Code for Ice-Front and Rampart-Moat Detection and Quantification in ICESat-2 Laser Altimetry

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Overview

This repository provides step-by-step tools to download ICESat-2 ATL06 Land Ice Height data (Smith et al., 2019) for a specific region using Python, build a user-friendly MATLAB structure, remove outliers, and search for large along-track jumps in height (that satisfy specified criteria) to identify the ice-shelf front. The code is currently tested on Ross Ice Shelf (Figure 1a), where ICESat-2 tracks are usually close to orthogonal to the ice front and height criteria for distinguishing between open water (including where there is sea ice) and the ice-shelf surface are easily established. The method is designed around stepping along track from open water to the ice shelf.

Once the ice front is detected, the user can apply the code package to search for rampart-moat (R-M) features at the ice front (Figures 1b–1c) and quantifies them according to the height of the rampart relative to the moat (dh_{RM}) and the along-track distance from the rampart to the lowest portion of the moat (dx_{RM}).

For more information, see subsections 2.2 and 2.3 of Becker et al. (2021).

Files

The following files are included in this repository:

Scripts

- Step_01_download_ross_front_atl06_data.ipynb
- Step_02_build_structure_from_h5_files.m
- Step_03_detect_front.m
- Step_04_detect_rm_features.m

Other files

- Depoorter_et_al_2013_mask.mat: MATLAB-formatted 1 km x 1 km gridded land, ice-shelf, and ocean mask based on Depoorter et al. (2013). Ice-front locations are for ca. 2003–2004. The file uses a MATLAB structure (‘SM’) to store the mask grid and distance vectors. Mask values are as follows: 0 = ocean, 1 = land and grounded ice, and 2 = ice shelf. Polar stereographic distances are stored in km. Standard latitude and longitude are 71^{o}S, 0^{o}E.
- Readme.pdf (this document)

The code package consists of one Python and three MATLAB scripts and requires a few external files/libraries/access items as noted below (on page 3):

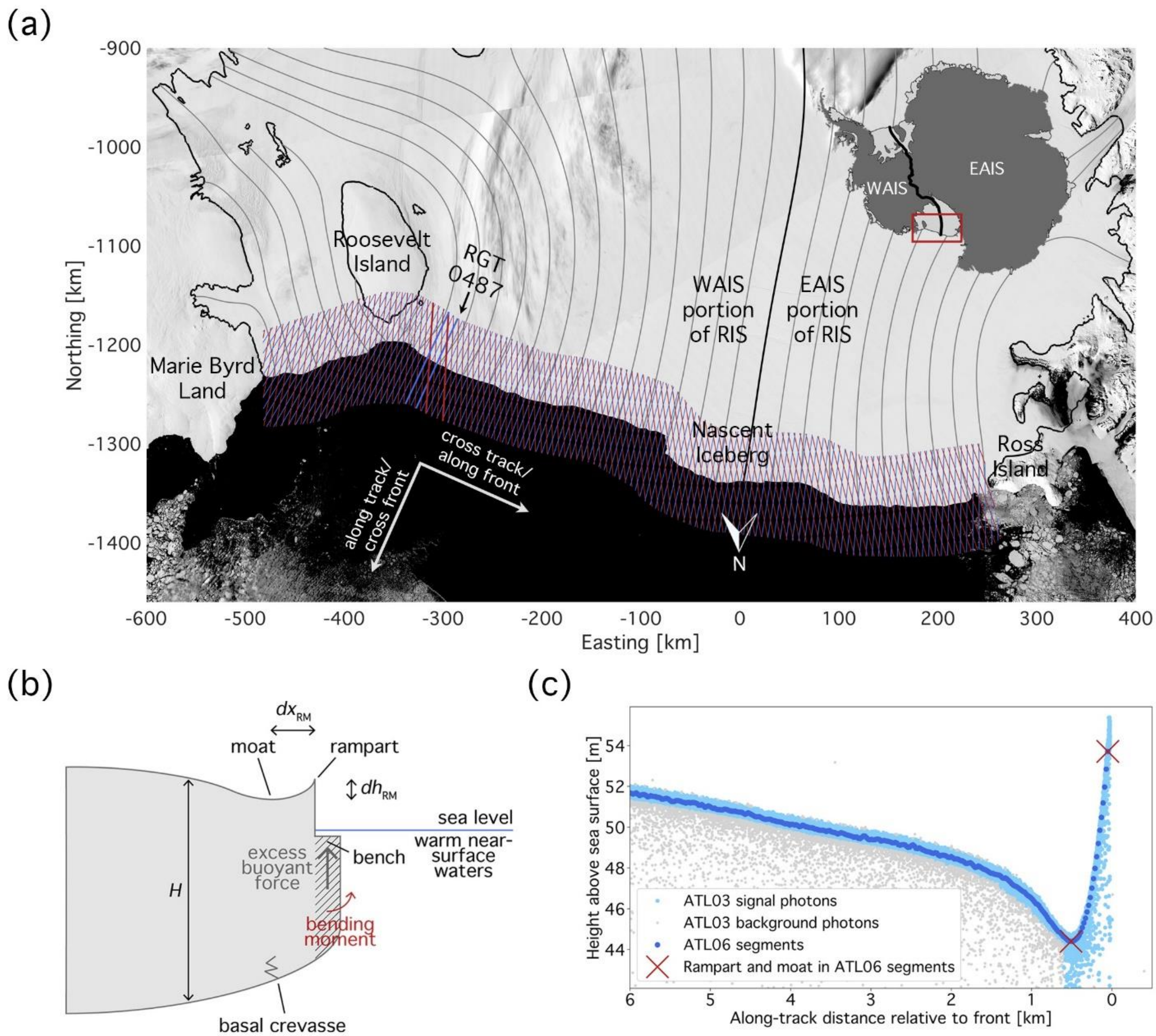

Figure 1. (a) Map showing the distribution of ICESat-2 reference ground tracks (RGTs) near the Ross Ice Shelf (RIS) front (ascending in red and descending in blue) overlaid on a December 2, 2018, Moderate Resolution Imaging Spectroradiometer (MODIS) image downloaded from NASA Worldview. The Depoorter et al. (2013) ice-shelf mask is shown with a black line. Gray lines on the ice shelf show modern ice streamlines derived from Rignot et al. (2017) velocity fields, with the streamline delineating the boundary between ice originating from the West and East Antarctic ice sheets (WAIS and EAIS, respectively) in black. Inset map (created using Antarctic Mapping Tools data; Greene et al., 2017) features the Mouginot et al. (2017) WAIS–EAIS boundary. (b) Schematic of ice-shelf bench (hatched area), R-M structure, and the conditions under which the bench forms. Three relevant R-M parameters, relative height (dh_{RM}), relative along-track distance (dx_{RM}), and near-front thickness (H), are indicated. (c) Height above instantaneous sea surface for Cycle 7 ICESat-2 ATL03 signal (light blue dots) and background (gray dots) photons, andATL06 segments (dark blue dots) for gt3r (strong beam) for RGT 0487, which is labeled in (a). ATL06-derived rampart and moat locations are marked as red crosses.

Step_01_download_ross_front_atl06_data.ipynb:

This Jupyter Notebook uses the icepyx library (Scheick et al., 2019; https://github.com/icesat2py/icepyx) to download spatially and temporally subsetted ATL06 granules from the National Snow and Ice Data Center. Running this notebook should result in the download of these granules in the location defined by the variable 'path' in the last code block. The user should adjust the path according to their own workflow. An HTML version of the notebook is provided in the documents folder.

This script implements the ATL06-specific methods described in Subsection 2.2 of Becker et al. (2021).

Requirements:

- Icepyx library (https://github.com/icesat2py/icepyx)
- Earthdata login (https://urs.earthdata.nasa.gov/)

Step_02_build_structure_from_h5_files.m:

This MATLAB script builds and saves a MATLAB structure with all relevant information from the HDF5 files downloaded in Step 01 and plots the approximate ice-shelf front location for each ground track profile over the mask from Depoorter et al. (2013). The user should specify the locations of (1) the HDF5 files with the variable 'data_dir,' which should match the path specified at the end of the Step 01 Jupyter Notebook, and (2) the location of the *.mat file containing the Depoorter et al. (2013) mask data.

This script implements part of Step (i) described in Subsection 2.3 of Becker et al. (2021).

Requirements:

- ll2ps.m: This script calls the Antarctic Mapping Tools 'll2ps' function (Greene et al., 2017), which can be downloaded from the MathWorks File Exchange: https://www.mathworks.com/matlabcentral/fileexchange/47638-antarctic-mapping-tools.
- Depoorter_et_al_2013_mask.mat: MATLAB version of the Depoorter et al. (2013) mask, included in this repository.

Step_03_detect_front.m:

This script cleans up the structure from Step 02; applies various filters, flags, and geophysical corrections; and removes outliers. Then, for each ground track profile, it searches for the ice-shelf front moving from the ocean to the ice shelf; if the front is found, the script gathers various data on the front crossing.

This script implements part of Step (i) and steps (ii)–(iv) described in Subsection 2.3 of Becker et al. (2021). This text also describes choices for cleaning up the data, specifically assessed for Ross Ice Shelf.

Step_04_detect_rm_features.m:

This script searches each ground track profile in which the ice front was detected for an R-M structure. If an R-M structure is found, it gathers various data on the structure and uses those data to compute dh_{RM} and dx_{RM}.

This script implements steps (v) and (vi) described in Subsection 2.3 of Becker et al. (2021).

Contact

Please contact Susan Howard (showard@esr.org) or Maya Becker (mayakbecker@gmail.com) for assistance.

References

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