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The Cryosphere Discussions

Interactive comment on "Formation and metamorphism of stratified firn at sites located under spatial variations of accumulation rate and wind speed on the East Antarctic ice divide near Dome Fuji" *by* S. Fujita et al.

Anonymous Referee #2

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Review Fujita TCD2012

Fujita et al report results from snow pit studies from one of the most remote regions in East Antarctica. The data are new, interesting, however they are presented in a context much to much focussed on the insolation (Milancovitch) signal observed in O2/N2 and the total air content in ice cores trying to explain the insolation signal's origin.

Studies of the formation and metamorphism of firn in the central parts of East Antactic plateaus are important because it is the area where the longest ice core records come

from. What controls densification of firn and air enclosure? Which processes determine the age difference between ice and air, thus the gas age, any temperature-CO2 lead-lag analysis but also the Milancovitch signals in ice core used to date ice core records? Is it the depositional history (precipitation, redistribution by winds and metamorphism) at the surface or the impurities in the ice as proposed recently by Hörhold et al. (2012) but published after this manuscript was submitted?

What is the relevance of the manuscript? Is it possible to make the case that in some way thermal processes as proposed by Fujita et al. imprint an insolation signature at or close to the surface in the firn matrix which is preserved through the entire firnification when the density increases by a factor of almost three from 300 kg/m3 to more than 820 kg/m3? I am not convinced that the top-down approach will be successful. We may understand the nature of the insolation signal in O2/N2 or total air content (TAC) much earlier by a bottom up approach after we have understood how the air enclosure works. Of course, I may not be right. However, right now we have no clue how the insolation signal becomes imprinted in the air components. What I mean is that the model Fujita et al. develop misses an important part, the energy balance of the surface. Without a thorough energy balance of the surface and the firn close to the surface it is hard to understand which components of the energy balance contribute to the formation of density signal and so on. Is this study relevant to understand the insolation signal in O2/N2 and TAC? I am also not convinced by the data presented.They present many aspects and sometimes it hard to follow how all these aspects are interrelated. Are three pits representative enough? A whole series of pits would be needed similar to the work the same authors presented in their paper by Sugiyama et al. (2012) or fig. 4f.

The insolation aspect in the introduction is much to long. As one motivation it can be condensed to a single paragraph. There are other interesting aspects than the insolation signal. Is there a change in the predominant type of precipitation? Is it diamond dust / clear sky precipitation as it is so common at Dome Fuji? The mean

surface density seems to be pretty stable despite the change in elevation, accumulation rate and wind in the paper by Sugiyama et al (2012). Are the same data shown also in Fig. 4 which indicate somewhat higher densitie around site DK190 or is it a different data set?

Is the D2m a meaningful grain size if site MP is only half as old as Dome F?

The cross over of initially high/low density firn has now been questioned by Hörhold et al. (2012). Impurities seem to play an important role for the entire firnification in the deeper firn and modulate the density of deep firn. This probably means that the surface density signature is not important for the densification of the deep firn and the density structure at the firn-ice transition where the air is entrapped in ice. What is the consequence for your interpretation and conclusions?

The paper deals with to many aspects. For example, Fig. 9 does not give much additional information. Probably also Fig. 14-16 are not very helpful.

References Hörhold, M.W. , T. Laepple , J. Freitag , M. Bigler, H. Fischer, and S. Kipfstuhl (2012), On the impact of impurities on the densification of polar firn. EPSL 325-326, 93-99. doi:10.1016/j.epsl.2011.12.022

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