G.J. Heij and J.W. Erisman (Editors). Acid Rain Research: Do we have enough answers?

Dry deposition monitoring of SO_2, NH_3 and NO_2 over a coniferous forest

Jos Hogenkamp§, Jan Willem Erisman§, Marcel Mennen§, Erik Kemkers§, Addo van Pul§, Geert Draaijers§, Jan Duyzerξ (TNO) and Paul Wyers (ECN)ϕ

§RIVM, P.O.Box 1, 3720 BA Bilthoven, the Netherlands,

ξTNO, P.O.Box 6011, 2600 JA Delft, the Netherlands,

ϕECN, P.O.Box 1, 1755 ZG Petten, the Netherlands

1. INTRODUCTION

In 1990 a large project was initiated to develop a monitoring method for measurement of deposition of acidifying components onto forests. This project is the continuation of the successful development of monitoring methods for SO_2, NO_2 and NH_3 deposition to low vegetation [1:3]. From January to August 1992 tests were done with the equipment over low vegetation at the heathland Elspeetsche Veld [4]. These tests included experiments determining effects of obstacles (monitor housing) to be installed in the mast above the forest on the momentum and heat flux measurements, optimisation of the gradient system for NO_2 and SO_2, and tests of eddy correlation measurements of the NO_2 flux. At the end of 1992 the optimised monitoring systems for SO_2, NO_2 (RIVM) and NH_3 (ECN) were installed at the forest site. Since then continuous vertical concentration gradient measurements of these components are available. In June 1992 also eddy correlation measurements of NO_2 were started. These data, however, have not yet been validated and evaluated. In this paper, the first results of the measurements made between November 1992 and September 1993 are presented.

2. SITE DESCRIPTION AND FLUX PROFILE RELATIONS

The measuring site consists of a homogeneous 2.5 ha monoculture of Douglas fir, 35 years old with a stem density of 785 ha^{-1}. The mean tree height is 20 m. The canopy is well closed with the maximum leaf area density, one-sided LAI = 9, at a height of 10-14 m. The measuring system is extensively described in [4].

Flux profile relations for ozone and heat were evaluated from simultaneous eddy correlation and gradient measurements by TNO in 1993 [5]. The α_h factors found by TNO for O_3 and heat are similar to those found by [6]. It is concluded that the conventional flux-profile relations can be used for the estimation fluxes of heat and ozone using gradient measurements. It is assumed that these relations can be applied for other trace gases (SO_2, NO_2 and NH_3).

The eddy correlation measurements of $u*$ and H at 30 m height by TNO and those at 36 m height by RIVM were compared to evaluate the constant flux layer assumption (Fig. 1 and 2). The agreement between the 30 m and 36 m $u*$ values was reasonable, whereas the difference between the heat fluxes measured at the two levels was much. From the two figures it was concluded that during these measurements the constant flux layer assumption for momentum and sensible heat fluxes is valid

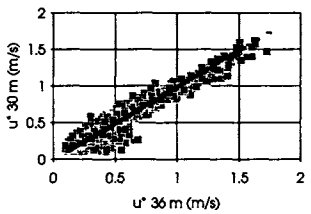

FIGURE 1. Eddy correlation $u*$ measurements at 30 m compared to those measured at 36 m height.

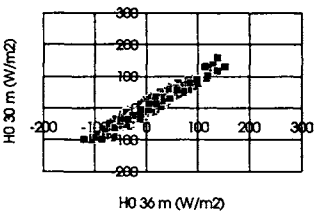

FIGURE 2. Eddy correlation H measurements at 30 m compared to those measured at 36 m height).

3. AVERAGE DEPOSITION PARAMETERS FOR SELECTED PERIODS

For each hour three vertical SO_2 and NO_2 gradients were averaged and $c*$, F, V_d, R_a, R_b and R_c were calculated. The ten NH_3 gradients measured within one hour were also averaged and the deposition values were calculated accordingly. The dataset thus obtained has to be 'cleaned' by selection of hours during which the theoretical demands for the gradient technique were fulfilled [1], during which the concentrations were well above the detection limit, and during which there was no loss of necessary measurements due to technical problems. R_c values show strong variations with time; when the surface becomes wet, R_c values drop to zero, whereas at very dry conditions R_c values can easily increase up to values of 1000 s m^{-1} at night. An R_c parameterization derived from analogous measurements over a heathland during three years [2] was tested. This parameterization can be applied for routinely measured components; it is based on literature values for the stomatal resistance, on empirical values for wet surfaces (due to rain or at high relative humidity) and for snow covered surfaces. Parameterized and 'measured' R_c values for SO_2 show reasonable agreement (40% of variance accounted for), with high values during dry periods at night, low values during daytime and values approaching zero during wet surface conditions. R_c values for NH_3 show similar variations. Emission of NH_3 was observed on several occasions and seemed to be strongly related to drying of the canopy. Emission was observed mainly during the day at a relative humidity decreasing below 80%. When the canopy is dry and the flux is towards the surface, this flux is higher than the inferred stomatal flux, indicating that the external leaf surface is also an important receptor for NH_3. For the whole dataset no influence of NH_3 on deposition parameters for SO_2 and vice versa was observed. This in contrast to the observations of [3] who demonstrated influence of both gases on the deposition of each other under extreme conditions.

4. References

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