Storm surges along the Indian coastline

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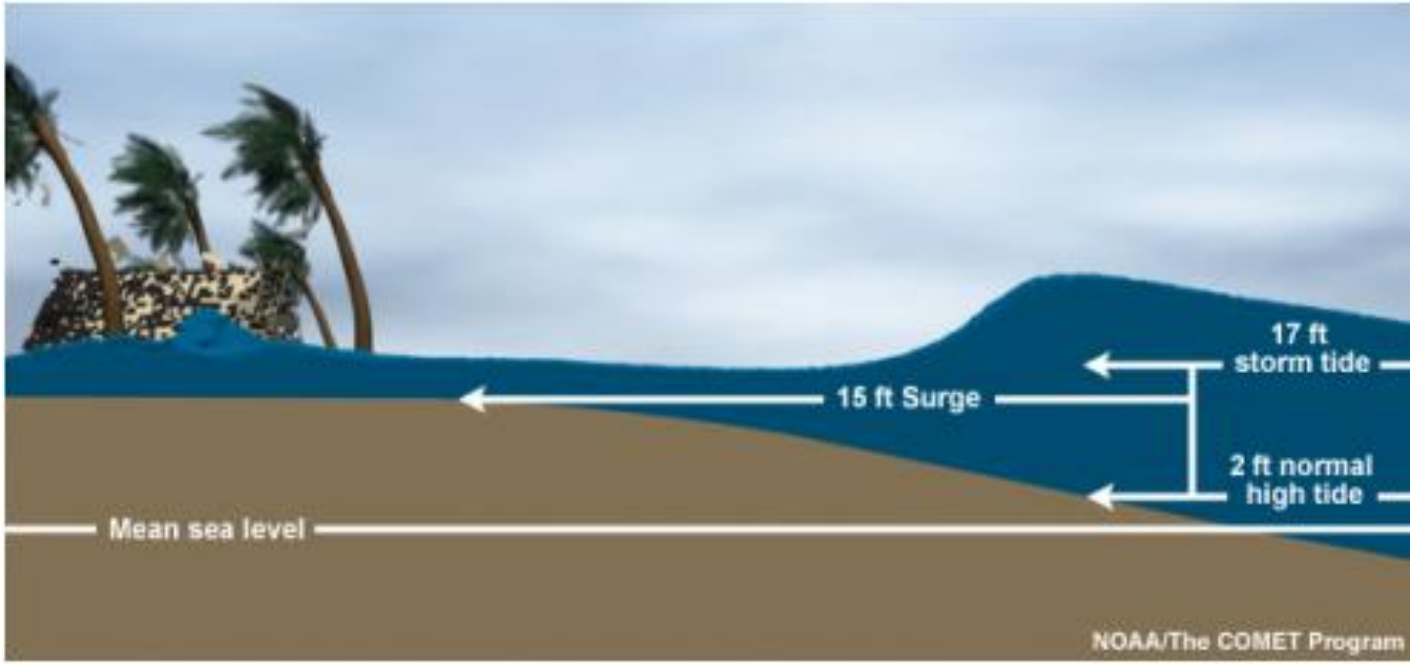
Storm Surge and Storm Tide

What is storm surge ?

Storm surge is an abnormal rise of water generated by a storm, over and above the astronomical tide.

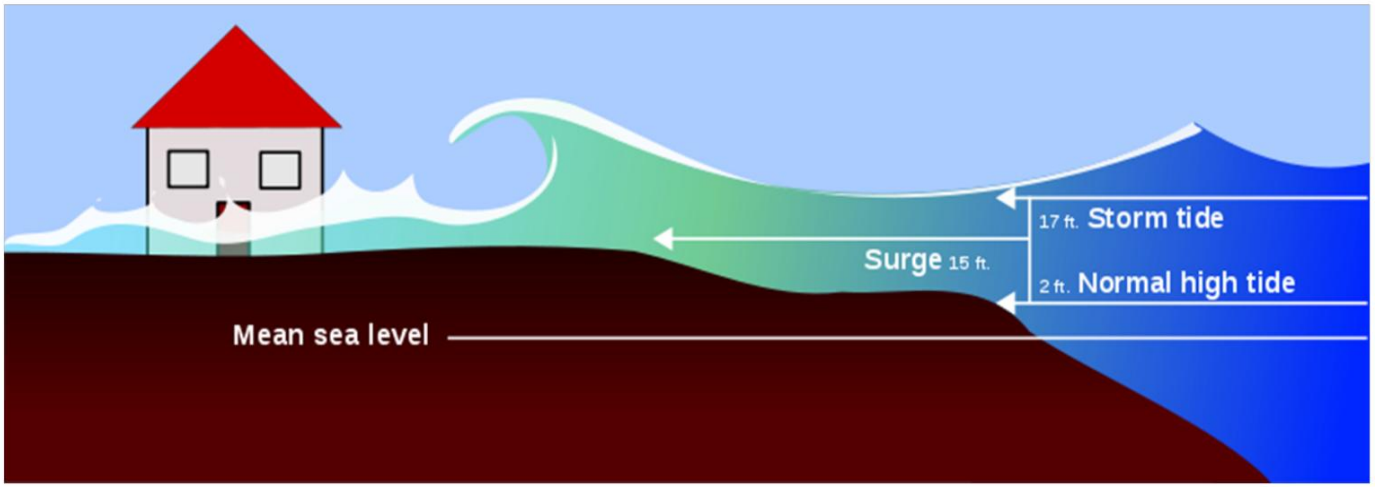
What is storm tide ?

Storm tide is the water level rise during a storm due to the combination of storm surge and the astronomical tide.



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
- Low storm pressure over the ocean
- Tides – phase of the tides contribute to storm surge height
- Slope and width of the continental shelf

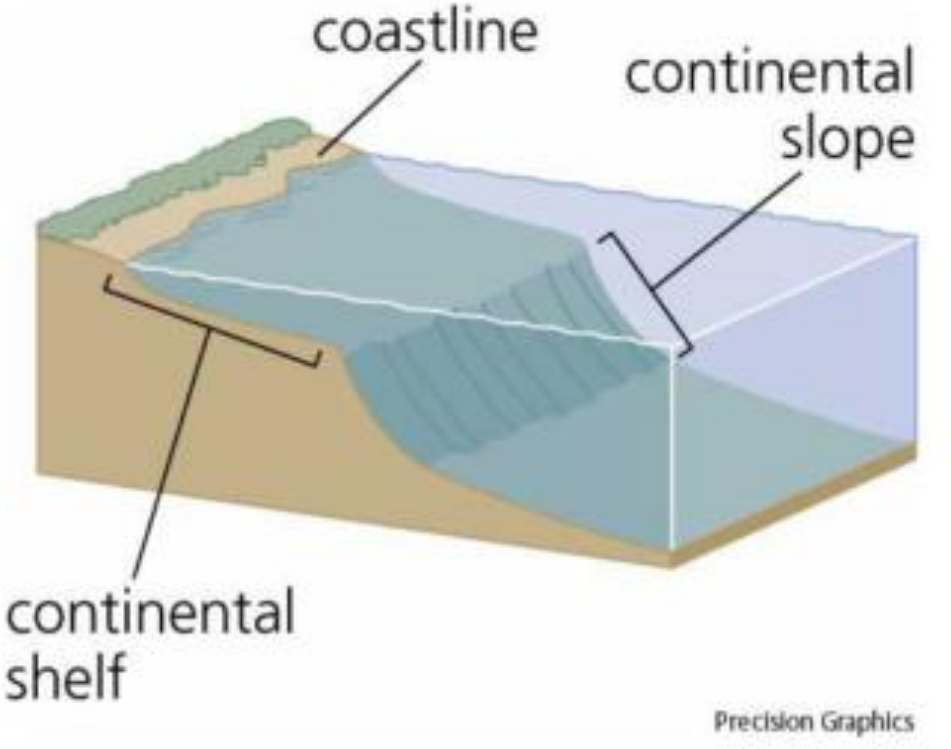
  - wide, shallow shelves are prone to larger storm surges.

Factors contributing storm surge

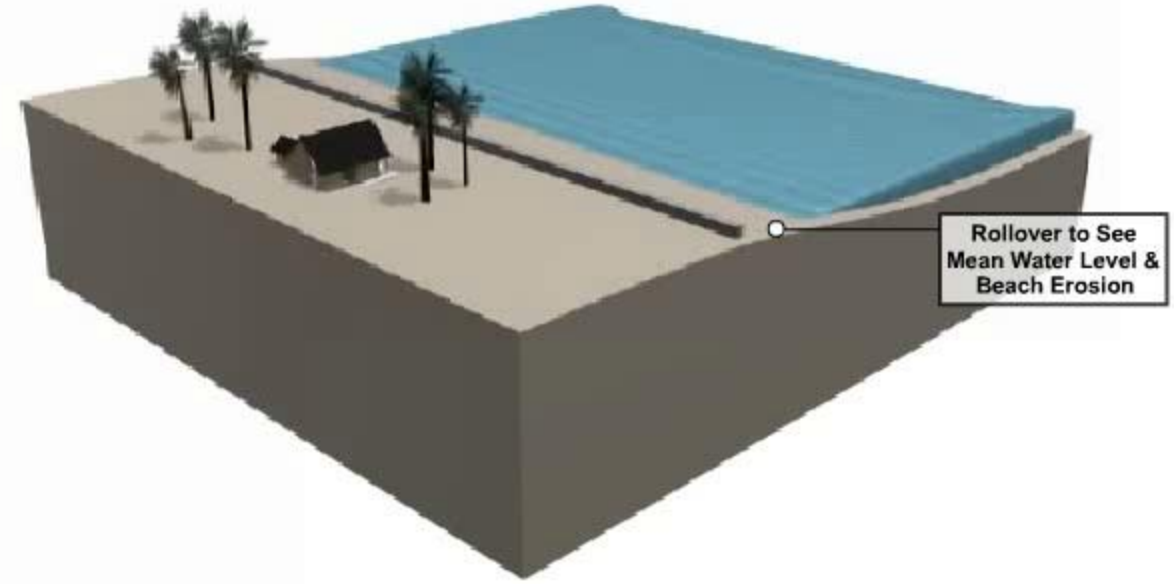
• Coastal geometry:

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

*"Experiments suggest that the curving coasts not only shift the peak surge position but also affect its height(**Dube et al. 1982**) "*



Example of Storm Surge

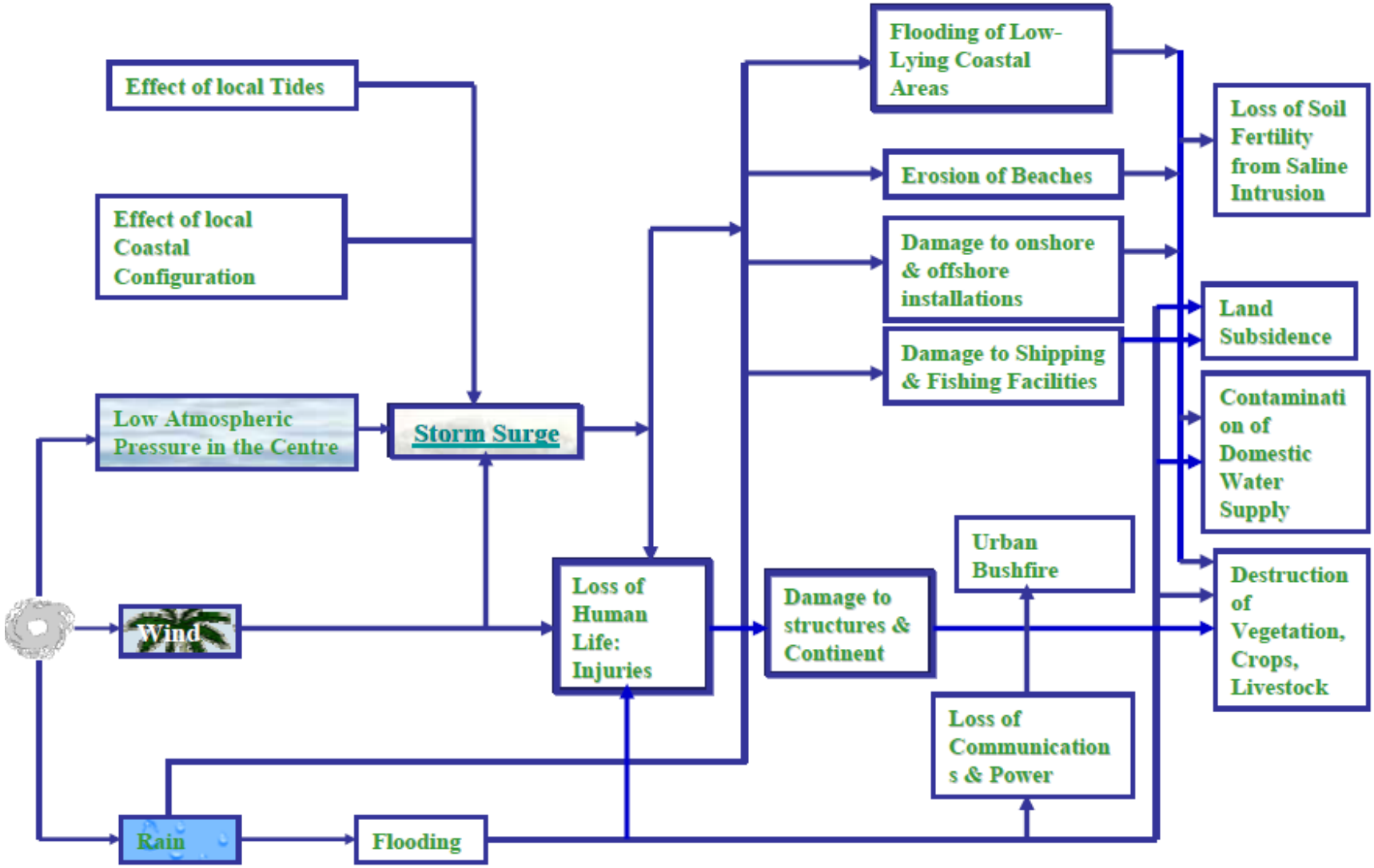


Entire Indian coast can be categorized into 4 zones

- Very high risk zones (Surge height > 5m)
- High risk Zone (Surge height between 3-5m)
- Moderate risk zone (Surge height between 1.5 to 3m)
- Minimal risk zone (Surge height < 1.5m)

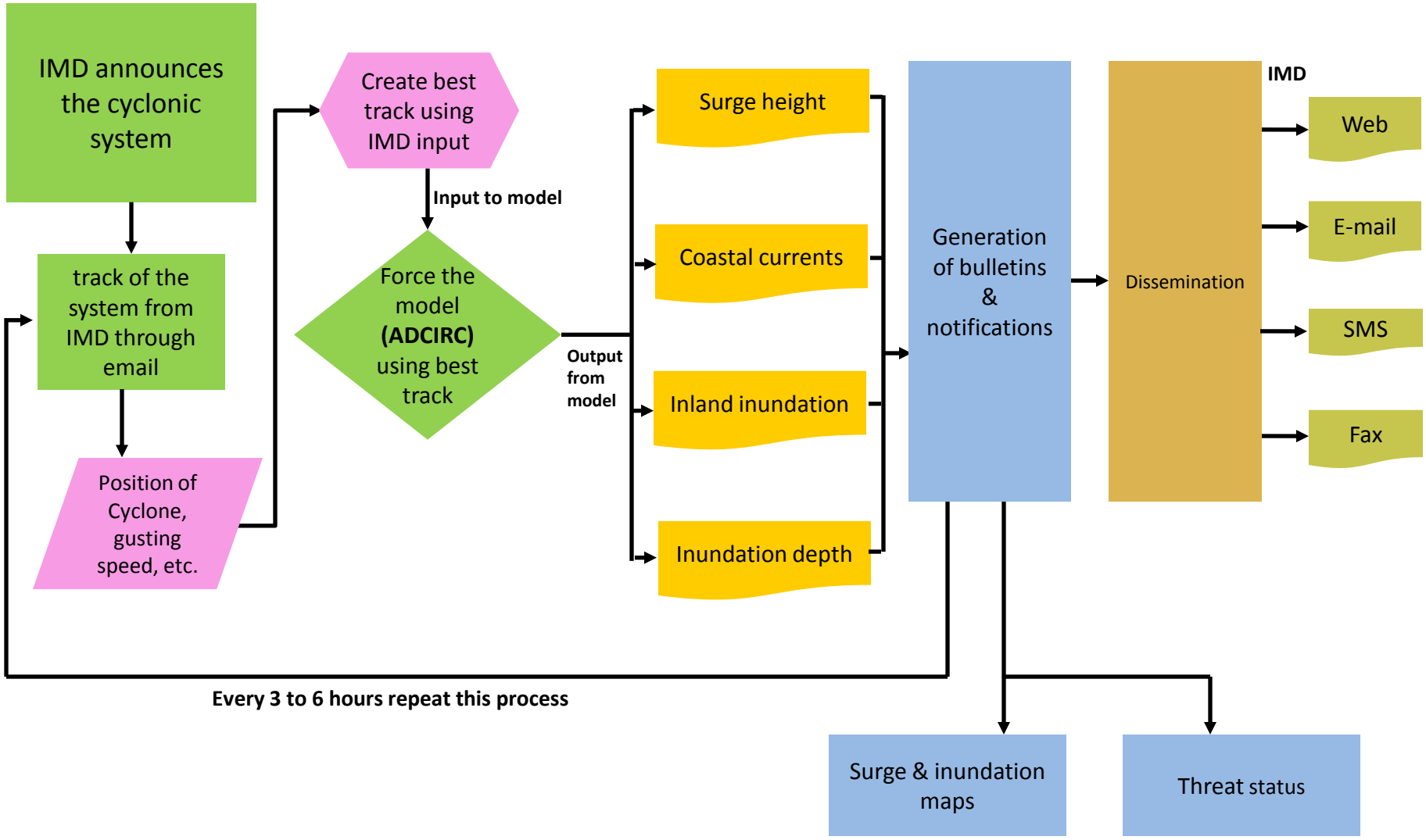
Accordingly

- The coastal areas and off-shore islands of Bengal and adjoining Bangladesh are the most storm-surge prone (~ 10-13m) – VHRZ
- East coast of India between Paradip and Balasore in Orissa (~ 5-7m) – VHRZ
- Andhra coast between Bapatla and Kakinada holding estuaries of two major rivers Krishna and Godavari (~ 5-7m) – VHRZ
- Tamilnadu coast between Pamban and Nagapattinam (~ 3-5m) – HRZ
- Gujarat along the west coast of India (~ 2-3m) -MRZ

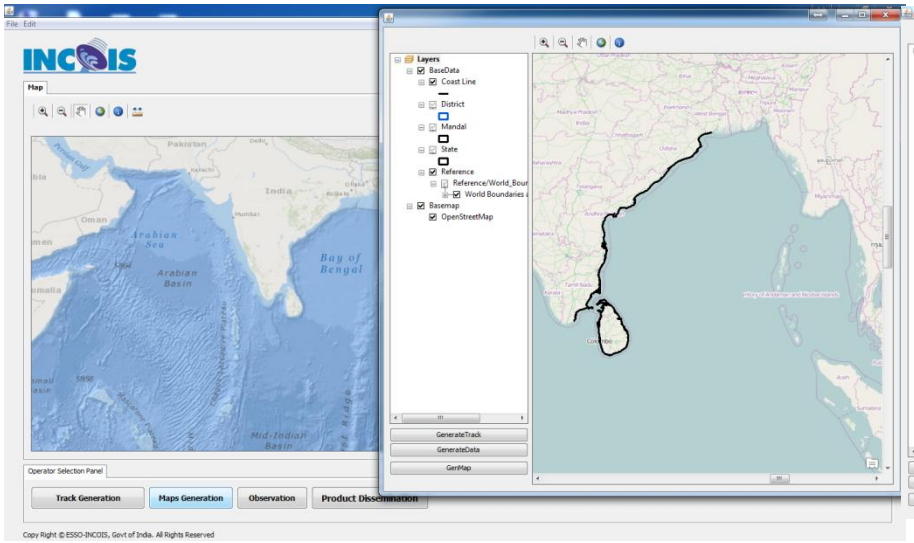


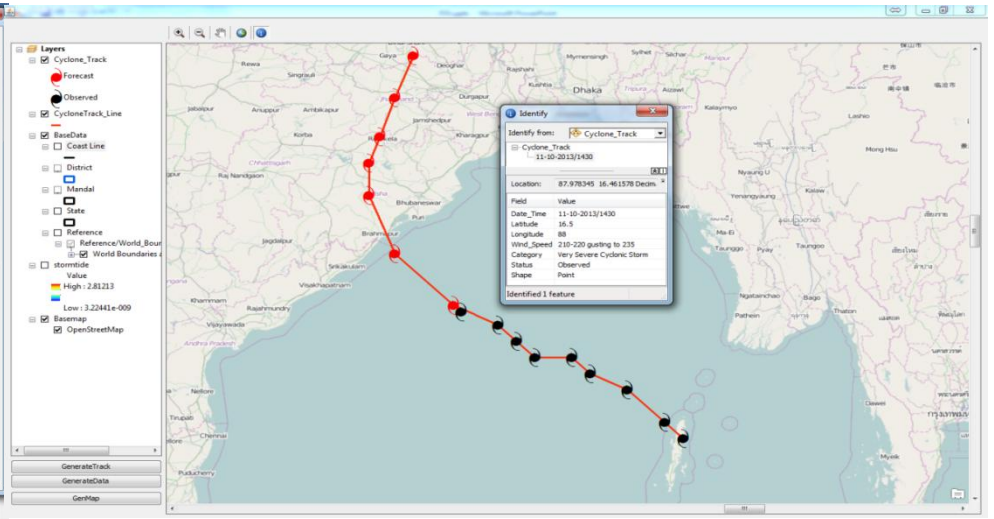
Potential Impact upon Landfall of a Tropical Cyclone

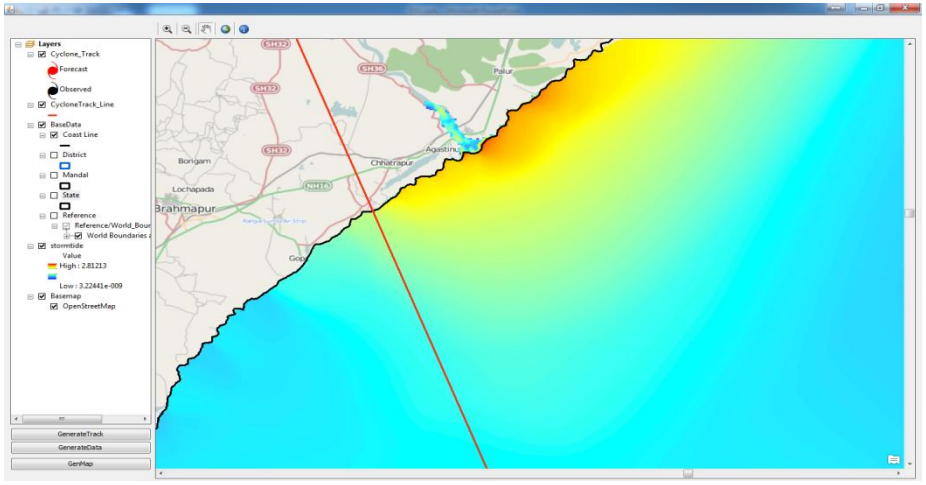
Storm Surge Warning SOP Flow Chart

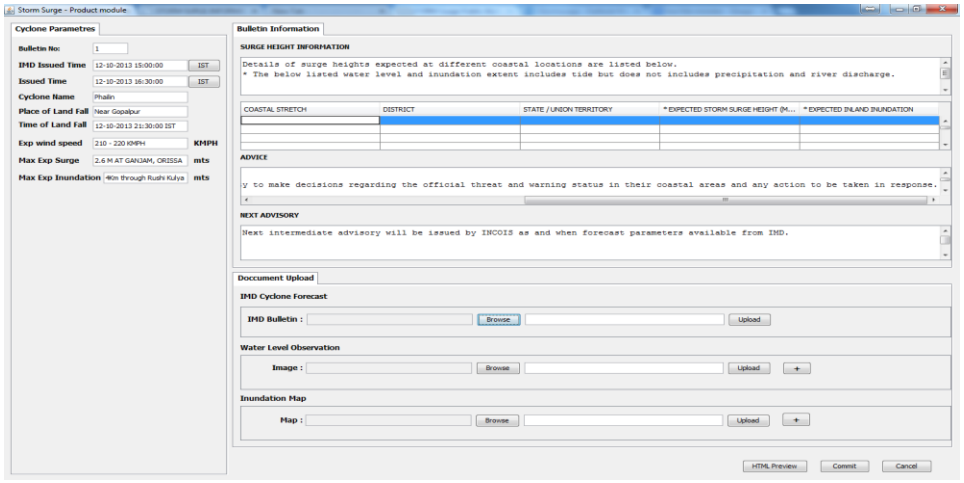


Decision Support System

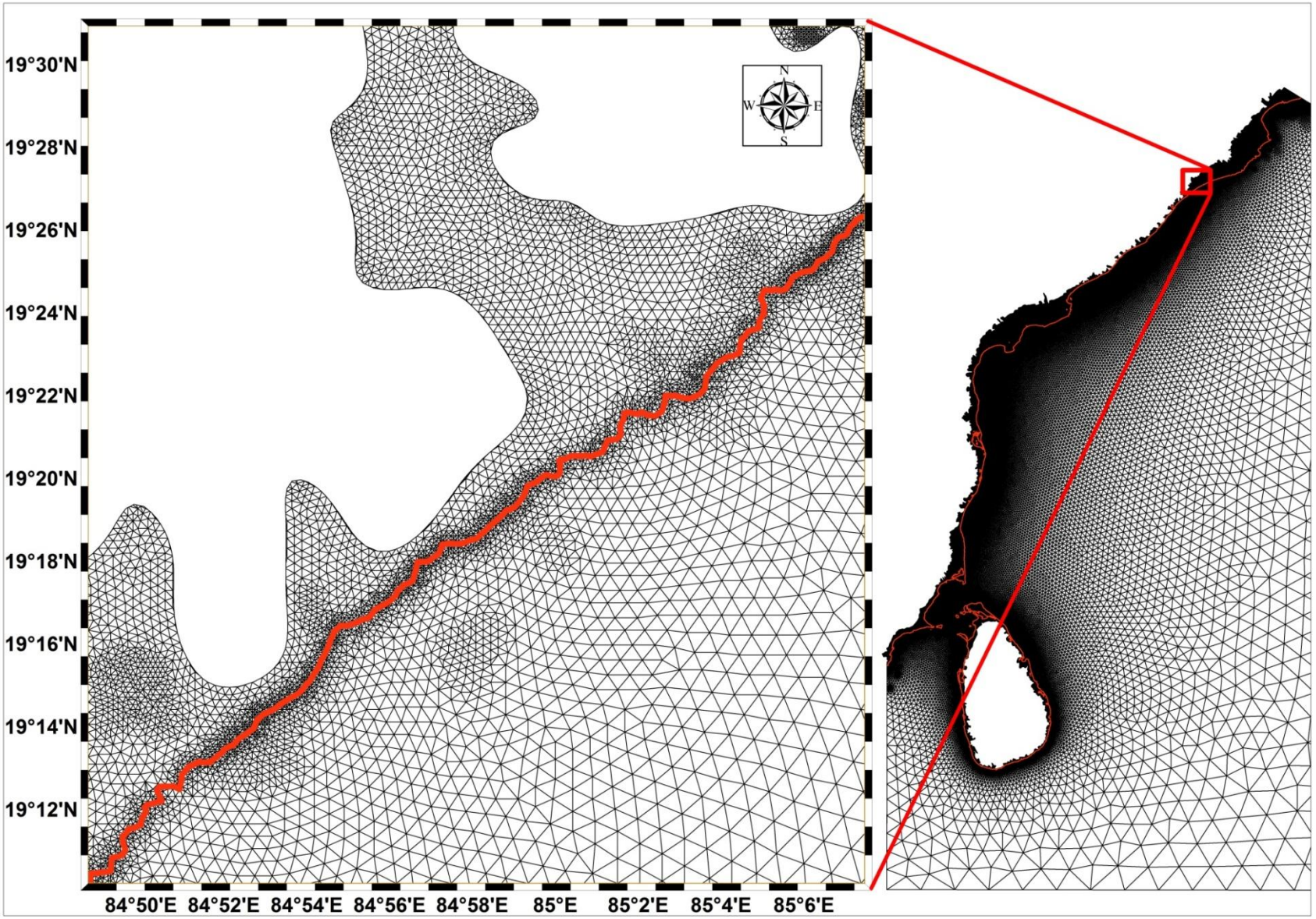








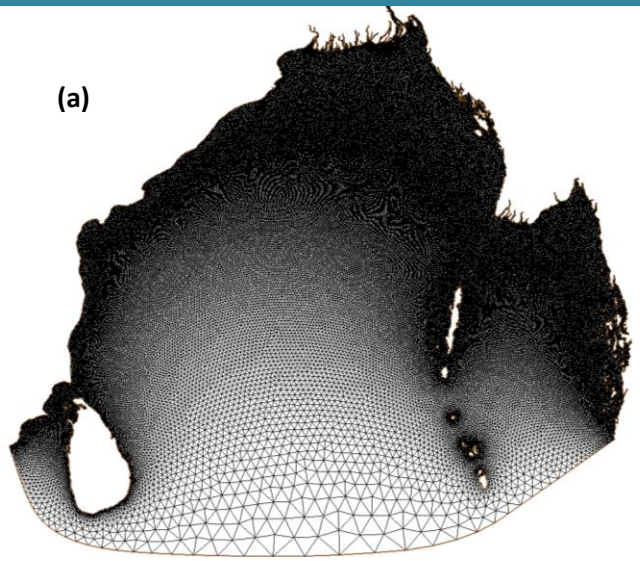
High Resolution grids at Coast



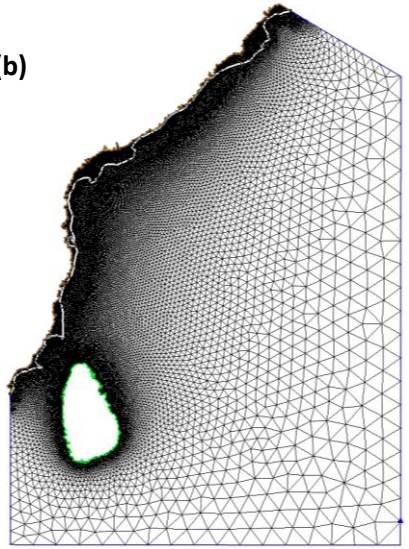
Near shore grid resolution is very much crucial factor in order to achieve accuracy in storm surge computation (Blain et al., 1994)

Model Grids for simulation

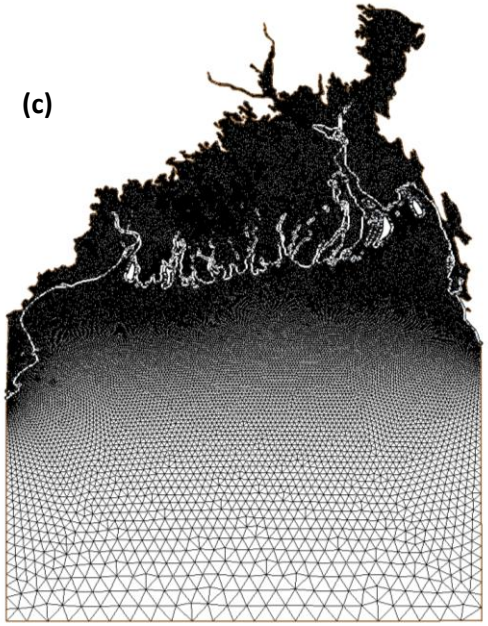
(a)



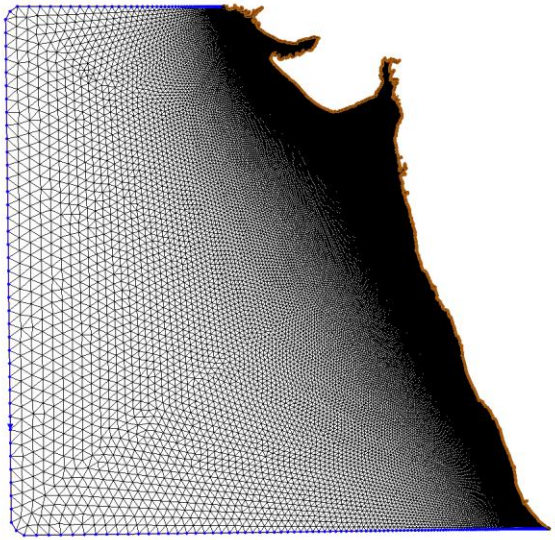
(b)



(c)

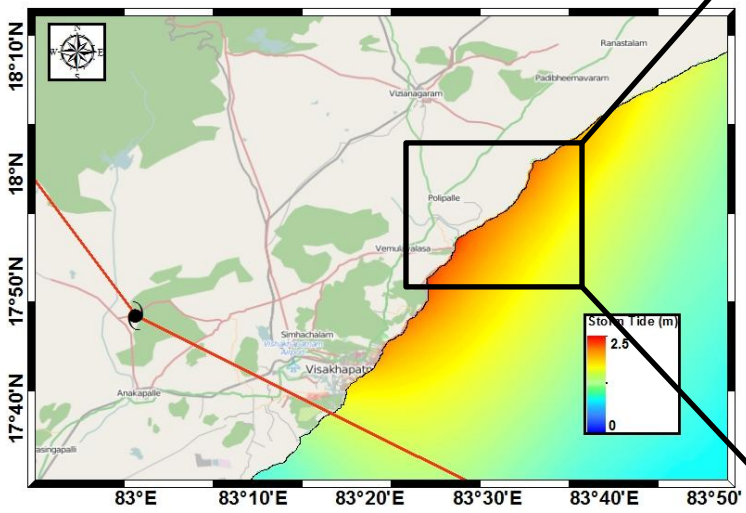


(d)

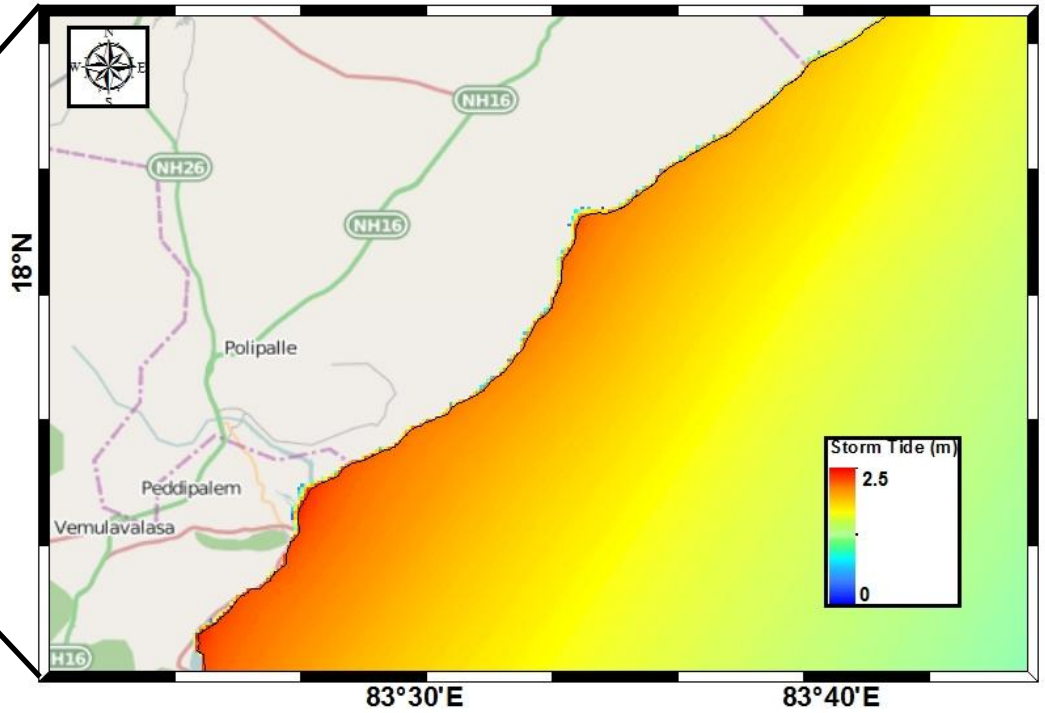


- Finite element mesh of BOB region (fig.a) for simulation of surges alone
- East coast is divided into two domains (fig.b, c) for the simulation of inundation due to surges.
- Triangular gridded mesh for the west coast of India (fig.d)

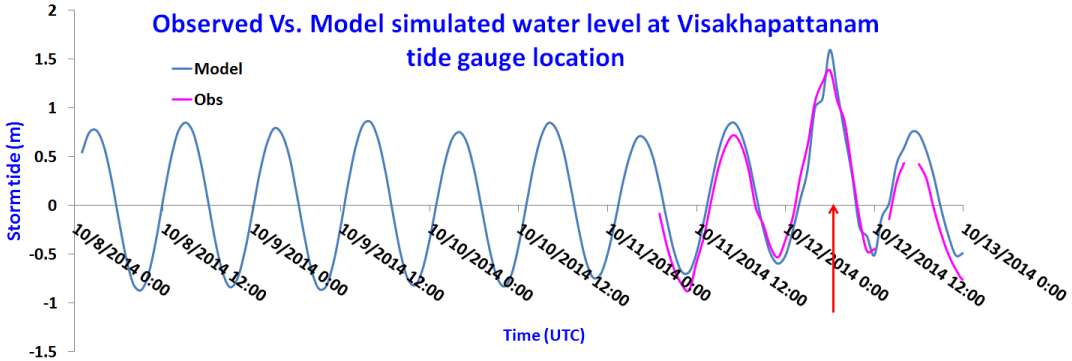
Operational Storm Surge forecast for VSCS Hudhud (8-12 October, 2014)



Model computed inundation extent along the coastal stretch



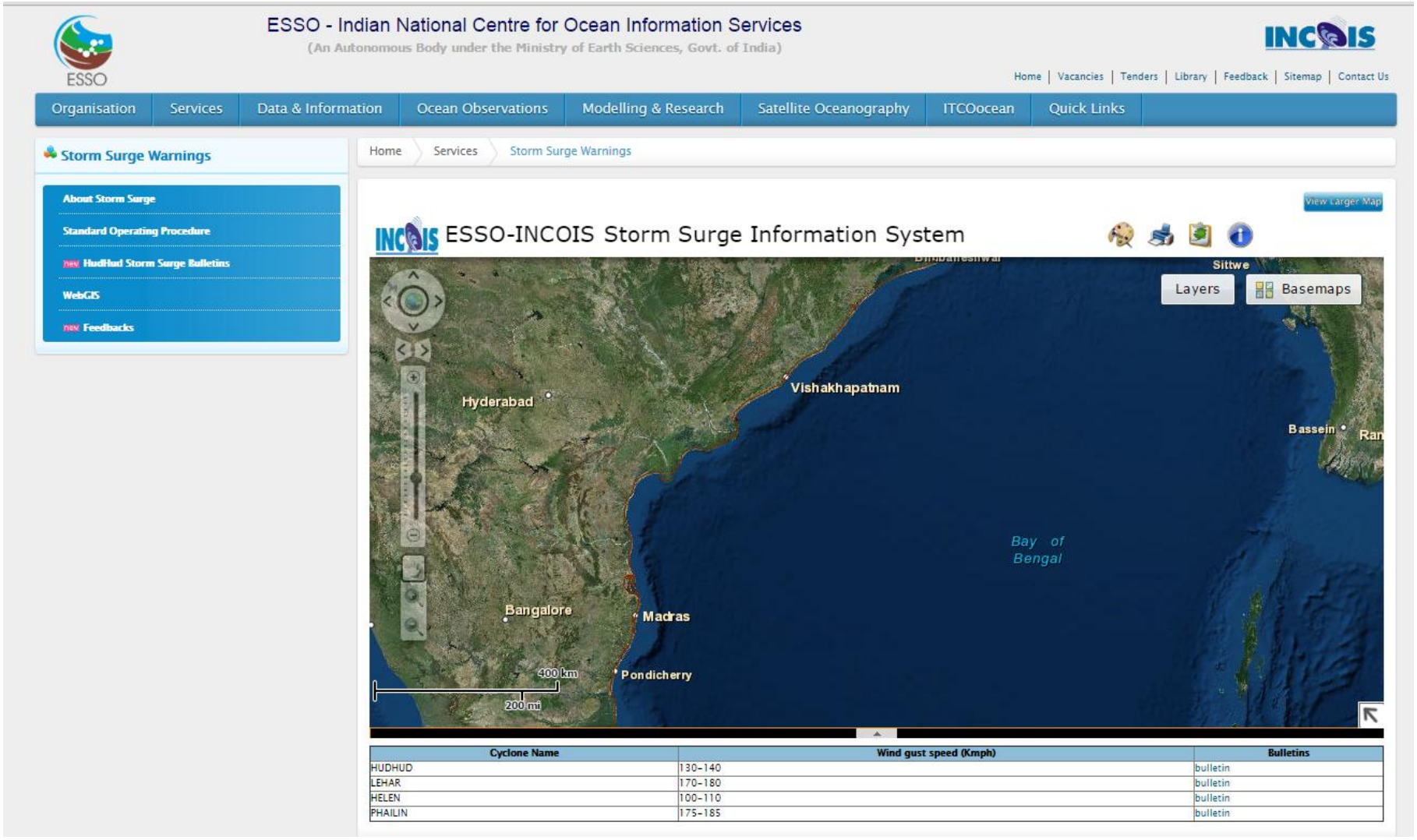
First simulation	0530 IST of 08th October 2014
Forecast duration	5 days
Bulletins issued	29
Maximum Expected storm Tide	2.4 m near Pedanagayyapalem, Puspatirega Mandal, Andhrapradesh
Maximum Expected inundation extent	400 m near Pedanagayyapalem, Puspatirega Mandal, Andhrapradesh



List of storm surge forecast s

Event	Starting Simulation	Last simulation	Number of bulletins issued
HudHud	0530 IST of 08th October 2014	1730 IST of 12th October 2014	29
Phailin	0530 IST of 9th October 2013	0130 IST of 13th October 2013	20
Helen	1330 IST of 20th November 2013	1630 IST of 22nd November 2013	20
Lehar	0230 IST of 23rd November 2013	1100 IST of 28th November 2013	33
Madi	0100 IST of 6th December 2013	0130 IST of 16th December 2013	-

Where can find the Storm Surge information during a tropical event?



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

Sample Bulletin

INCOIS

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

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INDIAN STORM SURGE EARLY WARNING CENTRE

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FINAL STORM SURGE BULLETIN BASED ON TRACK FORECAST ISSUED BY IMD AT 2030 IST

Click Here to View- WebGIS Interface

SURGE MAP | FORECAST INFORMATION | IMD CYCLONE FORECAST

EVENT SUMMARY

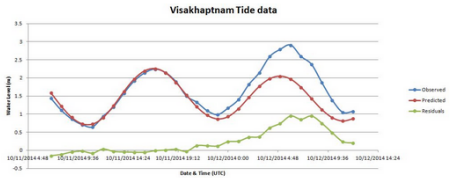
CYCLONE NAME	HudHud
EXPECTED PLACE OF LAND FALL	NORTH ANDHRA PRADESH COAST NEAR VISAKHAPATNAM
EXPECTED TIME OF LAND FALL	Between 12 -13 hrs IST
EXPECTED WIND SPEED	100 kmph
MAX EXPECTED STORM TIDE (SURGE + TIDE)	0.6 m Near Kapulupada, Vishakhapatnam
MAX EXPECTED INUNDATION EXTENT	Nil

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 (Filter: All)	DISTRICT (Filter: All)	STATE / UNION TERRITORY	NEAREST PLACE OF HABITATION	* SURGE (m)	* EXPECTED INUNDATION EXTENT (km)
BHIMUNIPATNAM	VISHAKHAPATNAM	ANDHRA PRADESH	Kapulupada	0.6	Nil
CHIPURUPALLE	SRIKAKULAM	ANDHRA PRADESH	Mentada	0.6	Nil
PUSPATIREGA	VIZIANAGARAM	ANDHRA PRADESH	Kancheru	0.6	Nil
SRIKAKULAM	SRIKAKULAM	ANDHRA PRADESH	Mofusbandar	0.6	Nil
VISHAKHAPATNAM	VISHAKHAPATNAM	ANDHRA PRADESH	Devada	0.6	Nil
YELLAMANCHILI	VISHAKHAPATNAM	ANDHRA PRADESH	Chatametta	0.5	Nil



Water level comparison at Vishakhapatnam tide gauge location

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

This will be the final bulletin from INCOIS for HUDHUD Severe Cyclone unless additional information available from IMD, Delhi.

CONTACT INFORMATION

Indian Storm Surge Early Warning Centre (ISWC)
Indian National Centre for Ocean Information Services (INCOIS)
Address:"Ocean Valley", Pragathi Nagar (BO), Nizampet (SO),
Hyderabad - 500 090, India.
Tel: 91-40-23895011
Fax: 91-40-23895012
Email: stormsurge@incois.gov.in
Website: www.incois.gov.in

National Bulletins issued at Mandal level Bulletin Formats

- Notification Messages are issued in text format via E-mail
- Bulletins are issued in both PDF and html formats
- Graphics are made available in jpg or png format on the website
- Spatial data is made available in dbf format through the ftp site

Sample Bulletin

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INDIAN STORM SURGE EARLY WARNING CENTRE

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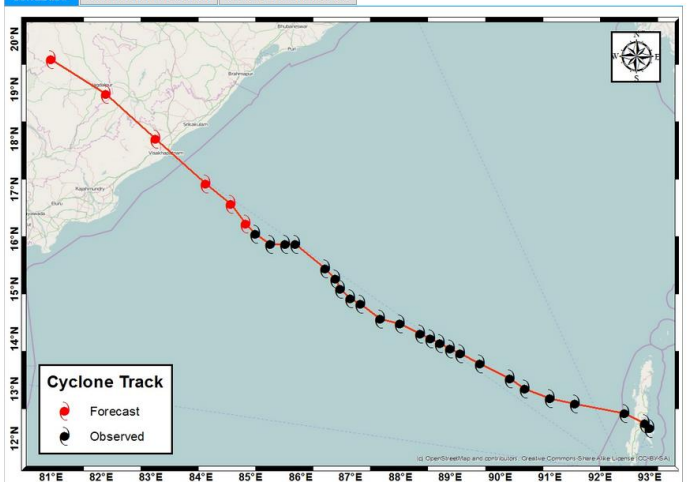
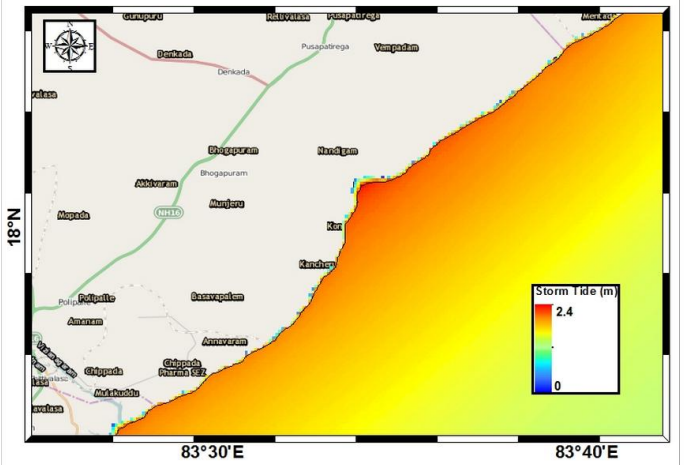
SURGE MAP | FORECAST INFORMATION | IMD CYCLONE FORECAST

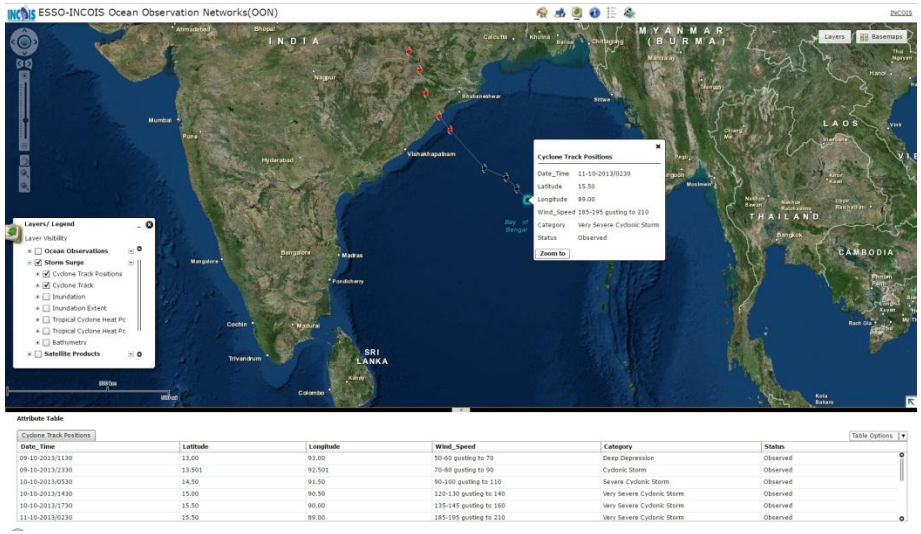


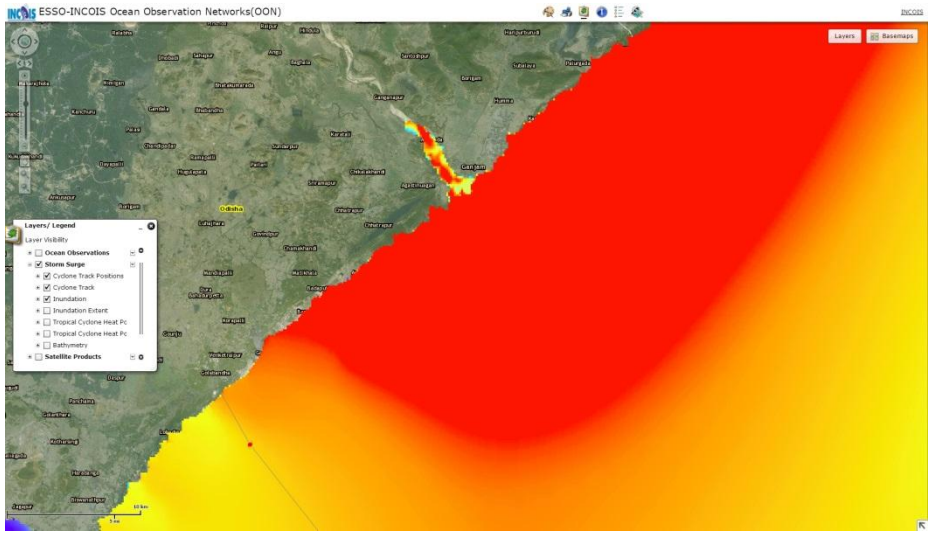
Track of the HudHud cyclonic storm based on latest forecast issued by IMD

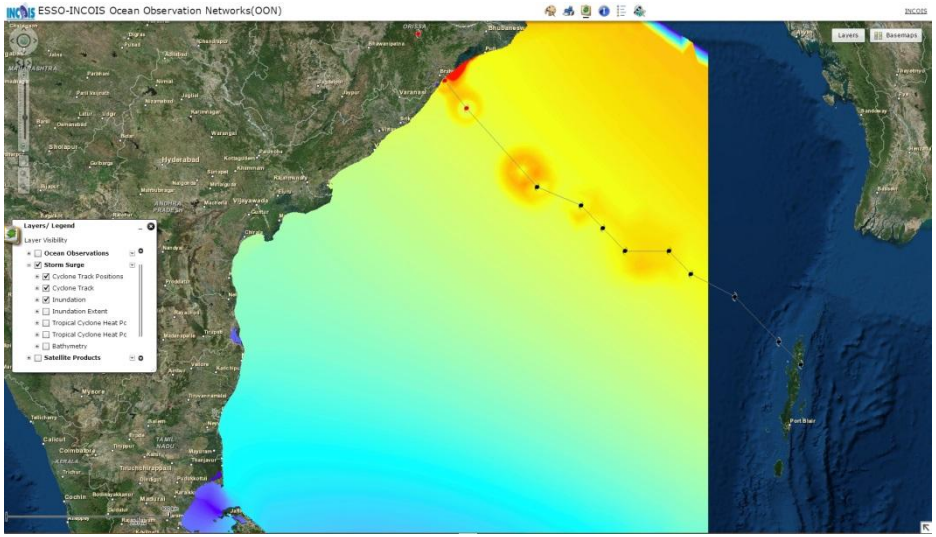


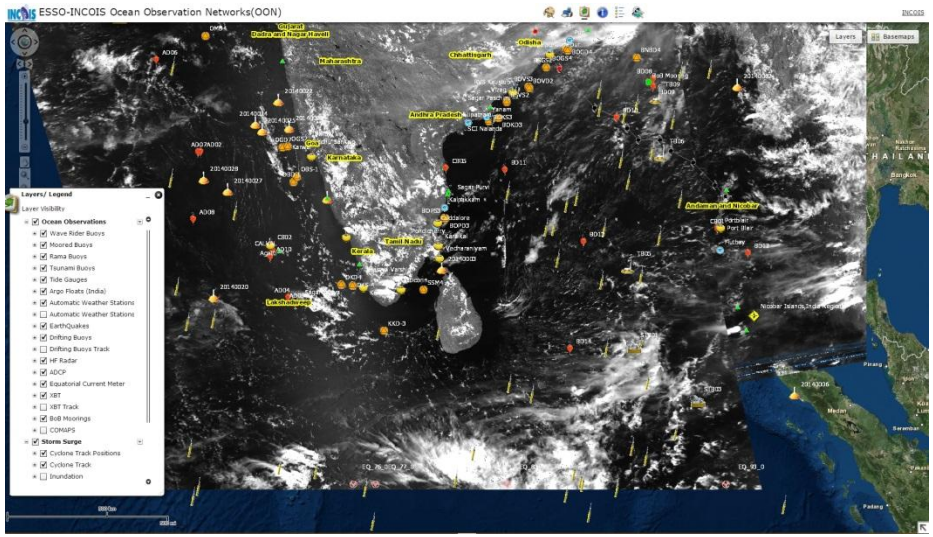
Storm Surge & Inundation Extent due to HudHud cyclonic storm based on latest forecast issued by IMD

Interactive Web GIS Portal



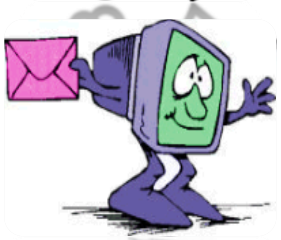






Dissemination of Storm Surge Bulletins

Fax



Email

SMS

Web

National Level

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

State Level

Principal Secretaries (Revenue) of coastal states

District Level

DROs of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasham, and S.P.S Nellore

Thank You