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New Sensing Technologies for Indoor Air Quality Monitoring: Trends and Challenges

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Numerical Study of Atmospheric Composition in Urban Areas - Some Preliminary Results for the City of Sofia

I.Georgieva, G.Gadzhev, K.Ganev, D.Syrakov, M.Prodanova,N.Miloshev

National Institute of Geophysics, Geodesy and Geography,

National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences

Sofia, Bulgaria

iivanova@geophys.bas.bg

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Objectives:

- Study of regularities of atmospheric pollution in local and urban scale.

- The simulations aimed at constructing of ensemble, comprehensive enough as to provide statistically reliable assessment of the atmospheric composition climate of Sofia city - typical and extreme features of the special/temporal behavior, annual means and seasonal variations, etc.

- Utilization of the computer simulated ensemble for studying the AQI climate in Sofia. Calculation of AQI for the Sofia city. Analysis of its spatial - temporal behavior.

- Local transport processes and chemical transformations in the atmosphere of urban areas. Determining the contribution of different types of pollutants and pollution sources to the selected city – Sofia.

Activities:

Modeling tools – US EPA Models-3 System:

- **WRF** (Shamarock et al. 2007) used as meteorological pre-processor;
- **CMAQ** - the Community Multiscale Air Quality System (Byun et al., 1998, Byun and Ching, 1999) - the Chemical Transport Model (CTM)
- **SMOKE** - the Sparse Matrix Operator Kernel Emissions Modelling System (CEP, 2003) – the emission pre-processor.

Input Data

The simulations were performed day by day for a period of 7 years – from 2008 to 2014.

Meteorological data

NCEP Global Analysis Data with 1º×1º resolution in Grib2 format at every 6 hours.

5 nested domains for WRF
D1 (Europe) – 81 x 81 km
D2 (Balkan peninsula) – 27 x 27 km
D3 (Bulgaria) – 9 x 9 km
D4 (Sofia municipality) – 3 x 3 km
D5 (Sofia city) – 1 x 1 km

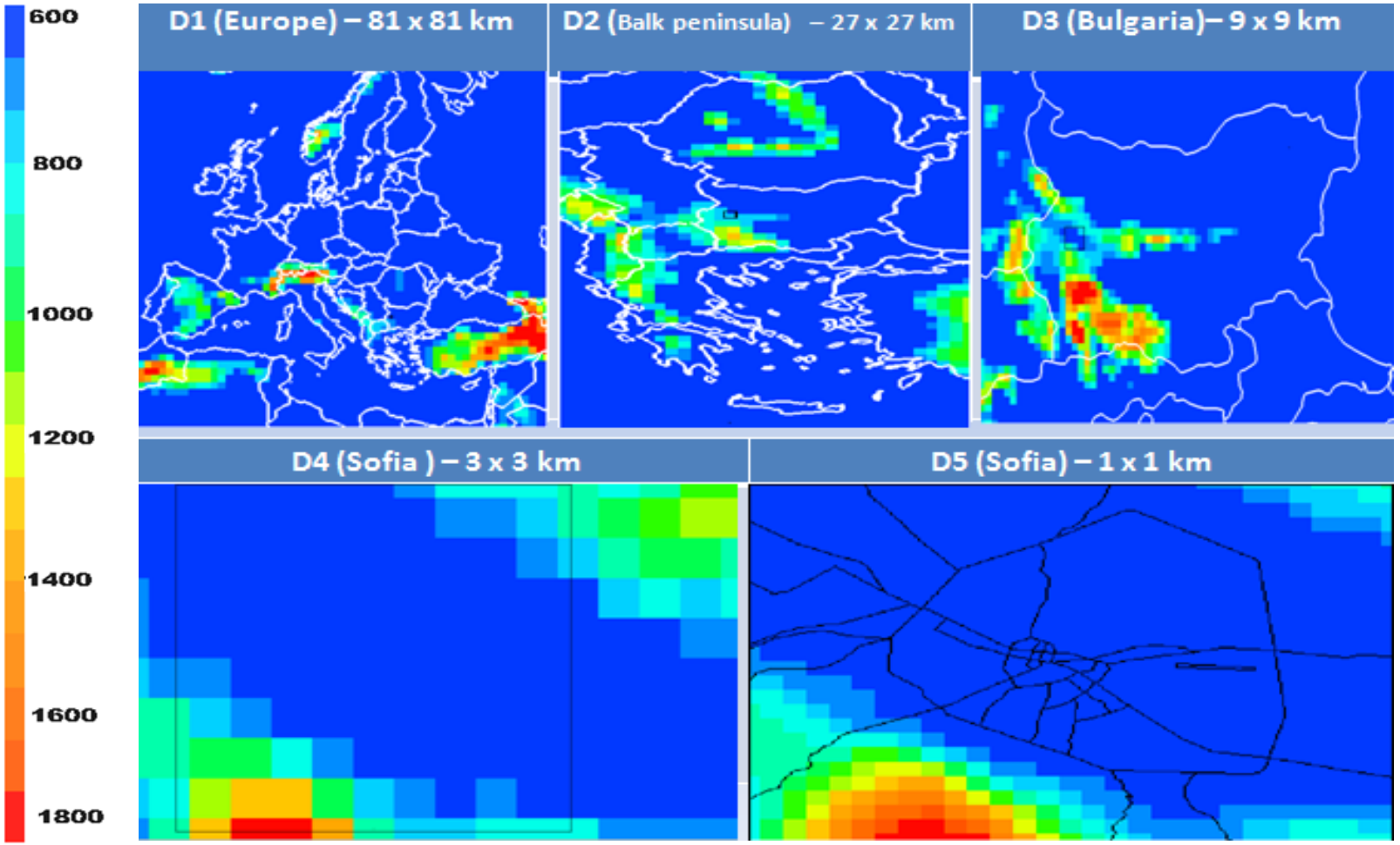
Emission data

The national emission inventory - for Bulgaria, outside the country - TNO with 0.25ºx0.125º in 10 SNAP categories. The biogenic emissions of VOC are estimated by the model SMOKE.

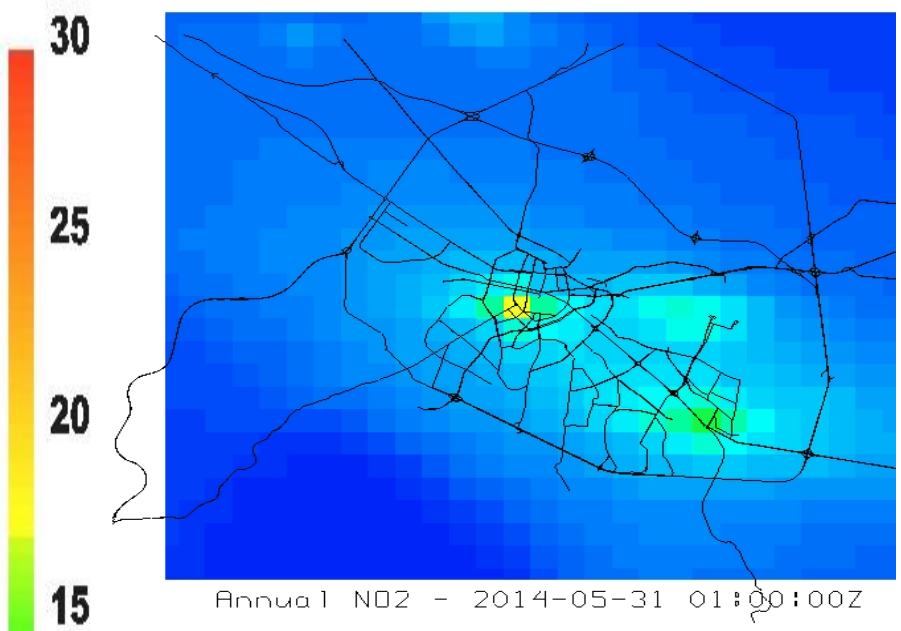
4 nested domains for CMAQ
D2 (Balkan peninsula) – 27 x 27 km
D3 (Bulgaria) – 9 x 9 km
D4 (Sofia municipality) – 3 x 3 km
D5 (Sofia city) – 1 x 1 km

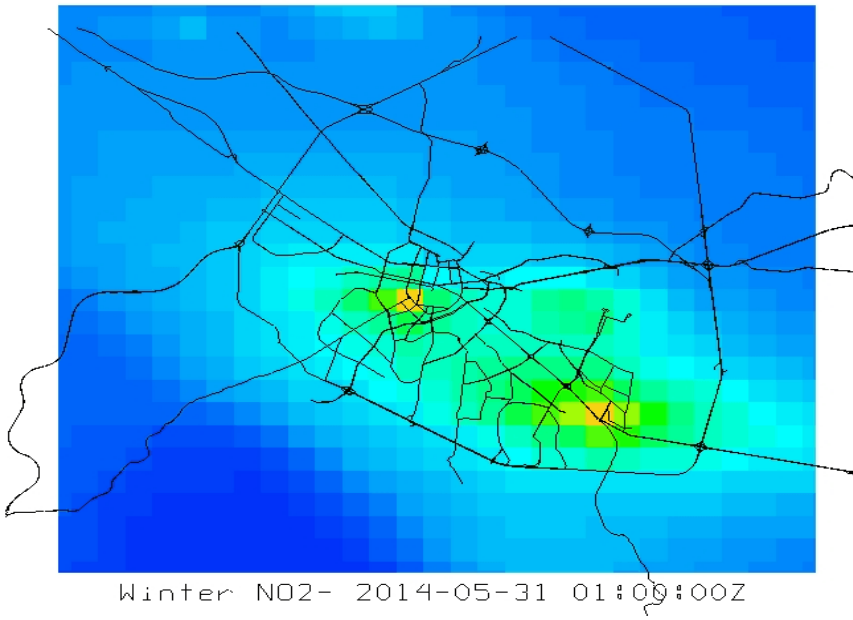
Downscaling effect:

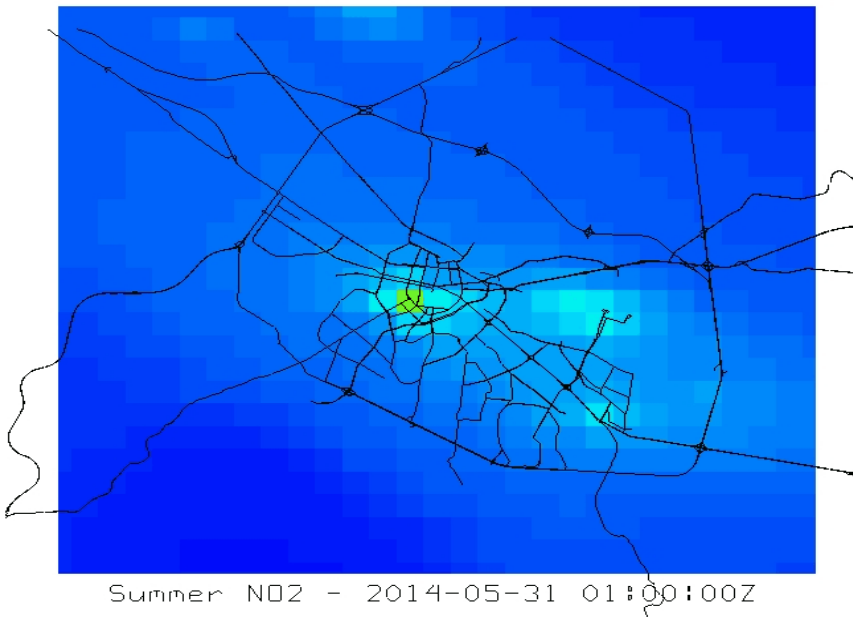
WRF and CMAQ nesting capabilities are applied for downscaling the simulations to a 1 km step for the innermost domain (Sofia).



Annual and seasonal surface NO_2 concentrations *[$\mu g/m^3$]*







✓ Higher NO_2 concentrations early in the morning and smaller at noon

✓Bigger winter NO_2 concentrations than in summer

✓The maximal concentrations are formed in the city centre and along the boulevard with most busy traffic

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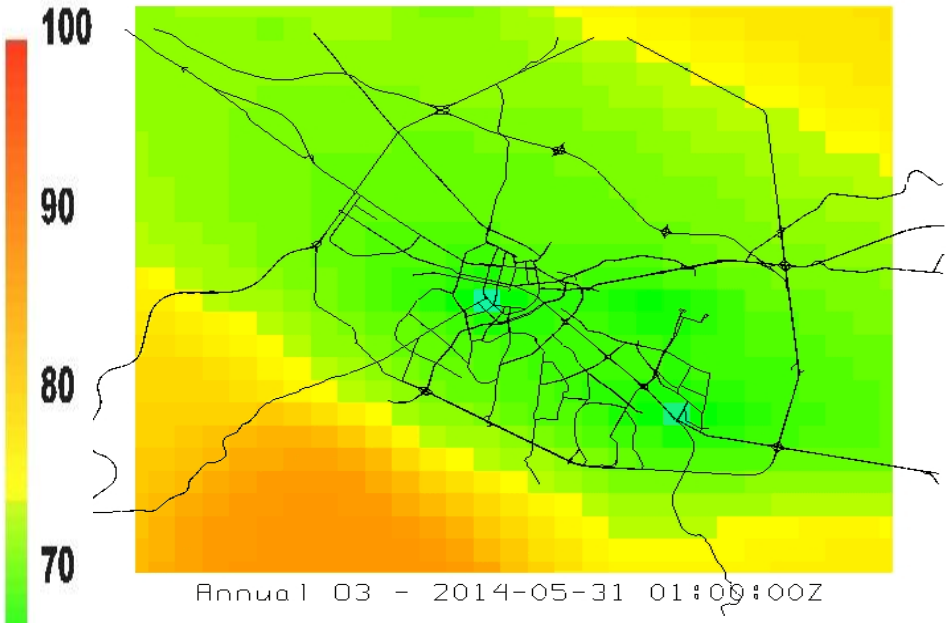
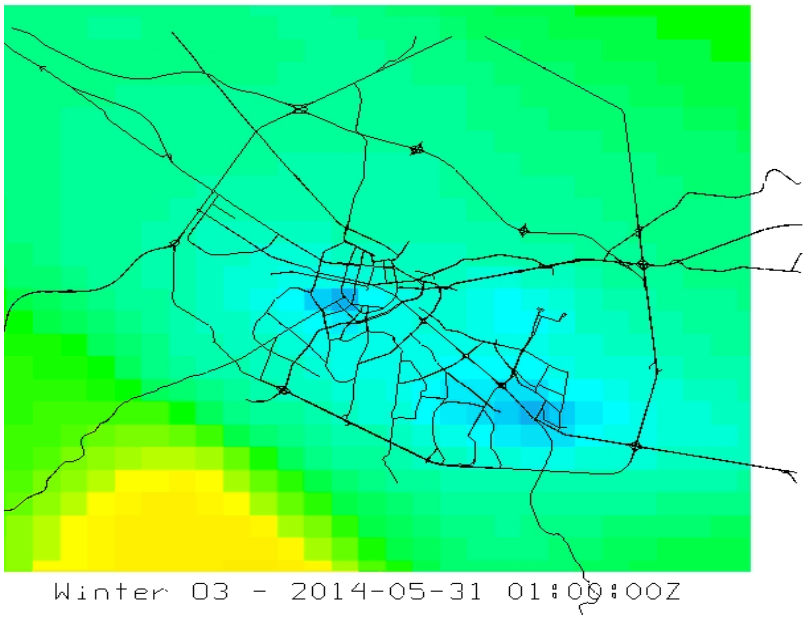
Annual and seasonal surface O_3 concentrations *[$\mu g/m^3$]* :



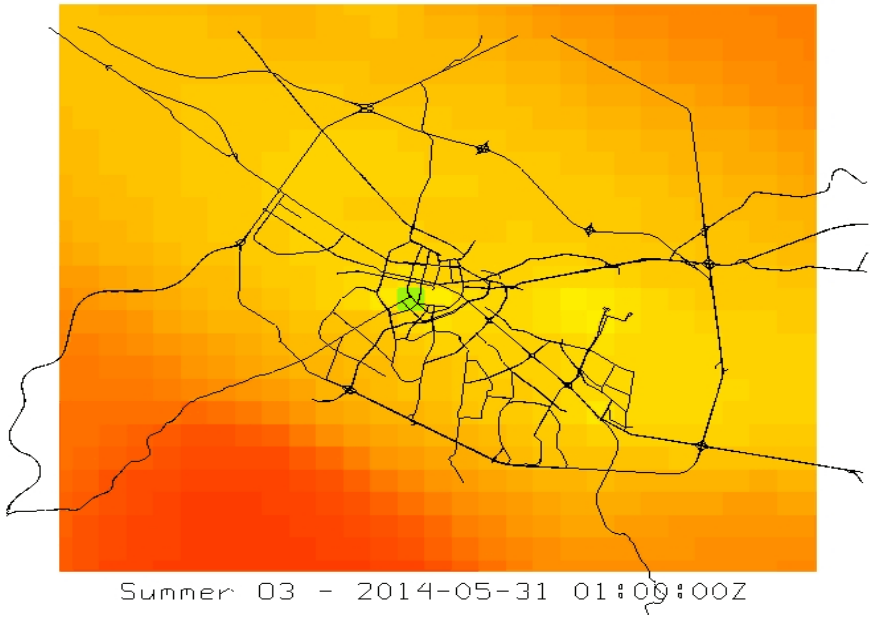


✓Smaller O_3 concentrations early in the morning than at noon

✓ Higher O_3 concentrations at daytime and during the Summer

✓O3 gaps in the regions, where the NO_2 concentrations are large

✓The maximal concentrations - around and over Vitosha Mountain



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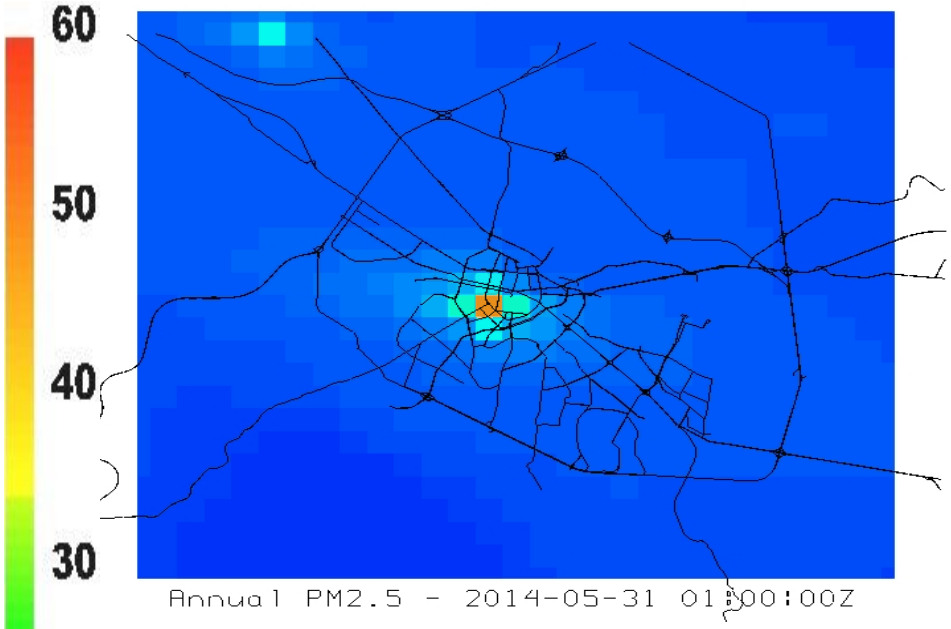
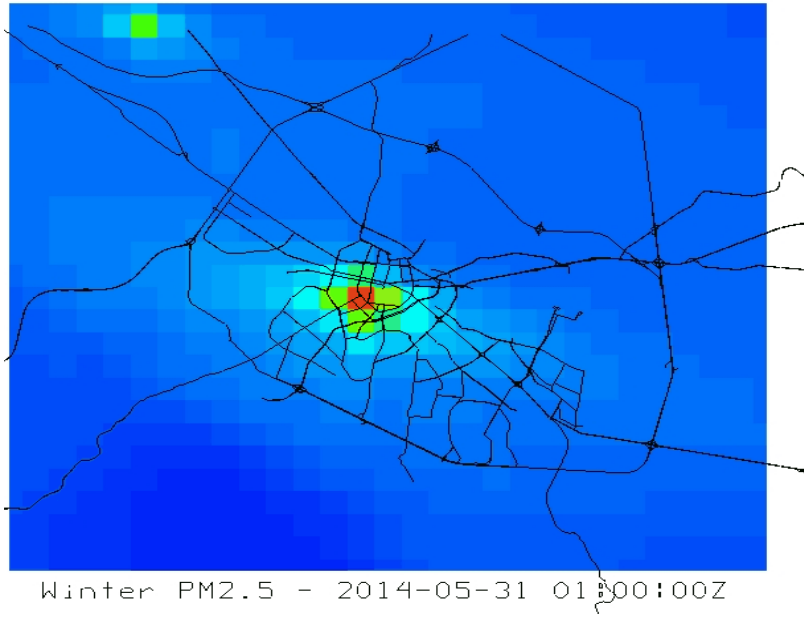
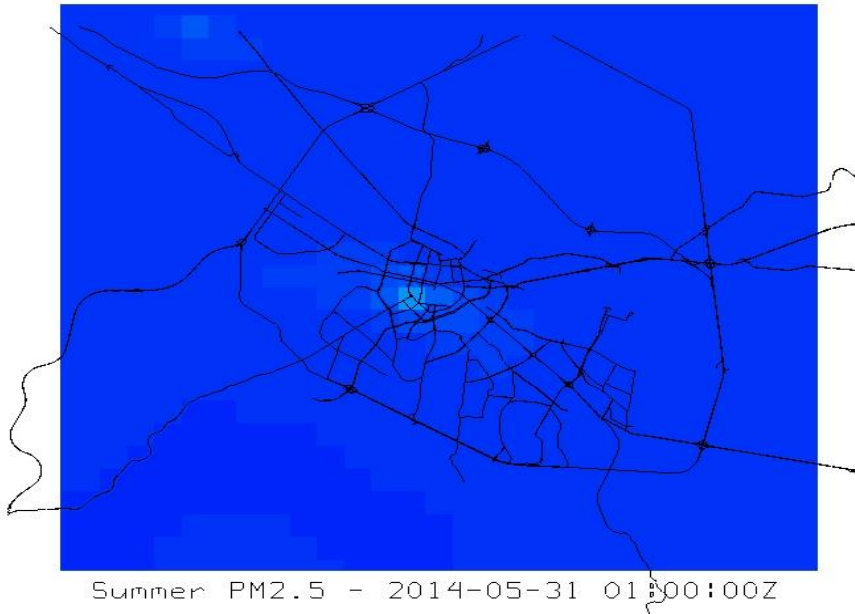
Annual and seasonal surface $PM_{2.5}$ concentrations *[$\mu g/m^3$]* :







- ✓**Higher PM concentrations early in the morning and smaller at noon**
- ✓**Bigger winter PM concentrations than in summer**
- ✓**The maximal concentrations are formed in the city centre**

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Air Quality Index in Bulgaria

The AQI, calculated in the frame of Bulgarian Chemical Weather Forecast System follows the UK Air Quality Index.

Boundaries Between Index Points for Each Pollutant

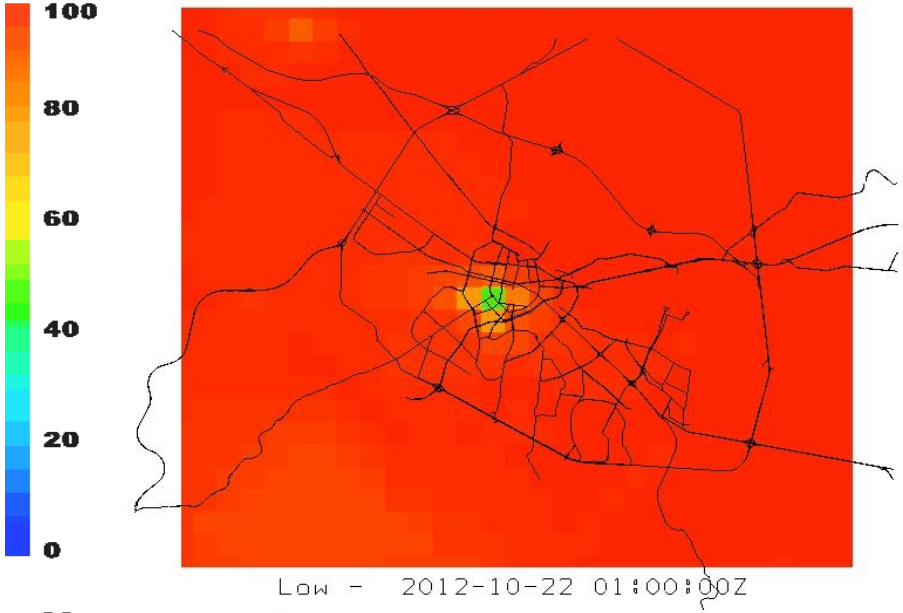
Index	O_3 Running 8 hourly mean ($\mu g/m^3$)	NO_2 Hourly mean ($\mu g/m^3$)	SO_2 15 minute mean ($\mu g/m^3$)	PM10 Particles, 24 hour mean ($\mu g/m^3$)	PM2.5 Particles, 24 hour mean ($\mu g/m^3$)
1 (Low)	0-33	0-66	0-88	0-11	0-16
2 (Low)	34-65	67-133	89-176	12-23	17-33
3 (Low)	66-99	134-199	177-265	24-34	34-49
4 (Moderate)	100-120	200-267	266-354	35-41	50-58
5 (Moderate)	121-140	268-334	355-442	42-46	59-66
6 (Moderate)	141-159	335-399	443-531	47-52	67-74
7 (High)	160-187	400-467	530-708	53-58	75-83
8 (High)	188-213	468-534	709-886	59-64	84-91
9 (High)	214-239	535-599	887-1063	65-69	92-99
10 (Very High)	≥ 240	≥ 600	≥ 1064	≥ 70	≥ 100

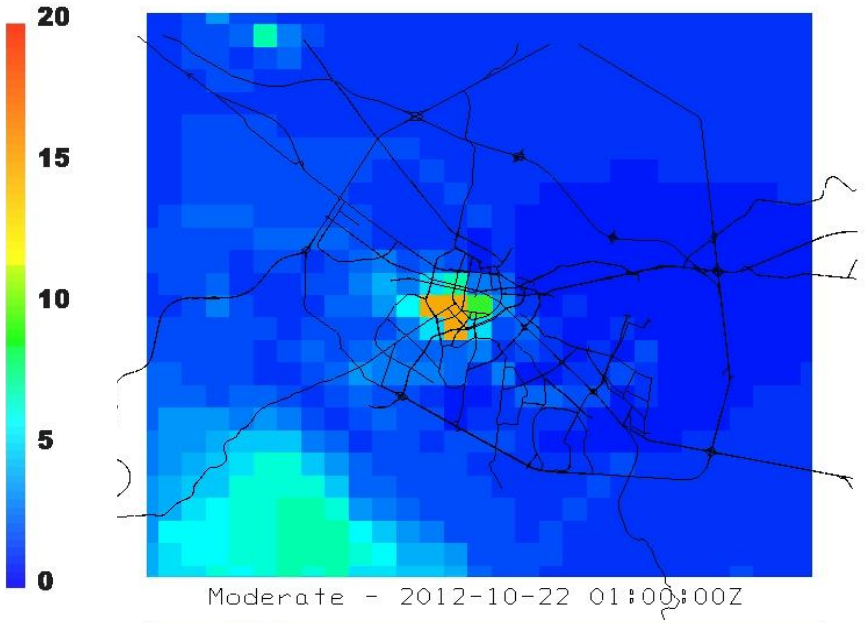
- 10 categories from green to purple
- 4 bands: low, moderate, high and
- very high
- based on the concentrations of 5 pollutants: O_3, NO_2, SO_2, $PM_{2.5}$ and PM_{10}.
- The breakpoints between index values are defined for each pollutant separately and the overall index is defined as the maximum value of the index.

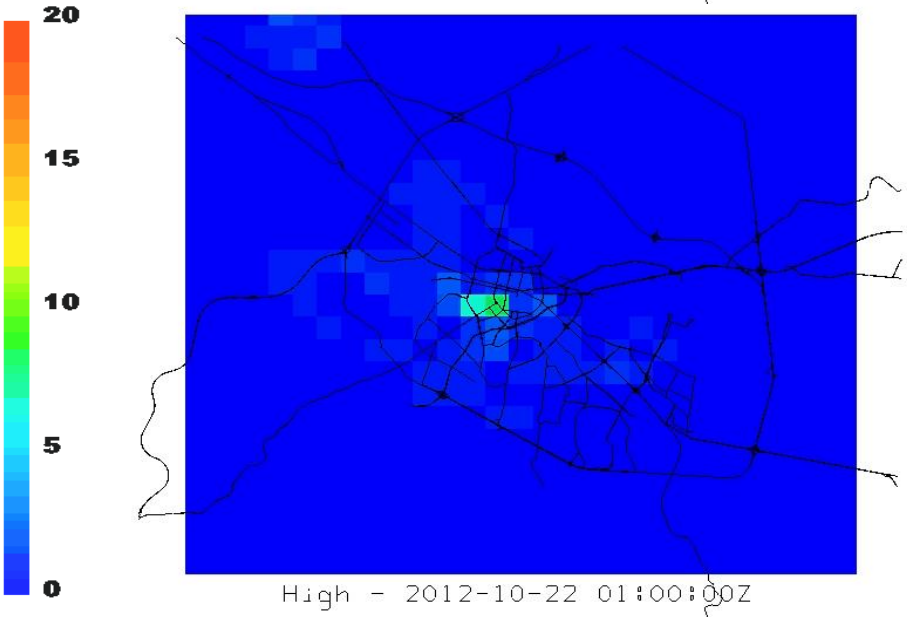
Air Pollution Bandings and Index and the Impact on the Health of People who are Sensitive to Air Pollution

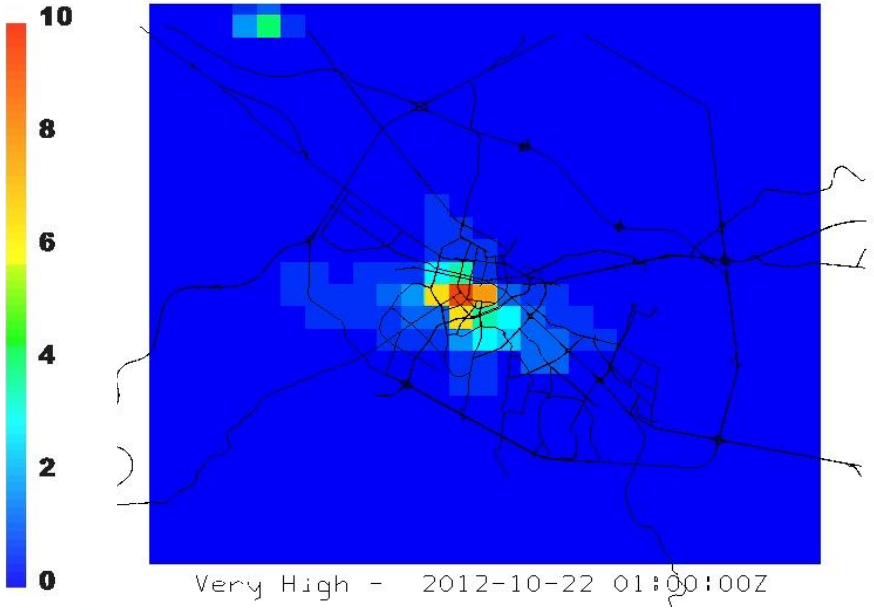
Banding	Value	Health Descriptor
Low	1–3	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
Moderate	4–6	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	7–9	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Winter plots of the percent recurrence of the AQI in the “Low”, “Moderate” and “High” bands over Sofia

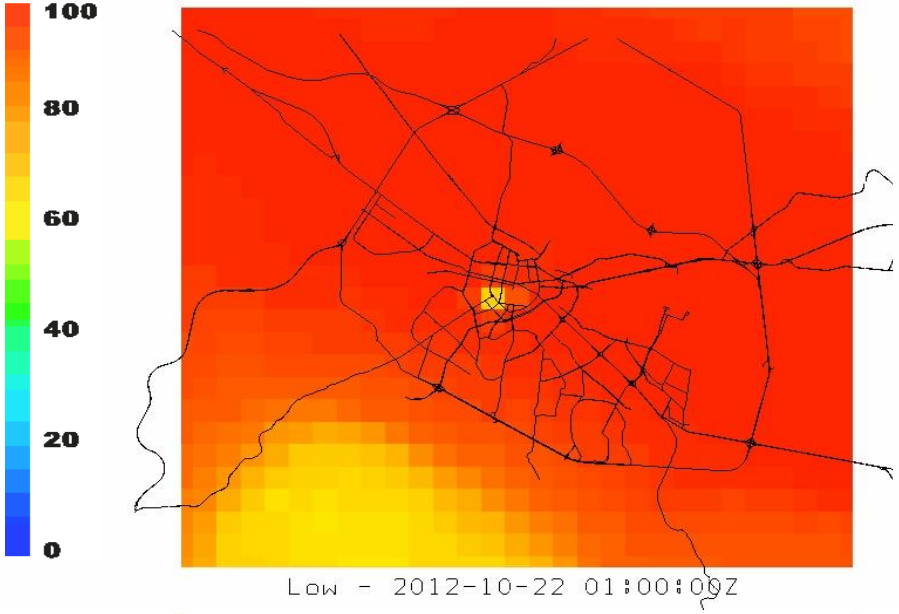


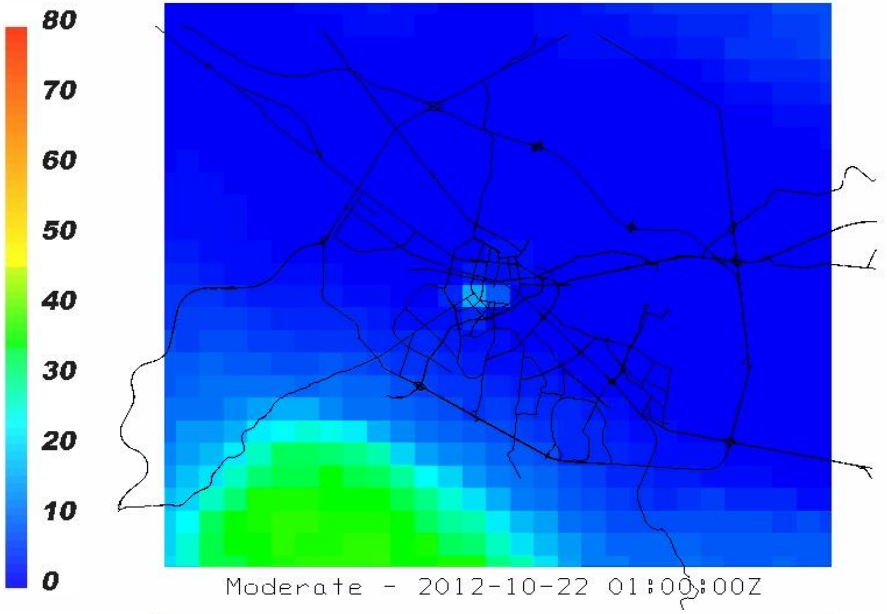


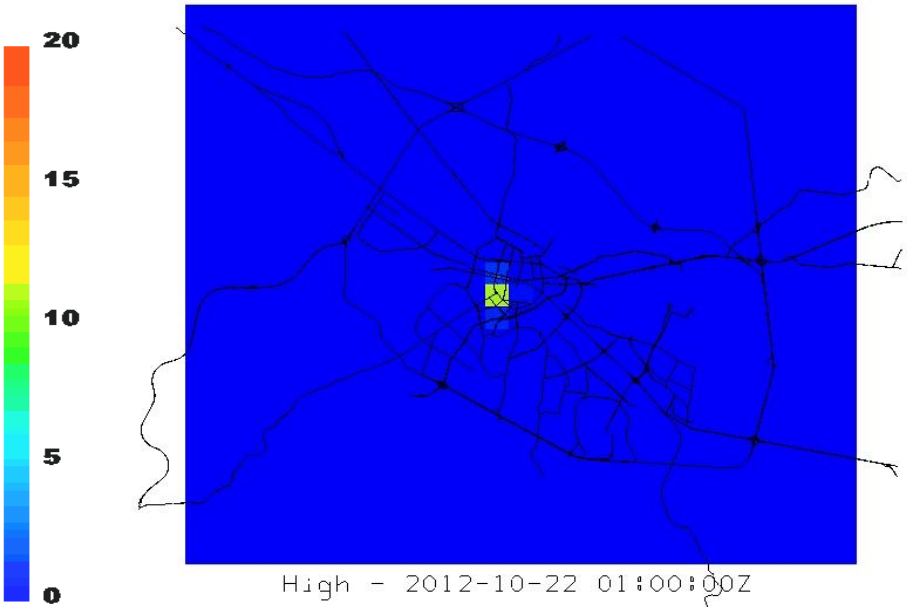


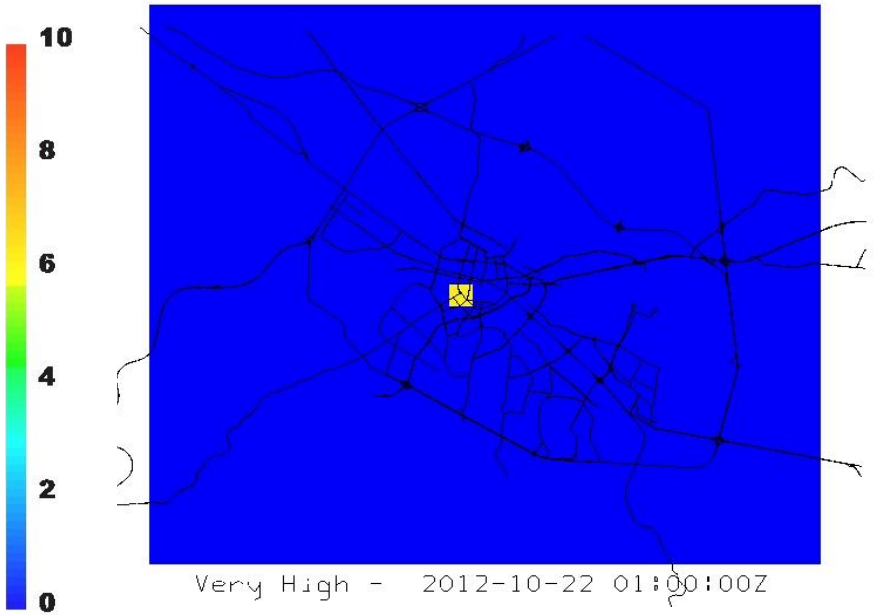


Summer plots of the percent recurrence of the AQI in the “Low”, “Moderate” and “High” bands over Sofia

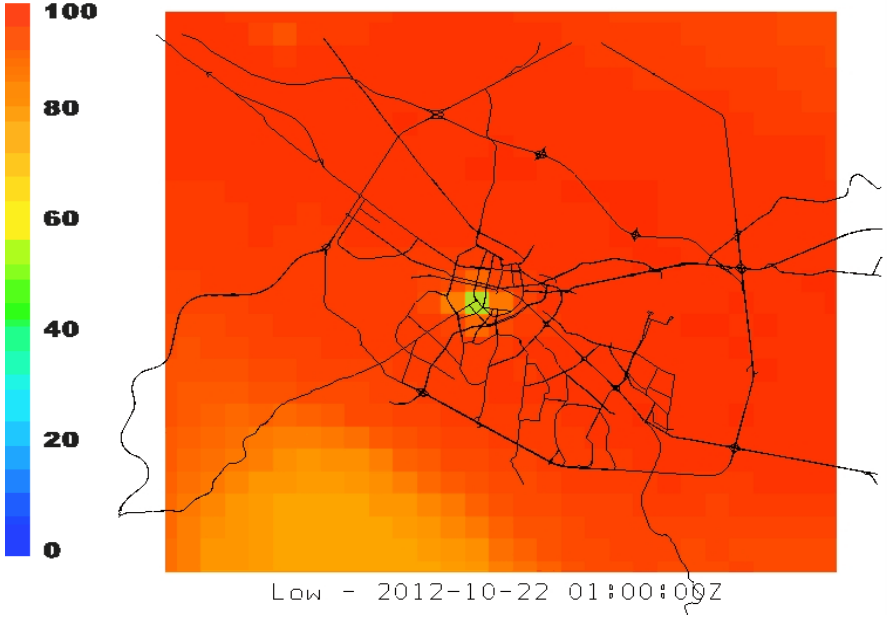


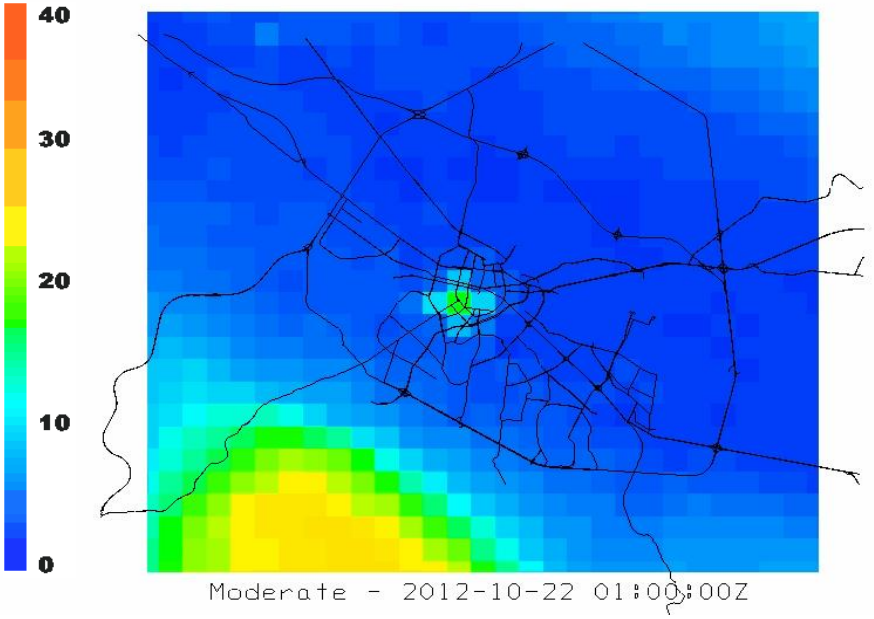


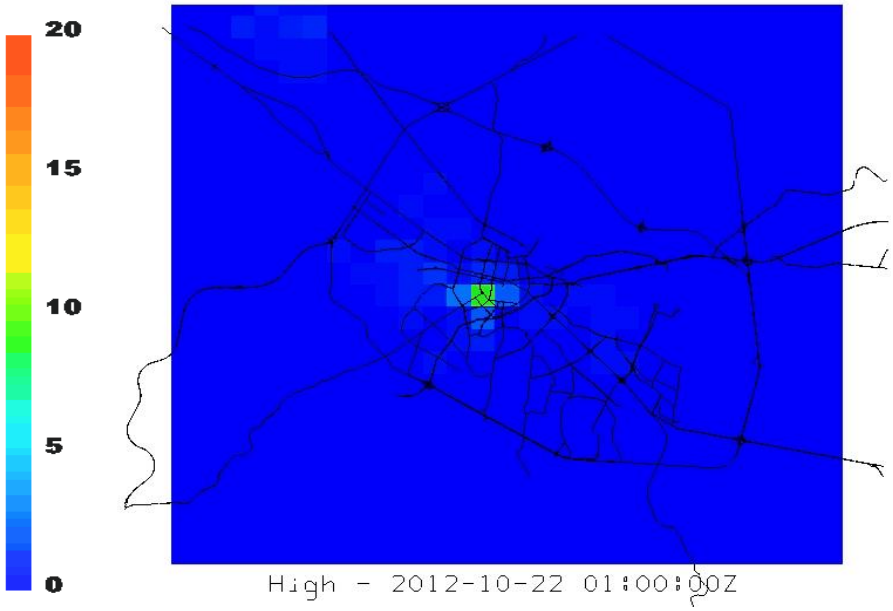


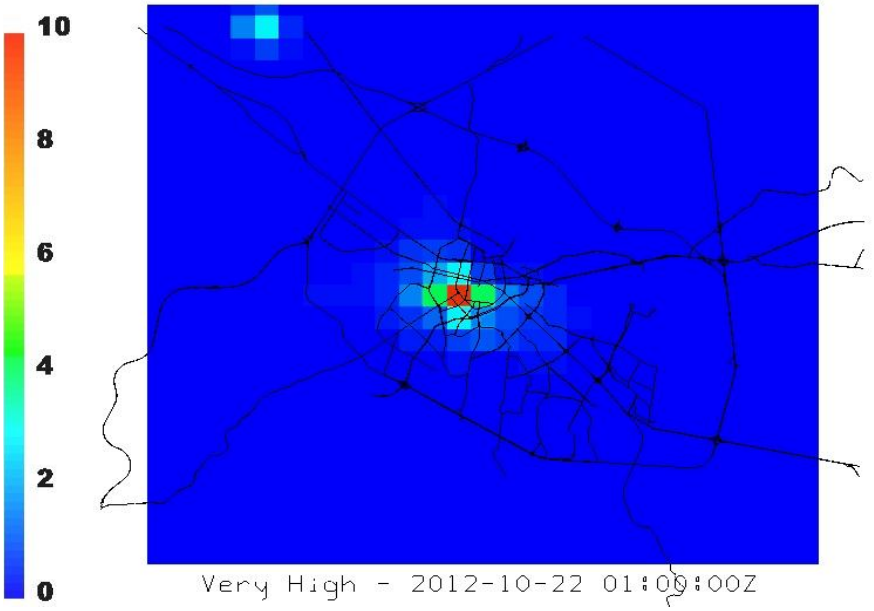


Annual plots of the percent recurrence of the AQI in the “Low”, “Moderate” and “High” bands over Sofia









Determining the contribution of different types of pollutants and pollution sources to Sofia city.

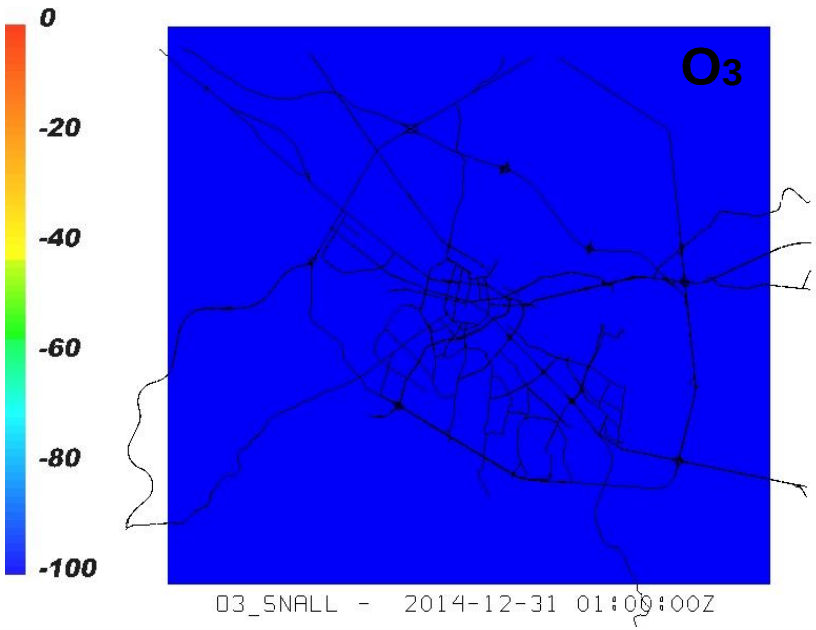
The calculations are made for 7 years from 2008 to 2014 for 6 scenarios: with all emissions, with all reduced emissions and reduced emission from SNAP1, SNAP2, SNAP3, SNAP7.

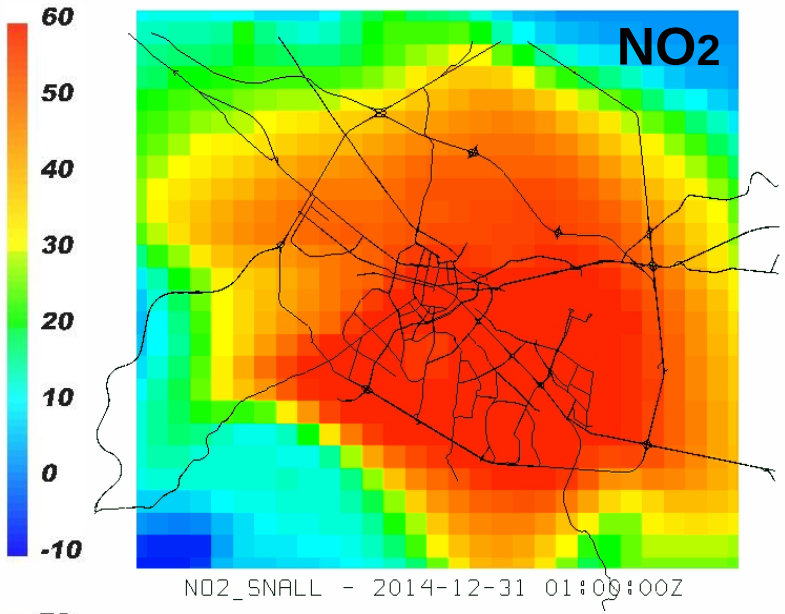
- **All 10 SNAPs – reduced with factor 0.8**

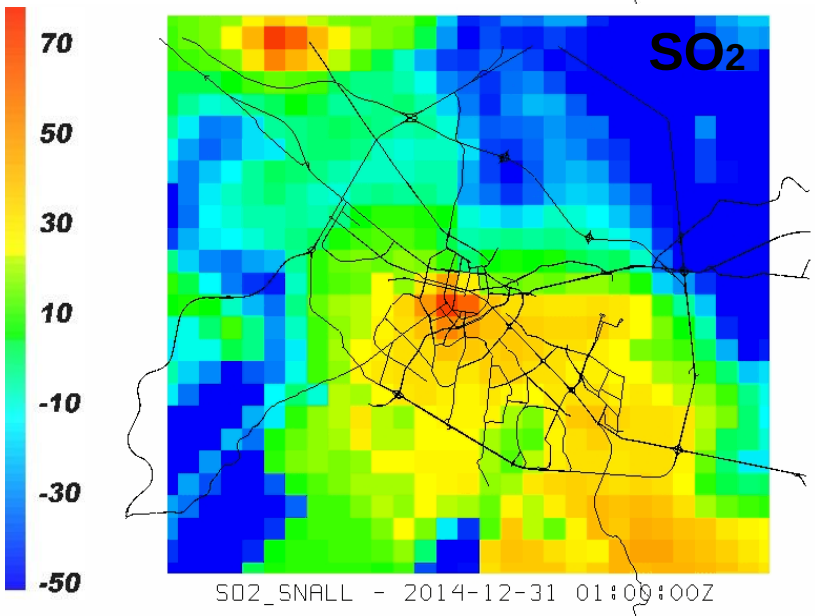
1. **SNAP 1 (Combustion in energy) reduced with factor 0.8;**
2. **SNAP 2 (Non-industrial combustion plants) reduced with factor 0.8;**
3. **SNAP 3 (Combustion in manufacturing industry) reduced with factor 0.8;**
4. Production processes;
5. Extraction and distribution of fossil fuels;
6. Solvent and other product use;
7. **SNAP 7 (Road transport) reduced with factor 0.8;**
8. Other mobile sources and machinery;
9. Waste treatment and disposal;
10. Agriculture.

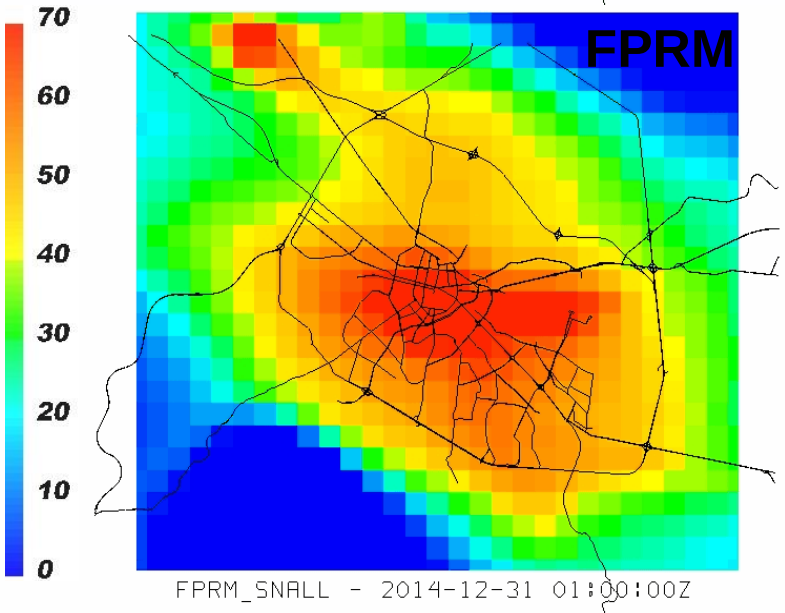
- **The relative contribution of scenario with all the reduced SNAP's was calculated for each day of this 7 year period and then by averaging the typical fields of relative contribution of this emissions to each of the compound surface concentrations were calculated for the 4 seasons and annually.**

Annually averaged surface contribution [%] of scenario with ALL SNAPs reduced to the formation of (O_3), (NO_2), (SO_2), (FPRM).









Futures:

- Annually and seasonal averaged surface contribution of different SNAPs to the formation of different types of pollutants.

Calculate all other scenarios:

- SNAP 1 (Combustion in energy)
- SNAP 2 (Non-industrial combustion plants)
- SNAP 3 (Combustion in manufacturing industry)
- SNAP 7 (Road transport)

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Thanks for your attention!!!