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Synoptic Circulation Patterns and Climate Regionalization of East Africa

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Abstract. Climate regionalization is crucial for climate studies, especially in the case of heterogeneous regions like East Africa. This paper focuses on categorizing Ethiopia into homogeneous climatic sub-regions by applying a classification of circulation patterns on precipitation. The sub-regions obtained will be applied on the verification of WRF-NOAHMP seasonal simulations performed over the Horn of Africa. We analyzed the occurrence of each circulation type per month and per year over the whole country. Then, trend analysis of temperature and precipitation over the respective sub-regions were performed. Principal Component Analysis (PCA) were applied to group daily mean Sea Level Pressure (SLP) into Circulation Types (CTs). Then, PCA coupled with k-means clustering employed to regionalize precipitation fields (distributed spatially) following CTs into homogeneous climatic sub-regions. Observational data were obtained from the National Center for Environmental Prediction (NCEP) reanalysis, Climate Hazards Group Infrared Precipitation with Stations (CHIRPS version 2), and National Meteorology Agency (NMA) of Ethiopia (gauge 1st and 2nd classes). Five principal components, which explain 98% of the total variance, were maintained using the Scree test technique. Ten CTs were obtained using positive and negative phases of each principal component scores following the extreme score values (> 2 and < −2) procedure. From ten CTs, we found that three (CT1, CT3, and CT8) were characterized by low pressure over the southwest corner of the domain, which consequently brings rainfall over the Ethiopian highlands. The number of days classified under different CTs shows different trends. CTs seasonal distribution agreed with the regional seasons. Long-term monthly mean rainfall ranges from 0-600 mm over the region. Ethiopia is clustered into four homogeneous sub-regions based on the spatial distribution of precipitation following CTs. Rainfall from CHIRPS and gauge did not have any specific trend over the sub-regions, however high standardized anomalies were observed compared to the long term mean. The temperature showed a 2 °C change for the past three decades. There was a negligible difference in the shape, size, and location of regions using data from different sources. The final decision on the optimal number of homogeneous climatic sub-regions depends upon the research objective, geographical domain size, and topographic features of the domain. This study provides an assessment and decision pathway.

Keywords: climatology, regionalization, Ethiopia, precipitation, k-means, circulation types