Implementation of bidirectional flux in DEHM, MATCH and EMEP and links to the SEEDS project

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Introduction

Emissions of ammonia and deposition of reactive nitrogen are of great importance in Denmark

Denmark has very little area with nature, and the areas are located close to agricultural activities

Quantification of emission of NH_3 and deposition of Nr must be as accurate as possible

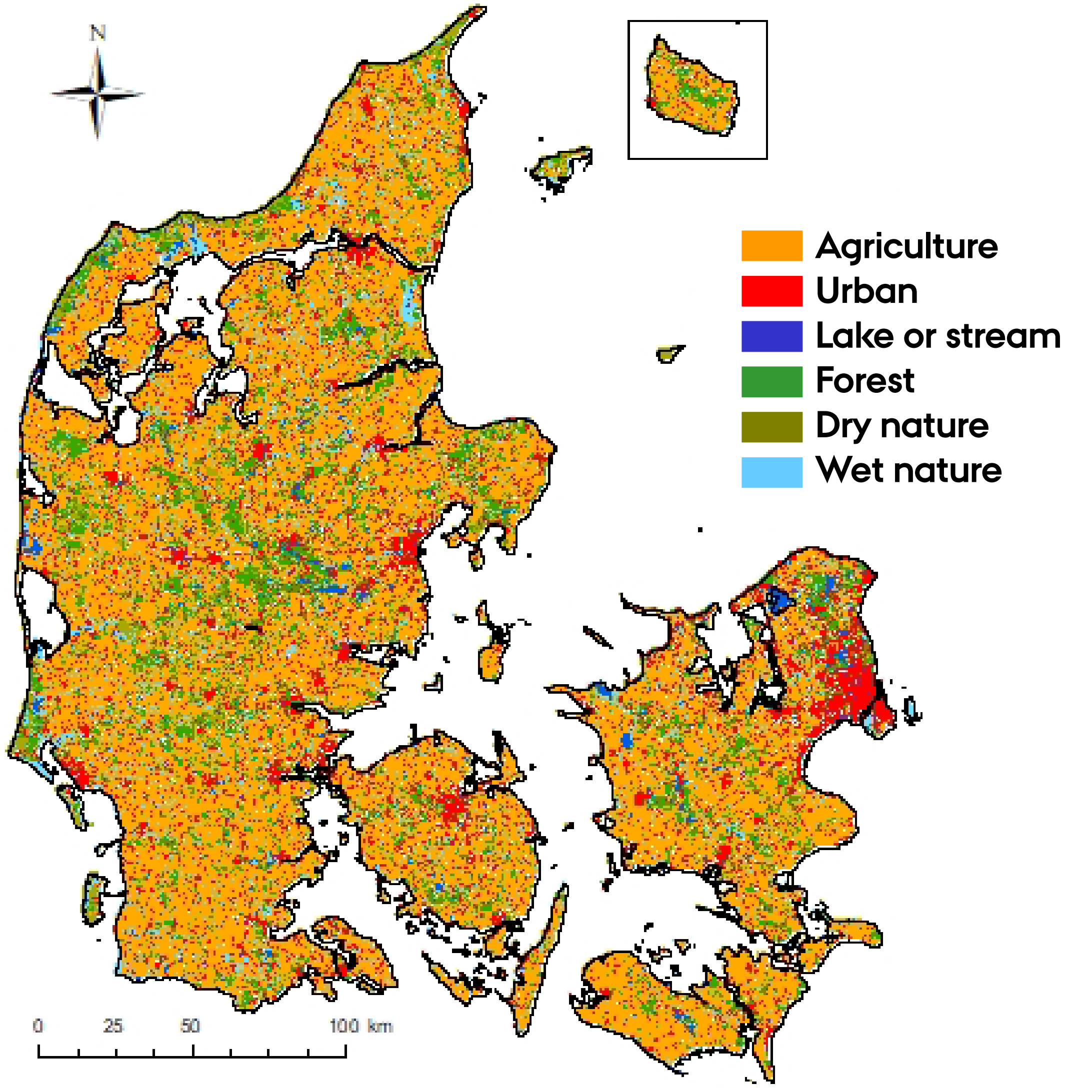
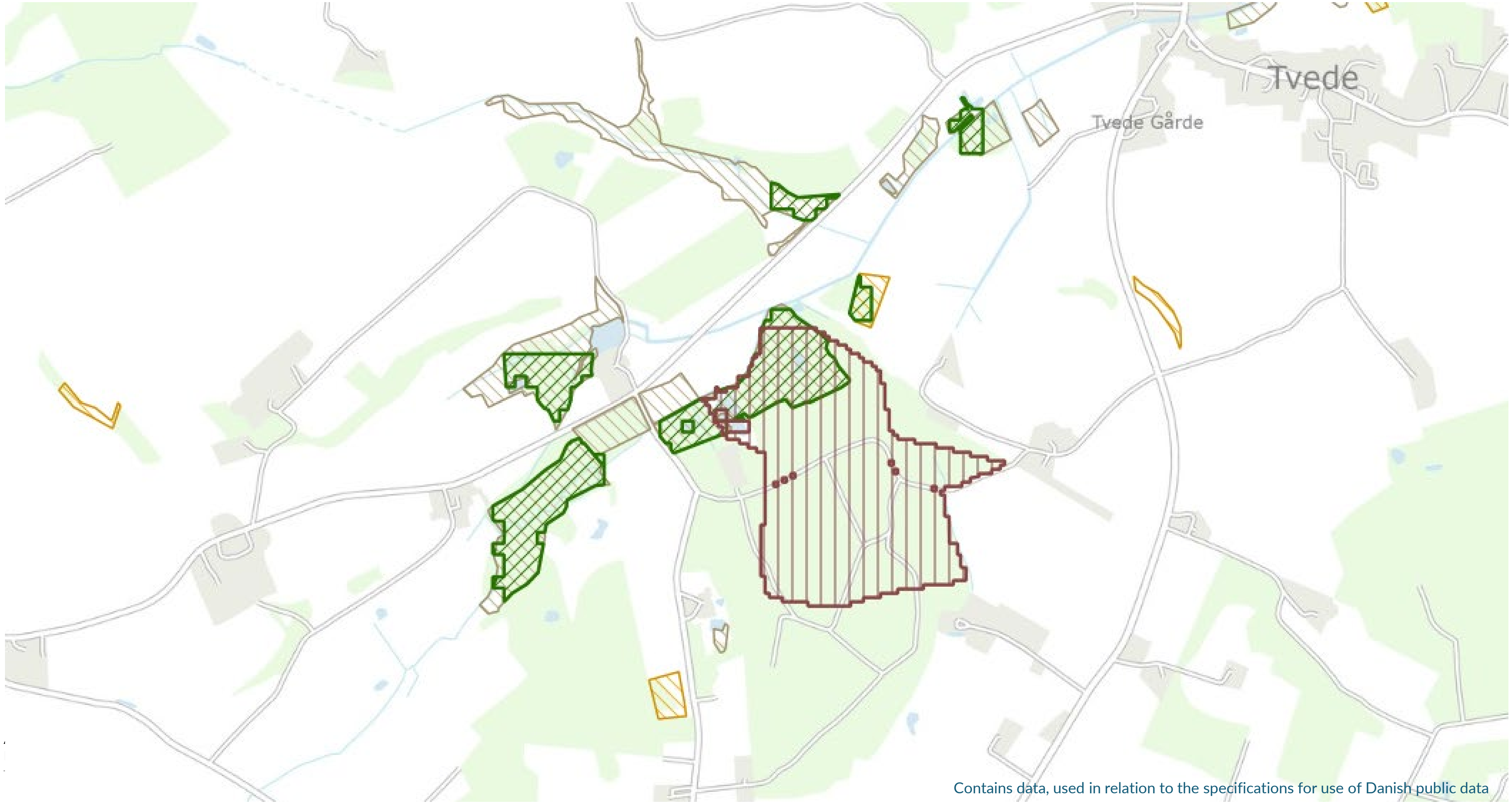


Illustration by Gregor Levin, AU

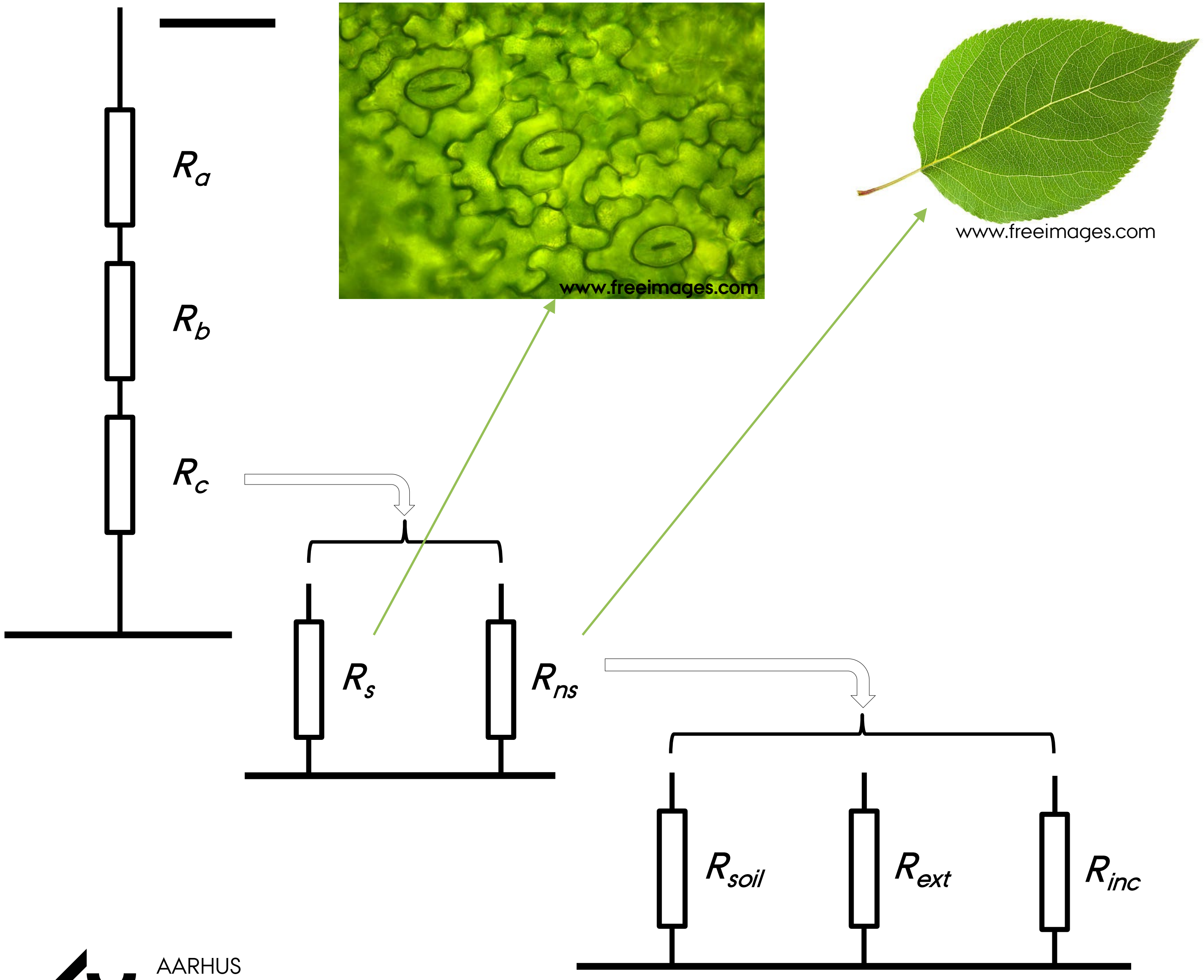
Example: Ammonia sensitive forest area and §3 nature

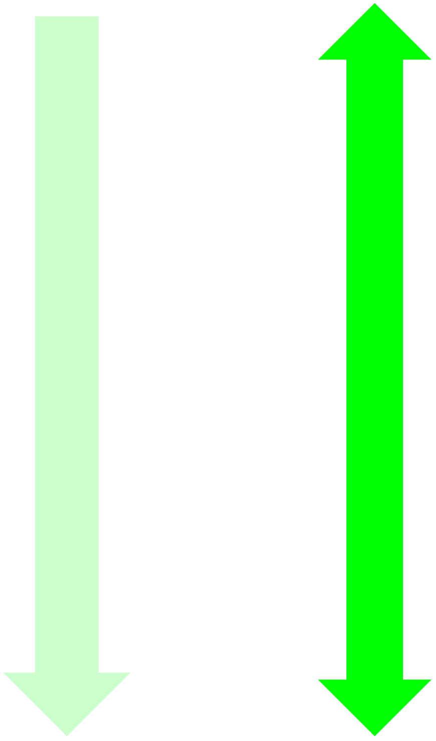


Contains data, used in relation to the specifications for use of Danish public data


Contains data, used in relation to the specifications for use of Danish public data
The sensitive area is surrounded by emissions – a typical situation
How does local emissions influence local deposition?
Google.com/maps

NH_3 dry deposition parameterisation





The fluxes are treated as bidirectional

Bidirectional flux proces

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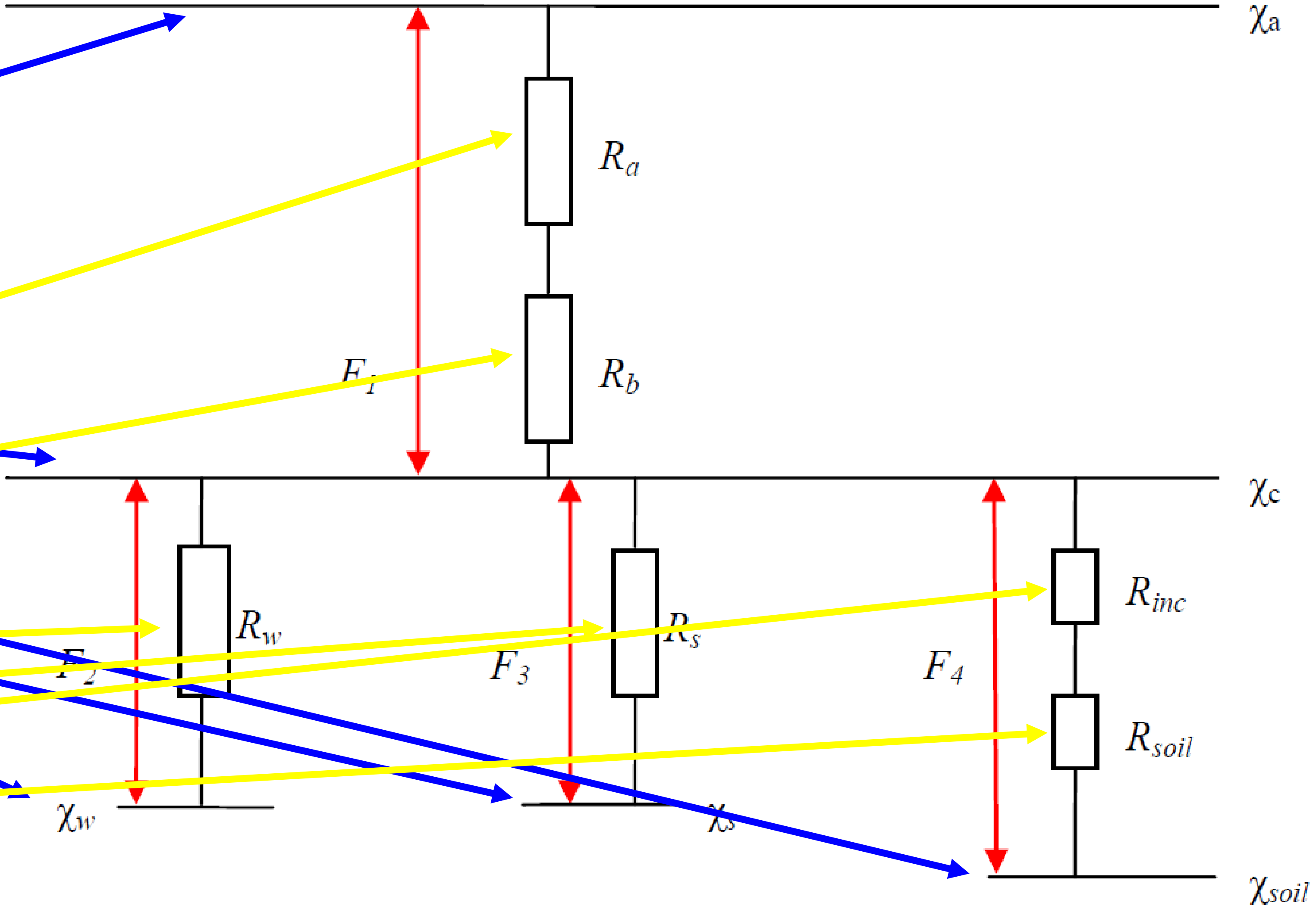
Modeling the surface–atmosphere exchange of ammonia

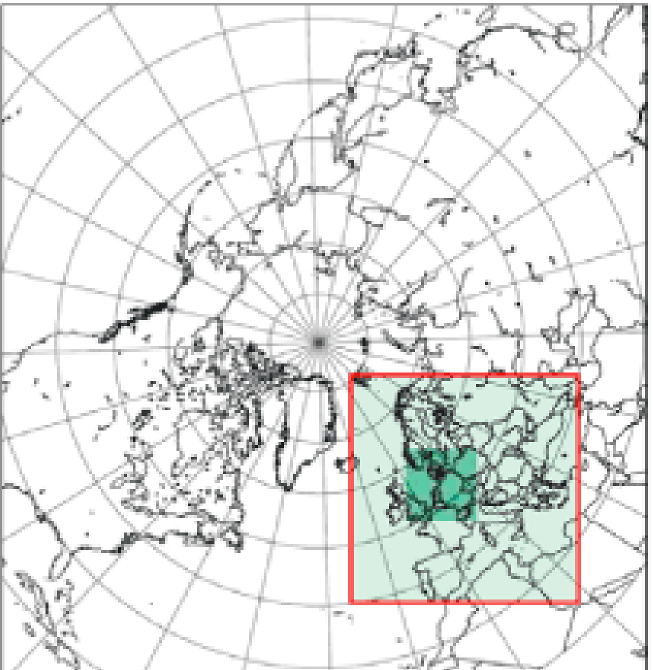
R.J. Wichink Kruit [a b], W.A.J. van Pul [a], F.J. Sauter [a], M. van den Broek [a], E. Nemitz [c], M.A. Sutton [c], M. Krol [b d], A.A.M. Holtslag [b]

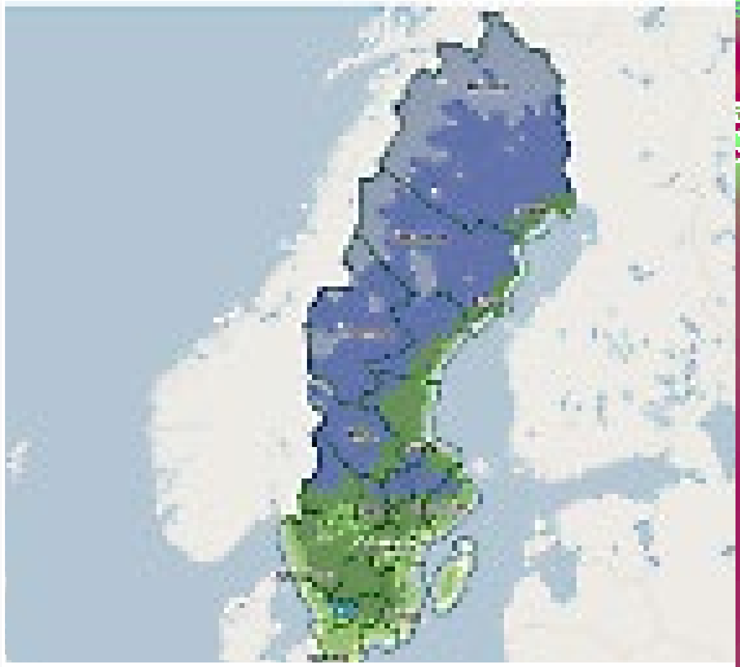
name of parameter	explanation
χ_a	concentration in air
χ_c	concentration at canopy top
χ_w	concentration at external leaf surface
χ_{soil}	concentration at soil surface
χ_s	concentration in stomata
R_a	aerodynamic resistance
R_b	quasi-laminar layer resistance
R_w	external leaf surface or water layer resistance; cuticular resistance
R_s	stomatal resistance
R_{inc}	in canopy resistance
R_{soil}	soil resistance
$R_{soil,eff}$	effective soil resistance = $R_{inc} + R_{soil}$
R_c	canopy resistance

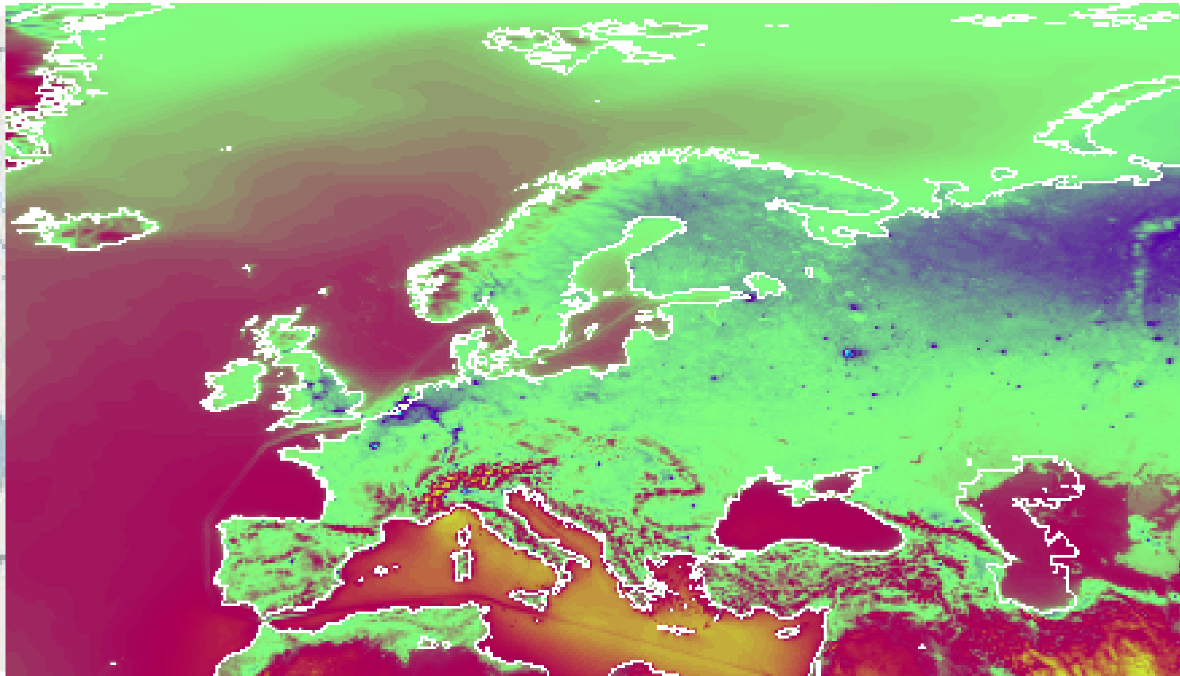


Aim of our study

- To implement the process of bidirectional flux in the regional models DEHM, MATCH and EMEP
- To attempt to give a more accurate distribution of N deposition over sensitive nature areas
- To try to understand what the inclusion of the return-flux from plants – some already at their highest level of N (e.g. crops) - might mean for the transport of NH_3







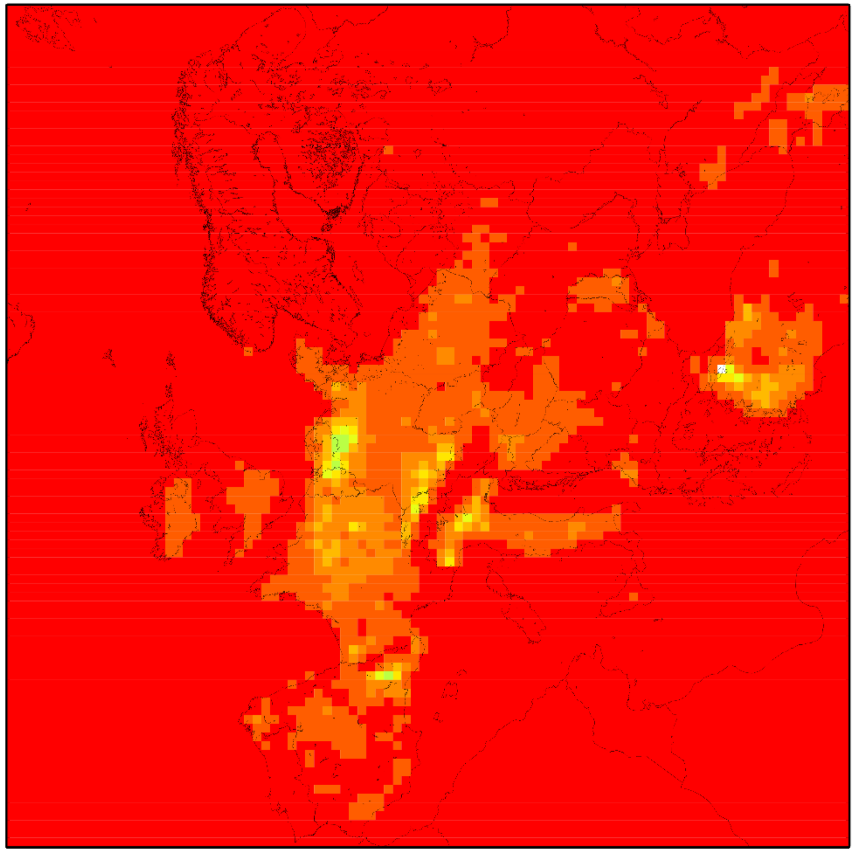
Very preliminary results - DEHM

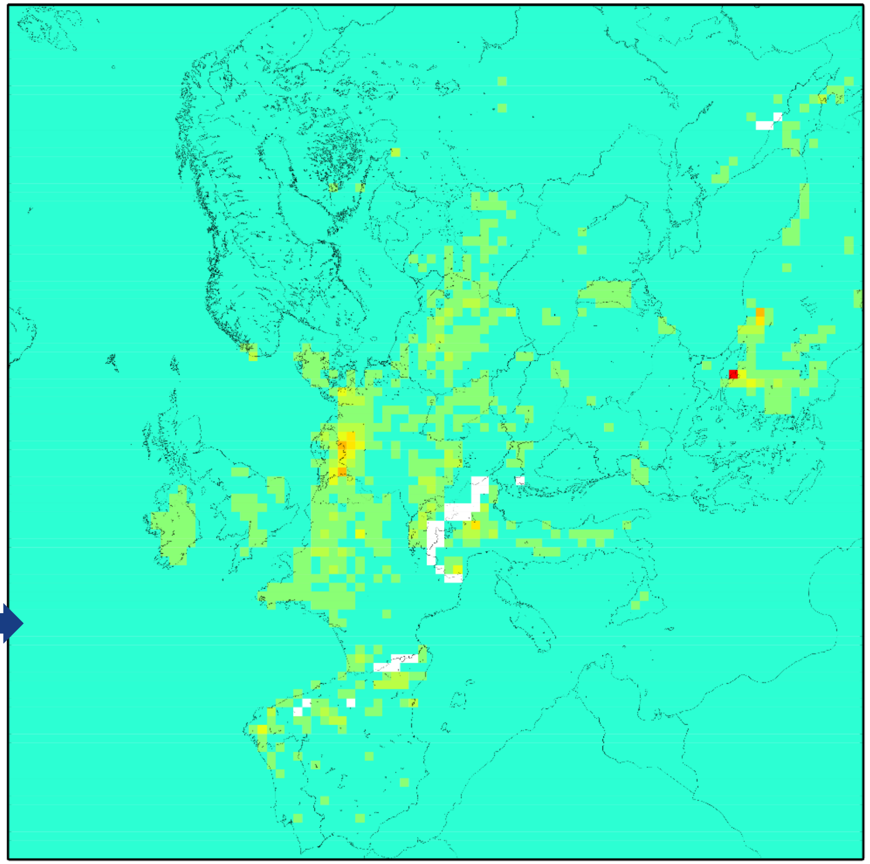
July 2018

Changes in:

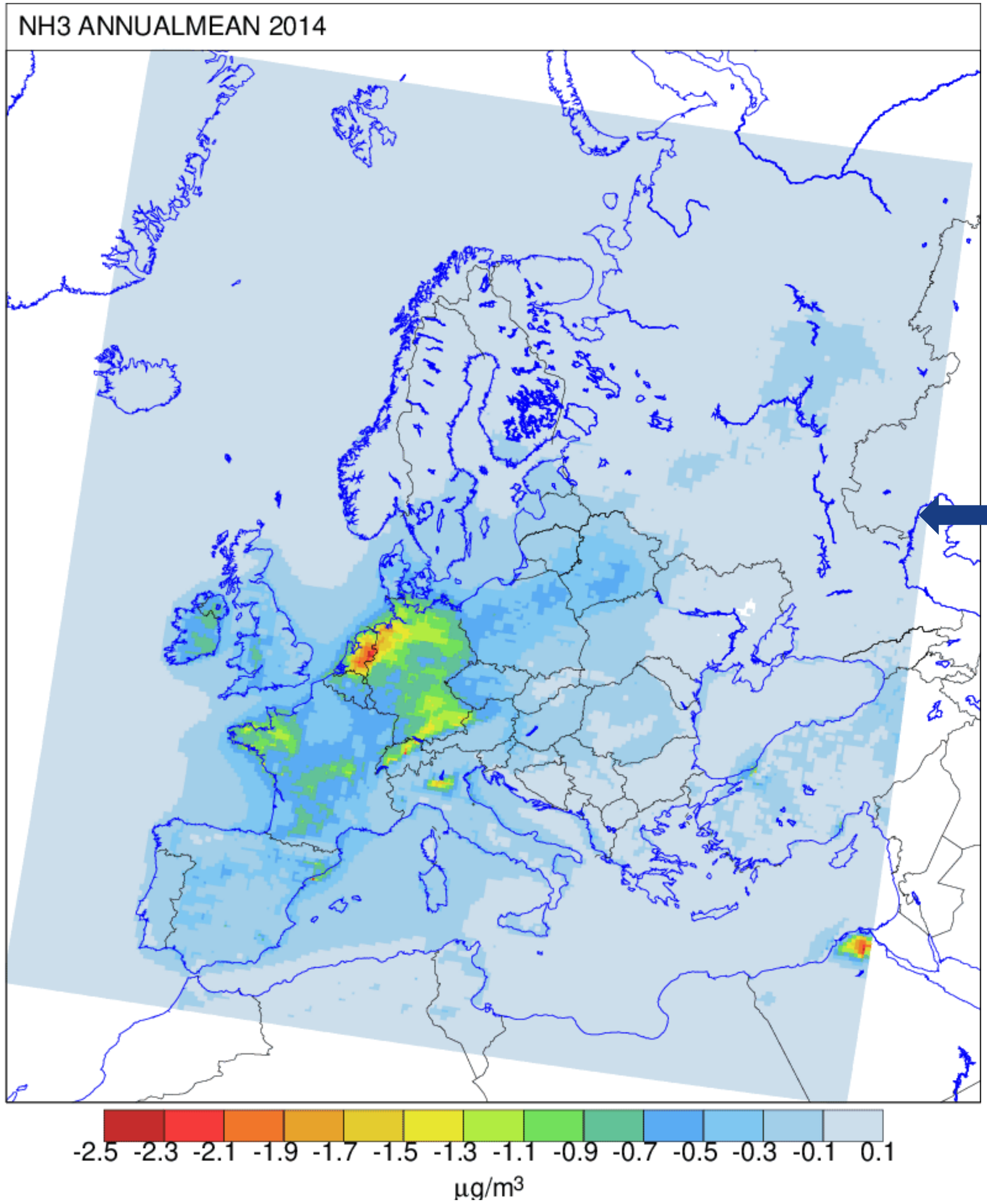
Concentration

Deposition





Very preliminary results - MATCH

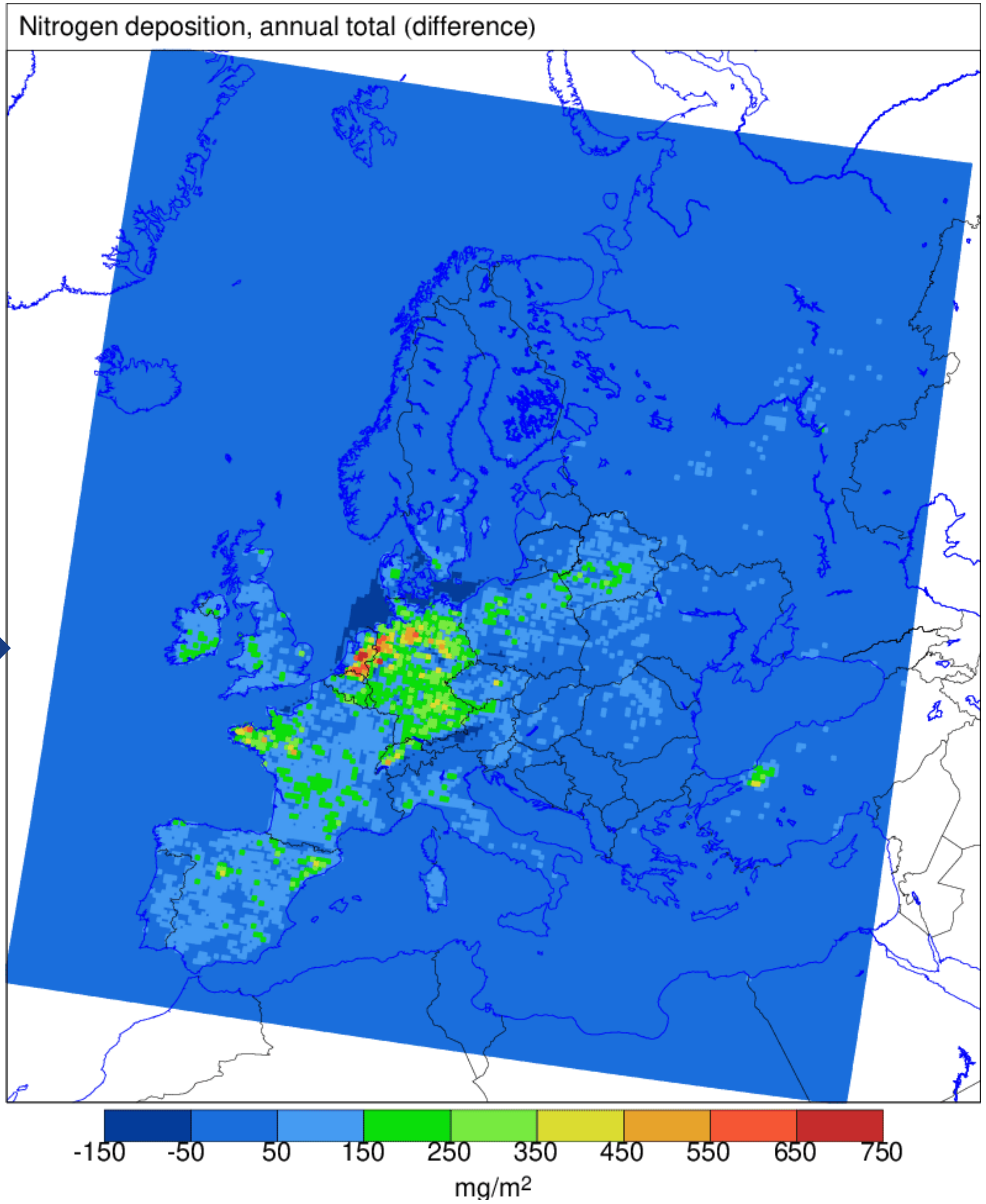


2014

Changes in:

Concentration

Deposition

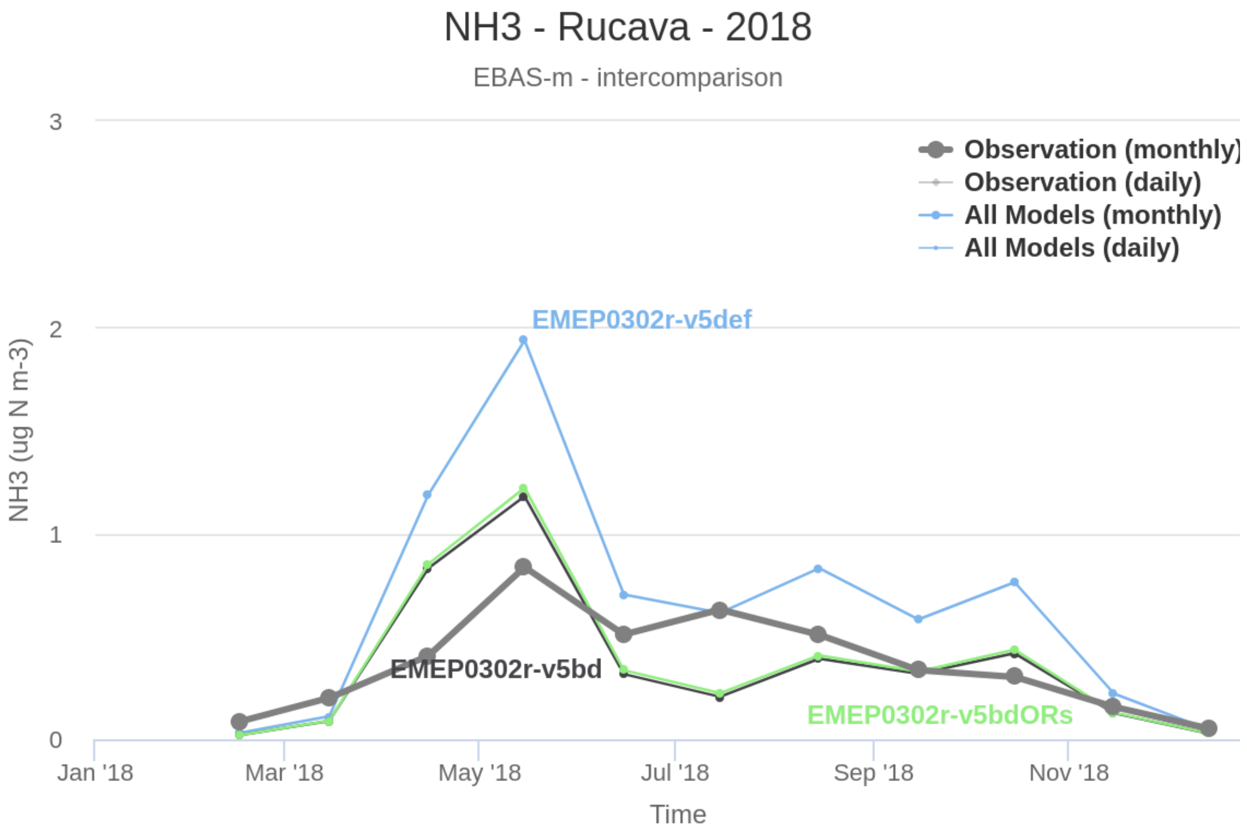


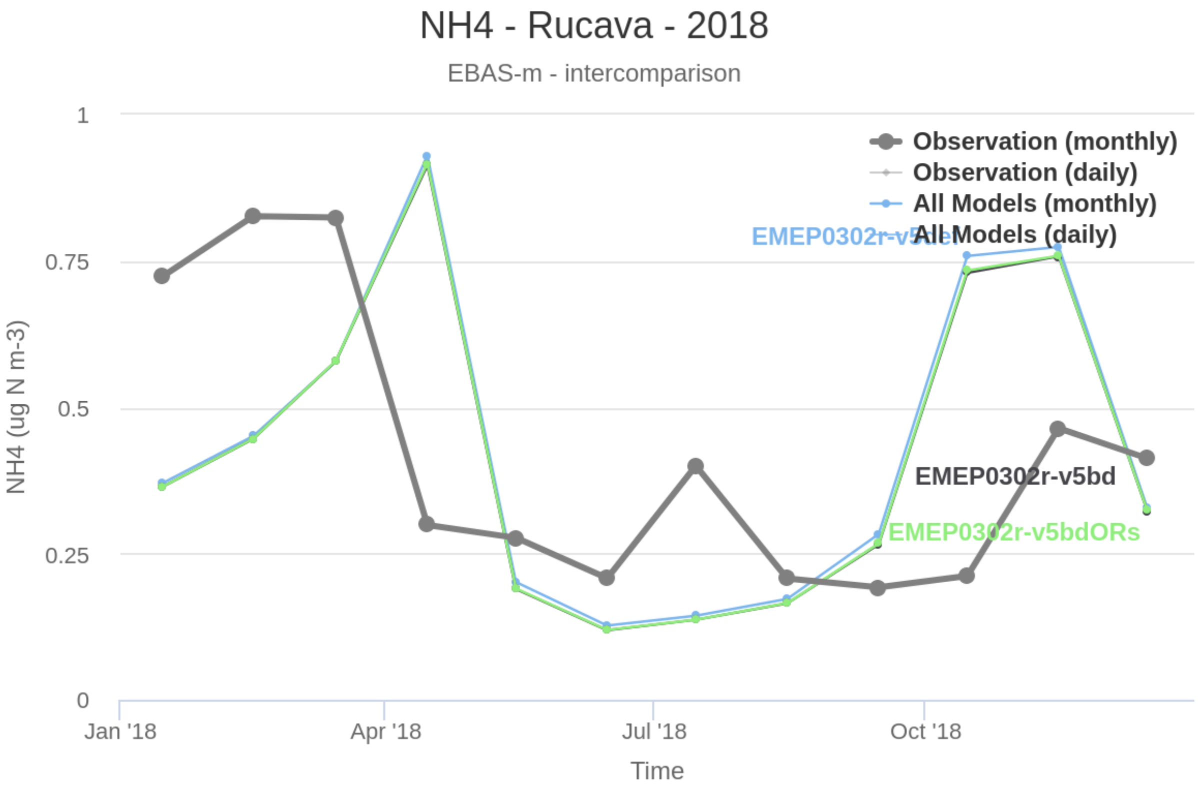
Very preliminary results - EMEP

EMEP reference run
EMEP with bidir
Observations
(Skip)

Monthly concentrations in 2018 of

NH_3 NH_4^+





Summary initial results

- DEHM
  - Spatial distribution of NH_3 concentrations shows mainly areas with decreases
  - Spatial distribution of NH_3 total deposition shows mainly areas with increases
  - No evaluation with measurements yet
- MATCH
  - Spatial distribution of NH_3 concentrations shows mainly areas with decreases
  - Spatial distribution of total N deposition shows mainly areas with increases
  - Slightly better performance for NH_3 concentrations when compared with obs. (not shown here)
- EMEP
  - Tendency to lower concentrations of NH_3 (and very slightly lower NH_4^+ values) when compared to observations.

Initial reflections

Some difficulties: in EMEP it doesnt get better when compared to measurements, in MATCH it gets slightly better (DEHM hasn't compared to measurements yet)

Concentrations go down in both MATCH and DEHM (and for most of EMEP stations) – probably due to changes in surface resistance not directly connected with the compensation points; the old code typically had a more crude way of trying to compensate for the missing bidirectional flux treatment.

-> there is a need to dig deeper – what is actually the governing parameters in the parameterisations of dry depositon?

Bidirectional flux gives rise to emissions of NH_3. How should this be handled in relation to "official" national total NH_3 emissions?

Bidirectional flux parameterisations

https://doi.org/10.5194/acp-10-10359-2010

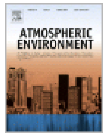
Article | Peer review | Metrics | Related articles

04 Nov 2010

Review and parameterisation of bi-directional ammonia exchange between vegetation and the atmosphere

R.-S. Massad, E. Nemitz, and M. A. Sutton

Abstract. Current deposition schemes used in atmospheric chemical transport models do not generally account for bi-directional exchange of ammonia (NH_3). Bi-directional exchange schemes, which have so far been applied at the plot scale, can be included in transport models, but need to be parameterised with appropriate values of the ground layer compensation point (χ_g), stomatal compensation point (χ_s) and cuticular resistance (R_w). We review existing measurements of χ_g, χ_s as well as R_w and compile a comprehensive dataset from which we then propose generalised parameterisations. χ_s is related to Γ_s, the non-dimensional ratio of $[NH_4^+]_{apo}$ and $[H^+]_{apo}$ in the apoplast, through the temperature dependence of the combined Henry and dissociation equilibrium. The meta-analysis suggests that the nitrogen (N) input is the main driver of the apoplastic and bulk leaf concentrations of ammonium ($NH_{4\ apo}$, $NH_{4\ bulk}$). For managed ecosystems, the main source of N is fertilisation which is reflected in a peak value of χ_s a few days following application, but also alters seasonal values of $NH_{4\ apo}$ and $NH_{4\ bulk}$. We propose a parameterisation for χ_s which includes peak values as a function of amount and type of fertiliser application which gradually decreases to a background value. The background χ_s is based on total N input to the ecosystem as a yearly fertiliser application and N deposition (N_{dep}). For non-managed ecosystems, χ_s is parameterised based solely on the link with N_{dep}.



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Modeling the surface–atmosphere exchange of ammonia

R.J. Wichink Kruit [a b], W.A.J. van Pul [a], F.J. Sauter [a], M. van den Broek [a], E. Nemitz [c], M.A. Sutton [c], M. Krol [b d], A.A.M. Holtslag [b]

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Abstract

New parameterizations for surface–atmosphere exchange of ammonia are presented for application in atmospheric transport models and compared with parameterizations of the literature. The new parameterizations are based on a combination of the results of three years of ammonia flux measurements over a grassland canopy (dominated by *Lolium perenne* and *Poa trivialis*) near Wageningen, the Netherlands and existing parameterizations from literature. First, a model for the surface–atmosphere exchange of ammonia that includes the concentration at the external leaf surface is derived and validated. Second, a parameterization for the stomatal compensation point (expressed as Γ_s, the ratio of $[NH_4^+]/[H^+]$ in the leaf apoplast) that accounts for the observed seasonal variation is derived from the measurements. The new, temperature-dependent Γ_s describes the observed seasonal behavior very well. It is noted, however, that senescence of plants and field management practices will also influence the seasonal variation of Γ_s on a shorter timescale. Finally, a relation that links Γ_s to the atmospheric pollution level of the location through the 'long-term' NH_3 concentration in the air is proposed.

Links to SEEDS

- Intercomparison with dry deposition parameters will be very valuable (ongoing with Paul)
- The SEEDS project results in a series of very helpful data sets for the ongoing research in dry deposition:
  - LAI data on high (daily) resolution (and phenology? and soil moisture) – potentially very helpful both because it gives access to ”real” data for the vegetation, and because it helps quantifying more accurately to which extent parameters related to LAI are driving the process
  - Maps of deposition velocities (also for other components than O_3?),
  - and maps of stomatal conductances are also interesting for comparison and process understanding
  - The monthly emission maps help understanding the resulting emission flux

Thank you for the attention!