

# Flood generation in a changing world and its uncertainty

Thorsten Wagener

*Alexander von Humboldt Professor of Hydrologic Systems*

With contributions from Laura Devitt, Gemma Coxon,  
Lina Stein, Jeff Neal, James Savage

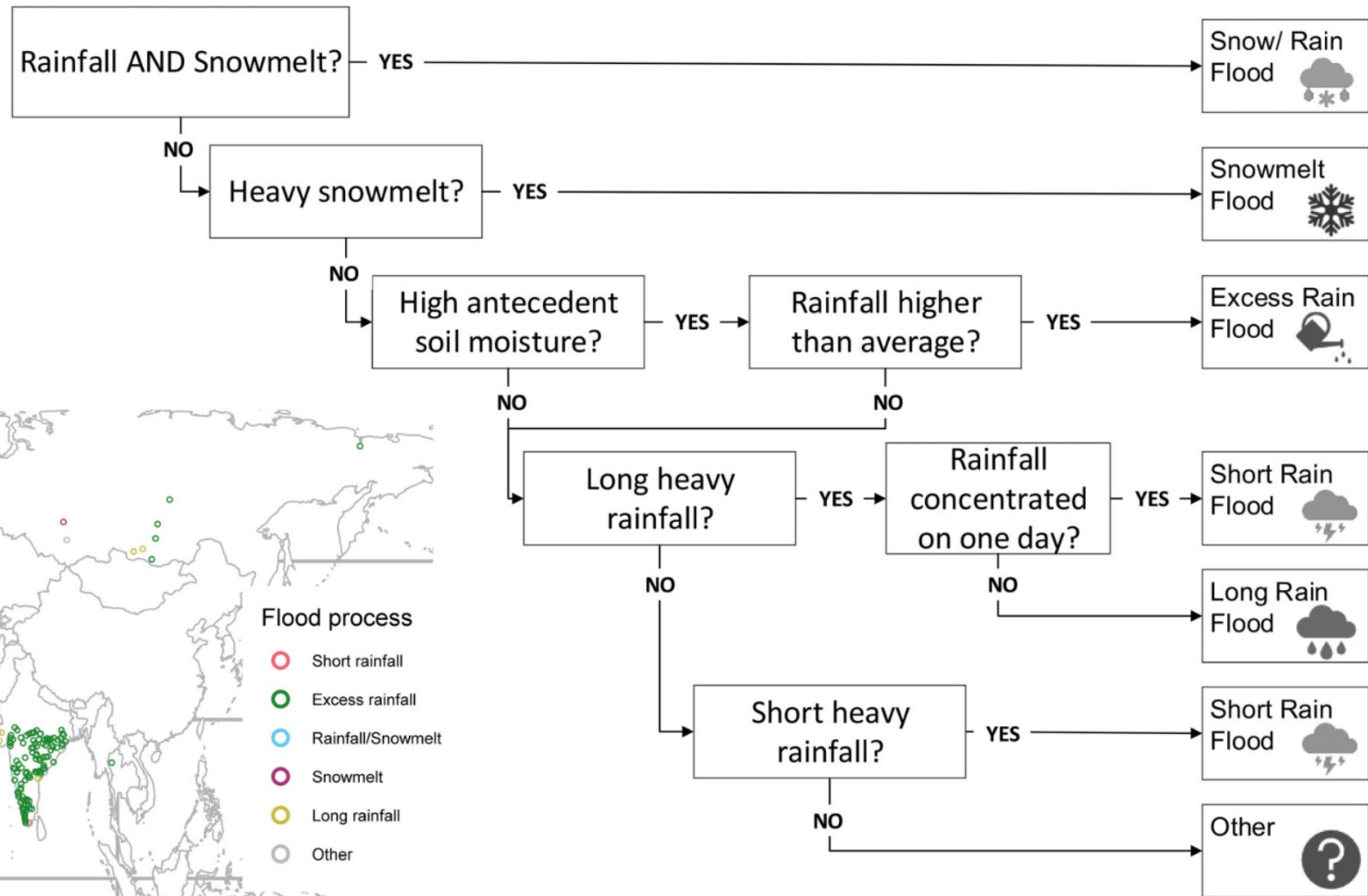
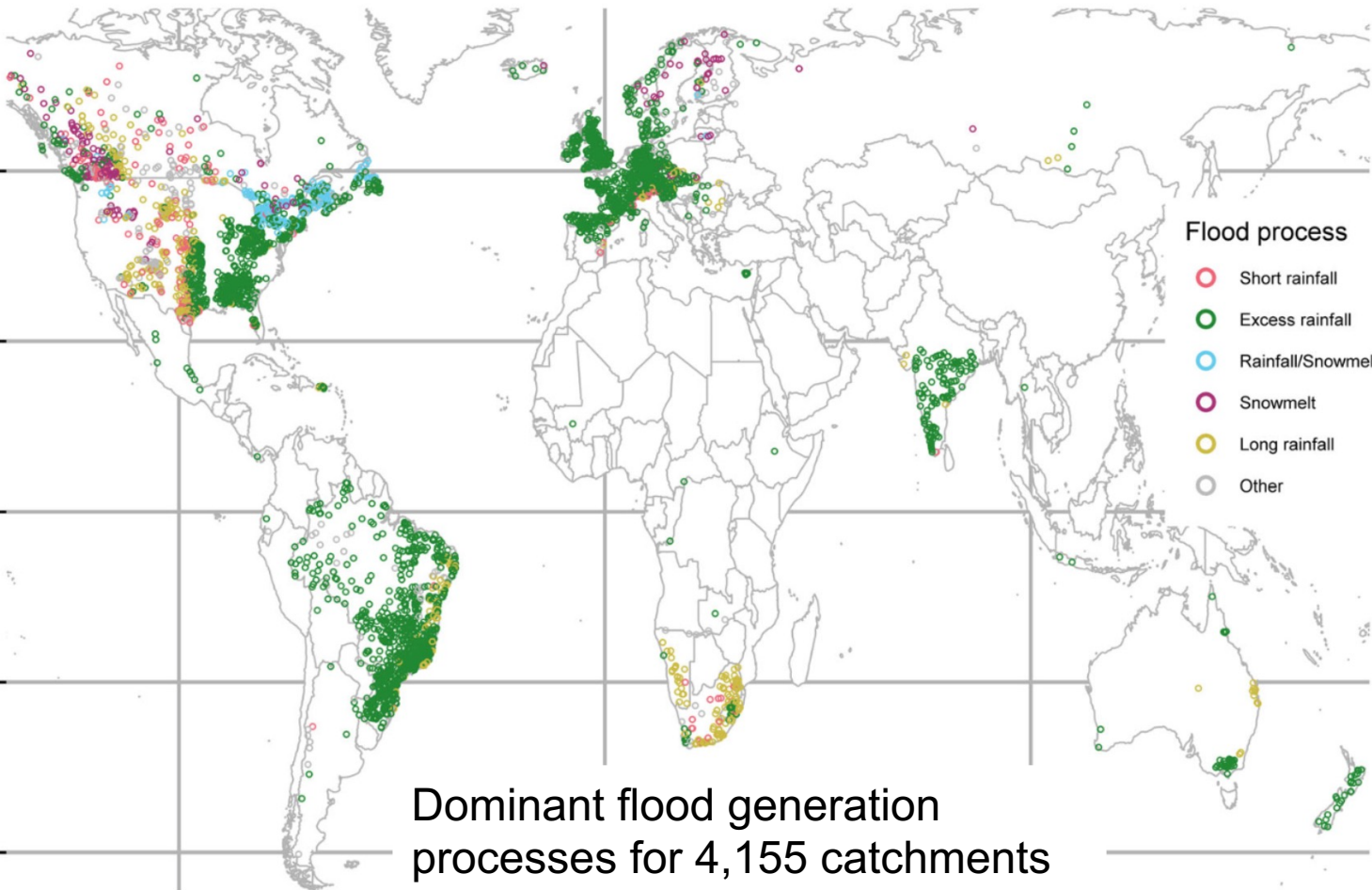


University of  
**BRISTOL**



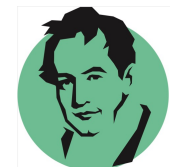
Alexander von  
**HUMBOLDT**  
STIFTUNG

# Flood generation mechanisms vary in space and time



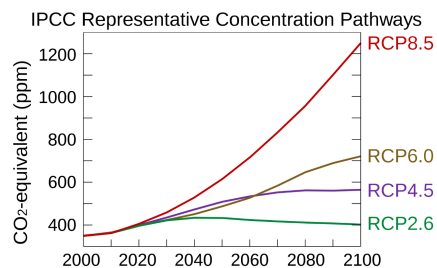
*Extreme floods often diverge from their usual flood generation pattern*

Stein, Pianosi, Woods  
(2020) *HP*



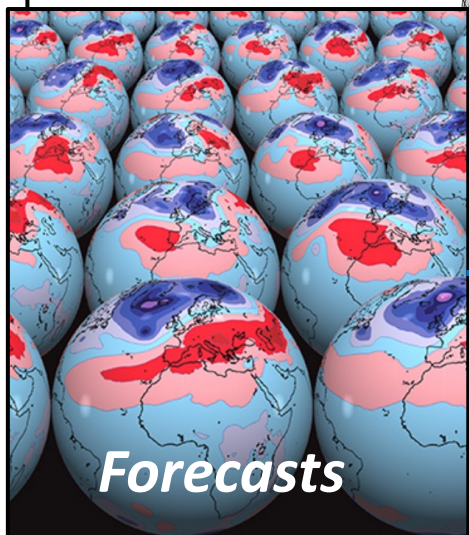
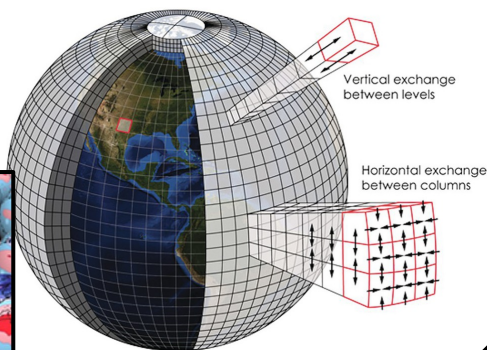
Alexander von  
**HUMBOLDT**  
STIFTUNG

## Emission Scenarios



## Projections

Global Climate Models (GCMs)



Forecasts

ECMWF

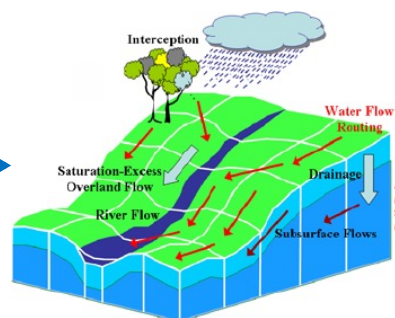
NOAA



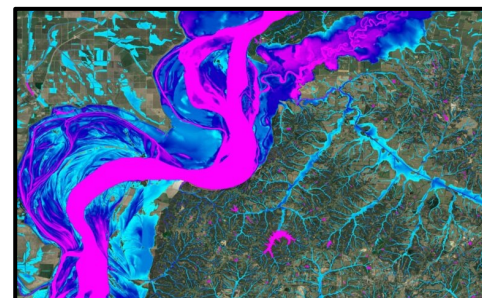
Observations

We use model-chains to understand past, current or future floods/impacts with flood generation in a central role

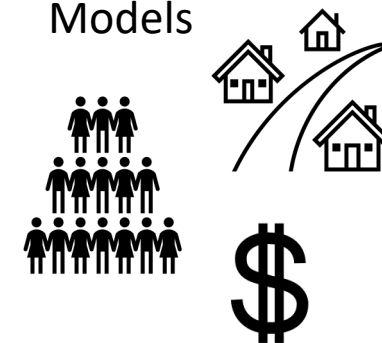
Hydrological models



Flood Hazard Models

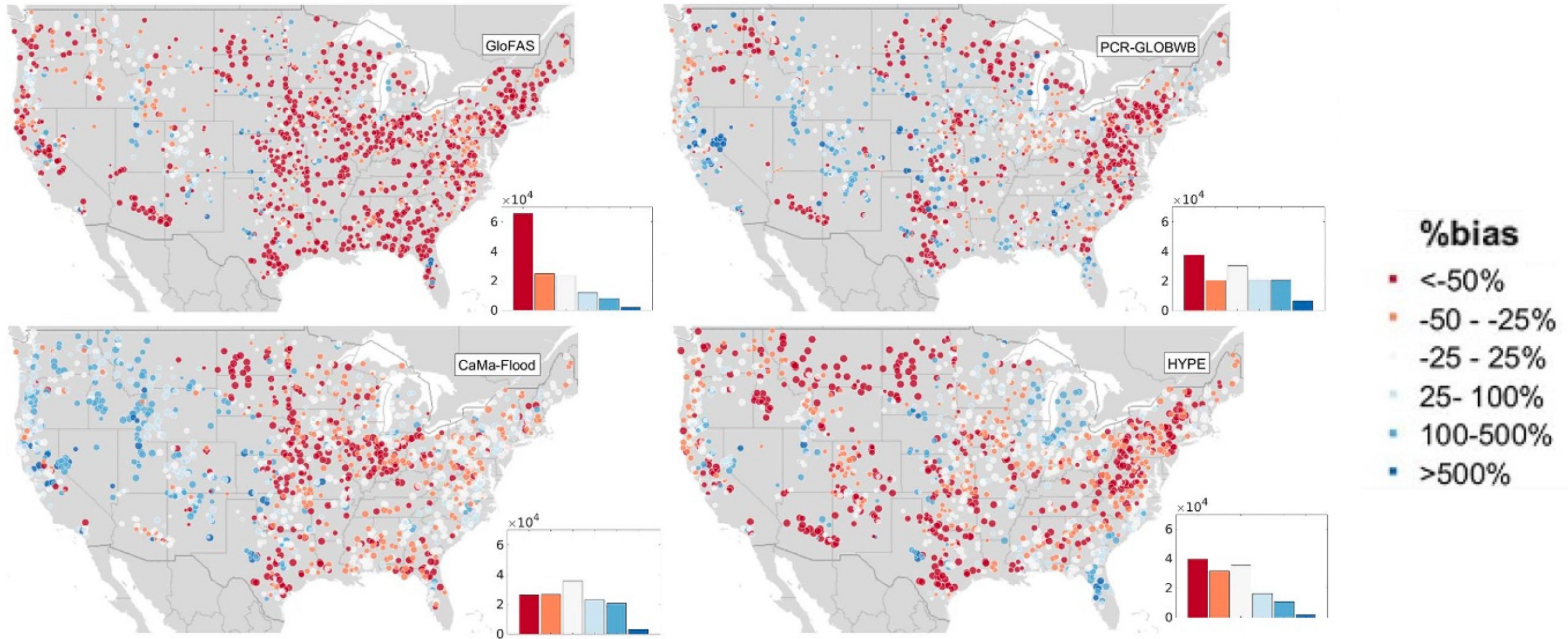


Impact Models





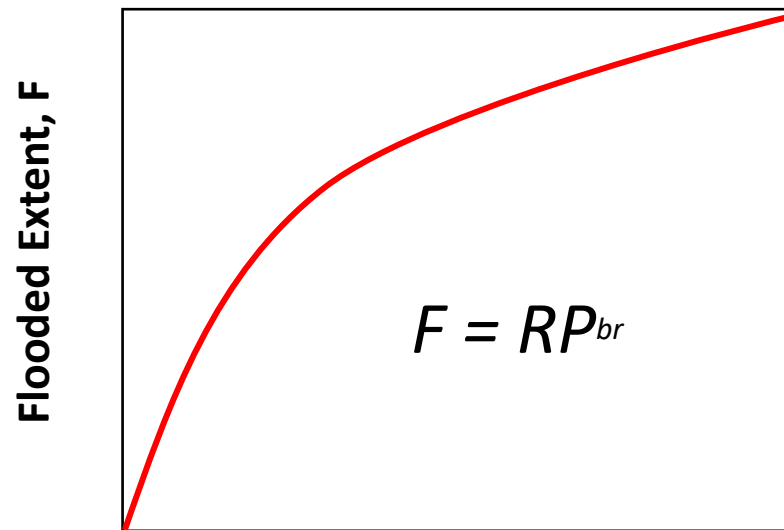
However, the uncertainty in large-scale hydrologic model estimates of flood flows is often high



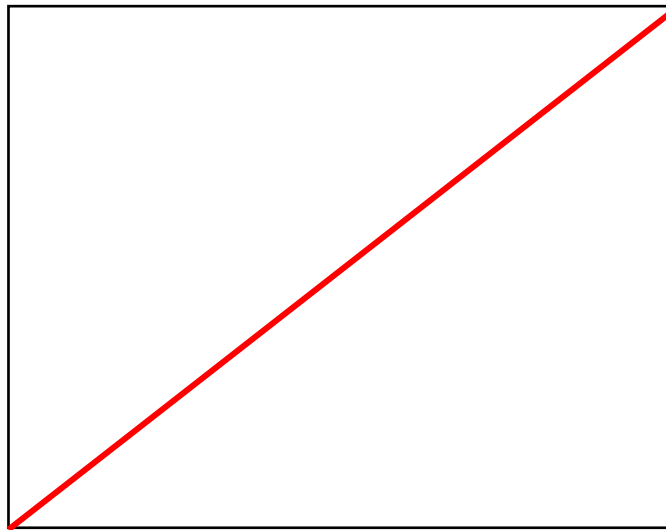
# Alternatively, we can calculate the sensitivity of river reach flood extents to increasing flood magnitudes

Flood extent is driven by...

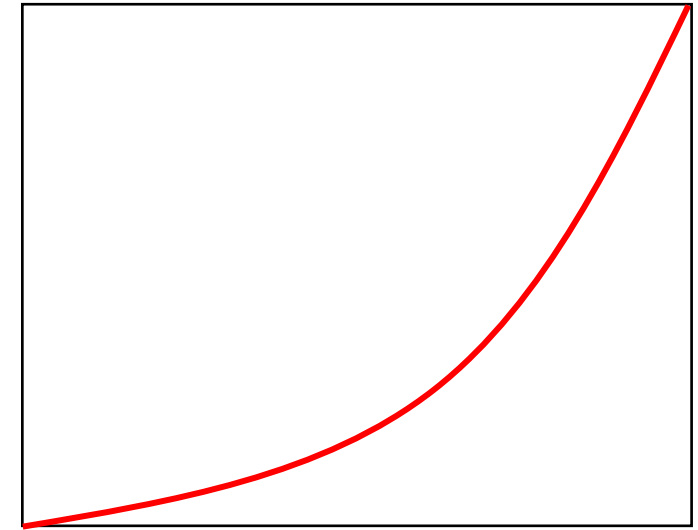
(1) Frequent, low magnitude events



(2) Equally sensitive to all event magnitudes

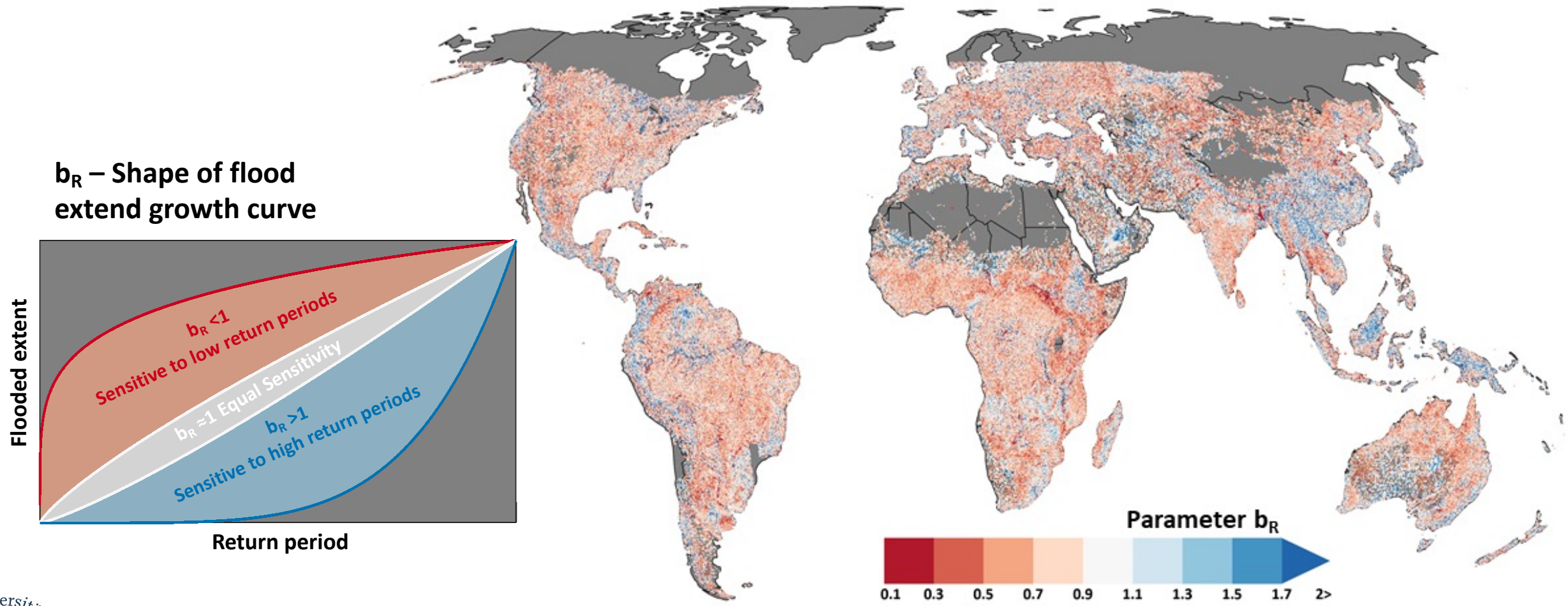


(3) Rare, extreme magnitude events



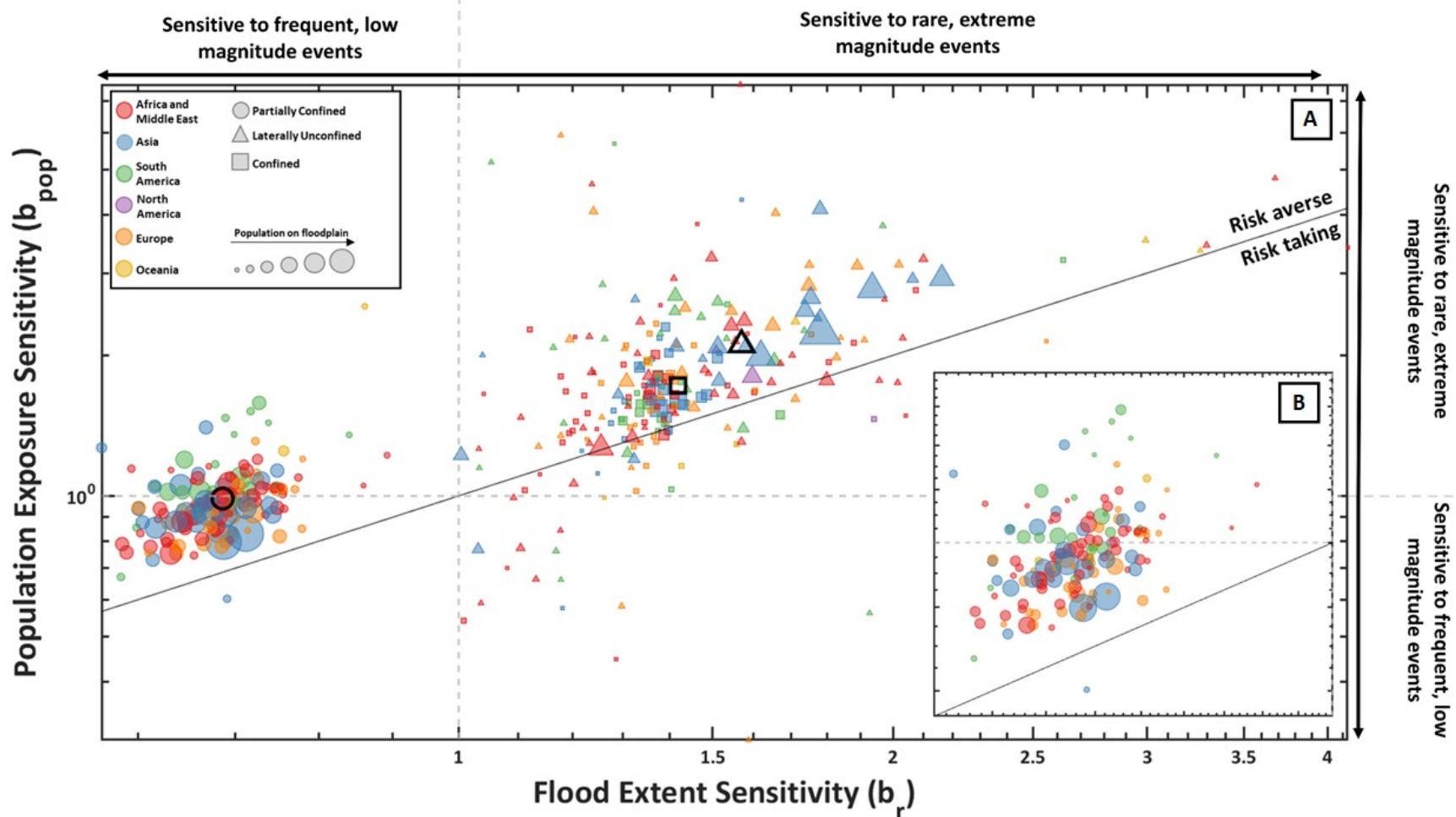
Return Period, RP (5-, 10-, 20-, 50-, 75-, 100-, 200-, 250-, 500- and 1000-year)

# Sensitivity pattern of flood extent to flood event magnitude for 1.1 million river reaches





We can quantify the sensitivity of inundated areas and up to 2 billion exposed people to flood event magnitudes globally



Devitt, Neal, Coxon, Savage, Wagener  
(2023) *Nature Communications*

# In summary, we can stress-test the (global) flood system to gain baseline information under large uncertainty

Recent flood related studies with our group:

\*Devitt et al. 2023 *Nature Communications*

Kreibich et al. 2022 *Nature*

\*Devitt et al. 2021 *Environmental Res. Letters*

Stein et al. 2020 *Hydrological Processes*

Lane et al. 2019 *HESS*

- Uncertainties in flood estimates are high in global/large-scale models\*
- We stress-tested the system as a baseline analysis of flood extent/exposure from different flood magnitudes\*
- This can then be a guide to where changes in flood magnitude might be particularly critical – e.g. where changing flood generation processes might be most critical (→ Merz et al. 2021 *Nature RE&E*)

\*Devitt et al. analyses based on pre-existing model runs