



Flood responses to increases in rainfall extremes vary depending on event severity

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The paradox

Are we
maybe
looking at the
'wrong'
events?

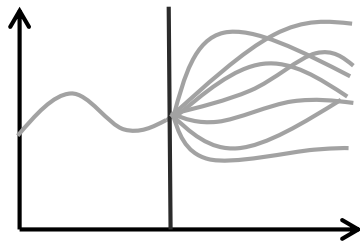
There is little observational evidence of widespread flood increases despite an increase in extreme precipitation.

When do **increases** in extreme precipitation translate to **increases** in flooding?

Seeking answers with a SMILE

Increase sample size to study very rare events

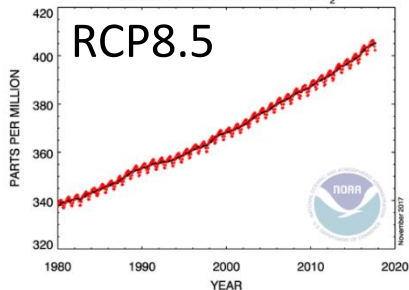
Initial conditions



GHG emissions

GLOBAL MONTHLY MEAN CO₂

RCP8.5



GCM:

CanESM2-LE

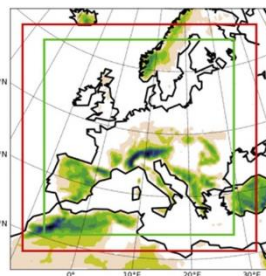
(Kirchmeier-Young 2017)



RCM:

CRCM5-LE*

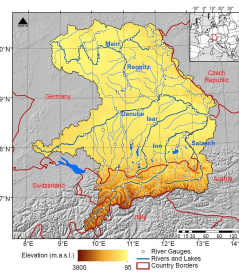
(Leduc 2019)



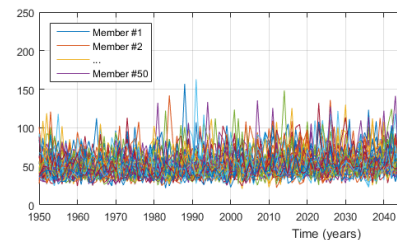
Hydrology:

WaSiM*

(Willkofer 2020)



Streamflow

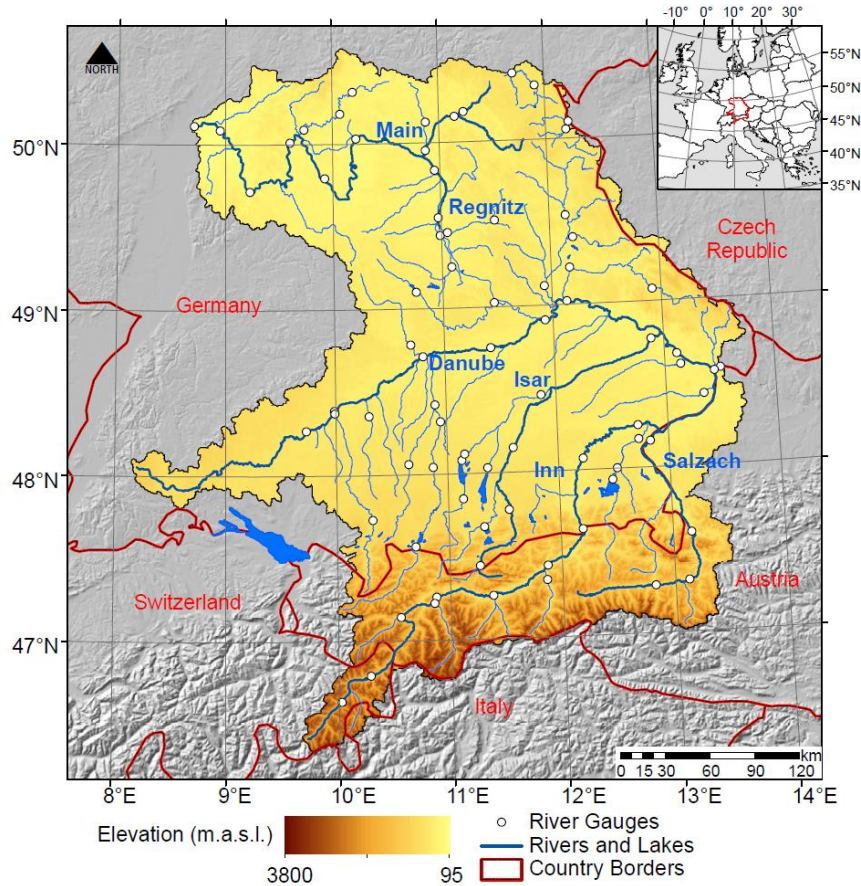


50 member x 40 years = 2000 years
Historic + Future streamflow

* Simulations with the CRCM5 and WaSiM were performed within the ClimEx project funded by the Bavarian Ministry for the Environment and Consumer Protection

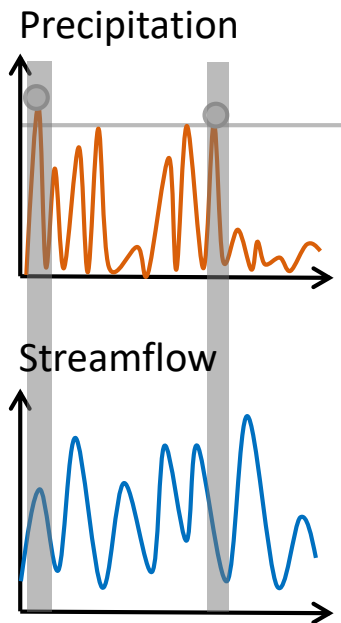
Hydrological Bavaria

78 catchments, only weakly influenced

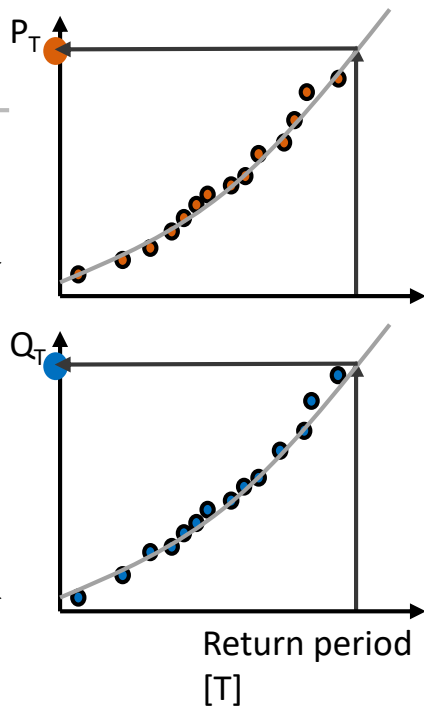


Extreme value analysis

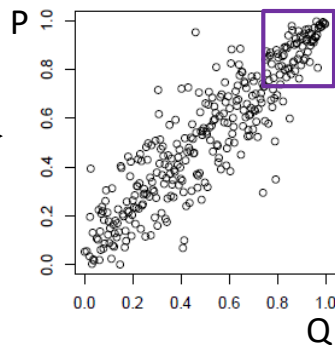
Identify P-Q pairs



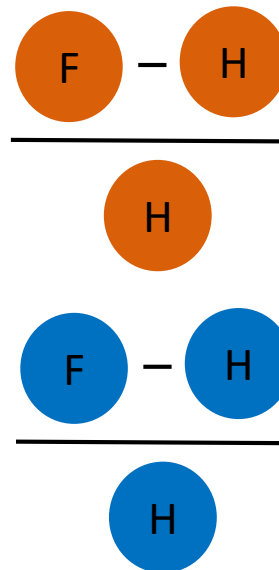
Frequency analysis



Dependence analysis



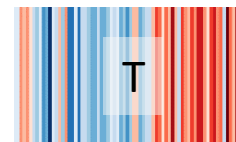
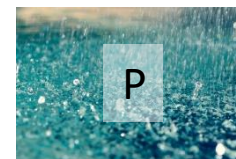
Change assessment



Historic: 1961-2000

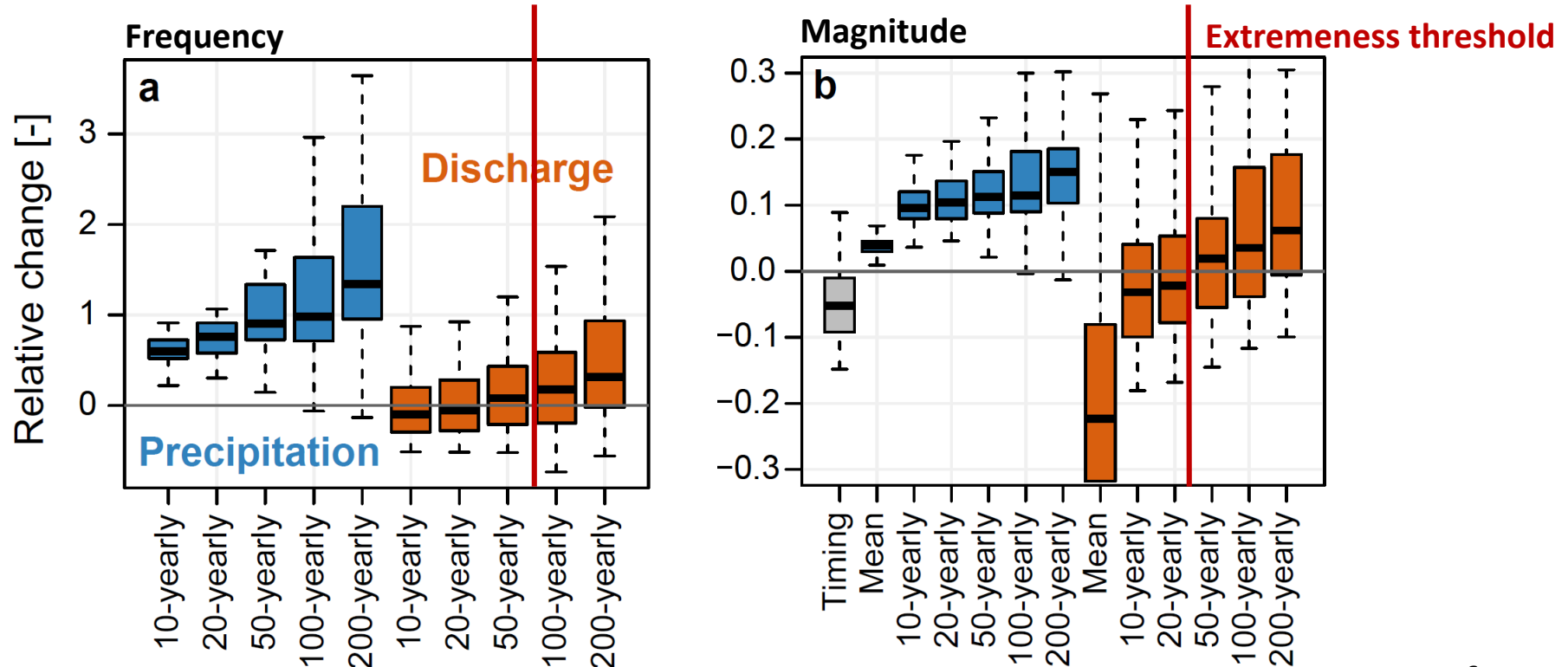
Future: 2060-2099

Drivers

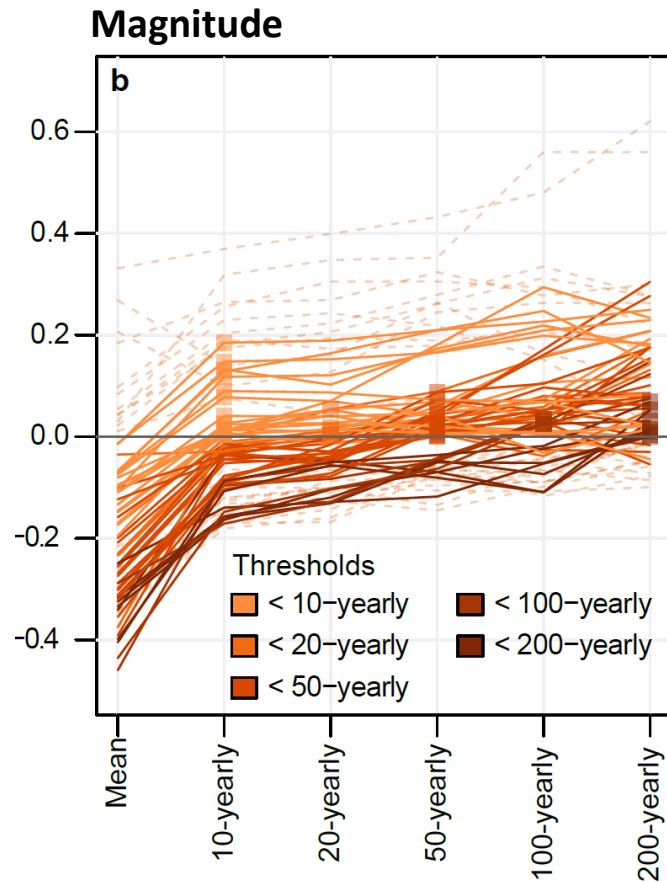
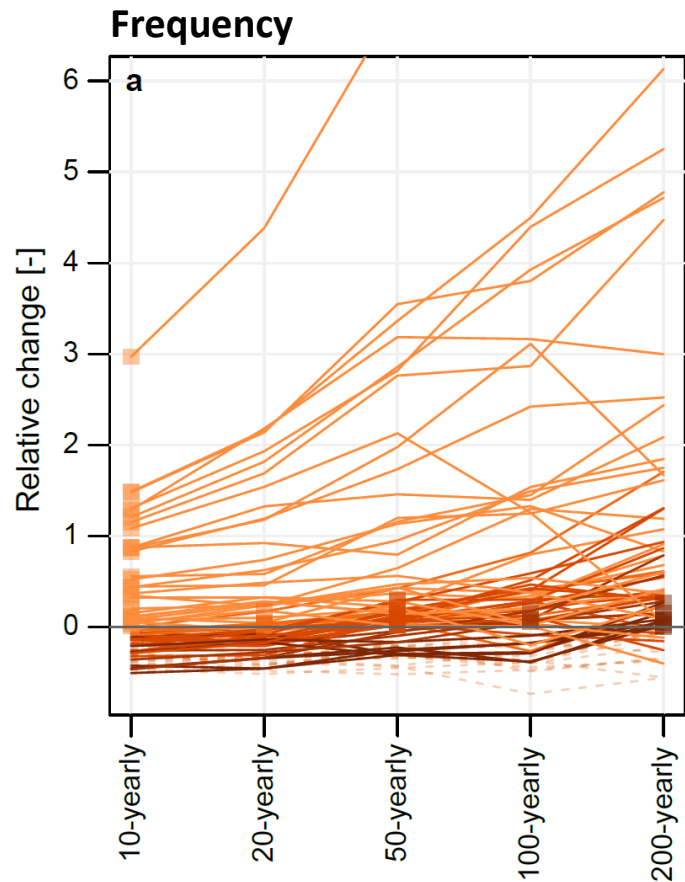


Future changes in extremes

Threshold behavior in flood response to extreme precipitation: above threshold response is dominated by precipitation, below modulated by land-surface processes



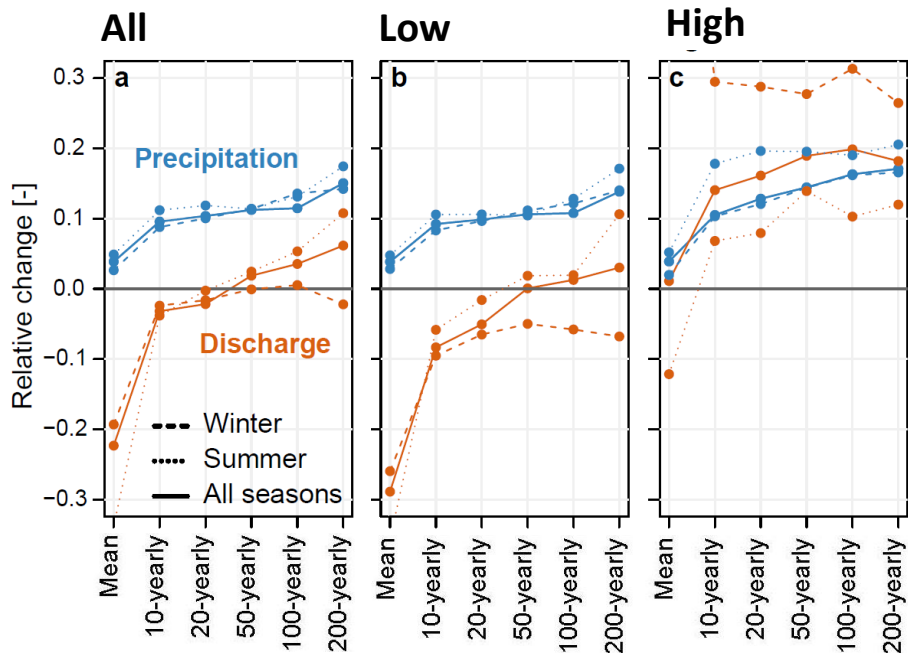
Threshold depends on catchment



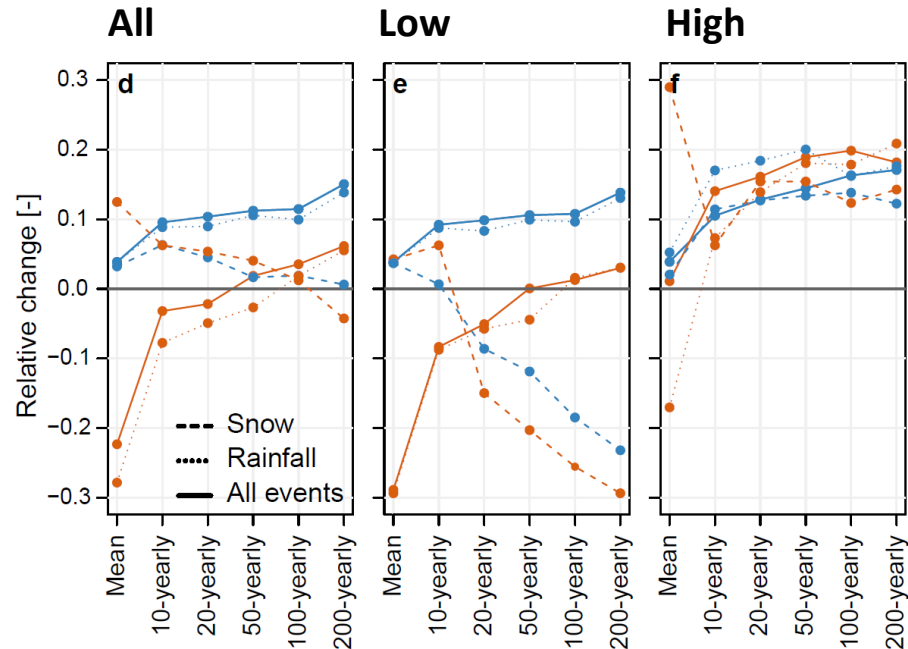
Threshold depends on season and event type

Magnitude

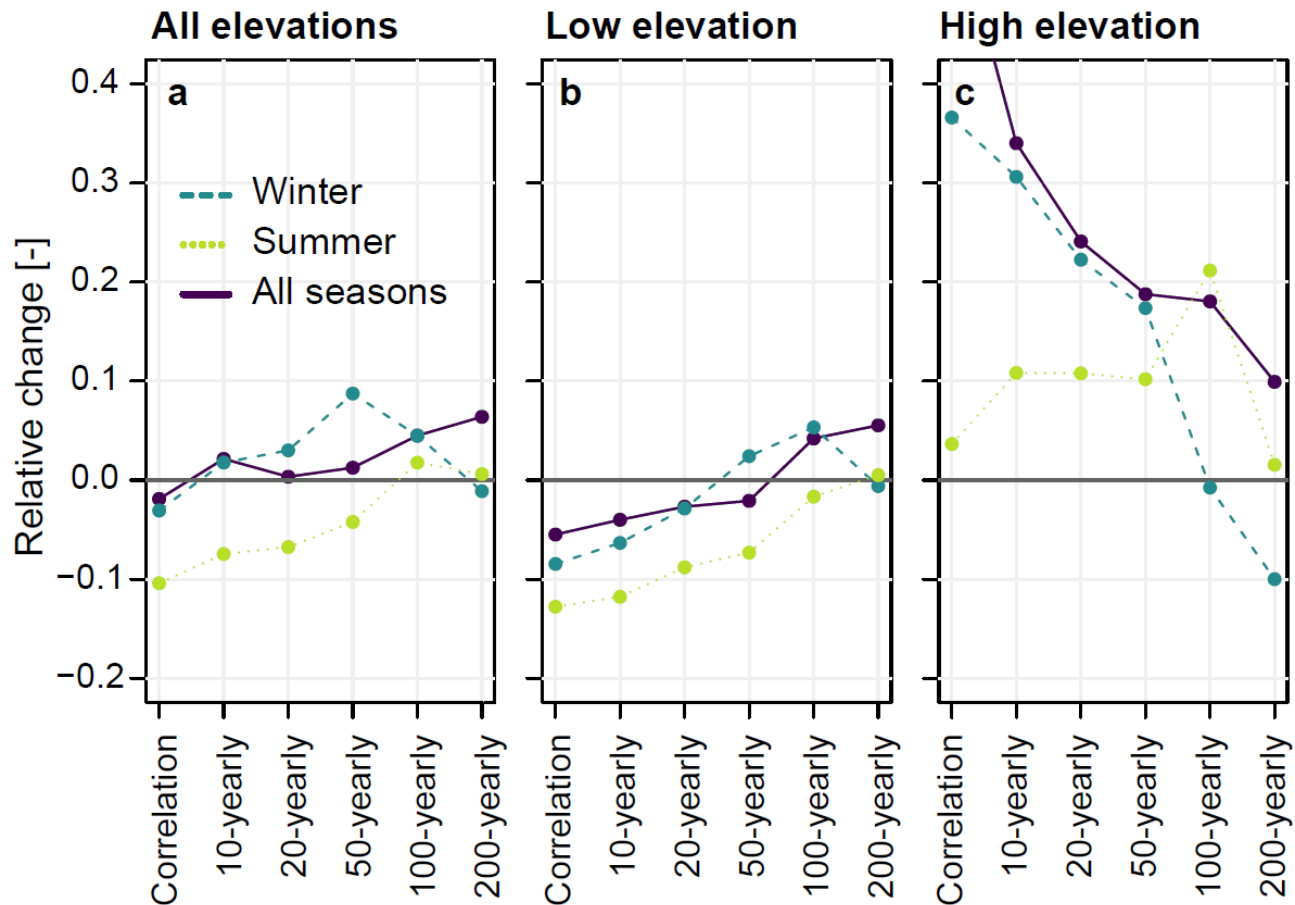
Season



Event type



Dependence changes



Changes in the strength of the P-Q relationship are generally positive above a certain return interval threshold

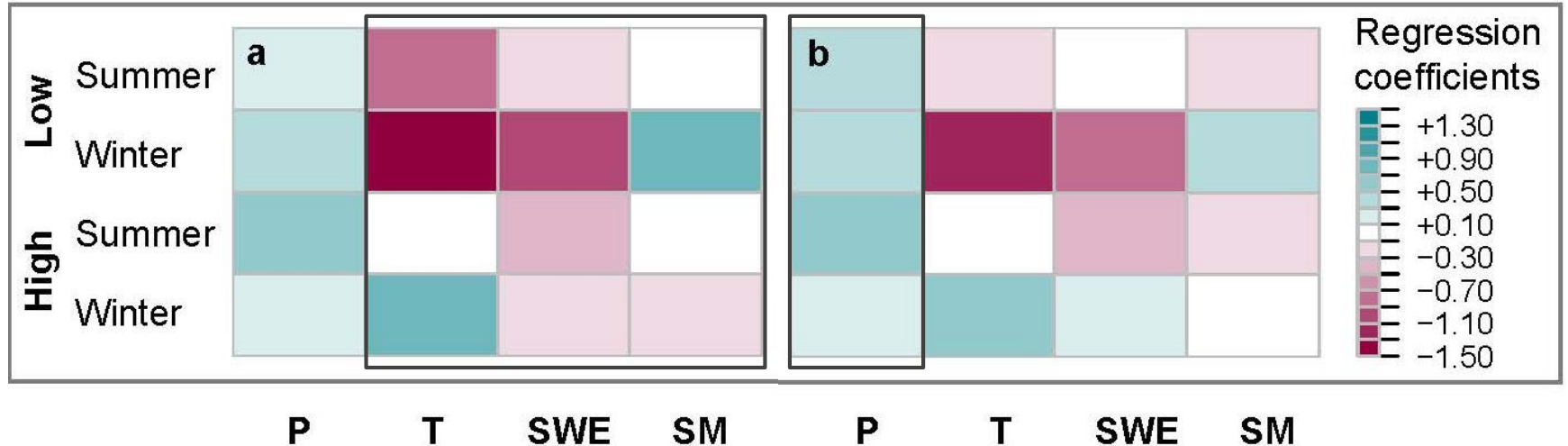
Importance of flood drivers

For moderate and severe extremes, precipitation is positively related to discharge magnitude

The role of all the other drivers – particularly that of temperature – strongly depends on level of extremeness, elevation, and season

Moderate floods

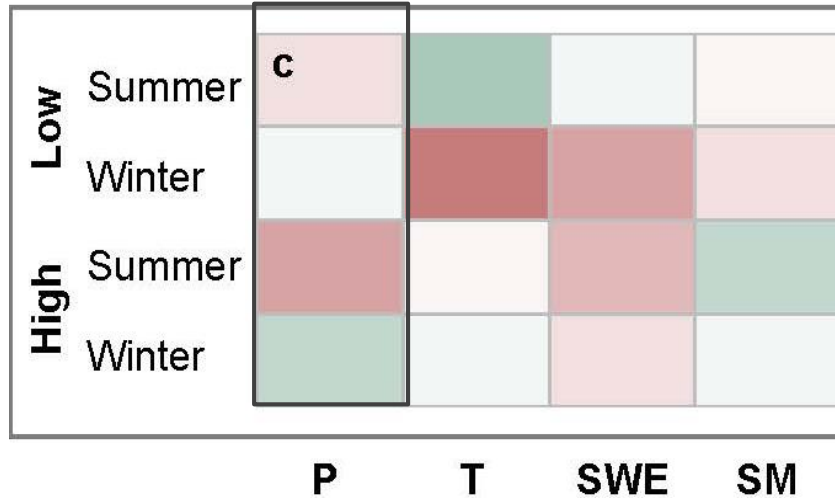
100-year flood



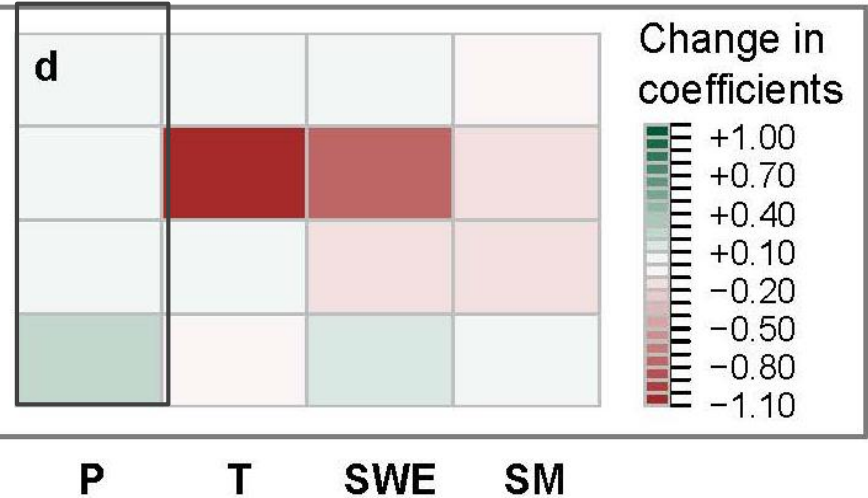
Changes in importance of flood drivers

The future relevance of precipitation as a flood driver increases for severe events while the importance of temperature increases for moderate but decreases for severe extremes

Moderate floods

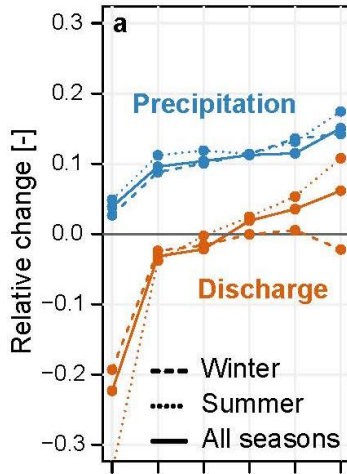


100-year flood

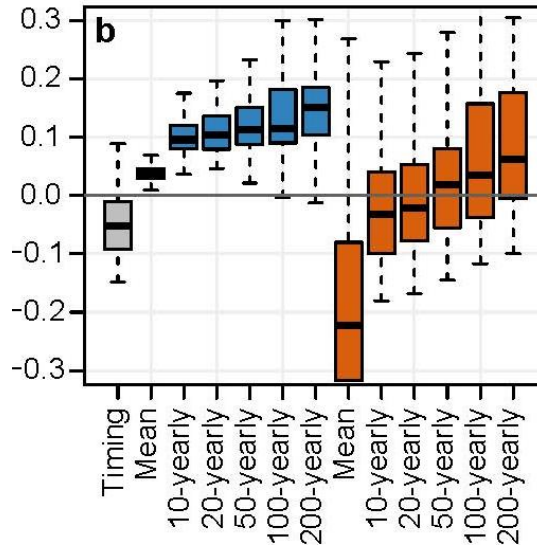


Conclusions

There is a threshold above which extreme precipitation increases outweigh soil drying



Large increases in flood magnitude are likely for the very largest events



Flood paradox can be resolved by separating floods by their intensity

Moderate floods are modulated by land surface processes

Precipitation is the dominant driver for very extreme events

