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Rajkovic Borivoj

Grsic Zoran

Popov Zlatic

Djurdjevic Vladimir

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Rajković Borivoj [a] , Gršić Zoran [b] , Popov Zlatica [c] , Djurdjević Vladimir [a]

[a]Department for Meteorology, College of Physics, Belgrade University, Serbia and Montenegro

[b]Radiation and Environmental Protection Laboratory, Institute of Nuclear Sciences Vinca P.O. Box.522, 11001 Belgrade, Serbia and Montenegro

[c]Center for Environmental Modeling, University of Novi Sad, Republican Meteorological Institute of Serbia, Meteorological Observatory, Novi Sad, Serbia and Montenegro

Abstract: The main goal of this paper is to assess differences in calculations of air pollution using standard, one hour wind averages and shorter time averages of ten minutes. A puff model has been used to estimate concentrations of a passive substance for four days in January, March, June and September as representatives of variations of wind and stability during a year. Meteorological inputs were ten meters winds and two meters temperature, measured at a weather station. The additional data of temperature gradients, measured at the same station two times a day, were also available.

The standard practice is to form hourly averages of wind speed and hourly prevailing direction based on the data tape records. To infer the importance of the shorter averaging period, tapes were re-analyzed forming ten minutes averages. After extrapolation to fifty meters heights we forced a puff model with these, two differently averaged, wind data.

Keywords: Wind extrapolation; Monin-Obukhov theory ; Stability of the PBL; Calculation of pollution dispersion ; Puff model

1 INTRODUCTION

If we want to estimate possible influence of a future pollution source, we should perform calculations of concentrations of a passive pollutant for an extended period of time such as one year or even up too five years. On a given location we might be in a situation where only the standard measurements of wind and temperature are available. That means that we have data of wind at ten meters and temperature at two meters with time resolution of one hour. The wind direction is the so-called prevailing wind direction, which is defined as the most frequent wind direction in an hour. Since the source of pollution is usually at greater heights than those of ten meters we have to perform vertical extrapolation of the wind speed. The standard procedure would be to use Monin-Obukhov theory (MO in the further text)y. Unfortunately in that case we need temperature gradients as well. If we have temperature gradients MO theory enables us to calculate the sensible heat flux and the friction velocity, which finally leads the extrapolation of the wind speed.

Holstag and Van Ulden [1] and Holstag [2] have proposed an alternative procedure for calculation of the sensitive heat flux using only standard wind, temperature measurements and cloud cover. Once we have sensible heat flux we can, using the MO theory do the extrapolation. Once we do the wind extrapolation we can then use some simple model to estimate possible influence of a pollution source. That can be done for instance with a Gaussian plume model as less computer demanding method or a puff model, of the Gaussian type, but with considerable more demand for computer time.

2 THE WIND EXTRAPOLATION

Following Holstag and Van Ulden [1] and Holstag [2] we can estimate sensible heat flux using only routine measurements, wind at ten meters, temperature at two meters and cloud cover. Basically the method relies upon energy balance of the ground surface. To reassess the quality of this approach we have compared this extrapolation method with the standard MO theory for one site where concurrently with the routine measurements, measurements of temperature gradients were done. The station is Rimski Šancevi near Novi Sad lat($45^o20^{'}$ N) and lon($19^o51^{'}$ E). We have also addressed the question of time resolution of the wind data by doing the re analysis of the anemometer tapes and thus forming ten minutes winds with corresponding changes in directions.

In course of a year we meet high range of stability, from very unstable stratification during summer days to very stable stratification during winter nights. In the case of very stable stratification straightforward use of MO theory will give excessively high values of wind. In that case Holsatg [2] had proposed an ad hock procedure, which seems to perform well in such extreme conditions. In order to reexamine that method we did extrapolation using the same wind data but now without the use of the temperature gradients. Comparison of the two methods is presented in one variable, the diurnal variation of wind averaged over a year, figure 1. The lowest curve (black) shows the measured data. The next curve is the extrapolated wind using MO theory with the proposed modification for high stability when needed(red) and the third curve (green) is the extrapolated wind from standard measurements only. Inspection of that figure shows that there is quite good agreement between the two methods except between sixteen hours and nineteen hours when Holstag and Van Ulden method produces slightly higher values for the wind speed. We should note that the proposed method has several parameters which vary for different locations. They are related to the state of the ground and to its radiation properties as well. If one has more accurate local values concerning these processes that will improve the quality of the results.

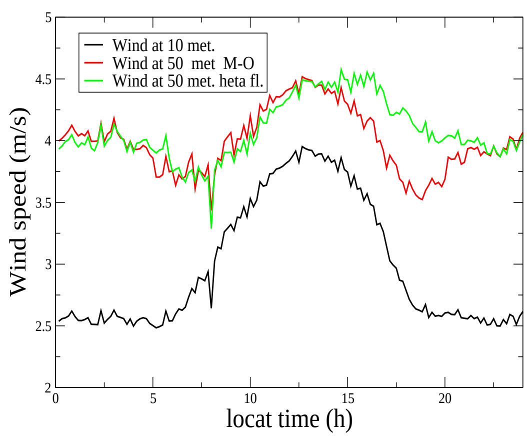

Figure 1: Diurnal variation of wind averaged over a year

3 CALCULATION OF POLLUTION DISPERSION

For the purpose of calculation of the atmospheric dispersion of airborne material we can use the standard Gaussian plume model. It is a simple concept and is extremely computationally efficient. Its shortcomings are pronounced if we have large temporal variability of wind and/or if we want to estimate concentrations for larger areas, say beyond ten kilometers. In that case it is better to use a model from the puff category wherein one has series of consecutively released puffs. Details of a such model design are given in [3] and [4]. Local dispersion, of a individual puff, is still Gaussian like. This means that we still have dispersion parameters in horizontal and vertical whose values are parameterized using the Pasquill-Gilfford scheme with the use of the vertical temperature gradients.

When we want to give an estimate of the possible influence of a source of pollution, we should perform calculations covering a longer period say one year or, if possible, up to five years. Here, at the beginning of our work, we did just a few, pilot runs, covering all four seasons and with runs three hours long which were performed twice a day, at midnight and at noon. Puff releases were done every ten minutes in both cases. In the case of hourly averaged winds the releases were done but with the same wind, inside each hour. To quantify, in some extent, the results we have presented, in table 1, values of the maximum concentrations for each run. We see that ratios of maximums, for two types of wind averaging, are quite different from one month to another. Values of these ratios are 22.6, 4.6, 7.1 and 1.1 for night cases for January, March, June and September respectively. For the noon cases these ratios are much smaller i.e 2.1, 1.3, 7.2 and 1.1. The biggest

Month	Hour	Hourly averages	ten min averages
01	0	5.2E-03	2.3E-04
01	12	4.4E-05	2.1E-05
03	0	2.5E-05	5.4E-06
03	12	3.9E-06	2.9E-06
06	0	2.7E-07	3.8E-08
09	12	1.8E-07	2.5E-08
09	0	1.9E-06	1.7E-06
09	12	1.4E-06	1.3E-06

Table 1: Values of maximum concentrations for **hourly** averaged winds and for **ten minutes** averaged winds in the right panels

value is for January at midnight, while the smallest value is for September at noon. These differences, presumably come from the differences in the respective stability regimes and wind strengths.

Figures 2 3, 4 and 5 are graphical representations of the concentrations of three hour averages for the the continuous release with constant rate of the release. The left panels represent results using hourly averaged winds while on the right panels we have results form ten minutes averaged winds. General characteristic, as seen from these panels is that concentrations are smaller for ten minutes winds (i.e. respective areas are wider). We also see quite strong signal of seasonal dependence as well as diurnal variations though in smaller magnitude. The differences, as in the case of corresponding maximums, presumably come from two reasons. Differences in the wind strength and in stability at that moment. Comparison between two panels, left and right is comparison of differences in the averaging method only. But that difference has twofold consequence. First temporal variation in ten minutes wind might ”stretch” the passive substance and secondly through parameterization of dispersion coefficients (Pasquill-Gilfford scheme).

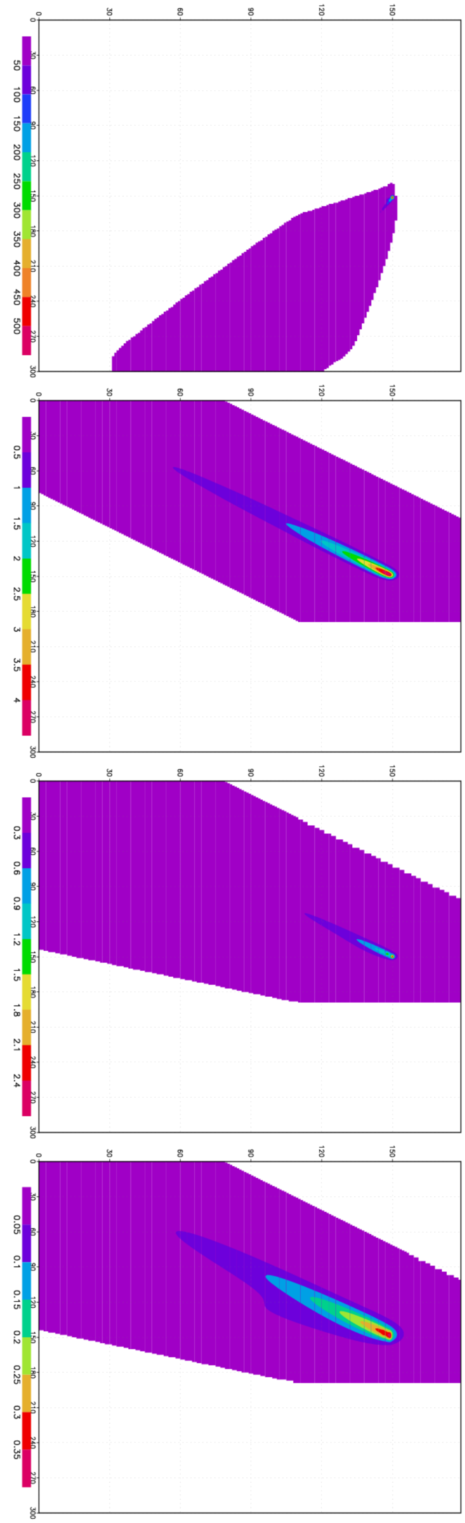

Figure 2: Concentration of pollution after three hours of continuous release. Upper two panels are for the 15nth of January. Start of the release at midnight and at noon while lower two are for the 15nth of March, with the same starting of the release. Winds are **hourly** averages. Please note that the scales are different for different panels

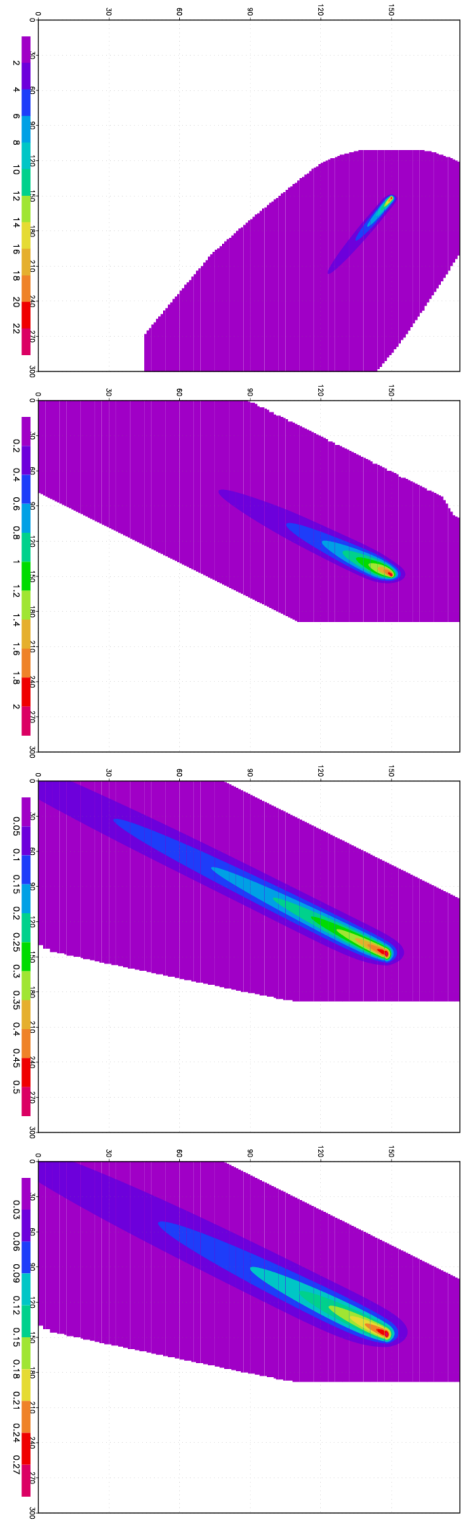

Figure 3: Concentration of pollution after three hours of continuous release. Upper two panels are for the 15nth of January. Start of the release at midnight and at noon while lower two are for the 15nth of March, with the same starting of the release. Winds are **ten minutes** averages. Please note that the scales are different for different panels

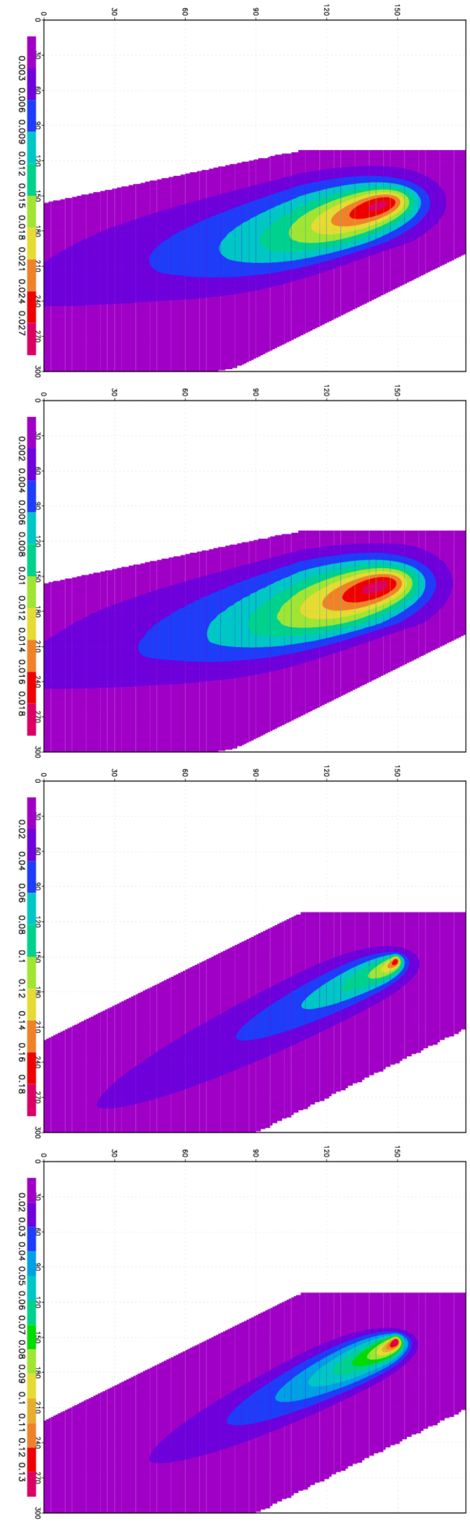

Figure 4: Concentration of pollution after three hours of continuous release. Upper two panels are for the 15nth of June. Start of the release at midnight and at non while lower two are for the 15nth of September, with the same starting of the release. Winds are **hourly** averages

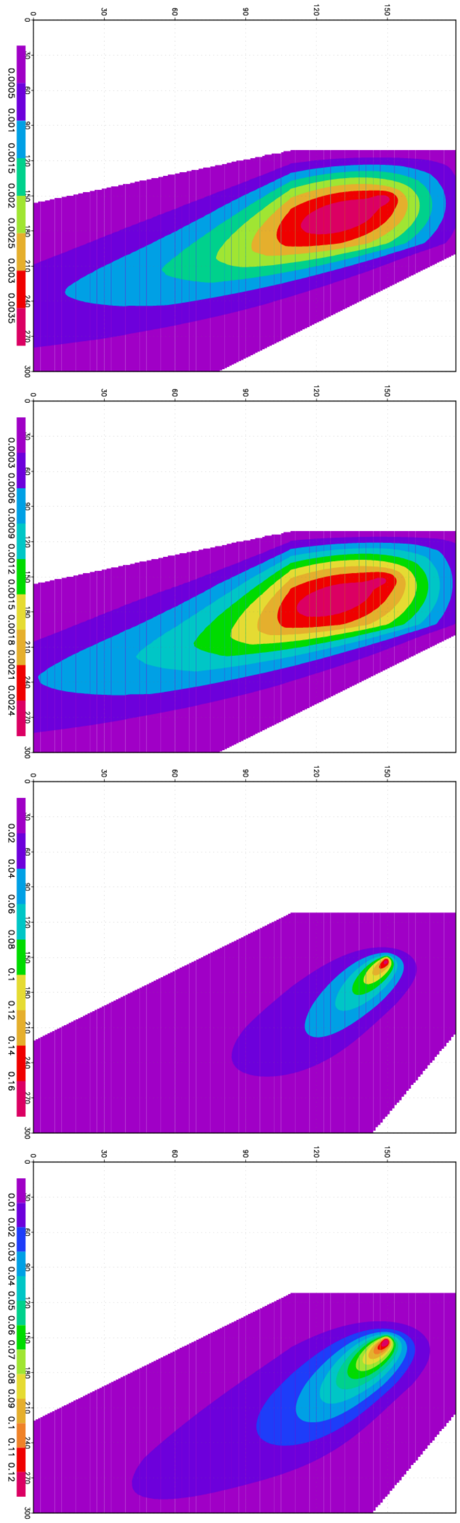

Figure 5: Same as in figure 4 except for the winds, which are ten minutes averages

4 Conclusions

The differences in calculations of dispersion of a wind borne material having ten minutes averages and hourly averages are quite evident. They come basically from two effects. Firstly there are differences in the wind intensity and in wind direction. The second difference comes from different states of the atmosphere for different seasons (stability). These differences are present also going for midnight to noon. Ratios of the maximums in these run are quite different and are quite large for stable cases and weaker winds. Having in mind the underlying physics of a puff model we may say that ten minutes winds are preferable to the longer period averaged winds in longer term calculations of concentrations an an airborne material.

5 INQUIRIES AND CORRESPONDENCE

All inquires concerning papers, at any stage of the process of preparation, review and publication should be addressed to:

Dr Borivoj Rajković, Department for Meteorology, College of Physics, Belgrade University Dobračina 16, 11000 Belgrade, Serbia and Montenegro

Phone: +381 11 625 981

Fax: +381 11 3282 619

Email: bora@ff.bg.ac.yu

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