Atmospheric circulation types and winter extreme dry/wet spells in the southeast district of Iran

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(Received: 31 July 2021, Accepted: 4 Oct 2022)

Summary

In arid environments, extreme wet and dry periods are considered a serious threat to human societies. These periods affect the agricultural sector, transportation networks, vegetation, the environment, water resources, and the sustainability of human societies. Extra-arid and arid regions of southeastern Iran are good examples of an area affected by extreme climate events hazards, such as, floods and droughts. This study, to better understanding the causes and processes leading to extremely dry and wet episodes in southeastern Iran, investigates the space and time variability of winter dry/wet events and their associated large-scale atmospheric driving circulations. The data of this research are of two categories. Monthly gridded data from 1-month standardized precipitation-evapotranspiration index (SPEI01) and daily average geopotential field data of 500 hPa (HGT500) retrieved from NCEP/NCAR Reanalysis data over a period of 55 years (1960-2015) have been used to evaluate the dry and wet spells and circulation types (CTs) of winter atmosphere, respectively. December to March (DJFM) are selected as winter months and data for 55 winters are extracted through MATLAB programming facilities in the southeastern part of Iran. 168 gridpoints cover the southeastern part of Iran. The western and northern boundaries of the study area are bounded by the meridian 55 degrees east and 32 degrees north. Finally, a new database with the arrangement $SPEI01_{220\times168}$ was formed and became the basis for further processing. Of course, the database of the variable height of geopotential is different and has a matrix with dimensions $HGT500_{6668\times609}$. Extreme wet and dry periods have been identified based on SPEI01 values outside the range [+1.5, -1.5], respectively. By applying the Principal Component Analysis (PCA) with Varimax rotation on S-mode analysis and correlation matrix of the SPEI01 field, three sub-regions of independent climatic variability are identified. Large-scale daily atmospheric circulation patterns are then classified into twelve circulation types (CTs) by applying PCA to the 500 hPa geopotential height fields and non-iterative K-means clustering technique to the retained PCA scores, followed by Esteban et al. (2005). The linkage between daily CTs and winter, dry/wet spells in the region are investigated by applying the performance index (PI) to the daily precipitation data of three representative stations of the identified sub-regions. Results show a significant relationship between the frequencies of occurrence of the identified CTs and of dry/wet spells at the three representative stations, in extra-arid and arid regions of southeastern Iran. 6 circulation patterns (CT) were identified for the study area, each of which has a negative phase and a positive phase, and a total of 12 patterns were identified. According to the results of the performance index, CT1+ pattern with deep Trough and ridge pattern on the Mediterranean Sea and the Caspian Sea, respectively, has a large share in providing above-average rainfall (P1> 1) in the east and southeast (Zahedan station). But this phase is related to the dry periods of the study area. Unlike the second type (CT2), its positive phase (+CT2) is associated with dry periods and its negative phase (-CT2) is associated with wet periods.

Keywords: PCA, atmospheric circulation patterns, K-means clustering, SPEI, PI.

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