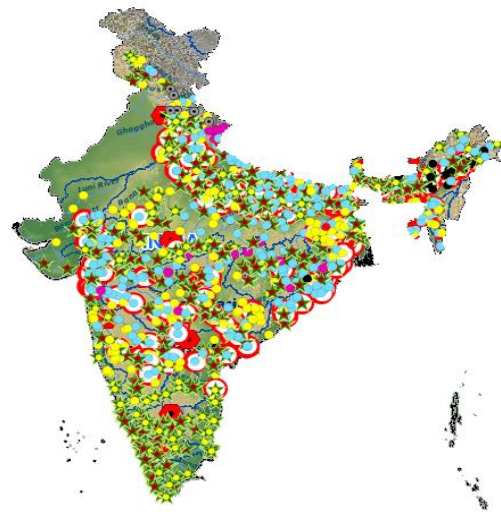
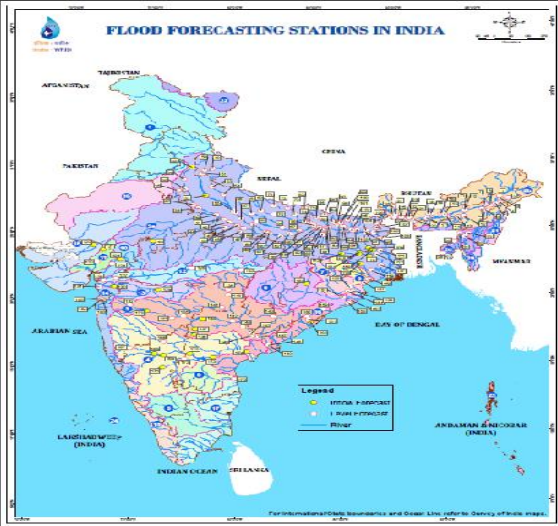


FF Network of CWC

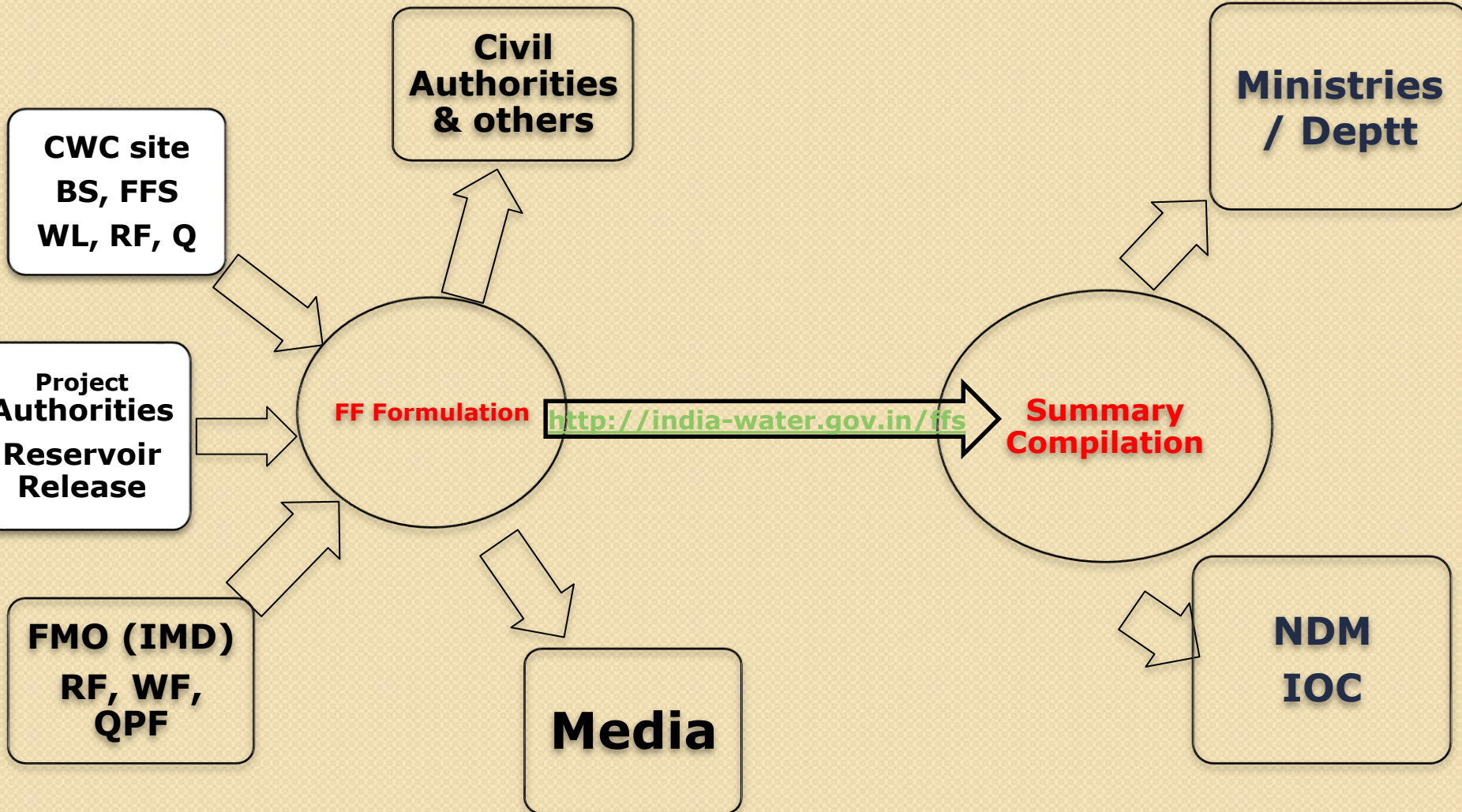
- 13 Regional Field Offices
- 19 Major River Basins
 - 22 States/UTs
- Present network - 226 FF stations (166 WL+60 Inflow)
- During 2018
 - another 49 FF stations
 - 24 State/UTs

○ 2020

Additional 50 FF stations covering 25 States/UTs



FLOOD FORECASTING Set up





Flood Period

#	Basin	Modified Period
1.	Brahmaputra Basin	1 st May to 31 st Oct
2.	All other Basins upto Krishna Basin	1 st June to 31 st Oct
3.	Basins South of Krishna Basin (Pennar, Cauvery and Southern Rivers)	1 st June to 31 st Dec

In case of floods beyond designated period due to unexpected rain/releases from dams or other reasons, FF activity shall be resumed by concerned organisation/division till water level falls below threshold limit & necessary bulletins shall be disseminated.

SOP – Floods Category & Alert Colour Codes

Category	Levels	Stage	Communication
I	Extreme $L \geq HFL$	Red	PMO/ Cabinet Sect. – 1 hr. or frequent
II	Severe $HFL > L \geq DL$	Orange	PMO/ Cabinet Sect. – 3 hr. or frequent
III	Above Normal $DL > L \geq WL$	Yellow	Not to PMO/ Cabinet Sect.
IV	Normal $L < WL$	Green/ Blue	

Forecast Frequency & Advance Warning Time



- **Major rivers (Travel time >24 hours) – 45% FF Stations**
 - Forecasts formulation based on 0800 hrs/ 0900 hrs WL
 - Forecast issued once in a day at 1000 hrs with advance warning time from 24 hrs to 36 hrs
- **Medium rivers (Travel time 12-24 hours)**
 - Forecasts formulation based on 0600 hrs & 1800 hrs WL
 - Forecast issued twice in a day at 0700 hrs and 1900 hrs with advance warning time from 12 hrs to 24 hrs
- **Flashy rivers (Travel time < 12 hours)**
 - Forecasts formulation based on any hr WL
 - Forecast issued multiple times (more than twice) in a day with advance warning time less than 12 hrs

Forecast Dissemination



- **Mode of communication**



– Like @cwccfcr



– Emergency Flood Messages



– Follow @FFM_CWC



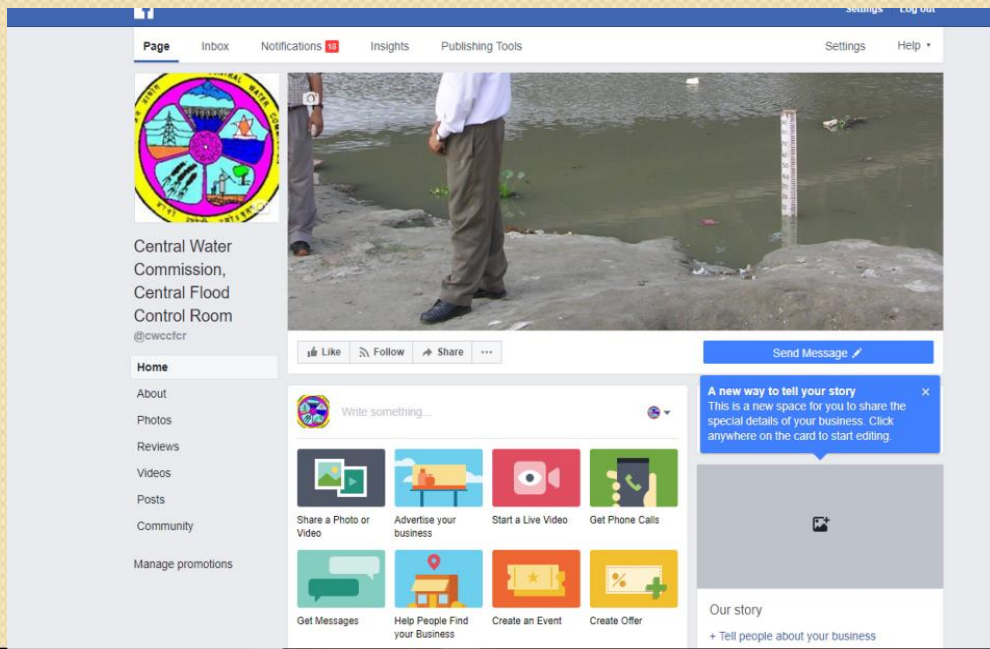
-Google Public Alerts
(www.cwc-captool.appspot.com)

- **Special Messenger, Telephone, Fax, Wireless**
- **Email, SMS**

◦ <http://india-water.gov.in/ffs>

- **Mailing List/Beneficiaries**

- **Civil/engineering authorities of**





Flood Forecast

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DATA FLOW MAP BASED



LIST BASED EXPLORATION



FLOOD CATEGORYWISE
ABSTRACT



CURRENT STATUS OF
FLOOD FORECAST



HYDROGRAPH VIEW



Special Message

No Special Message today

Logged as Guest

User

Pass

Submit

Legends for various Tabs in CWC Flood Forecast Information :

This is a website for Central Water Commission's Flood Monitoring and Forecast dissemination. This can be explored using map based exploration or list based exploration or Hydrograph View.

Map can be used as a tool to find information of 226 CWC Flood Forecasting Station consisting of 166 Level Forecasting Stations for towns/important villages and 60 Inflow Forecasting Stations for Dams/Reservoirs. List Based exploration or Hydrograph view should be used for information of all flood monitoring stations around 700 including Flood Forecasting Stations. The Colour of any point signifies the basic Characteristics of the Station. Green is for Flood Level Forecast Station basically important towns/villages and Blue is for Inflow Forecast station basically a dam/reservoir/barrage/weir etc.

These colours will be dynamically changing for Flood Level Forecast Stations as per the river water level with respect to Warning Level (WL), Danger Level (DL), Highest Flood Level (HFL). Normally latest dynamic information is available during flood period 1st May/1st June to 31st October/31st December every year.

“Yellow” when the river is flowing in Above Normal Flood: when river water level is at or above WL but below DL

“Orange” when the river is flowing in Severe Flood : when the river water level is at or above Danger Level and below HFL.

“Red” when the river is flowing in Extreme Flood : when the river water level is at or above HFL

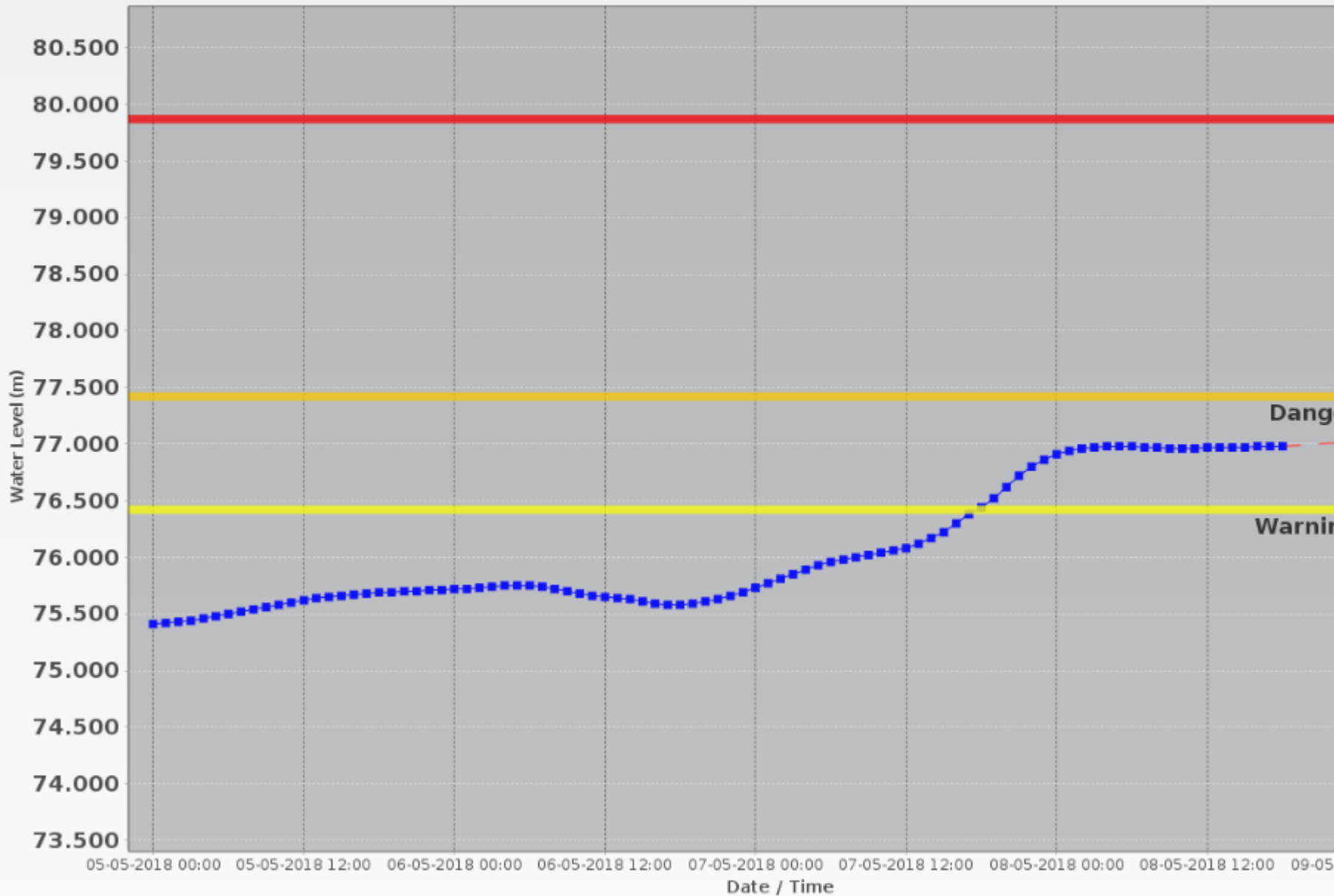
HFL is updated on an yearly basis before start of the flood season. Newly attained HFL during the flood season of a particular year in any station will be updated in the next year before start of the flood season.

On clicking a particular station, a window opens showing the static information of the station. The latest available dynamic information such as water level and flood forecast issued are also displayed in the window.

Division Name (For CWC users only)

Upper Brahmaputra Division (UBD), Dibrugarh

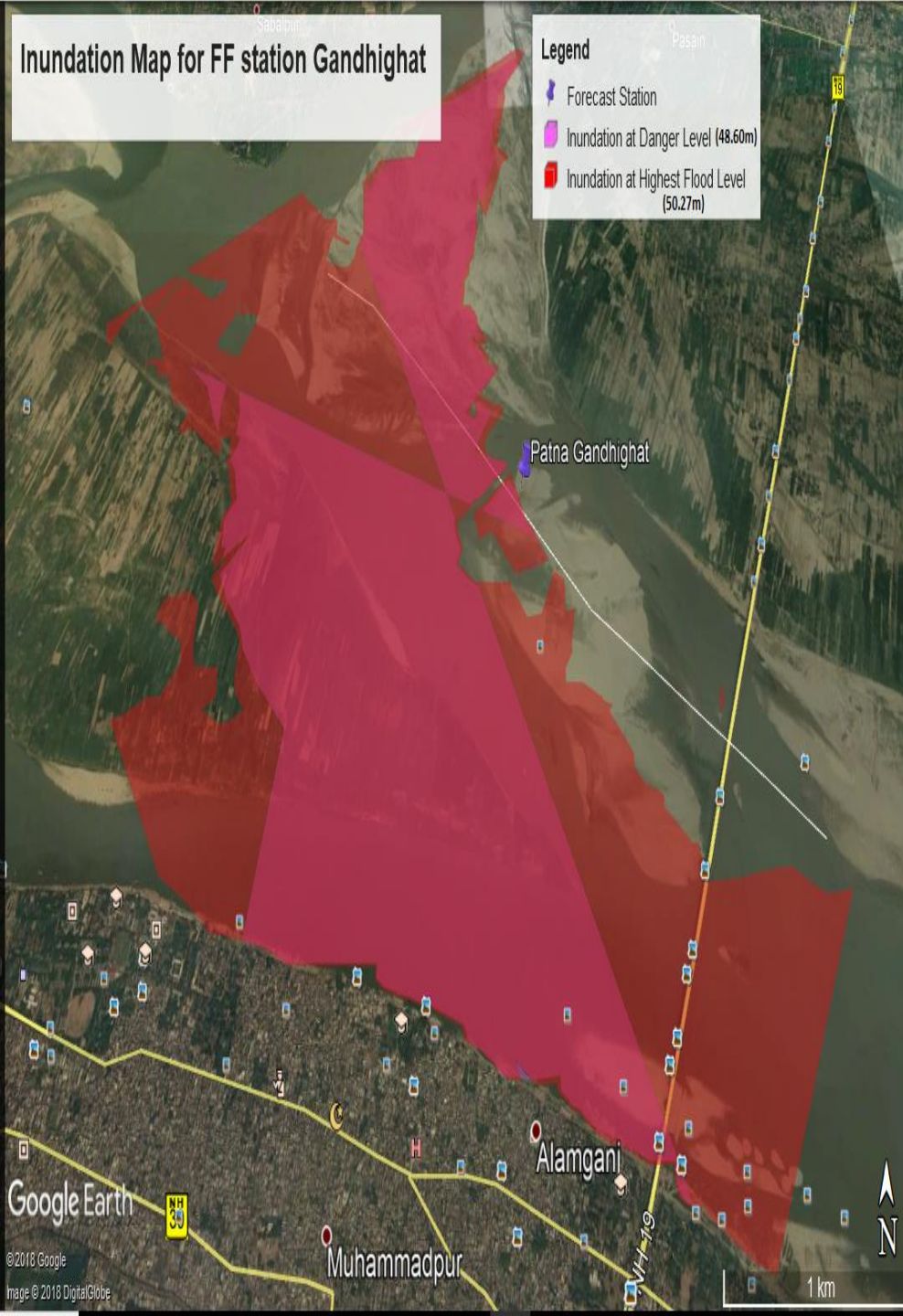
Hydrograph For NUMALIGARH(024-UBDDIB) Basin : BRAHMAPUTRA State : Assam



Inundation Map for FF station Gandhighat

Legend

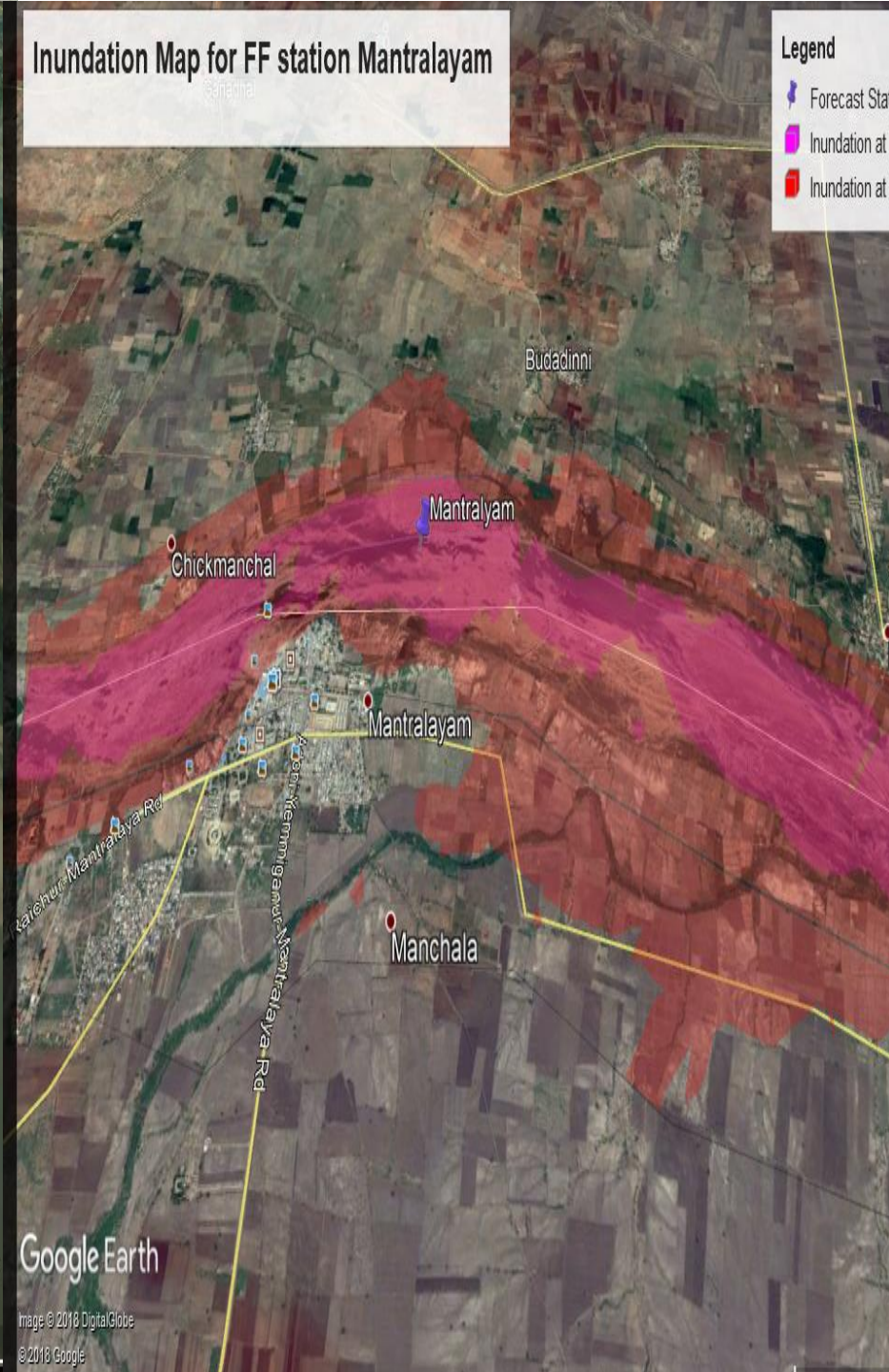
- Forecast Station
- Inundation at Danger Level (48.60m)
- Inundation at Highest Flood Level (50.27m)

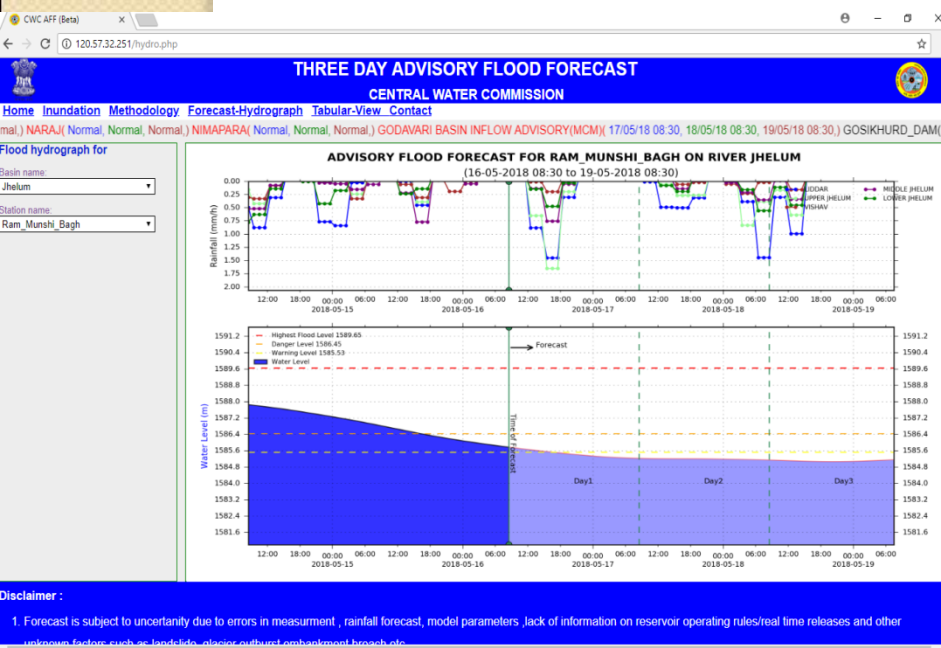
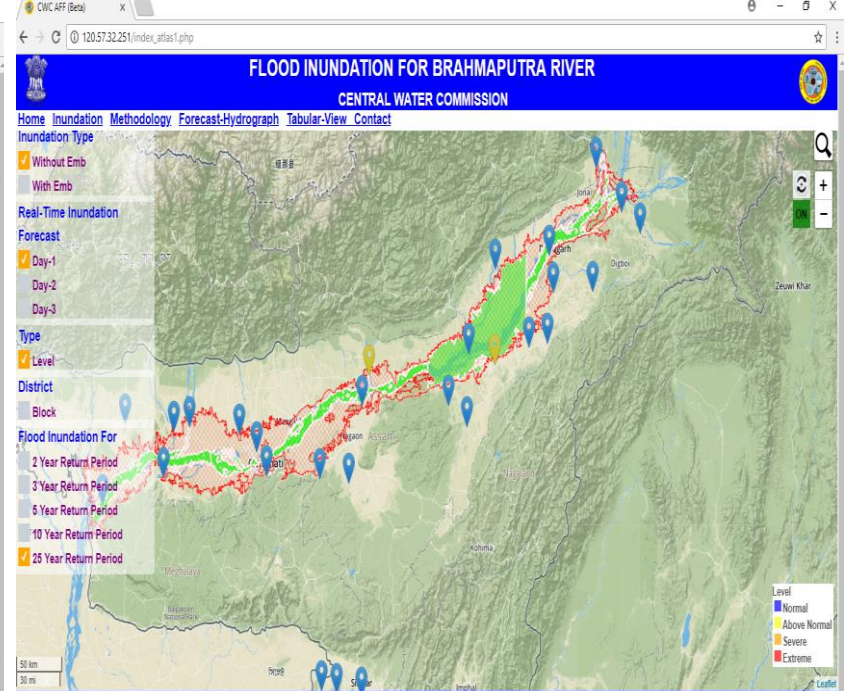
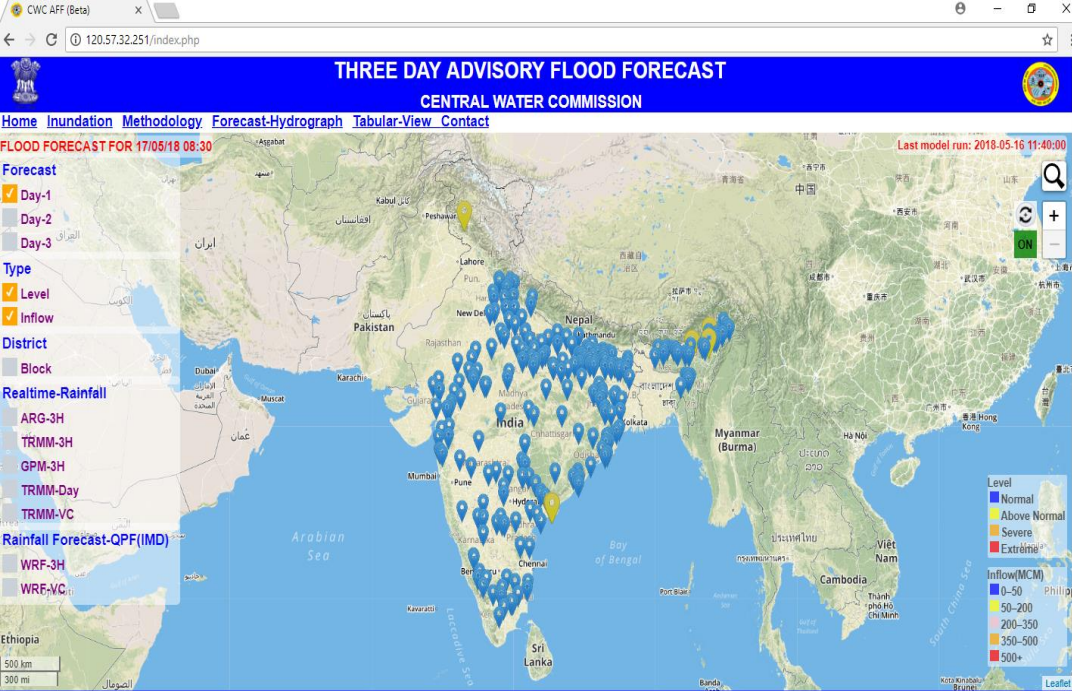


Inundation Map for FF station Mantralayam

Legend

- Forecast Station
- Inundation at Danger Level (48.60m)
- Inundation at Highest Flood Level (50.27m)





THREE DAY ADVISORY FLOOD FORECAST

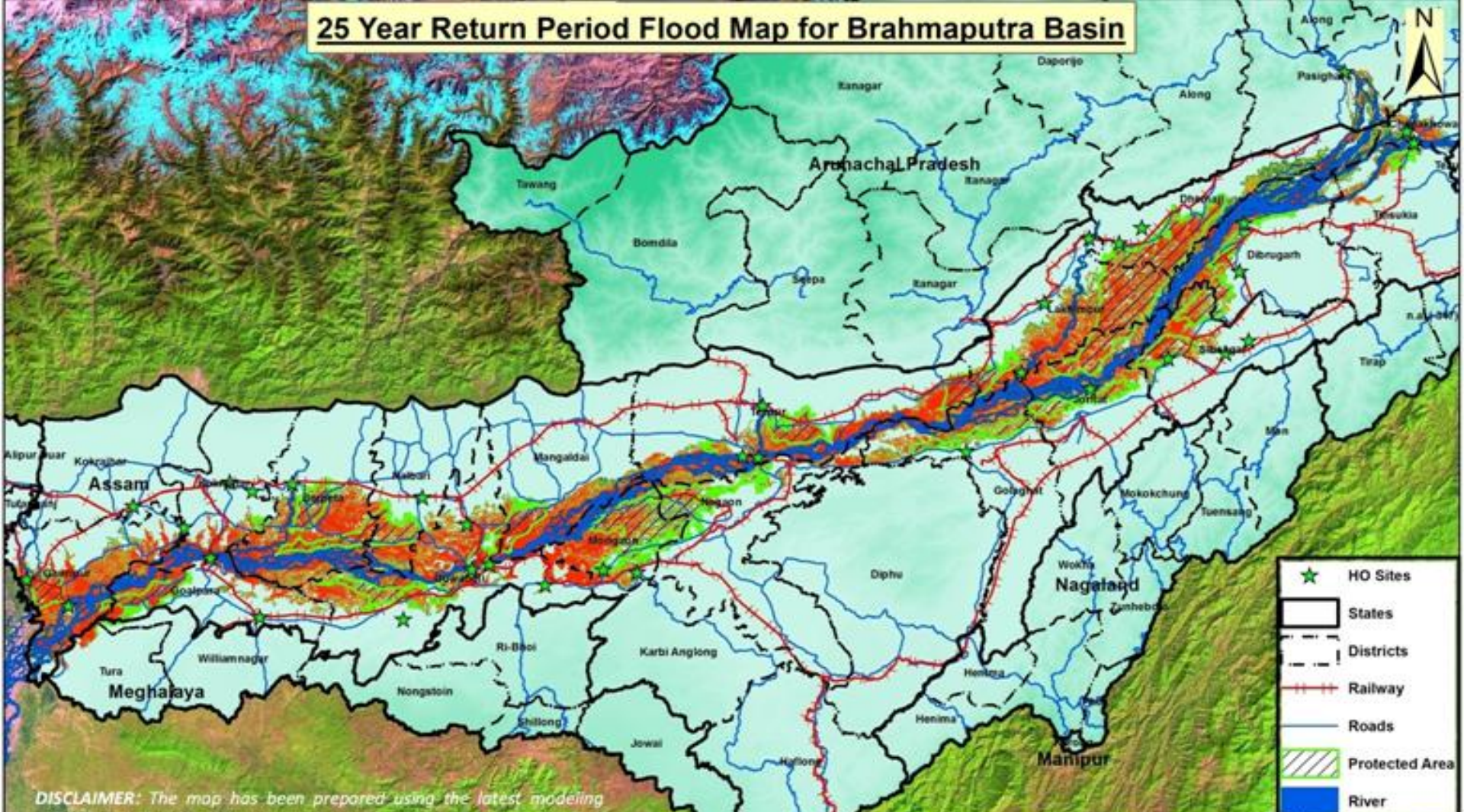
CENTRAL WATER COMMISSION

Home Inundation Methodology Forecast-Hydrograph Tabular-View Contact

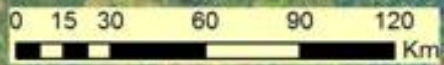
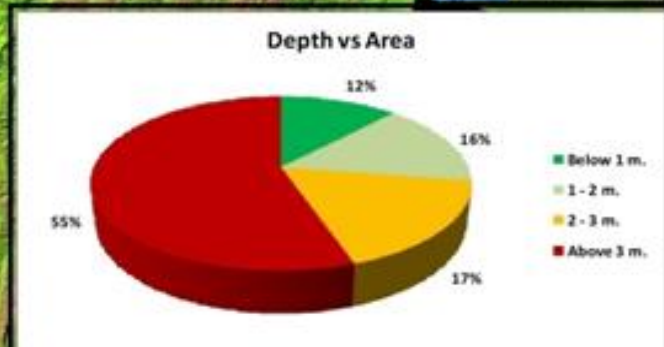
Details of likely Flood condition at various gauging stations of CWC

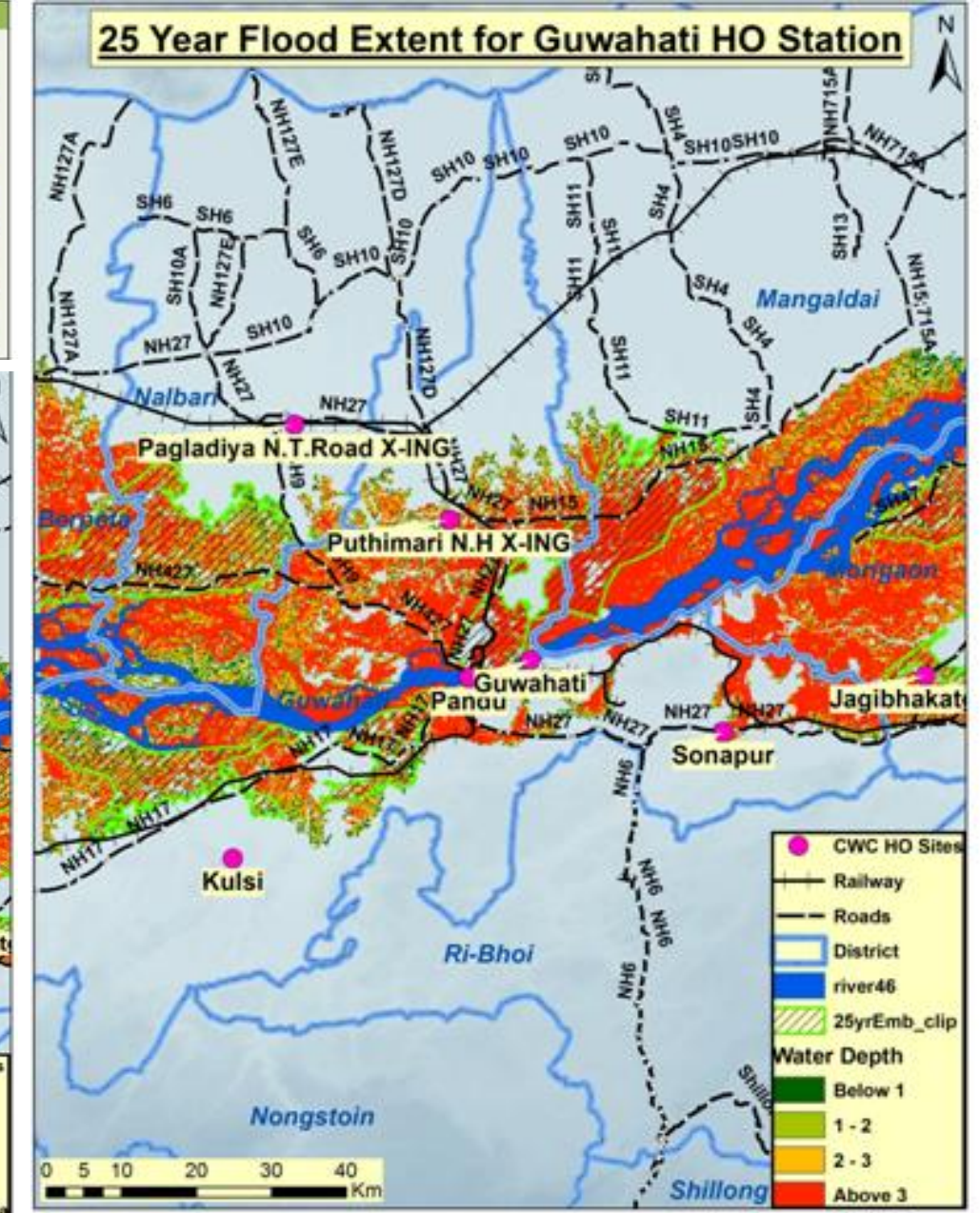
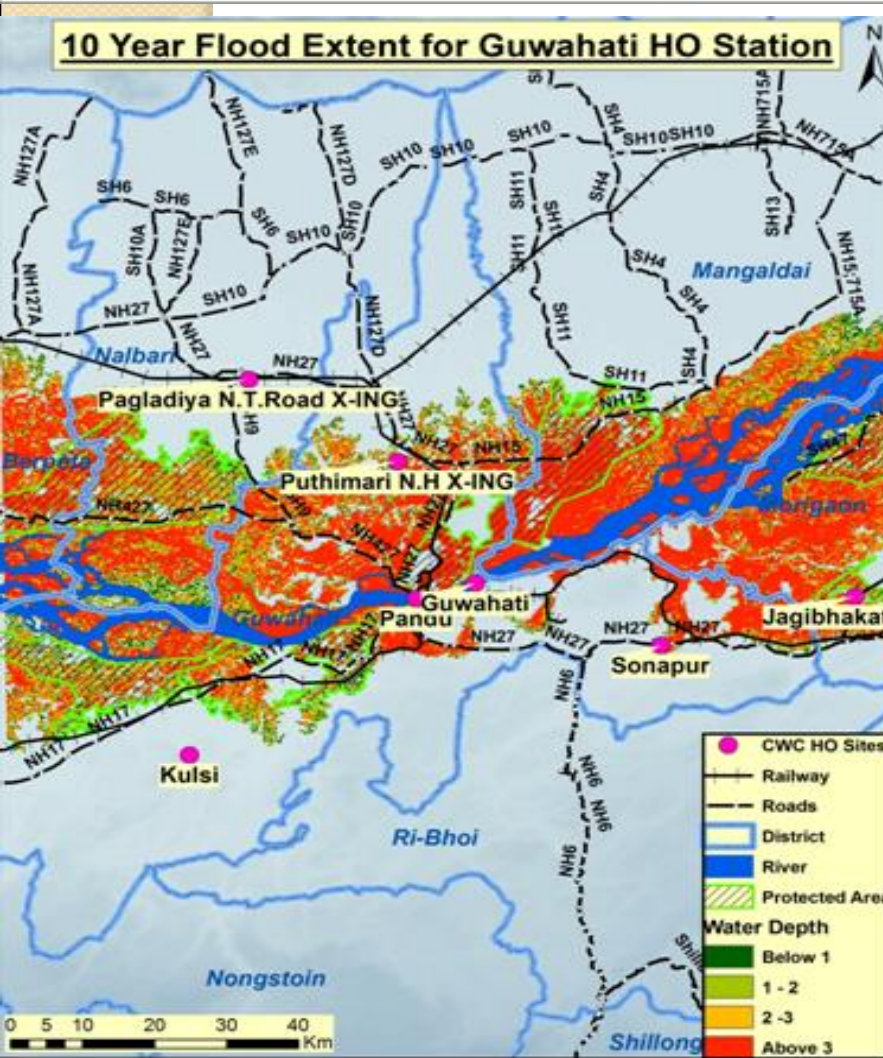
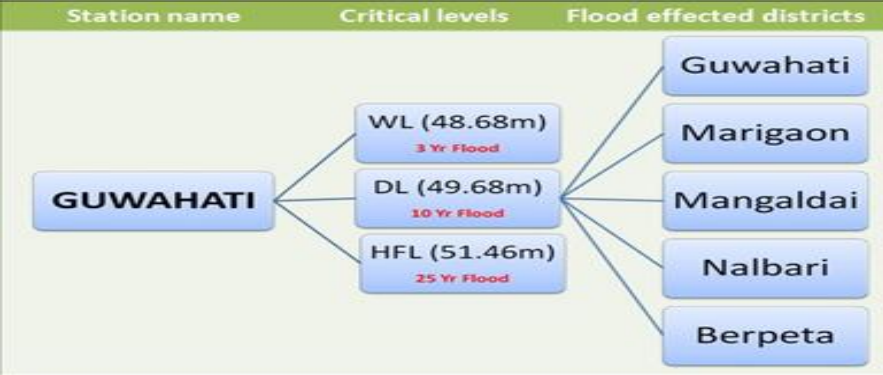
CWC gauging stations	River	Critical WL	Day-1 Forecast	Day-2 Forecast	Day-3 Forecast								
						Date	Flood condition	Max WL	Date	Flood condition	Max WL	Date	Flood condition
1	RAM_MUNSHI_BAGH	1585.53	1586.45	1589.65	16/05/18 09:30	Above Normal	1585.74	17/05/18 09:30	Normal	1585.22	19/05/18 07:30	Normal	1585.16
2	JIABHARALI_NT_X	76.0	77.0	78.5	16/05/18 11:30	Above Normal	76.59	18/05/18 02:30	Above Normal	76.48	18/05/18 09:30	Above Normal	76.45
3	NEAMATIGHAT	84.04	85.04	87.37	16/05/18 21:30	Above Normal	84.17	17/05/18 09:30	Above Normal	84.16	18/05/18 09:30	Above Normal	84.11
4	ALIPINGAL	10.85	11.76	13.11	16/05/18 09:30	Normal	4.23	17/05/18 09:30	Normal	4.16	18/05/18 09:30	Normal	4.12
5	NARAJ	25.41	26.41	27.61	16/05/18 09:30	Normal	20.98	17/05/18 09:30	Normal	20.96	18/05/18 09:30	Normal	20.95
6	NIMAPARA	9.85	10.76	11.6	16/05/18 09:30	Normal	3.58	17/05/18 09:30	Normal	3.51	18/05/18 09:30	Normal	3.46
7	BAMNI	171.5	174.0	176.45	17/05/18 07:30	Normal	158.82	18/05/18 07:30	Normal	158.88	19/05/18 07:30	Normal	158.95
8	BHADRACHALAM	45.72	48.77	55.66	16/05/18 09:30	Normal	34.64	17/05/18 09:30	Normal	34.37	18/05/18 09:30	Normal	34.17
9	DUMMUGUDEM	53.0	55.0	60.25	16/05/18 09:30	Normal	43.24	17/05/18 09:30	Normal	43.08	18/05/18 09:30	Normal	42.96
10	ETURUNAGARAM	73.32	75.82	77.66	16/05/18 09:30	Normal	65.08	17/05/18 09:30	Normal	64.88	18/05/18 09:30	Normal	64.73
11	GANGAKHED	374.0	375.0	377.57	16/05/18 09:30	Normal	363.67	17/05/18 09:30	Normal	363.62	18/05/18 09:30	Normal	363.58
12	JAGDALPUR	539.5	540.8	544.68	17/05/18 07:30	Normal	534.81	18/05/18 07:30	Normal	534.83	19/05/18 07:30	Normal	534.84
13	KALESWARAM	103.5	104.75	107.05	16/05/18 09:30	Normal	93.77	17/05/18 09:30	Normal	93.63	18/05/18 09:30	Normal	93.46
14	KOPERGAON	490.9	493.68	499.17	16/05/18 09:30	Normal	485.28	18/05/18 07:30	Normal	485.29	19/05/18 07:30	Normal	485.29
15	KUNAWARAM	37.74	39.24	51.3	16/05/18 09:30	Normal	23.52	18/05/18 09:30	Normal	23.25	18/05/18 09:30	Normal	23.03
16	MANCHERIAL	130.0	131.0	132.0	16/05/18 09:30	Normal	125.99	17/05/18 09:30	Normal	125.83	18/05/18 09:30	Normal	125.74
17	NANDED	353.0	354.0	357.1	16/05/18 09:30	Normal	341.71	17/05/18 09:30	Normal	341.63	18/05/18 09:30	Normal	341.56
18	PALNI	226.73	227.73	237.115	17/05/18 07:30	Normal	218.64	18/05/18 07:30	Normal	218.75	19/05/18 07:30	Normal	218.8
19	SIRPUR	159.95	160.95	161.95	17/05/18 07:30	Normal	149.08	18/05/18 07:30	Normal	149.12	19/05/18 07:30	Normal	149.17
20	AGRA	151.4	152.4	154.76	16/05/18 09:30	Normal	146.35	17/05/18 09:30	Normal	146.28	18/05/18 09:30	Normal	146.23
21	AHRWALIA	56.6	57.6	58.6	16/05/18 09:30	Normal	52.96	17/05/18 09:30	Normal	52.95	18/05/18 09:30	Normal	52.94
22	ALLAHABAD	83.73	84.73	88.03	17/05/18 07:30	Normal	70.82	18/05/18 07:30	Normal	71.3	19/05/18 07:30	Normal	71.68

25 Year Return Period Flood Map for Brahmaputra Basin

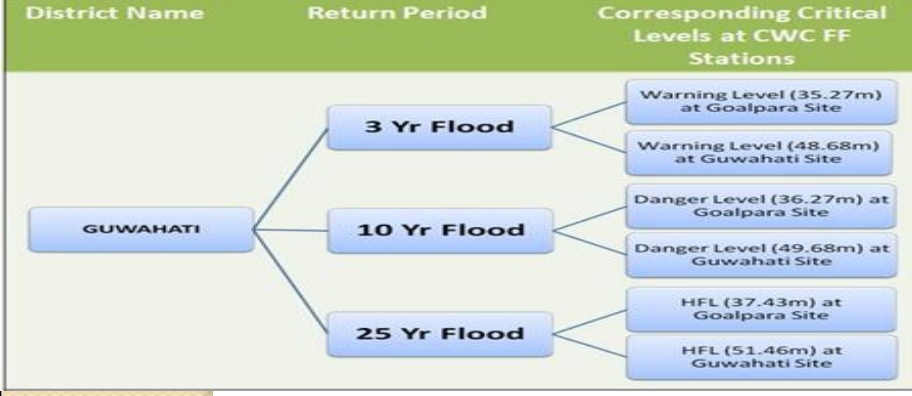


DISCLAIMER: The map has been prepared using the latest modeling technique and validated with available satellite imageries to the best possible extent. However, its preparation required many assumptions and actual conditions during a flood event may vary from the assumed conditions. The limits of flooding shown should only be used as a guideline for emergency planning and response action for state and local agencies. Actual area inundated will depend on specific flooding conditions and may differ from the areas shown on the map.

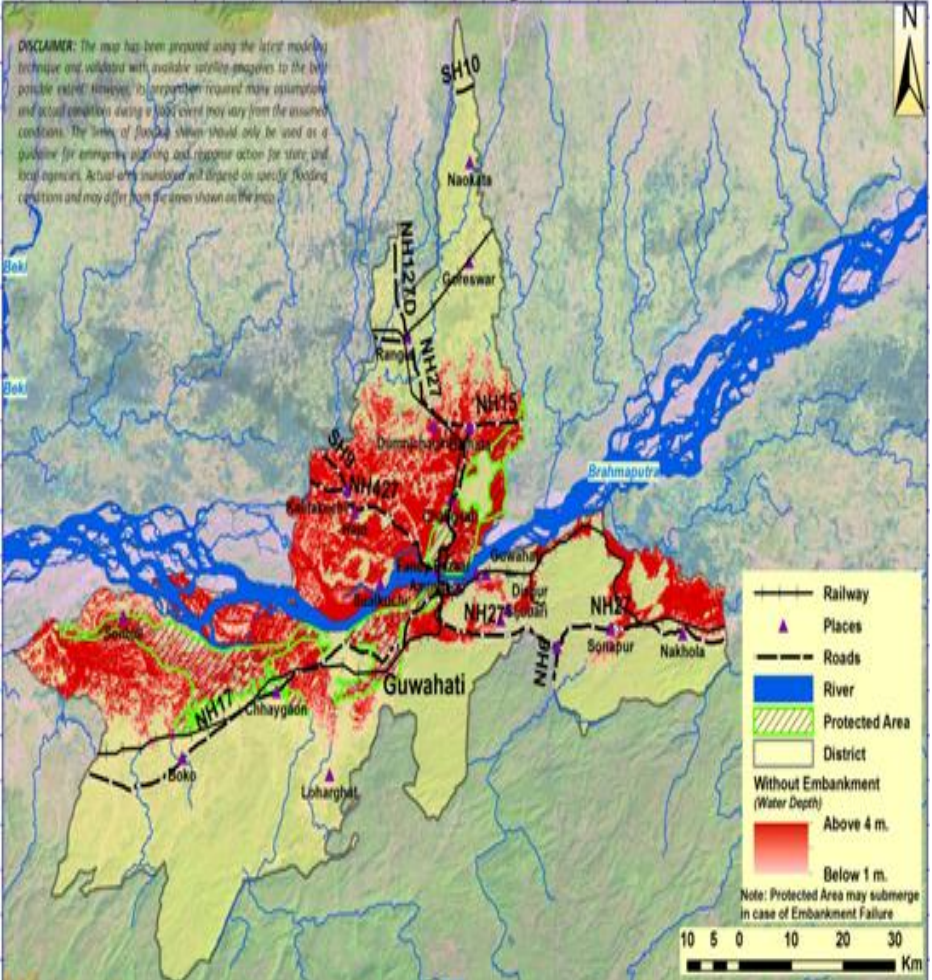




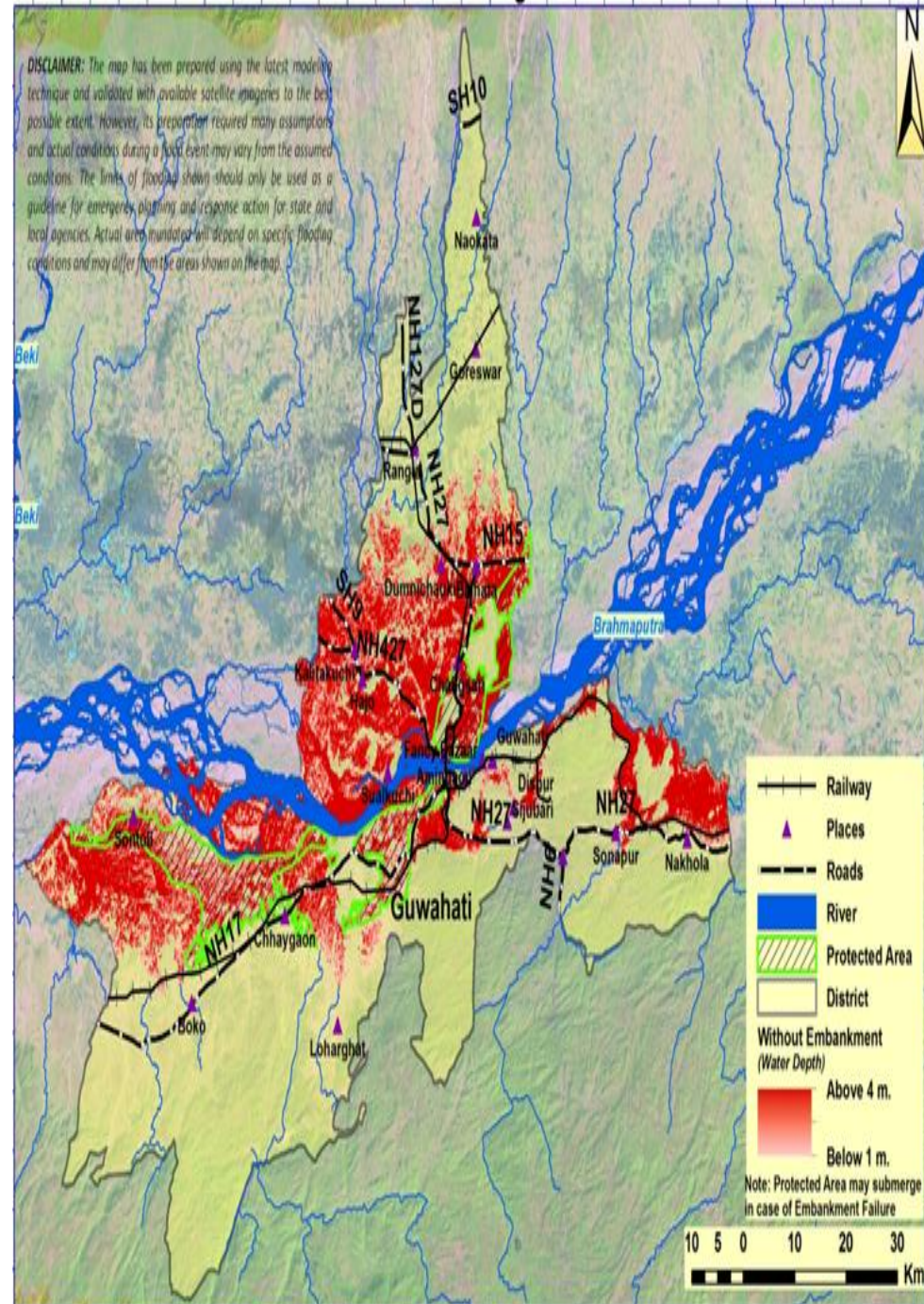
DISCLAIMER: The map has been prepared using the latest modeling technique and validated with available satellite imageries to the best possible extent. However, its preparation required many assumptions and actual conditions during a flood event may vary from the assumed conditions. The limits of flooding shown should only be used as a guideline for emergency planning and response action for state and local agencies. Actual area inundated will depend on specific flooding conditions and may differ from the areas shown on the map.



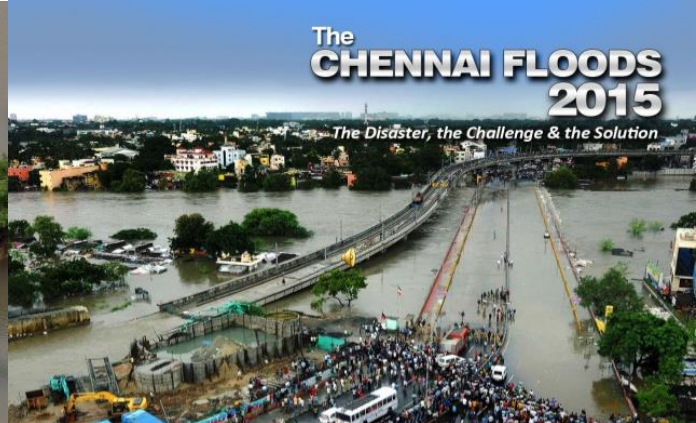
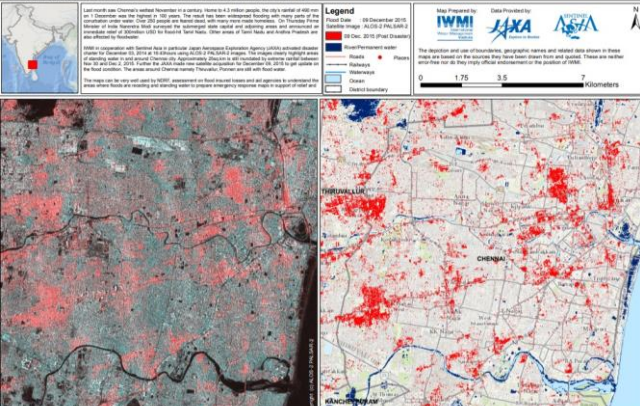
25 Years Return Period Flooding in Guwahati District



10 Years Return Period Flooding in Guwahati District



Second Wave of Catastrophic Flooding in Chennai (Tamil Nadu), India



The CHENNAI FLOODS 2015
 The Disaster, the Challenge & the Solution



MEDIA REPORTS

As rain subsides, Mumbai floods death toll is five, 12 missing



The Hindu Net Desk

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Smart Owner

- Sit back & let your money work for you



2015 South Indian floods

From Wikipedia, the free encyclopedia

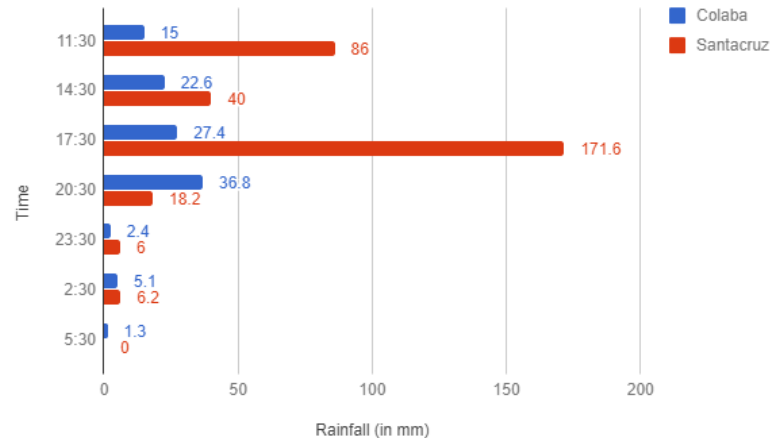
The **2015 South Indian floods** resulted from heavy rainfall generated by the annual northeast monsoon in November–December 2015. They affected the Coromandel Coast region of the South Indian states of Tamil Nadu and Andhra Pradesh, and the union territory of Puducherry, with Tamil Nadu and the city of Chennai particularly hard-hit.^[12] More than 500 people were killed^{[1][2][3][4][5]} and over 18 lakh (1.8 million) people were displaced.^[13] With estimates of damages and losses ranging from nearly ₹200 billion (US\$3 billion) to over ₹1 trillion (US\$15 billion),^{[7][8][14][15][16][17]} the floods were the costliest to have occurred in 2015, and were among the costliest natural disasters of the year.^[18] The flooding has been attributed to the 2014–16 El Niño event.

Contents [hide]

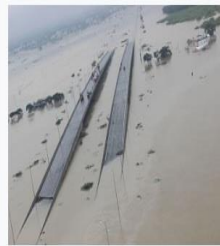
- Background
 - Geographical and meteorological explanation
 - The weather systems
- The Floods
 - Chennai
 - Puducherry
 - Andhra Pradesh
- Consequences
- Relief efforts
 - Tamil Nadu
 - Andhra Pradesh
 - Puducherry
- Response
 - National
 - International
 - Religious
 - Individual
- Aftermath
 - Unregulated
 - Improvement

Colaba and Santa Cruz rainfall from 8:30 am yesterday to 05:30 am today

(Data from IMD)



2015 South Indian floods



Submerged bridges in Chennai

Date 8 November 2015 – 14 December 2015

Location South India (Tamil Nadu, Puducherry, Andhra Pradesh)

Deaths 500+^{[1][2][3][4][5]}

Tamil Nadu: 422 (official, likely more)^{[1][2][3][4][6]}

Andhra Pradesh: 81^[5]

Puducherry: 3

Property damage ₹19,895 crore (US\$3 billion) – over ₹100,000 crore (US\$15 billion) (unofficial estimates)^{[7][8]}

Tamil Nadu: ₹14,602 crore-₹50,000+ crore (US\$2.2 billion-US\$7.5+ billion, unofficial estimates)^{[7][9]}

Andhra Pradesh: ₹4,960 crore (US\$760 million)^[10]

Pondicherry: ₹333 crore (US\$51 million)^{[8][11]}





Issues being addressed

- **No Flash Flood Guidance System/ SOP/ Framework exists in India**
- The primary agency for issuing hydrological flood warnings/ alerts lies with the independent institution called Central Water Commission under Ministry of Water Resources, Govt. of India.
- India Meteorological Department with its vast observational networks and advancements in weather predictions has a shadow mandate in delivering meteorological services to Central Water Commission, stake holders at state & district level in producing flood warning services to people.
- Once flood warning is disseminated, National Disaster Management Authority (NDMA) get ready along with the local bodies to pre-disaster management and risk reduction activities.
- National Disaster Relief Force (NDRF) adopts SOP and carries out the rescue operation during the disaster and post disaster events.





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.

Flash Flood Guidance (FFG) is the amount of rainfall of a given duration over a given catchment that is enough to cause a bankfull conditions at the outlet of the draining stream.

SAsia-FFG - Southern Asia Regional Flash Flood Guidance System

Current Date: 2018-04-04 11:46 UTC Product Date: 2017-08-12 00:00 UTC

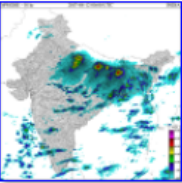
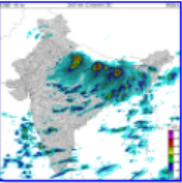
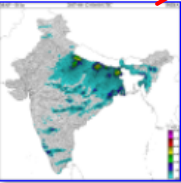
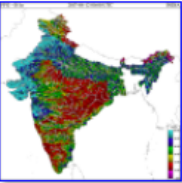
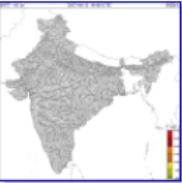
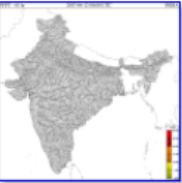
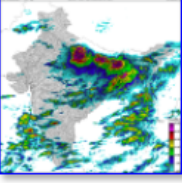
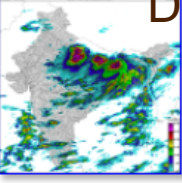
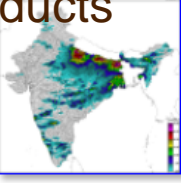
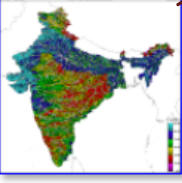
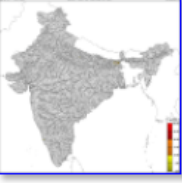
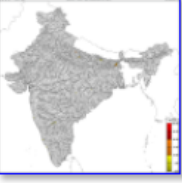
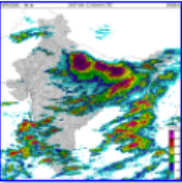
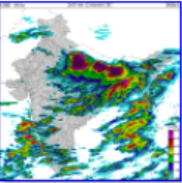
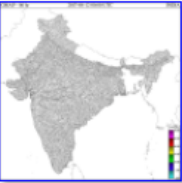
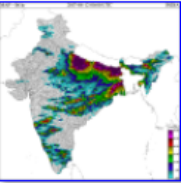
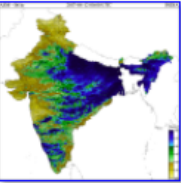
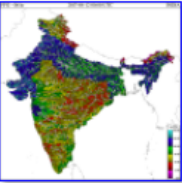
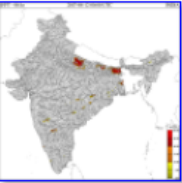
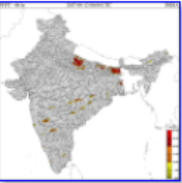
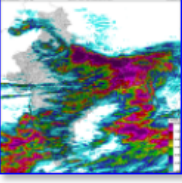
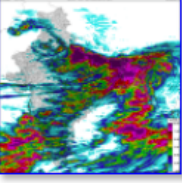
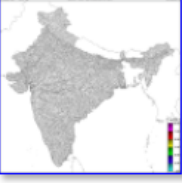
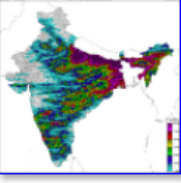
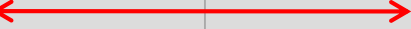
Year: 2017 Month: 08 Day: 12 Hour: 00 REGION: INDIA OPTION: MEDIAN Submit

-1 Month -1 Day -6 Hours -1 Hour +1 Hour +6 Hours +1 Day +1 Month

Prev 6-hr Interval (18 UTC) Reset to Current Next 6-hr Interval (06 UTC)

Observed Precipitation

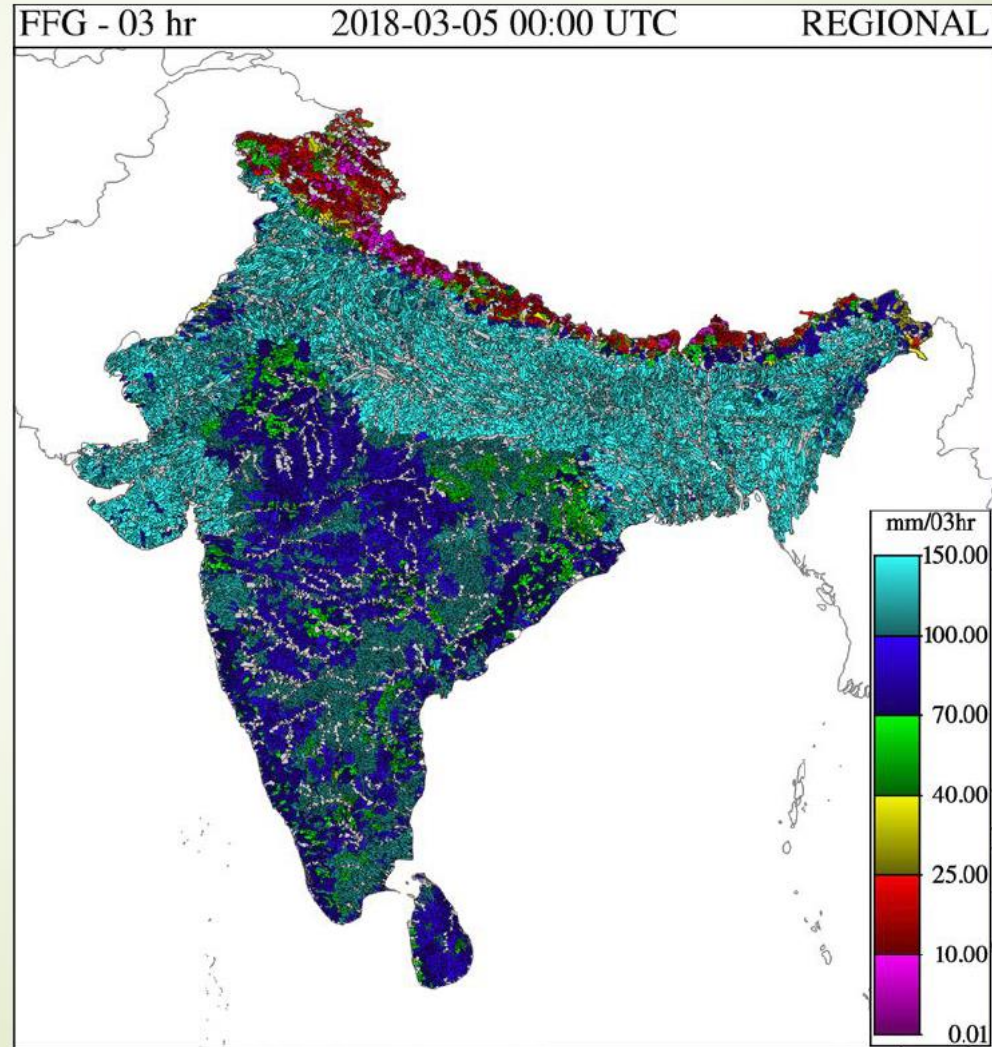
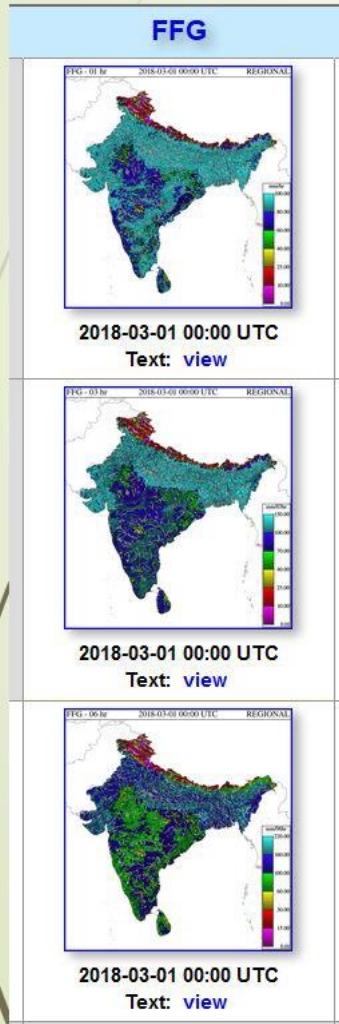
Product Console - Main Table

DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP	ASM	FFG	IFFT	PFFT
01-hr	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view		 2017-08-12 00:00 UTC Text: view		 2017-08-12 00:00 UTC Text: view	 2017-08-11 19:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view
03-hr	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view		 2017-08-12 00:00 UTC Text: view		 2017-08-12 00:00 UTC Text: view	 2017-08-11 21:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view
06-hr	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view
24-hr	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 2017-08-12 00:00 UTC Text: view	 Hydrological State (Land Surface)			

Diagnostic Products

FFG: Flash Flood Guidance

System computes *current* FFG values for each small watershed for rainfall durations of 1-, 3- and 6- hours. Updated every 6 hours.



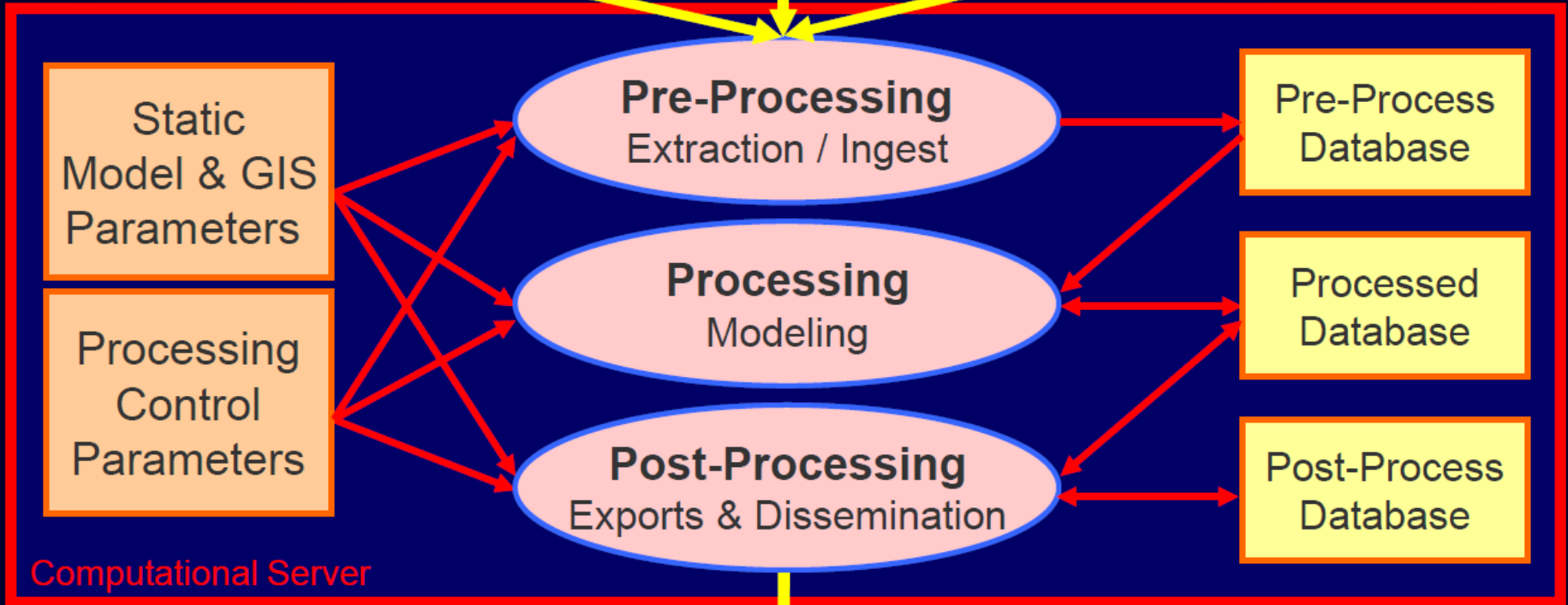
SAsiaFFG General Data Flow Processing Design

MWGHE & GHE
Satellite
Precipitation

Gauge Data

Forecast Model
Precipitation

Real-Time Data Acquisition



Computational Server

Dissemination

Regional Center



HRC

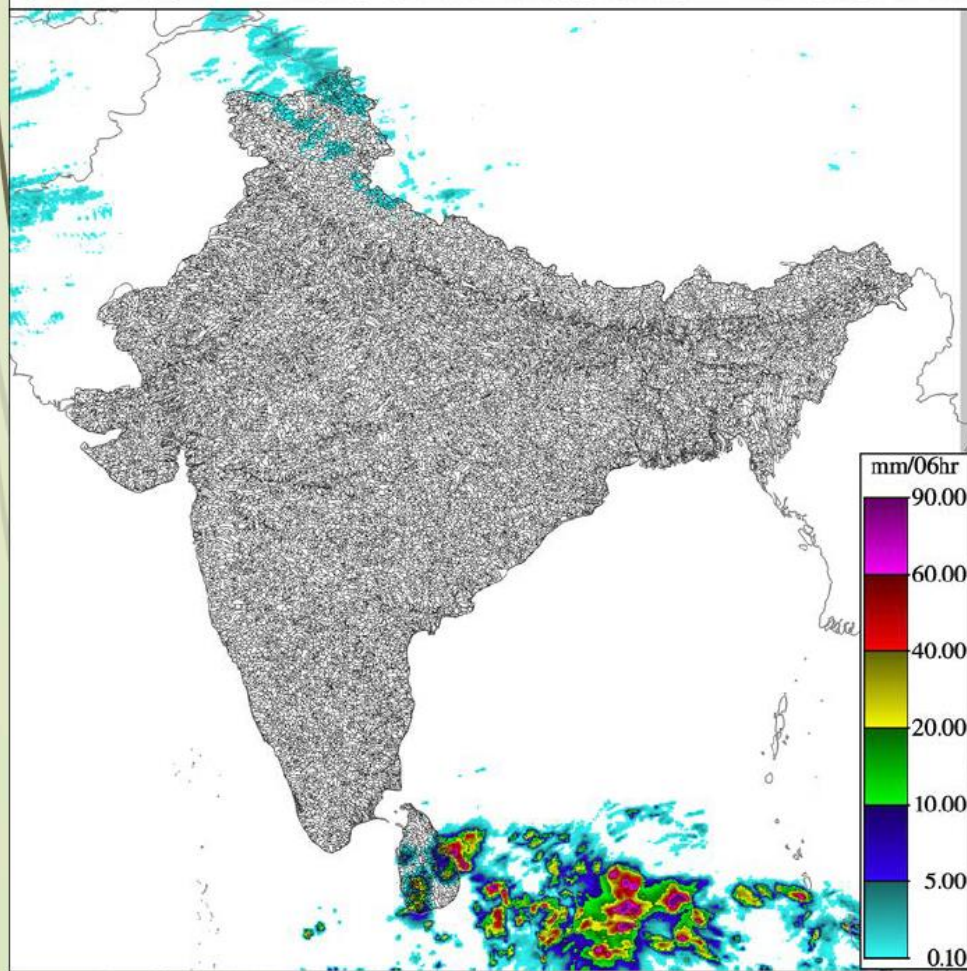
National Centers

Partners

FFGS Satellite Precipitation: GHE

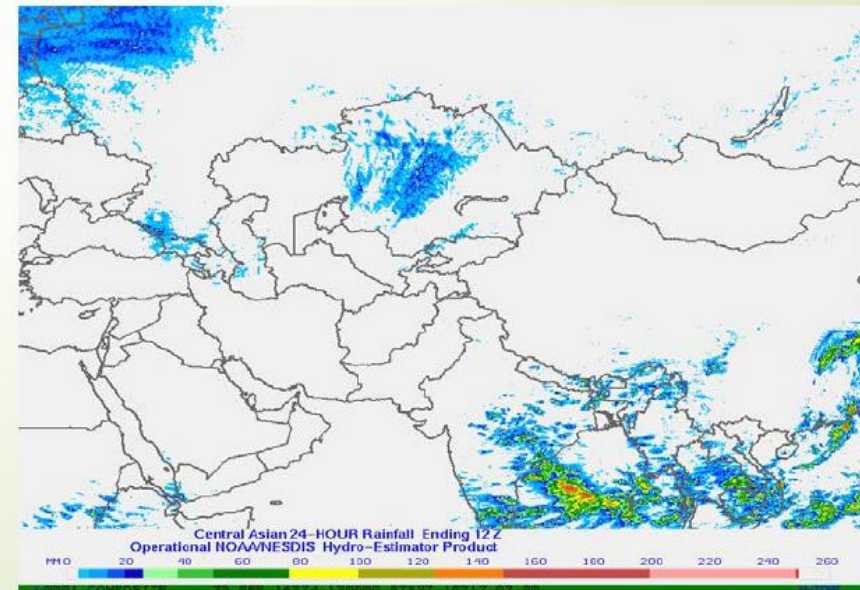
Remotely-sensed precipitation estimates provide good spatial coverage and detail.
In situ observations (rain gauges) provide “ground truth” but often have sparse coverage.

GHE - 06 hr 2018-02-27 12:00 UTC REGIONAL



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)

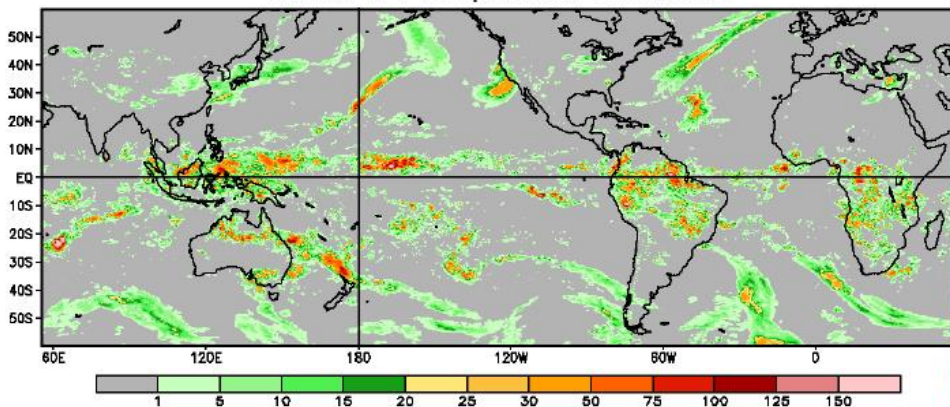


FFGS Satellite Precipitation: MWGHE

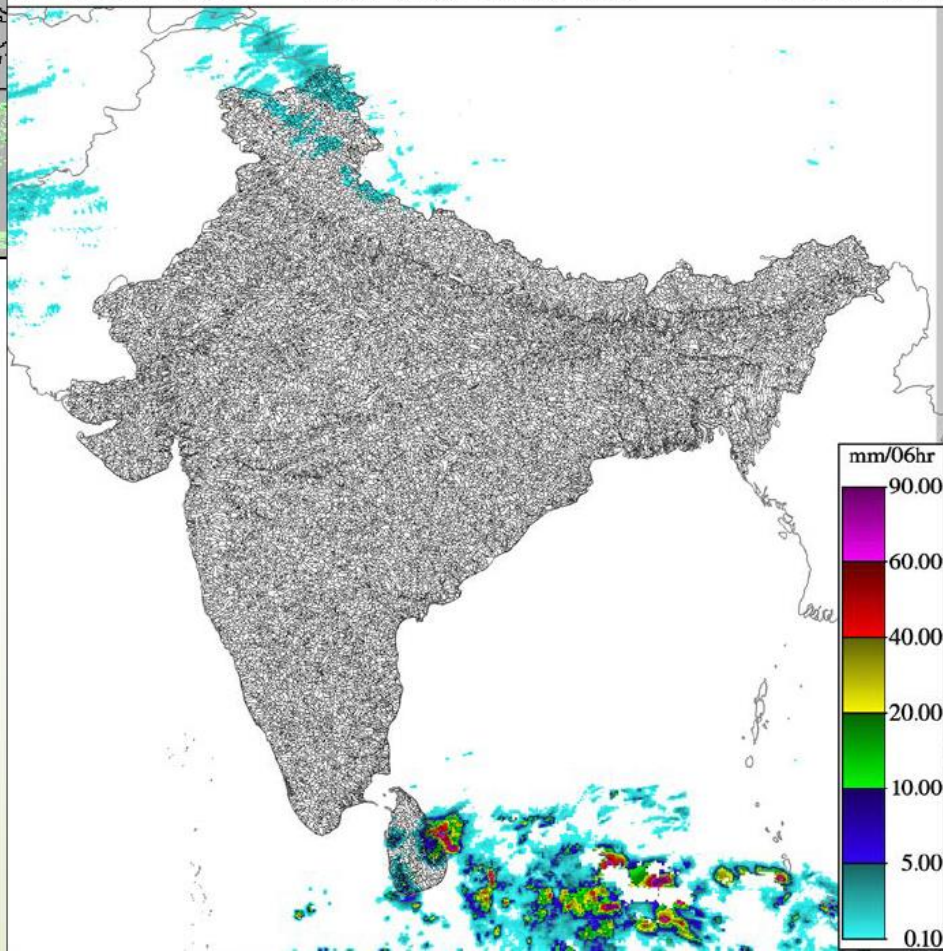
HRC effort to combine IR-based GHE rainfall with MW-based CMORPH rainfall.

Daily Precipitation for: 20 Mar 2011 (00Z-00Z)
Data on .25 x .25 deg grid; UNITS are mm/day

CMORPH Precipitation Estimates



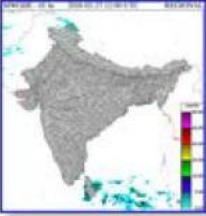

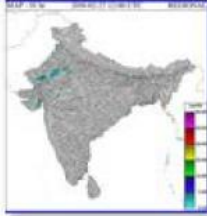

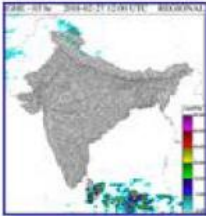



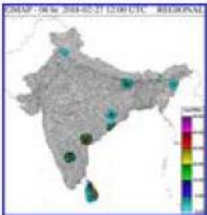
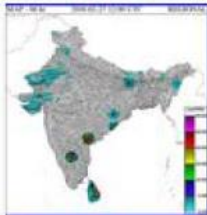
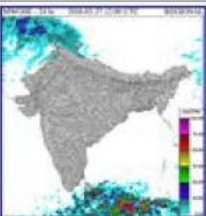

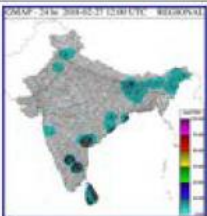
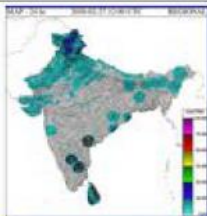
MWGHE - 06 hr 2018-02-27 12:00 UTC REGIONAL



CMORPH is based on microwave scattering from hydrometeors.
This is still an indirect measurement.

- ~ 8km resolution
- 18-26 hour latency in operations

Merged MAP Product

DT	MWGHE Precipitation	GHE Precipitation	Gauge MAP	Merged MAP
01-hr	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>		 <p>2018-02-27 12:00 UTC Text: view</p>
03-hr	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>		 <p>2018-02-27 12:00 UTC Text: view</p>
06-hr	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>
24-hr	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>	 <p>2018-02-27 12:00 UTC Text: view</p>

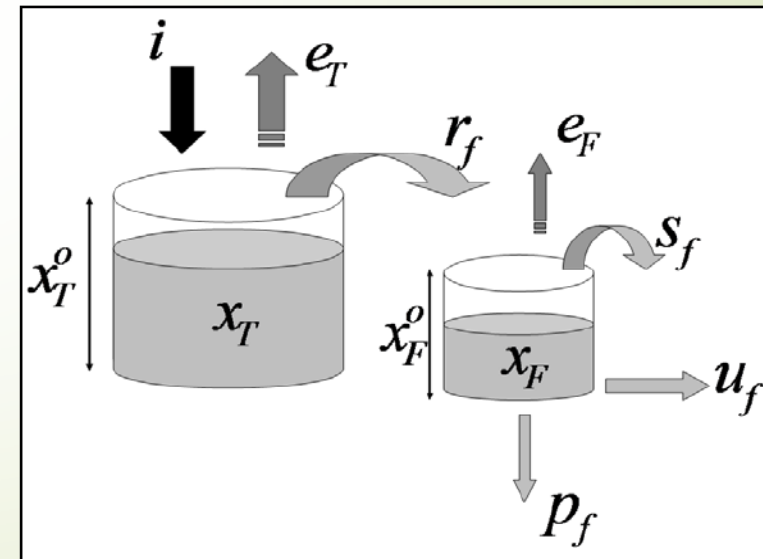
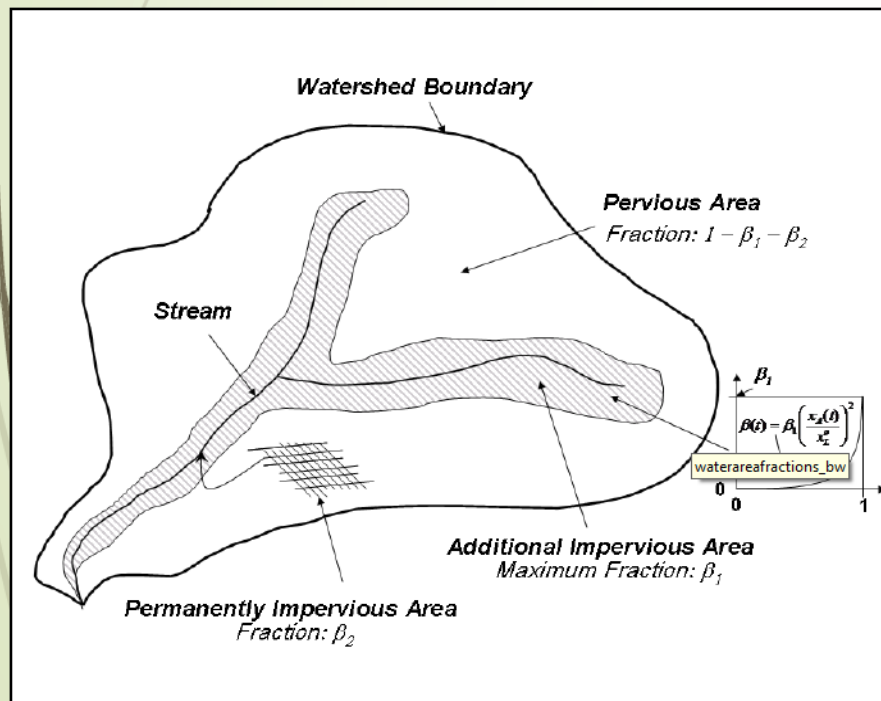
Merged MAP is the *best estimate* of Mean Areal Precipitation over each small watershed. 1-, 3-, 6-, and 24-hour accumulations.

- Satellite
- Real-time gauges
- Radar (if available)
- * Includes bias adjustment

Soil Water Modeling for SAsiaFFG

A conceptual lumped hydrologic model is used for modeling of soil water for each small watershed.

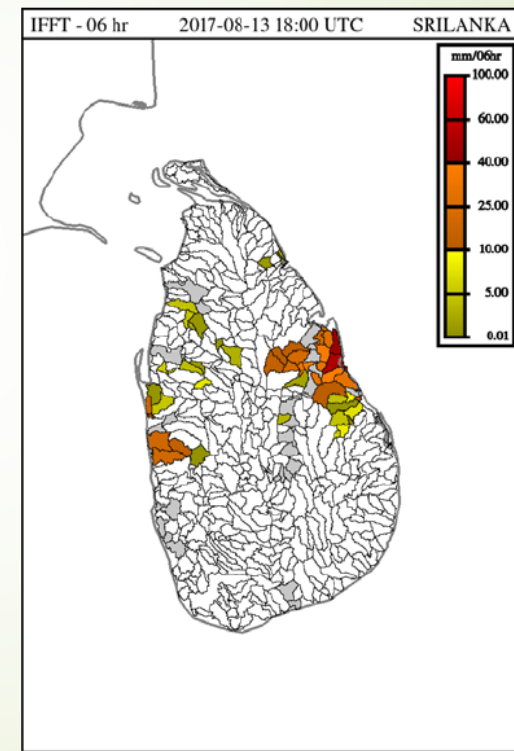
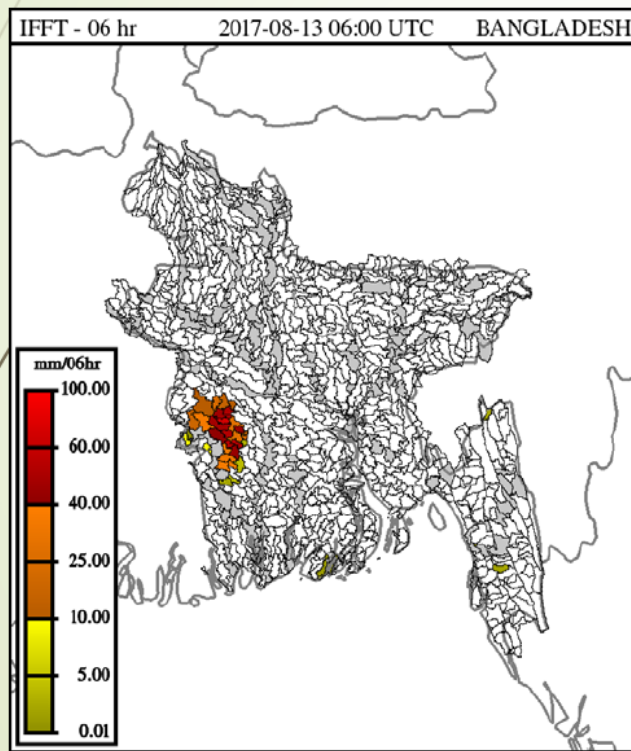
A two-layer conceptual representation of the movement of soil water through a vertical, homogeneous soil column using the Sacramento Soil Moisture Accounting Model (SAC-SMA).



FFT: Flash Flood Threat

Potential for flash flooding is increased when **PRECIPITATION** > **FFG**.

Flash Flood Threat, FFT, defined: **FFT = MAP - FFG**



*FFT provides indication of regions of potential concern.
Color bar provides magnitude of FFT.*



FFGS Products: FFTs

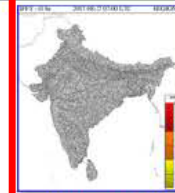
SAsia-FFG - Southern Asia Regional Flash Flood Guidance System

Current Date: 2018-03-05 06:28 UTC Product Date: 2017-08-27 12:00 UTC
Year: 2017 Month: 08 Day: 27 Hour: 12 REGION: REGIONAL OPTION: MEDIAN Submit
-1 Mon +1 Day +1 Month
SAsia-FFG Real-Time Product Console Main Product Table - Mozilla Firefox
Prev 4-hr Interval (00 UTC) Reset to Current Next 4-hr Interval (18 UTC)

Product Console - Main Table

DT MWGHE Precipitation GHE Precipitation Gauge MAP Merged MAP ASM FFG

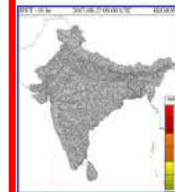
IFFT PFFT



2017-08-27 07:00 UTC
Text: view



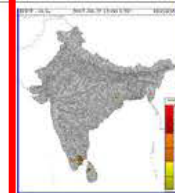
2017-08-27 12:00 UTC
Text: view



2017-08-27 09:00 UTC
Text: view



2017-08-27 12:00 UTC
Text: view



2017-08-27 12:00 UTC
Text: view

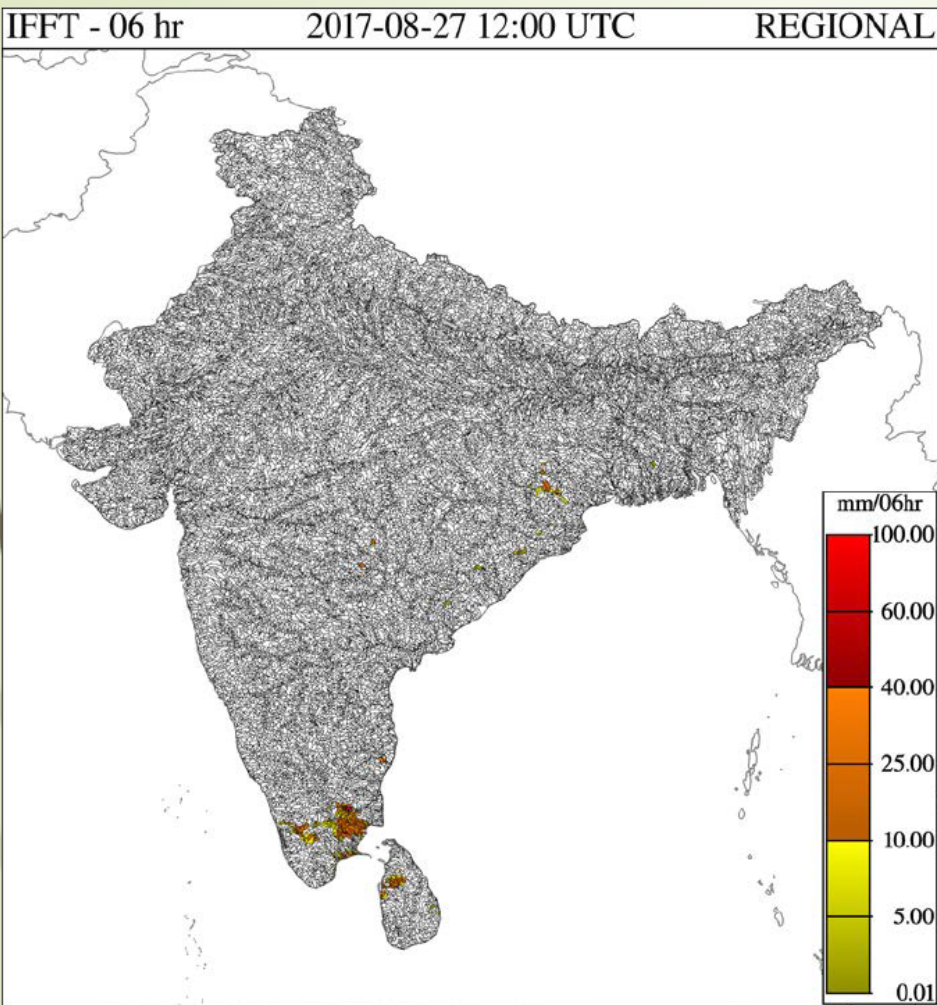


2017-08-27 12:00 UTC
Text: view

Different FFT products are provided, based on observed or forecasted precipitation and timing.

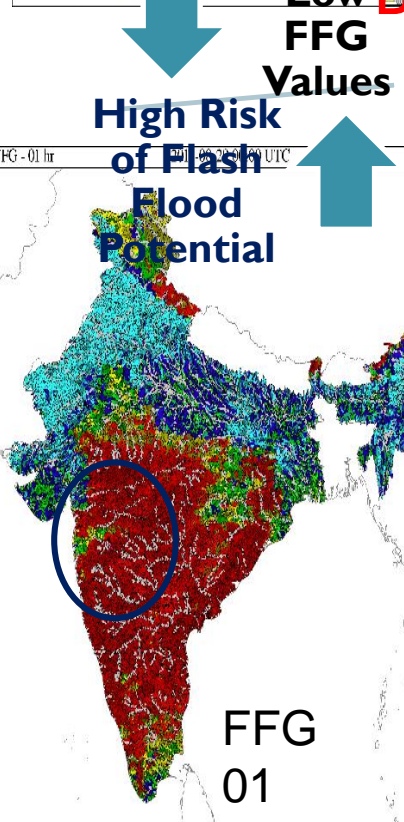
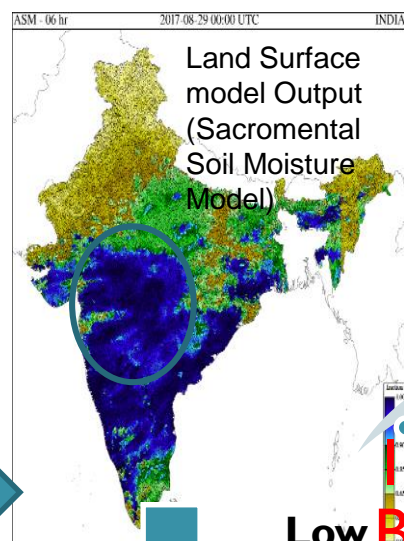
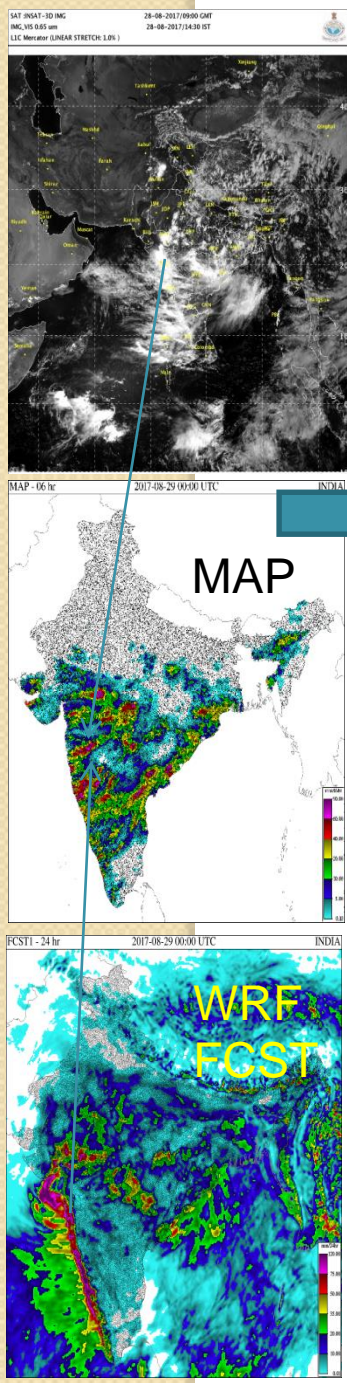
- IFFT: imminent, based on observed precipitation that has fallen.
Flash flooding may be occurring!
- PFFT: forecast of persistence – *IF* rainfall continues at current rate
- FFFT: based on forecast precipitation.

Flash Flood Threat Products



Operational forecasters recognize FFG System products and precipitation forecasts carry uncertainty, and must evaluate the current situation and forecast.

*FFT products are ***not*** intended to be the forecast, but are system indicators of potential concern. The role of the forecaster in evaluating available information is **critical**.*



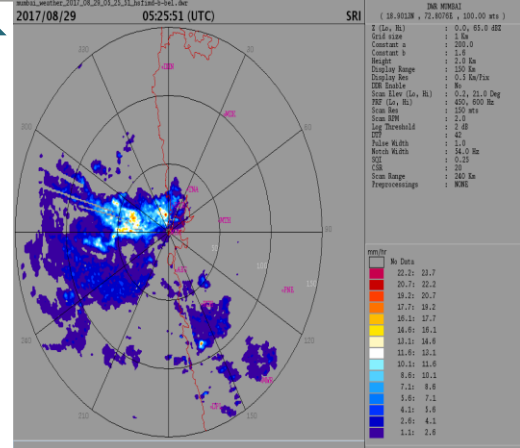
MAPSERVER Visualises multiple outputs/ forecasts of the micro level catchment areas at the same time which identifies flash flood prone zones.

28780
Micro watersheds

146
Sub Basins

Low FFG Values

High Risk of Flash Flood Potential



Verified by
Mumbai
Radar Data
on 28th &
29th August
2017

SAsiaFFGS Project : Status & Implementation Time line – Things to do

Experimental implementation of the system this Monsoon by July 2018

Bias correction & sensitivity analysis being performed at all the meteorological sub divisions of the region. (subject to availability of QC gauge datasets of the region at least from last 5 years)

SAsiaFFGS Server setup to be done at IMD (Computation & Dissemination) by June 2018 as per given specifications for hosting the products to neighbouring countries. (Presently HRC Remote server access is available at IMD)

Test, Calibration & Validation of various products being performed on various scenarios of weather systems by end of June 2018

Step 4: Regional Operations training workshop will be held at IMD during 5th – 7th June'2018 by trainers from WMO & HRC.

MAPSERVER Web interface needs to be deployed by late August' 2018 for operationalisation & visualisation of all the products over the GIS layers.

Hands on training needs to be inducted to all the meteorologists involved in the hydromet services of IMD.

Advanced Functionalities of this system are providing guidance on fields :

- Impact based flood warning
- Urban Flash Flood Warning
- Seasonal to sub seasonal run off

Landslide occurrence prediction
Riverine / Channel routing
Flow forecasting.

Base Layers

- SASIAFFG Operational Product
- SASIAFFG Basin Outlines
- Open Street Maps - Water Only
- Open Street Maps - Roads Only

Zoom to Country
Select Country

Product Selection Table
Basin: MAP 06HR
Raster:

Product Date Selection
Product Date: 2017-08-29 00:00 UTC

00	01	02	03	04	05
06	07	08	09	10	11
12	13	14	15	16	17
18	19	20	21	22	23

Prev Hour Next Hour
Prev 6hr Interval Next 6hr Interval
Prev Day Next Day

Reset to Current

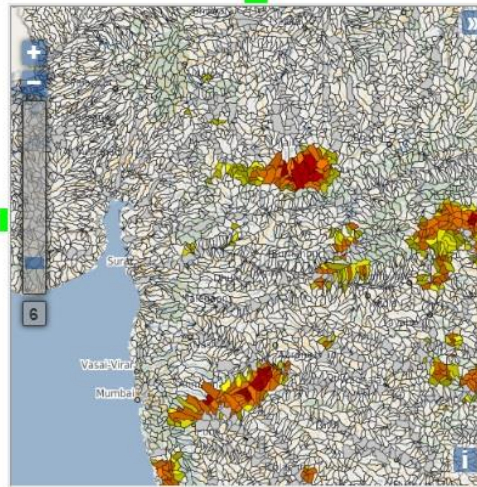
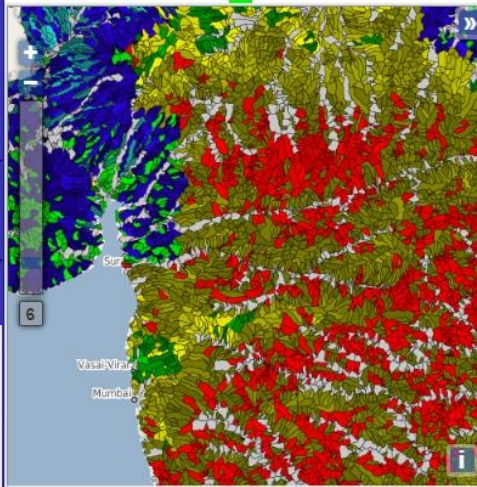
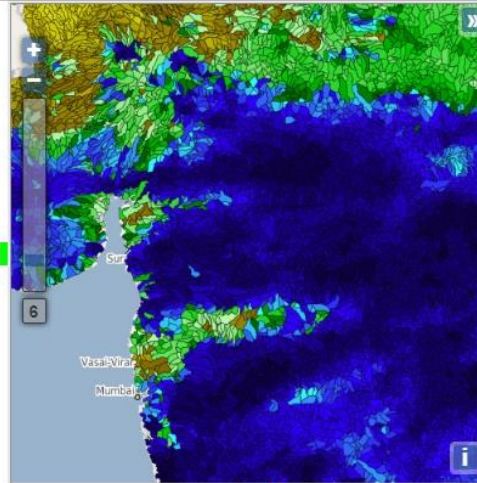
Sync Date Controls

Product Selection Table
Basin: FFG 06HR
Raster:

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Select Country

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Zoom to Country
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Product Selection Table
Basin: ASM 06HR
Raster:

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Prev Hour Next Hour
Prev 6hr Interval Next 6hr Interval
Prev Day Next Day

Reset to Current

Sync Date Controls

Product Selection Table
Basin: PFFT 06HR
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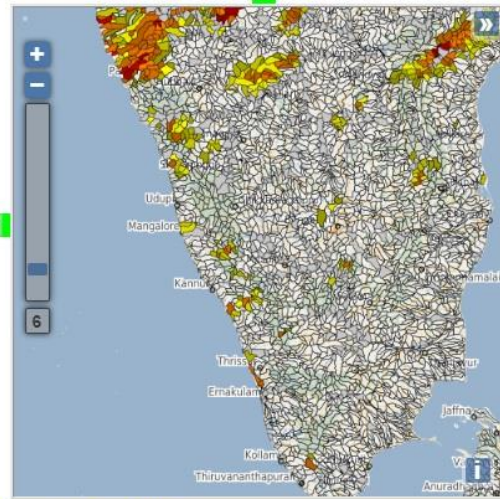
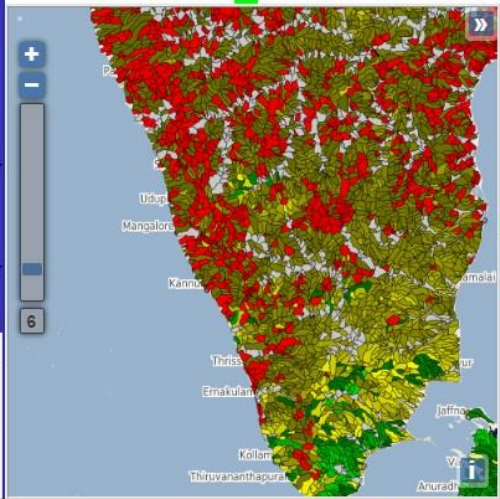
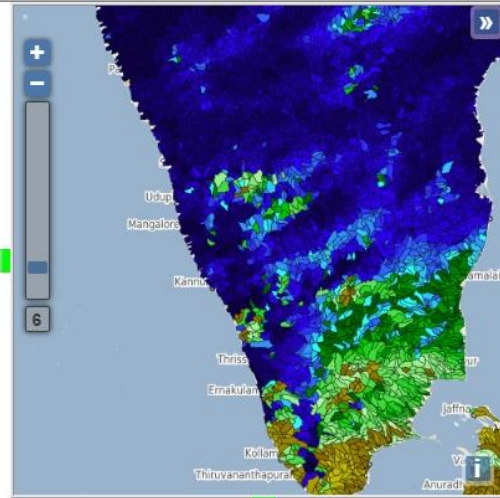
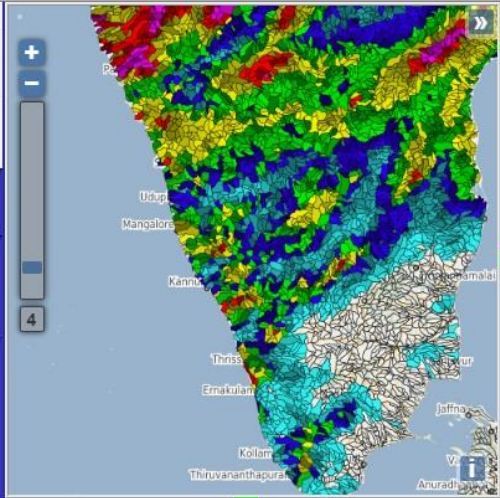
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Base Layers +

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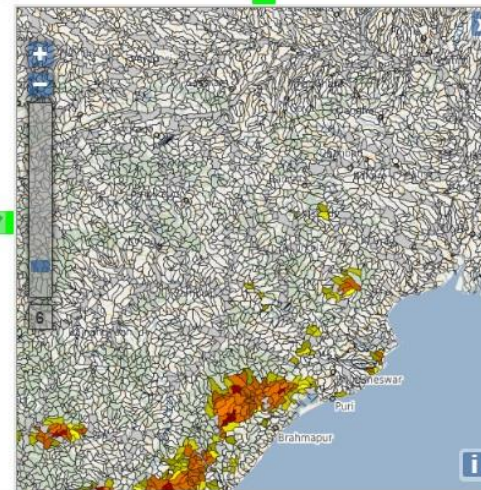
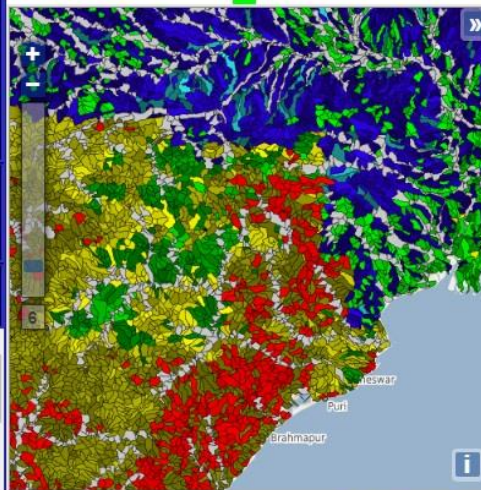
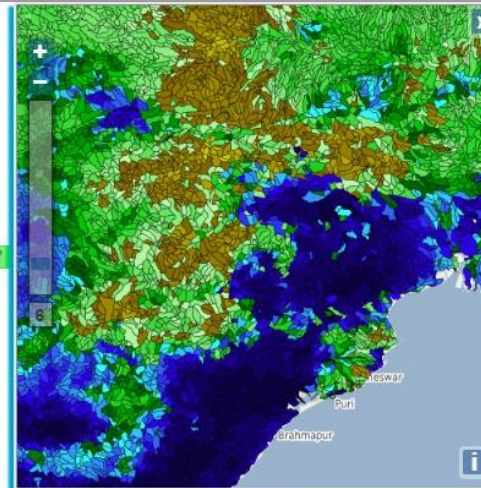
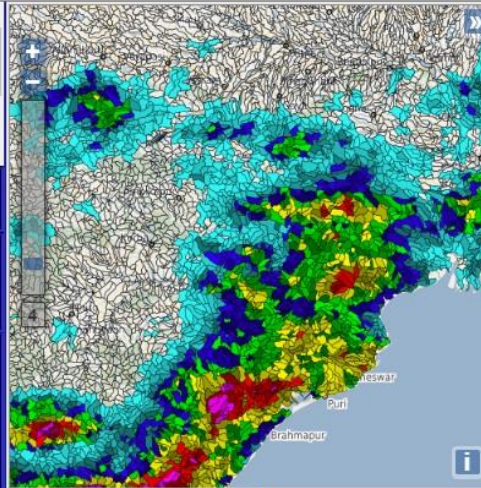
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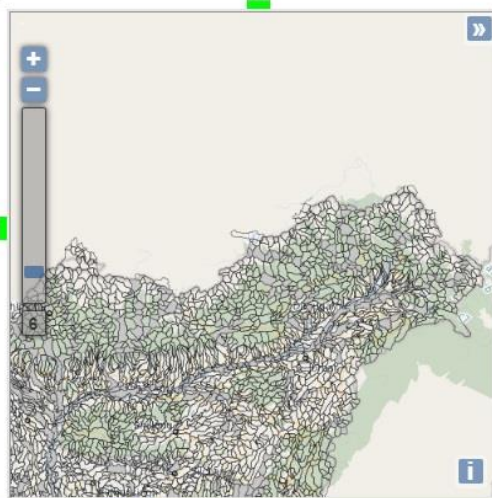
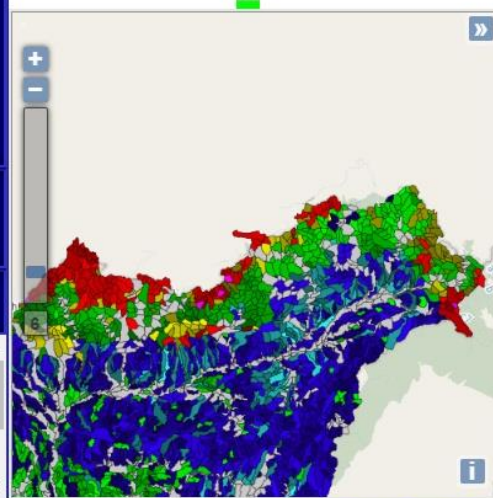
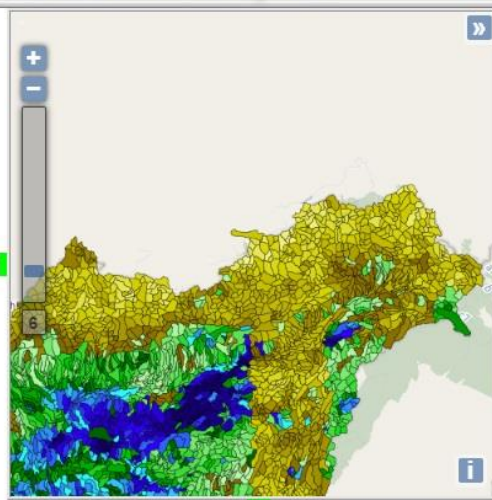
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Successful completion of Step 3: Specialised training on advanced operations & interactive simulator on various aspects of the FFG system

All the 9 participants from 5 countries had successfully completed the training course on 31st March 2018 at HRC, San Diego, CA, USA.



One day visit to National Weather Service, NOAA, San Diego, CA, USA for observations & visualisations on various operational needs during scenarios.



THANK YOU FOR THE OPPORTUNITY

