Task Force on Hemispheric Transport of Air Pollution

TF-HTAP

Update on HTAP activities: Methane as an ozone precursor; Ozone in future scenarios

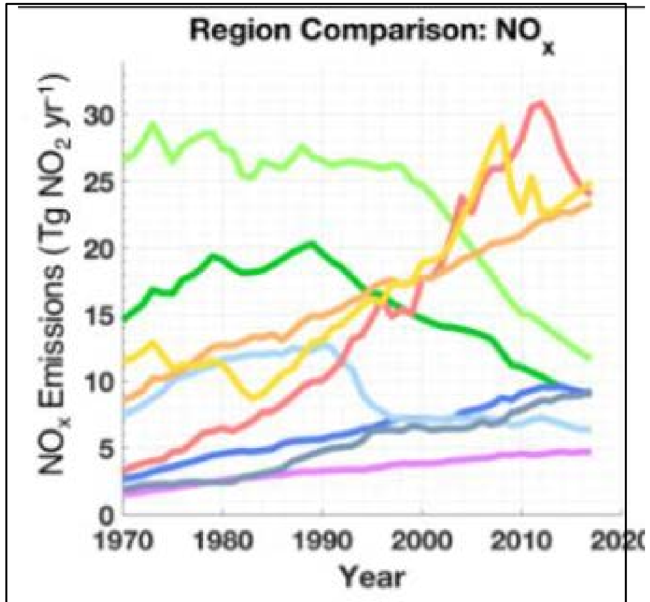
Terry Keating, Rosa Wu, Jacek Kaminski, and Tim Butler

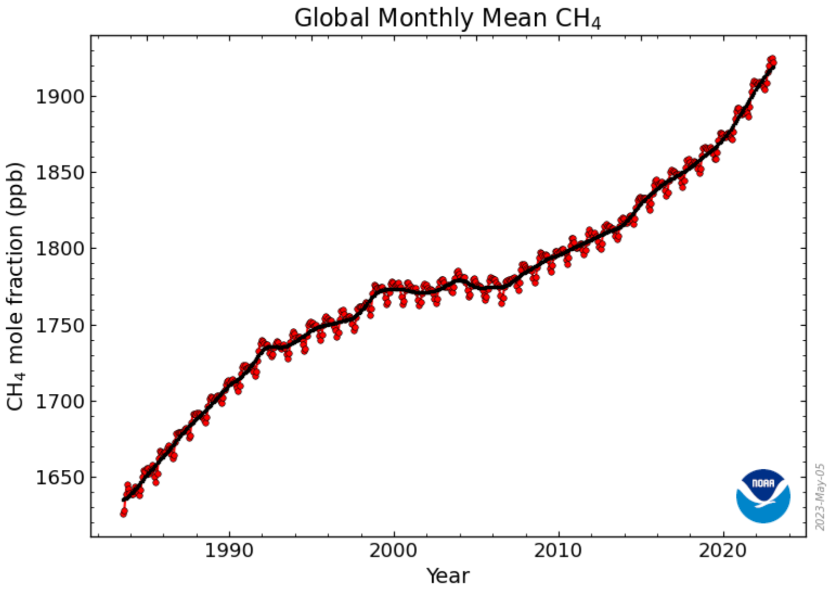
52nd Meeting of the Task Force on Integrated Assessment Modelling
Utrecht, 24 May 2023

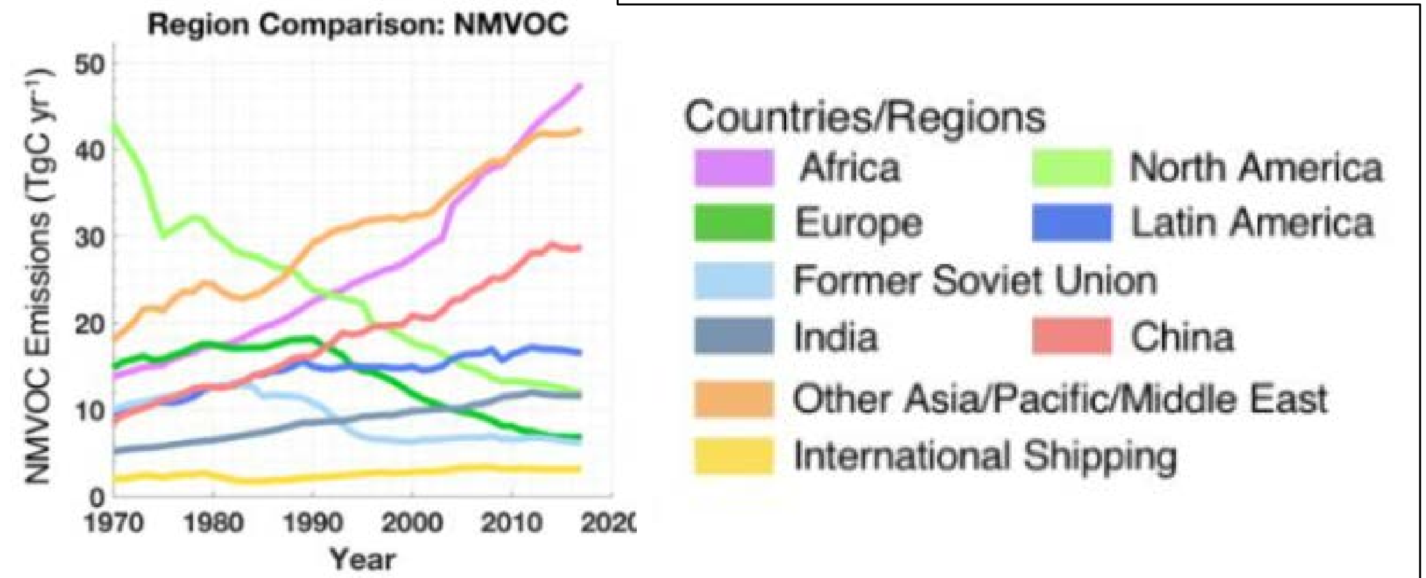
TFHTAP and TFIAM in the 2022-2023 workplan

- 1.1.3.3: contribution to the GP review
- 1.1.3.5: evaluate the impact of methane mitigation on regional ozone
- 1.1.4.2: development and design of global emission scenarios
- 2.1.7: discuss the implications of future global and regional emission scenarios

Global trends in ozone precursors







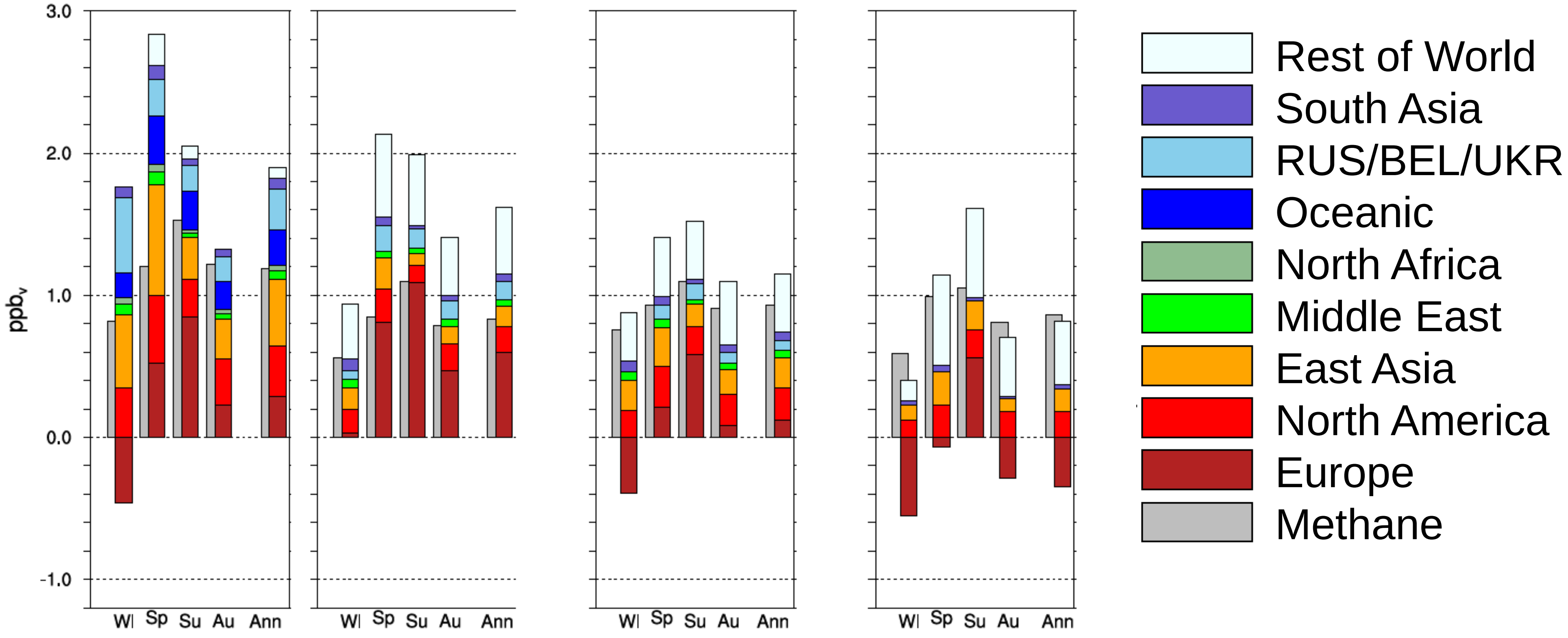
McDuffie et al. (2020) http://doi.org/10.5194/essd-2020-103

- Consistent downward trends in NOx and NMVOC emissions in the UNECE
- Recent reversal in NOx trend from China and stabilisation in NOx from international shipping
- Continuing increase in NMVOC emissions from several regions
- Accelerating increase in global methane concentration

Atmos. Chem. Phys., 18, 13655–13672, 2018
https://doi.org/10.5194/acp-18-13655-2018

The effects of intercontinental emission sources on European air pollution levels

Jan Eiof Jonson[1], Michael Schulz[1], Louisa Emmons[2], Johannes Flemming[3], Daven Henze[4], Kengo Sudo[5], Marianne Tronstad Lund[6], Meiyun Lin[7], Anna Benedictow[1], Brigitte Koffi[8], Frank Dentener[8], Terry Keating[9], Rigel Kivi[10], and Yanko Davila[4]



(a) EMEP_rv48 (b) CHASER_re1 (c) OsloCTM3_v2 (d) IFS_v2

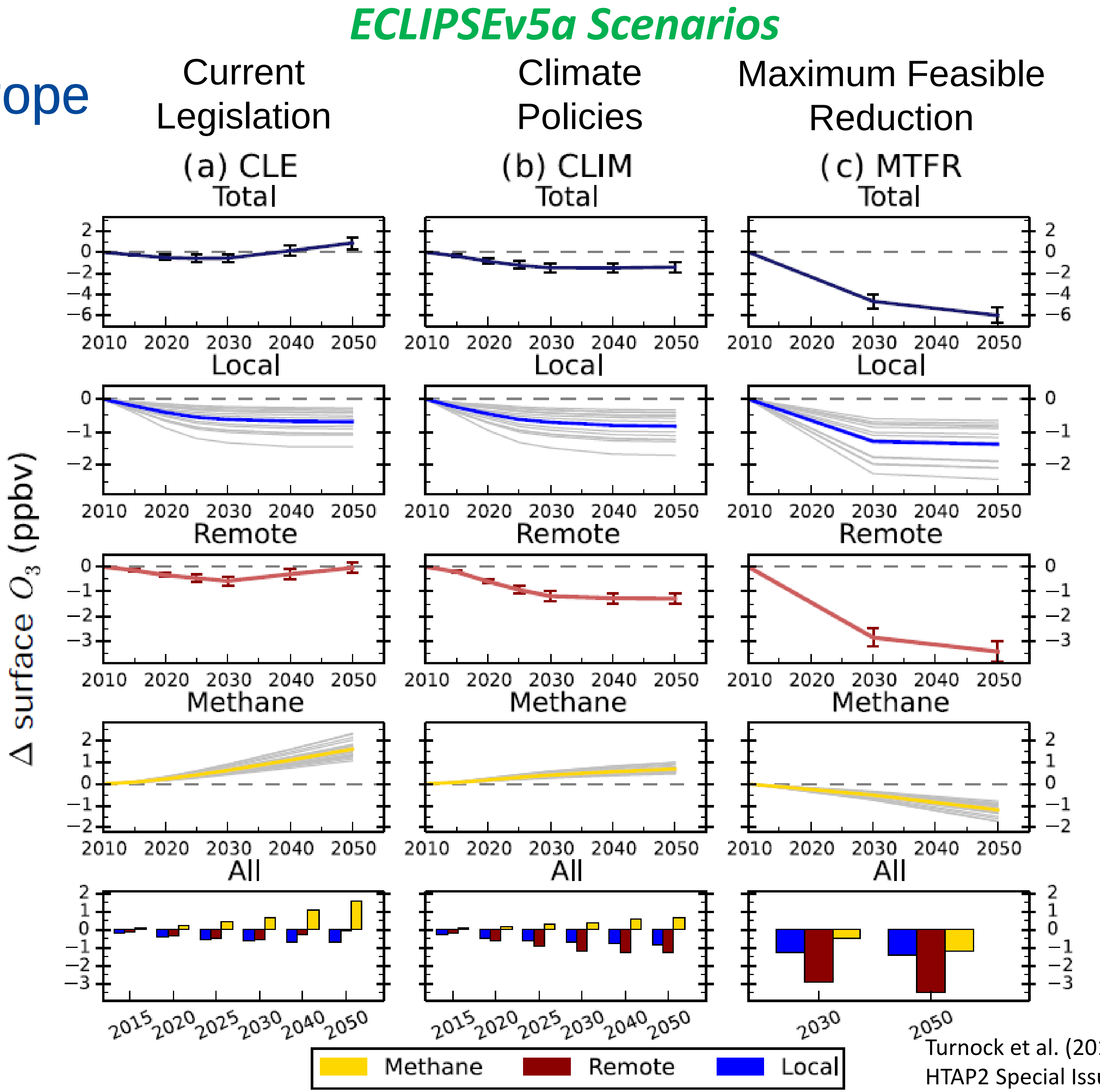
- 2010 conditions
- Large inter-model variability
- Anthropogenic emissions of NO_x and VOCs outside of Europe contribute a comparable amount of ozone as local emissions
- Methane drives ozone formation in Europe to the same extent as non-European NO_x and VOCs
- International shipping contributes a similar amount as remote continental regions (where included)

Regional and extra-regional components of change in Europe

- CLE: O_3 in Europe will decrease as a result of European and (mainly) North American air pollution legislation. Increasing CH_4 will more than offset other emissions decreases after 2030.

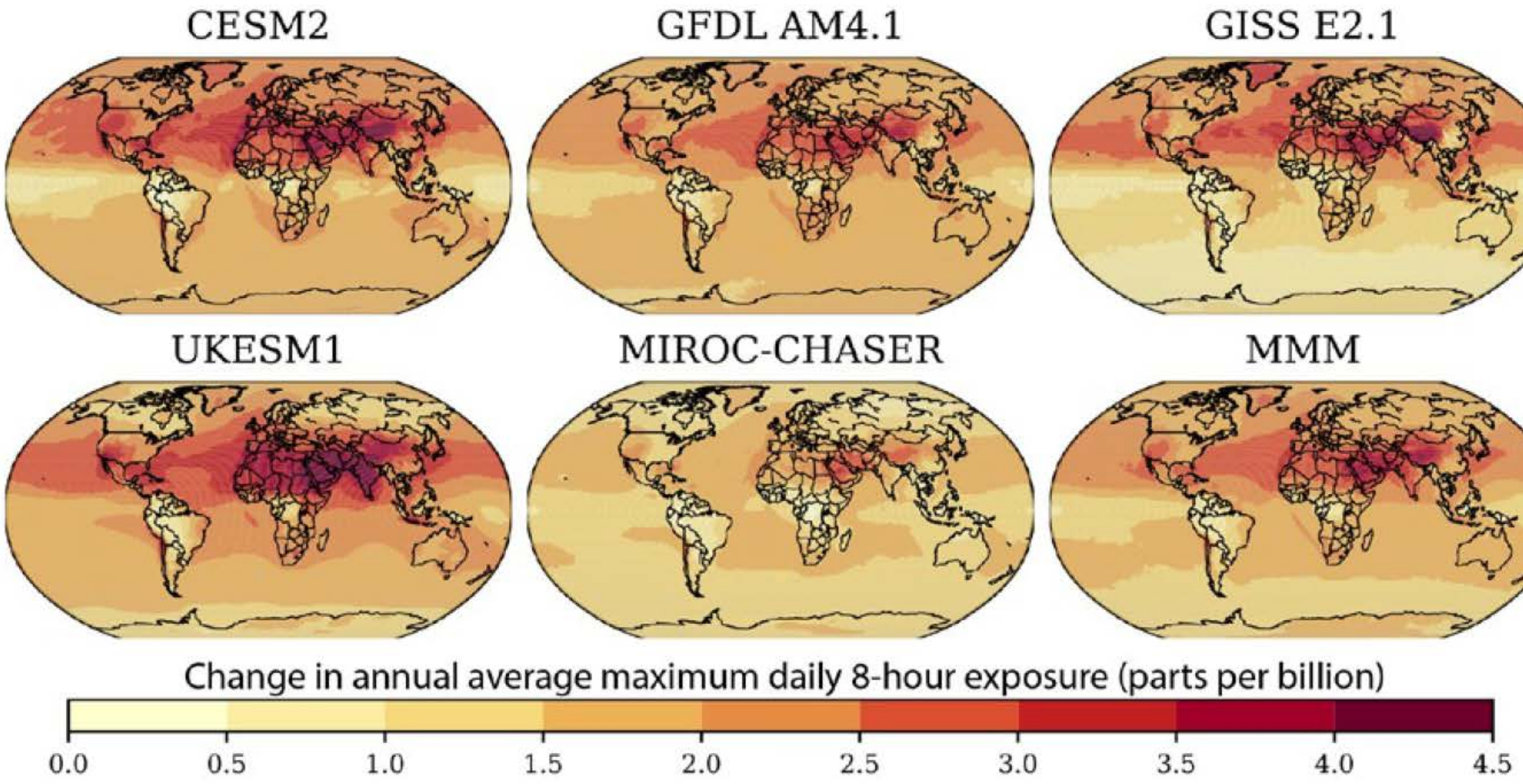
- CLIM: Decreased CH_4 emissions and cobenefits from the energy sector will help to stabilize the O_3 concentrations after 2030.

- MTFR: Enhanced technologies inside and outside Europe will decrease emissions of O_3 precursors, including CH_4, and have strong benefits for air quality.



Turnock et al. (2018) HTAP2 Special Issue

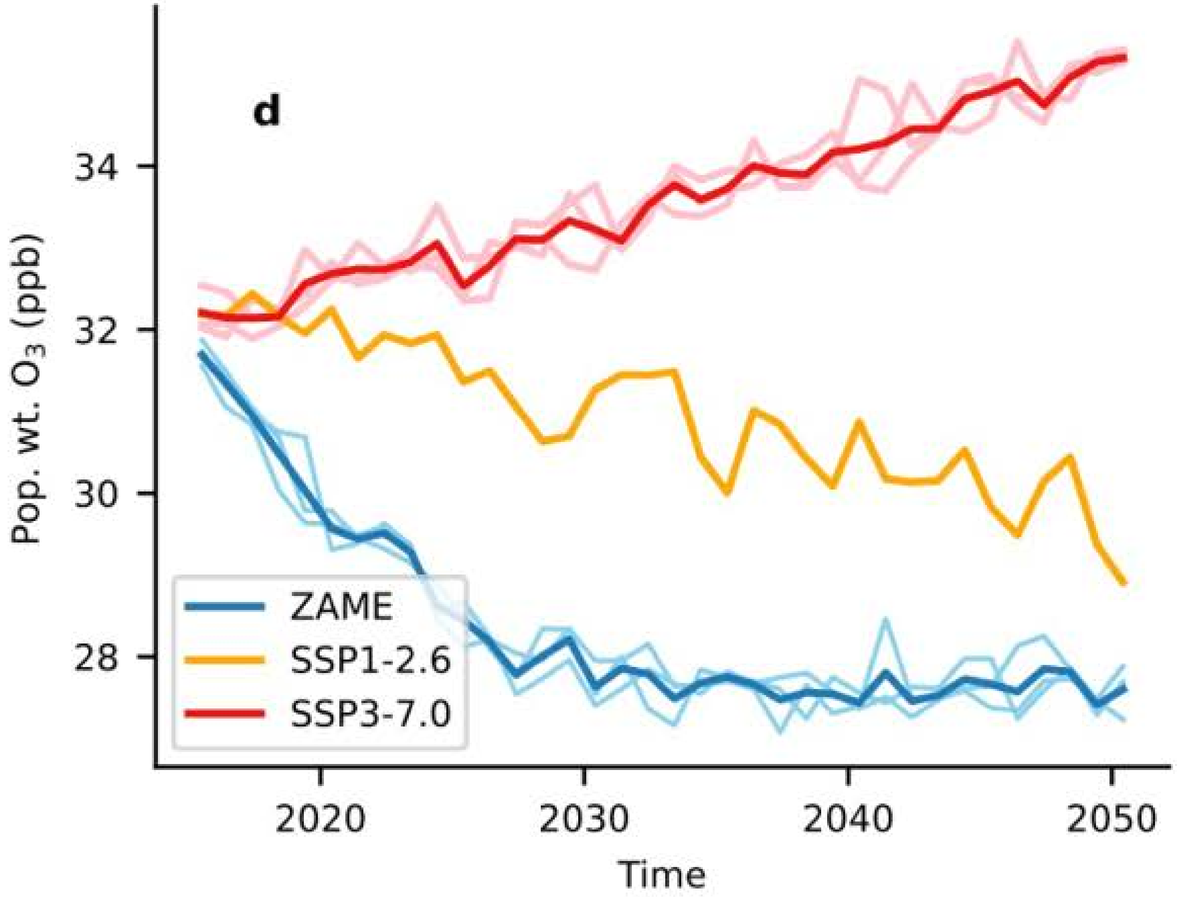
Surface ozone sensitivity to 50% methane emission cuts (2015 conditions)

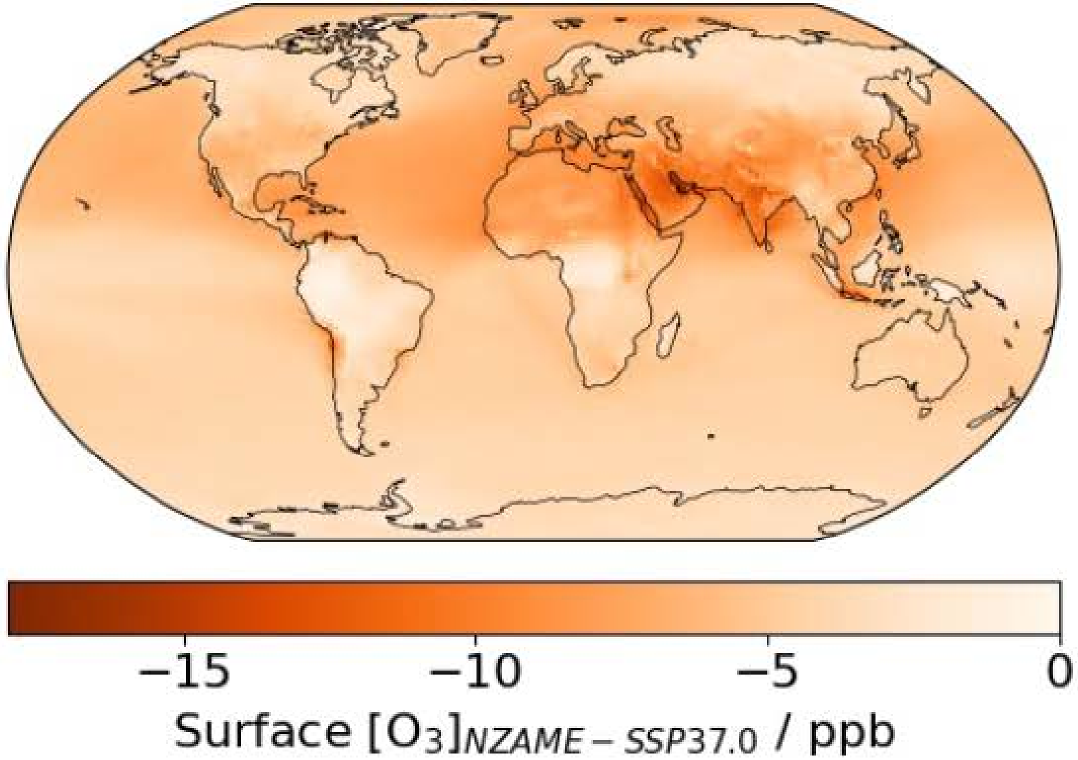


- Large spread between different global models, but clear general pattern
- Regional response related to local photochemical activity and NOx emissions

CCAC/UNEP Global Methane Assessment (2021)

Ozone impacts (of methane in transient emissions-driven UK-ESM simulations)





Slide from Zosia Staniaszek (Cambridge), presented at TF-HTAP April 20

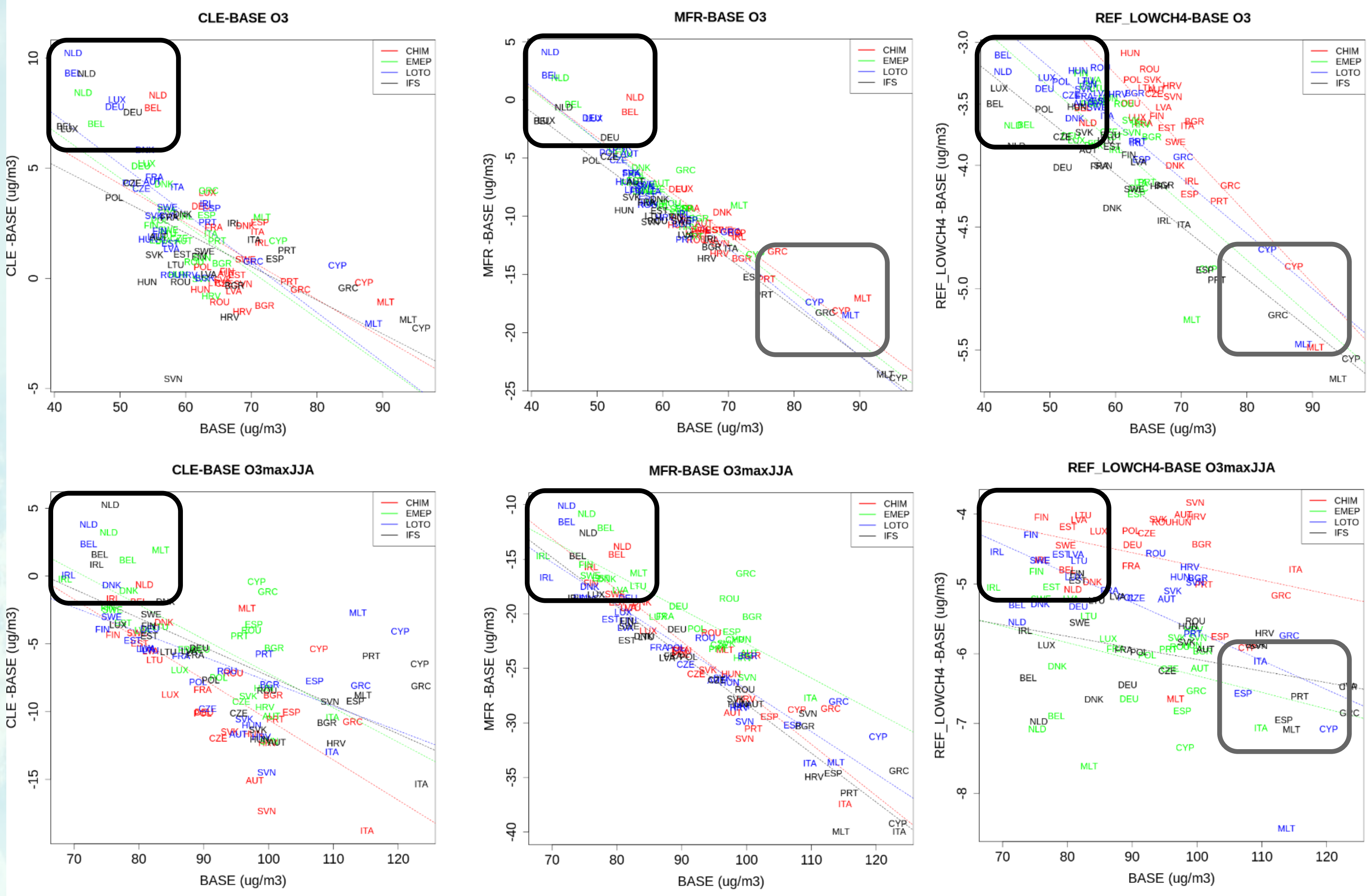
Staniaszek, Z., Griffiths, P.T., Folberth, G.A. *et al.* The role of future anthropogenic methane emissions in air quality and climate. *npj Clim Atmos Sci* 5, 21 (2022). https://doi.org/10.1038/s41612-022-00247-5

Atmosphere Monitoring

Response to emission scenarios (all models)

O_3 annual mean (2050)

O_3 MDA8 JJA average (2050)



Legend

- Scatter plot to compare the exposure (as the population weighted average concentration by country)
- Two ozone metrics (O3 annual mean, top, and the JJA average of the daily peaks, bottom)
- Three 2050 scenarios (from left to right)
- X-axis: 2015
- Y-axis: difference between 2050 and 2015 for one GCTM (IFS) and 3 RCTM (CHIMERE, EMEP, LOTOS-EUROS)

Results

- The CLE scenario is detrimental in Benelux/Germany (NOx-saturated), especially for O_3 annual mean, but also for peaks
- This penalty is compensated in the MFR scenario (which also includes CH_4 reductions).
- 30-50% of this compensation is due to CH_4, the rest to VOC/NOx
- In high exposure countries, the benefit of CH_4 is about 30% the benefit of MFR
- The benefit of CH4 reduction is larger for high exposure countries for annual avg O3, but quite homogeneous (and significant) for O3 peaks

Emission (2050 relative to 2015 BASE, %)	CLE	MFR	LOW CH4
NOx	-18%	-64%	0%
NMVOC	-2%	-38%	0%
CH_4	+15%	-53%	-50%

Slide from Augustin Colette (TFMM) at TF-HTAP April 20

Impacts of LOW emission reductions and CH_4 relative to 2050 CLE

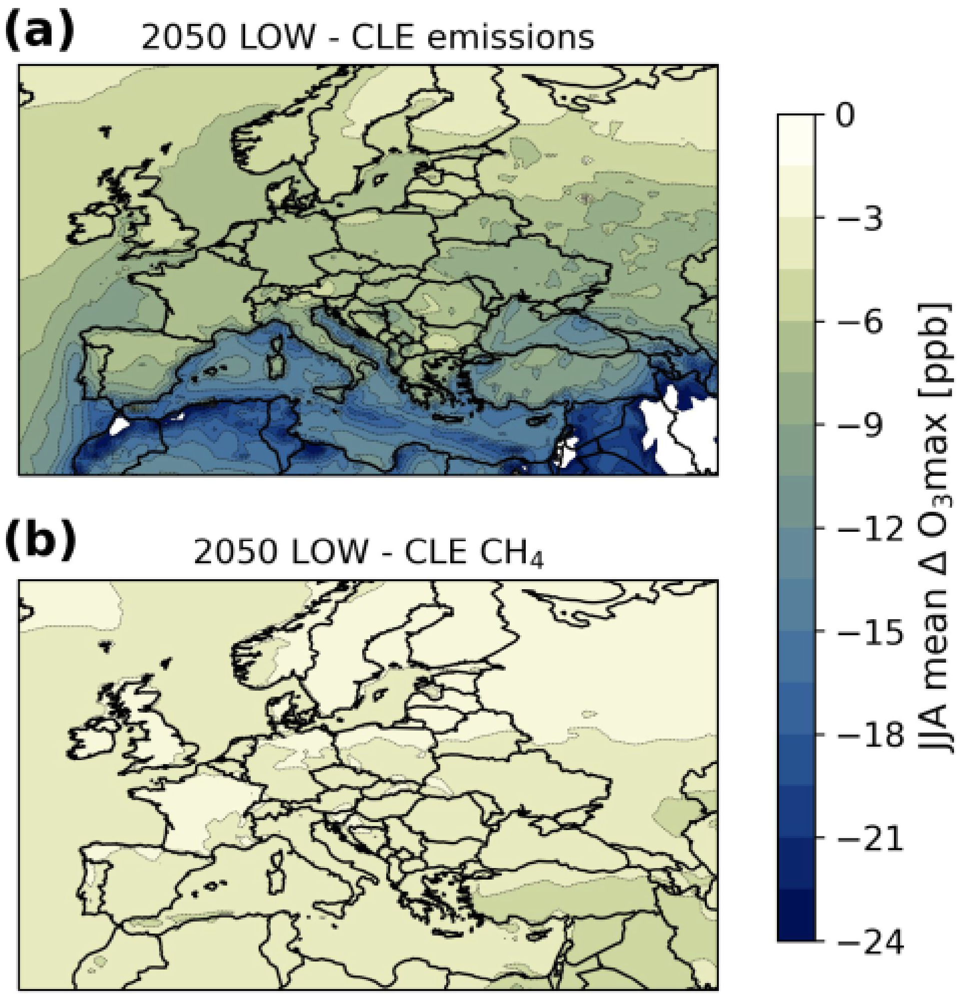
Global simulations

(a) {CLE2050,CLE2050CH_4} - {LOW2050,CLE2050CH_4}

(b) {LOW2050,CLE2050CH_4} - {LOW2050,LOW2050CH_4}

784 ppb difference between LOW (1431) and CLE (2215) CH_4

Compared to 2050 CLE, LOW scenario EU O_3max reductions ⅔ from emission reductions, ⅓ from CH_4



Norwegian Meteorological Institute

Slide from Willem van Caspel (MSC-W), presented at TFMM, May 12

Summary of work on methane as an ozone precursor

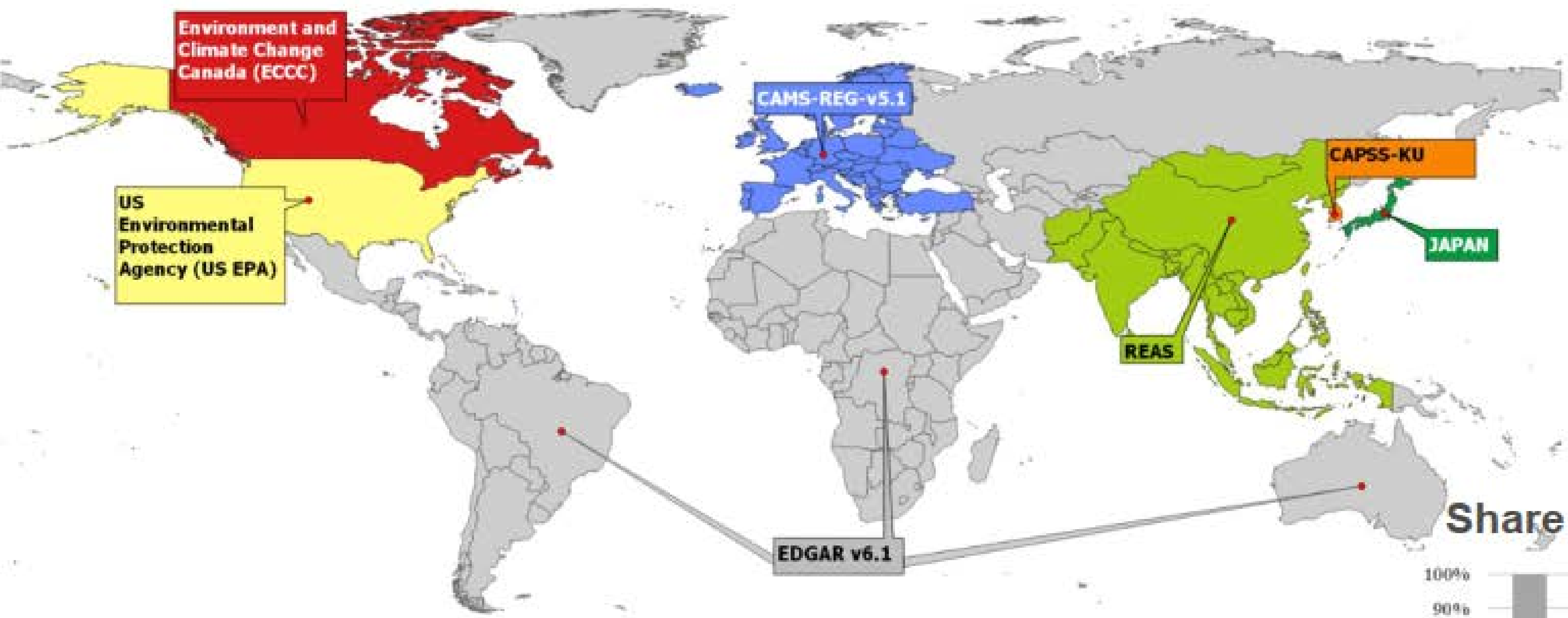
- Difficult to intercompare all existing studies
  - Different scenarios / base years
  - Different model setups
  - Different ozone metrics
  - Large inter-model differences
- Synthesis/summary of knowledge needed for the proposed special session on methane at the EMEP/WGE SB meeting (Geneva, September)
- Future work should aim to minimize uncertainty
  - Consistent policy-relevant emission scenarios
  - Large multi-model ensemble
  - Consistent policy-relevant impact metrics

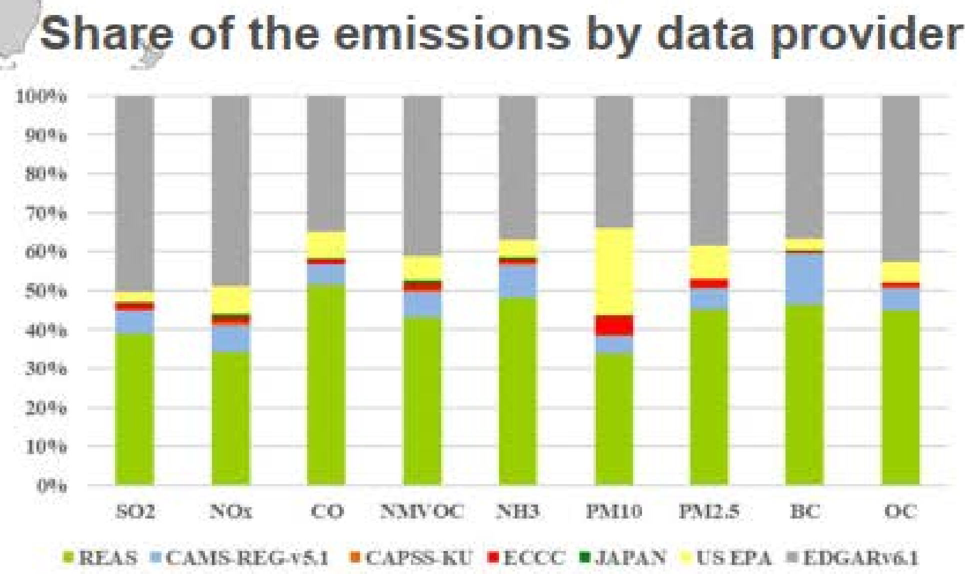
Summary of HTAP future work plans for ozone

- Simulations for the recent historical period (2000-2018) with HTAPv3 anthropogenic emissions
  - Contribution to WMO MMF-GTAD
  - Comparison of ozone source attribution methods
  - Ensemble emulators
  - Multi-pollutant study of wildfire impacts
- Future scenarios with GAINS emissions (2015-2050)
  - Workplan item 2.1.5, draft workplan 2024-2025
    - TFHTAP (with TFIAM, CIAM, TFMM, MSC-W, ICP Vegetation)
  - Baseline, MTFR, Low
    - To do: Gridding on HTAPv3 sectors
  - "In-between" or additional scenarios for hemispheric ozone
    - high ambition on NOx/VOC, low ambition on CH_4 (?); additional CH_4 scenarios
    - International shipping, including high seas; global hydrogen economy
  - CTMs and chemistry-climate models
    - To do: CO_2 emissions
- Global-regional downscaling

Extra slides – HTAPv3 emission mosaic

Updated HTAPv3 global mosaic emission inventory





- Explicit spatial distribution with gap filling
- Timeseries 2000-2018
- High number of emission sectors (16)
- Dataset released April 2022
- Discussion paper: https://essd.copernicus.org/preprints/essd-2022-442/essd-2022-442.pdf
- Dataset at https://edgar.jrc.ec.europa.eu/dataset_htap_v3

Slide from Monica Crippa, JRC

HTAPv3 emission sectors