An ensemble-based method for investigating the predictability of fluvial flooding from tropical cyclones

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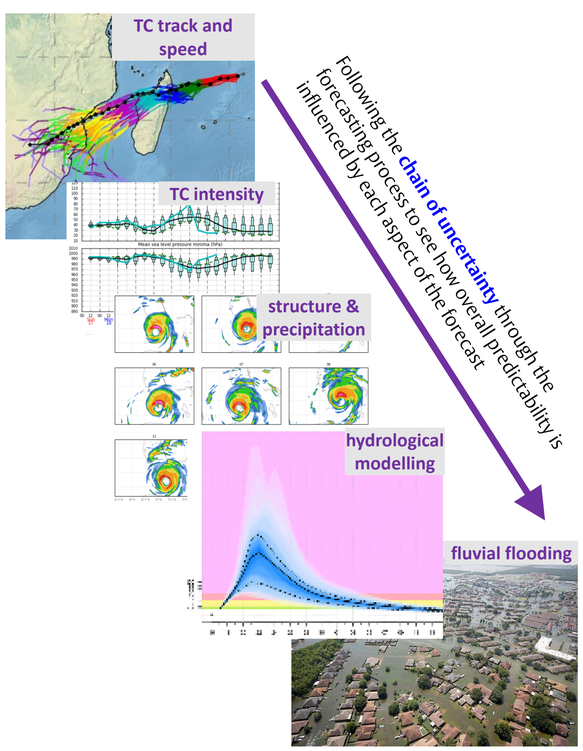
Introduction

This research aims to investigate how well global ensemble forecasts can predict one of the most important and deadly hazards from tropical cyclones (TCs): fluvial flooding. Initial work showed that global ensembles have good skill in forecasting the track probabilities of tropical cyclones (Titley *et al.* 2020). Observed and reanalysis data were then used to find the key factors that influence TC-related flood severity (Titley *et al.*, 2021). Ongoing work described here is exploring the chain of uncertainty through the forecasts, showing how each part of the forecasting chain influences the overall predictability of flooding from TCs.

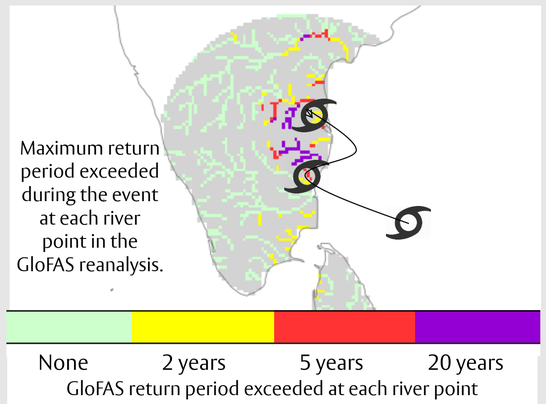
Data and methods

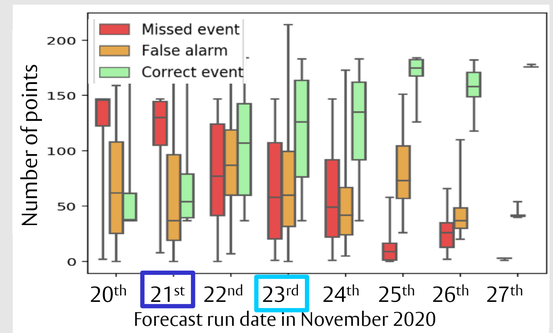
Forecast and reanalysis data from the Global Flood Awareness System (GloFAS, https://www.globalfloods.eu/), and the driving ensemble forecasts from ECMWF ENS, are being used to evaluate the influence on the flood forecasts in TC cases from the track, intensity, precipitation, and hydrological components of the forecasting chain.



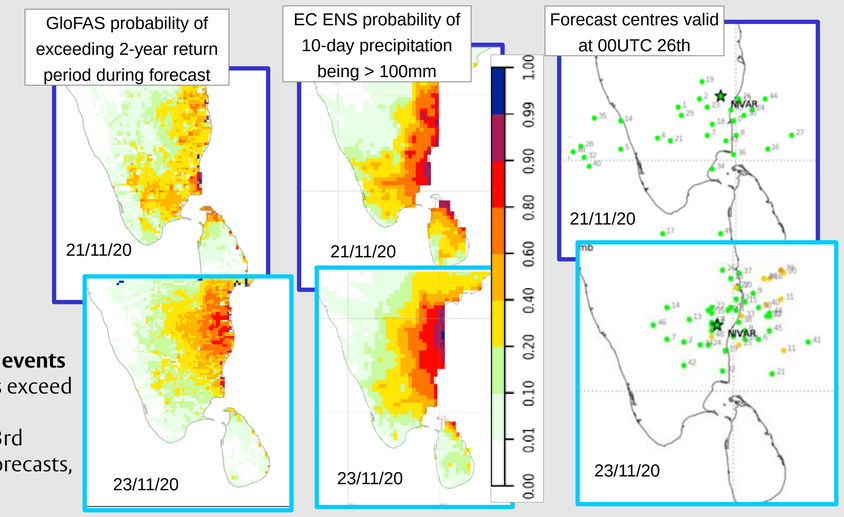
Example case studies

1) Cyclone Nivar, Nov 2020

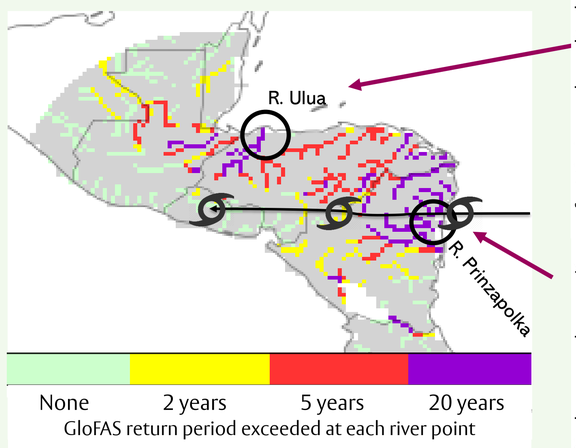


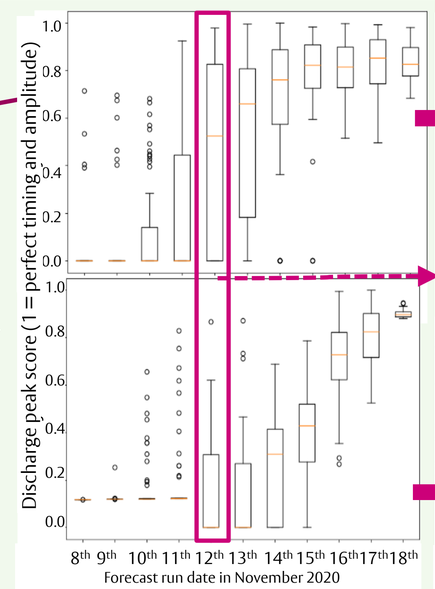


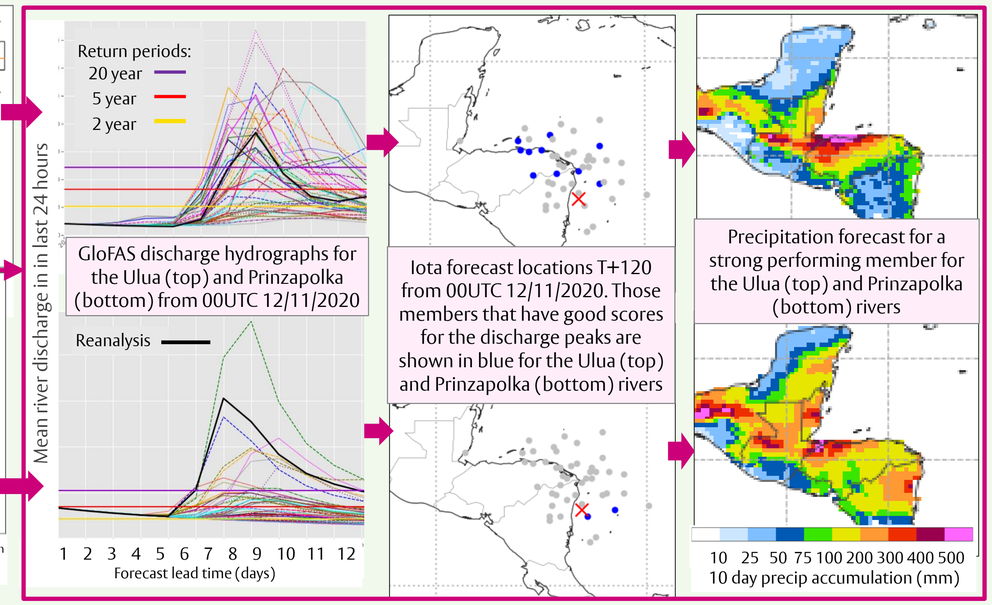
- River points are classed as **misses, false alarms** or **correct events** depending on whether or not the forecasts and reanalyses exceed the 2-year return period (above).
- The plots on the right trace the forecasts from 21st and 23rd November back through the forecast chain from GloFAS forecasts, to precipitation forecasts, to TC centre location forecasts.



2) Hurricane Iota, Nov 2020







- A new discharge peak verification score compares the timing and amplitude of the forecast discharge peak against the reanalysis at each river point. The distribution of the scores in the GloFAS members is used to summarise how well the discharge peak was forecast from all forecast runs. Flooding on rivers in northern Honduras (top) is well predicted further in advance than in Eastern Nicaragua (bottom).
- The score can be used to investigate which aspects of the forecast lead to better flood forecasts. In Ulua river (top), the prediction of the broader onshore flow into the mountains is key and is less sensitive to landfall location. For Prinzapolka river (bottom), successful flood forecasts relied on the accurate prediction of landfall location and of heavy rainfall close to the TC centre, which was less predictable at longer lead times.

Summary

- Initial work showed global ensembles have good forecast skill for TC track probabilities, and identified key factors that influence the severity of TC flooding, such as translation speed (Titley *et al.*, 2020; 2021).
- The ongoing development of the ensemble-based methods described here will be used to investigate the main influences on TC flood predictability. This work adds a new hydrological perspective to the traditional methods of verifying global ensemble forecasts for TCs, and will lead to recommendations as to how to improve TC flood forecasts and their use by decision-makers.

References

1. Titley, HA, Bowyer, RL, Cloke, HL. A global evaluation of multi-model ensemble tropical cyclone track probability forecasts. *QJRMS*, 2020; 146: 531– 545 https://doi.org/10.1002/qj.3712
2. Titley, HA, Cloke, HL, Harrigan, S, Pappenberger, F, Prudhomme, C, Robbins, JC, Stephens, EM, and Zsoter, E. Key factors influencing the severity of fluvial flood hazard from tropical cyclones. *Journal of Hydrometeorology*, 2021, *Available online at* https://doi.org/10.1175/JHM-D-20-0250.1

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