Potsdam Institute for
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# Evaluation of a global modeling chain for flood-induced displacement risk

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## 1. Background

River flooding has displaced more than 100 million people worldwide, just during the last decade (IDMC, 2019). It is important to understand the spatiotemporal patterns of displacement risk and the determinants of vulnerability to flood displacement, and to anticipate future changes in risk, for instance, due to global climate change. Here, we investigate a global modeling chain built around this objective (Fig. 1). We evaluate estimates of flood hazard produced by a global flood model (GFM), driven with runoff simulated by an ensemble of global hydrological models (GHMs) under three different climate reanalysis products.

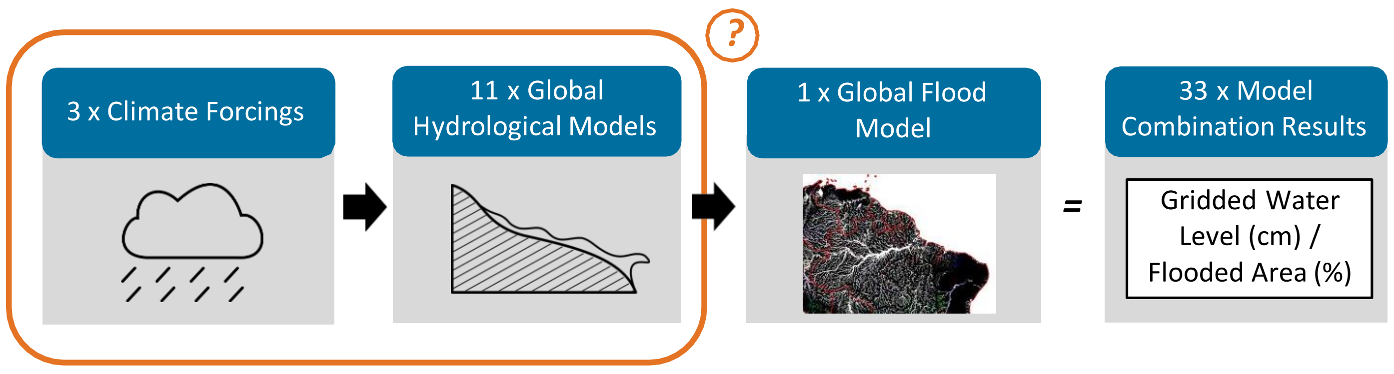


Fig. 1 Uncertainty regarding the choice of climate forcings and global hydrological models, both part of the global flood modeling chain.

## 2. Case study

We evaluate input sensitivity of the GFM by comparing simulated flood extent to satellite imagery for eight major floods on four continents, covering a variety of climates and hydraulic characteristics, and analyze:

- Model agreement maps
- Spatial performance metrics: critical success index (CSI) to assess model "fit" and Bias score to indicate over-/underprediction of flood extent
- Effects of a 2-year protection level and the inclusion of spatially explicit flood protection levels by the FLOPROS database (Scussolini et al., 2016)

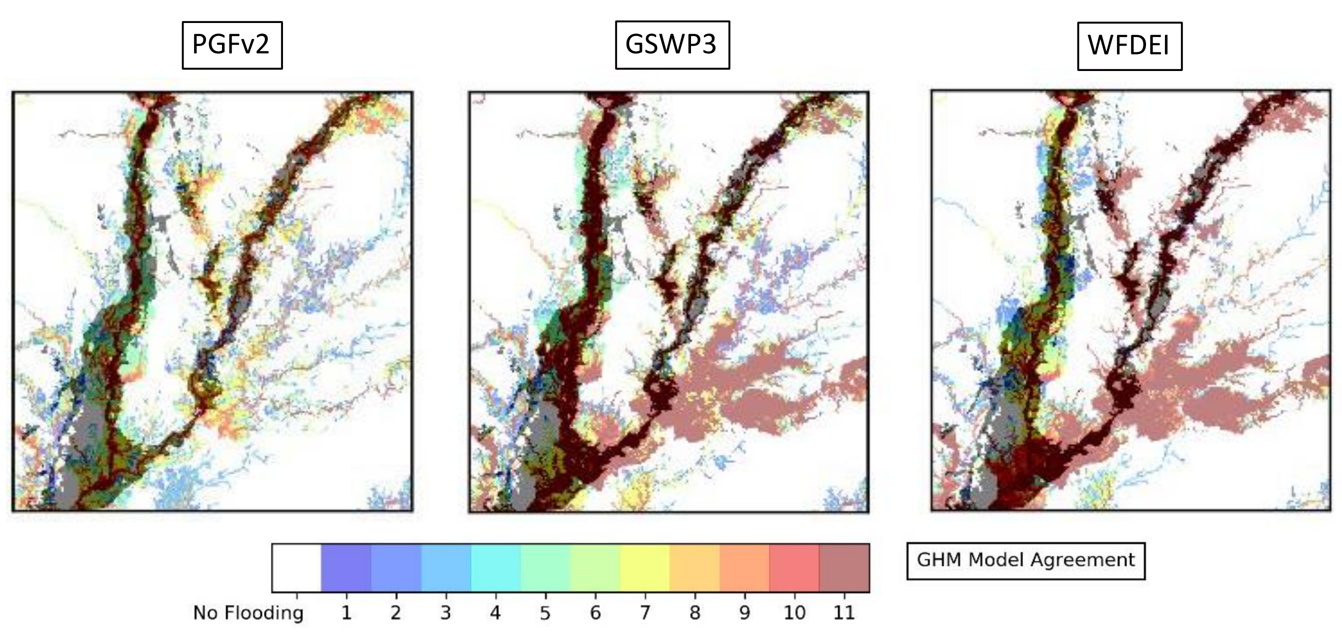


Fig. 2 Model agreement maps indicating the flood extent overlap between the 11 GHMs and the satellite data (grey) for each study region (here: Alipur (PAK)) and climate forcing (column). The cell colour represents the number of GHMs that computed the corresponding cell to be flooded. (Mester et al., 2021)

## 3. Results and discussion

A number of key results emerge from our analysis (Mester et al., 2021):

- The model agreement maps reveal that the choice of GHM and climate forcing have mutually dependent effects on the spatial distribution of flooded areas, e.g., as observed for Alipur in Pakistan (Fig. 2).
- The performance scores differ considerably between events and show that no climate forcing or GHM performs best for all regions (Fig. 3).
- A 2-year protection level achieves a similar agreement between simulations and observations as the "default" setup with no protection. The FLOPROS protection level vastly reduces the simulated flood extent and hence degrades the performance scores dramatically. (Fig. 4)

| GSWP3 | CLM | DBH | H08 | JULES-W1 | LPJmL | MATSIRO | MPI-HM | ORCHIDEE | PCR-GLOBWB | VIC | WaterGAP2 | Median GHMs | Min. GHMs | Max. GHMs | Spread GHMs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sayaxché (GTM) | 0.53 | 0.56 | 0.54 | 0.56 | 0.55 | 0.58 | 0.54 | 0.54 | 0.56 | 0.55 | 0.56 | 0.55 | 0.53 | 0.58 | 0.05 |
| Trinidad (BOL) | 0.53 | 0.54 | 0.54 | 0.53 | 0.54 | 0.49 | 0.53 | 0.54 | 0.53 | 0.46 | 0.53 | 0.53 | 0.46 | 0.54 | 0.08 |
| Chemba (MOZ) | 0.69 | 0.71 | 0.70 | 0.60 | 0.71 | 0.53 | 0.70 | 0.62 | 0.71 | 0.00 | 0.53 | 0.69 | 0.00 | 0.71 | 0.71 |
| Alipur (PAK) | 0.32 | 0.33 | 0.36 | 0.33 | 0.35 | 0.33 | 0.35 | 0.35 | 0.36 | 0.35 | 0.37 | 0.35 | 0.32 | 0.37 | 0.05 |
| Ghotki (PAK) | 0.34 | 0.40 | 0.44 | 0.35 | 0.35 | 0.42 | 0.43 | 0.34 | 0.42 | 0.40 | 0.34 | 0.40 | 0.34 | 0.44 | 0.10 |
| Phimai (THA) | 0.46 | 0.45 | 0.42 | 0.50 | 0.47 | 0.41 | 0.47 | 0.46 | 0.45 | 0.43 | 0.46 | 0.46 | 0.41 | 0.50 | 0.09 |
| Huainan (CHN) | 0.28 | 0.28 | 0.29 | 0.33 | 0.30 | 0.38 | 0.31 | 0.31 | 0.28 | 0.31 | 0.32 | 0.31 | 0.28 | 0.38 | 0.10 |
| Dalby (AUS) | 0.23 | 0.18 | 0.24 | 0.18 | 0.20 | 0.23 | 0.25 | 0.22 | 0.22 | 0.26 | 0.25 | 0.23 | 0.18 | 0.26 | 0.08 |
| Median Region | 0.40 | 0.43 | 0.43 | 0.42 | 0.41 | 0.42 | 0.45 | 0.40 | 0.44 | 0.38 | 0.42 | 0.43 | 0.33 | 0.47 | 0.09 |

Fig. 3 CSI scores for all combinations of GHMs and the climate forcing GSWP3 ('default'). The 'Median Region' across the even number of regions is calculated as the mean of the two middle values. (Mester et al., 2021)

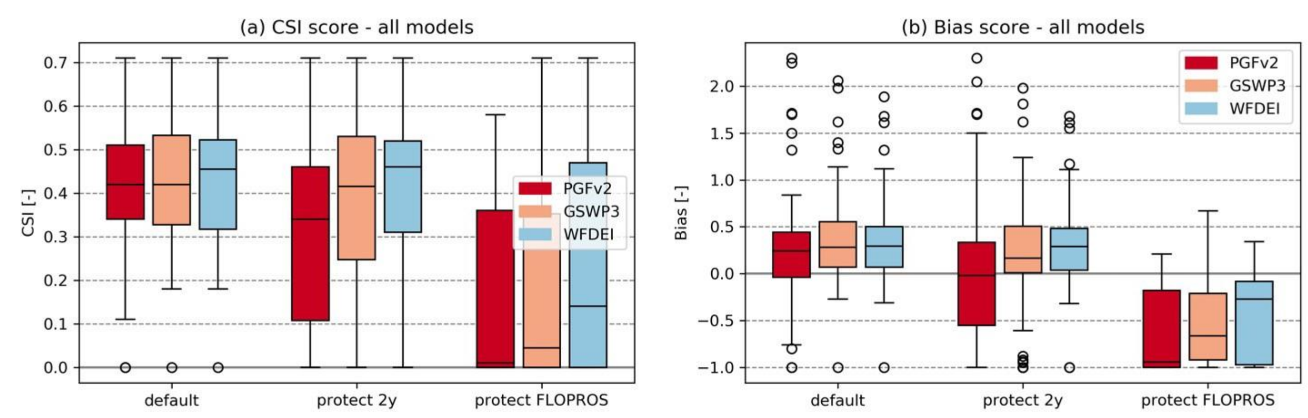


Fig. 4 Comparison of CSI and Bias scores between the default setting ('default'), protection against floods with an ARI of 2 years ('protect 2y') and protection standards according to FLOPROS ('protect FLOPROS') for the climate forcings PGFv2, GSWP3 and WFDEI. (Mester et al., 2021)

## 4. Conclusion

Our case study highlights that the global flood modeling chain partially achieves satisfying results, similar as in Bernhofen et al. (2018), with no clear recommendation for any specific climate reanalysis and GHM. For some regions, however, it remains a major challenge for many or all input combinations to reproduce observations of flood extent. This leads to severe consequences in computing the correct number of affected people and relating it to the corresponding number of displaced people. Future work should focus on identifying more detailed flood protection levels in place and the improvement of GHMs with respect to the generation of high-end surface runoff.

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