EGU24-11714, updated on 14 Oct 2024
https://doi.org/10.5194/egusphere-egu24-11714
EGU General Assembly 2024

Subseasonal prediction of heatwaves in the Iberian Peninsula using causality-based transformer networks.

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Subseasonal prediction of heatwaves, although highly valuable for risk reduction, is challenging because heatwave onsets and propagation are complex processes with both fast and slow drivers from local to global scale. Traditionally, subseasonal forecasting relies heavily on dynamical model ensembles, which are complex and of high computational cost. As an alternative, machine learning provides potentially performant solutions that may match or even outperform these physical-based models. Transformers, in particular, are the current state-of-the-art deep learning infrastructures, and using multi-head-attention allows them to keep track of long-term complex dependencies in timeseries data. However, to better forecast heatwaves subseasonally, it is essential to move beyond purely predictor-to-target associative measures when identifying the sources of predictability. Such endeavours require causal frameworks that provide directionality and explainable power for the predictor-to-target relationships.

This study seeks to implement the PCMCI$^+$ (Runge, 2020) framework to identify causal drivers of heatwaves on the Iberian Peninsula on a subseasonal scale. Causally-selected predictors are employed to forecast the occurence of heatwaves up to six weeks in advance using transformer networks, both for different seasons and sub-regions in the Iberian Peninsula. Preliminary results reveal heatwaves can be predicted with reasonable accuracy with a forecast window of six weeks, particularly in water limited regions, using causality-based machine learning.

Reference:

Runge, J. (2020). Discovering contemporaneous and lagged causal relations in autocorrelated nonlinear time series datasets. In Conference on Uncertainty in Artificial Intelligence, pages 1388–1397. PMLR.