ICE SPLICE: Template Matching for Automated Ice Drift Correction

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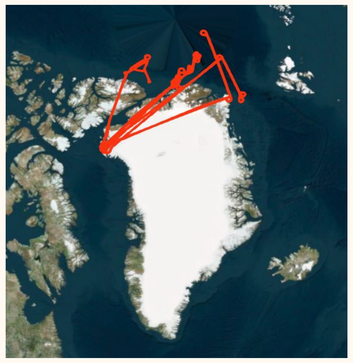
Motivation



Tracking changes in Arctic sea ice extent is instrumental in assessing climate change.

The ATLAS altimeter on ICESAT-2 is our primary source for understanding global sea ice extent and volume.

Problem

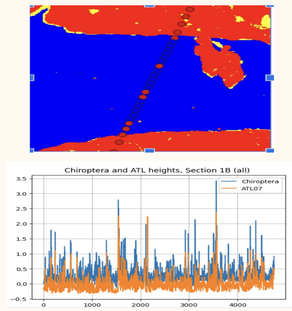
ATLAS ALTIMETER (ICESAT-2)

- Collected via satellite through the ICESAT-2, a satellite which aims to measure sea ice elevation and thickness
- ICESAT-2 orbits the Arctic daily utilizing a photon-based altimeter to calculate surface height and classify surface type
- 34km section from Summer 2022

Chiroptera Imagery

- On plane flyovers, the Chiroptera-4X collected high-res imagery and LiDAR along the ATLAS track to validate ICESAT collection.
- ATL and Chiroptera data are collected at different times. The ice shifts during this period of time, requiring correction.

Goal

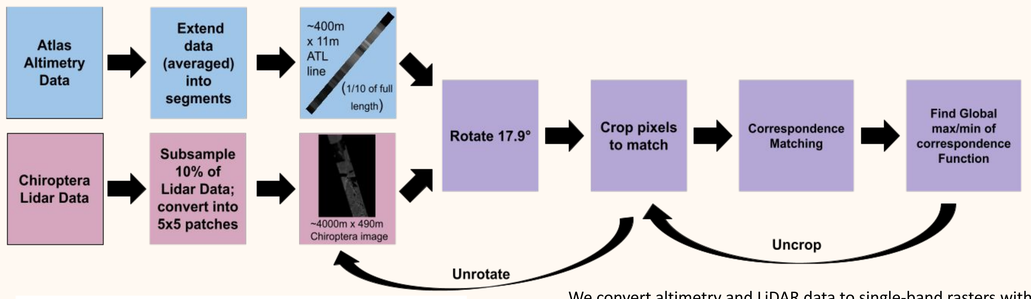


- Create an image pipeline with a feature matching algorithm to derive drift correction vectors.
- Emphasize efficiency while preserving accuracy.

Methodology

Existing drift correction techniques involve shifting georeferenced data, and are computationally expensive and slow.

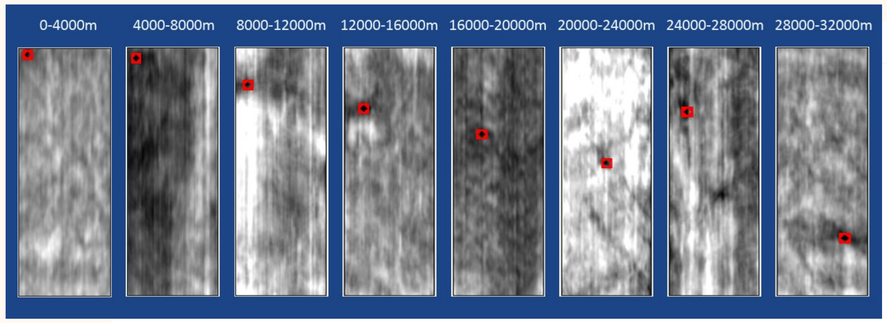
We investigate a novel application of template matching to make drift correction faster and less prone to error.



$$R(x,y) = \frac{\sum_{x',y'}(T(x',y') - I(x+x',y+y'))^2}{\sqrt{\sum_{x',y'} T(x',y')^2 \cdot \sum_{x',y'} I(x+x',y+y')^2}}$$

We convert altimetry and LiDAR data to single-band rasters with brightness corresponding to normalized heights. Normalized SSD is used to identify the optimal translation for the altimeter line, which is then reinterpreted geospatially.

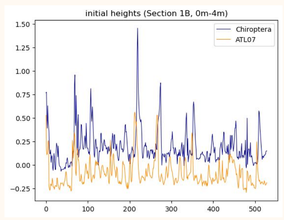
ICESPLICE Matches



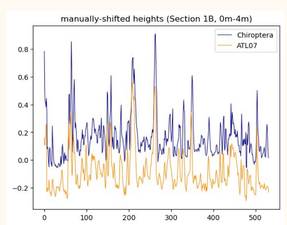
From the correspondence maps above, we observe a minima shifting consistently along the track, reflecting sea ice drift. The differences in optimal corrections validates the need for kilometer-level drift correction.

Data Comparisons

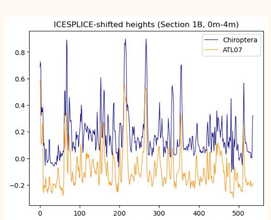
Initial evaluation of ICESPLICE shifts indicate a significant improvement over both baseline and manually shifted data.



r^2: 0.08

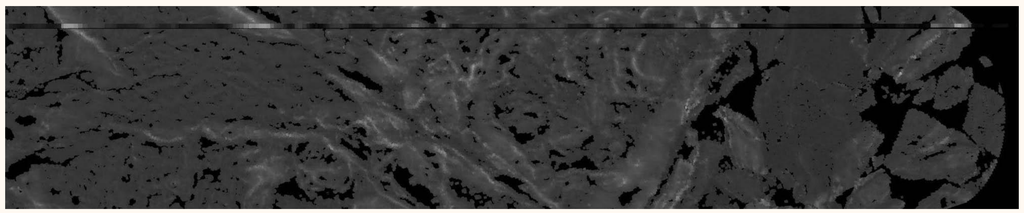


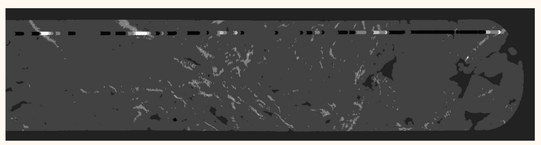
r^2: 0.585



r^2: 0.645

Results





Due to time constraints, we have not yet reversed the transformations to derive geocorrected altimetry; however, hand-shifted data approximating the template-matched raster above was used for validation.

Previous attempts to automate drift correction through georeferenced methods take several hours, while manually drift correcting takes days.

The ICESPLICE pipeline demonstrates that template-matching is an effective way to derive drift corrections, and improves accuracy while also speeding up the process many times.

References

[1] J. Bryan Blair et al, LVIS Greenland ICESat-2 Cal/Val, NASA 2022
[2] NSIDC DAAC ICESat-2, ATLAS Data collection, 2022

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