



Getting the balance closed – eddy covariance measurements vs. bottom-up modelling vs. soil and forest inventory at Hainich Forest, Germany

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Hainich Forest is a verification site of the CarboEurope cluster. At these sites eddy-covariance (EC) measurements of net ecosystem carbon exchange are combined with tree inventory measurements and repeated soil sampling in order to assess the ecosystem's carbon budget with independent methods.

The experimental site is located within the 'Hainich National Park', near the city of Eisenach in central Germany (51°04'46"N, 10°27'08"E), 440 m a.s.l.). The Hainich tower is located on a gentle north facing slope (less than 2° inclination around the tower) with a steepening about 300 m further downhill. The ecosystem is an old uneven-aged mixed beech forest that has been taken out of management for decades resulting in a large tree age class distribution, a diverse canopy and large deadwood pools.

Eddy covariance measurements have been conducted since 1999 and data evaluation with standard u^* -correction showed that the forest is an unexpectedly high sink with annual budgets between 450 and 500 g C m⁻² y⁻¹ during the years 2000 – 2002. In 2003 the annual budget was affected by the severe drought affecting Europe between July and September decreasing carbon uptake to 410 g C m⁻² y⁻¹. During the year 2004 the photosynthetic capacity of the canopy was reduced resulting in a carbon uptake of 380 g C m⁻² y⁻¹. We assumed that this was due to a complex interaction between extended storage depletion during a mast-year in 2002 and reduced assimilate income in 2003. The vegetation period of 2005 showed a recovery of the photosynthetic capacity.

However, the high carbon uptake measured by EC could not be confirmed by preliminary inventory measurements. A possible explanation could be that standard u^* -correction does not adequately consider the occurrence of advection, in this case the horizontal flow of CO_2 rich air downhill. Direct measurements as well as the comparison of EC data with an independent bottom-up model indicated that advection due to katabatic flow occurs at the site. Particularly, the nighttime fluxes and – consequently – the calculation of total ecosystem respiration (TER) were affected. For the year 2004, the difference in TER obtained from EC data alone and from the bottom-up model was $100 - 200 \text{ g C m}^{-2} \text{ y}^{-1}$ depending on the filtering rules used for rejecting unreliable EC data. This resulted in a span between 300 and $380 \text{ g C m}^{-2} \text{ y}^{-1}$ for the net ecosystem exchange (NEE) in 2004.

Tree inventory studies showed a high spatial variability of annual growth rates within the forest stand and a relatively weak climatic signal between 2002 and 2005 at the stand level. This was due to a complex interaction of tree size, age, species, position within the canopy, fructification and drought. Intensive soil sampling in the footprint area was performed in 2001 and 2004 to study trends in soil carbon concentrations and stocks. Additionally, mineralization experiments were conducted in 2000 and 2004, serving as the basis for soil respiration models.