

Storm Surge Early Warning System @ INCOIS

Mr. J. Padmanabham

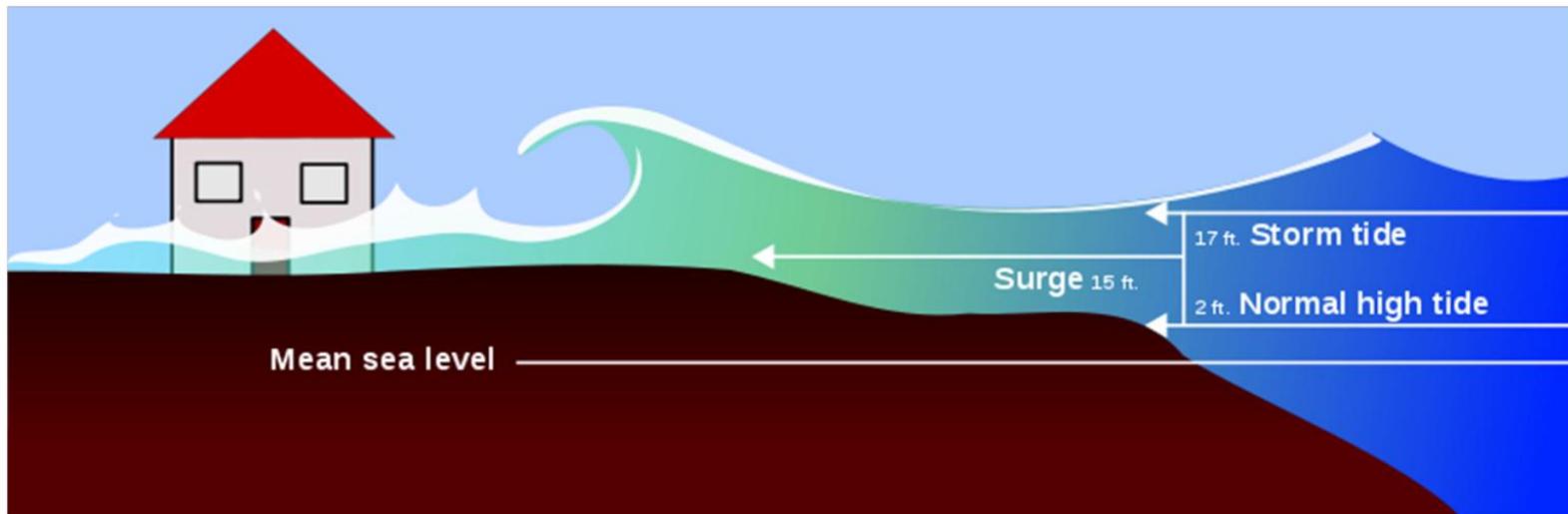
Dr. P L N Murty

Storm Surge ???

Storm surge is an abnormal raise in sea level at the coast due to a high winds of a tropical storm.

How it all piles up the water:

- *Low pressure system (storm)* generates wind
- **Wind** blows across the sea surface
- **Friction** between the wind and water pushes the water in the direction of wind
- **Tides** caused by the gravity of the sun and moon contribute to the rise in ocean surface
- The sea level starts to pile up along the coastline due to **approaching storm**.



“Piling up of water at the coast”

Factors contributing storm surge:

- Wind – Usually associated with a tropical storm
 speed , direction, angle of approach to the coast
- Storm forward speed

Strong wind + large fetch + long time + track perpendicular to the coast = Highest surge

where,

Fetch – The distance over which the wind interacts with the surface of the ocean

Time – The length of time wind blows over an area of the ocean

$$\Delta\eta = - \Delta p / \rho g$$

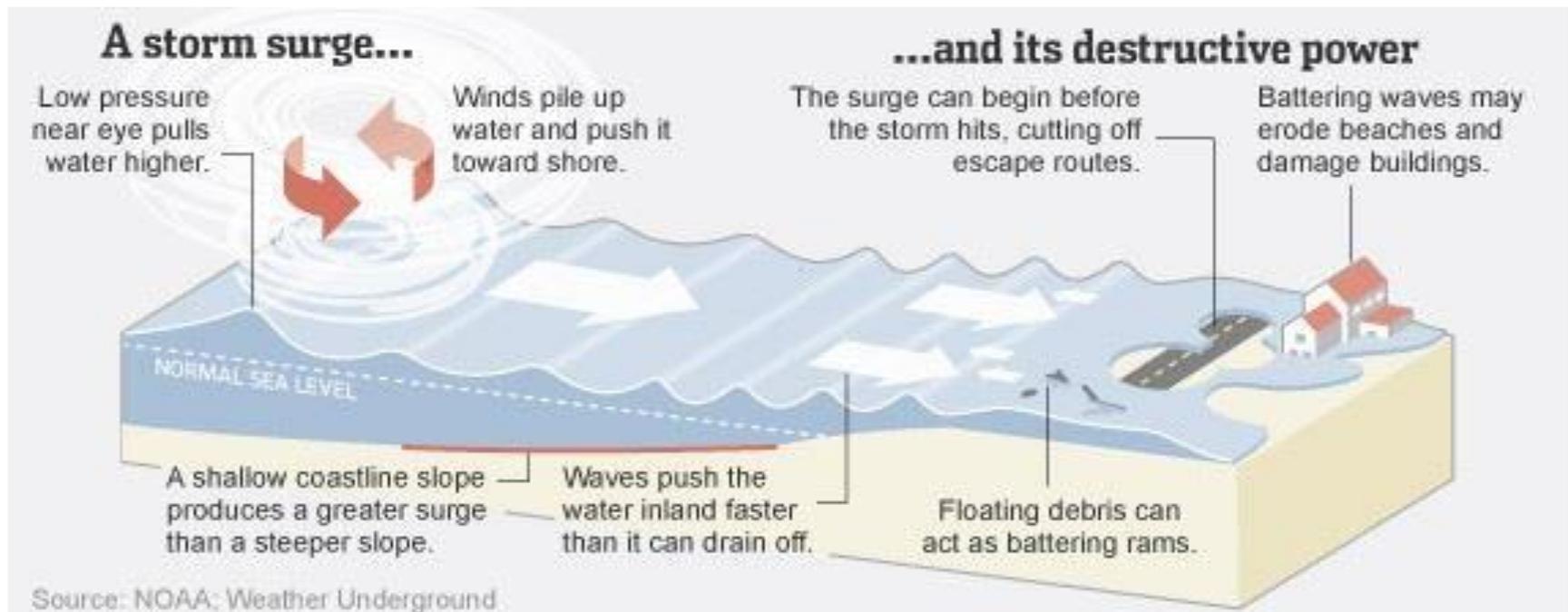
- Low storm pressure over the ocean
- Tides – phase of the tides contribute to storm surge height
- Slope and width of the continental shelf
 - wide, shallow shelves are prone to larger storm surges.

$$\eta = \frac{\tau_s}{\rho g h} L$$

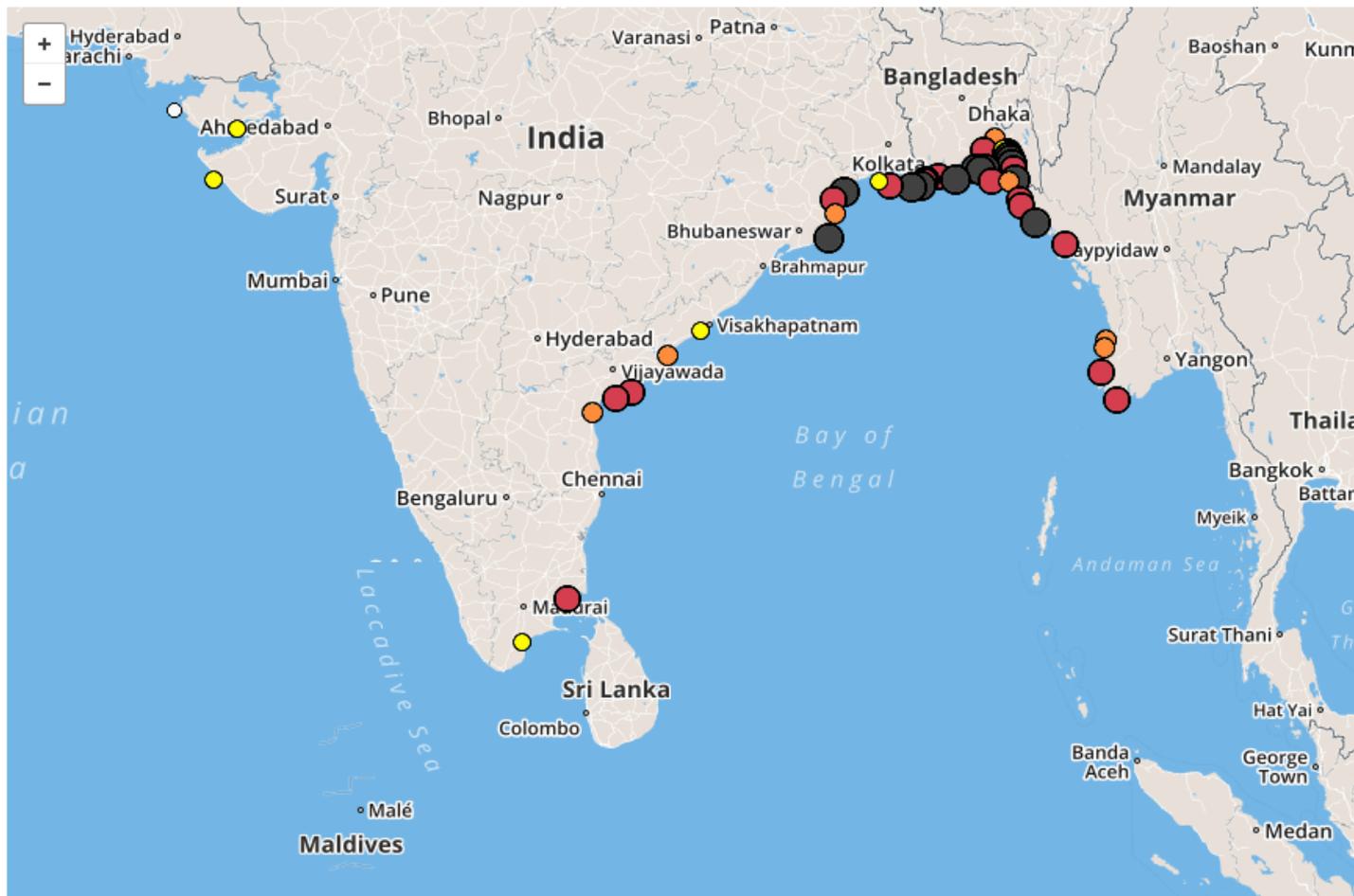
Factors contributing storm surge:

- Coastal geometry:

Storm surge is much depend on the shape of the coast line.



Historical Events (Peak Surge Map)

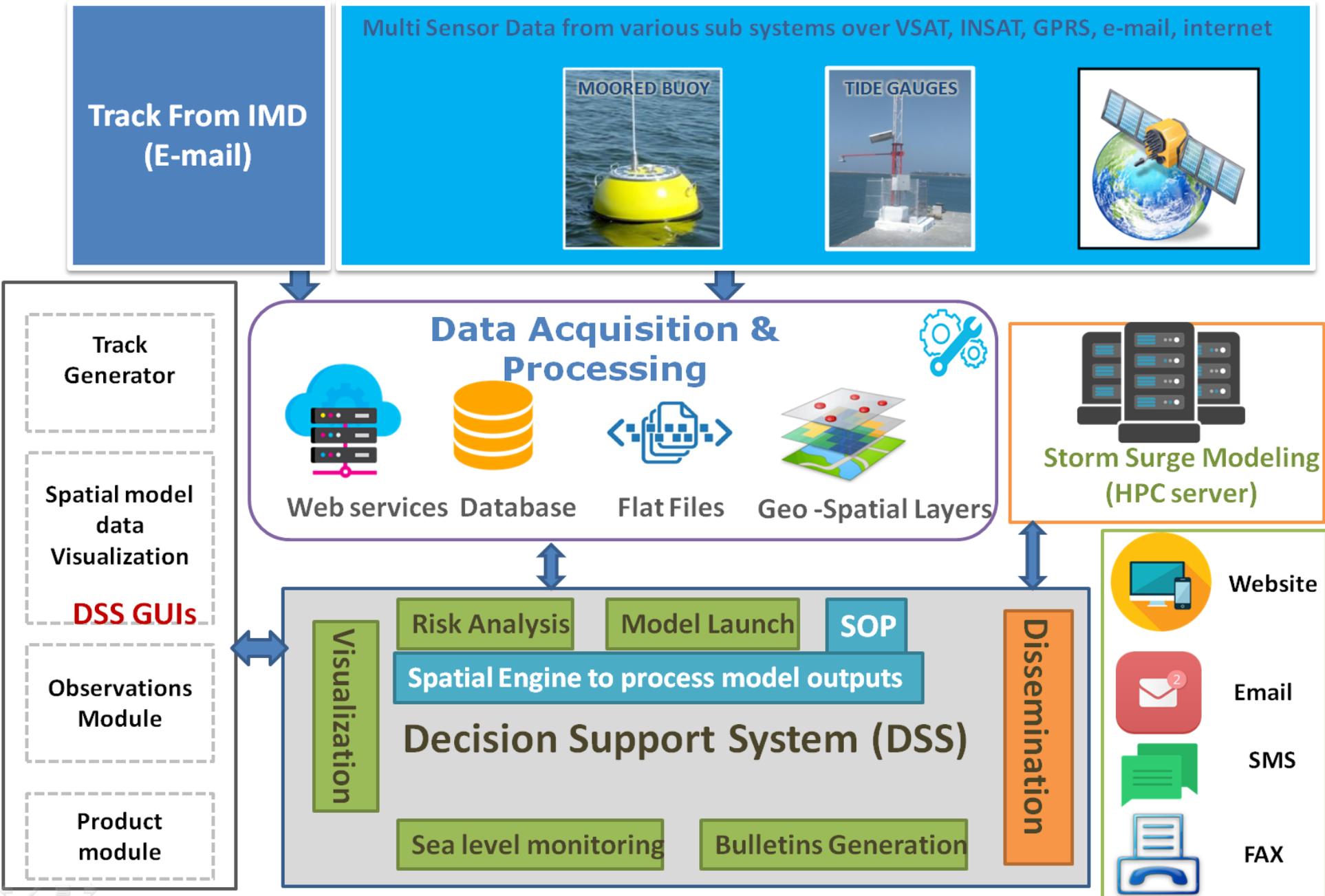


Tropical Surge

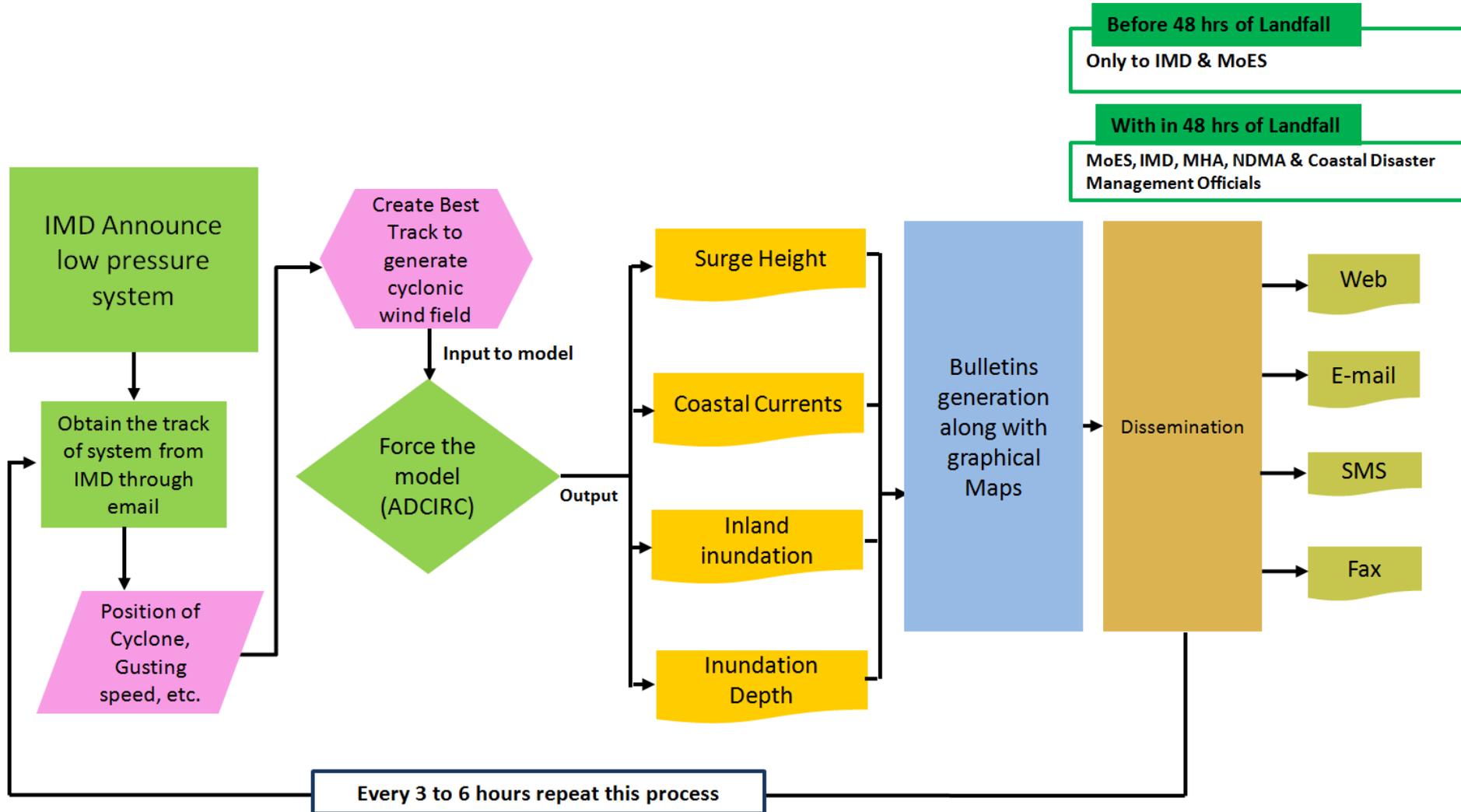
< 1.5m (5ft)
1.5 - 3.0m (5 - 10ft)
3.0 - 4.5m (10 - 15ft)
4.5 - 6.0m (15 - 20ft)
$\geq 6.0m$ (20ft)

On Off

Architecture of Storm Surge Early Warning System



Standard Operating Procedure (SOP)



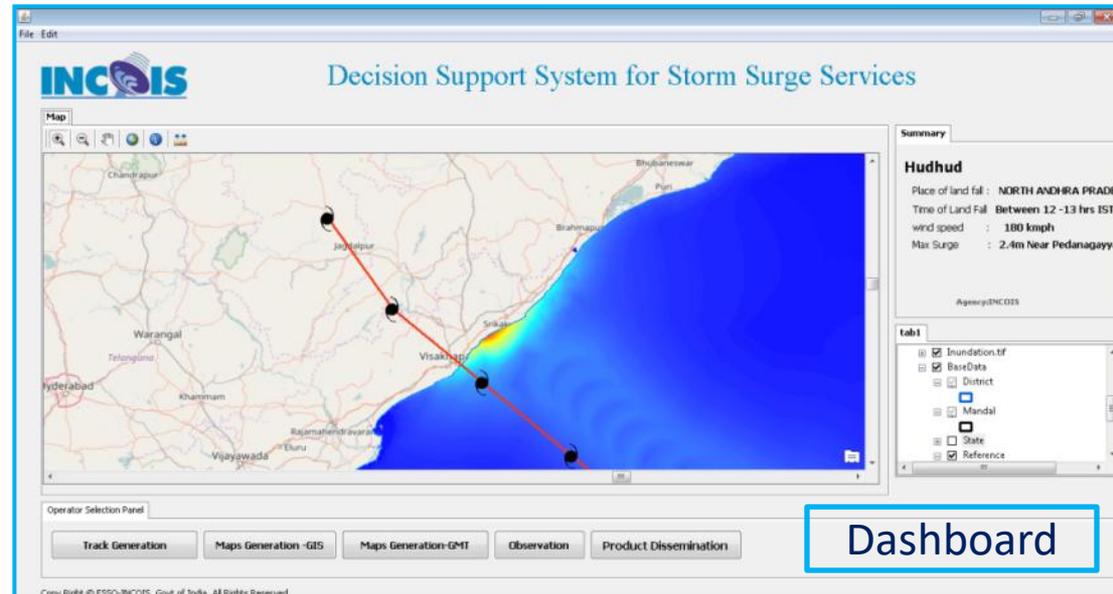
Decision support System

DSS provides **data processing**, launching of model in real time, **assessment, visualization, decision support**, analysis, **bulletin generation**, **web publish** and **dissemination** to the disaster management officials, MoES, IMD and other stakeholders

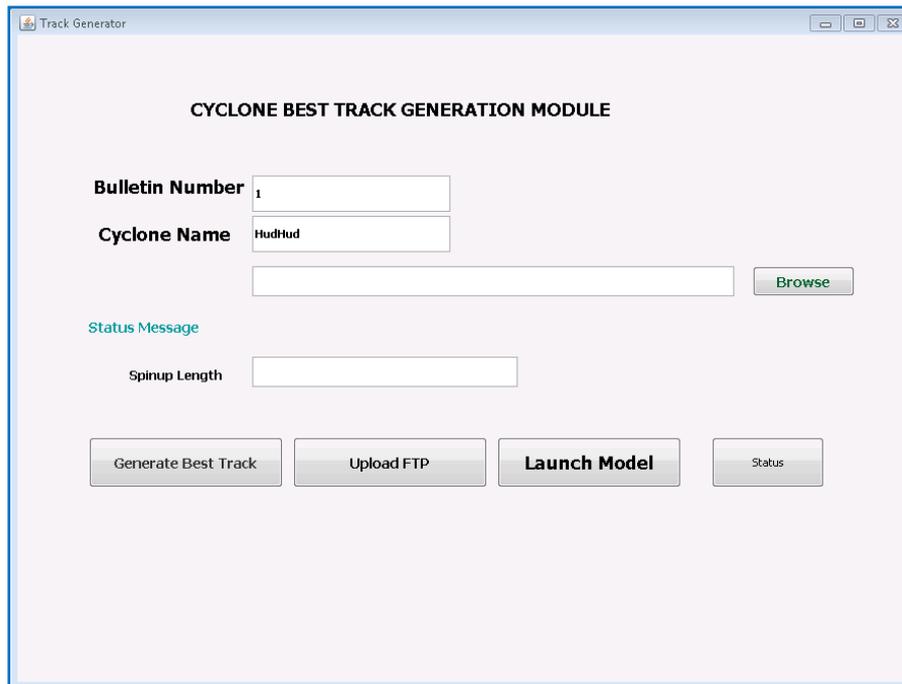


Modules:

- ❖ **Track Generator**
- ❖ **Model Launch**
- ❖ **Spatial visualization and mapping tool**
- ❖ **Bulletin Generation**
- ❖ **Dissemination**



Track Generator & Model launch



The screenshot displays the 'Track Generator' application window. The title bar reads 'Track Generator'. The main content area is titled 'CYCLONE BEST TRACK GENERATION MODULE'. It features several input fields and buttons:

- Bulletin Number:** A text input field containing the value '1'.
- Cyclone Name:** A text input field containing the value 'Hudhud'. Below it is a file selection area with a 'Browse' button.
- Status Message:** A label in blue text.
- Spinup Length:** A text input field.
- Buttons:** Four buttons are located at the bottom: 'Generate Best Track', 'Upload FTP', 'Launch Model', and 'Status'.

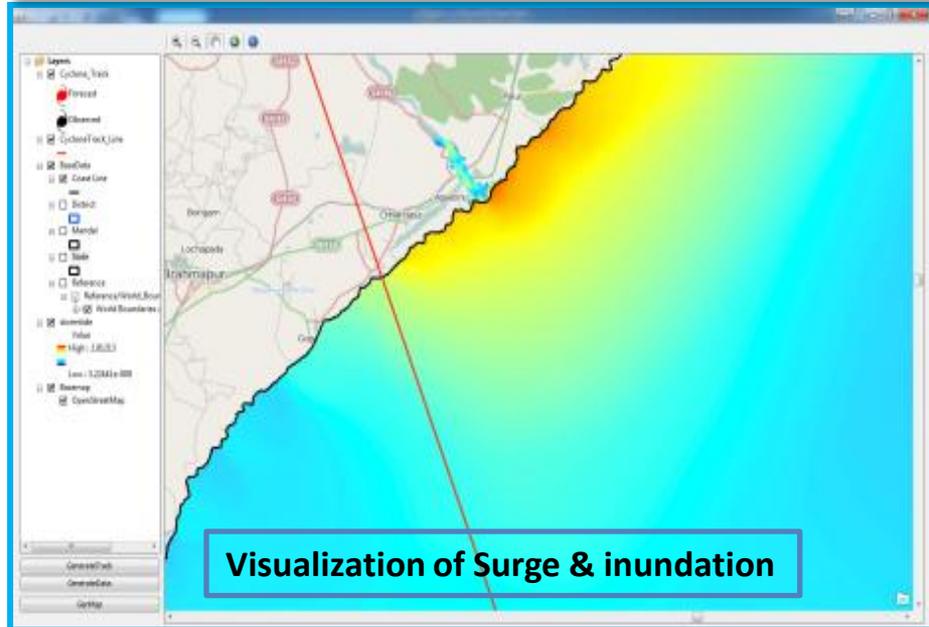
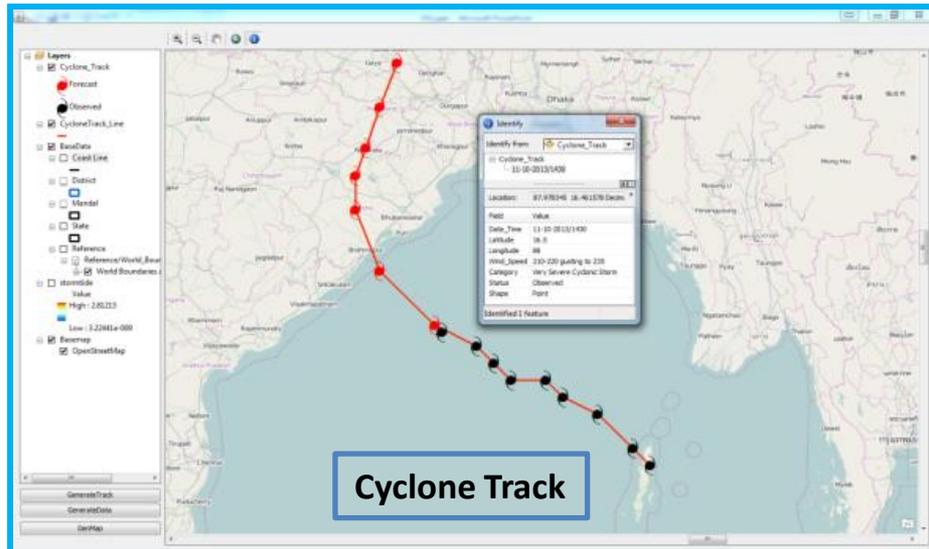
❑ **Track Generator:** Based on the IMD **bulletin** received over E-mail, data will be derived from the document and converted into **standardized global tropical cyclone best track data format** and prepare the model inputs for launching of the ADCIRC model.

❑ **Model launcher:** It is a GUI component for automating the execution of ADCIRC model in real time on the available HPC facility at ESSO-INCOIS.

❑ It allows read and develop information between geospatial databases and ADCIRC files or creating new input files for storm surge simulations.

❑ Here , the operator can provide the spin up value as input and click on the model launch button for data preparation, ftp and launching in HPC.

Spatial visualization and mapping tool



❑ A **data model Schema** that **integrates Geographic Information Systems (GIS)** and the **surge model ADCIRC**

❑ In addition to the data model schema, this module includes a **number of pre and post-processing tools** that help integrate spatial data and numerical modeling.

❑ A customizable geodatabase to accommodate model input and output and a set of **Arcpy tools designed to:**

- 1) pre-process input data (finite element grid editing);
- 2) post-process model outputs from ADCIRC simulations ;
- 3) The model outputs are also converted to GIS for use in coastal flood mapping, inundation extent or to be published using web services.

Product Generation & Dissemination

Decision Support System - Product generation & Dissemination Module

INC OIS

Product Generation & Dissemination

CYCLONE PARAMETERS

Bulletin No:

IMD Issued Time: IST

Issued Time: IST

Cyclone Name:

Place of Land Fall:

Time of Land Fall:

Expected Wind Spe...: kmph

Max Exp Surge: m

Tide Level:

Tidal Range:

Max Inundation: km

1.get Table 2.pdf 3.Commit

4.Commit Table 5.upload

6.send

Forecast summary scrolling text

SURGE HEIGHT INFORMATION

Details of storm surge heights expected at different coastal locations are listed below.
* The below listed surge heights are over and above astronomical tide.
Definitions:
Storm Surge - The abnormal rise in sea level over and above astronomical tide due to approaching storm.

COUNTRY	MANDAL	STATE / UNION TERRITORY	PLACE NAME	SURGE (m)	EXPECTED INUNDATION EXTENT (m)

IMD Bulletin Information

ADVICE

This bulletin is being issued as advice.
Only national/state/local authorities and disaster management officers have the authority to make decisions regarding the official threat and warning status in their coastal areas and any action to be taken in response.

NEXT ADVISORY

Next intermediate advisory will be issued by INCOIS as and when forecast parameters available from IMD.

Responsible for

- ✓ **Generation** of storm surge advisory **bulletins**
- ✓ **Bulletin notifications**
- ✓ **Dissemination**
- ✓ Notification messages are sent to respective coastal disaster management officials through **email** with bulletin pdf as attachment, **SMS** and **Fax**.
- ✓ Auto Publish to Website for access to the DMOs.

Web Bulletins



Indian Storm Surge Early Warning System Ministry of Earth Sciences, Government of India

[Home](#) > [STORM Surge Public Bulletins](#)

Bulletin 27

📁 Archived Bulletins

Bulletin 26

Bulletin 25

Bulletin 24

Bulletin 23

Bulletin 22

Bulletin 21

Bulletin 20

Bulletin 19

Bulletin 18

Bulletin 17

Bulletin 16

Bulletin 15

Bulletin 14

Bulletin 13

Bulletin 12

Bulletin 11

Bulletin 10

Bulletin 09

Bulletin 08

Bulletin 07

Bulletin 06

Bulletin 05

[Click Here to View- WebGIS Interface](#)

SURGE MAP **FORECAST INFORMATION** **IMD CYCLONE FORECAST**

EVENT SUMMARY

CYCLONE NAME	HudHud
EXPECTED PLACE OF LAND FALL	NORTH ANDHRA PRADESH COAST NEAR VISAKHAPATNAM
EXPECTED TIME OF LAND FALL	Forenoon of 12th October 2014
EXPECTED WIND SPEED	180 kmph
MAX EXPECTED STORM TIDE (SURGE + TIDE)	2.4m Near Pedanagayypalem, Vizianagaram
MAX EXPECTED INUNDATION EXTENT	400m Near Pedanagayypalem, Vizianagaram

STORM TIDE INFORMATION

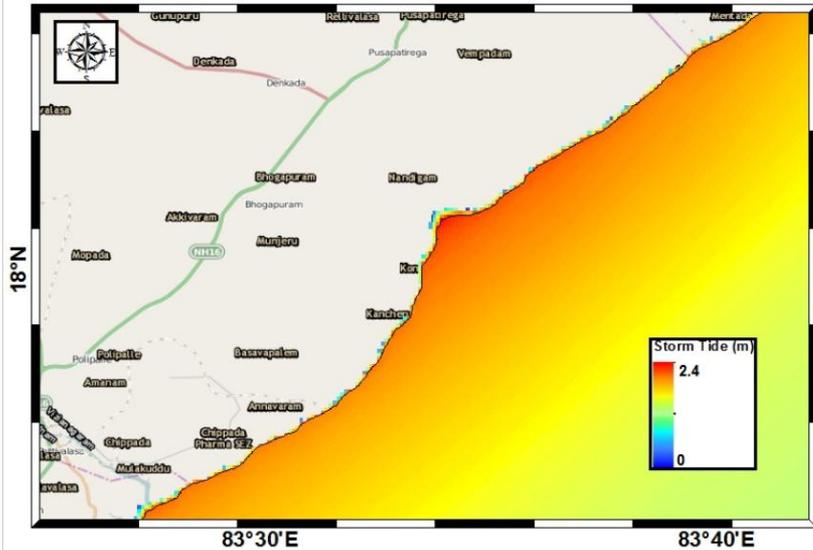
Details of storm tides expected at different coastal locations are listed below.

* The below listed water level and inundation extent includes tide but does not includes precipitation, river discharge and wind waves.

MANDAL	DISTRICT	STATE / UNION TERRITORY	NEAREST PLACE OF HABITATION	* SURGE (m)	* EXPECTED INUNDATION EXTENT (km)
Filter: All ▼	Filter: All ▼				
ANAKAPALLI	VISHAKHAPATNAM	ANDHRA PRADESH	Between Tantadi And Cheepurupalle East	0.6-0.8	Nii
BHIMUNIPATNAM	VISHAKHAPATNAM	ANDHRA PRADESH	Rishikonda Beach	1.6-2.2	Upto 0.24
CHIPURUPALLE	SRIKAKULAM	ANDHRA PRADESH	Chintapalle	0.7-2.1	Upto 0.23
PUSPATIREGA	VIZIANAGARAM	ANDHRA PRADESH	Pedanagayypalem	1.2-2.4	Upto 0.40
SRIKAKULAM	SRIKAKULAM	ANDHRA PRADESH	Atchanna Agraharam	0.6-1.5	Upto 0.24
VISHAKHAPATNAM	VISHAKHAPATNAM	ANDHRA PRADESH	Tikkavanipalem	0.6-1.5	Nii
YELLAMANCHILI	VISHAKHAPATNAM	ANDHRA PRADESH	Rajavaram	0.6-0.9	Nii
ANAKAPALLI	VISHAKHAPATNAM	ANDHRA PRADESH	Between Tantadi And Cheepurupalle East	0.6-0.8	Nii

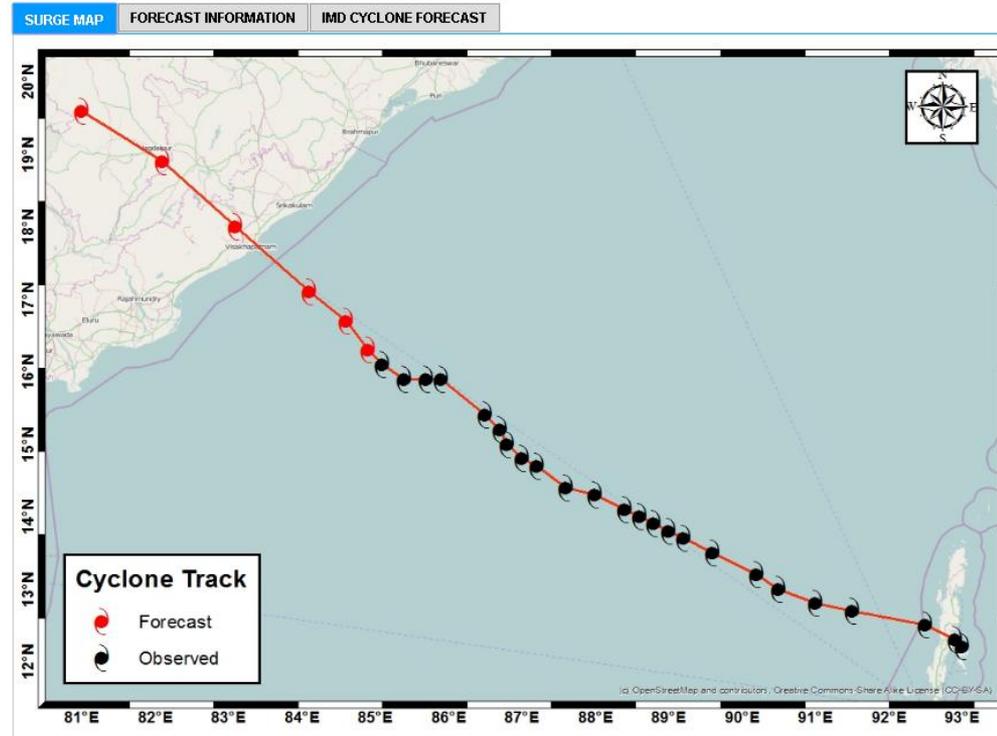
Graphic Products

Bulletins



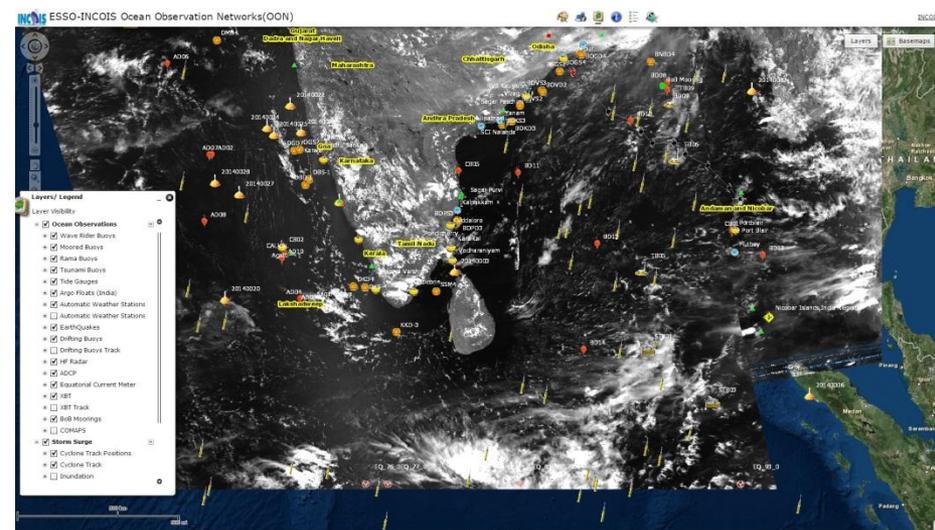
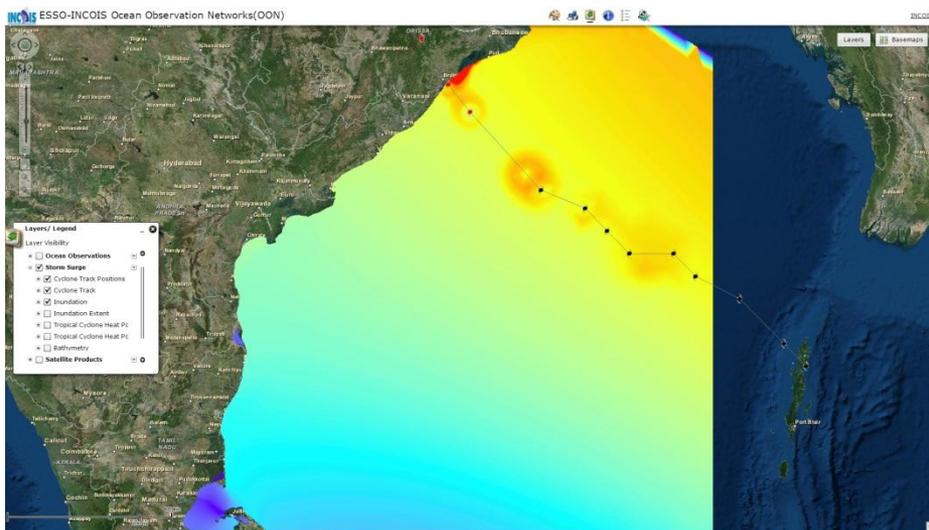
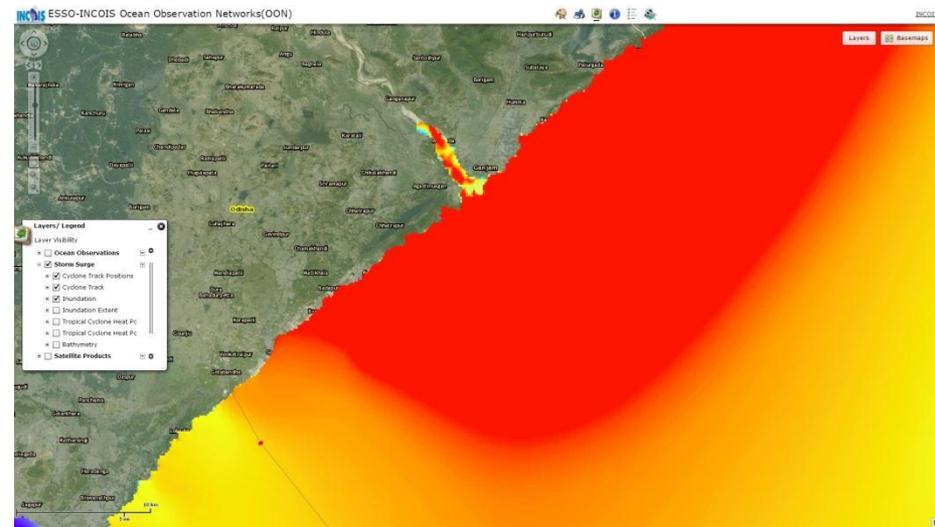
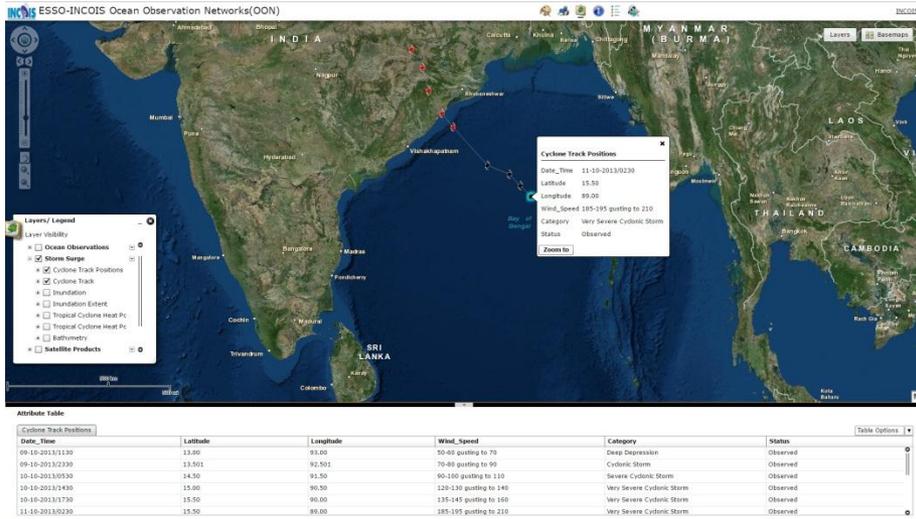
Storm Surge & Inundation Extent due to Hudhud cyclonic storm based on latest forecast issued by IMD

Surge Guidance



Cyclone Track

WebGIS Application for Storm Surge warning system



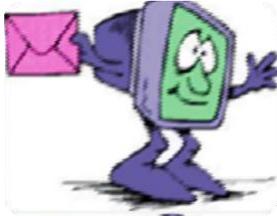
Dissemination Modes



Fax

National Level

MHA, NDMA, MoES, NDRF Head quarters, IMD & CWC



Email

State Level

Principal Secretaries (Revenue) of coastal states



SMS

District Level

District Collectors, District EOCs, DROs, others



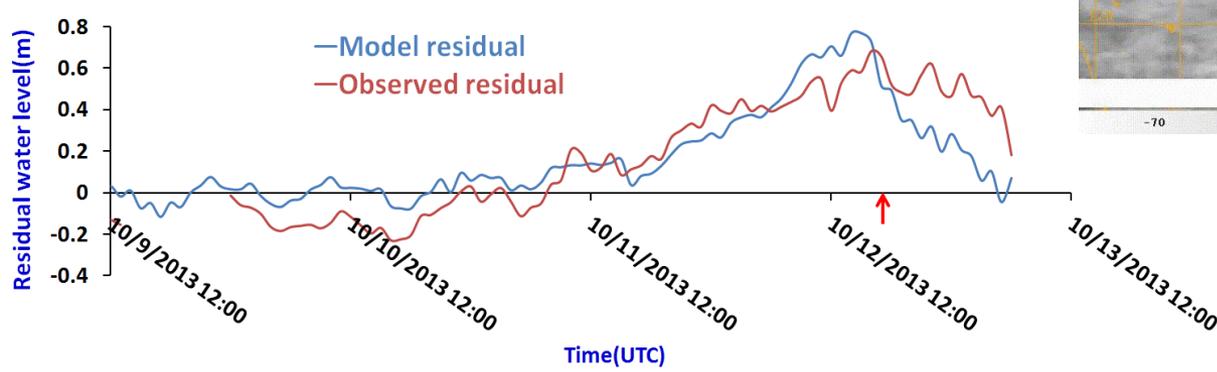
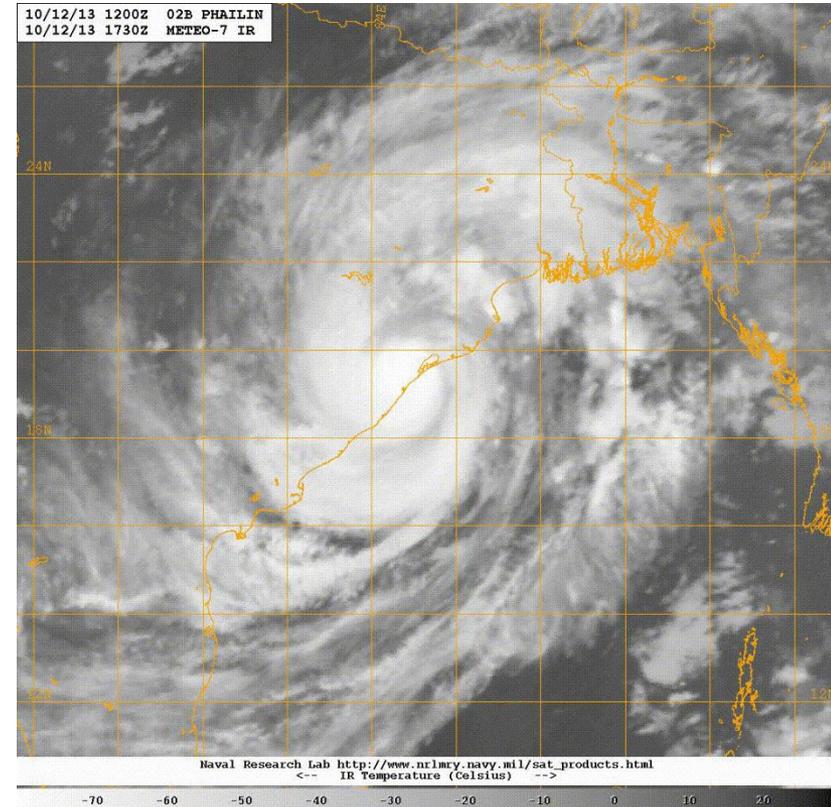
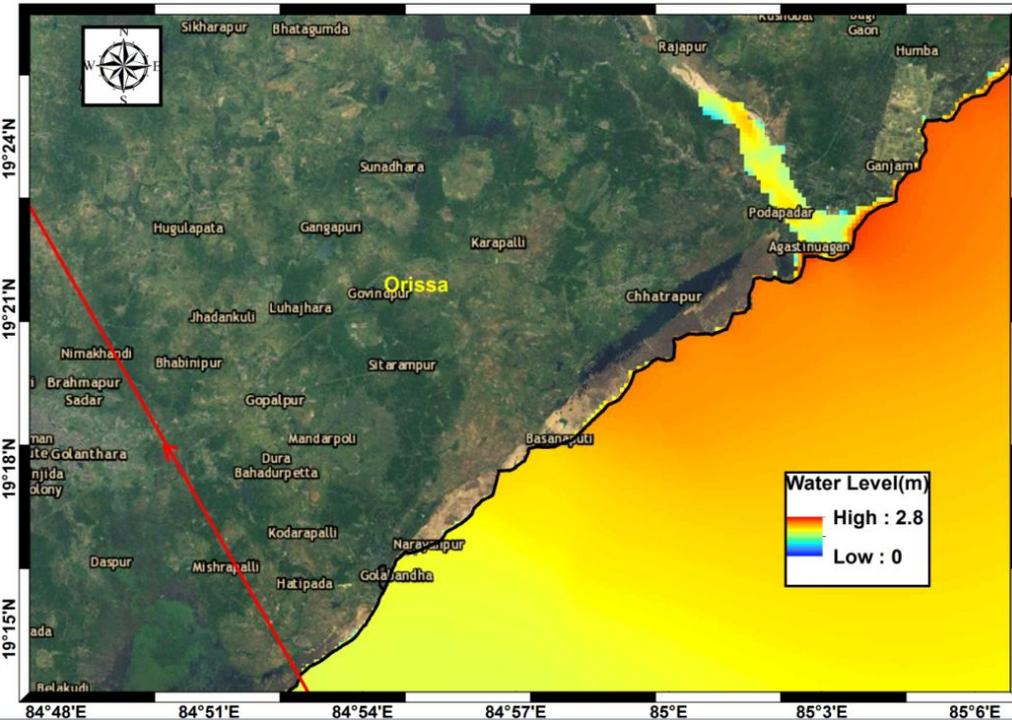
Web

<http://www.incois.gov.in/portal/stormsurge>

Real Time Simulation of Cyclone PHAILIN at INCOIS

FORECAST SUMMARY	
First Simulation	0530 IST of 09-10-2013
Last Simulation	0130 IST of 13-10-2013
Number of Computational Grid Points in the Inundation Model Domain	0.5 Million
Model Integration	4.5 Days
Time Taken for Each Simulation on HPC	45 Minutes using 256 Processors
Total number of bulletins issued	12
Maximum surge simulated for the entire duration of the event	2.6m near Ganjam, Orissa based on track forecast issued by IMD at 1500 IST of 12 th October
Maximum inundation extent simulated for the entire duration of the event	3km through river near Ganjam, Orissa based on track forecast issued by IMD at 1500 IST of 12 th October

Storm Surge model simulated water levels and inland inundation based on forecasted track issued by IMD



- (a) Model estimated water levels and inundation extent using forecasted track (Precipitation is not included in the model)
- (b) Comparison of model simulated residual water level to that of observed at Paradeep tide gauge (nearest tide gauge available about 202 km from the landfall point)

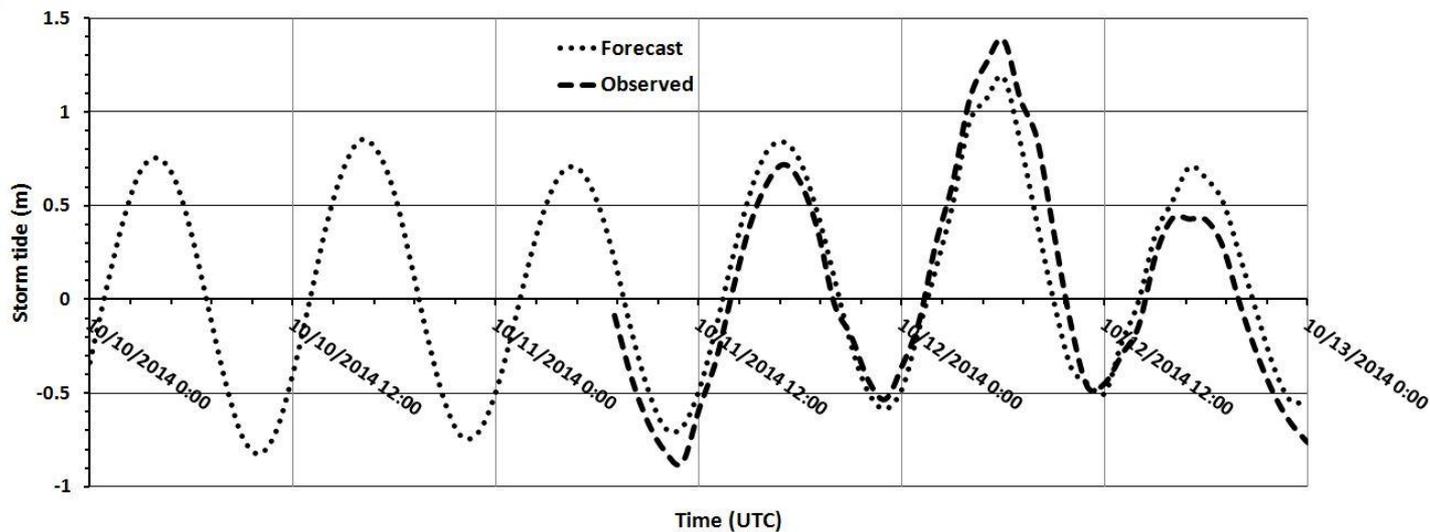
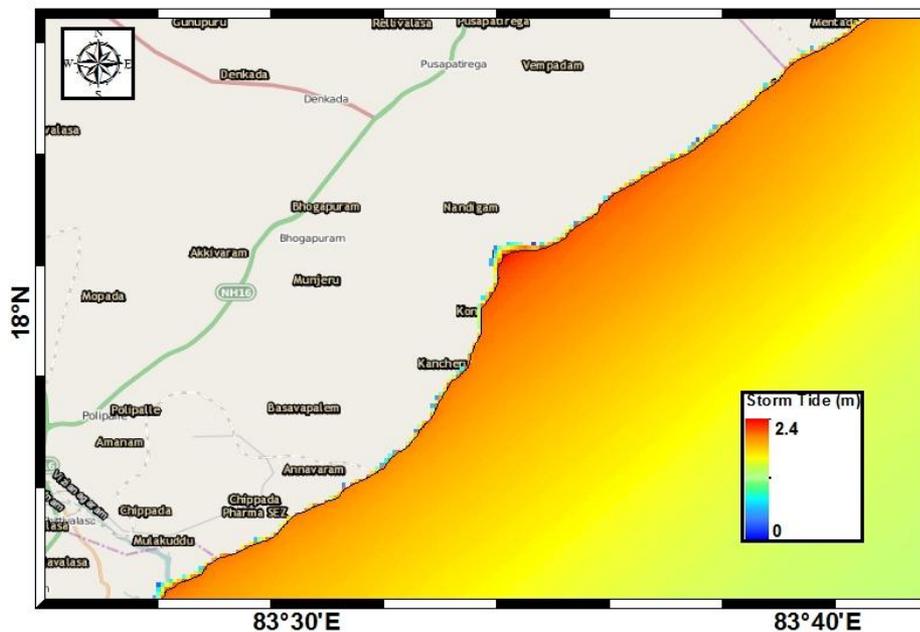
Comparison of model estimated inland inundation with post storm field measurements (Precipitation is not included in the model)

Locations along Odisha Coast	Model estimated inland extent of inundation (m)	Observed inland extent of inundation based on field measurement (m)
Dhepanuapada	-	23
Lohadigam	-	35
Humirbana	120	101
Humirbana	100	11
Podapadar	150	120
Podapadar	100	106
Agasti Naugam	250	173
Agasti Naugam	800	110
Ganjam	300	670
Mayarpada	150	160
Mayarpada	200	67
Jayamangalhil	300	65
Bhramarakudi	-	35
Bhramarakudi	-	44

Real time storm surge warning for the very severe cyclonic storm 'Hudhud'

FORECAST SUMMARY	
First Simulation	0530 IST of 08-10-2014
Last Simulation	1730 IST of 12-10-2014
Number of Computational Grid Points in the Inundation Model Domain	0.5 Million
Model Integration	5 Days
Time Taken for Each Simulation on HPC	45 Minutes using 256 Processors
Total number of bulletins issued	29
Maximum surge simulated for the entire duration of the event	2.4m near Pedanagayyapalem, Puspatirega mandal, Andhra Pradesh based on track forecast issued by IMD at 1430 IST of 11 th October
Maximum inundation extent simulated for the entire duration of the event	400 m near Pedanagayyapalem, Puspatirega mandal, Andhra Pradesh

Real time storm surge warning for the very severe cyclonic storm 'Hudhud'



Real time validation of surge levels with observed tide gauge records.
(Tide gauge station: Visakhapattanam)

Validation of inundation extent forecast for ‘Hudhud’ event

(Observed values were obtained by GPS survey soon after the cyclone landfall)

Place	Mandal	District, State	Inundation extent	
			Forecasted (m)	Observed (m)
Konada	Puspatirega	Vijayanagaram, AP	300	400
Kollayavalasa	Puspatirega	Vijayanagaram, AP	100	90
Pathiwada	Puspatirega	Vijayanagaram, AP	200	150
Kancheru	Puspatirega	Vijayanagaram, AP	160	150
Pedanagayyapalem	Bhimunipattanam	Visakhapattanam, AP	100	50
Chintapalle	Puspatirega	Vijayanagaram, AP	200	80
Mentada	Chipurupalle	Srikakulam, AP	150	110
Kancherupalem	Puspatirega	Vijayanagaram, AP	nil	nil
Ramachandrapuram	Chipurupalle	Srikakulam, AP	180	120
Nerellavalasa Rural	Bhimunipattanam	Visakhapattanam, AP	nil	60
Kothuru	Bhimunipattanam	Visakhapattanam, AP	100	70
Kolli Bheemavaram	Chipurupalle	Srikakulam, AP	140	140
Rishikonda beach	Bhimunipattanam	Visakhapattanam, AP	nil	60
Thimmapuram	Bhimunipattanam	Visakhapattanam, AP	100	100
Kottapalem	Chipurupalle	Srikakulam, AP	150	160
Yethapeta	Chipurupalle	Srikakulam, AP	100	80
Atchanna Agraharam	Chipurupalle	Srikakulam, AP	nil	60
Bontalakoduru	Srikakulam	Srikakulam, AP	150	190
MVP Colony	Visakhapattanam	Visakhapattanam	nil	20
Rama Krishna Beach	Visakhapattanam	Visakhapattanam	nil	50
Galla Peta	Srikakulam	Srikakulam, AP	200	150
Pathiwada	Puspatirega	Vijayanagaram, AP	200	180
Kuppili	Chipurupalle	Srikakulam, AP	200	180
Tekkali	Chipurupalle	Srikakulam, AP	100	100

Storm Surge Advisory was provided in collaboration with IMD for the following cyclonic storms:

Provided experimental forecast using DSS

Phailin (Oct, 2013)

Helen (Nov, 2013)

Lehar (Nov, 2013)

Madi (Dec, 2013)

Nanauk (Jun, 2014)

DSS made operational during VSCS- HudHud

❖ Hudhud (Oct, 2014)

❖ Nilofar (Oct, 2014)

❖ Ashobaa (Jun, 2015)

❖ Roanu (May, 2016)

❖ Kyant (Oct, 2016)

❖ Nada (Nov, 2016)

❖ Vardah (Dec, 2016)

❖ Maarutha (Apr, 2017)

❖ TITLI , Luban (Oct, 2018)

❖ Gaja (Nov, 2018)

❖ Phethai (Dec, 2018)

❖ Pabuk (Jan, 2019)

Thank You



ESSO-Indian National Centre for Ocean Information Services

**(Ministry of Earth Sciences, Government of India), "Ocean Valley",
Pragathi Nagar (B.O.), Nizampet (S.O.),
Hyderabad-500 090**

Email: stormsurge@incois.gov.in

Website: <http://www.incois.gov.in/portal/stormsurge>