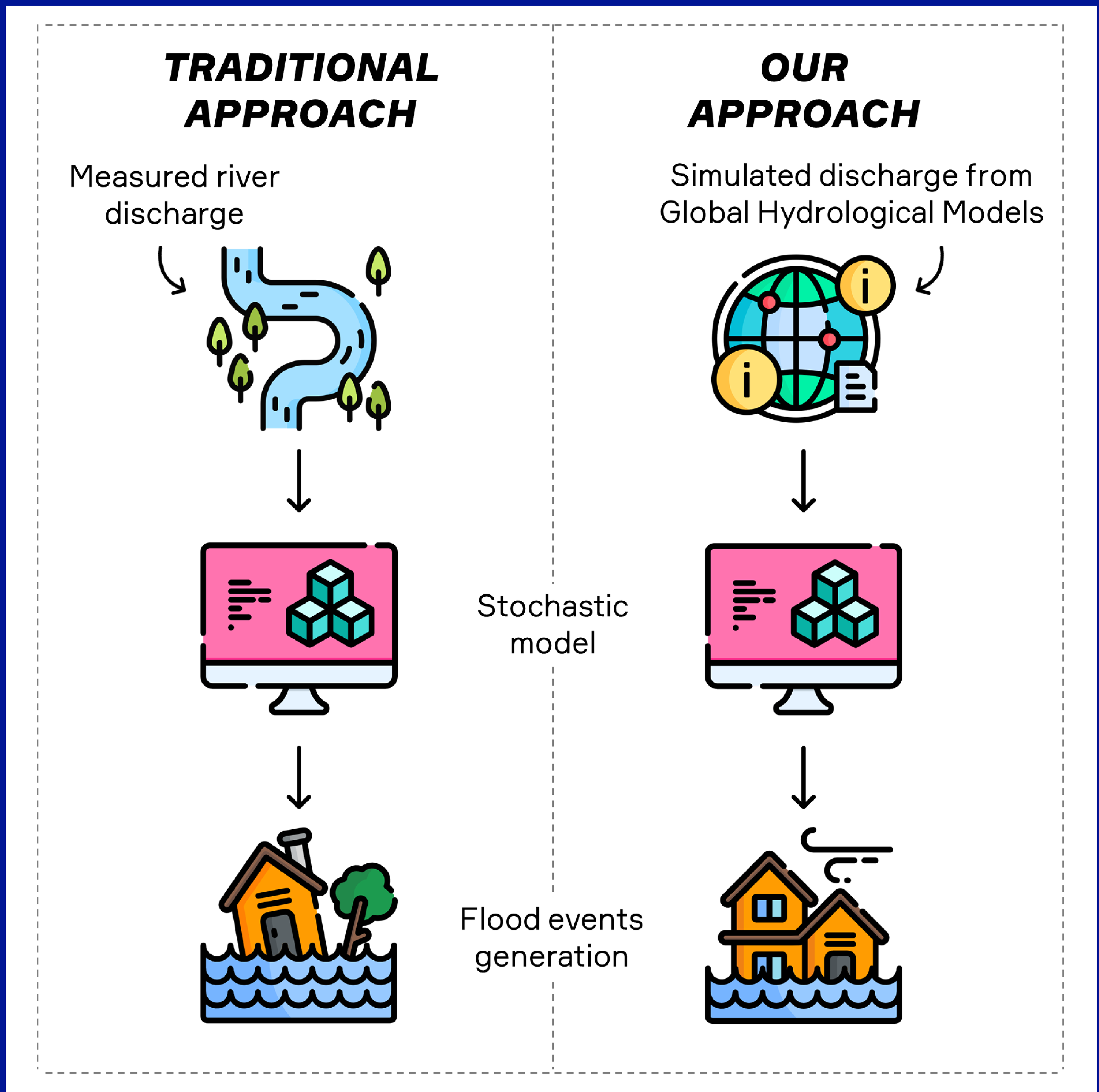
One step closer to simulating stochastic flood events globally



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Can hydrological models be used to characterize spatial dependency in global stochastic flood modelling?

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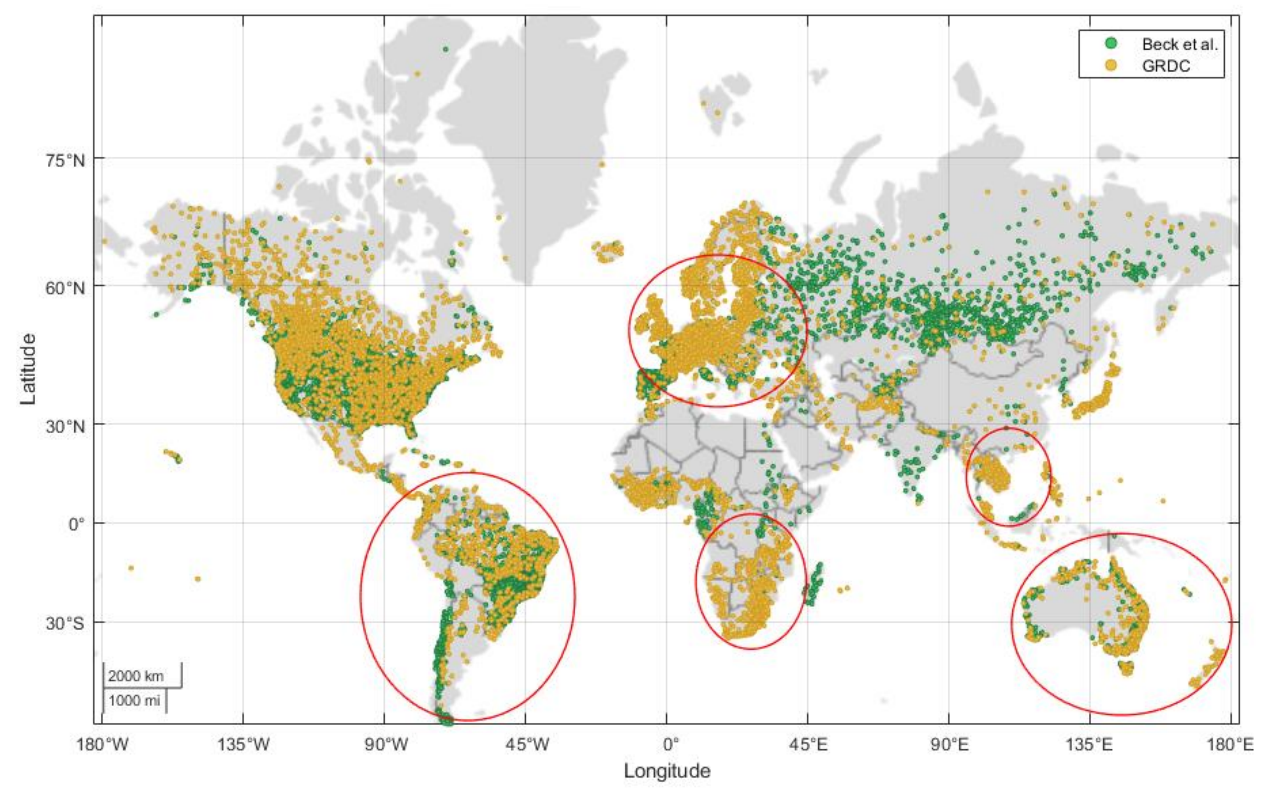
Background

With stochastic flood modelling we can simulate realistic flood event sets, with spatial dependency between different areas. This is very useful at a large scale and improves our accuracy in assessing flood risk.

To generate flood event sets **we typically need measured streamflow data** as input to the stochastic model, in order to derive spatial dependency, but relying on measured data makes this method not applicable in data-scarce regions. Global hydrological models (models that simulate river discharge globally) can help in overcoming this limitation. **Could discharge from global hydrological models be used to characterize spatial dependency in stochastic flood modelling, even though we know such models have significant biases at individual sites?**

This approach has been previously tested in the United States showing a good performance, in this research we focus on testing this method globally.



Map representing the two global discharge databases used in this research and highlighting the regions used as case studies.

Methods and case studies

To test this methodology, we run a stochastic model using gauged discharge data and then using simulated discharge from two global hydrological models: CaMa-Flood (University of Tokyo) and PCR-GLOBWB (University of Utrecht) .

We then compare the results to check if the model-based approach can replicate the spatial dependency that we see in the gauged data.

This process has been done in Australia, Malaysia and Thailand, South America, Africa and Europe (*see regions on the map on the left*).

Two global gauge datasets were used for this research: global discharge data from the Global Runoff Data Centre (GRDC) and a daily streamflow global dataset produced by Beck et al. (2013).

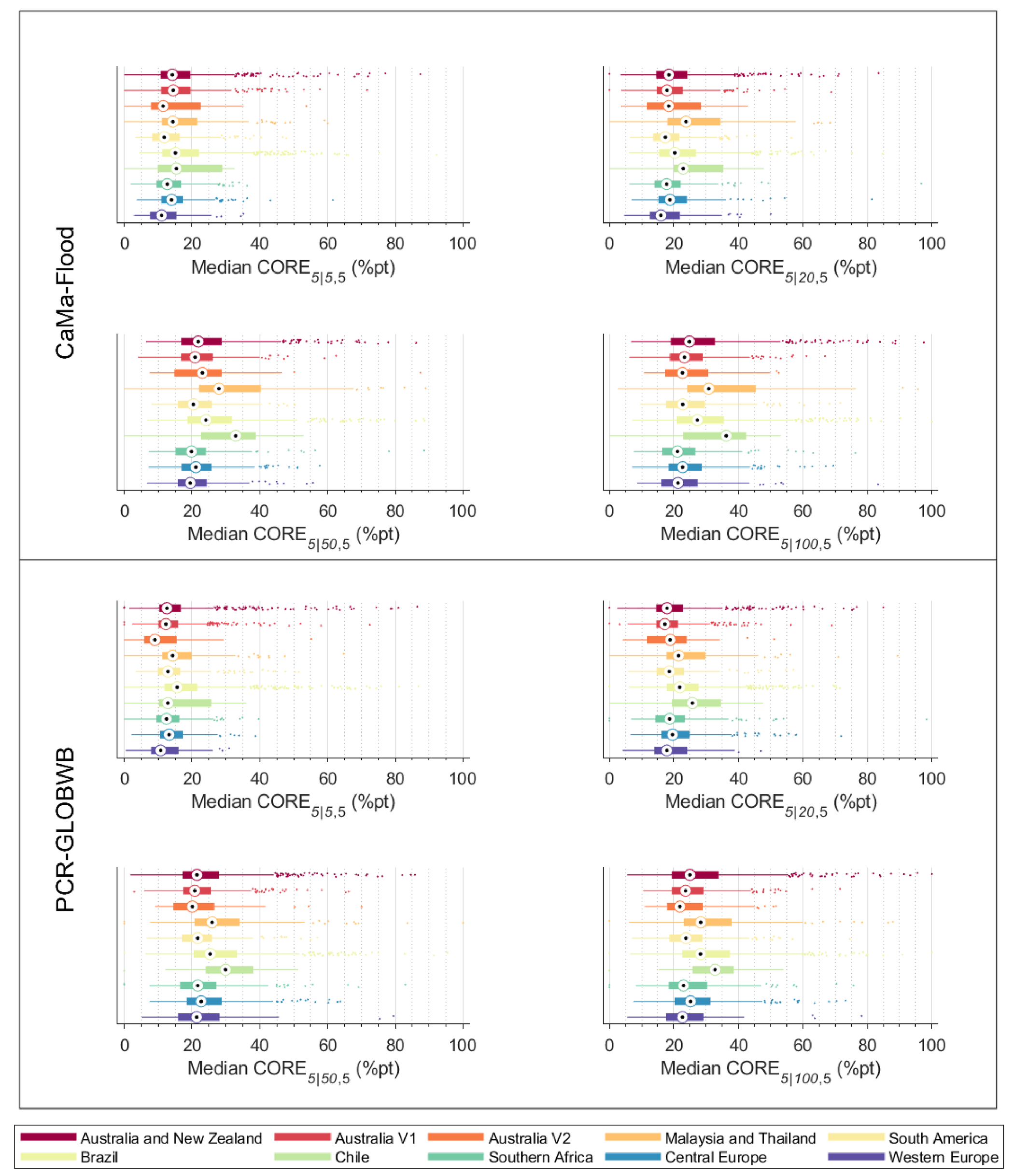
To analyze the performance of the model-based approach compared to the traditional method we compare the co-occurrence rate (COR). The COR is the probability of an event occurring at both neighboring and conditioning sites at the same time: for each conditioning site Y_i (gauge) the COR is the probability of the neighboring site Y_j experiencing an event with a return period greater or equal to p_j, when the conditioning site is facing an event with return period p_i.

The COR will have a value between 0% and 100%.

$$COR_{p_j|p_i} = \frac{\sum(Y_j > p_j | Y_i > p_i)}{\sum(Y_i > p_i)} \times 100$$

The CORE is the root mean square error between the observed and the modelled co-occurrence rate (COR).

$$CORE_{p_j|p_i,x} = \sqrt{\frac{\sum_1^N [\left(COR^{obs}_{p_j|p_i} \geq x\right) - \left(COR^{mod}_{p_j|p_i} \geq x\right)]^2}{N}}$$



Summary of the performance of the model-base approach in different areas. COREs between gauge-based and model-based approach, referring to four different return periods thresholds.

Conclusions

The **general performance of the model-based approach is promising.**

The median COREs of most regions do not exceed 25%pts (*as shown the figure on the right*) and are comparable to the results obtained by previous research in the United States. With this magnitude of errors, the loss distributions obtained from the gauge-based approach and the model-based one are almost identical.

This suggests that this method can potentially be used in other regions.

Developing a stochastic flood model with detailed spatial dependency, driven by a network of synthetic gauges, would allow the generation of realistic event sets in data-scarce regions and could be used to derive loss exceedance curves where exposure data is available.

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