The effects of intercontinental emission sources on European air pollution levels (HTAP2 + ship emissions)

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Frank Dentener and Terry Keating

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The first part of this presentation is mainly based on the Jonson et al. (2018) paper included in the ACP special issue:

Global and regional assessment of intercontinental transport of air pollution: results from HTAP, AQMEII and MICS

1. what fraction of European air pollution (ozone) concentrations can be attributed to sources of contemporary anthropogenic emissions within Europe compared to extra-regional sources of pollution?
2. Does the ozone metric matter?

Additional calculations focusing on ship emissions

- Main focus on ozone
- Ship emissions sub-divided into separate sea areas
- Focus on Europe

HTAP2
European source and receptor regions.

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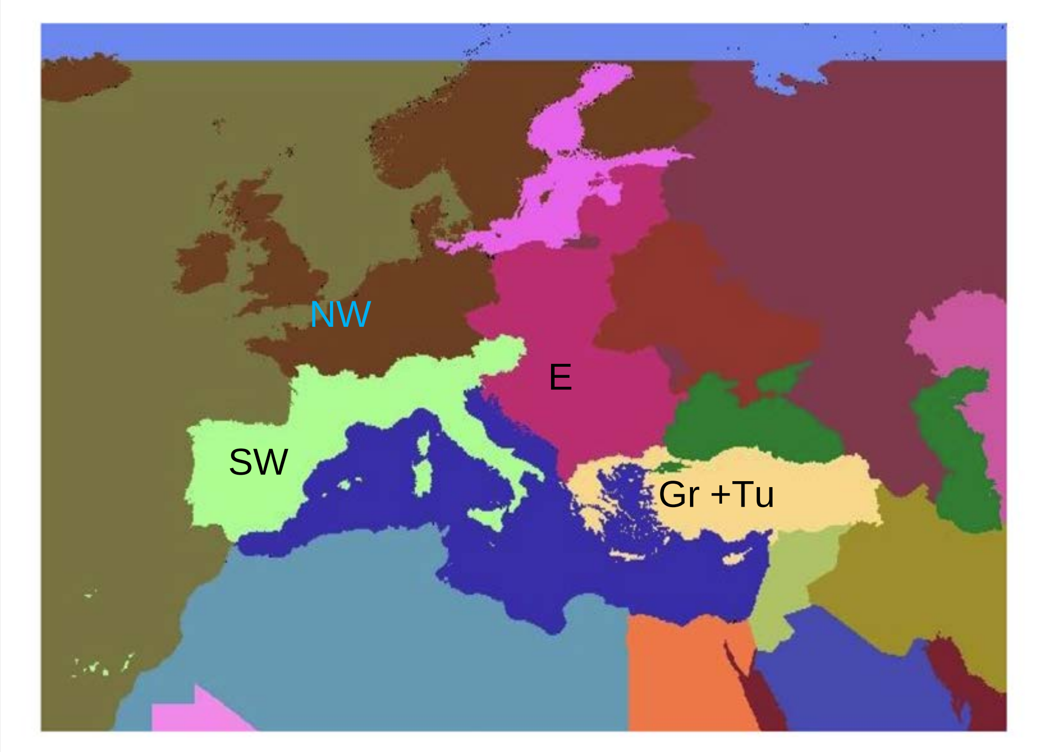
Nearby source regions:
(partly included in HTAP1 def. of Europe)

- Shipping
- Russia, Ukraine and Belarus
- Middle East
- North Africa



Question 1: (Europe only)

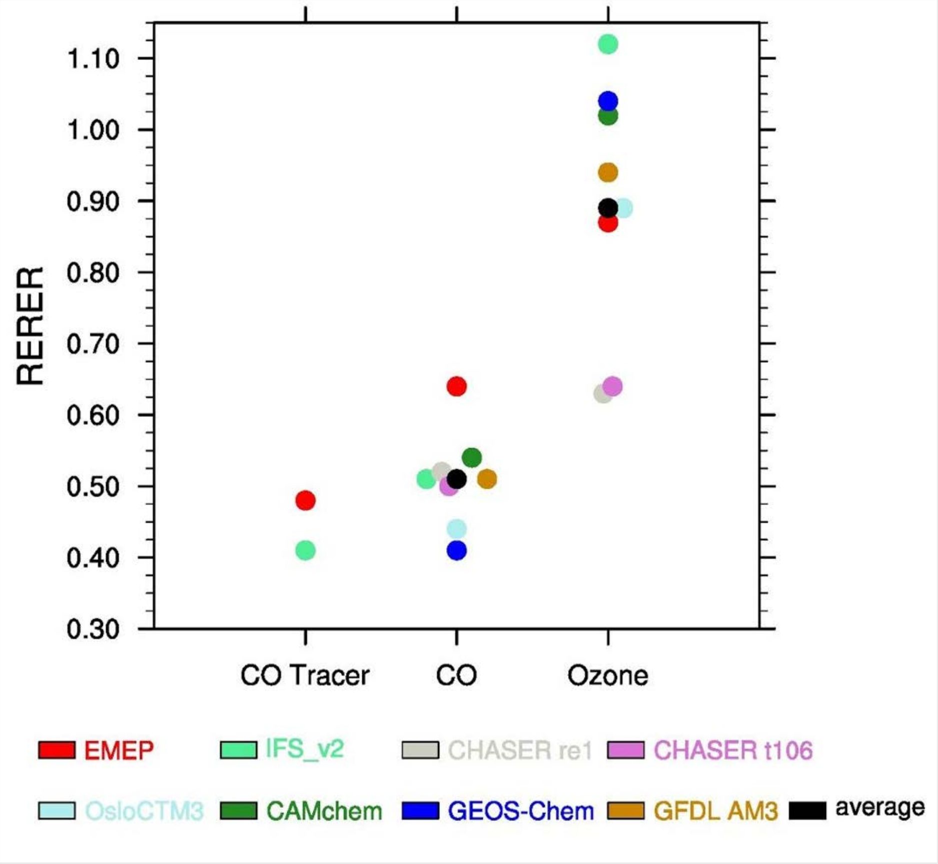
Europen versus non- European sources.

$$RERER = \frac{EURALL - GLOALL}{BASE - GLOALL}.$$

- GLOALL: All anthropogenic emissions reduced with 20%
- EURALL: All European emissions reduced by 20%
- Base: Reference model run

RERER = 1: Dominated by external anthropogenic sources

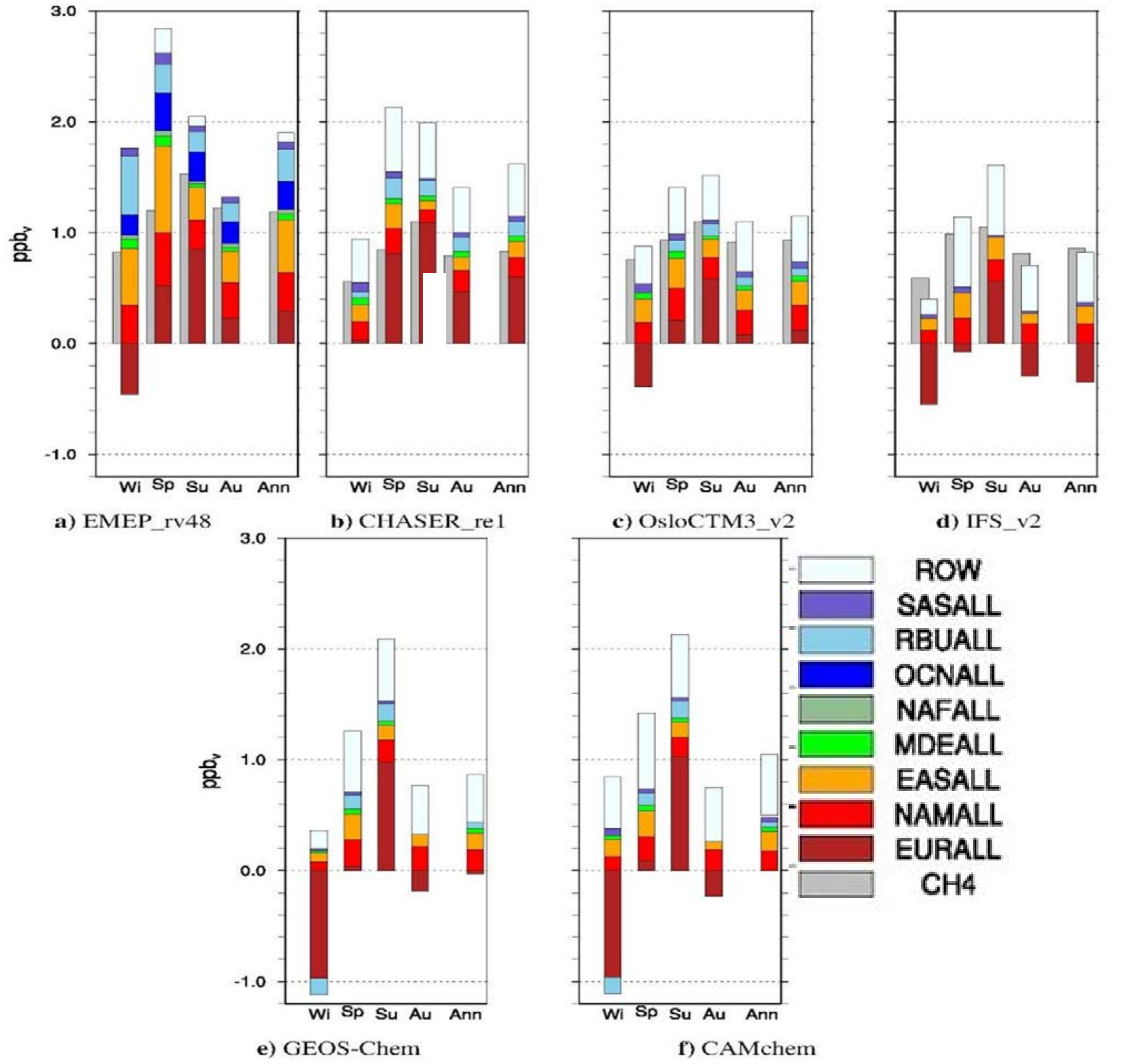
RERER= 0: Dominated by internal (European) sources.



European ozone from different word regions

NB! Effect of CH_4 calculated from a 20% change in concentrations and NOT emissions

NB! Regions in ROW model dependant



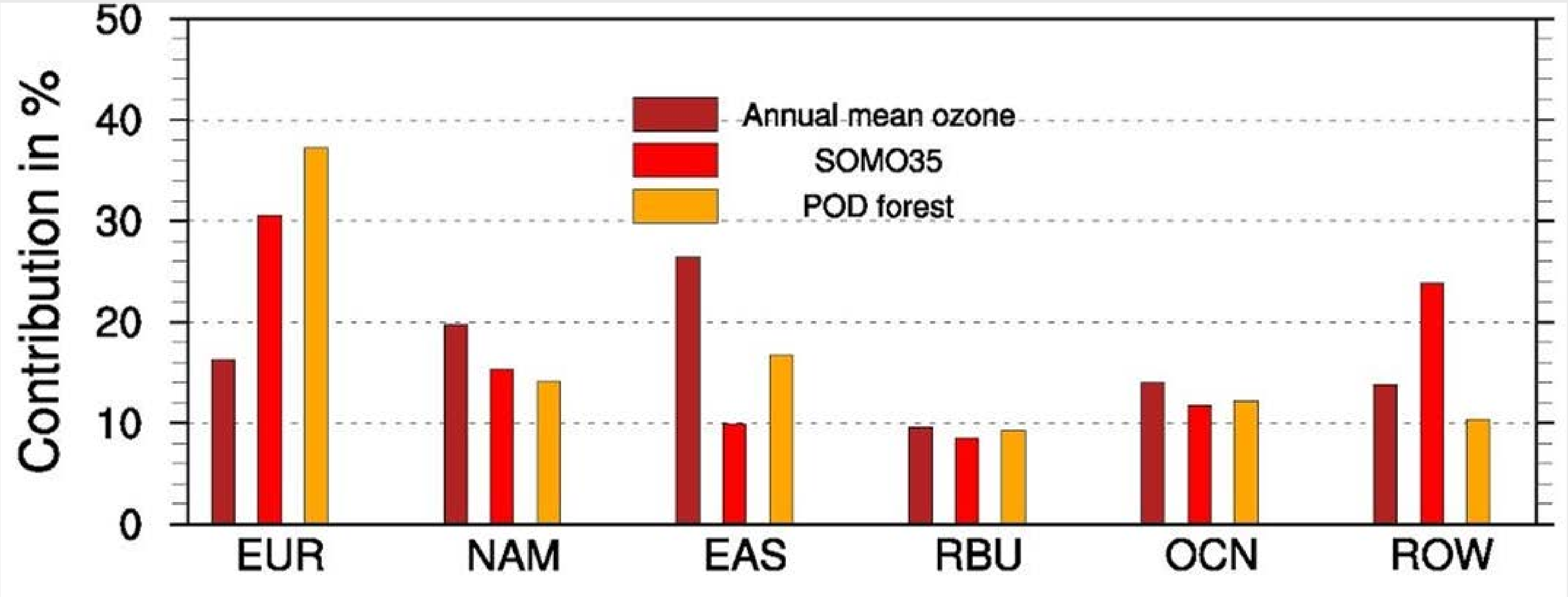
Question 2: Ozone metric: Does it matter?

% contribution to athropogenic ozone

Only results from EMEP model, but:

In Jonson et al. 2018 we show that other HTAP2 models show similar patterns when showing results for summer only.

SOMO35:	Annual sum of ozone over 35 ppb
POD forest:	Phyto-toxic ozone dose for forests



Ship emissions

1. In what way will emissions from separate sea areas affect Europe?
2. And how are individual European countries/regions affected?

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We use:

- Land based emissions from Eclipse
- Global ship emissions from FMI (Finnish Meteorological Inst.)

Model runs (2015 meteorology and emissions)

1. Base run (with spinnup)
2. SR All: Reducing all anthropogenic emissions by 15% (with separate spinnup)
3. SR AllSh: Reducing all ship emissions by 15% (with separate spinnup)
4. SR BALNOS:Reducing North Sea and Baltic Sea emissions by 15%
5. SR MEDBL: Reducing Mediterranean and Black Sea emissions by 15%
6. SR ROW: Reducing ROW (Rest Of World) shipping by 15% (with separate spinnup)

Disregarding non-linearities:
In the next slides we assume Base - SR All represent 100% of the anthropogenic contribution

Percentage anthropogenic contribution to PM2.5

Length of bars for:

All Ships

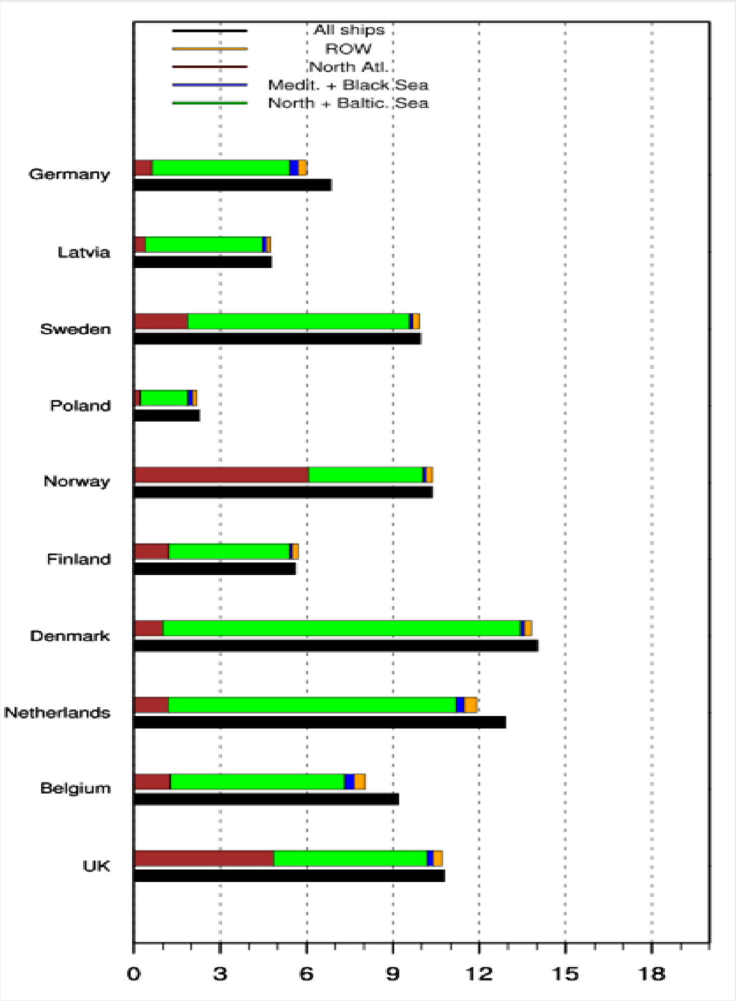
and

other sea areas

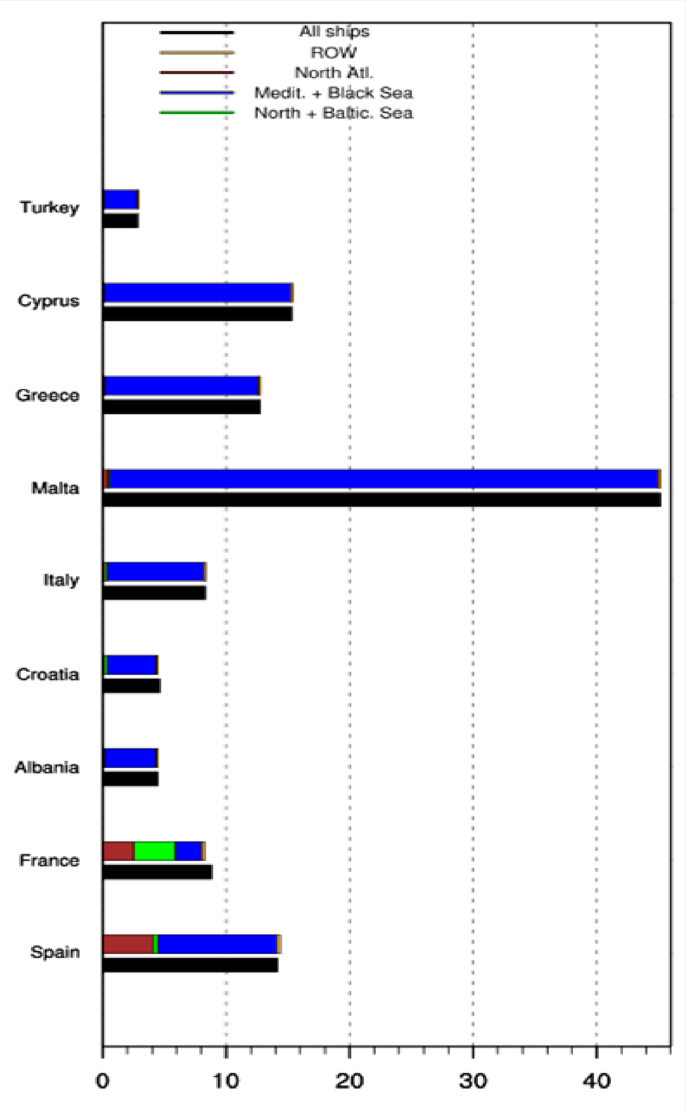
indication of linearity.

Regional emissions dominates in the Mediterranean

North Sea and Baltic countries



Mediterranean countries



And ozone, North Sea and Baltic Sea countries (**far from linear, metric matters**)

SOMO35 - larger effects from emissions near Europe compared to annual average ozone

(But more similar for All Ships)

NB! upper limit. Ship plumes not resolved

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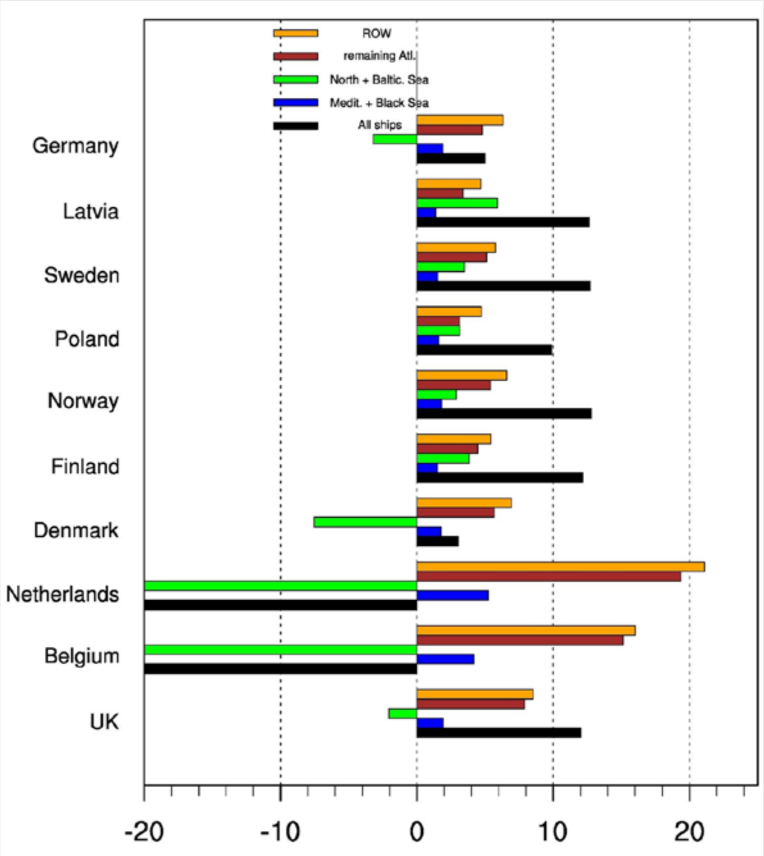
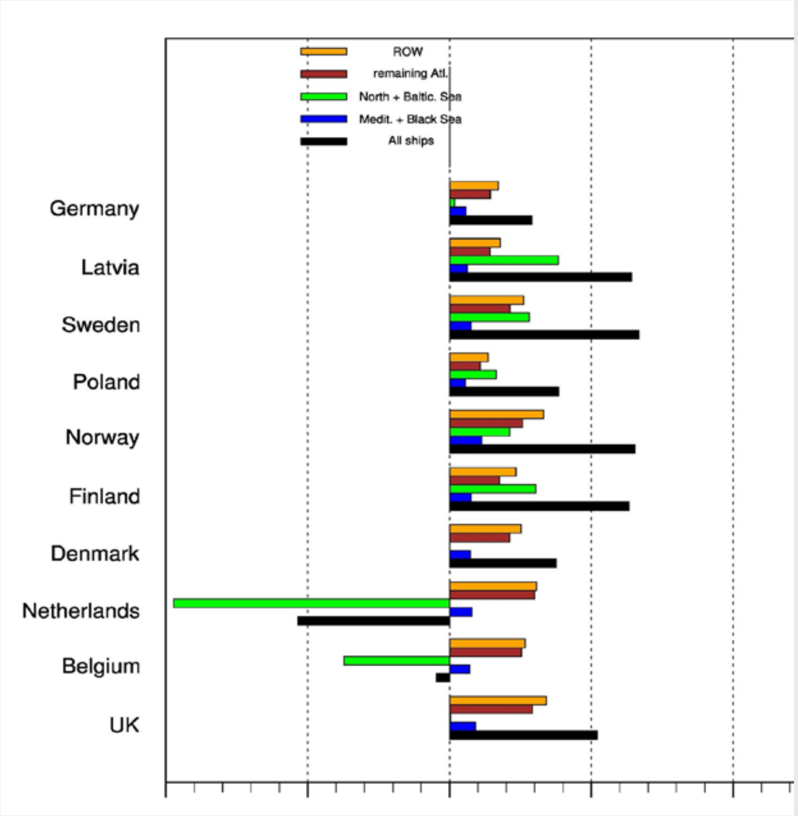
Annual average ozone



SOMO35

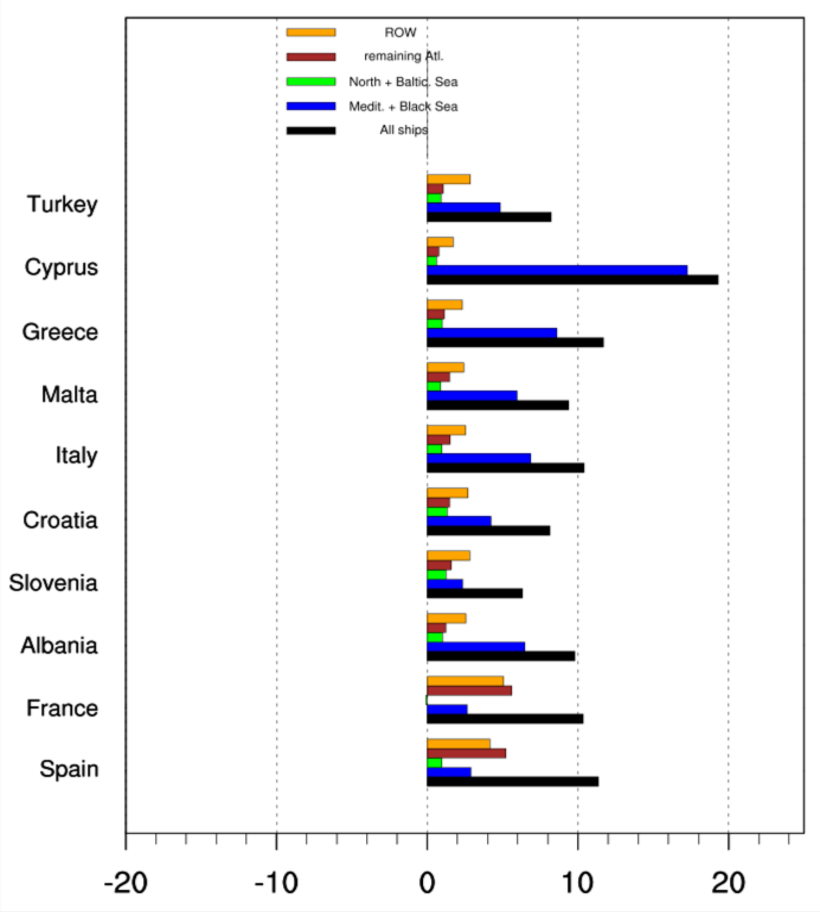


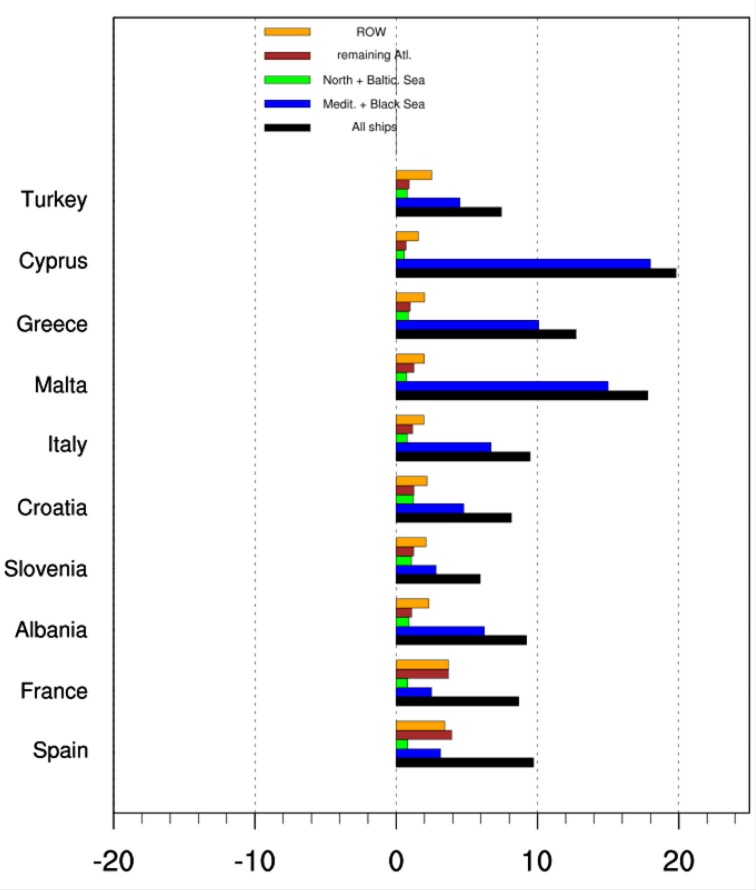
Ozone, Mediterranean countries (less non-linear)

Annually averaged ozone and SOMO35 more similar

ROW largest non-Mediterranean in most countries

No overall titration





Conclusions:

HTAP2

- HTAP2 Q1: For ozone in Europe intercontinental contribution larger than regional (European) sources
- HTAP2 Q2: but it is sensitive to choice of ozone metric
- Role of methane?
- Model diversity same range as HTAP1 even when using the same emissions.

Ship emissions:

- Sh Q1: For ozone substantial contributions from distant (ROW) sources.
- Sh Q2: NB! Difference Mediterranean and NW Europe
- For PM2.5 emissions close to shore most important

Ship emissions: Recent and coming regulations

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Recent or impending regulations:

- (S)ECA Outside N. America, North Sea and Baltic Sea. Maximum 0.1% sulphur in fuel.
- (N)ECA: Outside N. America (2016), North Sea and Baltic Sea (both from 2021). Tier III NO_2 (~80% reductions) on new ships.
- Global sulphur cap (0.5% sulphur in fuel) from 2020

Coming IMO regulations/ambitions:

- 30% reductions in CO_2 by 2030 (even when allowing for volume growth)
- 50% reductions in CO_2 by 2050 (even when allowing for volume growth)

Press release December 2018

A.P. Moller - Maersk (worlds largest container carrier) aims at having carbon neutral vessels commercially viable by 2030 and calls for strong industry involvement. And fully carbon neutral by 2050.

Direct quote from IMO:

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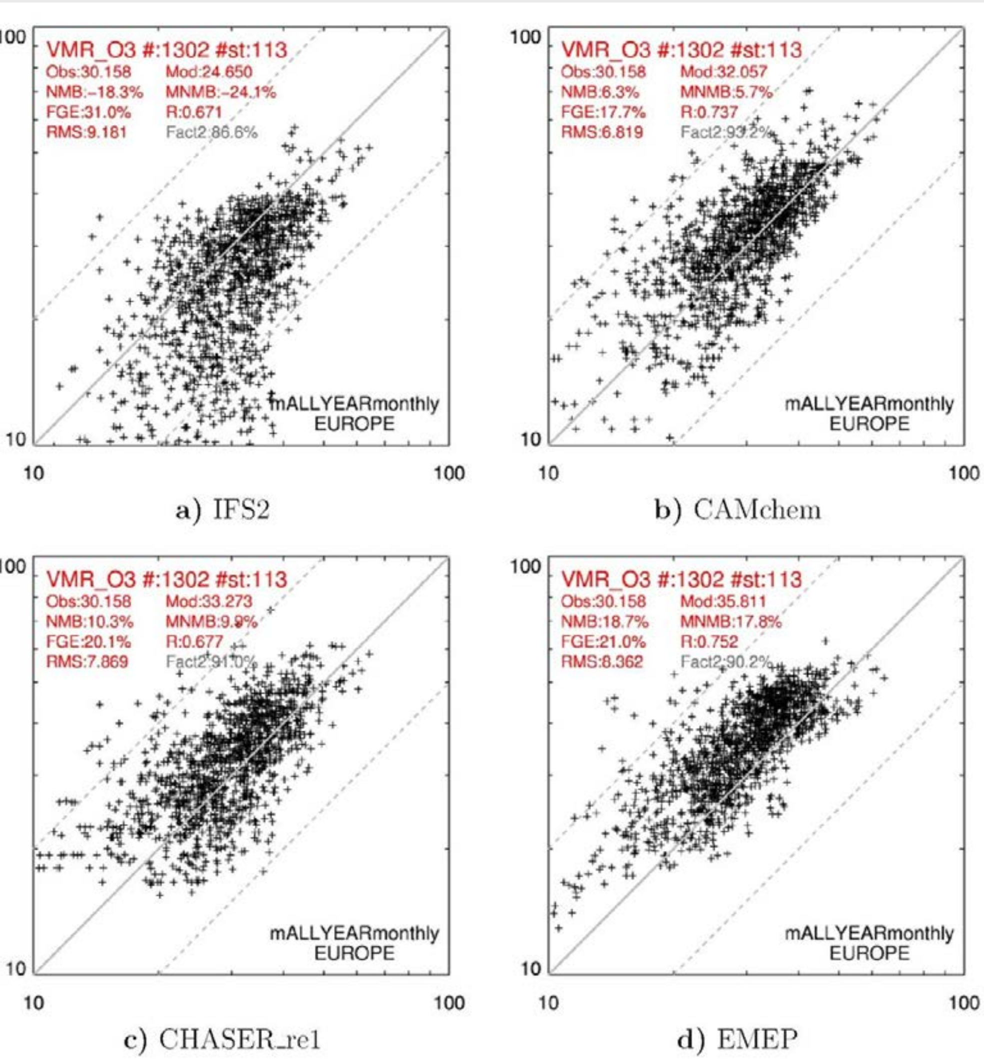
IMO: Adoption of the initial IMO strategy on reduction of GHG emissions from ships and existing IMO activity related to reducing GHG emissions in the shipping sector., Available at: https://unfccc.int/sites/default/files/resource/250_IMO%20submission_Talanoa%20Dialogue_April%202018.pdf,

“to reduce CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008; and GHG emissions from international shipping to peak as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008 whilst pursuing efforts towards phasing them out as called for in the Vision as a point on a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals.”

It is believed that this goal can only be reach with a large penetration of zero emission ships

Model validation: Ozone in Europe

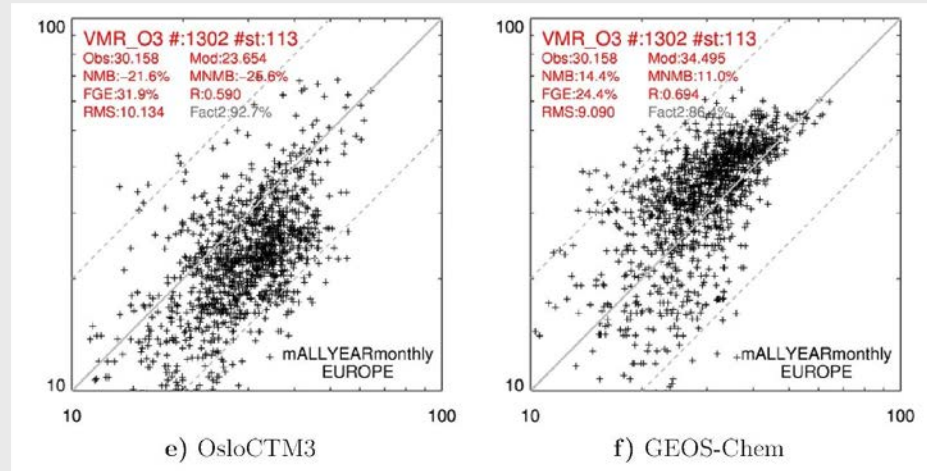


a) IFS2

b) CAMchem

c) CHASER_re1

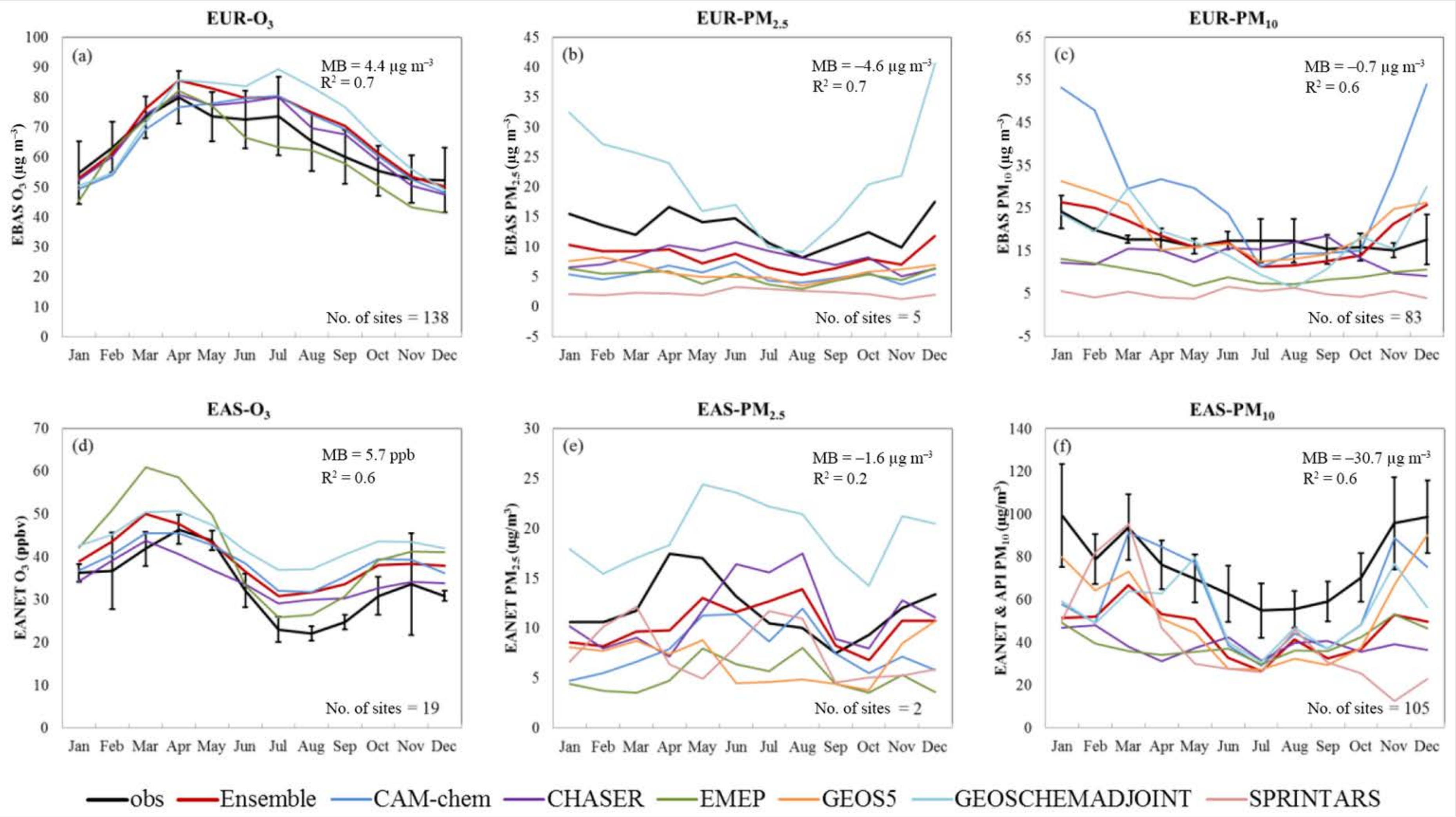
d) EMEP



e) OsloCTM3

f) GEOS-Chem

From Dong et al. 2018 (acp special issue) Europe and East Asia



HTAP1 report 2010 - HTAP2 RAIR now 82% for Europe

Table 3.1. Annual and spatial mean surface O_3 response (ppbv) to 20% decreases in anthropogenic precursor emissions (NO_x, CO, VOC, plus aerosols and their precursors). Values are mean ± one standard deviation across the 15 models that conducted the regional perturbation simulations. Bold font denotes responses to foreign emission perturbations that are at least 10% of the response to domestic emission perturbations. Also shown is the relative annual intercontinental response for each receptor region defined as the ratio of the total response in mean surface O_3 due to changes in the other three source regions compared to that due to changes in all regions. (NA: North America, EU: Europe, EA: East Asia, SA: South Asia)

	Receptor Region			
Source Region	NA	EU	EA	SA
Annual mean dec **NA+EU+EA+SA: 1.43**				
NA	1.04±0.23	**0.37±0.10**	**0.22±0.05**	**0.17±0.04**
EU	**0.19±0.06**	0.82±0.29	**0.24±0.08**	**0.24±0.05**
EA	**0.22±0.06**	**0.17±0.05**	0.91±0.23	**0.17±0.05**
SA	0.07±0.03	0.07±0.03	**0.14±0.03**	1.26±0.26
Relative Annual Intercontinental Response (RAIR)				
	32%	43% 82%	40%	32%

HTAP2

requested SR model runs

Global

Regional

13 regions

+ Oceans

All anthropogenic | By pollutant | By sector

Region of Emissions Perturbation		20% Δ All Anthr Emiss			-20% Δ By Pollutant (3)			-20% Δ By Sectors (~5)		
		2008	2009	2010	2008	2009	2010	2008	2009	2010
Global	GLO									
N America	NAM									
Europe	EUR									
East Asia	EAS									
South Asia	SAS									
Rus, Bel, Ukr	RBU									
Middle East	MDE									
SE Asia	SEA									
Central Asia	CAS									
N Afr/Sahara/Sahel	NAF									
Mex/C America	MCA									
Southern Africa	SAF									
South America	SAM									
Aust/NZ/Pacific	PAN									
Oceans	OCN									

	Highest Priority
	Next Priority
	Lower Priority

Pollutants/Sectors	
All Anthropogenic	AA
NOx	NX
VOC, CO, NOx	VC
Particles and Precursors	PM
Electricity/Power	EP
Industry	IN
Residential	RS
Transport	TR
Agricultural	AG
Wildfires	WF
Dust	DU