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Interactive comment on "Surface formation, preservation, and history of low-porosity crusts at the WAIS Divide site, West Antarctica" *by* John M. Fegyveresi et al.

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Anonymous Referee #2

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Review of Surface formation, preservation, and history of low-porosity crusts at the WAIS Divide site, West Antarctica. By John M. Fegyveresi, Richard B. Alley, Atsuhiro Muto, Anaïs J. Orsi and Matthew K. Spencer

General This is a comparatively comprehensive study of the formation of so-called surface crusts, involving daily observations of surface crust formation at the WAIS divide site in West Antarctica over five consecutive summers (2008/09 to 2012/13), including annual shallow snow-pit studies, snow temperature profiles and data (including short-wave ra- diation measurements) from an automatic weather station (AWS). The main conclusion is that crusts form most commonly in the summer from the effects of a large daily tem- perature cycle. There also appears to be crust formation in winter, as yet for unknown reasons. The paper provides useful and original data for model development and evaluation, and the topic is suitable for publication in TC. The paper is rather descriptive, but useful, as the authors state in line 275: "Our data provide strong constraints on models of many of the observed processes." However, the value of the study and analysis would be greatly quantified if the AWS and snow temperature data were used to calculate the surface energy balance, see comments below. I recommend to do this, which will require major revisions.

"We did correct all noted issues and responded to reviewer comments, specifically with the inclusion of more on the crust extent and on related snow pit studies (that were previously left out), although we did not add either additional modeling or a full energy balance study. The paper is already quite long, and we have specific challenges with attempting to incorporate either of these additional and lengthy studies. We are aware of the additional papers cited by the referees, and note the large amount of careful work involved. We do also hope to be able investigate further the possible effects of solar heating on the specific type of PRT sensors. We have added relevant citations to our paper. With our manuscript being this long and the difficulties with adding such large/expansive analyses, we believe it is better to write a phenomenological paper first and then address modeling and a full energy balance in a separate/future study."

Major comments While explicit modelling of microphysical snow processes is beyond this MS's scope, a more quantitative interpretation can be achieved relatively easily by using the AWS and snow temperature data to close the surface energy balance.

This will greatly aid the discussion by quantifying the sign and magnitude of surface energy fluxes, including the transport of water vapour by sublimation/deposition, during episodes of crust formation. See e.g. Van As and others (2005; 2006).

l. 45: “often warmed the near-surface snow above the air temperature, contributing to mass transfer. . .” This suggests that temperature gradient is a sufficient condition for sublimation, but this requires a specific humidity gradient (a less stringent condition. The relative humidity in the air may be below saturation; that in the snow is likely to be much closer to saturation because of proximity to the moisture source in the snow. So temperature gradient really is enough.

"We reworded for clarity."

l. 118: Were relative humidity measurements corrected for low-temperature offsets (See Andersen and others, 1994)?

"They were. All humidity values shown are corrected and represented in terms of saturation vapor pressure over ice (as described by Anderson 1994)"

l. 152: “accumulation at the site is relatively evenly distributed through the year, justifying this approximation”; this may be true for the climatological precipitation, but is there quantitative support that this holds for individual years as well?

"We added back the more-detailed pit study (including 3 figures) to help better illustrate/quantify this."

l. 201: “following the air temperatures as expected“. Figure 10: Surface energy balance considerations dictate that the amplitude of the daily cycle in surface temperature exceeds that in air temperature, to allow for nocturnal cooling and daytime heating by sensible heat exchange. This appears not to be the case in these time series. Please comment.

"It is accurate that if sensible heat transfer is occurring, the temperature must be as the reviewer states; however there is no guarantee that sensible heat transfer is occurring.

We edited wording and identified specific sensors for clarity."

Figure 13: please translate y-axis into average crusts per individual month, and include standard deviation as error bar. Mention ice core time interval in caption.

"Adjusted figure to show an inset showing average crusts per month with 1 sigma stdev."

Minor/Textual comments l. 38: “insolation sensors” refers to incoming shortwave radiation. Better: “shortwave radiation sensors” . “Insolation sensors” was used as there were both short and longwave sensors used. . .depending on the year.

"We adjusted text to “short and longwave radiation sensors”."

l. 113: pyrogeometers -> pyrgeometers .

"Corrected"

l. 191: crust removal -> hoar removal (?)

"Correct. Adjusted text to read “hoar”."

l. 330: “warm and windy air masses” an air mass cannot be windy, please reformulate.

"Reworded to “Such warm air masses paired with these high winds,”"

References Anderson, P., 1994: A method for rescaling humidity sensors at temperatures well below freezing, J. Atmos. Oceanic. Technol. 11, 138801391. (Added) Van As, D. andÂa ÌĘM. R. van den Broeke, 2006: Structure and dynamics of the summertime atmospheric boundary layer over the Antarctic plateau, II: Heat, mo- mentum and moisture budgets,Âa ÌĘJournal of Geophysical ResearchÂa ÌĘ111, D007103, doi:10.1029/2005JD006956. VanAs,D.,Âa ÌĘM.R.vandenBroeke,R.S.W.vandeWal,2005:Dailycycleofthesur- face layer and energy balance on the high Antarctic plateau,Âa ÌĘAntarctic ScienceÂa ÌĘ17, 121-133.

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