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Numerical investigation with a coupled single-column lake-atmosphere model: An application to Western Switzerland

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The potential of a novel atmospheric single-column model (SCM) developed in the framework of the Canadian Regional Climate Model, CRCM, driven by NCEP-NCAR reanalyses is investigated. The approach to solve the model equations and the technique described here may be implemented in any RCM system environment as a model option. The working hypothesis underlying this SCM formulation is that a substantial portion of the variability simulated in the column can be reproduced by processes operating in the vertical dimension and a lesser portion comes from processes operating in the horizontal dimension. This SCM offers interesting prospects as the horizontal and vertical resolution of the RCM is ever increasing. Due to its low computational cost, multiple simulations may be carried out in a short period of time. In this paper, a range of possible results from changing the lower boundary from land to open water surface, and varying model parameters are shown for western Switzerland. The benefit of using Newtonian relaxation, or "nudging", is demonstrated. Results show that air temperature, moisture and windspeed profiles are modified in a coherent manner in the lowest levels. Such changes are consistent with those of the surface vertical sensible, latent heat and momentum fluxes. Compared to atmospheric profiles over land, switching to and open water surface representative of Lake Geneva over the annual cycle of 1990, air temperature is increased by up to 1°C during the autumn and winter seasons, and by 0.5°C during the spring and summer seasons. Specific humidity is increased by up to 0.2 g kg-1 during the autumn and winter seasons and decreased by 0.3 g kg-1 during the spring and summer seasons. The increased windspeed at the surface, often more than 1.5 m s-1, is due to the smaller roughness height. The surface radiation and energy budgets are also modified subsequent to the different partionning of the latent end sensible heat fluxes, but also the solar and thermal infrared fluxes undergone siggnificant changes. The question of how the open water and the overlying atmosphere interact and which of these "factors" has the most influence also needs attention. The sole presence of the lake is shown to be a major feature with regard to the surface energy budget components whose contributions counteract those of the lower atmosphere, thus supporting the fact that Lake Geneva acts as a damping factor to the regional climate system. It is also shown that not only did the presence of the lake and the overlying atmosphere independently modulate the surface energy budget, but also the synergistic nonlinear interaction among them, either positive or negative, was often found non-negligible. Moreover, some processes may turn out to be important on short time scales while being negligible on the long term as shown in Goyette (2016).