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Thermal regime and water-atmosphere interactions of shallow mid-latitude lakes: a case study within the framework of the Lake Model Intercomparison Project

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Lakes play a prominent role in weather and climate conditions over the adjacent land. The effect of lakes should be accounted for in atmospheric models used for numerical weather prediction, climate studies, and other environmental applications. During the last decade a number of lake models (parameterisation schemes) have been developed and implemented into numerical models of the atmosphere. Given several different approaches to handle vertical transport of heat, mass and momentum in lakes and the air-lake interactions, a Lake Model Intercomparison Project (LakeMIP) was launched after the Workshop "Parameterisation of Lakes in Numerical Weather Prediction and Climate Modelling" held 18-20 September 2008 in Zelenogorsk (near St. Petersburg), Russia. The main goals of LakeMIP [1,2] are (i) to identify key physical, chemical and biological processes to be accounted for within lake models for various environmental applications, and (ii) to develop improved parameterisations of these processes.

We report the results from a modelling study of thermodynamic regime of two mid-latitude shallow lakes. These are Kossenblatter See, Germany (a polymictic lake with the mean depth of about 2 m) [3], and Lake Valkea-Kotinen, Finland (dimictic, mean depth of 3 m) [4]. Results of numerical simulations performed with a number of one-dimensional lake models, ranging from finite-difference eddy-viscosity and k-ε models to bulk models (as e.g. FLake) with parameterised vertical structure of temperature and turbulence characteristics, are compared with data from in situ temperature measurements. The capability of different lake models to develop, maintain and destroy temperature stratification and to reproduce other salient features of thermal regime of the above lakes is assessed. The effect of water-bottom sediment interaction on the vertical turbulent mixing and the development of stratification is emphasised, and the parameterisations of the heat flux through the lake bottom used within different models are scrutinised. Uncertainties in the atmospheric forcing often result in large errors in the vertical temperature profiles in lakes, even though the vertical mixing and the water-bottom sediment interaction may be modelled quite accurately. Therefore particular emphasis is placed on the surface fluxes of momentum and of sensible and latent heat. The way these fluxes are handled is critically discussed. The heat and momentum fluxes computed with different surface-flux computation schemes are compared with data from eddy covariance measurements in the surface air layer over lakes.

[1] Stepanenko, V. M., S. Goyette, A. Martynov, M. Perroud, X. Fang, and D. Mironov, 2010: First steps of a Lake Model Intercomparison Project: LakeMIP. Bor. Env. Res., 15, 191-202.
[2] http://www.unige.ch/climate/lakemip
[3] Observational data measured and processed by Lindenberg Meteorological Observatory – Richard Aßmann Observatory, Deutscher Wetterdienst
[4] Observational data collected and processed by the University of Helsinki