

# Near-ground free convection events in the valleys of the Black Forest Mountains

R. EIGENMANN (1)\*, N. KALTHOFF (2), M. KOHLER (2), D. SCHÜTTEMEYER (3), M. DORNINGER (4),  
G. PIGEON (5), O. TRAULE (5), D. LEGAIN (5), B. PIGUET (5), T. FOKEN (1)

(1) Department of Micrometeorology, University Bayreuth, Bayreuth, Germany  
(2) Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany  
(3) Meteorological Institute, University of Bonn, Bonn, Germany  
(4) Department of Meteorology und Geophysics, University Vienna, Vienna, Austria  
(5) Centre National de Recherches Météorologiques - Groupe d'étude de l'Atmosphère Météorologique (CNRM-GAME), Météo France-CNRS, Toulouse, France

## Overview

High-quality eddy-covariance (EC, measurement height: 2.3m) and Sodar/RASS measurement data of the COPS (Convective and Orographically-induced Precipitation Study) field campaign 2007 are used to investigate the generation of very near-ground free convection conditions (FCCs) in the Kinzig valley, Black Forest, southwestern Germany.

## Generation of FCCs

FCCs occur in the atmospheric surface layer if the buoyancy term (**B**) dominates over the shear term (**S**) of the turbulence kinetic energy equation ( $|B| > |S|$ ).

$$B = \frac{g}{\theta_v} (\overline{w'\theta_v'})_0 \quad S = -\overline{u'w'} \frac{d\bar{u}}{dz}$$

The ratio **B** to **S** can be expressed as the flux Richardson number  $R_f$ . During unstable stratification ( $R_f < 0$ ),  $R_f$  equals the stability parameter  $\zeta$  calculated from the EC measurements.

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

Consequently, FCCs can be detected with the help of  $\zeta$  for values of  $\zeta$  below -1 ( $\zeta < -1$ ).

Regarding the equation of  $\zeta$ , low values of the friction velocity  $u_*$  and high buoyancy fluxes  $(\overline{w'\theta_v'})_0$  will facilitate the occurrence of FCCs.

## FCCs in the Kinzig valley on IOP8b

In the Kinzig valley, a strong drop of  $u_*$  (Fig. 1b, horizontal wind speed) is induced by the valley circulation system which changes its wind direction from down to up-valley winds in the morning (Fig. 1a).

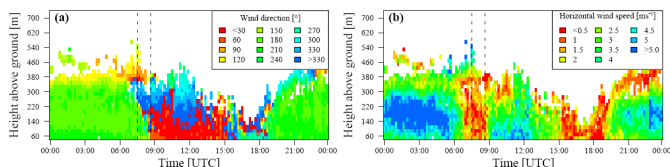


Fig. 1: Sodargrams of the wind direction (a) and the horizontal wind speed (b) at Fußbach in the Kinzig valley on IOP8b (15 July 2007). The black dotted lines in each graph denote the period of FCCs (7:35-8:40 UTC) detected by the EC in Fig. 2a.

Triggered by the drop of  $u_*$  (Fig. 2c), FCCs are detected by the EC (Fig. 2a) at the time of the valley wind reversal (Fig. 2b). Moderate sensible heat fluxes are measured simultaneously (Fig. 2d).

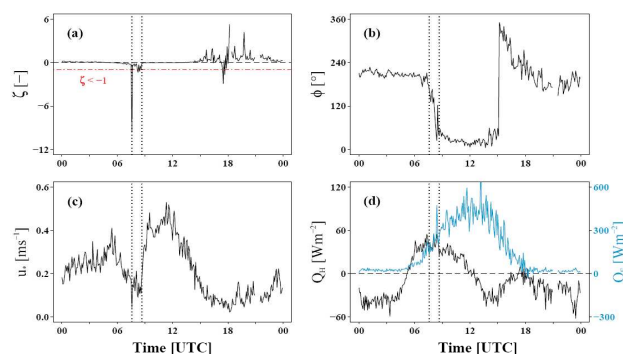


Fig. 2: Stability parameter  $\zeta$  (a), wind direction (b), friction velocity  $u_*$  (c) and sensible ( $Q_h$ ) and latent heat ( $Q_e$ ) flux (d) derived from the EC system at Fußbach in the Kinzig valley on IOP8b (15 July 2007). The black dotted lines in each graph denote the period of FCCs (7:35-8:40 UTC) detected by  $\zeta < -1$  in Fig. 2a.

## Turbulence structures during FCCs on IOP8b

An analysis of the scales of turbulent motions using wavelet transform suggests that coherent large-scale turbulence structures emerge during the period of FCCs from 7:35-8:40 UTC on IOP8b (Fig. 3a/b). These large-scale structures can effectively transport surface quantities of heat and moisture into the ABL.

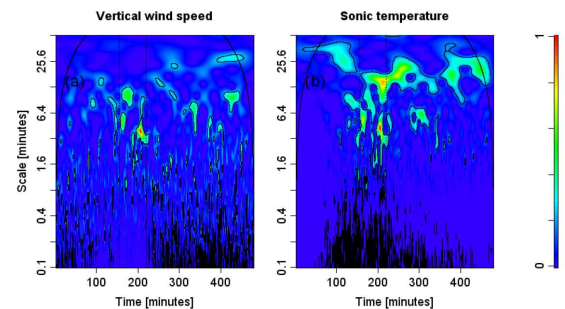


Fig. 3: Normalized wavelet power spectra of the vertical wind speed (a) and sonic temperature (b) from 5:00-13:00 UTC (480 min) at Fußbach in the Kinzig valley on IOP8b (15 July 2007). The period of FCCs in the morning from 7:35-8:40 UTC is indicated by the black dotted vertical lines.

## FCCs in the Kinzig valley during COPS

FCCs were detected on 23 days (25%) in the Kinzig valley during the entire COPS measurement period (Fig. 4).

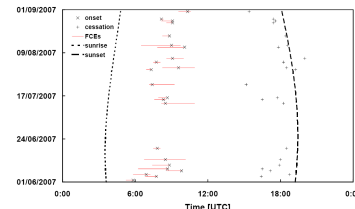
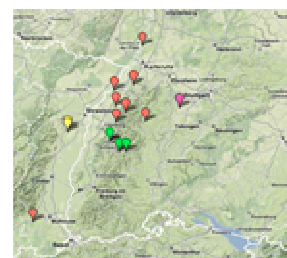


Fig. 4: Onset (x) and cessation (+) times of the up-valley wind direction and the corresponding periods of FCCs (-) in the morning hours during the entire COPS measurement period at Fußbach in the Kinzig valley. Also depicted are the times of sunset and sunrise.

## Outlook: Investigations of FCCs at all stations

At a first glance, FCCs frequently occur in all valleys of the Black Forest Mountains (Murg, Rench, Kinzig valley), but on the mountain summits (Hornsgrinde, Igelsberg) FCCs are rarely observed.



### Institutes:

- University Bayreuth
- Karlsruhe Institute of Technology
- University of Bonn / University Vienna
- Météo France-CNRS

Fig. 5: COPS energy balance and turbulence network.

## Conclusions

- ✓ FCCs are triggered by a change of the local circulation system
- ✓ Large-scale turbulence structures emerge during the period of FCCs
- ✓ FCCs seem to frequently occur in all valleys of the Black Forest