Sensitivity of Regional Air Quality to Contribution from Source emissions: A modelling Study using WRF-CMAQ

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Outline

- Purpose
- Methodology
- General Meteorological Condition Over Europe in January and July 2005
- General Air Quality Over Europe
- Performance of Regional Air Quality Model
- Quantitative Assessment of Contribution from different Source emission
- Conclusion

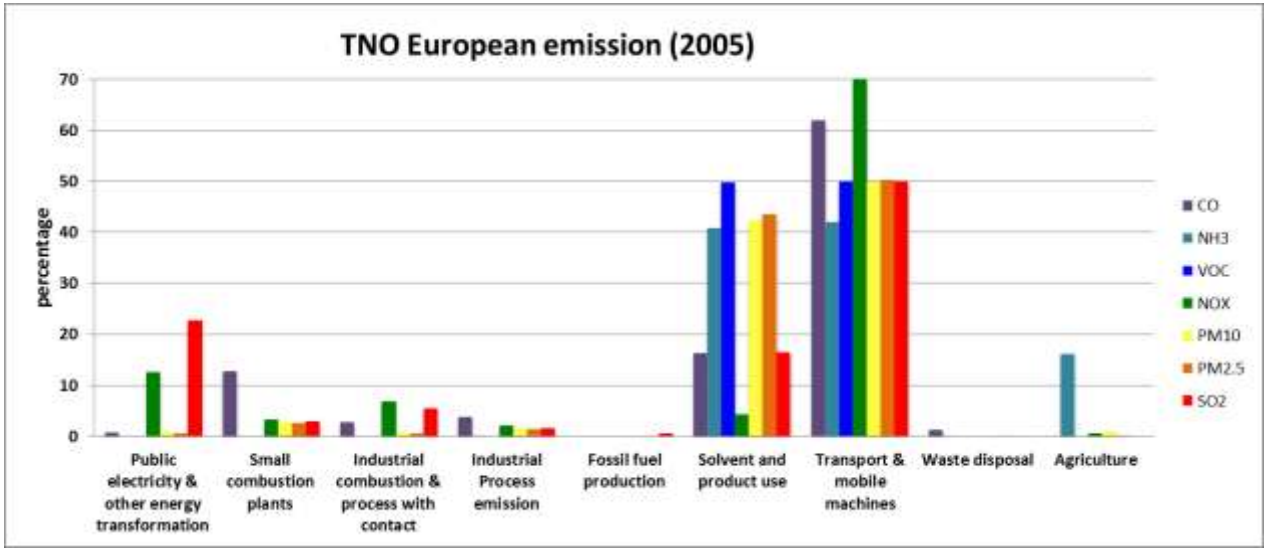
Purpose

- It has been estimated that the majority of anthropogenic emissions are generated by transport (SNAP 7&8) and solvent-product use (SNAP 6) sectors in Europe.

- The objective of this study is to quantify the relative importance of the different emission sources on the concentration of pollutants, especially for PM2.5 and Ozone (O3) as they adversely affect human health.

- To identify the effect of seasonal changes on concentration of air pollutants, inter-comparison of contribution of source sectors to the concentration of pollutants were done and quantified for January and July 2005

Methodology



For the purposes of this study the total ten anthropogenic SNAP sectors have been grouped into four main source sectors.

1) Industry
2) Solvent and Product Use
3) Transport
4) Agriculture and Other

Methodology

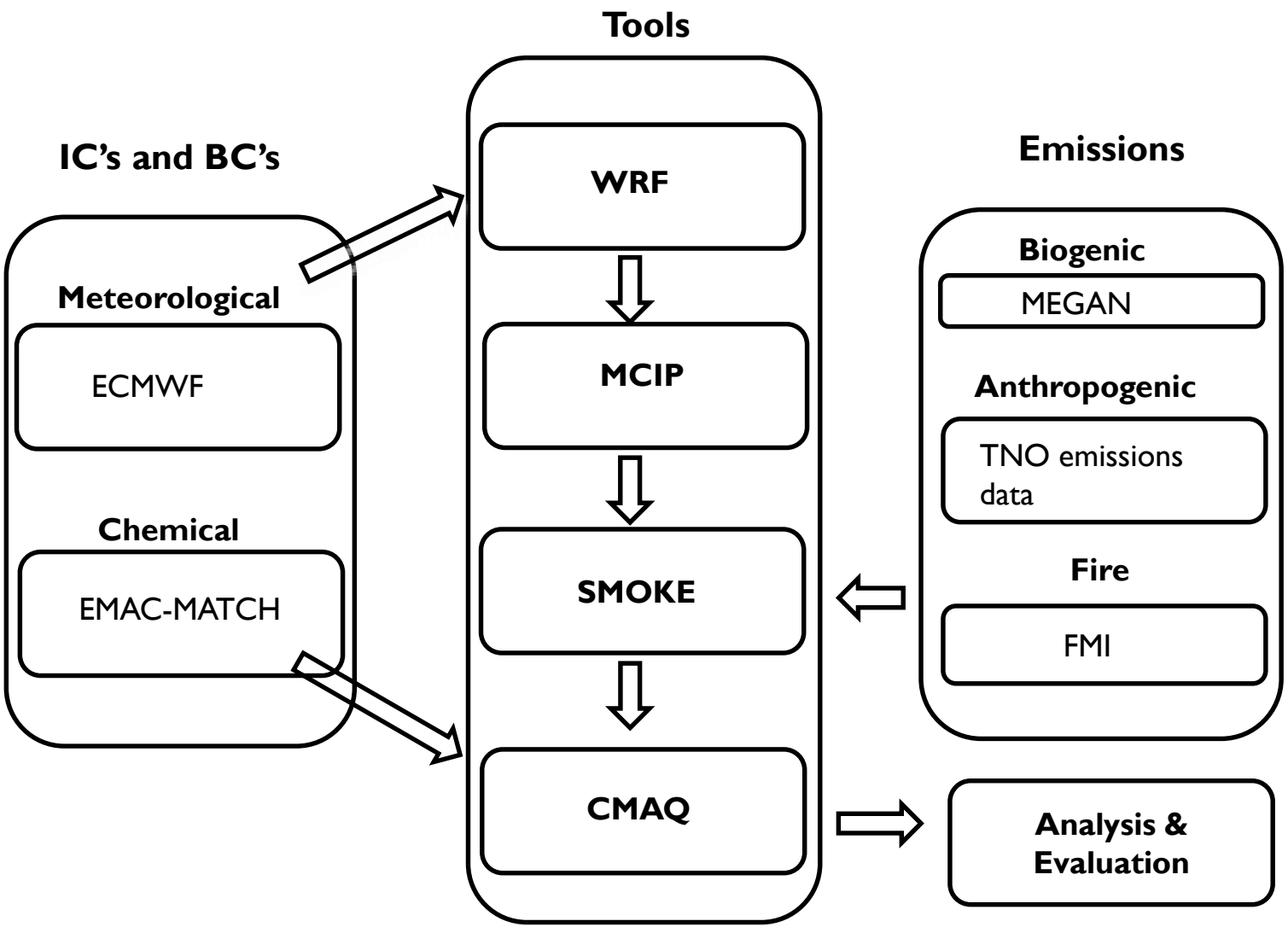
- An annual WRF-CMAQ simulation is carried out for the base year 2005 with all emission sources.

- To study the sensitivity of air quality to source sectors, a Brute-force approach has been employed for the emission

- Four sensitivity runs have been carried out for January and July 2005 and they are

1. Remove all emissions from SNAP 1-5 (Industry)
2. Remove all emissions from SNAP 6 (solvent and Product use)
3. Remove all emissions from SNAP 7-8 (Transport)
4. Remove all emissions from SNAP 9-10 (Agriculture and Other)

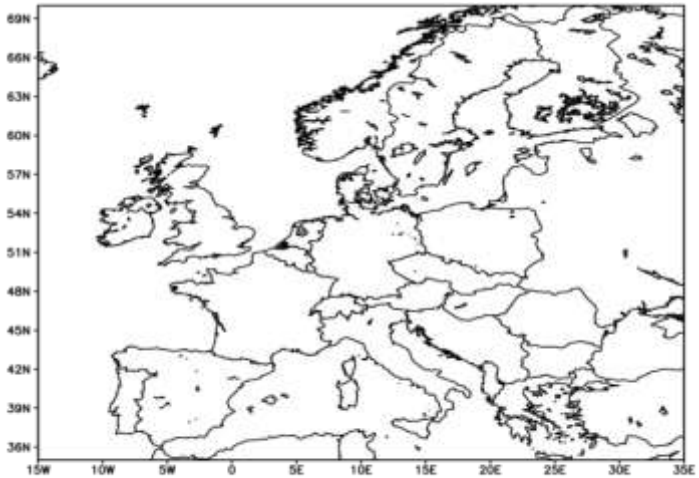
Methodology



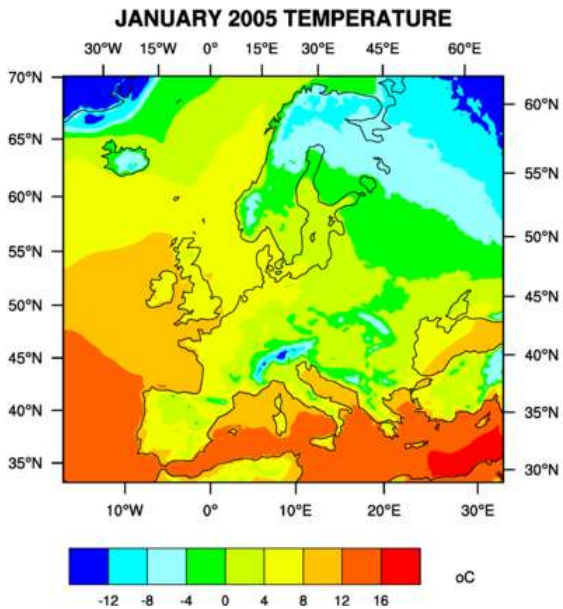
Methodology

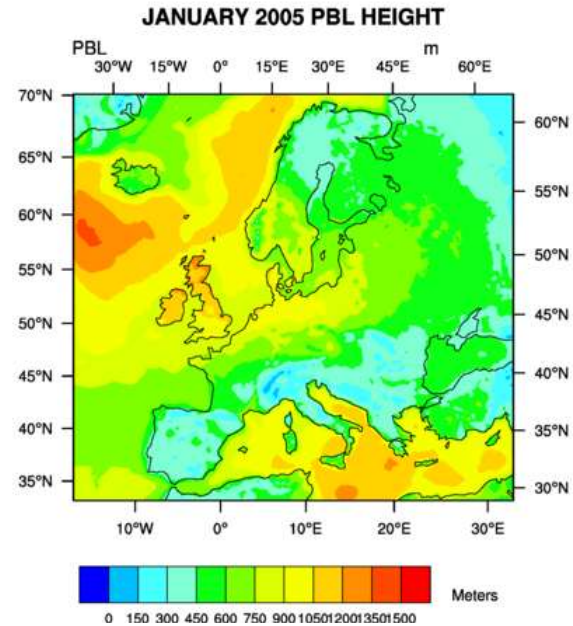
- Europe: One domain with 18 km horizontal resolution.
- WRF-CMAQ Model Simulation was performed for year 2005. Also four sensitivity runs were carried out with out grouped source emission categories
- CB05 as gas phase Mechanism and AE4 as aerosol module were used in CMAQ simulations

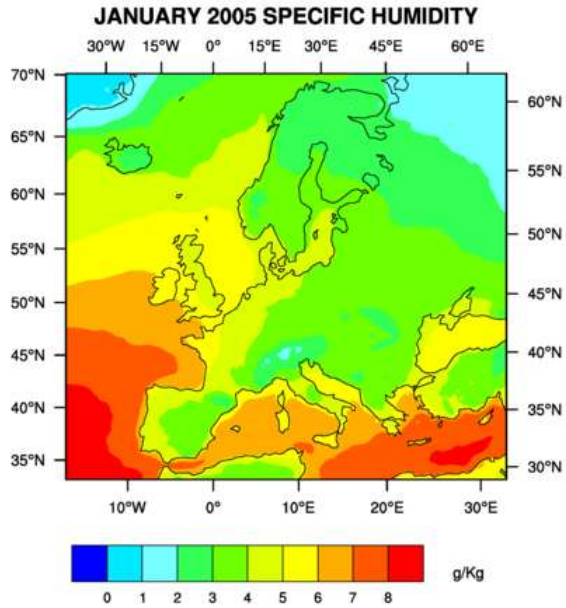
Model Domain

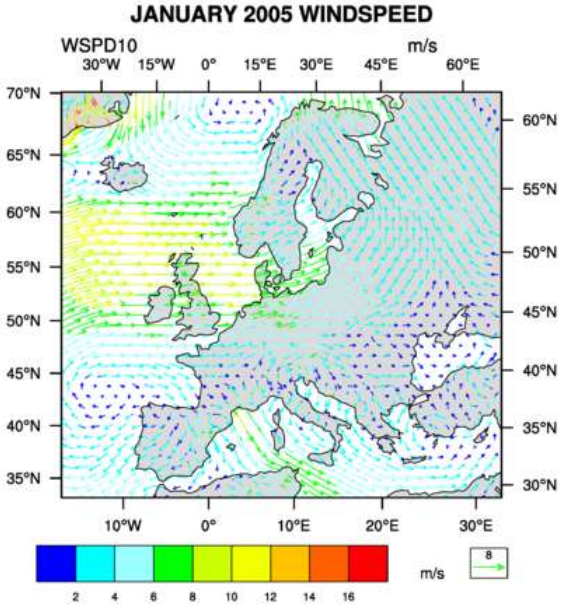


MEAN MONTHLY TEMPERATURE, PBL HEIGHT, SPECIFIC HUMIDITY, AND WIND SPEED (JANUARY 2005)

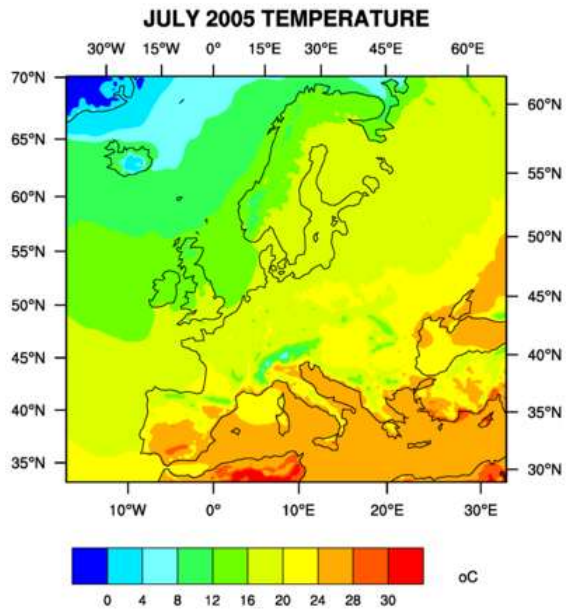


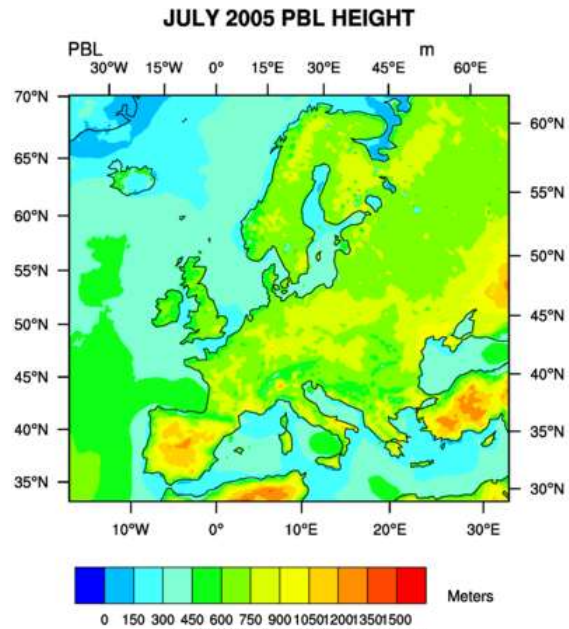


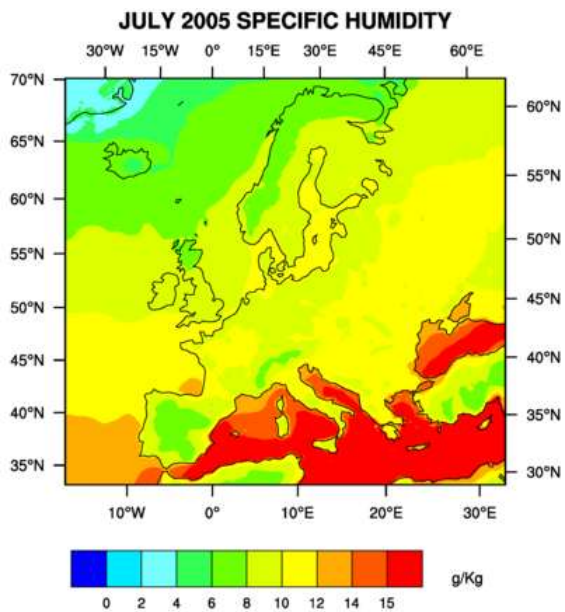


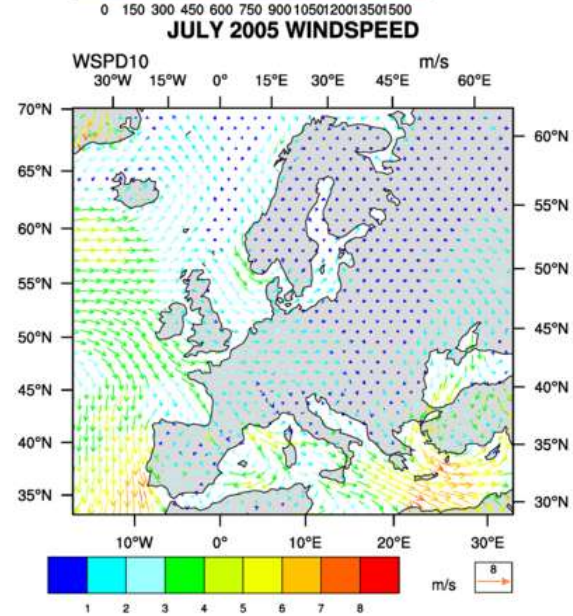


MEAN MONTHLY TEMPERATURE, PBL HEIGHT, SPECIFIC HUMIDITY, AND WIND SPEED (JULY 2005)

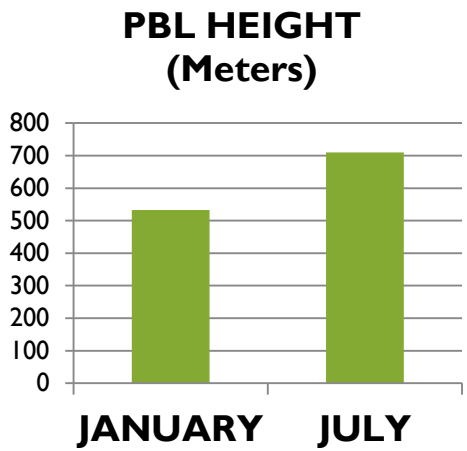


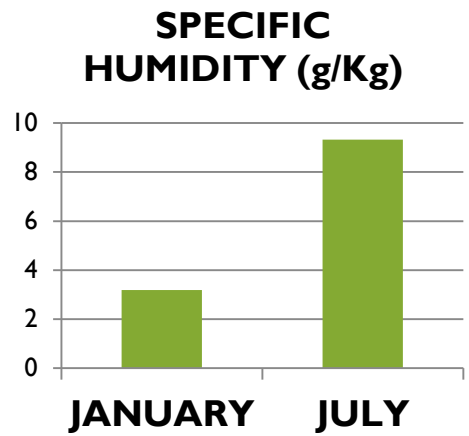


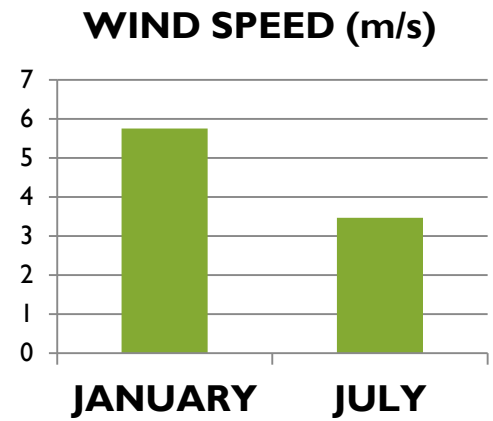




AVERAGE PBL HEIGHT, SPECIFIC HUMIDITY, AND WIND SPEED OVER EUROPEAN LAND MASS



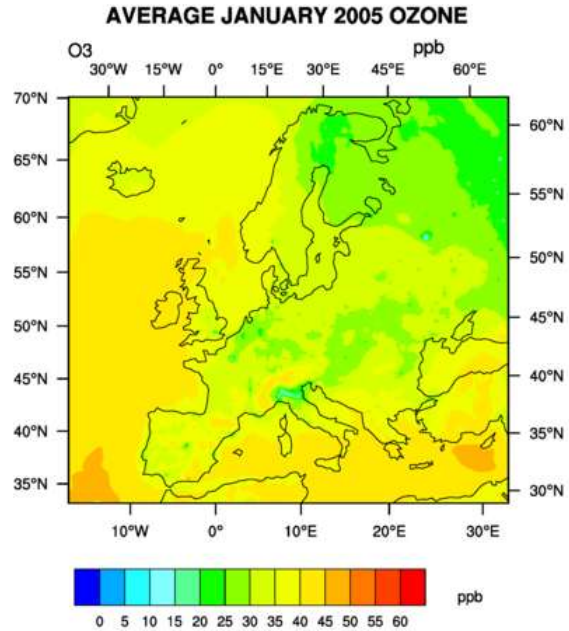


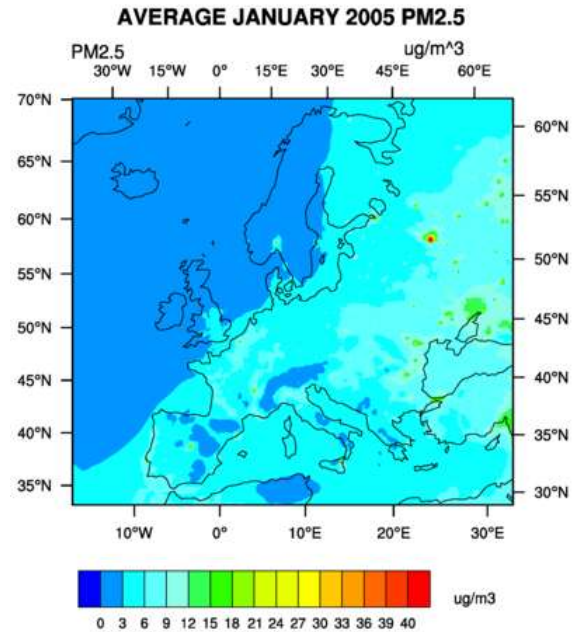


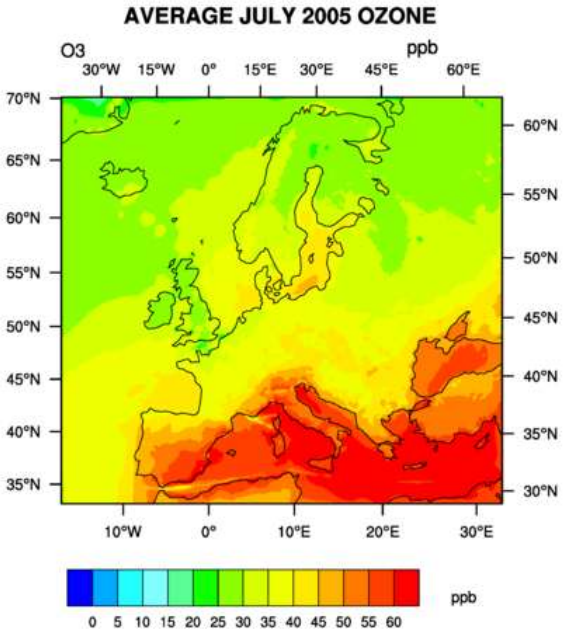
MEAN BIAS, MEAN ABSOLUTE ERROR, ROOT MEAN SQUARE ERROR, AND INDEX OF AGREEMENT OF TEMPERATURE (T), DEW POINT TEMPERATURE (DT), WIND SPEED (WS) AND WIND DIRECTION (WD) AT 27 WMO SYNOP STATION IN AND AROUND LONDON

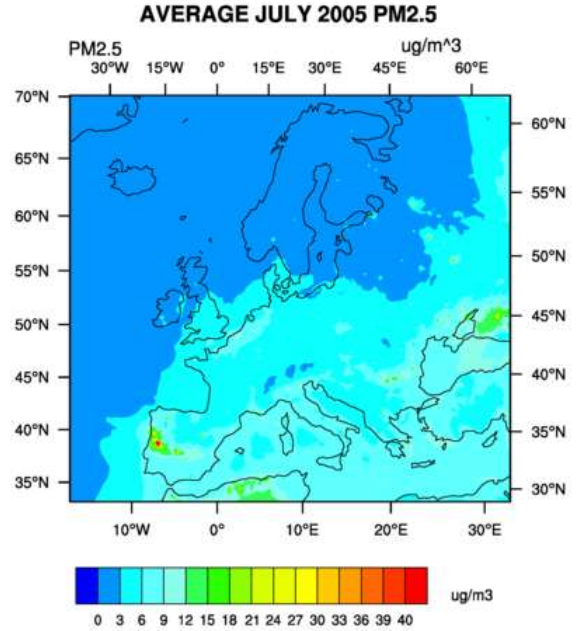
STAT								
	JANUARY				JULY			
	T	DT	WS	WD	T	DT	WS	WD
MB	1.08	0.24	2.09	-1.38	0.28	-0.16	0.25	4.78
MAE	1.87	1.87	2.42	42.52	1.19	1.19	1.25	46.3
RMSE	2.42	2.49	2.78	92.49	1.52	1.58	1.56	92.44
IA	0.80	0.81	0.79	0.71	0.95	0.87	0.81	0.80

MEAN MONTHLY OZONE, PM2.5 DURING JANUARY AND JULY 2005

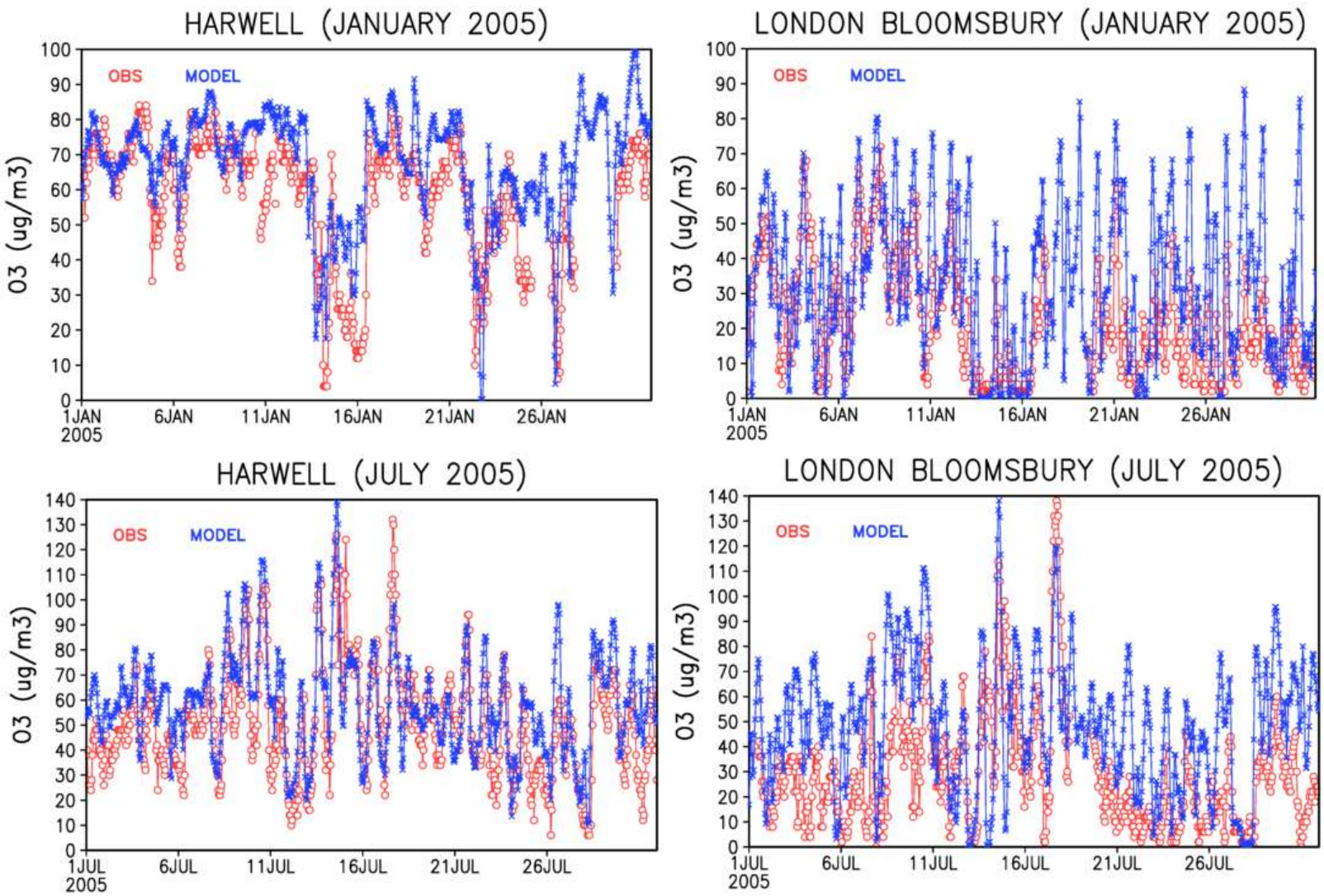




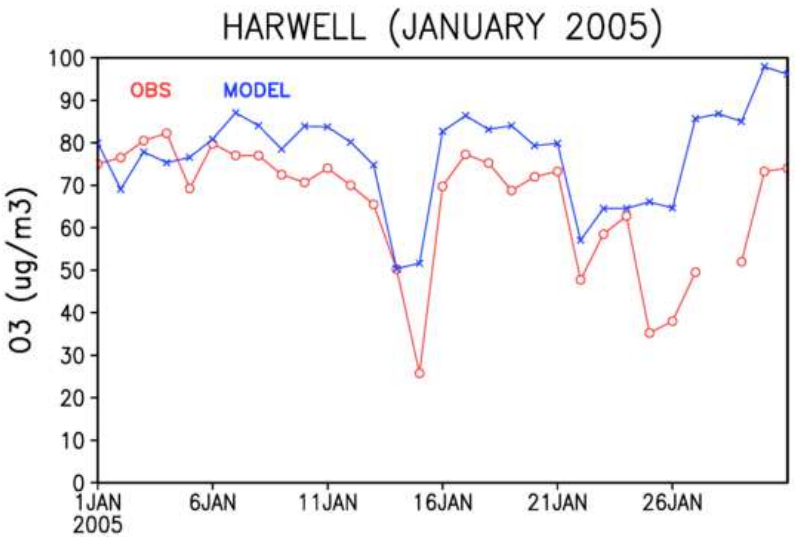


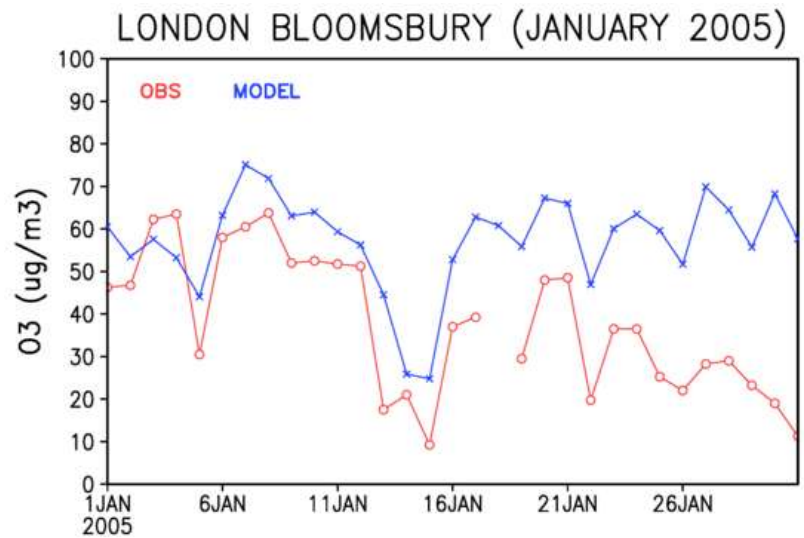


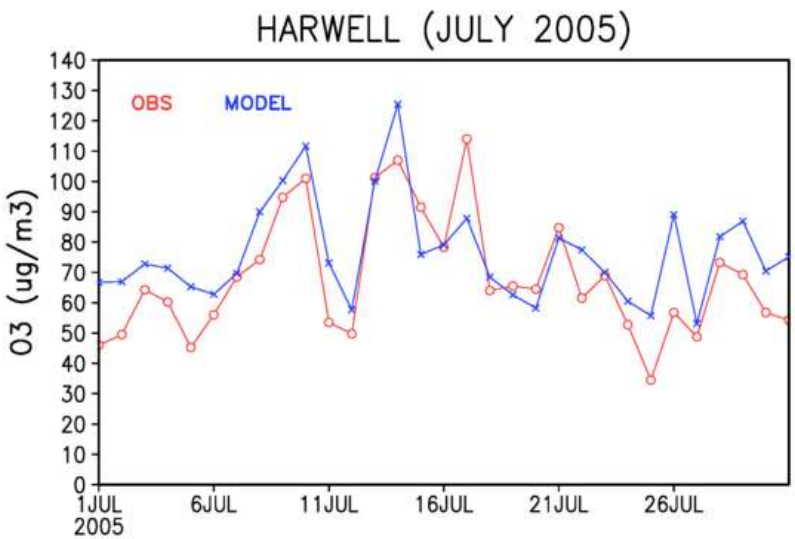
HOURLY OZONE CONCENTRATION

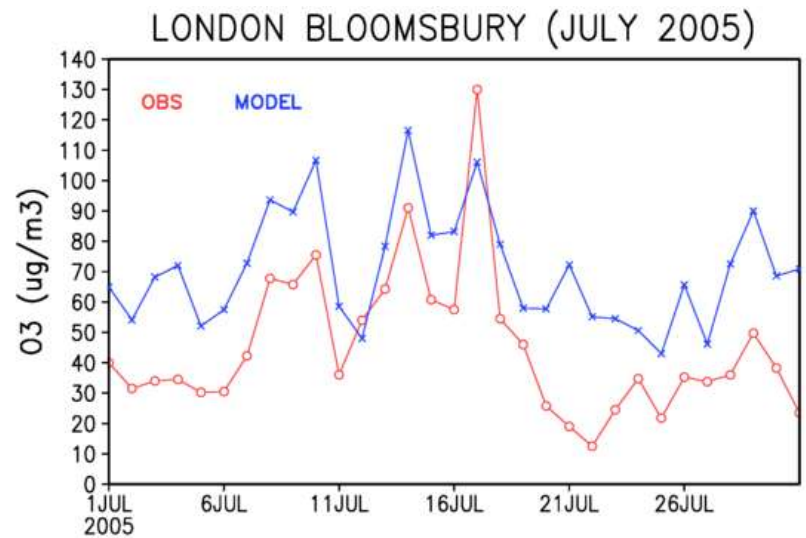


MAXIMUM 8 HOURLY RUNNING MEAN OF OZONE CONCENTRATION

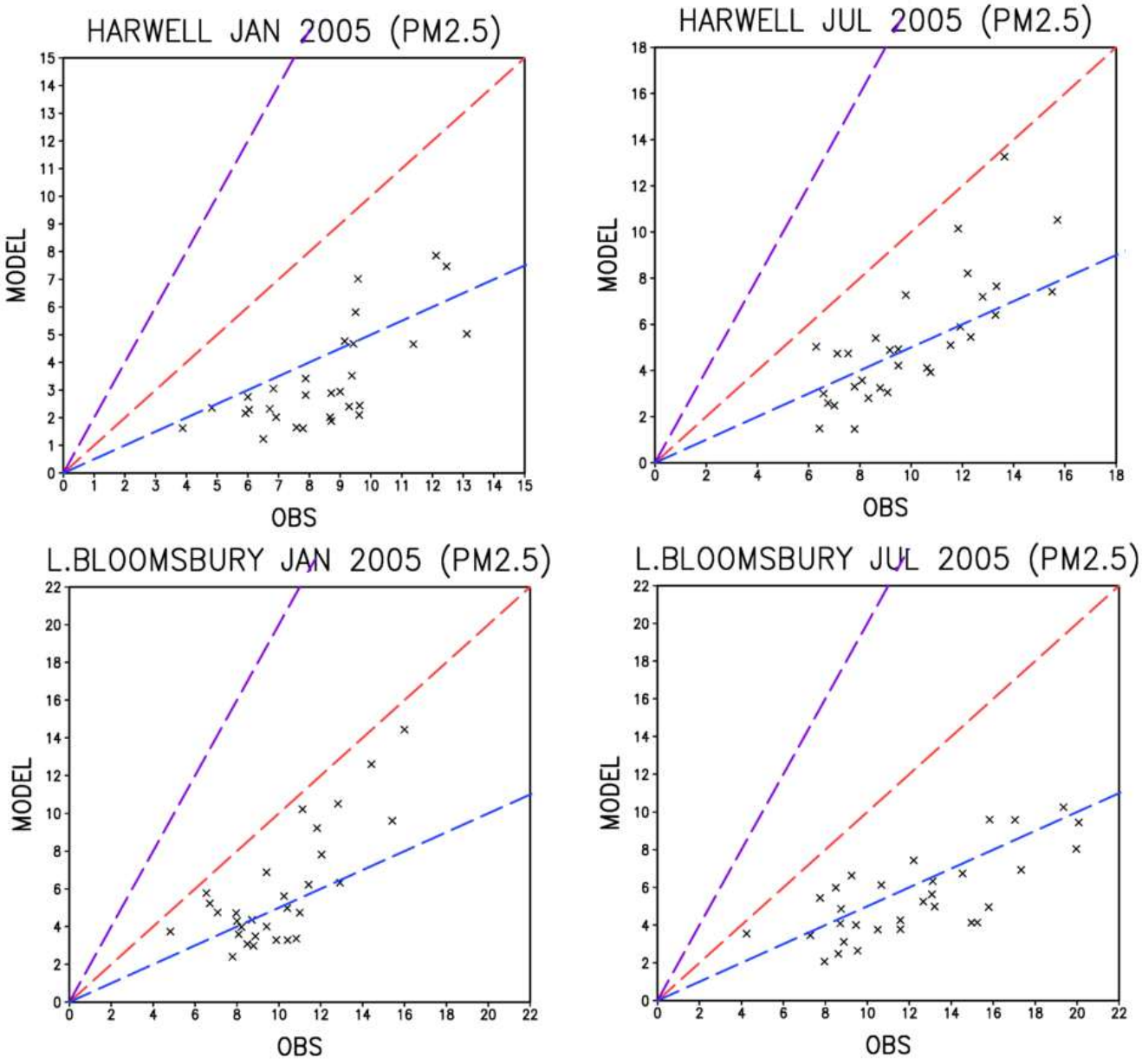




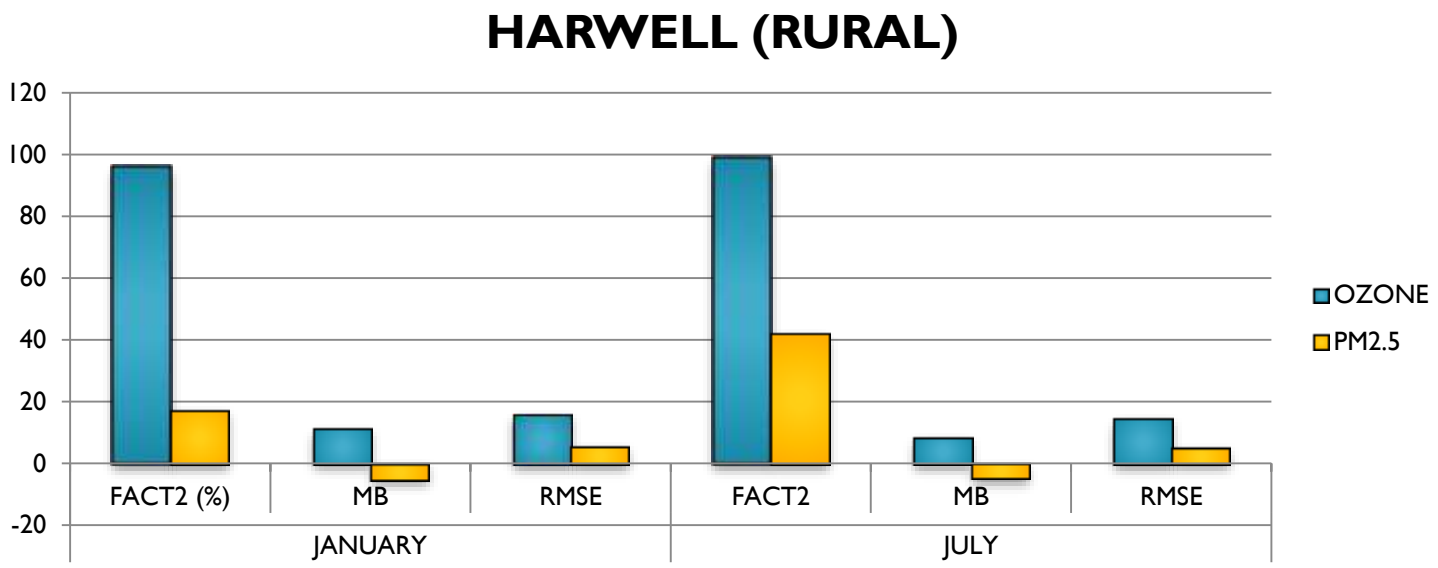


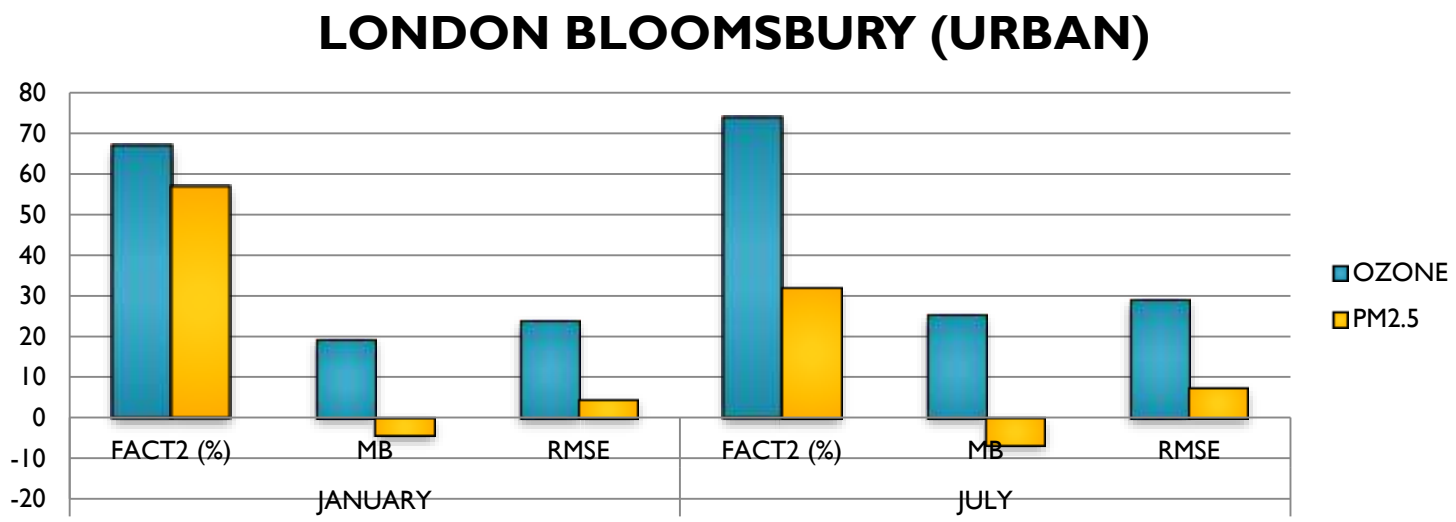


24 HOUR AVERAGE PM2.5

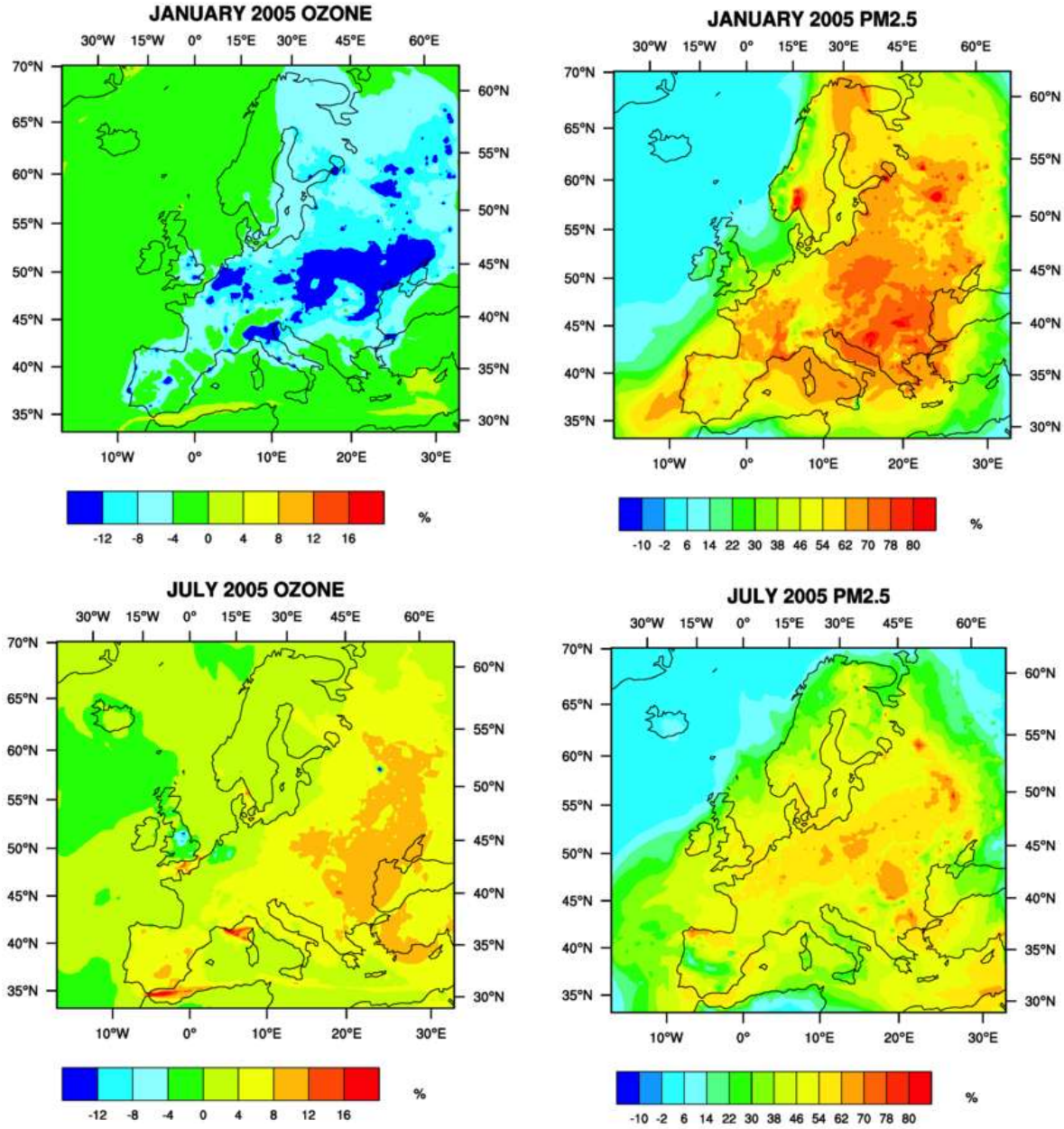


OVERALL PERFORMANCE OF CMAQ

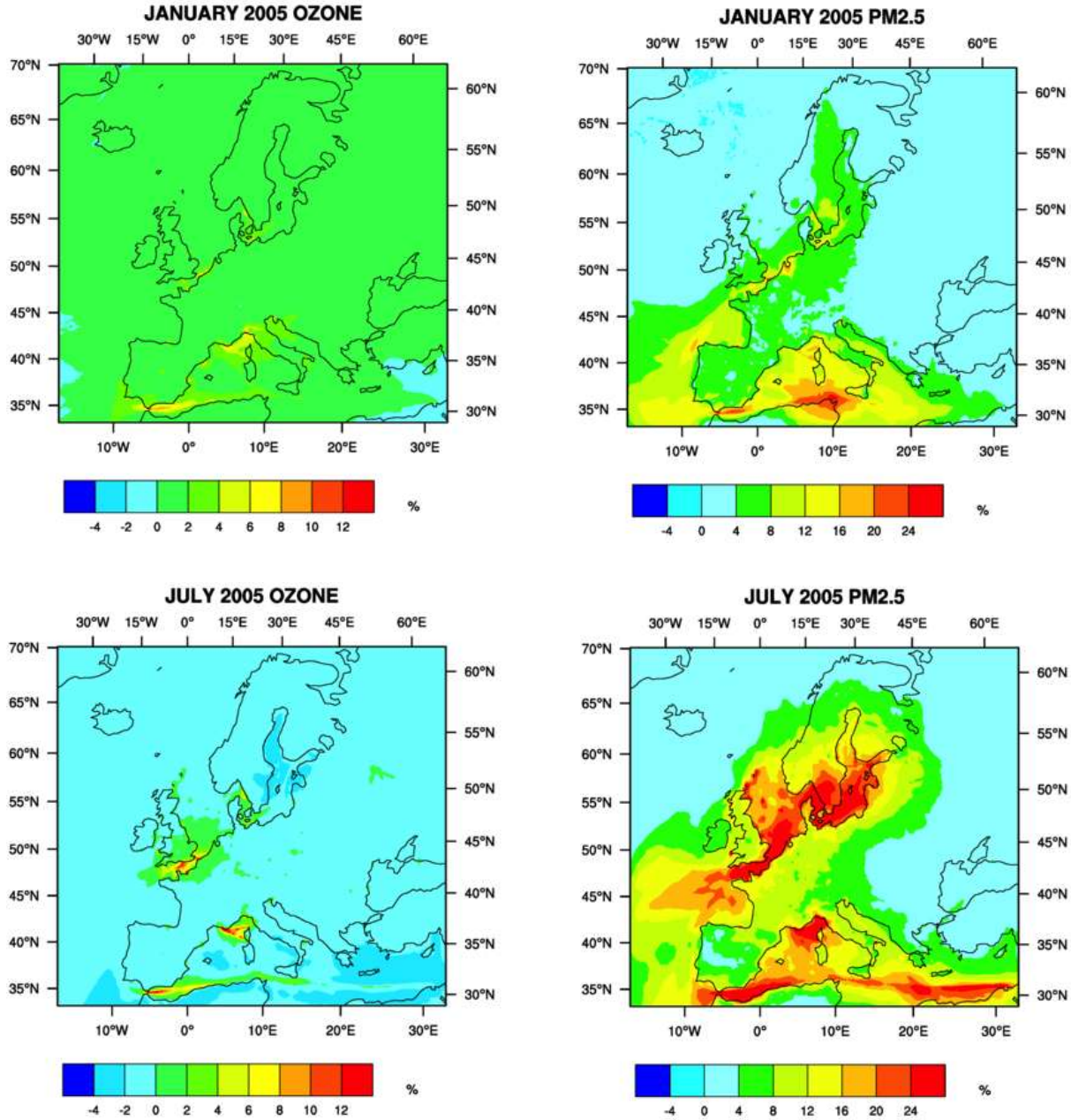




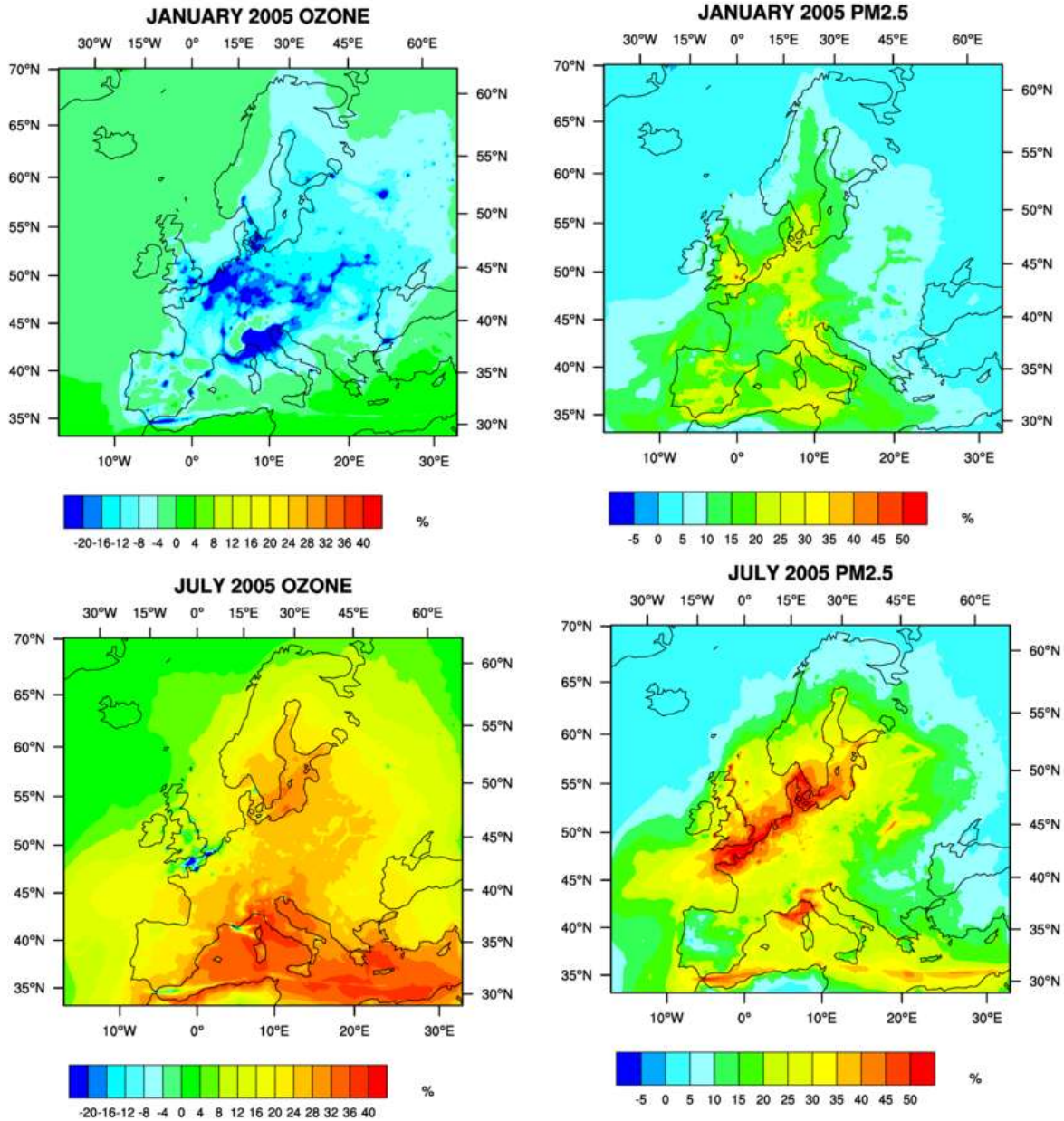
Contribution from Industry emissions to concentration of Ozone and $PM_{2.5}$ in Europe during January and July 2005



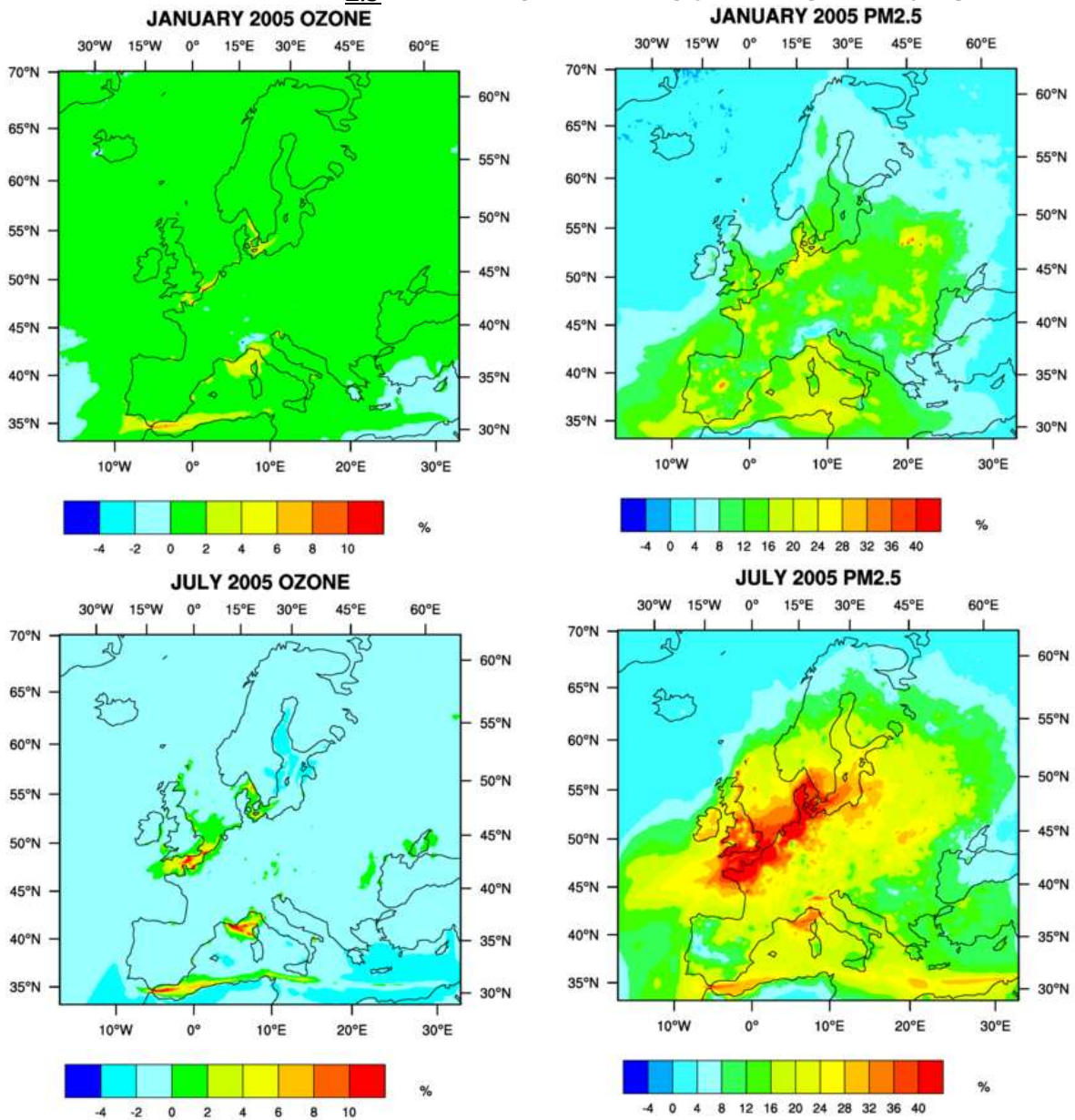
Contribution from Solvent and Product use emissions to concentration of Ozone and $PM_{2.5}$ in Europe during January and July 2005

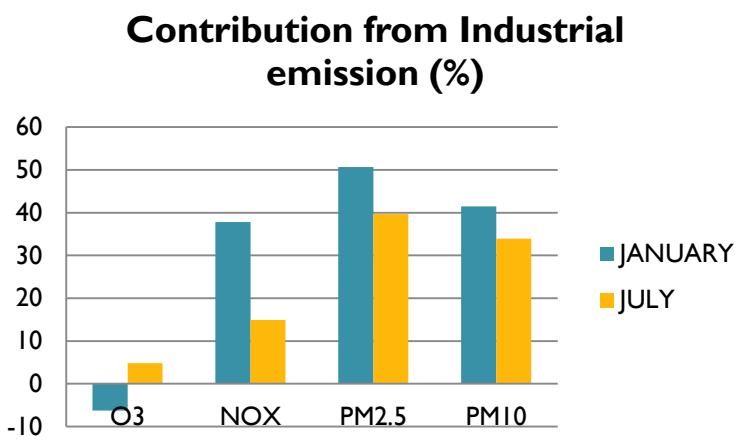


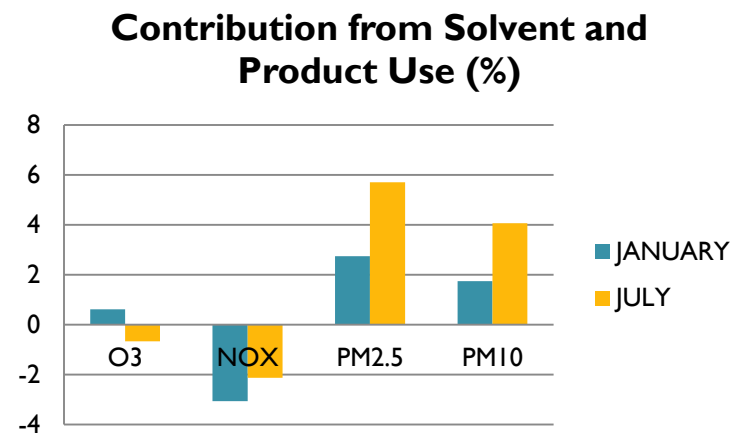
Contribution from transport sector emissions to concentration of Ozone and $PM_{2.5}$ in Europe during January and July 2005

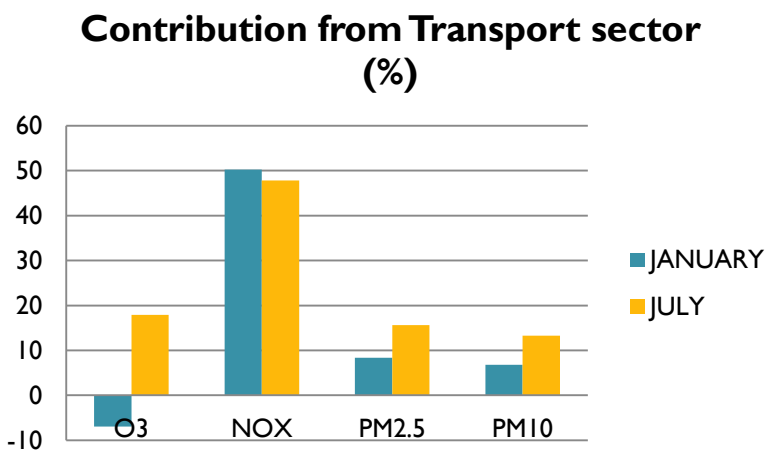


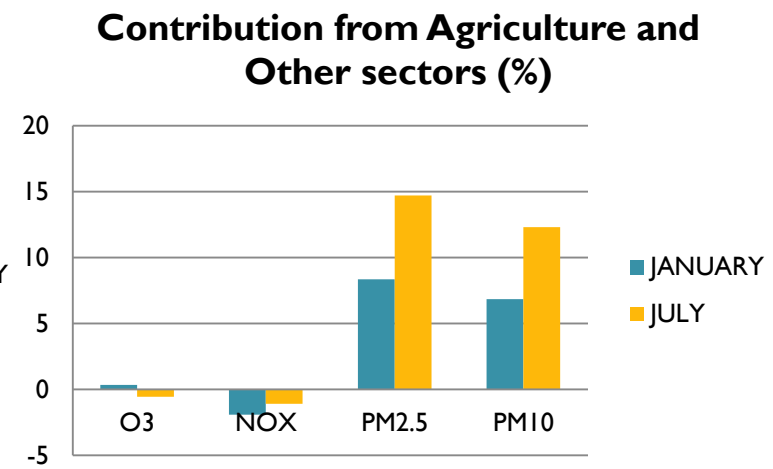
Contribution from Agriculture and other sectors emissions to concentration of Ozone and $PM_{2.5}$ in Europe during January and July 2005




Contribution from Industrial emission (%)
60
50
40
30
20
10
0
-10
O3
NOX
PM2.5
PM10
JANUARY
JULY


Contribution from Solvent and Product Use (%)
8
6
4
2
0
-2
-4
O3
NOX
PM2.5
PM10
JANUARY
JULY


Contribution from Transport sector (%)
60
50
40
30
20
10
0
-10
O3
NOX
PM2.5
PM10
JANUARY
JULY


Contribution from Agriculture and Other sectors (%)
20
15
10
5
0
-5
O3
NOX
PM2.5
PM10
JANUARY
JULY

Conclusion

- The WRF-CMAQ simulation with all emission included (Base run) shows fairly satisfactory performance of the model. However, an underestimation of PM2.5 concentration has been observed in the model simulation.

- The largest impact of emission sources on concentrations occurs in summer than winter in Europe.

- The sensitivity experiments show a negative contribution to ozone concentration in January and positive contribution in July over European land mass. This indicates a seasonal changes in meteorology, photochemical reactions, biogenic emissions etc. influence more on the distribution of ozone concentration than the NOx/VOC emissions.

- All the sources of emission positively contribute to concentration of Particulate matter in Europe. The emission from industrial sources contribute more to PMs compared to the other source sector.

- The results presented here needs to be extended to examine the health impact in different cities in Europe and efforts in these directions are going on.

Thank You