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Measuring methane accumulations from small lakes via eddy covariance
Los Gatos Research (LGR)

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Measurement made easy

Problem

While wetlands are responsible for a relatively large percentage of methane emissions, some scientists have suggested that lakes and other bodies of water may also contribute heavily. Small lakes have higher methane fluxes per unit area than large lakes. Recent estimates have significantly increased the number of small lakes worldwide. New research efforts can help to determine the scope of these emissions.

During the spring and summer when small lakes are biologically productive, they become thermally-stratified. Methane accumulates in the denser bottom water layer called the hypolimnion. Later in the season (late fall and early winter), the lake layers mix and assume a uniform temperature. This suggests a potential for large methane emissions during this period.

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ABB solution

Researchers* in Switzerland have evaluated this methane-emission potential with eddy covariance flux measurements from Lake Rot, near Lucerne. The research team employed the Fast Methane Analyzer (FMA) from Los Gatos Research, a member of the ABB Group. This analyzer provides continuous measurements of methane (CH_4) at speeds up to 20 Hz.

The FMA analyzer is ideal for eddy covariance flux field studies because it's rugged, simple to use, and reliable even under outdoor conditions. The analyzer uses LGR's patented Off-axis ICOS technology, the fourth-generation cavity enhanced laser absorption technique. This technology employs a high-finesse optical cavity as the measurement cell that greatly extends the laser's optical path (several kilometers), increasing its sensitivity.

Lake Rot is about 1.5 miles long and 650 feet wide. It is relatively wind shielded, leading to wind speeds between 0.9 to 16 mph about 4 feet above the lake surface. During these lake studies water temperature stayed between about 40 and 45 °F from October 20 to the 1st December.

In making the eddy covariance measurements, the researchers first constructed a small floating buoy. On the buoy they mounted an ultrasonic anemometer-thermometer and an air intake hose inlet protected by a funnel. They moored the buoy about 230 feet from shore. A vacuum pump on shore pulled air from the intake through Synflex tubing to the FMA analyzer situated nearby. Methane flux is computed as covariances between vertical wind speed and concentration measurements where delays caused by the tube and the analyzer are taken into account.

In this study researchers also used three other techniques to measure methane emissions from the lake: floating chambers, anchored funnels, and boundary model calculations.

Fig. 1: Postdoc Torsten Diem (right) and technician Michael Schurter launch floating buoy containing an ultrasonic anemometer-thermometer and an air intake hose inlet – a shore-mounted pump delivers the air samples to the LGR FMA analyzer nearby (Photo courtesy of Werner Eugster)

Results

Methane concentrations from October 14 to January 6 varied between minimum values of 1.88 ± 0.02 ppm (close to the mean global methane concentration in the atmosphere) and maximum values of 3.26 ± 0.30 ppm. Cumulative methane fluxes amounted to 5.4 g m-2 during the study period.

Fig. 2 shows daily methane flux determined by the FMA analyzer. The top graph shows methane accumulations over the study period. To eliminate system noise, researchers processed 30-minute flux data with a 5-point running average low-pass filter, indicated by the bold line in the bottom figure. As shown, two main emission events occurred during the three months, creating the main increments in the cumulative flux. During these events deep water containing high concentrations of dissolved methane was mixed upward toward the surface layer.

The study resulted in comparable cumulative methane emission data using the eddy covariance analyzer, floating chambers, and funnel methods. Uncertainties in the flux data measured by the funnel and floating chamber methods are likely higher than those of the eddy covariance analyzer. Effluxes derived from the boundary layer model may strongly underestimate methane fluxes when ebullition (bubbling) and convective turbulence dominate in the lake.

To conclude, estimating methane emissions from natural aquatic systems using eddy-covariance flux measurements--such as those made by the FMA analyzer--offer the most promise. Such measurements can capture diffusive plus ebullition methane flux. And they are also the only practical way to accumulate data over two or more months.

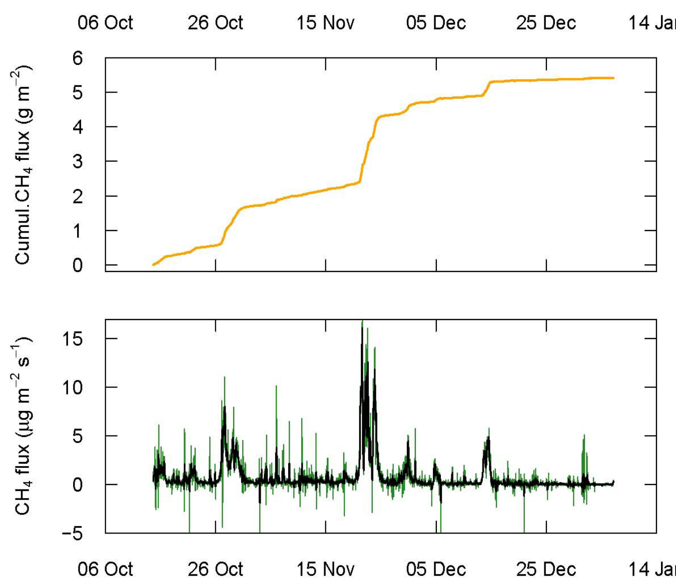

Fig. 2: Large methane emissions peaked around October 27-31 and November 20-25, indicated by the step changes in the upper graph that accumulates flux measurements

*References

Based on information from "*Methane Emissions from a Small Wind Shielded Lake Determined by Eddy Covariance, Flux Chambers, Anchored Funnels, and Boundary Model Calculations: A Comparison*" by Carsten J. Schubert, Torsten Diem, and Werner Eugster, Environmental Science & Technology, 2012, 46(8), pp 4515-4522.

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