Quality assessment of eddy fluxes measured in complex conditions

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Introductory section

Aims of the study

A. Estimating the effect of a site-specific spectral correction of the eddy covariance fluxes, dependent on relative humidity
B. Analyzing the changes in energy balance closure when different data selection criteria are applied
C. Finding additional dependences due to complex topography of a forest site

Study site

Eddy covariance measurements were carried out over a Norway spruce (*Picea abies* [L.] Karst.) stand, 34 years old, 14.6 m high, at the Ecological Ecosystem Study Site Bílý Kříž in the Moravian-Silesian Beskydy Mountains (900 m a.s.l.), Czech Republic. The site is situated at a 25% SSW-exposed slope near the top of a mountain ridge.

Eddy-covariance system

Gill R3 ultrasonic anemometer

Li-7000 (closed path) infrared analyzer

Measurement height 18 m

Tube length 5 m

Methods of data postprocessing

EdiRe: double rotation of high-frequency velocity components, conversion to mixing ratio, block averaging, spectral correction according to Moncrieff

EddyUH: double rotation of high-frequency velocity components, conversion to mixing ratio, block averaging, site-specific spectral correction, dependent on relative humidity

Energy balance equation and closure

$$Rn - G - J = H + LE$$

Available energy side of the equation consists of the net radiation (Rn), soil heat flux (G) and heat storage change (J). The heat storage was evaluated according to Moderow et al. (2009). The eddy fluxes of sensible and latent heat are denoted H and LE, respectively. Ratio of the right-hand side and left-hand side of the equation gives the energy balance closure.

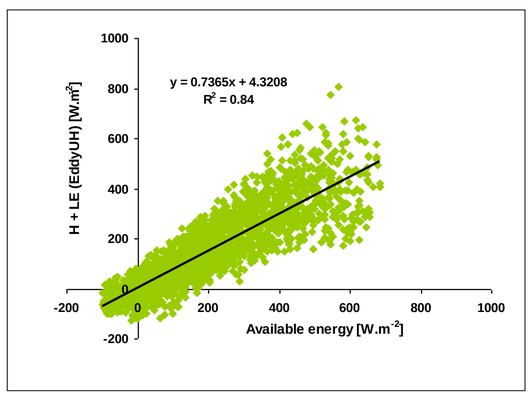
Energy balance ratio (EBR)

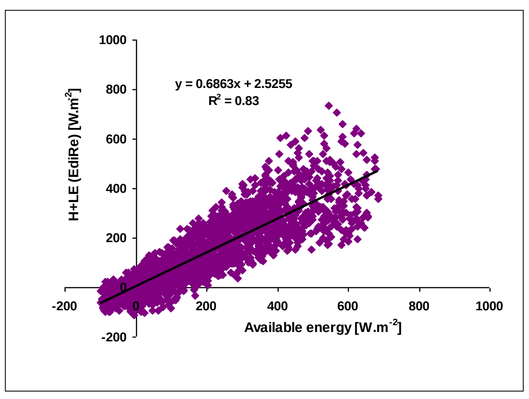
Energy balance ratio is obtained by summing up the 30-min averages of eddy fluxes and of the available energy, and then making their ratio.

Results

Energy balance closure (EBC) for two postprocessing outputs

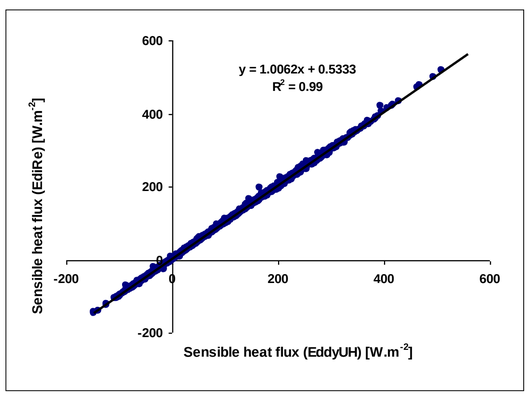
EBC is better for EddyUH output (left plot) than for the EdiRe output (right plot). The reason is the underestimation of LE fluxes in the EdiRe output.

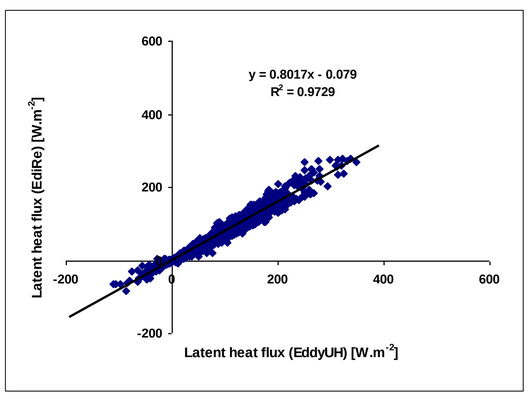




Comparison of H and LE fluxes from two postprocessing outputs

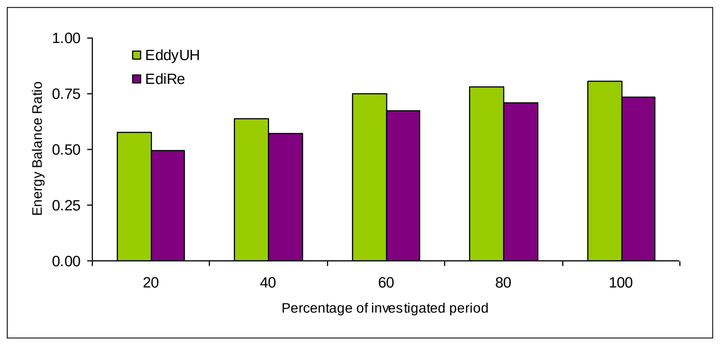
H fluxes from EdiRe are slightly larger when compared with EddyUH output (left plot). By contrast, LE fluxes are significantly underestimated by EdiRe (right plot) because no RH-dependent spectral correction was applied.





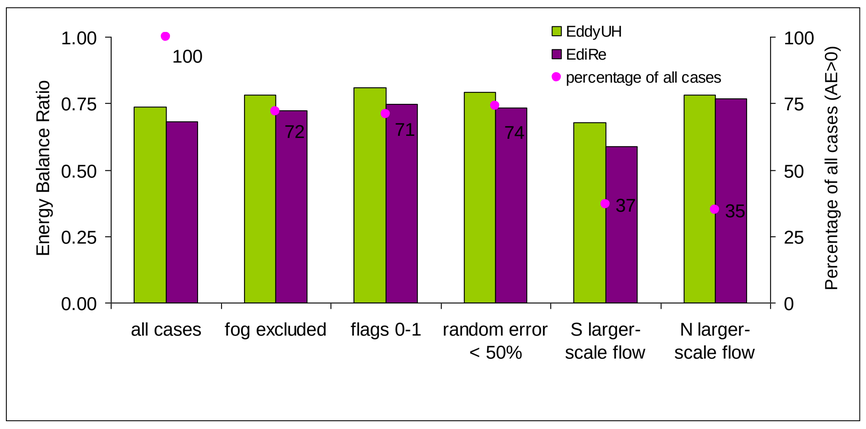
Energy balance ratio (EBR) for all data (daytime and nighttime)

EBR should be better evaluated for longer periods (e.g. Wilson et al., 2002), ideally for year-long time series in order to capture entire yearly cycles. The plot below suggests that the length of our 100-day period could be acceptable. The EBR values do not change much when the 80-day or the 100-day period is used.

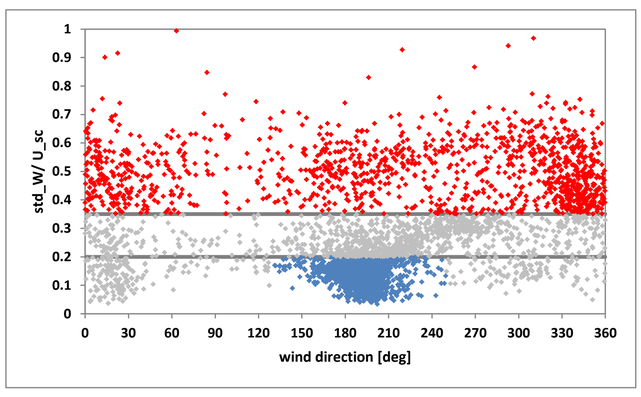


Energy balance ratio (EBR) for several subgroups of cases with positive available energy

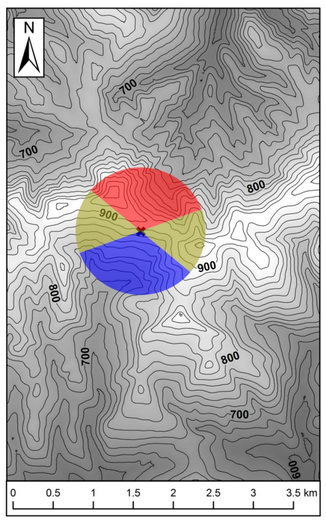
When (i) foggy/rainy cases, (ii) fluxes flagged 2, (iii) fluxes with random error > 50% are excluded, then EBR increases but the original group of "all cases" with positive available energy is reduced by about 25%. EBR for the EdiRe output remains 0.06 lower than EBR for the EddyUH output. The most remarkable feature is the EBR decrease for the subgroup of the south larger-scale flow, particularly for the EdiRe output. By contrast, the subgroup of the north larger-scale flow is characterized by large EBR values despite the foggy and bad flagged cases were not excluded.



Airflow regimes at the forested ridge of Bílý Kříž



Bílý Kříž site (marked by a cross on the map) is situated near the top of a forested ridge. Bílý Kříž data should be analyzed separately for the cases when the site is on the upwind, resp. downwind side of the ridge relatively to the larger-scale airflow. Our recent results indicate that a ratio of the standard deviation of the vertical velocity to the scalar wind speed from the eddy covariance data can be quite a successful separation criterion. In the plot, blue points (red points) correspond to a stronger larger-scale flow from the south (north) sector,



Summary of results

A. The site-specific spectral correction of the eddy covariance fluxes, dependent on relative humidity, improved substantially the latent heat fluxes and thus the energy balance closure.

B. For the cases of positive available energy (daytime cases), the exclusion of about 25% of data (either foggy/rainy periods, or bad flagged data, or fluxes with large random error), leads to comparable improvement of energy balance closure.

C. There is a substantial effect of the larger-scale airflow direction on the energy balance closure.

References

Moderow U., Aubinet M., Feigenwinter C., et al. (2009): Available energy and energy balance closure at four coniferous forest sites across Europe. *Theoretical and Applied Climatology*, **98**, 397-412.

Wilson K., Goldstein A., Falge E., et al. (2002): Energy balance closure at FLUXNET sites. *Agricultural and Forest Meteorology*, **113**, 223-243.

Acknowledgement

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