2015 Aquatic Sciences Meeting

Aquatic Sciences: Global And Regional Perspectives — North Meets South

22-27 February 2015, Granada, Spain

SESSION SCHEDULE

062 - INTEGRATED MODELLING OF LAKES IN THE CLIMATE SYSTEM

Lakes act as sensors in the landscape, responding to events in their surrounding catchments and to climate processes. They integrate signals and respond by changes in thermal stratification, water level, ice cover, evaporation, heat exchange with, and gas emission to the atmosphere. Lakes also serve as moderators for local and regional climate due to radiative and thermal processes. Integration of hydrodynamic lake models in comprehensive model systems, such as regional climate, earth system or ecosystem models, allows the study of these interactions. In-depth comparisons of model capabilities in determining thermal stratification and heat exchange with the atmosphere have been conducted. But there is still need in closing knowledge gaps, e.g. surface boundary processes, generalizing lake specific functional relations, and scaling up to regional and continental processes. This session welcomes contributions dealing with lake modelling in the context of climate processes, including - but not limited to - the presentation of new lake models and improvement of existing ones, data assimilation from e.g. earth observation, model validation and intercomparison (e.g. LakeMIP), and their coupling to comprehensive model systems (including applications). Contributions on novel modelling approaches of climate-related aquatic processes, especially greenhouse gas dynamics and emission are stimulated.

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Oral Presentations – 2015-02-23
Location: Andalucia 1 (Floor 1)

From hydrodynamics into the atmosphere

15:00 MacIntyre, S.Vidal, J.CAPTURING THE CONSEQUENCES OF NON-LINEAR INTERNAL WAVES IN HYDRODYNAMIC MODELS (Abstract ID:27618)

15:15 Hofmeister, R.Lemmen, C.Nasermoaddeli, H.Wirtz, K.W.; DATA, MODELS, AND VIEWS: TOWARDS INTEGRATION OF DIVERSE NUMERICAL MODEL COMPONENTS AND DATA SETS FOR SCIENTIFIC AND PUBLIC DISSEMINATION (Abstract ID:26362)

15:30 Kuiper, J.J.; van Gerven, L.Janssen, A.Janse, J.H.; de Klein, J.Mooij, W.M.; SERVING MANY AT ONCE: HOW WATER QUALITY MODELLING CAN BENEFIT FROM A DATABASE APPROACH TO MODELLING (DATM) (Abstract ID:26959)

Global lake modelling

15:45 Toffolon, M.Piccolroaz, S.Majone, B.HOW LAKES RESPOND TO AIR TEMPERATURE CHANGES: A LUMPED MODEL FOR LONG-TERM PREDICTIONS (Abstract ID:27027)

16:00 Bruce, L.C.; Frassl, M.A.; Adiyanti, S.Gal, G.Read, J.S.; Hipsey, M.R.; BUFFERING THE EFFECTS OF CLIMATE CHANGE: A GLOBAL LAKE MODELLING STUDY (Abstract ID:27721)

16:15 Janssen, A.Beusen, A.Janse, J.Mooij, W.GLOBAL VARIATION IN LAKE RESPONSE TO ANTHROPOGENIC STRESSES: AN INTEGRATED MODELLING APPROACH (Abstract ID:26915)

16:30 – 17:00 Coffee break

Lake modeling case studies

17:00 Perroud, M.Goyette, S.DEVELOPMENT AND VALIDATION OF A COUPLED SINGLE COLUMN LAKE – ATMOSPHERIC MODEL TO SIMULATE THERMAL PROFILES IN LAKE GENEVA (Abstract ID:25891)

17:15 Bueche, T.Vetter, M.THE MIXING BEHAVIOR OF A MEDIUM-SIZED LAKE IN SOUTHERN GERMANY. A MODELING APPROACH BY THE IMPLEMENTATION OF THE NEW COMMUNITY MODEL GLM AND FABM. (Abstract ID:26805)

17:30 Gal, G.Schlabing, D.Gilboa, Y.Shachar, N.ENSEMBLE MODELING OF THE IMPACT OF INCREASED FREQUENCY OF CLIMATIC DISTURBANCES ON A SUB-TROPICAL LAKE ECOSYSTEM (Abstract ID:25469)

17:45 Soulignac F.LEMAIRE, B.J.; MARTINS, J.R.; TCHIGUIRINSKAIA, I.VINCON LEITE, B.3D MODELLING OF THE INTER-ANNUAL VARIABILITY OF THE MIXING REGIME IN A SHALLOW URBAN LAKE: LAKE CRETEIL, FRANCE (Abstract ID:27232)

18:00 Wen, L.IMPACT OF LAKE SALINITY ON LOCAL CLIMATE WITH THE WRF_CLM MODEL (Abstract ID:25563)

18:30 – 19:00 **Session meeting**

Poster Presentations - 2015-02-24, 18:30-20:00
Location: Poster/Exhibit Hall

Goyette, S.Perroud, M.ON A SINGLE-COLUMN ATMOSPHERIC MODEL FRAMEWORK TO STUDY LAKE PROCESSES: THE CASE OF DEEP LAKE GENEVA, SWITZERLAND (Abstract ID:25717)

Thiery, W.Davin, E.Panitz, H.Demuzere, M.Lhermitte, S.van Lipzig, N.MODELING THE INFLUENCE OF THE AFRICAN GREAT LAKES ON THE REGIONAL CLIMATE (Abstract ID:26100)

CAPTURING THE CONSEQUENCES OF NON-LINEAR INTERNAL WAVES IN HYDRODYNAMIC MODELS

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Non-linear internal waves are ubiquitous in lakes from the tropics to the Arctic during stratification. The upwelling and breaking of these waves contribute to vertical transport, but modeling them can be difficult. Hydrostatic models include the low period non-linear waves, so accuracy in predicting the extent of mixing associated with the degeneration of the non-linear waves depends on what fraction of the internal wave spectrum is included. The period and amplitude of non-linear internal waves was well captured using a hydrostatic model (ELCOM) in 150 km2 Mono Lake, CA, and indicated regions where the turbulence would be enhanced but underestimated its magnitude. With the current interest in quantifying greenhouse gas (GHG) emissions and lake metabolism, and spatial variability in concentration of gases, capturing inshore-offshore transports simultaneously with emissions is critical for accuracy in budgets. ELCOM captured the upwelling and basin scale transport of CO2 in a 4 km2 temperate lake. Process studies during weak stratification, when many models fail, are required to quantify the extensive transports of heat, dissolved gases and plankton and to develop appropriate scaling arguments.

http://www.msi.ucsb.edu/people/faculty/sally-macintyre

DETAILS

INVITED

Session #:062
Date: 2/23/2015
Time: 15:00
Location: Andalucia 1 (Floor 1)

DATA, MODELS, AND VIEWS: TOWARDS INTEGRATION OF DIVERSE NUMERICAL MODEL COMPONENTS AND DATA SETS FOR SCIENTIFIC AND PUBLIC DISSEMINATION

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Data and models for describing coastal systems span a diversity of disciplines, communities, ecosystems, regions and techniques. Previous attempts of unifying data exchange, coupling interfaces, or metadata information have not been successful. We introduce the new Modular System for Shelves and Coasts (MOSSCO, http://www.mossco.de), a novel coupling framework that enables the integration of a diverse array of models and data from different disciplines relating to coastal research. In the MOSSCO concept, the integrating framework imposes very few restrictions on contributed data or models; in fact, there is no distinction made between data and models. The few requirements are: (1) principle coupleability, i.e. access to I/O and timing information in submodels, which has recently been referred to as the Basic Model Interface (BMI) (2) open source/open data access and licencing and (3) communication of metadata, such as spatiotemporal information, naming conventions, and physical units. These requirements suffice to integrate different models and data sets into the MOSSCO infrastructure and subsequently built a modular integrated modeling tool that can span a diversity of processes and domains. We demonstrate how diverse coastal system constituents were integrated into this modular framework and how we deal with the diverging development of constituent data sets and models at external institutions. Finally, we show results from simulations with the fully coupled system using OGC WebServices in the WiMo geoportal (http://kofserver3.hzg.de/wimo), from where stakeholders can view the simulation results for further dissemination.

http://ecomod.hzg.de

DETAILS

Session #:062
Date: 2/23/2015
Time: 15:15
Location: Andalucia 1 (Floor 1)

SERVING MANY AT ONCE: HOW WATER QUALITY MODELLING CAN BENEFIT FROM A DATABASE APPROACH TO MODELLING (DATM)

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Water quality modelling deals with multidisciplinary questions ranging from fundamental to applied. This requires the use of multiple analysis techniques and - hence - multiple frameworks. Through the recently developed database approach to modelling (DATM) it has become possible to run a model in multiple software frameworks without much overhead. Here we apply DATM to the ecosystem model for lakes PCLake. Using DATM, we run PCLake in six frameworks (including DELWAQ, MATLAB and R). We argue that the dynamic link between frameworks and models has the following main advantages: it allows one to use the framework one is familiar with for most model analyses and eases switching between frameworks for complementary model analyses, including the switch between a 0-D,1-D and 3-D setting. The strength of each framework – including runtime performance – can thereby be easily exploited. It also allows for easy exchange of models and process formulations within the community of water quality modellers. We envision that a community-based further development of the concept will be of importance for successfully addressing the current and future challenges in aquatic ecosystem modelling.

DETAILS

Session #:062
Date: 2/23/2015
Time: 15:30
Location: Andalucia 1 (Floor 1)

HOW LAKES RESPOND TO AIR TEMPERATURE CHANGES: A LUMPED MODEL FOR LONG-TERM PREDICTIONS

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Changes of water temperature in lakes are the result of complex processes involving the quantification of the different heat flux components and the estimation of the vertical thermal structure. With this contribution we present *air2water*, a simple lumped model that simulates the temperature of the lake surface layer parameterizing the net heat exchange and the layer depth as a function of air and water temperatures. The parameters, which are calibrated using observed temperature records, can be related to the main physical quantities of the lake. The model was shown to correctly reproduce both the seasonal evolution and the interannual variability in 14 temperate lakes with different morphology (Toffolon et al., Limnol. Oceanogr. 2014), obtaining mean absolute errors of approximately 1°C, comparable with those of more complex models. A deeper analysis on the thermal response of Lake Superior during the extraordinarily warm 1998 summer allowed us to further illustrate how the model is capable to grasp the main mechanisms controlling lake surface temperature.

DETAILS

Session #:062
Date: 2/23/2015
Time: 15:45
Location: Andalucia 1 (Floor 1)

BUFFERING THE EFFECTS OF CLIMATE CHANGE: A GLOBAL LAKE MODELLING STUDY

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Due to their sensitivity to changes in climate and catchment hydrology, lakes have been described as "sentinels of climate change”. In this study we have undertaken a global warming scenario study as part of a multi-lake modelling project involving 30 lakes with a variety of morphometries, climatic, hydrological and trophic characteristics in an attempt to explore the extent to which response to climate change is driven by lake characteristics. A simple 1-D hydrodynamic model was used to simulate each lake for a period of 2 years. Initially local boundary conditions were used as input and temperatures were then increased by 2oC to simulate a "global warming" scenario. Changes in surface energy budgets and thermodynamic properties were then compared to test the sensitivity of lake response across a variety of lake metrics. It was found that large lakes tended to buffer change more where colder lakes were more sensitive to temperature increases. The analysis demonstrates how simple models can be an effective way to explore how complex relationships between limnological characteristics can effectively buffer or magnify climate change response.

http://aed.see.uwa.edu.au

DETAILS

Session #:062
Date: 2/23/2015
Time: 16:00
Location: Andalucia 1 (Floor 1)

GLOBAL VARIATION IN LAKE RESPONSE TO ANTHROPOGENIC STRESSES: AN INTEGRATED MODELLING APPROACH

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The amount of lakes on earth is enormous. Estimates of their abundance vary between hundred thousands up to several millions. The variation among lakes in e.g. ecosystem functioning, lake ecosystem services and biodiversity is huge due to differences in morphology, hydrology and climate. Understanding how these processes lead to the variation in responses of lakes to anthropogenic stress is of great value to lake management. Due to the large numbers of lakes it seems merely impossible to grasp all the variability with observations alone. Here we present an approach where the global environmental model IMAGE is coupled with the lake ecosystem model PCLake. Where IMAGE takes care of the global run-off of nutrients using land use maps and climatological data, PClake is used as a tool to predict the ecological status of lakes. The coupling of these models may help to reduce the knowledge deficiency and support lake managers to make decisions in cases when observations are scarce or absent.

DETAILS

Session #:062
Date: 2/23/2015
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Location: Andalucia 1 (Floor 1)

DEVELOPMENT AND VALIDATION OF A COUPLED SINGLE COLUMN LAKE – ATMOSPHERIC MODEL TO SIMULATE THERMAL PROFILES IN LAKE GENEVA

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A single column atmospheric model coupled to a single column lake model with an application to Lake Geneva is presented. Here, the potential for shorter term realistic simulations is demonstrated. The atmospheric model, FIZC, is a column isolated from the Canadian Regional Climate Model (C-RCM). This atmospheric model is thus physically-based and it requires outputs from a previous C-RCM integration driven by NCEP-NCAR reanalyses. The issues of local lake weather conditions is addressed by combining precomputed atmospheric large-scale transports of momentum, heat, and moisture, called “the dynamics,” and recomputed subgrid-scale parameterized effect, called “the physics,” with the explicit numerical computations of the evolving lower boundary conditions provided by the lake model. The lake model, called SIMSTRAT, combines a buoyancy-extended k-ε model with a seiche excitation and damping model to predict the diffusivity below the surface mixed layer. In this model, the vertical turbulent diffusivities are determined from the turbulent kinetic energy and energy dissipation. Details of the atmospheric-lake interface module will be explained and sensitivity of the simulated thermal profiles to the coupler parameter values will be presented for a number of case studies.

DETAILS

Session #:062
Date: 2/23/2015
Time: 17:00
Location: Andalucia 1 (Floor 1)

THE MIXING BEHAVIOR OF A MEDIUM-SIZED LAKE IN SOUTHERN GERMANY. A MODELING APPROACH BY THE IMPLEMENTATION OF THE NEW COMMUNITY MODEL GLM AND FABM.

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The mixing regime of lakes might change under altering climatic conditions. To indicate this, investigations of future mixing behavior are required. In contrast to mixing periods, the spatial patterns of circulation events (esp. the depth) can hardly be derived from the water temperature distribution in the lake only. So, an additional parameter is required to investigate lake mixing. The distribution of oxygen is frequently used for that purposes. Hence, to simulate future mixing behavior of lakes, hydrodynamic lake models have to be combined with biochemical models. Our study object (Lake Ammersee, situated in Southeast Germany, max. depth 83 m) is determined as dimictic. Regarding the mixing behavior data analysis of water temperature, oxygen distribution, air temperature and wind influences show, that the lake has monomictic seasons and also years without holistic mixing are observed. A first discussion based on our results should consider, whether the mixing behavior has been changed recently and even the regime could change in the future. Since an increasing occurrence of meromictic seasons would have a strong impact on lake’s biology, the limnophysical-biological ecosystem lake model GLM-FABM is implemented to Lake Ammersee in order to be able to simulate future alterations in mixing behavior. In a summary, we show in our contribution the results of the analysis of the observed mixing behavior. This takes into account the lake model GLM-FABM and presents the first results of the biochemical simulations, but also discuss the problems of this simulation approach. Furthermore, some simulations regarding the ice cover and tests with tracers are presented.

DETAILS

Session #:062
Date: 2/23/2015
Time: 17:15
Location: Andalucia 1 (Floor 1)

ENSEMBLE MODELING OF THE IMPACT OF INCREASED FREQUENCY OF CLIMATIC DISTURBANCES ON A SUB-TROPICAL LAKE ECOSYSTEM

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Typical outputs of climate change models include moderate, monotonic, long-term changes to weather conditions. Recent data suggest, however, an increase in the frequency of extreme events due to climate change. Increased frequency of extreme events may have a greater impact on lake ecosystems than slow gradual increases in temperature. We therefore used a weather generator to emulate the observed increase in frequency of extreme events occurring in the Lake Kinneret (Israel) region. We used the weather generator to create numerous 30-yr scenarios varying in the frequency and amplitude of extreme events and over-all change in meteorological conditions. We evaluated the impact on the lake using two different 1D hydrodynamic models and by studying the changes to the thermal structure and dynamics. In contrast to our expectations, the increased frequency of extreme events did not always have the largest impact though the increased frequency in tandem with a gradual increase in temperature always resulted in large changes to the lake thermal dynamics. Though both models provided similar trends there were obvious differences between them highlighting the advantage of the ensemble approach.

DETAILS

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Date: 2/23/2015
Time: 17:30
Location: Andalucia 1 (Floor 1)

3D MODELLING OF THE INTER-ANNUAL VARIABILITY OF THE MIXING REGIME IN A SHALLOW URBAN LAKE: LAKE CRETEIL, FRANCE

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Modelling accurately ecological processes in shallow lakes requires modelling accurately the lake hydrodynamics. For example, full mixing episodes during summer cause sediment re-suspension and trigger consecutive phytoplankton growth. Therefore, a validated model forced with outputs of a regional climate model could be very useful to predict changes in mixing regime and to discuss the future of phytoplankton dynamics in temperate urban lakes similar to Lake Créteil. We used the 3D hydrodynamic model Delft3D-FLOW and successfully validated it using meteorological variables, water temperature and current velocity collected at high frequency (30 s) in several points of Lake Créteil, France from spring to summer (May to August) in 2012, 2013 and 2014. Calibration was performed in 2012 and verification in 2013 and 2014. Particular hydrodynamic episodes were analyzed: destratification events and periods of internal wave activity. The number of stratified days, mixed days, destratification events and the duration of thermal stratification episodes were calculated for each year to quantify the inter-annual variability. Simulation results reproduced very well the observed inter-annual polymictic patterns and internal wave characteristics for all three years.

DETAILS

Session #:062
Date: 2/23/2015
Time: 17:45
Location: Andalucia 1 (Floor 1)

Presentation cancelled

IMPACT OF LAKE SALINITY ON LOCAL CLIMATE WITH THE WRF_CLM MODEL

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The Great Salt Lake (GSL) is famous for its high salinity and triggering effects for strong precipitation over downstream area of the GSL during early winter and spring. In this study, the Weather Research and Forecasting Model coupled with Community Land Model (WRF_CLM) is used to investigate impacts of the GSL and its salinity from October 2001 to April 2002. A newly developed salinity parameterization scheme is incorporated into the sophisticated 10-layer lake physics scheme of CLM. The coupled WRF_CLM model with the salinity parameterization scheme can better simulate temperature over and in the GSL, and precipitation in the downstream area of the GSL when compared to that without considering the salinity effects. The improvement of simulation is especially significant under cold weather condition. The precipitation caused by the GSL effect is always positive over the downwind area of the GSL during the study period. This increased precipitation is largely attributed to the warm lake surface temperature and high latent heat flux over the GSL, which are favorable for the development of strong convective activity and horizontal wind and moisture convergence. Such kind of GSL-induced dynamic forcing is the primary mechanism for the downstream lake effect precipitation. Note that the precipitation caused by GSL effect is largely contributed by fresh water effect when the temperature is close to or higher than the freezing point of fresh water. However, under cold weather condition with lower temperature, the salinity effect becomes dominant for the saline lake effect precipitation.

DETAILS

Session #:062
Date: 2/23/2015
Time: 18:00
Location: Andalucia 1 (Floor 1)

ON A SINGLE-COLUMN ATMOSPHERIC MODEL FRAMEWORK TO STUDY LAKE PROCESSES: THE CASE OF DEEP LAKE GENEVA, SWITZERLAND

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This paper discusses the benefits of using a single-column atmospheric modelling approach (SCM) to drive lake models. An application is presented of such a SCM, termed FIZC, which has been interfaced with the lake model SIMSTRAT with an application to Lake Geneva, Switzerland. FIZC has been developed in the framework of the Canadian Regional Climate Model (CRCM) driven by NCEP-NCAR reanalyses. This SCM may be embedded anywhere within the CRCM grid mesh, thereby providing a great potential for further applications to study lake-atmosphere interactions. The structure of FIZC offers interesting prospects as the spatial resolution of the CRCM is continuously increased. The benefit of using Newtonian relaxation is also demonstrated and the potential to nudge simulated profiles towards measurements issued from radio-soundings is discussed. Coupling FIZC with lake models would circumvent a number of limitations inherent to driving the latter with surface observations due to the absence of interactions with the overlying atmosphere. Within the Lakemip initiative FIZC could eventually be used for an assessment of many types of lakes in order to cover a range of issues and processes.

DETAILS

Poster presentation

Session #:062
Date: 2/24/2015
Time: 18:30 - 20:00
Location: Poster/Exhibit Hall

MODELING THE INFLUENCE OF THE AFRICAN GREAT LAKES ON THE REGIONAL CLIMATE

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Although the African Great Lakes are important regulators for the East-African climate, their influence on atmospheric dynamics and the regional hydrological cycle remains poorly understood. We assess this impact by conducting a regional climate model simulation which resolves individual lakes and explicitly computes lake temperatures. The regional climate model COSMO-CLM, coupled to a state-of-the-art lake parameterization scheme (FLake) and land surface model (Community Land Model), is used to dynamically downscale the COSMO-CLM CORDEX-Africa simulation to 7 km grid spacing for the period 1999-2008. Evaluation of the model reveals good performance compared to both in-situ and satellite observations, especially for spatio-temporal variability of lake surface temperatures with biases generally around 1 K, and precipitation (-79 mm/yr bias). Model integrations indicate that the four major African Great Lakes almost double precipitation amounts over their surface relative to a simulation without lakes, but hardly exert any influence on precipitation beyond their shores. Except for Lake Kivu, the largest lakes also cool their near-surface air by -0.6 to -0.9 K on average, this time with pronounced downwind influence. The lake-induced cooling happens during daytime, when the lakes absorb incoming solar radiation and inhibit upward turbulent heat transport. At night, when this heat is released, the lakes warm the near-surface air. Furthermore, Lake Victoria has profound influence on atmospheric dynamics and stability as it induces cellular motion with over-lake convective inhibition during daytime, and the reversed pattern at night.

DETAILS

Poster presentation
Session #:062
Date: 2/24/2015
Time: 18:30 - 20:00
Location: Poster/Exhibit Hall