Notes on discussions of
Third Workshop on Parameterization of Lakes
in Numerical Weather Prediction and Climate Modeling

Finnish Meteorological Institute, Helsinki, September 18-20.2012

Key items for discussions were allocated among 4 main topics:

- Model development
- Lake observations, assimilation and validation
- External parameters
- Model inter-comparison (LakeMIP).

The special item was discussed in addition:

- Lake Victoria problem

Practical questions were also addressed:

- Publications and next workshop

I. Model development

Here, the following items were discussed: bug fixing in FLake, a warm bias in surface temperature in FLake, salinity aspects in FLake, snow on lake ice aspects, hypolimnion aspects, model errors during melting ice period.

1. **FLake bug fixing**
(i) In COSMO model runs with FLake, a problem with too large arguments of exponential functions in FLake solar radiation transfer routine was reported. Security in FLake code is necessary.
(ii) In COSMO model runs with FLake, a problem of accuracy was reported. Due to inaccurate GRIB IO, the stratification which is mathematically not allowed in FLake may appear. Security in IO routines of hosting model is necessary.
(iii) In REMO model runs, the negative values of mean buoyancy frequency were reported. Security was introduced locally.
For (i), Dmitrii Mironov will provide a new version of FLake with security lines added. For (ii), he will provide detailed explanations of how to avoid it. He will ask permission from DWD to give examples from COSMO code. He will write a one-page document on these two items and circulate it by e-mail. For (iii), Jussi Kaurola and Dmitrii Mironov will look in more detail.

2. **Warm bias in surface temperature in FLake** was reported from many validation studies and also from data assimilation experiments. This bias results from underestimation of the mixed layer depth. The problem is difficult to handle by data assimilation algorithms because the mixed layer depth is a fast variable. Probably in turn, the mixed layer depth is underestimated because of errors in momentum flux or roughness length. The problem should be studied thoroughly to find the cause of biases. The first step may be a simple sensitivity experiment with an artificially increased momentum flux. The study needs good observations, including eddy-covariance observations of fluxes. The problem is also related to model inter-comparison and data assimilation.

3. Much interest was expressed to **salinity aspects:** how to include salinity in FLake? It is necessary mostly for stand-alone applications and for climate studies, less for NWP. In some regions saline lakes cover large territories, and in future the interest to model them will increase. At present, we have only little experience with salinity. Patrick Le Moigne initiated a suite of experiments with

dependency of thermodynamic parameters on salinity using measurements from salty lagoon for validation. Salinity is taken into account in ice model HIGHTSI developed by Bin Cheng. It was noted that modeling of saline ice and saline water differ greatly in complexity. Probably saline ice is simpler because water buoyancy is dependent on salinity. The first step in the development may be a constant profile of prescribed salinity. The task needs lot of research and code development. For the volunteer, advice from Dmitrii Mironov will be available.

4. It was noticed that **snow on lake ice** is very important. Model lake ice is much thinner with presence of model snow because of isolating effect. Ice break-up date is also dependent on snow effects.
Possibilities to know about presence of snow on lake ice from remote-sensing observations were questioned (link with data assimilation). Homa Kheyrollah Pour gave an overview of remote-sensing products on lake ice and snow cover (from SAR, MODIS, AATSR). SAR products contain different classes of lake ice. But it is an open question, if it is possible to use them to get snow information. SAR data have high resolution in space but low in time. The problem of how to get snow on lake ice information from remote-sensing is complicated and may be considered as a long-term task. For lake ice observations from remote-sensing, we need better methods to interpolate them optimally on the NWP model grid and to assimilate into FLake.
At present, there are two working versions of the snow block in FLake with different representations of snow density and snow heat conductivity: (i) version by Dmitrii Mironov and Ekaterina Machulskaya and (ii) version by Tido Semmler. Further developments of the snow block are very welcome. We need to parameterize better: snow albedo, density, heat conductivity, temperature profiles in snow. Results of different field campaigns, which are available online, may be used.
Jussi Kaurola reported large model errors in a situation of too thick a snow layer on too thin ice. He also gave evidence from observations that snow-ice transformations are very important. Bin Cheng stressed the different physics of snow-ice transformations in autumn, during the freezing period, and in spring, during the melting period. It was concluded that parameterization of snow-ice transformations is very welcome.
Some aforementioned advanced features of snow parameterization are already included into snow schemes of land surface models or ice models, e. g. HIGHTSI. Possibilities, pro and contra were discussed to couple these snow schemes with FLake. Feasibility of this approach is still an open question.

5. Georgiy Kirillin presented ideas on how to include **hypolimnion layer** into FLake. The task needs a lot of research. Extensive discussions are very helpful. There is an open postdoc position in Berlin (IGB) for this model development.

6. **Model errors during melting ice period** in FLake were detected in HIRLAM by Kalle Eerola (flip-flopping over Lake Ladoga) and in offline runs by Ekaterina Kurzeneva (numerical problem). It is not clear, if these are the same problem or not. In HIRLAM the error may come also from technical reasons. The numerical problem is also not well-defined. Is it instability or another phenomenon? This should be studied further and solved.

II. **Lake observations, assimilation and validation**

In this topic, the following problems were addressed: methods to assimilate lake surface temperature (LST) observations into FLake, quality control of remote-sensing observations of LST, structure functions for OI of LST, validation and impact studies, local datasets for validation.

1. Two **methods to assimilate LST observations into FLake** were presented by Dmitrii Mironov and Ekaterina Kourzeneva: nudging and EKF. Nudging is computationally cheap and easy to implement. EKF needs almost no tuning. Comparison of their performance would be very useful, e.g. for better tuning of nudging coefficients or for detecting weak points of EKF. But for this, a common framework is needed: dataset of lake observations, atmospheric forcing, methods of diagnostics of results. This may be considered as a medium-term task. At the moment, more discussions, cooperation and sharing of experience in this field are planned.

2. Quality of remote-sensing LST observations was recognized to be high (as presented by Homa Kheyrollah Pour, validating MODIS observations against in-situ for Canada and Finland), but **quality control** of them is still needed. Standard quality control methods (against background and OI quality control) may be enough, but this should be studied carefully. Quality control methods need information about standard errors – this information should be provided. Quality control is expected to be necessary when spreading information both in horizontal (OI) and in vertical (nudging, EKF). No evaluation of lake ice data from remote sensing was performed up to now – this study is very necessary.

3. At present, we use the same **structure functions for LST in OI** as for sea surface temperature (SST), as was presented by Homa Kheyrollah Pour. It was stressed that unlike sea points connected by sea currents, lakes are isolated from each other. So, LST is much more controlled by external parameters, such as lake depth or lake elevation above sea level. The dependency on separation in terms of these parameters should be introduced into structure functions for LST. This is a study of high priority. Homa Kheyrollah Pour and Ekaterina Kourzeneva will work on it.

4. **Impact** of the lake parameterization on the quality of weather forecasts was demonstrated by Kalle Eerola, with a case study over Lake Ladoga. More case studies are welcome. Studies to demonstrate the impact of LST observations on weather forecasts are planned.

5. It was noticed, that in many studies several **local datasets** for evaluation of model performance and for model developments were used: Kossenblattersee, Kuivjärvi, Valkea-Kotinen lake and others. Finnish Environmental Institute (SYKE) data are freely available for research purposes. Bin Cheng advertised that data from ice mass balance buoys including temperature profiles in snow, ice and water during winter over Lake Orajärvi in Sodankylä will be available soon. It is necessary to provide the list of available data with links on LakeMIP and FLake web sites. Also the SRNWP expert team could provide links to these dataset. Probably not all data are open, so a permission system might be needed. In many cases references are strictly needed when publishing the results.

III. External parameters

This topic included the following items: global lake depth database developments, use of Globcover dataset, information about extinction coefficients.

1. New developments of the **global lake depth database** were presented in a talk given by Margarita Choulga. She presented the second version of the database. The new version includes typical lake depth of boreal lakes obtained from a geological method. This version provided with documentation in the form of a peer-reviewed paper will be soon freely available for downloading. This release was made possible due to financial support from ECMWF. Further developments, maintenance and support of the database are necessary. The next development may be to obtain the typical lake depth in the tropical zone and in the Southern Hemisphere using geological knowledge.

The new director of ECMWF will be asked for the continuation of funding. Margarita Choulga will continue this research and development during her PhD study.

2. A new fine resolution physiography dataset **Globcover** based on MERIS sensor measurements appeared recently. It is widely used in remote-sensing applications. Should we use it in atmospheric modeling also, in particular for mapping of lakes? Patricia de Rosnay and Juergen Helmert reported significant difference in the lake fraction from GLCC or GLC2000 and Globcover. But no real validation was performed. The problem should be studied in more detail, we need a feasibility study. Attention may be given to gross errors (presence or absence of individual lakes) or to systematic bias in the lake fraction. Key regions may be Canada, Finland and Russia. This study will be combined with the development of the global lake depth database.

3. Data about **extinction coefficients** of lakes were recognized to be very important but difficult to obtain. A related study was presented by Miguel Potes. Collecting of data is an ongoing job, which Miguel Potes will continue. Measurements are available from Portugal, Canada, Russia, Germany. Rui Salgado is a contact person, he will coordinate communication and exchange of information.

IV. Model inter-comparison (LakeMIP)

Here, the following items were discussed: comparison of model fluxes, adding FLake to the list of compared models, experiments for Lake Kivu.

1. **Model fluxes** from atmosphere to lake, although very important, were not yet compared. This comparison may be recommended to be included into the LakeMIP project. Eddy covariance observations (e. g. for Lake Kuivajärvi presented by Ivan Mammarella) may be used for this purpose.

2. It was recommended to **compare FLake with other models** in more inter-comparison experiments.

3. Experiments with lake model inter-comparisons for **Lake Kivu** were presented by Wim Thiery. This lake is very complicated for modeling: it is a large deep non-freezing meromictic saline lake located in central Africa, with quite poor atmospheric observations. A unified protocol of model inter-comparisons for this lake was elaborated. It includes the following aspects: influence of salinity, distribution of carbon dioxide and methane, influence of geothermal heat flux, model sensitivity to turbulence exchange coefficients and surface flux schemes. For atmospheric forcing, hybrid data from two stations will be used. Five models will be included into the inter-comparison experiment: LAKE, LAKEoneD, FLake, model of Hostetler and DYRESM. The roadmap includes obtaining results, publication of manuscript and LakeMIP meeting at EGU in 2013.

V. Lake Victoria problem

Jeanette Onvlee presented a WMO initiative devoted to the problem of severe flash thunderstorms over Lake Victoria. These thunderstorms kill up to 5000 people per year. Their mechanism is not clear and forecasting methods have not been developed. Measurements over this area are very poor. The role of the lake itself is also not clear. Jeanette Onvlee forwarded a question from WMO for the atmosphere-lake interactions modeling community about the possible influence of the lake and how to understand it. Is it necessary to model the lake, should we do it in a coupled mode or offline,

what kind of models are necessary, if we need a 3D model, or 1D models might be enough? We promised to perform several express-studies and to send results to Jeanette Onvlee shortly. Namely, the LakeMIP community will perform single column experiments at several lake points. Ekaterina Kourzeneva will extract data on model lake climatology for Lake Victoria from the archive. Anrdey Martinov will perform climate model runs with coarse resolution with the Canadian climate model for this area. These results will be used in planning of research by WMO.

VI. Publications and next workshop

Most participants are planning to publish their results and to contribute to the next special issue devoted to parameterization of lakes in NWP and climate modeling. The first special issue was published in the journal Boreal Environmental Research, the second in Tellus A. The organizing committee will investigate the following possibilities:

- Tellus A
- JAMES (Zakharia Subin may be asked for his experience)
- Geoscientific Model Development
- Hydrology and Earth system sciences.

The next workshop will be organized in 2014. It may be held in Evora, Portugal (Rui Salgado as a local organizer) or Berlin, Germany (Gergiy Kirillin as a local organizer). For both possibilities, financial support will be needed, because MUSCATEN will have ended by then. Jean-Françous Mahfouf proposed to combine it with SRNWP surface expert team meeting, in this case probably some funding will be possible from SRNWP. Dmitrii Mironov and Georgi Kirilling will look for funding in Germany.