A decade of sea ice concentration retrieved from Sentinel-1

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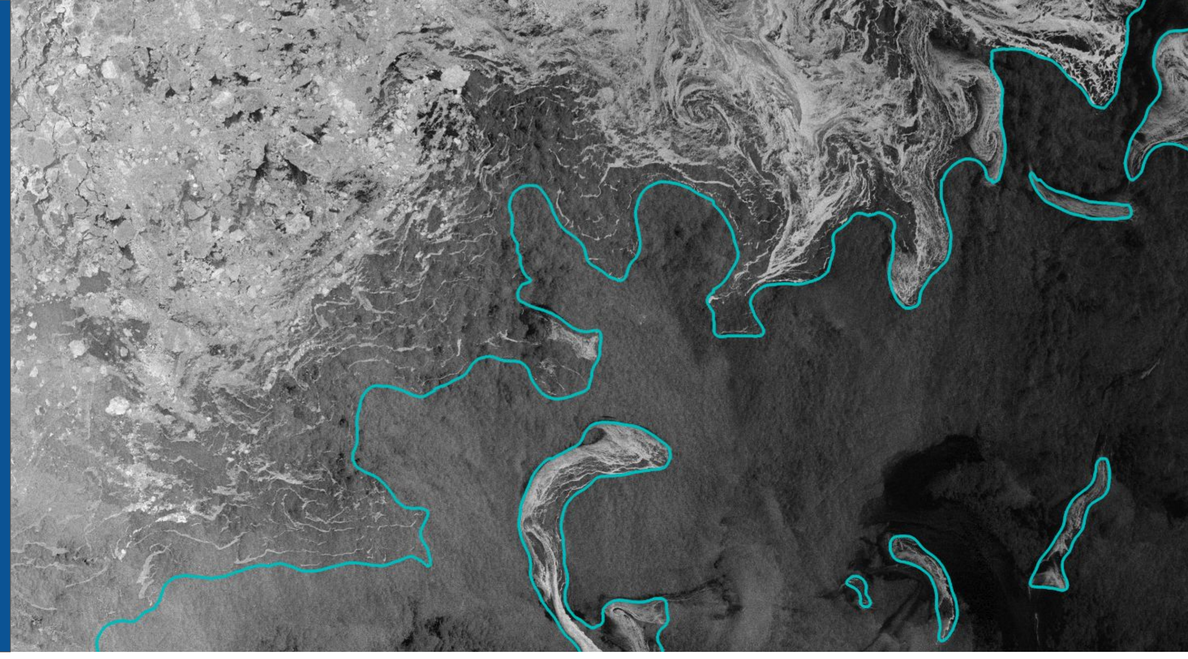


Introduction

Arctic sea ice is fundamental to the global climate engine, modulating heat exchange between the ocean and the atmosphere and impacting large-scale oceanic and atmospheric movements. While the monitoring of sea ice concentration (SIC) from satellites has long depended on coarse-resolution passive microwave (PMW) sensors, Synthetic Aperture Radar (SAR) missions, such as Copernicus's Sentinel-1, have emerged as complementary and fine-resolution sources of sea ice information.

This work introduces the DMI-ASIP (Danish Meteorological Institute - Automated Sea Ice Products) data record; the first decade-long (2014-2024) and pan-Arctic SIC record derived from Sentinel-1 SAR imagery and provided at a high spatial resolution on a 0.5km grid [1].

Data

Sentinel-1

Sentinel-1 is the C-band SAR component of the Copernicus Programme satellite constellations operated by the European Space Agency (ESA). The DMI-ASIP data record was generated from >300k Sentinel-1 GRD EW scenes.

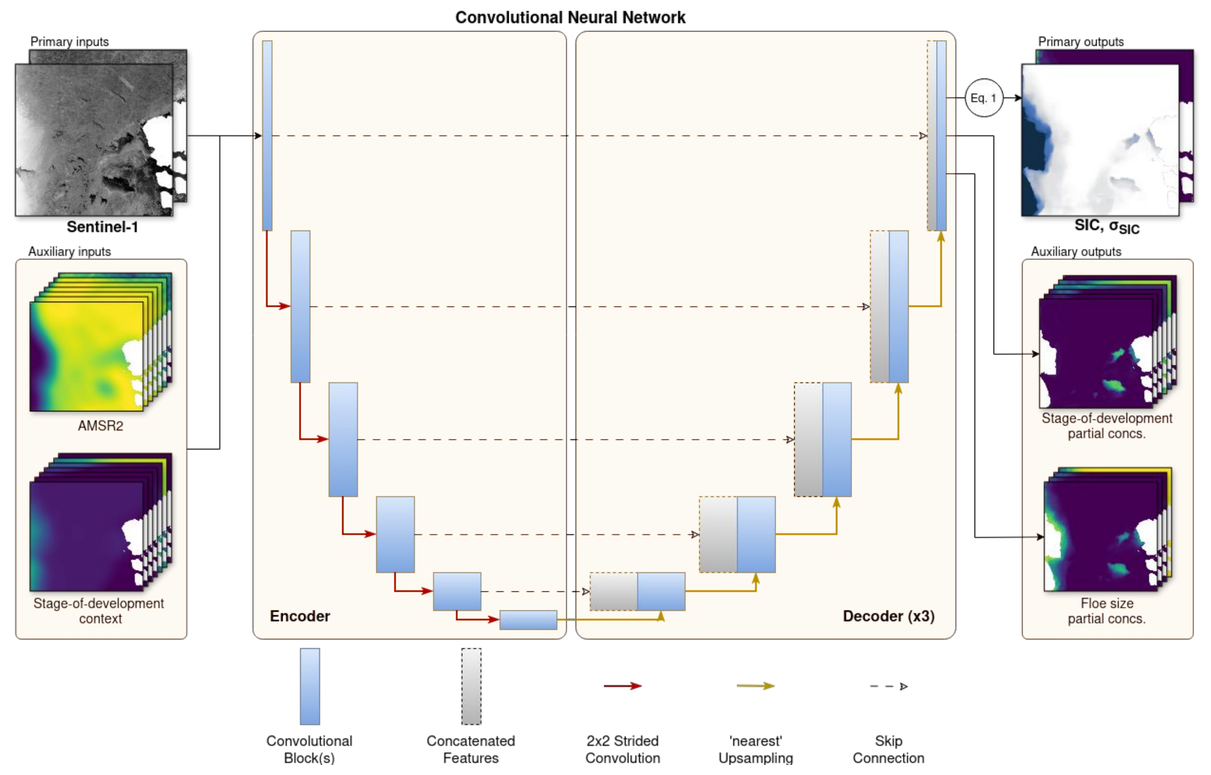
Comparison data

- Microwave CDRs: OSI SAF (OSI-458) [2] and G02202 (NOAA/NSIDC) [3] SIC Climate Data Records, based on AMSR2 and SSMIS, respectively, and provided as daily gap-free products.
- Optical reference: SNU-Landsat-SIC [4], a high-resolution SIC reference dataset, based on optical images from Landsat-8 (2020-2022).

All quantitative comparisons were carried out on a common 25km polar stereographic grid with daily matching of the data records.

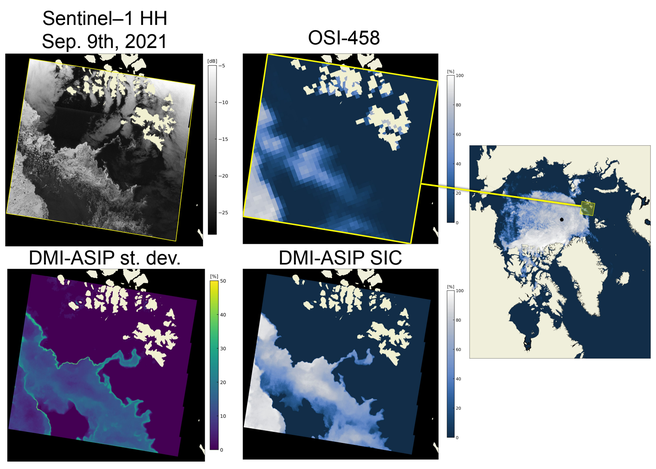
Methodology

We employ a modified UNet-based ConvNet to retrieve the SIC and its associated uncertainty from Sentinel-1 and auxiliary inputs. The ConvNet is trained on the ASIDv2+ dataset [5] using ice charts drawn manually at the Greenland and Canadian Ice Services as the labels.

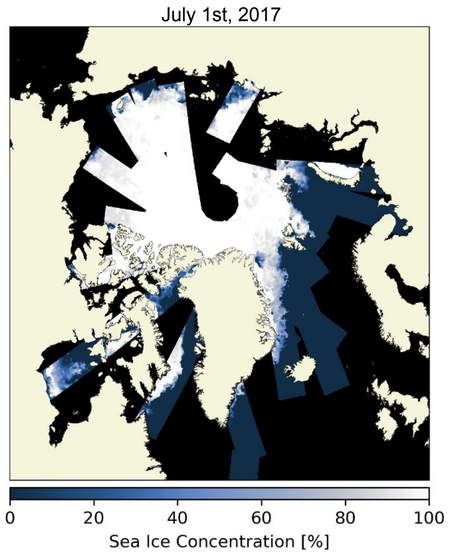


Results - comparison with microwave CDRs

DMI-ASIP L2 example

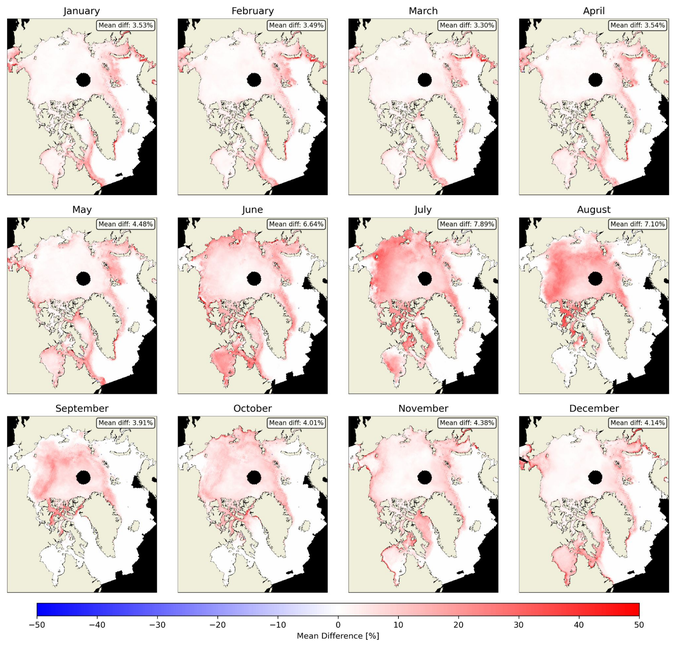


Daily DMI-ASIP L3 example



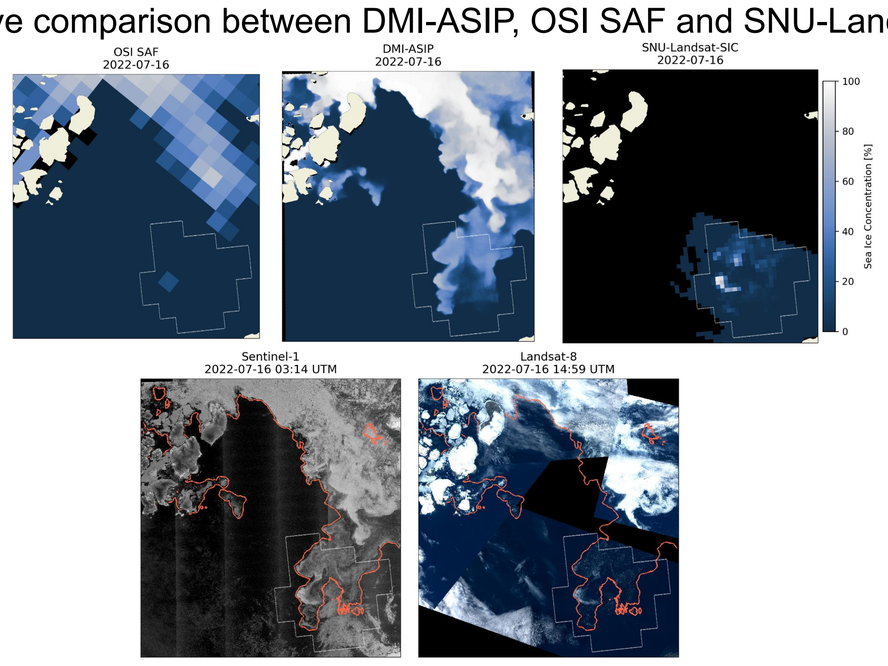
When averaging the differences between DMI-ASIP and OSI SAF for each month across the 2014-2024 time-series, we find:

- A consistently positive bias for DMI-ASIP compared to OSI SAF.
- The lowest biases occur in late winter/early spring.
- The largest biases occur in the summer months (i.e. the melting season)
- The biases primarily manifest in the marginal ice zone.



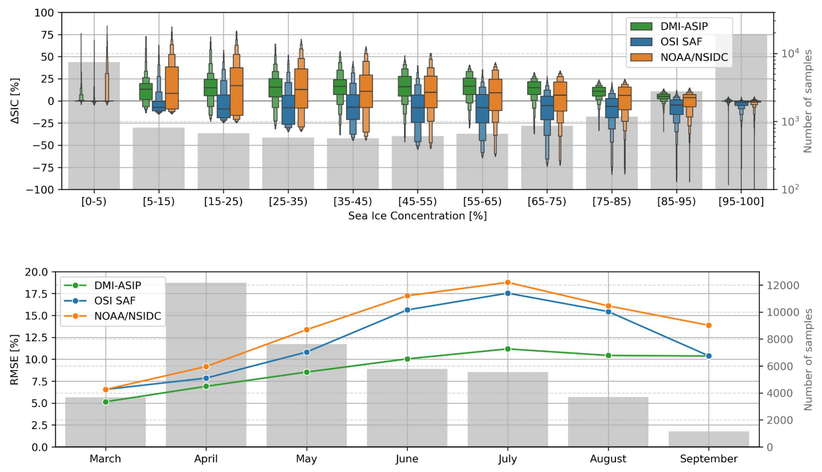
Results - evaluation against optical reference

Qualitative comparison between DMI-ASIP, OSI SAF and SNU-Landsat-SIC



DMI-ASIP exhibits:

- Lower error (RMSE 8.7%) vs. microwave records (>12%).
- Less seasonal performance variation than PMW records, especially during melt season.
- A positive mean bias (+2.5%) over the evaluation period.



Conclusion

We introduce the DMI-ASIP SIC data record, providing a 10-year, 0.5km resolution view of Arctic sea ice based on SAR. Evaluation against independent optical data shows that DMI-ASIP exhibits lower error compared to widely used SIC CDRs. Notably, DMI-ASIP shows better accuracy during the challenging melting season.

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References

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[4] Jung, H.S., Lee, S.M., Kim, J.H., Lee, K., 2025. **An arctic sea ice concentration data record on a 6.25 km polar stereographic grid from 3 years of landsat-8 imagery**. Earth System Science Data 17, 233–258. URL: https://essd.copernicus.org/articles/17/233/2025/, doi:10.5194/essd-17-233-2025.

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