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Preface

Processes controlling the exchange of ammonia between grassland and the atmosphere (GRAMINAE) – results from the Braunschweig field experiment

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1 Rationale

The last decades have brought substantial reductions in emission of several air pollutants. However, ammonia (NH_3) still constitutes a major problem. Ammonia can cause formation of aerosols in the atmosphere. When deposited to terrestrial or aquatic environments, both the gaseous form as well as the derived aerosols can lead to soil acidification, eutrophication and loss of biodiversity. The relative importance of NH_3 in acidification has increased because of the reductions in emissions of sulphur and nitrogen oxides in Europe. There is an increasing recognition of the role of NH_3 as a precursor for secondary aerosol formation affecting human health, visibility and radiative forcing.

A key uncertainty in quantifying atmospheric ammonia budgets and nitrogen deposition is the exchange of NH_3 between the land surface and the atmosphere. The existence of bi-directional fluxes complicates the biosphere-atmosphere exchange of NH_3. These fluxes are affected by a range of environmental, plant, soil and management factors. Grasslands are particularly interesting in this respect because intensively managed grasslands are frequently sources of NH_3 whereas semi-natural grasslands may act as NH_3 sinks.

Previous international projects have dealt with these issues, but, because of their dispersed network approach, they have not considered all of the interacting factors that affect NH_3 exchange at a single measurement site. On this background, the major aim of the GRAMINAE field experiment was to integrate the different processes affecting NH_3 exchange. The experiment therefore combined micrometeorological, cuvette and bioassay analyses for NH_3, gas-particle interactions, effects of management practice and the role of advection from agricultural sources on NH_3 fluxes in the rural landscape.

The Experiment itself was conducted as a key part of the GRAMINAE project (GRassland AMmonia INteractions Across Europe), with the subsequent analysis completed under the NitroEurope Integrated Project. Both of these projects have been jointly funded under the Framework Research Programmes of the European Commission, together with the financial support of many national ministries, agencies and insitutes.

2 The Braunschweig Experiment

The experiment took place at the German Federal Agricultural Research Centre Bundesforschungsanstalt für Landwirtschaft, (FAL) near Braunschweig and involved 50 researchers from 23 institutions in 12 countries.

The choice of field site is often very difficult because there is no such thing as an "ideal field site" when taking all criteria into account. The Braunschweig site is, however, quite close to the ideal site in that it has a large extension, is flat, is composed of managed grassland including a farm with NH_3 emission, is controlled by the research station and has excellent logistics.

The Braunschweig Experiment was carried out during 4 weeks in May–June 2000. The planning of the experiment, including design and timing of management activities, started one year before. Overall, the experiment was successfully conducted according to the plans made. The weather

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could not be planned, but the range of actual weather conditions during the experiment was quite typical for the time of the year. After the experimental work was completed, it has taken several years to analyze fully and publish the results. What has been achieved with this large effort?

3 Results

The current Special Issue contains 16 research papers. Fourteen of these deal with the individual topics of the experiment and encompass a broad range of research disciplines, while two papers describe the rationale for and the layout of the field experiment and provide a final synthesis of the results.

The experiment compared the aerodynamic gradient method and relaxed eddy accumulation (REA) for NH_3 flux measurements. A close agreement was found, but the REA systems proved insufficiently precise to investigate vertical flux divergence. Inverse modelling of NH_3 emission from the farm agreed closely with inventory estimates, and horizontal variations in NH_3 concentration were used to quantify advection effects on the measured grassland fluxes, and to derive the appropriate corrections. The NH_3 emission potential of the grass plants was successfully estimated by bioassays of the leaf apoplastic solution, combined with other bioassay measurements. For the first time, the potential contribution of individual plant species to the exchange pattern of a whole canopy was estimated. Three different models each reproduced the main temporal dynamics in the flux, highlighting the importance of canopy temperature dynamics, interactions with ecosystem nitrogen cycling, and the role of leaf surface chemistry. The net above-canopy fluxes were controlled by the stomatal and cuticular uptake before cutting the grass, by leaf litter emissions after the cut, and by fertilizer and litter emissions after application of nitrogen fertilizer.

4 Wider impact

The results presented in this Special Issue contribute significantly to advancing the scientific knowledge of processes controlling the NH_3 exchange between the atmosphere and the biosphere. We foresee that the results will have a major impact on future modelling and design of experiments focusing on biosphere-atmosphere NH_3 exchange. However, there are still large uncertainties in estimation of the NH_3 exchange due to the many interacting processes. Such uncertainties include the physiology of the plants, the chemical reactions in the atmosphere, the properties of soil litter and the perturbations by management. There is an ongoing need for the development of more-accurate, fast and easy-to-operate NH_3 analyzers and a special need for studying the dynamics of NH_3 emission from leaf litter. While these represent ongoing challenges, the outcomes from the uniquely detailed Braunschweig Experiment contribute a firm foundation to improve future measurement strategies and the description of ammonia exchange processes in local, regional and global scale models.