COST-STSM-FP1203-21550

STSM report: Eddy-Covariance data processing of a Cork-Oak Montado

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Introduction

The STSM took place at the Helmholtz-Zentrum für Umweltforschung, Leipzig, from 19-4-2015 to 1-5-2015. The proposed end date (2-5-2015) was anticipated by one day as 1-5-2015 was an holiday.

The work developed consisted in processing eddy covariance raw data from the Herdade da Machoqueira site in Coruche, Portugal. This site is an open cork oak woodland, and the eddy covariance equipment has been running since 2009.

The main objective of this STSM is to transfer and share data and knowledge between the UFZ and the Instituto Superior de Agronomia (ISA) on Eddy covariance (EC) data processing in heterogeneous sites. Data collected from 2009 to 2014 was used in this STSM, allowing for tests with different meteorological conditions and differentstructures of data gaps.

Methodology

The methodology used was based on the Eddysoft eddy covariance software package and some Python scripts written in the UFZ.

1. Data preparation

The first step is to choose a time period (the year 2011, in the present case) and copy all raw data (i.e., the slt files and the meteo data to a new folder). The slt files are then filtered to remove incomplete files, that are too small for processing.

2. Calculation of raw fluxes

Raw fluxes are calculated for the entire time period, to be used later for the coordinate rotation. The EddyFlux program, from the Eddysoft suite, is used to calculate raw, uncorrected fluxes with the following options:

- no meteorological files

- no time lag

- no filters

- no inductances

- no coordinate rotation

- no extra output

- no spike detection

- p=1000

- sonic direction = 330 (for the Coruche site)

3. Synchronizing meteorological data with eddy covariance raw data

Meteorological data has to be synchronized with flux data, so that each half hour period has the corresponding meteorological data available.

4. Calculate time lags

In this case the IRGA used is the Licor 7000, a closed path analyser, so the time lag analysis is particularly important.

Time lags are calculated between the vertical wind component (w) and the CO_2 and H_2O fluxes, using the EddyCorr program, with the following options selected:

- transform to meteorological data

- every 1. value

- scan rate 20 Hz

- lag: 200 (the bigger, the longer it takes)

- substract mean

- extreme values

After that, the missing lags are modeled using a python script. If the modeling isn't good enough, missing values are replaced with the median values for the CO_2-lag and the H_2O -lag.
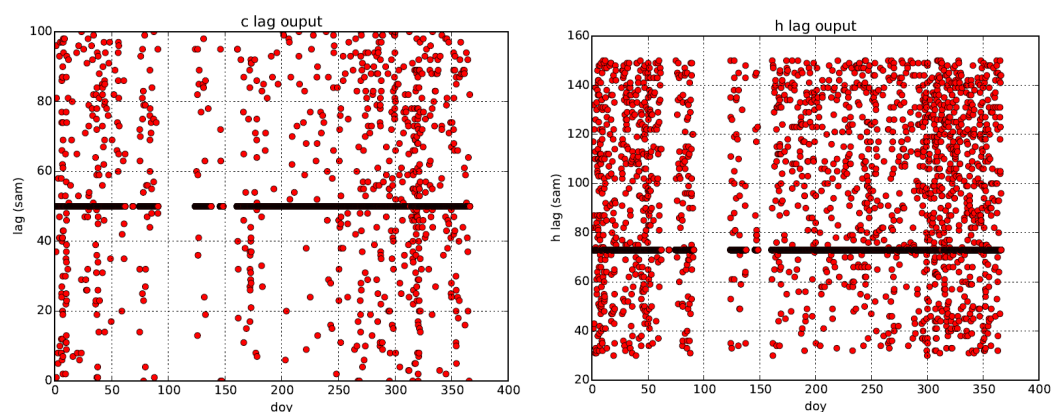

Figure 1. CO_2 and H_2O time lags. Water lags are typically higher, as water tends to adhere to the tubing walls.

6. Calculate inductances for carbon and water fluxes

Inductances are calculated for multiple times within the year, typically for periods of one to three months. EddySpec calculates inductances according to Eugster and Senn (1995).

For each period, the following procedure is applied:

1 - Choose a period of +/- 6 hours around noon, with good quality fluxes, through a graphic.

2 - Register the time lag for carbon flux and water flux for that period

3 - Register date in doy.ddd format from interactive python graphic

4 - Use Eddyspec, with co- and quadrature spectra option. Select the corresponding slt files and the following options:

- Transform to meteorological data

- Normalize to 1

- No inductances

- Dynamic smooth

- Multiply by frequency

- Log equidistant frequencies (20)

- Frequencies 4096

- Welch data windowing

5 - Select w and T, with lag=0. Calculate

6 - Select w and C, with lag=Clag. Calculate

7 - Select w and H, with lag=Hlag. Calculate

8 - Run Specmean, to calculate the mean spectra.

- Select all files beggining with 34 (variables 3 and 4, w and T, respectively). Calculate

- Select all files beggining with 35 (variables 3 and 5, w and C, respectively). Calculate

- Select all files beggining with 36 (variables 3 and 6, w and H, respectively). Calculate

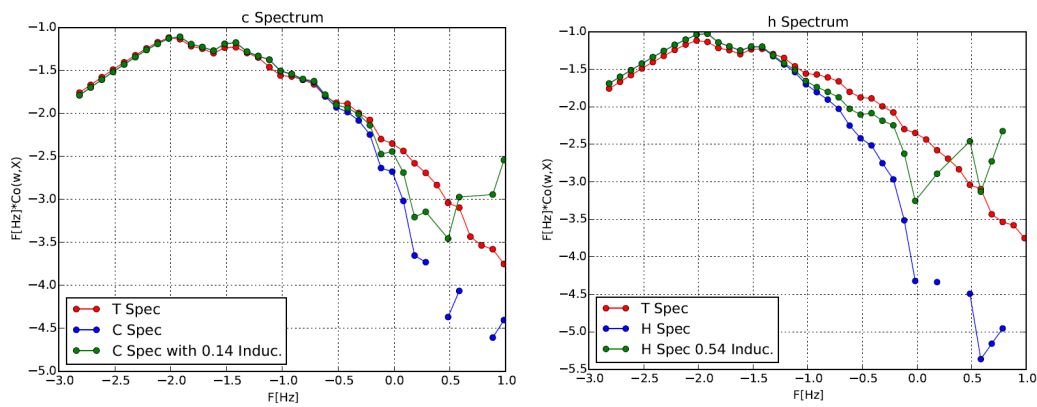*9 - Use the corresponding python script to calculate the inductances.*

Figure 2. Plots of the T, CO_2 and H_2O spectra, and the corresponding CO_2 and H_2O spectra adjusted with the calculated inductances

7. Coordinate rotation

The planar fit rotation (Wilczak et al., 2001) was selected, as the site is an open canopy cork oak woodland. A python script is used to generate the input files for EddyPFit. EddyPFit is then used with the following options:

- file format csv

- minimum 100/sector

- start at 0

- width 30 deg

- upper limit 1 m/s

- lower limit .1 m/s

- sonic direction: 330

8. Corrected flux calculation

The corrected fluxes are calculated using the EddyFlux program. The followin option must be selected:

- Enable spike detection in EddyConf

- use inductances from spec folder

- use PF sect. with pfitmatrix file from pfit folder

- extra output

- save the settings in flux folder

After calculation of the raw fluxes, a time step check must be performed, either with a script or manually. All incorrect time stamps, i.e., not starting or ending at 00 or 30 should be corrected, and all missing half-hour periods should be inserted, with values set to -9999.

9. Ustar filtering

Data must be filtered for periods where atmospheric turbulence is not enough to make the eddy covariance technique valid. This can be achieved via scripts, or using the online gapfilling tool created by the Max Planck Institute for Biogeochemstry (http://www.bgc-jena.mpg.de/~MDIwork/eddyproc/). For increased comparability with other sites, we chose to use the online tool for ustar filtering and gap filling.

The corrected flux data must be prepared for the online tool. Variables NEE, LE, H, qcNEE, Rg, Tair, RH and Ustar are copied to a csv file and uploaded to the tool, which then submits the results.
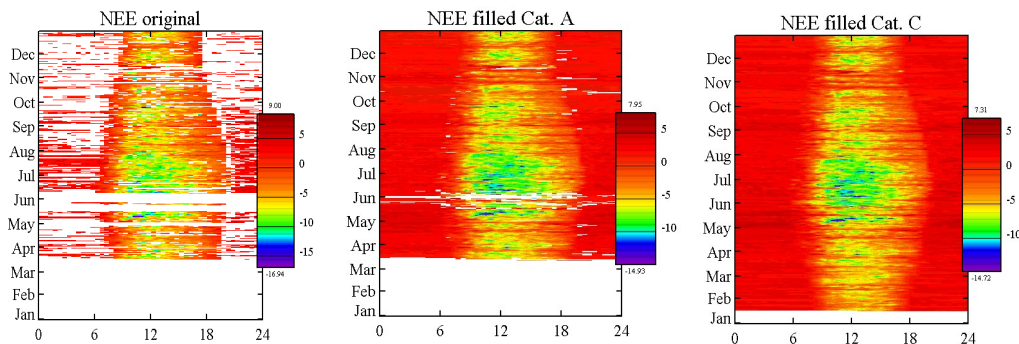

Figure 3. NEE plots of orginal data (ustar filtered), NEE gapfilled data (quality category A) and NEE gapfilled data (quality A to C).

Conclusion

The work developed during the STSM was very successful, it was possible to address all the main steps involved in the processing of eddy covariance data, and specifically those that are more relevant to open canopy forests (the coordinate rotation) and those that are inherently more complicated (spectral analysis). Furthermore, this work period has strengthened the relations between the research group at the University of Lisbon and the UFZ, facilitating future collaborations between the research groups and greatly improving the communication. While no publications are foreseen that stem directly from this STSM, all future publications on the Coruche site will benefit from the work developed during this STSM, as a result of better quality EC data.

I am very thankful to Dr. Corinna Rebmann, for all the time and effort spent in these two weeks, to the UFZ, for allowing me to use the facilities, and to COST FP1203 for providing funding to this STSM, that is invaluable for my phD work.

References

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