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Fluxes of reactive and non-reactive trace gases close to the forest floor

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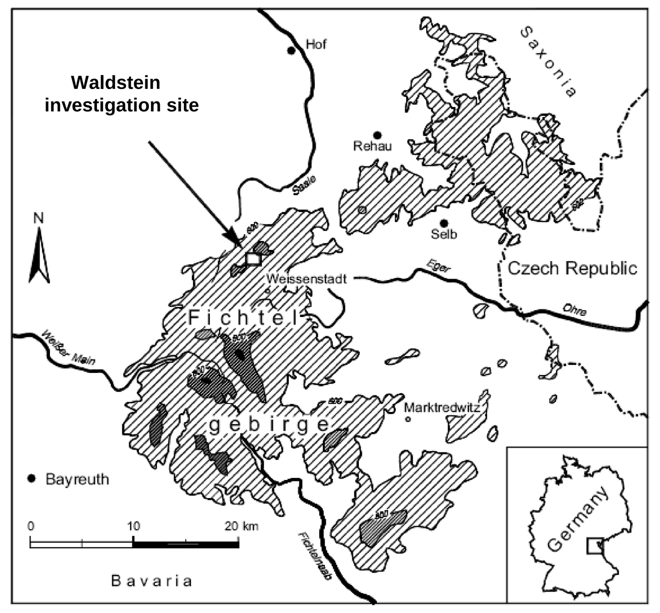


Figure 1: Location of the Waldstein research site (Gerstberger 2004).

Introduction

The EGER experiment takes place in the Fichtelgebirge, a low mountain range in the northeast of Bavaria (Figure 1). Under direction of the Department of Micrometeorology (University of Bayreuth) and the Max Planck Institute for Chemistry in Mainz, soil-vegetation-atmosphere exchange processes in a spruce forest are investigated. Flux measurement and modelling of reactive as well as non-reactive trace gases is an essential part. Not only in high vegetation and close to the ground, the occurrence of unexpected results is common in meteorology and air chemistry. By introducing a coupling events detecting and identifying method, one element of uncertainty is to be better understood and considered. Two different modelling approaches, which help to accomplish that, are explained in the following.

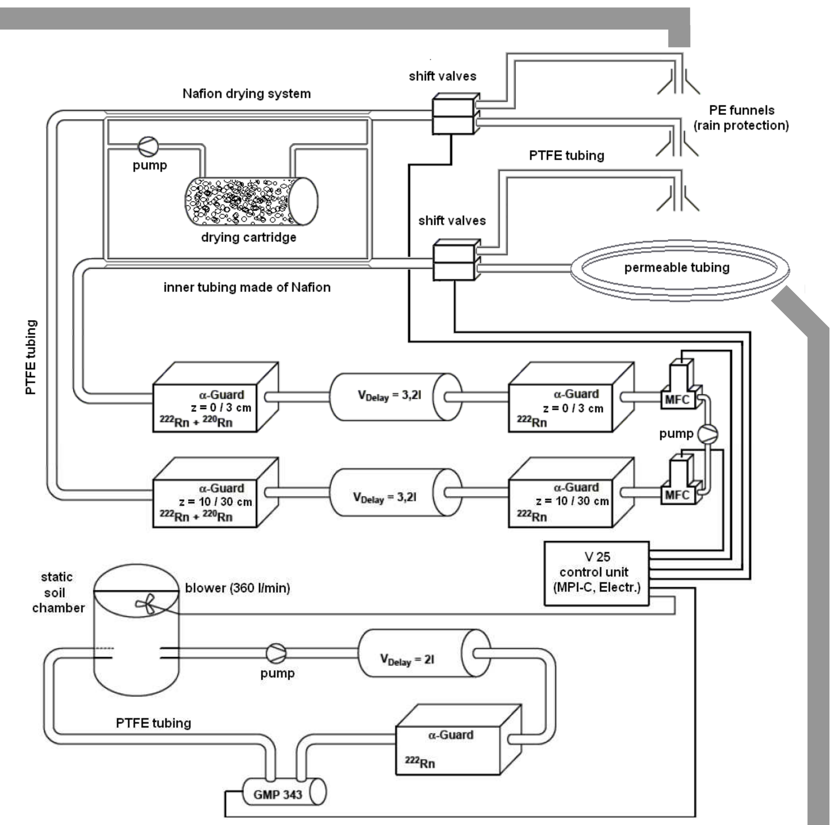


Figure 2: Radon measurement setup during EGER IOP2 (extended from Hens 2009).

model 1

modelled flux by **Richter and Skeib** approach

$$c(z_2)-c(z_1)=\frac{\overline{w'c'}}{\alpha_{0E}\kappa u_*}\ln\left(\frac{z_2}{z_1}\right)$$

$$z_1<z_2<z_c$$

model 2

surface concentration modelling by **hydrodynamical multilayer model**

$$\Gamma=\frac{\kappa\cdot u_*}{\kappa\cdot Sc\cdot 6+\kappa\cdot 4+\ln\dfrac{u_*\cdot z}{30\nu}}$$

$$\overline{w'c'}=-\Gamma\left[c(z)-c_0\right]$$

"effective" surface concentration — **comparison** — measured surface concentration

Identification of coupling and decoupling situations

As the modelling sceme above illustrates, two models are involved. Richter and Skeib (1984 and 1991) developed a method (model 1) to determine turbulent fluxes from profile measurements in two heights. Thus we get a flux, which is put into model 2. Foken 1979 evolved a hydrodynamical multilayer model, that parameterizes exchange processes in the laminar boundary layer, the viscous sublayer or buffer layer and the dynamical sublayer separately. Close to the ground surface this is really essential. With the flux between 0.1 and 0.3 m and the profile coefficient *Γ*, that considers the different layers, a so called "effective" surface concentration can be derived and afterwards compared to a measured surface concentration. The results are shown in Figure 3 and 4. ^{222}Rn suits perfectly for this task, because it is chemically inert and unaffected by the biosphere. As a first approximation, ground level coupled (C) and decoupled situations (D) have been classified visually. Further statistical investigation is intended. In Figure 4, where the method is applied to water vapour, a large consensus to ^{222}Rn confirms the applicability of the method. The periods that disagree (labelled with red and green bands) can be explained by advection of air masses with different composition and by dewfall events in the early morning hours, followed by steeply rising air temperature as well as water vapour concentration (green band).

Figure 3: Comparison of measured (black) and effective surface concentration (red) of ^{222}Rn. Vertical teal lines separate periods with different coupling situations (classified visually according to concentration differences; coupled = C, decoupled = D).

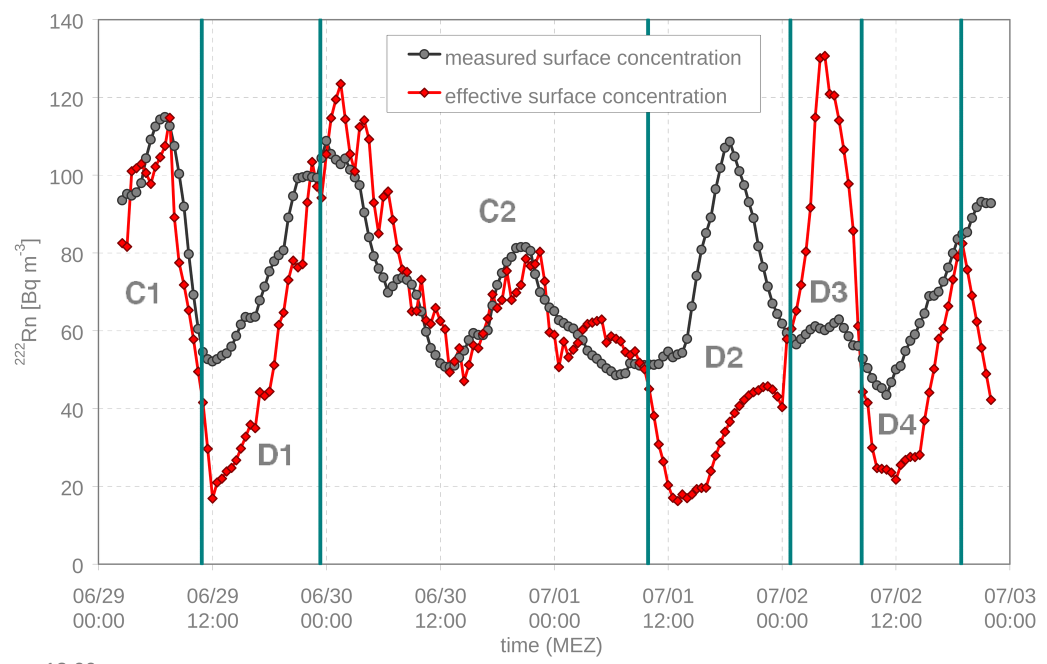
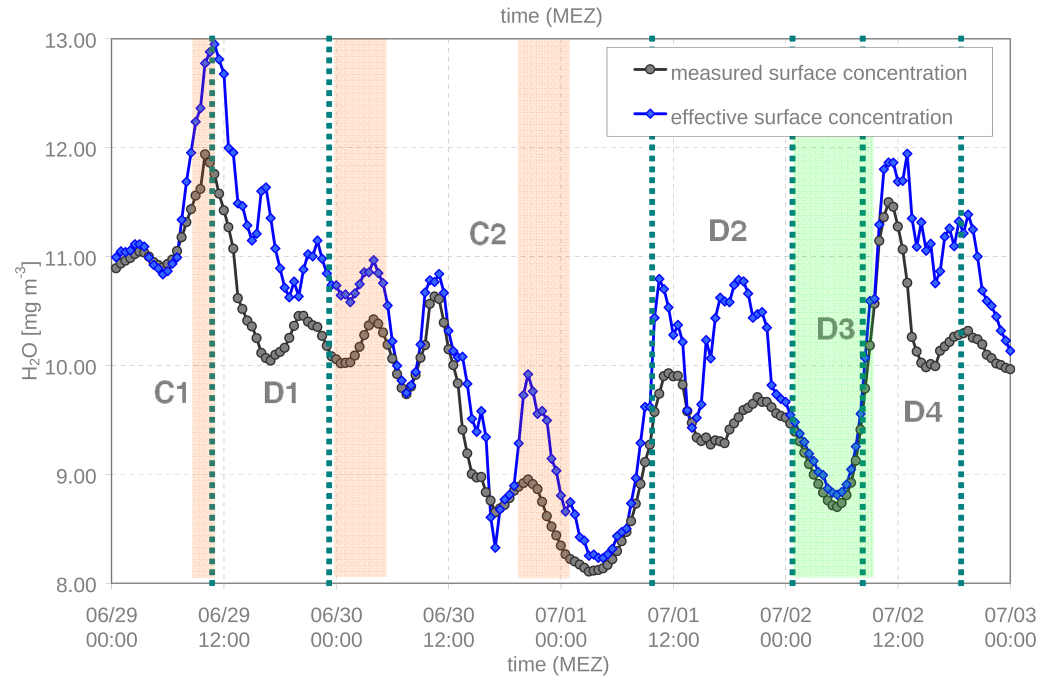


Figure 4: Comparison of measured (black) and effective surface concentration (blue) of H_2O. Vertical teal lines separate periods with different coupling situations (classified visually according to concentration differences; coupled = C, decoupled = D).



Comparison of fluxes

Among surface concentration modelling, the hydrodynamical multilayer model is used for trace gas flux determination. Figure 5 shows temporary similarity and a curve progression in the same dimension of a modelled ozone flux (red) and one, which was measured by eddy covariance technique (black). However, the much higher similarity than in Figure 6, between modelled (blue) and static soil chamber measured ^{222}Rn fluxes (black), demands discerning reflection of the soil chamber method. This is mainly, because eddy diffusion coefficient (*K*) profiles are to be determined partly by static soil chamber measurements. Figure 7 and 8 illustrate possible changes of the *K*-profiles by using the fluxes of Figure 6.

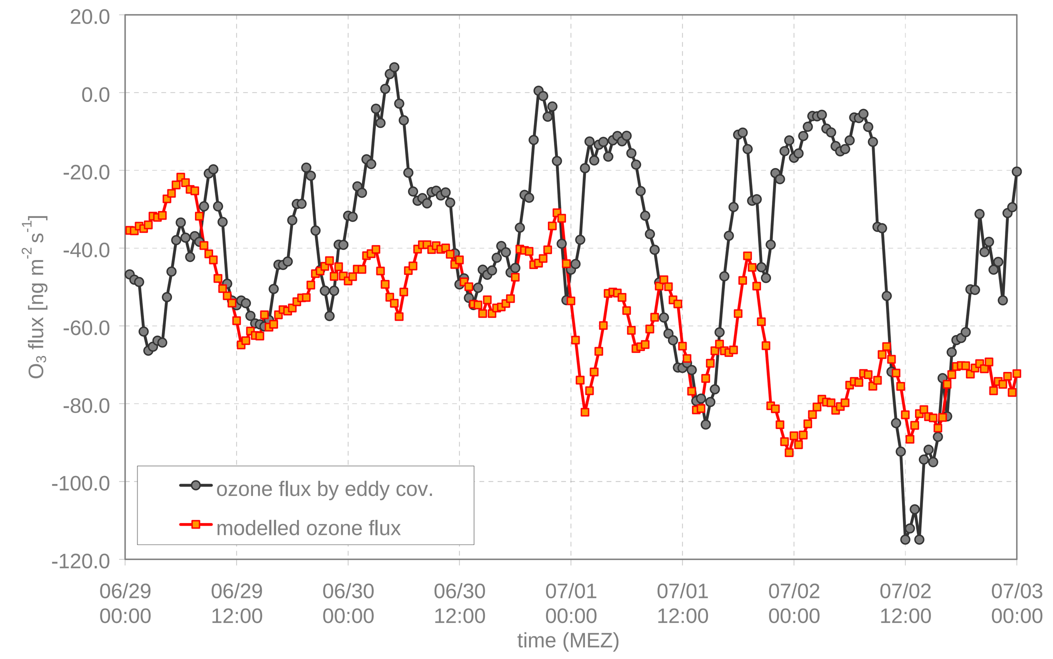


Figure 5: Comparison of measured (black, by eddy covariance method in 1 m) and modelled ozone flux (red, by hydrodynamical multilayer model for 1 m).

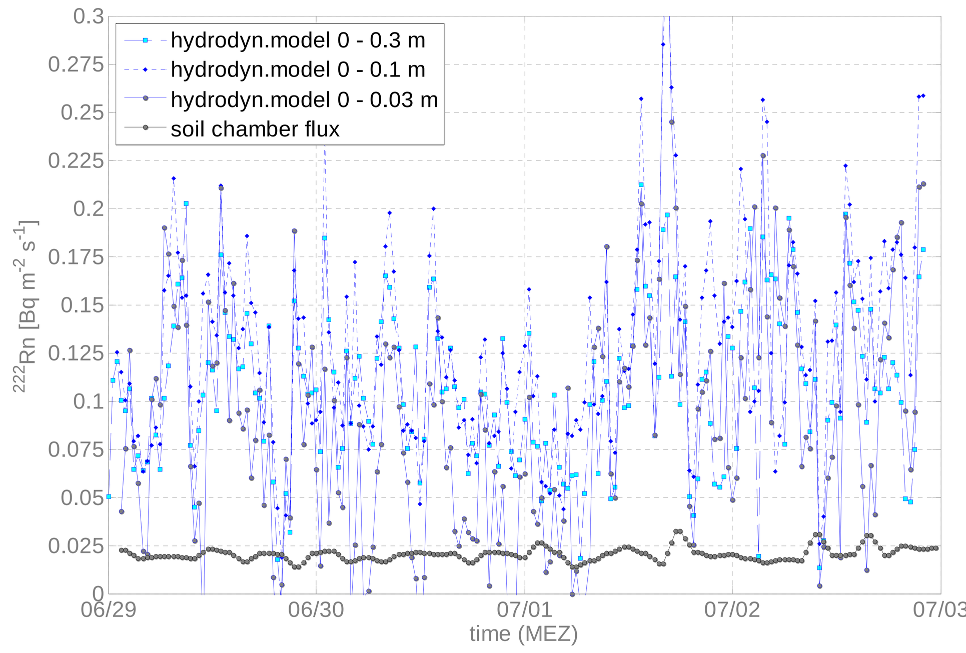


Figure 6: Comparison of measured (black, by static soil chamber) and modelled ^{222}Rn flux (blue, by hydrodynamical multilayer model).

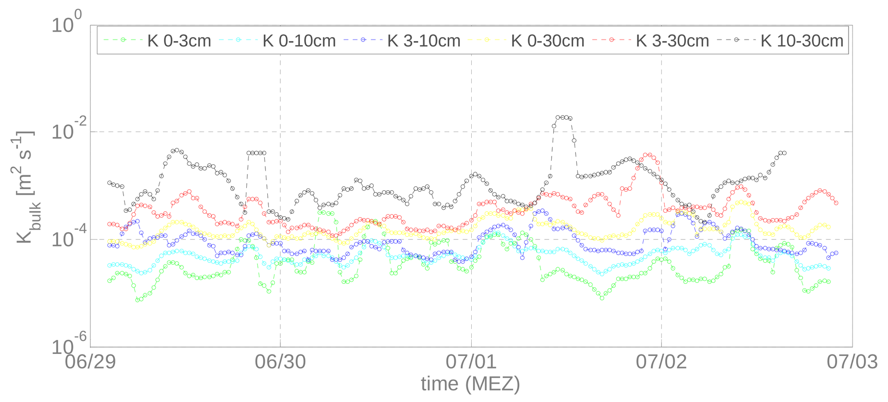


Figure 7: Eddy diffusion coefficient (K) profile determined by a static soil chamber flux and profile measurement of ^{222}Rn.

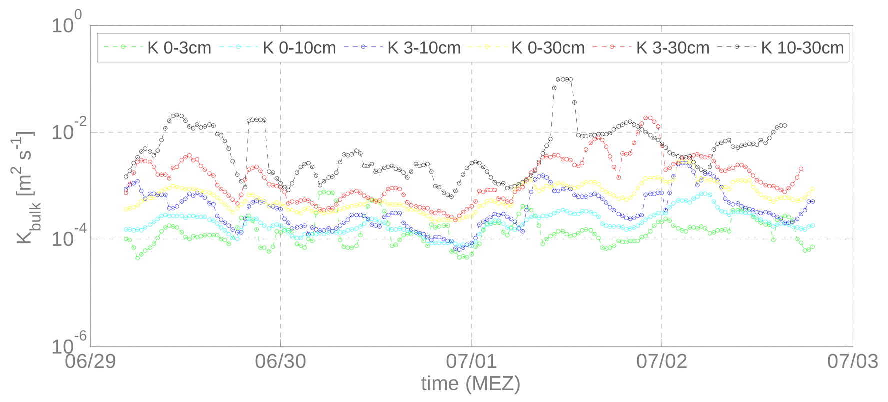


Figure 8: Eddy diffusion coefficient (K) profile determined by modelled surface flux and profile measurement of ^{222}Rn.

Conclusions

- Further development of the coupling situation detection and classification can provide explanation for trace gas characteristics.
- Static soil chamber measurements have to be handeled with care in a scientific sense.

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