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Assessment of Antarctic moss health from multi-sensor UAS imagery with Random Forest Modelling

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ABSTRACT

Moss beds are one of very few terrestrial vegetation types that can be found on the Antarctic continent and as such mapping their extent and monitoring their health is important to environmental managers. Across Antarctica, moss beds are experiencing changes in health as their environment changes. As Antarctic moss beds are spatially fragmented with relatively small extent they require very high resolution remotely sensed imagery to monitor their distribution and dynamics. This study demonstrates that multi-sensor imagery collected by an Unmanned Aircraft System (UAS) provides a novel data source for assessment of moss health. In this study, we train a Random Forest Regression Model (RFM) with long-term field quadrats at a study site in the Windmill Islands, East Antarctica and apply it to UAS RGB and 6-band multispectral imagery, derived vegetation indices, 3D topographic data, and thermal imagery to predict moss health. Our results suggest that moss health, expressed as a percentage between 0 and 100% healthy, can be estimated with a root mean squared error (RMSE) between 7 and 12%. The RFM also quantifies the importance of input variables for moss health estimation showing the multispectral sensor data was important for accurate health prediction, such information being essential for planning future field investigations. The RFM was applied to the entire moss bed, providing an extrapolation of the health assessment across a larger spatial area. With further validation the resulting maps could be used for change detection of moss health across multiple sites and seasons.

1. Introduction

The health of moss beds in Antarctica is of scientific interest due to their sensitivity to climate change. Several studies have investigated their response to dynamic climatic conditions (Amesbury et al., 2017; Casanovas et al., 2015; Clarke et al., 2012; Convey et al., 2009; Dunn and Robinson, 2006; Robinson et al., 2003; Turnbull and Robinson, 2009). The growth and health of these moss beds is highly reliant on environmental factors, particularly availability of liquid water and sufficient nutrient supply, typically originating from guano in ancient penguin rookeries (Melick et al., 1994; Wasley et al., 2012). While the Windmill Islands region of East Antarctica contains some of the most extensive vegetation communities found in the Antarctic region (Smith, 1988), these moss beds are of limited extent (< 1 ha) and highly spatially fragmented. Their complex topography, combined with the isolation of the site, generally create a challenge for spatial monitoring of community change (Convey et al., 2014). In our previous studies, we have demonstrated that Unmanned Aircraft Systems (UAS), also known as Unmanned Aerial Vehicles (UAVs) or drones, provide an excellent tool for mapping these areas (Lucieer et al., 2014b; Malenovský et al., 2017; Turner et al., 2014a). The advantage of UAS, combined with imaging spectroscopy and other optical observations, is that it allows mapping of moss health over large areas relatively quickly, non-destructively and on demand under clear sky or overcast conditions (Malenovský et al., 2017; Malenovský et al., 2015).

The use of high resolution remote sensing techniques for mapping the spatial patterns and dynamics of Antarctic vegetation is relatively limited. The concept of mapping Antarctic moss beds was first introduced by Lucieer et al. (2011) and Lucieer et al. (2012). A relationship between water availability and moss health was then found by Lucieer et al. (2014b) but unlike our current study a continuous map of moss health was not produced. Relating moss health to the MTVI vegetation index (Turner et al., 2014a) allowed the first thematic maps of moss health to be produced. Lucieer et al. (2014a) first introduced the concept of using hyperspectral imaging to map moss vigour, followed by Malenovský et al. (2017) who used hyperspectral data to map

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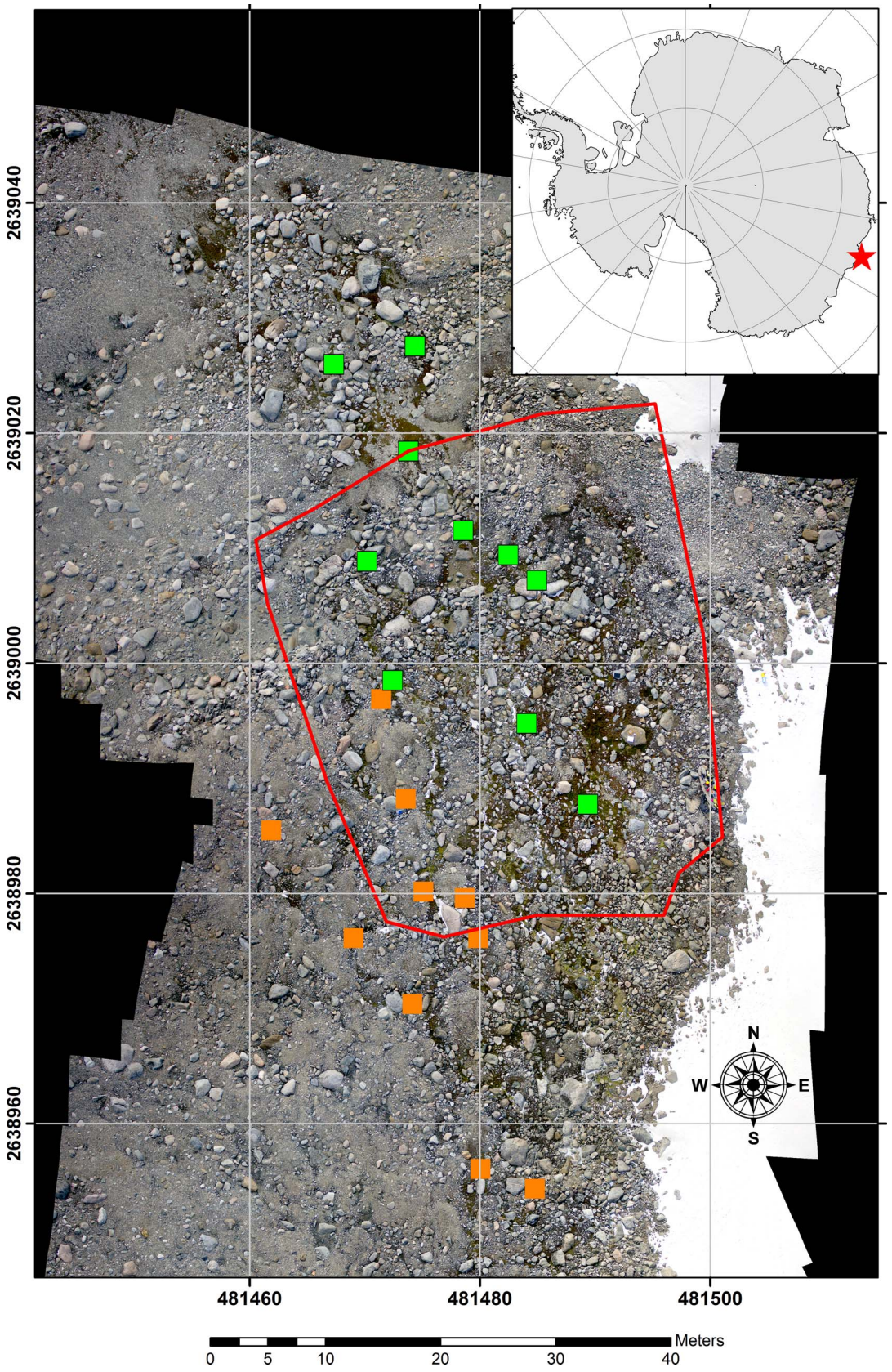

Fig. 1. Site location map of the Robinson Ridge field site within the Windmill Islands, East Antarctica. Imagery is from RGB sensor flight in 2011.Coloured boxes show locations of the long-term monitoring quadrats, Green markers – Bryophyte quadrats, Orange markers – Transitional quadrats. Red outline indicates extent of 2014 data aerial collection. Drainage channels run NNW from the snow bank on the eastern side down the slope towards the sea. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)