UP 7: Aquatic Systems: Limnology, Natural Waters, Wetlands and Soilmoisture

Cohesive freshwater and wetland focus, combining circulation, properties, biogeochemistry, and innovative sensing/quantification.

Time: Wednesday 11:15–12:30 Location: MER/0002

UP 7.1 Wed 11:15 MER/0002

One Dimensional Thermobaric Mixing in a Deep Lake — •Joshua Marks[1,2], Kazuhisa A. Chikita[3], and Bertram Boehrer[1,2] — [1]Department of Lake Research, Helmholtz Centre for Environmental Research - UFZ, Magdeburg, Germany — [2]Department of Physics and Astronomy, Heidelberg University, Heidelberg, Germany — [3]Arctic Research Center, Hokkaido University, Sapporo, Japan

Thermobaricity is defined as the temperature dependence of the compressibility of water. It leads to a decrease of the temperature of maximum density T_{md} with increasing pressure. This effect has significant impacts in many deep lakes, like Lake Shikotsu, Hokkaido, Japan. Despite this, it is often not implemented in lake models, except in combination with external forcing. We created a simplified 1D model with the surface temperature input as only external forcing, excluding salinity and any other competing influences. For stability considerations, we used the in-situ density. The model recreated the one dimensional deep water renewal with the following key features: (1) at the intersection of the temperature profile with the T_{md} line diffusion induces cabbeling which leads to thermobaricity driven deep water circulation, (2) this deep water circulation cell is detached from the surface, (3) the deep water stays isothermal, (4) and after the winter stratification the temperature profile aligns with the T_{md} line. The results emphasize the necessity and the feasibility of the implementation of thermobaricity in lake models to ensure correct behaviour of the deep water renewal.

UP 7.2 Wed 11:30 MER/0002

Sound Speed Contributions of Solutes in Water — •Ivan Selyakov, Lutz Hrdlicka, and Bertram Boehrer — Helmholtz Centre for Environmental Research, Magdeburg, Germany

This study provides a structured investigation of the fundamental property of sound speed in limnic waters, presenting systematic experimental data on the contributions of various electrolytes over a temperature range from 1 °C to 30 °C and concentrations up to 0.05 mol L-1. While established approaches such as the UNESCO formula and the TEOS-10 package describe sound speed in oceanic waters, information on the contributions of specific solutes in freshwater environments remains limited. We observed no evidence of nonlinearities in either temperature or concentration dependences within the studied range and accuracy. Coefficients for calculating sound-speed excess are provided for a range of salts containing all major ions commonly found in natural waters. Contributions in mixtures of salts can be directly added, and a numerical approach is introduced for predicting sound speed in arbitrary mixtures of the investigated ions, including unusual combinations found in volcanic or meromictic conditions. Using our data, isothermal and adiabatic compressibility as well as in-situ density can be calculated with enhanced accuracy. These findings are valuable for applied fields such as acoustic sensing and environmental monitoring, and for advancing theoretical understanding in physical limnology and aquatic thermodynamics. The numerical tool implementing this approach has been validated against the UNESCO formula.

UP 7.3 Wed 11:45 MER/0002

First Observations of Extreme Gas Accumulation in Meromictic Lake Kilevann — •Bertram Reventlow[1,2], Bertram Boehrer[2], Florian Meienburg[1], Joshua Marks[2], Marius Feuerle[1], Martina Schmidt[1], and Werner Aeschbach[1] — [1]Institute of Environmental Physics, Heidelberg, Germany — [2]Helmholtz Centre for Environmental Research - UFZ, Magdeburg, Germany

Lake Kilevann in southern Norway is a former fjord that became isolated from the sea about 8000 years ago due to isostatic rebound. In its deepest basin, a strongly stratified layer of ancient seawater remains trapped between 60 and 100 m depth. Such isolated layers in meromictic lakes tend to accumulate gases, which can lead to limnic eruptions. In Lake Kilevann, we measured methane concentrations among the highest ever recorded in lakes. Isotopic analyses of CO_2 and CH_4 indicate long carbon residence times, a biogenic origin, and active methanogenesis in the water column. Preliminary noble gas measurements suggest strong depletion, supporting the hypothesis of bubble-mediated gas transfer, which could potentially trigger an eruption. On the other hand, the water column is strongly stratified, except for a single double-diffusive convection cell near the lake bottom. Major ions exhibit fractionated depletion relative to oceanic values, indicating that molecular diffusion over the lake's lifetime is a key mechanism driving the dilution of the seawater.

UP 7.4 Wed 12:00 MER/0002

Airborne Lidar Measurements of Methane over Canada — •Arunima Das[1,2,3], Christoph Kiemle[2,3], Sabrina Zechlau[1,2], Martin Wirth[2], and Andreas Fix[2] — [1]Ludwig Maximilian University of Munich — [2]Deutsches Zentrum für Luft- und Raumfahrt — [3]Technical University of Munich

Methane(CH4) is a key greenhouse gas with an atmospheric lifetime of about 10 years and high mitigation potential. Wetlands, coastal zones and offshore oil and gas facilities are major CH4 sources yet quantifying emissions over these remains challenging. Passive sensors struggle over low-albedo water surfaces and in-situ data are sparse. The French-German MERLIN mission aims to address this gap. Its Integrated Path Differential Absorption(IPDA) lidar will retrieve global column-averaged CH4 independent of sunlight. IPDA maintains high precision over dark water, flooded wetlands, and high-latitude regions with low sun angles. A robust retrieval algorithm performing accurately across diverse surfaces is crucial for detecting small CH4 gradients. CHARM-F, MERLIN's airborne demonstrator provides essential testing. During the CoMet 2.0 campaign, it measured XCH4 across Arctic wetlands and lake systems in the Hudson Bay Lowlands with agreement to in-situ vertical profiles within 1%. Further analysis shows negligible bias over land and higher biases over water, majorly driven by varying signal-to-noise ratio. The upcoming campaign CoMet 3.0 will broaden environmental coverage over tropical wetlands in Brazil, further testing CH4 retrieval performance over extensive water-dominated regions. These observations significantly reduce gaps in global CH4 monitoring.

UP 7.5 Wed 12:15 MER/0002

Environmental monitoring with cosmic-ray neutrons: new experiments on ships, blimps, and trains — •Martin Schrön[1], Lasse Hertle[1], Daniel Altdorff[1,2], Solveig Landmark[1], Bernd Heber[3], Sascha Oswald[2], Peter Dietrich[1], and Steffen Zacharias[1] — [1]UFZ - Helmholtz Centre for Environmental Research, Leipzig — [2]Institute of Environmental Science and Geography, University of Potsdam — [3]Institute of Experimental and Applied Physics, University of Kiel

Cosmic-ray neutron sensing (CRNS) technology has emerged as a robust technique for measuring root-zone soil moisture and snow water equivalent at the hectare scale, addressing many limitations of traditional electromagnetic and remote-sensing methods. Here we will present three new applications that utilize mobile cosmic-ray neutron detectors to explore (i) Earth's geomagnetic field with the "Polarstern" research vessel from Bremerhaven to Antarctica, (ii) the soil moisture distribution of inaccessible regions in Germany using hot-air blimps, and (iii) country-scale soil moisture patterns using CRNS on trains along German railway networks. The three experiments showcase recent advancement in CRNS research which may contribute to new applications in hydrology, environmental physics, and even space wheather.