Norwegian Meteorological Institute

Modelling impacts of condensable organics 2005-2019: results of the NMR-RWC project

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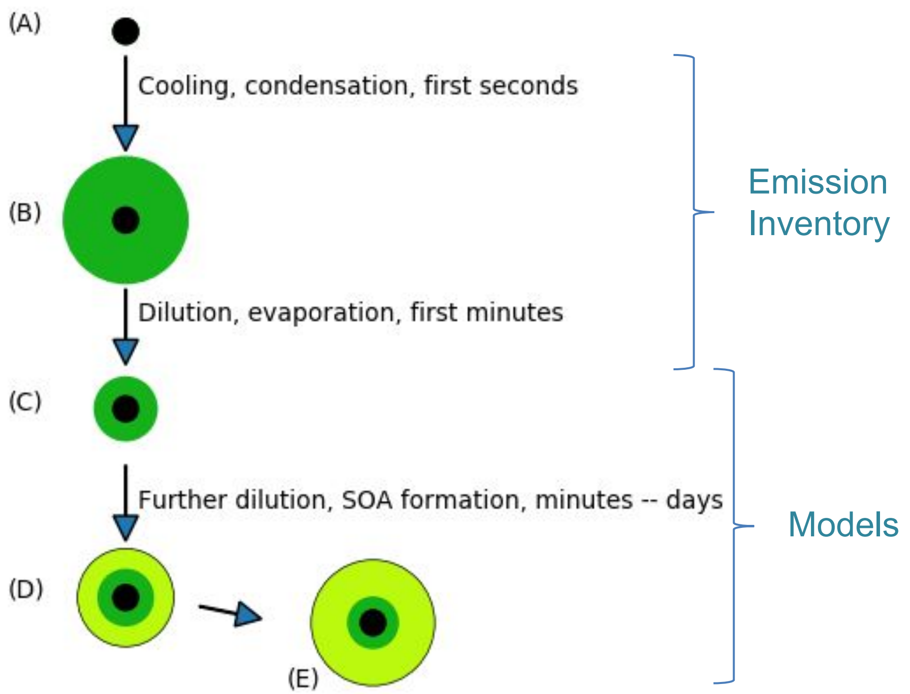
From Primary Organic Aerosol (POA) to Secondary OA (SOA)– the first seconds/hours

- Condensables: low- and semi-volatile VOC (dark green in sketch) which can condense on particle
- Countries may define EFs from step (A), (B) or likely between (B) and (C).
- Basically, countries report apples and oranges!
- Important steps towards increased comparability made in last years



NMR-RWC project, overview

- NMR project: Revising historical $PM_{2.5}$ emissions from RWC to consistently include condensable organics and assess the implications for the Gothenburg Protocol.
  - Partners: MET (coordinator), TNO, IIASA, SYKE, NILU.
  - Start June 2021, final report 30/6 2022
- Sub goal:
  - Review and update TNO Ref2 inventory to cover 2005-2018
  - Separate solid/condensables in PPM
  - Coordinate/evaluate/improve with IIASA/GAINS emission data
  - EMEP/MSC-W model calculations with new PM data, trends, SR and comparison to observations
- Important issues:
  - The range of uncertainty in the estimates of the condensable component
  - How important is the volatility distribution?
  - How to include the results in GAINS?

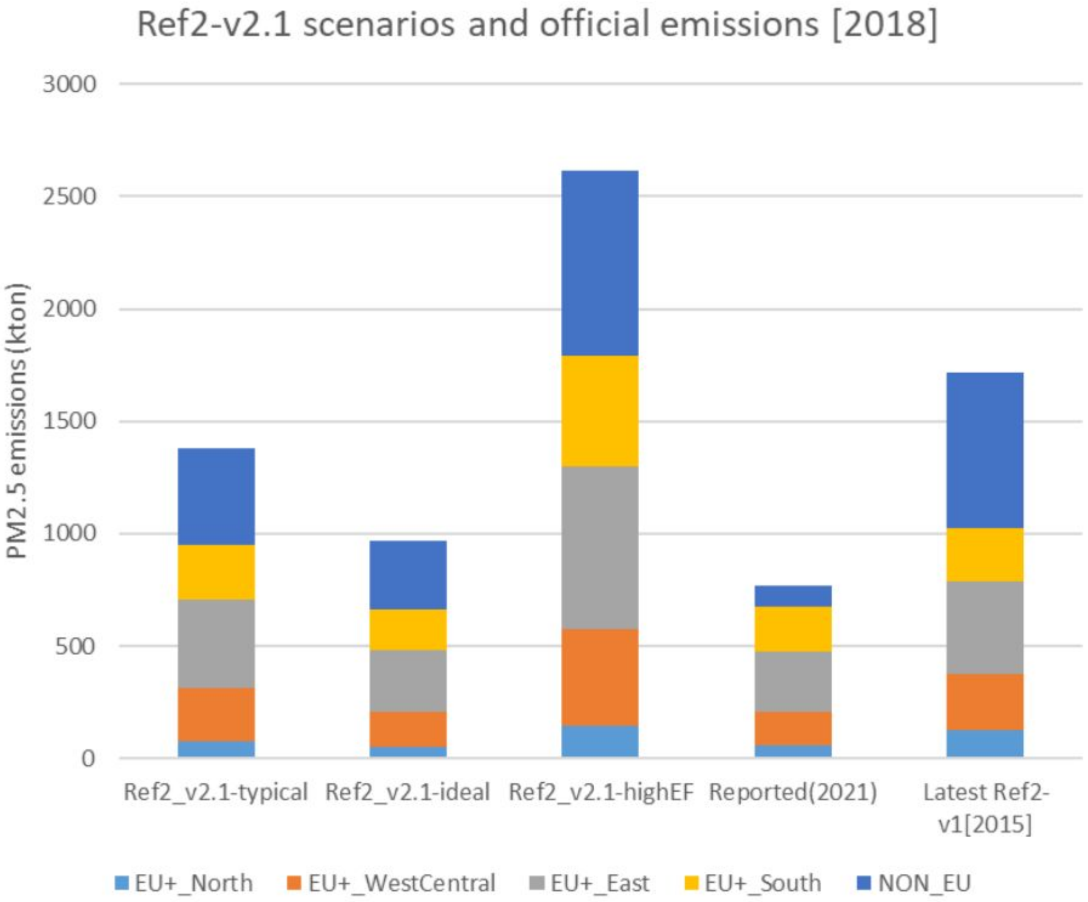
TNO Ref2_v2.1 scenarios

Full revision of Ref2 scenario produced, cooperation with IIASA.

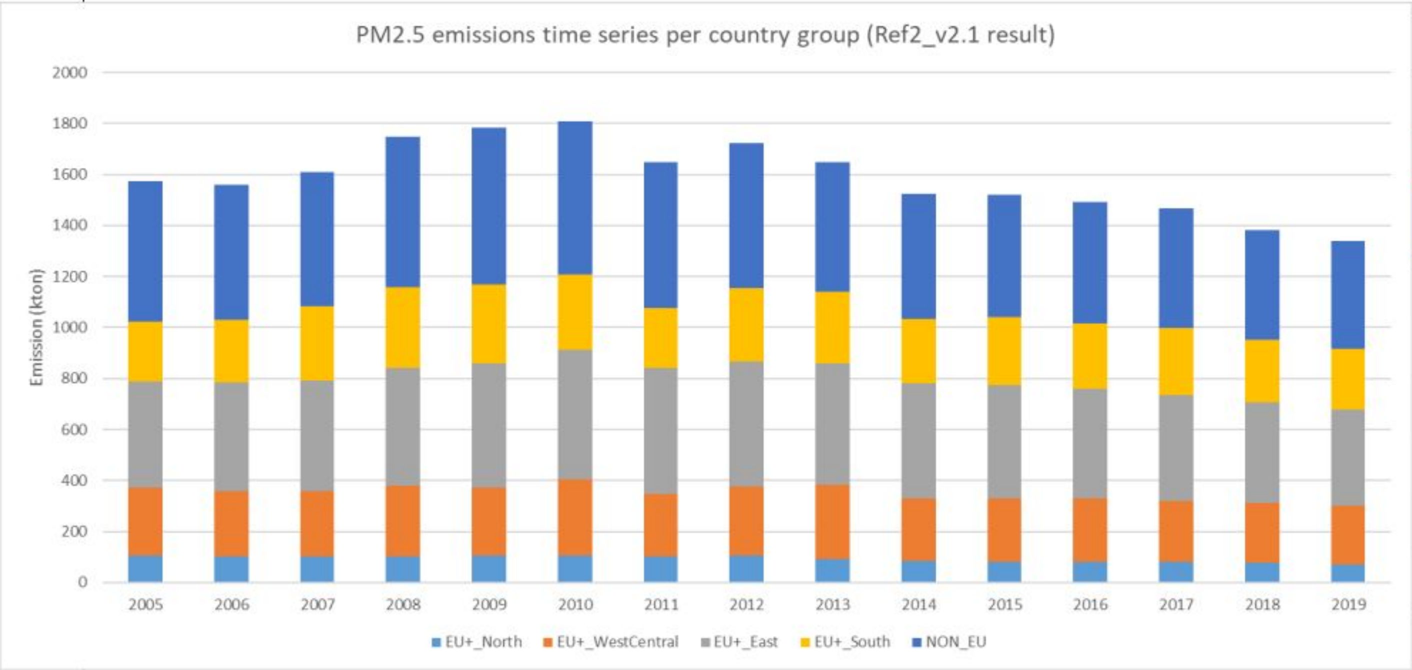
Revision included activity data and emission factors.

Three scenarios produced:

1. Ideal conditions (assuming good burning conditions, e.g. dry wood, full load).
2. Typical conditions (also allows for `bad’ combustion)
3. High emission factors



PRELIMINARY RESULTS
TYPICAL SCENARIO - TREND



Emission trend per year	2005-2019	2010-2019
EU+_North	-2.3%	-3.6%
EU+_WestCentral	-1.0%	-2.5%
EU+_East	-0.6%	-2.9%
EU+_South	0.1%	-2.1%
NON-EU	-1.7%	-3.3%
Average	**-1.1%**	**-2.9%**

Reported emission trend per year	2005-2019	2010-2019
EU+_North	-2.7%	-3.9%
EU+_WestCentral	-2.1%	-3.1%
EU+_East	-0.5%	-2.3%
EU+_South	0.2%	-1.8%
NON-EU		
Average	**-1.0%**	**-2.5%**

(based on submission 2021)

TNO innovation for life

Model configurations

- **EMEP:**
  - reported EMEP emissions
- **NVC:**
  - TNO GNFR C emissions (and Emep for other sectors) **‘Typical’,C=Central’**
- **NVH:**
  - TNO GNFR C emissions (and Emep for other sectors) H=**‘High’**

0.1x0.1 degree
Default SOA schemes
(PPM assumed inert)

- **NVC32:**
  - Similar to NVC, but 0.3x0.2 degree
- **SVC32:**
  - as NVC32, but semivolatile OA allowed to evaporate (uses 1-5D VBS)
- **SIVC32:**
  - as SVC32, but with added intermediate volatility compounds (IVOC is assumed to be 4.75 * mass of POA, following Ciarelli)

0.3x0.2 degree
PPM assumed inert, semivolatile and semivolatile with added IVOC

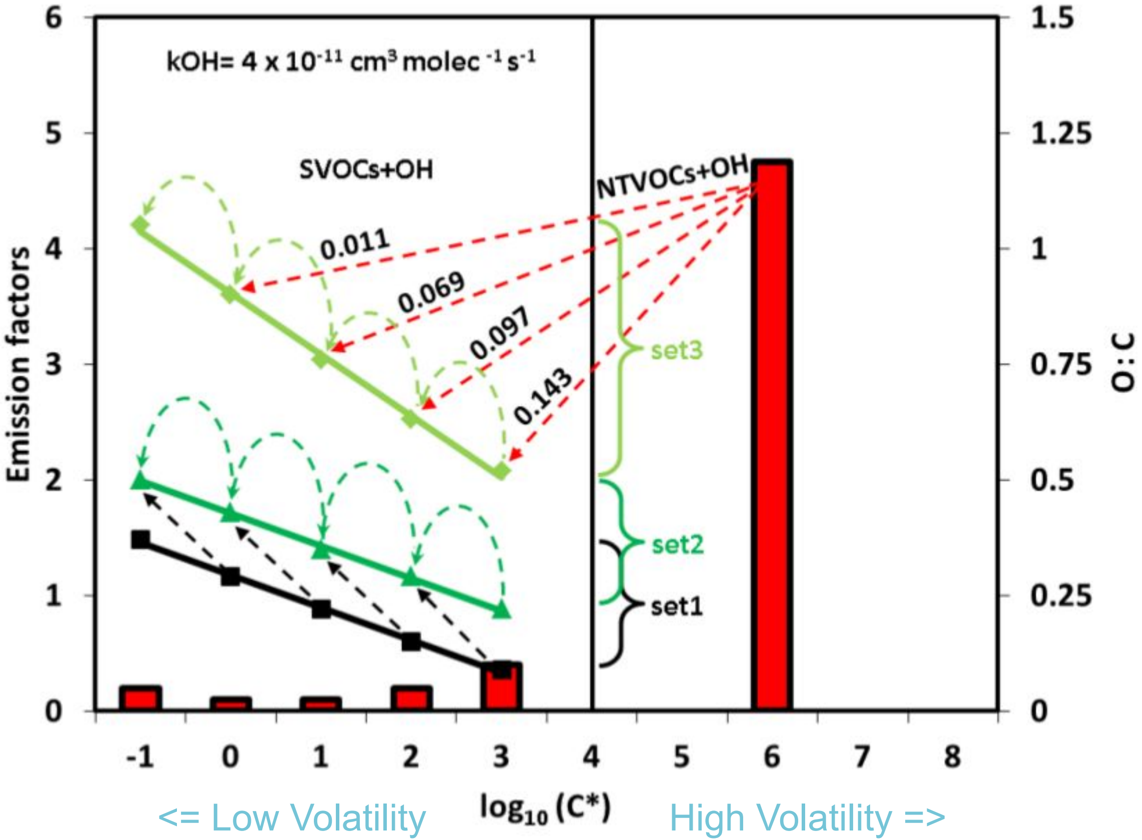
VBS system

RWC emissions implemented with volatility basis set (VBS) approach

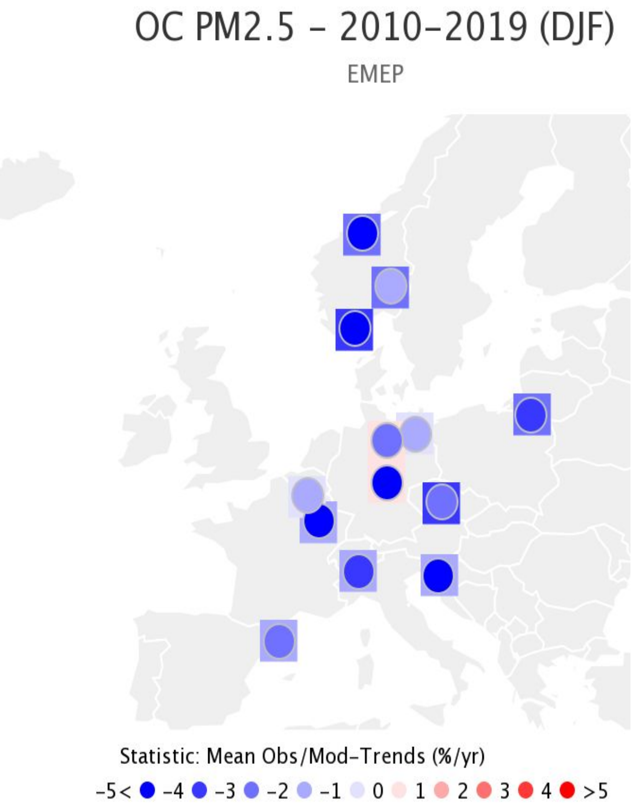
“1.5D” VBS used for RWC emissions - from Ciarelli et al., GMD, 2017

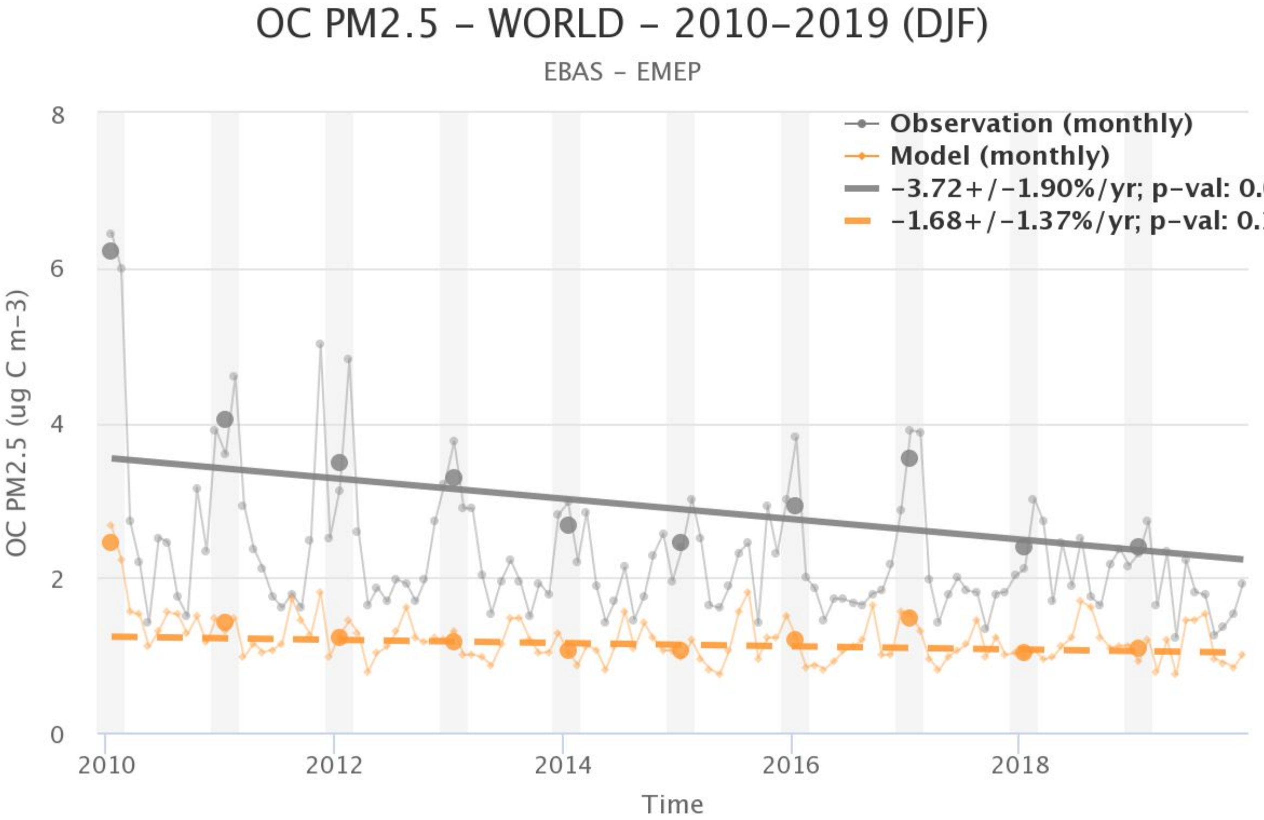
NV and SV runs use low and semi-volatile compounds - to match TNO emissions ($\log_{10}(C^*)$ <= 3)

SIVOC has “assumed” extra IVOC source (~4.75xPMf by mass) - following Ciarelli et al. (PSI approach)

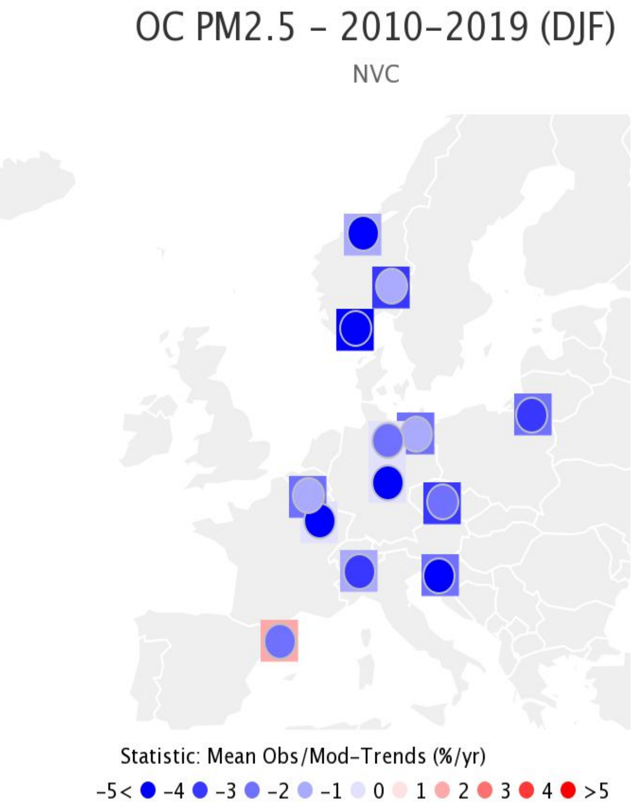


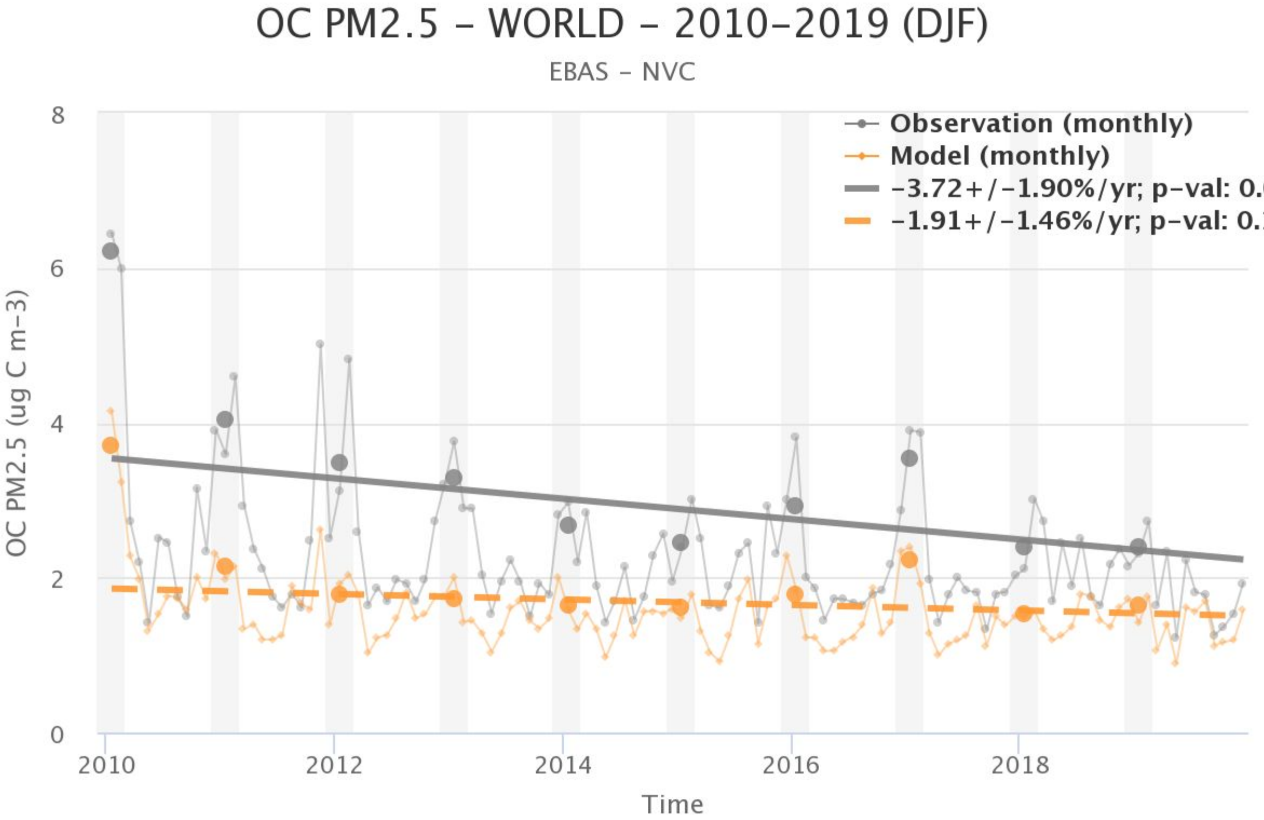
OC trends (DJF) 2000-2019 using **reported emission data**



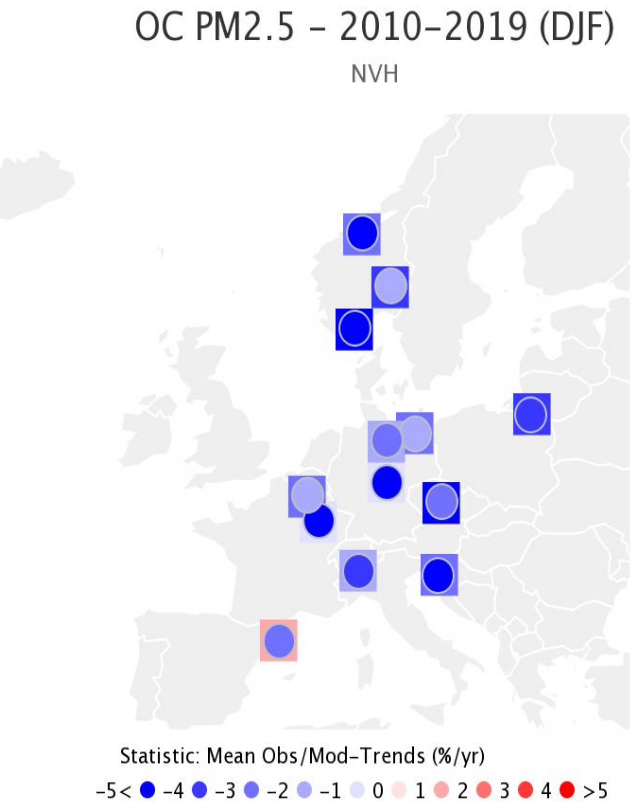


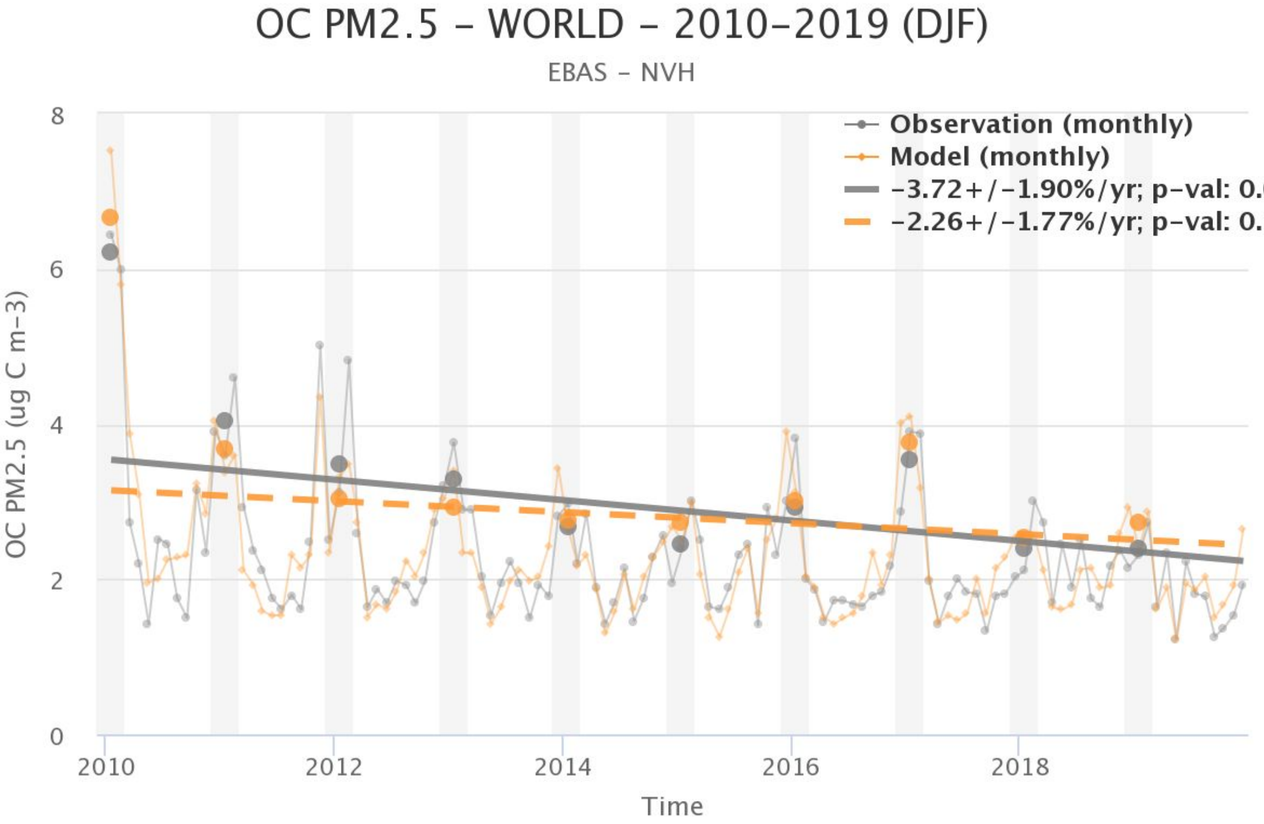
OC trends (DJF) 2000-2019 using **TNO ‘typical’ emission data** (NVC)



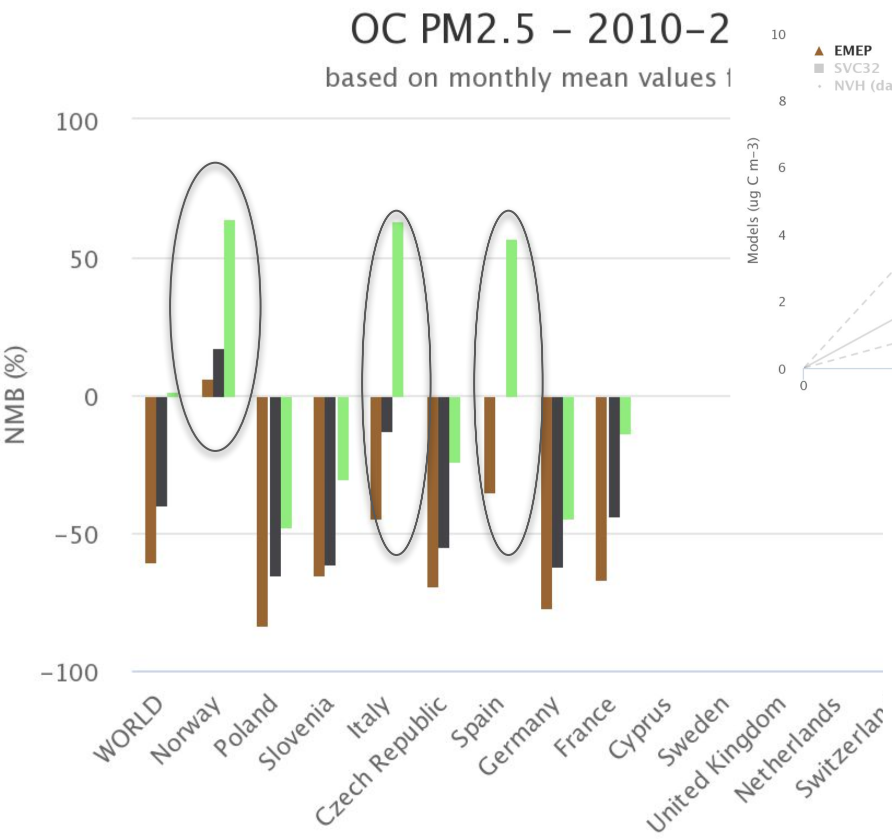


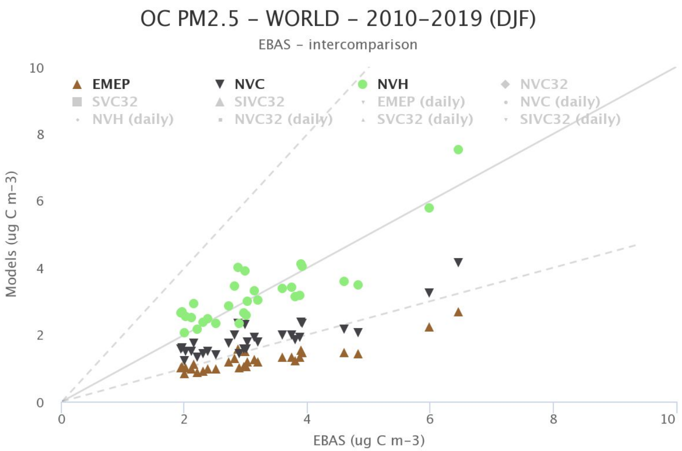
OC trends (DJF) 2000-2019 using **TNO 'high EF' emission data** (NVH)

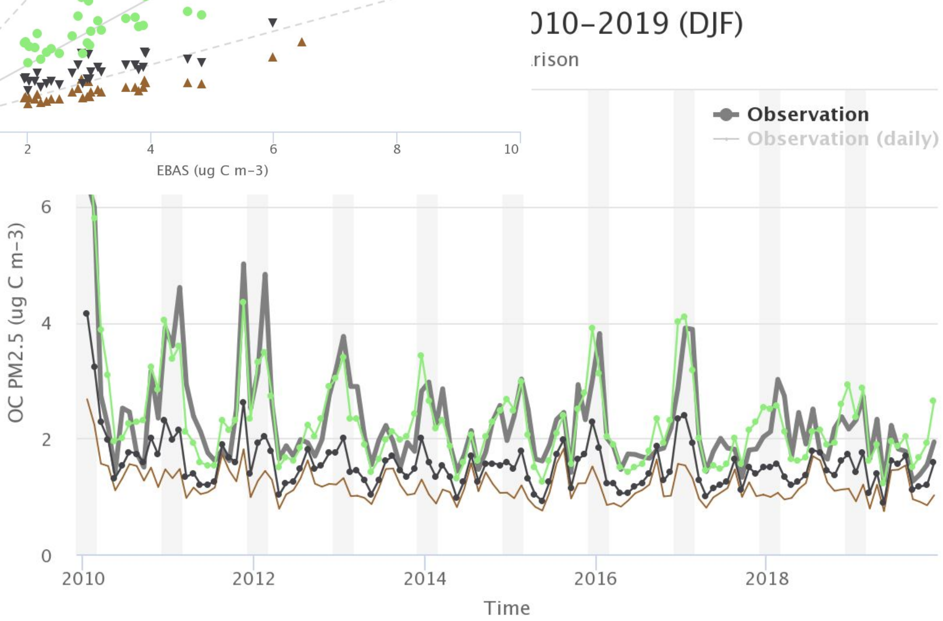




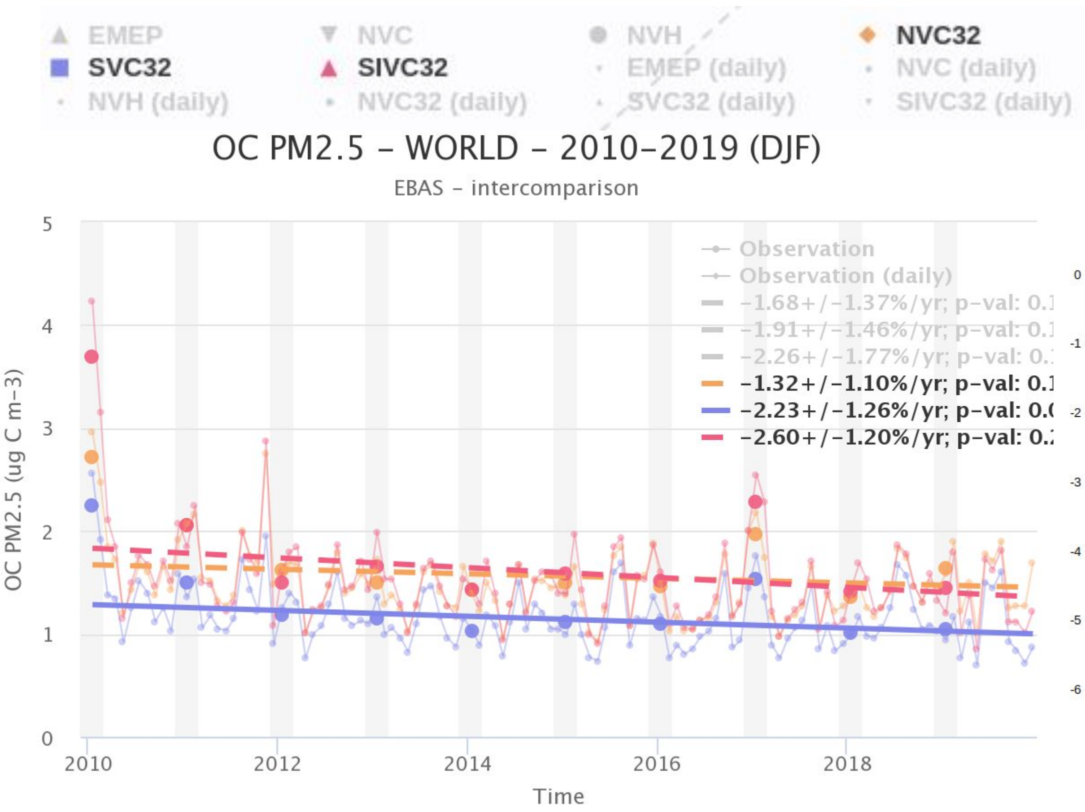
OC trends (DJF) 2000-2019, NVC vs NVH (high EFs)



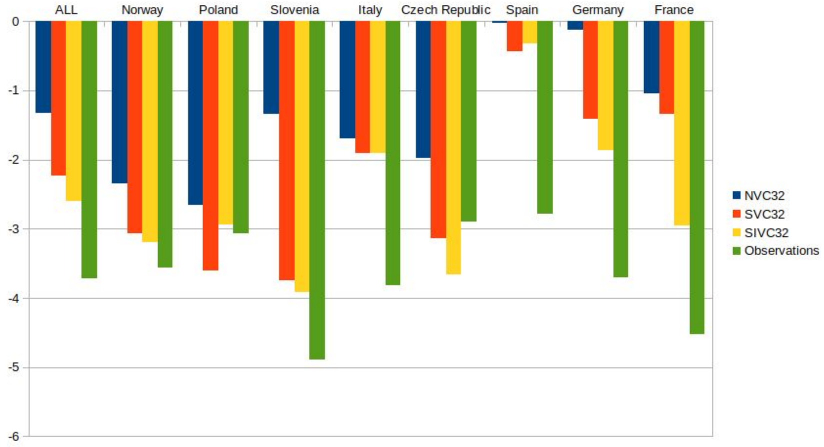




Are trends affected by the assumed volatility of condensables and added IVOC?



The SVC (+IVOC) scenarios tend to show the largest negative trends, with better comparison to observed trends.



Trends (%/year) DJF

Is the model configuration important for SR?

- EMEP model runs have been performed for some selected source-receptor estimates (0.3x0.2 degree) both assuming **PPM to be inert** and **using various schemes in the model which allows condensables to evaporate, age and condense, and where possible IVOC emissions have also been considered.**
- All emission scenarios using TNO GNFR C ‘typical’ emissions for RWC

Repetition:

NVC: non-volatile = inert PPM

SVC: semivolatile OA allowed to evaporate (uses 1-5D VBS)

SIVC: as SVC, but adding IVOC

TABLE: Source-receptor relationships derived from different base-cases, for 30% reductions in PMf from Italy. Year: 2016. The yellow line indicates the impact of Italy on itself.

Receiver	Conc. PM_f ($\mu g\ m^{-3}$, Emep base)	ΔPM/ΔEmis(IT)			
		Emep	NVC	SVC	SIVC
AT	6.51	0.018	0.021	0.020	0.077
ATL	3.48	0.000	0.000	0.000	0.002
BG	8.55	0.003	0.004	0.004	0.020
CH	5.66	0.034	0.041	0.035	0.110
DE	8.89	0.003	0.003	0.003	0.017
FR	6.21	0.009	0.011	0.011	0.047
IT	9.87	0.755	0.924	0.683	1.089
MK	8.89	0.005	0.006	0.006	0.029
NL	11.75	0.001	0.001	0.001	0.007
PL	8.74	0.001	0.002	0.002	0.011
RO	9.13	0.003	0.004	0.005	0.023
SI	9.84	0.076	0.091	0.085	0.236

NOTE: ALL RESULTS ARE PROVISIONAL!

Summary & Conclusions (PRELIMINARY)

- New emission data from TNO cover 2005-2019 with consistent inclusion of condensable organics
- Including condensables (consistently) gives results (trends and bias) in better agreement with observations for OC and $PM_{2.5}$
- Although the ‘high’ scenario agree best with observations overall it is clearly too high for some/many(?) countries, e.g. Norway, Italy, Spain
- The model setup (e.g. VBS and inclusion of IVOC) matters for trends and SRs. The higher emission (+IVOC) scenarios tend to show the largest negative trends, with better comparison to observed trends.
- Assumption about volatility seems to be important for e.g. country-to-itself contribution. In the few cases investigated so far, assuming inert PPM or VBS+IVOC gives relatively similar results for SR (conflicting trends in that case…)

Some caveats

- 10 years of observational data is not much for trends…
- The NMR-RWC study deals only with RWC, and mainly with SVOC. The amount of IVOC that should be used is very uncertain.
- Other source sectors likely have IVOC that isn’t in the PM or VOC inventory, so we should expect our models to underestimate OM to a certain degree. Again, the amounts involved are very uncertain.

Summary & Conclusions cont. (PRELIMINARY)

Confused? ….

Is it all too difficult? Can we not say which approach is best? Consider an environmental lawyer's comment:

"I don't care if it is right, as long as it is fair" §

Still:

- Use of consistent condensables is the only way to give fair source-receptor relationships.
- Continued evaluation against observations will give clues (ongoing work!), but no simple answers

§Vaguely remembered 1990s anecdote from a US chemist who regularly had to comment on air quality models in USA courts.

Thank you for listening

Funded by UNECE/EMEP & the Nordic Council of Ministers (Revising historical $PM_{2.5}$ emissions from RWC to consistently include condensable organics and assess the implications for the Gothenburg Protocol)

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