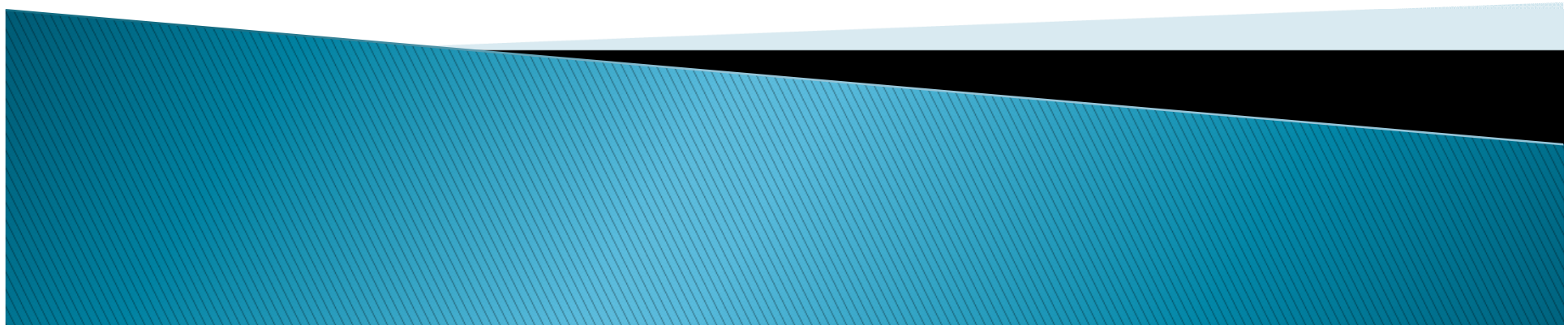


Atmospheric transport model applied to understand the effect of biogenic emissions to secondary atmospheric aerosol in hemiboreal zone

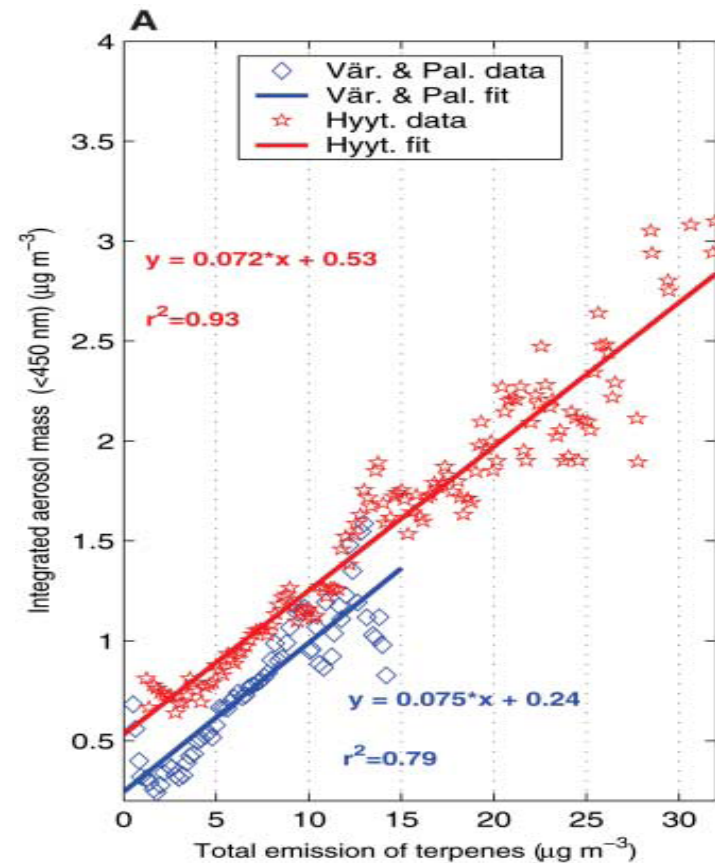
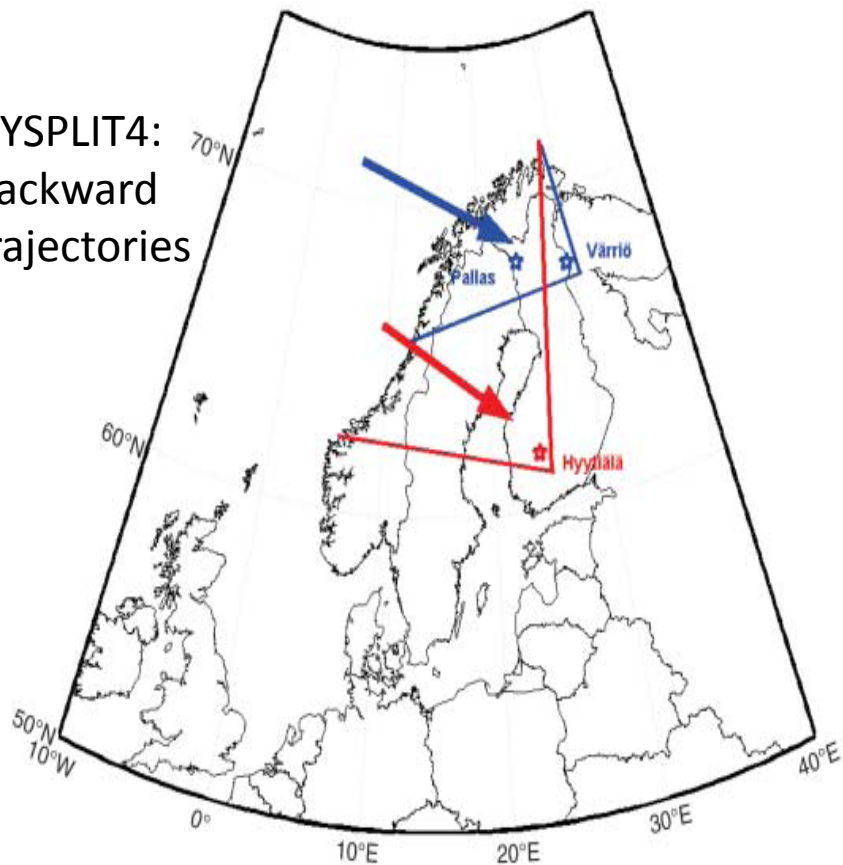
Ardi Loot, Riinu Ots, Marko Kaasik, Hilja Iher
University of Tartu




“Inspired” by:

P. Tunved, H.-C. Hansson, V.-M. Kerminen, J. Ström, M. Dal Maso, H. Lihavainen, Y. Viisanen, P. P. Aalto, M. Komppula, M. Kulmala (2006) High natural aerosol loading over boreal forests, Science 312, 261, DOI: 10.11/science.1123052

HYSPLIT4:
backward
trajectories



Goals

- ▶ To clarify the possible contribution of hemiboreal forest VOC(isoprene, monoterpene) emissions to the aerosol formation
 - ▶ To test the performance of air quality model SILAM in respect to emission and dispersion of biogenic emissions
 - ▶ Investigate possible effect of sea salt, anthropogenic and natural sulphur to the formation of aerosol
- 

About SILAM

- ▶ Numerical advection–diffusion model with Eulerian core.
- ▶ Developed by Finnish Meteorological Institute (FMI).
- ▶ Emissions and atmospheric transport of isoprene and monoterpenes (bio–VOC–s), CAMx emission model.

A. Poupkou, T. Giannaros, K. Markakis, I. Kioutsioukis, G. Curci, D. Melas, C. Zerefos (2010) A model for European Biogenic Volatile Organic Compound emissions: Software development and first validation. *Environmental Modelling & Software* 25, 1845 – 1856.



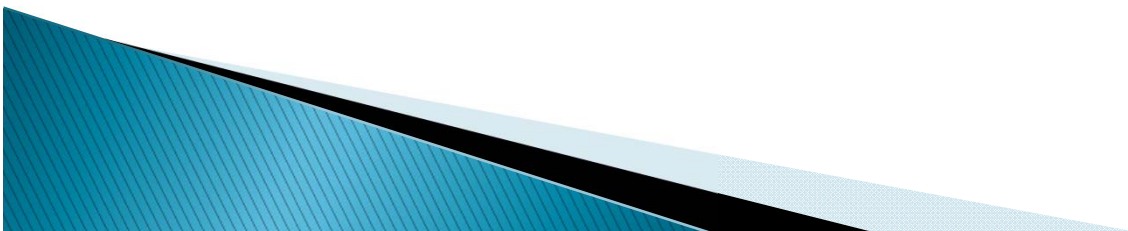
Data

- ▶ Land use data for estimating the bio-VOC emissions: U.S. Geological Survey (USGS) (http://edc2.usgs.gov/glcc/eadoc2_0.php).
- ▶ Emissions of sulphate (incl. $\text{SO}_2 \rightarrow \text{SO}_4$ conversion), sea salt.
- ▶ Concentrations of sulphur dioxide and sulphates from AQMEII (Air Quality Model Evaluation International Initiative) – performed by FMI, also with SILAM.



Setup

- ▶ Domain:
 - 53 – 71 degrees N
 - 6 – 36 degrees E
 - Resolution: about 20km
- ▶ Timeframe from 25 May to 13 August 2006
- ▶ VOC-s advected as passive tracers – no chemical transformations included.

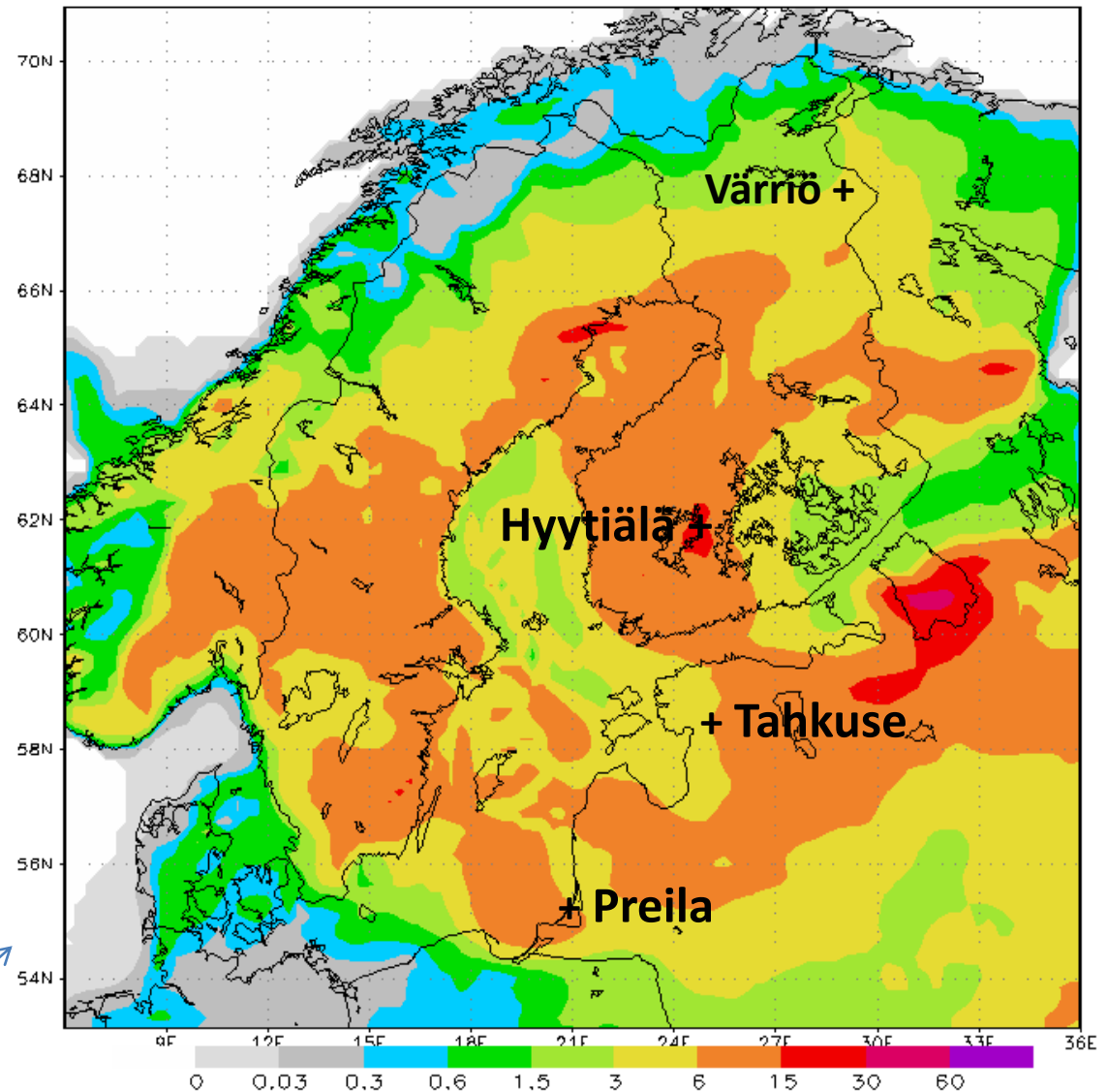


Aerosol measurements sites

20:12Z29JUN2006

- Preila, Lithuania
– (55°22'23"N, 21°2'2"E)
- Tahkuse
– (58°18'52"N, 24°33'19"E)
- Hyytiälä
– (61°50'49"N, 24°17'42"E)
- Värriö
– (67°45'17"N, 29°36'35"E)

Test sites
(and monoterpene
concentration at
arbitrary moment,
 $\mu\text{gC}/\text{m}^3$)



Measurement data

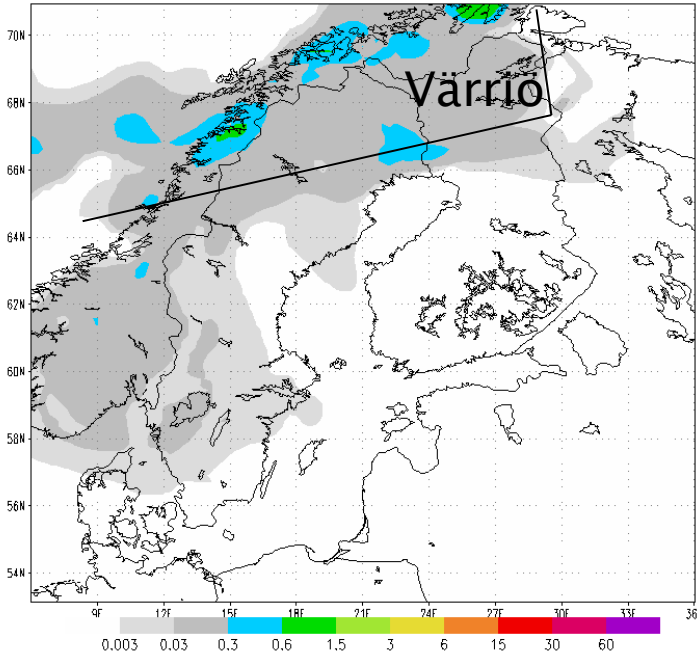
for validation

- ▶ Measured concentrations of PM_{0.45} (analogically with Tunved)
- ▶ Chemical composition of total PM in Preila, Lithuania : SO₄, NO₃, Na, Cl (filter measurements)
- ▶ Inverse(adjoint) runs made to trace back air masses
 - Based on these runs, time intervals of “clean” directions were subjectively selected (relatively large fraction of forest and less human activities)

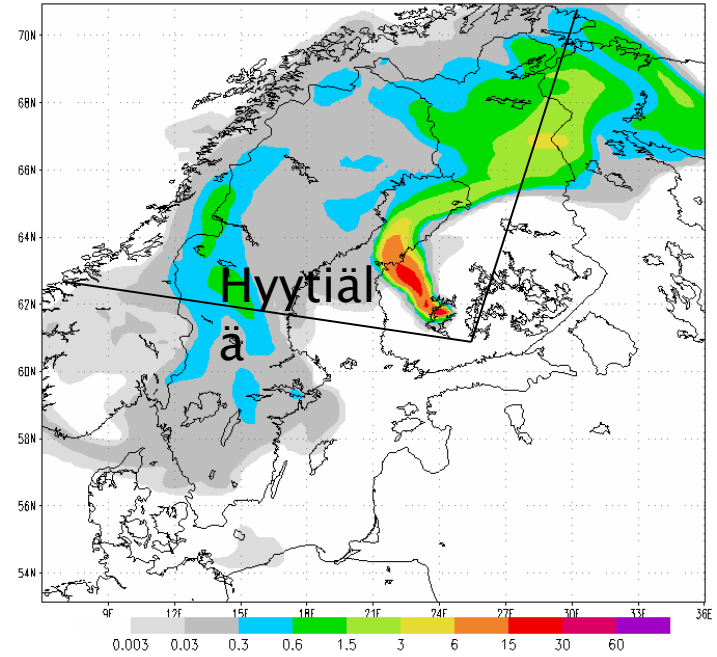


Selecting wind directions

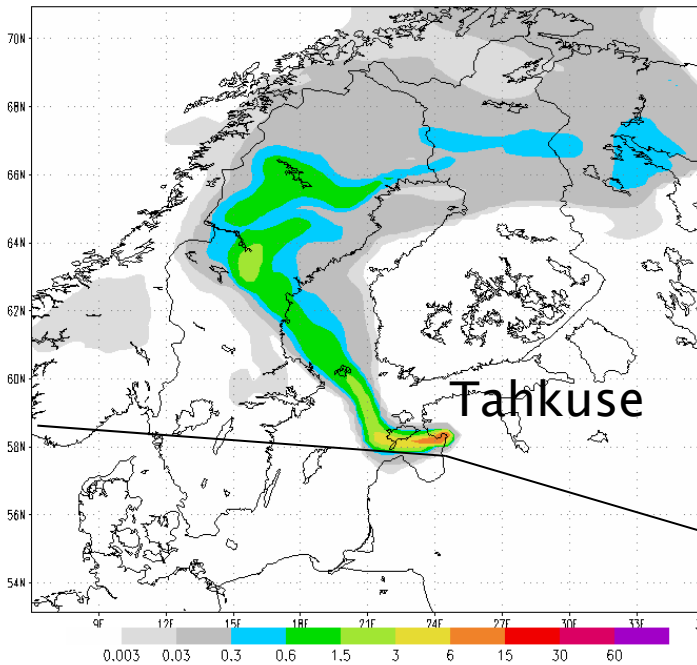
2006-06-28 22:00 UTC



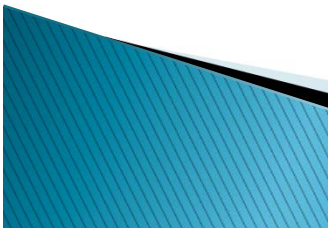
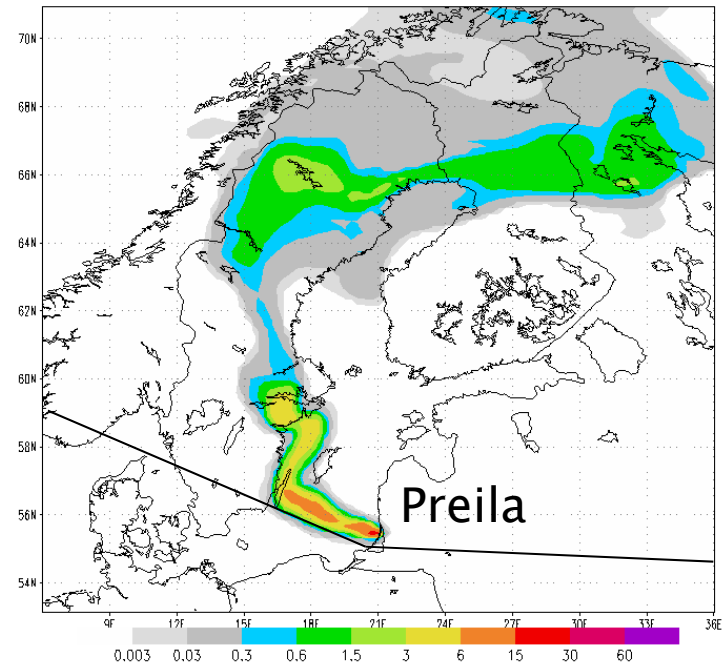
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2006-06-28 22:00 UTC



2006-06-28 22:00 UTC

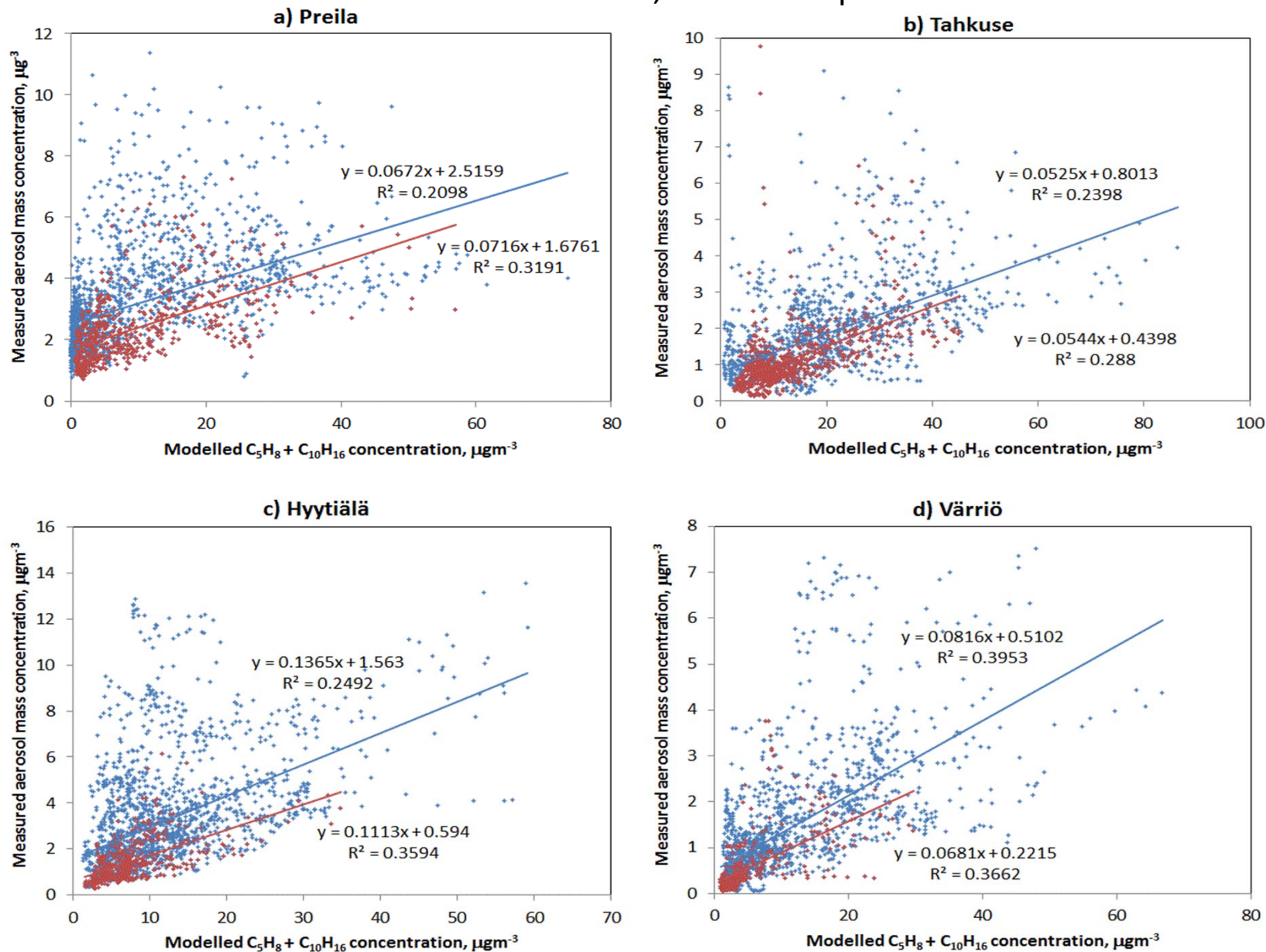


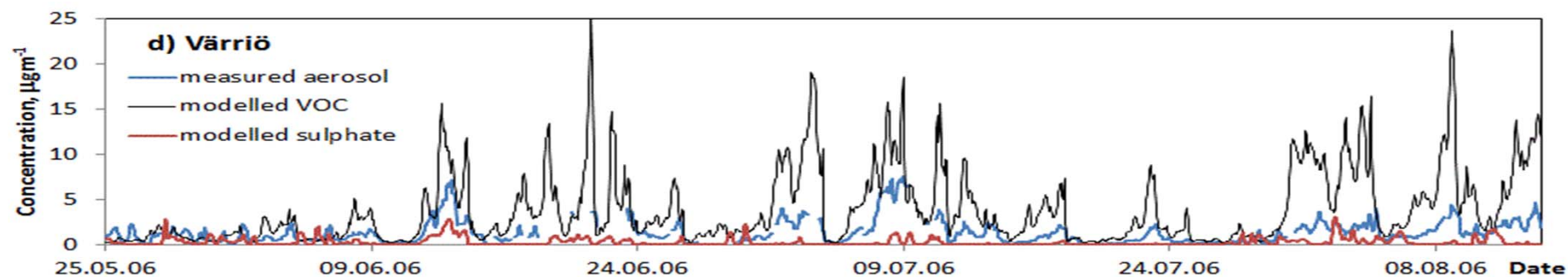
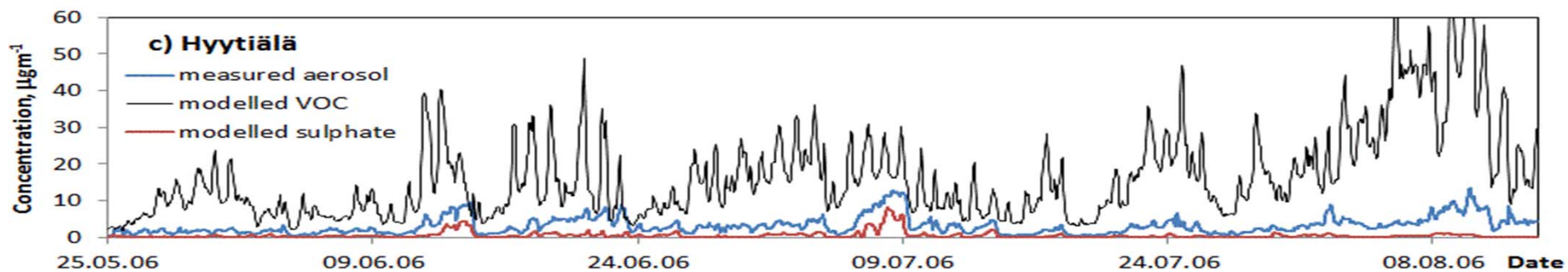
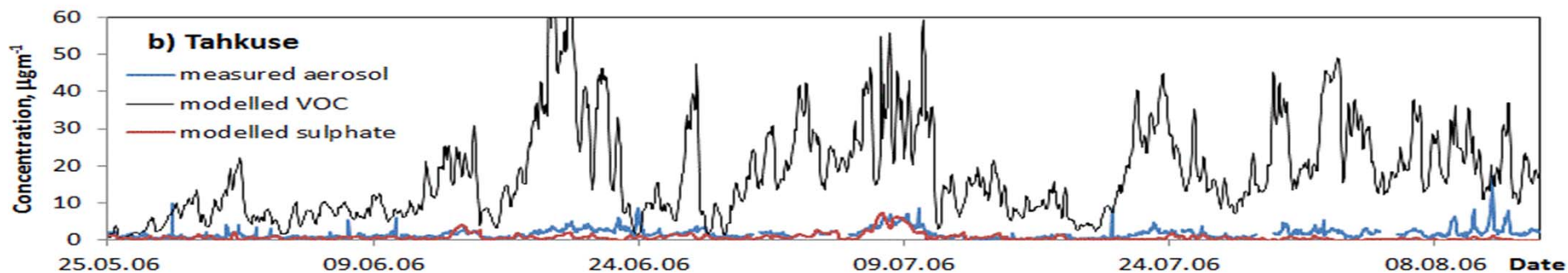
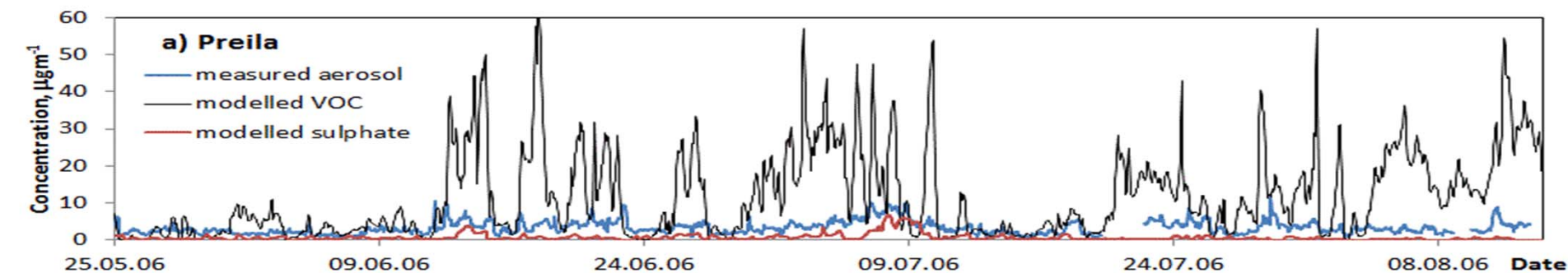
Results: Measured aerosol ($d < 0.45 \mu\text{m}$) vs. modelled bio-VOC concentration

Site	Precursor	Correlation (not selected)	Correlation (selected)
Värriö	Isoprene	0.75	0.75
	Monoterpenes	0.63	0.61
Hyytiälä	Isoprene	0.61	0.63
	Monoterpenes	0.50	0.60
Preila	Isoprene	0.46	0.53
	Monoterpenes	0.36	0.55
Tahkuse	Isoprene	0.47	0.45
	Monoterpenes	0.39	0.54

Measured particles vs. modelled total VOC($\mu\text{g}/\text{m}^3$),

Red = selected directions, blue = complete data





Results: Measured aerosol ($d < 0.45 \mu\text{m}$) vs. modelled SO_4

Site	Correlation	Correlation (selected directions)
Värriö	0.46	0.34
Hyytiälä	0.55	0.51
Tahkuse	0.42	0.07
Preila	0.46	0.49

Results: Bilinear fit

Site	Intercept, mg/m ⁻³	Slope for VOC	Slope for SO ₄	R ²
Preila	2.125	0.057	0.703	0.36
Tahkuse	0.593	0.044	0.447	0.33
Hyytiälä	0.800	0.092	1.597	0.70
Värriö	0.337	0.236	0.659	0.58

Results: Daily-based total PM composition vs. modelled components

	Correlation
SILAM sea salt vs. Cl	0.40
SILAM sea salt vs. Na	0.42
SILAM sea salt vs. Na+Cl	0.39
SILAM sea salt vs. SO ₄	-0.08
SILAM(AQMEII) SO ₄ vs. SO ₄	0.36

S. Bycenkiene, V. Ulevicius, S.Kecorius (2011) Characteristics of black carbon aerosol mass concentration over the EastBaltic region from two-year measurements, J. Environ. Monit., 2011, 13, 1027 – 1038.

Conclusions

- ▶ Isoprene and monoterpenes are important aerosol precursors in hemiboreal zone.
- ▶ About 10% of the total VOC mass is converted to aerosol
- ▶ Scatter of data points is much larger (Tunved has nearly perfect fit, $R^2=0.79$ for Värriö–Pallas and $R^2=0.93$ for Hyytiälä)
 - Different data set
 - Different selection rules
- ▶ High concentration of aerosol can occur with low concentration of VOC precursors, but low aerosol concentrations with high VOC-s almost never
 - Other precursors: sulphates



Thank You!

