Seasonal variability in lakes' environmental processes reveal susceptibility to climate change

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Lake Geneva. Credit: Hugo Ulloa

A new study has shown how climate change could impact the ecosystems of the planet's largest lakes by revealing varying levels at which their water layers are mixed together through the seasons. As the climates warm, changes to the this process in the winter months could affect oxygen levels and other vital natural environmental systems.

Mixing, caused by natural turbulence of deep water bodies, controls the movement of heat, oxygen, nutrients and pollutants between different layers and therefore plays a major role in shaping how ecosystems adapt to environmental forces. In lakes and other inland waterbodies, where tidal currents are weak, the energy required for mixing is supplied by wind blowing at the surface, which energizes currents within the waterbody.

For this new study, an international study team used the 100-square-meter research platform LéXPLORE, floating in Lake Geneva, to continuously measure wind speed, lake current velocities and temperature, in the interior of the water body and near the sediment, for an entire seasonal cycle.

The findings, publishing the journal *Nature Communications Earth & Environment*, showed that the energy pathways are controlled by seasonality though changes in the intensity of winds and different layers of density within the water. In summer, mixing is weaker and restricted to the interior of the waterbody; this is the result of lighter winds and the stability brought about by heat from the sun which retains the wind energy in the upper water layers.

The LéXPLORE platform. Credit: Camille Minaudo

In the windier winter season, mixing was three times stronger and most of it took place in the bottom boundary layers over the lake sediments.

The study was led by Dr. Bieito Fernández Castro, a research fellow at the University of Southampton who began the study whilst working at École Polytechnique Fédérale de Lausanne, Switzerland.

Dr. Fernández Castro said: "Inland freshwater bodies like lakes are an important resource for the communities living around them; they can provide drinking water, food, generate energy and offer recreational opportunities. However this close interaction also means they face threats from human factors such as climate warming."

Previous studies on mixing in lakes have faced technical and operational challenges of measuring turbulence in the field with sufficient temporal coverage and resolution. This is therefore the first this is the first time

that such variability has been recorded, revealing the risk to the natural mixing process of rising global temperatures.

"This work illustrates the importance of monitoring lake currents and turbulence over long-periods of time to understand their response to climate change. Our results show that warmer climates in the winter months could strongly affect the patterns of turbulent mixing, particularly in the lowest layers. This could in turn have a significant effect on a lake's oxygen levels, resuspension of sediments—where particles on the bed are redistributed within the lake's water layers—and other vital environmental processes," Dr. Fernández Castro concluded.

The team also advise that many questions remain open for further research, particularly around the variability of this process near the shores compared to open water and on the response of near-surface mixing to strong, episodic wind events.

More information: Bieito Fernández Castro et al, Seasonality modulates wind-driven mixing pathways in a large lake, *Nature Communications Earth & Environment* (2021). DOI: 10.1038/s43247-021-00288-3

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