CORRECTION OF A SURFACE WIND SPEED DUE TO VERTICAL AVERAGING

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In regional and global numerical models of atmosphere a vertical momentum flux in a surface layer is expressed as follows *(IFS ECMF, 2001)*:

$$J_u = \rho C_M |U|^2 \tag{1}$$

Where ρ is the surface air density, C_M is the transfer coefficient, which depends on height z_k, (the lowest model level) roughness parameter z_0 and static stability. The wind speed U is determined at z_k. In numerical atmospheric models *(Pielke, 1984)* variables represent an average over grid cell volume. It gives the following expression for the model wind speed U_M at a lowest layer with a thickness of Δz, assuming a unit horizontal cross-section of the cell:

$$U_M = \frac{1}{\Delta z} \int_{Z_0}^{\Delta Z} U(z)dz \tag{2}$$

The layer-averaged U_M value is used in (1) instead of $U(z_k)$ in numerical models. The difference between U_M and $U(z_k)$ values arises from non-linear (logarithmic for the neutral surface layer stratification) variation of a wind speed with a height. There is no difference between U_M and $U(z_k)$ values in a case of the linear variation of a wind speed between model layers. It is easy to show that U_M is always less than $U(z_k)$ value. The ratio between them can be expressed as follows: $U(z_k)/U_M = \ln(z_k / z_0)/[\ln(\Delta z / z_0) - 1]$. Use of U_M in (1) will reduce a surface drag force and will cause an overestimation of a surface wind speed.

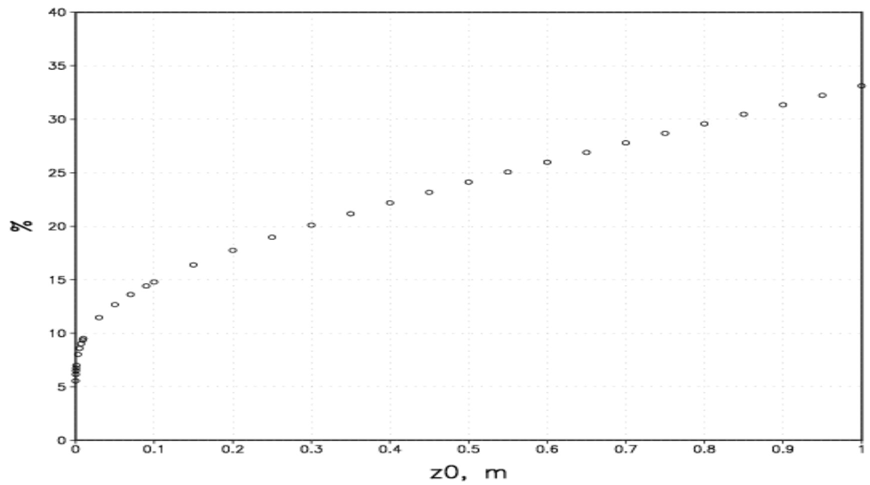
Expression $[(U(z_k)/U_M)^2 - 1]100$ gives a percentage of increasing in a surface drag force if we will use $U(z_k)$ instead of U_M in (1). This expression is shown in Fig. 1 as a function of z_0 and for z_k = 10m and for Δz = 20m. One can see that this correction to the surface drag force is substantial (20% and more) for relatively high z_0 (more than 0.30m) values.

Sensitivity runs were done using the COAMPS (Hodur, 1997) model to evaluate the significance of this correction. Two-nested domain (27-km and 9-km) and 48 hours "cold-start" run started at December 19 00 UTC were used. The 9-km domain covered Mississippi and Louisiana littoral zone with typical roughness values around 0.3-0.4 m over land. Fig. 2 shows 10-m wind speed forecast at *KPTN* (29.72N, 91.33W) and at *KPQL* (30.46N, 88.53W) produced at 9-km grid for a standard run and for a run with $U(z_k)$ speed used instead of U_M in (1). Use of $U(z_k)$ results in a slight lowering of 10-m wind speed (up to 0.5 m/s) as compare to the standard run.

References

Hodur R.M., 1997: The Naval research laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev.*, **125**, 1414-1430.

Pielke R.A., 1984: Mesoscale Meteorological Modeling. AP, 612 pp.



IFS documentation (CY21r4), 2001: Available online at http://www.ecmf.int/research/ifsdocs/index.html.

Fig. 1. $[(U(z_k)/U_M)^2 - 1]100$ as a function of a roughness parameter.

Fig. 2. 10-m wind speed from the standard COAMPS forecast (o) and from the forecast which takes into account effect of a wind speed vertical averaging in estimation of a drag force (•). *KPTN* (a) and *KPQL* (b).