Potsdam Institute for Climate Impact Research

A Network of Networks Approach to Investigate the Influence of Sea Surface Temperature Variability on Monsoon Systems

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Abstract

In this study, we analyze large-scale inter-dependencies between Sea Surface Temperature (SST) and rainfall variability using climate networks. On account of this analysis, we coarse-grain gridded SST and rainfall data sets by merging grid points that are dynamically similar to each other. We consider the SST and rainfall systems as two distinct climate networks and use established cross-network measures to understand their interrelations. As a first step, the spatial distributions of these cross-network measures illustrate regions which are of particular importance in the interaction between SST and rainfall. Secondly, we go into further detail by investigating the cross-network topology explicitly for these regions. Here, strong influences from regions in the SST system in relation to other regions in the rainfall system are detected. These influences structured in a spatially embedded directed network describe important mechanisms behind monsoon systems. For example, behind the Indian Summer Monsoon, which is known to be controlled by SST variability over the adjacent Indian Ocean.

Data

Monthly mean SST 1 x 1 grid for 1982 - 2008 (NOAA Optimum Interpolation SST V2 by NCEP).

Monthly mean precipitation 0.5 x 0.5 grid for the same period (APHRODITE).

Climate Networks

For each observable the detrended anomalies are clustered by the arccos distance metric from Spearman correlation values between the time series. For each cluster the most central time series is the representative (see Fig. 1, 2). Possibly lagged Spearman correlation values between SST and precipitation representatives define the weighted cross topology of the studied climate network.

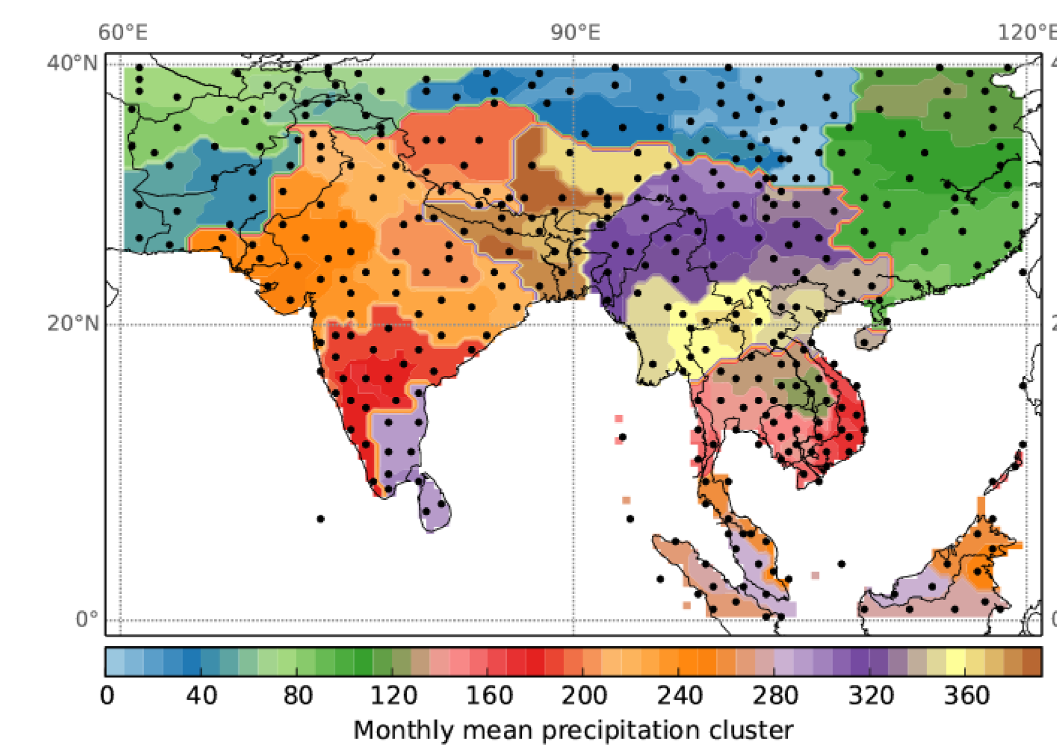

Figure 1: Hierarchical clustering of monthly mean precip. by Spearman correlation with a minimum correlation of 0.5 between members of a given cluster.

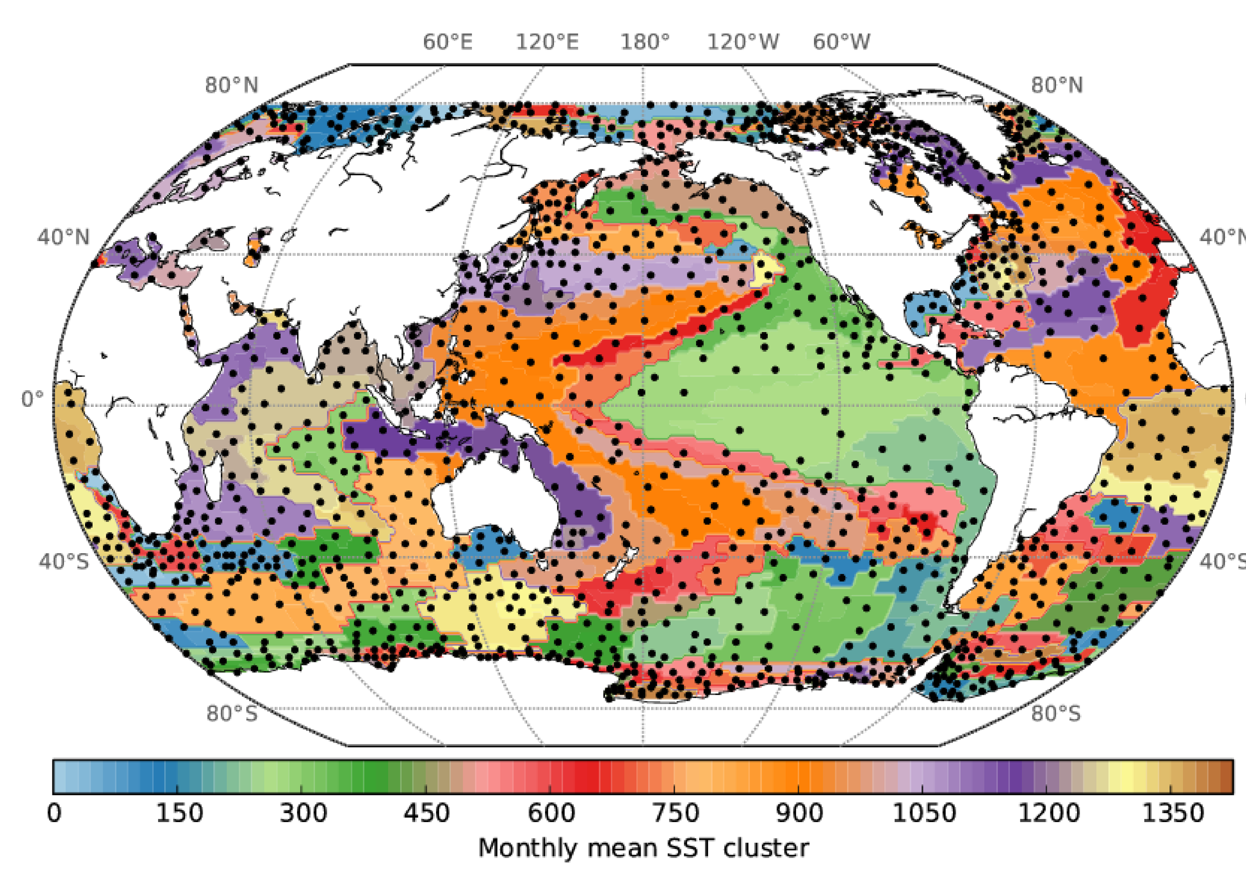

Figure 2: Hierarchical clustering of monthly mean SST by Spearman correlation with a minimum correlation of 0.5 between members of a given cluster.

Results

The weighted cross topology between SST and precipitation nodes is analyzed exclusively for positive lags, that is for SST dynamics preceding precipitation dynamics. The hereby studied influence of SST variability on precipitation variability separates into different influence modes (see Fig. 3).

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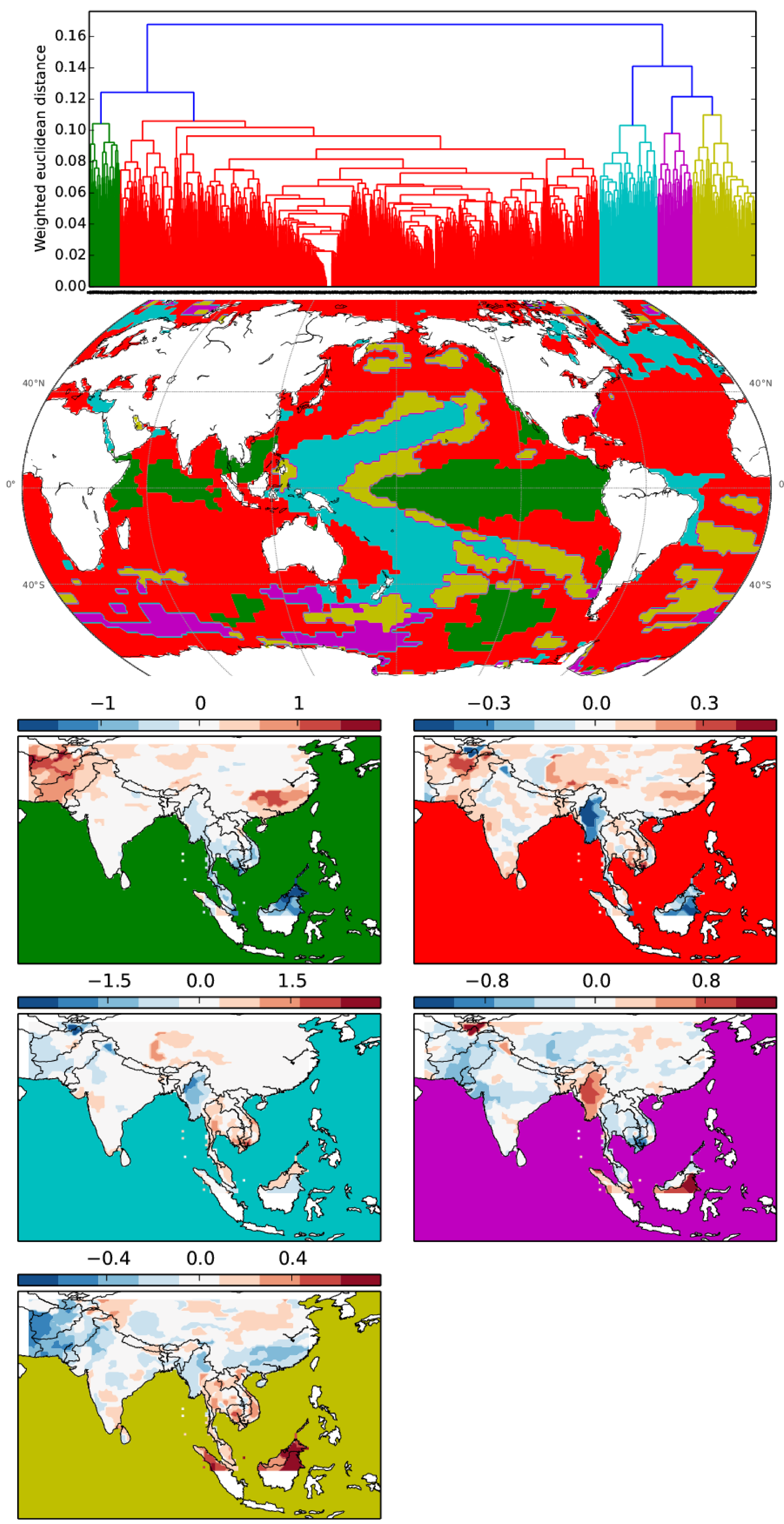

Figure 3: Five distinct influence modes determined by climate network topology.