The anomalous character of Northeast monsoon precipitation over southern India-revelation through an array of instrumental, proxy records and future projections

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The water crisis and subsequent threats to ecosystem degradation become prominent in the agrian economy based regions such as southern India. In contrast to core monsoon zone, southern India recieves dominant fraction of annual precipitation during boreal winter (Oct-Dec), and this phase is known as Northeast monsoon (NEM). Till date, multiple competitive and secular mechanisms cited in existing investigations framed our understanding of the natural variables-NEM precipitation-vegetation relationship, but each of the factor is found to be associated with certain assumptions, spatially heterogenous impact and large uncertainties. To provide a comprehensive picture of NEM dynamics, here, we present a detailed analysis of winter monsoon precipitation trends over southern India, combining gridded datasets (for the last 117 years), historical record based on hydrogen isotopic composition of lipid biomarker from chronologically constrained lacustrine archive (for the last 5000 cal yr BP) and future climate projection using CIMP6 MMM preductions. Our analysis of modern data demonstrates an increasing NEM precipitation trend over the southern peninsular India, which stands in contrast to the weakening trend observed from Indian summer monsoon dominated regions. We found that the consipuqous increase in NEM precipitation is related to rise in surface and sub-surface heat budget in the south-eastern Bay of Bengal. The historical record reveals that the NEM intensification is persistent since the last 3000 cal yr BP. Along with the local oceanic thermal condition, remote forcing factors such as pressure gradient between Arabian Sea Warm Pool and equitorial Pacific Ocean and El-Nino like condition facour the rise in NEM precipitation. Based on CMIP6-MMM, we further show an increasing trend of precipitation at a rate of ca. 1.5 mm per day during NEM. We further demonstrate that the increase in cold season precipitation helped in the expansion of C_3 plants in southern India.