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Percolation Phase Transition of Surface Air Temperature Networks under Attacks of El Niño/La Niña

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In this study, we studied the air-sea interaction over the tropical central eastern Pacific from a new perspective, climate network. The sea surface air temperature over the Pacific was constructed as a network, and the influences of sea surface temperature anomaly in the tropical central eastern Pacific (El Niño/La Niña) were regarded as a kind of natural attack on the network. The results showed that El Niño/La Niña leads an abrupt percolation phase transition on the climate networks from stable to unstable or metastable phase state, corresponding to the fact that the climate condition changes from normal to abnormal significantly during El Niño/La Niña. Using three different reanalysis datasets, we verified the percolation phase transition. That was, when the influences of El Niño/La Niña are strong enough to isolate more than 48% of the nodes which is a percolation critical threshold Pc to be estimated to determine whether the percolation phase transition happens, the network may abruptly be divided into many small pieces, indicating a change of the network state. By comparing the networks constructed by CMIP5 coupled general circulation models (CGCMs) datasets and reanalysis datasets, it revealed that some models could simulate the phenomenon of abrupt phase transition with a critical probability Pc approaching the result of reanalysis dataset during El Niño/La Niña while others failed. The unrealistic sea-air interactions simulated in the tropical central Pacific may be responsible for the missing of percolation phase transition in some models. Accordingly, percolation phase transition is proposed as a new test bed to evaluate the performance of El Niño/La Niña simulation in CGCMs, which is a new perspective that deserves more attention in the future.