Early Warning System (EWS)

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Presentation layout

❖ **Overview of hazards**

❖ **Institutional mechanisms and framework for EWS**

❖ **Determining the possibility for establishing EWS**

❖ **Tools for end-to-end EWS**

❖ **Conclusions**

Overview of Major Natural Hazards and risk management

- Floods   - Days
- Earthquakes   - Second/Minutes
- Cyclones   - Days
- Droughts   - Months
- Landslides   - Days
- Avalanches   - Days
- Heat/Cold waves - Days/Weeks
- Tsunami   - Minutes/ Hours
- Thunderstorm   - Minutes/ Hours

Risk management

- Hazard Analysis and statistics
- Vulnerability Analysis
- Preparedness and Planning
- Early Warning System
- Prevention and Mitigation

Early Warning Components

- Monitoring
- Observation and analysis
- Prediction
- Warning generation
- Warning dissemination
- Out-reach

SFDRR: PRIORITY ACTION 4:
ENHANCING DISASTER PREPAREDNESS FOR EFFECTIVE RESPONSE AND TO "BUILD BACK BETTER" IN RECOVERY REHABILITATION AND RECONSTRUCTION

Key Issues :

- To invest in, develop, maintain and strengthen people-centred multi-hazard, multisectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies and hazard-monitoring telecommunications systems;

- develop such systems through a participatory process;

- tailor them to the needs of users, including social and cultural requirements, in particular gender;

- promote the application of simple and low-cost early warning equipment and facilities; and

- broaden release channels for natural disaster early warning information;

SFDRR: PRIORITY ACTION 4:
REHAENHANCING DISASTER PREPAREDNESS FOR EFFECTIVE RESPONSE AND TO "BUILD BACK BETTER" IN RECOVERY AND RECONSTRUCTION

Key Issues :

- **To promote the further development of and investment in effective, nationally compatible, regional multi-hazard early warning mechanisms, where relevant, in line with the Global Framework for Climate Services, and**

- **facilitate the sharing and exchange of information across all countries;**

OVERVIEW OF ACCOMPLISHMENTS AND CHALLENGES IN EARLY WARNING SYSTEM

- **Institutional Mechanism**
- **Early Warning system**

  Infrastructure

  Standard Protocols

- **Regional cooperation**
- **R&D**
- **Capacity Building**
- **Confidence building measures**

Institutional Arrangement : India as an Example

- **India Meteorological Department** : **All Meteorological hazards**

- **Central Water Commission** : **Floods,**

- **Geological Survey of India** : **Landslides**

- **National Centre for Seismology, MoES** : **Earthquake**

- **Indian National Centre for Ocean Information Services** : **Tsunami**

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Better Institutional Arrangement with establishment of MoES in 2006

MoES 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 (IMD)
-Coastal Zone Management (ICMAM)
-Coastal Erosion (ICMAM)
-Eco-system monitoring/ modeling
(IITM and IMD)

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

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Role of Meteorological Information in DRR

❖ **Meteorological Information is used in several ways for Disaster Risk Reduction. Key roles are mentioned below:**

- **Hazard Monitoring and Assessment**

- **Early warning and mitigation.**

- **Technical support in vulnerability analysis, mapping and risk assessment**

- **Technical support in preparedness & planning,**

- **Technical support in management of natural resources from disasters (Agriculture/Water resources, Energy Resources etc)**

Early Warning System

Broad Classification of Observations

Space Based
- Geoststionary Satellites
- Polar Orbiting Satellites

Upper Air
- Pilot Balloon
- RSRW
- Profiler
- Ground Based RADAR
- Aircraft

Surface
- AWS
- ARG
- SYNOP
- BUOYS
- AVIATION
- SHIPS
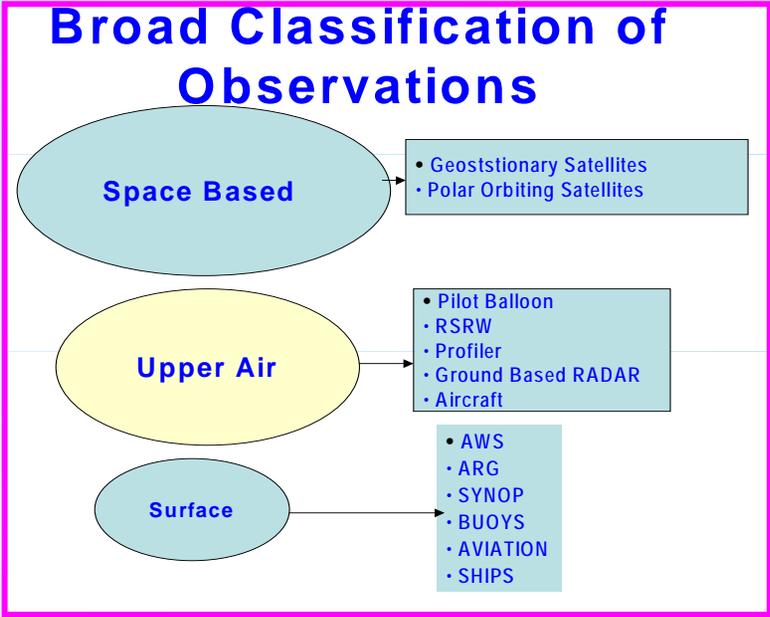
Initial conditions (Observations)

Action

Runs of different Models,

Consecutive runs from the same model,

Ensemble runs ("choosing the best member")

Model runs

Forecaster

Decision maker

Numerical forecasts
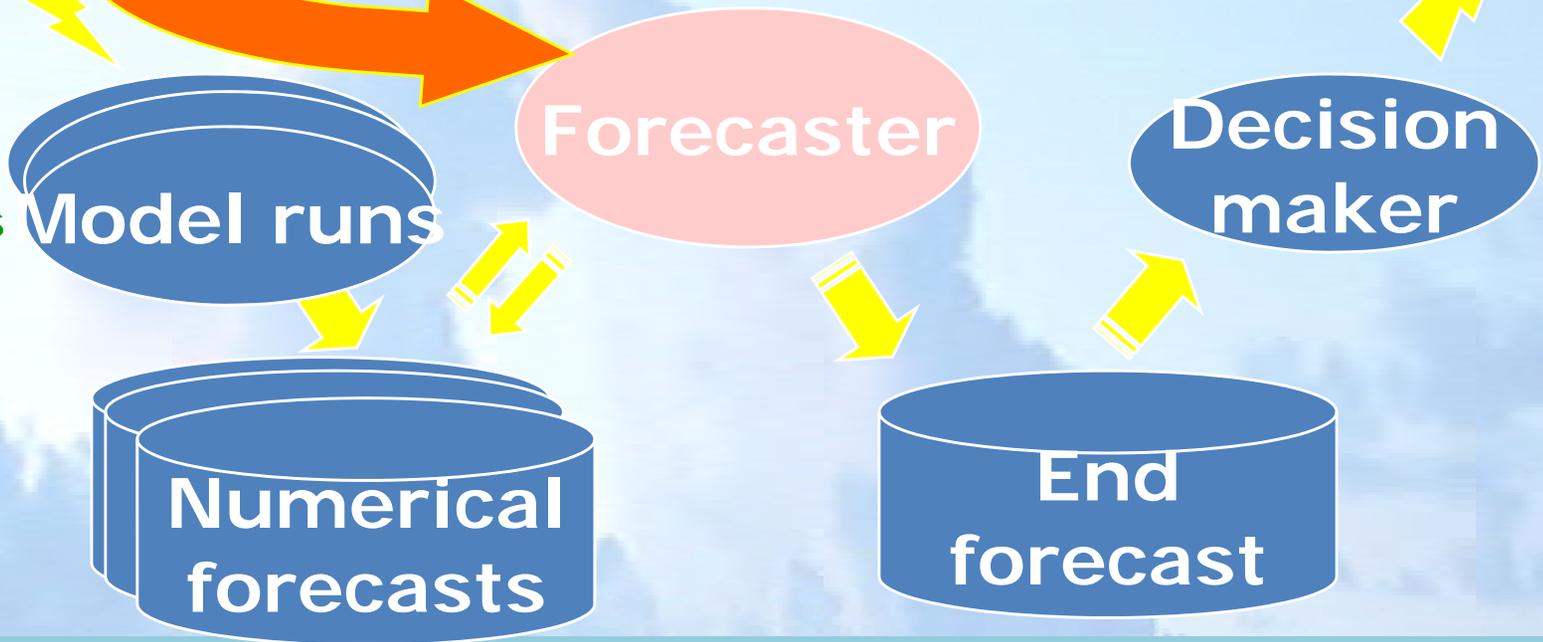
End forecast

Improved Early warning system with respect to all the above components

Hazard Weather Monitoring and Forecasting System

- **Observations** - **Communication** - **Analyses & Forecasting** - **Dissemination**

Surface Observations- Manned/Automatic

Upper-Air Observations

Aircraft Reports

Ship Reports

Ocean Buoys data (Deployed by Dept. of Ocean Development)

Satellite Observations (Deployed by Department of Space)

Radar Network

Global Data

Data-flow 24x7 mode

Global Telecom Hub

Data Flow

Delhi Northern Hemispheric Analysis Centre

Pune Weather Central

IMD, Delhi **LAFS NWP forecasts**

Data ported to NCMRWF for medium range weather forecasts

State Level Met. Centres

Airport Met. Offices

Regional Centres – 6

Cyclone Warning Centres - 6

Central / State Govt/ Media/ Public

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TECHNOLOGY NEEDS FOR IMPROVEMENT IN EARLY WARNING SYSTEM

- **Observational systems**

- **Lab Simulation studies :**

- **Calibration, Validation and visualization :**

- **Data Management and visualization :**

- **Assimilation :**

- **Post Processing of Model Outputs :**

- **Dissemination of forecast & warning :**

- **Upgradation, Indigenous development of New Instruments**

- **Set-up Laboratory experiments in Cloud Physics, Atmospheric Chemistry**

- **Establishment of facilities/sites**

- **Development of Meteorological Information System**

- **Development of 4D-Var**

- **Development of Indigenous Package**

- **Development of Indigenous Package**

HPC Resource & Models (2006 to 2016)

1st Supercomputer

CYBER-2000U
1994 ~ 2009

25 Mflops/10GB
Models: LAM (110 km)/QLM (40 km)

×56

2nd Supercomputer

IBM P6/P574
24 nodes
2009 ~

14 Tflops/200TB
Models: GFS (23 km), WRF (27/9 km)

×7

3rd Supercomputer

IBM iDataPlex-X series
300 nodes, 2014 ~

1.2 Pflops/600TB
Models: GFS (12 km), WRF (9/3 km), HWRF (8/2 km)

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Numerical Weather Prediction (NWP) Modeling : Backbone for Early Warnings

	120 h	96 h	72 h	48 h	24 h

Ensemble Pred. Tools →

Multi-model ensemble, Single Model Ensemble, Grand Global Ensemble

Global Models →

Global models

Regional Models →

Regional models

Nowcasting Tools →

Nowcasting

Warnings Activities →
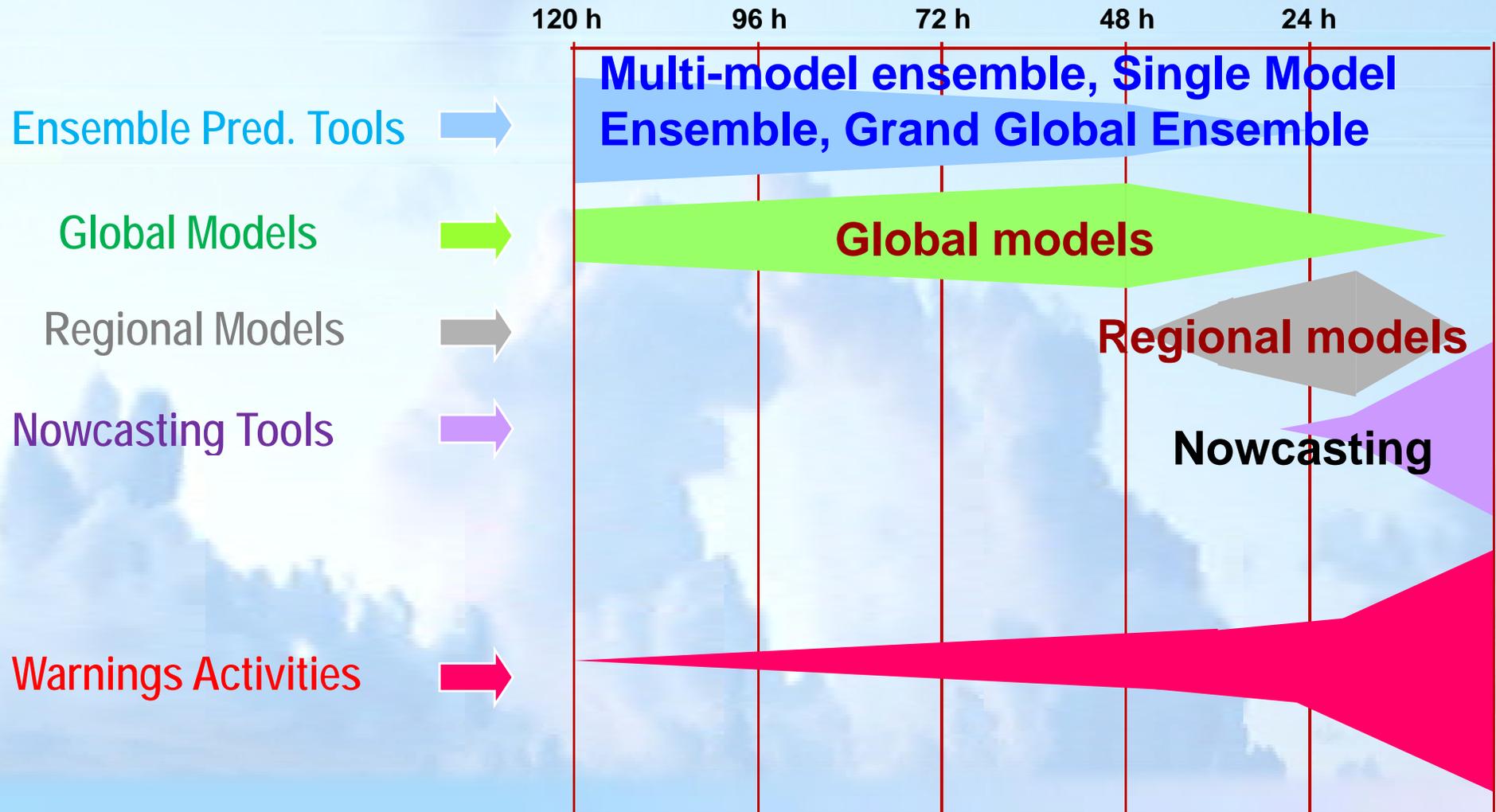
Technology for Decision Support System for Early Warning
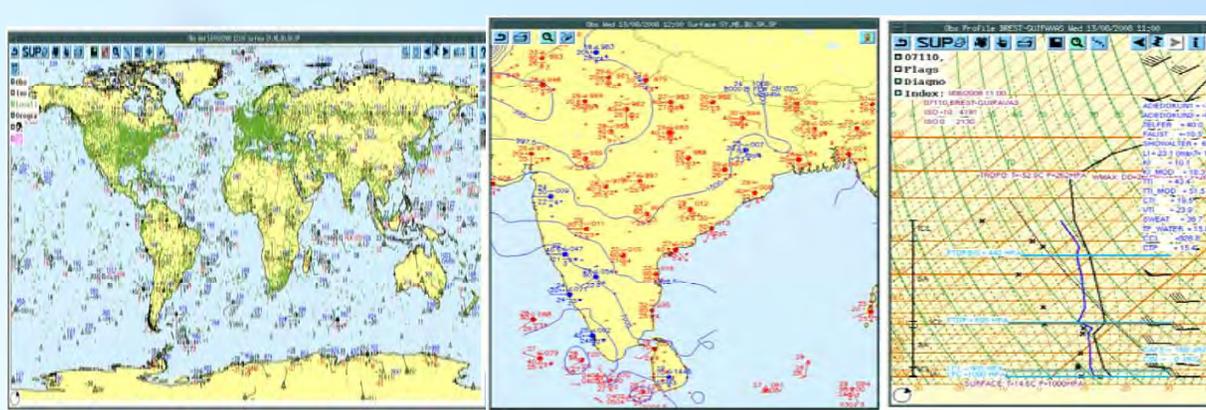
Global plotting

Conditional plotting

Profile

Satellite
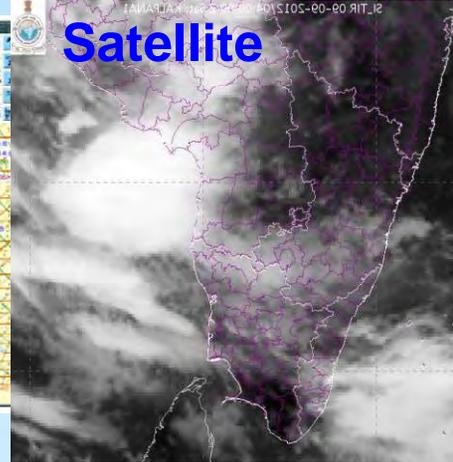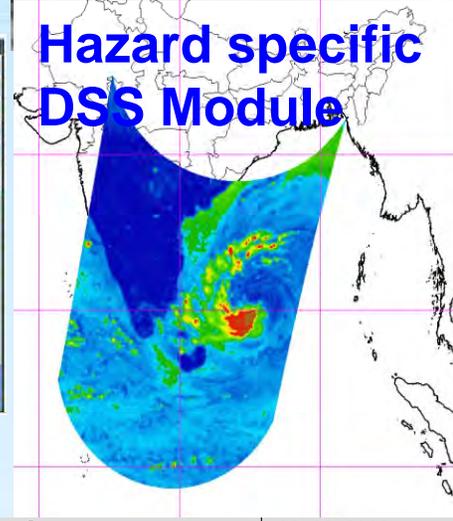
Hazard specific DSS Module

Plane trajectories

Gauges
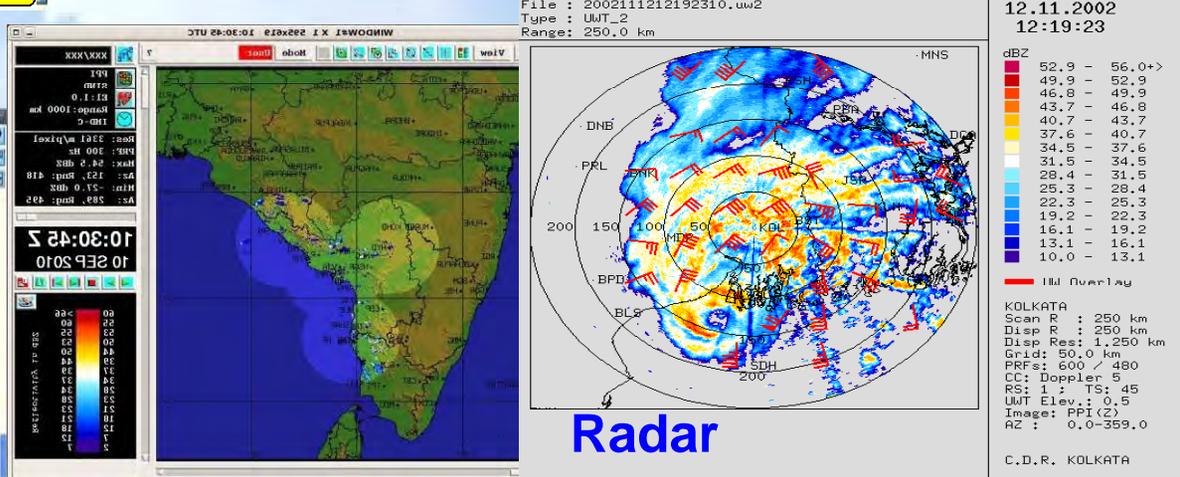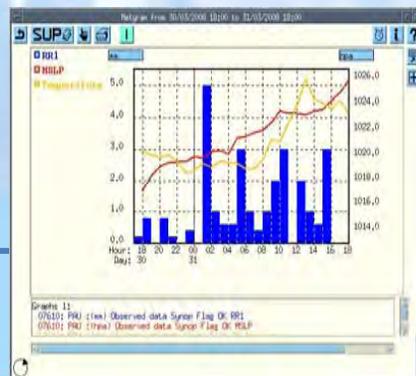
Radar

Nead for Information Technology for Early Warning Dissemination

- **Global Telecommunication System**
- **VPN Circuits**
- **IVRS:**
(Toll free number 1800 180 1717)
- **VSNL**
- **INMARSAT**
- **VSAT**
- **LAN**
- **HSDT**
- **National Knowledge Network**
- **Web based communication, Mobile Phone, SMS**
- **Web based Pilot Briefing System for civil aviation**
- **Radio/TV, Press**
- **Development of centralized GIS based content managed website.**

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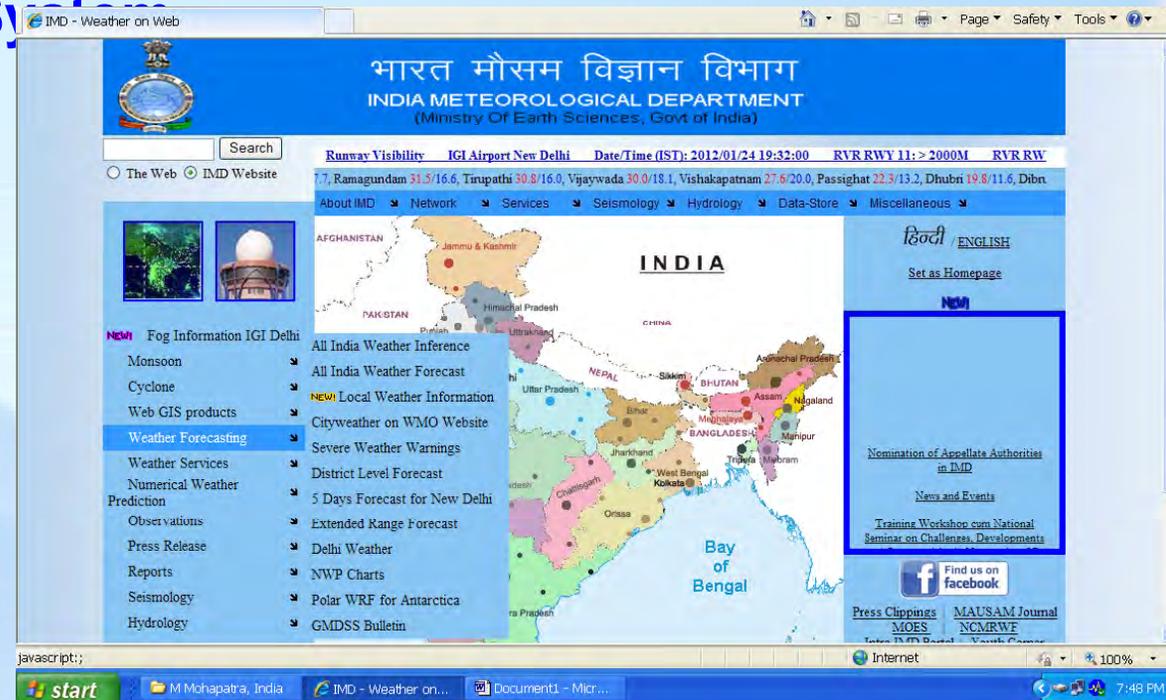
Warning System

❖ **Goal** : maximizing actions for safety

➢ 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**

➢ NMHS + Hazards Community (other government organizations + local officials + emergency managers + media + voluntary and NGOs+...)

Need for Investment in Early Warning System

❖ **Requirement of Disaster Managers**

- **Improvement in Skill in monitoring and prediction with high spatial resolution and longer lead period,**

- **User friendly Warning products generation and dissemination,**

❖ **All these need investment for :**

- **Development of observation, computational and communication infrastructure**

- **Decision support system**

- **Capacity building**

Existing Regional Mechanism for EWS

❖ **RSMC-New Delhi for cyclonic disturbances**

❖ **INCOIS Hyderabad for Tsunami warning and sea state forecasting**

Pilot project

❖ **RSMC New Delhi for SWFDP**

❖ **RSMC New Delhi for CIFDP**

❖ **SAARC-STORM discontinued for last two years**

WMO/ESCAP RECOGNISED Regional Specialised Meteorological Centre, New Delhi

- **Provides 3 hourly cyclone advisories and daily outlooks to 9 Members countries**

  Bangladesh

  India

  (RSMC, New-Delhi)

  Maldives

  Myanmar

  Oman

  Pakistan

  Sri Lanka

  Thailand

  Yemen
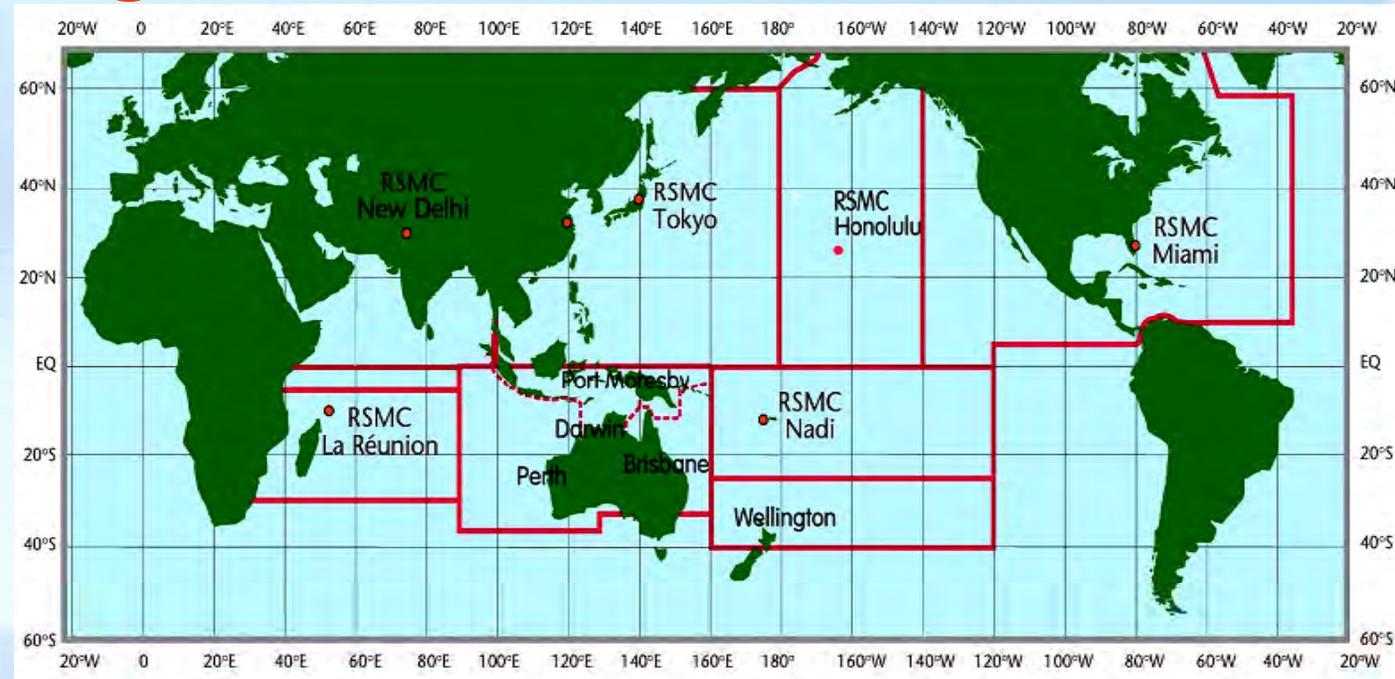
- **For national purpose, IMD has 3 tier organisation to provide cyclone warning**

- **Area Cyclone Warning Centres at Mumbai, Kolkata and Chennai**

- **Cyclone Warning Centre at Ahmedabad, Visakhapatnam and Bhubaneswar**

- **Cyclone Warning Division at New Delhi**

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RESPONSIBILITIES OF RSMC – NEW DELHI

1) Round the clock watch over the entire North Indian Ocean.

2) Analysis and processing of global meteorological data for diagnostic and prediction purposes.

3) Detection, tracking and prediction of cyclonic storms in the NIO.

4) Running of numerical models for tropical cyclone track and intensity prediction.

5) Bulletins

- Tropical weather outlook : Once a day based on 0300 UTC observation

- Special ropical Weather Outlook :
- Twice a day based on 0300 and 1200
   UTC observation during depression

- Tropical Cyclone Advisories :

- Every three hourly during cyclone

- Tropical Cyclone Advisories for Aviation every six hourly during cyclone period

- Quadrant winds (Structure Forecast)
   for coastal and high sea shipping

- Storm surge guidance

6) Implementation of the Regional Cyclone Operational Plan of WMO/ESCAP Panel.

7) Collection, processing and archival of all data pertaining to cyclonic storms viz. wind, storm surge, pressure, rainfall, satellite information etc.

8)Exchange of composite data and bulletins pertaining to cyclonic storms with Panel countries.

9)Preparation of comprehensive reports on each cyclonic storm.

10)Continued research on storm surge, track and intensity prediction techniques.

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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

- ❖ 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
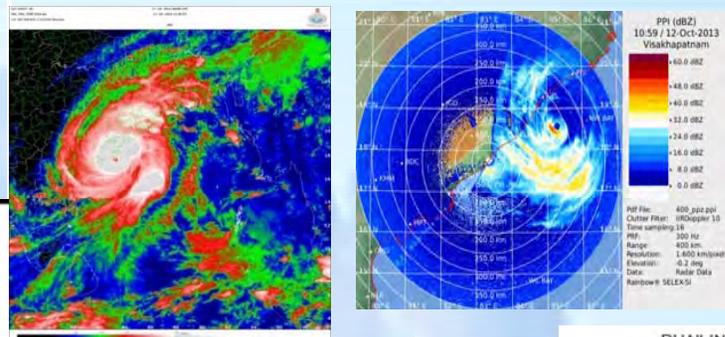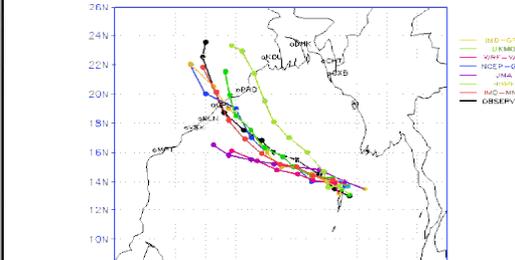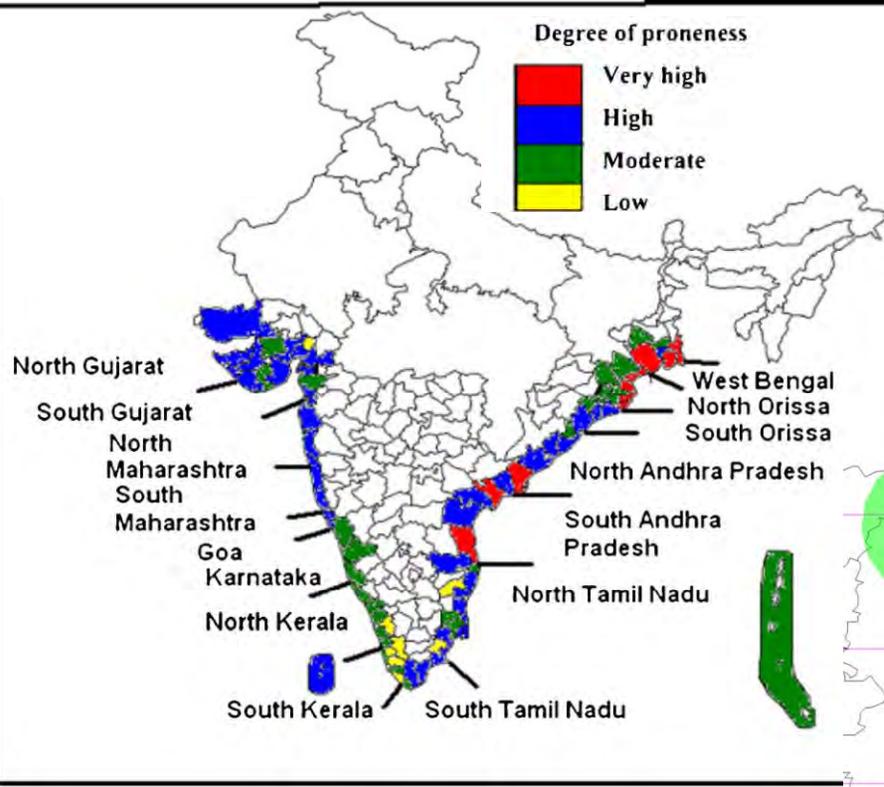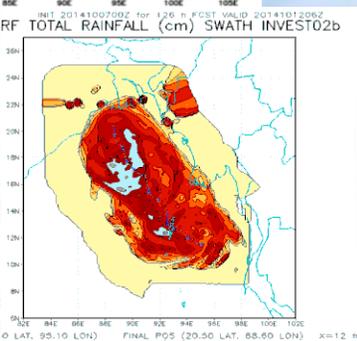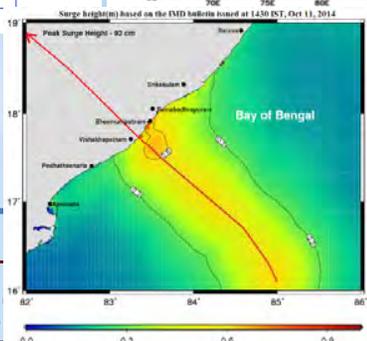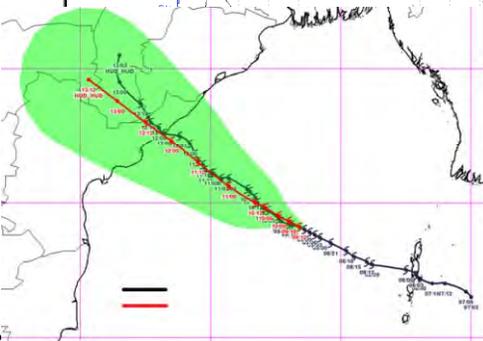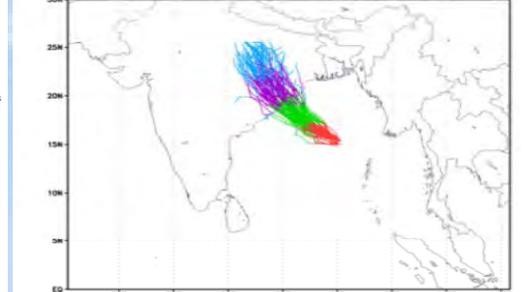
Cyclone Forecast Accuracy: Accomplishments and Challenges

Bar chart: **2007-11** (green), **2012-16** (pink). Track error: 137 km, 97 km. Landfall error: 101 km, 56 km. **24 hr forecast errors**

(b) Five Year Moving Average-Track forecast Skill (%) — lines for 12-hours, 24-hours, 36-hours, 48-hours, 60-hours, 72-hours across periods 2003-07 to 2012-16.
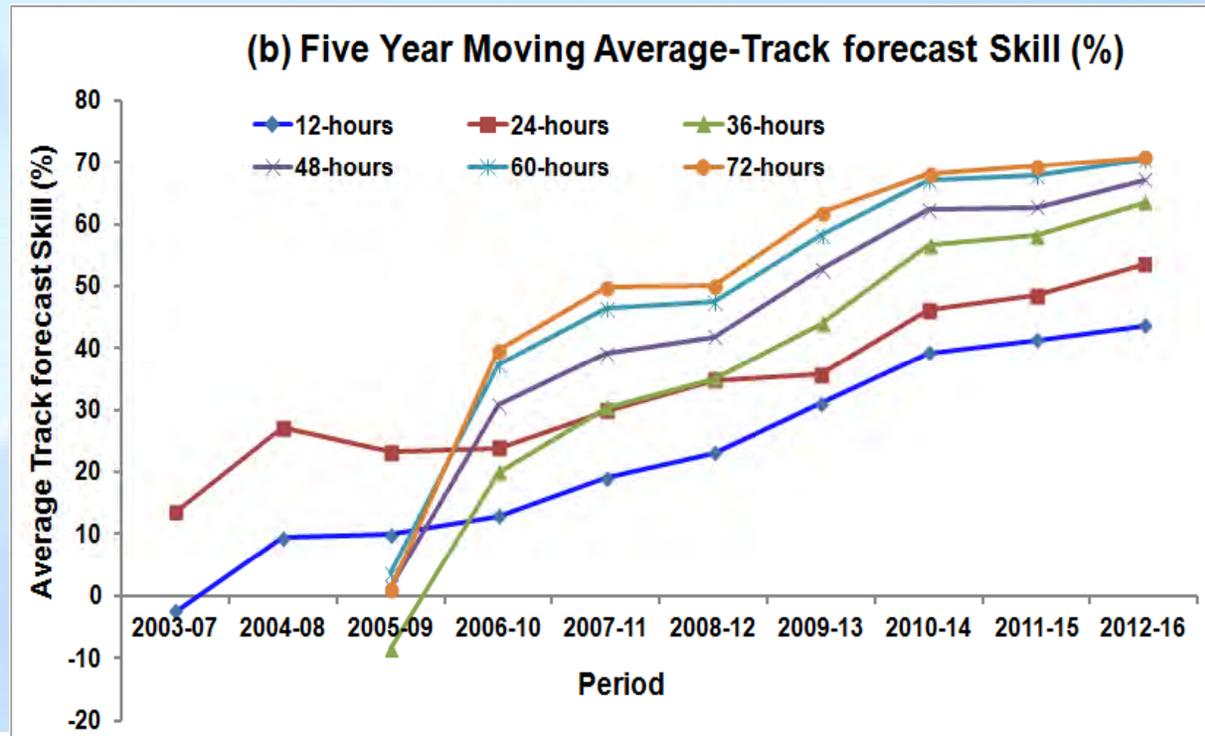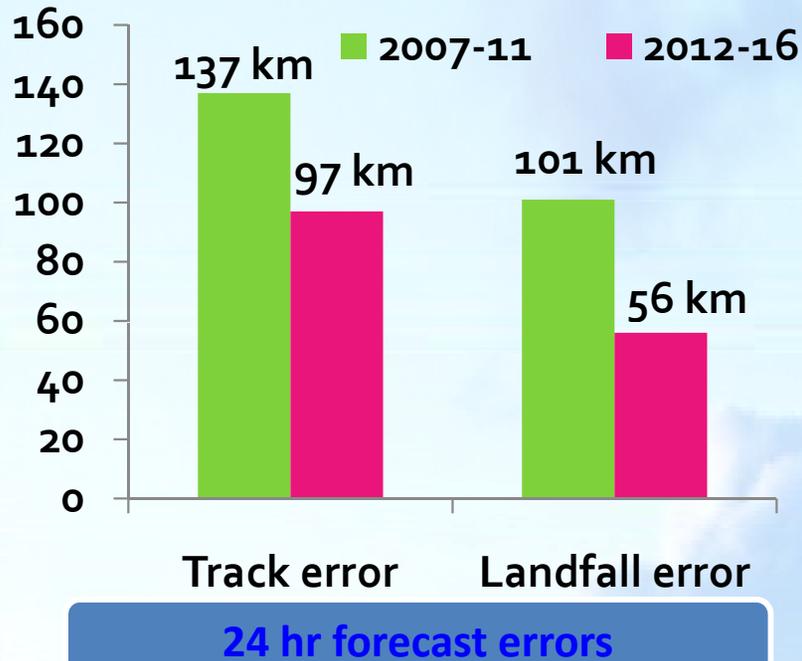
Noteworthy improvement in track and intensity forecast of the tropical cyclones (**24 hour forecast error in track prediction reduced from 137 km to 97 km and Landfall error from 101 Km to 56 Km during 2007-11 to 2012-16**).

Probabilistic genesis Forecast up to 3 days and Track and intensity forecast up to 5 days in text and graphics

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

Target for 2024 : Dynamical Impact based Forecast and Warning

Severe Weather Forecasting Demonstration Project (SWFDP)

SWFDP Main Goals

❖**Improve Severe Weather Forecasting**

❖**Improve lead-time of Warnings**

❖**Improve interaction of NMHSs with users: media, disaster management, civil protection authorities, public**

SWFDP Cascading Forecasting Process

❖ **Global NWP centres** to provide available NWP/EPS and sat-based products, including in the form of probabilities, cut to the project window frame;

❖ *Regional centres* to interpret information received from global centres, prepare daily guidance products (out to day-5) for NMCs, run limited-area model to refine products, maintain RSMC Web site, liaise with the participating NMCs;

❖ *NMCs* to issue alerts, advisories, severe weather warnings; to liaise with user communities, and to contribute feedback and evaluation of the project;

❖ *NMCs* have access to all products, and maintained responsibility and authority over national warnings and services.

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SWFDP: a cross-cutting activity involving multiple TCs and Progs, concerning prediction of hydro-meteorological hazards
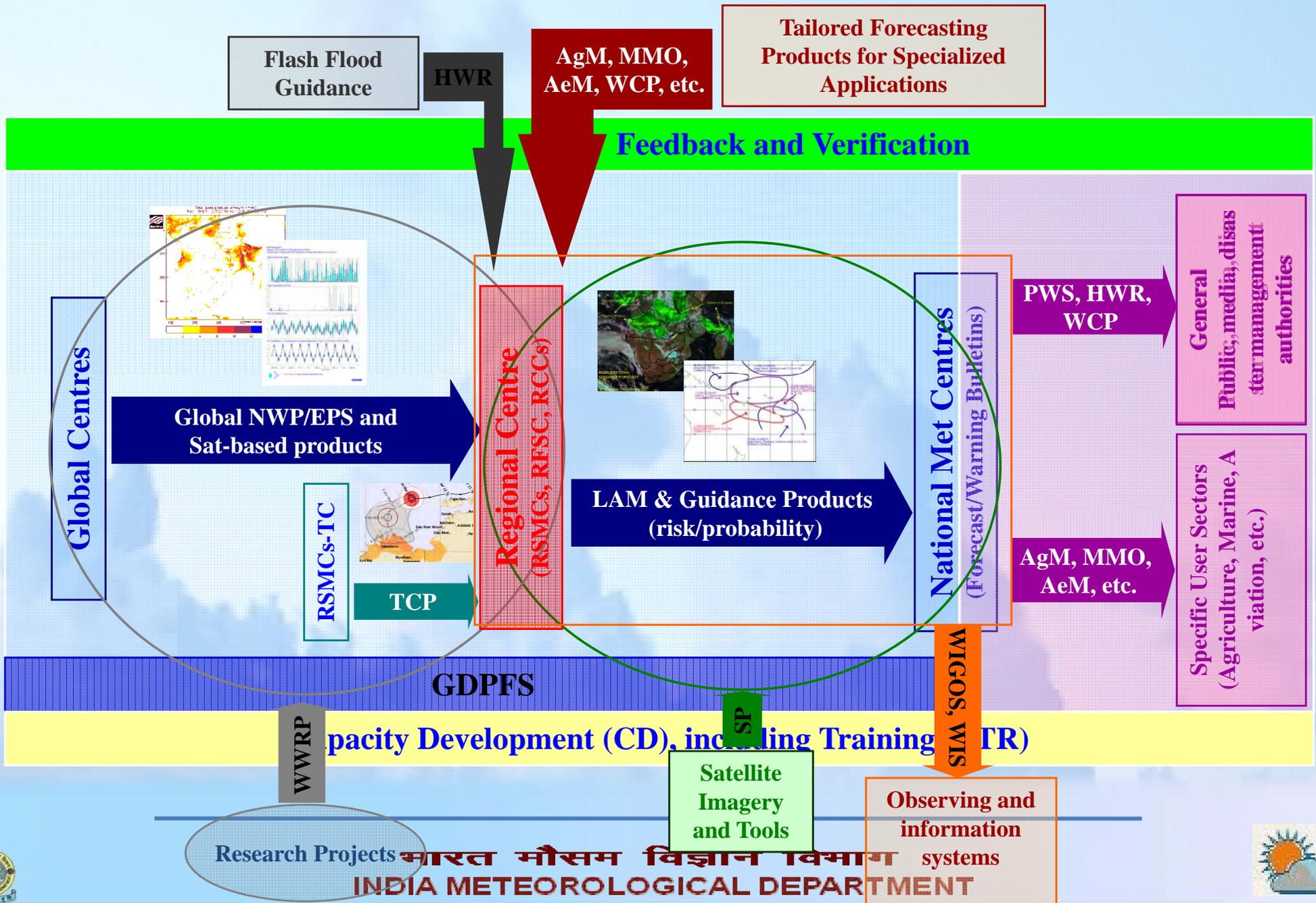
SWFDP – Bay of Bengal

Focus: Coastal communities and activities

45E – 1105E   10S – 45N
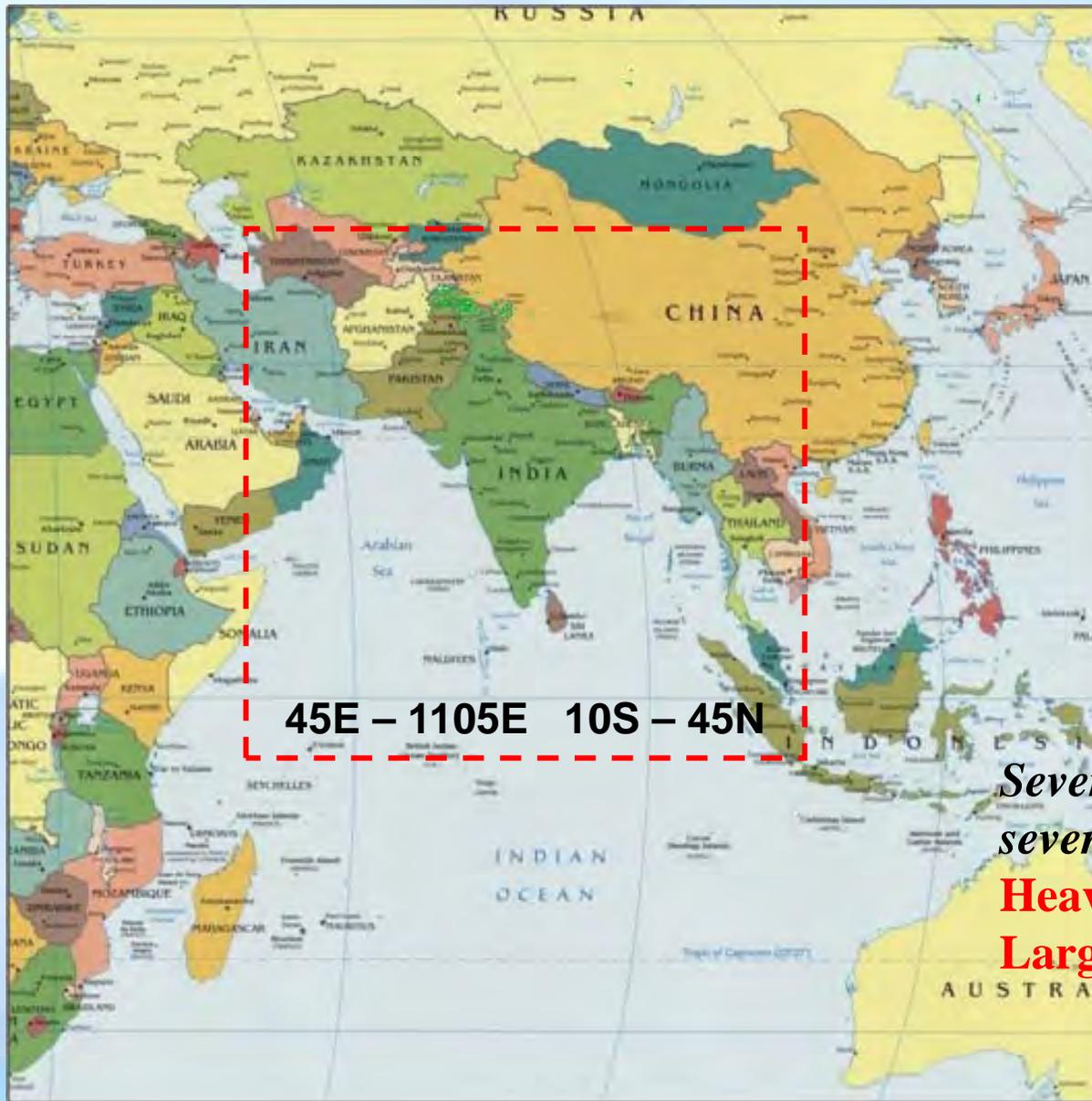
- **Bangladesh**
- **India**
- **Maldives**
- **Myanmar**
- **Sri Lanka**
- **Thailand**
- **Bhutan**
- **Nepal**
- **Afghanistan**
- **Pakistan**

Severe Weather from TCs, severe thunderstorms and monsoon:

Heavy precipitation, Strong winds
Large waves / swell, Storm Surge

...es to disaster management (PWS)

...and with agriculture

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SWFDP- Bay of Bengal - severe weather events

a) Heavy rain (due to tropical cyclone, thunderstorm, monsoon, etc) /flooding;

b) Strong winds (due to tropical cyclone, thunderstorm, monsoon, etc);

c) Deficit of precipitation/dry spells;

d) High waves / swells;

e) Storm surge;

f) Heat waves and cold waves / frost;

g) Fog

THRESHOLD VALUES USED IN RSMC DAILY SEVERE WEATHER FORECASTING GUIDANCE

HAZARD	THRESHOLD	COMMENTS
Heavy Rain	≥ 50 mm in 24 hours ≥ 100 mm in 24 hours (the risk over 200mm/24 should be described in discussion in the Regional Guidance)	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
Strong winds	≥ 17 knots (over land and Sea) ≥ 34 knots (over Sea)	Affecting oceanic and coastal areas especially. Gusts on land from severe convective systems are not predictable on this time scale effectively
High Waves	≥ 2.5 m	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.
Storm Surge	≥ 1m	

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# Field phase period
(The Pilot and Demonstration Phases

❖ **The pilot phase is executed from May 2016 and the demonstration phase shall be executed from January 2018.**

❖ **Both pilot and demonstration phases shall be key components of the Phase II of SWFDP-BoB**

SEVERE WEATHER FDP (SWFDP),BAY OF BENGAL
REGIONAL SPECIALIZED METEOROLOGICAL CENTRE,NEW DELHI

Risk map for **DAY 1**: 06Z 15/09/2015---→06Z 16/09/2015

Short Range Guidance

Rainfall > 50 mm/24h
Rainfall >100 mm/24h

15-20 KTS
Moderate to
Rough Sea

10-15 KTS
Moderate Sea
condition

20-25 KTS
Rough Sea

SEVERE WEATHER FDP (SWFDP),BAY OF BENGAL
REGIONAL SPECIALIZED METEOROLOGICAL CENTRE,NEW DELHI

Risk map for **DAY 3**: 06Z 17/09/2015---→06Z 18/09/2015

Medium Range Guidance

Rainfall > 50 mm/24h
Rainfall >100 mm/24h
Strong wind > 30kts
Strong wind > 50kts

10-15 KTS
Moderate Sea
condition

SEVERE WEATHER FDP (SWFDP),BAY OF BENGAL
REGIONAL SPECIALIZED METEOROLOGICAL CENTRE,NEW DELHI

Risk map for **DAY 5**: 06Z 19/09/2015---→06Z 20/09/2015

Medium Range Guidance

Rainfall > 50 mm/24h
Rainfall >100 mm/24h
Strong wind > 30kts
Strong wind > 50kts

10-15 KTS
Moderate Sea condition

(Officially, SWFDP-BoB website was inaugurated by Secretary, MoES on 2nd May, 2016) during WMO meeting in Delhi.

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SWFDP-BoB (Through IMD webpage and RSMC)

http://www.imd.gov.in ➡ **cyclone (RSMC)** ➡ **SWFDP-BoB**

And Way forward

▪**NMHS will be able to strengthen forecasting capability of extreme weathers events**

▪**All the NWP models products and EPS products will be available to the forecasters in a singe platform**

▪**RSMC-New Delhi will be able to provide guidance to south and Southeast-Asian countries in the field of extreme weather forecasting.**

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OPERATIONAL PLAN FOR EWS

✓**Tropical Cyclone Operational Plan : TCP 21 is updated with RSMC inputs every year**

✓**SWFDP Implementation Plan**

WORLD METEOROLOGICAL ORGANIZATION
TECHNICAL DOCUMENT

WMO/TD No. 84

TROPICAL CYCLONE
PROGRAMME
Report No. TCP-21

TROPICAL CYCLONE OPERATIONAL PLAN
FOR THE BAY OF BENGAL AND THE ARABIAN SEA

Edition 2014

SECRETARIAT OF THE WORLD METEOROLOGICAL ORGANIZATION
GENEVA SWITZERLAND

Edition 2014

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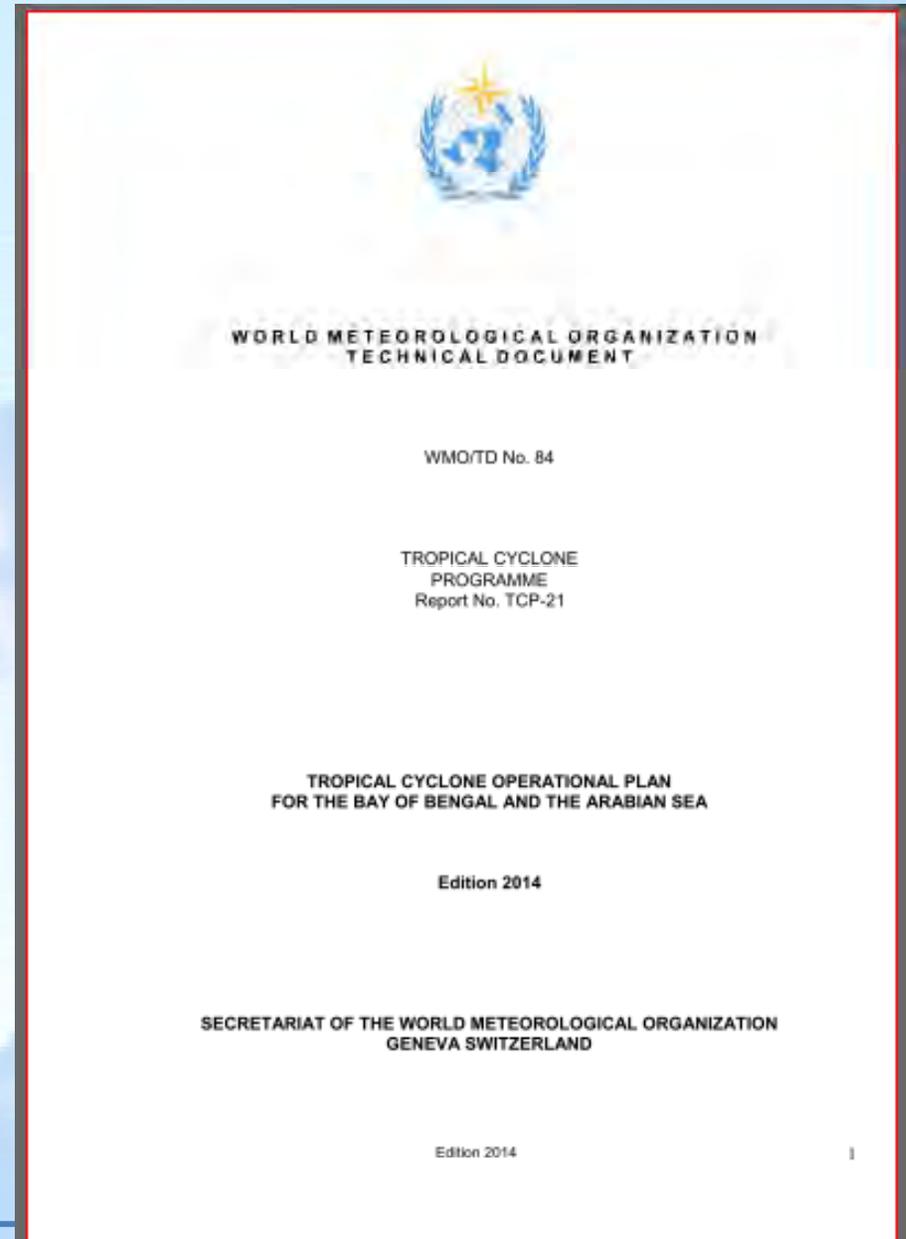
Publications

- **Annual RSMC Report on Cyclonic Disturbances**
- **Annual Cyclone Review Report of WMO/ESCAP Panel countries**
- **Annual Tropical Cyclone Operation Plan (TCP-21)**
- **WMO/ESCAP Panel News**
- **Preliminary reports of cyclonic disturbances – circulated to all member countries**
- **Handbook on cyclone warning modified every year**
- **Publication in reviewed Journals**
- **Special Issue of Journals and Books on Proceedings of conference/workshop**
- **Video Film on Cyclones**
- **SOP and SSOP**

Digital program India initiative
Digitisation of RSMC Reports (1990-2013)

Digitization of all the available annual reports from 1990 onwards By scanning and making the PDF version of the reports.

Path for 2005-2013:

Home /Publications /

Annual RSMC Report

Path for (1990-2004):

Home / Archive /

RSMC Report (1990-2004)

Training

❖ **WMO Cyclone forecasters training was conducted for the forecasters from WMO/ESCAP Panel countries since 2005**

❖ **Training on SWFDP**

❖ **Special trainings on satellite, Radar and NWP**

LESSONS LEARNT FOR IMPROVING EWS :

Accuracy and improvement in Service is achieved by :

- Science and Technological Upgradation
- Improvement in observational network (Ocean, land and atmosphere) and quality of data
- Remotely sensed observations using Satellite and Radar
- Fast communication and data Exchange system
- Superior computational capabilities, super computer facilities
- Improved Numerical modelling capabilities
- Skilled Human Resource Capabilities
- Improved tools and techniques of forecasting including DSS
- Excellent support and Inter- ministerial collaborations from centre and state
- Confidence building measures for disaster management agencies and general public
- International collaborations
- Research and Development

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Challenges

- ❖ Scale up Observing Systems
- ▪ Surface, Upper Air, Radar and Satellite
- ❖ Improve Data assimilation & NWP Models
- ❖ Forecasts
- ▪ Smaller spatial scale, e.g. Block level forecast, location specific & Agro-met Advisories
- ▪ Further improvement in Nowcast, short/medium/Extended Range Forecast, Climate Scale forecast
- ▪ Improve sub-basin scale precipitation forecasts for surface hydrology for river basins and urban hydrology for major cities.
- ▪ improve in predicting severe weather episodes, viz., prolonged heat and cold wave spells, thunder-storms spells etc., and improved forecast accuracy of these episodes in particular for flash flood events over the urban and complex topography.
- ❖ Improved information dissemination system
- ❖ Improvement in Sectoral applications:

Thank you