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The effect of surge on riverine flood hazard and impact in deltas globally

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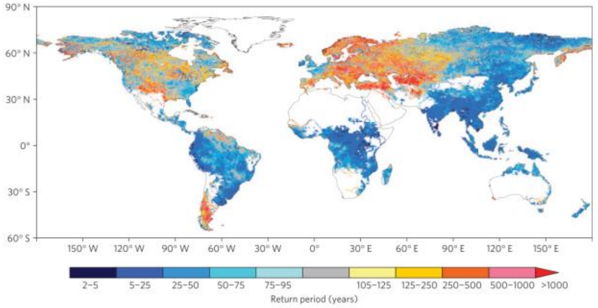
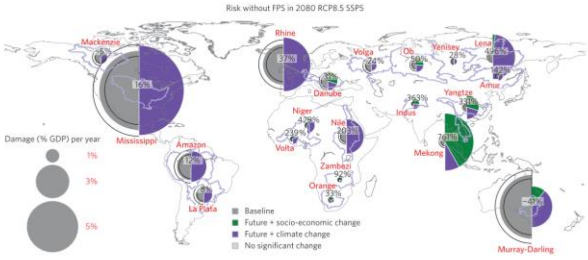
Intro: Global flood modelling - status quo

Fluvial



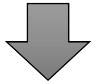
Hirabayashi et al. (2013) - NCC



Winsemius et al. (2015) - NCC

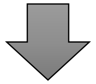
OR

runoff



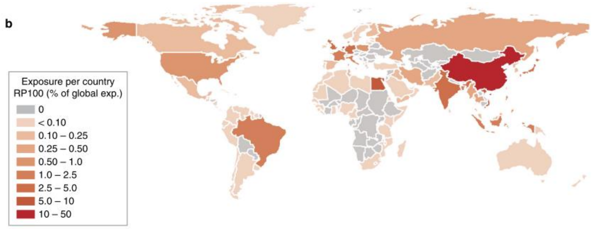
flood hazard


waves, surge & tides

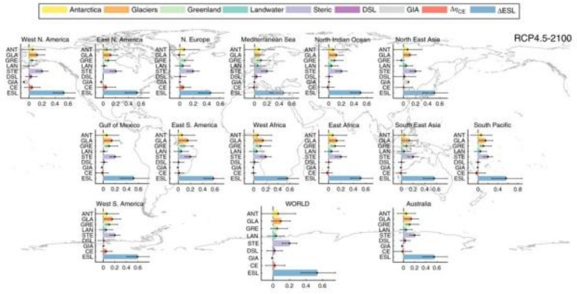


flood hazard

Coastal



Muis et al. (2016) - NComms



Vousdoukas et al. (2018) - NComms

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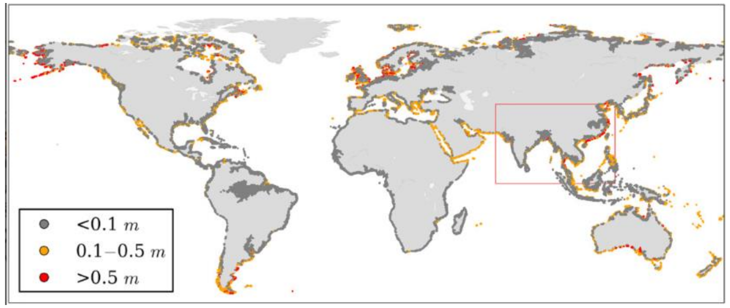
Intro: Global flood modelling – integrated analysis

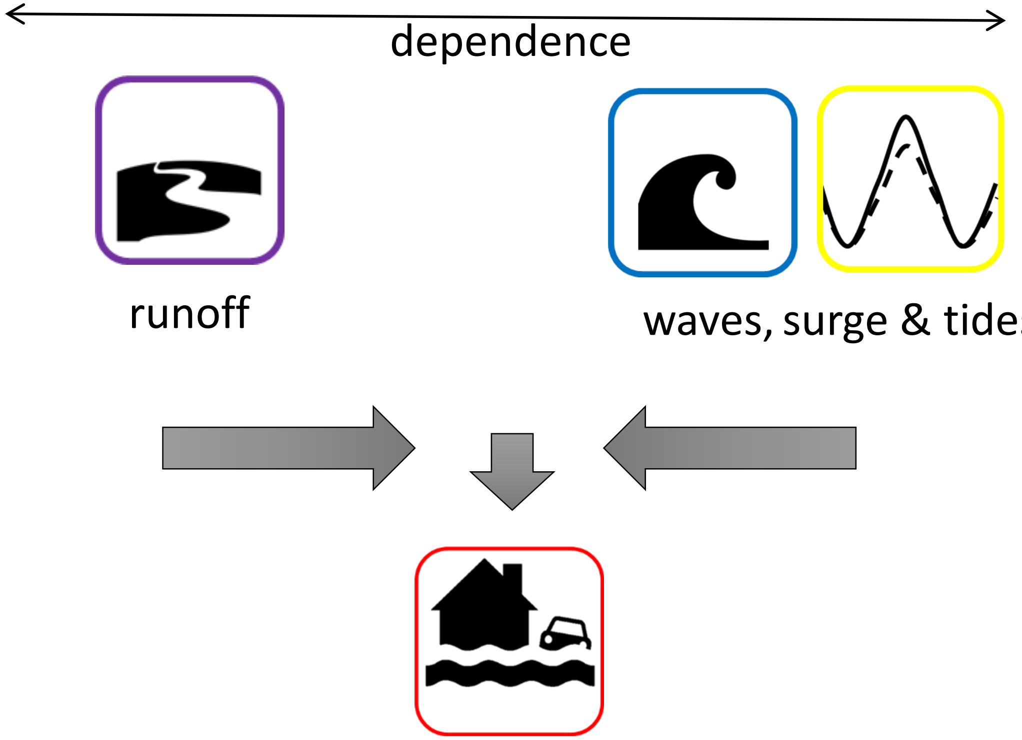
Fluvial **AND** **Coastal**

dependence

Hydrodynamic model analysis



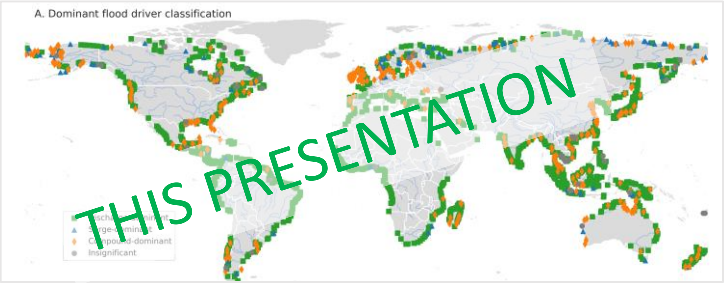
Ikeuchi et al. (2017) - JAMES



runoff

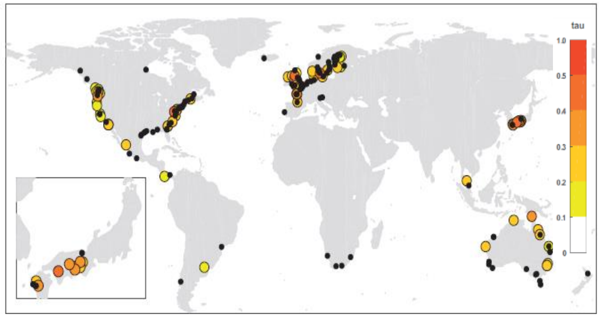
waves, surge & tides

flood hazard

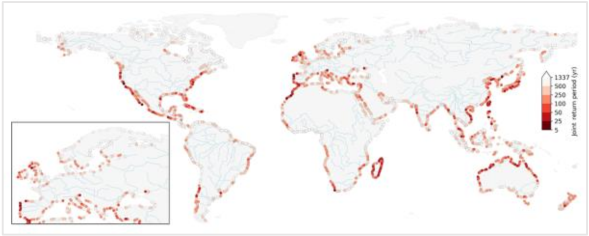


Eilander et al. (2020) – ERL

Statistical dependence analysis



Ward et al. (2018) - ERL



Couasnon et al. (2020) - NHESS

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Experiment setup

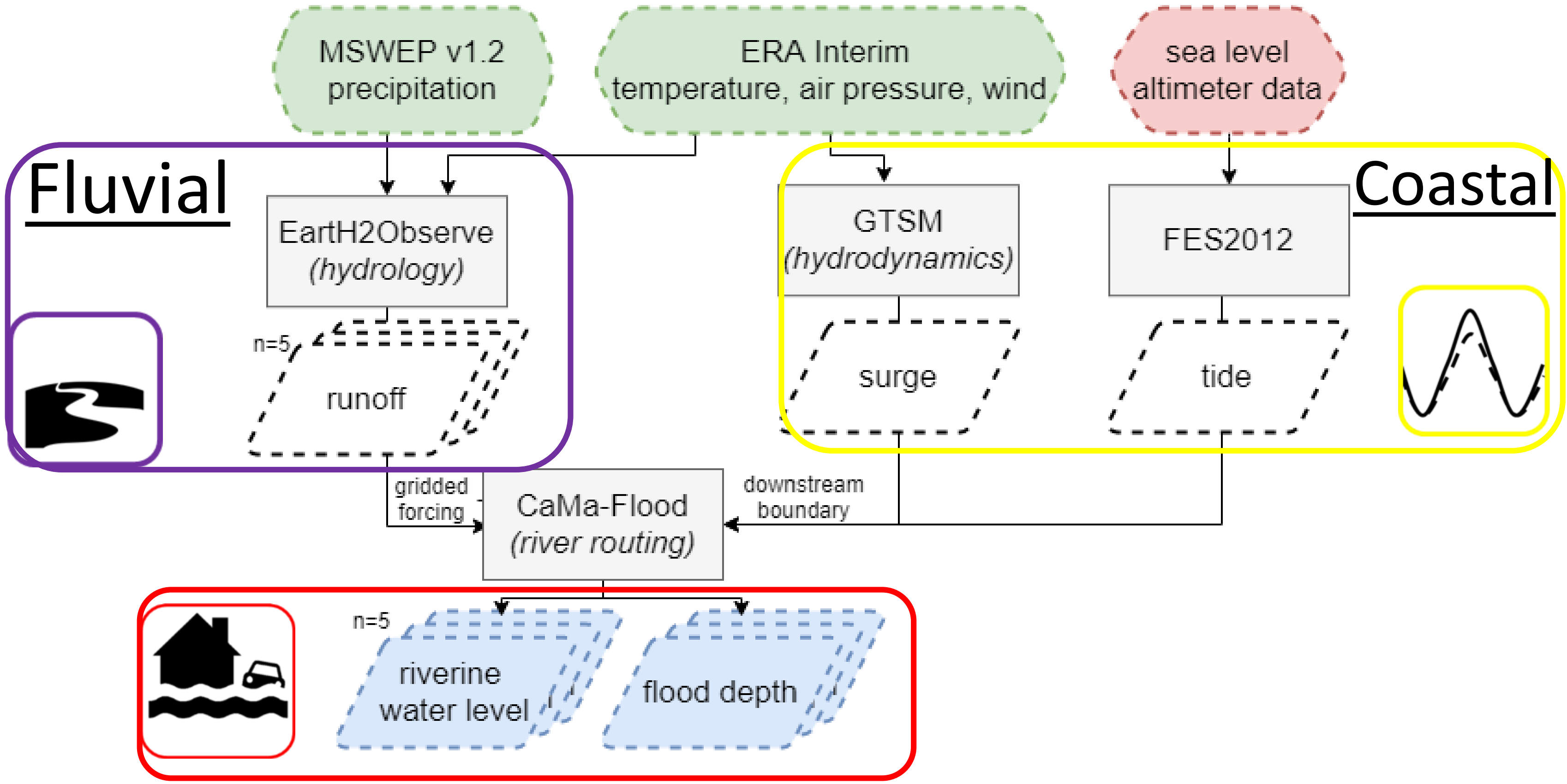
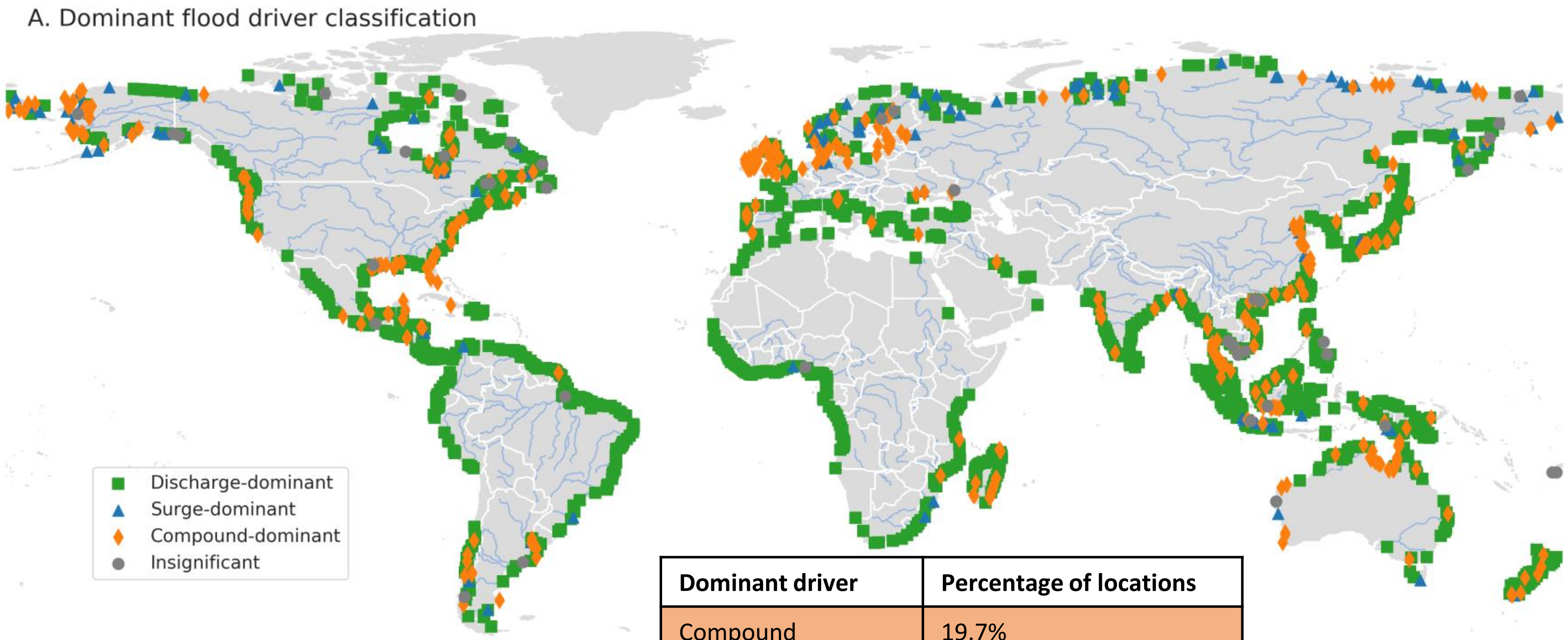


Figure: Model framework showing: the individual hydrologic and hydrodynamic models (grey); the meteorological forcing (green); tidal forcing (red); intermediate outputs (white); and final output used in our analysis (blue).

- First global scale assessment of the joint influence of riverine and coastal drivers on flooding in deltas.
- The assessment is based on extreme water levels at 3433 river mouth locations
- Simulations are based on a state-of-the-art global river routing model, forced with a multi-model runoff ensemble and bounded by dynamic sea level conditions derived from a global tide and surge reanalysis.

Dominant flood driver



Dominant driver	Percentage of locations
Compound	19.7%
Discharge	69.2%
Surge	7.8%
Insignificant	3.3%

- We classified the drivers of riverine flooding based on the rank correlation between annual maxima water levels and associated levels of discharge/surge drivers.
- We find compound-dominant flood drivers at 19.7% of the locations analyzed
- Locations with compound-dominant flood drivers generally have larger surge extremes and are in basins with faster discharge response and/or flat topography.

Figure: Flood driver classification into four classes: surge-dominant (blue), discharge-dominant (green), compound-dominant (orange) or insignificant (grey) based on Spearman rank correlations between

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Flood levels

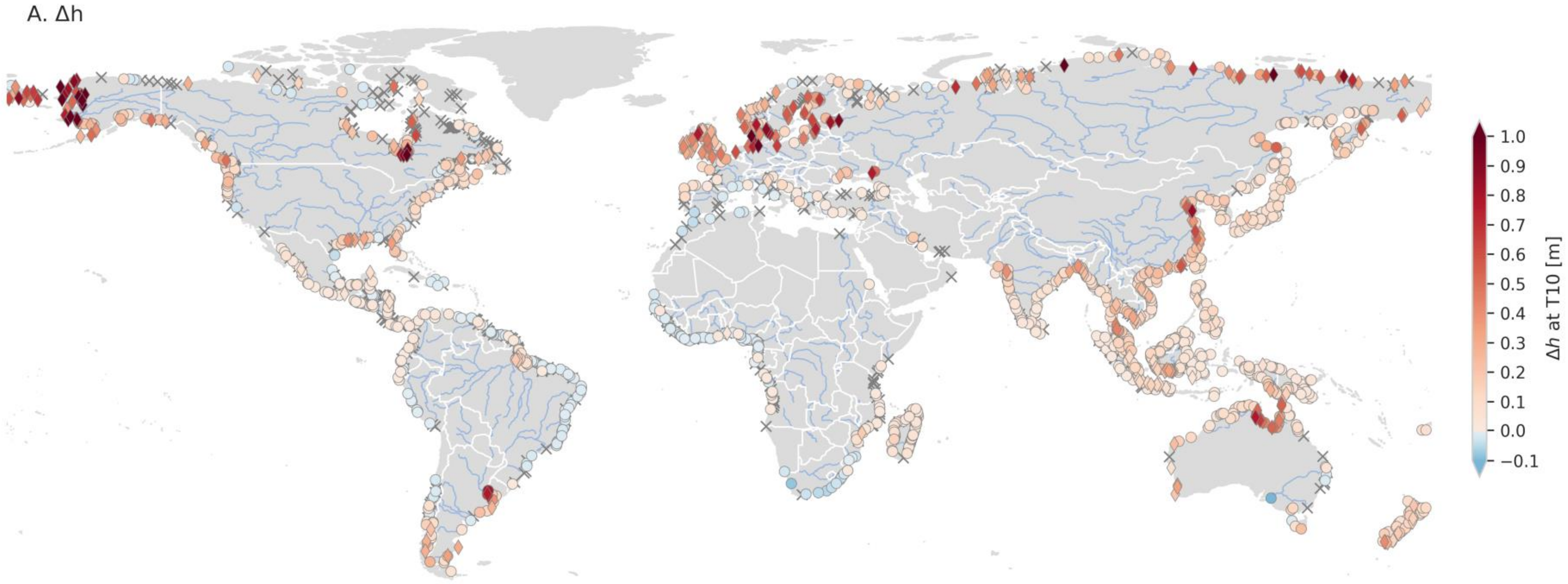

Figure: Ensemble-mean difference in 1-in-10 years (T10) flood levels at the river mouth due to surge. At locations indicated with a diamond, the difference is larger than the 5-95% bootstrap confidence intervals for all ensemble members; at locations indicated with a cross, the sign of difference is not consistent across the ensemble members.

- We assessed the effect of surge on riverine water levels based on experiments with and without surge in the dynamic sea level boundary.
- Globally, surge exacerbates T10 flood levels at 64.0% of the locations analyzed, with a mean increase of 11 cm.
- A small decrease in T10 flood levels is observed at 12.2% of locations analyzed due to negative surge levels associated with dominant seasonal gyre circulations.
- This increase is generally larger at locations with compound- or surge-dominant flood drivers.

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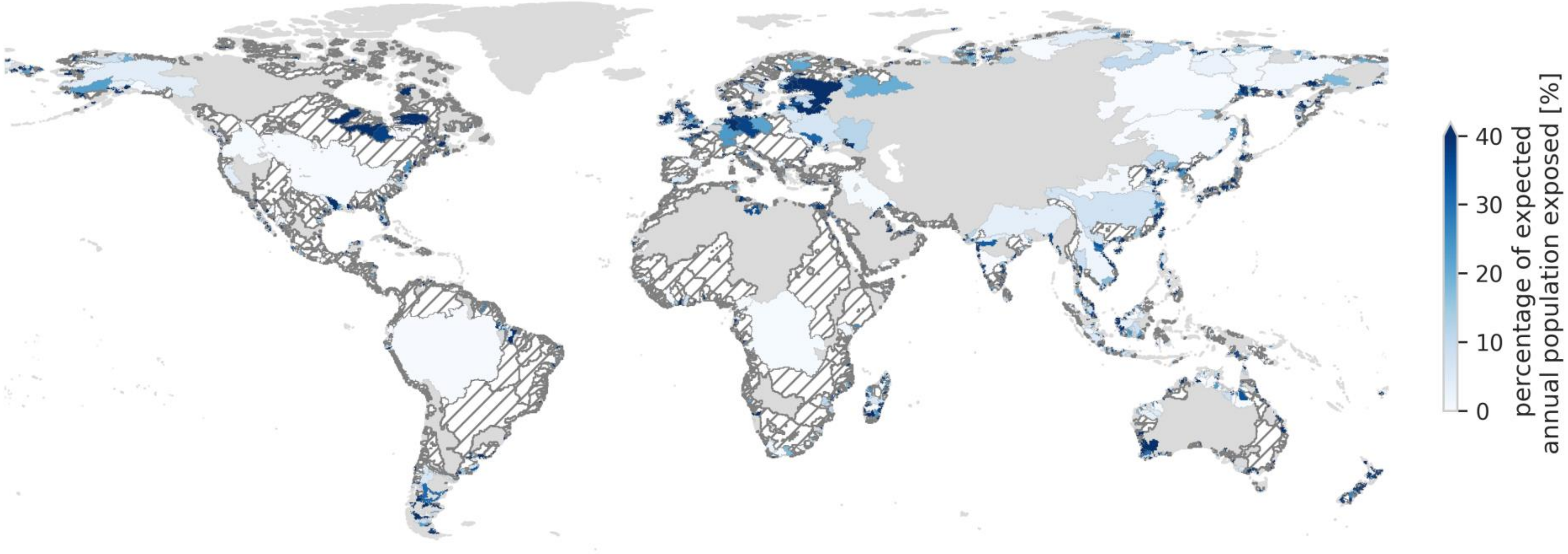
Population exposed



- If storm surge is ignored, flood depths are significantly underestimated for 30.7 million out of a total of 332.0 million (9.3%) of the expected annual population exposed to riverine flooding

Figure: Percentage of ensemble-mean expected annual mean population exposed to riverine flooding for whom flood depths are underestimated if surge is ignored, assuming no flood protection. Hatched basins show insignificant difference in flood depth; grey areas are not simulated (i.e. Greenland and Iceland) or not connected with GTSM (e.g. Irrawaddy). Note that the entire basins are colored while the underestimation of flood depths occurs in the coastal areas of the basin.

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Conclusions

- Our research underlines the importance of including dynamic downstream sea level boundaries in (global) riverine flood risk studies.
- Large scale flood risk studies would improve from a more holistic representation of flooding in our models.

Full paper: Eilander et al. (2020) - ERL
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The effect of surge on riverine flood hazard and impact in deltas globally

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