Networks constructed by Phase Syncronization Analysis

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Networks are often used to formulate the dynamics of complex systems that are built from many interacting components. While in some cases the representation of the system as a network is obvious and the nodes and links are identified directly (e.g. cables connecting computers in a computer network), there are cases in which the process that couples the individual interacting components is more complex and a link is guessed by tracking similarities in the dynamical behavior of two nodes.
Even when the usual traces of dynamics of interacting nodes on a network, such as partial synchronization, clusters with correlated dynamics, oscillatory synchronization, and phase slips, are evident, the mission of designing a generic tool that reliably extracts information about the network structure from measurements of the dynamics of nodes is still far from being accomplished.
In this work we develop a method for generating climate networks, which is suitable for tracking structural changes in these networks (dynamics **of** a network). These changes correspond, in our case, to strong climate changes due to El-Niño. We find that networks constructed from temperature measurements on different sites in the world are changed dramatically during El-Niño events in a similar way. These structural changes are seen even for geographical zones where the mean temperature is not affected by El-Niño. We also study the blinking of links during El-Niño, which was missing.

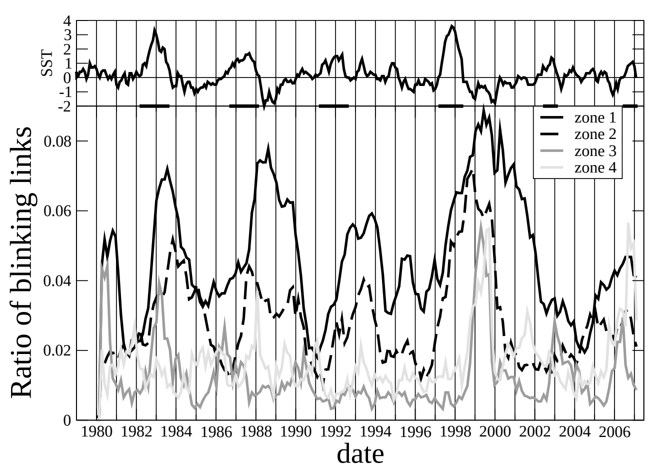

Figure 1: Number of blinking links $b(y)$ as a function of time. The top panel shows the temperature based El-Niño index NINO3. The bottom panel shows the number of blinking links as a function of time that exhibit the patterns 1,0,1 or 0,1,0 in the four zones.

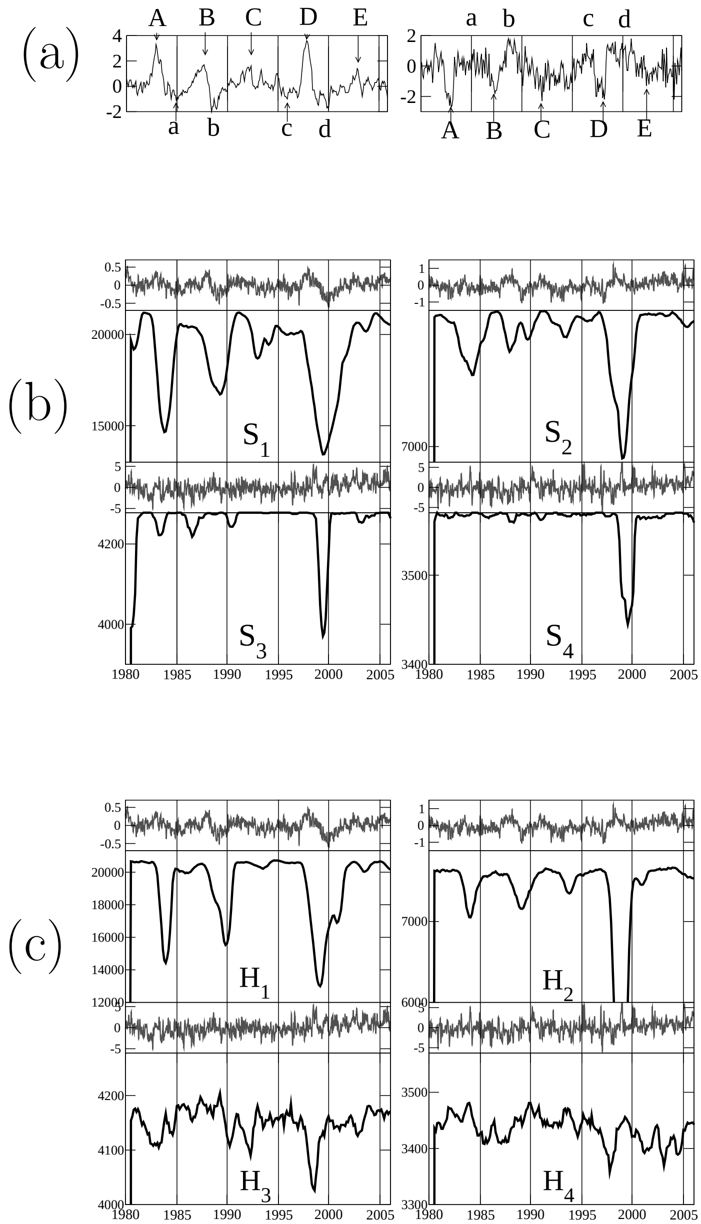

Figure 2: (a) Mean sea surface temperature (left) in the standard basin , and the difference in sea level pressure (right) between Tahiti and Darwin, both are standard indexes for El-Niño/La-niña. (b) and (c) The upper curves represent the temperature anomaly series in zones (b) S_1, S_2, S_3, S_4 (temperature measured at surface) and (c) H_1, H_2, H_3, H_4 (temperature measured at 500mb pressure level). The lower curves present by phase synchronization the number of links $n_k(s)$ that survive in the network as a function of time, for these same zones.

Keywords

climate networks, phase syncronization analysis,direct coupling, indirect coupling

References

[1] K. Yamasaki, A. Gozolchiani,and S. Havlin. “Phys. Rev. Lett.,” *Climate networks around the globe are signifcantly afected by el ni no.*, 100:228501, 2008.

[2] A. Gozolchiani, K. Yamasaki, O. Gazit, and S. Havlin. “Europhys. Lett.,” *Pattern of climate network blinking links follows el ni no events.* , 83:28005, 2008.