emep

Co–operative programme for monitoring and evaluation of the long–range transmissions of air pollutants in Europe

Norwegian Meteorological Institute

LRTAP
Long-range Transboundary Air Pollution

Progress in EMEP/MSC-W activities 2021/2022

Hilde Fagerli, Bruce Denby, David Simpson, Svetlana Tsyro, Agnes Nyri, Daniel Heinesen, Augustin Mortier, Arjo Segers, Anna Benedictow, Peter Wind, Lewis Blake & the rest of the MSC-W team

TFMM, 3-5th May, 2022

Activities 2021/2022

1. **Application of EMEP/uEMEP for the AAQD review process**, *Bruce Denby (Thursday 10:00)*
2. **Modelling impact of condensable organics, 2005-2019; results of the NMR-RWC project**, *David Simpson (Wednesday 9:20)*
3. Work to feed the new extended multiscale GAINS -> **Gregor Kiesewetter CIAM/IIASA 10:40 on Thursday**
4. **Trends & trend interface**
5. **Using satellite data to evaluate West Balkan/EECCA emissions & model simulations**
6. **Preparation for VOCs campaign**

Norwegian Meteorological Institute

Trends & the Trend interface

The EMEP trend interface

- Interface: https://aeroval.met.no/evaluation.php?project=emep-trends
  (Comments on observational data by Parties very welcome)
- All EMEP observations & EMEP/MSC-W model runs
- 2000-2019, 2000-2010, 2010-2019, 2005-2010
- EBAS & EBAS-raw (all observation sites)
- EC/OC only from 2010 onwards
- Regional trends, mean (median) of individual stations
- MSC-W & CCC cooperation


AeroVal
Maps
Evaluation
Intercomparison
Overall Evaluation
Information
Experiments
2000-2019
2000-2010
2005-2019
2010-2019
Trends in EMEP observations and EMEP/MSC-W model
Trends over regions are found either by calculating the trends over the averaged regional timeseries (called 'obs-trend' or 'mod-trend') or by taking the mean/median
+ Show More
Daniel Heinesen
NO2
EBAS
EMEP
2000-2019
Mean Obs/Mod-Trends
NO2 - 2000-2019
EMEP
Search for a station
Statistic: Mean Obs/Mod-Trends (%/yr)
-5< -4 -3 -2 -1 0 1 2 3 4 >5
NO2 - 2000-2019
based on monthly mean values from all stations
Mean Obs/Mod-Trends (%/yr)
WORLD
Norway
Sweden
Hungary
Spain
Ireland
Poland
Iceland
Italy
Denmark
Slovenia
Germany
Finland
Czech Republic
Switzerland
Lithuania
Latvia
Netherlands
Russian Federation
Slovakia
France
United Kingdom
Serbia
Belgium
Estonia
Svalbard and Jan Mayen
Belarus
Cyprus
Austria
Malta
Bulgaria
NO2 - WORLD - 2000-2019
EBAS - EMEP
Observation (monthly)
Model (monthly)
-1.68+/-1.54%/yr; p-val: 0.00
-2.23+/-0.67%/yr; p-val: 0.00
NO2 (ug m-3)
Time
lin
NO2 - WORLD - 2000-2019
EBAS - EMEP
Linear regression (monthly)
n: 240
y = 0.95 x + 0.02
R2: 0.91
Other statistics (monthly)
n: 12420
NMB (%): -5.2
R: 0.86
EMEP (ug m-3)
EBAS (ug m-3)

Trends in air pollution 2000-2019

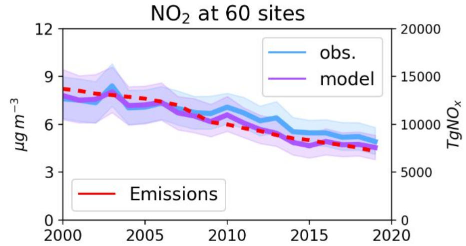
- How has the trend study been done:
  - Model calculations in 0.1x0.1 with **revised emissions** (total and gridding)
  - EMEP observations
  - Sulphur (SO_2, SO_4^{2-}, wet dep), oxidized nitrogen (NO_2, HNO_3, NO_3^-, wet dep), reduced nitrogen (NH_3, NH_4^+, wet dep), $PM_{2.5}$ and PM_{10} (chemical species, **including EC/OC from 2010-2019**), ozone
- Issues: trends for EECCA (and western Balkan) countries are not presented as reported emissions to a large extent is missing and observations are lacking - large uncertainties
- For PM: 'condensables' are included *as they are in reported EMEP emissions*, thus they are not consistently included (historical data set including condensables did not yet exist)
- Documented in EMEP Status Report 1/2021

LRTAP Long-range Transboundary Air Pollution

Norwegian Meteorological Institute

NILU

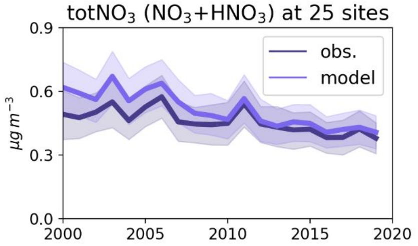
Trends in oxidized nitrogen



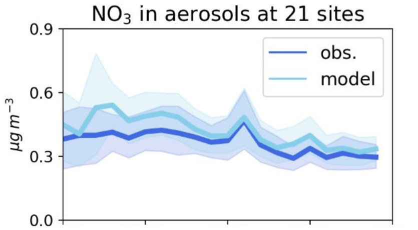
Change in NOx emissions (west EMEP): -48%

NO_2:
Obs: -24%
Mod: -42%

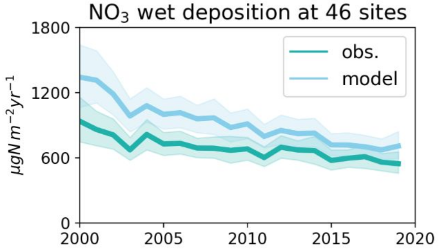
Depend on inclusion/ exclusion of observations



HNO_3+NO_3^-:
Obs: -30%
Mod: -40%



NO_3^- aerosol:
Obs: -38%
Mod: -48%

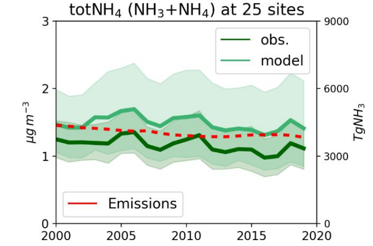


Wet deposition of oxidized nitrogen:
Obs: -26%
Mod: -45%

Substantial reductions in NOx emissions have lead to large reductions in observed oxidized nitrogen - but the changes in observations are not as large as the reported emission reductions

LRTAP Long-range Transboundary Air Pollution
Norwegian Meteorological Institute
NILU

Trends in reduced nitrogen

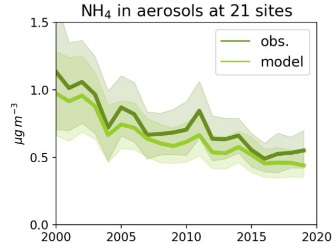


Change in NH_3 emissions**: -12% (west EMEP)**

NH_3+ NH_4^+:

Obs: - 28%

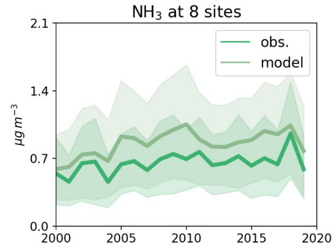
Mod: - 26%



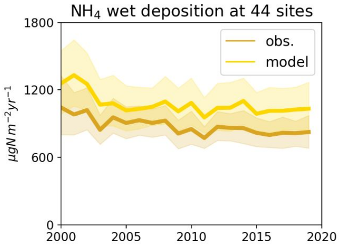
NH_4^+ aerosol:

Obs: - 49 %

Mod: - 49 %



NH_3 in air: very few statistically significant trends (and few sites), but on average a positive trends (by ca. 30%)



Reduced N wet deposition: few statistically significant trends

Obs: - 6%

Mod: - 5%

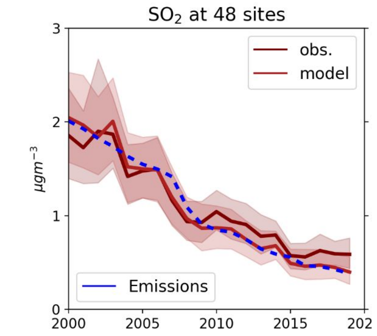
The modest reductions in reported NH_3 emissions in EMEP west is confirmed by observations and modelling results. Large differences in trends for different reduced nitrogen compounds can be explained by interactions with sulphur and oxidized nitrogen compounds

LRTAP Long-range Transboundary Air Pollution

Norwegian Meteorological Institute

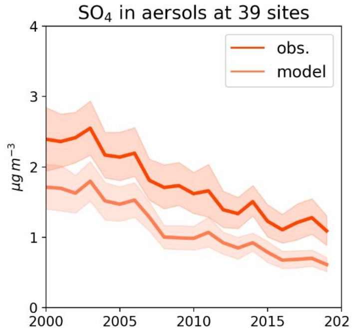
NILU

Trends in sulfur



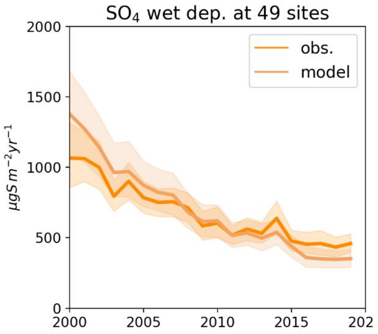
Change in SO_2 emissions: -82% (west EMEP)

SO_2:
Obs: - 74%
Mod: - 97%



SO_4^{2-} aerosol:
Obs: - 61%
Mod: - 72%

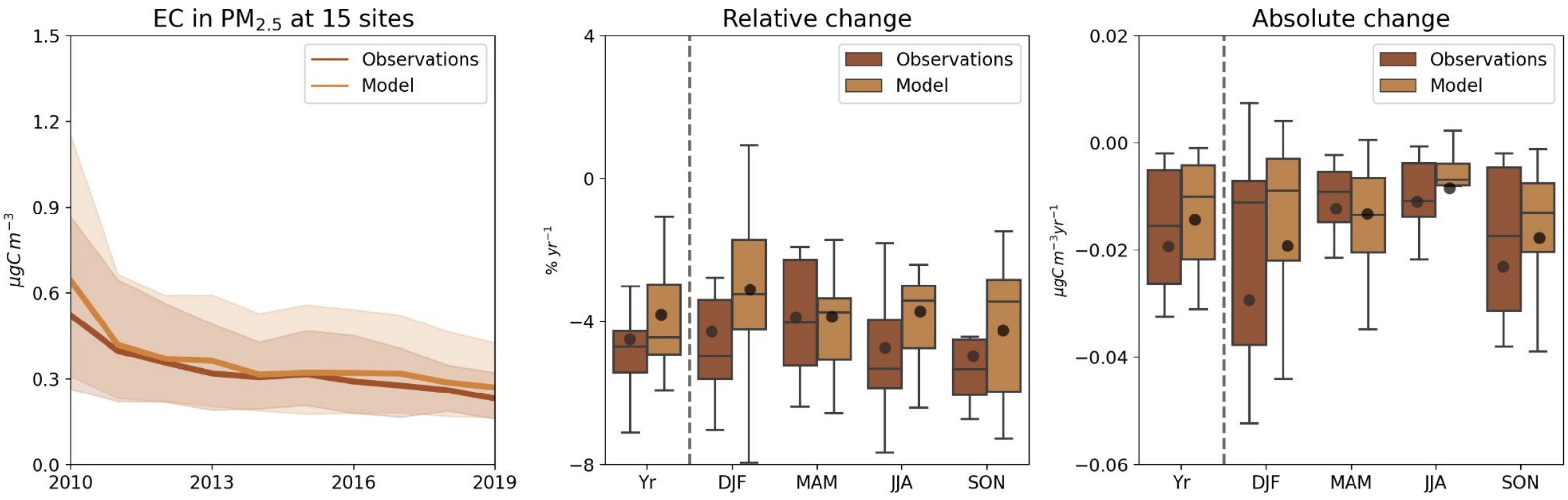
Significant reductions in SOx emissions have led to decreasing concentrations of sulphur dioxide, particulate sulphate and wet deposition of oxidized sulphur (although a observations show a somewhat smaller decrease)



Sulfur wet deposition:
Obs: - 60%
Mod: - 81%

LRTAP Long-range Transboundary Air Pollution
Norwegian Meteorological Institute
NILU

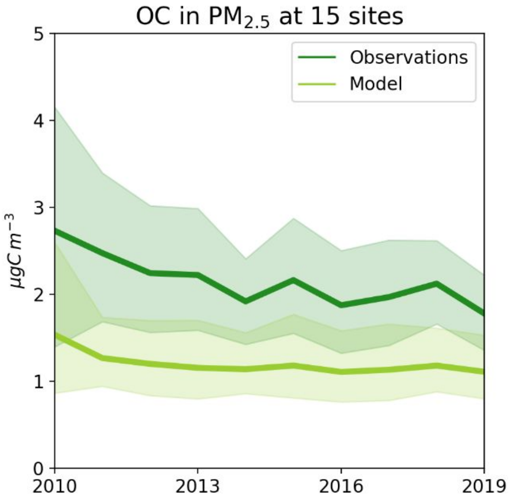
EC 2010-2019

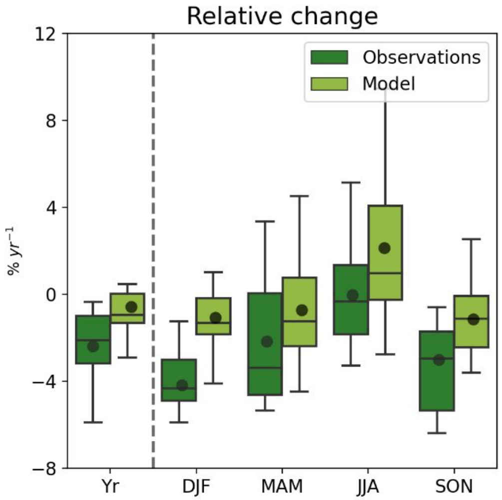


EC:

Ca. -4%/yr 2010-2019 both in observations and model

OC 2010-2019





OC:

- Only 2 sites show statistically significant trends in observations
- More pronounced downward trends in winter time OC in observations (6/15), only 1/15 in the model
- Trends in summertime OC were much less clear in both the model and observations (biogenic sources).
- The model underpredict OC, both in terms of absolute values and trends at least partly due to condensables

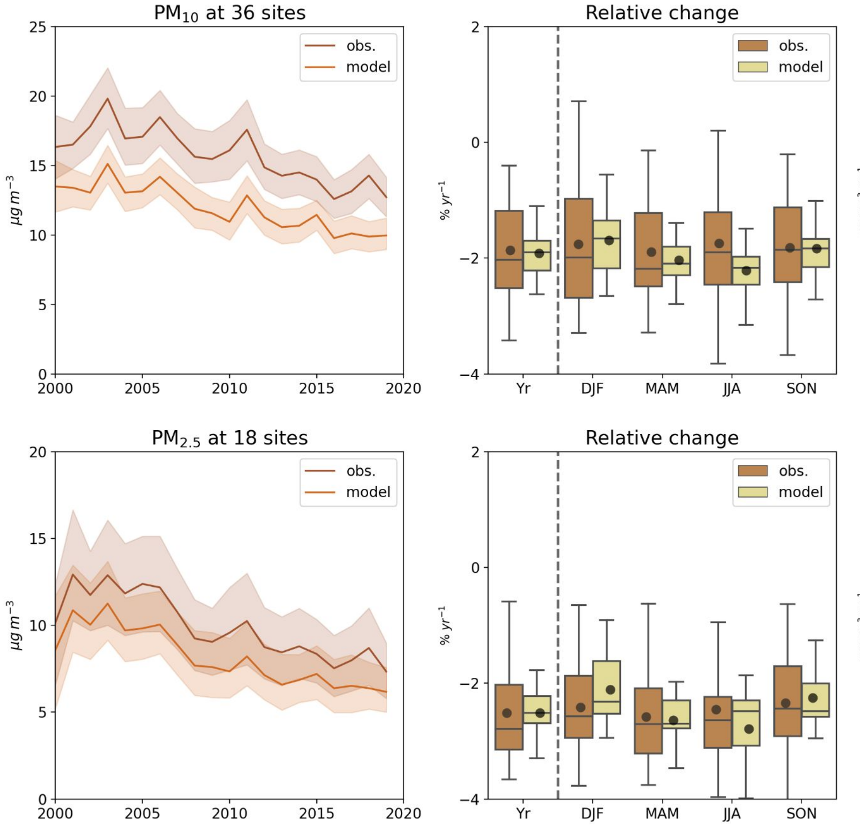
Efforts are needed to separate and understand natural and anthropogenic components of OC, in order to get a quantitative overview of the abatable fractions

LRTAP Long-range Transboundary Air Pollution

Norwegian Meteorological Institute

NILU

PM_{10} and $PM_{2.5}$ 2000-2019



PM_{10}:
Obs: - 35%
Mod: - 37%

$PM_{2.5}$:
Obs: - 46%
Mod: - 48%

Reductions in SIA (SO_4^{2-}, NO_3^-, NH_4^+) contributed substantially. Considerable reductions in EC and winter time OC (at least in 2010-2019).

Relative trends are well reproduced by the model, although absolute levels and trends are somewhat underestimated (partly due to condensables)

Lower trends in PM_{10} than $PM_{2.5}$ due to natural contributions to the coarse fraction

LRTAP Long-range Transboundary Air Pollution

Norwegian Meteorological Institute

NILU

Summary, Trends

- Large changes in emissions the last 20 years have led to large reductions in concentrations and depositions of S and N species and concentrations of PM
- Overall there is consistency between reported emission changes, model runs and observations, except OC and NO_2/OXN

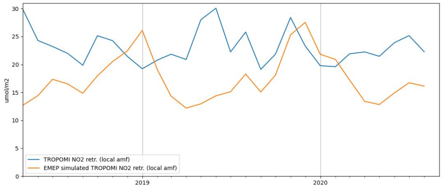
Norwegian Meteorological Institute

Using satellite data for evaluation of (emissions used for) West Balkan & EECCA

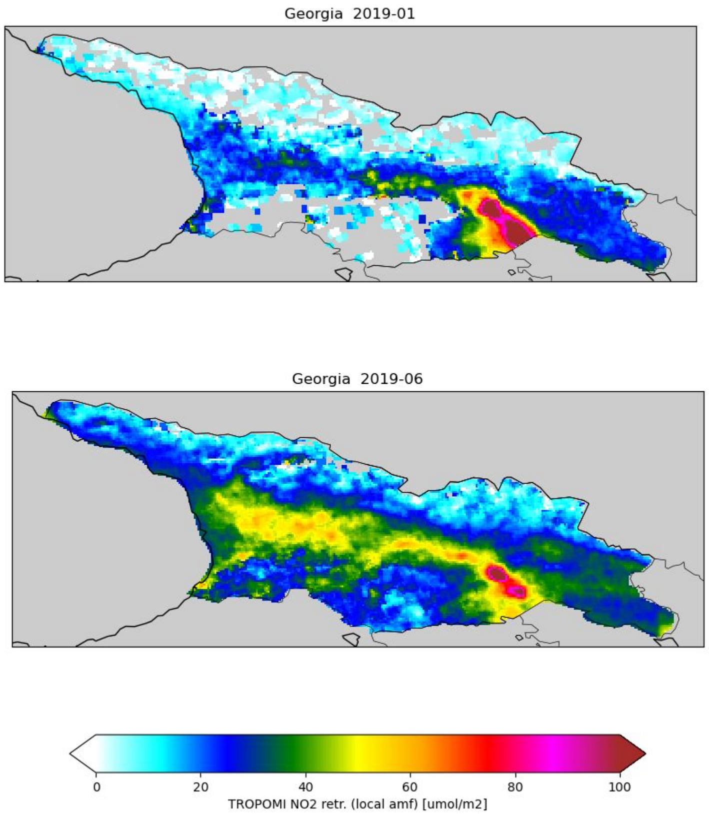
Use of satellite data: why and how

- Why?
  - Very few surface observations available for West Balkan, EECCA
  - Emissions are more uncertain that in ‘EMEP West’
- Tropospheric columns of NO_2 (SO_2, HCHO, CO) from TROPOMI/Sentinel-5p
- Model runs May 2018-2020 (ensuring similar overpass and kernel so that data from model and observations are directly comparable)
- Overall levels, spatial distribution, seasonal cycles
- Next step: analyses, including analyses using ‘new’ GAINS emissions

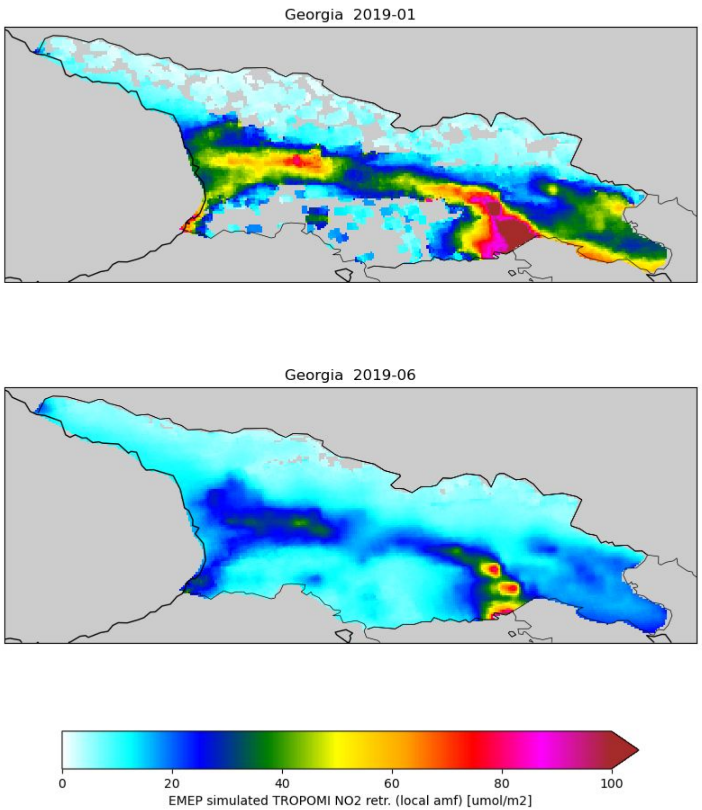
Example Georgia (emission data used in 2021)



TROPOMI

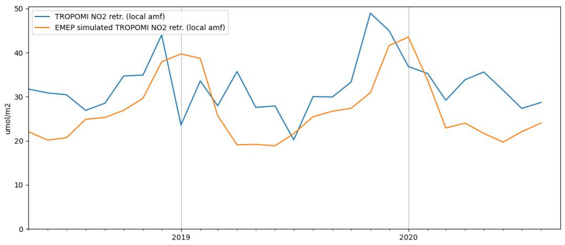


EMEP simulated TROPOMI

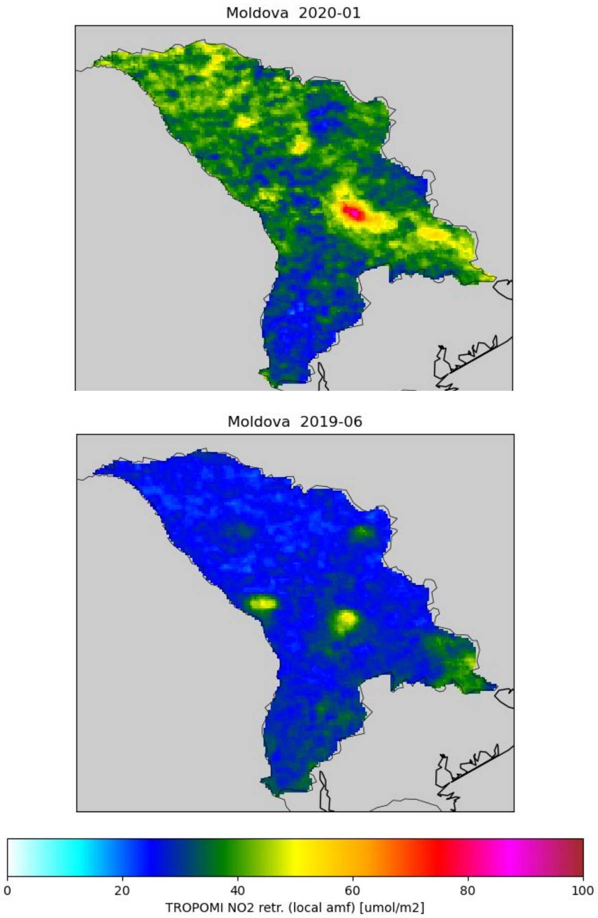


titute

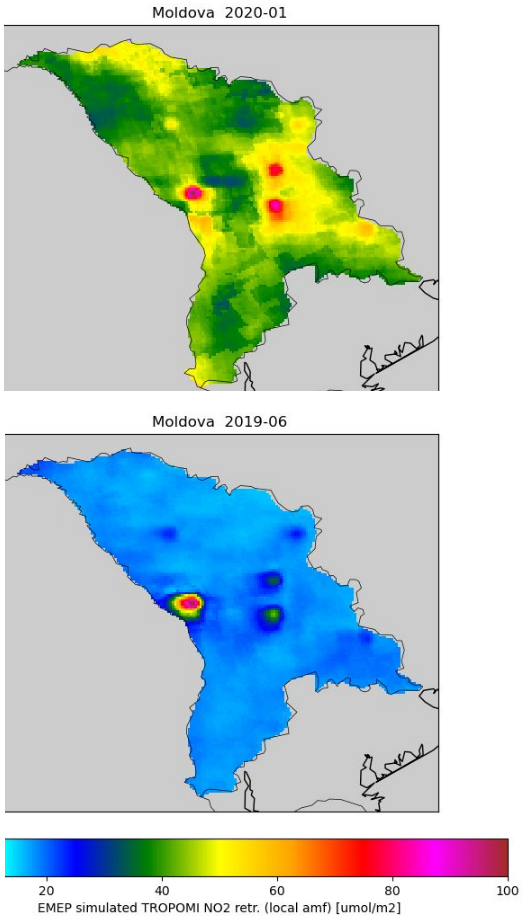
Example Moldova (emission data used in 2021)



TROPOMI



EMEP simulated TROPOMI



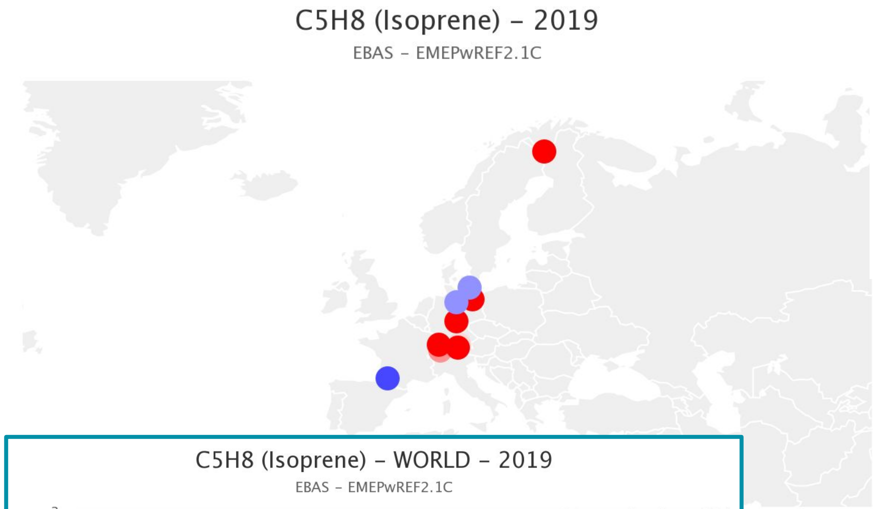
Norwegian Meteorological Institute

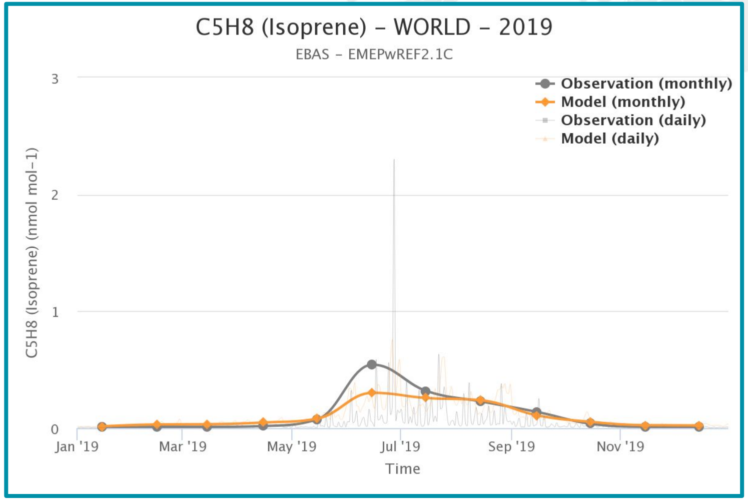
Preparing for the VOC campaign

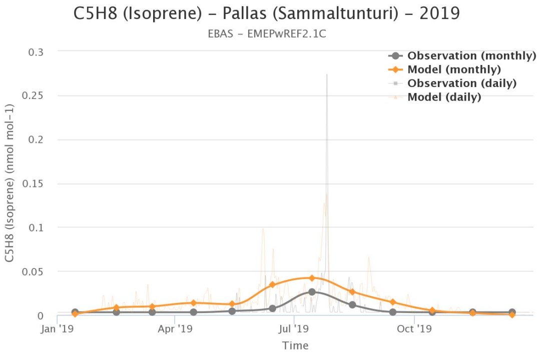
Preparing for the VOC campaign

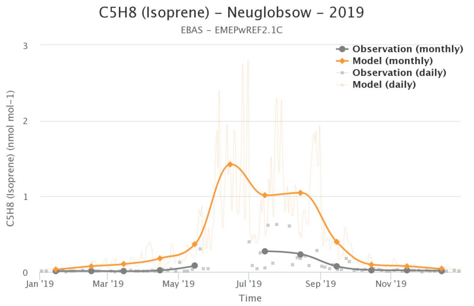
- Evaluation of EMEP MSC-W results towards existing EMEP measurements (add species with direct emissions that are measured) -> assessing assumed emissions
- VOC speciation
- Satellite data, TROPOMI Sentinel-5p HCHO

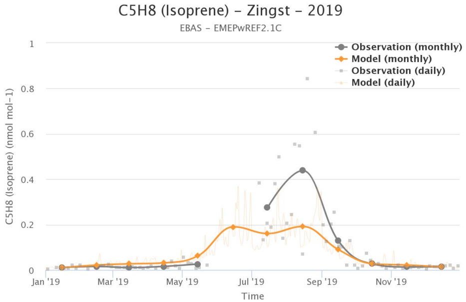
Isoprene (10 sites in 2019)

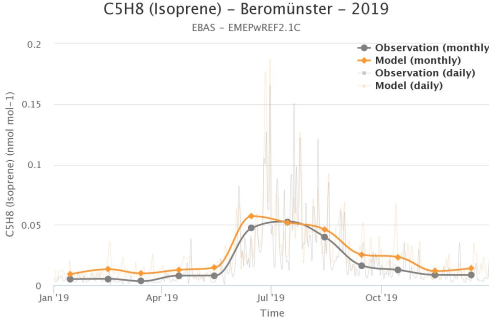


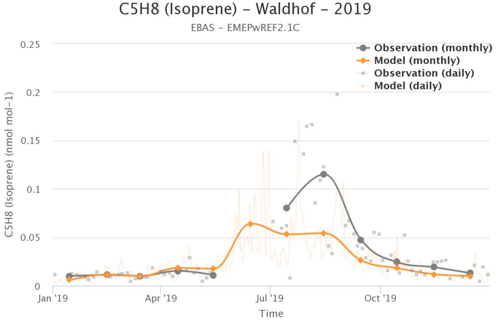


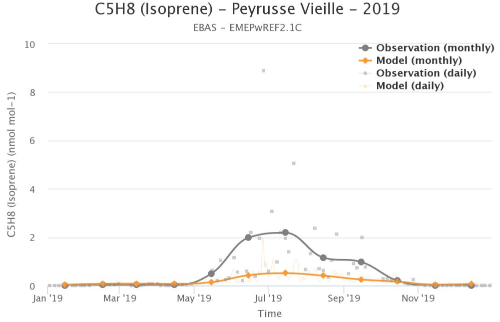




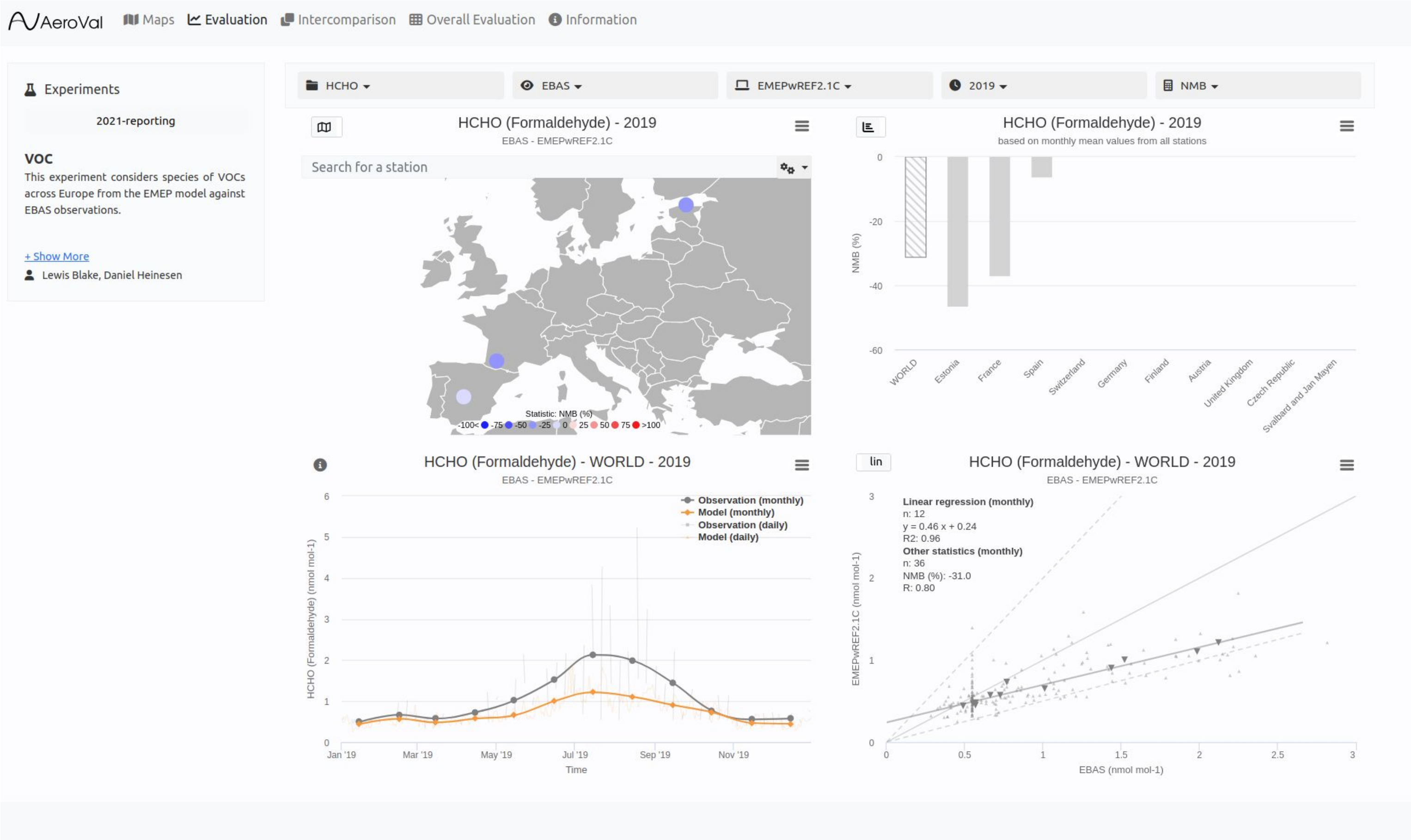






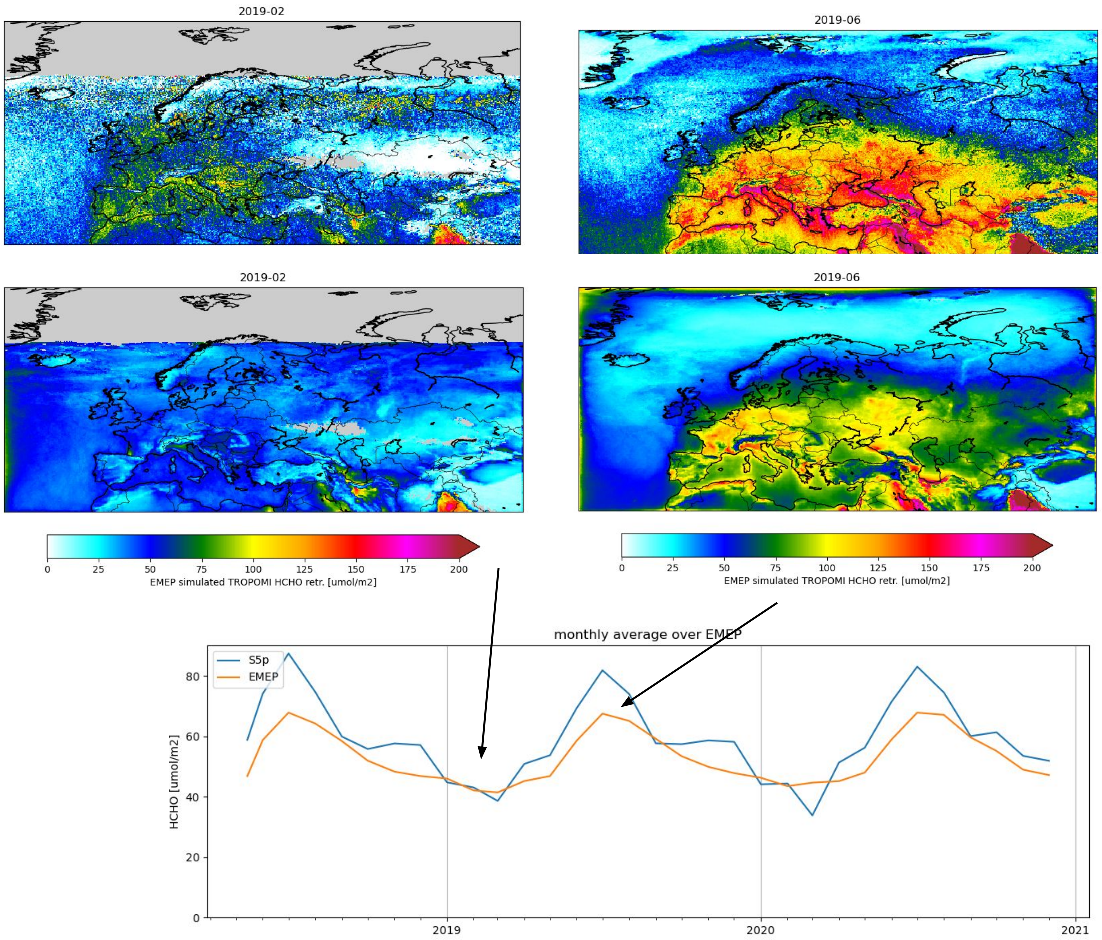


Formaldehyde (3 sites in 2019)



rological Institute

Comparison S5p and EMEP : HCHO



- S5p HCHO
  - somewhat noisy product ...
  - higher values around 60N in winter?
- EMEP simulation:
  - too low in summer

Norwegian Meteorological Institute

Thank you for listening!