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Dynamical analysis of the Indian Ocean climate network and its correlation with Australian Millennium Drought

Laura Carpi (1), Cristina Masoller (1), Albert Díaz-Guilera (2), Martín G. Ravetti (3,2)

(1) Departamento de Física e Ingeniería Nuclear, Universitat Politecnica de Catalunya, Terrassa, Spain, (2) Departament de Física Fonamental, Universitat de Barcelona, Barcelona, Spain, (3) Departamento de Engenharia de Produção, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

During the period between the mid-1990s and late 2000s Australia had suffered one of the worst droughts on record. Severe rainfall deficits affected great part of southeast Australia, causing widespread drought conditions and catastrophic bushfires. The “Millennium Drought”, as it was called, was unusual in terms of its severity, duration and extent, leaving important environmental and financial damages.

One of the most important drivers of Australia climate variability is the Indian Ocean dipole (IOD), that is a coupled ocean and atmosphere phenomenon in the equatorial Indian Ocean. The IOD is measured by an index (DMI) that is the difference between sea surface temperature (SST) anomalies in the western and eastern equatorial Indian Ocean. Its positive phase is characterized by lower than normal sea surface temperatures in the tropical eastern coast, and higher than normal in the tropical western Indian Ocean. Extreme positive IOD (pIOD) events are associated to severe droughts in countries located over the eastern Indian Ocean, and to severe floods in the western tropical ones.

Recent research works projected that the frequency of extreme pIOD events will increase significantly over the twenty-first century and consequently, the frequency of extreme climate conditions in the zones affected by it.

In this work we study the dynamics of the Indian Ocean for the period of 1979-2014, by using climate networks of skin temperature and humidity (reanalysis data). Annual networks are constructed by creating links when the Pearson correlation coefficient between two nodes is greater than a specific value. The distance distribution Pd(k), that indicates the fraction of pairs of nodes at distance k, is computed to characterize the dynamics of the network by using Information Theory quantifiers.

We found a clear change in the Indian Ocean dynamics and an increment in the network’s similarities quantified by the Jensen-Shannon divergence in the late 1990s. We speculate that these findings are capturing mean state changes within the Indian Ocean that result in the increase of extreme positive IOD frequency, among other unknown consequences. We show that the unusual characteristics of the Australian Millennium Drought is strongly associated with this new Indian Ocean dynamics showing its relevance in the Australia climate variability.