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Evaluating fine-resolution, regional outputs of a variable resolution global climate model

Alan Di Vittorio[1], Zexuan Xu[1], Jie Zhang[2], Xiaoge Xin[2], Hongmei Xu[2], and Chan Xiao[2]
[1]Lawrence Berkeley National Laboratory, Climate Sciences Department, Berkeley, United States of America (avdivittorio@lbl.gov)
[2]National Climate Center, China Meteorological Administration, Beijing, China

Climate models have been used to study water resources and regional hydrologic responses to climate change, but climate model outputs must be downscaled to provide relevant regional data. However, the accuracy of this regional data is limited by uncertainties across and within downscaling methods, uncertainty across global outputs, and discontinuities at downscaled boundaries. A new alternative to traditional downscaling is a variable resolution model that incorporates fine-resolution regions directly into a coarse-resolution, global climate simulation in order to capture contiguous dynamics across resolution boundaries. In this study, we used the Variable-Resolution Community Earth System Model (VR-CESM) to generate one-eighth degree (14 km) fine-resolution outputs for the western U.S. and eastern China from 1970-2006.

We focus our evaluation on precipitaiton, temperature, snow pack, solar radiation, and wind. We compare the model outputs with remote-sensing-based precipitation data, and both reanalysis and gridded weather station data for precipitation and temperature. VR-CESM generally has a cold bias in winter and a warm bias in summer in the western U.S., which compensate each other to reduce the annual bias. In eastern China, however, the sign of temperature biases are more consistent throughout the year with cold biases in the higher mountains and warm biases throughout most of the rest of the region. Precipitation biases are dependent upon reference data, and show slight overestimation in high mountain regions in both the U.S. and China with respect to gridded weather station data. Simulated snow cover in the western U.S. is reasonable compared to remote sensing data, but snow cover and snow water equivalent have larger biases when compared to reanalysis data. In eastern China there are widespread snow cover biases compared to remote sensing data. VR-CESM underestimates downward shortwave radiation to a greater degree in summer than in winter, and underestimates surface layer windspeed over mountains to a greater degree than in other areas. Comparison between VR-CESM and a coarser simulation (1-degree Beijing Climate Center model) shows reduced precipitation biases in the mountainous regions with finer resolution, indicating the value of variable-resolution modeling for reigonal studies.