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

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Climate models have been widely applied to study water resources and regional hydrologic responses under climate change, but climate model outputs need to be downscaled to provide relevant inputs to regional models because it is too expensive to run global models at fine-resolution. However, the accuracy of inputs to regional hydrological and energy analyses is limited by uncertainties across and within downscaling methods, uncertainty across global outputs, and discontinuities at downscaled boundaries. The boundary discontinuities result from the inability of post-processing downscaling methods to capture the reciprocal interactions between local and global processes. A new alternative to traditional downscaling is to use a variable resolution model that incorporates fine-resolution regions directly into a coarse resolution climate simulation. In this study, we applied the recently developed variable-resolution Community Earth System Model (VR-CESM) to validate regional downscaling within a global simulation and to make fine-resolution regional climate projections for assessing potential impacts on water and energy resources. We have generated one-eighth degree (14 km) fine-resolution outputs for the western U.S. and eastern China from 1970-2006 and will also make projections for these regions from 2007 to 2050. We run the VR-CESM model on the NERSC supercomputer system, at an approximate computational cost of 4 million core hours per 40 years of simulation.

We compare the model outputs with PERSIANN-CDR precipitation data estimated using an Artificial Neural Network and the climate data record and with PRISM gridded weather station data for precipitation and temperature. Seasonal precipitation and temperature biases are greater than annual biases, and overall VR-CESM does a good job of estimating these variables at fine resolution, including improved precipitation accuracy due to new prognostic cloud microphysics. The comparison between VR-CESM outputs and a coarser simulation (1-degree BCC AMIP model) indicates that simulated precipitation in the mountain regions significantly improves in the finer resolution simulation with a better representation of topography. We also evaluate the water budget and availability by large watersheds in both the western U.S. and eastern China, which are particularly important for other studies including groundwater and hydropower. Upcoming work will evaluate additional variables relevant to assessing water and energy resources, including snowpack, wind speed, and surface solar radiation. We also aim to characterize the frequency and severity of extreme hydrometeorological events projected by VR-CESM relative to an extreme precipitation database developed by project partners.