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Ammonia fluxes and derived canopy compensation points over non-fertilized agricultural grassland in The Netherlands using the new gradient ammonia—high accuracy—monitor (GRAHAM)

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Abstract

During a measurement period from June till November 2004, ammonia fluxes above non-fertilized managed grassland in The Netherlands were measured with a Gradient Ammonia—High Accuracy—Monitor (GRAHAM). Compared with earlier ammonia measurement systems, the GRAHAM has higher accuracy and a quality control system.

Flux measurements are presented for two different periods, i.e. a warm, dry summer period (from 18 July till 15 August) and a wet, cool autumn period (23 September till 23 October). From these measurements canopy compensation points were derived. The canopy compensation point is defined as the effective surface concentration of ammonia. In the summer period (negative) deposition fluxes are observed in the evening, night and early morning due to leaf surface wetness, while in the afternoon emission fluxes are observed due to high canopy compensation points. The mean NH_3-flux in this period was $4\,ng\,m^{-2}\,s^{-1}$, which corresponds to a net emission of $0.10\,kg\,N\,ha^{-1}$ over the 28 day sampling period. The NH_3-flux in the autumn period mainly shows (negative) deposition fluxes due to small canopy compensation points caused by low temperatures and a generally wet surface. The mean NH_3-flux in this period is $-24\,ng\,m^{-2}\,s^{-1}$, which corresponds to a net deposition of $0.65\,kg\,N\,ha^{-1}$ over the 31 day sampling period.

Frequency distributions of the NH_3-concentration and flux show that despite higher average ambient NH_3-concentrations ($13.3\,\mu g\,m^{-3}$ in the summer period vs. $6.4\,\mu g\,m^{-3}$ in the autumn period) there are more emission events in the summer period than in the autumn period (about 50% of the time in summer vs. 20% in autumn). This is caused by the high canopy compensation points in summer due to high temperatures and a dry surface. In autumn, deposition dominates due to a generally wet surface that induces low canopy compensation points.

For our non-fertilized agricultural grassland site, the derived canopy compensation points (at temperatures between 7 and 29 °C) varied from 0.5 to $29.7\,\mu g\,m^{-3}$ and were on an average $7.0\,\mu g\,m^{-3}$, which is quite high for non-fertilized conditions and probably caused by high nitrogen inputs in the past or high dry deposition amounts from local sources. The

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average value for the ratio between NH_4^+ and H^+ concentration in the canopy, Γ_c, that was derived from our data was 2200.

Keywords: Ammonia; Flux; Distribution; Compensation point

1. Introduction

Ammonia deposition is an important eutrophying input to ecosystems. As such it may lead to a number of detrimental effects such as a loss in biodiversity (Fangmeier et al., 1994; Bobbink et al., 1998). Quantifying the ammonia deposition to ecosystems has been the subject of many studies over the last two decades. However, the quantification of the exchange of ammonia above agricultural areas is also important in terms of obtaining a correct mass balance of ammonia over a regional scale. Recently, a number of studies on the ammonia exchange above agricultural surfaces (Sutton et al., 2000 (EXAMINE)) and specifically above grassland (Bussink et al., 1996; Sutton et al., 2001; Mosquera et al., 2001; Milford et al., 2001; Spindler et al., 2001) have been carried out. To obtain a better insight into the long-term ammonia exchange above grassland in The Netherlands new measurements are carried out varying from fertilized to non-fertilized conditions. In this paper we report and discuss long-term measurements of concentrations and fluxes above a non-fertilized agricultural grassland site. With non-fertilized we mean that no fertilizer (mineral or organic) has been applied nor grazing by animals has taken place for more than at least 10 years.

The exchange of ammonia is basically induced by differences in concentration between the atmosphere and the surface. The actual exchange flux depends on the sign and magnitude of the concentration difference, as well as on the efficiency of all mechanisms involved in the transport and transfer. Only few techniques are available for high time resolution ammonia flux measurements (one value in 10 min). Up to now, in most cases ammonia fluxes were measured using AMANDA-systems which did have a precision of about 1%. This is adequate to derive fluxes, however, the AMANDAs did not always operate to this precision and were not always sufficiently reliable. A system is requested that can maintain a high precision and that remains reliable under different conditions. Therefore a new device, the so-called GRadient Ammonia—High Accuracy—Monitor (GRAHAM) system, was built. The GRAHAM has a higher precision (of about 0.4%), which enables us to derive more accurately fluxes and deposition parameters such as canopy compensation points and canopy gamma values (ratio between NH_4^+ and H^+ concentration in the canopy).

In this paper we give a description of the experimental set up and we present measurements with this new instrument above non-fertilized agricultural grassland. We show the typical daily behavior of the ammonia flux in two different periods, a summer period of 28 days and an autumn period of 31 days. We also show the typical concentration and flux distributions for these two periods. Furthermore, we present canopy compensation points obtained from flux direction changes and its dependency on temperature. We also show the apparent seasonal behavior of the derived gamma values.

2. Materials and methods

2.1. Site description

Long-term gradient measurements of ammonia were made from June till November 2004 at the 'Haarweg' meteorological observatory in Wageningen, The Netherlands. The data contain two interesting periods on which we focus in this paper, a warm and sunny summer period (between 18 July and 15 August 2004) and a cool and cloudy autumn period (between 23 September and 23 October 2004). At the meteorological observatory continuous measurements of air and soil temperature, air humidity, radiation, wind direction and wind speed are available.

The measurement site and its homogeneous surrounding are located west of Wageningen in The Netherlands (51°58′N, 5°38′W) on a heavy clay soil. The vegetation predominantly consists of temperate humid perennial ryegrass (*Lolium perenne* L.). There was no application of any kind of fertilizer (mineral or organic) at the measurement