CSQ-26 Summary

Question	Knowledge Advancement Objectives	Geophysical Observables	Measurement Requirements	Tools & Models	Policies / Benefits
What are the next generation of satellite data products for the Polar regions that will be generated through AI and ML?	Develop new methods and datasets using deep learning techniques to deliver the next generation of Earth observation information.	• Raw satellite input data of all types, SAR, multispectral optical, and altimetry waveforms • Training datasets • Validation data	Fine temporal (weekly) resolution, and high (meters) spatial resolution.	EO satellite datasets. Training and validation data	Advance knowledge of the Polar regions. Improve future projections

CSQ-26 Narrative

Deep learning and AI are methodological advances that enable the production of a new generation of satellite data products. In the polar regions, prominent examples of this include using machine learning to delineate glacier and ice shelf calving front locations (Baumhoer et al., 2019), mapping crevasses or damage on the ice sheet and ice shelves (Surawy-Stepney et al., 2023), and measuring summer sea ice thickness in the Arctic for the first time (Landy et al., 2022). In many cases, these products were previously only measurable using the time-consuming method of manual delineation, which has a low accuracy in itself, and is also logistically unfeasible for processing the large volumes of satellite data acquired today. While generating high spatial-resolution static maps of these Polar parameters is a key milestone, in the future, methods must evolve and be sensitive enough to detect change in these variables.

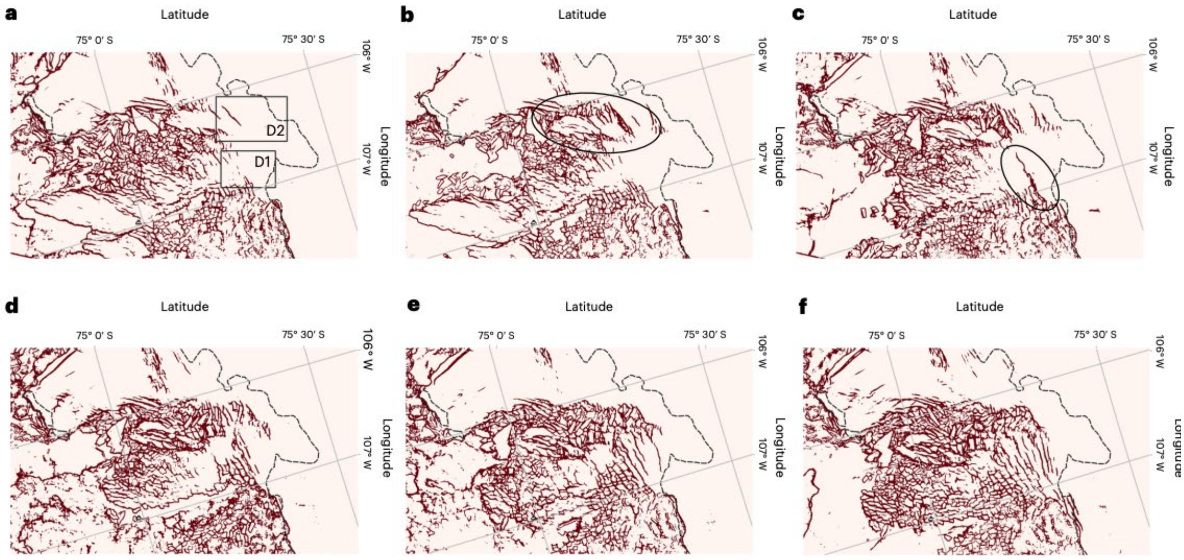

Fig. 7: Observed fractures on the TGIT. Annual fracture maps generated by applying a trained neural network to Sentinel-1 SAR images acquired in March of each year during 2016 to 2021. a–f, Snapshots of mapped fractures on 29 March 2016 (a), 12 March 2017 (b), 25 March 2018 (c), 26 March 2019 (d), 8 March 2020 (e) and 27 March 2021 (f). Time series of relative fracture density shown in Fig. 3c,d are extracted from bounding boxes D1 and D2 in a. We highlight the location of a large section of ice that detached from the upstream shear margin in 2017 (black oval, b) and an approximately 14 km-long transverse crack (black oval, c), with the MEaSUREs grounding line location also shown on all maps (dashed black line)31. From Surawy-Stepney et al., 2023.

References

- Wallis, B.J., Hogg, A.E., van Wessem, J.M. *et al.* Widespread seasonal speed-up of west Antarctic Peninsula glaciers from 2014 to 2021. *Nat. Geosci.* (2023). https://doi.org/10.1038/s41561-023-01131-4
- The IMBIE Team,. (2019) Mass balance of the Greenland Ice Sheet from 1992 to 2018. Nature https://doi.org/ 10.1038/s41586-019-1855-2.
- Landy JC, Dawson GJ, Tsamados M, Bushuk M, Stroeve JC, Howell SEL, Krumpen T, Babb DG, Komarov AS, Heorton HDBS, Belter HJ, Aksenov Y. (2022) A year-round satellite sea-ice thickness record from CryoSat-2. *Nature*. 609(7927):517-522. doi: 10.1038/s41586-022-05058-5.
- Baumhoer, C. A., Dietz, A. J., Kneisel, C., and Kuenzer, C., (2019) Automated Extraction of Antarctic Glacier and Ice Shelf Fronts from Sentinel-1 Imagery Using Deep Learning, *Remote Sens.11*(21), 2529; https://doi.org/10.3390/rs11212529
- Mottram R., Hansen, N., Kittel, C., J. van Wessem, M., Agosta, C., Amory, C., Boberg, F., van de Berg, W. J., Fettweis, X., Gossart, A., van Lipzig, N. P. M. van Meijgaard, E., Orr, A., Phillips, T., Webster, S., Simonsen, S. B., and Souverijns, N. (2021) What is the surface mass balance of Antarctica? An intercomparison of regional climate model estimates, *The Cryosphere*, 15, 3751–3784, doi.org/10.5194/tc-15-3751-2021.
- Slater, T., Lawrence, I. R., Otosaka, I. N., Shepherd, A., Gourmelen, N., Jakob, L., Tepes, P., Gilbert, L., and Nienow, P. (2021) Review article: Earth's ice imbalance, *The Cryosphere*, 15, 233–246, https://doi.org/10.5194/tc-15-233-2021.
- Surawy-Stepney, T., Hogg, A.E., Cornford, S.L. *et al.* Episodic dynamic change linked to damage on the Thwaites Glacier Ice Tongue. *Nat. Geosci.* **16**, 37–43 (2023). https://doi.org/10.1038/s41561-022-01097-9
- P. R. Holland, G. K. O'Connor, T. J. Bracegirdle, P. Dutrieux, K. A. Naughten, E. J. Steig, D. P. Schneider, A. Jenkins, and J. A. Smith, (2022) Anthropogenic and internal drivers of wind changes over the Amundsen Sea, West Antarctica, during the 20th and 21st centuries, The Cryosphere, 16, 5085–5105, doi.org/10.5194/tc-16-5085-2022.
- Maclennan, M. L., Lenaerts, J. T. M., Shields, C., & Wille, J. D. (2022). Contribution of atmospheric rivers to Antarctic precipitation. Geophysical Research Letters, 49, e2022GL100585. https://doi.org/10.1029/2022GL100585
- Nilsson, J., et al. (2015), Green- land 2012 melt event effects on CryoSat-2 radar altimetry, *Geo-phys. Res. Lett.*, *42*, 3919–3926, doi:10.1002/2015GL063296.
- Fretwell, P. T., and Trathan, P. N., (2021) Discovery of new colonies by Sentinel2 reveals good and bad news for emperor penguins, Remote Sensing in Ecology and Conservation, https://doi.org/10.1002/rse2.176