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High-Resolution Regional Climate Simulations of Arctic Hydroclimatic Change

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The Arctic has warmed during the recent observational record and is projected to keep warming through the end of the 21st century in nearly every future emissions scenario and global climate model. This will drive continued thawing of permafrost-rich soils, alter the partitioning of rain versus snow events, and greatly affectthe water cycle and land-surface processes across the Arctic. However, previous analyses of these impacts using dynamical models have relied on global climate model output or relatively coarse regional climate model simulations. In the coarse simulations, projections of changes to the water cycle and land-surface processes in areas of complex orography and high land-surface heterogeneity, which are characteristic of many regions in the Arctic, may thus be limited.

Here, we discuss recent work examining high-resolution regional climate simulations over Alaska and NW Canada. Completed and upcoming simulations have been and will be run at a 4 km grid spacing, which is sufficient to resolve orography across this region's mountain ranges. The initial simulation results are very encouraging and show the regional climate model yields a realistic representation of the seasonal and spatial evolution of precipitation, temperature, and snowpack compared to previous studies across Alaska and other Arctic regions. A paired future climate simulation uses the Pseudo-Global Warming (PGW) approach, where the end of century ensemble mean monthly climate perturbations (CMIP5 RCP8.5) are used to incorporate the thermodynamic effects of future warming into the present-day climate as represented by ERA-Interim reanalysis data. Changes in major components of the hydroclimate (e.g. precipitation, temperature, snowfall, snowpack) are projected to sometimes be significant in this future scenario. For example, the seasonal snow cover in some regions is projected to mostly disappear. However, there are also projected increases in snowpack in historically very cold areas (e.g. high elevations) that are able to stay cold enough in the future to support snowfall and snowpack.

Finally, we will present a new effort to couple an advanced land-surface model, the Community Terrestrial Systems Model (CTSM), within the Regional Arctic Systems Model (RASM) in an effort to better represent complex land-surface and subsurface (e.g. permafrost, streamflow availability

timing and temperatures) processes for climate change impact studies. CTSM is a complex physically based land-surface model that is able to represent multiple snow layers, a complex canopy, and multiple soil layers including organic matter and frozen soils, which enables us to explicitly represent spatial variability in the regional hydroclimate and land states (e.g. permafrost) at relatively high spatial resolutions relative to other simulations (4 km land and atmosphere grids). Successful coupling of CTSM within RASM has been completed and we will discuss some preliminary land-atmosphere coupled test results.