Automated Polynya Identification Tool (APIT)

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The deployment of the Automated Polynya Identification Tool (APIT) aims to implement a machine- and deep-learning method alongside Earth Observation data for the identification of frequently un-detected polynya formations. Polynyas are holes in the polar winter ice masses, where water and or thin-ice is present and form in an open-water setting. These often small and short-lived phenomena often go-undetected and are important for climate scientists to understand the change in the climate of the polar systems.

The opening of these formations exposes relatively warm ocean water to the cold winter atmosphere, which has a significant impact on the entire climate system (i.e. water column modification, deep water formation & global ocean circulation), expressing the importance of tracking these formations.

This tool is being developed as part of the SO-Fresh project, which aims to contribute to one of the studies, to understand the drivers and consequences from the Weddell Sea polynya formation. This will provide fundamental locality information for climate scientists, enabling for polynya identification in near-real time. Collecting in-situ measurements will lead to a clearer understanding of how these formations occur and what their key drivers are.

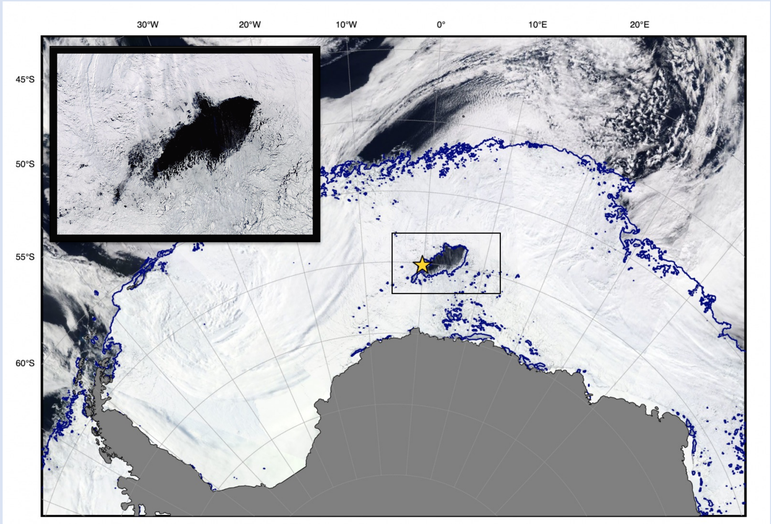

Figure 1 – MODIS Aqua image acquired of the Weddell Sea Polynya on 25th September 2017. (Taken from: SOCCOM)

IMPORTANCE

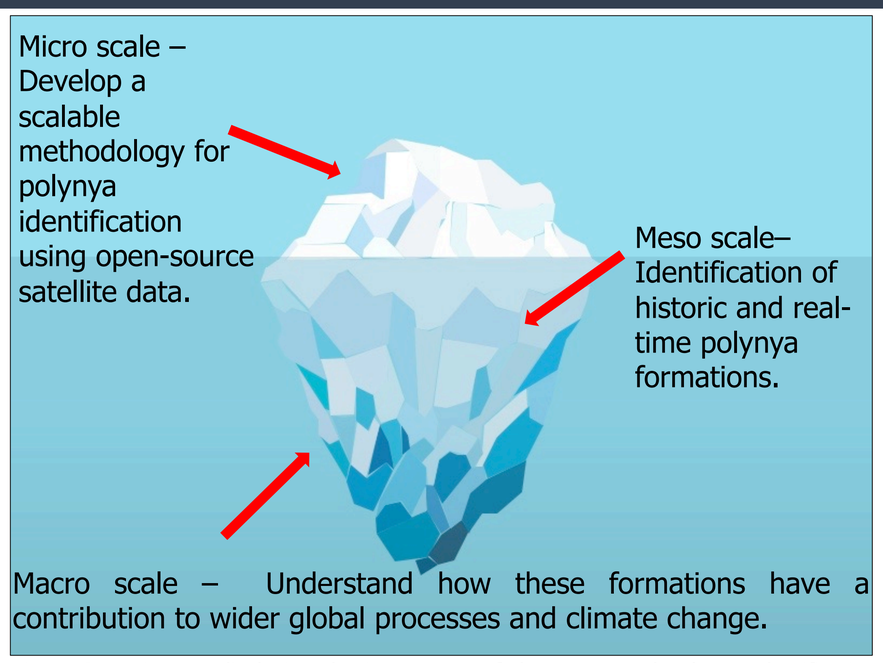

Figure 2 – Diagram displaying the importance of the Automated Polynya Identification Tool on a micro, meso and macro scale.

METHODOLOGY

The APIT methodology is carried out in four steps using MODIS (MYD09GA) imagery. Initially, a threshold classification is undertaken, differentiating between open-water and ice/cloud cover based on spectral reflectance values. This classification is then smoothed through a 3x3 moving window, applying the cumulative sum of all pixels to the centre pixel. A noise removal step is then executed to remove any boundary pixels which could be erroneous, through an erosion and dilation stage. Finally, analysis focused on identifying open-water polynyas to avoid land and ice sheet contamination, therefore a criteria was implemented where areas must be > 200 km^2 and > 200 km from land.

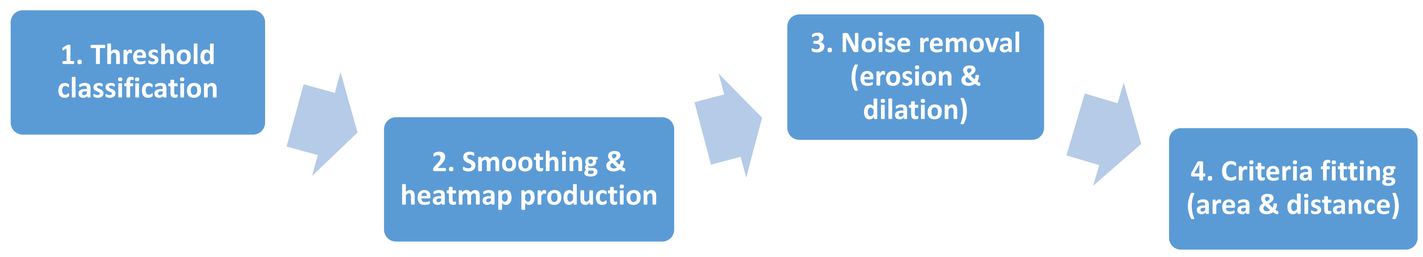

Figure 3 – Workflow diagram for the Automated Polynya Identification Tool.

RESULTS

Preliminary results from APIT are displayed in Figure 4, where the potential of this tool is shown. The identification of the 2017 Weddell Sea polynya extent by APIT and Campbell et al. (2019) are comparable. Where position, size and shape are all very similar, even through the use of different data and methodology. Assessing the impact of cloud-cover was undertaken across the period of the 2017 polynya formation (01/08/2017 – 12/12/2017), where polynya identification was undertaken manually by the user and by APIT (Figure 5). Results displayed that the polynya was identified in 45.83 % and 54.17 % of the imagery by the user and the tool, respectively.

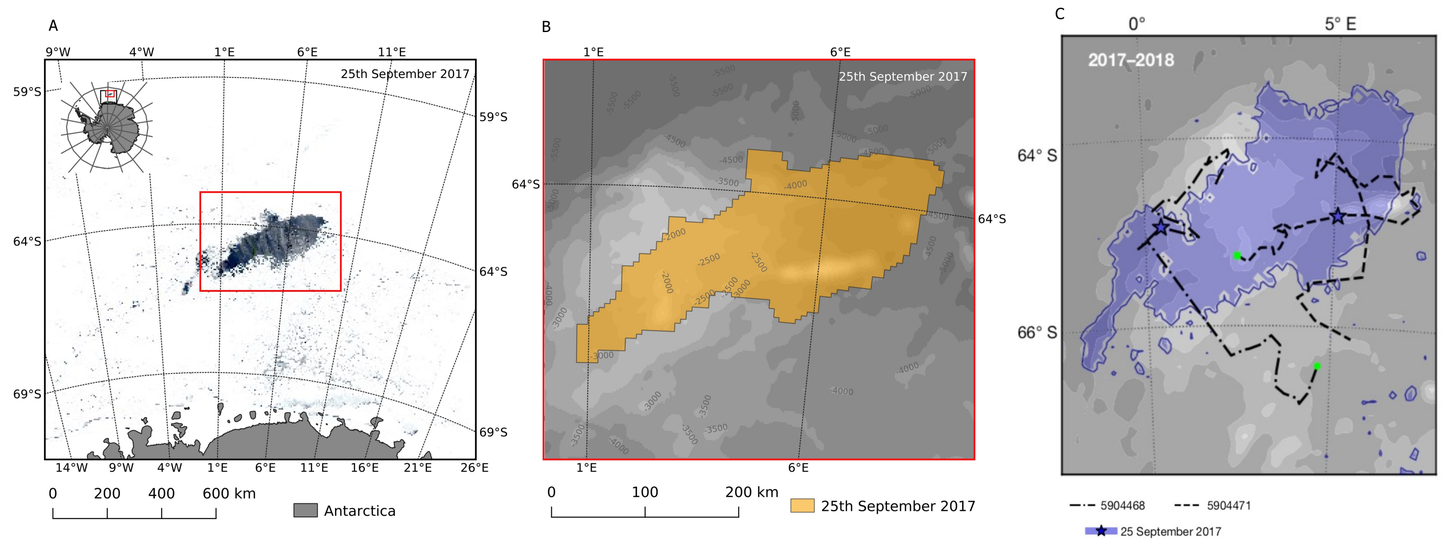

Figure 4 – Weddell Sea Polynya of 2017 near Maud Rise. (A) Raw MODIS imagery of the Weddell Sea polynya on 25 September 2017. The red box encompasses the area shown in B. (B) Bathymetry around Maud Rise (values display depth contours in metres) with Weddell Sea polynya extent shaded (orange) as identified by APIT from 25 September 2017. (C) Bathymetry around Maud Rise and the 2017 polynya extent (blue) measured form sea-ice concentration measurements, with the trajectories for floats (5904468 (January 2017 – May 2018) and 5904471 (January 2017 – June 2018)) where they began are the green marked locations and were at the blue star locations during the polynya opening.

(C taken from Campbell et al., 2019)

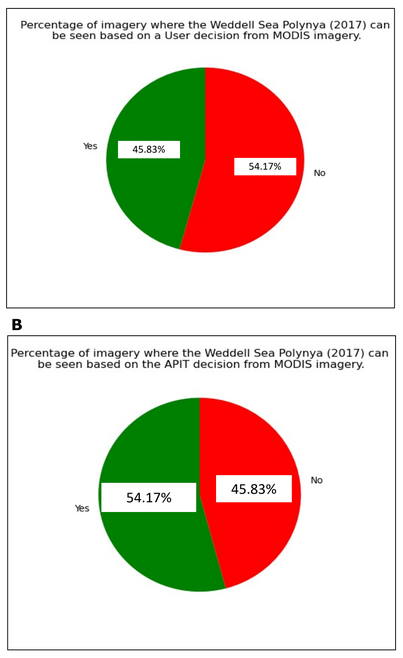

Figure 5 – Assessment of cloud cover on 2017 Weddell Sea polynya identification between user (A) and APIT (B).

FUTURE WORK

Implementation of Machine Learning Methods

- Adaptive thresholding
- Cloud identification

APIT validation

- Visual user validation
- Identification using active-sensors (i.e. Sentinel-1, CryoSat-2)

Investigate the change in polynya characteristics throughout its lifetime to better understand and develop an early identification method

- Temperature
- Ice concentration / thickness
- Sea salinity
- Chlorophyll
- Phytoplankton
- Colourised, Dissolved Organic Matter

INTERIM CONCLUSIONS

- The results of the identification of the 2017 Weddell Sea polynya between APIT and Campbell *et al.*, 2019 were comparable.
- The developed methodology proved to be:
  - Computationally efficient
  - Quick (considering the processing of the entire MODIS archive for Antarctica)
  - Inexpensive

REFERENCES

Campbell, E.C., Wilson, E.A., Moore, G.K., Riser, S.C., Brayton, C.E., Mazloff, M.R. and Talley, L.D., 2019. Antarctic offshore polynyas linked to Southern Hemisphere climate anomalies. *Nature*, *570*(7761), pp.319-325.

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