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Measuring and modelling dry deposition of ammonia to deciduous forest using high temporal and spatial resolution techniques

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Aim

- To compare vertical NH_3 concentrations and fluxes measured above deciduous forest using Conditional Time Average Gradient (COTAG) and Relaxed Eddy Accumulation (REA).
- To examine the performance of the Danish applied local-scale deposition model OML-DEP on calculating dry deposition of NH_3 to deciduous forest, by comparing calculations with new flux measurements.

Conclusion

- Measurements and model calculations are in good agreement on estimating atmospheric NH_3 concentration.
- REA indicate a clearly bi-directional NH_3 flux while fluxes determined using COTAG are non significant and associated with high uncertainty.
- There is a further need for improving the description of dry deposition in local-scale models whereby the NH_3 vegetative emission and its contribution to the atmospheric NH_3 flux is considered.

Introduction

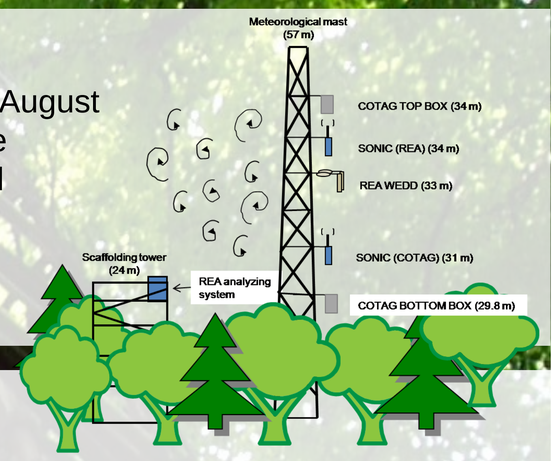
Calculations of ammonia (NH_3) deposition to Danish nature resorts indicate exceedance of critical loads for N deposition particular to forests (ref.1). A continuous high N load in terrestrial ecosystems can cause critical effects to the biodiversity (ref. 3).

Modeling dry deposition processes of NH_3 above forest is challenging due to the complex forest-atmosphere interactions along with a lacking knowledge of vertical NH_3 fluxes between vegetative surfaces and the atmosphere. Therefore further measurements of fluxes are still needed to improve the current knowledge of NH_3 fluxes and to verify the local-scale deposition models.

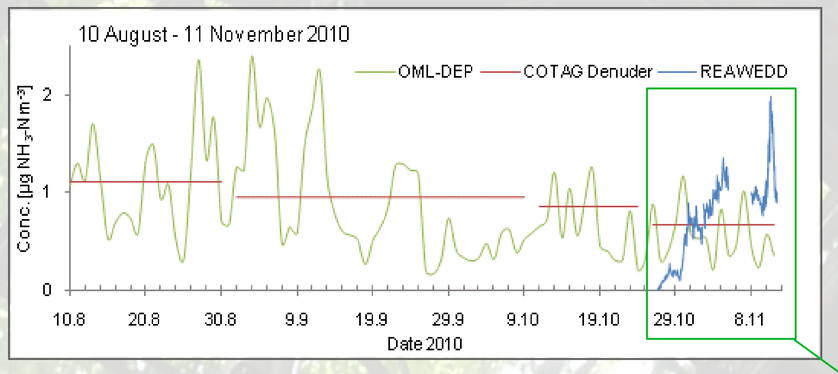
The measurement site (Lille Bøgeskov, Sorø) in Denmark in January 2011.

Method

Vertical fluxes of NH_3 was measured above a beech forest (Fagus sylvatica) in Denmark from 10 August to 11 November 2010 using the long-term COTAG technique (29.8 m and 34 m) and the high time resolution technique REA (33 m). Calculations of concentration and dry deposition are performed using the local-scale deposition model (OML-DEP) applied in DAMOS (ref. 2). The DAMOS calculations are based on state-of-the-art emission inventories with hourly time resolution and a spatial resolution down to single farm level (ref. 4).



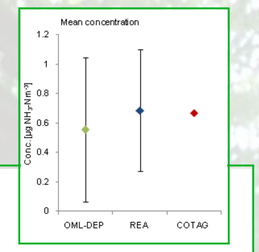
Concentrations

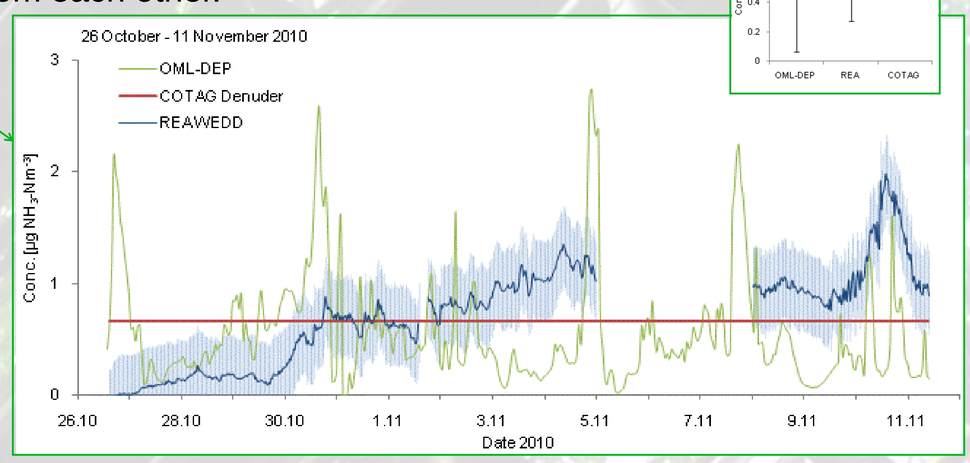


NH_3 concentration above Lille Bøgeskov measured using COTAG Denuder (29.8 m) in four sampling periods and REA WEDD (33 m) only in the fourth sampling period and calculated by OML-DEP through the full measuring period.

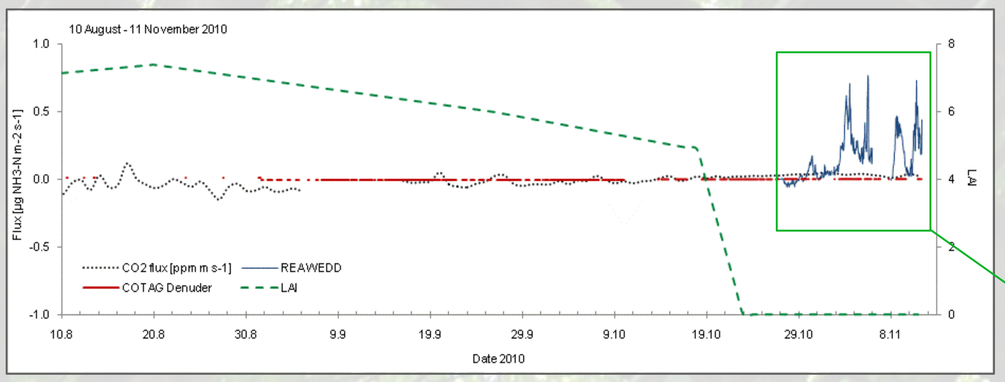
OML-DEP calculations indicate an overall decreasing trend in the measuring period. These results are in good agreement with the concentration measured using COTAG that indicates mean concentrations decreasing from 1.1 to 0.7 µg NH_3-N m^{-3}.

REA WEDD measurements are only performed in the fourth sampling period and indicate an increasing concentration in the end of the measuring period, but the mean concentrations assessed by the three different techniques are all in good agreement through the fourth sampling period and deviate only by 0.56 to 0.68 µg NH_3-N m^{-3} from each other.





Fluxes

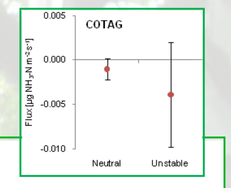


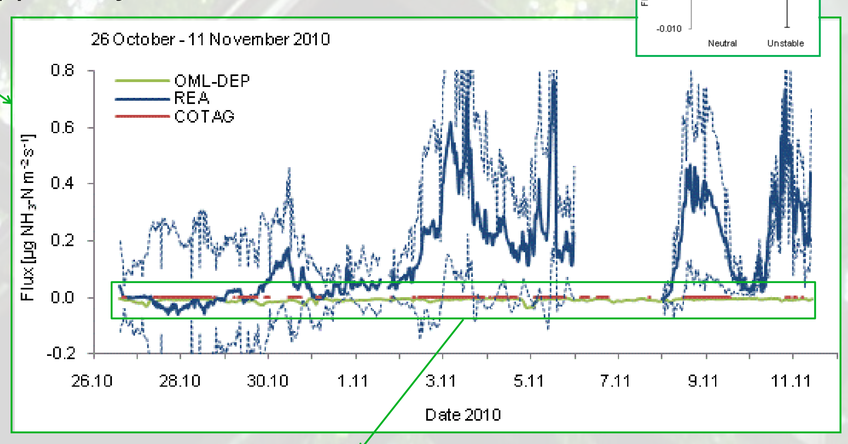
NH_3 fluxes above Lille Bøgeskov for 10 August – 11 November 2010 along with leaf area index (LAI) and CO_2 fluxes.

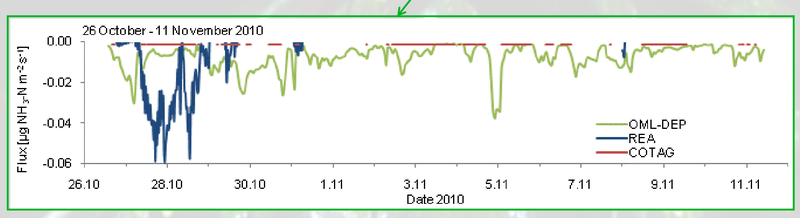
High temporal resolution measurements of NH_3 flux using REA indicate a bidirectional flux that could be related to LAI. After defoliation the NH_3 flux begins changing direction from deposition to emission equally to the pattern of CO_2 fluxes.

OML-DEP doesn't take natural contributions as the NH_3 vegetative emission into account in calculating NH_3 deposition fluxes. Furthermore, the calculated flux seems underestimated due to an underestimation of the turbulent transport to the canopy.

The conditional COTAG fluxes indicate non significant deposition fluxes and the comparable conditional averaged REA fluxes indicate emission fluxes. Though the uncertainty on the estimated COTAG fluxes indicate that the flux could be oppositely directed.







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