Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
and Water Management

VU UNIVERSITY AMSTERDAM

Detecting trends in extratropical storms using analogues

Vikki Thompson

Izidine Pinto, Sjoukje Philip, Sarah Kew,

Dim Coumou, Robert Vautard, Hylke de Vries

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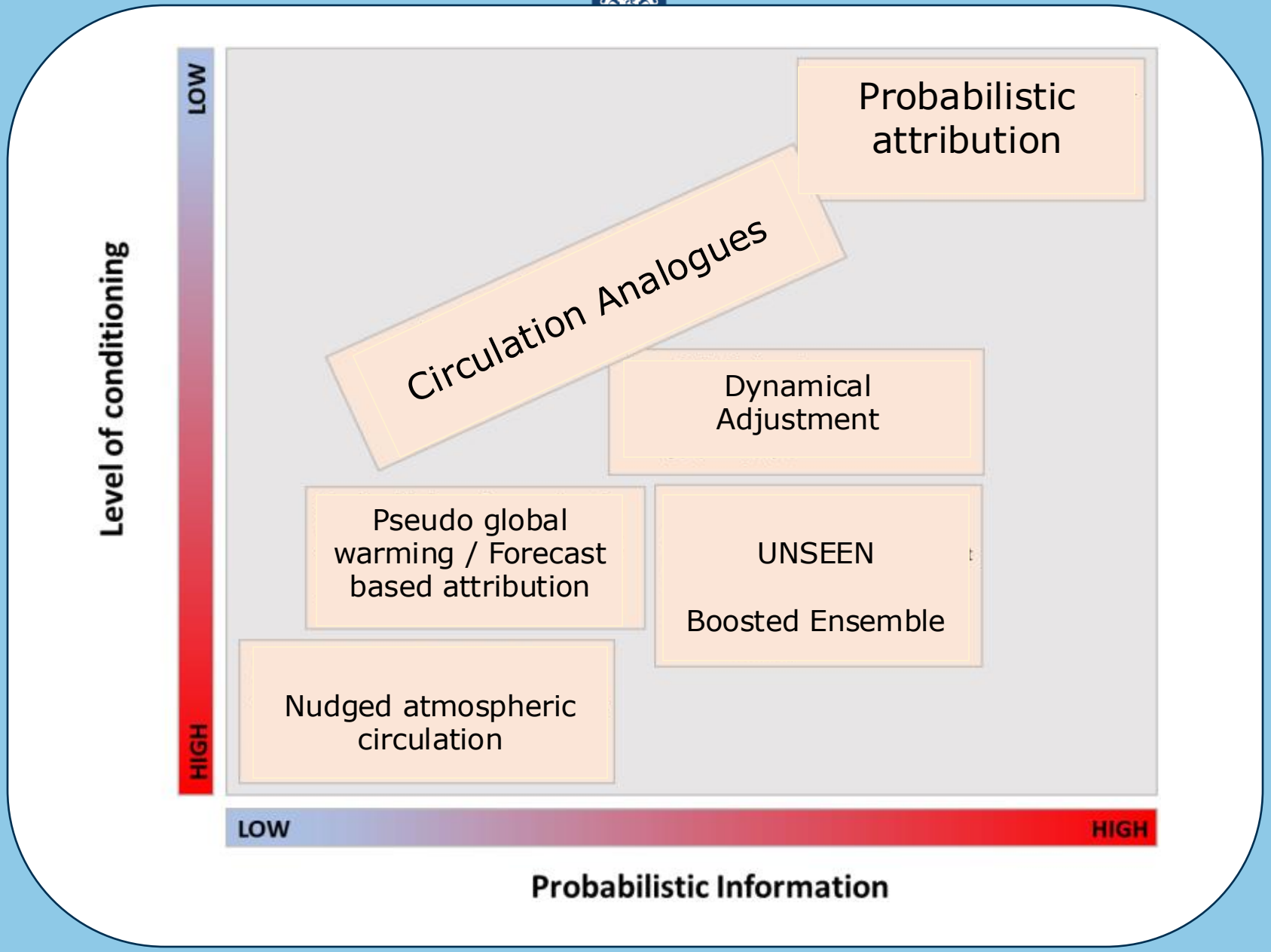

Adapted from Coumou et al. (2024) PNAS

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Take away messages

Analogues provide a useful method to assess how extreme weather events are changing

There are many methodological choices needed when identifying the best analogues

We want to create a set of rules to enable rapid assessment of analogues for many event types and locations (including European storms!)

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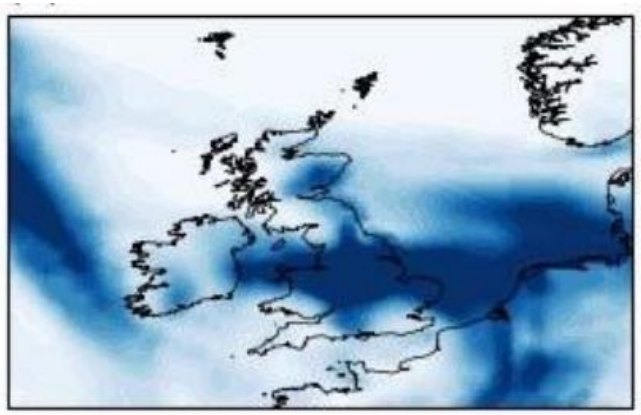
Observed Event



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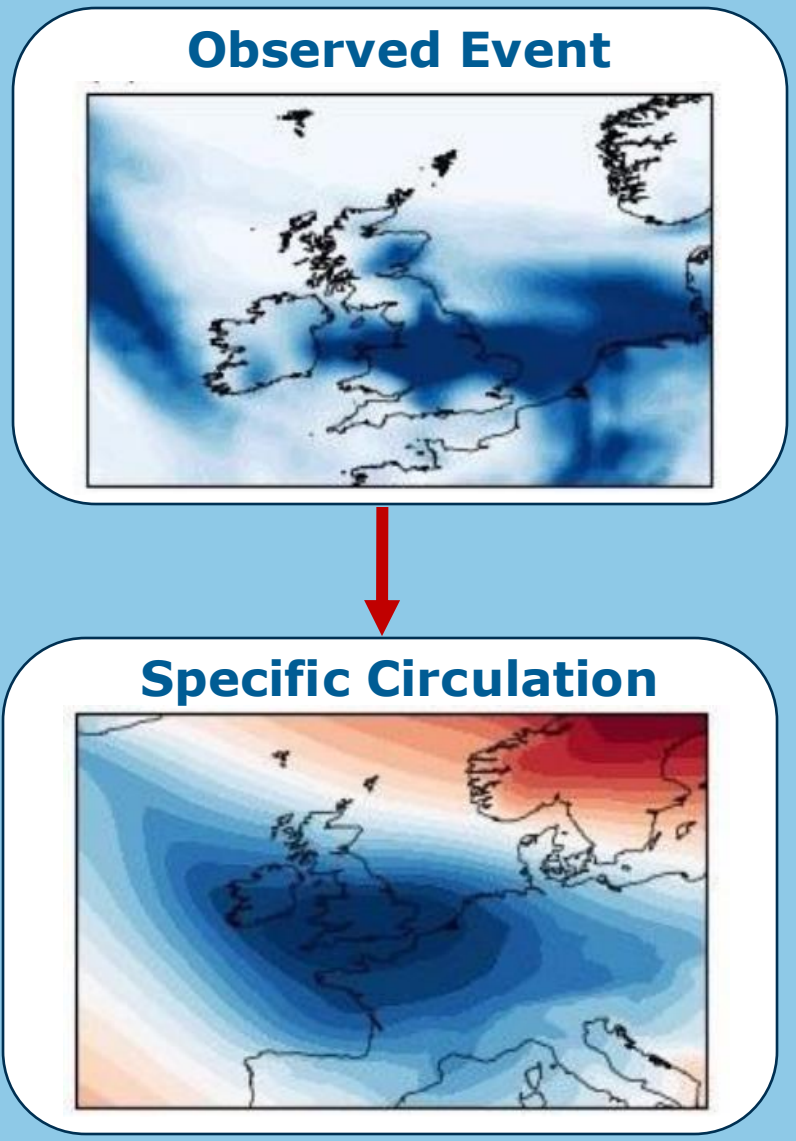

Analogue = day with similar circulation pattern

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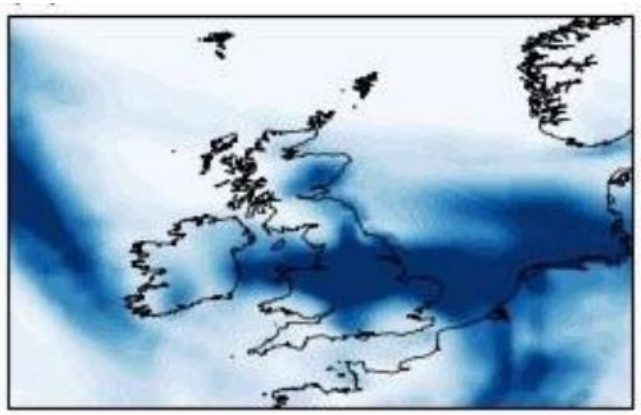
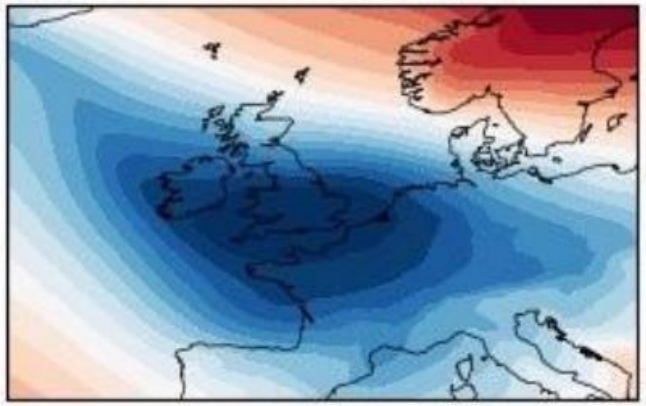
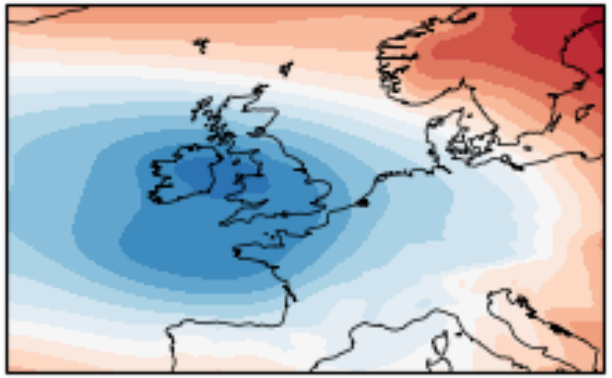
Observed Event



Specific Circulation



Similar Circulation



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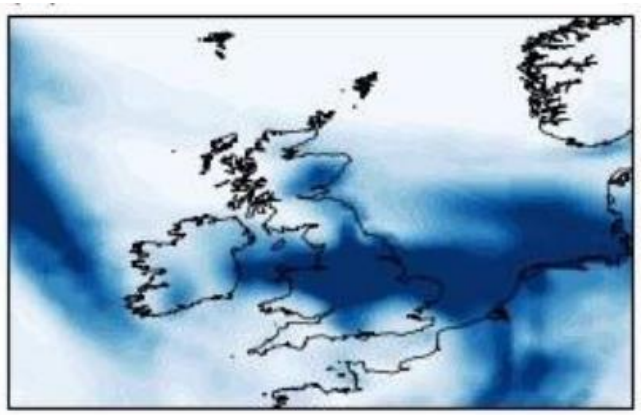
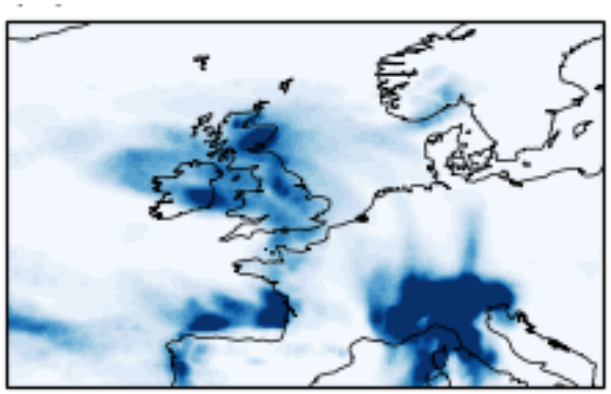
Observed Event



Impacts?



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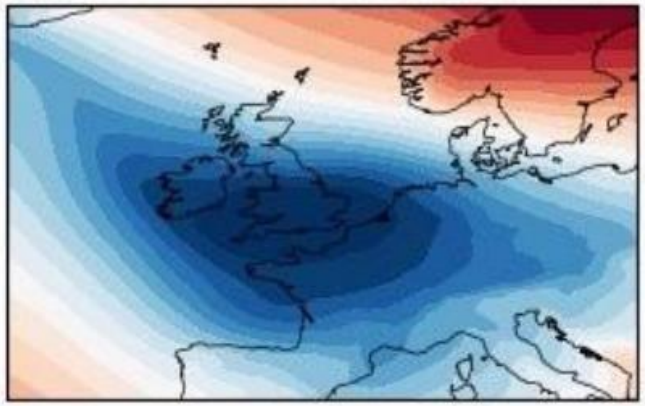

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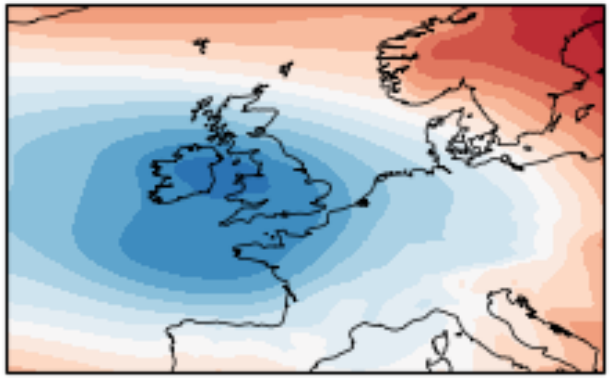

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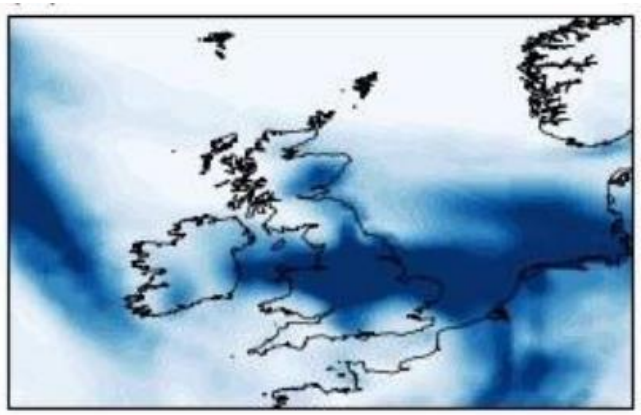

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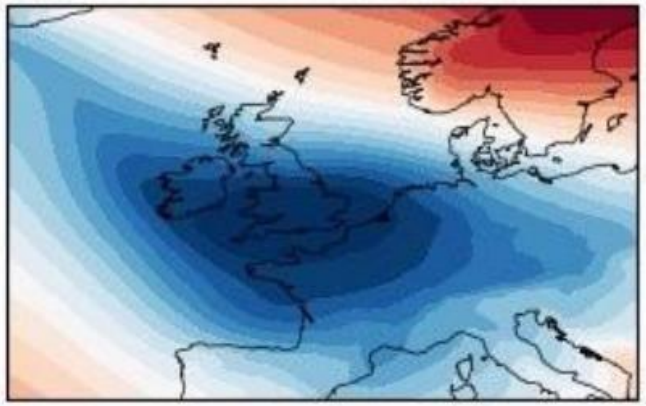

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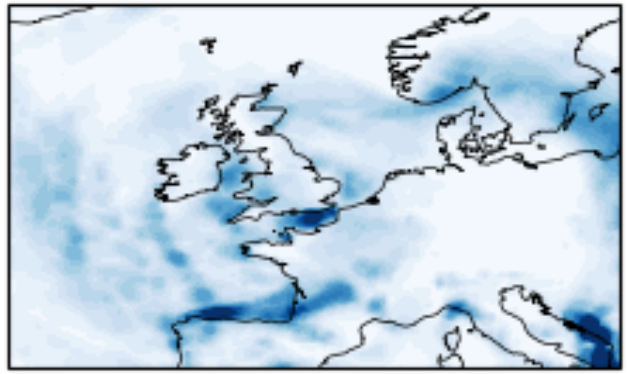

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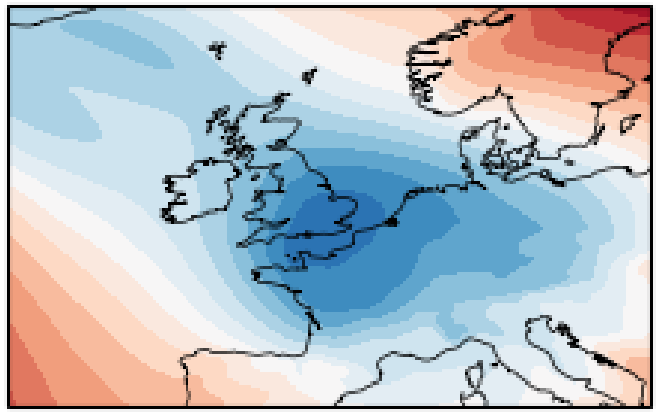

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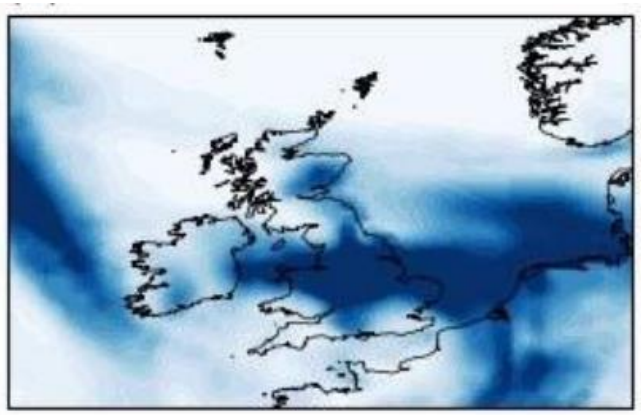

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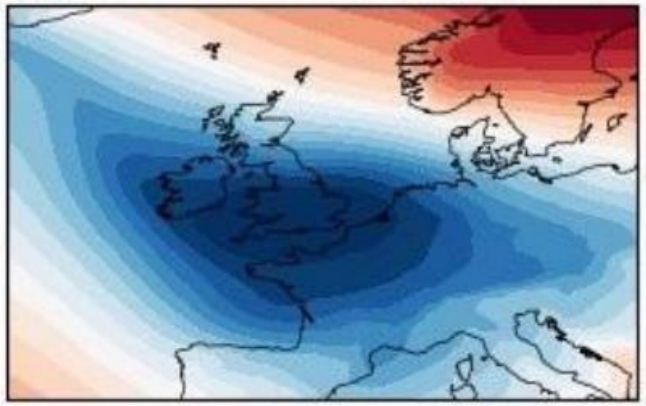

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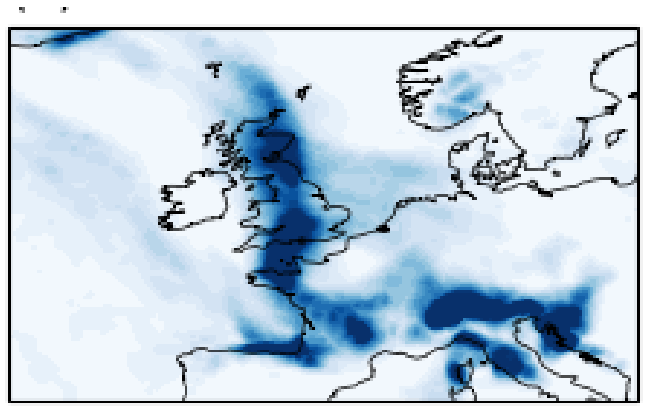
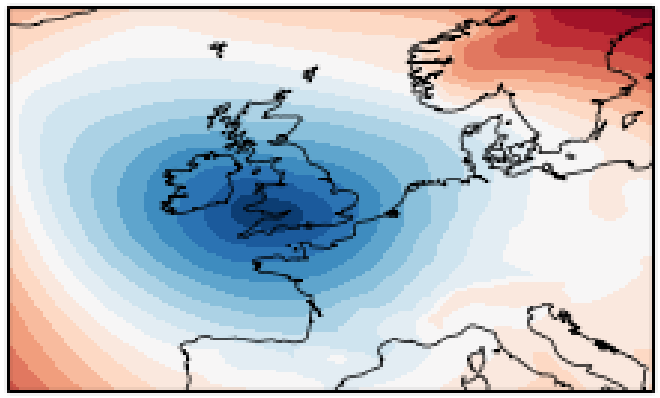


Similar Circulation



Top 30 analogues from ERA5 1950-2022

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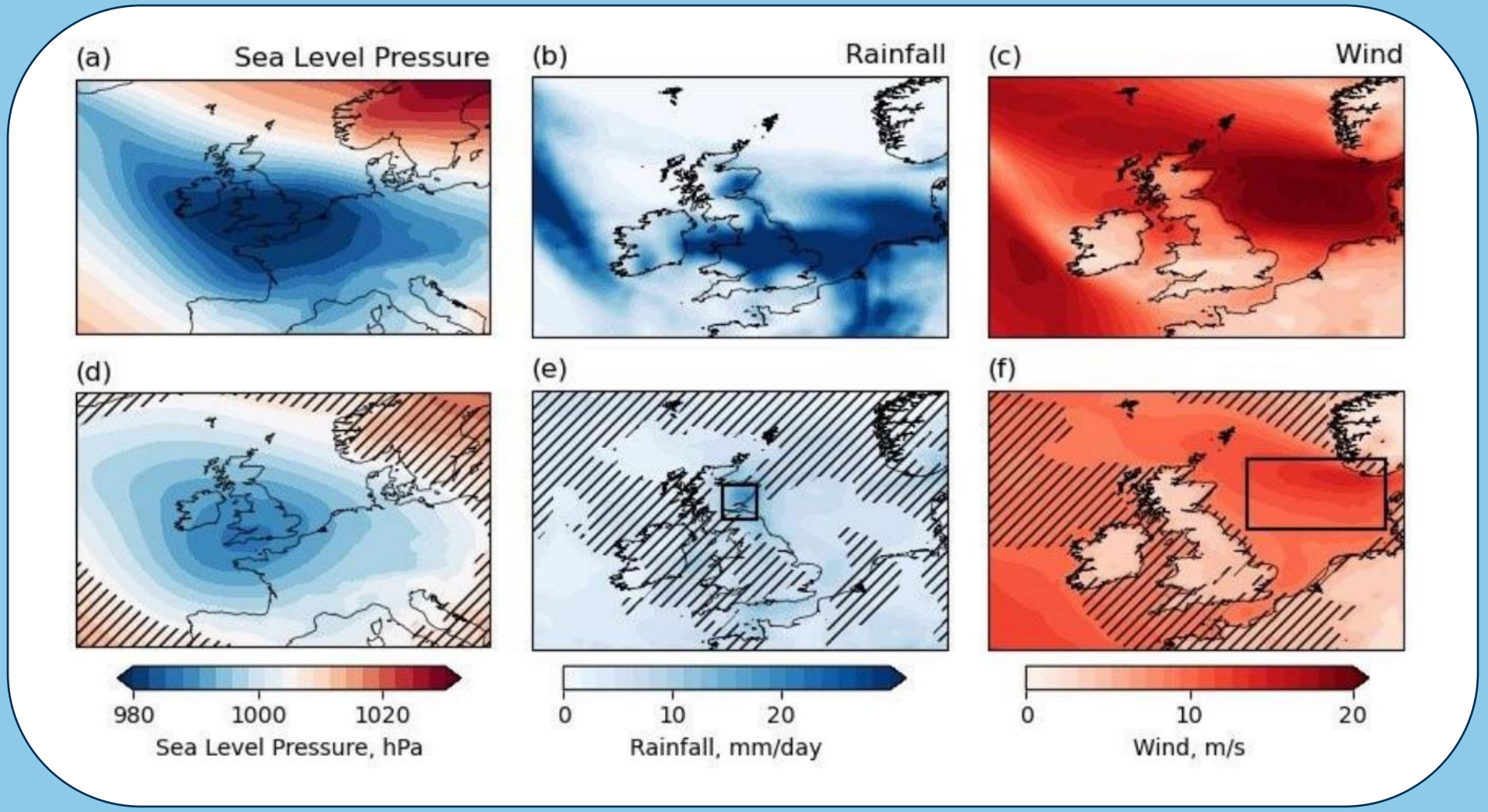

Analogues show consistent rain over Aberdeenshire and wind over the North Sea

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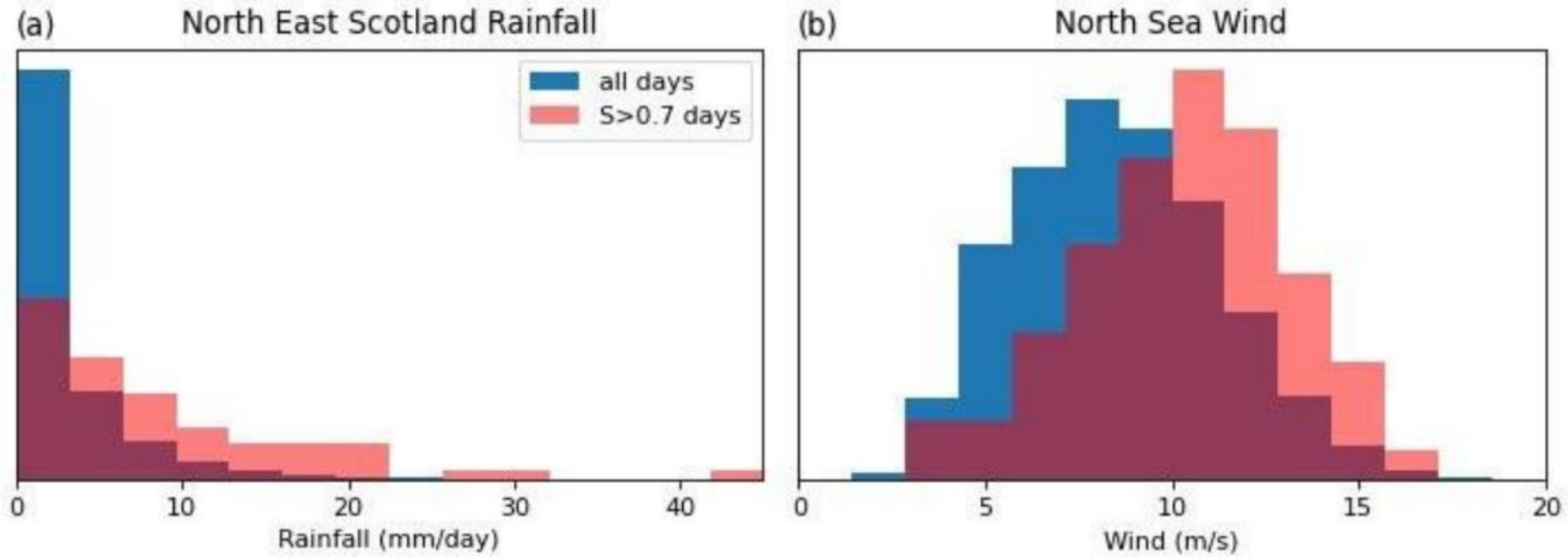

Analogues show consistent rain over Aberdeenshire and wind over the North Sea

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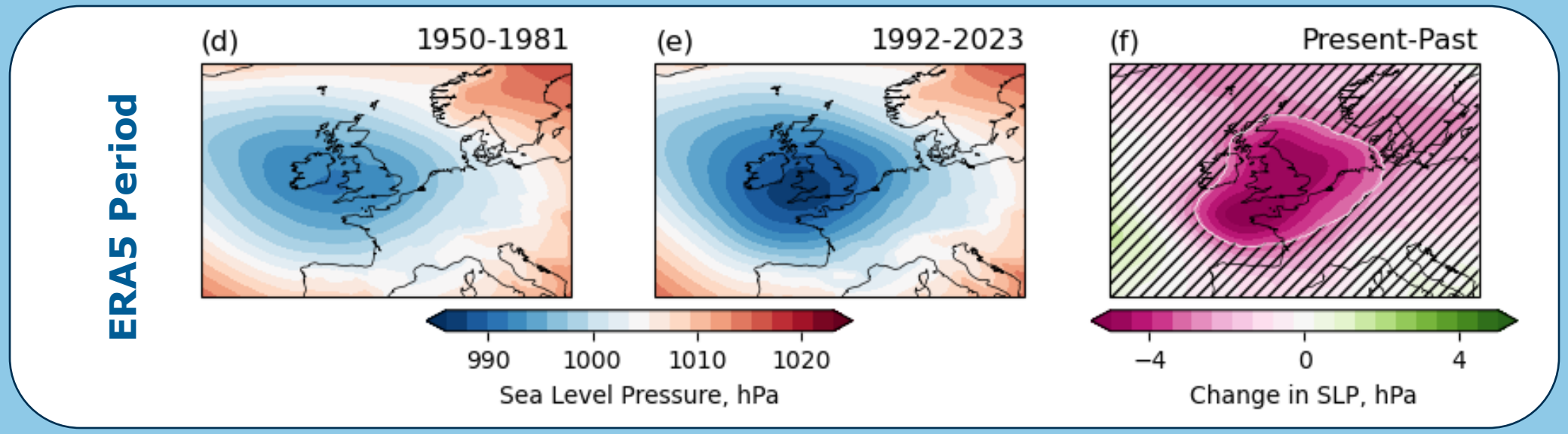
Compare timeslices: increase in intensity



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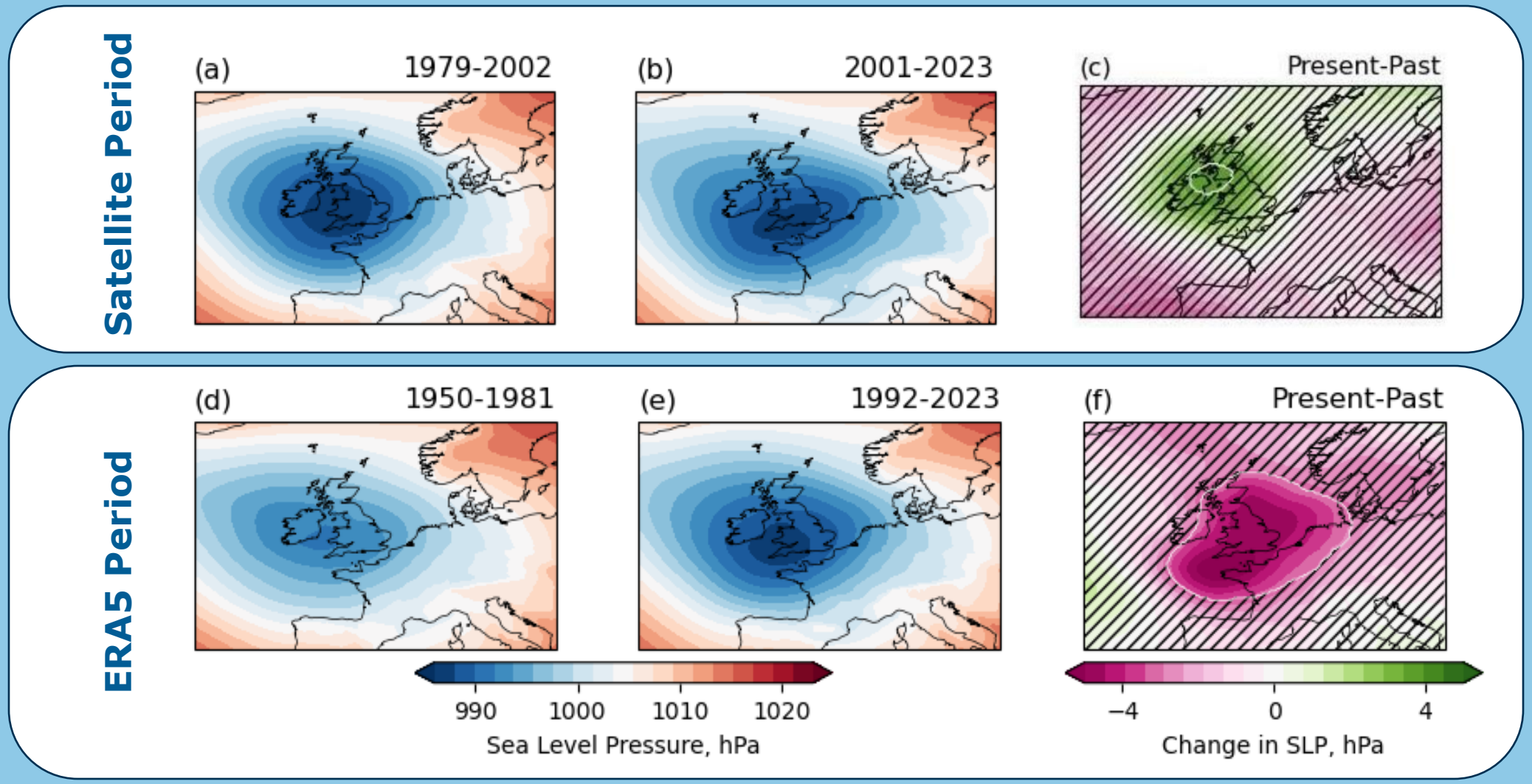

Different timeslices: different trends

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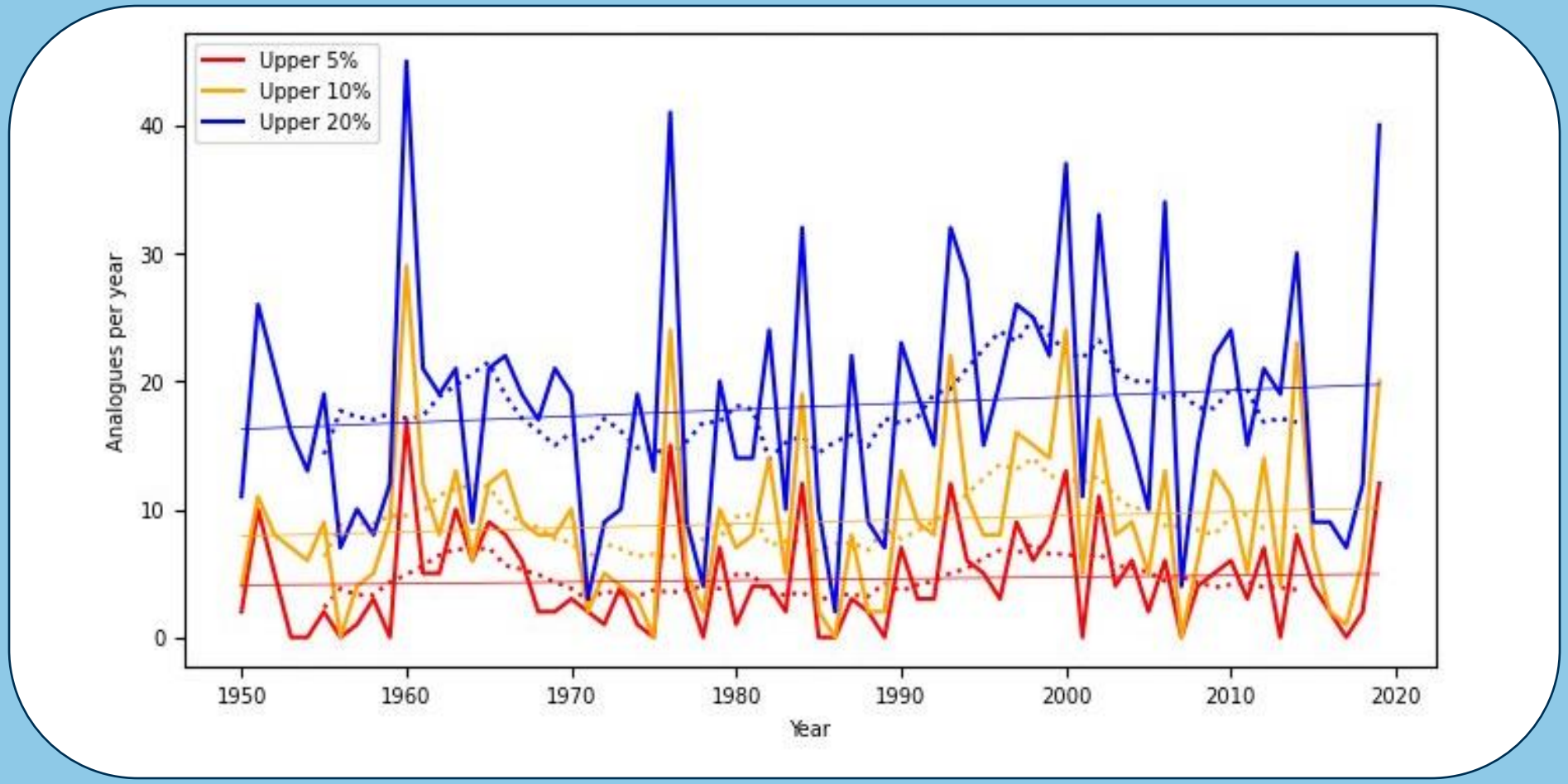
Assess change through time



multidecadal variability dominates

Climate Explorer

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Home — Compute analogues: ERA5

Compute analogues

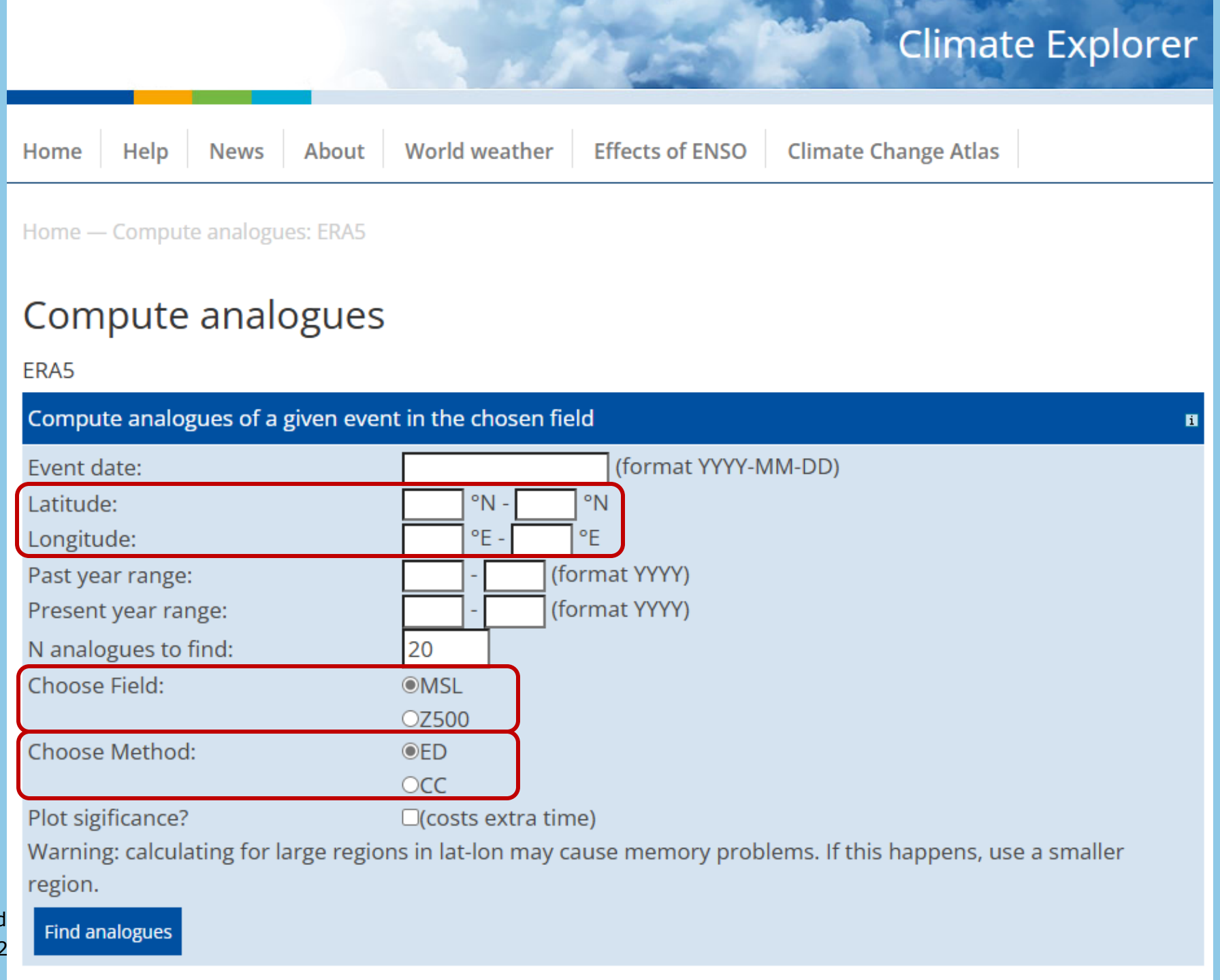
ERA5

Compute analogues of a given event in the chosen field

Event date:	(format YYYY-MM-DD)
Latitude:	°N - °N
Longitude:	°E - °E
Past year range:	- (format YYYY)
Present year range:	- (format YYYY)
N analogues to find:	20
Choose Field:	◉MSL
	○Z500
Choose Method:	◉ED
	○CC
Plot sigificance?	☐(costs extra time)

Warning: calculating for large regions in lat-lon may cause memory problems. If this happens, use a smaller region.

Find analogues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Home — Compute analogues: ERA5
Compute analogues
ERA5
Compute analogues of a given event in the chosen field
Event date:
(format YYYY-MM-DD)
Latitude:
°N -
°N
Longitude:
°E -
°E
Past year range:
-
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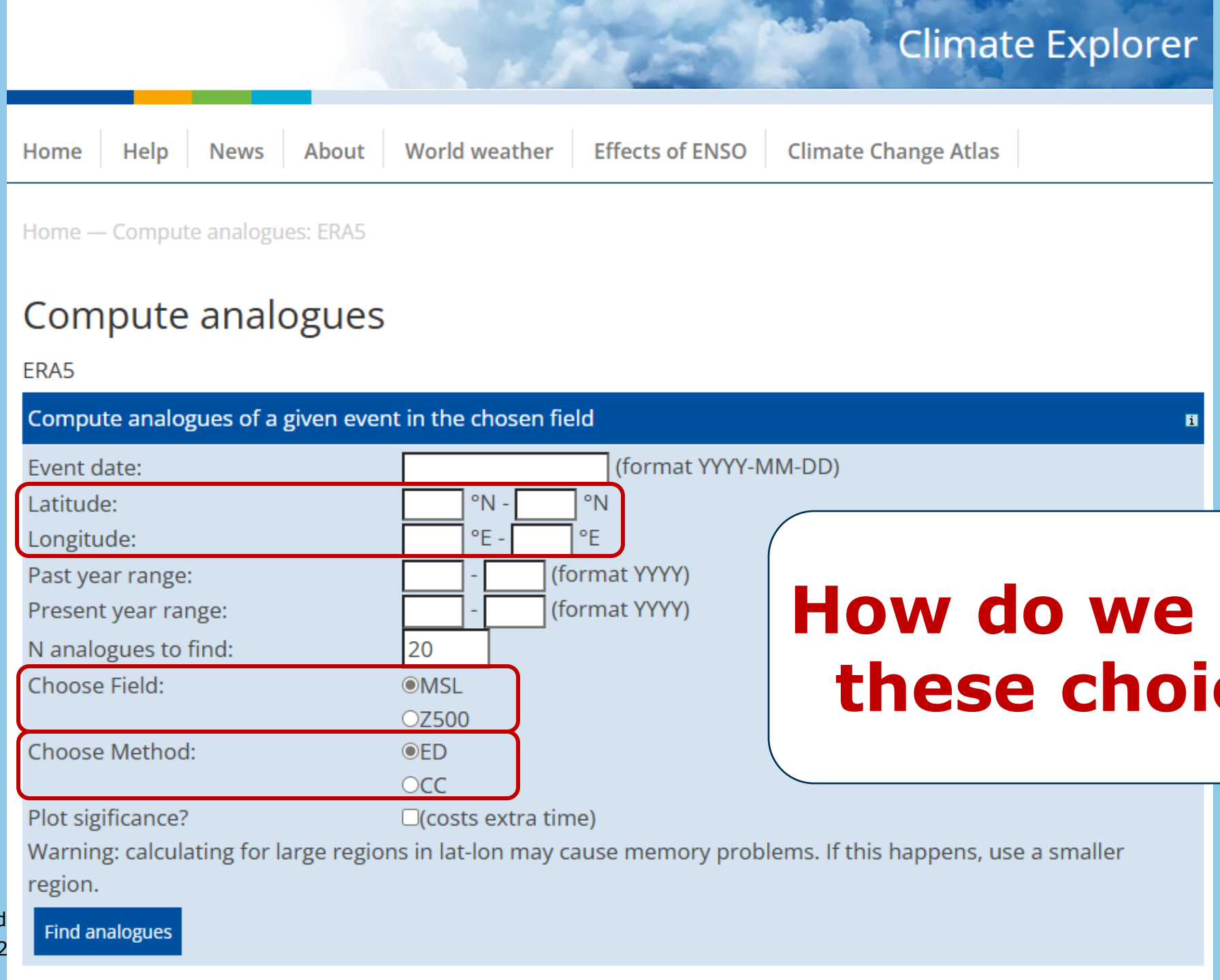

How do we make these choices?

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Let's go on an excursion into heatwaves

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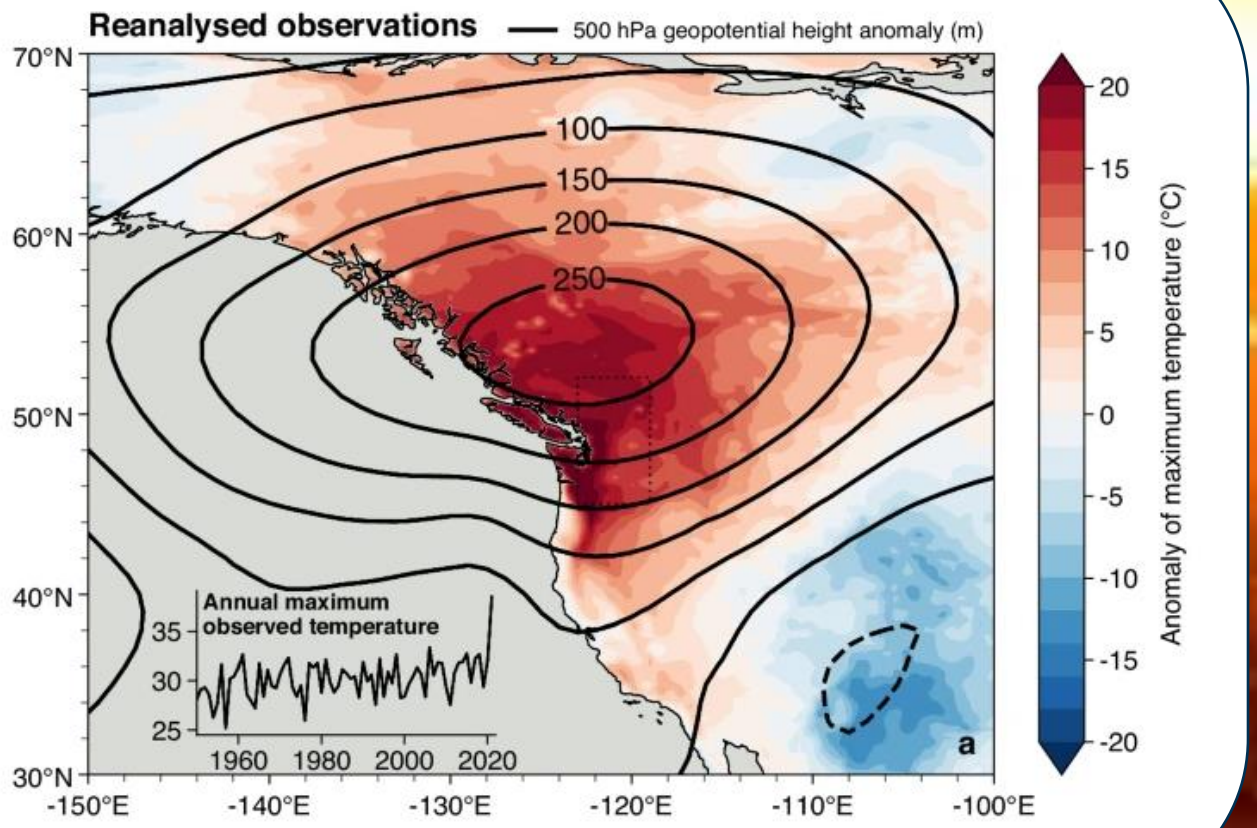
Western North America heatwave, 2021



Leach et al. (2024) Nature Comms.

Thompson et al. (2022) Science Advances

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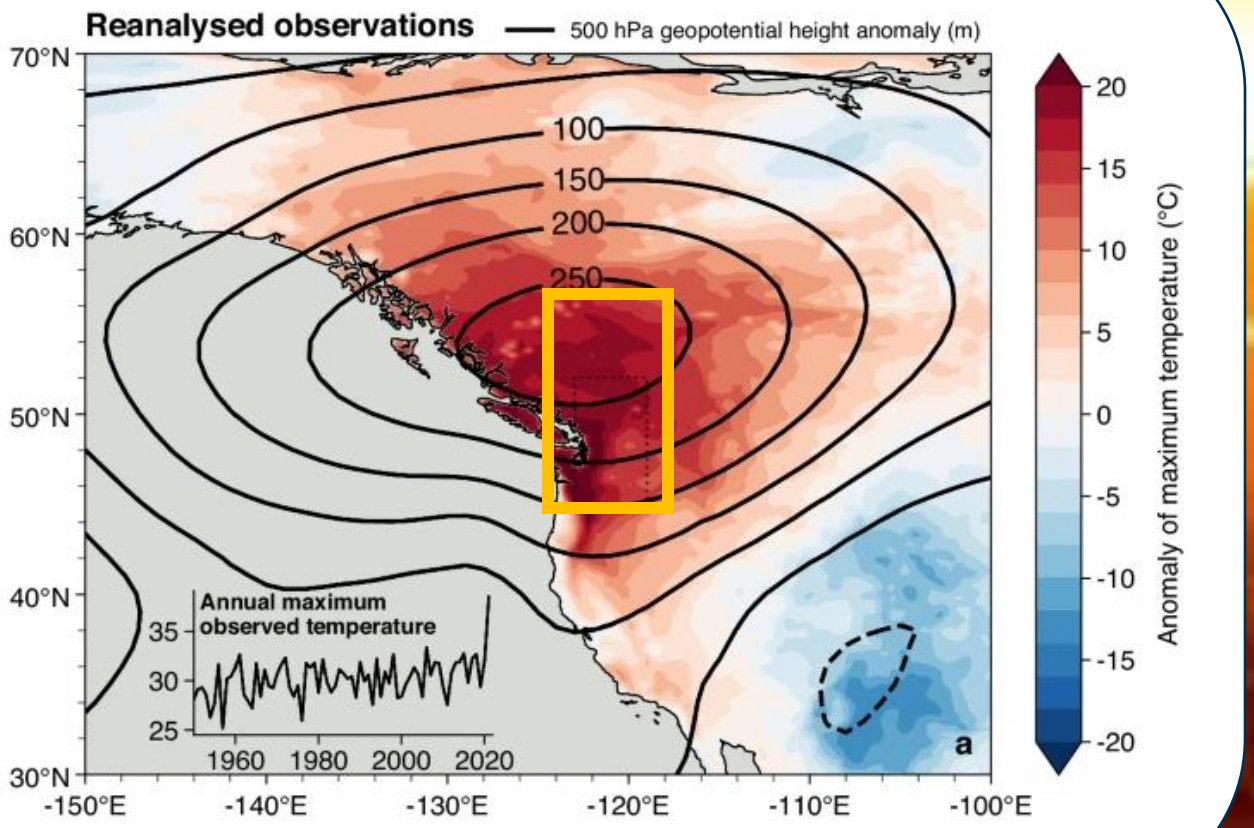
Western North America heatwave, 2021



Impacts region

Taken from the WWA study of the event

Philip et al (2022) Earth System Dynamics

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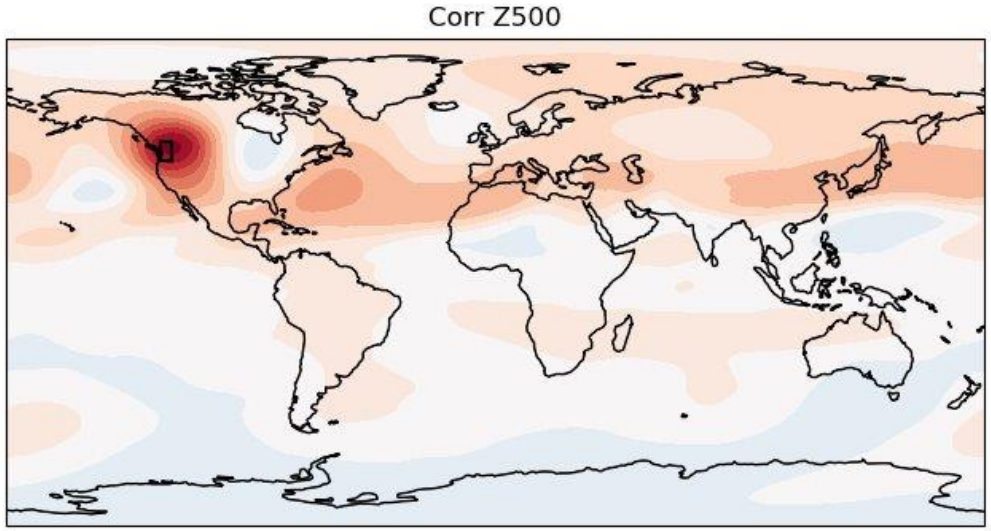
Deciding the analogue domain



Correlation field for every JJA day, local field against impact timeseries

Higher correlation may indicate the dynamics are driving the temperatures

Choose a domain that covers the region where the field correlates best

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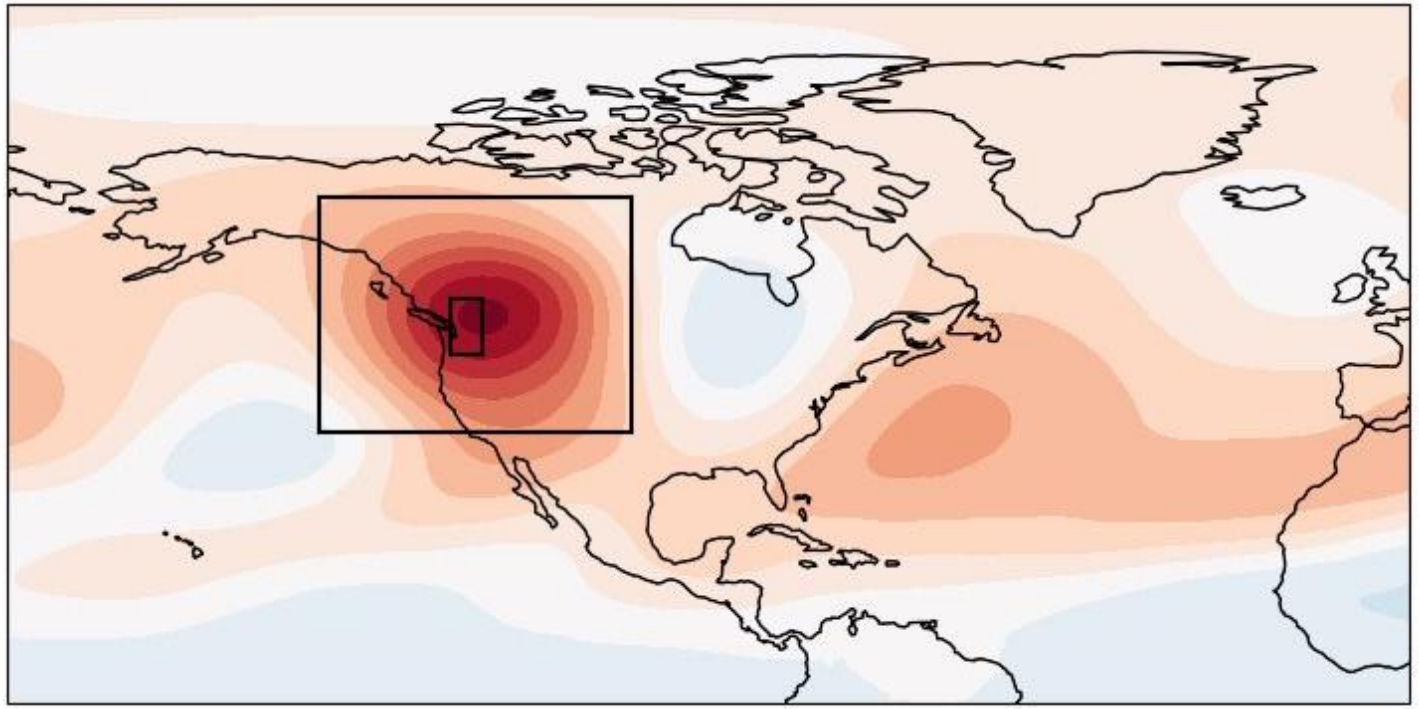
Determine the analogue domain



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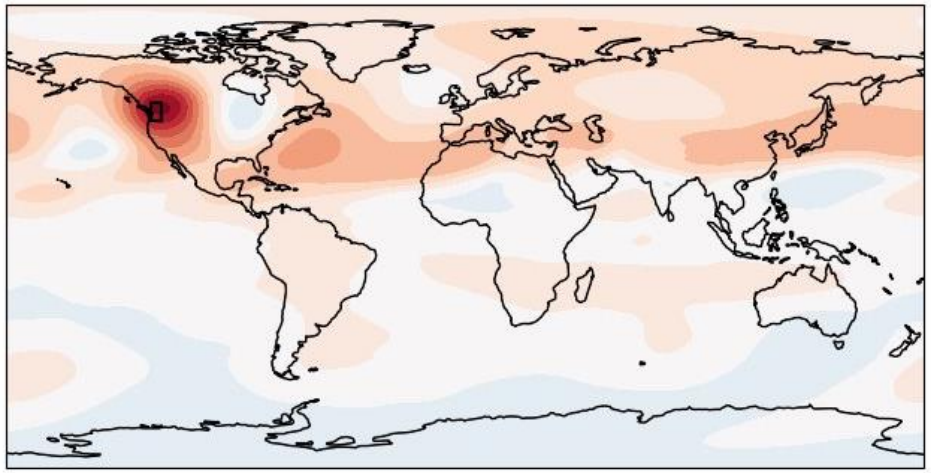
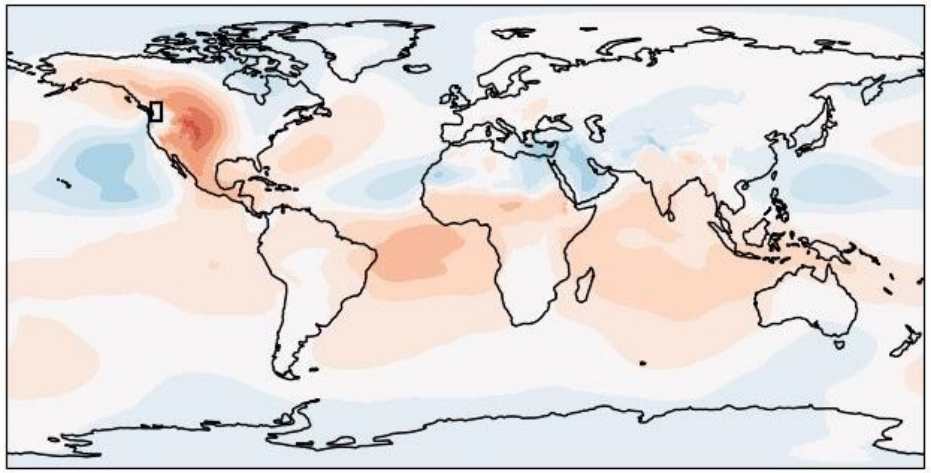
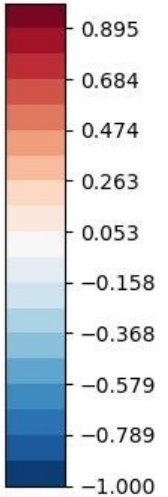
Z500 correlates more strongly

Z500 Correlation



SLP Correlation





Correlation field for every JJA day, local field against impact timeseries

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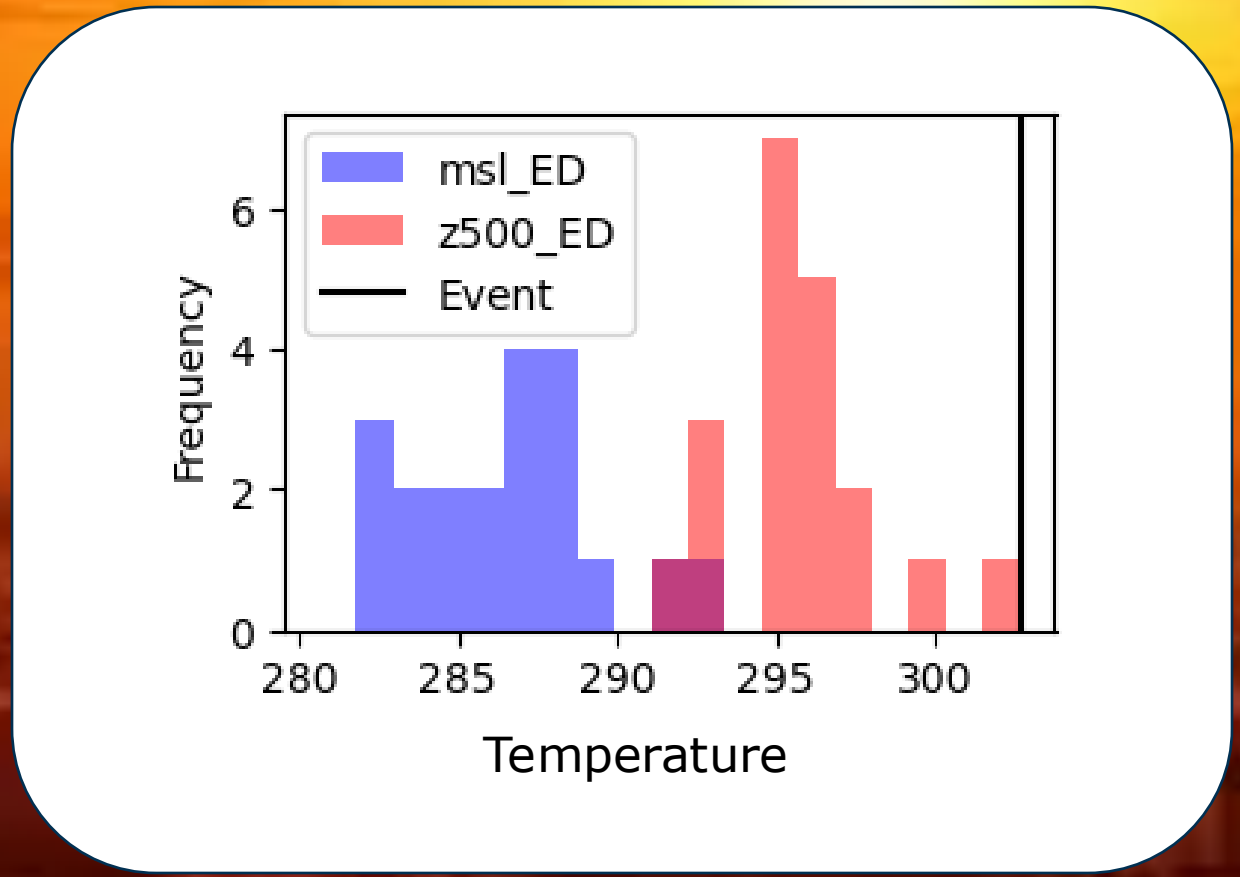
Z500 finds hotter events



Choosing the method:

Euclidean distance: finds the fields with smallest absolute difference, therefore captures events of closer intensity

Spatial Correlation: events can have high correlation but not be as extreme
i.e. a weaker version of the same circulation pattern

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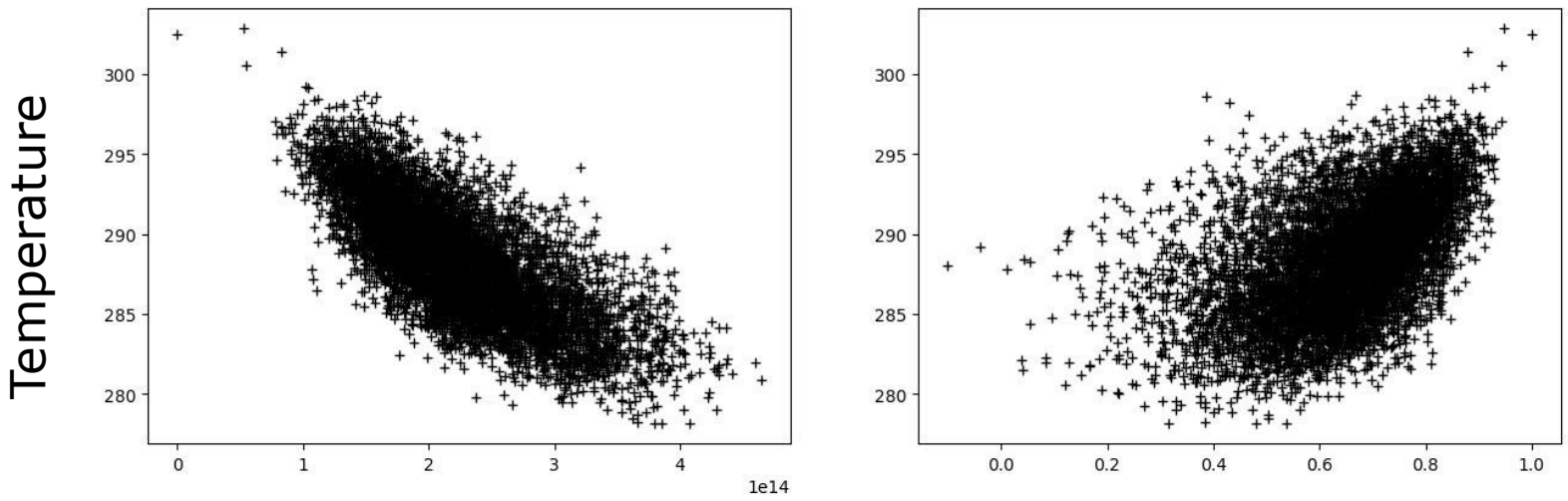
Choosing the method:



Euclidean Distance

Spatial Correlation

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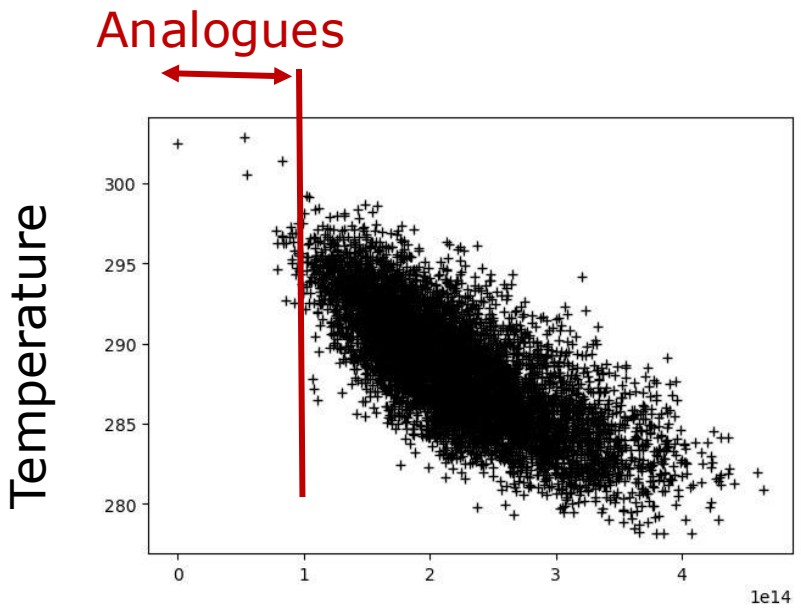
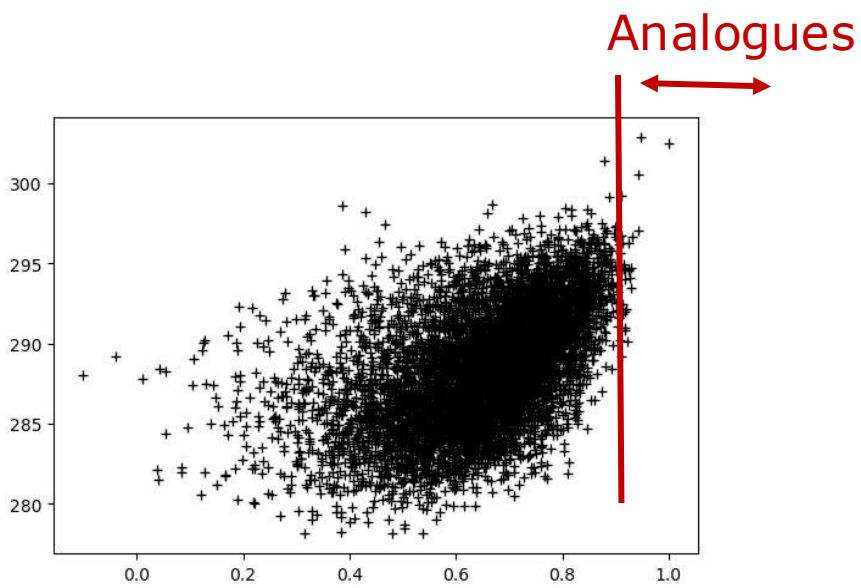
Choosing the method:



Euclidean Distance



Spatial Correlation

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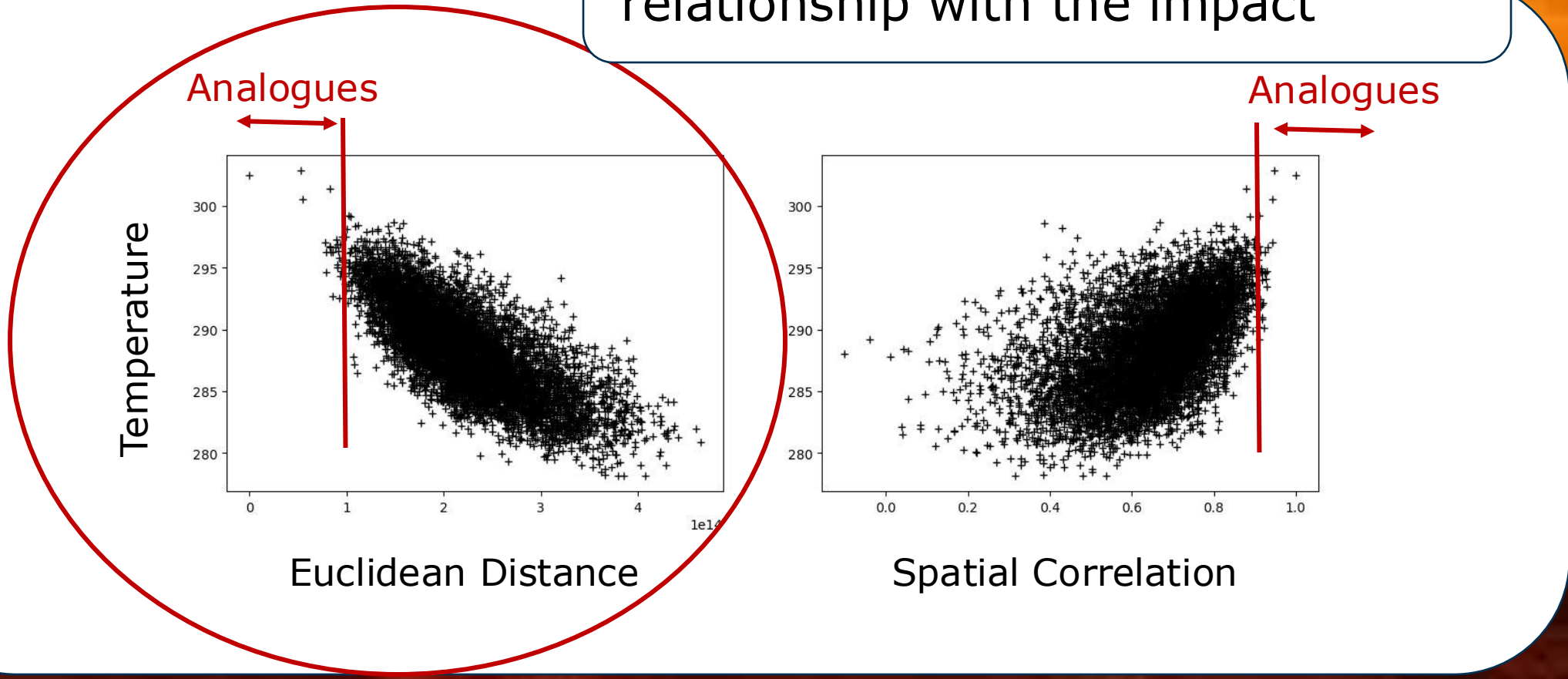
Choosing the method:

Euclidean distance has a stronger relationship with the impact



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For heatwaves it is best to use Z500

Warm air rises creating a local depression, which acts to decrease the high pressue anomaly. This flattens the SLP patterns and blurs the signal.

Jézéquel et al (2018) Climate Dynamics

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For heatwaves it is best to use Z500

What about extreme rainfall events?

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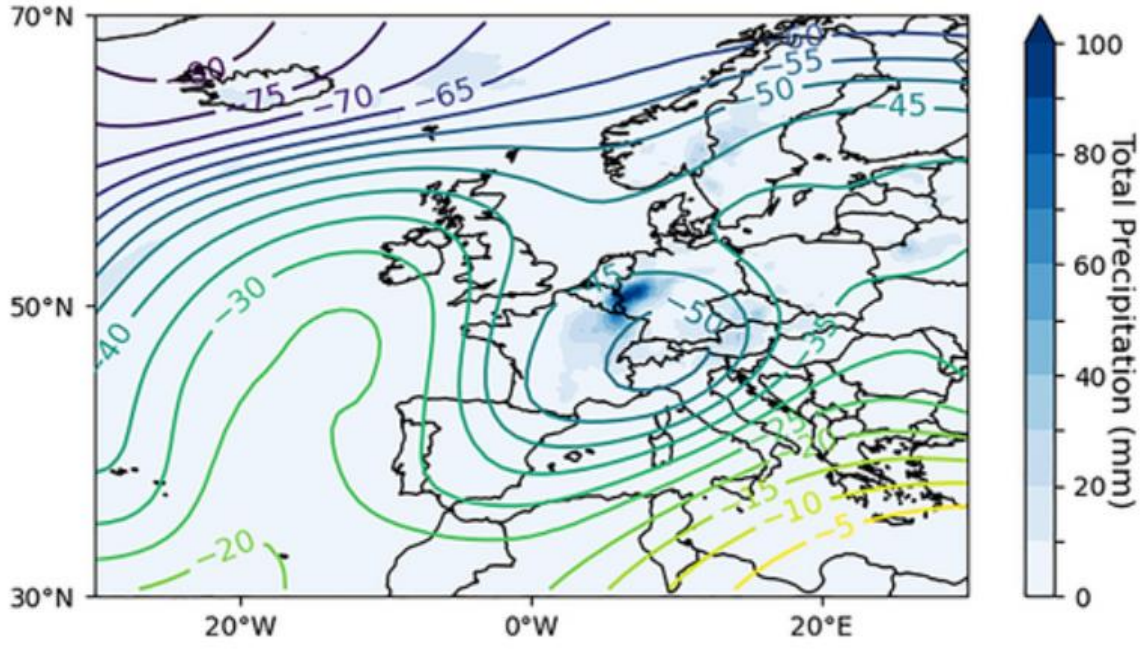
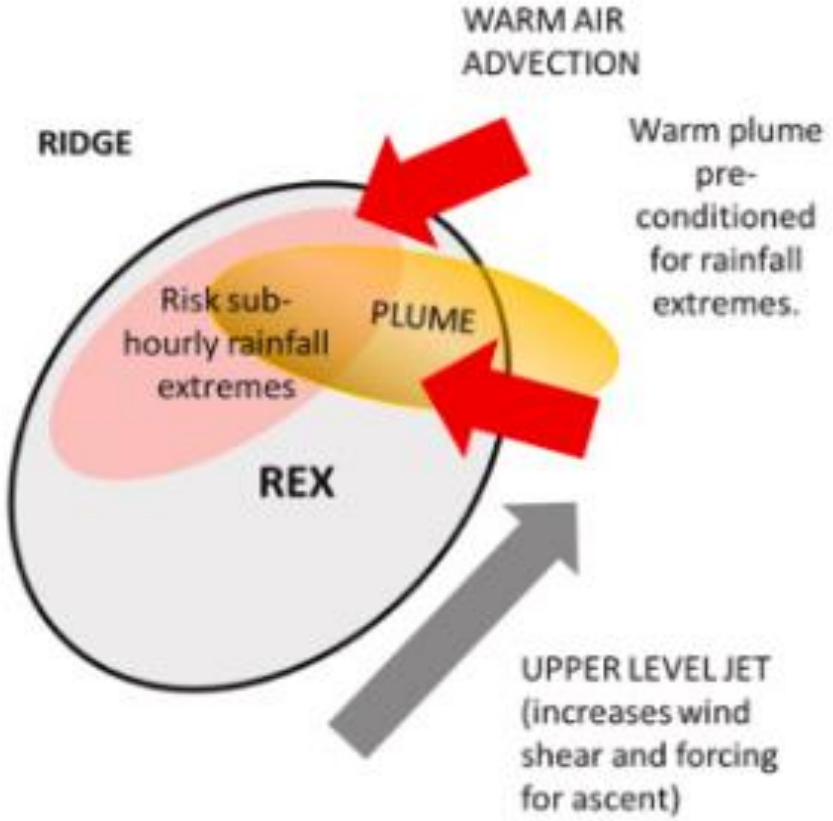
July 14th 2021





Thompson et al. (2024) ASL

Davies et al. (2024) WACE

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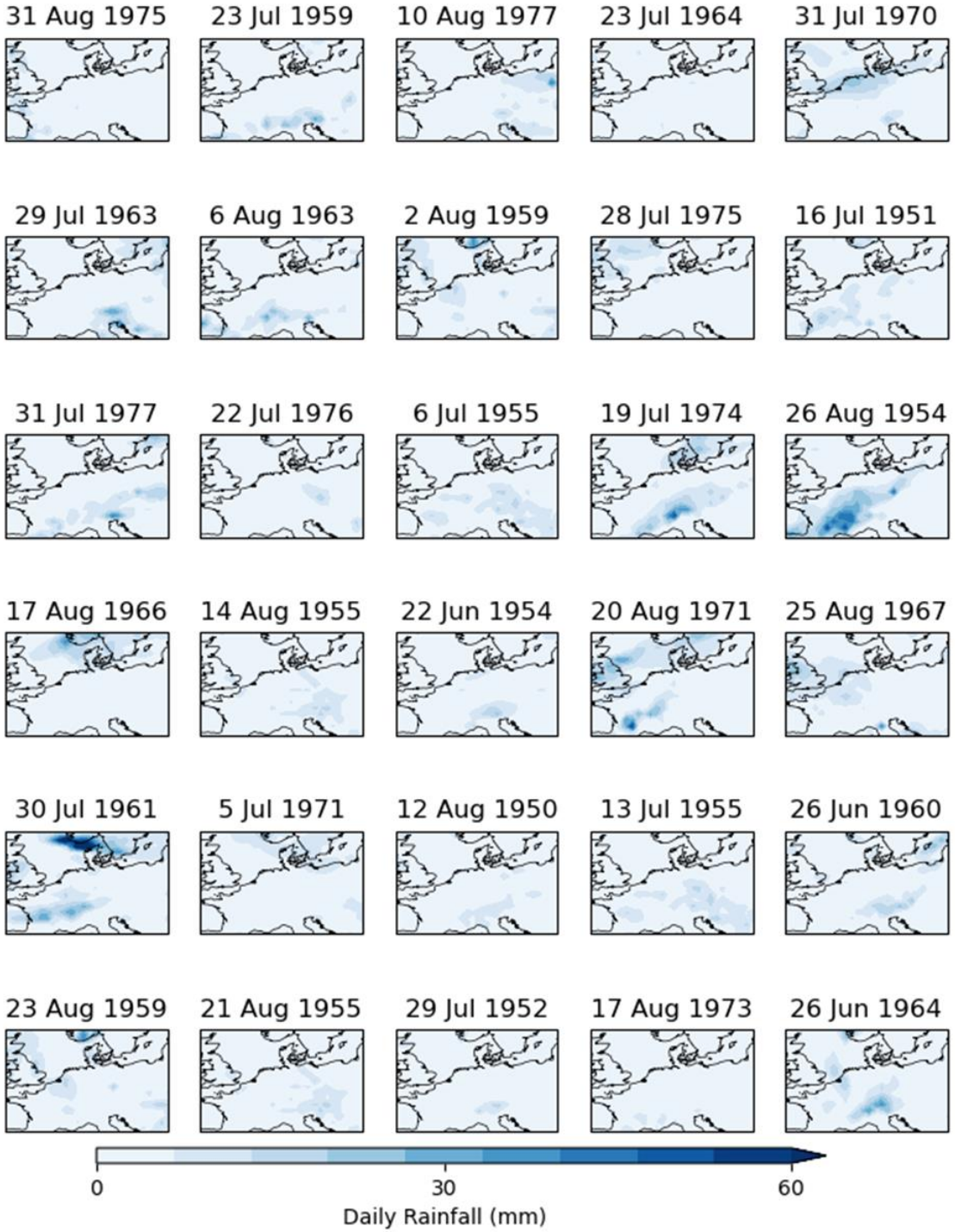

Not all dynamical analogues show extreme rainfall

Relationship between impact and dynamics is weaker

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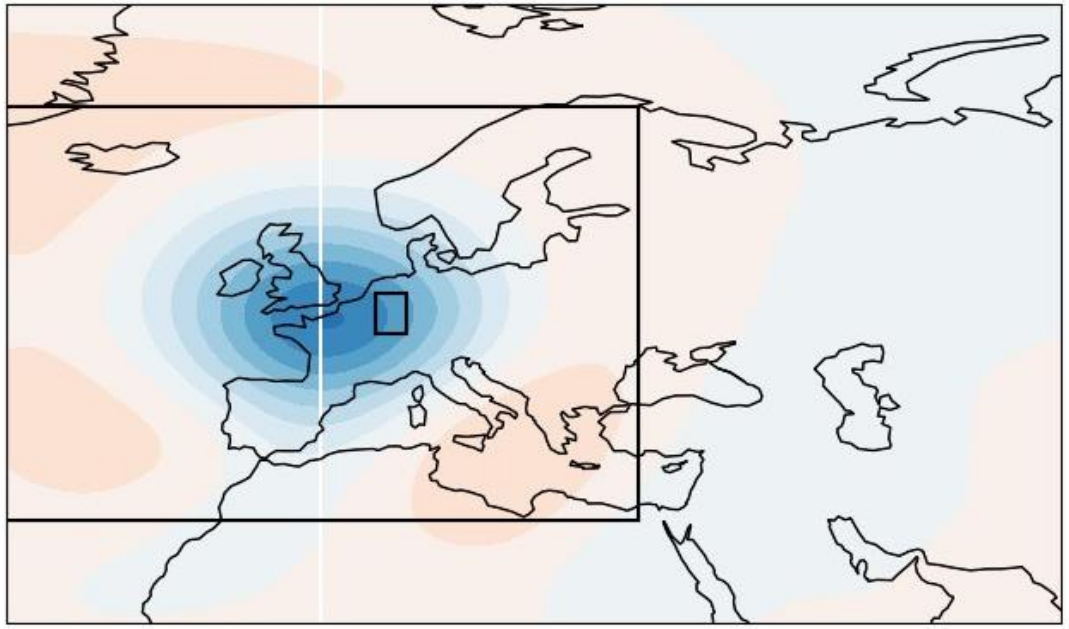
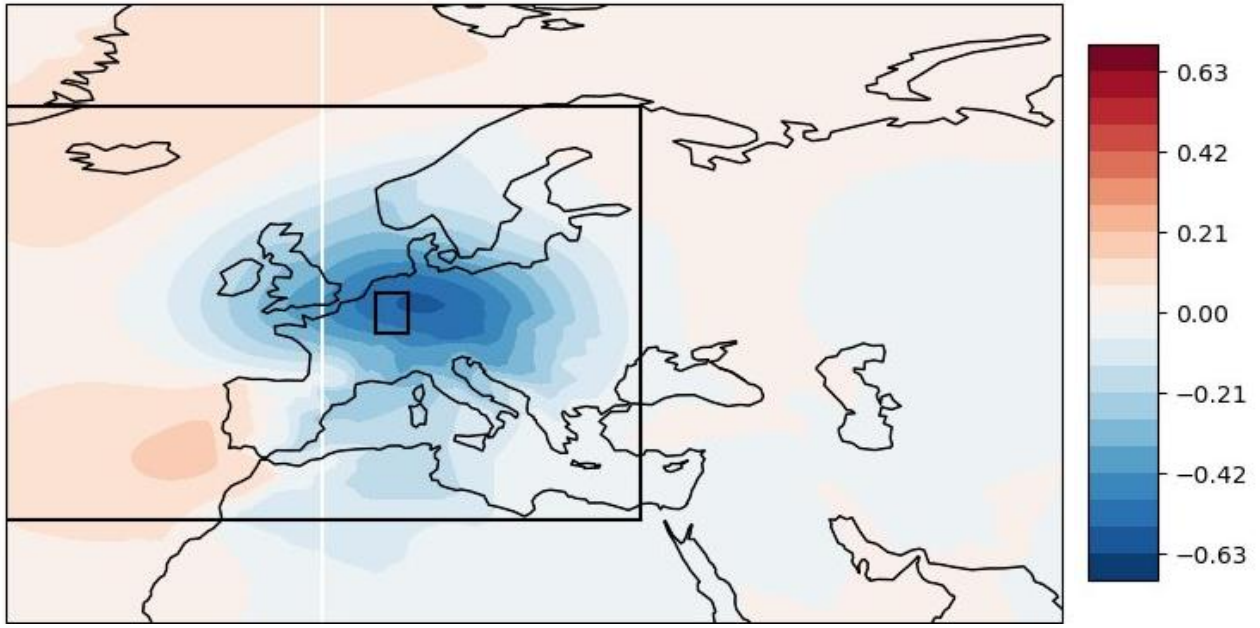
SLP correlates more strongly

Z500 Correlation



SLP Correlation



but correlation weaker

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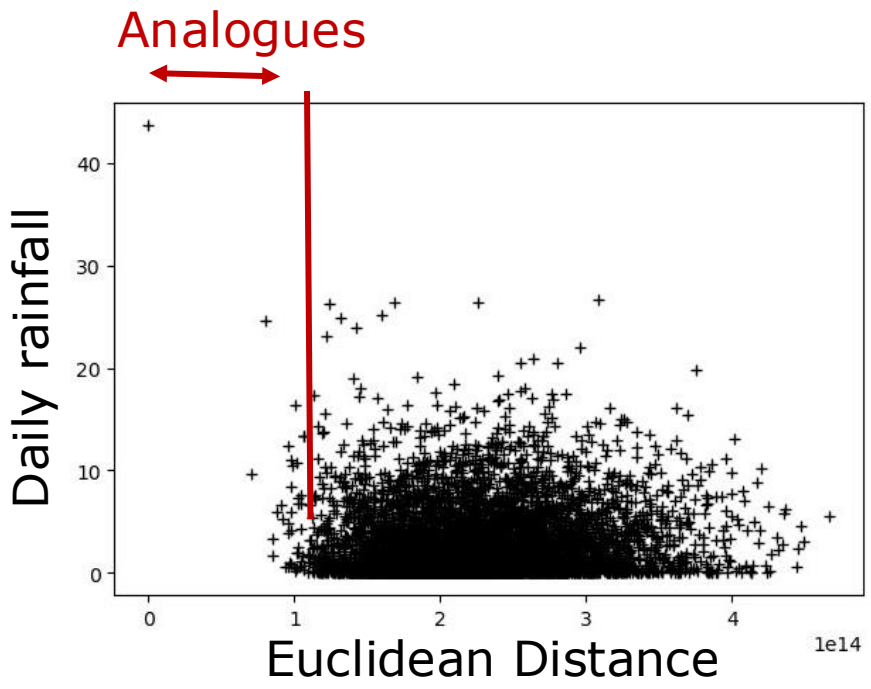
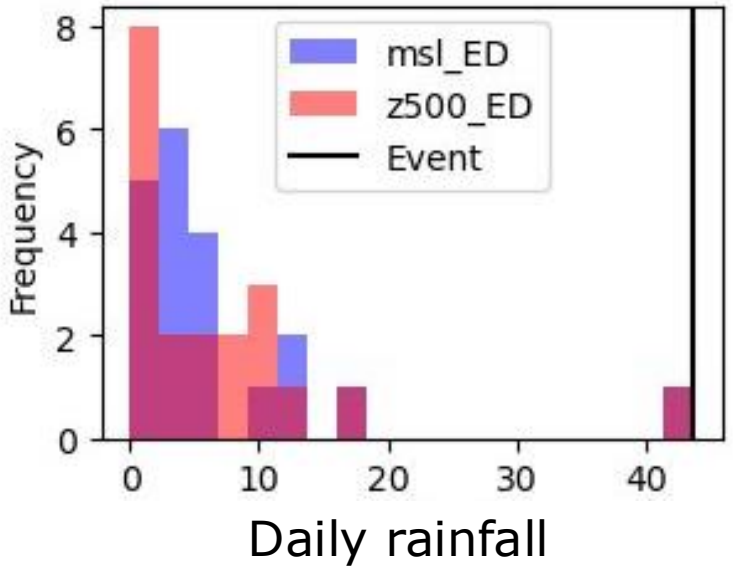
Weaker relationship – many analogues without impacts





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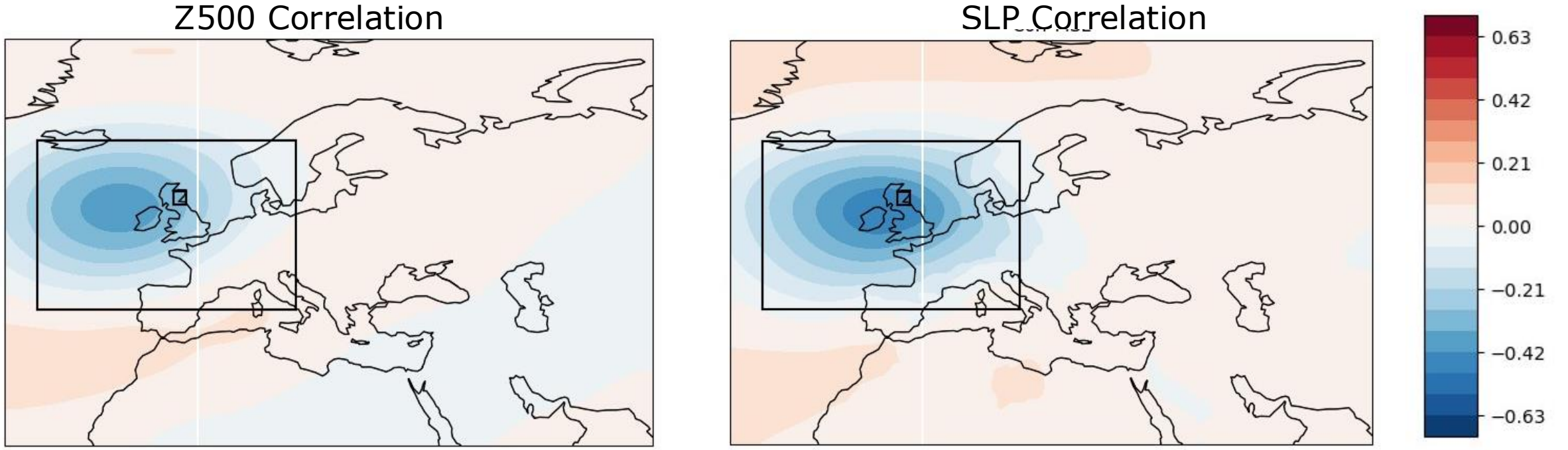
Storm Babet



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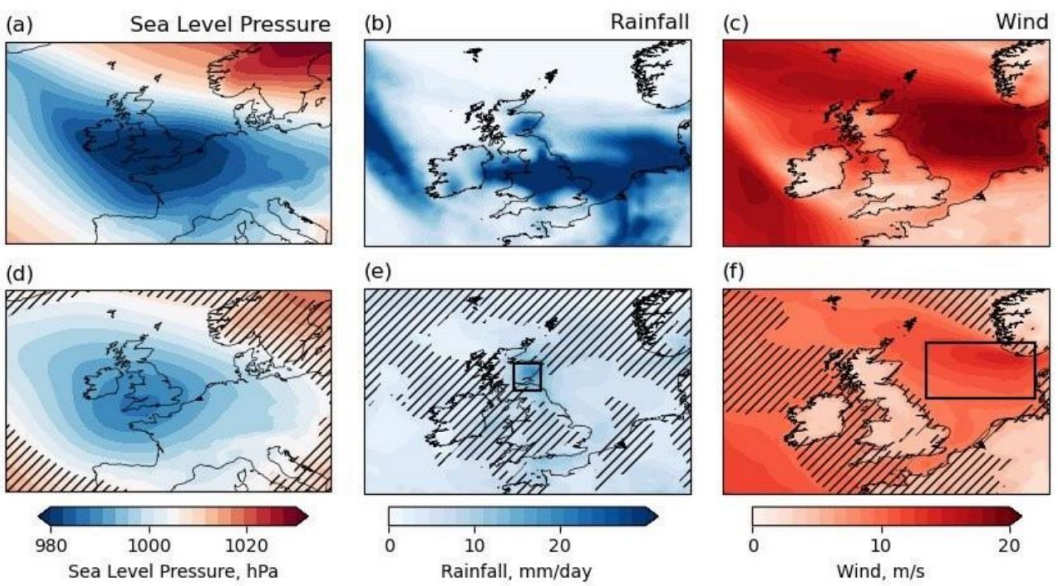
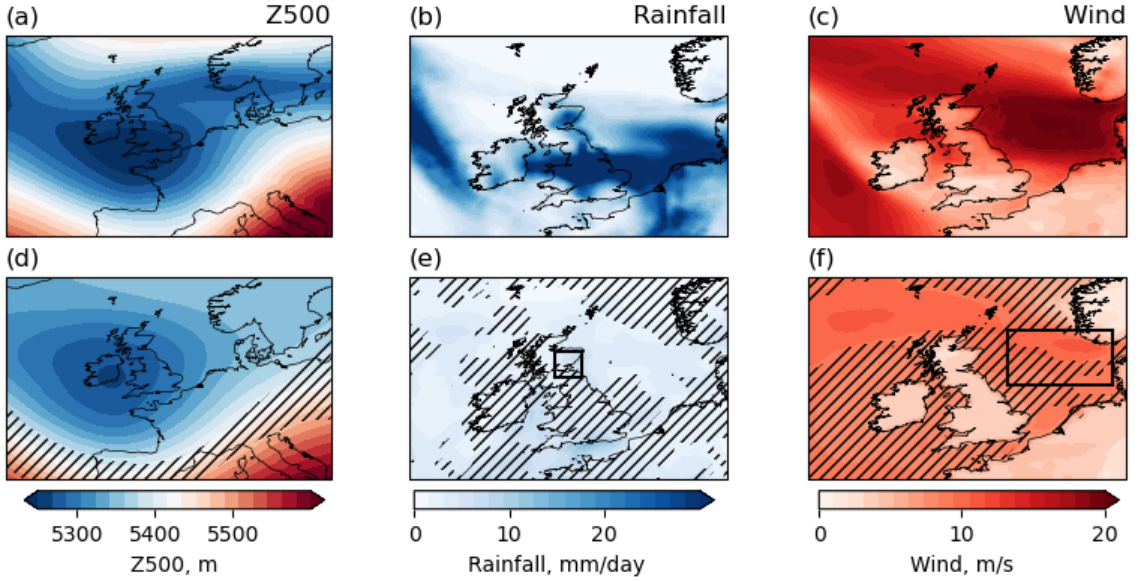
SLP analogues identify events with greater rainfall





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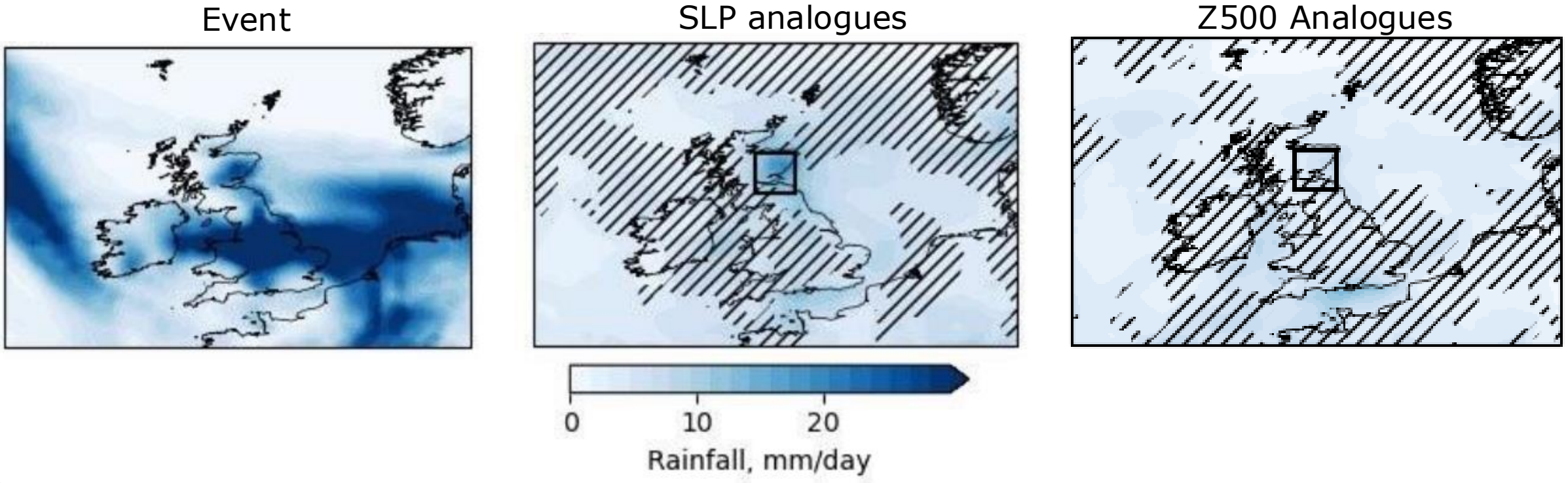
SLP analogues identify events with greater rainfall



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So far, we have been unable to find a clear set of rules for rainfall events.

Despite this, analogues can be used to assess extreme weather events which caused impactful rainfall...

Valencia flooding

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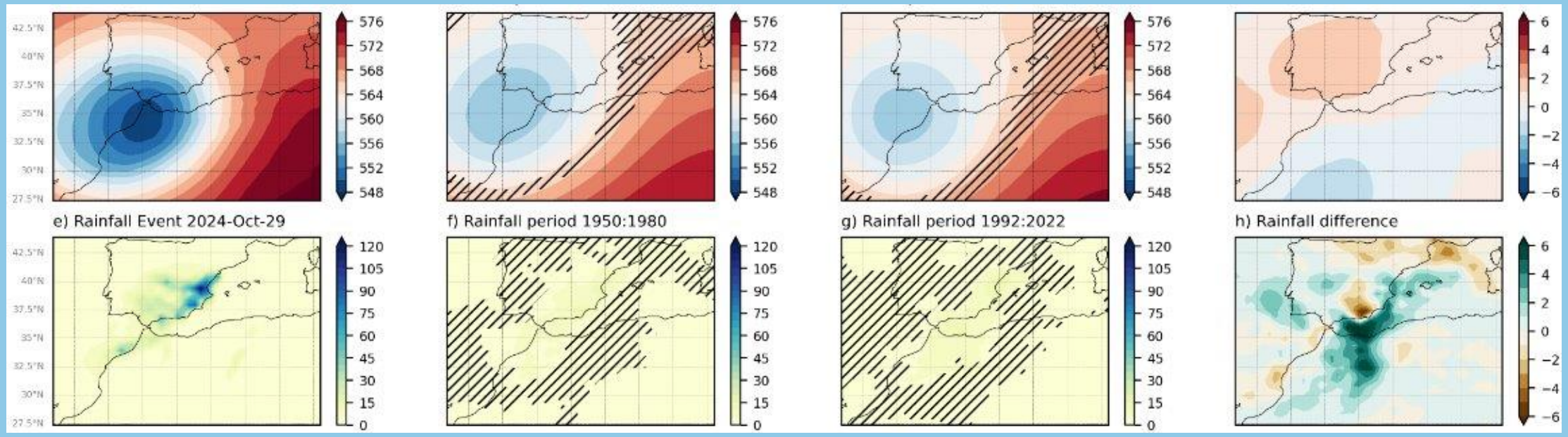

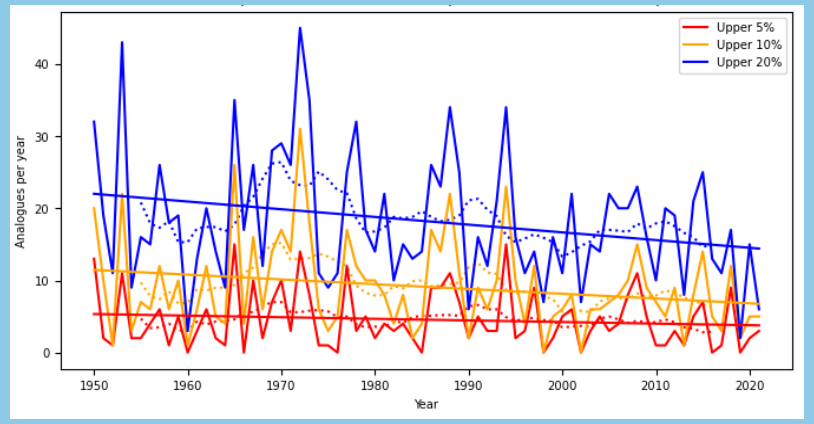

ERA5 analogues show the cut-off low feature, and statistically significant rainfall in eastern Spain.

Impact: Increased coastal rainfall
Frequency: Decreasing
Intensity: No evidence of change

Storm Boris

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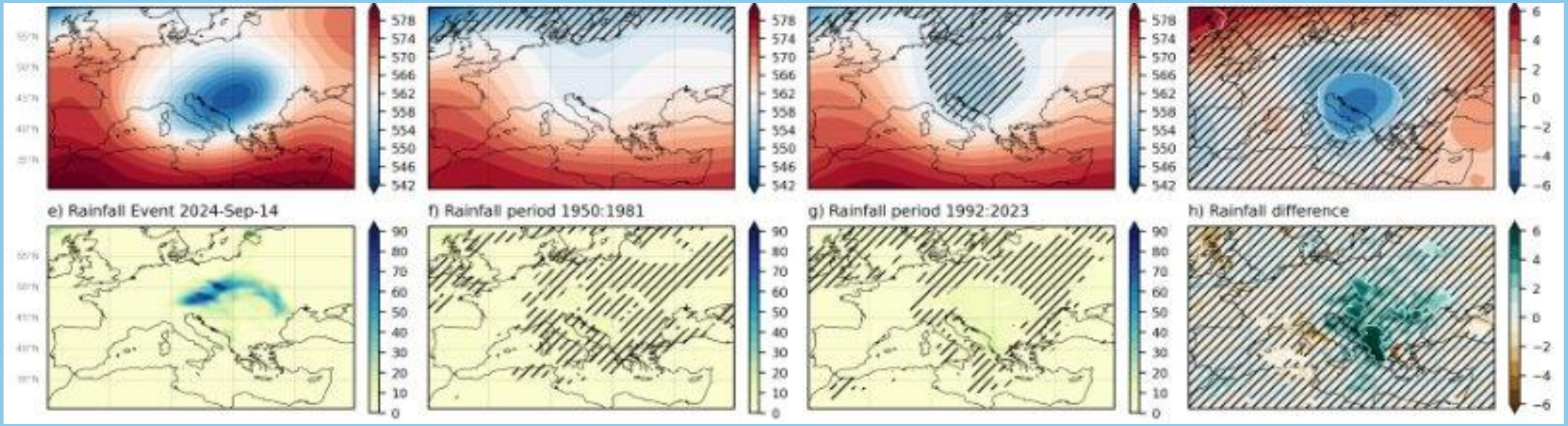

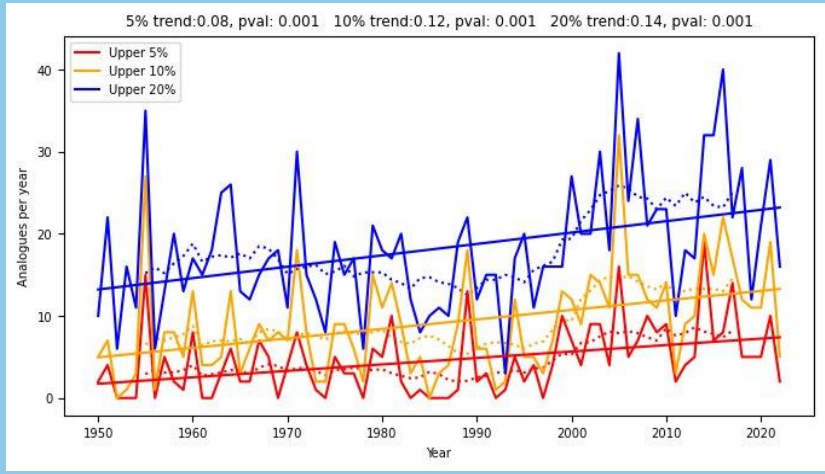

ERA5 analogues show the cut-off low feature, and statistically significant rainfall

Impact: Increased rainfall
Frequency: Increasing
Intensity: Increasing

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Future directions...

Apply to model data to enable attribution and assessment of potential futures

Use multiple variables to identify analogues

Removing the spatial constraint, allowing analogues to occur in different locations

Explore changes in persistence & seasonality

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Take away messages

Analogues provide a useful method to assess how extreme weather events are changing

There are many methodological choices needed when identifying the best analogues

We want to create a set of rules to enable rapid assessment of analogues for many event types and locations (including European storms)