CONSISTENT BLACK CARBON AND PM INVENTORIES FOR EUROPE

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TNO innovation for life

OUTLINE

- Considerations on BC, EC, PM
- Methodology and result EUCAARI year 2005 OC/EC inventory
- The PM split approach developed for TNO-MACC European emissions data
- Improvements & issues
- Conclusions
- Bonus

CONSIDERATIONS BEFORE….

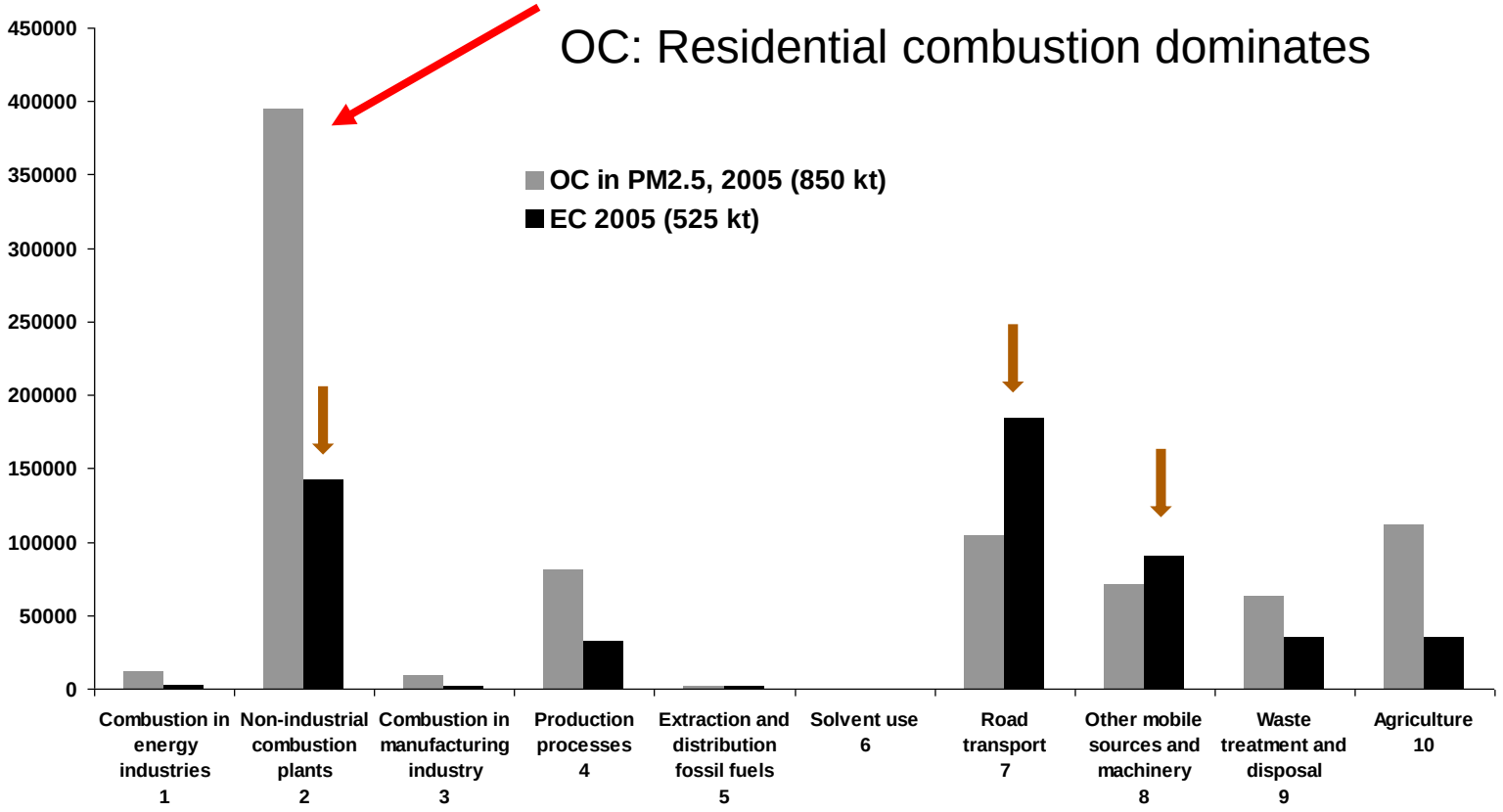
- *elemental carbon (EC)≠ Black carbon (BC) but they are strongly related*
- ***Inventories need completeness!*** *No consistent set of BC emission factors exists for all (major) sources. We make an EC inventory and assume it is suitable for BC studies (at the point of emission, discrepancy is limited)*
- *EC / BC is a fraction of PM10 and PM2.5; all fractions together cannot be more than 1*
- *Focus of legislation, air quality limits and policies is on PM10 and PM2.5*
- *Consistency between BC and PM is important for mitigation and policies (less for climate change research)*

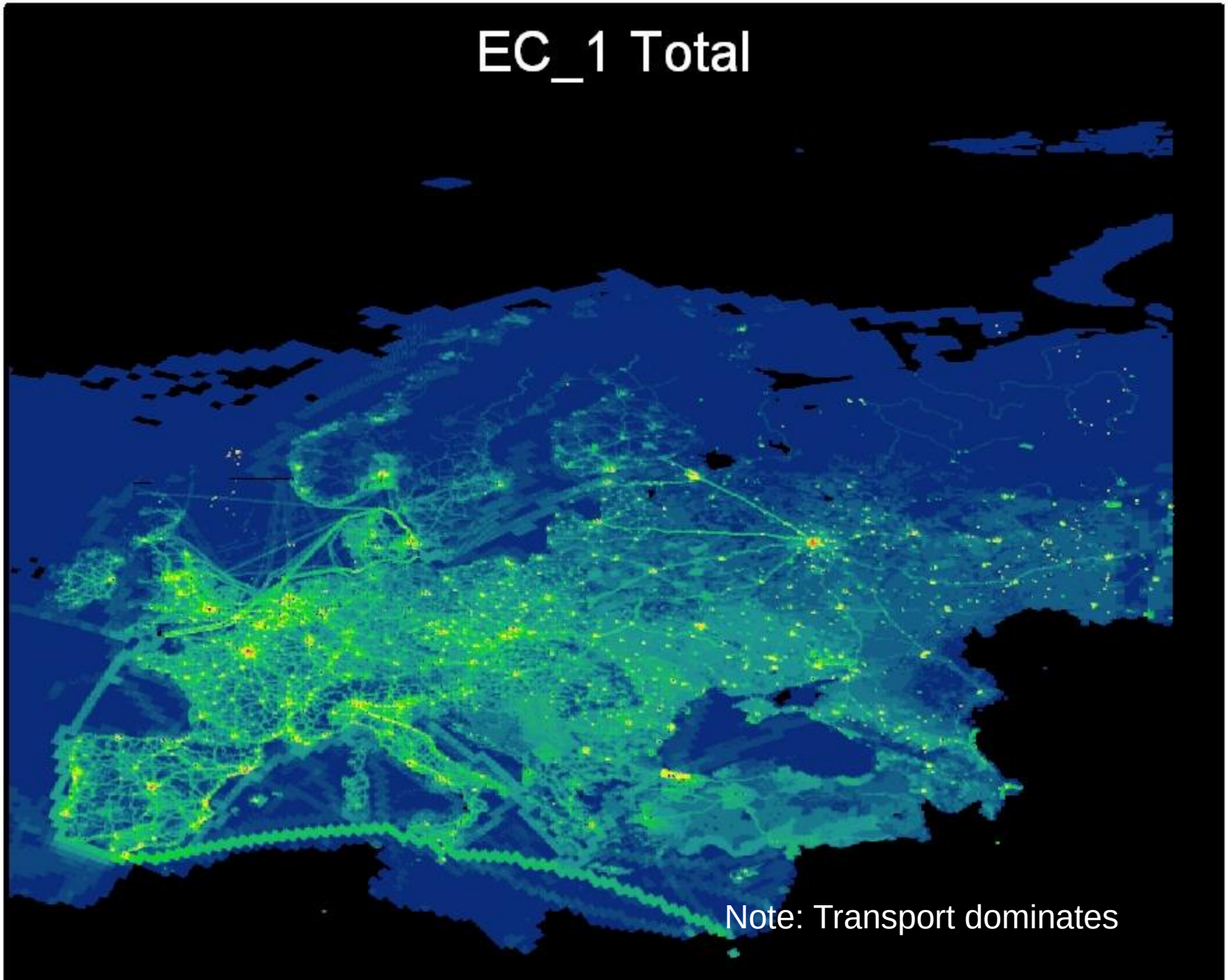
TNO EUCAARI EC/OC INVENTORY FOR YEAR 2005 (2008-2010)
METHODOLOGY – VERY SHORT VERSION

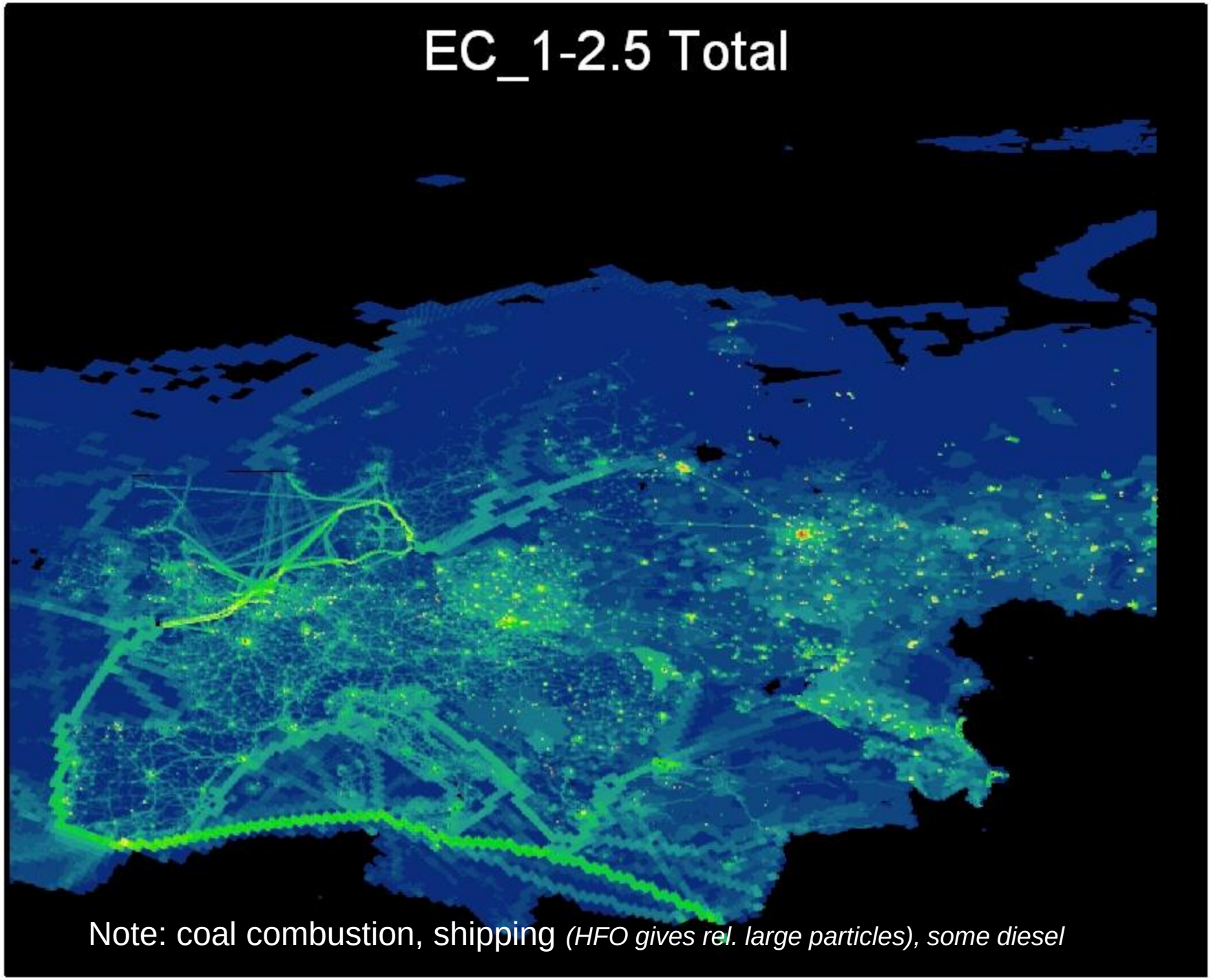
- Using country data or direct Emission factors resulted in large gaps and inconsistencies…..
- Start from IIASA's GAINS PM10/2.5/1 emission inventory
- Deriving representative size-differentiated EC and OC fractions for over 200 source categories using e.g., Kupiainen et al. 2004, Bond et al. 2004; Streets et al. 2001, Schauer et al. 2006 and more….

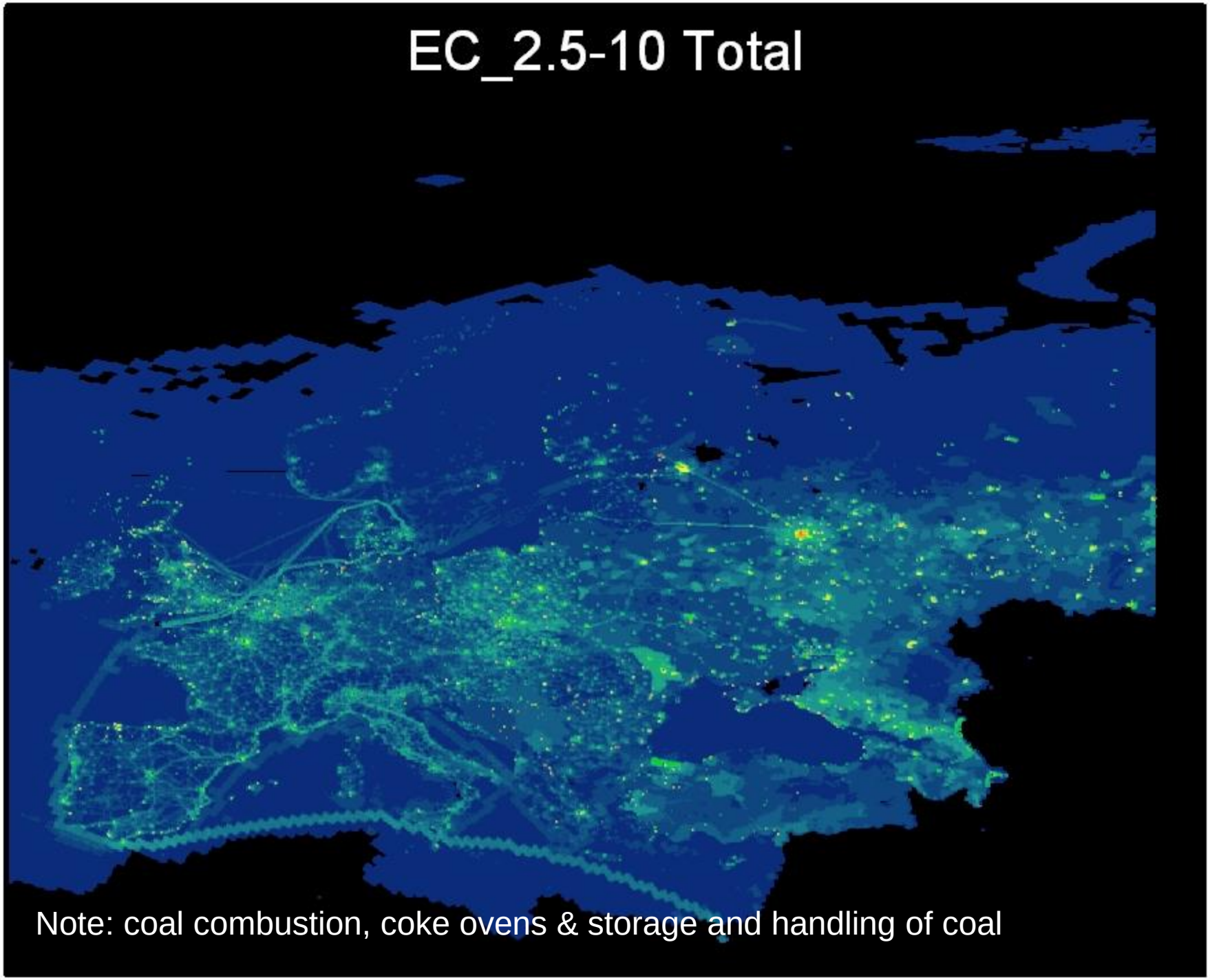
- EC and OC calculated as a share of PM10/PM2.5/PM1 emissions.
  - Constrains EC / OC and
  - Use TNO spatial distribution proxy maps

ANTHROPOGENIC CARBONACEOUS PM EMISSIONS IN EUROPE 2005; TNO EUCAARI EC/OC INVENTORY (KULMALA, 2011)




EC_1 Total
Note: Transport dominates


EC_1-2.5 Total
Note: coal combustion, shipping (HFO gives rel. large particles), some diesel


EC_2.5-10 Total
Note: coal combustion, coke ovens & storage and handling of coal

TNO_MACC-III AIR POLLUTANTS 2000-2011

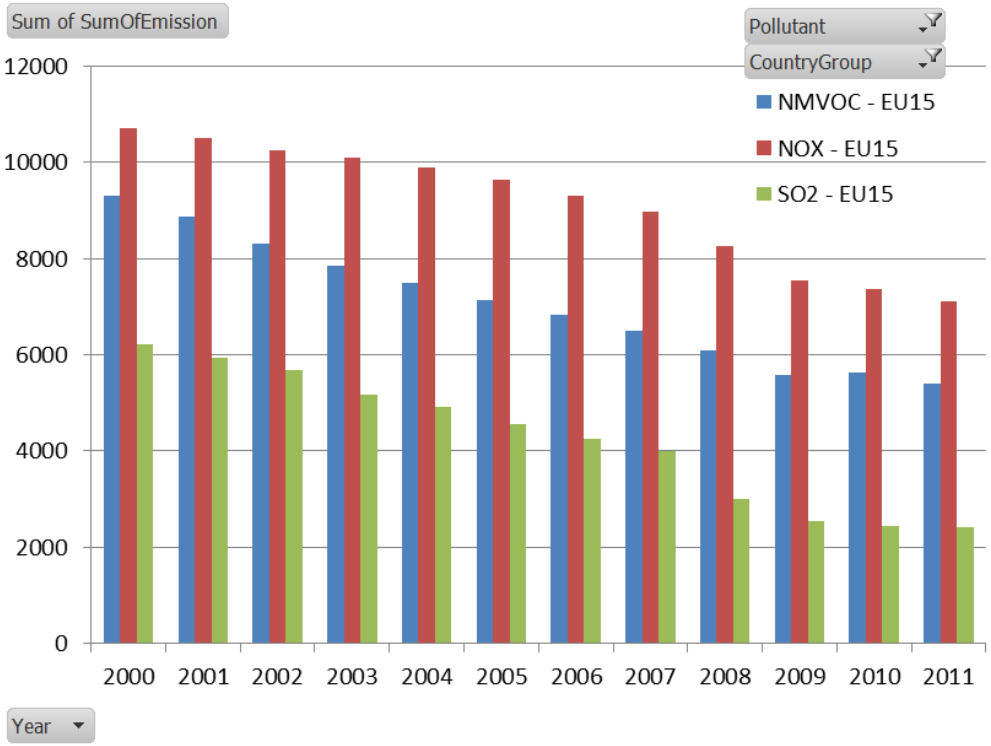
The most used emission inventory for air quality modelling in Europe by

- MACC and CAMS air quality forecasts and re-analysis
- The AQMEII project (JRC – US EPA AQ model Intercomparison Initiative)
- Many individual research teams and policy support studies

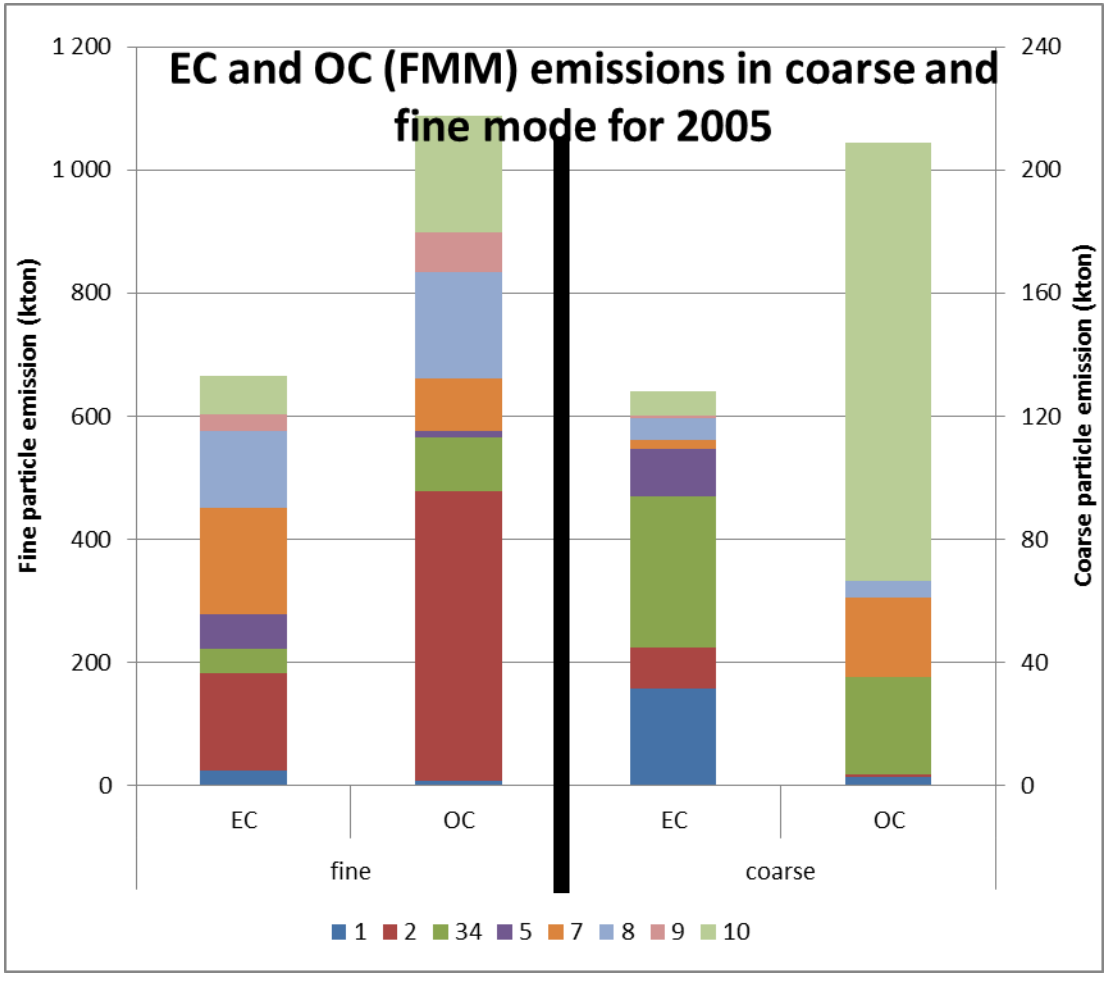
Consistent emission trends 2000-2011

- Individual countries in the EU-15+NOR+CHE; EU-NMS (13); Non-EU
- Largely based on official reported, merged with expert judgement, GAINS, EDGAR

Example EU15:



PM COMPONENTS



SNAP source categories:

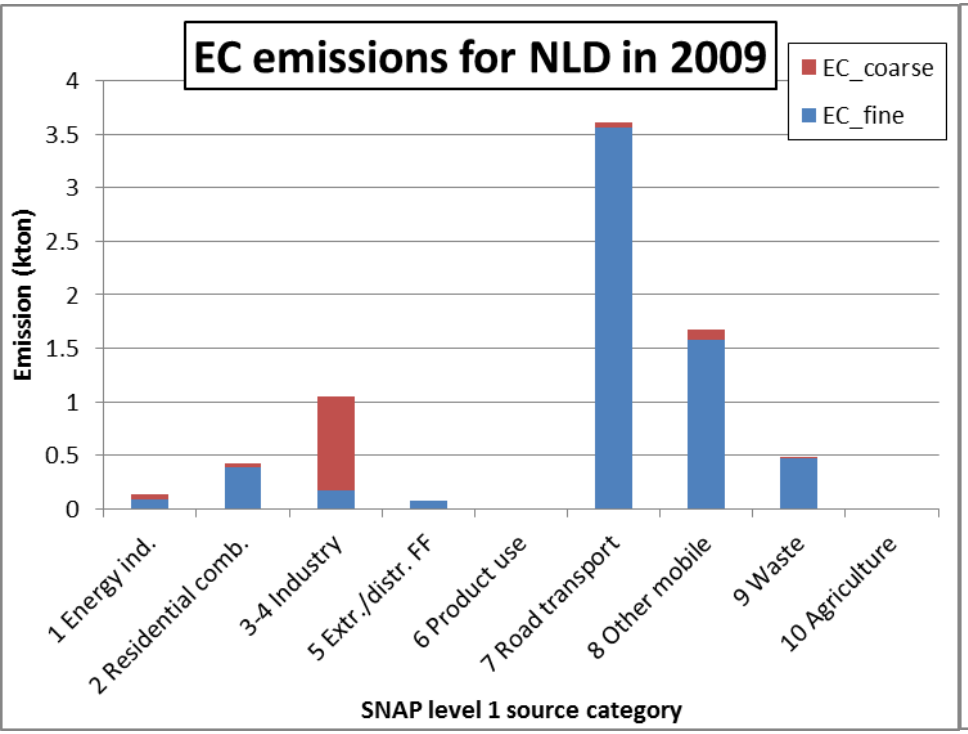
1 energy industry
2 residential combustion
3-4 industry
5 extraction/distribution FF
6 product use
7 road transport
8 other mobile sources
9 waste
10 Agriculture

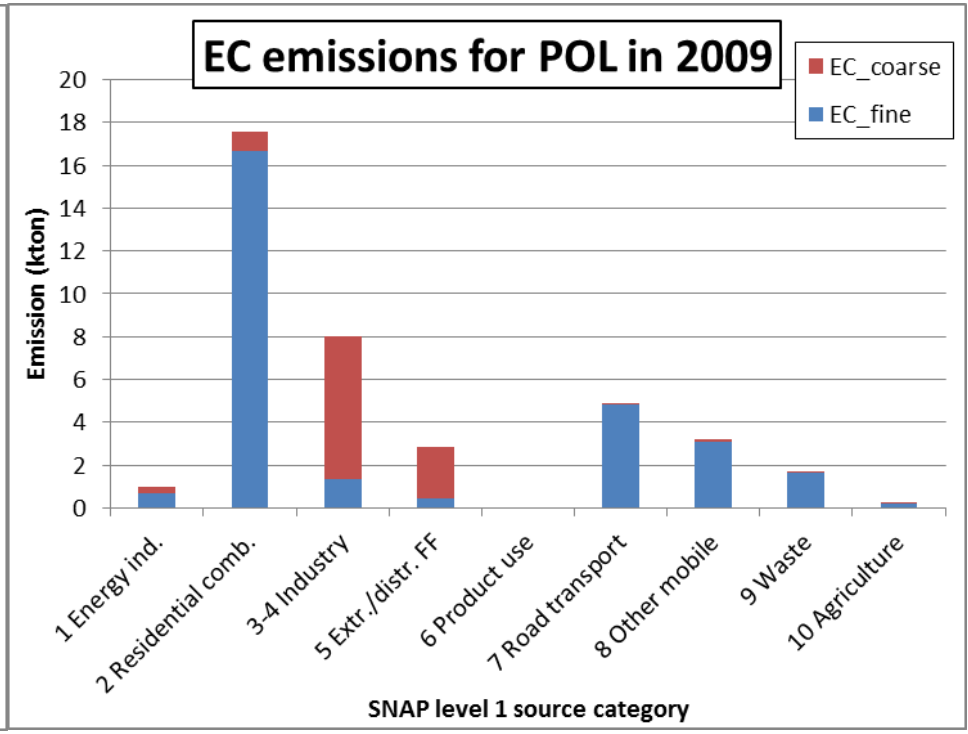
Note different Y-axis scale

- EC_fine = Residential + transport
- EC_coarse = Energy and industry
- The PM split table is “country x source” specific

Example of derived

Elemental carbon emissions by country by sector





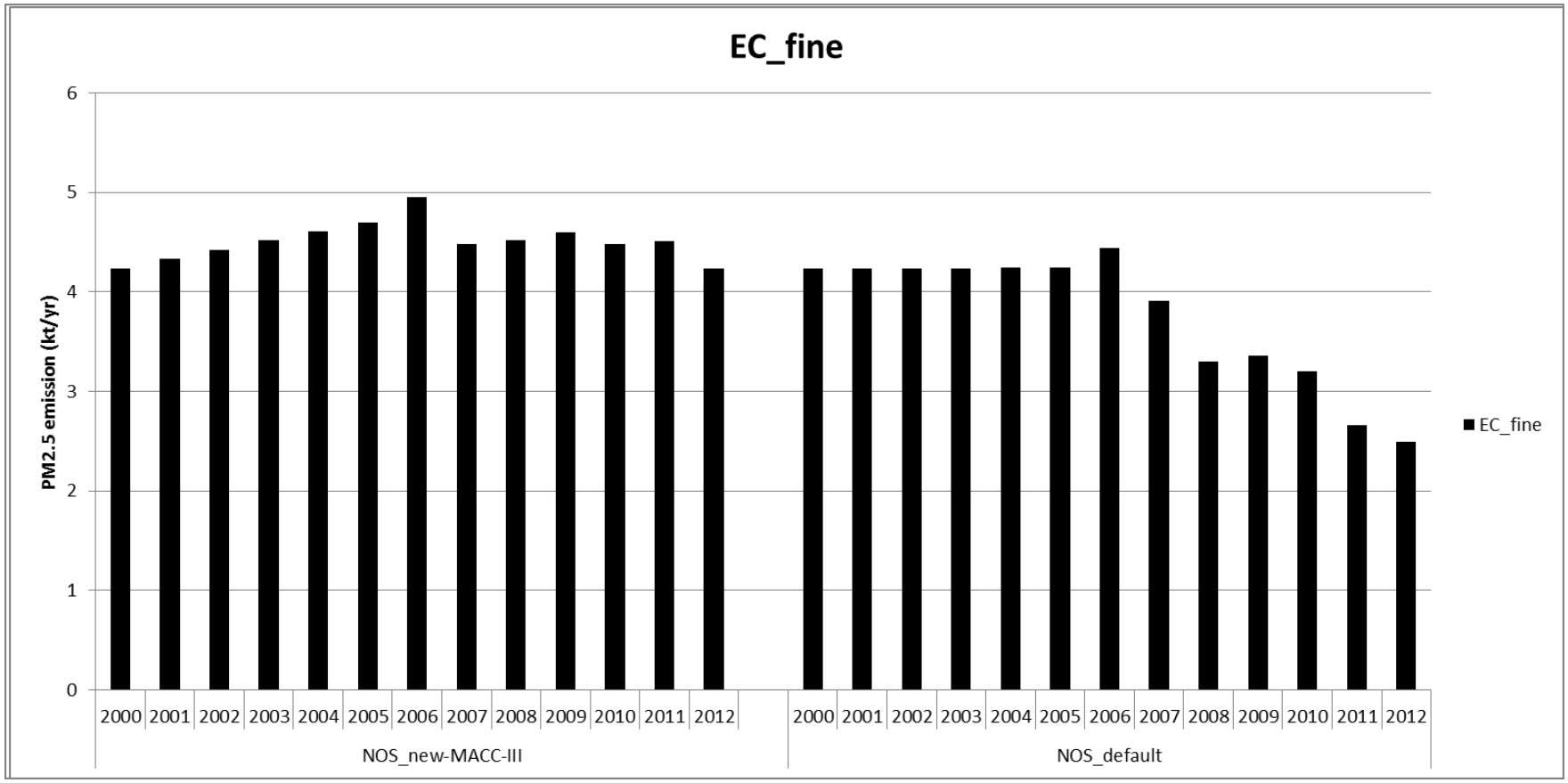
Dominant sources vary by country!
Effective policy in Netherlands addresses road transport,
in Poland focus should be on residential combustion

IMPROVEMENTS AND ISSUES

- Uncertainty in activities, emission factors, allocation
- Fraction of PM versus direct emission factors
- Errors in distribution
- Wrong PM emissions leading to wrong derived EC

THE SULPHUR EMISSION CONTROL AREA (SECA)

Reducing the S-content of heavy fuel oil for shipping on the North Sea and Baltic Sea results in less PM emission



EVALUATION OF THE SIZE SEGREGATION OF ELEMENTAL CARBON (EC) EMISSION IN EUROPE *(Y. CHEN ET AL., ACP, 2016)*

- Comparisons of measured and simulated EC indicated that coarse mode EC (ECc) emitted from nearby point sources is overestimated (factor of 2–10).
- The fraction of ECc was overestimated in the emission inventory by about 10–30% for Russia and 5–10% for Eastern Europe (e.g., Poland and Belarus).

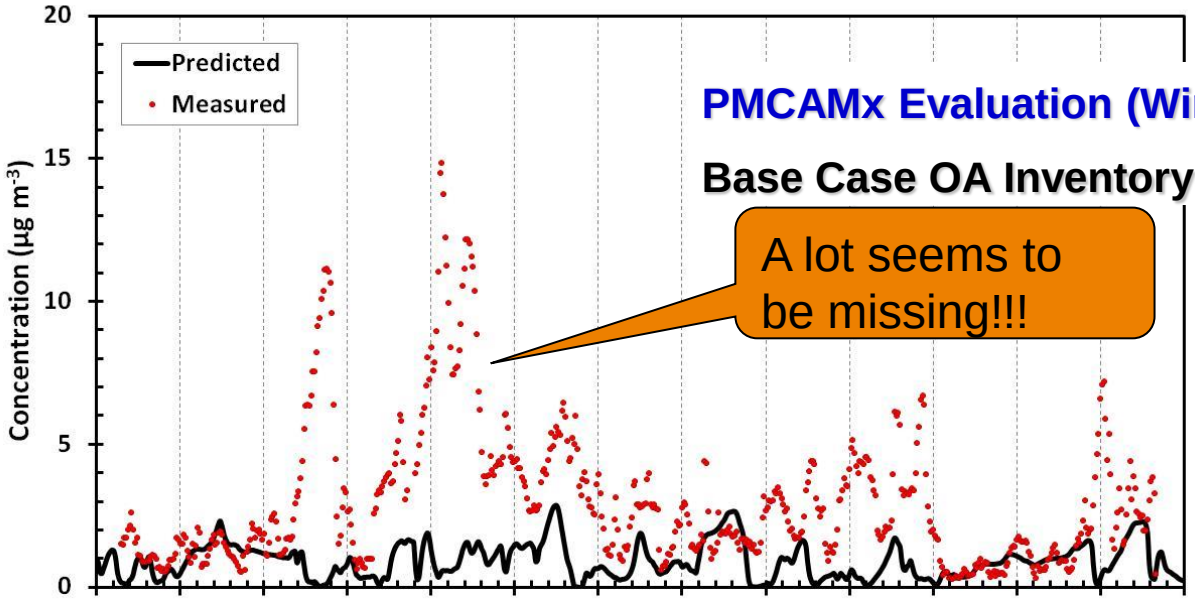
<u>These are ideal starting points for further research!</u>

- Is it an overestimated emission? Or a wrong top-down spatial distribution (as we now know from one of the point sources).
- Is it a wrong size distribution (so total EC is correct but more in fine and less in coarse?) (but part of EC coarse is not combustion but wind blown and resuspended (coal)dust.

Chen, Y., Cheng, Y.-F., Nordmann, S., Birmili, W., Denier van der Gon, H. A. C., Ma, N., Wolke, R., Wehner, B., Sun, J., Spindler, G., Mu, Q., Pöschl, U., Su, H., and Wiedensohler, A.: Evaluation of the size segregation of elemental carbon (EC) emission in Europe: influence on the simulation of EC long-range transportation, ***Atmos. Chem. Phys., 16, 1823-1835****, doi:10.5194/acp-16-1823-2016, 2016.*

RETHINKING PM FROM WOOD COMBUSTION?

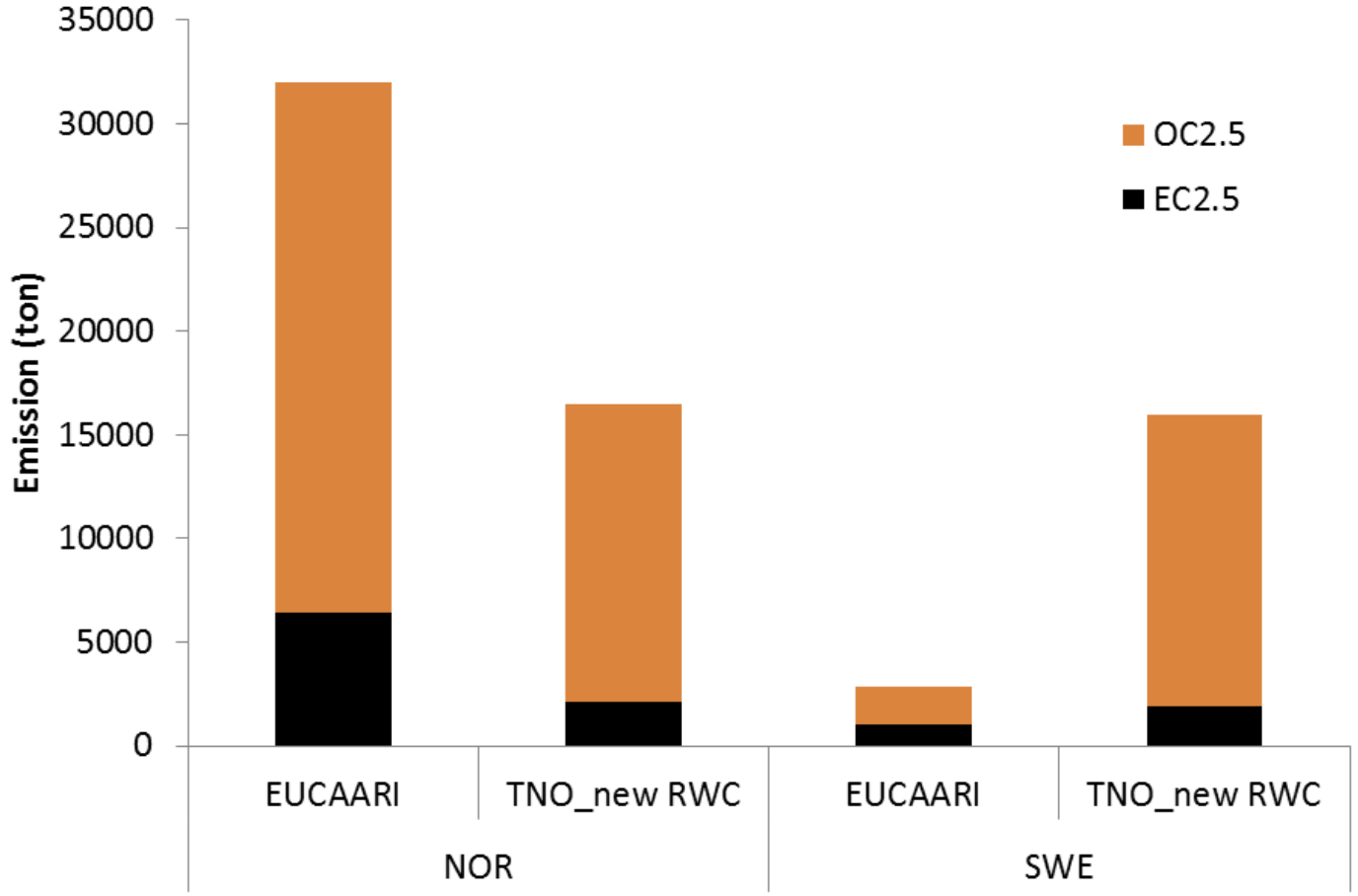
- In 2010 good results EUCAARI EC / OC inventory but….major model vs observed discrepancies during episodes influenced by residential wood combustion (RWC).



Similar performance in e.g. Payerne, Melpitz

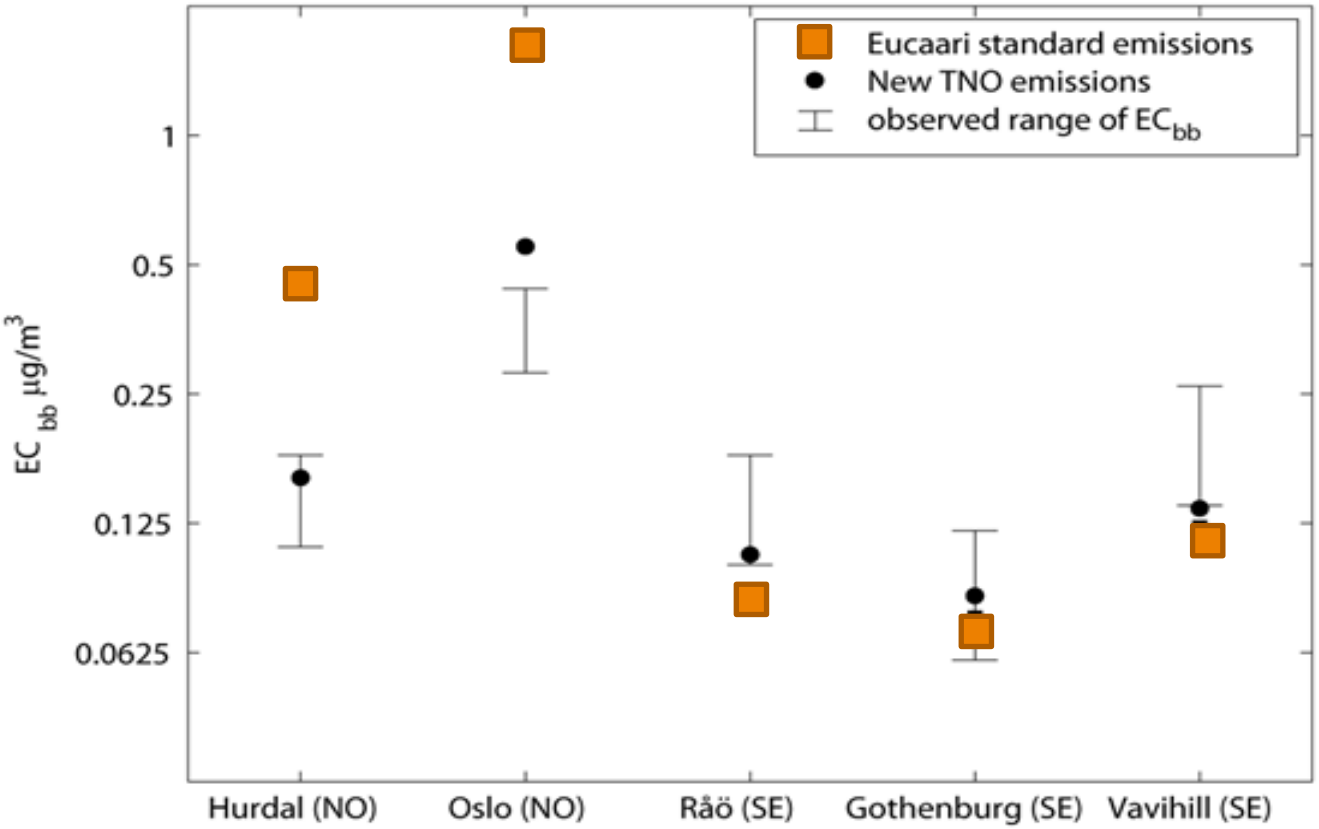
Regional CTMs have a problem with mass closure for PM – mostly an "OC problem". At the time we thought the VBS approach would solve it, now we see it helps but there is still a substantial gap, especially close to the sources……

NORWAY & SWEDEN TOTAL RWC EMISSIONS YEAR 2005



Source Denier van der Gon et al., Atmos. Chem. Phys., 15, 6503-6519, 2015

BIOMASS BURNING EC (ECBB) FROM WINTER TIME SOURCE APPORTIONMENT STUDIES IN SCANDINAVIA COMPARED TO MODEL CALCULATIONS USING DIFFERENT EMISSION INVENTORIES.



Bars represent 10th and 90th percentiles of observed EC from biomass burning. Note the logarithmic scale on the y-axis.

Source: Genberg et al., Atmos. Chem. Phys., 13, 8719-8738, 2013

BONUS....

R. Timmermans, R. Kranenburg, C. Hendriks M. Schaap, H. Denier van der Gon (*TNO*)
Qiang Zhang (*Tsinghua University*)

马可·波罗 MARCOPOLO

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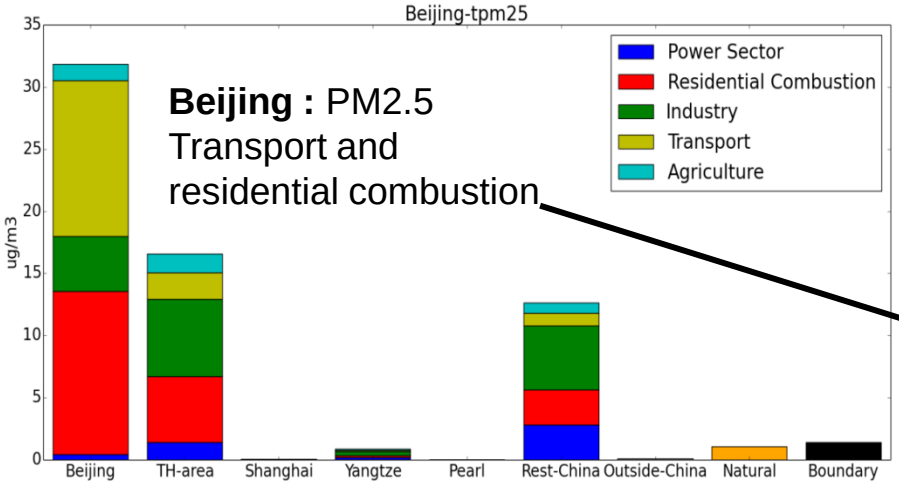
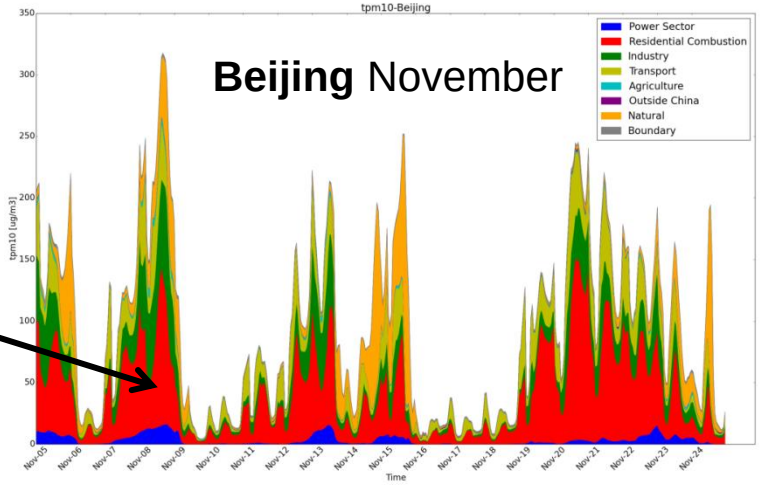
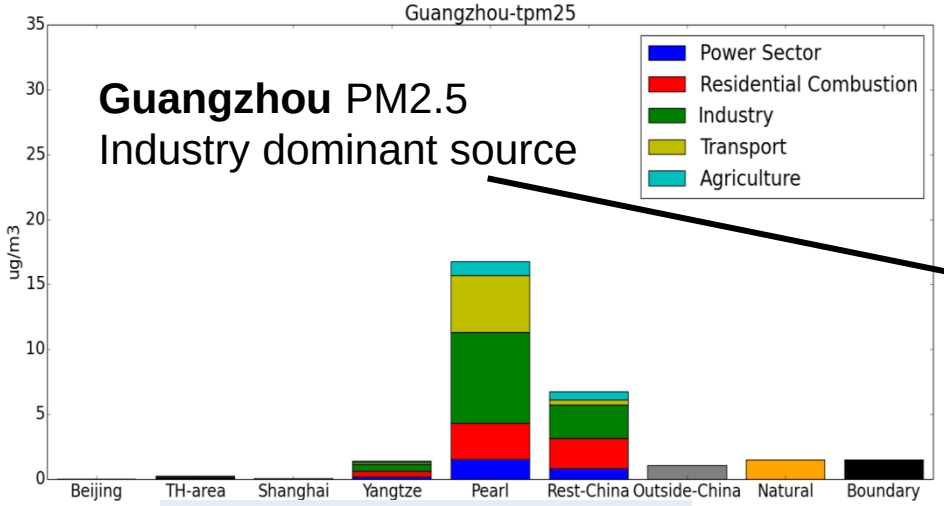
SOURCE ATTRIBUTION OF PARTICULATE MATTER IN CHINESE CITIES



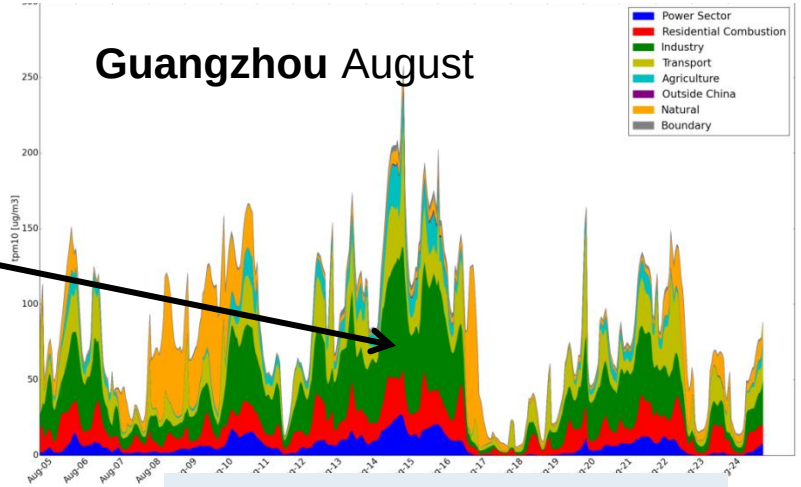
Beijing : PM2.5
Transport and
residential combustion



Beijing November



Guangzhou PM2.5
Industry dominant source



Guangzhou August

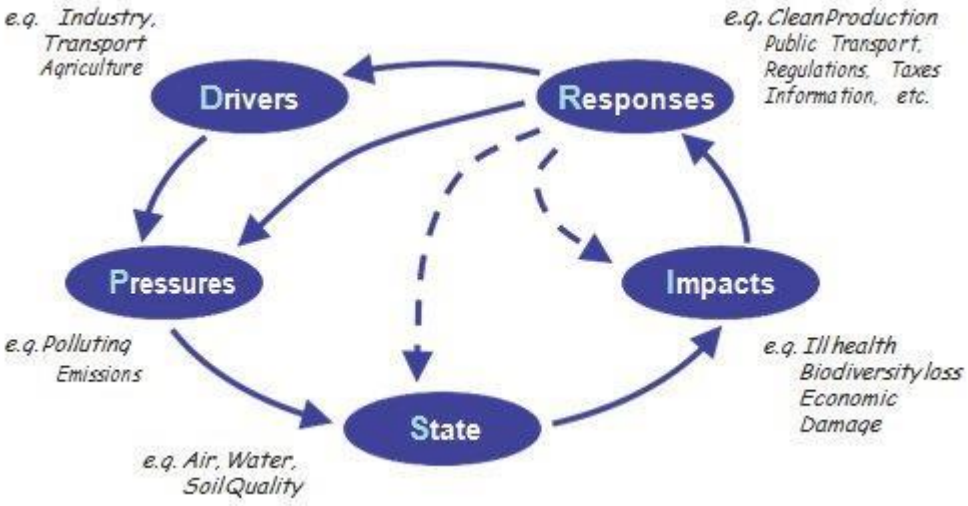
Annual average PM2.5

Episodes of high PM2.5

Acknowledgements – this research was partly funded by EU-FP7 project MARCOPOLO

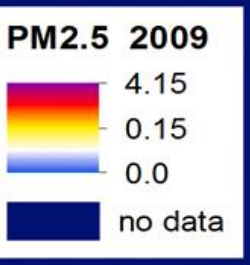
CONCLUSIONS

- **Measurements are essential** – they tell us the “STATE” of our environment
- It is monitoring and the “thermometer” – is the patient getting worse or better?



- **But mitigation will always be at the sources!**
- Close cooperation between measuremetns, modellers and inventory compilers is needed to understand the observed concentrations, predict developments and advice on effective strategies. This needs “cyclic” research.

Thank you for your attention



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Acknowledgements

EMEP-CEIP
IIASA GAINS
JRC EDGAR

EUCAARI

macc Monitoring atmospheric composition & climate

SEVENTH FRAMEWORK PROGRAMME