INFLUENCE OF THREE DIFFERENT WIND FIELD INITIALIZATIONS IN CALMET MODEL ON DISPERSION MODELLING IN COMPLEX TERRAIN

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ABSTRACT: In the present study we focus on evaluation of results from CALPUFF modelling system around Šoštanj thermal power plant (TPP) in northern Slovenia. Šoštanj TPP presents a significant emission source located in a very complex terrain where local scale dispersion modelling is extremely challenging due to meteorological conditions characterized by weak winds, mesoscale circulations (weak up- and down-slope winds, valley channeled winds) and strong temperature inversions. Consequently, in our study we decided to focus on the influence of different wind field initialization strategies on modelling results.

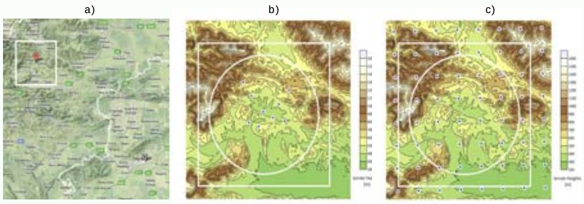

Figure 1. Location of a) modelling domain (white square) with Šoštanj TPP and radio-sounding measuring site in Zagreb, b) air quality stations around Šoštanj TPP, c) grid points of mesoscale model ALADIN. Stacks are located in centre of modelling domain and white circle represents the evaluation area.

CONFIGURATION OF MODEL

- CALMET and CALPUFF modelling system
- 3D terrain evaluation and CORINE land use data
- available data:
  - -> representative meteorological data from 6 surface stations
  - -> radio-sounding measurements in Zagreb 100 km away from Šoštanj TPP
  - -> meteorological 3D fields simulated by mesoscale prognostic model ALADIN
- three experiments – three different wind field initializations of CALMET:
  - A - surface measurements and vertical profile from radio sounding data
  - B - no observation data option – only analyses from mesoscale prognostic model ALADIN
  - C - combination of data from surface measurements and analyses from mesoscale prognostic model ALADIN
- constant emission from 2 stacks in center of modelling domain

CALMET RESULTS:

- many stable situations in all three experiments: very complex terrain characterized with low wind speeds and frequent temperature inversions in winter time (Fig. 2)
- more stable and unstable situations in experiments A and C than in experiment B, but experiment B has more slightly unstable, neutral and slightly stable situations (Fig. 2)
- small difference in calculated temperature between experiment A and B and almost no difference between experiments A and C (Fig. 3)
- good correlations are obtained for estimations of mixing heights in all three experiments (Fig. 4)
- wind speeds in experiments A and C are higher than in experiment B, probably because meteorological analyses of mesoscale model are not so representative near ground (Fig. 5)

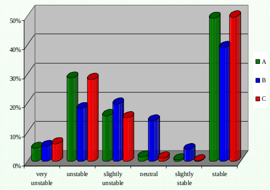

Figure 2. PGT stability classes distribution for one year meteorological data.

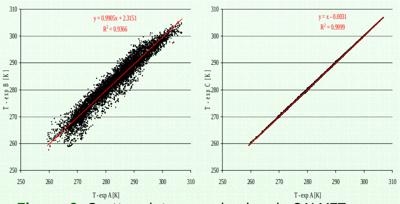

Figure 3. Scatter plot comparing hourly CALMET calculations of ambient temperatures between experiments A and B and between experiments A and C at the location of the stack at height 10 m.

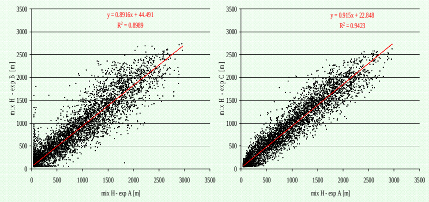

Figure 4. Scatter plot comparing hourly CALMET calculations of mixing heights between experiments A and B and between experiments A and C at the location of the stack.

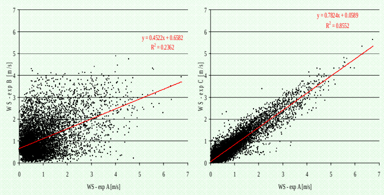

Figure 5. Scatter plot comparing hourly CALMET calculations of wind speeds between experiments A and B and between experiments A and C at the location of the stack at height 10 m.

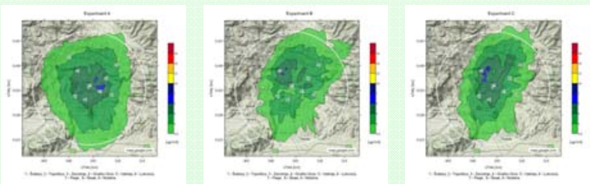

Figure 6. Annual SO_2 concentration in experiments A, B and C.

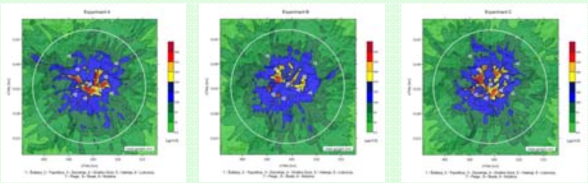

Figure 7. Maximum hourly SO_2 concentration in experiments A, B and C.

CALPUFF RESULTS:

- annual mean and hourly maximum SO_2 concentration in Fig. 6 and Fig. 7 with respect to limit value, lower and upper threshold value:
  - -> red color: limit value
  - -> yellow color: upper threshold value
  - -> blue color: lower threshold value
  - -> green color: 3 % of annual limit value
- comparison of results in point with maximum concentration in Table 1
- annual SO_2 concentrations are smaller than the half of limit value in all three experiments
- highest maximum hourly SO_2 values and number of exceedings of hourly limit value are higher in experiment A and C than in experiment B: Fig. 2 -> experiment A and C have more stable situations

Table 1. Comparison of results in point with maximum concentration.

Value	Experiment A	Experiment B	Experiment C	Limit value
Annual SO_2 concentration [μgm^{-3}]	6.9	6.1	8.8	20.0
Maximum hourly SO_2 concentration [μgm^{-3}]	785.0	585.4	759.2	350.0
Number of exceedings of limit SO_2 hourly value	18	5	11	24
Maximum daily SO_2 concentration[μgm^{-3}]	73.5	90.0	119.5	125.0
Number of exceedings of limit SO_2 daily value	0	0	0	3

CONCLUSION: In this study comparison of different possibilities for wind field initialization with model CALMET were prepared. Results differ between experiments and it is hard to judge which experiment gives better results. If radio-sounding close the TPP would be available, probably a combination with wind data from surface stations (experiment A) would be the best option – for our location this is not the case. Calculations based on 3D meteorological fields by a mesoscale meteorological model (experiment B) are an acceptable solution for prediction of air pollution dispersion for areas with no observation data at surface. Results of a mesoscale also have better temporal and spatial resolution than the upper-air soundings and this is advantage of experiment C against experiment A. As in our case radio-sounding measurements are far away from TPP, we could conclude that for such cases experiment C probably provides the best results.
In this study only six-hour meteorological analyses from mesoscale model ALADIN were included in calculations because only analyses were archived in year 2010. Results with hourly ALADIN prognostic fields might improve the final results, but in this case also ‘spin-up’ effect should be taken into account. As hourly archiving of ALADIN prognostic fields predictions started in June 2011, such data could be included in further simulations.

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