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The Cryosphere Discussions

Interactive comment on "Analysed and observed moisture transport as a proxy for snow accumulation in East Antarctica" *by* Ambroise Dufour et al.

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In our response below, we will show the comments of the reviewer in bold, our own in plain text and the excerpts from the article in italics.

This is a very high quality and comprehensive piece of work. It demonstrates the continuing challenges of determining Antarctic snow accumulation variability and change from radiosonde observations and global reanalyses via the moisture flux and its convergence. And continental-scale accumulation cannot reconstructed from surface observations like snow stakes, nor from space for long time scales.

We thank the reviewer for his appraisal of our work and kind words.

Because reanalyses are a central aspect of this work, "reanalysis" should appear in the title to facilitate discovery of this important effort.

We have changed the title accordingly to :

Moisture transport in observations and reanalyses as a proxy for snow accumulation in East Antarctica

The Cryosphere may not be the best journal for this effort that has a strong atmospheric component.

We respectfully disagree. The discussion over atmospheric processes is only a means to an end and this end is to estimate snow accumulation. We concede that our reasoning needed to be explicited. This we did in the paragraph starting on page 3, line 31 :

The study of snow accumulation via upstream atmospheric processes relies on the conservation of water vapour. Over long time scales, the rate of change of precipitable water can be ignored (Peixoto and Oort, 1992) so that the moisture budget equation is reduced to :

$$\oint_{\partial EAa} \int_0^{p_s} q\, v_n\, dl \frac{dp}{g} = \int \int_{EAa} \int_0^{p_s} c - e\, ds \frac{dp}{g} \quad (1)$$

where "EAa" refers to the East Antarctic ice sheet and ∂ to its boundary. p_s is the surface pressure, q is the specific humidity and v_n is the wind component normal to the boundary. c and e are the condensation and evaporation rates per unit mass. One must then assume that the vertical integral of condensation and evaporation is equal to net precipitation i.e. that the transport of water only occurs in the gas phase. As it happens, the convergence of cloud frozen and liquid water is in the order of 10 % of the vapour convergence in Antarctica according the few reanalyses that provide these variables (Dufour et al. 2016). The final step is to equate net precipitation with snow

accumulation. Liquid runoff is indeed negligible given the low temperatures (King and Turner, 2007). Sublimation and hoarfrost will appear under evaporation. However, our method cannot account for snow blown out of the domain by the wind.

Blowing snow receives further treatment in the conclusion :

Regarding exports, the conflation of net precipitation with accumulation ignores wind erosion in particular. Since blowing snow leaves a signature on the humidity profile (Barral et al., 2014), radiosoundings could in fact lend themselves to the study of snow fluxes too.

Some smaller items:

Make reference to Antarctic snow accumulation estimates from extrapolation of ice core time series, like: Thomas, E. R., van Wessem, J. M., Roberts, J., Isaksson, E., Schlosser, E., Fudge, T. J., Vallelonga, P., Medley, B., Lenaerts, J., Bertler, N., van den Broeke, M. R., Dixon, D. A., Frezzotti, M., Stenni, B., Curran, M., and Ekaykin, A. A.: Regional Antarctic snow accumulation over the past 1000 years, Clim. Past, 13, 1491-1513, https://doi.org/10.5194/cp-13-1491-2017, 2017.

We had overlooked this synthesis. In spite of the 1000 year scope, the authors comment 20th century trends relevant to our short and recent period of study. We made two references to Thomas et al., 2017: in the introduction (page 2, line 5) and in the comparison of time series (page 7, line 28). Previous references to ice core studies include Monaghan et al., 2006 ; Van Ommen et al., 2012 ; Medley et al., 2017

I didn't see explicit mention of the two tables in the text.

This oversight has been corrected.

In Fig. 7(b), why is the specific humidity equal to zero for JRA 55 and MERRA 2 at 1000 hPa? Is this also the case for IGRA? What do you do for that part of the periphery between McMurdo and Halley where 1000 hPa is far below the ice surface?

The abnormal profiles in Figure 7 (b) were due to an inconsistent treatment of fictitious underground values sometimes provided by reanalyses on pressure levels. They are now systematically masked and the phenomenon has disappeared in the new figure.

The horizontal averages receive more attention in the methods section (page 4, line 9). When a pressure level is partly underground, the path integral is performed only over the sections above the surface.

Because there is no significant time trend in P-E/C values, include in Table 2 an estimate of the time averaged snow accumulation from the best available observational synthesis.

We have added a reference to Arthern et al., 2006 in Table 2. Fortunately, they provided accumulation estimates over East Antarctica as well as the whole continent.

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