

4th Workshop

“Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling”

co-organized with the WG3 meeting of COST Action ES1404

“A European Network for a harmonized monitoring of snow for the benefit of climate change scenarios, hydrology and Numerical Weather Prediction”

University of Évora, Évora, Portugal, 7-9 May 2015

Workshop Summary

Sessions and presentations

The workshop agenda included opening session, sessions on lakes and climate, lake parameterizations in NWP models and lake observations, cold lakes and warm lakes sessions, the session on databases and data assimilation, and final discussion. Sessions were convened by Laura Rontu (FMI, Finnish Meteorological Institute, Helsinki, Finland), Gabriel Rooney (UKMO, Met Office, Exeter, United Kingdom), Maria Monteiro (IPMA, Portuguese Sea and Atmosphere Institute, Lisbon, Portugal), Arkady Terzhevik (NWPI, Northern Water Problems Institute, Petrozavodsk, Russia), Jürgen Helmert (DWD, German Weather Service, Offenbach am Main, Germany), Pedro Viterbo (IPMA), and Gianpaolo Balsamo (ECMWF, European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom). The workshop was opened by an overview of presentations made at the session “Integrated modeling of lakes in the climate system” at the ASLO (Association for Sciences of Limnology and Oceanography) meeting held in Granada, Spain, in February 2015. The overview was given by Victor Stepanenko (MSU, Moscow State University, Moscow, Russia) and Klaus Joehnk (CSIRO, Commonwealth Scientific and Industrial Research Organisation, Dickson, Australia). Klaus Joehnk participated via SKYPE. The opening talk was followed by an extensive discussion providing a useful link with the community of limnologists. The progress in using lake parameterizations in operational NWP models at different weather forecasting centres was reported by Gabriel Rooney (UKMO), Dmitrii Mironov (DWD) and Gianpaolo Balsamo (ECMWF). Rui Salgado (UE, University of Évora, Évora, Portugal), Attila Nagy (OMSZ, Hungarian Meteorological Service, Budapest, Hungary) and Lijuan Wen (CAREE, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China) described experiments with lake parameterizations in research atmospheric models Meso-NH and WRF. Results of global climate simulations with parameterized lakes were presented by Patrick Le Moigne (MeteoFrance, Toulouse, France), and results from regional climate simulations of African Great Lakes were presented by Wim Thiery (University of Leuven, Leuven, Belgium). Using the simulation results, Wim Thiery proposed an explanation of severe night-time thunderstorms over Lake Victoria. Margarita Choulga (RSHU, Russian State Hydrometeorological Institute, St. Petersburg, Russia) reported on the progress in the development of the global lake dataset (incl. data on lake fraction, lake depth, freshwater vs. saline lakes) which is used at many NWP centres and research institutions to generate lake-related external-parameter fields for atmospheric models.

Many presentations addressed the measurement issues (incl. continuous in situ measurements and intensive observational campaigns) and the associated off-line lake-simulation issues. Various aspects of observations over/in lakes were presented by Rui Salgado, Miguel Potes,

Francisco Lopes and André Sá of UE, and by Ivan Mammarella, Elena Shevnina and Bin Cheng of FMI. Much attention to interpretation of observation results was given in the talks by Arkady Terzhevik (NWPI), Sergey Golosov (IL, Institute of Limnology, Russian Academy of Sciences, St. Petersburg, Russia), and Lijuan Wen (CAREE). Comprehensive observational studies have been conducted in many world lakes that differ in terms of their size, depth, location, altitude, thermal and hydrological regime, and mixing conditions. In a number of lakes, regular (monitoring-type) observations are taken. Mention should be made of large and deep warm Alqueva Reservoir (Portugal), small shallow lakes in the Antarctic, small shallow boreal lakes Kuivajärvi (Finland) and Vendyurskoe (Russia), several small lakes in Finland, and large medium-depth mountain Lake Ngoring (China). Apart from "routine" meteorological quantities, various other quantities are often measured over lakes, including fluxes of momentum, heat and water vapour, CO₂ and CH₄ fluxes, and atmospheric electric field. Within the lake water, measurements are made of the temperature (at a few levels or of the entire temperature profile), of the water turbidity, and of a number of water-quality parameters, including concentration of dissolved oxygen and of other gases, phytoplankton concentration, and bacterial decomposition. Over ice-snow covered lakes, the temperature profile within ice and snow, surface albedo, and optical properties of ice, snow and water are measured. On the catchment-area scale, measurements are made of the components of water balance. A talk by Homa Kheyrollah Pour (UWO, University of Waterloo, Waterloo, Canada) provided an extensive overview of remote sensing observations for lakes, with the focus on winter period. Presentation by Ekaterina Kourzeneva (FMI) was devoted to the assimilation of the lake water surface temperature measurements into a 1D lake model.

A number of presentations addressed various physical, chemical and biological processes in inland water bodies. Victor Stepanenko presented a model study of greenhouse gas dynamics in lakes influenced by internal waves. Patrick Le Moigne reported a method to calculate the water skin temperature, which is very important considering the possibility of the assimilation of satellite products. In the context of Alqueva Reservoir studies, presentations by Manuela Morais (UE) and by Francisco Lopes (UE) were devoted to ecological aspects and to the electric field aspects, respectively. Presentations by Arkady Terzhevik and Sergey Golosov considered a delicate interplay of various processes in and near the bottom sediments in ice-covered lakes. Various hydrological and environmental aspects of natural and man-made reservoirs were considered by Maria Grechushnikova (MSU), Ana Ilhéu (EDIA, a company responsible for Alqueva Reservoir management, Beja, Portugal), and Elena Shevnina.

Several talks on observations of snow and ice were given at the special session on cold lakes. The session was combined with the meeting of the Working Group 3 of the COST Action ES1404. The session was opened by the presentation of Jürgen Helmert (ES1404 WG3 leader) about the objectives and tasks of the COST Action ES1404 WG3 whose activities are focused on the snow data assimilation and validation methods for NWP and hydrological models. Bin Cheng presented a new instrumentation to measure the snow thickness over ice, which is usually problematic due to metamorphic processes within snow and ice. Arkady Terzhevik and Sergey Golosov described distributed in situ measurements of snow over ice-covered lakes and measurements of snow and ice optical properties. Homa Kheyrollah Pour made an overview of different satellite products on snow and ice over lakes. Presentation by Laura Rontu was devoted to the experience of using snow measurements and modelling results for the avalanche forecasting within the framework of the project SNAPS. The session included an intensive discussion on the ES1404 WG3 Questionnaire concerning the use of snow observations in different environmental applications and details of snow data assimilation in NWP and hydrological studies. Jürgen Helmert, Laura Rontu, Ekaterina Kourzeneva, Patrick Le Moigne, Elena Shevnina, Bin Cheng, Arkady Terzhevik, Sergey Golosov, Homa Kheyrollah Pour and Dmitrii Mironov took part in the discussion. The discussion was led by Jürgen Helmert. Jürgen

Helmert presented two tentative versions of the questionnaires and collected the ideas as to (i) how to improve the questionnaire, and (ii) whom the questionnaire should be sent to. A number of useful suggestions were made during the discussion. These will be summarized by Jürgen Helmert who will then complete the preparation of the questionnaire. Details of the COST Action ES1404 WG3 meeting are given in the meeting report prepared by Jürgen Helmert.

A Final Discussion concluded the Workshop.

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Summary of discussions

- There is considerable progress in using lake parameterization schemes within operational NWP models in many weather forecast centres of Europe. A lake parameterization scheme FLake is used operationally within ECMWF IFS, UM, COSMO, ICON, and HIRLAM (the use of a lake parameterization scheme within a new NWP system HARMONIE is planned). MeteoFrance plans to represent lakes in the global NWP system ARPEGE. ECMWF plans to run a version of IFS with parameterized lakes for the ensemble forecasts. Using different forecasting systems, sensitivity studies are performed that showed a substantial impact of parameterized lakes on the forecast quality. The improvement of some forecast skill scores is clearly shown, but more studies are needed as well as careful monitoring and analysis of operational results. Dmitrii Mironov proposed to prepare short summaries of operational implementation/use of lake parameterization schemes at various NWP centres. Summaries may be made available via the FLake web page.
- Different parameterizations of lakes are successfully utilized to study various PBL processes/phenomena in research atmospheric models (e.g. WRF and Meso-NH). The height of surface waves is of considerable importance for some applications. For practical purposes, relatively simple wave parameterizations appear to be sufficient and can be readily implemented and used.
- Lakes are an important component of climate system, and the impact of lakes depends on the scale considered. On regional scales, lakes influence the screen level temperature, cloudiness, and precipitation. On the global scale, lakes represent an important greenhouse gas source. The representation of CO₂ and CH₄ transport in lake models is recognized to be important. The gas transport is influenced by internal waves, which in turn need to be parameterized in a plausible way. Lake models including internal wave parameterizations are being developed in the community of limnologists, and some models are coupled to the atmospheric models (e.g. models of large lakes). However, development of fully coupled modelling systems operating on a global scale is still a long-term goal. An important co-operation with the community of limnologists is provided via LakeMIP project.
- The LakeMIP project makes considerable progress, being strengthened by the co-operation with the ASLO community. A large number of lake models participate in the inter-comparison studies ranging from simple force-restore-like models to sophisticated 3D models (such as POM and NEMO). Extensive studies are planned with a large number of models, both in off-line mode and coupled to the atmospheric models. Numerous lakes of

different kinds will be simulated, and different aspects will be investigated systematically. Special attention will be paid to the representation of gas transport, including processes in bottom sediments and under the lake ice. Lake models will be coupled to different atmospheric models in order to better understand the model errors. A 1D (column) atmospheric model of the University of Geneva will be used to consider the vertical aspects of coupling. In off-line simulations, it is important to calculate fluxes of heat, mass and momentum between the atmosphere and the lake surface with the same method. A protocol of the study will be created and published on the web site of the University of Geneva. The LakeMIP activities might be interpreted as a multi-model prediction of climate of lakes and of the effect of lakes on the atmosphere. LakeMIP participants are requested to prepare a brief note, outlining their present and future activities. The LakeMIP community is open, new participants are welcome to join.

- Observations are vitally important to satisfy different needs. Operational measurements over selected lakes are needed to monitor the performance of lake parameterization schemes in operational NWP models and to validate lake models within the framework of inter-comparison projects. Flux measurements, including measurements of greenhouse gas fluxes, are particularly valuable for model development and validation. Measurements of water turbidity and of optical parameters of snow and ice should provide improved estimates of model parameters. Regular in situ measurements in lake regions (such as SYKE measurements in Finland) and remote sensing observations may/should be used for data assimilation. There are a lot of efforts being made to collect more observational data and improve their quality. These efforts urgently need harmonization, however. As a first step in this direction, the following actions are proposed.
 - (i) In order to monitor the performance of lake parameterization schemes within operational NWP models, operational results should be provided regularly for several observational lake sites where measurements are conducted both on a regular basis and during the field campaigns (intensive observation periods). Possible candidates for such "super sites" are Lake Kuivajärvi site and Alqueva Reservoir site, data from Lake Ngoring may also become available. University of Évora agreed to collect simulation results from different NWP centres and to start the development of a monitoring system (which is a difficult task), first, for the Alqueva Reservoir site, and the other sites may be added later. The SYKE measurements in Finland may also be used, but the permission from SYKE should be requested. Some satellite products, such as OSTIA water surface temperature and ice fraction data for large lakes, may also be used for monitoring. The NWP centres require a list of sites to be monitored and the information on the site locations.
 - (ii) More greenhouse gas flux measurements over lakes are needed. There is an initiative at FMI (c/o Ivan Mammarella) to create "Lake Carbon Portal" that should provide access to the existing data from measurements as well as to several important links. The GLEON initiative may be taken as an example. Contacts with the ICOS project may also be established.
 - (iii) Information about various field campaigns, which provide a large variety of data from measurements including optical measurements, snow and ice measurements over lakes, biological and hydrological measurements, should be collected and made available via a web page. Arkadii Terzhevik will shortly start developing a list of lakes, and collecting observational data and links. Information will be provided via the FLake web page.
 - (iv) Homa Kheyrollah Pour is requested to write an overview of remote sensing products for lakes, paying special attention to the information on snow and ice. An overview will be linked to the COST ES1404 activities and should be made available via the COST Action web page.

- Further development of data assimilation systems for lakes, which is vitally important to correct model errors, is in progress. ECMWF operationally uses nudging to assimilate OSTIA data. This experience may be used by the other NWP groups. Experiments with the EKF to assimilate in situ SYKE measurements show high potential. The required computational resources are rather moderate, but operational implementation needs more studies.
- Further development of the global lake database (GLDB) is in progress. Various versions of GLDB (version 3 has recently been released) are extensively used by many researchers to generate external-parameter fields (lake fraction, lake depth) for NWP and climate models. Considering strong dependence of the simulation results (both in the NWP and climate modelling context) on the quality of external-parameter fields, further development of GLDB is of paramount importance. The database is constantly updated by including new data. First steps are made towards the sub-kilometre resolution. In 2015, the work on the GLDB development is supported by the ALADIN consortium. Beyond 2015, financial support is required and should be sought. A person to perform the work should also be found, if Margarita Choulga is no longer available.
- It is proposed to publish the workshop result as a series of articles in a journal special issue (cf. publications in *Boreal Env. Res.* and *Tellus A*, following previous workshops). *Tellus A*, *Boreal Env. Res.* and *Frontiers in Environmental Science* are being negotiated. An introductory article for the special issue is proposed (to be co-authored by Victor Stepanenko, Dmitrii Mironov, Ekatherina Kourzeneva, Laura Rontu, Arkadii Terzhevik, Rui Salgado and Miguel Potes).
- There is an idea to apply for a COST Action dealing with the lake-parameterization and related issues. A COST Action should facilitate co-operation and support harmonization of model development, simulation and observation activities. A COST proposal is to be drafted by the end of 2016.
- The next workshop on parameterization of lakes is planned for 2017. Possible host countries are China, Latvia, and Germany.