

# Storm Surges

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# ***Outline of the Presentation***

**Tropical cyclones and its impact**

**Characteristics of storm surges**

**Coastal Inundation**

**Coastal Vulnerability**



## Different types of Ocean related Disasters

- 1) Tsunami
- 2) Oil Spills
- 3) Swell surge (Kallakadal)
- 4) Ocean acidification
- 5) Harmful algal blooms / Hypoxia
- 6) Sea level rise due to climate change
- 7) Coastal erosion
- 8) Marine plastics/debris
- 9) Storm surge due to Tropical cyclones
- 10) Marine Heat Waves

# Tropical cyclones

## Statistics of Tropical Cyclone Formation over the Global Ocean basins

### Statistics of Tropical Cyclones over the Global Ocean basins

Northern Hemisphere (70%)

June - November

S. No.	Ocean Basin	% of Total Count	Overall Ranking
1.	North Western Pacific Ocean	31	1
2.	North Eastern Pacific Ocean	19	2
3.	North Atlantic Ocean	16	3
4.	North Indian Ocean	4	7

Southern Hemisphere (30%)

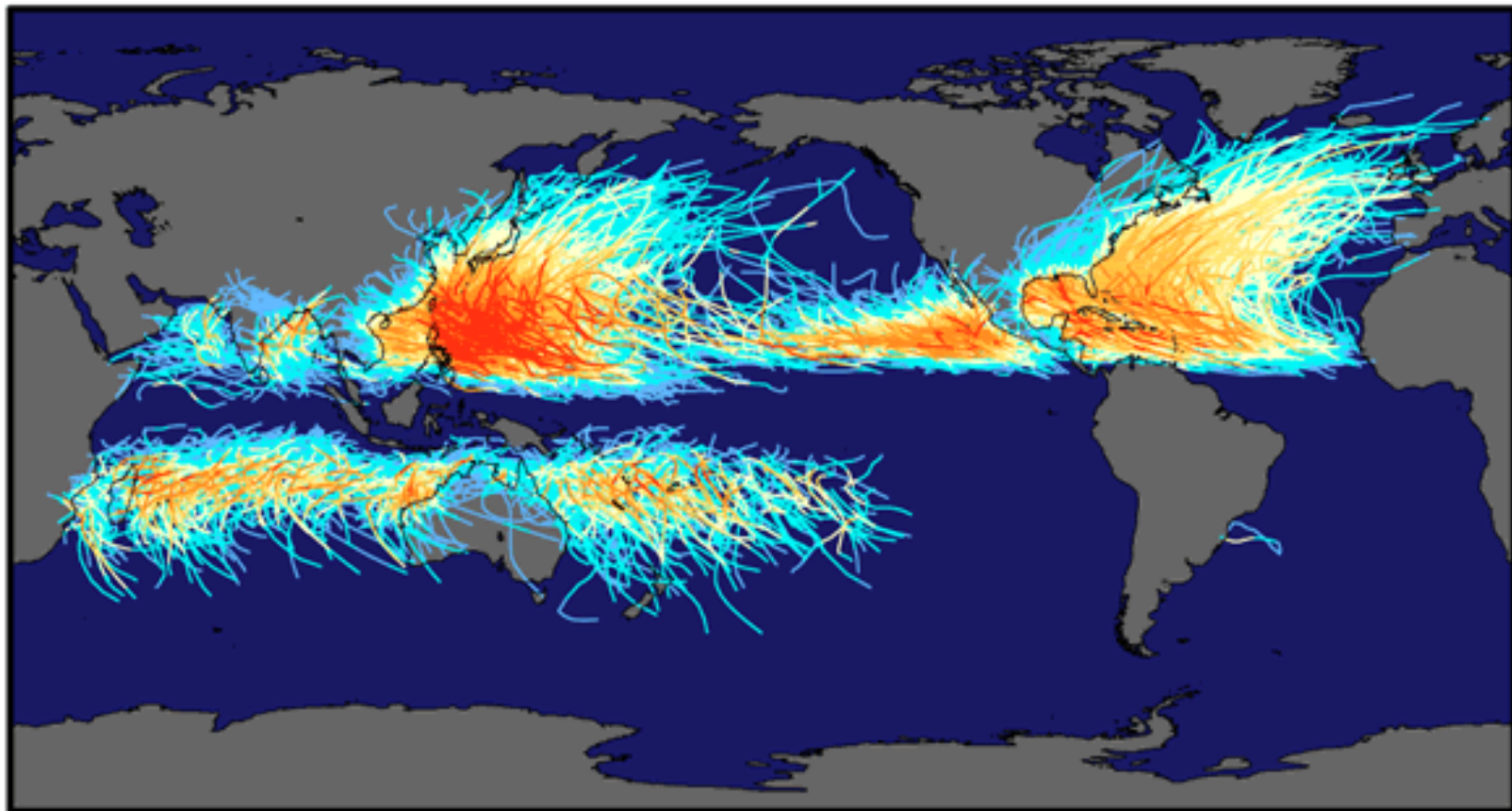
November - May

4.	South Indian Ocean	11	5
5.	Australian region	12	4
6.	South Pacific Ocean	7	6

# Tropical cyclones

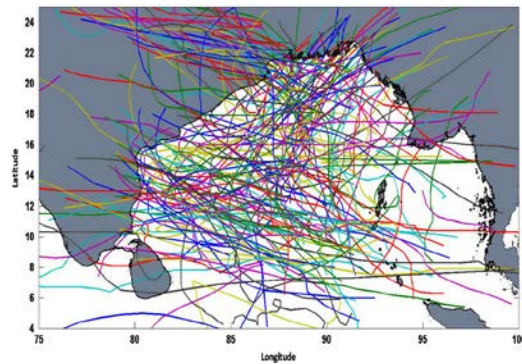
## Tracks and Intensity of Tropical Cyclones over the Global Ocean basins (from 1851 – 2006)

Tracks and Intensity of Tropical Cyclones, 1851-2006

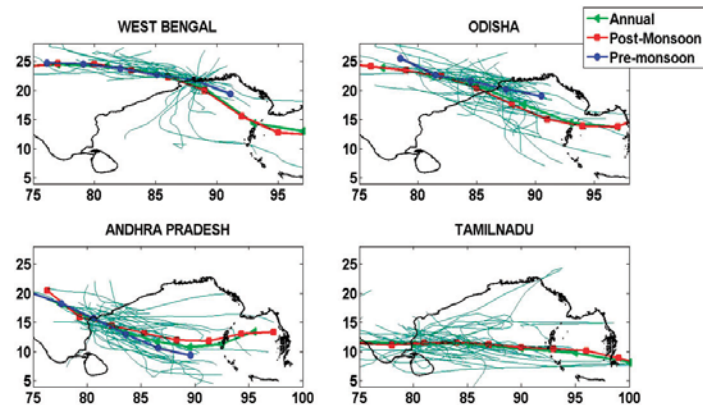


Saffir-Simpson Hurricane Intensity Scale

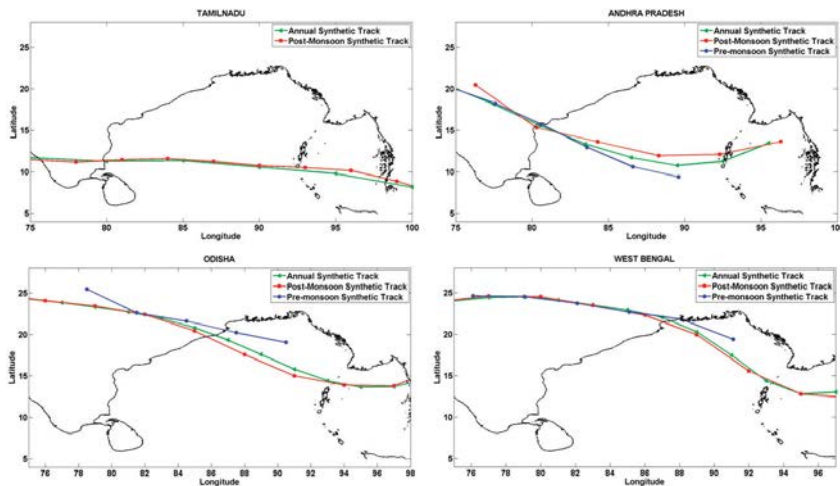
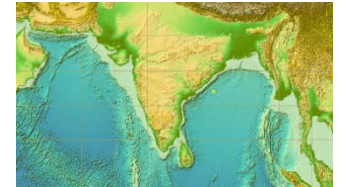
# Tropical cyclones



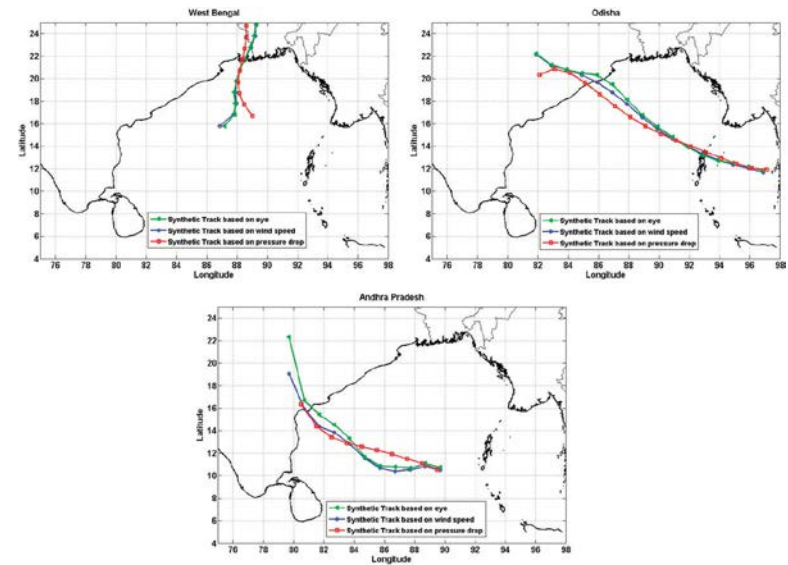
Composite cyclone tracks in the Bay of Bengal during the past four decades



State-wise distribution of composite and their respective synthetic tracks



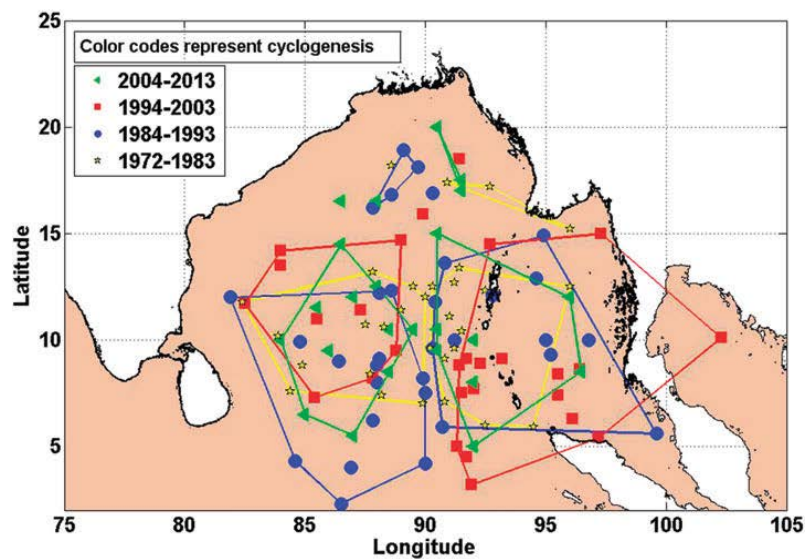
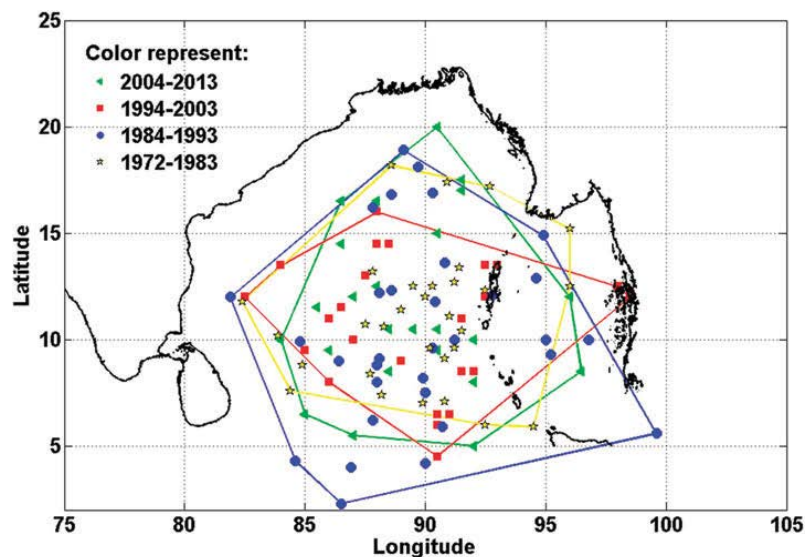
Synthetic tracks for the east coast of India during pre-monsoon season and (c) post-monsoon season.



Synthetic tracks based on eye, wind speed, and pressure drop



# Tropical cyclones



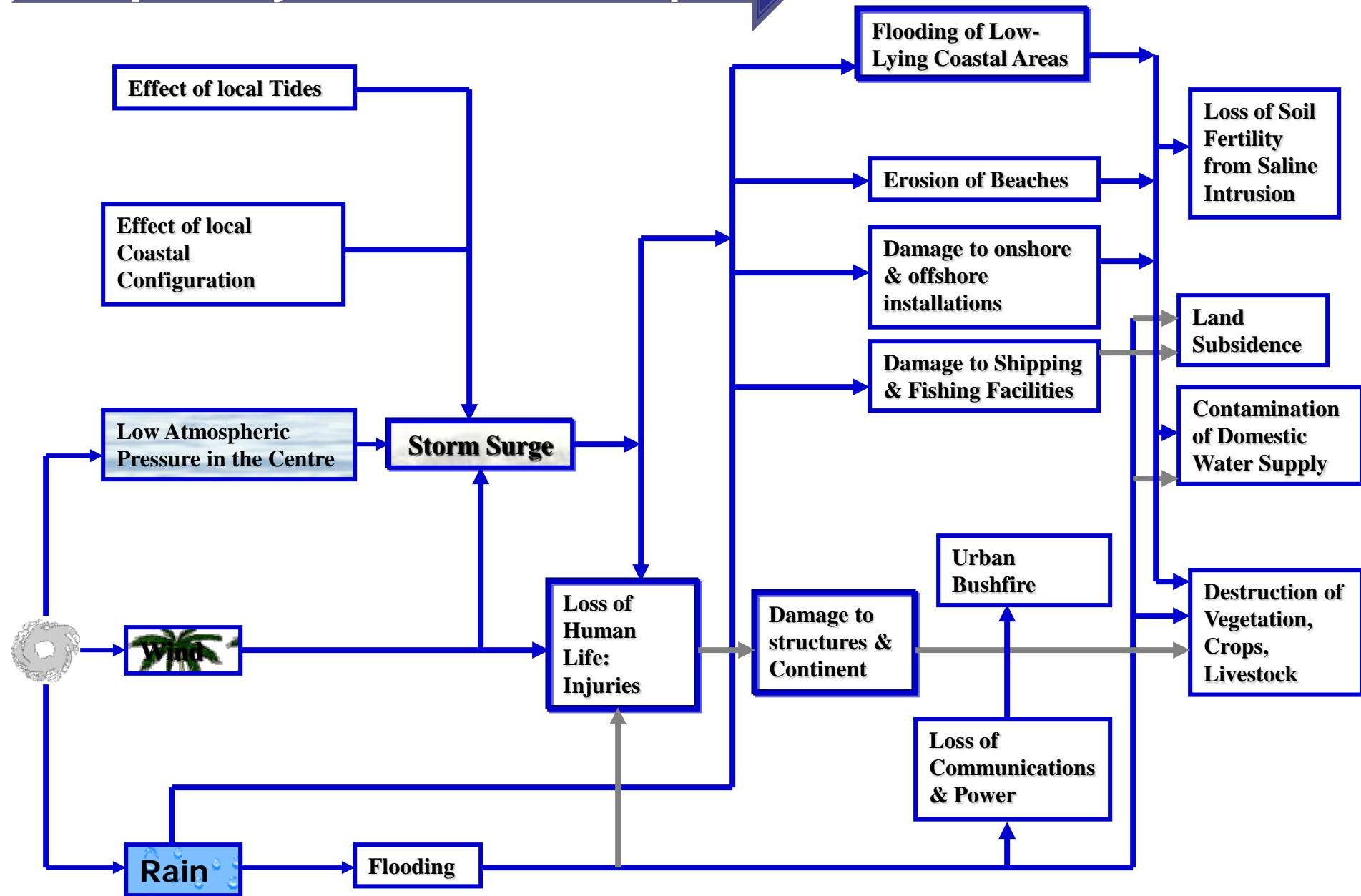
## Power Dissipation Index

S.No	Year	PDI ( $\times 10^7$ )
01	1970-1980	1.4006
02	1980-1990	1.2547
03	1990-2000	1.9259
04	2000-2010	3.0017
05	2010-2014	7.7143

## Accumulated Cyclone Energy

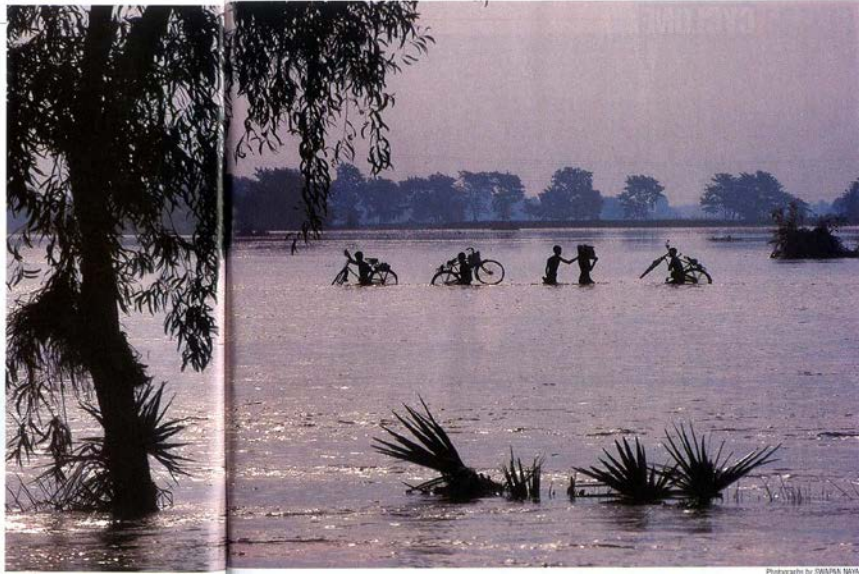
S.No	Year	ACE ( $\times 10^5$ )
01	1970-1980	2.1886
02	1980-1990	2.0144
03	1990-2000	2.8813
04	2000-2010	3.6635
05	2010-2014	8.6849

# Tropical cyclones and its impact





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## DEATHS IN TROPICAL CYCLONES

YEAR	COUNTRIES	DEATHS
1970	Bangladesh	300,000
1737	India	300,000
1886	China	300,000
1923	Japan	250,000
1876	Bangladesh	200,000
1897	Bangladesh	175,000
1991	Bangladesh	140,000
1833	India	50,000
1864	India	50,000
1822	Bangladesh	40,000
1780	Antilles(West Indies)	22,000
1965	Bangladesh	19,279
1999	India	15,000
1963	Bangladesh	11,520
1961	Bangladesh	11,466
1985	Bangladesh	11,069
1971	India	10,000
1977	India	10,000
1966	Cuba	7,196
1900	USA	6,000
1960	Bangladesh	5,149
1960	Japan	5,000
1972	India	5,000

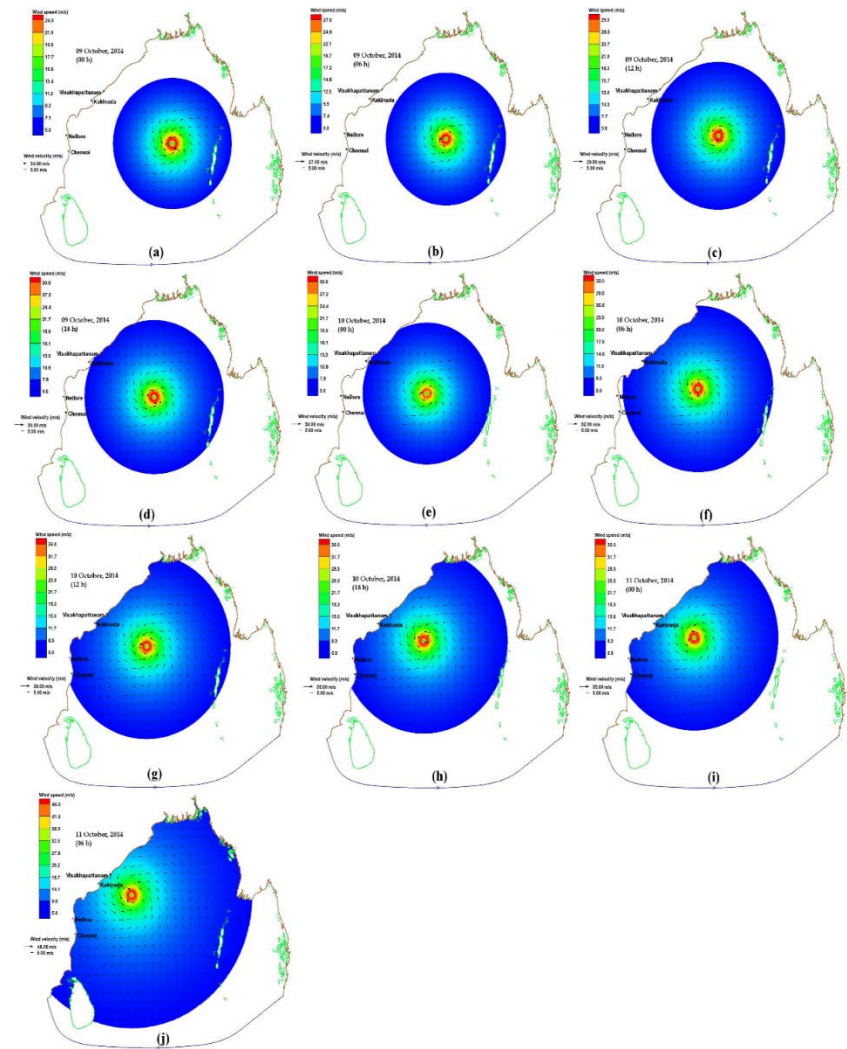
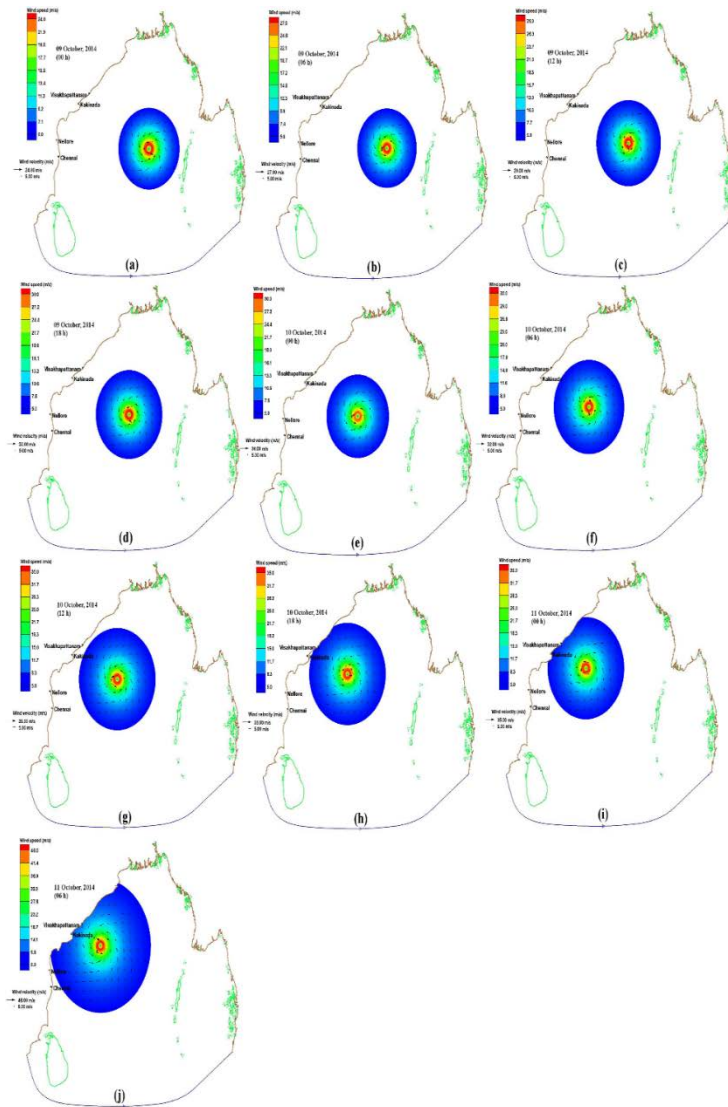
# Factors Contributing to Disastrous Surge in the Bay of Bengal

- **Convergence of the Bay**
- **Shallow Water**
  - Large bottom friction**
  - Retards return undercurrent**
- **Thickly Populated Low Lying Islands**  
(Ramgati, Sandwip, Hatiya, Bhola & Kutubdia)
- **High Astronomical Tides**
- **Inlets & Estuaries**



# Tropical cyclones

## Hudhud Cyclone

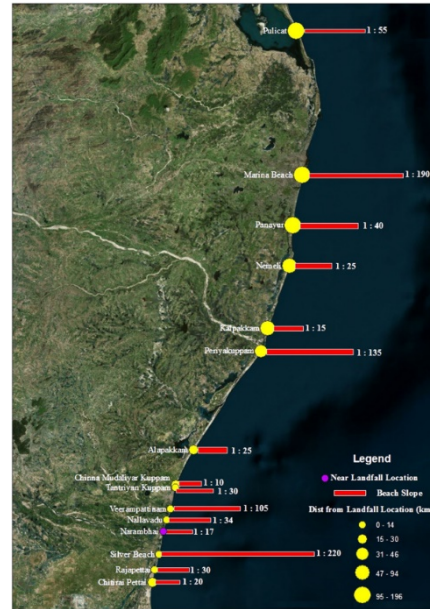


Time series plot of the wind speed envelope from un-modified and modified Jelesnianski wind formulation.

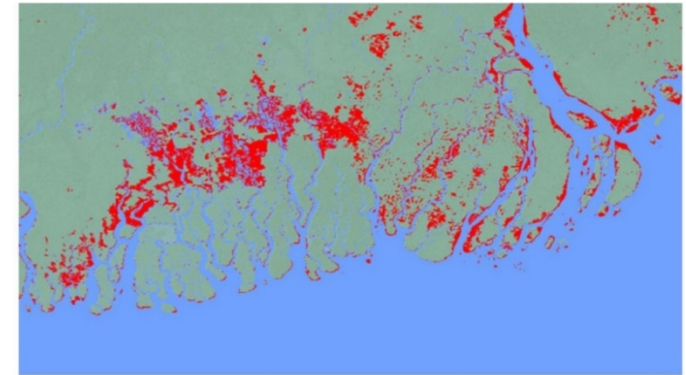
# Coastal inundation and vulnerability



Model computed inland inundation (in m) for forty locations along Tamil Nadu coast



Beach slopes along the Tamil Nadu coast



(a)



(b)

Comparison of inundation scenarios (a) MODIS imagery of onshore inundation, and (b) ADCIRC computed inundation for the Aila cyclone



Storm surge affected areas and associated onshore inundation range (in meters) for the head Bay region

Thank You