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EGER

# Free convection events on a spruce forest clearing

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## Overview

Experimental data of a modified Bowen ratio (MBR) mast (Fig. 1a) installed during the EGER (ExchanGE processes in mountainous Regions) project on a clearing (diameter: 100 m) in a spruce forest (Picea abies, canopy height: 25 m) at the Waldstein site in the Fichtelgebirge Mountains (Fig. 1b) are used to investigate the generation of free convection events (FCEs). The observed FCEs on the clearing are compared with eddy-covariance data of a nearby installed turbulence tower (TT, 36 m) and a mini Sodar located on the clearing. Furthermore, aspects of the energy balance closure are discussed in relation to the occurrence of FCEs.

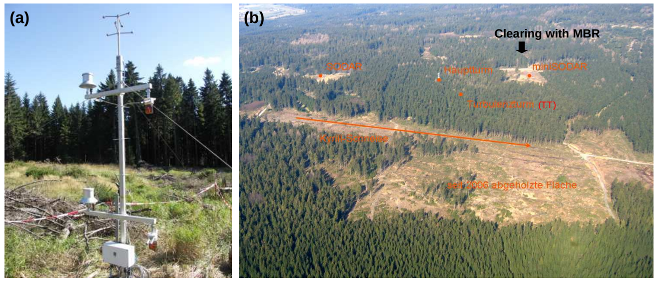


*Figure 1: Modified Bowen ratio (MBR) mast (a) and location of the clearing in relation to the measuring setup (b).*

## Generation of FCEs

FCEs occur in the atmospheric surface layer if buoyant forces dominate over shear forces within turbulence production. The ratio of the buoyancy to the shear term of the turbulence kinetic energy equation can be expressed as the flux Richardson number Rf. During unstable stratification (Rf < 0), Rf equals the stability parameter $\zeta$ which can be calculated from the MBR and TT measurements. Consequently, FCEs can be detected with the help of the stability parameter $\zeta$ (ratio of the measurement height to the Obukhov length) for values of $\zeta$ below -1 (Eigenmann et al., 2009).

$$\zeta = \frac{z}{L} = -\frac{z \cdot \kappa \cdot g \cdot \left(\overline{w'\theta_v'}\right)_0}{\overline{\theta_v} \cdot u_*^3}$$

Regarding the equation, moderate to high buoyancy fluxes and a simultaneously occurring drop of the wind speed/ friction velocity are a precondition and a trigger for a FCE.

## FCE examples

FCEs are frequently detected on days of both measurement periods (IOP1 + IOP2). Generally the FCE starts on the clearing (MBR) and can be observed at the TT at the same time (Fig. 2). Buoyancy/ sensible heat fluxes and global radiation are high during the event and often a change in wind direction can be found (Fig. 2).

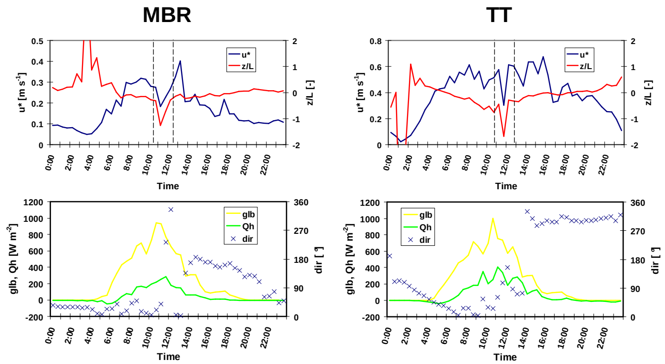


*Figure 2: Stability parameter (z/L), friction velocity $u_*$, global radiation (glb), sensible heat flux (Qh) and wind direction (dir) on the clearing (MBR) and at the TT on 17 June 2008. The black dashed vertical lines indicate the FCE times.*

Enhanced vertical wind speeds measured with the mini Sodar can be associated with the observed FCE (Fig. 3a). Furthermore, a wavelet analysis reveals a gain of low frequency scales of turbulent motion during the event time (Fig. 3b).

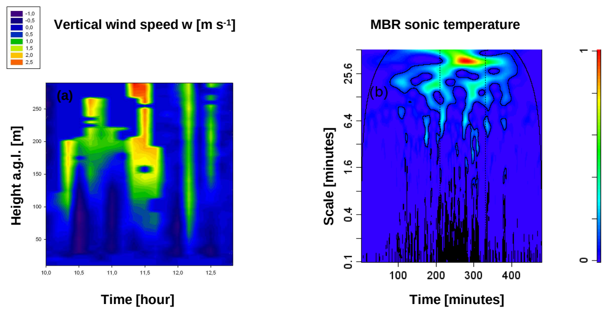


*Figure 3: Vertical wind speed values w measured with the mini Sodar (a) on the clearing on 17 June 2008 during the FCE time (10:30-12:30) marked in Fig. 2. Figure 3b shows the wavelet power spectra of the MBR sonic temperature during the above-mentioned FCE time indicated by the black dashed vertical lines.*

## Bowen ratio

The clearing was found to be an enhanced source of moisture compared to its surrounding (Fig. 4) facilitating the generation of FCEs by making more buoyancy available.

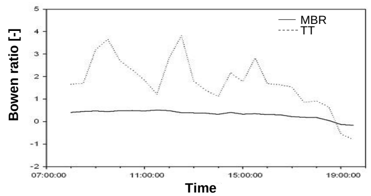


*Figure 4: Example of typical Bowen ratios measured at the TT (dashed) and on the clearing with the MBR mast (solid) on 20 June 2008.*

## FCEs and energy balance closure

It was found that on days with detected FCEs (17 June 2008, Fig. 5a) the residuum of the energy is higher compared to days with no occurrences of a FCE (20 June 2008, Fig. 5b). An explanation might be the large-eddy scale character of the detected plume-like coherent FCEs introducing low frequency flux contributions not caught by the common flux measurement techniques.

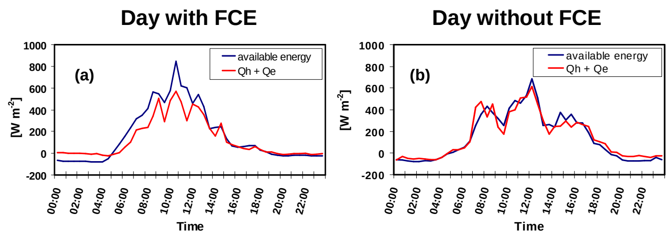


*Figure 5: Available energy values (net radiation minus ground heat flux) and the sum of sensible (Qh) and latent (Qe) heat fluxes at the TT on 17 June (a) and 20 June 2008 (b). On 17 June 2008, a FCE was detected (see Fig 3), however, on 20 June 2008 no FCE occurred (not shown).*

## Conclusions

FCEs are generated on the clearing at the Waldstein site. The occurrence of the FCEs seems to have an impact on the surface energy balance closure.

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References:

Eigenmann, R., Metzger, S., and Foken, T.: Generation of free convection due to changes of the local circulation system. Atmospheric Chemistry and Physics Discussions, 9, 11367-11411, 2009.