Source contributions
to (future) ozone trends in Europe

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What changed
from HTAP-II to HTAP-I ?

- Different emissions
- emission&met year reference changed
- receptor regions
- updated models
- changed model ensemble

FULL Comparison HTAP 1 ensemble and HTAP 2 ensemble

Ozone Concentration Contribution in Europe
due to a 20 % reduction in anthropogenic emissions

[ppb]	from Europe	from NorthAmerica	from East Asia
HTAP 1 (box)	0.82	0.37	0.17
HTAP 2 (land only)	0.15	0.21	0.22

HTAP 1 all the box
HTAP 2
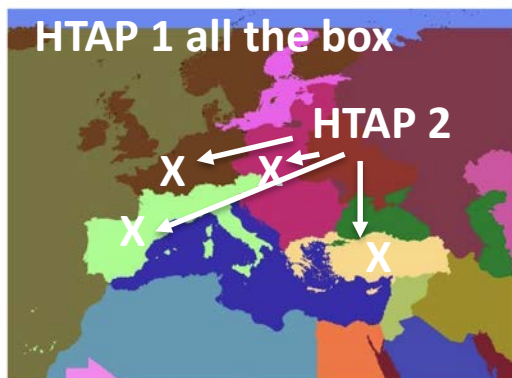
Why?
Change in receptor region definitions
Change in emissions (2001=>2010)
Change in source regions
Change in models contributing

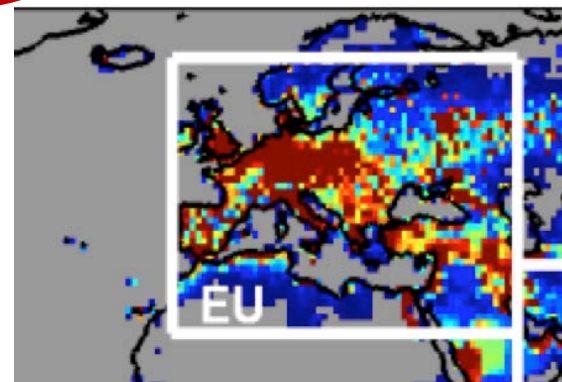# Impact of receptor region change
Region choice HTAP1 versus HTAP2

MODEL	RERER htap2	RERER on old htap1 Europe region
Chaser re1	0.62	0.72
Chaser t106	0.60	0.74
C-IFS v2	1.05	TBD
EMEP	0.82	0.89
OsloCTM3	0.84	TBD
CAMchem	0.90	TBD
GEOSchemADJ	0.80	0.76
Mean htap2 =>	80%	
Mean RAIR htap1 =>	43%	

≠

Impact of receptor region change
Region choice HTAP1 versus HTAP2

European surface ozone response
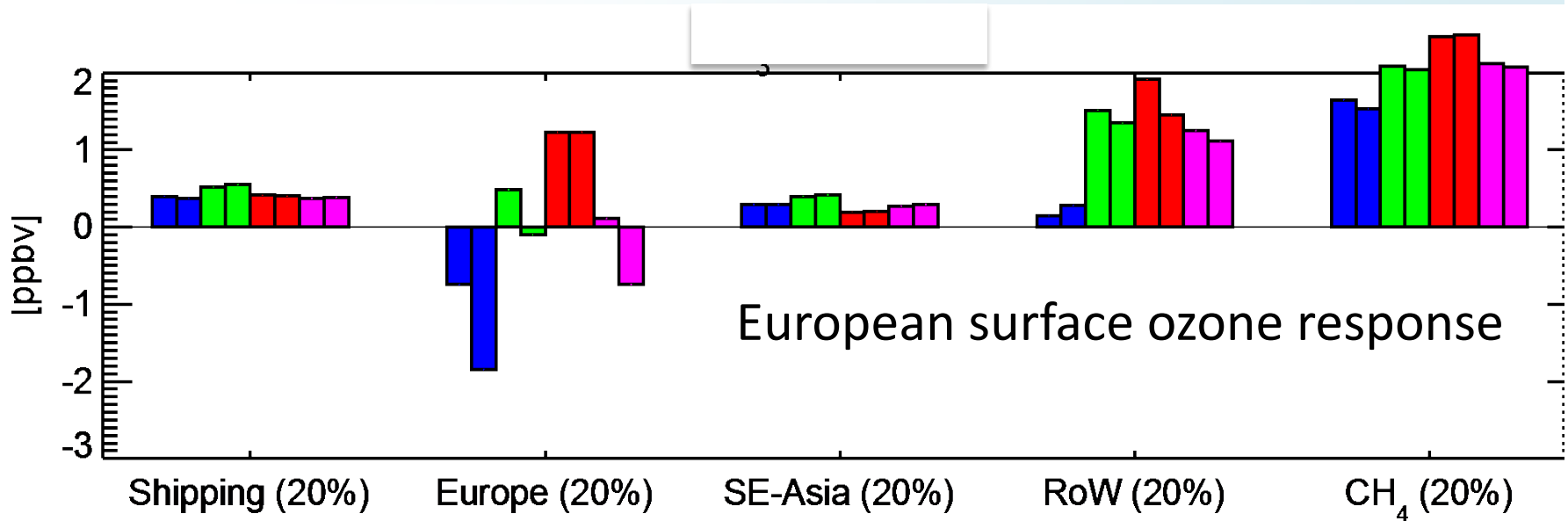
HTAP 2 source regions / **NorESM model**

Left bar: HTAP1 box - right bar HTAP 2 only over land
DJF, **MAM**, **JJA**, **SON**

*Receptor region definition matter little (exceptor for homebaked ozone)*

Can ship emissions explain discrepancy between ozone RAIR-htap1 and RERER-htap2 ?

Meteorologisk institutt

EMEP **European RERER** is similar
to mean RERER from all models

MODEL	RERER
Chaser re1	**0.62**
Chaser t106	**0.60**
C-IFS v2	**1.05**
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Mean RERER htap2 =>	80%
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Δ 40%
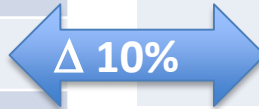
Attempt to recompute
EMEP htap1* "RAIR" from EMEP htap2:

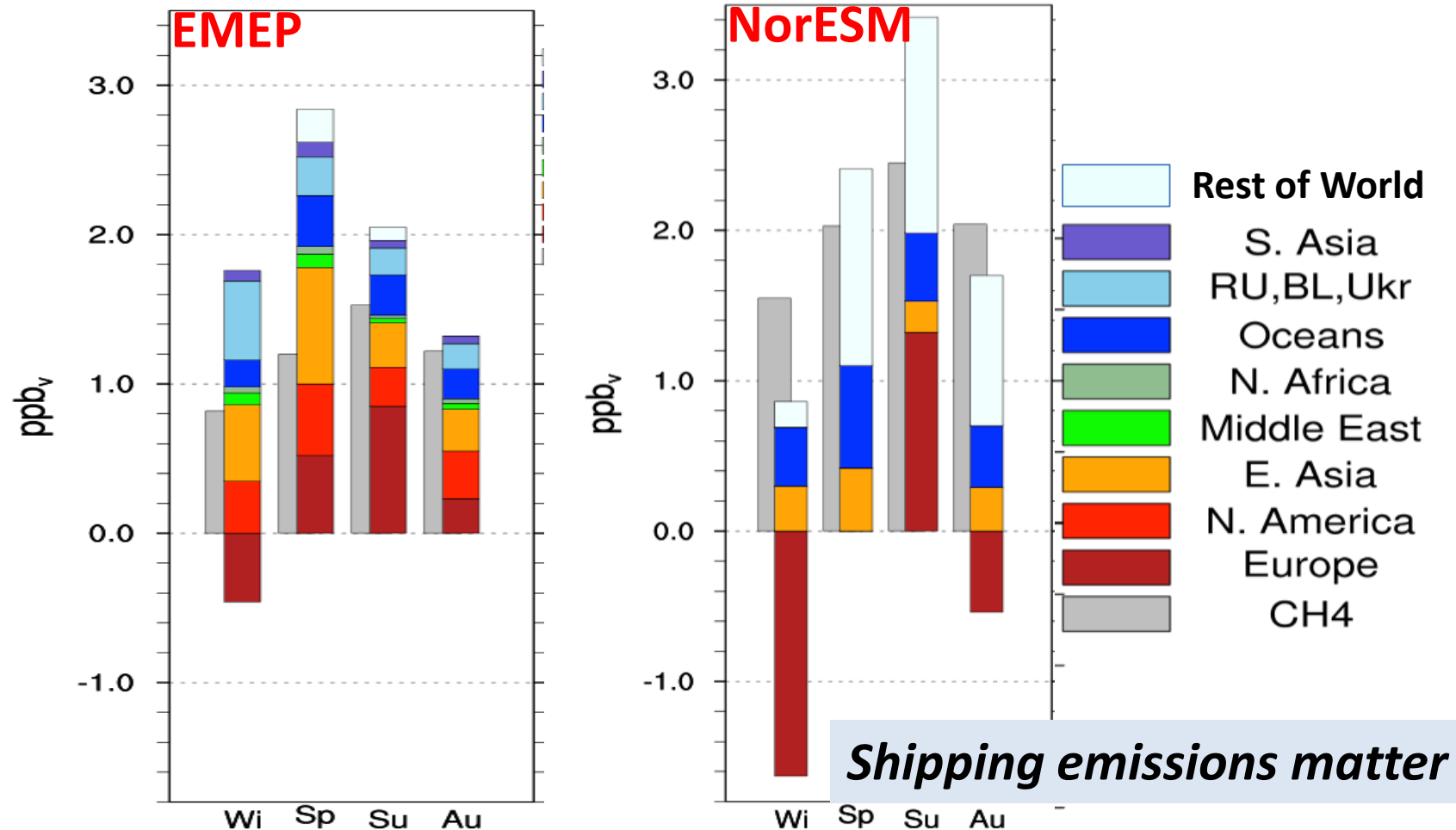$$EU_{htap1*} = EU_{htap2} + 25\%OCN_{htap2}$$
$$GLO_{htap1*} = (NA+EU+SE+AS+50\%OCN)_{htap2}$$

$$RAIR_{EU*} = (GLO_{htap1*} - EU_{htap1*}) / EU_{htap1*}$$

Δ 10% = **0.70**

CA 30% OF DISCREPANCY RAIR - RERER DUE TO DIFFERENT
SHIP EMISSION INCORPORATION in HTAP1 and HTAP2

What is the role of shipping emissions to European surface ozone concentrations ?

EMEP

NorESM

Rest of World
S. Asia
RU,BL,Ukr
Oceans
N. Africa
Middle East
E. Asia
N. America
Europe
CH4

Shipping emissions matter

How important is CH4 mitigation vs other anthropogenic emission reductions in 2030 for European ozone (1)?

Global EMEP
SR runs
GAINS scenarios
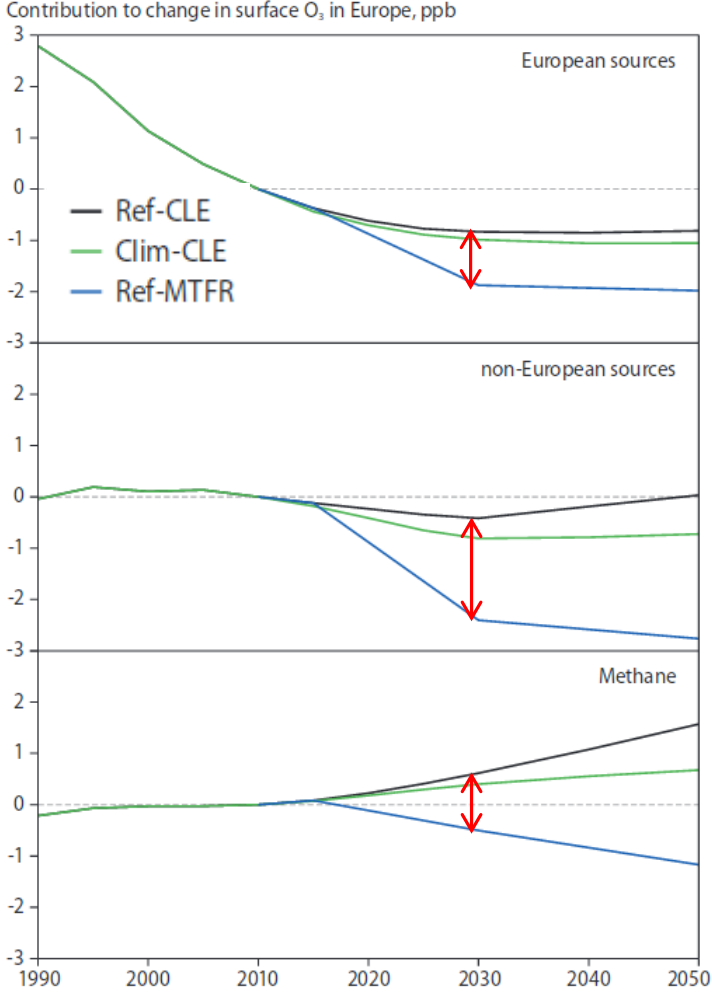MFR-CLE

(HTAP service contract report; Schulz, 2014)

Ozone metric SOMO35
Reduction with respect to CLE scenario in 2030

Europe

CH4

Rest of World
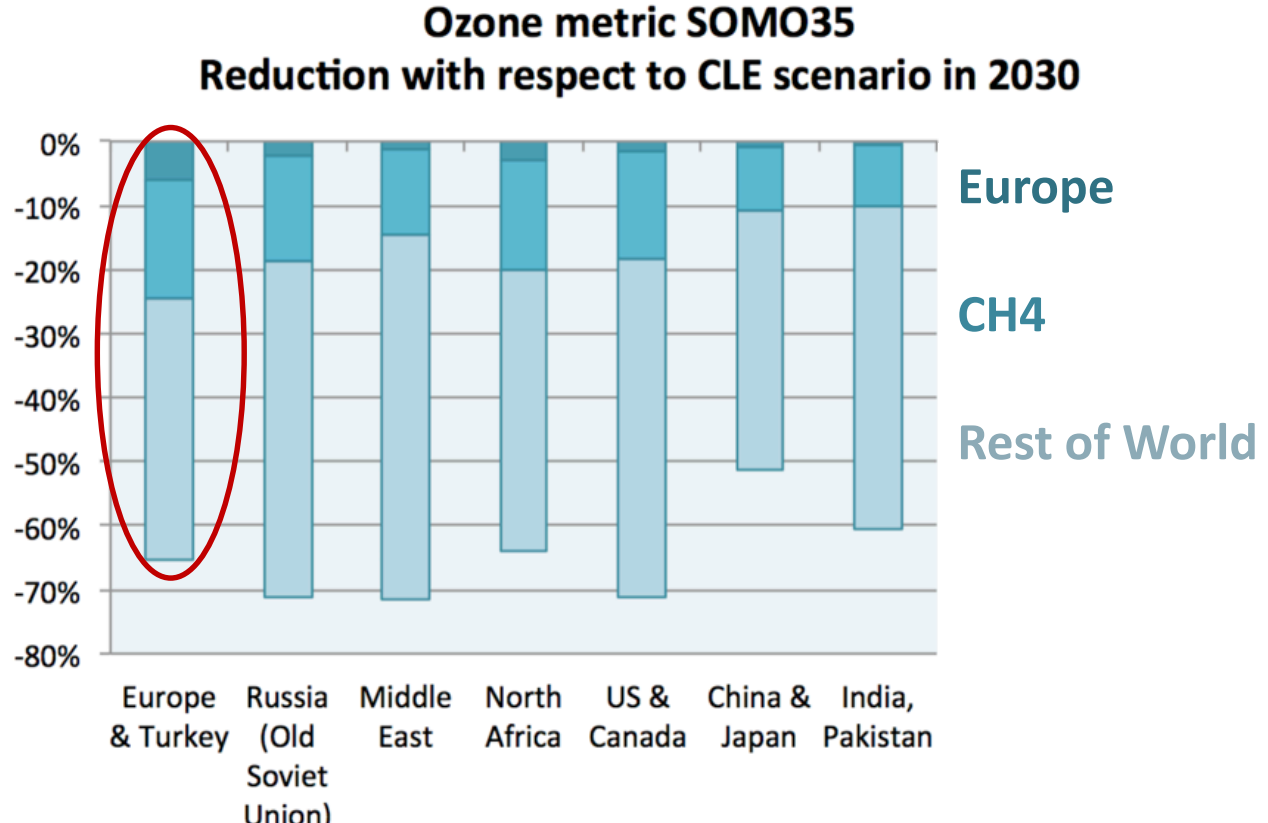
Additional reductions in Europe are less important than CH4 and ROW

How important are CH4 vs other reductions in 2030 for European ozone (2)?

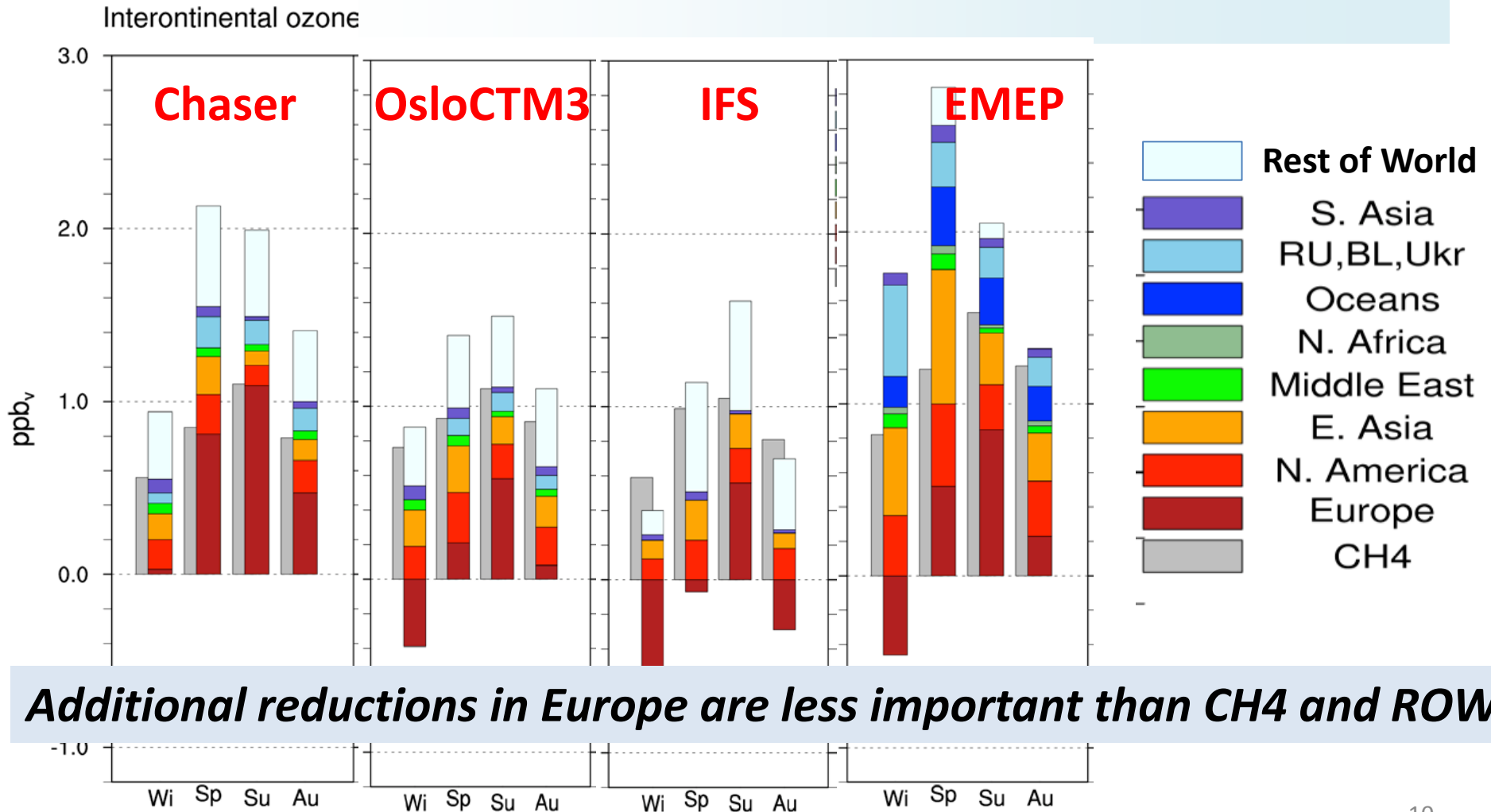Contribution to change in surface O₃ in Europe, ppb

Additional reductions in Europe as important as CH4

...but different metrics, scenarios, multi-model vs. EMEP model etc.

From CLRTAP Ass. Rep., based on HTAP1

HTAP II source contributions to European Surface Ozone due to Δ20% anthropogenic emissions / CH4 levels

Interontinental ozone

Chaser   **OsloCTM3**   **IFS**   **EMEP**

- Rest of World
- S. Asia
- RU,BL,Ukr
- Oceans
- N. Africa
- Middle East
- E. Asia
- N. America
- Europe
- CH4

Additional reductions in Europe are less important than CH4 and ROW

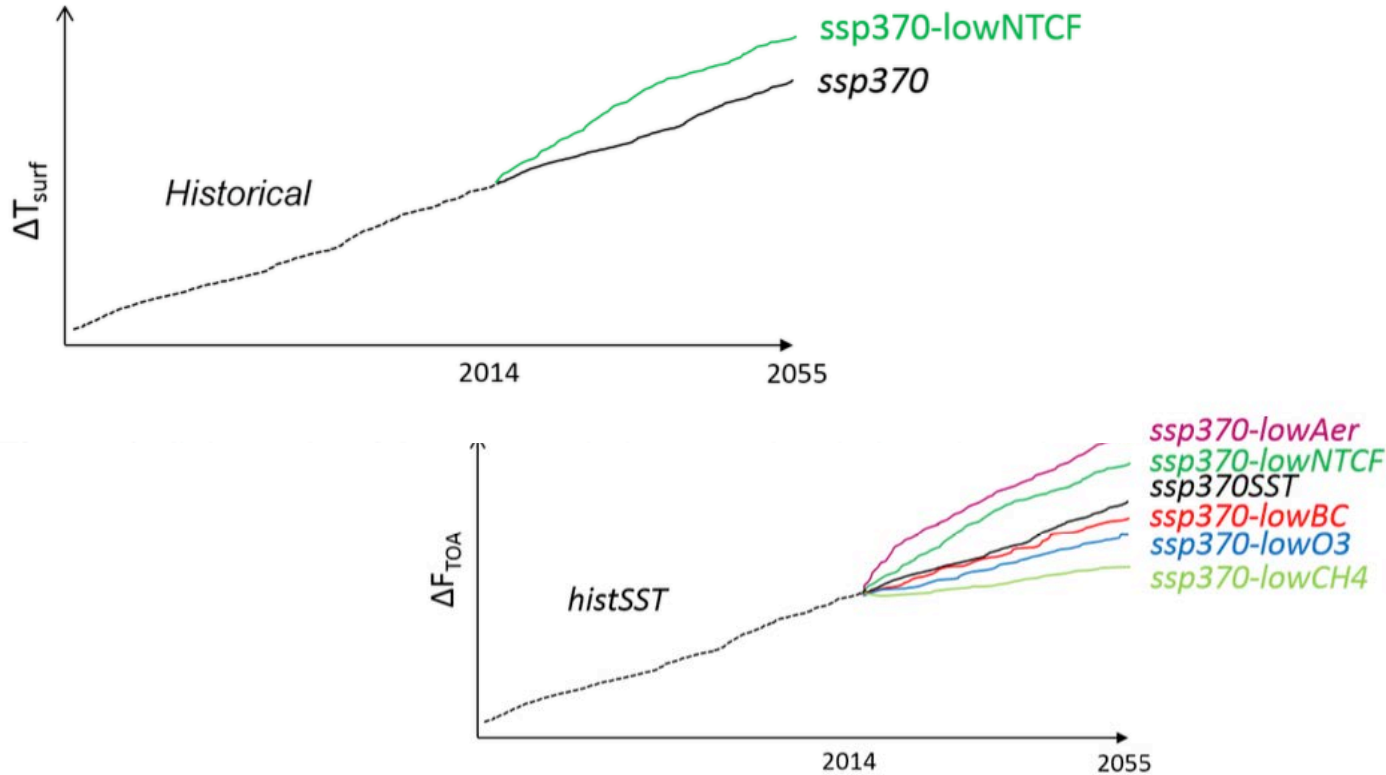# Will ozone import to Europe decrease or increase in the future?

- Factors changing the import:
  - NOy/VOC Emissions in Asia and N America
  - NOy/VOC Emissions in Europe themselves
  - Lifetime of NOy/VOC, PAN, ozone
  - CH4 emissions
  - CH4 life time
  - Circulation changes along with climate change

Will ozone import to Europe decrease or increase in the future?

Work to do….

- Parameterization work
- Review CH4 life time projections
- Emission scenarios analysis
- Indirect effects of changing European emissions
- Overview of uncertainty of factors
- **Three factor problem (Climate, Europe, ROW emissions)**
- **Optimistically - the import decreases (absolute)**
- **More uncertain is possibly, whether the relative import increases, less titration of O3 ?**

Outlook testing Future AQ reductions SSP3^{+} - AerchemMIP/CMIP6 simulations

AerChemMIP: quantifying the effects of chemistry and aerosols in CMIP6

William J. Collins[1], Jean-François Lamarque[2], Michael Schulz[3], Olivier Boucher[4], Veronika Eyring[5], Michaela I. Hegglin[1], Amanda Maycock[6], Gunnar Myhre[7], Michael Prather[8], Drew Shindell[9], and Steven J. Smith[10]

Cooperation with ScenarioMIP, AIM model, *Fujimori et al.*

Summary
What we still need to *quickly* sort out

- Integrate different experiments to derive "import efficiency" and uncertainty - parameterization
  - HTAP1 and HTAP 2, ECLIPSE, EMEP, individual studies
  - Scenarios and idealized x% reduction experiments
    - Which species, which feedbacks, which climates
- Ozone and CH4 lifetime in background conditions in future
- Impact of form of receptor region
- Impact on ozone fluxes, health – weighting
- Seasonal variation impact on metrics

Take home messages formulating

- **Shipping emissions matter** ! contribution to be extracted
- **CH4 matters** ! Uncertainty analysis ..