Measurements of Mass, Momentum and Energy fluxes over an ice/snow covered lake

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Abstract

A better understanding of the interactions between ice and snow and the atmosphere requires improved measurements of energy, mass and momentum fluxes, which continue to have a high degree of uncertainty. In this communication, observed near surface fluxes of momentum, heat and mass (H_2O and CO_2) over a boreal lake during a freezing period (winter 2015/2016) will be analysed and compared with observations over ice free lakes. Continuously measurements of near surface fluxes of momentum, heat and mass (H_2O and CO_2) are obtained with a new eddy covariance (EC) system, the Campbell Scientific's IRGASON Integrated Open-Path CO_2/H_2O Gas Analyzer and 3D Sonic Anemometer, over lake Vanajavesi in Finland.

Measurement Site

The measurement site is located in a tip of narrow peninsula on the lake (61.133935°N ; 24.259119°E), offering very good conditions for eddy covariance flux measurements.

Installation 3 November 2015
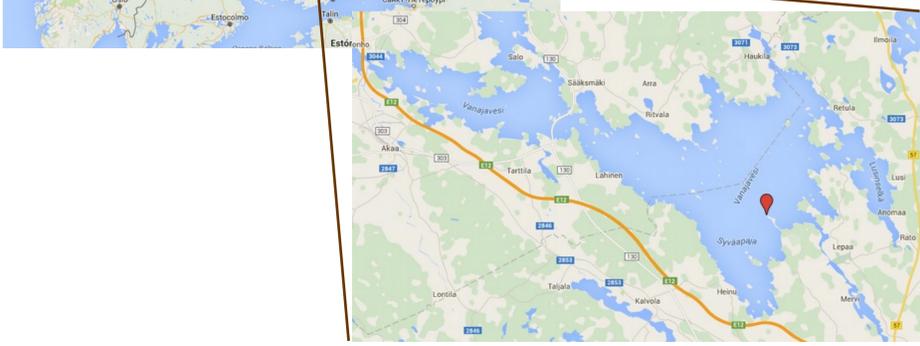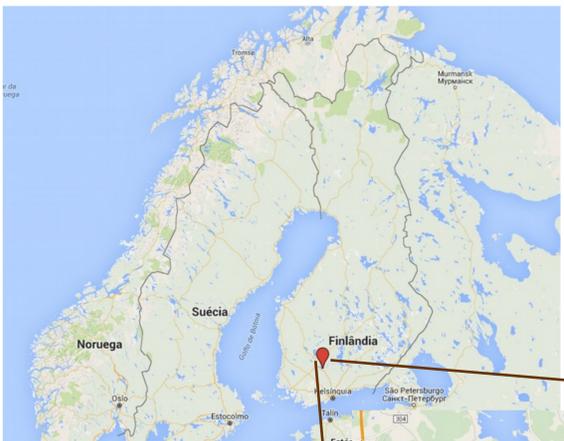
This study is part of an inter comparison experiment between the University of Helsinki, Finland, and the University of Évora, Portugal in the framework of COST Action ES1404

Évora University acquired a new Campbell Scientific's IRGASON Integrated Open-Path CO2/H2O Gas Analyzer and 3D Sonic Anemometer It was used in measurements over a not frozen lake: Alqueva, Portugal (Potes et al. 2016)

University of Helsinki is carrying EC measurements in boreal lakes since a long time and therefore has great experience in lake-atmosphere interaction either on ice free conditions (Mammarella et al., 2015) or over ice/snow covered lakes (Miettinen et al., 2015)

The present work is about the measurements carried out with this one in Vanajavesi

Eddy-covariance system

Continuously measurements of near surface fluxes of momentum, heat and mass (H2O and CO2) are obtained with a new eddy covariance (EC) system: the Campbell Scientific's IRGASON Integrated Open-Path CO2 /H2O Gas Analyzer and 3D Sonic Anemometer.

It simultaneously measures absolute carbon-dioxide and water-vapour densities, air temperature, barometric pressure and three-dimensional wind speed. Is the first eddy-covariance system with truly co-located measurement volumes for both analyser and anemometer

The EC system was installed at 2.5m height above the lake surface and was oriented against the prevailing wind direction in the site.

The eddy-covariance system was installed in November 3, 2015 and is collecting data, continuously since then.

Lake Vanajavesi started freezing over on 30 Dec, and it was completely frozen by 5 Jan

## Results   Sensible Heat Flux
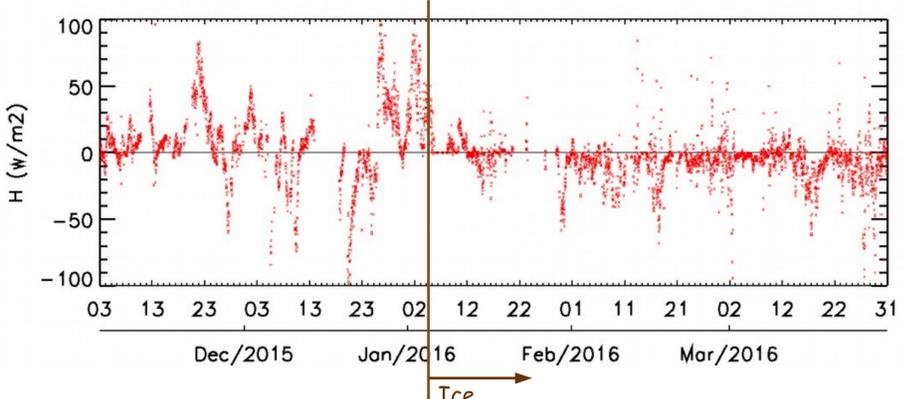
• As expected, sensible Heat fluxes (H) are very weak
• During freezing period H reaches 100 Wm^{-2}
• Over ice/snow, H are in general between – 50 and 50 Wm^{-2}
• In November, H is positive (water is losing energy), in March H is negative (air is heating the surface)
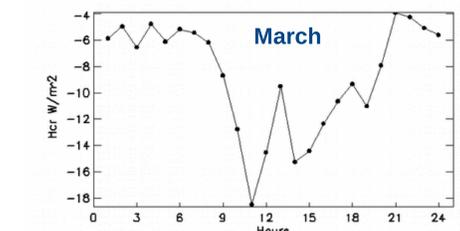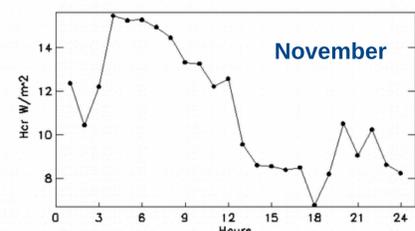
November   March

Monthly mean daily cycle in November 2015 and March 2016

## CO$_2$ Flux
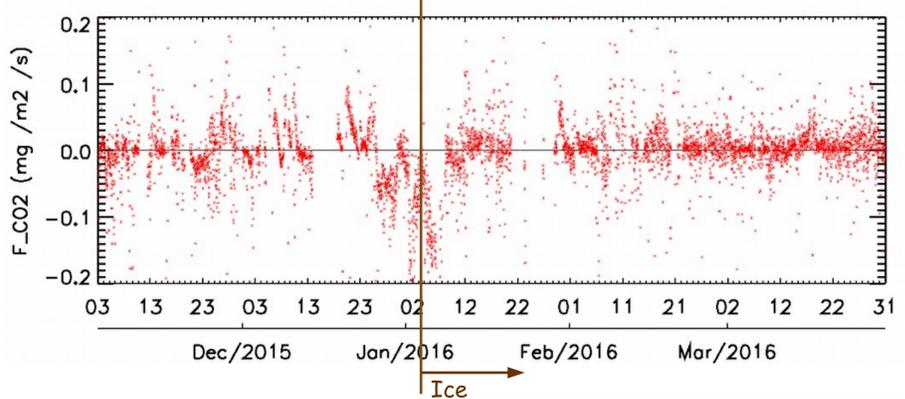
• As expected, CO2 flux over frozen lake is very weak, close to zero.
• Before, even in the freezing period, the CO2 flux was negative. The Lake act as carbon sink
• In March, the lake (frozen) emits CO2 into the atmosphere
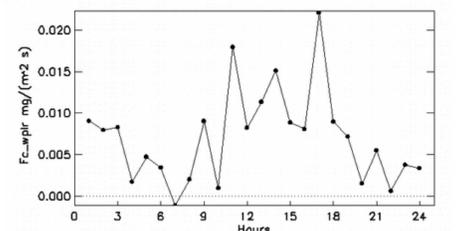
Latent Heat Flux
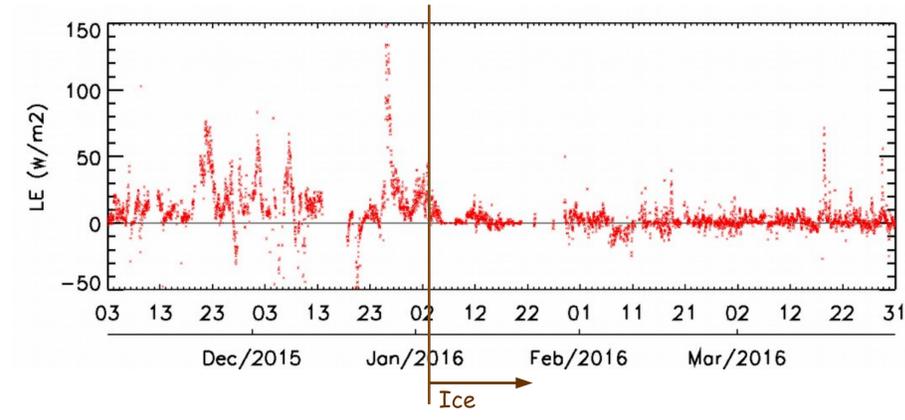
• Latent heat fluxes over the frozen lake are very weak, close to zero.
• Nevertheless, in March the fluxes are slightly positive
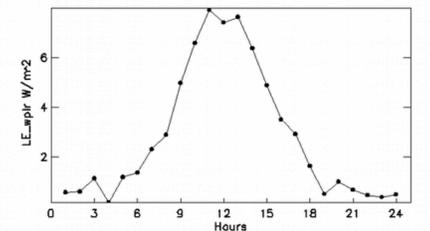
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• Potes M., Salgado R., Costa M.J., Morais M., Bortoli D., Kostadinov I., 2016. Lake-Atmosphere interactions at Alqueva reservoir, a case study in the summer of 2014. Submited to Tellus