Ocean Weather to Climate Services
-The Space Contribution

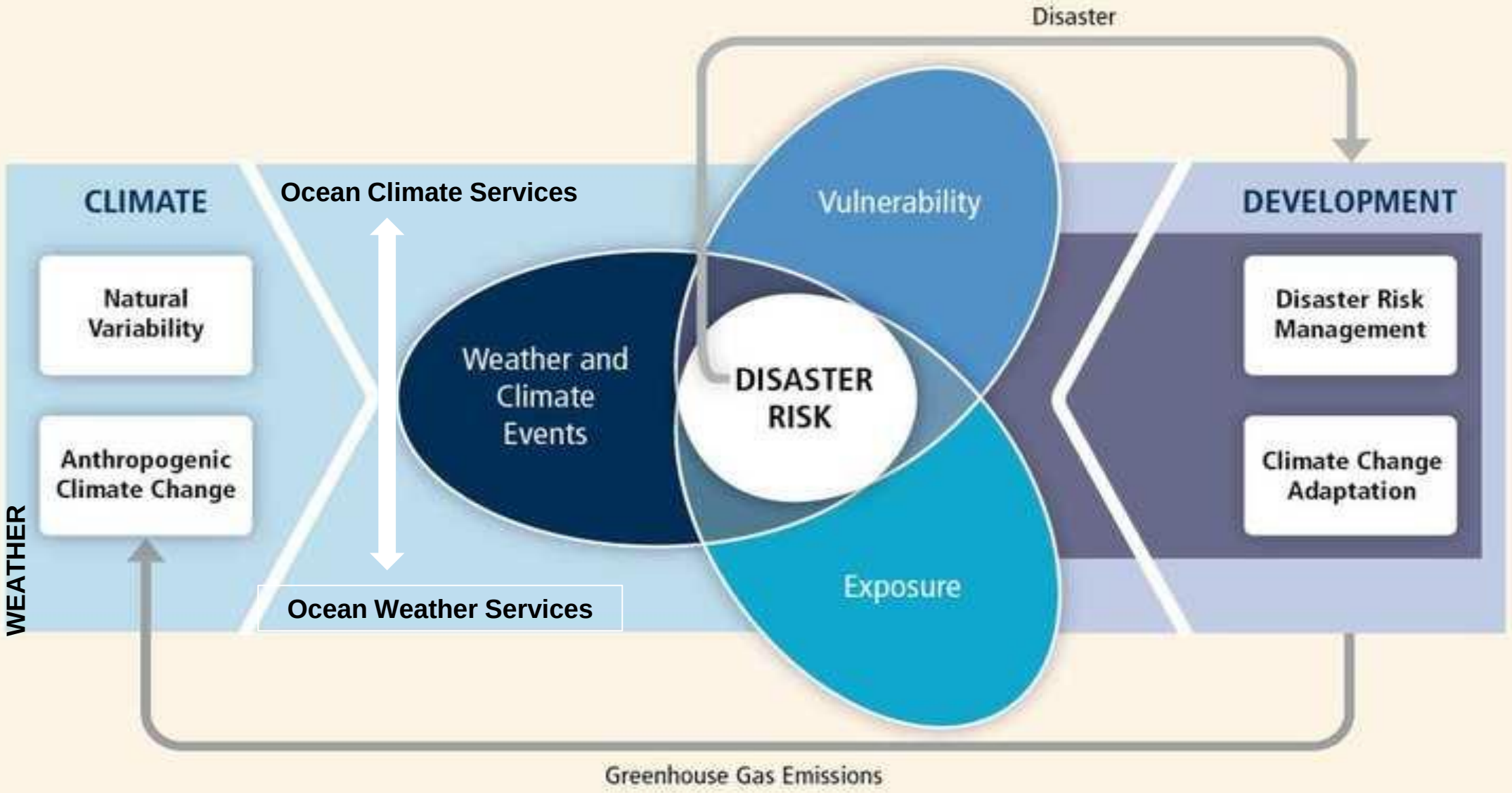
Dr. Balakrishnan Nair
Group Director

Contribution : Prakash Mohanty, Abhishek Chatterjee & Nimit Kumar

Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences (MoES), Hyderabad, India

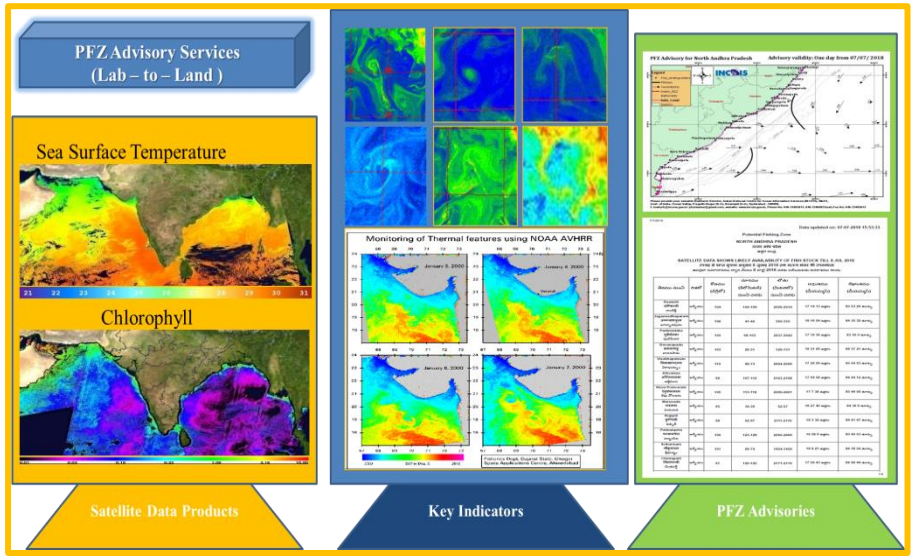
14 September, 2022
UN/Austria symposium "Space for climate action: experiences and best practices in mitigating and adapting to climate change and supporting sustainability on Earth."

Links between climate change and disaster risk (source: IPCC, 1012)

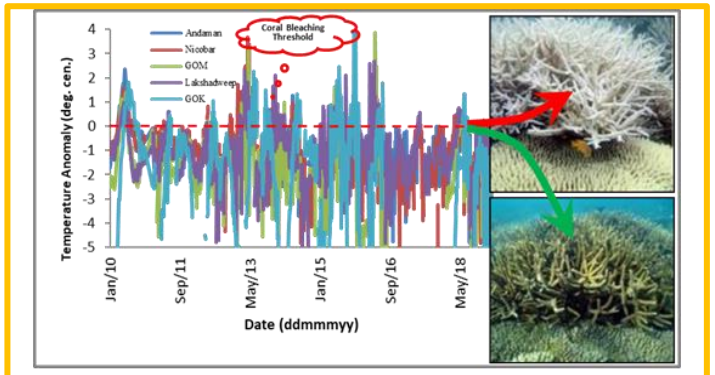


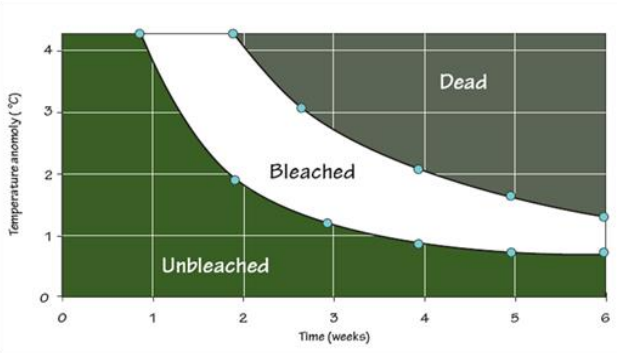
Swart et al., 2012

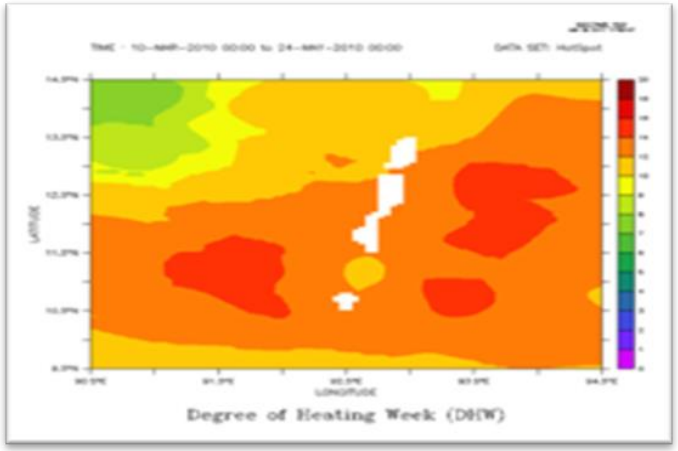
Ecosystem Services



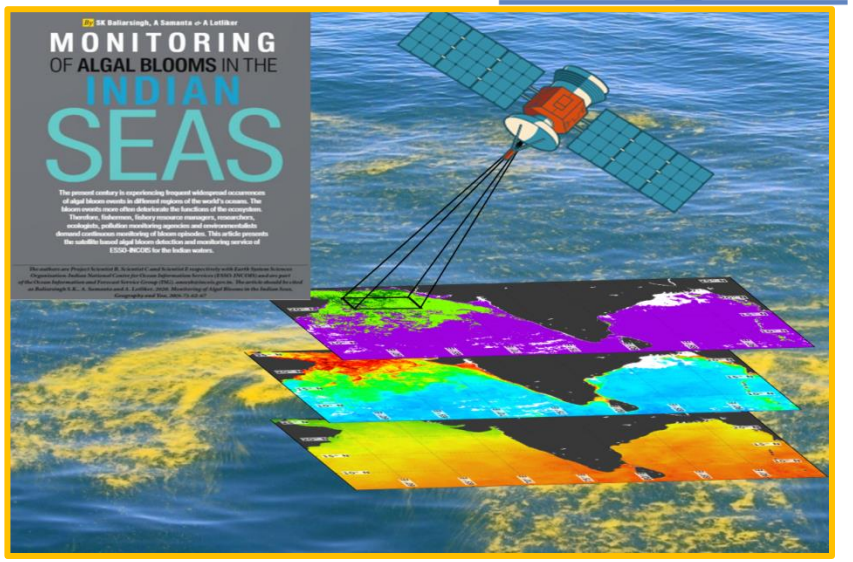
Marine Fishery Advisory Services



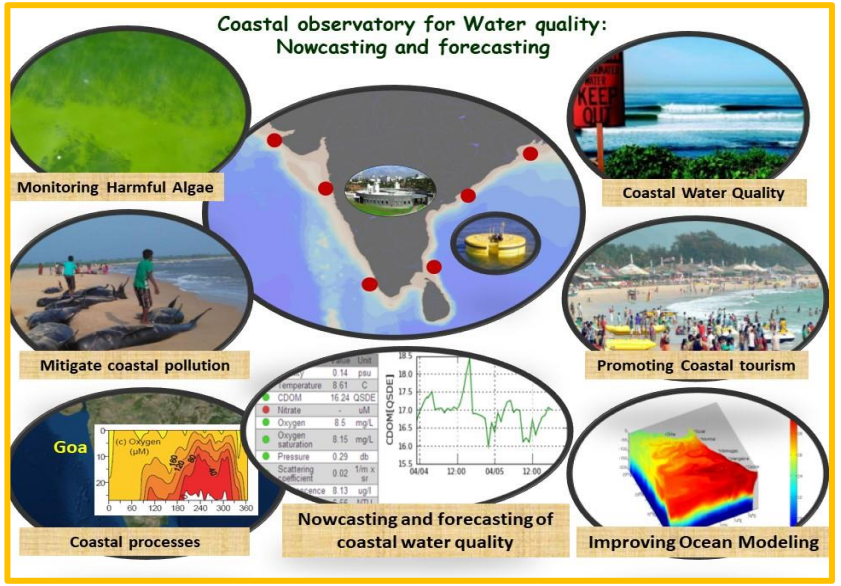




Coral Bleaching Alerts



Algal Blooms Information Services

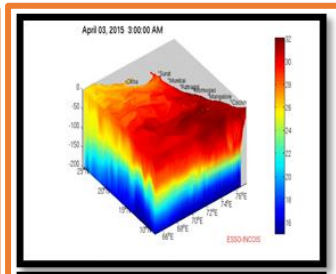


Water Quality Services

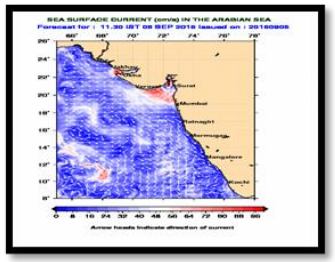
Marine Safety Services

Ocean State Forecasts

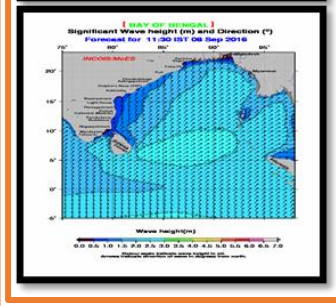
45 User specified daily forecast products for India and 06 Neighbouring Countries



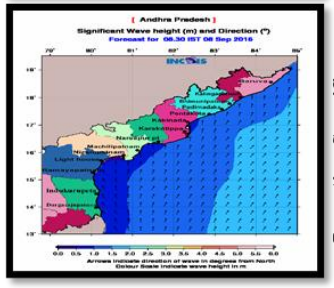
Salinity



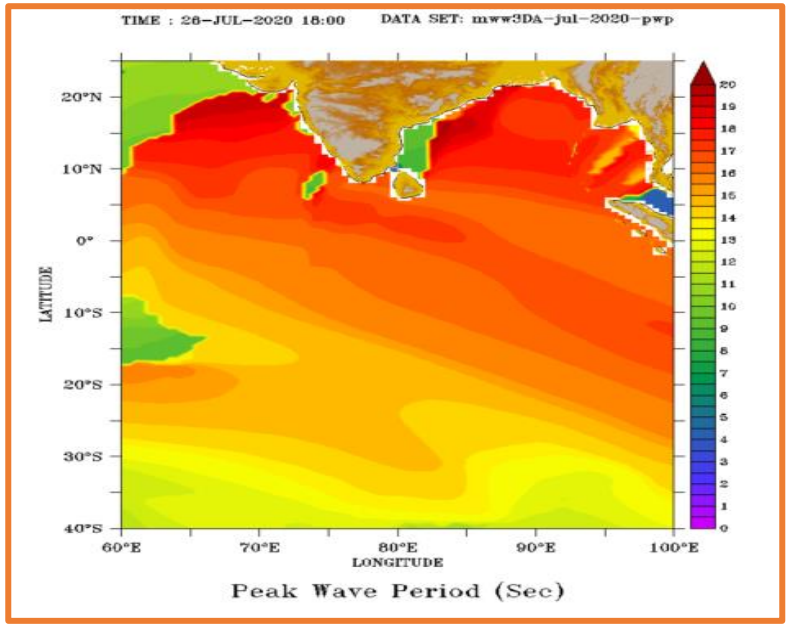
Surface Currents



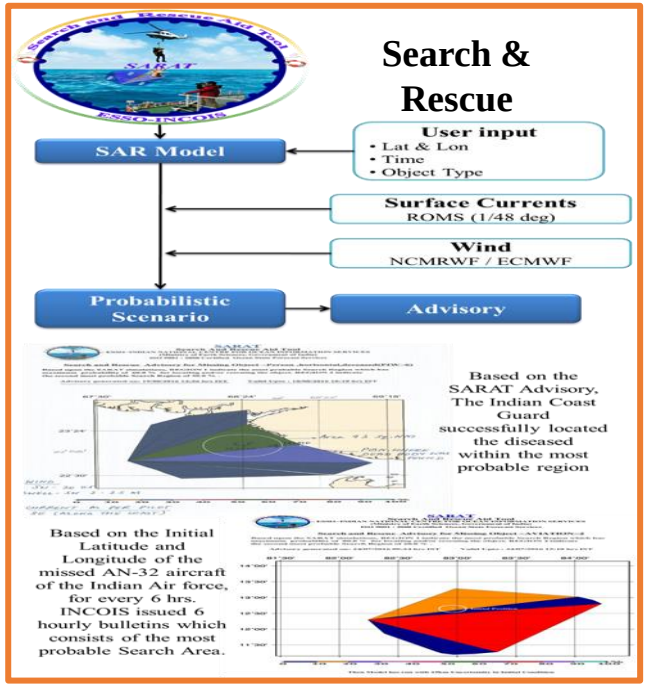
Regional wave Forecast

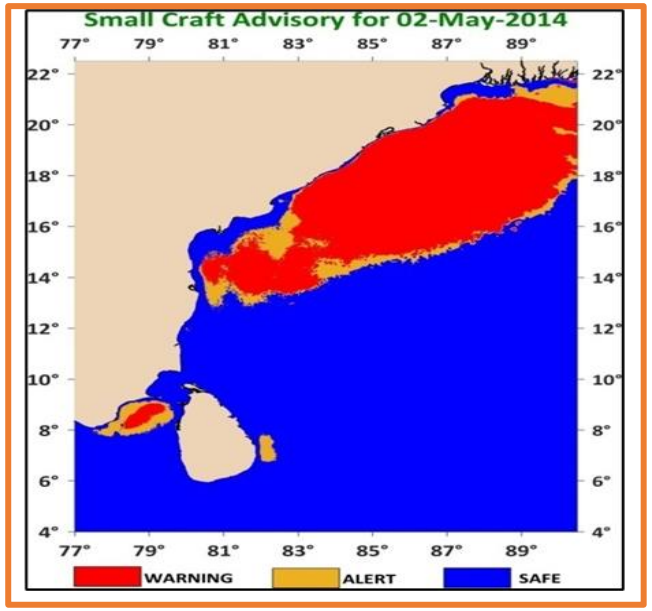


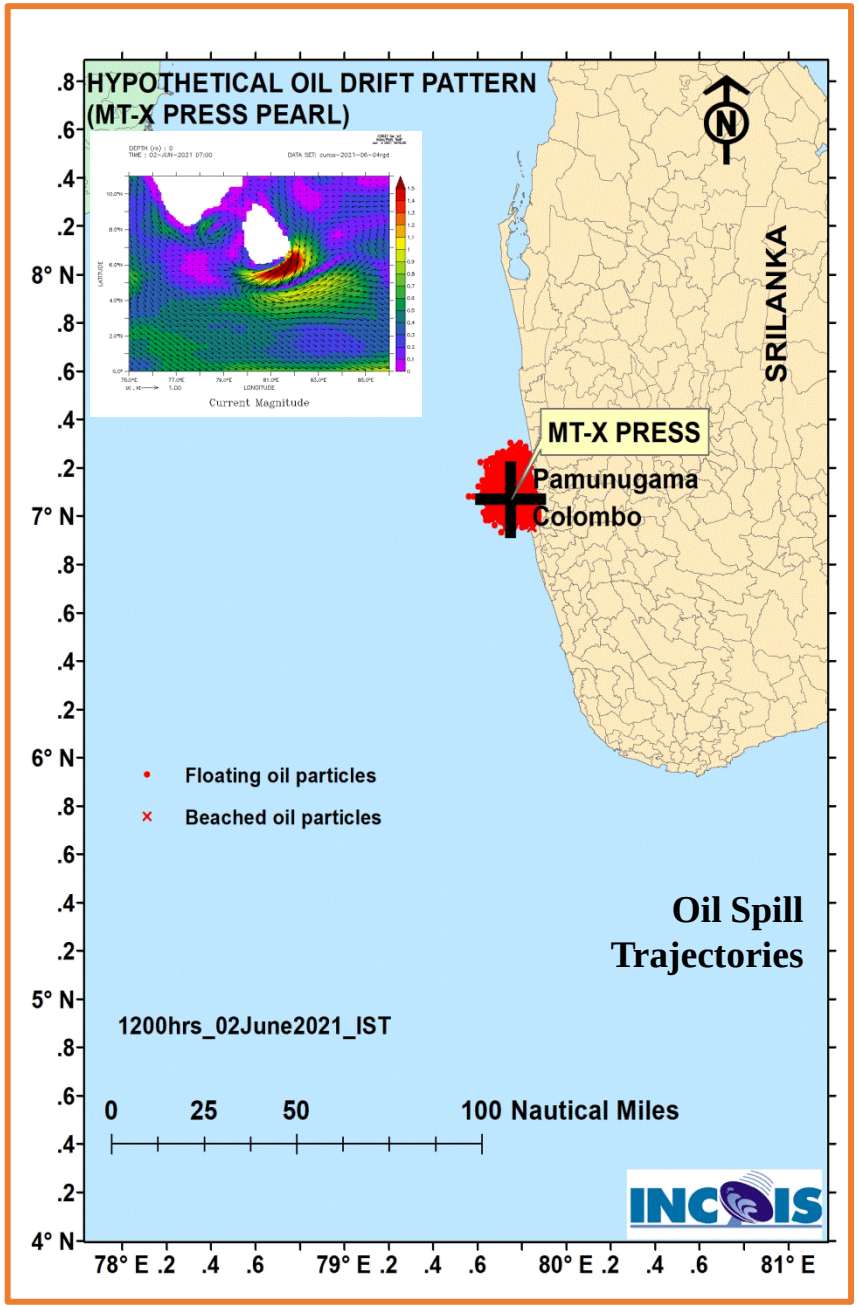
Location Specific forecast



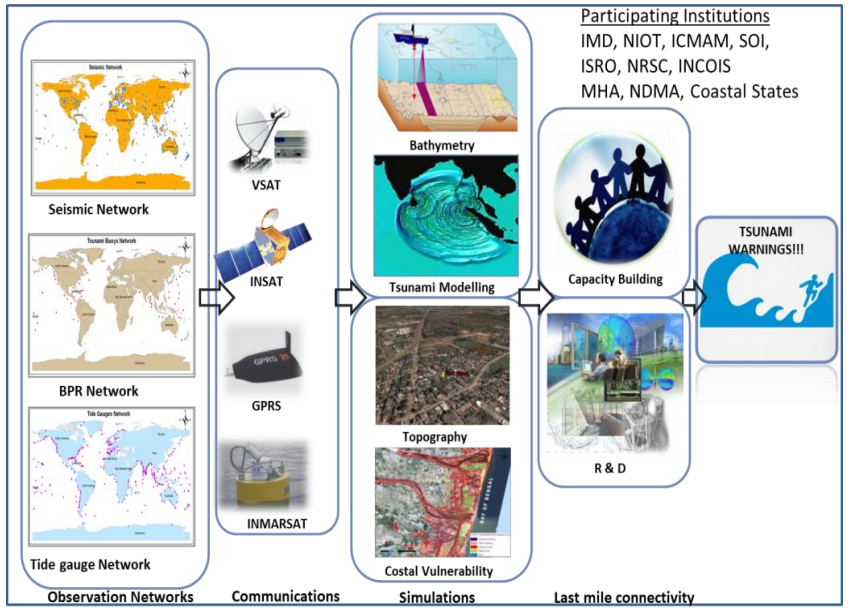
Swell Surge Forecast



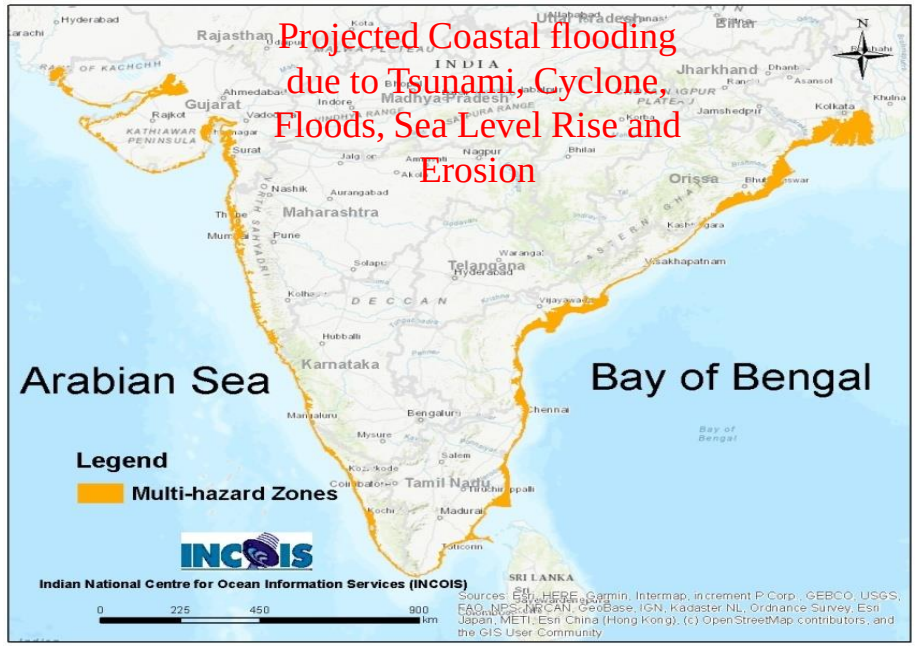


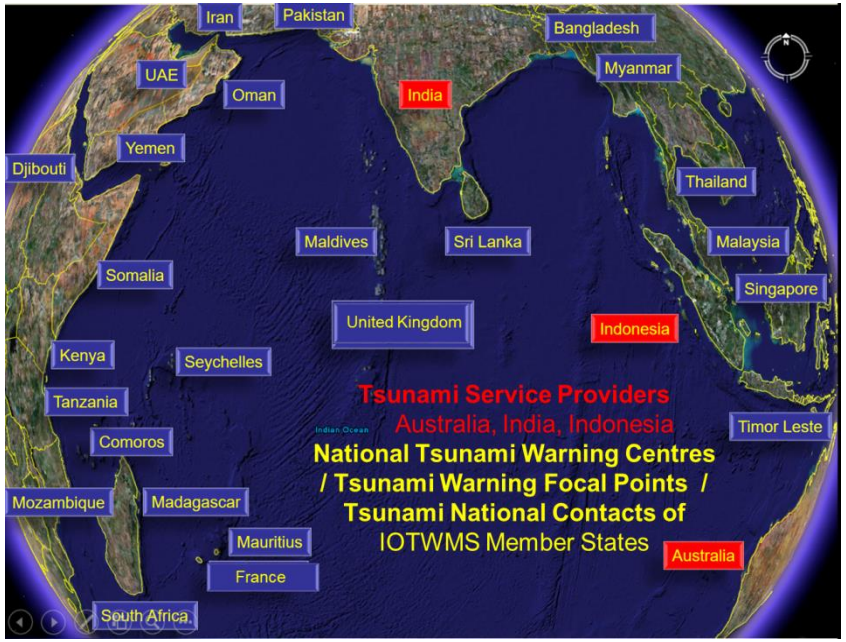


Tsunami & Coastal Multi-hazard Warning Services



Indian Tsunami Early Warning Centre





Tsunami Early Warning Services

Certificate of Recognition
The Community of Venkatraipur
Ganjam District, Odisha, India

For successfully piloting the UNESCO-IOC Tsunami Ready Initiative in Venkatraipur, Ganjam District, India

Intergovernmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS)

Certificate of Recognition
The Community of Noliasahi
Jagatsinghpur District, Odisha, India

For successfully piloting the UNESCO-IOC Tsunami Ready Initiative in Noliasahi, Jagatsinghpur District, Odisha, India
28 May 2020

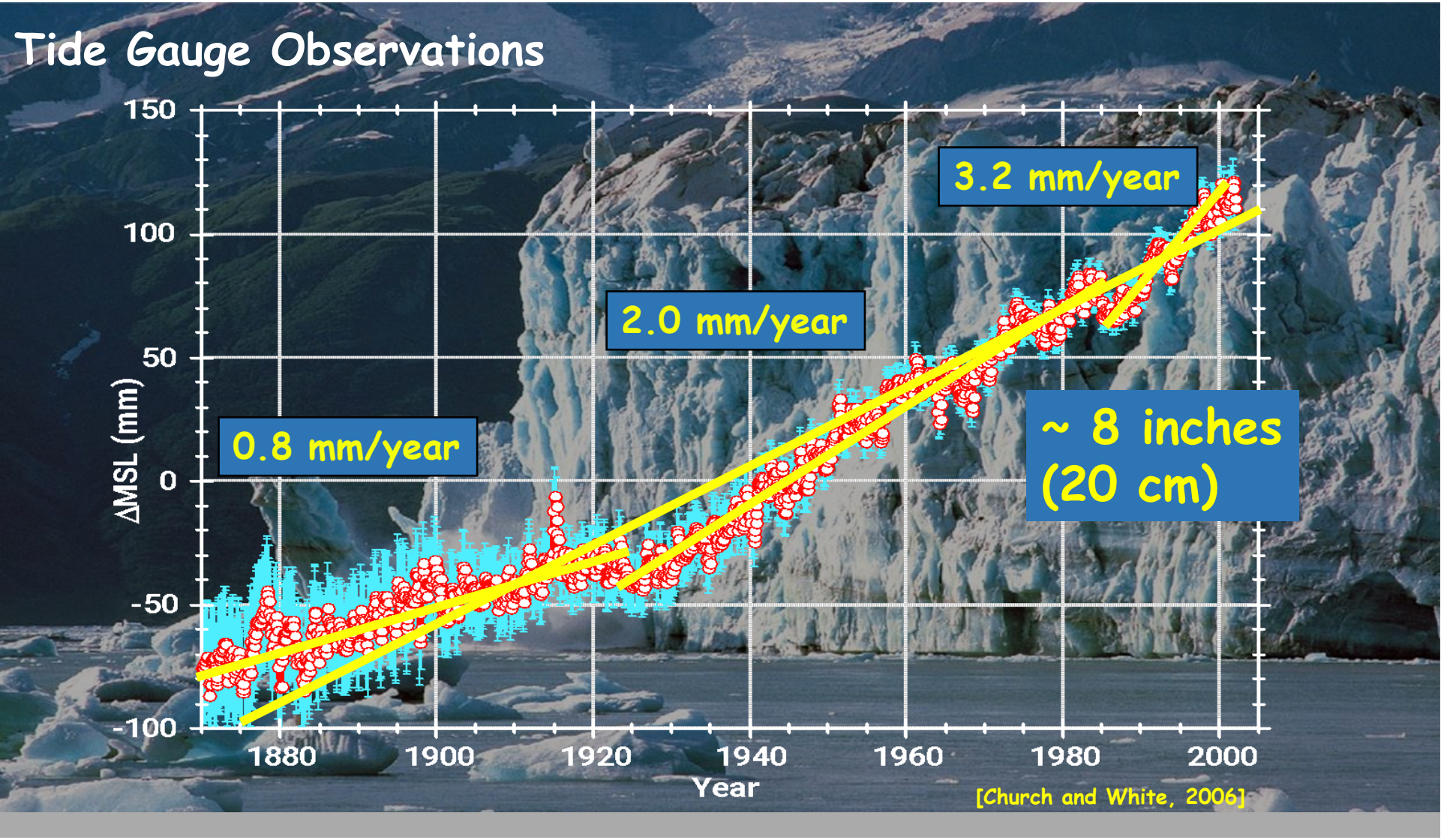
Vladimir Ryabinin, PhD
Assistant Director General and Executive Secretary
UNESCO

Dr. Satheesh Shenoi, PhD
Chair
National Tsunami Ready Board of India

Prof. Dwikorita Karnawati, PhD
Chairwoman
UNESCO-IOC ICG/IOTWMS

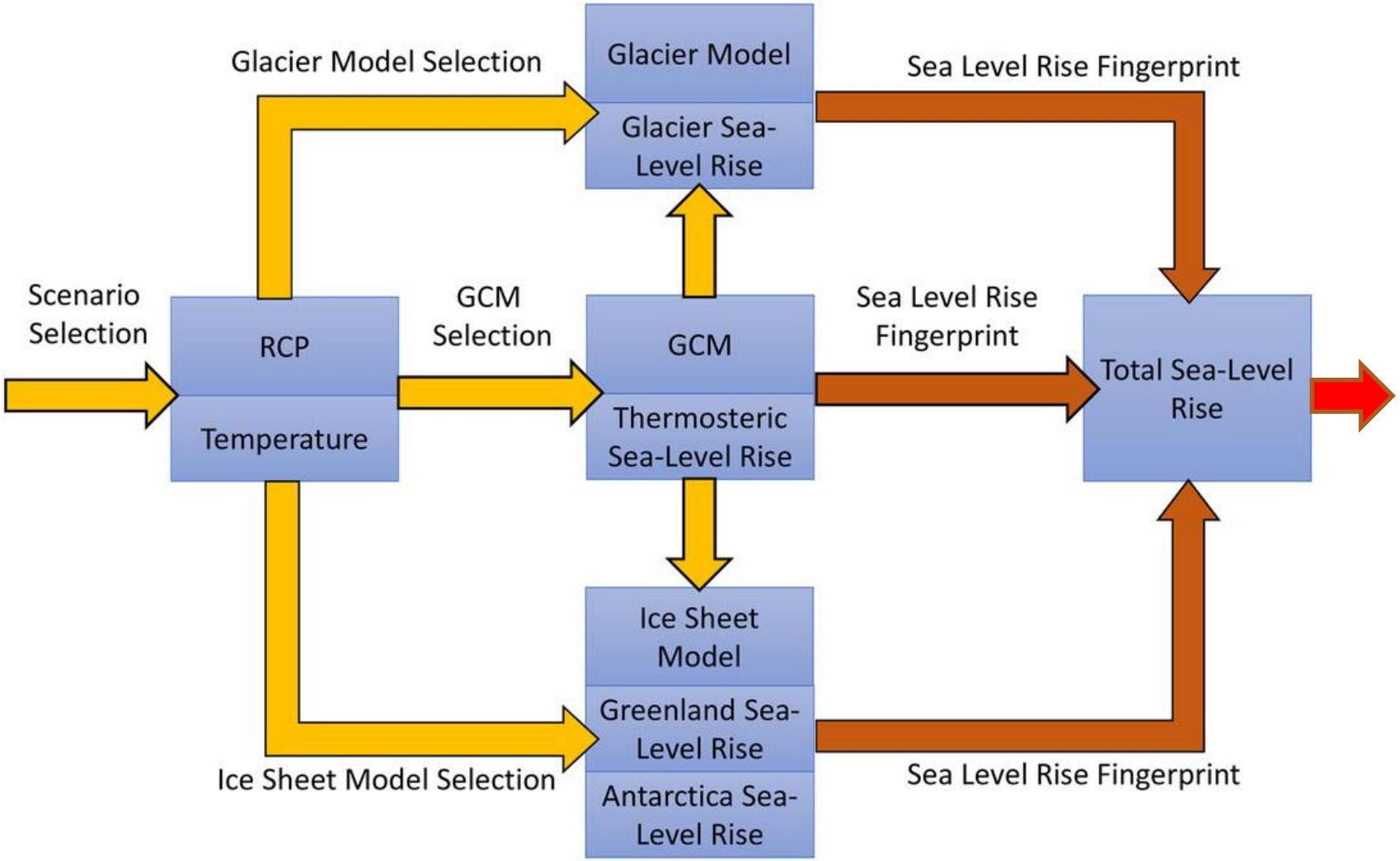
Coastal Inundation – 3D Mapping

Global sea-level rise trend



Globally, the rate of sea level rise almost doubled (from 1.8 mm/yr during last century) to 3.2 mm/yr in the last few decades.

Impact of sea-level rise on multi-hazard



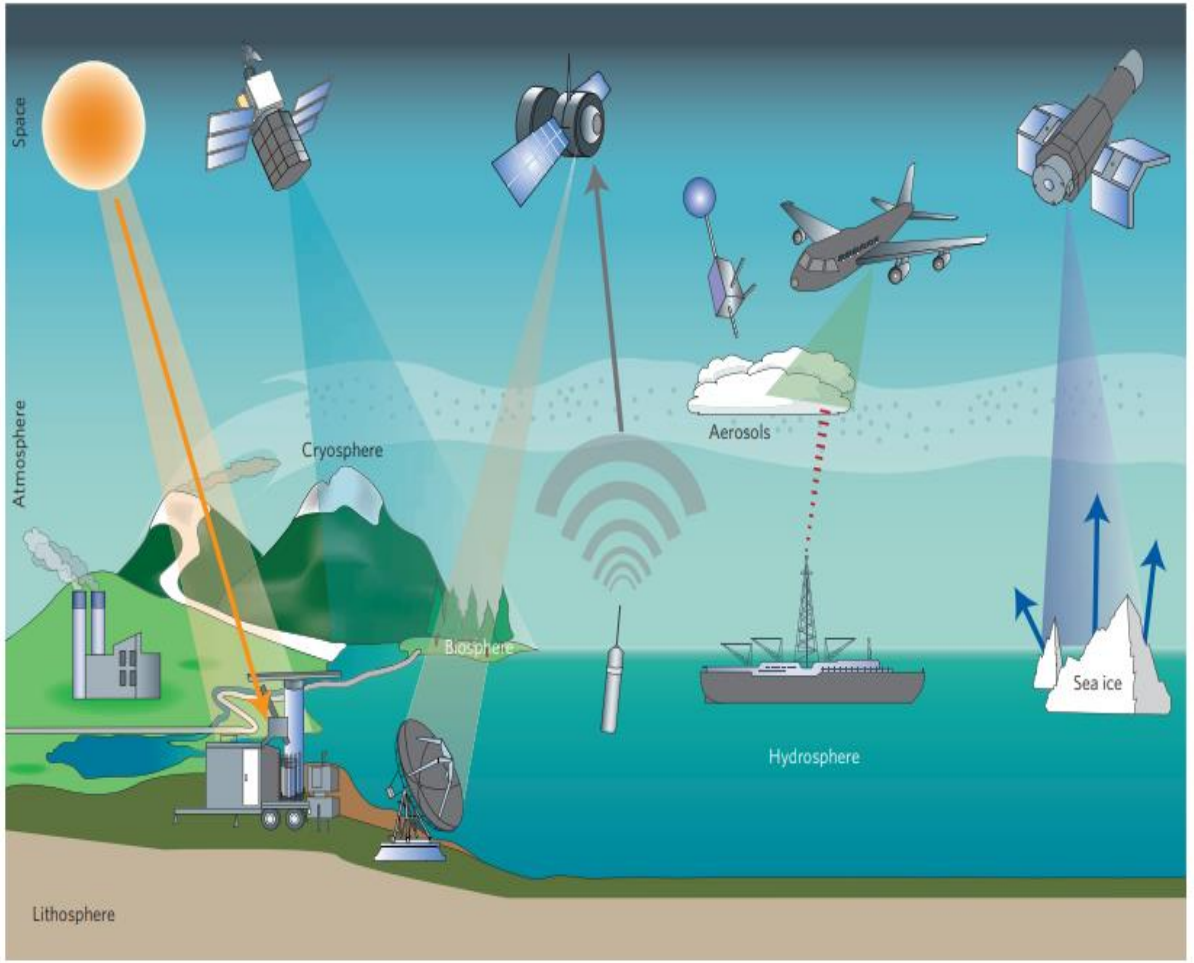
Flowchart for sampling climate forcing scenarios and sea level rise cases increasing Multi-Hazard Events(Thomas at al., 2020)

- Multi-Hazard Events:
- Increase frequency and intensity of storm surge
- Coastal flooding led to loss of continent
- Increasing Erosion of Shoreline and change the beach profile
- Rise the ocean temperature led to shifting/loss of the marine ecosystem.
- Increasing ENSO, IOD, Flood and drought etc

Application of Remote sensing data for Ocean weather and climate services

Remote sensing techniques, used in a wide range of climate change fields, such as for:

- Investigating global **temperature trends** of ocean atmosphere
- Detecting changes in solar radiation affecting **global warming**,
- Monitoring **aerosols**, water vapour concentration, and changes in precipitation regime,
- studying the dynamics of **snow extension** and ice cover
- monitoring sea-level changes and coastal modifications,
- monitoring **vegetation** status and change,
- monitoring water resources and impact due to **droughts** and dry periods,
- monitoring fire events and fire emissions,
- predicting **disaster risk**, such as cyclone, floods, and drought.
- Guiding **decision-making** processes on climate change adaptation.
- **Cost Benefit**: climate change related data and information can get for **extensive areas**.
- Continuous **seamless observation** In all the weather.



Remote sensing of the climate system of different platforms, including plane, boat and Argo floats. Ground-based instruments (Gong at al., 2013)

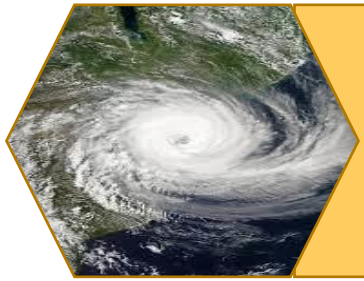
Remote sensing data for Ocean Services

Model	Assimilated parameter	Satellite	Analysis/Forecast parameters
Wave and Swell Surge Forecasting System (WAVEWATCH III, SWAN, ADCIRC)	Significant wave height	Saral-AltiKa Altimeter –Jason2, Jason3,	Height, direction and period (of both wind waves and swell waves), Swell surge (arrival time and extent of inundation).
Regional Ocean forecast (ROMS) System	SST SLA	GHRISST L2 track data	Sea surface currents, Sea surface temperature, Mixed Layer Depth, Depth of the 20^{o}C isotherm, Temperature & Salinity profiles
Global Ocean ANALYSIS (INCOIS-GODAS) System	Temperature and salinity profiles (SST is relaxed with 5 day time scale from OI SST)	NOAA OI (for daily SST relaxation)	Sea surface currents, Sea surface temperature, Mixed Layer Depth, Depth of the 20^{o}C isotherm, Temperature & Salinity profiles
Basin wide Ocean Forecast (HYCOM)	SST, SLA	Jason3, Saral-AltiKa GHRSST	Sea surface currents, Sea surface temperature, Mixed Layer Depth, Depth of the 20^{o}C isotherm, Temperature & Salinity profiles
HWRF-HYCOM coupled model	SST, SLA,	Jason3, Saral- AltiKa GHRSST	Cyclone intensity and track forecast

DEEP OCEAN MISSION
Vertical 2: Ocean Climate Change Advisory Services

- **Advisories on the decadal-to-longterm projections, trends and coastal impacts:**
  - Sea level rise
  - Intensity & frequency of tropical cyclones
  - Storm surges
  - Wind waves
  - Primary productivity, harmful algal blooms and coastal hypoxia
- **Modelling and Deep Ocean Observations**
- **Multi-hazard Vulnerability Maps for the coastal regions of India**
- **Climate assessment report**


Sea Level Rise

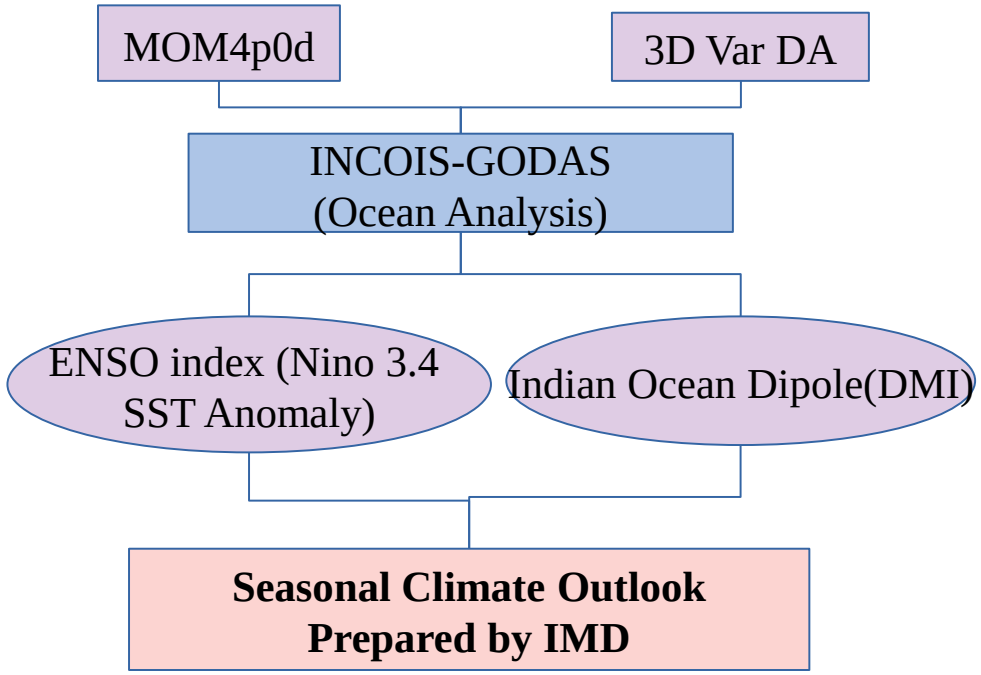

Cyclone Intensity & Frequency


Storm Surges & Waves


BGC & Ecology

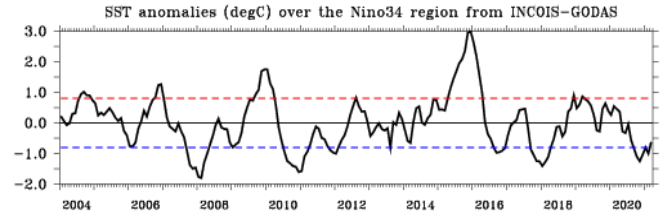

Observation

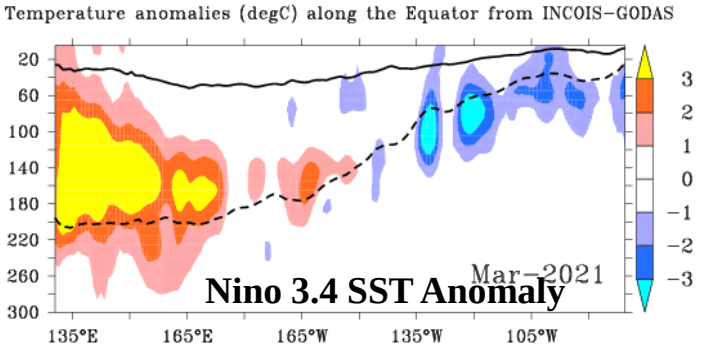
Ocean Climate Services



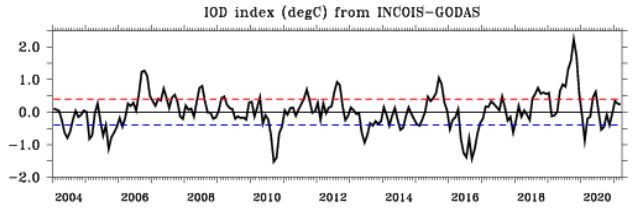
Indian Ocean Dipole Index based on INCOIS-GODAS SST analysis and Monthly climatology of OISST (Reynolds sst;constructed using 1981-2010 data).

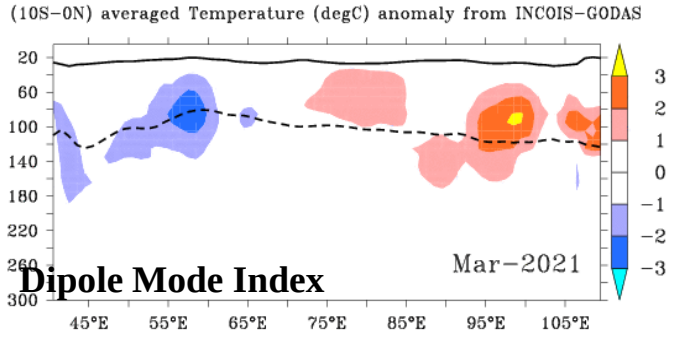
	WESTERN BOX 10S-10N 50E-70E		EASTERN BOX 10S-Eq 90E-110E		DMI WEST-EAST
DD-MMM-YYYY / SNO:	SSTA	SST	SSTA	SST	SSTA
14-SEP-2020 / 1:	0.0604	27.70	0.5108	28.59	-0.4504
15-OCT-2020 / 2:	0.4862	28.58	0.5632	28.76	-0.0769
14-NOV-2020 / 3:	0.1866	28.55	0.5837	29.08	-0.3971
15-DEC-2020 / 4:	0.0968	28.37	0.1434	28.83	-0.0465
14-JAN-2021 / 5:	-0.3390	27.69	-0.6831	28.11	0.3441
13-FEB-2021 / 6:	-0.1117	28.23	-0.3688	28.50	0.2571
16-MAR-2021 / 7:	0.0746	29.08	-0.1602	29.03	0.2349
15-APR-2021 / 8:	0.2222	29.96	-0.1112	29.37	0.3333
16-MAY-2021 / 9:	-0.1431	29.34	0.2384	29.74	-0.3815
15-JUN-2021 / 10:	-0.0367	28.26	0.3424	29.58	-0.3791





Nino 3.4 SST Anomaly



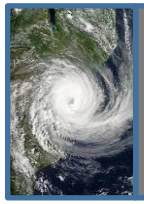


Dipole Mode Index

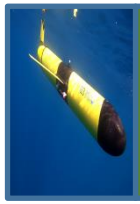
Ocean Climate Change Advisory Services of Deep Ocean Mission

- Regional Climate Change Assessment for Northern Indian Ocean
- Future Projections of important climate variables and their Impact on coastal regions of India
  - Sea level
  - Cyclones, Storm Surges, Waves
  - Marine Ecosystem

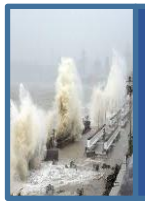
Sea Level Rise



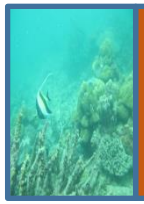
Cyclone Intensity & Frequency



Observation



Storm Surges & Waves

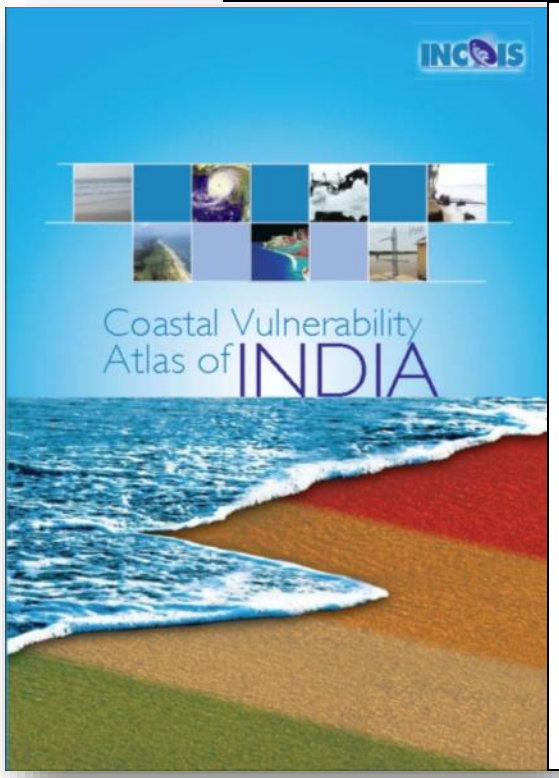


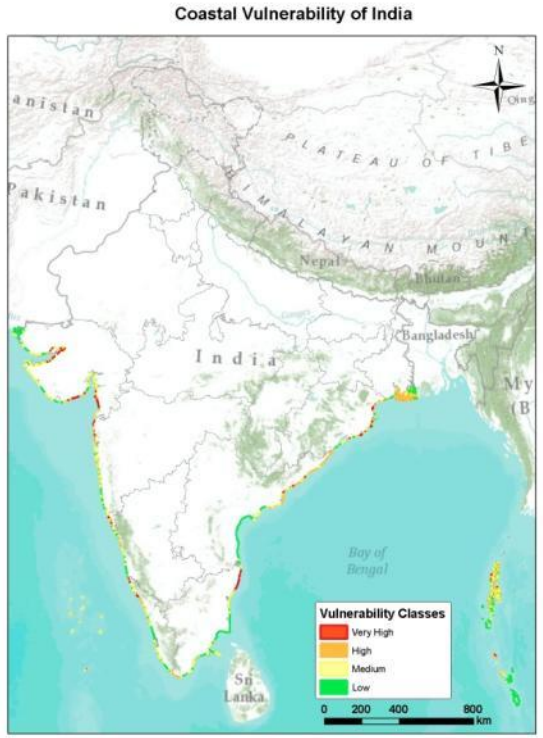
BGC & Ecology

Coastal Vulnerability Atlas

CVI Atlas covering Indian coast comprising 156 maps on 1:1lakh scales has been prepared and first edition released on May 09, 2012

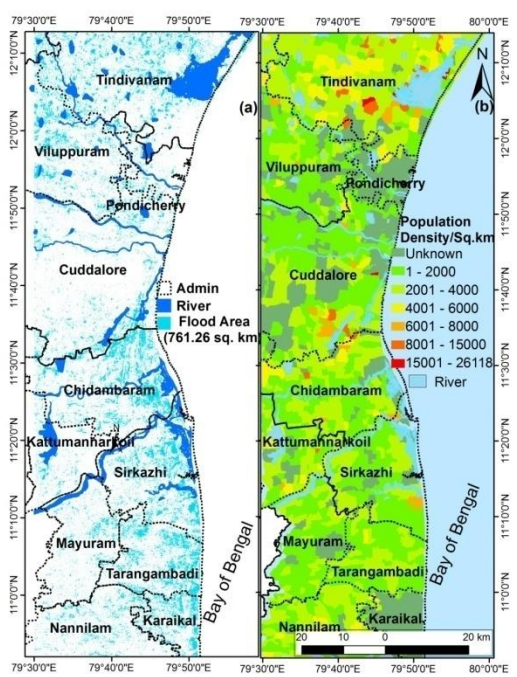
Parameter	Data
Geomorphology	IRS LISS-IV
Slope	GEBCO
Elevation	SRTM
Tidal Range	Astronomical tide from WXTide-32
Shoreline Change Rate	Landsat data (1972-2000)
Historical Sea Level	GLOSS long term tide gauge observation
Significant Wave Height	Mike-21 SW modeling



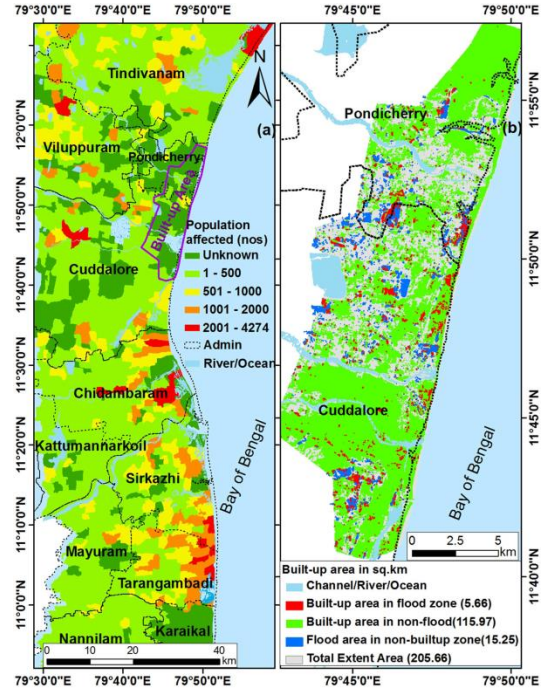


INCOIS, (2012). Coastal Vulnerability Atlas of India. INCOIS-ASG-CGAM-CV-2012-01, Pages 212, Maps 156, INCOIS, Hyderabad, India. ISBN 978-81-923474-0-0.

Geospatial assessment of flood hazard along the Tamil Nadu coast



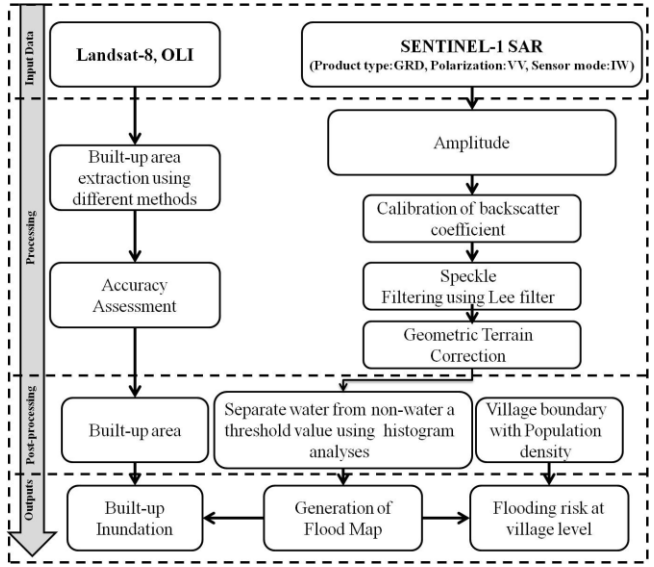
Flooding Areas | Population Density



Population In inundation | Built-up area In inundation

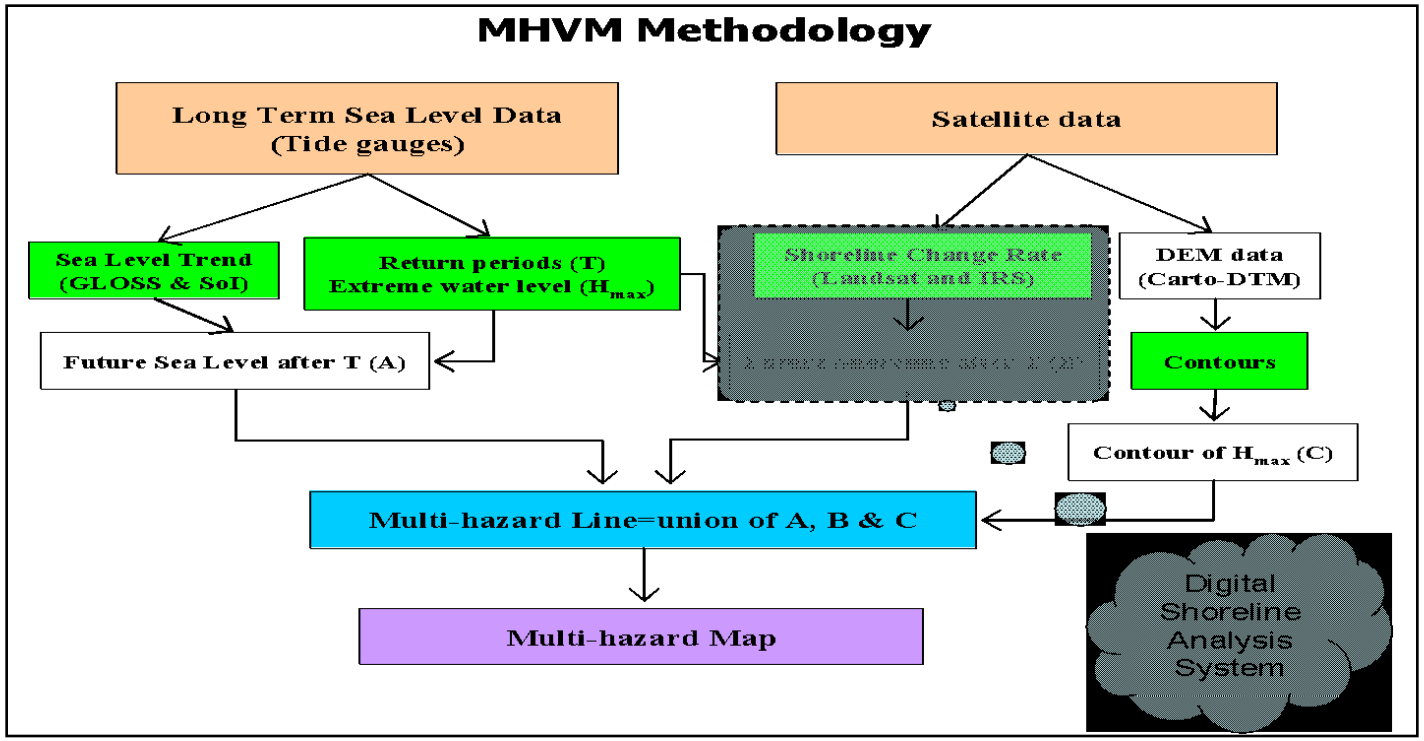
Flood period:
November–December 2015

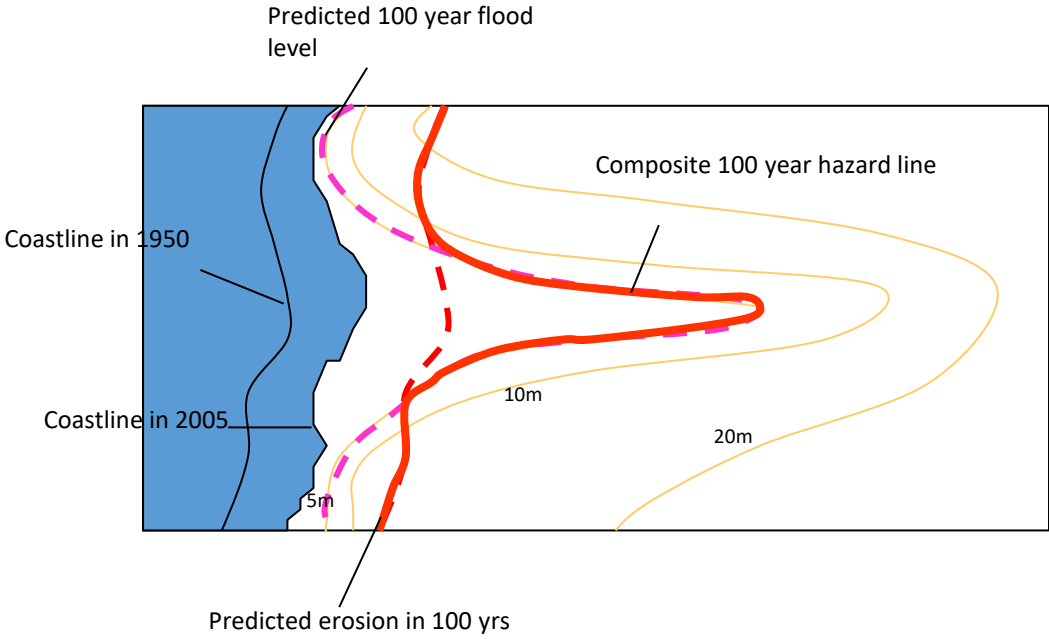
Data Used:
Sentinel-1 SAR, Landsat OLI



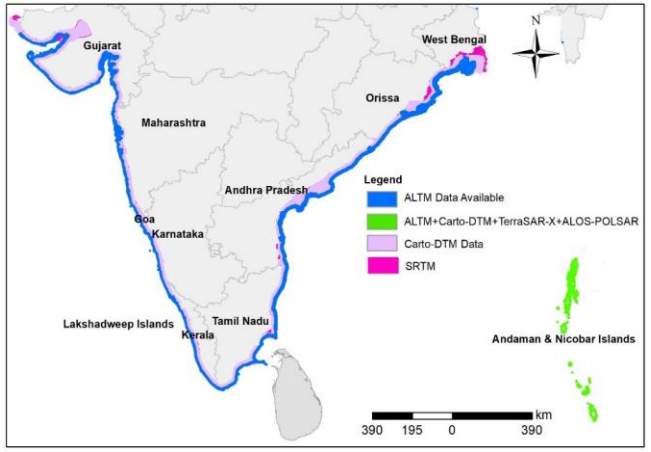
Coastal Multi-hazard Vulnerability Assessment

"The Multi-Hazard Map is a "composite, synthesized and overlay of multiple hazards"



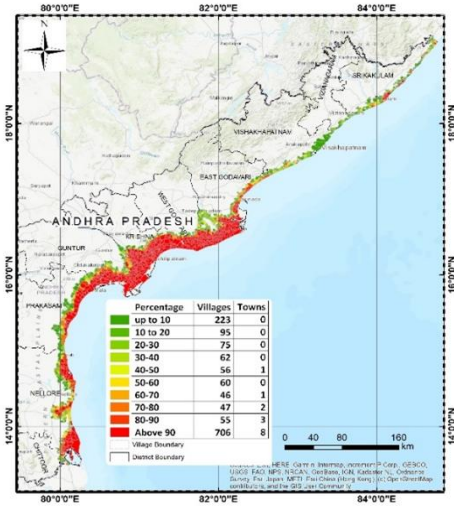


Data	Resolution (m)	Parameters
ALTM	5	Elevation Contours
Carto DTM	10	
Landsat, MSS	57-30	Shoreline Change
Tide gauge	--	Sea Level Change
Hourly Tide gauge data and published literature	--	Extreme Water Levels

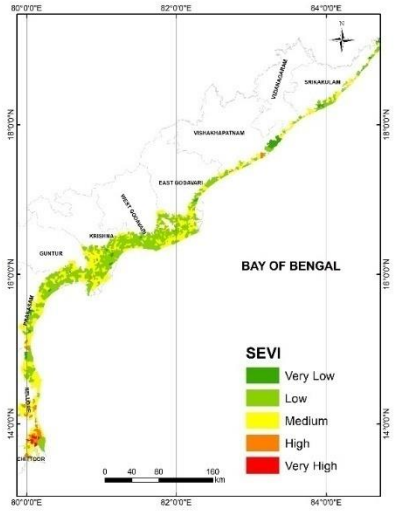


Socio-economic Vulnerability Index (SEVI)

Village wise MHVM



Village wise SEVI



Climate services and strategic management framework

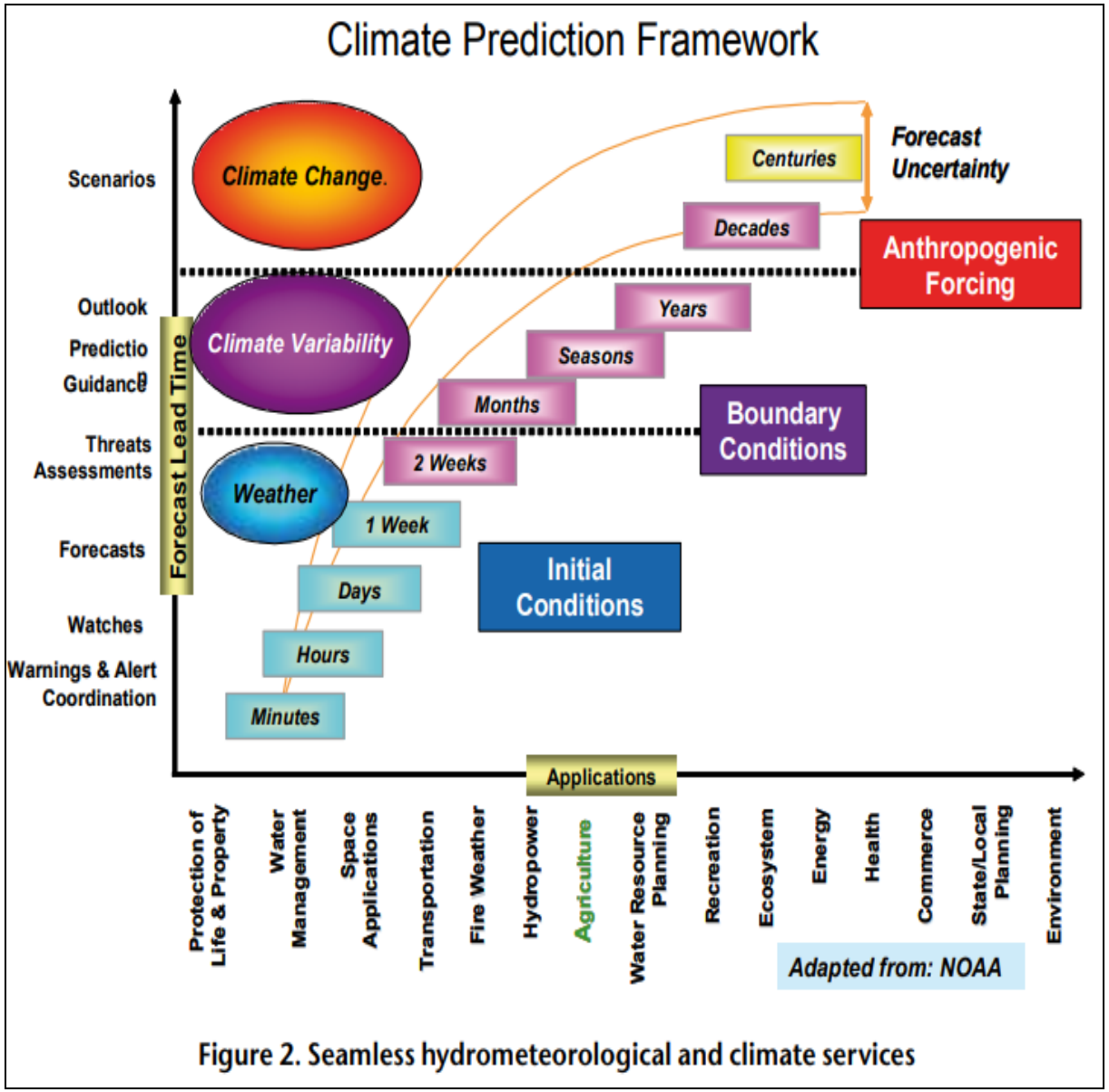
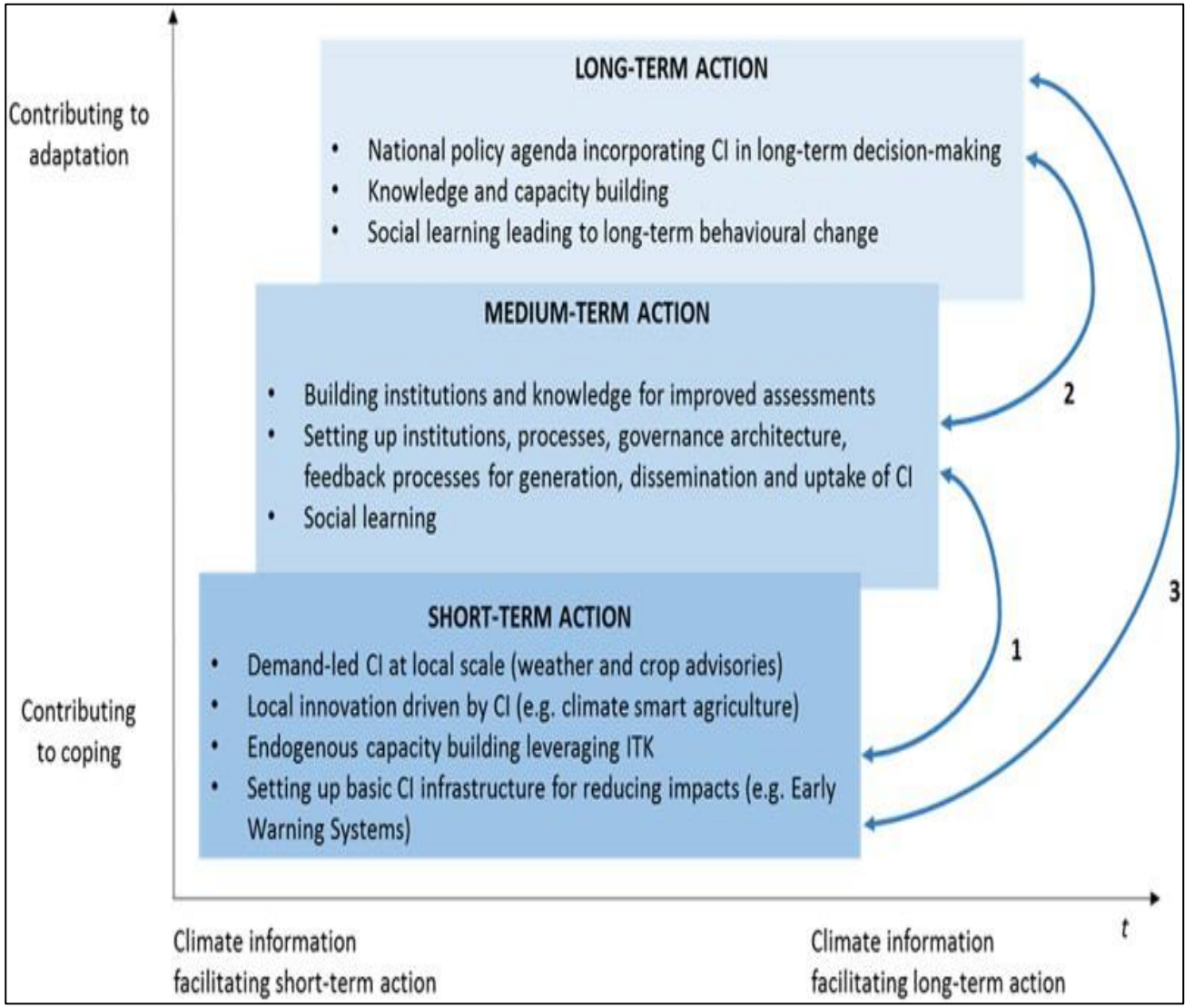


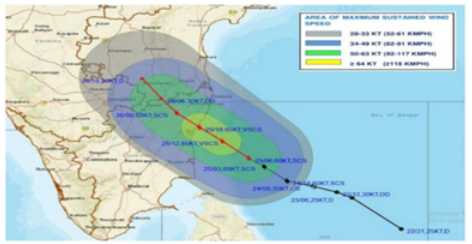
Figure 2. Seamless hydrometeorological and climate services



Climate information in multi-scalar adaptation decision-making (Singh et al, 2017).

Climate and weather services for supporting climate change adaptation framework: A example (Cyclone impact)

Hazard Analysis and mapping



Cyclone generated winds and storm impact mapping

Need historical and real time hazard data for mapping
(Cyclone track, maximum wind speed, translation speed, surge height, time of land
fall, topographic data etc)

Exposure and Vulnerability Assessment

Exposure of socio-economic Assets: Population density
Land use and land cover (LULC): Built-up area, agriculture land, road network etc

Need for historical loss and damage data, Development and engineering Information

Issue risk advisory and Potential loss Estimation report

Issue Bulletin at the time of events: Time of land fall, surge height in spatio-temporal, Inundation level, Risk map for public at village and building level etc

No of lives in risk
property loss: Destruction of Building and Infrastructures
Reduction of crop yield
Loss of industries/business

Decisions for risk reduction and mitigation

Built-up cyclonic shelter and other Infrastructures for reduction of risk based on historical impact (pre-plan)

Policy and planning
Disaster risk financing
Relief and mitigation
Sectoral risk Management

Thank you