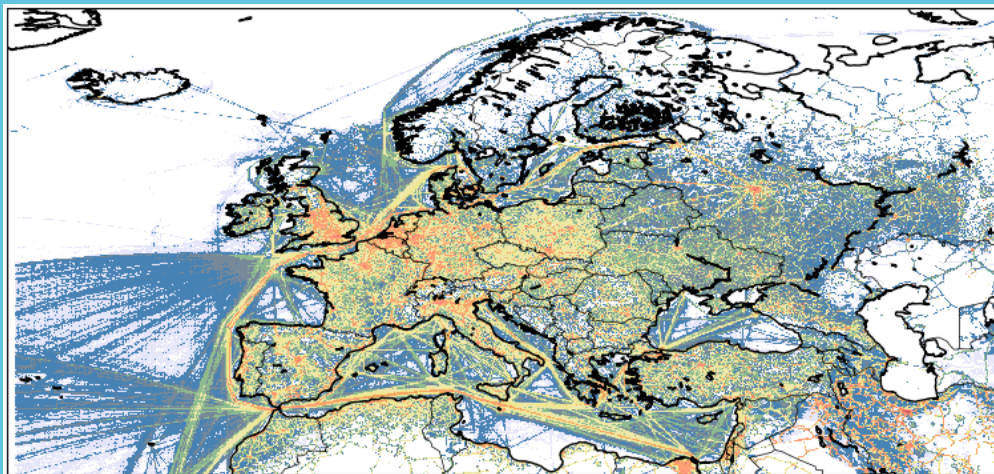




Atmosphere Monitoring



CAMS European emissions

Development and applications of emissions data in
CAMS and beyond

presented by Jeroen Kuenen (TNO)





OUTLINE

- Introduction to CAMS-REG (European) emissions
 - Some analysis of emission data done under CAMS
- What are emissions data used for in CAMS?
- Application of emissions data



Atmosphere

Mo

HISTORY

History

1. TNO-MACC 2003-2007 (not CO₂)
2. TNO-MACC-II (2003-2009) (not CO₂)
3. TNO-MACC-III (2000-2011) + CO₂
4. *No more updates provided until the start of CAMS emissions project (CAMS_81)*



CAMS_81 started Sept 2017

Policy (related) use

1. Input for MACC/CAMS AQ forecasts over Europe + reanalysis
2. Input for national AQ forecasts and research –often use national emission data but need the outside domain; list of users very long!
3. Benchmark for other initiatives

Deliverables (Short-term)

Done by

D81.1.1.1 Regional emissions for 2015

March 2018

D81.1.1.2 European emissions time series 2000-2015

Sept 2018

D81.1.1.1 Regional emissions for 2016

March 2019



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METHODOLOGY IN A NUTSHELL

Official reported
emissions
(CEIP/UNFCCC)

GAINS & EDGAR
emission datasets

TNO internal
estimates

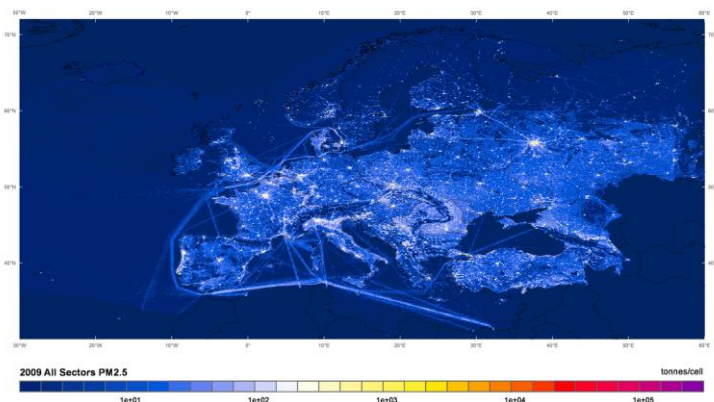
~ 250 subsectors:
aggregated CRF/NFR
with fuel splits

CAMS_81
emissions by
subsector

Shipping grids (*FMI*)

Spatial proxies
(*TNO*)

- Inland shipping
- Agricultural waste burning
- Modifications for agriculture, road transport



CAMS_81 regional
emission product

TNO

ECMWF Copernicus
Europe's eyes on Earth

European
Commission



EUROPEAN DOMAIN

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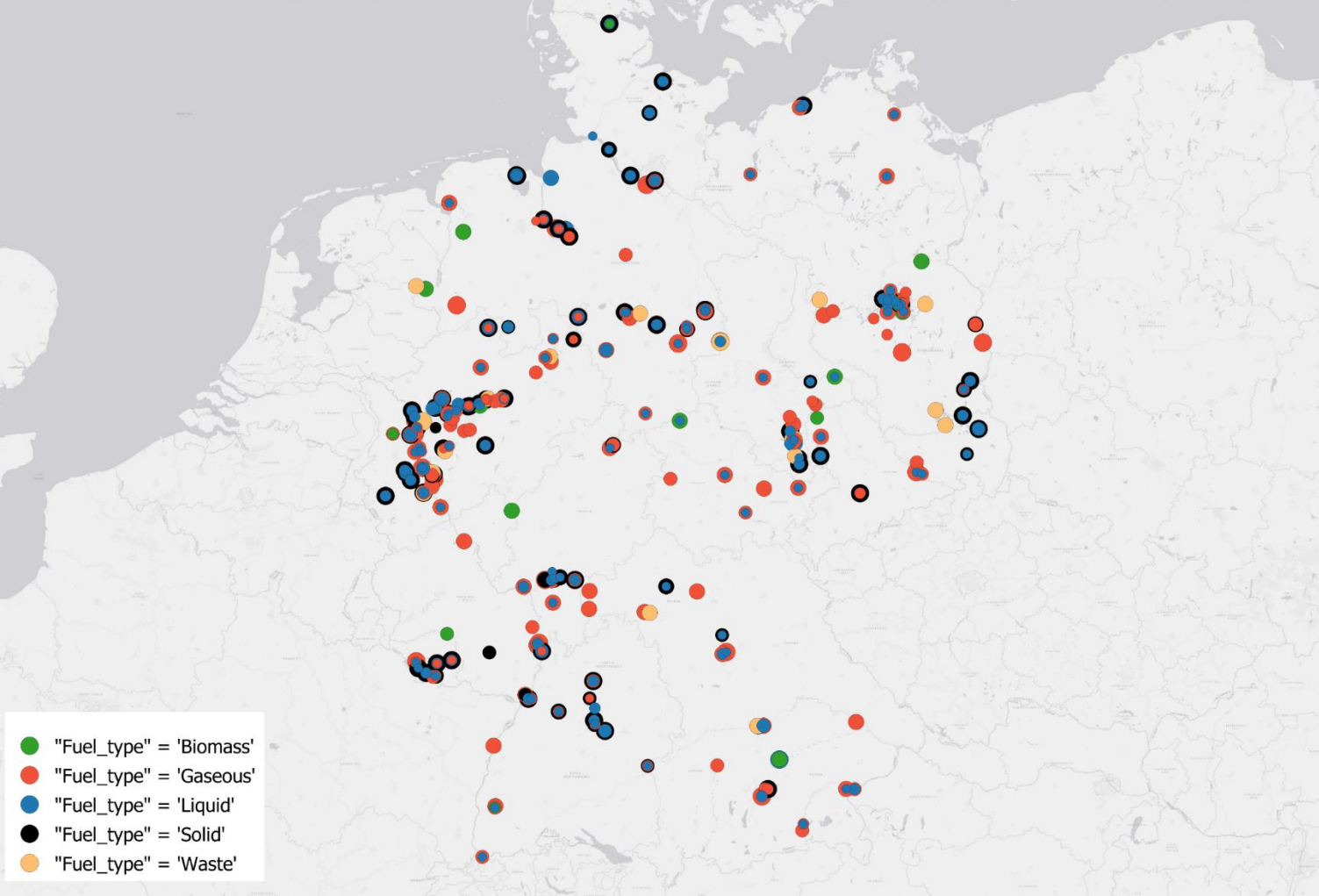




SPATIAL DISTRIBUTION (latest version)

GNFR	Key spatial proxies used	Detail / Comment
A_PublicPower	Own point source database developed based on E-PRTR / LCP / CARMA	"Remaining" emissions distributed using CORINE industrial area
B_Industry	E-PRTR reporting	"Remaining" emissions distributed using CORINE industrial area
C_SmallComb	Population density; for wood specific proxy derived based on availability of wood & heating demand	
D_Fugitives	Own point source databases	
E_Solvents	Population / CORINE industrial area	
F_RoadTransport	Open street map / Open transport map	Fleet distribution over vehicle types / road types obtained from EMISIA
G_Shipping	AIS based shipping tracks (FMI)	Existing TNO map used for inland shipping
H_Aviation	Specific locations of airports	Point source data
I_OffRoad	Rail network; population density	CORINE Arable land, industrial area for agri/industrial off-road
J_Waste	Point sources: WWTPs (EEA), own point source database for waste incineration plants	Population/industrial area for non-PS
K_AgriLivestock	Gridded livestock (FAO)	
L_AgriOther	Arable land (CORINE)	

CO2 emissions from public power and heat plants in Germany, by fuel type and emission quantity



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DATASETS

Pollutants covered:

- AP version: NO_x, SO₂, NMVOC, CO, NH₃, PM₁₀, PM_{2.5}, CH₄
- GHG version: CO₂_ff, CO₂_bf, CH₄

Dataset	Resolution	Sector classification	Year(s) covered	Version released	Availability
CAMS-REG-v1.1	0.125° x 0.0625°	SNAP (13 sectors)	2015	April 2018	Open
CAMS-REG-v2.2.1	0.1° x 0.05°	GNFR (15 sectors)	2000-2015	December 2018	Restricted (CAMS users), will be public
CAMS-REG-v3.1	0.1° x 0.05°	GNFR (15 sectors)	2016	March 2019	Restricted (CAMS users), will be public

And more is to come in the next years...





GRIDDED DATA

“Smiley table” published by CEIP (most recent for 2018 reporting)

- **Green:** gridded data at $0.1^\circ \times 0.1^\circ$ for at least 4 years reported
- **Yellow/orange/blue:** only a part of the required data reported, or not in time
- **Red:** no gridded data reporting at all

To create the “EMEP emissions”, CEIP performs some basic gapfilling for missing countries/years as needed, the results are provided to MSC-W/MSC-E, this is input for the S/R calculations

Note that:

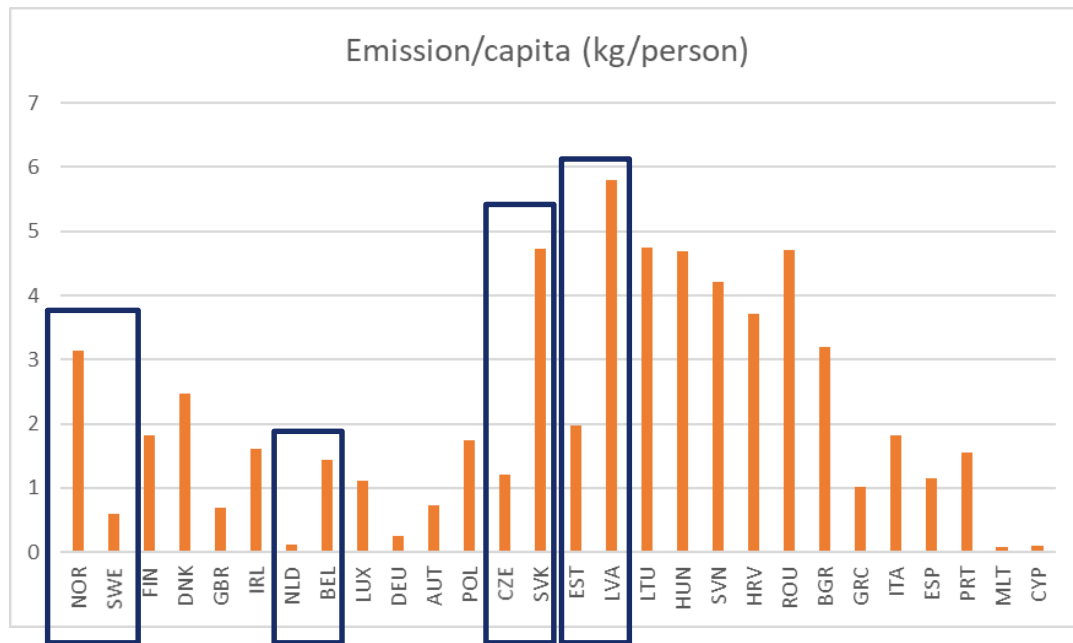
- Completeness: green means 4+ years of gridded data while CAMS needs annual data from 2000 onwards
- Even when all is reported, consistency at borders and comparability between countries are potential issues

	NECD					Gridded data	CLRTAP					Gridded data
	Timeliness	Completeness	IIR	Projections	LPS		Timeliness	Completeness	IIR	Projections**	LPS	
AL												
AM												
AT												
AZ												
BA												
BE												
BG												
BY												
CA*												
CH												
CY												
CZ												
DE												
DK												
EE												
ES												
EU												
FI												
FR												
GB												
GE												
GR												
HR												
HU												
IE												
IS												
IT												
KG												
KZ												
LI												
LT												
LU												
LV												
MC												
MD												
ME												
MK												
MT												
NL												
NO												
PL												
PT												
RO												
RS												
RU												
SE												
SI												
SK												
TR												
UA												
URS*												



CONSISTENCY IN EMISSION REPORTING

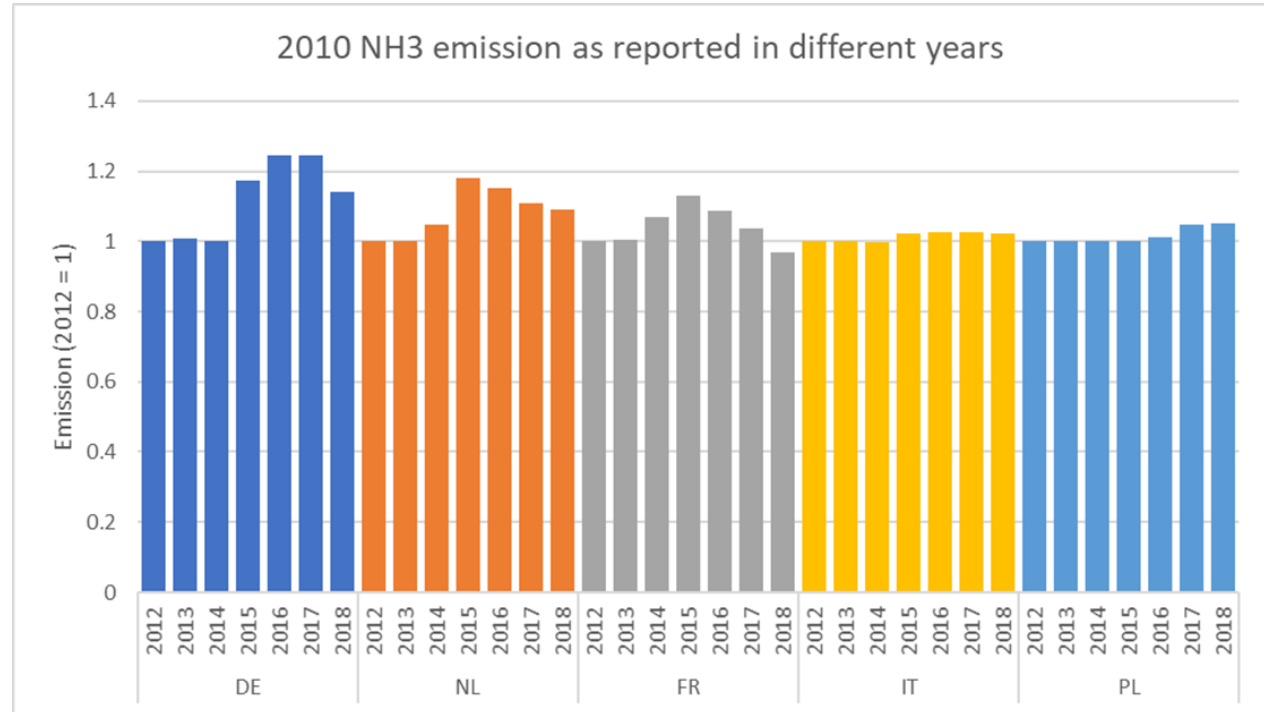
- Consistency remains an issue, also in CAMS-REG inventories
- Example for PM_{2.5} from small combustion activities from CAMS-REG-v2 (latest version)
- Note the differences between:
 - Norway vs Sweden
 - Netherlands vs Belgium
 - Czech Rep vs Slovakia
 - Estonia vs Latvia
- Not the objective of CAMS to harmonize these





CONSISTENCY IN EMISSION REPORTING

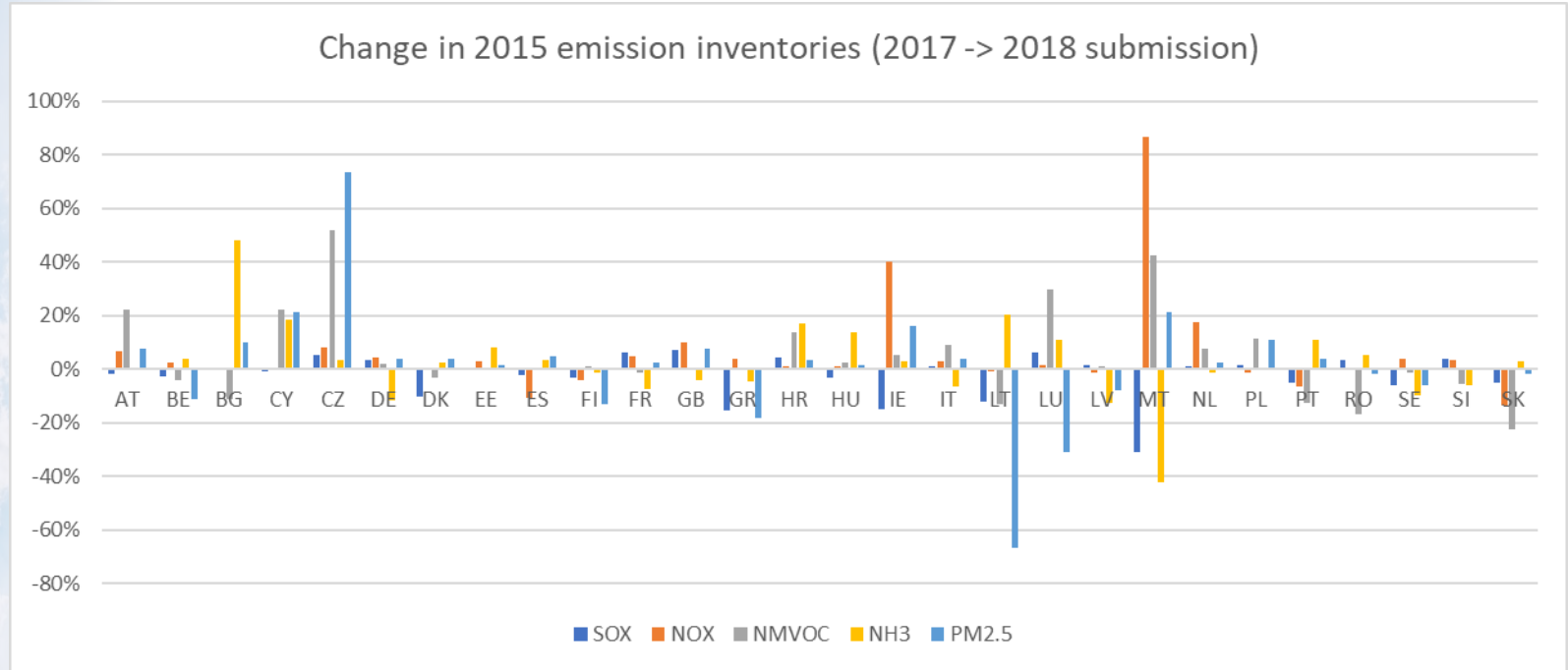
- EMEP emissions are reported by countries every year again
- Methodologies to calculate emissions change over time => progressing science
- This implies that emissions for a given historical year can change considerably from one year to the next





RECALCULATIONS

- Recalculations are still very significant and important to take into account!!!

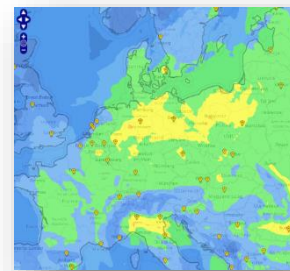
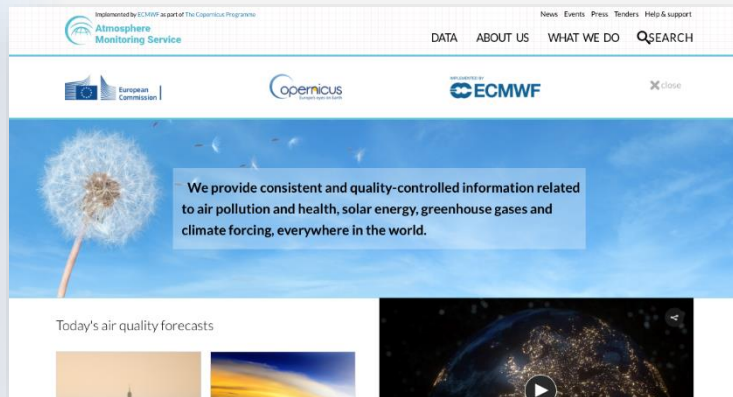


Source: CEIP/reporting 2018 (nat'l totals)



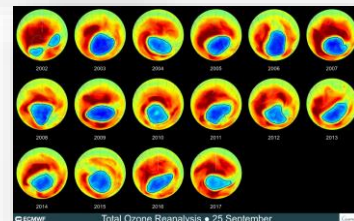
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Monitoring

THE CAMS PORTFOLIO

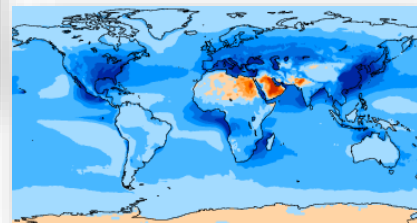


*European Air
Quality and
products in
support of
policy users*

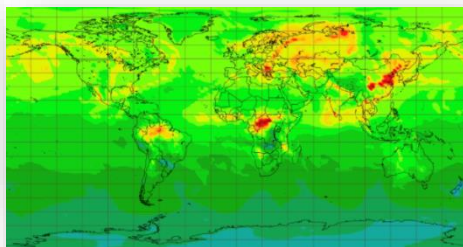
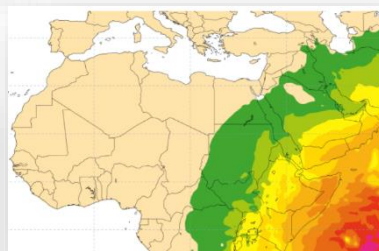
Ozone layer



Climate forcings



*Solar radiation
and UV index*



*Global analyses, forecasts and
reanalyses (2003-...)*

From V-H Peuch, ECMWF



*Bottom-up
emissions and
surface fluxes of
greenhouse gases*

TNO

ECMWF

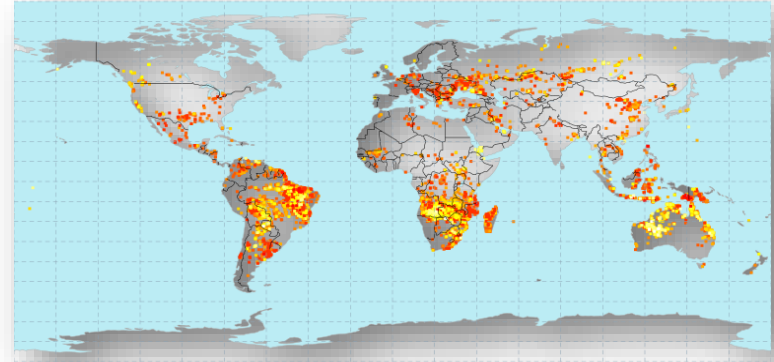
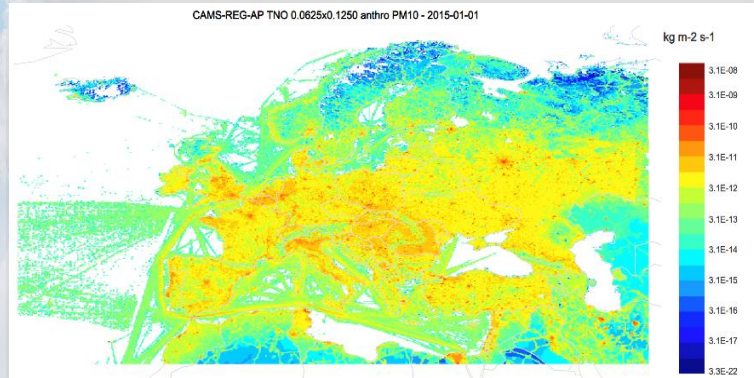
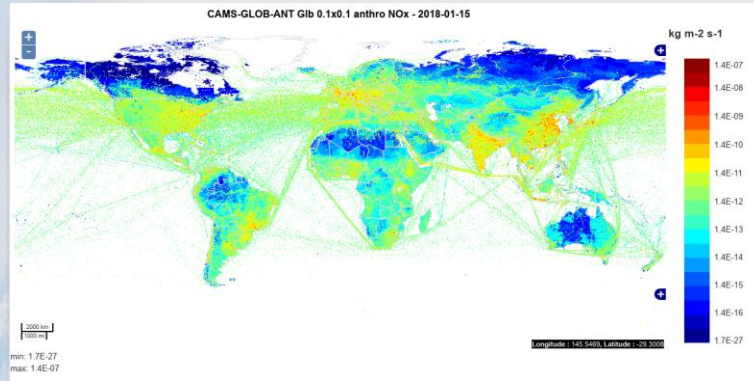
Copernicus
Europe's eyes on Earth

**European
Commission**



Atmosphere
Monitoring

CAMS EMISSION PRODUCTS



- Fire emissions
- Global anthropogenic emissions
- Regional anthropogenic emissions
- Natural emissions

From V-H Peuch, ECMWF

TNO

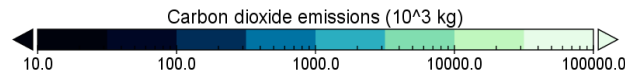
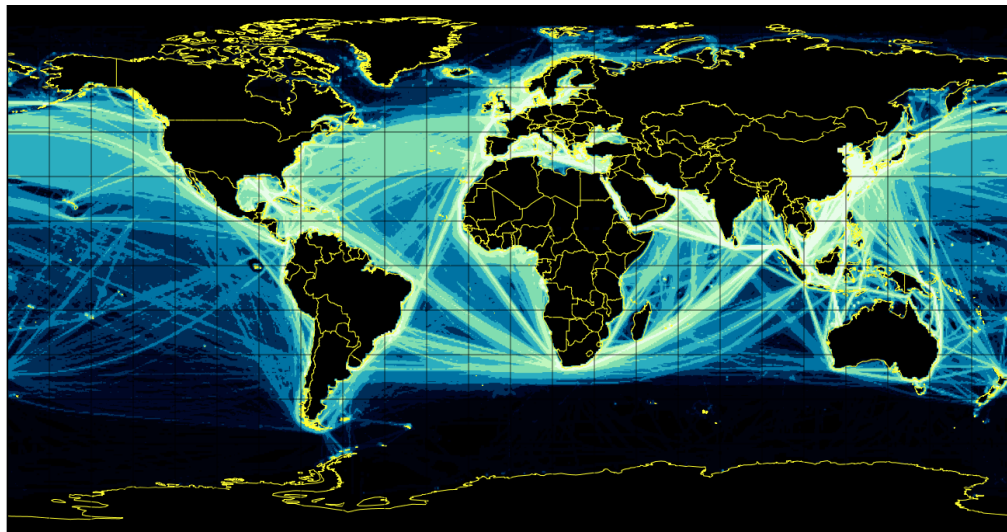
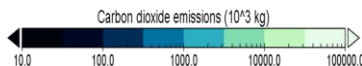
ECMWF Copernicus
Europe's eyes on Earth

 European
Commission



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Monitoring

NEW: CAMS BOTTOM-UP EMISSIONS



Emissions are both an input to CAMS global and regional systems and a popular product. Entirely new datasets have been released covering 2003 to 2019 (extrapolation). Example: CO₂ emissions from shipping activities (provider: FMI, Finland).

From V-H Peuch, ECMWF

TNO

ECMWF Copernicus
Europe's eyes on Earth

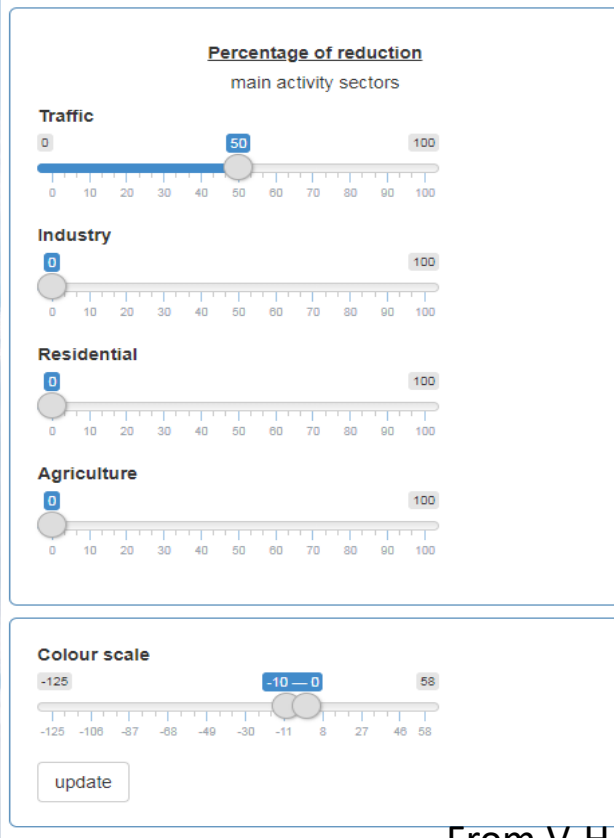
European
Commission



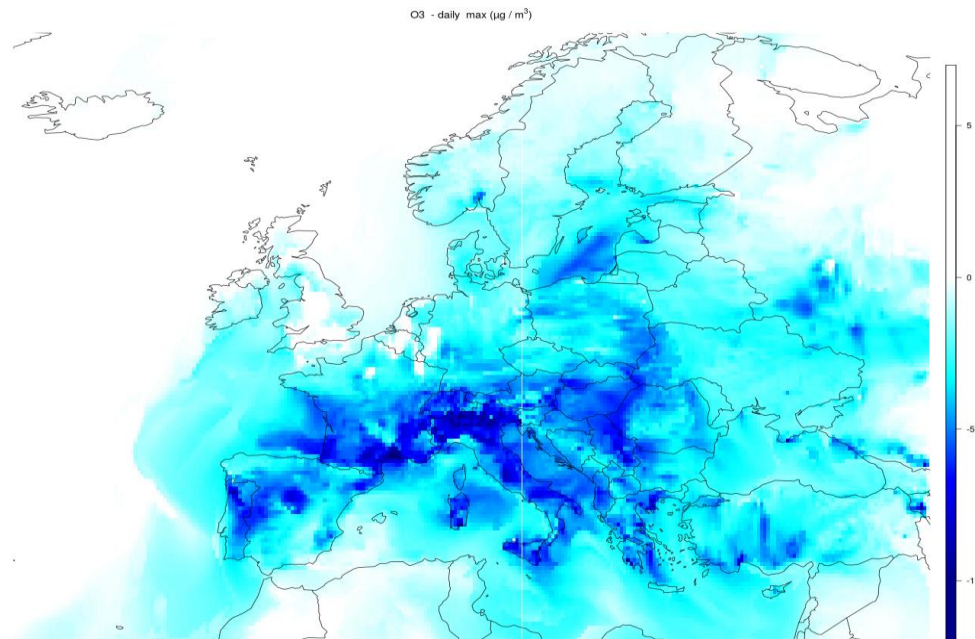
PRODUCTS IN SUPPORT OF POLICY USERS

Atmosphere
Monitoring

Assess the effect of emission reductions on daily forecasts



CAMS_ACT : O3, PM10 (PM2.5 coming)



http://policy.atmosphere.copernicus.eu/CAMS_ACT.html

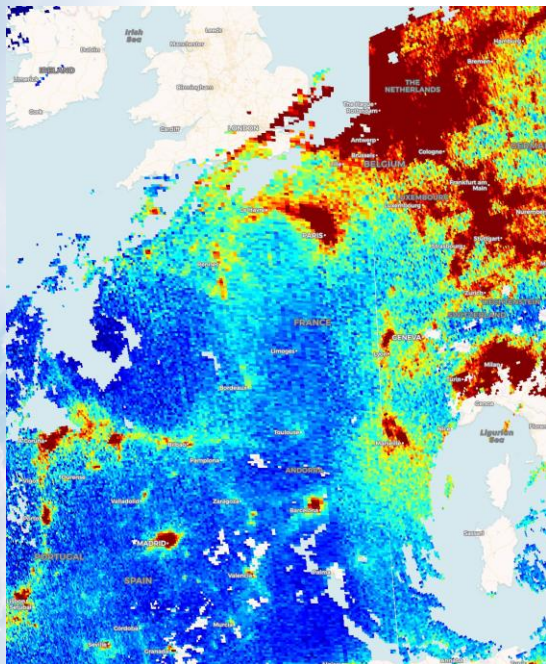
From V-H Peuch, ECMWF

CAMS European emissions





NEW: UPTAKE OF SENTINEL-5P IN CAMS



Example: NO₂ tropospheric column from Copernicus Sentinel-5P (7/10/2018)

Thanks to excellent collaboration with ESA and entities in charge of Level-2 processing, 6 products are now used in the CAMS system (assimilated, monitored or off-line tested).

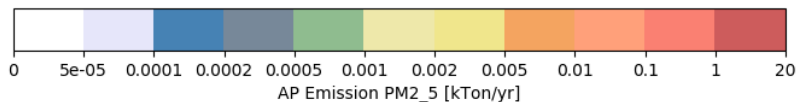
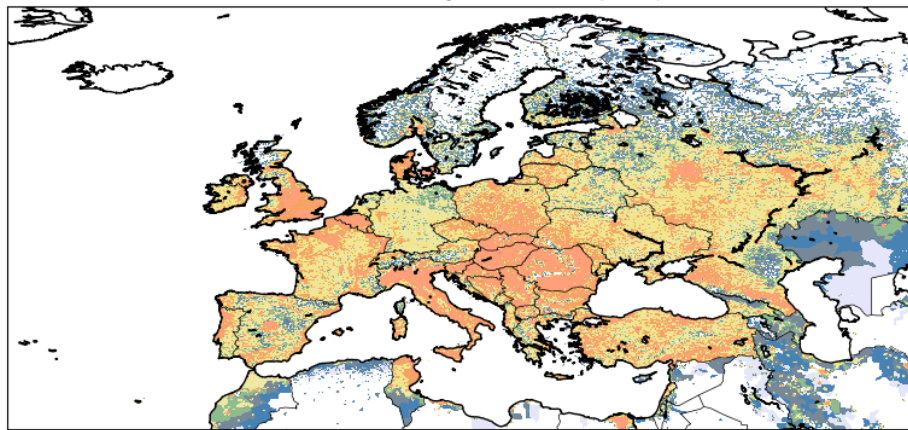
Detailed daily operational statistics are available here:
https://atmosphere.copernicus.eu/charts/cams_monitoring/

Species	Status	Since
Ozone	Operational assimilation	4/12/2018
NO ₂	Operational monitoring	11/07/2018
CO	Operational monitoring	22/11/2018
SO ₂	Operational monitoring	22/11/2018
HCHO	Operational monitoring	22/11/2018
CH ₄	Off-line monitoring	22/11/2018

BEYOND ANNUAL EMISSIONS...

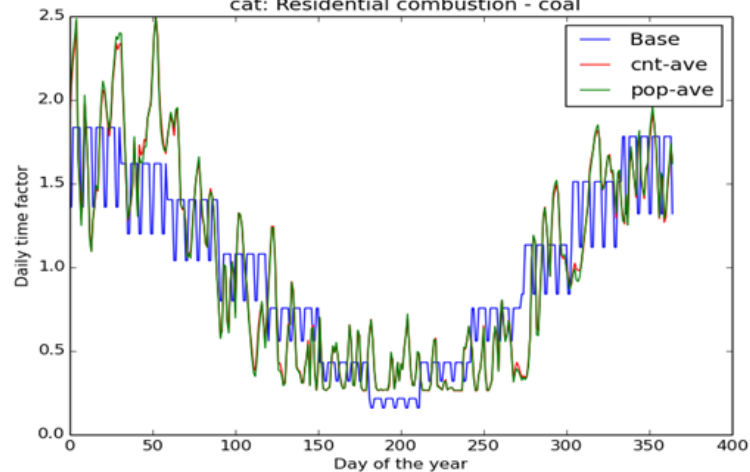
EMISSION MODELLING (IN SPACE & TIME)

C - Other Stationary Combustion (2015)

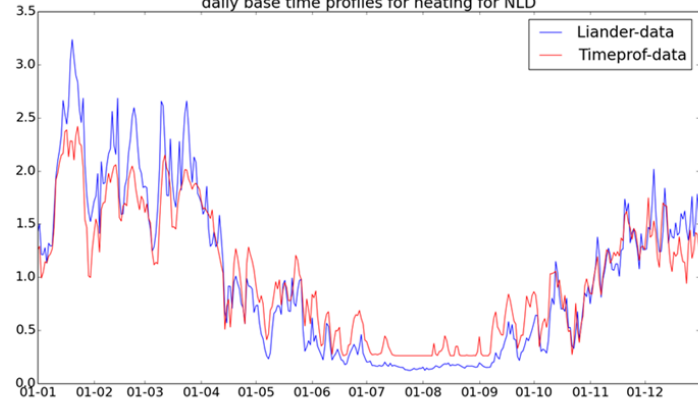


Novel spatial distribution developed for wood use depending on wood “availability” (more use near forests)
Note discrepancies at country borders => artefact of reporting

Timeprofile 2011 DEU
cat: Residential combustion - coal



daily base time profiles for heating for NLD

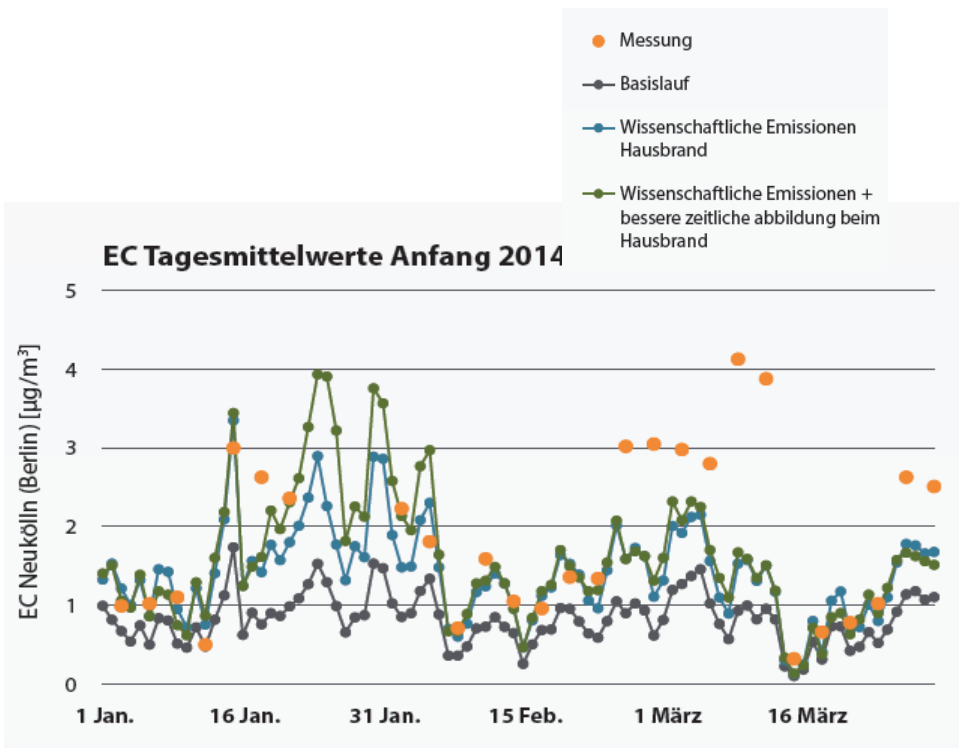


TIMING

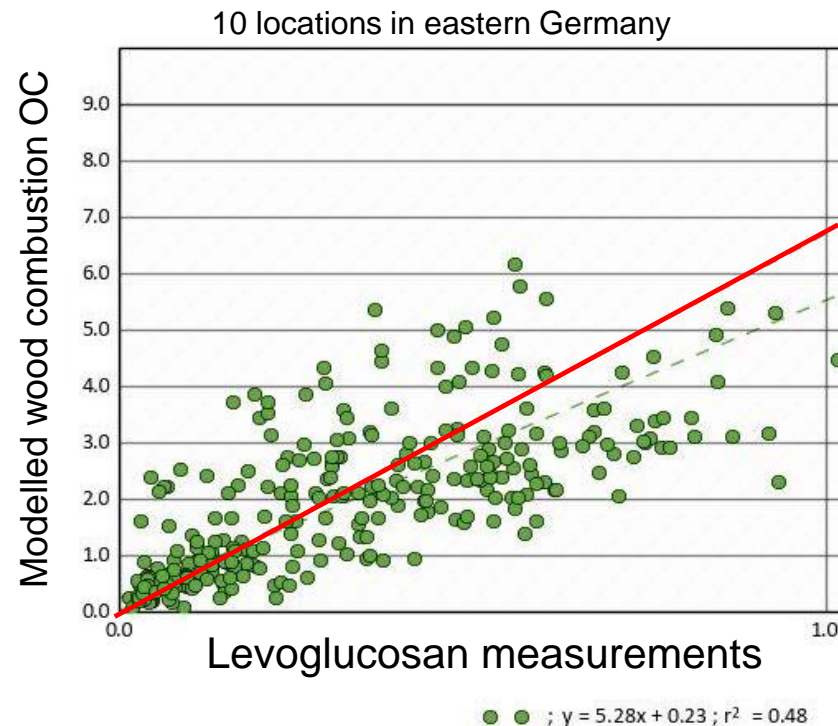
- › Under CAMS emission project, a report on temporal profiles for each sector was published recently
- › This report provides state of the art information on how to break down annual emissions in time (both at global and European level)
- › Useful for TFEIP to refer to these kind of reports for up-to-date information on fine time scale emissions



IMPACT ON MODELLED EC AND OC IN BERLIN AND EASTERN GERMANY

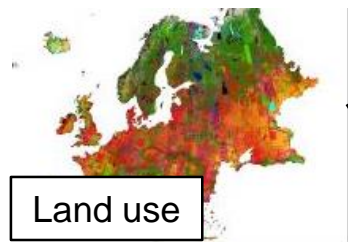
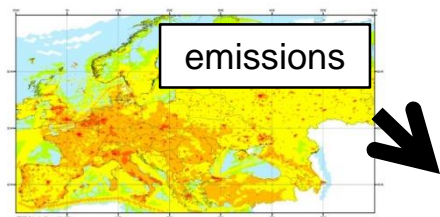


PM source apportionment



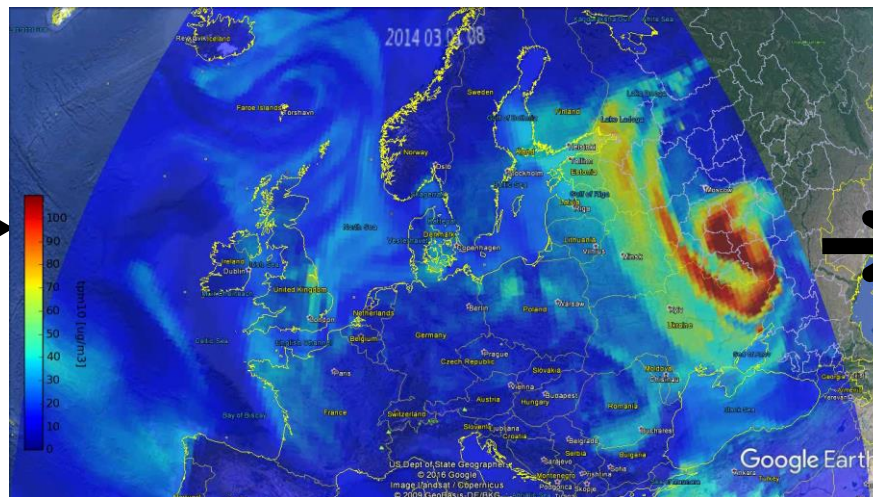
From literature: Levoglucosan : OC = 1 : 6.7 (red line)

CHEMISTRY TRANSPORT MODELS PROVIDE THE LINK BETWEEN EMISSION AND CONCENTRATION



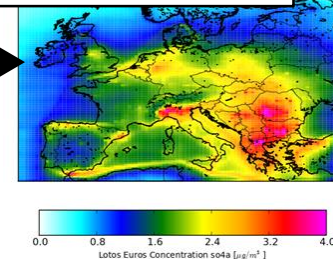
PM source apportionment

The weather and thus pollutant formation and transport are highly variable



Labelling approach to track origin of PM

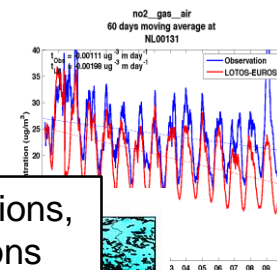
Concentrations,
Depositions



Source
contributions

The Netherlands
- Road transport

Belgium
- Power generation





GOAL OF TOPAS

 <https://topas.tno.nl>

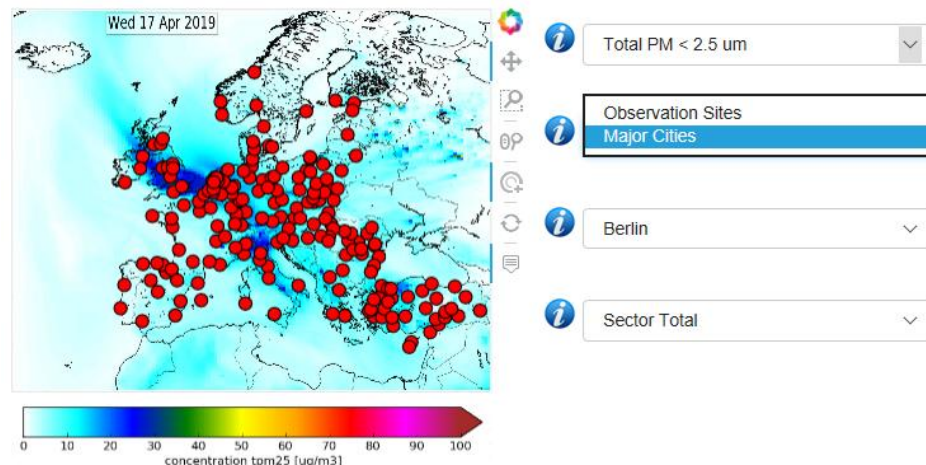
To quantify the origin of air pollution on a daily basis using our latest insights.

The prototype TNO Operational Pollution Apportionment Service (TOPAS) is based on the chemical transport model LOTOS-EUROS with its labeling approach forced by TNO emission information and CAMS products.

TOPAS aims to differentiate the origin of PM in:

- Local contributions
- Source sector contributions
- Transboundary contributions
- Natural contributions

Daily **modelled** PM10/PM2.5 based on hourly model output (model resolution 0.5x0.25°)





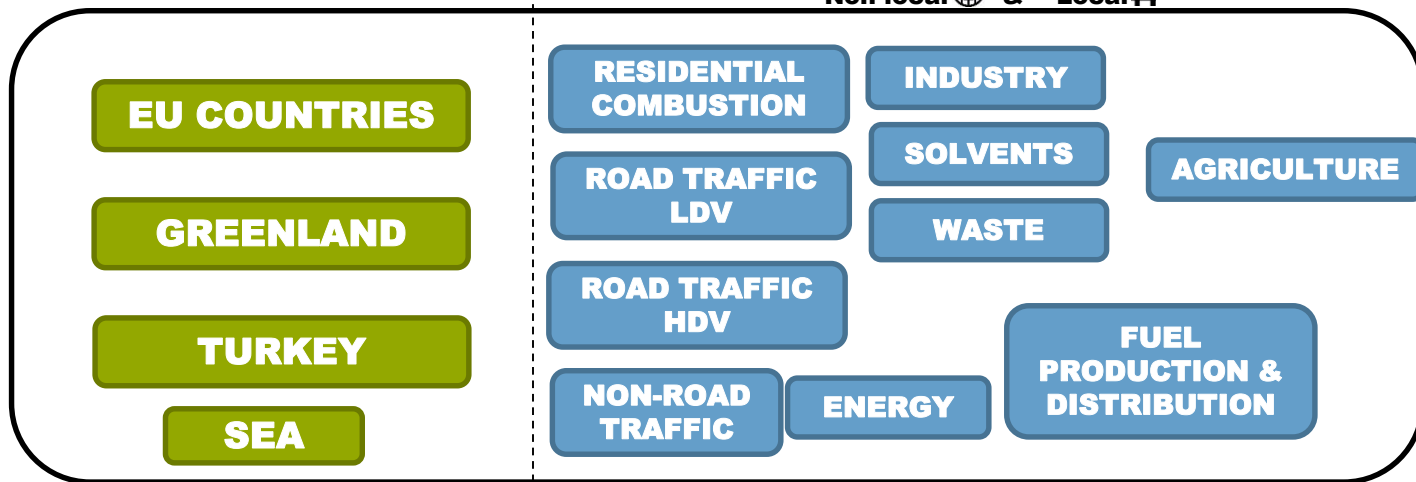
WE EXPLOIT THE LABELLING SYSTEM OF LOTOS-EUROS – TWO SIMULATIONS IN PARALLEL

GEOGRAPHICAL



SECTOR

Non-local  & Local 



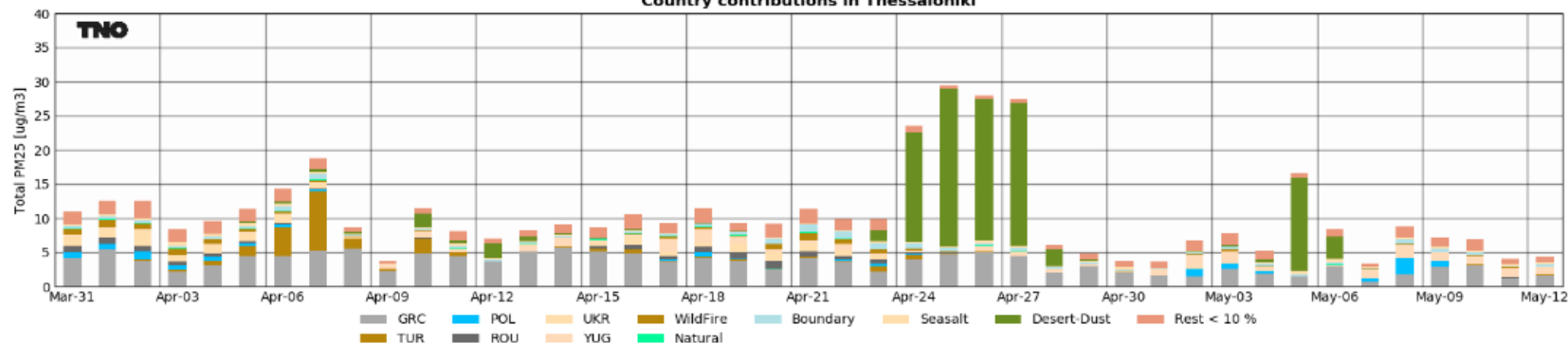
NATURAL

BOUNDARY

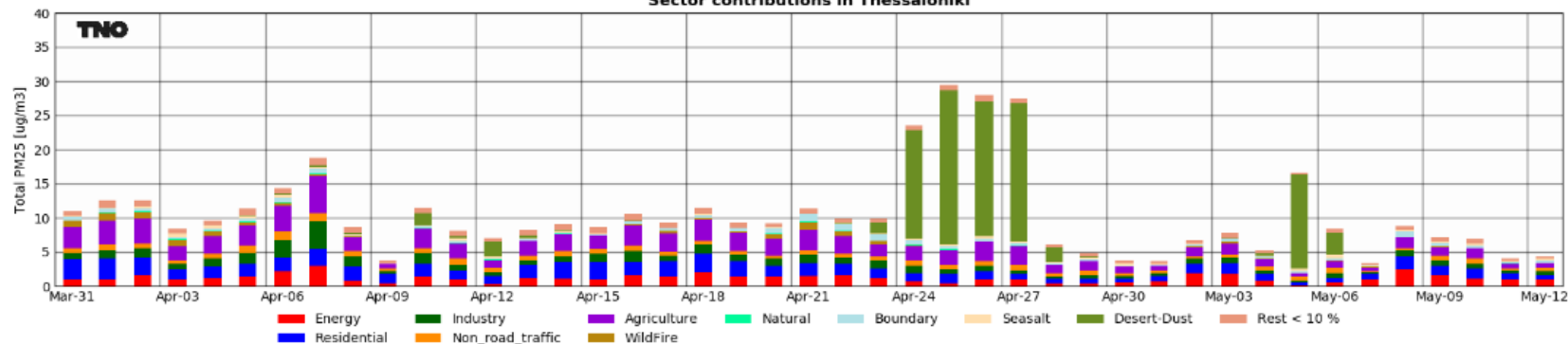
REST (CONTRIBUTIONS < 10%)



Country contributions in Thessaloniki



Sector contributions in Thessaloniki



A nighttime photograph of a city street. On the left is a traditional brick building with many lit windows. On the right is a modern, curved building with a glass facade, also lit up. In the foreground, a curved pedestrian bridge or walkway with a metal railing is visible. The background shows a street with light trails from moving vehicles, including a prominent green light trail. The overall scene is illuminated by city lights.

› **THANK YOU FOR YOUR
ATTENTION**

Take a look:

[HTTPS://TOPAS.TNO.NL](https://topas.tno.nl)

TNO innovation
for life

JEROEN.KUENEN@TNO.NL