Potsdam-Institut für Klimafolgenforschung

Leibniz Gemeinschaft

CapTainRain

Too wet, too hot, too dry

The role of the weather persistence in Europe

Peter Hoffmann

Hydro-Climatic Risks

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Content

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- **Topic 2:** local weather extremes in a large-scale context
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- **Topic 6:** re-identification of weather-types in climate scenarios
- **Topic 7:** a case study
  - contextualization of extreme rainfall in Jordan

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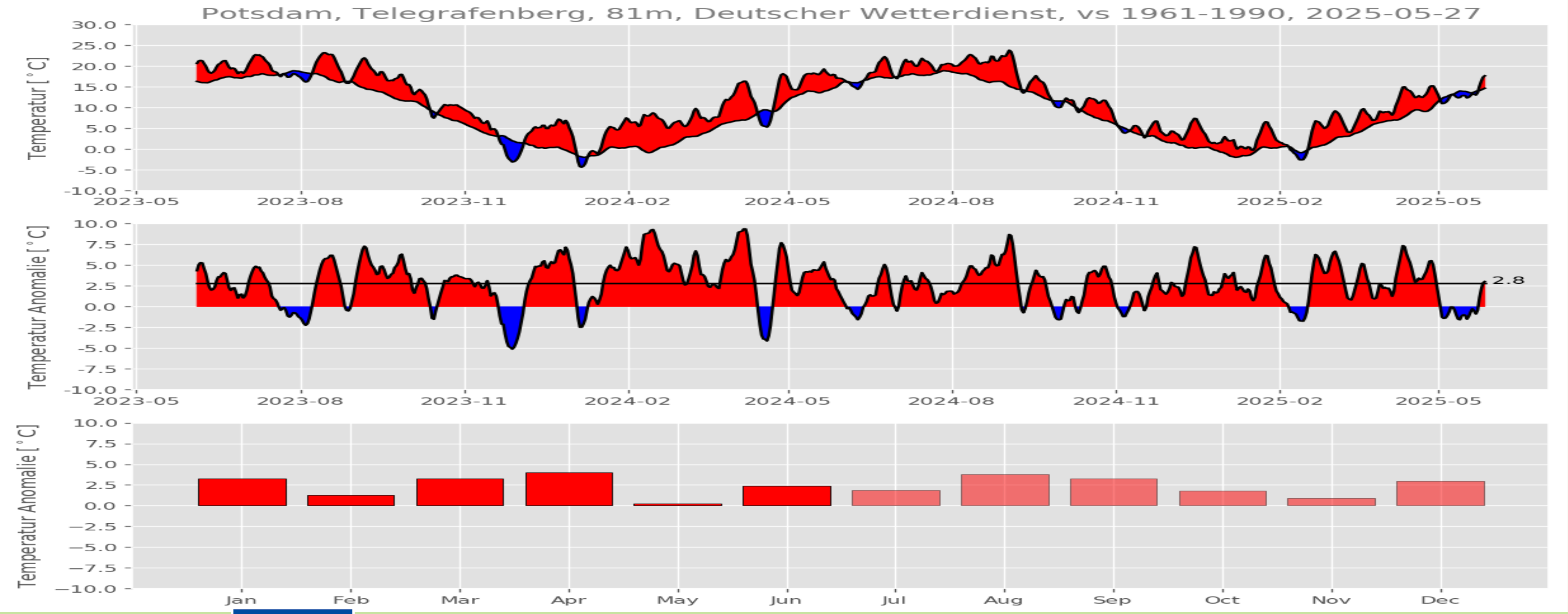
Topic 1 of 7

weather variability and meteorological phenomena

Monitoring

local temperature variability in a climatic context



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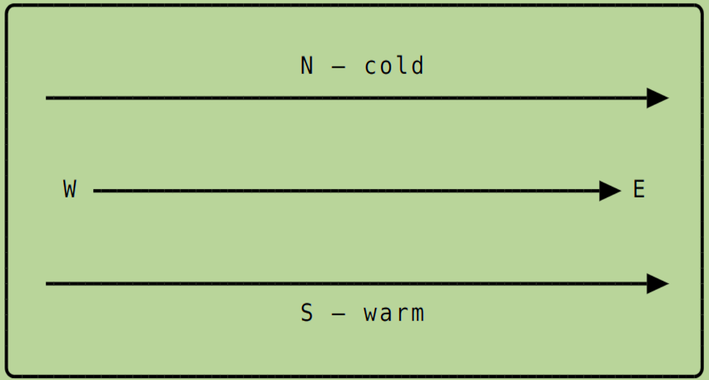
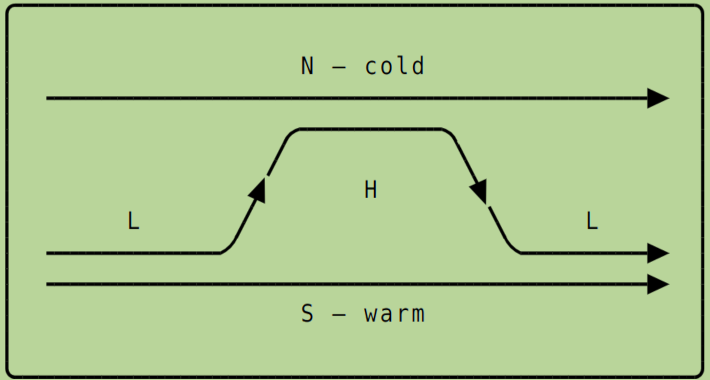
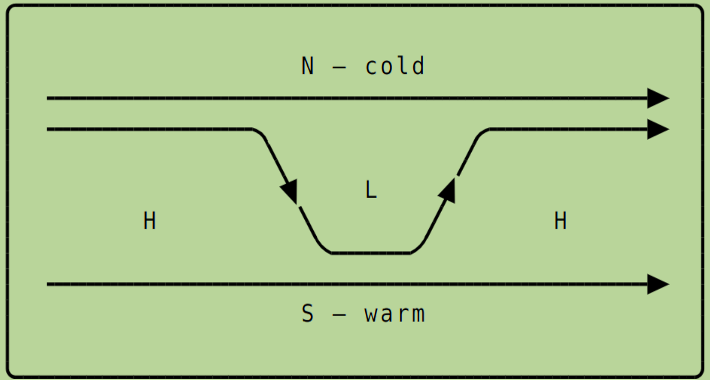
Synoptic Scale Variability

Transport of air masses across longitude and latitude

west	south	north
WZ 	HM 	TRM 
zonal	meridional	meridional

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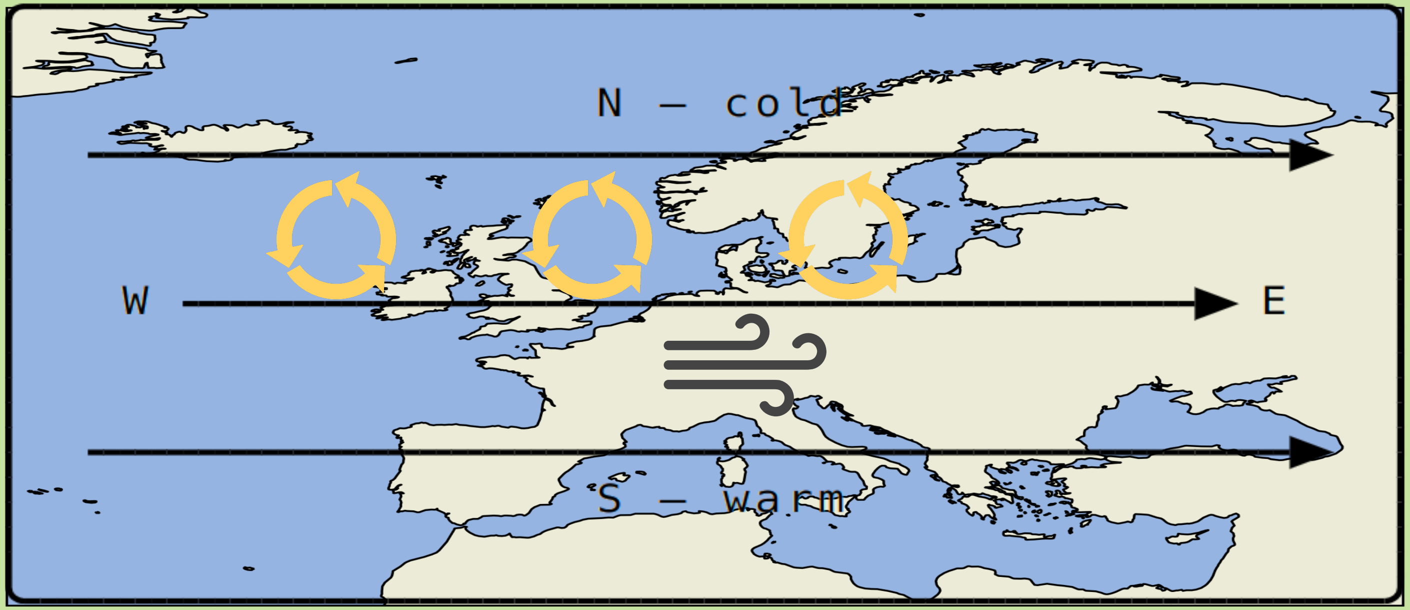
Zonal

high latitudes cold – low latitudes warm – moderate weather condition

WZ



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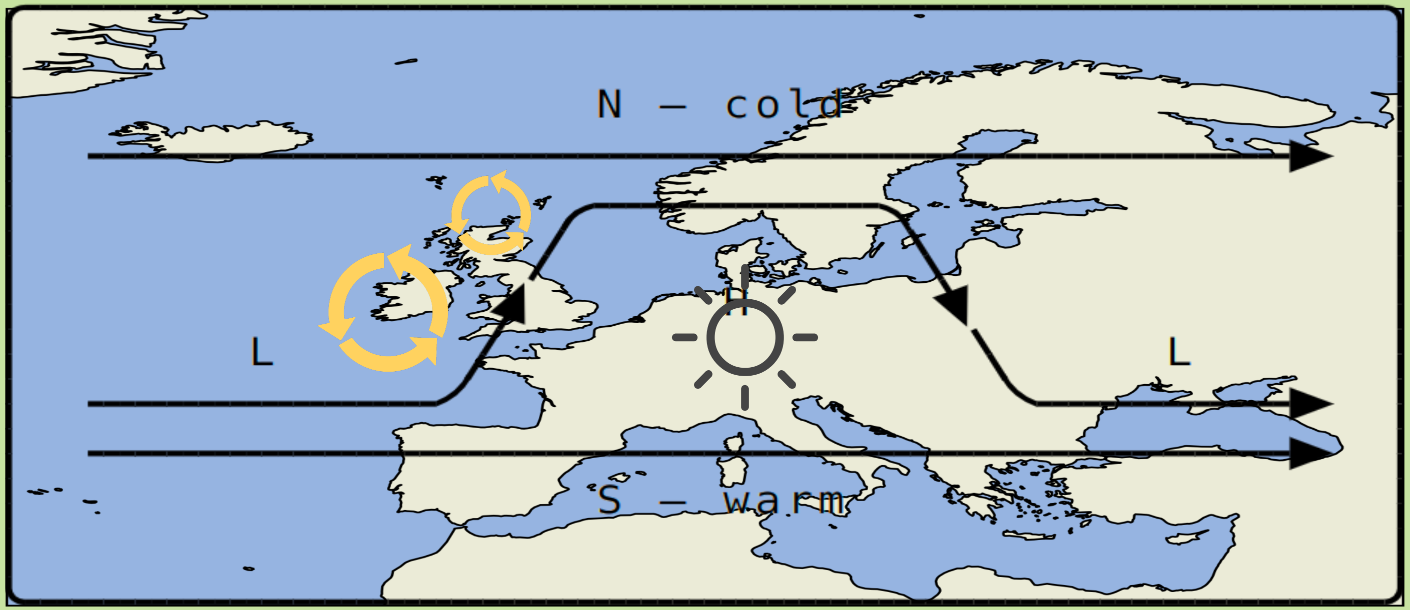
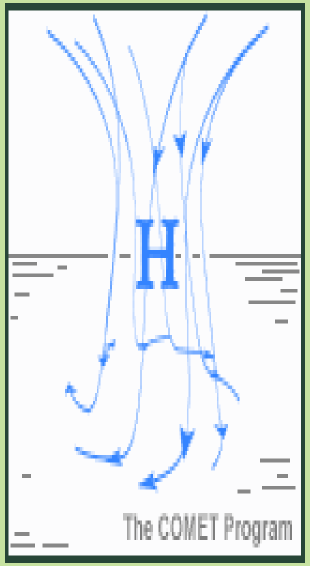
Meridional – Ridge

transport across latitudes – wet, hot and dry extremes are more likely

HM





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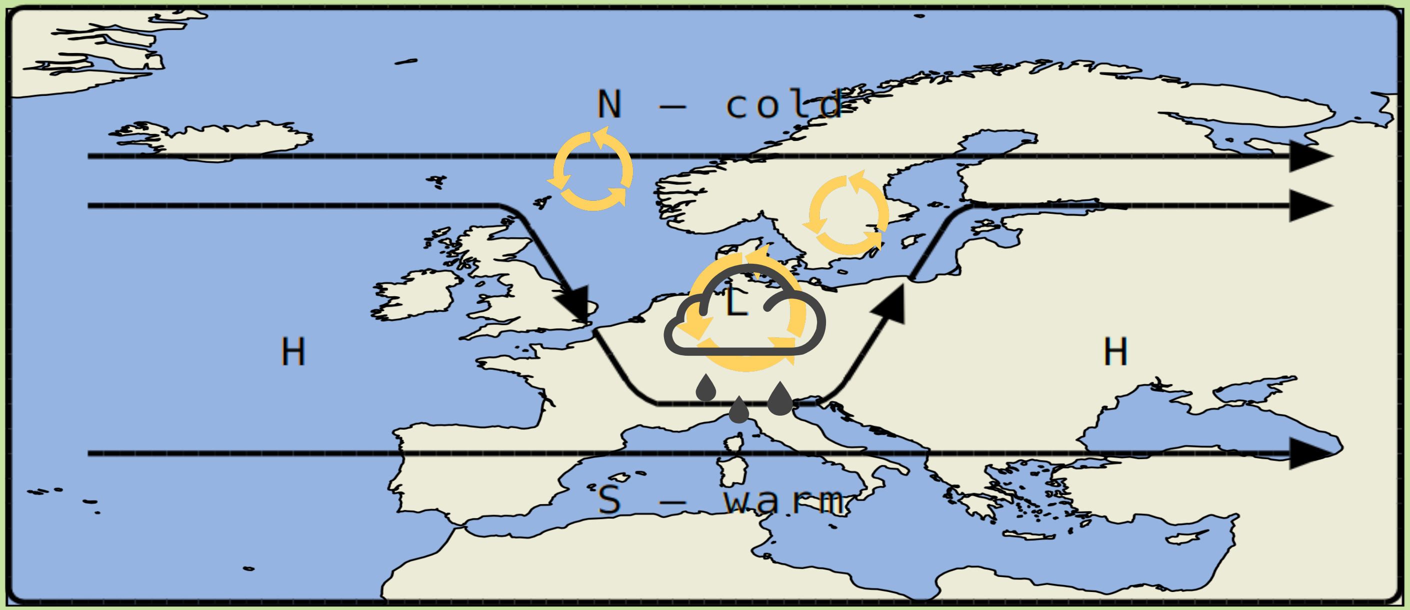
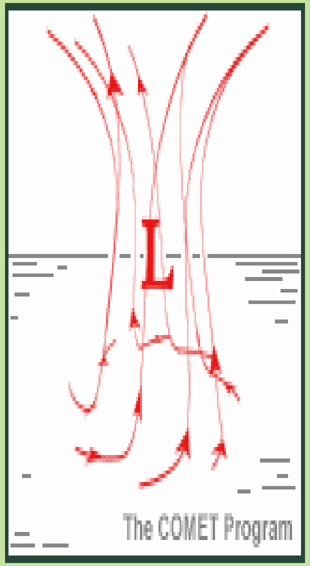
Meridional – Trough

transport across latitudes – wet, hot and dry extremes are more likely

TRM





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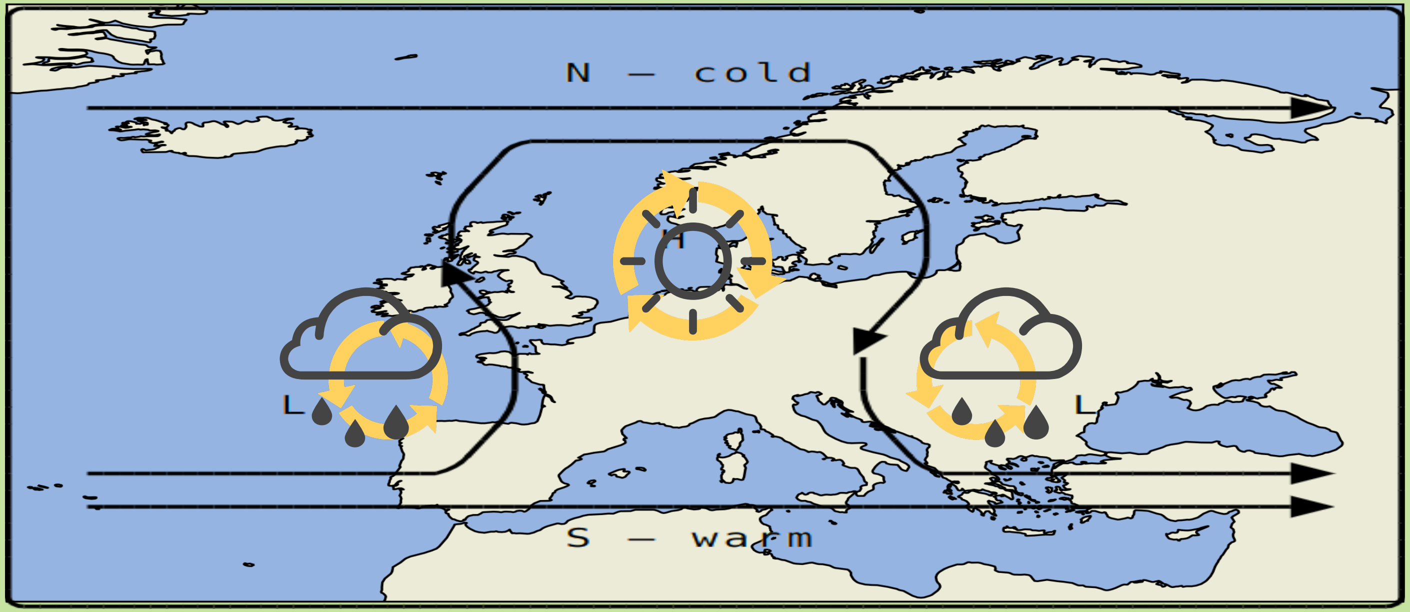
Omega – High over Low

atmosphere blocking – high latitude positive pressure anomalies

Omega



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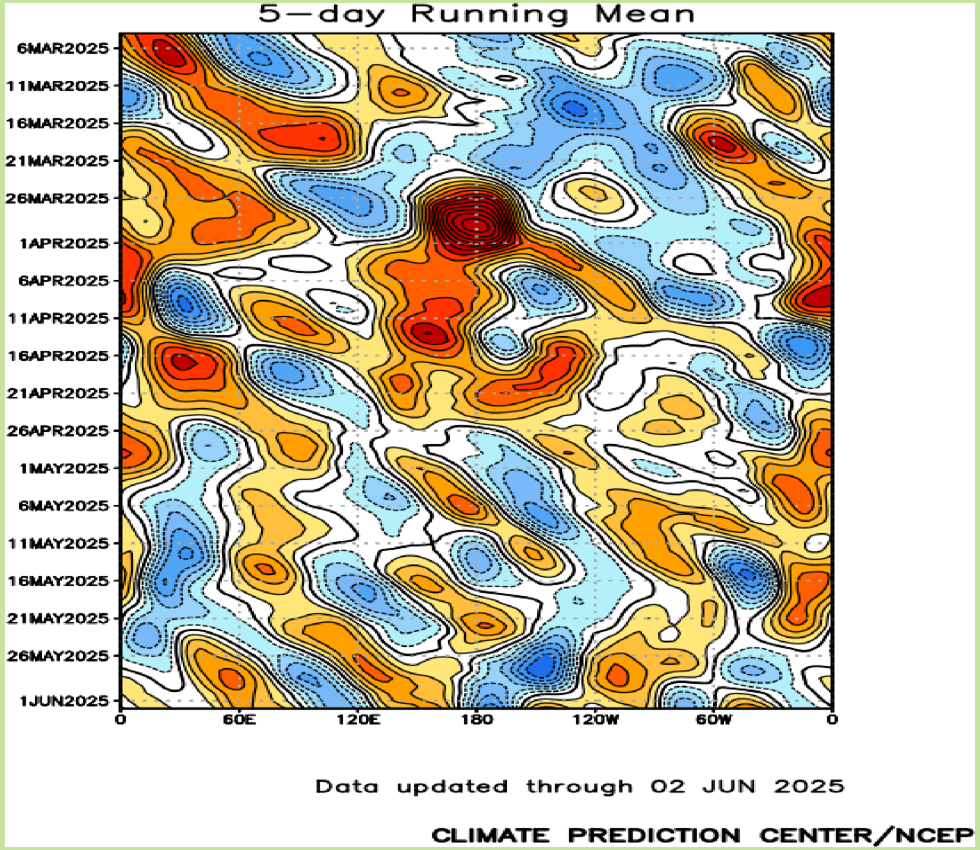
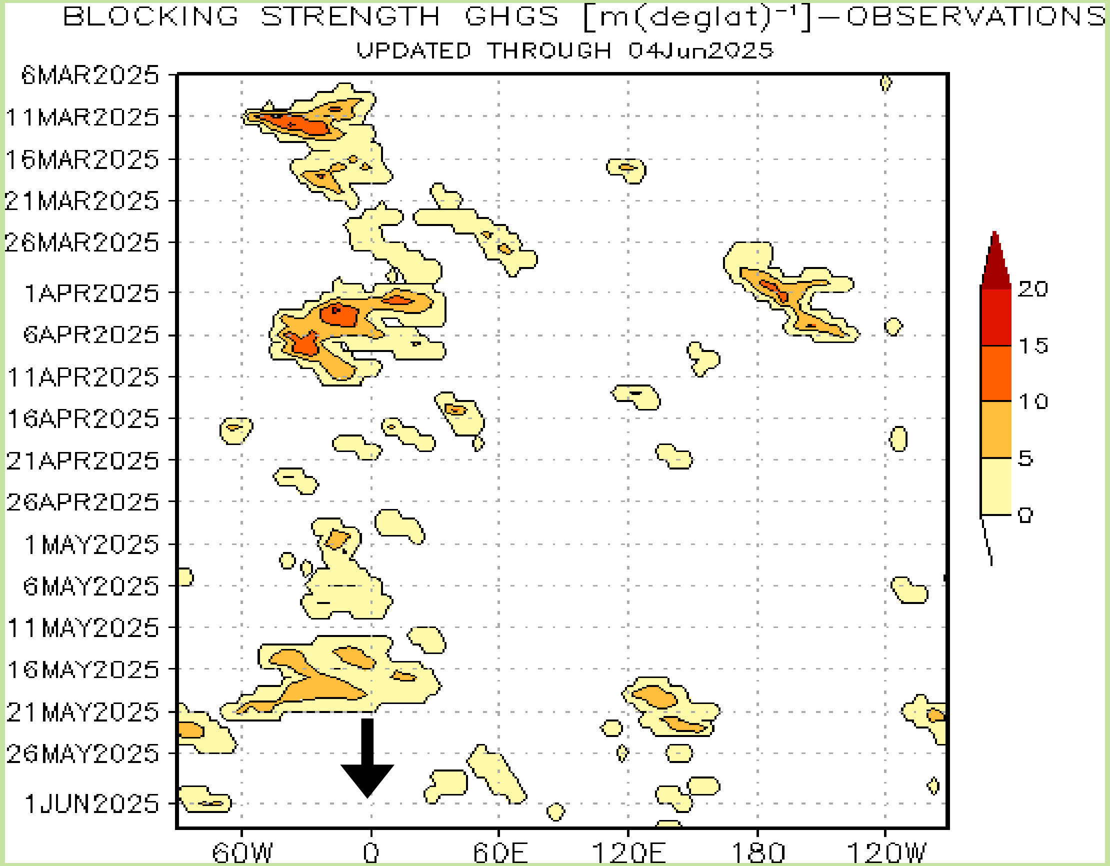
Blocking Index





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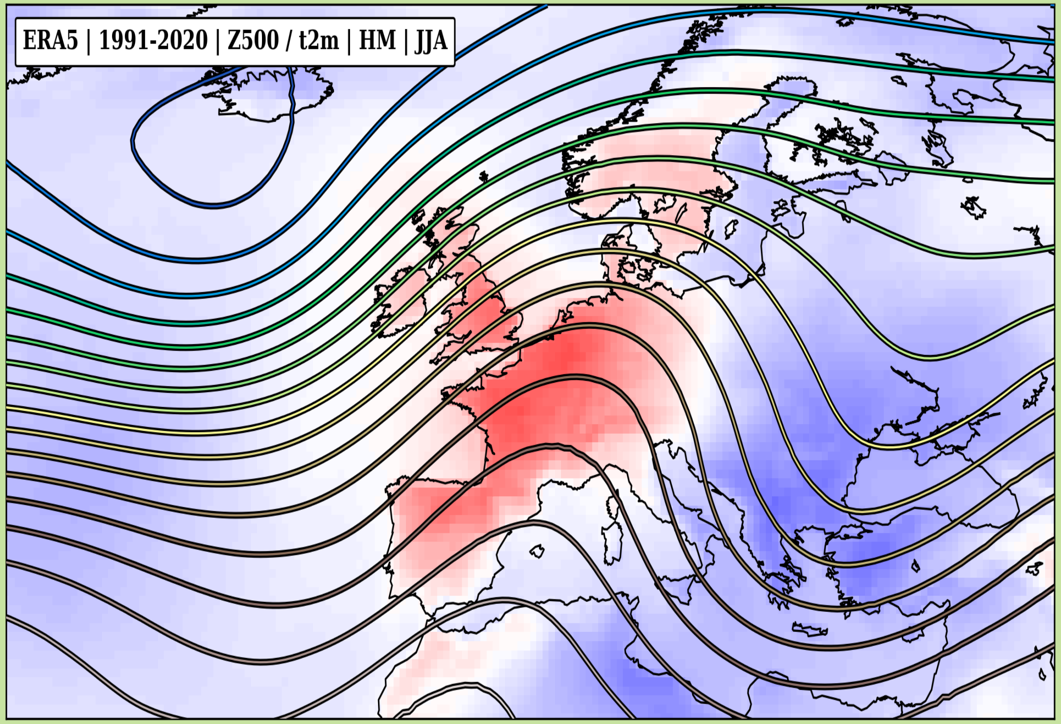
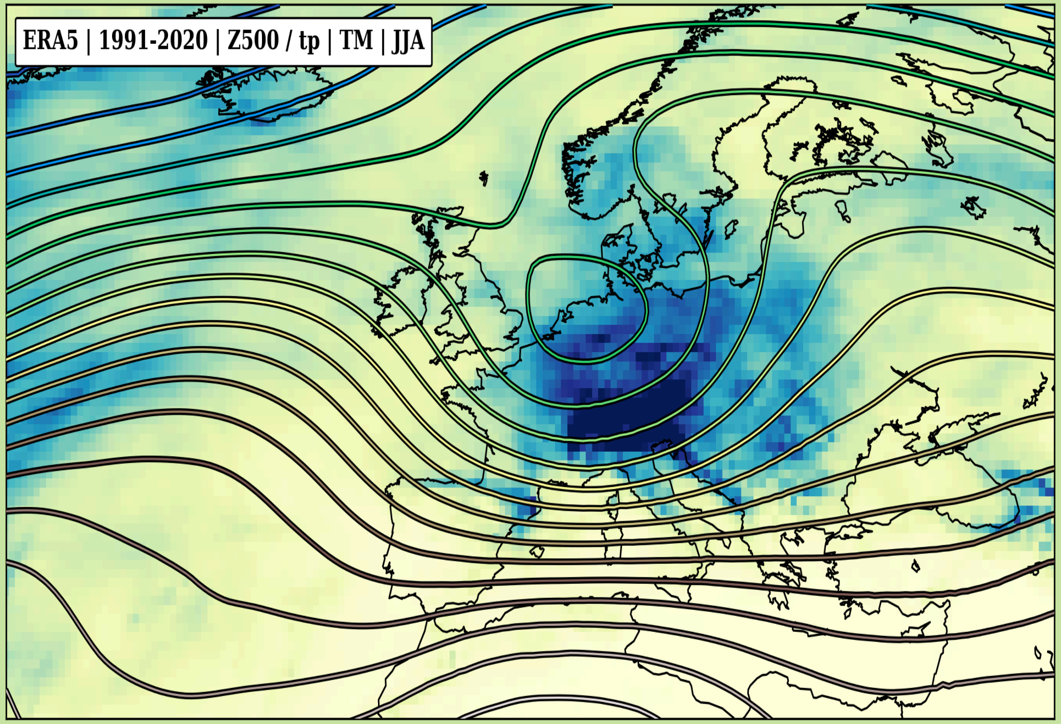
Causality

linkage between circulation patterns and weather maps





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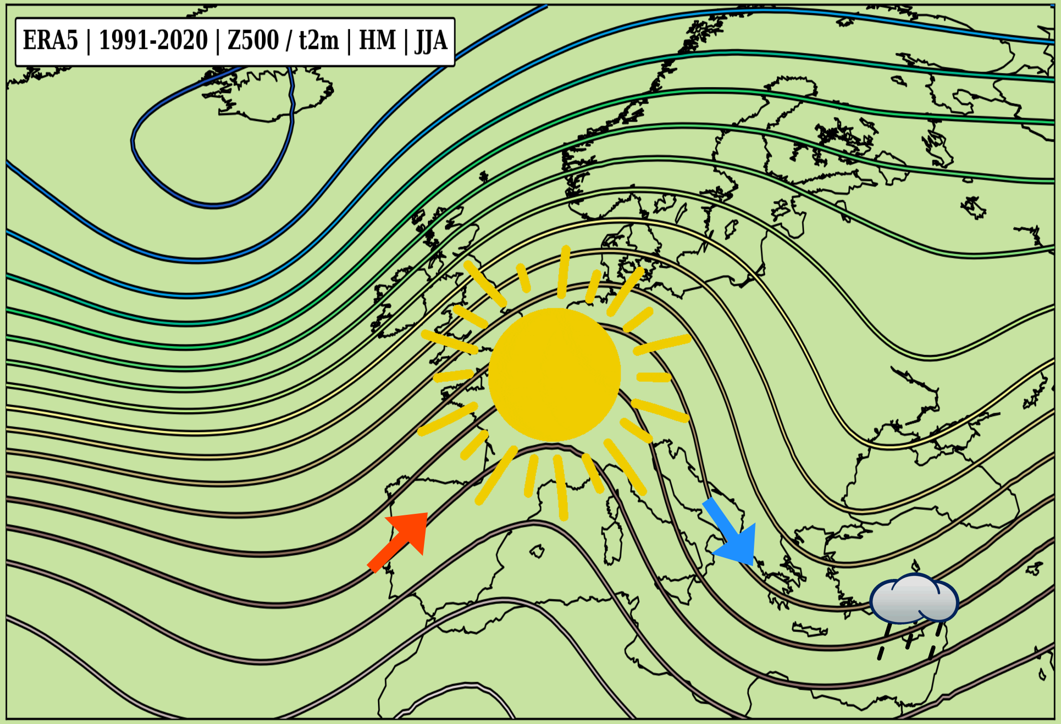
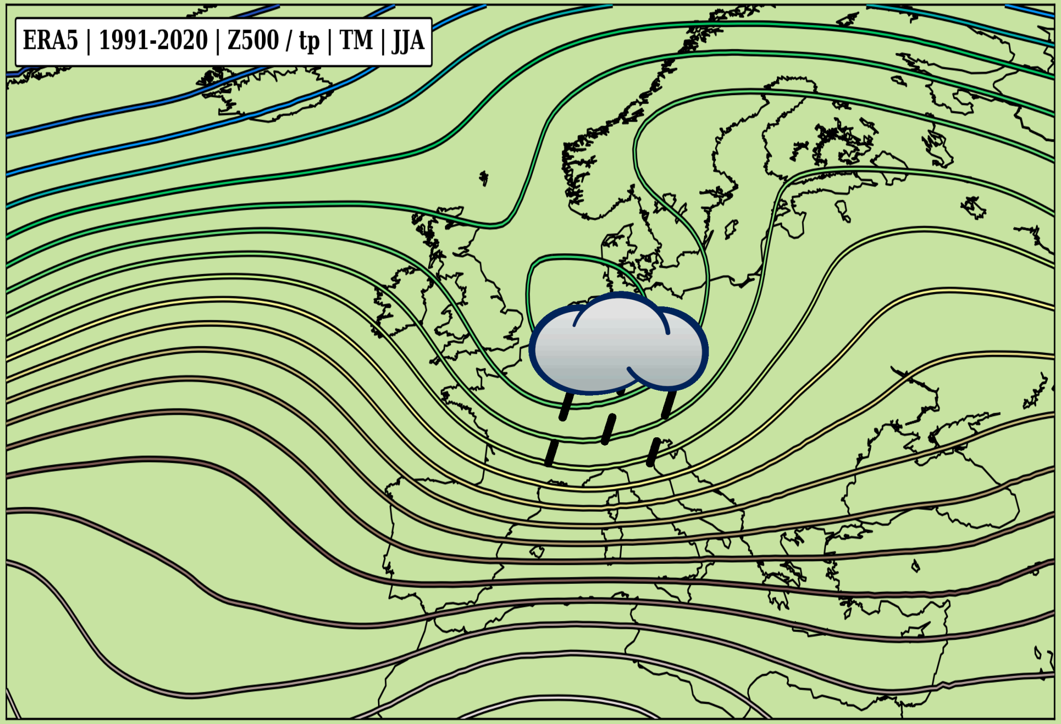
Causality

linkage between circulation patterns and weather maps





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Topic 2 of 7

local weather extremes in a large-scale context

Contextualization

meteorological phenomena and weather maps

Web Application

filtering of atmospheric fields by local timeseries

Example 1: high temperature Central Europe

http://localhost:5000/ncep?para=temp&lo=12.0&la=52.0&perc=99.00

Example 2: very high temperature Central Europe

http://localhost:5000/ncep?para=temp&lo=12.0&la=52.0&perc=99.90

Example 3: very high precipitation Central Europe

http://localhost:5000/ncep?para=temp&lo=12.0&la=52.0&perc=99.95

Example 4: very high precipitation Montenegro

http://localhost:5000/ncep?para=prate&lo=18.0&la=43 .0&perc=99.95

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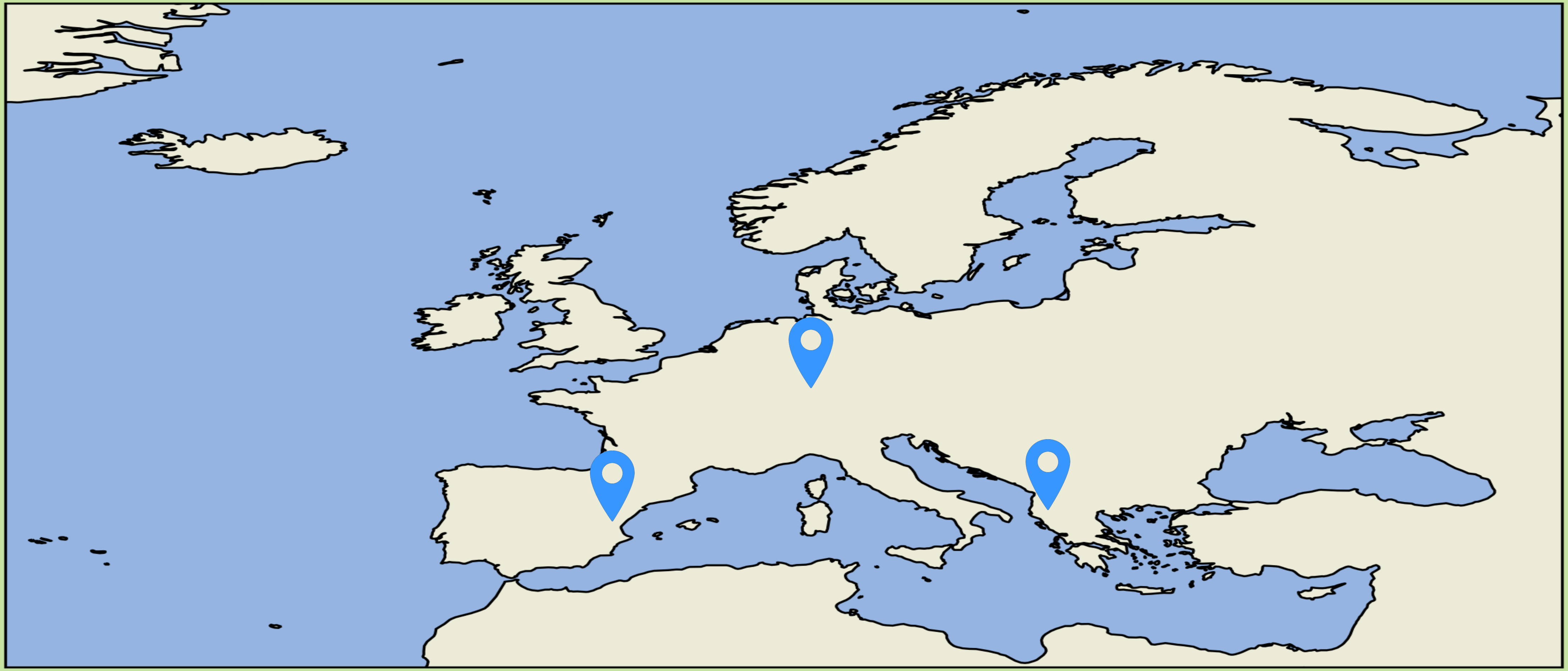
Heavy Rainfall Events



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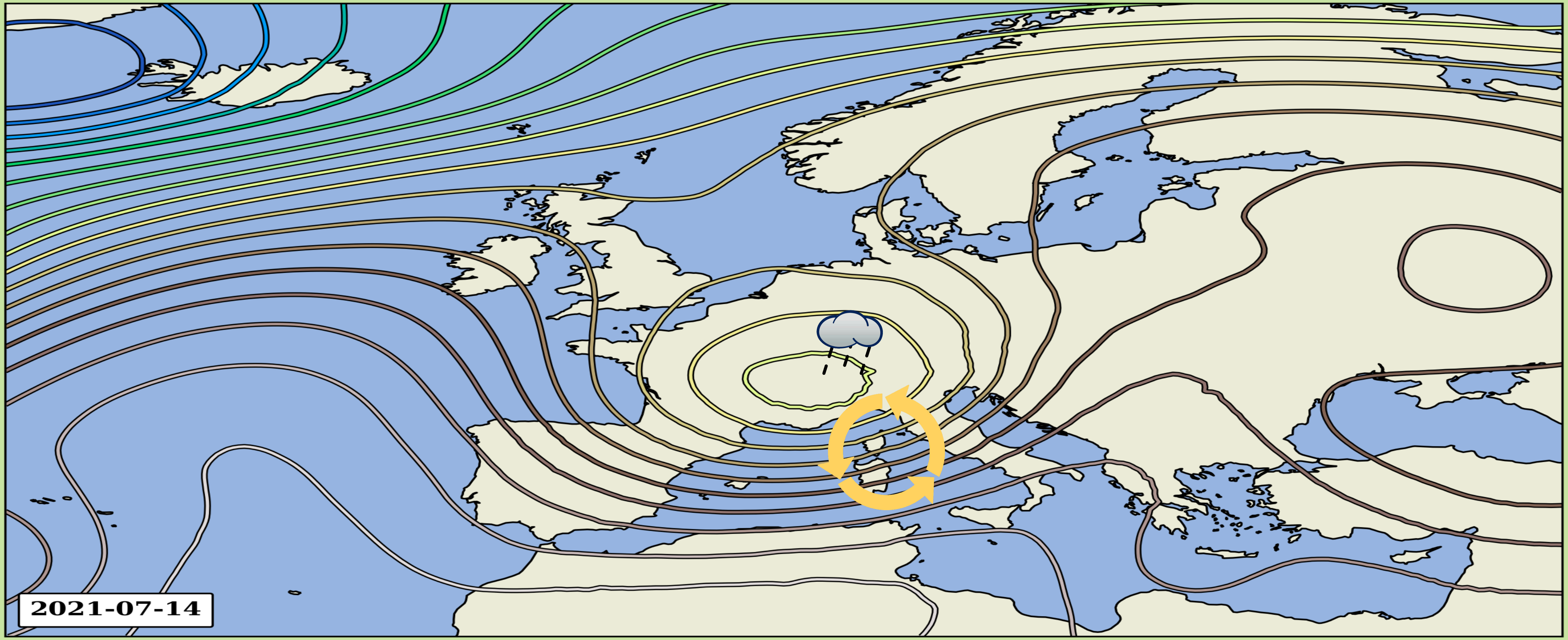
Ahrtal, Germany, Flood



Geopotential Height 500hPa (Z500)

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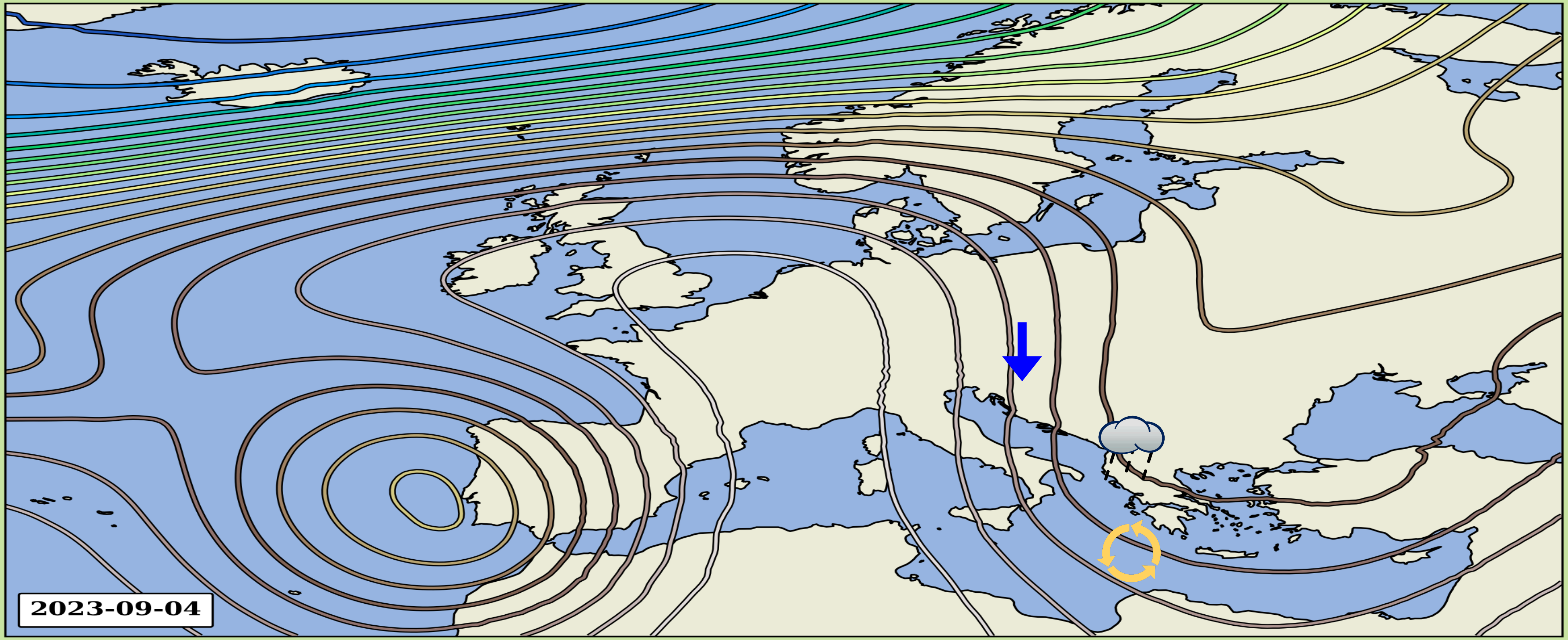
Zagora, Greece, Stormwater



Geopotential Height 500hPa (Z500)

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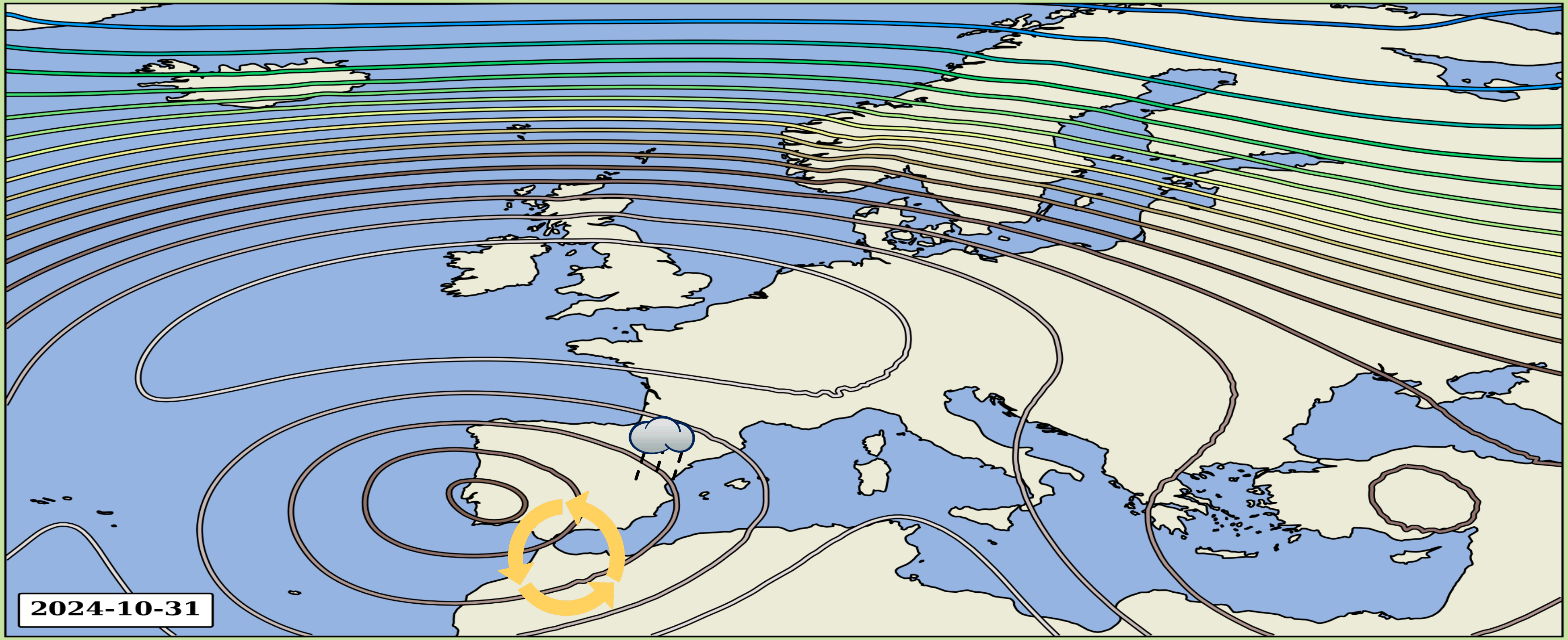
Topic 2 of 7: local weather extremes in a large-scale context

Valencia, Spain, Stormwater



Geopotential Height 500hPa (Z500)

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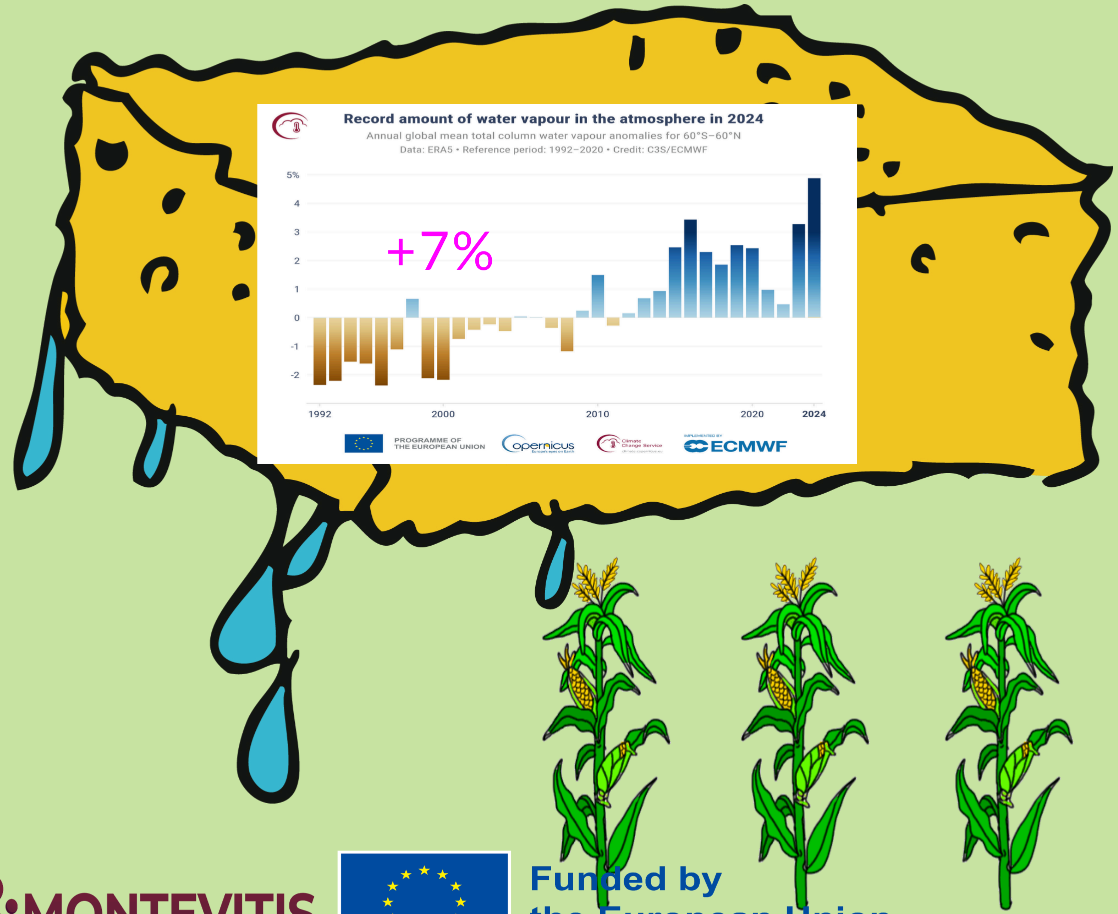
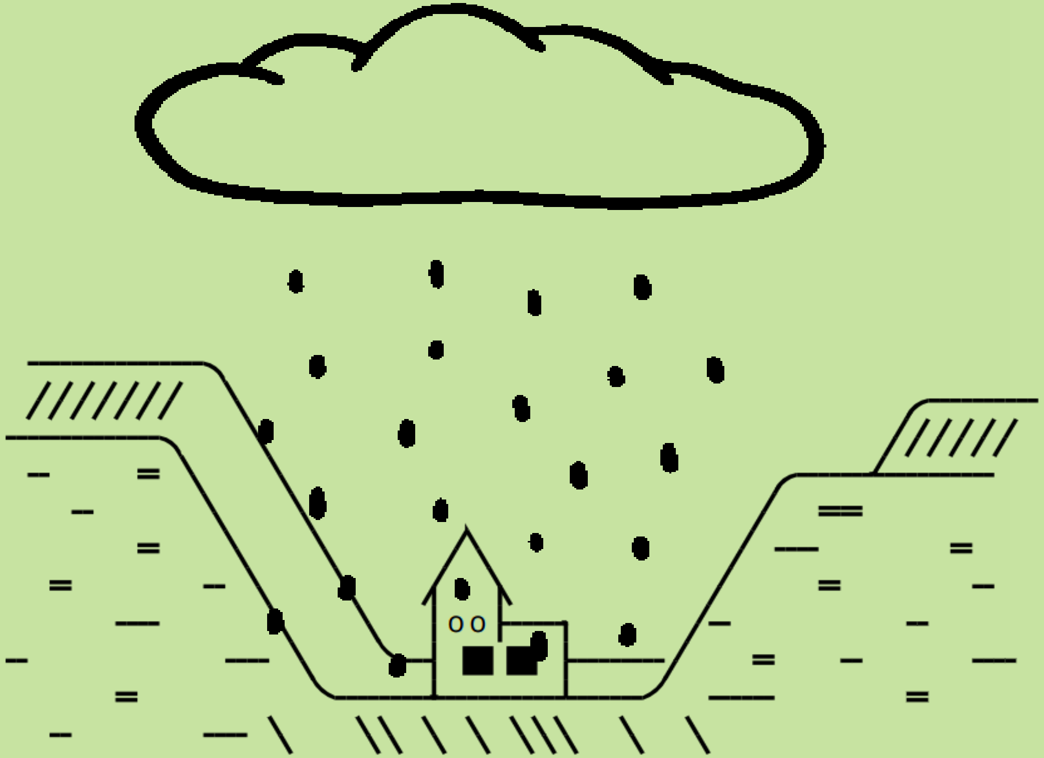
Weather Extremes

water vapor content – thermodynamical factor





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Topic 3 of 7

a weather-type classification for Europe and application

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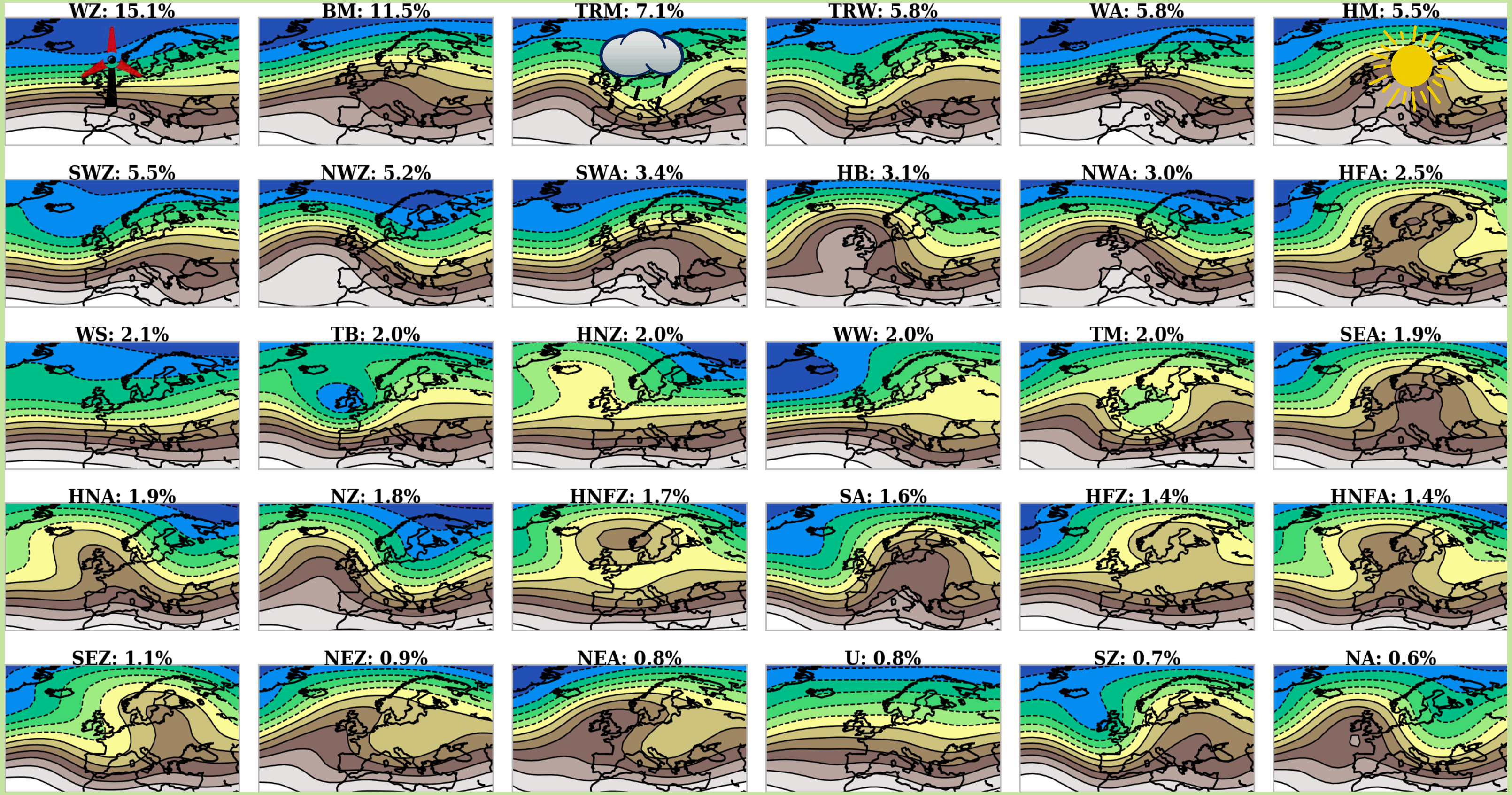
Classification

recurring circulation patterns over Europe



30 Weather-Types
every day is asigned to one

most dominant:

WZ: West Cyclonic
TRM: Trough Central Europe
HM: High over Central Europe

1	7	2021	TRM
2	7	2021	TRM
3	7	2021	HFZ
4	7	2021	HFZ
5	7	2021	HFZ
6	7	2021	TRW
7	7	2021	TRW
8	7	2021	TRW
9	7	2021	TRW
10	7	2021	TRW
11	7	2021	TRW
12	7	2021	TRW
13	7	2021	TM
14	7	2021	TM
15	7	2021	TM
16	7	2021	NEZ
17	7	2021	NEZ
18	7	2021	NEZ
19	7	2021	NA
20	7	2021	NA
21	7	2021	NA
22	7	2021	HNA
23	7	2021	HNA
24	7	2021	HNA
25	7	2021	TRW
26	7	2021	TRW
27	7	2021	TRW
28	7	2021	TRW
29	7	2021	TRW
30	7	2021	WZ
31	7	2021	WZ

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https://www.dwd.de/DE/leistungen/grosswetterlage/grosswetterlage.html

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Mean Local Weather Character

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NA	-4.5	-0.1	0.9	6.9	10.1	15.1	17.9	14.7	11.3	8.4	4.9	-0.9
SZ	-1.8	1.9	6.7	15.2	18.8	23.3	21.7	22.1	16.6	10.1	5.2	1.3
U	-1.5	0.2	2.6	7.8	14.3	18.5	18.6	17.8	14.4	9.5	4.5	-2.1
NEA	1.2	-2.5	-0.2	8.6	13.4	17.2	19.2	20.0	14.7	7.8	1.1	1.0
HNFA	-7.3	-4.5	0.8	9.6	15.9	20.1	21.7	19.6	11.4	5.8	-3.3	-1.5
NEZ	-2.2	-1.5	1.6	7.6	10.8	16.2	19.3	17.9	12.9	6.5	2.3	-1.2
SA	-2.3	1.5	6.4	14.2	17.3	21.1	24.6	23.3	17.4	11.0	6.3	0.6
HFZ	-6.4	-2.0	0.4	8.8	15.3	19.6	21.7	19.9	15.0	8.9	1.0	-2.7
TM	0.8	-3.6	2.3	6.0	13.6	15.4	18.5	18.0	12.7	8.3	3.0	0.2
HNZ	-5.9	-4.5	1.0	5.7	12.8	16.8	18.4	15.7	12.5	6.9	2.6	-3.0
TB	-0.4	-0.3	5.4	10.6	14.8	17.5	19.2	19.4	15.0	11.8	6.5	-1.6
HNFZ	-6.9	-3.4	1.2	7.3	14.3	19.0	22.3	18.2	13.0	7.3	0.4	-6.0
NZ	-3.1	-1.0	1.7	4.4	9.8	13.2	15.2	14.4	11.6	6.0	0.6	-1.6
HNA	-8.1	-5.0	2.0	8.0	12.8	17.5	19.6	19.2	12.0	5.7	1.8	-5.2
WW	1.1	2.0	3.5	10.0	13.5	18.7	19.3	19.6	14.6	9.4	4.3	1.1
WS	-1.5	0.6	2.3	7.9	12.5	15.3	15.1	15.4	12.2	8.4	4.1	-0.2
NWA	2.4	5.1	5.9	9.6	10.9	15.3	17.1	15.9	12.9	10.0	4.4	2.8
HFA	-4.9	-4.1	0.7	8.9	14.9	17.9	21.6	20.4	13.5	7.2	2.4	-3.9
HB	-1.5	-0.3	4.0	7.3	13.2	15.3	16.9	16.6	12.6	7.4	2.5	1.2
SE	-4.4	-1.5	4.4	13.1	16.4	21.5	22.5	20.5	16.0	8.7	2.7	-1.7
SWA	2.2	6.3	8.3	14.7	17.7	20.0	21.5	20.5	17.7	12.9	6.6	4.0
SWZ	3.7	5.1	7.5	11.6	14.8	18.4	20.7	20.3	15.5	12.3	8.4	3.6
NWZ	1.3	1.8	3.1	6.5	10.0	13.1	14.9	14.7	12.5	8.8	4.1	2.1
TRW	1.1	1.9	6.4	10.2	14.5	17.9	20.2	19.5	15.6	9.4	5.4	0.5
WA	4.1	4.3	7.6	10.4	13.9	17.3	18.8	18.3	14.8	10.7	7.5	4.7
TRM	-1.5	-0.4	2.7	6.0	10.1	13.7	15.3	16.0	12.4	6.7	2.7	-0.3
HM	-2.0	1.4	5.0	11.2	15.4	19.7	19.9	18.0	15.3	7.5	3.3	-0.8
BM	-2.0	-0.2	4.5	9.6	14.6	18.7	20.2	19.3	15.0	9.5	3.4	-1.0
WZ	4.3	4.3	5.8	9.1	12.7	15.4	16.9	17.2	14.0	9.9	6.2	4.5

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NA	1.2	1.7	0.2	0.4	1.9	0.6	0.7	0.8	0.7	1.1	0.6	2.1
SZ	0.4	0.3	0.5	1.8	1.9	2.4	1.8	7.1	2.2	1.3	0.5	2.6
U	0.7	1.0	0.5	1.3	2.8	2.9	3.0	1.0	1.1	1.0	3.9	1.4
NEA	2.0	0.8	0.2	0.4	0.7	0.3	0.0	0.7	0.3	0.5	0.4	0.4
HNFA	0.4	0.4	0.4	0.0	0.2	0.5	0.8	0.6	0.0	0.8	0.1	0.6
NEZ	0.7	1.0	0.7	1.2	2.1	1.8	4.4	3.7	1.8	1.9	1.1	2.6
SA	0.2	0.0	0.3	0.3	2.0	0.3	0.2	0.7	0.1	0.0	0.0	0.1
HFZ	0.7	0.8	1.8	1.0	1.6	1.4	2.4	1.1	3.1	1.2	1.1	1.1
TM	1.2	2.2	2.2	4.5	3.6	6.3	8.7	4.3	4.4	4.9	3.4	3.2
HNZ	1.6	1.3	2.5	1.1	2.5	2.2	2.2	3.4	1.7	1.8	0.2	0.7
TB	0.7	0.9	0.8	1.1	2.6	2.1	3.4	2.3	1.9	1.5	0.6	0.9
HNFZ	1.0	1.1	0.1	1.0	1.5	2.0	2.8	4.2	2.5	2.2	2.9	1.0
NZ	2.0	1.3	2.0	1.2	1.8	2.2	5.0	6.0	2.9	1.8	2.4	2.1
HNA	0.3	0.5	0.0	0.3	0.3	0.8	0.3	0.3	0.7	0.8	0.1	0.3
WW	1.6	2.0	0.9	1.9	1.4	2.3	1.6	1.4	2.3	2.2	2.9	2.5
WS	1.1	1.3	2.7	2.8	2.7	3.1	3.3	2.5	3.6	2.7	2.9	2.3
NWA	1.3	1.1	0.7	0.4	0.5	2.0	1.0	0.5	0.9	0.9	0.9	0.7
HFA	0.1	0.1	0.1	1.0	0.3	0.3	0.7	0.9	0.5	0.4	0.2	0.2
HB	0.8	0.7	0.2	0.4	0.3	1.2	0.4	1.3	0.7	0.2	0.7	0.6
SE	0.2	0.2	0.4	0.8	1.6	1.8	0.3	0.9	0.3	0.6	0.5	0.4
SWA	0.6	0.3	0.7	0.6	0.8	1.5	0.6	0.4	0.5	0.4	0.4	0.7
SWZ	1.7	1.8	2.6	2.6	2.9	3.2	2.9	2.6	1.9	1.9	2.2	1.8
NWZ	2.8	2.9	2.5	1.8	2.1	3.2	2.9	2.6	3.3	3.4	2.5	3.3
TRW	1.1	0.7	1.2	1.3	2.9	4.1	3.1	2.4	2.2	1.1	1.4	1.1
WA	1.0	1.1	0.8	0.6	1.1	1.8	1.3	0.9	1.0	0.7	0.9	0.9
TRM	1.2	0.9	1.7	1.7	2.2	2.9	2.8	3.9	2.6	1.6	1.6	1.5
HM	0.3	0.2	0.2	0.2	0.3	0.4	0.3	0.2	0.2	0.1	0.3	0.4
BM	0.6	0.5	0.4	0.3	0.7	1.2	0.7	1.0	0.6	0.6	0.5	0.3
WZ	2.9	2.7	2.3	2.1	2.4	2.9	2.8	2.5	2.4	2.5	2.5	3.1

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Sequences

episodes of extreme weather conditions

River Flood, Danube/Elbe, August 2002

Aug 07	Aug 08	Aug 09	Aug 10	Aug 11	Aug 12	Aug 13	Aug 12	Aug 13	Aug 14	Aug 15
TM	TM	TRM	TRM	TRM	TRM	TRM	TRM	HFA	HFA	HFA

Heatwave, Eastern Europe, September 2023

Sep 06	Sep 07	Sep 08	Sep 09	Sep 10	Sep 11	Sep 12	Sep 13	Sep 14	Sep 15	Sep 16
SEA	SEA	SEA	SA	SA	SA	U	U	SEA	SEA	SEA

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Topic 4 of 7

weather variability in a climatic context

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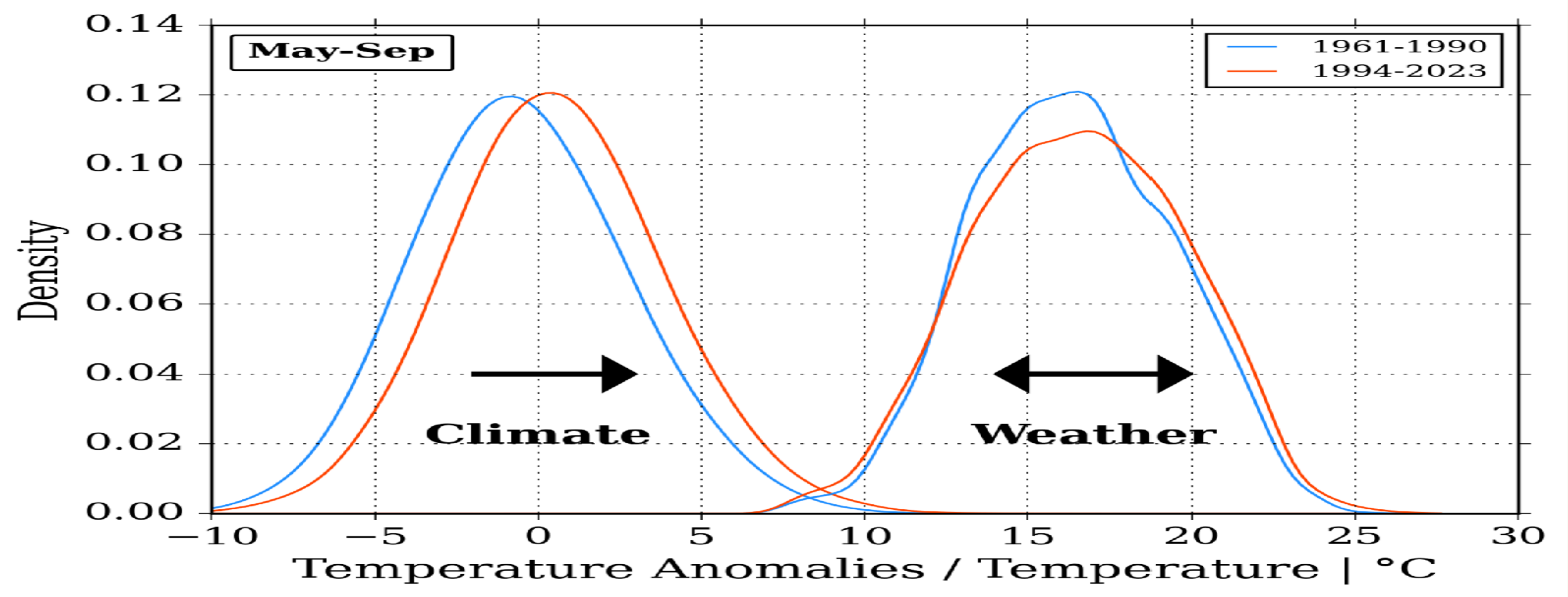
Decomposition

shift and spread of the distribution



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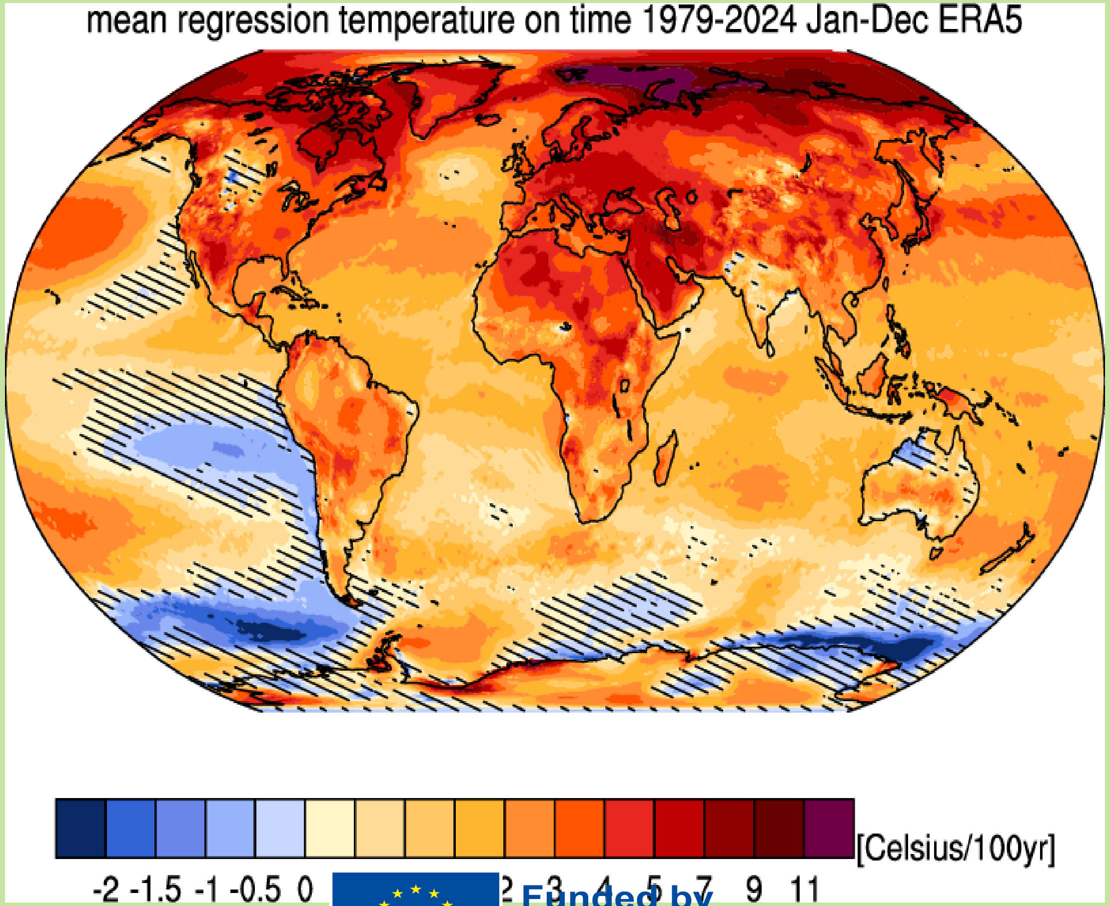
Differential Warming

expected changes in the midlatitude wind systems



less zonal

more meridional

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Trends

long-term changes in the weather variability

zonal: west – east

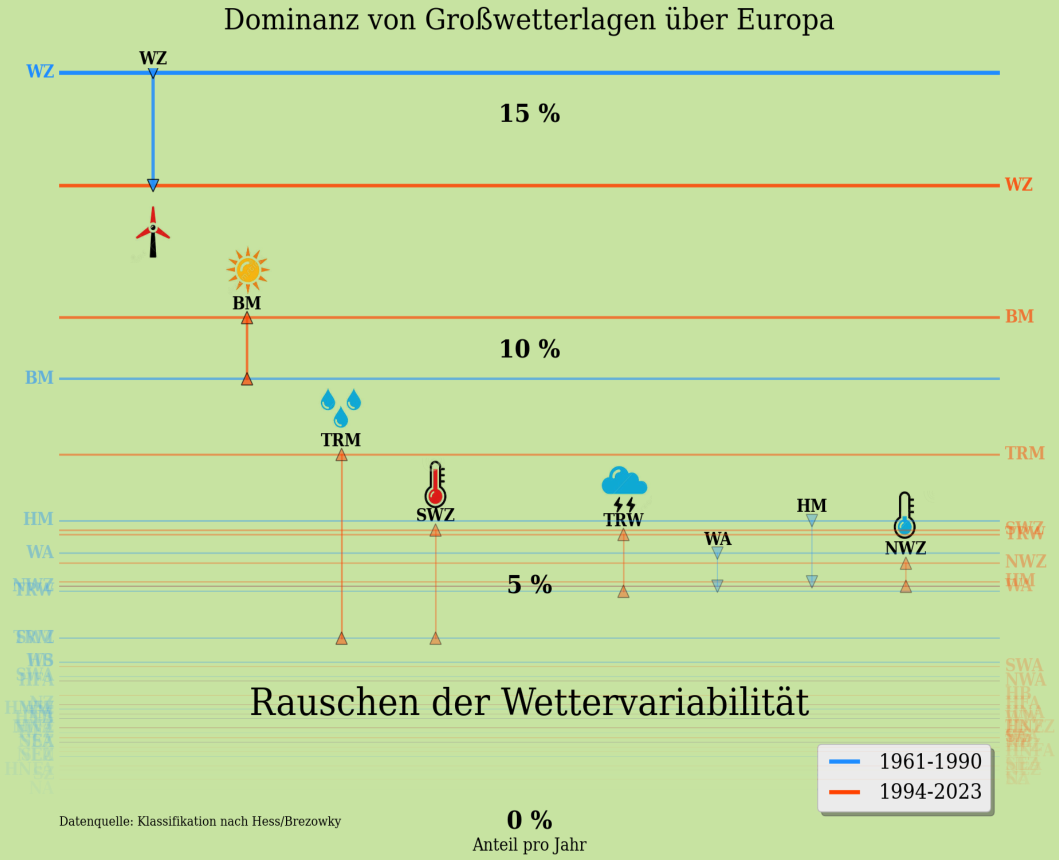
- **WZ** moderate weather from the North Atlantic is decreasing

meridional: north – south – north

- increasing explained variability
- **TRM** – permanent rainfall
- **SWZ** – heat waves

noise:

- low predictability



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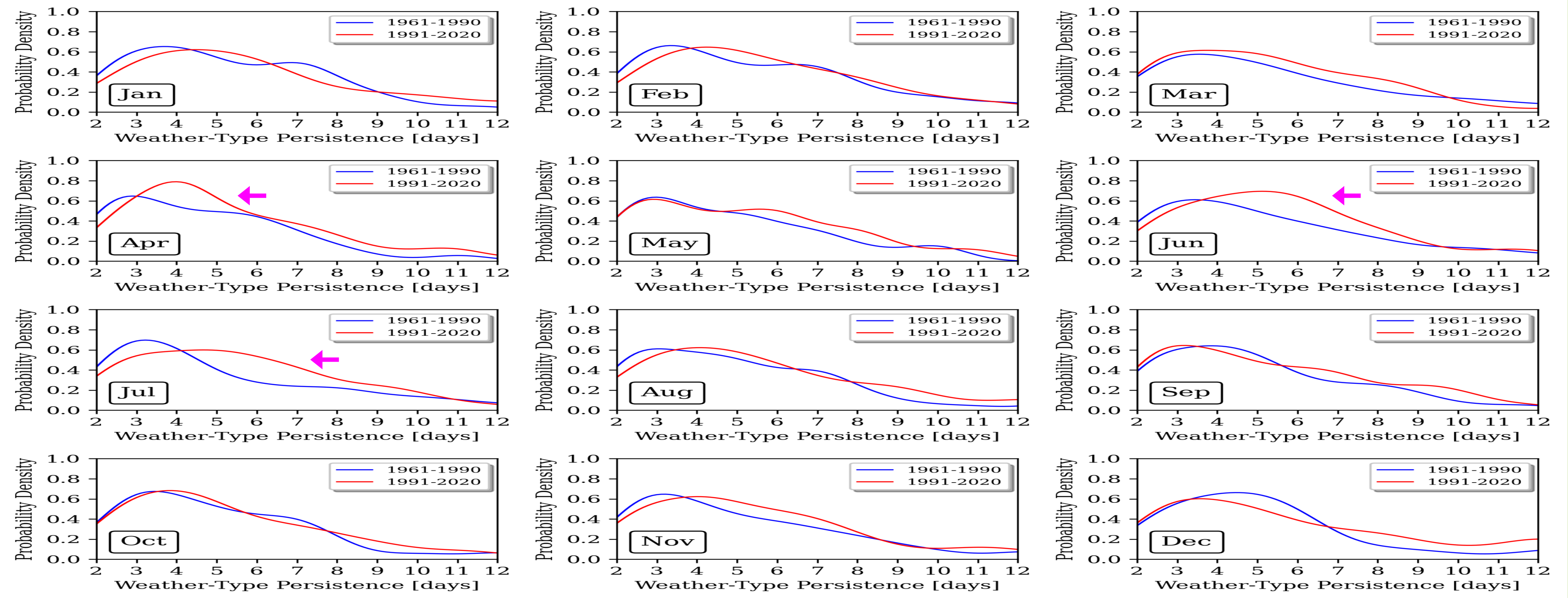
Trends

distribution of weather persistence



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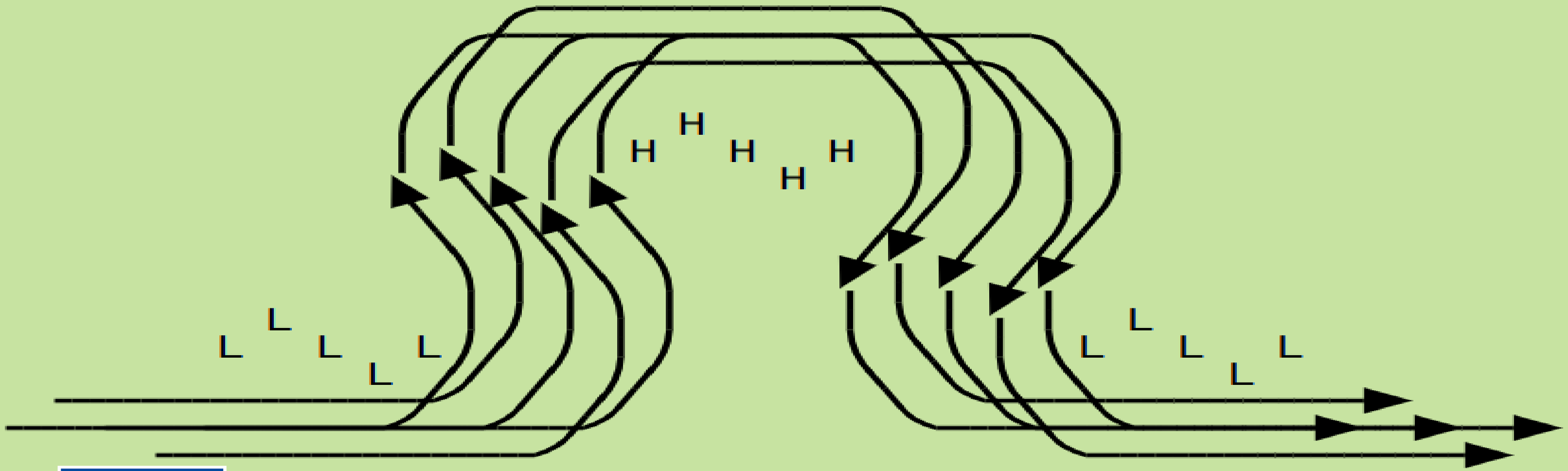
Topic 5 of 7

the role of the weather persistence in Europe



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Persistence

persisting summers are hot summers in Europe

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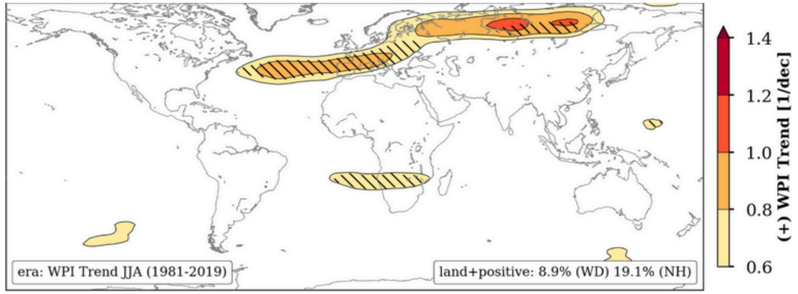
Too dry, too hot, or too wet: Increasing Weather Persistence in European Summer

12/06/2021 - Global warming makes long lasting weather situations in the Northern hemisphere's summer months more likely – which in turn leads to more extreme weather events, a novel analysis of atmospheric images and data finds. These events include heatwaves, droughts, intense rainy periods. Especially in Europe, but also in Russia, persistent weather patterns have increased in number and intensity over the last decades with weather extremes occurring simultaneously at different locations.



Regions of the world where an increase in persistent weather conditions is observed in summer (Jun-Aug). Photo: PIK Potsdam.

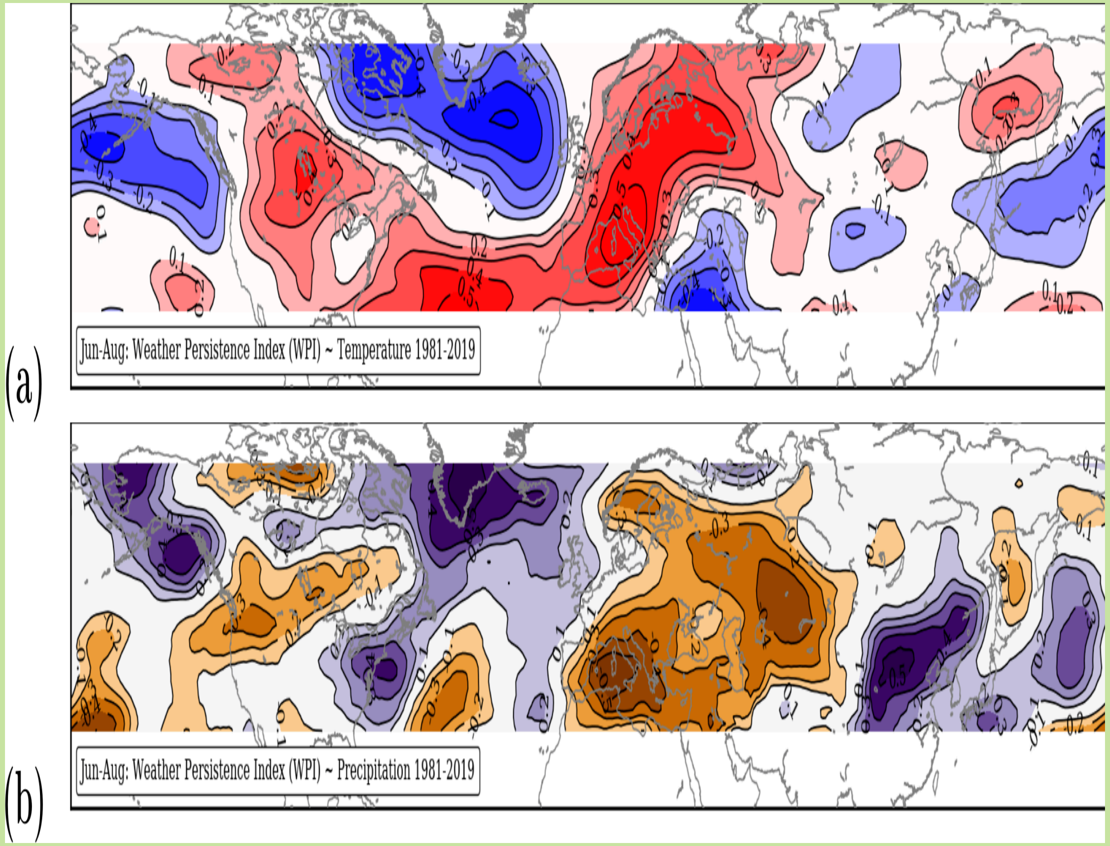


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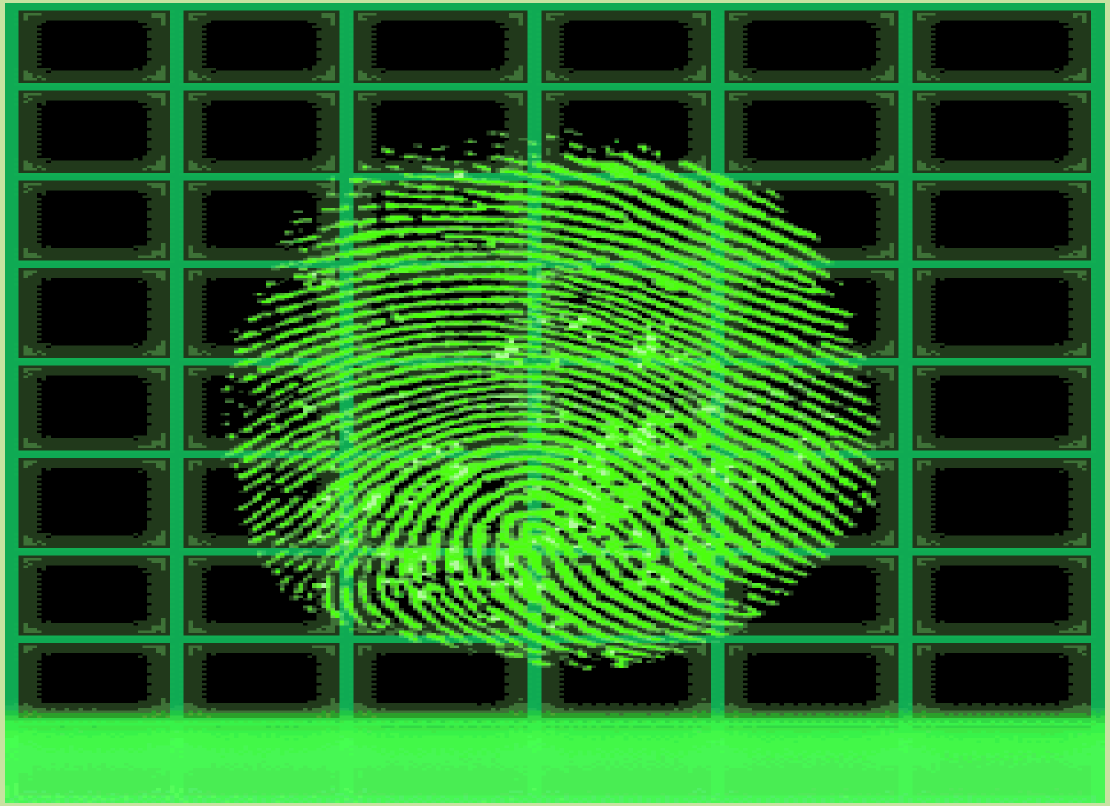
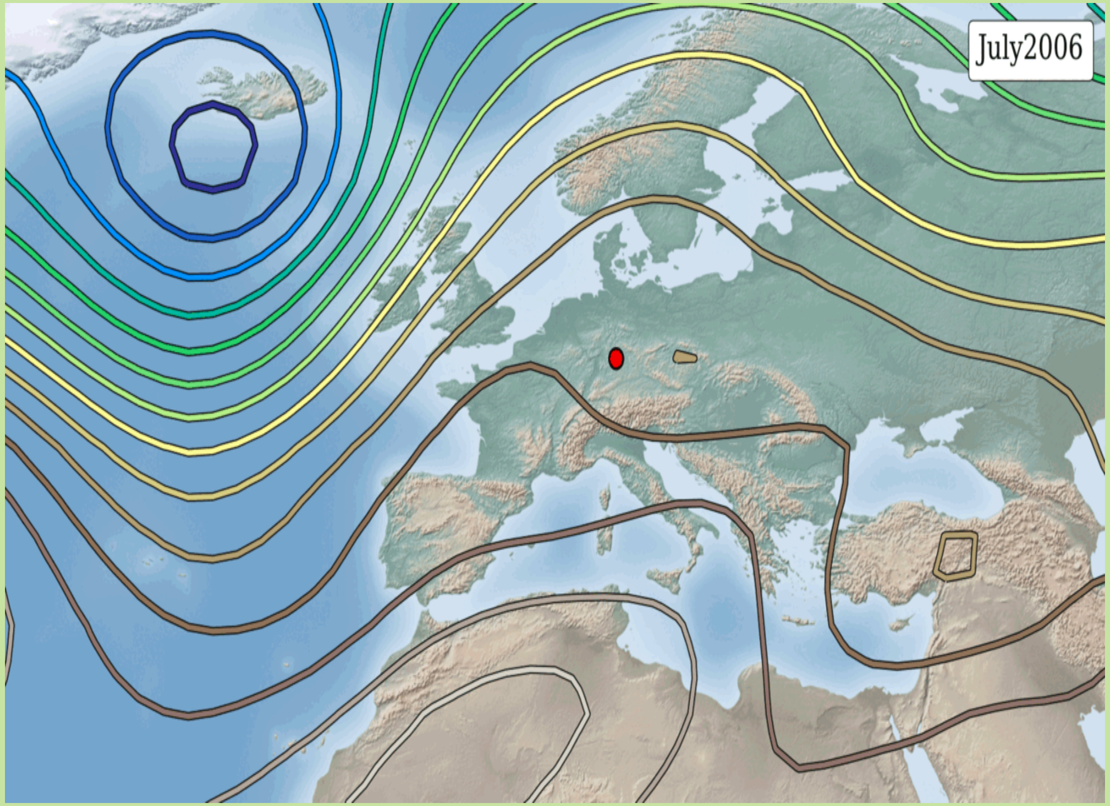
Image Recognition

detection of day-to-day atmosphere similarities





Hoffmann et al., 2021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Topic 6 of 7

re-identification of weather-types in climate scenarios

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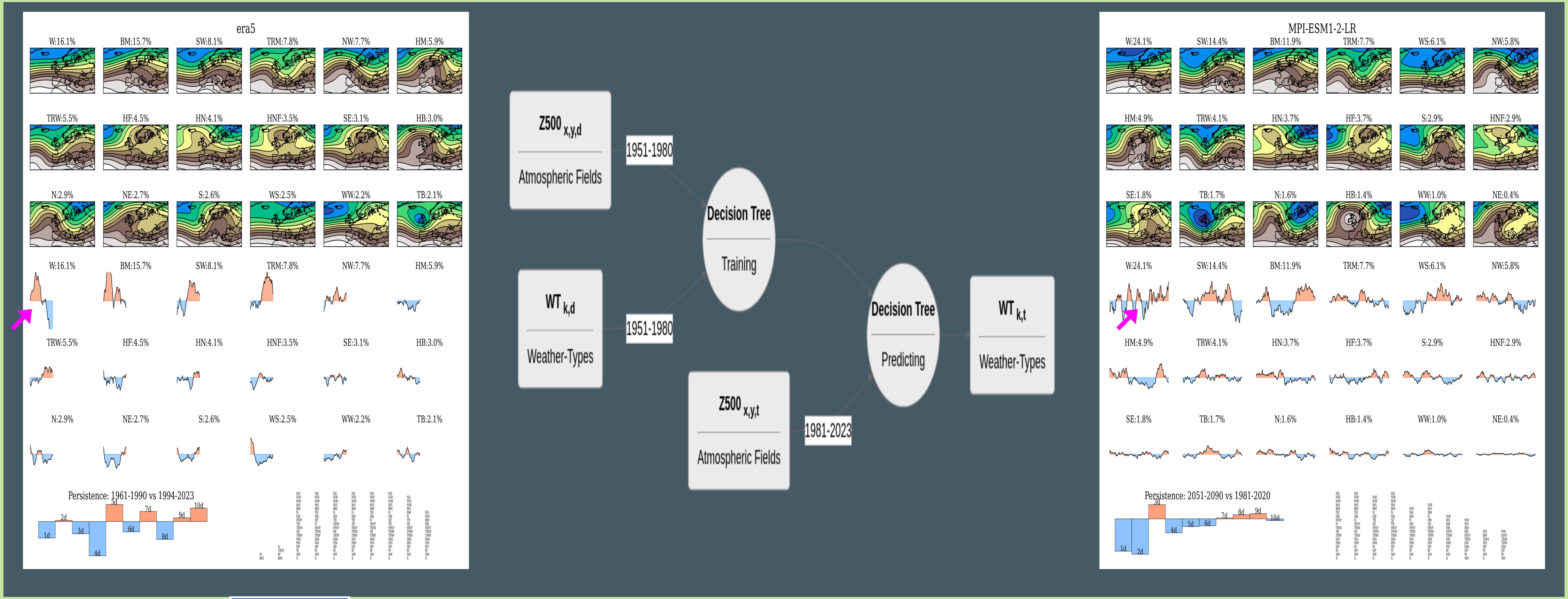
Random Forest Approach

training – re-identification of weather-types in climate models



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Applications

in weather- and climate forecasts

- reduction of complexity – physical fields to categories
- detection of sequences of critical weather-types
- early warning and future risks assessments
- comparison of the observed and simulated weather variability
- criteria for model ensemble evaluation and reduction
- attribution of thermodynamic and dynamic factors in the context of climate change

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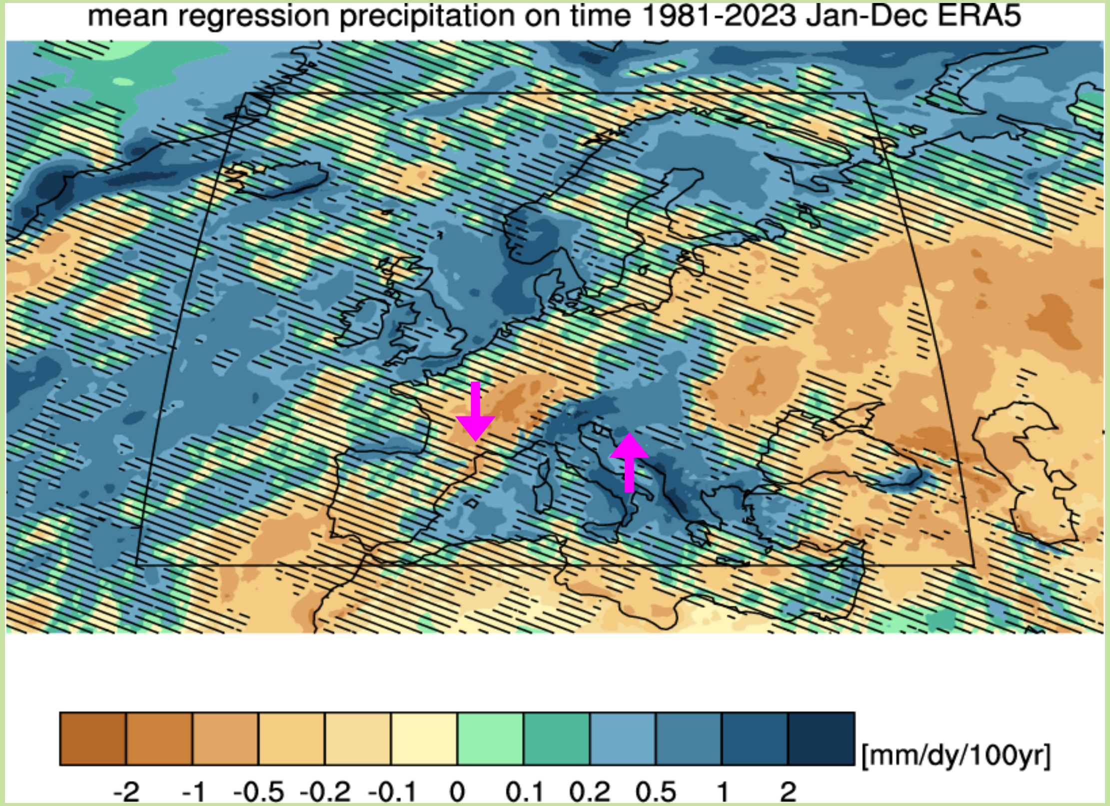
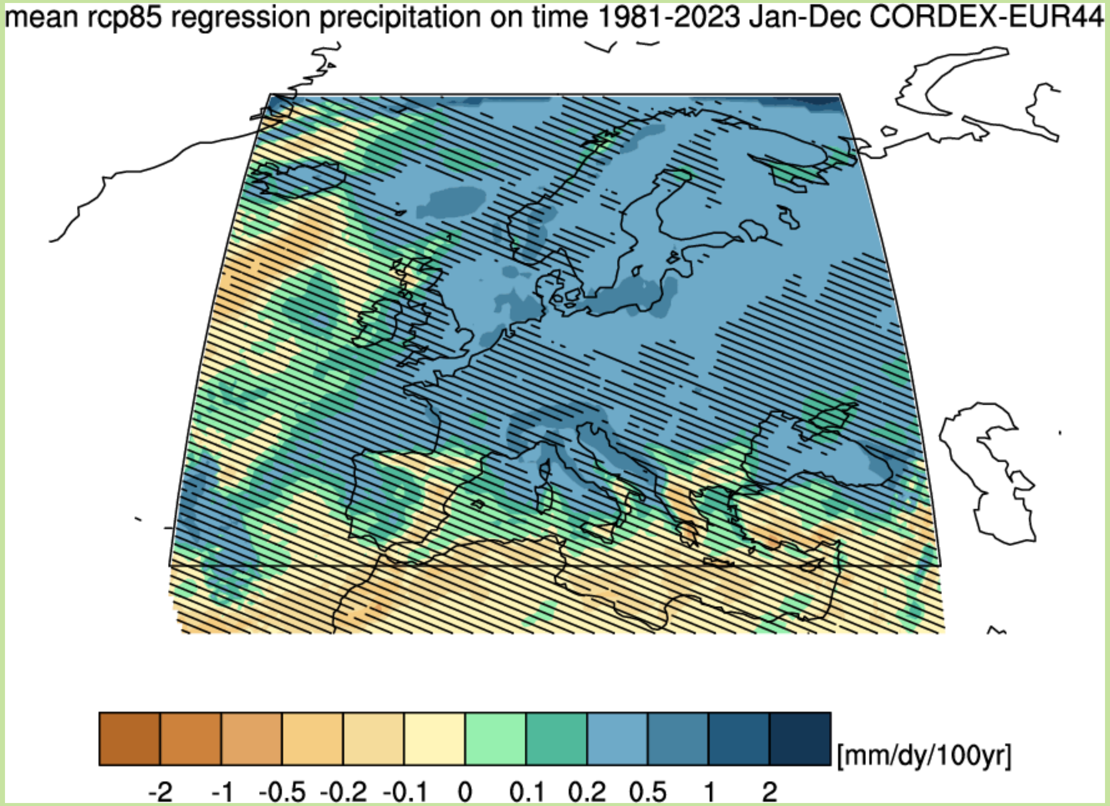
Challenges

observed vs simulated trends in annual precipitation





Topic 7 of 7

contextualization of extreme rainfall in Jordan

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Topic 7 of 7: contextualization of extreme rainfall in Jordan

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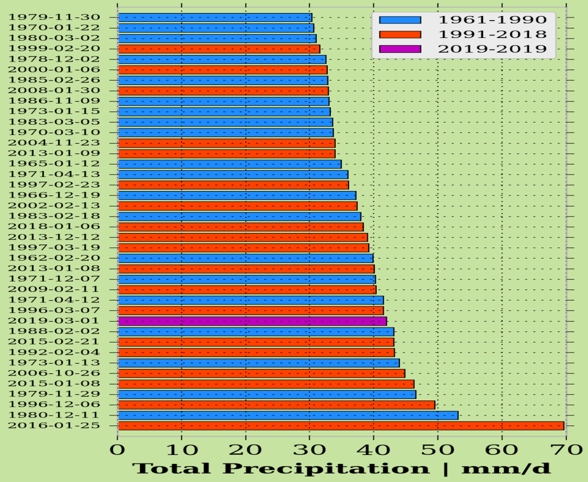

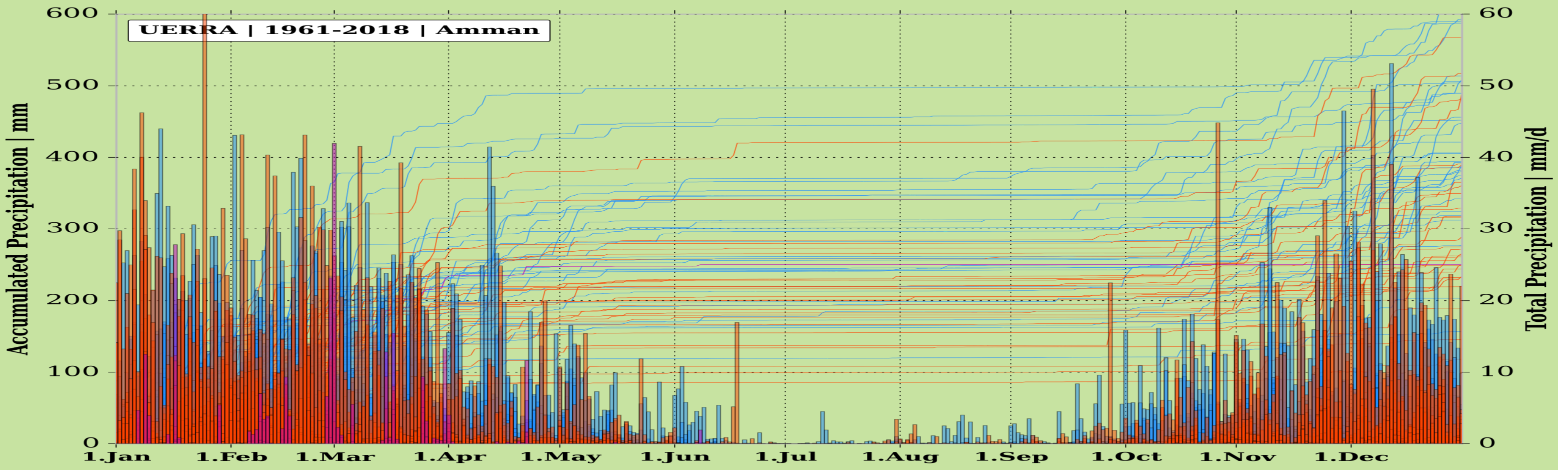

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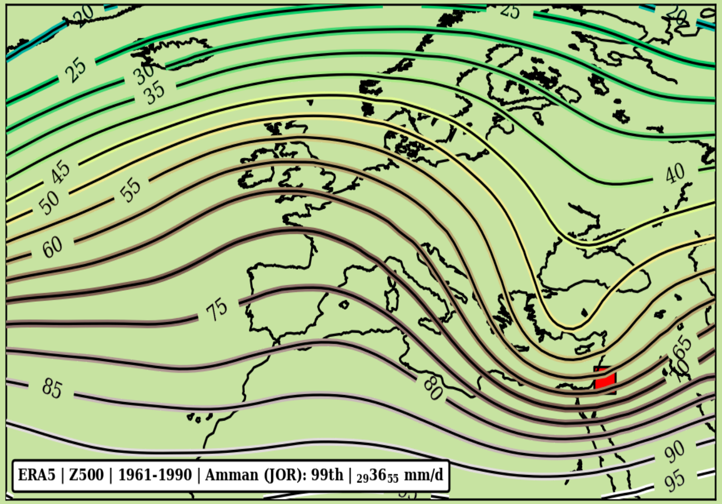

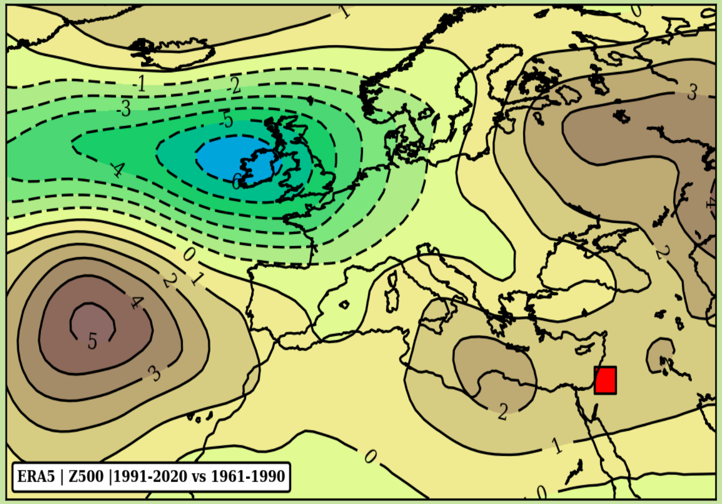

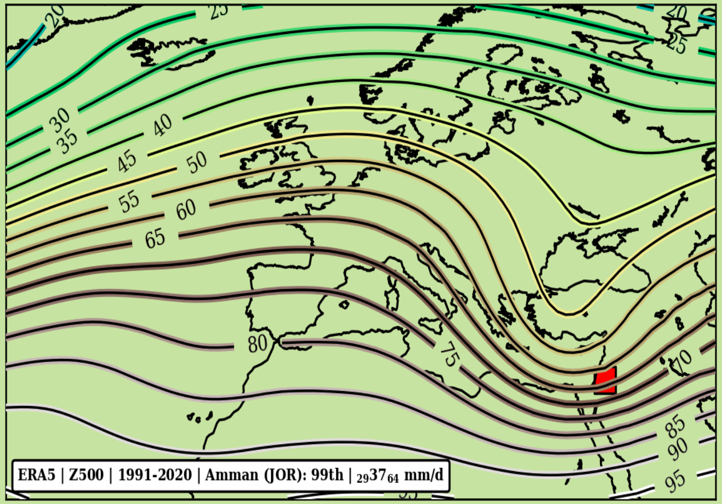

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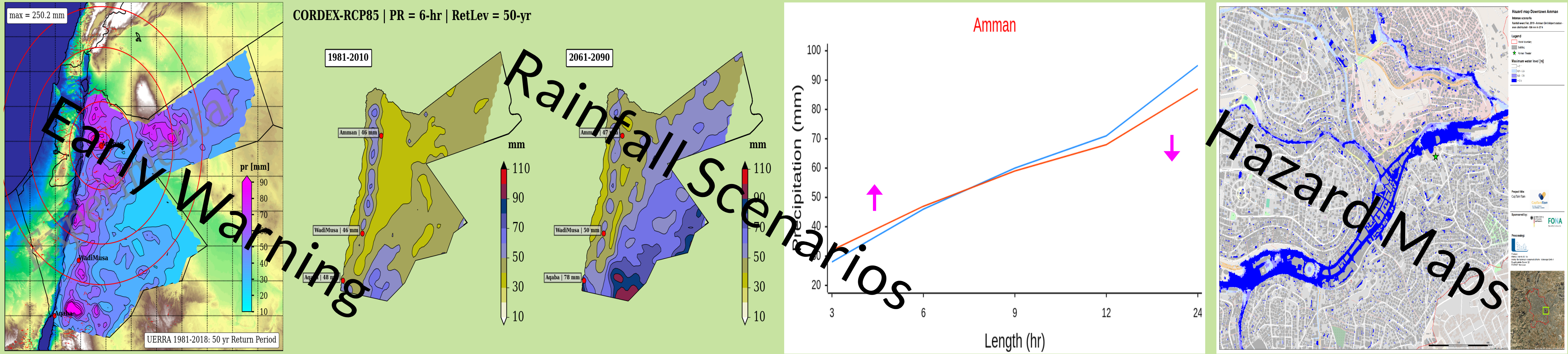

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Summary

take home messages

- there is causal linkage between large-scale weather patterns and local meteorological phenomena and extremes
- dynamical changes are the main source of uncertainties projecting future rainfall patterns beyond the mean temperature rise
- there are discepancies between the real and the model world in terms of e.g. drought conditions
- learning from the historical data and phenomena helps to better assess regional climate scenarios

Thank you for listening!

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