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Uncertainties analyses of the retrieved sea ice draft from the Upward looking sonar, operating in the Arctic

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Accurate retrieval of Sea Ice Thickness (SIT) in the Arctic is essential step for ice model simulations and calibration of satellite, airborne and submarine observations in the Polar region.
Upward looking Sonar (ULS) data have been widely used to measure Sea Ice Draft (SID), but error correction and uncertainties analyses have not been provided for all available SID observations due to complicated impact of environmental, systematic and random factors on accuracy of the retrieved SID from ULS. Uncertainties analysis with corresponding error correction of the retrieved SID from ULS is required for calibration of satellite products and evaluation of climate impact, using long term observations of SID. The purpose of this study is uncertainty analyses and error correction of ULS observations. The impact of open water offset, sea ice slope and footprint error on accuracy of the retrieved SID from ULS submarine data is analysed, providing error correction methodology. The retrieved SID from ULS observations during Tireless cruise in Beaufort Sea in March-April 2007 are validated using collocated data of SID from "Round Robin Data Package" (RRDP), derived from satellite radar altimeter (RA) observations.
SID statistic, including mean (d_m), standard deviation (d_{std}), confidence intervals, minimum, maximum and variances, as well as the open water correction (W_c) bias and the mean open water corrected draft ($d_{wc} = d_m - W_c$) are calculated along the track with 50km spatial resolution. Algorithms for calculation of ice slope and beam width impact on the mean SID are compared and results of SID correction are presented. The open water corrected SID (d_{wc}) are validated with collocated SID, retrieved from RA (d_{ra}) and the scatter plots, regression and residuals are analysed. The analyses shows that the correlation coefficient between the mean SID retrieved from ULS (d_m) and collocated SID, retrieved from RA (d_{ra}), has been increased from R= 0.7608, to R_{cw}=0.7718 (for d_{wc} and d_{ra}), which confirms the improved accuracy of the derived SID after applying open water correction (d_{wc}) along the track. The mean absolute residual (r_m = abs (d_m - d_{ra})) has dropped from 0.3196m to 0.2848m for corrected draft, considering open water correction along the track and mean footprint bias impact (0.3945m) for beam width (3°). The mean estimated value of the open water correction (W_{cm} = -14.13cm), with corresponding standard deviation (σ_{wc} = 6.25cm) and total standard deviation ($\sigma = \sigma_{wc}+\sigma_b$ = 15.49cm), considering the beam width impact (σ_b) and the open water correction bias along the track, have been calculated and compared with collocated SID, retrieved from RA, using statistical, histogram analyses and scatter plots. The impact of accuracy of SID, retrieved from ULS, and error correction on validation of satellite products is analysed.
The RRDP exercise and the results of this study are part of the Sea Ice Climate Change Initiative (SICCI), funded by European Space Agency (ESA). The developed methodology for errors correction of retrieved SID from ULS will have fundamental application to improve the accuracy of the derived SID from ULS data for geophysical and climate applications.