Norwegian Meteorological Institute

Impact of Condensable Organics on PM2.5 calculations 2005-2019; preliminary(!) results from the NMR-RWC project

David Simpson, **Jeroen Kuenen, Hugo Denier van der Gon, Antoon Visschedijk, Hilde Fagerli, Zig Klimont, Ville-Veikko Paunu & Karl Espen Yttri**

TFIAM Apr 6th 2022

Intro

- 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
  - Include fraction of biofuels
  - 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 parametrize ‘the volatility effect’ in GAINS?

Model setup

Runs:

- Emep - uses standard EMEP emissions, assumed split into EC, OA and remPPM (from CAMS), and default SOA schemes

- NV - uses TNO GNFR C emissions (and Emep for other sectors)
- SV - as NV, but semivolatile OA allowed to evaporate (uses 1-5D VBS)
- SIV - as SV, but with added intermediate volatility compounds

- Also NV2, NV3,...SIV3 - using TNO low and high emissions scenarios 2 and 3

- EMEP 0.3x0.2 degree runs for 2016 evaluation, 50km runs for trends

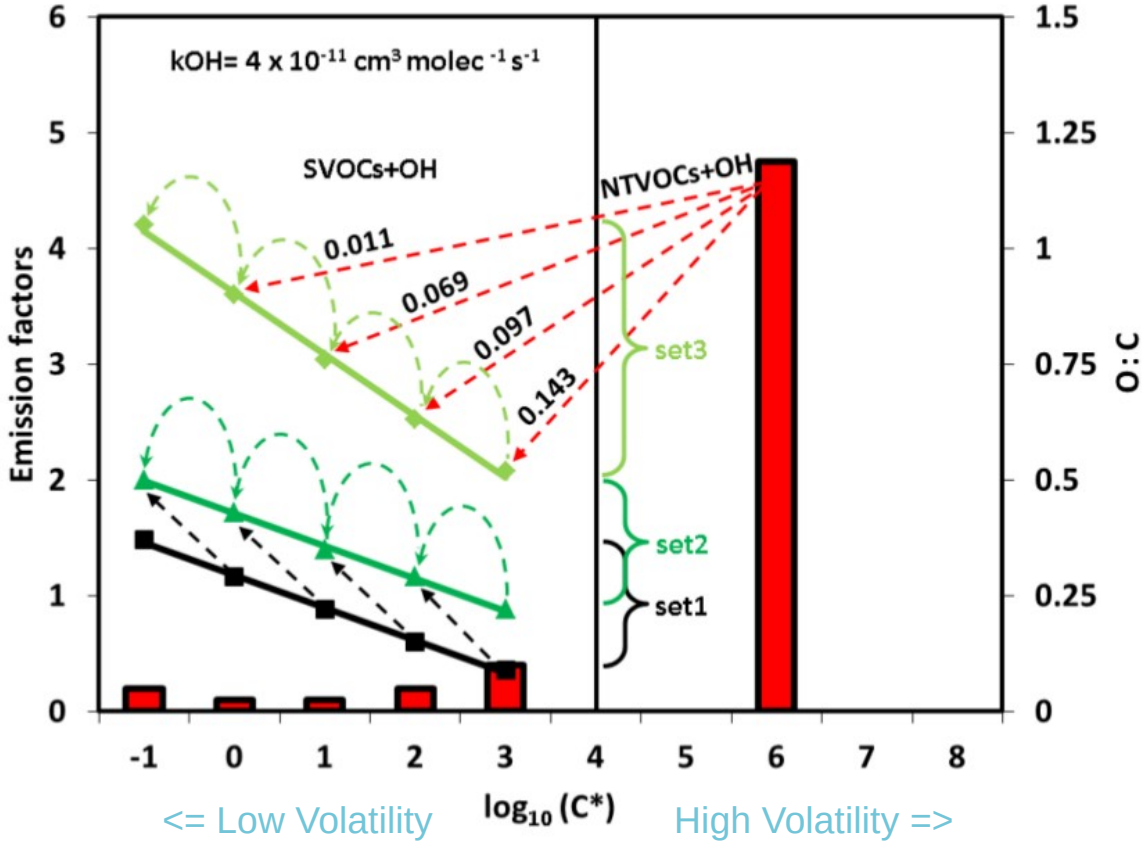
VBS system

RWC emissions implemented with volatility basis set (VBS) approach

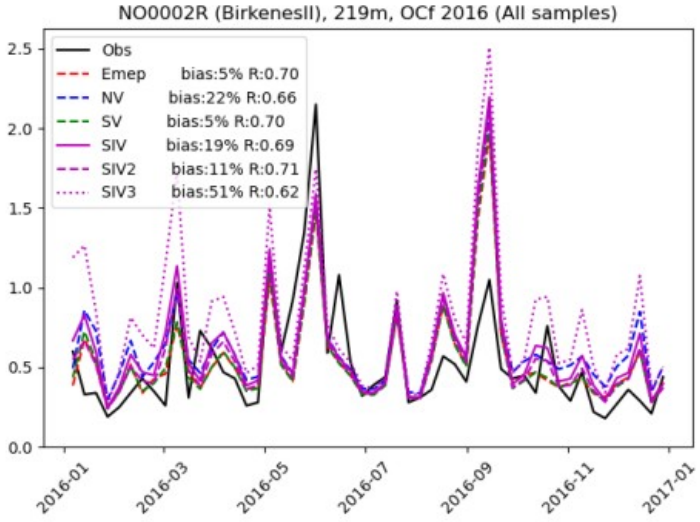
“1.5D” VBS used for RWC emissions - from Ciarelli et al., GMD, 2017

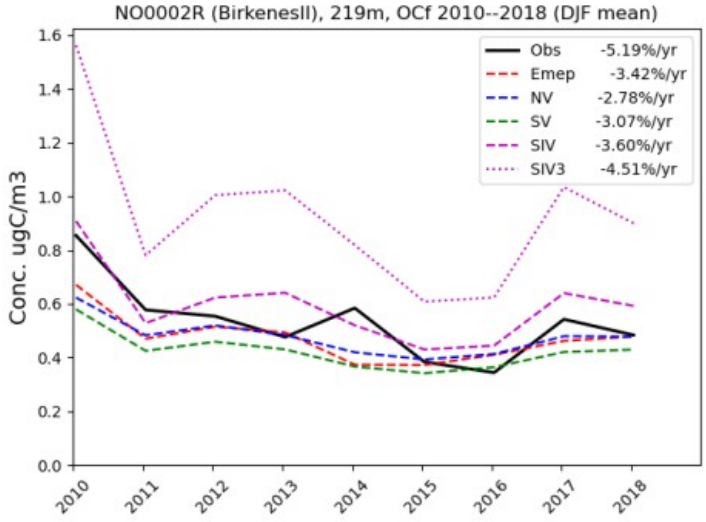
NV and SV runs use low and semi-volatile compounds - to match TNO emissions (log_{10}(C*) <= 3)

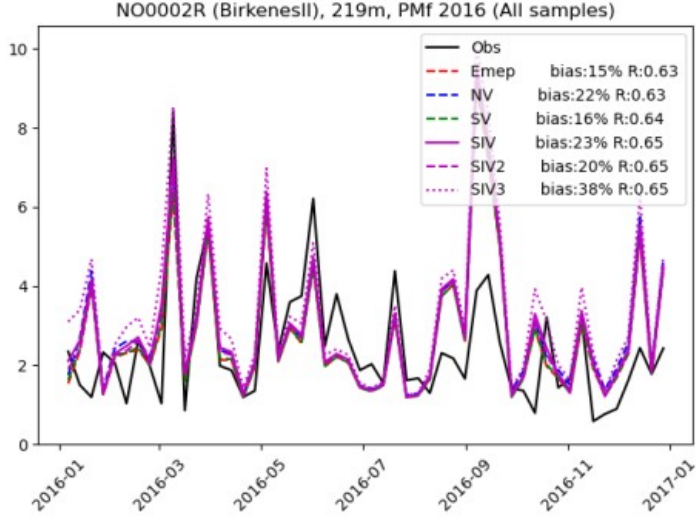
SIVOC has “assumed” extra IVOC source (~4xPMf) - following Ciarelli et al.

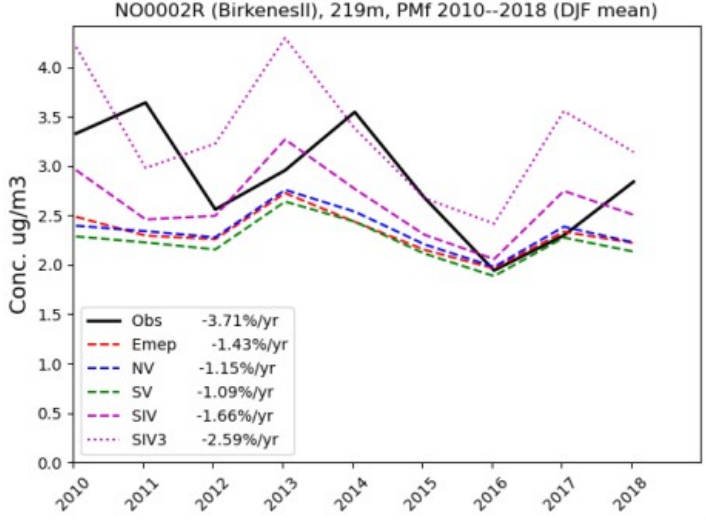


Preliminary results, evaluation and trends


NO0002R (Birkenesll), 219m, OCf 2016 (All samples)
Obs
Emep bias:5% R:0.70
NV bias:22% R:0.66
SV bias:5% R:0.70
SIV bias:19% R:0.69
SIV2 bias:11% R:0.71
SIV3 bias:51% R:0.62
2.5
2.0
1.5
1.0
0.5
0.0
2016-01
2016-03
2016-05
2016-07
2016-09
2016-11
2017-01


NO0002R (Birkenesll), 219m, OCf 2010--2018 (DJF mean)
Obs -5.19%/yr
Emep -3.42%/yr
NV -2.78%/yr
SV -3.07%/yr
SIV -3.60%/yr
SIV3 -4.51%/yr
Conc. ugC/m3
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2010
2011
2012
2013
2014
2015
2016
2017
2018


NO0002R (Birkenesll), 219m, PMf 2016 (All samples)
Obs
Emep bias:15% R:0.63
NV bias:22% R:0.63
SV bias:16% R:0.64
SIV bias:23% R:0.65
SIV2 bias:20% R:0.65
SIV3 bias:38% R:0.65
10
8
6
4
2
0
2016-01
2016-03
2016-05
2016-07
2016-09
2016-11
2017-01


NO0002R (Birkenesll), 219m, PMf 2010--2018 (DJF mean)
Obs -3.71%/yr
Emep -1.43%/yr
NV -1.15%/yr
SV -1.09%/yr
SIV -1.66%/yr
SIV3 -2.59%/yr
Conc. ug/m3
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2010
2011
2012
2013
2014
2015
2016
2017
2018

Results, 2016 evaluation (so far):

- Results are complex!
- In terms of bias, the different model cases show large differences, and sometimes span both negative and positive values.
- It is not easy to identify a `best' case; the setup which works best varies from site to site.
- The non-volatile NV assumption is often pretty good anyway. Phew..... ;-)
- Remember, there are many reasons why models and observations differ. This is especially true for organic aerosol.
- Suggest need for more constraints - e.g. multiple years, compare with ECBff & ECBbb from 2018/2018 campaign, COLOSSAL, etc.
- To be continued

Results, trends (so far)

- Results are complex!
- The observed downwards trends tend to be stronger than modelled trends
- This discrepancy is also seen in PM_f though, and as PM_f is usually far greater than EC+OC, trends in other pollutants would also seem to be problematic.
- Results for levoglucosan at Birkenes (not shown) are rather good, with DJF trends of -7.9%/yr from observations, and -5.3%/yr from the model. (The large values are likely influenced by very high concentrations in 2010 on both model and obs.)
- It does matter which model setup is used, e.g. from 0.25%/yr to 1.45%/yr for the TNO-based simulations. The higher emission (+IVOC) scenarios tend to show the largest negative trends.
- To be continued

Source-receptor? (Preliminary!)

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

Receiver	Conc. PM_f ($\mu g\ m^{-3}$, Emep base)	$\Delta PM/\Delta Emis(DE)$				
		Emep	NV	SV	SIV	SIV3
AT	6.51	0.031	0.036	0.034	0.051	0.078
BG	8.55	0.002	0.002	0.002	0.007	0.012
CH	5.66	0.038	0.042	0.038	0.054	0.081
DE	8.89	0.293	0.375	0.312	0.343	0.464
FR	6.21	0.019	0.022	0.020	0.030	0.045
IT	9.87	0.002	0.003	0.003	0.008	0.014
MK	8.89	0.001	0.002	0.002	0.005	0.009
NL	11.75	0.103	0.134	0.118	0.133	0.178
PL	8.74	0.022	0.028	0.027	0.039	0.059
RO	9.13	0.003	0.003	0.004	0.009	0.016
SI	9.84	0.008	0.009	0.010	0.022	0.037

NOTE: ALL RESULTS ARE PROVISIONAL!

Summary & Conclusions (PRELIMINARY!)

- New emission data from TNO cover 2005-2019 with consistent inclusion of condensable organics
- EMEP model runs have been performed for trend calculations, and some selected source-receptor estimates (0.3x0.2 degree) both assuming **POA to be inert** and **using various schemes in the model which allows CPOAs to evaporate, age and condense, and where possible IVOC emissions have also been considered.**
- Assumptions about volatility seems to be important for the results (e.g. the country to itself contribution etc). Consistency between assumed volatility inherent in emission factors and used in the VBS scheme investigated as well as other assumptions
- At the same time investigating how to include/parametrize this in GAINS (in the emission-concentration response functions)
- Uncertainties in emission/modelling unavoidable

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's right, as long as it's fair"*[§]

Still:

- Continued evaluation against observations will give clues, but no simple answers
- use of consistent condensables is the only way to give fair source-receptor relationships.

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

Next steps

- Re-run with April 5th version of TNO emissions!
- Use finer-scale (0.1 degree) EMEP model for selected scenarios
- Compare with EIMP 2017/2018 campaign EBCff, EBCbb concentrations
- Compare with other data (COLOSSAL, ACTRIS, other levoglucosan)..
- Sensitivity tests with spatial distributions (via NordicWelfair emissions)
- Test other POA/SOA schemes

NMR report is due to be delivered to TemaNord mid-May, published June, but work will continue….

The end :-)