Vertical Transports under Complex Natural Conditions

VERTIKO

Concentration of Ammonia in the Erzgebirge and at the Anchor Station Melpitz – Estimation of N-Deposition over Grassland in Melpitz

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Objective

Naturally and anthropogenically caused climate variations can influence the trace gas exchange at the lower border of the troposphere. This exchange is influenced by meteorological parameters but also by trace gas concentrations as well as their respective ratios (co-deposition). These effects can only be recognized, described and transferred to larger areas by long time measurements at typical sites (anchor stations). The dry deposition of N-containing gases (e.g. NO_x, HNO_3, HNO_2, NH_3) and particles (NH_4^+, NO_3^-), together with the wet deposition of ammonium and nitrate, establishes a major sink for nitrogen in the troposphere and a source for different ecosystems. Here results for the N-Impact at the anchor station Melpitz for six years are presented und compared with model results. The results for 2002 were effected by a data lag of six weeks caused by a Flood. After them fluxes also calculated from parameters of a sonic anemometer. Ammonia is a basic trace gas mainly emitted from agriculture and due to its high deposition velocity the part of N-Impact is high. Therefore Ammonia measurements were done and compared for the three anchor stations Melpitz, Tharandter Wald and Oberbärenburg with different heights above see level.

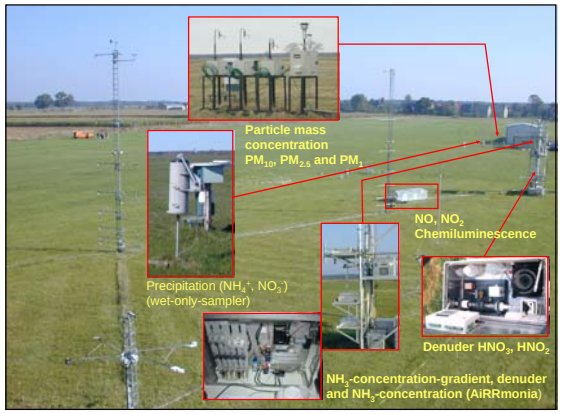

Figure 1: View of the anchor station Melpitz (12°56' E, 51°32' N, 86 m above see level). Measurements for N-containing chemical species are highlighted.

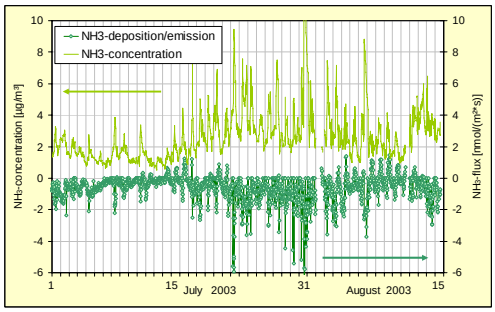

Figure 2: Example for NH_3-concentration measurement and calculated NH_3-flux using an bidirectional inferential model (parameters NH_3-concentration, R_a, R_b, global radiation, temperature and stomatal compensation point calculated for a concentration NH_4^+ 200 µmol l^{-1} and pH 6.3 for the leaf intercellular fluid, Γ = 400) for Melpitz in 2003.

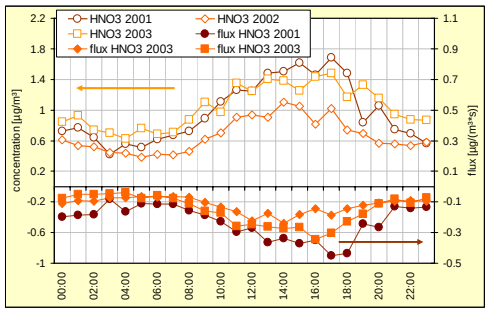

Figure 3: Example for the mean daily course of HNO_3-concentration and the calculated HNO_3-flux using the HNO_3-deposition velocity calculated as $(R_a+R_b+R_c)^{-1}$ with R_c = 0. Number of measured daily courses for 2001: 30, for 2002: 38 and for 2003: 33. R_a atmospheric resistance, R_b laminar boundary-layer-restistance, R_c canopy resistance.

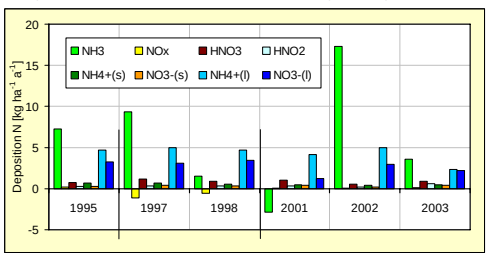

Figure 4: Estimation of yearly dry and wet deposition for N-species at Melpitz site (results for 2003 preliminary).

Table 1: Comparison of estimated N-Impacts for Melpitz with results of a model for mapping total deposition loads

N-Species		1995	1997	1998
Total-N	measured	17.4	18.8	11.1
	model	*18.0*	*18.9*	*16.7*
NH_x-N (NH_3, NH_4^+)	measured	12.6	15.0	6.7
	model	*7.4*	*6.0*	*6.6*
Wet deposition (NH_4^+, NO_3^-)	measured	8.0	8.1	8.1
	model	*10.0*	*7.6*	*8.5*

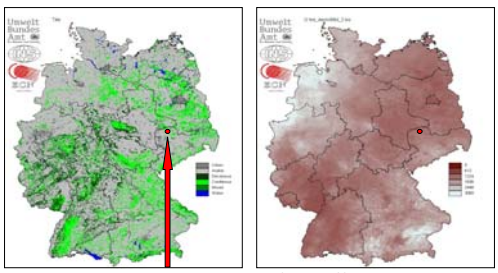

Figure 6: Example for land use and Total N-deposition from the model for mapping total deposition loads (the location of Melpitz site is highlighted)

Results

In Figure 4 the estimated N-impact for the anchor station Melpitz is shown for six years (results from 1995, 97 and 98 are from an other project, Erismann et.al. 2001b). The N-impact shows a high inter-annular variability between 5 and 27 kg N per hectare and year. The N-impact by wet deposition shows relatively constant amounts in the range about 7 kg throughout the year. In the dry summer 2003 the impact is lower. The strongest variability show the dry N-exchange caused by NH_3, especially the year 2001 shows a singularity with a N-emission . Reasons can by found in the local sources of NH_3 and in the possibility of an bi-directional flux influenced by meteorological conditions but also by different biological activities (Figure 2) . That means the grassland can be source or sink for NH_3. The dry deposition of HNO_3 is in the range between 0.5 and 1 kg and depends on the concentration of HNO_3 (Figure 3). The deposition by particulate matter is less than 10 % of the dry N-Impact.

A comparison with results from a model for mapping total deposition loads (Gauger et al., 2002, Figure 6) for the available years shows a good agreement between experimental determined N-Impact and model calculation for grassland at Melpitz site. The calculated values for NH_3 and NH_4^+ are lower for 1995 and 1997. NH_3-measurements were carried out with the 'AiRRminia'-system in summer and autumn in Melpitz and two stations in the Eastern Erzgebirge Mountains Tharandt (climate station Wildacker as open area in the forest) and Oberbärenburg (forest station). The three stations reflect a gradient in altitude in the VERTIKO target region.

Figure 5 presents the results as average daily concentration courses). The half hourly means were calculated from 10-minute means. The concentration measurements show different mean concentrations for the three sites. For Melpitz and Tharandt the NH_3-concentrations are higher as in Oberbärenburg. Mostly for Melpitz and Tharandt a typical pattern between day and night can be recognized. One reason could be that during times with higher temperatures (daytime) more NH_3 is in the gas phase. This emanates from evaporation of NH_4NO_3 from particles and from agriculture in the surroundings. For Melpitz the NH_3-concentration increase earlier as for Tharandt, one reason can by an earlier start of mixing of the boundary-layer for these flat grassland. For Oberbärenburg the mean NH_3-concentration is more than two times lower than in Melpitz and shows only little variation. The mean NH_3-concentrations decrease with increasing altitude and distance to sources.

Acknowledgements

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Methods

The flux measurements took place at the anchor station Melpitz (IfT research station) situated near Torgau in the river Elbe valley (Figure 1). The station is located on a flat meadow. The grassland was fertilized only in spring with 70 kg N ha^{-1} and cut normally three times per year. Aerodynamic profile technique was used to determine the net fluxes of the gaseous compounds NO, NO_2 (NO_x) and NH_3 (influences by reactions of NO with O_3 during the gradient measurements are not considered). Concentrations of NO_x, NH_3, HNO_2 and HNO_3 have been measured by chemiluminescence (NO_x) and wet annular denuder techniques (NH_3: acidic coating 'AMANDA-system'; HNO_3 and HNO_2: alkaline coating 'batch denuder'), respectively. The artefact formation for HNO_2 in the denuder can be neglected because SO_2 concentration is low (Spindler et al. 2003). Dry deposition of HNO_3 was estimated by resistance analogy (Figure 3), for HNO_2 a mean deposition velocity of 0.8 cm s^{-1} is used. NO_3^- and NH_4^+ concentration of aerosol particles are determined from a low flow filter sampler (upstream impactors for PM_1, $PM_{2.5}$ and PM_{10}). The size dependent deposition velocity was modeled on the basis of the friction velocities (Slinn, 1982). The N-input by precipitation (NO_3^-, NH_4^+) was quantified using a wet-only sampler (Brüggemann and Spindler, 1999). Alternatively the NH_3 concentration can be measured with the 'AiRRmonia' system (Figure 2 and 5). In principle this is a smaller version of the denuder system 'AMANDA' (Erisman et al. 2001a). The rotating wet annular denuder is replaced by a channel system positioned on a Teflon membrane, which is permeable for NH_3. The absorption solution counter flows on the opposite side of the membrane. Ammonia passes the membrane completely and forms ammonium in the absorption solution. Fluxes of ammonia can be calculated using a inferential model for a bi-directional flux (Figure 2, Spindler et al., 2001). NH_3 concentration measurements were done also at anchor stations Tharandt and Oberbärenburg in the VERTIKO-target area (Figure 5).

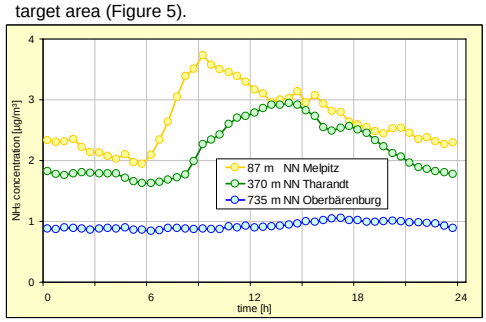

Figure 5: Average daily course of NH_3-concentration 2003 at Melpitz (29 days in July), Tharandt (32 days in May and June) and Oberbärenburg (15 days in October).

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Specific Contributions to the General Objective of VERTIKO

- **Fluxes for heat and trace gases are aviable for modeling in the VERTIKO data base.**
- **The complete N-impact was estimated for an anchor station in an agricultaral region (grassland) and compared with results of an total deposition model.**
- **NH_3- concentration measurements outside Melpitz (Oberbärenburg VERTIKO-TUBAF, TU-Freiberg and Tharandt VERTIKO-TUD, TU-Dresden).**
- **Validation and parametrization of SVAT.**

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