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EMEP NMVOC - model and observations

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EMEP MSC-W model: NMVOC

Recent developments:

- New species: EmChem19a chemistry has toluene, benzene as “pure” species.
- New NMVOC speciations added (2020):
 - Country specific profiles
 - Accounting for diesel, gasoline, LPG, non-exhaust
 - Data from TNO/CAMS databases (not national reporting)
 - Hopefully big improvement compared to earlier pan-European and old profiles

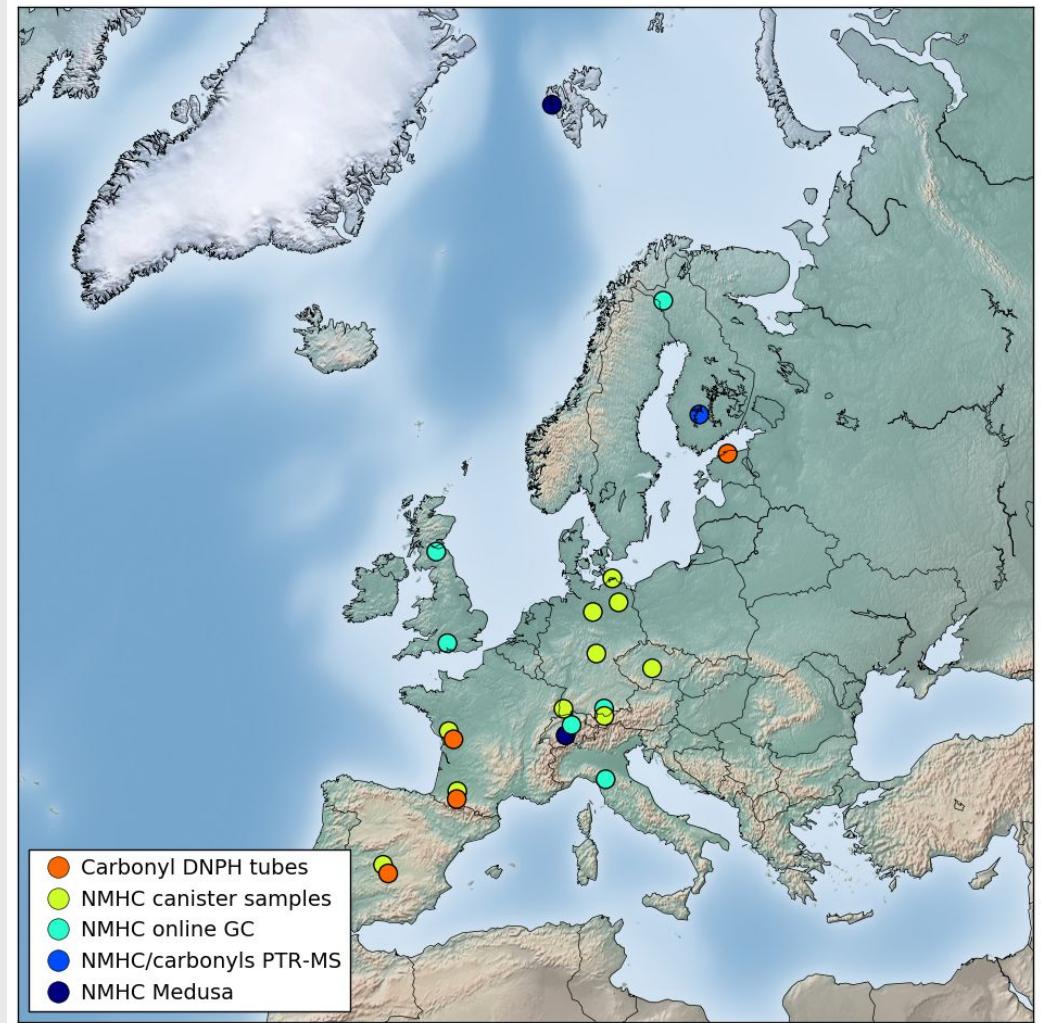
NMVOC measurements in EMEP

“Inhomogeneous” data:

- Different methods
- Different time resolution
 - Continuous, hourly
 - Canister samples (1-2 per week)
 - 4-h samples
- Changing network

But:

- ACTRIS project: Major improvement in QA/QC for NMVOC measurements



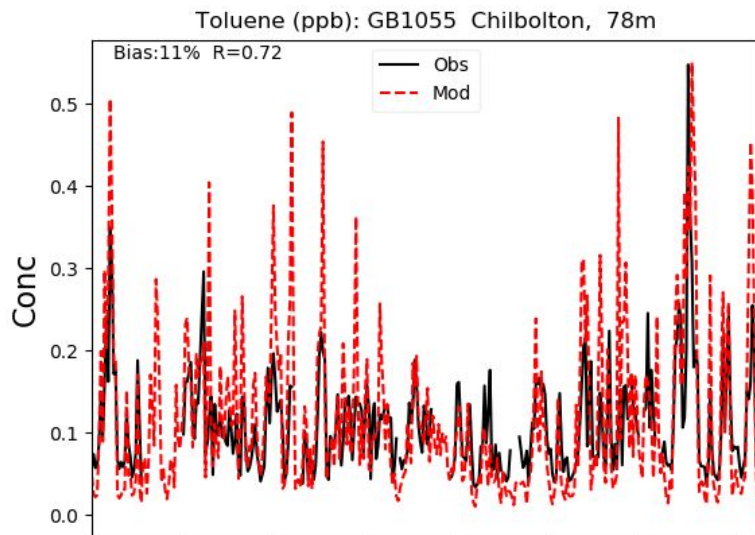
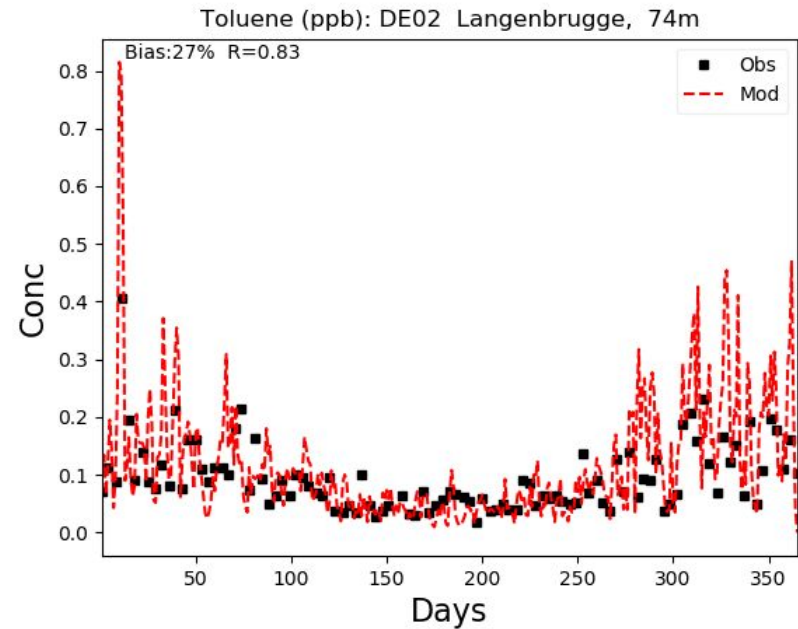
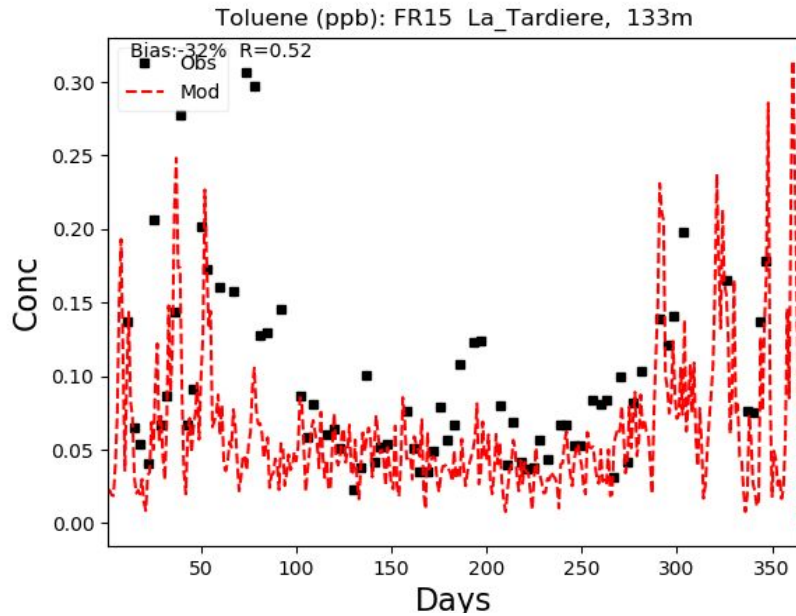
Status of monitoring of VOCs

- C2-C5 NMHC have been measured for several decades
- Very few sites measure OVOCs
- Methanol and terpenes reported for the first time in 2018

○

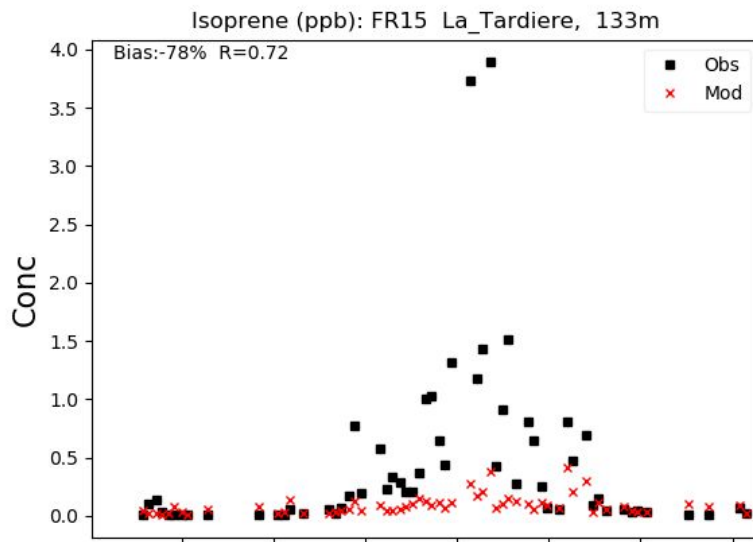
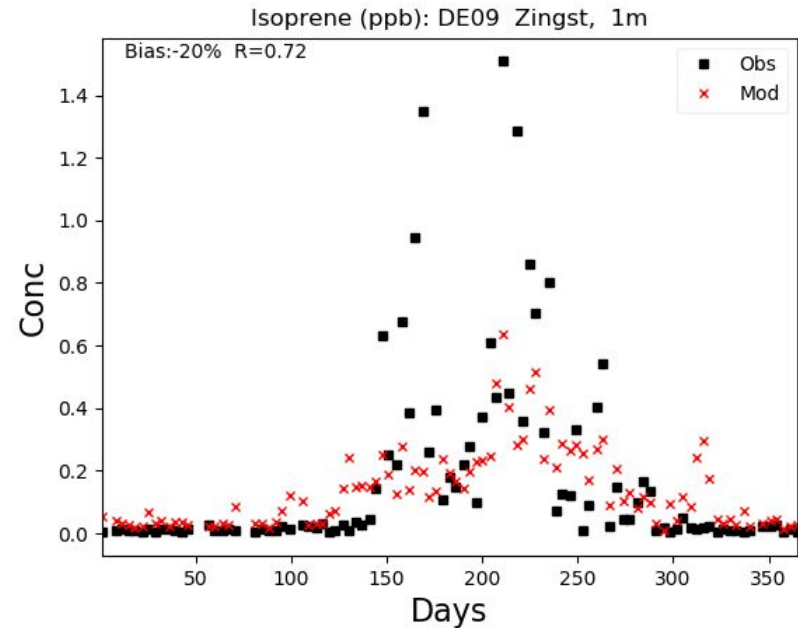
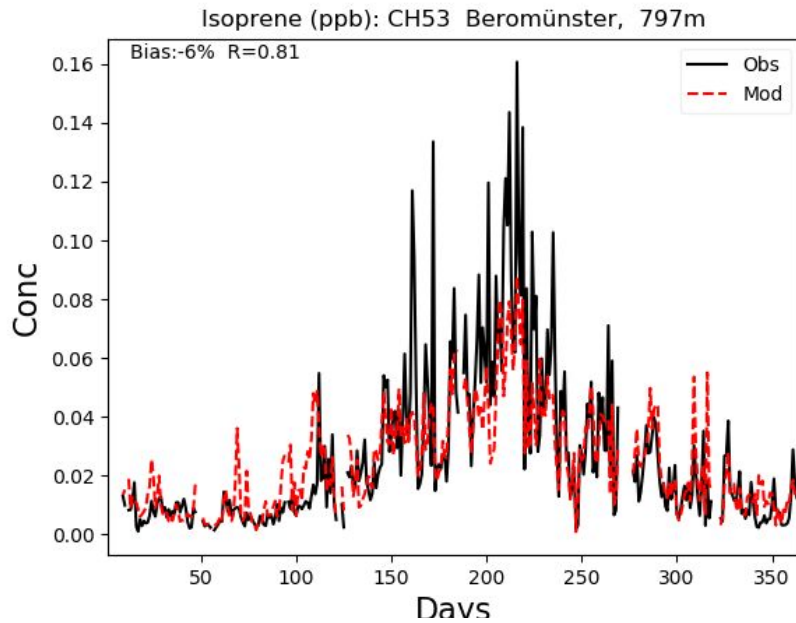
	EMEP required	EMEP desirable	Number of sites in 2018
Alkanes			
C ₂ -C ₅	X		19
C ₆ -C ₈		X	5-13
Alkenes			
C ₂ -C ₃	X		19
C ₄ -C ₅		X	3
Isoprene	X		12
Alkynes			
Acetylene	X		19
Styrene		X	0
Aromatics	X		17-19
Carbonyls			3 - 6
Other			
Monoterpenes	-	-	2
Acetonitrile	-	-	1
Methanol	-	-	2
DMS	-	-	0

Can we model toluene? (Prelim results, 2018!)



Yes, pretty well!

Can we model isoprene? (Prelim results, 2018!)



*Hmm, trickier!
(but no surprise)*

Issues with NMVOC comparisons

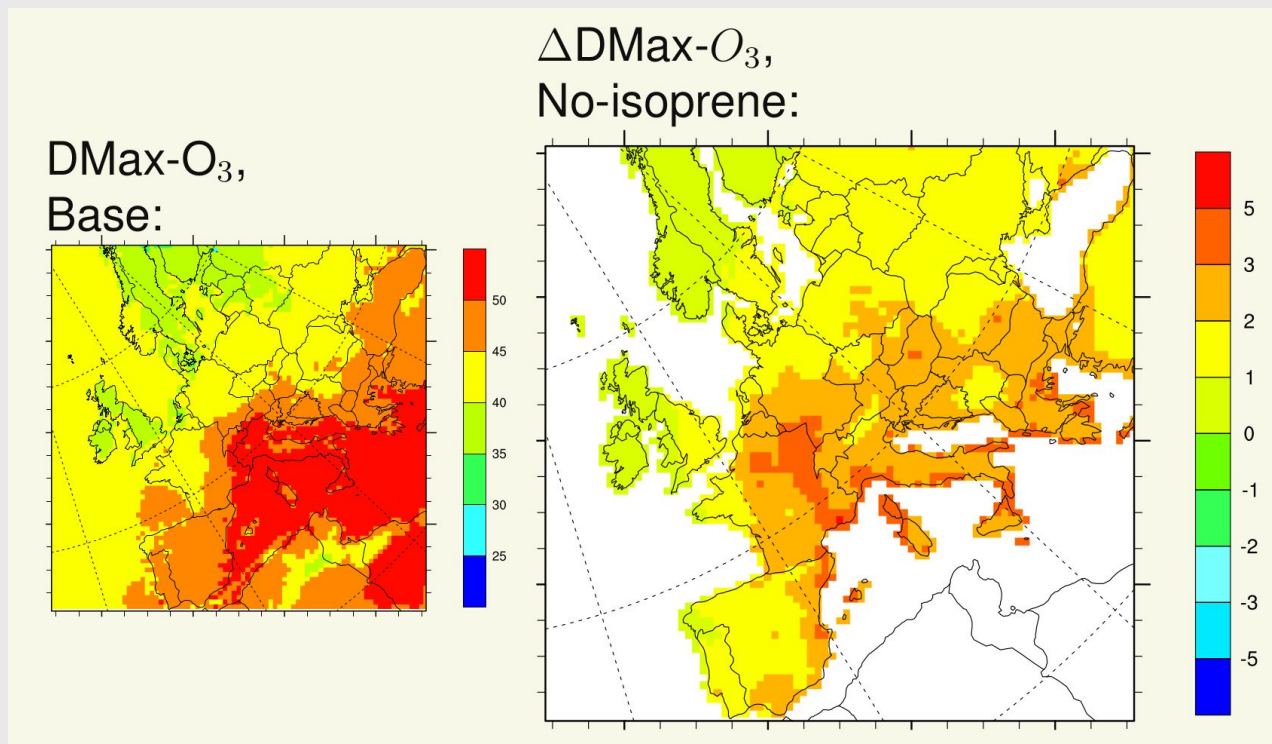
➤ Model issues:

- NMVOC speciation is coming from CAMS - unclear origin
- Some model species are surrogates, e.g. n-butane represents all heavier alkanes, and o-xylene represents many aromatics.
- Some species are “pure” and can be directly compared to observations - isoprene, toluene, benzene
- Biogenic emissions are very tricky - many super-emitters!

➤ Observation issues:

- Many sites are in mountains (e.g. $> 500\text{m}$) - creates difficulties when comparing to model
- Are data representative for grids? Many biogenic VOC have very short lifetimes and can come from those super-emitters!

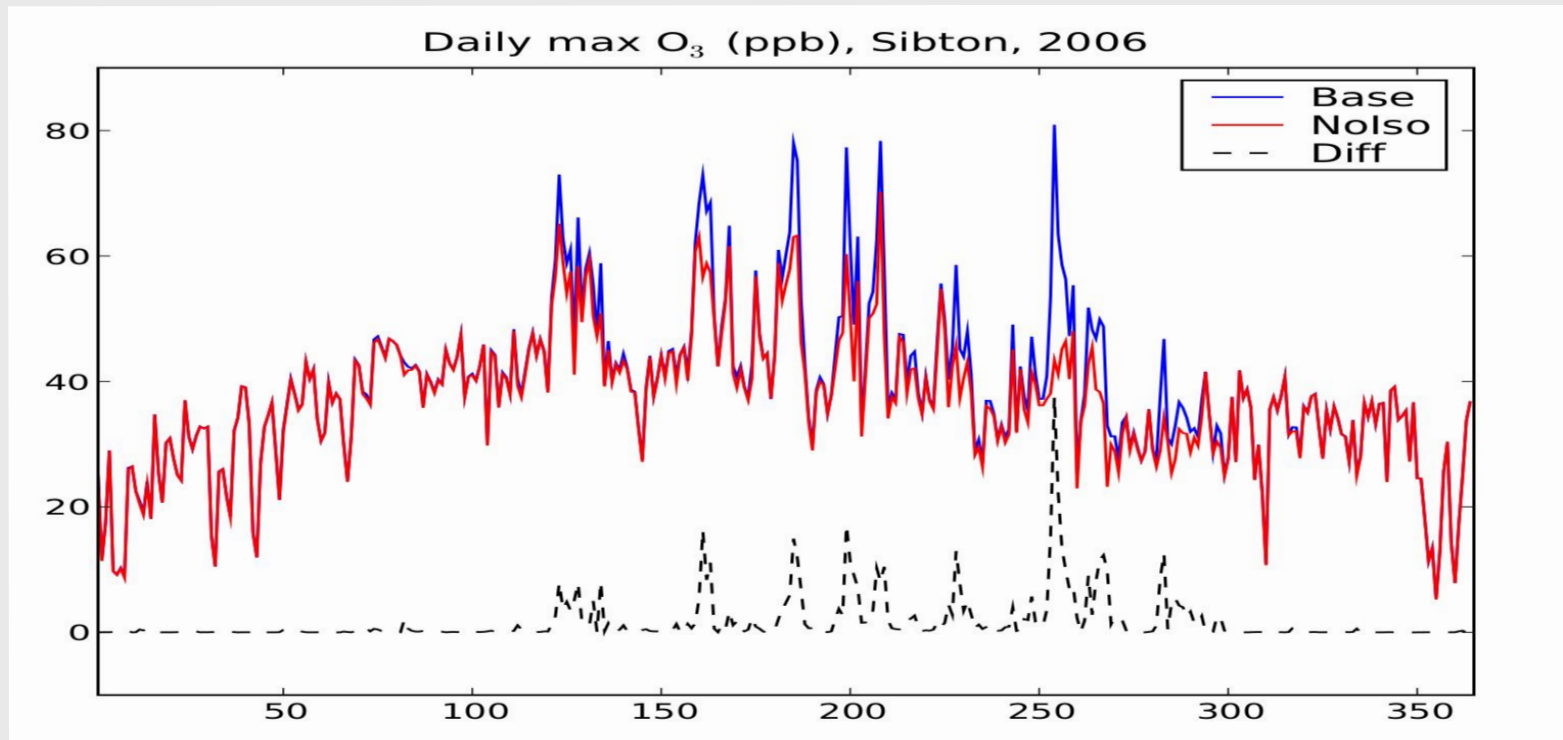
An aside: do BVOC matter?



- At first sight, not so much? Zero isoprene over Europe affected annual daily-max by $\sim 1-3$ ppb

EMEP model results (very old!)

Do BVOC matter? Yes!



- On particular days O₃ changes can be 10-40 ppb!
- Because ... VOC needs NO_x to make ozone. Only when BVOC passes over high NO_x regions do we get much O₃ production.

EMEP model results

Sources of BVOC: many, complex and uncertain!

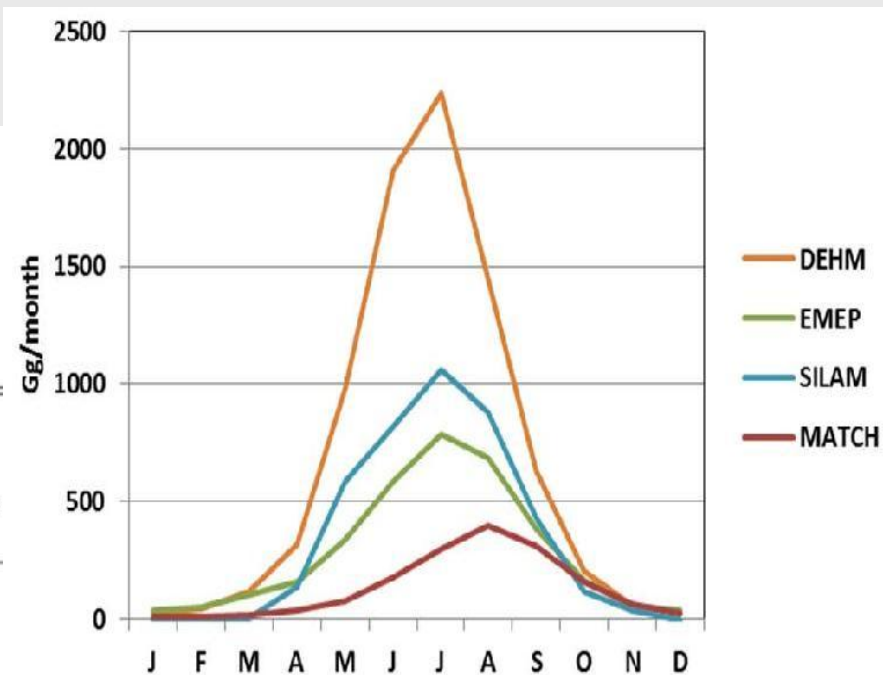
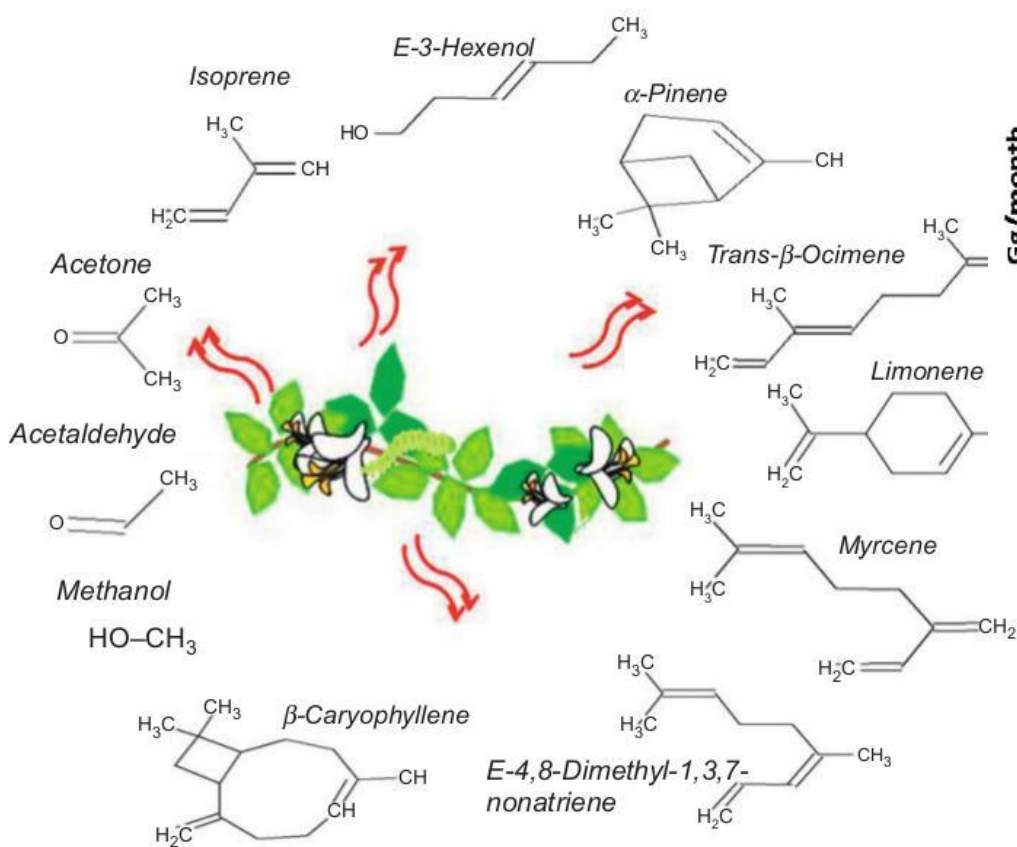


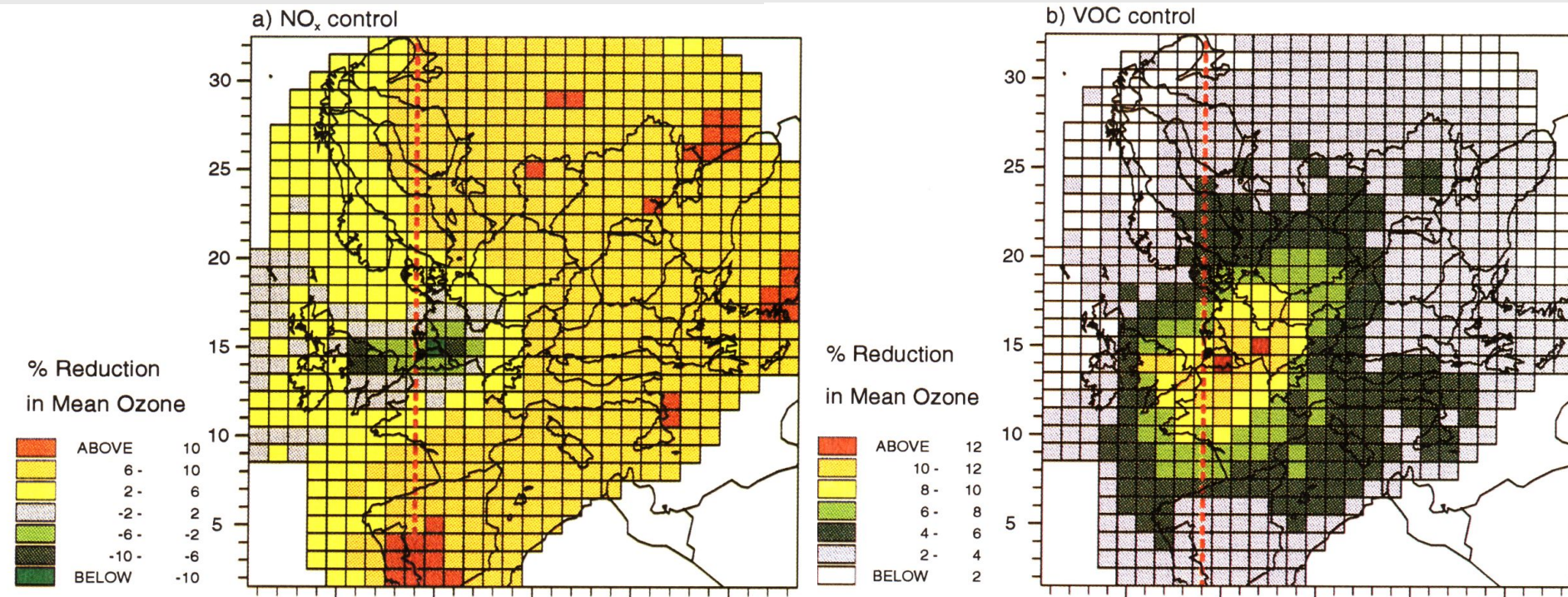
Fig: European isoprene emissions from four CTMs, Langner et al., ACP, 2012

NMVOC - final comments

1. A proper model-measurement comparison is long overdue
2. New VOC in EMEP model (e.g. toluene, benzene), and updated speciations, allow for more realistic testing
3. Information comes from TNO - need national evaluation?
4. Even surrogate species (e.g. n-butane) can be used to test overall ppbC levels
5. We can add “tracer” species to track other NMVOC if this is useful

The end... thank you!

Do AVOC matter? Yes! Contrast impacts of 50% emission control on NO_x and AVOC:

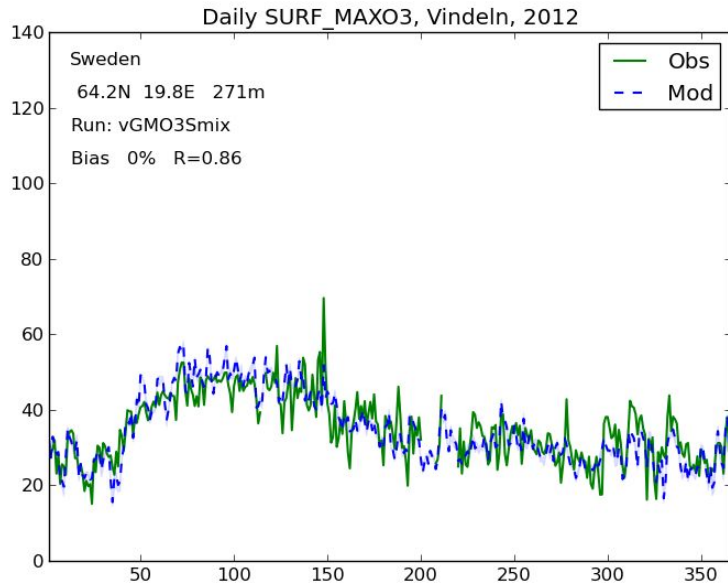


NOTE: different legends!

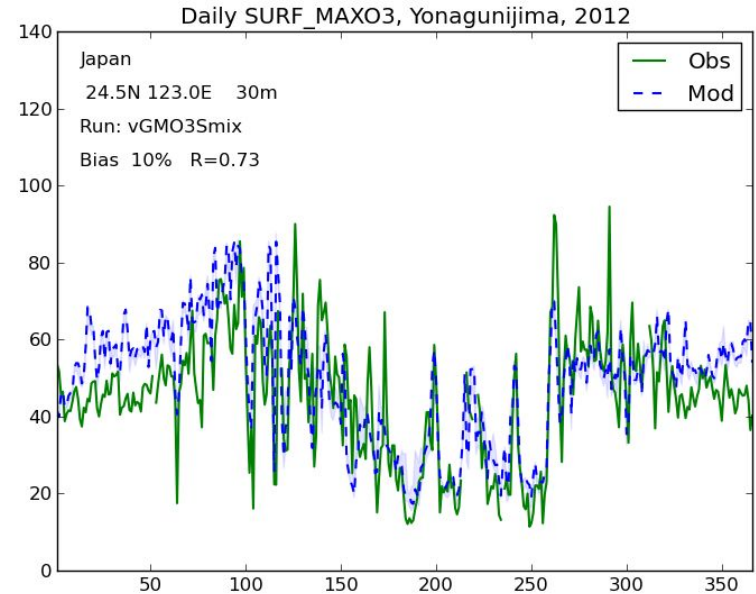
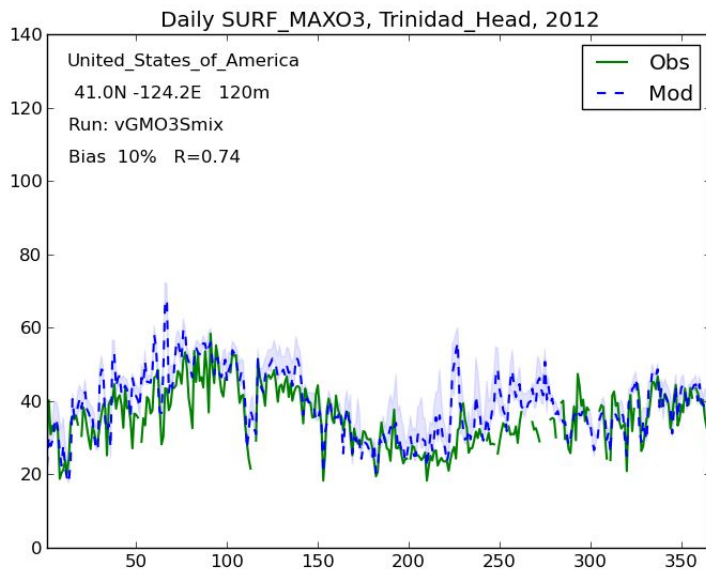
- As AVOC are usually located near NO_x sources, good ozone production conditions more likely than with BVOC. The higher the No_x, the more impact the AVOC!

Simpson, JGR, 1995 EMEP model results

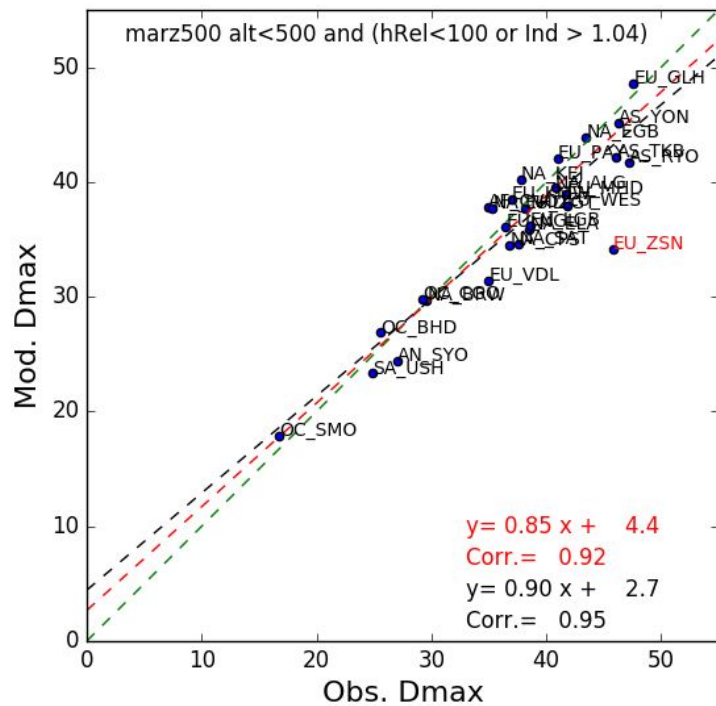
Can we model Ozone? Examples, EMEP model



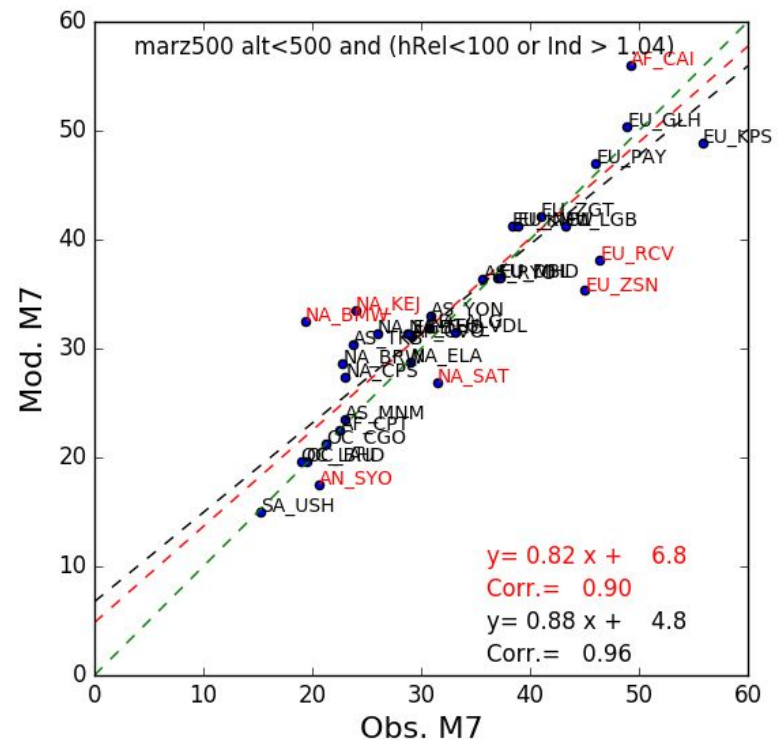
- Daily max O3 (ppb) vs GAW data



EMEP 3-D CTM performance – global (GAW)



- Daily max O₃, M7, 2012
- (From Mills et al 2018, SI)



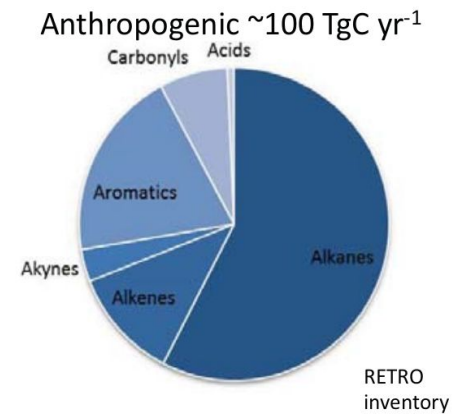
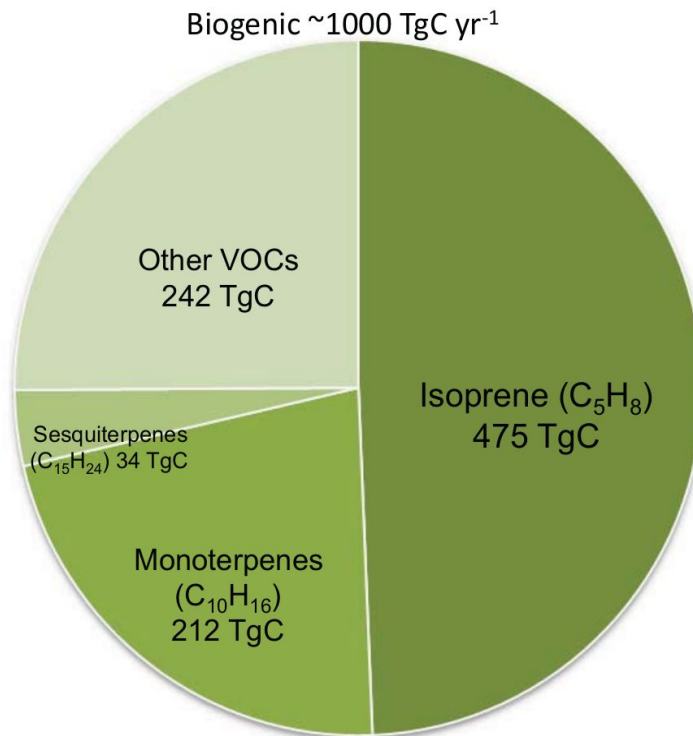
Lifetimes of VOC

	Lifetime due to:			
	OH	O ₃	NO ₃	<i>hν</i>
n-butane	5.7 days	-	2.8 yr	
propene	6.6 h	1.6 days	4.9 days	
toluene	2.4 days	-	1.9 yr	
HCHO	1.5 days	-	80 days	4 h
C ₅ H ₈	1.7 h	1.3 days	0.8 h	
α-pinene	3.4 h	4.6 h	2.0 h	
β-pinene	2.3 h	1.1 days	4.9 h	
d-limonene	1.1 h	1.9 days	53 min	
terpinolene	49 mins	17 min	7 min	
β-caryophyllene	56 min	1.8 min	5.4 min	

Notes: most values from Seinfeld & Pandis (1998), assuming OH of 1.5e(6) molecules cm⁻³, 30 ppb O₃, 1 ppt NO₃. β-caryophyllene estimated for same settings.

Sources of VOC

Global non-methane VOC emissions



Biomass Burning
 $\sim 500 \text{ Tg yr}^{-1}$
Yokelson et al., *ACP* 8:3509 (2008)

MEGAN 2.1, Year 2000
Guenther et al., *GMDD* 5:1503, 2012