Late Winter Observations of Sea Ice Pressure Ridge Sail Heights

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November 21, 2022

Abstract

Pressure ridges are deformation features within the sea ice pack created through the collision of sea ice floes. Pressure ridges play an important role in ice drift and influence the mass and energy budgets of the Arctic Ocean. Over the past decade annual airborne surveys over Arctic sea ice have been conducted in late winter (March and April) by NASA’s Operation IceBridge (OIB) mission. A total of 74 OIB flights between 2010 and 2018 surveyed tens of thousands of kilometers of sea ice, providing observations of pressure ridges at a higher spatial and temporal resolution than previous airborne studies. Here we utilize Digital Mapping System (DMS) imagery to identify shadows cast by pressure ridge sails and, then, use these shadows to derive sail height. Over 64,000 DMS images were analyzed, allowing for more than 33 million individual sail height measurements to be calculated. We present the full sail-height distributions of new pressure ridges recently formed across a range of ice conditions on first-year (FYI) and multiyear ice (MYI), and we assess year-to-year variability. We find distinct characteristics depending on the ice type in which the pressure ridge formed. The mean and standard deviation of sail heights on FYI is ~20-30 cm lower than those formed on MYI. Maximum sail heights on FYI are ~1.5 m lower on average. Arctic sea ice is getting younger, shifting from predominantly MYI to predominantly FYI. Our results may inform new model parameterizations of pressure ridges on sea ice in the changing Arctic, thereby supporting advances in sea ice forecasting.
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Introduction

- Sea ice pressure ridges play an important role in ice drift and influence the mass and energy budgets of the Arctic Ocean.
- An improved understanding of the regional distributions of ridge sail height, and their variability, is important to better quantify total sea ice mass, and can be used towards new model parameterizations of pressure ridges on sea ice, thereby supporting advances in sea ice forecasting.
- Here we present results describing sea ice pressure ridge sail height across the Arctic Ocean, at the end of winter.
- Sail heights are derived from high-resolution Digital Mapping System (DMS) imagery gathered during NASA’s Operation IceBridge (OIB) missions between 2010-2018 following methodology presented in Duncan et al., 2018.

Methodology

- DMS image of Arctic sea ice flow with linear pressure ridge features.
- Closeup of a pressure ridge showing cast shadows. White dashed line shows the length of a shadow used in a single sail height calculation.
- Depiction of geometry used for Sail Height (H) derivation.
- Same DMS image as in (a) but overlain with derived Mₚ, (a) Mₚ, Distribution and statistics for data shown in (d).
- Modified from Duncan et al., 2018.

Arctic Ocean Pressure Ridge Sail Height, March-April, 2010-2018

- Variability in Pressure Ridge Sail Height

Results

- Over 64,000 DMS images from 74 OIB flights used in analysis, producing over 33 million individual Hₚ measurements.
- We find distinct Hₚ characteristics depending on the ice type in which the pressure ridge formed.
- The mean of Hₚ on seasonal ice is 0.06 m lower than those formed on perennial ice and the 99th percentile of Hₚ on seasonal ice is 0.36 m lower on average than those on perennial ice.

Data Access

The NASA Laboratory for Satellite Altimetry [LSA] releases fully quality assessed and quality controlled sea ice data products to the community. Data shown here can be accessed through the LSA public FTP site at: [ftp://ftp.star.noaa.gov/pub/icedata/lsa/SeaIceProducts/IceBridge/PressureRidgeSailHeight/]

Please acknowledge NOAA / NNESSIS Center for Satellite Applications and Research (STN) and cite the following with any use of this data:


Acknowledgments

This study was supported under the NASA Cooperative Institute for Climate and Satellites award NNH14ZDA002N and the Office of Naval Research Award Number N00014-10-1-0009. This study utilizes the IceBridge DMS L1B Geolocated and Orthorectified Images, Version 1.3 data set (Dominguez, R., 2016, updated 2018, (including 2016-2017 Mission 1, Ortho and Geolocated Images, Version 1, 2018-2016), University of Colorado USA, NASA National Snow and Ice Data Center Distributed Active Archive Center, doi:10.5067/INO/GIBS/L1B/PRO. We also acknowledge the support of the NOAA IceBridge teams for their diligence in collecting these data.