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The Cryosphere Discussions
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Interactive comment on "Snow on the Ross Ice Shelf: comparison of reanalyses and observations from automatic weather stations" *by* L. Cohen and S. Dean

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We appreciate the reviewer's comments, which address some important point and have helped to improve the manuscript. In response to the comments, we have made several significant changes to the manuscript in order to make the main points of the study more clear and have added a more comprehensive discussion of several points, including the addition of two new figures and major changes to one figure. Below is our response to the reviewer's general remarks, which addresses the main points, followed by our responses to the specific remarks and proposed changes to the manuscript (reviewer's comments are denoted by – followed by our responses denoted by » and

proposed changes to text in quotes).

General Remarks: One of the main points that the reviewer makes in the general remarks and throughout the manuscript is that there is little discussion in the manuscript of how NWP models in general perform with respect to precipitation, and that the analysis is too specific to the ERA-Interim and NCEP-2 reanalyses. We argue that the use of the two reanalyses datasets is sufficient for this study because we are primarily presenting a newly developed methodology to utilize the ADG measurements as a proxy for precipitation, and to determine whether this new set of ADG measurements can be used for comparisons of model precipitation on synoptic timescales. The use of these measurements as a basis for comparison with precipitation is not straightforward, and no region-wide studies using these types of measurements have been previously done for polar regions. We think that this being the main motivation of the study was not made very clear in the manuscript, and have therefore re-worded several paragraphs, particularly in the introduction and conclusions sections. In this light, we think that an in-depth discussion of the strengths and weaknesses of NWP models in general is also beyond the scope of this manuscript. However, we have added further discussion of the differences between ERA and NCEP resolution and assimilation in Section 3.2, and a brief discussion of the possible effects on precipitation. We've also added a substantial discussion (including new Figures 3a and 3b) concerning the differences in the ERA and NCEP circulation and moisture representation in regards to differences in precipitation between the two reanalyses products. Concerning the distances between AWS locations and ERA and NCEP gridpoints, we agree this is an important point to address and have changed Figure 1 to address this, as well as adding further discussion in Section 3.2. We have also added a new figure (Fig 6) and discussion, which suggests that the correlations in event size appear to be driven more by wind speed rather than the distance between AWS and gridpoint locations. (The new figures are included as a separate Supplemental file.)

Specific remarks

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Abstract

– P1244 L2 replace 'is developed' with 'is carried out'. »Changed the wording of this sentence to better reflect the main point of this study. See next comment for new text.

– P1244 L4 See comment above. » With consideration to the point that the methodology described is not new, we disagree. Using the ADG measurements is not straightforward, and this manuscript describes a methodology developed to use this data to provide a new set of ground-based observations to compare with modeled precipitation (as discussed above in the General Comments). We have made some changes to the wording of the Abstract to try to make this point more clearly: "Snow accumulation measurements from Automatic Weather Stations (AWS) around the Ross Ice Shelf (RIS), Antarctica are used to provide a new set of ground-based observations which are compared to precipitation from the ECMWF ERA-Interim and NCEP/NCAR Reanalysis-2 datasets. The high temporal resolution of the AWS snow accumulation measurements allow for an event-based comparison of reanalyses precipitation to the in-situ observations. Snow accumulation records from nine AWS provide multiple years of accumulation data between 2008–2012 over a relatively large, homogeneous region of Antarctica and provide the basis for a statistical evaluation of accumulation and precipitation events. The complex effects of wind on snow accumulation (which can both limit and enhance accumulation) complicate the use of the accumulation measurements, but this analysis shows that they can provide a valuable source of ground-based observations for comparisons to modeled precipitation on synoptic time scales. The analysis shows that ERA-Interim reproduces more precipitation events than NCEP-2 and these events correspond to an average 8.2% more precipitation. Correlations between reanalyses and AWS event sizes are seen at several stations (at > 90% significance levels) and show that ERA-Interim consistently produces larger precipitation events than NCEP-2."

Introduction

–P1245 L25 See comment above, I am missing a discussion on general performance

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of NWP modeled precipitation. »Addressed in the response to General Remarks.

–P1245 L29 Write out the abbreviations when mentioned for the first time (such as ECMWF). »The abbreviations are written out previously (P1245 L6 & L9); deleted "(ERA)" and "(ECMWF)" here.

–P1246 L18 Replace 'represents' with 'represent'. »Done

Site description and snow accumulation data

– P1247 L24 Consider adding 1 or 2 figures illustrating the general (wind) conditions in the Ross Ice Shelf region. »Added vectors to Figure 1 showing surface winds on Ross Ice Shelf and new text (paragraph 3, section 2): "Figure 1 shows the near-surface (850 hPa) winds on the Ross Ice Shelf (from the ERA-Interim reanalysis data), which illustrates the varying wind conditions experienced at different stations."

– P1248 L22 Replace 'accumulations' with 'accumulation'. »Done

Data processing

– P1249 L26 The SR50 records the distance to the snow surface based on the speed of sound at 0_C. Are these data corrected for temperatures deviating from 0_C ? »Yes. Added text here: "The temperature-corrected ADG data. . ."

– P1250 L6 Remove 'of' between 'timing' and 'can'. »Done

– P1250 L20 See comment above. What is the effect of the different resolution on the estimated amount of precipitation? »Further discussion of reanalyses resolution (and other differences between ERA and NCEP) is added in Section 3.2 (see new text below). More in-depth discussion on this is beyond the scope of this manuscript as discussed in General Remarks above. New text (2nd paragraph, Sec 3.2): "The ERA forecast model runs at both higher spatial and temporal resolution than the NCEP model (three-hourly intervals versus six-hourly intervals and ∼80 km versus ∼210 km horizontal resolution). Thus, we expect the ERA precipitation model to perform bet-

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ter in regards to reproducing precipitation on smaller spatial and temporal scales. In addition, ERA reanalysis also incorporates more satellite observations (including GPS radio occultation measurements) and uses a more sophisticated variational assimilation system (4D-Var versus 3D-Var). Differences between ERA and other reanalyses precipitation products since 2006 have been attributed to the assimilation of the new satellite observations (Bromwich et al., 2011) and the more sophisticated variational assimilation system in ERA has also been shown to result in improved moisture analysis (Andersson et al., 2007; Simmons et al., 2010)."

– P1251 L3 Where are the grid points located with respect to the AWS and what is the effect of the horizontal difference of up to 100 km, which considerable, on the amount and timing of the events? »Added the reanalyses grid points to Figure 1 and added text (last paragraph, Sec 3.2): "Most of the gridpoints are relatively close to their respective AWS, and all are less than ∼100 kilometers from the AWS. Stations located in the region that has the highest topographic gradient (near the TAM) are closest to their respective gridpoints, which helps minimize differences due to orographically induced precipitation. Smaller topographic features such as Ross Island and Roosevelt Island are not resolved topographically in either of the reanalyses, and thus, localized precipitation due to these features is not expected to be reproduced. For large-scale, synoptically-driven precipitation events, the distances between gridpoints and AWS will not affect the timing or amount of precipitation considerably."

– P1251 L16 Consider adding a figure with time series of daily accumulation/precipitation rate for 1 site as a function of time including the cut off line to illustrate this procedure. »A figure like this would be very similar to the already existing Figure 4 and we think it would not add significantly to the understanding of the procedure. We have modified Figure 4 slightly to make it more clear.

– P1251 L17 Do I understand this correctly that when there is no overlap in time but there is not more that 1 day difference in time, the event is considered to overlap? »Yes, that is correct. Modified the text here slightly: "An event is defined for each dataset as

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the period of time that the accumulation/precipitation rate remains above the cutoff value (ADG: 5 mm snow day-1; reanalysis: 0.5 mm w.e. day-1), and only events lasting longer than 6 hours are considered. Coincident events are then determined by identifying the reanalyses events which overlap in time with or are within 24 hours of an ADG event. " Also new text in Section 4, 3rd paragraph: "The highly stepped nature of ADG accumulation events is clear, as is the more broad nature of reanalyses events. The duration of events are different for each dataset but the events overlap in time (or are within 24 hours as discussed in Section 3.3) as illustrated in Figure 4."

Results – P1252 L1 Remove 'the' before 'ERA'. »Done

– P1252 L4 Explain or discuss possibilities why ERA is producing much more precipitation than NCEP. »We have included a new Figure 3 and added text to discuss (2nd paragraph Section 4): "As precipitation in the reanalyses forecast models are largely driven by the meridional (moisture-bearing) circulation and amount of water available (Kalnay et al., 1996; Dee et al., 2011), we look at the differences between ERA and NCEP for these parameters in order to understand why the precipitation amounts differ so much. Figures 3a and 3b show the difference between ERA and NCEP (ERA minus NCEP) total precipitable water and near-surface meridional winds (850 hPa) over the RIS averaged from 2008–2012. Interestingly, Figure 3a shows that the ERA reanalysis has less moisture over much of the RIS and Ross Sea, but more along the TAM, which is consistent with the larger amounts of precipitation produced by ERA for stations along the TAM, while the stations further from the TAM (Ferrell, Margaret, and Nascent) produce similar amounts to NCEP. Figure 3b shows that ERA has a weaker southerly component (more positive v-wind) for air coming from the Ross Sea (moisture-bearing) onto the RIS, but a stronger southerly component along the TAM. The weaker cyclonic circulation over the RIS in ERA is thus able to explain the differences in total precipitable water. The figures show that the largest differences between ERA and NCEP for both water content and meridional circulation are along the TAM. This is possibly due to the higher spatial resolution of the ERA model being able to

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more accurately reproduce the effects of the barrier formed by the TAM."

– P1252 L23 In the last 2 paragraphs of this page a comparison between ERA and NCEP is given based on Tables 2 and 3. This comparison is a little difficult because the time periods for both models are different. For an easier and more honest comparison, please compare/present only for the same periods. » Table 2 does present the number of events for two different time periods, but all of the subsequent analysis and discussion uses the percentages shown in Table 3. As the time periods for all of the stations differ, we think these provide a valid comparison.

– P1253 Somewhere on this page, you should discuss the influence of model resolutions and distance between AWS and model gridpoint on the found correspondence between models and AWS, and the found difference in correspondence between NCEP and ERA. For example what role this plays in the found 'false' events. »We've added new text on the model resolution and distances between AWS and gridpoints (see comments above) as well as a new Figure 6 which suggests that the stations with better event-size correlations are likely due to wind conditions rather than model resolution or gridpoint distance (new text below). As discussed in the General Remarks, we think further discussion than this is beyond the scope of this manuscript. New text (last paragraph, Sec 4): "Figure 6 illustrates the relationship between average near-surface wind speed from 2008–2012 and the event-size correlation values from Figure 5 (including those that are not significant). The figure supports the notion that the sites located in windier locations tend have the lowest correlations between ADG-measured events and reanalysis events."

– P1254 L17 Although 90% is significant, I am not really convinced, especially since the figure 4 is too small to see anything in it. »See comment below concerning Figures 2 and 4 (now Figures 2 and 5).

– P1255 On this page some discussion on model resolution and inaccuracies is also appropriate. »In-depth discussion of this is beyond the scope of this manuscript (as

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discussed in General Remarks above).

Conclusions – P1255 L23 Remove 'new'. »We have reworded this sentence to better reflect the purpose of this study (as discussed in General Remarks above).

– P1255 L26 Add 'relatively' before 'dense'. Remark that although the Ross Ice Shelf is indeed relatively flat, the locations of the AWS are not really representative for the area since they are lined along the foot of the Trans Antartic Mountains or other topographic deviating regions. »Added 'relatively' before 'dense'. There is quite a bit of discussion about the locations of the AWS stations and effects on the observations in the site description (Sec 2) and results (Sec 4), as well as a discussion of the topography on reanalyses precipitation (Sec 3.2). We have added further brief discussion of this in this sections (Conclusions) making the point that despite the non-ideal locations of the ADG observations, there are still correlations with the reanalyses datasets, indicating that these measurements are a potentially valuable source of ground-based precipitation measurements.

– P1256 Discuss the resolution and other relevant model issues. »See comments in General Remarks.

– P1256 L16 Add that the significance level is 90%. »Done

– P1257 I am missing some remarks towards a more general conclusion on precipitation events in NWP models. It remains very specific for NCEP and ERA at the given resolution. »See comments in General Remarks.

Figures –Figures 2 and 4 are too small. Consider plotting them in 3 rows of 3 panels. The grey box for Margaret (fig. 2) is not visible in these size plots. »Unfortunately the figures were formatted for an A4-portrait-sized page, but not for the TCD page format. Since the format for final TC manuscript is A4, we will keep them in their current format and make sure they are formatted to full page.

–Figure 3. Check the second sentence of the caption, the last part about the different

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scales of the axes is not correct English. »Reworded this sentence (this is now Figure 4).

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/7/C999/2013/tcd-7-C999-2013-supplement.pdf

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Interactive comment on The Cryosphere Discuss., 7, 1243, 2013.