Rise of the Drones – opportunities of Unmanned Aircraft Systems (UAS) for environmental remote sensing

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Science for the Environment, Aarhus, Denmark, 1 Oct 2015

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Outline

- Unmanned Aircraft Systems (UAS) and remote sensing
- UAS for Antarctic moss bed mapping
- Saltmarsh vegetation mapping and biomass assessment
- Coastal erosion monitoring (geomorphology)
- UAS remote for studying Tasmania's mature Eucalyptus forests
- Conclusions

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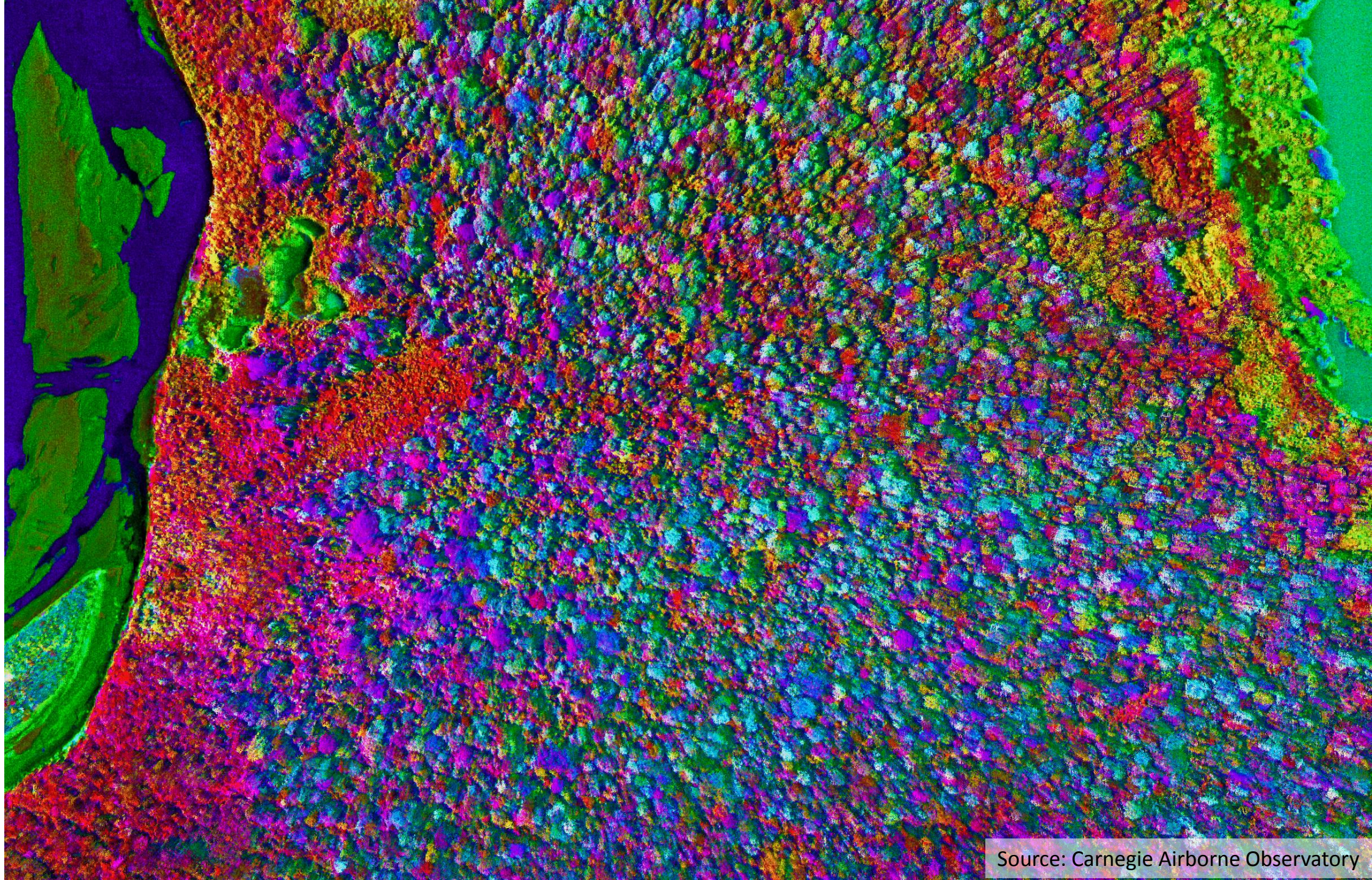

Source: Carnegie Airborne Observatory

Problems with satellite & airborne remote sensing

- Spatial resolution not high enough (2 m – 30 m pixel size)
- Not frequent enough + can't get imagery when needed
- High Res commercial imagery $$$$$$
- Mainly suitable for large areas
- Only one specific sensor
- Unmanned Aircraft Systems (UAS *also known as UAVs or drones*) **fill this niche**

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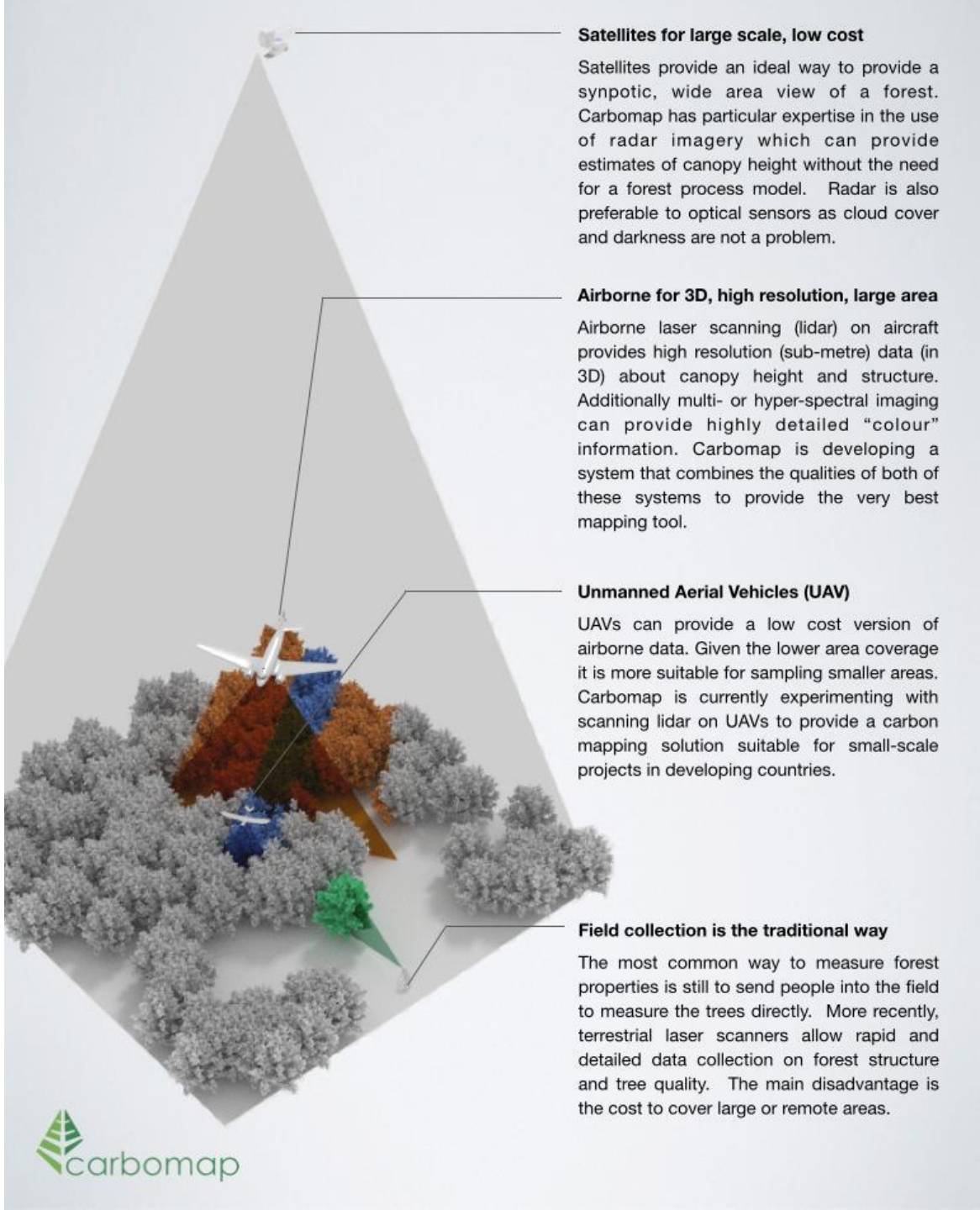
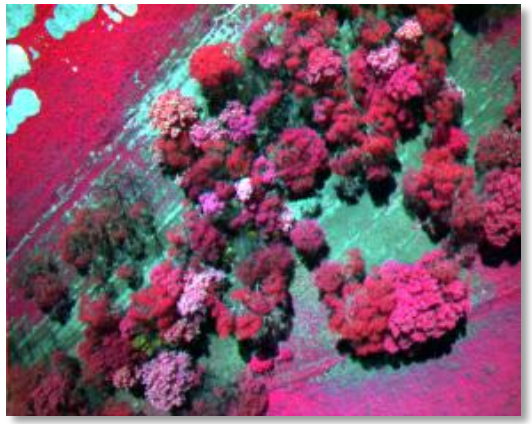


TerraLuma

- We develop Unmanned Aircraft Systems (UAS) and image processing techniques for environmental, agricultural, and high-precision aerial mapping applications
- Unique aspects of UAS for mapping/monitoring:
  1. Spatial resolution: Highest spatial *resolution* imagery available (1 cm)
  2. Temporal resolution: Fly *on-demand* at critical stages
  3. Sensor integration: Integration of *multiple sensors* imaging outside the visible range (both passive and active)



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TerraLuma UAS













Sensors

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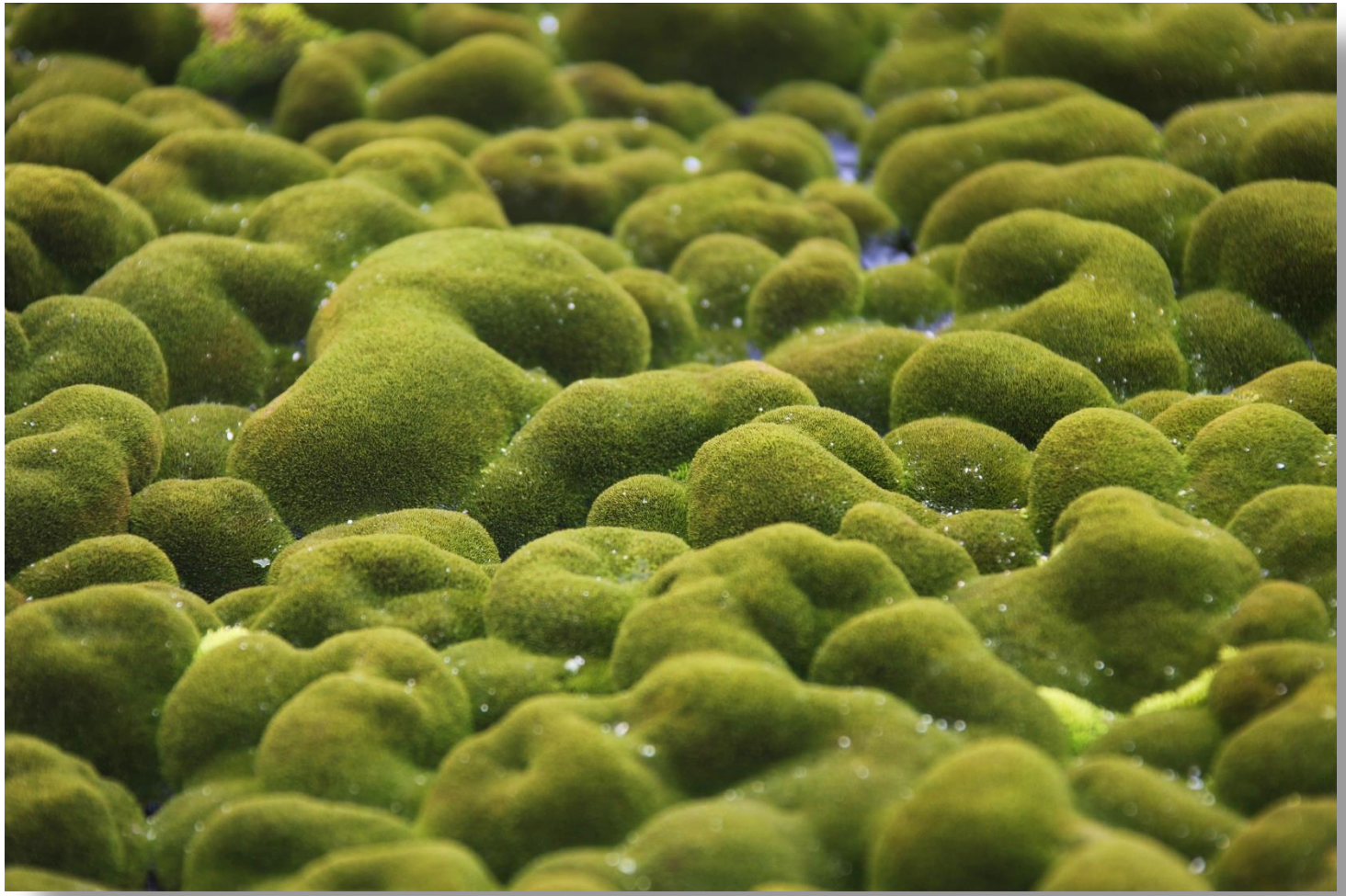
Antarctic moss beds




LIA and the
LIAN ANTARTIC
ORY
stralian station
Hobart to:
3443 km
4838 km
5475 km
1542 km
AUSTRALIA
30° E
160° E

Water availability

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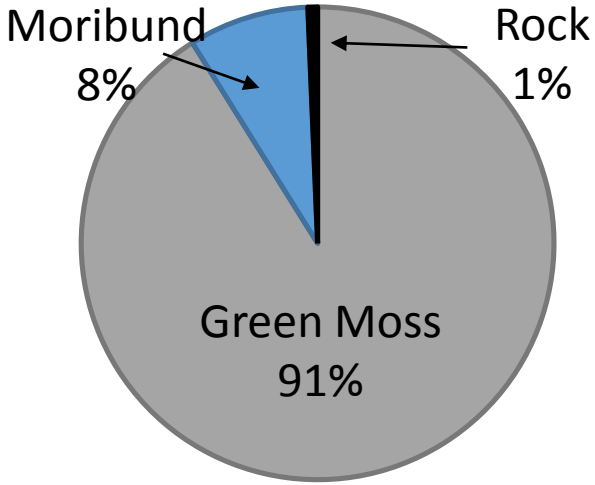
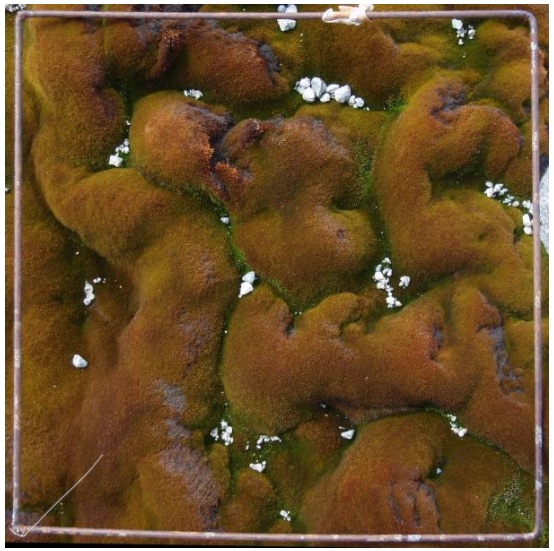
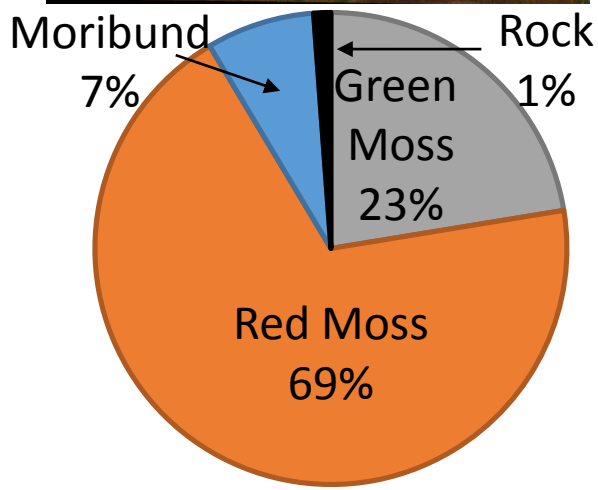
2003

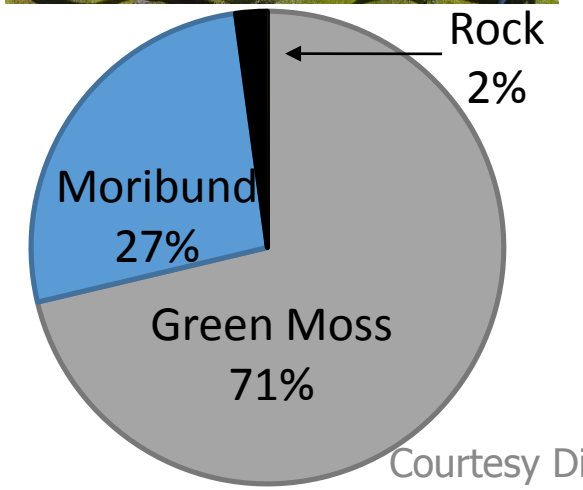


2008





2012



Courtesy Diana King

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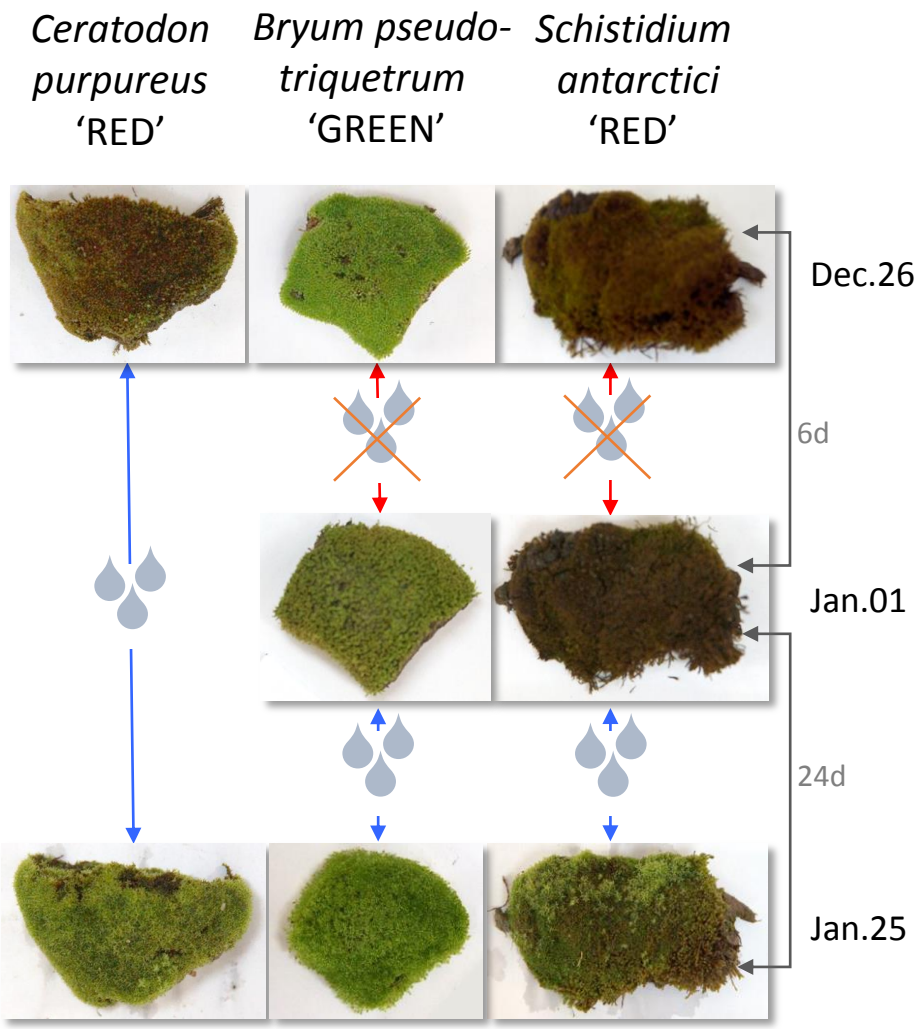
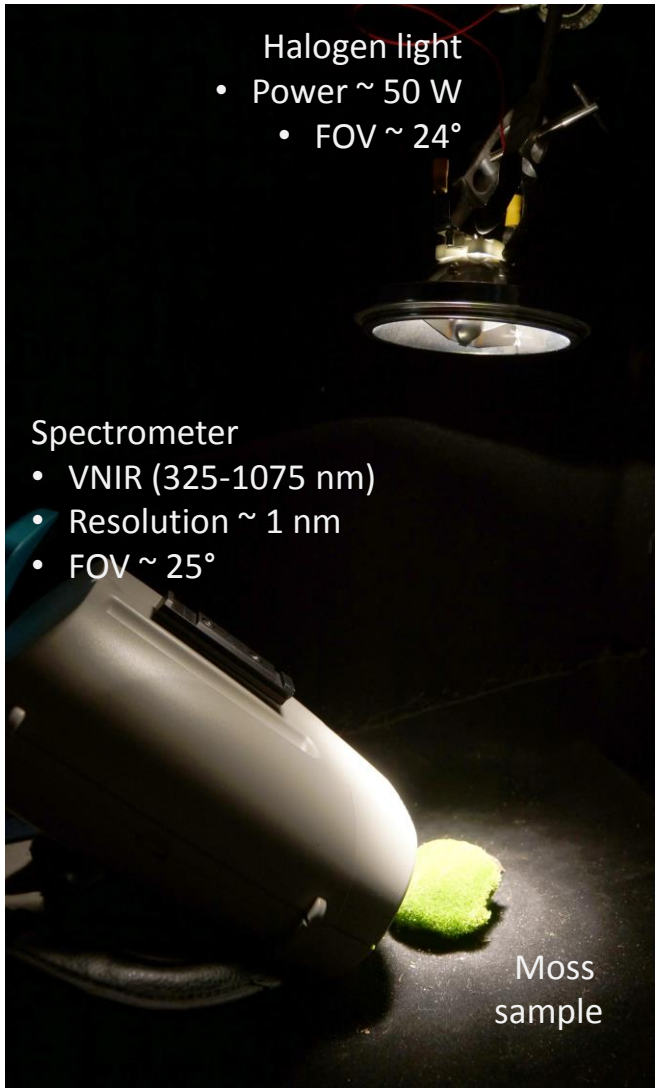
Spectroscopy of moss stress reactions





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Source: Zbynek Malenovsky

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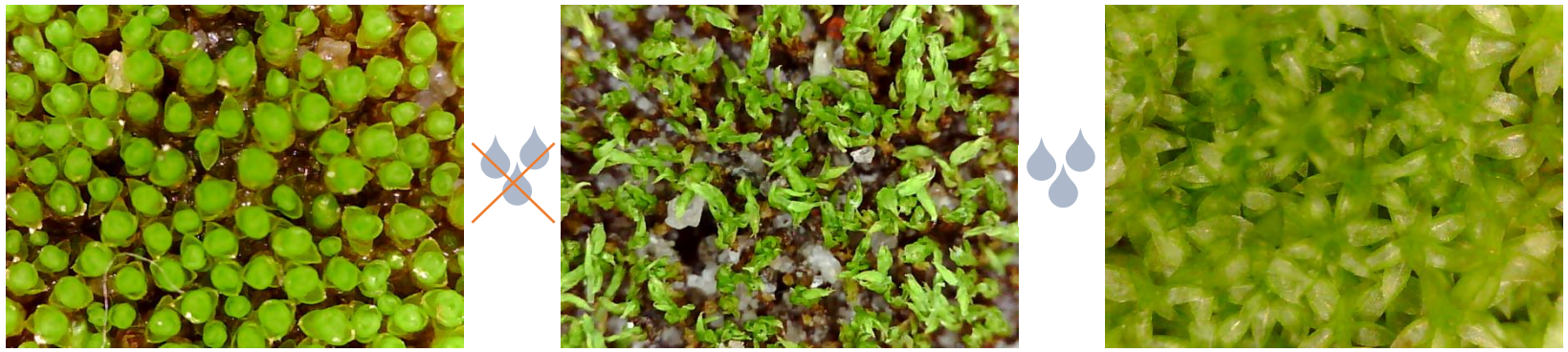
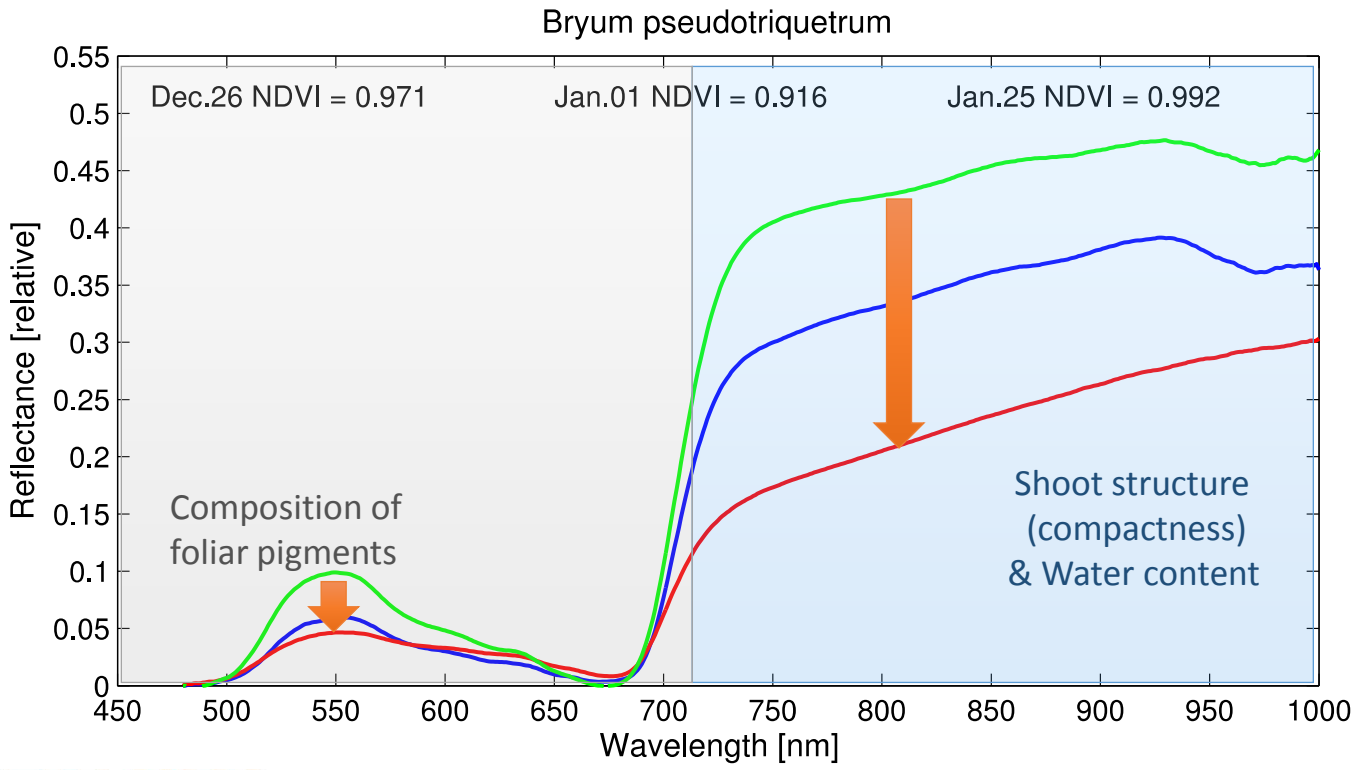
Spectral signatures of stress – *Bryum*





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Source: Zbynek Malenovsky

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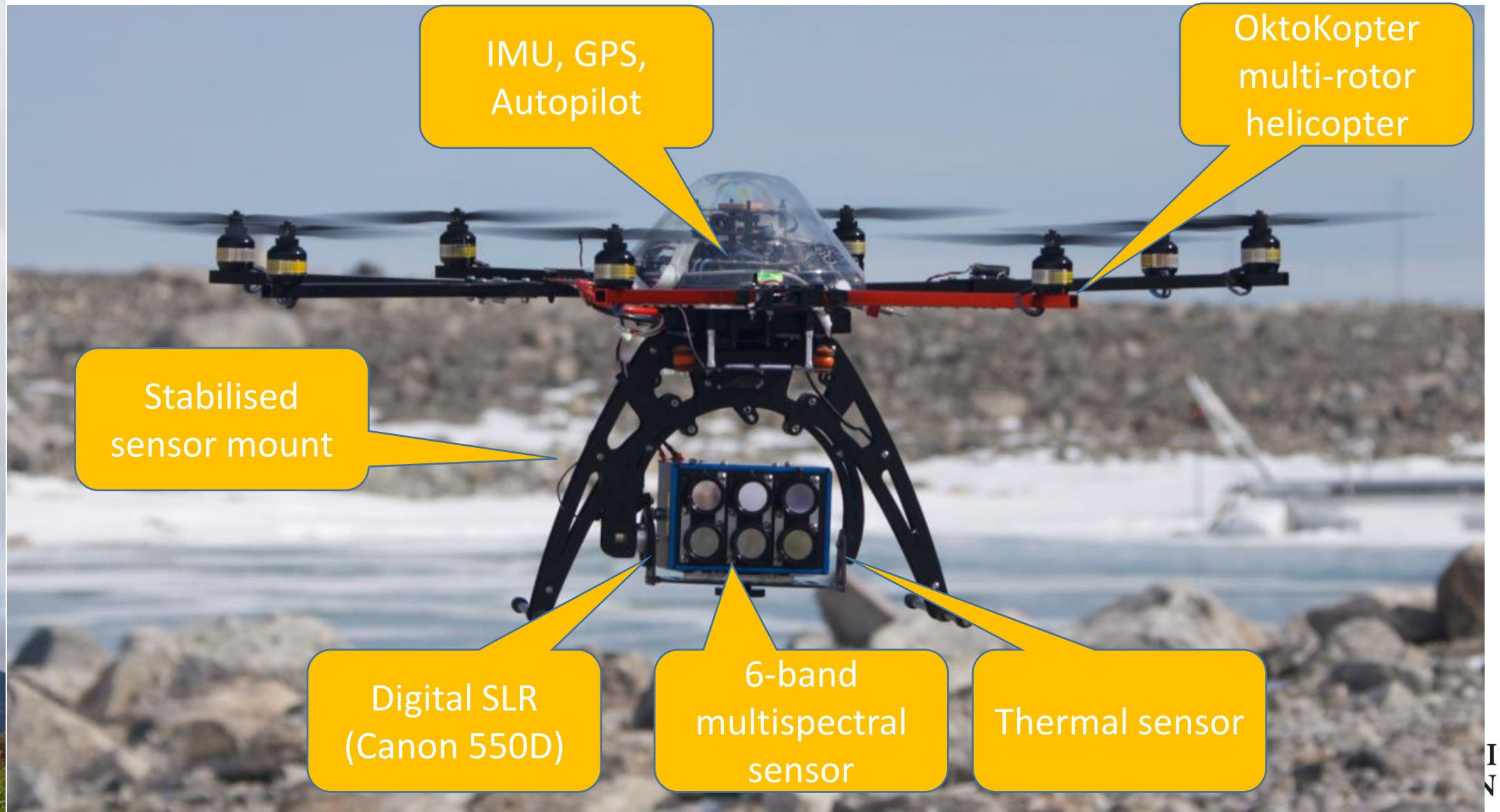
OktoKopter



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Structure-from-Motion (SfM)

source: www.pix4d.com

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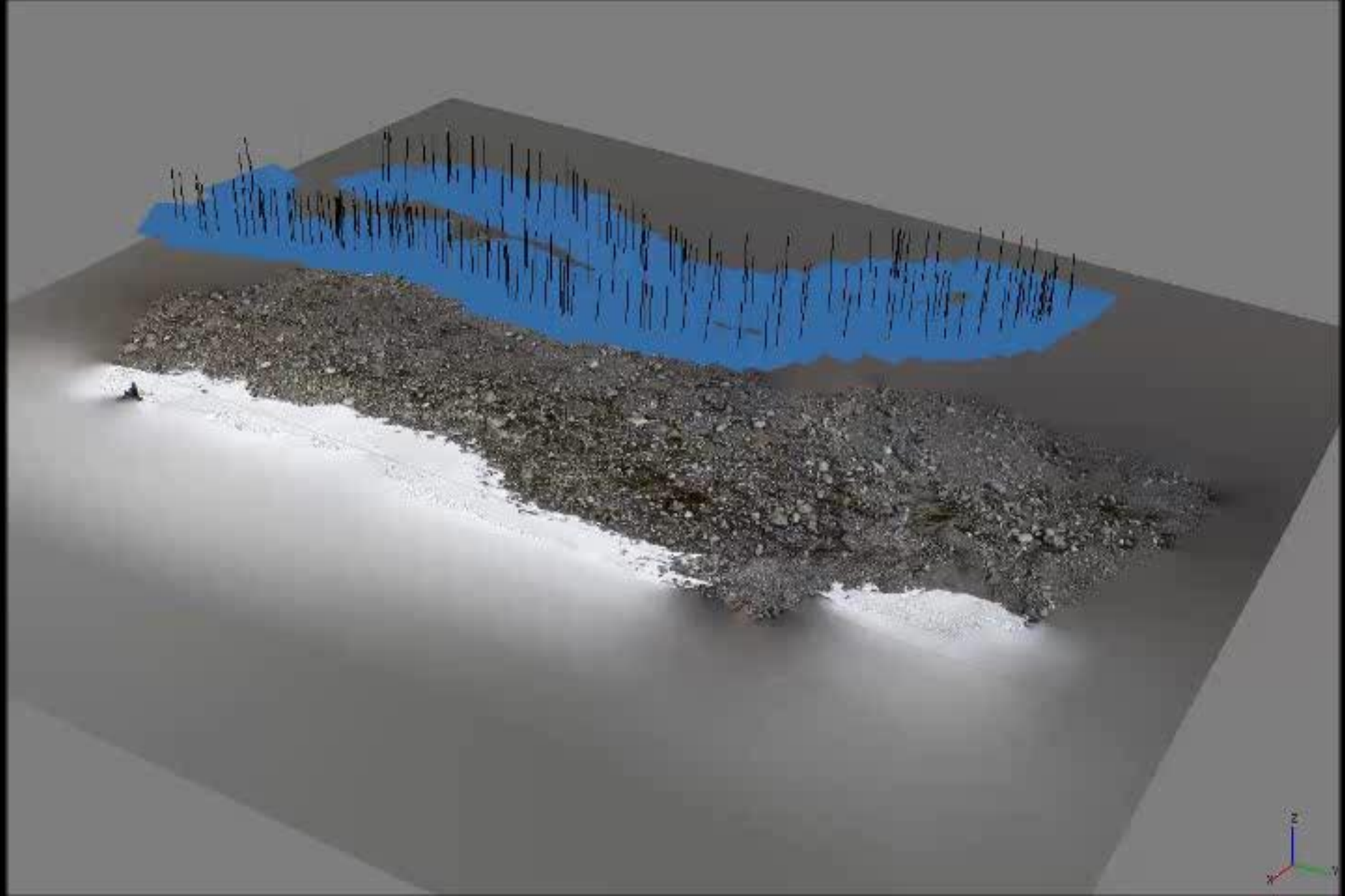
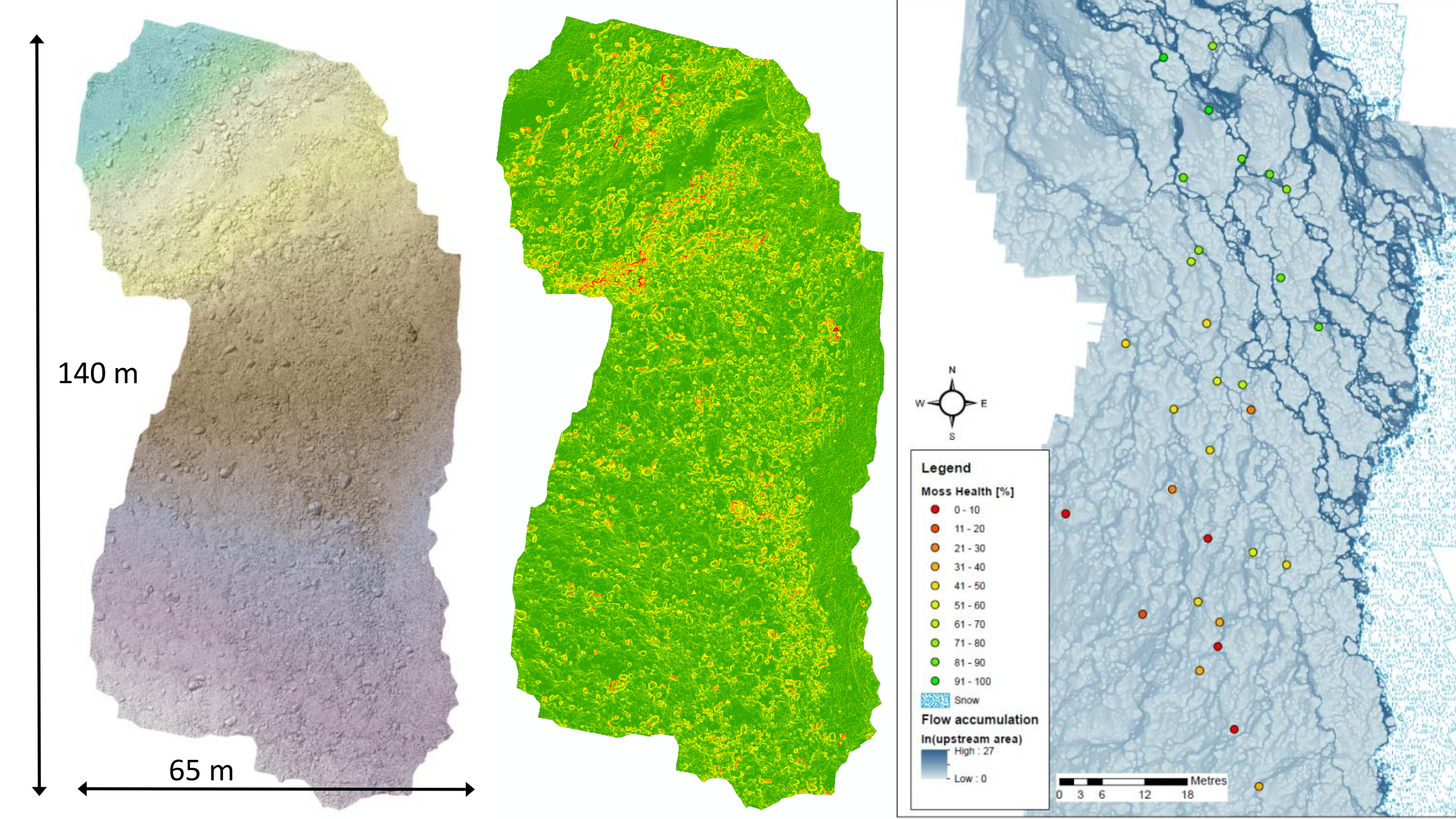
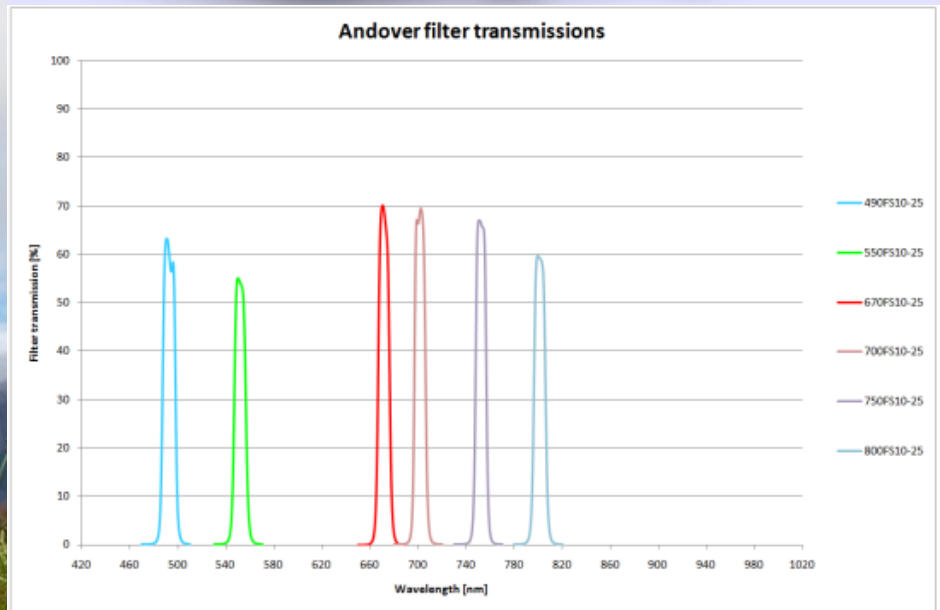



140 m
65 m
N
W
E
S
Legend
Moss Health [%]
0 - 10
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 70
71 - 80
81 - 90
91 - 100
Snow
Flow accumulation
ln(upstream area)
High : 27
Low : 0
Metres
0 3 6 12 18

Multispectral *imaging* sensor



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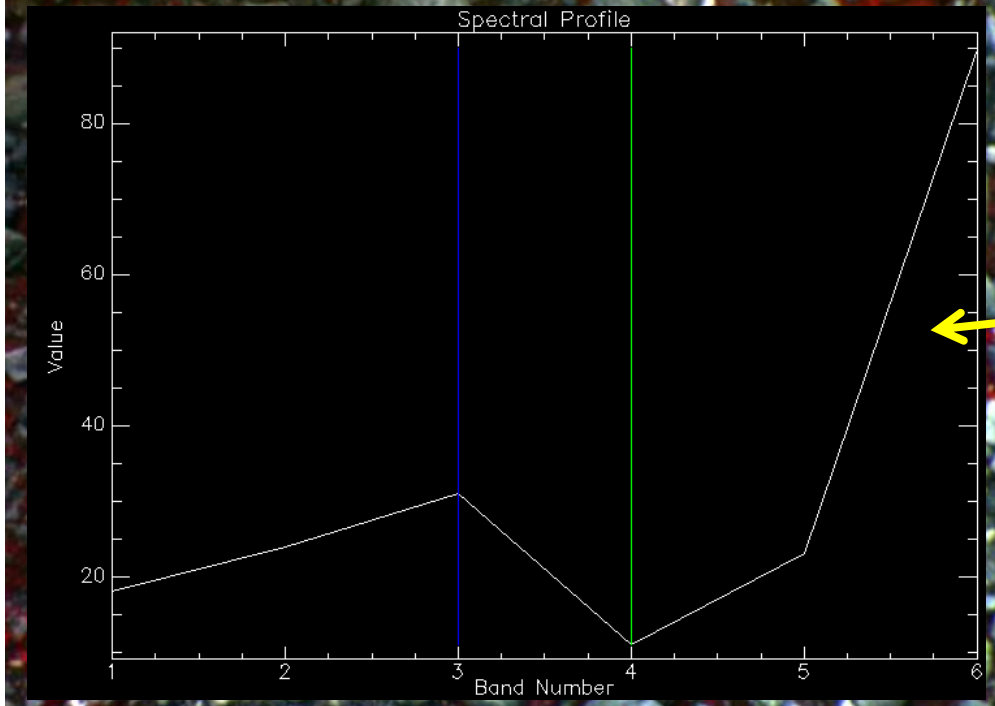
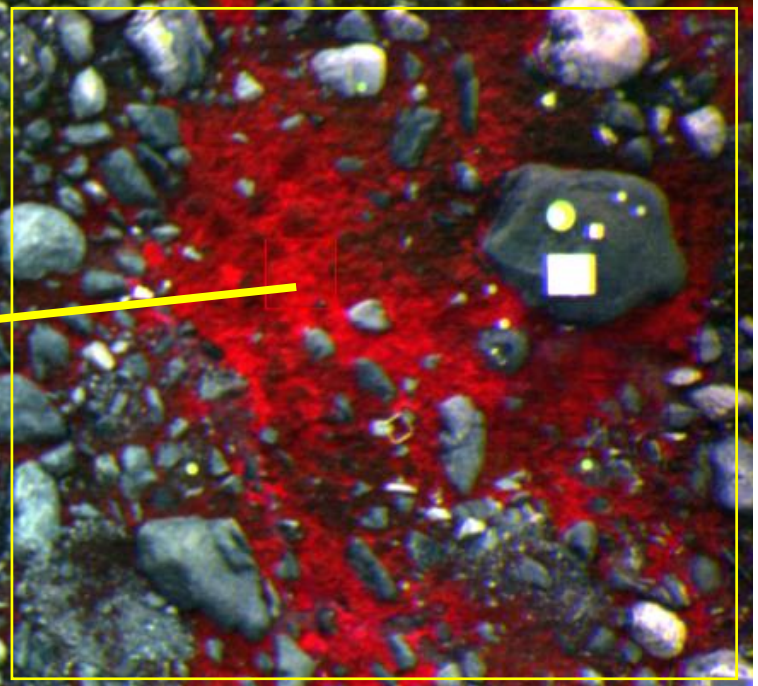
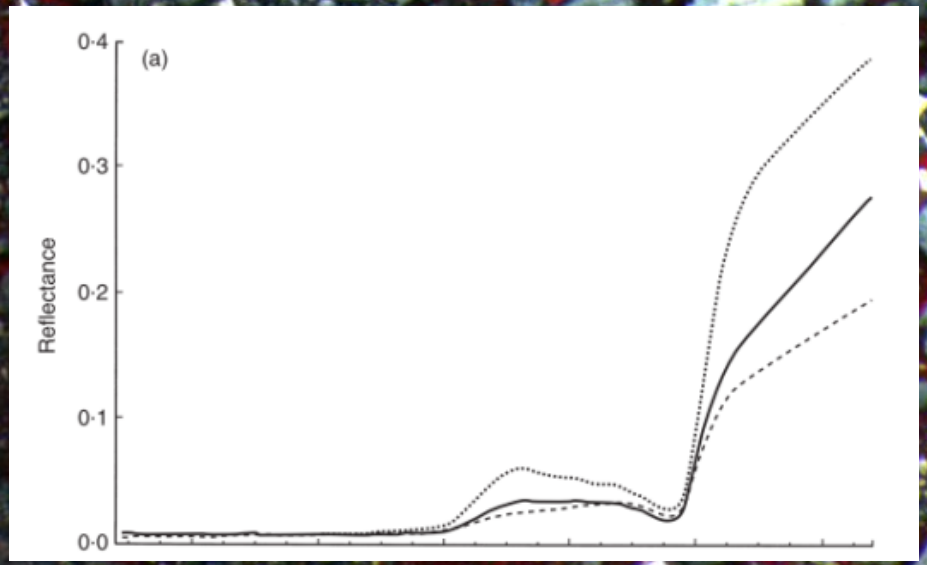
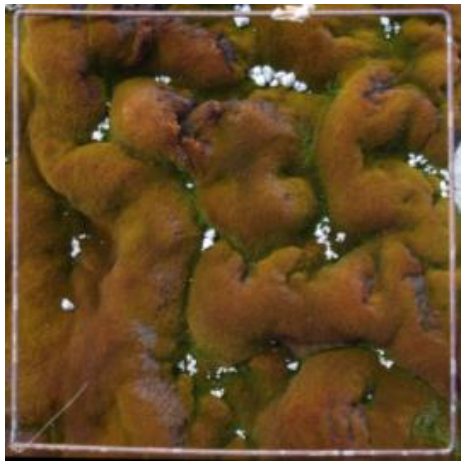

Spectral Profile
Value
80
60
40
20
1
2
3
4
5
6
Band Number




(a)
0·4
0·3
0·2
0·1
0·0
Reflectance

MTVI2



Unstressed moss

Stressed moss

Modified Triangular Vegetation Index 2:

$$MTVI2 = \frac{1.5\left[1.2\left(\rho_{800}-\rho_{550}\right)-2.5\left(\rho_{670}-\rho_{550}\right)\right]}{\sqrt{\left(2\rho_{800}+1\right)^2-\left(6\rho_{800}-5\sqrt{\rho_{670}}\right)-0.5}}$$

(Haboudane 2004, *Rem. Sen. Environ.*)

Composition of foliar pigments

Shoot structure (compactness) & Water content

Reflectance [relative]

0.3
0.25
0.2
0.15
0.1
0.05
0

450 500 550 600 650 700 750 800 850 900 950 1000

Wavelength [nm]

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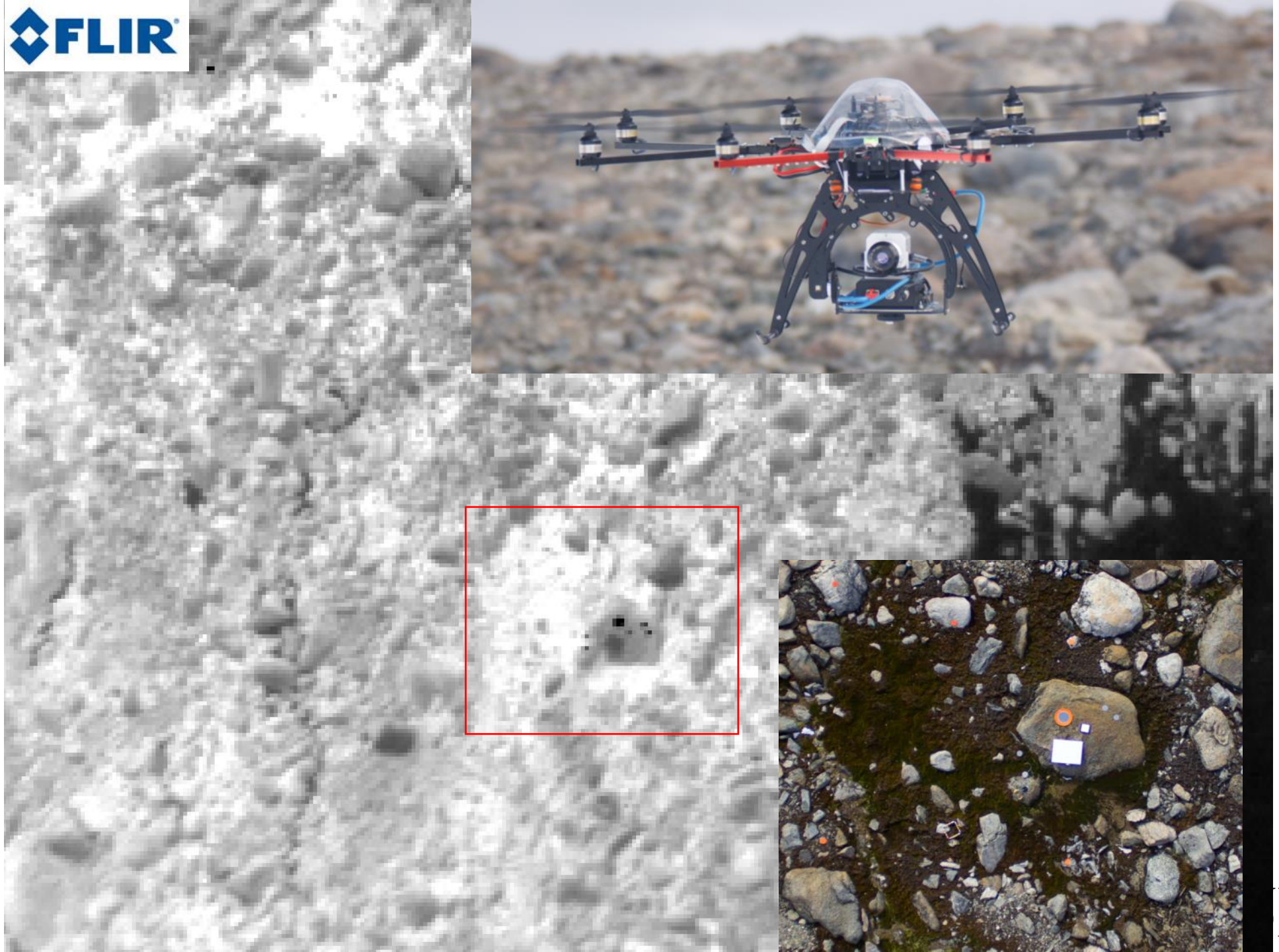

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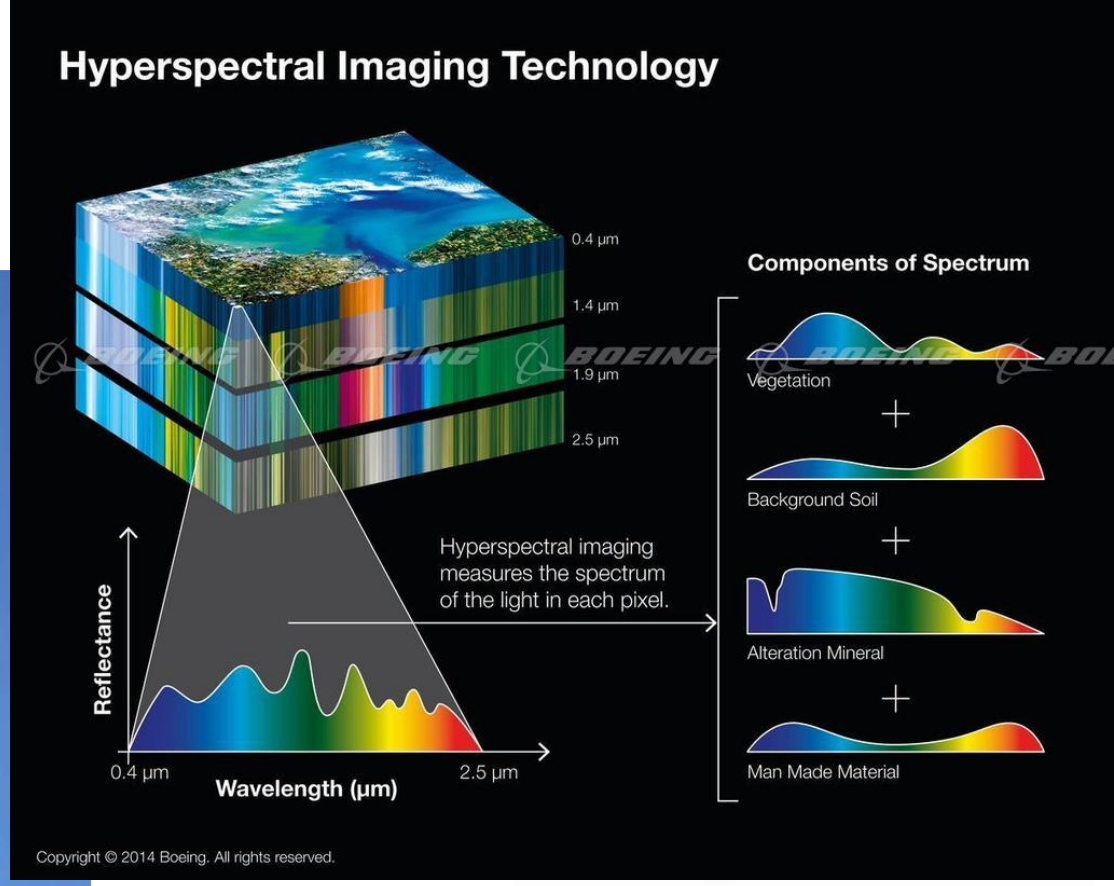
Moss health
0 - 1
1 - 35
35 - 60
60 - 80
80 - 100

HyperUAS



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Lucieer, A., Malenovsky, Z., Veness, T., Wallace, L. (2014). HyperUAS – Imaging spectroscopy from a multi-rotor unmanned aircraft system. *Journal of Field Robotics,* 31(4): 571-590. doi:10.1002/rob.21508

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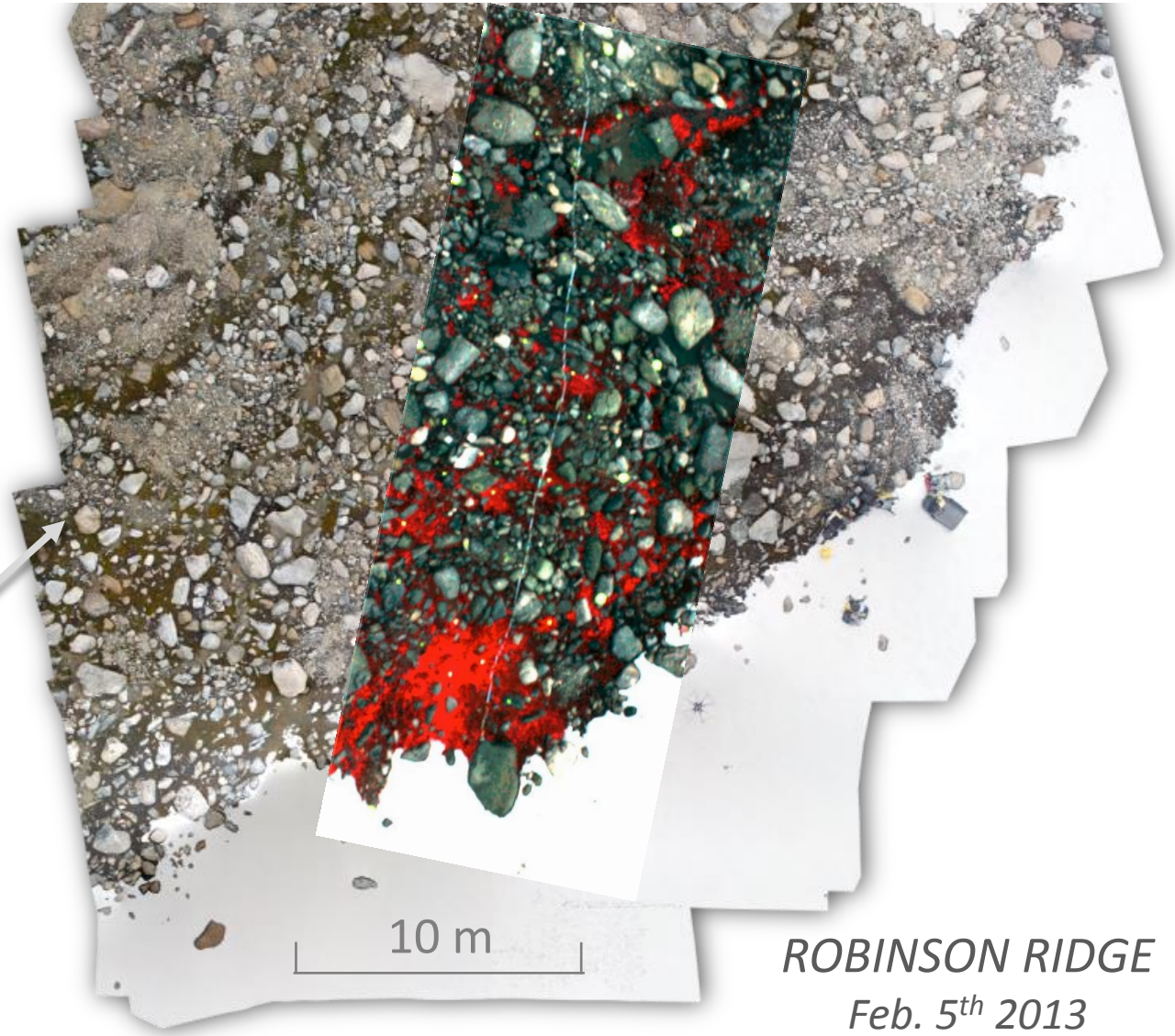
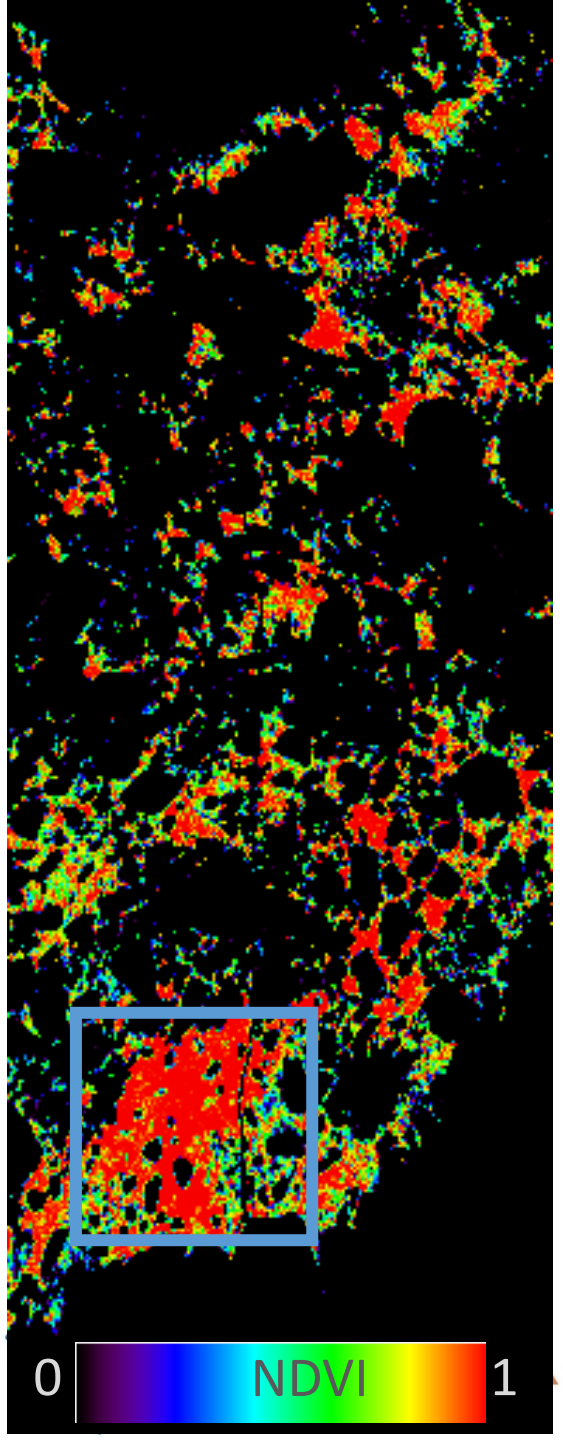
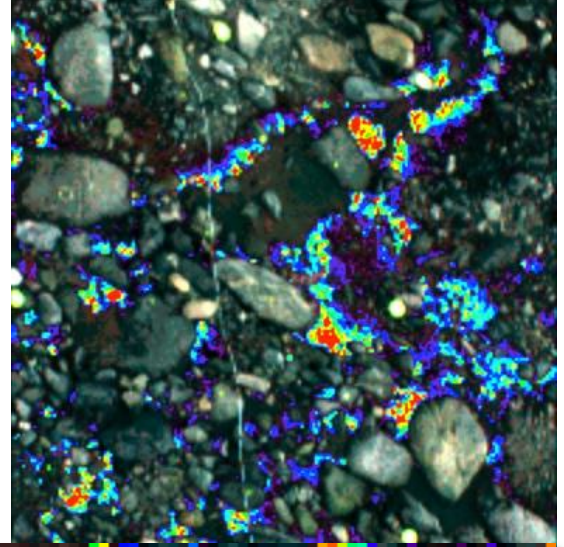
- 162 bands (VNIR: 363 - 960 nm)
- Band width 4.75 - 5.25 nm
- Flight line 10x30 m
- Pixel-size ~ 5 cm



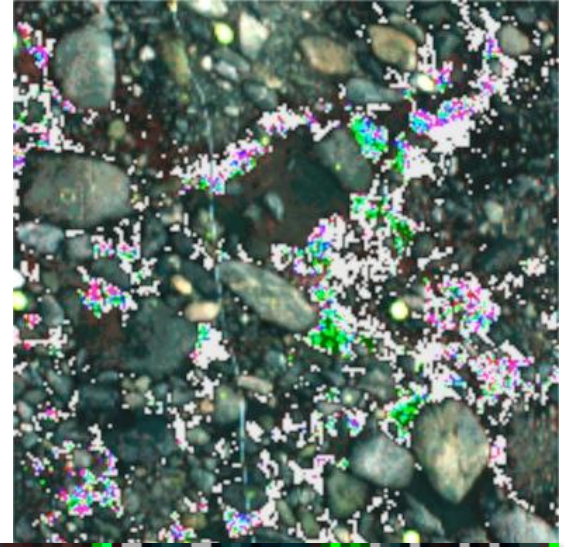
ROBINSON RIDGE
Feb. 5th 2013

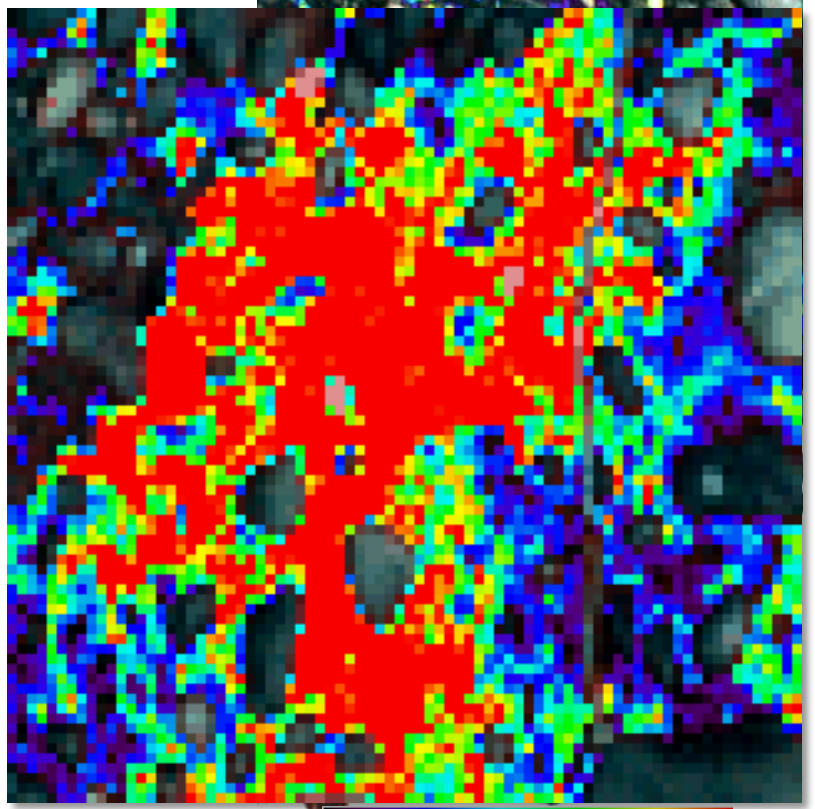


MOSS HEALTH

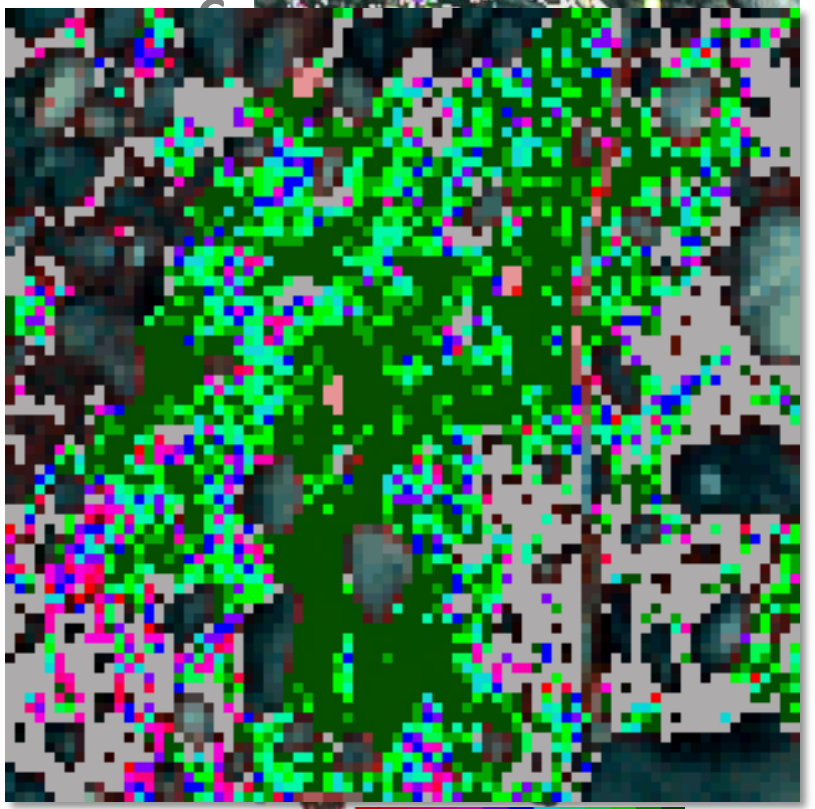


CHLOROPHYLL

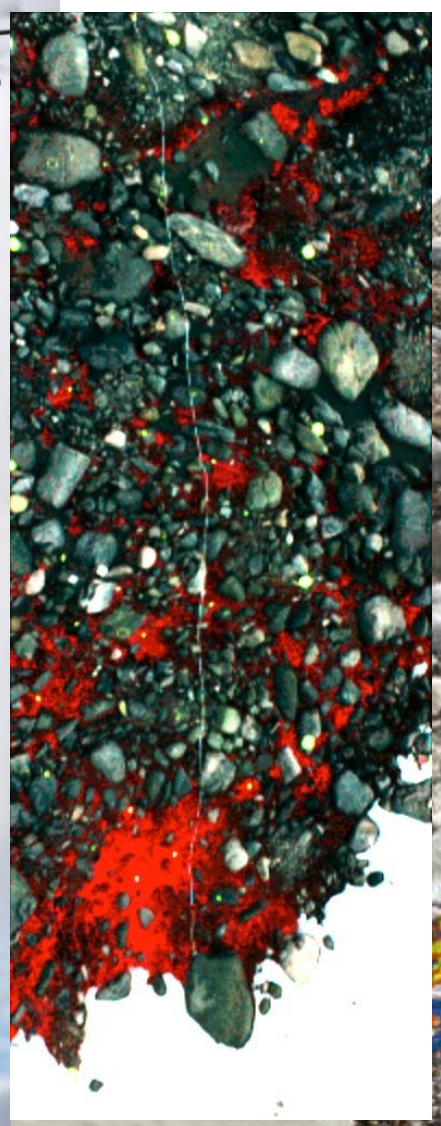




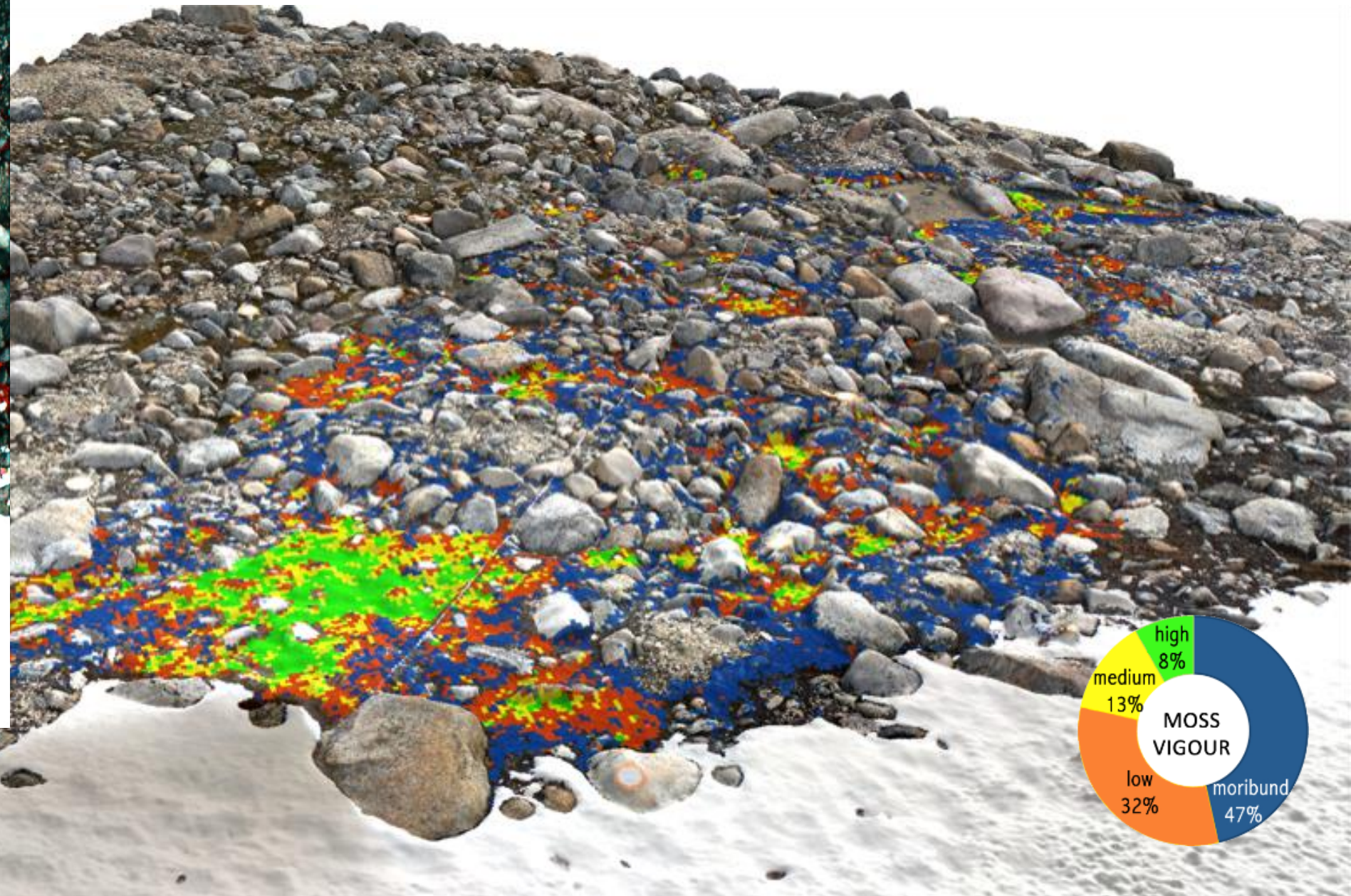
low MTVI2 high



low ANCB high



ROBINSON RIDGE (East Antarctica, 5th February 2013)



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Saltmarsh vegetation classification

Kelcey, J., & Lucieer, A. (2012). Sensor Correction of a 6-Band Multispectral Imaging Sensor for UAV Remote Sensing. *Remote Sensing*, *4*(5), 1462-1493. http://www.mdpi.com/2072-4292/4/5/1462

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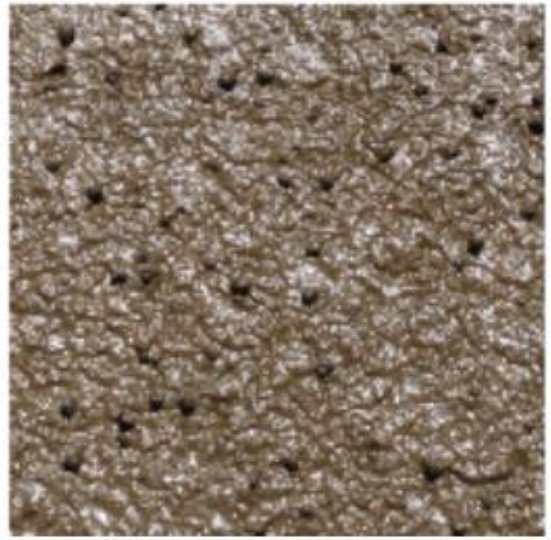
Samolus sp.

Sarcocornia sp.

Tecticornia sp.

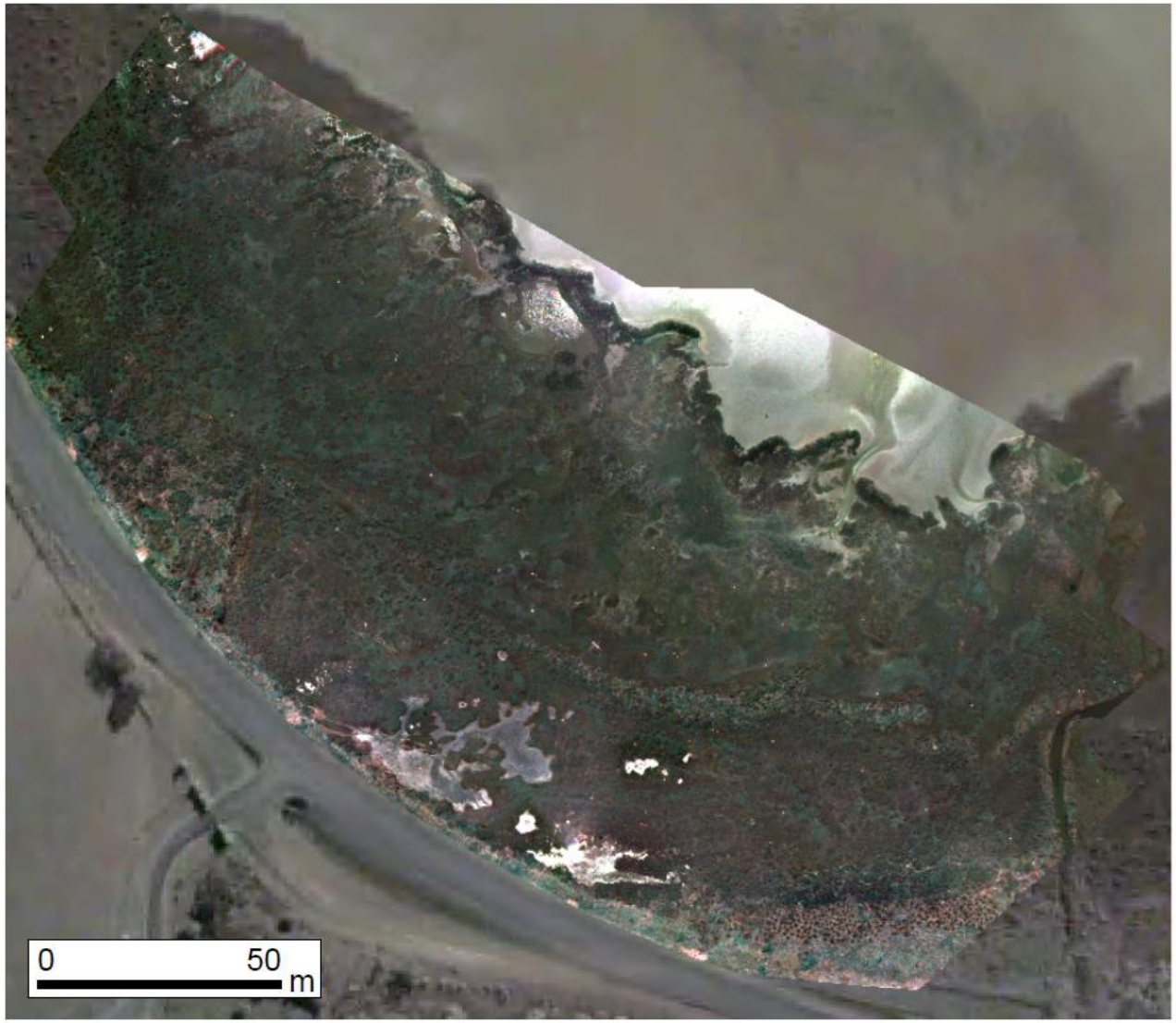
Gahnia sp.

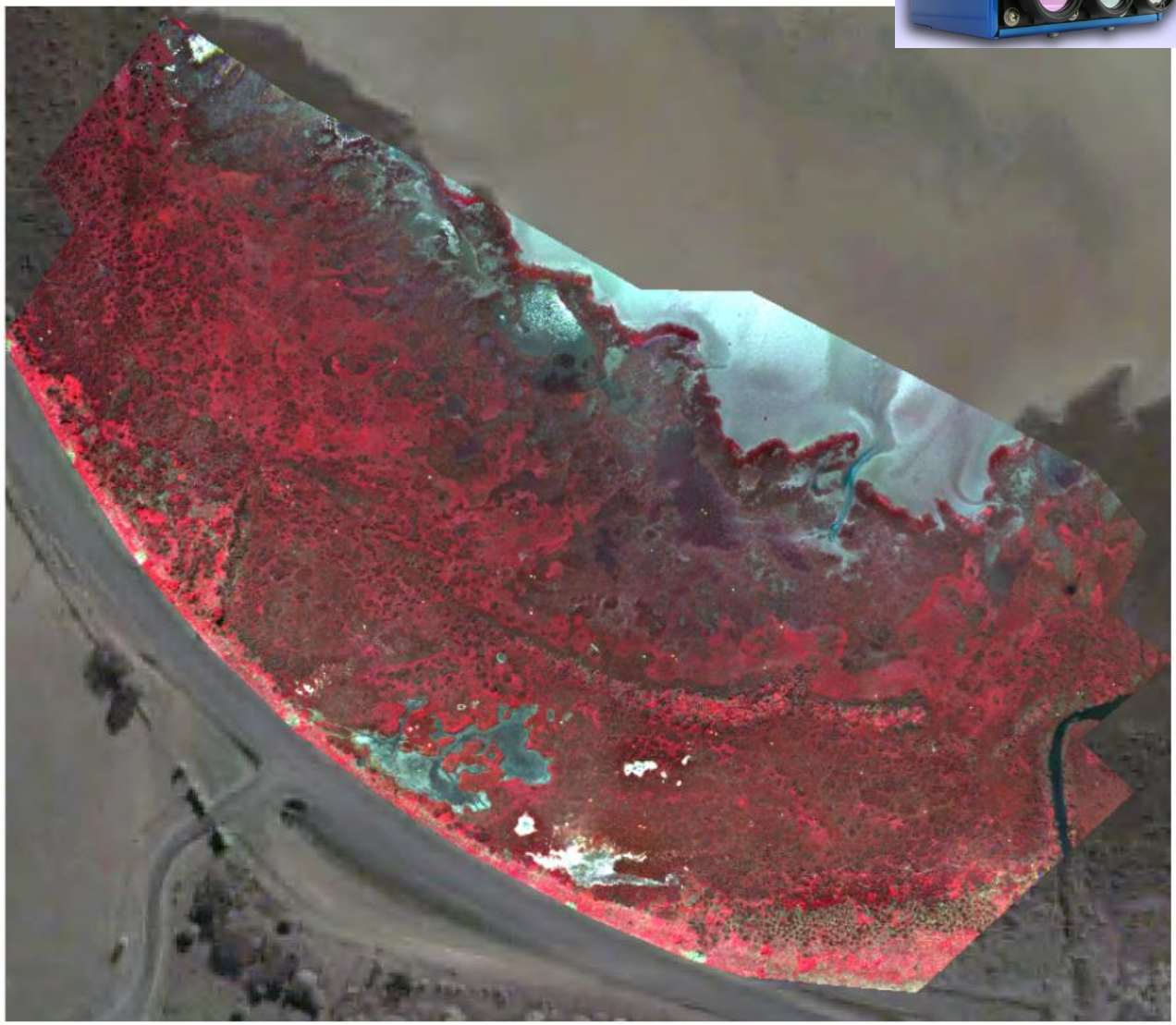
Sand



Mudflat

Saltpan





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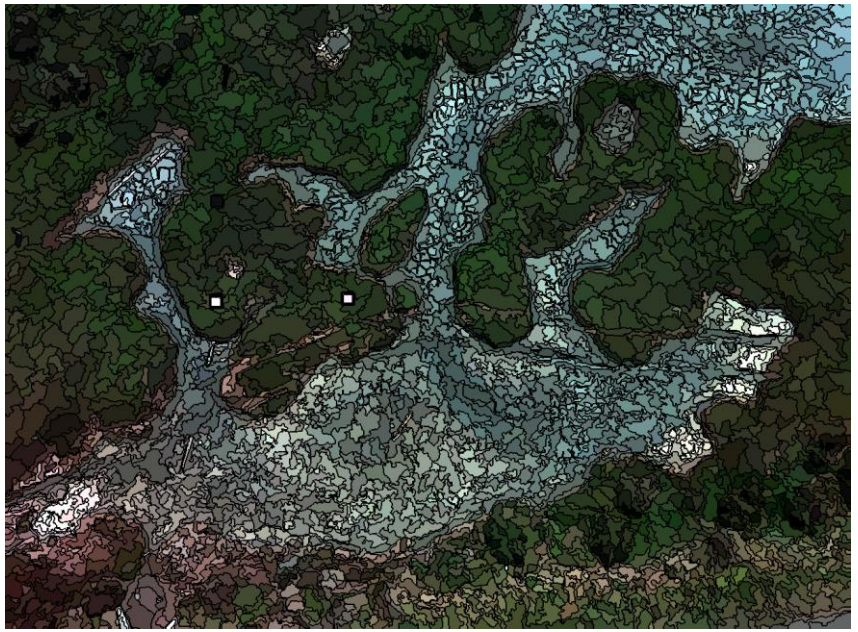
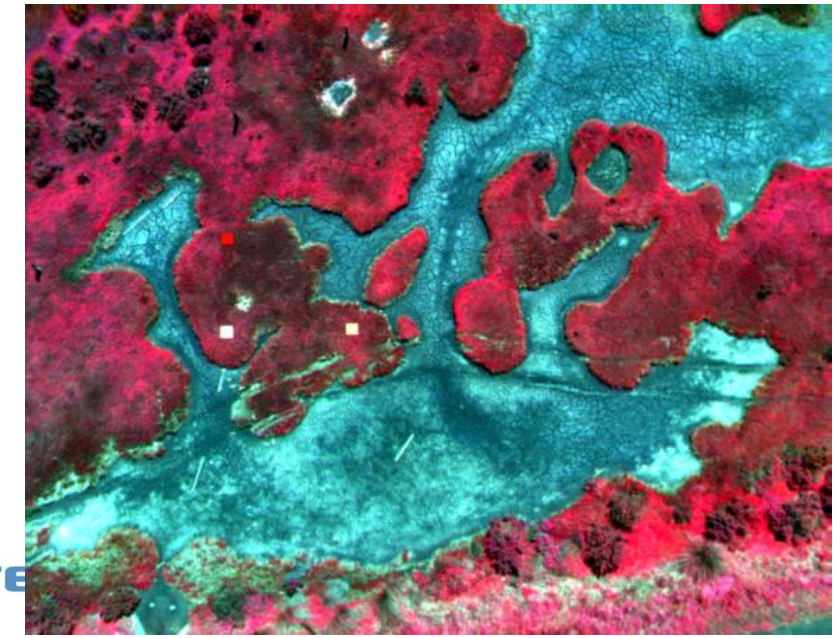
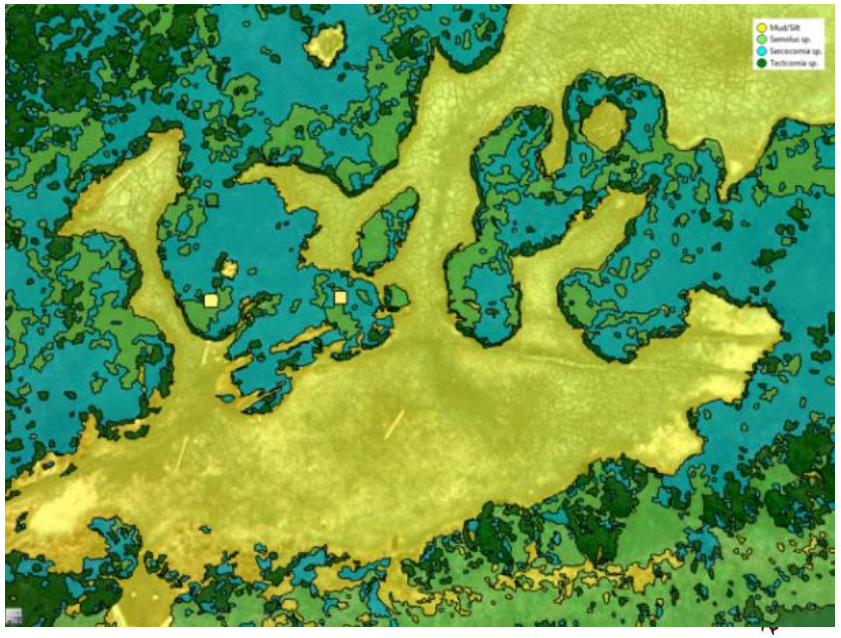
Geographic object-based image analysis





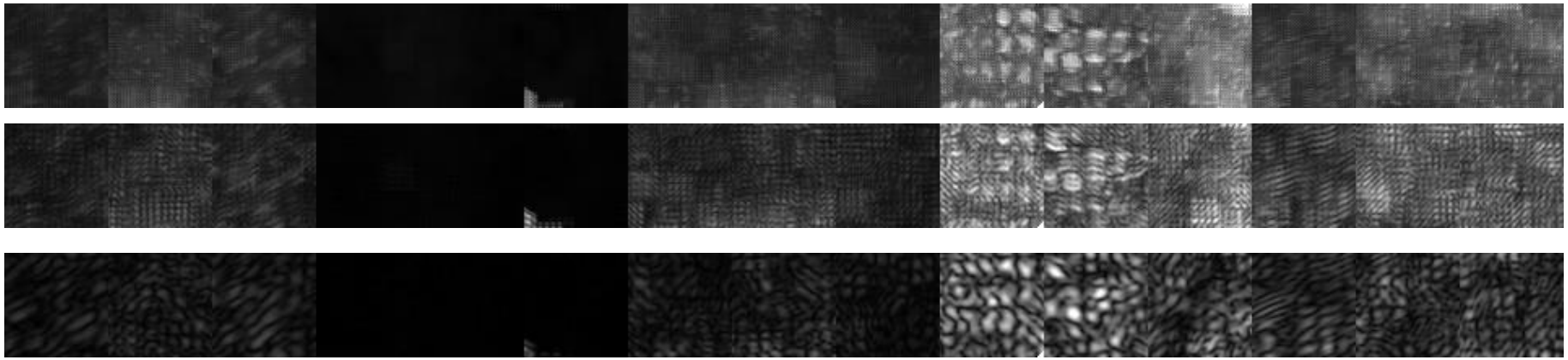


Sarcocornia sp. Mud/Silt/Sand Samolus sp. Gahnia sp. Tecticornia sp.

Grey Level Cooccurence Matrix (Variance)

Local Binary Patterns

Wavelet Decomposition



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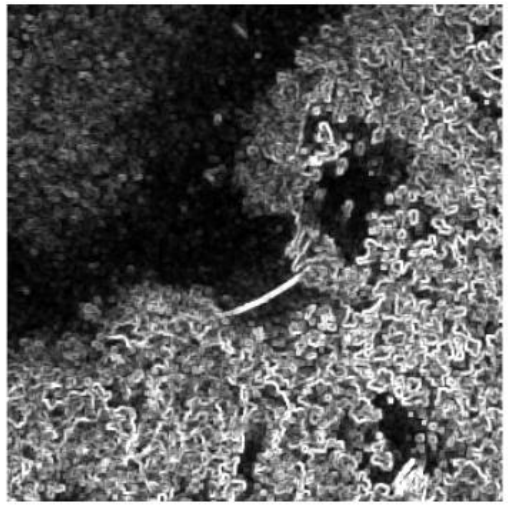
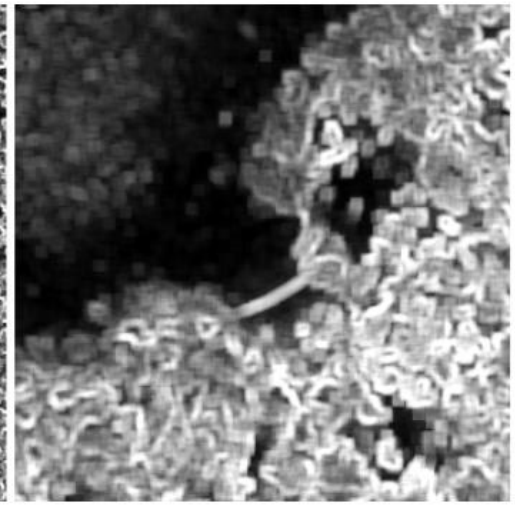
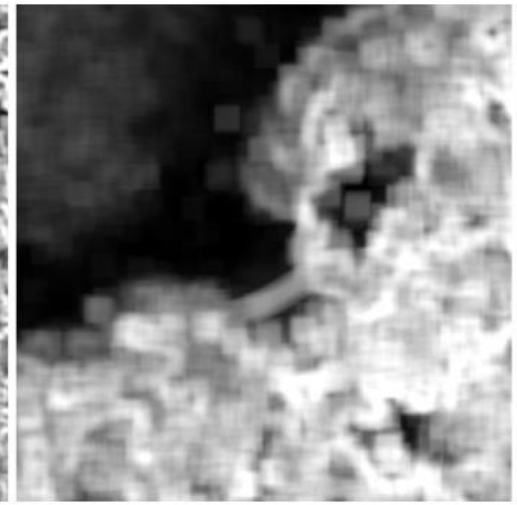
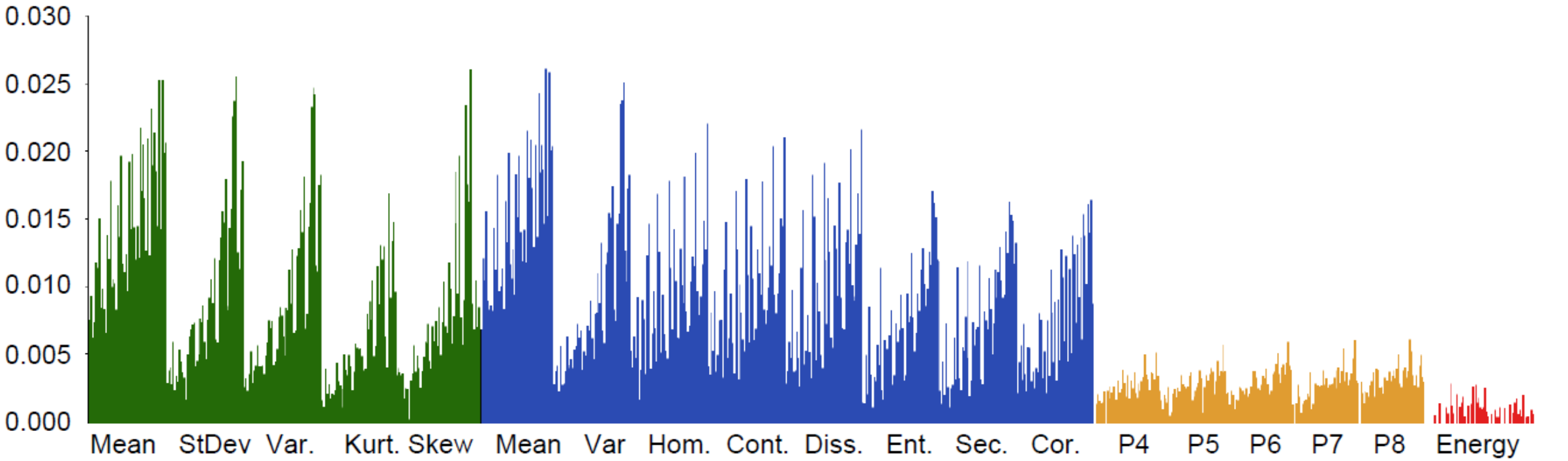
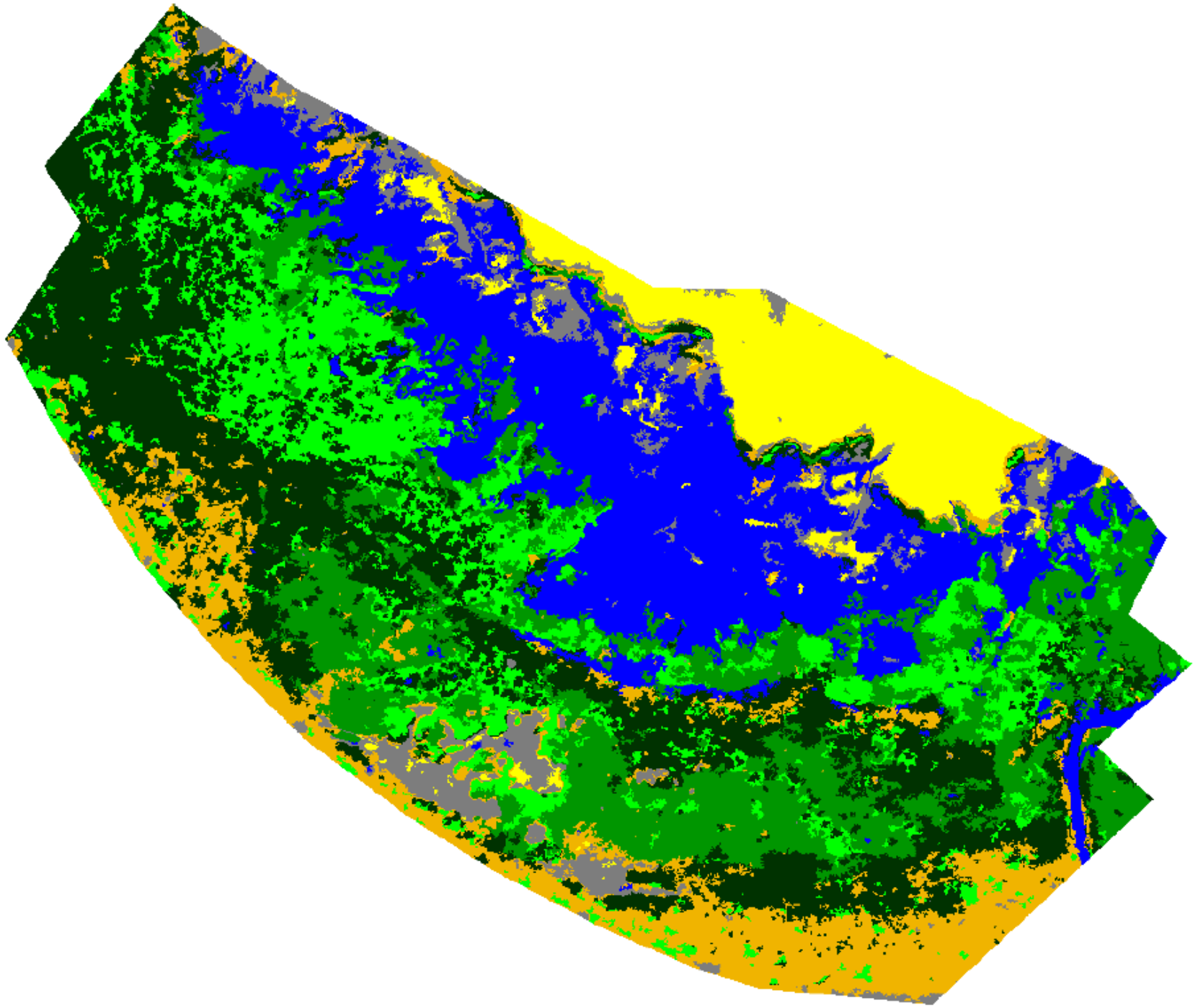






Standard Dev. K3 Standard Dev. K9 Standard Dev. K15 Standard Dev. K25





Samolus sp.
Sarcocornia sp.
Tecticornia sp.
Gahnia sp.
Sand
Mudflat
Saltpan

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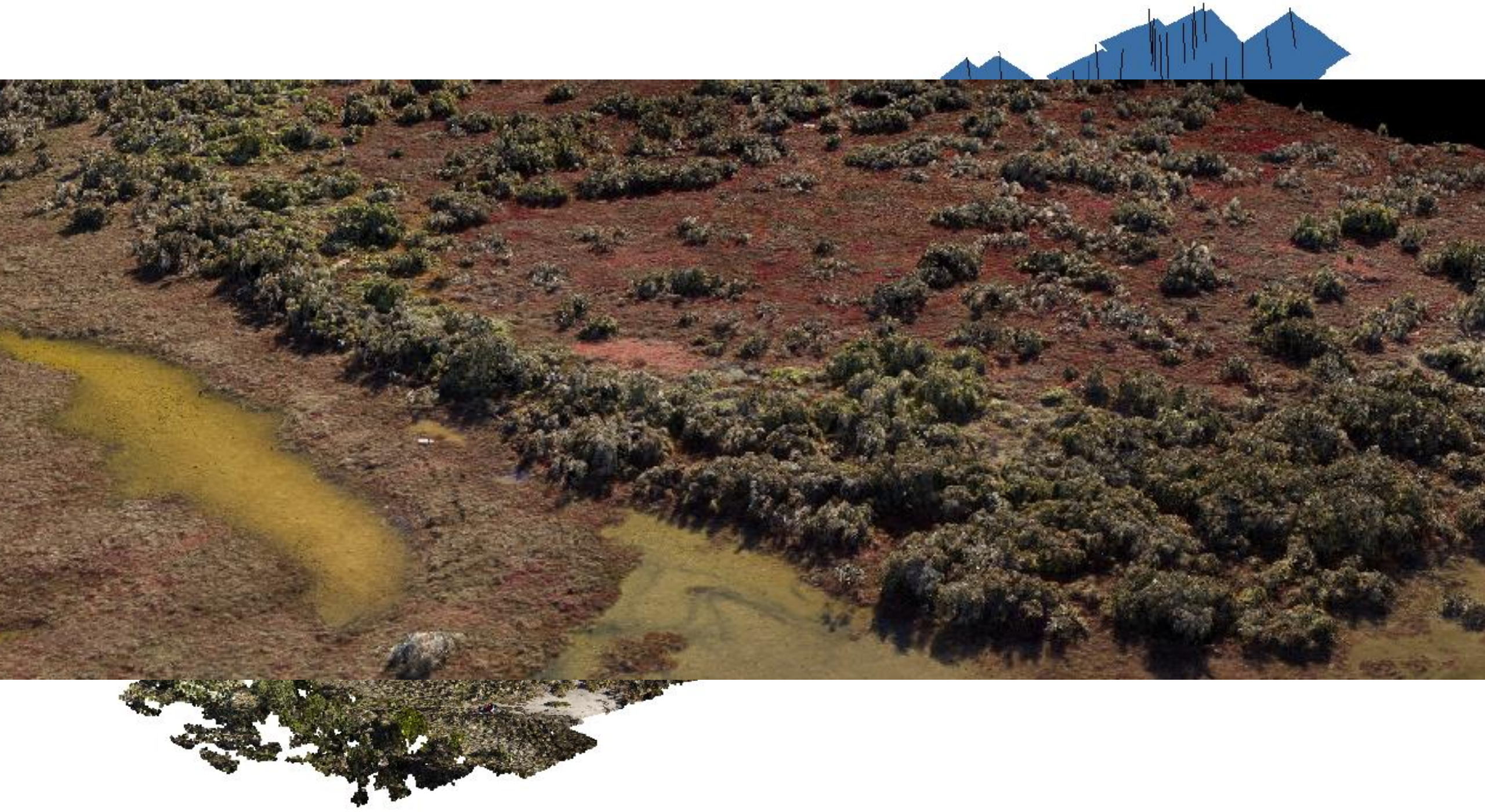
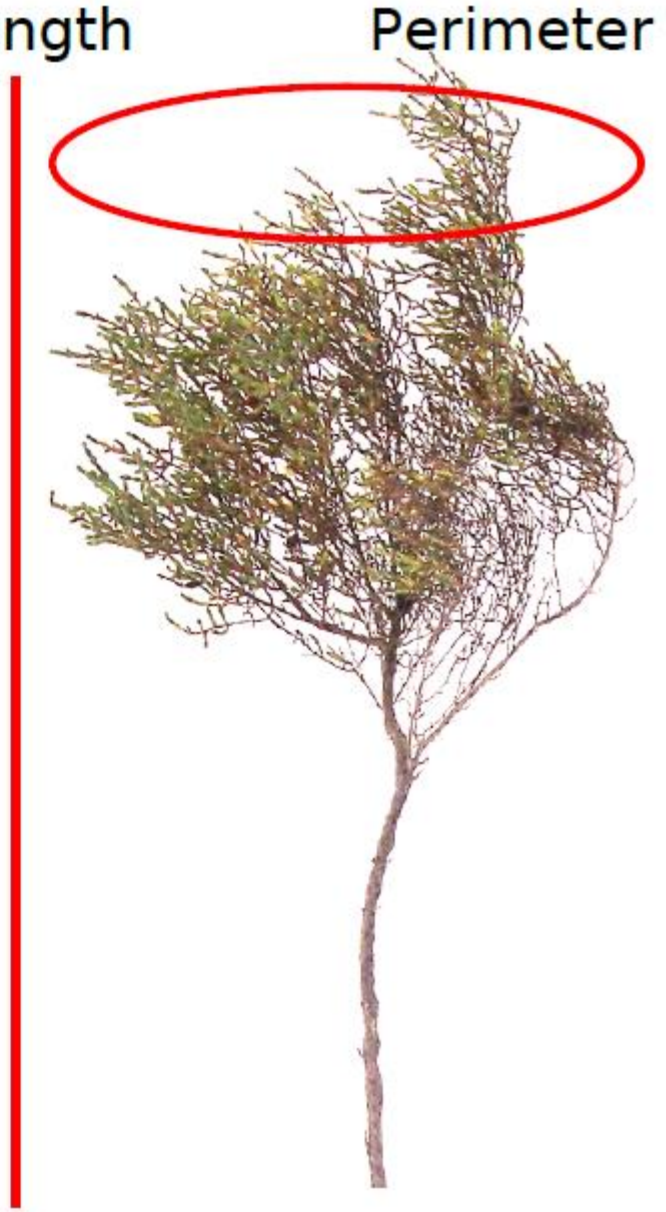
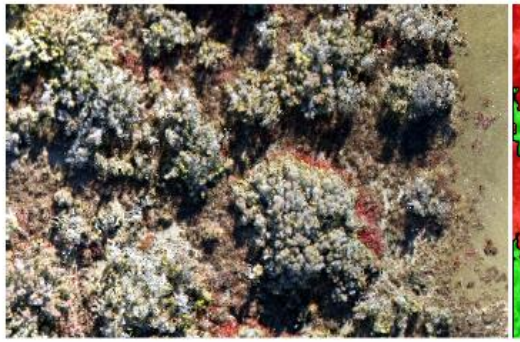
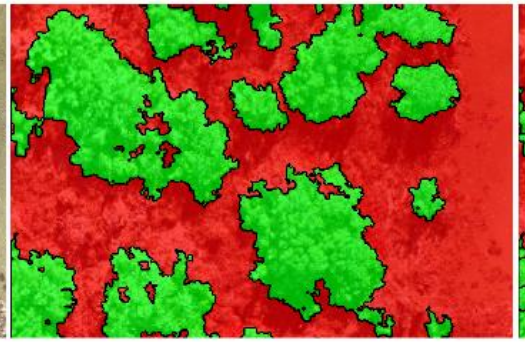


Tecticornia sp. Above Ground Biomass (AGB)

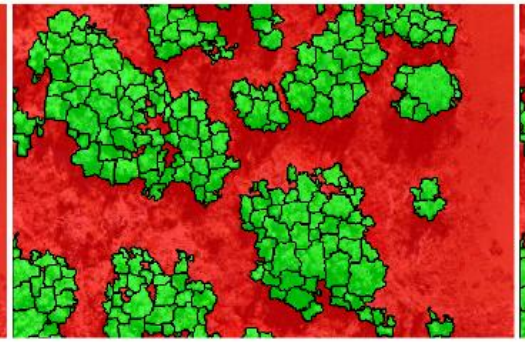


Identification of shrub stems

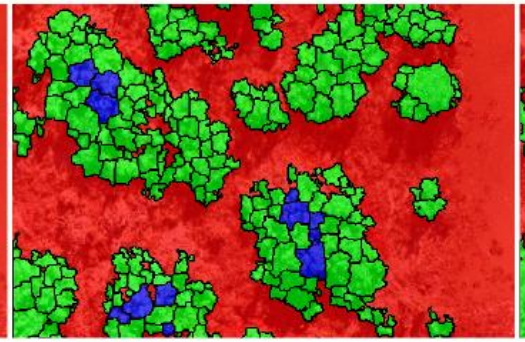




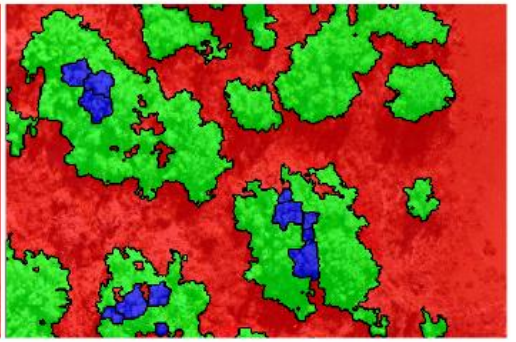
Tecticornia sp.
Classification Mask



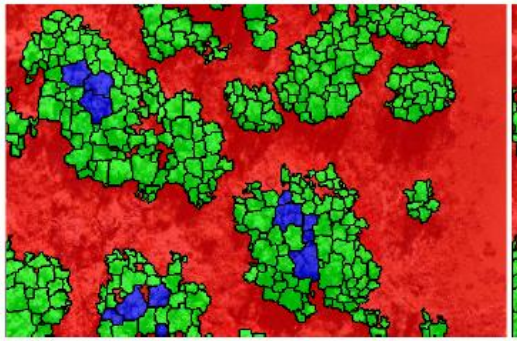
Segmentation



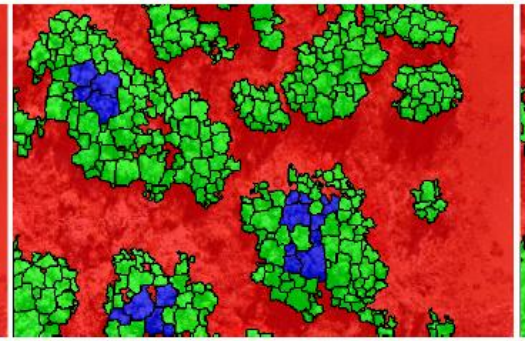
Identify Candidate Stem



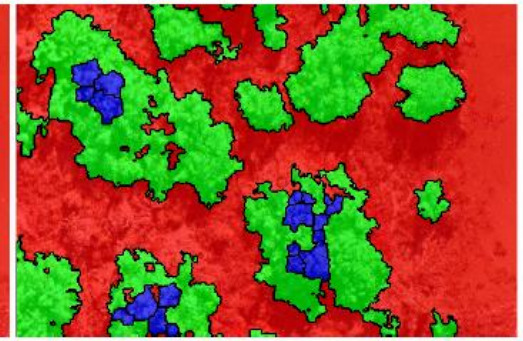
Extract Candidate Stem
Reset Segmentation



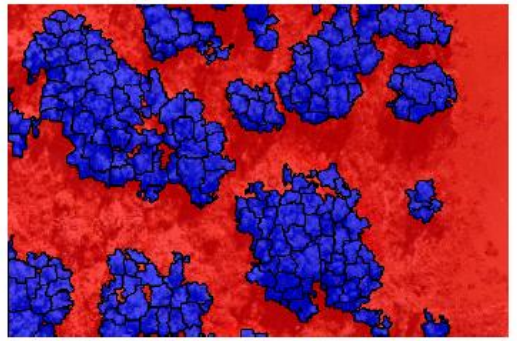
Reduced Segmentation Scale



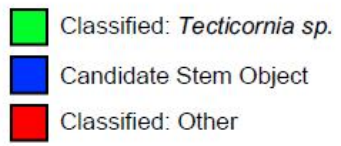
Identify Candidate Stem

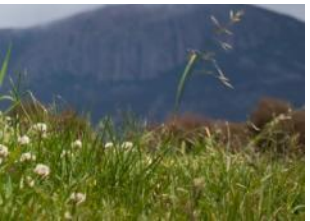


Extract Candidate Stem
Reset Segmentation



Tecticornia sp. fully deconstructed
into Candidate Stems





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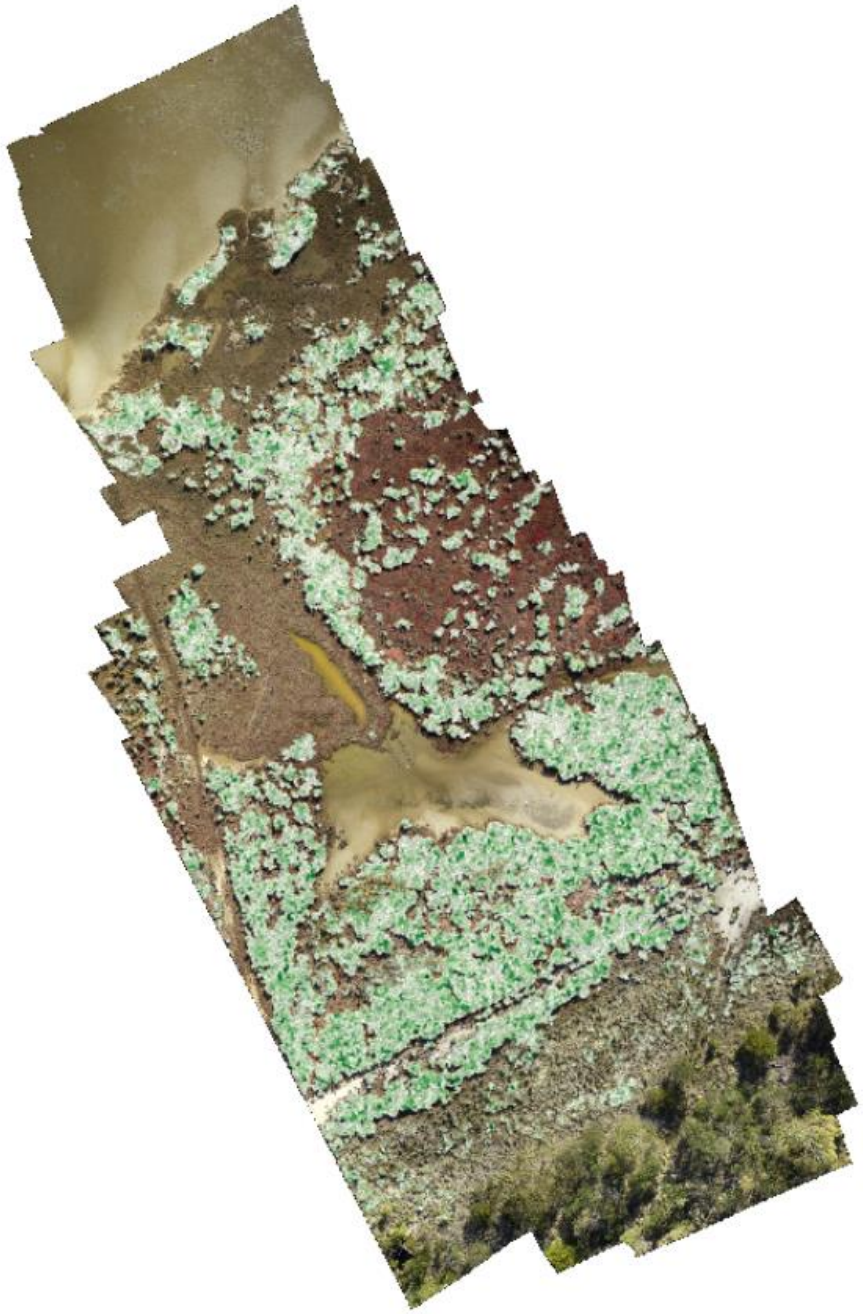
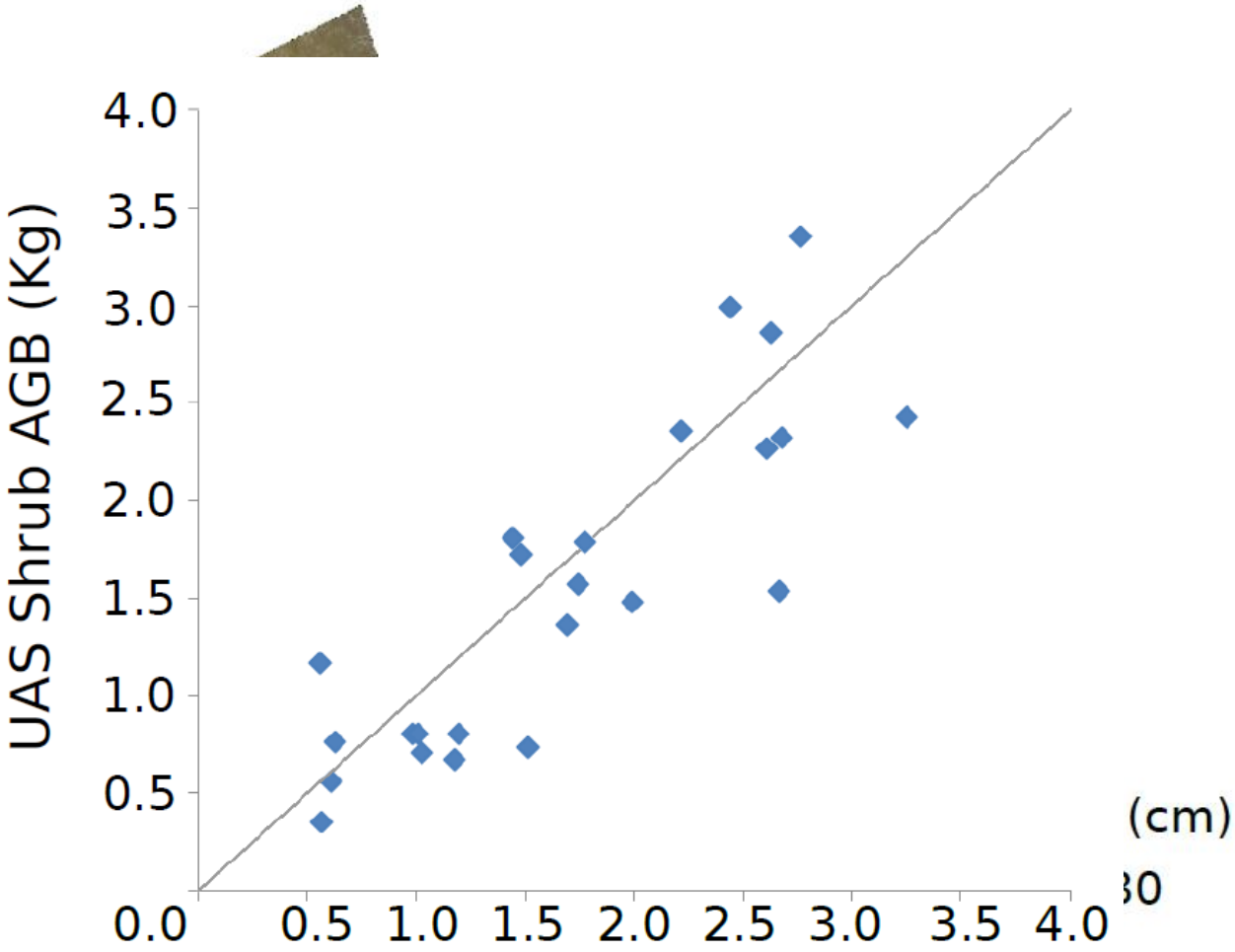


AGB (grams)

900

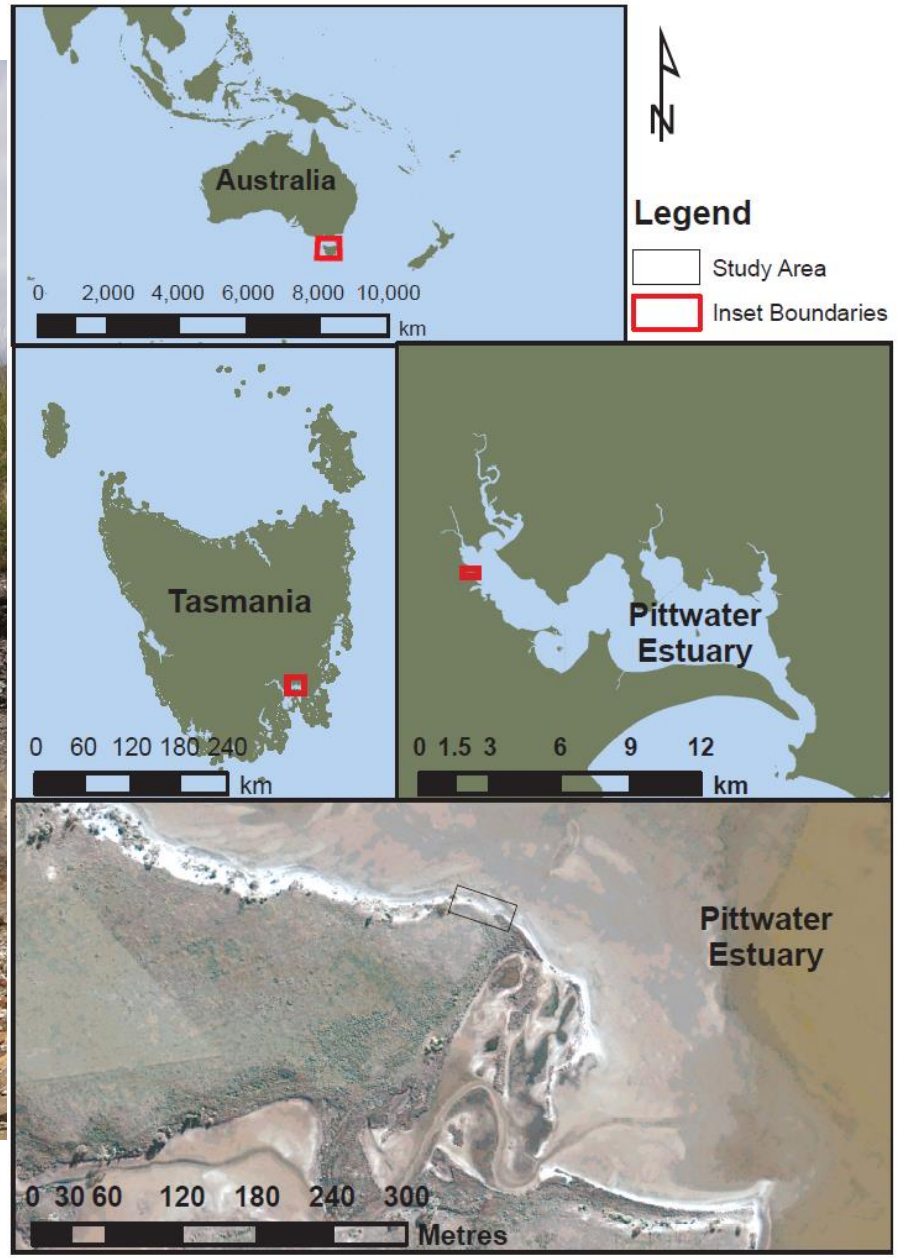
40



Field Shrub AGB (Kg)

0

Coastal erosion – Dr Steve Harwin



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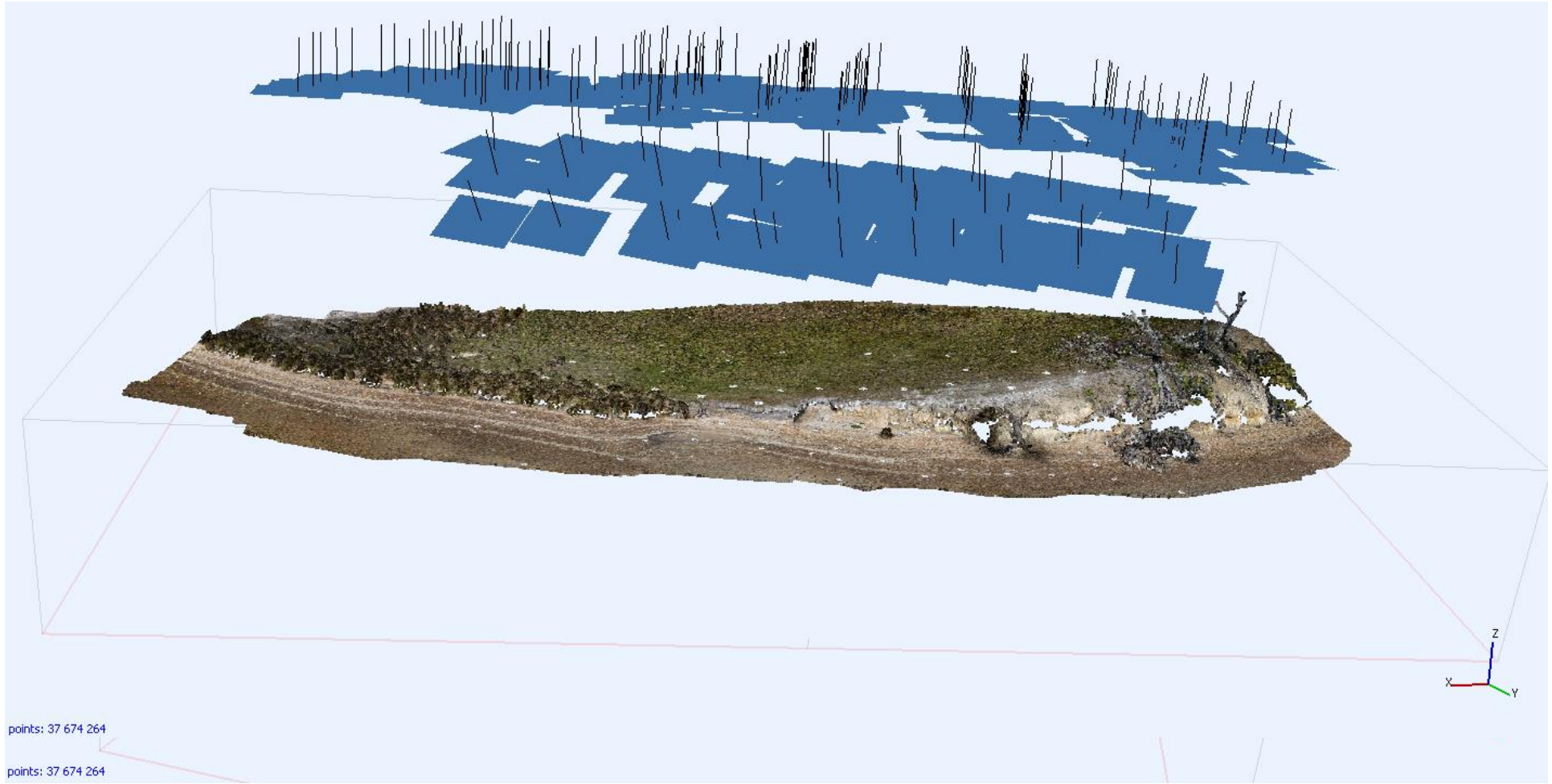
The Camera Network and Point Cloud



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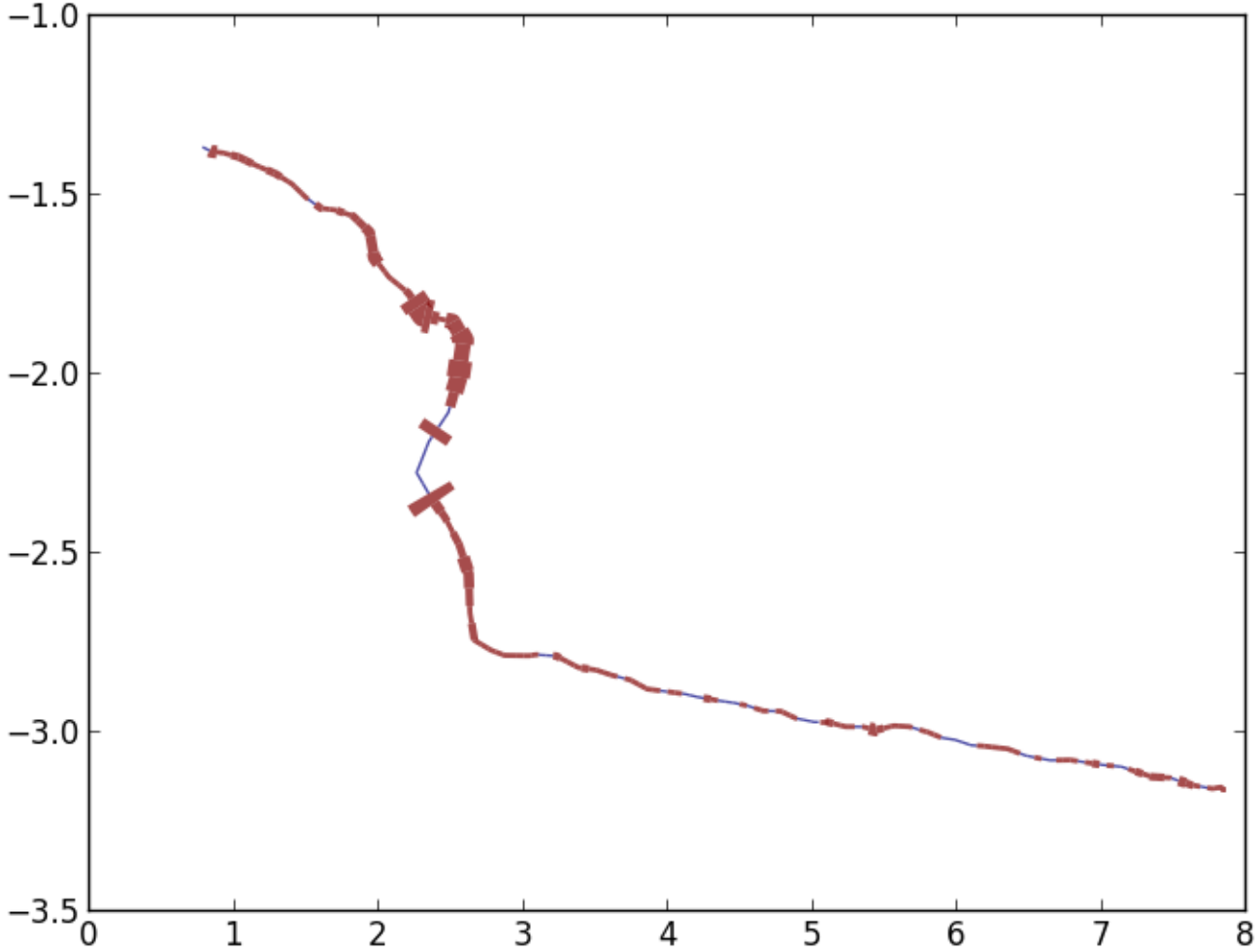
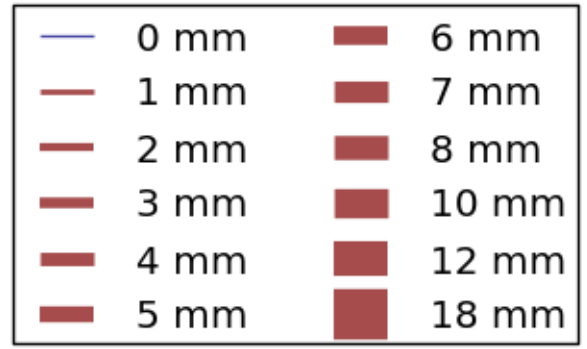
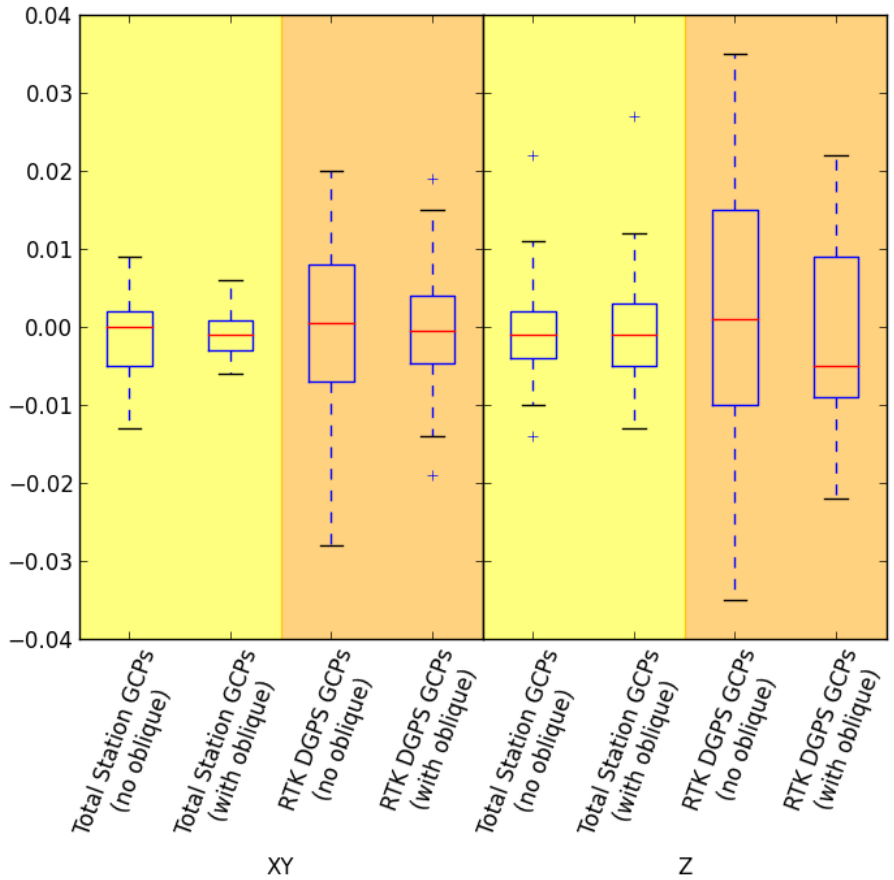
RMSE – Survey vs UAV-MVS







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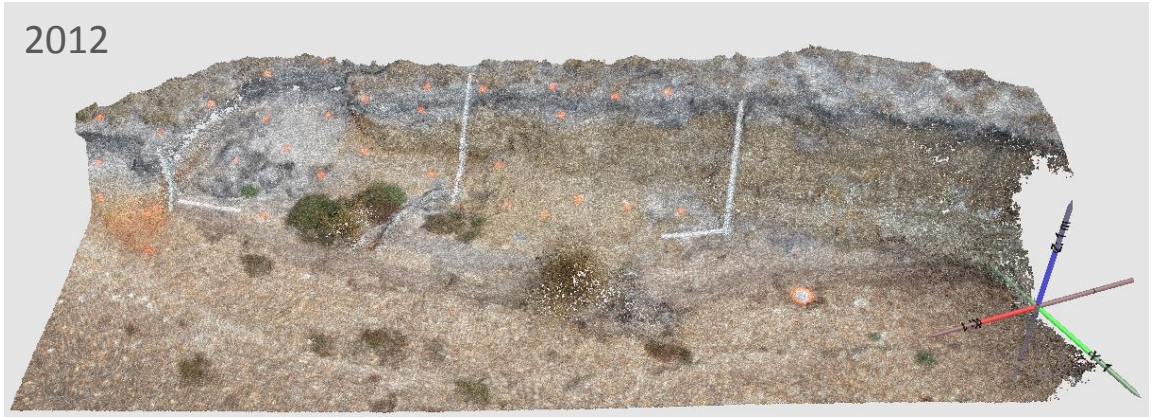
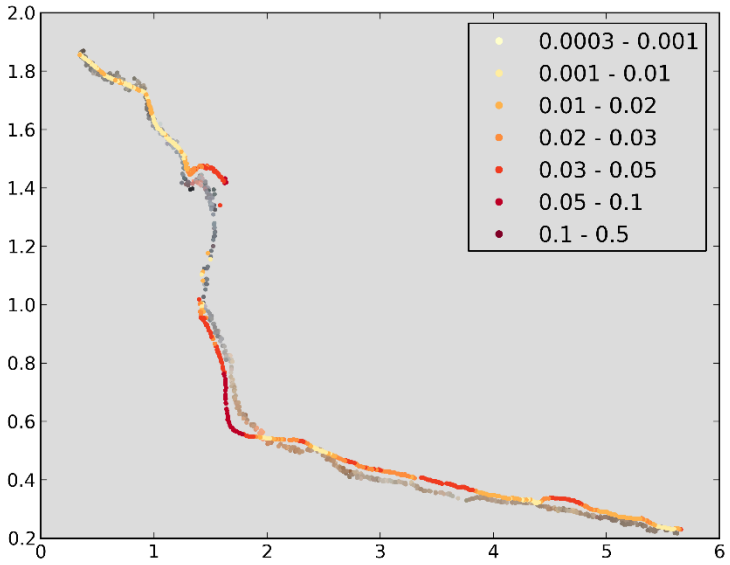
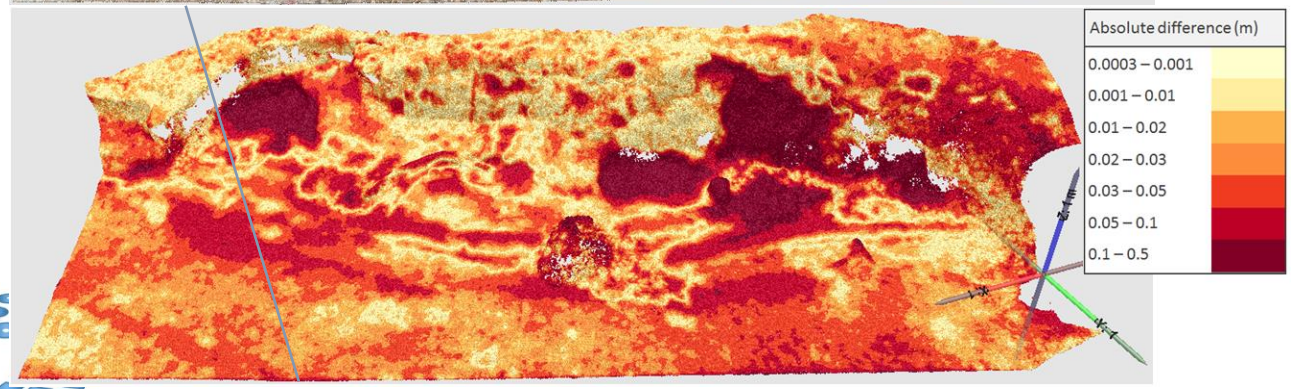
2012 versus 2013







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Warra Supersite

AusCover
Satellite remote sensing products and validation

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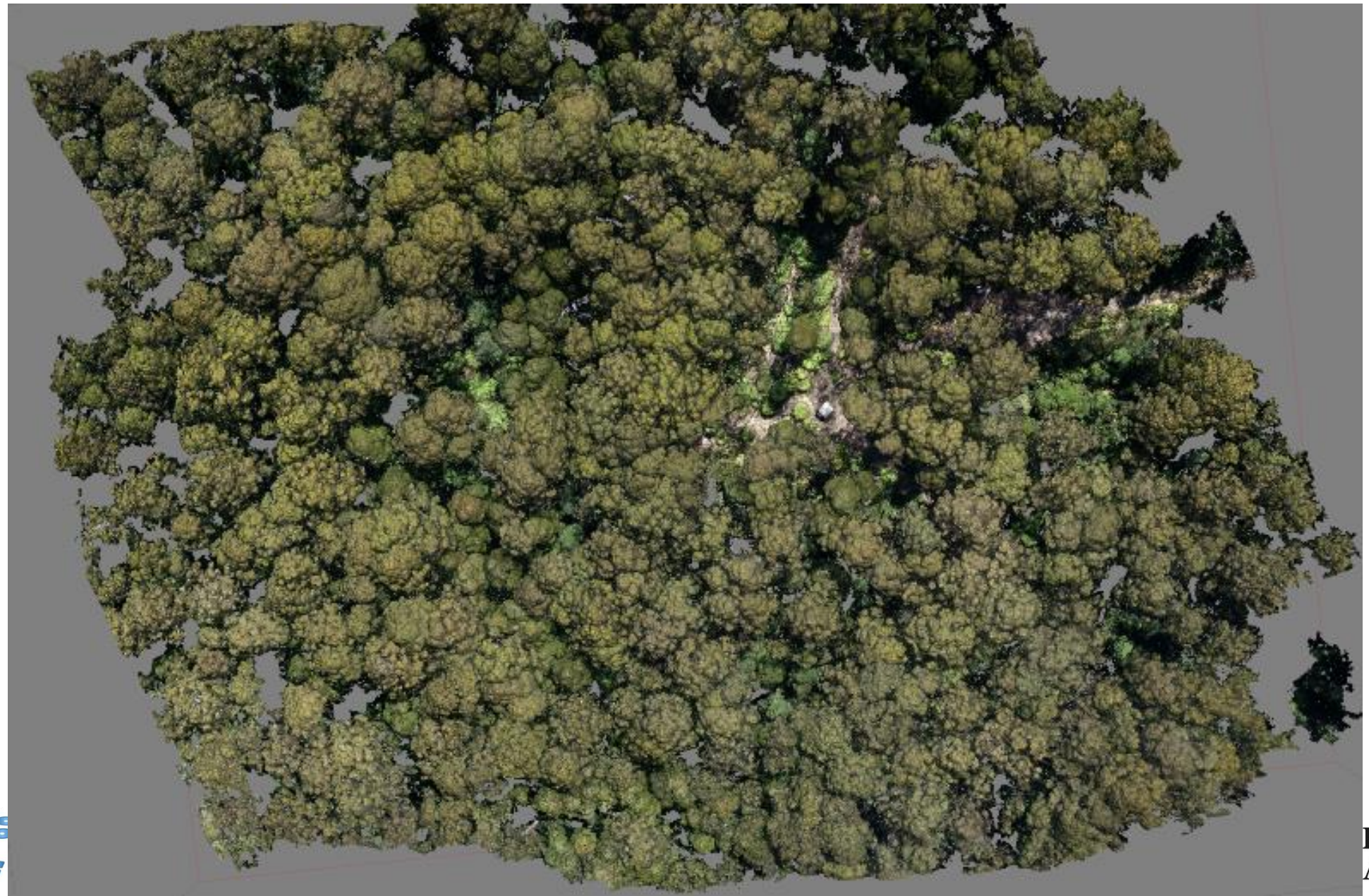
3D point cloud



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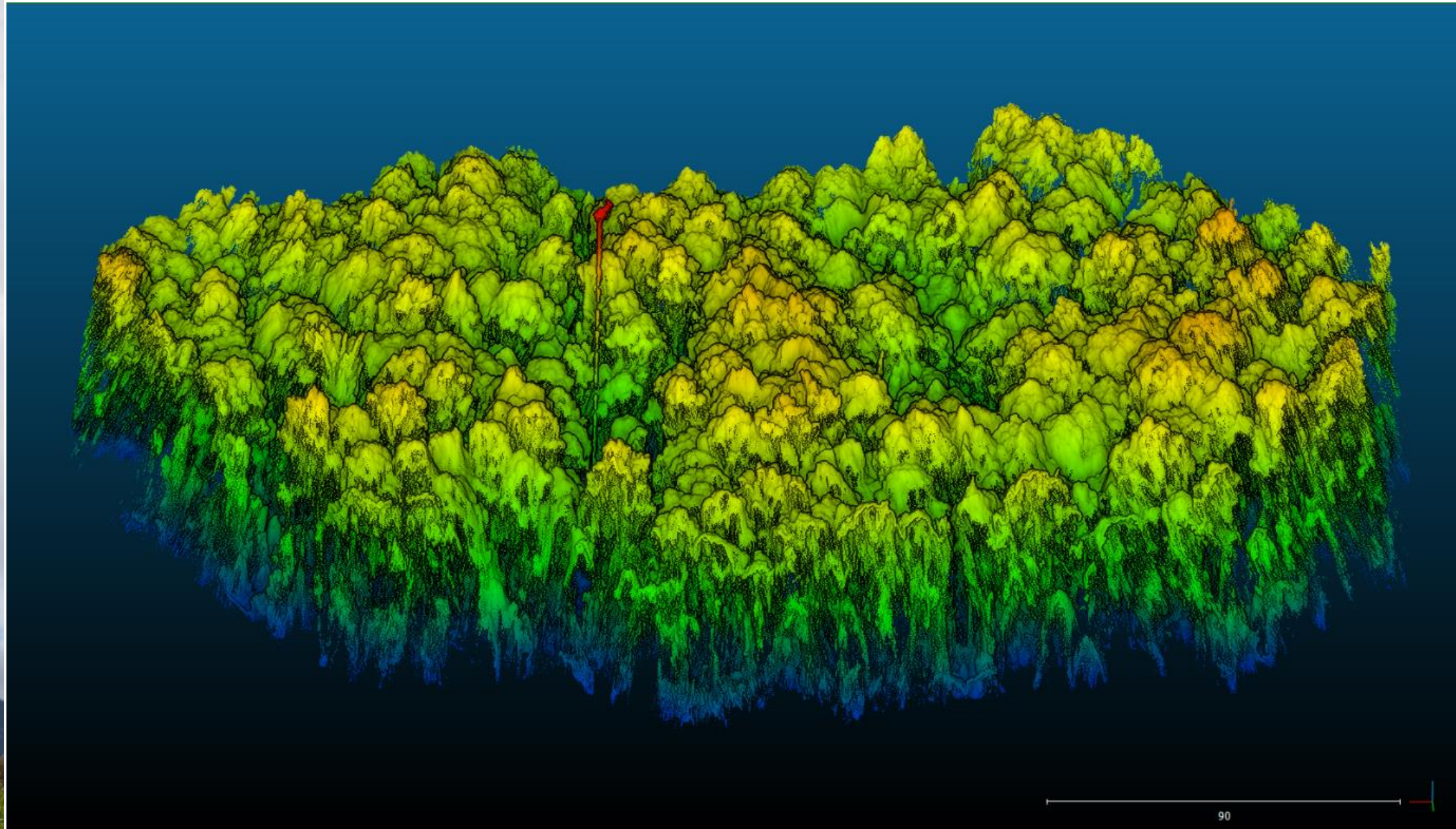
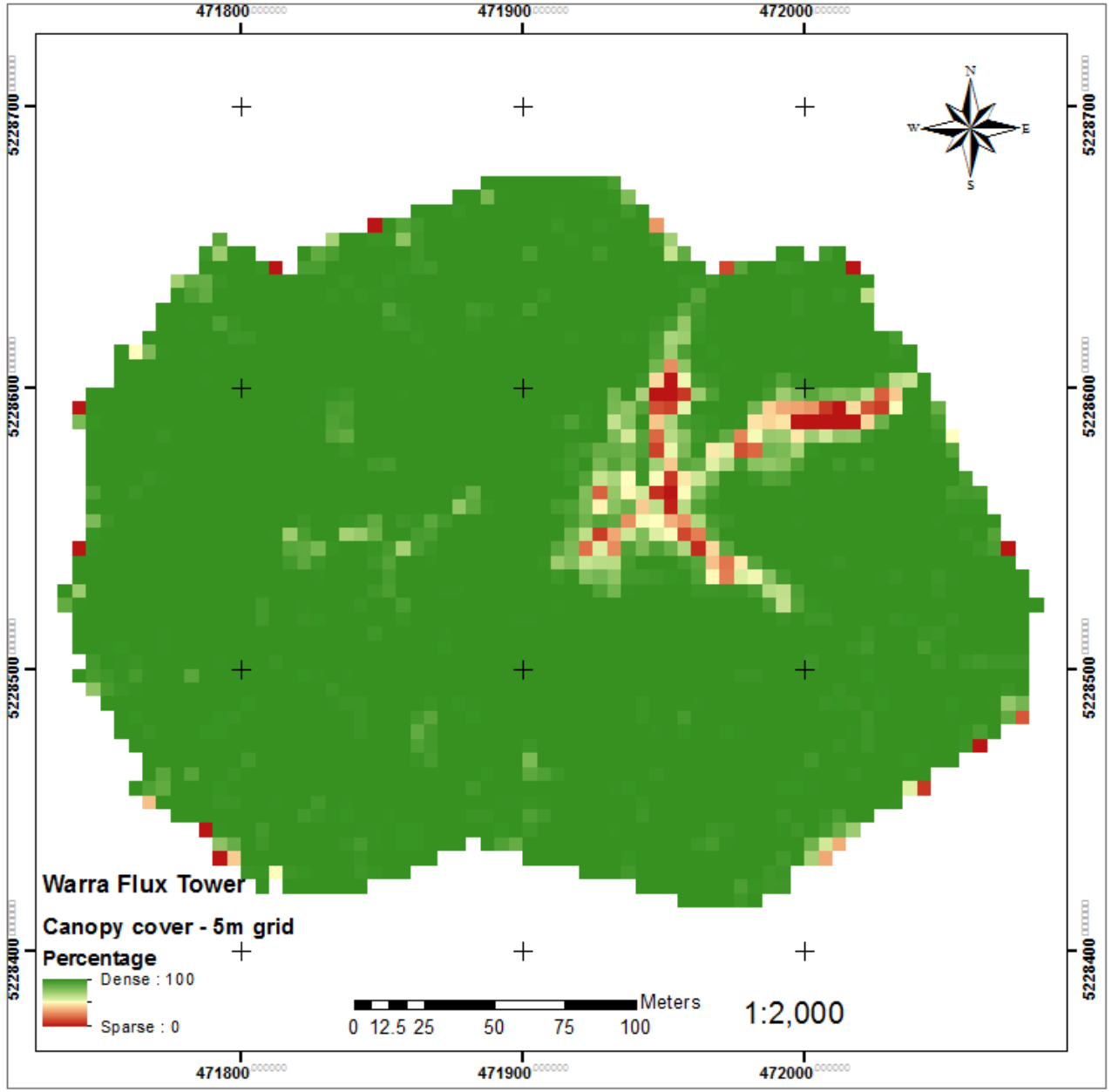
Canopy height



Canopy cover



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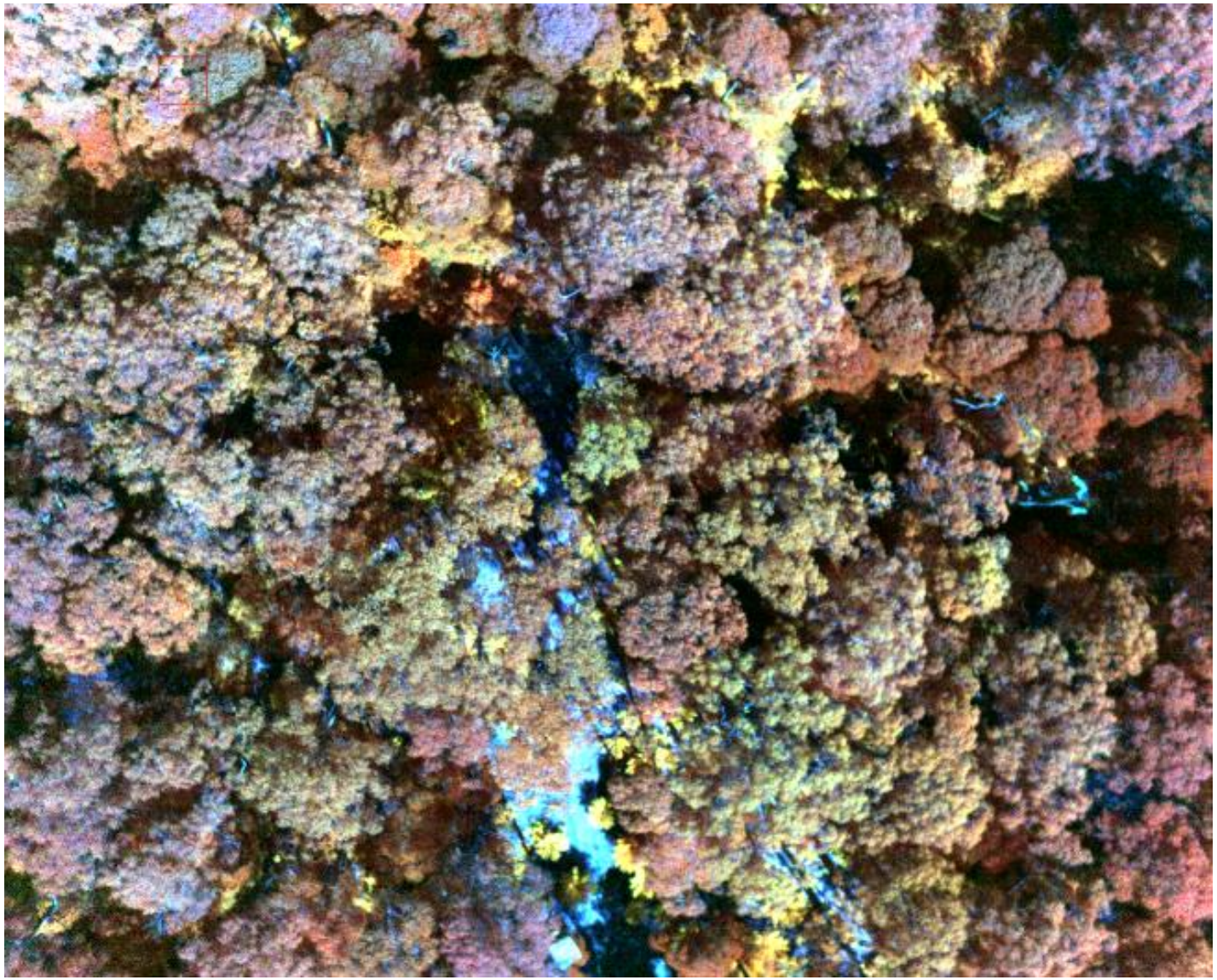
Multispectral UAV image of Warra Supersite



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Conclusions

- UAS are an effective tool to capture **ultra-high resolution data filling an observational scale niche**
- UAS are a **cost-effective and flexible** tool for collecting high-resolution spatial datasets on-demand
- Multiple sensors can improve mapping and monitoring of **biophysical** and **biochemical** characteristics at sub-decimetre resolution
- Still many problems to solve: **prototype to operations**
- The future of UAS remote sensing is exciting!

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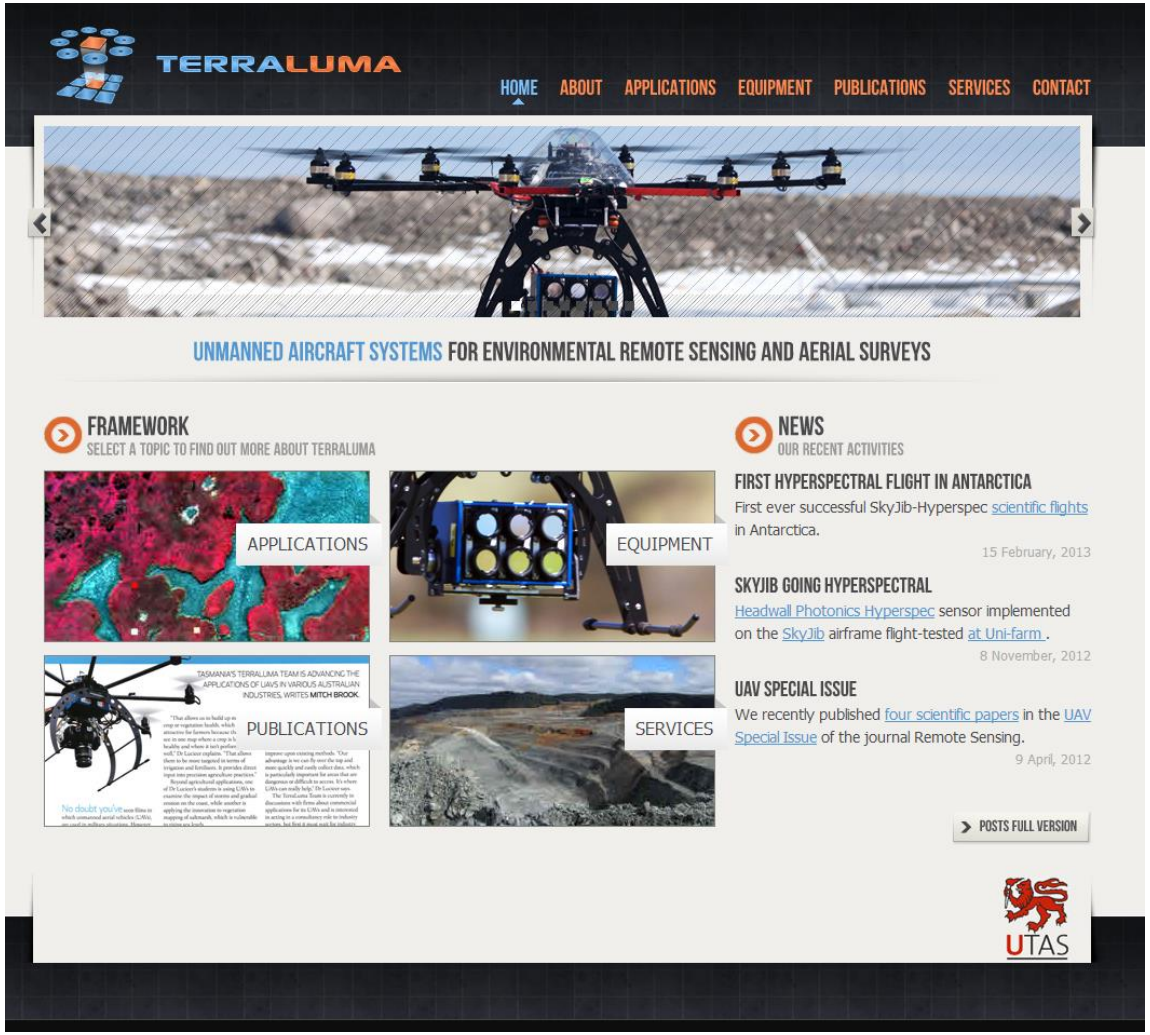

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