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The Cryosphere Discussions

Interactive comment on "Spatial and temporal variability in summer snow pack in the Dronning Maud Land, Antarctica" *by* T. Vihma et al.

Anonymous Referee #2

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The paper provides new observations of spatial and temporal variability of snow temperature and density of coastal and slope area of Dronning Maud Land (East Antarctica).

The main tool used in this study is snow pit observations integrated with operational analyses of the European Centre for Medium-Range Weather Forecasts (ECMWF).

Snow density measurement in Antarctica is a great challenge due to both spatial and temporal variability and difficulty to collect data due to environmental and logistical constrain. The paper contributes to ongoing debate concerning the snow density variability and its implications on integrated mass balance measurements using altimetry satellite.

The manuscript subject is appropriate for journal and data set is new and significant, but the analysis of data, result and discussion are partially adequate. Description and interpretations of data are not well organised and Authors should improve the readability writing more concisely.

Temperature gradient from daily to seasonal is one of the dominant process changing the structure of snow close to surface, and diurnal cycle have very important impact on snow temperature in the upper 50 cm of snow.

Authors analysed the data of temperature and density without taking in appropriate consideration the time and meteorological condition prior the measurements. Temperature and density of the first 50 cm of snow are strongly depended by previous meteorological condition from hourly to week time scale. The Authors must analysed the data taking in account the air temperature in the previously hours and week. Analogously, in the first decimetres the density of snow, in the area with a snow accumulation up to meter per year, is strictly correlated to the last snow fall and the duration of densification process and correlated meteorological condition. Due to the fact that the sampled area extends for more than 300 km and 1200 m in elevation and only an AWS is available, the analysis of meteorological condition should performed using ECMWF, after a comparison of representativeness using AWS present along the traverse. Moreover the analysis of data should be performed with more attention to the different geographical/climatological condition along the traverse that strongly influence the temperature (e.g. melting on coastal area and absence in escarpment 2, katabatic wind absent in coastal and important in the escarpment) and density process.

In the comparison with previous study (Granberg et al., 2009) should be taken in account the different scale of measurements and representativeness of the data analysed.

General comments:

The analysis and discussion would be improved by going further into the drivers of

density variability in terms of local meteorological parameters, such as temperature (for melting using positive degree days/hours), snow accumulation rate and precipitation, and wind scouring. Some of these data could be available from previous research (eg. snow accumulation see, Karkas et al., 2005; Richardson PhD thesis 2001, Rotschky et la., J. Glacol. 2007 and reference therein) and from AWS data and ECMWF.

Introduction should be reduced significantly; most of pag 1110 is not pertinent to the manuscript (air mass trajectory, snow on sea ice, etc.).

Most of previous authors that analysed the temporal and spatial variability of snow density (Sugiyama et al., 2010, Takahashi & Kameda, 2007) and their implication for surface mass balance and for satellite altimeter are not take appropriately in account (Helsen et al., 2008; Arthern etl al. 2010; Arthern and Wingham, 1998; Wingham, 2000; McConnell et al., 2000; Zwally and Li, 2002; Li and Zwally, 2004). Analogously the measurements conducted at South Pole for temperature (e.g. Brandt & Warren, 1997; Town et al., 2008). In the discussion should be describe the result of present manuscript and their implications on integrated mass balance measurements.

Specific Comments:

pag 1110 line 4-7 snow density and hardness increase during summer, but also at onset of fall season. On the plateau the hardness is higher during winter and spring time .....

pag 1110 line 24 explain error source or delete?

pag 1111 line 5 -9 The spatial variability is performed at scale 100 km scale, all the profile is 300 km long. The temporal variability is not analysed at diurnal scale.

pag 1113 1-5 taking in account the snow distribution of the area from previous snow accumulation study (eg Rotschky et al., 2007 and reference within)

Methods

Error in snow density must be provided, and the large difference and the anomalous high value (up to 700 kg/m3) using box must be explained.

Pag 1115 line 1 to 15 Are spatial and temporal distribution of profile homogenous between during the different campaigns? The difference should be analysed and their implication on the analysis and comparison discussed.

Data analyses and results paragraph should be revised and organised more concisely and describe only the data used in the discussion.

Pag 1118, should be reduced drastically.

Pag 1119 line 1-25, The snow precipitation conditions are not comparable in space/time during different campaign, this should be put in evidence and analysed in detail.

Pag 1120 line 19-27 why use 9.8°K/km and not others value? The dry-adiabatic lapse rate is not in agreement with the observed value.

Pag 1120 line 27 and pag 1121 line 1, The horizontal std is controlled by std of altitude, which is the scale of analysis? Is and obvious observation, or is a new result?

pag 1121 line 12. How much snow precipitation occurred on 7 and 8 January? Which implication for the measurements? analogously for line 27.

Pag 1121 line 17 The value of 700 kg/m3 is close to ice value, whereas the density of 150 kg/m3 could be explained only with a recent snow precipitation, the data must be discussed and explained.

Pag 1124 line 24-28 The research of Japanese colleagues are very important, but why quote here?

Pag 1127 It is not clear why Authors are against the conclusion of Granberg? Data from Granberg derived from fall and winter katabatic season and deeper measurements. These data are more close to climatic condition than meteorological condition of the Authors. The observations of Authors are strictly during summer and due to

shallow depth represent the meteorological condition of summer season. Katabatic wind is a clear driver of climate along the escarpment area during fall, winter and spring. Comparison with Granberg study should be revised taking in account the different time/depth measurements.

Pag 1128 Is it melting an important factor on snow metamorphism and temperature? or not? where (elevation/distance) melting occurs?

The discussion and conclusion should be revised taking in account the previous comments.

Fig 2 revised the X scale, hundred kg, described the site.

Fig 9 and 11 Lat and Long

Interactive comment on The Cryosphere Discuss., 4, 1107, 2010.