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Simulating high-resolution climate over East Asia for the Last Glacial Maximum utilising the pseudo-global warming approach

Ruolan Xiang, Christian R. Steger, and Christoph Schär
ETH Zurich, Institute for Atmospheric and Climate Science, Department of Environmental Systems Science, Switzerland
(ruolan.xiang@env.ethz.ch)

To better understand the landscape dynamics and changes in habitat connectivity influenced by glacial and interglacial oscillations over the biodiversity-rich Hengduan Mountains (HM) region, located at the south-eastern edge of the Tibetan Plateau (TP), high-resolution climate data for past periods are essential. We apply the non-hydrostatic limited-area model COSMO with a resolution of 12 km over East Asia for the Last Glacial Maximum (LGM), a period characterized by a generally colder and dryer climate compared to present-day conditions. We perform the downscaling with a novel approach for paleoclimate modelling, the Pseudo-Global Warming (PGW) method. The PGW method minimizes Global Climate Models' (GCMs') inherent biases and reduces computational demands. Despite its widespread use in future climate downscaling, this study represents the first application of the PGW method for paleoclimate simulation to our knowledge. The COSMO PGW simulation for the LGM shows that the regional climate model (RCM) replicates the large-scale dynamics of the driving GCM simulation in the colder climate. Both models suggest weaker Asian summer monsoon systems for this period. Consequently, regions such as the Bay of Bengal, the South China Sea, and the coastal region of China, which typically receive substantial monsoon rainfall, experienced significantly reduced precipitation. However, besides these model similarities, the high-resolution COSMO simulation exhibits distinctive differences on a smaller scale for variables like near-surface wind and precipitation — particularly over land. For instance, COSMO suggests a more significant southward shift of the jet stream during the LGM winter, with more pronounced annual cooling and a prolonged Meiyu season in southern China. Moreover, the COSMO simulation features increased LGM precipitation amounts for the majority of the HM despite the overall weaker summer monsoon circulation. Regarding snowfall, which is a crucial factor for the glaciation extent of the TP during LGM, COSMO suggests increases for certain sub-areas (e.g., central TP) during all seasons, while in the GCM, the increase is primarily constrained to summer and limited to a smaller region near the Himalayas. Furthermore, evaluation with proxy data indicates an improved representation of local climate by COSMO for specific regions. Our study suggests that the resource-saving PGW approach is a suitable method to bridge the gap between coarser climate data and regional climate impacts, also for past periods like the LGM.