High resolution mapping of Antarctic vegetation communities using airborne hyperspectral data

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Overview & Rationale

- The Antarctic Peninsula (AP) is one of the most rapidly changing environments on the planet; mean annual air temperatures have increased by ~3 °C in the last 50 years. This climatic change has lead to higher summer-growing season temperatures and coupled with local glacial retreat, new bare-ground is exposed for colonisation by pioneering vegetation communities.
- To monitor and assess changes of AP vegetation, a robust, quantitative assessment of vegetation is required. Previous studies have applied standard techniques, such as the Normalised Difference Vegetation Index (NDVI) to satellite data from the AP. However, because the reflectance spectra of lichens, the dominant and most diverse component of AP flora, differs from vascular plants in both visible and near infrared portion of the spectrum, any work using NDVI for the detection of vegetation might overlook the presence of lichens.
- This study presents a spectral matched filtering technique which was applied to an airborne hyperspectral dataset to produce a high resolution map of vegetated areas from a test site on Lagoon and Kirsty island in the AP.

Study Area & Data Acquisition

- Simultaneous deployment of the ITRES CASI-1500 and SASI-600 spectrometers imaging VNIR and SWIR with 172 bands between 0.35 and 2.5 µm.
- Complemented by a field campaign in February 2014 using an ASD FieldSpec Pro 3 acquiring spectral reflectance measurements from 0.4 and 2.5 µm using a contact reflectance probe from a number of sites on Lagoon and Kirsty Island (Figure 1).

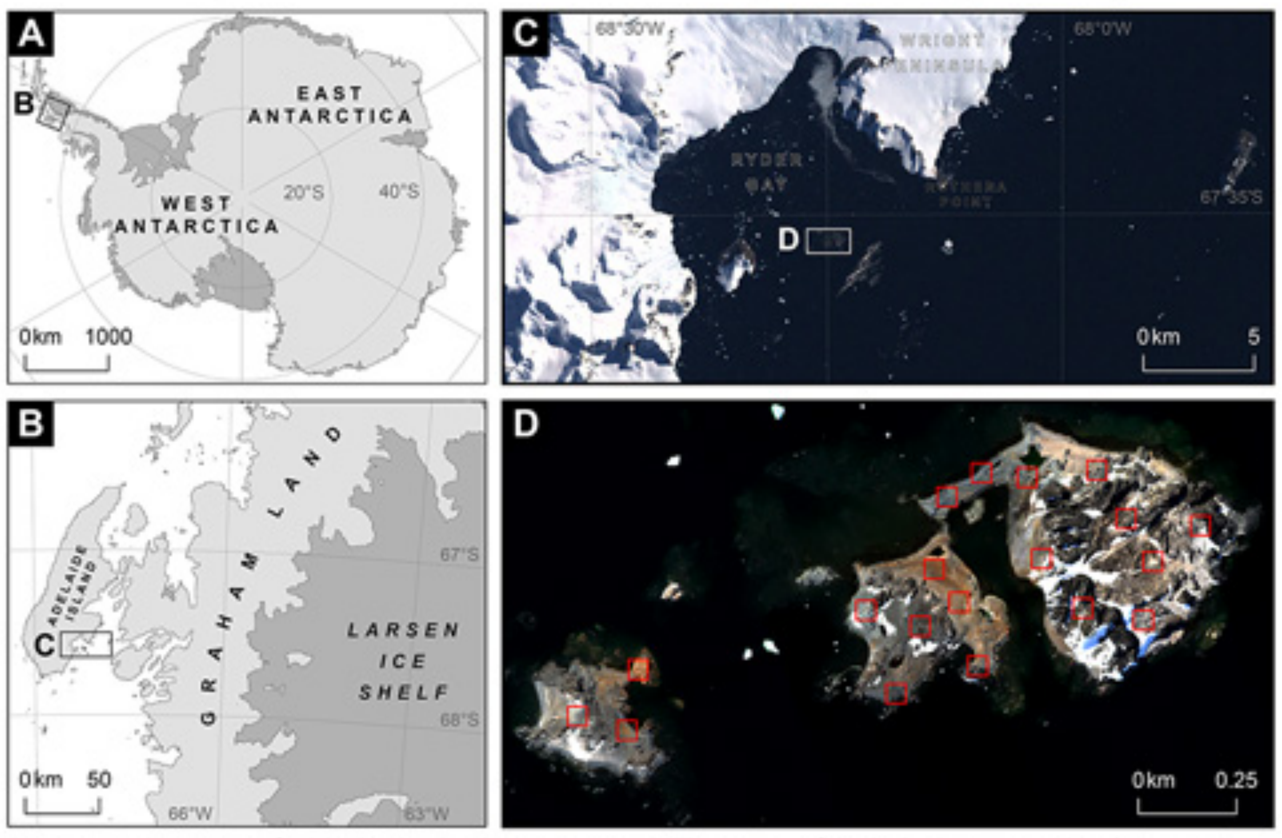

Figure 1. (A) the context of Adelaide Island within Antarctica; (B) The context of the Ryder Bay area within the Antarctic Peninsula; (C) the Ryder Bay area (with a Landsat colour image) showing extent of the hyperspectral area (Box labelled D); (D) CASI hyperspectral colour composite image of Kirsty Island (Left) and Lagoon Island (Right) with areas visited during the field campaign shown in red squares.

Methodology

- The airborne hyperspectral data was radiometrically, geometrically and atmospherically corrected [1], followed by a snow and sea water mask to leave areas of exposed rock and vegetation [2].
- NDVI was used to map vegetated areas [3] through the application of the equation: NDVI = (NIR - VIS) / (NIR + VIS), where the narrow spectral bands from the hyperspectral CASI imagery at 0.67 µm (VIS) and 0.8 µm (NIR) were used to calculate the NDVI. NDVI was thresholded at 0.2 to leave vegetated areas [3].
- Matched filtering [2] using the lichen spectra collected in the field was applied to find the abundance of lichens. The field spectra was mean normalised in the SWIR [4] and a matched filter applied to the 2 to 2.5 µm SWIR bands of the SASI imagery. It has previously been shown that a single lichen species endmember can account for the presence of all species of lichen, if mean normalisation is applied [4].
- As ground truthing the 19 (10 x 10 m) field sites which were visited in February 2014 were used. The presence of lichens was confirmed in the field at 17 of the 19 sites.

Results & Discussion

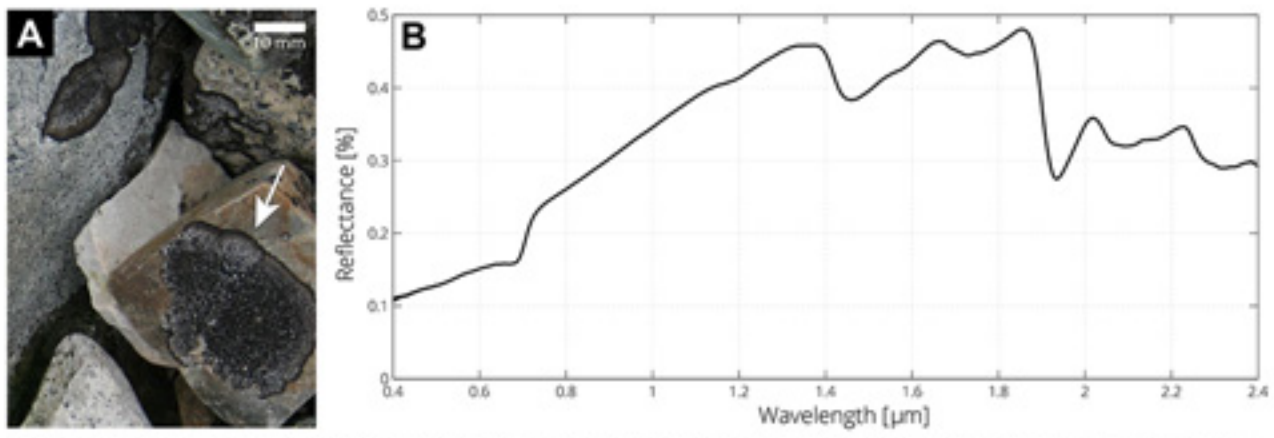

Figure 2. (A) Photograph of Buellia sp.; (B) Spectral profile of Buellia sp. acquired from an ASD FieldSpec Pro 3 using a contact reflectance probe in white reflectance mode (acquired during the February 2014 field campaign).

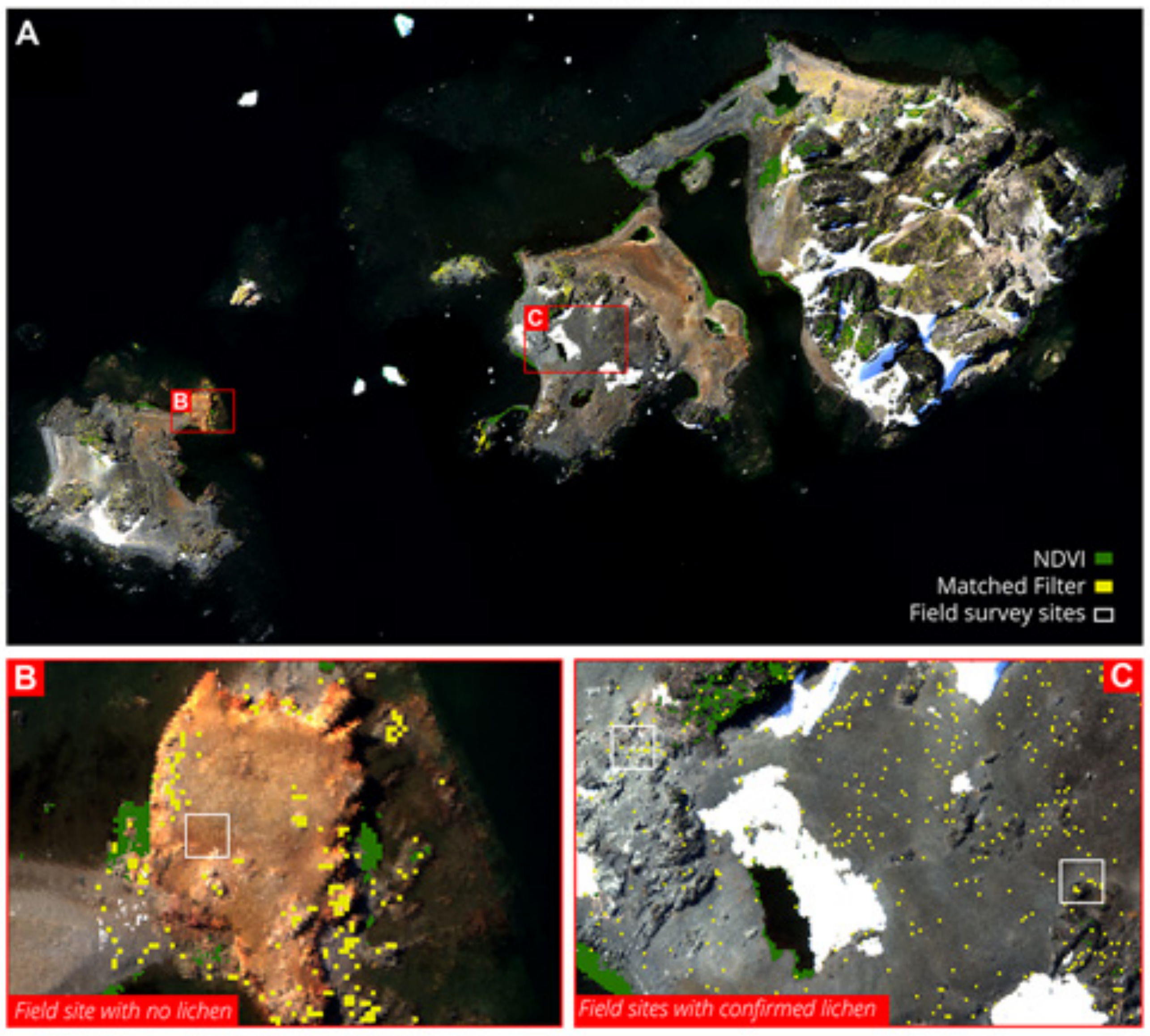

Figure 3. (A) Lagoon and Kirsty Island image with results from the matched filter (yellow) and NDVI (green) overlain; (B) inset showing a close up on Kirsty Island, where the white box indicates a field site without lichen present; (C) inset showing a close up of western Lagoon island with field sites with confirmed lichen shown in white squares.

- The matched filtering approach successfully identified the presence of lichens at 16 (of 17) sites where lichen was observed in the field, achieving an accuracy of 95%, with no false positives (compare Figure 3, insets B and C).
- The NDVI approach only successfully identified the presence of lichens at 9 (of 17) sites where lichen was observed in the field, achieving an accuracy of 53%.
- These results highlight the need for techniques such as matched filtering to complement mapping using NDVI in areas where lichen is the dominant flora.

Conclusion

The use of a matched filtering technique allows for the detection of lichen flora in the Antarctic Peninsula, showing a significant improvement over NDVI for the mapping of flora in this area. The results highlight the importance of using techniques other than NDVI for the detection and mapping of vegetation in areas where lichens are the main component of the communities; especially at high latitudes or high altitude environments.

The matched filtering technique presented here could be applied to intermediate spatial and spectral resolution imagery, which will be available in the future from planned satellite launches (e.g. WorldView-3, HyspIRI, Sentinel-2, EnMAP), contributing to the continued study, monitoring and mapping of vegetation communities on the AP.

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