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Meteorological Droughts in India under Climate Change Conditions: A Complex Networks-based Approach

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Droughts pose substantial challenges to water resources, ecosystems, and agriculture. Climate change is anticipated to result in more frequent and greater magnitude droughts in the future. The present study assesses meteorological droughts in India under climate change conditions using a complex networks-based approach. The Standardized Precipitation Index (SPI) values at a duration of 1, 3, 6, and 12 months are used to assess the meteorological droughts. Observed precipitation data from the India Meteorological Department (IMD) and precipitation outputs from 53 GCMs participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6) are used. The data considered are at a spatial resolution of 1° x 1°, covering a total of 288 grids across India. The Shortest Path Length is used as a network measure to rank the GCMs. First, the network is constructed by treating each grid as a node and identifying the links between any pair of grids according to certain threshold conditions in correlations in SPI values. Next, the GCMs are individually ranked for each of the 288 grids based on the difference in the shortest path length between the observed and GCM-simulated SPI networks. Then, the Group Decision-Making (GDM) approach is applied toidentify the top-performing GCMs across all the 288 grids. Finally, the inclusion of a comprehensive rating metric (RM) value provides a unified approach to combine the ranks obtained for GCMs across various duration (1, 3, 6, and 12 months). The results indicate that NorESM2-MM, CESM2-FV2, KACE-1-0-G, SAM0-UNICON, and CMCC-CM2-SR5 are the top five models in terms of performance. Data from these five models are then studied using Event Synchronization (ES) to uncover the spatial connections in drought events across space. This novel approach contributes to a better understanding of the spatial dynamics of meteorological droughts, especially under climate change.