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Interactive Comment

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

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First of all, we want to thank the reviewer for his comments.

Remark 1) *The heat budget equation as presented (equation 1) applies to a single level in the atmosphere. However, what is often presented in the paper (e.g. in Figure 6) appears to be the contributions to the temperature tendency averaged over the depth of the ABL. Since the ABL height is not constant, but varies spatially, additional terms involving the spatial derivatives of ABL height appear in the tendency equation. This is alluded to in the text but I think it would be clearer if the vertically-integrated form of the tendency equation were presented.*
Answer: In this paper, we present ABL averages of the various heat budget components. More specifically, the point-wise heat budget components are calculated first, and then these components are averaged over the ABL depth. As a result, there are

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no additional terms due to spatial patterns in the ABL depth. These additional advection terms would only appear if T and p are averaged over the ABL first, and then heat advection is calculated. In order to clarify this order of calculation, we added to the end of section 3.3:
"In the remainder of this paper, we will present averages over this ABL depth of pointwise calculated heat budget components."

Remark 2) *The rescaling used for ABL depth (section 3.3) seems rather arbitrary and it is not clear what physically motivates this choice. If the focus of interest is the surface inversion layer, why not use the surface inversion depth?*
Answer: We have considered several methods that provide an ABL depth that is spatially continuous, applicable year-round and satisfies the requirements that are listed in Section 3.3. We tried to define the ABL depth using (a combination of) the temperature deficit, ABL wind profile and flux profiles, but we rejected all these attempts because of lacking spatial and temporal continuity. Indeed, we agree that scaling of model diagnosed ABL depth is an empirical solution and not physically deduced, but we found it to be the best method to satisfy the requirements listed in Section 3.3. The basis of the ABL depth is model ABL depth, thus physical. We partly rephrased the last paragraph of section 3.3 in order to clarify our choices better.

Technical comments:
1) p273, l10-11: *"The wind field in a steady-state ABL must be divergent". Not necessarily. Thermal balance could be achieved by horizontal advection.*
Answer: We have to be more precise: "A *katabatic* wind field in a steady state ABL *over a large dome-shaped ice sheet* must be divergent as long as . . . ".
In case of ice sheet like in Antarctica, the air in the ABL would flow in a closed circle around the ice sheet dome if the wind field is non-divergent (= no entrainment), because in steady-state, the katabatic force balances with the Coriolis force. Since the temperature is constant in time, the temperature of an air parcel must be unchanged after completing one circle around the dome. Thus, averaged over the air parcel path,

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the effect of horizontal advection must be zero. Hence, horizontal advection cannot provide a thermal balance in absence of divergence. Since vertical advection implies ABL wind field divergence, the wind field in a steady-state ABL must be divergent.

3) p274, l17: *“gas", not “gasses".*

Answer: In our case it is gasses. We varied CO2, but also NH4, NO2 and CFCs.

5) p276, eqn. 1: *Why is there no latent heat flux term?*

Answer: Because the latent heat flux in the atmosphere is a vertical water vapor flux. As long as water vapor does not condensate (and contributes to Q), the heat is latent. The latent heat flux is part of the moisture budget equation (not discussed in this manuscript).

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