Joint Research Centre

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Influence of hemispheric transport on ozone pollution in Europe (a TM5-FASST analysis)

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TFIAM 46, May 2nd 2017

European Commission

Scope:

- Trends in O_3 and O_3 exposure metrics in Europe, from 2010 to 2050
- Local versus long-range transport contributions
- Role of CH_4
- Role of Shipping
- Co-benefits of climate mitigation

Method:

- HTAP2 emission scenarios: ECLIPSE V5a (IIASA, Zig Klimont) 2010, 2030, 2050

  REF-CLE, REF-MTFR, CLIM-CLE

- Model: TM5-FASST
  - global linearized source-receptor model, derived from TM5 CTM (Krol, Dentener, et al.)
  - Approach as in Wild et al., 2012 (CLRTAP assessment, HTAP1 regions)
  - Regional definition more like HTAP2

  (but only 1 model)

Take-home messages:

- Without further climate mitigation or technical controls beyond CLE, and despite emission reductions in Europe, the averaged O_3 health-relevant exposure metric in Europe will **not reduce below 2010 values by 2030**, and will even be **higher in 2050 than in 2010.**
- Under CLE, globally increasing emissions of **CH_4** emissions **offset the CLE mitigation effort in Europe**.
- Mitigation of CH_4 (as part of AQ and/or climate policy action) is an effective pathway to reduce future O_3 exposure to population and crops
- MFR technologies lead to a 17% (2030) to 21% (2050) reduction in O_3 exposure in Europe, compared to CLE. Roughly half of this benefit is due to reductions in **shipping emissions and CH_4**.

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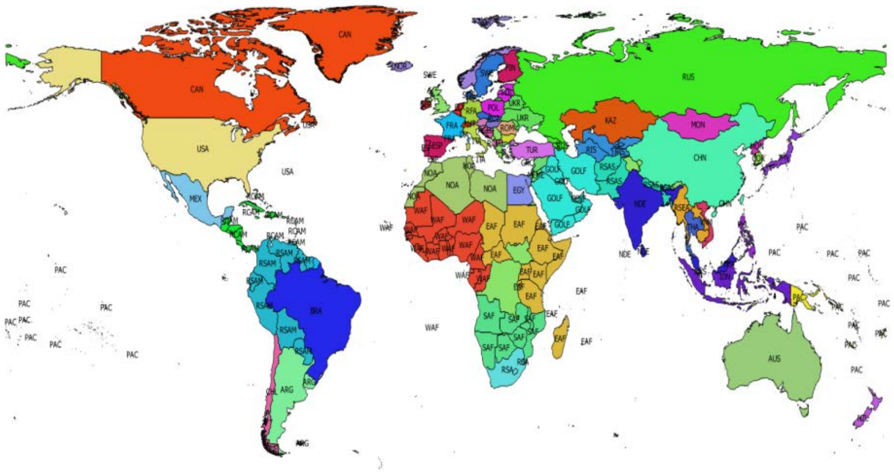
the FAst Scenario Screening Tool
TM5-FASST



- 'Emulator' of the full TM5-CTM global chemical transport model
- Source-Receptor model
- Linearized emission-concentration relations calculated with TM5-CTM (emissions: RCP 2000, meteo: yr 2001)
- 56 source regions
- EU27: 16 FASST regions
- Fixed natural PM (dust and seasalt) fields

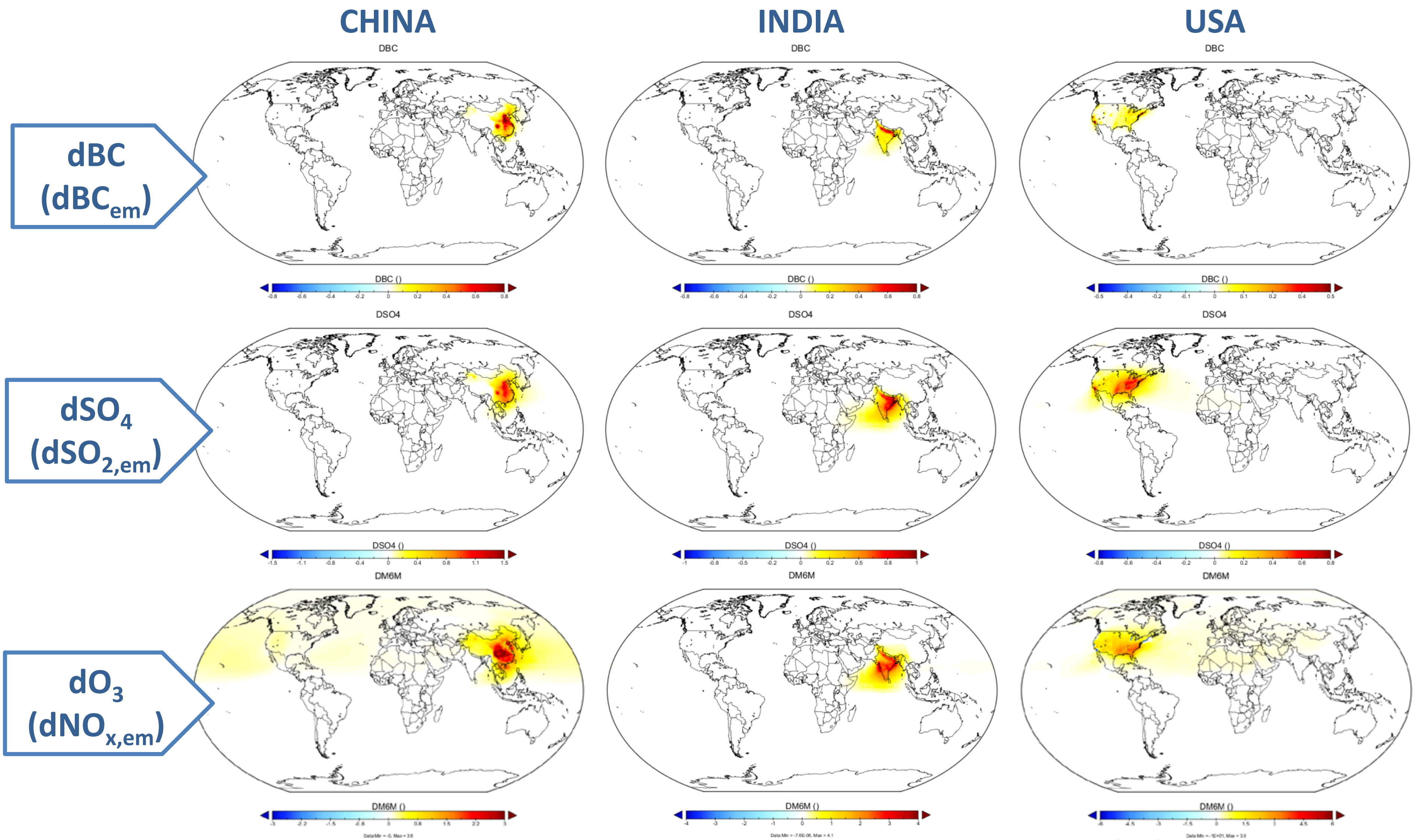
Model input: annual emissions by region of

SO_2, NO_x, NH_3, CO, NMVOC, Elemental Carbon, Primary Organic Matter, $PM_{2.5}$, CH_4

Model output (non exhaustive) – as gridmaps or region/country averages

- $PM_{2.5}$ concentration and impacts on human health
- O_3 and O_3 metrics, impacts on agricultural crop losses and human health
- NO_y and SO_x deposition (exceedences of critical loads)
- Radiative forcing
  CO_{2e} emissions of short-lived pollutants (EC, NOx, ...) based on GWP[H] and GTP[H]
  EC deposition (e.g. Arctic, Himalayas,...)

Delta concentration with base run = concentration response to 20% emission change in each source region



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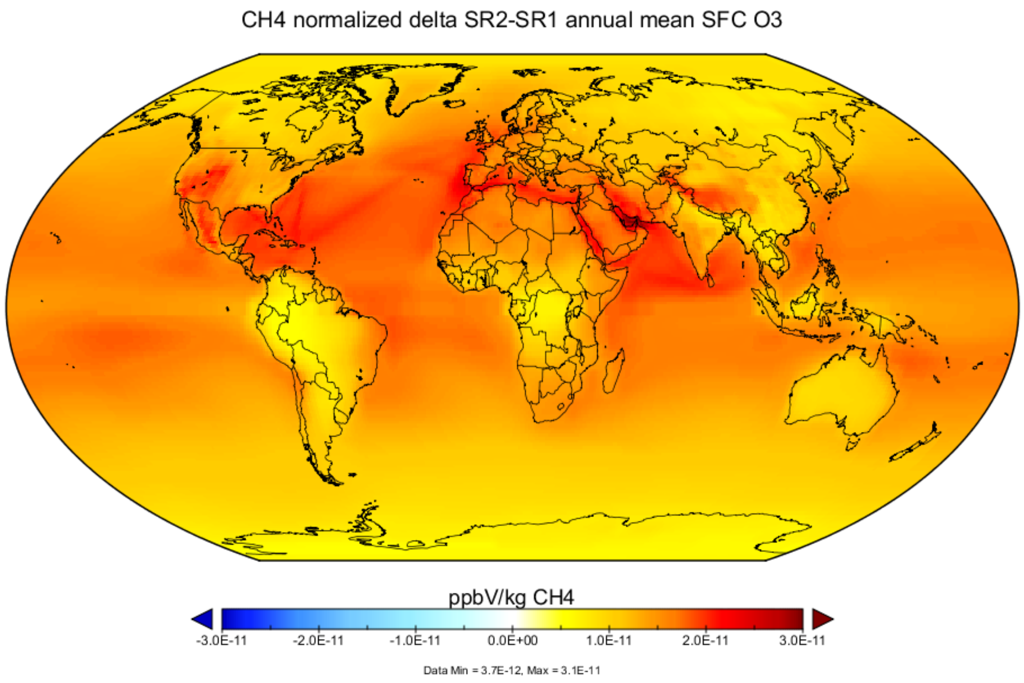
Ozone from CH_4:

- 1 global emission-concentration SR field
- From HTAP1 (SR2 – SR2)
  - SR1 [CH4] = 1760 ppb
  - SR2 [CH4] = 1408 ppb (-20%)
  - Corresponding delta emission (TM5 CTM) = 77 Tg



Note: CO → O3 not included (yet)

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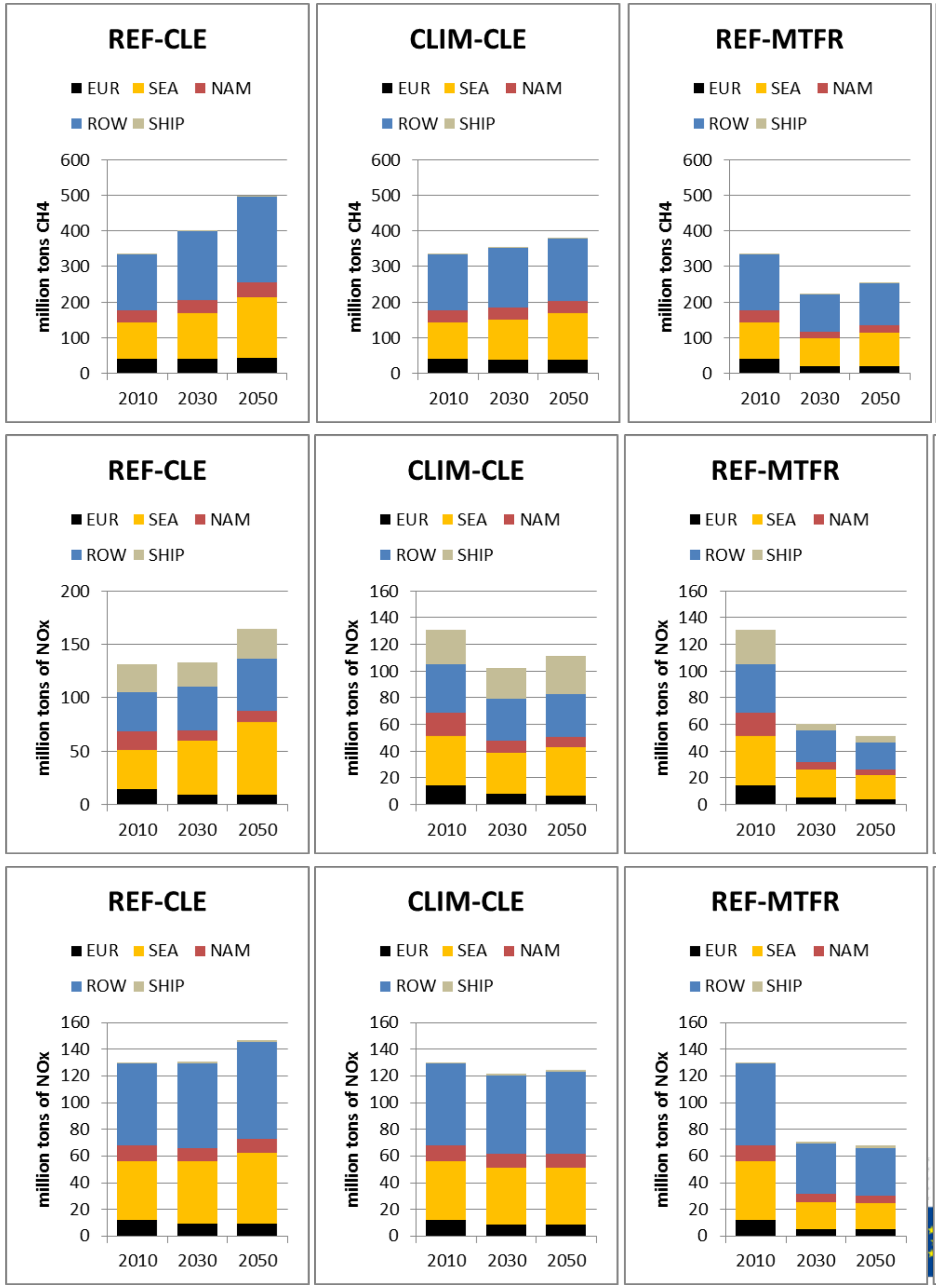
ECLIPSE v5a - Emission trends

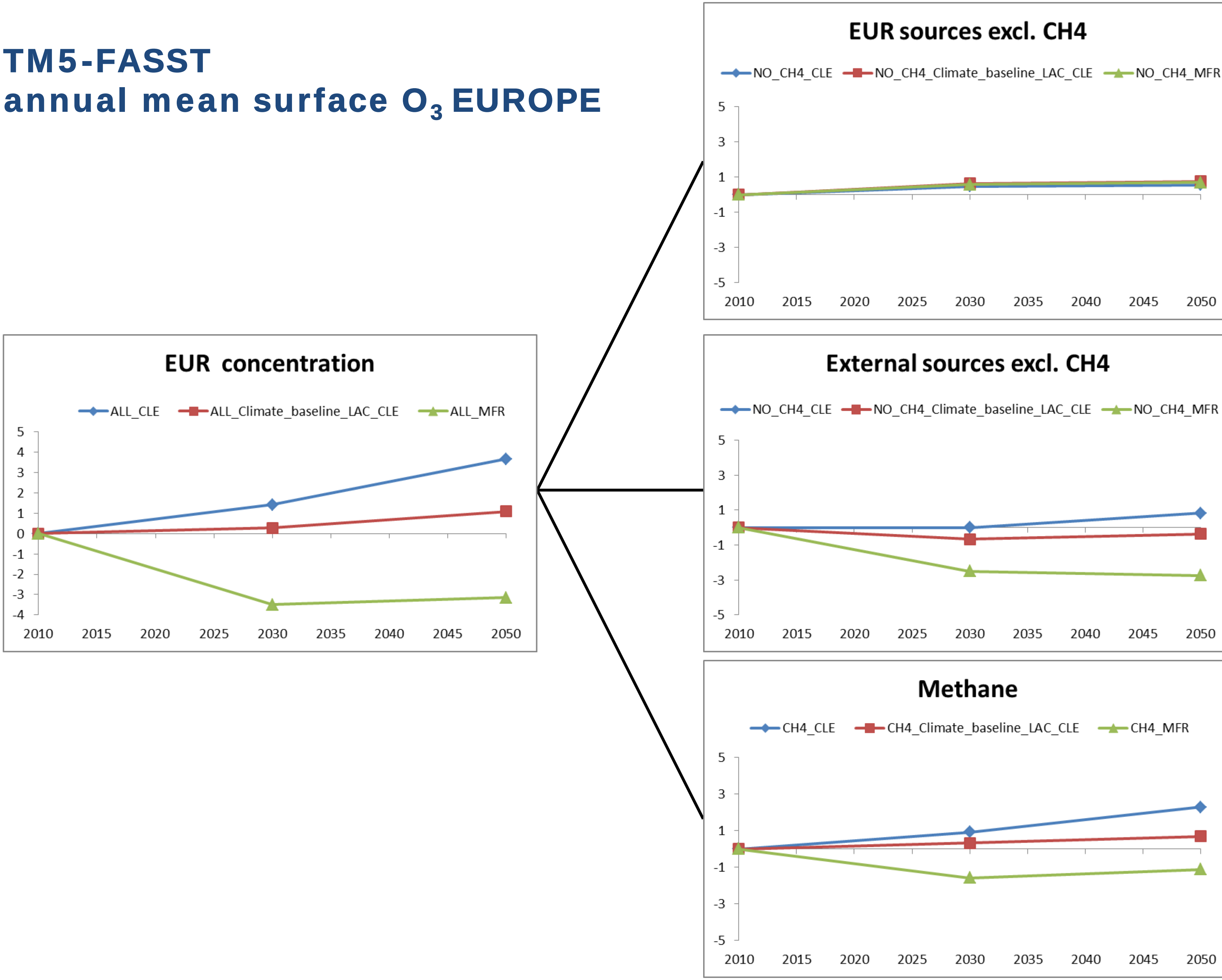
CH_4

NO_x

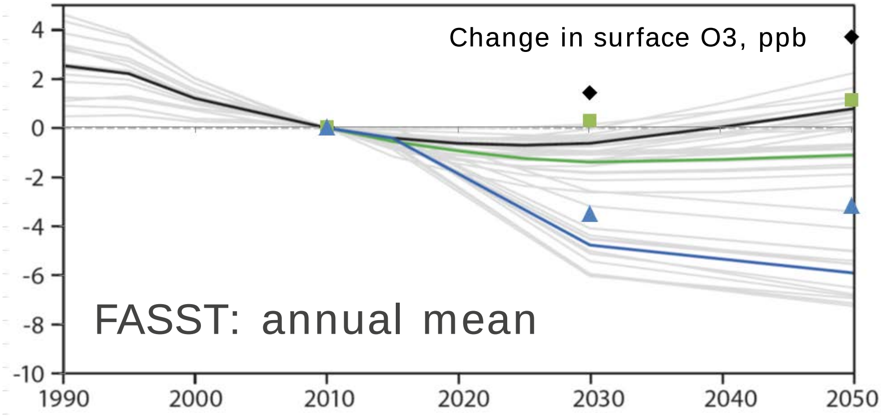
NMVOC

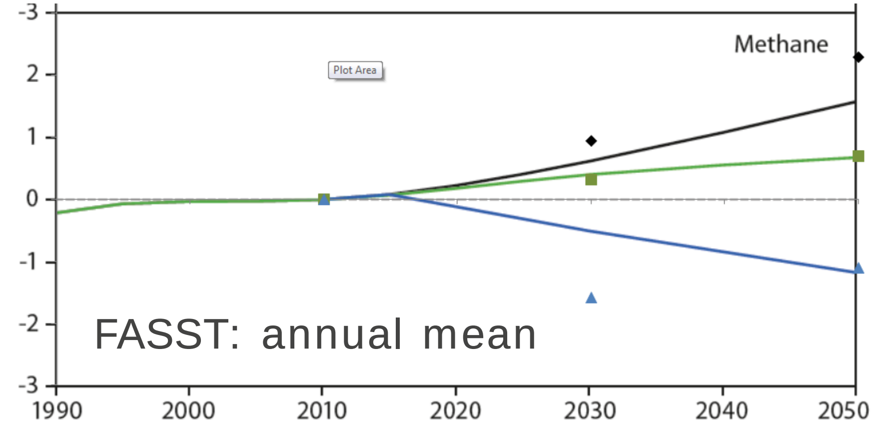


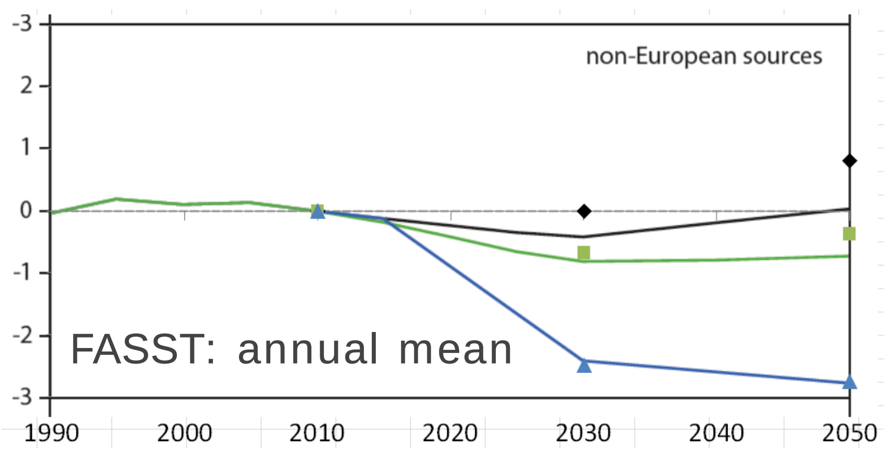
TM5-FASST
annual mean surface O_3 EUROPE



FASST vs. CLRTAP assessment

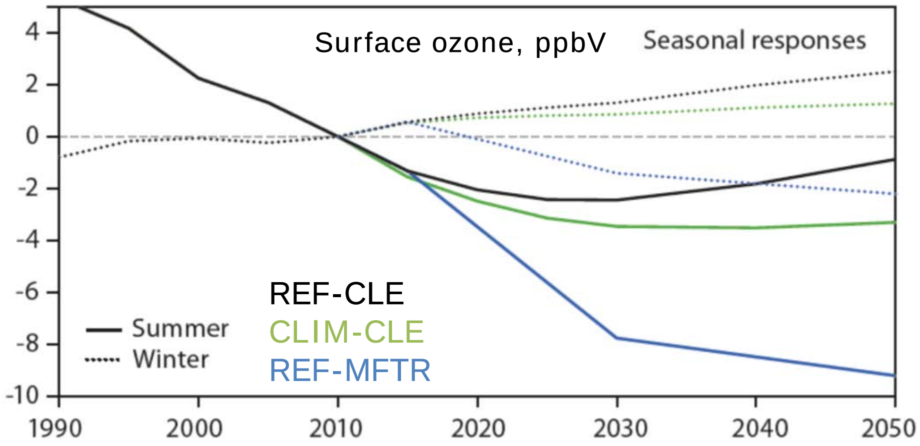




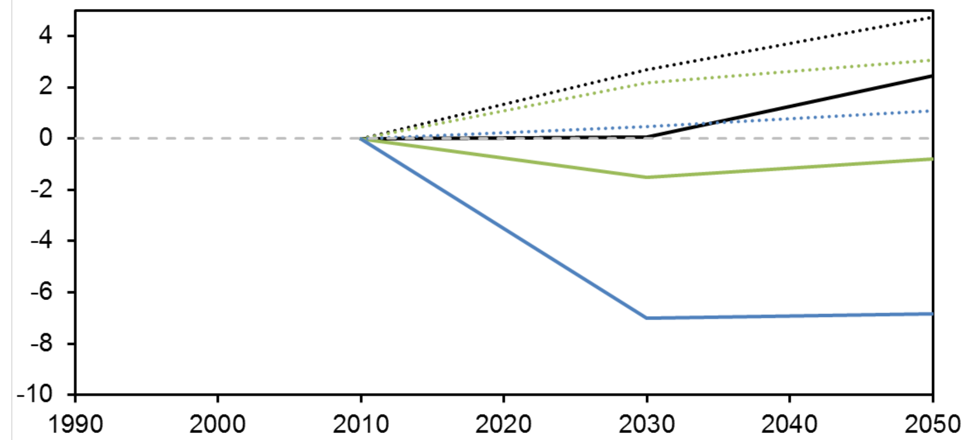


Summer vs. Winter

CLRTAP assessment



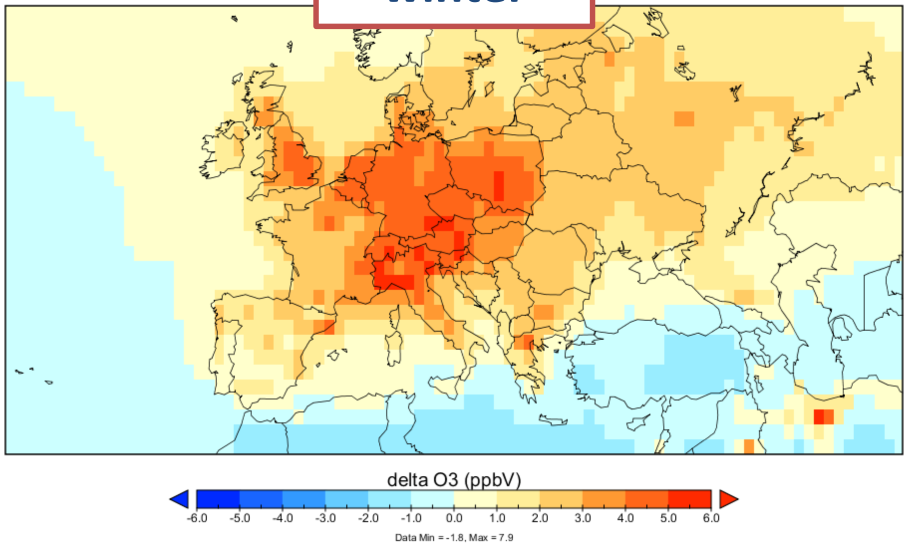
FASST



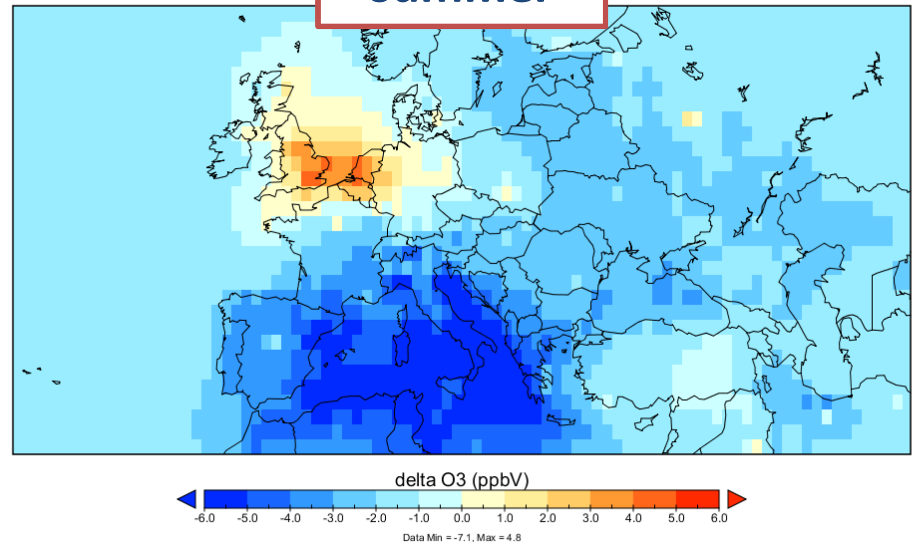
FASST: CLIM 2030 – 2010

Surface ozone, ppb

winter



summer



Possible issues:

- Linear extrapolation of titration effect: overestimates (winter time & annual mean) negative dNO_x – dO_3 correlation in Europe → increasing O_3 with decreasing NO_x

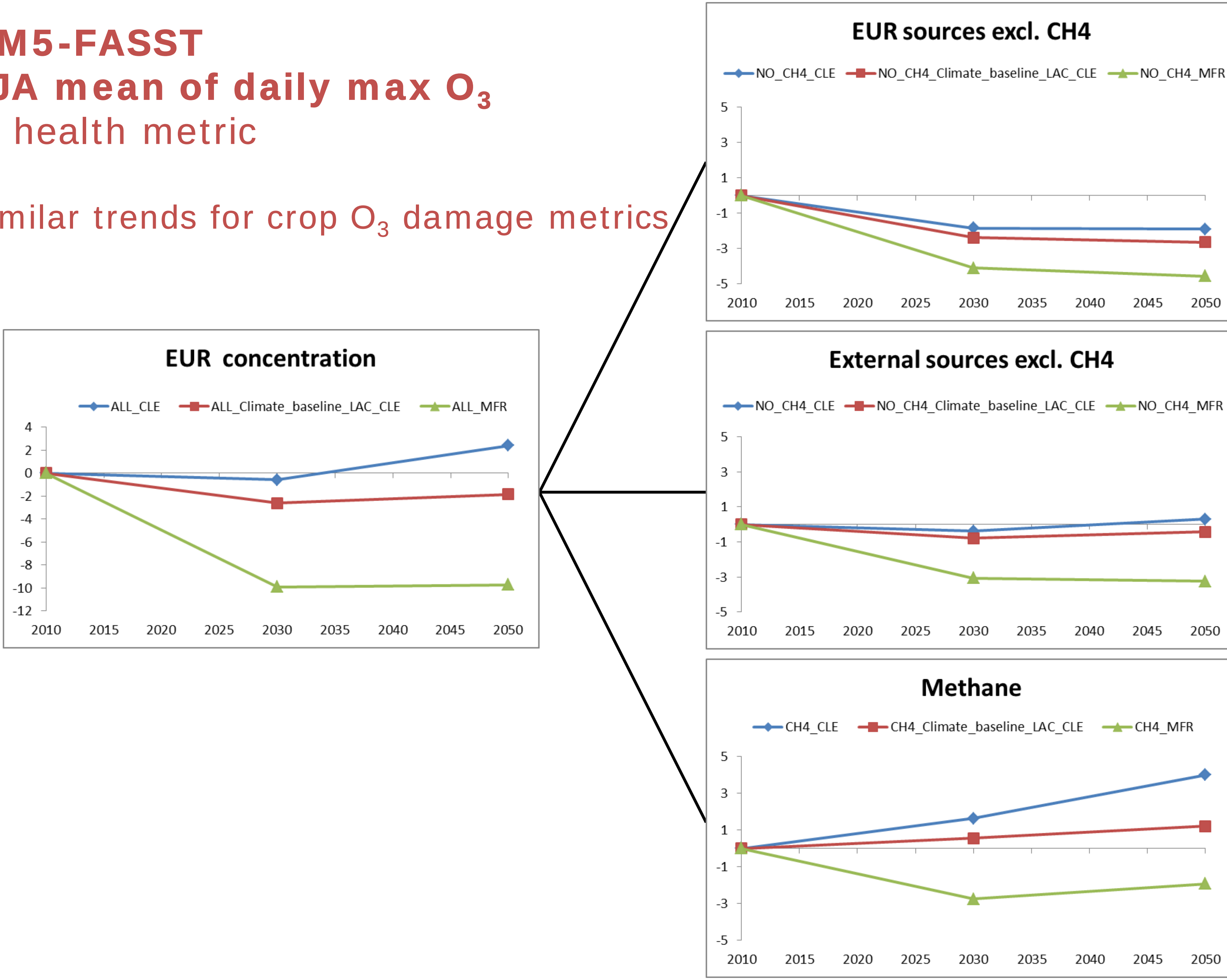
- Result of higher resolution of TM5 vs HTAP1 models?

- CH_4 → O_3 impact: time delay for steady-state not considered

- Effect of reducing CO not included

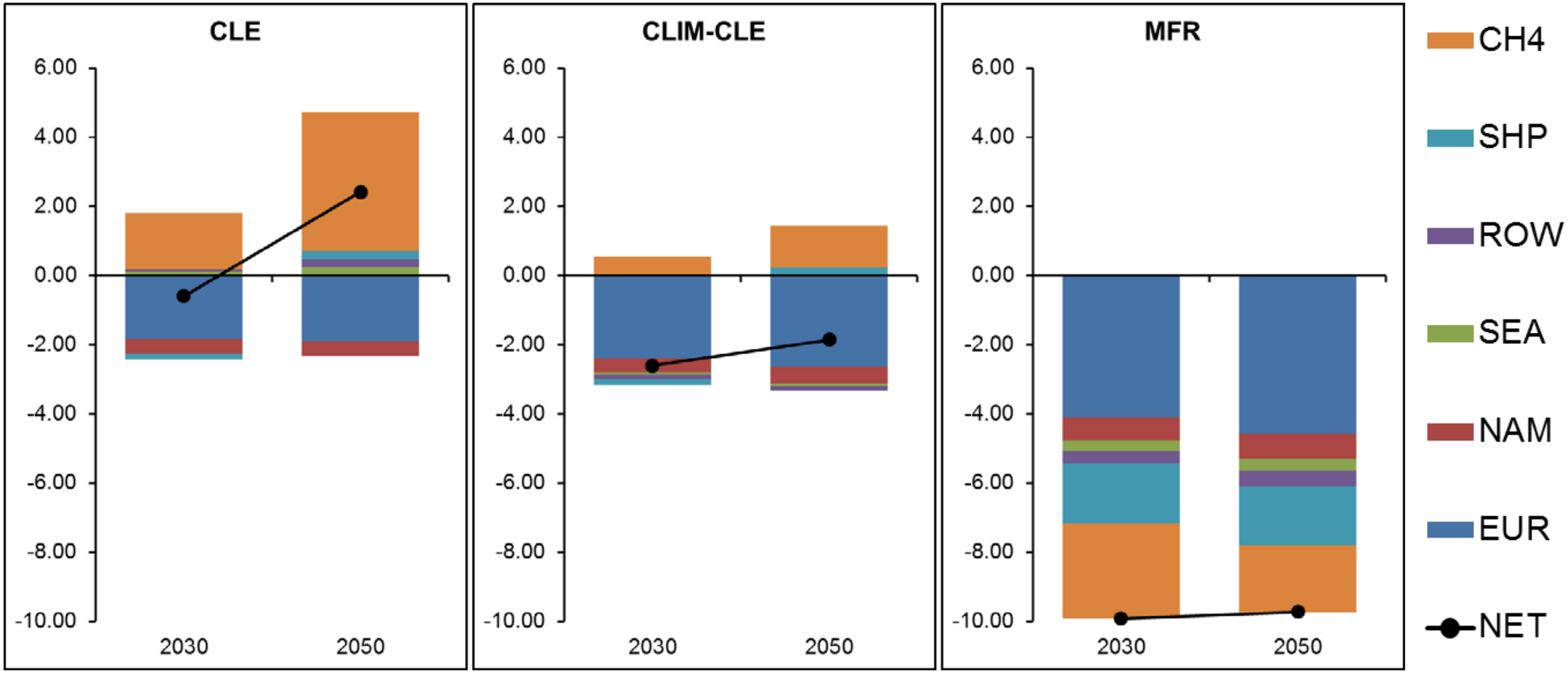
TM5-FASST
JJA mean of daily max O_3
= health metric

similar trends for crop O_3 damage metrics



JJA mean of daily max O3 (health metric)

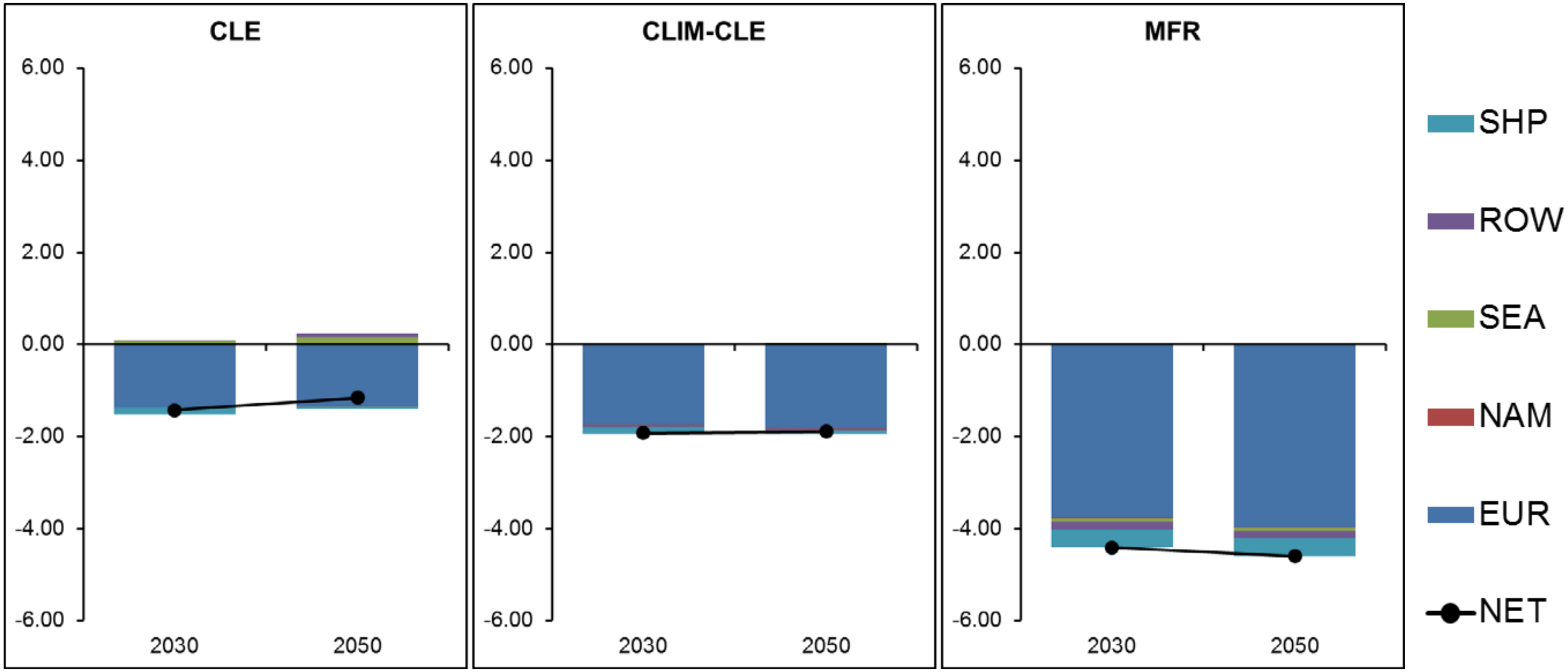
(ppbV)



	2010	2030	2050		2010	2030	2050		2010	2030	2050
Δ 2010		-0.59	2.42			-2.60	-1.85			-9.91	-9.72
Abs. value	55.8	55.2	58.2		55.8	53.0	53.7		55.8	45.9	46.0
% Δ CLE (yr)						**-4%**	**-8%**			**-17%**	**-21%**

Anthr. PM2.5 (pop. weighted mean)

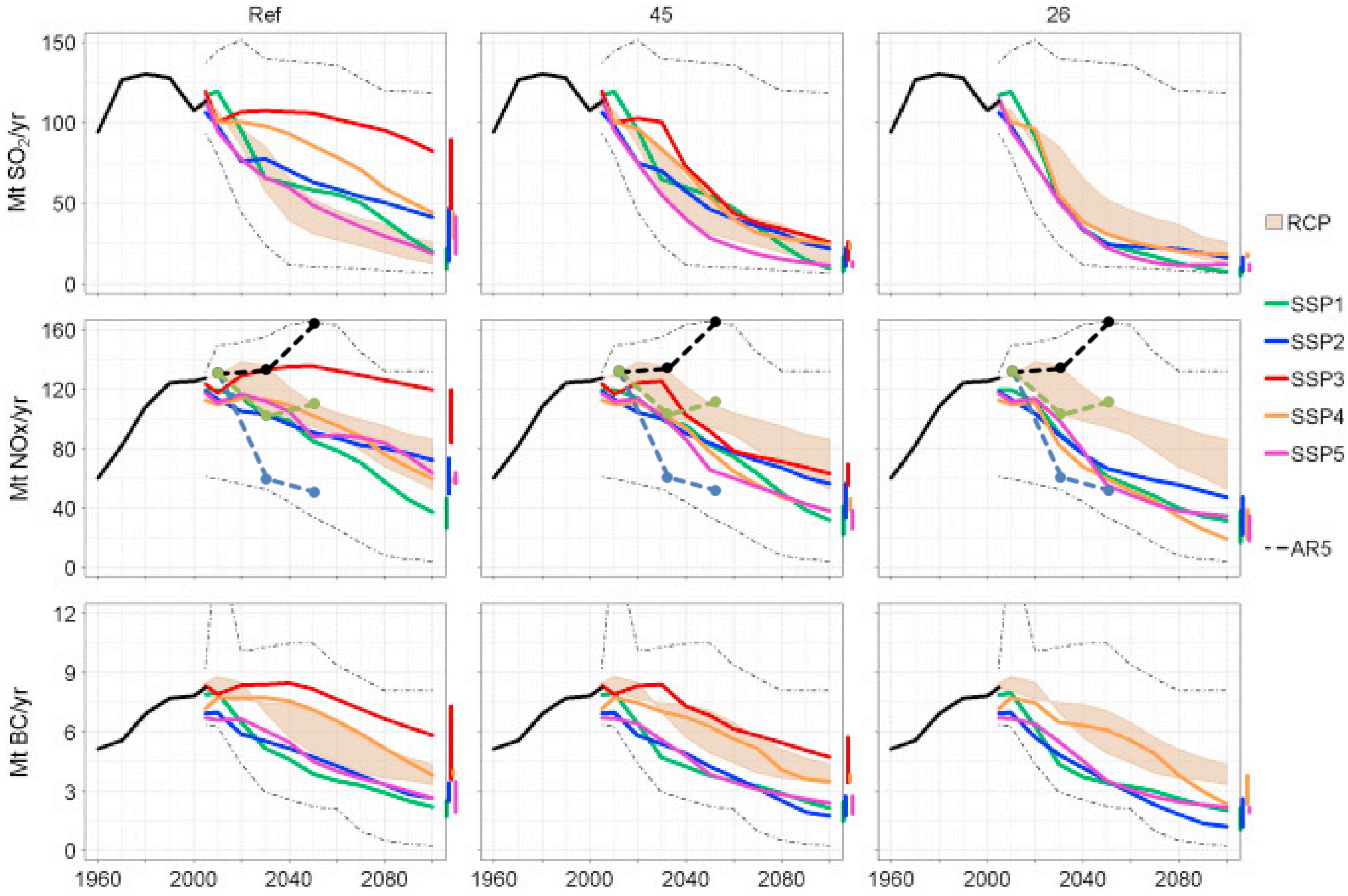
(μg/m³)



	2010	2030	2050		2010	2030	2050		2010	2030	2050
Δ 2010		-1.4	-1.1			-1.9	-1.9			-4.4	-4.6
Abs. value	7	5.6	5.8		7	4.9	4.9		7	2.6	2.4
% Δ CLE (yr)						**-12%**	**-15%**			**-54%**	**-59%**

Pollutant emission trends developed in the climate community (RCP, SSP)

Rao et al., 2017



https://tntcat.iiasa.ac.at/SspDb

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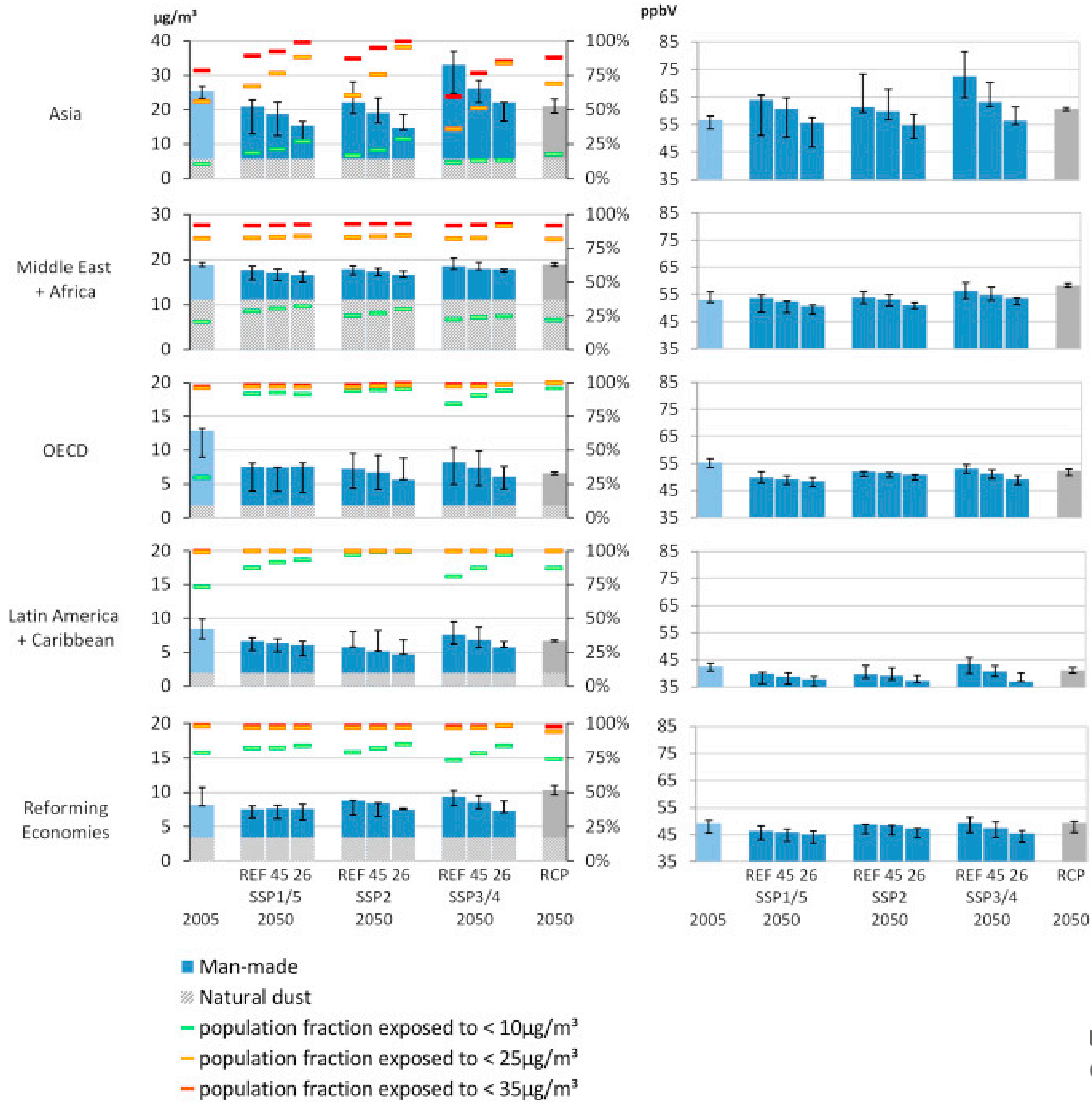
Pop. weighted PM2.5 & exposure to WHO limit levels

Pop. weighted O3 exposure metric

Rao et al., 2017



TM5-FASST on the web: http://tm5-fasst.jrc.ec.europa.eu/

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FAst Scenario Screening Tool - FASST

European Commission > EU Science Hub > FASST

- FASST restricted access
- Registration
- Contact

FASST - FAst Scenario Screening Tool

The TM5-FASST tool, developed at JRC Ispra (Italy), allows to evaluate how air pollutant emissions affect large scale pollutant concentrations and their impact on human health (mortality, years of life lost) and crop yield. The tool is specifically designed to compare a scenario (policy case) with a counterfactual case (baseline). The target policy domains are national to regional air quality policies, or air pollutant scenarios linked to other policy domains (e.g. climate policy). The tool is particularly user-friendly, web-based, flexible, does not require any coding or modelling experience and can be applied from the global to the regional domain. The user can make use of a number of built-in scenario groups or apply custom emission scenarios.

Features

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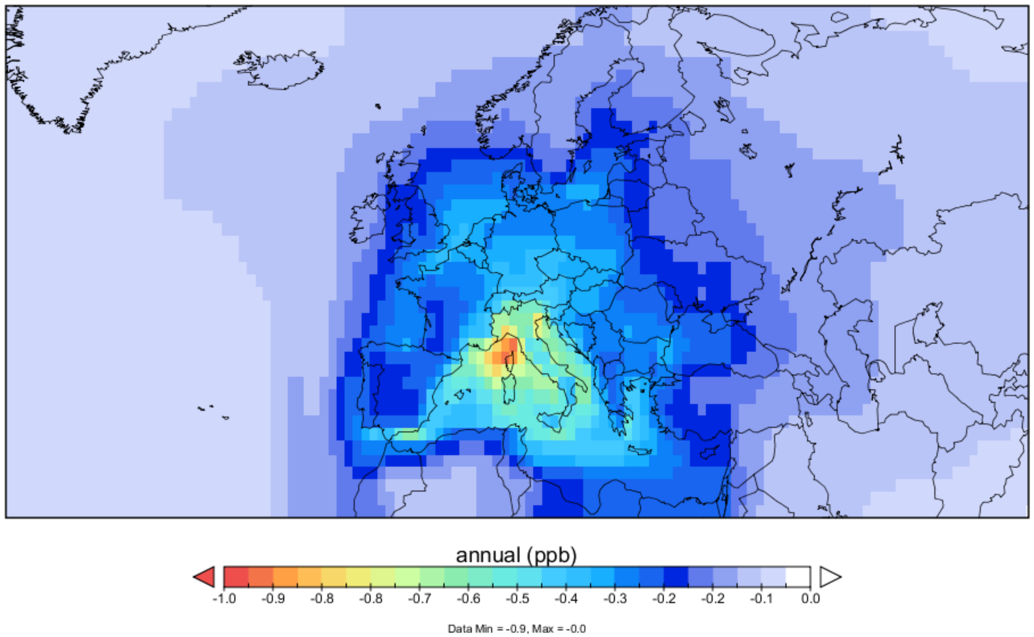
Outlook for FASST:

- EMEP-FASST (based on country-to-country EMEP SR matrices, multiple meteo and emission years, ensemble average and stdev)
- Towards HTAP-FASST
- Address non-linear regimes in O_3
- Include CO

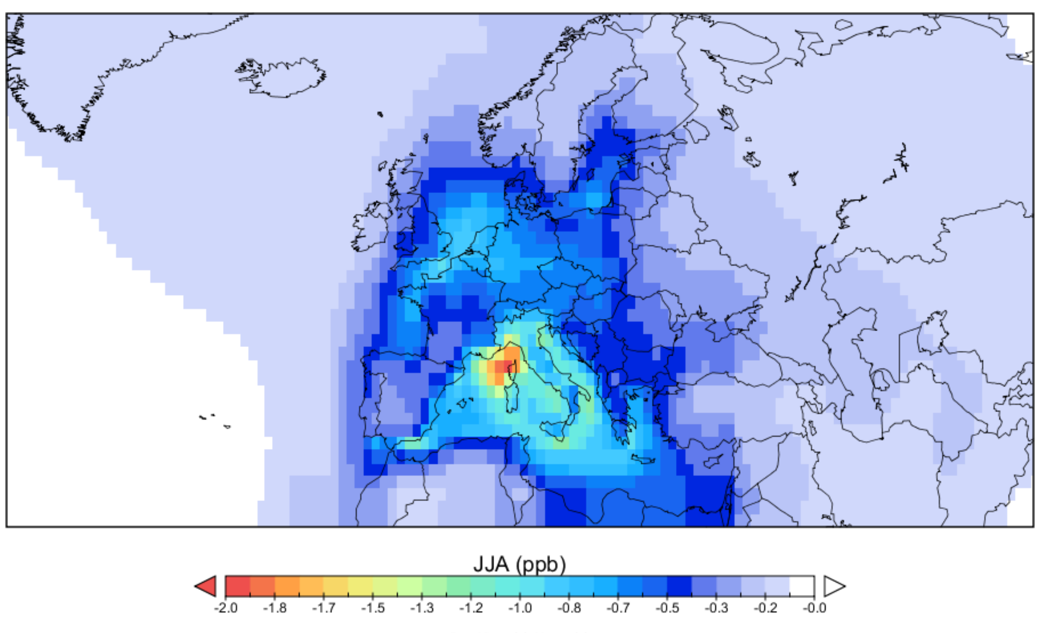
Thank you!

Questions?

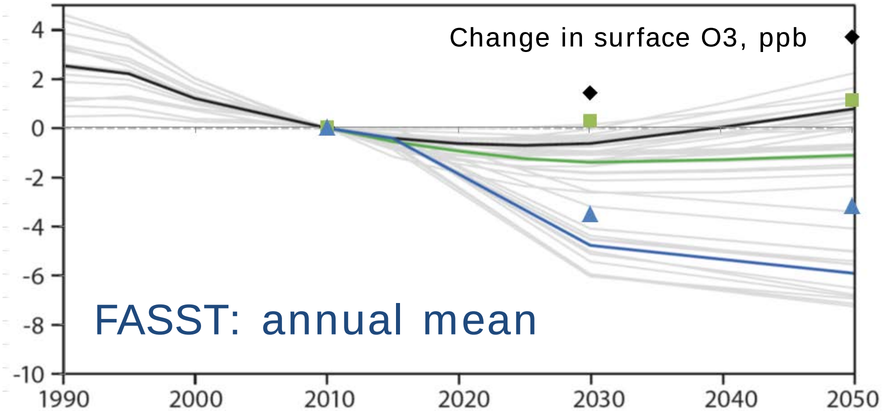
delta annual mean O3 for 80% reduction of CO (RCP year 2000)

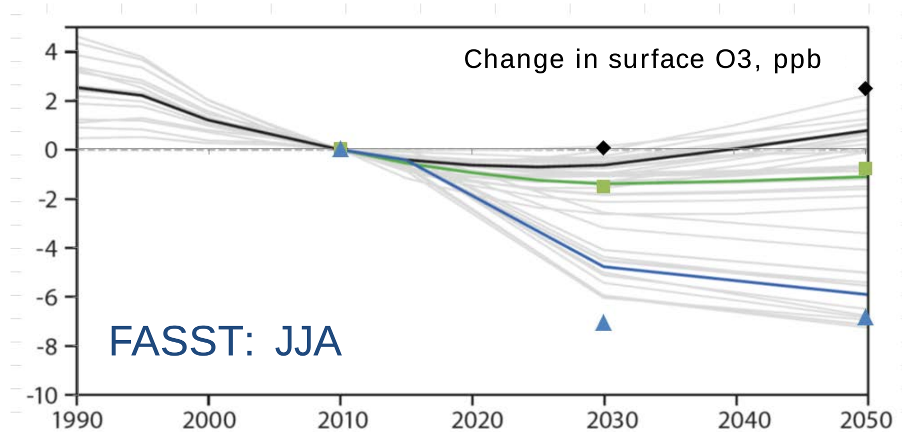


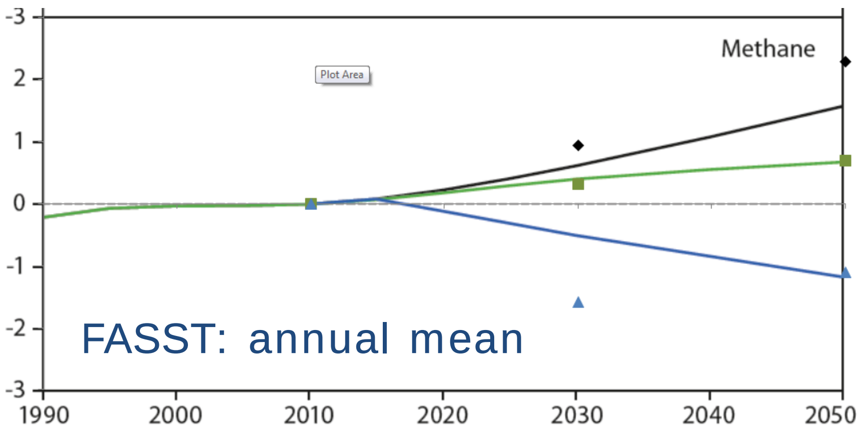
delta JJA O3 for 80% reduction in CO (RCP year 2000)

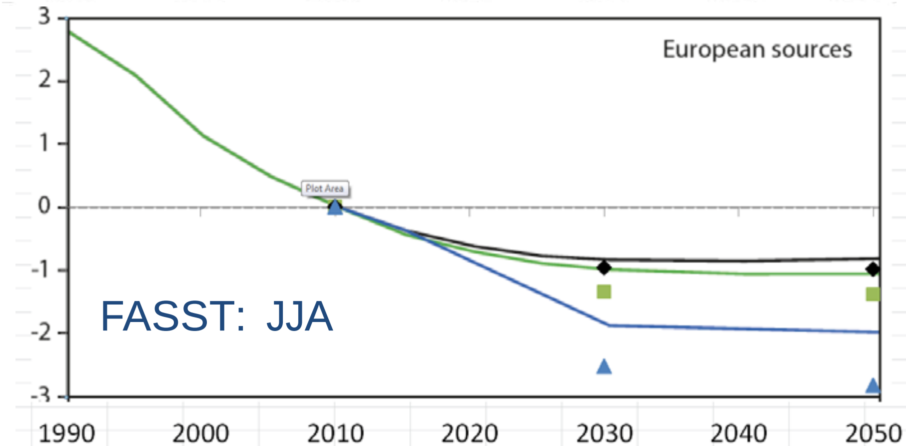


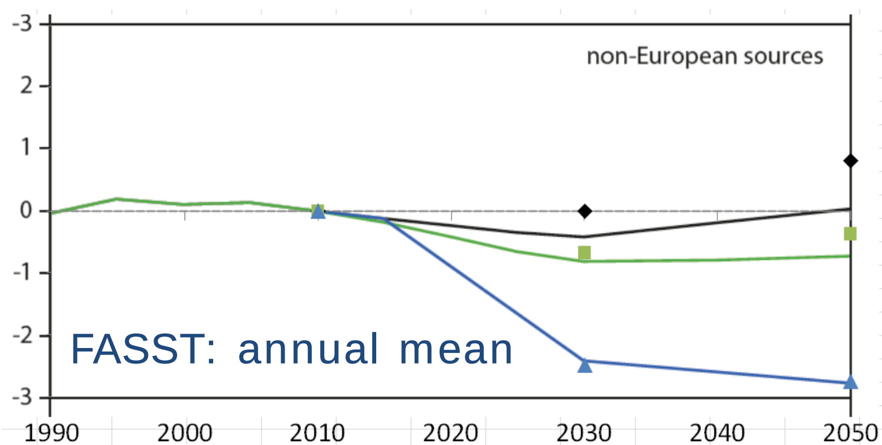
FASST vs. CLRTAP assessment











Issues with FASST linearized SRs:

- Linear extrapolation of titration effect: overestimates (winter time & annual mean) negative dNO_x – dO_3 correlation in Europe → increasing O_3 with decreasing NO_x
- CH_4 → O_3 impact: time delay for steady-state not considered
- CO not included