Climate change contribution to seasonal forecast anomalies

Louis Ledoux--Xatard, Damien Specq, Saïd Qasmi, Hervé Giordani
Centre National de Recherches Météorologiques (CNRS/Météo-France)

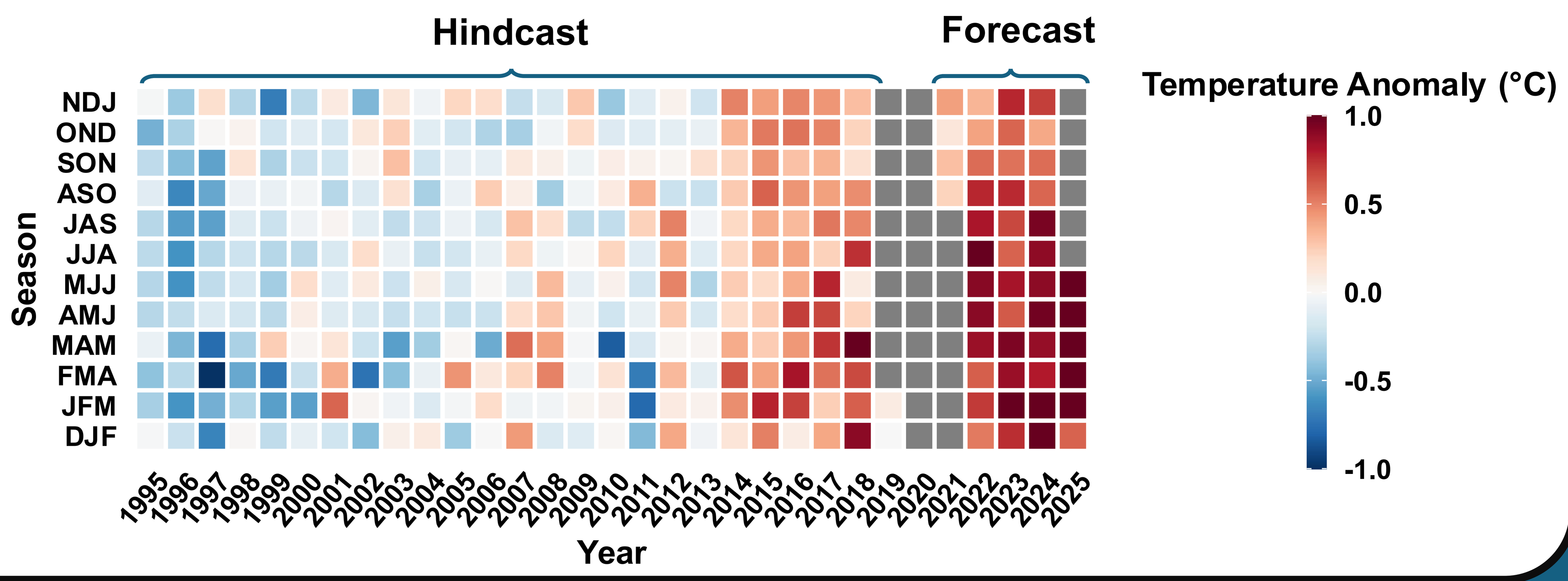
Introduction

- Météo-France provides seasonal forecasts as anomalies relative to a reference climate (hindcast 1995-2018).

$$\Delta T_{season,year} = T^{forecast}_{s,y} - \overline{T}^{hindcast}_{s,.} = \Delta T^{IV}_{s,y} + \Delta T^{CC}_{s,y}$$

- Due to climate change, this reference is becoming increasingly outdated (colder than current forecasts), prompting the need to isolate the forced climate response (Patterson 2022).
- One method currently in-use is a linear trend over 1995-2018 as reference. However persistent warm anomalies, especially over Europe, raise concerns about this method's reliability, leading to the exploration of two alternative approaches: a statistical method and counterfactual numerical experiments.

Europe Box Anomaly (Hindcast 1995-2018)



Comparing climate projections and seasonal forecast

Method

- Using climate projections to estimate forced climate response in a ssp3-7.0 scenario and comparing it to seasonal forecast.
- Climate projections brought back into model world using Kriging for Climate Change (Ribes et al 2022).
- Introducing a quantified uncertainty along the forced response estimation.
- For each season, the Hindcast (1995-2018) is used to constrain a distribution made of 27 CMIP6 models (1850-2100).

Constraint Europe (Hindcast 1995-2018)
Historical + SSP3-7.0 (DJF)

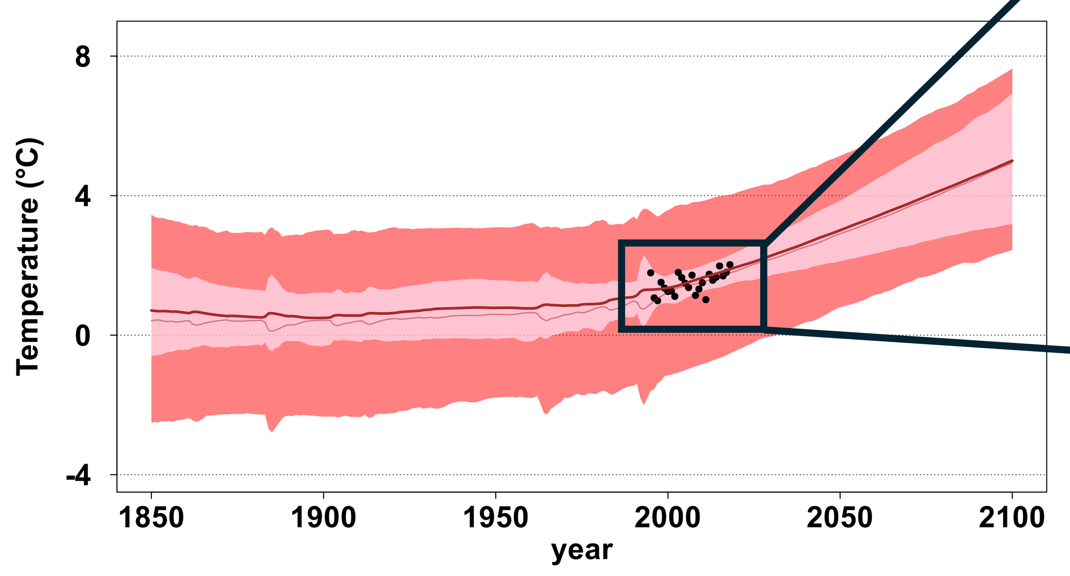
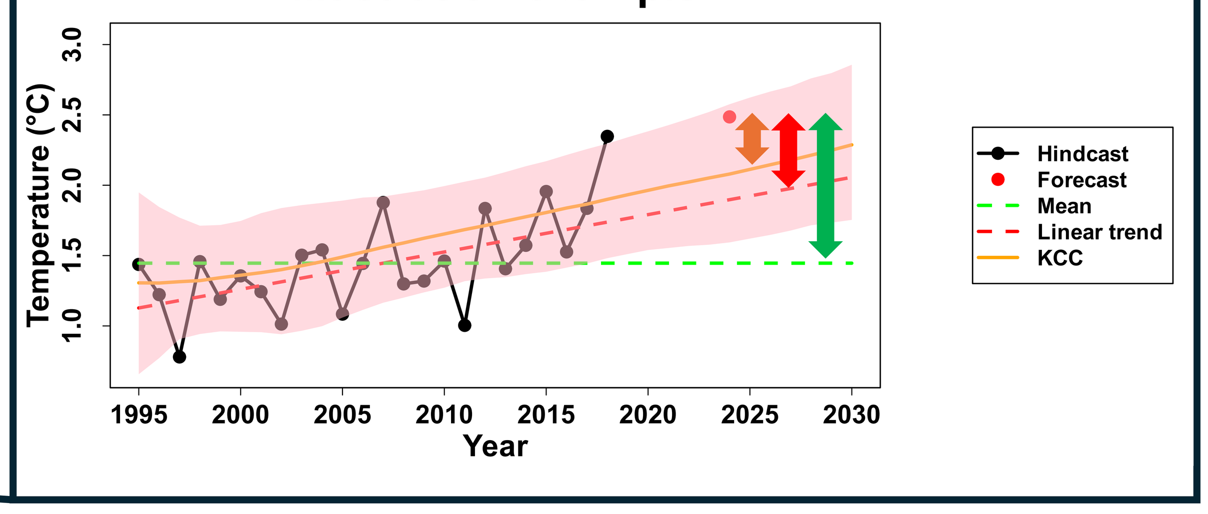


Illustration example

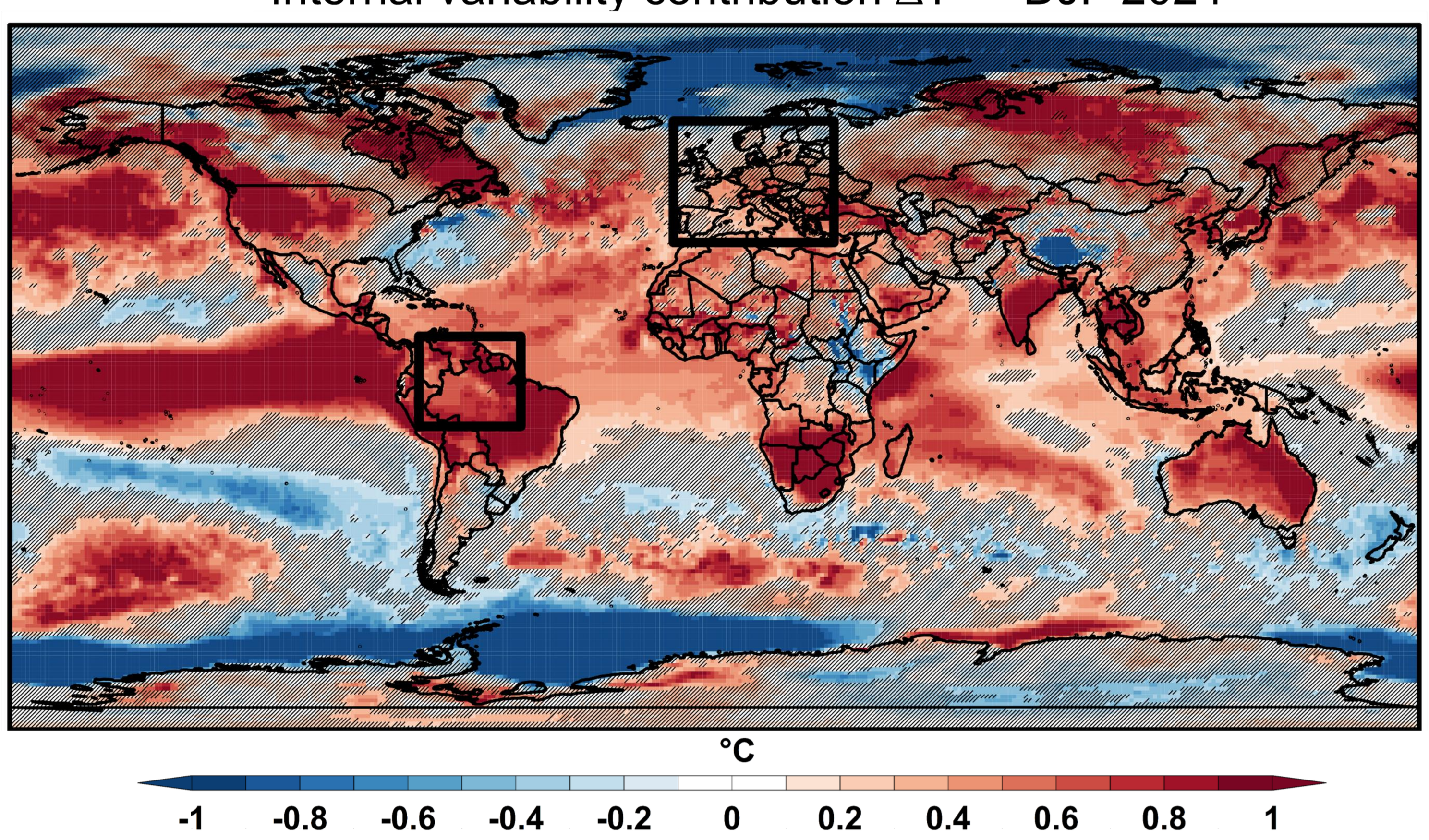


$$\Delta T_{season,year} = T^{forecast}_{s,y} - \overline{T}^{hindcast}_{s,.}$$

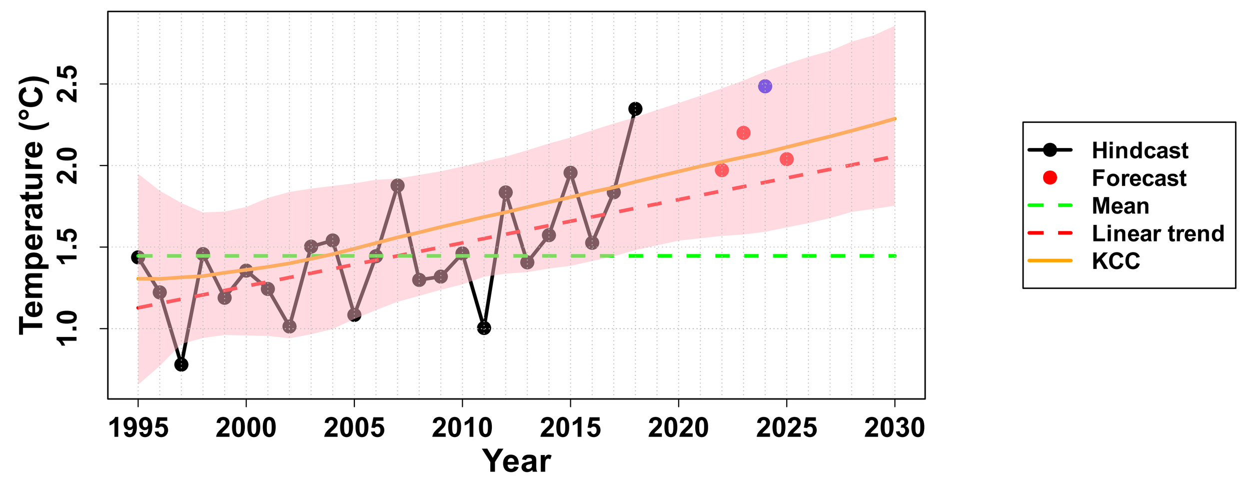
$$\Delta T^{IV}_{s,y} = T^{forecast}_{s,y} - T^{cmip6}_{s,y}$$

$$\Delta T^{IV}_{s,y} = T^{forecast}_{s,y} - T^{linear}_{s,y}$$

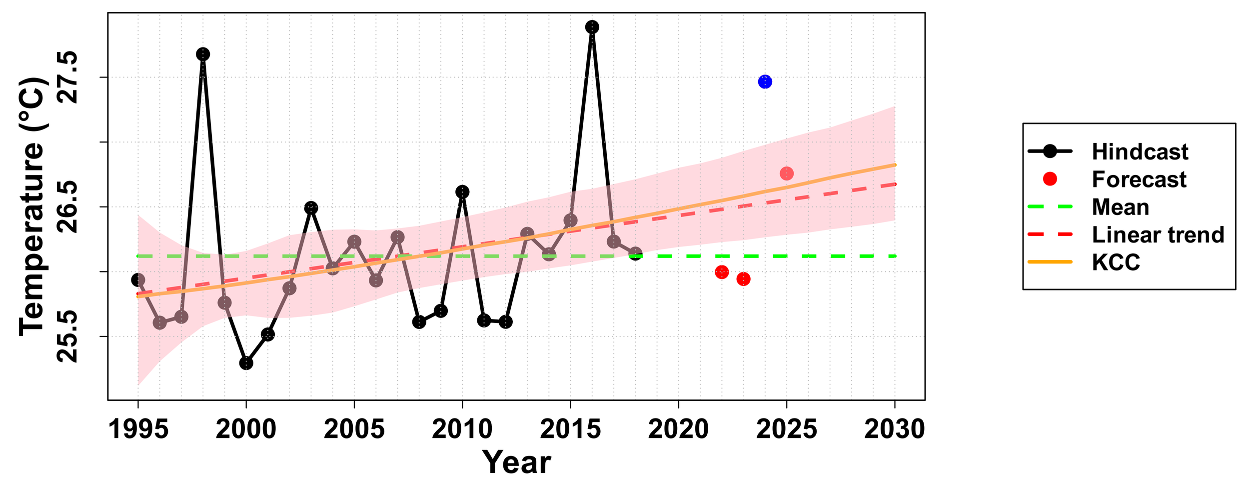
Internal variability contribution ΔT^{IV} - DJF 2024



Europe - DJF (init november)

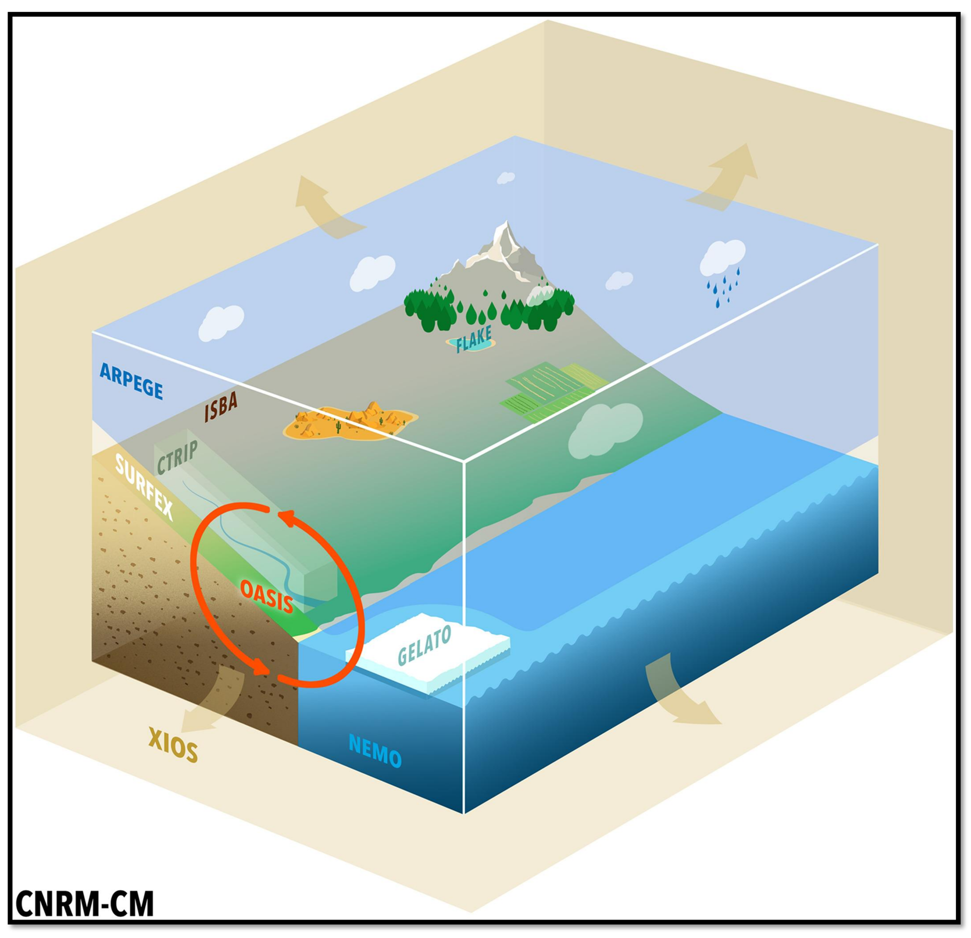


Amazon - DJF (init november)



- The climate projection method captures the natural variability of the 2023/2024 El Niño and its consequences (e,g,, significantly positive anomaly in the Amazon region).
- In Europe, any further interpretation is impossible since most grid points are included in the confidence range.

Traveling in the past : counterfactual experiment



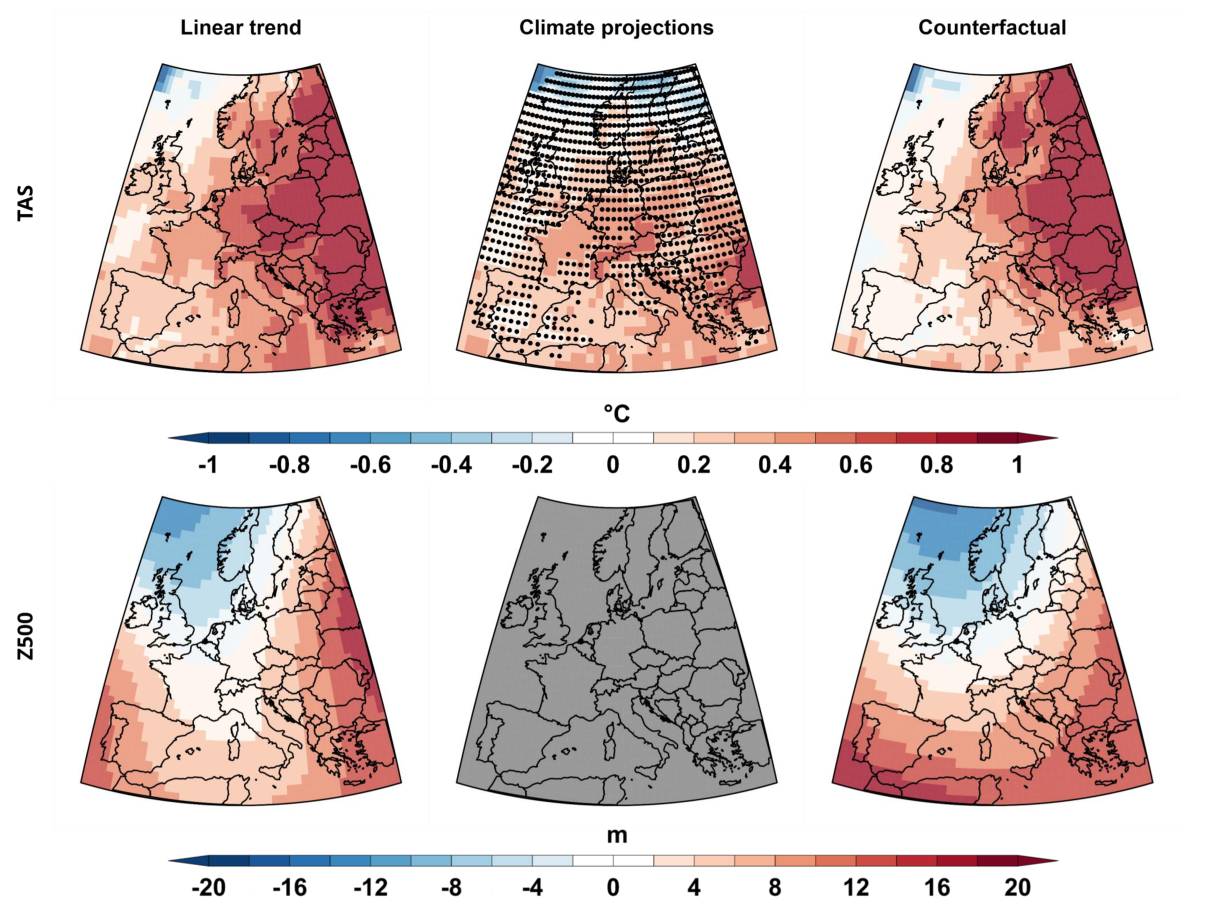
Method

- Counterfactual experiments aim to directly account for the contribution of the forced response in the forecast (Wang et al (2021)), leaving only the natural variability in the anomaly.

$$\Delta T^{IV}_{s,y} = T^{cf}_{s,y} - \overline{T}^{hindcast}_{s,.}$$

- Similar process as seasonal forecasting with the setting of atmospheric and ocean restarts (CNRM-CM, Voldoire et al (2019)) and forcings to 2006 climate (middle of hindcast period).
- Providing additional information on the forced response contribution in atmospheric and ocean dynamics.

Internal variability contribution ΔT^{IV} DJF 2023-2024 Europe



Discussion & prospects

- New statistical approach shows promising results in representing natural variability anomalies and complements the current method by quantifying the uncertainty of the forced response contribution.
- Initial results from numerical experiments show some differences in circulation anomaly positions over Europe but generally a similar pattern in surface temperature.
- Apply the statistical method to other variables affected by the forced response to improve comparison between methods.
- Additional numerical experiments to decompose the contribution of each component involved in the forced climate response.
- Additional numerical experiments with restarts set further in the past to provide a deeper insight into the evolution of the forced response contribution within the context of seasonal forecasting.

References

1. Patterson, M et al. (2022). Environ. Res. Lett.
2. Ribes, A et al (2022). Earth Syst. Dynam.
3. Wang, G et al. (2021). Journal of Climate