# Estimating ion exchange in plant canopies using the canopy budget model

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Uptake and release of mineral elements by terrestrial plants occurs both belowground by roots and aboveground by leaves and other aerial plant parts. Mineral nutrients in the form of gases are mainly exchanged by stomata. Dissolved elements can exchange or diffuse between the plant cell apoplasm and a water layer on aerial plant tissues. In addition, experimental and field research for different tree species indicates that the canopy release of cations such as potassium and calcium is accompanied by the canopy uptake of ammonium and/or protons and by the release of weak organic acids.

The canopy budget model simulates the interaction of major ions within vegetation canopies. The model calculations are based on measured ion fluxes in precipitation above and beneath plant canopies because the rainfall passing through canopies is chemically modified by the processes of ion exchange between vegetation tissue and rainfall as well as the wash-off of dry deposition. A better understanding of these two processes is important to improve insight in the biogeochemical cycling of nitrogen and so-called base cations in semi-natural ecosystems.

The basic assumptions of the canopy budget model are supported by experimental research, but have not properly been evaluated for different environmental conditions. Nevertheless, the model has been used for a wide range of forest ecosystems, and in principle, it can also be applied for other vegetation types. The first step in the model is the calculation of a dry deposition factor for estimating the dry deposition of particles containing base cations using a tracer ion that is hardly affected by canopy exchange processes. Based on these dry deposition fluxes, canopy leaching of these cations is then calculated. Finally, the ion exchange within the canopy between ammonium and protons versus base cations is modelled for determining the dry deposition and aboveground uptake of inorganic nitrogen.

For all these model steps, however, reported applications of the model have used varying approaches. We give an overview of variations with respect to the time step, type of precipitation data, and tracer ion used in the model, and discuss the strengths and weaknesses of possible ion exchange assumptions. Furthermore, little is known about the sensitivity of the estimated canopy exchange and dry deposition fluxes to variations of the canopy budget model. Therefore, we present the results of different model approaches applied for two deciduous forest plots in regions with a contrasting atmospheric deposition.