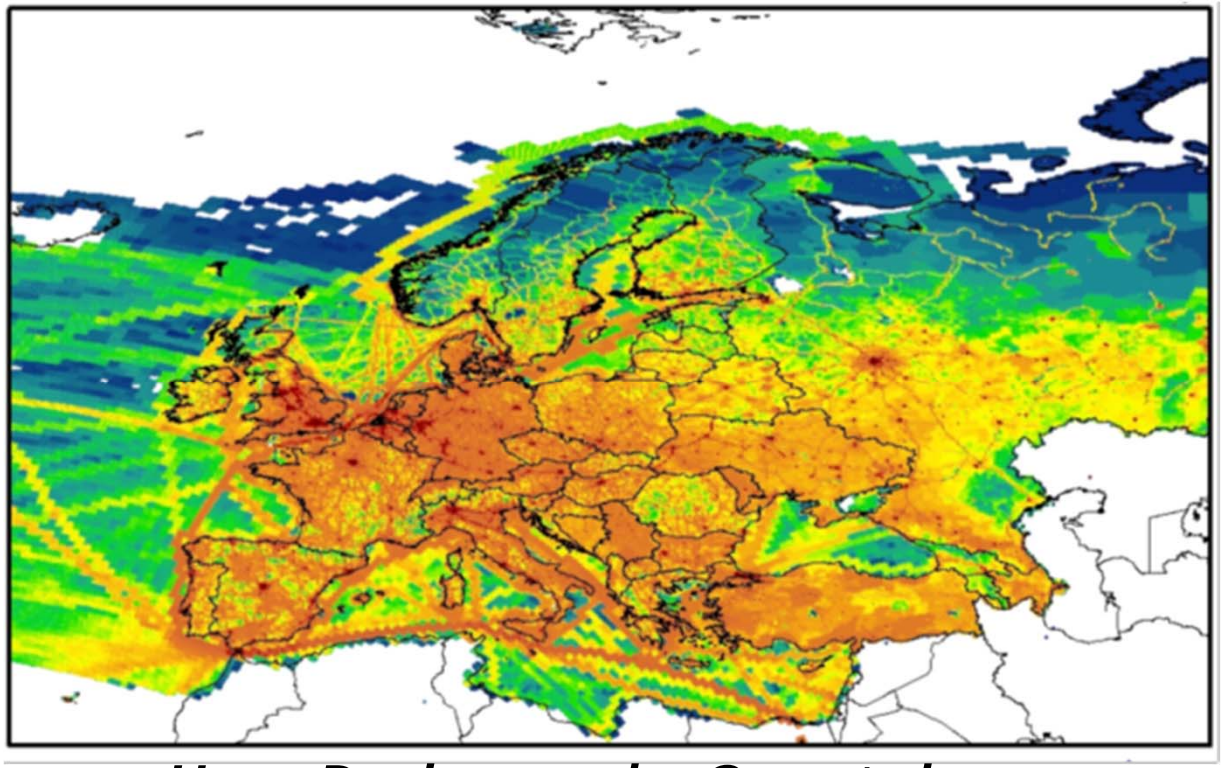
# TNO-MACC
# Anthropogenic European Emissions



***Hugo Denier van der Gon et al.***

**TNO - Netherlands Organisation for Applied Scientific Research**


# TNO organisation

## Netherlands Organisation for Applied Scientific Research

- ***"Knowledge in practice"***

**TNO is a knowledge organisation for companies, government bodies and public organisations. The daily work of some 4,500 employees is to develop and apply knowledge. We provide contract research and specialist consultancy as well as grant licences for patents and specialist software.**

**TNO Department of Air, Climate and sustainability (~ 45 p.)**

Includes teams on

- International emission inventories
- Regional Air Quality modelling (LOTOS-EUROS model)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# Contents

- Approach to emission inventory
- Spatial distribution
- Temporal profiles & PM split
- Recent trends
- Particle numbers?
- Space data & emissions
- Conclusions


# Approach to base year inventory (2005)

- In the past independent emission inventories were made …..
- The TNO year 2005 emission inventory is set up using official reported emissions at the source sector level – as much as possible –
  - Makes use of national expertise & links to the policy arena

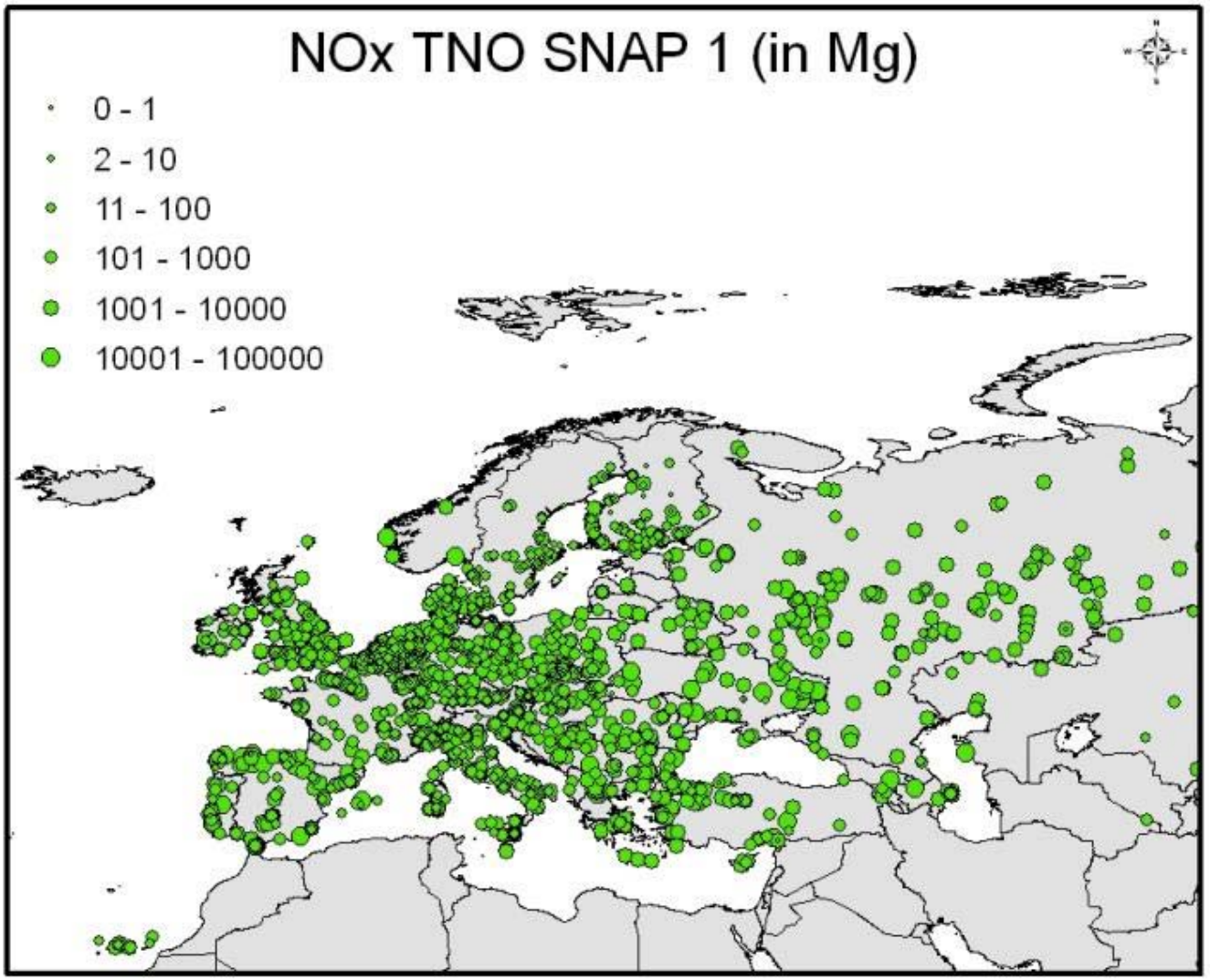
- Emissions are downloaded from the European Environment Agency (http://www.eea.europa.eu/data-and-maps/data).
- However, the reported emissions by individual countries contain gaps and errors – various consistency checks need to be made.
  - Alternative emissions : IIASA  GAINS emissions and /or TNO default.
  - Extreme deviations adjusted - allows maximum use of official data while not hazarding the quality of the final result


# Approach to a consistent & accepted inventory

- Use official reported emissions at the source sector level:
- downloaded from the European Environment Agency (http://www.eea.europa.eu/data-and-maps/data).

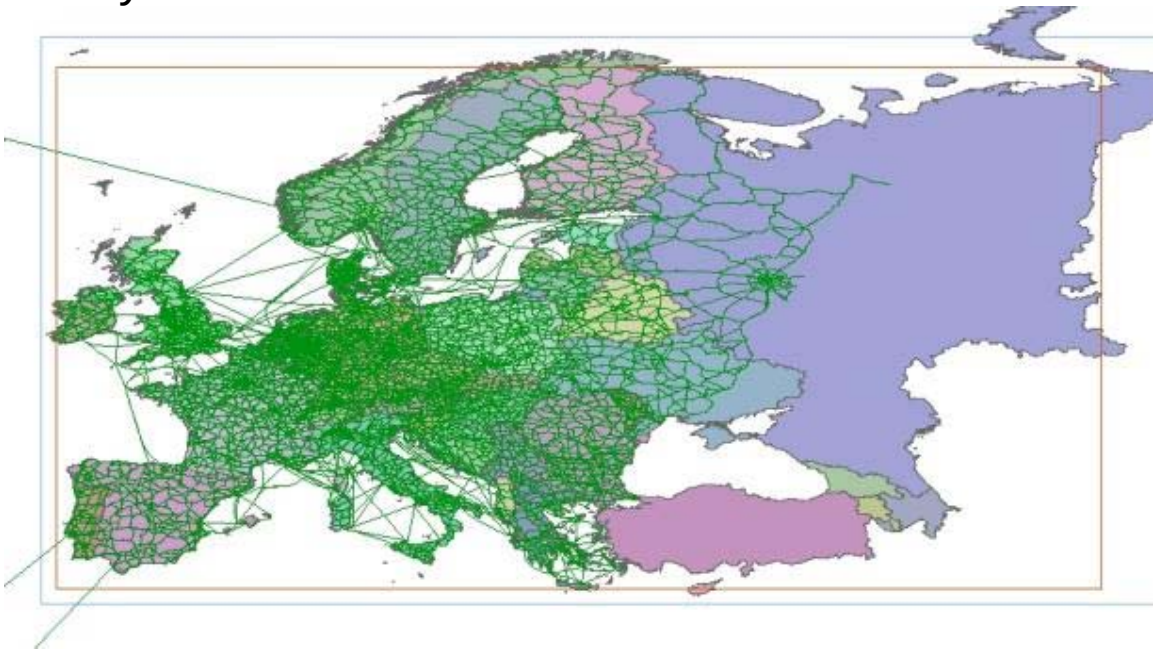
1. Remove unreliable data. Try to be complete…“make” it complete
2. Investigate trends for consistency
3. Create unique sets for specific sectors
4. Add or “do” components that are not or incompletely reported e.g., EC, OC,
5. Invest in spatial distribution! High resolution (~ 7x 7 km), consistent distribution patterns for road transport, agriculture, power plants, industry,….
6. Collaborate in interpretation and provide description of input.

Point sources distributed the TNO point source data base



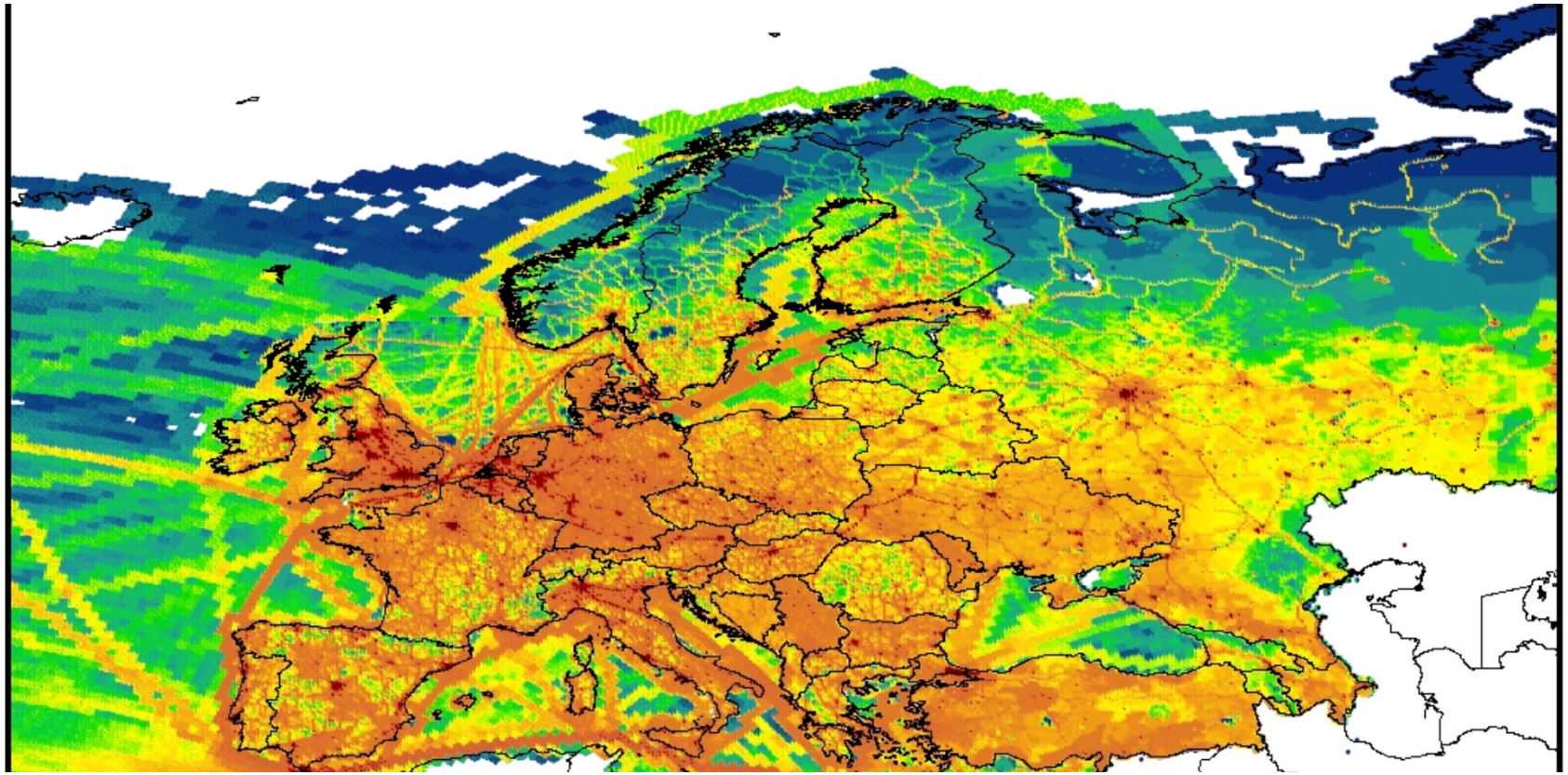

# Diffuse and / or area sources are distributed with proxy maps most resembling the emission cause

- European traffic intensity road map
- Animal density maps,
- Population density
- Land use
- Etc.



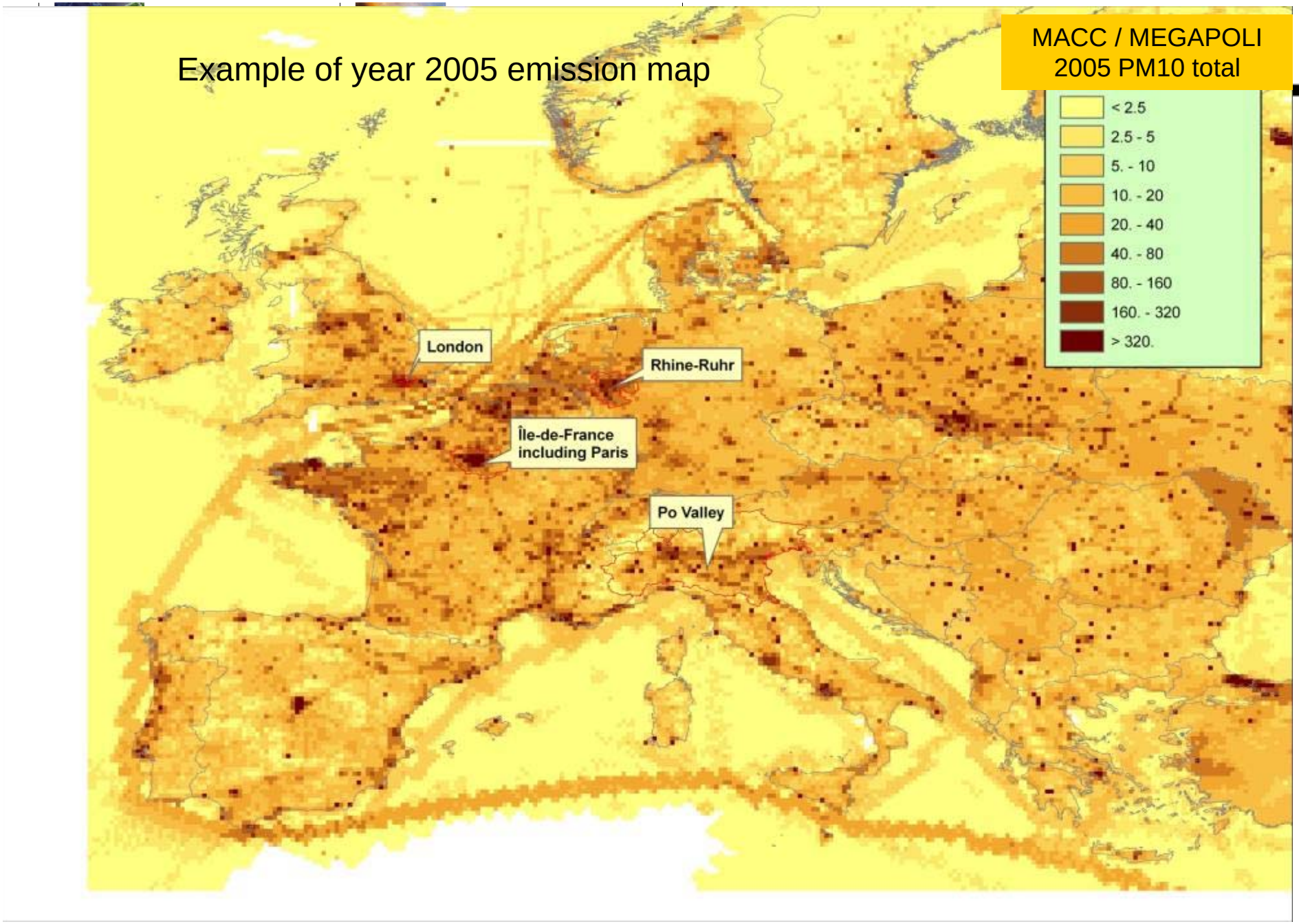
Documented in Denier van der Gon et al., 2010 (TNO report)

# Intensity of NOx emission Europe 2005 on 1/8th x 1/16th degree lon-lat



This data is currently being used by various groups (e.g. KNMI, TNO, EMPA) to validate emissions with NO2 satellite data

# Example of year 2005 emission map

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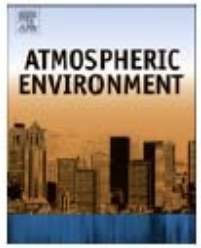
Atmospheric Environment xxx (2012) 1–11

Contents lists available at SciVerse ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv




# Comparing emission inventories and model-ready emission datasets between Europe and North America for the AQMEII project

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[b] TNO Environment and Geosciences, Utrecht, The Netherlands
[c] Air Quality Research Division, Environment Canada, Toronto, Ontario, Canada
[d] ENVIRON Corporation, Novato, CA, USA

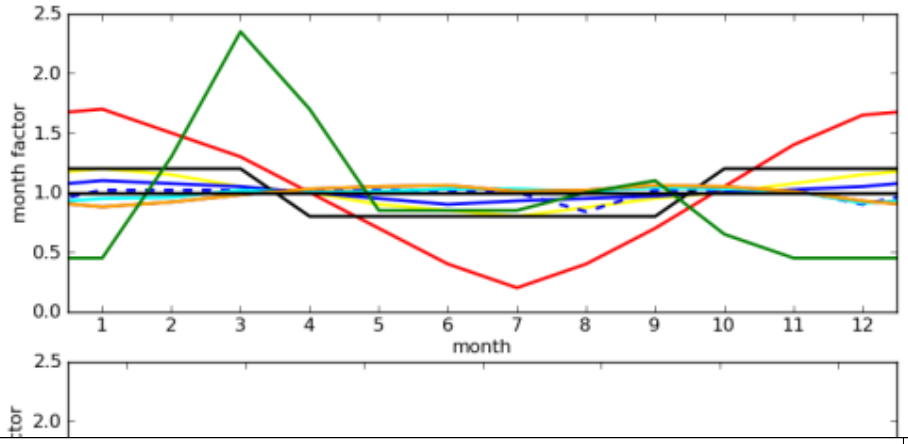
This paper highlights the similarities and differences in how emission inventories and datasets were developed and processed across North America and Europe for the Air Quality Model Evaluation International Initiative (AQMEII) project and then characterizes the emissions for the two domains.

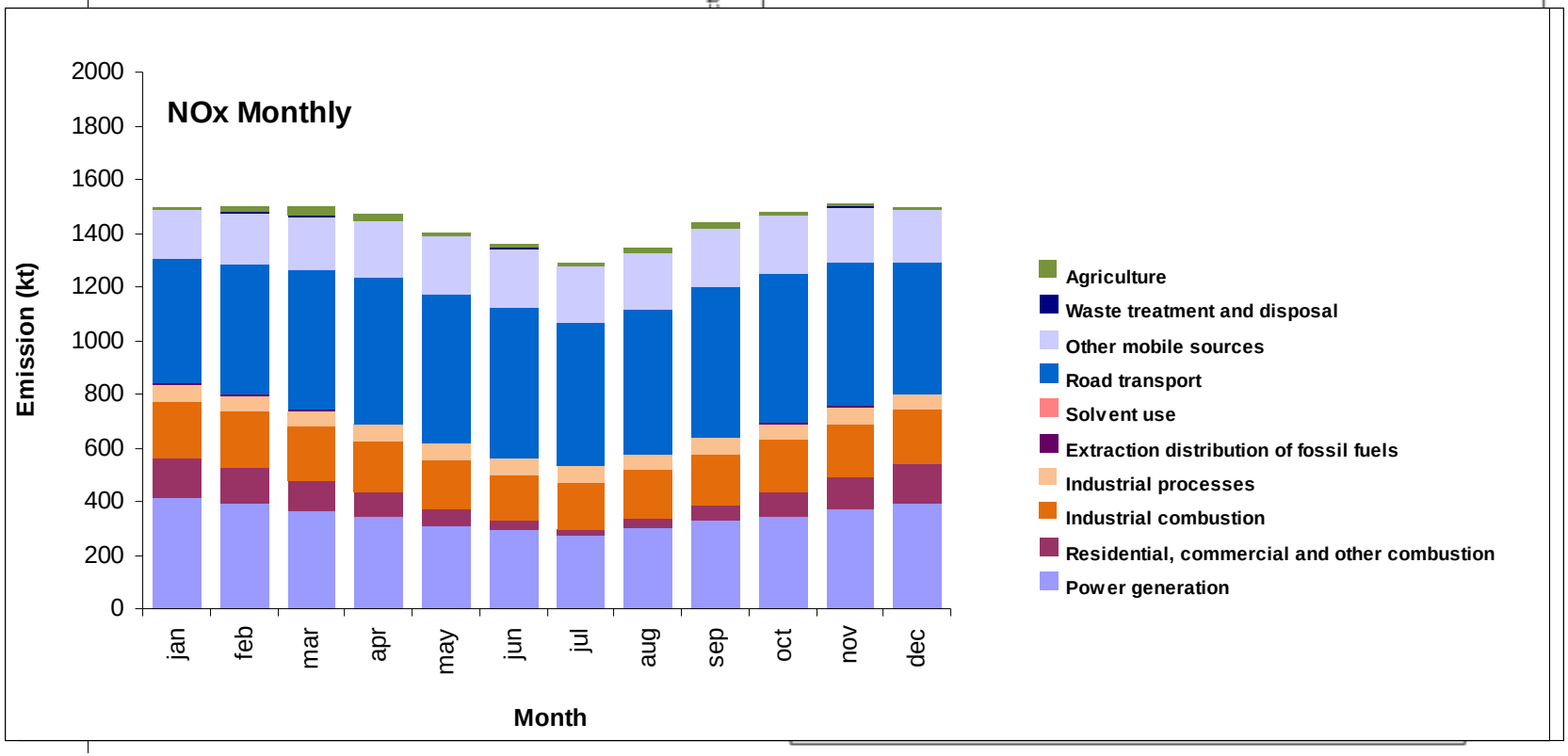

# Temporal emission profiles

- EI based on yearly emission totals for every sector in each country.

- For modeling purposes a set of temporal factors was constructed to breakdown annual total emissions into hourly emissions
- The profiles are for aggregated source sectors according to the SNAP level 1.
- Most profiles show a sinusoidal curve and distinguish monthly, daily and hourly factors

# Time profiles applied to anthropogenic emissions




# Chemical composition of the MACC PM emissions

- Air quality models often need to split the PM emissions into its chemical components to account for the particulate behaviour.
- To accommodate this need a specific PM bulk composition profile file was composed based on work done by TNO in e.g. FP6 EUCAARI and others.
- Chemical components: elemental carbon (EC), organic carbon (OC), sulphate, sodium and “other mineral components”.
- a PM split table by country by source sector that breaks down the PM10 and PM2.5 into components. (sum = 1)
- Why per country? Because fuel and technologies differ widely between countries (e.g. residential combustion NL vs Poland)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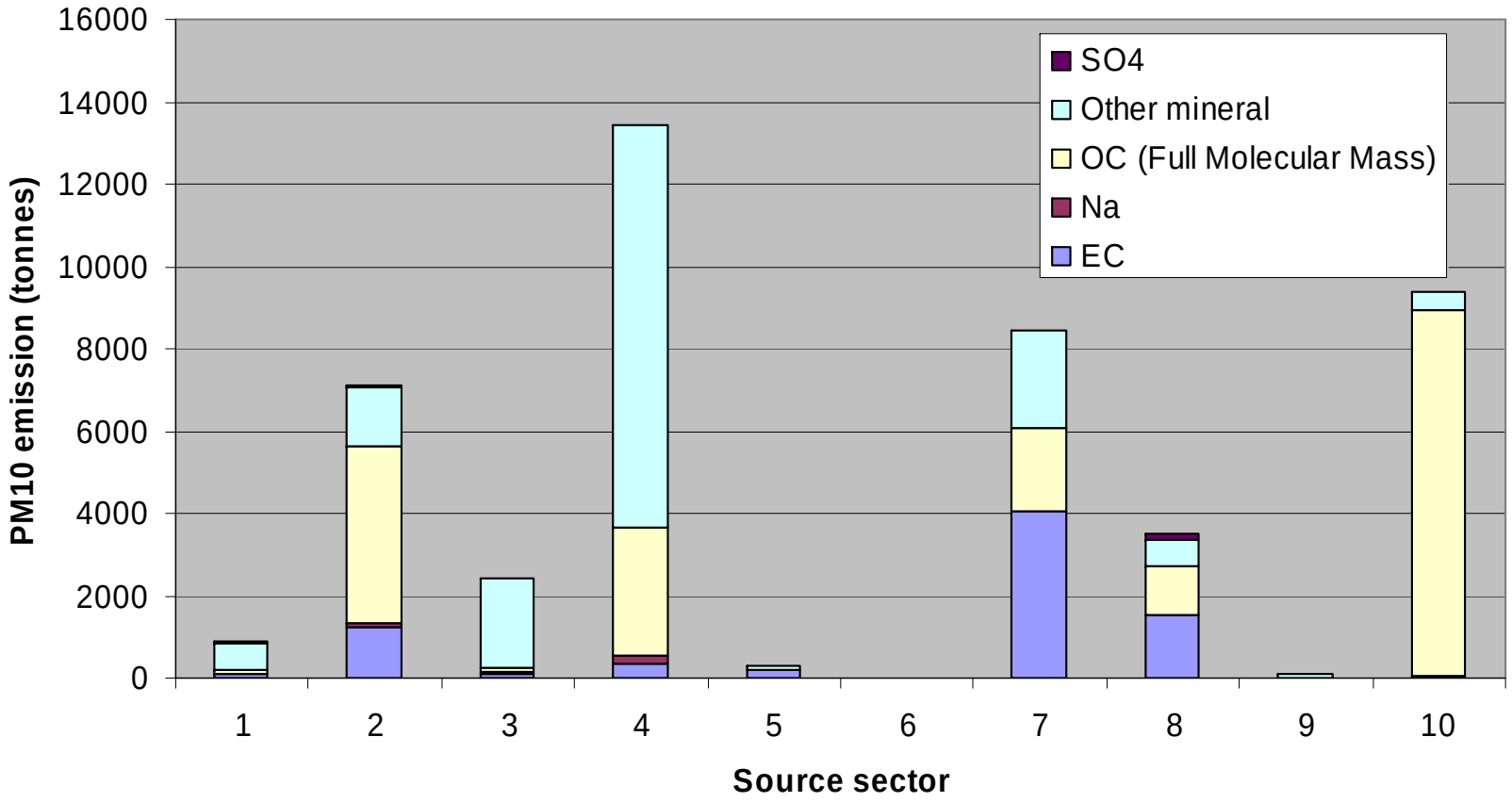
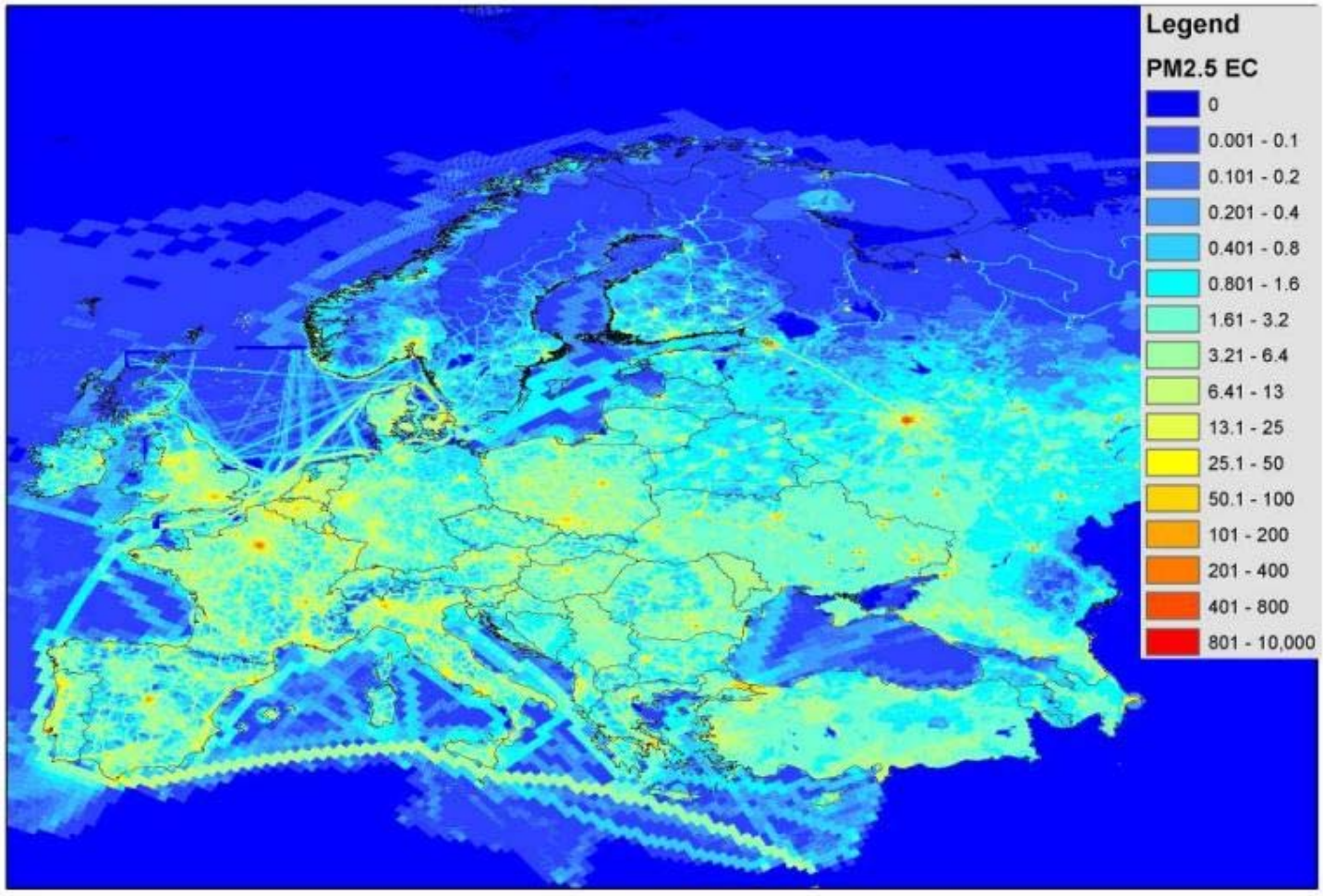
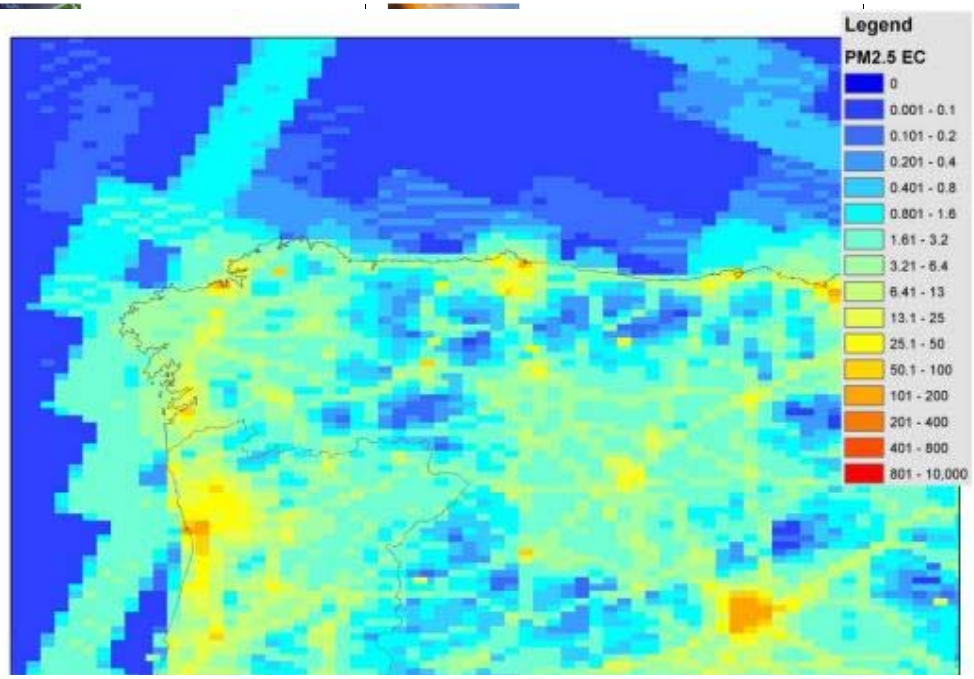
## Austria 2005 (45.5 kt)

**ns**

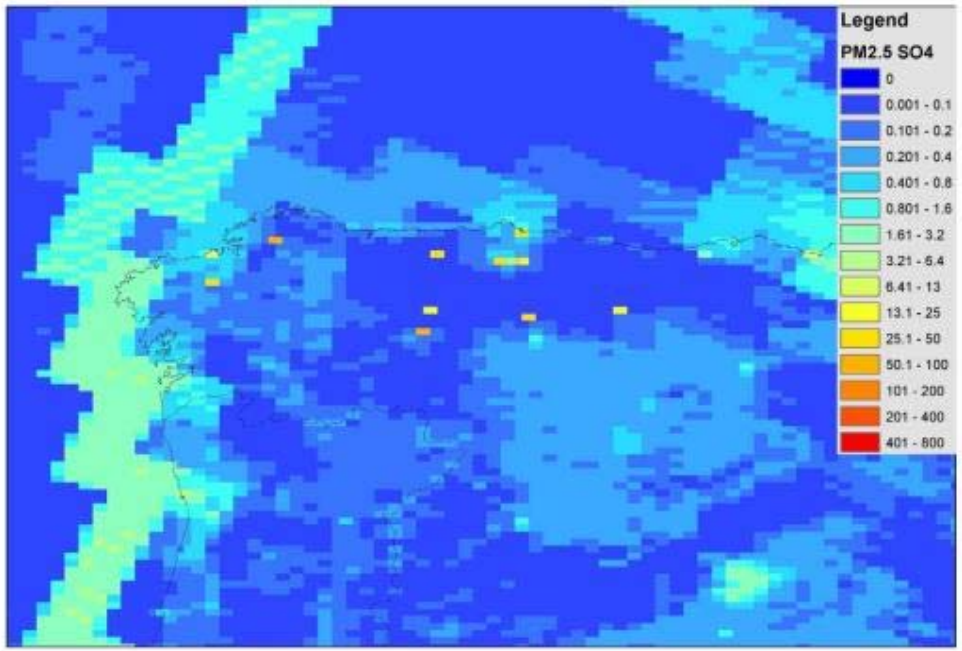


# Spatial distribution of the EC component in PM2.5





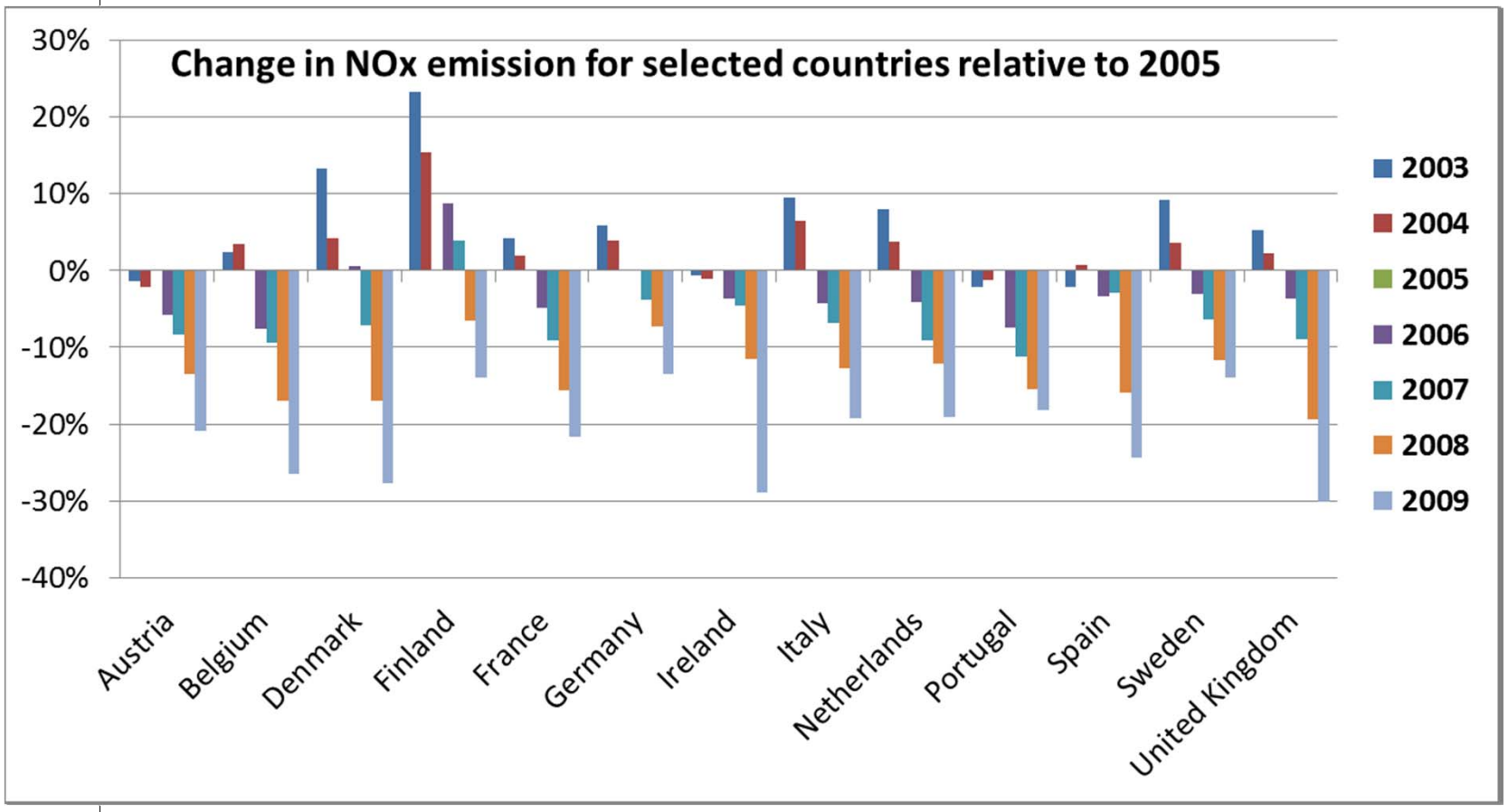

**Spatial distribution of EC emission over the North of Spain**




**Spatial distribution of particle-bound sulphate over the North of Spain.**

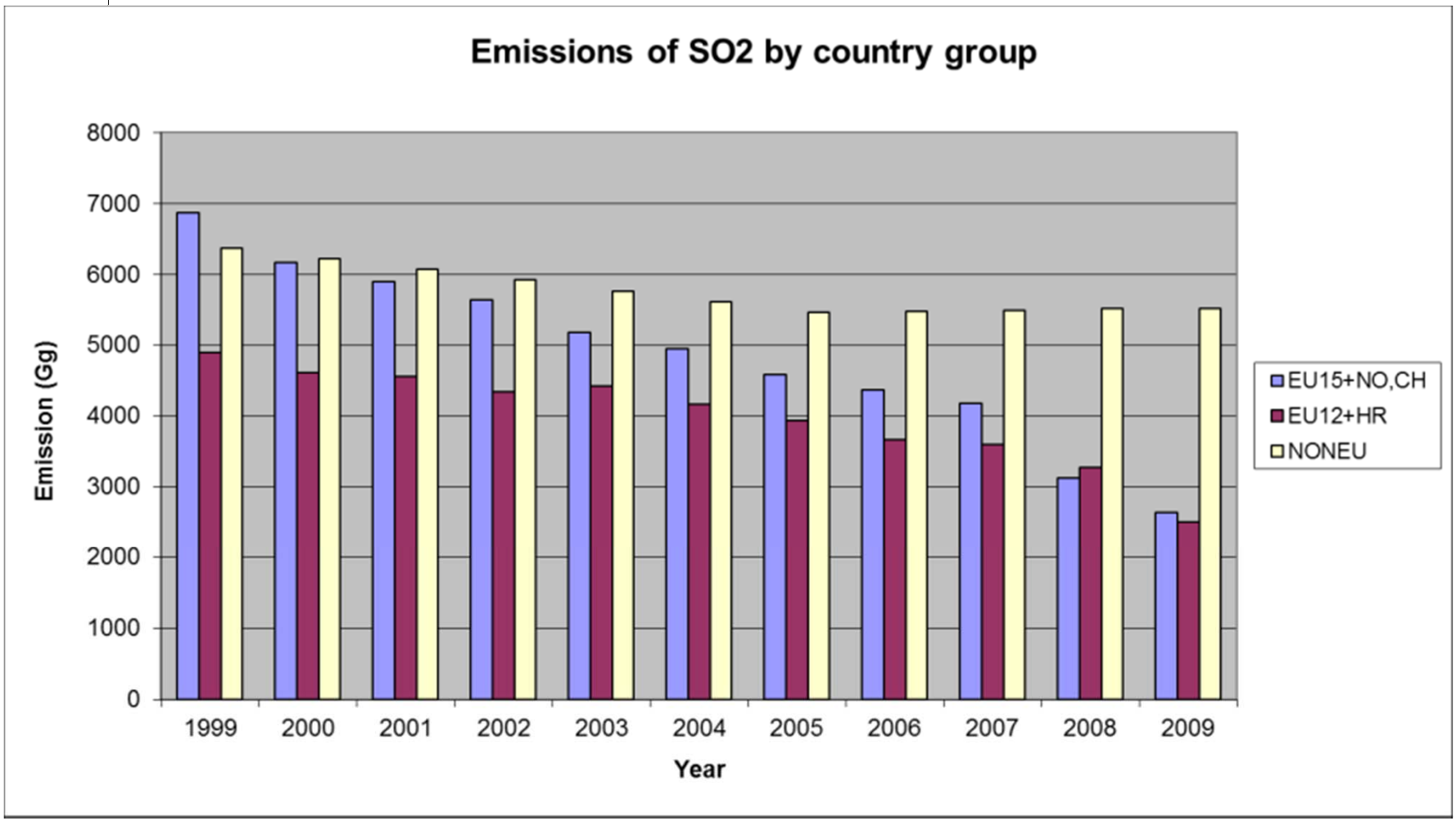
*Note the importance of point sources.*

# How is 2009 compared to previous years?




- A consistent decrease in NOx as a consequence of technology & crisis

# Preliminary absolute emission trends (more changes in secondary than primary PM)



# A first size resolved European particle number (PN) emission inventory…..

EUCAARI

- Disconnected from our PM inventories because mass EFs are not a good starting point for PN (< 300nm)
- A new ball game: no legislation, AQ directives, no reported emissions

  But…both from a climate and health perspective PN & their sizes are highly relevant

- Keywords:
  - *Climate:* CCN, direct and indirect aerosol effect
  - *Health:* small particles more health relevant (UFPs)

EUCAARI

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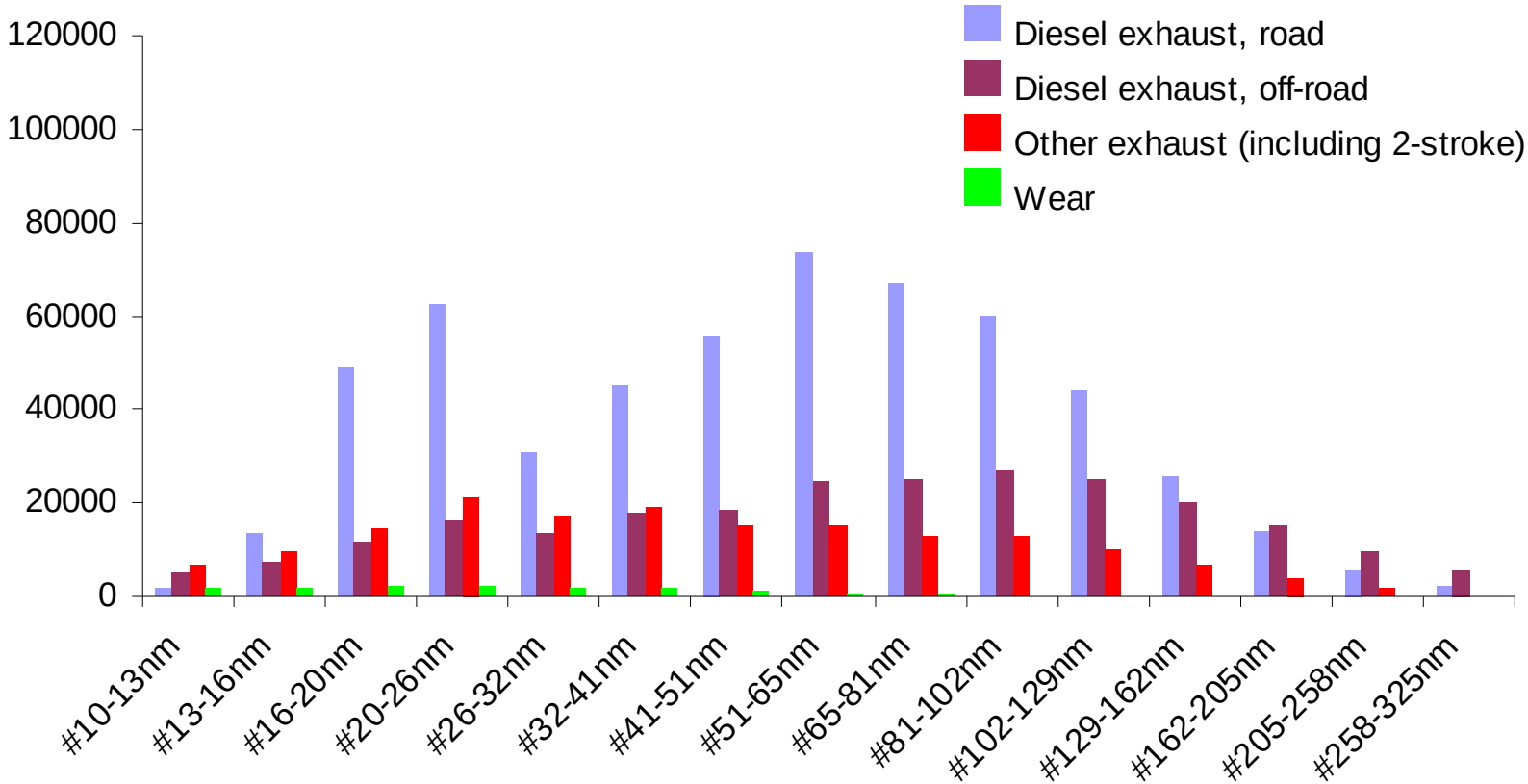
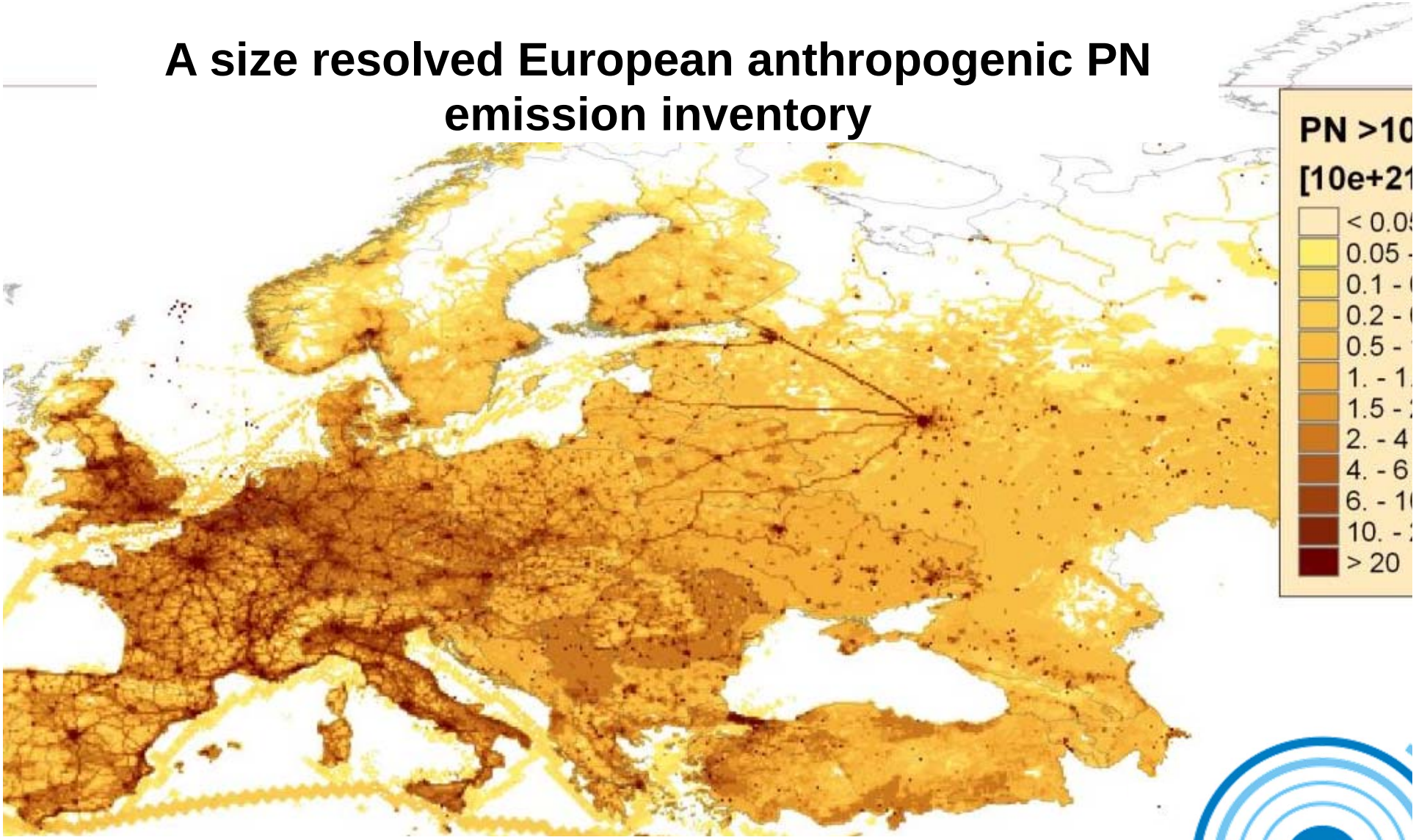
## PN (Z#) from transport in Europe (SNAP 7 and 8, excl. international shipping) by size class and type



# A size resolved European anthropogenic PN emission inventory




**ACKNOWLEDGEMENTS**

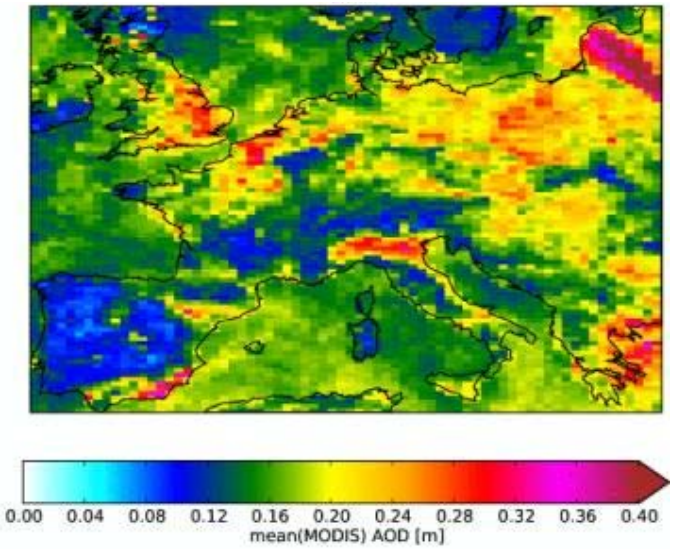
his work has been partly funded by **EUCAARI** (Kulmala et al., ACP 2011)

European Integrated project on Aerosol Cloud Climate and Air Quality interactions) No 0368

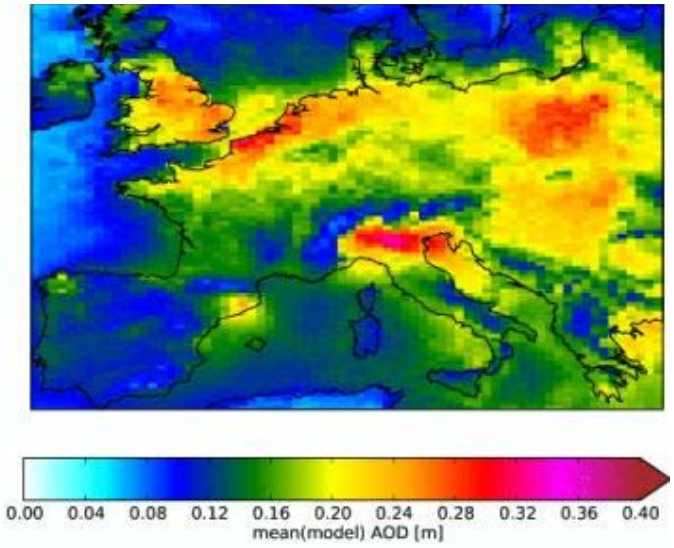

# Primary PM is only part of the dust load in the atmosphere…..

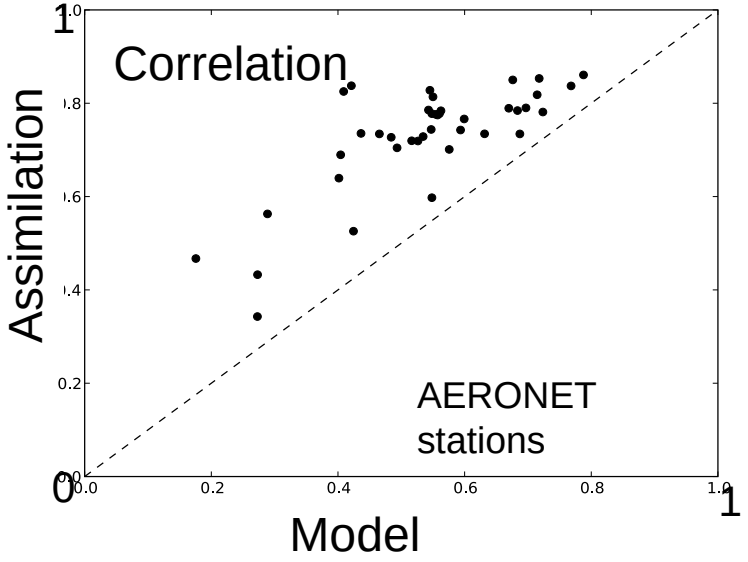
# Data assimilation – MODIS AOD

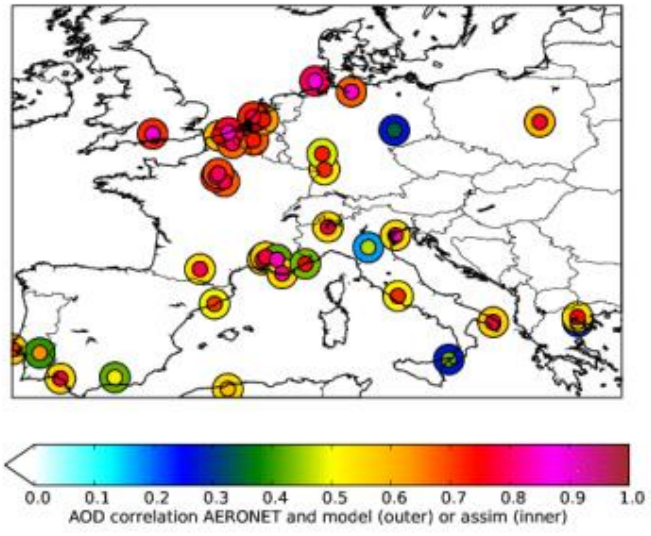
MODIS composite




Modelled composite

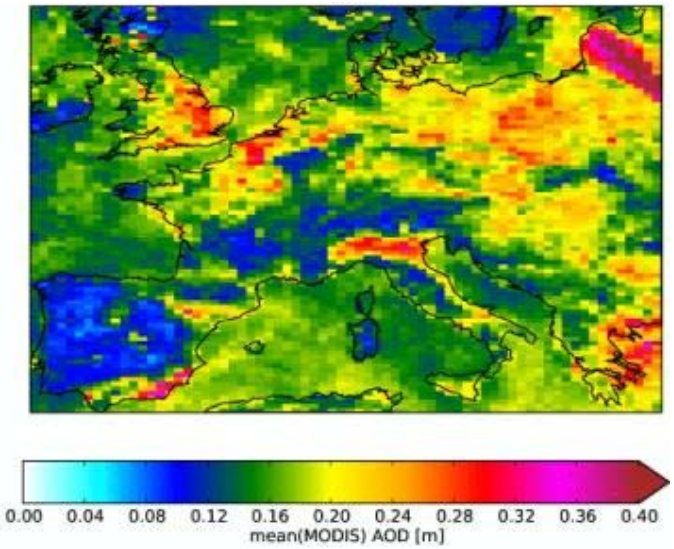


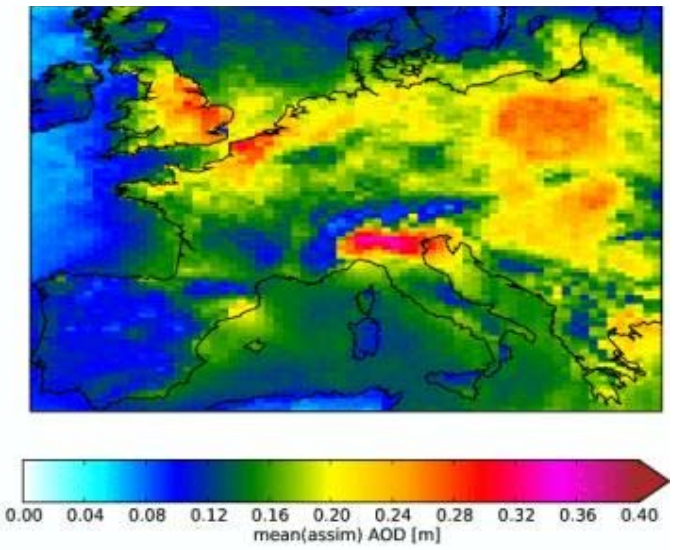



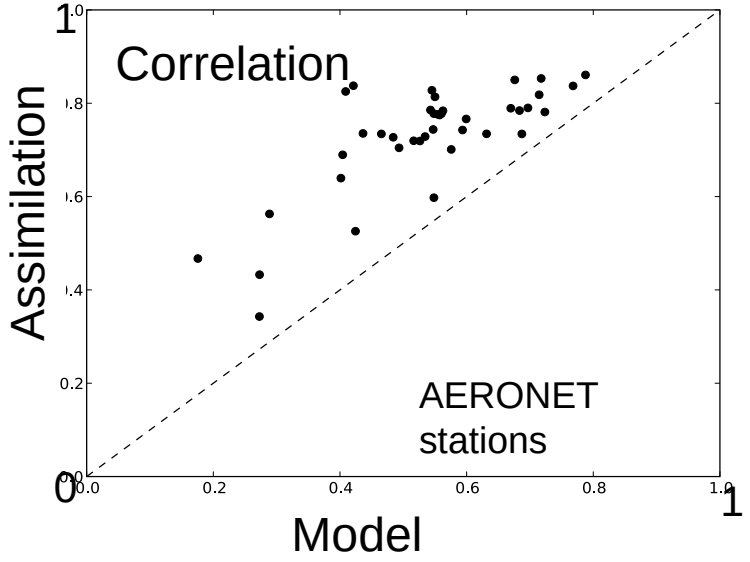
# Data assimilation – MODIS AOD

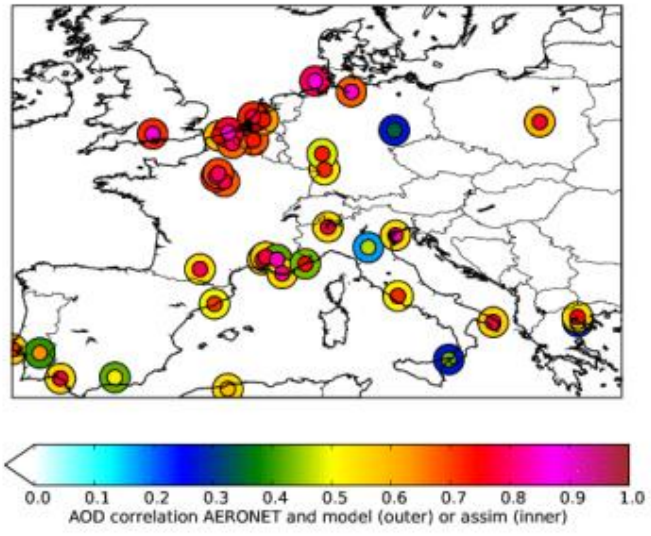
MODIS composite




Assimilated composite



# *Emission trends estimation using data assimilation*
# *NOx emissions in Po valley (Italy)*

Preliminary Results

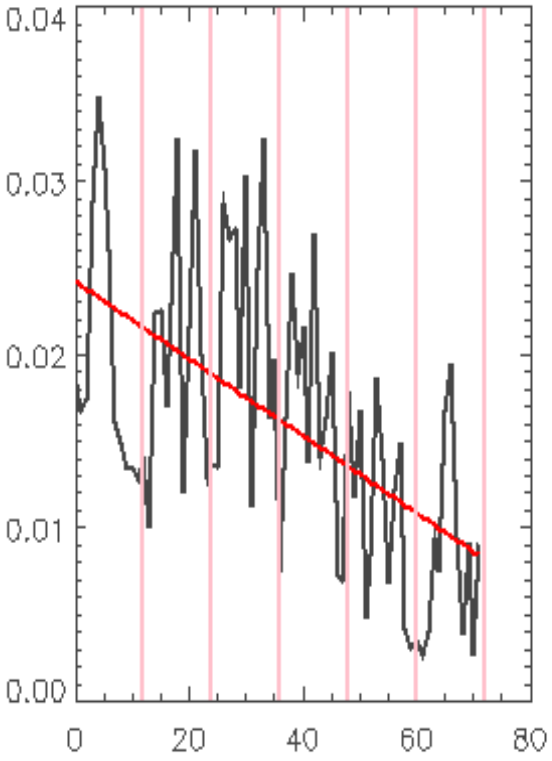
LOTOS-EUROS EnKF data assimilation

OMI NO2

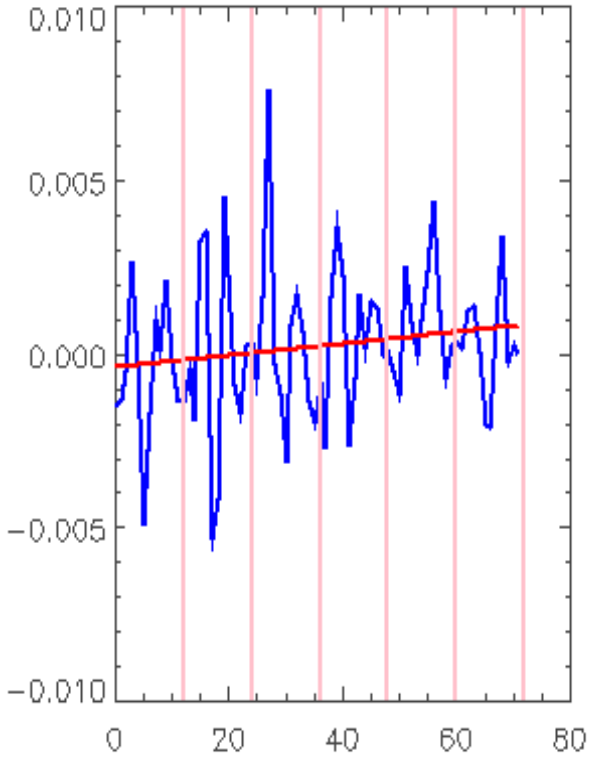
2005-2010

Principal component analysis on parameter estimates

Differentiate model uncertainty impact from emission information




PC 1: Decrease in time




PC 2 : Seasonal pattern

Frequently heard complaints

**FHC's**

**Emission Inventory world needs:**

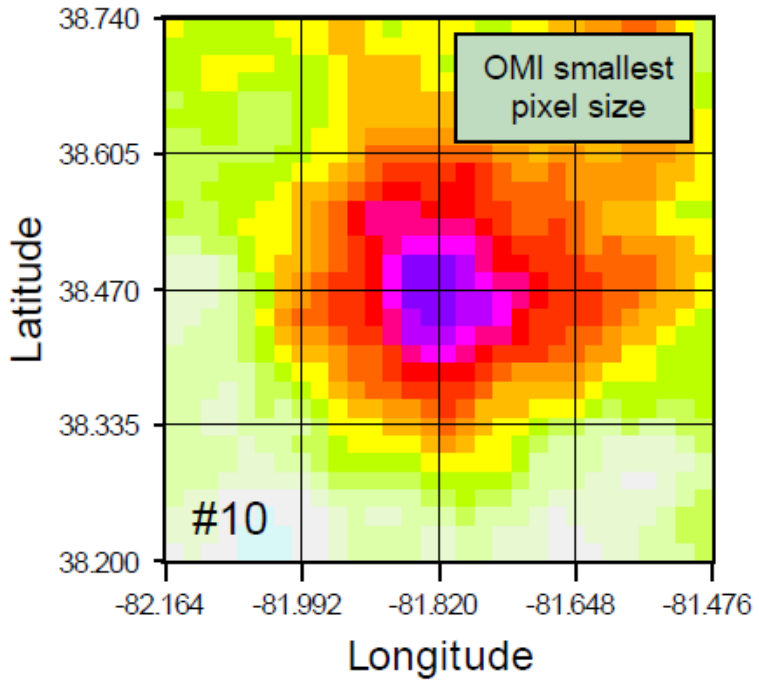
- Annu
- by so
- at poi
- Sepa
  intern
- *Nega*
- not c
  year c
- Satell

**Satellite community on emissions**

**Share noble goals:** Support policies for a sustainable world, Protect health & environment,

# Example OMI SO2 point source plot by Environment Canada

- Average period 2005 – 2010
- Corrected for local bias






# First comparison TNO-MACC top-10 with OMI observations

- MACC emissions derived with a generic method (or based on national totals by source sector)
- Distributed based on plant capacity
- In the EU a redistribution was done using EPER 2004

| Plant ID | | | MACC | | OMI observations | | |
|---|---|---|---|---|---|---|---|
| Name power plant | Country | Rank | SO2 (kt) | NOx (kt) | SO2 | NOx | Remarks |
| AS Pontes | Spain | 1 | 309 | 18 | Strong | Moderate | 1) |
| Ryazan | Russia | 2 | 283 | 48 | None | None | 2) |
| Oroszlany | Hungary | 3 | 237 | 3 | None | None | 3) |
| Megalopolis A 1 - 3 | Greece | 4 | 224 | 3 | Strong | - | 4) |
| Megalopolis A 4 | Greece | 88 | 36 | 2 | | | |
| Maritsa East 2 | Bulgaria | 5 | 214 | 16 | Strong | Strong | 5) |
| Varna | Bulgaria | 6 | 186 | 14 | None | Moderate | 6) |
| Elbistan A | Turkey | 7 | 178 | 20 | Strong | Moderate | 7) |
| Sugozo | Turkey | 8 | 173 | 19 | None | Moderate | 8) |
| Andorra City | Spain | 9 | 162 | 30 | Strong | Moderate | |
| Nicola Tesla A B | Serbia | 10 | 157 | 25 | Moderate | Strong | 7) |
| Prydniprovska | Ukraine | 11 | 142 | 42 | Weak | Strong | 9) |
| Kryvorizka | Ukraine | | | | Weak | Moderate | |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## Conclusions

- A high resolution emission database for the years 2003-2007
- Available upon request under certain conditions
- A split of PM in components can be provided
- It is widely used (MACC, various other EU IPs, AQMEII) we can claim it is state of the art – used by basically all model groups in Europe!
- In MACC-II we hope to work on updating of temporal profiles, inclusion of 2008-2010, and improved shipping emissions

- At various degrees we are actively involved in using satellite data for emission verifications (NO2, SO2, NH3, PM)
- Often focussing on trends or spatial patterns
- Very interested in the (regional) ICAP work

*Acknowledgements:*

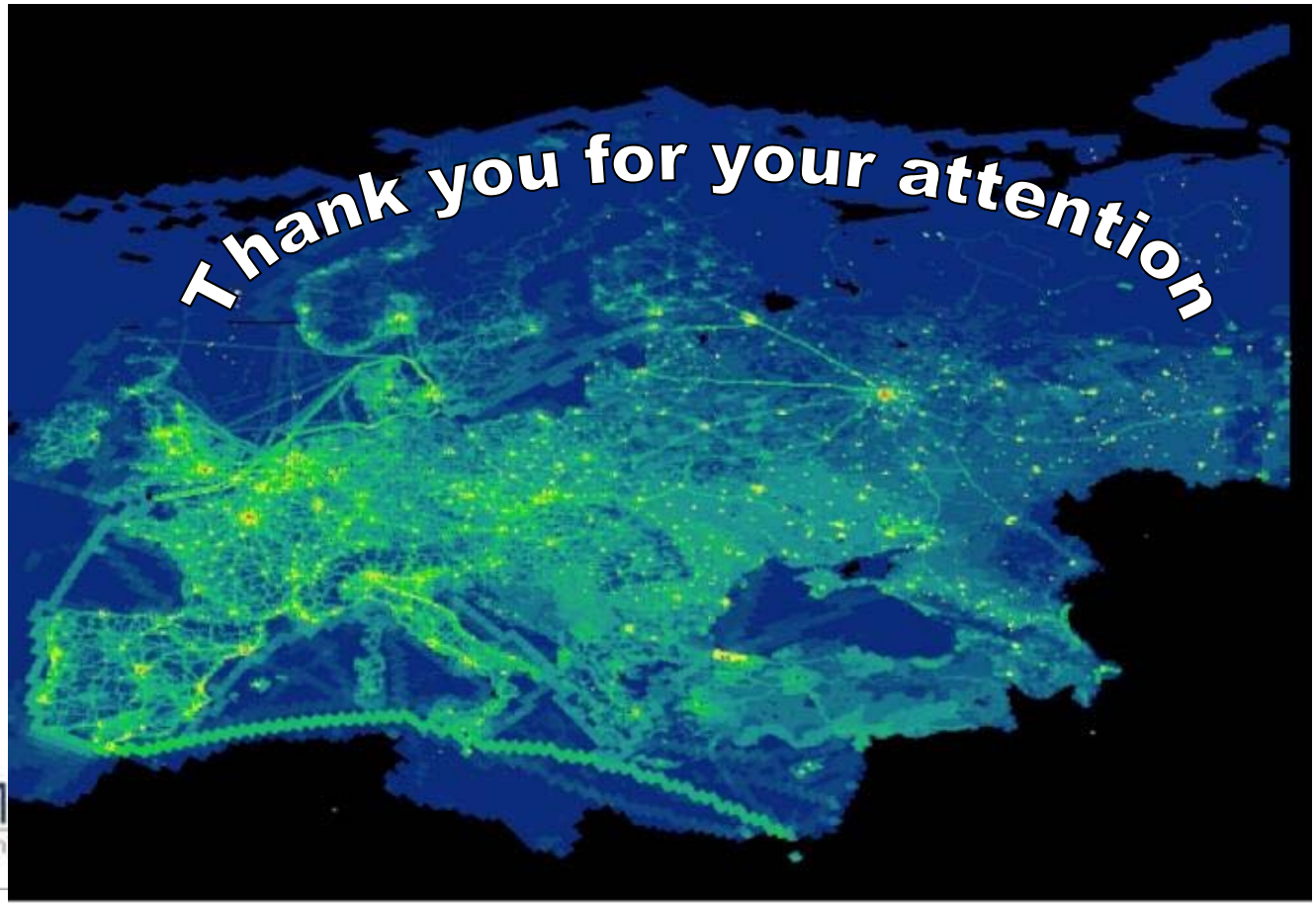
macc Monitoring atmospheric composition & climate

PM PAREST

EUCAARI

MEGAPOLI

TRANSPHORM transport pollution health

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