

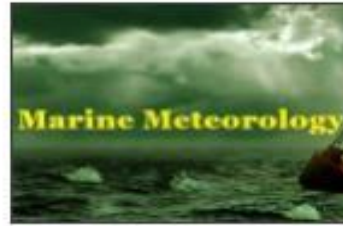
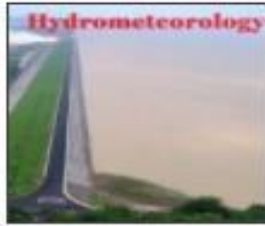


# Current status and strategies in India for provision of impact based weather forecasting services

Sunitha Devi.S,  
India Meteorological Department,  
New Delhi, India

**भारत मौसम विज्ञान विभाग**  
**INDIA METEOROLOGICAL DEPARTMENT**

# Weather Services by India Meteorological Department



# Natural Hazards-India

- ❖ **India is vulnerable to natural hazards on account of its unique geo-climatic conditions**
- ❖ **2 monsoons, 2 cyclone seasons, heat waves /cold waves, severe thunderstorms, hail storms**
  - **8% of the total area is prone to cyclones**
  - **40 million hectares prone to floods**
  - **68% of the area is susceptible to drought**
  - **60% of the landmass prone to earthquakes of various intensities**



# Natural hazards of significant impact in India

❖ Earthquakes

❖ Cyclones

❖ Floods

❖ Droughts

❖ Tsunami

• Landslides

• Heat wave

• Cold wave

• Fog

• Pest Attacks

• Forest Fires

• Snowfall

• Avalanches

• Thunderstorm

• Lightning

• Tornado

• Squall and gale

• Hailstorm



# Time scale of major natural hazards affecting India

Phenomenon	Timescale
Earthquake	Seconds / Minutes
Tsunami	Minutes / hours
Thunderstorm	Hours
Cyclones	Days
Floods	Days
Landslides	Days
Heat & Cold waves	Days / weeks
Drought	Months



# Agencies dealing with various Hazards

## **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)**

## **ENVIRONMENTAL IMPACTS**

**-Air pollution & Haze, FOG, Smog (IITM, IMD & CPCB)**

**-Coastal Zone Management (NCCR)**

**-Coastal Erosion (NCCR)**

**-Eco-system monitoring/ modeling (IITM and IMD)**

## **GEOLOGICAL HAZARDS**

**Earthquakes & Tsunamis (NCS and INCOIS)**

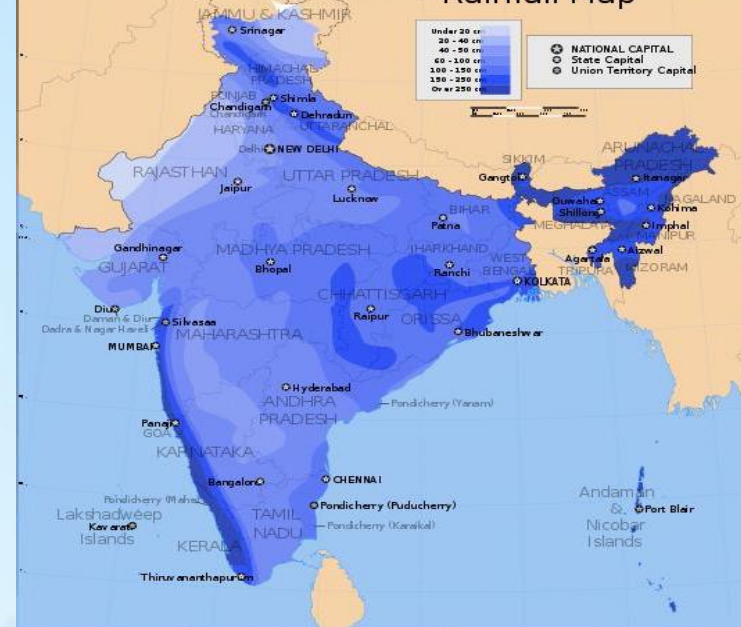
**Support for Rain Induced Landslides/Mudslides (IMD)**



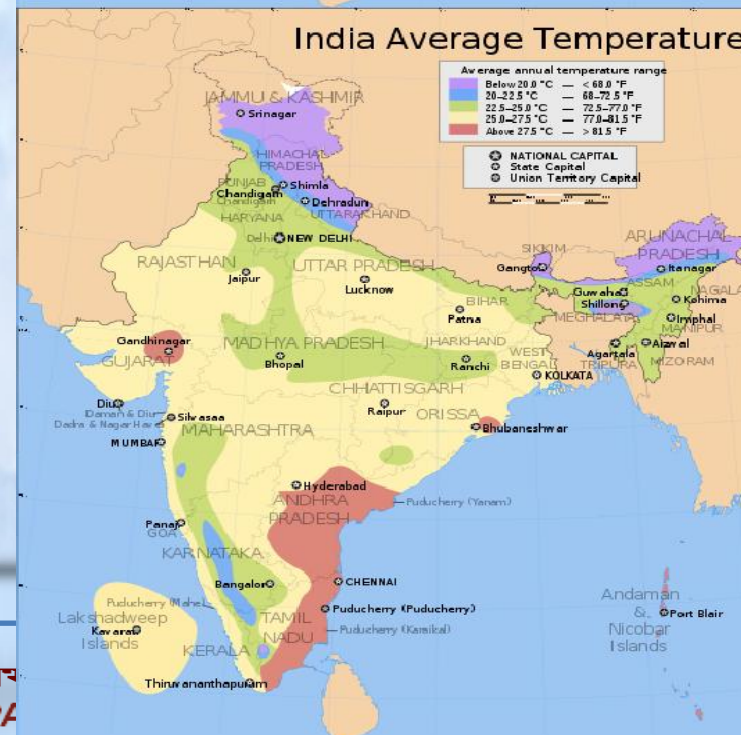
# Weather related natural hazards

- ❖ **WINTER (JAN-FEB)**
- ❖ **WESTERN DISTURBANCES COLD WAVE, FOG**
- ❖ **PRE-MONSOON (MAR-MAY)**
- ❖ **CYCLONIC DISTURBANCES HEAT WAVE THUNDER STORMS, SQUALLS HAIL STORM DUST STORM**
- ❖ **MONSOON (JUN-SEP)**
- ❖ **MONSOON DISTURBANCES HEAVY RAINFALL DROUGHTS**
- ❖ **POST-MONSOON (OCT-DEC)**
- ❖ **NORTHEAST MONSOON CYCLONIC DISTURBANCES**

India Annual Average Rainfall Map



India Average Temperature



# Warning System of IMD

- ❖ **Goal** : maximizing actions for safety
- ❖ **Components of the warning system:**
  - 1. Detection, monitoring and Warning**
    - Global, regional, national and local observations
    - Numerical weather prediction
    - Forecasts on different timescales (nowcasting to several days)
  - 2. Timely** issuing and dissemination of authoritative warning information
  - 3. Communication:** complete only after information received and understood (vs Fire and Forget)
  - 4. Risk Analysis and impact assessment**
    - Who and what is at risk and why? What will the impacts be?
  - 5. Mitigation and response:** Actions of recipients depend on:
    - **Content and clarity** of the warning
    - **Credibility** of issuing organization
    - State of **preparedness** of receiving authorities
  - 6. Scientific knowledge alone not sufficient**
    - IMD + other organizations (government organizations + local officials + emergency managers + media + voluntary and NGOs+...)



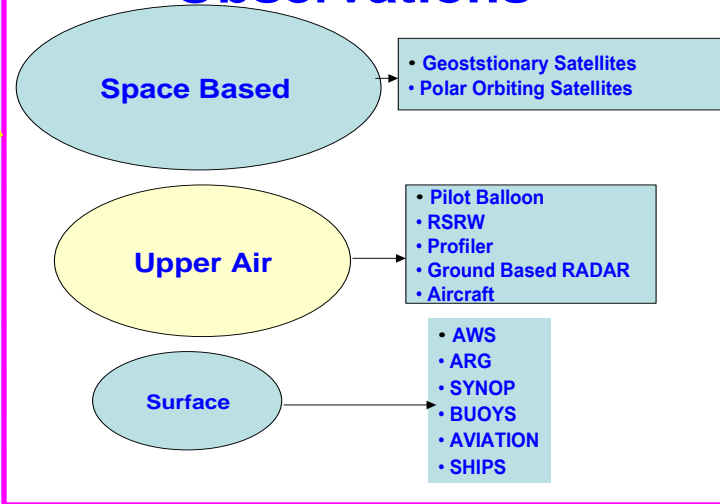
# IMD's Forecast & Warning

- ✓ Nowcast, short, medium and extended range Forecast
- ✓ Public Weather Forecast
- ✓ Long Range Forecast
- ✓ Tropical Cyclone Forecast & Warnings
- ✓ Warnings related to all other Disaster
- ✓ Sea State Forecast
- ✓ Coastal Zone Forecasts
- ✓ Forecasts to Aviation
- ✓ Forecasts for Agriculture
- ✓ Customized Forecasts to different Sectors- Power, Tourism, Defense, Adventure, Road/Railway transports, Public Utility, VIP functions, Strategic operations, Space, event based etc



# Monitoring and Forecast Process

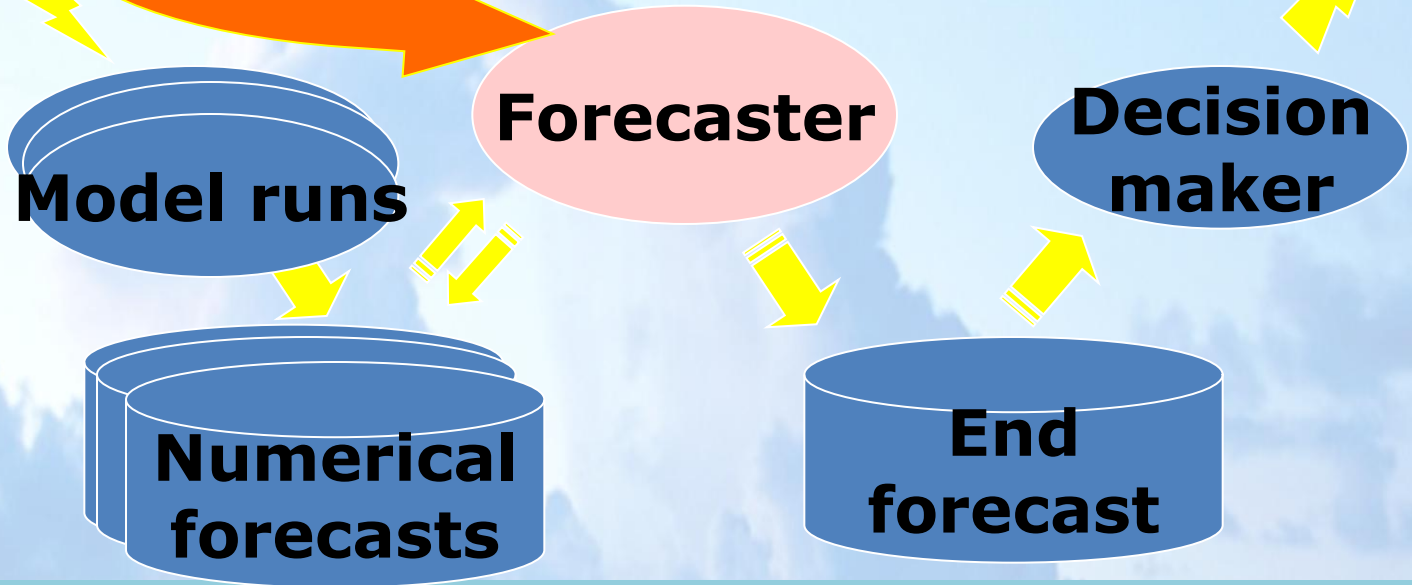
## Broad Classification of Observations



**Initial conditions (Observations)**

**Action**

Runs of different Models,  
Consecutive runs from the same model,  
Ensemble runs ("choosing the best member")



# Monitoring and Forecast Process of Tropical Cyclone



# Present practice of provision of Impact based weather forecasts: A few examples



# FOG

- Development of a system to warn of fog at least 6-24 hours in advance, calculate its severity and estimate when it is likely to lift enough for flights to take off and land safely.
- About 30 instruments have been installed along the runways to measure the surface meteorological conditions, radiation balance, turbulence, thermodynamical structure of the surface layer, droplet and aerosols microphysics, aerosol, fog water chemistry, vertical profile of winds, temperature and humidity, which are used to improve a fog weather model fine tuned by IITM.
- A new 'Fog Alert' system has recently been introduced, which enables to inform passengers about fog probability along the route, severity of fog and its probable impact on train schedules.



# Fog/visibility warning



Visibility at one or two places	<500M	Yellow
Visibility at a few/many places	<200 M	Orange
Visibility at most places	<200 M or less than <50 M	Red
No Warning	Nil	Green



# Cold wave/ visibility & ground frost warning



Cold wave (5.0 to 6.0°C below normal)	Ground frost at one or two places	Visibility at one or two places < 500 M	Yellow
Severe cold wave (7°C below normal)	Ground frost at a few places	Visibility at a few/many places <200 M	Orange
Cold day (day temp. <15°C) or severe cold wave	Ground frost at many places	Visibility at most places <50 M	Red
No warning	No warning	No warning	Green



# Heavy rain/snow & hail storm warning



Very heavy snow at one or two to many places	>65 cm	Ths + hail+Squa II	
Heavy snow at a few places	>35 cm	Ths+ hail+ squall	
Heavy snow at one or two places	>35 cm	Ths+ squall	
No warning	Nil		



# Heat wave & Thundersquall warning



Heat wave (5.0 to 6.0°C above normal)	Thundersquall at one or two places	>22 kts and above	
Severe heat wave (7.0°C above Normal or station reported 45.0° C or more)	Thundersquall at a few places	>22 kts and above	
Severe heat wave (7.0°C above Normal or station reported 45.0° C or more) at wide area	Severe Thundersquall at many places	>22 kts and above	
No warning	No warning	Nil	





# Heavy Rainfall Warning



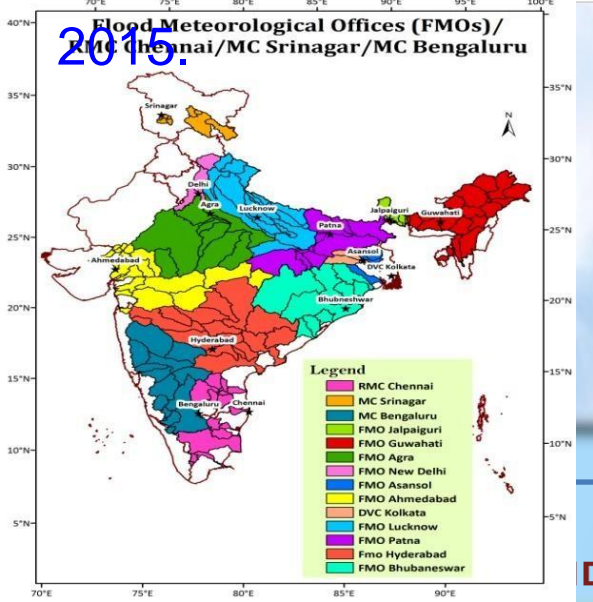
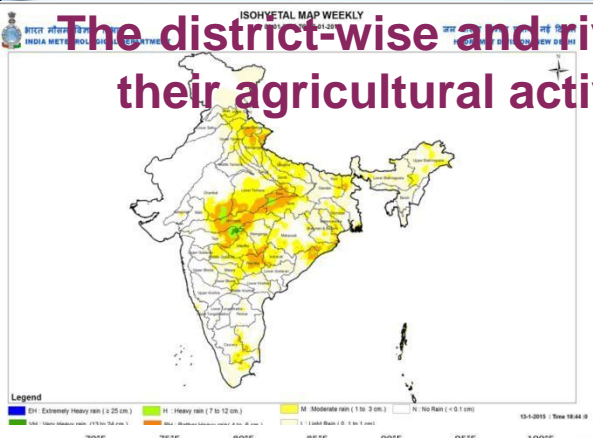
Heavy rain at one or two places	>6.5 cm or more	Yellow
Heavy to very heavy at one or two / at a few places	>12.5 cm or more	Orange
Heavy to very heavy at <b>a few places</b> or <b>extreme heavy</b>	>12.5 cm or more	Red
No warning	Nil	Green



# HYDROLOGICAL SERVICES FOR FLOOD MONITORING AND FORECASTING

- Preparation of Rainfall Statistics; following recommendation by the President of India, daily, weekly & monthly rainfall statistics prepared.
- 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.

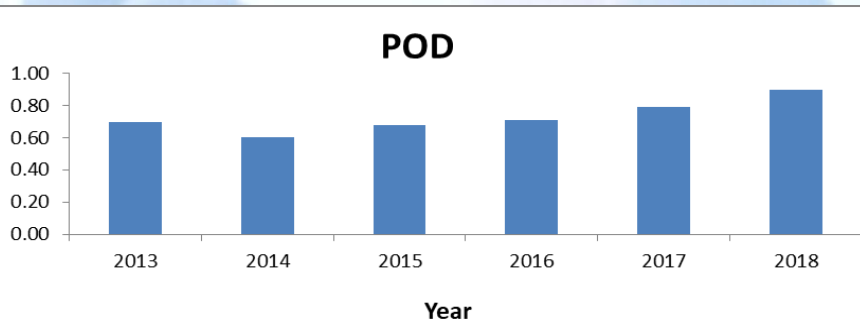
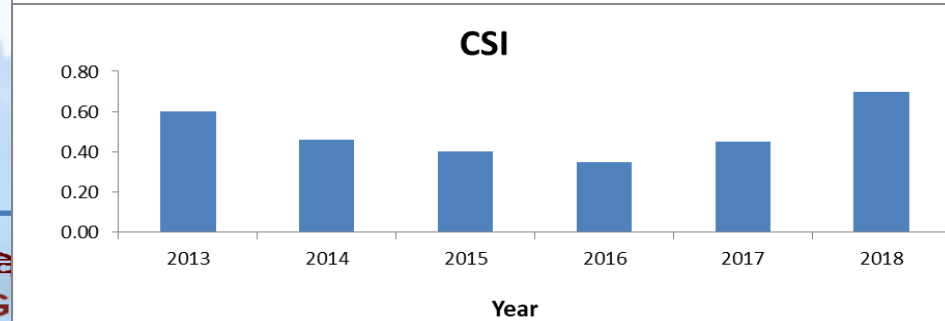
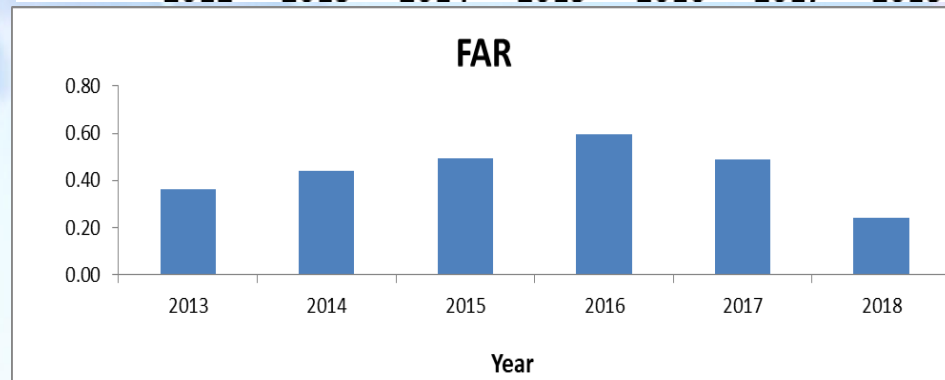
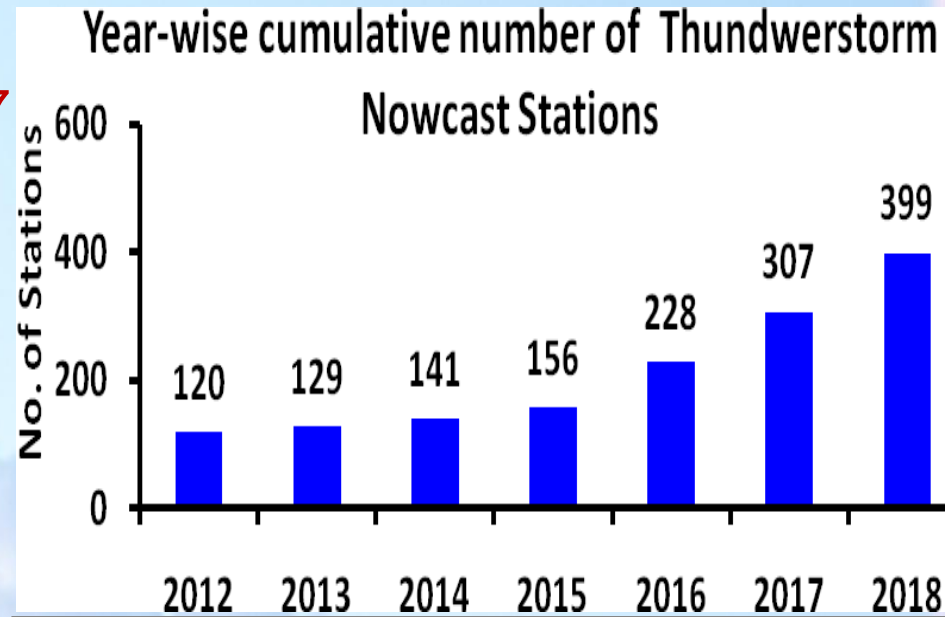


- Quantitative precipitation forecast (QPF) to CWC for flood forecast purposes increased from 125 to 146 river sub-basins.
- QPF increased from 5 day to 7 days from flood season
- Sub catchment wise QPF from NWP models- GFS for 7days in addition to WRF, MME for 3 days
- QPF for 4 new catchments Jhelum,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



# Advances in Thunderstorm Warning

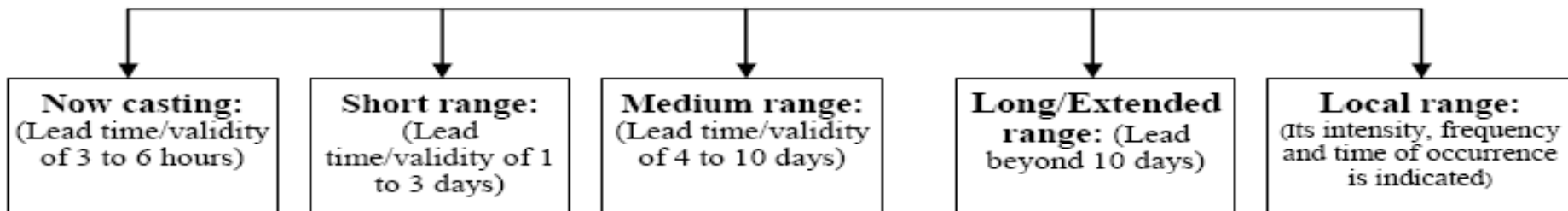
- 399 stations covered by May 2018
- Nowcasting for district level since 2017
- Nowcast Page is updated by Meteorological Centres
- Nowcast bulletins by SMS issued for severe weather for district level and transmitted through SMS and e-mail
- Enhanced DWR network by 2019 with IMD and IAF network covering entire country
- Target: location specific nowcast for 660 stations by 2019



# Sectoral Application: Health

- Seasonal and extended range (upto two weeks) outlook
- District level heat wave warning (upto five days)
- **Heat Action plan for 9 cities including Ahmedabad, Nagpur are already in place**

## Temperature Forecast: Specific Range, Time duration and area



### 3.3 Identification of Color Signals for Heat Alert<sup>3</sup>:

<b>Red Alert (Severe Condition)</b>	<b>Extreme Heat Alert for the Day</b>	<b>Normal Maximum Temp increase 6° C to more</b>
<b>Orange Alert (Moderate Condition)</b>	<b>Heat Alert Day</b>	<b>Normal Maximum Temp increase 4° C to 5° C</b>
<b>Yellow Alert (Heat-wave Warning)</b>	<b>Hot Day</b>	<b>Nearby Normal Maximum Temp.</b>
<b>White (Normal)</b>	<b>Normal Day</b>	<b>Below Normal Maximum Temp.</b>

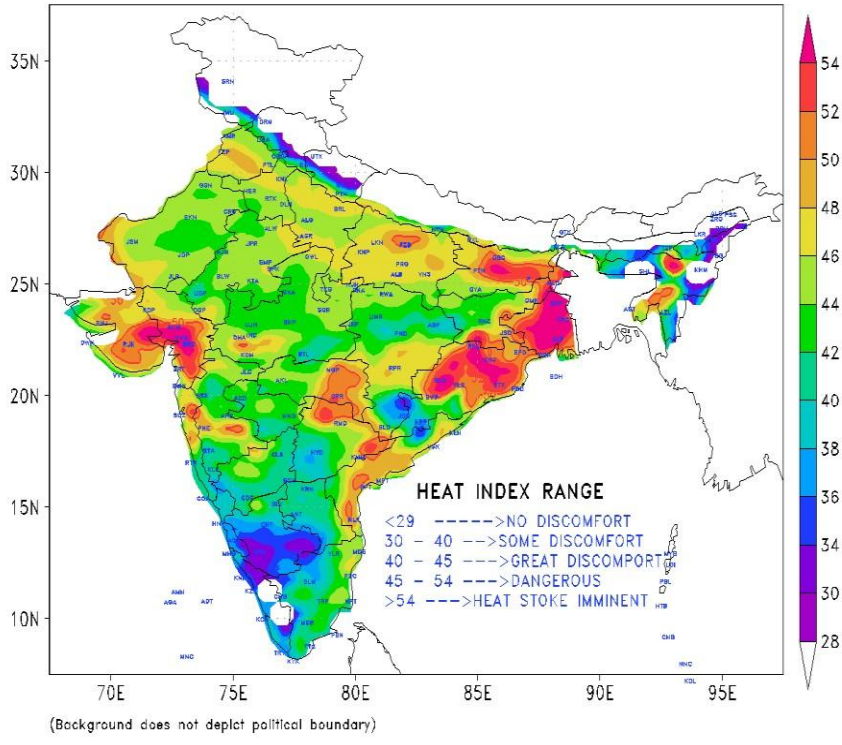
<sup>3</sup> Ahmadabad Heat Action Plan 2015



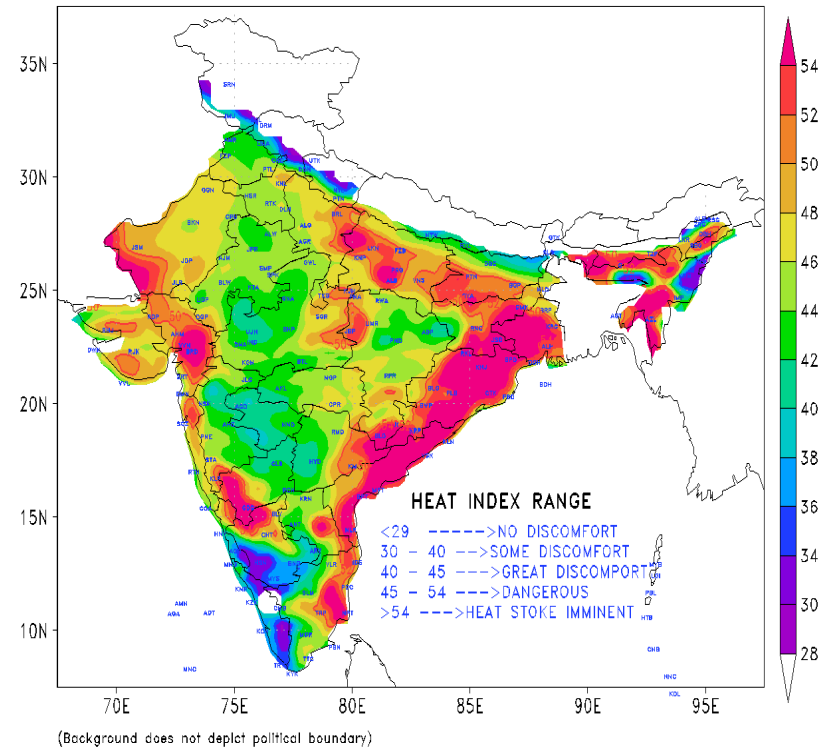
# Sectoral application-Health

## Forecast Heat index map

IMD GFS(T1534) Maximum HEAT INDEX (C) FORECAST (240 HR)  
based on 00 UTC of 24-05-2017 valid for 00 UTC of 03-06-2017



IMD GFS(T1534) Maximum HEAT INDEX (C) FORECAST (120 HR)  
based on 00 UTC of 24-05-2017 valid for 00 UTC of 29-05-2017



# Advances in Heat Wave Warning

- Seasonal and extended range (upto two weeks) outlook
- District level heat wave warning (upto five days)
- Heat action plan with different states
- Heat action plan for cities

IMD jointly received “Awards for Excellence in Climate Change Mitigation & Adaptation” under the category “Leadership in Urban Climate Action” on 17<sup>th</sup> April 2018 at New Delhi for the development & implementation of *Heat Action Plan in the country for the city of Ahmedabad* contributing to the UN sustainable development Goal on Climate

Green (No action)	Normal Day	Maximum temperatures are near normal
Yellow Alert (Be updated)	Heat Alert	Heat wave conditions at isolated pockets persists on 2 days
Orange Alert (Be prepared)	Severe Heat Alert for the day	(i) Severe heat wave conditions persists for 2 days (ii) Through not severe, but heat wave persists for 4 days or more
Red Alert (Take Action)	Extreme Heat Alert for the day	(i) Severe heat wave persists for more than 2 days. (ii) Total number of heat/severe heat wave days exceeding 6 days.



# Sectoral Application: Health

Temporal evolution of the spatial distribution of transmission window for vector borne disease using ERFs model output.

weeks	VBD	Threshold minimum temp (Th-Tmin)	Region(s) with Predicted Tmin within range of Th-Tmin	Threshold maximum temp (Th-Tmax)	Region(s) with Predicted Tmax within range of Th-Tmax
19 <sup>th</sup> May to 25 <sup>th</sup> May	Malaria Plasmodium Falciparum	16–19 °C	Himachal Pradesh and some part of Uttarakhand	33-39°C	Himachal Praedsh, Uttarakhand, Punjab, Haryana, Major part of Uttar Pradesh, whole Bihar, West Bengal, Tamilnadu, Kerala, Karnataka, Konkan, Madhya Maharashtra, Sourashtra & Kutch, Major part of Gujarat region, Northeastern states, Major part of Jharkhand.
	Malaria Plasmodium vivax	14–15 °C	Jammu and Kashmir.		
26 <sup>th</sup> May to 01 <sup>st</sup> June	Malaria Plasmodium falciparum	16–19 °C	Some part of Himachal Pradesh.	33-39°C	Uttarakhand, Himachal Pradesh, Bihar, West Bengal, Tamilnadu, Kerala, Karnataka, Madhya Maharashtra, Konkan, Sourashtra & Kutch, Major part of Jharkhand, Some part of Orissa, Andhra Pradesh, All Northeastern states.
	Malaria Plasmodium vivax	14–15 °C	Jammu and Kashmir.		



# SECTORAL APPLICATION: AGRICULTURE

## Agro-Meteorological Advisory Services (AAS):

- Based on the weekly weather forecast, advisories for farmers are developed in association with State Agricultural Universities and ICARs Krishi Vigyan Kendras (KVKs).
- These services are available in 539 districts of the country currently.
- Through this service, farmers receive weather based farm management services like crop & location -specific advisories with regard to the time of sowing of weather-sensitive high yield variety of seeds, need-based application of fertilizer, pesticides, insecticides, efficient irrigation and harvest.
- The services are made available through multi channel dissemination system like web, radio, TV, newspaper, and mobile.
- Currently about 40 million farmers have subscribed for receiving this information through mobile in vernacular languages.





# Dissemination of Agromet Advisory

## 1. Mass Mode

- ❖ All India radio, Television, Print Media

## 2. Outreach at Village level

- ❖ Ministry of IT Internet based Village Connectivity
- ❖ Web Pages: IMD, SAUs, ICAR Web Pages
- ❖ Mobile Phones (SMS & IVRS) through Public & private agencies
  - 21.69 million farmers
- ❖ Kisan Call Centres

## 3. Human face for advisory dissemination

- ❖ KVK (ICAR): Training + interaction
- ❖ DAO (SDA): Coordinate Farm inputs with Line Dept. in rhythm of weather forecast
- ❖ NGOs & other intermediary groups, Awareness Programme



# Extreme weather - Special Advisories Issued by Agromet Field Unit (AMFU), Bhubaneswar, Odisha



## Advisories for cyclonic storm “PHAILIN” on standing crops

- Drain out the excess water from the rice fields .
- Completely drain out non-paddy crops
- Spray 2% salt solution to standing crop at maturity.
- Harvest non-harvested Matured crops and keep on aerated safe place
- Strait up the lodged crops
- Apply 2<sup>nd</sup> top dressing of nitrogen or foliar spray of urea to long duration rice after flowering
- Control pests such as leaf eating caterpillar
- Harvest groundnut and hang in bunches at aerated safe place.
- Pop the sugarcane crops again

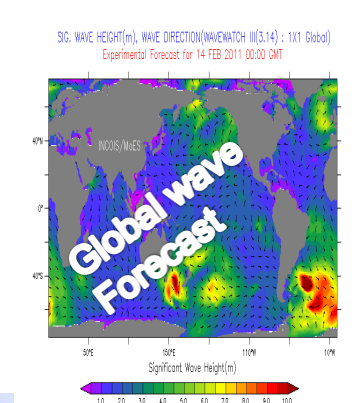
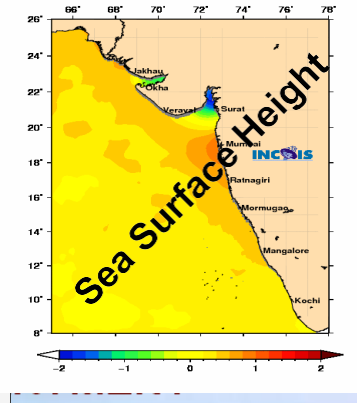
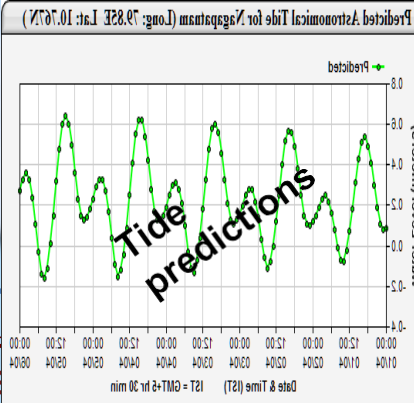
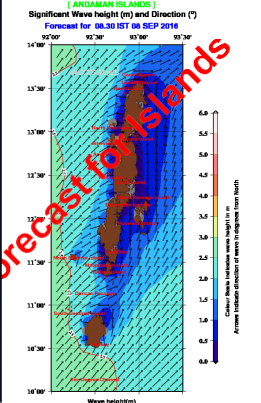
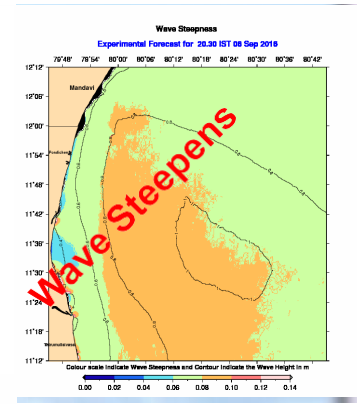
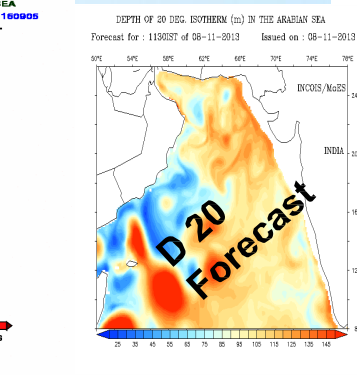
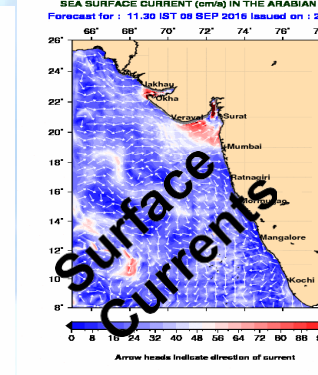
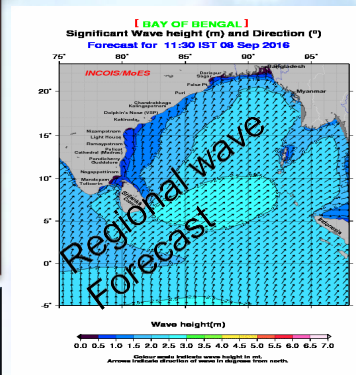
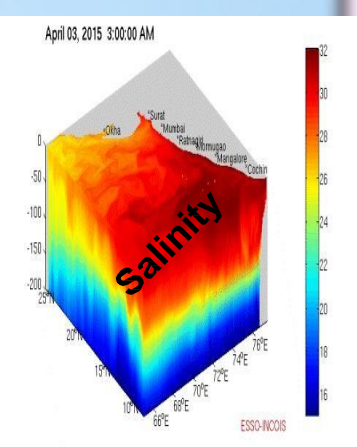
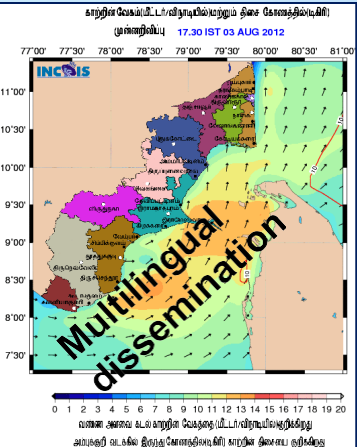
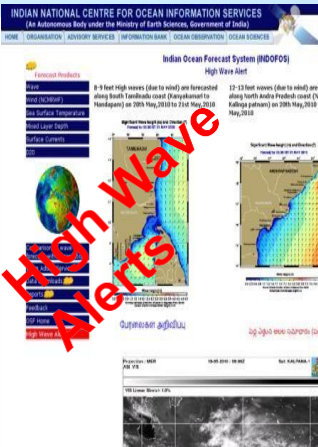
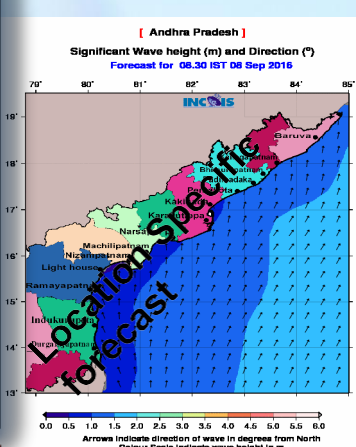
**IFFCO Kisan Sanchar Limited (IKSL) has saved many lives in coastal Odisha by sounding an alert ahead of the devastating cyclone Phailin through its unique mobile phone message facility.**

# General Ocean State Forecast Products

- Global Forecast
- Regional – 7 Regions
- Coastal – 9 Coastal states of India
- Island – A&N and Lakshadweep
- Location specific -100 locations
- Tidal forecast system for 178 locations
- Real time validation System
- Forecast dissemination in local languages

- High Wave/swell/bulletins
- Joint INCOIS – IMD Bulletins
- Bulletins on Ocean State Forecast along Standard shipping routes
- Wave surge warning

- Forecast along ship-track
- Eddy Forecasts
- OSF for Neighbouring countries through RIMES
- Navy specific forecast products
- OSF Web Map Services
- Sea State Forecast for ports and Harbours
- Online Oil spill advisories (OOSA)



# Advisories to fishermen Sudden winds and high waves

Utilise mobile phone technology to develop a sustainable warning service that reduces the vulnerability of communities in the coastal areas in the country



(1)  
Integrated  
Observations



(2)  
Severe Weather  
Forecasting



(3)  
Communication via  
mobile phone



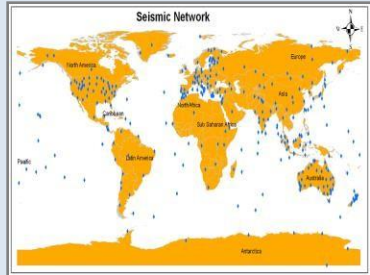
(4)  
Stakeholder  
Engagement

# Tsunami Early Warning System

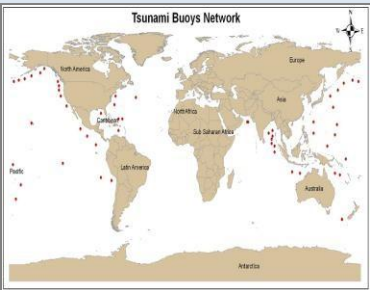
Detection

Warnings

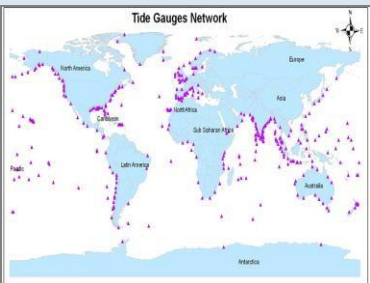
Dissemination



Seismic Network



BPR Network



Tide gauge Network

Observation Networks



VSAT



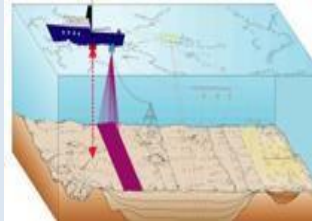
INSAT



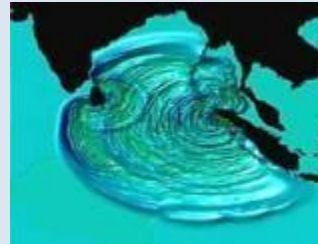
GPRS



INMARSAT



Bathymetry



Tsunami Modelling



Topography



Costal Vulnerability

Participating Institutions: IMD, NIOT, ICMAM, SOI, NRSC, INCOIS

COMMS Tests  
Tsunami Drills  
Trainings  
Publicity  
Material

MHA, NDMA, Coastal State



Capacity Building



R & D

Paleo-tsunami Modelling  
GNSS

Data Use



# CYCLONE FORECAST/ WARNING



भारत मौसम विज्ञान विभाग  
INDIA METEOROLOGICAL DEPARTMENT



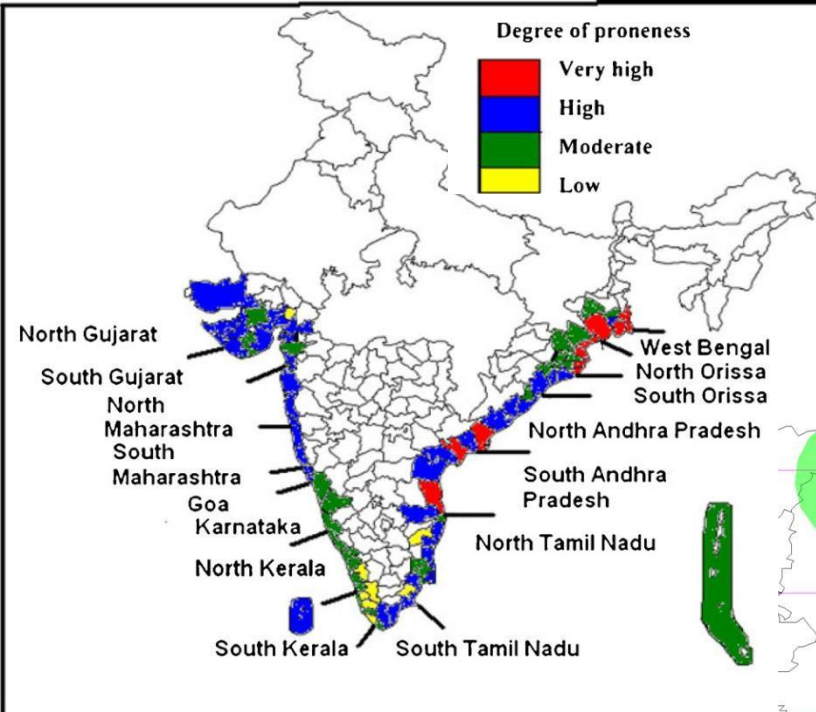
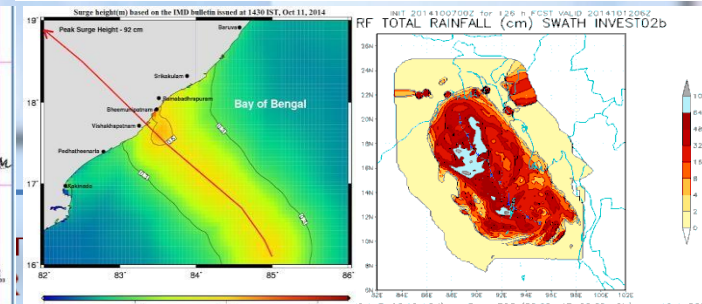
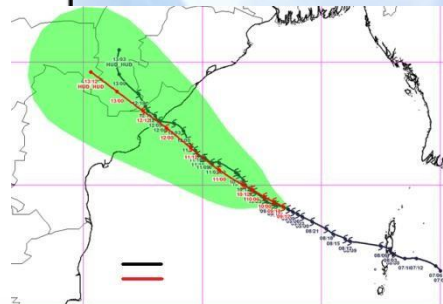
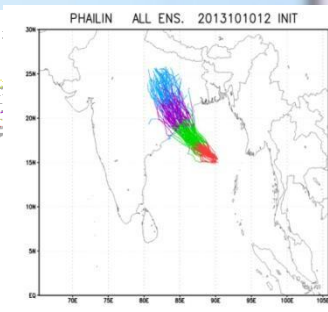
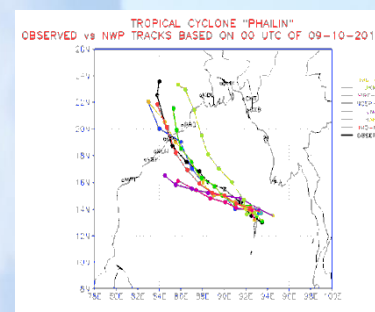
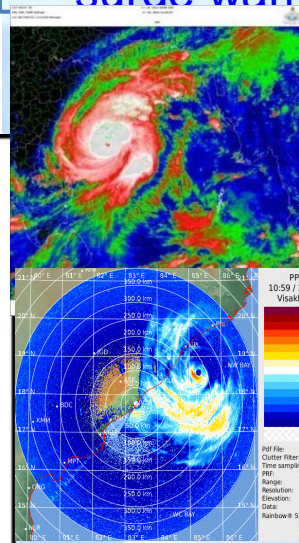
# Cyclone Monitoring & Forecasting Process Accomplishments and Challenges

## Cyclone Hazard Prone Districts

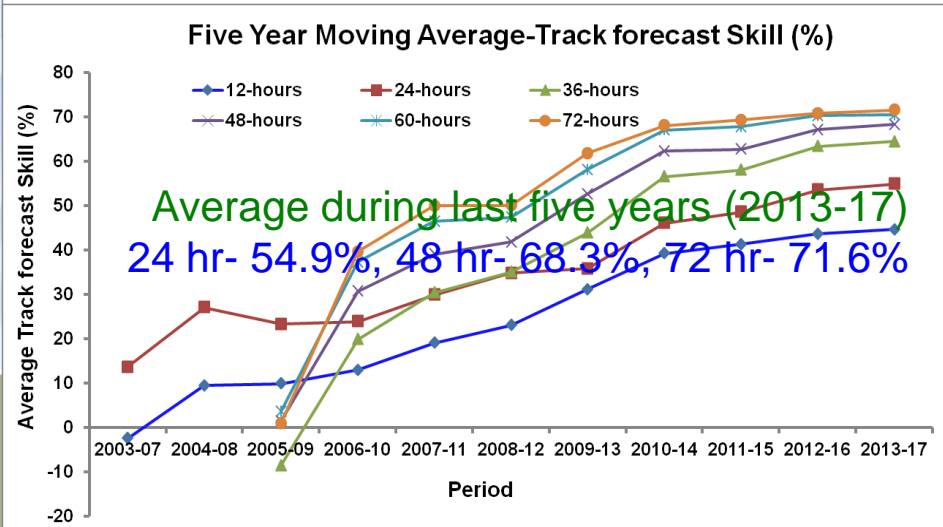
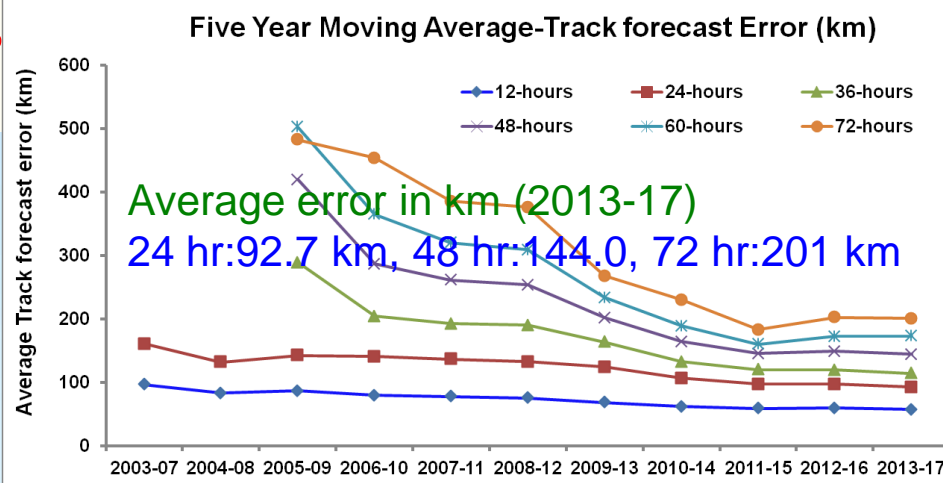
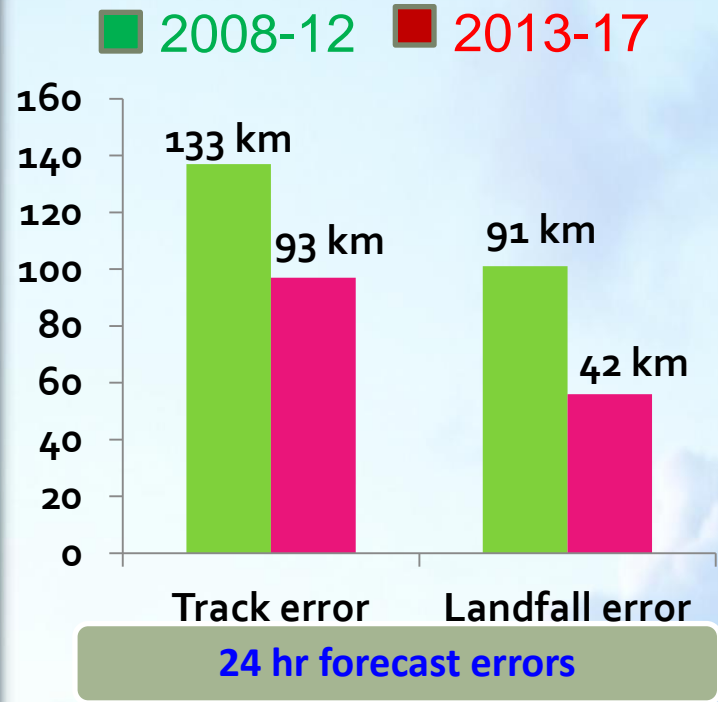
- ✓ Frequency of cyclone
- ✓ Frequency of severe cyclone
- ✓ Probable maximum Precipitation
- ✓ Wind strength
- ✓ Storm surge

About 4-5 cyclones develop over NIO, 2-3 become severe

- ❖ IMD is nodal agency for cyclone services
- ❖ Probabilistic Cyclogenesis Forecast upto 3days
- ❖ Track and intensity forecast upto 5 days in text and graphics
- ❖ Impact based heavy rainfall, wind and storm surge warning 5 days with advice for action



# Cyclone Forecast: Accomplishments and Challenges



## Challenges:

- Genesis forecast with lead period for systems developing near coast
- Intensity forecast, specially rapid intensification and weakening
- Heavy rainfall warning 9 Location specific and river catchment wise

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

Target for 2024 : Dynamical Impact based Forecast and Warning



# Advances in Warning Dissemination Mechanism

- ❖ Telephone, Tele-fax
- ❖ Mobile Phones (SMS) through IMD severe weather network, Agromet Network, INCOIS network.
- ❖ VHF/HFRT/Police Wireless
- ❖ Satellite based cyclone warning dissemination System
- ❖ Aeronautical Fixed Terminal Network
- ❖ Global telecommunication system (GTS) : (International Telecom centres)
- ❖ NAVTEX
- ❖ Internet (e-mail), ftp
- ❖ Websites, Dedicated website for cyclone ([rsmcnewdelhi.imd.gov.in](http://rsmcnewdelhi.imd.gov.in))
- ❖ Radio/TV, News Paper network (AM, FM, Community Radio, Private TV) : Prasar Bharati and private broadcasters
- ❖ GAMES and NAVIK

Fishermen warning being provided for entire Bay of Bengal and Arabian Sea valid for next five days

# Warning Dissemination Mechanism

- ❖ Telephone, Tele-fax, Mobile Phones (SMS) through IMD severe weather network, Agromet Network, INCOIS network.
- ❖ VHF/HFRT/Police Wireless, Satellite based system, NAVTEX
- ❖ Aeronautical Fixed Terminal Network
- ❖ Global telecommunication system (GTS)
- ❖ Internet (e-mail), ftp, Websites, Dedicated website for cyclone (rsmcnewdelhi.imd.gov.in), earthquake, webpages for monsoon, thunderstorm, heat wave etc
- ❖ Radio/TV, News Paper network (AM, FM, Community Radio, Private TV) :
- ❖ Social Media (Face book, Twitter)
- ❖ Last Mile connectivity by state Govts

## By 2024

- More use of IT to increase reach out to general public, media, disaster managers, specific users and decision making authorities.

- Display System at all mega cities and tourist places
- Mobile APP for cities and tourist places, Common Alert Protocol for all hazards



# Present System of Four Stage Warning

- ❖ **First stage-‘pre-cyclone watch’** issued 72 hours in advance -as soon as a depression forms in the Indian seas-Issued to all key functionaries of Central government and chief secretaries of concerned maritime states. **(Yellow Message)**
- ❖ **Second stage is the ‘Cyclone alert’** issued to all concerned states and central government officials 48 hours before the commencement of bad weather. **(Orange Message)**
- ❖ **Third stage is the ‘cyclone warning’** issued to all concerned people 24 hours in advance of commencement of bad weather indicating latest position of Tropical Cyclone, intensity, time and point of landfall, storm surge height, type of damages expected and actions suggested. **(Red Message)**
- ❖ **Fourth stage is the ‘post – landfall outlook’,** issued at least 12 hours in advance of the landfall & till cyclone force winds prevail; District Collectors of interior districts besides the coastal areas are also informed.
- ❖ **Finally a ‘De-Warning’ message is issued when the Tropical Cyclone weakens into Depression stage.**



# WARNING PRODUCTS PRESENTATION

- The TC warning system serves primarily as a trigger for action.
- The content of the bulletins should contain information on the TC useful to the targeted audience.
- Precautionary advisories are particularly useful to the underprivileged people for taking protective actions.
  - The set of precautionary announcements and advisories based on pre-agreed courses of actions with the parties concerned are selected at the time to reflect prevailing circumstances to give maximum protection.
  - Textual warning bulletins are broadcast over radio and TV. As long bulletins are difficult to be read out, it is important to curtail the length of bulletins without sacrificing safety.
  - Visual impacts with graphics and animations are the strength of television.



# FORMAT FOR CYCLONE WARNING BULLETIN FOR AIR/PRESS / PUBLIC

Cyclone Alert / Warning Bulletin No. \_\_\_\_\_ issued by \_\_ at \_\_ Hrs. IST on \_\_\_\_\_ (Date) for repeated broadcast at hourly / half hourly intervals.

Cyclone Alert / Warning for \_\_\_\_\_ Districts. Cyclone centred at \_\_\_\_\_ hrs. IST of \_\_\_\_\_ (date) about \_\_\_\_\_ kms. \_\_\_\_\_ of (direction) \_\_\_\_\_ (Place). Expected to intensify further and move in a

\_\_\_\_\_ direction and cross  
\_\_\_\_\_ coast near /  
\_\_\_\_\_ between  
\_\_\_\_\_ (Place) \_\_\_\_\_ (day/time).

Under its influence heavy to very heavy rain/extremely heavy rain likely cause floods in \_\_\_\_\_ districts commencing from \_\_\_\_\_ (time/day). Gales speed reaching \_\_\_\_\_ kmph causing \_\_\_\_\_ damage \_\_\_\_\_ in \_\_\_\_\_ districts commencing from \_\_\_\_\_ (Date/Time) Gale force winds reaching -- kmph likely extend into

\_\_\_\_\_ Districts, causing damage in \_\_\_\_\_ districts. Tidal wave of \_\_\_\_\_ m Likely inundate low lying area of \_\_\_\_\_ Districts at the time of crossing coast.

Fishermen advised not to venture out. Public advised to cooperate with the State authorities in disaster management efforts



# FORMAT FOR STATE/CENTRAL GOVT. OFFICIALS/VITAL INSTALLATIONS / REGISTERED USERS

**Cyclone Alert/ Cyclone Warning Bulletin No. Date and Time of Issue:**

**(i)Information on cyclone :**

**The cyclonic storm lay over.....Bay of Bengal/Arabian Sea Center.....kms.....(Direction) of ..... place.**

**(ii)Forecast Further intensification: Direction of Movement:**

**Expected landfall area: Expected time of landfall:**

**(iii)Weather Warning (a)Rainfall.....in.....Districts(Names) (b)Gales reaching.....in.....Districts(Names)**

**(c)Gale force winds reaching 35 knots in ..... Districts**

**(d)Tidal waves ..... in coastal areas of ..... Districts (Names)**

**(e)Sea condition: (**

**f)Damage(As per IMD instruction).....Districts(Names)**

**(g)Likely impacts as per IMD Monograph on “Damage Potential of Tropical (iv)Advice**

- (a) Fishermen not to venture into open sea.**
- (b) Evacuation of people from low lying areas to safer places/Cyclone Shelters.**
- (c) General public in the threat area advised to be indoors.**
- (d) Rail & road transport to be regulated.**



# SWFDP – Bay of Bengal

*Focus: Coastal communities and activities*



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

*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 with*



<b>HAZARD</b>	<b>THRESHOLD</b>	<b>COMMENTS</b>
<b>Heavy Rain</b>	<p>≥ 50 mm in 24 hours            ≥ 100 mm in 24 hours            (the risk over 200mm/24 should be described in discussion in the Regional Guidance)</p>	<p>The operational country-thresholds may differ widely among participating countries of SWFDP-Bay of Bengal. NMHSs may translate the heavy rain into potential flooding in areas likely to be affected by heavy rain depending upon the soil condition, topography and drainage systems in respective areas</p>
<b>Strong winds</b>	<p>≥ 17 knots (over land and Sea)            ≥ 34 knots (over Sea)</p>	<p>Affecting oceanic and coastal areas especially. Gusts on land from severe convective systems are not predictable on this time scale effectively</p>
<b>High Waves</b>	<p>≥ 2.5 m</p>	<p>NMHSs may use the information contained in the RSMC Guidance Product to generate impact-based forecasts and risk-based warnings for use by the coastal communities, fisheries, disaster managers etc. at national levels.</p>
<b>Storm Surge</b>	<p>≥ 1m</p>	





## Coastal inundation FDP (CIFDP): Bangladesh

- ❖ Coastal Inundation Forecasting Demonstration Project (CIFDP), Bangladesh
- ❖ RSMC, New Delhi to provide TC forecast for running coastal inundation model
- ❖ INCOIS in collaboration with IMD organized training for the forecasters from the WMO/ESCAP Panel region for storm surge, coastal inundation and Ocean waves with the support of UN-ESCAP in 2016
- ❖ Further training is planned in 2018 with support from WMO



# South Asia Flash Flood Guidance (SAsiaFFGS)

- ❖ **IMD, New Delhi is the SAsiaFFGS Regional Centre.**
- ❖ **The responsibilities include: (i)Collection of the required historical hydrometeorological data and spatial (GIS) data needed for system development from the participating countries; and (ii) assisting the HRC in coordinating country-specific reviews of various products created and data sets used during system development.**
- ❖ **Regional Centre will provide appropriate communications, infrastructure facilities and human resources to maintain and operate SAsiaFFGS computational hardware that is used to develop and disseminate regional and country graphical products and data for participating NMHSs in the South Asian region.**



# SAsiaFFGS

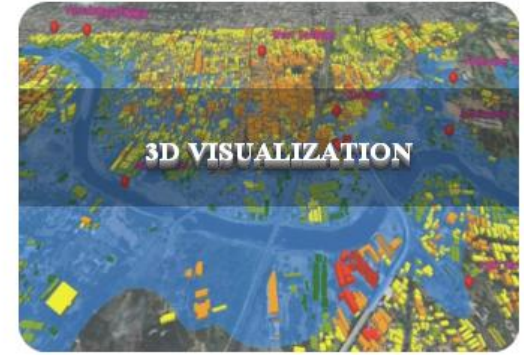
- ❖ Regional Centre will provide regional and national verification of SAsiaFFGS flash flood forecasts and warnings and will advise the participating NMHSs of any concerns with system products.
- ❖ Where appropriate, the Regional Centre will assist the participating NMHSs with the issuance of flash flood watches and warnings in a consistent format using the SAsiaFFGS as well as other information and tools that may be available. However, the participating NMHSs retain the responsibility for disseminating forecasts and warnings to users within their respective jurisdictions.
- ❖ Regional Centre, in collaboration with WMO, will organize and provide routine training on system operations, product interpretation, product verification, and other items as deemed appropriate to participating NMHSs forecasters. Regional Centre may provide on-the-job training to forecasters from participating NMHSs.



**An example of development of an impact  
forecast model.....**



# Chennai Flood Warning System Dashboard



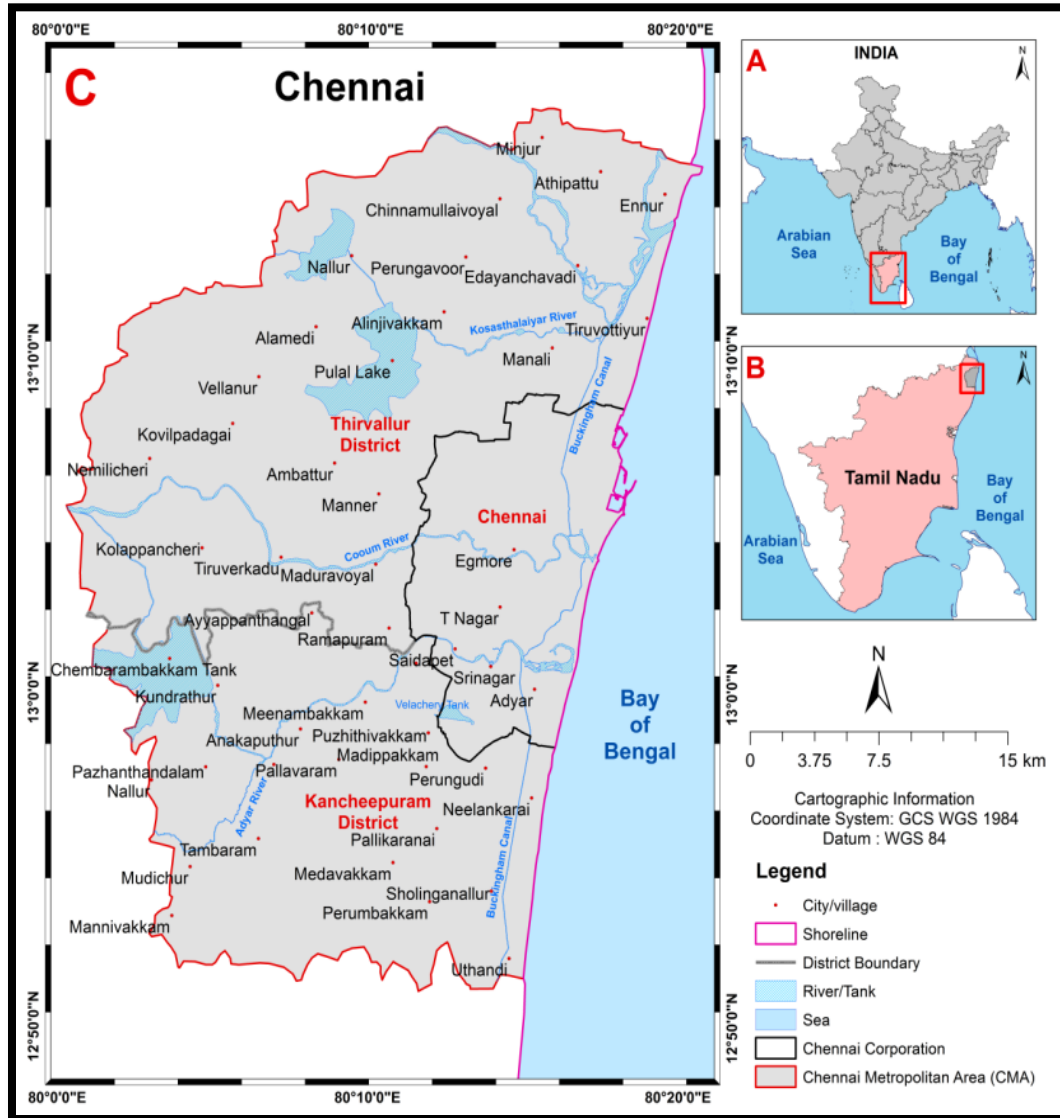
- *A disaster preparedness decision support system for coastal flooding in urban areas*

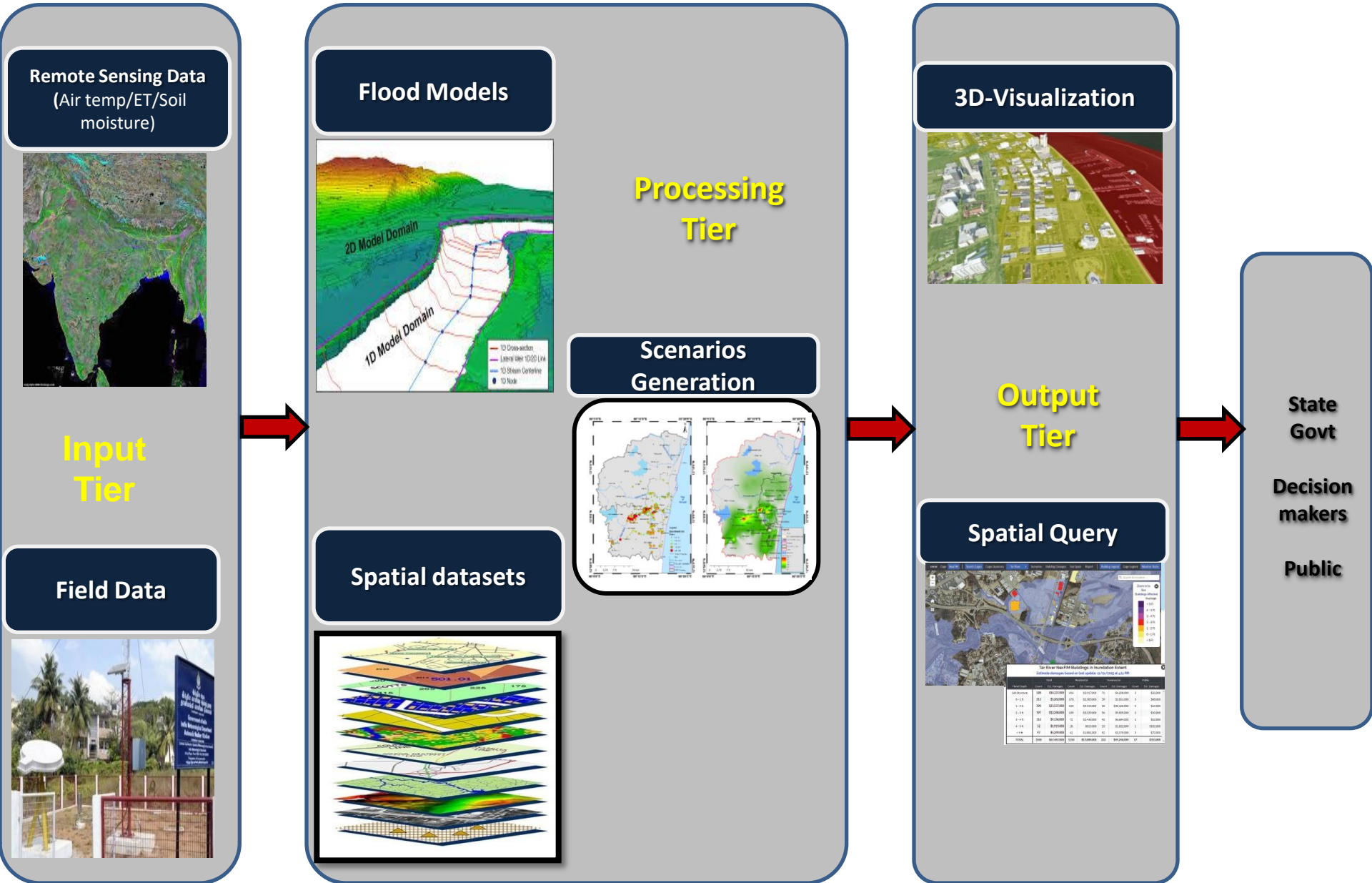


# About Chennai

Chennai's drainage system--both natural and man-made--is unparalleled. Three rivers Kosasthalaiyar to the north, the Cooum through the centre and the Adyar to the south, 16 major drains criss-cross the metro, in addition to the mammoth Buckingham canal along the coast. Around 2000 km of micro drains flush stormwater out in addition to the Ennore creek and the Pallikaranai marsh.

The northeast monsoon season (NEM) - October to December is the chief rainy season for Tamil Nadu.

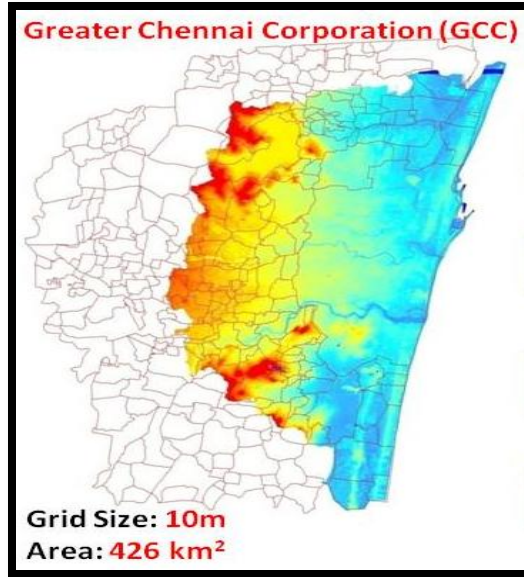




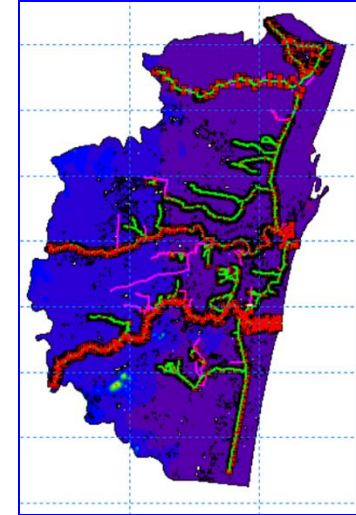
### Thematic layers of Chennai



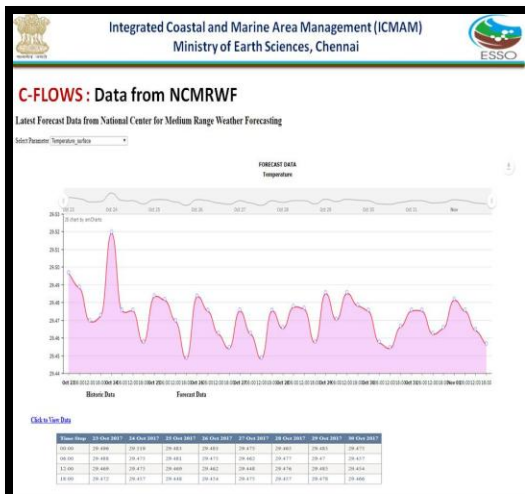
### Elevation



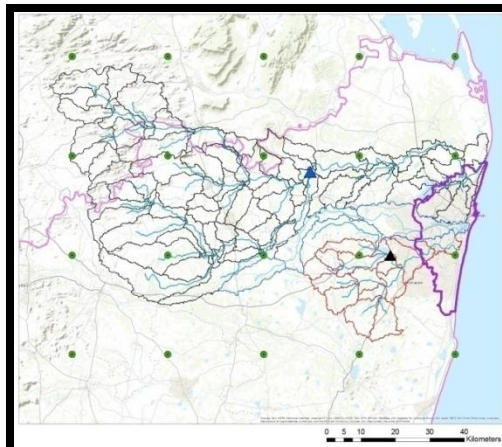
### River Cross section



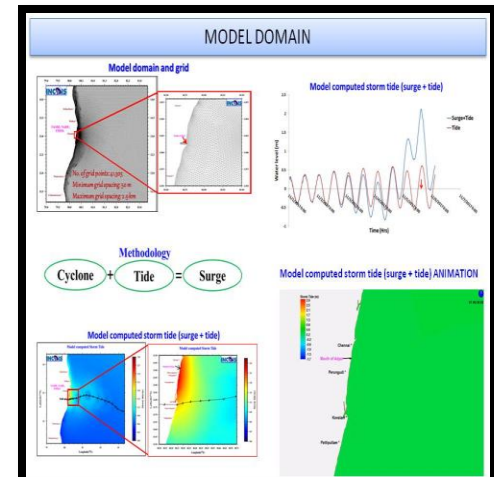
### Met data



### Discharge/flow data



### Ocean State





## IMD

# Meteorological Models

### GFS

12km X 12km grid  
Twice update /day  
Forecast for ten days  
Precipitation  
Temperature  
Run off  
Soil moisture etc

### WRF

9km X 9km grid  
Twice update /day  
Forecast for three days  
Precipitation  
Temperature  
Run off  
Soil moisture etc.

### Satellite Meteorology

0.1° X 0.1° grid  
30 minutes interval  
Accumulated Rainfall

### ARG & AWS

Point data  
One update/day

### Radar

## NCMRWF

NEPS – with 23 members (In 2015, 44 ensemble)  
Six hourly  
13km X 19km grid

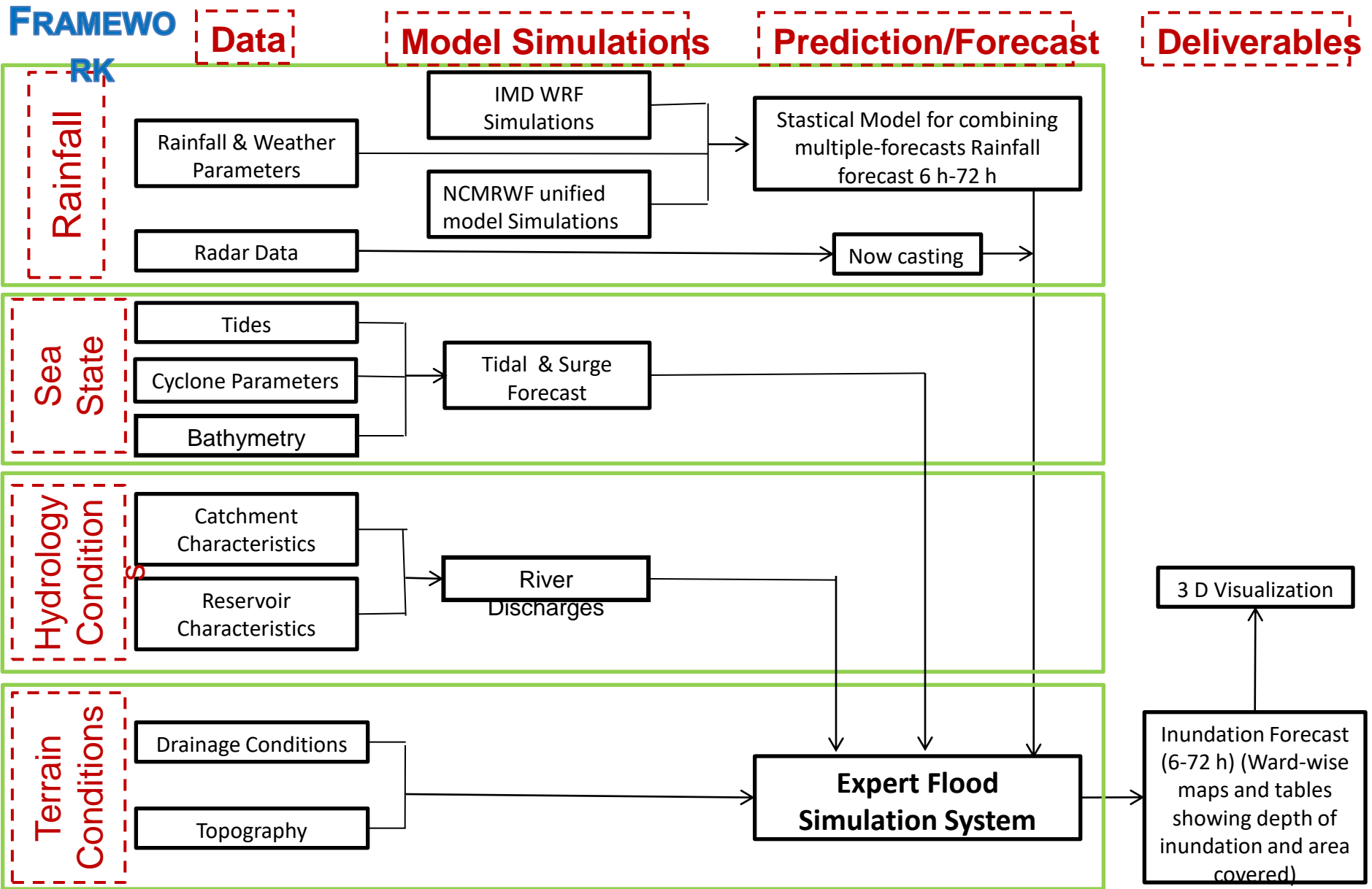


# National Centre for Coastal Research (NCCR)

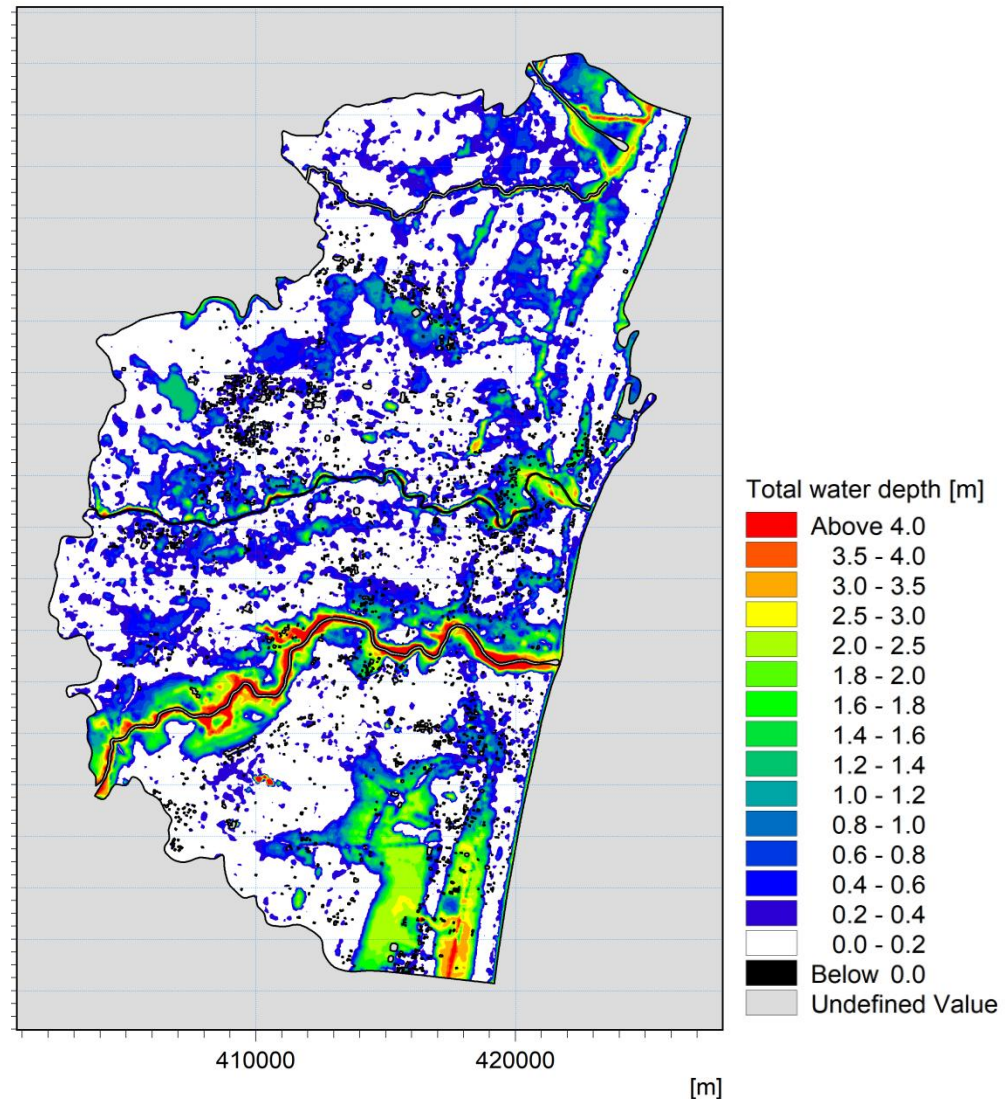
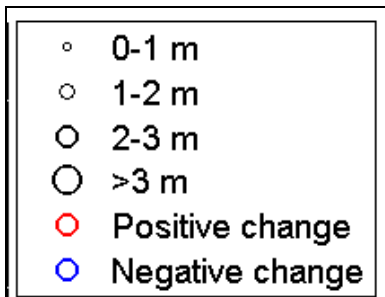
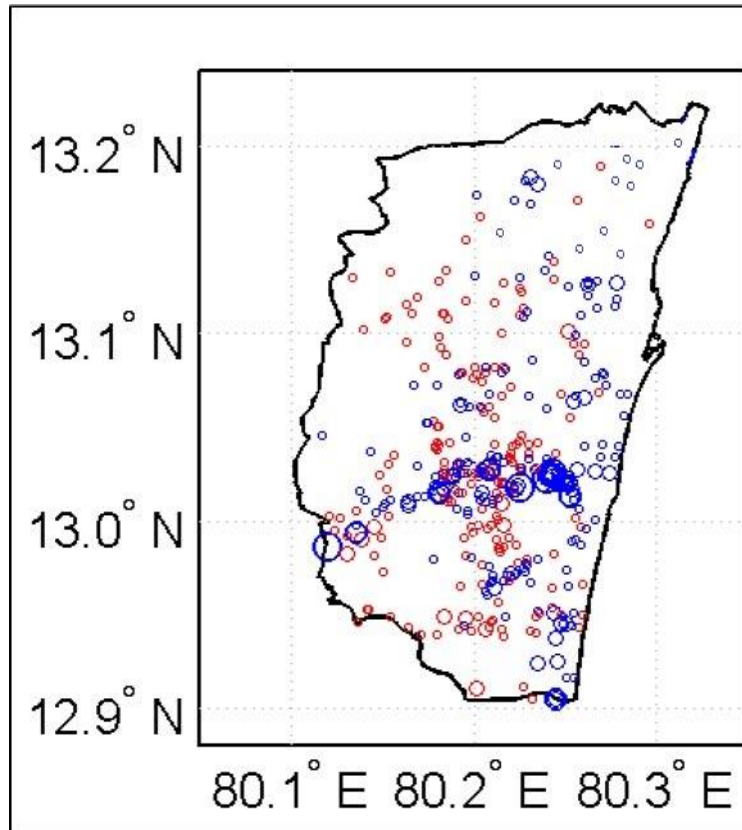
## Ministry of Earth Sciences



### FRAMEWORK



# FIELD DATA VALIDATION - 2015



# Field data collection



Field data collection  
Along with  
Geotagged  
pictures





# LIBRARY CASES

## Water Elevation

- ✓ HHWN Surge
- ✓ HHWS Surge
- ✓ HHWN Surge
- ✓ LLWS Surge
- ✓ HHWS
- ✓ LLWS

## Discharge

- ✓ Dry
- ✓ Average
- ✓ Wet

## Rain Fall

- ✓ Return Periods -  
>2,5,10,25,50,75,100,200
- ✓ Duration -> 1, 3, 6, 12, 18, 24

➤ Flood Scenarios (792) generated for Possible range of met-ocean condition.



# Modules in C-FLOWS

**Module I : Chennai SmartCity Database**

(CSD)

**Module II : Chennai Flood Vulnerability (CFV)**

**Module III : 3D GIS Visualization Module (3D GIS)**

**Module IV : Online Data Hub (ODH)**

**Module V : Flood Info – Crowd sourcing (FCS)**

**Module VI : DSS for C-FLOWS (DSS)**

## Module III :

### 3D GIS Visualization Module (3D GIS)

Build using Arcscene, the model outputs are overlaid on data layers such as infrastructure, building and roads, ward boundaries etc to enable realistic visualization.

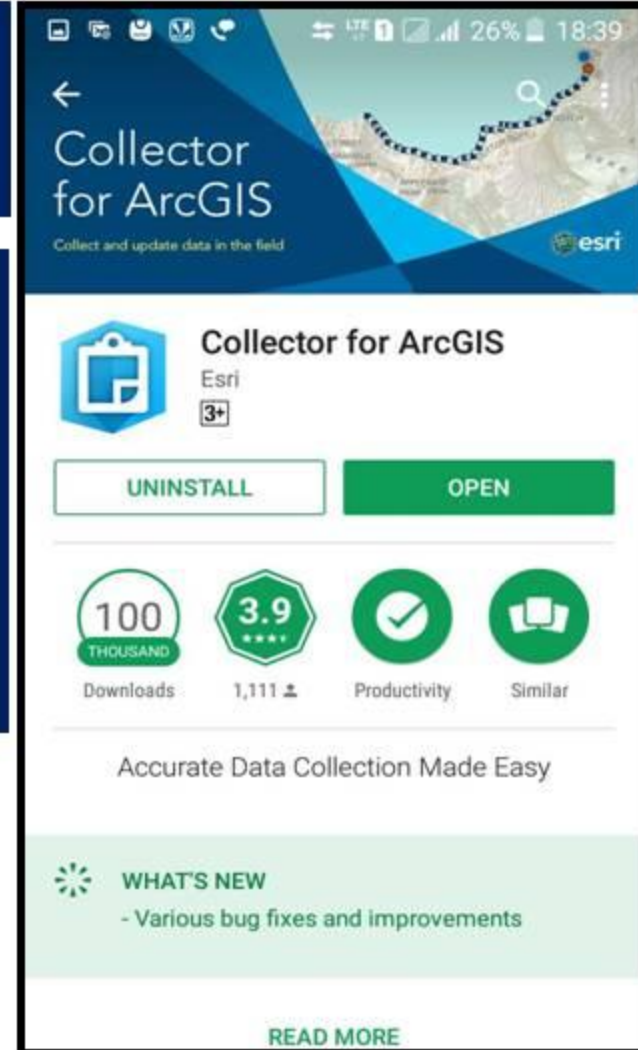


## Module V :

### Flood Info – Crowd sourcing (FCS)

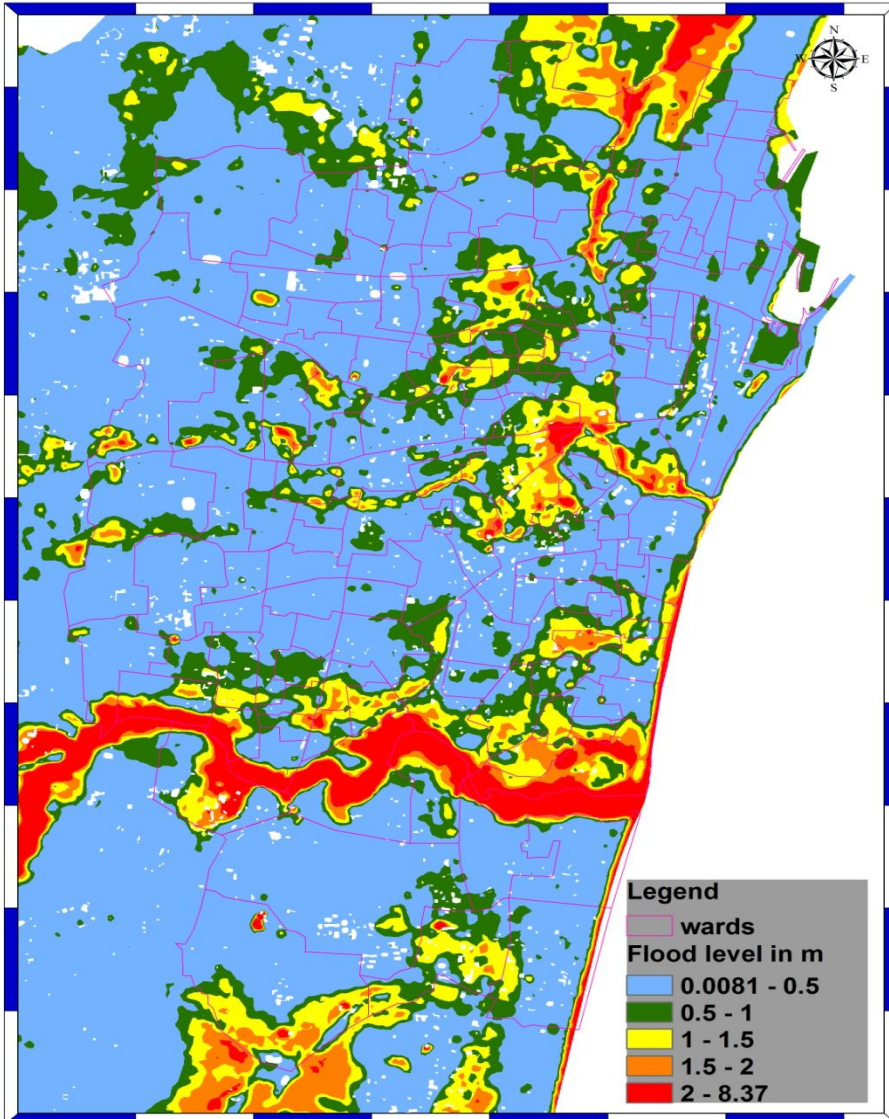
ArcGIS Collector  
ODK Forms

- An mobile app has been developed to enable the data collection on Flood levels and directly upload it on the server to view the present ground condition.
- Both data and geo tagged field photographs can be seen and checked by the decision maker as and when it is being uploaded.
- This would provide the primary information for the decision maker to plan relief and mitigation operations.





### C-FLOWS : Query Module : Wards where flooding is more than 2m



S.No	Ward Name	S.No	Ward Name
1	Adikesavapuram	28	Kumaran Nagar (South)
2	Adyar (East)	29	Kumarasamy Nagar (South)
3	Adyar (West)	30	Maraimalai Adigal Nagar (South)
4	Alwarpet (South)	31	Marina
5	Anna Nagar (Central)	32	Nehru Nagar
6	Anna Nagar (East)	33	Panneer Selvam Nagar
7	Anna Nagar (West)	34	Pattalam
8	Avvai Nagar (South)	35	Poonga Nagar
9	Avvai Nagar (South)	36	Pudupet
10	Azas Nagar (South)	37	Raja Annamalai Puram
11	Azhagiri Nagar	38	Saidapet
12	Bharthidasan Nagar	39	Saidapet (West)
13	Dr.Radhakrishnan Nagar (North)	40	Saligarmam
14	Dr.Radhakrishnan Nagar (South)	41	Santhome
15	Egmore	42	Thiruvanmiyur (East)
16	G D Naidu Nagar (East)	43	Thiruvanmiyur (West)
17	G. D Naidu Nagar (West)	44	Thousand Lights
18	Guindy (West)	45	V O C Nagar
19	Kachaleeswarar Nagar	46	Vallalseethakathi Nagar
20	Kalaingar Karunanidhi Nagar	47	Velachery
21	Karaneeswarapuram	48	Villiwakkam (South)
22	Kilpauk (North)	49	Virugambakkam (South)
23	Kodambakkam (North)	50	Vivekananda Puram
24	Kodambakkam (South)	51	Vyasarpet (North)
25	Kodungaiyur (East)	52	Vyasarpet (South)



# C-FLOWS : Proposed Setup



**C-FLOWS is developed as an integrated WebGIS based portal to primarily help the Tamil Nadu Government in their flood mitigation and relief operations**

# Concluding Remarks

- ✓ Impact threshold based warnings have been provided since long under Registered / Designated warnees list
- ✓ At present India follows a combination of phenomenon based and impact based weather warnings
- ✓ Under Weather & Climate Science for Service Partnership (WCSSP) – programme, further improvements in Risk based forecasting of High impact weather & climate events are planned on an extensive scale in collaboration with UKMO, during next 3 year period.



**Thank You ALL**



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**भारत मौसम विज्ञान विभाग**  
**INDIA METEOROLOGICAL DEPARTMENT**

