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The Cryosphere Discussions

Interactive comment on "Spatial structures in the heat budget of the Antarctic Atmospheric Boundary Layer" *by* W. J. van de Berg et al.

Anonymous Referee #2

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In this paper, a regional atmospheric model is used to gain insight in the processes occurring in the Antarctic atmospheric boundary layer. I have read the manuscript with pleasure. The paper certainly gives the reader a more in-depth insight in processes occurring in the Antarctic boundary layer. Therefore I think this manuscript is worth to be published in "The cryosphere discussions", provided that the comments below are addressed.

General comments:

- The definition of the boundary layer height (BLH) is crucial in this paper. After all, average terms of the heat budget over the depth of the boundary layer are discussed and presented throughout the paper. It is therefore necessary to evaluate the model ability to correctly represent the BLH compared to available measurements. This needs to be done using a consistent definition of the BLH in model and measurements. Moreover, I find it somewhat surprising that the authors choose to define the boundary layer as the level where the bulk Richardson number reaches 0.25 of its surface value (as is standard in the model) and modify this using an ad-hoc function given in Fig 4a. It seems that this function is chosen to get about the right order of magnitude. From the manuscript it is not at all clear that this new BLH satisfies the criteria given on page 278. I think it is more straightforward to use the modeled profiles to determine the BLH, and therefore directly satisfy the criteria given on page 278.

- Although the heat budget is discussed in detail, there is no discussion on how this would affect the near-surface temperature distribution. In the introduction is written: *Analysis of the heat budget provides a tool to understand the processes that control the near-surface temperature in Antarctica.* But is the small scale variability in the horizontal and vertical heat advection really relevant for the current temperature distribution? A simple way to answer this question might be the following: One could perform a linear regression between the 2m potential temperature and surface elevation (possibly continentality could also be included). The predicted temperature could then be substracted from the modeled temperature (Fig 1). Subsequently the spatial variability in the different terms in the heat budget could be used to understand the temperature spatial distribution, corrected for differences in elevation. Does such a study confirm that the regions with subsidence are warmer than other regions of equal height where no subsidence takes place? It would also be interesting to include a quantitative estimate of the effect.

- "Horizontal advection" (AdvH) is derived along the hybrid eta-coordinate of the model. Therefore, AdvH is not a horizontal advection, but is more closely related to the "along slope" advection. The vertical advection is approximately the advection perpendicular to the slope. This should be made clear especially in the abstract and conclusions. Some related issues: i) Page 281: Line 20: *Warming by AdvH is related to the deepening of the inversion layer.* This statement needs to be worded more carefully: After all, there is also a contribution to the "horizontal" rise of free the atmosphere potential temperature towards the interior in Fig 7a due to increasing surface elevation in a stably stratified atmosphere. ii) The spatial variability in AdvH in the region of the Antarctic Peninsula and Marie Byrd Land region are related to orographic uplift. Since the atmosphere is stably stratified, an uplift (downward motion) always leads to adiabatic cooling (warming). By using hybrid coordinates, this cannot be separated from horizontal advection (for example the transport of relatively warm air from the west of the Peninsula to the east side). This information should be included in the manuscript, and I think it would also be a good idea to mention this in the figure captions where the spatial variability of AdvH is shown.

- In the abstract it is written that: *meso-scale (about 10 km) topographic structures have thus a strong impact on the ABL winter temperature.* This seems in contrast with what is written in the manuscript: *AdvV reaches its extreme positive values in valleys and ridges with length scales of 100 km.* (Page 282; line 16). Moreover(as indeed recognised by the authors on page 282) the effective model grid spacing is about 4 times the model grid spacing (so 200 km). The patchy structures in Fig 8, 9 and 11, with typical length scale in the order of this effective model grid spacing, is therefore likely to be related to the grid spacing used and not necessarily a phenomenon with a physical meaning. I therefore think that it is inappropriate to mention such a length scale in the abstract. Furthermore, it cannot be excluded that smaller scale structures appear when the grid spacing of the model decreases. An extension of the discussion on this issue is needed.

- The comparison between modelled TOA net radiation and ISCCP data indeed shows a good correspondence for winter but there are also some small deficiencies namely: i) an overestimation in the region with the highest elevation and ii) an underestimation at the steep slopes around the ice shelves, and to a lesser extent on the ice shelf. Do you know the reason for this deficiency? (surface temperature, temperature profile, clouds?)

- Page 281: line 14 *The near surface warming at the ice sheet margin is related to the persistently large temperature difference between the ice shelf and the ocean.* I do not understand this argument: Vertical advection can only take place when a vertical potential temperature gradient is present. Such a strong vertical potential temperature gradient is not represent in Fig 7a. Please explain.

- Fig 7c: Please show the meridional wind in this figure. After all, this component determines, together with the meridional temperature gradient which is already shown, the meridional horizontal heat transport. The zonal wind component is already shown in Figure 7a. Is the zonal heat transport negligible?

- Page 284: Line 28: *Convex topographic features have a weak inversion..* I think this statement is not correct: in case of convex topography, subsidence takes place. In absence of other processes, subsidence leads to a strengthening of the inversion, rather than a weakening.

Technical corrections:

- Page 274, line 1: some text is probably missing from this line. *Van den Berg et al. (2007) presented*

- Page 274, line 23: replace *token* by *taken*

- Page 281: line 23: Please remove *which*

- Page 282: Line 10: Strictly speaking the 3D wind field is not divergent, so it is better to write *horizontal divergence*

TCD

1, S168–S172, 2007

Interactive Comment

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- Line 284: Line 18: Change degrees S to degrees E?
- Fig 5c: RAdv is not defined in the manuscript.

Interactive comment on The Cryosphere Discuss., 1, 271, 2007.