Webinar series: Challenges, Lessons, and Innovations for IFRM

Session 3: Coastal Flood Risk Assessment

Lessons from coastal flood risk analysis in Philippines and Pakistan

TA 9634-REG: Strengthening Integrated Flood Risk Management

Webinar Agenda

1. Welcome and opening remarks

2. Overview of the KSTA project and introduction to the Webinar series

3. Presentation on Lessons from coastal flood risk analysis in Philippines and Pakistan
   - Fay Luxford
   - Blair Spendelow

4. Discussion, question and answer

TA 9634 REG ‘Strengthening Integrated Flood Risk Management’

Overall objective:

Strengthen the design and implementation of IFRM solutions, enhancing knowledge and application of IFRM strategies

Commenced in February 2019, concludes in June 2022

8 Countries: Indonesia, Philippines, Viet Nam, Myanmar*, Bangladesh, India, Nepal and Pakistan

Webinar series

Date	Title
March 9	A country-scale view on IFRM and applications of global datasets
March 15	Application of an IFRM Approach at a River Basin Level
March 22	Coastal Flood Risk Assessment
March 30	Economic and Finance for IFRM
April 5	Outlook for IFRM and Ways Forward

Objective:

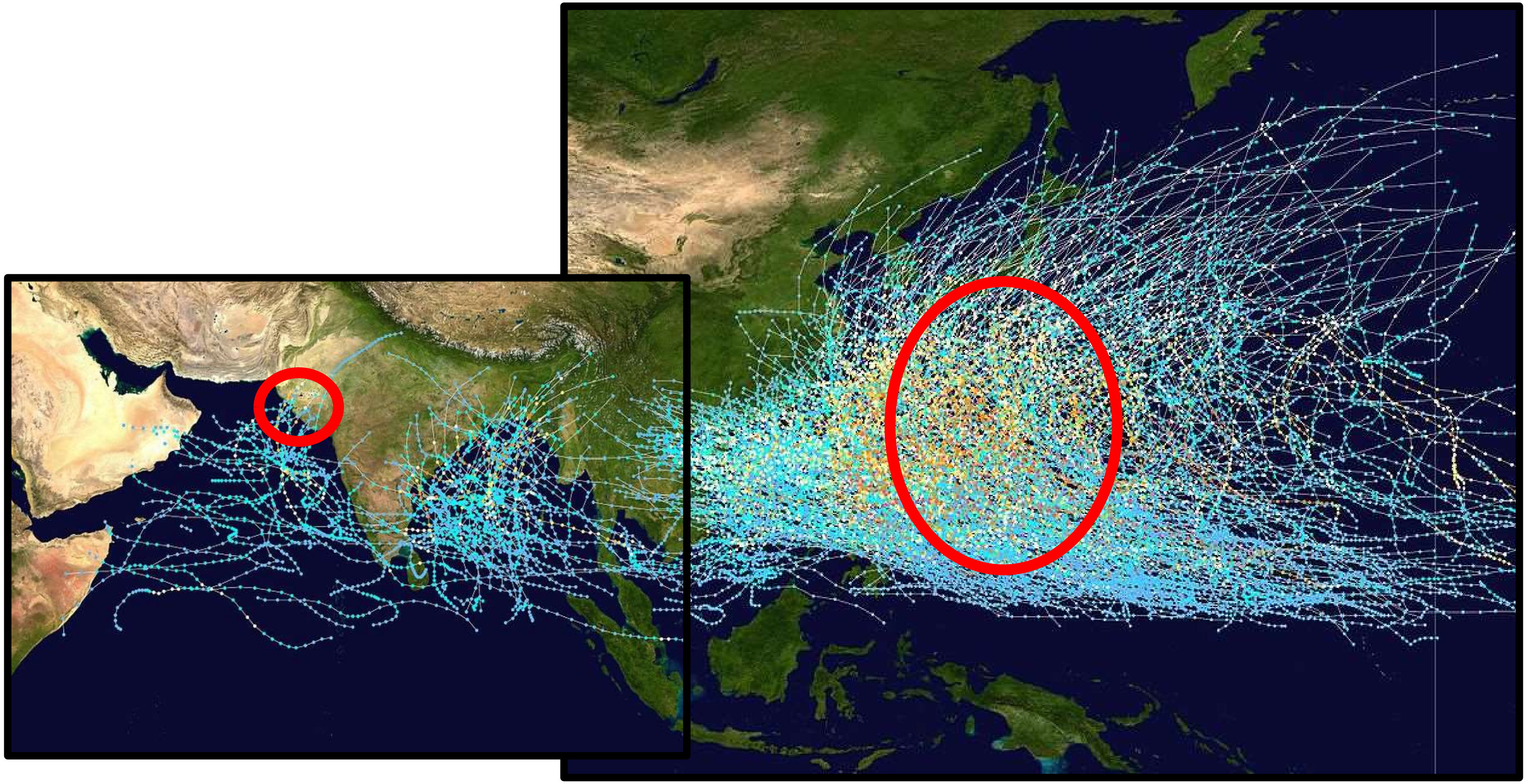
To share our experiences from implementing the KSTA project and reflect on issues and lessons learned for applying IFRM in practical applications

Coastal Flood Risk Assessment

Contents

- Why is coastal flood risk important?
- Example of coastal flood risk analysis and benefits of Nature Based Solutions (NBS)
- Coastal data challenges & lessons learnt
- Capacity building

Technical Assistance Background



Indus Delta

Philippines
Archipelago

WHY IS COASTAL FLOOD RISK IMPORTANT?

Blair Spendelow & Fay Luxford

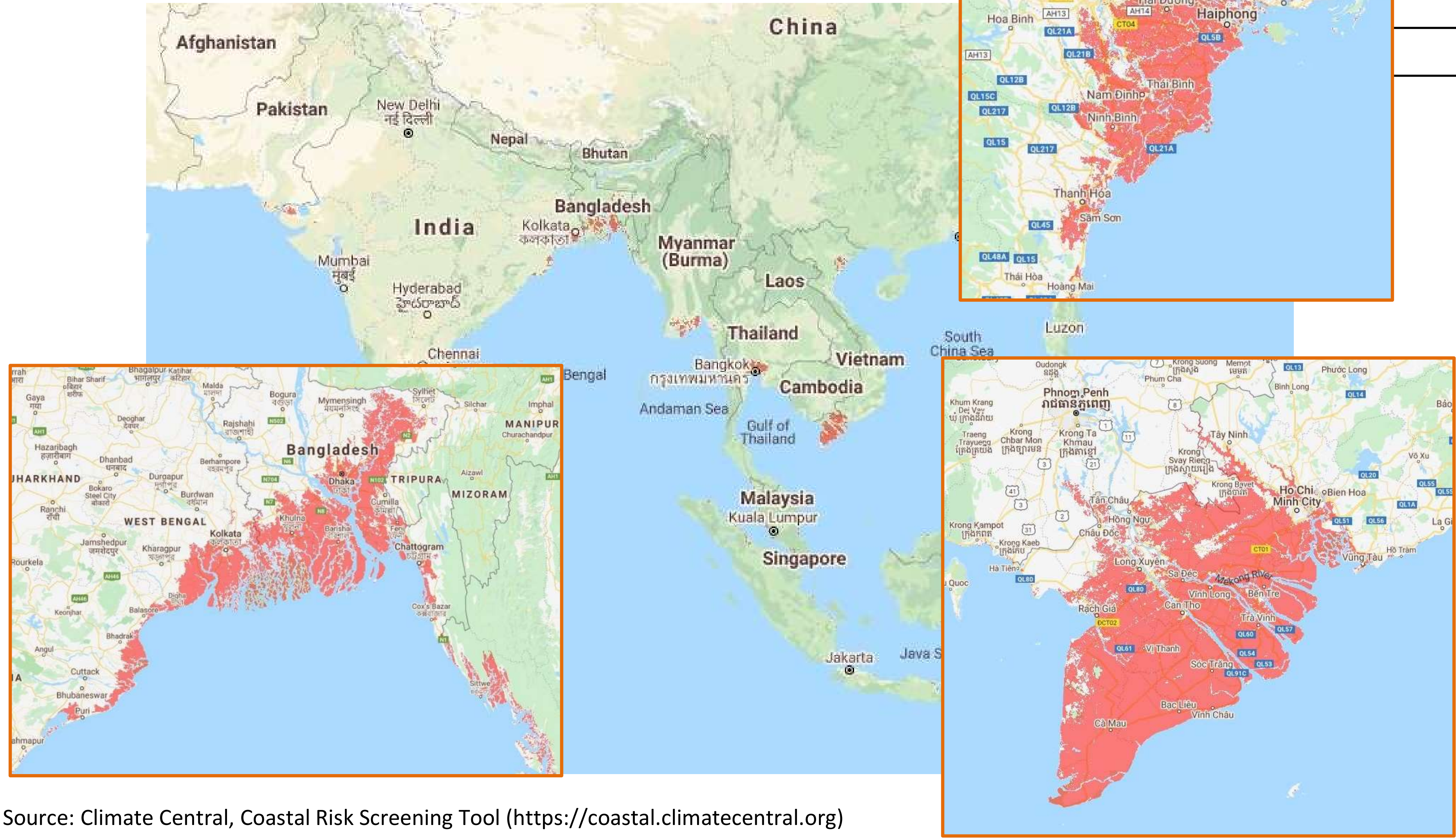
Why is coastal flood risk important?

Destroyed houses in Tacolban, Philippines after Typhoon Haiyan 2013.
Source: https://www.bbc.co.uk/bitesize/guides/z9whg82/revision/4

Vulnerable areas - 2030

Pollution Pathway	SSP2-4.5 (2.7^{o} by 2100)
SLR projection percentile	50th
Inundation method	Bathtub (exclude areas ... ner land)
	...sus

Land below 1-year storm water level with 2030 Mean Sea Level



Source: Climate Central, Coastal Risk Screening Tool (https://coastal.climatecentral.org)

Data sources

Same/Similar	Different
10-year flood in 2030 Climate change scenario Extreme sea levels GIS based projection modelling of flooding	DTM: Aqueduct used MERIT | Climate central used CoastalDEM

Aqueduct floods	**Climate central**

Changes in Coastal flood risk

1) Population changes / urban development

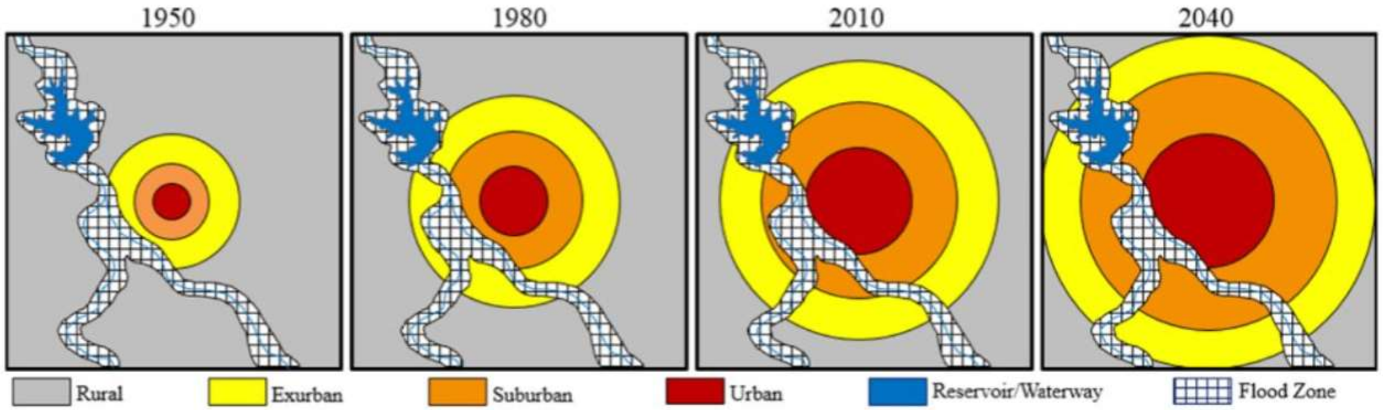


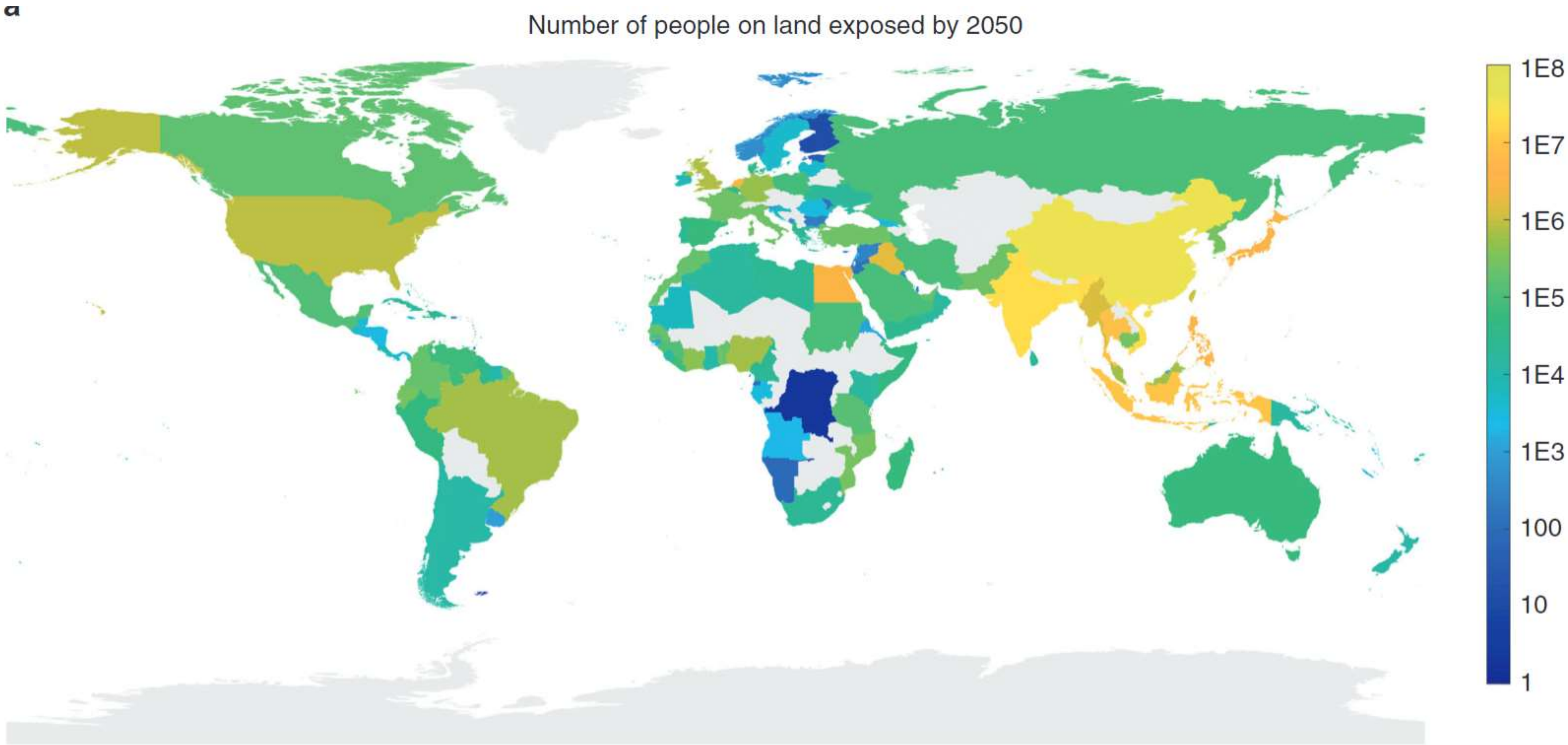
Fig. 7. The Expanding Bull's-Eye effect: A hypothetical flood impacting a city that is growing will cause moderate damage in 1950 and much more damage in 2040, because of many more people and wealth exposed to the flooding. From (Ashley et al., 2014); see also http://chubasco.niu.edu/ebe.htm.

2) Climate change

[1]https://www.emdat.be/

National Exposure

Sea levels projected by 2050 (moderate scenario) are high enough to threaten land currently home to a total of 150 million people to a future permanently below the high tide line, or a marginal increase (2019) of 40 million.



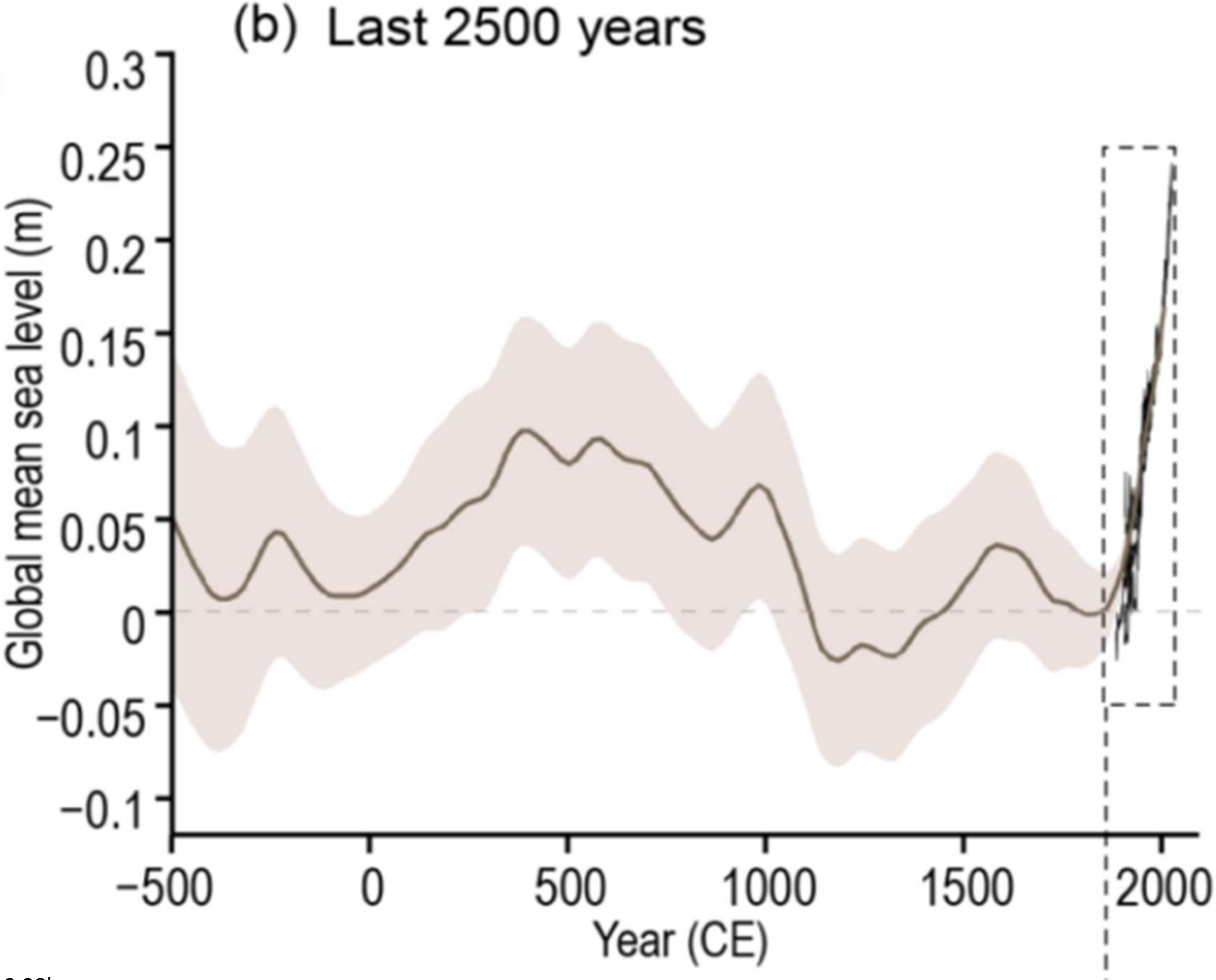
https://www.nature.com/articles/s41467-019-12808-z

Impacts of Sea Level Rise on Drivers of Economic Growth

- Severe coastal flooding is less common than riverine flooding
- Permanent losses of natural capital
- Permanent loss of physical capital
- Permanent loss of social capital
- Temporary floods
- Increased mitigation costs

https://iopscience.iop.org/article/10.1088/1748-9326/7/1/015604/pdf

The Inevitability of Sea Level Rise



Source: IPCC AR6 Fig. 2.28b

Sea Level Rise Projections

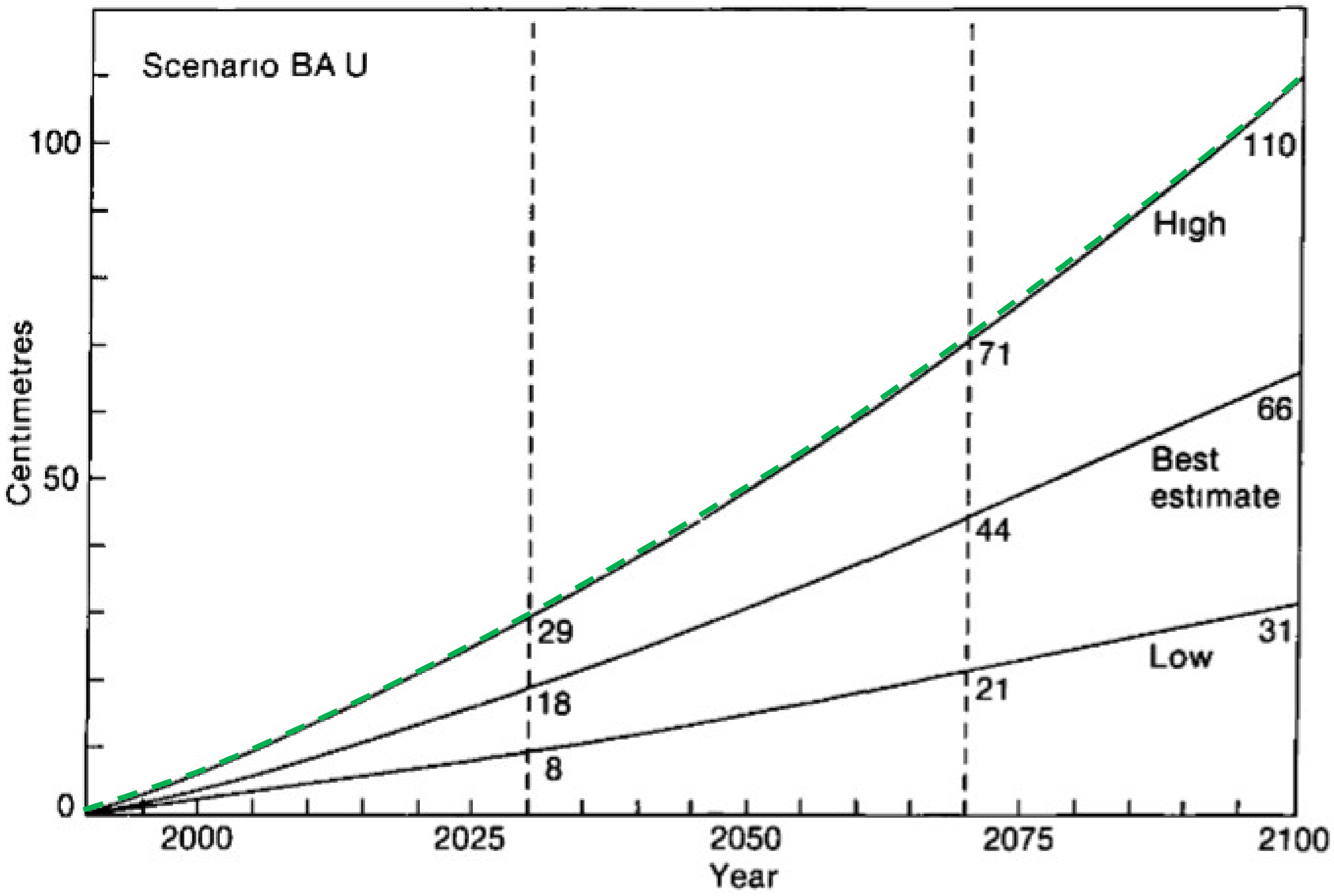
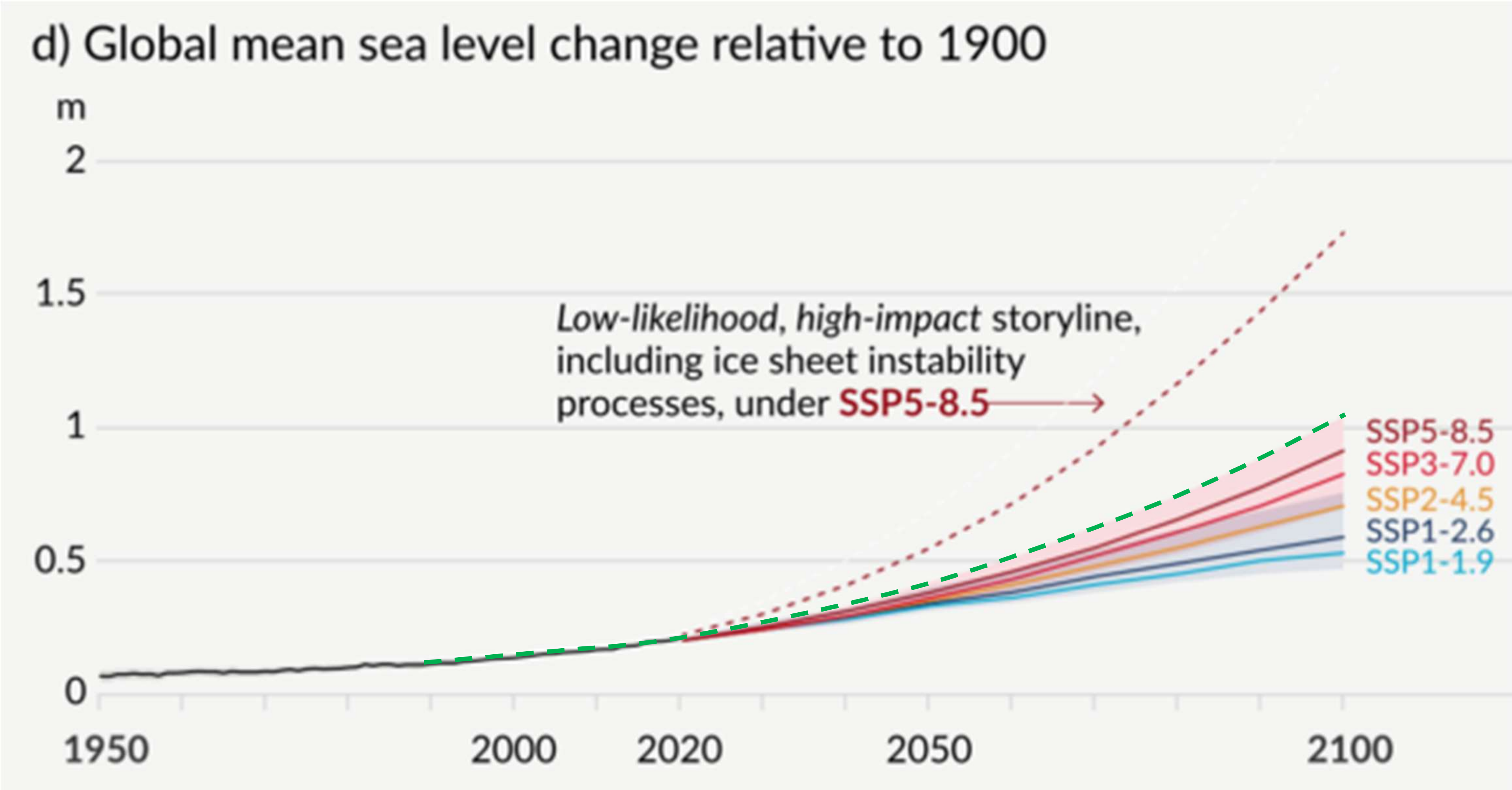


Figure 9.6: Global sea-level rise, 1990-2100, for Policy Scenario Business-as-Usual

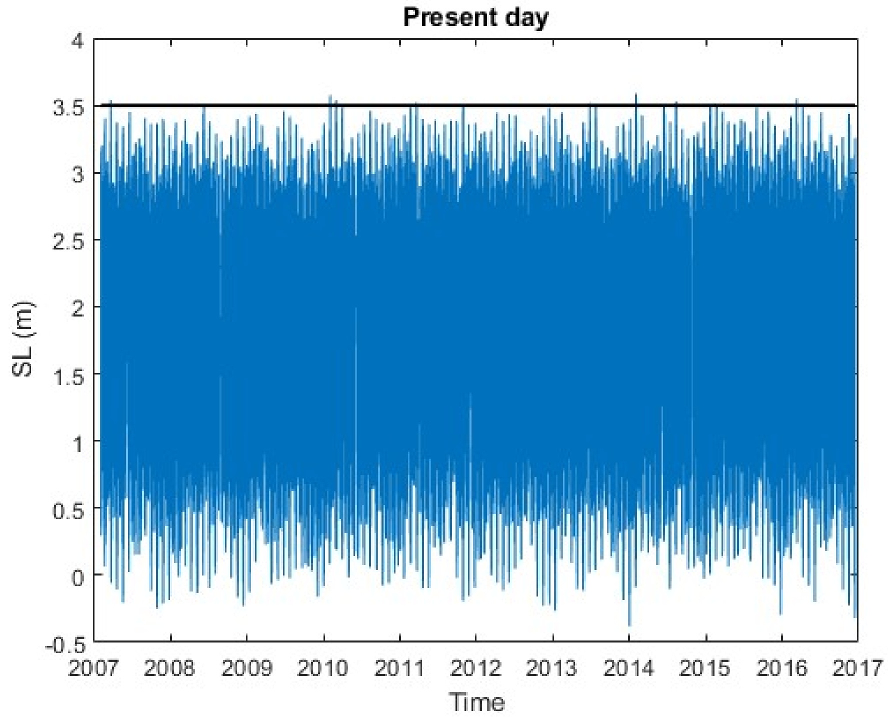
Sea Level Rise Projections

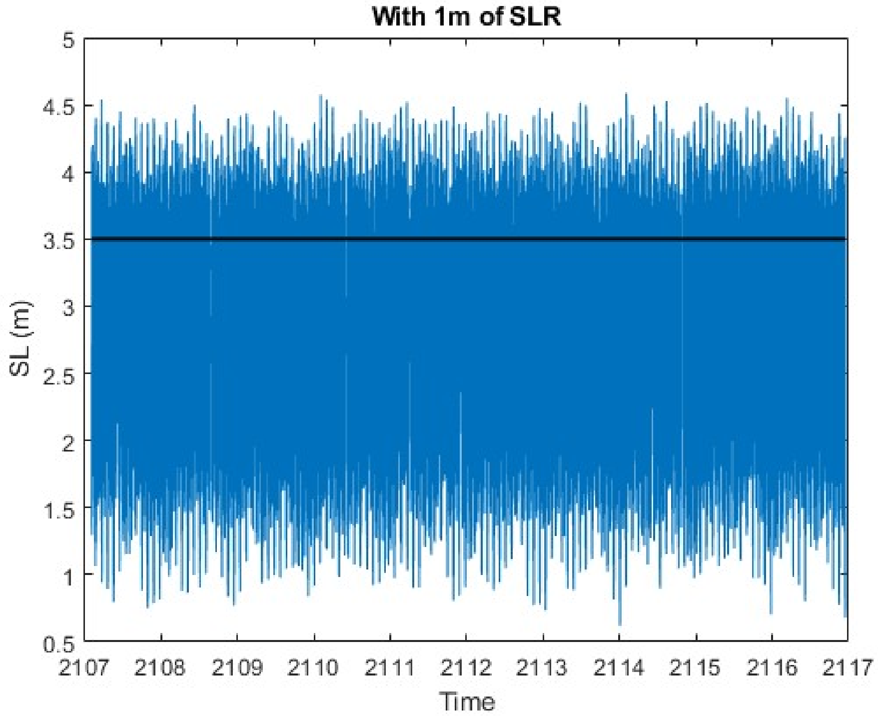


Source: IPCC AR6, Figure SPM.8

Coastal flood risk is increasing

Example – Karachi – assume 3.5m is an extreme sea level which causes flooding





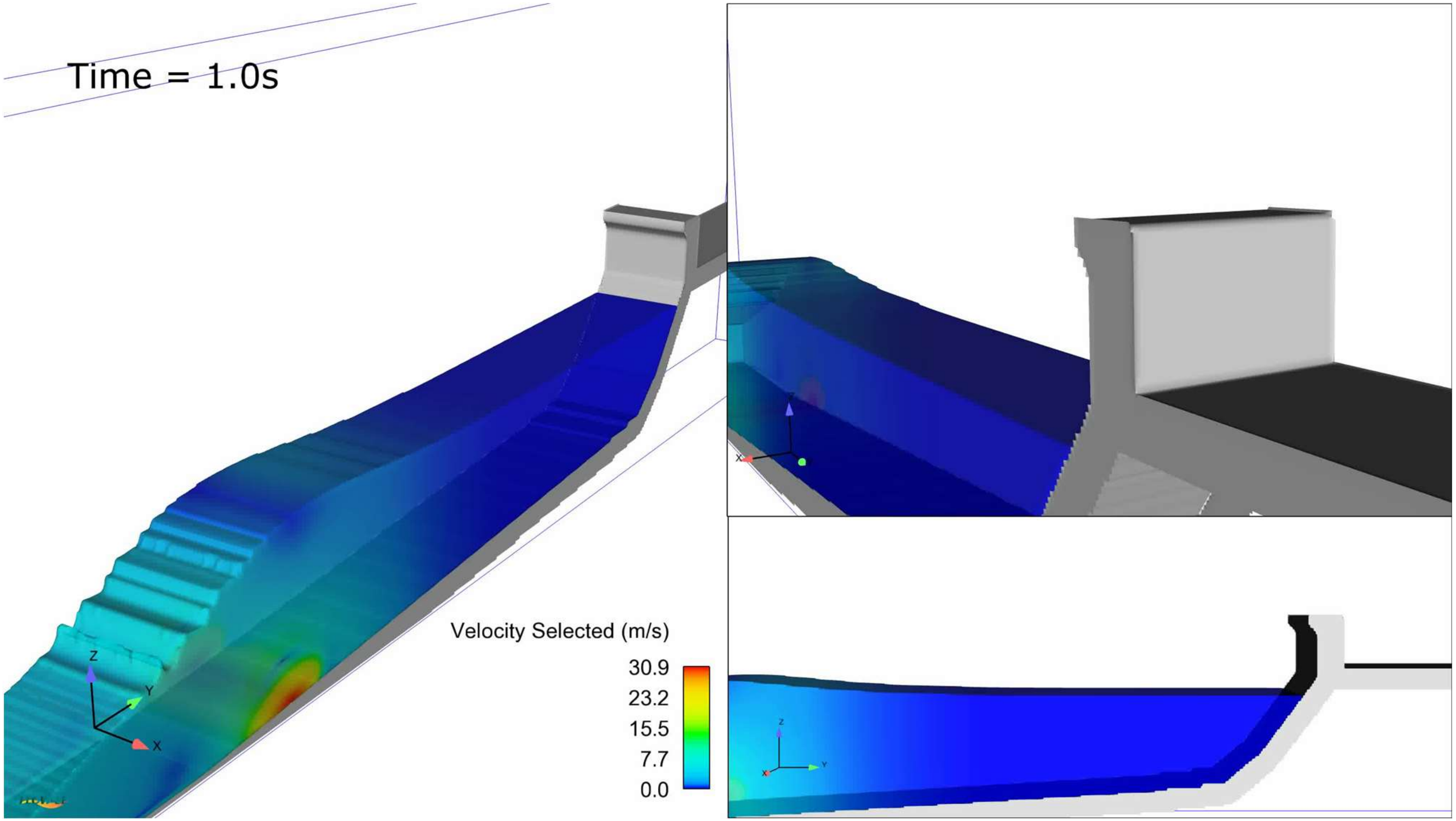
EXAMPLES OF ANALYSIS IN COASTAL RISK

Blair Spendelow

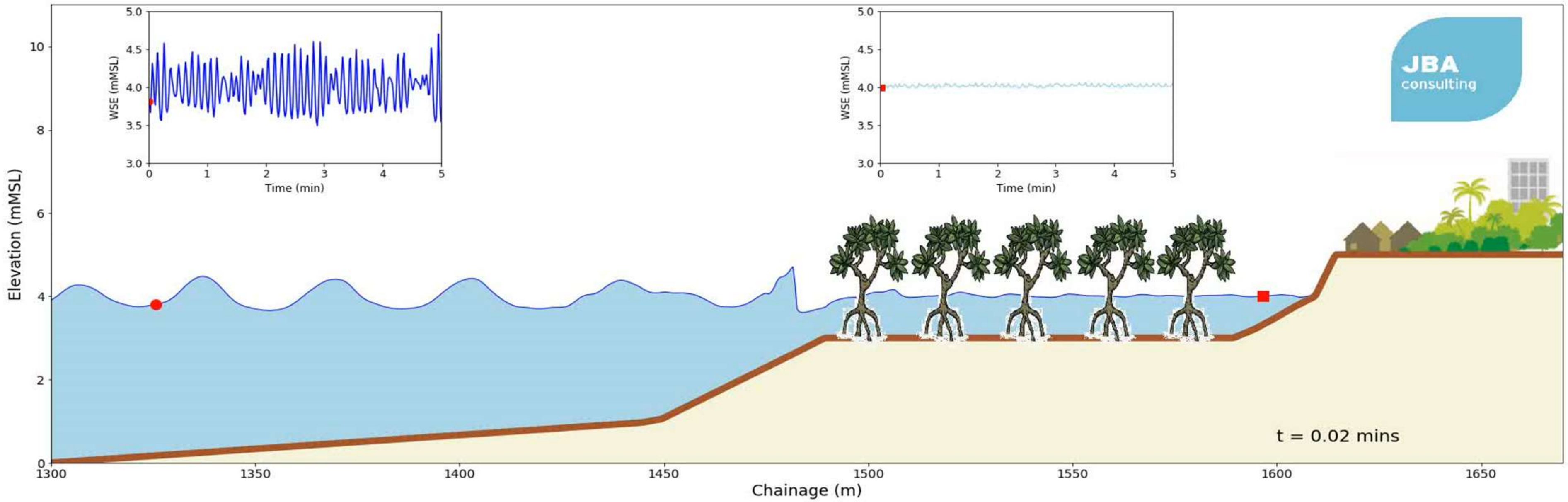
Range of Coastal Risk Topics

- Flooding:
  - Storm surge (storm tide)
  - Mean Sea Level Rise
  - Wave overtopping
  - ‘Sunny day’ flooding
- Erosion:
  - Storm-event (short term)
  - Long term morphodynamics
  - Vegetation loss
- Infrastructure:
  - Coastal protection and restoration
  - Maritime structure design
  - Reclamation

Different Solutions -> Approaches



Modelling Nature-based Solutions



“All Models are Wrong…

George Box (1967):

“Since all models are wrong the scientist cannot obtain a "correct" one by excessive elaboration…over-elaboration and overparameterization is often the mark of mediocrity.”

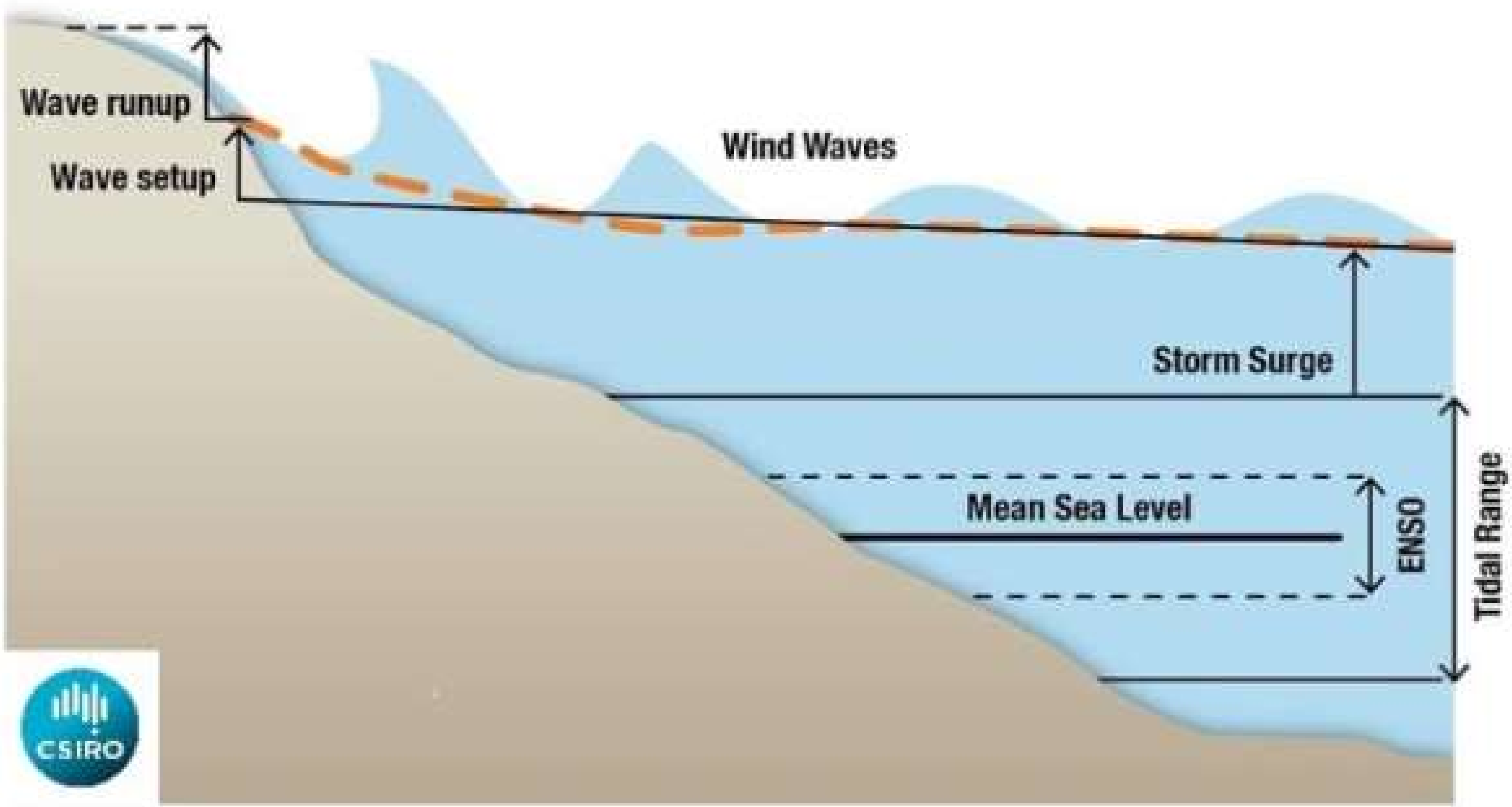
“Since all models are wrong the scientist must be alert to what is importantly wrong. It is inappropriate to be concerned about mice when there are tigers abroad.”

… But some are useful”.

EXTREME SEA LEVELS

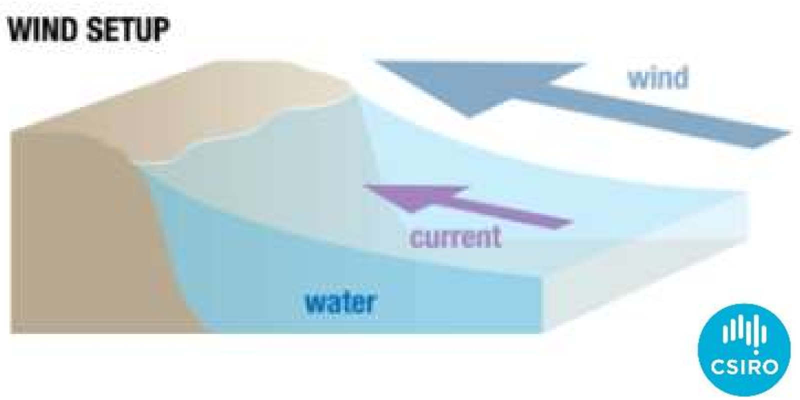
Fay Luxford

Introduction: Causes of extreme sea levels



Storm surges

- Storm surges arise from the inverse barometer effect and wind stress, with wind stress typically the largest component
- The inverse barometer effect elevates sea levels approximately 1 cm for every 1 hPa fall in atmospheric pressure relative to surrounding conditions.
- Wind stress directed onshore leads to an increase in sea levels, particularly within semi-enclosed embayments or under severe wind forcing such as produced by typhoons.
- Under the same wind conditions a coastline fronted by a shallow sea will experience a greater storm surge than a coastline fronted by deep water

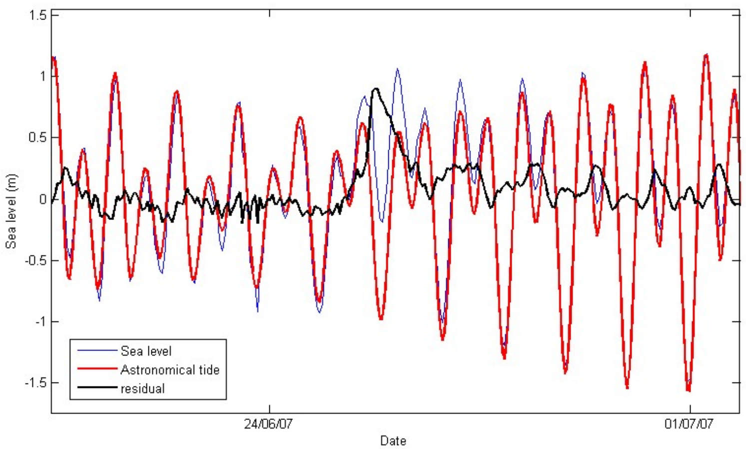


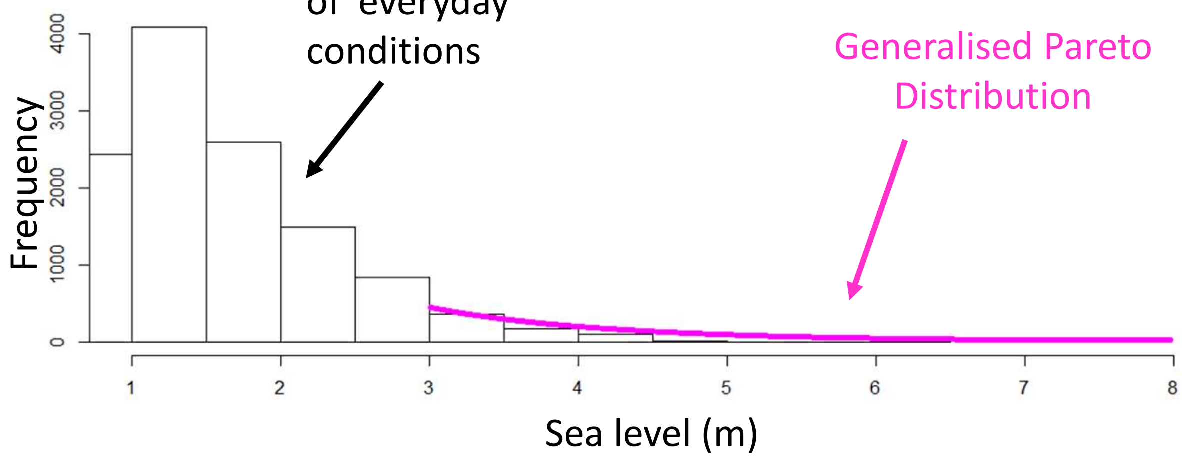
Surge animation with shallow continental shelf

Surge animation with steep continental shelf

Method 1: Extrapolate observations

Tide gauge observations

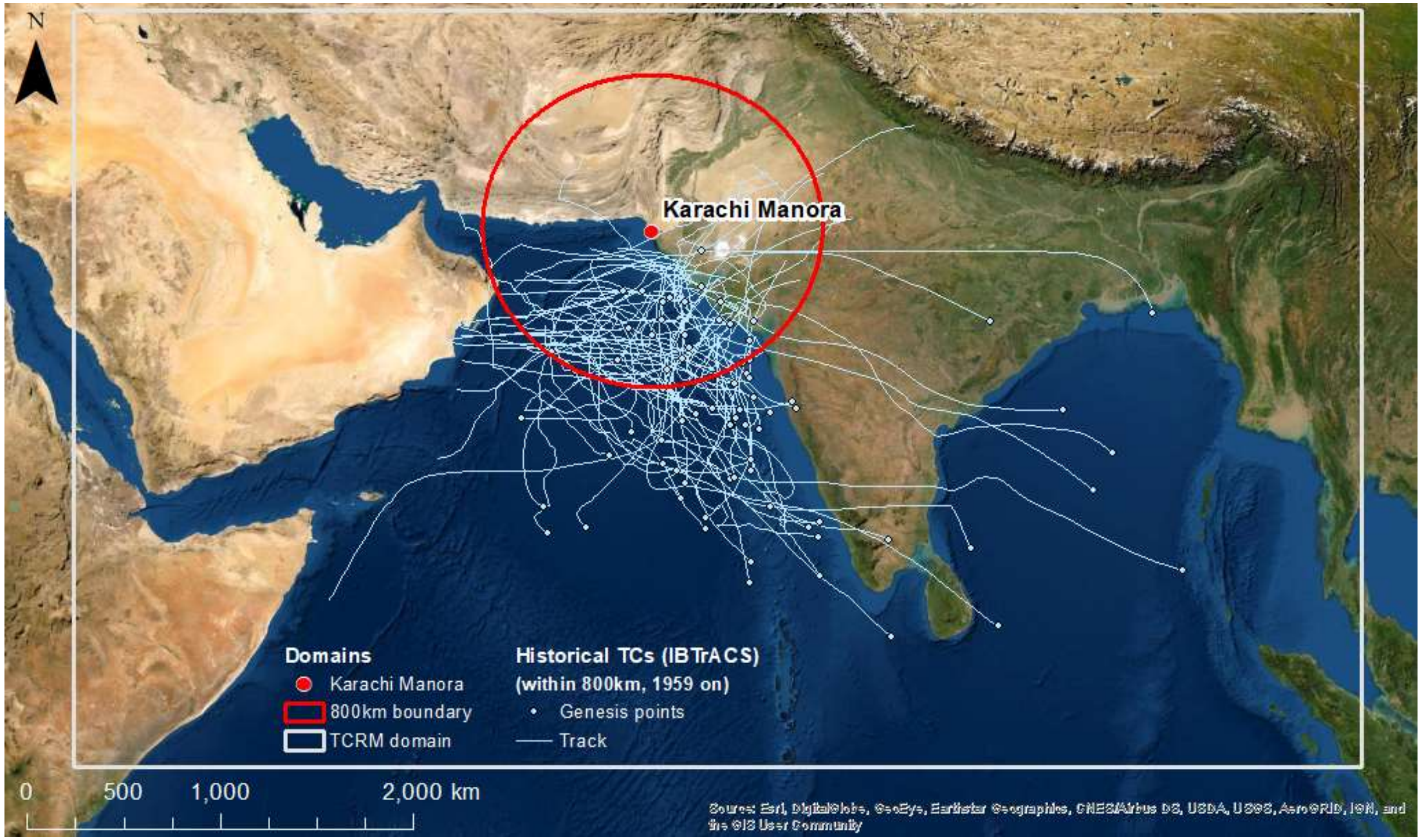




Advantages	Disadvantages
Observations don't include model error	In most locations there are no observations to use. Where there are observations, the records are usually very short and thus capture very few typhoons. With limited data on previous typhoon generated storm surges, extrapolation may not be suitable and usually leads to under-estimation of the risk.

Method 2: Extrapolate Hindcast

Example: Global Tide Surge Model dataset[1] A model of tides and surges around the world was run for 36-years. Fitted a Gumbel distribution to the annual maxima. However authors acknowledge: 36 years contains insufficient number of typhoons to obtain reliable statistics of extreme values.

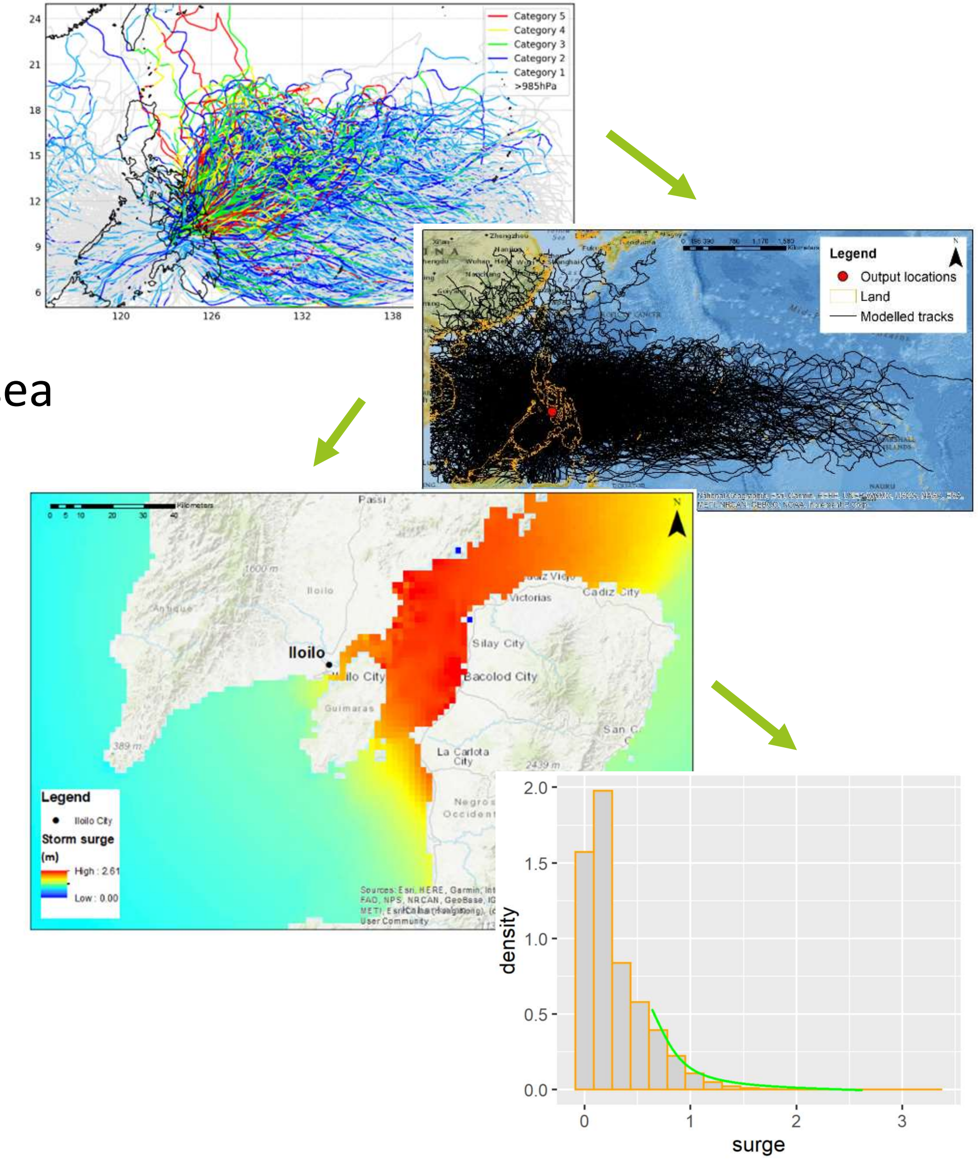


[1]Muis, S., Verlaan, M., Winsemius, H.C., Aerts, J.C.J.H., Ward, P.J. (2016) A global reanalysis of storm surges and extreme sea levels. Nat Commun 7, 11969.

Method 3: Generate more storm surge data

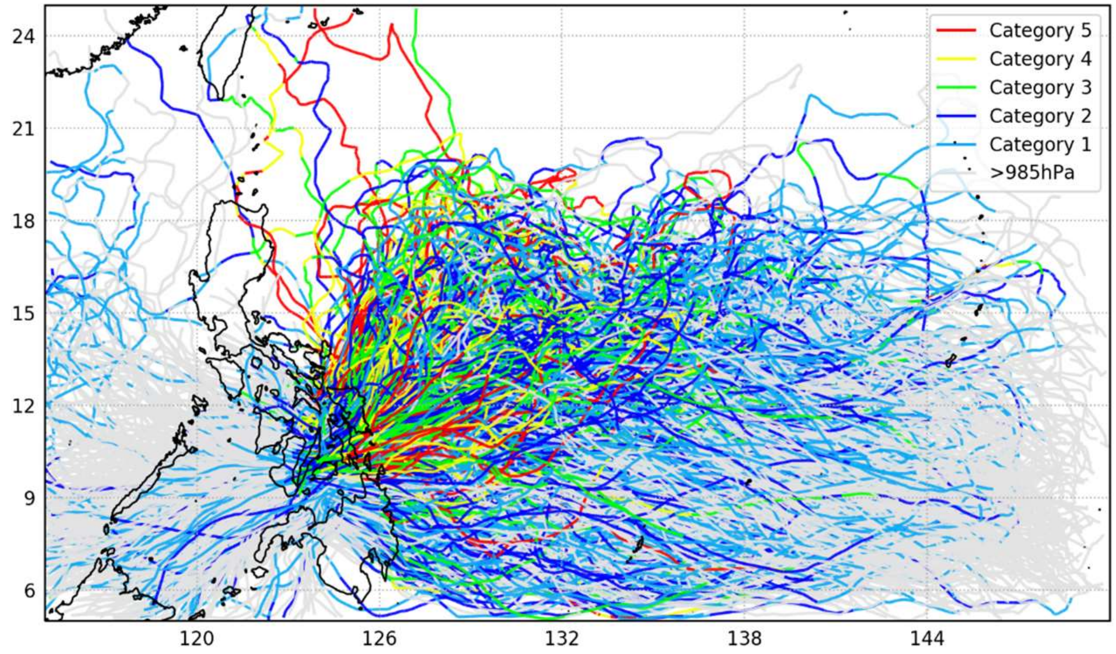
Method

- Generation of synthetic typhoon dataset
- Model resulting storm surge
- Combine storm surge data with mean sea level and tides to calculate return period sea levels



Method 3: Synthetic typhoon dataset

- Generated using Geoscience Australia's Tropical Cyclone Risk Model (TCRM)
- Synthetic dataset is statistically like the input track data, but has also been extrapolated to include more extreme events
- Dataset represents 10,000-years of typhoons

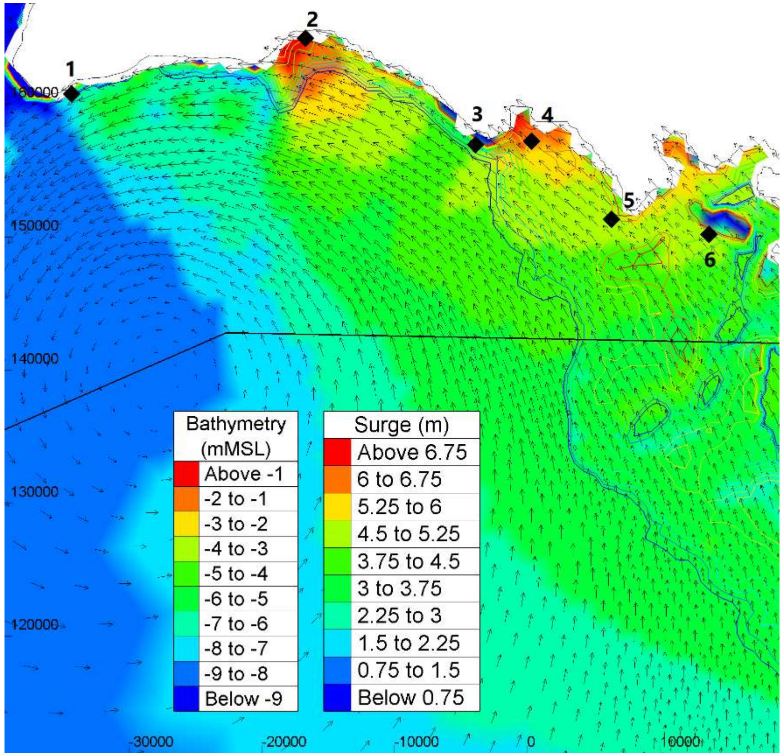


Philippines dataset provided by PAGASA

Method 3: model storm surge

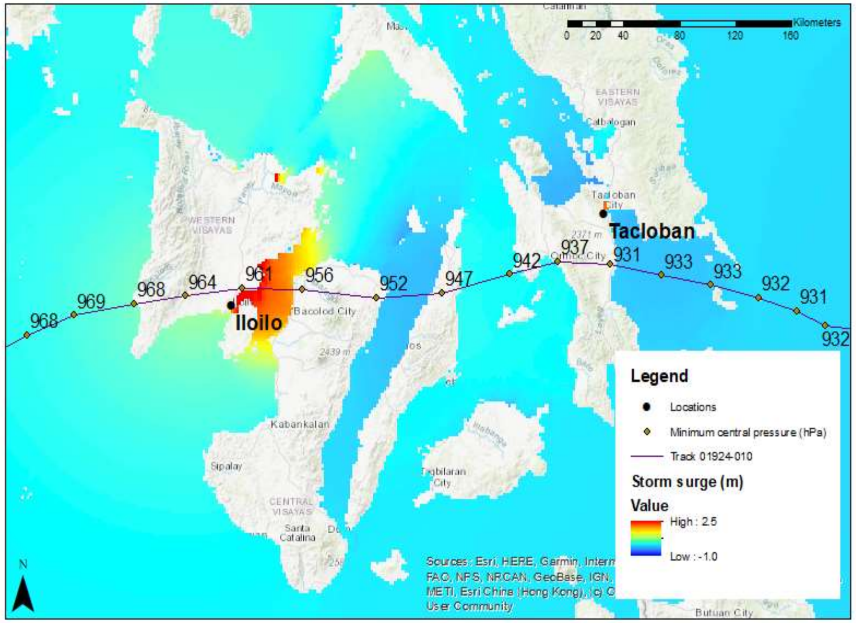
- Pakistan – modelled all 7,889 typhoons
- Philippines – PAGASA unable to model 19,819 typhoons so they modelled a subset and we used machine learning to emulate the storm surge for the remaining typhoons

Modelled storm surge along Sindh coast, Pakistan



Maximum storm surge for event 004-00678-2 (coloured grid), TC track (black line), output locations (black diamonds), bathymetry contours (black line along the coast is the zero mAMSL) contour and wind arrows

Modelled storm surge Iloilo, The Philippines



COASTAL DATA CHALLENGES & LESSONS LEARNED

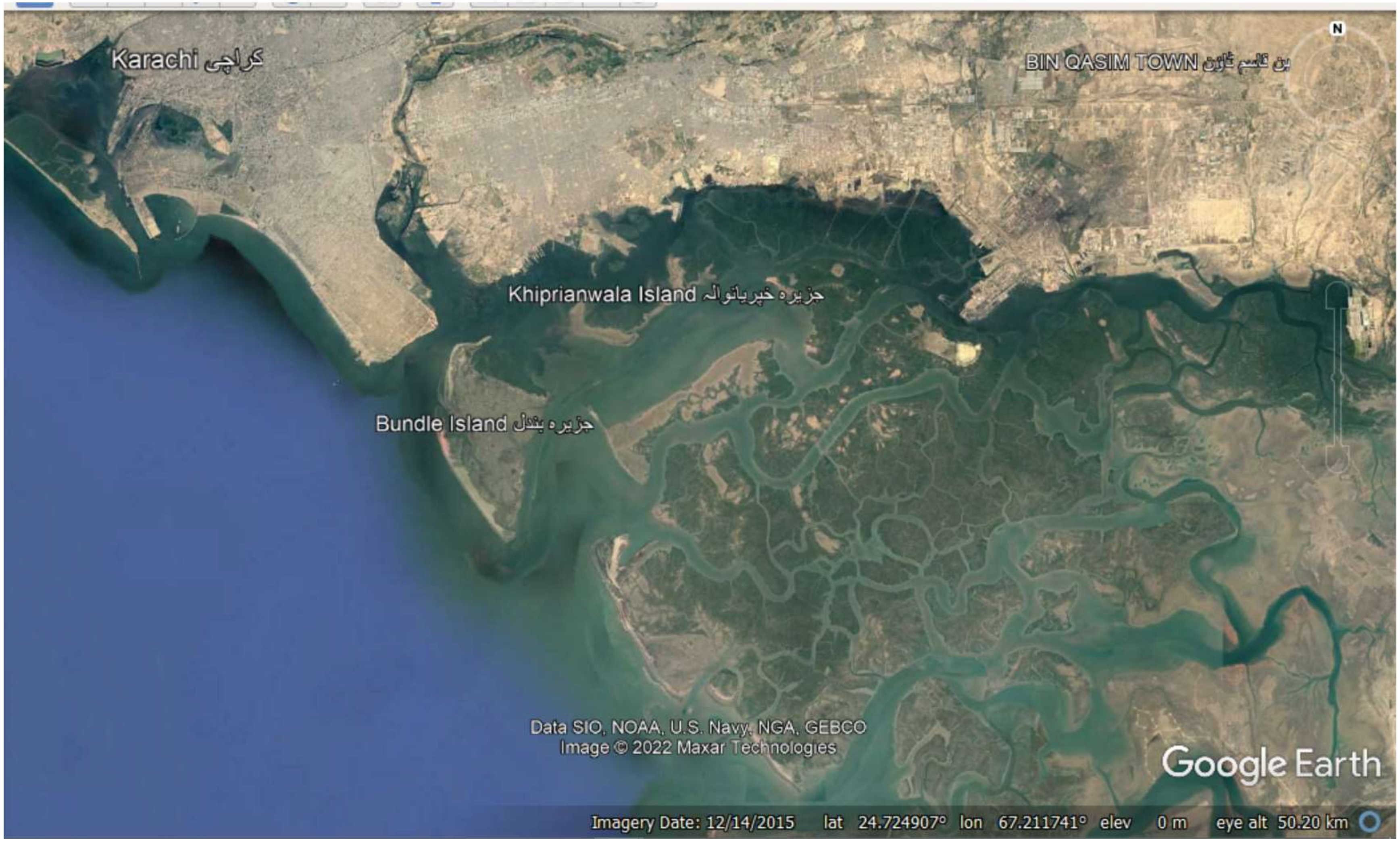
Blair Spendelow

Indus Delta Coastal Hazard Mapping

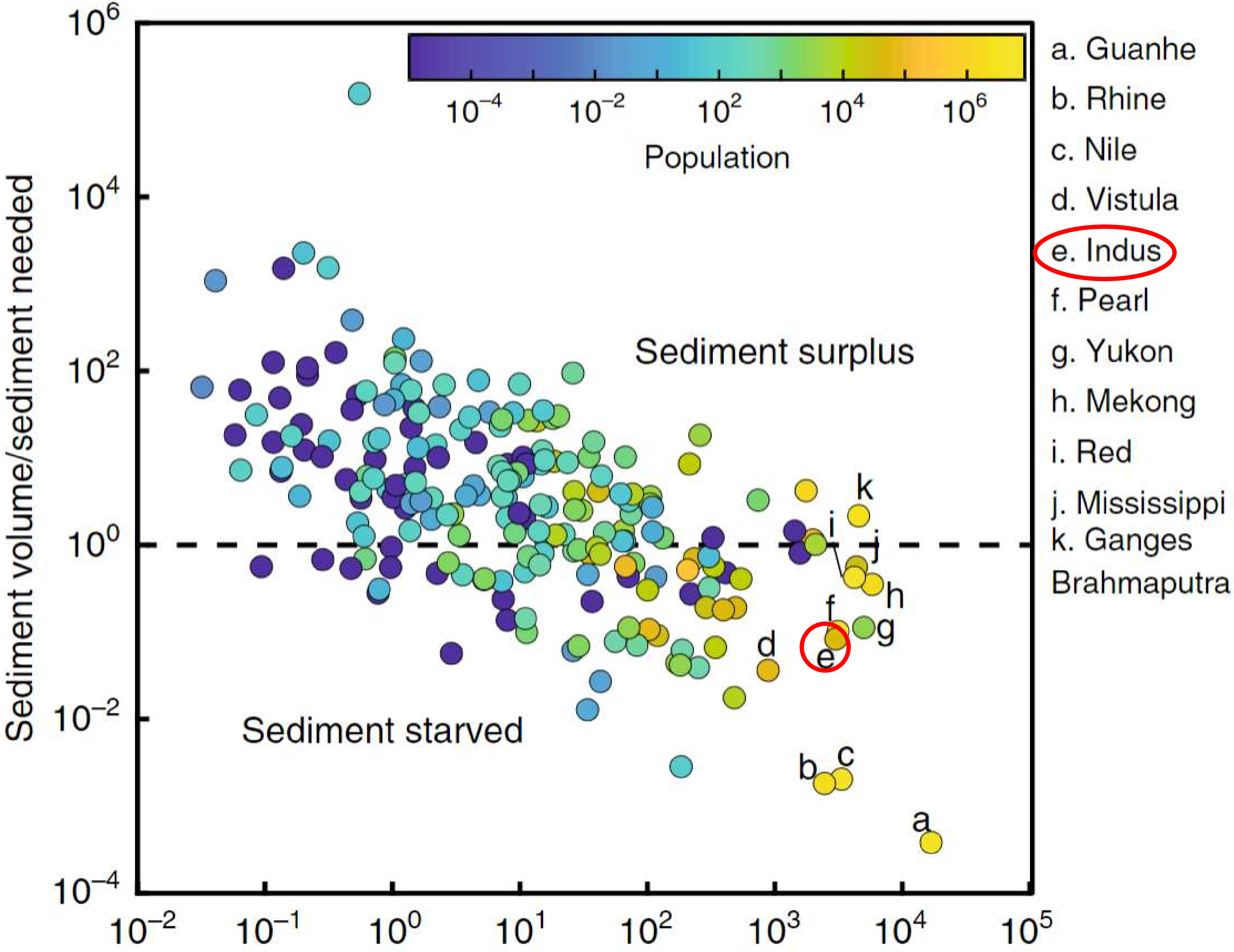
Insights into pragmatic model development:

- Overview and data
- Delta morphology
- Relative sea level rise
- Bathtub vs dynamic modelling

Overview: Horizontal scale

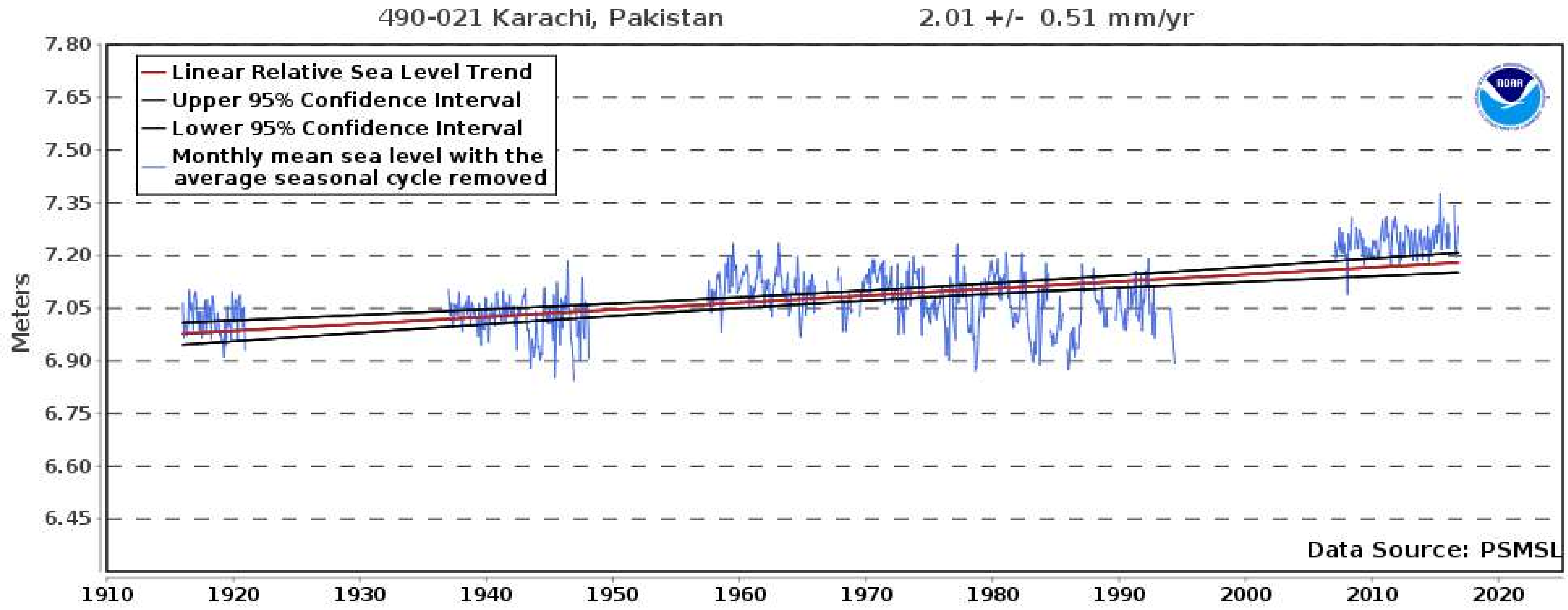


Delta Morphodynamics



Edmonds et al., 2020

Relative Sea Level Rise



Overall, the Mekong Delta is subsiding at 1.6 cm per year (Schmidt, 2015)

Ganges–Brahmaputra–Meghna: mean of 0.6 cm per year, highest rates of ~9cm per year (Brown & Nicholls, 2015)

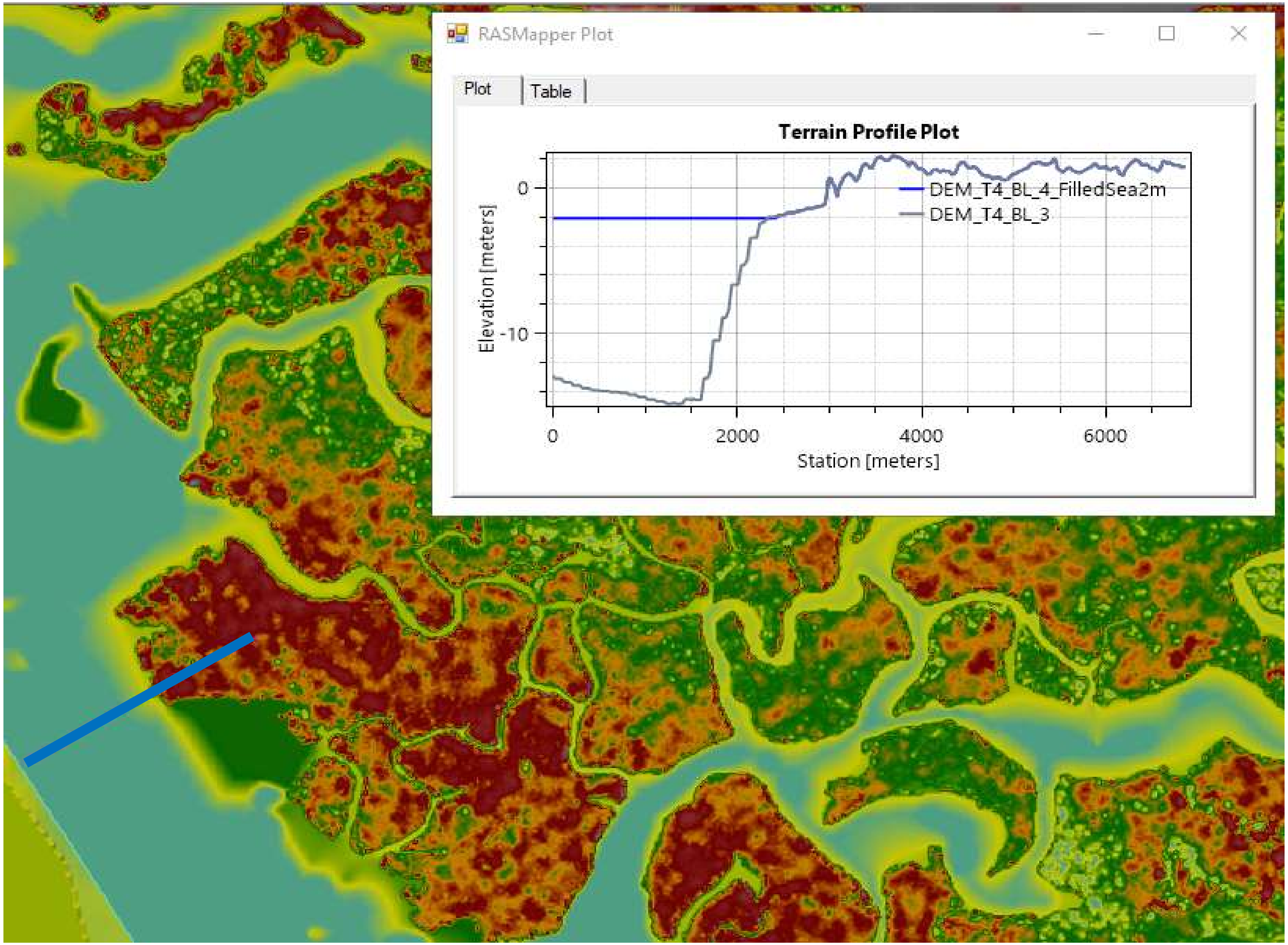
Vertical uncertainty

Table 2.4 Minimum Sea-Level Rise Scenarios for Vulnerability Assessments Supported by Elevation Datasets of Varying Vertical Accuracy.

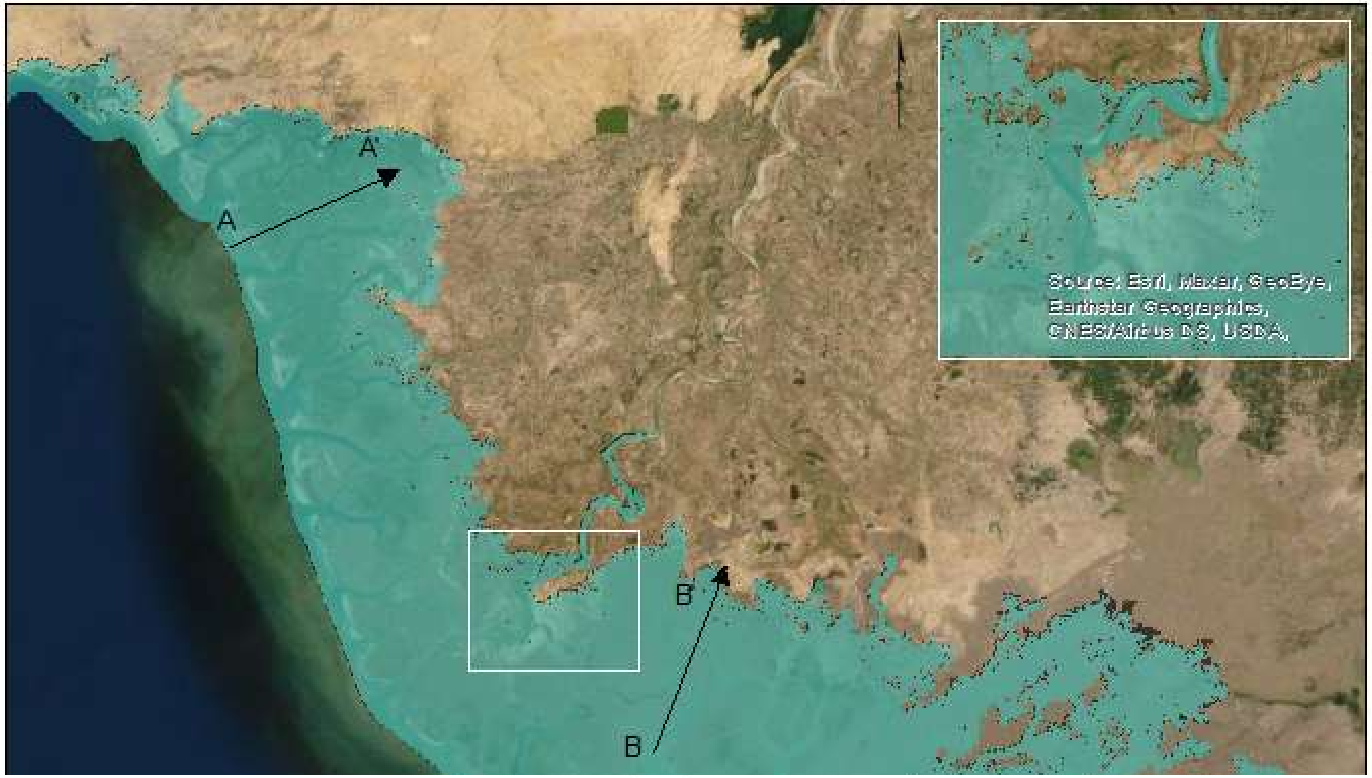
Elevation Data Source	Vertical accuracy: RMSE	Vertical accuracy: linear error at 95-percent confidence	Minimum sea-level rise increment for inundation modeling
1-ft contour interval map	9.3 cm	18.2 cm	36.4 cm
lidar	15.0 cm	29.4 cm	58.8 cm
2-ft contour interval map	18.5 cm	36.3 cm	72.6 cm CoastalDEM
1-m contour interval map	30.4 cm	59.6 cm	1.19 m
5-ft contour interval map	46.3 cm	90.7 cm	1.82 m
10-ft contour interval map	92.7 cm	1.82 m	3.64 m SRTM
20-ft contour interval map	1.85 m	3.63 m	7.26 m
cm = centimeters; m = meters; ft = feet			

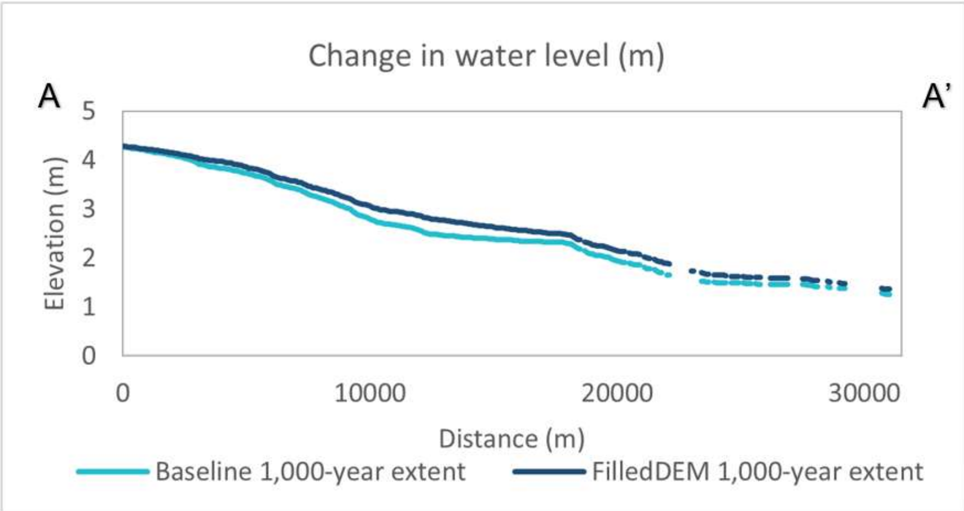
Gesch 2009. http://epa.gov/climatechange/effects/coastal/pdfs/CCSP_chapter2.pdf

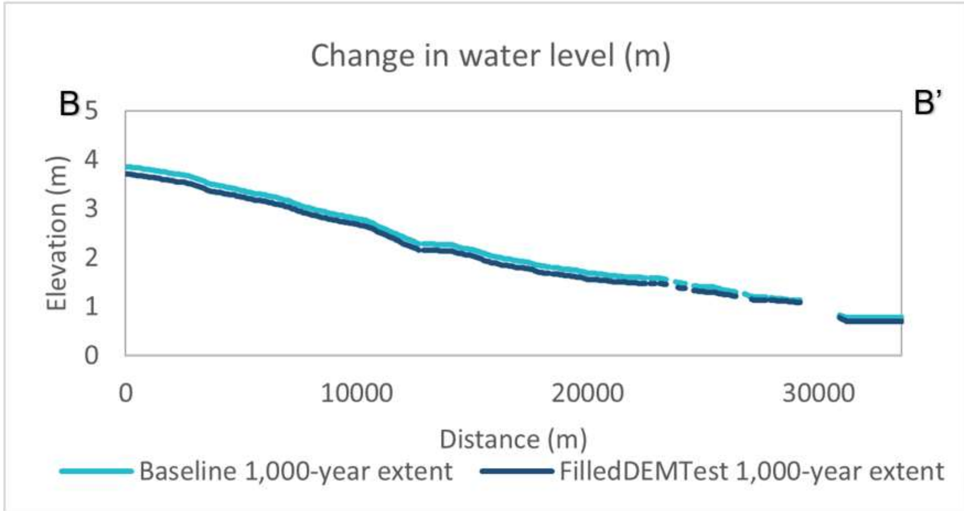
Sensitivity Testing



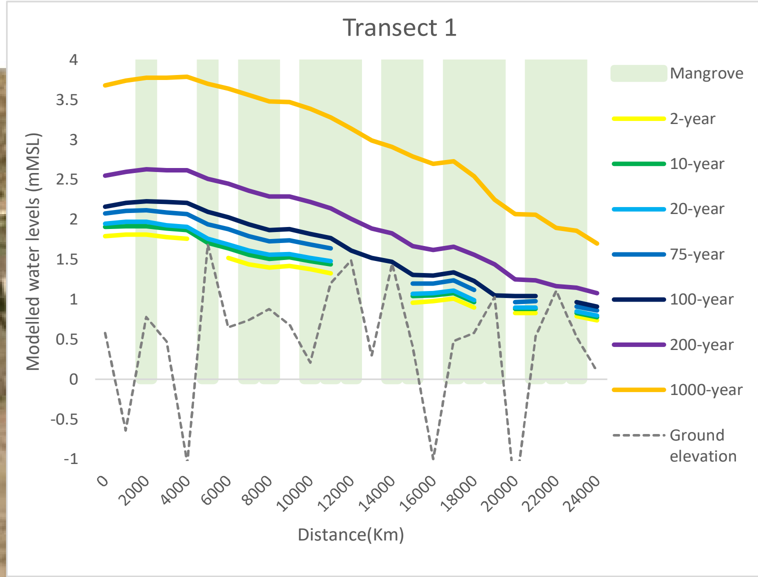
Sensitivity Testing

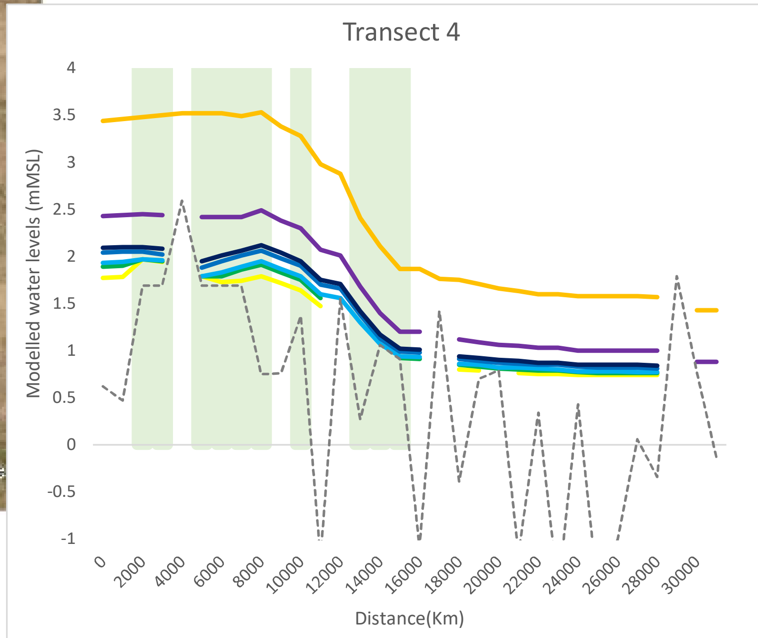






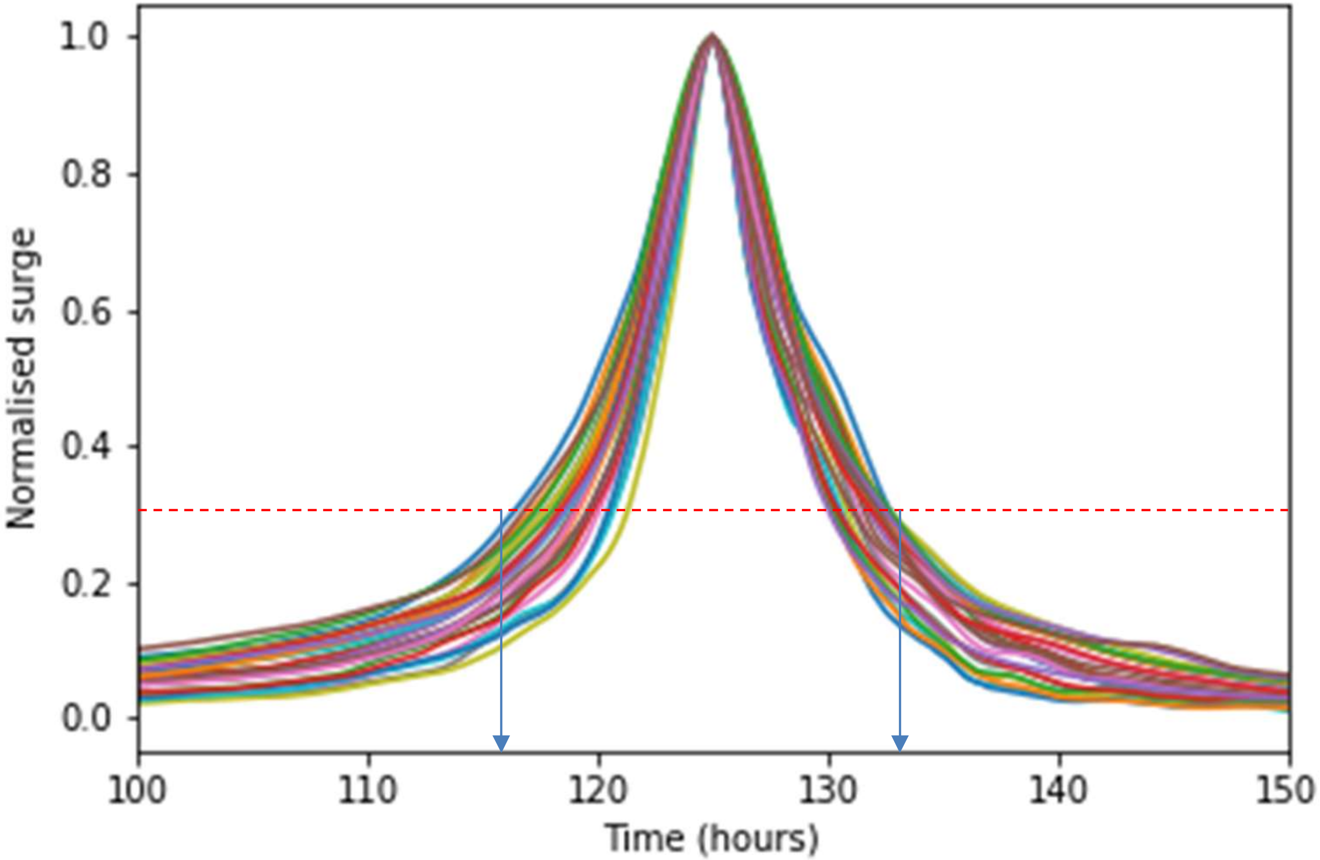
Surge Attenuation





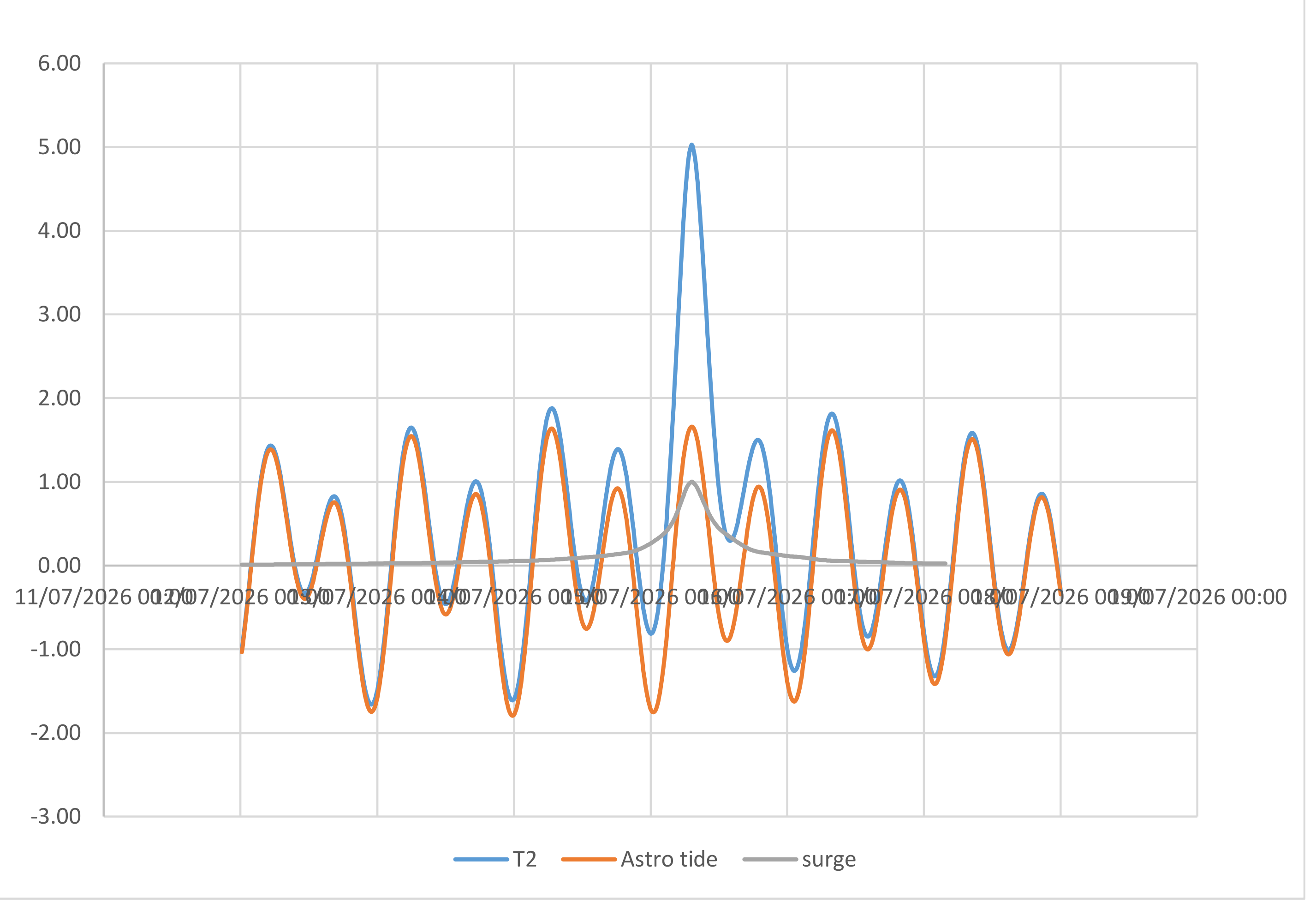
Model Boundary Conditions

The ‘bathtub’ approach vs dynamic modelling



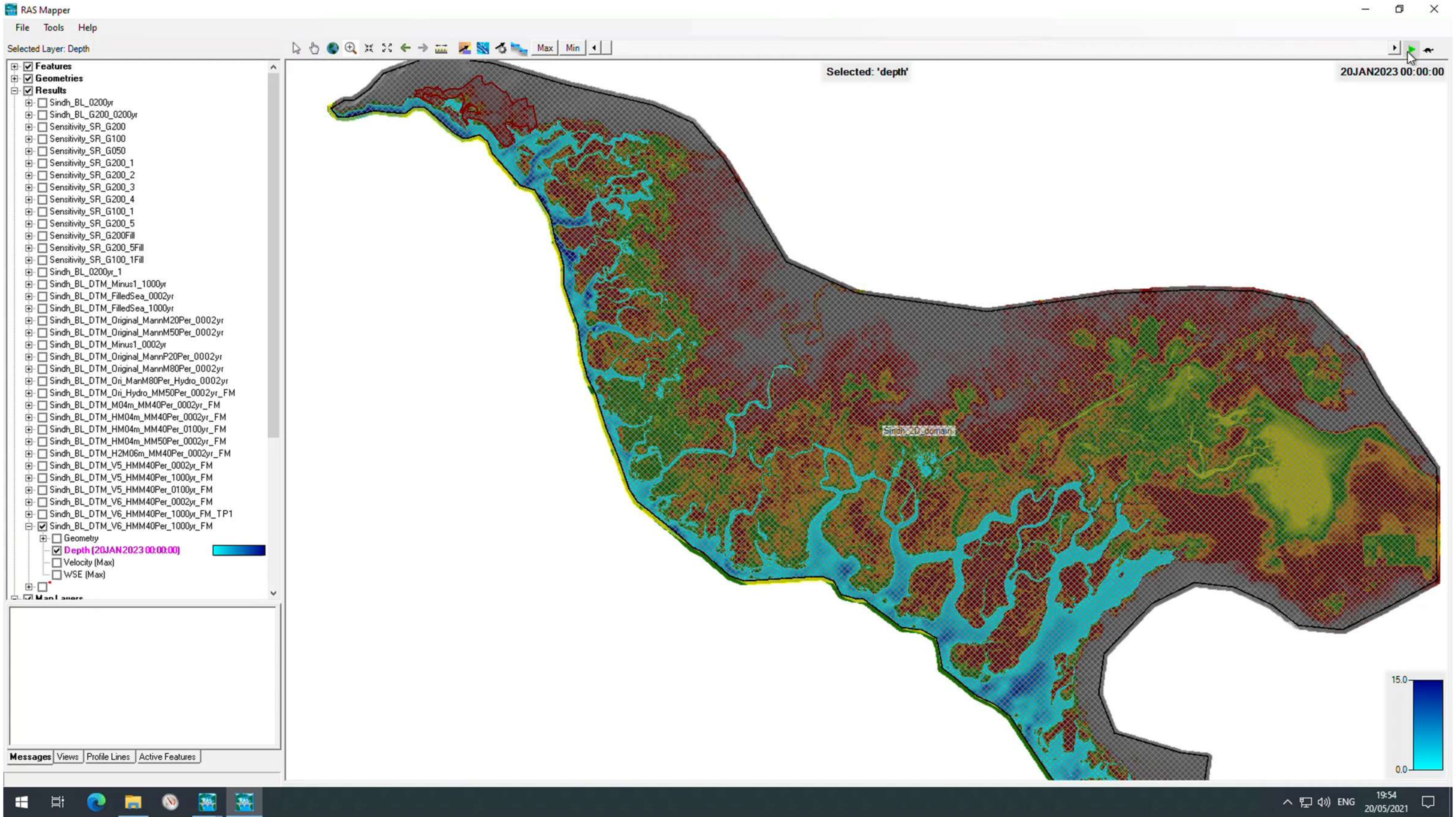
Model Boundary Conditions

- 1000-year event - Dynamic



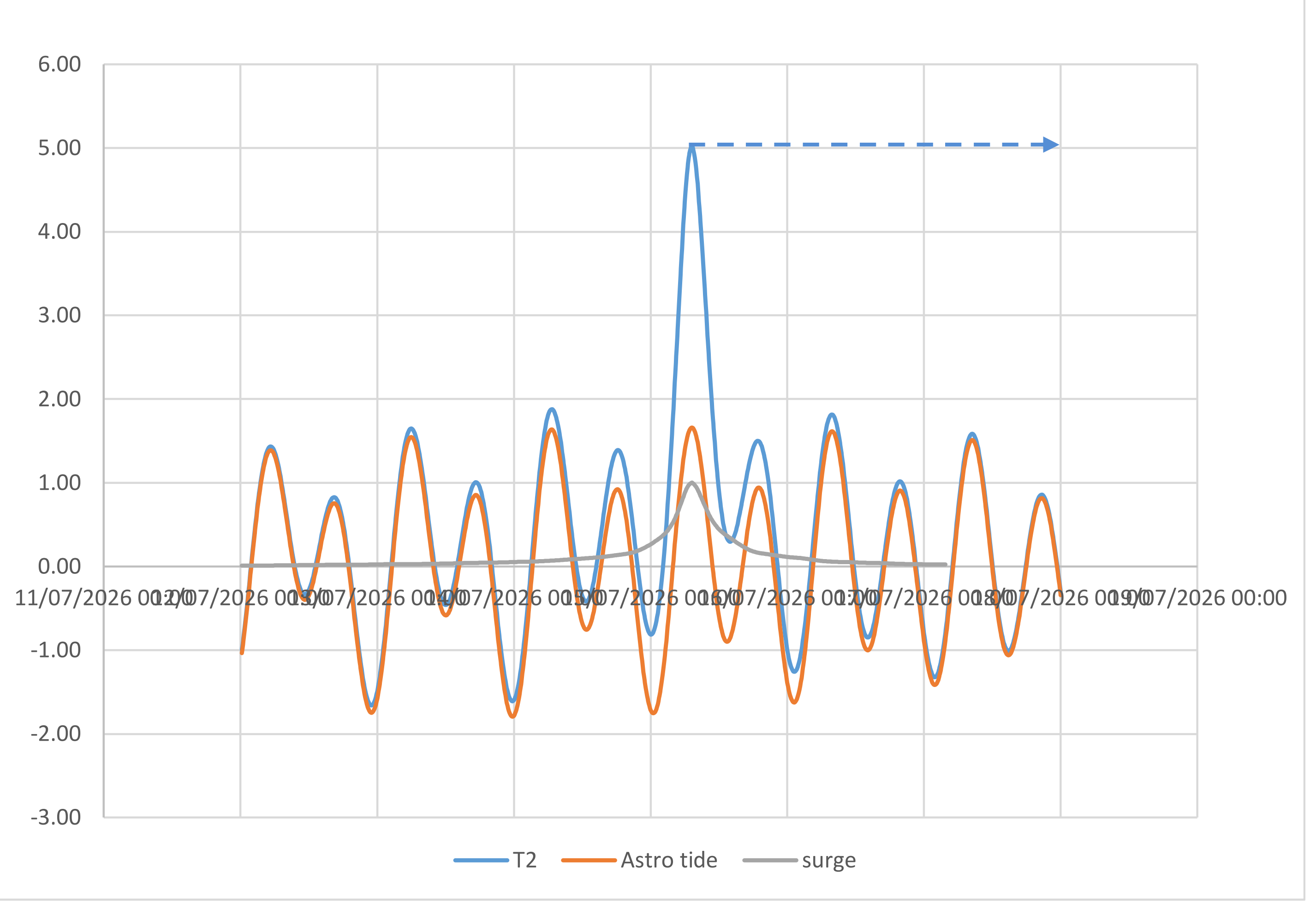
Model Boundary Conditions

- 1000-year event



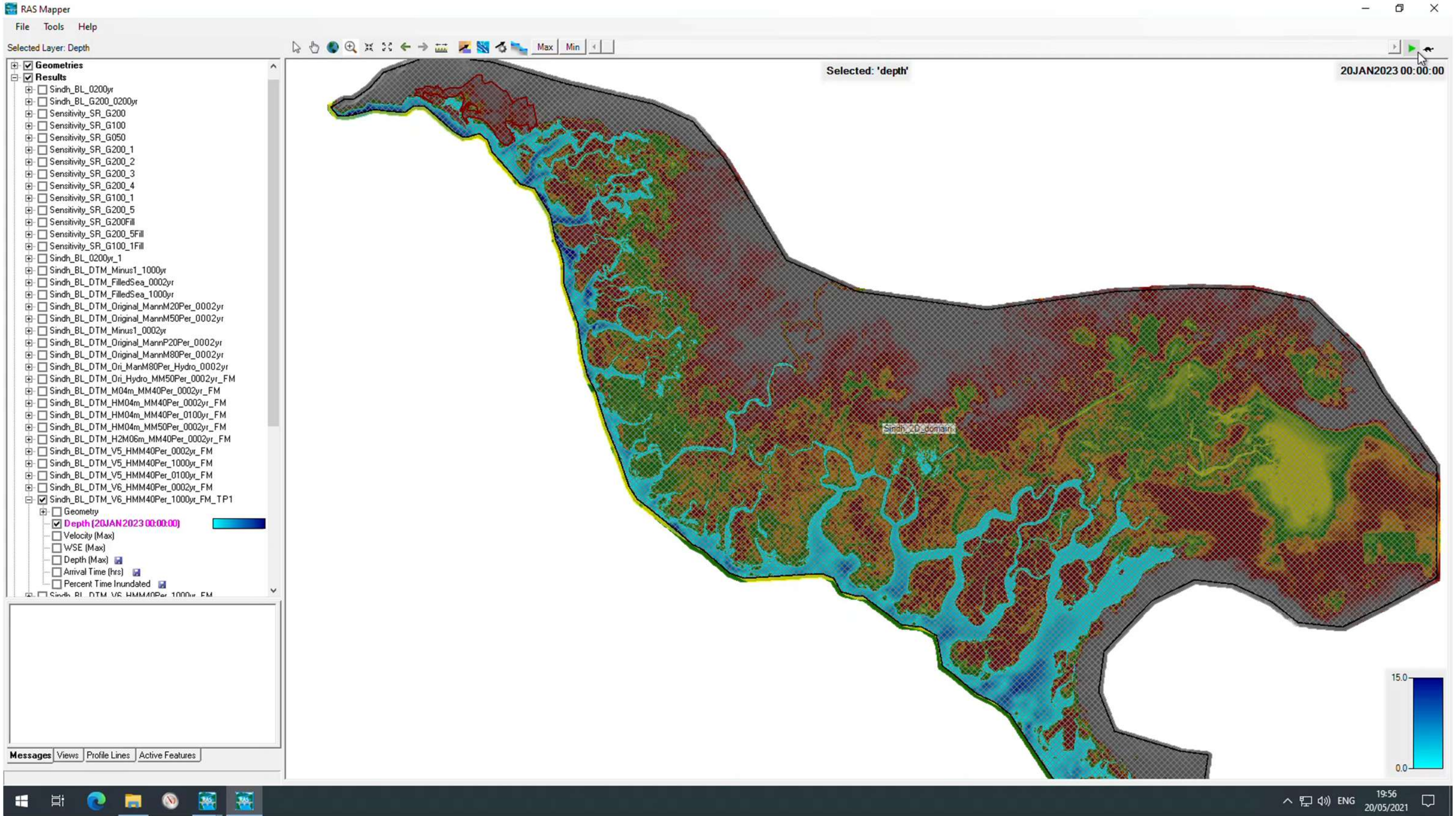
Model Boundary Conditions

- 1000-year event – the 'bathtub' approach



Model Boundary Conditions

- 1000-year event – the ‘bathtub’ approach



Indus Delta Coastal Hazard Mapping

Insights into pragmatic model development - Understanding what might be importantly wrong:

- Identifying implications of a lack of data
- Delta morphology
- Relative sea level rise
- Bathtub vs dynamic modelling

CAPACITY BUILDING

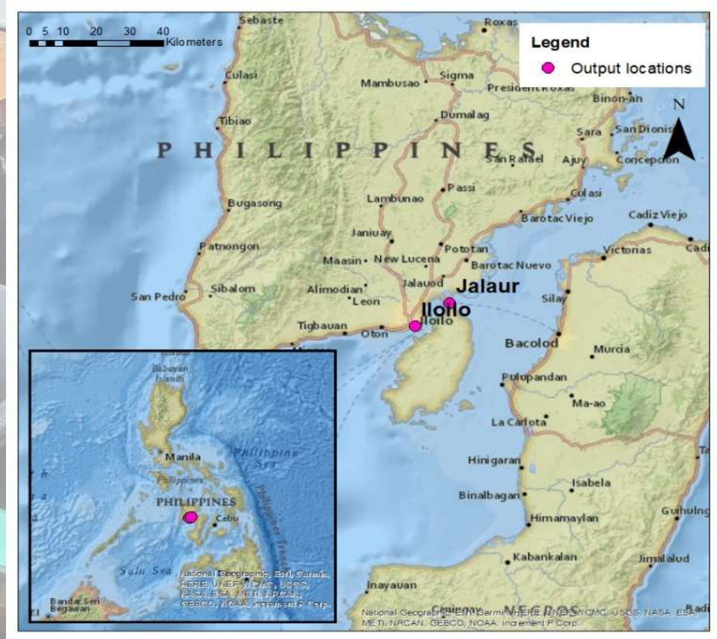
Fay Luxford

PAGASA Philippines

Philippine Atmospheric, Geophysical and Astronomical Services Administration

We worked together with PAGASA to calculate extreme sea levels for one region, the aim is that PAGASA can now do it for other regions and that they can use this data to perform inundation risk modelling.

- PAGASA provided the tropical cyclone event set and completed the hydrodynamic storm surge modelling using their forecasting model.
- JBA provided training on the method and codes used to assess astronomical tides, mean sea level anomalies, emulate storm surges and calculate extreme sea levels.



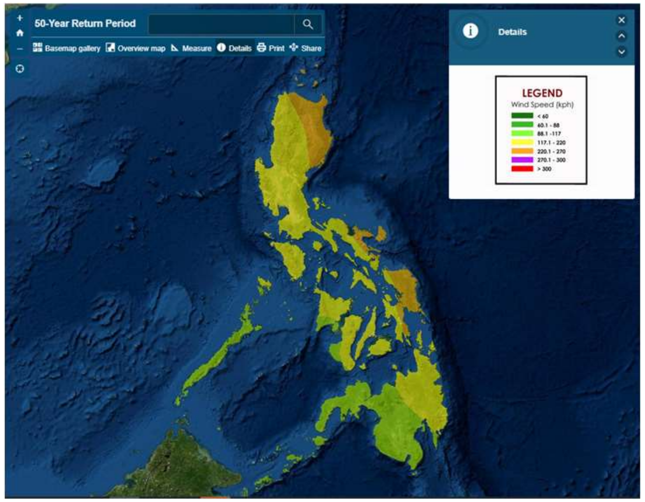
Challenges, Lessons and Innovations

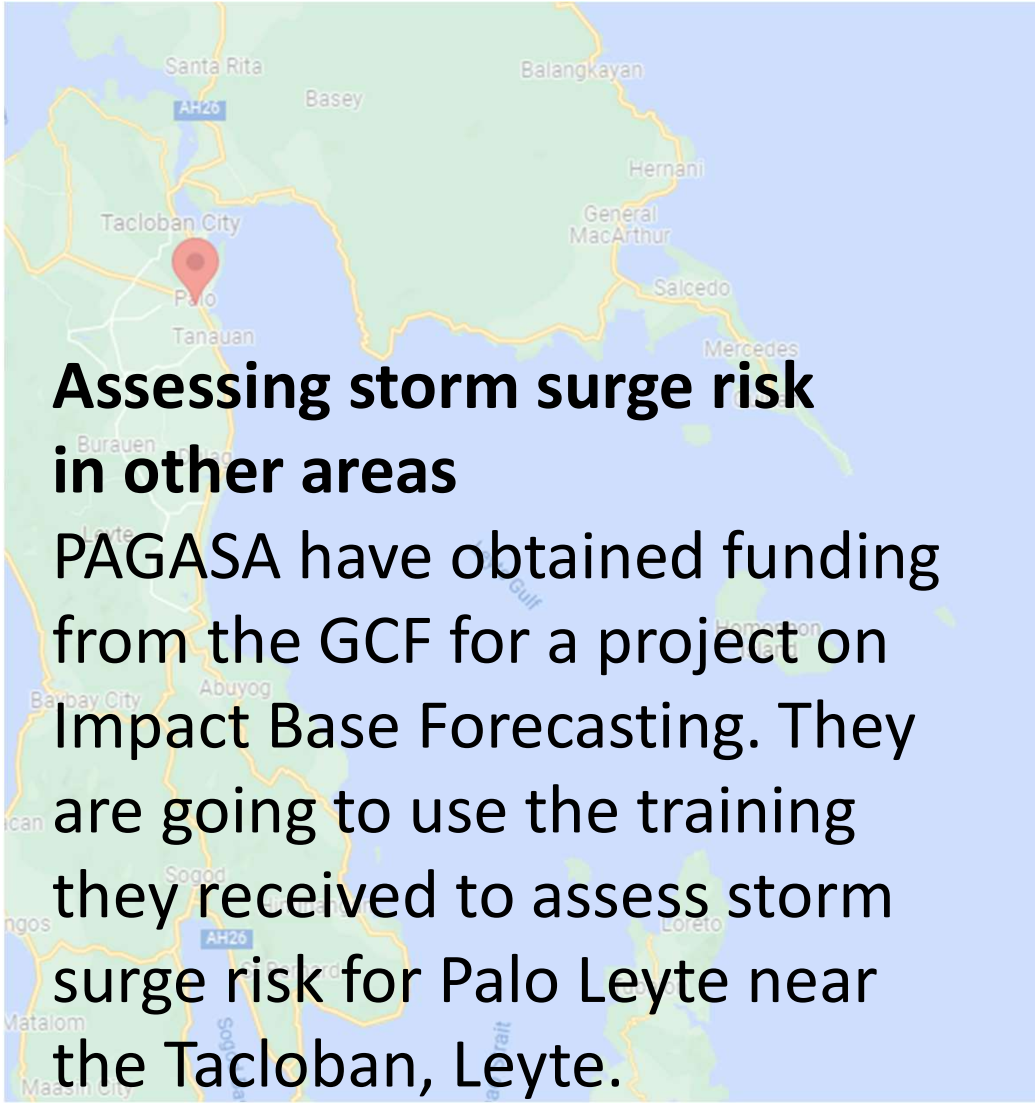
Challenge	Innovation	Lessons
Covid prevented in person training	Delivered Philippines training remotely via Teams. Split training into 6 sessions, each lasting 1-1.5 hours, delivered over 4 weeks. Made use of screen sharing for presentations and to help students with exercises.	There were several benefits to running sessions remotely: • Gave attendees a chance to run codes in their own time between sessions to gain a better understanding and get more out of QA sessions. • Cheaper • Lower emissions • Removed travel time Worked well for this group were we had already worked together previously and everyone had a high level of a shared language. The following, likely reduce effectiveness of remote training compared to in person training: • More difficult to gauge if you need to give additional explanation/ speed up, as you can't see everyone • More difficult to bridge language barriers Additionally, it is essential for attendees to have a good internet connection to participate.

Outcomes

Improved hazard maps

PAGASA re-used the bias correction method we devised for the tropical cyclones to improve their probabilistic wind hazard maps for the 2020 release.





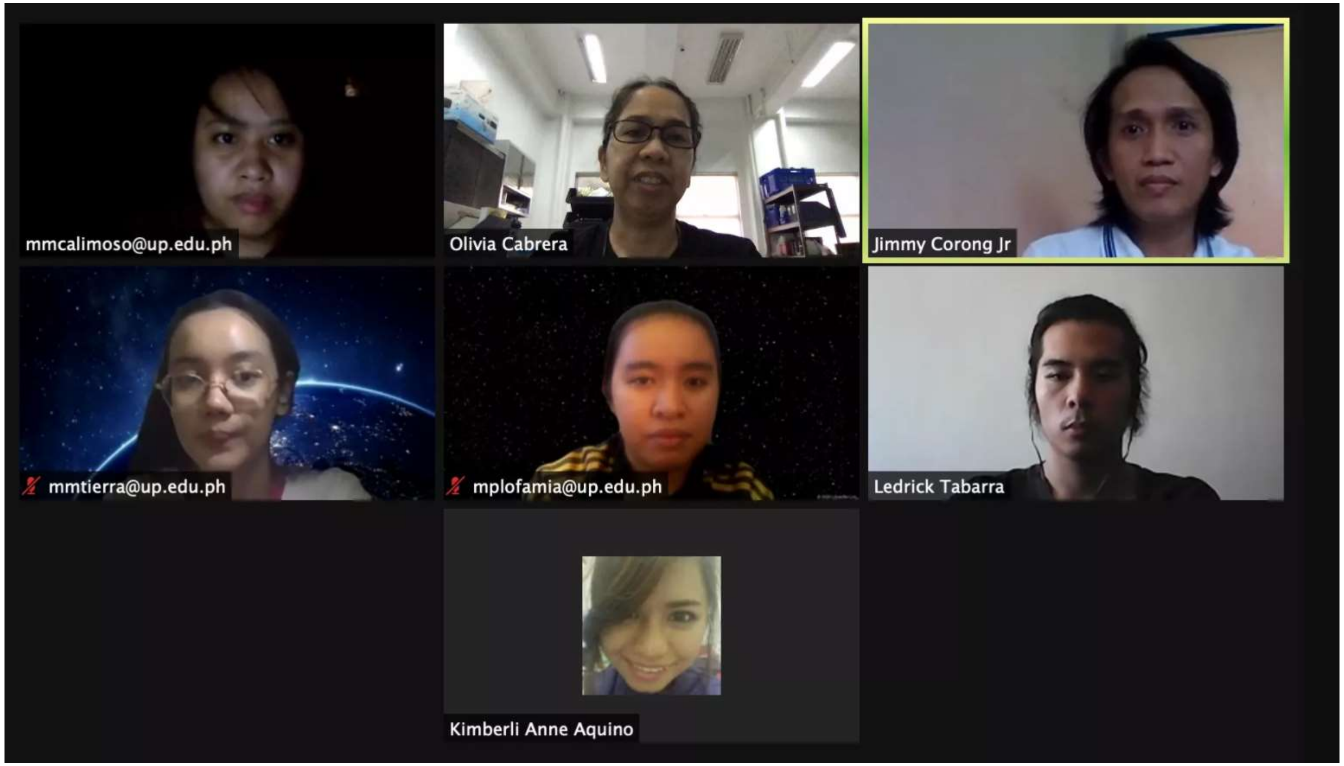
Assessing storm surge risk in other areas

PAGASA have obtained funding from the GCF for a project on Impact Base Forecasting. They are going to use the training they received to assess storm surge risk for Palo Leyte near the Tacloban, Leyte.

Outcomes

Knowledge shared outside PAGASA

Jimmy who attended my course used the knowledge he learnt and some of my content to deliver a lesson on Extreme Sea Level to Meteorology Masters Students from the University of the Philippines




Thank you

SESSION 4

MAR **30**
2022 Wednesday

Economic and Finance for IFRM

Approaches to economic analysis for IFRM measures.
The role of flood insurance for post-disaster recovery.

16:00
Manila time
90 minutes

Jane Toothill

Flood Risk and Insurance Specialist
JBA Risk Management

Guillaume Dulac

IFRM and Economics Specialist
Landell Mills

See you next week!

For recordings and any follow up questions, please access the event site at the ADB Knowledge Events in Development Asia

https://events.development.asia/learning-events/challenges-lessons-and-innovations-strengthening-integrated-flood-risk-management