SENSITIVITY ANALYSIS OF THE MESOSCALE PUFF MODEL – RIMPUFF

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INTRODUCTION

Dispersion models are used to control two basic environment outcomes:

1, regulatory aim: possible environmental effects of the investment are examined with a diffusion-climatological data base. In this case the diffusion model relies on the existence of the diffusion-climatological data base.

2, decision support in case of accidents: after an industrial accident, the critical situation has to be evaluated. Forecasts have to be produced as soon as possible. In this situation the meteorologist has a special task: providing the dispersion model with suitable data in real time. Nowadays, with the computer and the progress of IT, this difficult task still requires a well planned and developed meteorological preprocessor. The development of a meteorological preprocessor must precede the sensitivity analysis of the dispersion model to get information about the required accuracy of these parameters as inputs of the model.

The effect of weather is determinant in the transport and deposition of pollutant material released with an industrial accident. This is the reason why meteorological services across the world have an important role in the operation of emergency response system. The Hungarian Meteorological Service (HMS) not only provides meteorological information to the General Directorate for National Emergency Management and the Hungarian Atomic Energy Authority, but operate transport models which can be used both in regional and large scale. Since the synoptic experts are working in the forecast center of the HMS all day, they can run the model immediately when the information about a release is received. A 24 hour forecast for the transport of the plume and the deposition / concentration fields are ready in 10-15 minutes.

The emergency response system of HMS contains two dispersion models: the French MEDIA model (*Pidelievre et al.*, 1990), which can directly use the output fields of ALADIN and ECMWF numerical weather prediction models, and the Danish RIMPUFF model (*Thykier-Nielsen et al.*, 1998), which is more difficult to use, and to automate. Using MEDIA is more suitable at European scale, where the impact of large scale formations, like fronts, can be examined. Applying RIMPUFF offers a better advantage at regional or local scale, because the effect of turbulent movements can be taken into account.

The model MEDIA runs automatically twice a day with the latest meteorological data provided by the numerical weather prediction models, with a predefined accidental situation. RIMPUFF becomes important when we want to analyze the situation in details, therefore, RIMPUFF is run only in real accidental situations, but the meteorological preprocessor producing the input data runs every hour of every day.

There is a new add-in to the emergency response system, FLEXPART the Lagrangian particle dispersion model (*Stohl et al.*, 1998) which calculates trajectories of a large number of individual particles to describe the transport and diffusion of substances in the atmosphere.

SENSITIVITY ANALYSIS

First, we examined the effect of the stability and wind speed on the plume spread. The diffusion of the plume results from the atmospheric turbulence which can be thermal or mechanical. The mechanical turbulence depends on the wind speed and surface roughness, while the thermal turbulence depends on the vertical temperature gradient of the air in the lower atmosphere. In our case we did not change the wind speed but the stability category was changed. The different plume shapes result from the thermal turbulence. In the other case, when the stability of the air was unchanged and the wind speed was increased, the effect of the mechanical turbulence was growing and the plume spread more. Thus we can say that the more intensive the mixing process – ie. the more unstable the atmosphere and the higher the wind speed -, the bigger the contamined area. When the stratification of the air is stable, the mixing processes are slower, the plume covers smaller area, but the contamination over this area is much higher than in the previous case. (Fig.1.)

The aim of sensitivity analysis in case of mixing height was to get information about the dynamical behavior of the model and to determine the accuracy needed for this parameter as input of the diffusion model. In our experiment the value of the mixing height was changed with 50 meters interval from the top of the mixing layer (2000 m) to the bottom (100 m). The initial value of the mixing height was in every case the value suggested by the authors of the RIMPUFF model. Table 1. shows the used intervals in every Pasquil categories. Four different release height were used (1 m, 10 m, 50 m, 100 m) in this model runs based on our pre-experiments.

1.Table: Mixing heights.

Definition	Pasquill stability categories					
	A	B	C	D	E	F
Suggested mixing height values (in meters)	2000	1500	1000	800	500	200
The used mixing height intervals (in meters)	2100-1800	1750-1300	1250-950	900-700	650-400	350-100

After the modification of the height of the mixing layer we had the following result: decreasing values of this parameter make the concentration values higher and higher, in every stability classes. The difference between the maximum and minimum concentration was the biggest in case of **F** (most stable) stability type, and the smallest in **A** (most unstable) stability type. Summarizing the results we can conclude that the model outputs were most sensitive to the height of the mixing layer in case of **F** stability type, which means in this situation we should determine the mixing height with the most precision. A realistic requirement for this parameter is a 50 m punctuality as the computation methods can not give more accurate results. (Fig.2.)

The effect of release height on the concentration field is different in every stability class. **A** stability: increasing the stack height the ground level concentration to decrease. The highest concentration values can be found in case of 1 m release height. **D** (neutral) stability: the highest concentrations can be observed when the release height is 100 m. There are no significant differences between the concentration fields when the release height is 10 or 50 m. **F** stability: this situation is the most difficult. The 50 m release height causes the highest ground level concentrations, while the 100 m stack height causes the lowest concentrations.

Summarizing the result of the sensitivity analysis we can say: the model outputs were the most sensitive on the stability of the surface layer, and the effect of the release height was the lowest.

CONCLUSIONS

At the Hungarian Meteorological Service an Emergency Response System is operated to predict the concentration fields resulting from the dispersion of air pollution materials. This system includes dispersion models and well planned meteorological preprocessors. The development of a meteorological preprocessor has to precede the sensitivity analysis of the dispersion model to get information about the accuracy needed for these parameters as inputs of the model. This paper presented the results of the sensitivity analysis of the dispersion model RIMPUFF which helped us to develop modules for calculating the Pasquill stability categories/Monin-Obukhov length and mixing height with the accuracy required. In case of Pasquill categories first the Monin-Obukhov length is determined using the new input parameters of numerical weather prediction models (momentum flux, sensible heat flux), and this this parameter is converted to the suitable Pasquill stability category under a given roughness value. To calculate the input parameter mixing height the bulk Richardson number approach was used extending it to the convective situation.

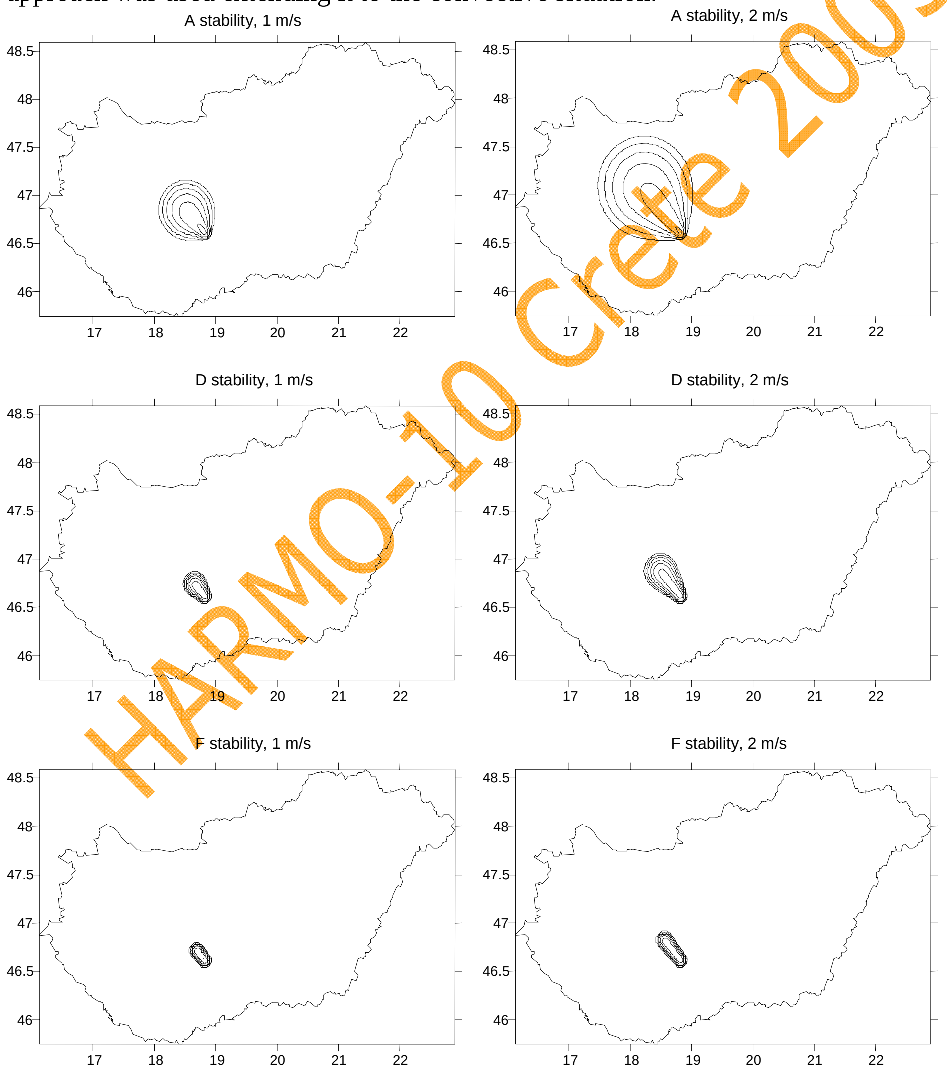

Fig. 1 Sensitivity of air concentractions for the Pasquill stability cathegory and the windspeed (the isolines have logarithmic scale and have same value for every picture: 10^{-4} – 10^{6} Bq m^{-3}).

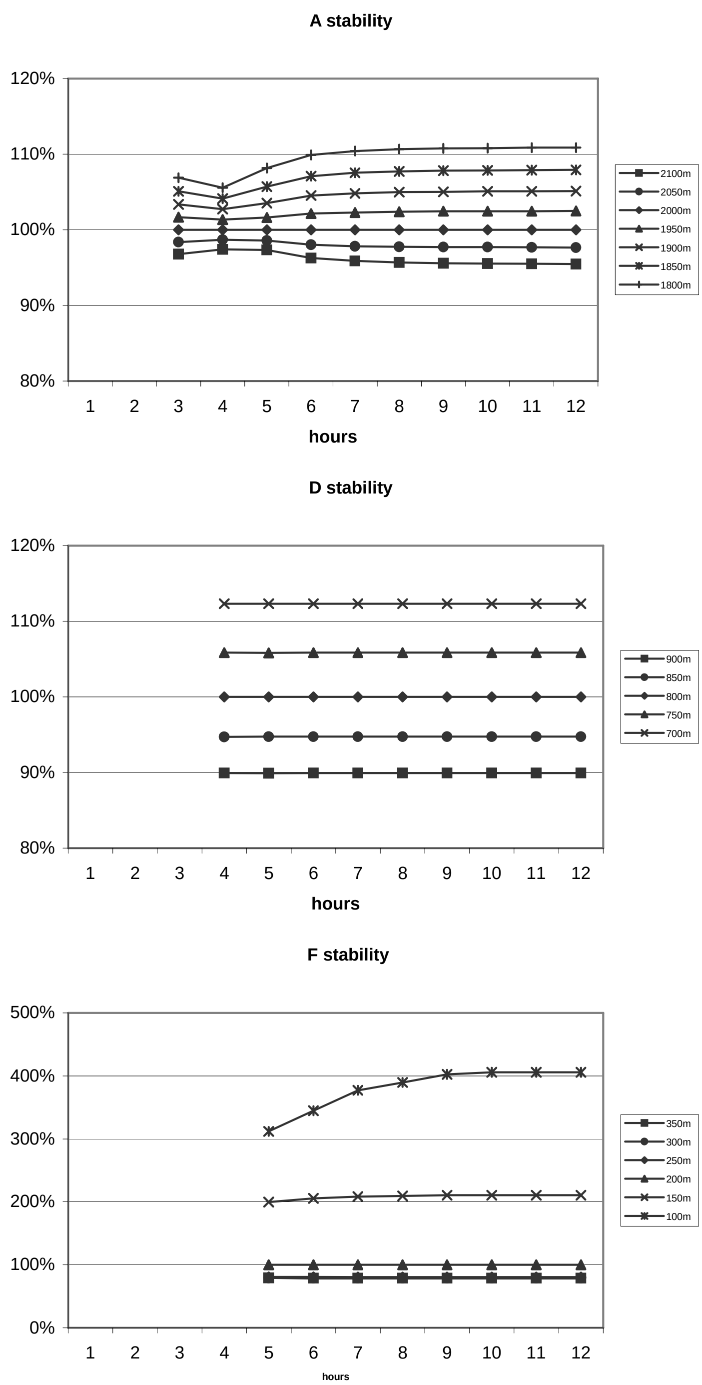

Fig. 2. Percentage difference of concentration values in different mixing heights for the calculated concentration values with A, D, F stabilities with recommended mixing height values.

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