



Hydrodynamic modelling of small upland lakes under strong wind forcing

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Small lakes (Area < 1 km²) represent 46.3% of the total lake surface globally and constitute an important source of water supply. Lakes also provide an important sedimentary archive of environmental and climate changes and ecosystem function. Hydrodynamic controls on the transport and distribution of lake sediments, and also seasonal variations in thermal structure due to solar radiation, precipitation, evaporation and mixing and the complex vertical and horizontal circulation patterns induced by the action of wind are not very well understood. The work presented here analyses hydrodynamic motions present in small upland lakes due to circulation and internal scale waves, and their linkages with the distribution of bottom sediment accumulation in the lake. For purpose, a 3D hydrodynamic is calibrated and implemented for Llyn Conwy, a small oligotrophic upland lake in North Wales, UK. The model, based around the FVCOM open source community model code, resolves the Navier-Stokes equations using a 3D unstructured mesh and a finite volume scheme. The model is forced by meteorological boundary conditions. Improvements made to the FVCOM code include a new graphical user interface to pre- and post process the model input and results respectively, and a JONSWAT wave model to include the effects of wind-wave induced bottom stresses on lake sediment dynamics. Modelled internal scale waves are validated against summer temperature measurements acquired from a thermistor chain deployed at the deepest part of the lake. Seiche motions were validated using data recorded by high-frequency level sensors around the lake margins, and the velocity field and the circulation patterns were validated using the data recorded by an ADCP and GPS drifters. The model is shown to reproduce the lake hydrodynamics and reveals well-developed seiches at different frequencies superimposed on wind-driven circulation patterns that appear to control the distribution of bottom sediments in this small upland lake.