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Dynamical Downscaling over the Great Lakes Basin of North America using the WRF Regional Climate Model: The impact of the Great Lakes system on regional greenhouse warming

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In this study we investigate the regional climate changes to be expected over the Great Lakes Basin of North America during the next century. Large freshwater systems, such as the Great Lakes, play a key role in determining the climate of their basins and adjacent regions by air mass modification through the exchange of heat and moisture with the atmosphere. Even systems as extensive as the Great Lakes are unresolved in coarse resolution global climate simulations but may be accurately captured in finer-mesh regional simulations by dynamical downscaling. Historical (1979-2001) and future (2049-2059 and 2089-2099) conditions are simulated using the Weather Research and Forecasting model (WRF) forced by CCSM3 global simulations. Our analyses are based upon the IPCC SRES A2 emissions scenario which assumes a rapid increase in greenhouse gas concentrations. A two-step nesting procedure is employed for the purpose of downscaling, in which the first nested WRF model is of North American continental scale at 30 km resolution, whereas the innermost domain at 10 km resolution covers the Great Lakes Basin and the Canadian Province of Ontario. Results from the historical period are compared to the 32 km NCEP North American Regional Reanalysis (NARR) to assess the validity of the method. The differences in extreme temperature and precipitation events delivered by the different scales of simulation are discussed.
As the WRF model does not currently have an explicit lake component, lake ice and lake surface temperature need to be prescribed in the model. A first set of simulations is performed using climatological (1979-2001) data for lake ice and lake surface temperature. A second set is performed using outputs from the freshwater lake model "FLake" (Mironov, D. V., 2008, COSMO Technical Report, No. 11, Deutscher Wetterdienst, Offenbach am Main, Germany) forced by atmospheric fields from the global simulations. Changes in surface temperatures and ice cover, and especially ice-out dates, for the Great Lakes under future atmospheric conditions are discussed. The trends in temperature and precipitation for the future regional climate as simulated by WRF are discussed in view of these effects.