Sensitivity of CryoSat-2 Arctic sea-ice freeboard and thickness on radar-waveform interpretation - DTU Orbit (11/08/2019)

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In the context of quantifying Arctic ice-volume decrease at global scale, the CryoSat-2 satellite was launched in 2010 and is equipped with the K-u band synthetic aperture radar altimeter SIRAL (Synthetic Aperture Interferometric Radar Altimeter), which we use to derive sea-ice freeboard defined as the height of the ice surface above the sea level. Accurate CryoSat-2 range measurements over open water and the ice surface of the order of centimetres are necessary to achieve the required accuracy of the freeboard-to-thickness conversion. Besides uncertainties of the actual sea-surface height and limited knowledge of ice and snow properties, the composition of radar backscatter and therefore the interpretation of radar echoes is crucial. This has consequences in the selection of retracker algorithms which are used to track the main scattering horizon and assign a range estimate to each CryoSat-2 measurement. In this study we apply a retracker algorithm with thresholds of 40, 50 and 80% of the first maximum of radar echo power, spanning the range of values used in the current literature. By using the selected retrackers and additionally results from airborne validation measurements, we evaluate the uncertainties of sea-ice freeboard and higher-level products that arise from the choice of the retracker threshold only, independent of the uncertainties related to snow and ice properties. Our study shows that the choice of retracker thresholds does have a significant impact on magnitudes of estimates of sea-ice freeboard and thickness, but that the spatial distributions of these parameters are less affected. Specifically we find mean radar freeboard values of 0.121m (0.265 m) for the 40% threshold, 0.086m (0.203 m) for the 50% threshold and 0.024m (0.092 m) for the 80% threshold, considering first-year ice (multiyear ice) in March 2013. We show that the main source of freeboard and thickness uncertainty results from the choice of the retracker and the unknown penetration of the radar pulse into the snow layer in conjunction with surface roughness effects. These uncertainties can cause a freeboard bias of roughly 0.06-0.12 m. Furthermore we obtain a significant rise of 0.02-0.15m of freeboard from March 2013 to November 2013 in the area for multiyear sea ice north of Greenland and Canada. Since this is unlikely, it gives rise to the assumption that applying different retracker thresholds depending on seasonal properties of the snow load is necessary in the future.

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