Parameterization of Lakes in Numerical Weather Prediction models

Dmitri Mironov, Laura Rontu, Ekaterina Kurzeneva & 26 participants of the Lake12 workshop

SRNWP-EWGLAM meeting
Helsinki 8-11 October 2012
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INTRODUCTION

Lakes in regional weather and climate

- Consideration of lake-atmosphere interactions is an important issue in climate modeling and numerical weather prediction (NWP).

- Lakes have an important role in the surface radiation balance, heat and water vapor exchanges with the atmosphere.

- The presence (or absence) of ice cover on lakes in winter has an effect on the surrounding climate.

- Earlier/later freeze-up and break-up results in ice cover duration change, and this strongly influences the radiation and energy balance.

A good representation of lake ice/temperature-atmosphere interactions is necessary to improve weather forecasting and climate modelling.
INTRODUCTION

Why to parametrise the lake processes in NWP models?

Example of freezing Ladoga from the presentation by Kalle Eerola in the 3rd Lake workshop

MBE71  25.1.2012 00UTC+30h  V74beta1
PAST

Three workshops on parametrisation of lakes in NWP and climate modelling

2008 Zelenogorsk, http://netfam.fmi.fi/Lake08
Thank you for participation! Please find the presentations in pdf linked to the programme. We will find out later how to make the Centra recordings available via this page. The draft of discussion notes can be downloaded as pdf. 24.9.2012

Participants on the roof of FMI 20 September. Photo: Markku Kangas.

The third workshop on "Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling" was arranged in Helsinki on September 18-20, 2012.

The aim of the workshop is to discuss and develop the methods of handling lakes in the numerical weather prediction (NWP) and climate models. Attention is paid to the prognostic parametrisations, assimilation of lake observations, description of lake physiographic properties in the models. The Helsinki workshop continues the work started in the previous workshops in Zelenogorsk, 2008, results published in a special issue (No 2, Vol. 15) of Boreal Environment Research and Norrköping, 2010, material to be published in special lake issue of Tellus A in 2012.
Two special open access journal issues on lakes

Boreal Environment Research, 2010, No 2, Vol. 15

Tellus A, 2012, Thematic cluster

Thematic cluster - Parameterization of lakes in numerical weather prediction and climate models

Parameterisation of sea and lake ice in numerical weather prediction models of the German Weather Service

Dmitrii Mironov, Bodo Ritter, Jan-Peter Schulz, Michael Buchhold, Martin Lange, Ekaterina Machulskaya

Simulation of surface temperature and ice cover of large northern lakes with 1-D models: a comparison with MODIS satellite data and in situ measurements

H. Kheyrollah Pour, C. Duguay, A. Martynov, L. C. Brown

Data assimilation and parametrization of lakes in HIPLAM

Laura Rontu, Kalle Eerola, Ekaterina Kourzeneva, Bertel Vehviläinen

Snow and ice on Bear Lake (Alaska) – sensitivity experiments with two lake ice models

Tido Semmler, Bin Cheng, Yu Yang, Laura Rontu

Climate data for parameterisation of lakes in Numerical Weather Prediction models

Ekaterina Kourzeneva, Eric Martin, Yuriu Batrak, Patrick Le Moigne

On the contribution of lakes in predicting near-surface temperature in a global weather forecasting model

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

Climate change impact on thermal and oxygen regime of shallow lakes

Sergey Golosov, Arkady Terzhevik, Iliia Zverev, Georgiy Kirillin, Cristof Engelhardt

Global gridded dataset of lake coverage and lake depth for use in numerical weather prediction and climate modelling

Ekaterina Kourzeneva, Hermann Asensio, Eric Martin, Stephanie Faroux

Boreal lakes moderate seasonal and diurnal temperature variation and perturb atmospheric circulation: analyses in the Community Earth System Model 1 (CESM1)

Zachary M. Subin, Lisa N. Murphy, Fuyu Li, Céline Bonfils, William J. Riley

Interactive lakes in the Canadian Regional Climate Model, version 5: the role of lakes in the regional climate of North America

Andrey Martynov, Laxmi Sushama, René Laprise, Katja Winger, Bernard Dugas

Numerical modelling of snow and ice thicknesses in Lake Vanajavesi, Finland

Yu Yang, Matti Leppäranta, Bin Cheng, Zhijun Li
**FLake Freshwater Lake Model**

applied as parametrisation scheme in several European and Canadian NWP and climate models

- common platform for development

<table>
<thead>
<tr>
<th>Component</th>
<th>ALADIN</th>
<th>COSMO</th>
<th>HIRLAM</th>
<th>UM/JULES</th>
<th>ECMWF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow model</td>
<td>depths) – liquid water in snow pack as an additional prognostic variable</td>
<td>multi-layer – liquid water in snow pack as additional prognostic variable</td>
<td>Three-layer snow scheme</td>
<td>snow mass, snow density; liquid water in snow pack, dynamic snow layer depths</td>
<td>albedo revision and rainfall interception in the snow pack</td>
</tr>
<tr>
<td>Lake model</td>
<td>bulk fresh water lake model (FLake)</td>
<td>None</td>
<td>FLake in SURFEX/HARMONIE</td>
<td>FLake coupled via surface fluxes</td>
<td>bulk fresh water lake model (FLake)</td>
</tr>
<tr>
<td>Sea-ice</td>
<td>Sea-ice model</td>
<td>None</td>
<td>Sea-ice model with snow on top</td>
<td>Multi layer thermodynamics with ice categories</td>
<td>None</td>
</tr>
</tbody>
</table>

**Table**: Developed from the SRNWP surface expert group tables (tables under development)

**Present**

- One layer – prognostic variables: snow water equivalent, snow density, snow albedo
- One layer - prognostic variables: snow temperature, snow water equivalent, snow density, snow albedo
- balance for snow pack and snow interception reservoir (HIRLAM)
- one layer no separate every budget (HARMONIE)
- Zero layer (uses top soil layer) – snow depth, albedo interception on needleleaf trees
- Revised snow density and diagnostic liquid water storage

**Future**

- Prescribed surface temperature (analysis)
- FLake
- FLake (HIRLAM) and prescribed LST (HARMONIE)
- Saturated soil or high thermal inertia
- Prescribed surface temperature (analysis)

Background from the SRNWP surface expert group tables (tables under development)
FLake Freshwater Lake Model

is used operationally at the German Weather Service:

since 15 December 2010 FLake within COSMO-EU configuration (ca. 7 km mesh size) of the limited-area NWP model COSMO model,

and since 1 April 2012 within COSMO-DE configuration (ca. 2.8 km mesh size).

It seems that FLake within COSMO is the first successful attempt to use a prognostic lake model (parameterization scheme) in operational (!) NWP practice.
Lake description

Global lake depth data base

Available at http://www.flake.igb-berlin.de/ep-data.shtml

Lake Model FLake

Lake-Depth Data Set

Version 2.0 (download a zipped file).
Developed by Ekaterina Kourzeneva, using a prototype data set of Natalia Schneider.

The Global database provides the external parameters fields for the parameterisation of lakes in atmospheric modelling. It combines depth information for the individual lakes from different sources with a map. For mapping, the raster map of ECOCLIMAP2 dataset for ecosystems was used. For some large lakes the bathymetry is included. Additionally, the software to project the lake-related information accurately onto an atmospheric model grid is provided.

The dataset for individual lakes contain information about freshwater lakes (LakeDepthDataSet201002_for_web.txt.gz) and about saline lakes (SalineDepthDataSet201002_for_web.txt.gz). By now, the dataset comprises ca. 13 000 freshwater lakes.
Lake Model Intercomparison Project - LakeMIP

MODEL EXPERIMENTS

The setup of model experiments should eliminate model discrepancies due to any source except the model physics. That means the initial and boundary condition at the lake-atmosphere interface must be the same for all models. In order to ensure this, and unifying some other setup parameters, the following conditions will be provided:

1) All models will run the same scheme for the computations of sensible, latent heat and momentum fluxes

2) The surface radiation parameters (shortwave and longwave albedos, longwave emissivity for water, ice and snow) will be identical

3) The initial profiles of temperature and other common variables of lake models will be provided by observations, if they exist. Otherwise, the initial lake state will be generated individually by every model during the spinup

4) The unique lake depth for all models will be the depth in the point of observations

5) The strategy on vertical resolution of 1D models must be discussed

http://www.unige.ch/climate/lakemip/
PRESENT

Further development and maintenance of the global lake depth data base

Tectonic map of the world
Geo-morphological map of the world
Actual geological map of the world
World map of quaternary deposits

From slides by Margarita Choulga in Lake12
Automatic processing of the materials
Gridded lake climatology is needed for the Cold Start of any operational NWP model coupled with a lake model.

**CliLake1:**

model lake climatology from off-line runs of FLake

20 year global runs with a resolution of 1°
12 different depths
Annual cycle with resolution of 10 days

Serious **errors in spring** - corrected in **CliLake2**, version to be released

Slide based on the presentation by Yuri Batrak & Ekaterina Kurzeneva in Lake12
Development of data assimilation for lakes

Optimal interpolation of in-situ and remote sensing observations
Assimilation of lake observations into the lake model and parametrisations using extended Kalman filter or nudging

Several presentations in the Lake12 workshop
Optimal interpolation of lake observations for independent analysis of LWST / ice cover

Example of a different analysis due to different background (climate or Flake)

HIRLAM

Figure from presentation by Homa Kheyrollahpour in Lake12
Assimilation of SYKE obs

Lake Inari, mean depth 14m

From the presentation by Ekaterina Kurzeneva in Lake12
Lake Valkea-Kotinen: effect of assimilation (nudging) of water-surface temperature data

Mixed-layer temperature (red), mean temperature of the water column (green) and bottom temperature (blue) in Lake Valkea-Kotinen over the period from 2 May to 31 December 2006. Dotted curves show observational data. Solid curves are computed by FLake: left panel – no nudging, right panel – with nudging, using “best choice” values of the relative weights $\alpha_w$, $\alpha_v$, $\alpha_c$ and $\alpha_h$. 

Slide from presentation by Dmitri Mironov in Lake12
Present

Applications of lake modelling

WMO Lake Victoria initiative

Usage of FLake for ice forecast in the Netherlands

Ecological modelling and water quality studies

Use of online Flake for education and offline studies by anyone interested
The problem of Lake Victoria

• Frequent severe thunderstorms over the lake, mostly at night
  – 200,000 fishermen active
  – 5000 deaths / year? Many presumed weather-related
  – Local weather/lake conditions/casualty information poorly known from observations
  – National weather services (NMS) in surrounding countries: little experience with warning services for severe weather

• NMS’s requested WMO assistance

• Gaps:
  – Observations/Technology
  – Understanding (Nocturnal thunderstorms)
  – Knowledge/Capacity
  – Concept of Operations for Warnings
  – Warning services to the lake community

• Satellite, lightning and NWP based nowcasting / forecasting systems needed

From the slides by Jeanette Onvlee in Lake12
Overshooting top detections – indicator of high convective clouds

Top left: 24h average
Top right: daytime average
Bottom left: nighttime average
Recommendations on the Lake Viktoria WMO initiative

WMO initiative presented in Jeanette's talk
Lake MIP single column experiments in several points?
3D lake models done already and more needed?
Lake climatology runs with bathymetry and varying forcing done by Katya et al. when preparing FLake climatology
Climate model results of coarse resolution, with FLake included, exist in Canada by Andrey et al
Problem of the lack of continuous observation data
Exchange of information: send to jeanette.onvlee at knmi.nl > WMO
Motivation

- Interest by ice skaters for frozen waterways in the Netherlands
- Interest by transport sector for navigable waterways
- Need for interactive tool for ice prediction
Motivation

• Interest by ice skaters for frozen waterways in the Netherlands
• Interest by transport sector for navigable waterways
• Need for interactive tool for ice prediction
HARMONIE (AROME physics)

SURFEX

FLake

ECMWF model

Observations

Operational

FLake off line

Cisco de Bruijn in Lake workshop sept 2012
FUTURE
- key tasks from the point of view of NWP

Improvement of FLake model used as a parametrisation scheme in NWP: snow on ice, three-layer structure, salinity?

Usage of remote sensing observations on lake water surface temperature and ice cover

Development and operational application of in-lake data assimilation in NWP models which apply prognostic lake parametrisations

Improvement of physiographic and climatological input data: lake depth, cover, extinction coefficient
Possible role of SRNWP in coordinating the lake - NWP work in the future?

Three workshops on parametrisation of lakes in NWP and climate modelling

2008 Zelenogorsk, http://netfam.fmi.fi/Lake08
2014 Evora/Berlin?

Two special open access journal issues on lakes

Boreal Environment Research, 2010, No 2, Vol. 15
Tellus A, 2012, Thematic cluster
Journal, 2014, Special issue
Acknowledgements

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