Identification of diverse air pollution sources in a complex urban area of Croatia

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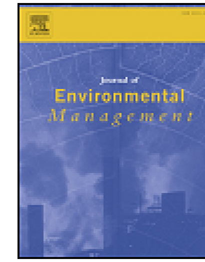

Research article

Identification of diverse air pollution sources in a complex urban area of Croatia

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Introduction

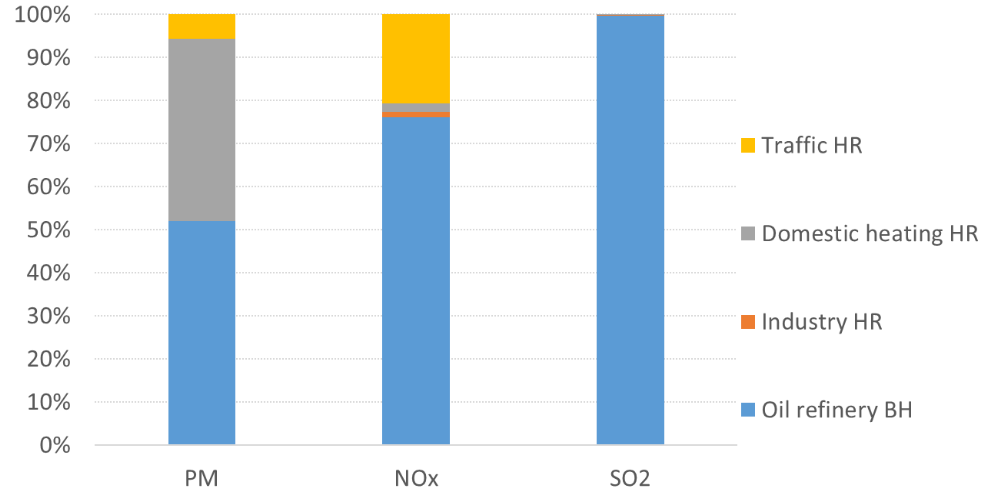
- Identification of sources
- Commonly used source apportionment techniques:
  - Emission inventories
  - Receptor modelling (MBA, PMF)
  - Inverse modelling
  - Artificial neural network
  - Air quality models
- Factor analysis – better illustrate source apportionment (Conditional bivariate polar plots, CBPF - extension of Conditional probability function)
- Here we used:
  - PMF – quantitative information on the contribution of specific source
  - CBPF – identification of geolocation of sources of PM

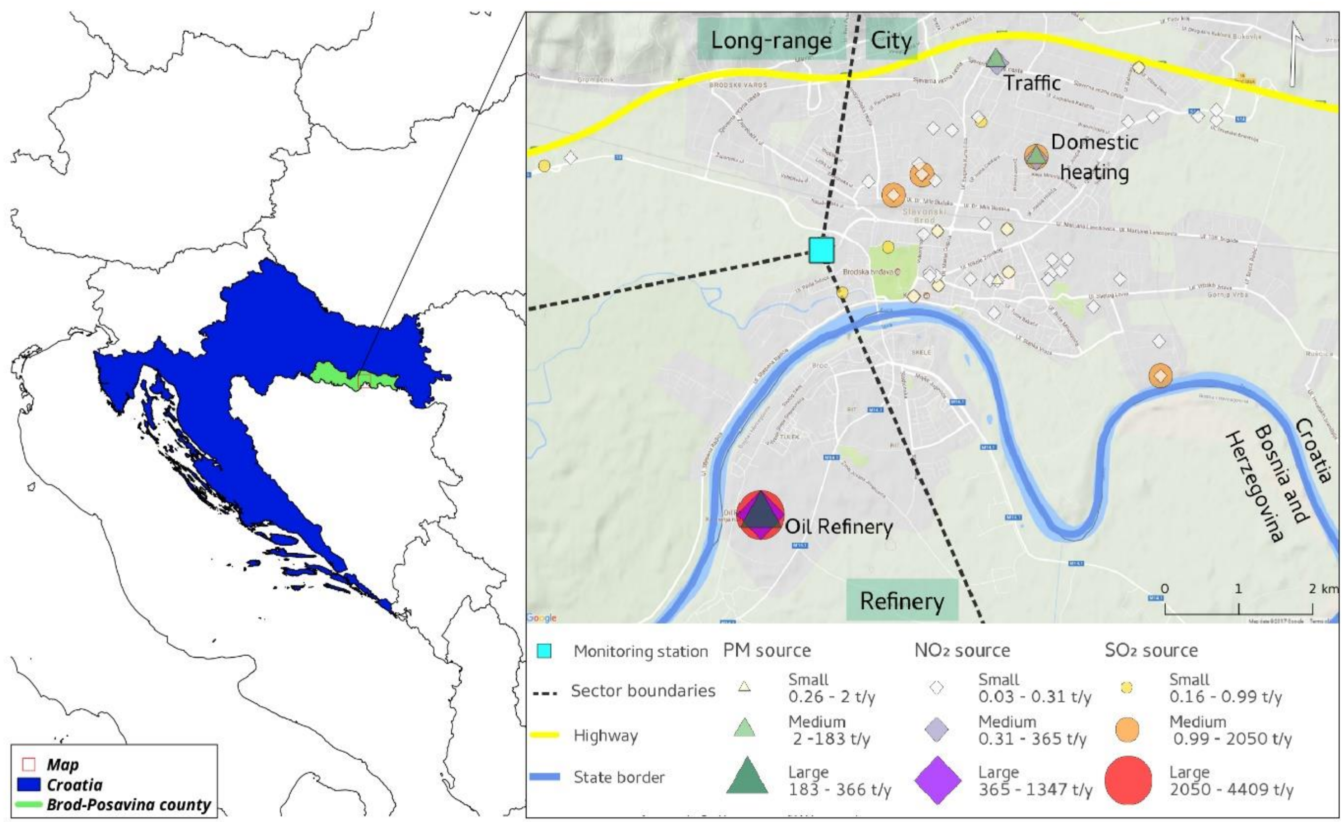
Study area

City of Slavonski brod

Recognised sources from Action plans:

- Traffic
- Domestic Heating
- Industry
- Long range
- Oil refinery (BIH)





In this work we made analysis of measurements from periods:

- 2010 – 2014 for aerosols + gaseous compounds
- 2015 for $PM_{2.5}$

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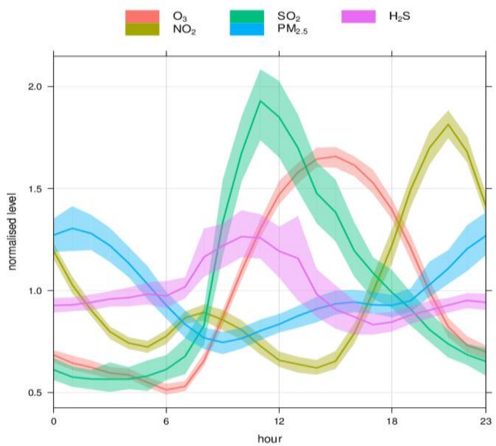
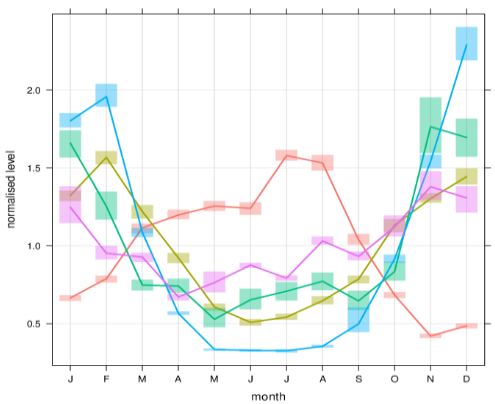
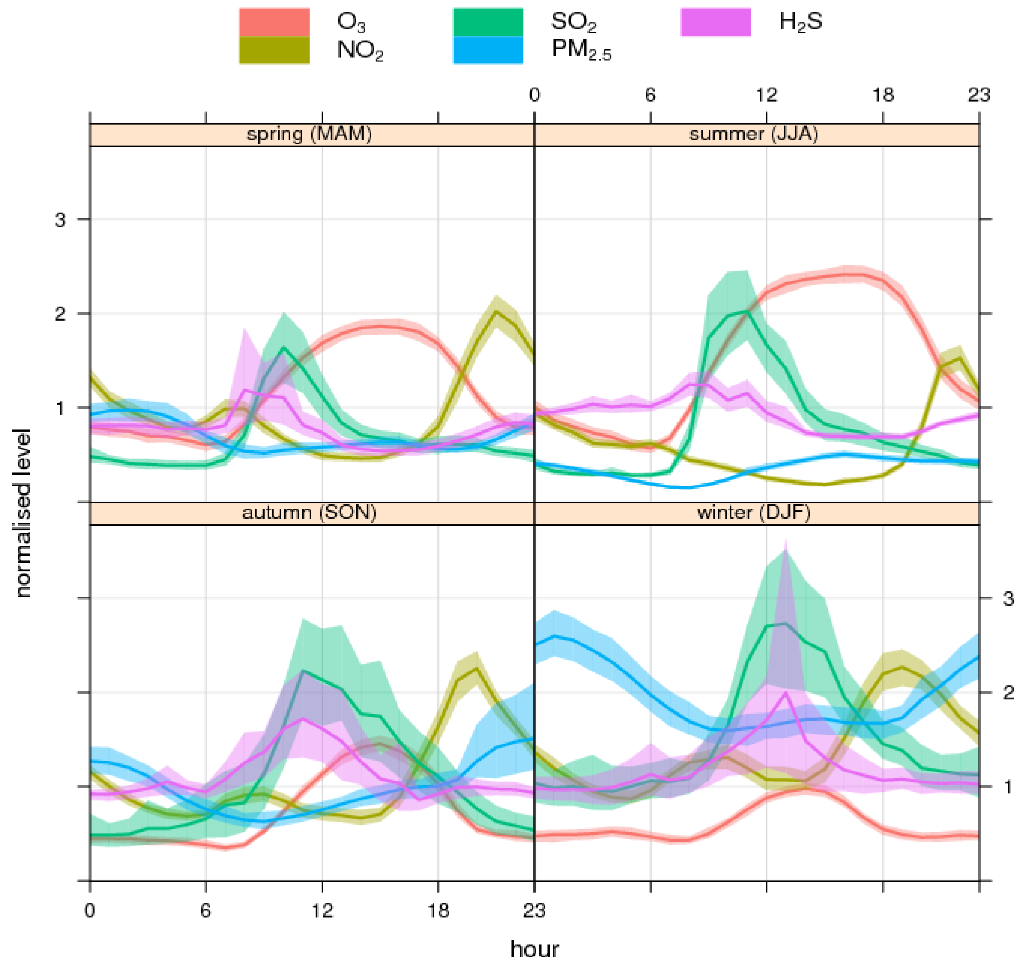
Relationship of diurnal and annual variations in pollutant concentrations with anthropogenic activities

Qualitative evaluation of the impact of the anthropogenic sources

- Understanding temporal diurnal, yearly variability
- The amount to which pollution follows human activities







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$PM_{2.5}$ chemical composition analyses

Reliable techniques for source apportionment of PM – chemical analysis.

During seasons and year, dominating particles:

- OC
- Sulfate
- Ammonium
- EC

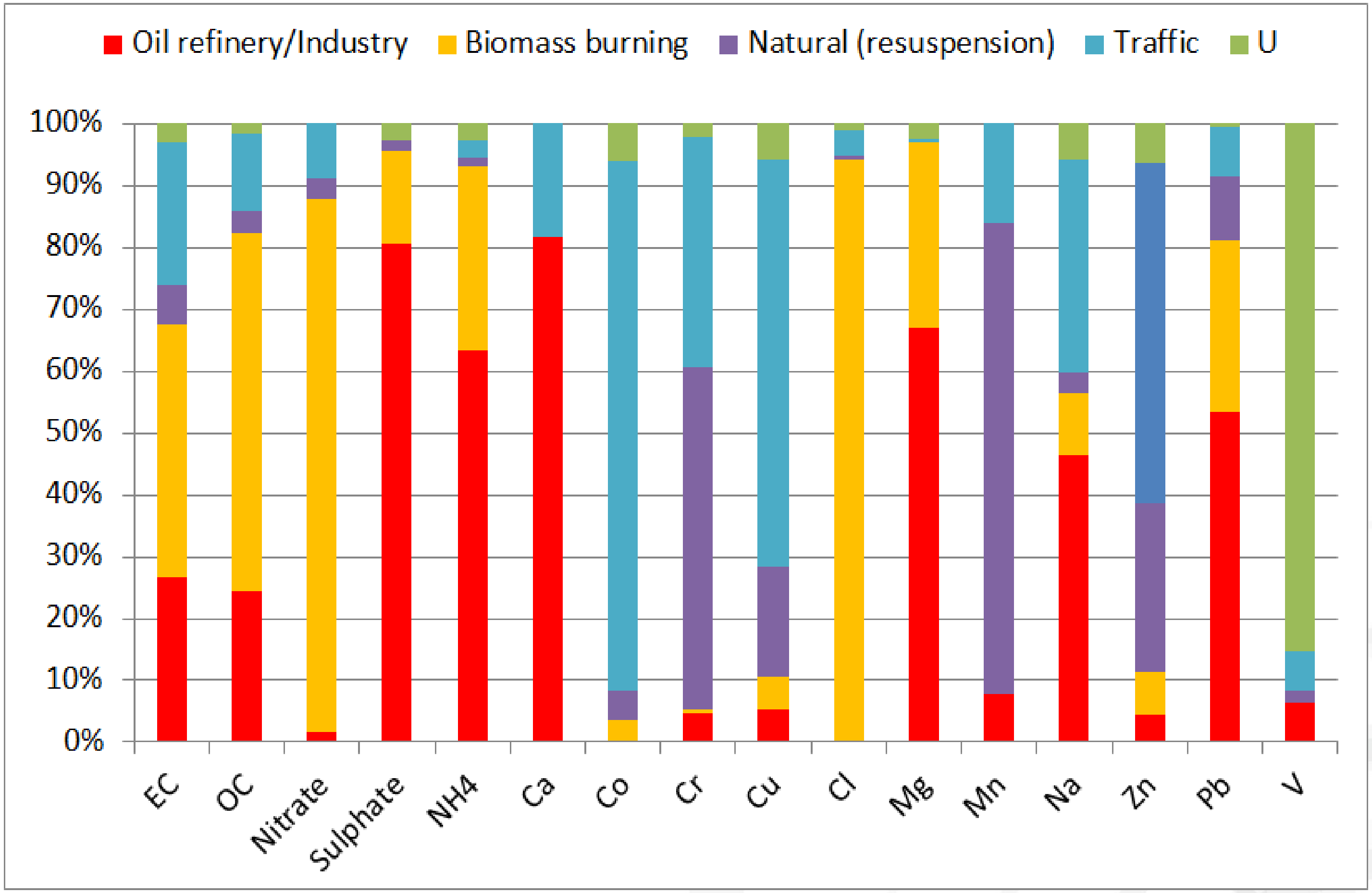
	Spring		Summer		Autumn		Winter		Year	
Element	(μg/m³)	(%)	(μg/m³)	(%)	(μg/m³)	(%)	μg/m³)	(%)	μg/m³)	(%)
Total mass	23.95	100	16.04	100	39.71	100	65.00	100	36.174	100.00
EC	1.23	5.14	0.58	3.62	1.67	4.20	2.15	3.31	1.408	3.89
OC	9.78	40.83	4.13	25.75	16.50	41.55	31.64	48.68	15.51	42.88
SO_4^{2-}	2.47	10.32	4.11	25.63	4.49	11.30	6.60	10.16	4.42	12.21
NH_4^+	1.43	5.95	1.68	10.48	2.31	5.81	3.42	5.25	2.21	6.10
NO_3^-	1.34	5.58	0.18	1.09	2.00	5.04	3.36	5.17	1.72	4.75
Unidentified	7.35	30.7	5.11	31.8	12.43	31.3	17.4	26.7	10.58	29.25
	(ng/m³)	(%)	(ng/m³)	(%)	(ng/m³)	(%)	(ng/m³)	(%)	(ng/m³)	(%)
Cl^-	92.52	0.39	4.29	0.03	118.08	0.30	177.09	0.27	98	0.27
Ca	92.34	0.39	176.34	1.10	118.02	0.30	158.91	0.24	136	0.38
Cu	71.02	0.30	15.59	0.10	15.65	0.04	5.70	0.01	27	0.07
Na	53.02	0.22	31.82	0.20	25.07	0.06	24.04	0.04	33	0.09
Mn	21.35	0.09	4.32	0.03	5.56	0.01	2.69	0.00	8	0.02
Mg	8.47	0.04	9.78	0.06	19.17	0.05	14.59	0.02	13	0.04
V	7.29	0.03	4.69	0.03	3.66	0.01	2.63	0.00	5	0.01
Cr	5.91	0.02	1.92	0.01	1.45	0.00	0.58	0.00	2	0.01
Zn	2.44	0.01	4.02	0.03	4.49	0.01	3.45	0.01	4	0.01
Co	0.67	0.00	0.22	0.00	0.16	0.00	0.04	0.00	0.3	0.00

Identification of sources of PM and gaseous pollutants using receptor modelling

PMF (EPA PMF 5.0) method reveals 5 sources:

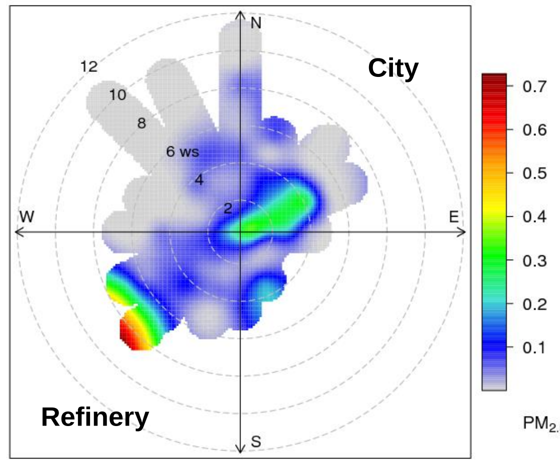
- Oil refinery
- Biomass burning
- Traffic
- Natual
- Undefined (V)

Oil refinery	29.6%
Biomass burning	25.5%
Traffic	23.6%
Natural	13.3%
U	7.8%

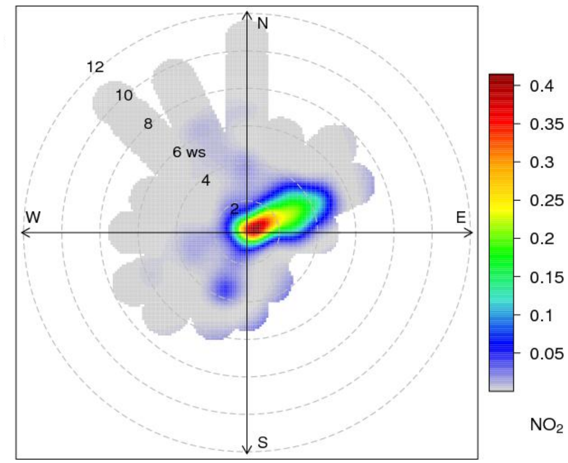


Identification of sources of PM and gaseous pollutants using receptor modelling

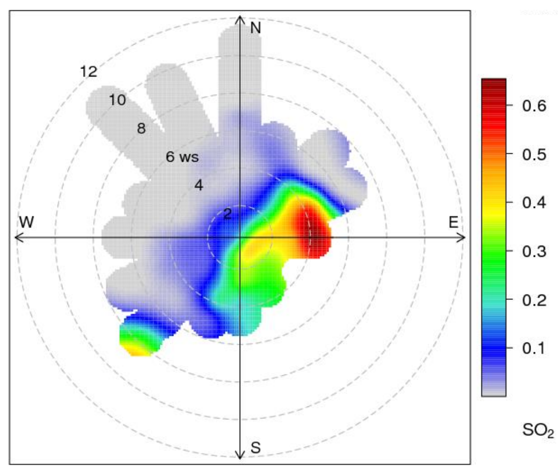
CBPF – 80th percentile
high concentrations



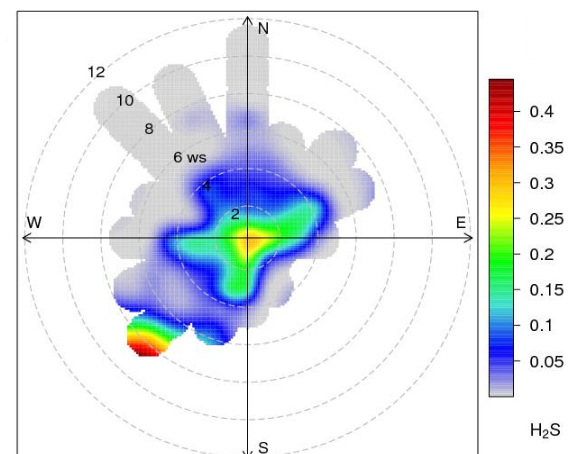
CBPF at the 80th percentile (=37)



CBPF at the 80th percentile (=22)



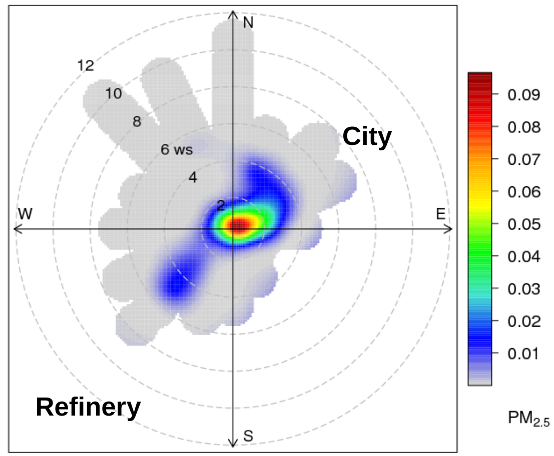
CBPF at the 80th percentile (=15)



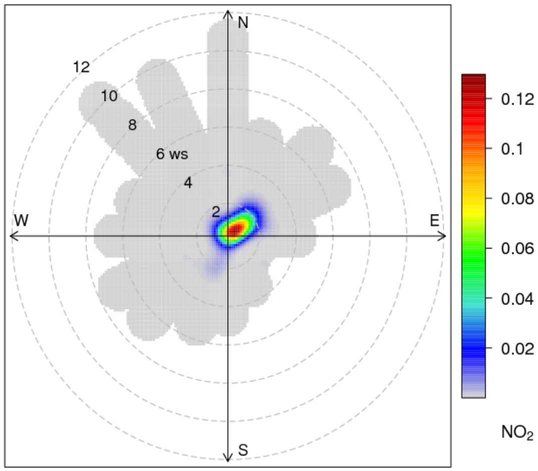
CBPF at the 80th percentile (=2.2)

Identification of sources of PM and gaseous pollutants using receptor modelling

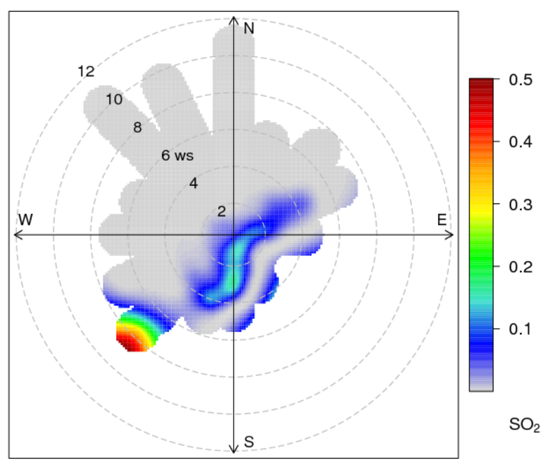
CBPF – 95th percentile
peak concentrations



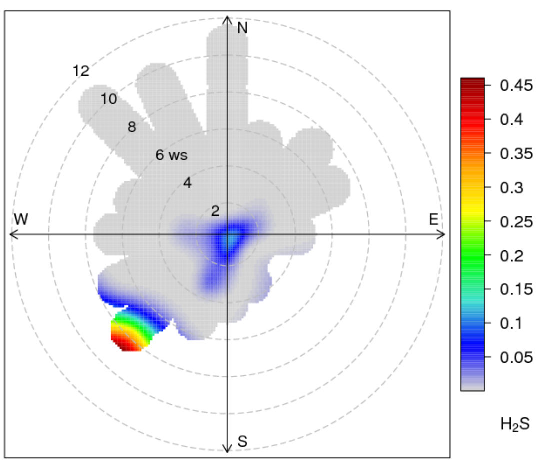
CBPF at the 95th percentile (=81)



CBPF at the 95th percentile (=42)



CBPF at the 95th percentile (=46)



CBPF at the 95th percentile (=3.8)

Air quality modelling

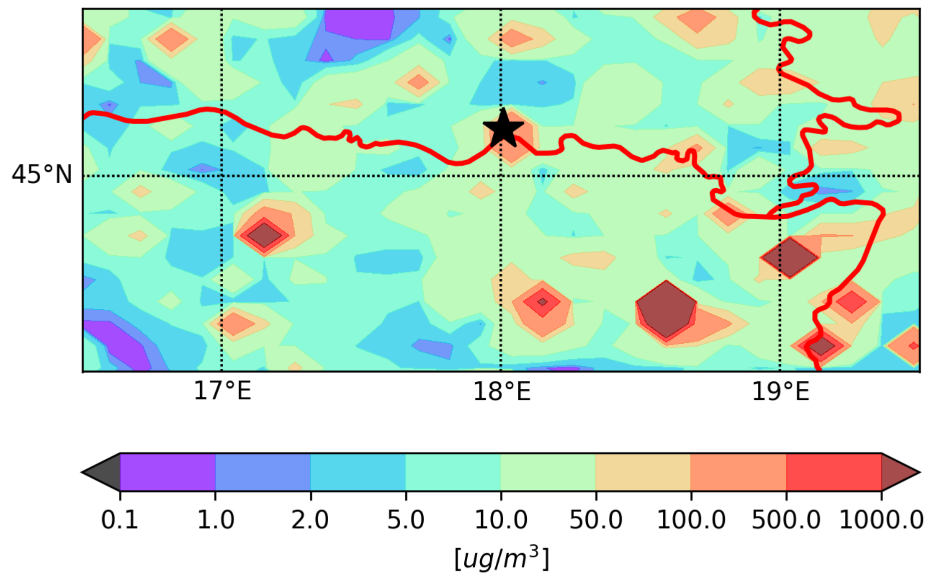
WRF-Chem model was used to tackle addressed problems in the JEM paper:

- What is a relation between meteorological conditions and daily variability (with focus on SABL)
- Maximum/peak of SO_2 concentrations at noon?
- Key mechanism behind daily PM_{10} variability (high concentrations during night, lower during early morning)?

The modelling setup:

- Meteorology 1x1km
- Chemistry 9x9km
- Emission: TNO MACC III
- Chem BC: Mozart
- Meteo IC/BC: FNL GFS

Modelling domain



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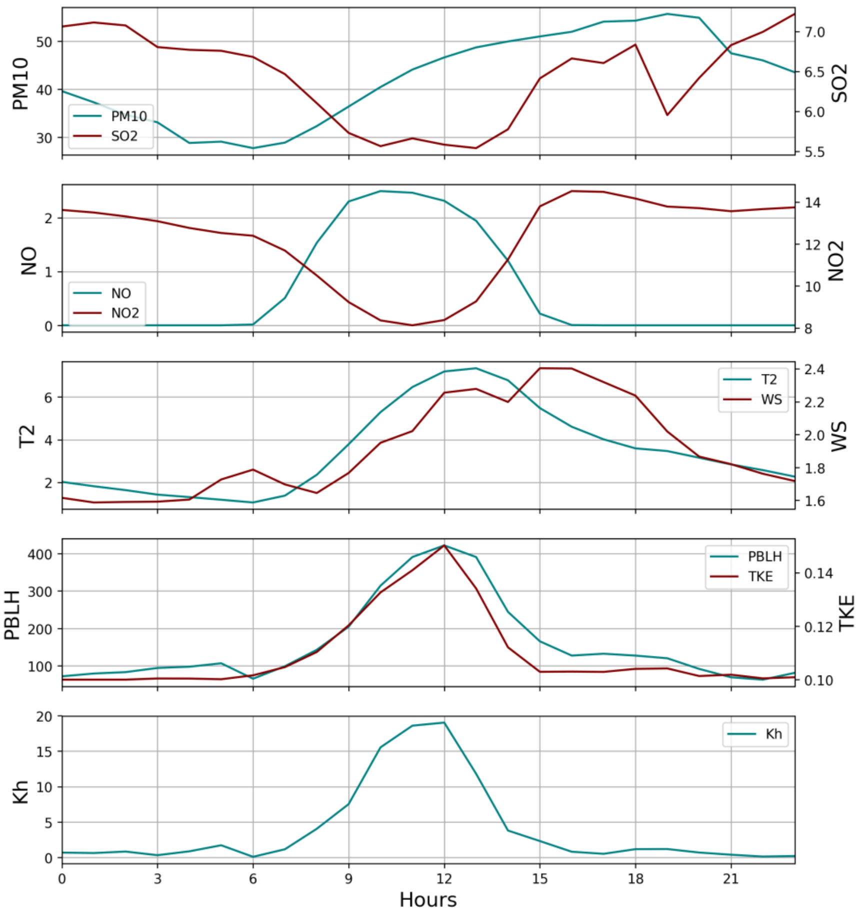
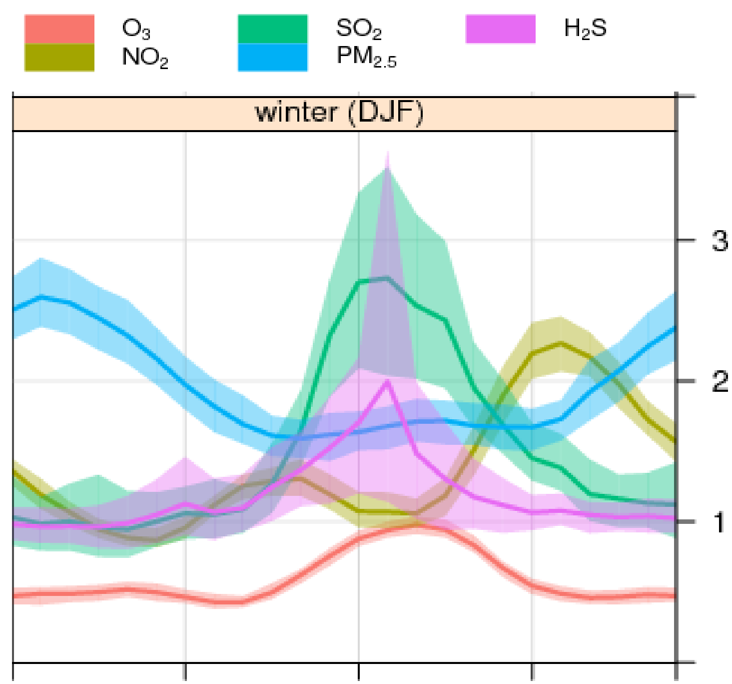
AQ modelling

Modeling concentrations

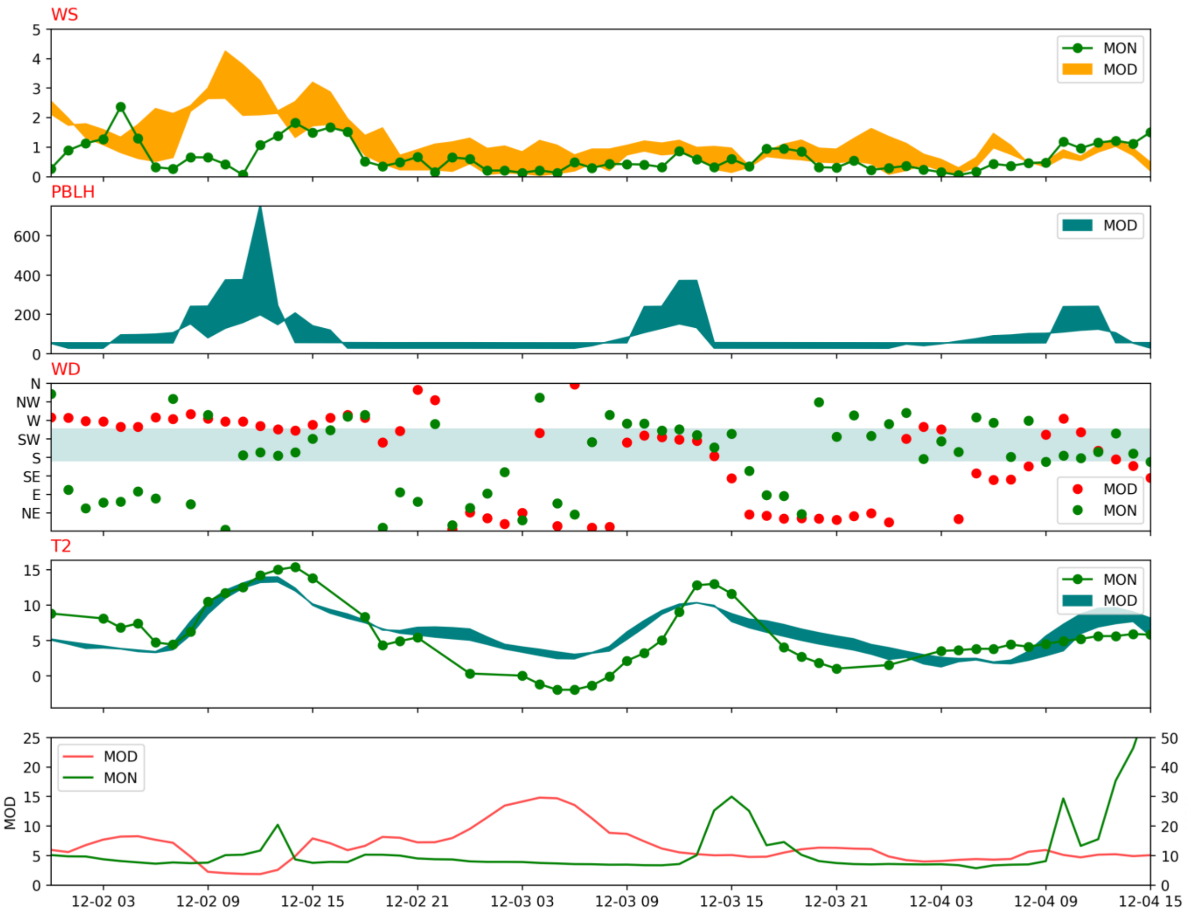


→ Different performance for SO_2 and PM



Measurements

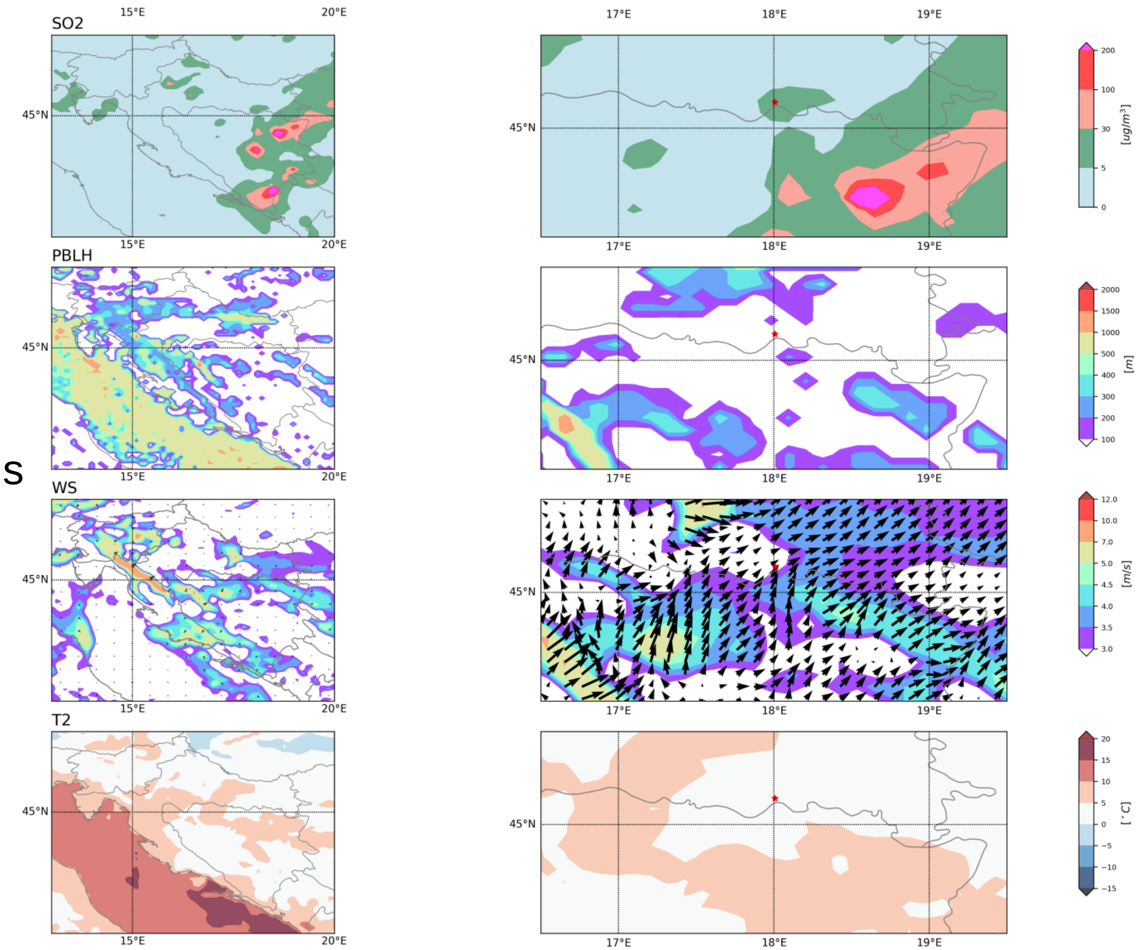
AQ modelling



	BIAS [%]	R	Sys	Unsys	RMSE
WS	-42	0.5	0.3	0.7	1.4
T	1.88	0.9	0	0.04	1.8
SO2	15.1	0.1	0.02	2.7	30.6

AQ modelling

Model recognised:
- Increased concentrations over area of interest
- Low PBLH values
- Low wind speed conditions (indicate SABL conditions)
- Cold pool over area of interest during increased concentrations



Summary

- We could distinguis the contribution to the measured concentration between different emission sectors - a large emission source (oil refinery), road traffic, domestic heating, natural (resuspension, or long range transport)
- Dominating carbonaceous material in $PM_{2.5}$, followed by SIA and nitrogen oxides
- PMF results indicate reveals 5 major sources
    - Oil refinery 29.6%
    - Biomass burning 25.5%
    - Traffic 23.6%
    - Natural 13.3%
    - U 7.8%
- CBPF – indicate importance of including meteorological factors in the analysis
    - Influence of SABL
    - Highest contribution to the peak SO_2 and H_2S concentrations from Oil refinery
- AQ modeling preliminary results:
    - difference in diurnal pollutant patterns
    - Importance of accurate emission inventory
    - SABL conditions – building up of concentration, SW wind lead to increase of concentrations