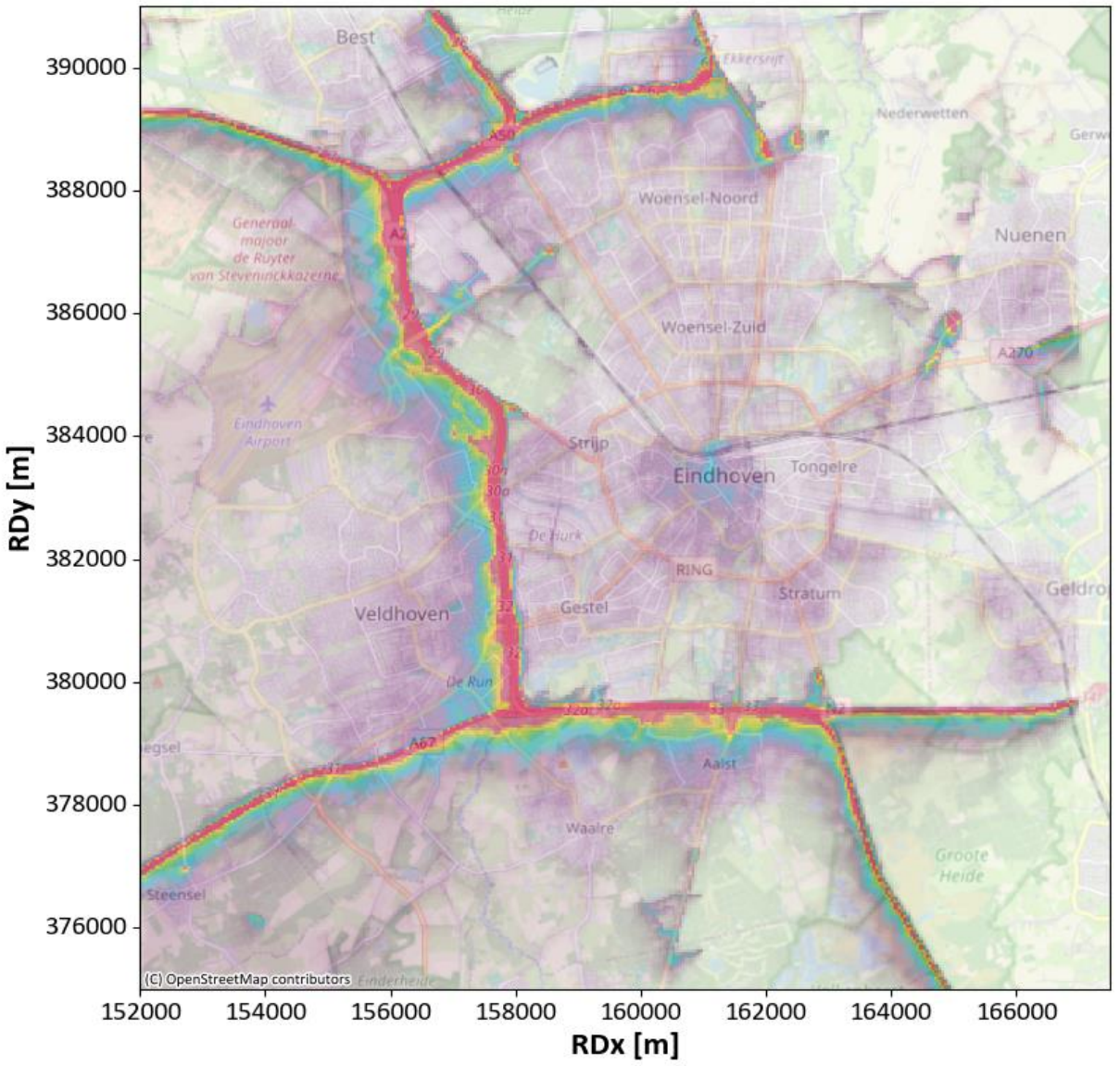
Hoge resolutie stikstofberekeningen met DALES

Ruud Janssen, Leon Geers, Martijn Schaap

GTL congres, Hilversum, 12/11/2024

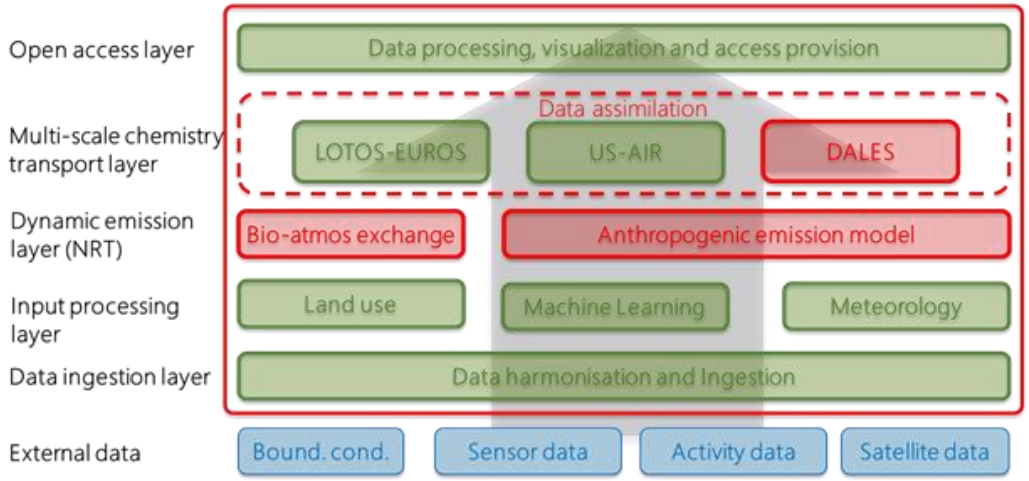
Ruud.Janssen@tno.nl



Framework

TNO EARLY RESEARCH PROGRAM

- **To develop and advance technologies that enable realistic simulations of atmospheric composition at a high resolution (25m)**

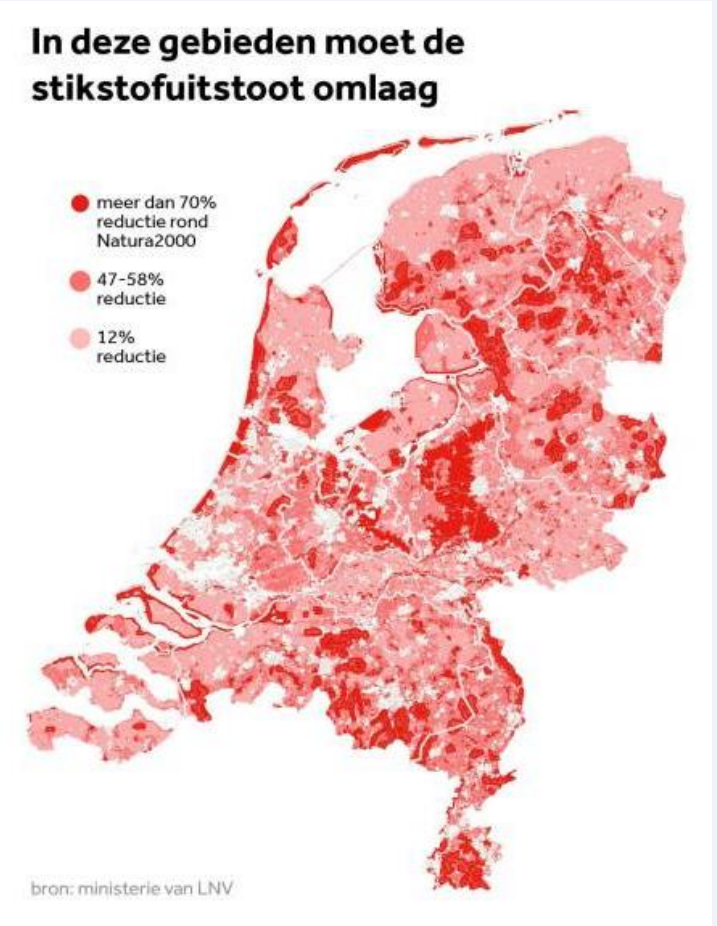


- **Research lines:**
  - **Dynamic anthropogenic emissions.** Combination of activity information based on big data analyses (IoT, AI) and emission factor models incorporating meteo dependencies
  - **Hyper local air quality modeling.** Interfaces to land use, emissions and boundary conditions, chemistry and deposition routines, building resolved modelling
  - **Assimilation of satellite and sensor data.** Objective validation of the model system and its input data
  - **System integration & demonstration.** Flexible and seamless integration of multi-scale modelling elements and data, and application of the model system for Eindhoven.

Motivation

- Strong need for accurate tools to assess the impact of nitrogen emitting sources on Natura 2000 areas

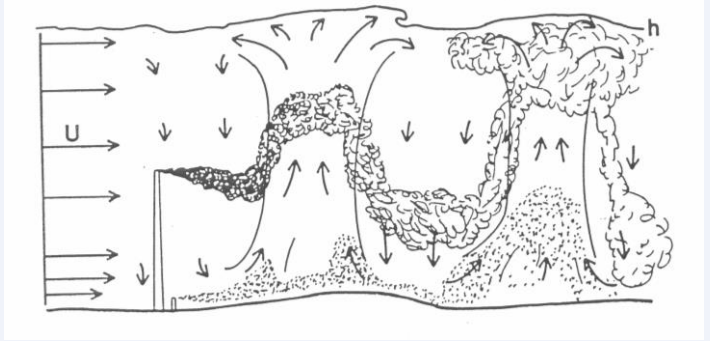
- Why high-resolution modeling?
  - Policy support, both national and local
  - Local impact calculations of reduction scenarios on exposure → health effects
  - Scenario analysis for impacts of urban development and land use change on deposition & exposure



NOS, 10-6-2022

Het DALES model

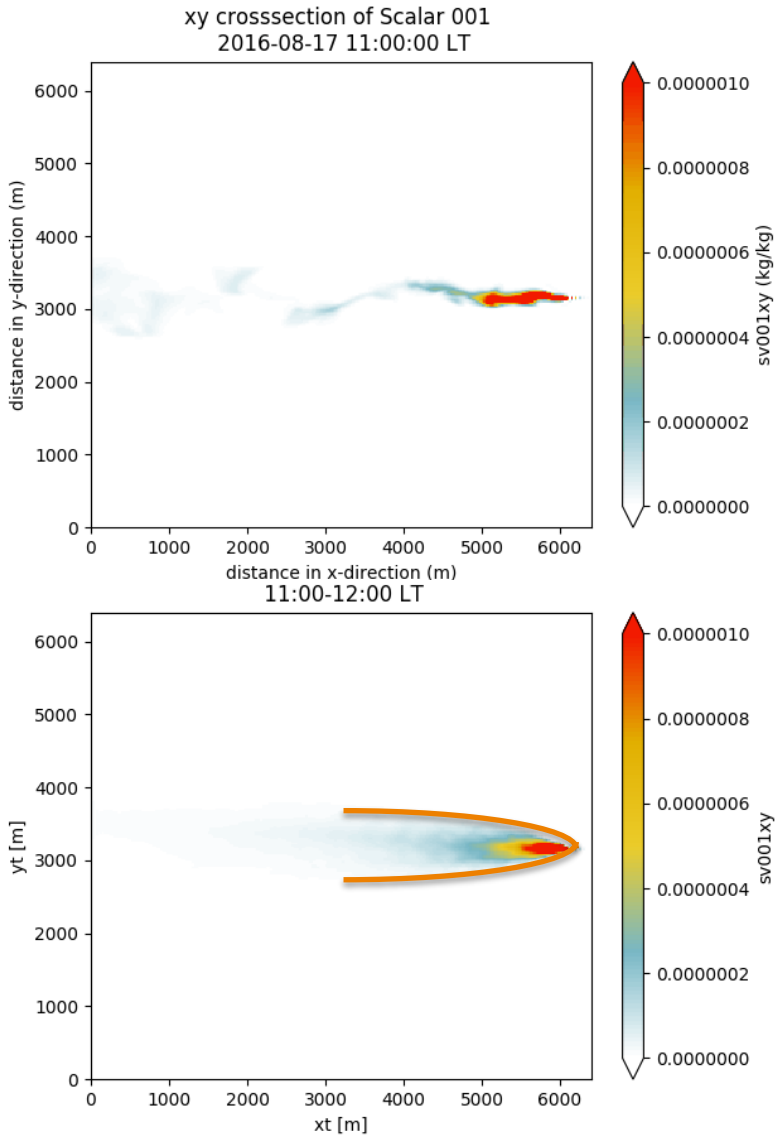
- Large Eddy Simulation
  - Turbulente stroming in de atmosfeer
  - ‘digitale windtunnel’
- Toegepast in studies van de atmosferische grenslaag
  - Atmosferische chemie
  - Steden
- Ontwikkelingen:
  - Toepasbaar maken voor realistische condities
  - Koppeling met een depositie module (DEPAC)



Vergelijking met Pluimmodelen

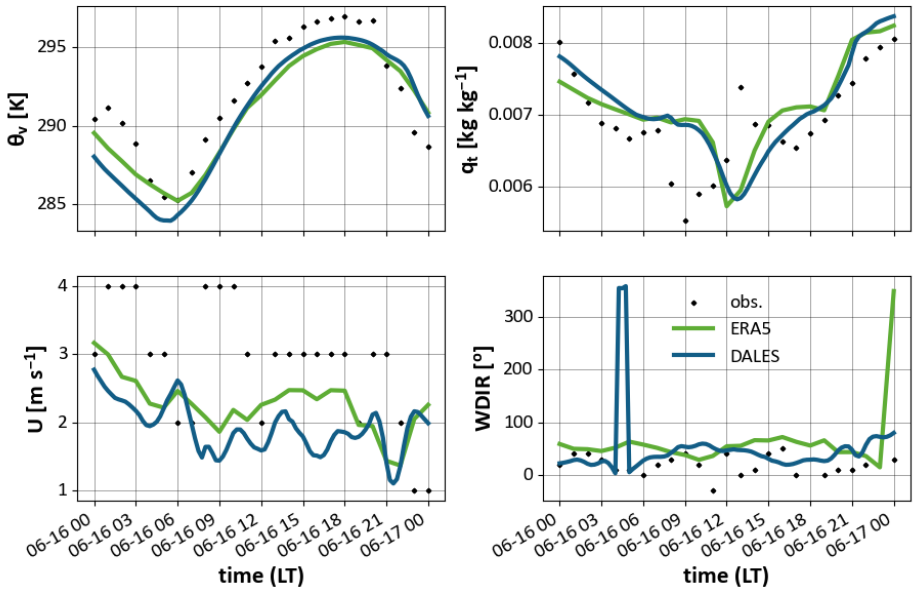
Geïdealiseerde puntbron

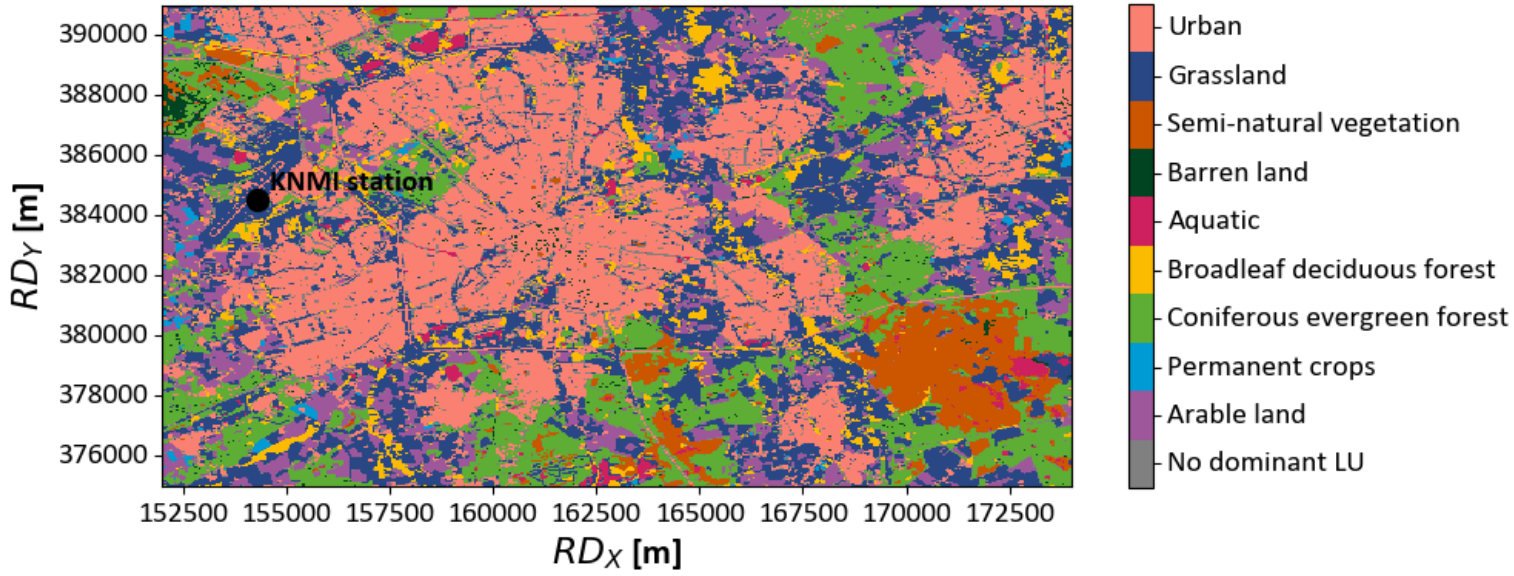
- Puntbron met constante emissie
- De pluim volgt de hoofdwindrichting
- Gemiddeld over 1 uur heeft de DALES-pluim de typische vorm van een Gaussische pluim.



Eindhoven case study

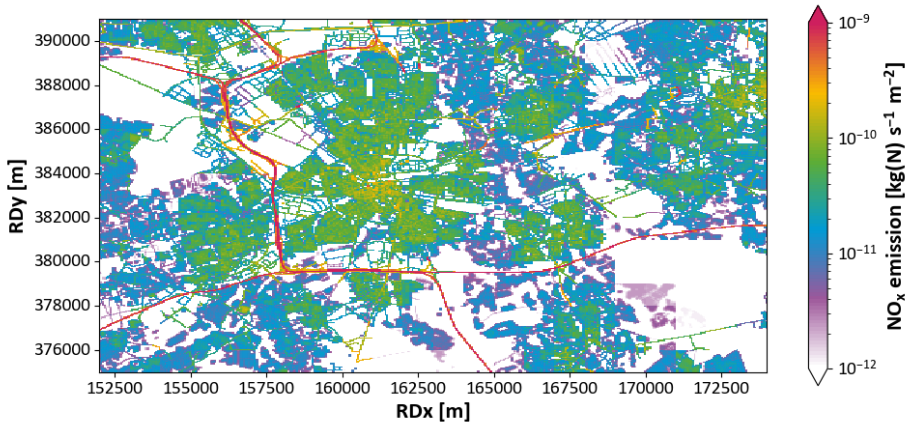
- Het effect van landgebruik op stikstof depositie
  - Domein van 16x22 km^2 met 50x50 m^2 resolutie
  - 1 dag
- Emissies, turbulent transport en landgebruik bepalen samen de patronen van stikstofdepositie

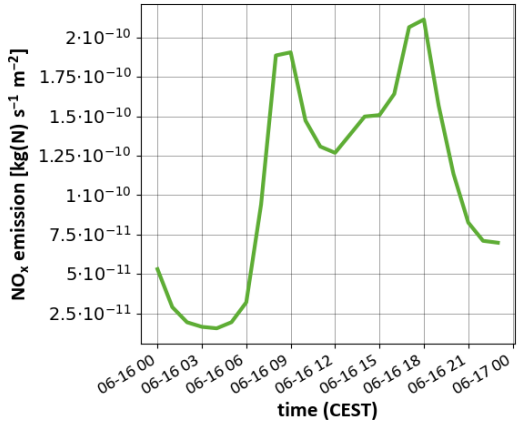




High-res emissions

Stikstofoxiden

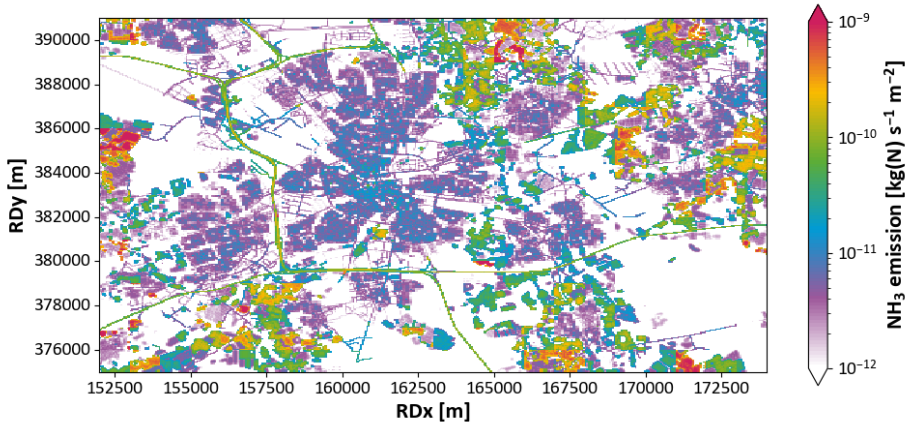


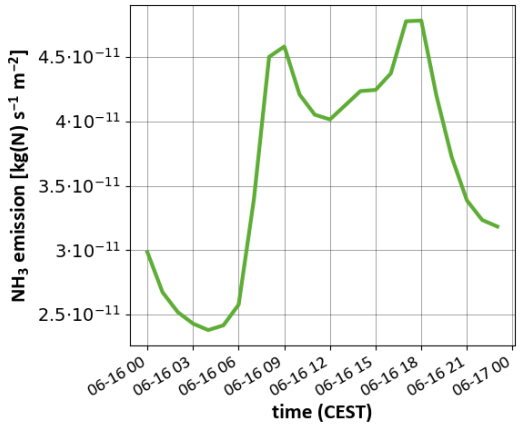


NOx and NH3 emissions @ 50x50 m^2

Maps at 06:00 CEST / 04:00 UTC

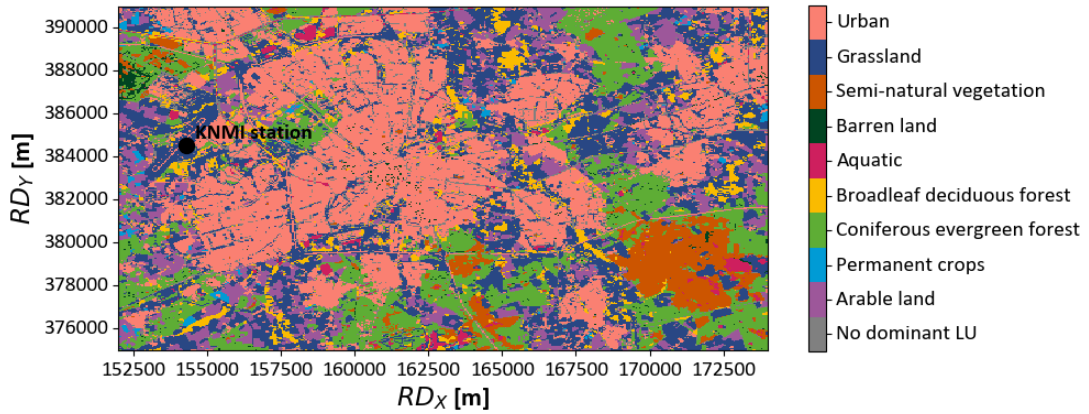
Ammoniak



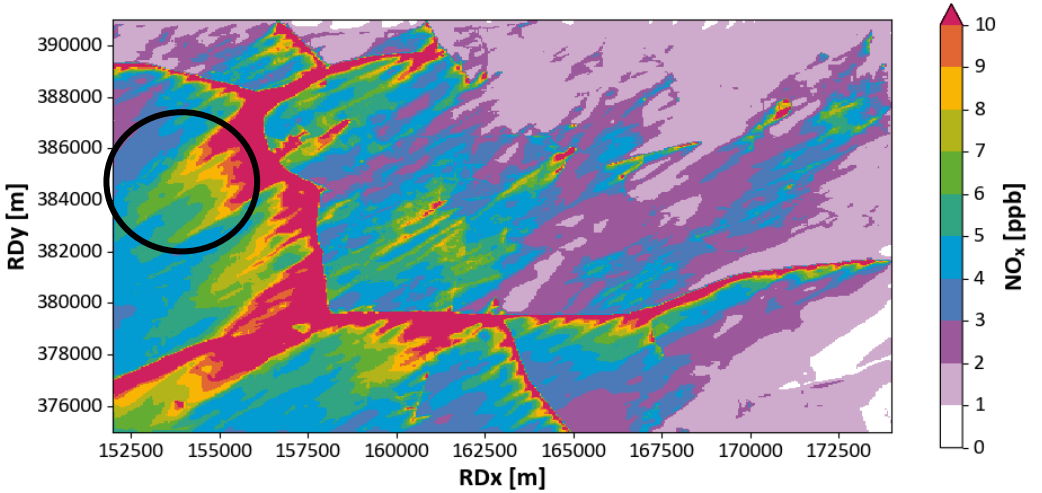


DISPERSION AND DEPOSITION

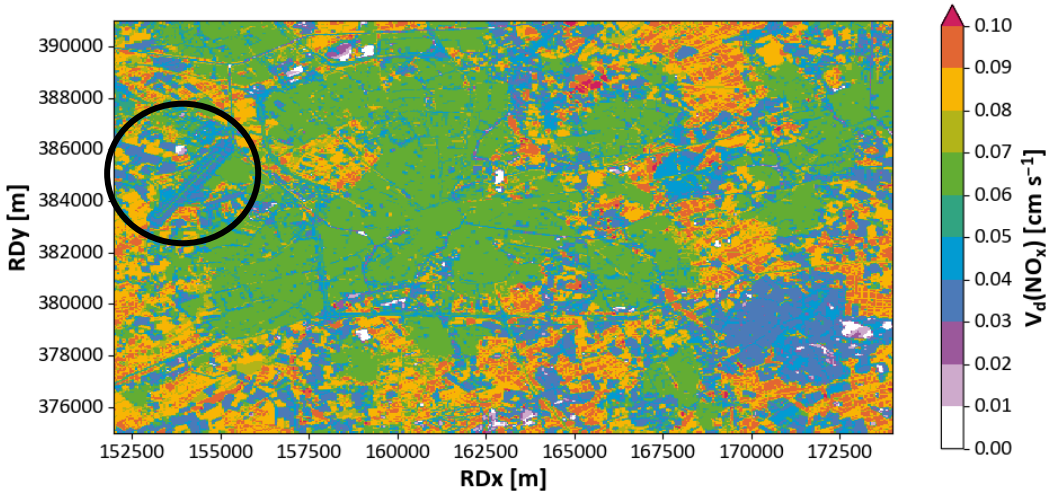
NO_X – XY-CROSSSECTION

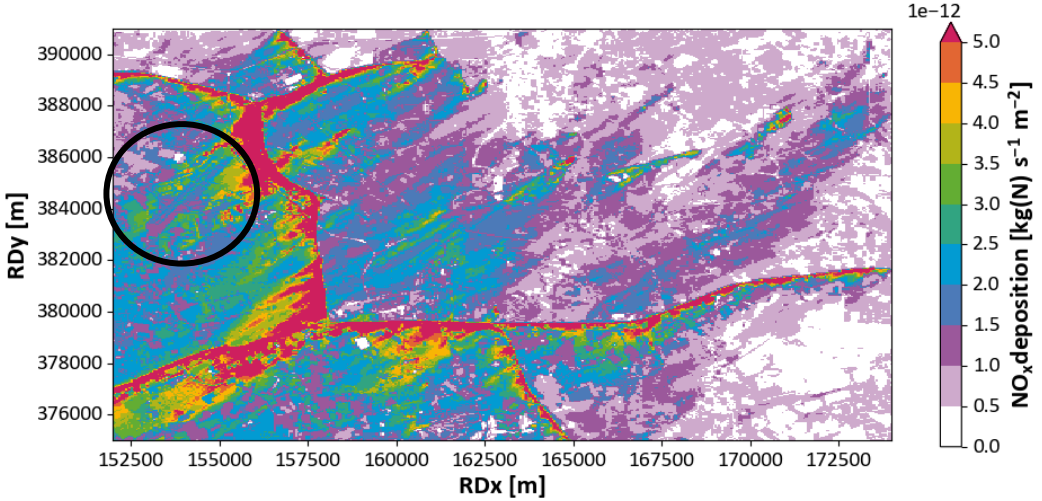


08:00 LT



Concentration



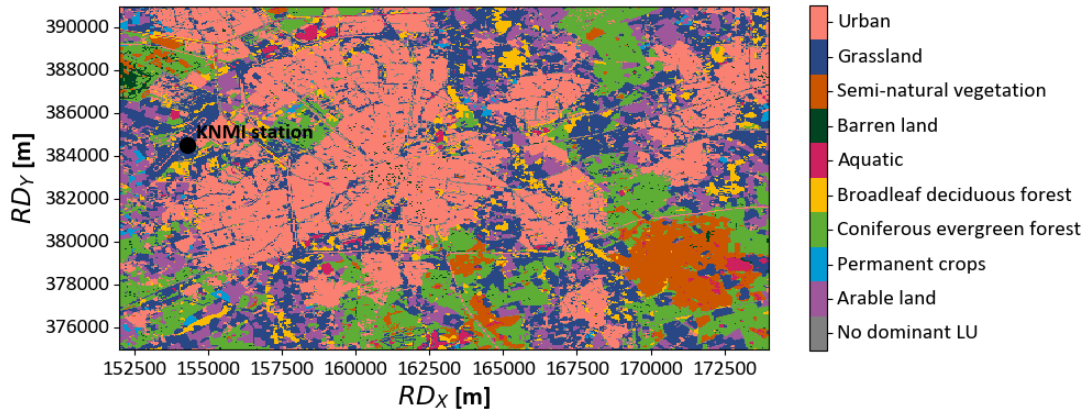


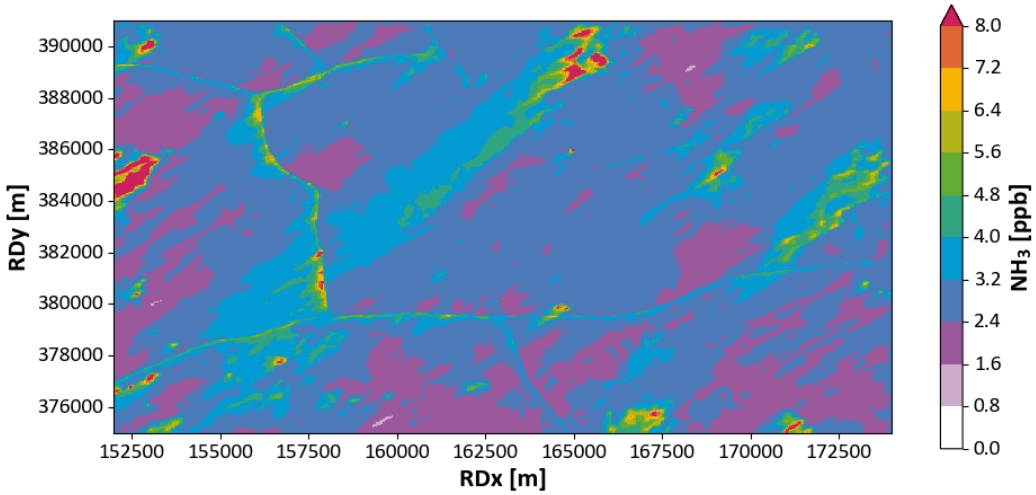
Dry dep.

DISPERSION AND DEPOSITION

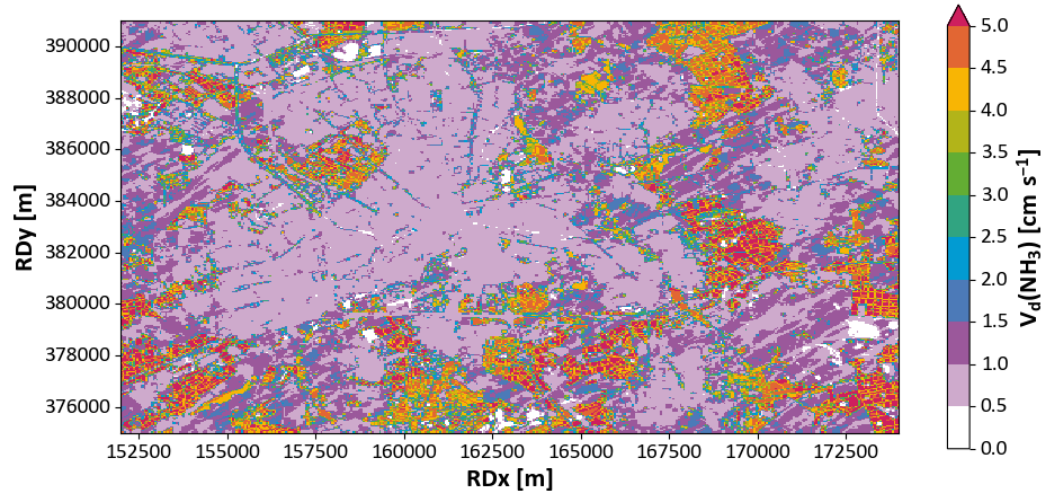
NH_3 – XY-CROSSSECTION

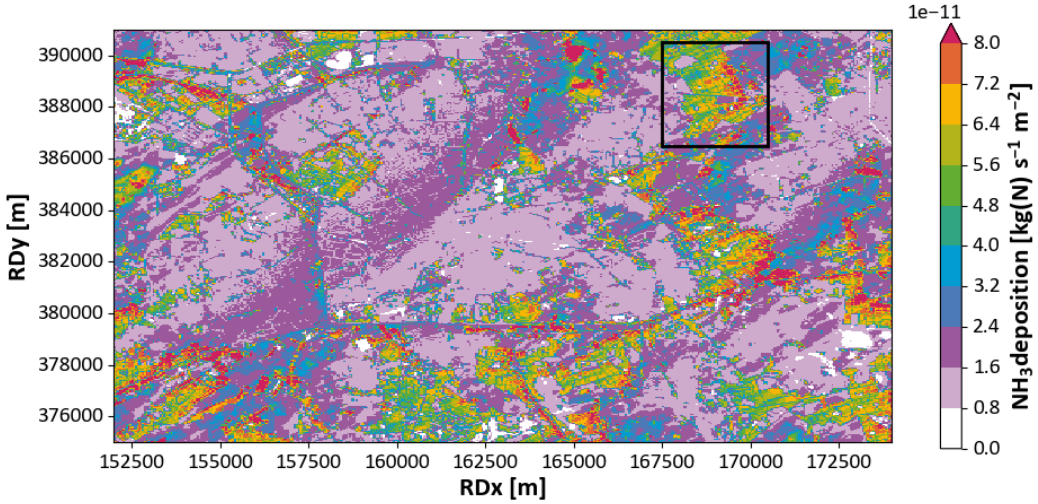
08:00 LT





Concentration





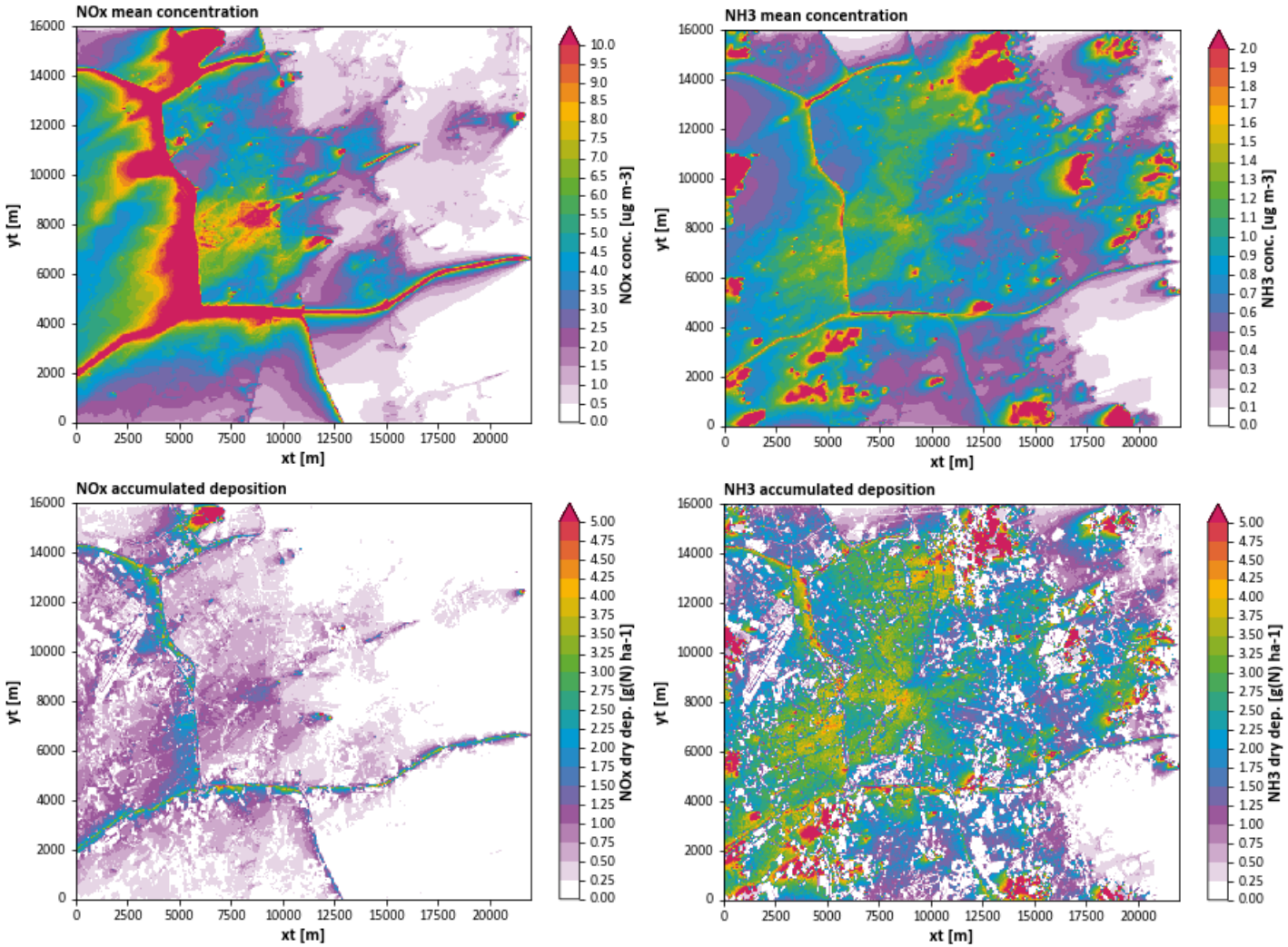
Dry dep.

DISPERSION AND DEPOSITION

NOX AND NH3

- Mean concentrations in µg/m^3
- Accumulated fluxes in g(N)/ha
- 2016-08-18 06:00-18:00 UTC
- Extrapolation from ½ day to year:
  - NH_3: 2x2x365 = 1460 g(N)/ha/yr
  - NO_x: 0.5x2x365 = 365 g(N)/ha/yr

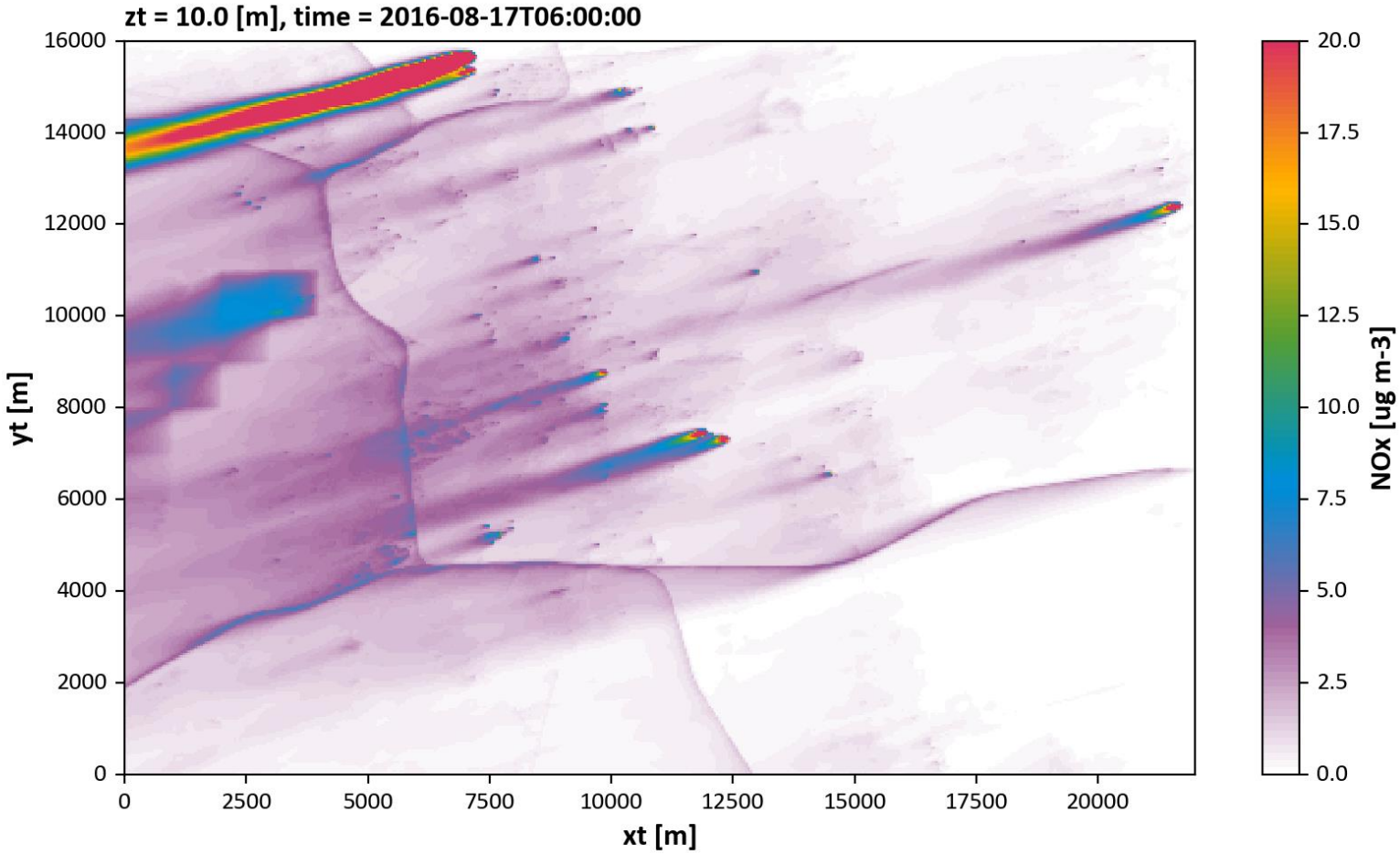
NO_x NH_3



DISPERSION AND DEPOSITION

NOX

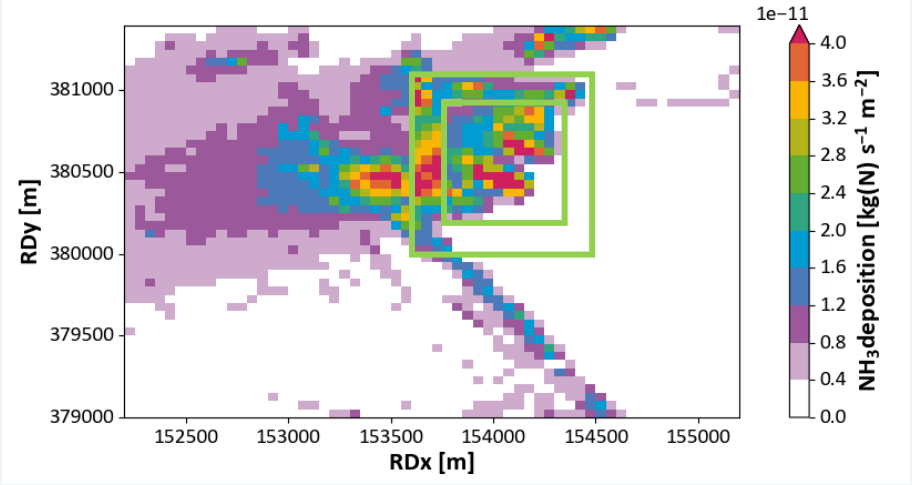
- Ontwikkeling over 4 uur
- 1 min. snapshots



Invloed landgebruik op depositie

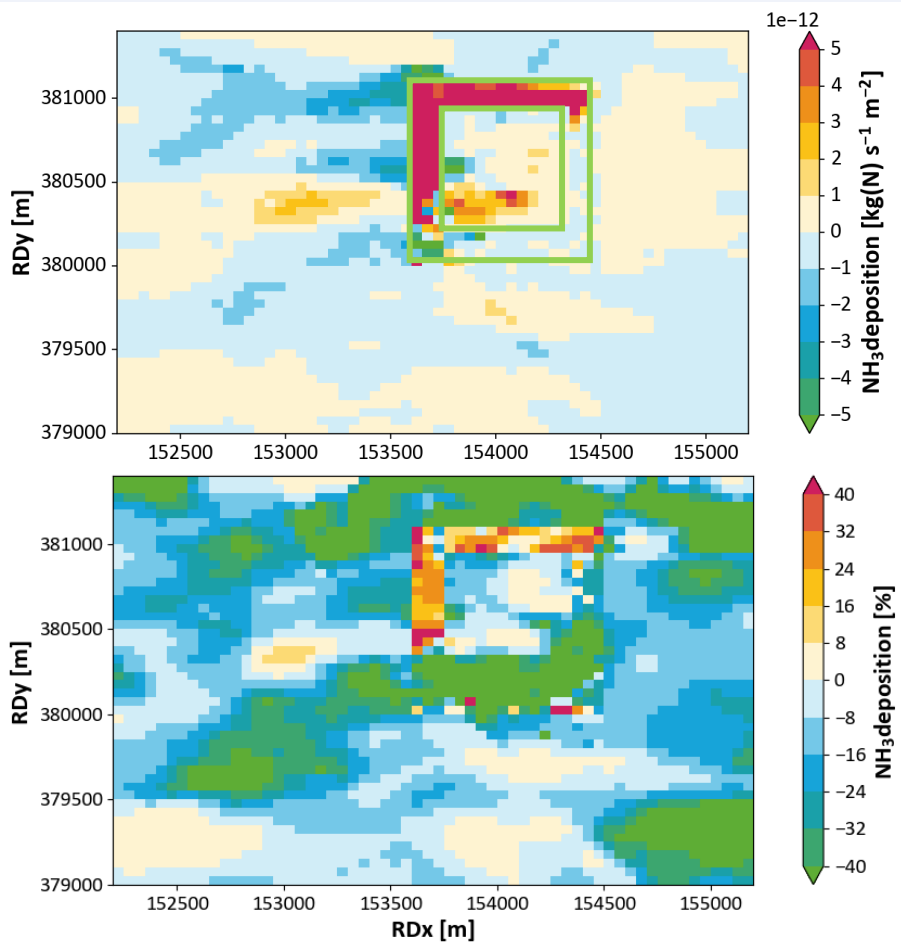
- Wat als we een virtuele rij bomen planten om een NH_3 grote bron?

Depositie met bomenrij



- Verhoogde depositie in bomenrij
- Afname van depositie achter bomenrij
  - Afname van ~20% over hele domein

Verschil in depositie met/zonder bomenrij

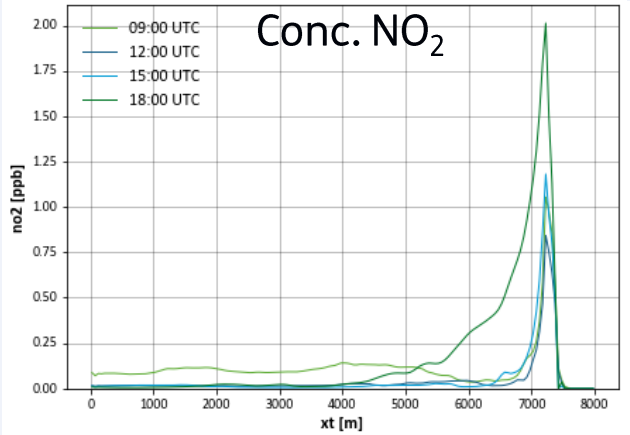


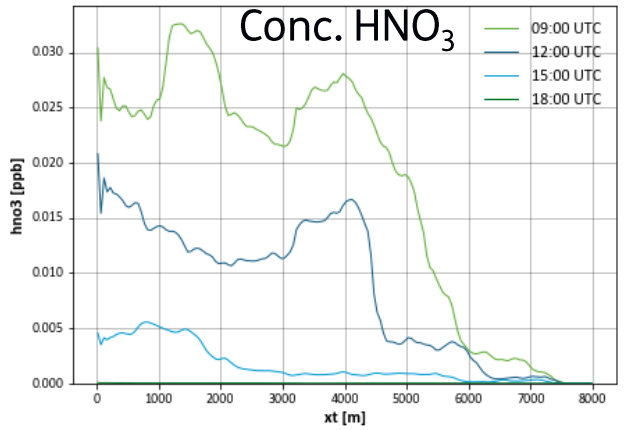
Absoluut verschil

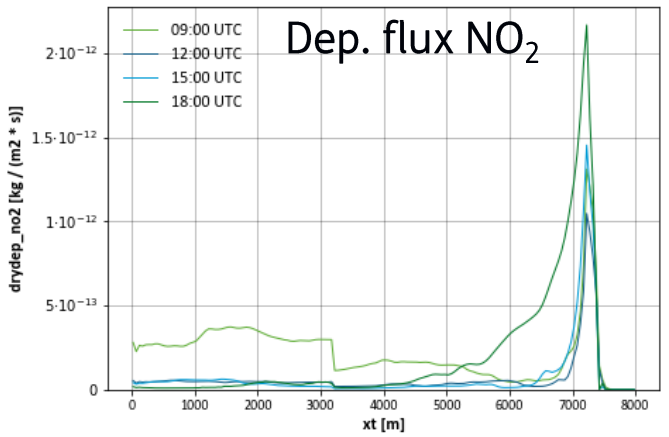
Relatief verschil

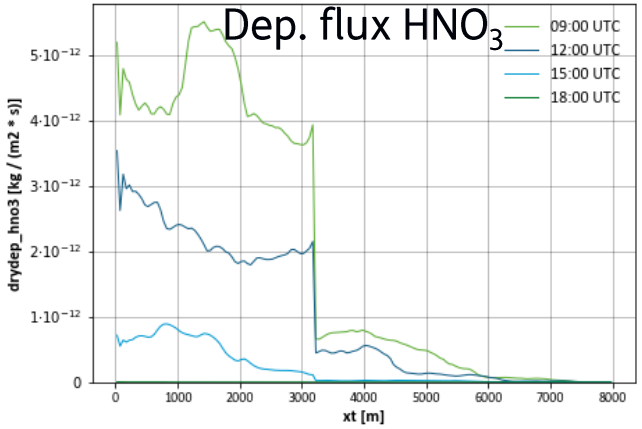
Chemistry & deposition

- **Goal: Assessing effect of chemistry on deposition for different LU classes**
- Artificial test case: “Veluwe A50”
  - Forced east wind, 2 m/s
  - Terrain divided into highway, grassland and forest
- Deposition NO_2 mainly near emission site
- But transport and reaction lead to deposition of HNO_3 at much greater distances
- Very significant difference in deposition fluxes between forest and grass land







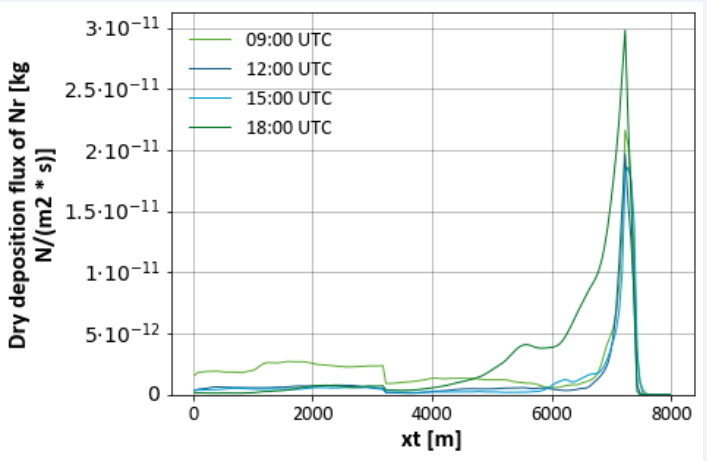


Chemistry & deposition

- Dramatic difference between situations with and without chemistry
- No chemistry ➔ N-deposition fluxes 20x as high as with chemistry
- N-deposition over forest
  - ~6x as high as over grass land
  - comparable to deposition near source
- Calculations were done with low background concentration of O_3. Increasing it led to increased formation of NO_2 and HNO_3

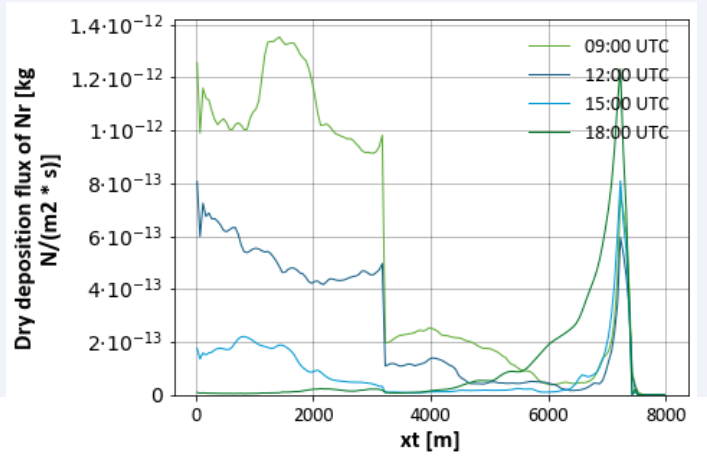
N deposition

(Only NO_2)



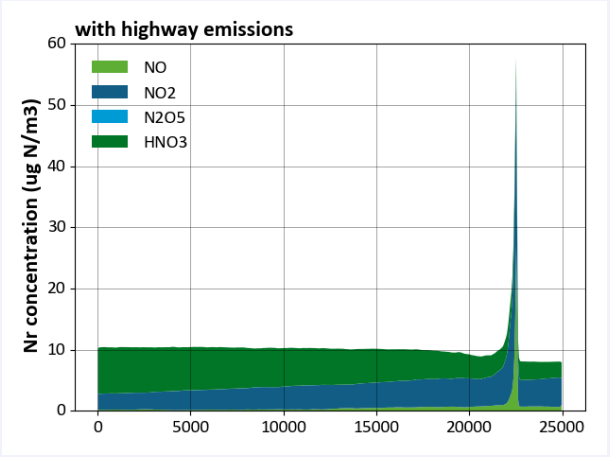
Reactions & N deposition

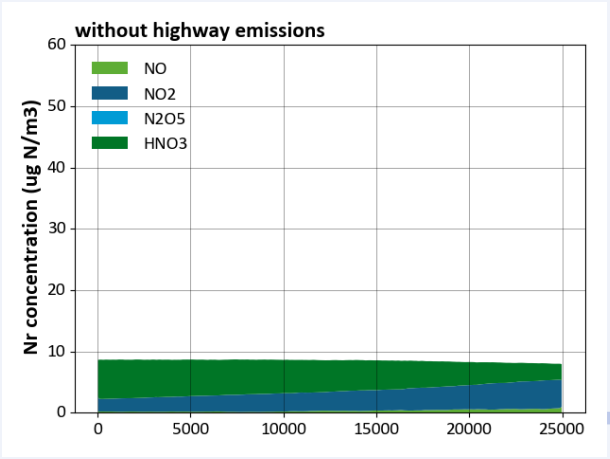
($NO/NO_2/N_2O_5/HNO_3$)



Long domain – Highway contribution to Nr concentration

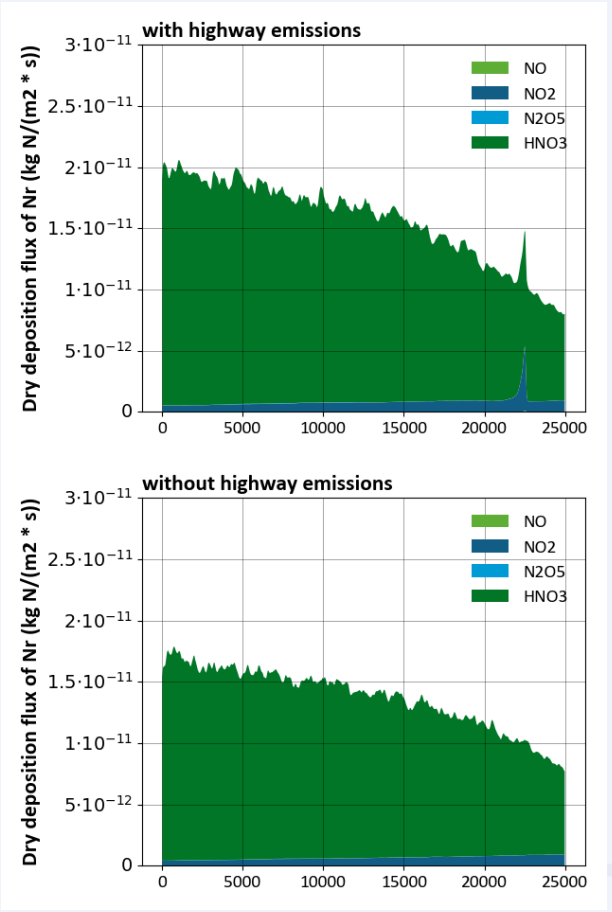
- Zien we hetzelfde effect voor een groter domein en alleen gras?
- 25 x 12 km^2 domain
- Average between 12:00 – 13:00 UTC

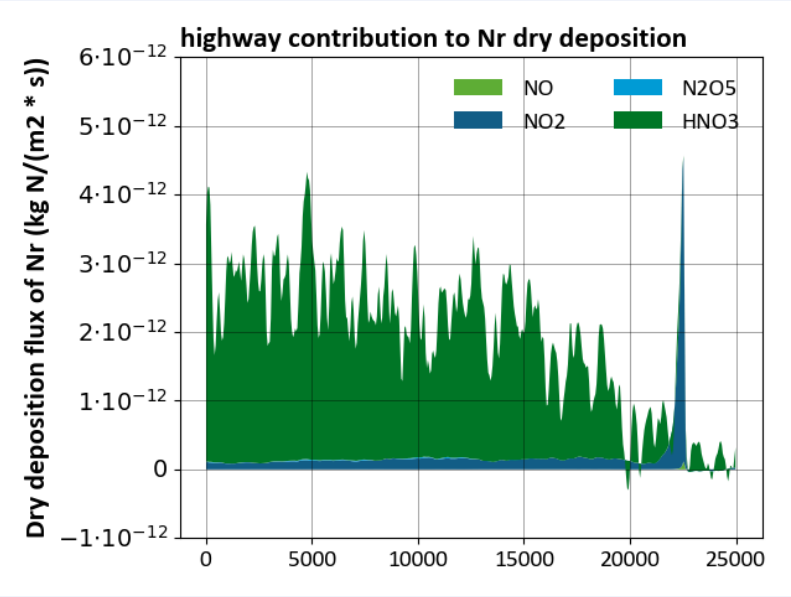




Long domain – Highway contribution to Nr deposition

- 25 x 12 km^2 domain
- Land use is grass only
- Average between 12:00 – 13:00 UTC
- Fluctuations due to turbulence
  - Does deposition increase with distance from highway? Up to which distance?
  - Coarsened grid to show trend. Figure shows increase of Nr deposition up to ~16 km from highway





Conclusies

- DALES is een hoge-resolutie model voor luchtkwaliteit & stikstofdepositie
- Toepassingen:
  - Depositiestudies in complexe landschappen
  - Scenario-studies m.b.t. landschapsinrichting
  - Proces studies, bv. invloed chemie op depositie
- Meer weten:
  - Ruud.Janssen@tno.nl (Onderzoeker - DALES)
  - Bas.Henzing@tno.nl (Business Developer)
  - Bezoek onze stand over Geluid en Lucht
  - Vacature voor een Business Developer