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Improving global coastal inundation forecasting

WMO Panel, UR2014, London, 2 July 2014

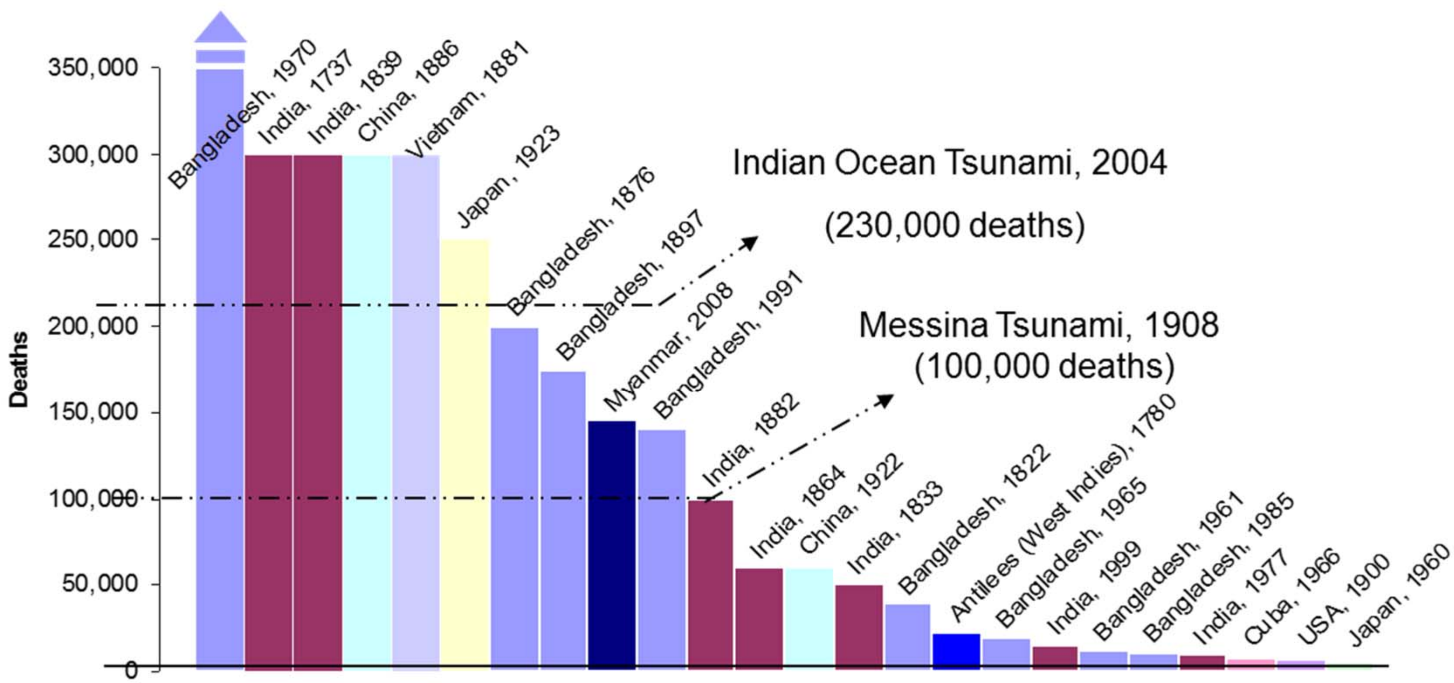
Cyclone Sidr, November 2007

Hurricane Katrina, 2005

Prof. Kevin Horsburgh
Head of marine physics, UK National Oceanography Centre
Chair of the JCOMM Expert Team on Waves and Coastal Hazards (ETWCH)

Casualties by Cyclones and Storm Surges

- Deaths in tropical cyclones in each year, for highest ranks in the history (with indication of relative level of casualties by major tsunami events). Most fatalities in tropical storms are due to storm surges. All casualty figures are estimates and vary widely according to sources (Dube, 2007).



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Storm surges

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- Deviations from predicted tidal heights are mainly due to the effect of severe weather on the sea surface
  - Low atmospheric pressure
  - Strong winds

- Hurricane Katrina (August 2005) – 1600 fatalities and losses of $80 billion
- 2008 US hurricane season - over $50 billion in damage

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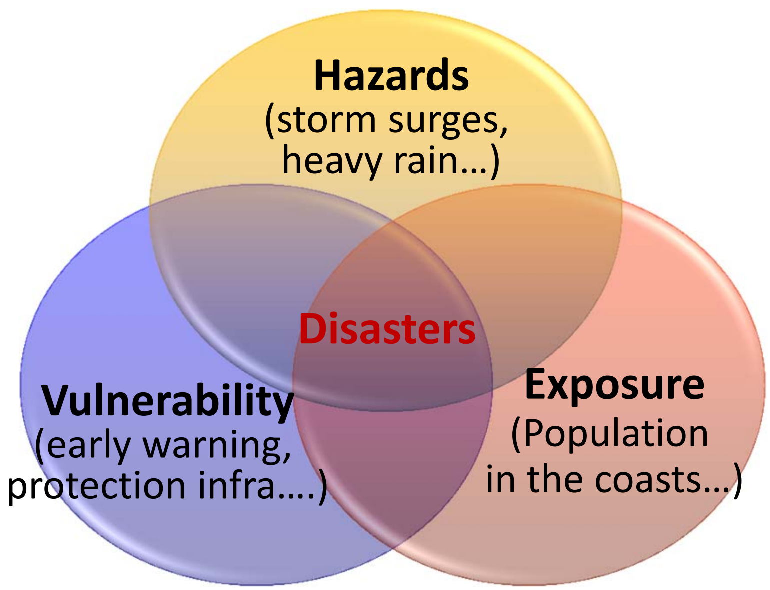
Exposure to coastal inundation is growing

- Population is attracted to coasts by an abundance of local resources
    - Growing coastal population
    - Urbanising coastal zone
    - Tourism, recreation, retirement…
- In many parts of the world, the population is directly exposed to the coastal hazards and this will increase with Climate Change and Sea Level Rise.



Disasters are more likely when Hazards and exposed population overlap with Vulnerability.

- A reactive approach to adaptation increase the vulnerability.

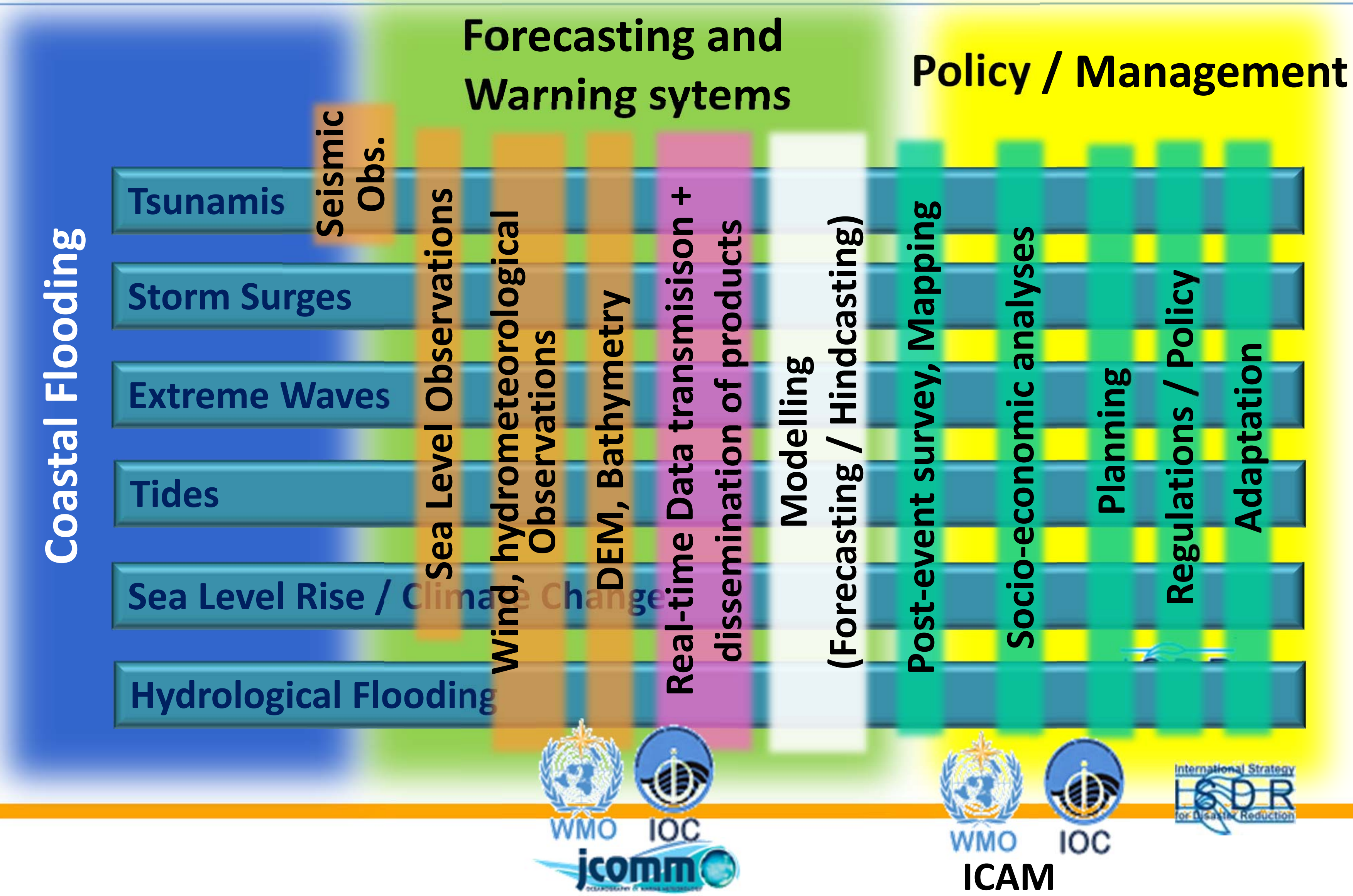
WMO

World Meteorological Organization

Working together in weather, climate and water

Coastal Inundation Forecasting Demonstration Project (CIFDP)

End-to-end Coastal Inundation Management



CIFDP: Benefit for Implementing Countries

- Upon completion of national sub-projects of CIFDP: countries will implement an **operational system for integrated coastal inundation forecasting and warning**, providing objective basis for coastal disaster (flooding) management; contributing to saving lives, reducing loss of livelihood and property, and enhancing resilience and sustainability in coastal communities.
- Upon completion of each Phase of the Project: countries will be provided with valuable **input to the assessment and awareness of the issues of coastal inundation management** within its governments. It would also assist the countries to advance steps toward the integrated forecasting and warning services.

Strategy for CIFDP implementation

- CIFDP is implemented through **national sub-projects**, launched for a country that meets the essential requirement: <u>national agreement</u>
- CIFDP sub-projects are designed based on **users' perspectives and requirements**, considering existing and available open source techniques. Final products of the Demonstration Project should be operated and maintained by national operational agencies which have the responsibility/authority for coastal inundation warnings;
- The procedures/best practices developed through sub-projects should be applicable to other (neighbouring) countries with common issues and interests, and should be closely linked to and cooperating with related projects and activities.

CIFDP: National commitment

- Lead / Participation of **operational forecast agency(ies)**
  - Mandates/responsibilities for coastal inundation forecasting /warning services;
  - Availability of qualified staff to run the system in 24/7 mode, with appropriate infrastructure for operational services;
  - Commitment to sharing all data and information relevant to the inundation forecast process.
- **National Agreement** among responsible national agencies
  - To be basis of Definitive National Agreement (DNA);
  - Key/leading role of National Meteorological and Hydrological Services (NMHSs);
  - Close cooperation/collaboration with national authorities for coastal disasters risk and emergency management ;
  - Establishment of National Coordination Team (NCT), to ensure sustainable operation by national agencies as well as continuous engagement of “USERS” of forecasting services.

CIFDP: Project Implementation

The project will be implemented in a phased approach that leaves scope for adjustment in the next phases to fit the prevailing requirements:

Phase 0 : Project **preparation**

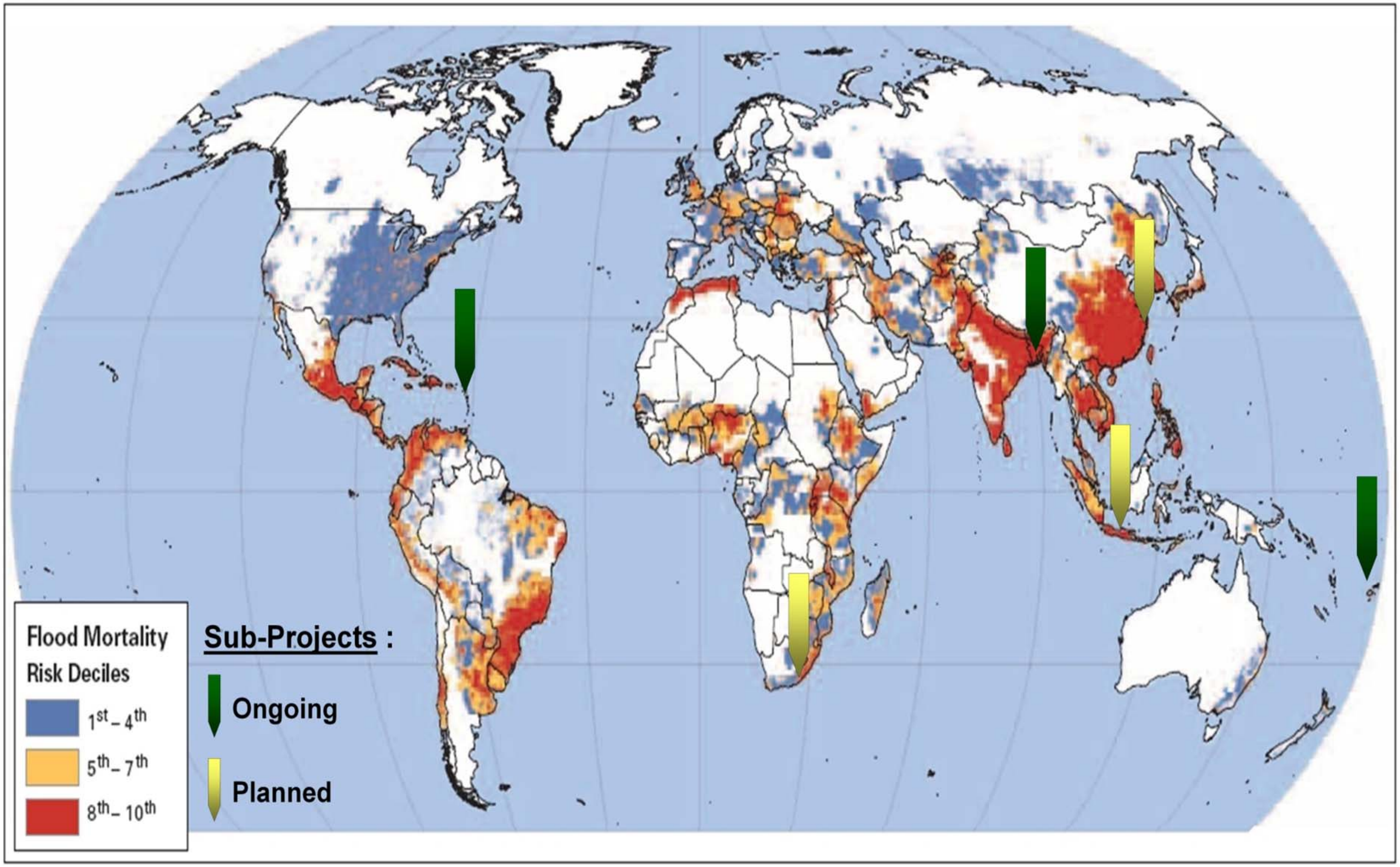
Phase 1 : Information gathering – Project Adaptation

Phase 2 : System Development / **Implementation**

Phase 3 : Pre-operational testing

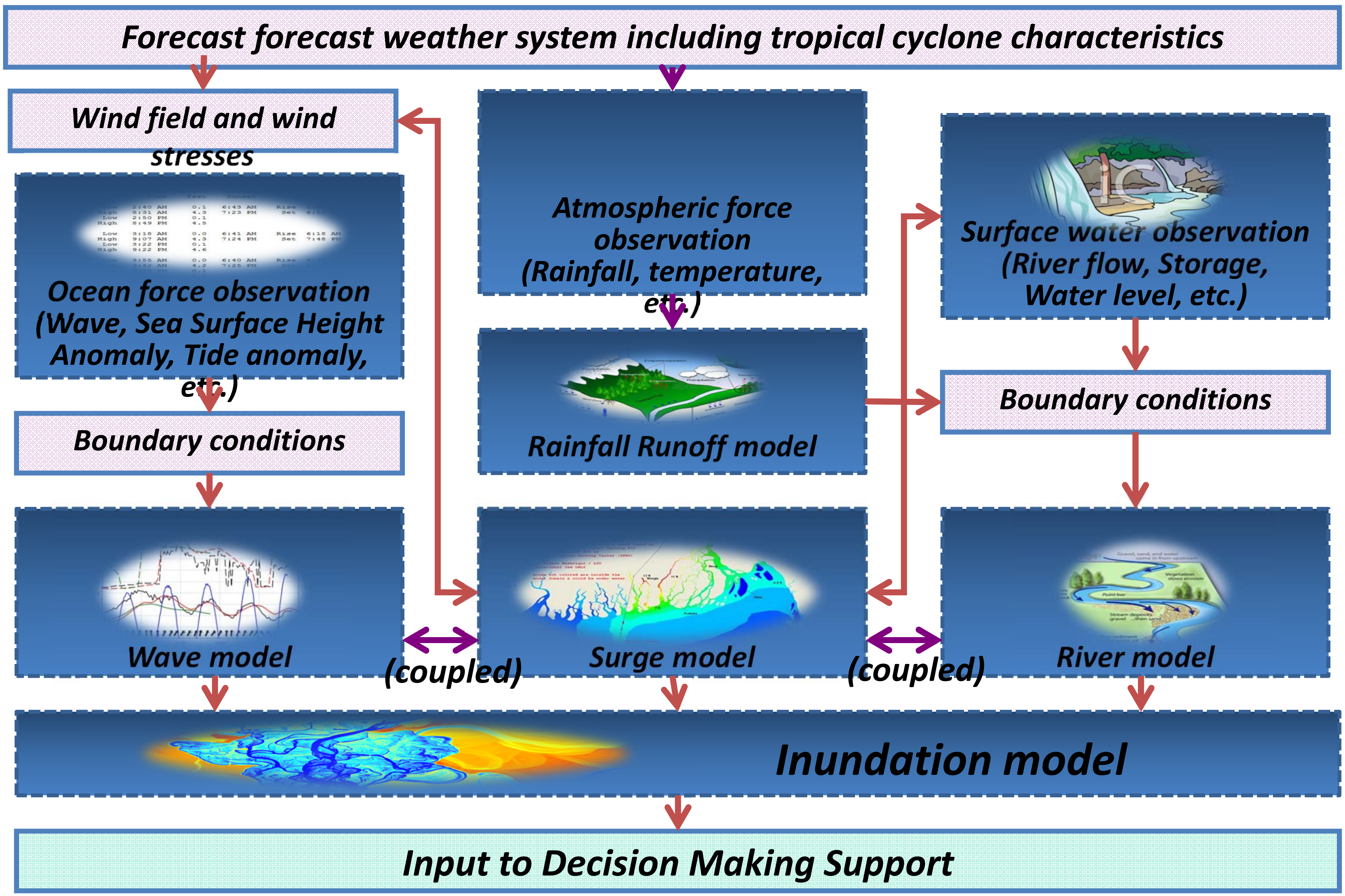
Phase 4 : Live Running and **Evaluation**

CIFDP Implementation



Natural Disaster Hotspots: A Global Risk Analysis. World Bank, 2005

CIFDP: Technical Development for Coastal Inundation Forecasting/Warning



Probabilistic interpretation of weather & climate

Probabilistic interpretation of weather & climate

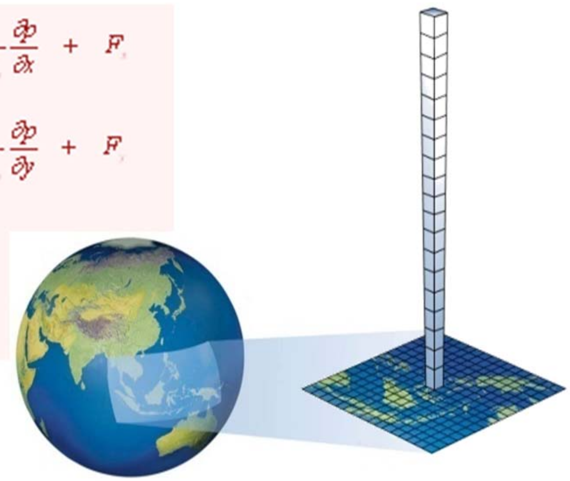
X

$$\frac{\partial u}{\partial t} + \mathbf{v}.\nabla u - fv = -\frac{1}{\rho_0}\frac{\partial p}{\partial x} + F_x$$

$$\frac{\partial v}{\partial t} + \mathbf{v}.\nabla v + fu = -\frac{1}{\rho_0}\frac{\partial p}{\partial y} + F_y$$

$$\frac{\partial p}{\partial z} = -\rho g$$

$$\nabla.\mathbf{v} = 0$$



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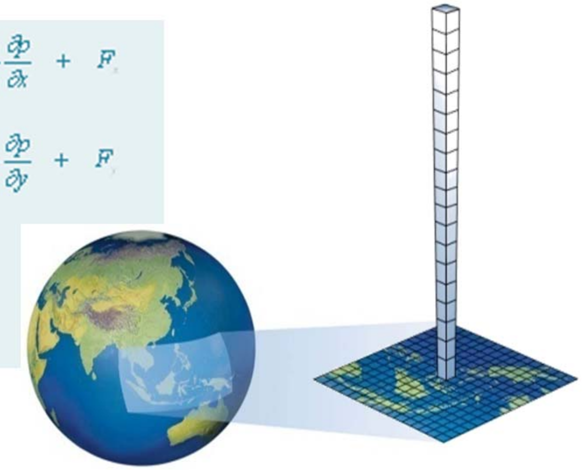

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So much for our barbecue summer

Long-range forecasters should leave the spin to politicians, suggests Eden.

By Philip Eden
Published: 7:42PM BST 29 Jul 2009

Comments 36 | Comment on this article

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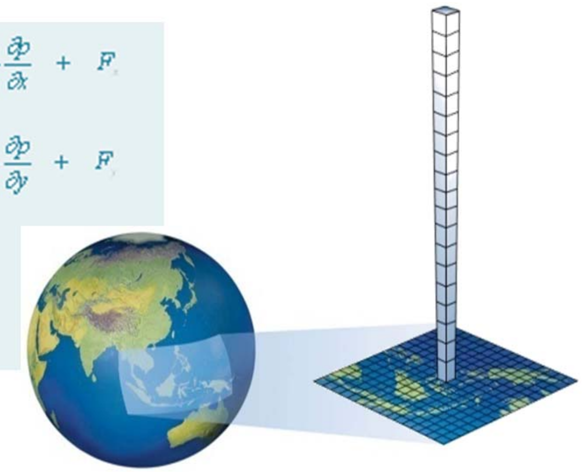

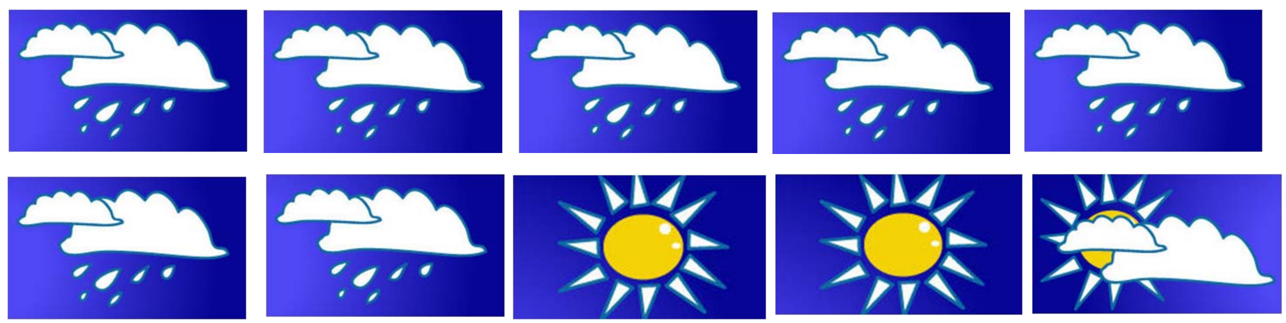

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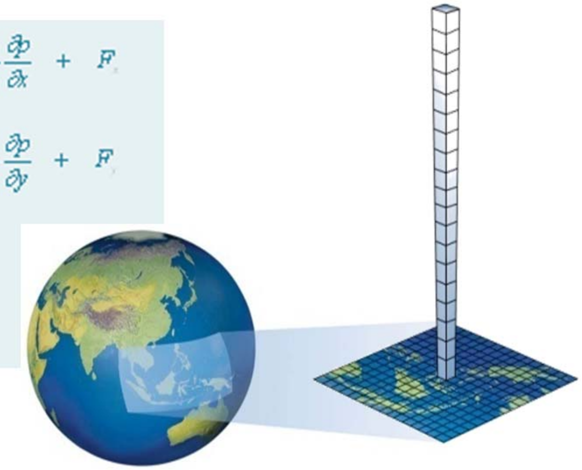

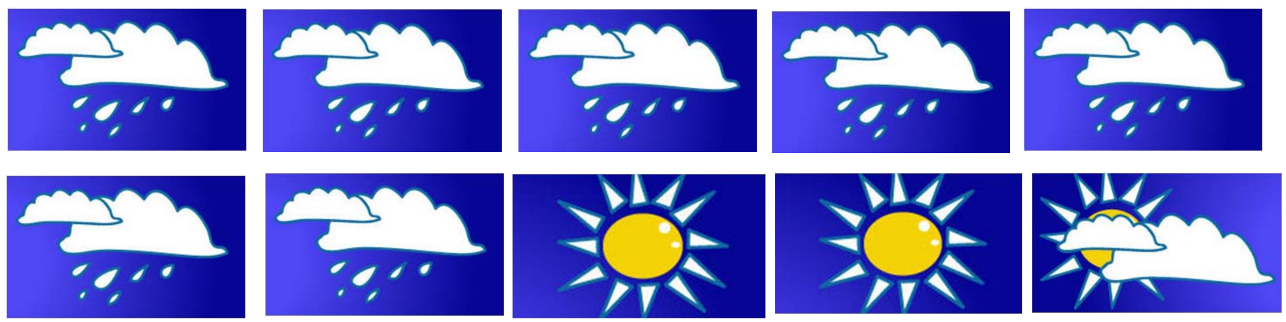

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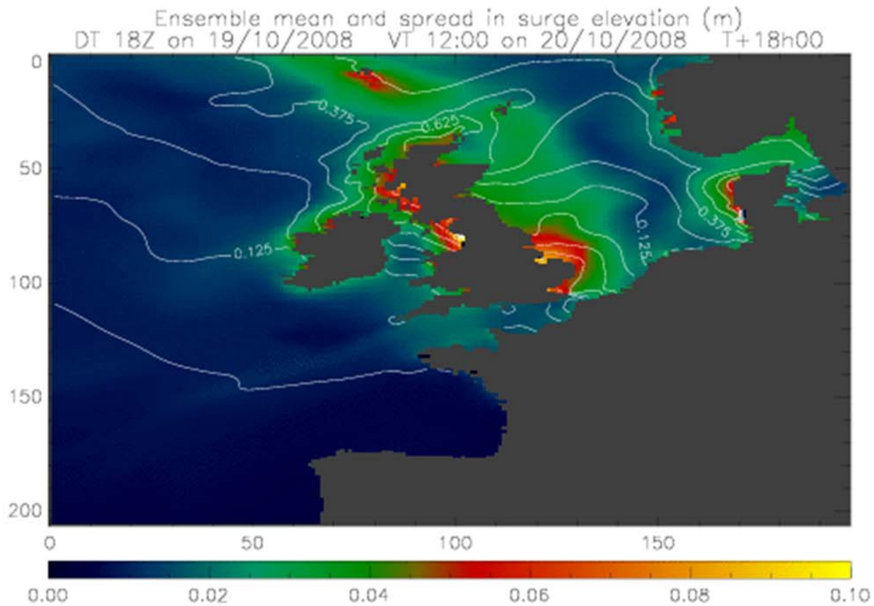
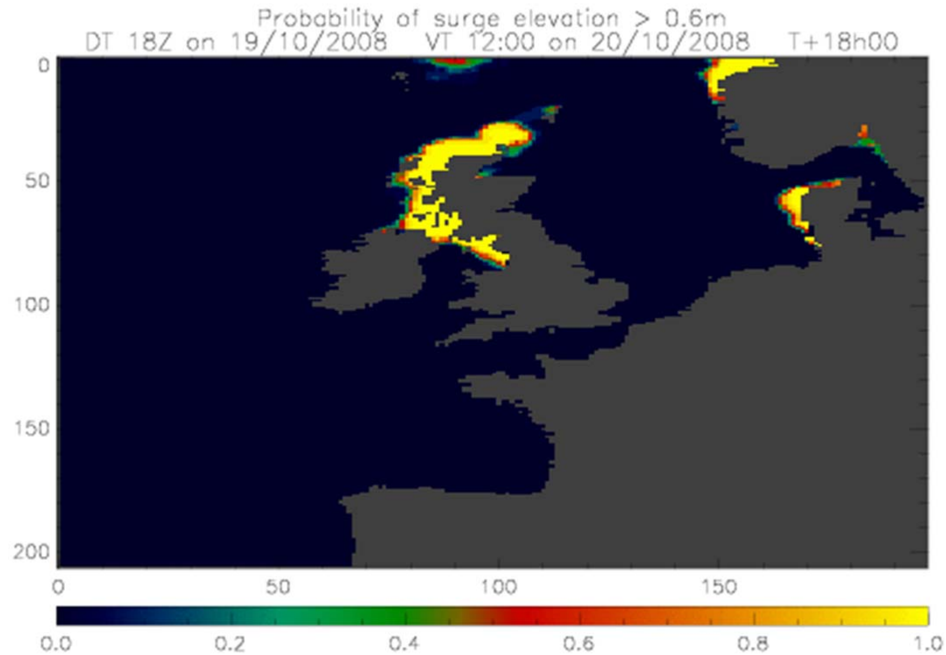
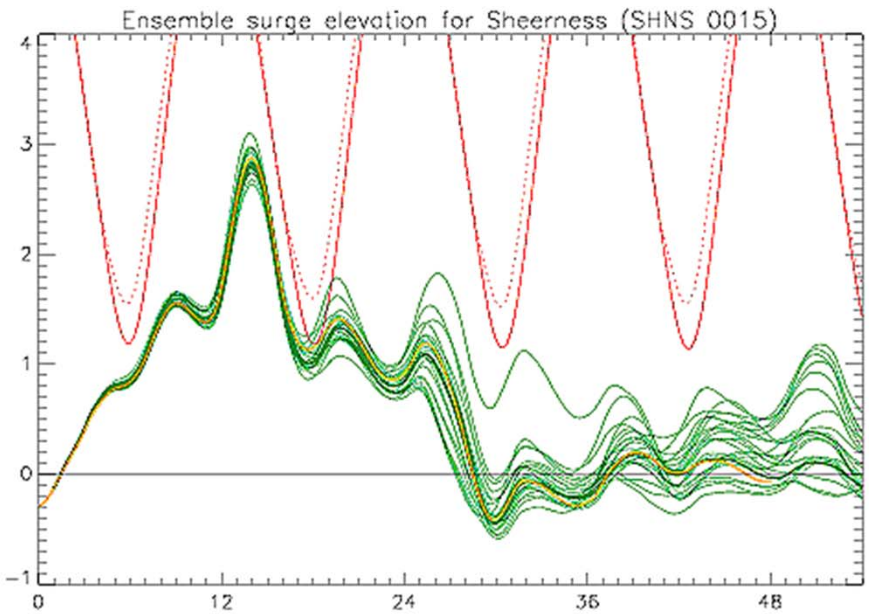
Ensemble products for forecasters

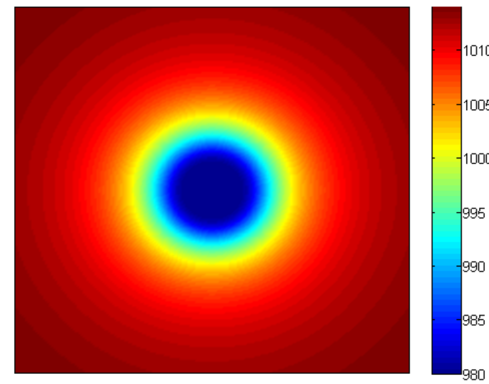






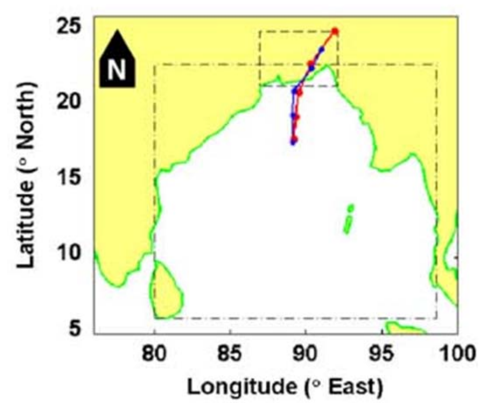
Ensemble methods for cyclone surge forecasting

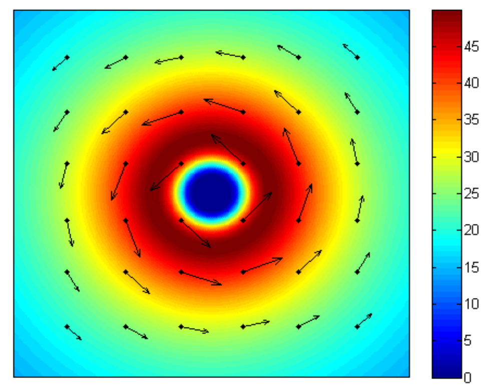
- No high quality tide gauge records in Bangladesh, so extreme water-level estimates can be made using a cyclone parameter database (e.g. IBTrACs) and a well-proven storm surge model



- The study established the statistical variability of the key cyclone parameters that are used in cyclone storm surge forecasting to facilitate a simple ensemble method:

  1. **central pressure,**
  2. **storm size (RMAX),**
  3. **angle of attack,**
  4. **storm speed (mvspeed),**
  5. **landfall location.**





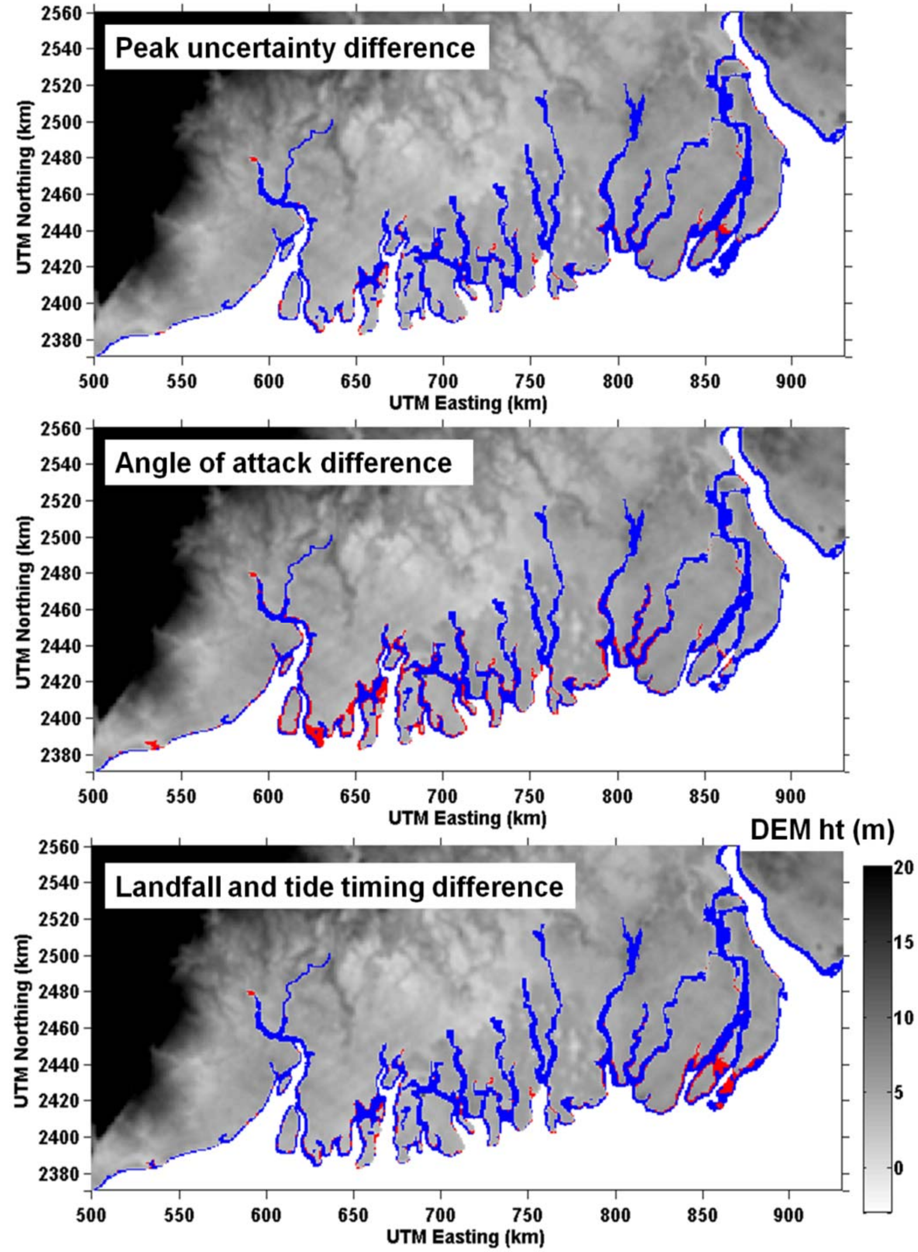
Lewis, M., Horsburgh, K.J., and Bates, P. (2014) Bay of Bengal cyclone extreme water level estimate uncertainty, *Natural Hazards*, January 2014, doi: 10.1007/s11069-014-1046-2

Uncertainty in terms of inundation

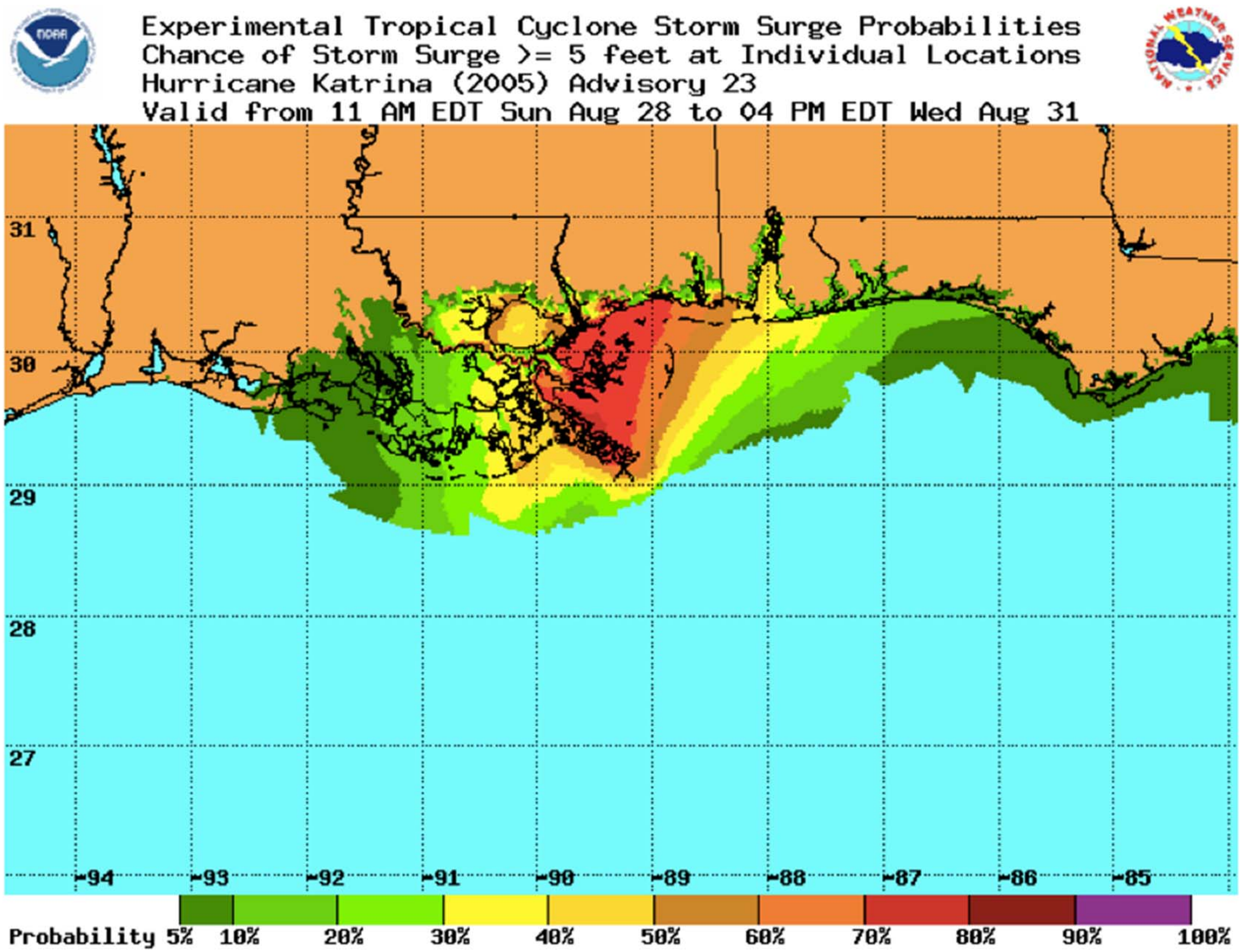
Inundation differences due to natural variability around a 1 in 50yr cyclone with the track of Sidr:

- ΔP uncertainty = 279 km²
- Timing (maximum surge height at low water or high water) = 441 km²
- Track = 1179 km²
- DEM uncertainty = 1416 km²

So, once DEM is as good as possible, inundation extent appears most sensitive to cyclone track uncertainty and tidal state



PROBABILISTIC GUIDANCE FOR HURRICANE STORM SURGE



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CLIMATOLOGY, VARIABILITY AND EXTREMA OF OCEAN WAVES: THE WEB-BASED KNMI/ERA-40 WAVE ATLAS

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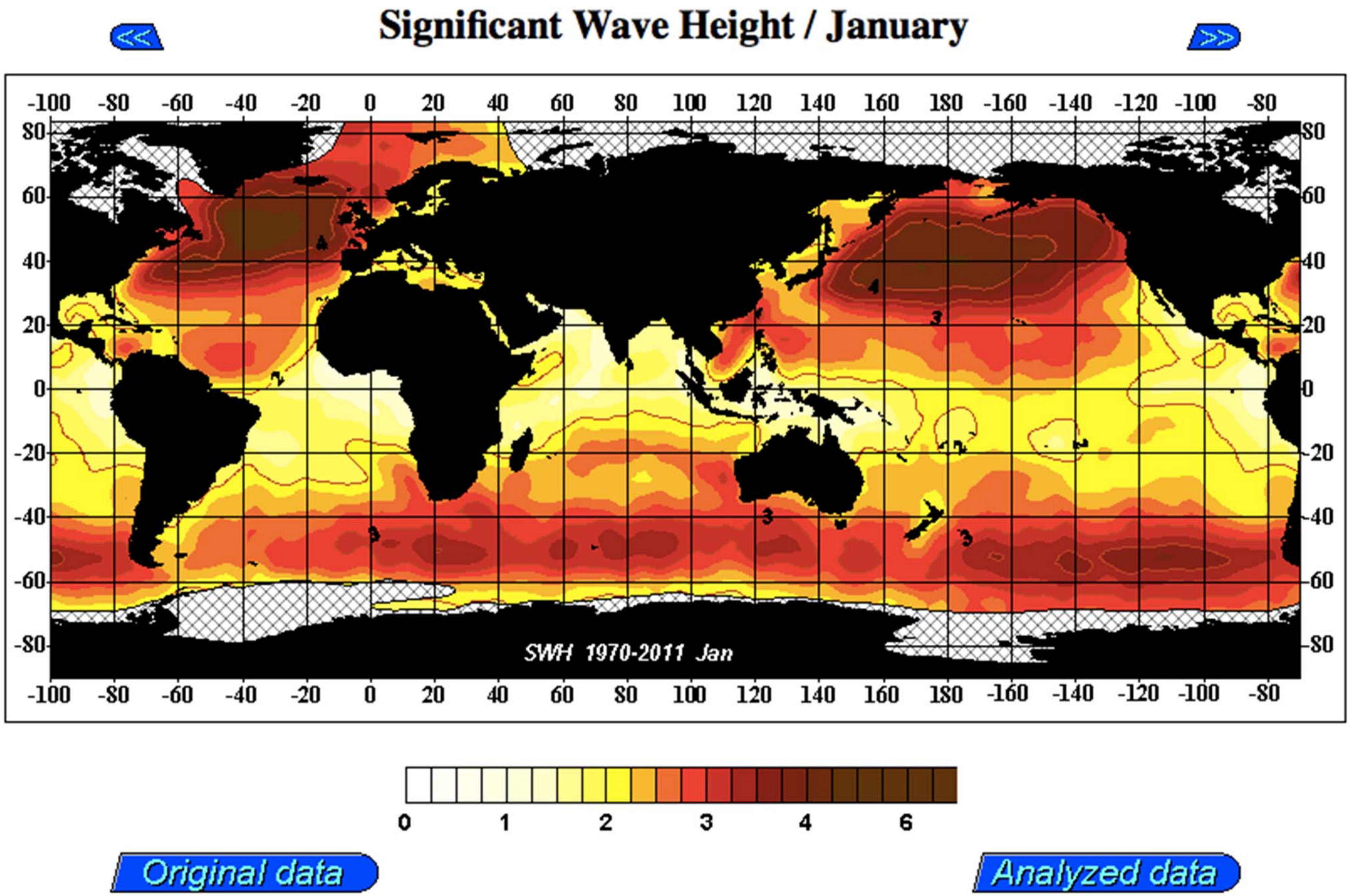
ABSTRACT

The European Centre for Medium-Range Weather Forecasts (ECMWF) has recently finished ERA-40, a reanalysis covering the period September 1957 to August 2002. One of the products of ERA-40 consists of six-hourly global fields of wave parameters, like significant wave height and wave period. These data have been generated with the centre's WAM wave model. From these results we have derived climatologies of important wave parameters, including significant wave height, mean wave period, and extreme significant wave heights. Particular emphasis is on the variability of these parameters, both in space and time. Besides being important for scientists studying climate change, these results are also important for engineers who have to design maritime constructions. This paper describes the ERA-40 data and gives an overview of the results derived. The results are available on a global 1.5° × 1.5° grid. They are accessible from the Web-based KNMI/ERA-40 wave atlas at http://www.knmi.nl/waveatlas.

Wave climatology



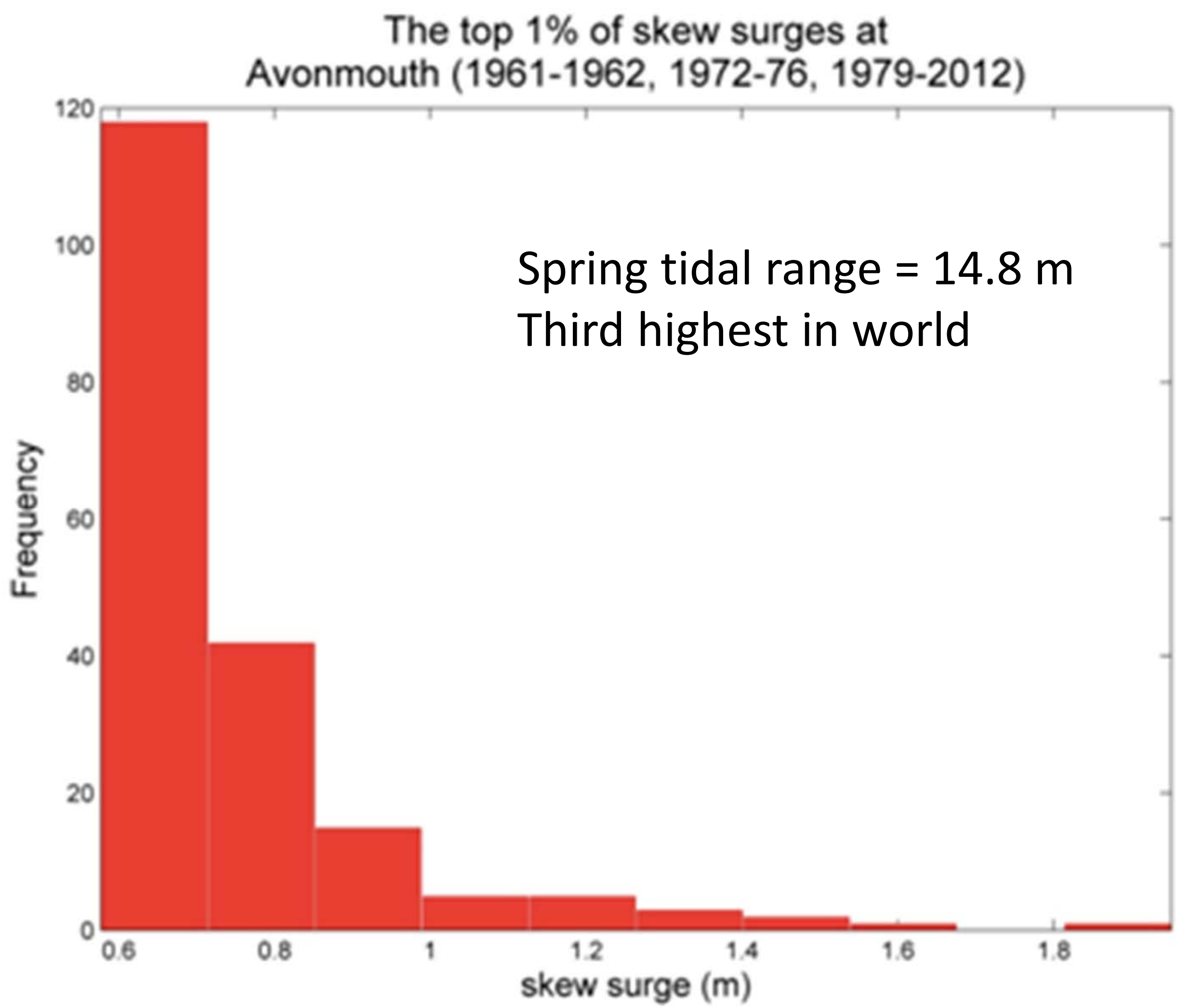
Why are there no equivalent climatologies for storm surges?

Sandwip, Bangladesh (Nov. 2007)

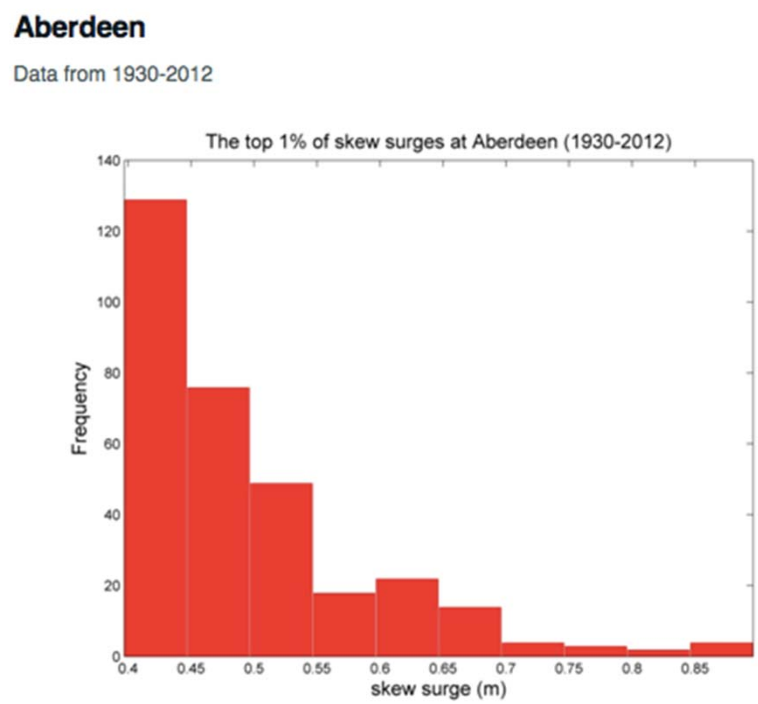
Sea Palling, Norfolk (1 Feb 1953)

- Because there is not a unified global programme of storm surge observations: no VOS for surges; individual satellite measurements of SLA are not accurate; surges are episodic so harder to measure;
- Because there is no systematic approach to isolating storm surge from a tide gauge record
- Because there is not – as yet – any validated global numerical model for storm surges

From tide gauge data, storm surge appears to be independent of tidal range. We analysed the top 1% of skew surges at each UK gauge.



Analysis of all skew surge statistics for UK gauges is available on NOC webpages; analysis of Dutch and then US tide gauge data is ongoing Methodology can be extended to other parts of the world with reliable sea level measurements



Final remarks

Effective coastal flood warning globally is essential to protect lives, property and infrastructure

CIFDP helps develop flood warning systems that are effective and integrated

Ensemble forecasting is an essential ingredient in any well designed forecasting system to explicitly represent uncertainties

An ensemble approach to storm surges resulting from tropical cyclones is feasible based on perturbations to fast-improving databases of cyclone tracks and parameters

Final remarks

There is a pressing need to accelerate the development of a storm surge climatology to a level a maturity comparable to wave climatologies. This is a priority task for ETWCH but poses certain challenges:

- lack of consistent observational data from all affected regions
- no established methodology for defining/isolating storm surges from the sea level record
- no validated and reliable global model for tides and surges

Progress has now been made through:

- Good database of metadata from the satellite era thanks to the eSurge project
- Analysis of skew surge statistics for UK and (ongoing) Dutch and US data

A global tidal is now available for a global self-consistent hindcast of storm surge characteristics

Thank you for your attention