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Global co-variability patterns of sea-surface temperatures and precipitation as revealed by coupled climate network analysis

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We study the mutual statistical interrelationships between sea-surface temperature (SST) and precipitation anomalies at monthly scales for the time period 1979-2015. Based upon two global benchmark data sets (ERSST and GPCP) with homogeneous latitude-longitude grids and a spatial resolution of 2° (SST) and 2.5° (precipitation), respectively, we compute pairwise linear correlations between all pairs of time series within any of the two considered climatological fields. In order to account for effects of season as well as different stages of the El Nino Southern Oscillation (ENSO), we perform the analysis separately for the four climatological seasons (DJF, MAM, JJA, SON) and positive (El Nino), negative (La Nina) and neutral ENSO phases classified according to the Oceanic Nino Index (ONI).

In order to highlight the most relevant spatial patterns of co-variability, we keep only the 1% strongest correlations among all SST (precipitation) series and the 0.5% strongest correlations among all pairs of SST and precipitation time series. By reducing the amount of information accordingly, we are able to interpret the spatial placement of the strongest correlations within the framework of coupled climate network analysis. In order to further differentiate between different climatological mechanisms that may be responsible for interdependencies between SST and precipitation, we perform the same analysis by thresholding for the strongest absolute, positive and negative correlations, respectively.

As revealed by the cross-degree patterns of the resulting coupled climate networks, SST anomalies in the Pacific Ocean are most important for explaining global precipitation anomalies, while Atlantic and Indian Ocean play only minor roles. The corresponding spatial structures differ markedly among the different seasons and ENSO phases and include not only the tropical oceans, but also some characteristic regions of the extratropics. In turn, the regions with precipitation anomalies being strongly correlated with SST variations at many different grid points comprise both, the Central to Eastern tropical Pacific and the southern Ocean along the Antarctic coast. While the former regions mostly represent positive correlations (i.e. high SST coinciding with stronger precipitation), the subpolar-to-polar regions also reflect strong negative correlations.