Atmospheric Chemistry and Physics Discussions

Interactive
Comment

Interactive comment on "A semi-analytical solution for the mean wind profile in the Atmospheric Boundary Layer: the convective case" *by* L. Buligon et al.

L. Buligon et al.

lidianebuligon@gmail.com

Received and published: 26 November 2009

First of all, we would like to sincerely thank the reviewer for the questions about of the manuscript.

Anonymous Referee:

The manuscript deals with a derivation of the wind profile from the Navier-Stokes equations, accounting for large scale flow divergence and vorticity. The derivation is base don the GITT-method. The description of the model equations in chepter 2 is clear and transparent (2.1 basic equations; 2.2 boundary and interface conditions).

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Item 1. *However, chapter 3 on solutions is too long and the overview of the manuscript is lost. I suggest to shorten and move large parts to an appendix.*

The suggestion was accepted, but it is not possible to shorten the section very much. It was, therefore, split into subsections and the constants now appear in an appendix.

Wind profile simulations using the new method are compared to day 33 and 40 of the Wangara experiments.

Item 2. *With respects to day 33, then the agreement with the measurements is poor, although it is stated in the manuscript that "are similar to those observed". A discussion on the differences in the observation and model prediction and some possible explanations for the differences should be offered in the manuscript.*

Indeed, the affirmation that the profiles are "similar to those observed in Wangara" is incorrect. What we meant, and should have been written, is that the mean wind magnitudes are similar between model and observations. It has been corrected in the revised manuscript. Anyway, it is still important to understand why the model is incapable of solving the detailed shape of the observed vertical wind profile. The following paragraph, included in the manuscript, addresses this question.

The mean wind magnitudes simulated by the model are similar to the average magnitudes observed at Wangara (figure 3). It is important to stress that such agreement concerns only the vertical overall average, but not the local maxima and minima observed at day 33, which characterize an unmixed wind profile. Indeed, such vertical variability is quite difficult to capture with a simplified model, as stated by Wyngaard (1988): "unfortunately, our knowledge of PBL physics does not yet allow us to calculate the wind profile from first principles . . .". Unmixed wind profiles, such as those observed at day 33, may be attributed to a number of reasons, such as local baroclinicity or vertical eddy diffusivity variability. Any of these reasons are, however, case-specific, and cannot be reproduced by a model where thermal wind is assumed to be constant.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Item 3. *I also note the pronounced differences in the vertical gradient of the wind speed near top of boundary layer; the models seems to have a very pronounced positive gradient ($\frac{du}{dz}$) but the measurements have a negative gradient. This deserves a thorough discussion. It can be noted that for barotropic conditions the geostrophic flow is constant with height above the boundary layer corresponding to the zero wind speed gradient at the top of the boundary layer.*

The reviewer is correct. However the model is not barotropic, although this issue was not properly described in the original manuscript. The following sentences, addressing this issue, have been added to the manuscript.

The geostrophic wind components in the baroclinic case are approximated by: $u_g = u_T\,z + u_{g0}$,
$v_g = v_T\,z + v_{g0}$, where u_{g0} and v_{g0} are the surface geostrophic winds components and u_T and v_T are the thermal wind components (Sorbjan (1989)).

The wind components at the top of the domain are given by a thermal wind approximation (Equations 1), and both the surface geostrophic winds (u_{g0} and v_{g0}) and the thermal wind magnitudes (u_T and v_T) are given by Wangara observed values.

Thermal winds were observed only twice a day, at synoptic times, and those values were interpolated to 1500 LT. The large gradients near the top of the boundary layer arise from the assumed baroclinicity. For any case, the different modeled profiles agree to each other as a consequence of the top boundary conditions. They do not necessarily agree to the observed winds at the boundary layer top as a consequence of the interpolation used to calculate the thermal wind. This limitation has been noticed by Sorbjan (1989): "Finally, results of the Wangara experiment pointed out the difficulties and limitations of obtaining accurate measurements of thermal winds, vertical velocities, and representative spatially averaged fluxes."

Item 4. *Similary for Wangara day 40 (Fig. 4, the figure legend tells day 33 but this must be a mistake). Again the wind speed gradient ($\frac{du}{dz}$) of the simulated wind profiles*

is vary large nearthe top of the boundary layer for all combinations of divergence and vorticity, but the wind speed gradient of the measurements is small. Please comment.

Yes, the caption was incorrect. The reply to the previous comment applies here as well.

Item 5. *The tables with quality índices are not useful without na explanation of the índices and a thorough discussion of the numbers in the tables. This should be added to the manuscript.*

The following appendix was added to the manuscript.

Appendix

Following Hanna (1989) the statistical indices used in this study are defined as:

NMSE=$\frac{\overline{(C_o - C_p)^2}}{\overline{C_o}\ \overline{C_p}}$ (Normalized Mean Square Error)

$FB = \frac{(\overline{C_o} - \overline{C_p})}{0,5(\overline{C_o} + \overline{C_p})}$ (Fractional Bias)

$FS = 2\frac{(\sigma_o - \sigma_p)}{(\sigma_o + \sigma_p)}$ (Standard Fractional Bias)

$R = \frac{\overline{(C_o - \overline{C_o})(C_p - \overline{C_p})}}{(\sigma_o \sigma_p)}$ (Correlation Coefficient)

$FA2 = 0,5 \leq \frac{C_o}{C_p} \leq 2$ (Factor of 2)

where C is the analyzed amount and the subscript o and p refer to observed and predicted quantities, respectively, the over bar indicates an averaged value. The statistical index FB says if the predicted quantity underestimates or overestimates the average observed ones. The statistical index $NMSE$ represents the quadratic error of the predicted quantities related to the observed ones. The statistical index FS indicates the as the model gets to simulate the dispersion of the observed data. The statistical index $FA2$ supply the fraction of the data (%) for the ones which $0,5 \leq \frac{C_o}{C_p} \leq 2$. The best results are expected to have values near zero for the indices $NMSE, FB$ and FS and near 1 in the indices R and $FA2$.

Interactive
Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

The following paragraphs, with the interpretation of the statistical indices, were also added.

Regarding the vertical profiles for day 33 (Figure 3), the analysis based on statistical indices shows that, when $\delta = \zeta = 0$ and $\delta = \zeta = -f_c$, the model overestimates the mean observed wind magnitude (small negative values of FB). On the other hand, the statistical index FB shows that the horizontal wind direction is underestimated regardless of δ and ζ, meaning that the modeled winds are rotated counterclockwise with respect to the observations. The statistical index FS indicates that, except for the case $\delta = \zeta = 0$, the dispersion of the mean wind magnitude underestimated the experimental data. For the wind direction, this same index is negative in all cases, a consequence of the very small wind direction variability with height in the observed data, while the model results indicate a slight wind rotation with height. Other indices, such as $NMSE$, and $FA2$ are similar for all cases, and indicative of good agreement between model and observations. Finally, the correlation coefficient R was more variable, and therefore, serves as a measure of the best agreement in each case.

A similar analysis of the statistical indices as that made for day 33 can be made for day 40 (Tables 4 and 5).

Please also note the Supplement to this comment.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 19817, 2009.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper