North Atlantic SST and jet stream anomalies related to European heat waves

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This study highlights the relevance of North Atlantic SSTs and certain jet stream properties for the onset of high European temperatures by using the ERA-5/ERA20c reanalysis product and a targeted experiment with the OpenIFS model. We found that certain European heat wave events could be related to the simultaneous appearance of cold North Atlantic SST events, specific jet stream wave numbers and further to transient and recurrent Rossby wave activity.

The coexistence of cold North Atlantic sea surface temperature (SST) and positive European surface temperature anomalies during several summer seasons, like in 1994, 2015 and 2018 motivated us to evaluate whether and how widespread and significant North Atlantic SST anomalies could be associated with European heat waves. Therefore we investigated the role of the jet stream in serving as a medium for a downstream signal propagation.

A composite study reveals that cold North Atlantic SST anomalies in summer are accompanied by a more undulating jet stream and a preferred trough-ridge pattern in the North Atlantic-European sector. A wave analysis covering two-dimensional probability density functions of phase speed and amplitude after compositing cold SSTs show that cold North Atlantic SST events reveal a preference for a dominance of transient waves. In the presence of a trough during cold North Atlantic events, we obtain a slow-down of the transient waves, but not necessarily an amplification or stationarity. The deceleration of the transient waves results in a longer duration of a trough over the North Atlantic accompanied by a ridge downstream over Europe, favouring the conditions for the onset of European heat episodes.

A study of the jet stream energetics via a kinetic energy power spectrum of meridional wind anomalies reveals that generally a trend shows up towards wave numbers 4 to 6. This is supported by an enhanced activity of specific wave numbers within this increased range during summer seasons of European heat wave events happening in the last two decades. An arising question poses whether the increased energy for a certain wave number originates from an SST forcing or different drivers. We investigate this by performing targeted OpenIFS model runs forced by different SST conditions.