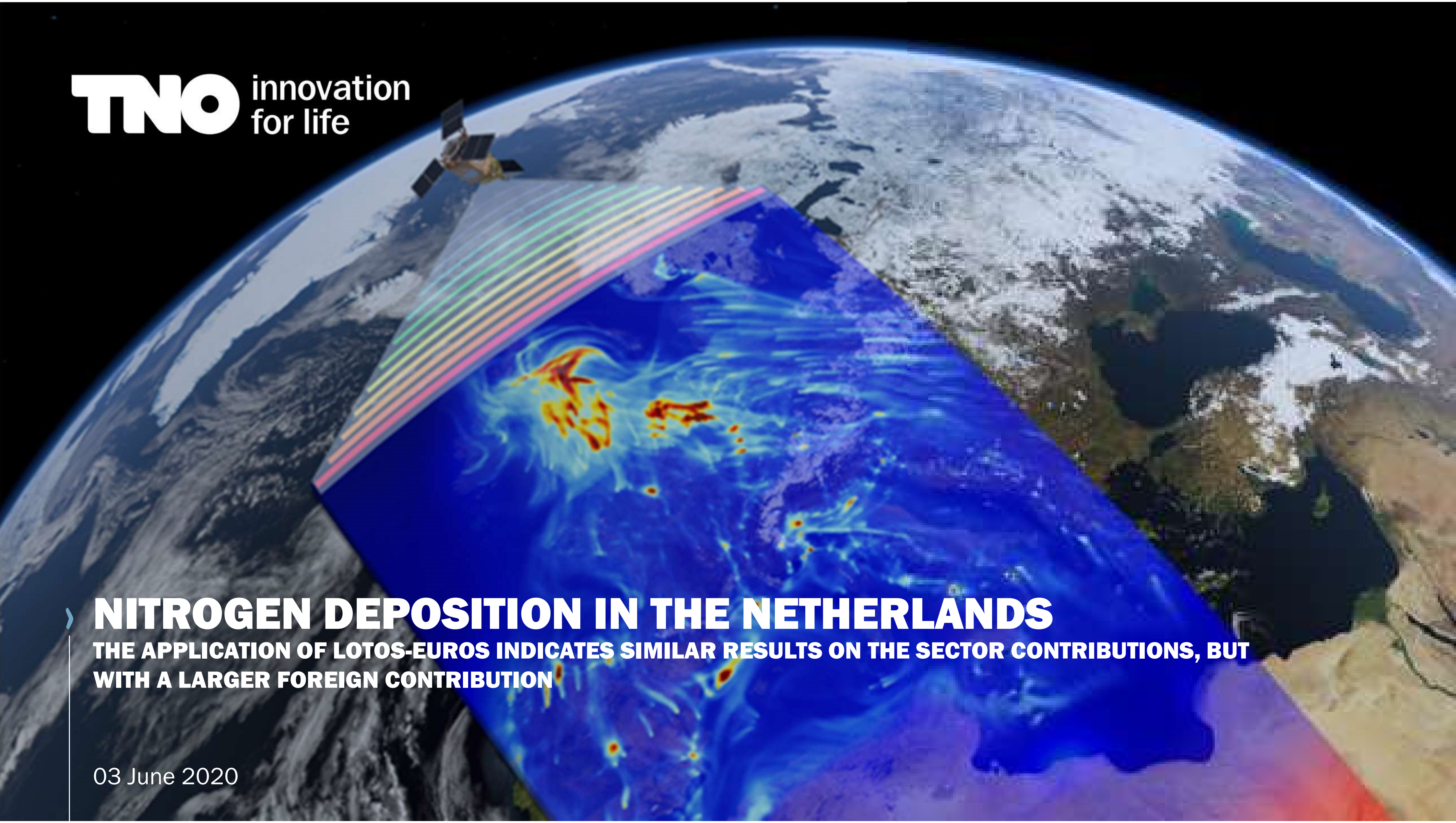

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NITROGEN DEPOSITION IN THE NETHERLANDS

THE APPLICATION OF LOTOS-EUROS INDICATES SIMILAR RESULTS ON THE SECTOR CONTRIBUTIONS, BUT WITH A LARGER FOREIGN CONTRIBUTION

03 June 2020

NITROGEN DEPOSITION IN THE NETHERLANDS

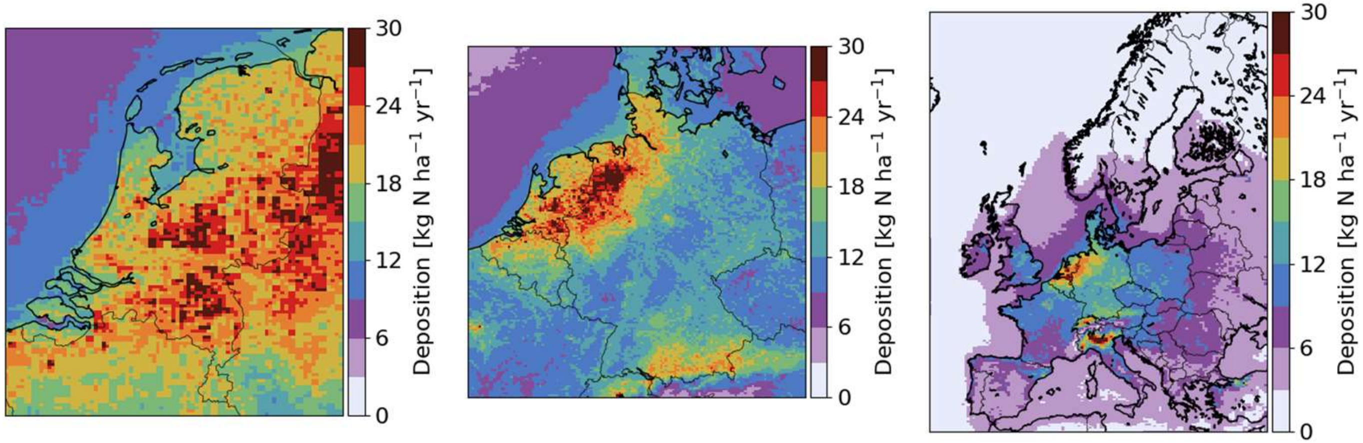
THE APPLICATION OF LOTOS-EUROS INDICATES SIMILAR RESULTS ON THE SECTOR CONTRIBUTIONS, BUT WITH A LARGER FOREIGN CONTRIBUTION

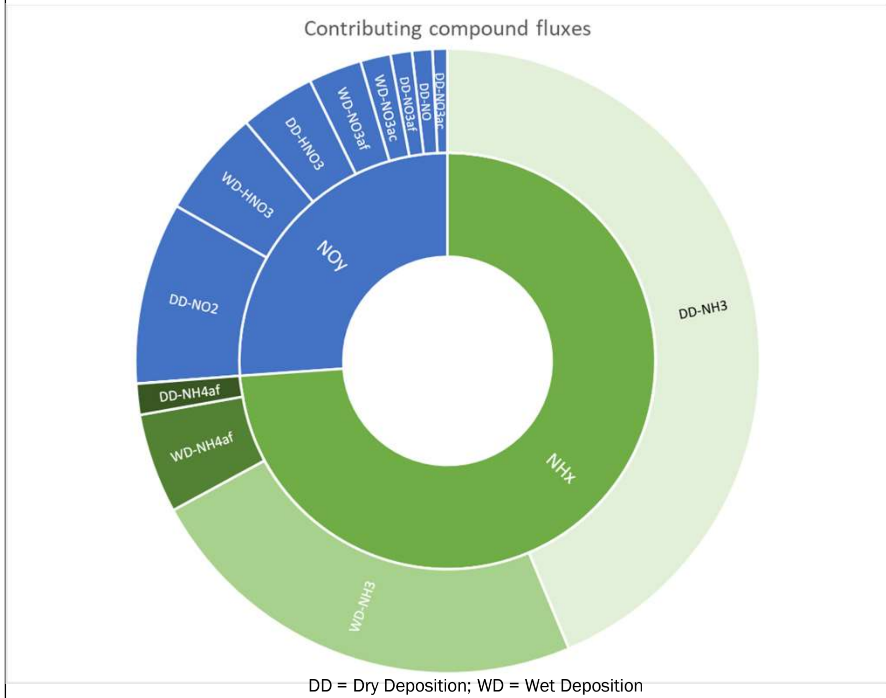
- Currently, a large societal debate is ongoing on nitrogen deposition in the Netherlands. During the discussion the quality of the underlying science was questioned.
- TNO develops an independent modelling system (LOTOS-EUROS), which is applied here to quantify the origin of nitrogen deposition in the Netherlands. LOTOS-EUROS is a grid model with explicit atmospheric chemistry.
- There is a large degree of consistency between LOTOS-EUROS results and those of the RIVM-GDN. This study should be regarded as a complimentary analysis and observed differences should foremost be interpreted as an indication of the uncertainty envelop in current state of science.
- Our results show that the combined national (38%) and international (25%) agricultural sector is by far the largest contributor (63%) to modelled total nitrogen deposition in the Netherlands. Transport (road traffic, shipping + other) is the second largest contribution (18%)
- The relative importance of the domestic source sectors is very similar to that in the GDN.
- LOTOS-EUROS results indicate a larger foreign contribution (44%) than the GDN (34%)
- The calculations clearly highlight the need to promote ambitious European policies to mitigate emissions in the transport, agriculture, energy and industry sectors, especially in view of the proposed targets by the commission Remkes

All percentages relate to the total modelled nitrogen deposition on the Netherlands (=100%)

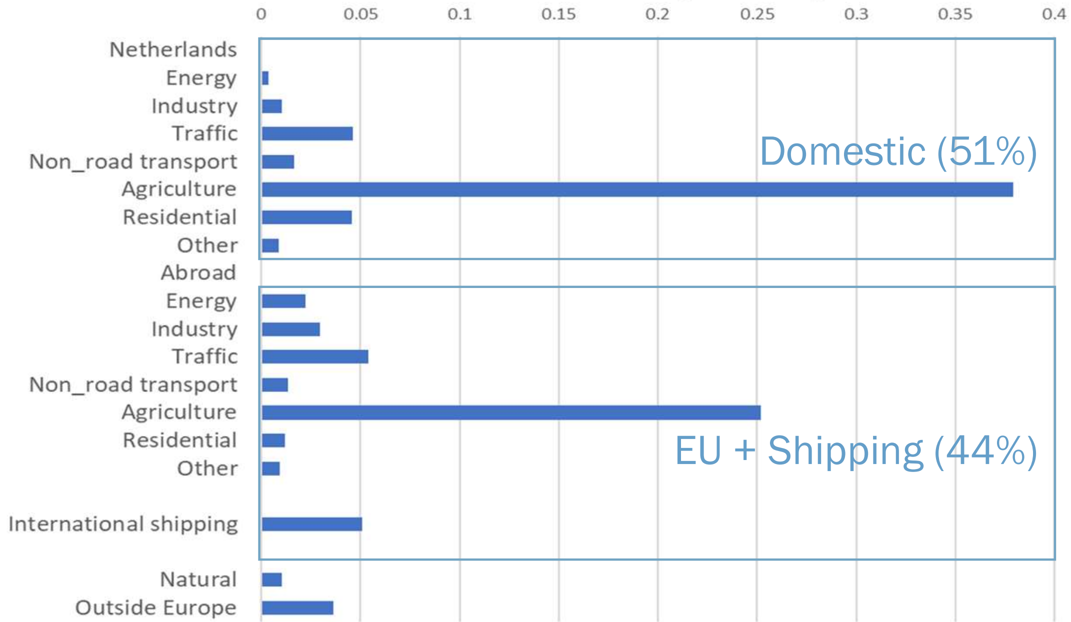
CURRENT RESULTS
SOURCE ATTRIBUTION

- Domestic contribution 51 %
- 74 % NHx, 26 % NOy





Fractional source contribution to country average N deposition

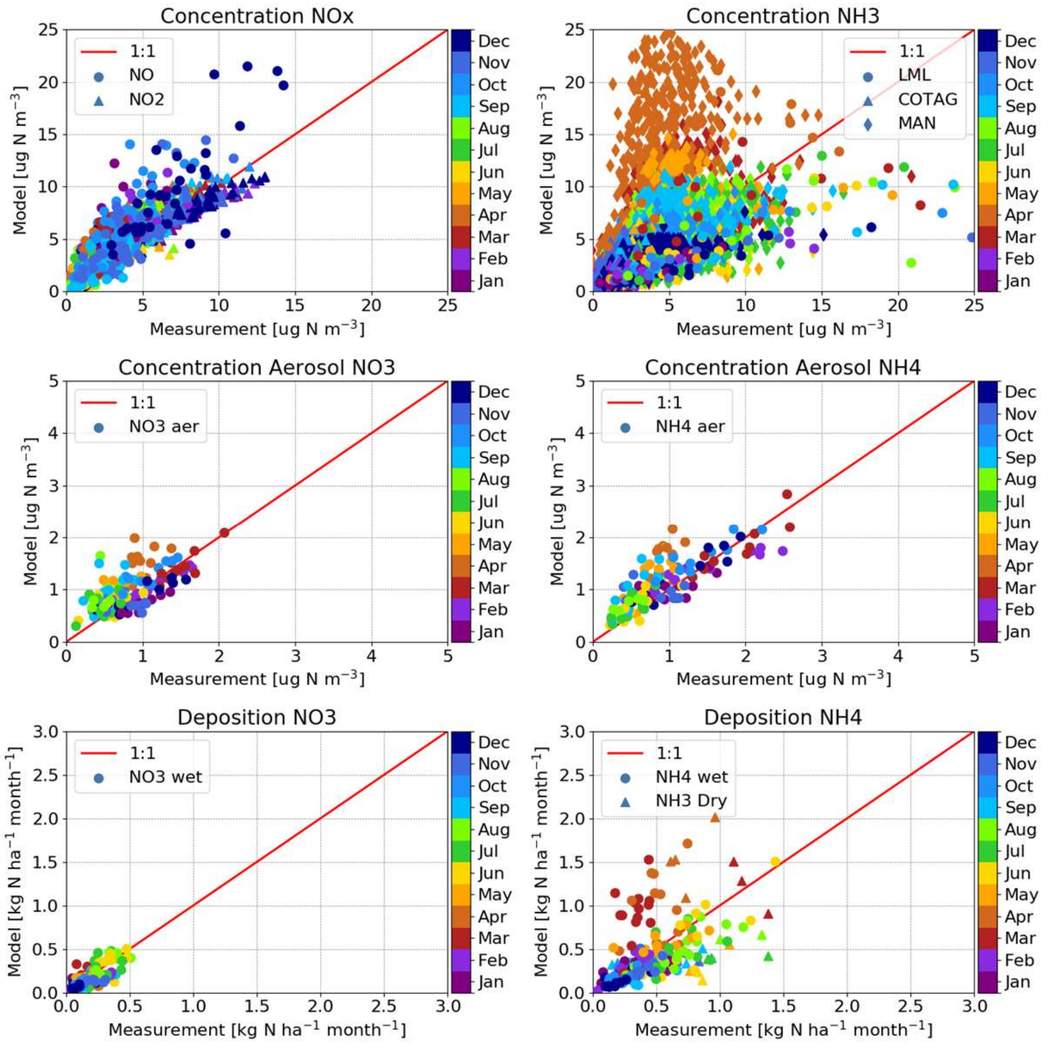


CURRENT RESULTS
MAIN CONCLUSIONS

- For the Netherlands LOTOS-EUROS calculates an average total nitrogen deposition of 20.4 Kg N/Ha/a
- Domestic contribution is calculated to be 51 %
- Largest domestic contributions are from agriculture (38%), road traffic (4.5%) and residential emission (4.5%)
- Foreign sources (44%) are dominated by agriculture (25%), followed by road traffic (5%) and int. shipping (5%)
- Deposition is mostly explained by the fluxes of ammonia, nitric acid and nitrogen dioxide
- Consistency between modelled and observed concentrations and fluxes of the compounds is considered relatively high
- Largest model-measurement deviations are found for the spatio-temporal variability of ammonia concentrations
- Uncertainties in these estimates are discussed in the TNO factsheet nitrogen deposition and similar to those in RIVM-GDN

The application of LOTOS-EUROS indicates similar results on the sector contributions in comparison to RIVM-GDN, but with a larger foreign contribution

Comparison of all monthly mean concentrations during two years (2015-2016)



THANK YOU FOR YOUR TIME

For questions please contact Martijn Schaap:
Martijn.schaap@tno.nl

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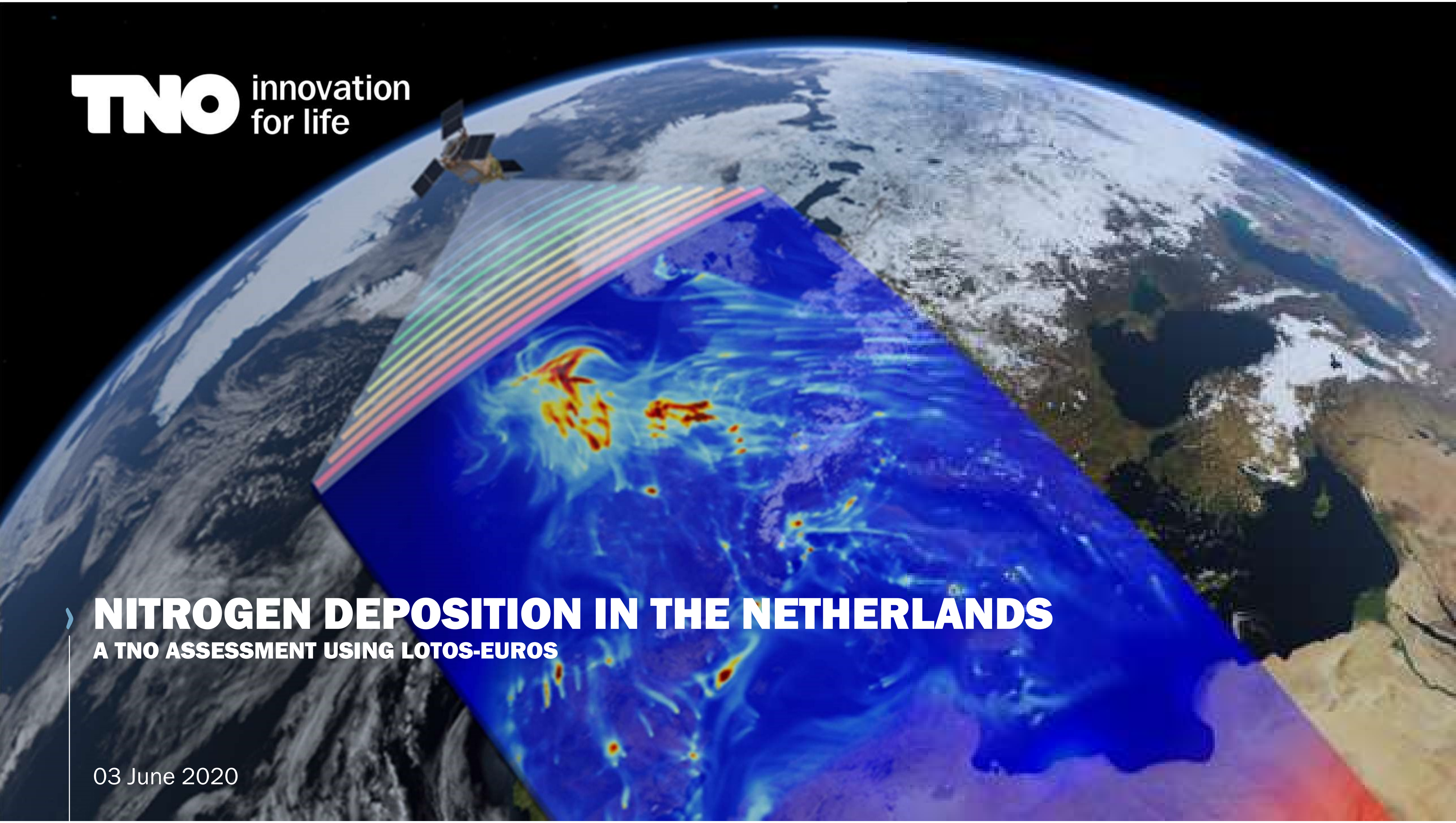


NITROGEN DEPOSITION IN THE NETHERLANDS

A TNO ASSESSMENT USING LOTOS-EUROS

03 June 2020

INTRODUCTION

Background

- Currently, a large societal debate is ongoing on strategies to reduce the nitrogen deposition in the Netherlands
- During the discussion the quality of the underlying science was questioned.
- Independent efforts are required to substantiate the current knowledge base for policy makers
- TNO develops the modelling system LOTOS-EUROS which is also applied for reactive nitrogen studies and is part of the regional ensemble within the Copernicus Atmosphere Monitoring Service (CAMS)

Goal of this study:

- To quantify the origin of nitrogen deposition to the Netherlands using the chemistry transport model LOTOS-EUROS
- To evaluate the model system with the observation data currently available within the Dutch monitoring networks

This presentation provides insights in the current results obtained using LOTOS-EUROS at TNO. The results are under continuous scrutiny and are obtained within ongoing activities within the strategic knowledge development at TNO. Sharing of this information is based on the timeliness with respect to the ongoing societal N discussion.

METHODOLOGY
LOTOS-EUROS MODELLING SYSTEM

LOTOS-EUROS

- 3D Chemistry transport model
- Eulerian grid model
- Open source
- Lead developer: TNO
- Operated within CAMS in collaboration by KNMI and TNO
- Central reference: Manders et al. (2017)

PREVIOUS APPLICATIONS

- Operational Air Quality forecast for the Netherlands (O_3, PM, NO_2)
- CAMS European air quality analyses and forecasting
- TOPAS source apportionment service for particulate matter
- Policy support studies for regional and national governments
- Research and policy support applications have been performed in several continents (Europe, US, S-America, Africa, Asia)

NITROGEN FOCUS

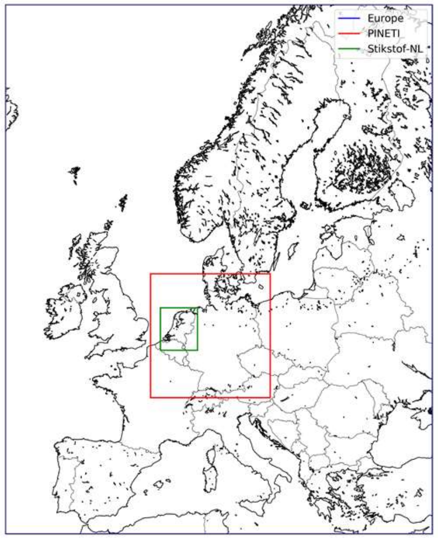
- TNO is responsible for the nitrogen deposition mapping across Germany through a combination of empirical approaches and LOTOS-EUROS modelling
- Exploiting satellite remote sensing in collaboration with VU and ECCC (NH_3), and TUD and KNMI (NO_2)
- Dynamic emission modelling (agriculture in collaboration with WUR)
- Dry deposition evaluation in collaboration with German partners (e.g. vTI)

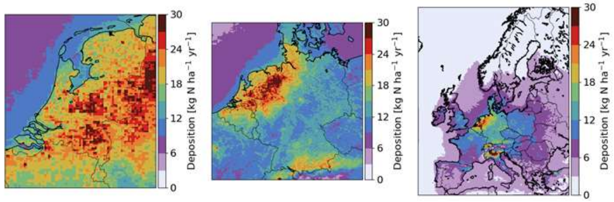
METHODOLOGY
MODELLING

SIMULATION SETUP

- 2 years: Jan-2015 till Dec-2016
- Meteorology: ECMWF
- Nesting approach
  - Europe, 0.4x0.2 degree (~22km)
  - NW-Europe, 0.1x0.05 degree (5.5km)
  - Netherlands, 0.05x0.025 degree (2.7km)
- 12 vertical layers upto ~ 9000m
- Land use (Corine 2012)
- Note that given the landscape structure and size of most nature areas this resolution implies that an overestimation of ammonia in nature areas and underestimation is source areas is anticipated

DOMAINS





...

- In this study we chose to sacrifice resolution above source sector detail (29 labels). Hence, somewhat higher resolution is possible with less labels
- We have to note here that the emissions and dry deposition routine for ammonia (the most important sources of uncertainty) are the same as used in the OPS model. This warrants a degree of comparability, but also means that the full uncertainty envelope is larger than indicated by the indicative differences discussed above.

METHODOLOGY
EMISSIONS

Emission totals:

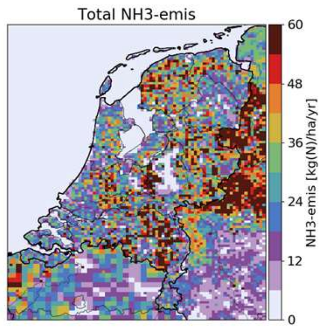
- 2015 totals as reported in 2019

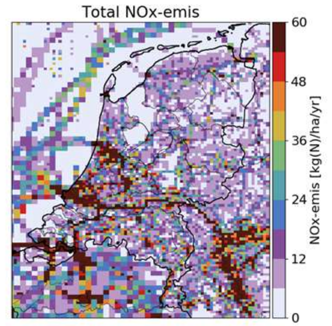
Emission distributions

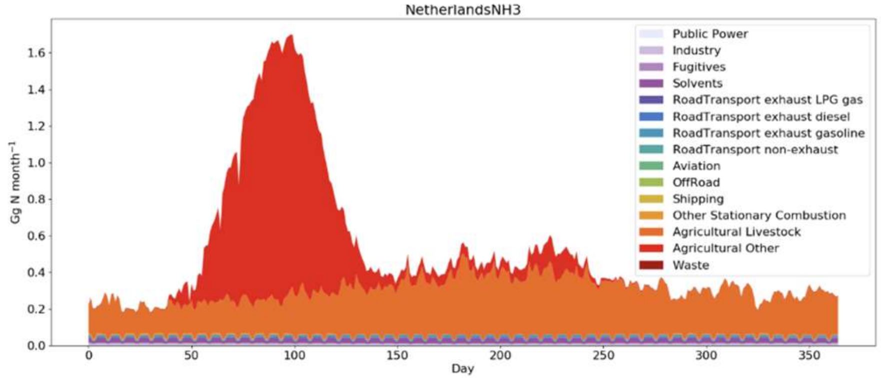
- National emission inventory Netherlands
- German UBA emission distribution
- All other countries following CAMS-v4.1.

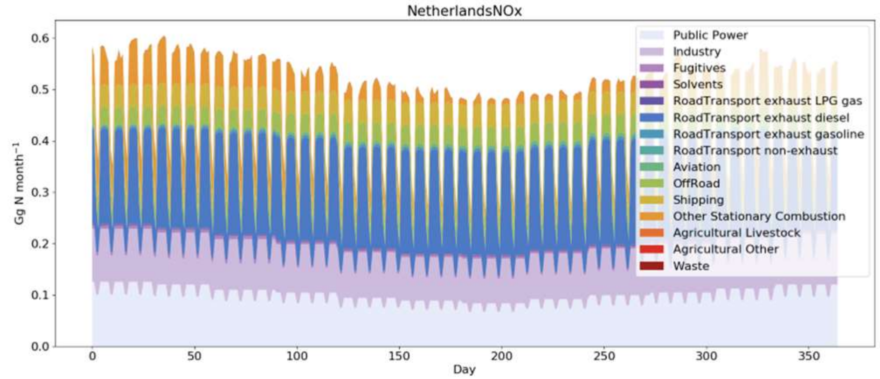
Temporal distribution within the year includes:

- Livestock housing following Gyldenkaerne et al (2005)
- Manure / fertilizer application timing following adapted approach of Skjoth et al (2011) – See Hendriks (2016)
- Temperature dependent cold starts and residential heating
- using standard static profiles for all other sectors









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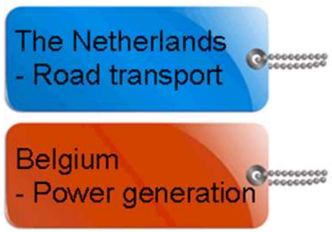
METHODOLOGY
SOURCE APPORTIONMENT

LABELLING APPROACH

- Labelling of source contributions
  - To track of oxidized and reduced nitrogen molecules in all physical processes
  - Nitrogen atoms are conserved throughout all processes
  - For each concentration change also the update source attribution is calculated
  - Label definition is flexible and be a sector, region or combination thereof
- Here we store all labelled concentrations and deposition fluxes



LABELLING DEFINITION

Main source differentiation:

- Dutch Emissions
  - Split in sectors (next column)
- Foreign Emissions (Europe)
  - Split in sectors (next column)
- International shipping
- Natural: Biogenic NOx emissions
- Sources outside Europe

DIFFERENTIATED SECTORS

Dutch and Foreign emissions tracked for:

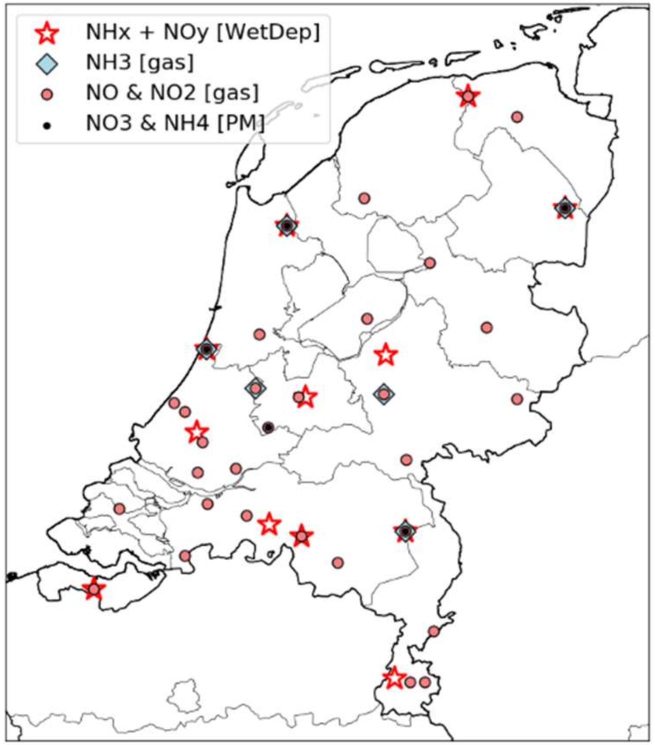
- Energy production
- Industry
- Residential combustion
- Road transport
  - Light duty vehicles (combustion)
  - Heavy duty vehicles (combustion)
  - Tyre and brake wear + evaporation
- Off-road transport
  - Aviation
  - Shipping
  - Rail transport + machinery
- Agriculture
  - Animal housing
  - Manure spreading and storage
- Other Sectors

MODEL EVALUATION
COMPARISON TO LML AND MAN

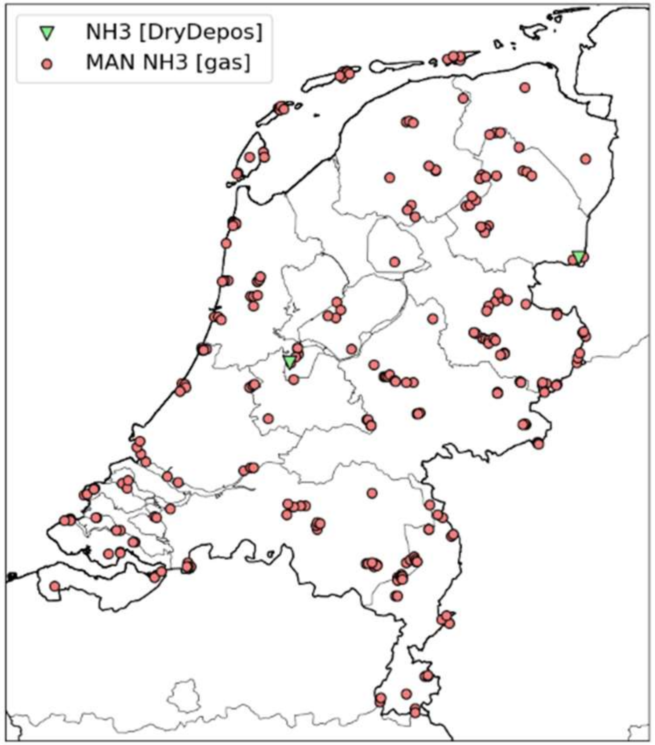
METHODOLOGY

- LML: Dutch Air Quality Network (NO, NO_2, PM, O_3, NH_3, etc) measuring concentrations and wet deposition (hourly, daily). Only regional and urban background stations.
- MAN: network focussed on measuring ammonia concentrations in Natura 2000 areas. (monthly)
- COTAG: NH_3 Concentration & Dry Deposition network (monthly)
- All comparisons paired in time and shown in units N

LML



MAN & COTAG



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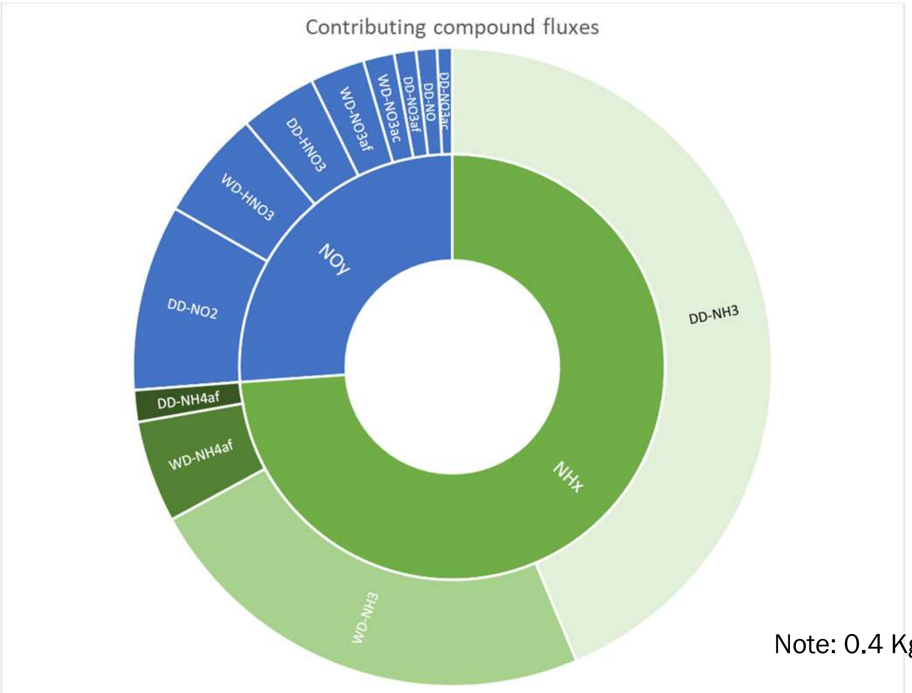
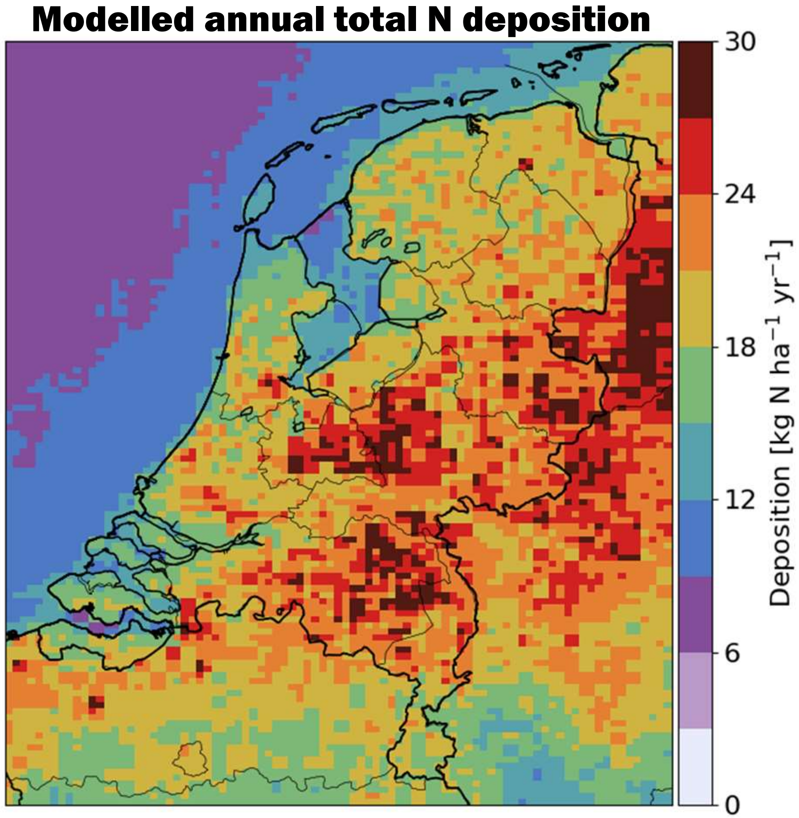
CURRENT RESULTS
TOTAL DEPOSITION

On average for the Netherlands LOTOS-EUROS calculates:

- Total nitrogen deposition 20.4 Kg N / Ha / a
- 74 % NHx, 26 % Noy
- Deposition is mostly explained by the fluxes of ammonia, nitric acid and nitrogen dioxide

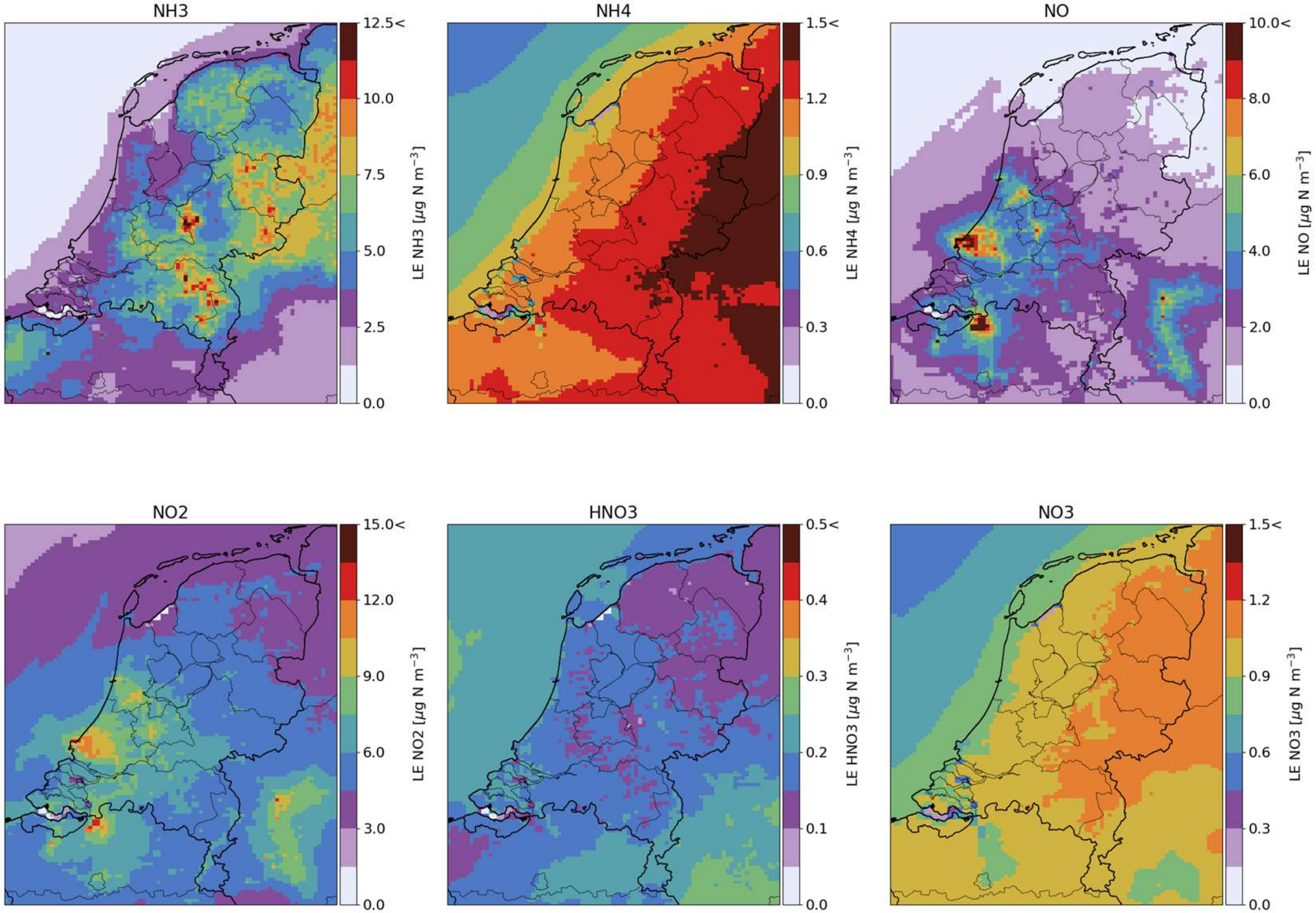




Note: 0.4 Kg N through PAN and HONO still te be added!

CURRENT RESULTS

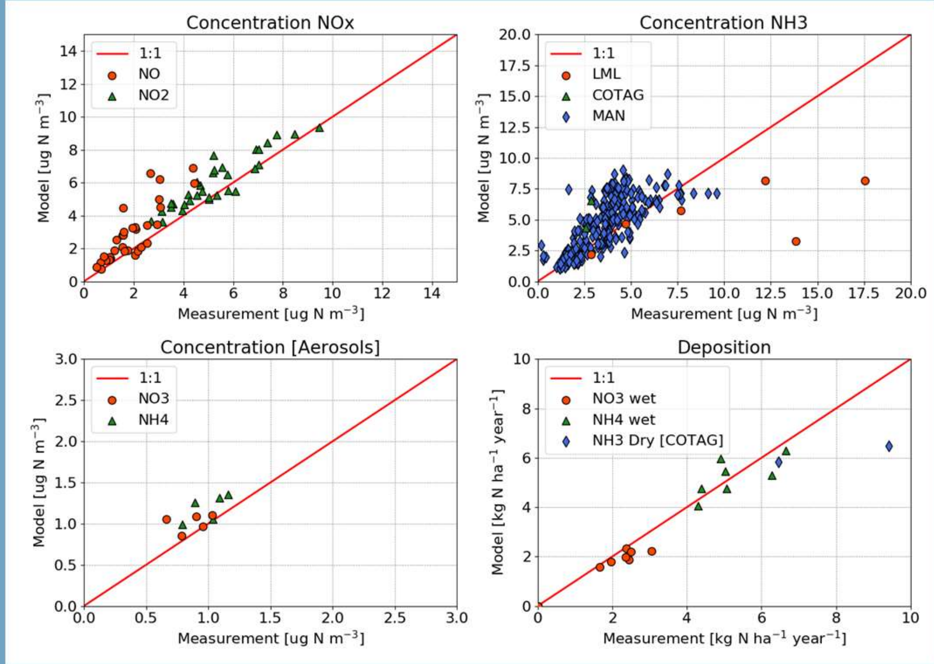
Modelled annual mean air concentrations of nitrogen compounds



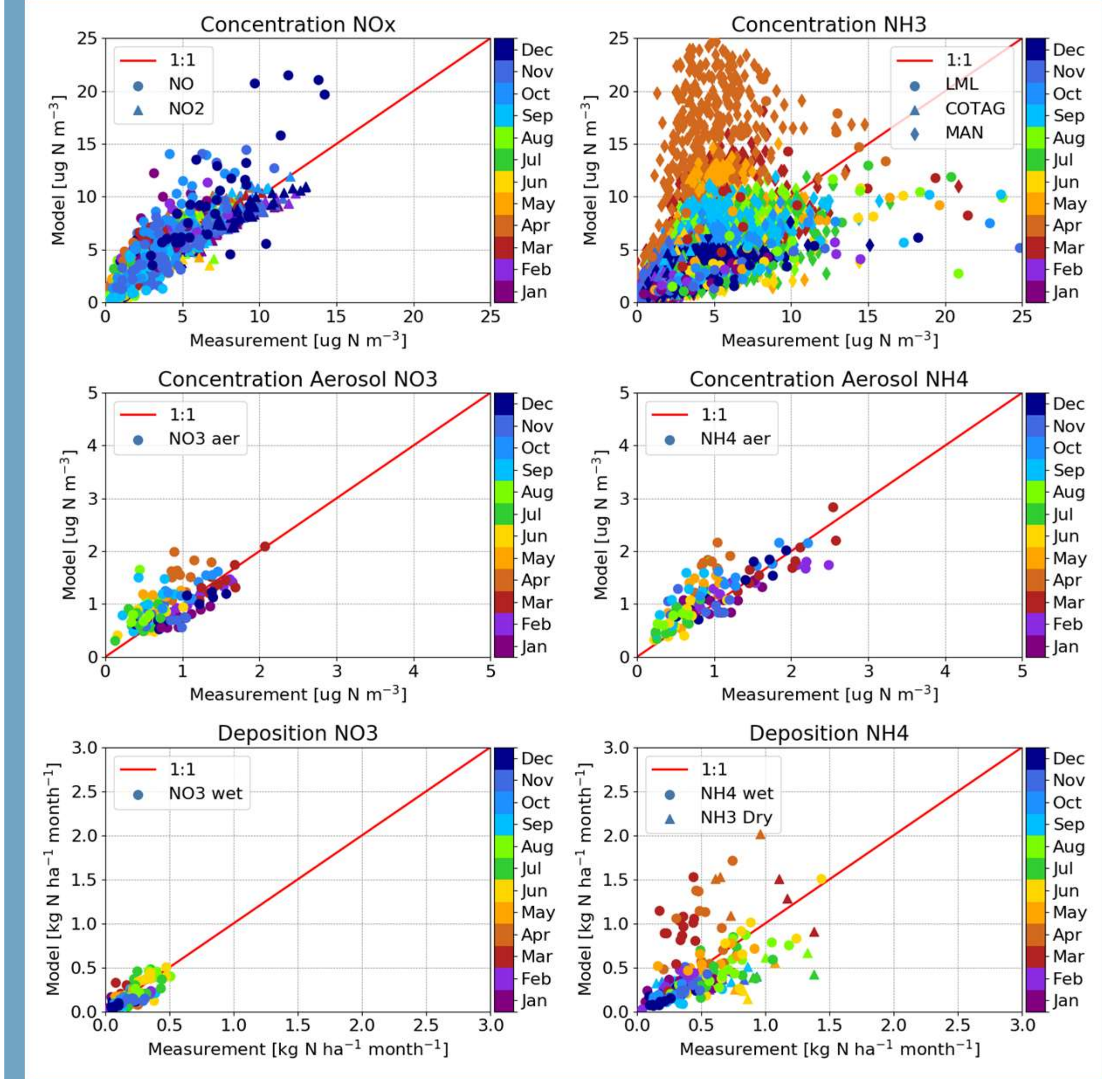
CURRENT RESULTS

SCATTERPLOTS – ANNUAL AND MONTHLY

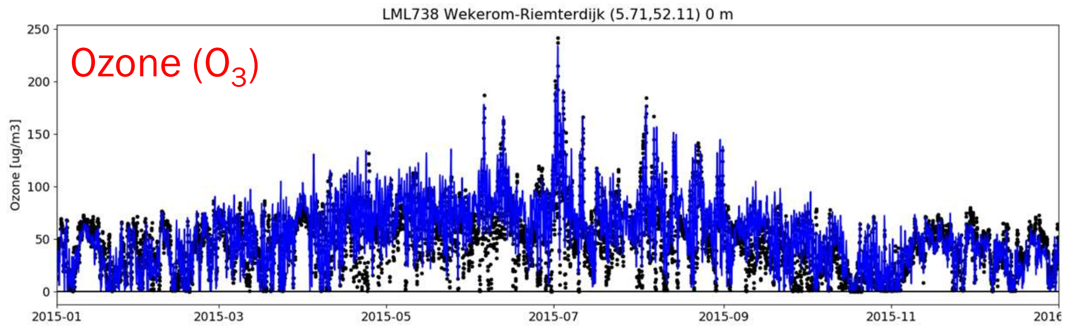
Annual mean comparison

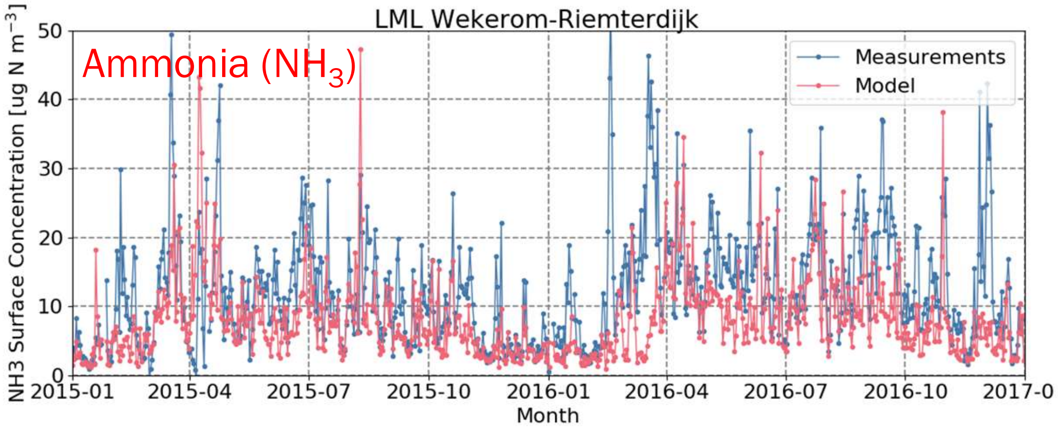


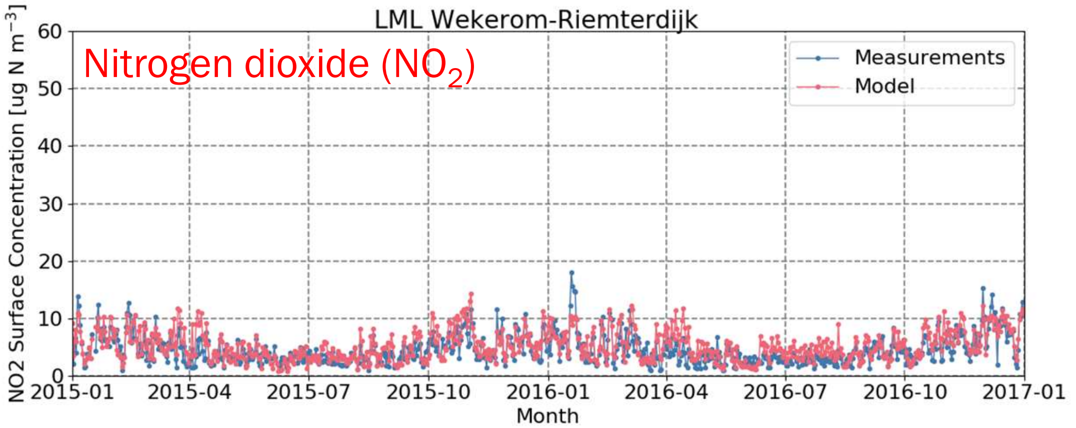
Monthly mean comparison

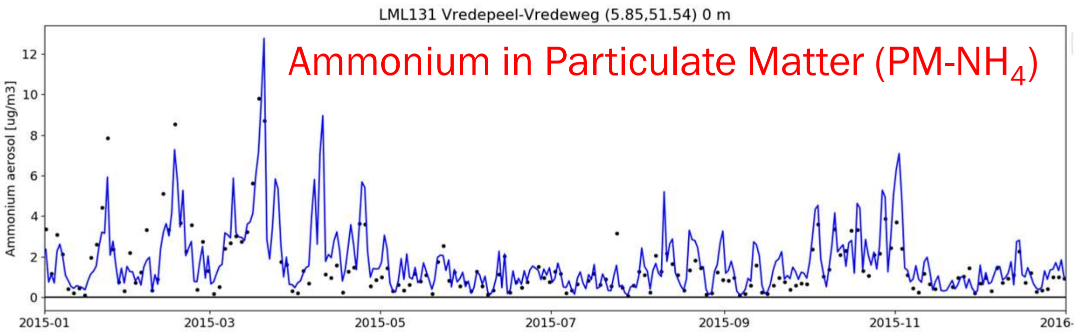


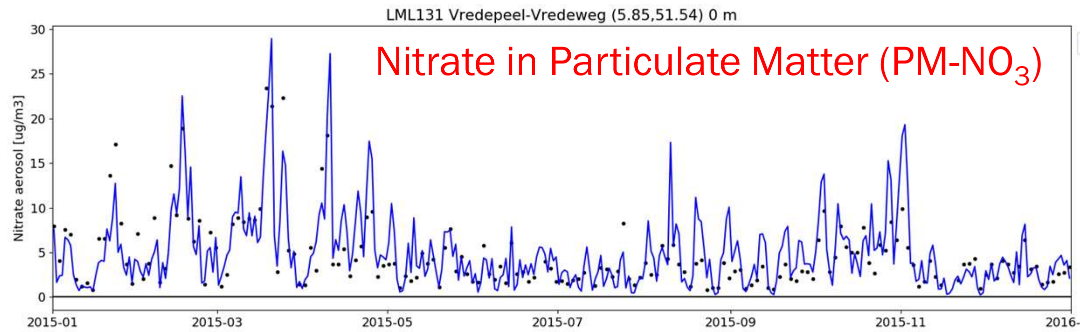
CURRENT RESULTS
EXAMPLE DAILY TIME SERIES









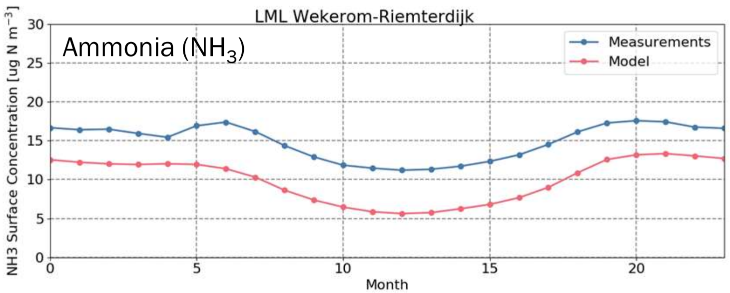


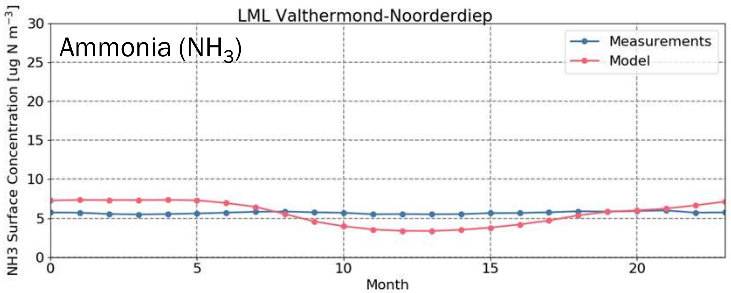
CURRENT RESULTS

ANALYSING TEMPORAL VARIABILITY IMPORTANT TO GUIDE MODEL IMPROVEMENT

DIURNAL CYCLES

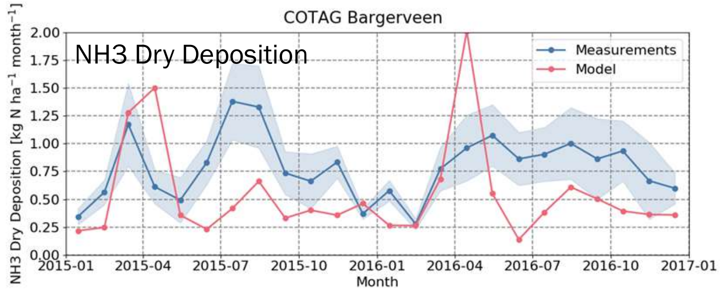
- Diurnal cycles at LML sites show variable degree of agreement and seem to indicate housing vs application emission impact

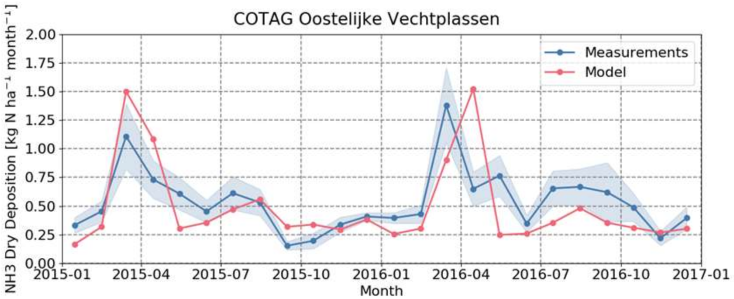




NH3 DRY DEPOSITION

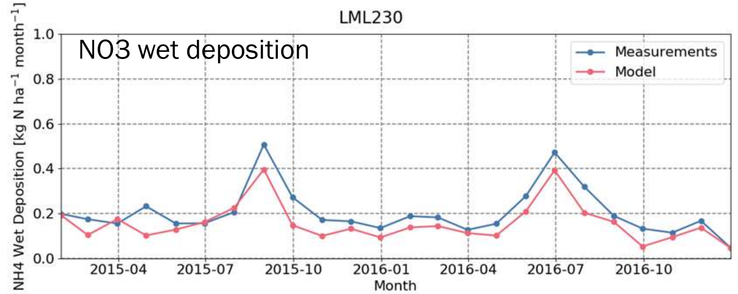
- Monthly time series for ammonia in air, dry deposition and wet deposition show consistent picture

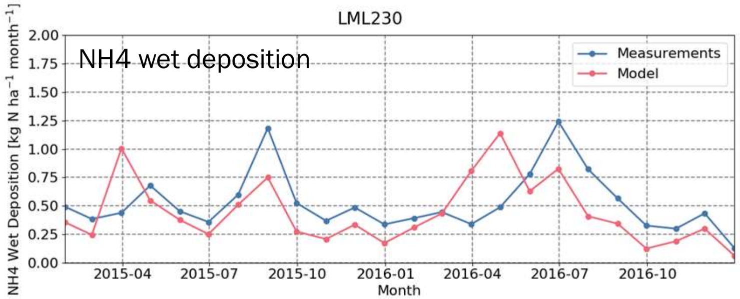




WET DEPOSITION

Evaluaiton shows modelled spring time application emission for NH_3 is too high and summer time application emissions are too low





CURRENT RESULTS
SOURCE APPORTIONMENT

Domestic contributions total 51 %

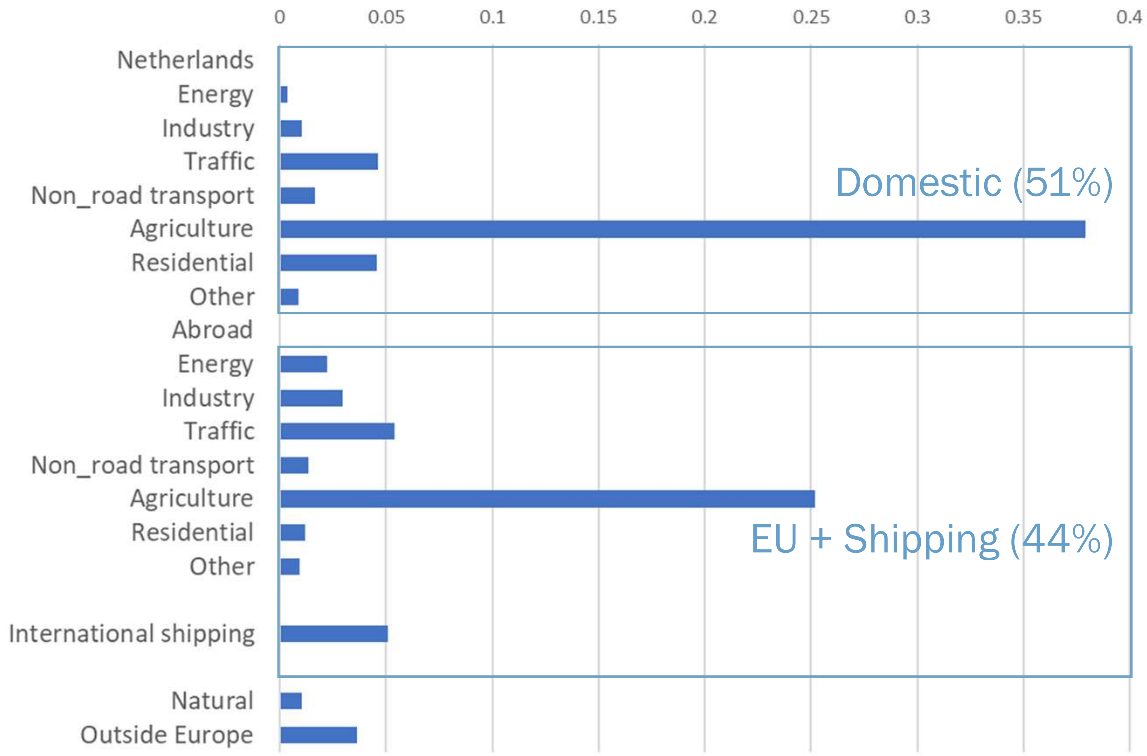
- Dutch agriculture = 38 %
- Road traffic = 4.5 %
- Residential = 4.5 %

Foreign EU contributions (39%)

- Agriculture contributes 25 %
- Road traffic = 5.5 %
- Energy and industry relatively more important

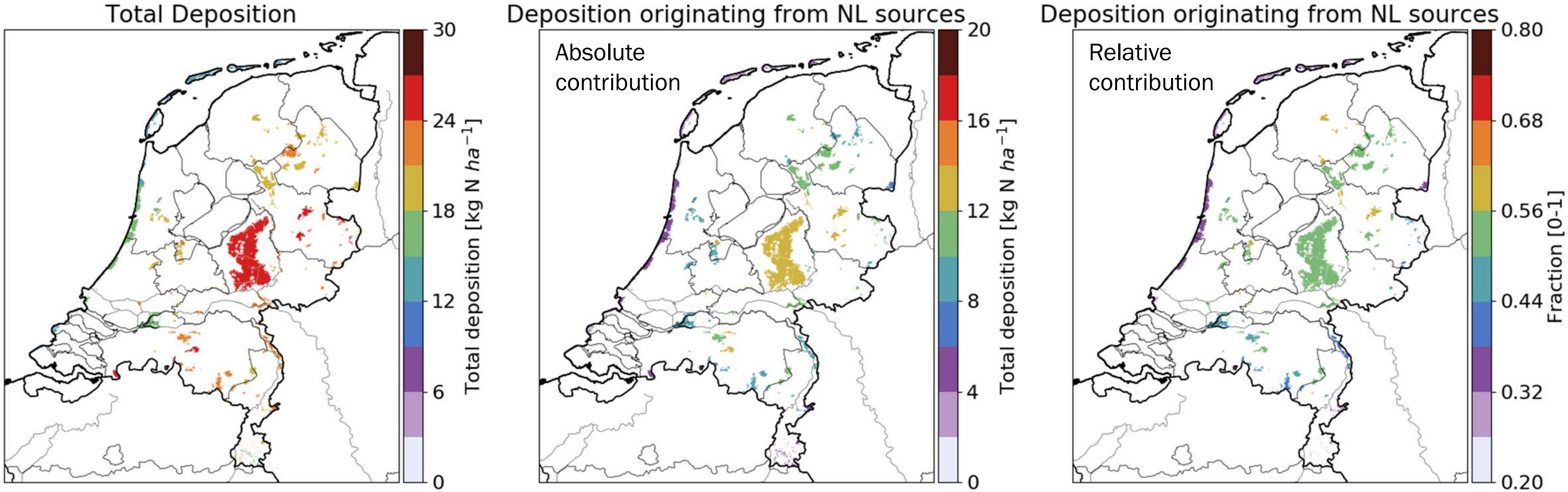
International shipping = 5 %

Fractional source contribution to country average N deposition



Note: Domestic to foreign sector compatability not allways easy due to inconsistencies in emission inventories

CURRENT RESULTS
NATURA2000 AREA AVERAGED SOURCE APPORTIONMENT



Due to small size of many regions and the current grid resolution we choose not to analyse individual regions in much detail

CONCLUSIONS

- For the Netherlands LOTOS-EUROS calculates an average total nitrogen deposition of 20.4 Kg N/Ha/a
- Domestic contribution is calculated to be 51 %.
- Most important domestic contributions are from agriculture (38%) and road traffic and residential emissions (each 4.5%)
- Foreign sources (EU + shipping = 44%) are dominated by agriculture (25%), followed by road traffic (5.5%) and international shipping (5%)
- Deposition is mostly explained by the fluxes of ammonia, nitric acid and nitrogen dioxide
- Consistency between modelled and observed concentrations and fluxes of the different species is considered relatively high (remember no scaling applied at all)
- Largest deviations are found for the representation spatio-temporal variability of ammonia concentrations
- Uncertainties in these estimates are discussed in the TNO factsheet nitrogen deposition and are of similar magnitude to those in RIVM-GDN

All percentages relate to the total modelled nitrogen deposition on the Netherlands (=100%)

DIRECTIONS FOR IMPROVEMENT OF THIS STUDY

- Improve the spatial-temporal variability in agricultural (ammonia) emissions through dynamic emission modelling
- Include the best-available Dutch land use information and expand vegetation classes and detail their parameters in the dry deposition routine DEPAC
- Evaluate the dry deposition routine DEPAC against new and international dry deposition measurement studies
- Perform sensitivity analysis of different emission variability and dry deposition velocity to check uncertainty envelope
- Perform a detailed comparison to OPS results (currently not performed as model resolutions do not match)
- Further model evaluation using CrIS-NH_3 and TROPOMI-NO_2 satellite data and emission estimation (first efforts ongoing)
- Detail the emission information of the border regions in Germany and Belgium (+ consistency check)
- Update process descriptions for soil-NOx emissions and organic-nitrogen production
- Connect LOTOS-EUROS non-hydrostatic meteorological input data (to account for sea-breeze circulation, etc)
- Develop a methodology to include a nitrogen vegetation and soil pool to model ammonia exchange dynamically and interaction

TAKE HOME MESSAGE

THE APPLICATION OF LOTOS-EUROS INDICATES SIMILAR RESULTS ON THE SECTOR CONTRIBUTIONS, BUT WITH A LARGER FOREIGN CONTRIBUTION

- Currently, a large societal debate is ongoing on nitrogen deposition in the Netherlands. During the discussion the quality of the underlying science was questioned.
- TNO develops an independent modelling system (LOTOS-EUROS), which is applied here to quantify the origin of nitrogen deposition in the Netherlands. LOTOS-EUROS is a grid model with explicit atmospheric chemistry.
- There is a large degree of consistency between LOTOS-EUROS results and those of the RIVM-GDN. This study should be regarded as a complimentary analysis and observed differences should foremost be interpreted as an indication of the uncertainty envelop in current state of science.
  - The (combined national and international) agricultural sector is by far the largest contributor (63%) to nitrogen deposition in the Netherlands, Transport (road traffic, shipping + other) is the second largest contribution (18%)
  - The relative importance of the domestic source sectors is very similar.
  - LOTOS-EUROS results indicate a larger foreign contribution (44%) than the GDN
- The calculations clearly highlight the need to promote ambitious European policies to mitigate emissions in the transport, agriculture, energy and industry sectors, especially in view of the proposed targets by the commission Remkes


THANK YOU FOR
YOUR TIME
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