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Seasonal Variations of the backscattering coefficient measured by radar altimeters over the Antarctic Ice Sheet

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Spaceborne radar altimeter is a valuable tool for observing the Antarctic Ice Sheet. The radar wave interaction with the snow captures information from both the surface and the subsurface of the snowpack. However the penetration of the radar wave within the snowpack also induces a negative bias on the estimated surface elevation. Empirical corrections of this space and time-varying bias are usually based on the backscattering coefficient variability. We investigate the spatial and seasonal variations of the backscattering coefficient at the S (3.2 GHz $\sim$ 9.4 cm), Ku (13.6 GHz $\sim$ 2.3 cm) and Ka (37 GHz $\sim$ 0.8 cm) bands. We identified that the backscattering coefficient at Ku band reaches a maximum in winter in part of the continent (Region 1) and in the summer in the remaining (Region 2) while the evolution at other frequencies is uniform. To explain this contrasted behaviour between frequencies and between regions, we studied the sensitivity of the backscattering coefficient at the S, Ku and Ka bands to several parameters (surface snow density, snow temperature and snow grain size) using an electromagnetic model. We also interpreted the seasonal variations of brightness temperature polarization ratio at 37 GHz. The results show that the seasonal cycle of the backscattering coefficient at Ka band, is dominated by the volume echo and is mainly driven by snow temperature evolution everywhere. In contrast, the cycle is dominated by the surface echo at the S band and is also uniform. At Ku band, which is intermediate in terms of frequencies between S and Ka bands, the seasonal cycle is in the Region 1 dominated by the volume echo and by the surface echo in the other one. The high seasonal amplitude of the backscattering coefficient observed in the Region 1 can be explained by the presence of wind-glazed surfaces formed in the most windy regions which tend to increase the surface echo contribution, thus increasing the total backscattered power. This investigation provides new information on the Antarctic Ice Sheet surface seasonal dynamics and provides new clues to build robust correction of the radar altimetric surface elevation signal.