



Royal Netherlands  
Meteorological Institute  
*Ministry of Infrastructure  
and Water Management*

# Scheepvaart

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Boersma, Jieying Ding

RIVM, 1 June 2018

# Luchtvervuiling door zeeschepen vanuit de ruimte gezien

Wat is er te detecteren?

Waar is het meetbaar?

Wat is de relatie met emissies?

Hoe verandert uitstoot in de tijd?

Inverteren van emissies uit satelliet data

# Scheepvaart uitstoot = groot probleem

**“Scheepvaart is de meest ontransparante industrie”**

**Efficiëntere milieucontrole van zeeschepen: de trage weg naar schone scheepvaart**

De FOD Mobiliteit kan sinds kort schepen efficiënter controleren op hun zwavelgehalte. Maritieme inspecteurs kunnen nu binnen de minuut zien hoeveel zwavel de scheepsbrandstof bevat. Een hele vooruitgang voor een sector die nog een weg heeft af te leggen.

ende scheepvaart

**'In de autowereld is de transitie ingezet, nu moet ook de scheepvaart volgen'**

Bruno Mostrey van de denktank Oikos roept op om na de automotoren, ook de vervuiling door scheepsmotoren aan te pakken.

193  
Keer gedeeld



Lees later



# Waarom?

Ships are strong sources of greenhouse gases and air pollutants:

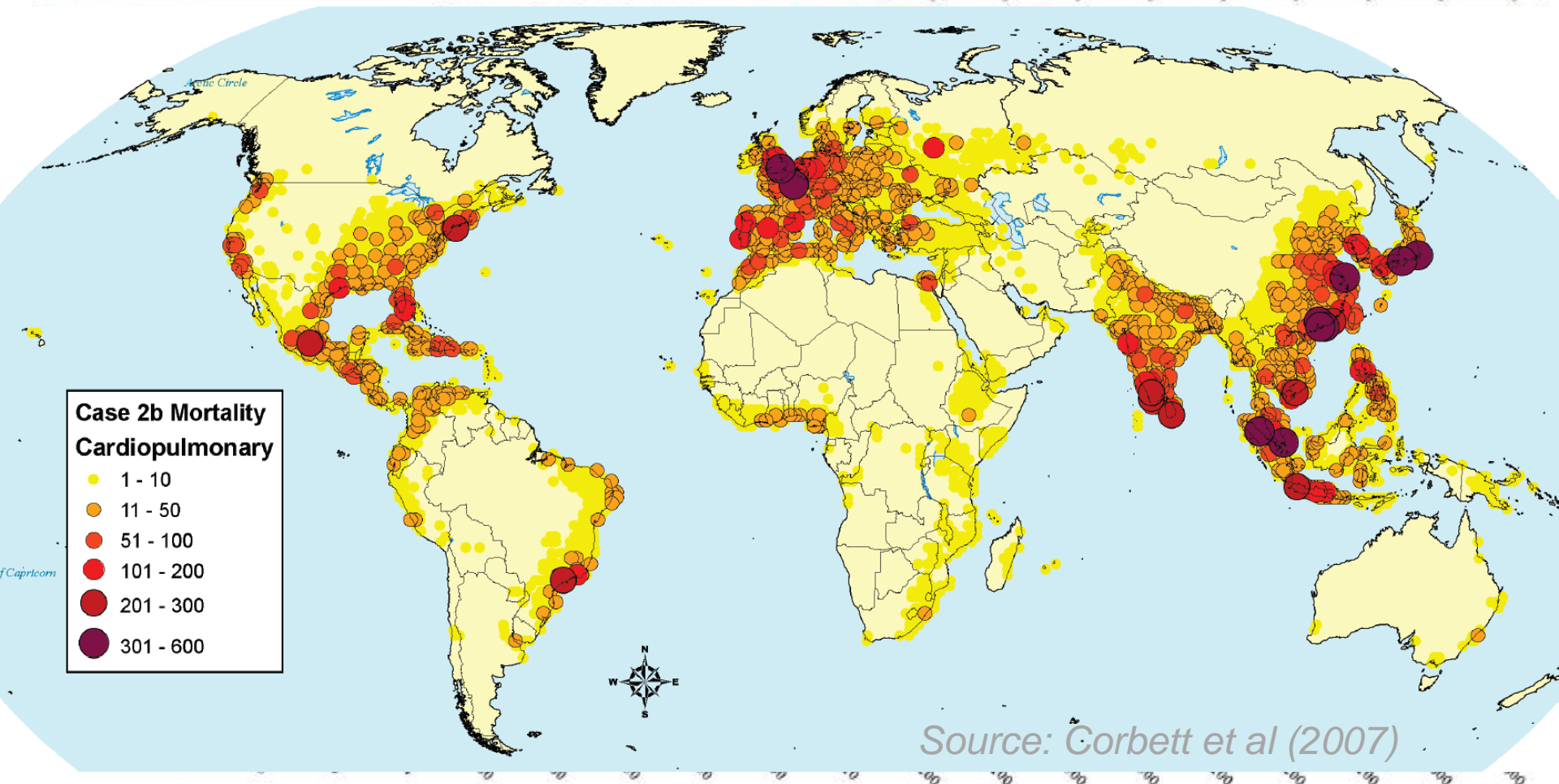
- 3% of global CO<sub>2</sub> emissions
- ±13% of global NO<sub>x</sub> emissions (5-20%)
- ±12% of global SO<sub>2</sub> emissions





# Waarom?

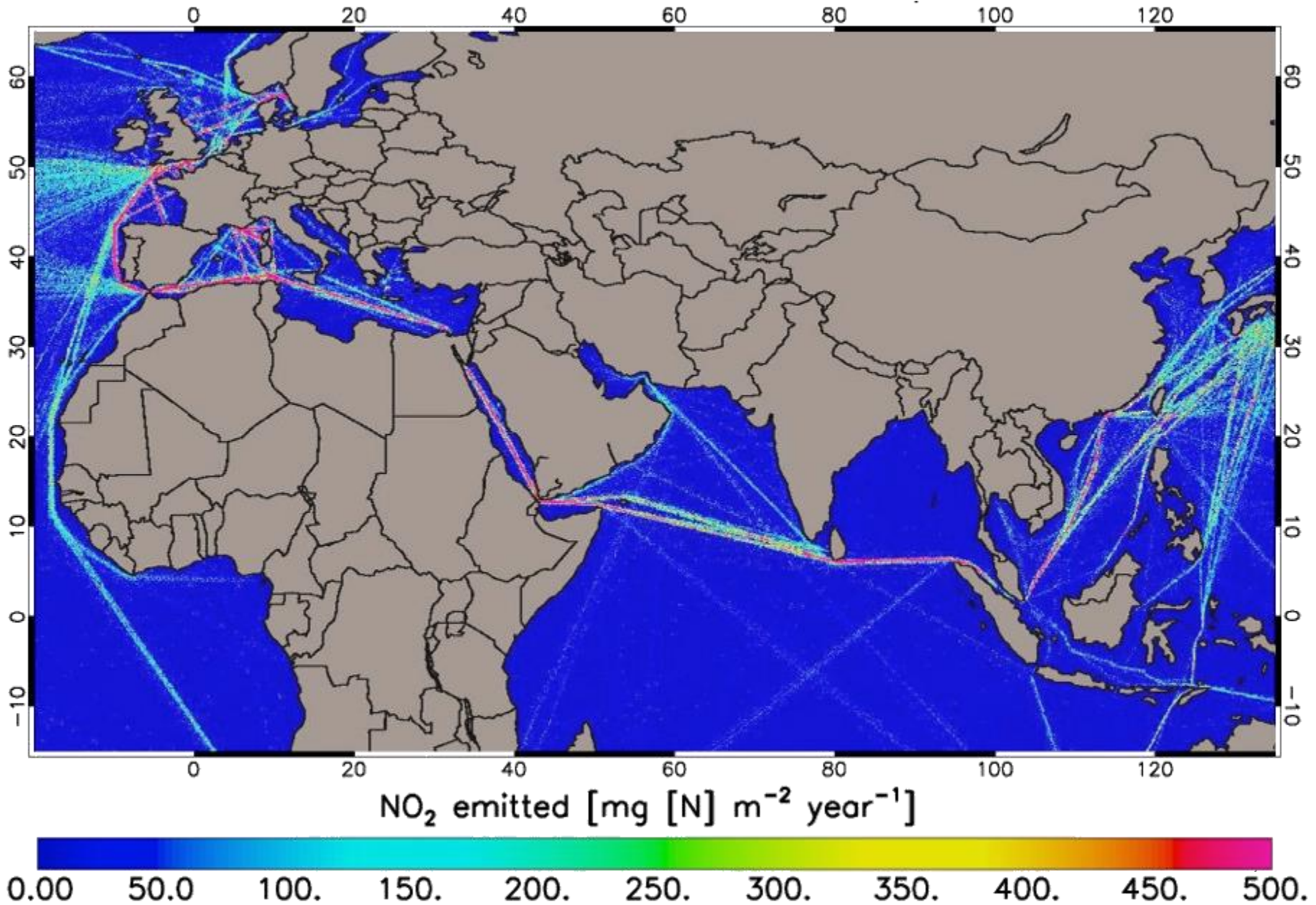
- 70% of ship emissions occur within 400 km to shores
- Pollution from the world's 90,000 cargo ships leads to 60,000 deaths per year



# 1. Wat valt er te detecteren vanuit de ruimte?

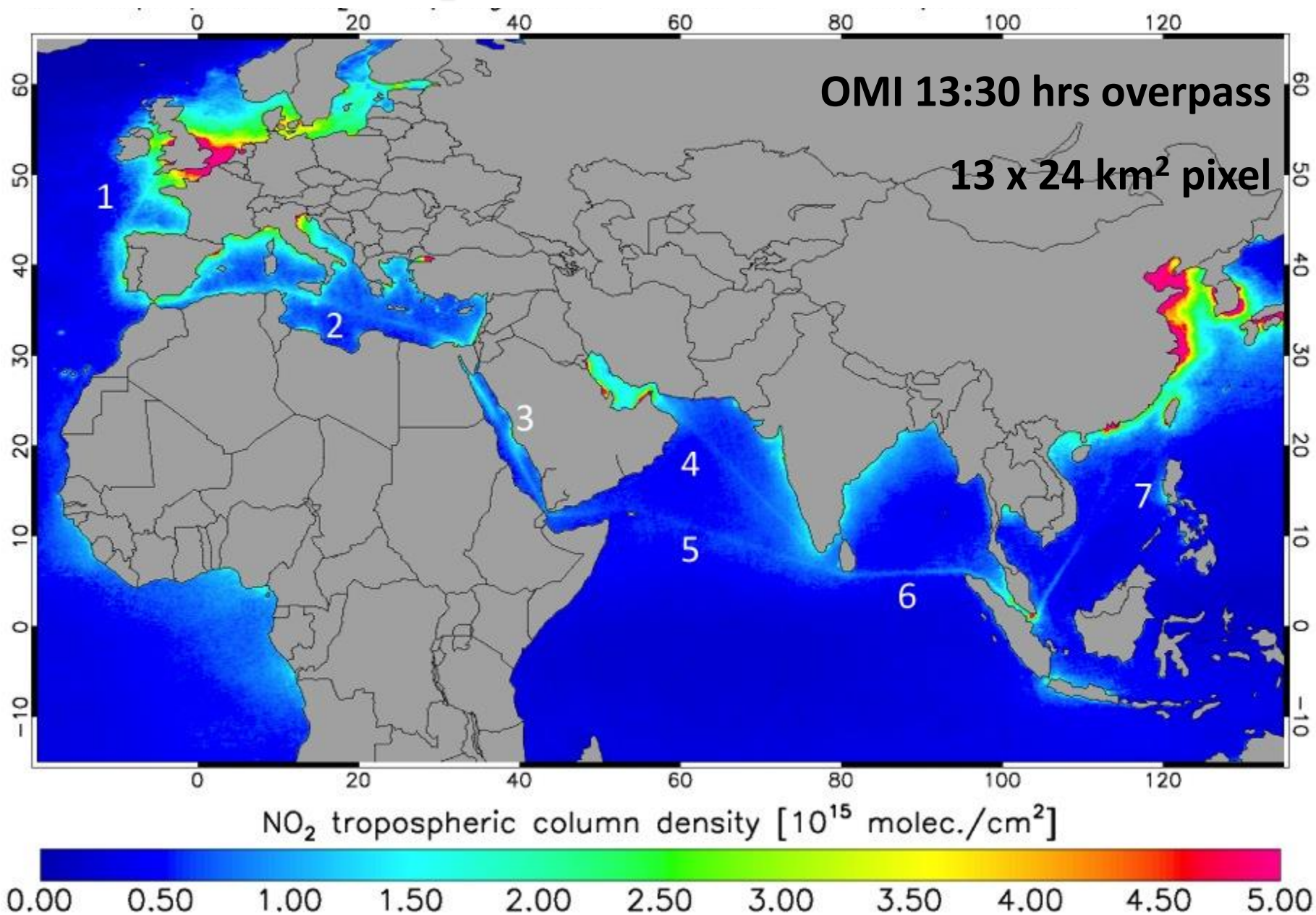
- $\text{NO}_2$  als er geen wolken zijn
- $\text{SO}_2$  tot nog toe zeer moeilijk
- $\text{CO}_2$  alleen indirect
- Fijnstof – vooral via 'ship tracks'

# Emissions of $\text{NO}_x$ (AMVER-ICOADS database)





# Observations of NO<sub>2</sub> (from OMI)

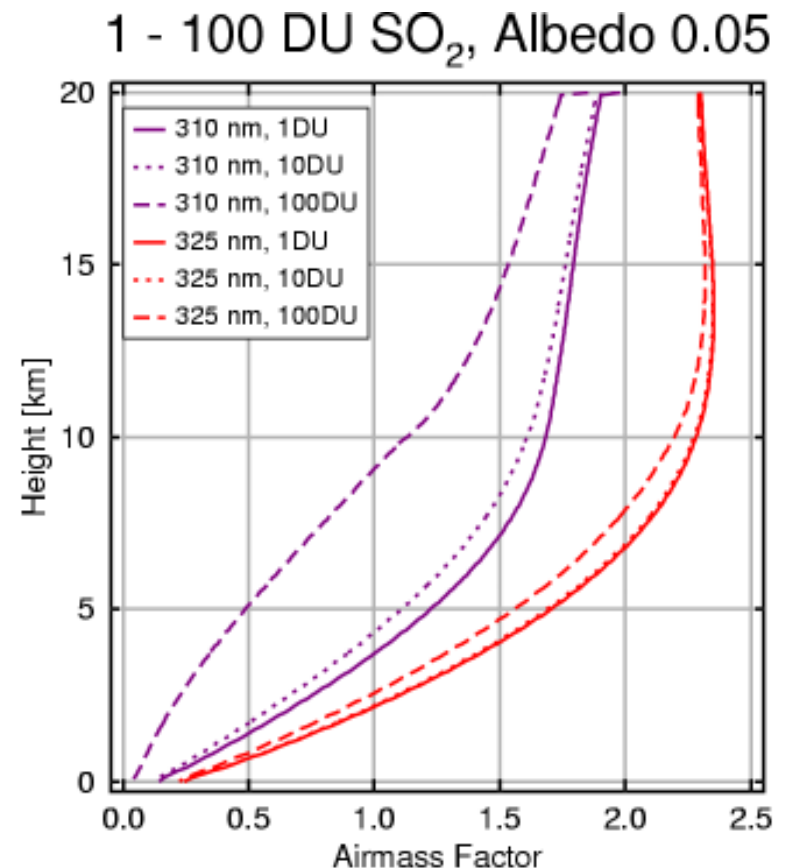




## Gap analysis: SO<sub>2</sub>

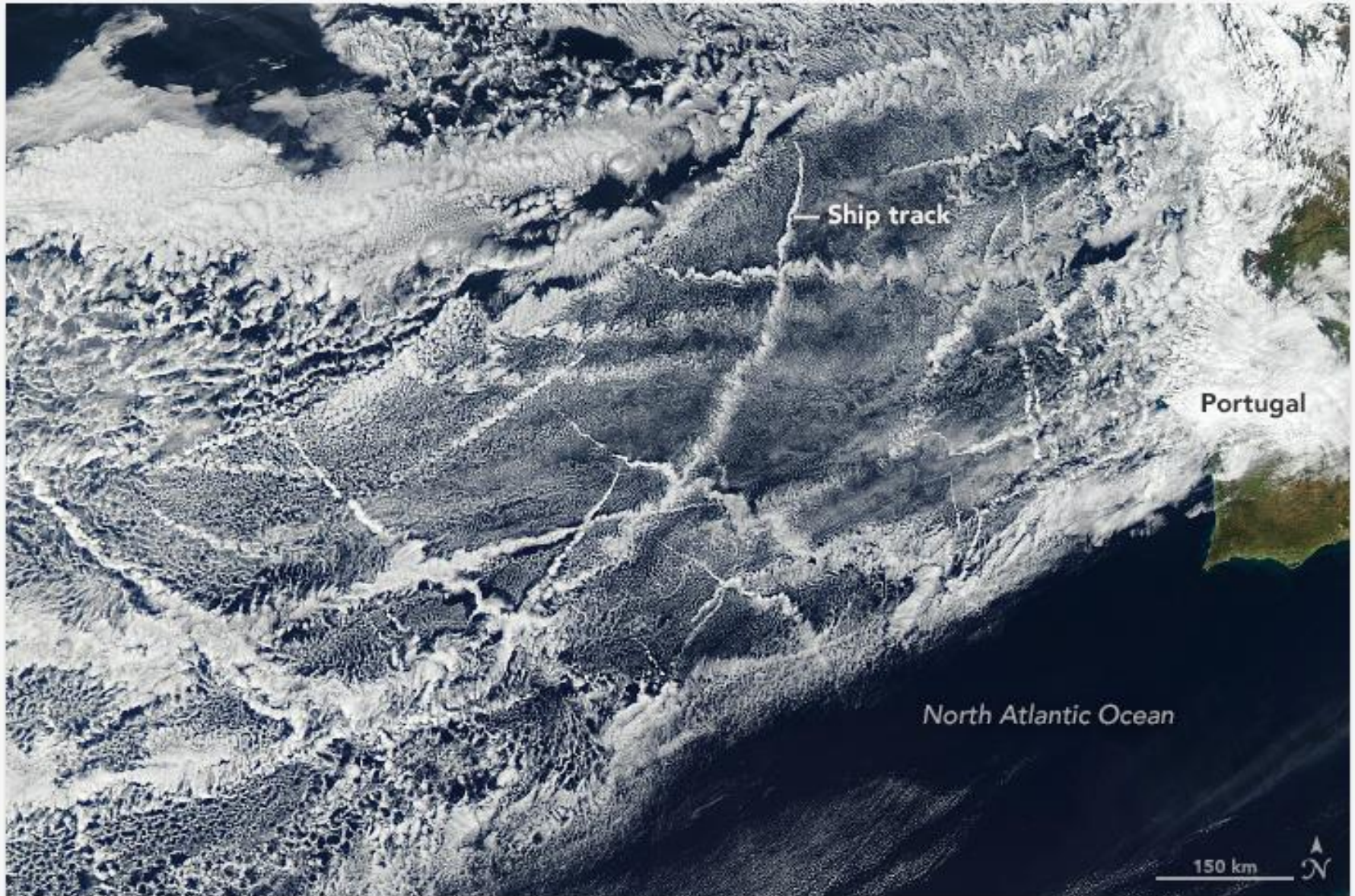
*For which pollutants and sectors can techniques such as inverse modelling be applied for an independent check of reported national emission inventory data and at what scale?*

- Possible for NO<sub>x</sub> pollution from the international shipping sector.
- More difficult for SO<sub>2</sub>, that cannot be retrieved down to the marine boundary layer.
- Perhaps that future instruments can be of help there (TROPOMI, geostationary instruments).



*Richter et al., ESA, 2006*

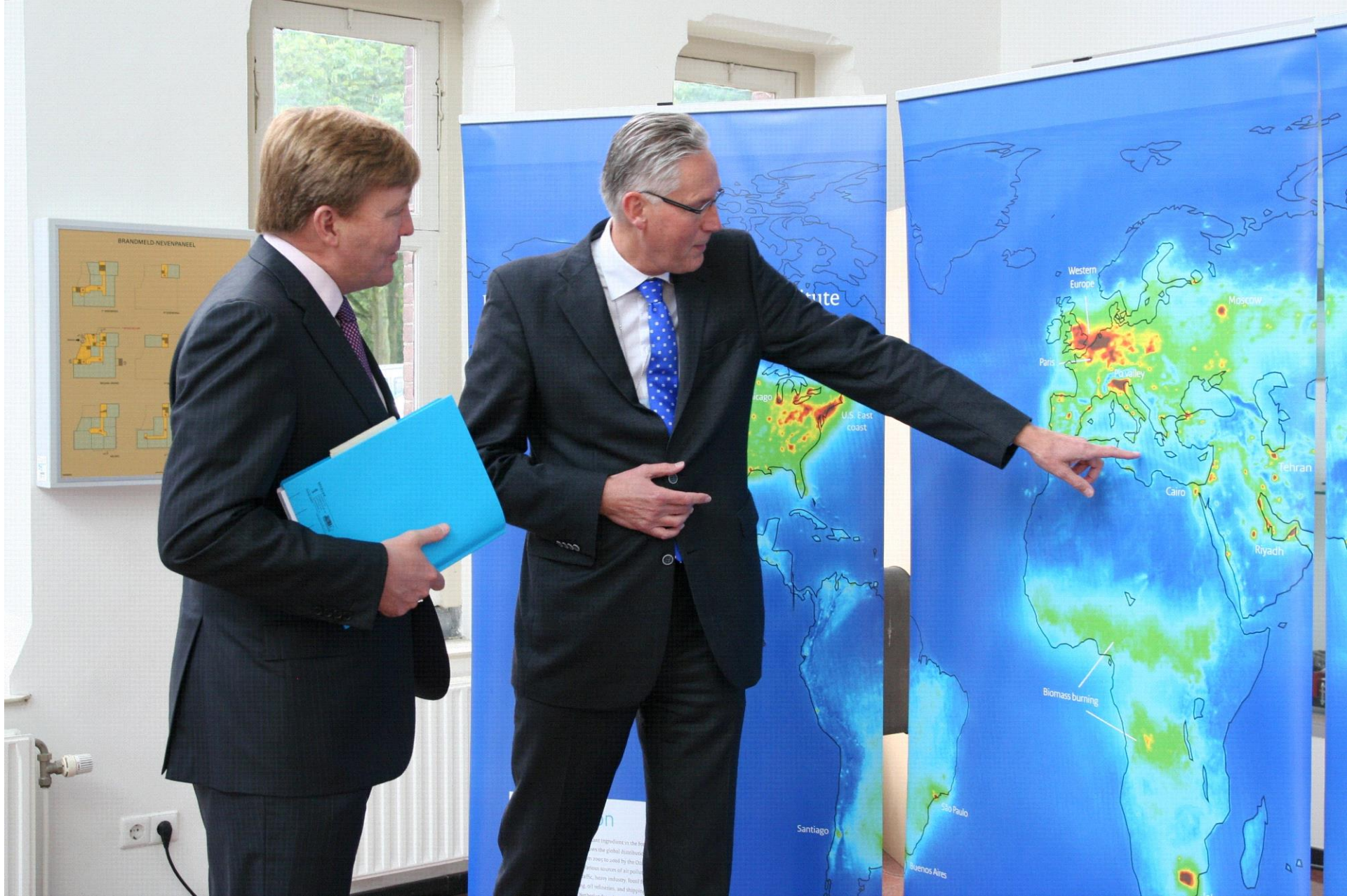
# Fijnstof – vooral via ‘ship tracks’



## 2. Waar is het direct meetbaar?

- Wereldwijd met satellieten
- Emissies moeten substantieel zijn
- Onbewolkt, weinig wind

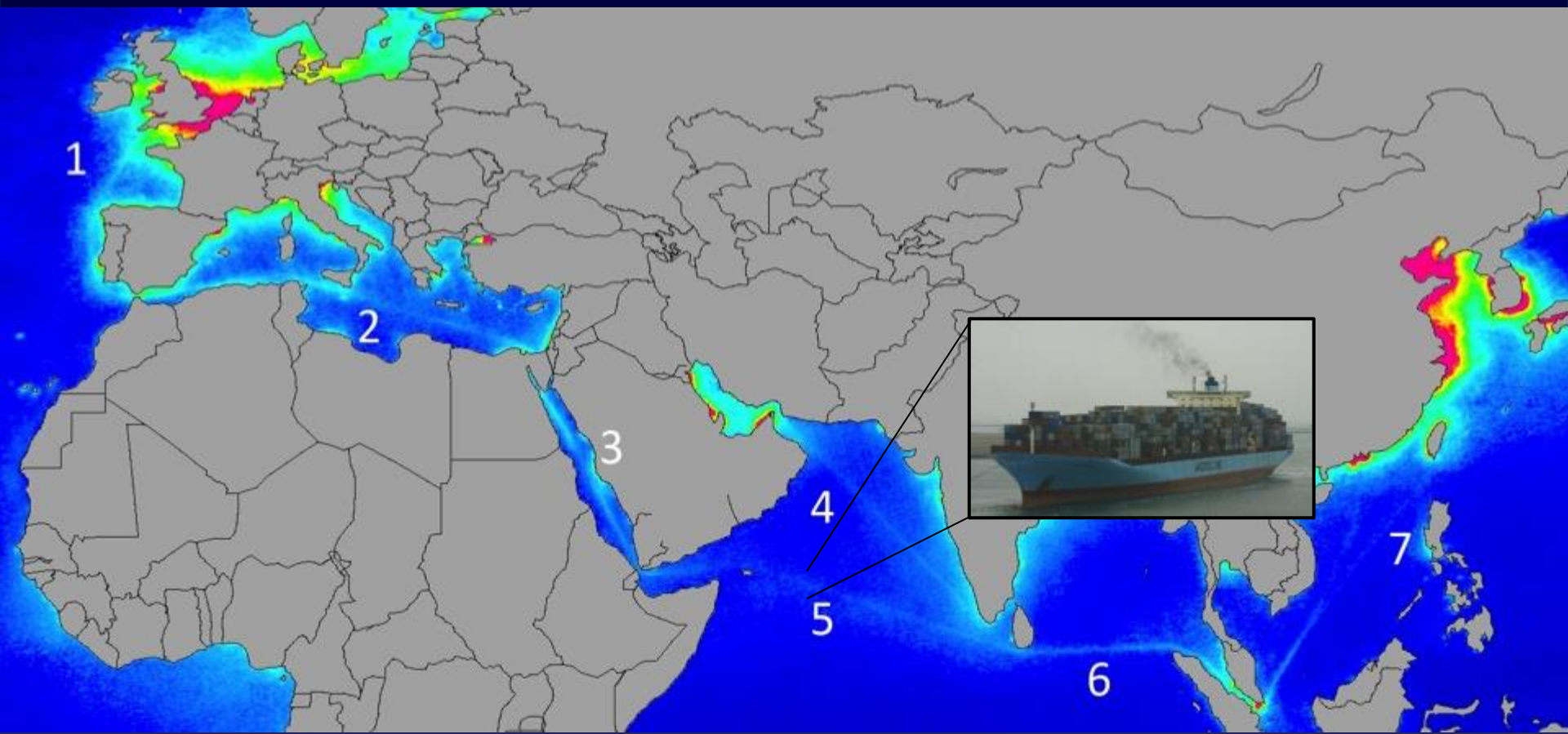




25 September 2012



# Previously in OMI multi-year averages



Geert Vinken, Folkert Boersma, Ronald van der A,  
12 October 2012

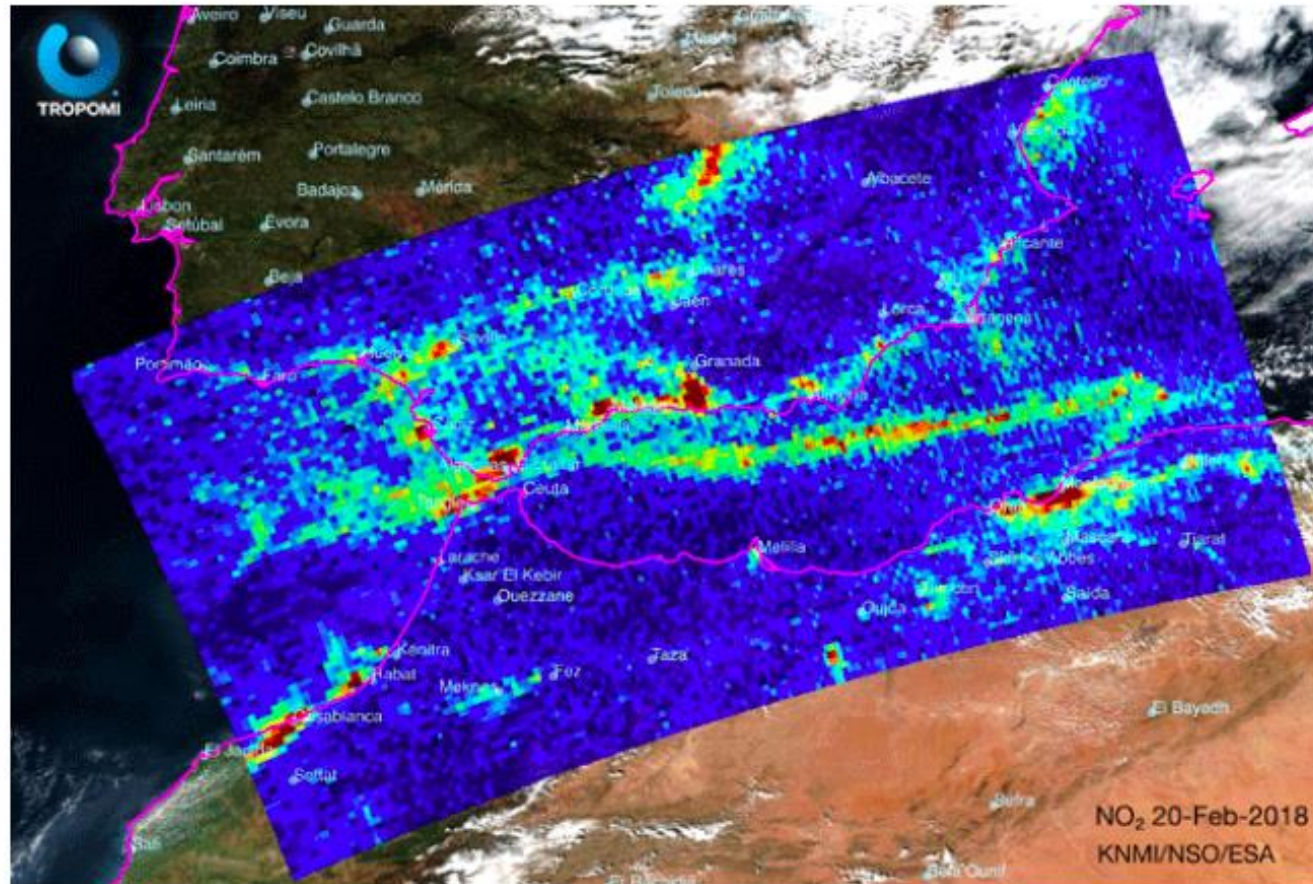
# Nu in 1 dag TROPOMI NO<sub>2</sub> data

## Sentinel tracks ships' dirty emissions from orbit

By Jonathan Amos  
BBC Science Correspondent

🕒 27 April 2018

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Shipping lane: The Tropomi instrument detects a suite of gases including nitrogen dioxide

# Scheepvaart routes

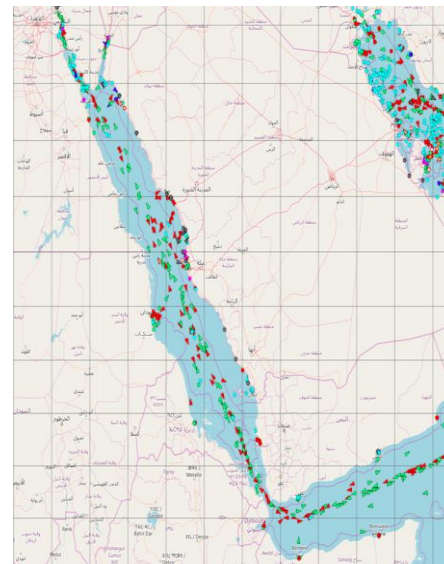
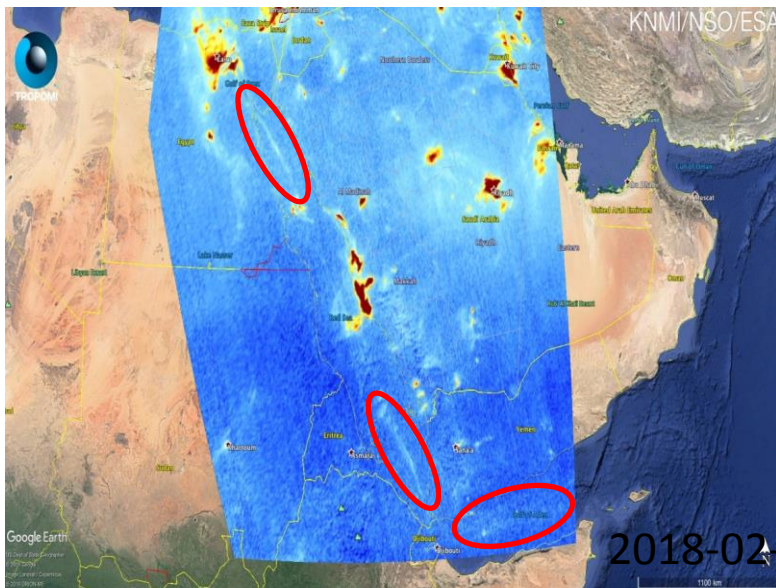
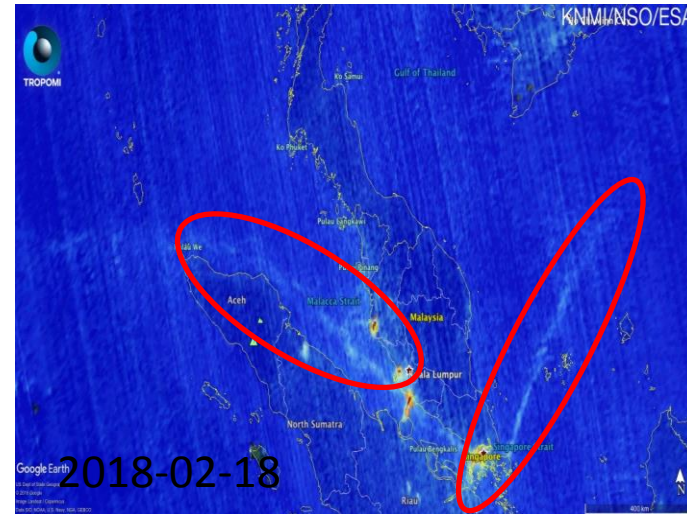
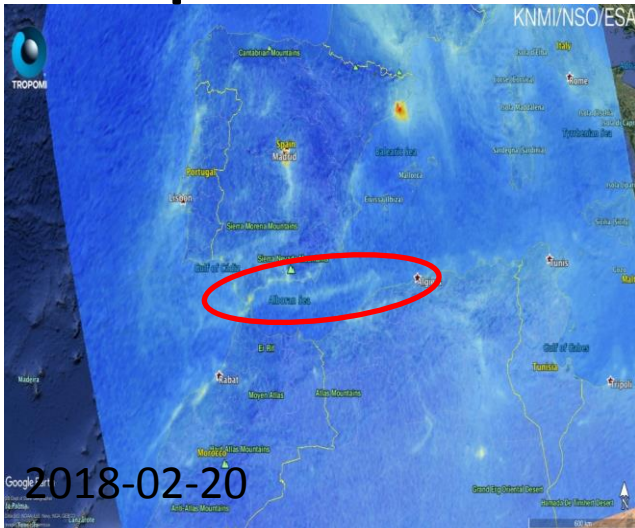








# Ship lanes in individual observations

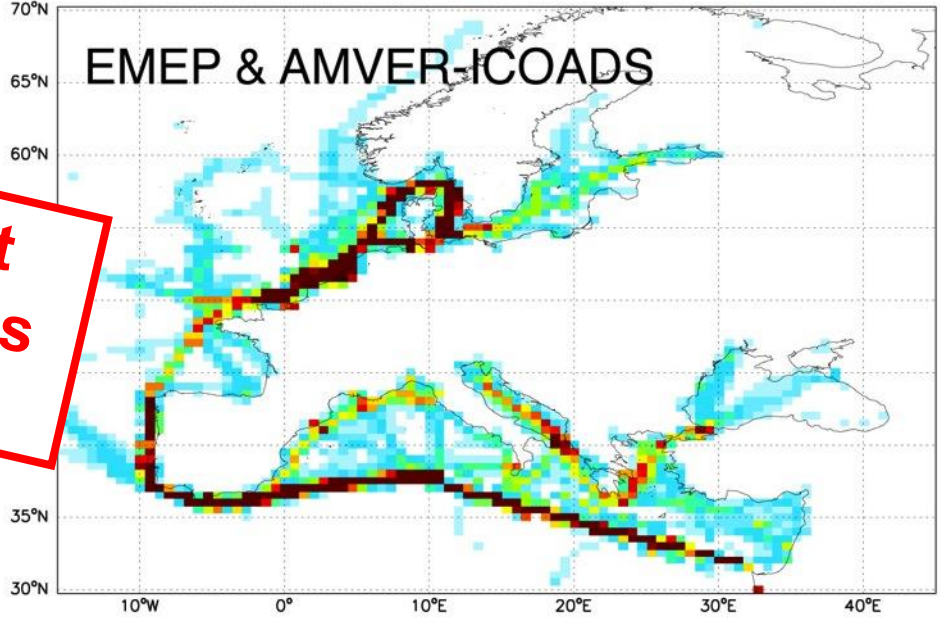
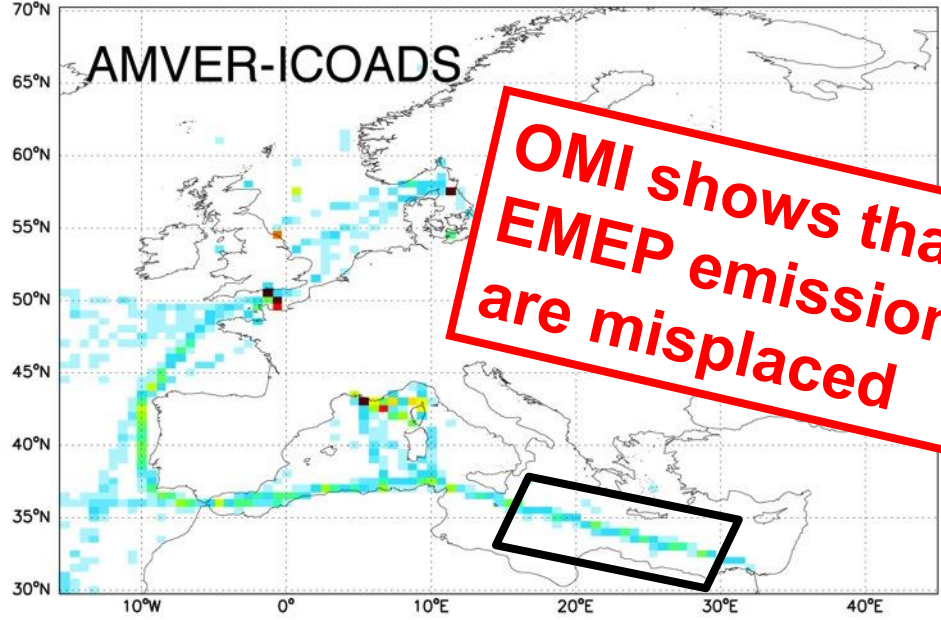
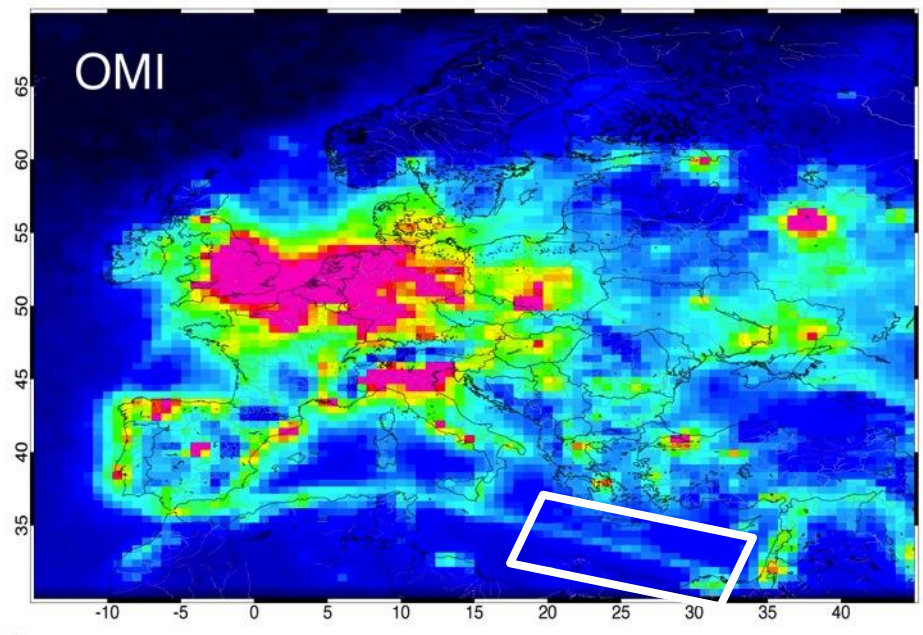
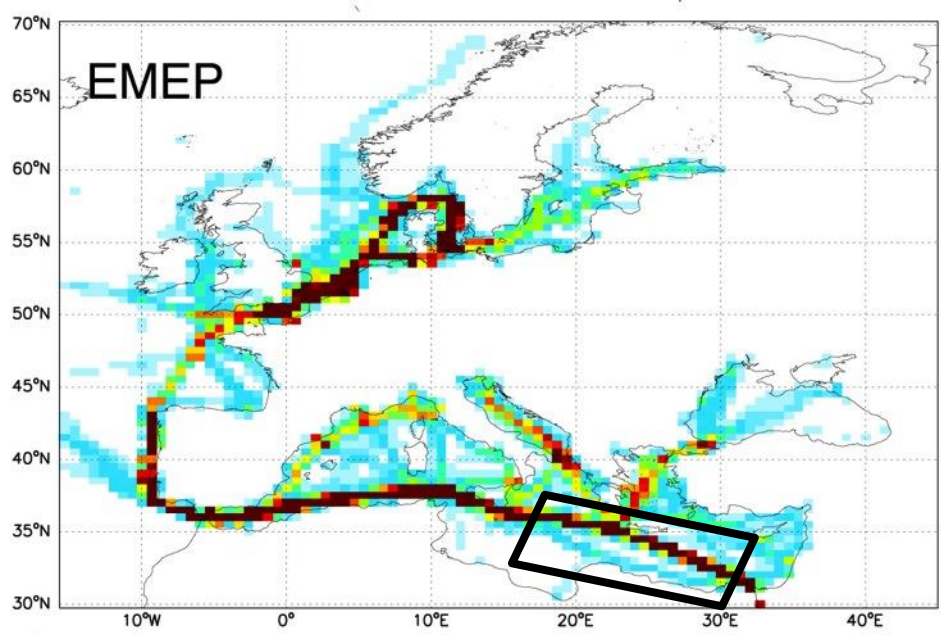


### **3. Wat is de relatie met emissies**

- Verificatie van locatie van emissies
- Monitoren van trends
- Link leggen met economische patronen en gedrag (slow steaming)



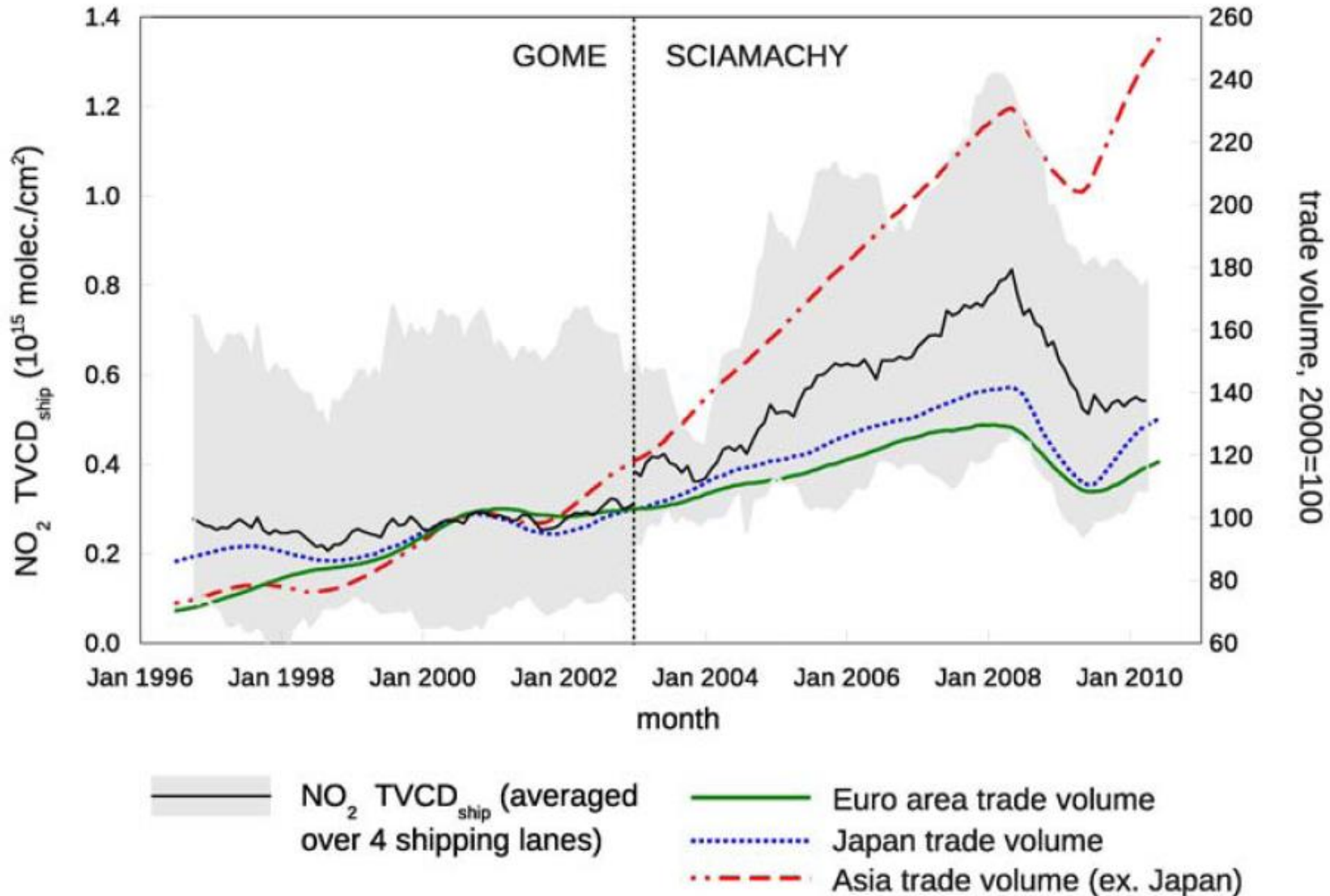
# Satelliet data laat zien dat emissies 'misplaatst' zijn



**OMI shows that EMEP emissions are misplaced**

# Scheepvaart vervuiling volgt ritme economie

80-90% of global trade volume is transported by ships





# NO<sub>x</sub> pollution from ships increasing in relevance

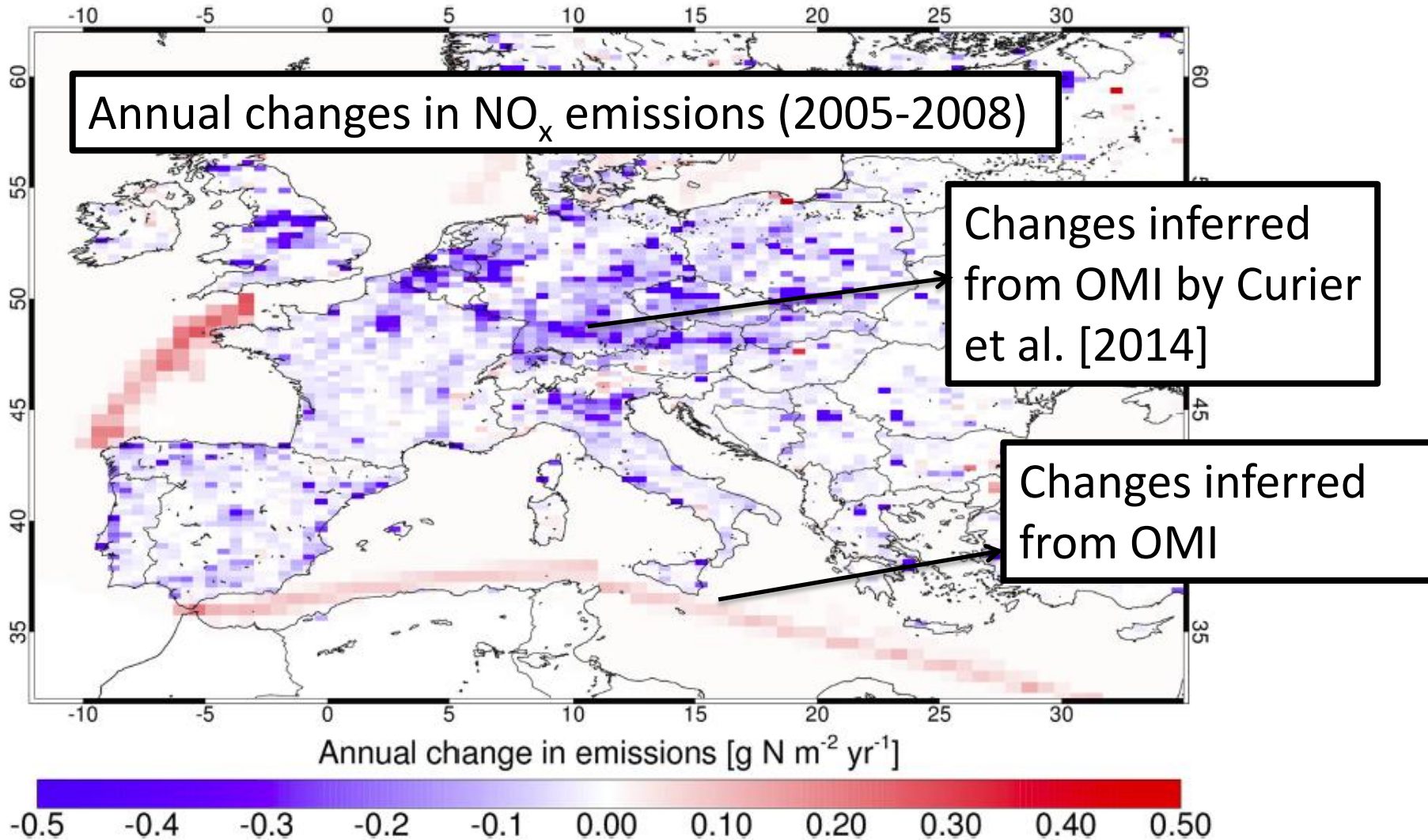


Figure 3. Composite map of annual changes (between 2005 and 2008) in NO<sub>x</sub> emissions derived from OMI NO<sub>2</sub> observations. Annual changes in OMI-inferred ship NO<sub>x</sub> emissions (this work, 1/2° × 2/3° resolution) are combined with annual changes in OMI-inferred land-based NO<sub>x</sub> emissions based on the annual trends reported by Curier *et al* (2014) (at 1/4° × 1/2° resolution) and absolute land-based emissions from the TNO/MACC-II inventory for the year 2009 (Kuenen *et al* 2014).

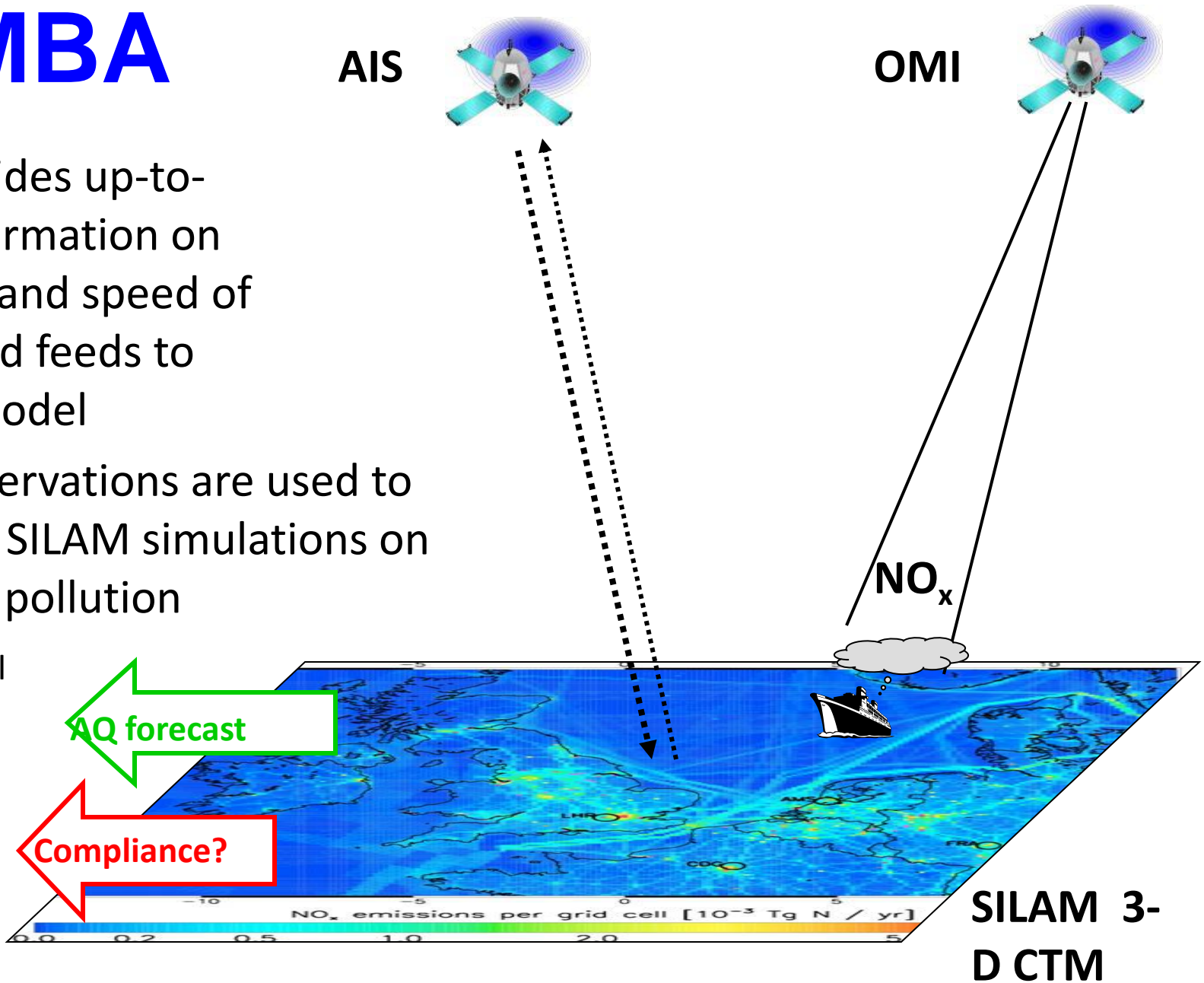
# SAMBA

**AIS** provides up-to-date information on location and speed of ships, and feeds to SILAM model

**OMI** observations are used to evaluate SILAM simulations on shipping pollution

Environmental agencies (e.g. DCMR)

National maritime authorities, EU



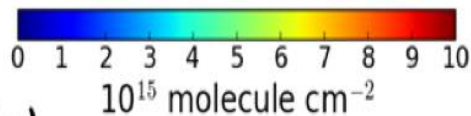
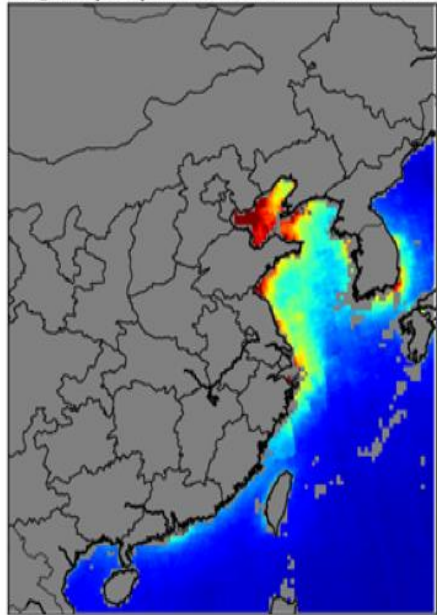
## 4. Scheepvaart emissies bepaald uit satelliet data

- Snelle kwantificatie van emissies
- Monitoren van trends en maandelijkse veranderingen
- Emissie database voor modelberekeningen
- Relatie met luchtvervuiling over land

# Emissies bepaald uit OMI metingen

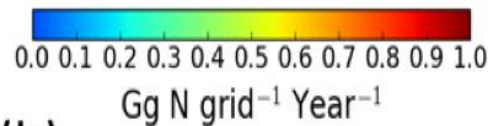
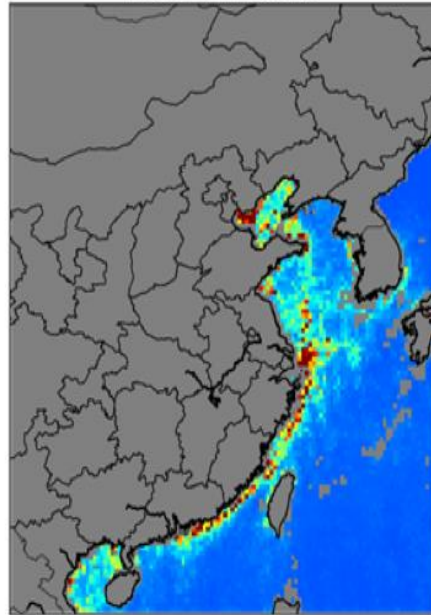
*zelfs als ze onder de outflow van het vaste land van China liggen !*

NO<sub>2</sub> tropospheric column from OMI

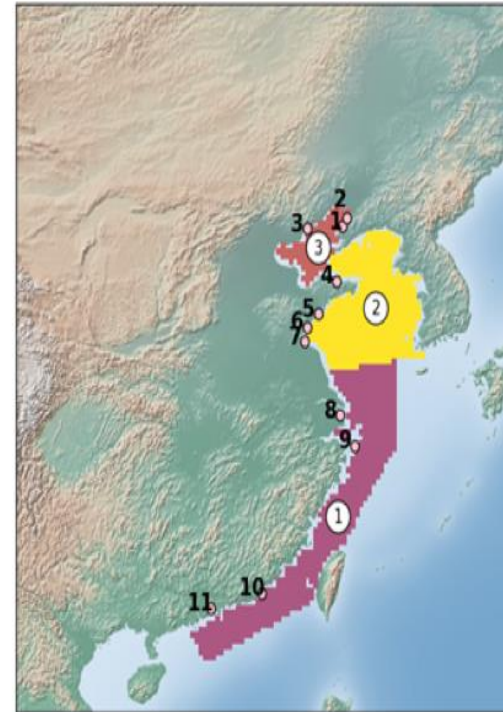


(a)

NOx Emissions



(b)



- ① Shanghai-Guangzhou
- ② Yellow Sea
- ③ Bohai Sea
  
- 1. Dalian
- 2. Yingkou
- 3. Qinhuangdao
- 4. Yantai
- 5. Qingdao
- 6. Rizhao
- 7. Lianyungang
- 8. Shanghai
- 9. Ningbo-Zhoushan
- 10. Shantou
- 11. Guangzhou

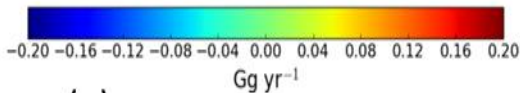
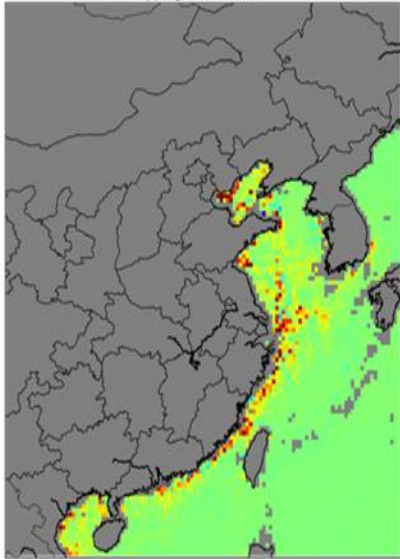
(c)

- 1. Clear ship track: shanghai to Guangzhou
- 2. A track: Shanghai to Yantai, disperses in Bohai Sea
- 3. Bohai: shipping activities and offshore platforms



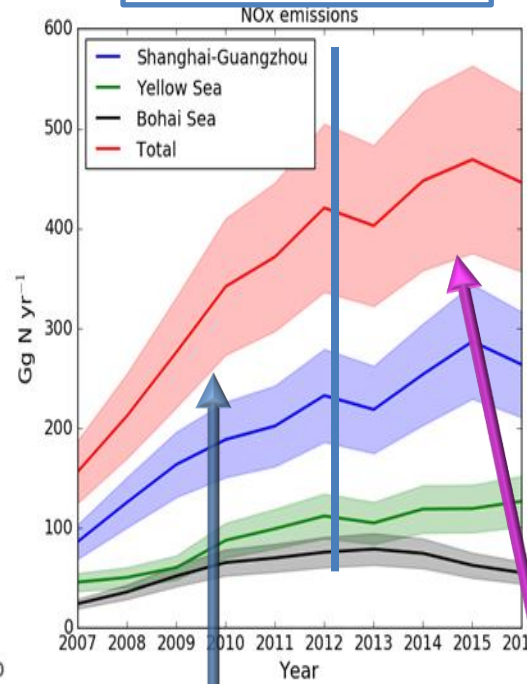
# Trend in emissions

Shipping emission trend

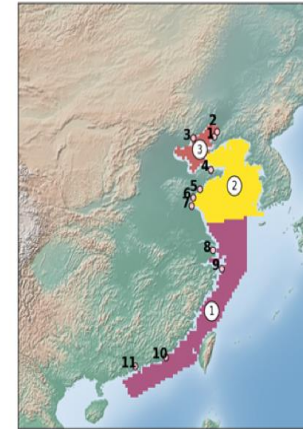


(a)

DECSO NO<sub>x</sub> emissions

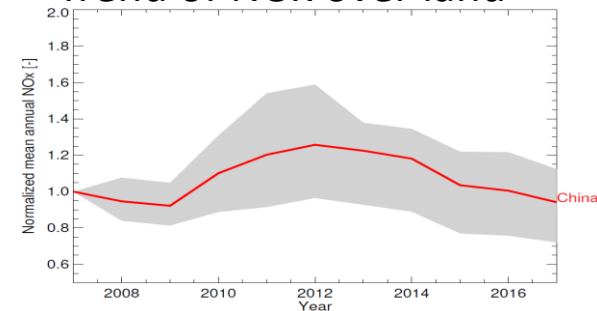


(b)



- ① Shanghai-Guangzhou
- ② Yellow Sea
- ③ Bohai Sea
- 1. Dalian
- 2. Yingkou
- 3. Qinhuangdao
- 4. Yantai
- 5. Qingdao
- 6. Rizhao
- 7. Lianyungang
- 8. Shanghai
- 9. Ningbo-Zhoushan
- 10. Shantou
- 11. Guangzhou

Trend of NO<sub>x</sub> over land



The linear trend of NO<sub>x</sub> emissions

- An average increase rate of about 0.1 Gg/grid along the clear ship track

Increase rate of 20% per year

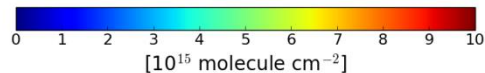
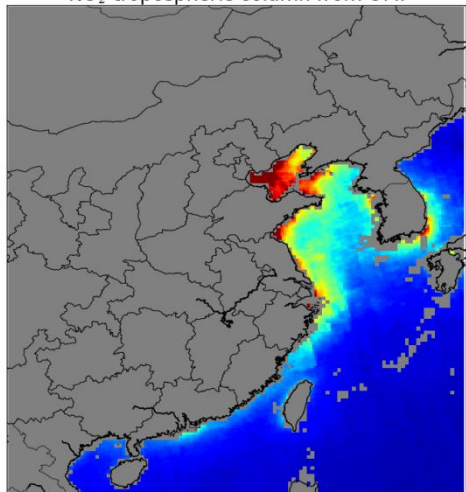
about 3% per year

# CO2 emissions gebaseerd op NO2 emissies

- OMI NO<sub>x</sub> used as indicator for the CO<sub>2</sub> emissions from ships and off-shore industry in the Chinese coastal waters
- Emission ratios of the STEAM model (Jalkanen , FMI) are used.
- OMI & TROPOMI even more relevant for climate monitoring for COP21, Paris.

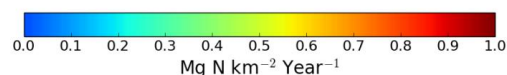
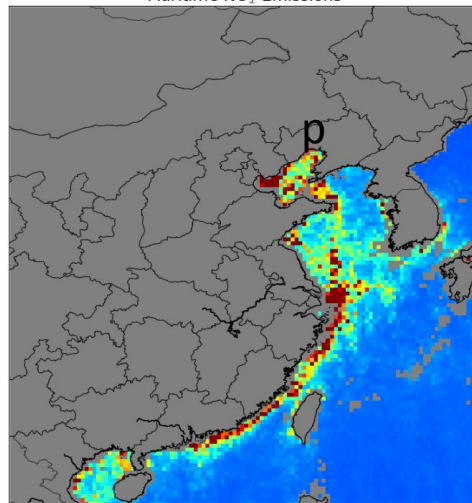
## NO<sub>2</sub> concentrations

NO<sub>2</sub> tropospheric column from OMI



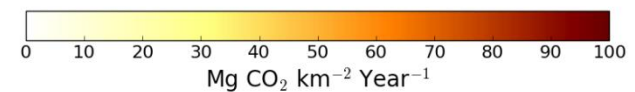
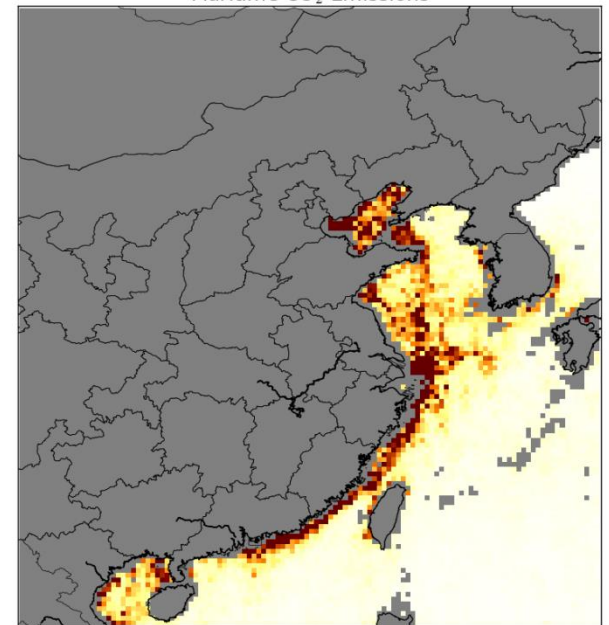
## Maritime NO<sub>x</sub> emissions

Maritime NO<sub>x</sub> Emissions



## Maritime CO<sub>2</sub> emissions

Maritime CO<sub>2</sub> Emissions



July 4, 2018

# Bijdrage van scheepvaartemissies aan luchtvervuiling over land

Two model runs for 2015:

- MIX inventory (no maritime emissions)
- MIX + DECSO maritime emissions

Toename van 5-20  
% luchtvervuiling  
aan de kust

