



Forecasting tropical cyclone surge for humanitarian relief

Dr Stephen Grey



Flood Early Warning Pilot



Purpose

- Monitor and provide early awareness to the UK Foreign, Commonwealth and Development Office (FCDO) of the risk of flooding from imminent tropical cyclones



Operation

- Produce a bulletin describing prediction of flooding and impact on local population and infrastructure.
- Response within one working day



Audience

- The bulletin is circulated to governments, local meteorological organisations and humanitarian decision-makers.



Flood Early Warning Pilot

Fluvial flooding

- Global Flood Awareness System (ECMWF, University of Reading, IFRC Climate Centre)

Coastal flooding from surge

- TELEMAC-2D (HR Wallingford)
- LISFLOOD-FP (Fathom)

Exposure analysis

- Impact on population and infrastructure (University of Bristol, Fathom)

VERY SEVERE CYCLONIC STORM MOCHA [BANGLADESH AND MYANMAR]

Event Start	13 May 2023	Update number #	2
Forecast issue date	12 May 2023	First forecast issued	11 May 2023

Situation Summary

- Very severe cyclonic storm Mocha is expected to strengthen in the next 36 hours and make landfall between Cox's Bazaar (Bangladesh) and Kyaukpyu (Myanmar), perhaps close to Sittwe (Myanmar) early on Sunday morning (UK time).
- A coastal surge is expected along the coast of Rakhine State, Myanmar, with water levels up to 2m above the highest astronomical tide.
- We currently forecast ~34,000 to be directly exposed to flooding. The highest direct exposure is within the Sittwe district (~21,700 directly exposed).
- There is still considerable uncertainty at present as location and depth of flooding is very sensitive to cyclone track, intensity and size.
- Should Cyclone Mocha make a more northerly landfall, vulnerable locations are around the Nef River and Cox's Bazaar.
- While flooding of major rivers is unlikely, flash flooding and landslides should be expected, even in locations not immediately along the central track of the storm.

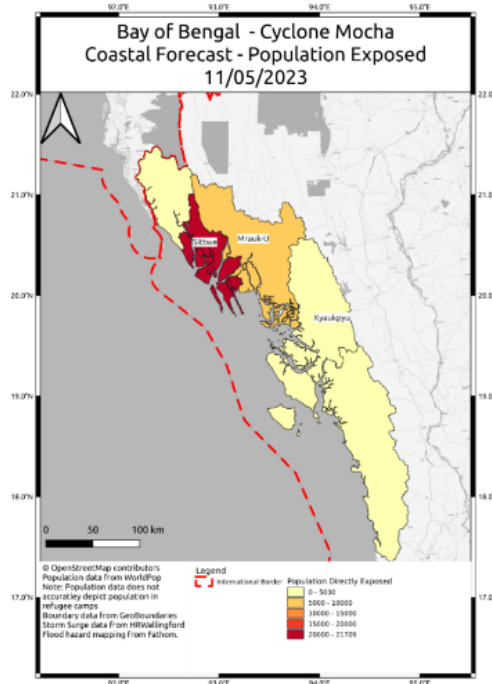
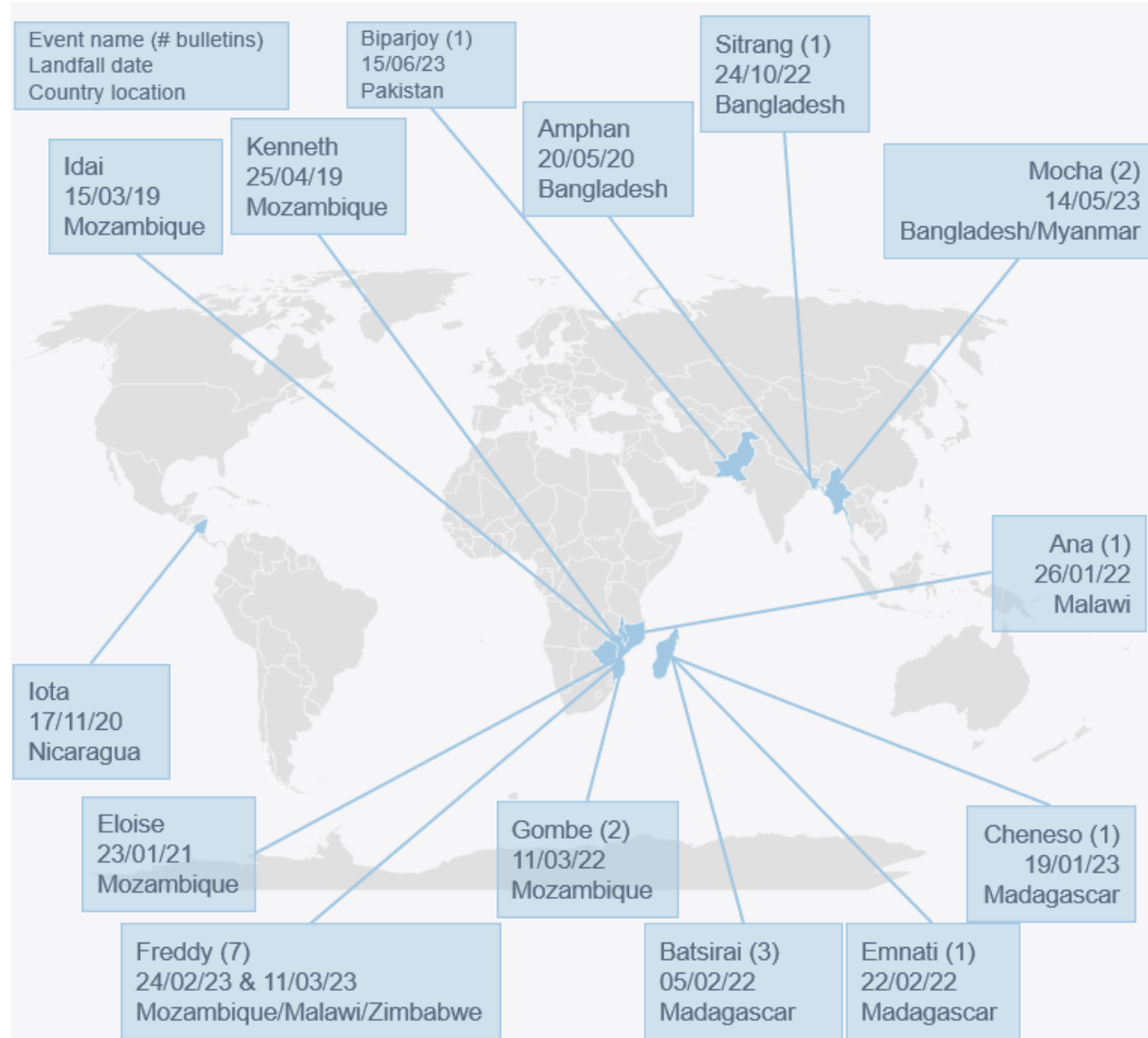


Figure 1: Map showing districts with the highest population exposure to coastal storm surge induced flooding. This has not been updated since the previous bulletin (11th May 2023) as there has been no significant change in the forecast

Note: GloFAS is designed to simulate large scale hydrological systems, so predictions for smaller watercourses should be evaluated with caution. GloFAS also does not simulate dam release or dam breaks. Estimates of exposure only account for flooding from rivers.

This Flood Risk Bulletin has been produced for and with the support of the Research and Evidence Directorate of the Foreign, Commonwealth and Development Office (FCDO) as part of a Flood Early Warning Pilot contract managed by DAI Global UK Ltd (DAI). The Bulletin utilises template Standard Operating Protocols (SOPs) developed by the project team, which have been tested in a limited number of real fluvial and storm surge flooding events. The protocols employed in the production of this Bulletin incorporate ongoing rapid process-learning and remain in the development stage. Users of this Bulletin should therefore note the provisional and pilot nature of this work and only use it for situational awareness. The views set out in this Bulletin are those of the authors and do not necessarily represent those of the FCDO, DAI or Red Cross Red Crescent Climate Centre. The Bulletin was produced as an internal advisory document for the purposes of the Flood Early Warning Pilot - use of this report by third parties or for any other purposes is entirely at the user's risk. In relation to the actual flood or surge events, it is anticipated that other sources of advisory information would also be drawn on, for example from relevant regional and national hydro-meteorology agencies.

14 responses 2019 to 2023



Requirements for modelling of surge

- Cover areas at risk of TC surge that are of interest to FCDO
- Resolve wind & pressure fields, coastal bathymetry and shoreline
 - ~1km nearshore
- Include tide
- Runtime should be short – target of < 1 hour (36 cores)
- Regional hydrodynamic models
 - Bay of Bengal
 - Caribbean Sea
 - Mozambique Channel
 - Philippines
 - East coast Madagascar
 - Arabian Sea

TELEMAC-2D hydrodynamic model

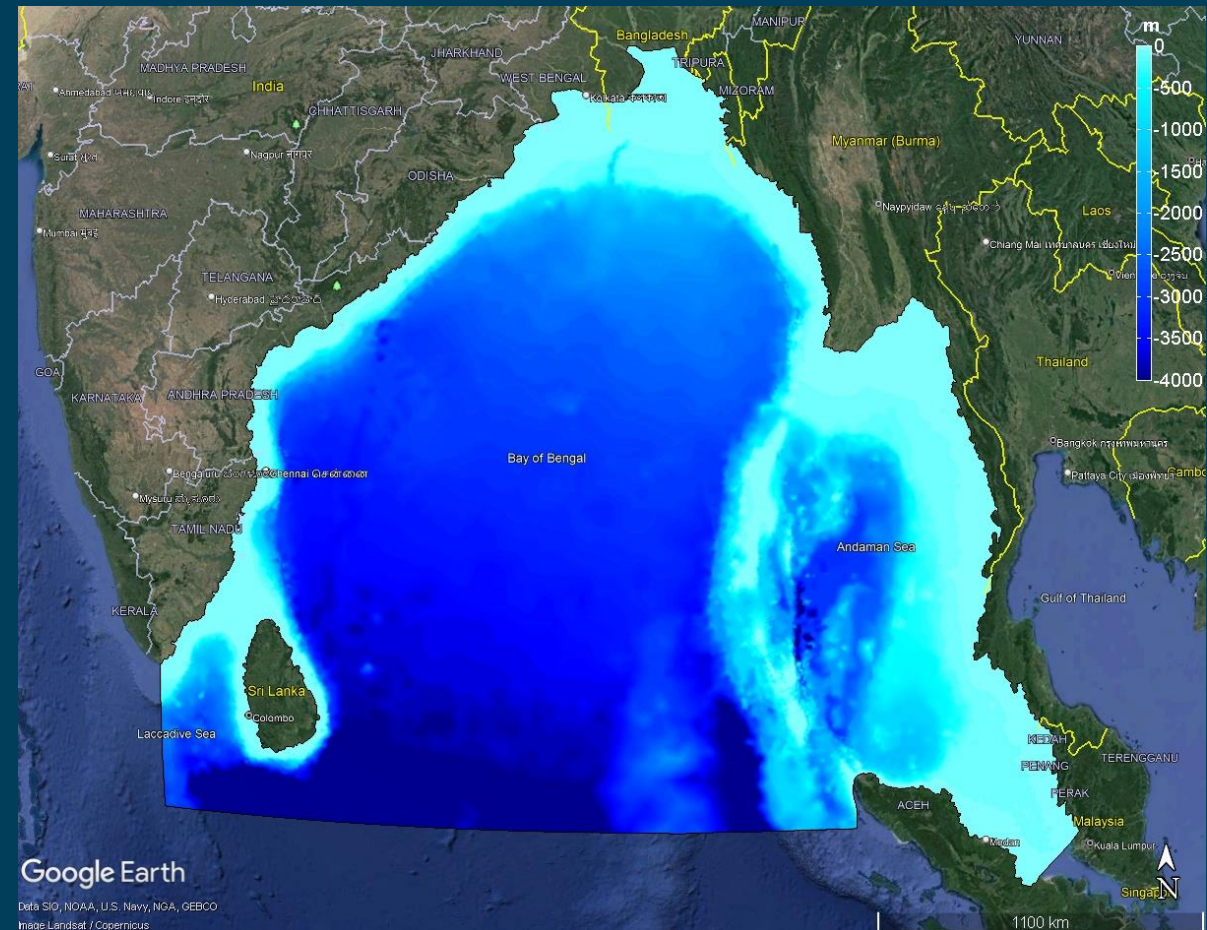
TELEMAC-2D has been used to hindcast TC surge and currents

Validated as part of previous projects:

- Australia
- Bangladesh
- The Bahamas

Include tide, wind and air pressure

Start from a basic level and incrementally improve methodology



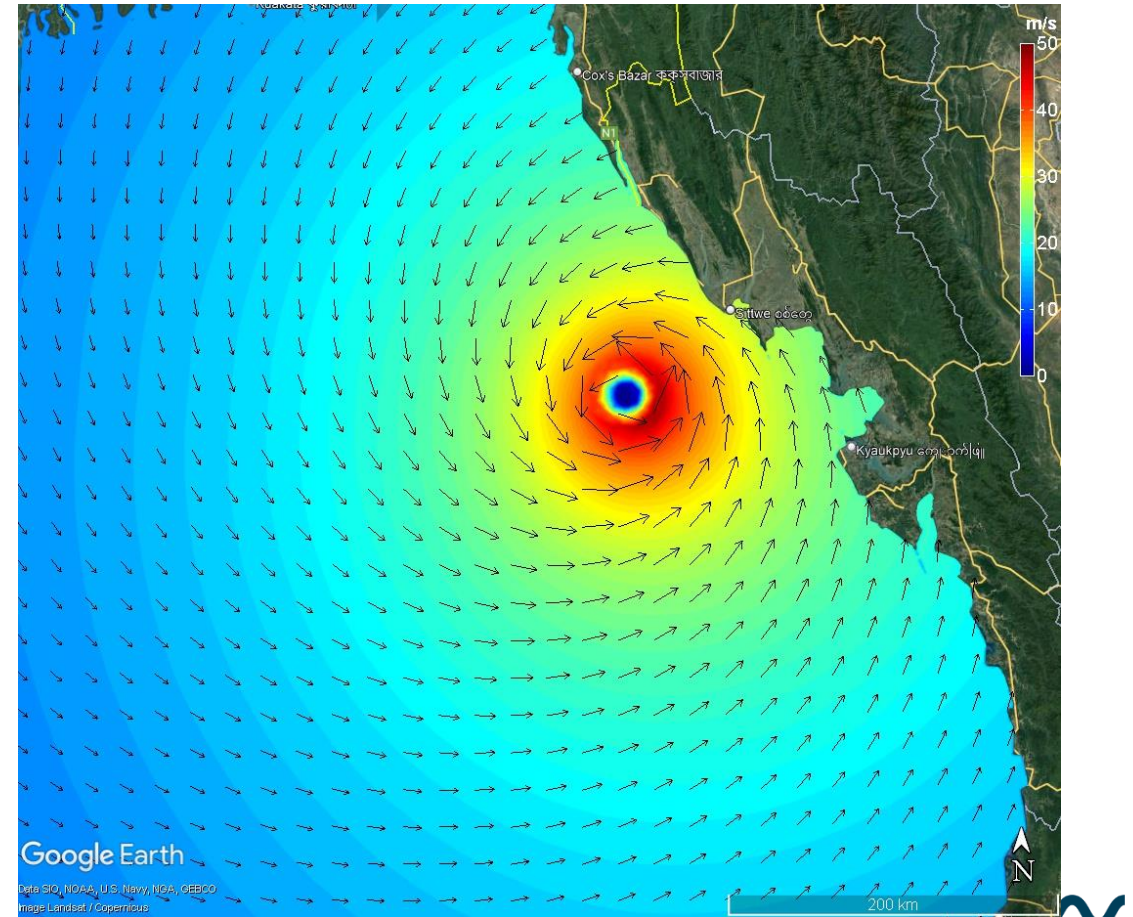
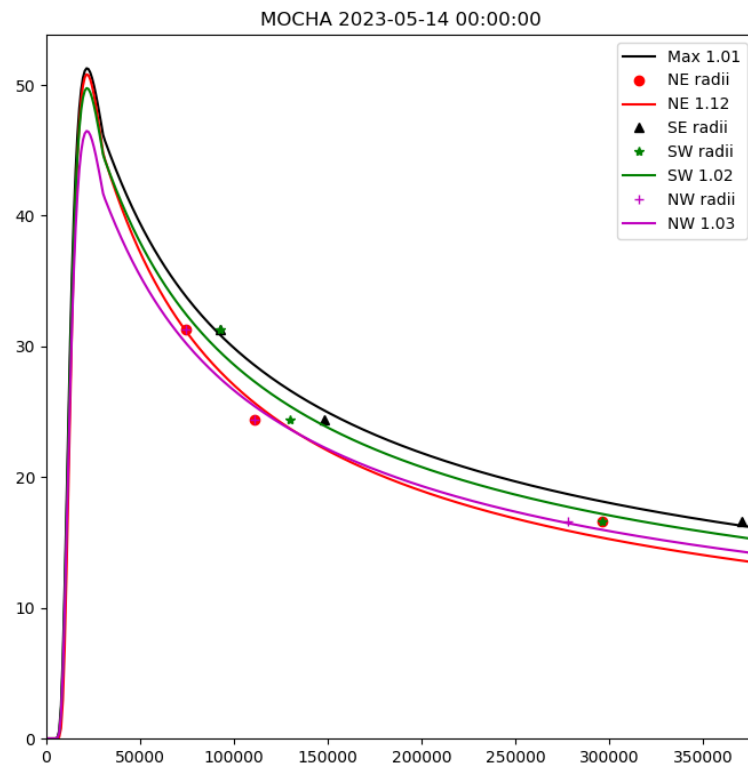
Analysing warnings

Warnings issued by agencies provide forecast

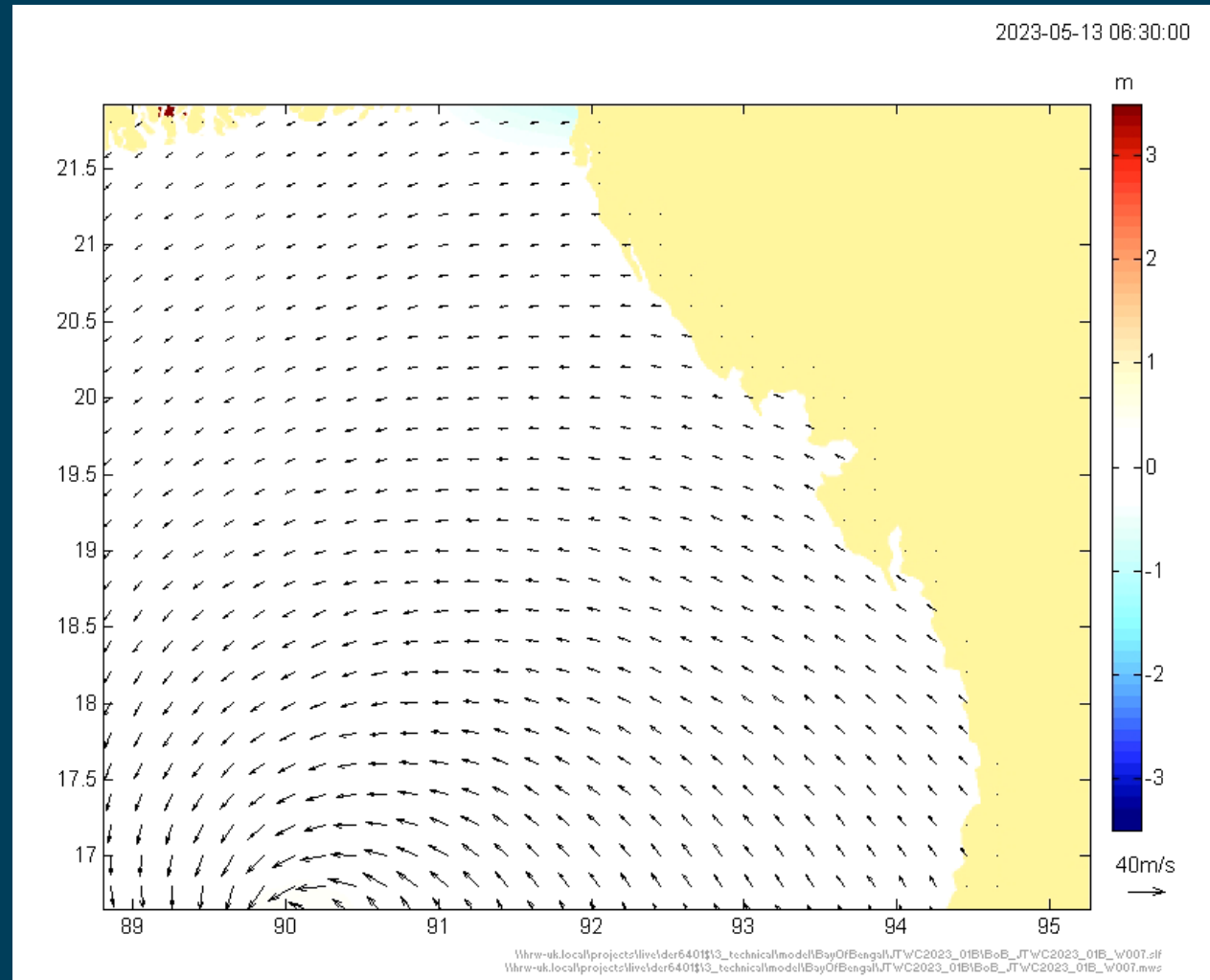
- Position of centre of cyclone
- Maximum sustained wind speed
- Radii of wind speed thresholds
- Provided at 6 or 12 hour forecast times

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SUBJ/TROPICAL CYCLONE 12S (ELOISE) WARNING NR 011//
RMKS/
1. TROPICAL CYCLONE 12S (ELOISE) WARNING NR 011
03 ACTIVE TROPICAL CYCLONES IN SOUTHIO
MAX SUSTAINED WINDS BASED ON ONE-MINUTE AVERAGE
WIND RADII VALID OVER OPEN WATER ONLY
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WARNING POSITION:
220600Z - NEAR 18.8S 38.0E
MOVEMENT PAST SIX HOURS - 255 DEGREES AT 15 KTS
POSITION ACCURATE TO WITHIN 020 NM
POSITION BASED ON CENTER LOCATED BY SATELLITE
PRESENT WIND DISTRIBUTION:
MAX SUSTAINED WINDS - 065 KT, GUSTS 080 KT
WIND RADII VALID OVER OPEN WATER ONLY
RADIUS OF 064 KT WINDS - 025 NM NORTHEAST QUADRANT
                                025 NM SOUTHEAST QUADRANT
                                025 NM SOUTHWEST QUADRANT
                                025 NM NORTHWEST QUADRANT
RADIUS OF 050 KT WINDS - 040 NM NORTHEAST QUADRANT
                                040 NM SOUTHEAST QUADRANT
                                040 NM SOUTHWEST QUADRANT
                                040 NM NORTHWEST QUADRANT
RADIUS OF 034 KT WINDS - 110 NM NORTHEAST QUADRANT
                                100 NM SOUTHEAST QUADRANT
                                090 NM SOUTHWEST QUADRANT
                                110 NM NORTHWEST QUADRANT
REPEAT POSIT: 18.8S 38.0E
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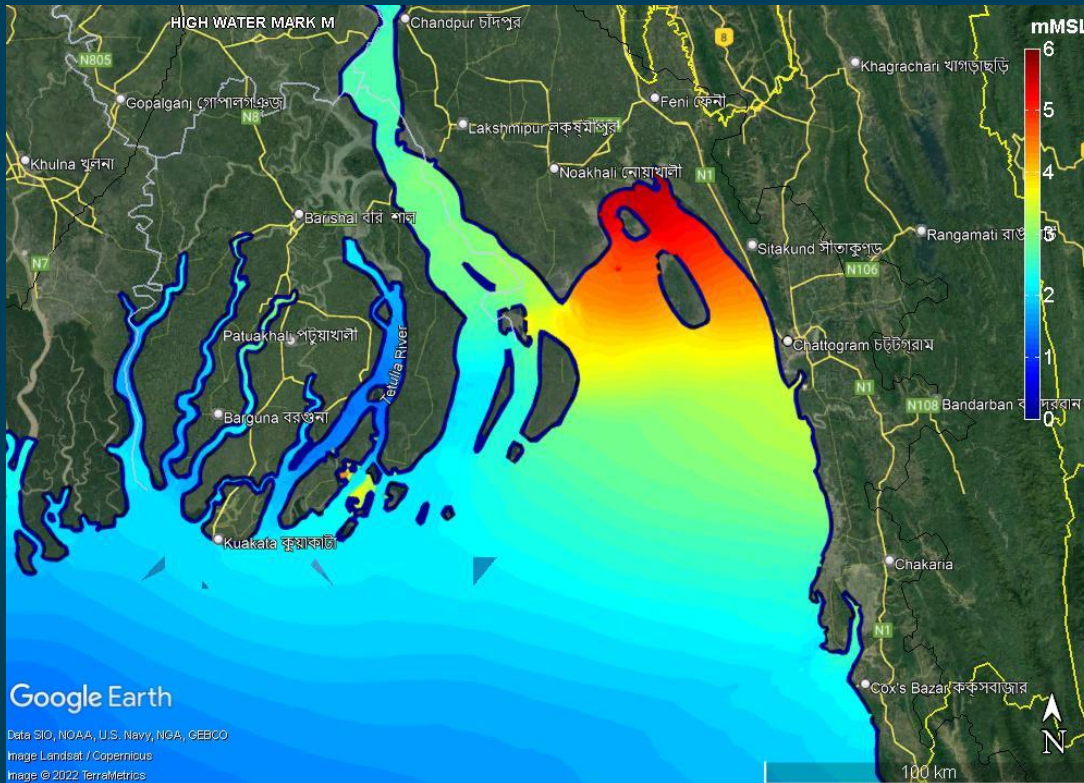
Wind field set up - Cyclone Mocha



Cyclone Mocha - Myanmar May 2023



Cyclone Sitrang - October 2022



Water level peak

- Forecast: 7.6mCD
- Observed (BN): 7.3mCD

Deterministic and probabilistic approaches

Deterministic approach

- Used forecasts from 2 or 3 organisations (RSMC/JTWC/ECMWF)

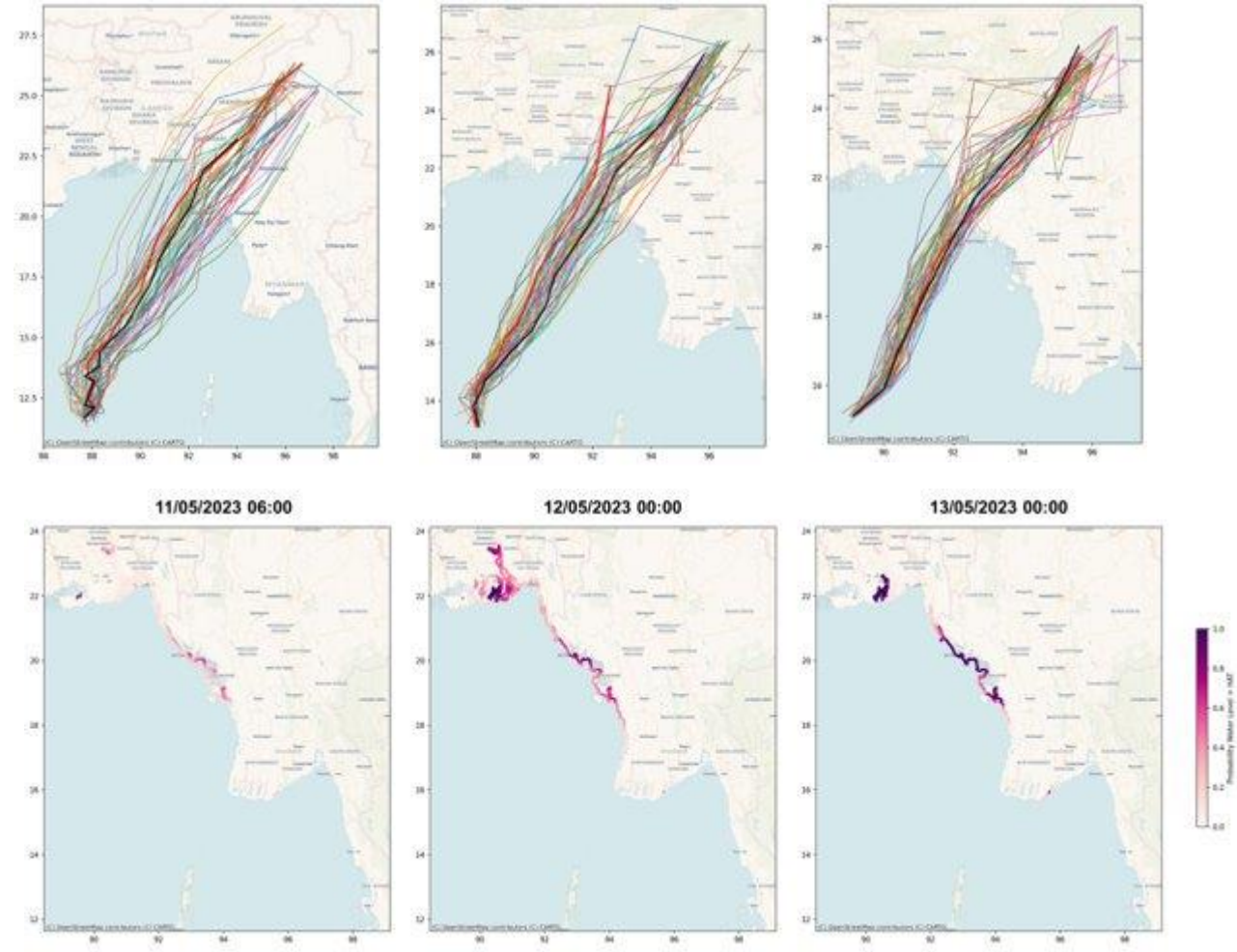
Long lead time forecasts

- Large uncertainty
- Limited value

Complex locations (e.g. Philippines)

- Small change in cyclone track or intensity \Rightarrow large change in predicted surge

Investigating a probabilistic approach with ensemble tracks



Reflections

Despite assumptions and simplifications, warnings have been well received

- Prediction of no coastal flooding is valuable
- Any advance warning is useful
 - Where is flooding most likely?
 - Indication of severity

Presentation of predictions

- Concise and clear
- Understandable
- Simple explanation of uncertainties
- Expert interpretation is vital

Incremental improvement is valuable

Open TELEMAC- MASCARET

Open source suite of models

<http://www.opentelemac.org/>



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open TELEMAC-MASCARET
The mathematically superior suite of solvers

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Welcome to TELEMAC-MASCARET

TELEMAC-MASCARET is an integrated suite of solvers for use in the field of free-surface flow. Having been used in the context of many studies throughout the world, it has become one of the major standards in its field.

Latest News

TELEMAC Training in Hangzhou, China, 9-11 December, 2020
20 October 2020

A training session on open TELEMAC-MASCARET will be held

TELEMAC-2D

2D free-surface flow model

Depth-averaged model

Solves the Shallow Water equations

- Bed elevation, free-surface level, u and v velocity components

Flows in rivers, estuaries and seas

- For navigation studies, sediment modelling and effluent discharge simulations
- Assessment of available tidal energy sites
- Impact of coastal/waterfront developments
- Flushing assessments of marinas, harbours and canals
- Flooding risk to storm surge, rainfall or tsunami events

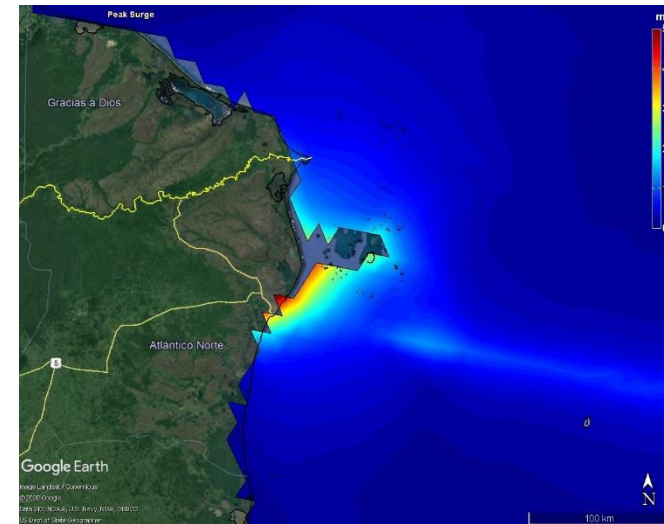
Hurricane Iota

Hurricane Iota

- Made landfall on east coast of Nicaragua on 17th November 2020
- Category 4 hurricane at landfall

TELEMAC-2D Modelling

- Used The Earth by TELEMAC¹
- Coarse model - useful for identifying location of surge
- Regular mesh and bathymetric errors (GEBCO)



¹S. Bourban, M Turnbull, A. J. Cooper, “The Earth by TELEMAC” Proceedings of the XXIVth TELEMAC-MASCARET User Conference, Graz, Austria, pp1-8, 2017.

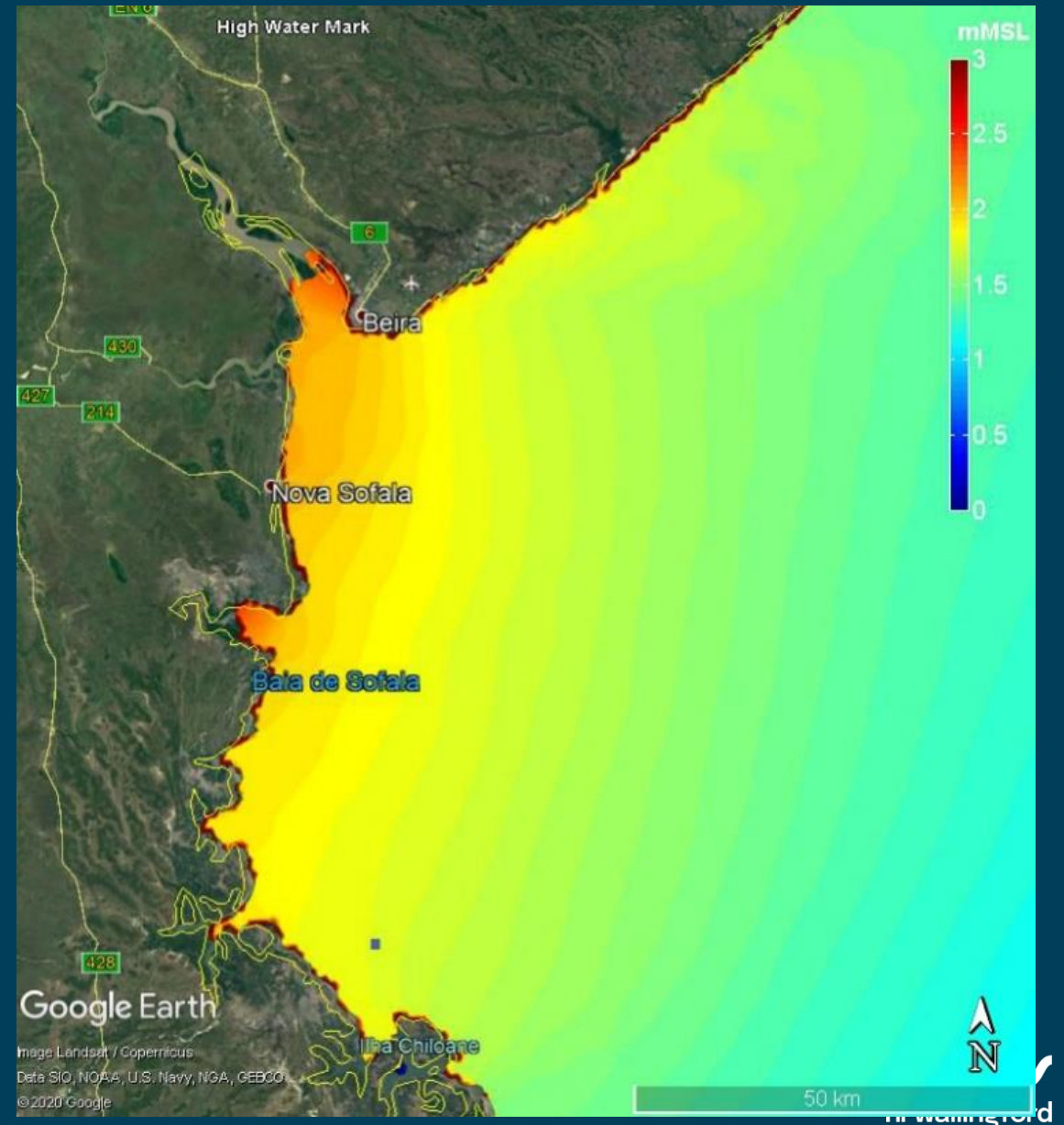
Cyclone Eloise

Cyclone Eloise

- Landfall near Beira in Mozambique on 22nd January 2021
- Category 2 at landfall

TELEMAC-2D Modelling

- Dedicated model of Mozambique Channel
- Includes tide
- 2.5m surge forecast coinciding with neap tide
- Total water level forecast to be less than MHWS



Typhoon Rai

Typhoon Rai

- Philippines 16th December 2021
- Category 5
- Tracked across Visayan Islands, central Philippines

TELEMAC-2D Modelling

- Dedicated model covering Philippines
- 2D structure of wind fields important
- Tide difficult to model
- Resultant surge *very* sensitive to track

