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Interactive comment on "The global land Cryosphere Radiative Effect during the MODIS era" *by* D. Singh et al.

D. Singh et al.

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We would like to thank the reviewer for spending their valuable time reviewing our paper, and providing us with invaluable comments. Here are our responses:

1) Referee Comment: The paper is titled "cryosphere radiative effect", but it presents only the shortwave effect. There is a longwave effect as well; the presence of the cryosphere reduces both absorbed SW and emitted LW. If Antarctica and Greenland had no ice, those continents would be radiating longwave to space from lower elevation and therefore warmer temperatures. The authors may not want to quantify this LW effect, but they should at least mention it.

Our Response: It is true that the LW cryosphere radiative effect may be substantial,

and that this study focuses exclusively on the shortwave component of CrRE. We have clarified this through edits to the Abstract and Introduction indicating that the scope of this study is limited to SW effects and that LW effects result from snow-induced changes to surface emissivity and temperature. Quantifying the LW cryosphere radiative effect in a separate study would be a worthy endeavour, but several assumptions and calculations would need to be incorporated, including the surface elevation change (as noted by the reviewer), the change in surface temperature that would result from the lack of insulating snow cover, and the change in surface emissivity.

2) Referee Comment: The second paragraph of Section 3.1 gives some percentage contributions to the global LCrRE. I think Table 1 should be expanded to include these percentages for each of the four regions mentioned (glaciated and non-glaciated NH and SH). I would also like to see a separate table to show contributions to the global LCrRE from each continent (and Greenland). In this second table, one could read (for example) the small total contribution from South America, separated from Antarctica.

Our Response: We've expanded Table 1 and added two sub-tables (attached as supplement here) in the paper.

3) Referee Comment: Abstract line 3. Change "Spectrometer" to "Spectroradiometer".

Our Response: We changed it.

4) Referee Comment: p 3927 line 18. Change "much of the Antarctic continent" to "West Antarctica".

Our Response: We changed it.

5) Referee Comment: p 3928 line 6. Flanner et al 2011 is missing from the reference list.

Our Response: Added to the list.

6) Referee Comment: p 3929 line 24. "unfilled pixel". Is this the same as "missing

pixel", or does it mean a pixel that is only partly snow-covered?

Our Response: "Unfilled pixels" are the subset of pixels (only snow-covered) that did not receive defined albedo values in the previous step of the algorithm.

7) Referee Comment: p 3930 line 14. Removal of the East Antarctic Ice Sheet would indeed expose barren land (albedo 0.26), but removal of the West Antarctic Ice Sheet would instead expose open ocean (albedo 0.07).

Our Response: This is a very good point, considering the current bed topography. We have decided not to re-do our analysis, however, in light of several other uncertain effects that would occur in the event of total ice sheet ablation. First, isostatic rebound would elevate some of the West Antarctic land mass currently residing below sea level to elevations above sea level. Second, the sea level rise associated with ice ablation would offset some of this effect. Third, new vegetation would encroach onto the continent that would alter the ice-free surface albedo. In light of the uncertainties associated with these additional assumptions, we have chosen not to alter our analysis. Assuming a darker ice-free albedo or West Antarctica would slightly raise (make $\sim$10% more negative) our LCrRE estimates. We have added a brief description of these issues to the manuscript. We also note that the MODIS land mask applied in our study excludes ice shelves.

8) Referee Comment: Table A1. Why do snow-covered open shrubland (albedo 0.54) and snow-covered grassland (albedo 0.48) have higher albedo than snow-covered barren land (0.37)? Is this because snow depth over barren land is small?

Our Response: This is a good question, and we can only speculate on the reasons for this. The reviewer's hypothesis of lower snow depth (and consequently increased snow patchiness) over barren land seems quite plausible, given that barren land is almost always associated with low precipitation and often with high surface wind speeds. Second, a related effect is that barren land may be more susceptible to snow darkening from local wind-blown soil dust. A paper from Wang et al.,

2013 (http://onlinelibrary.wiley.com/doi/10.1029/2012JD018291/abstract) provides images and evidence of patchy, dust-darkened snow in regions of China with little or no vegetation, supporting these hypotheses as explanations for lower mean albedos over snow-covered barren land.

9) Referee Comment: Figure 3. Extend the curves by one additional month, so that the complete seasonal cycle can be seen graphically (i.e. from January to January rather than January to December).

Our Response: We've extended the plots by one additional month (attached as supplement here).

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/9/C1902/2015/tcd-9-C1902-2015-supplement.pdf

Interactive comment on The Cryosphere Discuss., 9, 3925, 2015.