

Regional Model Simulations in Support of the Revision of the Gothenburg Protocol

HTAP3-OPNS: Multi-model simulations of Ozone, Particles, and
deposition of N and S

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TFMM and TFHTAP: common workplan items 2026-27

1.52	Update of EMEP gridded emissions (incl. cooperation with expert panel, CAMS, JRC, FAIRMODE)	CEIP, MSC-W, TFMM, TFHTAP, CAMS, JRC, FAIRMODE
1.55	Development and assessment of risk reduction options and further modelling scenarios for Gothenburg Protocol revision	TFIAM, CIAM, TFMM, MSC-W, CCC, TFHTAP, CCE, CDM, TF Health, WGE centres, CEIP
1.56	O ₃ modelling of future scenarios in support of Gothenburg Protocol revision	TFHTAP, TFIAM, CIAM, TFMM, MSC-W, ICP Vegetation
1.6	New global and regional model simulations of historical trends and future scenarios (health and vegetation impacts)	TFHTAP, TFMM, MSC-W, CIAM, ICP Vegetation
1.64	Collection of emission inventories, modelling approaches, and observational data on PFAS; planning of global multi-compartment modelling exercise	TFHTAP, MSC-E, CCC, TFMM
1.65	Strengthen network of experts and policymakers on multilevel governance of air quality; continue model comparison work; report to TFIAM	TFIAM/EPCAC, CIAM, TFMM, TFH, TFHTAP

HTAP3-OPNS: Ozone, Particles, N and S deposition

- Four workplan items in one multi-model exercise
 - In planning since 2024
- Primary goal: supporting the revision of the Gothenburg Protocol
 - Assessment of scenarios from the GAINS model
 - Source/receptor relationships for long-range hemispheric transport
 - Special focus on methane
 - Quantify and understand the model spread in surface ozone response
- Seeking input from different modelling systems
 - Global CTMs and ensemble emulators (as for previous HTAP assessments)
 - Coupled chemistry-climate models
 - **Global-regional downscaling**
- Experiment description paper:
<https://egusphere.copernicus.org/preprints/2026/egusphere-2026-1367>

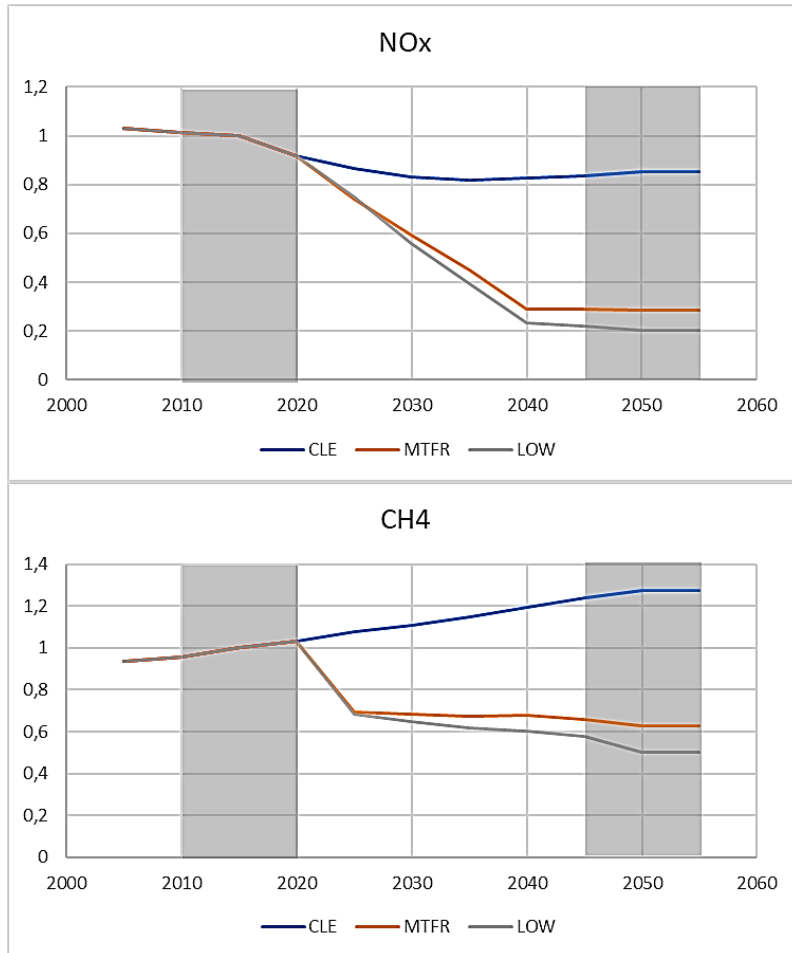


GAINS LRTAP future scenarios (2010-2050)

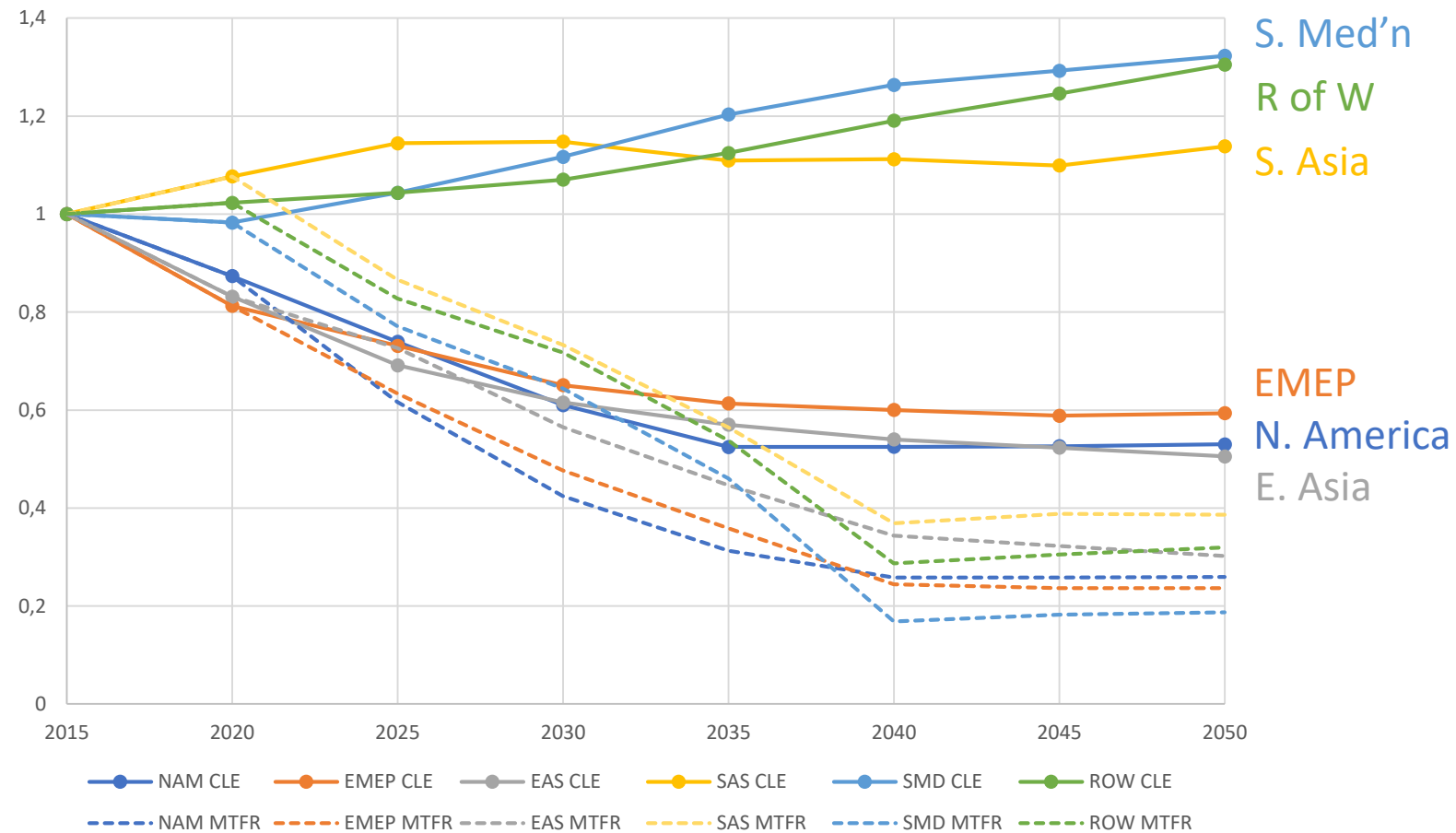
- <https://zenodo.org/records/14748815>
- Scenarios developed by IIASA/CIAM to inform the review of the Gothenburg Protocol
 - "Ex-post" analyses from MSC-W/WGE
- **CLE**
 - Includes all current air quality policies and implementation plans
 - Climate forcing broadly consistent with SSP2-4.5
- **MTFR**
 - Same activity datasets as the CLE scenario
 - Maximum technically feasible reduction in emissions of all air pollutants (including methane)
 - Full implementation of proven measures regardless of cost effectiveness
- Hybrid scenario proposed by TF-HTAP
 - **HILO**
 - Methane from CLE and other pollutants from MTFR
 - High ambition on "Gothenburg Pollutants" and low ambition on methane

GAINS LRTAP future scenarios (GP review)

Global emissions of NOx and methane



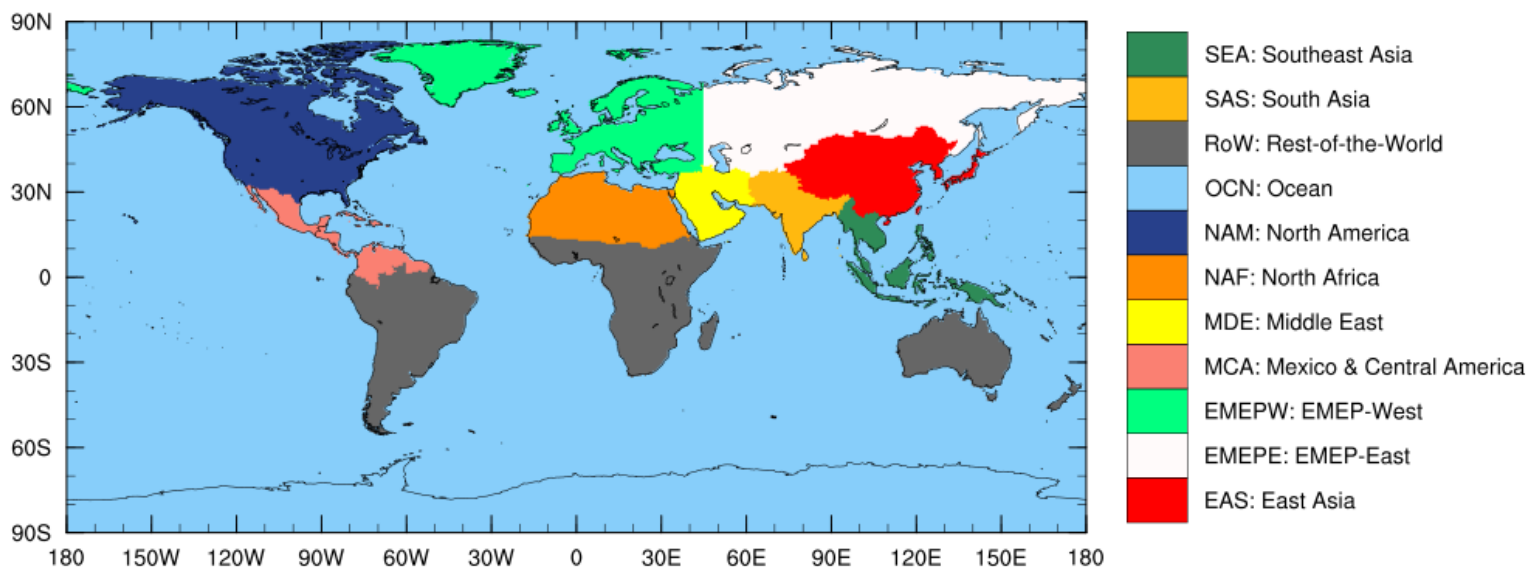
NOx Change Within a Region Relative to 2015



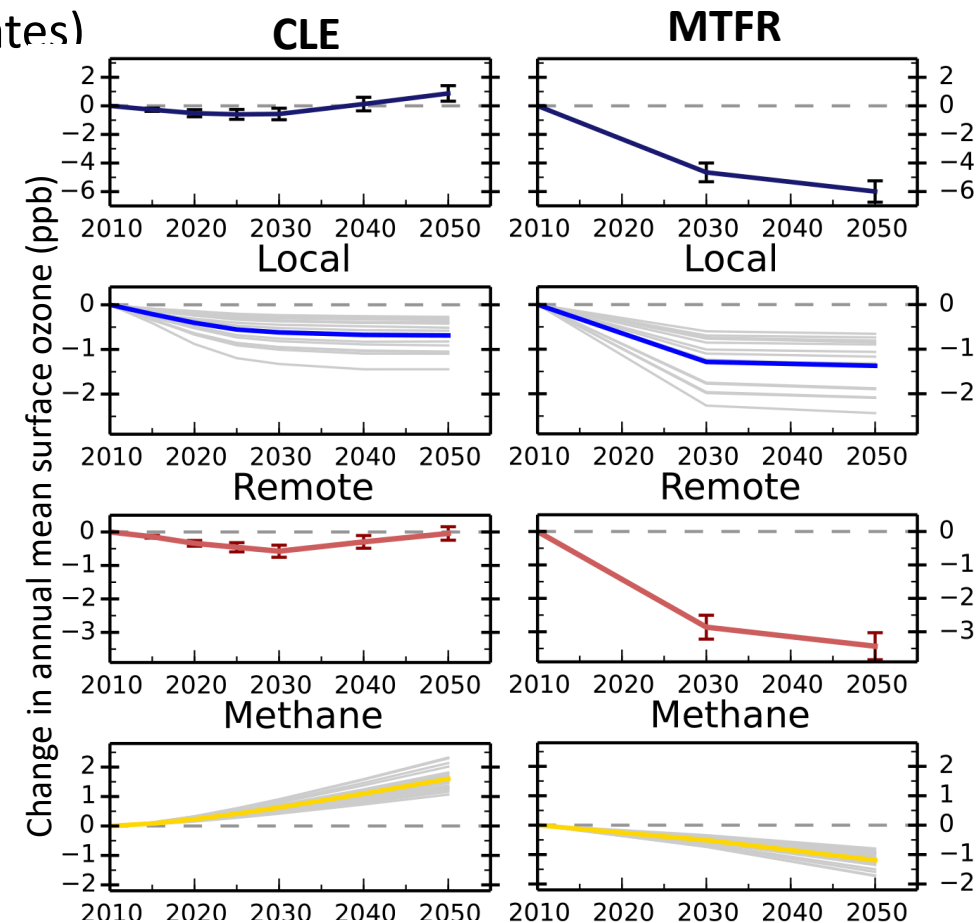
Global models: Perturbation runs and ensemble emulator development

- Simulations with an ensemble of global CTMs (2015 meteorology)
 - Set of ~25 emission perturbation runs (GAINS 2050 CLE emissions)
 - Source-receptor relationships (with uncertainty estimates)
 - Emulator development

HTAP3 source regions



Results from HTAP2 (Europe)



2015 meteorology / 2050 emissions

BASE (CLE 2050)

1

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CH4INC

CH4DEC

CH4ALL

CH4NOX

H2DEC

GLOALL

GLONOX

GLOVOC

GLOCO

CLE2015

MTR

HILO

All

VOC	
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Global CTM runs for regional boundary conditions

NAM

EMEP

EMEPW

EMEPE

EAS

SAS

SMD

MDF

NAF

SFA

MCA

ROW

SAM

SAF

PAN

SHIP

AVI

FIRE

Regional model simulations in HTAP3-OPNS

- Motivation
 - CLRTAP workplan
 - Ensemble assessment of GAINS scenarios at the regional scale
 - Improving the robustness of the “ex-post” analyses CIAM/MS-CW/WGE
 - Parties have access to their “own” modelling for GP negotiations
- Experiment design
 - Discussed at TFMM meetings in 2024 and 2025
 - Five model runs, one year each
 - Standardized emissions
 - GAINS anthropogenic emissions
 - GFAS4HTAP biomass burning
 - 2015 meteorology
 - Standardized data reporting
 - Boundary conditions from an HTAP global model
- **All other model configuration at the discretion of each modelling group**

Boundary condition data

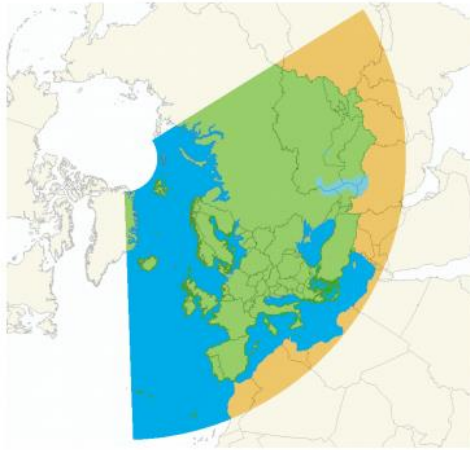
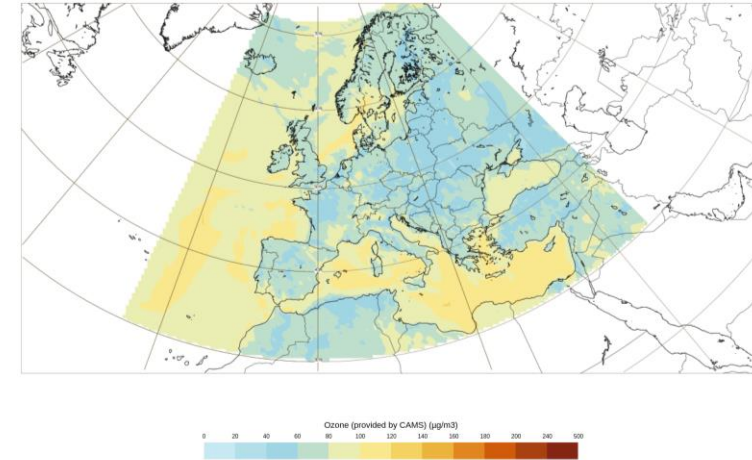


Figure 1.1: The EMEP domain covering the geographic area between 30° N-82° N latitude and 30° W-90° E longitude.

- EMEP domain
- EMEP model
- Download available from the AeroCom server



PROGRAMME OF
THE EUROPEAN UNION



IMPLEMENTED BY



- CAMS domain
- EMEP model: AeroCom server
- IFS-COMPO model: directly from ECMWF

Regional model simulations

Simulation number	Simulation name	Emissions in the EMEP West region	Emissions in all other regions	Boundary conditions from global model
1	CLE2015	CLE2015	CLE2015	CLE2015
2	CLE2040	CLE2040	CLE2040	CLE2040
3	MTFR2040	MTFR2040	MTFR2040	MTFR2040
4	HILO2040	MTFR2040	MTFR2040	HILO2040
5	EMEPWLO2040	MTFR2040	CLE2040	CLE2040

Technical guidance document:
<https://docs.google.com/document/d/1wQFd29yCqeNKOcGZdJQvelB-SjULTyFi>



Current status

- Global Modelling
 - 12 models expressed interest in 2024
 - Experiments began Q4 2025
 - 5 models already have results, more on the way
- Regional Modelling
 - Expressions of interest collected at the 2025 TFMM/TFHTAP meeting
 - All datasets are available (since the start of 2026) and all runs can begin
 - The EMEP model at MSC-W has completed all regional runs
 - Online kick-off meeting January 21, 2026
 - Simplified data request for regional models
 - “F1-F4 split” will be available from MSC-W / Met.Norway
 - Email list for communication:
<https://www.listserv.dfn.de/sympa/subscribe/htap-opns-regional>
- Regular online check-in meetings as needed



Timeline for the revision of the CLRTAP Gothenburg Protocol

- Revision process formally launched in 2023
 - Originally expected completion by 2026
- Expected completion currently 2028
 - Scientific inputs most useful by spring 2027
- What does this mean for this work?
 - **Model runs should be completed in 2026** – the earlier the better
 - Preliminary analysis presented to EMEP SB in September 2026
 - Policy-relevant findings
 - Presented to EMEP/WGE extended bureaux in March 2027
 - Presented to WGSR in May 2027
 - Work can continue after these dates!
 - “Late” runs
 - Scientific publications
 - Further reports to EMEP/WGSR

Summary and outlook

- Joint TF-HTAP / TFMM contribution to the revision of the Gothenburg Protocol
 - Global-regional downscaling of GAINS LRTAP future scenarios
 - Role of European/remote ozone precursors and methane
 - Robust results due to ensembles of global and regional models
- Regional simulations can start immediately
- Results will be presented to CLRTAP between September 2026 and May 2027
- Contributions are welcome!