5.07 THE CALCULATED MIXING HEIGHT IN COMPARISON WITH THE MEASURED DATA

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INTRODUCTION

The mixing height values is one of the most important parameter needed for the air pollution dispersion calculations. The diagnosis formulas and meteorological pre-processors are the most common sources of these data.

In this paper the mixing height values generated by CALMET pre-processor are compared with a monostatic sodar measurement (SAMOS 4C Polish sodar with range 30m to 1000 m, repetition each 6s). Vertical component of the wind is measured, too. The mixing height values were interpreted from the sodar backscatter signal with dedicated scheme (*Bielak, A., J. Burzyński, W. Kaszowski and J. Walczewski*, 1997; *Walczewski, J.*, 1997; *Walczewski, J.*, 1998; *Walczewski, J., A. Bielak and W. Kaszowski*, 1999).

The comparison of widely used simple schemes for the mixing height calculation with measurement of monostatic sodar is also presented in this paper.
The sodar algorithm for determination of the mixing height was preliminary improved; the new version was prepared to be tested. The tested version of algorithm is based on the scheme, in which mixing height is derived from:

- height of the ground based inversion layer (in the presence of this layer), or of the top of the multi-layer structure connected to the ground based inversion;
- height of the capping inversion, when the elevated inversion covers the convective cells beneath, (morning evolution of the convective boundary layer);
- height of the maximum range of the convective plumes multiplied by factor 1.5 in condition of well developed CBL until the maximum of such layer is reached, then the mixing height derived from the sodar is decreasing to the end of the day to the values of 80% of maximum to the end of the day (when the stable layer begins).

This is preliminary algorithm which can be tested to the measured data and will be improved in the future.

The comparison of the mixing heights determined by CALMET meteorological pre-processor with measurement of sodar in Cracow-Czyżyny

The model data were generated by the meteorological pre-processor CALMET (preparing the data for dispersion model CALPUFF (*Scire, J. S., R. J. Yamartino and M. E. Fernau*, 2000; *Scire, J. S., D. G. Strimaitis and R. J. Yamartino*, 2000)) for the location of the urban meteorological station Cracow-Czyzyny. The measurement data are coming from the measurements conducted at the station Cracow-Czyżyny.

The input to the model CALMET has been filled by the data (standard and aerological data) generated by the meteorological mesoscale model ALADIN. This refers to the 4-month period including months: April, June, September and December 2001. The results of calculation are presented on the Figure 1 for the each of these months separately.

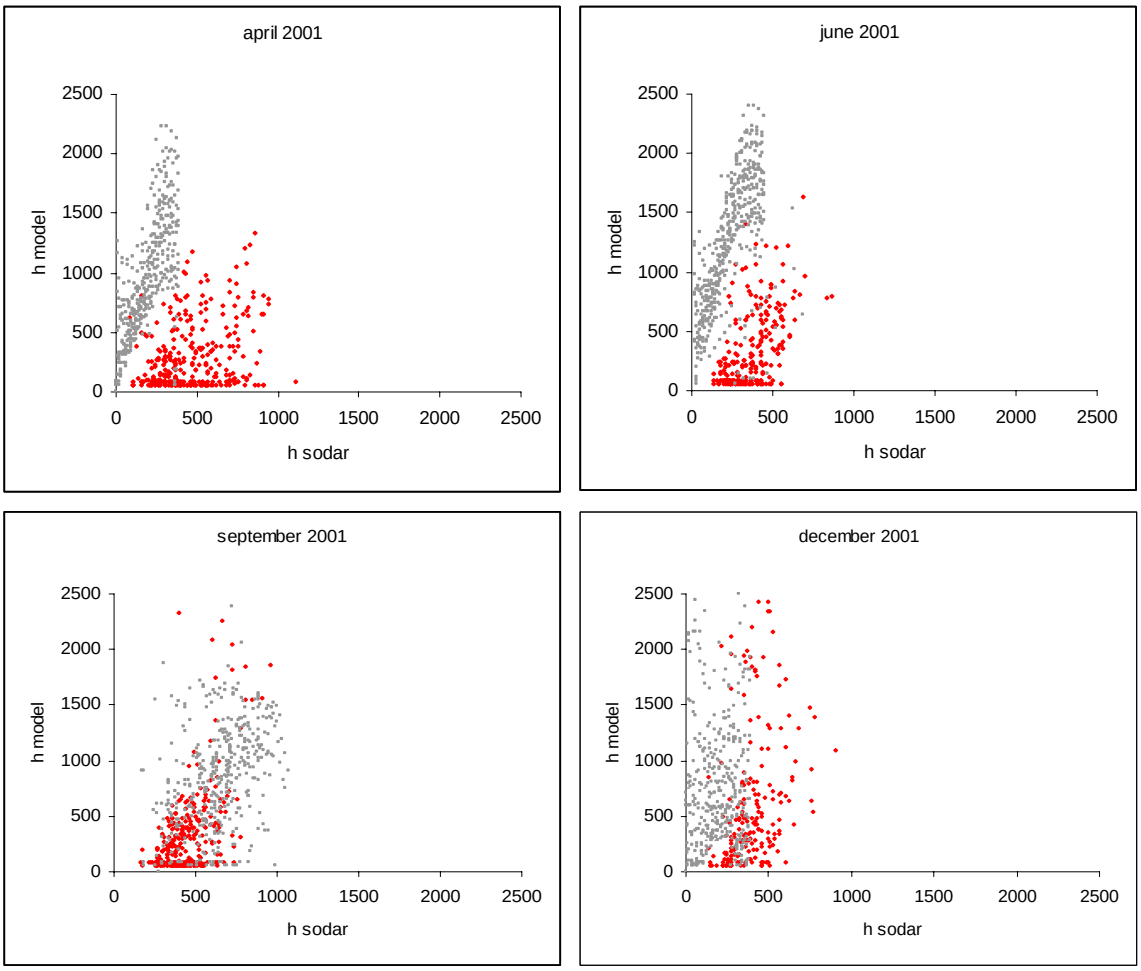

Figure 1. The comparison of the mixing height taken from the sodar measurement with values calculated by CALMET model, based on the ALADIN mesoscale model. April correlation coefficient r=0.62 , June r=0.76 , September r=0.54 and December r=0.3 (Grey dots –day cases, red dots night cases)

CONCLUSIONS

In the night time CALMET underestimates the mixing height, in the daytime (unstable case) it overestimates the mixing height.

The comparison of the mixing heights determined by simple diagnosis formulae with measurement results of sodar in Cracow Czyżyny

A collection of standard meteorological data and the results of monostatic sodar measurements was completed for the analysis. The data are taken from the period of two years - 1997 and 1998, covering more than 6200 hours cases of simultaneous measurement in one location (station Cracow Czyżyny) . Only data for stable and neutral stability conditions were selected. Calculated mixing heights were determined with use of formulae presented in the Table 1.

Table 1. Diagnosis formulae for the mixing height calculation

Reference	Mixing height equation	Range of use (PGT)	Correlation coefficient	Mean values [m]	Standard deviation [m]
1.Arya (1981) (after Zilitinkevich, 1972)	$h = a\left(\frac{u_* L}{f}\right)^{1/2} + b;$ $a = 0.43, b = 29.3$	D-F	0.138	150.7	130
2.Zilitinkevich (1972)	$h = c_2\left(\frac{u_* L}{f}\right)^{1/2}$, $c_2 \approx 0.4$ (0.13÷0.72)	E,F	0.138	115.6	130.6
3. Arya (1981)	$h = 0.089\frac{u_*}{f} + 85.1$	D-F	0.178	179	62.5
4. Mahrt (1982)	$h = 0.06\frac{u_*}{f}$	D-F	0.178	63.4	42
5.Nieuwstadt (1984)	$h = 28u_{10}^{3/2}$	D-F	0.298	60.3	35
6. Benkley & Schulman (1979)	$h = 125u_{10}$	D-F	0.31	200.8	78.4
7. H van Dop	$h = 0.263L\left[\left(1+\left(2.28\frac{u_*}{fL}\right)\right)^{1/2} - 1\right]$	E-F	0.135	65.6	76.5
8. Dierdorff	$h = \left[\frac{1}{30L} + \frac{f}{0.4u_*}\right]^{-1}$	D-F	0.173	262.5	194.5

Where: h- mixing height; u - wind speed (10m); f - Coriolis parameter, u_* roughness wind speed; L – Monin – Obukhov Length. The mean value for the mixing height in the sodar data set equals to 364.7 m with standard deviation 137.5 m

The correlation coefficients and the comparison of the means and standard deviations are also presented in the Table 1. The information of the mean values and the standard deviation for the sodar data set is presented below this table The scatter of the data for each formulae is presented on the Figure 2.

CONCLUSIONS

These diagnosis formulae are not good source of data needed for dispersion calculation. Some of them can be a little bit improved, but promising tools can be formulae including the Brunt-Väisälä frequency, where *N* represents non-local effects through background stratification at the top of the ABL. (*Joffre, S. M., M. Kangas, M. Heikinheimo and S. A. Kitaigorodskii*, 2001). Unfortunately for the N calculation the vertical profile of temperature is needed, up to heights above the top of the ABL. This is limiting the application of that method.

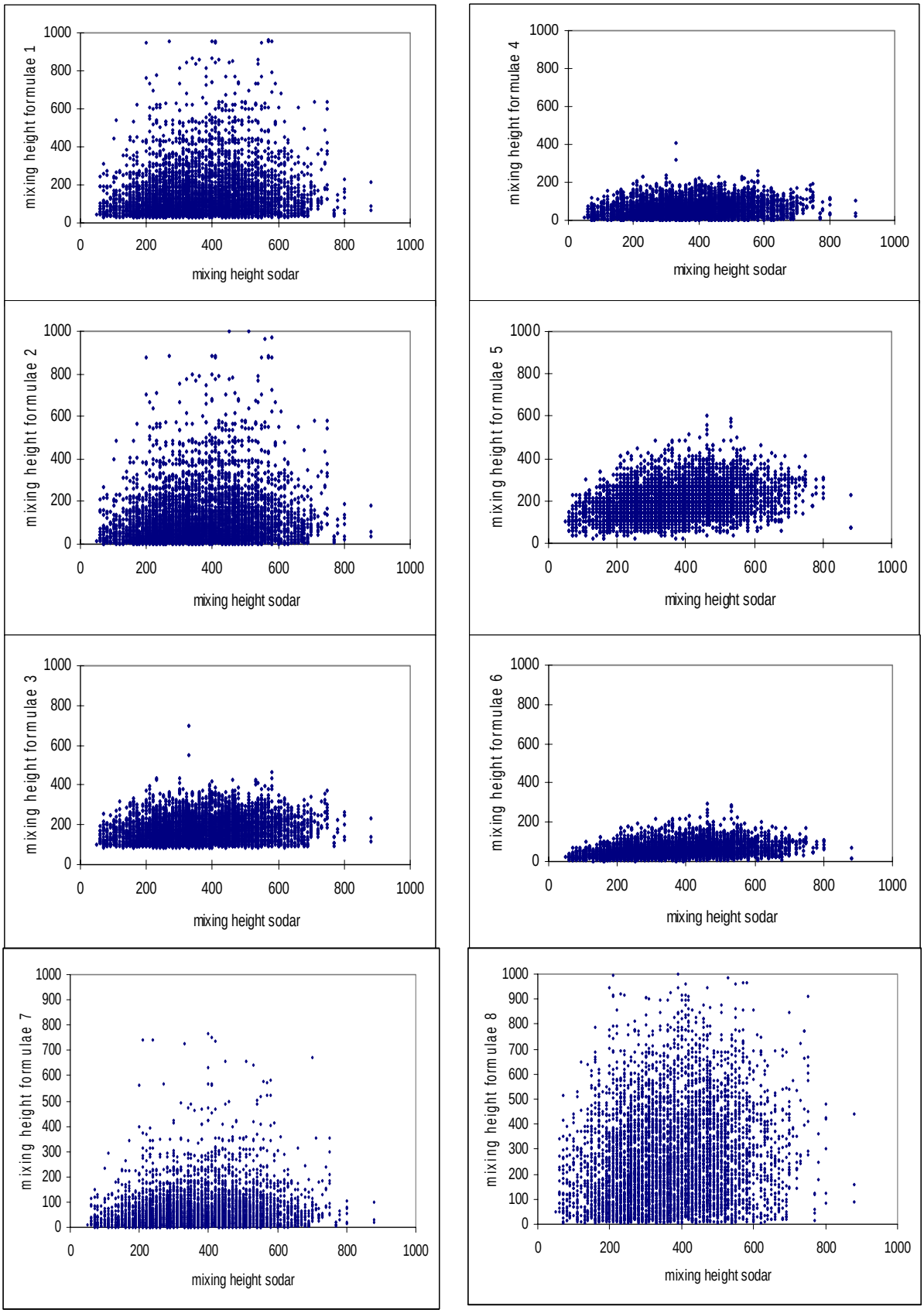

Figure 2. The comparison of the mixing height taken from the sodar measurement with values calculated with use of formulae from the Table 1.

REFERENCES

Bielak, A., J. Burzyński, W. Kaszowski and J. Walczewski, 1997: Some parametrization formulae for mixing height compared with joint sodar and lidar observations. EURASAP Workshop Proc., 1-3 Oct. 1997, Riso Nat. Lab., Roskilde, Denmark, 113-116.

Joffre, S. M., M. Kangas, M. Heikinheimo and S. A. Kitaigorodskii, 2001: Variability of the stable and unstable atmospheric boundary layer height and its scales over a boreal forest. *Boundary Layer Meteorol*. **99**(3), 429-450.

Scire, J. S., R. J. Yamartino and M. E. Fernau, 2000: A user's guide for the CALMET meteorological model. Eartch Tech, Concord, MA., http://www.src.com (accessed March, 2000)

Scire, J. S., D. G. Strimaitis and R. J. Yamartino, 2000: A user's guide for the CALPUFF dispersion model. Eartch Tech, Concord, MA., http://www.src.com (accessed March, 2000)

Walczewski, J., 1997: Some aspects of estimation of mixing height using vertical sodar records. EURASAP Workshop Proc., 1-3 Oct. 1997, Riso Nat. Lab., Roskilde, Denmark, 91-94.

Walczewski, J., 1998: Sodar data as a basis for an empirical model of diurnal and annual variability of mean mixing height. Proc., 9 th Int. Symp. On Acoustic Remote Sensing – ISARS'98, Österreich. Beitraege zu Meteorologie und Geophys., No 17, Vienna 1998, 235-238.

Walczewski, J., A. Bielak and W. Kaszowski, 1999: Aerosol layers in the atmosphere observed by vertical-sounding lidar as an indication of mixing layer height – comparison with acoustic sounding data. Optica Applicata, Vol. XXIX, No. 4, 1999, 449-459.