

Chapter 18

Application of Two Soil Acidification Models to Historical Soil Chemistry Data from Sweden

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Summary

Soil chemistry data from southern Sweden, first sampled in 1949 and resampled in 1984, are used to test two models of the RAINS (Regional Acidification INformation and Simulation) model for soil acidification. Both versions were developed for predicting the acidification of forest soils on a large regional scale. The first one is part of the present RAINS model, designed at IIASA as a tool for evaluating policies for controlling the acidification of Europe's environment. The second model, SMART (Simulation Model for Acidification's Regional Trends), comprises a more detailed description of the cation exchange processes and will replace the first in the overall RAINS system. The soil chemistry data from southern Sweden offer a unique opportunity to test these models, since they provide a detailed description of the changes of the pool of base cations as well as the soil pH at different depths in the soil profile in 1949 and 1984. Results show that the changes in the amount of exchangeable base cations are predicted reasonably well by both models. The order of magnitude of the pH changes is predicted in the shallow profiles of the most acid soils, but they are clearly underestimated when deeper soil layers are included. The findings suggest that even rather simple soil acidification models can describe the changes of base cation reservoirs in soils. Describing soil pH, an "intensive" variable, is clearly more difficult. Since these models are driven by acid deposition and reproduce the observed base cation depletion reasonably well, the deposition of acidifying compounds is found to be the main source of soil acidification at these sites.

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Introduction and Data Material

The main objective of the RAINS soil models is to provide an overview of the long-term changes of European soils as a consequence of different deposition scenarios. The focus is on forest soils, since agricultural soils are intensively managed, and acidification is not considered a problem. Due to the large spatial coverage one of the main problems is to test and validate such models against measurements. What is needed is a European wide, statistically sound survey of key soil variables, preferably repeated every decade or so. However, due to the lack of such a data base, we have to confine ourselves to comparing the soil models to measurements from individual sites.

Berdén et al. (1987) have reviewed a large number of investigations reporting on the changes in pH and exchangeable cations in soils. The general tendency is that "new" measurements indicate lower pH values and smaller pools of exchangeable cations than "old" measurements. Interpretation of these results is difficult, however, because the methods are partly incompatible and sometimes poorly documented. In addition, the contribution of acid deposition due to natural acidification (vegetation changes) varies from site to site.

In most cases "new" soil chemistry information has been compared with the results of old analyses completed years or decades previously. The data of Falkengren-Grerup and co-workers (Falkengren-Grerup et al. 1987; Falkengren-Grerup 1987) from southern Sweden are of particular interest because the sampling sites used in the 1949 survey were relocated and both "old" and "new" (1984) samples were re-analyzed using present-day techniques.

Concentrations of Al^{3+} , H^+ , Na^+ , Ca^{2+} , Mg^{2+} , K^+ , as well as measurements of the total cation exchange capacity and base saturation were taken at 3 to 7 depths within the soil profiles that were 30 to 100 cm deep (Falkengren-Grerup et al. 1987). Out of the ten sites, located in Skåne in the southernmost part of Sweden, we selected six sites for our comparison (sites 2,3,6,7,8 and 9 in the notation of Falkengren-Grerup et al. 1987; sites 1,4,5 and 7b were excluded from the analysis since the soil layer was not deep enough or there were no measurements for the top soil layer). Site 7 is in a spruce stand and the other sites are covered by deciduous trees.

The driving variables of soil acidification, in addition to natural acidification and biomass accumulation, are the deposition of sulfur and nitrogen compounds and, as a counteracting force, the deposition of base cations. The sulfur deposition onto the above sites for the time period 1949–1984 was estimated by the Energy-Emission and Long-Range Transport Module of the RAINS model (Alcamo et al. 1987). Coniferous forests were assumed to filter sulfur deposition such that they receive 1.6 times the amount received by open field, while there is no significant filtering by deciduous trees (Ivens et al., this volume). Calcium and magnesium deposition was assumed to buffer one third of the acidity due to sulfur deposition. In this study we tested two soil acidification models. While the first model is sulfur driven, the second model also takes into account the deposition of nitrogen species (NO_x and NH_3). Estimates for the deposition of these species are taken from Alcamo and Bartnicki (1988). The deposition histories used to drive the soil acidification models (expressed in eq m^{-2}) are displayed in Figure 18.1.