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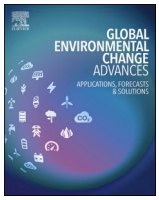

Assessing the past and future dynamics of the Asian summer monsoon: Insights from palaeomonsoon synthesis and CMIP6 data

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ABSTRACT

The Asian summer monsoon is one of the active synoptic scale weather phenomena, and has significant socio-economic implications. A vast population relies on the associated precipitation, mostly dominating the agricultural practices of the region. Therefore, it is essential to assess past behavior to understand the present, including future projections. We used palaeomonsoon precipitation synthesis and Coupled Model Intercomparison Project Phase 6 (CMIP6) data to interactively show the dynamics and changes in the summer monsoon for the Asian region throughout the past millennium behavior to understand the present and future projections. In this study, we precisely analyzed and quantified the dynamics of summer precipitation variation throughout the last millennium (LM; 850–1849 CE) at an annual resolution, in which the major climatic events were the Medieval Warm Period (MWP; 900–1300 CE) and Little Ice Age (LIA; 1500–1850 CE). We also analyzed the historical or base climate (HC; 1850–2014 CE) and future monsoons (FM; 2015–2100 CE) using CMIP6 SSP2–4.5 and SSP5–8.5, to project the summer monsoon for Asia and the Indian subcontinent. The findings are encouraging, showing slightly increased precipitation during the MCA and low precipitation during the LIA in Asia. Moreover, the average summer monsoon daily rainfall remained 6.398 ± 0.634 and 6.310 ± 0.649 mm/d for the MCA and LIA, respectively, indicating a relatively slight variation in the summer monsoon precipitation during these climatic phases. In addition, for the twenty-first century, the CIMP6 projection shows increased summer monsoon precipitation over Asia, particularly in the northeast region. Further, the CMIP6 projections for SSP2–4.5 shows 6.457 ± 0.658 mm/d, and for SSP5–8.5 is 6.686 ± 0.837 mm/d for the twenty-first century. Furthermore, the results of Empirical Orthogonal Functions (EOFs) analysis suggest that the monsoon system may become more intense in some regions, whereas other regions may experience reduced precipitation in the Asia-Pacific region, with a regionally heterogeneous rise in heavy rainfall and high moisture throughout most of Asia. Orography, evaporation, moisture content, and circulation all affect the severity of precipitation in addition to fine-scale surface moisture feedback. The findings show that it is essential to consider both the past and the future to accurately estimate local and regional-scale susceptibility to climate change. Moreover, the synthesis of past data and analysis of future projections of the monsoon will provide a basis for reducing the unpredictability of future climate models.

1. Introduction

The Asian summer monsoon affects more than half of the world's population and preserves some of the most vulnerable species on Earth (Trenberth et al., 2000; Cook et al., 2010; Wang et al., 2014). The Asian summer monsoon is a crucial component of the Asian-Australian monsoon system. It affects a large portion of the Indian subcontinent and Southeast Asia, providing rainfall to the region during the summer. Its strength is often represented by the all-India monsoon rainfall (Parthasarathy et al., 1992), which is perhaps the most significant and crucial climatic phenomenon globally (Chao & Chen, 2001; Clift & Plumb, 2008; Gadgil, 2003; Sodhi et al., 2004). The Asian summer

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