SMEAR II LAKE KUIVAJÄRVI METEOROLOGY, WATER QUALITY AND EDDY COVARIANCE

INTRODUCTION

Lake Kuivajärvi is situated in Juupajoki, southern Finland (61°50'N, 24°17'E), in the middle of a managed mixed coniferous forest. The lake is oblong in shape with the surface area of 0.62 km^2, length of 2.6 km and maximum width approximately 500 m. The lake has a maximum depth of 13.2 m and the mean depth of 6.3 m.

The catchment area of the lake is 8.7 km^2 of which 0.86 km^2 is covered by water. The rest of it consists of natural and drained peatlands, and Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L). Karst) dominated managed forests. Total area of agricultural fields in the catchment is only 0.032 km^2. The terrain around the lake has modest height variations of up to 40 m. The primary soil type is haplic podzol and a thin layer of soil at most 2 m deep sits above igneous and metamorphic bedrock. The mean annual temperature and precipitation in the area in 1971–2000 were 3.3 °C and 711 mm, respectively.

The lake is humic, the low water clarity is mainly due to high dissolved organic carbon (DOC) concentration in the lake. Lake Kuivajärvi has median light extinction coefficient Kd=0.59 m^{-1} that decreases to 0.50 m^{-1} during mixing periods. Furthermore, the lake is mesotrophic; the mean annual surface water total nitrogen (TN) and total phosphorus (TP) concentrations vary mainly between 300–500 µg l^{-1} and 12–17 µg l^{-1}, respectively. Lake Kuivajärvi is a dimictic lake that mixes thoroughly right after ice out usually in the beginning of May, stratifies for summertime and then mixes again latest in October, until it freezes and stratifies again underneath the ice cover for 5–6 months.

There were no recent major disturbances in Lake Kuivajärvi. However, there was clearcutting in the western side forests in early 2000s. Silvicultural measures in the catchment area may be reflected in the water quality.

DESCRIPTION OF MEASUREMENTS

Lake Kuivajärvi has two separate basins and a measurement raft (4 m × 3 m) is mounted on the southern basin, near the deepest part of the lake. Due to the oblong shape, the wind blows usually along the longest fetch. Continuous measurements of carbon exchange between water and air started in 2011 with flux measurement setup on the raft. The setup is placed at 1.8 m height and consists of an ultrasonic anemometer and enclosed path infrared gas analyzer for measuring CO_2 and water vapor (H_2O) fluxes. Another gas analyzer (Picarro G1301-f) was employed in 2012–2015 for measuring CH_4 fluxes. The raft is also equipped with water quality measurements and basic meteorological instruments. More meteorological measurements are carried out on the shore and at the nearby SMEAR II main station, which is situated approximately 700 m east of the lake shore.

The underwater radiation measurements were always dismantled in late autumn and re-installed when the lake was free of ice in May. Otherwise the measurements have been running throughout years, excluding maintenance breaks.

Figure 1. Land cover around Lake Kuivajärvi. The aerial photo shows 1 km x 1 km area around the raft which is located in the centre of the photo at 61.8465°N, 24.2805°E (WGS84). The aerial photo was obtained from the National Land Survey of Finland Orthophotos dataset in April 2016.

Figure 2. The raft from the south.

DATA PROCESSING

The processing of the raw meteorological and water quality data into end-user variables in physical units was done by a collection of Matlab scripts and functions. Time resolution was set to 1 min. During the processing, the raw data were filtered out of periods of known invalid data and with pre-set min and max values and spike values. The processing also includes calibration corrections to the data.

The processing of the raw 10 Hz eddy covariance data to 30 min fluxes and ancillary variables was done with EddyUH software (Mammarella et al., 2016). The calculation of fluxes involved

1. Quality control and spike removal; spikes in the data were removed on the basis of a maximum allowed difference between two adjacent points
2. Conversion of mixing ratios to dry mole fraction
3. Linear detrending and calculation of turbulent fluctuations
4. Coordinate rotation to align the along-wind component with the mean horizontal wind and make the mean vertical wind speed zero
5. Crosswind correction of sonic temperature
6. Time lag determination from the maximum of the cross-covariance function
7. Calculation of statistics (flux stationarity and integral turbulence characteristics, flux random error).

The flux corrections involved

1. Corrections for high and low frequency losses
2. Correction for fluctuations of air density (WPL correction) for open-path gas analyzers
3. Spectroscopic correction for Picarro G1301-f
4. Humidity correction of sonic temperature.

DESCRIPTION OF DATA FILES

The data are collected into yearly KVJ_META_YYYY.csv and KVJ_EDDY_YYYY.csv files where “META” referes to meteorology and water quality, “EDDY” to eddy covariance and YYYY is the year. The measured variables are arranged in columns, the first column named "samptime" indicates the time (UTC+2) when the measurement was made and the following columns contain the measured variables. The files have column headers. There’s no symbol for missing data, therefore the files must be read in a way that consecutive column separators (commas) are separating empty fields.

The variables and their units, source instruments and temporal coverage are listed in files KVJ_META_VariableMetadata.csv and KVJ_EDDY_VariableMetadata.csv, where metadata column "variable" refers to the column name in the corresponding data file. Columns "title" and "description" give short human-readable description of each variable, "unit" is the physical unit of the variable, "source" the source instrument(s) or variable(s) of the variable, and "period_start" and "period_end" the temporal coverage of the time series (UTC+2). Note that there may be long breaks between the start and end dates due to instrument malfunction or removal of the instrument for winter.

Part of the fluxes are accompanied by quality flags that range from 0 to 2. They were assigned based on the following criteria on flux stationarity (FST) and the skewness (SK) and kurtosis (KU) of the corresponding quantity during each 30-min flux calculation period:

Quality flag = 0 if FST<=0.3, -2<SK<2, 1<KU<8
Quality flag = 1 if 0.3<FST<=1, -2<SK<2, 1<KU<8
Quality flag = 2 if FST>1 or |Sk|>2 or KU<1 or KU>8

0: High quality, no limitations in the use of a flux datapoint
1: Intermediate quality, use with caution
2: Low quality, reject

The quality flags include also wind direction. Wind directions other than along the lake were flagged as quality class 2 as the contribution of the shore to the fluxes is significant. The undisturbed wind directions were 130°–180° and 320°–350°. See considerations on the effect of surrounding landscape on fluxes in Erkkilä et al. 2018.

REFERENCES

Erkkilä K-M, Ojala A, Bastviken D, Biermann T, Heiskanen JJ, Lindroth A, Peltola O, Rantakari M, Vesala T, Mammarella I 2018. Methane and carbon dioxide fluxes over a lake: comparison between eddy covariance, floating chambers and boundary layer method. Biogeosciences 15, 429–445. DOI: 10.5194/bg-15-429-2018.