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ORIGINAL PAPER

Temporal and spatial evolution of the standard precipitation evapotranspiration index (SPEI) in the Tana River Basin, Kenya

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Abstract

The focus of this paper was to investigate the spatial and temporal variability of dry and wet events using the standard precipitation and evapotranspiration index (SPEI) in the Tana River Basin (TRB) in Kenya. The SPEI is a new drought index which incorporates the effect of evapotranspiration on drought analysis thus making it possible to identify changes in water demand in the context of global warming. The SPEI was computed at 6- and 12-month timescales using a 54-year long monthly rainfall data from the Global Precipitation and Climate Center (GPCC) and temperature data from the Climate Research Unit (CRU) both recorded between 1960 and 2013. Both datasets have a spatial resolution of 0.5° by 0.5° and were extracted for every grid point in the basin. The SPEI was used to assess the temporal and spatial evolution of dry and wet events as well as determine their duration, severity, and intensity. The evolution of significant historical dry and wet events and the frequency of occurrence were clearly identified. The index showed that the period between 1960 and 1980 was dominated by dry events while wet events were dominant in the period between 1990 and 2000. The SPEI6 had the longest duration of dry events of 30 months and severity of 44.67 which was observed at grid 5while the highest intensity was 2.18 observed at grid 31. Grid 19 had the longest duration (52 months) and highest severity (88.08) of dry events for SPEI12 and the intensity was highest (1.94) in grid 31. The longest duration (23) and highest severity (40.03) of wet events for SPEI6 were recorded in grid 39. The highest intensity of wet events for SPEI6 was 1.91 at grid 23 and 1.81 at grid 37 for SPEI12. The principal component analysis (PCA) was applied to the SPEI time series in order to assess the spatial pattern of variability of the dry and wet events in the basin. The PCA showed that there were two leading components which explained over 80% of the spatial variation of dry and wet events in the basin. Further, the continuous wavelet transform (CWT) was applied to the PCA scores in order to capture the time-frequency dynamics. The wavelet transform of the SPEI6 and SPEI12 identified significant periodicities of 1 to 2 years across the spectrum.

1 Introduction

Currently, there is great concern that climate change coupled with human-induced environmental degradation is a major threat to contemporary water resources management in the world (Githui et al. 2009; Huang et al. 2012). Many studies have indicated that global warming alters the patterns of rainfall resulting into more frequent extreme weather events such as droughts and floods (Zhang et al. 2009). Climate models predict that climate change is expected to increase the risk of drought in some areas of the world and the risk of extreme precipitation and flooding in others (IPCC 2007).

Kenya has frequently witnessed prolonged and severe droughts leading to electric power and water rationing with negative impacts on the economy (The World Bank 2011). Power rationing and reduction in water supplies (especially to Nairobi and the environs) have been attributed to a reduction in available surface water resources in the TRB (Nakaegawa and Wachana 2012). Moreover, increasing water demands lead to conflicts among competing water users that are mostly pronounced during drought periods (Hisdal and Tallaksen 2003; Santos et al. 2010). Studies have shown that

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