Do we need to account for lakes in climate and NWP modelling?

P. Samuelsson, E. Kourzeneva and D. Mironov

One of the most important issues in regional climate and weather prediction models is the interaction of the atmosphere with the underlying surface. For decades, the interaction with land and sea surface has gotten much attention, but lakes have many times been disregarded or treated in a very simplistic way. The reason for this is of course that land and sea surface dominate the surface of the earth while lakes are only regionally important. In regions where lakes represent a non-negligible fraction of the surface their large thermal inertia, when compared to the land surface, may cause them to have a substantial impact on the regional climate. This is particularly the case in Fennoscandia, Russia and in Canada.

In RCM and NWP modelling the lower boundary condition for the atmosphere with respect to lakes must be described. The boundary condition is represented by the energy fluxes of radiation, heat and momentum. Thus, the lake interior is really not of importance per se. As long as the surface temperature (including ice) is well simulated the lake model can be made simple. For climate simulations, a computationally cheap model is also of high priority. A lake model that fulfils these criteria is FLake (see http://lakemodel.net and references therein). FLake is a two-layer model based on a self-similar representation (assumed shape) of the temperature profile in the mixed layer and in the thermocline. The model incorporates (i) a flexible parameterisation of the evolving temperature profile, (ii) an advanced formulation to compute the mixed-layer depth, including the equation of convective entrainment and a relaxation-type equation for the depth of a wind-mixed layer, (iii) an improved module to describe the vertical temperature structure of the thermally active layer of bottom sediments and the interaction of the water column with bottom sediments, and (iv) a snow-ice module. The ability of Flake to predict the temperature structure in lakes of various depths on diurnal and seasonal time scales has been successfully tested against data through single-column numerical experiments. Today FLake is implemented into the NWP model COSMO-LM (DWD) and into the regional climate models RCA (SMHI) and CLM (GKSS). It is also on its way into the NWP model HIRLAM.

We will present results based on simulations with the Rossby Centre regional climate model RCA coupled to FLake. Two 30-years simulations with RCA-FLake set up over Europe has been analysed for the period 1961-1990 using ERA40 as lateral and SST boundary conditions. In the first simulation lakes were present (applying FLAke) while in the second simulation all lakes were replaced by open land. A comparison of the two simulations shows that the presence of lakes has a warming effect on the climate for all seasons except spring. In cold winter climates the warming effect during winter is explained by the fact that the ice covered period usually extends from mid winter until mid spring. Thus, during the first half of the winter the lakes are warmer than a corresponding open land area would be. During summer the warming effect of lakes is due to a relatively warm lake surface temperature during night time. The results also show that many small lakes (as in Southern Finland) act differently on the summer climate than a few big lakes. Many small, and relatively warm, lakes enhance the summer precipitation due to more evaporation while big, and relatively cool, lakes suppress evaporation and consequently also the precipitation.

The answer to the title question is: Yes we should account for lakes in climate and NWP modelling, at least in Northern Europe, where they make the surrounding mean temperature climate warmer for most seasons.