Interreg Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

CSHIPP

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EFFECTS OF INTERNATIONAL SHIPPING ON EUROPEAN AIR POLLUTION LEVELS

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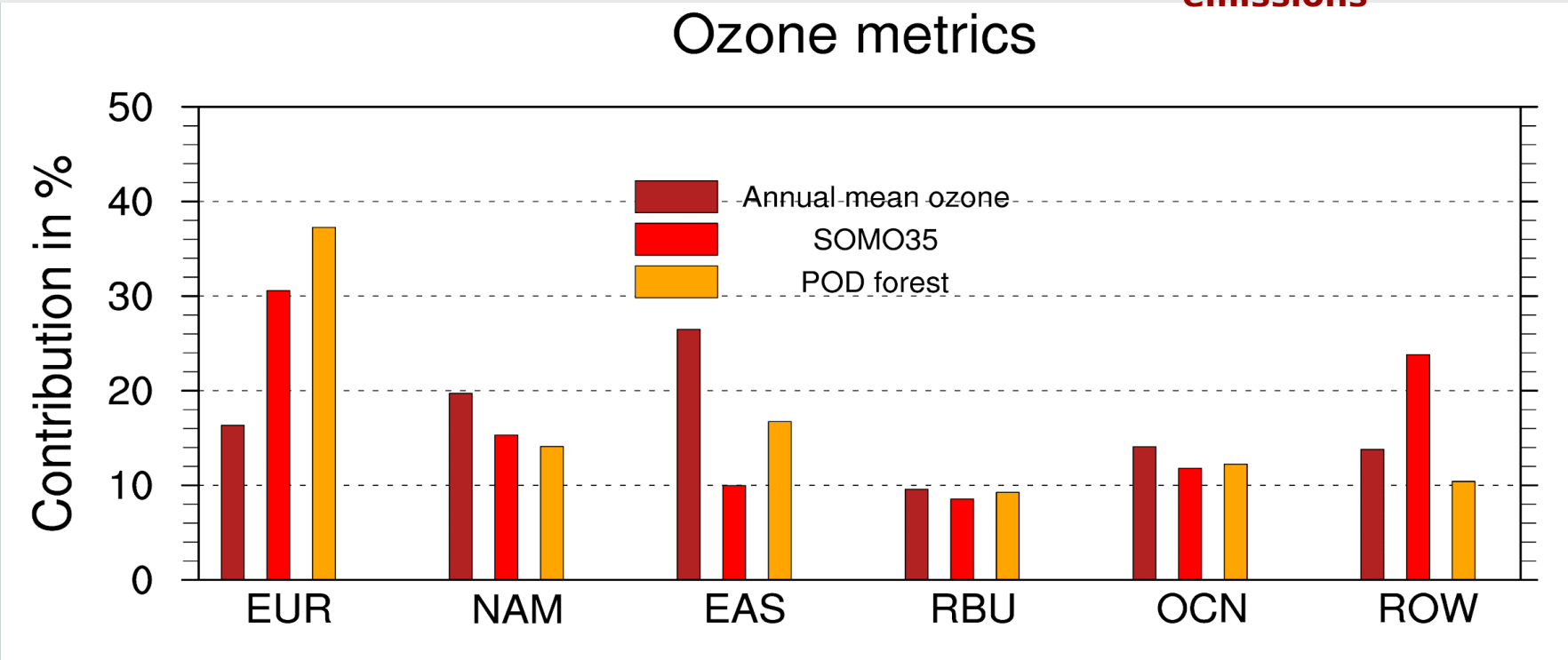
Why shipping:

- Major source in many regions for PM, NOx, surface ozone, depositions of sulphur and eutrophication.
- Large, partially unregulated source.
- Other (land based) sources have decreased in large parts of the world.

Percentage anthropogenic contributions to European ozone (but there are substantial regional differences within Europe)

FROM HTAP II

OCN = Ship emissions



Citation: Jonson, J. E., Schulz, M., Emmons, L., Flemming, J., Henze, D., Sudo, K., Tronstad Lund, M., Lin, M., Benedictow, A., Koffi, B., Dentener, F., Keating, T., Kivi, R., and Davila, Y.: The effects of intercontinental emission sources on European air pollution levels, Atmos. Chem. Phys., 18, 13655–13672, https://doi.org/10.5194/acp-18-13655-2018, 2018.

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Emissions used in model calculations

(Almost) All emissions representative for year 2015.

Land-based emissions from Eclipse.

Ship emissions calculated by FMI (Finnish Meteorological Inst.) based on AIS positioning and technical specifications of the individual ships.

A maximum of 0.1% sulphur content in marine fuels (or use of cleaning technology) from January 2015 in SECA areas.

(North Sea and Baltic Sea are SECA areas as well as sea areas located off the coasts of North America)

FMI Ship emissions in numbers:

Emission in Gg. All PM emissions assumed emitted as $PM_{2.5.}$
SO_2 and SO_4 emissions included separately (but added in the table).

Land based emissions from EU project Eclipse. EU and German emissions added for comparison.

	Sulphur as SO_2	NO_x as NO_2	CO	PM (Ash + OC + EC)
Global ships	9349	19572	1394	91 313 124
Med + Black Sea	787	1525	107	7 25 10
Balt + North Sea SECA	36	1016	73	5 17 7
Near Atlantic	506	996	73	5 16 7
EU	15385	23611	19888	1290
Germany	352	1187	2683	99

Near Atlantic: Bounded by 30 W - 90 E
and 30 N

EMEP MSC-W model, version rv4.9, available as Open Source from emep.int

Model resolution: 0.5 x 0.5 degrees

Meteorology: ECMWF IFS

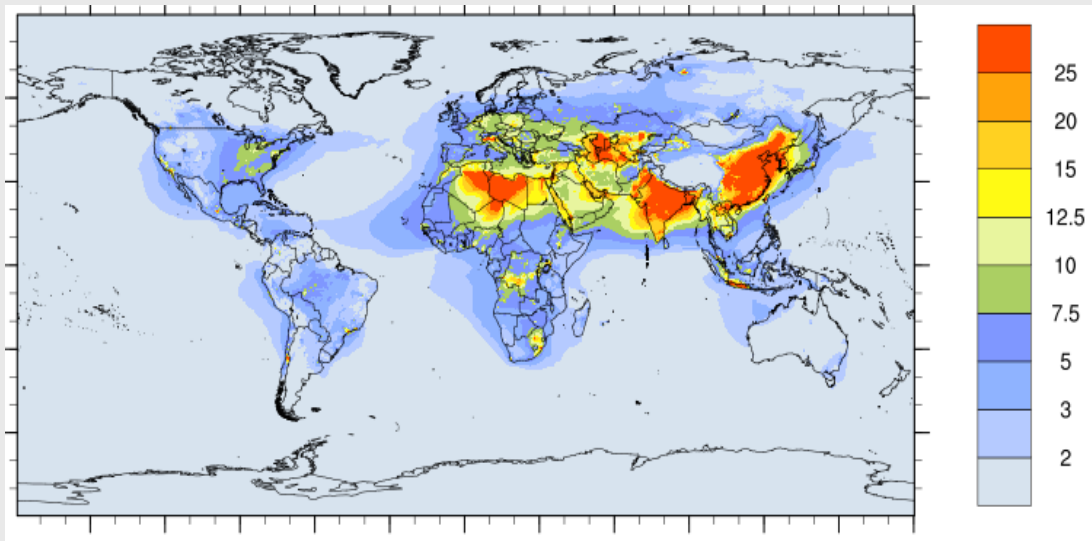
5 months spin-up for most individual global model runs

1. Global reference model run for 2015
2. All anthropogenic emissions reduced by 15% (“All15”)
3. All ship emissions reduced by 15% (“Ship15”)
4. Mediterranean and Black Sea emissions reduced by 15% (“Med15”)
5. North Sea and Baltic Sea emissions reduced by 15% (“BlNs15”)
6. Rest Of World emissions reduced by 15% (ROW)

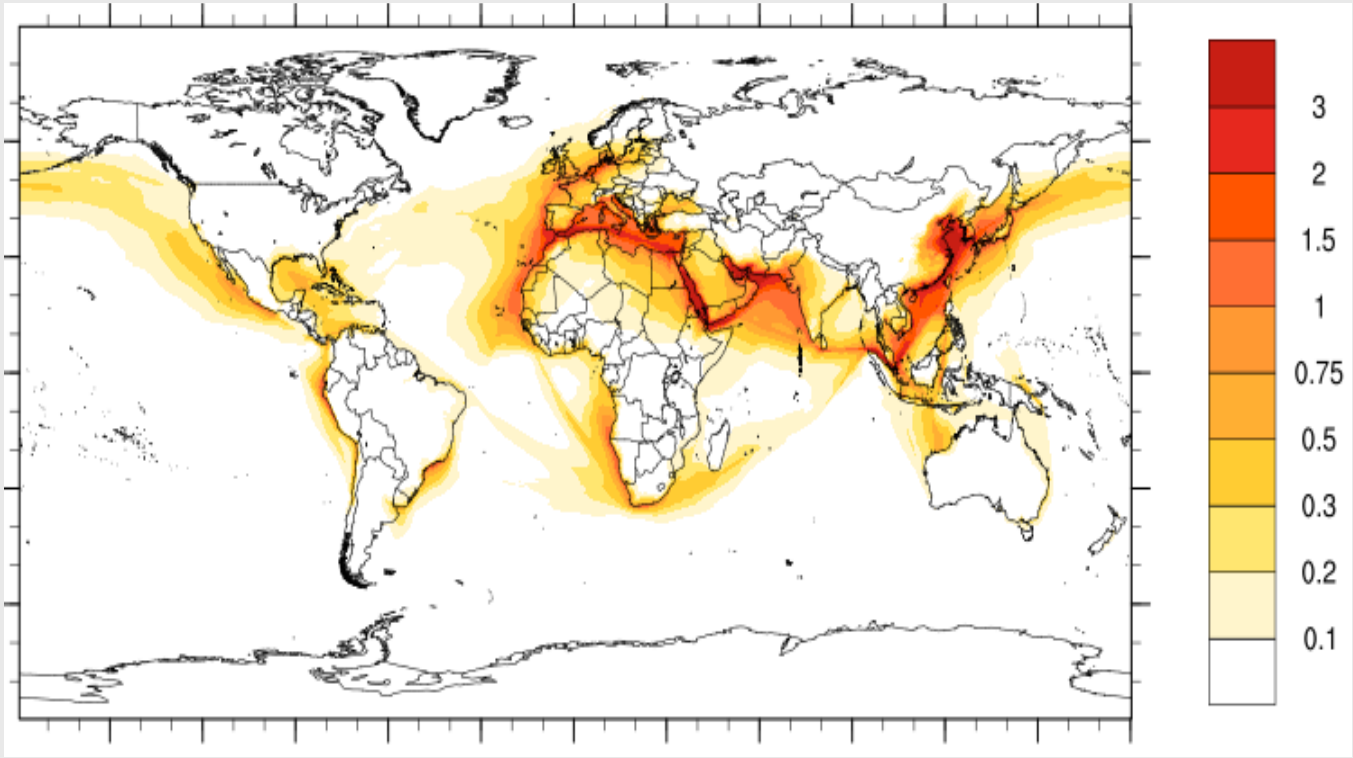
In addition NOx sensitivity tests - ozone production

$PM_{2.5}$ in µg m^{-3}

Right:
Global PM2.5 concentrations



Below:
Effects of a 15% reduction in global ship emissions(in µg m^{-3}) scaled by 100/15.



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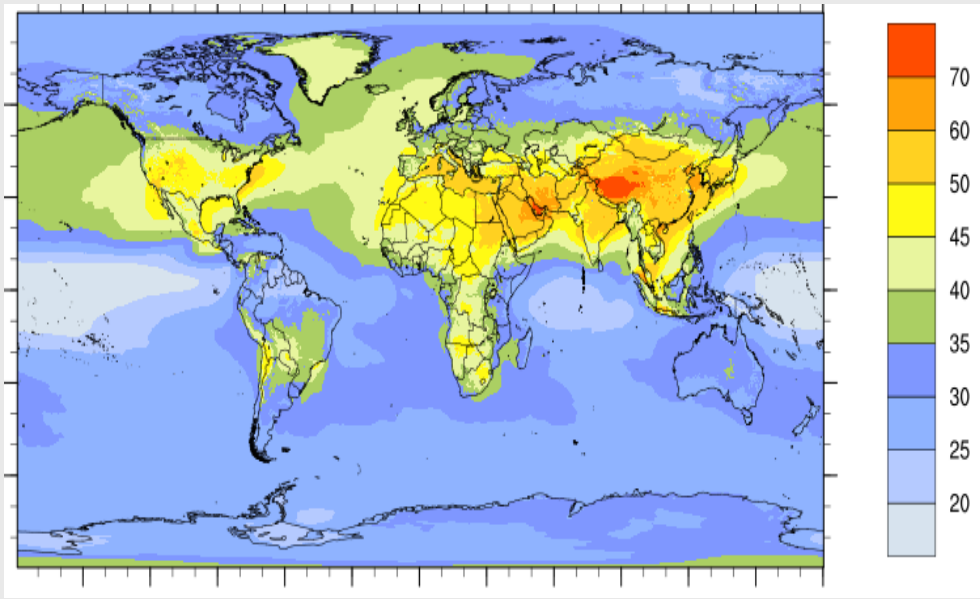
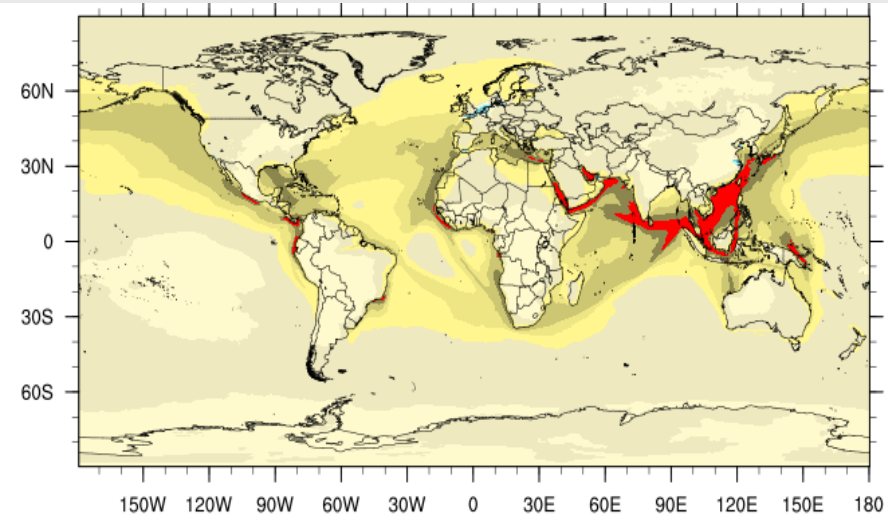
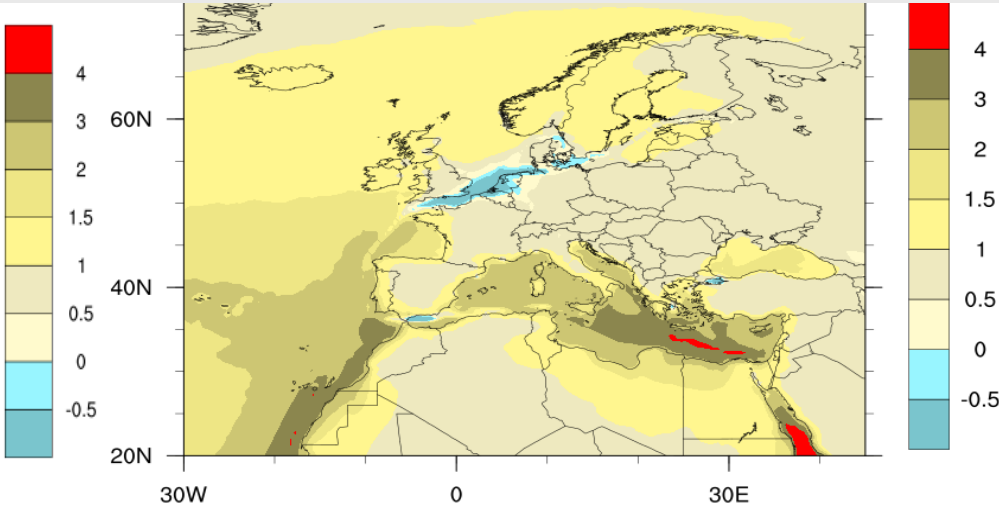
Ozone in ppb

Right:
Global concentrations



Below:
Effects of a 15% reduction in global ship emissions on daily maximum ozone in ppb scaled by 100/15.





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NOx sensitivity - ozone production in ship plumes

ship emissions are usually instantly mixed throughout the model grid cell - this may lead to overestimation of ozone production

EMEP model option: split 50% of the NOx emissions from ships into pseudo-species “ShipNOX”

ShipNOx + OH	$\Rightarrow$	HNO_3	[R1]	R1 as OH+ NO_2
ShipNOx	$\Rightarrow$	HNO_3	[R2]	R2 half life 6 h

We have repeated the scenarios in order to give a “range” for the net ozone production from ships.

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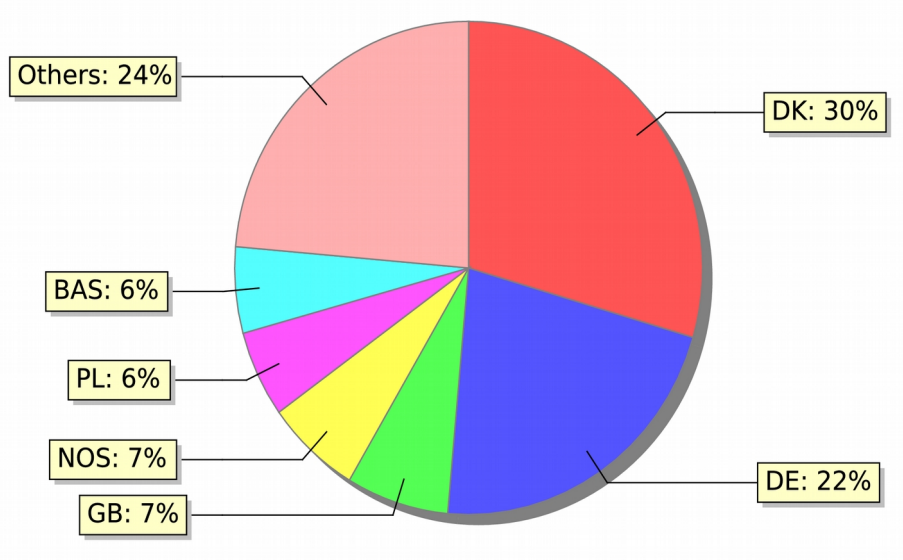
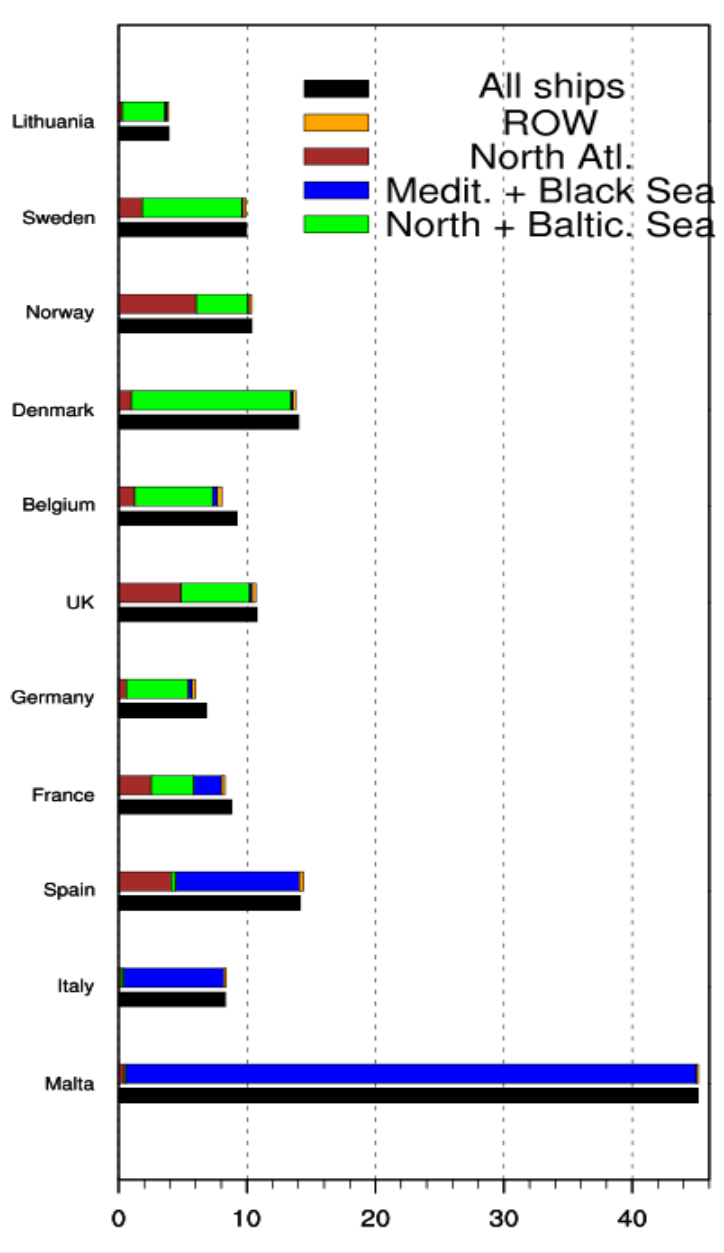
2015

Percentage of **anthropogenic** $PM_{2.5}$ from shipping for selected countries.

Source receptor calculations from 2017 EMEP report.
Largest contributors to $PM_{2.5}$ in Denmark.
(BAS + NOS 13%) 12.4%





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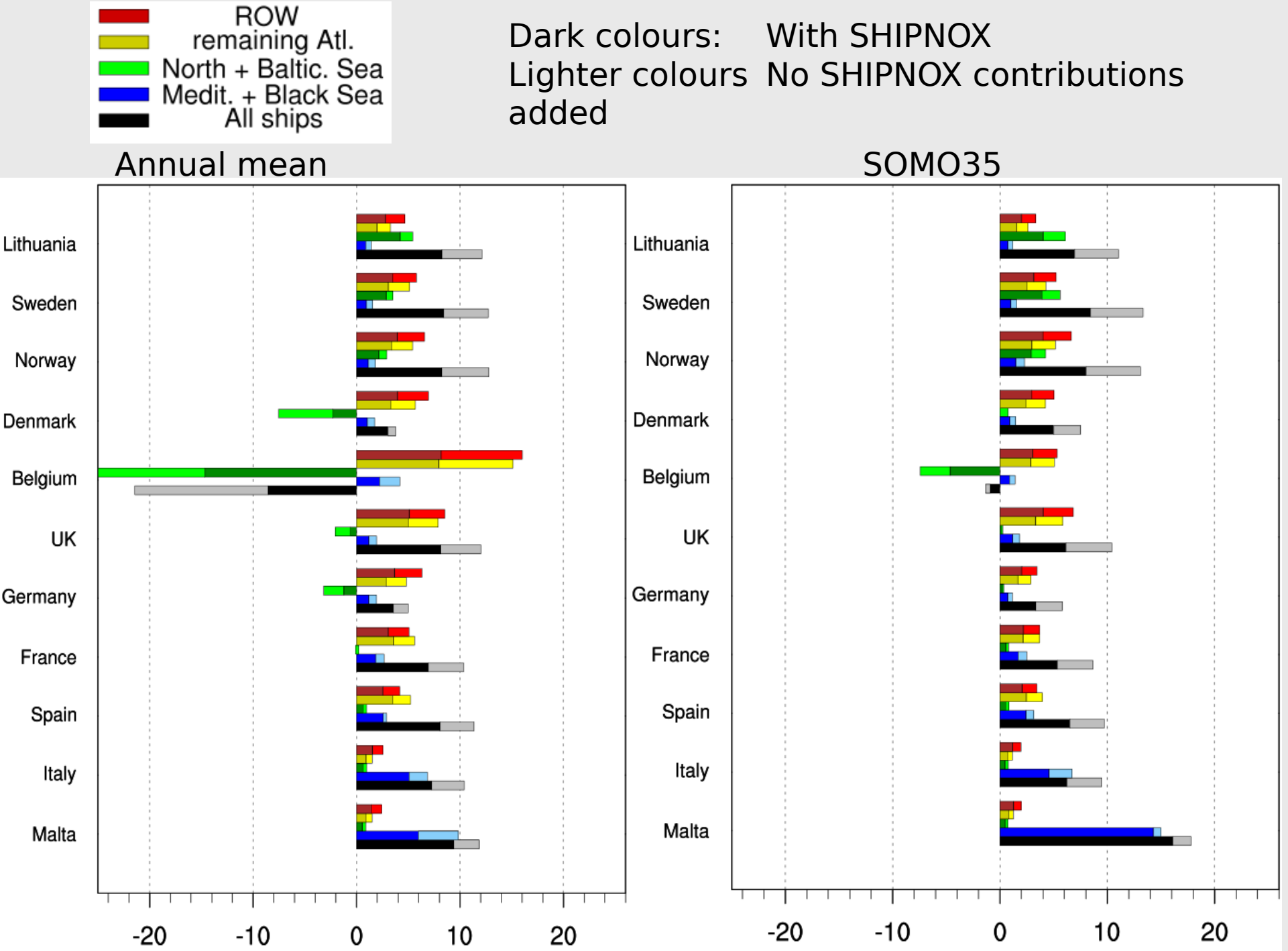
ROW
remaining Atl.
North + Baltic. Sea
Medit. + Black Sea
All ships
Dark colours: With SHIPNOX
Lighter colours No SHIPNOX contributions added
Annual mean
SOMO35
Lithuania
Sweden
Norway
Denmark
Belgium
UK
Germany
France
Spain
Italy
Malta
-20
-10
0
10
20

Some take home messages

A large portion of $PM_{2.5}$ and ground level ozone of anthropogenic origin in Europe can be attributed to ship emissions.

15% contributions from regional shipping to PM2.5 almost add up to 15% contribution from global. => close to linear.

For ozone, the response is nonlinear, and decreased (NOx) emissions locally lead to higher ozone.

PM2.5 mainly from sources close to shore, whereas for ozone “it all adds up”. with large contributions also from distant emissions.

We are not able to resolve the chemistry in ship plumes. This will most likely result in an overestimation of ozone production in background air. We have tried to give a range for this effect.

For ozone large contributions from ROW and N. Atlantic