MODELLING PM10 DISPERSION FROM ROAD TRAFFIC AND INDUSTRY IN LJUBLJANA BASIN

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ABSTRACT: Ljubljana has unfavourable geographical location in the basin, almost entirely surrounded by high hills. Winds in the basin are often weak and situations with temperature inversion are very frequent therefore many PM10 daily limit value exceedances were observed in year 2011. The Directive 2008/50/EC (EU, 2008) requires Member States to adjust or provide new air quality plans in order to comply with air quality standards for over-polluted area in near future. This is why it is necessary to provide the action plan for PM10 pollution reduction in Ljubljana. Firstly, it is important to determine sources of PM10 particles and its spatial distribution. In the present study traffic emissions as the major local emission source were estimated with NEMO pollution model. The map of important point sources in Ljubljana was prepared as well as emissions from these sources were estimated. This detailed emissions database was then introduced into CALPUFF/CALMET modelling system coupled with meso-scale meteorological model ALADIN. Correlation between observed and simulated PM10 concentrations was examined for year 2011, while for some selected episodes also more detailed evaluations of simulated and observed temporal evolution of PM10 concentrations was performed to enhance our understanding about strengths and deficiencies of the selected modelling system. Major focus was on the model ability to represent dispersion under calm conditions related to the local temperature inversion.

MODEL CONFIGURATION

- CALMET and CALPUFF modelling system
- CALMET is coupled with meso-scale meteorological model ALADIN
  - -> First guess field from ALADIN hourly predictions (synoptic scale forcing, meso-scale circulations and temperature inversions)
  - -> step 2 of CALMET calculation: meteorological observations from ground stations (local meteorological conditions such as valley wind channelling, slope flows, kinematic terrain effects and terrain blocking effects)
- 125 × 125 horizontal points, 200 m horizontal resolution, 22 vertical levels up to 3000 m

PM10 MESUREMENTS AND EXCEEDANCES 2011

- 3 stations at basin bottom (S1, S2, S3):
  - -> S1 - city centre,
  - -> S2 – traffic station
  - -> S3 – suburb
- many exceedances of daily PM10 limit value in 2011

Value / Station	S1	S2	S3	Limit value
Annual PM_{10} concentration [μgm^{-3}]	32	44	37	40
Maximum daily PM_{10} concentration [μgm^{-3}]	167	134	191	50
Number of exceedances of limit PM_{10} daily value	63	94	69	35

a) b) c)

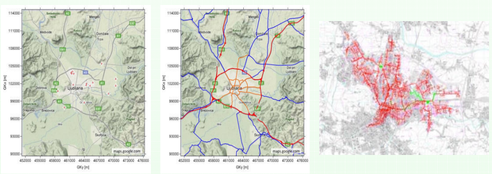

Figure 1. Main PM10 emissions sources in Ljubljana: a) important energetic and industry plants; b) important roads; c) good network of district heating system reduces emissions from domestic heating sources.

SIGNIFICANT PM10 EMISSION SOURCES

- industry and energetic units
  - -> 16 units with 187 point sources
  - -> periodical emission measurements
- road traffic emissions
  - -> traffic emission model NEMO
  - -> 612 area sources
  - -> traffic counters, traffic road patterns and emission factors
  - -> ratio between non-exhausted and exhausted particle emissions: 1:1
- good network of district heating system reduce domestic heating sources emissions

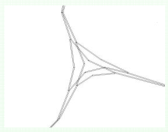

Figure 2. Roads were introduced as area sources in CALPUFF. As an example there is the motorway intersection in the south-western part of Ljubljana city.

RESULTS:

- calculated PM10 concentrations as a consequence of the road traffic emissions are much higher than calculated industry sector pollution (Figure 3 and 4)
- time series for January, February, November, December (Figure 5 and 6)
- temperature inversions: 1st, 2nd, 6th, 14 -19th January and 4-11th February and 12-19th November, 27th November to 3rd December, 7th, 8th, 21-27th December
- wet deposition:4th, 20-22nd, 28th January, 4th, 23rd November and 3rd, 10th, 13th, 16th December
- no wet deposition with precipitations: 11th, 12th January, 4th, 15th, 16th February and 15th, 17th December
- another sources:
  - -> new year days: fireworks
  - -> 7th November: Sahara dust transport
  - -> station S3 is in suburb -> domestic heating sources
- higher concentrations on S4 -> long range transport

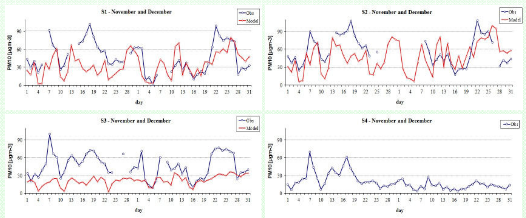

Figure 5. Comparison of observed and modelled PM10 concentrations in November and December

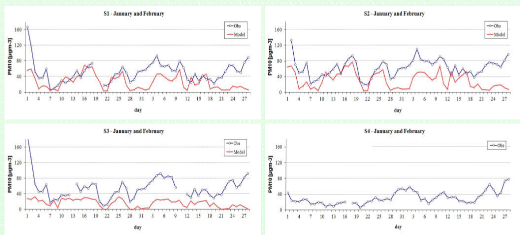

Figure 6. Comparison of observed and modelled PM10 concentrations in January and February.

a) b)

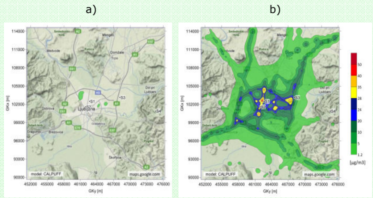

Figure 3. Annual PM10 concentration in Ljubljana: industry sector pollution (a) and road traffic pollution (b).

a) b)

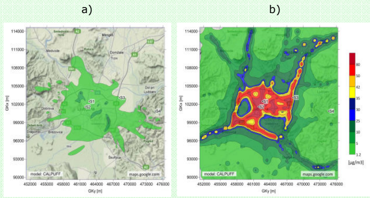

Figure 4. Maximum daily PM10 concentration in Ljubljana: industry sector pollution (a) and road traffic pollution (b).

CONCLUSION: Ljubljana has unfavourable geographical location in the basin with weak wind and frequent temperature inversions especially in winter time. The observed and modelled high PM10 concentrations are correlated with situations of temperature inversions which was shown in this study. A correlation in cleaning situations such as wet deposition with precipitation and atmosphere destabilization was found. Calculations were prepared with CALMET/CALPUFF model system coupled with meso-scale meteorological model ALADIN. Complex phenomena such as synoptic scale forcing, slope winds and temperature inversions were well simulated with ALADIN/CALMET meteorological system. Calculation of PM10 pollution was prepared with only daily traffic cycle and with continuous industry sector operation. Therefore almost no dynamics of emission were considered in calculation and so weather dynamics play the most important role in air pollution modelling. The case of study was determination of PM10 sources in Ljubljana region and their influence on air quality. Energetic and industry sectors have already installed filters and cleaning devices so the pollution from these sectors is well controlled. New, lower emission limits will come with implantation of 2010/75/EU directive (European Commission, 2010) after 2016 which leads in additional reduction of industry sector emissions. Road traffic emissions were recognized as the most important source of PM10 pollution. Solutions for reduction of these sources must be founded in future. Ljubljana city also took place at international project CIVITAS ELAN as a member where action plans such as cleaner and efficient public transport, new cycling roads and city centre closure were prepared for creating a more sustainable urban mobility culture.
Some other possible sources were determined but not modelled such as pollution from fireworks, transport of Sahara dust and long range pollution transport from other countries. District heating system network is not available in the south part of Ljubljana city and outside of motorway ring where domestic heating systems may play an important role. These PM10 emissions could be reduced by a district heating system network expansion to those parts of the city.

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