MODELING & ANALYSIS OF AVIATION EMISSIONS IMPACT ON LOCAL AIR QUALITY

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Overview

-Emissions estimations

-Measurements analyses

-Model (WRFChem, CAMx) calculation

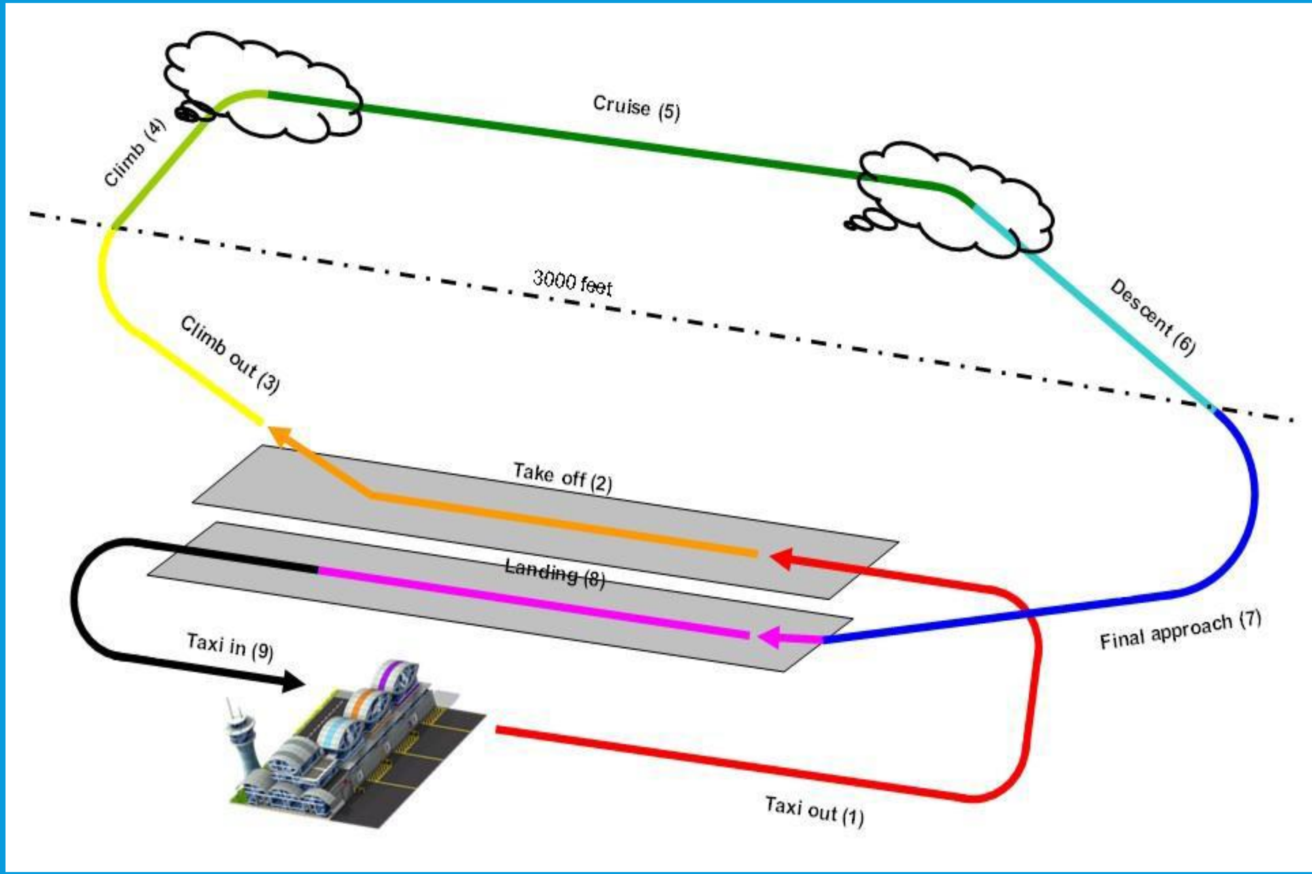
-Conclusions

Aviation emissions

$$E_{pollutant} = AR_{fuel\ consumption} \times EF_{pollutant}$$

TIER 1
The emission factors have been averaged over all flying phases assuming 10 % of the fuel is used in the LTO

The emissions produced by aviation come from the use of jet fuel (jet kerosene and jet gasoline) and aviation gasoline (small piston engine aircraft only)
the principal pollutants (common to other combustion activities)
CO_2, CO, HC and NO, SO_2 (dependent of the level of sulphur in the fuel.)
Other important species, emitted at relatively low concentrations include PM , N_2O and CH_4.



Contribution of air traffic to total emissions

- The total contribution of aircraft emissions to total global anthropogenic CO_2 emissions is considered to be about 2 % (IPCC, 1999).

- This relatively small contribution to global emissions should be seen in relation to the fact that most aircraft emissions are injected almost directly into the upper free troposphere and lower stratosphere. IPCC has estimated that the contribution to radiative forcing is about 3.5 %.

- The importance of this source is growing as the volume of air traffic is steadily increasing.

ICAO LTO cycle
Below 3000 ft

- The ICAO Aircraft Engine Exhaust Databank (AEED) contains rates of fuel flow and emission indices for NOx, HC and CO as a function of the engine thrust setting for a large number of types of aircraft engine.

TABLE 1-50
EXAMPLES OF AIRCRAFT TYPES AND EMISSION FACTORS FOR LTO CYCLES AS WELL AS FUEL CONSUMPTION PER AIRCRAFT TYPE

	Emission factors (kg/LTO)							Fuel consumption (kg/LTO)
Aircraft type[a]	CO_2	CH_4 [b]	N_2O[c]	NO_X	CO	NMVOC[b]	SO_2[d]	
A300	5470	1.0	0.2	27.21	34.4	9.3	1.7	1730
A310	4900	0.4	0.2	22.7	19.6	3.4	1.5	1550
A320	2560	0.04	0.1	11.0	5.3	0.4	0.8	810
BAC1-11	2150	6.8	0.1	4.9	67.8	61.6	0.7	680
BAe 146	1800	0.16	0.1	4.2	11.2	1.2	0.6	570
B707*	5880	9.8	0.2	10.8	92.4	87.8	1.9	1860
B727	4455	0.3	0.1	12.6	9.1	3.0	1.4	1410
B727*	3980	0.7	0.1	9.2	24.5	6.3	1.3	1260
B737-200	2905	0.2	0.1	8.0	6.2	2.0	0.9	920
B737*	2750	0.5	0.1	6.7	16.0	4.0	0.9	870
B737-400	2625	0.08	0.1	8.2	12.2	0.6	0.8	830
B747-200	10680	3.6	0.3	53.2	91.0	32.0	3.4	3380
B747*	10145	4.8	0.3	49.2	115	43.6	3.2	3210
B747-400	10710	1.2	0.3	56.5	45.0	10.8	3.4	3390
B757	4110	0.1	0.1	21.6	10.6	0.8	1.3	1300
B767	5405	0.4	0.2	26.7	20.3	3.2	1.7	1710
Caravelle*	2655	0.5	0.1	3.2	16.3	4.1	0.8	840
DC8	5890	5.8	0.2	14.8	65.2	52.2	1.9	1860
DC9	2780	0.8	0.1	7.2	7.3	7.4	0.9	880
DC10	7460	2.1	0.2	41.0	59.3	19.2	2.4	2360
F28	2115	5.5	0.1	5.3	54.8	49.3	0.7	670
F100	2340	0.2	0.1	5.7	13.0	1.2	0.7	740
L1011*	8025	7.3	0.3	29.7	112	65.4	2.5	2540
SAAB 340	945	1.4(E)	0.03(E)	0.3(E)	22.1(E)	12.7(E)	0.3(E)	300(E)
Tupolev 154	6920	8.3	0.2	14.0	116.81	75.9	2.2	2190
Concorde	20290	10.7	0.6	35.2	385	96	6.4	6420
GAjet	2150	0.1	0.1	5.6	8.5	1.2	0.7	680

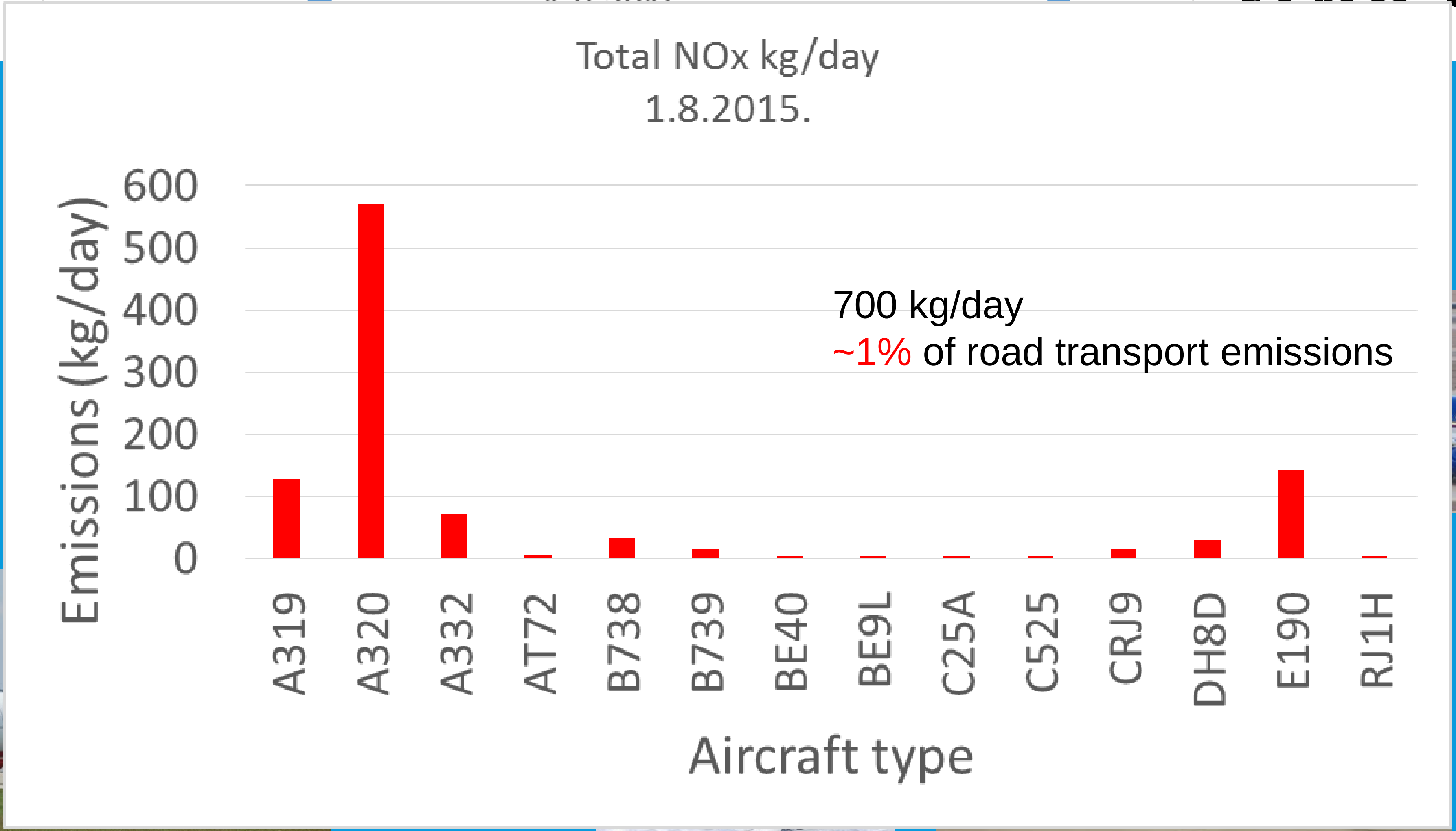
Source: ICAO (1995).

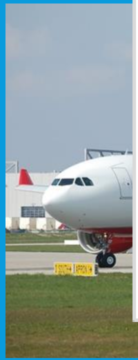
Aircraft movements-Eurocontrol database

*Emissions_LTO= Activity(N_ LTO cyclus)*E_LTO*

DDR2
SAAM tool

Emissions per type and freq.





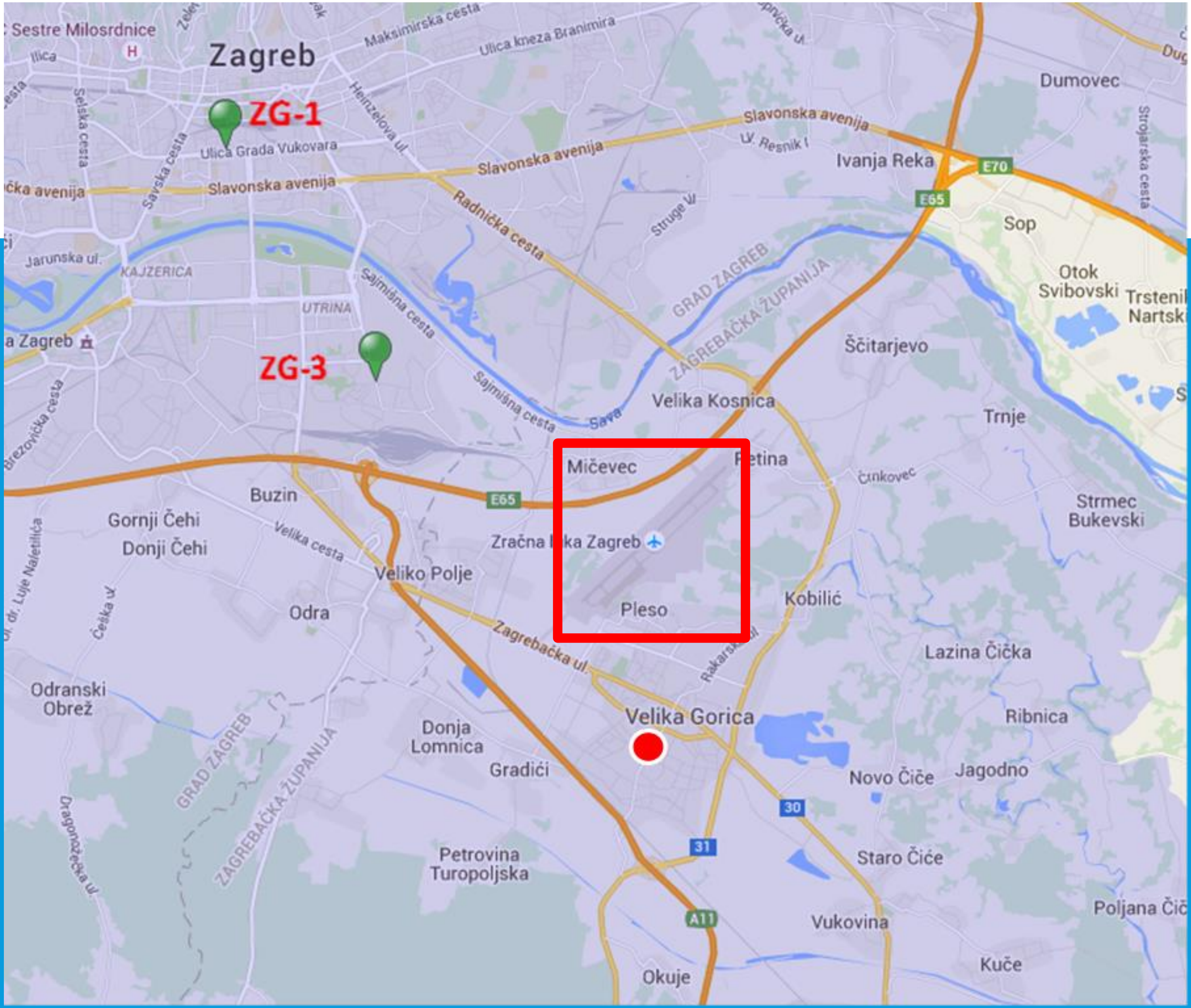
AQ Measurements

Emission contribution quantified through monitoring

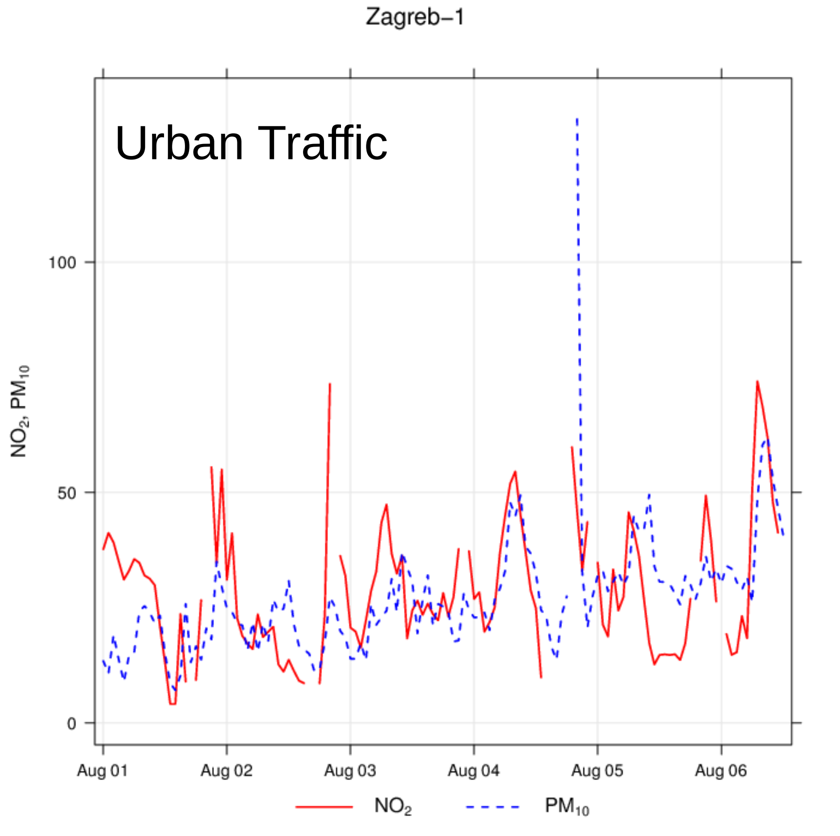
Gorica
~1 km SE (NOx)

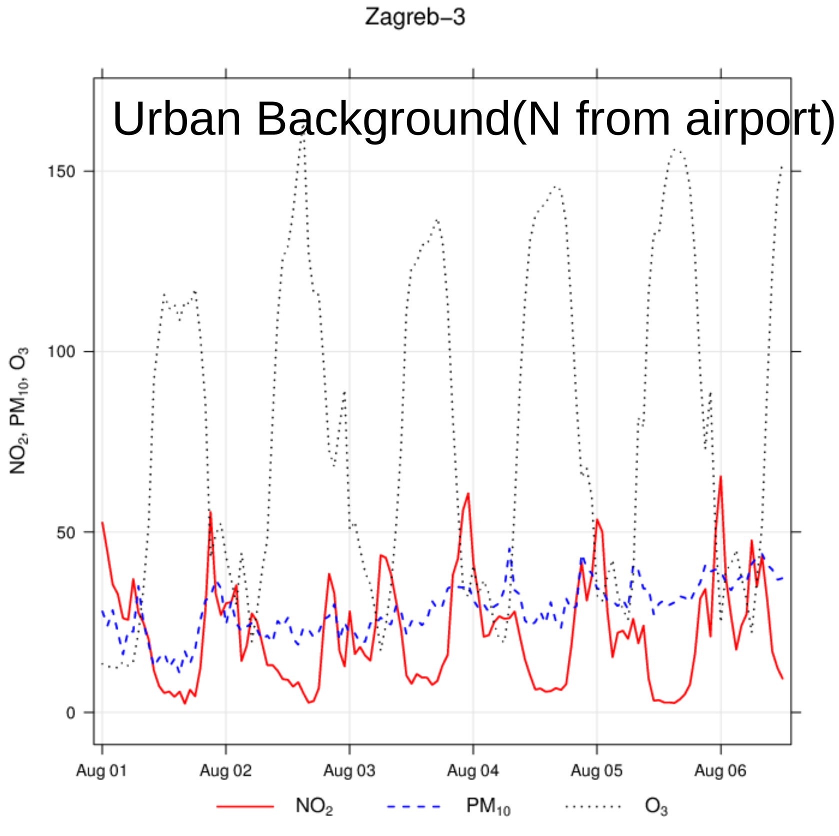
ZG3 (UB)
~ 3.5 km NW (NOx, O3, SO2,CO, PM10)

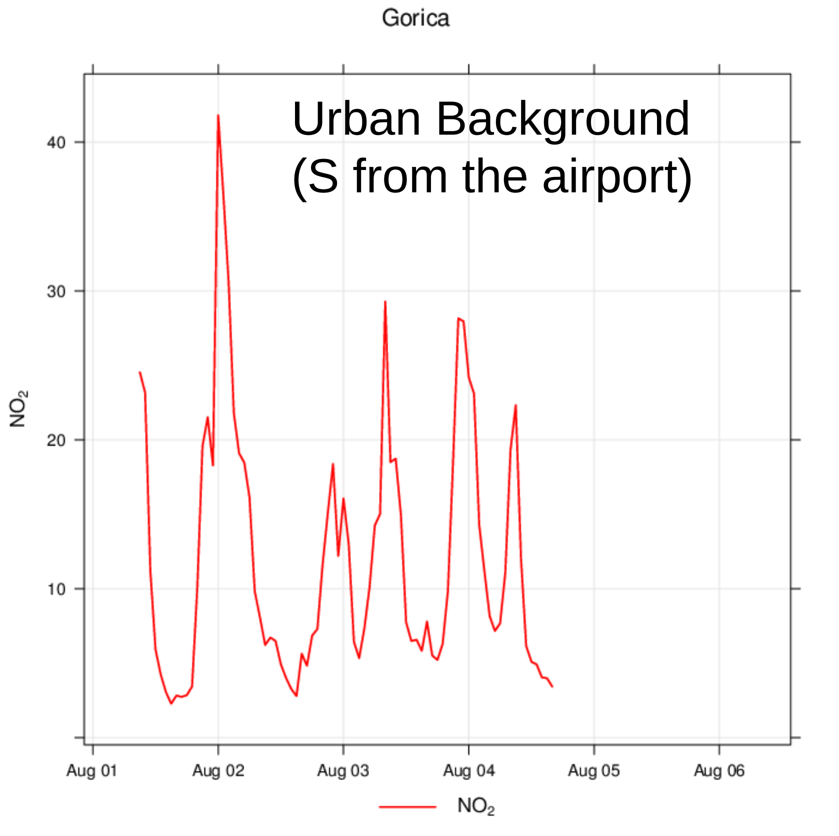
ZG1 (UT)
~ 6 km NW (NOx, PM10, CO, SO2)

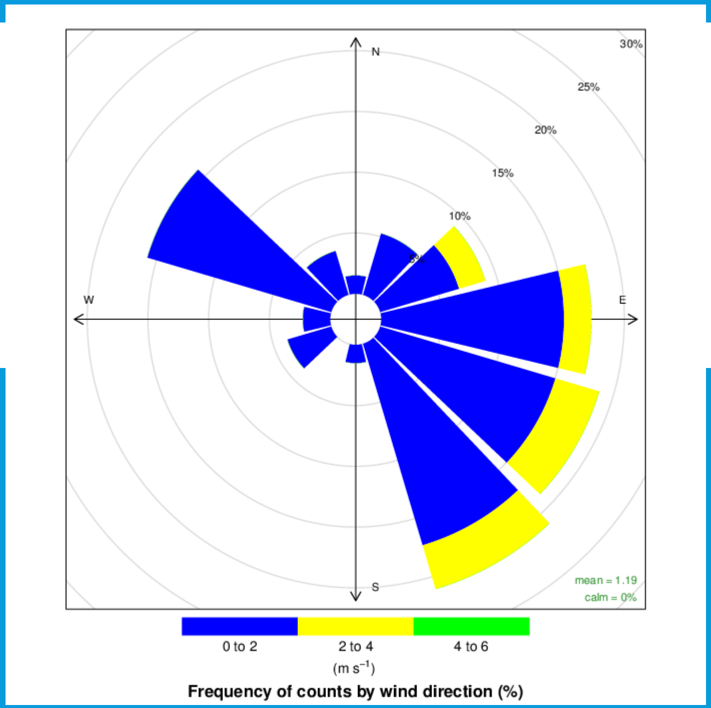


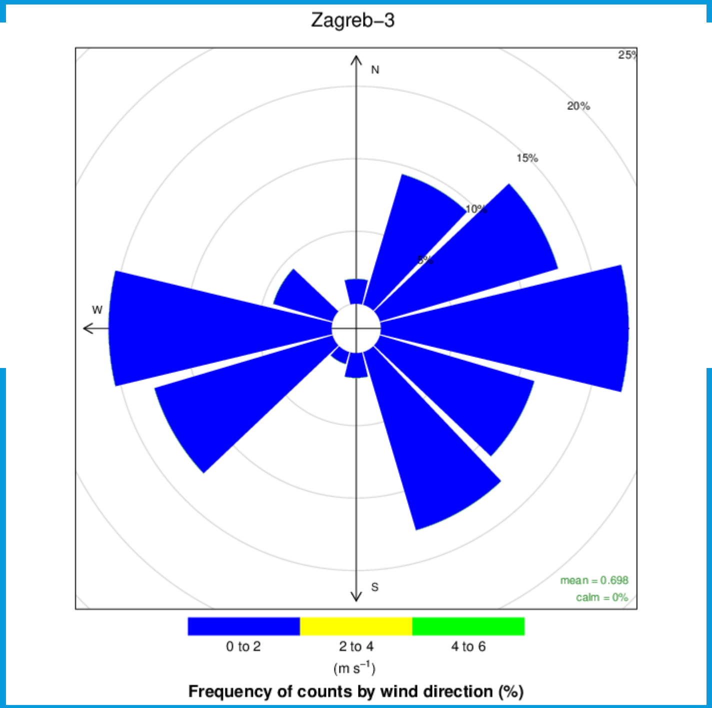
Measurements-time series

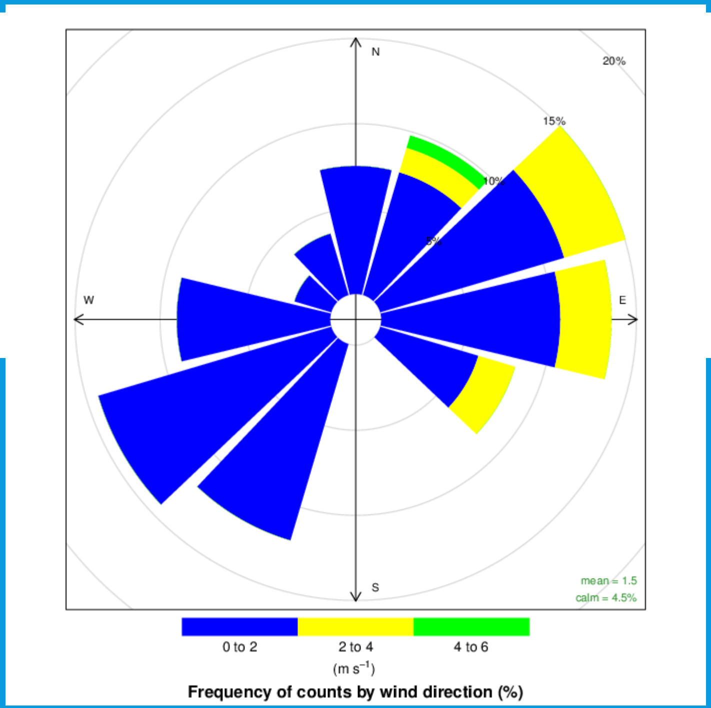


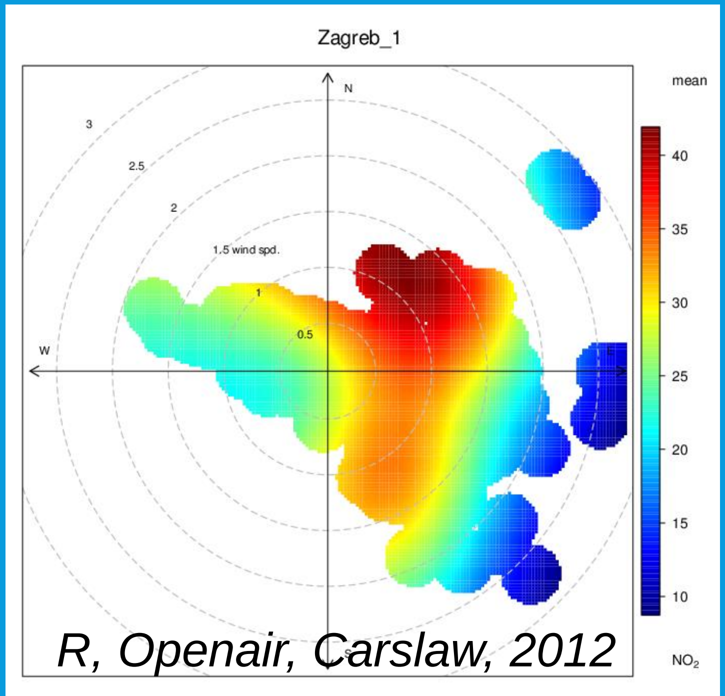




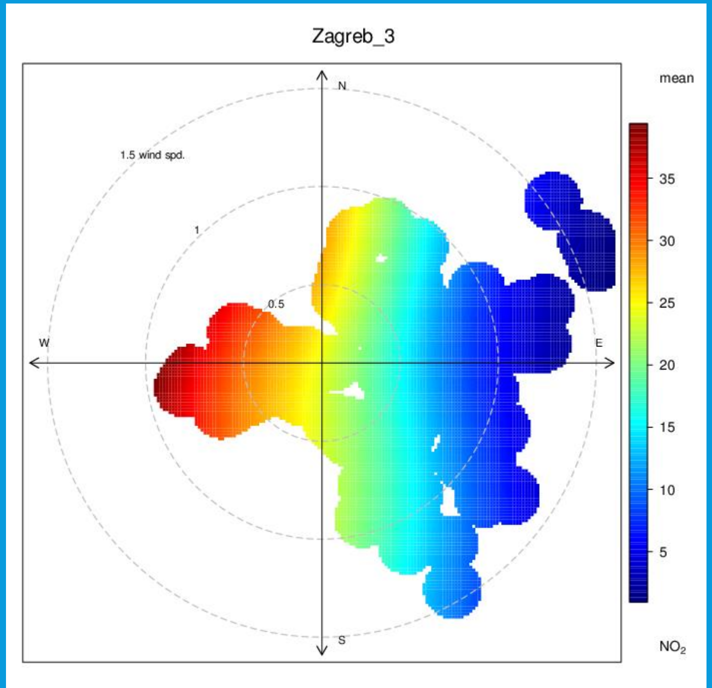


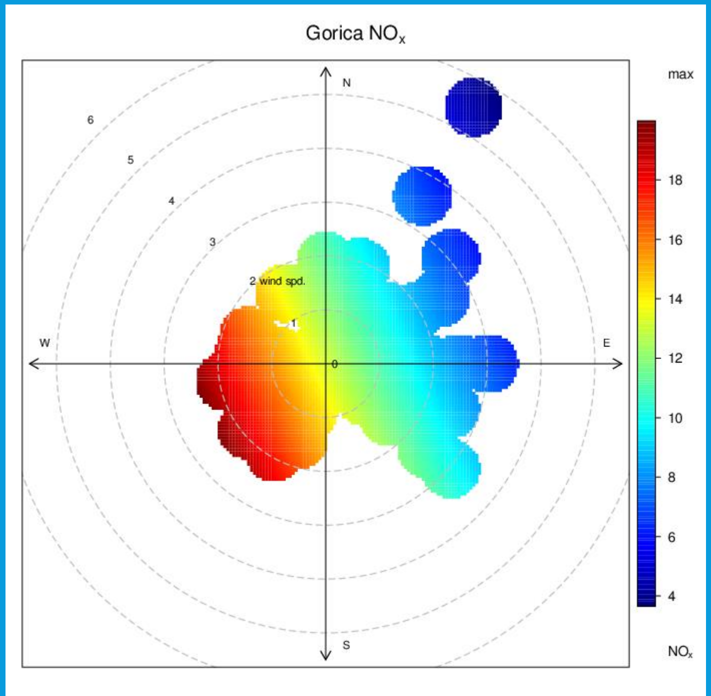






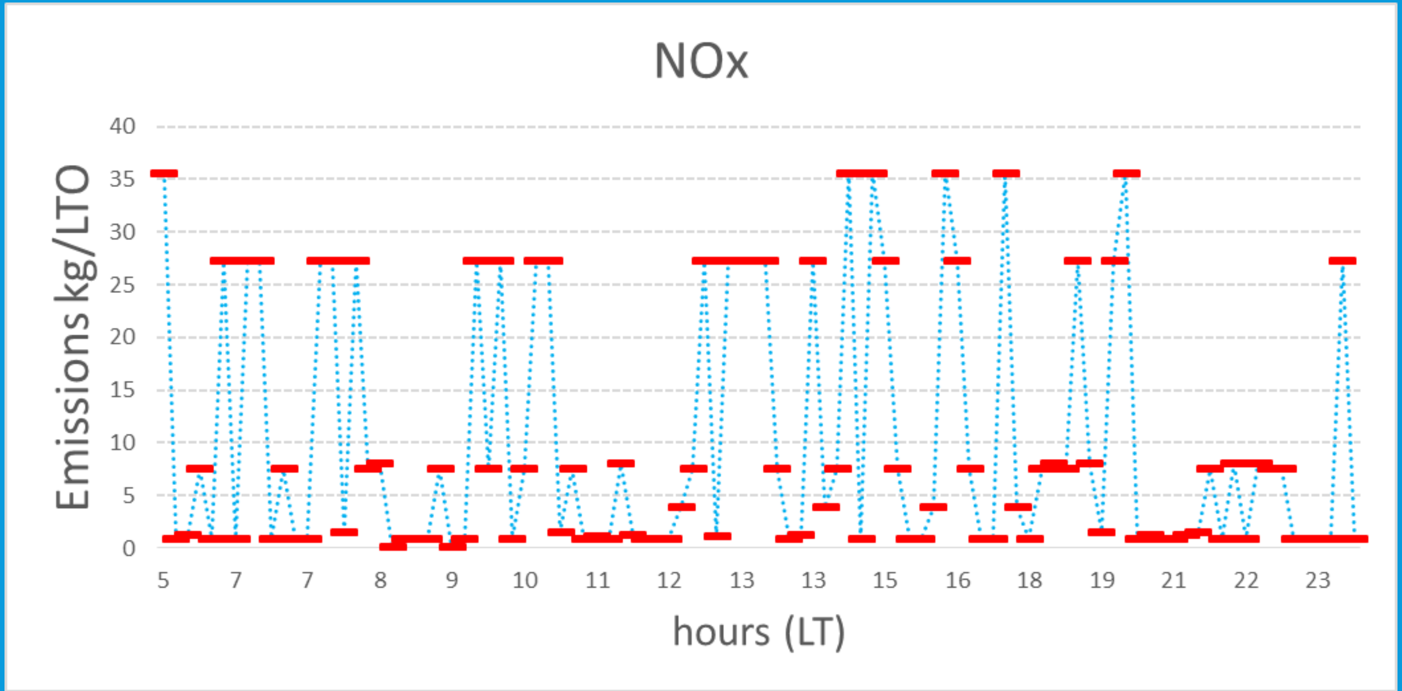
R, Openair, Carslaw, 2012

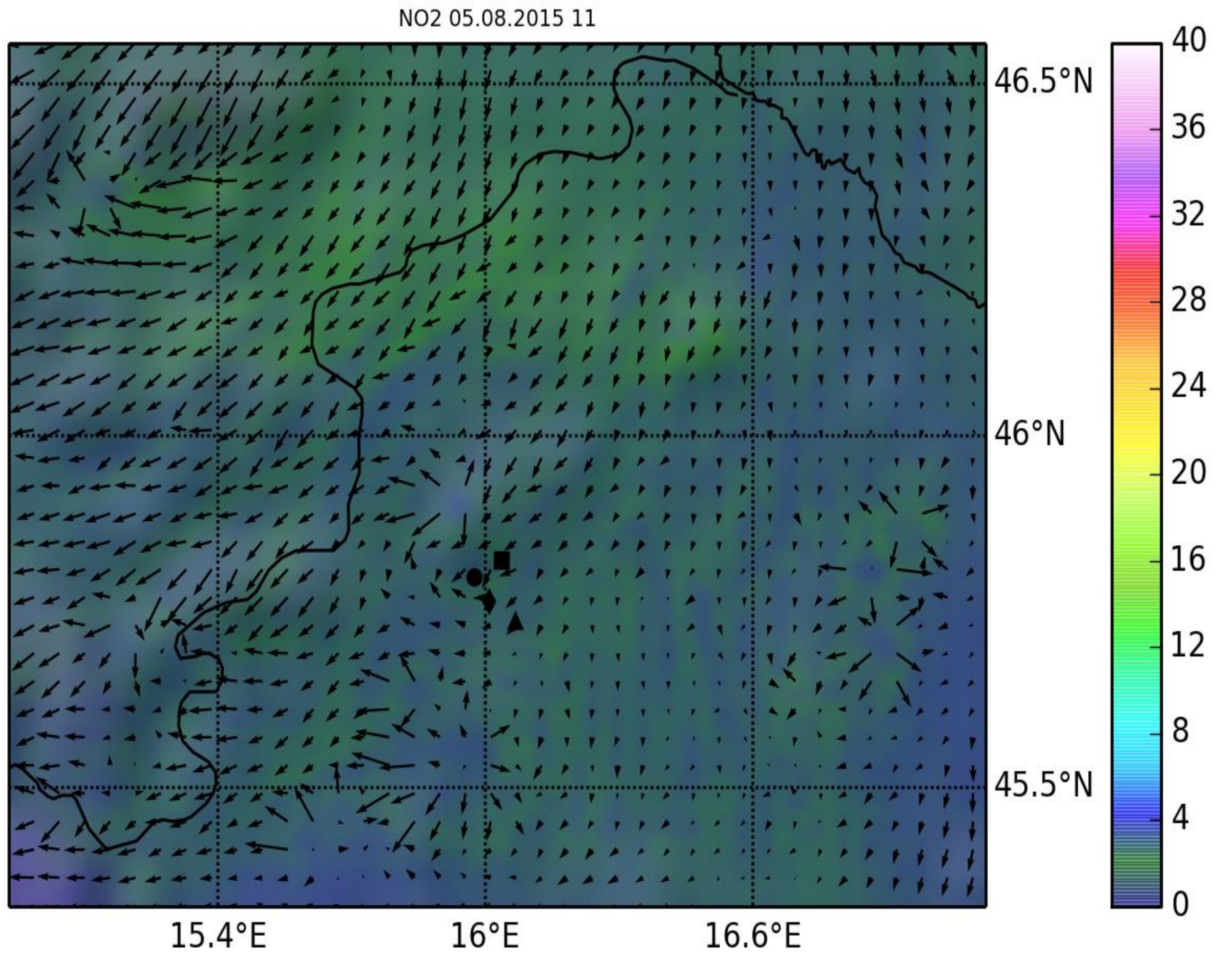


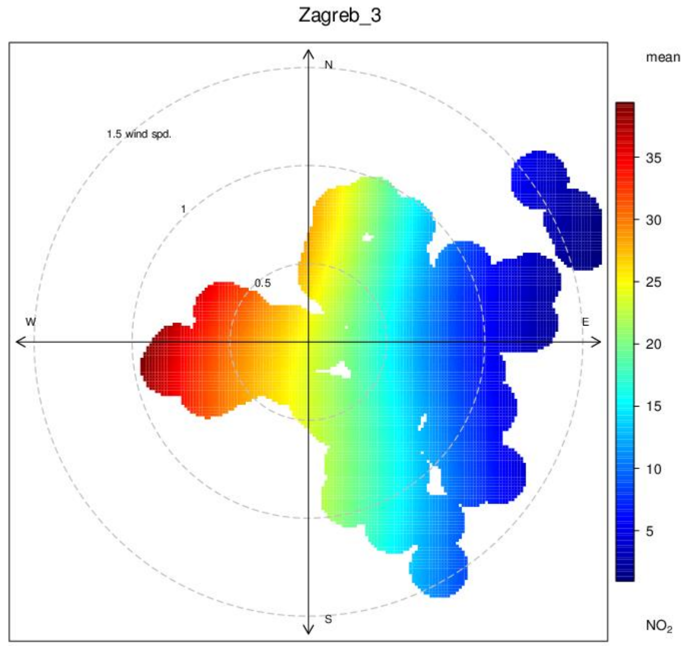


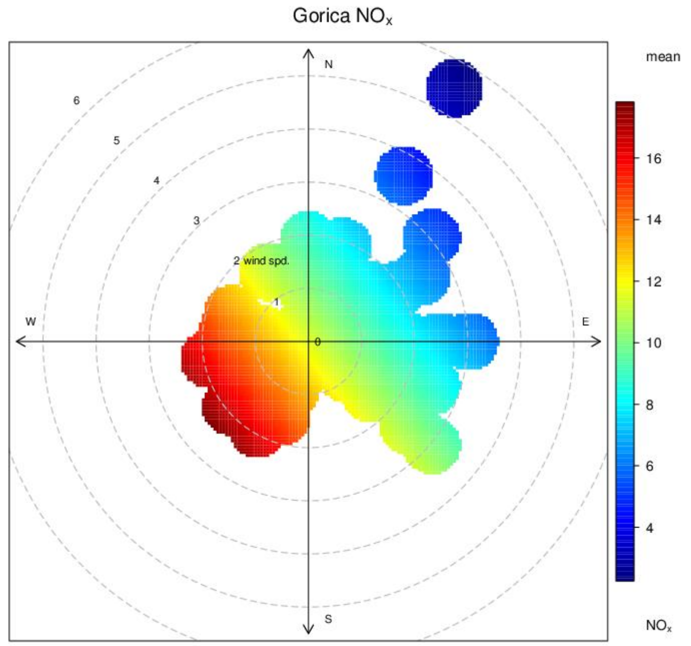
WRFChem & CAMx

Model was run for the case study period 1.-6. August 2015.
-Models setup horizontal domains (2.2 km x 2.2 km), 50 vertical levels
EMISSIONS
-Anthropogenic emissions- RETRO/EDGARv4
-aviation emissions: vertically agregated in the grid in WRFChem and CAMx

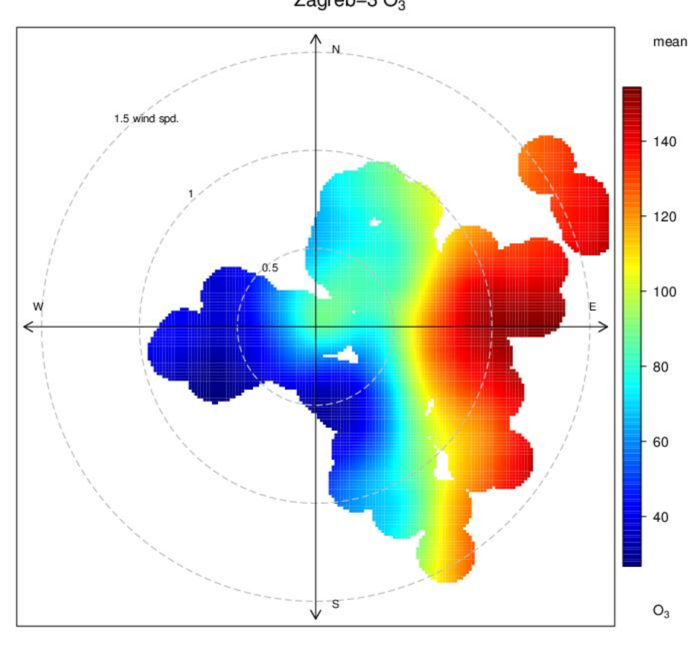


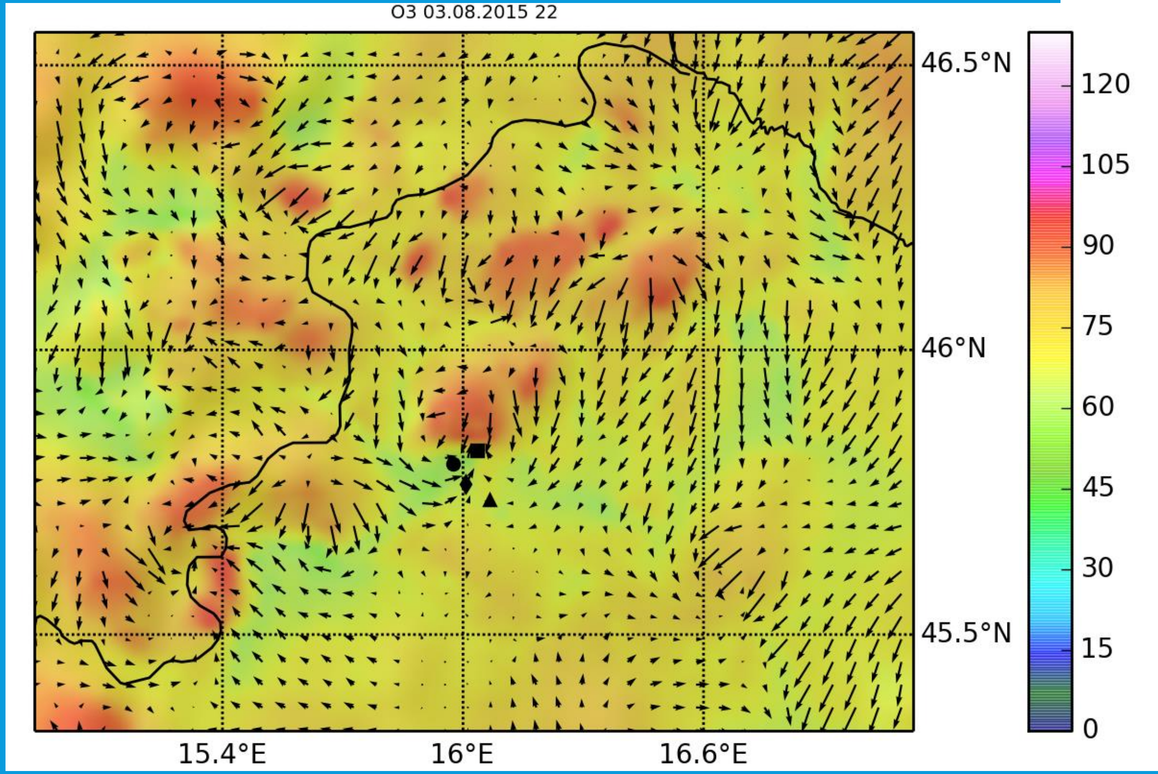

NO2 05.08.2015 11
46.5°N
46°N
45.5°N
15.4°E
16°E
16.6°E
40
36
32
28
24
20
16
12
8
4
0

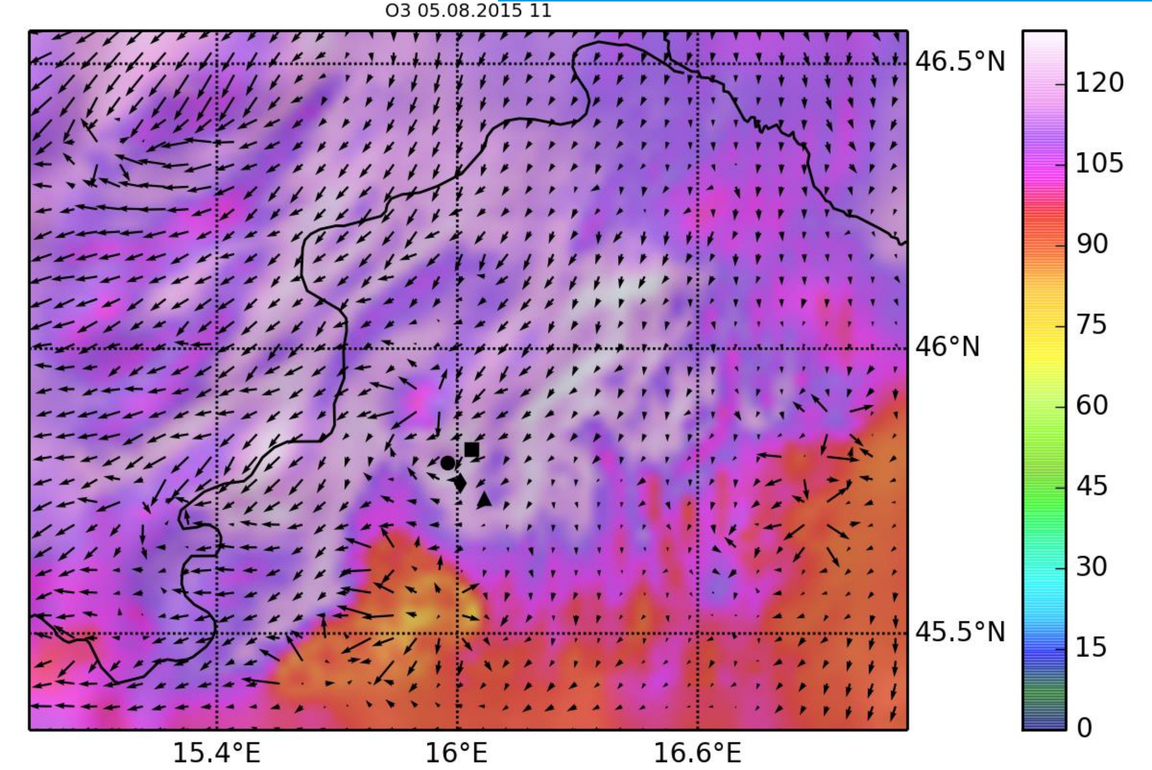

Zagreb_3
mean
N
S
W
E
1.5 wind spd.
1
0.5
35
30
25
20
15
10
5
NO_2


Gorica NO_x
mean
N
S
W
E
6
5
4
3
2 wind spd.
1
0
16
14
12
10
8
6
4
NO_x

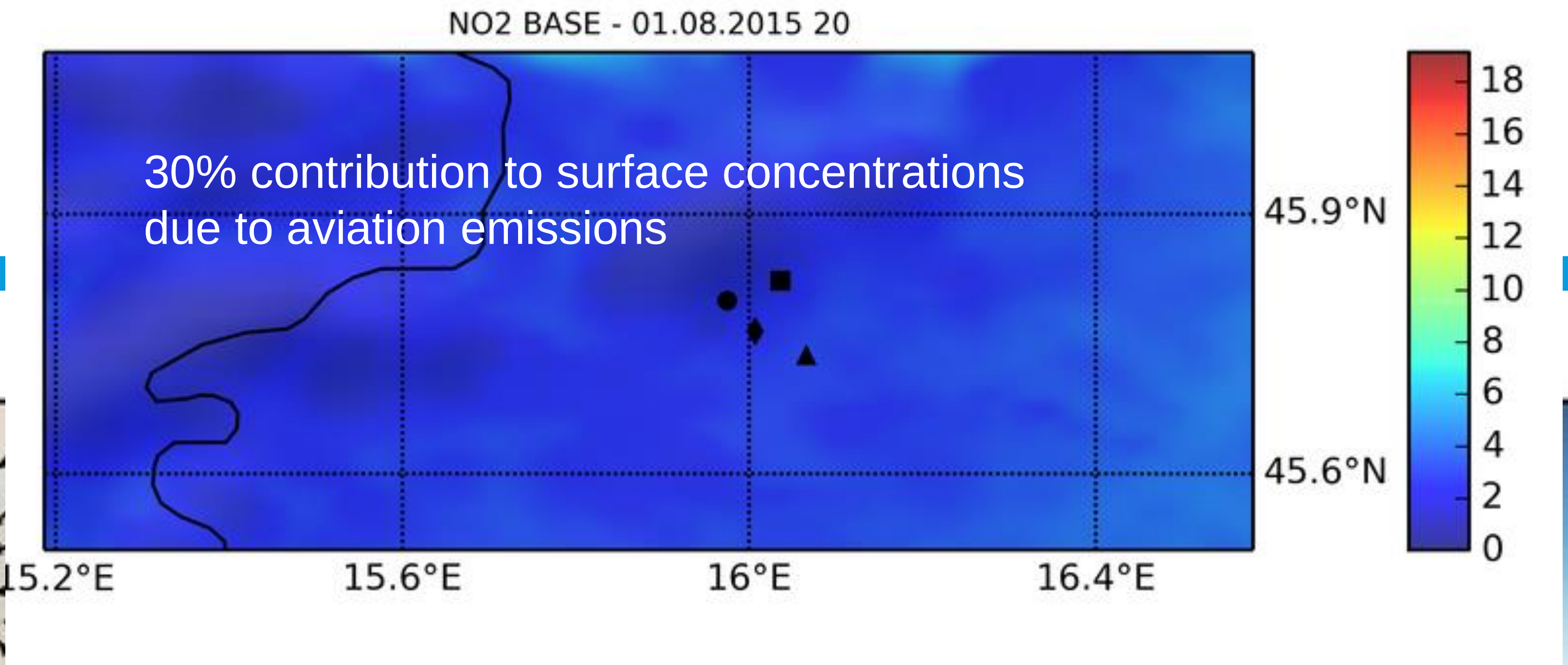
Ozone


mean
1.5 wind spd.
1
0.5
N
W
E
S
140
120
100
80
60
40
O_3

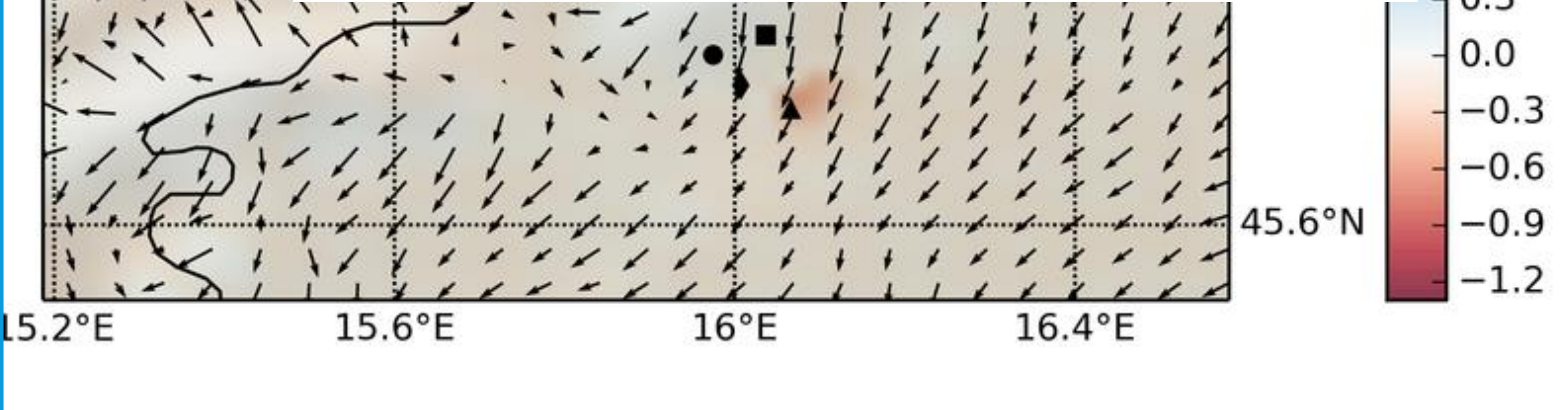

O3 03.08.2015 22
46.5°N
46°N
45.5°N
15.4°E
16°E
16.6°E
120
105
90
75
60
45
30
15
0


O3 05.08.2015 11
46.5°N
46°N
45.5°N
15.4°E
16°E
16.6°E
120
105
90
75
60
45
30
15
0

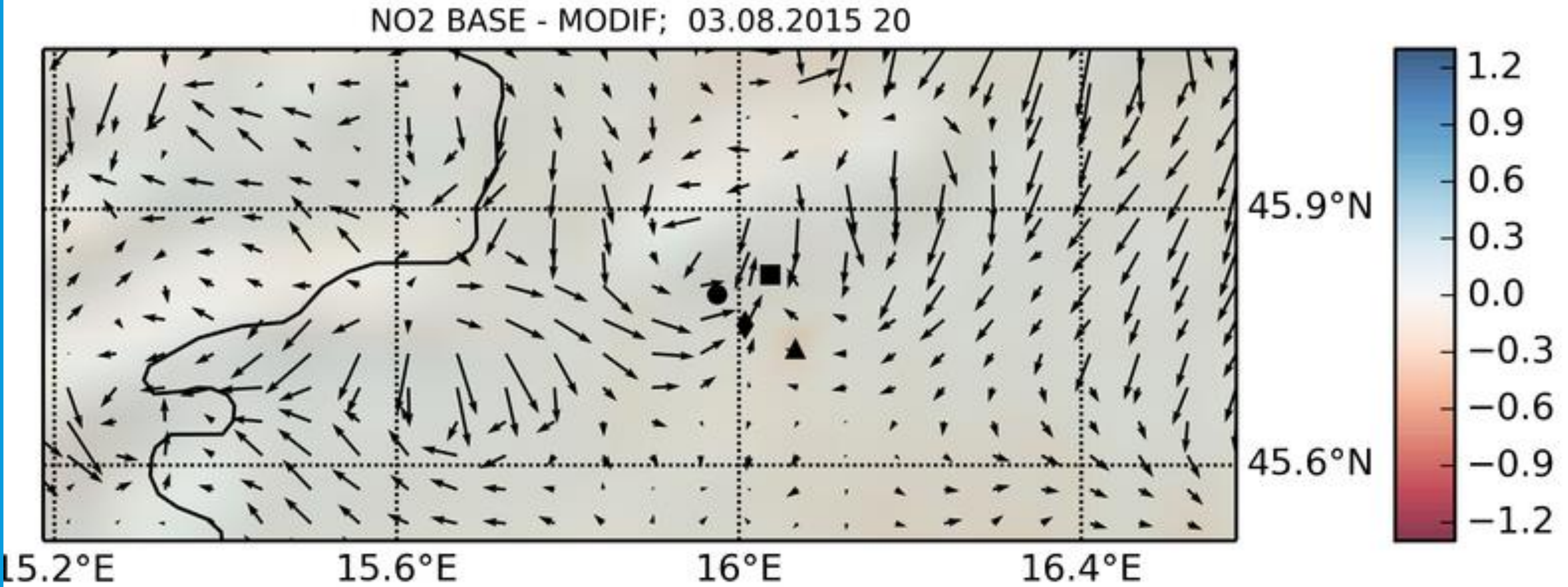
CAMx

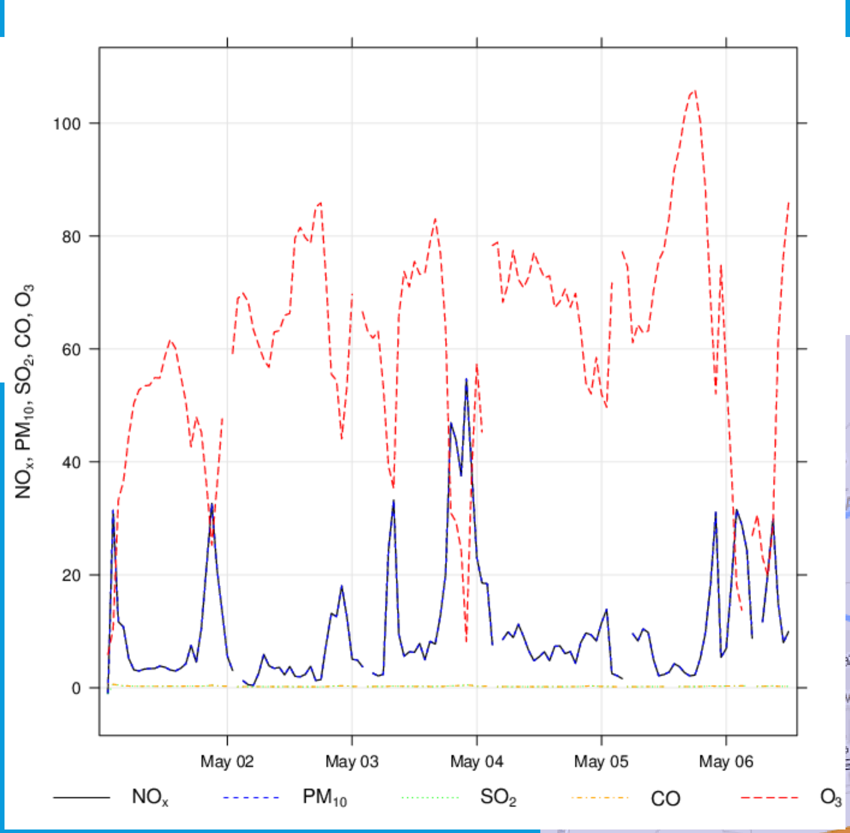


30% contribution to surface concentrations
due to aviation emissions

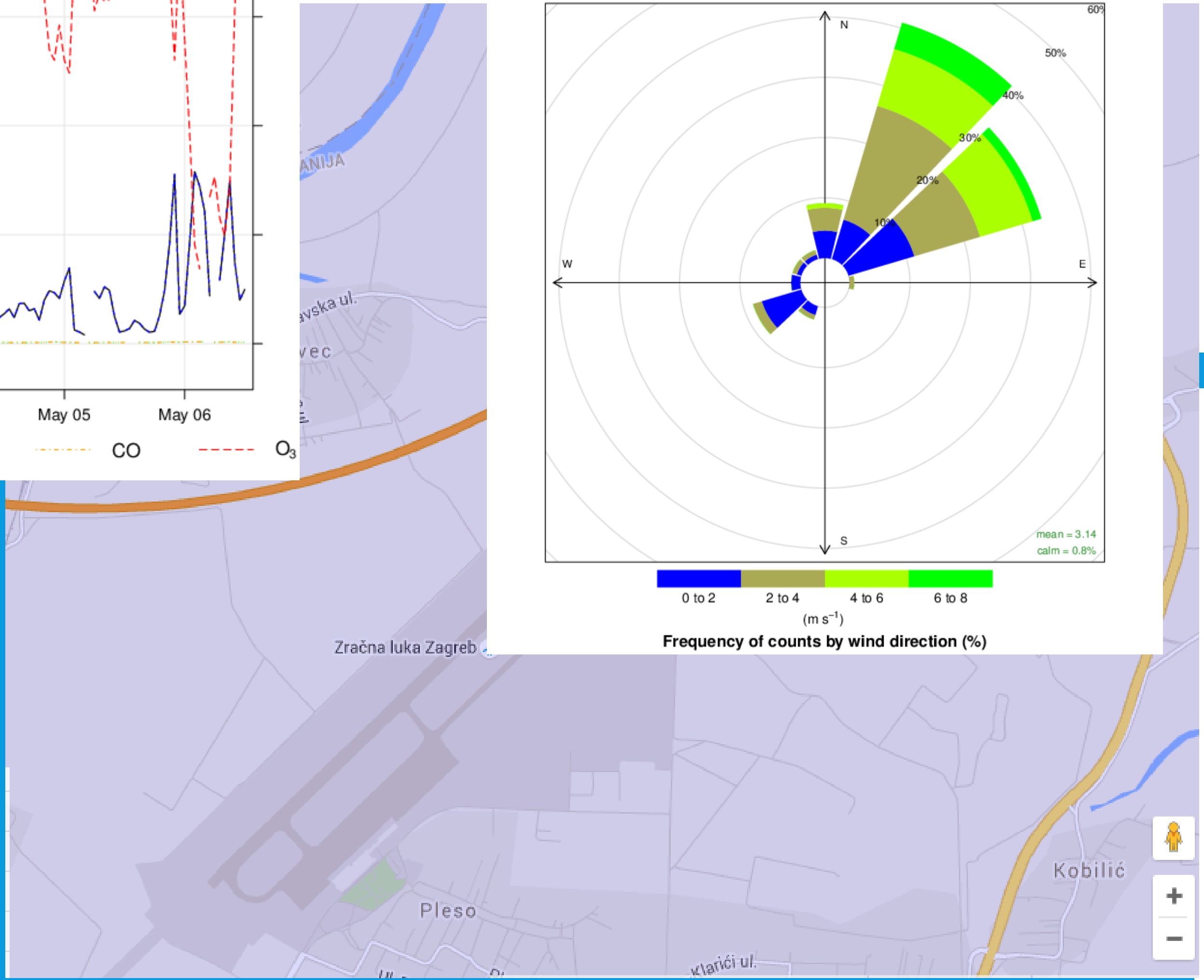


CAMx-cont

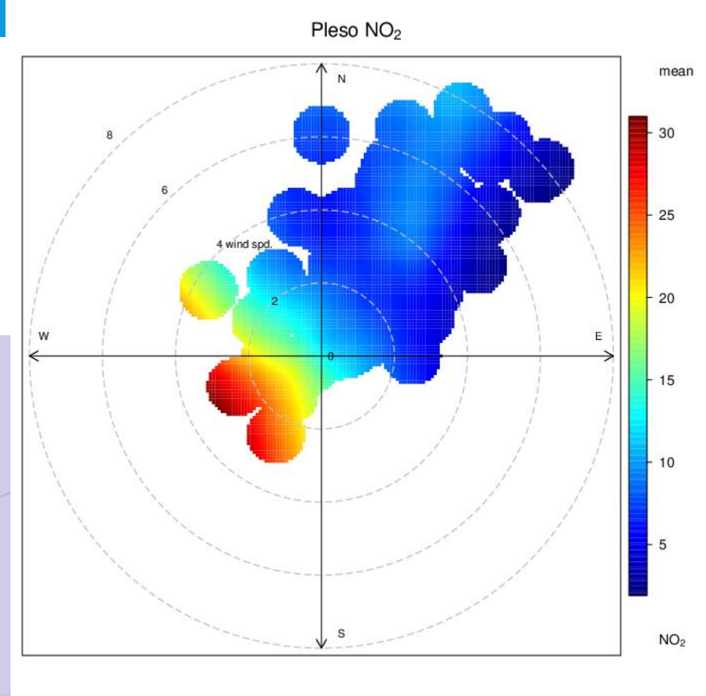

NO2 BASE - MODIF; 03.08.2015 20
45.9°N
45.6°N
15.2°E
15.6°E
16°E
16.4°E
1.2
0.9
0.6
0.3
0.0
−0.3
−0.6
−0.9
−1.2



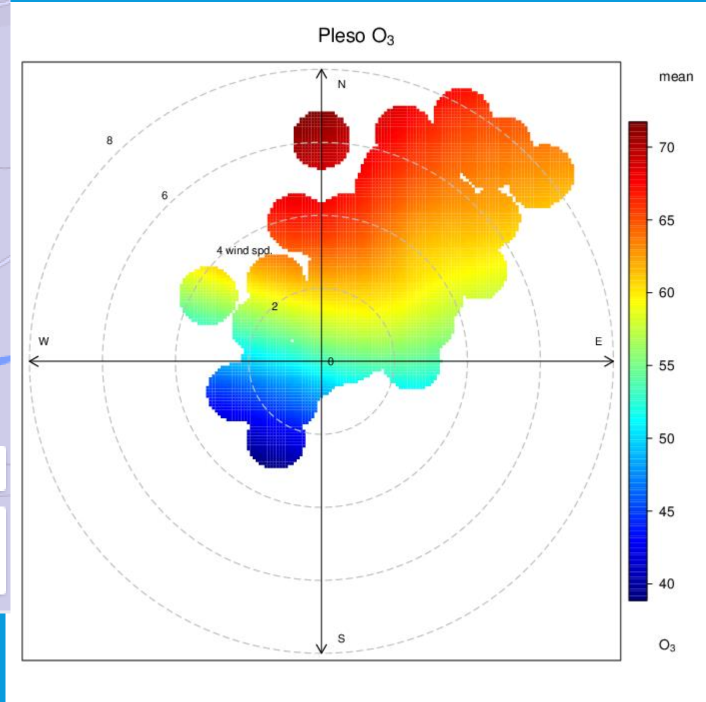
NO_x, PM_{10}, SO_2, CO, O_3
100
80
60
40
20
0
May 02
May 03
May 04
May 05
May 06
NO_x
PM_{10}
SO_2
CO
O_3



Zračna luka Zagreb
Pleso
Kobilić
Klarići ul.
N
E
S
W
10%
20%
30%
40%
50%
60%
mean = 3.14
calm = 0.8%
0 to 2
2 to 4
4 to 6
6 to 8
(m s^{-1})
Frequency of counts by wind direction (%)



Pleso NO_2
mean
N
E
S
W
8
6
4 wind spd.
2
0
30
25
20
15
10
5
NO_2



Pleso O_3
mean
N
E
S
W
8
6
4 wind spd.
2
0
70
65
60
55
50
45
40
O_3

Conclusions

- WRFChem well represented the wind flow but both models underestimated night time NO2 – road transport emissions not well represented

- CAMx contribution due to aviation emissions up to 30%

- Bivariate polar plot usefull toll for assesing the sources of AP but the stations representativity should be carefully assessed

Future plans

- *Deatiled Emissions*

- There is currently little information available to estimate emissions from start up of engines and these are not included in the LTO cycle. This is not of great importance for total national emissions, but they may have an impact on the air quality in the vicinity of airports.

- *Models (ADMS)*

- *Mesurements-longer time periods and pollutants e.g. PM-fine*