The representation of large lakes in high-resolution regional climate models

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It has been found that large lakes, a common component of the North American (NA) landscape, can affect the water cycle and modulate temperatures in the surrounding regions. The purpose of this study is to evaluate different lake representations in regional climate model simulations. We use the Weather Research and Forecasting (WRF) model, a widely-used regional climate model, forced by the ERA5 reanalysis product. The study is performed for a 40 year historic period (1979-2019) at a resolution of 12 km. The lakes of concern include the Laurentian Great Lakes, which straddle the US-Canada border; the Great Slave and Great Bear Lakes of the Northwest Territories; and the Lakes Winnipeg and Winnipegos. Alongside the default lake model, two new column lake models are employed: FLake, a more widely used model, and GL25, a recent, physics-based model. These models have been somewhat successful at alleviating inadequacies of the default model by introducing additional process representations, such as a more realistic surface albedo formulation and a better parameterization for vertical overturning. Additionally, we consider the effect of vertical eddy diffusivity and lake stratification on the model performance. While no column lake model is expected to perform perfectly, our goal here is to identify when (seasonally) and where (geographically) a model produces reliable results, including ice cover distribution and near-surface temperature. The effect of the lake representation on the surrounding regions (e.g., lake-effect precipitation) is also evaluated. We find that the two new lake models perform reasonably well, but there are significant differences in seasonal biases with GL25 performing better in summer and FLake performing better in winter; in fact, FLake reproduces the ice cover of the Great Lakes very well. Furthermore, the biases do not seem to be affected by surface wind induced circulation, and hence 3D modelling may not be a requirement for lake modelling. This study can help with the selection of lake models for regional climate modelling in the NA region and inform the interpretation of the predictions.