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Understanding the performance of the FLake model over the East-African Great Lakes

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As a one-dimensional lake parameterisation scheme, FLake has already been coupled to a large number of numerical weather prediction systems, regional climate models and general circulation models. However, even though FLake has therewith become a vital tool to investigate and predict climate change impacts on lacustrine ecosystems, it has never been thoroughly tested for tropical conditions. In this study, the ability of FLake to represent tropical mixolimnion temperatures is investigated for three locations in East-Africa: Lake Kivu, Lake Tanganyika's northern and southern basins. Meteorological observations from surrounding automatic weather stations are corrected and subsequently used to drive FLake, whereas a comprehensive set of water temperature profiles serves to evaluate the model at each site. Careful input data correction and model configuration allows to reproduce the observed mixed layer seasonality at Lake Kivu and Lake Tanganyika (northern and southern basins), with correct representation of both the mixed layer depth and temperature structure. In contrast, when FLake is forced with uncorrected meteorological observations or with ERA-Interim reanalysis data, a correct mixing cycle is predicted only for Lake Tanganyika's southern basin: this is mainly due to an underestimation of wind velocities. At Lake Kivu, an extensive sensitivity study reveals that FLake's water column temperatures are sensitive both to minimal variations in the external parameters (lake depth and water transparency) and to small changes in the meteorological driving data, in particular wind velocity. In each case, small modifications may already lead to a regime switch from the correctly represented seasonal mixolimnion deepening to either completely mixed or permanently stratified conditions. Near-surface water temperatures are however more robust, with acceptable predictions even when the seasonal mixing regime is not reproduced. Furthermore, a study of different initial conditions shows that for lakes lacking reliable initial data, a fully mixed, artificially warm initialisation is to be preferred, but only if the model is allowed to spin up until convergence is reached. Finally, FLake is used to attribute the seasonal cycle at Lake Kivu to variations in the near-surface meteorological conditions. It is found that the annual mixing down to 60 m during the main dry season is primarily due to enhanced lake evaporation and secondarily due to the incoming long wave radiation deficit, both causing a significant heat loss from the lake surface and associated mixolimnion cooling.