The Cryosphere Discuss., 8, C566–C571, 2014
www.the-cryosphere-discuss.net/8/C566/2014/

The Cryosphere
Discussions
Open Access

Interactive comment on "How much snow falls on the Antarctic ice sheet?" *by* C. Palerme et al.

Anonymous Referee #2

Received and published: 30 April 2014

The study presents a climatology of Antarctic precipitation based on two CloudSat precipitation products. As such, it contributes to addressing a long-standing challenge in polar climate modeling, namely the validation of model-based estimates of Antarctic surface mass balance. The absence of reliable Antarctic-wide observation data sets of Antarctic SMB/precipitation explains why model intercomparison is often the only available means of assessing the reliability of the models. An accurate representation of Antarctic SMB is a prerequisite for realistic projections of Antarctic contribution to sea level, hence the importance of having model-independent climatologies such as the CloudSat data set presented here.

I found the method sound overall, the presentation clear, and the study fits well within the scope of The Cryosphere. I did however find some important weaknesses, which is why I recommend acceptance with major revisions. Listed below are my five most important concerns, followed by more minor comments/corrections.

1) The short abstract gives the false impression that the study provides a definite answer to the question asked in the title. Nothing is said about the uncertainties of the results, which are substantial. Can this new "model-independent" climatology be actually used to assess the output from atmospheric models? Do it allow a quantitative or only a qualitative assessment of Antarctic precipitation? For example, in the abstract, a distinction between the two CloudSat precipitation products (frequency versus rate) and their reliability would be in order.

2) The study is presented as "a fully model-independent climatology of Antarctic precipitation". Given the important role of ERA-Interim in the definition and validation of the CloudSat products, one can obviously question this independence. Some nuance should be added to the statement.

3) The determination of a precipitation threshold for one single, coastal site (DDU) and the use of the same threshold over all Antarctica is clearly not optimal. First, the availability of radiosonde data at DDU and their assimilation into ERA-Interim does not necessarily imply greater reliability of ERA-Interim precipitation in the area. Indeed, the amount of precipitation in the reanalysis are primarily influenced by the model physics, the model configuration (horizontal resolution), and the ability of the reanalysis to reproduce the characteristics of the synoptic disturbances around Antarctica. Therefore, I assume that DDU is probably no better than another location along the coast of Antarctica. Second, the authors should explain how they determine the precipitation threshold of 0.07mm/6h. Is it by maximizing the success rate for "no precipitation", or the one for "precipitation certain", or both?. Third, I assume that the procedure can be reproduced at other locations in Antarctica (ideally at every other grid point covered by the CloudSat products). This would certainly improve the agreement between CloudSat and ERA-Interim (for ex. in Fig. 5).

4) The assessment of uncertainties does not include the error related to the low temporal sampling of the CloudSat products. This issue should be briefly commented upon in section 2. The statement "...which represents one orbit every 5 days" leaves the

reader wondering about the impact the 80% of the days that are left out. The authors only briefly refer to this issue in the second-to-last paragraph of the manuscript (page 1290) and only in qualitative terms. One way to assess quantitatively the sampling error would be, for example, to use ERA-Interim data to determine the sensitivity of the multi-year average precipitation rates to the temporal sampling.

5) The comparison between CloudSat products and the accumulation map from Arthern et al. (2006) is not only complicated by the fact that one is measuring falling precipitation while the other is measuring net snow accumulation at the surface. It is also complicated by the numerous issues affecting the Arthern et al. data set, in particular the unreliability of a number of observations used in their spatial interpolation (see Genthon and Krinner 2001; Van de Berg et al. 2006; Magand et al. 2007; Magand et al. 2008; Bromwich et al. 2011; Favier et al. 2013). Some of these papers refer to the Vaughan et al. (1999) accumulation data set rather than the one from Arthern et al., but the two data sets used the same observations to carry out their interpolation. In short, it is not clear what can be concluded from the comparison CloudSat vs Arthern et al. For a comparison with in situ accumulation measurements, I suggest using the more reliable (yet more spatially limited) SMB data set described by Favier et al. (2013) and available at http://www-lgge.ujf-grenoble.fr/ServiceObs/SiteWebAntarc/database.php.

Minor comments and corrections:

Page 1280 line 11. Suggestion: "Antarctic snow accumulation". Also, change "melt, run-off" to "melt/run-off" or "meltwater run-off" as the two processes represent one single term in the surface mass budget.

Page 1280 line 14. The absence of significant change is for the *total* Antarctic snow accumulation.

Page 1280 line 16. Suggestion: "are likely to occur, with global consequences"

Page 1280 line 17. Suggestion: "the projected 25% increase"

Page 1280 line 24. The scatter in Antarctic precipitation estimates is not restricted to climate models. It is also seen in results based on global reanalyses and regional models. In addition, what is needed is not so much "to understand the processes controlling Antarctic precipitation rates", but rather to obtain observation-based, model-independent, and Antarctic-wide estimates of precipitation.

Page 1281 line 1. Atmospheric modeling (with global reanalyses and regional models) has also been paramount in the assessment of Antarctic precipitation/surface mass balance (Van de Berg et al. 2005, Monaghan et al. 2006, Bromwich et al. 2011, Lenaerts et al. 2012) and should be mentioned here. Arthern et al. (2006) used satellite microwave observations as the background field for their interpolation, not directly for their assessment of Antarctic snow accumulation.

Page 1281 line 11. Bromwich (1988) could also be cited with regard to diamond dust.

Page 1281 line 17. Suggestion: "provide/allow quantitative estimates" instead of "give quantities".

Page 1281 line 24. The last two paragraphs of the Introduction give the false impression that the paper presents the first investigation of Antarctic precipitation based on CloudSat precipitation products. The study by Boening et al. (2012) has obviously laid some important groundwork but is only cited at the very end of the manuscript. The authors should mention this paper at least once in their Introduction and say, for example, how they intend to build upon this earlier work.

Page 1281 line 26. Correction: "has been done"

Page 1282 line 7. Suggestion: "the characteristics"

Page 1282 line 13. Suggestion: "using the temperature"

Page 1284 line 8. The proper reference for ERA-Interim is Dee et al. (2011).

Page 1284 line 9. Suggestion: "ERA-Interim provides data from 1979..."

Page 1284 line 14. Suggestion: Replace "inserted" with "ingested".

Page 1284 line 14-15. Strictly speaking, ERA-Interim forecast model does not "use other observations such as temperature and humidity" to predict precipitation. Precipitation is a product of the model physics and is only to some extent influenced by the assimilation of observations (using the terminology of Kalnay et al. (1996), precipitation is a "class C" variable). Furthermore, the authors should at least briefly mention potential issues with ERA-Interim precipitation in Antarctica. For example, at least two studies of Antarctic surface mass balance (Bromwich et al. 2011; Favier et al. 2013) have shown that this reanalysis has a dry bias in the interior of East Antarctica.

Page 1284 line 22. Suggestion: "over the Antarctic continent"

Page 1284 line 26. Neither of the acronyms, WAIS and EAIS, are used in the rest of the manuscript. Consider deleting them.

Page 1285 line 16. Correction: "occurs"

Page 1285 line 25. The authors should discuss how the 171 mm/yr estimate from CloudSat compares with the values reported by other studies (e.g., Bromwich et al. 2011, Lenaerts et al. 2012)?

Page 1286 line 1. Is the fact that the precipitation rates for West Antarctica and peripheral Antarctica are identical just a coincidence?

Page 1286 line 3/7. I encourage the authors to use a), b) c), etc. in figures with multiple panels so that they can refer more precisely in text to the panel they are discussing.

Page 1286 lines 22/25. Correction: "at Dumont d'Urville"

Page 1287 line 8. Consider carrying out the comparison over three larger longitudinal sectors, instead of three lines. This would likely reduce the "noise" in the curves shown in Fig. 5 (in particular the blue curves).

Page 1287 line 9. Correction: "same as for Dumont d'Urville"

Page 1287 line 10. Correction: "depend on the location"

Page 1287 lines 25-29. The better agreement between CloudSat and ERA-Interim near the coast is more likely due to the fact that the threshold was derived for a coastal location (DDU).

Page 1288 line 6. Consider including the longitudes of Vinson Massif and Prince Charles Mountains, for readers not familiar with the geography of Antarctica.

Page 1289 line 12. Considering the earlier work by Boening et al. (2012), I suggest changing the text to something like "following Boening et al. (2012), its potential has been confirmed".

Page 1289 line 24. The discussion of Figure 8 seems out of place here. It could be inserted into Figure 1 (where it could replace panel #3 "Difference (%)").

Page 1290 line 21. Suggestion: "relatively low" rather than "not really good"

Page 1290 line 27. Is there any prospect of improvements in the measurement of precipitation rates over Antarctica with the upcoming satellite missions?

Interactive comment on The Cryosphere Discuss., 8, 1279, 2014.