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Presentations (updated July 1, 2010)

Impact of lakes in the ECMWF Integrated Forecasting System: Preliminary results and roadmap to an operational implementation.

G. Balsamo, R. Salgado, E. Dutra, S. Boussetta, T. Stockdale

A set of simulations performed with the Tiled ECMWF Scheme for Surface Exchange over Land (HTESSEL) including the Fresh water Lake model (FLake) treated as an extra surface tile and coupled with the ECMWF Numerical Weather Prediction (NWP) model is presented in order to show progress and current issues. In particular, the impact of fully resolved vs. subgrid (unresolved) lakes and the benefits of a more realistic treatment of the lake bathymetry and lake state initial conditions, as opposed to fixed depth and simplified initialization will be illustrated. A roadmap to a future operational implementation will be discussed.

Thermodynamic modelling of snow and ice for in-land water bodies

Bin Cheng

Snow and ice thicknesses for in land water bodies are modelled with a one-dimensional thermodynamic snow/ice model (HIGHTSI). We pay attention to the time series of snow accumulation in a seasonal scale. The model forcing was based on in situ observations from weather stations and numerical weather predication (NWP) results data. The results suggest that precipitation from NWP model and melting process described in sea ice model are equally important to reveal the snow time series against observations

Exploitation of EO-Based Technology for Improving the Characterization of Lake and River Ice Dynamics in Weather Forecasting, Climate and Hydrologic Models – ESA's STSE "North Hydrology" Project

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Lake and river ice play a key role in the physical, biological, and chemical processes of cold region freshwater. The frequency and size of lakes greatly influence the magnitude and timing of landscape-scale evaporative and sensible heat inputs to the atmosphere and are important to regional climatic and meteorological processes. Because lakes are such a major component of most northern atmospheric and hydrologic systems, the ability to determine their annual energy and water budgets is critical to our ability to forecast high latitude weather, climate, and river flow patterns. River-ice is also one of the major components of the terrestrial cryosphere. It affects an extensive portion of the global hydrologic system, particularly in the Northern Hemisphere where major ice covers develop on 29% of the total river length and seasonal ice affects 58%. River-ice duration and break-up exerts significant control on the

timing and magnitude of extreme hydrologic events such as low flows and floods. There are long-term observations of lake and river ice for many northern countries. However, the observation networks have been declining dramatically in recent decades. This lack of data hinders the use of river and lake ice data into numerical weather prediction, climate and hydrologic models. In this context, Earth Observation (EO) represents a unique tool to support the scientific and operational communities to characterize and monitor river and lake ice dynamics as a key component of the North Hydrology System.

In this presentation, an overview of a new project sponsored by the ESA's STSE (European Space Agency Support To Science Element) Programme – North Hydrology – will be provided. The North Hydrology project team is lead by University of Waterloo in collaboration with Environment Canada, ENVEO (Austria), the Finnish Environment Institute (SYKE) and the Finnish Meteorological Institute (FMI), INRS – Centre Eau Terre Environnement (Canada), the Northern Research Institute (Norut) and the Norwegian Computing Center (NR), and the Swedish Meteorological and Hydrology Institute (SMHI). The overall goal of North Hydrology is to support the international efforts coordinated by the Climate and Cryosphere (CliC) project of the World Climate Research Programme (WCRP) to exploit the use of EO technology, models and in situ data to improve the characterization of river and lake ice processes and their contribution to the Northern Hydrology system. To this end, North Hydrology aims at developing a portfolio of novel multi-mission geo-information products (maximizing the use of ESA data) to respond to the scientific requirements of the CliC community and the operational requirements of the weather and climate operational agencies (regional to global scale), and the requirements of the operational user community to better characterize river-ice (and glacier temporary lakes) dynamics in flood forecasting models at the basin scale. For this talk, emphasis will be placed on the lake component of the project.

On the sensitivity of the lake thermal profiles to the vertical resolution in numerical models: investigation with SIMSTRAT and FIZC for deep Lake Geneva, Switzerland

Marjorie Perroud¹ and Stéphane Goyette²

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This paper presents some results on the sensitivity of thermal profiles simulated in a mid-latitude deep water body to the vertical resolution of a lake model as well as to that of the driving atmospheric model. On the one hand, the vertical resolution set up in lake models may be of a concern when simulating the thermal evolution of deep lakes, particularly if these are interfaced with geo-chemical modules whose results are to be used and applied by limnologists, biologists, *etc.* On the other hand, high resolution numerical weather prediction and regional climate models mainly require accurate evolving lower boundary conditions, *e.g.* surface water temperatures, which determine the weather and climate in the surrounding region and beyond. The number of layers in deep lake models relevant for limnological applications, which may be not so for weather or climate applications, is thus the main issue of this study. The first question to be addressed is how would the simulated thermal profiles in such deep lakes respond to the reduction of the vertical resolution, or in other terms, how far thermal profiles would deviate from observations when the grid spacing increase in the vertical dimension. The next question to be addressed is related to the sensitivity of the lake

thermal profiles to the vertical resolution in the atmospheric model coupled to a lake model. The mid-latitude lake under investigation is Lake Geneva, a large and deep water body located in the western perialpine area of Switzerland bordered by France on its southern shore. The lake model is the one-dimensional finite difference $k-\epsilon$ called SIMSTRAT first driven by observations for which the vertical grid spacing increases from 1 m to few tens of meters. The atmospheric model is the single-column model FIZC which is then coupled to SIMSTRAT for which the number of vertical layers is increased from 10 to 30.

Treatment of the density stratification in the FLake model.

Georgiy Kirillin

The core of the FLake model is its original parameterization of the density stratification based on the idea of self-similarity of the lake thermocline. Initially thought as an elegant phenomenological representation, the thermocline self-similarity had received physical justification in some special situations. Still, representation of the real lake thermocline formation, erosion of its thickness and complete destruction— requires additional time and depth scales introduced in FLake through semi-empirical parameters. These parameters are often completely disregarded by FLake users/testers, resulting in misinterpretation of modelling results. Using observational data from several lakes, I estimate relaxation time scales for the thermocline shape factor and discuss length scales appropriate for parameterization of the thermocline thickness. The latter would allow extending of the FLake to a three-layer model directly applicable to deep lakes.

Simulation of surface water temperature and ice phenology from 1-D lake models: A comparison with in situ and satellite observations, Great Slave Lake, Canada

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The one-dimensional (1-D) Freshwater Lake (FLake) model and Canadian Lake Ice model (CLIMo) are used to simulate lake surface temperature (LST), freeze-up and break-up dates, and ice thickness for sections of various depths on Great Slave Lake (GSL), Northwest Territories, Canada. Model results are compared with LSTs from satellite remote sensing thermal data (Moderate Resolution Imaging Spectroradiometer (MODIS) and *Advanced Along-Track Scanning Radiometer* (AATSR)). Simulated ice conditions from both models are validated against historical data extracted from the Canadian Ice Database (CID). The main goal of this project is to evaluate the known FLake model, which is currently being implemented as a lake scheme in several numerical weather forecasting and regional climate models, for a large and deep lake (GSL) and to improve our understanding of the spatial and temporal variations in surface water/ice temperature on the lake.

Preliminary results show that ice-out (break-up) dates obtained with the FLake model occur earlier, when compared to in situ observations and estimates from CLIMo. One possible reason for the discrepancy between FLake and CLIMo ice-out dates is the different albedo schemes used by the two models. A better agreement is also found between CLIMo simulated ice thicknesses and CID in comparison to FLake. The root mean square error (RMSE) for CLIMo and FLake is 9 and 45 cm, respectively, while the mean bias error (MBE) is 6 and 33 cm. The larger overestimation of ice thickness with FLake is likely due to the fact that snow depth on ice is neglected in this model.

Global Lake Database for the parameterization of lakes in NWP and Climate Modelling

Ekatherina Kourzeneva
RSHU, St Petersburg, Russia

Abstract to be submitted.

Modelling the Thau lagoon in southern France, with FLake model : first results in off-line mode

Patrick Le Moigne

The goal of the study is to evaluate the ability of Surfex/FLake model, to simulate water temperature and surface fluxes of the saline Thau lagoon. For that purpose, a one-dimensional off-line simulation is realized and the results are compared to the available observations.

Interactive Lakes in the Canadian Regional Climate Model, version 5: the Role of Lakes in the Regional Climate of North America

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Interactive Lakes were recently introduced into the Canadian Regional Climate Model, version 5 (CRCM5), aiming at better simulation of regional climate, particularly for lake-rich regions, such as the Canadian Shield and the Laurentian Great Lakes region. The lake coupling for both resolved and subgrid lakes is realised, using two different 1D lake models. Simulations over the North-American continent using CRCM5 with interactive lakes will be presented and compared with standard CRCM5 version, which uses prescribed lake water temperature.

The Lake Model Intercomparison Project (LakeMIP): present state and perspectives

Andrey Martynov (1), Stéphane Goyette (2), Victor Stepanenko (3), Marjorie Perroud (4), Xing Fang (5), Klaus Jöhnk (6), and Dmitry Mironov (7)

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Abstract so be submitted.

Parameterisation of lake and sea ice in the NWP models of the German Weather Service

Dmitrii Mironov and Bodo Ritter

Long-term energy flux measurements over a small boreal lake

Annika Nordbo, Samuli Launiainen, Ivan Mammarella, Matti Leppäranta, Jussi Huotari, Anne Ojala and Timo Vesala

The four main energy balance components -water heat storage change, net radiation and the turbulent sensible and latent heat fluxes- were measured during four consecutive open-water periods at a small boreal lake (area 0.041km², mean depth 2.5m) in southern Finland. The lake appeared isothermal after ice break-up around April, but the development of a thermocline was induced in May by low water clarity and a sheltered location. The thermocline deepened toward fall hindering the interaction between the atmosphere and the deeper water layers, and a complete turnover was observed around September when the thermocline was at the depth of 3.5 m. The sensible heat flux peaked in the morning and had its minimum in the afternoon. The monthly means ranged from -9 Wm⁻² to 24 Wm⁻² and the largest amplitude in monthly mean diurnal courses was 43 Wm⁻². The latent heat flux had an opposite diurnal phase and was generally larger. The monthly means were from 4 Wm⁻² to 77 Wm⁻² and the largest monthly mean amplitude was 78 Wm⁻². Furthermore, the lake heat storage change and net radiation both peaked around midday and had negative values during night. The monthly mean diurnal amplitudes were as high as 440 Wm⁻² and 550 Wm⁻², respectively. On a longer temporal scale, the lake acted as a heat sink until July/August when the cumulative heat storage was 230 MJm⁻².

Abstract based on a manuscript submitted to Journal of Geophysical research 3.6.2010: Long-term energy flux measurements and energy balance over a small boreal lake using eddy covariance technique. Annika Nordbo, Samuli Launiainen, Ivan Mammarella, Matti Leppäranta, Jussi Huotari, Anne Ojala and Timo Vesala

Study of the water quality using satellite data

Miguel Potes

The successful launch of ENVISAT in March 2002 has given a great opportunity to understand the changes of water colour with high spatial resolution. In this study, the potential of MERIS sensor to describe variations of optically active substances in a Portuguese artificial lake, the Alqueva reservoir, is investigated. Regular *in situ* measurements, once a month, are used in combination with MERIS acquisitions. The surface reflectance is derived from Level 1b MERIS data, combined with radiative transfer calculations to account for the atmospheric effects. The parameterizations obtained are used to map some pigments. The results obtained are also compared with independent *in situ* measurements.

Effects of LST initialisation in long-term simulations with COSMO-CLM performed with and without Flake

Burkhardt Rockel

The standard initialisation and boundary conditions of the lake surface temperature (LST) in CCLM is taken from the driving global climate model. In cases where lakes are not resolved by the GCM the SST of the nearest ocean grid point is used. This can lead to substantial differences compared to the real LST, especially when the lake is located far from the next ocean or in high elevation area. A sensitivity experiment is performed to assess the influence on long-term simulations with the CCLM.

Interfacing Flake with the Met Office Unified Model

Gabriel Rooney

Results will be presented from the process of embedding FLake in the Met Office Unified Model, via the land-surface module JULES (www.jchmr.org/jules/).

Lakes in wintertime HIRLAM

Laura Rontu

Abstract to be submitted.

Lake parameters climatology for cold start runs (lake initialization) in the ECMWF forecast system

R. Salgado, G. Balsamo, E. Dutra, S. Boussetta and M.Potes.

The use of the FLake lake model inside an weather forecast system requires the knowledge of the initial conditions of its variables. These variables are currently not treated by the data assimilation systems. One possible solution is to create a climate of FLake variables from off-

line long periods simulations. For the ECMWF system, this climatology was generated from the Lake-Planet experiment, which consisted of an off-line HTESSEL coupled to FLake run forced by the ERA-interim reanalysis (1989-2009) and considering Earth's surface entirely covered by lakes. The depth of the lakes was obtained from the Kourzeneva database, the bathymetry of the Caspian Sea and assumed a value of 30 m at the grid points where there are no information on the presence of lakes. In order to validate the Lake-Planet experiment the following datasets were used: MODIS SST data, the IMS snow cover / sea ice product, the "Global Lake and River Ice Phenology" dataset.

The model for methane emissions from lakes in the permafrost zone

Victor M. Stepanenko

The permafrost zone in the Northern hemisphere is nowadays widely recognized as an important source of methane due to emissions from bogs and lakes, expected to increase while the climate is warming. Numerous observational and modelling efforts have been performed to assess the current magnitude of methane emissions from bogs and their potential positive feedback to the future climate change. However, much less attention has been paid to lakes that occupy a significant fraction of permafrost area. Particularly, thermokarst lakes which abundance is up to 40% in some Siberian regions are worth mentioning when considering the methane fluxes. Recent observations indicate thermokarst lakes as an important methane source likely to provide a positive feedback to climate warming since thermokarst lakes' area tends to expand when permafrost thaws. Hence, a modelling tool is needed to assess this feedback in future. In this talk a one-dimensional process-based model of a lake, that quantifies production, transport and sink of methane in the water column and the ground below is presented. Among other physical processes, the model takes into account the processes of heat and moisture transport in permafrost explicitly. The model thermodynamics and hydrodynamics are briefly described. More attention is paid on the methane model, discussing the main assumptions used to derive the equation set, its capabilities, limitations and perspectives. The model is verified and calibrated using the available data on measured methane fluxes over the thermokarst lake Shuchi in North-Eastern Siberia, that are kindly provided by Katey Walter, University of Fairbanks. The first results of coupling the lake model to regional atmospheric model are presented.

LakeMIP: the effects of mixing parameterizations and interaction with bottom sediments in a shallow lake

Stepanenko, V.M., A.Martynov, S.Goyette, M.Perroud, X.Fang, K.Jöhnk, D.Mironov and F.Beyrich.

Kossenblatter See is a 2 m deep (mean value) lake 60 km South East of Berlin, Germany. This lake has been chosen for lake model intercomparison for it being a typical representative of many shallow lakes in midlatitudes. Lakes of this size (1-2 km in horizontal scale) remain subgrid in large scale atmospheric models and thus have to be treated by one-dimensional (in vertical) parameterization. A detailed observational study on this lake including both near water surface meteorology and water temperature profiles was performed during the warm season of 2003 by Meteorological Observatory of Lindenberg (German Weather Service). Three k- ϵ models (Simstrat, LAKEoneD and LAKE) and three models employing simpler

vertical mixing schemes (Hostetler's model, FLake and MINLAKE96) were used to hindcast temperature structure and heat balance of the lake. Additionally a bulk model assuming homogeneous temperature profile in a lake and zero heat flux at the bottom was used to test if this simple parameterization could be reasonable for relatively well-mixed Kossenblatter See. Significant differences in the modelled lake stratification as well as in the surface temperature were found comparing k- ϵ models and the other models. A further significant difference between model simulations occurs in case models taking explicitly into account the heat exchange of the water column with the bottom sediments or not. For the usability of the different models in regional or large scale atmospheric model studies the comparison of simulated heat fluxes to the atmosphere versus observed ones is also discussed.

Can the Baltic Sea be modelled as a fresh or salt water lake?

Frederik Schenk

FLake is used as lake parameterization scheme in the regional climate model COSMO CLM. In a first model setup, the Baltic Sea is implemented as a fresh water lake including a highly resolved bathymetry. In a second model setup, FLake is modified to read in surface salinity concentrations from an external data file to calculate freezing temperature, maximum density and temperature of max. density as a function of salinity of the horizontal fields (Slake). The model skill of both cases is estimated by comparing sea-ice concentrations with observational data and simulations using no FLake for the Baltic Sea.

A thermodynamic model of Finish lake ice

Yu Yang

Freshwater ice plays an important role in physical, geochemical and biological process in cold-regions lakes. This study employs a one-dimensional thermodynamic snow/ice model (HIGHTSI) to simulate the freshwater ice thickness in lake Vanajavesi in Finland. The model forcing was based on weather station data. Comparison with the field thickness measurements showed good agreement between the modelled and observed results.