CAFE
Climate Advanced Forecasting of sub-seasonal Extremes

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Heatwaves over Europe: Towards an early warning system

ESR6 - Emmanuel Rouges

European Centre for Medium-Range Weather Forecasts

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Dr. Laura Ferranti, European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, United-Kingdom

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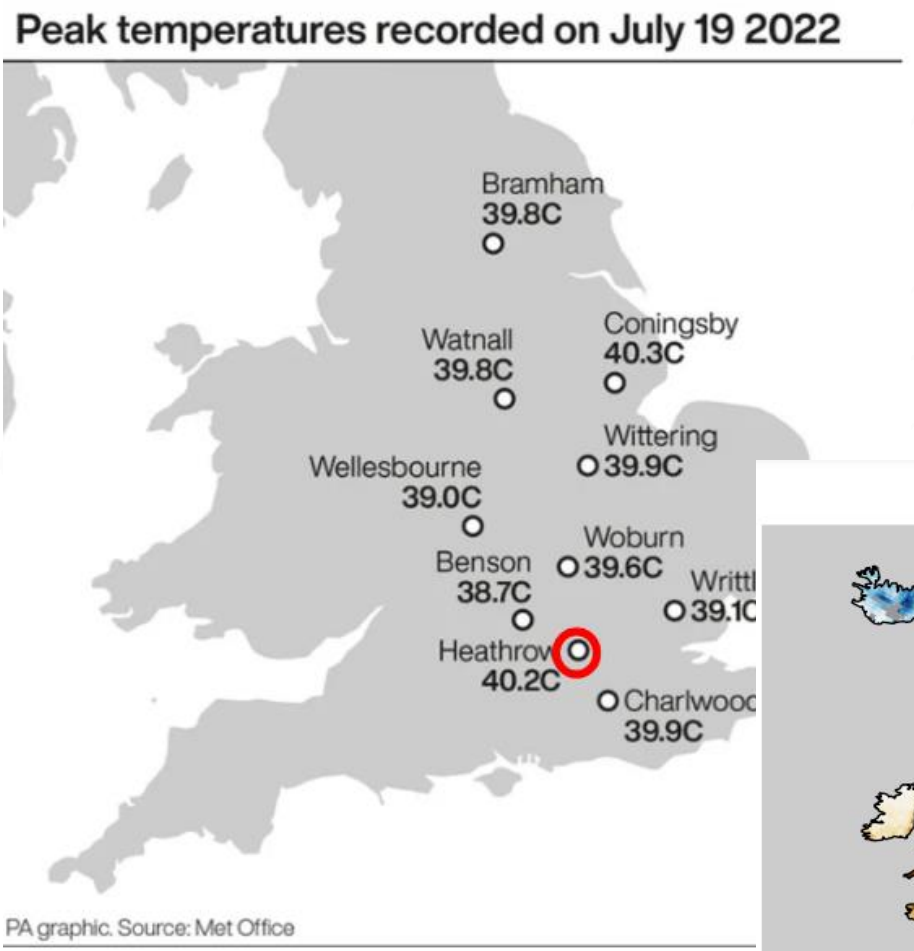
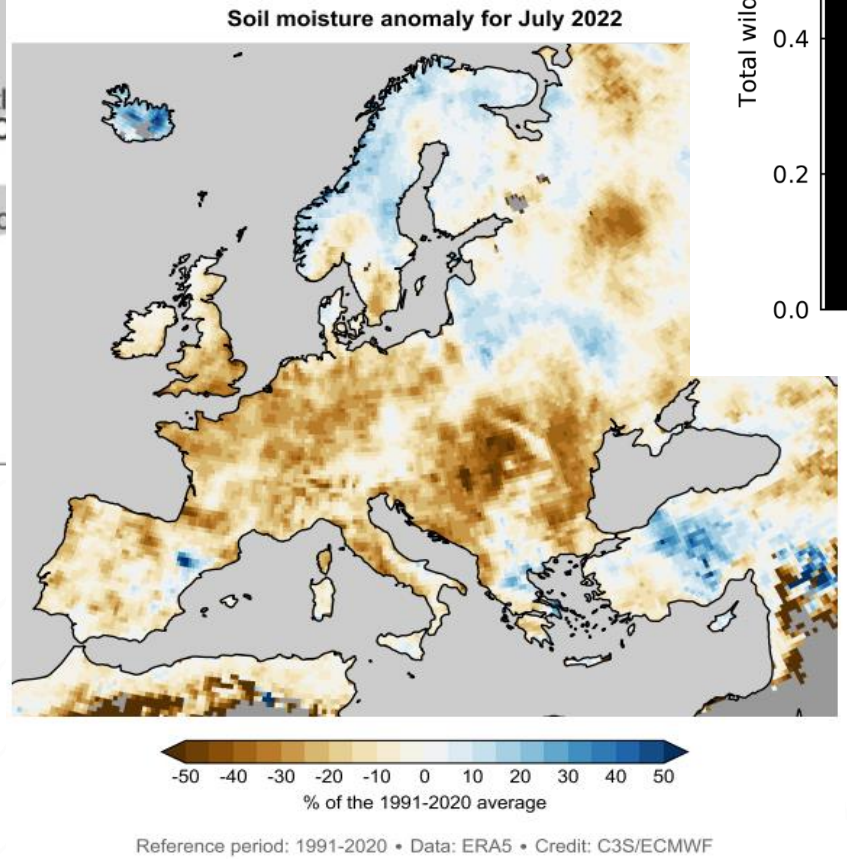
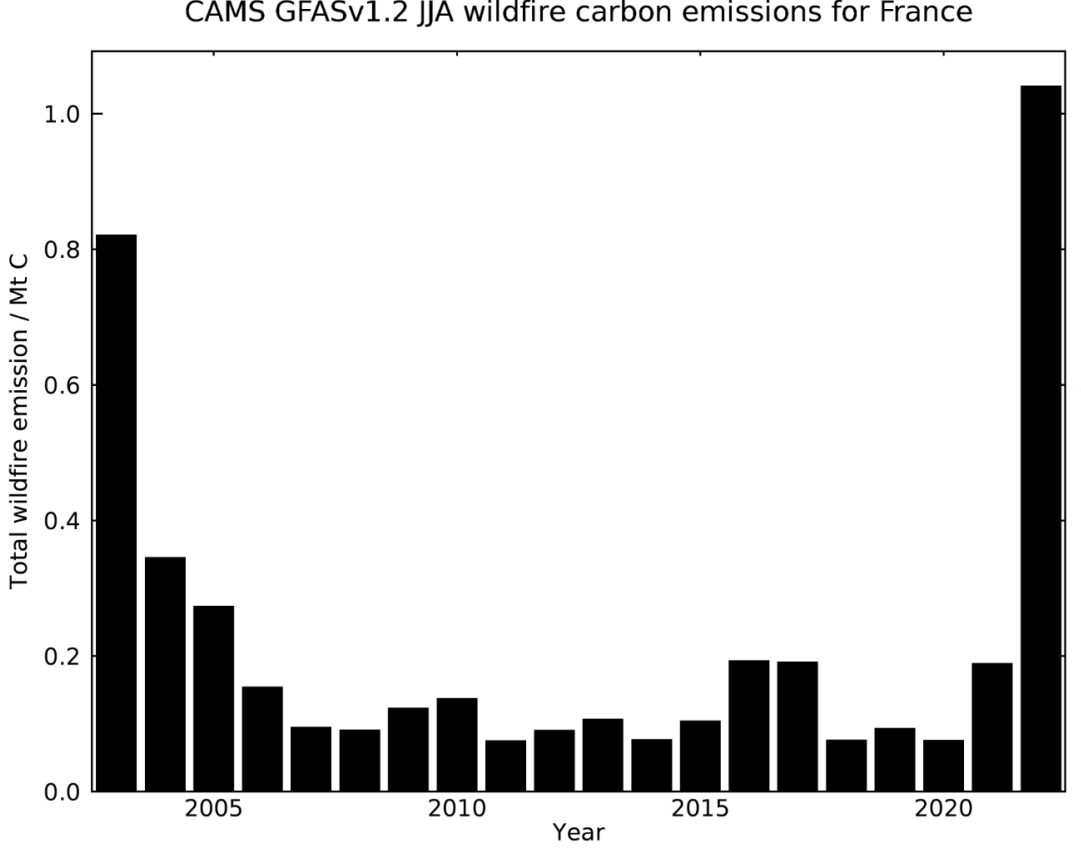

Peak temperatures recorded on July 19 2022
Bramham
39.8C
Watnall
39.8C
Coningsby
40.3C
Wittering
39.9C
Wellesbourne
39.0C
Woburn
39.6C
Benson
38.7C
Heathrow
40.2C
Charlwood
39.9C
PA graphic. Source: Met Office


Soil moisture anomaly for July 2022
-50 -40 -30 -20 -10 0 10 20 30 40 50
% of the 1991-2020 average
Reference period: 1991-2020 • Data: ERA5 • Credit: C3S/ECMWF


CAMS GFASv1.2 JJA wildfire carbon emissions for France
Total wildfire emission / Mt C
0.0
0.2
0.4
0.6
0.8
1.0
2005
2010
2015
2020
Year

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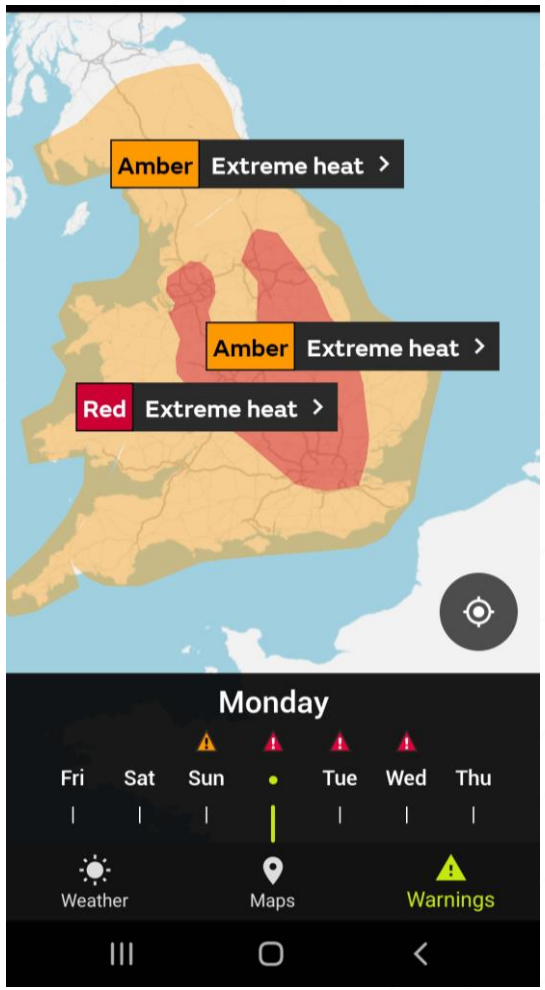
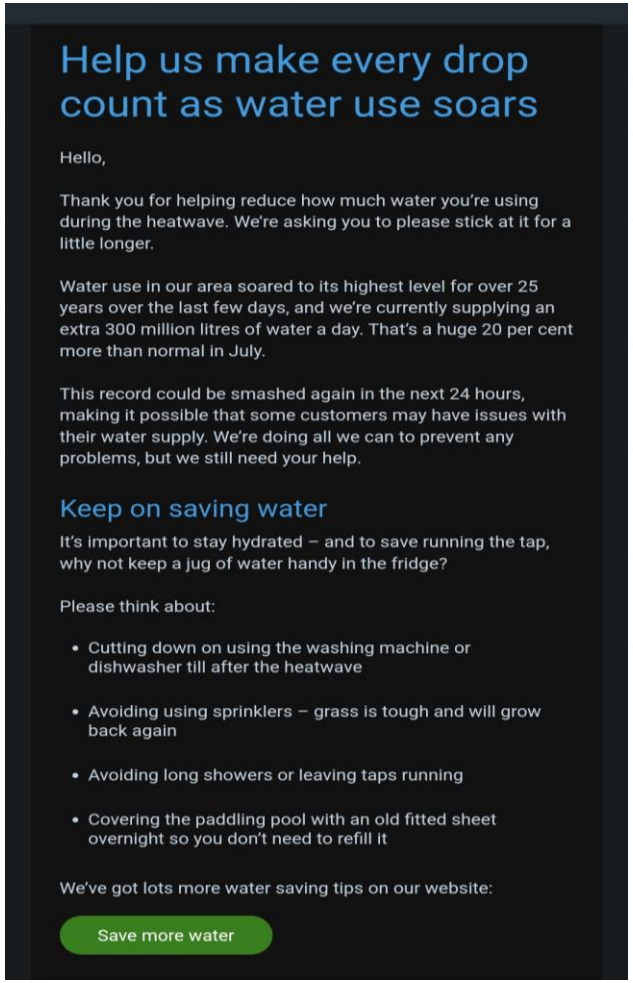
Warning by weather services



Mitigation instructions



Help us make every drop count as water use soars

Hello,

Thank you for helping reduce how much water you're using during the heatwave. We're asking you to please stick at it for a little longer.

Water use in our area soared to its highest level for over 25 years over the last few days, and we're currently supplying an extra 300 million litres of water a day. That's a huge 20 per cent more than normal in July.

This record could be smashed again in the next 24 hours, making it possible that some customers may have issues with their water supply. We're doing all we can to prevent any problems, but we still need your help.

Keep on saving water

It's important to stay hydrated – and to save running the tap, why not keep a jug of water handy in the fridge?

Please think about:

- Cutting down on using the washing machine or dishwasher till after the heatwave
- Avoiding using sprinklers – grass is tough and will grow back again
- Avoiding long showers or leaving taps running
- Covering the paddling pool with an old fitted sheet overnight so you don't need to refill it

We've got lots more water saving tips on our website:

Save more water

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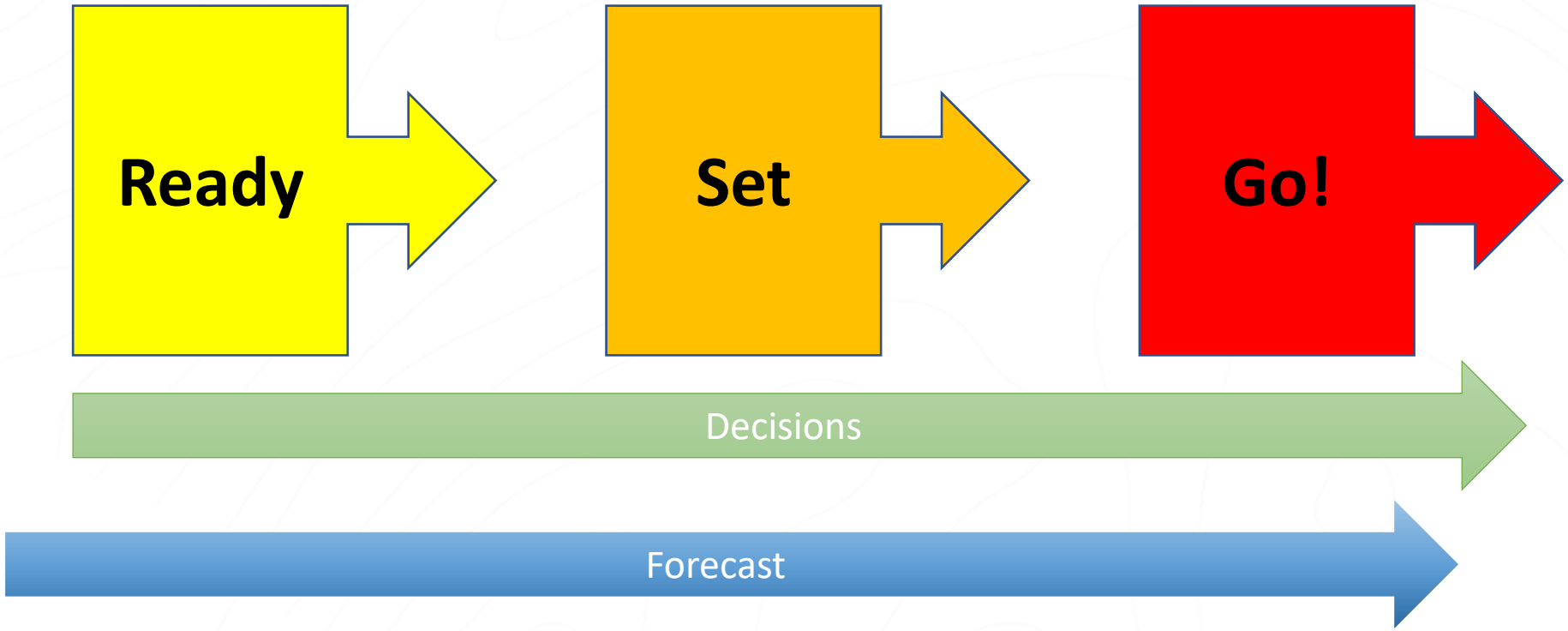
Mitigation:

- Early warning is essential for timely implementation of mitigation plans



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	Climate	Seasonal	Medium to short range
Methods and Drivers	• Look back into historical records to identify extend of extremes • Projections essential to estimate the new extremes	• Monitor and forecast slow varying processes • Mostly SST driven (ENSO, NAO…) • Land-Atmosphere feedback	• Shorter varying processes • Large atmospheric features (Rossby Wave Packets, Blockings…) • Diabatic and adiabatic processes
Predictive information	• Frequency and intensity, trends	• Seasonal to monthly mean anomaly	• Timing, extent and intensity of extreme

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	Climate	Seasonal	Subseasonal	Medium to short range
Methods and Drivers	• Look back into historical records to identify extend of extremes • Projections essential to estimate the new extremes	• Monitor and forecast slow varying processes • Mostly SST driven (ENSO, NAO…) • Land-Atmosphere feedback	• Borrowing both from Seasonal to medium range • Land-atmosphere, and slow varying processes • Use of weather regimes	• Shorter varying processes • Large atmospheric features (Rossby Wave Packets, Blockings…) • Diabatic and adiabatic processes
Predictive information	• Frequency and intensity trends	• Seasonal to monthly mean anomaly	• Daily to weekly anomalies	• Timing, extent and intensity of extreme

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How do we identify key drivers/predictors of heatwaves?

What potential forecast information is provided by these predictors?

How do we include this information into a warning system?

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Subseasonal drivers of heatwaves

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Circulation patterns

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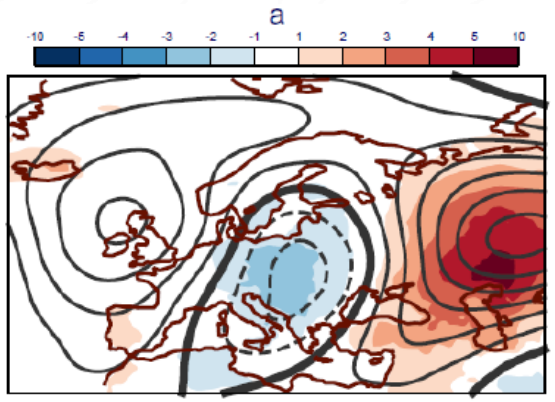
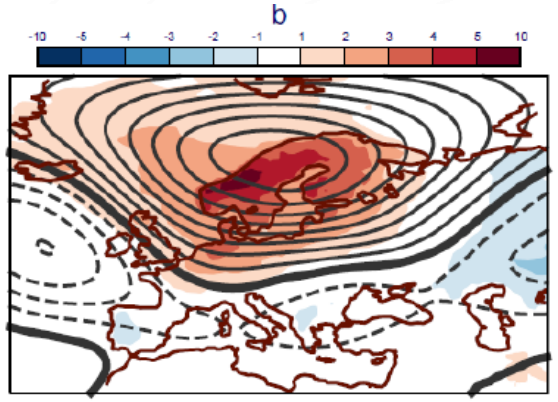
Identification of heatwave circulation types

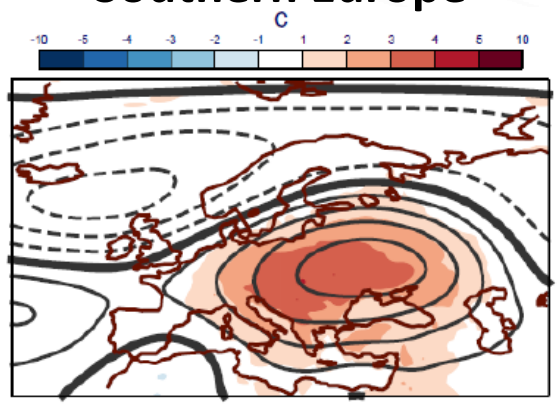
Tripole

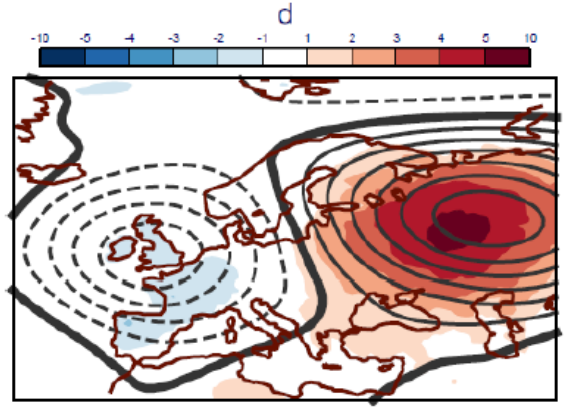


Scandinavia

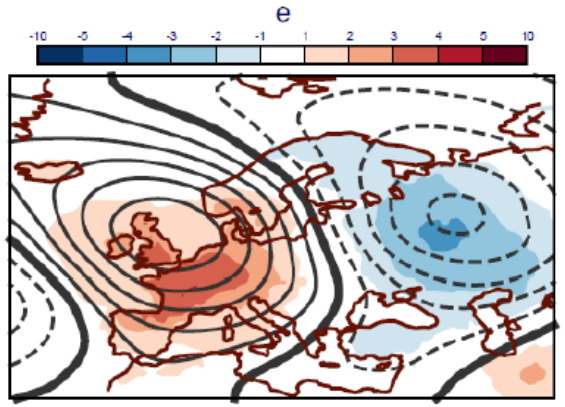


Southern Europe





Russia



Western Europe

Soil moisture conditions

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Soil moisture pre-conditioning:

- Evapotranspiration leads to latent cooling:
  - Reduced soil moisture content reduces this cooling effect and exacerbates heat extremes
- Soil wetness index:
  - Measure of the available water for evapotranspiration
  - Varies from 0 to 1 with a linear relationship with evapotranspiration rate (0 – 100%)

Soil moisture conditions

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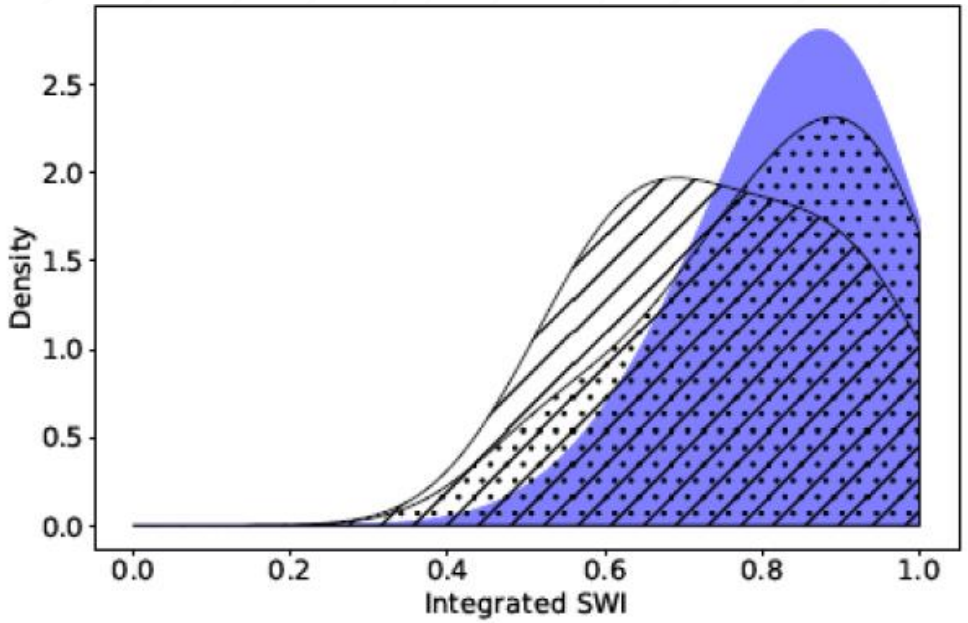
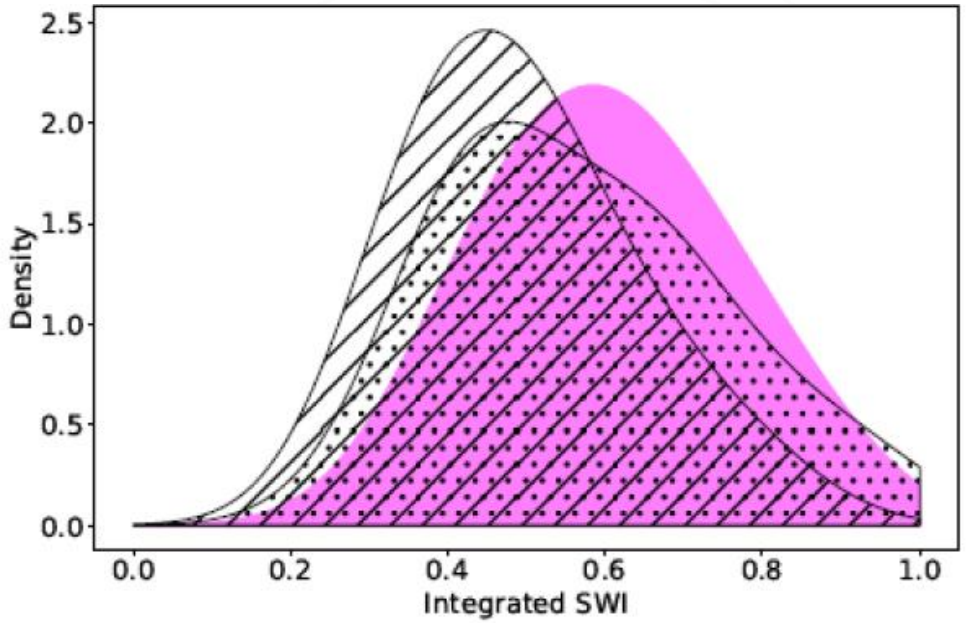
Only southern regions observe a significantly lower SWI

- Not systematic effect but essential for some extreme events

Scandinavia



Southern Europe



Tropical convection

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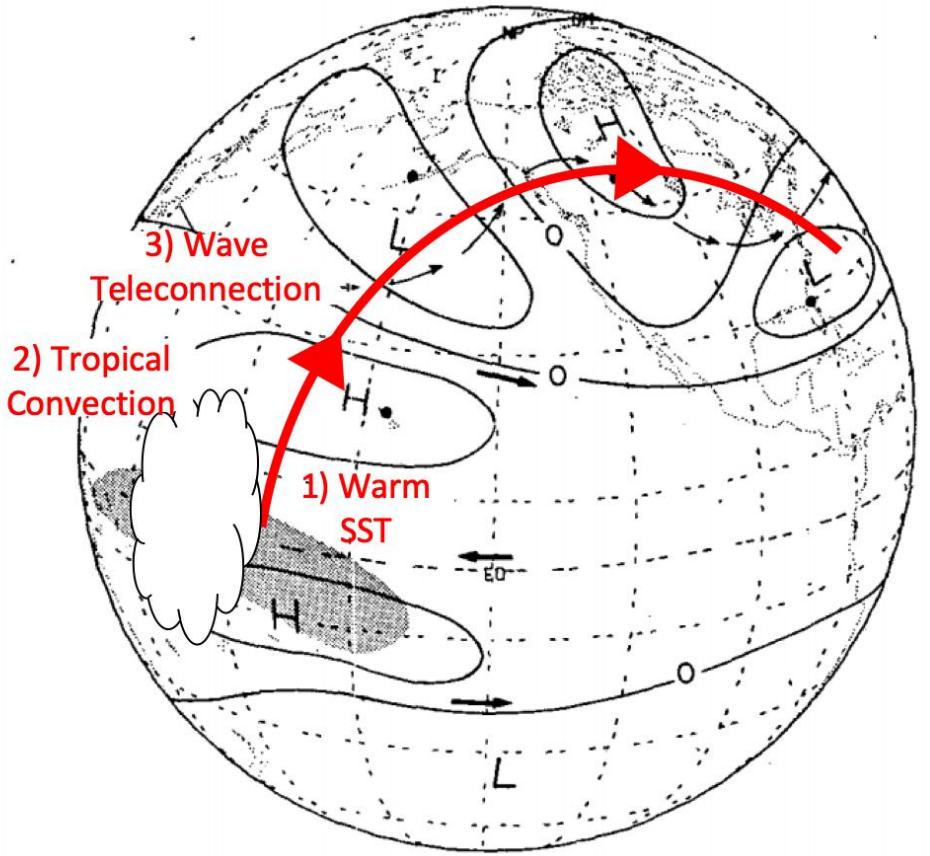
Tropical convection:

- Enhanced tropical convection can be a source of Rossby Waves
  - Rossby waves can be responsible for blocking anti-cyclones and their maintenance
- Boreal Summer IntraSeasonal Oscillation:
  - Can be seen as summer version of MJO
  - Has a northward component that influences active and break phases of the monsoon



Horel and Wallace, 1981

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Tropical convection

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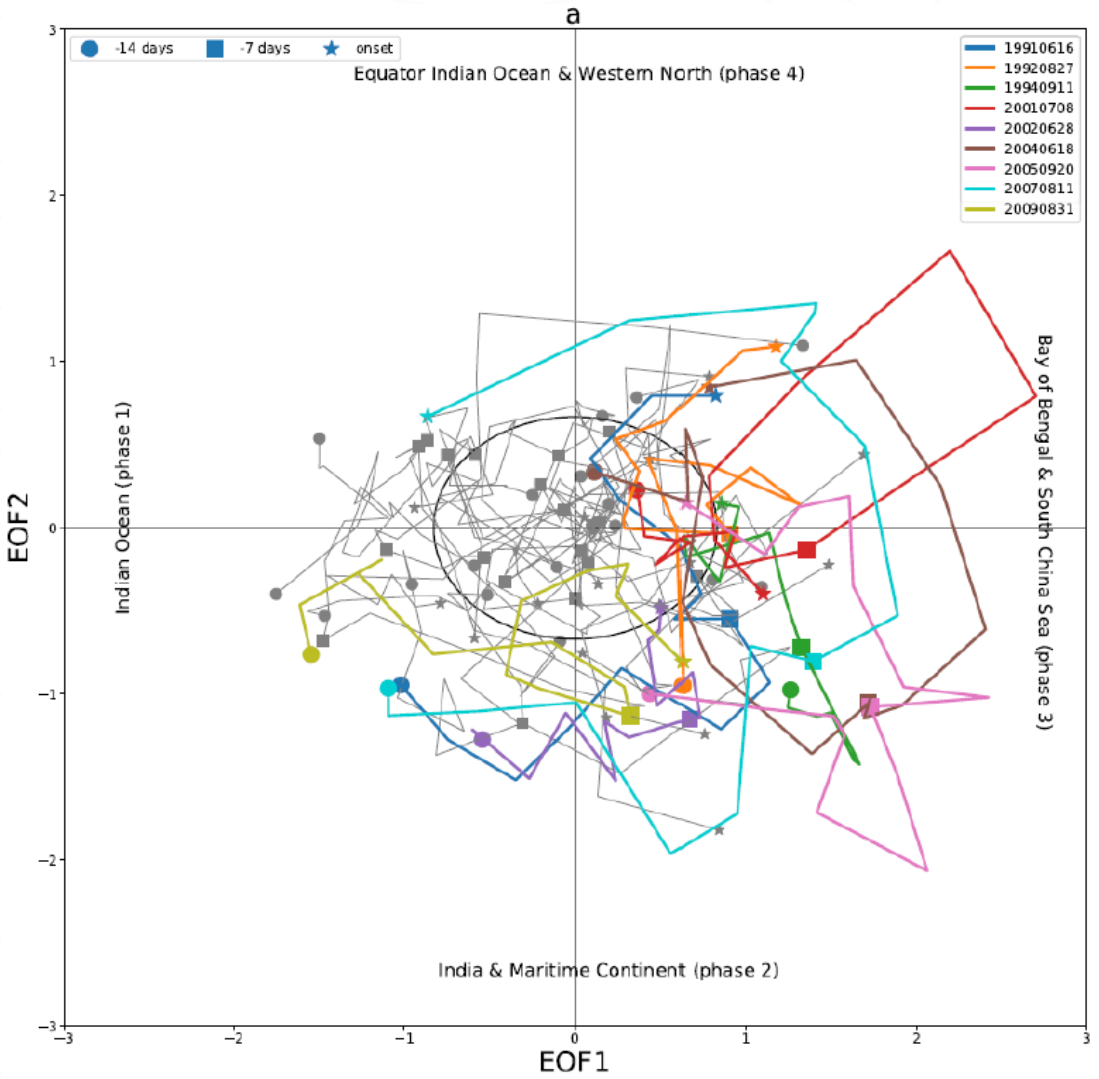
Tropical convection:

- Using first two EOFs of tropical precipitation, monitor the evolution of the BSISO and its link with heatwaves
- A third of RU heatwaves are connected with active phases of the BSISO
- Some individual events of other regions are also connected with the BSISO



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Forecast information

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Pattern-based forecast

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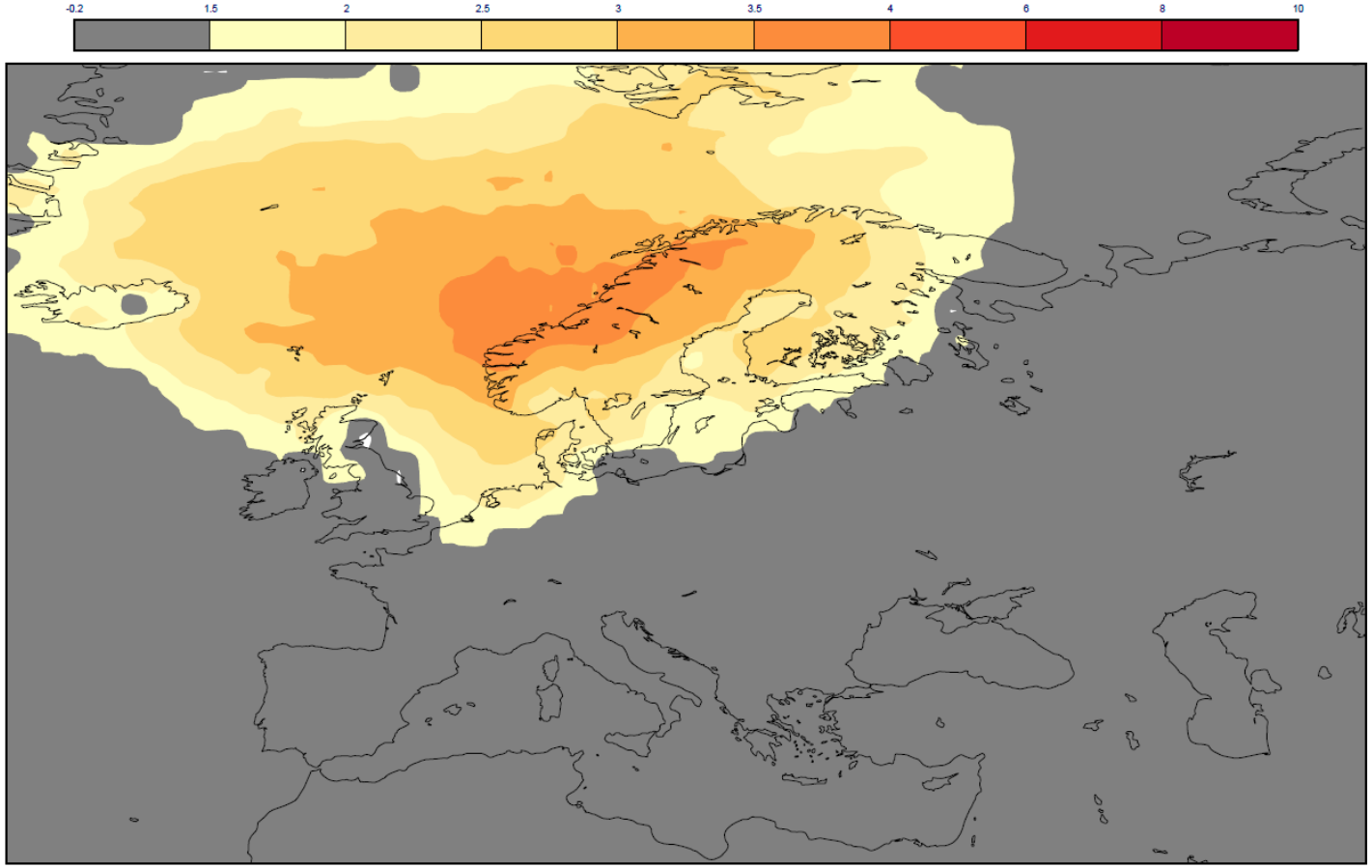
Pattern based forecast:

- Forecast the circulation patterns
- Use the associated conditional probability to infer the forecast probability of extreme temperatures

Increased likelihood for 2mT to exceed the 90th percentile compared to climatology



Pattern-based forecast

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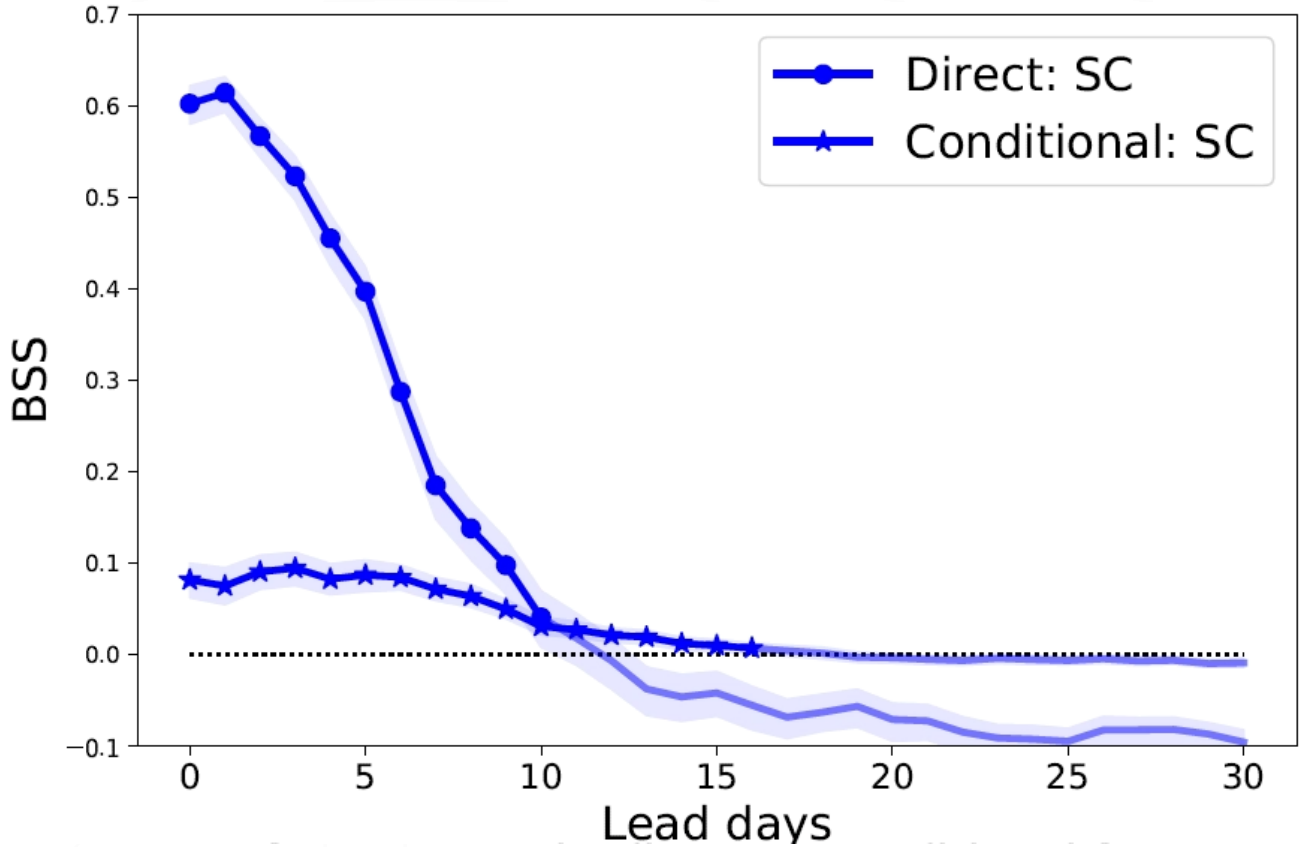
Pattern based forecast

- Improved forecast skill passed 10 days
- Improved forecast range
  - Key for early warnings



Soil moisture monitoring

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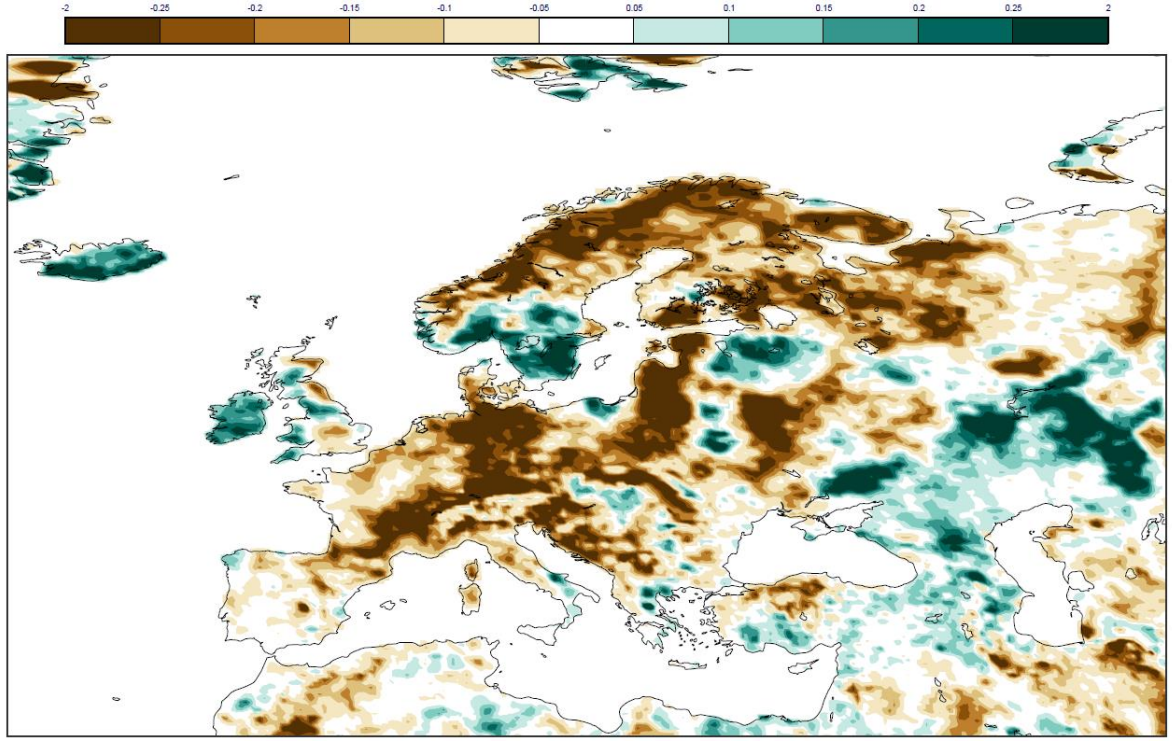
Soil moisture initialization is key to capture the intensity

- Very extreme cases are linked to very low soil moisture conditions



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BSISO monitoring

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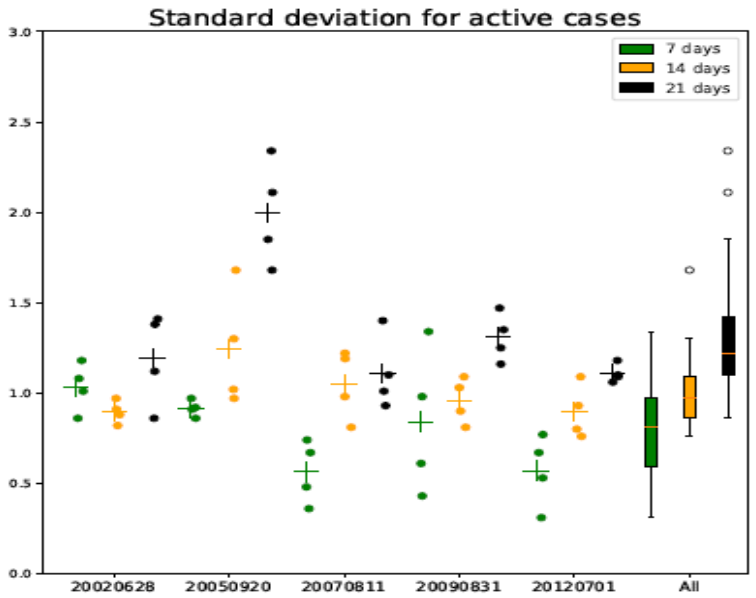
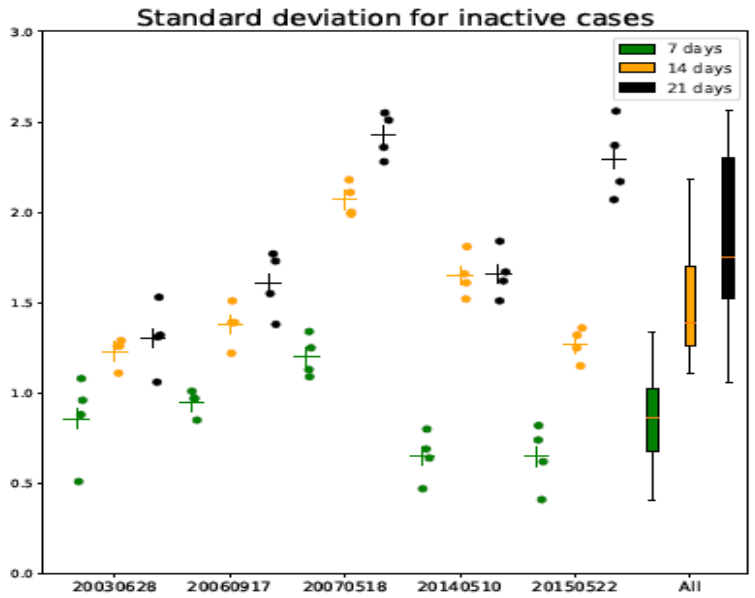
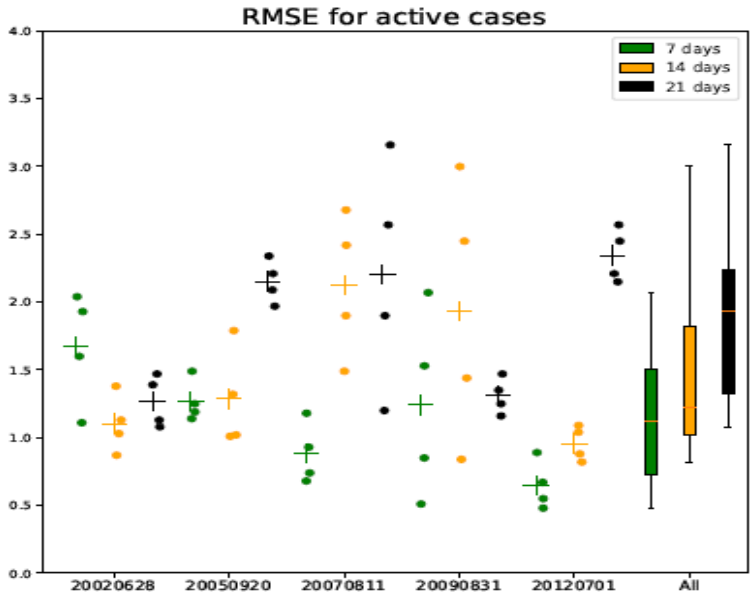
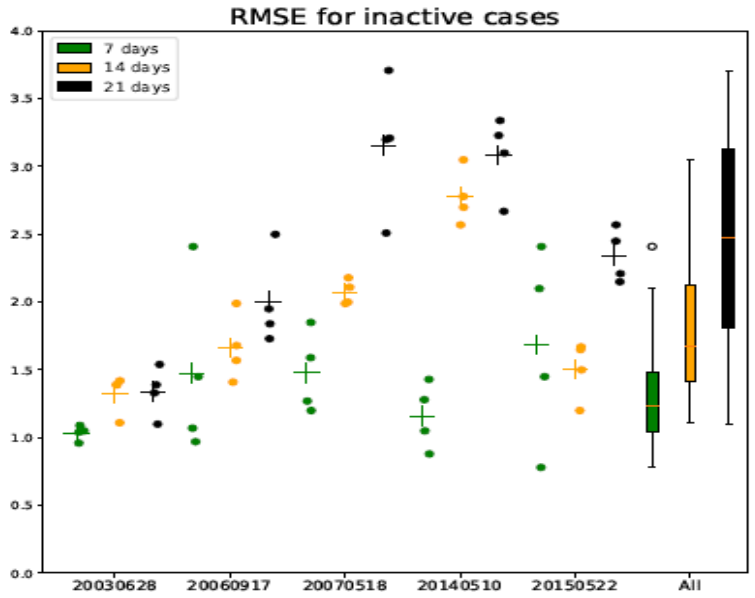
Reduced uncertainty

Increased accuracy









Tropical forcing enhances predictability

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Towards an early warning system

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Forecast product

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Forecast the circulation patterns

Probability of heatwave

Monitor BSISO

Confidence in the forecast

Monitor SWI

Indication of intensity

Forecast product

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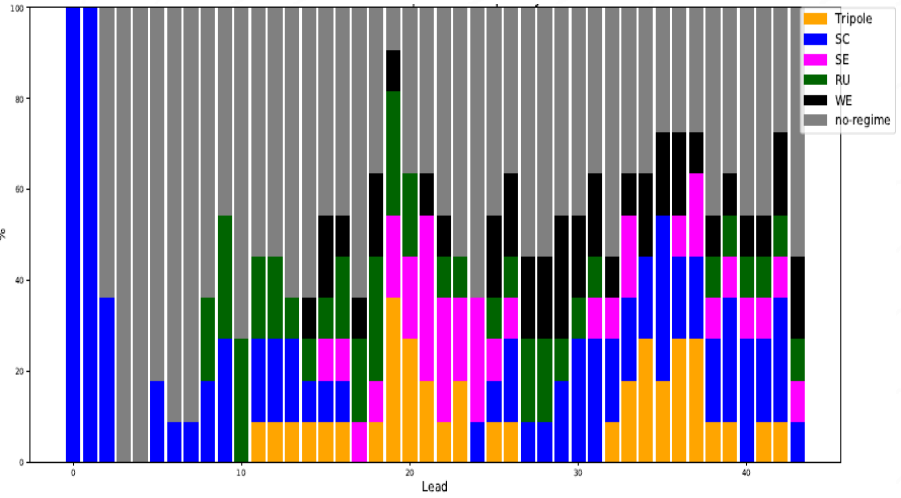
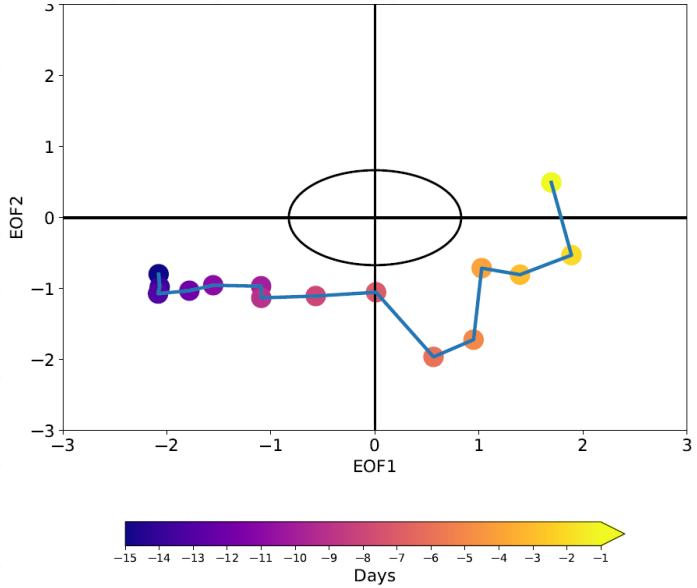
Forecast the circulation patterns

Pattern forecast probability



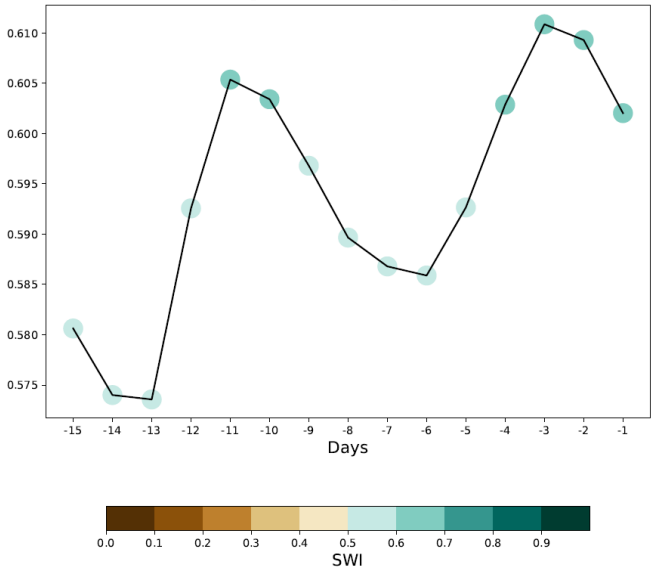
Monitor BSISO

BSISO evolution 15 days before forecast initialisation



Monitor SWI

SWI evolution 15 days before forecast initialisation



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Heatwave

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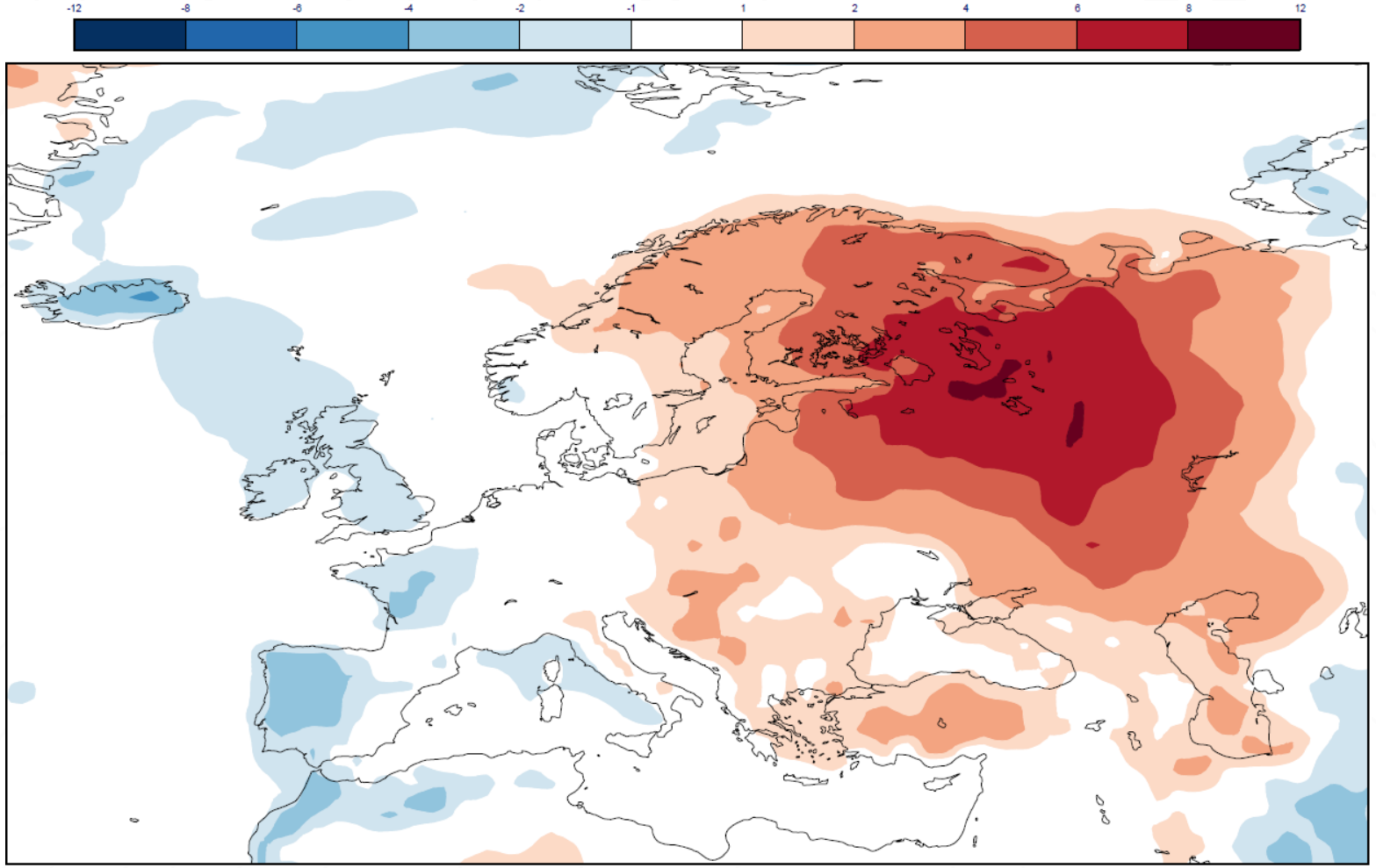
August 2007



Forecast product

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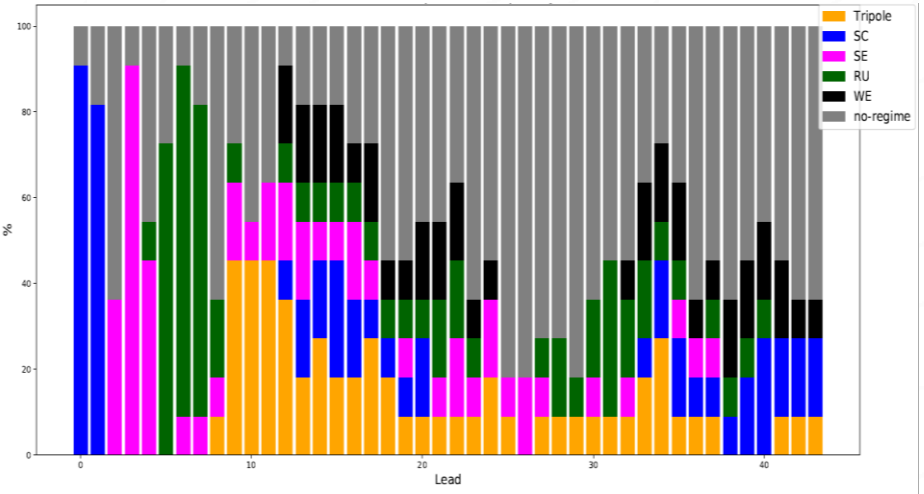
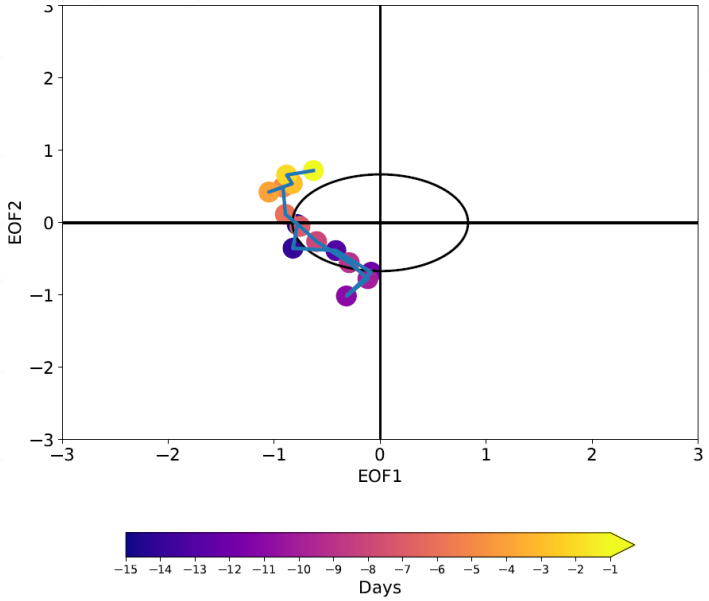
Forecast the circulation patterns

Pattern forecast probability



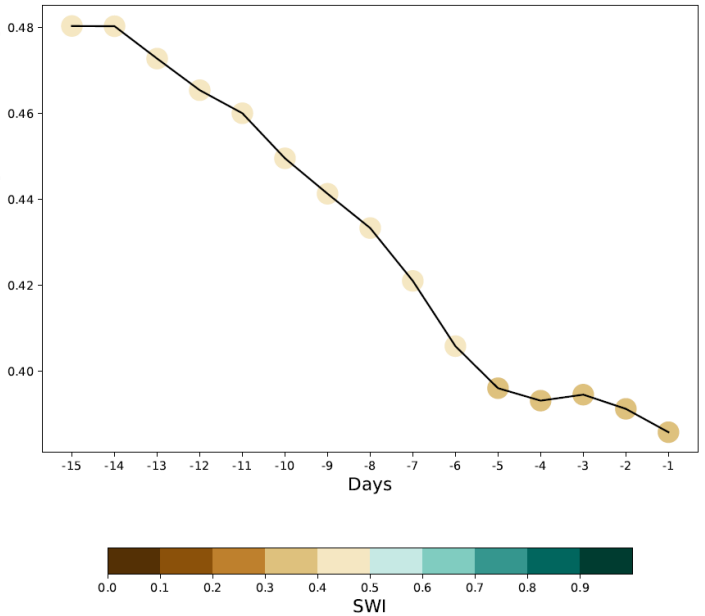
Monitor BSISO

BSISO evolution 15 days before forecast initialisation



Monitor SWI

SWI evolution 15 days before forecast initialisation



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Heatwave

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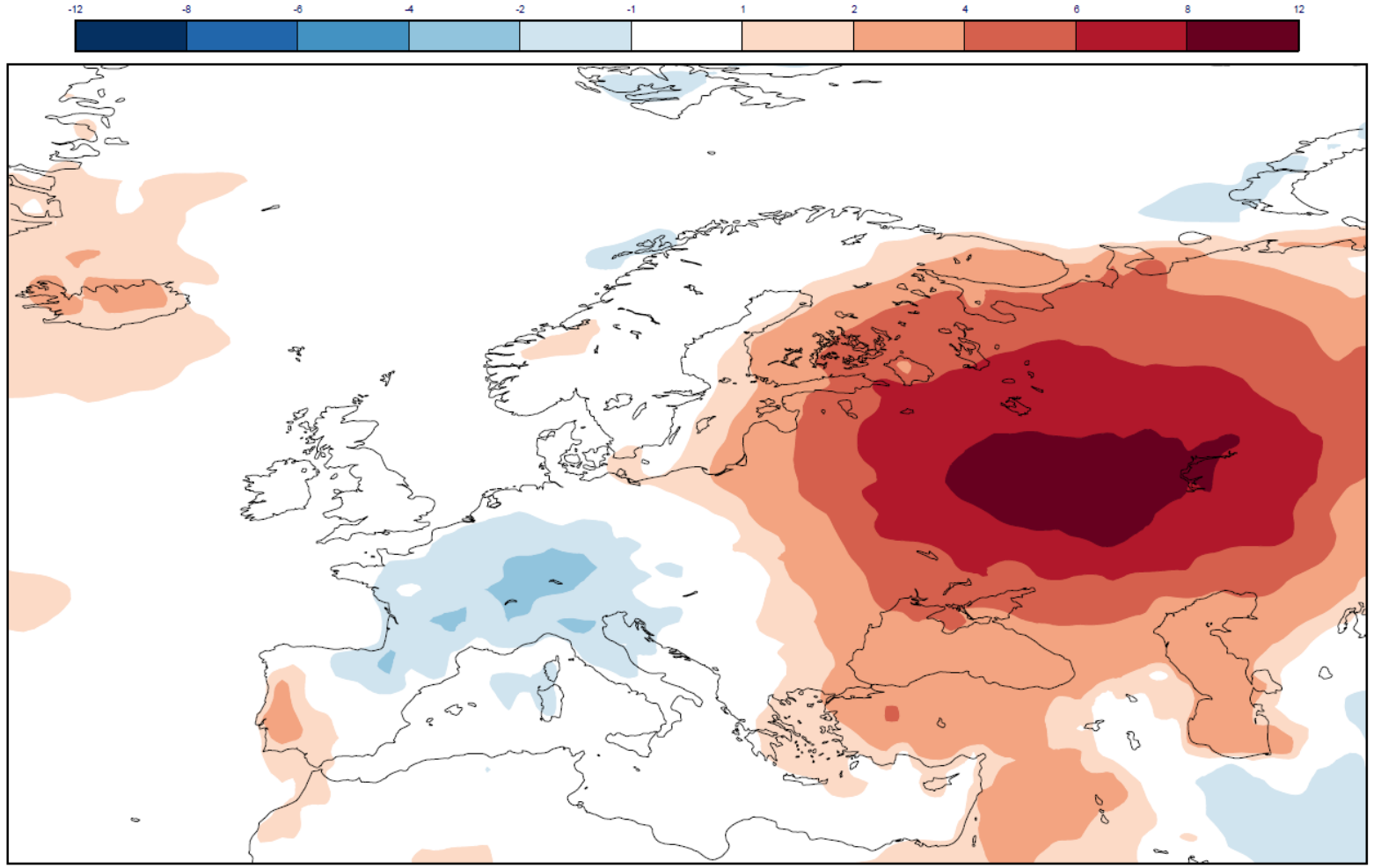
July/August 2010



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Summary/outlook

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Summary

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Summary:

- 3 drivers identified: circulation patterns, local soil moisture conditions and tropical convection
- Each provide different information: forecast probability of heatwaves, confidence in the forecast and intensity of the heatwaves

Monitoring drivers provides essential information for early warnings

Outlook

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How do you assess the usefulness of such a product?

- Skill scores is the conventional way of assessing the accuracy of a forecast
- Need to convert a probabilistic forecast to a decision **Yes** or **No**
- Metric is dependent on the requirements/needs
  - User specific metrics

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References

- Horel, J. D., & Wallace, J. M. (1981). Planetary-Scale Atmospheric Phenomena Associated with the Southern Oscillation, *Monthly Weather Review*, *109*(4), 813-829. Retrieved Sep 20, 2022, from https://journals.ametsoc.org/view/journals/mwre/109/4/1520-0493_1981_109_0813_psapaw_2_0_co_2.xml