Universität Basel

Research Project

Ecosystem connectivity effects on the metabolism and greenhouse gas fluxes in warming Arctic and Alpine lakes (“ConGas”)

Third-party funded project

Project title Ecosystem connectivity effects on the metabolism and greenhouse gas fluxes in warming Arctic and Alpine lakes (“ConGas”)

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The great majority of global lakes is oversaturated with respect to carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These lakes are recognized as a globally significant source of greenhouse gases (GHGs) releasing annually up to 560 Tg CO_2-C, 220 Tg CH_4-C, and 0.6 Tg N_2O-N to the atmosphere. Traditionally, the lacustrine GHGs oversaturation has been considered to result mostly from the metabolism of terrestrial organic matter (OM) imported to lakes from their catchments. However, some high-latitude and -altitude lakes may seasonally become undersaturated in CO_2 and N_2O, thus possibly turning into a sink for the atmospheric GHGs, which has been largely understudied. In fact, we anticipate that GHG saturation levels in these remote lakes are likely to fluctuate strongly depending on the efficiency of cross- and within ecosystem connectivity effects that modulate the OM transport, as well as on the efficiency of in-lake transport, ventilation, and exchange between sediments and the water column. This project, thus, aims to improve our understanding of how climate-controlled connectivity effects across and within aquatic, terrestrial and glacial environments influence the organic matter flow and greenhouse gas (GHG) production and emission in high-latitude and -altitude lakes, as well as to incorporate resulting estimates for these environments in global carbon and GHGs budgets. Anticipating that the climate in the Arctic and Alpine regions is changing two to three times faster than anywhere else on our planet, we will develop and calibrate a process-based lake metabolism model, combining paleolimnological data, real-time limnological monitoring and field investigations, as well as experimental simulations of extreme meteorological and hydrological events, to more accurately predict future feedback effects between organic-matter processing rates and fluxes and the GHGs saturation levels across sediment-water and water-atmosphere interfaces in high latitude and altitude regions. The particular goals of this project will be reached by addressing 15 research hypotheses, centered around interactive mechanisms responsible for climate- and connectivity-dependent changes in the regimes of organic matter import and nutrient availability in lakes, as well as anticipated links to changes in water transparency, stratification strength and phenology. The potential mechanisms that we plan to investigate include: 1) longer-term temperature effects that enhance organic matter import to Arctic and Alpine lakes, thus stimulating microbial respiration and GHG production in the water column and sediments; 2) shorter-term effects of higher rainfall rates and warming-enhanced cross-ecosystem connectivity that can lead to large pulsed OM inflows into lakes and, thus, can disproportionately stimulate CH_4 and N_2O

production rates; 3) extension of the ice-free period in lakes and catchments, through the effects of warming and higher rainfall, allowing for higher OM inflows and longer periods when CH_4 and N_2O can be directly released to the atmosphere; 4) effects of atmospheric warming that, in turbid lakes, result in “thermal shielding” leading to the extension of anoxia in bottom waters and sediments, which is conducive to higher CH_4 and N_2O production; 5) warming-enhanced cross-ecosystem “feeding” allowing for a more labile fraction of OM to be imported to lake waters and sediments where it can fuel CH_4 and N_2O production; 6) more efficient transport of nutrients across ecosystem boundaries that allows for a higher phytoplankton production, thus stimulating biological CO_2 uptake and creating more substrate for methanogenesis; 7) greater CO_2depletion in the Arctic and Alpine lakes through weathering-associated chemical uptake. Overall, we anticipate that, as a consequence of the ongoing environmental changes and altered cross- and within-ecosystem connectivity, higher summertime primary production at the surface and greater OM burial in the sediments will ultimately lead to enhanced production and emissions rates of potent GHGs, such as CH_4 and N_2O, from Arctic and Alpine lakes. Considering that CH_4 is about 30- and N_2O about 300-times more potent then CO_2 (in terms of global warming potential), enhancement of ecosystem connectivity, likely leading to the increasing release of these potent GHGs from remote lakes, will have implications for their future contribution to the global GHG budget and the atmospheric greenhouse effect.

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