LRTAP
Long-range Transboundary Air Pollution

MSC-W: Progress of activities

Hilde Fagerli, Willem van Caspel, Gunnar Lange, Peter Wind, David Simpson, Arjo Segers, Anna Benedictow, Alvaro Valdebenito & rest of the EMEP/MSC-W team

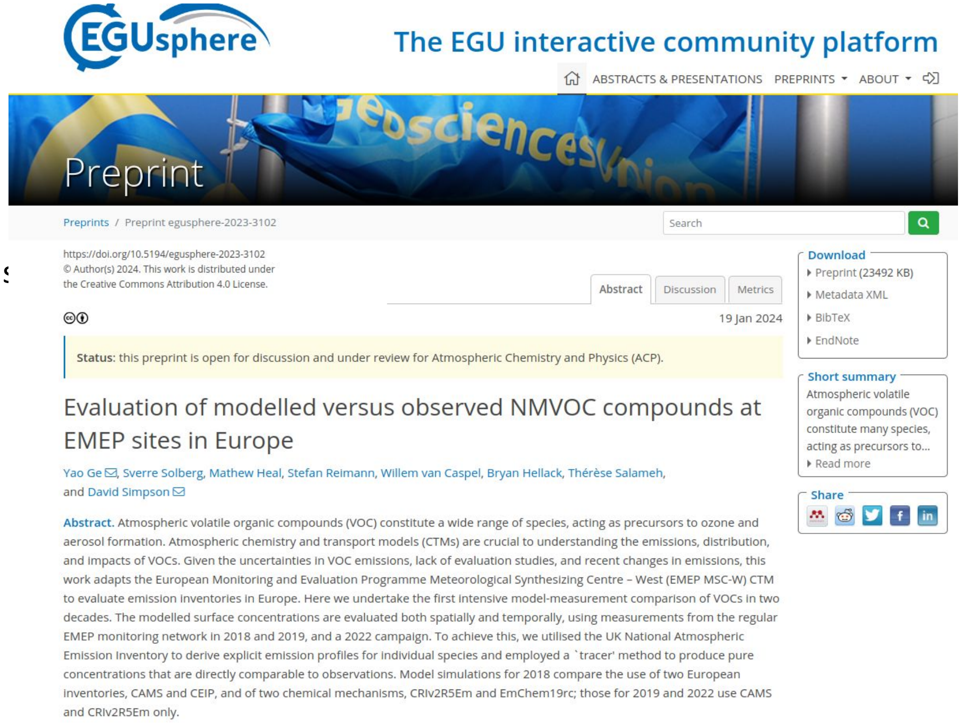
EMEP & WGE Extended Bureaux meeting, Geneve, 28.2-1.3.24

Overview

- VOC and ozone episodes
- O3/CH4
- Source receptor methodology - progress
- Updated O3 response in GAINS
- Condensables
- Improved modelling for West Balkan, Turkey and EECCA
- PBAP
- Cooperation with ICP Forest

1.1.1.1 Assess contribution of VOCs on high O_3 pollution episodes using observations from intensive measurement period (summer 2022) and regular time series from EMEP network. Including model intercomparison exercise for intensive measurement week

- **Speciation**: explicit emission splits are created for individual VOCs, based on UK NAEI and several other studies
- **VOC Tracers**: take pure emissions and follow species-specific chemistry to yield pure concentrations
- **2 different chemical mechanisms**: CRIv2R5Em and EmChem19rc
- **Large emitting sector**: Fugitive, Solvents, Road transport
- **Large emitting VOCs**: ethane, propane, benzene, toluene



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19 Jan 2024

Status: this preprint is open for discussion and under review for Atmospheric Chemistry and Physics (ACP).

Evaluation of modelled versus observed NMVOC compounds at EMEP sites in Europe

Yao Ge, Sverre Solberg, Mathew Heal, Stefan Reimann, Willem van Caspel, Bryan Hellack, Thérèse Salameh, and David Simpson

Abstract. Atmospheric volatile organic compounds (VOC) constitute a wide range of species, acting as precursors to ozone and aerosol formation. Atmospheric chemistry and transport models (CTMs) are crucial to understanding the emissions, distribution, and impacts of VOCs. Given the uncertainties in VOC emissions, lack of evaluation studies, and recent changes in emissions, this work adapts the European Monitoring and Evaluation Programme Meteorological Synthesizing Centre – West (EMEP MSC-W) CTM to evaluate emission inventories in Europe. Here we undertake the first intensive model-measurement comparison of VOCs in two decades. The modelled surface concentrations are evaluated both spatially and temporally, using measurements from the regular EMEP monitoring network in 2018 and 2019, and a 2022 campaign. To achieve this, we utilised the UK National Atmospheric Emission Inventory to derive explicit emission profiles for individual species and employed a `tracer' method to produce pure concentrations that are directly comparable to observations. Model simulations for 2018 compare the use of two European inventories, CAMS and CEIP, and of two chemical mechanisms, CRIv2R5Em and EmChem19rc; those for 2019 and 2022 use CAMS and CRIv2R5Em only.

Short summary
Atmospheric volatile organic compounds (VOC) constitute many species, acting as precursors to...
Read more

Yao Ge et al., 2024 https://egusphere.copernicus.org/preprints/2024/egusphere-2023-3102/

1.1.1.1 Assess contribution of VOCs on high O_3 pollution episodes using observations from intensive measurement period (summer 2022) and regular time series from EMEP network. Including model intercomparison exercise for intensive measurement week

- Capture spatial patterns and time series of some VOC species (e.g. n-butane, longer-chain alkanes, aromatics, HCHO)
- Performs less well for others (e.g. propane, ethyne).
- E.g. Propane-to-ethane ratios, ratios of isomeres of butane and pentane points to potential issues in speciation or total emissions in certain sectors (as well as BIC issues)

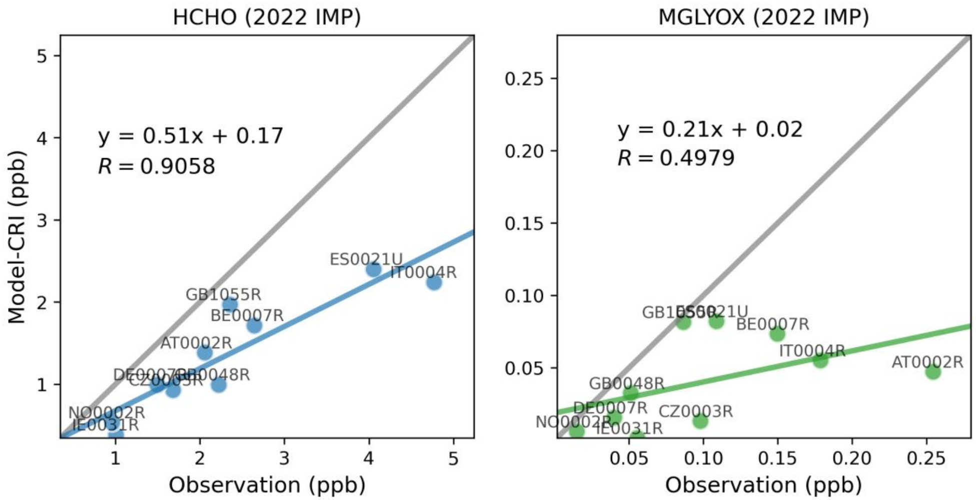


Figure 16. Scatter plots of average modelled and measured methanal and methylglyoxal concentrations during 2022 IMP.

Sensitivity to speciation of VOC emissions

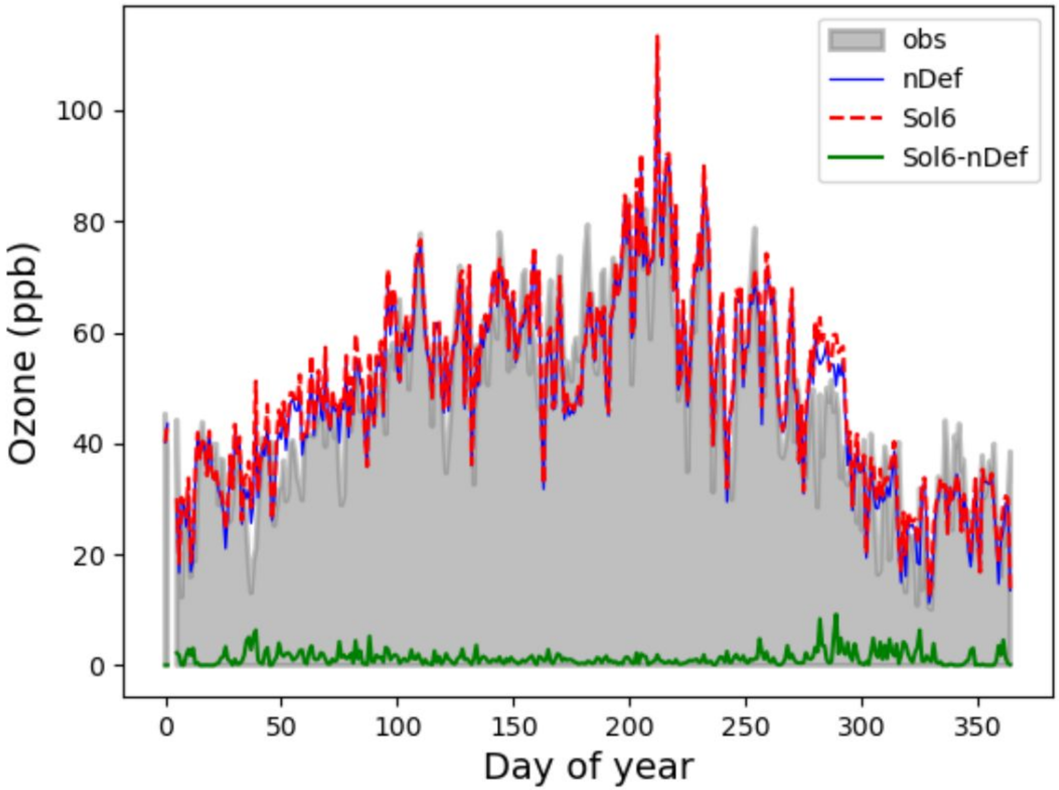


Figure 17. Impacts of VOC sensitivity tests on modelled daily maximum O_3 at Beromünster. nDef and Sol6 are two model runs, and the lowest line gives the difference, Sol6-nDef. Observed O_3 shown by shaded area. Model runs for 2018.

How:
Sol6: VOC speciation of solvent sector is replaced with the gasoline

Results:
Changes in VOC speciation have little impact on mean ozone levels, but changes can be significant **close to sources and in high NOx conditions**.

Next:
Importance of VOC (speciation) for the 2022 EIMP

Ozone - Importance of European, non-European and CH_4 mitigation

- What is it possible to achieve for ozone by 2050 by
  - reducing CH_4 emissions
  - reducing European emissions
  - reducing emissions outside of Europe (ROW)
- What can be achieved compared to 'no further policy' (CLE)?
- What is new compared to TFHTAP/TFMM work:
  - Gothenburg Protocol Review emission scenarios (CLE, LOW)
  - Including new indicators for ozone such as Peak Season MDA8
  - **Including other indicators such as POD_3crop and SOMO35**
  - **Meteorological variability**
  - **Being done now: Updated scenarios, including MFR scenarios**

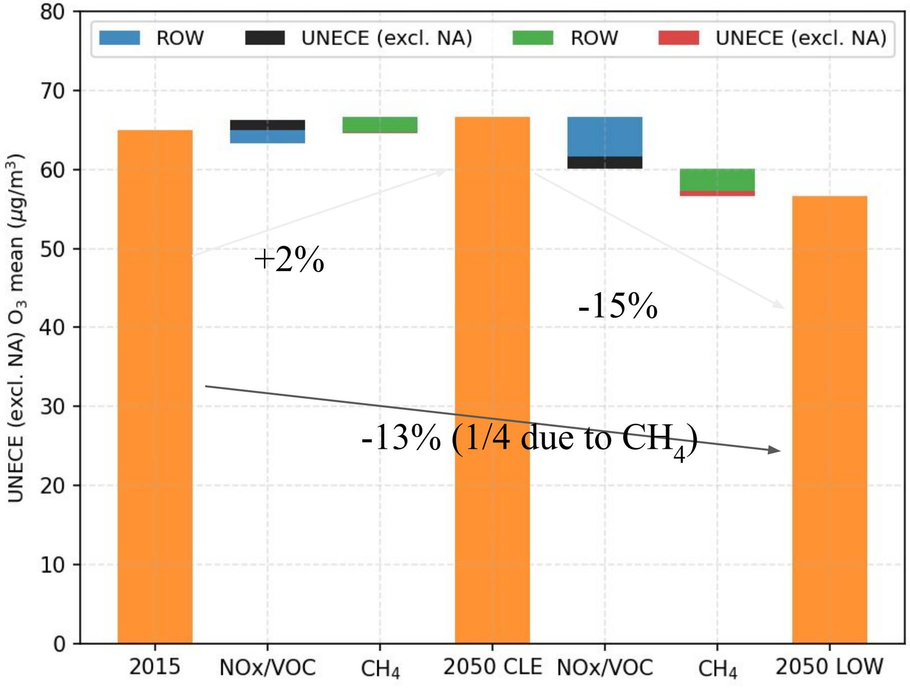
2050 LOW scenario - *Ambitious global action on air pollution and methane, including non-technical measures*

How?

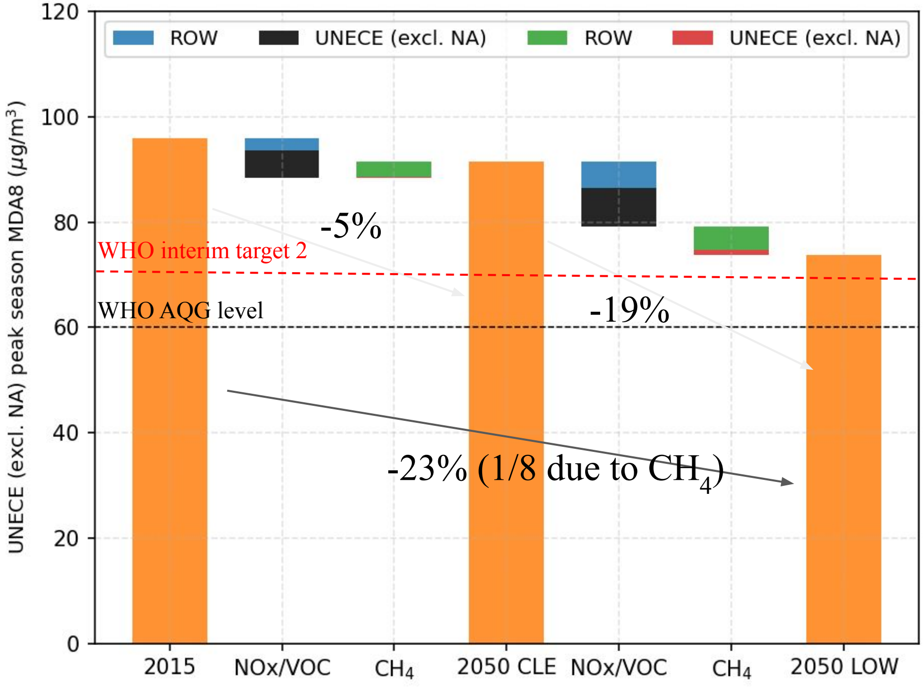
- Global EMEP MSC-W model runs for 2015, 2050 (CLE, **MFR**, LOW) and in addition with CH_4 concentrations changed -> **Boundary and initial conditions**
- European EMEP MSC-W model runs for 2015, 2050 (CLE, LOW) and CH_4 concentrations

Simulated ozone concentrations in the future and the impact of European NOx/VOC, Rest of World (ROW) NOx/VOC and CH4 emission mitigation

- Substantial reductions can be achieved, but WHO AQG levels not attained even in LOW
- CH_4 becomes more important because of its projected increase in CLE.
- Action on methane would only be part of the solution; (UNECE) NOx/VOC emission reductions would still be very important to reduce surface O_3



Ozone mean, population weighted



Peak season MDA8, population weighted

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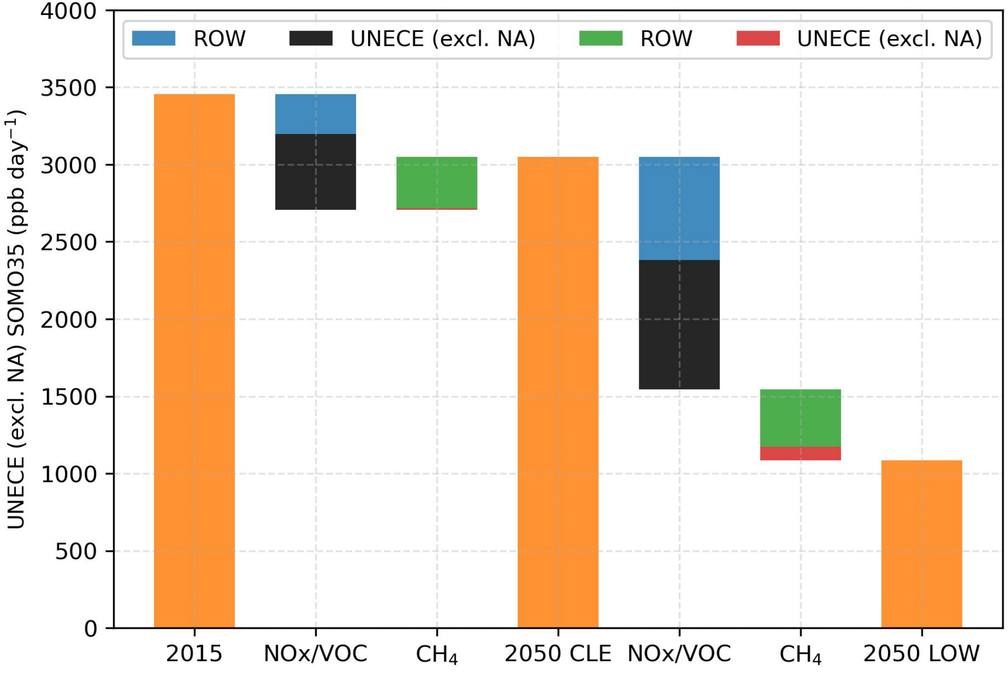
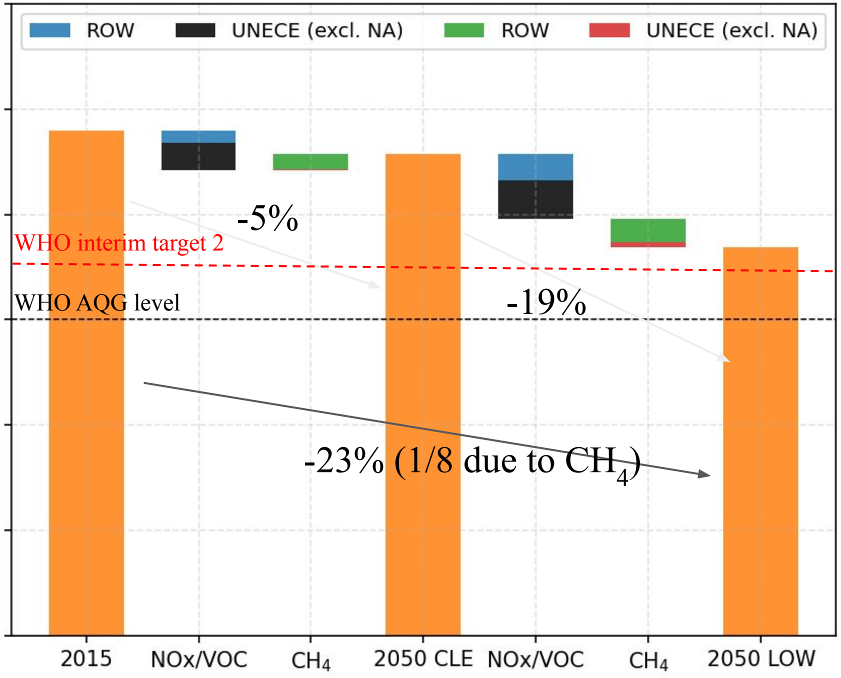


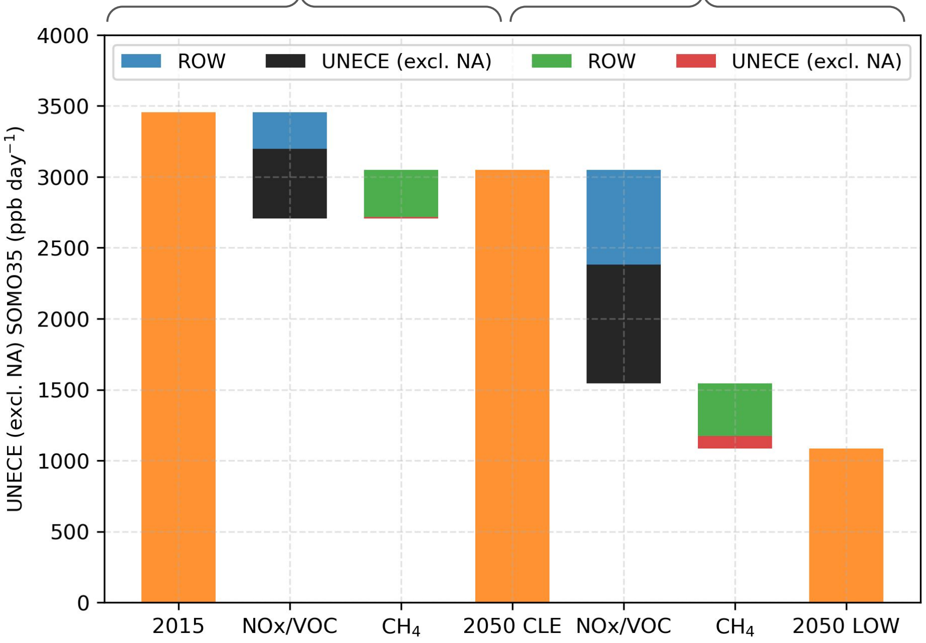
SOMO35, population weighted



Peak season MDA8, population weighted

Effect of NOx/VOC in Europe (black) and rest of world (blue)

Effect of CH4 in Europe (red) and rest of world (green)



Population weighted SOMO35

Effect of NOx/VOC in Europe (black) and rest of world (blue)

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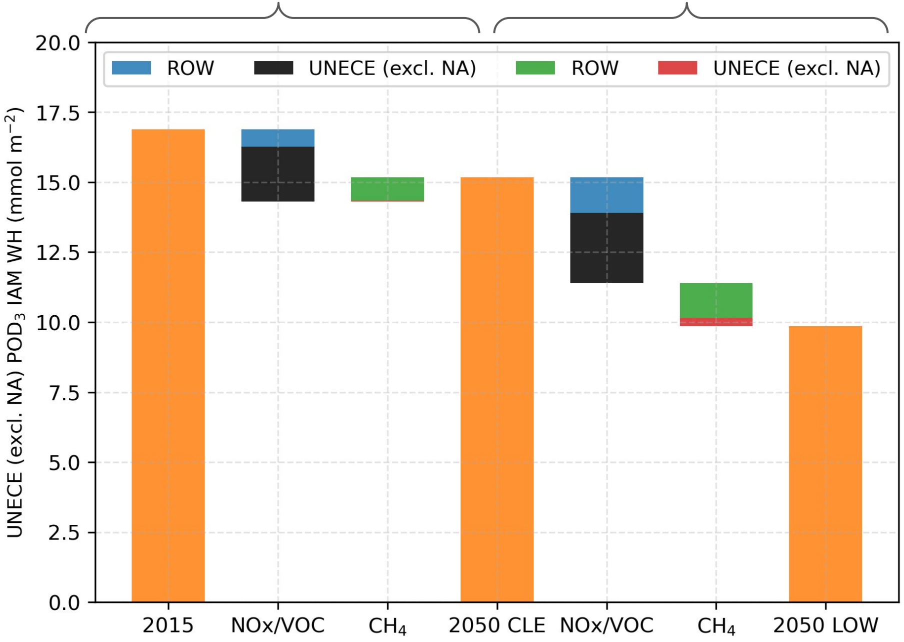
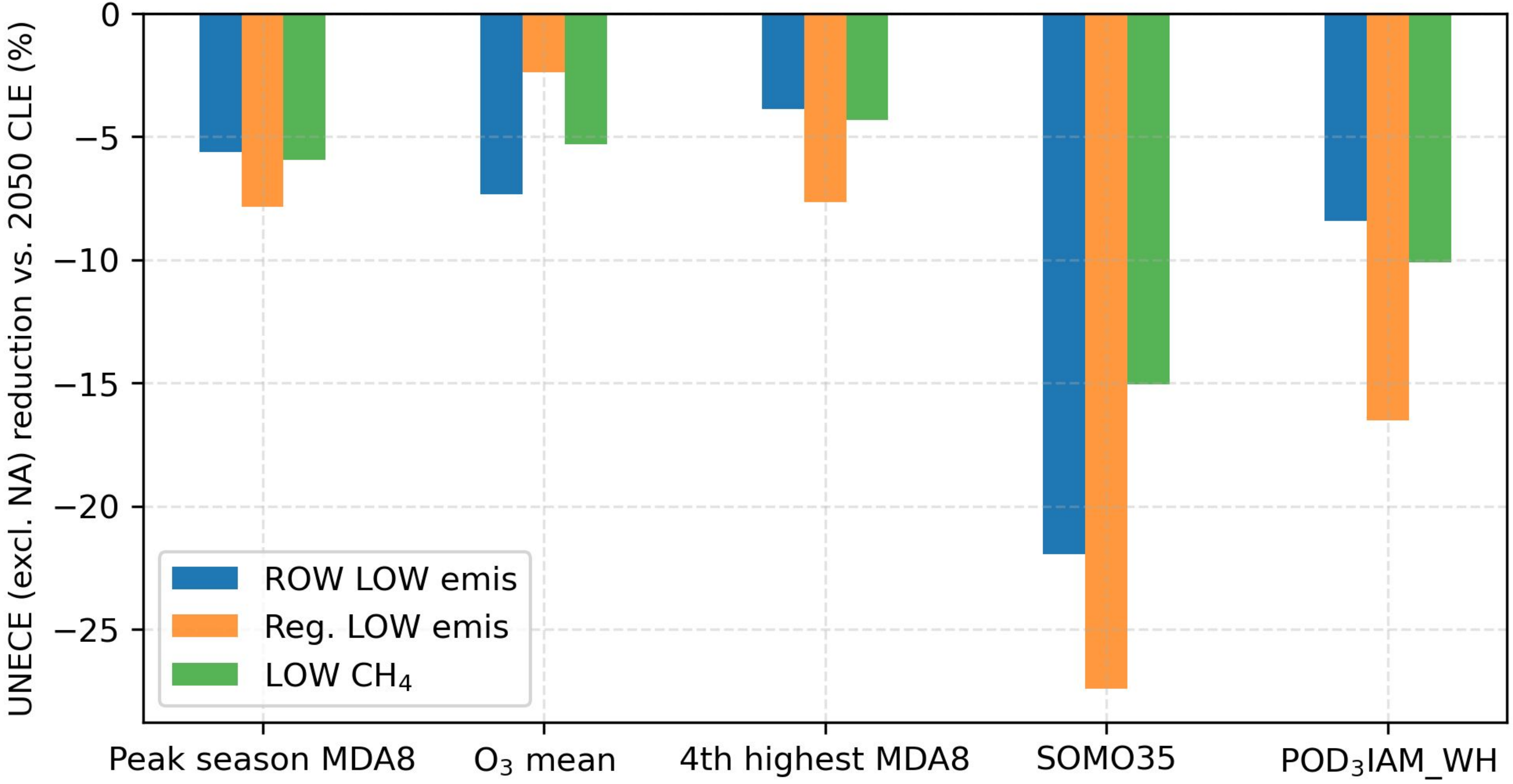


POD3 (crop area)

Results are qualitatively the same, but the effect of LOW versus CLE for 2050 is much larger (because of the cut off)

2050 LOW versus 2050 CLE



Results are qualitatively the same (except ozone mean for which Euroepan actions are less important), but the effect of LOW versus CLE for 2050 is much larger (because of the cut off)

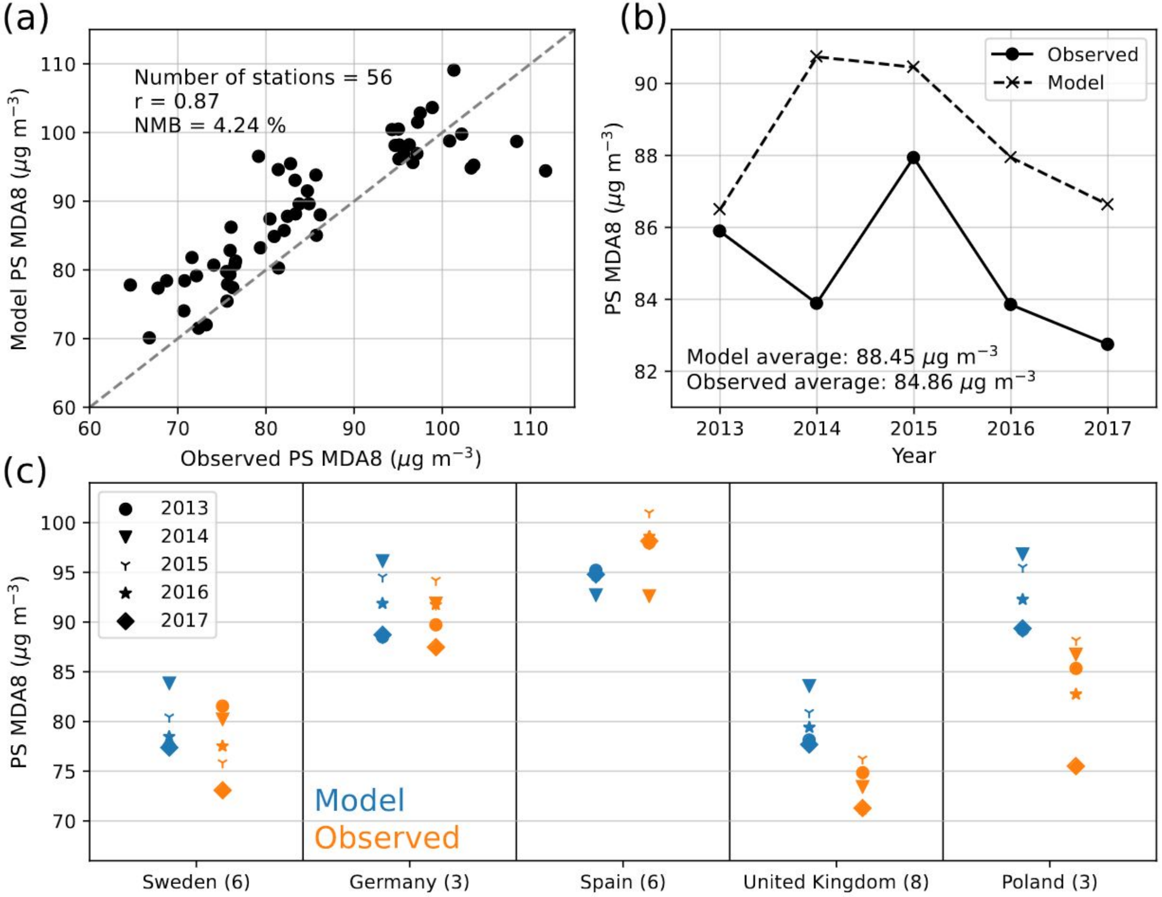
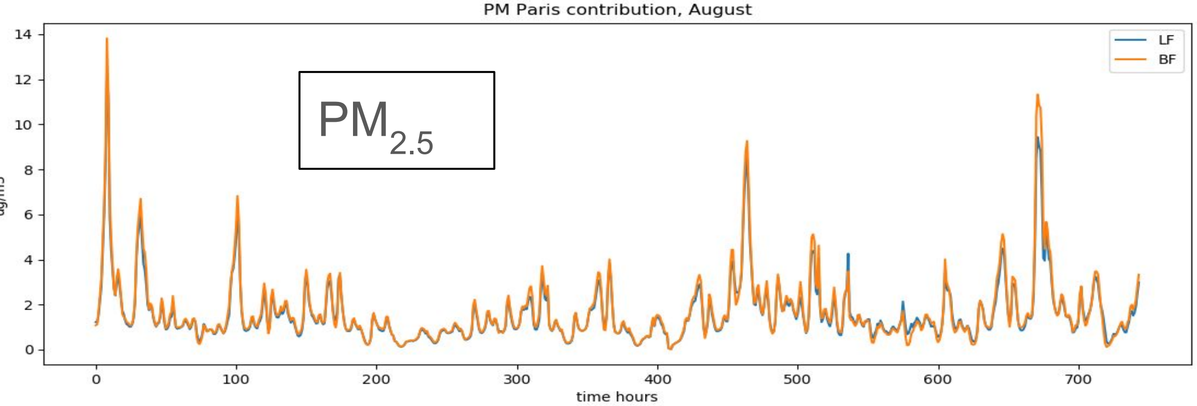


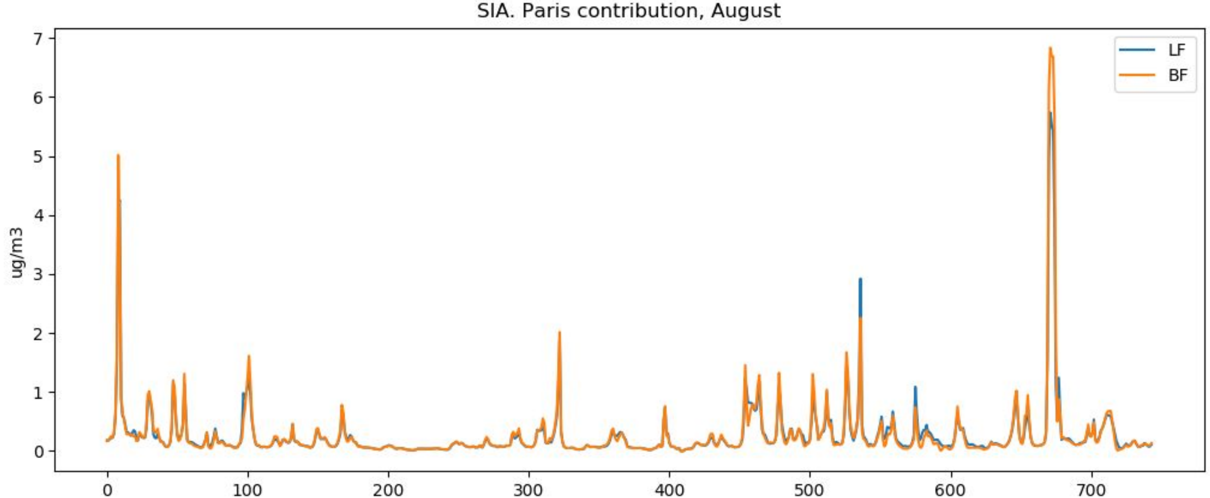
Figure 2. Modelled versus observed peak season MDA8 across Europe. Panel (a) shows five-year averaged values at each of the 56 stations, with panel (b) showing the annual values averaged over all stations. Panel (c) shows the yearly averages for Sweden, Germany, Spain, the United Kingdom, and Poland, with the number in brackets indicating the number of stations in each of the countries.

The EMEP MSC-W model is:

- reproducing MDA8 well for the 5-year average
- able to model and span the meteorological variability (compare well to observations for ‘high’ and ‘low’ MDA8 years)

Source-receptor methodologies: brute force and sensibilities (local fractions) and their applicability





The LF method was implemented & tested for:

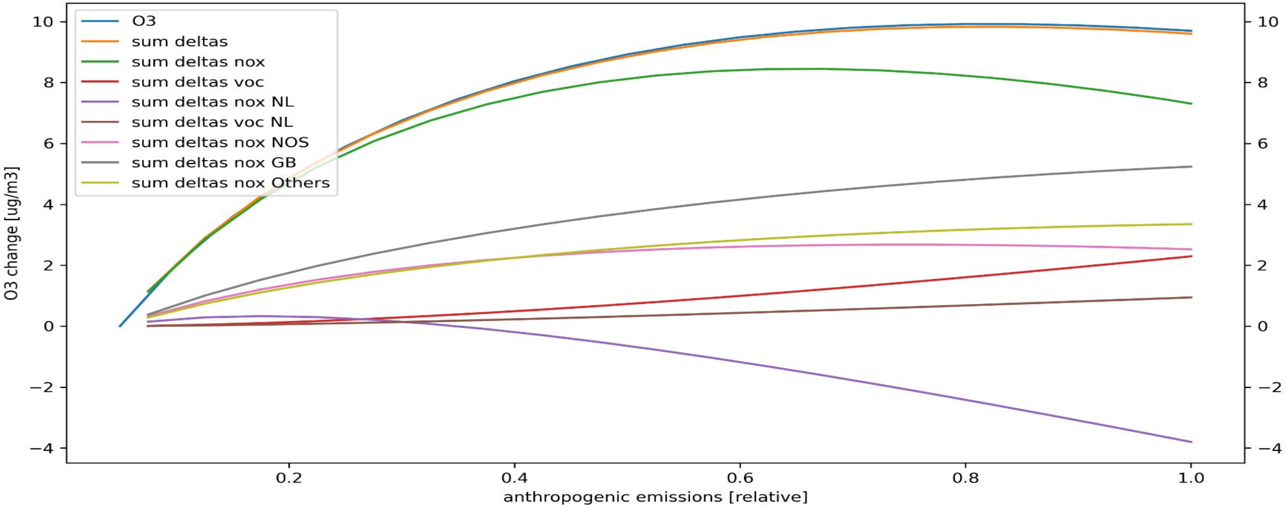
- PPM
- deposition of S and N
- O_3
- NO_2
- MDA8

NEW (implemented but not finished testing):

- SOMO35
- POD is being implemented
- SIA (Secondary inorganic aerosols)
- SOA (Secondary organic aerosols)
- BVOC (Biogenic Volatile Organic Compounds)
- $PM_{2.5}$ including water

1.1.1.6 Update GAINS for simulating O_3 response to reduction of precursor emissions

O_3 concentrations, July, due to NOx/VOC reductions, NL



Could potentially be parametrized and implemented in GAINS, but do you want to parametrize this?

- The local fraction method has been tested and compared to BF
- When and how far can we assume linearity?
  - (How large reductions - which regimes, NOx vs VOC etc)
- Which indicators should we focus on for GAINS?
  - Peak season MDA8?
  - SOMO35?
  - POD3_crop?
  - other?

1.1.1.4 Consolidate representation of intermediate and semi-volatile condensable emissions in models and validation against existing observations of PM composition (TFMM, MSC-W, CCC, CEIP, TFEIP)

- Compare modelled OC (and EC) from different sources to ‘new types’ of observations (PMF data and other tracers)
- Test different SOA mechanisms in the EMEP MSC-W model
- Supported by other projects: CAMAERA, RI-URBANs, EASVOLEE, CAMEO

Improve evaluation & modelling for EECCA, Türkiye and West Balkan countries

- Almost no EMEP measurements available in EECCA, Turkey or West Balkan - difficult to assess model and emissions
- Increasing availability of satellite data (but cannot be compared directly to model output)
- More countries have their own network/data with air quality measurements. Low(er) quality and less rural sites, but still useful

At present:

- Collecting surface data from different sources
- Making an archive of satellite data and prepare for comparison

ications.parliament.uk/pa/ld201719/ldselect/ldintrel/53/5304.htm

https://www.bilaterals.org/?empirical-data-on-isds-in-the-cis&lang=fr

75 RS stations
- 1 EMEP (R): SO2, NO2, O3
- 74 SEPA/IPH-BGD/+(U, 5R): SO2, NO2, PM10, PM2.5, O3, CO

13 KV stations
- 1 AirNow (U): PM2.5 2016-2023
- 12 KEPA (U, 2R): NO2, O3, SO2, PM10, PM2.5, CO 2018-2023

1 MD station
- AirNow (U): PM2.5 2022-2023

51 KZ stations
- 2 AirNow (U): PM2.5 2022(18)-2023
- 49 AIRKAZ: PM2.5 2017-2020

3 BA stations
- 1 EMEP (R): SO2, NO2, O3
- 2 AirNow (U): PM2.5 2021(18)-2023

1 KG station
- AirNow (U): PM2.5 2019-2023

9 ME stations
- 5 EPA (U): PM2.5 2019, 2020, 2022, 2023
- 4 EPA (2U+2R): NO2, SO2, PM10, O3, CH4

1 TJ station
- 1 AirNow (U): PM2.5 2019-2023

4 AL stations
- 4 MoEFWA (U): PM2.5 2023

21 MK stations
- 1 EMEP (R): PM10, SO2, O3
- 20 SAAAQMS (U): PM2.5 2021(15)-2023(22)

7 GE stations
- 7 MEPA (U): PM2.5, PM10, SO2, NO2, O3 2016-2019(d), 2020-2022(h)

1 AM station
- 1 AirNow (U): PM2.5 2022-2023

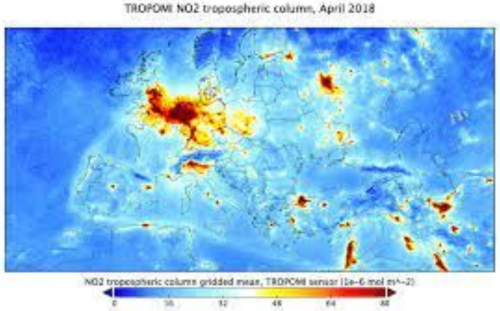
1 AZ station
- 1 AirNow (U): PM2.5 2022-2023

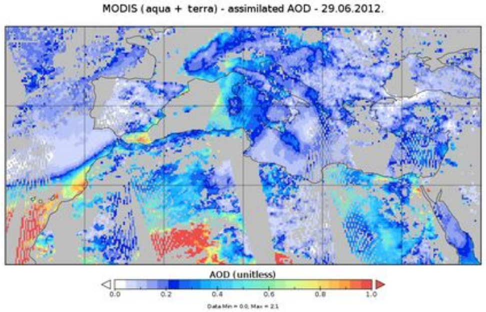
1 TM station
- 1 AirNow (U): PM2.5 2019-2023

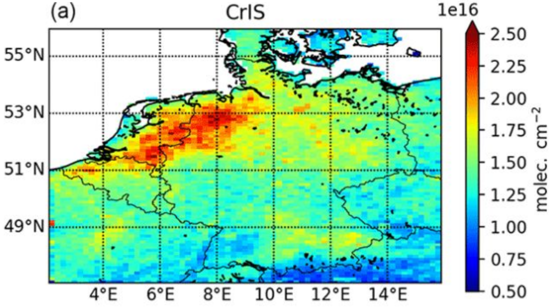
1 UZ station
- 1 AirNow (U): PM2.5, O3 2019-2023

Use of satellite data for EECCA, Türkiye and West Balkan countries

Instrument ***(satellite)***	**Products**
TROPOMI *(Sentinel-5P)*	NO_2, SO_2, CO, HCHO, glyoxal
VIIRS *(Suomi NPP, NOAA-20)*	AOD
CrIS *(Suomi NPP, NOAA-20/21)*	NH3

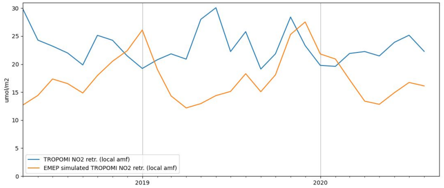






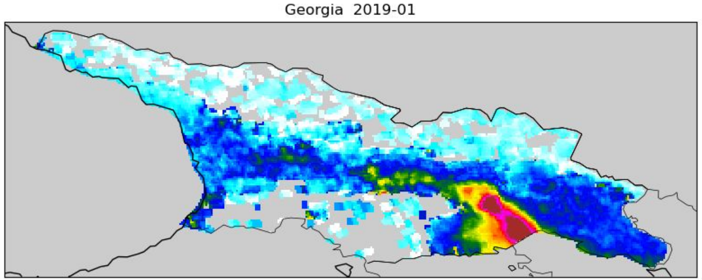
Co-funded by Norwegian Space agency - SESAM

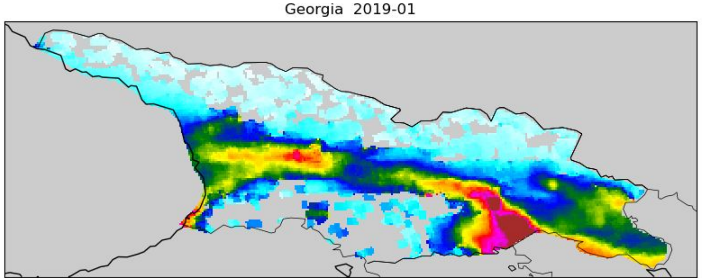
Example Georgia (emission data used in 2021)

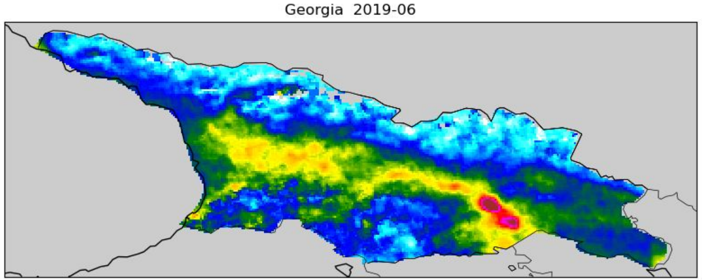


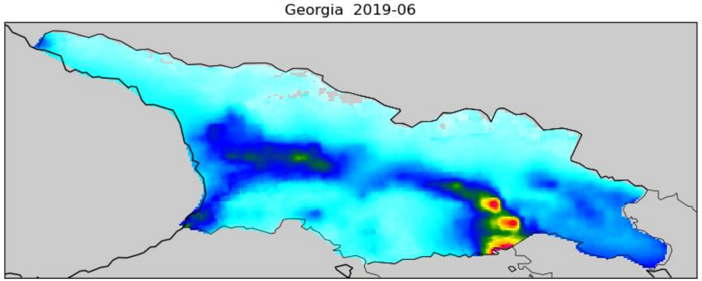
TROPOMI

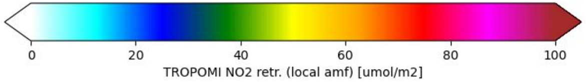
EMEP simulated TROPOMI

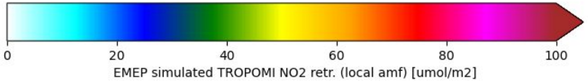

Georgia 2019-01


Georgia 2019-01


Georgia 2019-06


Georgia 2019-06



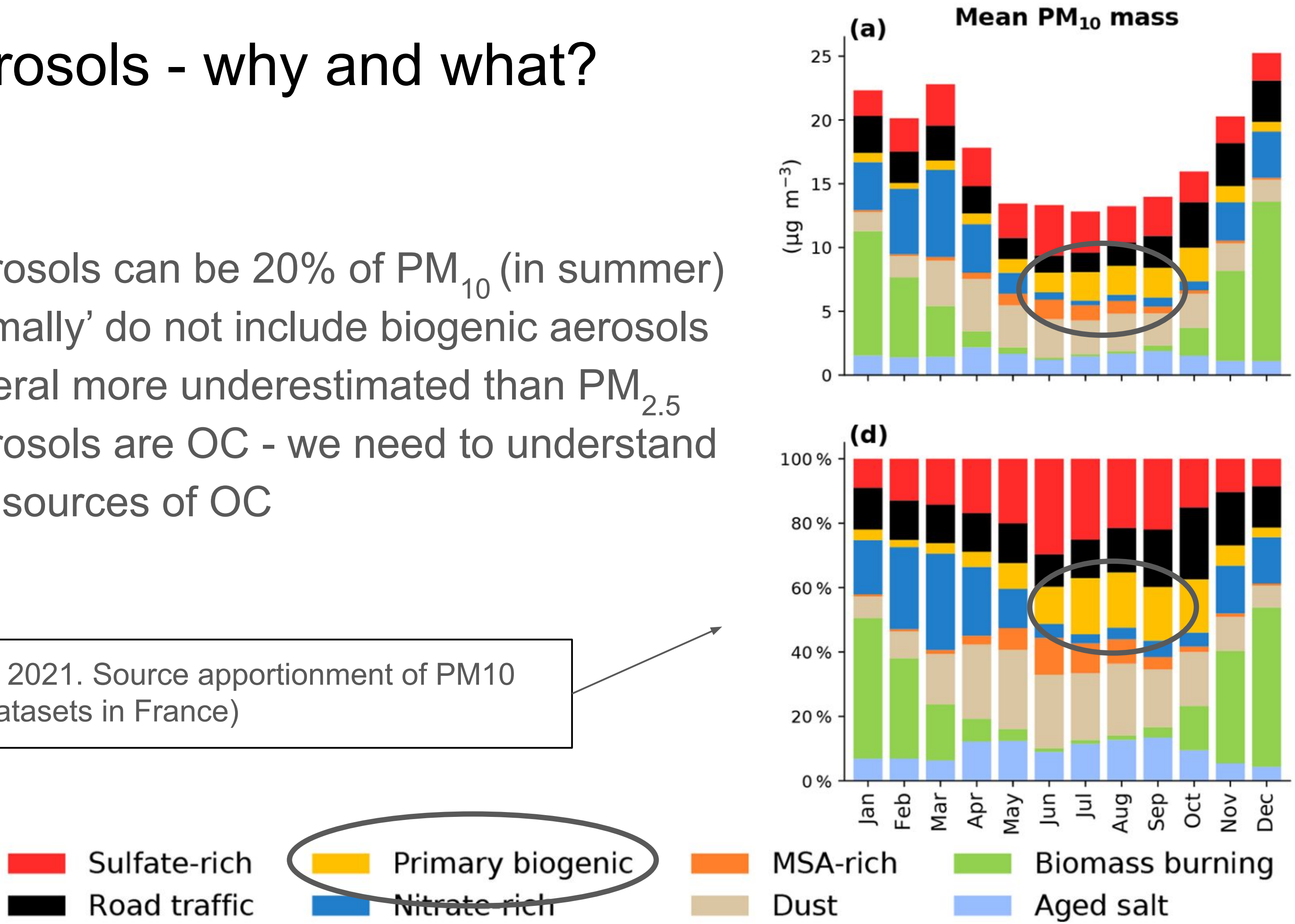


Biogenic aerosols - why and what?

Why?

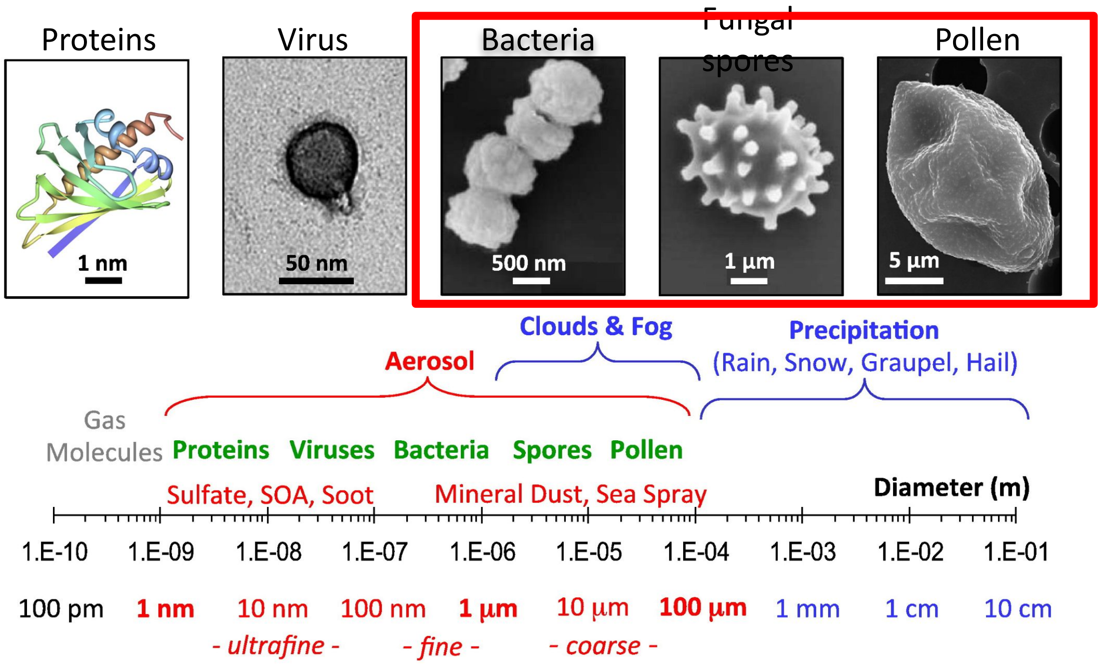
- Biogenic aerosols can be 20% of PM_{10} (in summer)
- Models ‘normally’ do not include biogenic aerosols
- PM_{10} in general more underestimated than $PM_{2.5}$
- Biogenic aerosols are OC - we need to understand the different sources of OC

Weber et al, 2021. Source apportionment of PM10 (15 yearly datasets in France)



PBAB: Primary **B**iological **A**erosol **P**articles

What will we attempt to model?



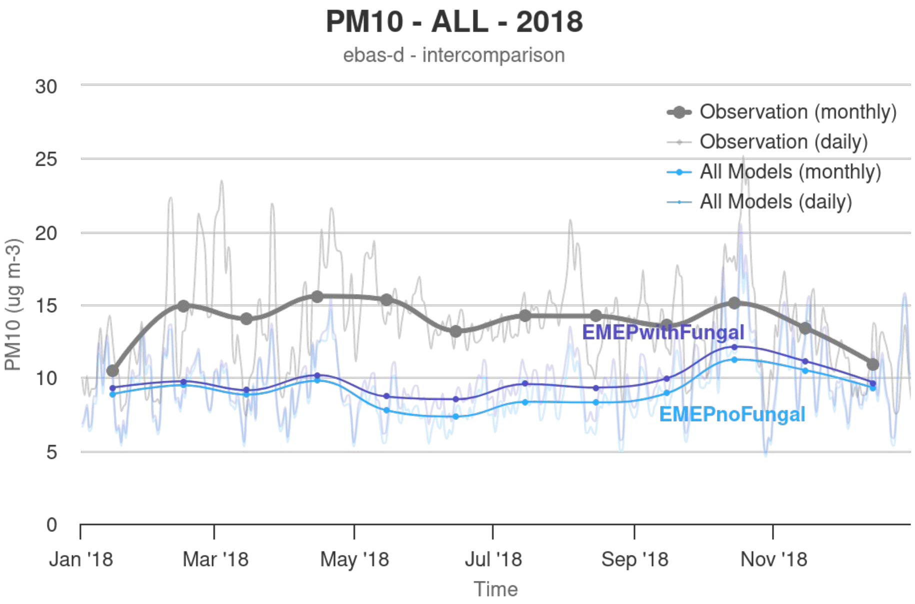
\+ Marine sources (algae)

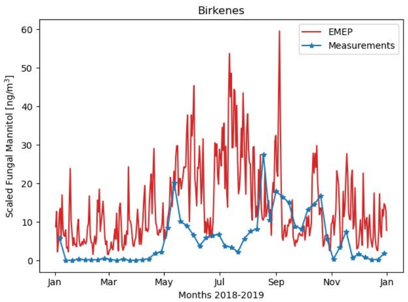
From: J. Fröhlich-Nowoisky et al. Bioaerosols in the Earth system: Climate, health, and ecosystem interactions, Atmospheric Research Volume 182, 346-376 (2016).

Preliminary results

Assumptions:

- Fixed fungal spore diameter (5µm)
- Fixed amount of mannitol per spore (38 pg)
- Using the parameterization from Heald and Spracken (2009)

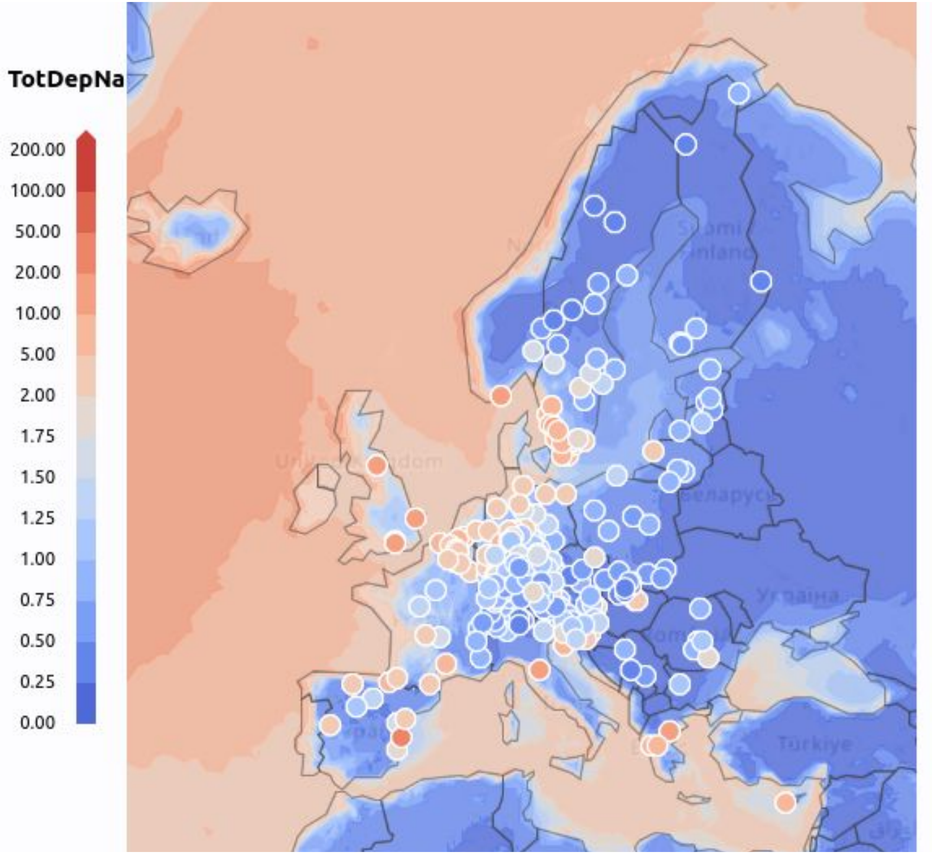


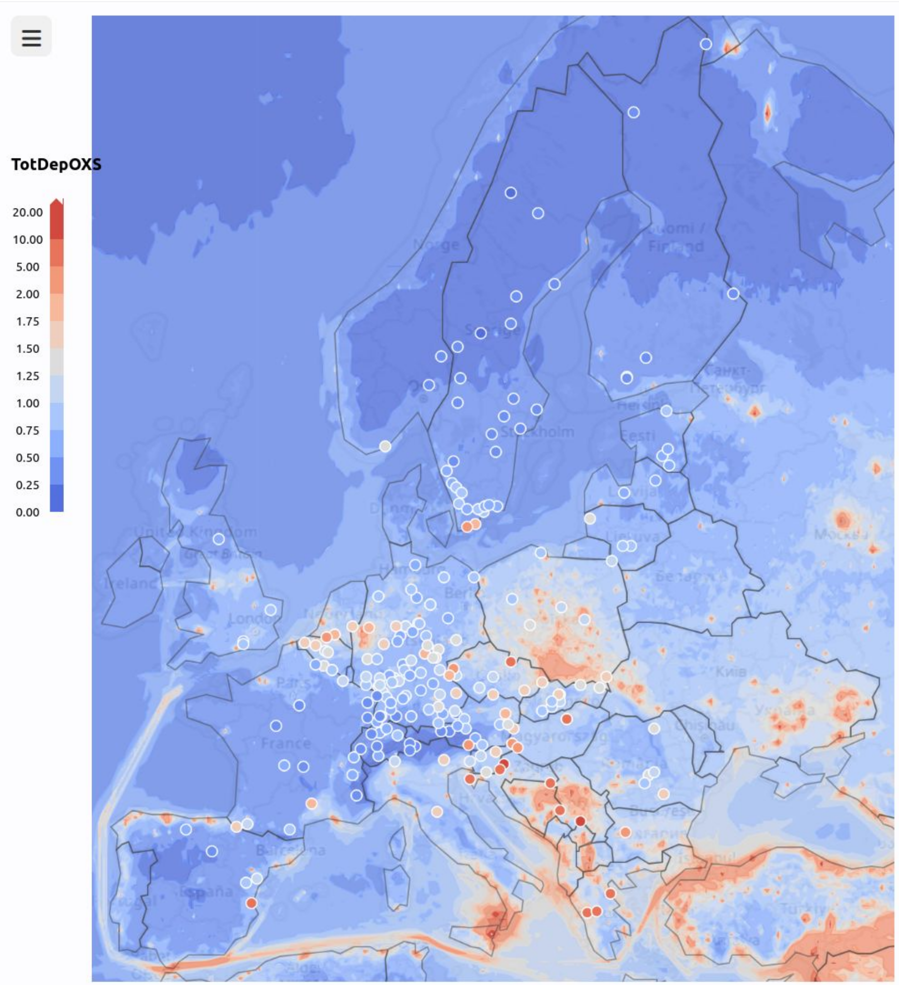


Results of including fungal spores in EMEP domain:

- Normalized mean bias (NMB) **decreases** from -34 % to -29%
- Temporal correlation **increases** from 0.54 to 0.59
- Spatial correlation **decreases** from 0.68 to 0.66

1.1.1.12 Collaborate with EMEP regarding data gap filling (ICP Forests, MSC-W)





Aerosol and Air Quality Research

Special Issue:
Carbonaceous Aerosols in the Atmosphere

Trends in Air Pollution in Europe

Wenche Aas[1*], Hilde Fagerli[2], Andres Alastuey[3] Anna Degorska[5], Stefan Feigenspan[6], Hans Brenn Daniel Heinesen[2], Christoph Hueglin[7], Adéla Holu Augustin Mortier[2], Marijana Murovec[10], Jean-Phi David Simpson[2,11], Sverre Solberg[1], Svetlana Tsyr Karl Espen Yttri[1]

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[3] Institute of Environmental Assessment and Water Researc
Research Centre, Ispra (VA), I
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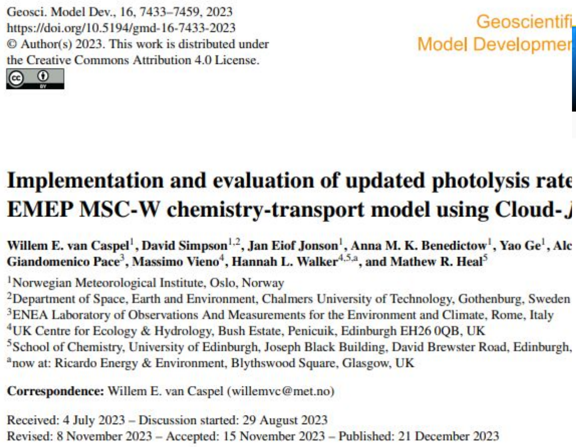

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Geoscientifi
Model Developmen

Implementation and evaluation of updated photolysis rate EMEP MSC-W chemistry-transport model using Cloud-J

Willem E. van Caspel[1], David Simpson[1,2], Jan Eiof Jonson[1], Anna M. K. Benedictow[1], Yao Ge[1], Alc Giandomenico Pace[3], Massimo Vieno[4], Hannah L. Walker[4,5,a], and Mathew R. Heal[5]

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19 Jan 2024

Status: this preprint is open for discussion and under review for Atmospheric Chemistry and Physics (ACP).

Evaluation of modelled versus observed NMVOC compounds at EMEP sites in Europe

Yao Ge, Sverre Solberg, Mathew Heal, Stefan Reimann, Willem van Caspel, Bryan Hellack, Thérèse Salameh, and David Simpson

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Short summa
Atmospheric vo
organic compo
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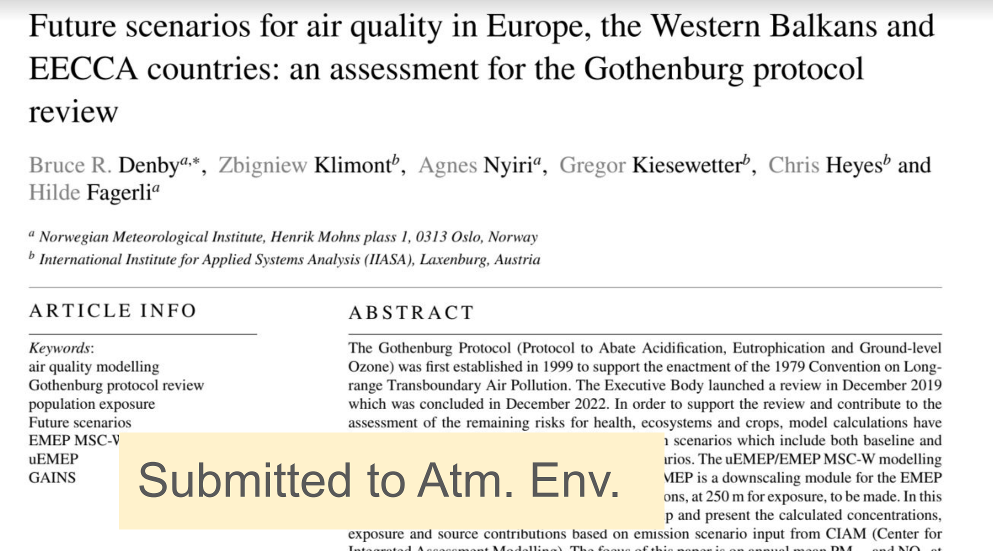
In discussion



Future scenarios for air quality in Europe, the Western Balkans and EECCA countries: an assessment for the Gothenburg protocol review

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ABSTRACT

The Gothenburg Protocol (Protocol to Abate Acidification, Eutrophication and Ground-level Ozone) was first established in 1999 to support the enactment of the 1979 Convention on Long-range Transboundary Air Pollution. The Executive Body launched a review in December 2019 which was concluded in December 2022. In order to support the review and contribute to the assessment of the remaining risks for health, ecosystems and crops, model calculations have n scenarios which include both baseline and rios. The uEMEP/EMEP MSC-W modelling MEP is a downscaling module for the EMEP ons, at 250 m for exposure, to be made. In this p and present the calculated concentrations, exposure and source contributions based on emission scenario input from CIAM (Center for

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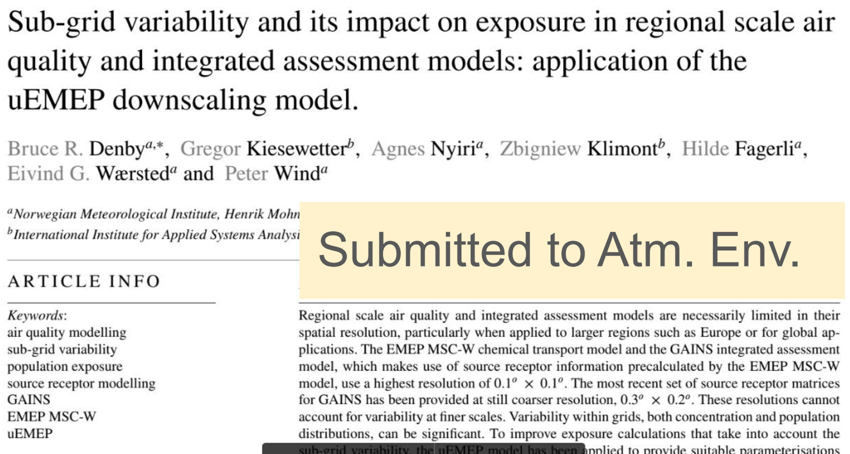

Sub-grid variability and its impact on exposure in regional scale air quality and integrated assessment models: application of the uEMEP downscaling model.

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Regional scale air quality and integrated assessment models are necessarily limited in their spatial resolution, particularly when applied to larger regions such as Europe or for global applications. The EMEP MSC-W chemical transport model and the GAINS integrated assessment model, which makes use of source receptor information precalculated by the EMEP MSC-W model, use a highest resolution of $0.1^o \times 0.1^o$. The most recent set of source receptor matrices for GAINS has been provided at still coarser resolution, $0.3^o \times 0.2^o$. These resolutions cannot account for variability at finer scales. Variability within grids, both concentration and population distributions, can be significant. To improve exposure calculations that take into account the

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