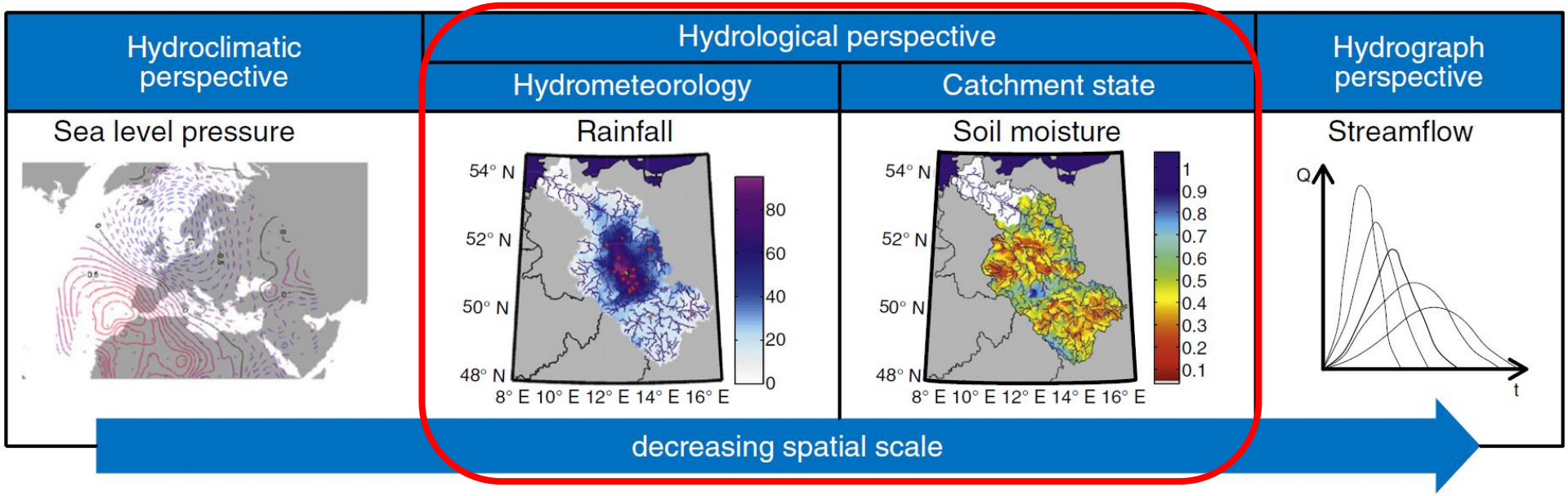
On the influence of extreme rainfall and antecedent soil moisture on flood hazards in Africa

Yves Tramblay[1], Gabriele Villarini[2], El Mahdi El Khalki[3], Gabi Gründemann[4,5], Denis Hughes[6]

1 HSM (Univ. Montpellier, CNRS, IRD), France
2 IIHR-Hydroscience & Engineering, The University of Iowa, Iowa City, Iowa, United States of America
3 Georesources, Geoenvironment and Civil Engineering Laboratory, University Cadi Ayyad, Marrakech, Morocco
4 Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, Netherlands
5 Centre for Hydrology, University of Saskatchewan, Canmore, Alberta, Canada
6 Rhodes University, Institute for Water Research, South Africa



Tarasova, L, Merz, R, Kiss, A, et al. Causative classification of river flood events. WIREs Water. 2019; 6:e1353. https://doi.org/10.1002/wat2.1353

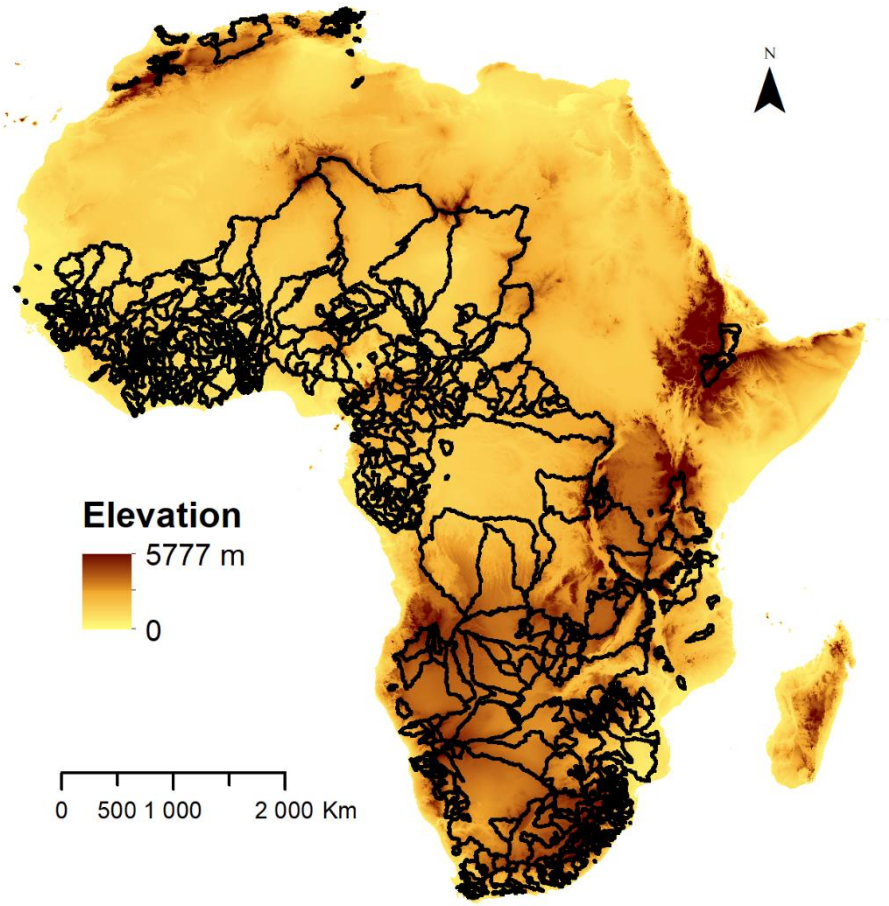
Different flood generation mechanisms can occur in different catchments

The African continent is largely under-represented on global studies on flood risk

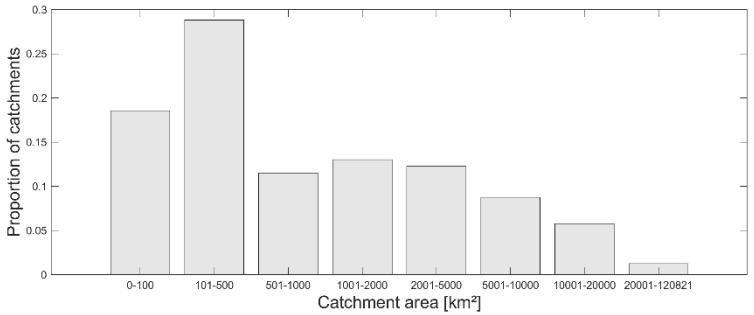
Knowing the key drivers of flood risk is useful for:

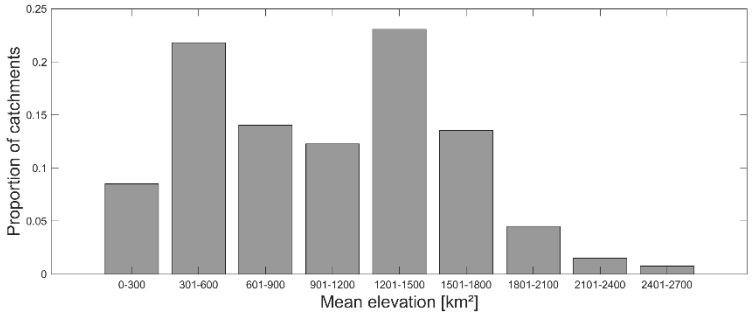
- flood forecasting on multiple timescales
- analyzing the long-term evolution of flood risk

Data and methods



We use a sample of 399 basins in Africa, with 10 years of daily discharge data during 1981-2018





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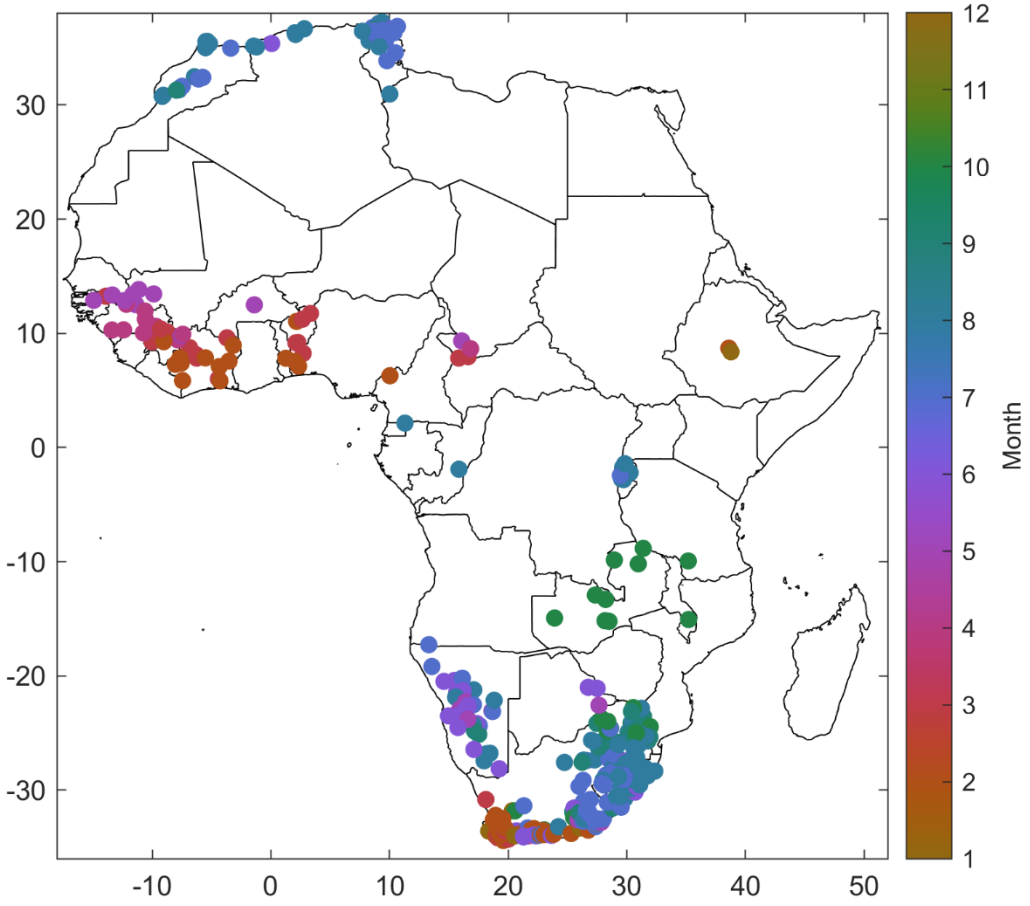
Month with the annual minimum discharge



We extract the Annual Maximum Flood (AMF), using local hydrological years (Wasko et al. 2020)

Local hydrological year starts after the month with the minimum discharge

Wasko, C., Nathan, R., & Peel, M. C. (2020). Trends in Global Flood and Streamflow Timing Based on Local Water Year. Water Resources Research, 56(8). https://doi.org/10.1029/2020WR027233

Comparison of different flood drivers:

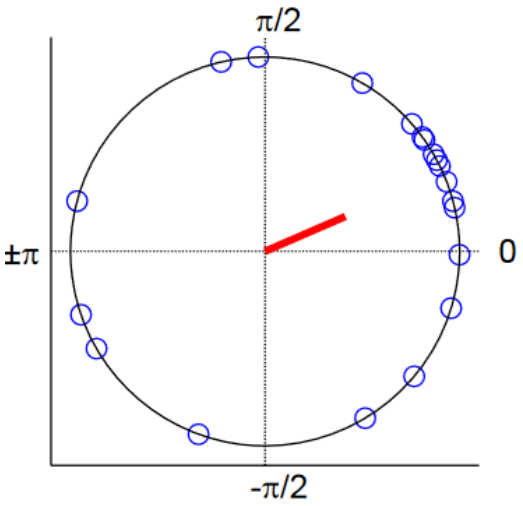
- 1-day annual maximum precipitation (CHIRPS and ERA5)
- 5-day annual maximum precipitation (CHIRPS and ERA5)
- 1-day annual maximum soil moisture (ERA5-Land)

Variable	Product	Resolution
Precipitation	Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)	Daily (1981-present) 5km
Precipitation	ERA5 reanalysis of ECMWF	Daily (1979-present) 30km
Soil moisture	ERA5-Land reanalysis of ECMWF	Daily (1981-present) 9km

Methods:

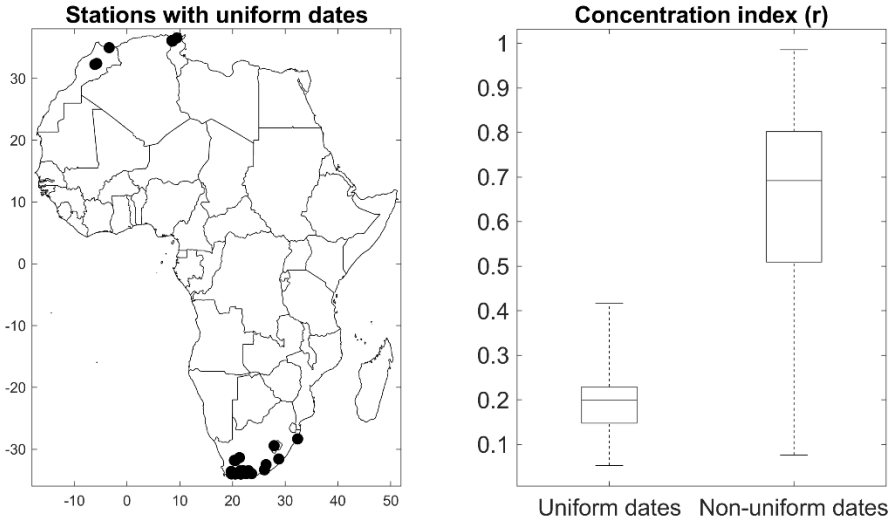
Directional statistics: each annual maximum is converted into an angular value, the mean date of occurrence (ϑ) and its variability (r) can be computed

Correlation analysis: the Spearman correlation coefficient is computed between the different time series of annual maximum

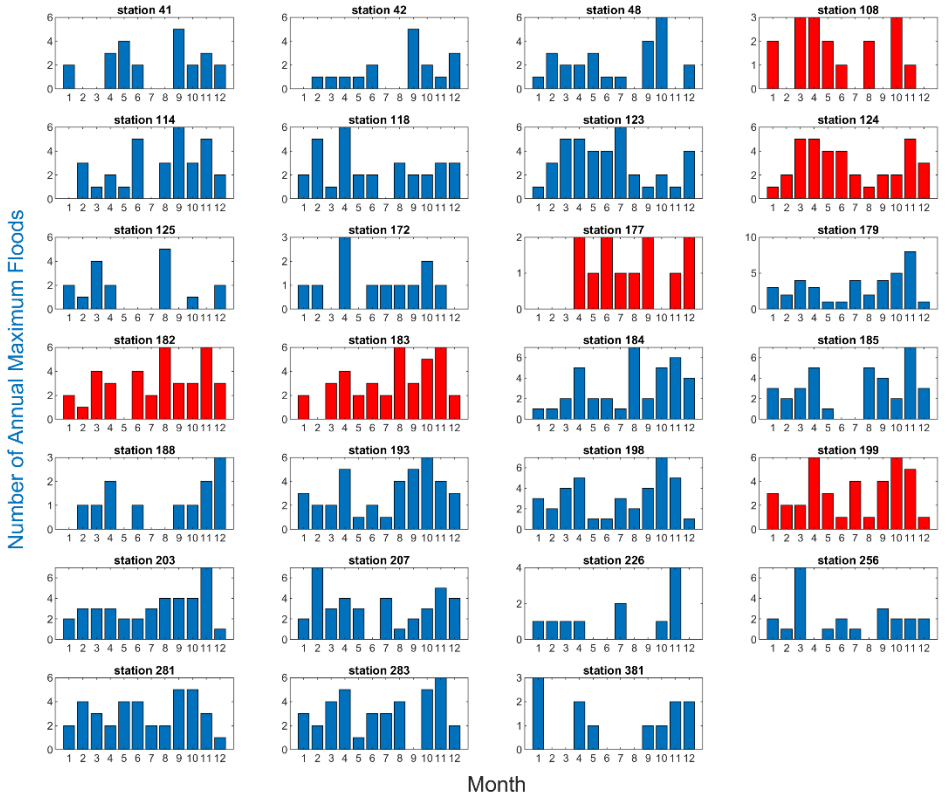


P. Berens, CircStat: A Matlab Toolbox for Circular Statistics, Journal of Statistical Software, Volume 31, Issue 10, 2009
http://www.jstatsoft.org/v31/i10

Results

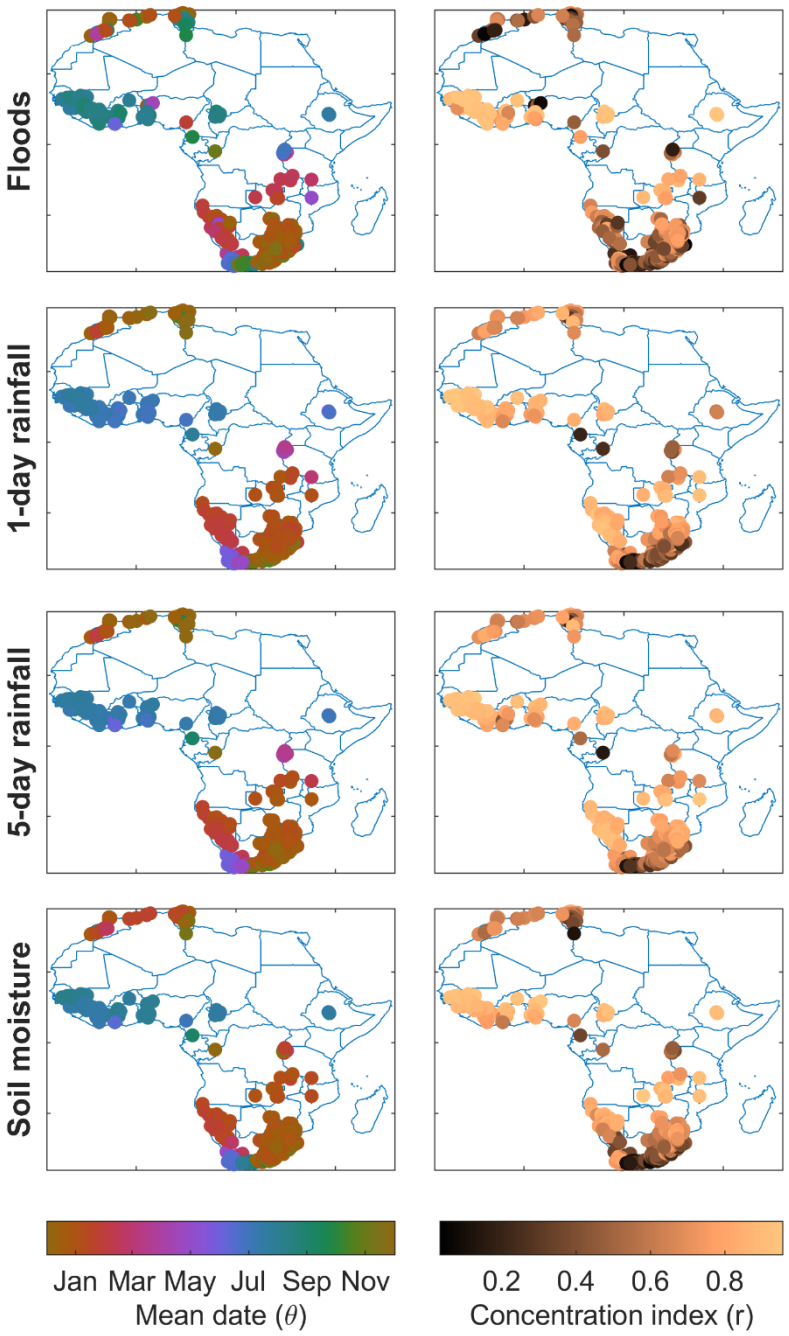


Prior to the analysis, we checked if stations have an uniform AMF seasonality (with the Rayleigh and Hermans-Rassons tests for circular uniformity)



An uniform seasonality is detected at 27 stations only, these stations are all located in semi-arid areas, with a strong interannual variability

Among these stations, only 6 can be considered uniform, in red (all are small basins <200km²)



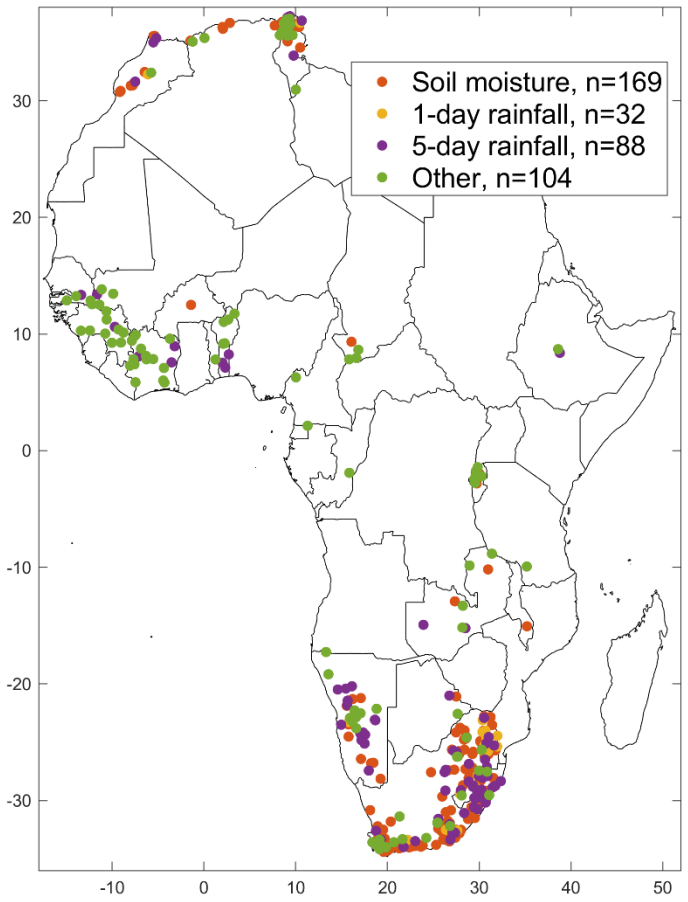
The spatial patterns of floods, extreme rainfall and soil moisture are remarkably consistent

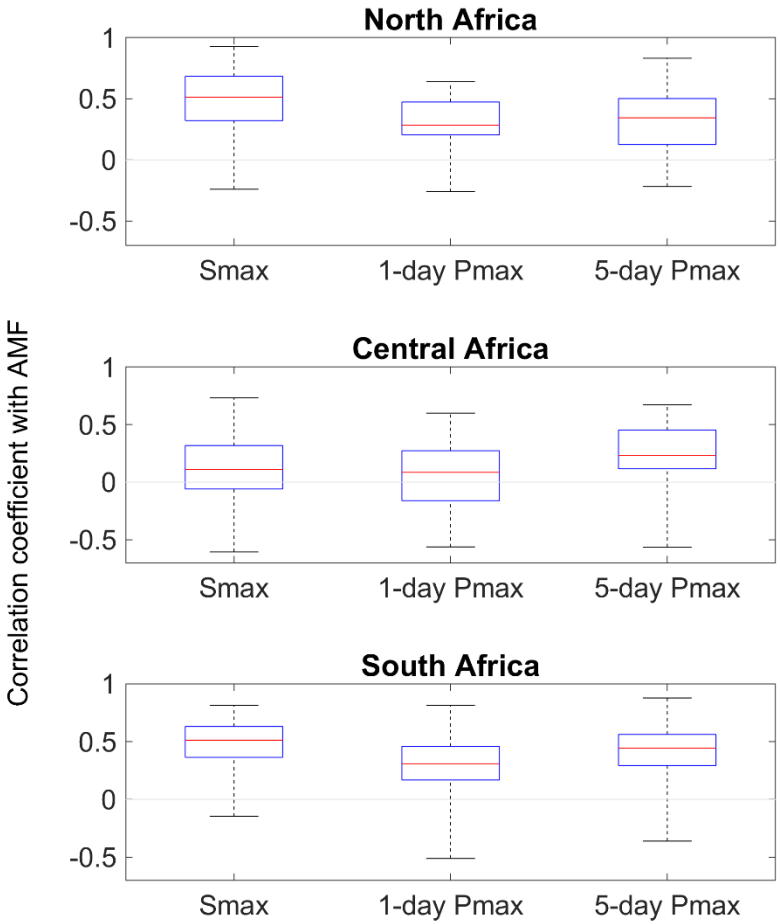
For 85% of stations, same seasonality of AMF and annual maximums precipitation and soil moisture (Kuiper test)

The correlations between the mean day of occurrence of AMF **stronger with soil moisture** (r=0.55) than with 5-day (r=0.47) or 1-day rainfall (r=0.44)

Very similar results with CHIRPS or ERA5 rainfall

Highest correlation reported between AMF, annual max. soil moisture and precipitation





Strongest correlations between AMF and annual maximum soil moisture (in 43% of basins)

Annual maximum rainfall is a poor descriptor of interannual AMF variability

For 27% of basins, mostly in West Africa, no significant correlations are detected

Conclusion

There is a strong seasonal cycle of floods in the different African regions

The seasonality of floods is more strongly related to annual maximum soil moisture than to annual maximum rainfall

Flood magnitude is more tied to soil moisture variability than annual maximum rainfall changes

- There is a need to consider multiple flood drivers; for small/large floods (limited by data availability)
- There is a need to consider the influence of land use and vegetation changes (as for example in West Africa)

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Tramblay Y., Villarini G., El Khalki M., Grüendemann G., Hugues D.: Evaluation of the drivers responsible for flooding in Africa. Water Resources Research, *submitted*

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