Validation of nitrogen dry deposition modelling above forest using high-frequency flux measurements

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Abstract

We determined total reactive nitrogen (ΣN_r) dry deposition into a remote mixed forest site with no local anthropogenic emission sources using eddy-covariance (EC) flux measurements. Measured ΣN_r dry deposition at the site was 4.5 kg N ha^{-1} yr^{-1}, in close agreement with modelled estimates using the bidirectional inferential scheme DEPAC (DEPosition of Acidifying Compounds) as standalone version (5.2 kg N ha^{-1} yr^{-1}) and as integrated in the chemical transport model LOTOS-EUROS (5.2 kg N ha^{-1} yr^{-1} to 6.9 kg N ha^{-1} yr^{-1}).

Keywords: Nitrogen, Eddy Covariance, Forest, TRANC, DEPAC, LOTOS-EUROS

1. Introduction

Atmospheric deposition of reactive N compounds influences the productivity of natural ecosystems and its carbon dioxide exchange. As increasing N deposition may become harmful for a variety of ecosystems, it is necessary to thoroughly estimate the nitrogen exchange between biosphere and atmosphere. Measurements of ΣN_r were carried out with a custom-built converter coupled to a chemiluminescene detector (CLD). The Total Reactive Atmospheric Nitrogen Converter (TRANC) (Marx et al., 2012) was used to convert all reactive nitrogen compounds (ΣN_r), except for nitrous oxide (N_2O) and molecular nitrogen (N_2), to nitrogen oxide (NO). Fluxes were determined with the EC method and used to validate deposition routines.

2. Measurement site and validation strategy

The measurements took place in the Bavarian Forest National Park at a natural mixed-forest site away from agricultural and industrial emission hotspots to determine background $\sum N_r$ deposition in the absence of anthropogenic sources. The measurement period was from January 2016 until June 2018.

To validate the deposition module DEPAC (Erisman and Pul, 1994) within LOTOS-EUROS (Manders et al., 2017), a multi-stage scenario comparison was carried out. In this, the broad-scale dry deposition predicted directly by LOTOS-EUROS was compared to site-specific modelling results obtained using measured meteorological input data as well as the directly measured ΣN_r fluxes. In addition, the influence of land-use weighting in LOTOS-EUROS was examined. Additionally, we compared our results to ΣN_r deposition estimates obtained with canopy budget techniques.

3. Results of different deposition routines

Figure 1 shows the mean annual dry deposition of the applied methods. After gap filling of measurements with modelled ΣN_r fluxes, the mean annual deposition was 4.5 ± 0.3 kg N ha^{-1} yr^{-1} for the EC measurements, 5.2 ± 0.5 kg N ha^{-1} yr^{-1} for site-based modelling and 5.2 ± 0.4 kg N ha^{-1} yr^{-1} for LOTOS-EUROS with uncorrected land use, 6.9 ± 0.8 kg N ha^{-1} yr^{-1} for LOTOS-EUROS with corrected land use. The highest value from canopy budgets was 6.5 ± 0.2 kg N

ha^{-1} yr^{-1} for the period from 2016 to 2017. Our results showed that continuous flux measurements are useful to validate deposition schemes in larger scale models.

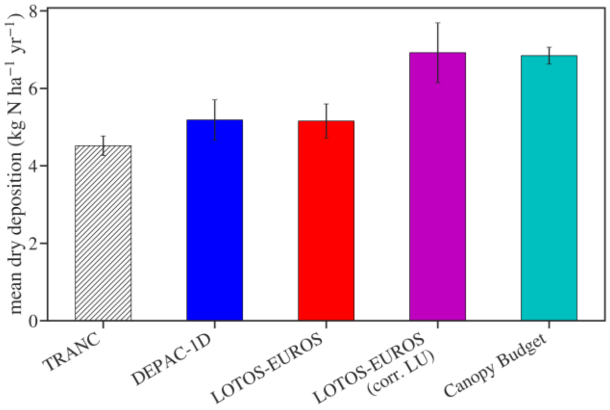

Fig. 1: Averaged annual dry deposition of ΣN_r of all applied methods. Error bars represent the standard deviation of the annual averages.

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