Institute of Geophysics
Polish Academy of Sciences

WARSAW UNIVERSITY OF LIFE SCIENCES

Variability of turbulent carbon dioxide flux netto at different time scales in an apple orchard ecosystem in Central Poland

Pawlak Izabela[1] and Kleniewska Małgorzata[2]
[1] Department of Atmospheric Physics, Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland
[2] Institute of Environmental Engineering, Warsaw Uniwersity of Life Sciences, Warsaw, Poland

Continuous measurements of CO_2 turbulent flux carried out with the eddy covariance method have been made in Mazovia Region (Central Poland) since mid-February 2023. The measurement station is located in the apple orchard in the rural area about 70 km south of Warsaw. The nearest neighborhood of the measurement site is characterised by flat terrain dominated by apple orchards with sparsely spaced households.

The measurements were carried out in a commercial apple orchard. Trees (variety-Gala, rootstock-M9) were planted in 2020 at distances of 3,4 x 1 m.

The measurement system consists of fast and slow response part. The eddy covariance measuremnets (10 Hz frequency) are performed using: 3D WindMaster sonic anemometer and LI-COR 7200 closed-path H_2O/CO_2 gas analyzer. Slow-response sensors provide data on the components of radiation balance (radiometer Kipp&Zonen) as well as air temperature and relative rehumidity at two levels (1 and 2m).

The turbulent CO_2 fluxes were calculated on a 30-min basis. The raw data were computed using the EddyPro -7.0.9 software taking into account the necessary corrections i.a.: angle-of-attack (Nakai and Shimoyama, 2012), despiking (Mauder et al., 2013), double axis rotation, block average detrending, time lags compensation and spectral correction of low-pass/high-pass filtering effects (Moncrieff et al., 1997; Moncrieff at al., 2004). The quality control of the flux data was performed based on stationarity test (Mauder and Foken, 2004). Finally we used data of the highest quality (qc=0). Additionally friction velocity (u*) threshold u*>0.1 m/s has been applied. Filling the data gaps and partitioning of the observed NEE into GEP and R_{eco} was performed based on nighttime data (Reichstein et al., 2005).

Fig. 1 Location of the measurement site.

Fig. 2 Pictures of an apple orchard with marked EC tower location.

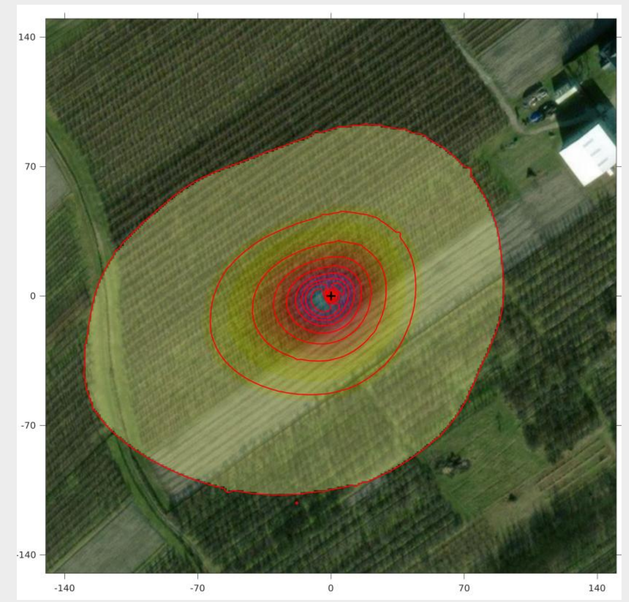

Fig. 3 Google map of the flux tower area with footprint raster and contour lines from 10 to 90%, in 10% steps, in the period Feb-Dec 2023 (Kljun et al., 2015).

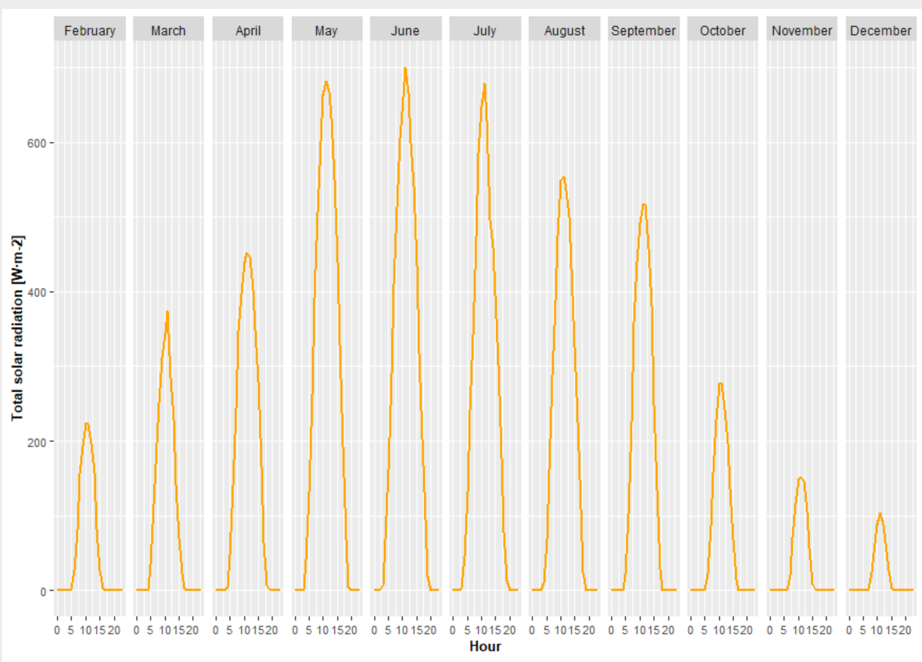

Fig. 4 Diurnal courses of mean total solar radiation [W/m²] by months, in the period Feb-Dec 2023.

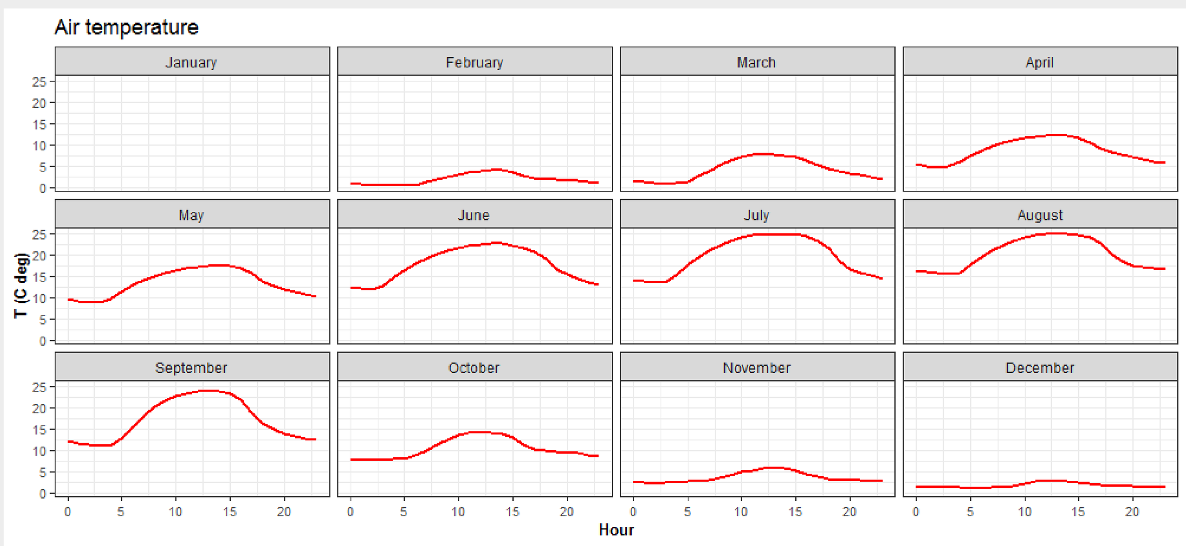

Fig. 5 Diurnal courses of mean air temperature [C deg] by months, in the period Feb-Dec 2023.

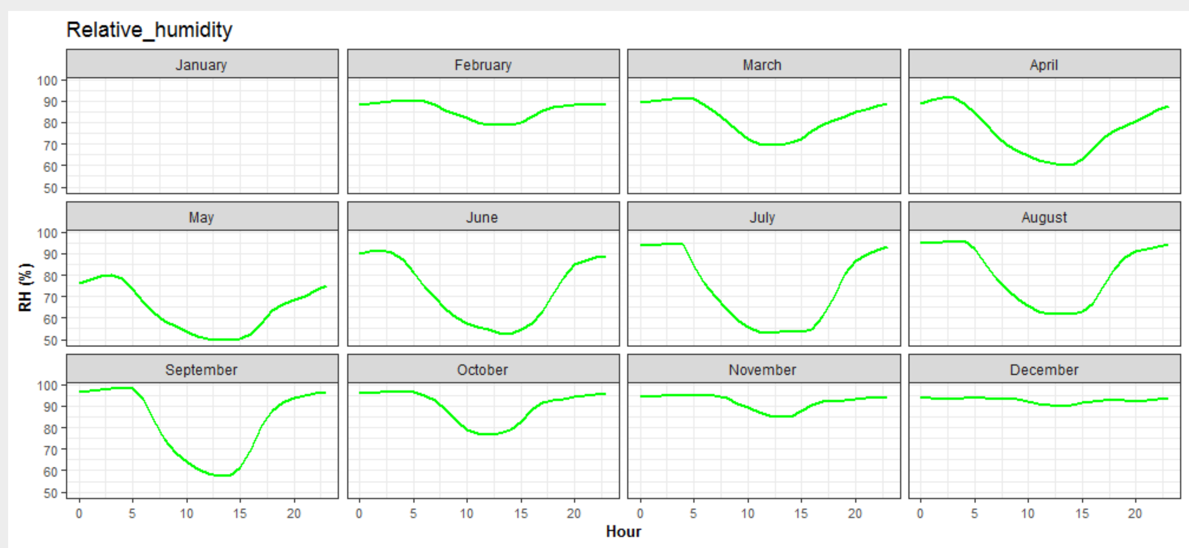

Fig. 6 Diurnal courses of mean relative humidity [%] by months, in the period Feb-Dec 2023.

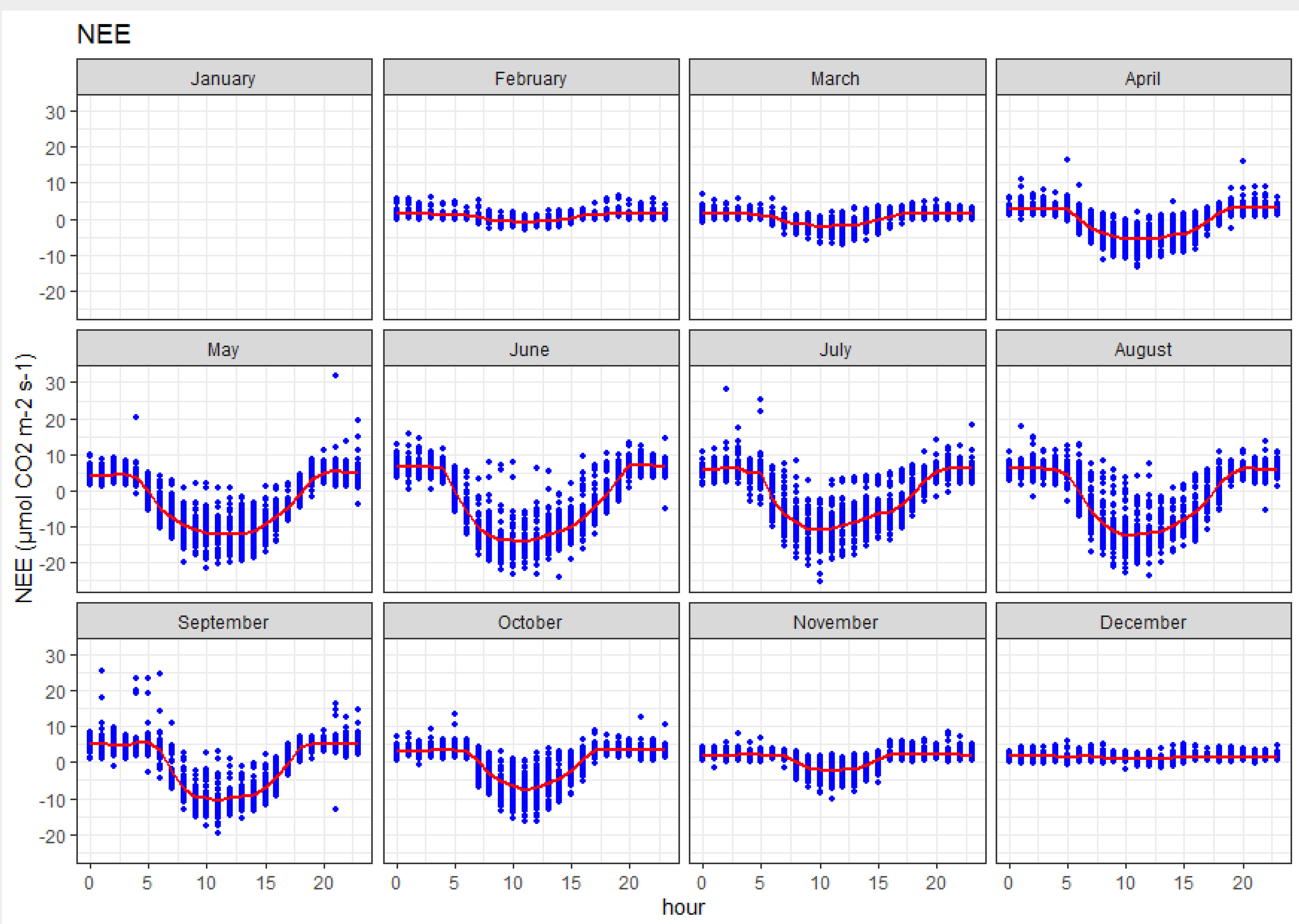

Fig. 7 Average diurnal pattern of NEE (μmol CO_2 m^{-2} s^{-1}) in the period Feb-Dec 2023 (negative NEE – net sink of CO_2).

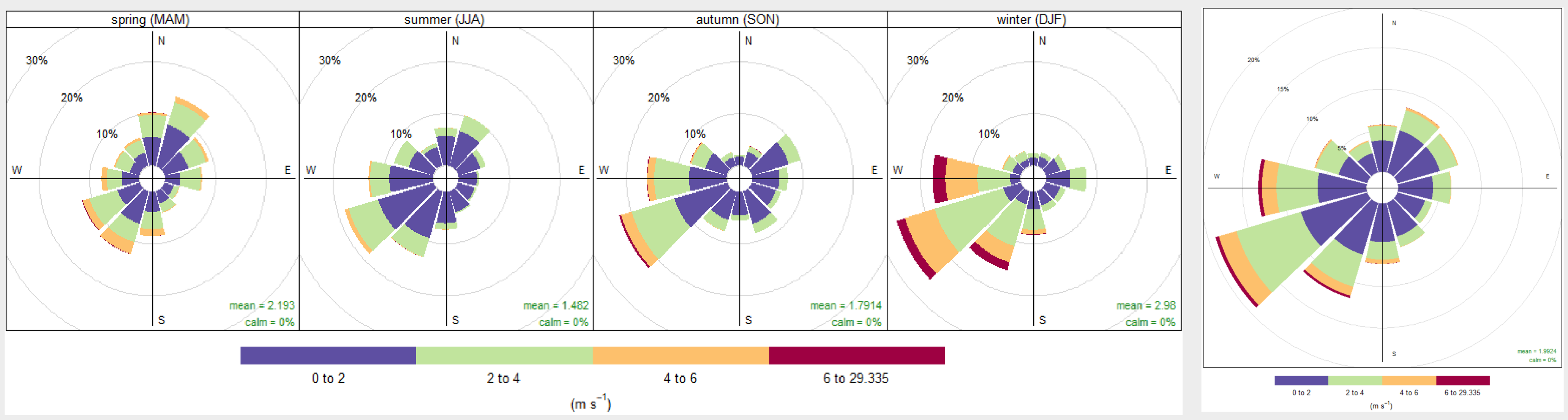

Fig. 8 Wind speed/direction frequency by season (left panel) and for whole measuring period (right panel) calculated for all available data in the period Feb-Dec 2023.

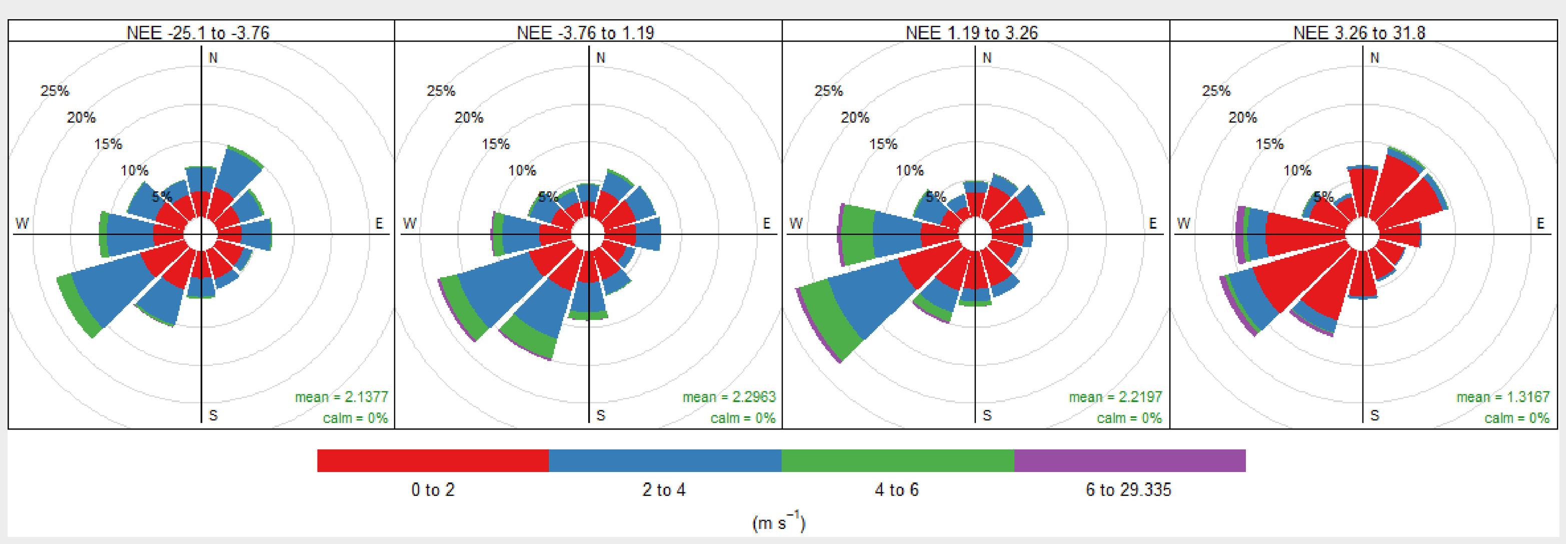

Fig. 9 Wind rose for four levels of NEE (μmol CO_2 m^{-2} s^{-1}) in the period Feb-Dec 2023.

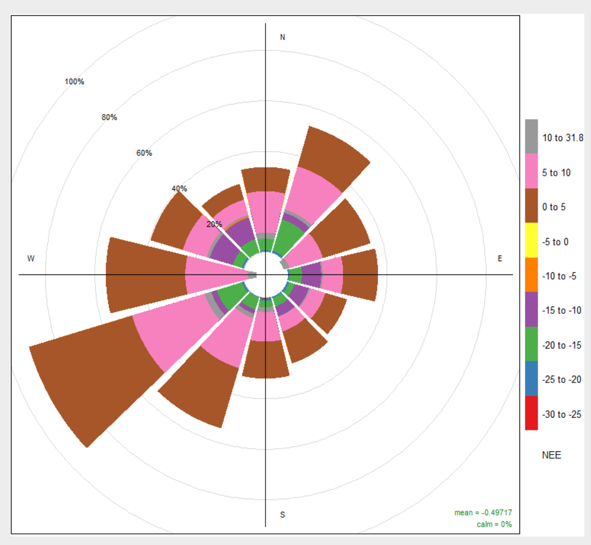

Fig. 10 Contribution of individual wind direction to overall mean of NEE (μmol CO_2 m^{-2} s^{-1}) in the period Feb-Dec 2023.

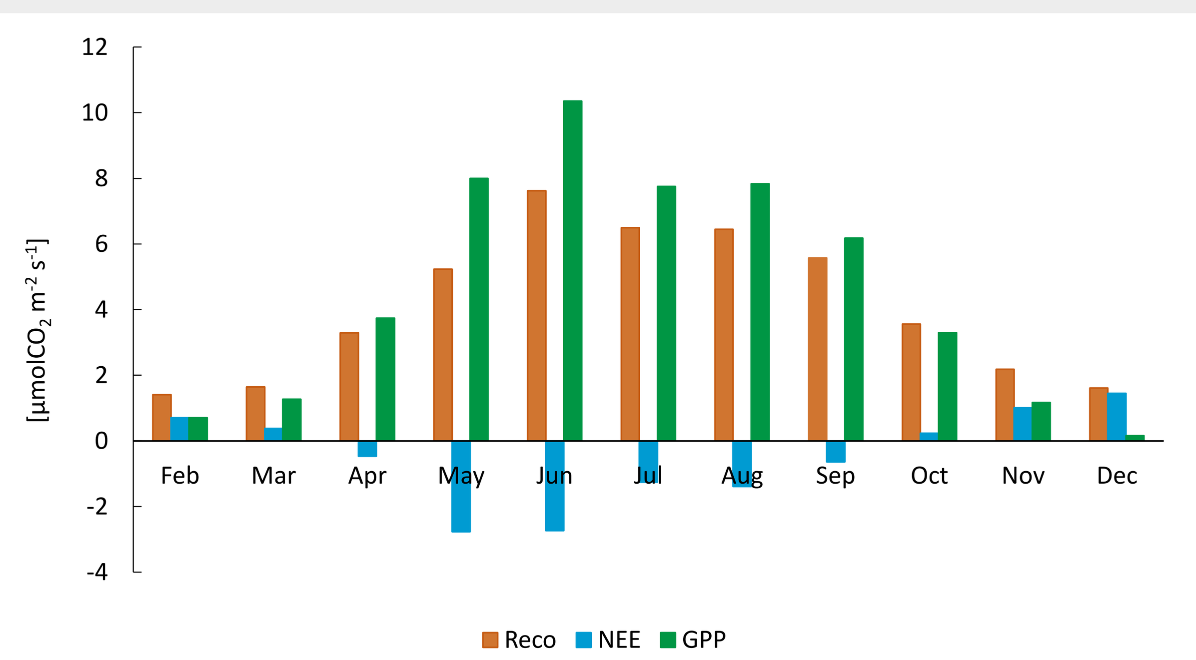

Fig. 11 Average monthly pattern of NEE, GPP and R_{eco} (μmol CO_2 m^{-2} s^{-1}) for all available data in the period Feb-Dec 2023.

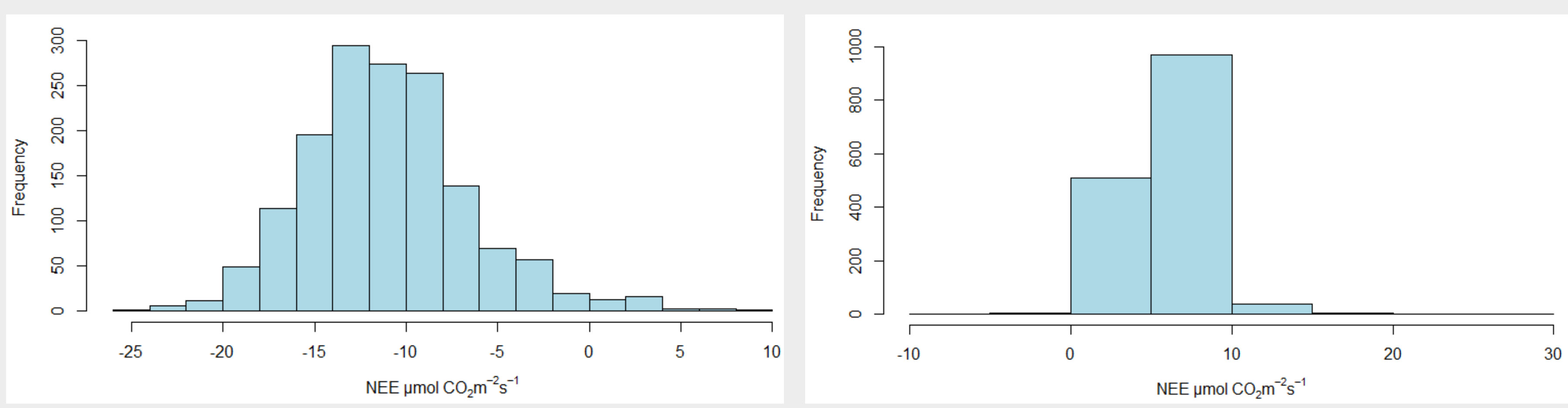

Fig. 12 Frequency distribution of 30-min NEE values calculated for midday (10:00-14:00) (left panel) and midnight (22:00-02:00) (right panel) hours during growing season (May-Sep).

Bibliography: Nakai and Shimoyama (2012): Ultrasonic anemometer angle of attack errors under turbulent conditions, Agricultural and Forest Meteorology, Volumes 162–163, 2012, Pages 14-26.
Mauder, M., Cuntz, M., Drüe, C., Graf, A., Rebmann, C., Schmid, H.P., Schmidt, M., Steinbrecher, R., (2013). A strategy for quality and uncertainty assessment of long-term eddy-covariance measurements, Agr. Forest Meteorol., 169, 122–135.
Mauder, M., Foken, T., 2004. Documentation and instruction manual of the eddy-covariance software package tk2. Arbeitsergebnisse, ISSN 1614-8924.
Moncrieff, J. B., Massheder, J. M., De Bruin, H., Elbers, J., Friborg, T., Heusinkveld, B., Kabat, P., Scott, S., Soegaard, H., Verhoef, A., 1997. A system to measure surface fluxes of momentum, sensible heat, water vapour and carbon dioxide, J. Hydrol., 188–189, 589–611.
Moncrieff, J., Clement, R., Finnigan, J., Meyers, T. (2004). Averaging, Detrending, and Filtering of Eddy Covariance Time Series. In: Lee, X., Massman, W., Law, B. (eds) Handbook of Micrometeorology. Atmospheric and Oceanographic Sciences Library, vol 29. Springer, Dordrecht.
Reichstein, M., Falge, E., Baldocchi, D., Papale, D., Aubinet, M., Berbigier, P., Bernhofer, C., Buchmann, N., Gilmanov, T., Granier, A., Grünwald, T., Havránková, K., Ilvesniemi, H., Janous, D., Knohl, A., Laurila, T.,Lohila, A., Loustau, D., Matteucci, G., Meyers, T., Miglietta, F., Ourcival. J.-M., Pumpanen, J., Rambal, S., Rotenberg, E., Sanz, M., Tenhunen, J., Seufert, G., Vaccari, F., Vesala, T., Yakir, D. and Valentini, R., 2005. On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm. Glob. Change Biol. 11, 1424–1439.
Wutzler T, Lucas-Moffat A, Migliavacca M, Knauer J, Sickel K, Sigut, Menzer O & Reichstein M (2018) Basic and extensible post-processing of eddy covariance flux data with REddyProc. Biogeosciences, Copernicus, 15.
Kljun, N., P. Calanca, M.W. Rotach, H.P. Schmid, 2015: A simple two-dimensional parameterisation for Flux Footprint Prediction (FFP). Geosci. Model Dev., 8, 3695-3713.