Short-term ammonia measures are not effective in reducing PM episodes in Flanders

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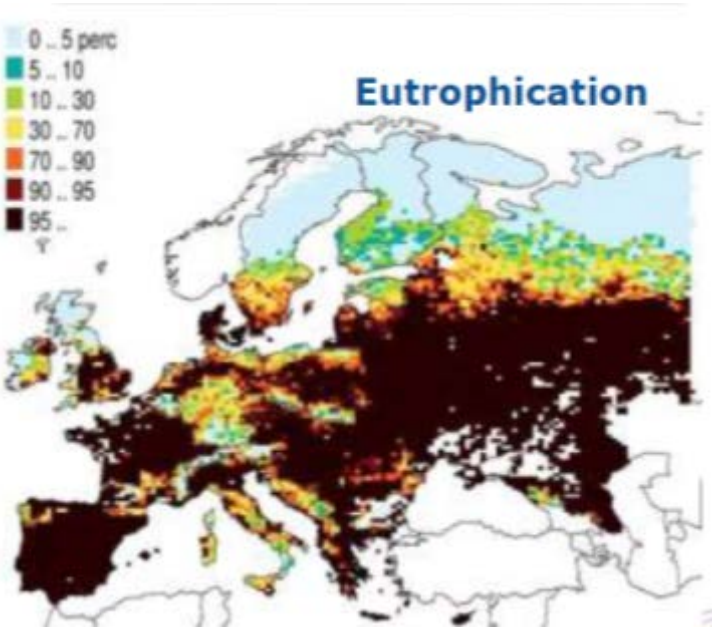
Ammonia emissions from agriculture …

- … form > 90% of total ammonia emissions in Europe
- … contribute to particulate matter formation;
- … are an important cause of eutrophication;
- … are difficult to reduce substantially: many diffuse sources;



- … are strongly dependent on meteorological variability.

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Role of ammonia in PM formation (in spring)

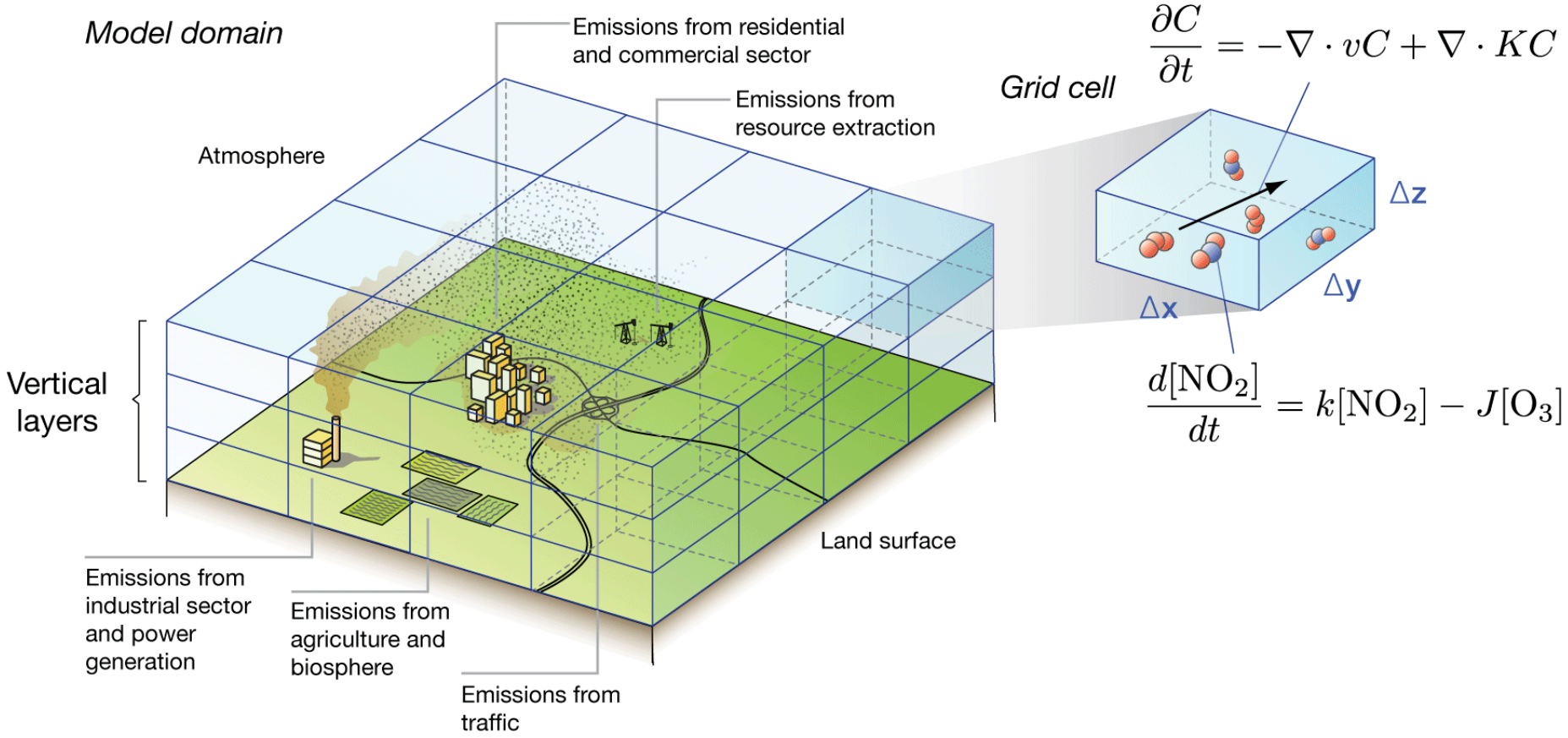
- Ammonia reacts with sulfuric acid or nitric acid to form ammonium salts
  $2\ NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$ or $NH_3 + HNO_3 \leftrightarrow NH_4NO_3$
- Spring often sees PM episodes during fair weather
- Manure application activity is high in springtime fair weather conditions
- Can a short-term reduction of NH_3 emissions from manure application help to prevent PM episodes in spring?
- Case study: Flanders (Belgium), agriculture-intensive region

Ammonia emissions are weather-dependent

Source (Flanders)	NH_3 (kton)	%
Livestock housing	24.8	62
Manure application	11.2	28
Fertilizer application	4.0	10

- Emissions from livestock housing increase with temperature, especially for open housing
- Emissions from manure and fertilizer application depend on when activity takes place:
  - Start and development of the growing season
  - Conditions at day of application
- How to take this into account in air quality modelling?

A chemistry transport model sketch



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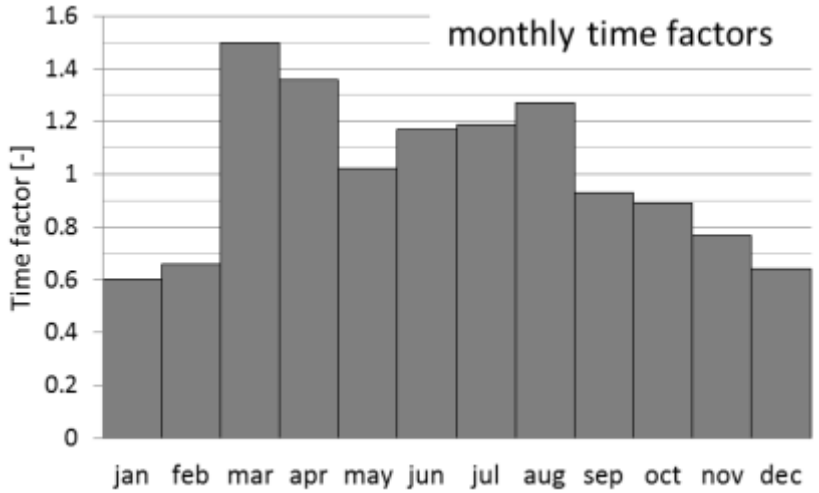
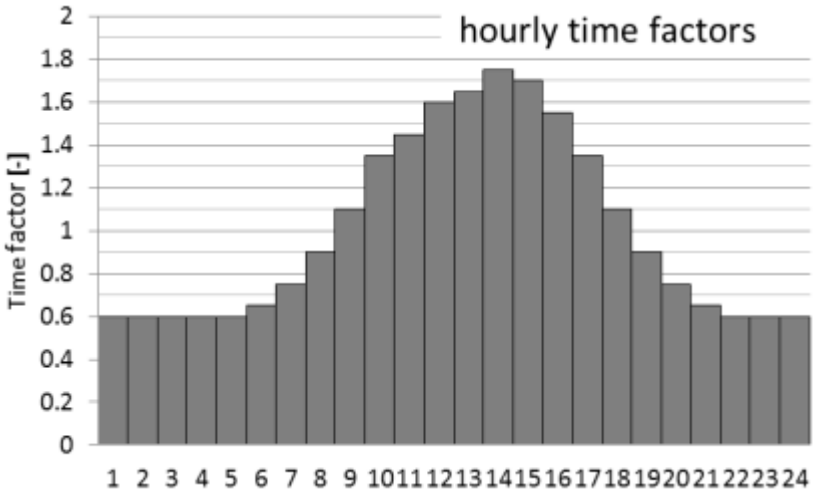
Standard approach for temporal variability NH_3 emission in air quality models

- Profile for month in year and hour in day
  - The same every year
  - Independent of meteorology
  - No distinction between activities or regions





- Improvement needed!

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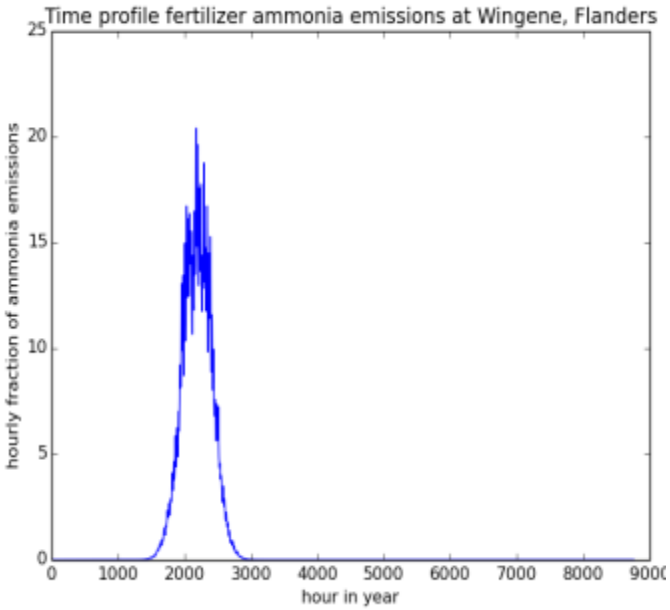
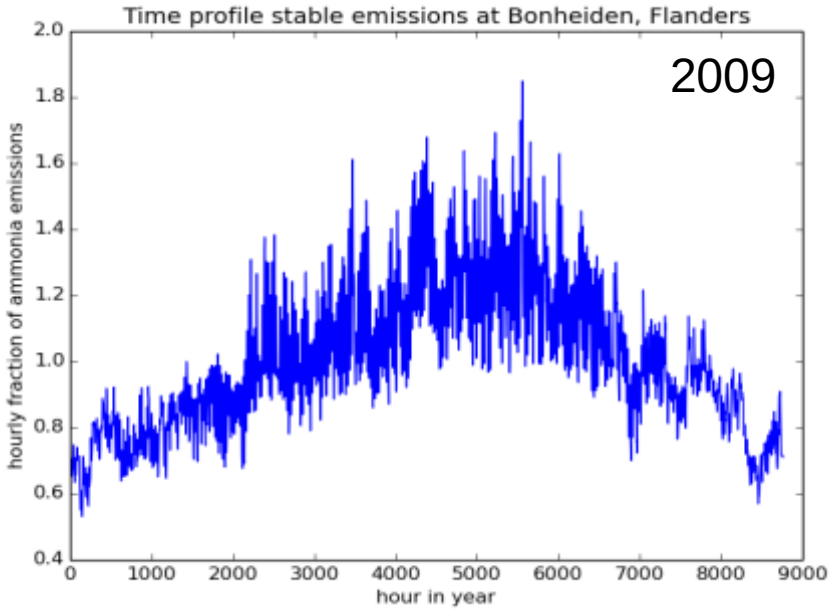
Fertilizer application and livestock housing





- Emission module of Skjøth et al. (2011), based on temperature dependence of emissions

- Normalised for each year

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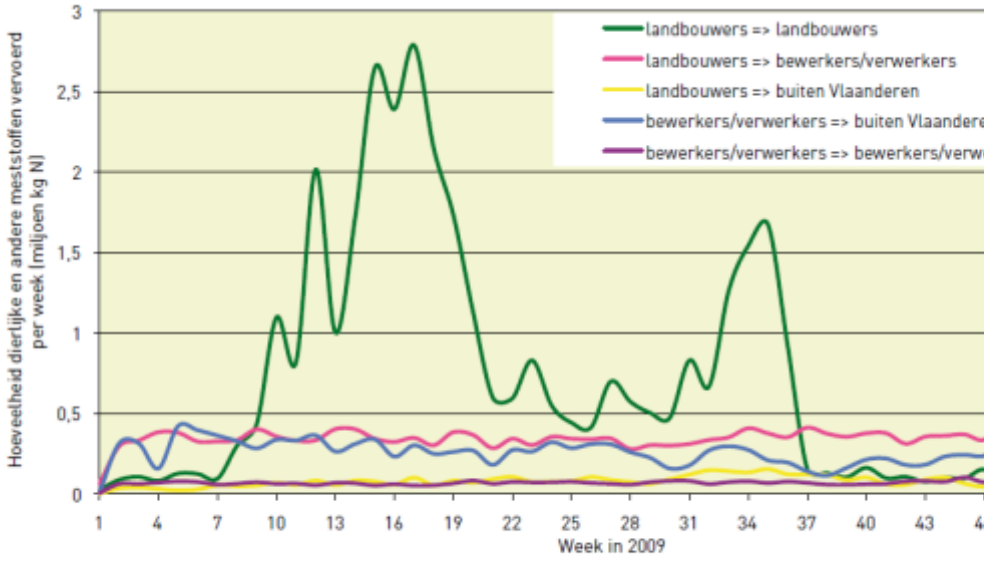
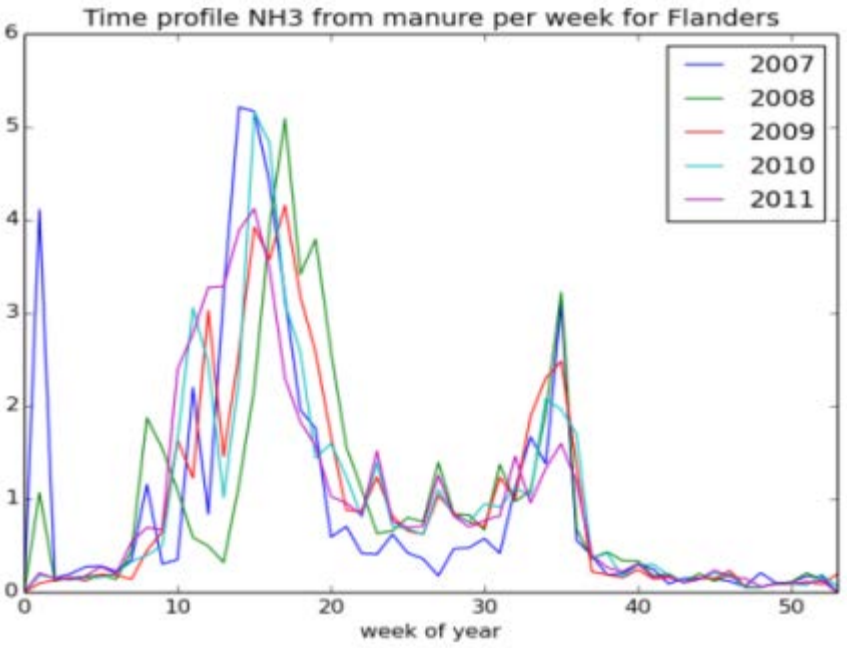
Manure application: use of local information

Temporal variability based on manure transport data (VLM)



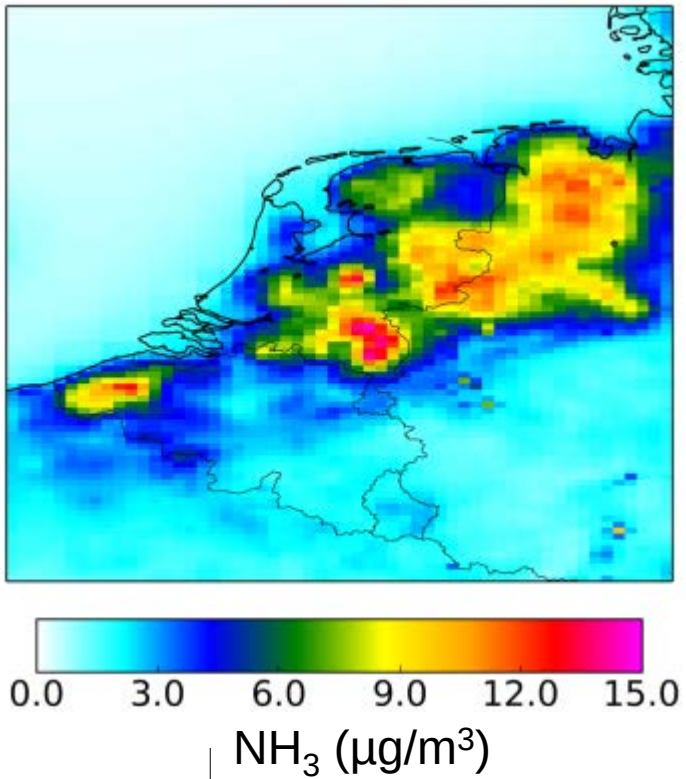
Figuur 25 Hoeveelheden dierlijke en andere meststoffen getransporteerd per week in 2009, voor een aantal belangrijke transportstr naar andere landbouwers, landbouwers naar bewerkers/verwerkers, landbouwers naar afnemers buiten Vlaanderen, bew naar afnemers buiten Vlaanderen en bewerkers/verwerkers naar andere bewerkers/verwerkers) (in miljoen kg N)

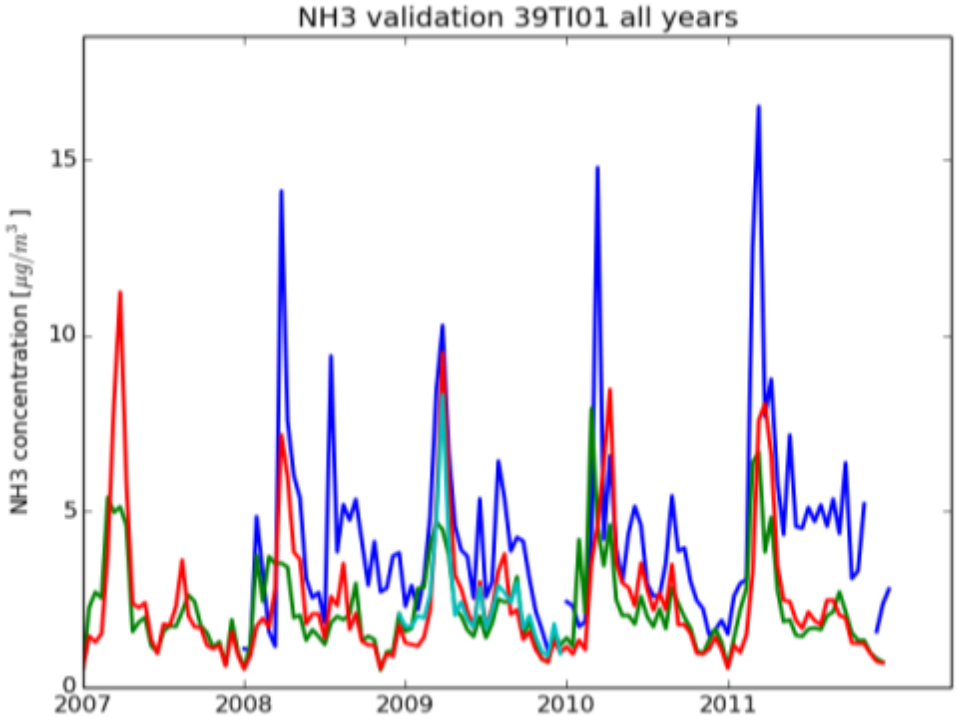


What are we looking for?

- Impact of updated NH_3 emission variability on modelled NH_3 concentrations;
- Impact on modelled PM (peak) levels;
- See if scenario with reduced NH_3 emissions before/during PM episode reduces PM levels;

Impact on modelled NH_3





Measurement
Default settings
New NH_3 timing

Observations at 2-week intervals

Main improvement: spring maximum

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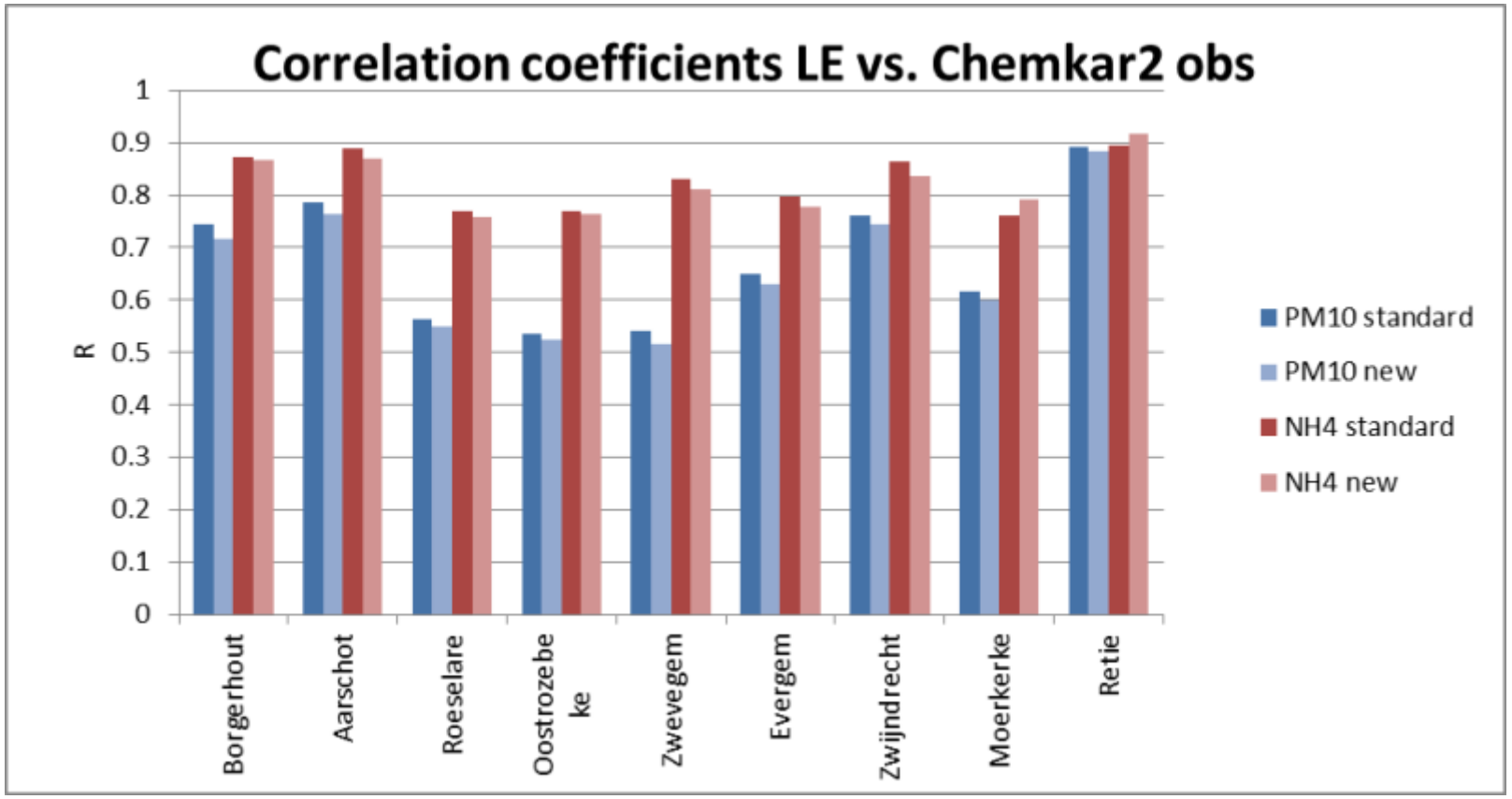
Impact on modelled PM



No change for PM_{10} and NH_4 for most stations

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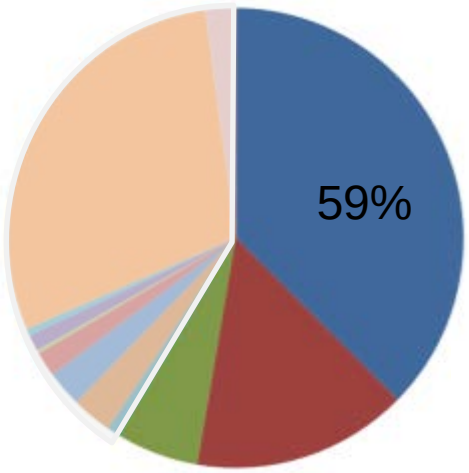
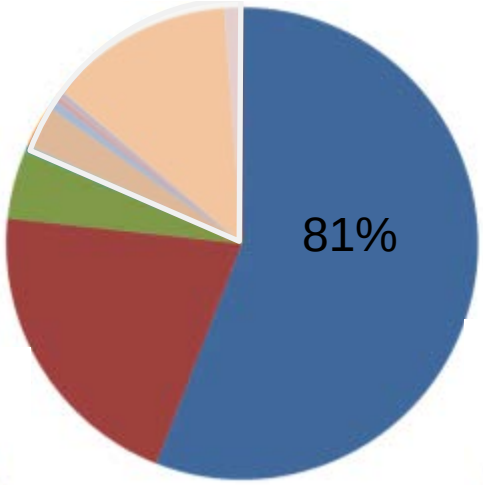
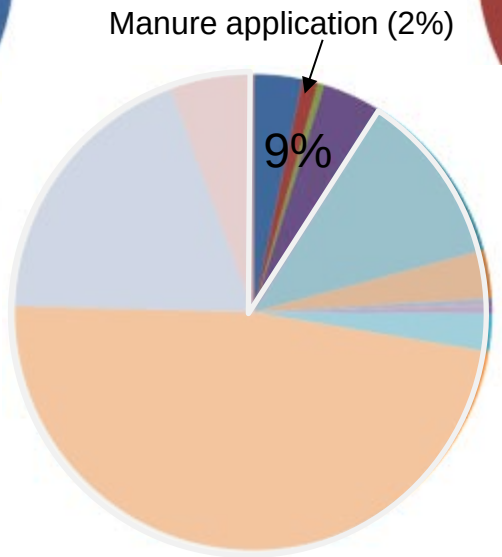
What is the contribution of Flemish NH_3 emissions to NH_3 and PM levels?

NH_3, Flanders average

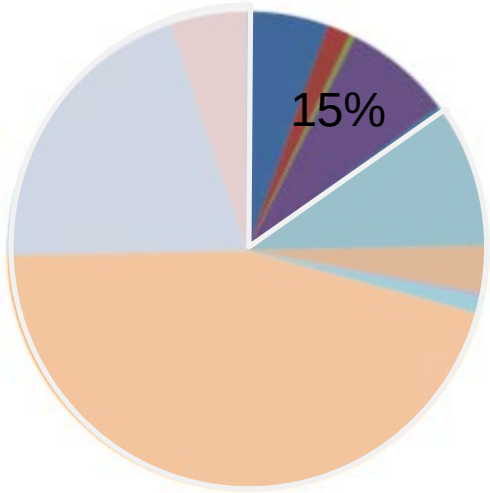


NH_3, Roeselare (agriculture hotspot)





PM_{10}, Flanders average



PM_{10}, Roeselare

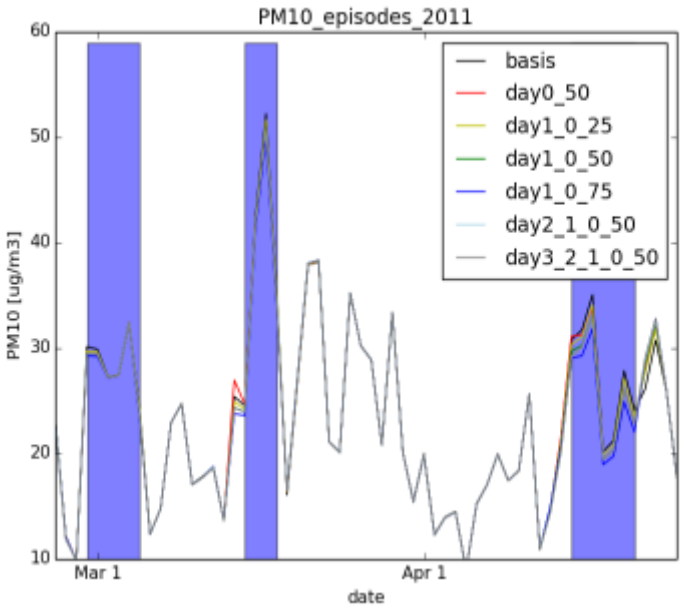
Scenarios with reduced NH_3 emissions before/during PM episode

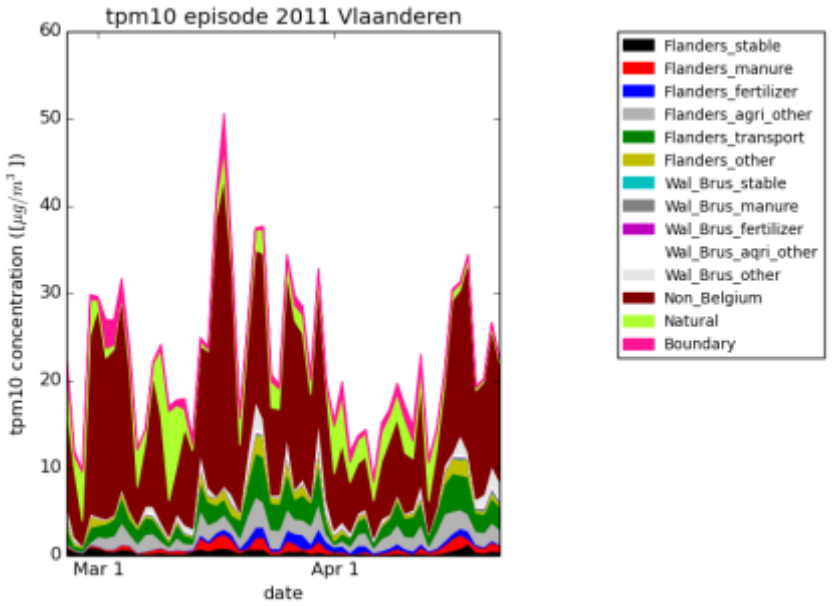
A few simple scenarios were used to test the impact of NH_3 emission reduction from manure application:

Day 0 (start of episode)	Day -1, 0	Day -2,0	Day -3,0
	-25 %		
-50 %	-50 %	-50 %	-50 %
	- 75 %		

- PM forecast available for 4 days ahead
- Emissions are shifted to days before and after the episode
- In 2007, 2009 and 2011 several local PM buildup episodes occurred in spring.

Results of scenario calculations





Impact of studied scenarios on PM_{10} levels are minor (max 3 µg/m^3)

- Contribution Flemish manure application to PM_{10} in Flanders is small (max 4 µg/m^3)
- Re-emission of deposited NH_3 in NH_3 emission hotspots
- NH_3 surplus in Flanders?

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Conclusions

- NH_3 modelling is much improved by using dynamic NH_3 emission variability.
- Effect on PM and SIA modelling is very small.
- Limiting emissions from manure application before and during an episode does not help a lot to reduce peak PM levels.
- More structural measures to reduce NH_3 (in both time and space) are needed to reduce PM levels.

Acknowledgements

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See also:

Hendriks, C., et al., 2016. Ammonia emission time profiles based on manure transport data improve ammonia modelling across north western Europe. Atm. Env. 131, 83-96