Arctic freeboard and snow depth from near-coincident CryoSat-2 and ICESat-2 (CRYO2ICE) observations: A first examination of winter sea ice during 2020-2022 (accepted)

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April 16, 2024

Abstract

In the summer of 2020, ESA changed the orbit of CryoSat-2 to align periodically with NASA's ICESat-2 mission, a campaign known as CRYO2ICE, which allows for near-coincident CryoSat-2 and ICESat-2 observations in space and time over the Arctic until summer 2022, where the CRYO2ICE Antarctic campaign was initiated. This study investigates the Arctic CRYO2ICE radar and laser freeboards acquired by CryoSat-2 and ICESat-2, respectively, during the winter seasons of 2020–2022, and derives snow depths from their differences along the orbits. Along-track snow depth observations can provide high-resolution snow depth distributions which are vital for air-ice-ocean heat and momentum transfer, understanding light transmission, and snow-ice-interactions. Generally, ICESat-2 is backscattered at a surface above the elevation of the CryoSat-2 signal. CRYO2ICE snow depths are thinner than the daily model- or passive-microwave-based snow depth composites used for comparison, with differences being most pronounced in the Atlantic and Pacific Arctic. Satellite-derived and model-based snow estimates show similar seasonal accumulation over FYI, but CRYO2ICE has limited seasonal accumulation over MYI which is linked to a slow increase in ICESat-2, and to some extent CryoSat-2, freeboards. We present a first estimation of along-track snow depth estimates with average uncertainty of 9 +/- 3 cm for 7-km segments, with random and systematic contributions of 7 and 4 cm. These observations show the potential for along-track dual-frequency observations of snow depth from the future Copernicus mission CRISTAL; but they also highlight uncertainties in radar penetration and the correlation length scales of snow topography that still require further research.

AGU PUBLICATIONS

Earth and Space Science

Supporting Information for

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Contents of this file

Introduction

This supplement contains text, figures, and tables in support of the main document.

Text S1 describes the pre-processing steps applied to CryoSat-2 along with the methodology used to identify corresponding LARM, CCI+ , AMSR2 and SMLG observations.

Text S2 presents the data binning methodology used to bin ICESat-2 to CryoSat-2 observations (to achieve CRYO2ICE observations). Here, a sensitivity analysis of the search radius is presented.

1

Figure 1: This is a caption

Submitted to GRL: 06th of June 2023, peer-reviewed, transferred to Earth and Space Science on 26th of September 2023.

Transferred to Earth and Space Science (AGU): 26th of September 2023, peer-reviewed, accepted on 30th of March 2024.