Chapter 9

Atmospheric Deposition of Sulfur, Nitrogen and Basic Cations onto European Forests: Observations and Model Calculations

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Summary

Measurements of sulfur and nitrogen deposition by means of the throughfall method are compared with model estimates. The sulfur model appears to estimate deposition to deciduous forests very well, but underestimates deposition to conifers by 30 to 40 %. The NH_4-N deposition to forest is underestimated by the applied model. The model predictions of NO_3-N deposition do not show any bias against observations, but are not better correlated with observations than NH_4 calculations. Reduced nitrogen compounds are the dominant nitrogen form in throughfall in ammonia polluted areas and contribute up to 50 % of the total nitrogen deposition in other areas. Deposition of alkaline material to forests is estimated by applying different methods. Basic cation deposition neutralizes about 31 % of the acid sulfur deposition to forest, on the average. Because of the large spatial variability of base cation deposition, it is recommended to develop a model for atmospheric transport and deposition of calcium- and magnesium-bearing particles.

Introduction

To assess the ecological impact of atmospheric pollutants on ecosystems, it is necessary to quantify the input of these pollutants. Long range transport models are used to quantify this input at a European scale. These kinds of models have a coarse spatial resolution. Thus surface characteristics like the aerodynamic surface roughness are averaged over large grid elements (> 10000 km^2). Forested areas might filter more pollutants than non-forested areas, because of the greater surface roughness and greater total receptor

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surface of forests compared with other kinds of vegetation. Therefore long range transport models might underestimate atmospheric deposition onto forests. The aim of this study was to analyze deposition measurements and model results thereby estimating sulfur and nitrogen deposition onto forests in Europe. We also wished to account for the deposition of alkaline compounds, because of their neutralizing effect on acidifying processes.

In this study observed deposition fluxes obtained from the literature were compared with deposition estimates from long range transport models. The model estimates were provided by the International Institute for Applied System Analysis (IIASA, Austria).

The analysis of the sulfur deposition given in this paper is a simplified version of an analysis given in Ivens et al. (in press).

Method

This study focuses on element fluxes to the forest floor by canopy drip and stemflow. Canopy drip is the water dripping from the canopy during rainfall and stemflow is the water descending the trunk or stem. The sum of these fluxes, henceforth referred to as throughfall flux, includes both wet and dry deposition.

At the canopy-atmosphere interface chemical interactions can take place involving transfer of gases or particulate matter (absorption or release by the canopy). When irreversible uptake of an element from the atmosphere by the canopy occurs, throughfall fluxes will underestimate total atmospheric deposition of this element. Conversely throughfall fluxes will overestimate total atmospheric deposition when an element is excreted by the tree tissue.

Allthough leaves are capable of absorbing SO_2, the major part of it will be leached from the leaf during rainfall (Bredemeier 1987). The internal flux of sulfur is insignificant ($< 5\,\%$) (Ulrich 1983; Lindberg et al. 1986; Garten et al. 1988) in conditions like in Central Europe, where the total deposition to the canopy is high, but might be of greater relative importance in remote areas.

In nitrogen deficient systems with low nitrogen deposition, a significant part of the nitrogen deposition can be absorbed irreversibly by the canopy (Grennfelt et al. 1987). In these systems throughfall fluxes will underestimate total nitrogen deposition. A substantial part of the calcium and magnesium flux in throughfall is thought to be caused by internal cycling of these elements (Parker 1983). Therefore atmospheric deposition of these elements will be less than the amount measured in the throughfall flux. To determine the magnitude of the atmospheric deposition of basic cations to forests, three approaches were used (Table 9.1):

- "minimum approach": it is assumed that basic cation deposition to forest takes place only by gravitational settling and by wet deposition; therefore deposition of alkaline particles to the forest equals deposition to other surfaces like bulk precipitation samplers

- "maximum approach": it is assumed that no significant leaching of calcium and magnesium from the plant tissue occurs; therefore throughfall flux of basic cations equals total deposition of these elements

- "filtering approach": it is assumed that the forest filtering of sodium-bearing particles is equal to the filtering of alkaline particles (Ulrich 1983)