RESHAPE
nature-inspired water-system solutions

VU VRIJE UNIVERSITEIT AMSTERDAM

IVM Institute for Environmental Studies

Deltares

Summary

HOW DOES STREAMFLOW RESPOND TO CLIMATE VARIABILITY IN EUROPE?

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abstract

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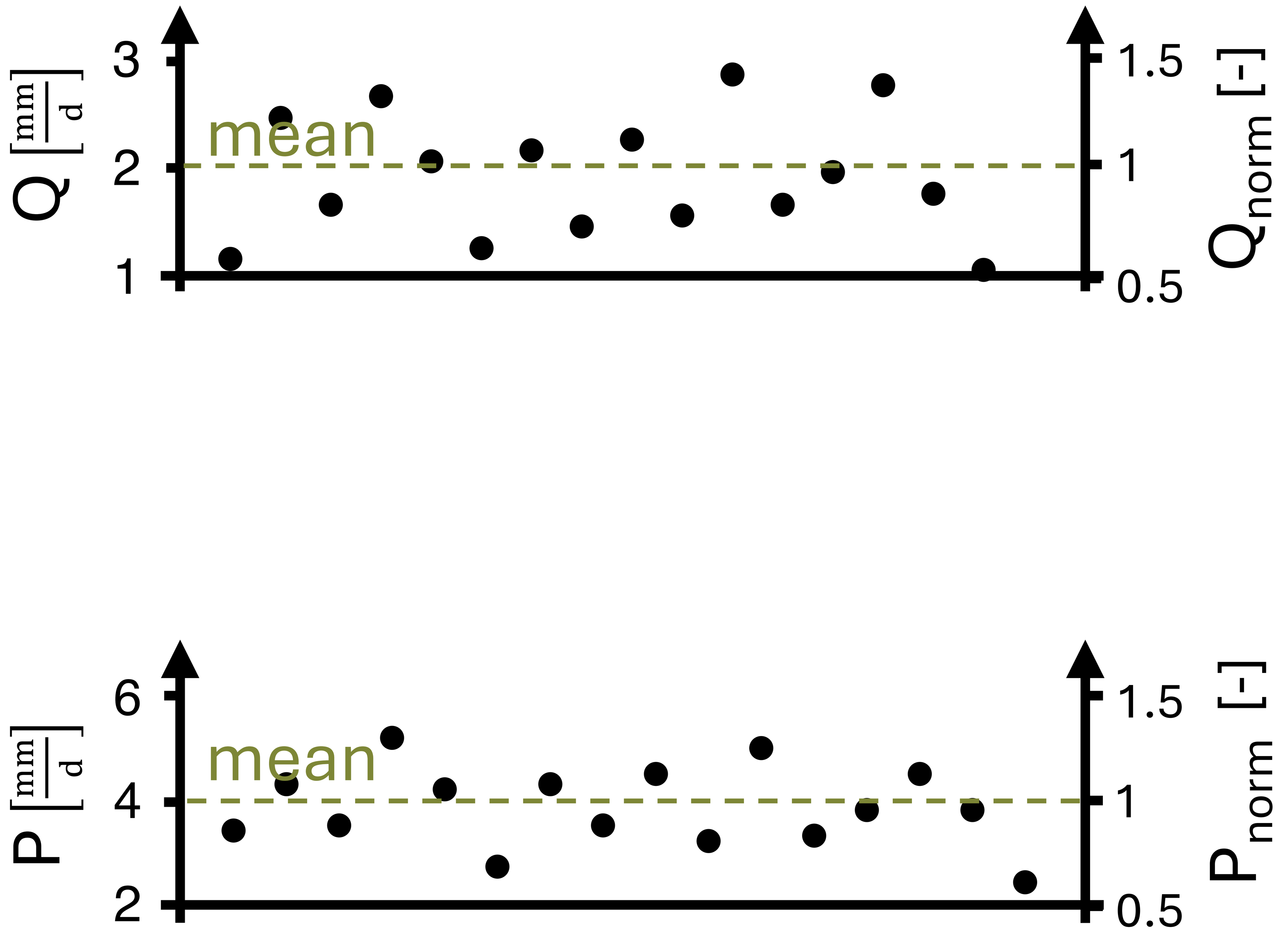
What is our aim?

Reveal the **spatial patterns of climate sensitivity of mean and extreme streamflow** across **European catchments** and

determine the **catchment characteristics** that **shape** these **sensitivities**.

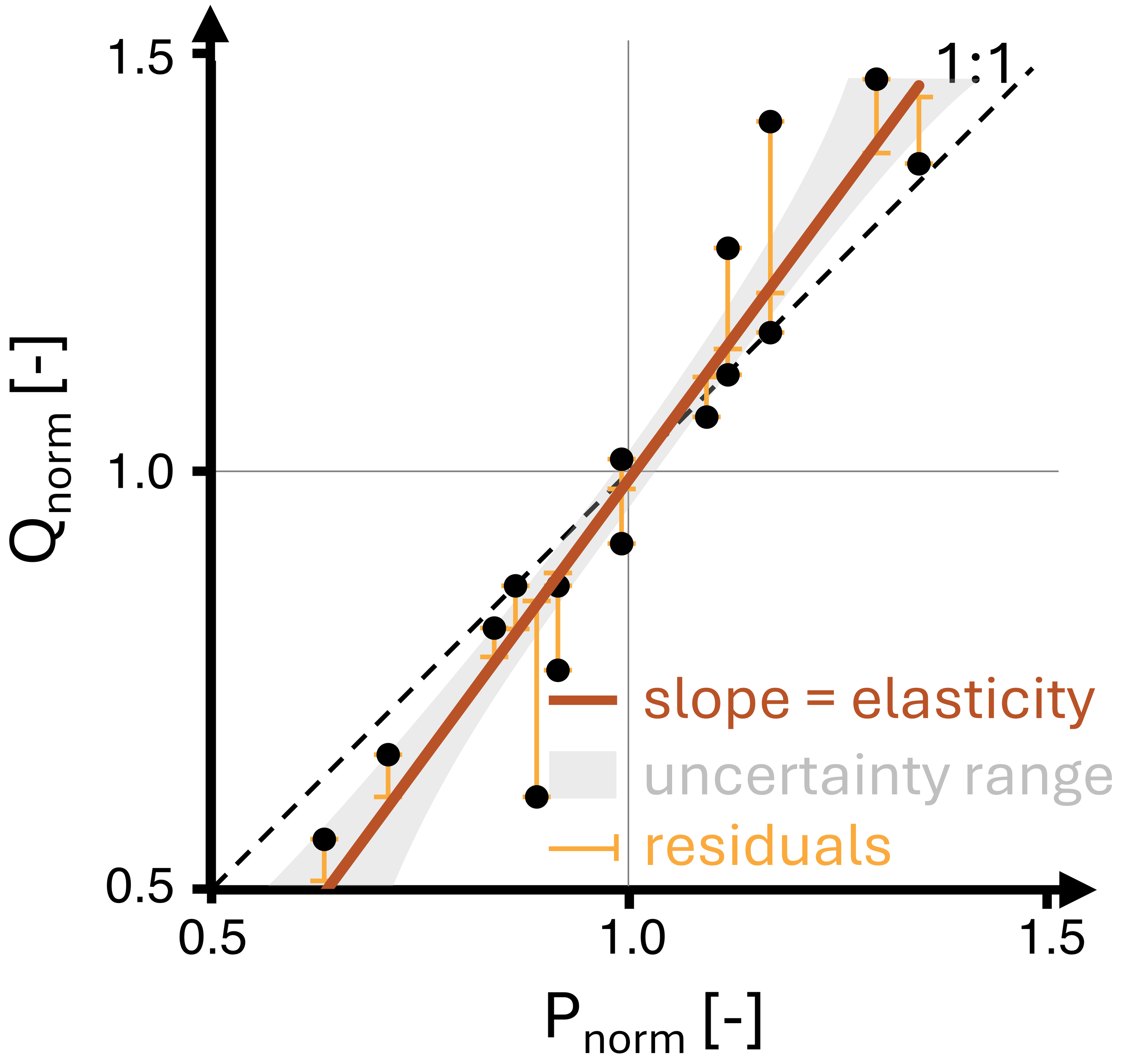
How do we address this?

annual timeseries



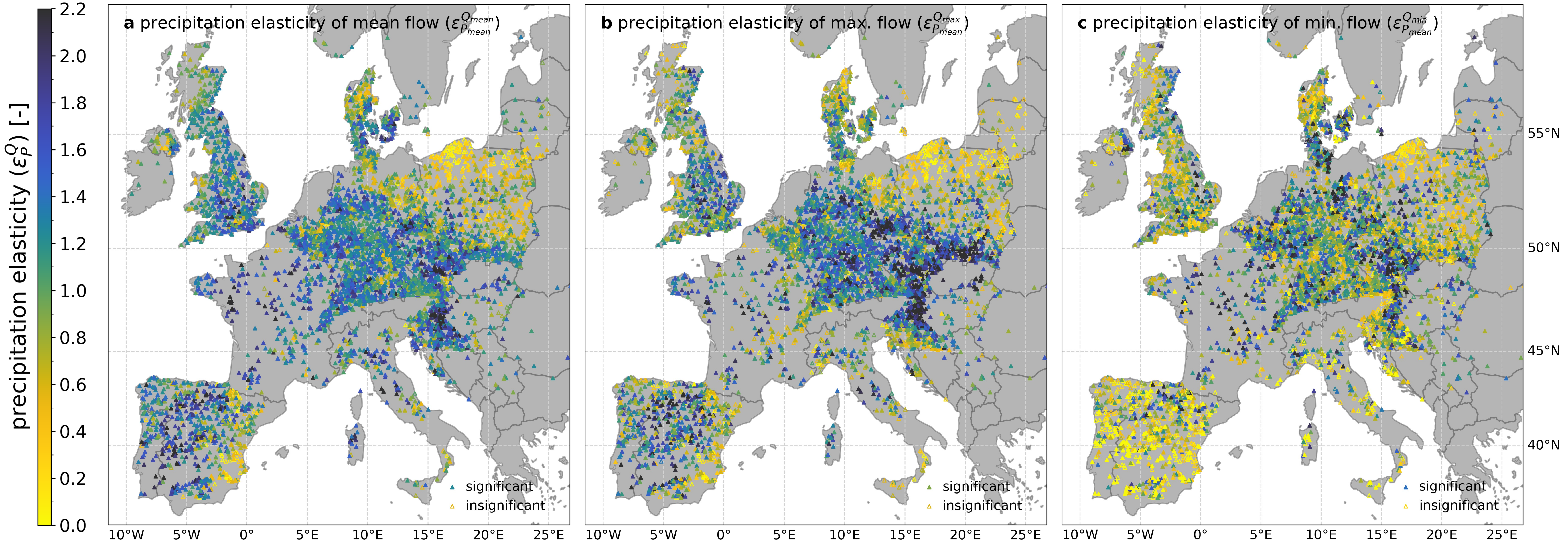
Q: streamflow
P: precipitation
X_{norm}: normalized

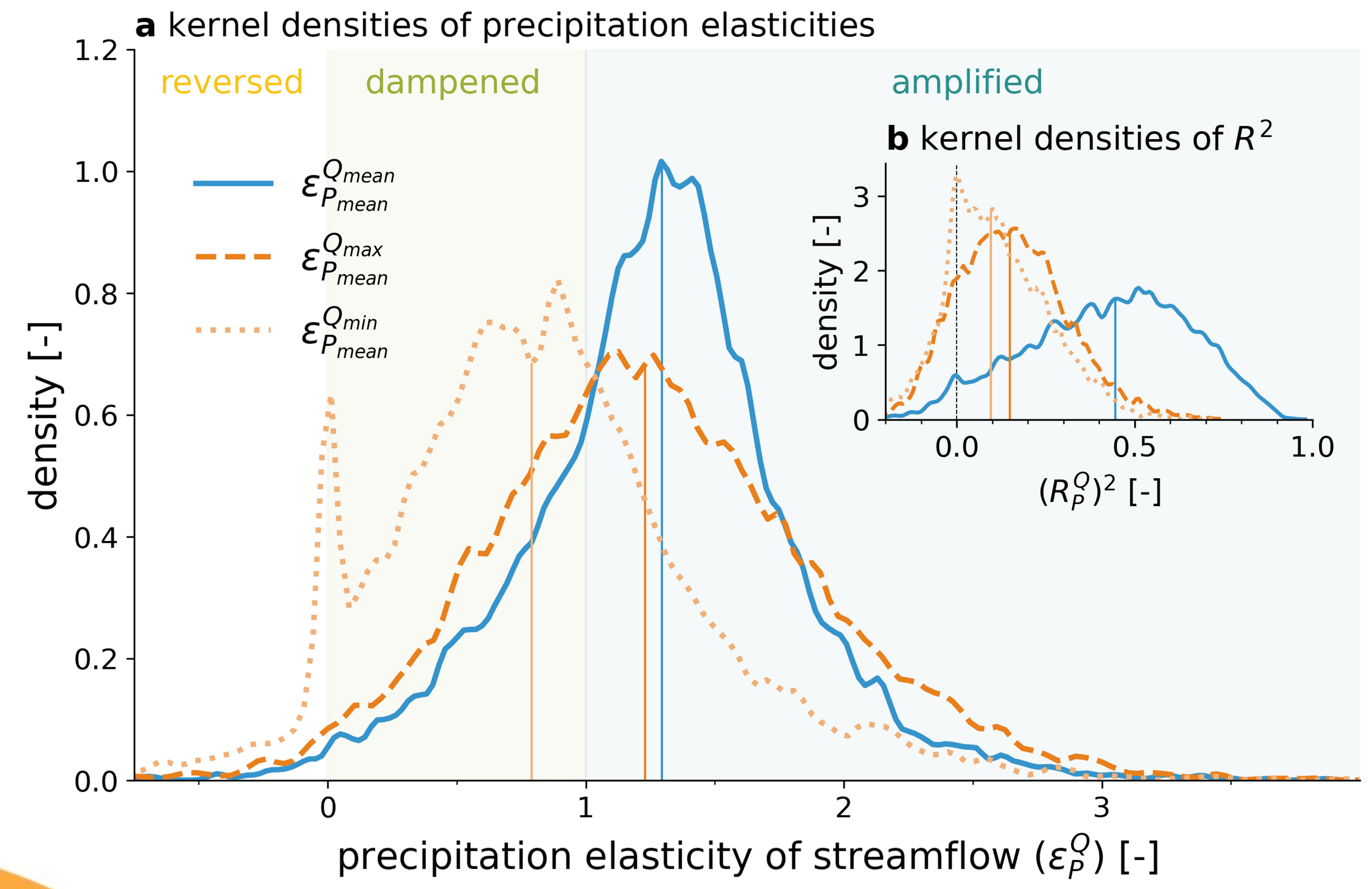
precipitation elasticity



\+ **empirical analysis** for importance of **catchment characteristics**

What do we find?





Typically, annual **mean and max flows amplify precipitation** variations, whereas **min flows dampen them.**

Extended presentation

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abstract

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This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

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RESHAPE
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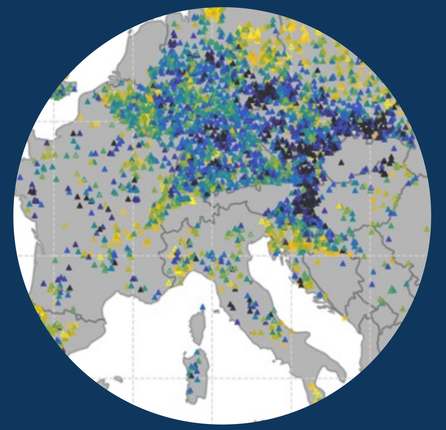
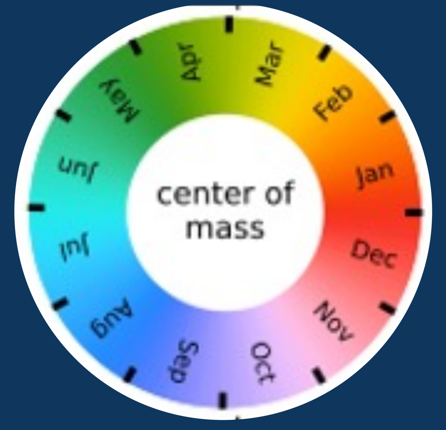
Background



Streamflow response to **annual precipitation**

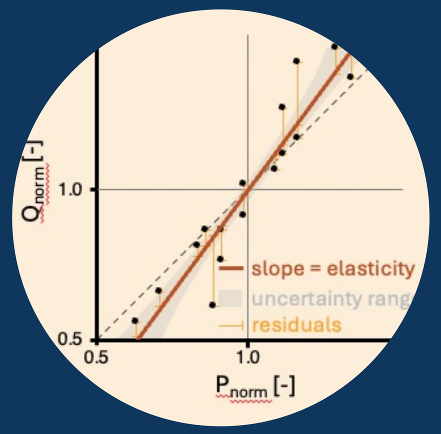


Streamflow response to **seasonal precipitation**

Aim

Streamflow response to **annual temperature**

Streamflow response to **seasonal temperature**



Method

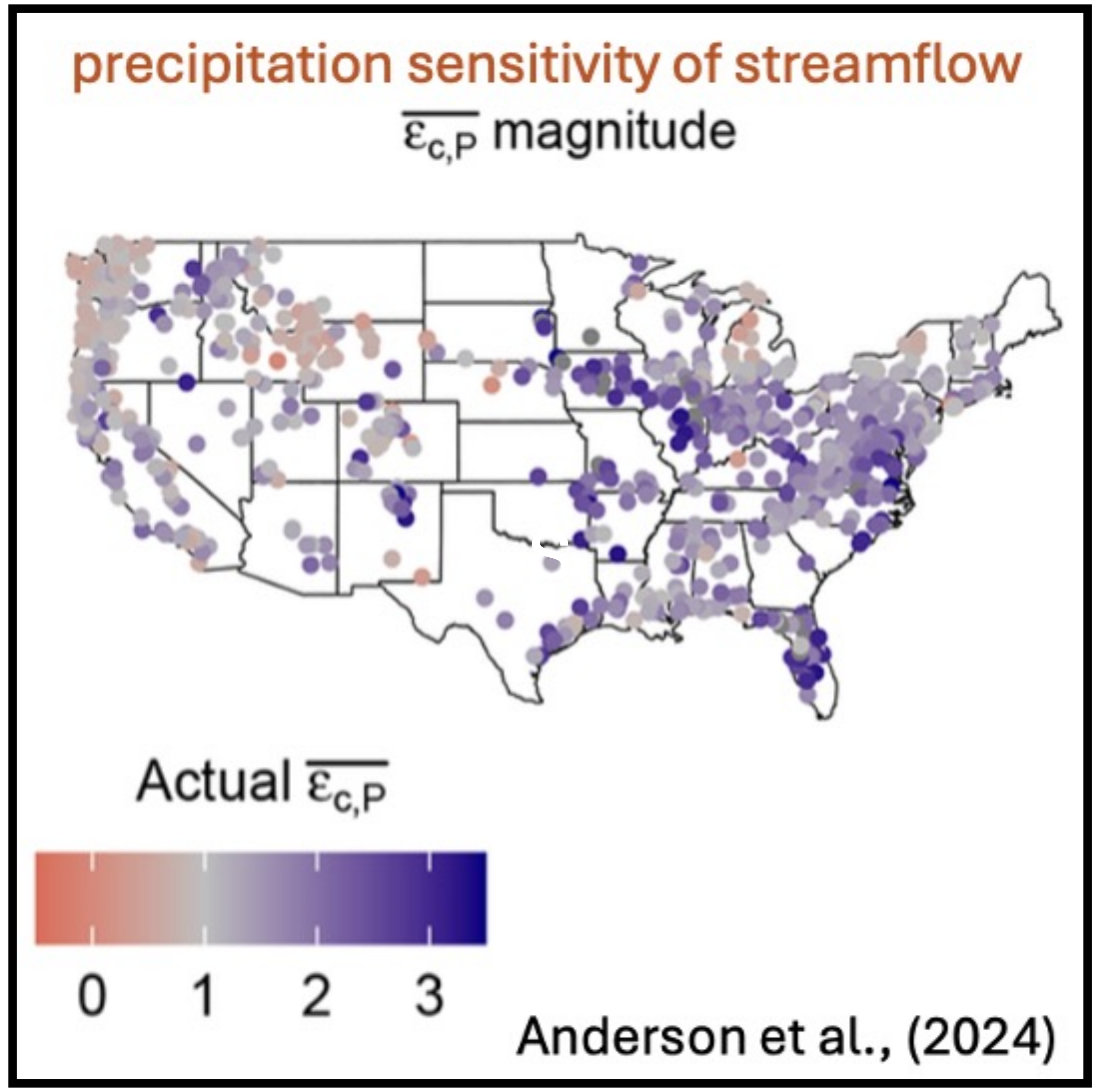
Conclusions

Literature

What do we know?

Climate will influence streamflow means and extremes[1,2]

Precipitation and temperature are key controls on streamflow[3,4]



Climate sensitivities of streamflow vary regionally[5] and with choice of model[3]

What is our aim?

Reveal the **spatial patterns of climate sensitivity of mean and extreme streamflow** across **European catchments** and

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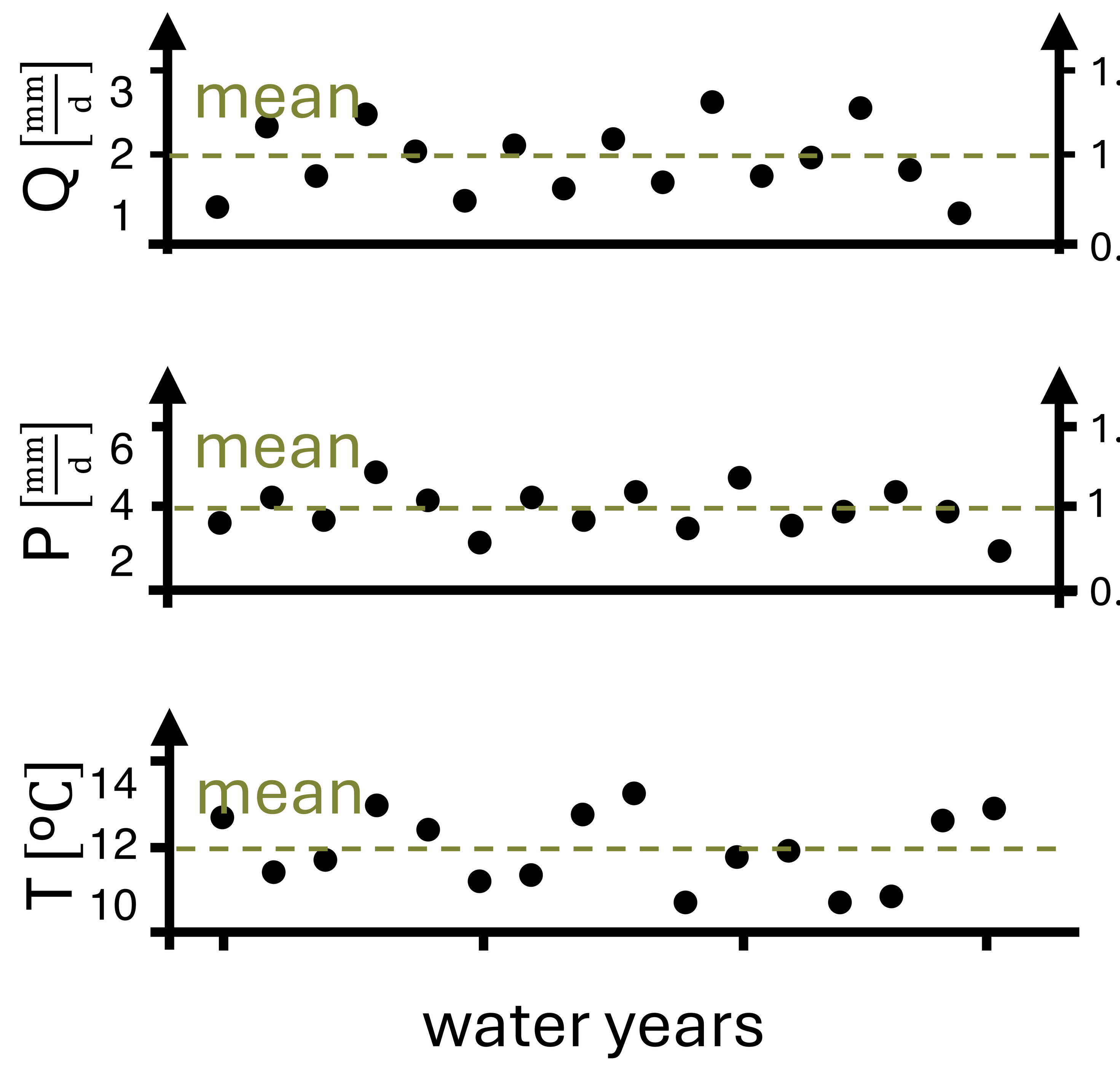
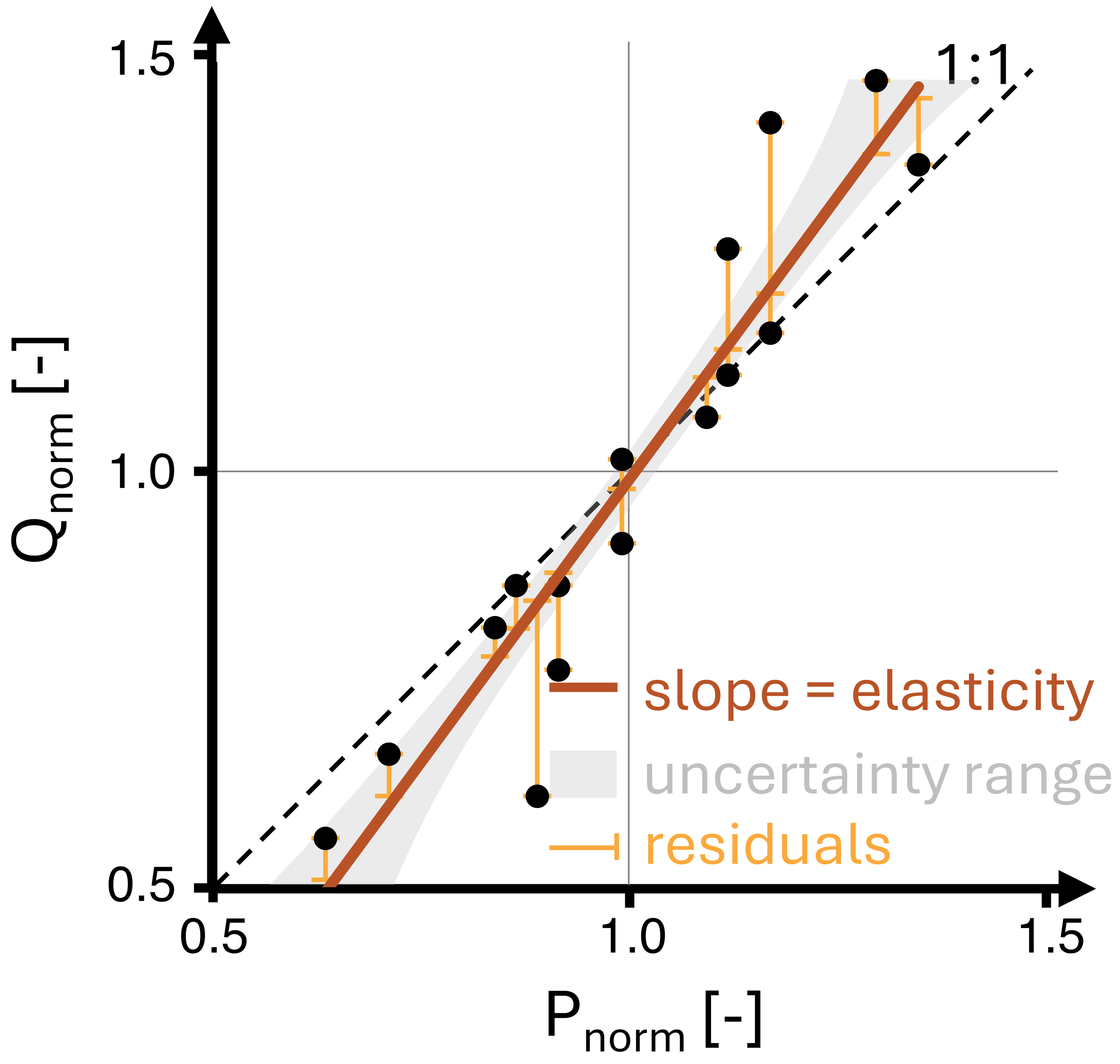
How do we address this?

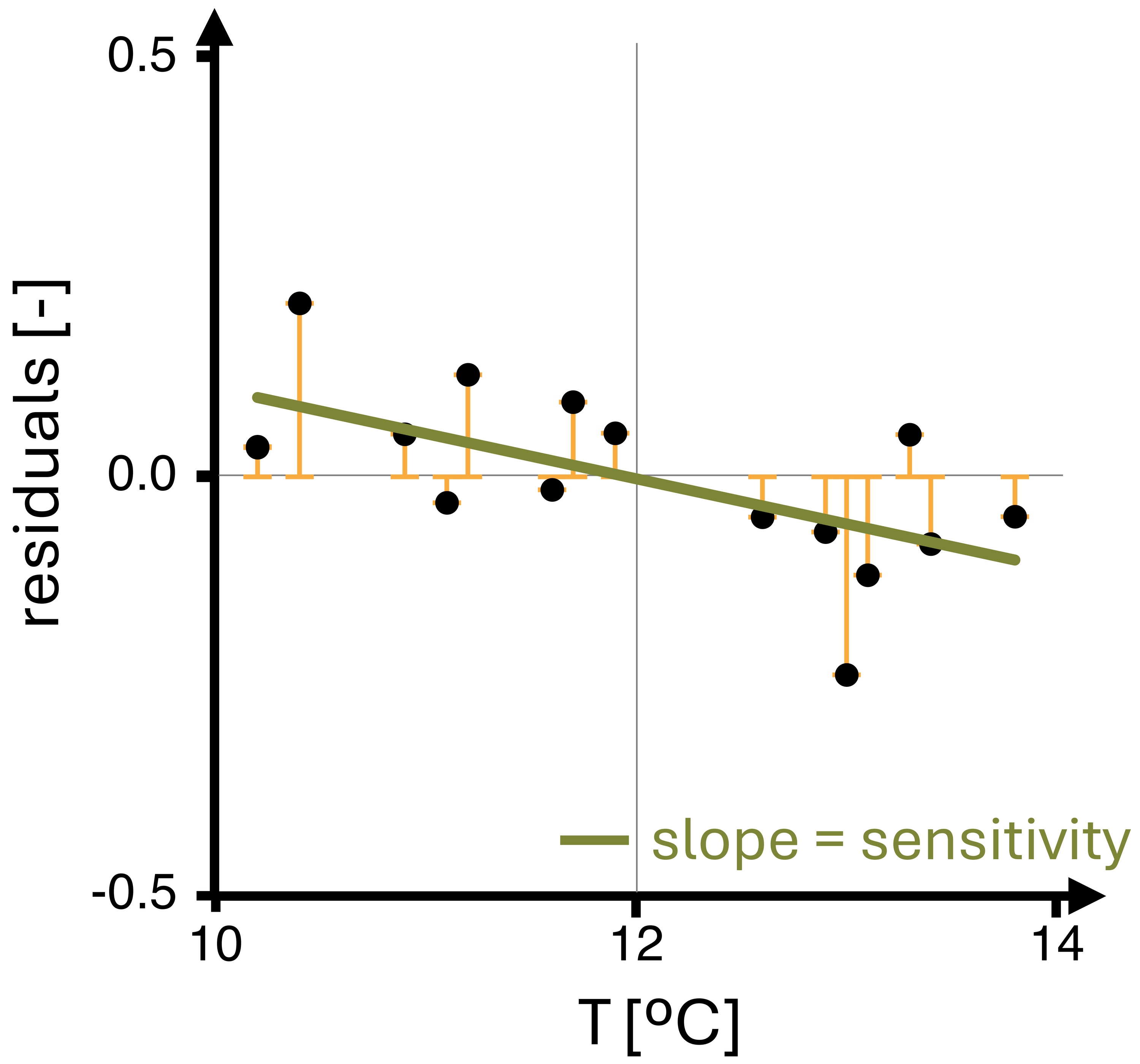
annual timeseries (EStreams[6])



precipitation elasticity[7,8]



temperature sensitivity



Q: streamflow
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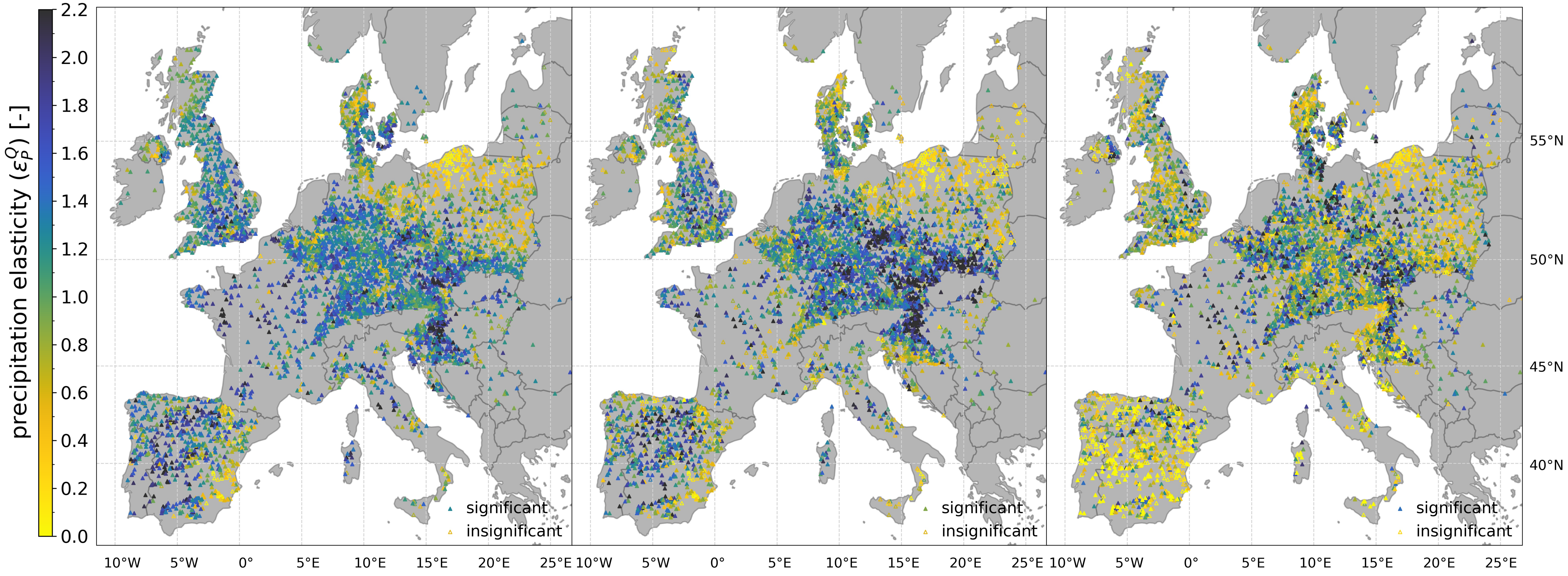
+ **empirical analysis** for importance of **catchment characteristics**

How does **annual streamflow** respond to **mean annual precipitation**?

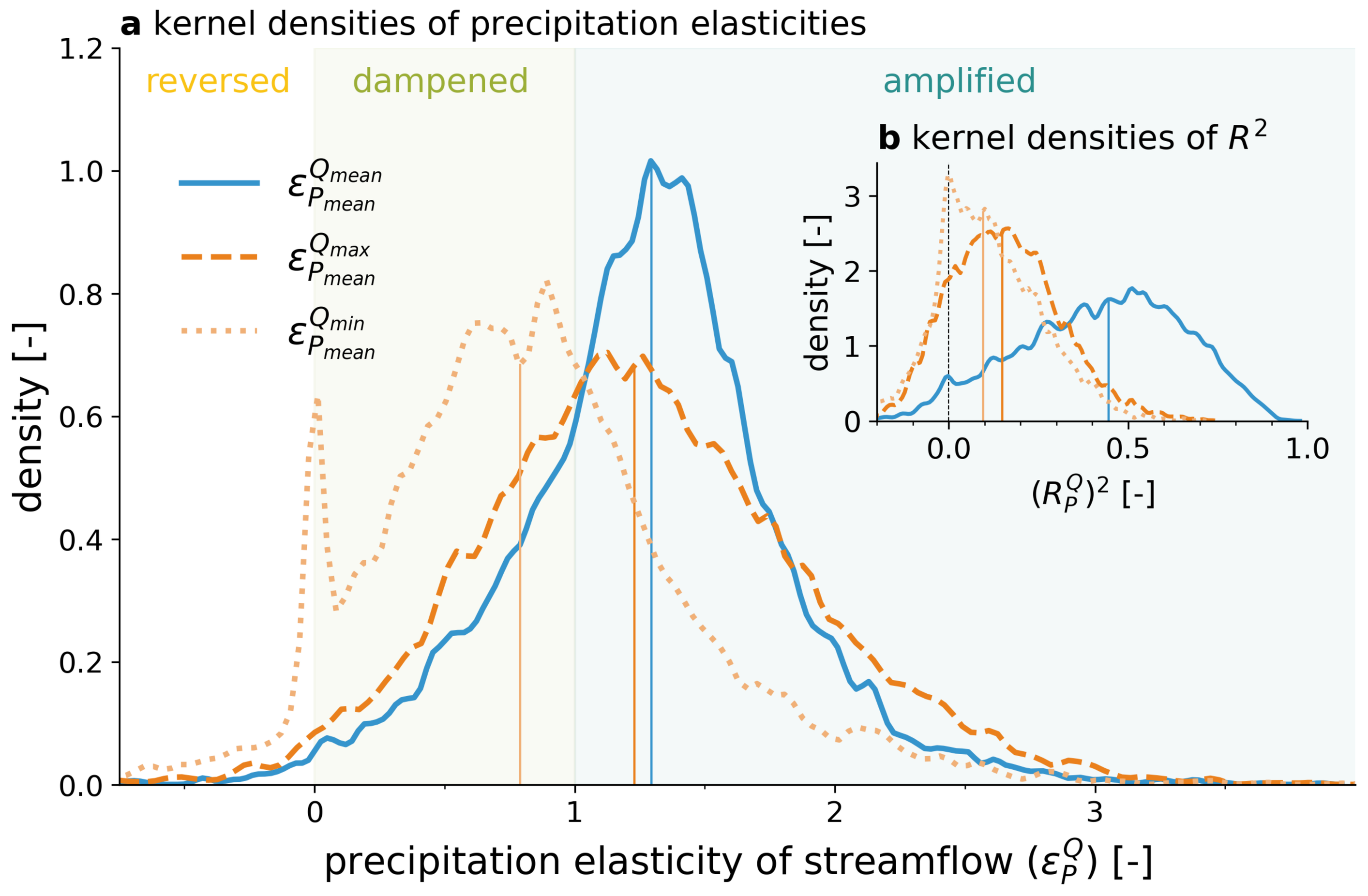


Mean and extreme flow **generally scale positively** with mean annual precipitation

Mean and max flows are typically **amplified** (ε on average >1)

Min flows are typically **dampened** ($0 < \varepsilon < 1$)

R^2 values are highest for mean streamflow and lowest for min flow



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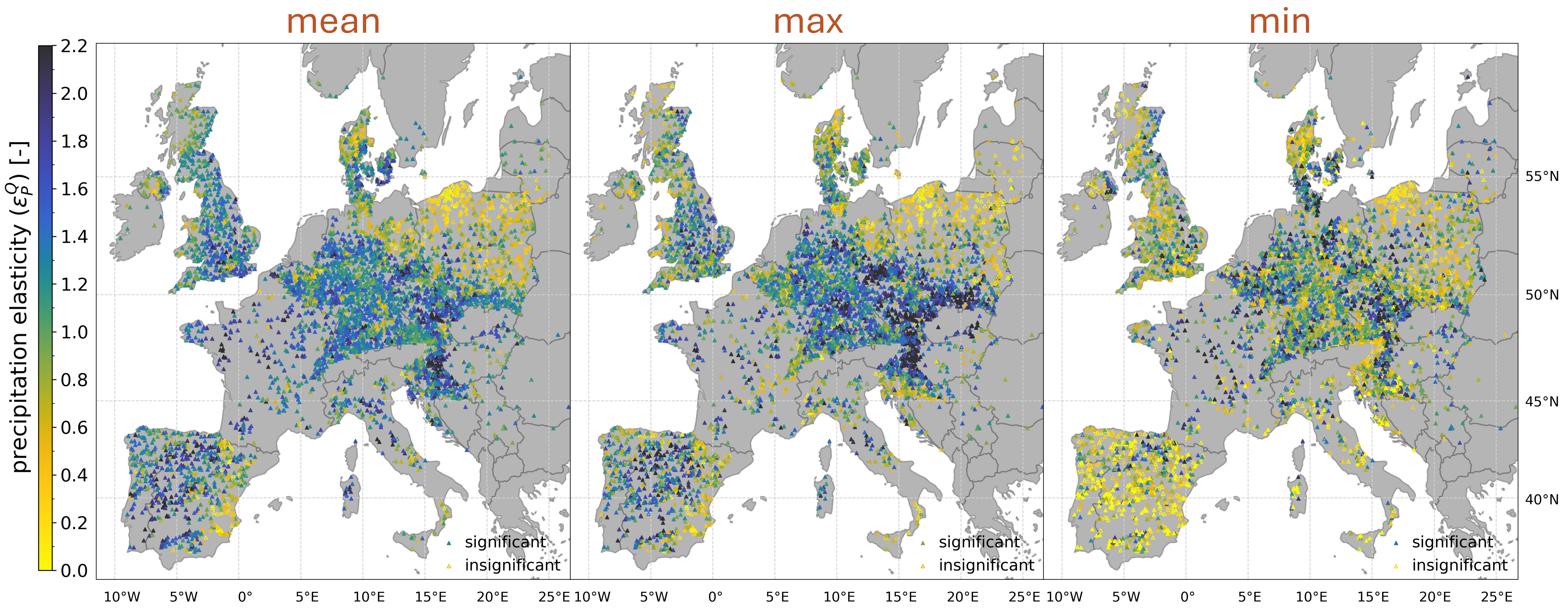
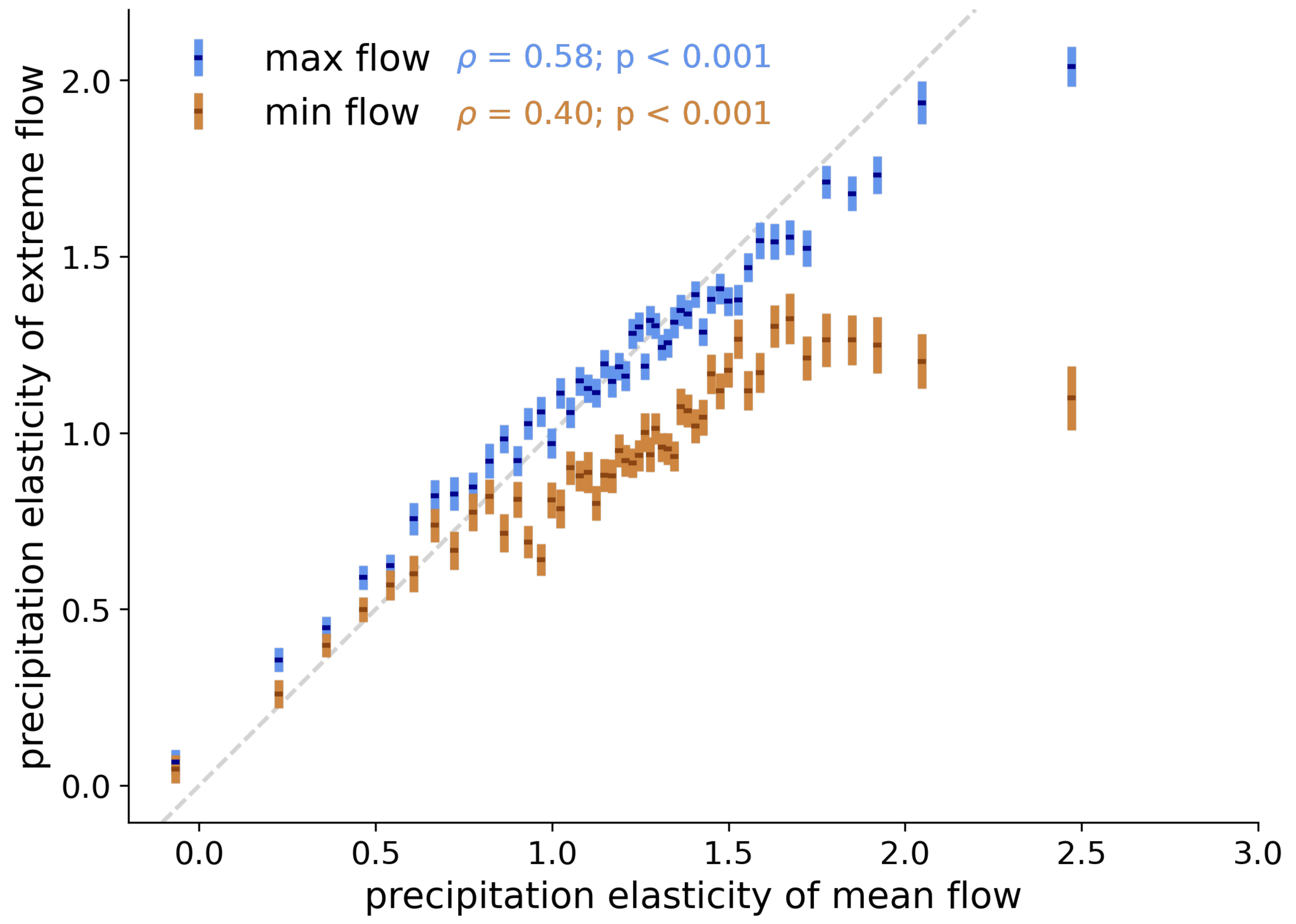


How does the **elasticity of mean annual flows compare** to the elasticity of **max and min flows**?

- Max flows respond very similar to mean flows
- Min flows respond less strong than mean flows



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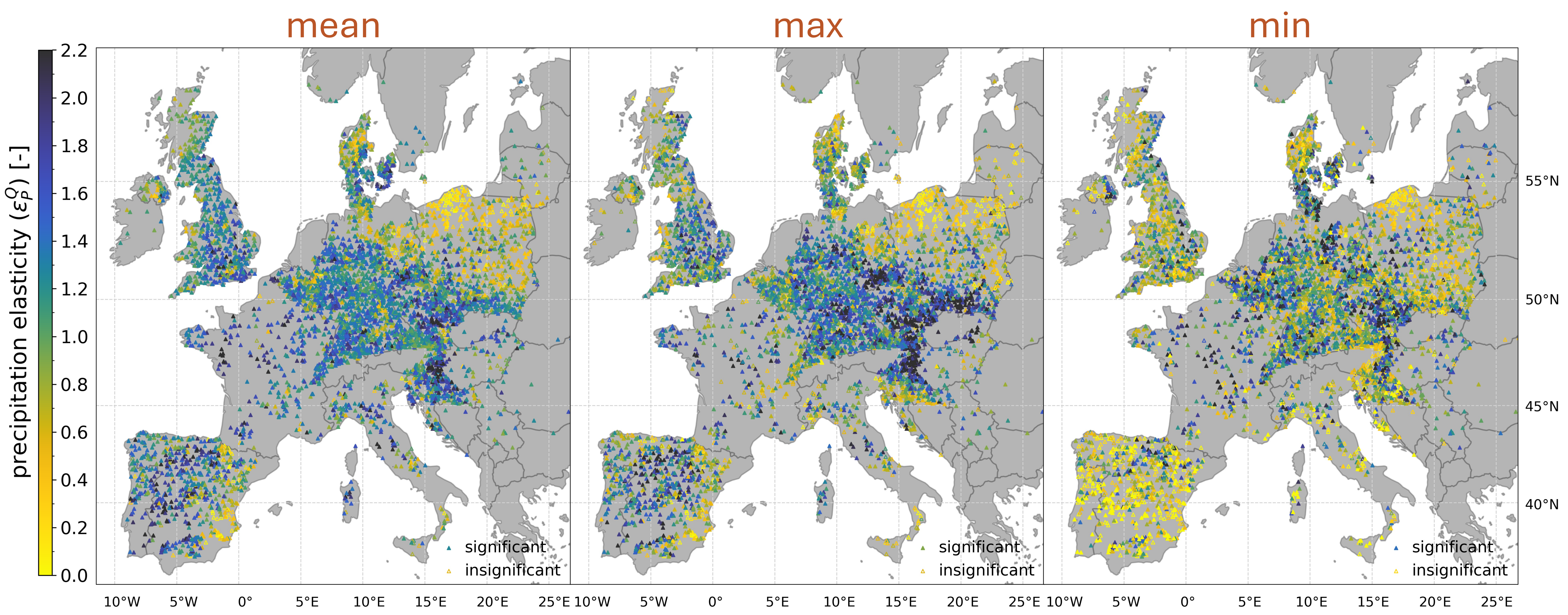
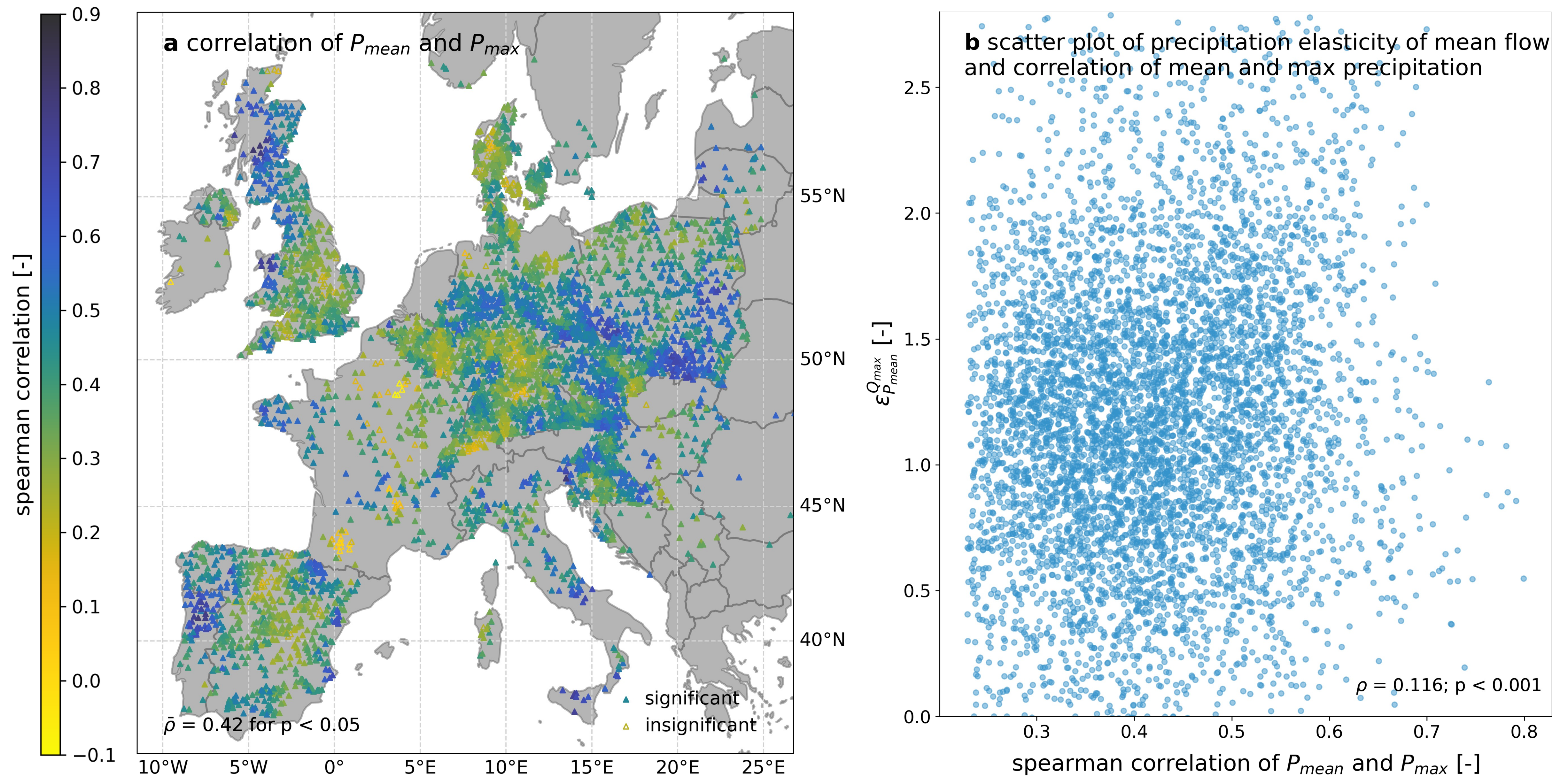


Why do **max flows respond similarly to mean** flows?

- Regions of correlating mean and max precipitation
- Wetter (drier) years leading to wetter (drier) landscape producing larger (smaller) max flows



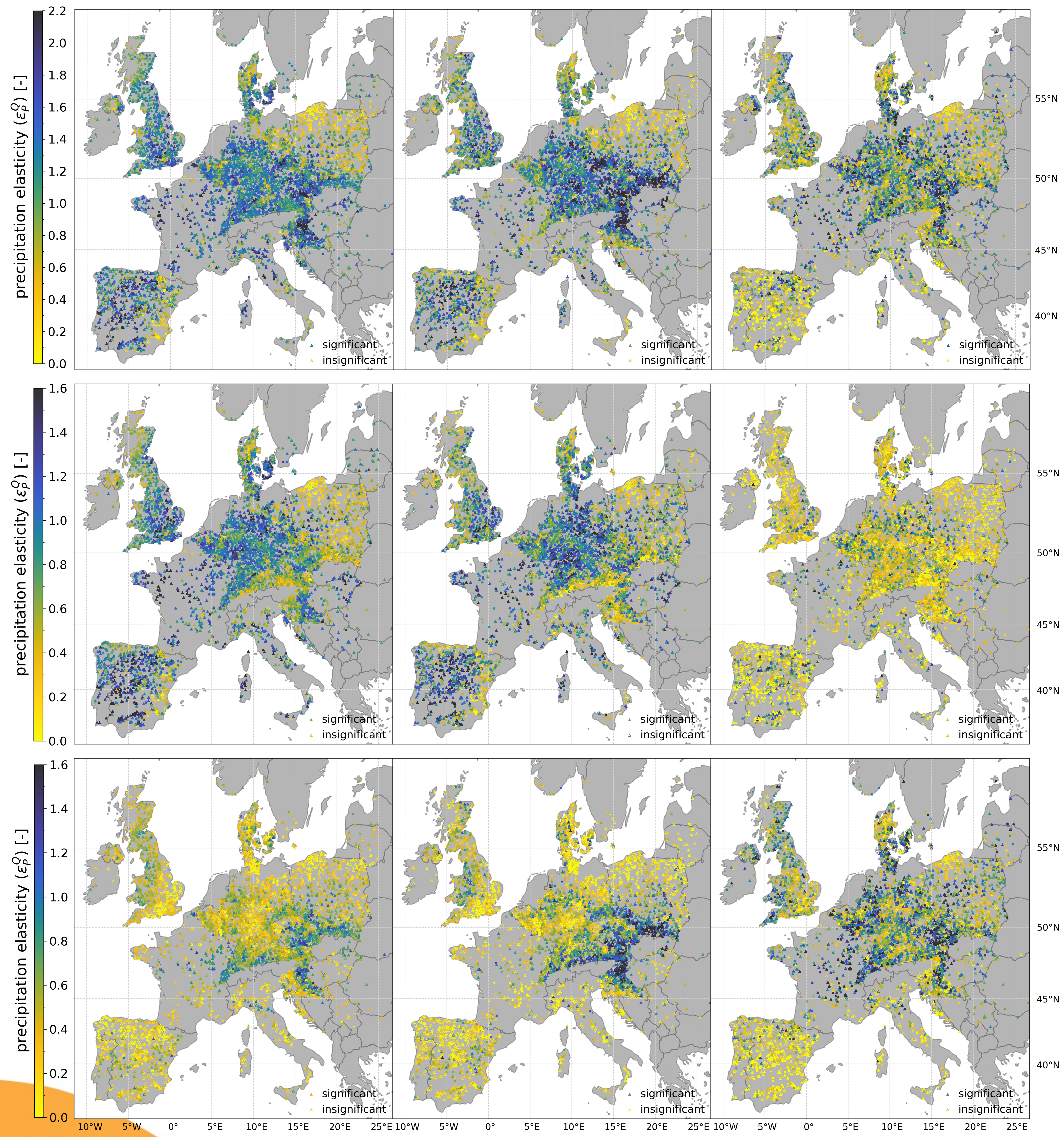
How does **annual streamflow** respond to **mean seasonal precipitation**?

mean max min

hydroyear
NOV-OCT

cold season
NOV-APR

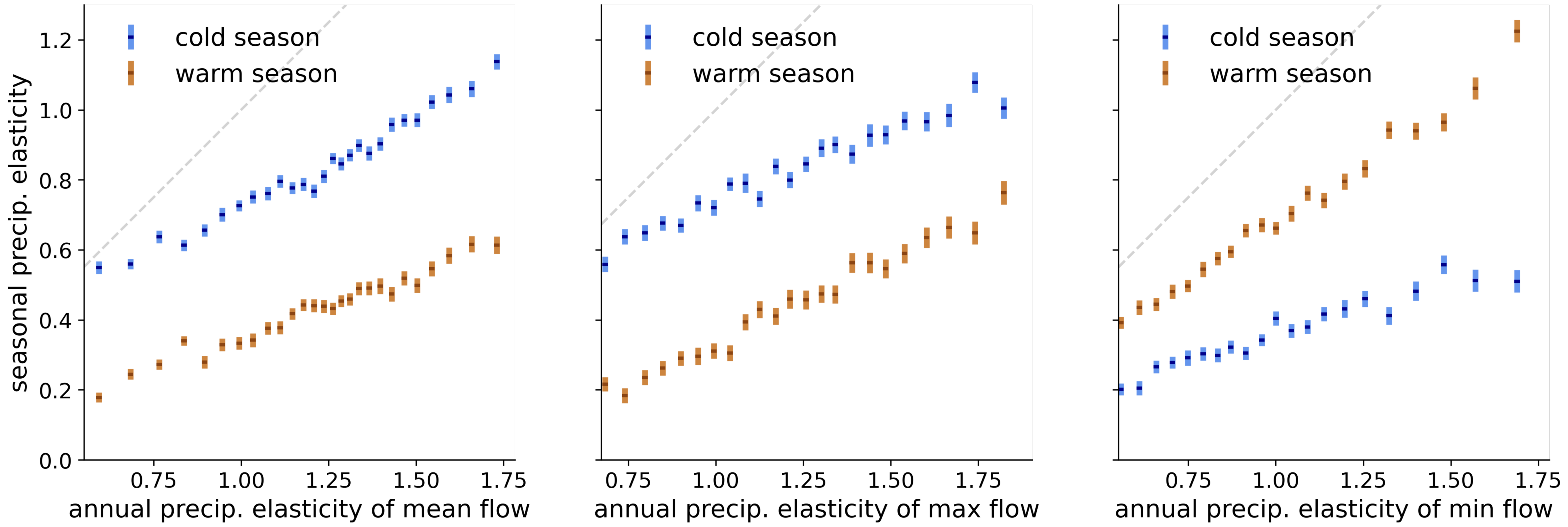
warm season
MAY-OCT



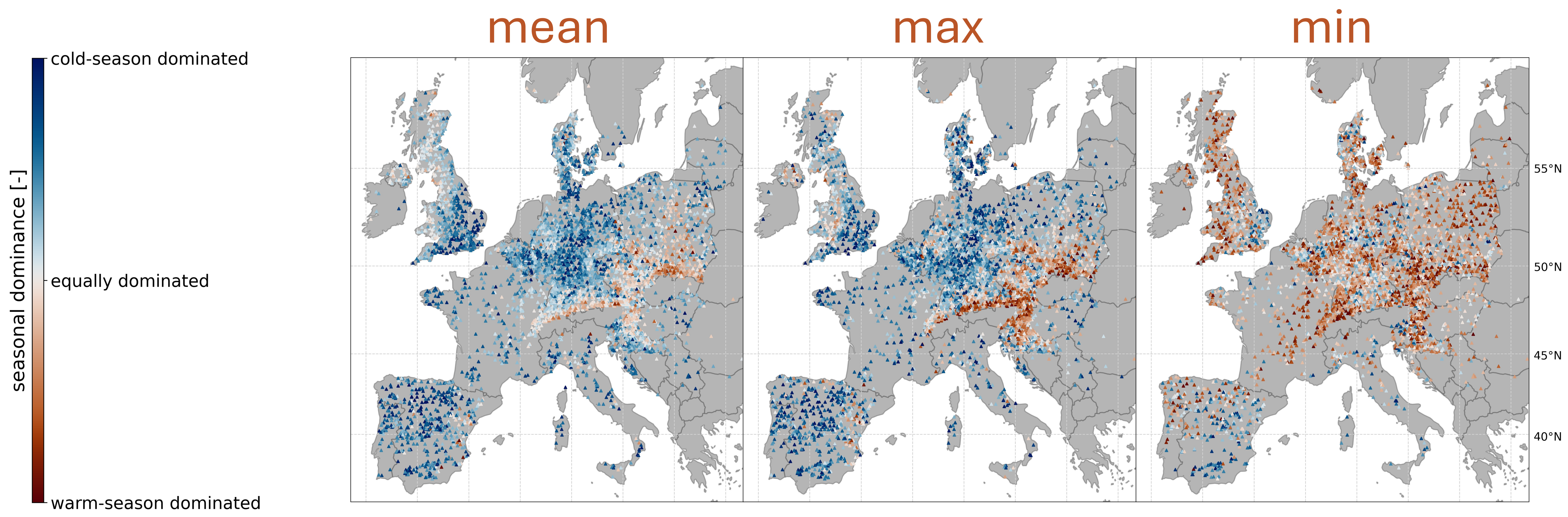
All flow metrics are less sensitive to seasonal than to annual precipitation

On average, **mean** and **max flows** are **more sensitive to cold-season precipitation**, with **regional exceptions**

Min flows are generally **more sensitive to warm-season precipitation**



How does **annual streamflow** respond to **mean seasonal precipitation**?



On average, **mean** and **max flows** are **more sensitive to cold-season precipitation**, with **regional exceptions**

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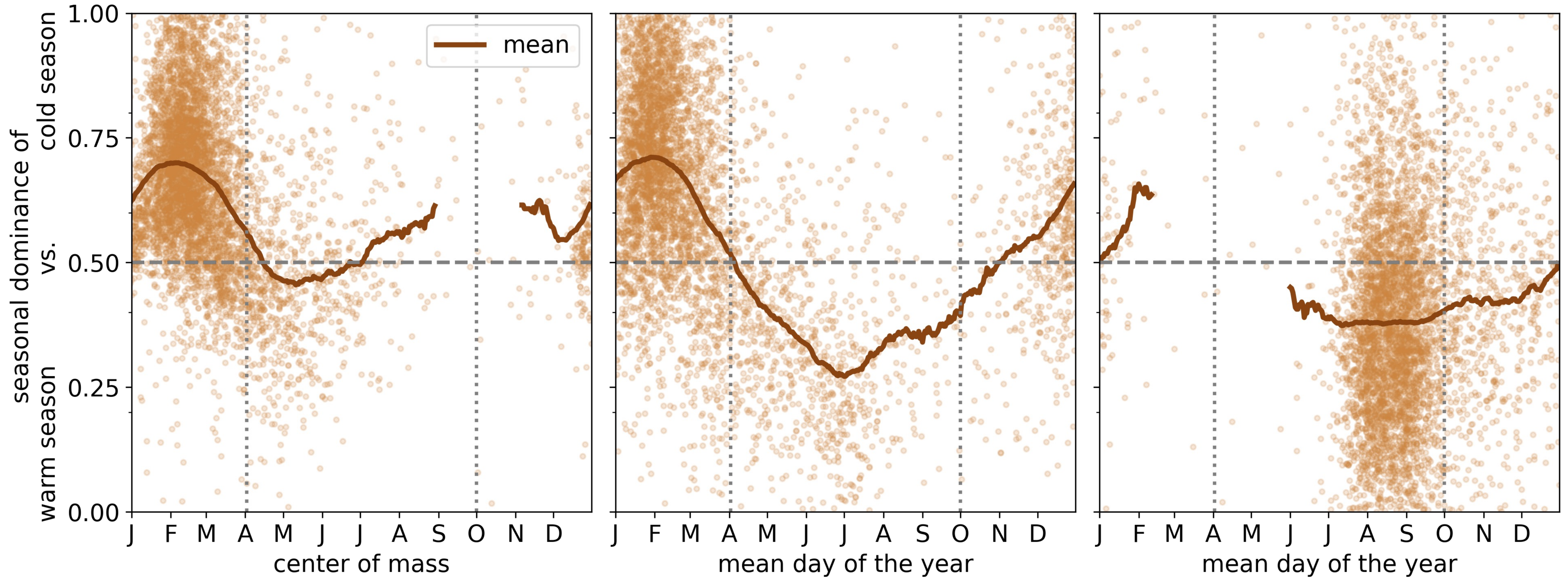
Do we just see that areas with summer-dominance have their flow centre of mass after April?



centre of mass of mean flow[9]

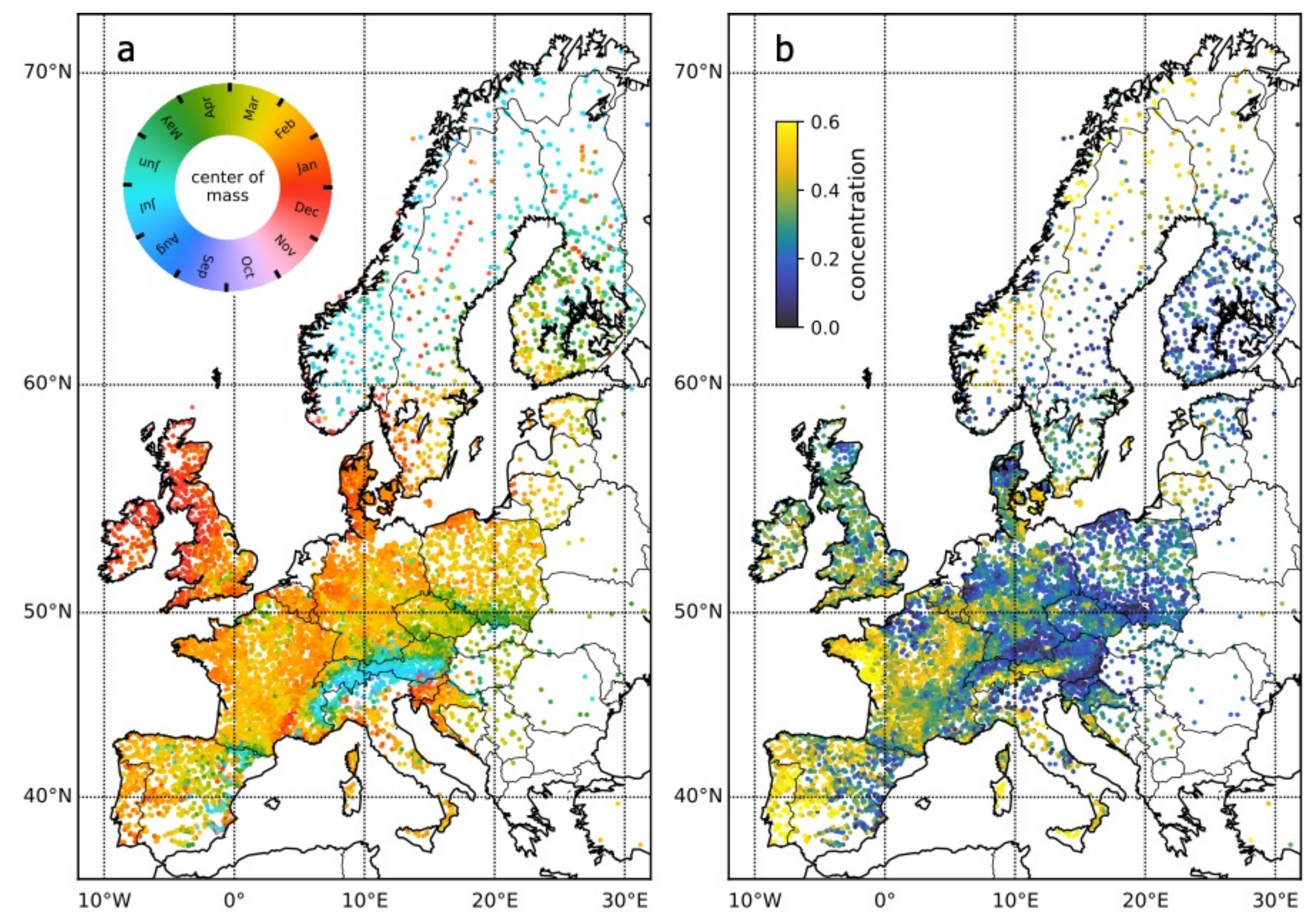
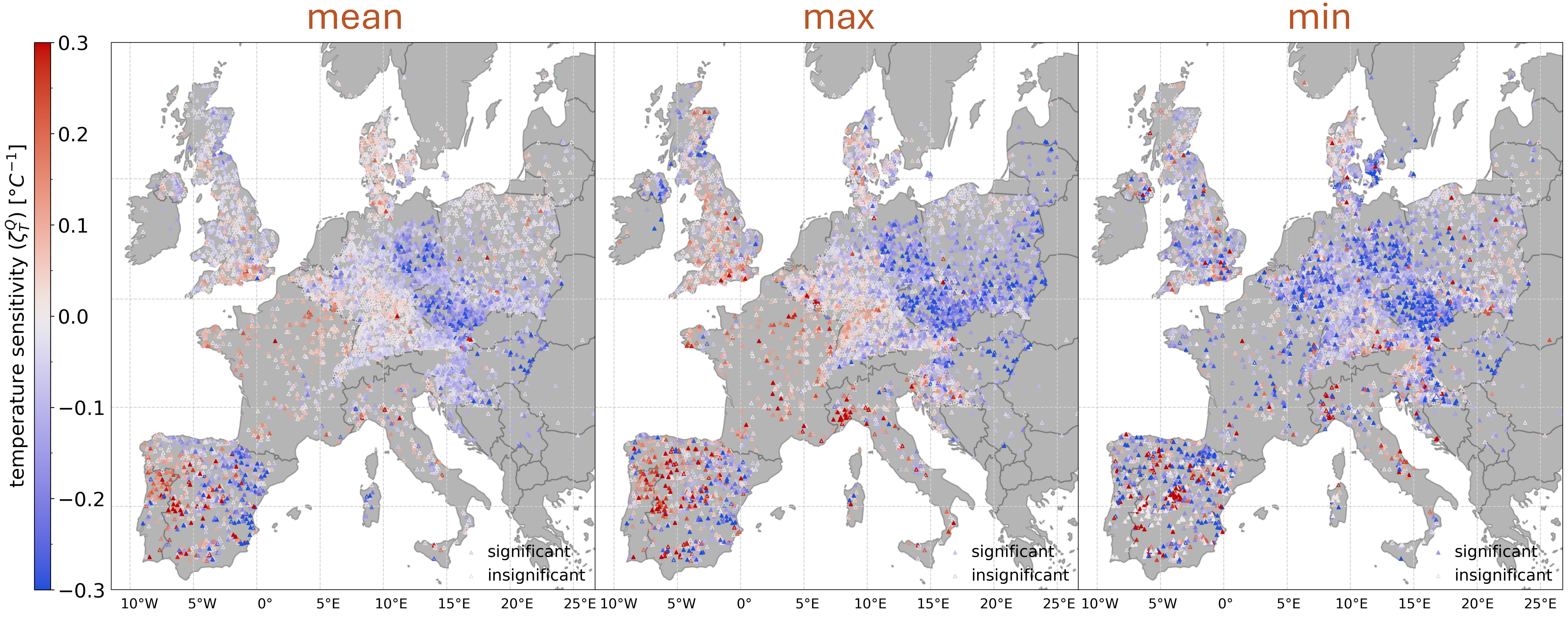
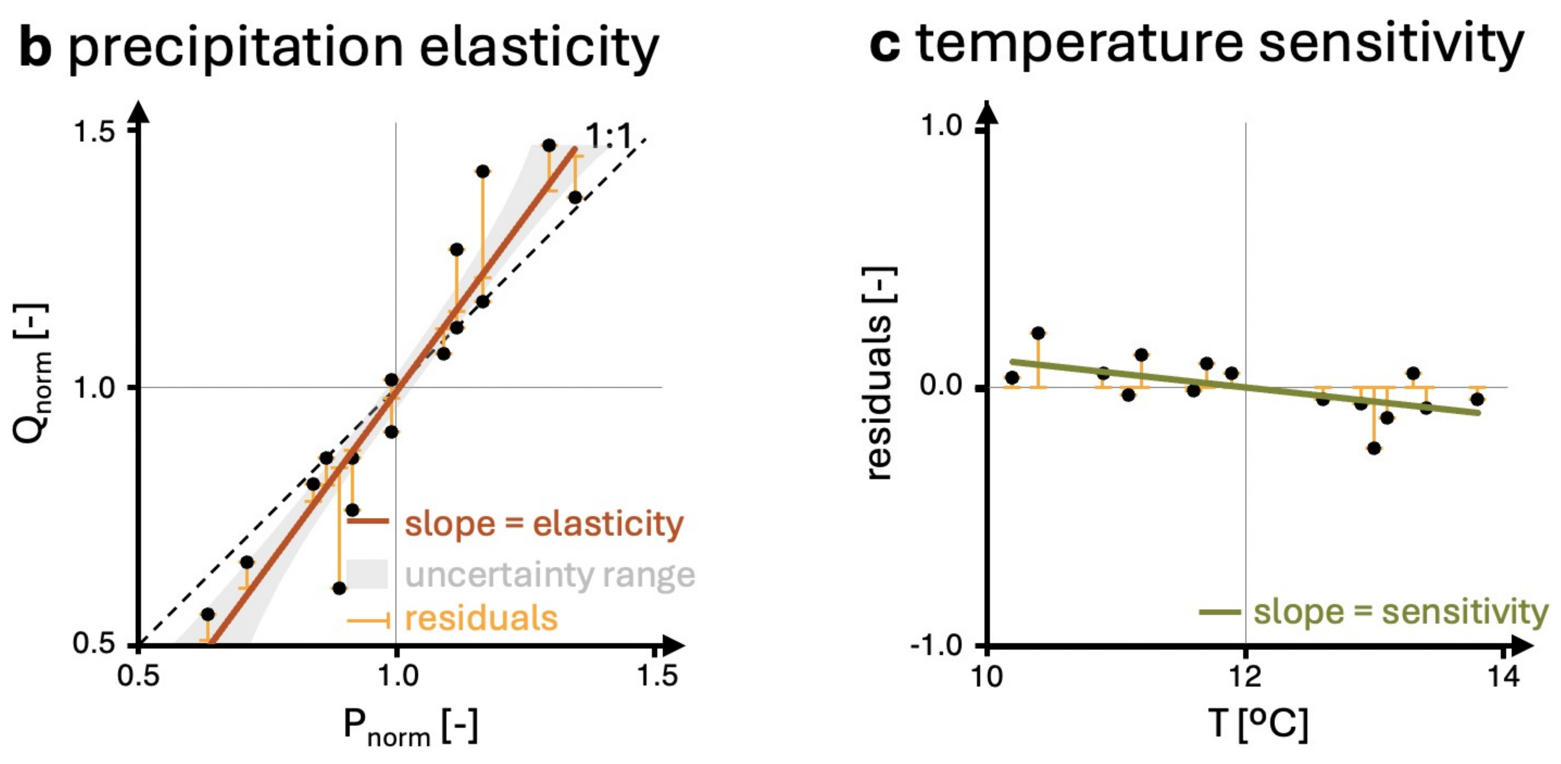


Figure 6: Seasonality of flow regimes according to directional statistics. The center of mass (a) and concentration (b) of catchments are shown at the location of the streamflow gauges and vary notably across Europe. Most of these variations are spatially highly autocorrelated. For illustration purposes, we do not show (the small number of) Icelandic catchments and streamflow gauges located East of 32°E.

How does **annual streamflow** respond to mean **annual temperature**?





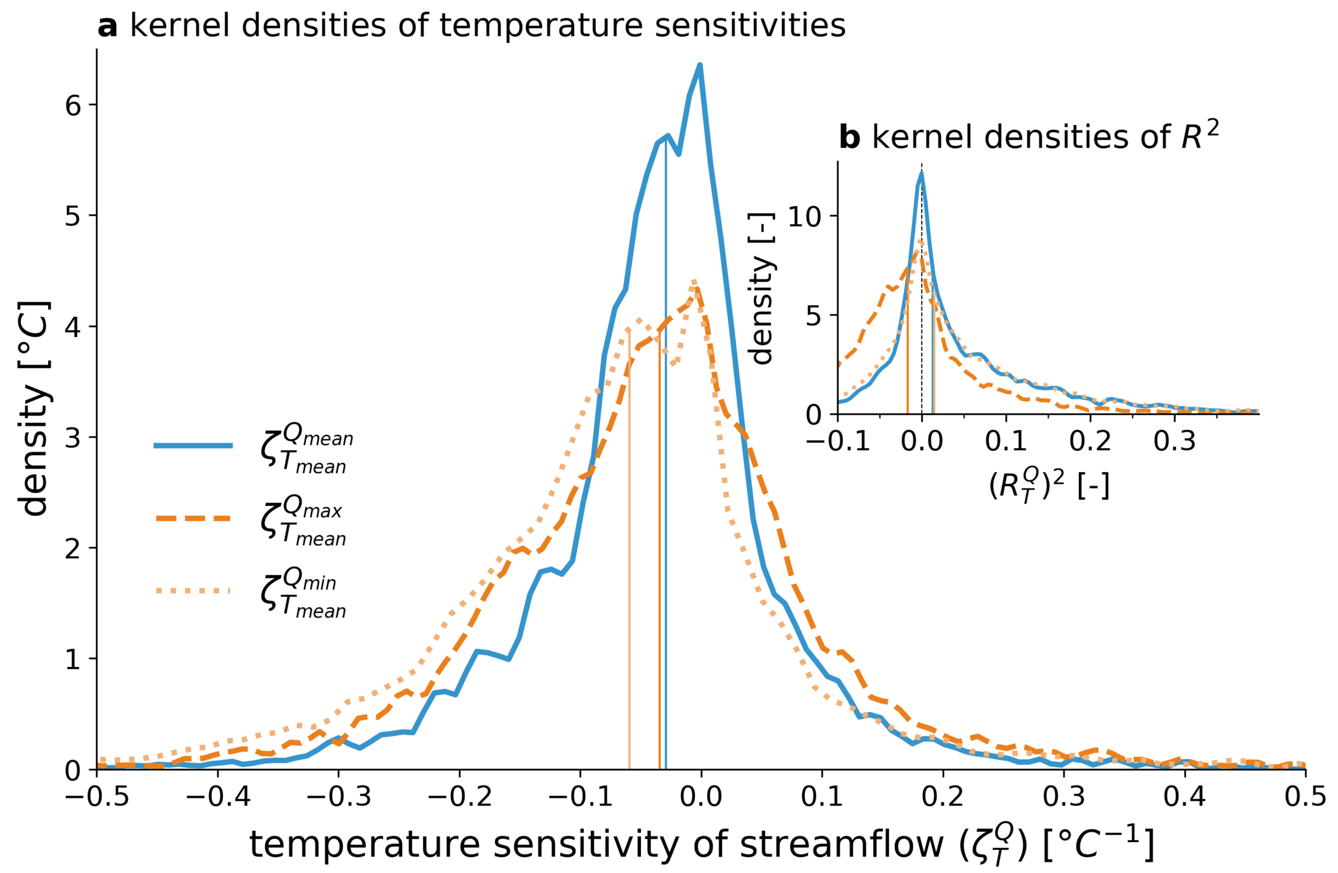
Annual **mean, max** and **min flows scale** both **negatively** and **positively with** annual **temperature**

Min flows are **more sensitive to temperature** than mean and max flows

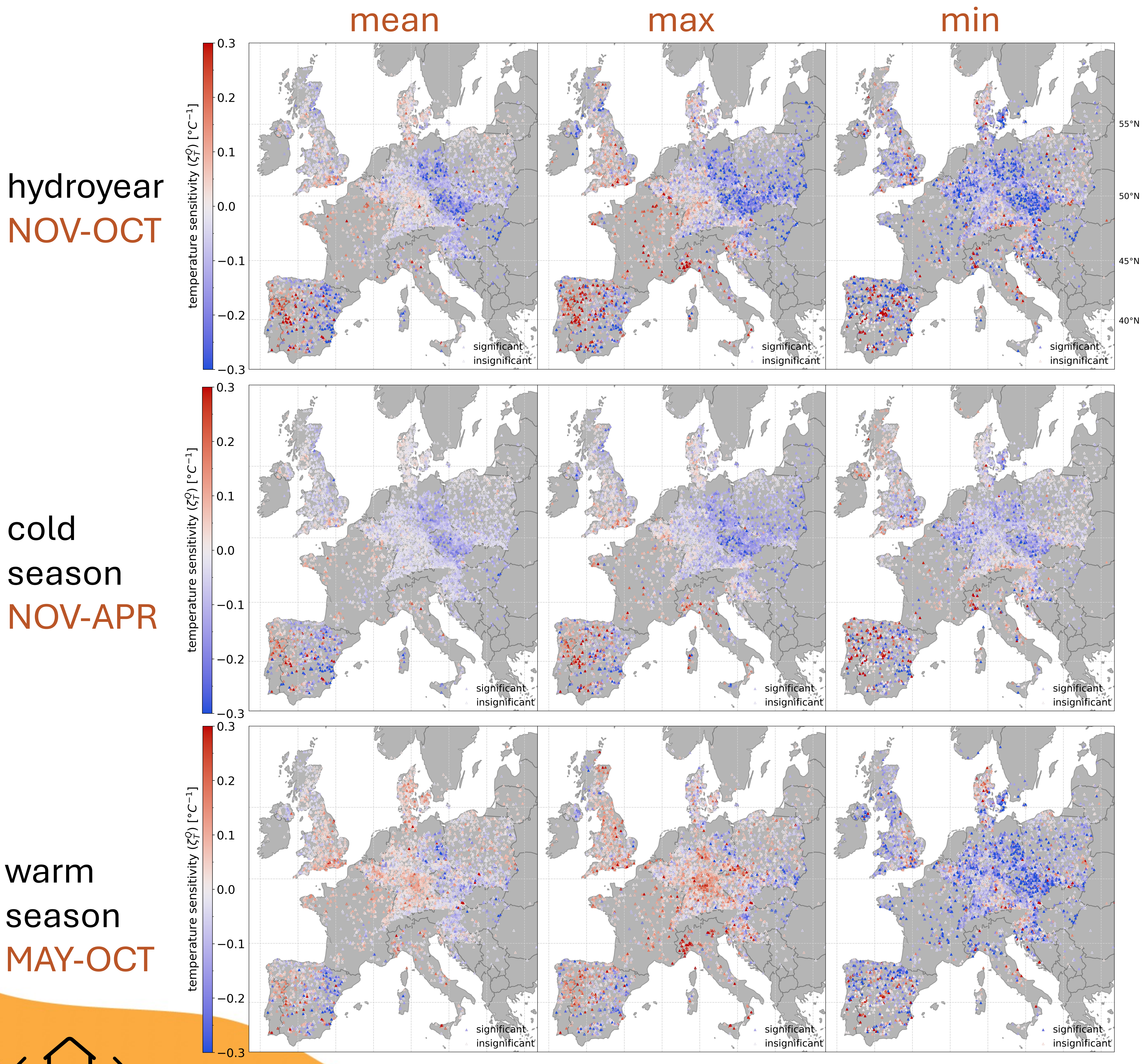
Streamflow declines with higher temperature are found e.g. in Germany

Surprisingly, flow increases with temperature in the Iberian Peninsula

On average, temperature is weakly related to streamflow



How does **annual streamflow** respond to **mean seasonal temperature**?



In the **cold season**

- **flows** generally **decrease with** warmer **temperatures**

In the **warm season**

- **mean and max flows** on average **increase with** warmer **temperature**
- while **min flows decrease with warmer temperatures**

What are our conclusions?

This data-based analysis shows how mean and extreme streamflow may change with precipitation and temperature across Europe

Typically, **mean and max flows amplify precipitation variations**, whereas **min flows dampen** them

On average, **mean** and **max flows** are **more sensitive to cold-season precipitation**, while **min flows** are **more sensitive to warm-season precipitation**

Annual **mean, max** and **min flows scale** both **negatively** and **positively with** annual **temperatures**

Next steps?

Determine the **catchment characteristics** that **shape** the climate **sensitivities**

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abstract

LET'S GET IN CONTACT

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ACKNOWLEDGEMENTS

Literature

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