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ORIGINAL PAPER

Analysis of reference evapotranspiration (ET_0) trends under climate change in Bangladesh using observed and CMIP5 data sets

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Abstract
ET_0 is an important hydro-meteorological phenomenon, which is influenced by changing climate like other climatic parameters. This study investigates the present and future trends of ET_0 in Bangladesh using 39 years' historical and downscaled CMIP5 daily climatic data for the twenty-first century. Statistical Downscaling Model (SDSM) was used to downscale the climate data required to calculate ET_0. Penman–Monteith formula was applied in ET_0 calculation for both the historical and modelled data. To analyse ET_0 trends and trend changing patterns, modified Mann–Kendall and Sequential Mann–Kendall tests were, respectively, done. Spatial variations of ET_0 trends are presented by inverse distance weighting interpolation using ArcGIS 10.2.2. Results show that RCP8.5 (2061–2099) will experience the highest amount of ET_0 totals in comparison to the historical and all other scenarios in the same time span of 39 years. Though significant positive trends were observed in the mid and last months of year from month-wise trend analysis of representative concentration pathways, significant negative trends were also found for some months using historical data in similar analysis. From long-term annual trend analysis, it was found that major part of the country represents decreasing trends using historical data, but increasing trends were observed for modelled data. Theil–Sen estimations of ET_0 trends in the study depict a good consistency with the Mann–Kendall test results. The findings of the study would contribute in irrigation water management and planning of the country and also in furthering the climate change study using modelled data in the context of Bangladesh.

1 Introduction

The anticipated impacts of climate change due to global warming are expected to cause different levels of changes in climatic variables like solar radiation, temperature, precipitation, wind speed and humidity (IPCC 2007). For temperature, Intergovernmental Panel on Climate Change (IPCC) has reported a global average increase of 0.85 °C during the period 1880–2012 (IPCC 2013). The changes found in different studies were not uniform globally and many studies have made similar findings for different regions (Solomon et al. 2007; Nick et al. 2009; Ji et al. 2014; Lorentzen 2014). Bangladesh is already experiencing the effects of climate variability and climate change (Ali 1996; Mirza 2002; Karim and Mimura 2008; Climate Change Cell 2008). The country's unstable agriculture-based economy, unique geographical locations, low-lying flat topography, high population density and lower adaptation capacity due to its poor infrastructural condition are considered as the main reasons for its high vulnerability to the effects of climate change (IPCC 2007). In the past 100 years, Bangladesh has warmed by an average of 0.5 °C, and the trend is likely to continue in future (Ericksen et al. 1996). According to IPCC's business as usual (BAU) emission scenario of 1990, Bangladesh may warm by 0.5–2 °C than the present decade by 2030. Changes in rainfall trends due to climate change of the country have also been studied by many researchers (Ahmed and Karmakar 1993; Ahmed and Kim 2003; Immerzeel 2008; Rahman and Lateh 2015; Rahman et al. 2017).

Approximately 80% of the total rainfall in Bangladesh is experienced during June to October rainy season (Das et al. 2005) and the remaining period of the year records very little

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