Application of Complex Networks to the study of Tropical Cyclones

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Abstract

Cyclones are one of the most destructive natural hazards that pose a serious threat to society, particularly to those in the coastal regions. Here, we study the temporal evolution of the regional weather conditions in relation to the occurrence of cyclones using climate networks. Climate networks encode the interactions among climate variables at different locations on the Earth's surface, and in particular, time-evolving climate networks have been successfully applied to study different climate phenomena at comparably long time scales, such as the El Niño Southern Oscillation, different monsoon systems, or the climatic impacts of volcanic eruptions. Here, we develop and apply a complex network approach suitable for the investigation of the relatively short-lived cyclones. We show that our proposed methodology has the potential to identify cyclones and their tracks from mean sea level pressure data [1]. We find that network measures such as degree and clustering exhibit significant signatures of cyclones and have striking similarities with their tracks. Next, we suggest an innovative approach to understand the evolving vortical interactions leading to the merging of co-rotating binary cyclones using time-evolving induced velocity based unweighted directed networks [2]. Identifying the transitions in the interaction of binary cyclones and predicting the merger is challenging for weather forecasters. We find that network-based indicators can quantify the changes during the interaction between the two cyclones, and are better candidates than the traditionally used separation distance to classify the interaction stages before a cyclone merger. The study of the network topology over time scales relevant to cyclones allows us to obtain crucial insights into the effects of cyclones on the spatial connectivity structure of sea-level pressure and vorticity fields.

References

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