Coupling the 1D lake model FLake to the JULES land surface scheme

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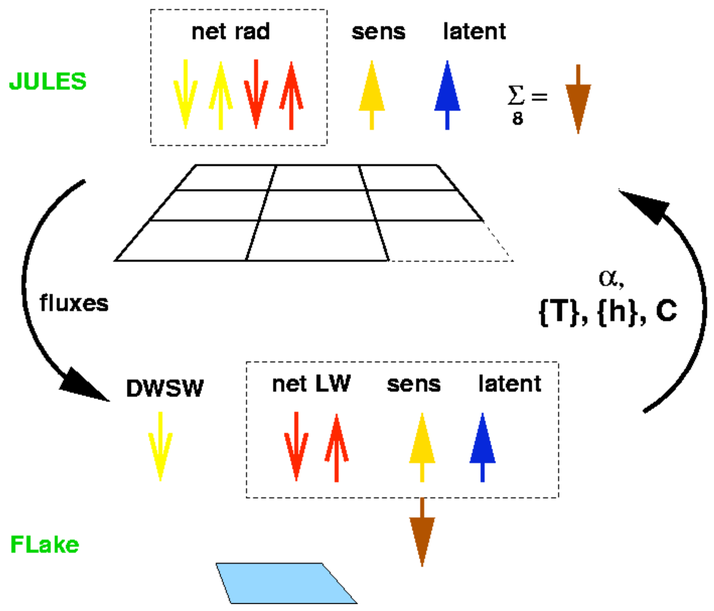
Introduction: JULES and FLake

Some results of coupling the land-surface model JULES with the lake model FLake are presented here.
JULES is the Joint UK Land Environment Simulator, a close descendant of the Met Office surface-exchange scheme in the Unified Model.

FLake is the Flexible Lake model of Mironov et al.
FLake models lakes in a 1D, average sense, by dividing the lake vertically into three zones. These are (from the top down) the mixed layer, the thermocline, and the deep layer. Temperature profiles in these zones are modelled using similarity theory, and the model outputs are the bulk characteristics of the lake such as mixed-layer temperature and depth. FLake also incorporates a model for the evolution of lake ice, and can be used with an accompanying flux package (SfcFlx) to run in stand-alone mode, forced by the same dataset as that used to run JULES at a point.

Coupling the models

FLake is coupled to JULES in place of the usual JULES lake tile. The surface fluxes are passed to FLake as a pair comprising the downwelling short-wave flux, which penetrates some distance into the lake depending on the lake extinction coefficient, and the resultant of the other fluxes, which is applied as a heat flux to the surface. FLake returns the set of zone temperatures {T} and thicknesses {h}, the 'shape factor' C which describes the similarity profile in the thermocline, and the lake albedo α.



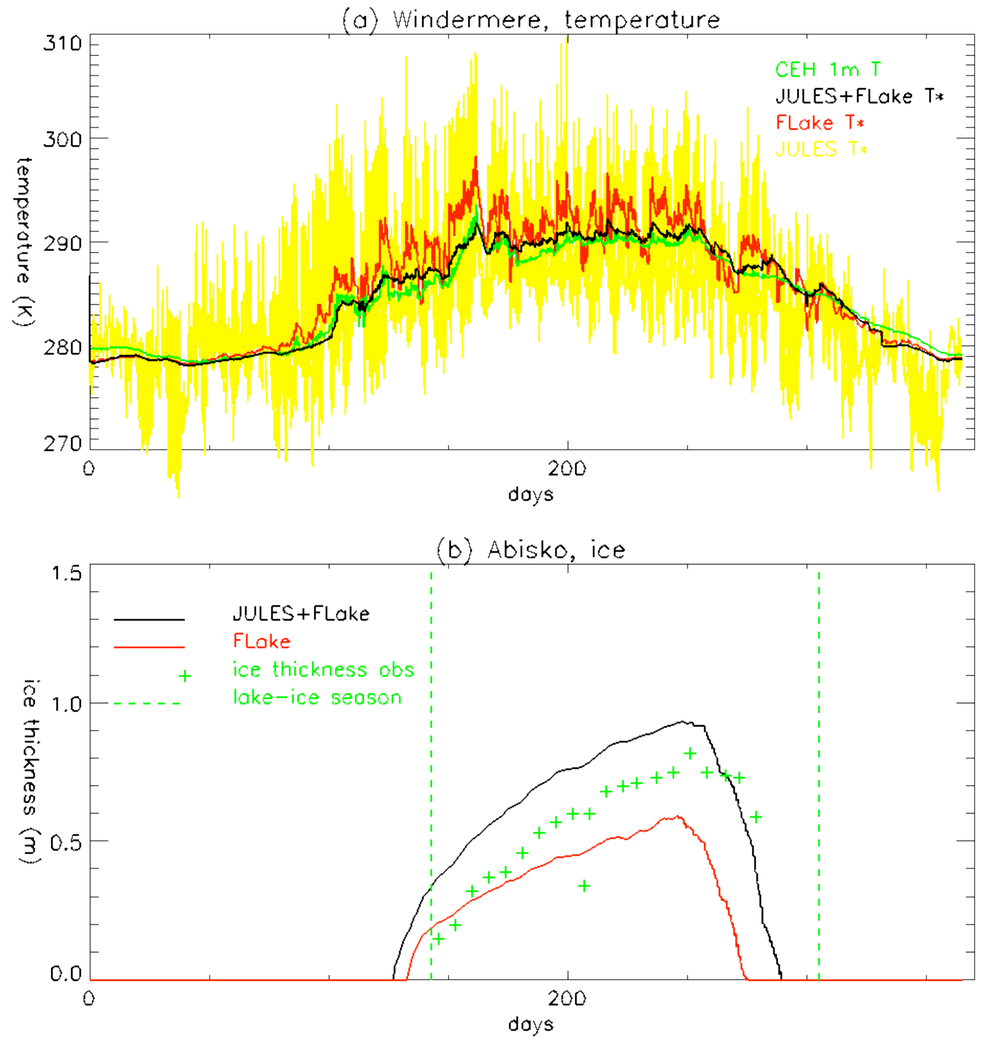
Data

Data for testing the model against a lake in the UK were taken from the Centre of Ecology and Hydrology (CEH) observing site at Windermere. These data span the whole of 2007, and consist of met. observations of air temperature, wind speed, relative humidity and downwelling short-wave (all hourly), and cloud cover (twice daily), as well as lake temperatures at 12 depths between 1m and 35m.

The model was also forced with a cold-region dataset, from the Abisko Scientific Research Station (ANS) in Sweden, to test the lake-ice behaviour in the model. These data cover a year starting in late summer 2003, and contain hourly JULES forcing data as well as ice-thickness observations.

Results

The results shown here are of surface temperature for Windermere, and ice thickness for Abisko. The lake tile fraction was set to 1 in all the JULES-type runs.



For Windermere, plot (a) shows how the introduction of the FLake model reduces the unrealistic diurnal T variation in JULES.
The difference between JULES+FLake and FLake on its own is most noticeable in summer, when the FLake temperature variations are greater. This difference is probably caused by the different surface-flux formulations of JULES and FLake. In general, JULES+FLake is cooler than FLake. The JULES+FLake model is closest to the measured 1m temperature out of the three models shown.

Regarding lake-ice, plot (b) shows a comparison of the results from FLake and JULES+FLake when forced with the cold-region data from lake Torneträsk, Abisko. It can be seen that the JULES+FLake ice season is slightly longer than that of FLake, and the ice is thicker, but overall the evolutions are similar. The models have not been tuned for the conditions at lake Torneträsk (other than using the correct mean lake depth of 52 m) and their performances are encouraging.
The differences in sign of the errors may be attributed to different surface-flux and snow-layer parametrizations.

References

D. Mironov Parameterization of lakes in Numerical Weather Prediction: description of a lake model. Technical Report 11, COSMO (DWD), 2008.

G.G. Rooney & I.D. Jones Coupling the 1-D lake model FLake to the community land-surface model JULES. Boreal Environment Research, in submission.

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