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Accuracy analysis of CryoSat-2 SARIn mode data over Antarctica

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In 2010, CryoSat-2 was launched, carrying a unique satellite radar altimetry (SRA) instrument called SAR/Interferometric Radar Altimeter (SIRAL), with the aim of measuring and monitoring sea ice, ice sheets and mountain glaciers. The novel SAR Interferometric mode (SARInM) of CryoSat-2 is designed to improve the accuracy, resolution and geolocation of height measurements over the steeper margins of ice sheets and ice caps. Over these areas, it employs the synthetic aperture radar (SAR) capability to reduce the size of the footprint to effectively 450m along track and $\sim$1km across track implemented from an airborne prototype originally termed a delay-Doppler altimeter. Additionally, CryoSat-2 used the phase difference between its two antennas to estimate surface slope in the across-track direction and identify the point of closed approach directly. The phase difference is 2pi for a surface slope of approximately 1deg. If the slope is above this threshold, the tracked surface in the returned waveform may be not the point of closed approach causing an error in slope correction. For this reason, the analysis was limited to slopes of 1deg or less in this study. We used extensive coverage of Antarctica provided by the ICESat laser altimeter mission between 2003 and 2009 to assess the accuracy of SARInM data. We corrected for changes in elevations due to the interval between the acquisition of the ICESat and CryoSat-2 data (from July 2010 and December 2013). Two methods were used: (1) the ICESat point was compared with a DEM derived from CryoSat-2 data (Point-to-DEM; PtoDEM), and (2) the ICESat point was compared with a CryoSat-2 point directly (Point-to-Point; PtoP). For PtoDEM, CryoSat-2 elevations were interpolated onto a regular 1km polar stereographic grid with a standard parallel of 71ºS, using ordinary kriging. For PtoP, the maximum distance between a CryoSat-2 point location and ICESat point location was set to 35m. For the areas with slopes less than 0.2deg, the mean differences (ICESat minus CryoSat-2) are less than 1.5m, and standard derivation (σ) below 3m. However, the mean differences over Filchner Ronne and Ross Ice Shelf are generally greater than 1m, and differences over Larsen C and Amery Ice Shelf are generally below 1m or negative. The known range biases amount to 0.67m from ESA. The remaining bias over the ice shelves of about 43-53cm is estimated as the average radar penetration depth for the retracker used in the ESA Level 2 processing chain, which is different over these four ice shelves. The strong relationship between firn density and remaining bias is appeared in the four ice shelves and the different backscattering power from the volume scattering in the tailing edge was found in four ice shelves from CryoSat-2 Level 1B data. The accuracy of CryoSat-2 SARInM data over Antarctica was related to the surface slope and roughness and decreased with the slope and roughness increasing.