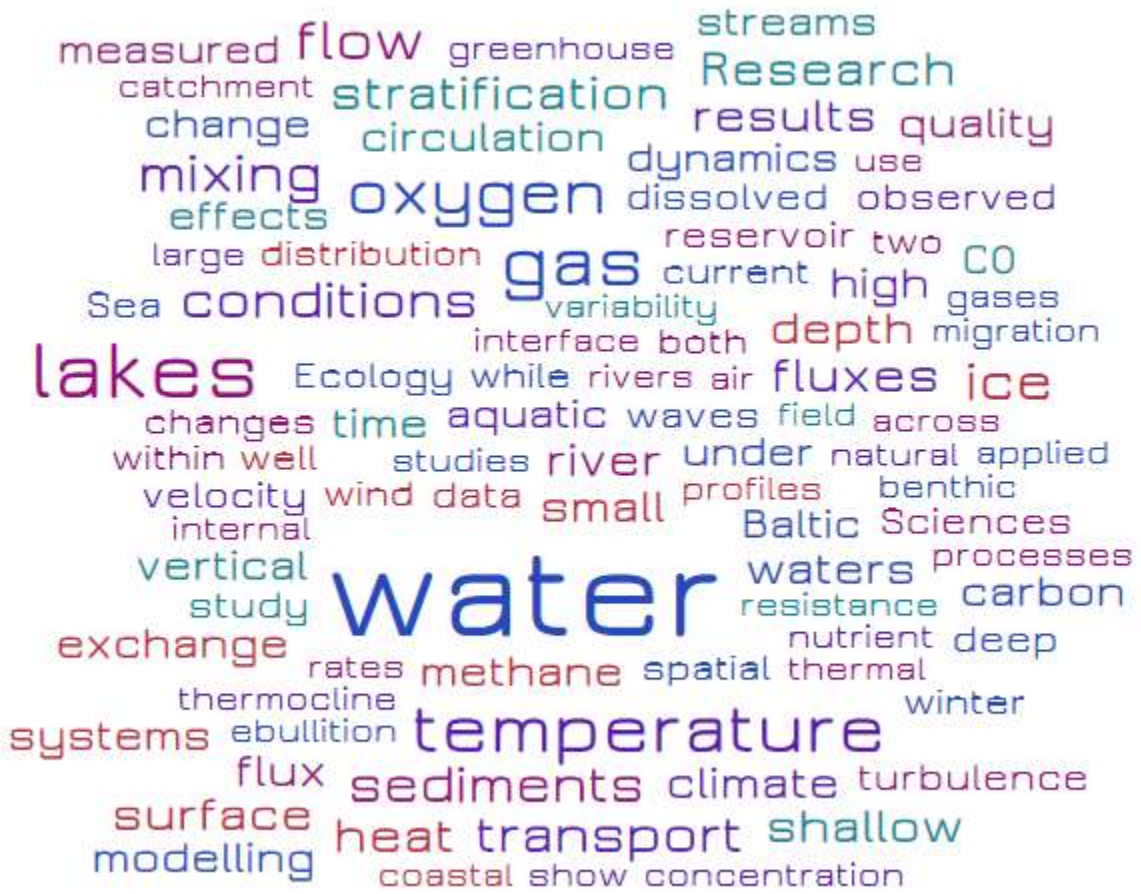
18th Workshop on Physical Processes in Natural Waters

Program & Abstracts



24 – 28 August 2015

University of Koblenz-Landau (Butenschoen-Haus)

Landau, Germany

The complete program including all abstracts can be download as a pdf-file under the following link:

https://www.uni-koblenz-landau.de/en/campus-landau/faculty7/environmental-sciences/uphys-en/ppnw-2015/docs/PPNW2015.pdf

Or by scanning this QR-code:

Program Overview

24.08.2015 (Monday)

19:00 –	Icebreaker meeting and registration

25.08.2015 (Tuesday)

08:00 – 08:45 h	Registration and workshop information
08:45 – 09:00 h	Opening
09:00 – 13:00 h	7 Talks with Coffee break (Climate change and lakes)
13:00 – 14:00 h	Lunch
14:00 – 18:00 h	7 Talks with Coffee break (Lakes and sediment-water interactions)
18:00 – 20:00 h	Poster session / Discussions / Local wine

26.08.2015 (Wednesday)

08:00 – 09:00 h	Keynote lecture: S. Monismith
09:00 – 18:30 h	Technical Tour (guided tour at the Rhine Impoundment Iffezheim, lunch, guided tour nature reserve Rhine flood plains)
19:00 –	Historic city tour and social meeting point

27.08.2015 (Thursday)

08:30 – 12:00 h	6 Talks with Coffee break (Running waters)
12:00 – 13:00 h	Keynote lecture: V. Nikora
13:00 – 14:00 h	Lunch
14:00 – 18:00 h	7 Talks with Coffee break (Greenhouse gases)
19:00 –	*Conference dinner*

28.08.2015 (Friday)

08:30 – 09:30 h	Keynote lecture: J. Imberger
09:30 – 13:00 h	6 Talks with Coffee break (Water Quality)
13:00 – 14:00 h	Lunch
	End of Workshop

Venue

The workshop will take place at the Butenschoen-Haus, a small conference center located right next to the Campus Landau of the University of Koblenz-Landau.

The address is: Protestantisches Bildungszentrum Butenschoen-Haus
Luitpoldstraße 8
76829 Landau/Pfalz

Please check the workshop web site for detailed travel directions and accommodation options. The accommodation in Butenschoen-Haus is at the same address.

Under the following link and QR-code, you can find a map with all important locations:

https://www.google.com/maps/d/edit?mid=zZorY1R48nFA.k9N4Y43fK-kU&usp=sharing

Registration

The conference fee, including fees for accompanying persons and room charges for accommodation in the Butenschoen-Haus, was due on 1 July 2015 and had to be paid by bank transfer. Please note, that only cash payments can be accepted during the workshop.

The workshop fee includes lunch at all workshop days, snacks and drinks at the icebreaker, the conference dinner and snacks and drinks during coffee breaks and the poster session.

Registered participants will receive the workshop material at the reception during the ice breaker, or at the beginning of the workshop.

Information for Speakers

Each presentation has a 30-minute time slot, but we strongly encourage all presenters to restrict their presentations to 15 minutes and allow for a 15-minute discussion.

Please provide your presentation on a USB storage device during the workshop. For the presentations we will provide a Windows computer with Microsoft Office 2013 and a pdf-viewer installed. Please contact the workshop staff if you have special technical requirements for your presentation, or if you need to use your own computer.

Information for Poster Presenters

Posters will be presented on movable walls and can have any size up to A0.

The poster exhibition will be close to the coffee-break area and to allow for a maximum of interaction, we strongly encourage all poster presenters to keep their posters there for the entire workshop.

Accompanying Program

During the workshop, Erich Bäuerle will present experiments, which open the possibility to play with „physical processes in water“. By removing the restrictions of purely analytical thinking we gain access to fascinating aspects of some phenomena of moving water which (eventually) get lost/drop away if not approached sensuously.

Carsten Wirtz (terra4 GmbH) will present new and state-of-the-art instruments from Nortek and PME.

Social activities include an icebreaker reception in the evening before the workshop, a technical tour, conference dinner, guided city tour and the possibility to taste local wines during the poster session.

Detailed Program

24.08.2015 (Monday)

19:00 -	Icebreaker meeting and registration Location: Palmers Irish Pub at Schillerpark This beer garden is located in the **Schillerpark**. The street name is "**An 44**", the number is **20**. Use the PPNW-map provided in the Venue section above, or: Get directions: http://www.yelp.com/map/palmers-irish-pub-landau

25.08.2015 (Tuesday)

08:00 – 09:00 h	**Registration, Opening and workshop information**

Session 1 Climate Change & Lake Physics	Chair: C. Engelhardt
09:00 – 09:30 h	A. Stips, D. Macias, E. Garcia-Gorriz Correlation or Causality: Drivers of the Earth climate (p. 15)
09:30 – 10:00 h	S. Piccolroaz, T. Wood, S. Wherry, S. Girdner Changes in the Mixing Regime of Crater Lake in a Future Climate (p. 16)
10:00 – 10:30 h	C. Dresti Effects of climate change on the overturn of holo-oligomictic lakes in the Southern Alps: the case of Lake Maggiore (p. 17)
10:30 – 11:00 h	D. Beletsky, R. Beletsky, N. Hawley, J. Wang Seasonal Circulation and Thermal Structure of Lake Erie (p. 18)
11:00 – 11:30 h	**Coffee break**
11:30 – 12:00 h	B. Flood, M. Wells Internal Kelvin waves in a large mid-latitude lake (p. 19)
12:00 – 12:30 h	F. Soulignac, B. J. Lemaire, J.R. Martins, I. Tchiguirinskaia, D. Schertzer, B. Vinçon-Leite Mixing regime of a shallow urban lake, Lake Créteil, France: measurements and simulations (p. 20)
12:30 – 13:00 h	J. Wang, A. Manome, X. Bai Modeling five Great Lakes ice-circulation system using an unstructured-grid coupled model (p. 21)
13:00 – 14:00 h	**Lunch**

25.08.2015 (Tuesday)

Session 2 Lake Physics & Benthic Boundary Layers	Chair: D. Wain
14:00 – 14:30 h	F. Pöschke, J. Lewandowski, C. Engelhardt, T. Ruhtz, G. Kirillin
	Upwelling in dimictic lakes in spring (p. 22)
14:30 – 15:00 h	A. Wüest, G. Fink, B. Wahl, M. Schmid, L. Råman Vinnå
	Using large lakes for heating and cooling – potential and limits (p. 23)
15:00 – 15:30 h	S. Ahmerkamp, C. Winter, M. Kuypers, F. Janssen, D. de Beer, M. Holtappels
	Solute transport in permeable sediments with stationary and migrating bedforms (p. 24)
15:30 – 16:00 h	A. de la Fuente, C. Meruane, S. López, F. Caicha
	Heat exchanges between water and sediment in extremely-shallow lagoons on the Altiplanic region of Chile (p. 25)
16:00 – 16:30 h	**Coffee break**
16:30 – 17:00 h	D. Donis, F. Janssen, D.F. McGinnis, F. Wenzhöfer, M.E. Böttcher
	Characterization of benthic oxygen exchange rates in permeable sediments (southern Baltic coast) – best practice for aquatic eddy correlation flux estimates in presence of surface waves (p. 26)
17:00 – 17:30 h	S. Flury, R. N. Glud, K. Premke, D. F. McGinnis
	The contrasting effect of sediment gas voids on diffusive fluxes of high-soluble and low-soluble dissolved substances (p. 27)
17:30 – 18:00 h	L. Bryant, A. Brand, G. Kirillin, C. Engelhardt
	Rocking Seiches and Sediment Dancers: Effects on Sediment Oxygen Uptake and Porewater Chemistry (p. 28)
18:00 – 20:00 h	**Poster session / Discussions / Local wine**

Posters presented:

Z. Alshboul, C. Noss, A. Lorke

Drifting versus static chambers for measuring air-water gas fluxes in running waters (p. 51)

A. Fenocchi, M. Pinardi, S. Sibilla, C. Giardino, M. Bartoli and M. Bresciani

Assessment of potential algal blooms in a shallow fluvial lake through hydrodynamic modelling and remote-sensed images (p. 52)

K. Koca, C. Noss, C. Anlanger, A. Lorke

An Assessment of the Vectrino Profiler for Mean Flow and Turbulence Measurements at the Sediment-Water Interface (p. 53)

A. Linkhorst, A. Isidorova, N. Barros, T. DelSontro, R. Mendonça, S. Sobek

Spatial variability of methane ebullition in tropical reservoirs assessed by hydroacoustics and bubble trapping (p. 54)

C. Noss, A. Lorke

Roughness, Resistance, and Dispersion – Relationships in Small Streams (p. 55)

S. Simoncelli, S. J. Thackeray, D. J. Wain

Observations of turbulence during a zooplankton migration in a small lake (p. 56)

C. Somlai, A. Lorke

Regional estimates of fluvial CO_2 gas fluxes (p. 57)

26.08.2015 (Wednesday)

08:00 – 09:00 h	**Keynote lecture: Stephen Monismith** Internal waves in the nearshore coastal ocean	
09:00 – 18:30 h	Technical Tour: Rhine Impoundment Iffezheim and Nature Reserve Rhine Floodplains (please bring your passport, we are crossing the border to France).	
	09:05	Bus departure in front of the Butrenschoen-Haus
	09:50	Arrival at the hydropower plant Impoundment Iffezheim Technical tour
	12:50	Bus departure in Iffezheim
	13:10	Lunch (Auberge du Rhin in Selz, France)
	14:30	Departure of the Rhine ferry (directly at the restaurant)
	15:30	Arrival in Plittersdorf – Rhine floodplains, ecological tour
	17:30	Bus departure in Plittersdorf
	18:30	Arrival in Landau, Butenschoen-Haus
19:00 -	Historic city tour and social meeting point	

27.08.2015 (Thursday)

Session 3 Running Waters	Chair: C. Noß
08:30 – 09:00 h	B. R. Hodges, Z. Li, R. Carothers, P. Passalacqua Challenges in fine-resolution modelling of marshes, bayous, and river deltas (p. 29)
09:00 – 09:30 h	C. Anlanger, U. Risse-Buhl, C. Noss, M. Weitere, T.R. Neu, A. Lorke The role of hydrodynamics in shaping the composition of stream biofilms under contrasting trophic conditions (p. 30)
09:30 – 10:00 h	A. Brand, C. Dinkel, B. Wehrli, M. Holzner Current measurements close to the sediment-water interface using a high resolution acoustic velocity profiler (p. 31)
10:00 – 10:30 h	M. Toffolon, S. Piccolroaz, A. Siviglia Contrasting response of river water temperature to heatwaves (p. 32)
10:30 – 11:00 h	**Coffee break**
11:00 – 11:30 h	A. Kurtenbach, T. Gallé, R. Bierl, W. Symader Temporal dynamics of cohesive sediment and associated pollutant transport in mid-mountain gravel bed rivers (p. 33)
11:30 – 12:00 h	M.-J. Lilover, T. Kõuts, K. Vahter On-line system to support winter navigation in ice channels (p. 34)
12:00 - 13:00 h	Keynote lecture: Vladimir Nikora Flow-biota interactions in running waters: recent advancements, challenges, and prospects
13:00 – 14:00 h	**Lunch**

27.08.2015 (Thursday)

Session 4 Greenhouse Gases	Chair: M. Holtappels
14:00 – 14:30 h	B. Boehrer, J. Sánchez-España, I. Yusta Quantifying and removing the carbon dioxide gas oversaturation in meromictic Guadiana pit lake (p. 35)
14:30 – 15:00 h	S. MacIntyre, A. Cortes, S. Sadro Under ice circulation and greenhouse gas Evasion in arctic lakes (p. 36)
15:00 – 15:30 h	I. Ostrovsky, B. Katsnelson, R. Katsman, A. Lunkov Shallow gassy sediment characterization in Lake Kinneret using low-frequency sound signal (p. 38)
15:30 – 16:00 h	D. F. McGinnis, G. Kirillin, K. W. Tang, S. Flury, P. Bodmer, C. Engelhardt, P. Casper, H.-P. Grossart Microbubble enhanced diffusive methane emissions from oligotrophic Lake Stechlin: A hypothesis (p. 39)
16:00 – 16:30 h	Coffee break
16:00 – 16:30 h	**Coffee break**
16:30 – 17:00 h	J. Kokic, M. Wallin, E. Sahlée, H.E. Chmiel, B.A. Denfeld, S. Sobek Carbon dioxide evasion from headwater systems strongly contributes to the total export of carbon from a small boreal lake catchment (p. 40)
17:00 – 17:30 h	J.M. Melack, B.R. Forsberg, S. MacIntyre, J.H. Amaral Inundation and gas fluxes from Amazon lakes and wetlands (p. 41)
17:30 – 18:00 h	T. Vesala, I. Mammarella, J. Heiskanen, M. Provenzale, K.-M. Erkkilä, M. Rantakari, A. Lohila, H. Miettinen, L. Arvola, S. MacIntyre and A. Ojala Lesson from long-term eddy covariance measurements over lakes (p. 42)
19:00 -	*Conference dinner* The bus departs at 19:00 from Butenschoen-Haus. The dinner will be in the village of Ilbesheim (15 min bus ride)

28.08.2015 (Friday)

08:30 – 09:30 h	**Keynote lecture: J. Imberger** **Adaptive Real-time, Self-Learning River Basin Living: Challenges** (p. 43)
Session 5 Water Quality	Chair: S. MacIntyre
09:30 – 10:00 h	M.A. Frassl, D. Schlabing, M.M. Eder, K.-O. Rothhaupt, K. Rinke Sensitivity of phytoplankton spring blooms to meteorological variability (p. 44)
10:00 – 10:30 h	J. Kreling, J. Bravidor, C. Engelhardt, M. Hupfer, M. Koschorreck, A. Lorke Oxygen transport and consumption during the formation of a metalimnetic oxygen minimum (p. 45)
10:30 – 11:00 h	**Coffee break**
11:00 – 11:30 h	M. Weber, B. Boehrer, K. Rinke Withdrawal regime changes and their consequences on stratification and water quality dynamics within a drinking water reservoir (p. 46)
11:30 – 12:00 h	R. Friedland, G. Schernewski, T. Neumann Integrated modelling of water quality targets for the south-western Baltic Sea (p. 47)
12:00 – 12:30 h	B. Lemonnier, Rob Uittenbogaard, D. Bouffard, A. Wüest Modelling vertical distribution of Planktothrix in Lake Hallwil (p. 48)
12:30 – 13:00 h	T. Sommer, J. Berg, F. Danza, H. Bürgmann, C. J. Schubert, A. Wüest Bacteria cause mixing in Lago di Cadagno, Switzerland (p. 49)
13:00 – 14:00 h	**Lunch**
	End of Workshop / Discussions

Presentation Abstracts

The order of the abstracts follows the order of presentation.

Correlation or Causality: Drivers of the Earth climate

A. Stips1*, D. Macias1, E. Garcia-Gorriz1

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Abstract

Here, we analyze recent measured data on global mean surface air temperature anomalies (GMTA) and various external forcing's covering the last 160 years using newly developed techniques that allow discrimination between correlation and causality. This evaluation is based on a new concept for calculating the information flow between time series.

The strong correlation between the global CO_2 concentration and GMTA of 0.889±0 is well known. But calculating the information flow in *nat* (natural unit of information) per unit time from the global CO_2 concentration to GMTA we get 0.348±0.112 [nat/year] and -0.006±0.003 [nat/year] in the reverse direction. Causality is expressed by an information flow significantly different to 0.0, whereas an information flow close to 0.0 indicates that the two time series are not causally related. Our result demonstrates one-way causality in the sense that the CO_2 increase is causing the temperature increase and not the other way around. The positive value of the information flow indicates further that CO_2 has a positive feedback and therefore a destabilizing effect on GMTA; more CO_2 would lead to a stronger increase in GMTA.

The results of investigating the information flow between the major radiative forcings and the GMTA time series clearly show that total Green House Gases (GHG), dominated in particular by CO_2 forcing, is the main driver of changing global surface air temperature. Radiative forcing caused by aerosols and clouds is still important, but significantly smaller. Neither forcing by solar irradiance nor volcanic forcing contributes in a significant manner to the GMTA development.

However on paleological time scales (800,000 years) the climate system seems to have behaved different, as on those time scales temperature changes seem to be the cause for subsequent changes in CO_2 concentration.

Finally, we applied the same causality analysis to the globally-gridded GMTA product in order to assess regional "sensitivity" to anthropogenic forcings versus natural modes of variability. This analysis reveals a surprising causal pattern: the increased anthropogenic forcing mainly originated in the northern hemisphere has especially strong warming effects in the southern hemisphere.

Keywords

Earth climate; anthropogenic forcing; correlation; causality.

Changes in the Mixing Regime of Crater Lake in a Future Climate

S. Piccolroaz1*, T. Wood2, S. Wherry2, and S. Girdner3

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[2] *U.S. Geological Survey Oregon Water Sciences Center, Portland, OR, USA*

[3] *U.S. National Park Service Crater Lake National Park, OR, USA*

**Corresponding author, e-mail piccolr@ing.unitn.it*

Abstract

We applied a 1-dimensional lake model developed to simulate deep mixing related to thermobaric instabilities in temperate lakes to Crater Lake, a 590-m deep caldera lake in Oregon's Cascade Range, in order to determine the frequency of deep water renewal in future climate conditions. The lake model was calibrated with 6 years of water temperature profiles, and then simulated 10 years of validation data with an RMSE ranging from 0.81°C at 50 m depth to 0.04°C at 350-460 m depth. The simulated time series of heat content in the deep lake accurately captured extreme years characterized by weak and strong deep mixing. The lake model uses wind speed and lake surface temperature (LST) as boundary conditions. LST projections under six climate scenarios (2 representative concentration pathways×3 general circulation models) were evaluated with *air2water*, a simple lumped model that only requires daily values of downscaled air temperature. *air2water* was calibrated with data from 1993-2011, obtaining a RMSE of 0.68°C. Preliminary results indicate that the frequency of deep water renewal events could change substantially in a warmer future climate as reverse stratification becomes rare and the entire water column warms to greater than 4°C, with potential implications for the clarity of Crater Lake if oxygen is depleted at the lake bottom.

Keywords

Crater Lake; thermobaric instability; *air2water*; 1-dimensional lake model; future climate.

Effects of climate change on the overturn of holo-oligomictic lakes in the Southern Alps: the case of Lake Maggiore

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Abstract

The Deep Subalpine Lakes (DSL: Maggiore, Lugano, Como, Iseo and Garda) are usually classified as holo-oligomictic lakes, which means that full overturn – chemical and thermal homogeneization of the whole water column – does not occur every year, but only at the end of particularly cold and windy winters.

According to the Intergovernmental Panel on Climate Change (IPCC), it is important to analyse the effects of climate change on lake ecosystems, as they are early warning indicators of change in weather conditions; furthermore, their physical and chemical structure may be strongly affected by global warming. Several studies have shown that climate change is expected to induce prolonged periods of stratification, and less frequent overturns: this can affect nutrient and oxygen levels in lake water, with an overall effect on water quality.

The present study focuses on Lake Maggiore, one the biggest and deepest lake in Italy, with the aim of evaluating the vertical extent of the overturn in the period 1956-2014 and assessing its possible relationship with the inter-annual variations of air temperature. The water mixing depth in spring will be evaluated, considering not only water temperature, but also some chemical parameters, such as dissolved oxygen, nitrate, reactive silica and conductivity. The causes which determine a complete mixing (meteorological conditions in winter and local climatic conditions) will be assessed.

Four additional years of measurements of water temperature on a monthly basis (1911-1914) have been recently made available and will be used in this study, after assessing their reliability, in comparison with the thermal behaviour observed in recent years.

Finally, the possible response of Lake Maggiore to the air temperature change scenario foreseen by IPCC for the next 30 years will be discussed, with special attention to the thermal stratification and deep-water dynamics.

Keywords

Lake Maggiore; climate change; deep subalpine lakes; complete overturn; holo - oligomixis.

Seasonal Circulation and Thermal Structure of Lake Erie

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Abstract

Lake Erie, being the shallowest of all Laurentian Great Lakes exhibits the largest fluctuations of the thermal regime: it is the warmest lake in summer and coldest in winter (having the highest concentration of ice). Observations and model results show that circulation of its largest basin (central) is frequently anticyclonic in summer and thermocline has a characteristic bowl shape, conducive to late summer hypoxia. Western basin doesn't have stable seasonal stratification because of its shallowness and its circulation is heavily influenced by the Detroit River flow, although wind events modify circulation patterns and impact propagation of river plumes, like that of nutrient rich Maumee River, critically important for lake-wide phosphorus load and hypoxia. Model results showed the importance of northwesterly winds for the transport of Maumee River waters to the central basin, enhancing nutrients delivery conducive to hypoxia.

Winter circulation in the presence of ice is less known than summer circulation and impacts of ice on lake circulation and lake ecology are poorly understood. Lake Erie is at least partially covered with ice from December until April, and its normal peak ice cover is about 90%. Observations in the central basin during two consecutive winters (2011 and 2012) revealed both cyclonic and anticyclonic monthly circulation patterns, although in the colder than average winter of 2010-2011 there was tendency to a cyclonic circulation while during mostly ice-free winter of 2011-2012 a tendency toward an anticyclonic circulation was observed. Temperature field was rather uniform both vertically and horizontally. Coupled ice-circulation model was applied to Lake Erie during 2010-2012 and results are compared with observations of ice concentration, thickness, velocity, water temperature and currents.

Keywords

Lakes; circulation; stratification; modelling; ice.

Internal Kelvin waves in a large mid-latitude lake

Flood, B.* 1, Wells, M1

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**Corresponding author, e-mail bryan.flood@mail.utoronto.ca*

ABSTRACT

Internal waves in a long embayment are examined to characterize the influence of Coriolis forces on structuring cold-water fish habitat usage. Lake Simcoe has a surface area of 722 km^2 and is located at 44.4° N, 79.7° W in Ontario, Canada. The 45 m deep, 15 km long and 2.5 km wide Kempenfelt bay is the main region of deep water that supports the commercially important cold water fishery. We will present detailed observations of late summer thermocline dynamics between August 18th to September 30th 2014 in Kempenfelt Bay. The dominant periods of the thermocline movements were approximately 70 hours and 4 hours, and the thermocline could move by as much as 15 metres in a day

We will show that wind-induced forcing sets up a Kelvin wave that propagates counter clockwise along the shore of the bay. The Burger number, Bu, is the ratio of deformation radius to basin width and is useful in determining which physical processes dominate in a lake and is defined as,

$$Bu = \frac{c}{fL} = \frac{\sqrt{g'H}}{fL}$$

where c is the phase speed of the internal wave, f is the Coriolis parameter, L is the length scale that characterizes the horizontal dimension, H is the equivalent depth, and g' is the reduced gravity. Kempenfelt bay is large enough to have a $Bu \approx 3$, resulting in the thermocline movements being strongly influenced by Coriolis forces. A lateral tilt of the thermocline across the 2.5 km wide bay of as much as 6 metres was observed due to the geostrophic balance of the Coriolis force. Idealized numerical simulations, using the MITgcm non-hydrostatic model, of the internal wave dynamics will be presented to help interpret our field data.

The deep, channel-like Kempenfelt provides habitat for cold-water fish species that have optimal growth in cold oxygen-rich water. The spatial dynamics of fish could thus respond to both the large amplitude and the lateral tilt of these internal waves. We will present preliminary statistics correlating the spatial abundance of fish measured by hydroacosutic surveys, with the variability of the thermocline depth, and discuss the potential biological implications of these persistent thermocline movements.

KEYWORDS

Lake Simcoe; Internal waves; Kelvin waves; Coriolis force; non-hydrostatic numerical model

Mixing regime of a shallow urban lake, Lake Créteil, France: measurements and simulations

F. Soulignac[1], B. J. Lemaire [1,2]*, J.R. Martins[3], I. Tchiguirinskaia[1], D. Schertzer[1] and B. Vinçon-Leite [1]

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[2] *AgroParisTech, Paris, France*
[3]*University of Sao Paulo, Brazil*

**Corresponding author, e-mail bruno.lemaire@leesu.enpc.fr*

ABSTRACT

Most urban lakes are shallow, *e.g.*, former sand pits or retention basins. They provide varied amenities, including the increasingly demanded outdoor activities and bathing. But many of them are eutrophic and threatened by proliferations of phytoplankton, especially of toxic species. Law often encourages the reduction of the external nutrient load to these lakes. But unlike in deep lakes, phytoplankton proliferations can continue for many years after the reduction, since wind-induced mixing can release an internal load from the sediment many times in the year (polymicticity). To warn for harmful algal blooms or to assess how climate change may impact their frequency, a correct simulation of the alternation between stratification and mixing periods is required.

We therefore investigated the mixing regime of a shallow urban lake, Lake Créteil, a former sand pit and now eutrophic lake (surface 0.40 km², mean depth 4.5 m, catchment area 1 km²). Meteorological variables and water temperature at 5 depths were measured in the deepest part of the lake (5.5 m) every 30 s from May to August in 2012, 2013 and 2014. Mixing and stratification periods were sorted on daily maximum and minimum differences between subsurface and bottom temperatures. The number of days of stratification (78, 81 and 60 days) and mixing (26, 34 and 47 days) and the number of stratification periods (6, 3 and 4) showed a strong inter-annual variability.

We then tested whether a hydrodynamic model could reproduce these features. We already presented last year the calibration of Delft3D-FLOW on a one-month period and its performance on vertical and horizontal temperature heterogeneities, current speeds and internal waves. Here we only modified the wind drag coefficient to calibrate it on 2012 temperatures, and verified it on 2013 and 2014 temperatures. Simulation results reproduced well the observed inter-annual polymictic patterns for all three years, with less than 10 % error in the number of mixing or stratification days.

Such a validated model, forced with outputs of a regional climate model, could be very useful to predict changes in mixing regime and phytoplankton dynamics in temperate shallow urban lakes.

KEYWORDS

Thermal stratification; biogeochemistry; high-frequency measurements; 3D modelling.

Modeling five Great Lakes ice-circulation system using an unstructured-grid coupled model

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[2] *Cooperative Institute for Limnology and Ecosystems Research, University of Michigan, Ann Arbor, Michigan, USA*

**Corresponding author, e-mail jia.wang@noaa.gov*

Abstract

A coupled Great Lakes ice-circulation model (GLIM) using an unstructured Finite Volume Coastal Ocean Model was modified and applied to all five Great Lakes simultaneously to simulate circulation and thermal structure from 1993 to 2008. Model results are compared to available observations of currents and temperature and previous modeling work. Maps of climatological circulation for all the five Great lakes were presented. Winter currents show a two-gyre type circulation Lakes Ontario and Erie and one large-scale cyclonic circulation in Lakes Michigan, Huron, and Superior. During the summer, a cyclonic circulation remains in Lakes Superior; a primarily cyclonic circulation dominates the upper and central Lake Huron; Lake Ontario turns to have a single cyclonic circulation, while circulation in the central basin of Lake Erie remains two-gyre type; Lake Michigan has a cyclonic gyre in the north and an anti-cyclonic one in the south. The temperature profile during the summer is well simulated when a surface wind-wave mixing scheme is included in the model. Main features of the seasonal evolution of water temperature, such as reverse stratification during the winter, the spring and autumn overturn, the thermal bar, and the stratification during summer are well reproduced. The lakes exhibit significant annual and interannual variations in current speed and temperature. The model successfully reproduced seasonal cycle of lake ice cover, the lake-wide mean surface temperature and lake circulation.

Keywords

Great Lakes; coupled ice-circulation model; unstructured grid model, stratification.

Upwelling in dimictic lakes in spring

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Abstract

Seasonal mixing and stratification processes in dimictic lakes are well known phenomena. The former is characterized by vertical exchange of water masses, the lattersecond is characterized by stable layers which inhibit the vertical exchange across the entire lake. Nevertheless, under certain conditions such as weak stratification and a sufficient strong and directional external force (mainly wind) a vertical exchange of water masses is also possible during stratified conditions. This process is called upwelling (UW) which is well described for great lakes but not for smaller lakes. In the present study two lakes in the North German Plains, Lake Arendsee and Lake Stechlin, were investigated by airborne infrared imaging (TIR), on site measurements of the temperature in the upper centimetres of the water column and temperature depth profiles. The first two approaches were used to identify the surface temperature pattern of the lakes since if upwelling is present it dominates the overall daily temperature pattern of the lake. Both approaches match in an overall pattern of warmer eastern/southern areas and colder western/northern areas. Comparing the pattern with the dominating wind direction indicate a close relationship. Moreover, the temperature depth profiles which were measured along two transects in Lake Arendsee confirm that the observed temperature pattern at the surface continues in the deeper water of the lake. Hence, the results indicate that upwelling occurred during the investigation period. To estimate whether the observation was by coincidence or if it is a reoccurring event Lake Number and Wedderburn number were calculated for several years. If both numbers are below one that indicates UW. Both numbers are below 1 for the investigation period. Additionally, this was found regularly in spring and autumn directly before or after the mixing period. Hence it could be concluded that UW periods have to be taken into account in studies focussing on transport processes in lakes.

Keywolds

Dimictic lakes; upwelling; thermal infrared imaging; Lake Number; Lake surface temperature

Using large lakes for heating and cooling – potential and limits

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Abstract

The will to reduce carbon fuel and the limits for shallow geothermal heat extraction in densely-populated cities, generates interest in the use of lake water for heating and cooling of urban infrastructures. We explored heat use effects on temperature and stratification of Lake Constance by applying a one-dimensional k-epsilon model to various scenarios of heat extraction and release and compared them with model runs for local current and climate-modified future heat flux boundary conditions (Fink 2014a). Generally, the study showed only minor effects for a realistic heat demand of ~2 Wm^{-2} quite independent of the heat extraction / discharge mode of operation. The evaluated effects are changes in temperature, seasonal deep-convective mixing, duration and strength of the seasonal stratification as well as secondary effects of combining cooling and heating (Fink 2014b).

These results are compared to the inverse scenario in Lake Biel, where the inflowing River Aare is used for heat discharge from a nuclear power station releasing ~20 Wm^{-2} of excess heat to Lake Biel which has a short residence time scale. The model allows to investigate the changes in the above mentioned parameters for the opposite mode of operation and for much larger heat flux changes, which are more in the range of the expected climate scenarios.

Keywords

Heat use; cooling water; climate change; Lake Constance; Lake Biel; Aare

References

Fink, G., M. Schmid, B. Wahl, T. Wolf and A. Wüest (2014a). Heat flux modifications related to climate-induced warming of large European lakes. Water Resources Research. 50: 2072 – 2085, doi: 10.1002/2013WR014448.

Fink, G., M. Schmid and A. Wüest (2014b). Large lakes as sources and sinks of anthropogenic heat: Capacities and limits. Water Resources Research. 50: 7285–7301, doi:10.1002/2014WR015509.

Solute transport in permeable sediments with stationary and migrating bedforms

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Abstract

Permeable sediments are widespread in river beds and continental shelves where they act as highly reactive natural filtration systems that modify the spreading of nutrients and contaminants. In these sediments, current-induced pressure gradients along small-scale topographies (ripples) drive porewater advection. The resulting dynamic and enhanced flux of solutes across the sediment-water interface stimulates benthic metabolism and especially microbial activity. The dynamic forcing, however, complicates the investigation of benthic-pelagic exchange processes under *in situ* conditions and the role of permeable sediments in regional and global elemental cycling is still poorly constrained. Although transport processes in permeable sediments were extensively studied in laboratory flumes and numerical models, dedicated *in situ* studies are rare and the effect of sediment transport, i.e. the migration of ripples, has been neglected so far. In this study we combine numerical modelling and *in situ* measurements to investigate porewater transport and quantify O_2 fluxes under dynamic boundary conditions, including ripple migration.

We applied a multi-physics model coupling the transport in bottom water (Large-Eddy-Simulation) and porous media (Darcy) with rates of O_2 respiration. Empirical relations were applied to predict migration celerities of bedforms. Migrating bedforms significantly changed the O_2 distribution in and below the bedform, as high migration velocities led to fully oxic bedforms which were separated from the underlying anoxic layer by a sharp oxycline.

Similar patterns were observed under *in situ* conditions in the North Sea. Combining *in situ* measurements of current velocity and high resolution topography scans with multiple crosscutting benthic O2 profiles we found benthic O_2 distributions to respond to stationary and migrating bedforms. Simultaneously measured volumetric O_2 consumption rates were integrated over a cross-section of measured O_2 profiles, which allowed for the estimation of O_2 fluxes ranging between 10-60 mmol/m^2/d. In contrast to findings of previous model studies no efflux of anoxic porewater was indicated, suggesting that transient currents and bedform migration lead to an increased O2 dispersion in surface sediments. The results indicate that dynamic sediment transport significantly increases the spatio-temporal variability of redox conditions to which micro-organisms are exposed in permeable sediments.

Keywords

Bedforms; Migration; Hyporheic flow; Modelling; Biogeochemistry; Measurements.

Heat exchanges between water and sediment in extremely-shallow lagoons on the Altiplanic region of Chile

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Abstract

Extremely shallow lagoons of a few centimetre depths are found in the Andean region called Altiplano. These shallow lagoons are located in the desert at 3500 masl, thus supporting the life of a unique ecosystem. Previous studies showed that water temperature varies 20 to 30ºC in a day, while the air temperature varies 0 to 30 °C in a day, and that the sediments act as a heat reservoir that retains heat during the day and releases it during the night. As a consequence, the amplitude of water temperature fluctuation in a day is reduced by heat exchanges with sediments.

The aim of this article is study periodic heat exchanges across the water-sediment interface (WSI) based on the combination of laboratory experiments and numerical simulations. Numerical simulations are based in a spectral model that decomposes the heat exchanges with the atmosphere in a Fourier series, and uses the analytic solution of the second problem of Stokes to compute heat fluxes across the WSI. Two dimensionless numbers are identified to describe the dynamics: i) the ratio between thermal inertial of the water column and heat fluxes at the WSI, which controls both the thermal amplitude and the lag between time series of water temperature and heat fluxes with the atmosphere. And ii) the ratio between the rate of heat transport in the water and the sediments, which quantifies the influence of turbulence in heat exchanges across the WSI.

Experiments were conducted in a tank that contains sediments collected from an artificial lagoon located near the university campus, and a water column of height that varied between 3 to 10 cm. Artificial lights were mounted above the water, and were periodically turned on and off to emulate the diurnal cycle. Water temperature micro-profiles were near the WSI were used to measure water temperature and the heat flux at the WSI.

Experimental and numerical results were used to: i) validate the spectral model for computing water temperature in extremely shallow lagoons; ii) quantify the role of heat exchanges across the WSI, and iii) quantify the influence of turbulence diffusion at the WSI.

Keywords

Water temperature; heat budget in extremely shallow lagoons; water-sediment interface;

Characterization of benthic oxygen exchange rates in permeable sediments (southern Baltic coast) – best practice for aquatic eddy correlation flux estimates in presence of surface waves

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Abstract

Oxygen exchange across the sediment-water interface is a central process for surface sediments biogeochemical activity, carbon turnover and composition of benthic communities. Resolving dissolved oxygen fluxes in coastal areas with aquatic eddy correlation (EC) offers considerable advantages over traditional flux measurement techniques. By the simultaneous recording of vertical velocities and oxygen concentrations at a specific distance to the seafloor, the EC method is the most qualified approach for studying shallow water benthic exchange, allowing relatively long-term flux estimates under naturally varying light and current flow. This is important because the hydrodynamics in coastal permeable sediments drive pore-water motion in the upper sand layers, inducing considerably rapid (hours) carbon turnover. The widespread consensus on the EC advantages for such highly dynamic environments however has not yet led to a clear approach when it comes to processing data obtained in the presence of high frequency surface waves (0.1-1 Hz). This is however a crucial aspect, since such waves are almost "physiologic" in shallow coastal areas where swells dominate.

Here we present oxygen exchange rates obtained by an EC system and simultaneously deployed stirred benthic chambers from a coastal ecosystem of the southern Baltic Sea (Hel Bight). Firstly we assess an interpretation of EC flux estimates when surface wave motions dominate the turbulence range, identifying if/when/how these may bias flux calculations. Secondly, we examine rates and controls of benthic oxygen fluxes for shallow water permeable sediments, comparing the results obtained at different spatial resolutions, as well as among other studies for similar conditions.

EC flux measurements at Hel Bight spanning over light and dark hours showed a consistent shift from oxygen production to consumption. Both chambers and EC showed similar gross oxygen production of approx. +80 mmol m^{-2} d^{-1}, revealing that at the time of this study (August/September 2011) the site was net autotrophic. It was further assessed that aerobic oxidation of organic matter represents the main mineralization pathway, with oxygen consumption rates of approx. -50 mmol m^{-2} d^{-1}, comparable to results measured in other coastal sandy sediments.

This work was supported by 7th framework EU ITN-project SENSEnet and BONUS+ project AMBER.

Keywords

Eddy correlation; benthic chambers; coastal permeable sediments; oxygen fluxes; surface waves

The contrasting effect of sediment gas voids on diffusive fluxes of high-soluble and low-soluble dissolved substances

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Abstract

Accumulation of free gas is a common phenomenon in aquatic sediments, where gas contents can reach up to 10% of the sediment volume. The presence of free gas in sediments and ebullition can influence the pore water exchange across the sediment water interface. It has been documented that, in some cases, ebullition can enhance the pore water flux in permeable and semi-permeable sediments and thus contribute to internal nutrient loading that in turn, further exacerbates CH_4 production. Our sediment ebullition experiments, however, indicate that apparent diffusivities of soluble substances in gas bearing sediments were in fact not enhanced, but reduced by ca. 25%, despite active ebullition. We attribute these results to stationary gas voids within the sediment acting as additional 'obstacles' for soluble species, thus increasing tortuosity and decreasing the apparent diffusivities of soluble species. Furthermore, we demonstrate with an example how O_2 oversaturation in autotrophic benthic sediment layer could increase the flux of low-soluble gases (i.e. O_2) by several factors. Finally we discuss the implications of these effects for the understanding of internal nutrient loading and dissolved gas fluxes in aquatic water bodies.

Keywords

Free gas; sediment; oxygen; methane; pore water fluxes

Rocking Seiches and Sediment Dancers: Effects on Sediment Oxygen Uptake and Porewater Chemistry

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Abstract

The vertical distribution of dissolved oxygen (O_2) across the sediment-water interface in freshwater systems is frequently controlled by diffusion of O_2 into the sediment from the overlying water. However, bioturbation is often an overlooked transport mechanisms in silty sediment and may have significant influence on the extent of the sediment oxic zone and porewater geochemistry. We performed a three-day study during August 2012 in Lake Stechlin (near Berlin, Germany) which is known for strong periodic seiching. Additionally, while bioturbation effects have not previously been actively studied in Lake Stechlin, high levels of bioturbation have been observed in neighboring lakes. Our goal for the study was to primarily focus on the influence of seiching on sediment oxygen and redox dynamics and to also assess if there were any bioturbation effects. Using in-situ microprofile and current velocity measurements, we assessed sediment O_2 uptake in Lake Stechlin and initially anticipated diffusion to dominate O_2 transport into the primarily silty sediment. According to the microprofile data, diffusion-controlled O_2 transport did occur; however, during approximately 50% of the campaign (~36 h), advective and/or bioturbative transport of O_2 seems to have dominated within the upper 2 cm of sediment, resulting in (1) an enhanced O_2-penetration depth (>1.5 cm), (2) considerably elevated O_2 porewater concentrations, and (3) the absence of a purely diffusive O_2 consumption curve at the sediment surface. Also somewhat surprising was the fact that negligible seiching occurred during our campaign. In parallel to O_2 microprofile measurements, in-situ redox microprofiles and voltammetric-electrode profiles of sediment cores were obtained to characterize corresponding variations in porewater redox and reduced-metal concentrations, respectively. This novel pairing of measurements shows beautifully the correlation between O_2 availability, shifts in redox potential, and subsequent reduction of available electron acceptors in the sediment (e.g, manganese and iron oxides). The considerable changes in sediment porewater O_2 concentration observed during the course of our study were not found to affect the redox-gradient position and porewater distribution of reduced metals. This work highlights the influence that transient 'dancing' infaunal communities and current velocity may have on sediment porewater O_2 levels and resultant geochemistry.

Keywords

Lakes; bioturbation; microprofiles; sediment oxygen uptake; porewater geochemistry.

Challenges in fine-resolution modelling of marshes, bayous, and river deltas

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Abstract

Airborne lidar provides detailed topography suitable for fine-resolution hydrodynamic modeling of marshes, bayous, and river deltas. Although lidar can readily provide 1 x 1 m resolution (or better), practical models typically use coarser than 10 x 10 m grid scales for marshlands larger than 1000 hectares. The recent widespread availability of lidar data inverts decades of hydraulic modeling practice: we have been accustomed to coarse data and (relatively) fine model grid scales, which are accompanied by globally calibrated roughness parameters. Now that we know what the finer scale actually are, we need to effectively interpret and model subgrid-scale flow effects without relying heavily on calibration.

In particular, the proliferation of small channels, ridges, heterogeneous vegetation, and multiple flow pathways through marshes and deltas can be difficult to represent at coarser scales. Failure to correctly represent these features can significantly affect predictions for salt/fresh water mixing that is critical to the ecology in many estuaries during summers and extended droughts. Using lidar data for the Nueces River delta and the Guadalupe River bayous along coastal Texas (USA), we illustrate how these challenges can be addressed within two-dimensional hydrodynamic models. Critical are new edge-blocking features to represent long and narrow ridges that control flood propagation during high flow conditions. Similarly, for low flow conditions new model features represent fluxes through the narrow channel networks that are finer than the model grid. Field data collected across the Nueces and Guadalupe systems are compared to the models and illustrate the challenges associated with calibration for multi-flowpath systems.

Keywords

River deltas; hydrodynamic modeling; lidar; estuaries; salinity-freshwater balance.

THE ROLE OF HYDRODYNAMICS IN SHAPING THE COMPOSITION OF STREAM BIOFILMS UNDER CONTRASTING TROPHIC CONDITIONS

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Abstract

Fluvial biofilms that are surface-associated microbial communities (usually dominated by bacteria, cyanobacteria, algae, fungi and protozoans) embedded in a matrix of extracellular polymeric substances constitute an integral part of aquatic ecosystems and are controlled by many factors such as light, grazing, resource availability, water chemistry and hydrodynamics. Natural mountainous streams are characterized by a high spatio-temporal variability of the stream bed and corresponding flow field. As a consequence, hydrodynamics become a dominant factor shaping biofilm attributes through drag forces and control the supply of nutrient resources through mass transfer processes. Previous studies have been restricted to flume experiments where the highly complex flow field of natural streams cannot be reconstructed to the full extent. In a novel approach we are linking detailed investigations on stream bed heterogeneity and associated near-bed flow to biofilm attributes like, e.g., biofilm community structure, spatial morphology, biomass and quality. We conducted measurements in two mountainous streams (Harz region, Germany) comparable in stream bed morphology but differing in water chemistry. Compared to the Kalte Bode, the water of the Selke has higher concentration of N, P and Chl a. The water of the Selke has a mean N : P ratio of 11 while that of the Kalte Bode has a mean value of 30 indicating P limitation. An acoustic Doppler velocimeter (Vectrino Profiler, Nortek AS) was used to estimate vertical profiles of shear stress above stream biofilms in pool and riffle structures along 700 m long reaches. Our results show that for higher shear stresses thin layered biofilms of bacteria, spherical cyanobacteria and the prostrate diatoms dominate, whereas at lower shear stresses biofilm appearance was more heterogeneous in terms of morphology and diversity. Furthermore we found indications that under different trophic levels the shear stress affected specific biofilm characteristics in opposing ways. Under non-limiting P conditions, Chl a abundance was negatively correlated to shear stress whereas biofilm autotrophic activity (as estimated by the ratio of dry mass to Chl a) was not affected by increased shear stress. In contrast, under P limitation, biofilms showed higher autotrophic activity with increasing shear stress whereas Chl a concentrations were not correlated to shear stress.

Keywords

mountainous streams; biofilms; shear stress; trophic level.

Current measurements close to the sediment-water interface using a high resolution acoustic velocity profiler

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Abstract

Current velocity measurements at high spatial and temporal resolution are required for the detailed study of solute and momentum transfer close to the sediment water interface. In this zone, advective fluid motions lose importance and molecular forces dominate transport. This transition zone extends in the order of a few millimeters above the sediment. Most devices which provide such a high spatial resolution only allow one-point measurements and therefore require stepwise profiling resulting in a loss of temporal resolution. Recently, a bistatic acoustic current profiler (Nortek Vectrino II) has become commercially available which allows the recording of profiles at 1 mm resolution with a maximum frequency of 100 Hz. We tested this profiler in the laboratory as well as in a lake. While average velocity measurements were in good agreement with theoretically expected profiles, variances of turbulent fluctuations as well as Reynolds stresses showed contaminations by high frequency noise. In our presentation, we will illustrate the potentials and shortcomings of the novel profiler for the study of fluid flow close to the sediment-water interface in natural systems.

Keywords

Sediment-water interface, acoustic Doppler profiler, viscous sublayer

Contrasting response of river water temperature to heatwaves

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Abstract

Heatwaves in Europe are expected to increase in intensity, timing and frequency in the whole alpine area during next decades. The consequences of such extreme climatic events on river water temperature, albeit largely unknown, are relevant for both society and ecosystems.

Here we use the instrumental record of the Swiss monitoring network to identify the anomalies of air and river water temperature during the period 1984-2013. We find that the thermal response of natural rivers is strongly correlated with air temperature, especially during summer months, and that the decline of water availability plays a negligible role. In particular, we show that monthly averaged air and water temperature anomalies soared to approximately 5°C during the two most intense heatwaves of the investigated period (June-August 2003 and July 2006). On the contrary, regulated rivers that receive cold water from reservoirs used for hydropower production did not respond to such extreme warm events, a response that is similar to that of high-altitude rivers fed by glaciers and snowfields. We conclude that heatwaves heavily affect natural rivers, whereas the alteration of the river thermal behaviour due to landscape features or hydropower production may mitigate the effects of such extreme events. Our findings highlights additional concerns and complexities in the integrative management of river ecosystems to predicted global changes in precipitation and temperature.

Keywords

Rivers; temperature anomalies; hydropower; climate change.

Temporal dynamics of cohesive sediment and associated pollutant transport in mid-mountain gravel bed rivers

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Abstract

As biogeochemical storage pools for contaminants, fluvial cohesive sediments and suspended particles have a considerable impact on the water quality. River bottom sediments for instance act as a temporary source and sink for hydrophobic pollutants particularly during and in the aftermath of natural floods, where fluvial transport, remobilisation and deposition processes occur during short time intervals. Consequently, a comprehensive assessment of this short-term cohesive sediment transfer through riverine systems is a prerequisite to elaborate sustainable river basin management strategies.

The objective of our investigation is twofold: First, we compare temporal dynamics of weekly-sampled river bottom sediments (<63µm) and associated pollutant transport in two mid-mountain gravel bed rivers of different size (24 & 240 km²) in order to evaluate the transferability to other mid-mountainous regions. Second, we analyse the steering in-channel processes in detail using controlled reservoir releases in both basins. The outstanding advantage of this artificial flood approach lies in the selective control on some governing processes by experimental design. This includes for instance hydraulic boundary conditions such as the total and peak discharge and the duration of the flood event. The measurement program contains particle bound heavy metals, PAHs and nutrients, grain size distributions and suspended matter amount. The influence of biofilms was estimated via analysing organic carbon, nitrogen and uronic acids. During the artificial floods, additional techniques such as FTIR-DRIFT spectrometry, turbidimetry and laser diffraction were applied to study in-situ cohesive sediment transport and controlling biophysicochemical particle characteristics.

Our results show that short-term variations in hydrological boundary conditions, the activation and exhaustion of sources, mixing and dilution effects during flood events as well as seasonal fluctuations of living organic material are responsible for high and scale-independent temporal dynamics of cohesive sediment and associated pollutant transport. While overall patterns at different scales matched very well, certain event-related chemical responses indicated basin specific processes. The artificial flood experiments reveal that in-channel kinematic waves are responsible for a scale-independent, discontinuous sediment transport comprising hysteresis effects and a short term alteration of erosion, transport, resuspension and deposition periods. Implications of these results for river monitoring strategies will be discussed.

Keywords

Cohesive sediments; floods; rivers; suspended matter; pollutant transport

On-line system to support winter navigation in ice channels

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Abstract

Ships in ice navigate mostly in ice channels, which icebreakers or ships themselves break into the fast or drift ice. Ship proceeding in such an ice channel experiences the ice resistance, which influences the ships speed and manoeuvrability or even ship safety. The ice resistance to be experienced by ships could be estimated beforehand by ship captains relying on ice charts data but the latter are rather coarse. We propose to use ship hull vibration intensity as the measure for ice resistance acting on ship. The recorded data on the ship hull vibrations together with the on-board ice observations and general ice conditions estimated from satellite images allowed us to assign a specific rank for the severity of ice conditions for the ice channel segment where ship was operating. In order to supply the system with forecasting skill, a fuzzy logic relational scheme was defined, applied and validated. The fuzzy model relaying on HIRLAM wind forecast and ice data deduced from MODIS satellite images produces 48 hours forecasts of ice resistance. An attempt was made to estimate ice characteristics from more frequently available TerraSAR-X Data. Web-based on-line system http://on-line.msi.ttu.ee/ship6a/ combines measured and forecasted ice resistance data, as well most important forcing parameters and available satellite imagery. System was designed and realised in the years 2013-2015 for the fairway into Pärnu Port (Gulf of Riga, Baltic Sea) and is open for wide range of users, showing on-line *in-situ* navigation conditions in ice in places where ships actually are operating.

Keywords

Winter navigation; ice resistance; shiphull vibration; fuzzy logic model.

Quantifying and removing the carbon dioxide gas oversaturation in meromictic Guadiana pit lake

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Abstract

Guadiana pit in Herrerias Mine (Andalusia, Spain) was filled by inflowing groundwater after mining activity had ceased. Oxidation of metal ores created acid mine drainage, which formed a heavily acidified lake (ph in the range of 2.5 to 4). This acidic water dissolved carbonates from within the ore material by forming carbonic acid (dissolved CO_2). Due to this process, each liter of deep water (monimolimnion) accumulated up to 2.5 liter of CO_2. The resulting gas pressure was getting close to the absolute pressure in the deep water that action had to be taken to prevent a possible eruptive release of the gas volume. In this talk, we demonstrate sampling of the extremely gas oversaturated waters for their gas content and the installation of a vertical pipe, which releases the gas pressure in the deep waters. The flow is solely driven by the buoyancy of the released gas. - Sánchez-España, J., Boehrer, B., Yusta, I. Environ. Sci. Technol. 48 (8), 4273 - 4281 (2014) doi: 10.1021/es5006797

Keywords

Dissolved gas, carbon dioxide, limnic eruption

Under ice Circulation and Greenhouse Gas Evasion in Arctic Lakes

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Abstract

Arctic lakes are ice-covered nine months of the year during which time greenhouse gases increase in bottom waters and increased discharge associated with snowmelt supplies greenhouse gases and dissolved organic carbon to the lakes. We tested the hypothesis that evasion of greenhouse gases depends on the duration of the mixing period after ice off by quantifying the greenhouse gases produced over the winter, those introduced at snowmelt, and those remaining after stratification in five lakes (from 1 ha to 150 ha in area) in the Alaskan arctic. Horizontal CTD and oxygen transects taken in one lake while the lake was ice covered and afterwards illustrated the path of incoming snowmelt water, numerous locations with hypoxia, and gravity current formation due to warming of bottom waters under the ice which also moderated stratification dynamics. Increased winds accompanying ice off led to large amplitude downwelling of the thermocline and formation of non-linear internal waves in the larger lake. The fraction of carbon dioxide emitted in spring depended on intensity of wind, density stratification, and lake morphometry, as described by the Lake number, and time for stratification to set up. We hypothesize that the fraction of methane which evades can be quantified by dimensionless indices which incorporate residence time and reaction times. Use of dimensionless numbers which incorporate hydrodynamics and rates of biogeochemical reactions enable scaling up across the landscape.

Keywords

Arctic lakes, ice cover, stratification, internal waves, gas exchange

Integrated modelling of water quality targets for the south-western Baltic Sea

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Abstract

The Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) aim both on achieving a good ecological status. For the MSFD ecological targets have been set for the Baltic subbasins within TARGREV and revised nutrient load reductions of the HELCOM parties have been adopted in the Baltic Sea Action Plan (BSAP).

To define the targets for the German WFD waterbodies we transferred today measured Secchi Depth and concentrations of Chlorophyll, Total Nitrogen and Phosphorus to the state of 1880, which serves as reference for an ecological status only minor disturbed by human activities. For that purpose we computed the change of the water quality parameters between two simulations with the Baltic Sea ecosystem model ERGOM-MOM, one with the present nutrient loads and one with the reconstructed loads for the historical state. For the historical German loads (including the Oder) we used the results of the catchment model MONERIS. Further, we estimated the upper limit of 2.6 mg TN/l for the German rivers entering the Baltic Sea to achieve the water quality targets, while on the other hand the nutrient input reductions of the BSAP from 2013 are not ambiguous enough to reach the WFD goals in the German coastal waters.

Keywords

Water quality of coastal waters; Water Framework Directive; Marine Strategy Framework Directive; Baltic Sea Action Plan; integrated modelling.

Shallow Gassy Sediment Characterization in Lake Kinneret Using Low-Frequency Sound Signal

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Abstract

Shallow gassy sediments abundantly found in various aquatic ecosystems worldwide are a source of potent greenhouse gases and concern for their contribution to air pollution and global warming. Gas bubbles within the sediment alter effective sediment properties, including geo-acoustical parameters; and, thus, gassy sediments characterization can be an important subject of acoustical research. Our experiment was carried out in winter 2015 in Lake Kinneret possessing typical shallow water waveguide properties (depth of ~40 m, nearly constant sound speed profile) and high gas methane content in the top sedimentary layer, as shown by earlier studies. An acoustic source was positioned at the 10-m water depth radiated 7 sequences over two-minute series of Linear Frequency Modulated (300 Hz – 2000 Hz) signals with the two-seconds duration each. Sound was recorded with a single hydrophone fixed at 10-m depth at various ranges from the source: from a few tens of meters up to 6000 m. Properties of signals passing from the source to the receiver demonstrated the large reflection coefficient from the bottom even for small reflection angles, which pinpoints the relatively small sound speed in the sediment and suggests the presence of free gas bubbles in the upper sediment layer. The theoretical model of the sound propagation was parameterized to find the characteristics of the surface gassy sediment (sound speed and thickness) that would provide the best agreement between the theoretical model and the experimental measurements. We showed that the following parameters best fit the experimental results: thickness of gassy sediments of ~ 20-50 cm and speed of longitudinal compressional waves of ~ 300-600 m s^{-1}. The details of the interference structure of the sound field and connection with sediment parameters are discussed.

Keywords

Gassy sediment; methane bubbles; hydroacoustics; sound propagation; acoustic parametrization of surface sediment.

Microbubble enhanced diffusive methane emissions from oligotrophic Lake Stechlin: A hypothesis

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Abstract

We resolved surface CH_4 and CO_2 fluxes from an oligotrophic lake during the onset of fall turnover using the floating chamber method. Assuming Fickian transport, the normalized exchange rates, K600, should be equivalent for the individual gases. While true for wind speeds < 2 m s^{-1}, we found that K600 for CH_4 increased faster with wind speed than K600 for CO_2, and was 4 times higher at a wind speed of 7 m s^{-1}. The most probable explanation for the K600-CH_4 enhancement is the exchange of microbubbles in the lake's surface layer. An increase in K600 due to microbubbles is much more pronounced for the sparingly-soluble gases CH_4, N_2 and O_2 than for soluble gases, such as CO_2. While the source of the microbubbles is unclear (atmospheric entrainment, dissolved gas supersaturation, or both), we determined that an average of 145 L m^{-2} d^{-1} of microbubble gas exchange is required to produce the observed elevated K600-CH_4. As K600 parameterizations are used to estimate diffusive CH_4 emissions from aquatic systems, the presence of microbubbles could substantially increase CH_4 fluxes and therefore alter C balances.

Keywords

Surface flux; methane; floating chamber; microbubbles; lake.

Carbon dioxide evasion from headwater systems strongly contributes to the total export of carbon from a small boreal lake catchment

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Abstract

Inland waters are hotspots for carbon (C) cycling and therefore important for landscape C budgets. Small streams and lakes are particularly important; however, quantifying C fluxes is difficult and has rarely been done for the entire aquatic continuum, composed of connected streams and lakes within the same catchment.

We investigated carbon dioxide (CO_2) evasion and fluvial fluxes of dissolved inorganic carbon and dissolved organic carbon (DIC and DOC) in stream and lake systems within a small catchment of a boreal lake in Sweden. Our results show pronounced spatial and temporal variability in all C fluxes even at this small spatial scale. C loss from the catchment through CO_2 evasion from headwaters for the total open water-sampling period in this study was 9.7 g C m^{-2} catchment, dominating the total catchment C loss (including CO_2 evasion, DIC, and DOC export from the lake, which were 2.7, 0.2, and 5.2 g C m^{-2} catchment, respectively). The aquatic CO_2 evasion was dominated by headwater streams that occupy ~0.1% of the catchment but contributed 65% to the total aquatic CO_2 evasion from the catchment. The importance of streams was mainly an effect of the higher gas transfer velocities (*k*) estimated, than compared to lakes (median, 67 and 2.2 cm h^{-1}, respectively).

Accurately estimating the contribution of C fluxes from headwater streams, particularly the temporal and spatial dynamics in *k*, is a key factor for estimating landscape-scale C budgets. Our study demonstrates that CO_2 evasion from headwaters can be the major pathway of C loss from boreal catchments, even at a small spatial scale. Future work aims to investigate *k* in these small stream systems further, by comparing *k* determined by tracer injections to turbulent kinetic energy dissipation rate (ε), measured by an Acoustic Doppler Velocimeter (ADV).

Keywords

Small lakes and streams; carbon flux; gas transfer velocity; tracer injections; ADV

Inundation and Gas Fluxes from Amazon Lakes and Wetlands

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Abstract

Inundation and wetland habitats for the lowland Amazon basin are combined with estimates of greenhouse gas evasion derived from field measurements and new formulations of gas exchange to improve regional estimates. Total floodable area within the lowland Amazon basin is about 800,000 km^2. We measured turbulence as rate of dissipation of turbulent kinetic energy based on microstructure profiling in an Amazon lake. Comparison of these measurements with those calculated from meteorological and time series measurements validated new equations for turbulent kinetic energy dissipation (TKE) rates during moderate winds and cooling and illustrated higher dissipation rates under heating. Measured gas exchange coefficients (k) were similar to those based on the TKE dissipation rates. These k values are several times higher than previous values applied to regional extrapolations in the Amazon basin.

Keywords

Amazon lakes, gas exchange, turbulence

Lesson from long-term eddy covariance measurements over lakes

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Abstract

The eddy covariance (EC) technique is the only standard tool to measure fluxes of material and energy at ecosystem scale representing the larger area of the studied surface, such as lake. EC data on carbon dioxide fluxes is presently available on about 30 lakes but the time series are mostly short, order of one year. Long series would allow for detection of e.g. inter-annual variability, effects of anomalous weather episodes and trends stemming from environmental changes and climate change. We discuss on challenges for long-term EC measurements over freshwater ecosystems and demonstrate the benefits of EC data for carbon cycle studies via examples from four EC sites in Finland (Lakes Kuivajärvi, Pallasjärvi, Valkeakotinen, Vanajanselkä). We discuss on the auxiliary measurements needed, the general design of the whole measurement set-up to get representative information together with floating chambers. We demonstrate some challenges for determining the gas exchange coefficient between water and air and for getting estimates for carbon cycle components like photosynthetic sink and respiratory sources. We also discuss on differences between small and large lakes and how they are reflected both in the planning of the measurements and in the analysis of the data. The knowledge on local micrometeorology and turbulence from atmospheric observations and flow modeling is an important pre-requisite to obtain the overall comprehensive picture on lake-atmosphere continuum.

Keywords

Lakes; carbon dioxide; eddy covariance; fluxes; turbulence; micrometeorology

Adaptive Real-time, Self-Learning River Basin Living: Challenges

Jörg Imberger

Abstract

Natural systems such as catchments, rivers, lakes, estuaries and coastal seas are under increasing threat from depletion of biodiversity, nutrient enrichment, metal contamination and introduction of very low levels of carcinogenic compounds. Human development is the cause of this degradation and so there is an urgent need to develop quantitative management strategies that allow balanced objectives to be achieved between the material benefits of development and the dangers of degradation of the functionality of the environment. The present response of naive legislating regulatory requirements only makes the problem worse. A new methodology, based on the Index of Functional Sustainability (ISF) has recently been developed that provides a quantitative foundation for multi-objective design where, for instance, a reservoir can be managed to function as a bulk water resource, flood control, recreational area, a carbon sink, a source of fish protein and the reservoir catchment may also be managed to induce greater rainfall. This methodology may be coupled with real time measurements of water properties in the natural system, the data from which are checked for integrity and then archived into a flexible relational data base system by the Aquatic Real Time Management System (ARMS). ARMS also controls a series of numerical models (Dynamic River Model (DYRIM), Dynamic Reservoirs Simulation Model (DYRESM), Estuarine, Lake Computational Model (ELCOM) and the Computational Ecological Aquatic Dynamic Model (CAEDYM)) as well as the atmospheric boundary layer Weather Research and Forecast model (WRF) that are validated in real time using the real time data. Further, ARMS automatically initiates, at regular intervals, simulation runs of pre-specified scenarios computing the associated ISF ready for interrogation at a manager's convenience. A web based interrogation tool, called OLARIS, is used for both mining the real time database and the results from the ARMS initiated simulations. The suite of new instruments and software combined with the ISF collectively offer a totally new way managing natural water bodies. The talk will illustrate the new methodology as applied to three operating examples; Swan Canning Estuary and River Basin including the Coastal Ocean, Western Australia; Lake Superior, North America and Lake knitter, Israel.

Sensitivity of phytoplankton spring blooms to meteorological variability

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Abstract

The phytoplankton spring bloom is a cardinal event in most lakes of the temperate zone. It is of importance as an energy supply for higher trophic levels. In deep lakes, the spring bloom is mainly determined by stratification onset and thus by abiotic conditions in the lake. Therefore, timing depends on local meteorological conditions. Quantifying this dependency remains difficult and has often been narrowed down to changes in air temperature. By generating several hundreds of meteorological time series with a weather generator, we were able to run a probabilistic simulation for a large monomictic lake (Lake Constance). We could show that meteorological variability alone leads to high variability in the timing of the phytoplankton spring bloom. Single meteorological variables did not explain this variability as different variables may counteract each other. Changing air temperature, shortwave radiation and wind speed separately from each other showed the strongest change in timing for wind speed and the least for air temperature. We therefore challenge the strong focus on air temperature in climate change studies. Rather, changes in overall weather situations and the impact of other meteorological variables have to be taken into account.

Keywords

phytoplankton spring bloom; weather generator; aquatic ecosystem model; meteorological variability; monomictic lake

Oxygen transport and consumption during the formation of a metalimnetic oxygen minimum

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Abstract

During summer stratification, eutrophic lakes often suffer from severe oxygen depletion in the hypolimnion. Some of these lakes also develop a metalimnetic oxygen minimum. Its formation generally can be attributed to the intrusion of oxygen-depleted or -depleting water; the respiration of zooplankton, bacteria, or algae; or a high sediment surface-to-water volume ratio. Besides these oxygen consuming processes, the oxygen concentration at a certain depth also depends on the net vertical transport towards this depth. But the role of the oxygen flux divergence during the formation of a metalimnetic oxygen minimum was rarely considered in former studies.

To examine the causes of the metalimnetic oxygen minimum in Lake Arendsee, Germany, and the relevance of oxygen transport in its formation, we deployed thermistor- and optodechains with high vertical and temporal resolution during the stratification period in 2013. Additionally, an automated profiler recorded depth profiles of temperature, dissolved oxygen, and turbidity during the first week of June 2013. The dataset was complemented by depth profiles of photosynthetically active radiation measured during monthly field campaigns. Analyses were based on an oxygen mass balance using diffusivities estimated with the heat budget method.

In the metalimnion of Lake Arendsee, the net oxygen transport was in the same order of magnitude as the observed temporal change in oxygen concentration. Net Transport counteracted respiration and thereby attenuated the observed metalimnetic oxygen decrease. Therefore, neglecting oxygen transport leads to a considerable underestimation of oxygen consumption. The metalimnetic oxygen minimum in Lake Arendsee was mainly caused by microbial respiration while sediment oxygen uptake did not contribute to the observed oxygen decrease considerably and a minor contribution of zooplankton respiration could not be excluded. Microbial respiration depended strongly on turbidity which is assumed to approximate the supply of organic matter, and to a minor extend on temperature.

Keywords

Lakes; metalimnetic oxygen minimum; respiration; oxygen transport; negative heterograde oxygen curve

Withdrawal regime changes and their consequences on stratification and water quality dynamics within a drinking water reservoir

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Abstract

The recent years have shown a growing pressure on using and managing drinking water reservoirs in Germany. Modifying the reservoir management in the focus of withdrawal depth and amount will have a strong effect on the ecosystem within the water body, besides varying environmental conditions. In this presentation an example of a modified withdrawal regime at the Gross Dhuenn Reservoir, the 2nd largest drinking water reservoir in Germany, will be given. Since the first operation in 1987, water for lower Dhuenn River (downstream the reservoir) has been taken from the bottom outlet and has therefore been cold. To improve habitat conditions for fish communities in Dhuenn River, warmer water is required. The reservoir management will therefore change the withdrawal regime from hypolimnetic (i.e. 4-5 °C) to epilimnetic withdrawal (i.e. 12-16 °C). A modelling study was initiated to explore the effects of a changing withdrawal regime on the physical structure and the water quality dynamics within the reservoir. We implement a 1D hydrodynamic model ("General Lake Model"-GLM, Hipsey et al., 2014) to simulate effects of a modified reservoir management on the stratification of the water body. The Grosse Dhuenn Reservoir model was successfully calibrated for the period of September 2006 to July 2013 and shows good agreement between the observed and modelled water levels and temperatures. Simple scenario runs with modified withdrawal depths show a remarkable effect on the temperature stratification. Changing parts of the GLM source code will allow us to account for a dynamically depth-changing withdrawal in the focus of an isotherm or a water temperature time series from the upstream river as a reference.

Keywords

Reservoirs; withdrawal depth; stratification; water quality; modelling.

REFERENCES

Hipsey, M.R., Bruce, L.C., Hamilton, D.P., 2014. GLM - General Lake Model: Model overview and user information. AED Report #26, The University of Western Australia, Perth, Australia. 42pp.

Integrated modelling of water quality targets for the south-western Baltic Sea

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Abstract

The Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) aim both on achieving a good ecological status. For the MSFD ecological targets have been set for the Baltic subbasins within TARGREV and revised nutrient load reductions of the HELCOM parties have been adopted in the Baltic Sea Action Plan (BSAP).

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Keywords

Water quality of coastal waters; Water Framework Directive; Marine Strategy Framework Directive; Baltic Sea Action Plan; integrated modelling.

Modelling vertical distribution of *Planktothrix* in Lake Hallwil

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Abstract

The buoyancy of cyanobacteria with gas vesicles such as *Microcystis aeruginosa* and *Planktothrix rubescens* is determined mostly by photosynthesis and respiration. The interplay between vertical mixing, irradiance and vertical mobility requires careful modelling for yielding the correct vertical distribution of cell mass. For *Microcystis aeruginosa* in temperature-stratified lakes the simulation of the vertical distribution is achieved by modelling the changes in specific weight of cell material through the Fokker-Plank equation, implemented in a 1DV model, for details see (Aparicio-Medrano et al. 2013).
We applied the previous methodology to Lake Hallwil, the medium-sized, phosphorous-limited, eutrophic, and 48 m deep lake is located on the Swiss Plateau. Since 1986 Lake Hallwil is artificially mixed in winter by air-bubble plumes and in summer its hypolimnion is oxygenated by weak oxygen-bubble plumes which preserve the natural thermocline structure. In the 1DV model we included the winter mixing by air-bubble plumes and adapted the light-dark changes of Planktothrix cell mass according to (Kromkamp & Walsby 1990). In simulations covering 2010 to 2014 we achieved the example shown in Figure 1: the vertical distribution is in excellent agreement with observations in Lake Hallwil. In agreement with (Bright & Walsby 2000) we show that their net growth-rate model overestimates the increase in total Planktothrix mass for reasons we are currently investigating.

Keywords

Lake Hallwil; *plankthotrix rubescens*, modelling; thermocline; air-bubble plume.

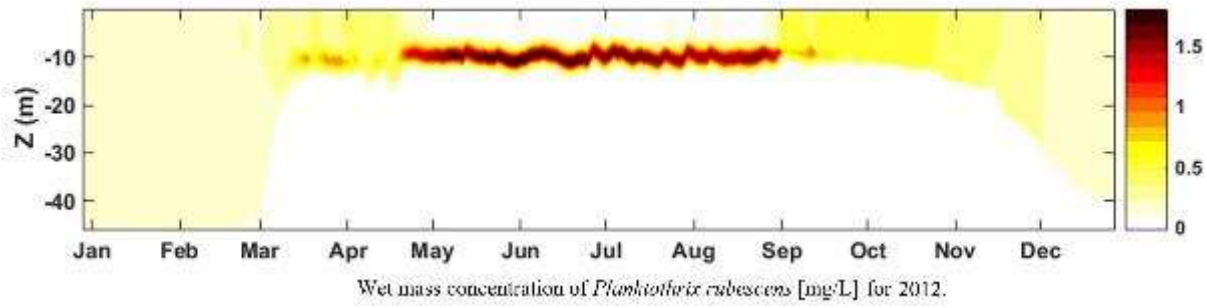

Figure 1. The simulated vertical distribution of *Planktothrix* filaments in Lake Hallwil for 2012 shows their concentration as soon as the thermocline evolves end April and the upward mixing in autumn.

References

Aparicio-Medrano, E. R.E. Uittenbogaard, L.M. Dioniso Pires, B.J.H. van de Wiel & H.J.H. Clercx (2013) Coupling hydrodynamics and buoyancy regulation in *Microcystis aeruginosa* for its vertical distribution in lakes. *Ecological Modelling*, 248, pp. 41-56.
Bright D.I. & A.E. Walsby (2000) The daily integral by growth of *Planktothrix rubescens* calculated from growth rate in culture and irradiance Lake Zurich. *New Phytol*, 146, pp. 301-316.
Kromkamp J.C. & A.E. Walsby (1990) A computer model of buoyancy and vertical migration in cyanobacteria. *J. Plankton Res.*, vol. 12, no. 1, pp. 161-183.

Bacteria cause mixing in Lago di Cadagno, Switzerland

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Abstract

Bacteria mix an approximately 1 m thick layer at 12 m depth in alpine Lago di Cadagno, Switzerland. The ≈ 10 µm long and ≈ 5 µm wide phototrophic *Chromatium okenii*, living at the interface of the sulfide-rich anoxic deep-water and the shallow oxic water, are able to induce bioconvection because they are (i) heavy (~20% denser than water due to intracellular sulfur deposits), (ii) able to swim upward (toward the light), (iii) of elongated shape and (iv) of so high abundance to affect the local density (10^5 ml^{-1}). The energy for mixing is supplied by upward swimming of the heavy bacteria. The downward motion is caused by sinking due to gravity. Sufficiently large sink velocities for mixing are achieved by accumulation of bacteria in the downward plumes. Accumulation occurs intrinsically because elongated upward swimming bacteria exposed to shear are always deflected into the downward plumes (gyrotaxis).

Our microstructure measurements in 2013 and 2014 showed that the strength of mixing agrees with the energy input of the bacteria. In August 2015 we plan simultaneous measurements of biological and physical parameters to explain the effect of bacterial metabolisms on the rate of mixing.

Keywords

Bioconvection; bacteria; phototaxis; gyrotaxis; motility.

Poster Abstracts

Abstracts are presented in alphabetical order.

Poster

Drifting versus static chambers for measuring air-water gas fluxes in running waters

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Abstract

A common method to estimate the gas flux of, e.g., of CO_2 and CH_4 across the air-water interface is to use flux chambers. While measuring the rate of a gas accumulation in their headspace, chambers can deployed either fixed at a certain position (static) or freely floating (drifting). The flux is related to the difference in gas partial pressure across the air-water interface and to the transfer velocity, which depend on near-surface turbulence. Hence, any modification of the flow field by the chamber deployment affects the transfer velocity and the measured flux. Because the chamber headspace is usually sealed against the atmosphere by submerged parts of the side walls, it is likely that the chamber measurements are affected by the shear flow at the chamber edges. We investigated the effect of penetrating side walls on the flow field under the chamber using particle image velocimetry in a laboratory flume. Comparative flux measurements were conducted under field conditions at stream reaches with distinct hydraulic conditions (ranging from slow smooth flows to fast rough flows). Direct comparisons of fluxes were obtained from static and from drifting chambers with different penetration depths of the chamber walls. The measured fluxes and gas partial pressures were used to estimate the transfer velocities under the chamber at the different deployment conditions. Our results highlight the non-negligible effect of chamber-induced shear flows at the submerged edges. A correction of flux estimates from static chamber measurements is recommended at sites where drifting chambers cannot be deployed.

Keywords

Inland waters; floating and static chambers; turbulence; gas transfer velocity.

Assessment of potential algal blooms in a shallow fluvial lake through hydrodynamic modelling and remote-sensed images

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Abstract

Shallow fluvial lakes consist of highly-dynamic ecosystems shaped by the interactions between biological, e.g. nutrient load and primary producers, and physical factors, e.g. wind and through-flowing discharge. Knowledge of their eutrophication potential and of their most vulnerable areas to possible anoxia and toxicity phenomena would warn on negative effects arising from man-made actions.

In this work, we show how areas of most likely phytoplankton accumulation can be forecasted from the simulated flow fields obtained for the meteorological and hydrological conditions of interest. We built a 3D numerical model of the Superior Lake of Mantua, a shallow fluvial lake in the Po Valley (Northern Italy), originated from damming of River Mincio in ancient times. The lake receives an high nutrient load, whose effects are exacerbated by low discharges during the summer because of ordinary water diversion and possible drought. The lake has wide lotus flower meadows, influencing the flow field as well as planktonic primary production. Adaptation time of lake circulations to variations in the external conditions was found to be in the order of few hours, much shorter than the one of algal dynamics, so that biological phenomena are secondary to the determination of phytoplankton distribution.

We performed numerical simulations of multiple past daily conditions, comparing the hydrodynamic variables to the chlorophyll-*a* fields obtained from remote-sensed airborne and satellite optical images. We found consistent relations between the two products, in particular we observed that algal horizontal patchiness is mostly linked to generalized advection in the wind direction, supported or opposed by the trough-flowing riverine current, according to the direction of the former, determining large-scale chlorophyll-*a* gradients. Phytoplankton accumulation is also prominent inside gyres and slow-flow areas, where water residence times are higher, leading also to increased proliferation. Local currents also contribute to shape small-scale assemblies.

The robustness of the relations also constitutes a validation for the hydrodynamic model. Its combination as a forecasting and insight tool to remote-sensed images, used for large-scale periodical monitoring, would support and extend ordinary ecological measurement campaigns based on local sampling, aiming at a more conscious water resource management and more effective ecosystem protection measures.

Keywords

Fluvial lakes; phytoplankton patchiness; numerical modelling; remote-sensing; water resource management.

Poster

An Assessment of the Vectrino Profiler for Mean Flow and Turbulence Measurements at the Sediment-Water Interface

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Abstract

Measurements of flow and turbulence with high spatio-temporal resolution are of critical importance for a variety of hydraulic applications, including river restoration and ecohydrological studies. In 2012, a new generation of the Acoustic Doppler Velocimeter (ADV), the bi-static Vectrino Profiler (Vectrino II, Nortek AS), has been introduced to meet the needs for increased spatial resolution. The instrument is capable of measuring three-dimensional flow velocities over a 35 mm profiling range with a resolution of 1 mm, and at a sampling rate of 100 Hz. Although it is a relatively new instrument, it has become an increasingly popular tool among hydraulic researchers and engineers for investigation of flow and turbulence in a variety of laboratory flows, small estuaries, river reaches, and coastal applications. We, for the first time, evaluated the performance of the Vectrino Profiler for measuring flow and turbulence characteristics by comparing it to Particle Image Velocimetry (PIV) in a laboratory flume. The measured mean velocities, turbulence kinetic energies, and stresses were compared with those of the PIV. The mean and turbulence flow characteristics measured by the ADV were dependent on seeding density and our results results suggest that Signal to Noise (SNR) values smaller than 15 dB should be discarded when the whole profiling range of the instrument is used. However, SNR values greater than 15 dB close to the sweet spot can still provide good measurements, which is a little less than recommended by the manufacturer. The errors in the mean velocities varied between 0.50 - 9.5 %, depending on the seeding concentration. Measurements in the vicinity of a rigid boundary revealed that boundary interference influenced the mean flow as close as 3 - 5 mm from the bed, depending on the bottom material and seeding concentration. The errors in the mean velocities were within 3.5 – 7 % of the PIV velocities at 3 - 5 mm above the bed.

Noise correction methods applied to the ADV measurements improved the agreement of TKE profiles and provided a very good match with the PIV close to the sweet spot (bin 12). The covariances of velocity components, however, deviated strongly from the PIV measurements. This is an unexpected result because the covariances were known to be not affected by the Doppler noise. We will present practical suggestions regarding the identification of the biased region

Keywords

Vectrino; Particle image velocimetry; acoustic doppler; velocity; turbulence; sediment-water.

Spatial variability of methane ebullition in tropical reservoirs assessed by hydroacoustics and bubble trapping

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ABSTRACT

Reservoirs are important atmospheric sources of methane, a greenhouse gas 25 times more potent than carbon dioxide. Methane emission from reservoirs is heterogeneous however, and current estimations are probably too low since they generally miss emission hotspot areas. Methane is a product of organic matter biodegradation in anoxic sediments. Reaching the water column, it can either be oxidized to carbon dioxide, or released to the atmosphere via diffusion, ebullition or plant-mediation. Ebullition, the release of methane through bubbles that are formed in the sediments and travel through the water column, is a major emission pathway especially in shallow waters. Methane production depends on temperature as well as on quantity and quality of available organic matter, and methane ebullition is eased by reduced pressure on the water column. We hypothesize therefore that emission is generally expected to be high in hot climates during periods of low water level (low hydrostatic pressure), with hotspots in areas where sediment is deposited and organic matter accumulates. To gain a better understanding on hotspots and spatial distribution of methane emission, we collect data from seven tropical reservoirs of different size, age, climatic and geographic characteristics in both wet and dry season. We use a hydroacoustic echosounder for a spatial description of methane ebullition. With bubble traps, flux chambers and methane profiles in the sediments, we compare methane flux and concentrations in hotspot and non-hotspot ebullition areas within and between reservoirs.

We collected first data from Chapéu d'Uvas, an oligotrophic drinking water reservoir in Minas Gerais state of Brazil and the hypereutrophic hydroelectric reservoir Funil in Rio de Janeiro state of Brazil. For Chapéu d'Uvas Reservoir, we found increased ebullition in inflow areas of streams, and observed a decrease in emission as the water level increased. We are currently collecting data from Funil Reservoir. With this dataset, we can compare hydroacoustic measurements and methane fluxes and concentrations from two reservoirs with different trophic state and thus different supply of organic material. We expect our results to highlight the contribution of methane ebullition and the importance of hotspot areas for total methane emission from tropical hydroelectric reservoirs.

KEYWORDS

Hydroacoustics; methane; bubbles; climate; lakes.

Poster

Roughness, Resistance, and Dispersion – Relationships in Small Streams

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Abstract

Although relationships between roughness, flow, and transport processes in rivers and streams have been investigated for several decades, the prediction of flow resistance and longitudinal dispersion in small streams is still a challenging objective. Major uncertainties in existing approaches to quantifying flow resistance and longitudinal dispersion at the reach scale arise from limitations in the characterization of riverbed roughness at all relevant scales. Here we analyze high-resolution measurements of stream depth and width, which resolve the complete roughness spectrum with scales ranging from ~1 mm up to the reach scale (22...111 m). Measurements were performed in small moderate-gradient streams with distinct channel types including fixed bed channelized reaches and near-natural reaches. Simultaneous tracer experiments and water level surveys were conducted to estimate discharge, mean flow velocity, longitudinal dispersion, and water surface slope. The estimated flow resistance and dispersion coefficients were related to riverbed roughness, which was analyzed through use of different multi-scale parameters. Both coefficients were strongly correlated with each other and affected by riverbed roughness. The results show that both flow resistance and longitudinal mixing in these small streams are mainly determined by roughness at the mesoscale, i.e., at length scales which are larger than grain size and small-scale form roughness, but smaller than the downstream variation of the river width. A comparison of our results to common approaches for estimating flow resistance from bulk parameters revealed a sound agreement with relationships obtained for high gradient rough flows, while approaches for high relative submergence overestimated the observed resistances.

Keywords

Riverbed; relative submergence; semivariogram; spectra; flow velocity.

Observations of turbulence during a zooplankton migration in a small lake

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Abstract

Recent researches in oceans suggest that the Diel Vertical Migration (DVM), a predator-avoidance mechanism adopted by most zooplankton organisms, may be a considerable and additional source of turbulence and mixing. In particular the migration can play a crucial role when organisms cross the thermocline, enhancing the mixing in the lake interior with a consequent impact on quality of lake ecosystem functioning. A pilot field experiment was performed to directly measure the kinetic energy dissipation rate generated by DVM of Daphnia spp., a 1-5 mm crustacean zooplankton of Cladocera order. Profiles of turbulence were acquired with a free falling microstructure profiler in Monkswood Reservoir (UK), a small manmade lake with small wind fetch, steep sides, and a flat bottom with a mean depth of 6m and a maximum of approximately 11 m. Twenty-seven profiles were measured over the course of three hours during sunset on 1 September 2014, during which there was no wind. Zooplankton horizontal and vertical distribution was quantified by collecting samples with a 100 µm mesh and analysing the specimens under a dissecting microscope. Tows were conducted before and after the turbulence profiling in three layers to verify the distribution of Daphnia spp. before and after the migration. The zooplankton tows showed an increase in Daphnia above 6 m depth and a decrease below 6 m after sunset with a variation of approximately 13 ind./dm^3 from 3 ind./dm^3 in the first 3 m. There was also an increase in the dissipation rate of turbulent kinetic energy to 10^{-7} W/kg (two orders of magnitude above the background levels) at 6 m depth over the course of the time series. Given the uncertainty in measuring the length scales of turbulence associated with small zooplankton, it is not certain if the observed turbulence during the time of migration was due the migration or due to other causes, such as the onset of penetrative convection associated with night-time cooling.

Keywords

Lakes; mixing; turbulence; zooplankton; water quality.

Poster

Regional estimates of fluvial CO_2 gas fluxes

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Abstract

Estimating greenhouse gas (GHG) emissions on a regional level is complex and challenging due to large spatial and temporal variations of fluxes. Despite their limited spatial extent, particularly inland water systems can have a disproportionately high impact on the GHG balance within the terrestrial landscape. Quantifying the role of inland water systems in terms of carbon sinks and sources and their connection to the terrestrial ecosystems and landscapes is fundamental for improving the balance approach of regional and global carbon budgets. Recent studies showed that freshwater bodies emit significant amounts of CO_2 into the atmosphere; however, most of the research effort has been focusing on lentic systems and larger lotic systems.

Here we estimated the regional evasion of CO_2 from the stream network of the State of Rhineland Palatinate (RLP) in Southwest Germany (48.9 – 50.9°N, 6.0 – 8.5°E) combining governmental water monitoring measurements from 1974 until 2011 with digitalized maps of stream network, catchment areas and digital elevation model.

Keywords

Fluvial systems; Headwaters; Greenhouse gases; Open channel method.