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A review of the current altimetry mission performances over the polar ice sheets: Cryosat-2, AltiKa and Sentinel-3A

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Earth's polar regions have been monitored near continuously by altimeter satellites for 30 years now. Thanks to their wide coverage and high temporal sampling, they have greatly improved our knowledge of the ice-sheet topography and our understanding of the ice sheet dynamics. Until the 2010s, radar altimeters have been exclusively operating in Ku-band, in Low Resolution Mode (LRM). This technique has been successfully exploited for oceanic surveys but suffers from several limitations over the polar ice sheets. The combined effects of surface roughness, surface slope and volume scattering affect the LRM measure in various ways.

A new generation of altimeter satellites has been launched in the last few years: Cryosat-2 (2010), Saral/Altika (2013) and Sentinel-3A (2016). Thanks to its Ka frequency, the penetration depth of the AltiKa signal in the snowpack is much smaller than usual Ku frequency radars, reducing the volume scattering measured in Ku-band. This is supposed to facilitate the estimation of the ice sheet elevation at snow/air interface. On the other hand, Cryosat-2 and Sentinel-3A carry a new generation of radar altimeter, operating in the innovative "Delay Doppler" mode (or SAR mode). Compared to conventional LRM, this technology improves the along track resolution from several kilometers to 300 meters. This brings valuable perspectives for the measure accuracy over the sloping surfaces of the polar ice sheets.

The main objective of this presentation is to show a cross-comparison of the current altimetry missions over the polar ice sheets' interior: Cryosat-2 (LRM, Ku-band), AltiKa (LRM, Ka-band) and Sentinel-3A (SARM, Ku-band). This work has been performed over one year of data in 2016/2017, corresponding to a common acquisition period for the three missions. Firstly, we will illustrate the measure sensitivity to the snowpack volume scattering by analyzing the waveform shapes. Secondly, we will assess the precision and accuracy of the surface elevation estimated from the waveforms in comparison with laser altimetry data (ICESat), GNSS acquisitions and existing DEMs. Finally, we will present a preliminary and promising Digital Elevation Model (DEM) obtained with the three missions measurements. This work is particularly instructive at that moment when a future polar observing mission has to be defined (Sentinel-9) and designed with the objective to monitor even more precisely the impact of global warming on polar ice-sheets.