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Eddy-Covariance Measurements over an Ice/Snow Covered Lake

Motivation

- 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 lake Vanajavesi, in Finland, a boreal lake during a freezing period (January 2016) will be shown.
- The field campaign was set up during a COST ES1404 Short Term Scientific Missions (STSM)
  - Miguel Potes (U. Évora / ICT)
  - Collaboration of Universities of Évora and and University of Helsinki
  - Maria Provenzale and Ivan Mammarella
  - The goal is to perform and analyse parallel measurement of heat and carbon dioxide turbulent fluxes over a snow/ice lake 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.

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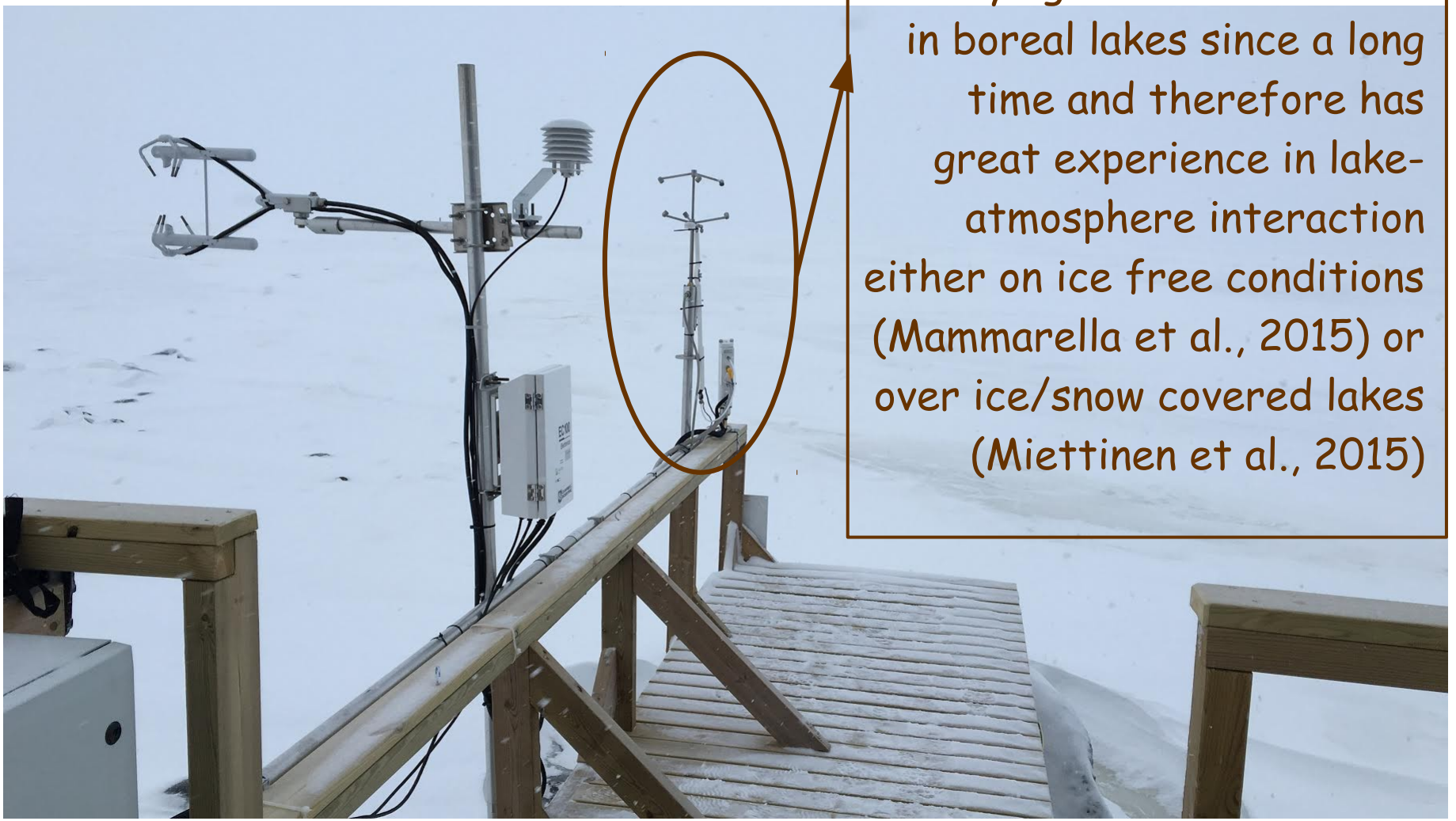
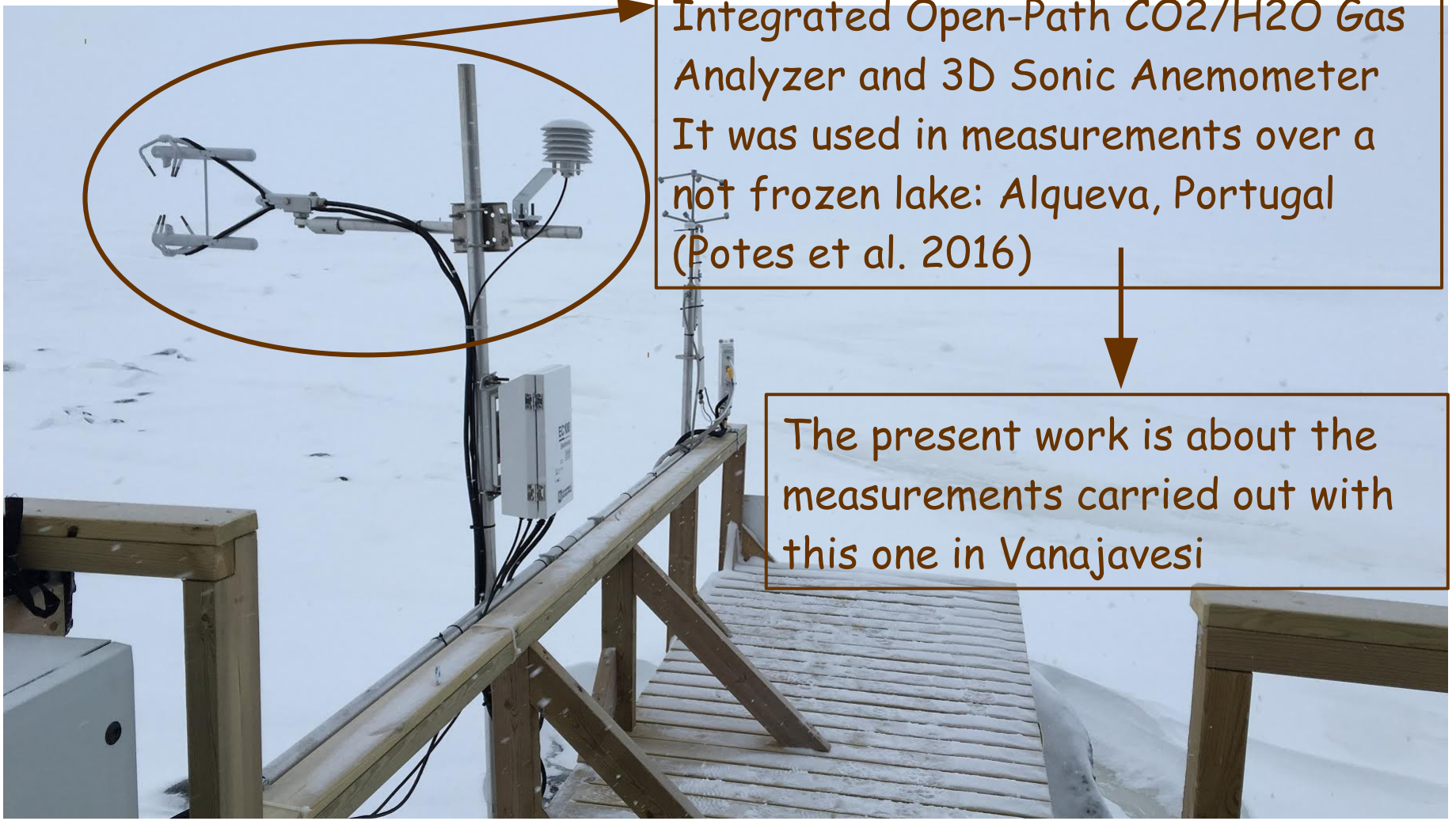
Inter-comparison experiment



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)

Inter-comparison experiment



Évora University acquired the 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)

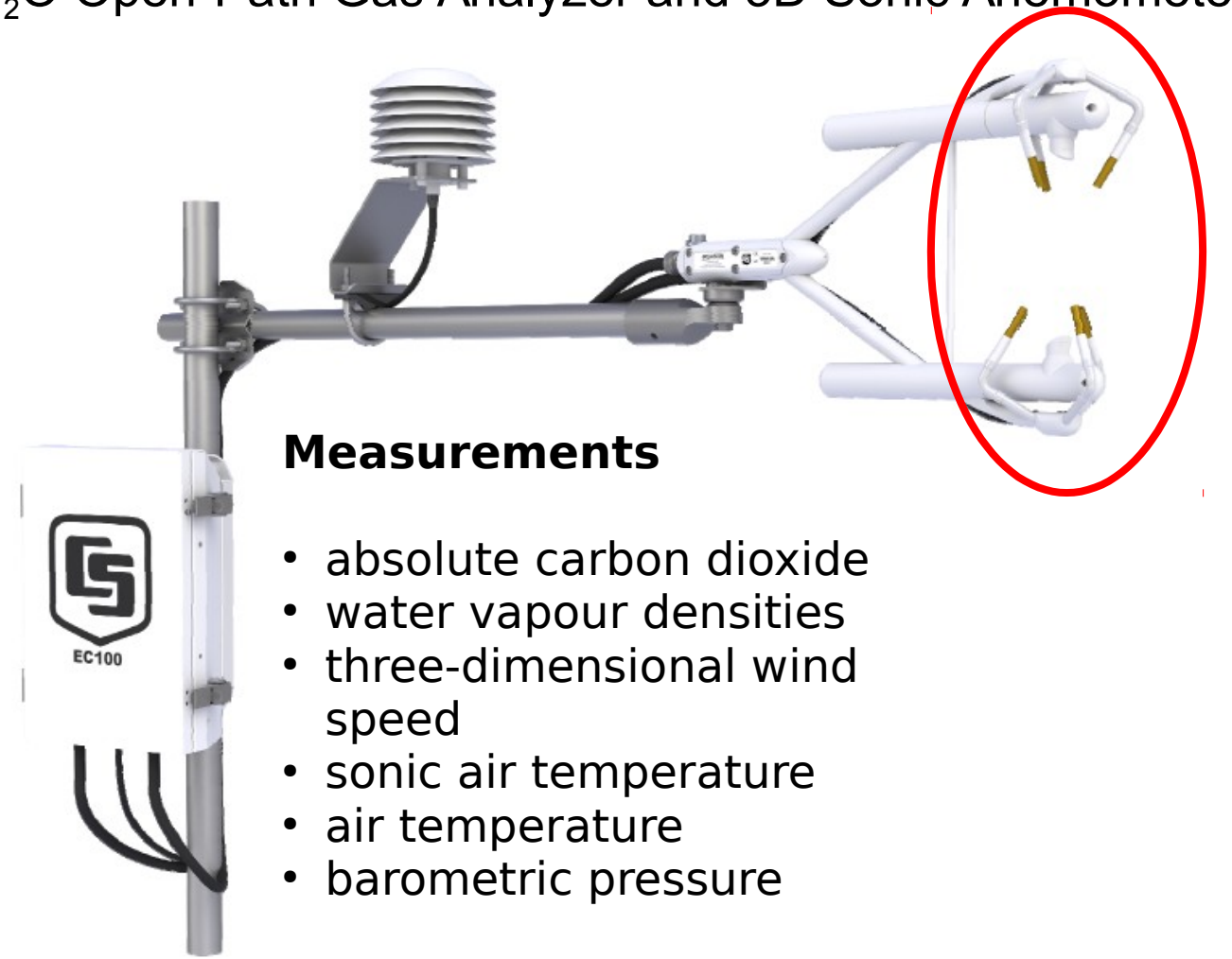
The present work is about the measurements carried out with this one in Vanajavesi

Eddy covariance system

- Continuously measurements of near surface fluxes of momentum, heat and mass (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
- The EC system was installed at 2.5m height above the lake surface and was oriented against the prevailing wind direction in the site.

Eddy covariance system - IRGASON

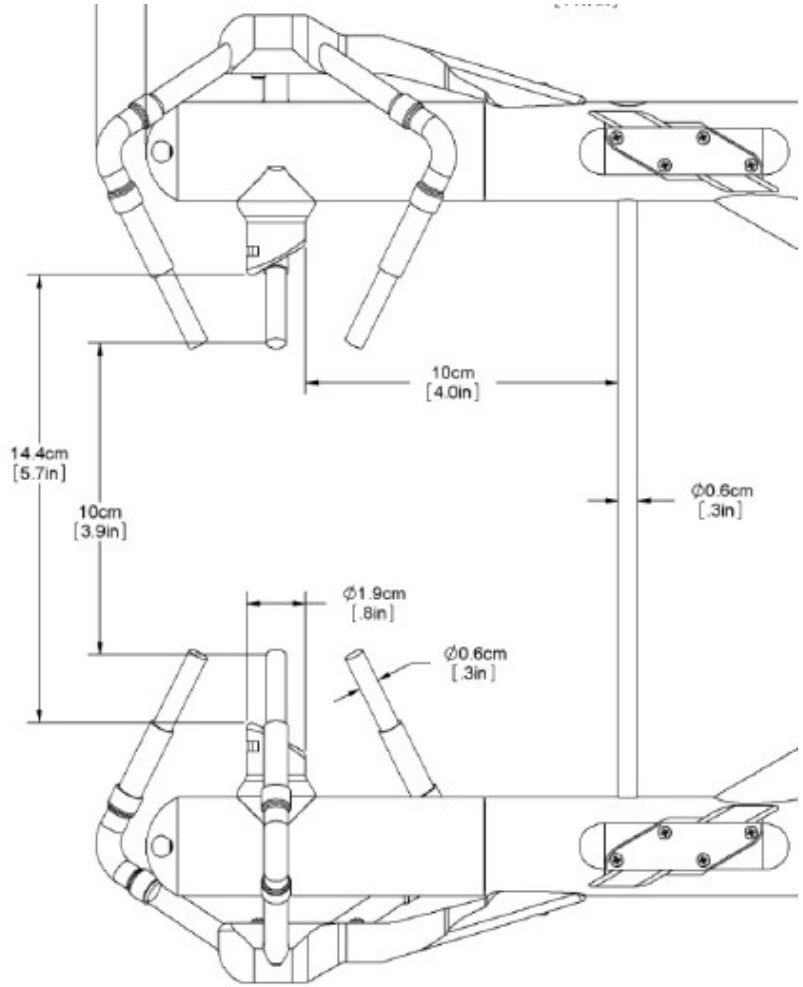
Integrated CO_2/H_2O Open-Path Gas Analyzer and 3D Sonic Anemometer



Measurements

- absolute carbon dioxide
- water vapour densities
- three-dimensional wind speed
- sonic air temperature
- air temperature
- barometric pressure

Measurement of Wind Speed



- Each axis of the sonic anemometer pulses two ultrasonic signals in opposite directions.
- The times of flight of the first signal and of the second signal allows the **determination of the wind speed components ux, uy, and uz**
- Those times are also used to determine the sound speed
- The speed of sound in moist air is a function of temperature and humidity. It is used to compute **the sonic virtual temperature, T_{vs}**

Gas analyzer

- The gas analyzer is a non-dispersive mid-infrared absorption analyzer.
- Infrared radiation is generated in the upper arm of the analyzer head before propagating along a 15 cm optical path.
- A detector in the lower arm measures the decrease in radiation intensity due to absorption

Gas analyzer

- For CO2, light with a wavelength of 4.3 μm is selected - the molecule's asymmetric stretching vibrational band.
- For H2O, radiation at 2.7 μm is used - water's symmetric stretching vibrational band

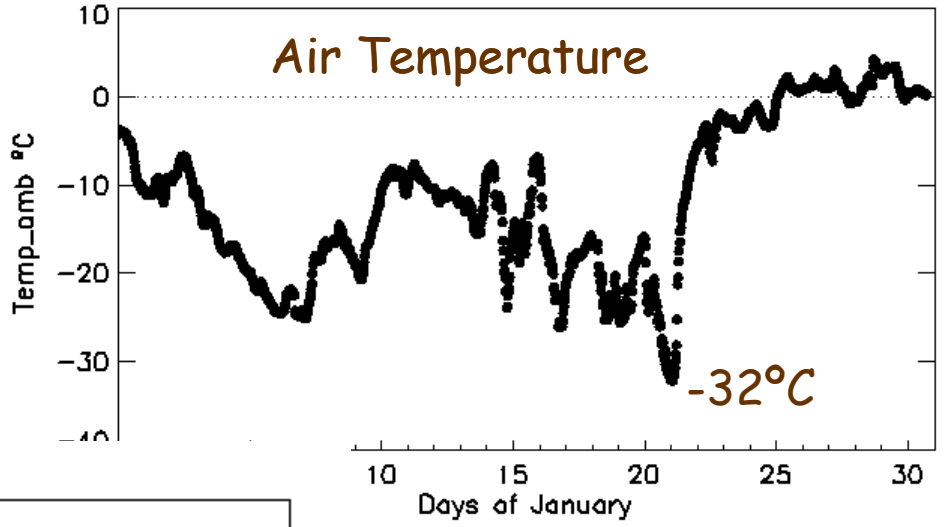
EC100

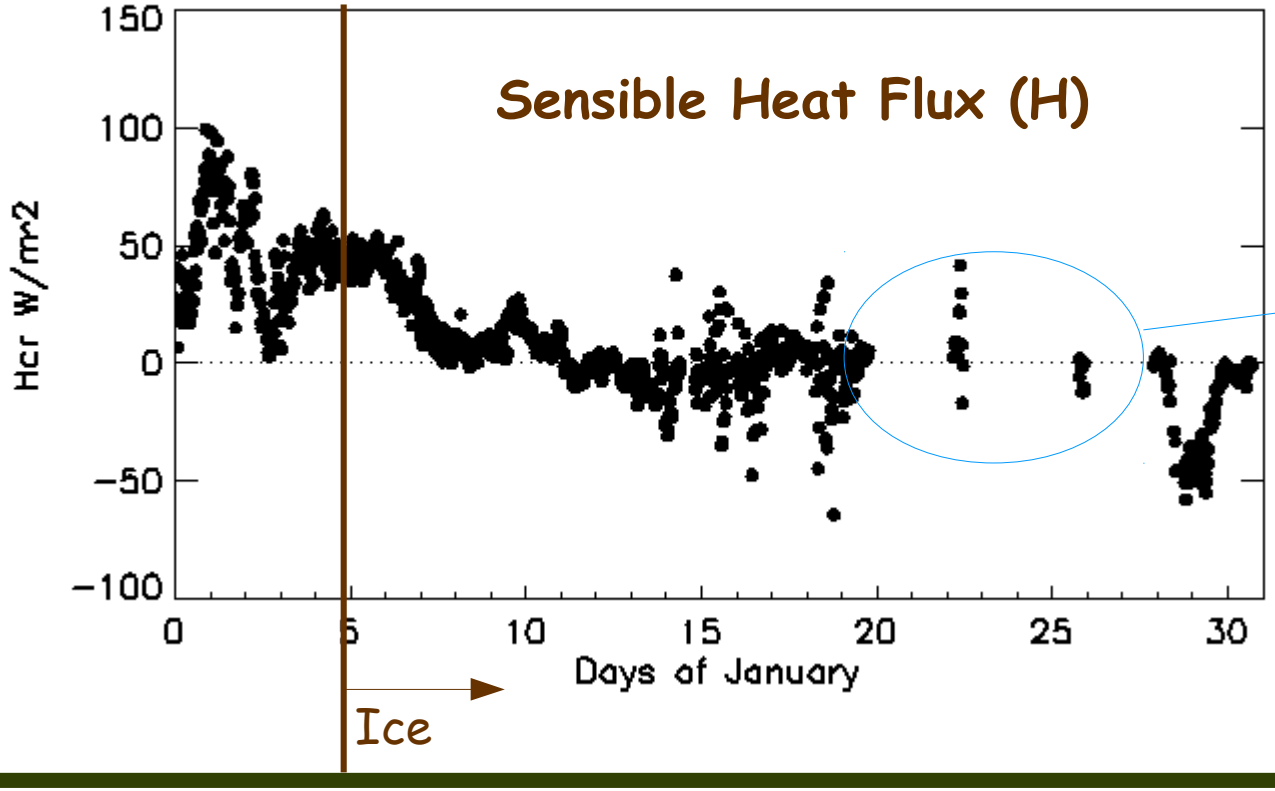
- The EC100 electronics digitize and process the detector data to give the CO2 and H2O densities after each chopper wheel revolution (100 Hz).
- The EC100 also synchronously measures and processes data from the sonic anemometer.

First Results – January 2016

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 between – 50 and 50 Wm^{-2}

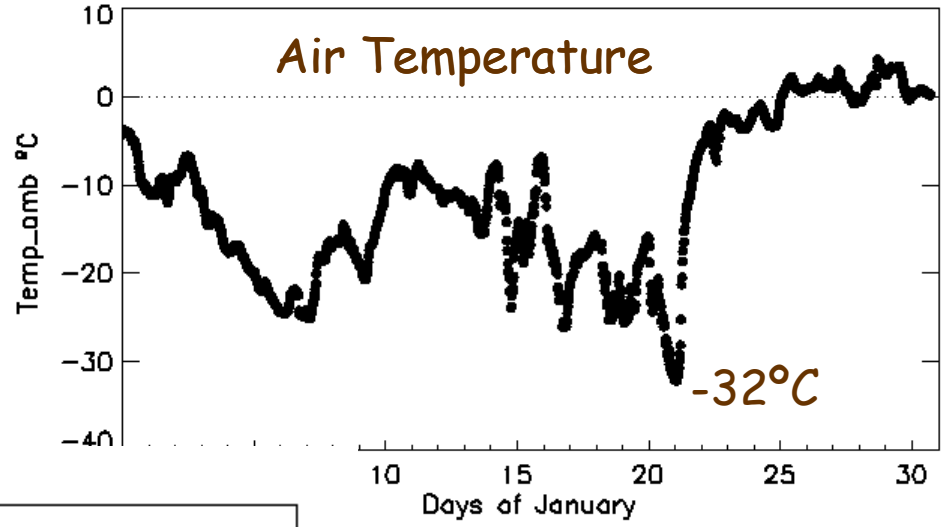


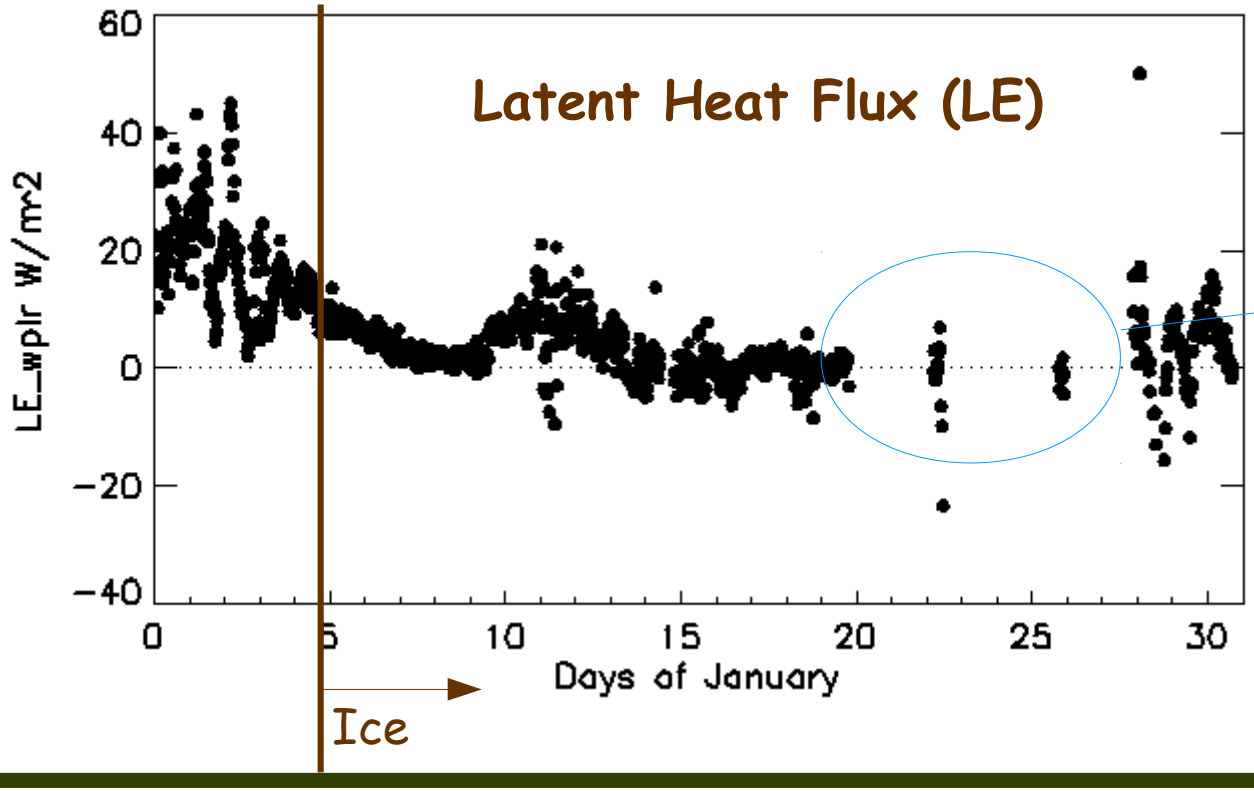


Problems with data quality: "Low signal strength"

Latent Heat Flux

- Latent Heat fluxes (H) are even weaker
- During freezing period H reaches 40 Wm^{-2}
- Over ice/snow, H are between – 20 and 20 Wm^{-2}





Problems with data quality: "Low signal strength"

Sensible and Latent Fluxes – daily cycle

- Mean cycles computed for the frozen period in January 2015 (25 days)
- Apparently, there are no significant cycle
- In average, the fluxes are positive (lake → Atmosphere)
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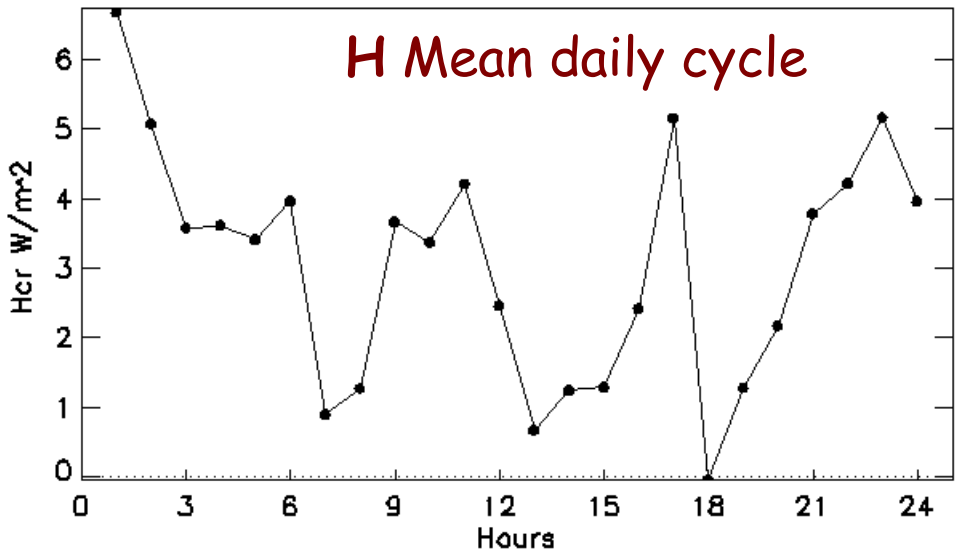
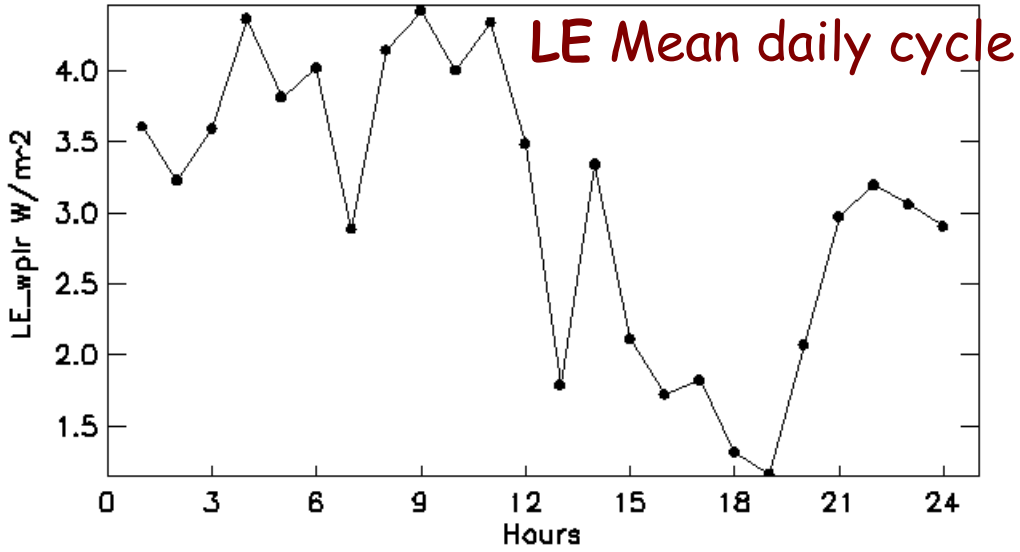
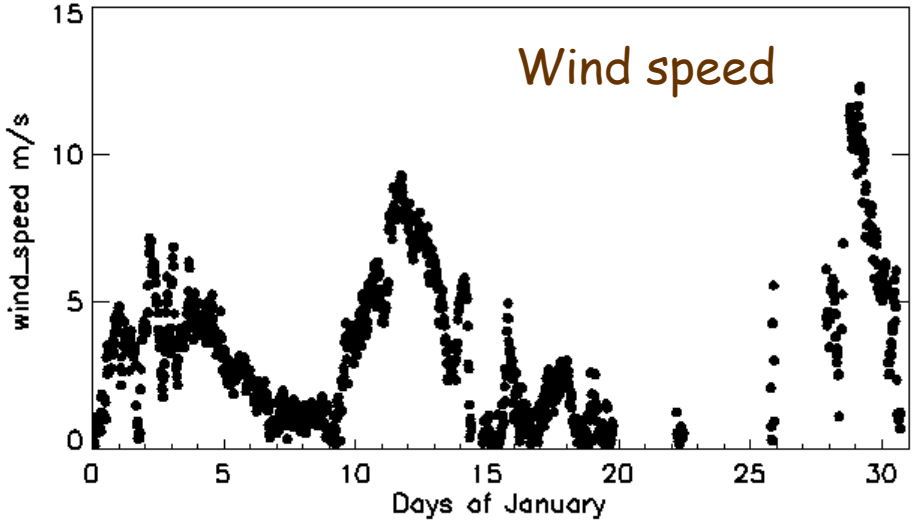
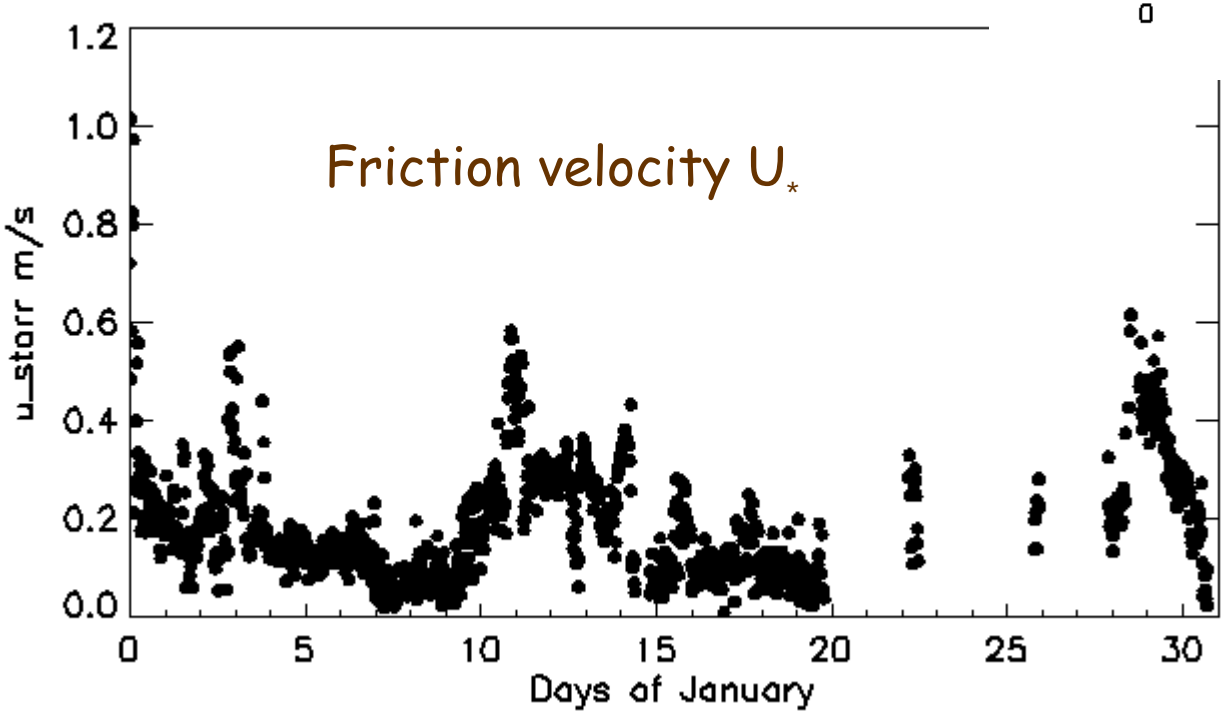




Momentum Fluxes

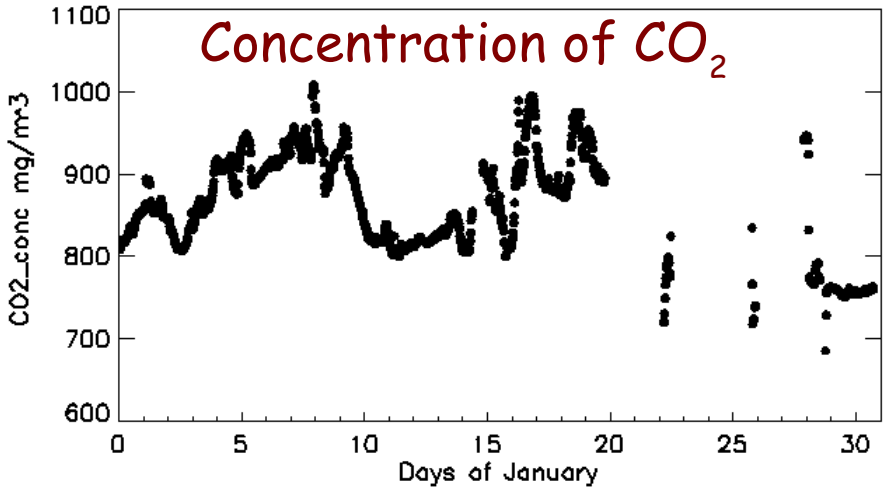
- Ustar over ice/snow, around 0.2 ms^{-1}
- Maximum values of ~0.6 ms^{-1}
- In general, slightly more intense from 00 to 12 TU (like wind speed)

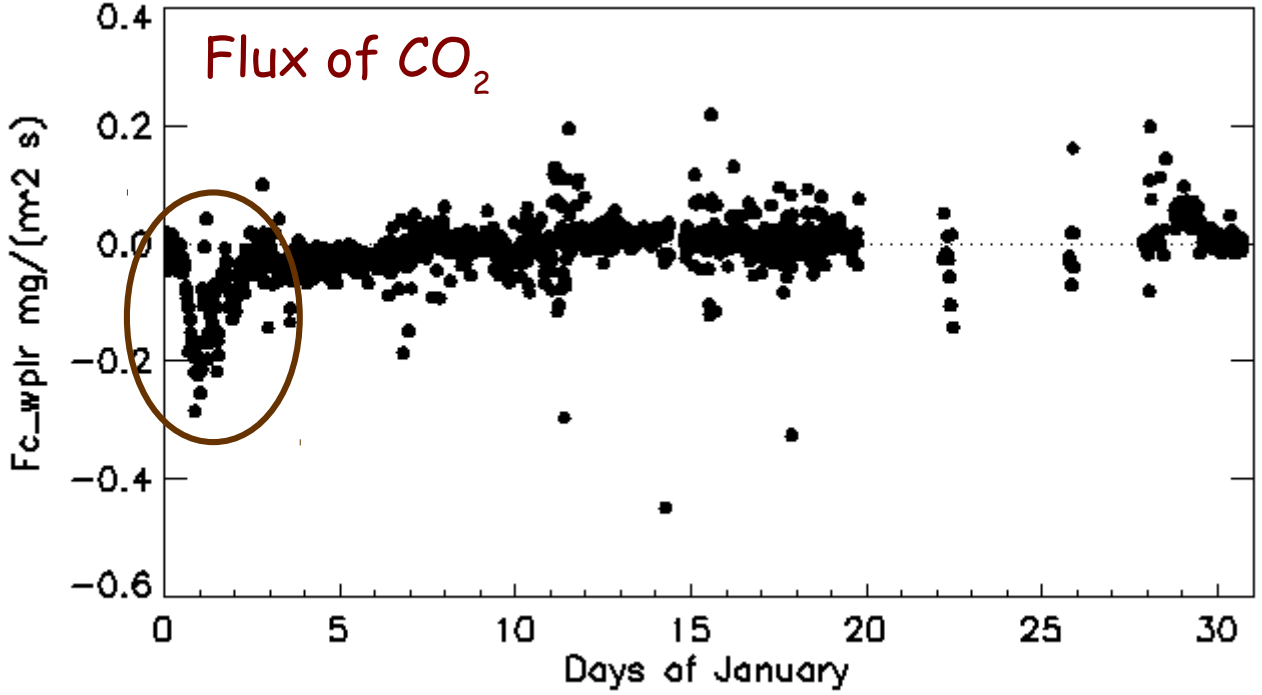




CO2 Fluxes

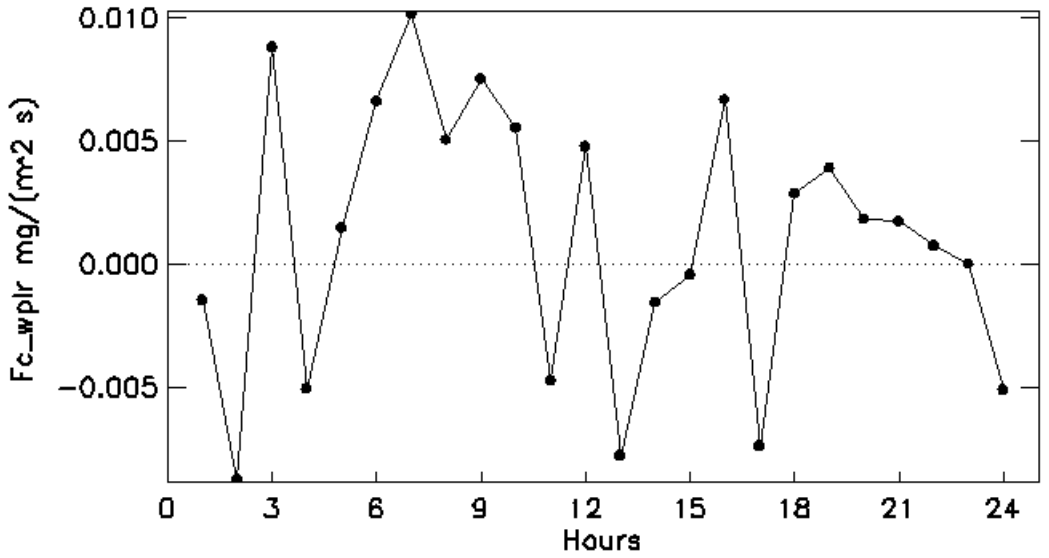
- As expected, CO2 flux over frozen lake is very weak, close to zero.
- Before, even in the freezing period, the CO2 flux was negative. The Lake act as carbon sink

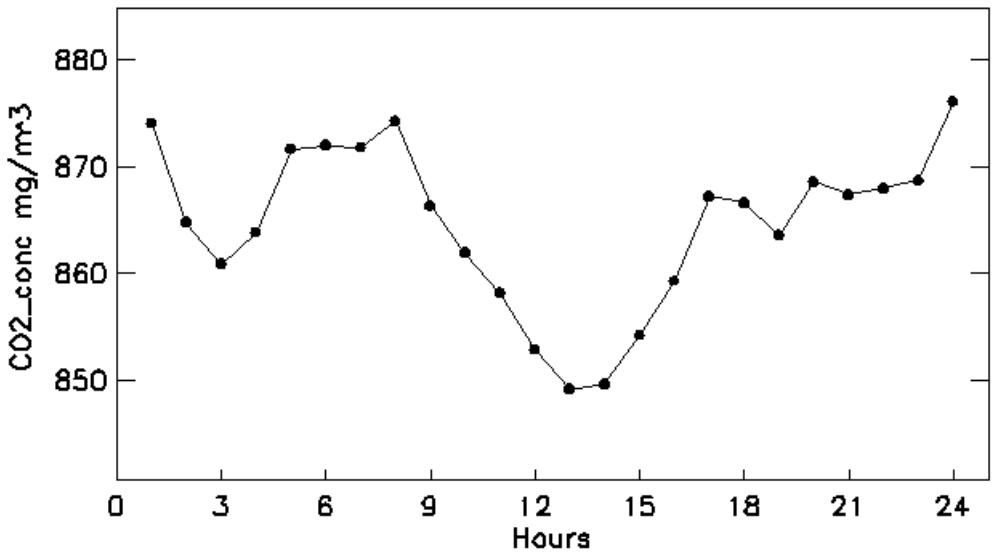




CO2 Fluxes – daily cycle

- Apparently, there are no daily cycle in CO2 Flux over the ice, values very low, mean equal to ~0.01 mg/m^2
- The CO2 concentration shows a daily cycle with lower values between 12 – 15 TU, due to near photosynthesises activity (Forest)





The END


I finish with a snowy picture in Algarve, southern Portugal last weekend (rare event).
Thank You

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