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Granger causality estimate of information flow in temperature fields is consistent with wind direction

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Granger causality analysis is designed to quantify whether one time series is useful in forecasting another. We apply the time domain Granger causality analysis based on autoregressive processes to gridded daily surface air temperature data. For each grid-point pair, the direction and strength of the causal influence were computed with the one-day lag, effectively assessing the direction of the information flow in the temperature field. In order to remove the influence of different distances of the grid-points in the original angularly regular grid of the NCEP/NCAR reanalysis, the data were transformed into an equidistant geodesic grid of 642 grid points. The strongest causalities have been found in the Northern Hemisphere's extratropics, where the temperature information is flowing eastward, in agreement with the prevailing westerlies. In contrast, only weak causalities have been observed in the tropics, which may be arising from higher spatio-temporal homogeneity.

In the second step, we quantitatively compared this estimate of information flow with the actual wind directions from NCEP/NCAR reanalysis data transformed onto the equidistant geodesic grid of 642 points. This was done for the surface layer and for the 850, 700, 500, 300 and 100hPa layers. The direction of the information flow matches the flow of the air masses, particularly well in the Northern Hemisphere's extratropics, i.e. for the strongest causalities. This agreement holds throughout the troposphere, slightly increasing with the height up to 500hPa level, then remains the same until bottom stratosphere. The agreement between the information flow in the air temperature field and the flow of air masses suggests the Granger causality as a suitable tools for constructing directed climate networks.