Summary of current and future work on methane as an ozone precursor

Including results from TFHTAP, CCAC, EC-JRC, TFMM/CAMS, MSC-W, and CIAM

Tim Butler (co-chair TF-HTAP)

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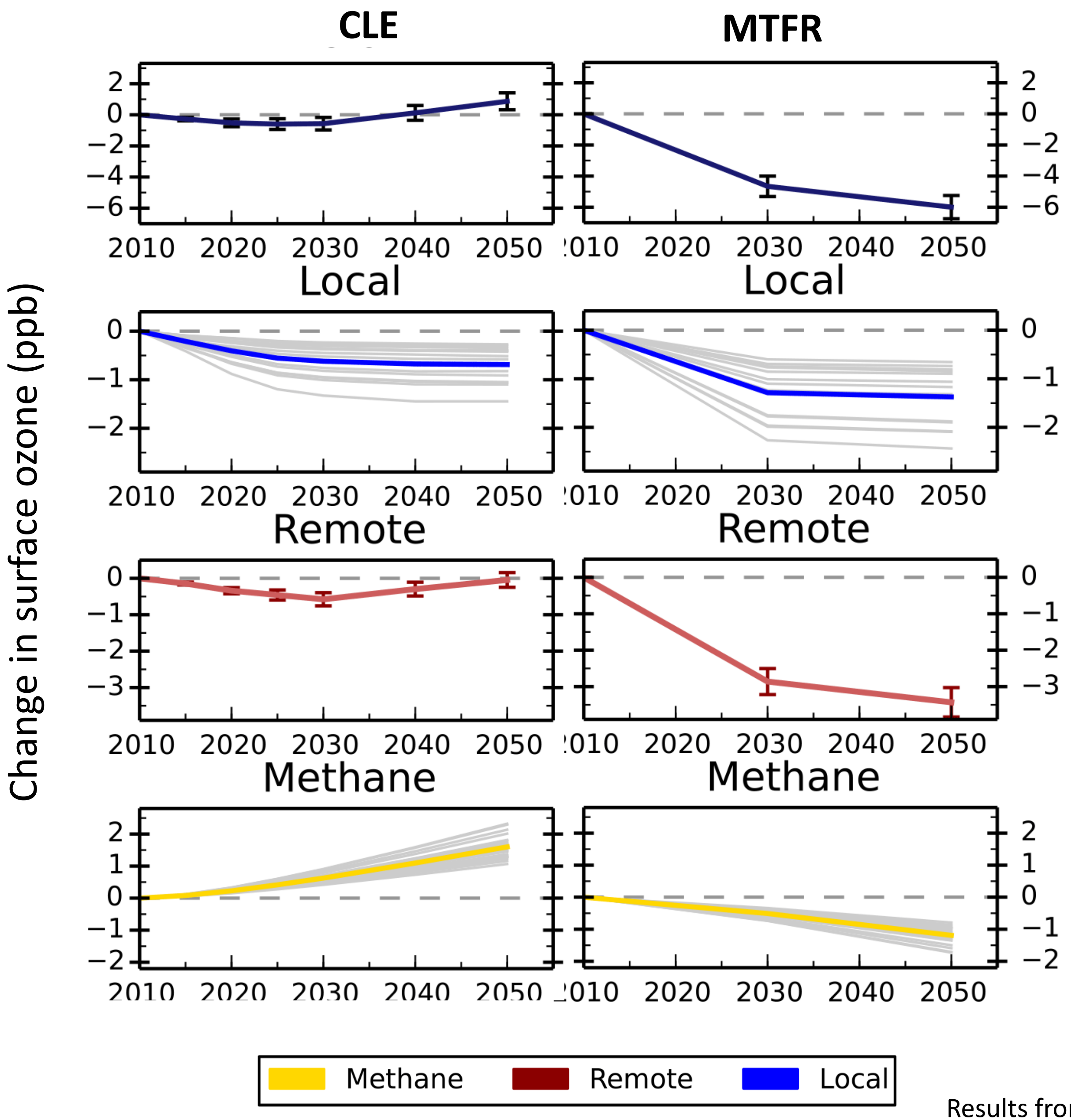
Introduction

- A large body of work over the past ~20 years has shown the importance of methane as an ozone precursor
- Recent work from within and outside the Convention on the relevance of methane for achieving the Convention's goals is difficult to synthesise:
  - Different emission scenarios
  - Different modelling approaches
  - Different base years
  - Different impact metrics
  - Etc…
- This presentation identifies common messages from the five most relevant studies since 2018
  - TFHTAP, CCAC, EC-JRC, TFMM/CAMS, MSC-W, and CIAM
- Key questions:
  - What is the impact of methane on ground-level ozone in the UNECE region compared with the impact of NOx and NMVOC?
  - How big is the potential of methane emission reductions in the UNECE region to reduce ground-level ozone compared with methane emission reductions in the rest of the world?
  - What future work is needed to quantify the influence of all ozone precursors and inform the negotiations on the revision of the Gothenburg Protocol?
  - What additional scenarios would be useful to perform this work?

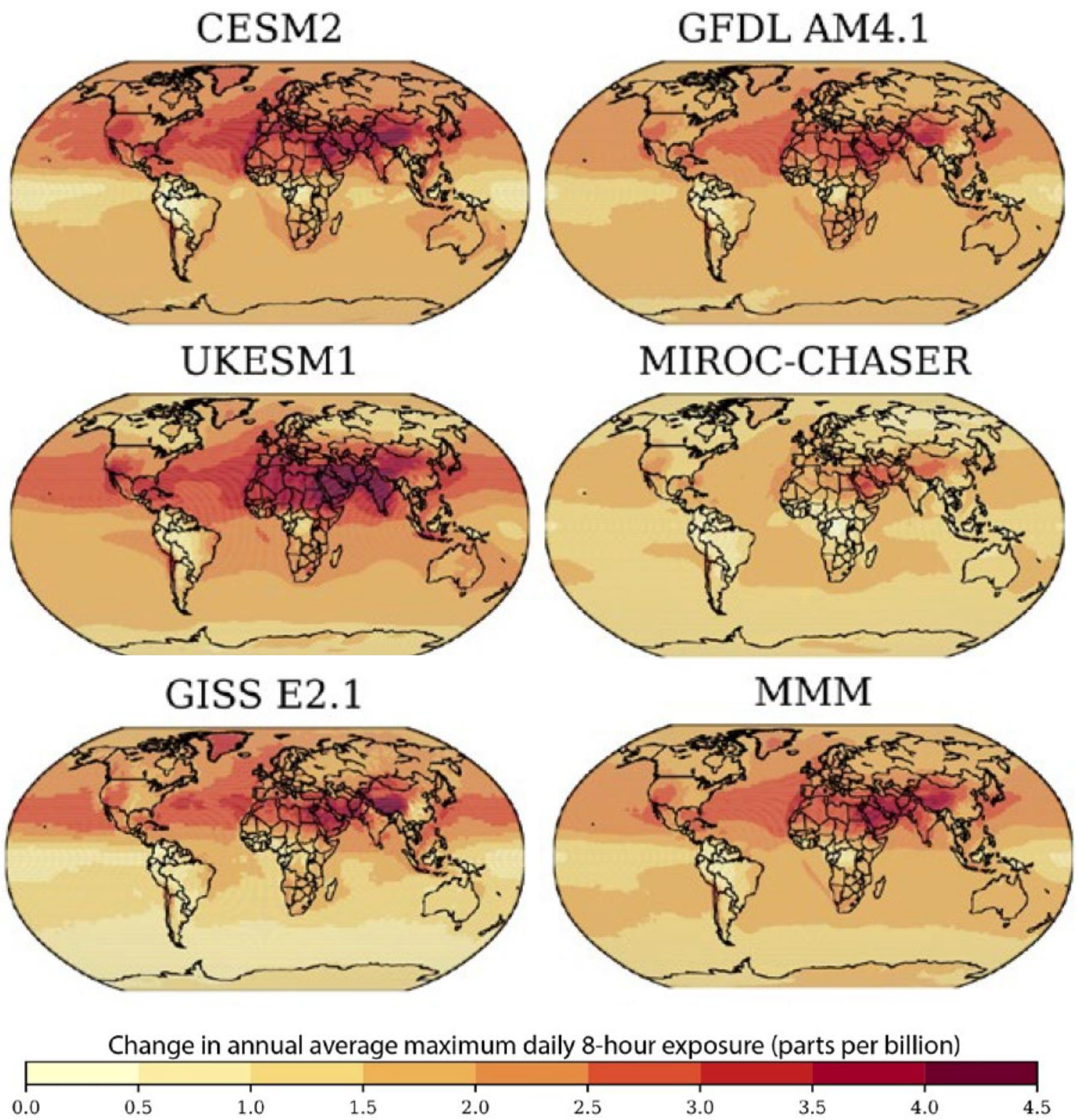
TFHTAP contribution to the review of the Gothenburg Protocol (2021)



- Annual average surface ozone in Europe
  - Ensemble of 14 global chemical transport models
- CLE: global increase in methane offsets effects of European NOx/NMVOC controls on surface ozone
- MTFR: large reductions in surface ozone due to combined effects of methane, local NOx/NMVOC and remote NOx/NMVOC
  - Without the reductions in global methane, ozone reductions under MTFR would be offset by about one half
- Significant inter-model spread
  - This shows the importance of using a large ensemble of models

Results from Turnock et al. (2018) https://doi.org/10.5194/acp-18-8953-2018

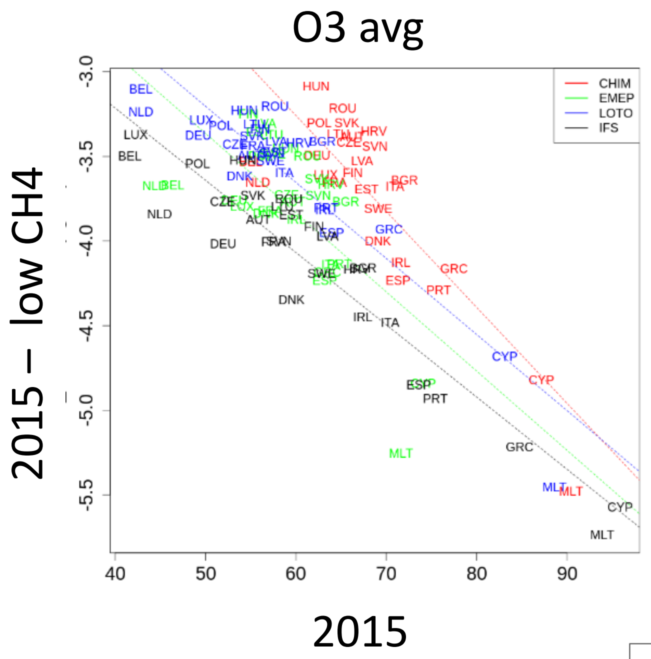
UNEP/CCAC Global Methane Assessment (2021)

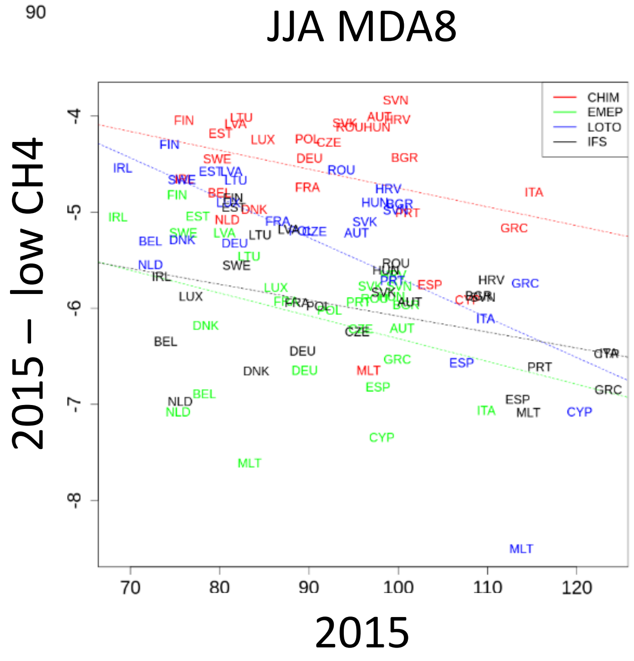


- Annual average global MDA8 ozone
  - Ensemble of 5 global chemistry-climate models
  - MMM: Multi-Model Mean
- 50% reduction in global anthropogenic methane emissions
- Range in the ozone response due to model spread
  - This shows the importance of using an ensemble of models

Based on Fig. 3.2 of https://www.ccacoalition.org/resources/global-methane-assessment-full-report

Results from TFMM/CAMS71 (2023)

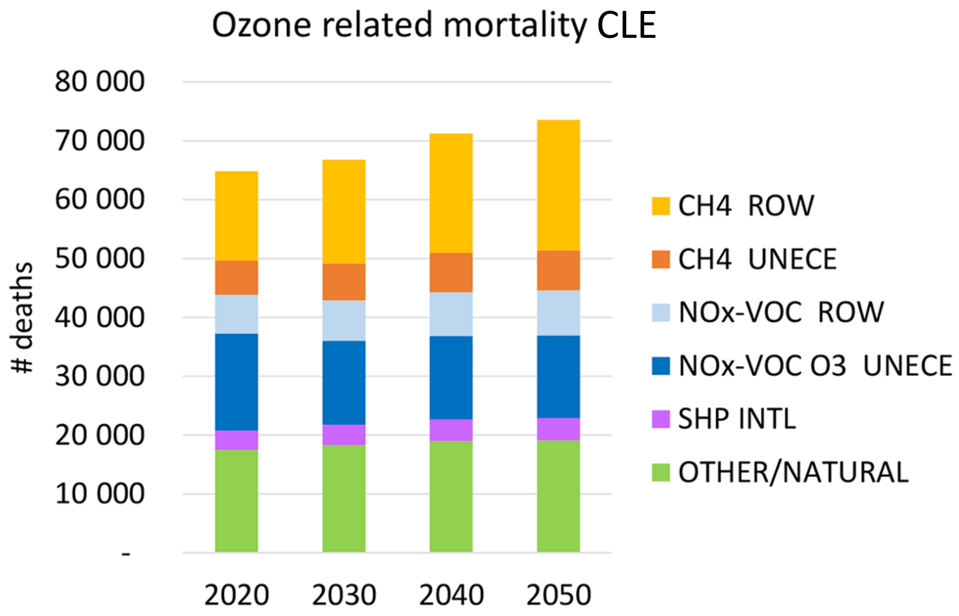


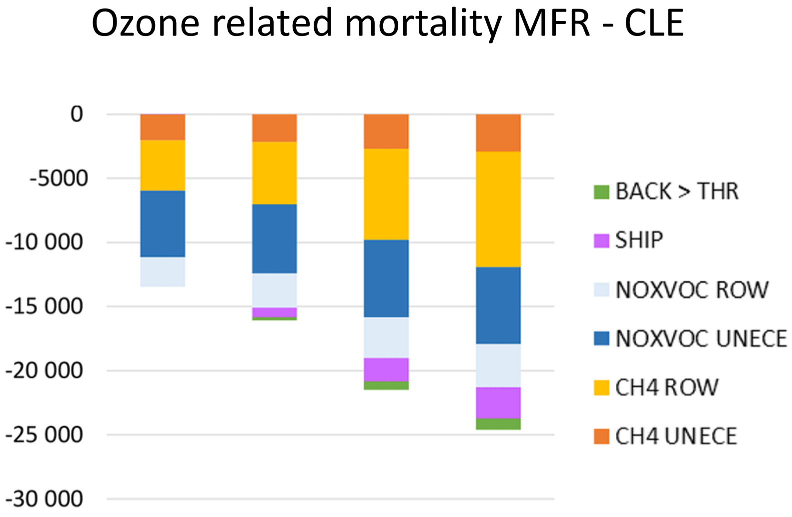


- Setup
  - Ensemble of 3 regional chemical transport models
  - Boundary conditions from a single global model
  - CH4: scenarios: -30% conc. 2050 compared to 2015
  - O3 annual avg and peaks (summer average MDA8)
- Key takeaway messages
  - The model spread is more important for ozone peaks than annual average, emphasizing the need for multi-model approach
  - The impact derived from global models for annual mean could apply for ozone peaks

Results from A. Colette, as presented to TFHTAP on 20.04.2023,
https://policy.atmosphere.copernicus.eu/reports/CAMS2_71_2021SC1-1_D4.1.1-2022P2_AQProjections_202211_v1.1.pdf

Results from the European Commission JRC (2023)

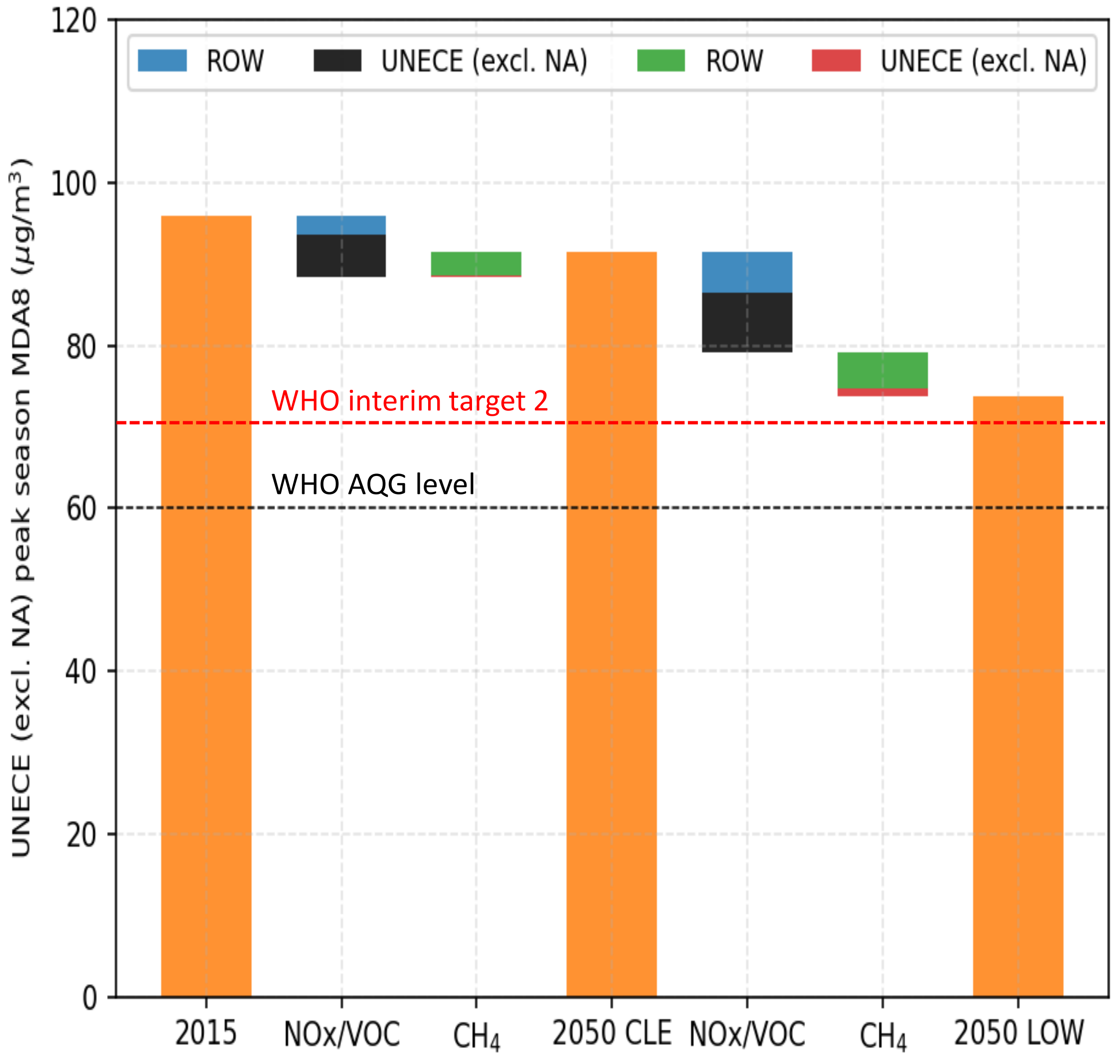




- Ozone related mortality in UNECE (incl. N.Am.)
- Results from TM5-FASST
  - Single model: no assessment of model spread
- CLE: ozone-related mortality increases due to ROW methane
- M(T)FR: large reductions in ozone-related mortality due to combined effects of methane, local NOx/NMVOC and remote NOx/NMVOC
- Role of methane:
  - About half of the difference in ozone related mortality between CLE and MFR is attributed to methane
  - The UNECE (incl. N.Am.) contribution to the required methane reductions is small

Based on Figs. 4 and 9 of Belis and van Dingenen (2023) https://doi.org/10.5194/acp-23-8225-2023

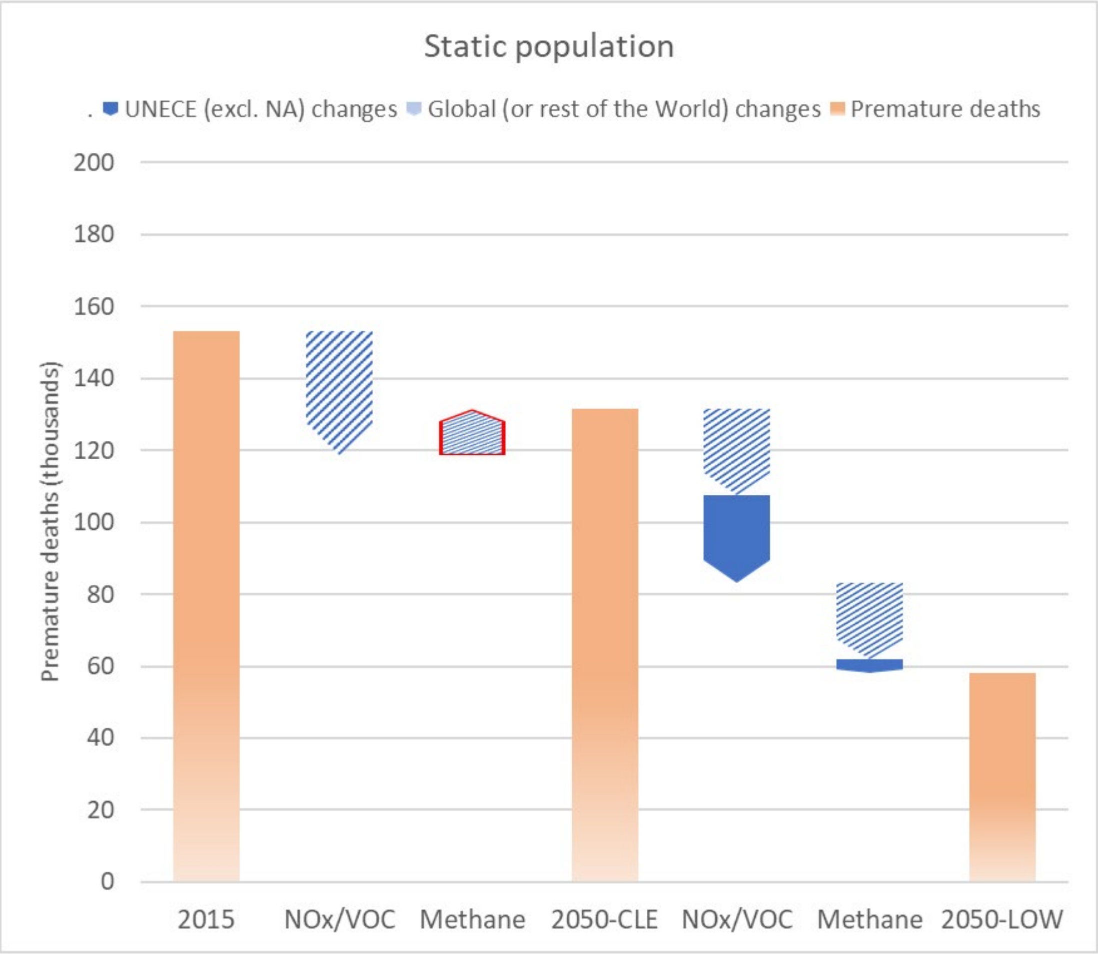
Peak season ozone: results from MSC-W (2023)



Results from H. Fagerli (personal communication)

- EMEP model run by MSC-W
  - Single model: no assessment of model spread
- New scenarios from GAINS
  - CLE: global increase in methane offsets effects of NOx/NMVOC controls on surface ozone
  - LOW: large reductions in surface ozone due to combined effects of methane, local NOx/NMVOC and remote NOx/NMVOC
- Peak season WHO ozone guideline not attained under any scenario
  - Deep reductions in all precursors required to approach the interim target value
  - UNECE NOx/NMVOC reductions have the largest effect
- Effect of methane:
  - WHO AQG are more difficult to reach without large global methane reductions
  - The UNECE (excl. N.Am.) contribution to the required methane reductions is small

Ozone health impact assessment from GAINS (2023)



- Based on results from MSC-W
- Premature deaths in the UNECE (excl. N.Am.)
  - 50% reduction from 2015 – 2050 is possible
- Benefit of 2050 LOW compared with 2050 CLE
  - UNECE sources contribute 1/3rd of the benefit
  - Non-UNECE sources contribute about 1/3rd
  - Global methane reductions contribute another 1/3rd
  - UNECE part of the methane contribution is small
- Global cooperation needed to reach this target

Ozone - impact of future emission policy

Action on methane would only be part of the solution; NOx/VOC emission reductions would still be very important to reduce surface O_3

- **Baseline (CLE)**
  - Average ozone concentrations in Europe will **increase** by 2-5% between 2015 and 2050. Peak season MDA8 will be **reduced** around 5-10%. In both cases, CH_4 emission increase in the baseline scenario offsets the reductions expected from NOx/VOC declines

- **The difference between the 2050 CLE and 2050 LOW** scenarios can be attributed to roughly ⅓ from reduction in global methane emissions, ⅓ from reduction in European precursor emissions and ⅓ from reduction of precursor emissions outside Europe, both for ozone mean and peak season MDA8

- CIAM estimates that methane emissions can be reduced (in the UNECE region) by almost 70% between 2015 and 2050, when **dietary change** and livestock reductions are included (2050 LOW scenario)

2050 LOW scenario - Ambitious global action on air pollution and methane, including non-technical measures

Based on TFHTAP/TFMM/MSC-W/CIAM work

TF-HTAP current work to support the revision of the Gothenburg Protocol

- A new round of model assessments using updated GAINS scenarios:
  - Focus on CLE and MTFR scenarios
  - Base year 2015, target year 2050
- Additional scenarios:
  - HILO: methane from CLE and other pollutants from MTFR
    - A scenario representing high global ambition on NOx/NMVOC but low global ambition on methane
  - CLE-global with MTFR-EMEP
    - How much ozone reduction can the EMEP region achieve on its own with only NOx and NMVOC control?
- Requirements for future quantitative assessments of methane as an ozone precursor:
  - An ensemble of global and regional models, including the EMEP model
  - Consistent experimental setup and output metrics, including impacts

Details of the modelling work in support the revision of the GP

- Transient future climate simulations
  - Global Chemistry-Climate Models
  - GAINS LRTAP future scenarios for 2010-2050
  - Assessment of future air quality and climate including the role of methane

- Source/receptor (perturbation) simulations
  - Global Chemical Transport Models
  - Source-receptor relationships based on GAINS LRTAP scenarios
  - Ensemble emulator for rapid scenario assessment

- Global to regional downscaling
  - Regional Chemical Transport Models using the GAINS LRTAP scenarios
  - TF-HTAP in cooperation with TFMM and CAMS
  - Boundary conditions from Global Chemical Transport Models
  - Comparison of the regional model ensemble with the EMEP model

Relevant items from the 2024-2025 workplan

1.1.1.7	On basis of recent evidence, long-term trends and uncertainty in future projections, provide insight into robustness of modelled long-term O_3 projections in relation to CH_4 mitigation	Synthesis of O_3 mitigation options	TFMM, MSC-W, TFHTAP	EMEP budget
1.1.2.1	Investigate practicalities and processes required for including CH_4 in annual emissions inventory reporting	Status report (2024)	TFEIP, CEIP	Additional resources required
1.1.3.1	Contribute to Gothenburg Protocol revision as mandated by Executive Body	Pending decision by Executive Body in December 2023	TFIAM, CIAM, TFMM, MSC-W, CCC, TFHTAP, CCE	EMEP budget and recommended contributions
1.1.3.2	Support policy process with scenario analyses	Calculation and analysis of scenarios	CIAM, MSC-W, TFHTAP, TFIAM	
1.1.3.4	Integrate knowledge from science bodies in integrated assessment framework and support policy process with scenario analyses	Specification of "optimized scenarios", "optimized and equity scenario", "ozone precursor scenarios", "health in cities scenarios"	CIAM, MSC-W, TFHTAP, TFIAM	Additional resources required
1.1.4.2	Organize new global and regional model simulations of historical trends and future scenarios for Gothenburg Protocol pollutants	Initial findings assessment (2025)	TFHTAP, TFMM	Parties' in-kind contributions
1.2.3	Regular coordination with task forces and expert groups on CH_4, O_3, N	Meeting notes	TFIAM, TFHTAP, TF-Health, TFRN, FICAP	

Timeline for this work

- July 2024
  - Revised GAINS scenarios available
  - TF-HTAP global model simulations can begin
- September 2024
  - Presentation of first results using GAINS scenarios to EMEP by MSC-W
  - First set of joint TF-HTAP/TFMM/CAMS regional simulations can begin
- Early 2025
  - Most TF-HTAP global simulations completed
- First half of 2025
  - Remaining joint TF-HTAP/TFMM/CAMS simulations can be done
  - Ongoing analysis of model results
- September 2025 – May 2026
  - Window for presentation of results to inform the revision of the Gothenburg Protocol