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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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We thank the reviewer for his thorough reading of our manuscript, manifest in the many minor comments he made to the body of the article, which we found very helpful. Below we address the three major points of the review (in bold) and present the subsequent changes to the manuscript (in italics).

1. The data sources used in the study (reanalyses, IGRA 2 radiosonde archive) are not described in sufficient detail. The differences between the various reanalyses (figure 5) cannot be properly understood without knowing how the reanalyses differ in terms of resolution, type of data assimilation used, etc., and

while these details may be found in the references given in the text, a short description of each analysis should be added to the text. Much of this information is provided in Table 1 which, as far as I can ascertain, is never mentioned in the text!

The table presenting the reanalysis is now explicitely referenced (page 2, line 27). In addition to the specifications, we briefly listed the distinctive feature of each dataset. The paragraph presenting the reanalyses (p.2, l.24) now reads :

We build upon a similar study in the Arctic (Dufour et al., 2016) and the reanalyses presented herewith. The first NCEP NCAR reanalysis was not included due to a well known moisture diffusion problem over Antarctica (Cullather et al. 1998) as well as unrealistic evaporation (Hines et al. 1999). Its successor, NCEP DOE R2 solved the main errors from the first attempt (Kanamitsu et al., 2002). At 2.5°, it has the lowest horizontal resolution of our ensemble (Table 1) as well as the fewest vertical levels. We left out JRA 25 and MERRA 1 because they were not extended up to 2016. CFSR has the highest resolution (T382 or approximately 35 km) and includes ocean and sea-ice physics in its forecast model. Our period of study starts in 1980 to adjust to the new reanalysis from NASA, MERRA 2. Among other things, the data assimilation system from MERRA 1 was improved to take into account satellites launched after NOAA-18 (2005) for instance the hyperspectral infrared radiances of EOS Aqua (Gelaro et al., 2017). ERA Interim and JRA 55 implement 4D-Var assimilation whereas CFSR and MERRA 2 run improved versions of 3D-Var. ERA Interim has been commended as especially reliable over Antarctica (Bromwich et al., 2011 ; Wang et al., 2016).

Likewise, two short lines introduce the radiosonde dataset (p.3, l.11) :

The Integrated Global Radiosonde Archive version 2 provided the sounding data (?). IGRA stores quality-controlled soundings from more than 2 700 stations worldwide dating as far back as 1905.

2. There is insufficient detail provided on the methodology used. Again, there

are references to other papers, which is appropriate for the details but the basic methodology should be described. Places where further detail is required include p2, line 26 and p3, lines 9-12.

The methods section was lengthened and detailed to make the article less dependent on cited papers. We were more explicit on :

- the co-location of reanalyses with soundings in time and space (old p.3 l.9-12, new p.3 l.28) :

When we needed to compare the datasets at specific locations, we co-located the gridded reanalysis data with the stations using bi-linear interpolation. In such cases, the year-round six-hourly reanalysis values were masked to match the irregular availability of observations.

- the relevant approximations from fluxes to accumulation (old p.2 l.26 ; new p.3 l.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 :

$$\oint\limits_{\partial EAa} \int\limits_{0}^{p_s} q\, v_n\, dl \frac{dp}{g} = \int\limits_{EAa}\int \int\limits_{0}^{p_s} c - e\, ds \frac{dp}{g} \quad (1)$$

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.

- the vertical and horizontal integrals, explicited with two equations

3. The Conclusions section does not adequately summarise and discuss the main findings of the paper. What are the key recommendations regarding the use of reanalysis data that have come from this study? Can the time series of moisture flux at the radiosonde stations only be used as a proxy for accumulation variability? This important question isn't properly addressed, although it could be using the data on figures 11a and 11b.

Thanks to this final point, we realised that our data justified stronger conclusions.

We exploited the time series of Figure 11 more deeply in the second to last section (p.8 l.8) :

We deduce from Figure 11 (b) a straightforward assimilation of radiosoundings by reanalyses when available. The reanalysis time series at the stations would be less consistent if the assimilation relied more on the model first guess or on remote sensing data. While the time series at the stations may be accurate, they would be irrelevant if they were not representative of East Antarctica as a whole. If that were the case, the two panels of Figure 11 would have little in common. As we saw, this true of decadal variability. However once trends are removed, the continental and the station detrended time series are significantly correlated on a year to year basis for all reanalyses except NCEP DOE R2. The significant correlation coefficients lie between 0.48 (JRA 55) and 0.61 (MERRA 2). This gives credibility to the claim that the network of stations is representative of the entire boundary of the ice sheet.

Regarding reanalyses, we confirm their unreliable representation of interdecadal variability. We further claim that our observational time series can be used to detect the said artefacts (p.8 l.30) :

Changes in the observing system confounds the interpretation of temporal variability in reanalyses. At the cost of spatial coverage, the original observations provide homogeneous time series that can be used as a proxy for accumulation. After a sharp decline in the 1980s, the moisture transport recovered gradually in the 1990s and early 2000s and has since slightly decreased. This time series can now serve as a reference to identify spurious trends in the reanalyses.

Finally, we explore the potential use of soundings to study blowing snow events (p.9 l.3) :

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.

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