

Recent advances in the developments of Unmanned Aircraft Systems (UAS) for environmental mapping and monitoring



Dr Arko Lucieer, Dr Zbyněk Malenovský, Darren Turner, Tony Veness, Steve Harwin, Josh Kelcey, Luke Wallace, Chris Watson, and Jon Osborn

School of Geography & Environmental Studies

University of Tasmania, Australia

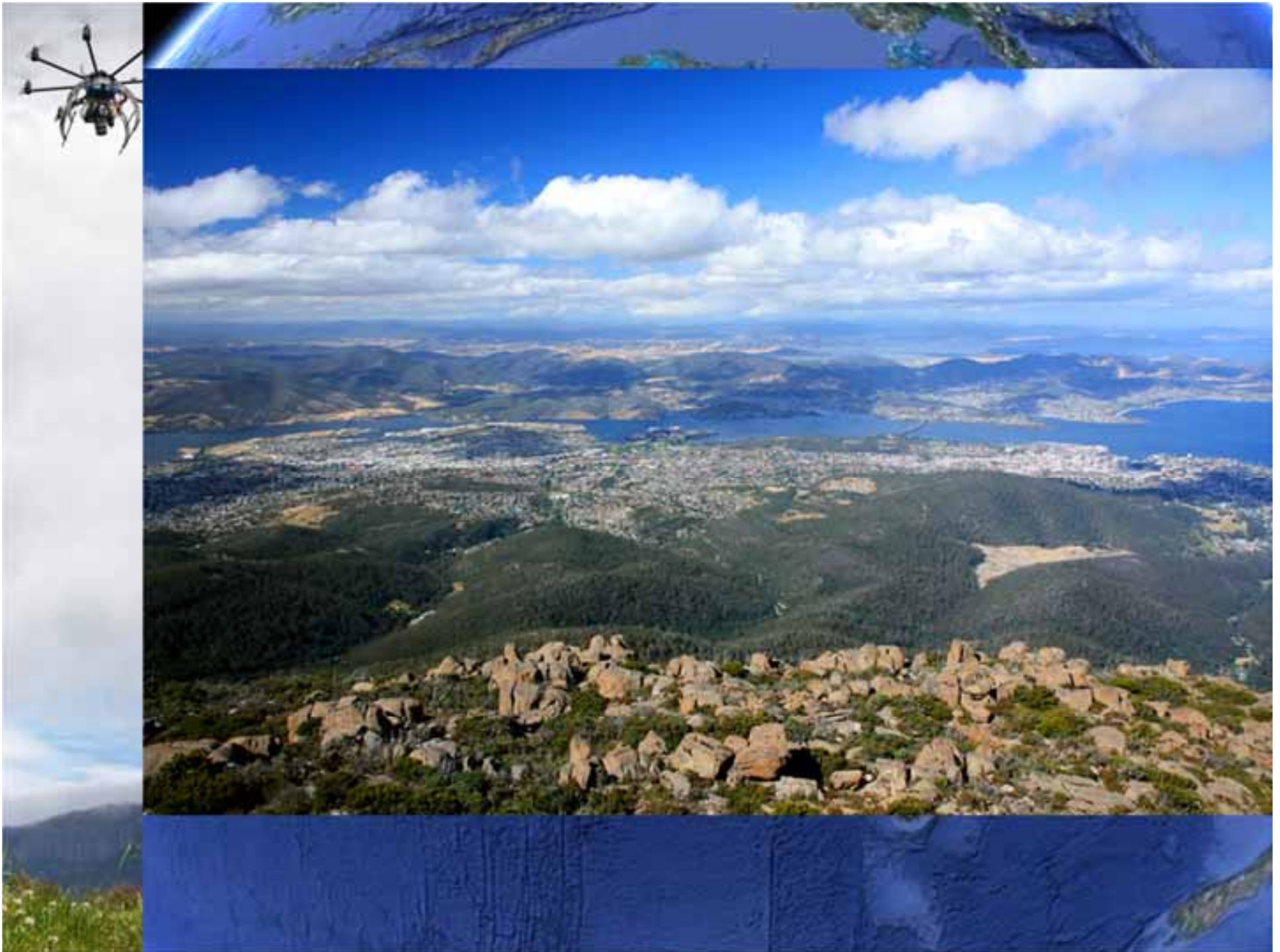


TERRALUMA





Hobart





Unmanned Aerial Vehicle (UAV) aka 'drone'



Scientific/civilian UAVs



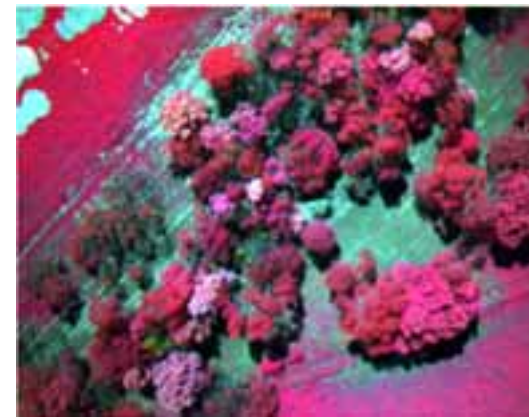
Sensors



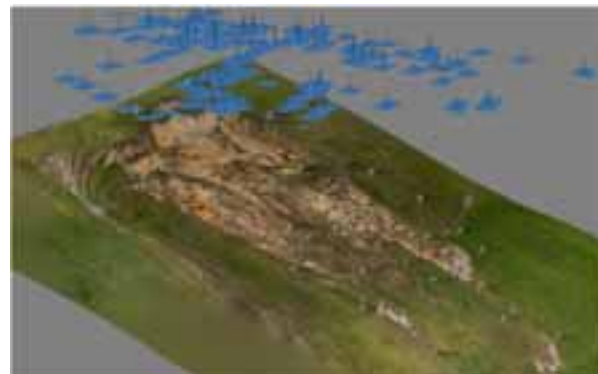
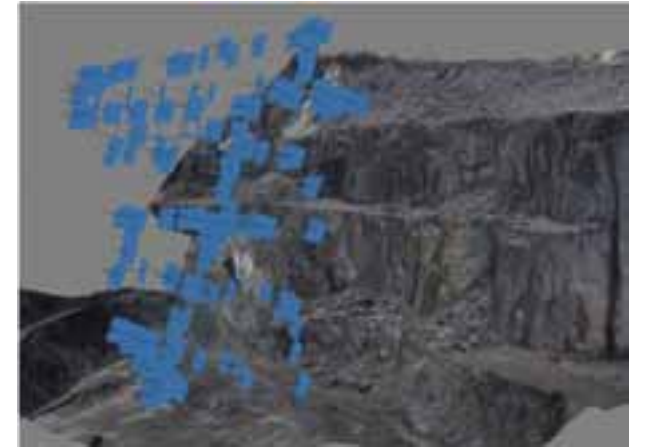
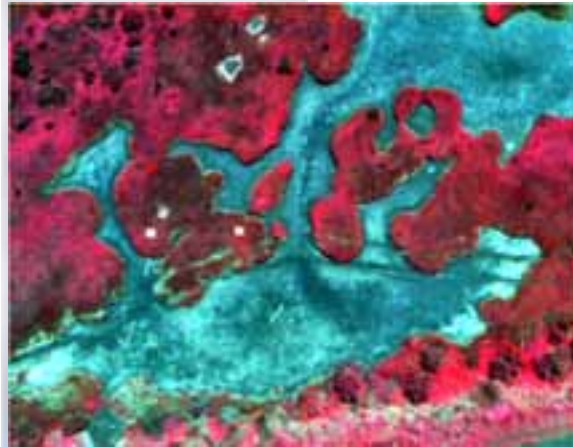
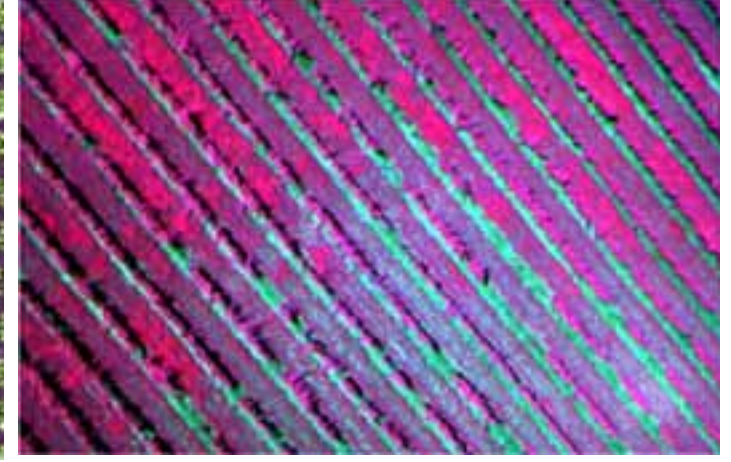
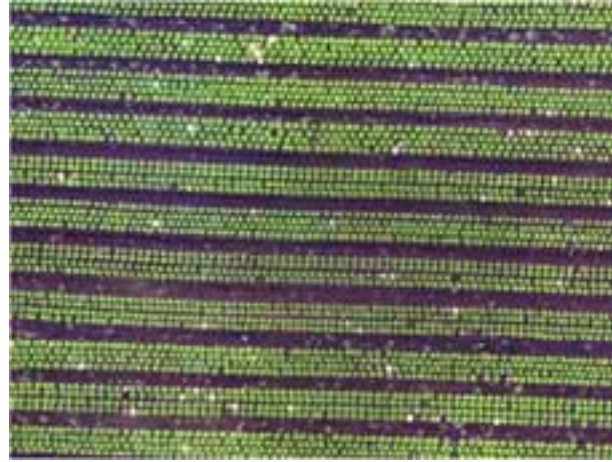
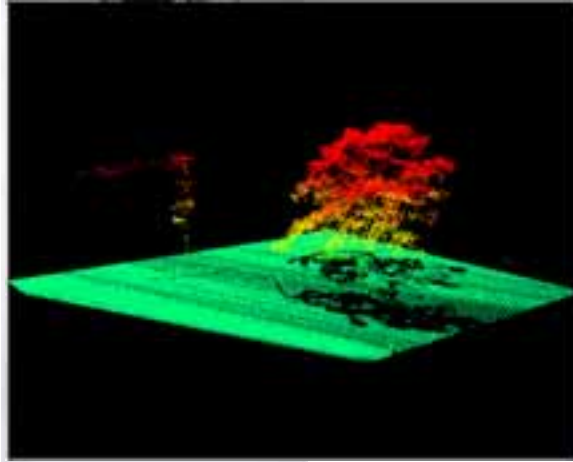


TERRALUMA

- 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)



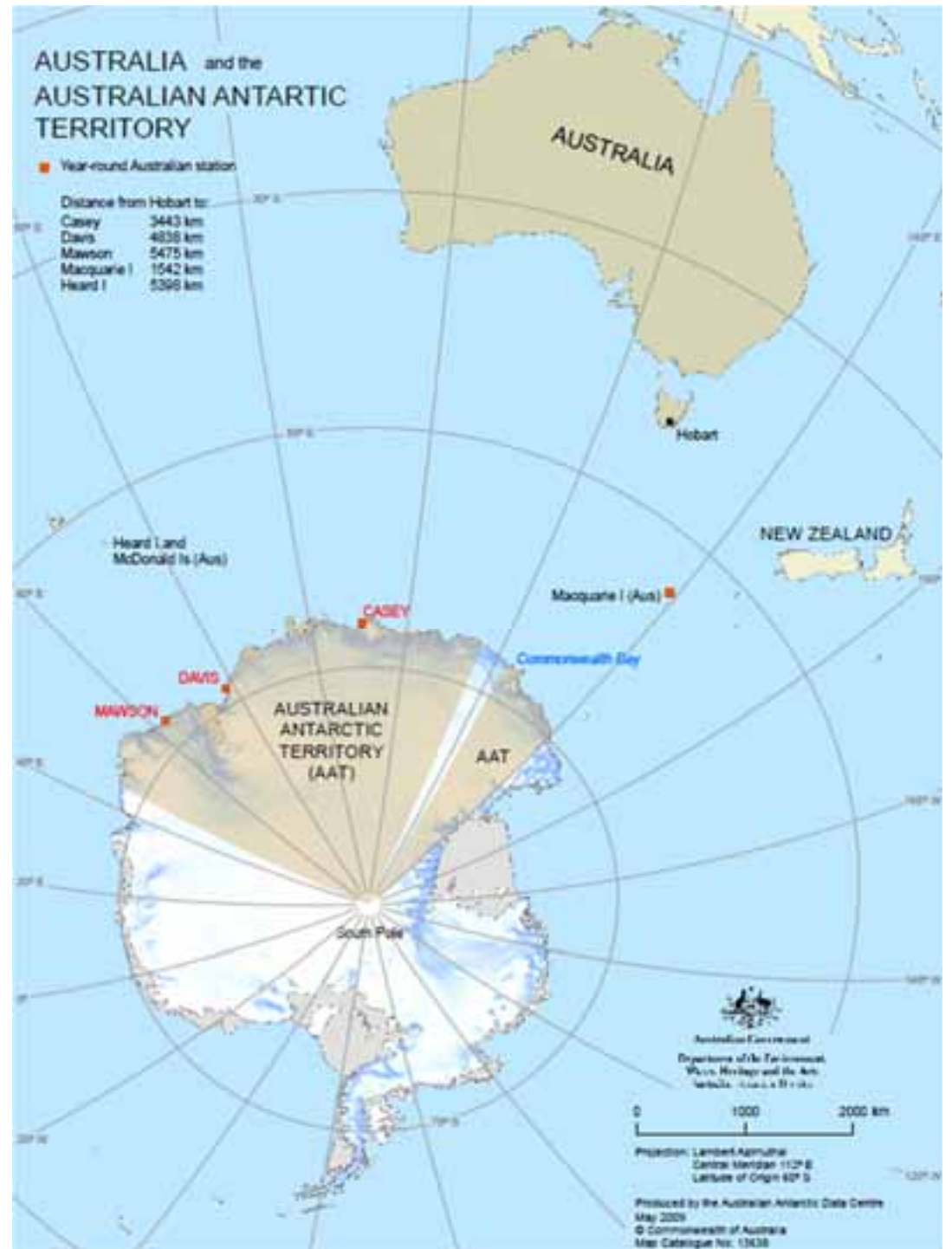
Applications

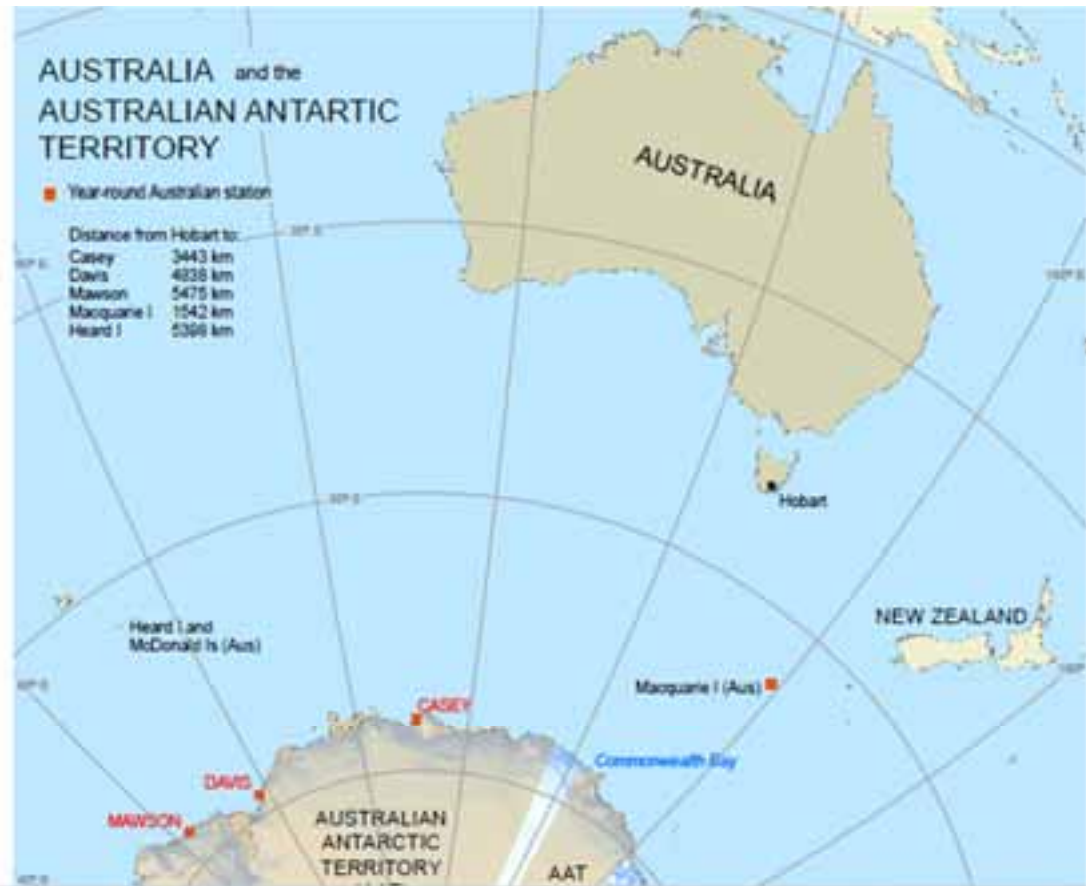




Mapping Antarctic moss beds with UAS

- To map the spatial extent and health of Antarctic moss beds from UAS photography, multispectral, thermal, and hyperspectral imagery
- Outline
 - Antarctic moss beds: what's the problem?
 - SfM terrain model + derivatives
 - Co-registration RGB ortho, DSM, multispectral, and thermal
 - Hyperspectral UAS prototype





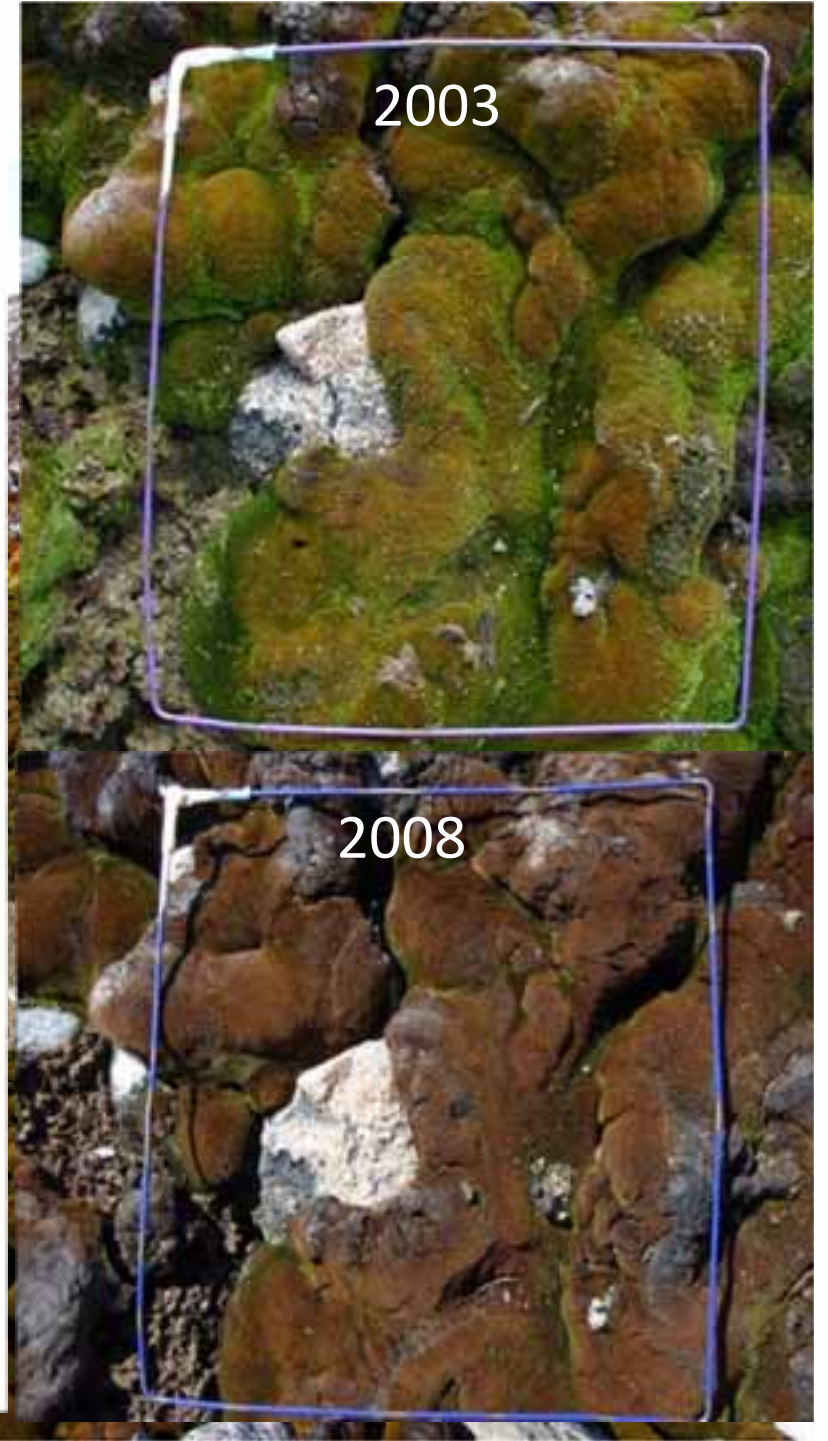






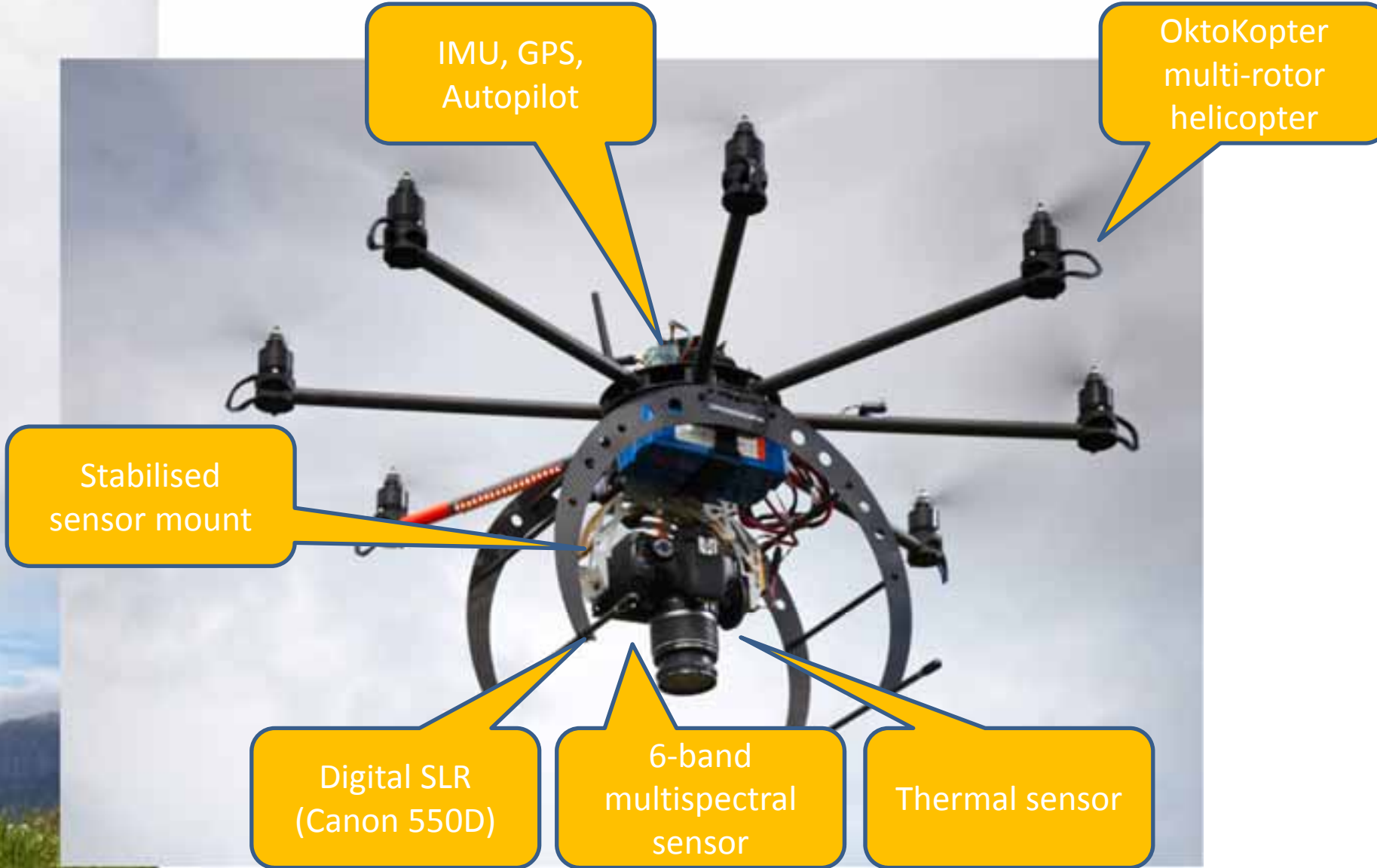
Water availability







OktoKopter



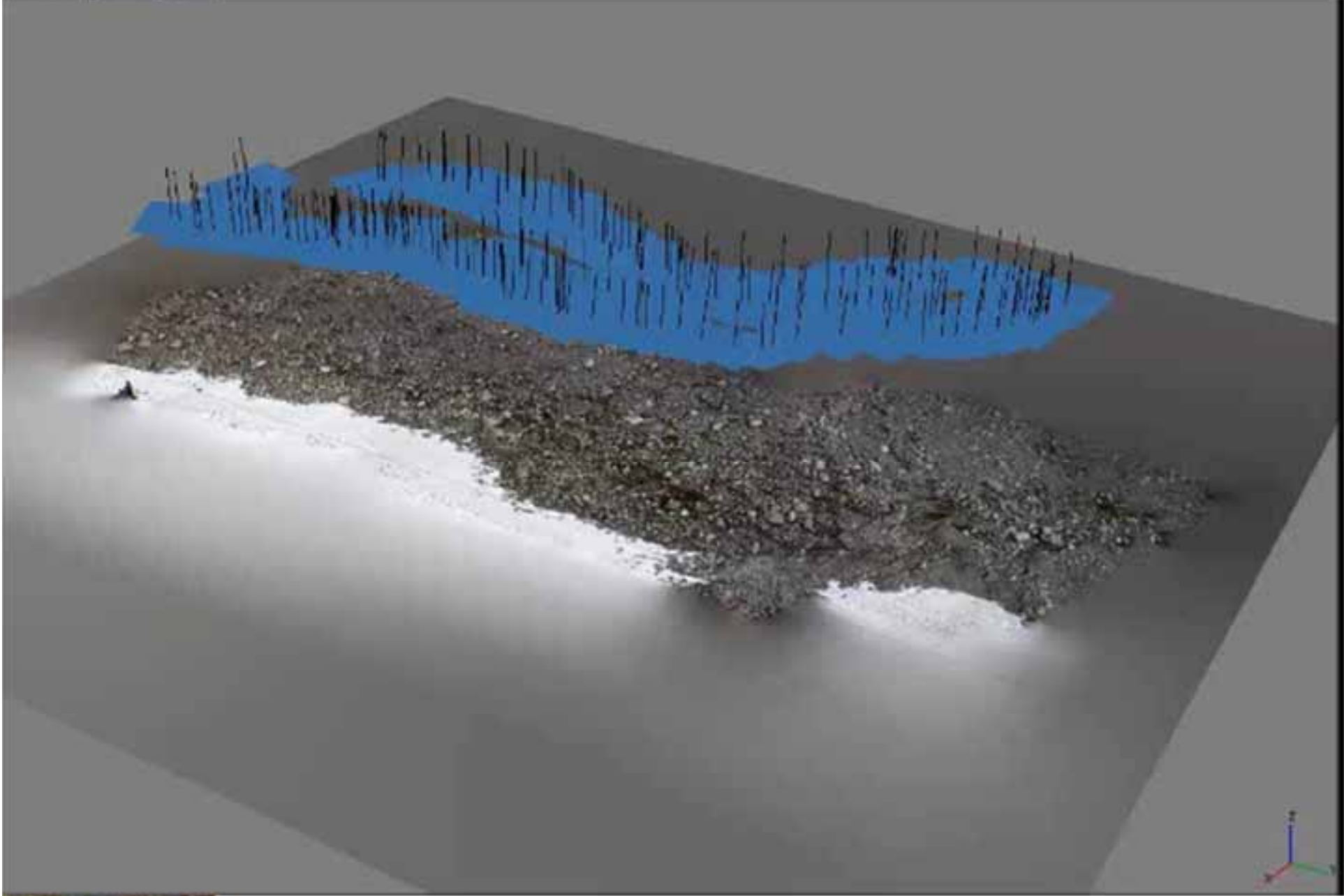




Structure from Motion (SfM)



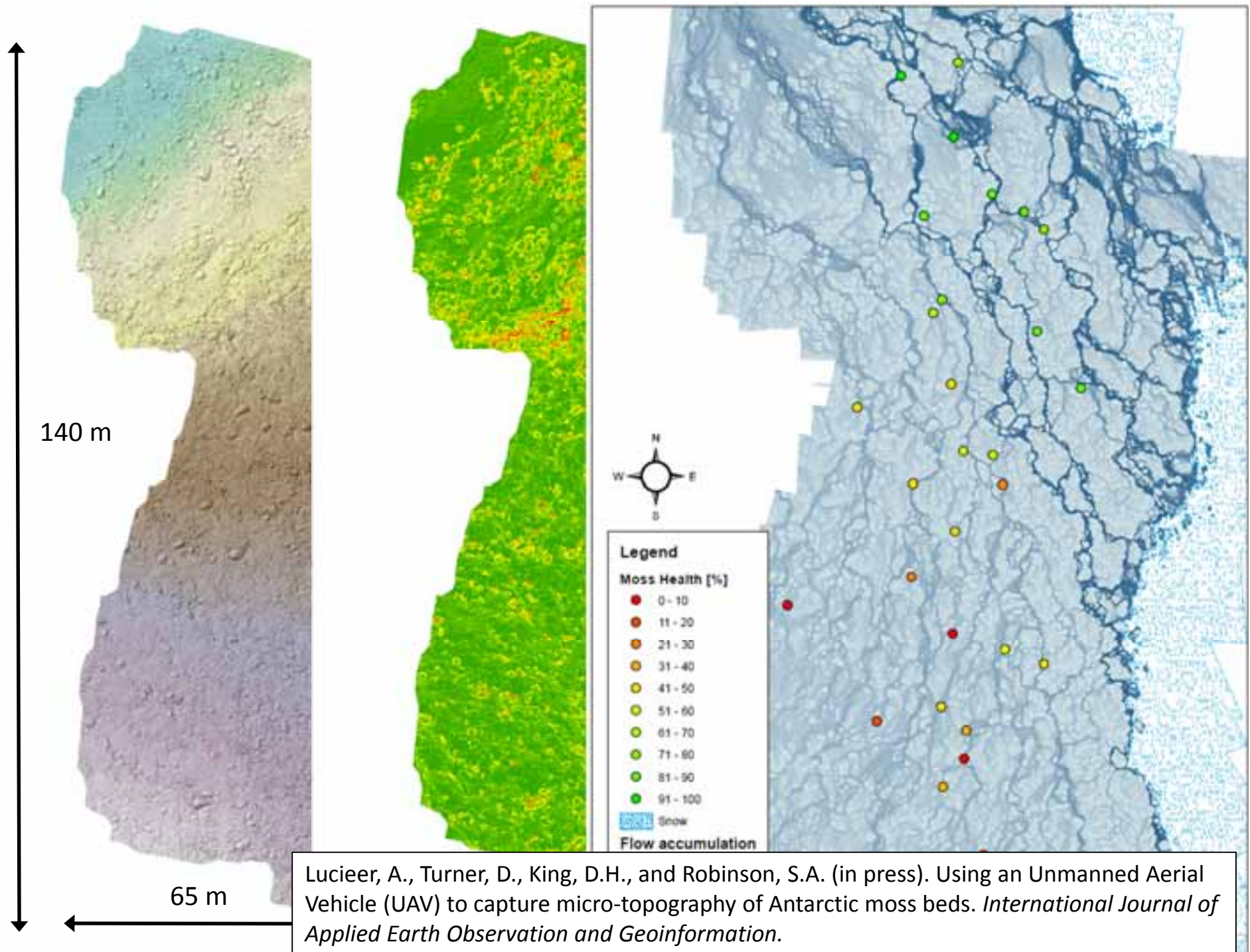
source: www.pix4d.com



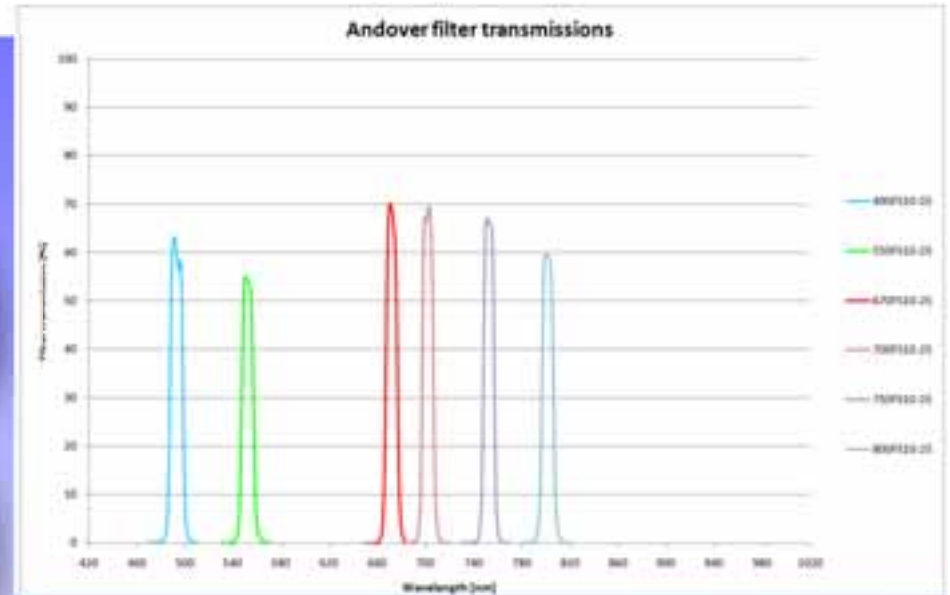


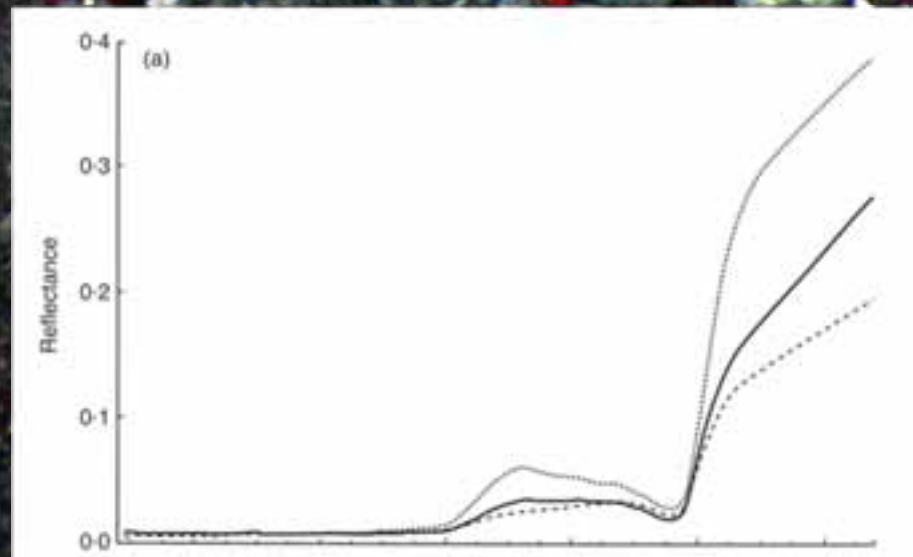
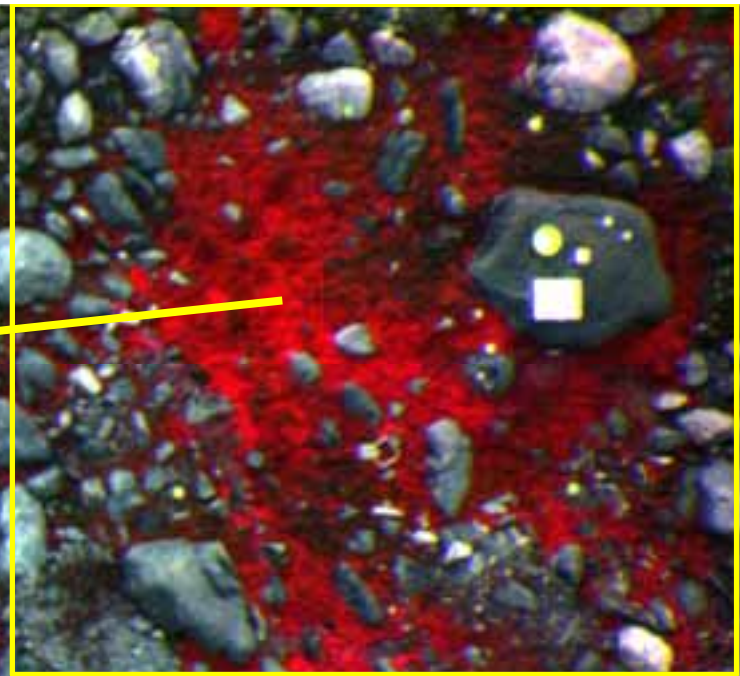
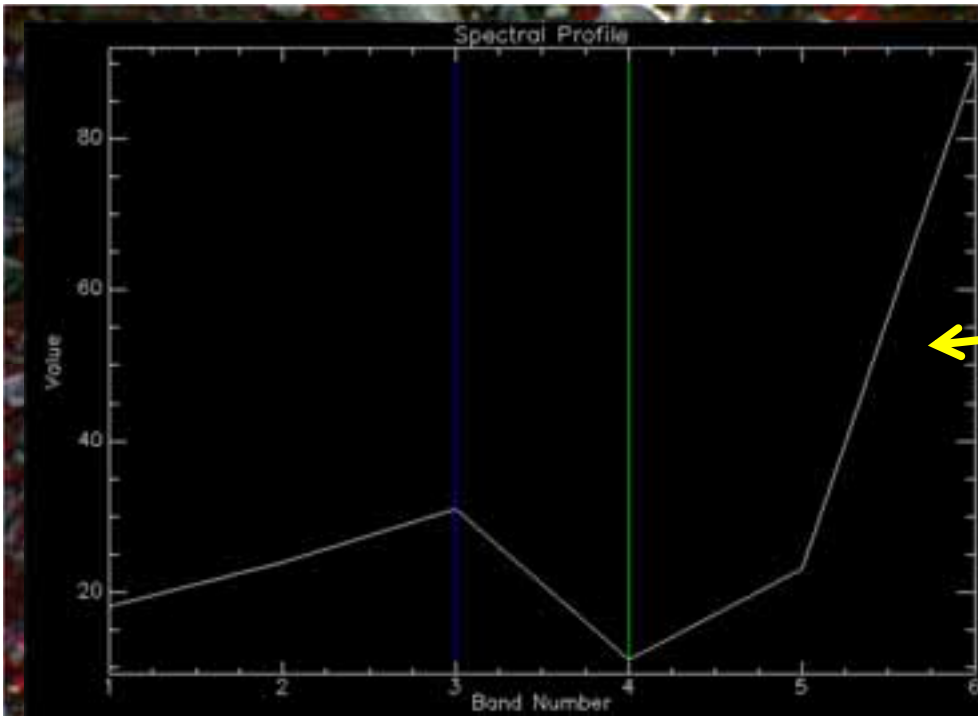
3D terrain models

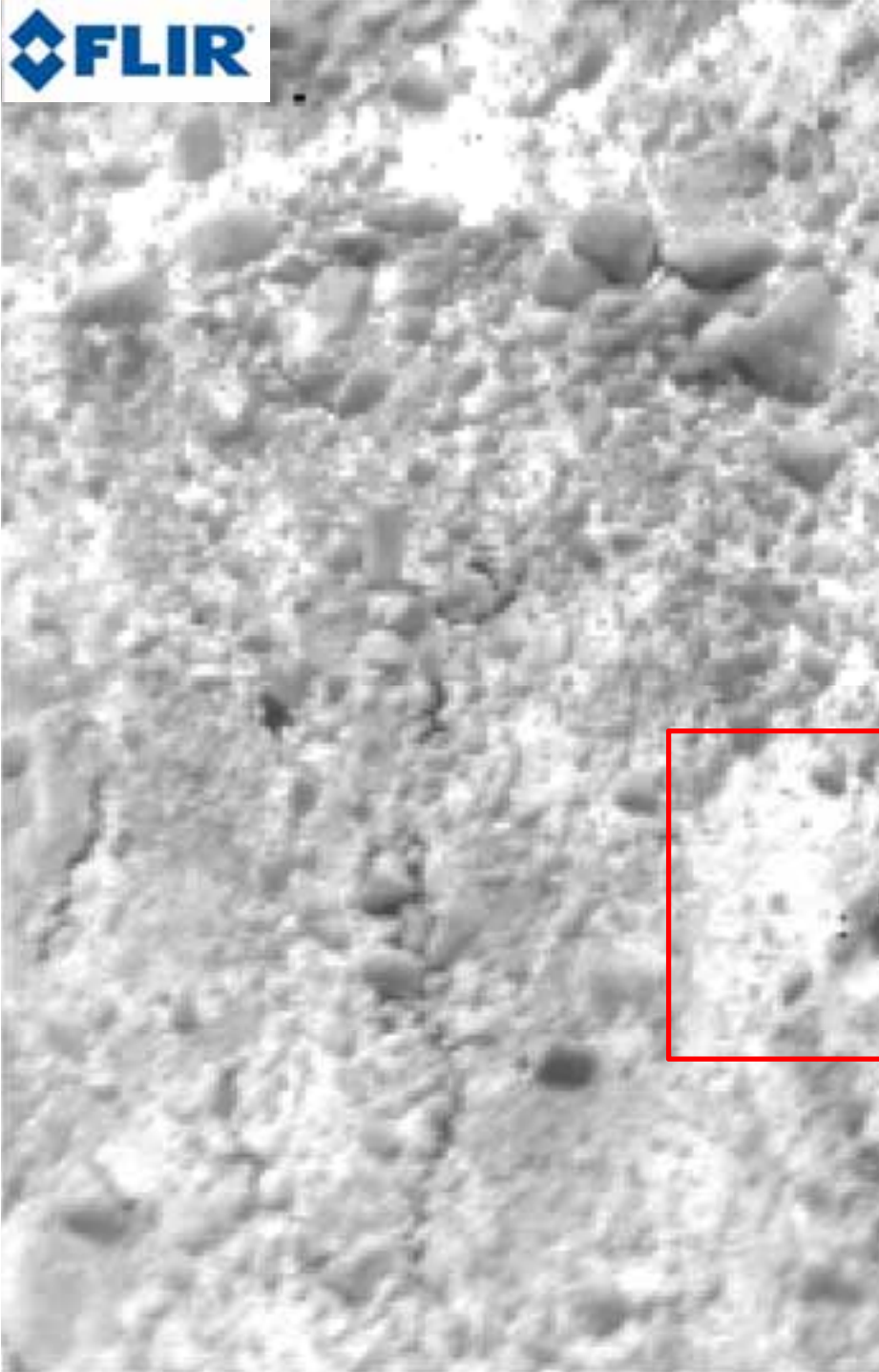




Multispectral *imaging* sensor 6-bands

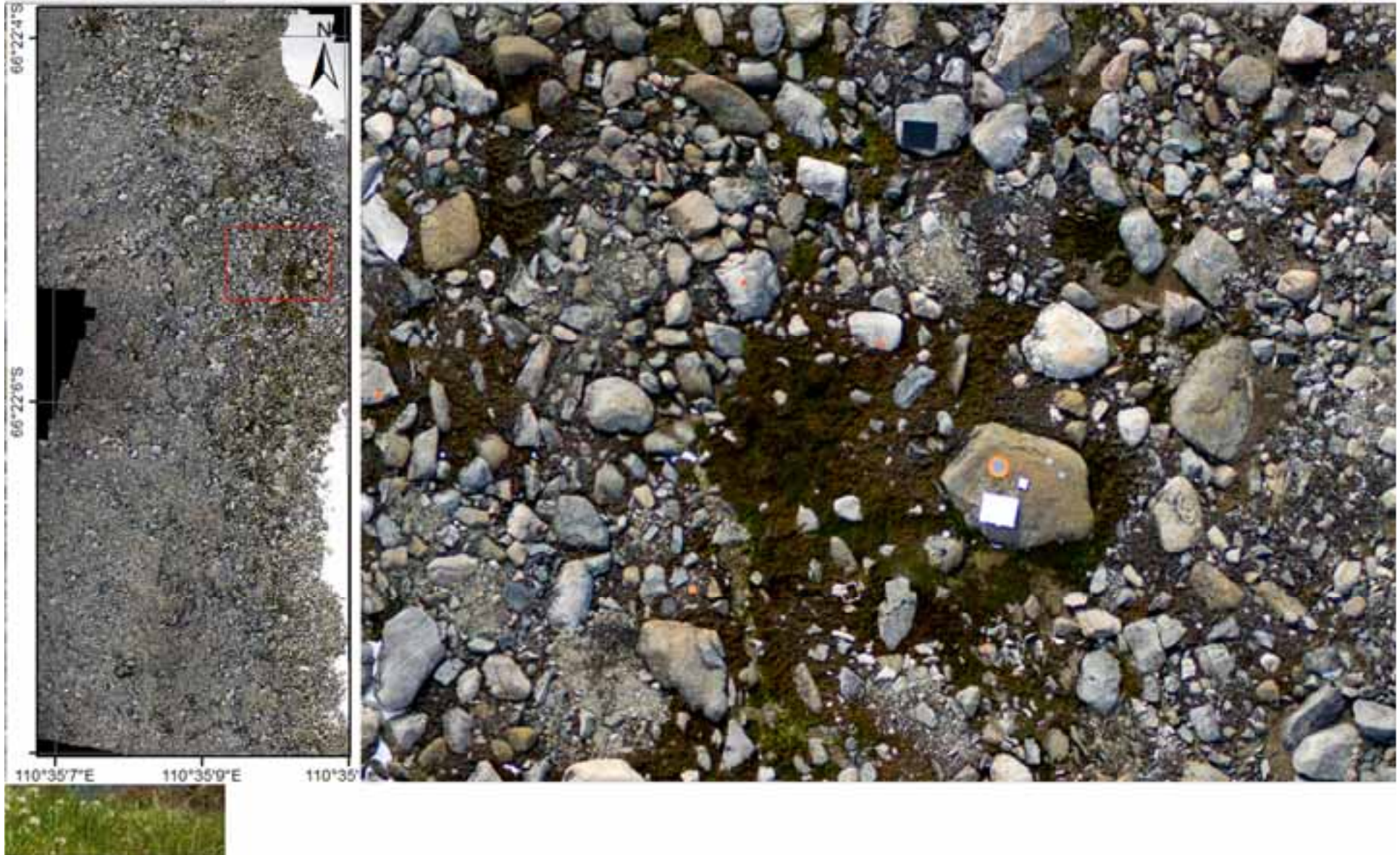






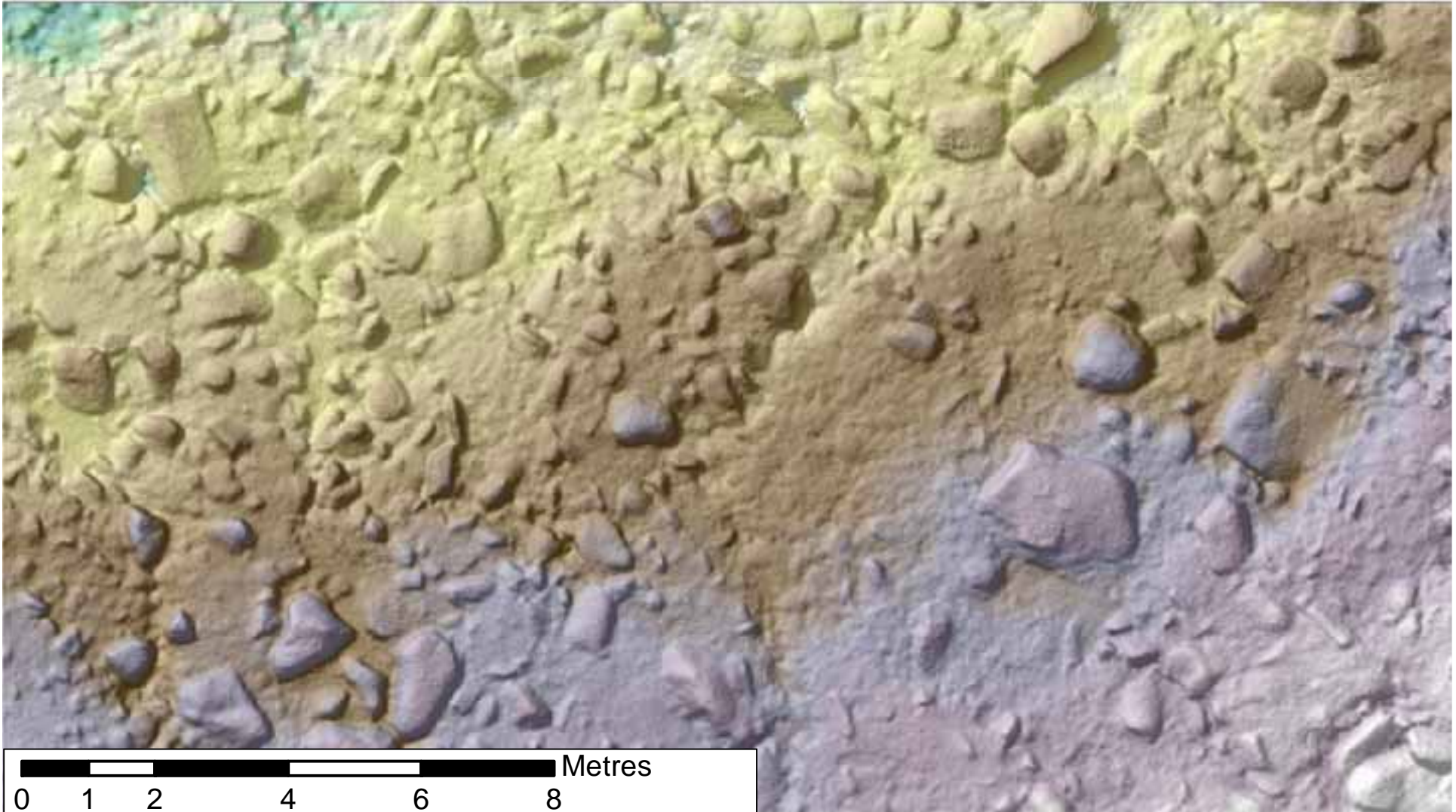


Co-registered UAS data





Co-registered UAS data



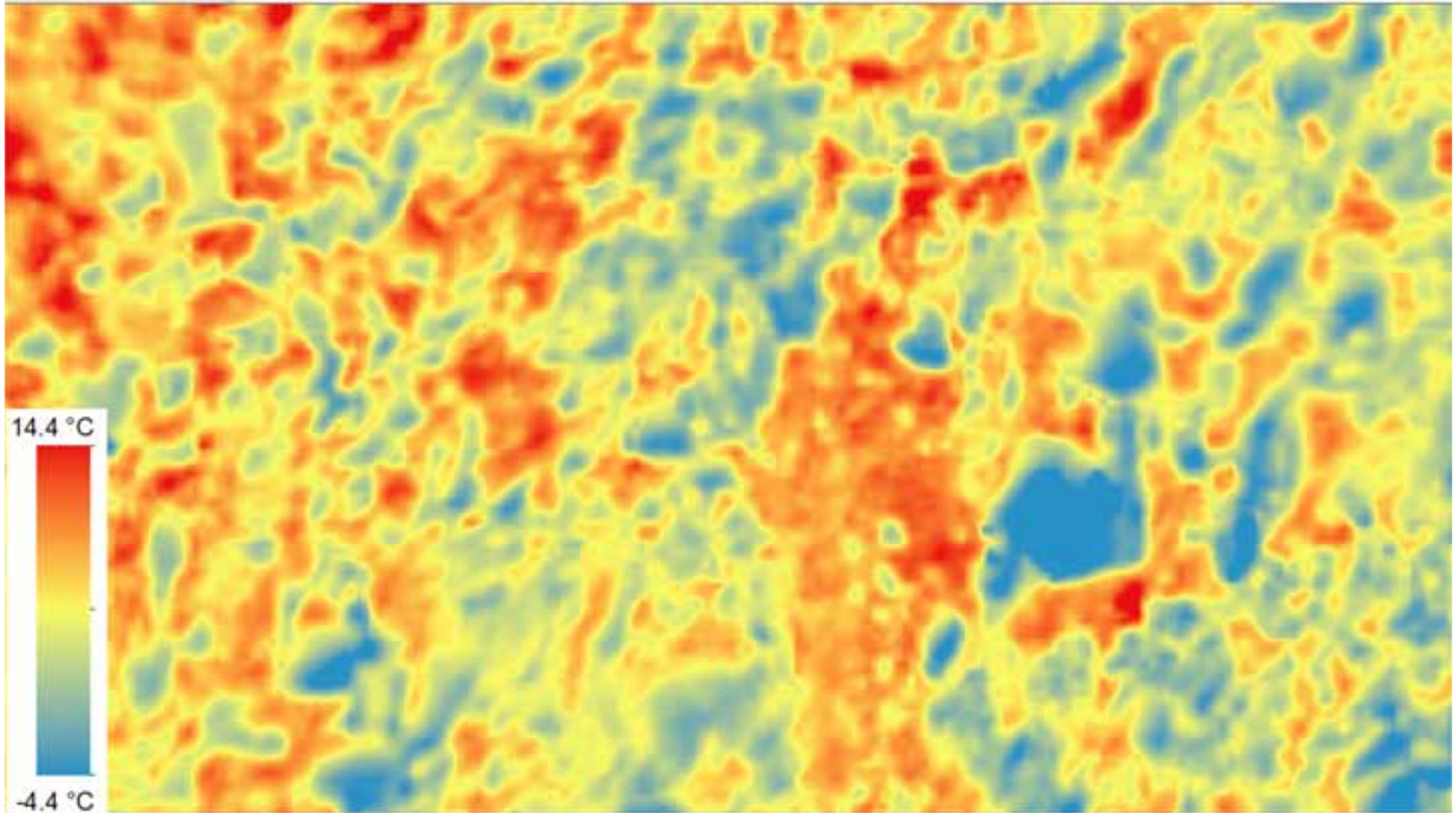


Co-registered UAS data



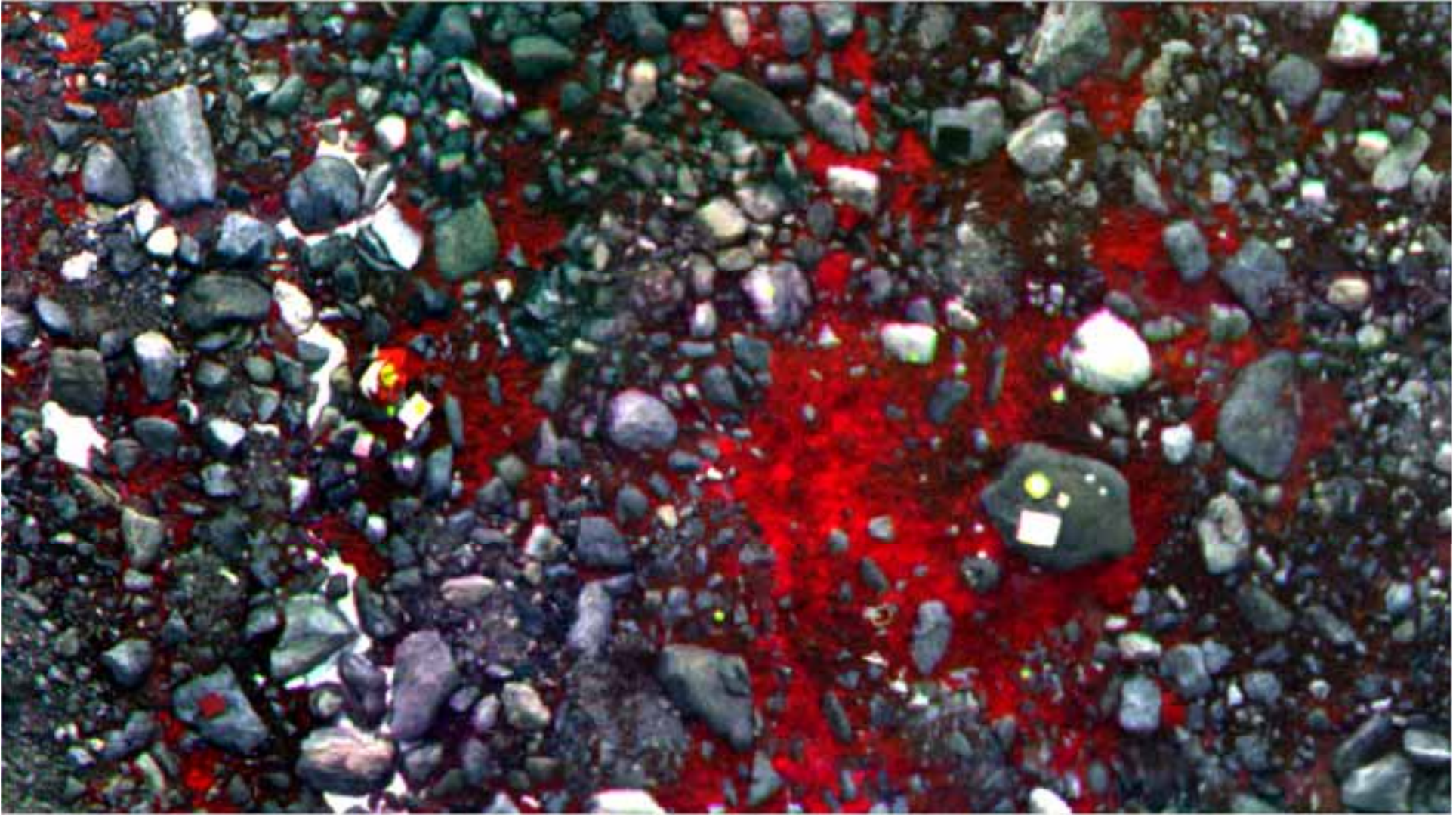


Co-registered UAS data



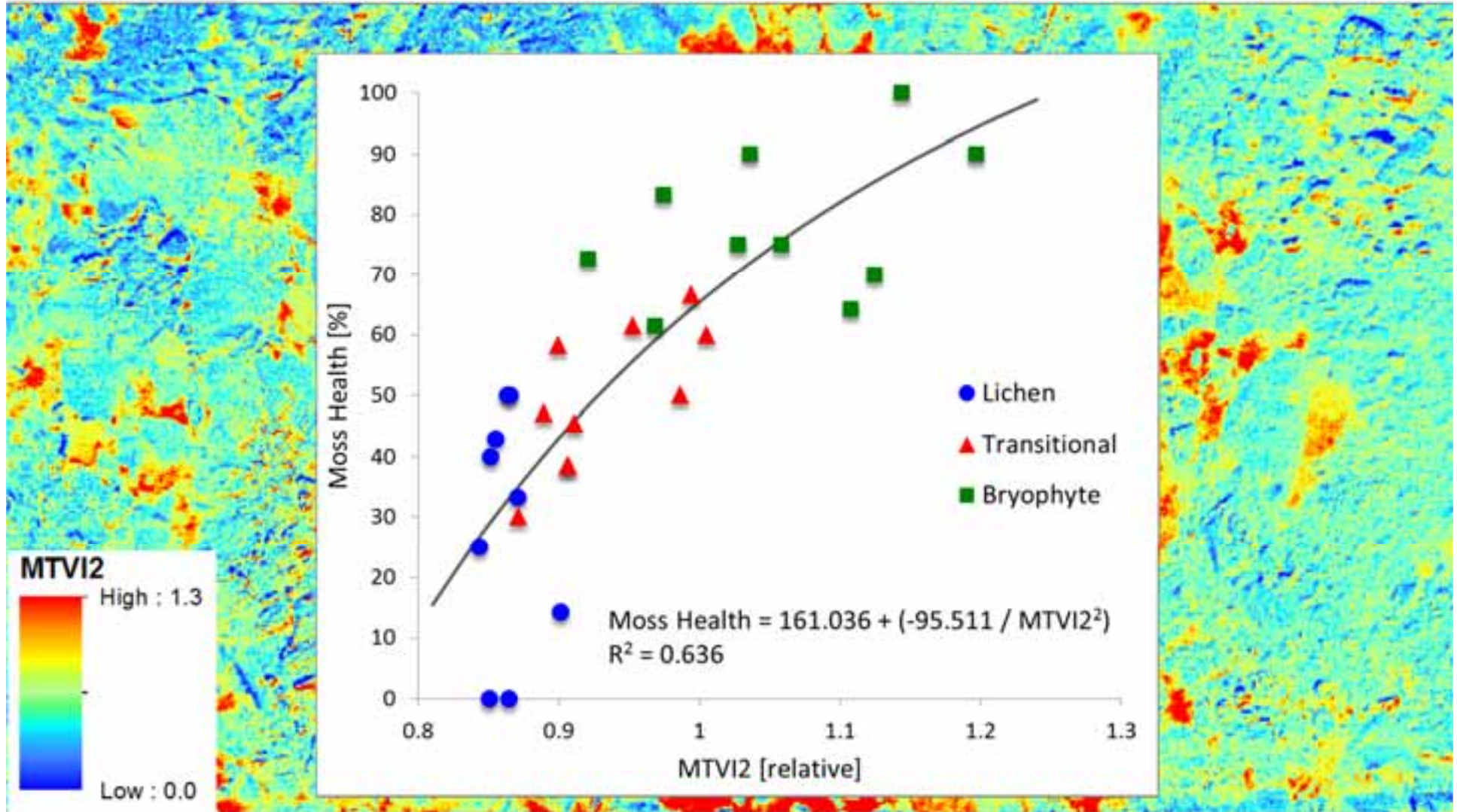


Co-registered UAS data



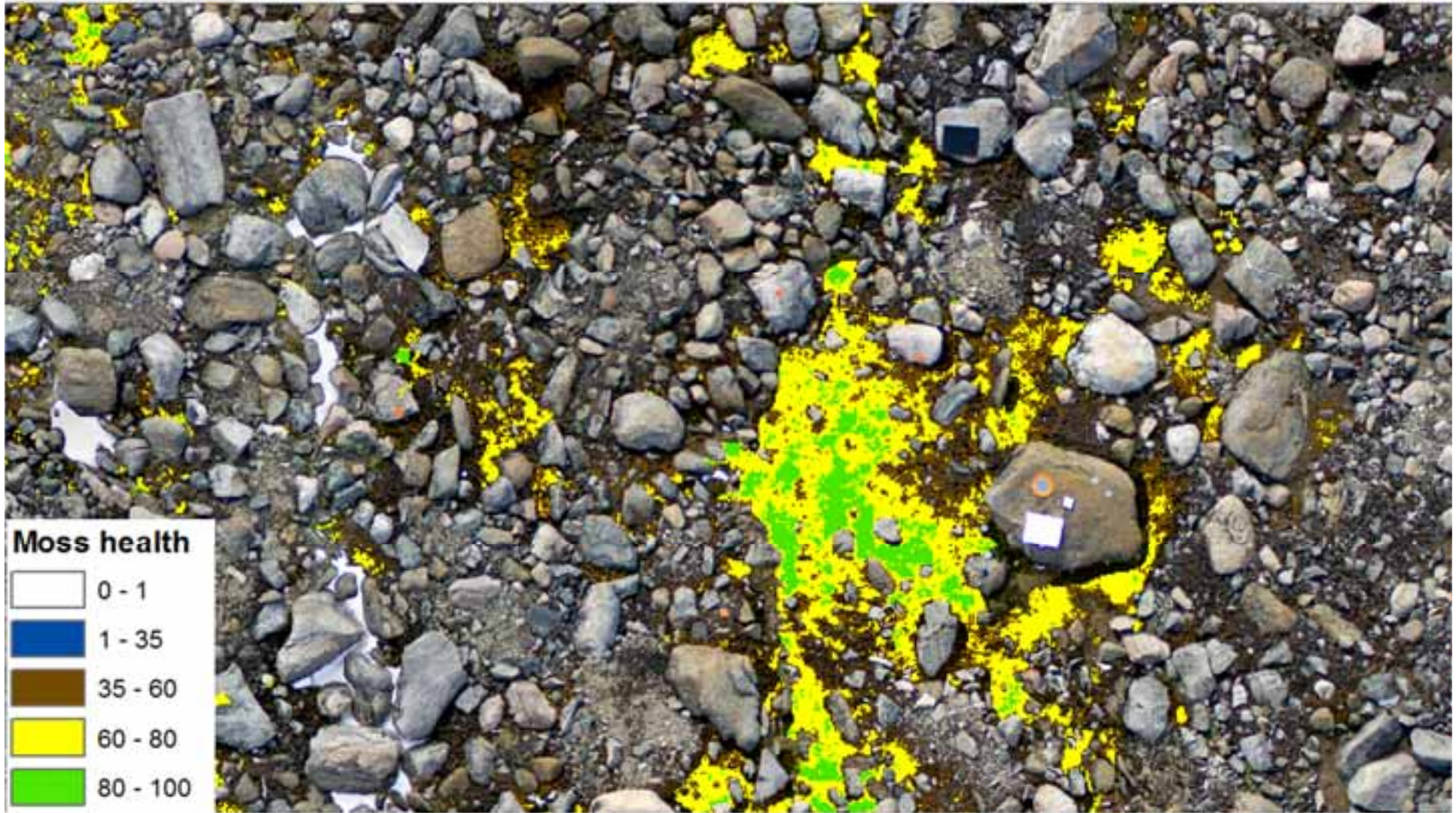


Co-registered UAS data



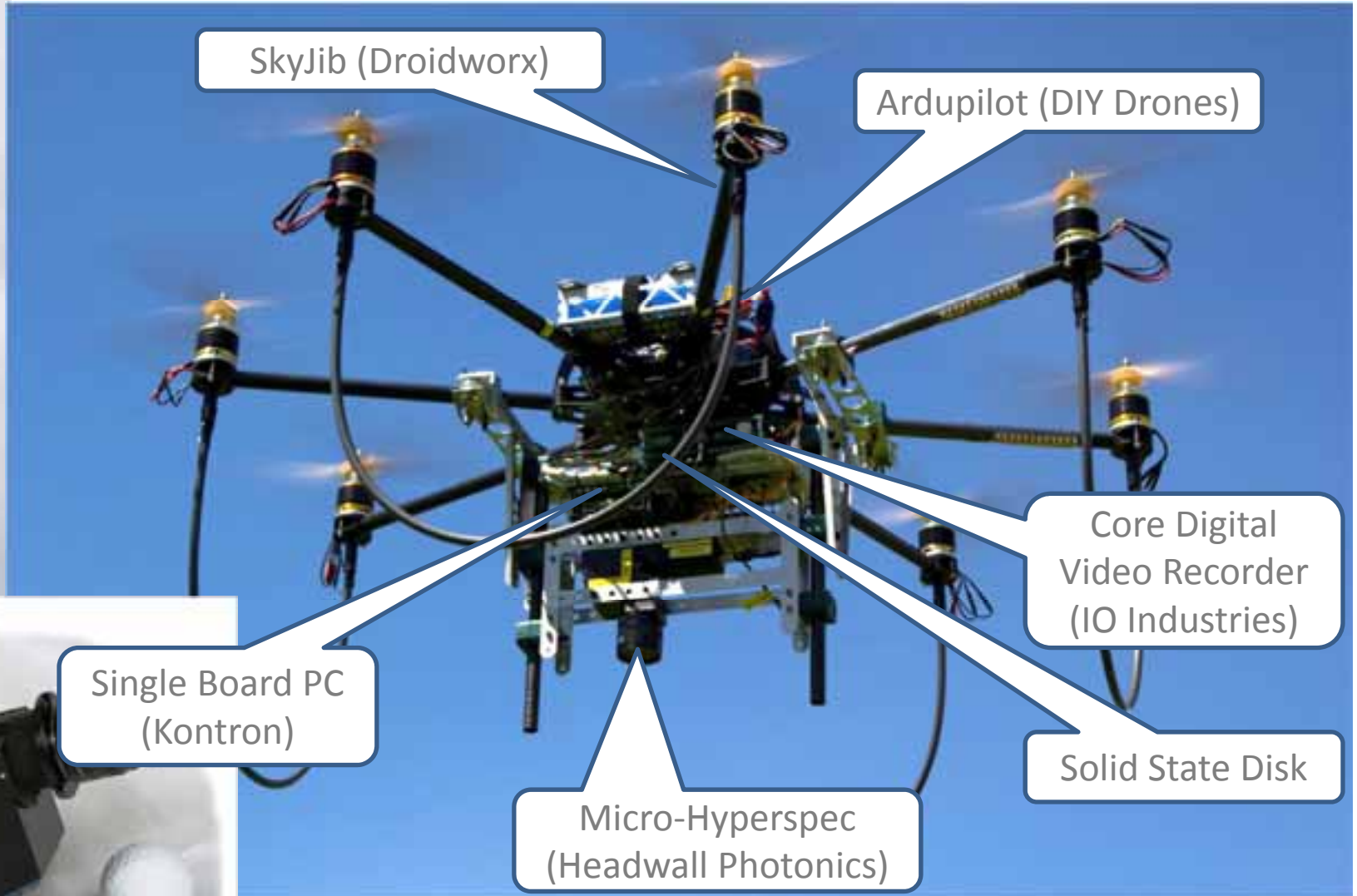


Co-registered UAS data



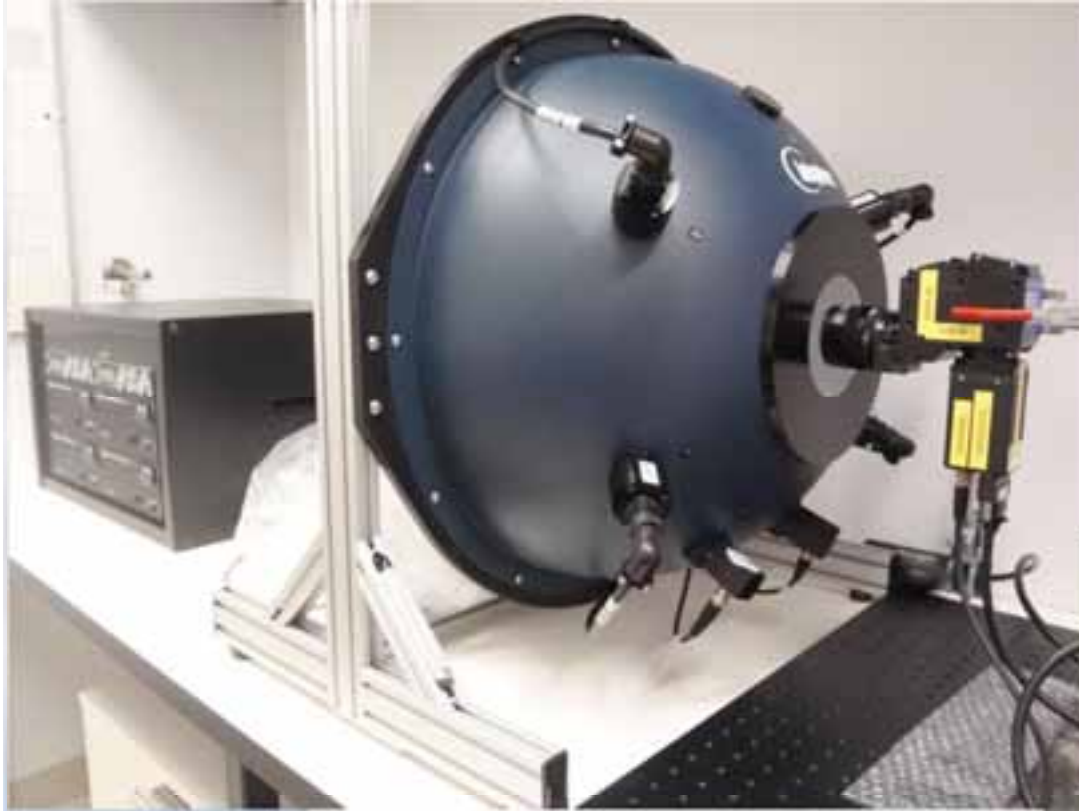


HyperUAS prototype





Radiometric and spectral calibration



Integrating sphere with variable and calibrated light source



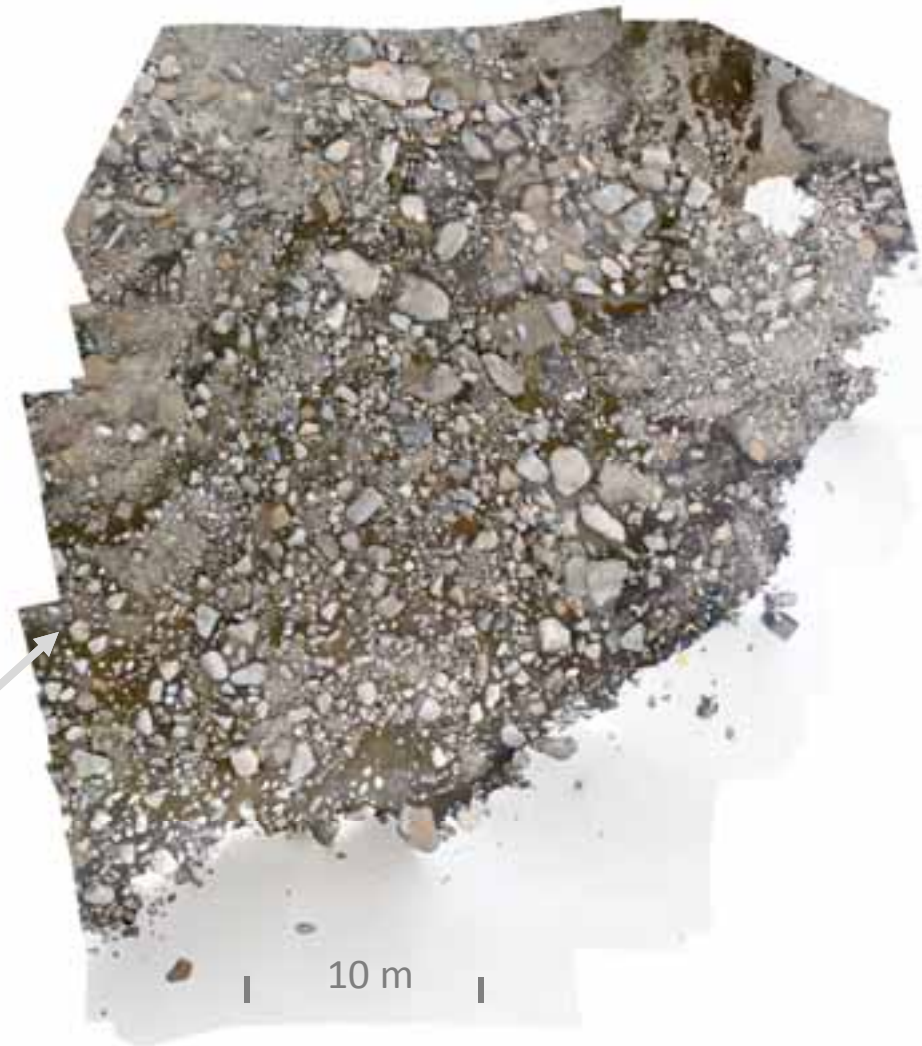
Mercury-Argon lamp with known spectral features







Airborne imaging spectroscopy data

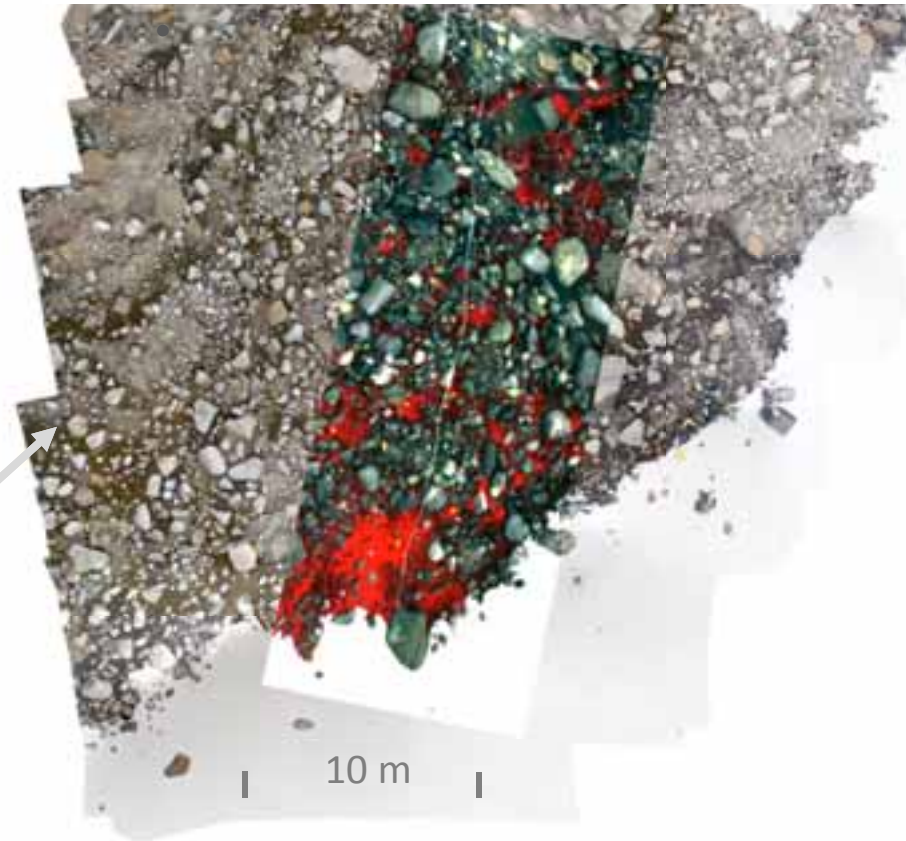


ROBINSON RIDGE
Feb. 5th 2013

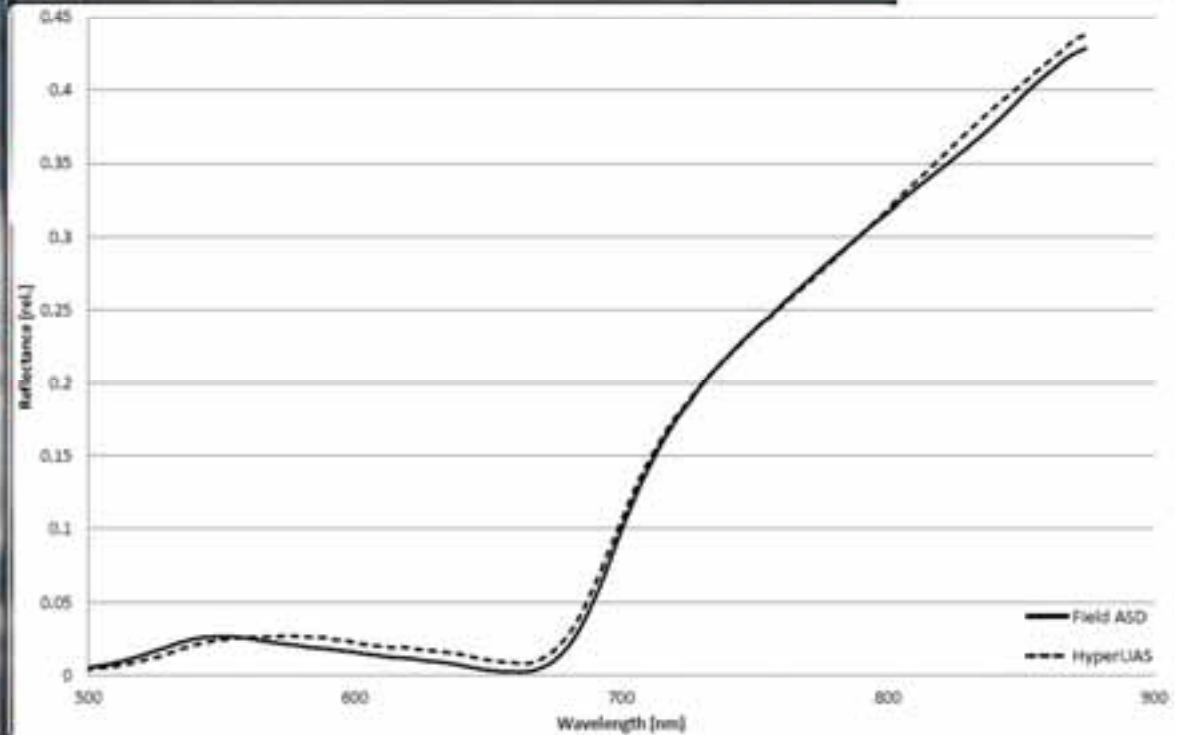
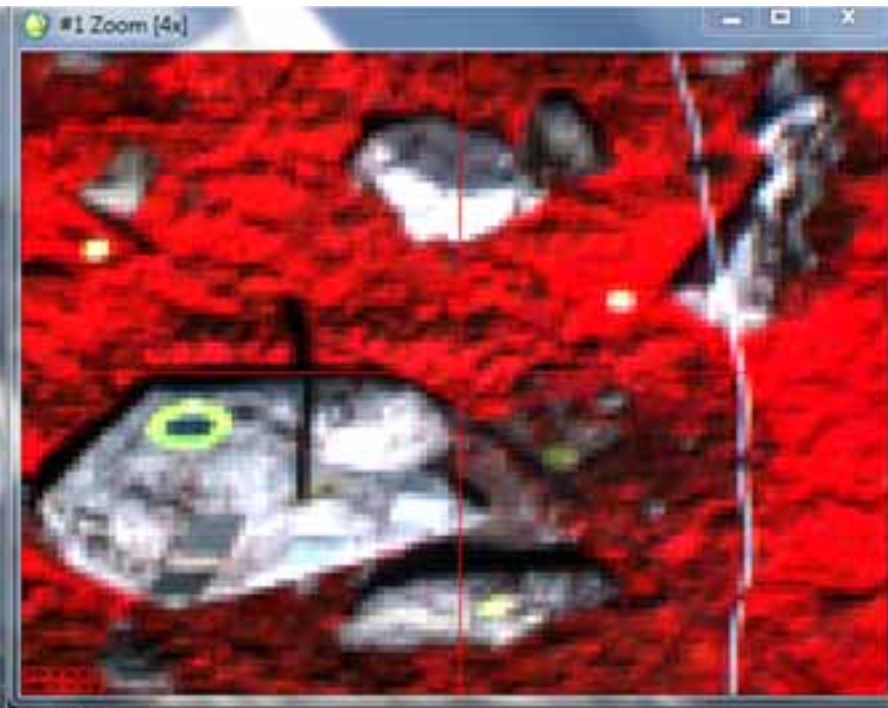


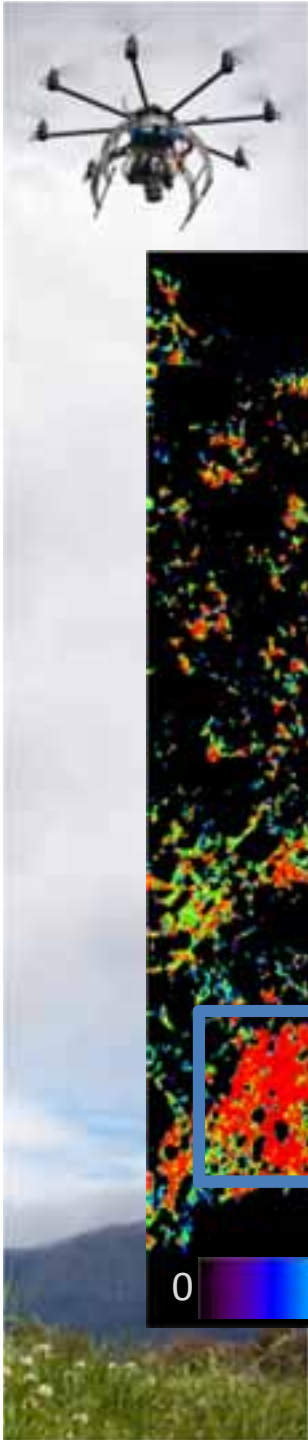
Airborne imaging spectroscopy data

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

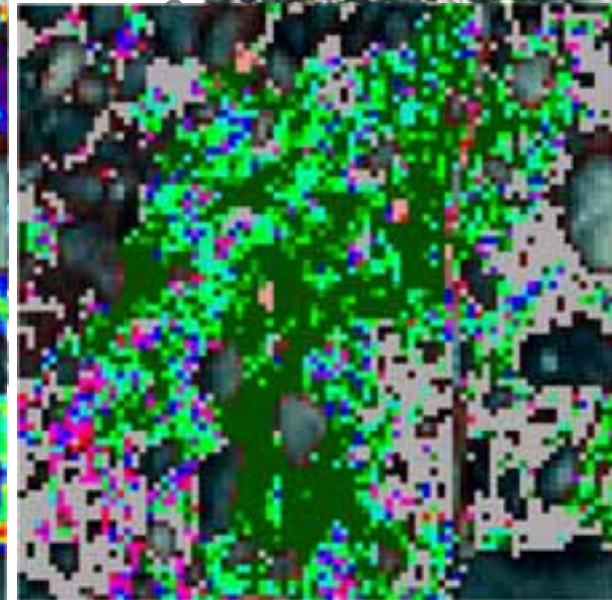
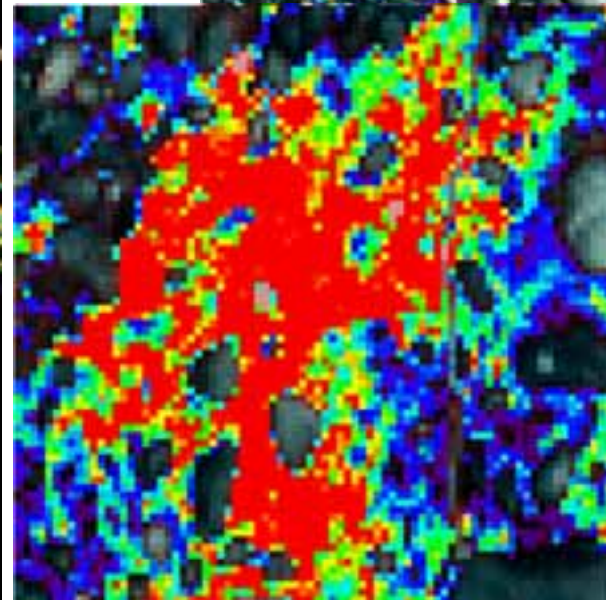
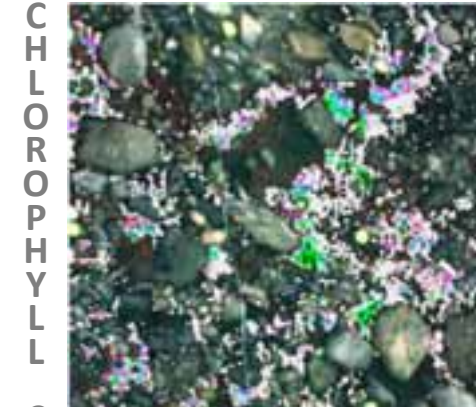
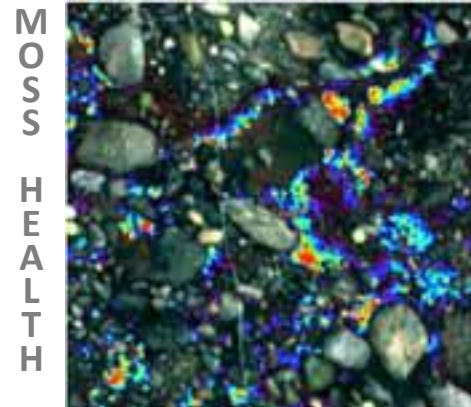
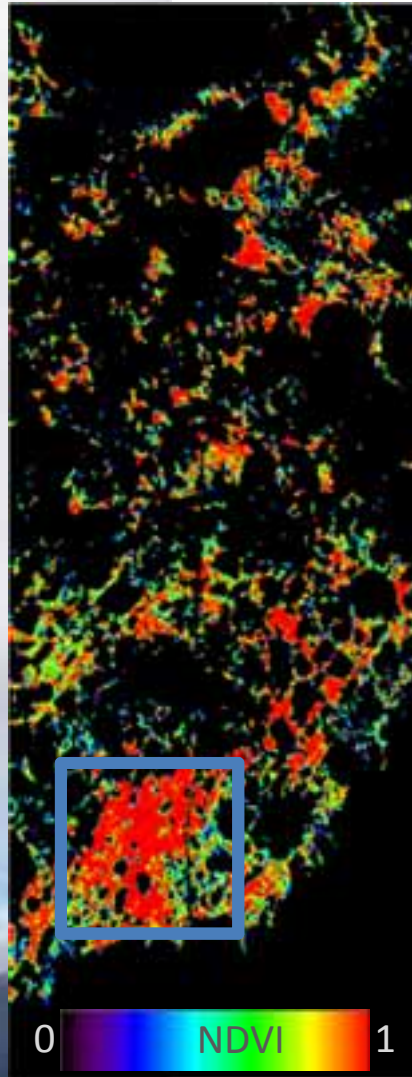


ROBINSON RIDGE
Feb. 5th 2013





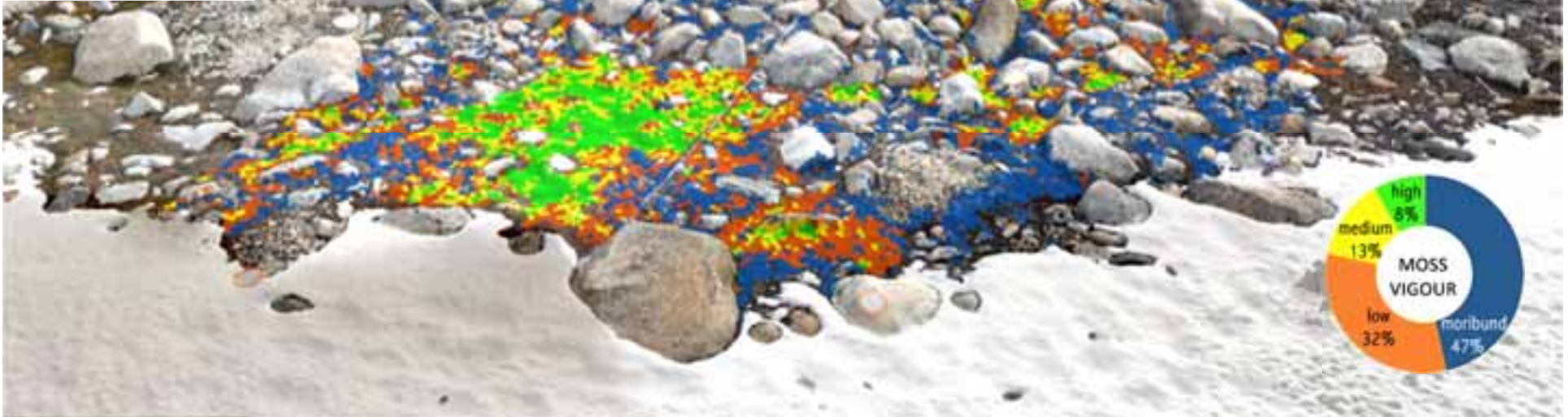
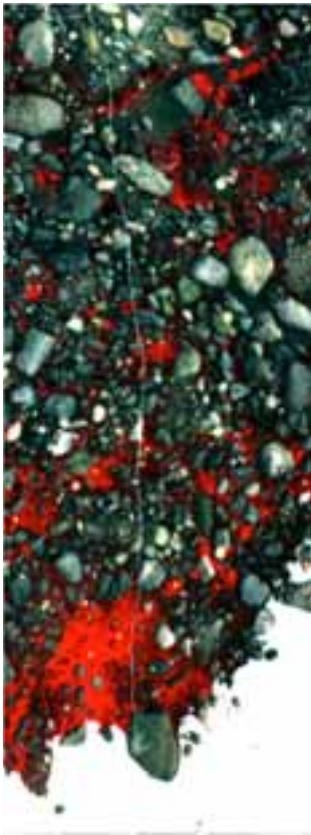
HyperUAS moss health assessment



low MTVI2 high

low ANCB high

ROBINSON RIDGE (East Antarctica, 5th February 2013)







Structure from Motion (SfM) and multi-view stereopsis (MVS) 3D mapping

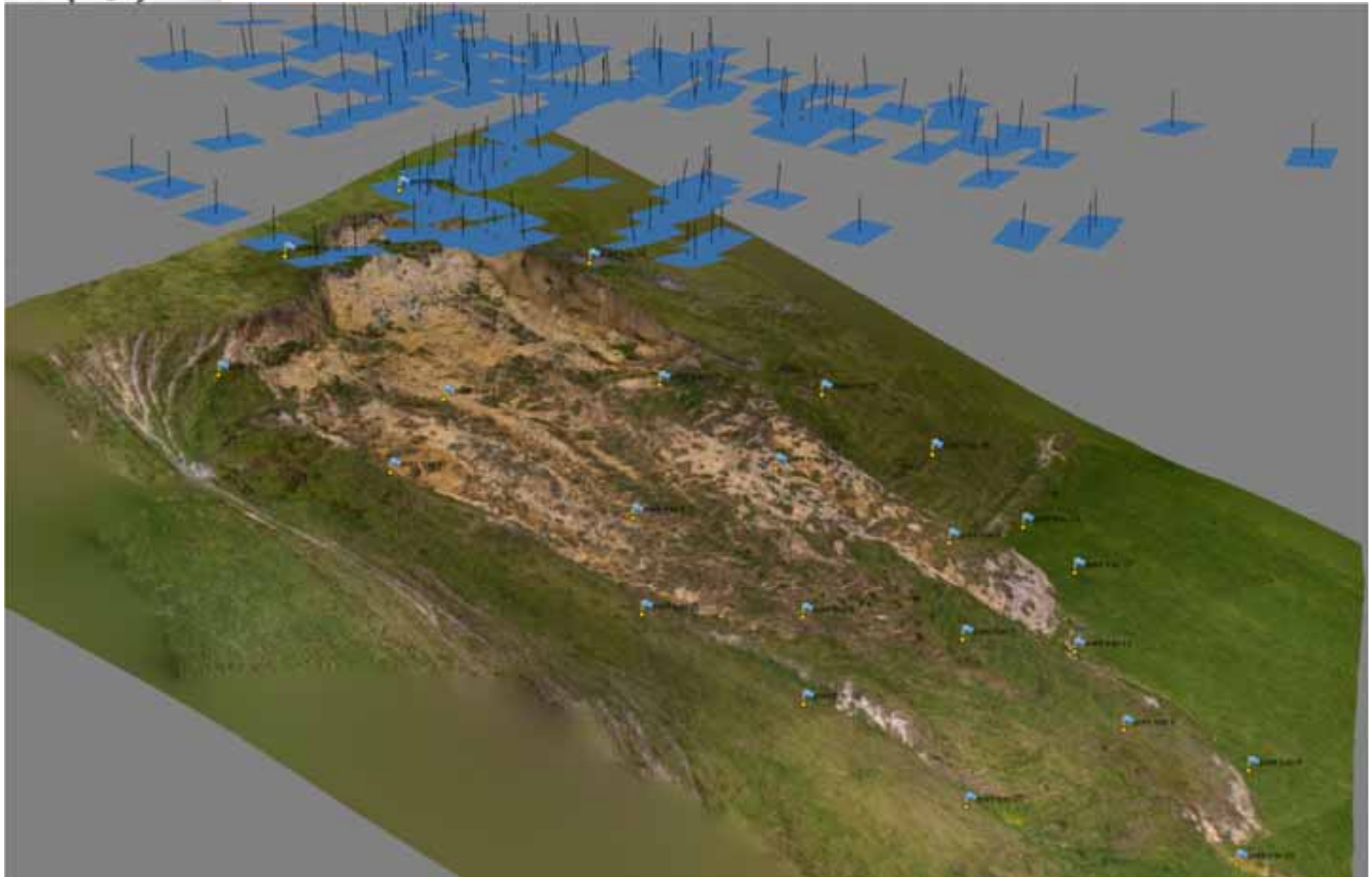
Darren Turner, Arko Lucieer,
and Prof. Steven de Jong



Lucieer, A., de Jong, S.M., and Turner, D. (in press). Mapping landslide displacements using Structure from Motion (SfM) and image correlation of multi-temporal UAV photography. *Progress in Physical Geography*.



Landslip point cloud



20 July 2010

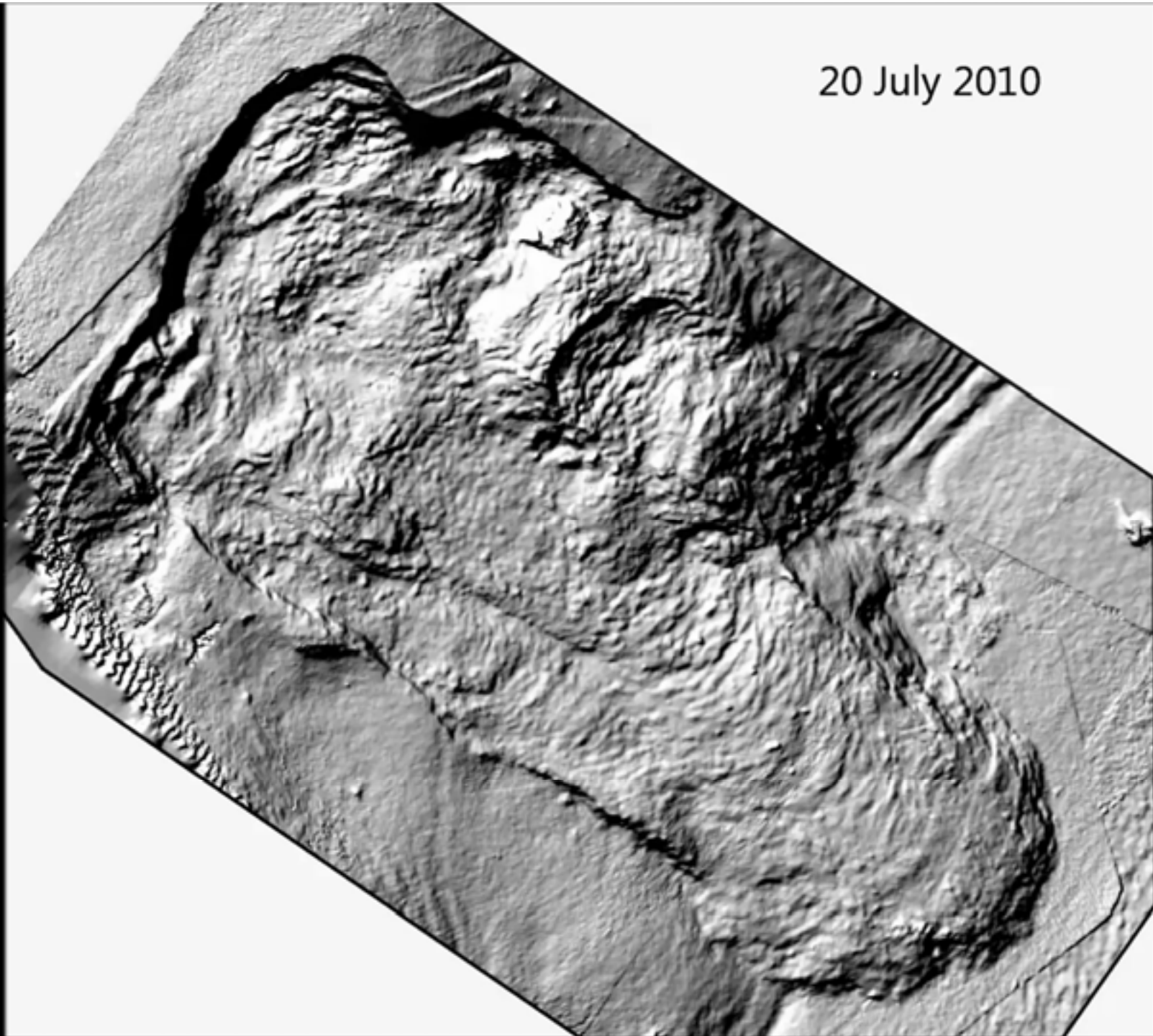
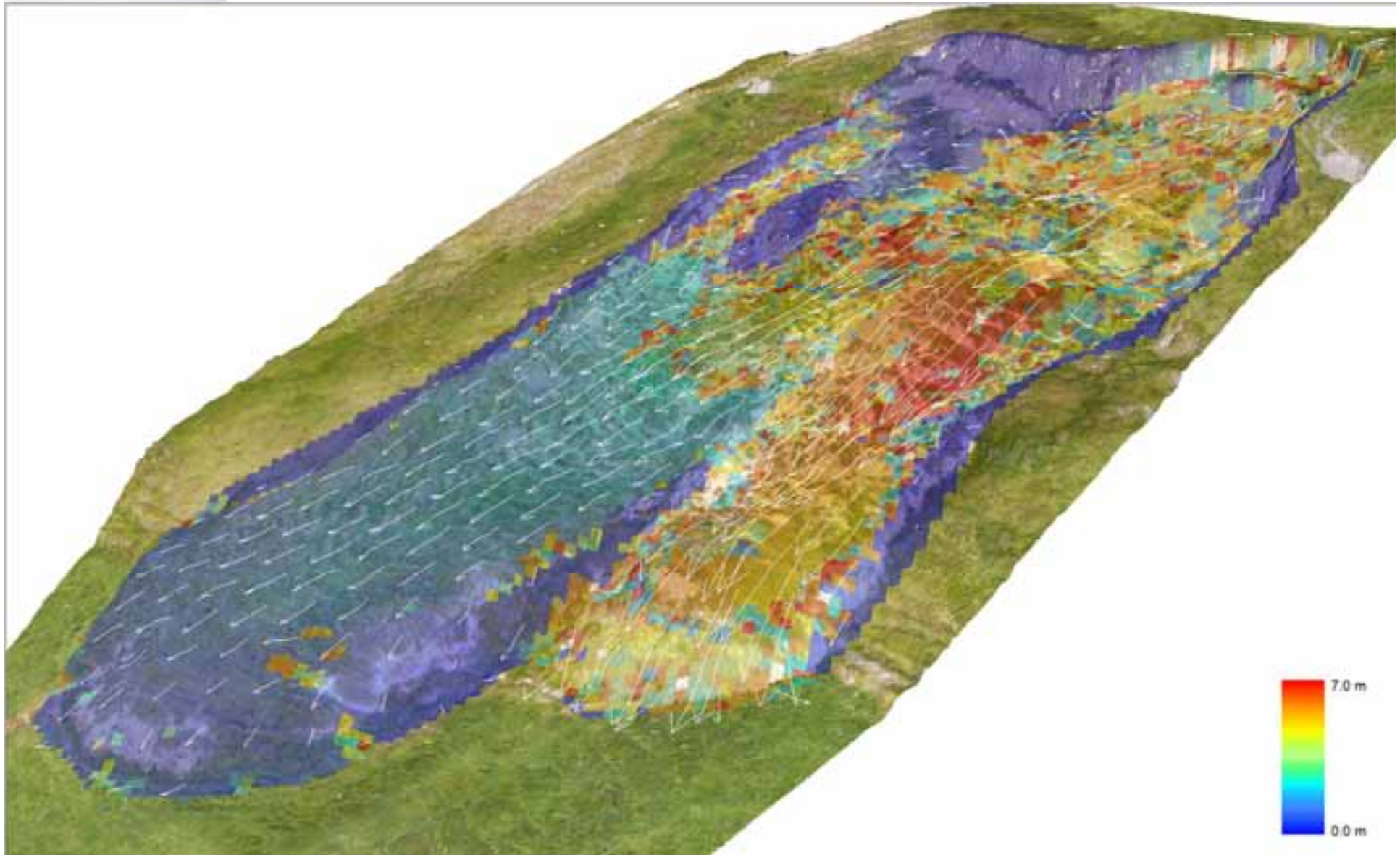




Image correlation displacement vectors





UAV multi-view stereopsis (MVS) point clouds Coastal erosion case study

Steve Harwin



Harwin, S., & Lucieer, A. (2012). Assessing the Accuracy of Georeferenced Point Clouds Produced via Multi-View Stereopsis from Unmanned Aerial Vehicle (UAV) Imagery. *Remote Sensing*, 4(6), 1573-1599.

<http://www.mdpi.com/2072-4292/4/6/1671>

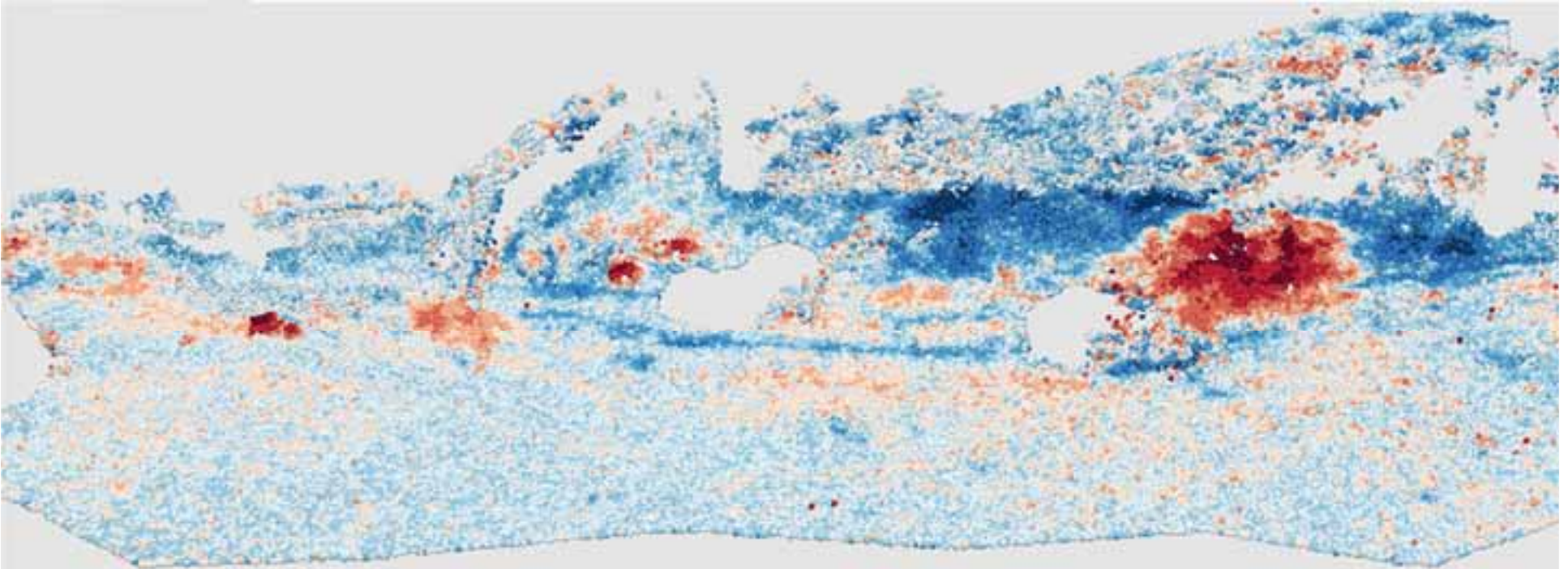


3D Point cloud





3D Point cloud





Sensor correction & saltmarsh vegetation classification

Josh Kelcey

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>

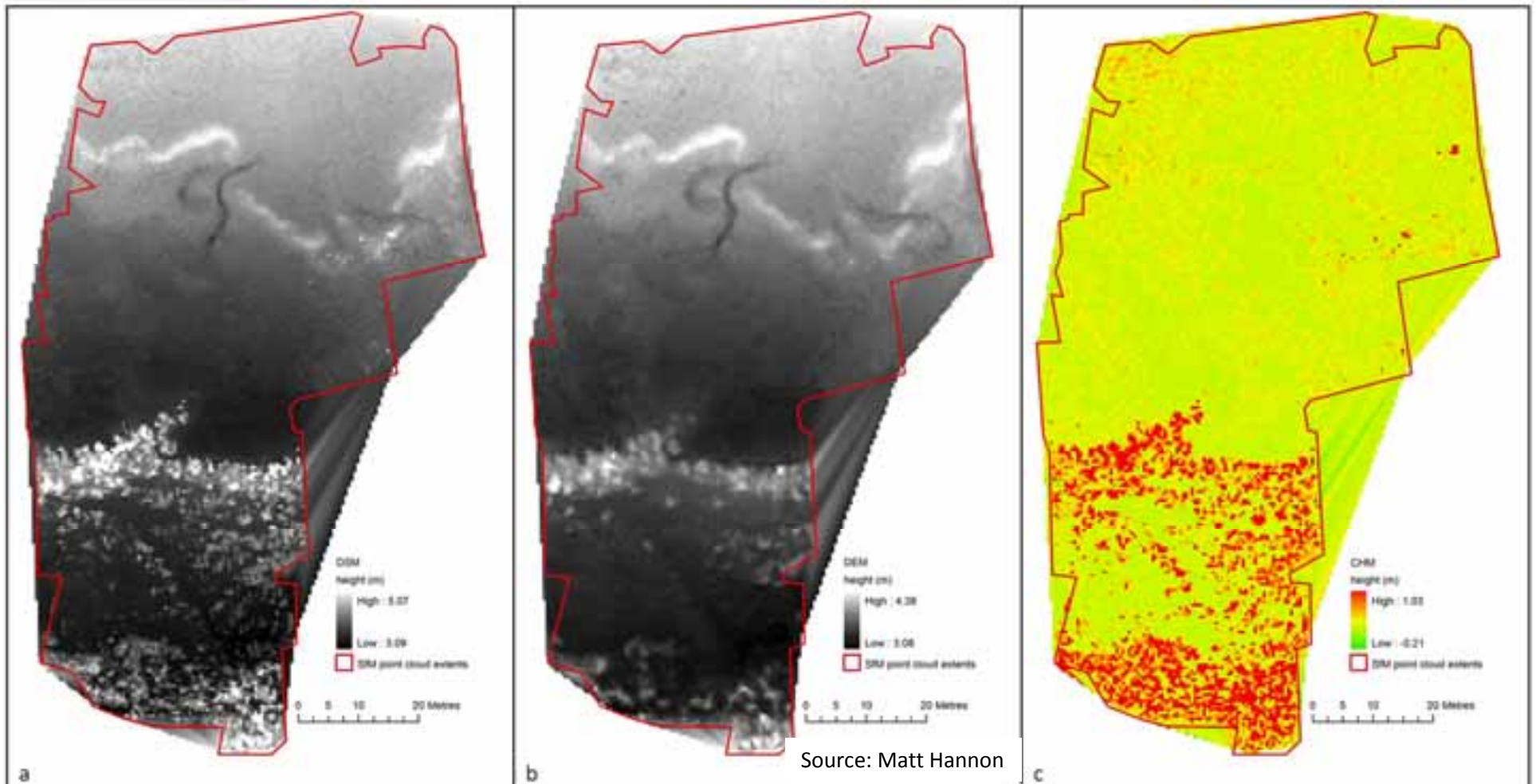


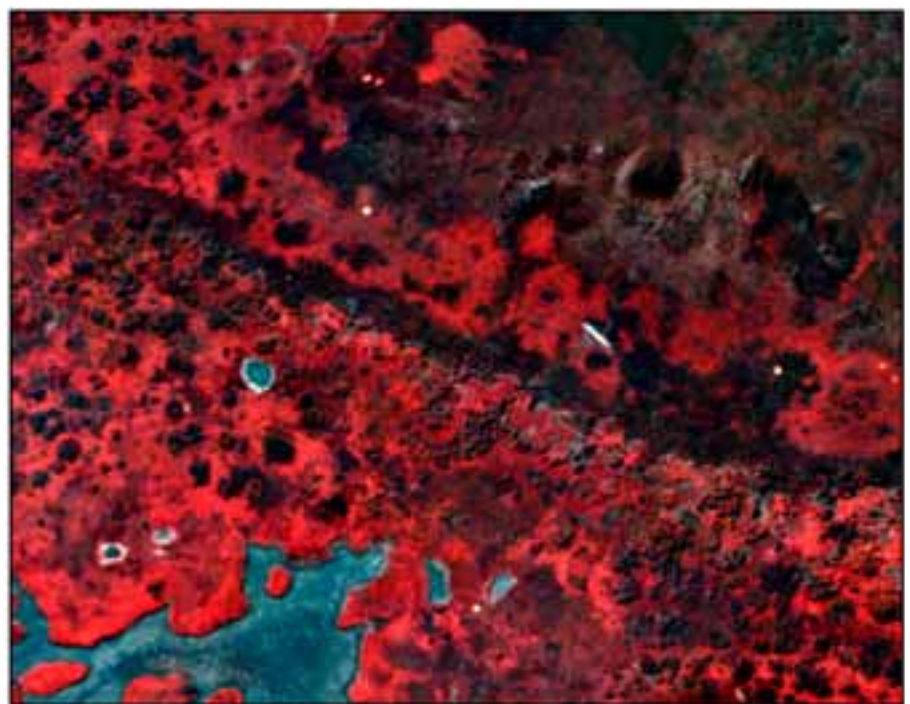
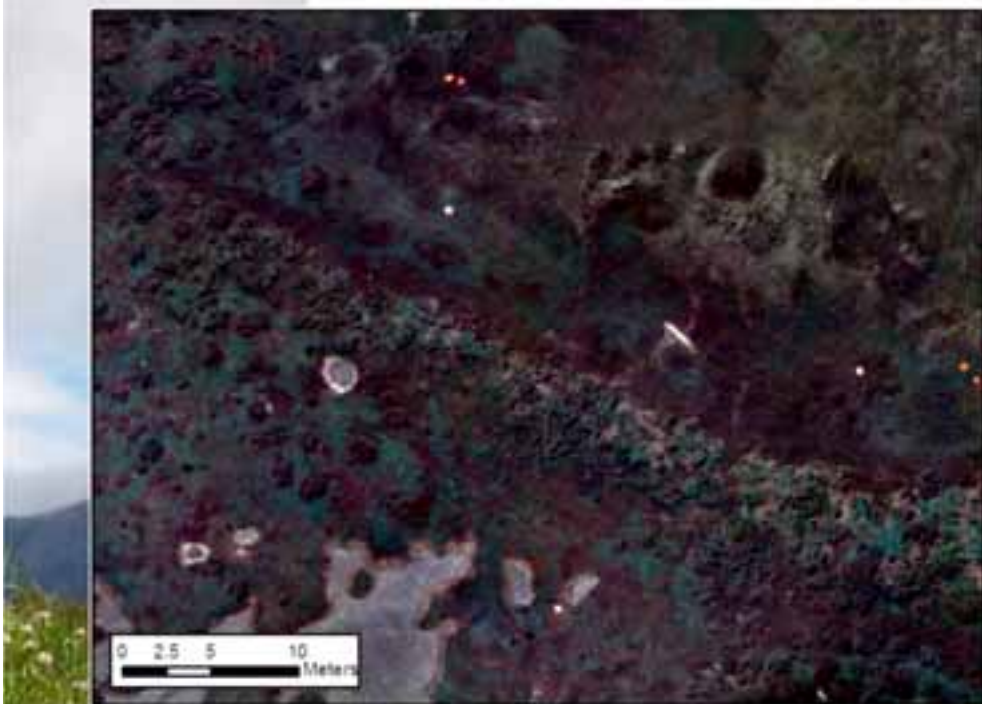
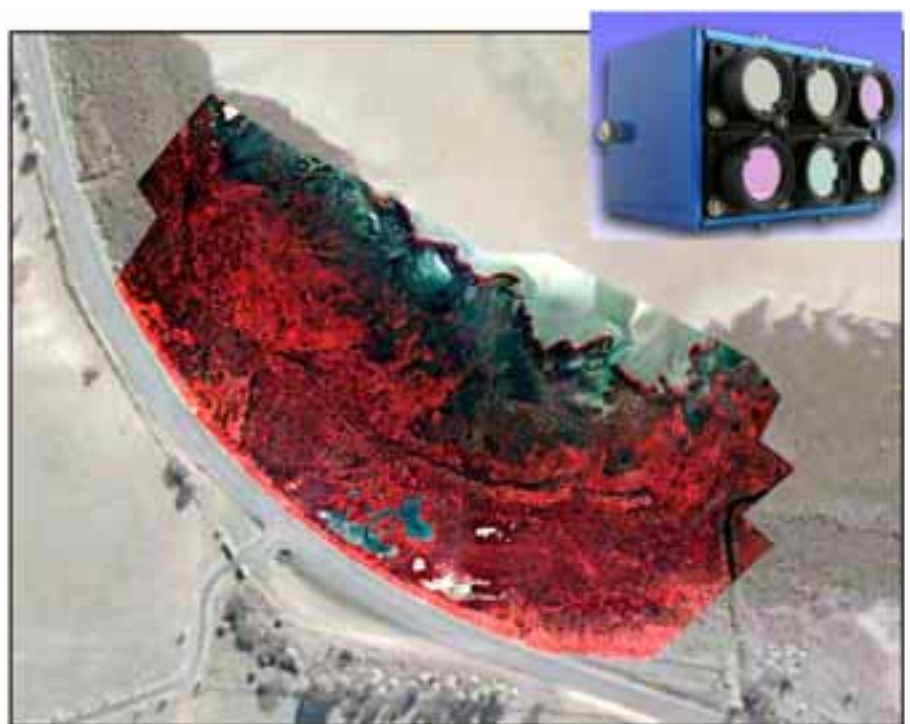




Canopy Height Model (CHM)

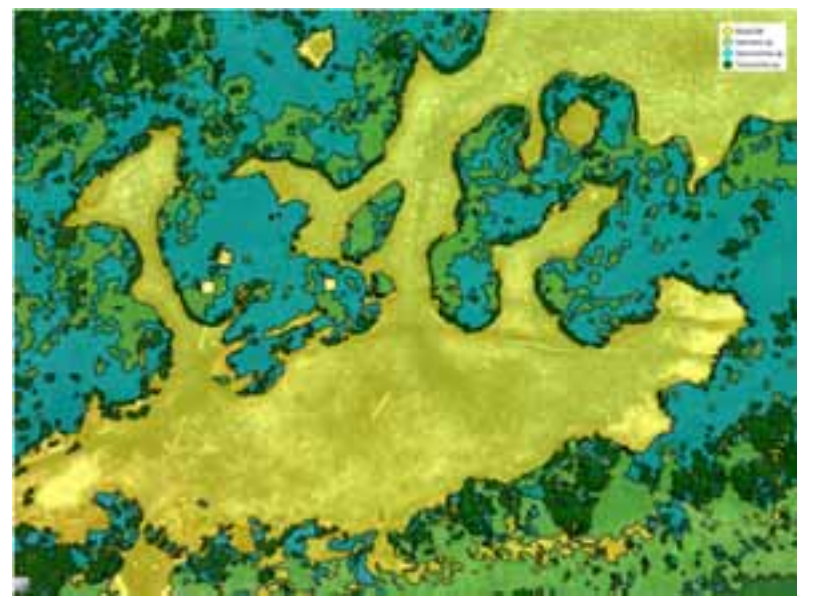
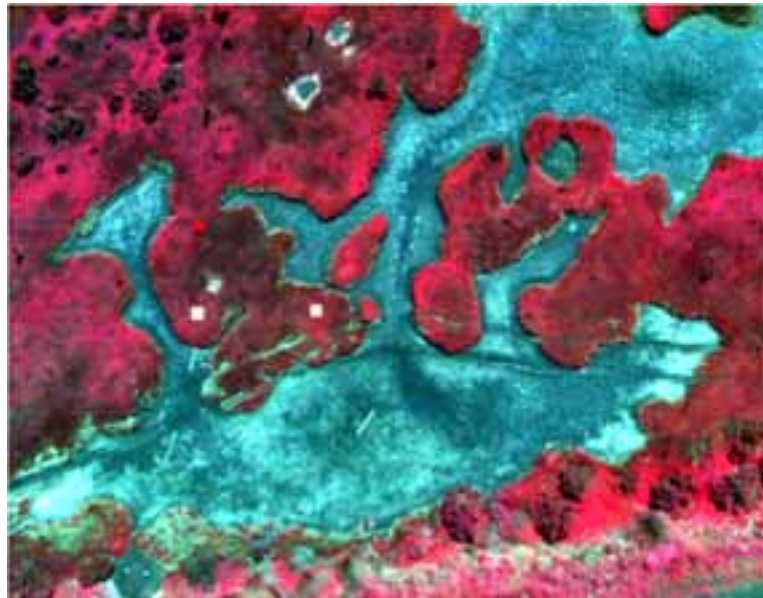
- Multiscale Curvature Classification (MCC)







Saltmarsh mapping





Precision agriculture trial





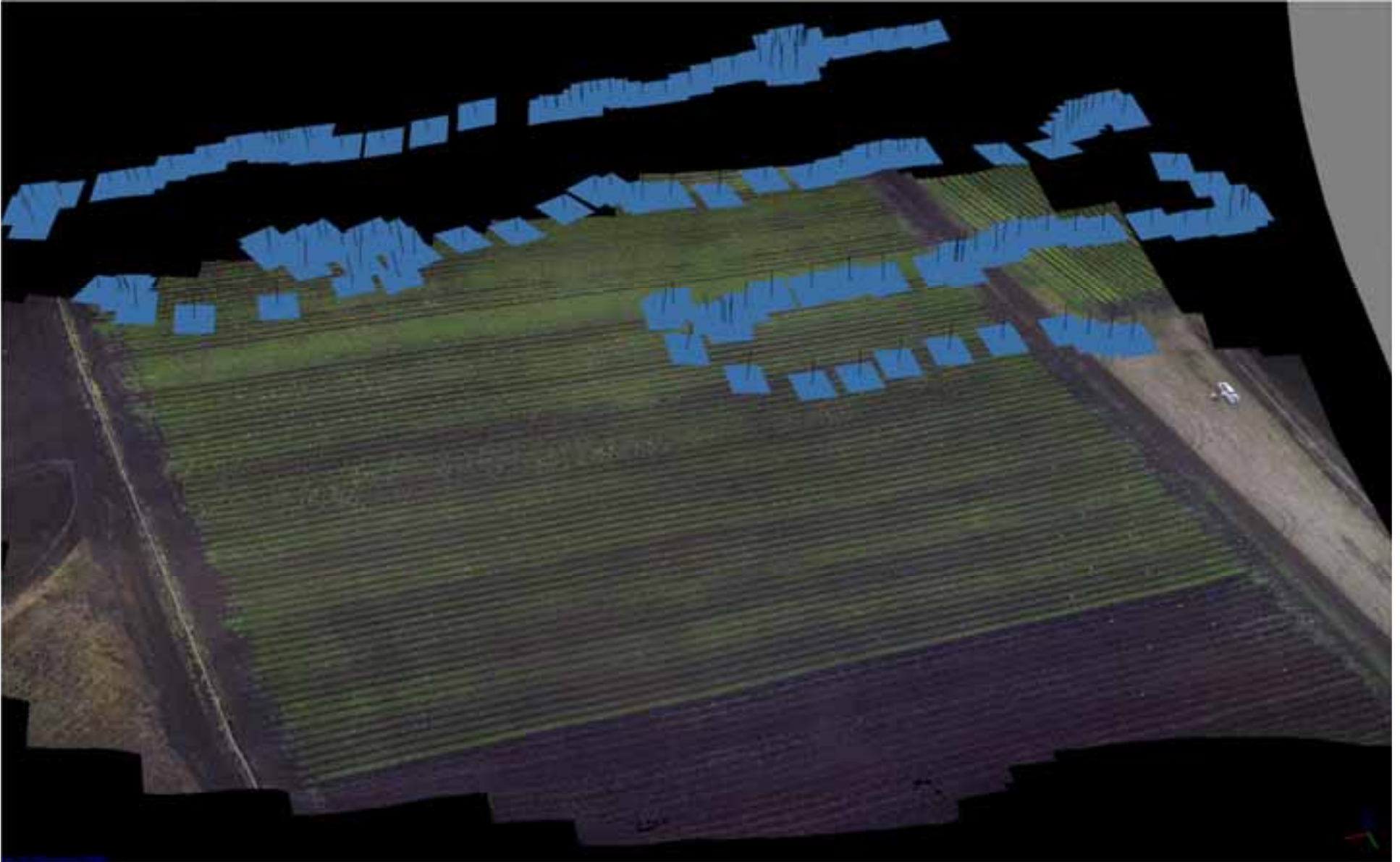
Case Studies - Agriculture



False colour composite (Green, Red, Infrared) of
Uni Farm Barley Crop – 30/11/2010



Houstons lettuce farm

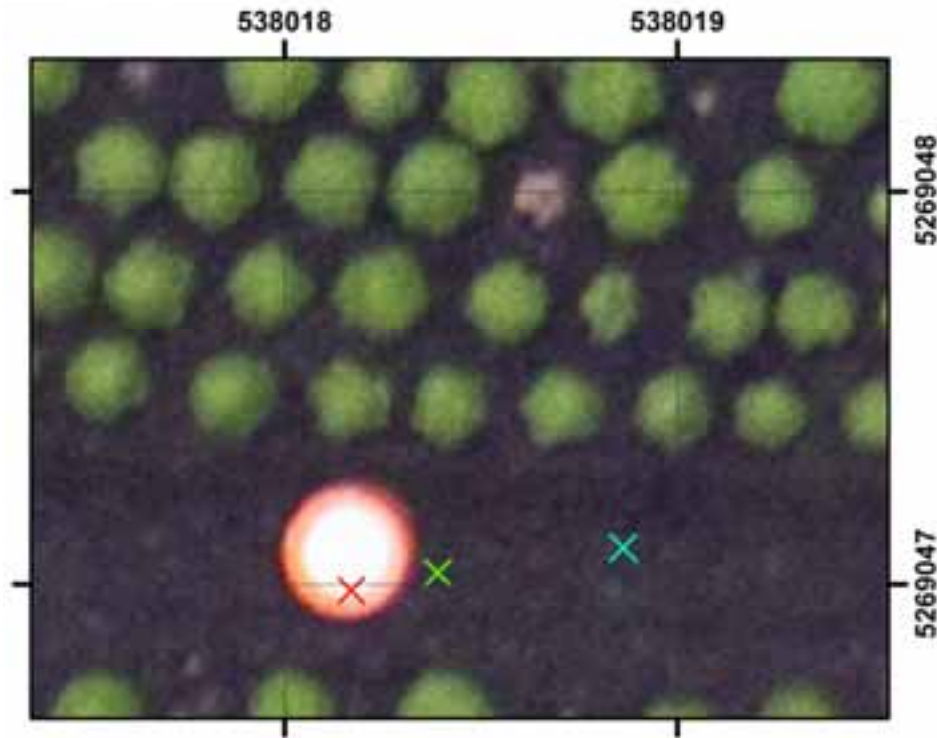


Example of diseased lettuce



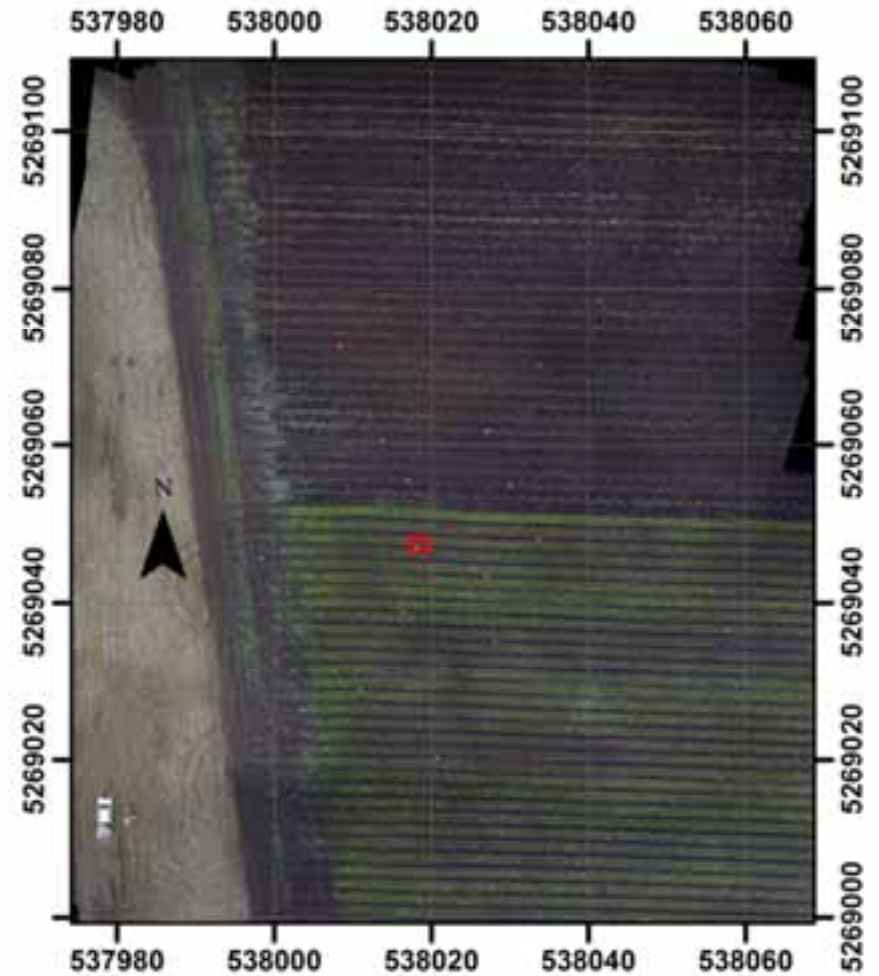


Accuracy assessment



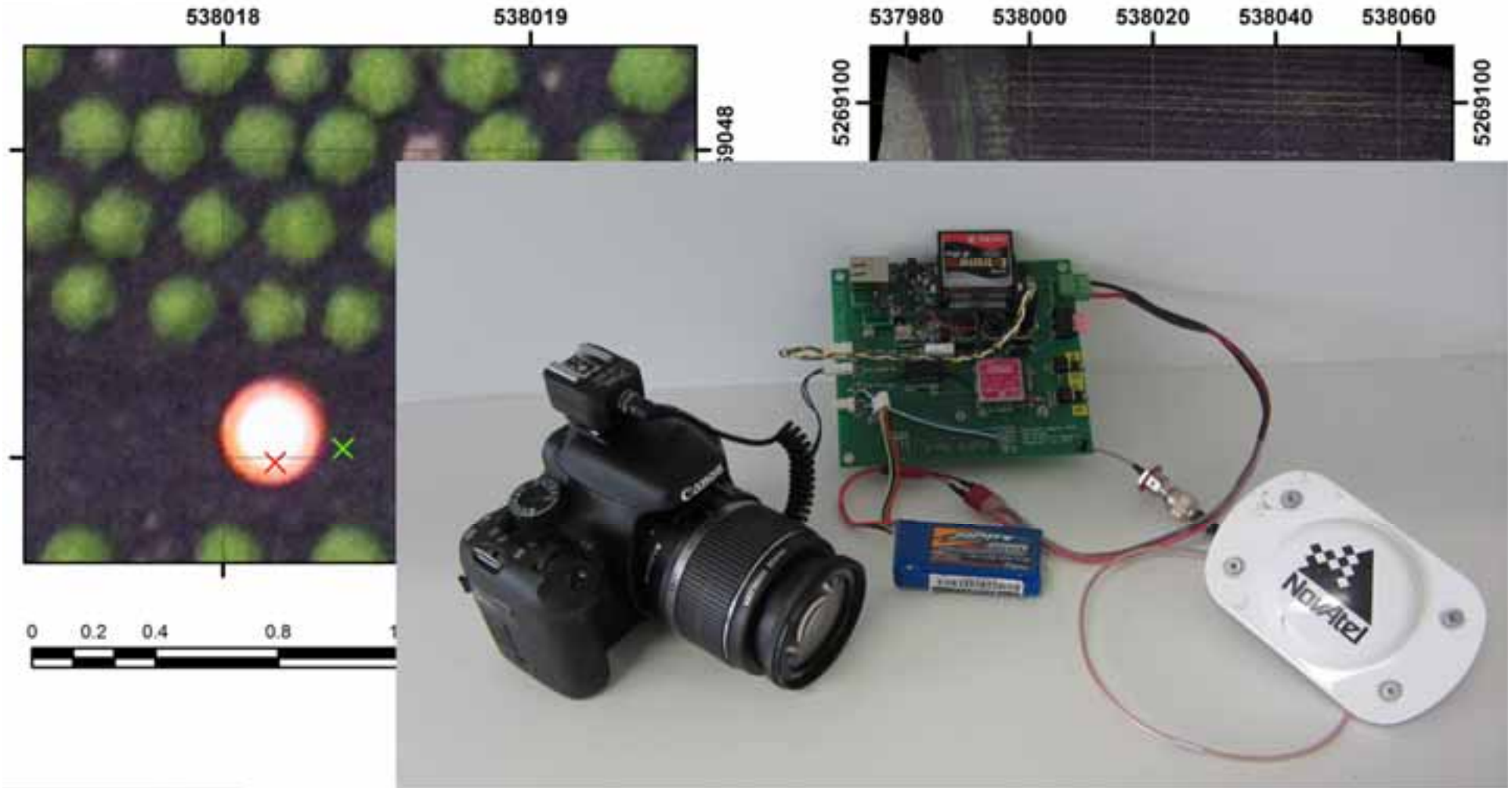
Legend

- Bundler method
- Photoscan
- Pix4D





Accuracy assessment





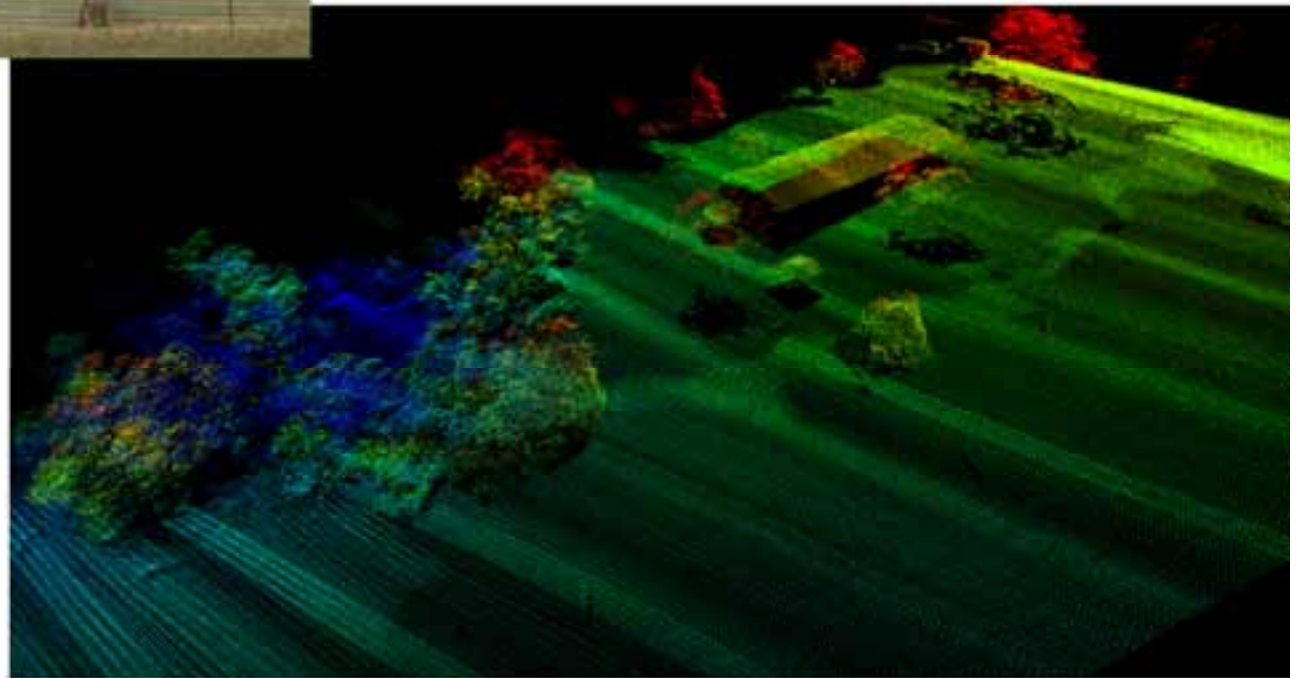
TERRALUMA

UAV LiDAR



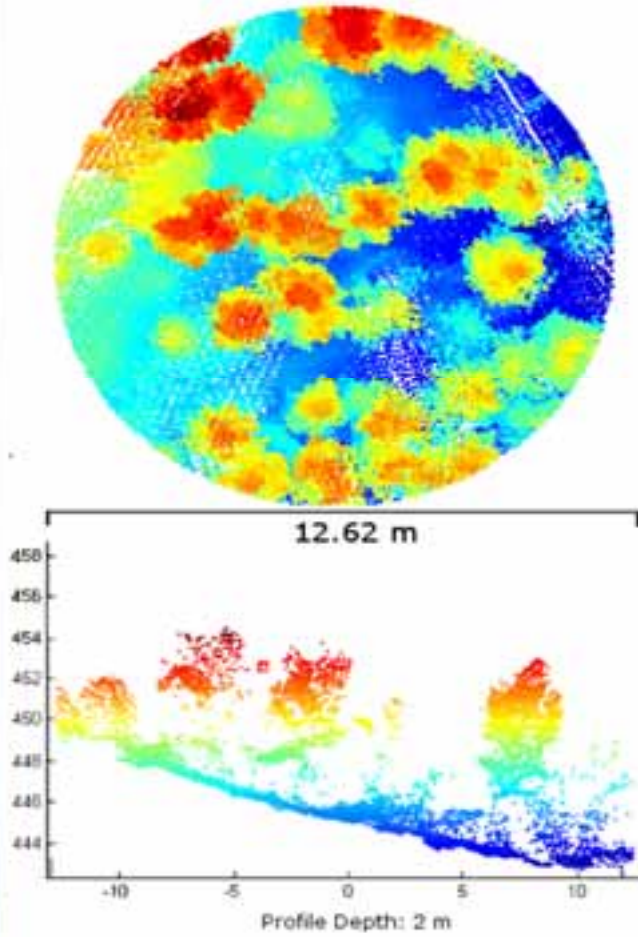
Wallace, L., Lucieer, A., Watson, C., & Turner, D. (2012). Development of a UAV-LiDAR System with Application to Forest Inventory. *Remote Sensing*, 4(6), 1519-1543. <http://www.mdpi.com/2072-4292/4/6/1519>

Farm, tree, shed trial

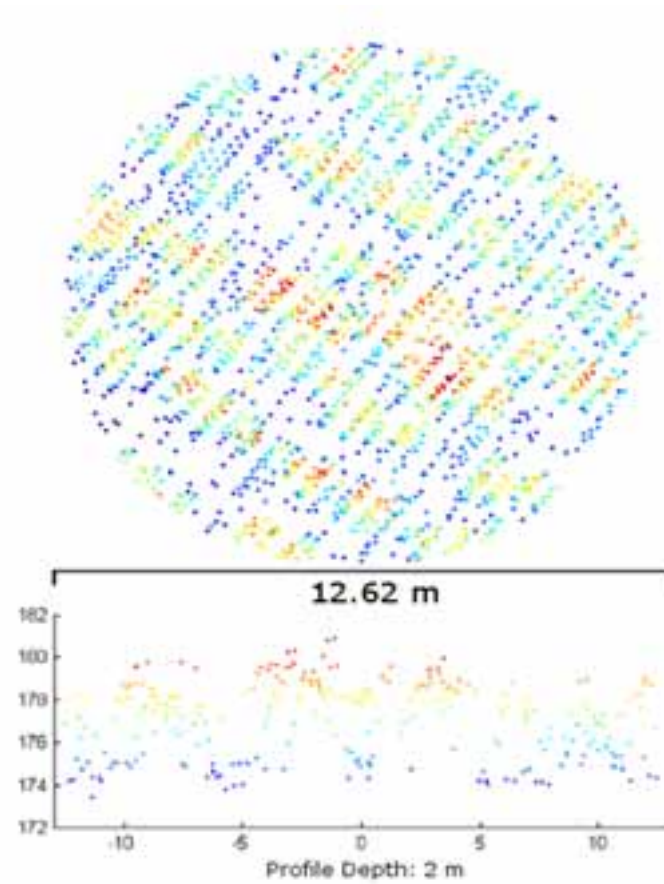




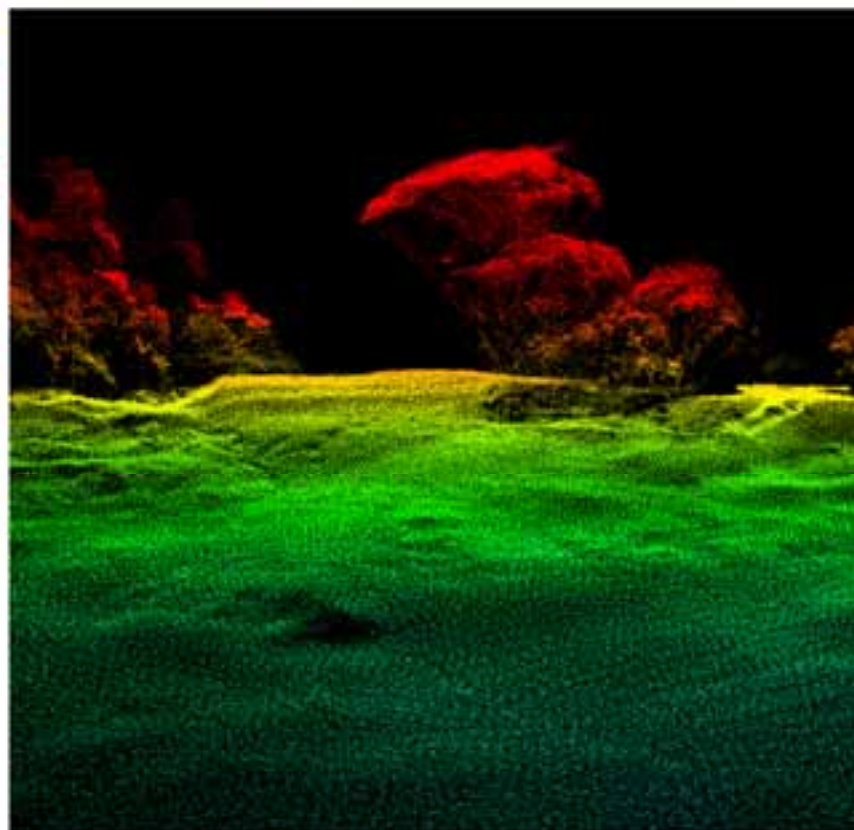
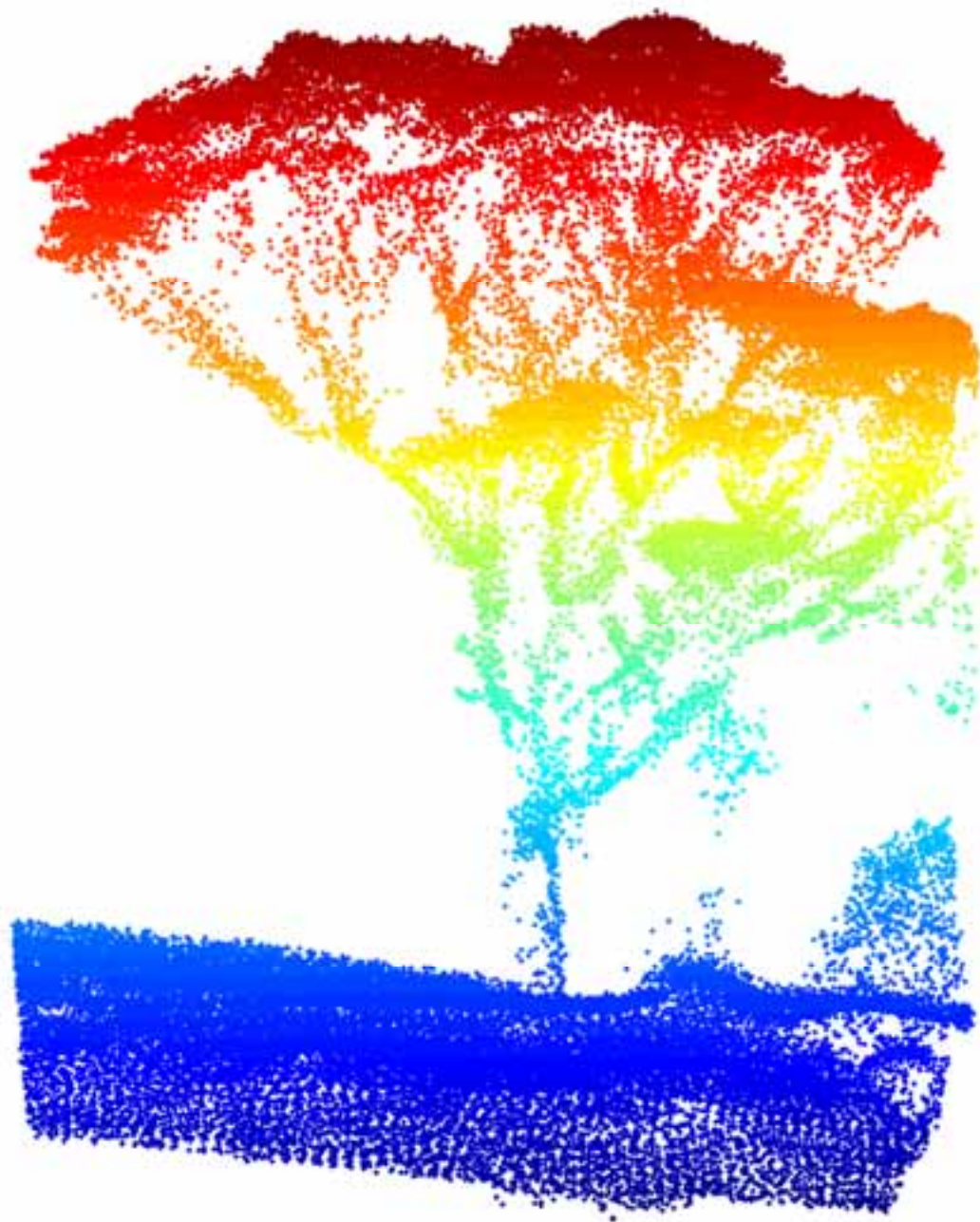
Point Density Comparison



LiDAR UAV: 80 pts/m²

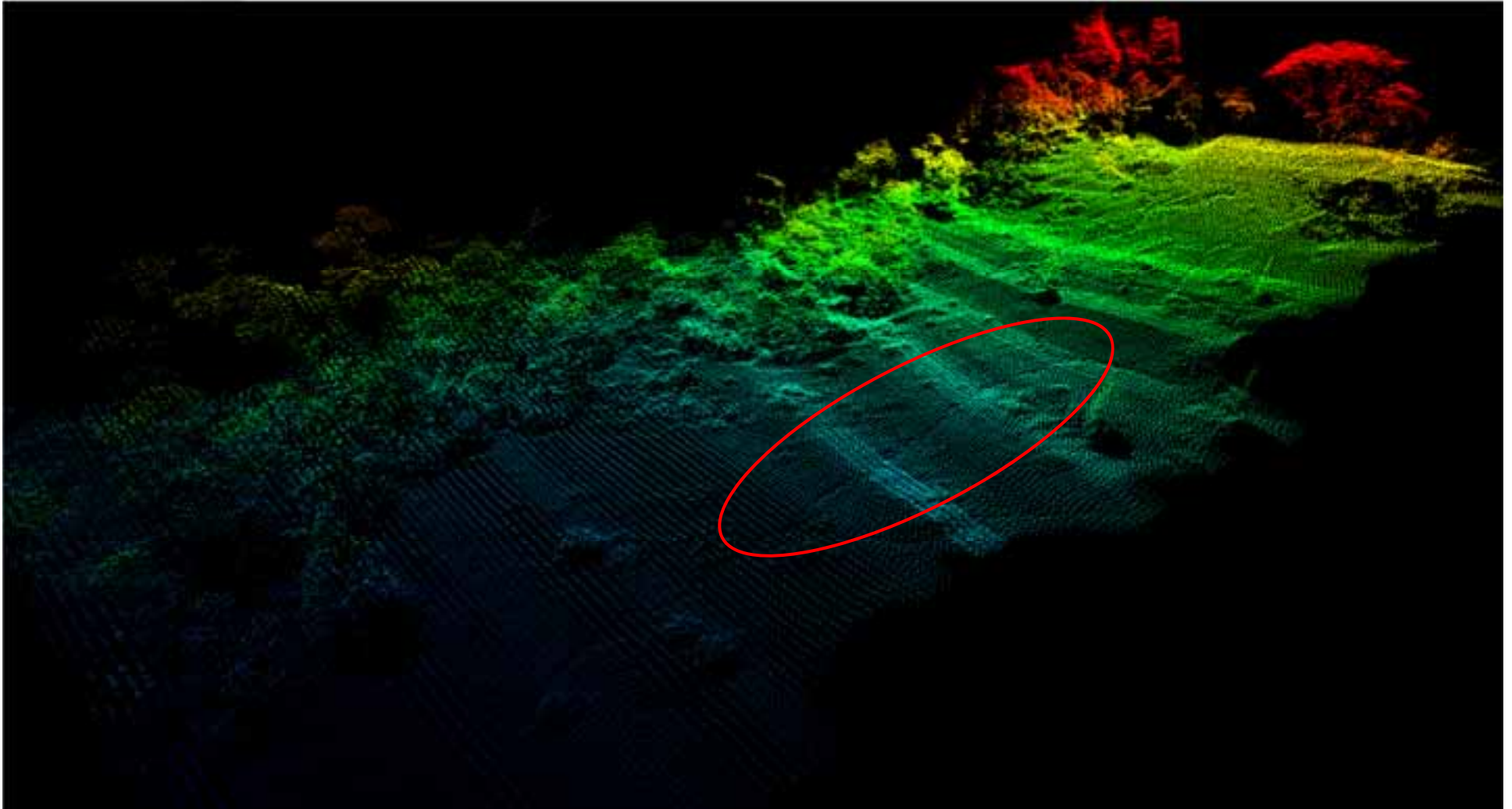


Manned LiDAR: ~8 pts/m²



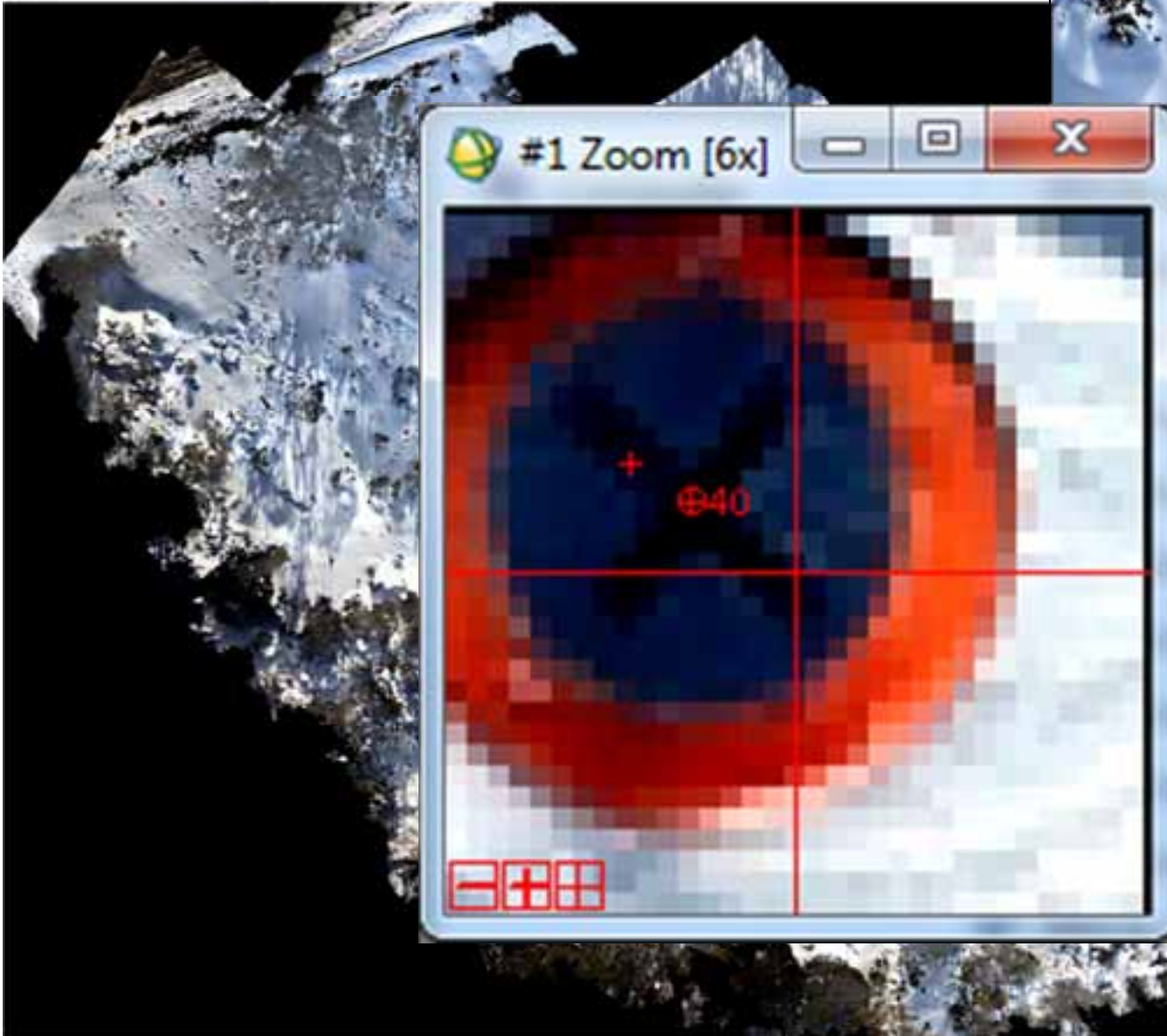


Footsteps in the snow





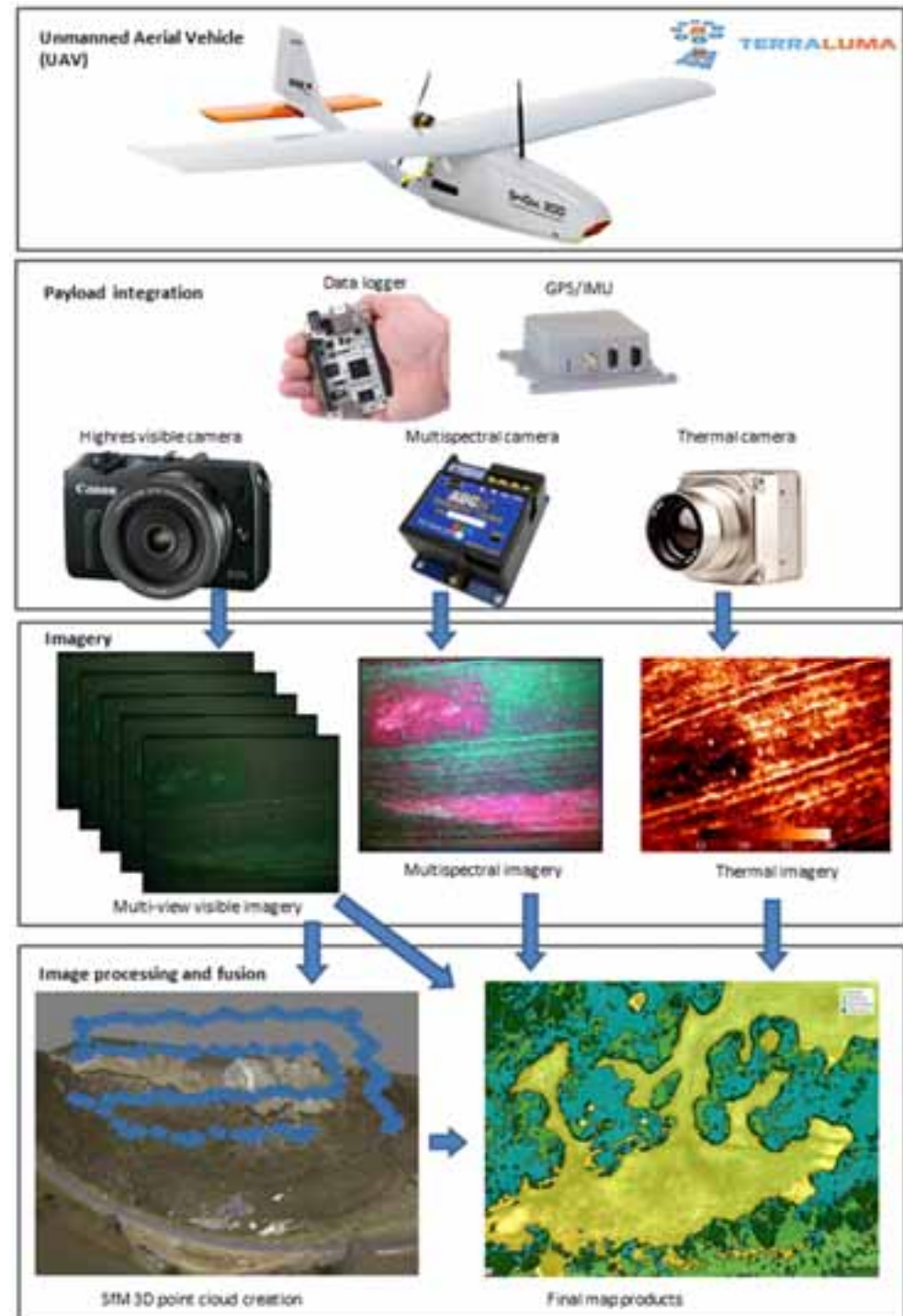
Orthophoto 1 cm





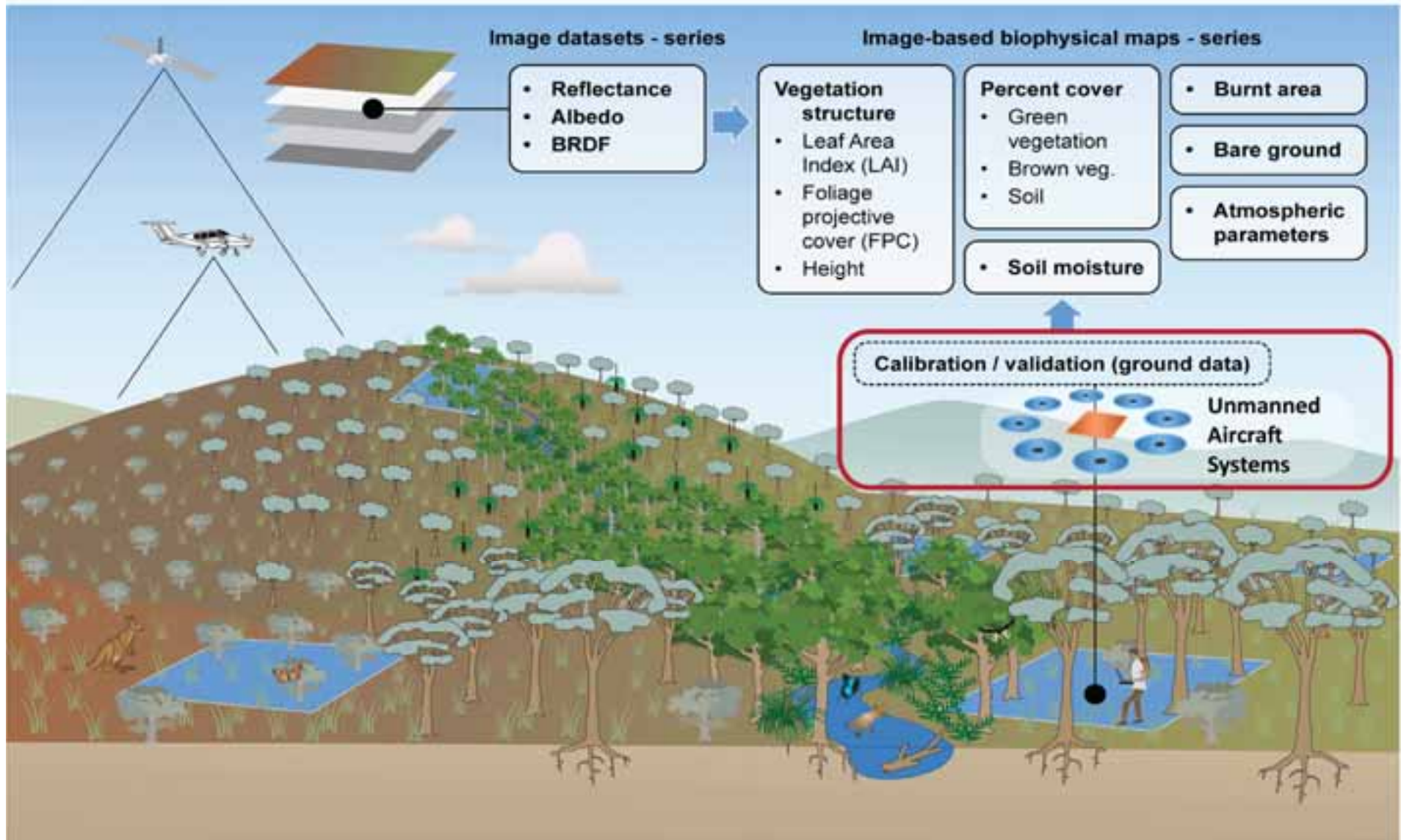
Future focus

- Hyperspectral: mapping of biophysical variables
- Multi-sensor UAV
- AirLIFT – active chlorophyll fluorescence
- Rigorous sensor calibration: physical measurements
- Image processing workflow: mission to products
- Precision agriculture applications
- Strengthen collaborations locally, nationally & internationally





Where do UAS fit?







Key challenges

- Robust sensor integration
- Sensor calibration
- Processing workflows: from raw data to reliable products
- Operational constraints: flight time vs payload vs operational ease of use
- Regulations
- Uptake and acceptance of technology by the public



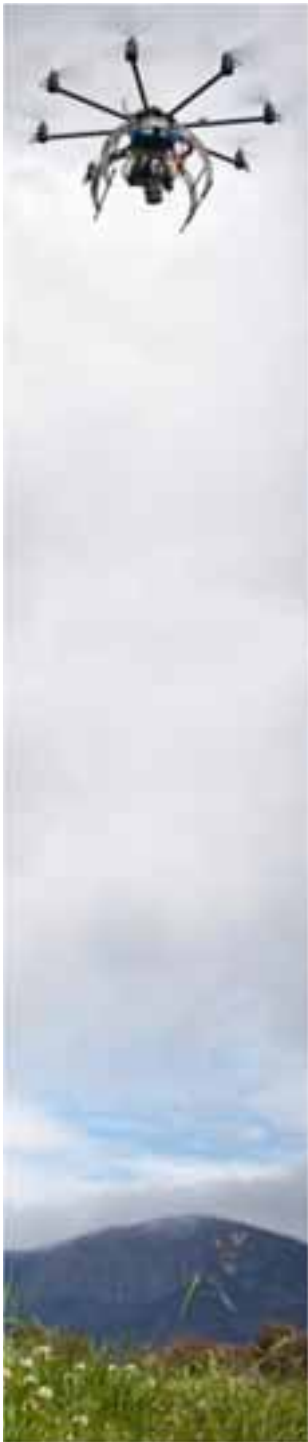
Conclusions


- UAS are an effective tool to capture a scale niche
- SfM and multi-view stereo techniques are accurate techniques for dense reconstruction of 3D geometry of landscape features
- Coregistration of ultra-high resolution RGB, DSM, multispectral, and thermal imagery is feasible
- Hyperspectral UAS prototype allows for 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!




Acknowledgements

- Joost Vandenabeele and Jean-Christophe Schyns (and Evelyn Stynen)
- Darren Turner, Steve Harwin, Josh Kelcey, Luke Wallace, Tony Veness, Dr Zbynek Malenovsky (UTAS)
- Drs Christopher Watson & Jon Osborn (UTAS)
- Prof Sharon Robinson and Diana King (UoW)
- Australian Antarctic Division (AAD)
- Australian Research Council (ARC)
- Winifred Violet Scott Trust
- Prof Richard Coleman (UTAS)
- Central Science Lab (CSL) & Engineering workshop
- Geoffrey Fenn (Greenability)
- School of Geography & Environmental Studies and UTAS support



 **TERRALUMA**

[HOME](#) [ABOUT](#) [APPLICATIONS](#) [EQUIPMENT](#) [PUBLICATIONS](#) [SERVICES](#) [CONTACT](#)



UNMANNED AIRCRAFT SYSTEMS FOR ENVIRONMENTAL REMOTE SENSING AND AERIAL SURVEYS

FRAMEWORK
SELECT A TOPIC TO FIND OUT MORE ABOUT TERRALUMA

APPLICATIONS

EQUIPMENT

PUBLICATIONS

SERVICES


NEWS
OUR RECENT ACTIVITIES

FIRST HYPERSPECTRAL FLIGHT IN ANTARCTICA
First ever successful SkyJib-Hyperspec [scientific flight](#) in Antarctica.
15 February, 2012

SKYJIB GOING HYPERSPECTRAL
[Resonant Photonics Hyperspec](#) sensor implemented on the [SkyJib](#) airframe flight-tested at [Ure farm](#).
8 November, 2012

UAV SPECIAL ISSUE
We recently published [four scientific papers](#) in the [UAV Special Issue](#) of the journal [Remote Sensing](#).
9 April, 2012

[POSTS FULL VERSION](#)



<http://www.terraluma.net>