

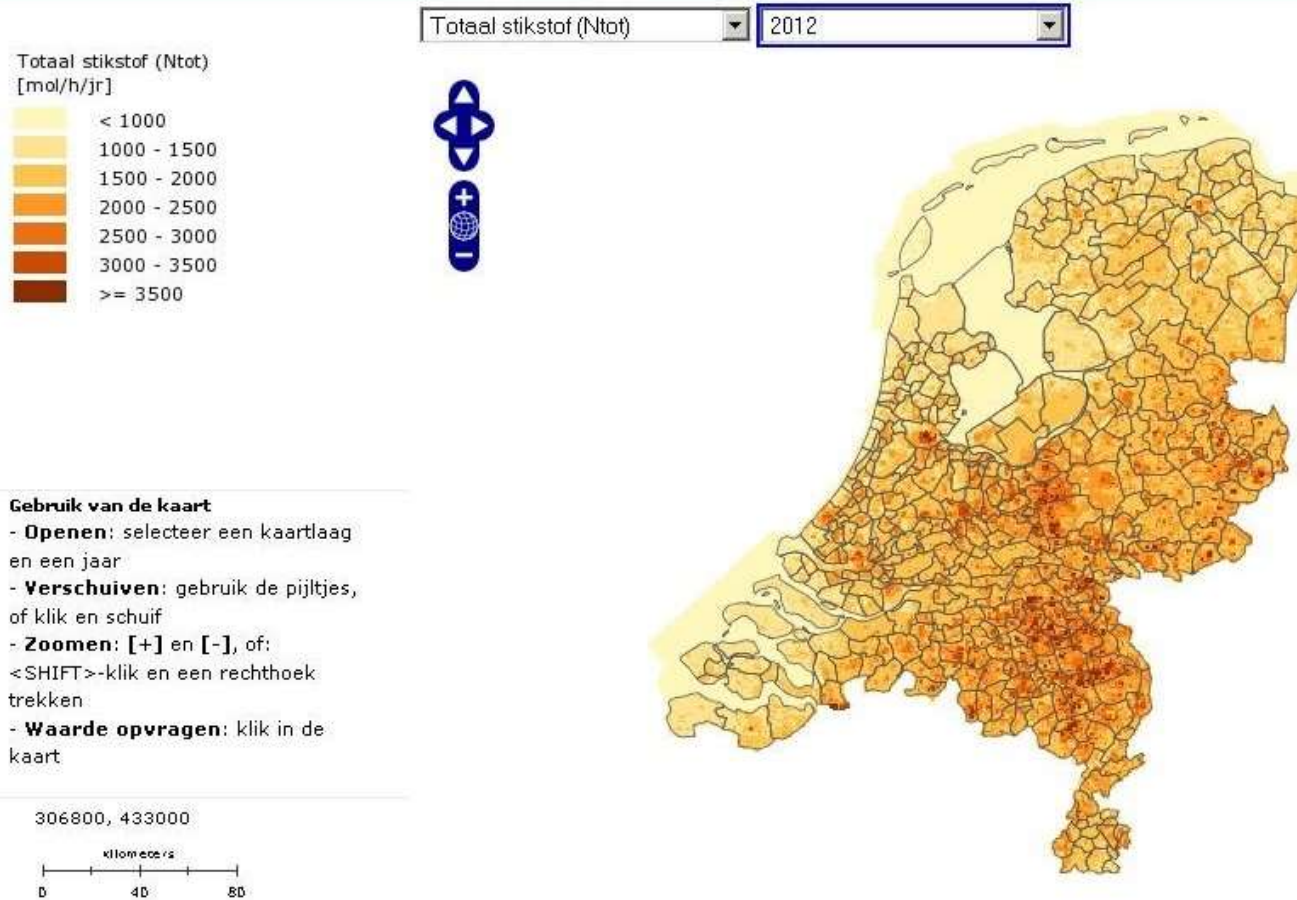


National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Atmospheric Ammonia in Coastal Areas

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Model calculations calibrated on 8 monitoring sites: is this map correct?

The MAN network

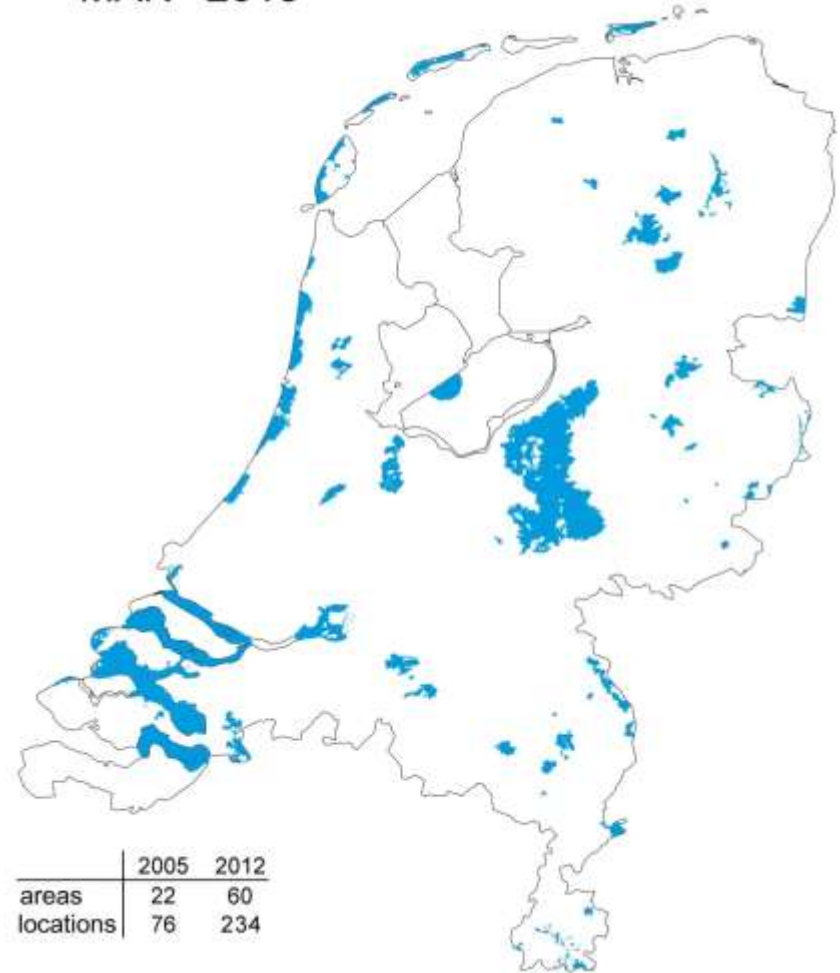


(Monitoring Ammonia in Nature)

- Gradko samplers
- Monthly sampling by volunteers in nature
- Monthly calibration on 6 Amanda sites

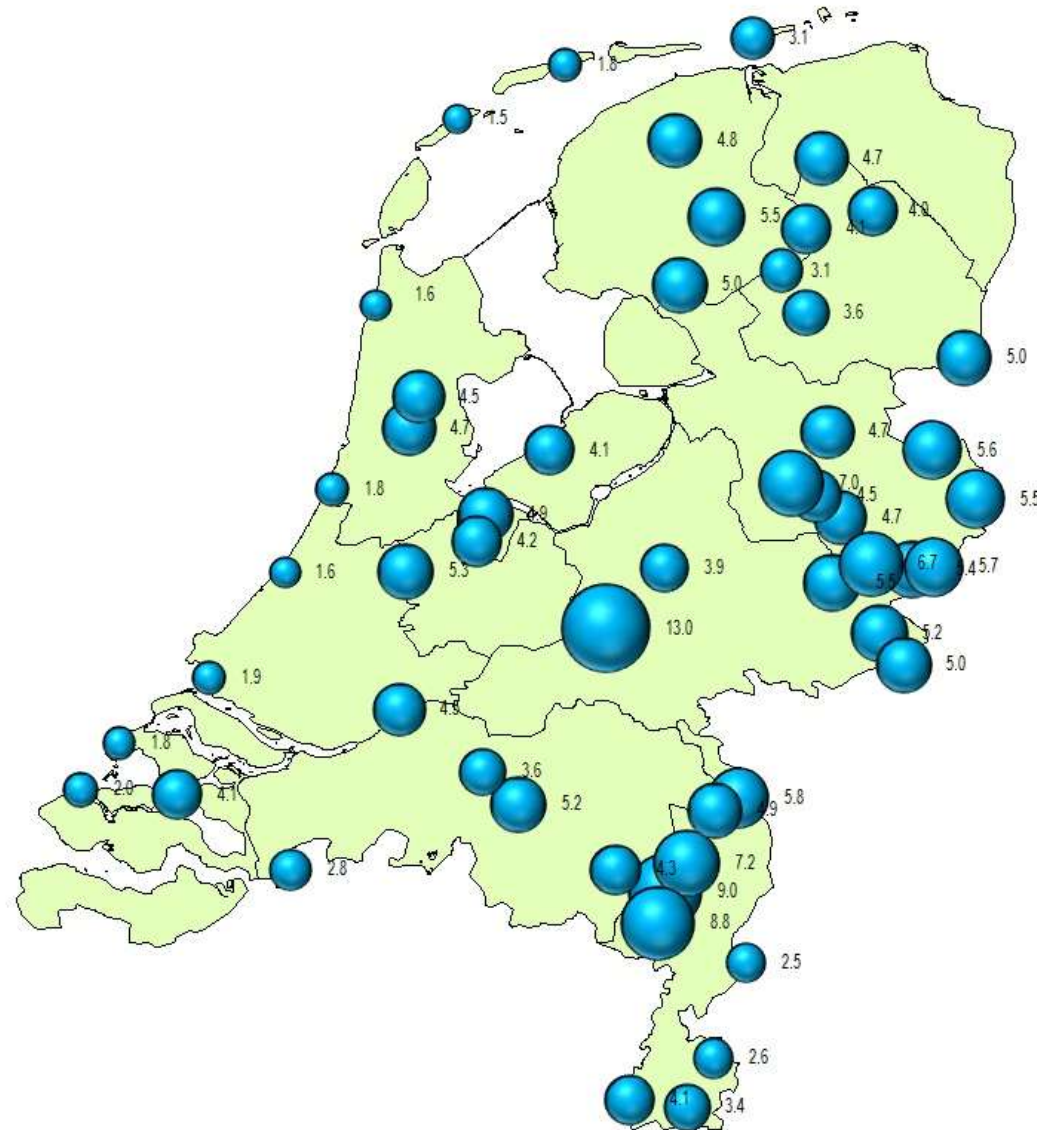


MAN 2013



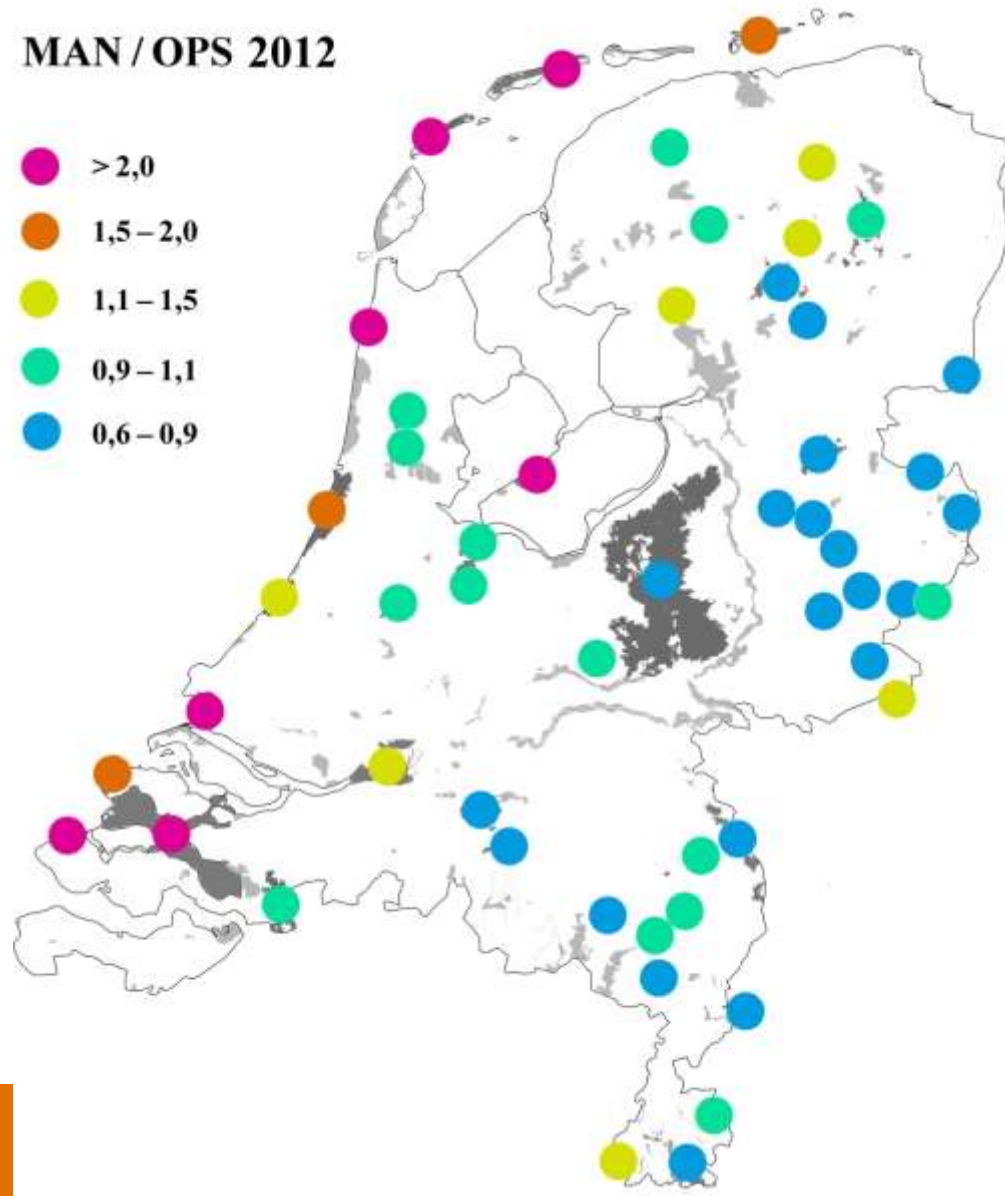


- Measured ammonia shows the same spatial pattern of modeled ammonia
- High concentrations in centre, southeast and east
- Low concentrations near the coast



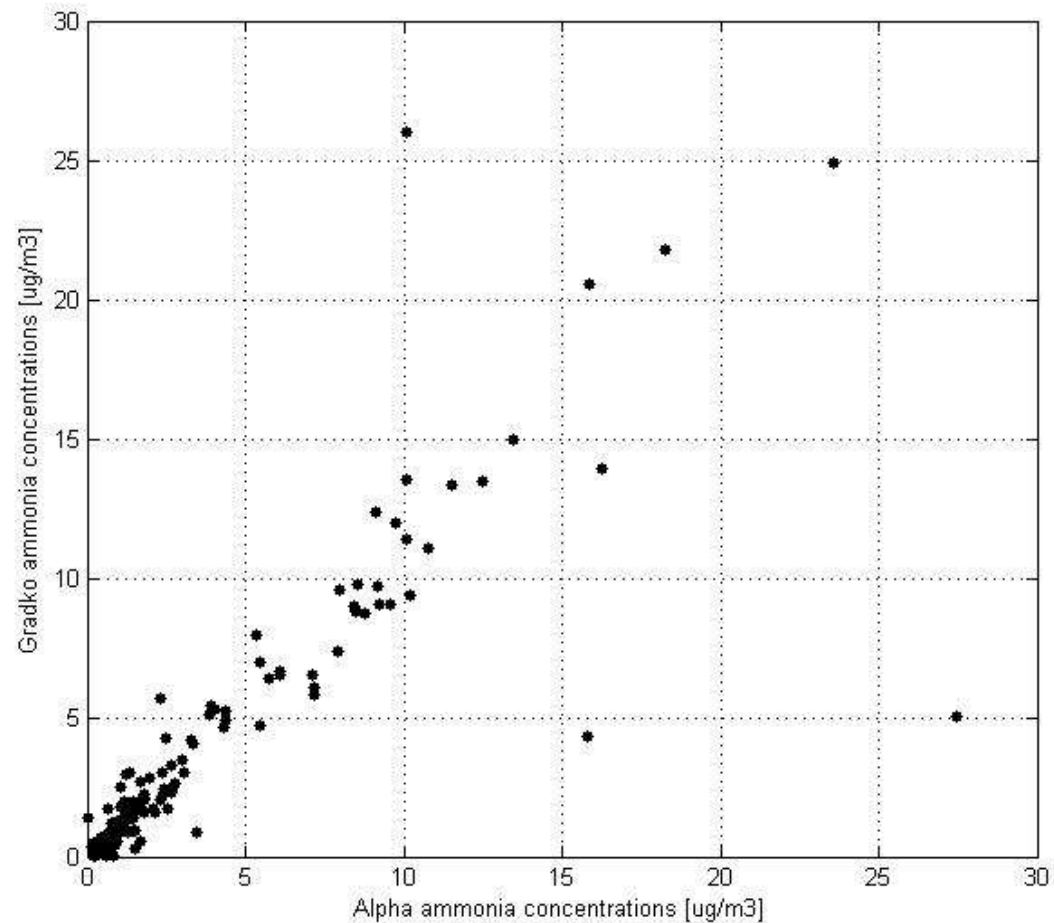
Performance model in detail

- Coastal areas show measured ammonia to be up to 4 times higher than OPS-model
- What is the reality?
Model or measurement?





- Alpha samplers are more sensitive and more reliable
- Good agreement Gradko and alpha
- The measurements are good, the model is flawed near the coast



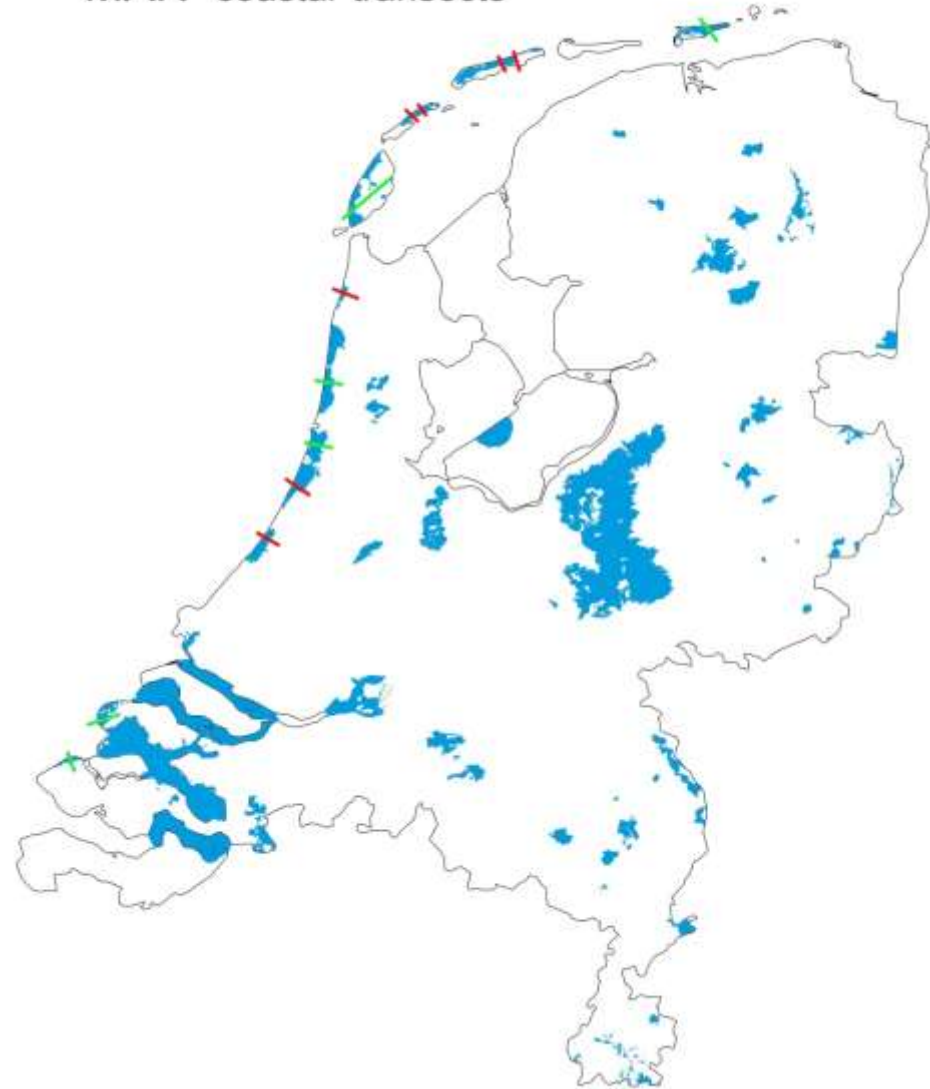
MAN monitoring setup

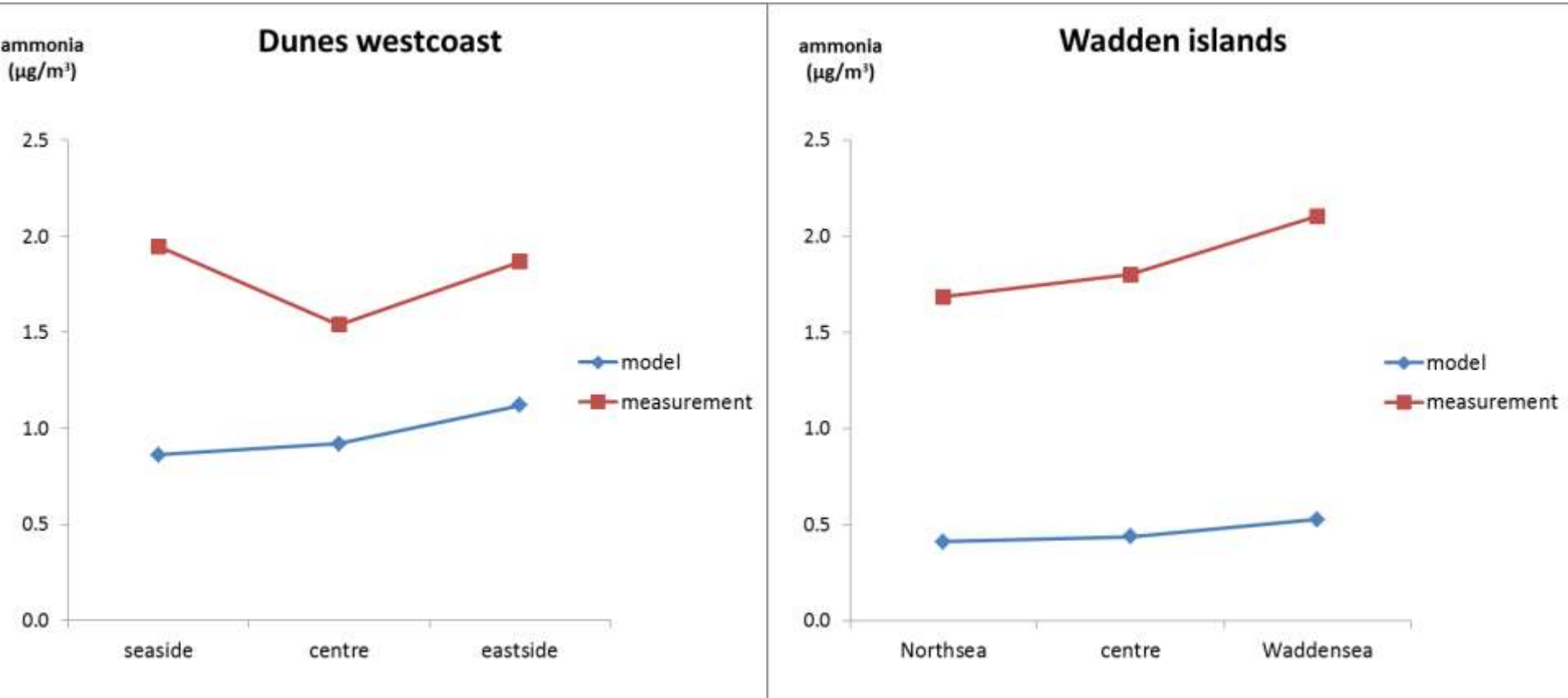


across the coast



MAN coastal transects





Many MAN-analyses indicate: sea = source of ammonia
Summer: monthly averages up to $5 \mu\text{g}/\text{m}^3$ higher due to the sea

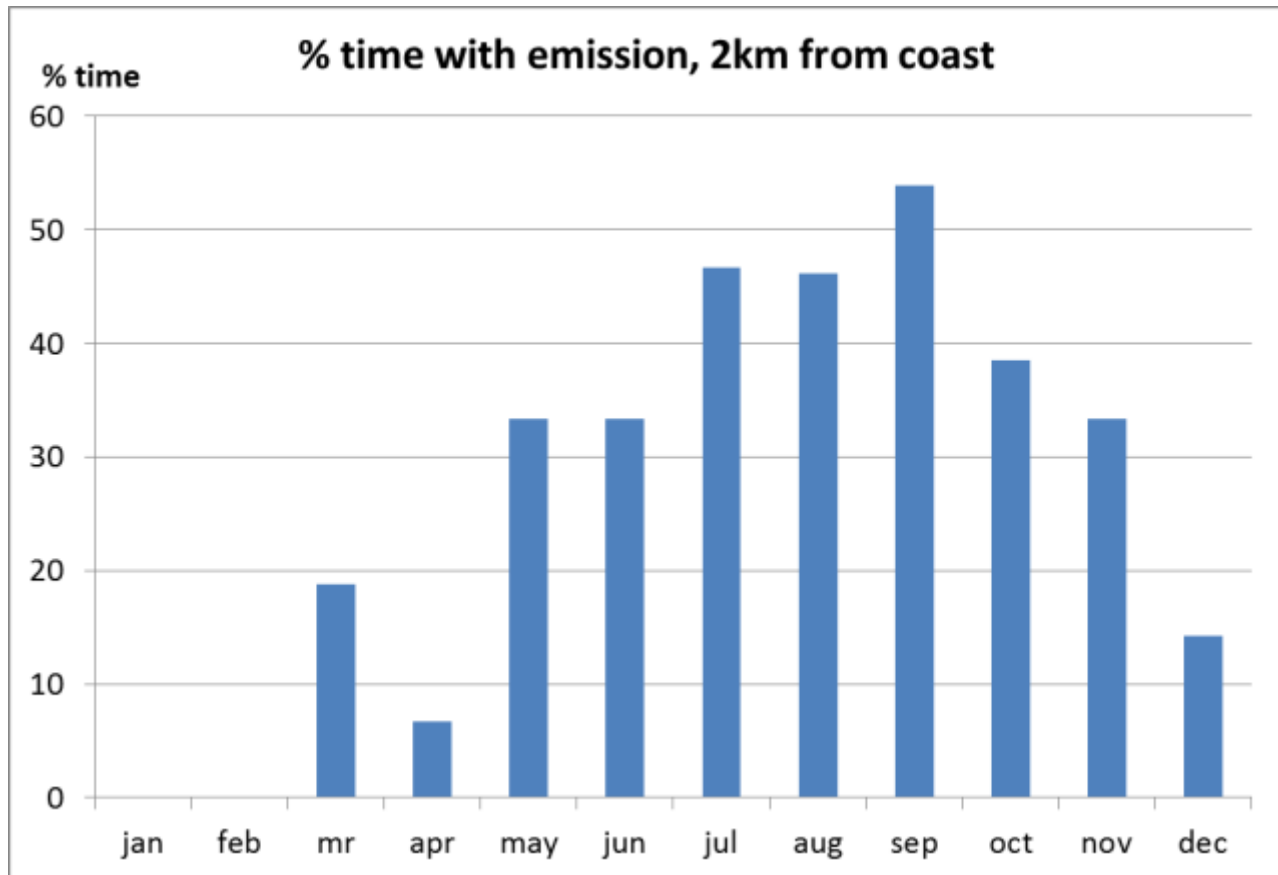
Evaporation of NH_3 from seawater



calculation based on:

seawater: measurements of NH_3 , NH_4^+ , Temperature and pH

air: assumptions on windspeed and NH_3



Other emission mechanisms

- “**Seaspray**” ammonia (seasalt as a proxy): emission is negligible

- **Influence of algae:**

Algae growth: uptake of N

increase pH during algae growth: more NH_3 (gas), less NH_4^+

Algae decay: release of N

Role of algae in emission is qualitatively plausible,

but

biology is more complex than just chemical equilibria

(too complex yet for causal model)

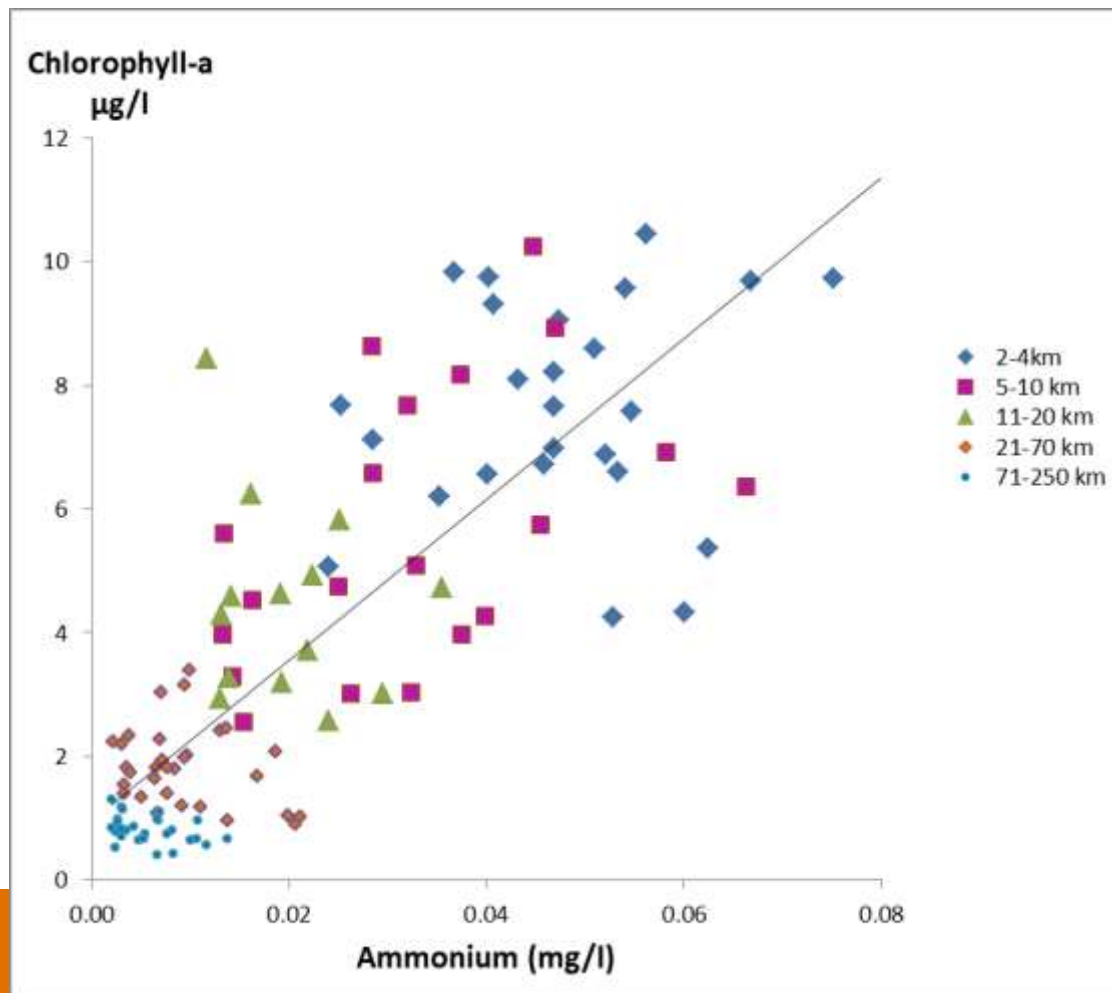


Basic assumption



Algae grow where nutrients (ammonium) are available

Good correlation (R^2 0.67) between algae and NH_3 in the North Sea

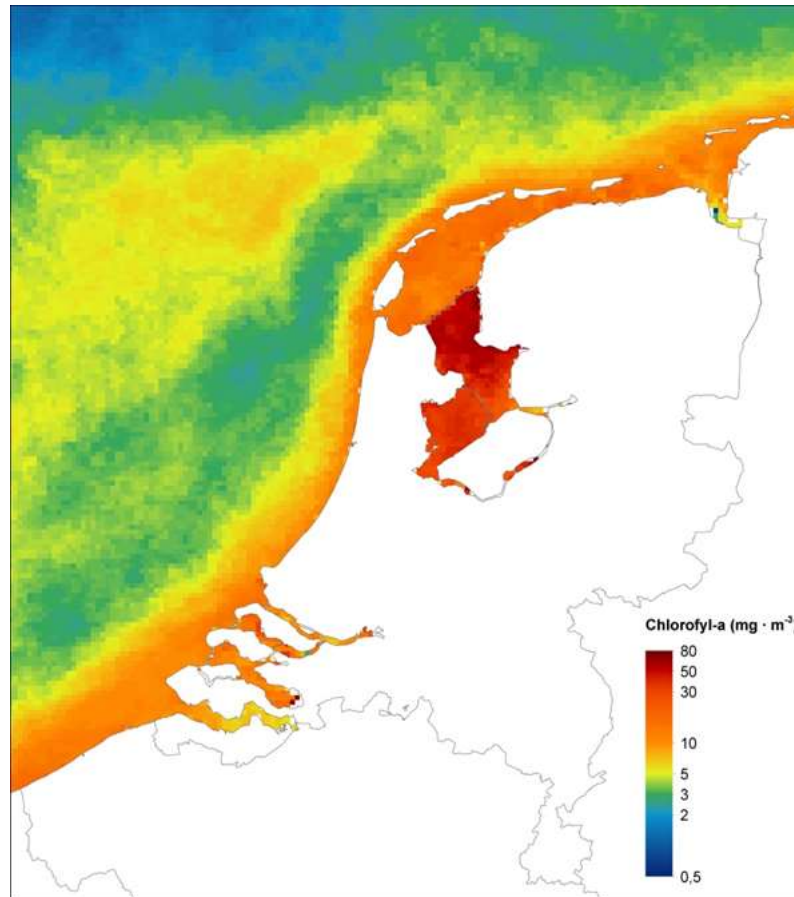


Algae as proxy for



ammonia emission

Map of Chlorophyll-a from sealevel-calibrated satellite data



Copyright Van der Woerd en Pasterkamp, 2008



Fill the gap between measurement & model with an emission estimate

BASIC ASSUMPTIONS:

- Ammonia emission is proportional to chlorophyll-a concentration
(the chlorophyll map gives the spatial emission distribution)
- Total ammonia emission from the sea:
fill the gap between modeled and measured coastal ammonia
(a simple fitting procedure)

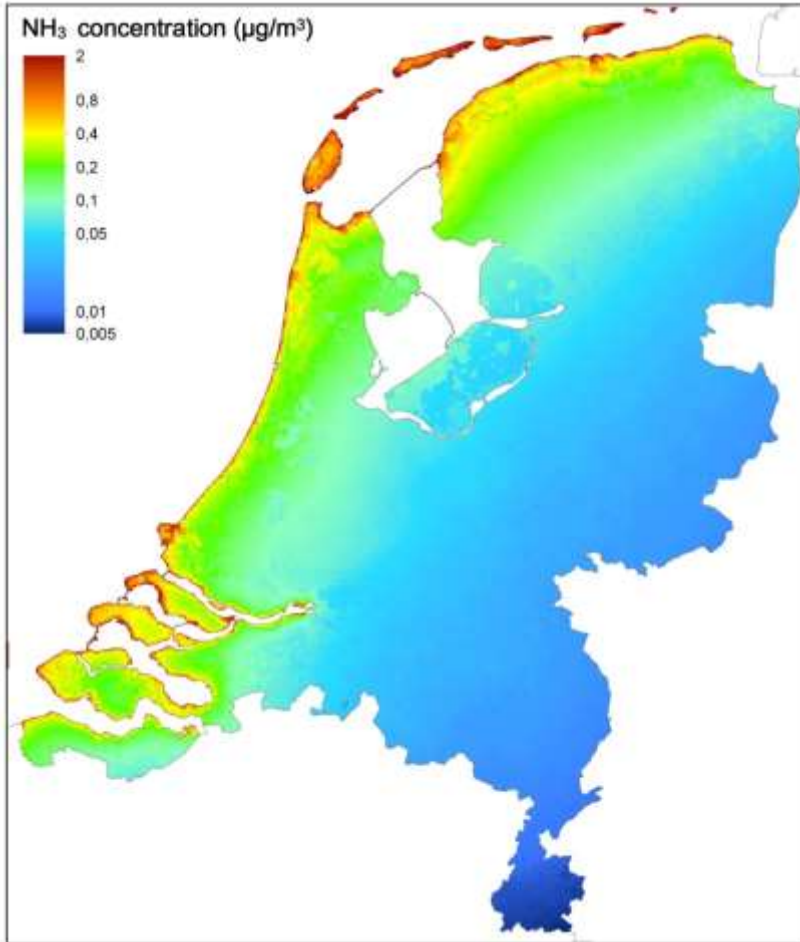
based on yearly averages

(seasonal behaviour is too complex, not supported by enough data)

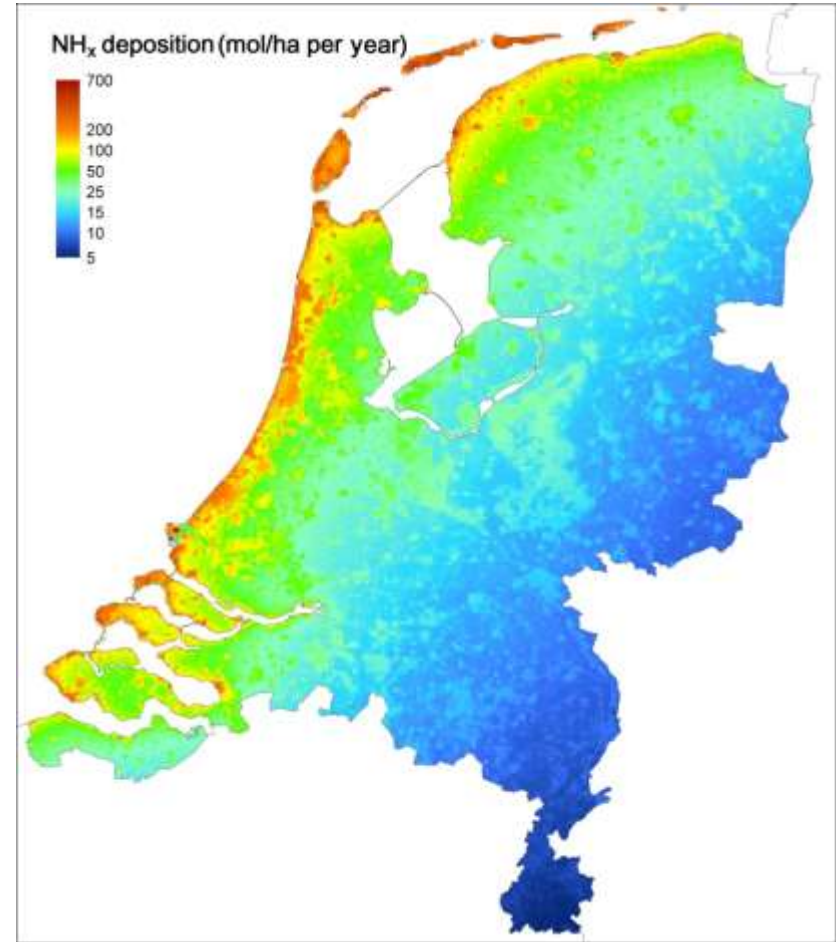
Results:



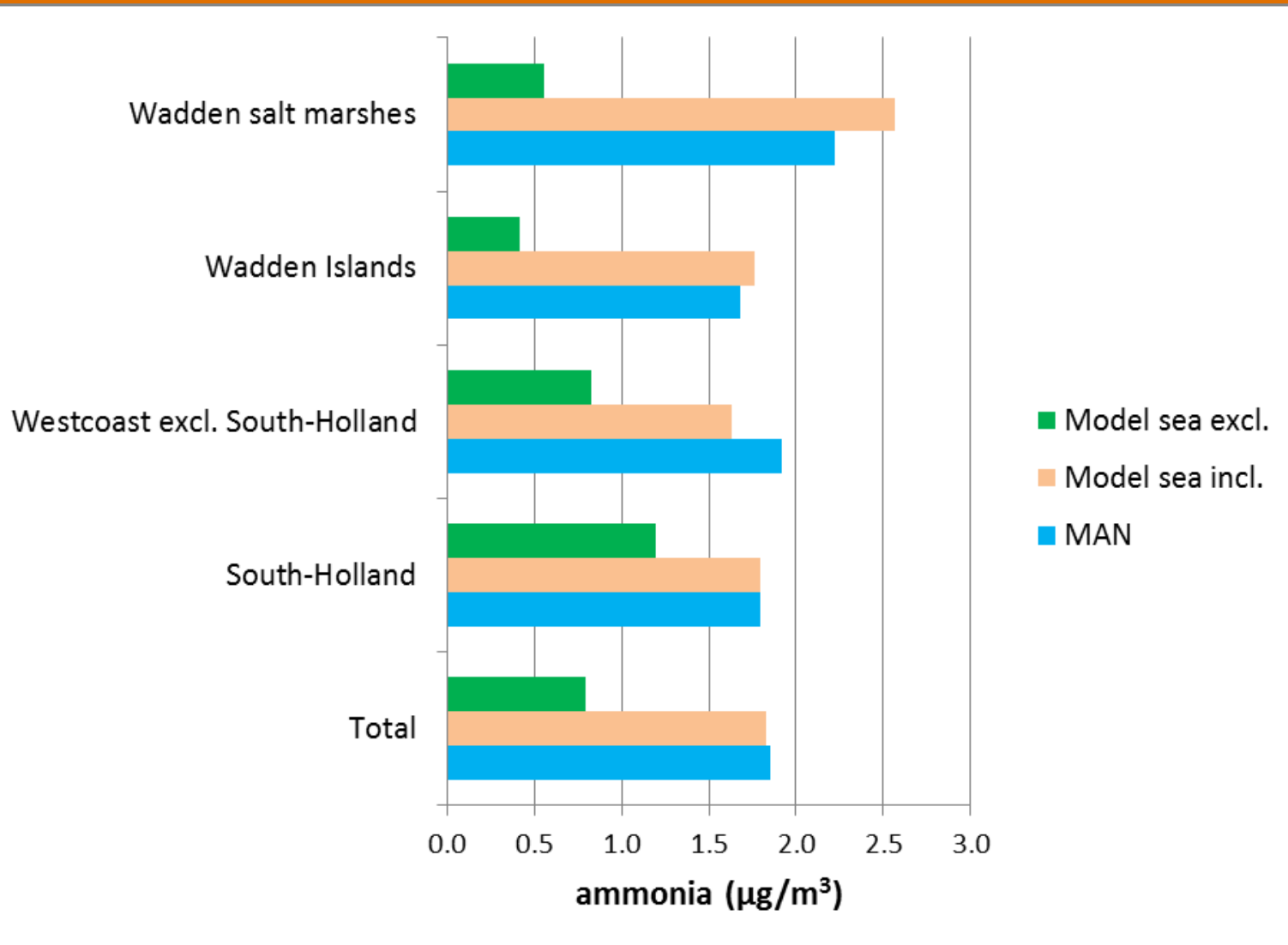
NH₃ from the sea



Concentration ($\mu\text{g}/\text{m}^3$ per year)

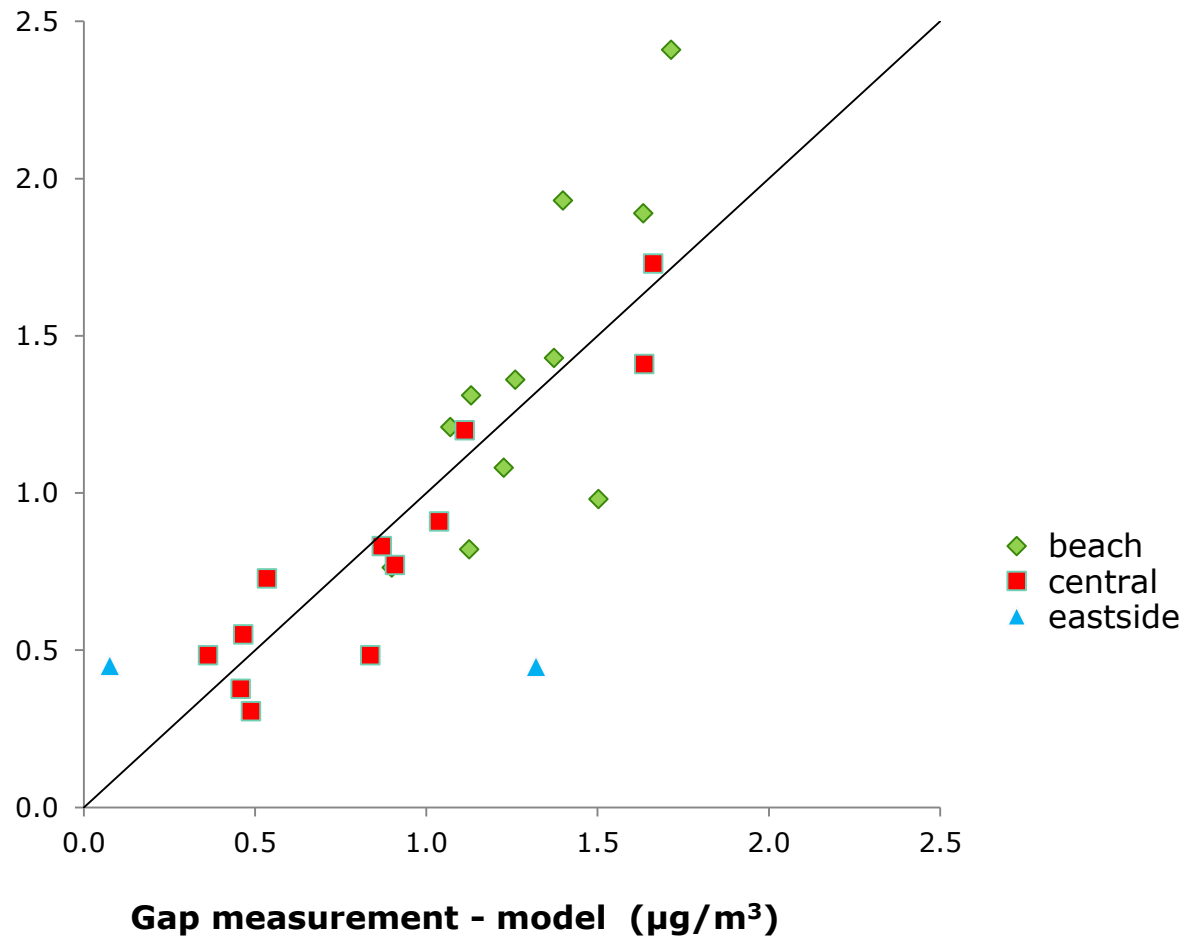


Deposition (mol/ha per year)





**Modeled NH₃
from the sea
(µg/m³)**



R² total is 0.76, R² central sites is 0.87

Emission totals:



are they plausible?

Dutch 20 km coastal zone: 10 kton/year NH_3
(97 % of the calculated seaborne NH_3 over Holland)

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Dutch emission 2011: ± 120 kton

Nitrogen load Rhine river: ± 150 kton/year

Emission totals:



are they plausible?

Dutch 20 km coastal zone: 10 kton/year NH_3
(97 % of the calculated seaborne NH_3 over Holland)

Dutch emission 2011: 119 kton

Nitrogen load Rhine river: about 150 kton/year

Literature values:

W. Asman: cruise North Sea 1989

emissions based on: *measured* NH_3 NH_4^+ in seawater and air
assumed pH T

	this study	Asman	(g/s per km ²)
20km zone / estuarium	0.02	± 0.01	

Conclusions



- Measurements indicate that near the Dutch coast the sea contributes more to atmospheric NH_3 than anthropogenic emissions to air
- No quantitative causal emission estimate (reality is too complex yet)
- Pragmatic approach – algae proxy - gives satisfying results



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LIMITATIONS OF THE STUDY

- A causal model is needed for projections, we only describe the present
- Tidal waters / estuaria are still a problem, not included in this study
- Other parts of the North Sea:
need for measurements in other countries to validate / expand the model