

Vegetation mapping and monitoring using UAS systems

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Norut CryoWing RPAS Fleet

CryoWing Micro (2012-)

MTOW: 2-9 kg

Wingspan: 1.5-2.5m

Range: 30-100 km

Telemetry: UHF

Payload Capacity: 0.8-2 kg

Fuel: Li-Pol Battery

CryoCopter (2012-)

MTOW: 1-15 kg

Range: 2 km

Telemetry: UHF and C-Band

Payload Capacity: 0.2-5.0 kg

Fuel : Li-Pol Battery

CryoWing Mk 1 (2007)

MTOW: 32 kg

Wingspan: 3.8 m

Range: 500 km

Telemetry:

3G/GSM Iridium, UHF

Payload Capacity: 10 kg

Fuel Capacity: 4.5 kg petrol

CryoWing Mk 2 (2012)

MTOW: 60 kg

Vingespenn : 5.2 m

Range: 2000 km

Telemetry:

3G/GSM, Iridium, UHF

Payload Capacity: 15 kg

Fuel Capacity: 15 kg petrol



Aircraft used



BLOS Permits Iceland and Finland

Iceland:

Application sent 2 months ahead (have not seen a formal requirement. NOTAM issued 7 days before start of operation. Coordination with local AFIS in Egilsstaðir.

Finland:

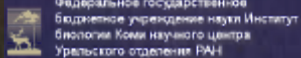
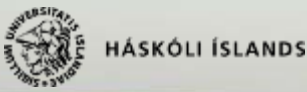
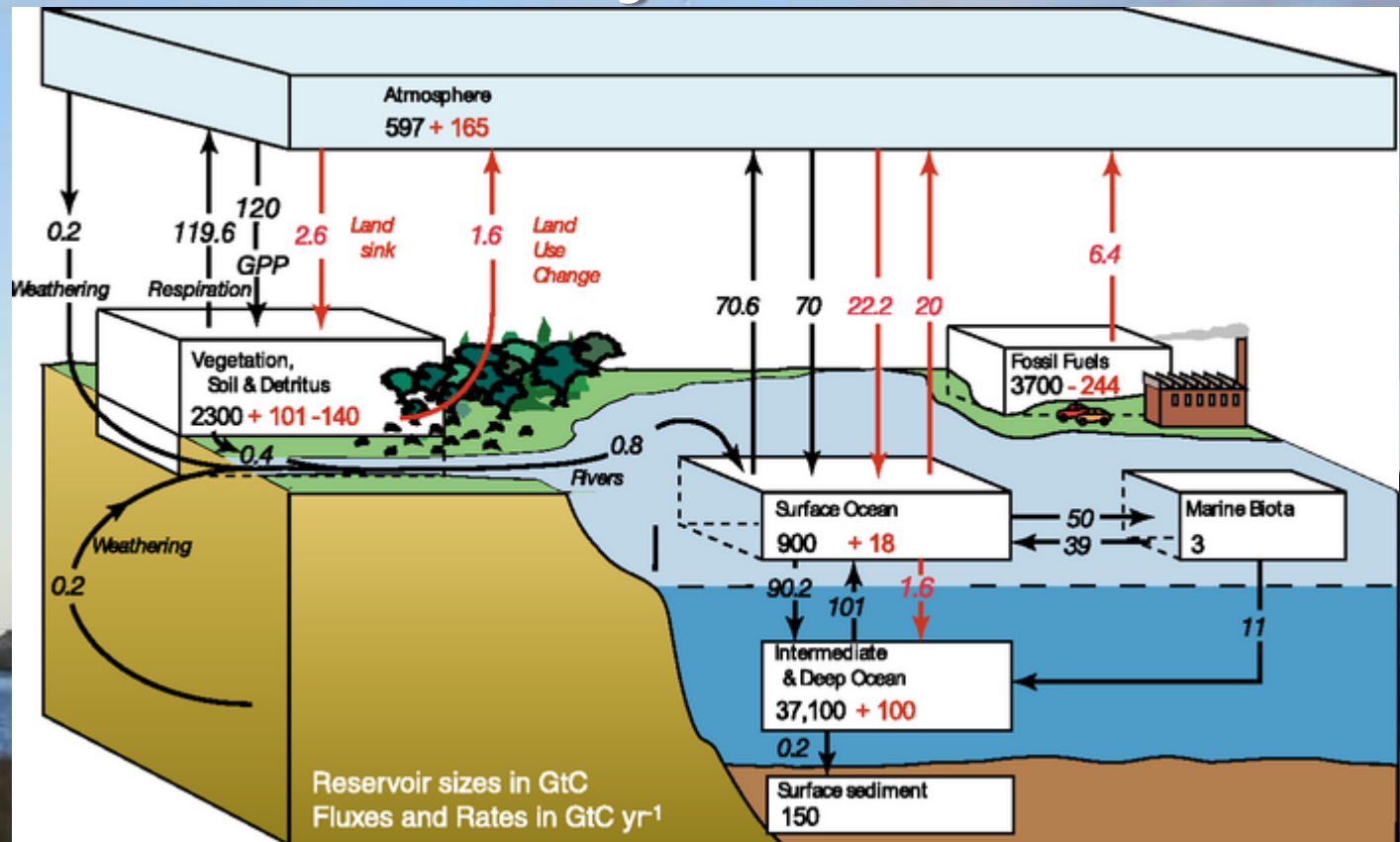
Airspace reservation form submitted 10 weeks prior to flight. Maximum 14 days reservation. Check activation of military danger areas prior to flights where overlapping with planned areas.

Used Norwegian operator permit as proof of competence

North State

A EU FP7 Space Project:

Enabling Intelligent Copernicus Services for Carbon and Water Balance Modeling of Northern Forest Ecosystems



Instrumentation

Rikola Hyperspectral Camera

From fixed wing limited to 15 channels due to collection time.

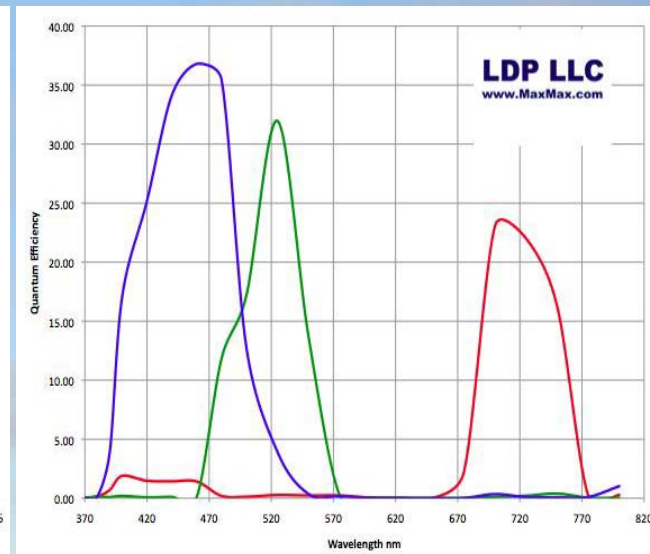
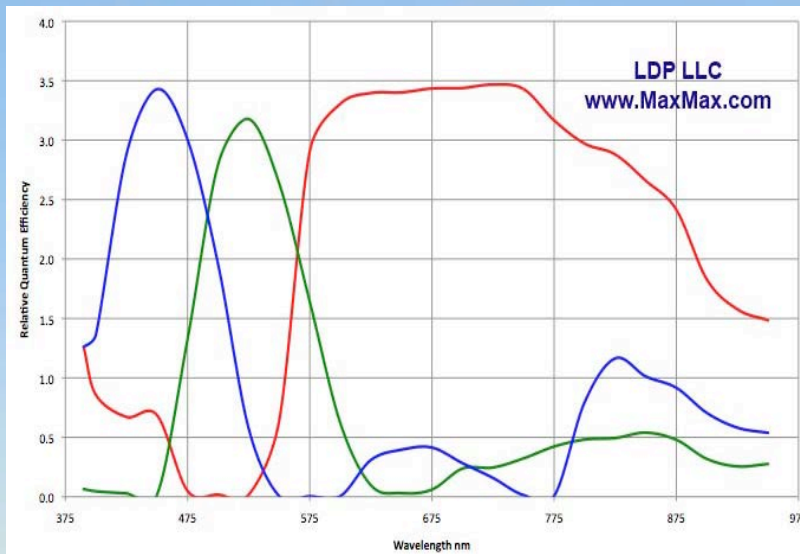
Time stamped and geo tagged by own GPS

PARAMETER	SPECIFIED VALUE	REMARKS
Horizontal FOV	> 37°	
Vertical FOV	> 37°	
Default Spectral Range	500-900 nm	Spectral range can be selected from range 400-950 nm with long and short pass filters
Min Spectral Resolution	10 nm, FWHM	For a high spectral resolution the spectral range needs to be limited.
Spectral Step	< 1 nm	
F-number	~2,8	
Image Sensor	CMV4000	CMOSIS CMOS image sensor with 5.5 μm x 5.5 μm pixels.
Image Sensor Pixel Clock Frequency	80 Megapixels/s	Readout of the whole 4 megapixel image takes 25 ms
Default Spectral Image Dimensions	1024 x 1024 pixels	
Max Spectral Image Dimensions	1024 x 1024 pixels	
Weight	< 700g	
Main Dimensions	80 mm x 97 mm x 159 mm	

Instrumentation

Canon Powershot SX260HS

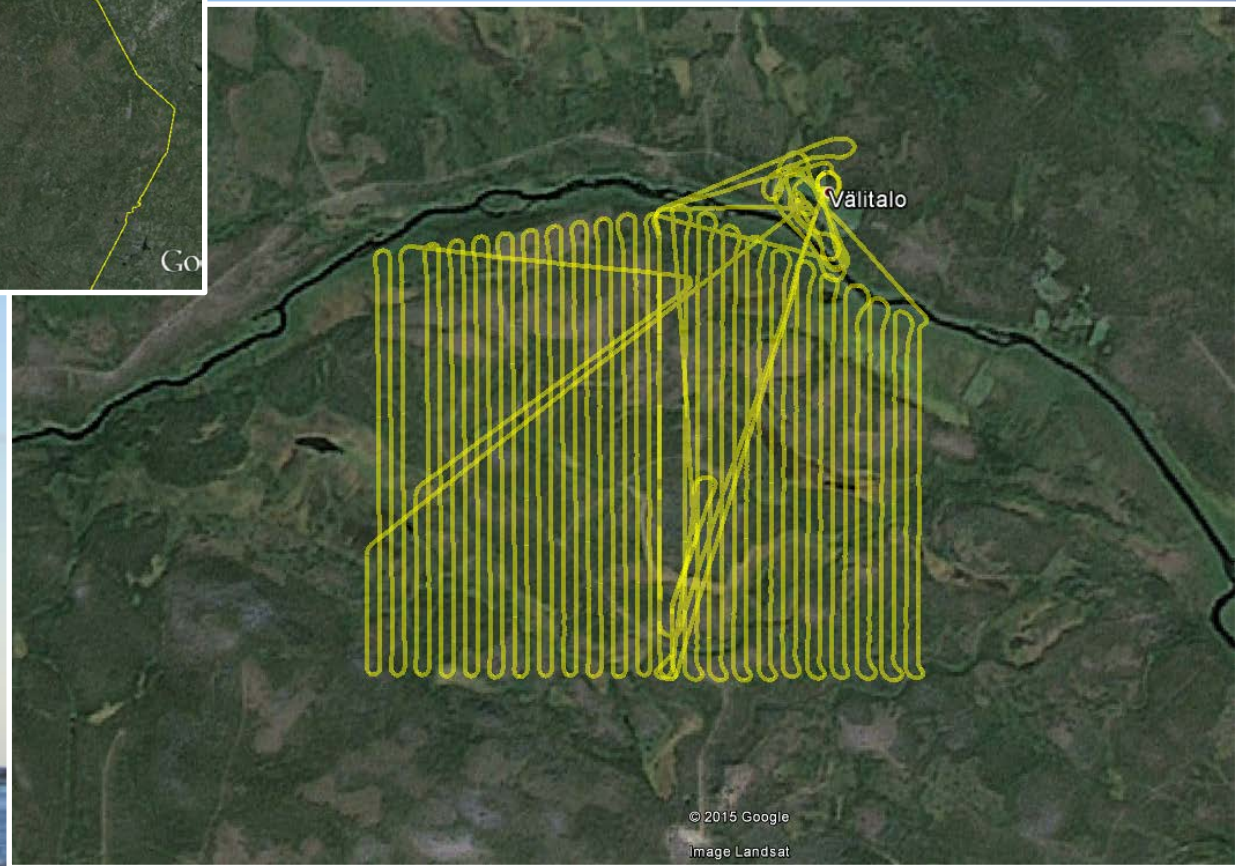
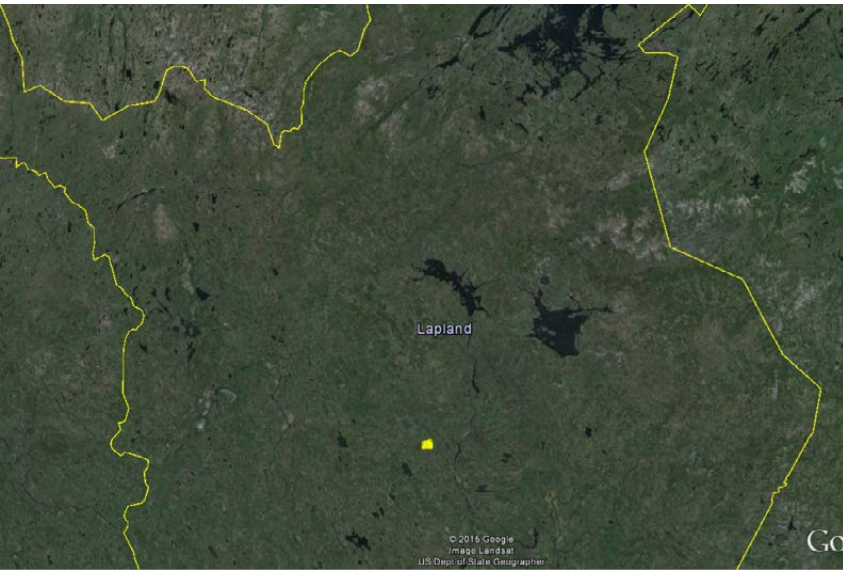
Red filter changed with NIR filter for blue NDVI measurements. More sensitive to atmospheric contribution



Parameter	Specified value
Camera model	Canon Powershot SX230HS NDVI w/GPS
Camera field of view	63 deg. i.e. 123x92 m. at 100 m altitude
Camera model	Canon Powershot SX260HS NDVI w/GPS
Camera field of view	67 deg. i.e. 137x101 m. at 100 m altitude
Exposure time	1/1000 second
Weight	230 grams incl. battery

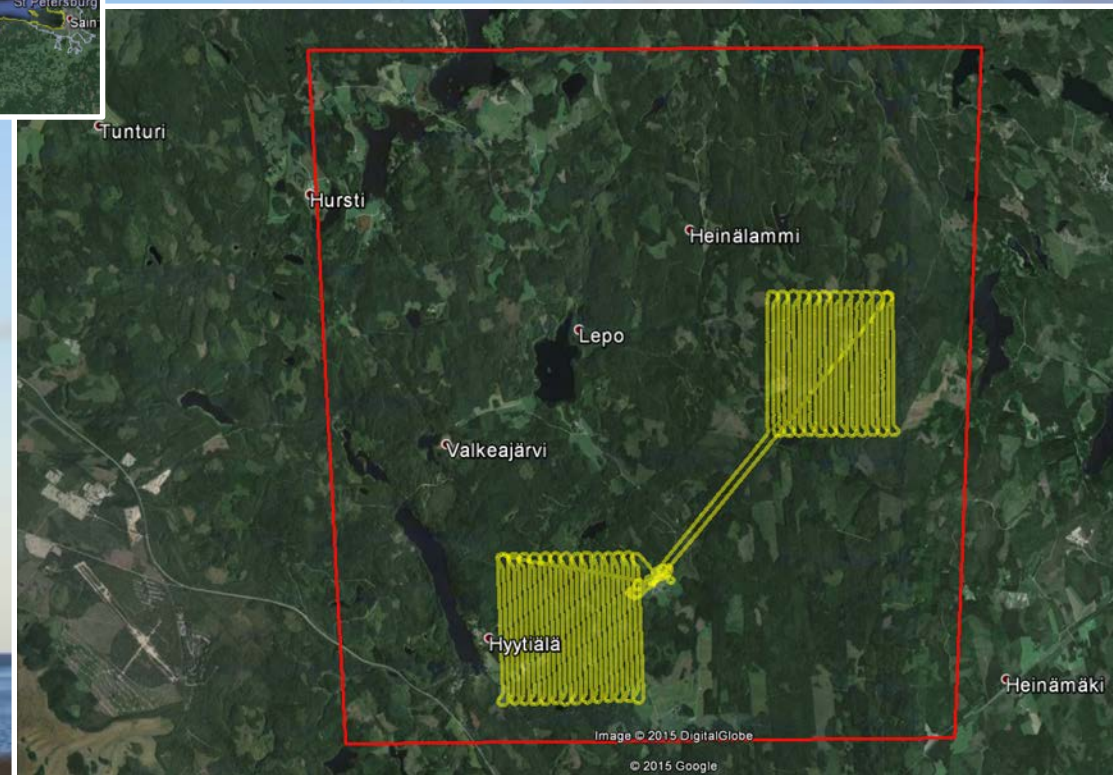
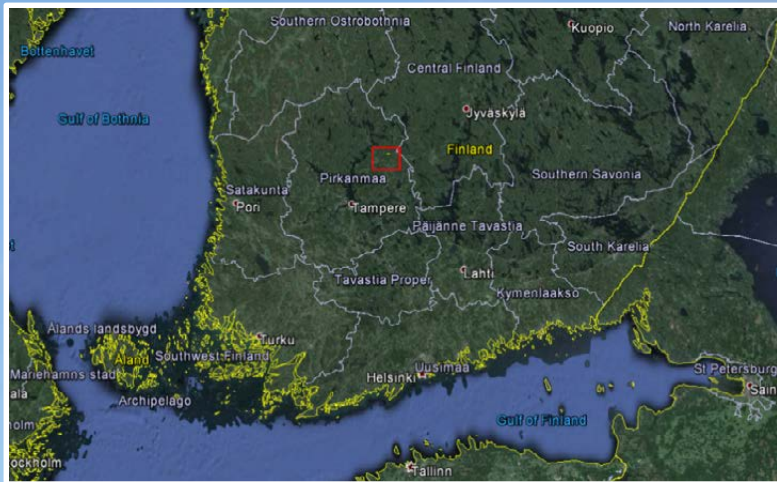
Areas Investigated with UAS

Sodankylä



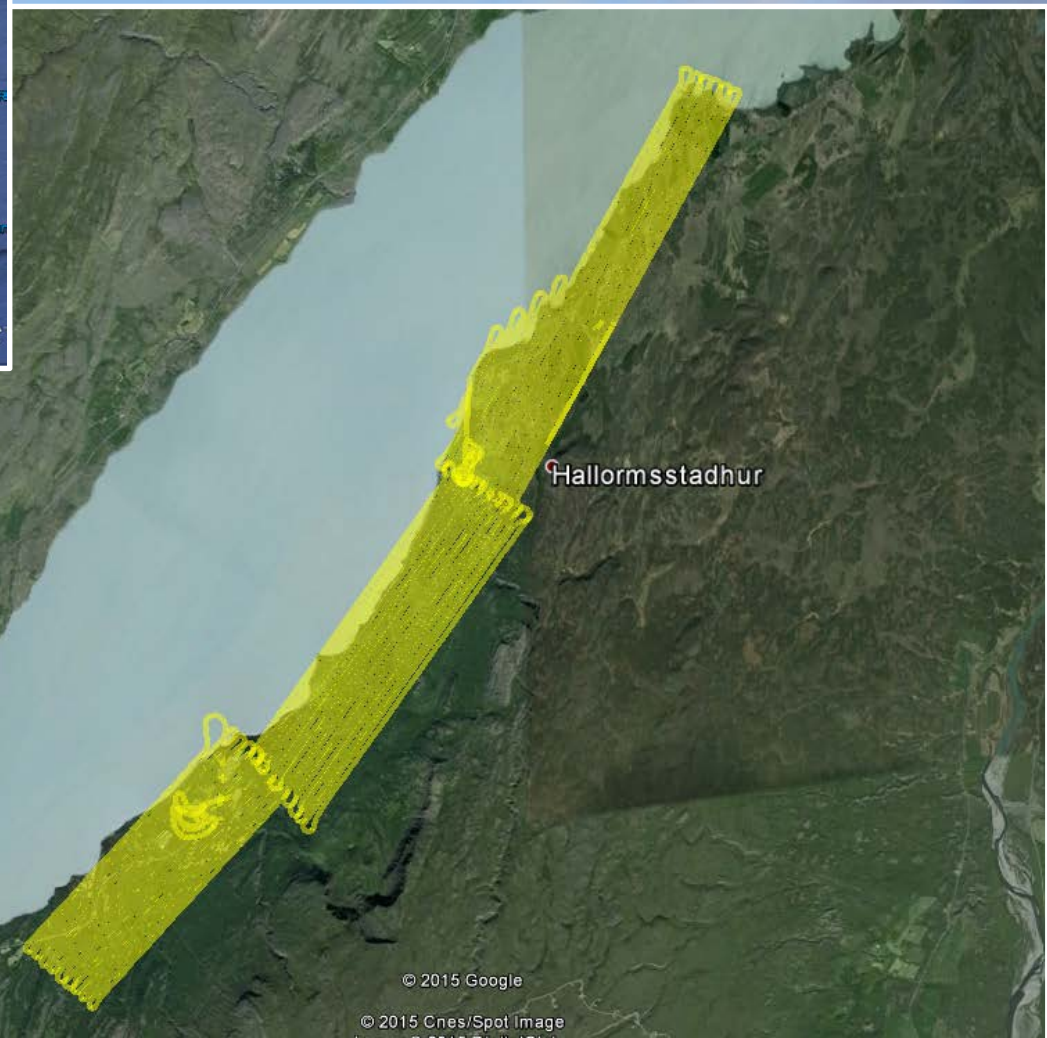
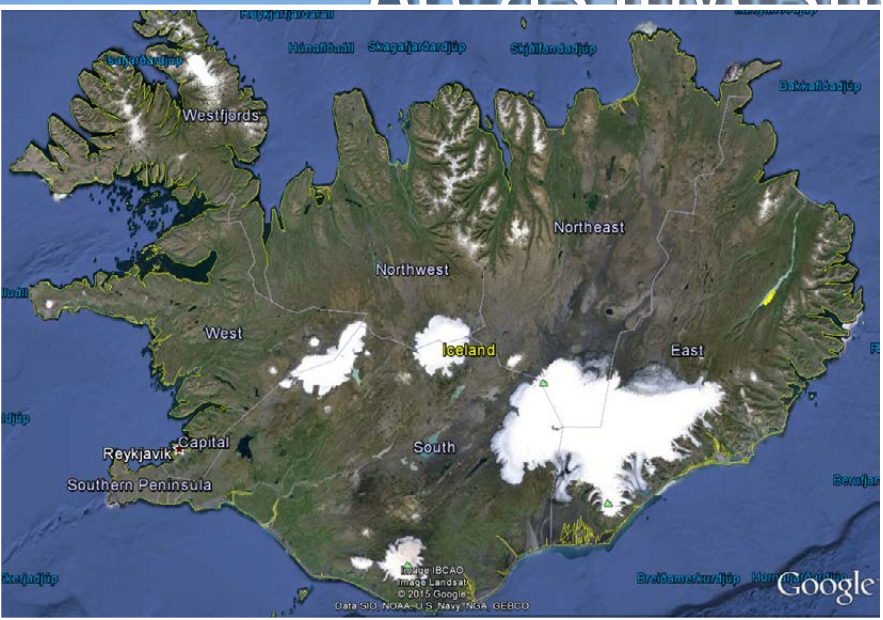
Areas Investigated with UAS

Hyytiälä



Areas Investigated with UAS

Hallormsstaður



Measurement Goals

HYPERSENSPECTRAL AND BLUE NDVI RPAS DATA

<p>FOREST AREA</p>	<p>Aircraft data: Rikola hyperspectral camera and Canon EOS M or Canon SX230HS Maxmax blue NDVI camera Methods: Spectral and spatial analysis Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland</p>
<p>TREE SPECIES, PFT (PLANT FUNCTIONAL TYPE)</p>	<p>Aircraft data: Rikola hyperspectral camera and Canon EOS M or Canon SX230HS Maxmax blue NDVI camera Methods: Analysis of a combination of Hyperspectral data and very high resolution RGB images. Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>
<p>TREE HEIGHT</p>	<p>Aircraft data: Canon EOS M or Canon SX230HS Maxmax blue NDVI camera. Methods: 3D model reconstruction using bundle adjustment techniques on cm resolution RGB data Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>

HYPERSENSPECTRAL AND VISIBLE RPAS DATA

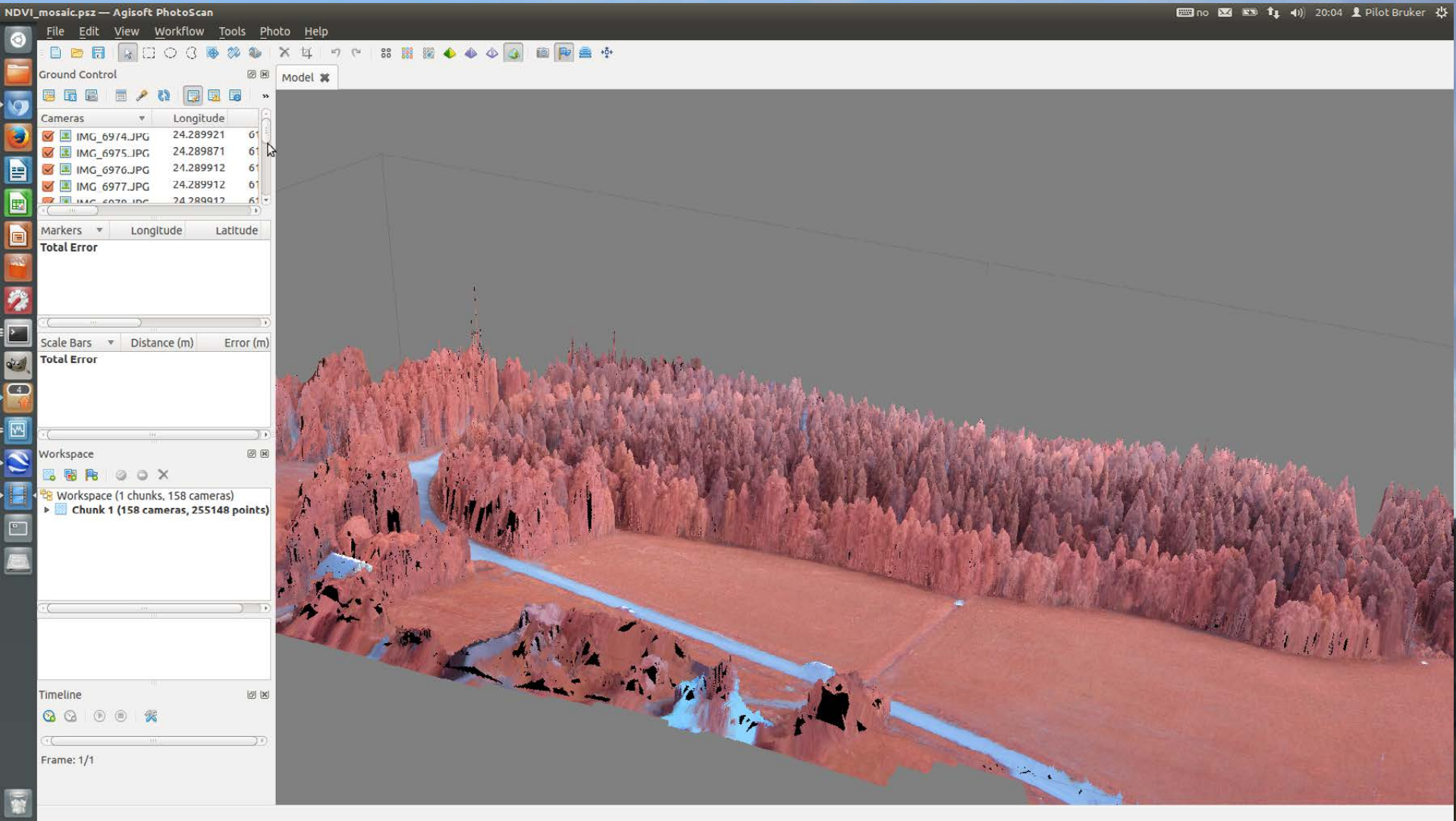
<p>fAPAR (Fraction of Absorbed Photosynthetically Active Radiation)</p>	<p>Aircraft data: Rikola hyperspectral camera Methods: Compute fAPAR using the hyperspectral data. Make custom products aimed at Sentinel 2, MODIS, SPOT-5, RapidEye, Landsat-8 by matching these channels with the Rikola hyperspectral Imager Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>
<p>LAI (LEAF AREA INDEX)</p>	<p>Aircraft data: Rikola hyperspectral camera and Canon SX230HS Maxmax blue NDVI camera Methods: analysis based on vegetation indices: NDVI and EVI with cm resolution. Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>
<p>GROWING STOCK VOLUME</p>	<p>Aircraft data: Rikola hyperspectral camera and Canon EOS M or Canon SX230HS Maxmax blue NDVI camera Methods: Model-based inversion based on species classification by optical data and canopy sizes. Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>
<p>PRI (PHOTOCHEMICAL REFLECTANCE INDEX)</p>	<p>Aircraft data: Rikola hyperspectral camera Methods: Match PRI channels with hyperspectral imager (531 and 570nm). Spatial coverage: Several rectangles of 1-2 sq km over test sites in the Hyytiälä area and test site at Hallormsstaður in Eastern-Iceland.</p>

Channel Selection, 2014

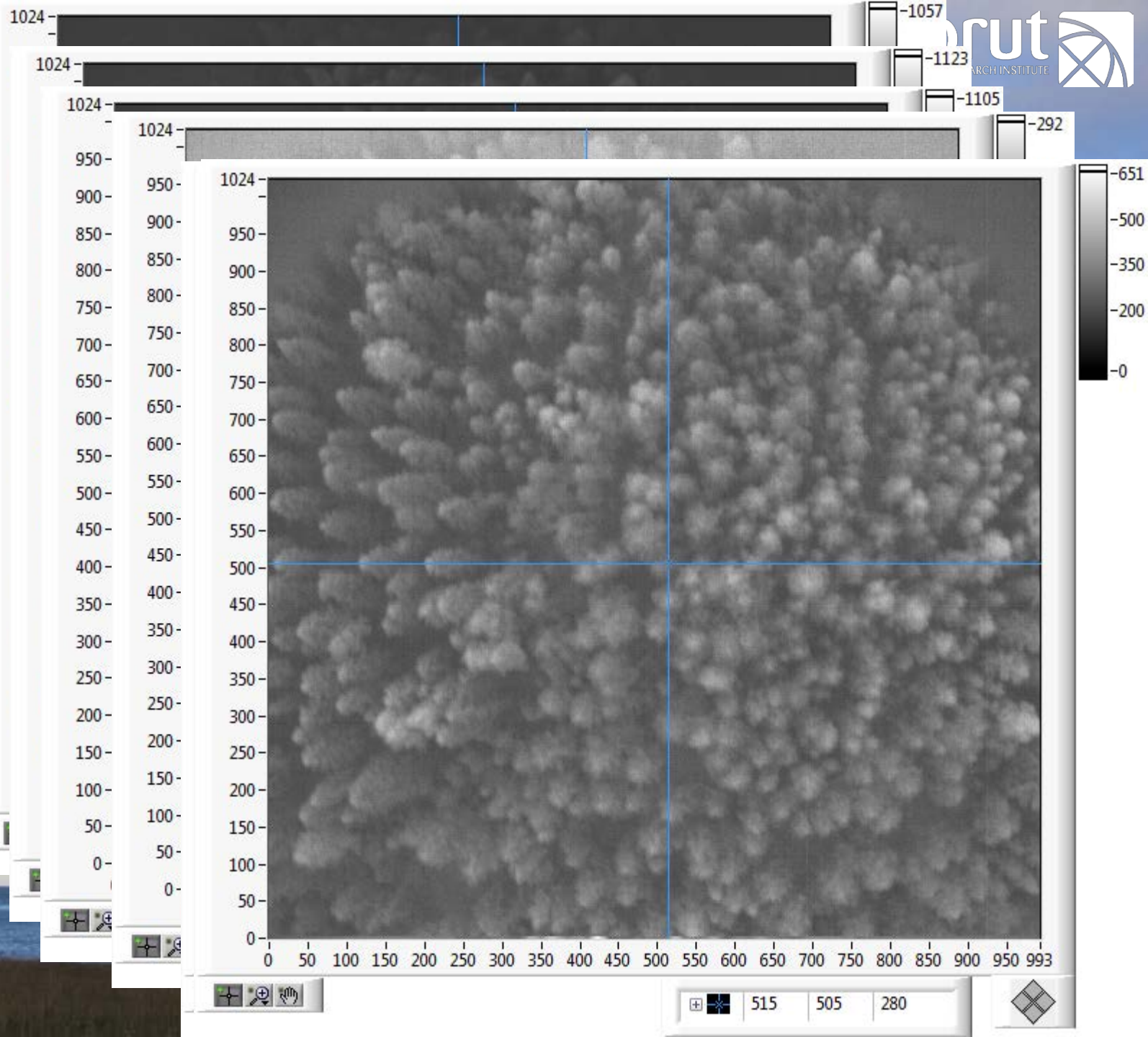
Changed slightly in 2015 to match Sentinel-2

Product/index	Satellite channels	Rikola channels (nm)
Phenology, LAI/NDVI, bNDVI	Modis 620-670, 841-876 AVHRR 580-680, 725-1080	500, 510, 645, 858
fAPAR	Modis 620-670, 841-876	645, 858
PRI		531, 570
NIR drop		700, 710, 720, 730, 745, 750, 760, 775, 790

3D processing of NDVI data

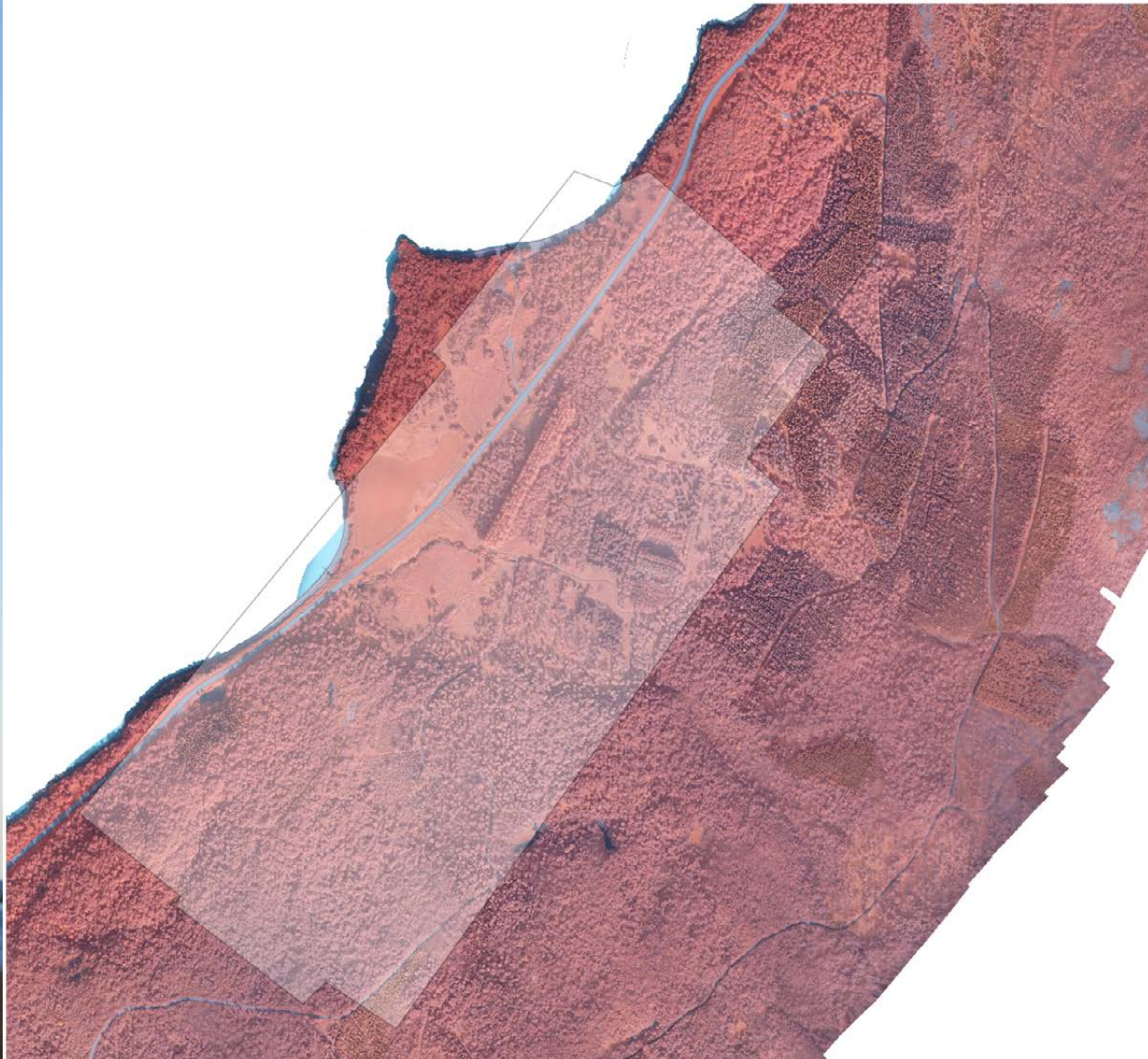




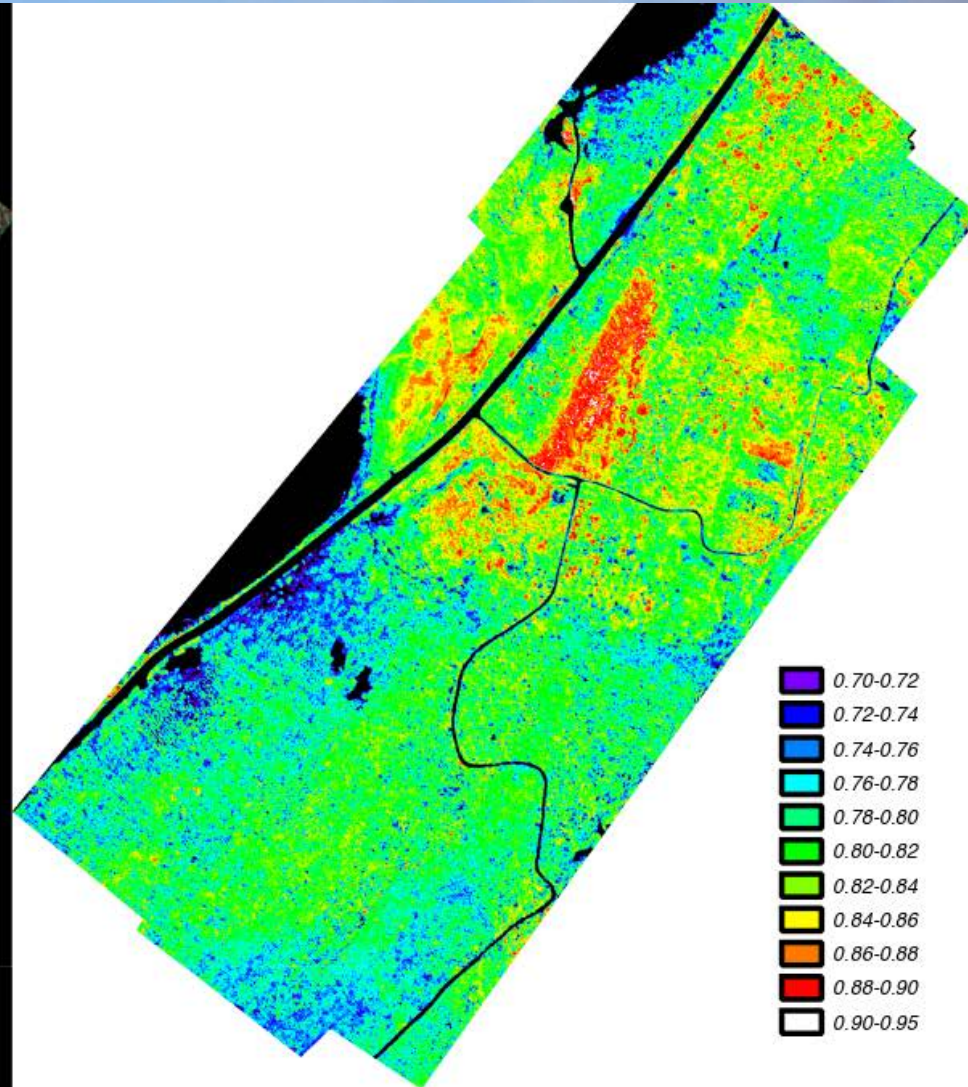
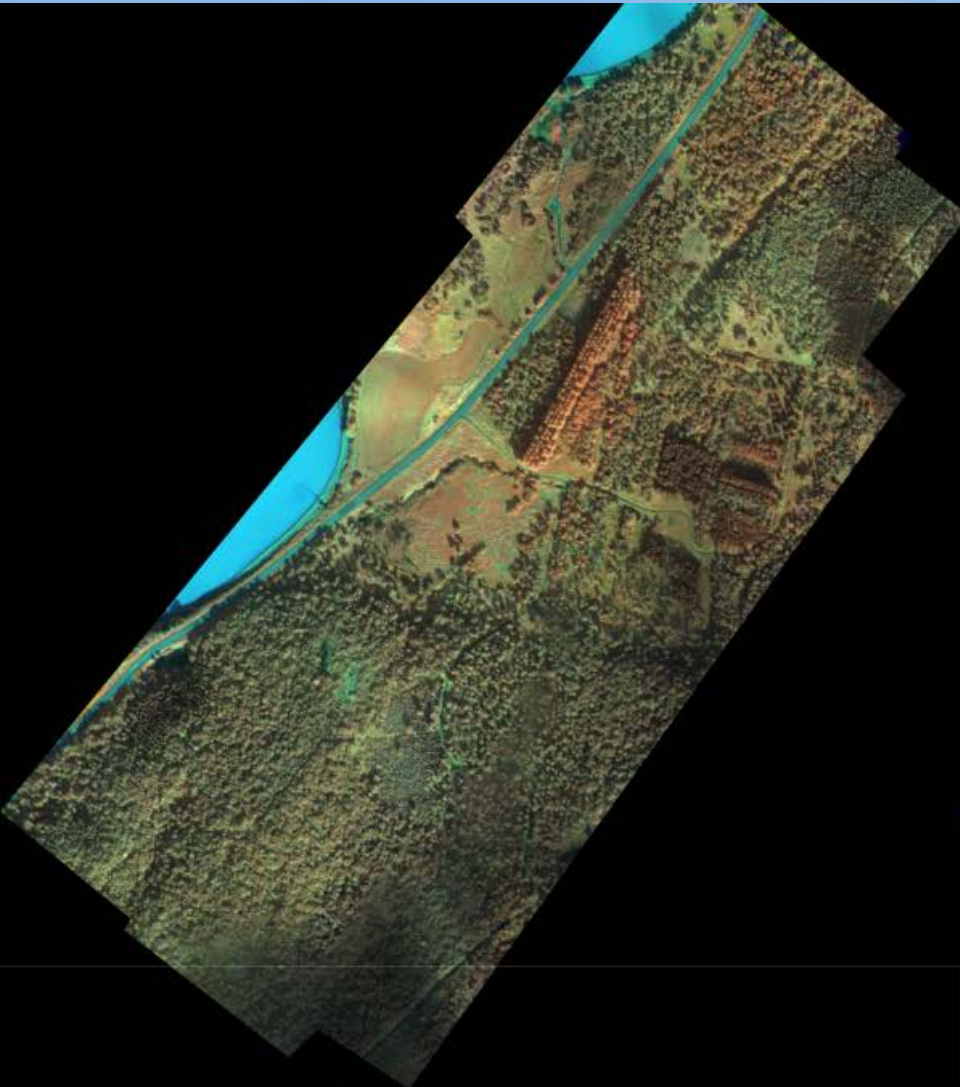


2014
Channels
500
510
531
570
645
700
710
720
730
745
750
760
775
790
858
5ms int

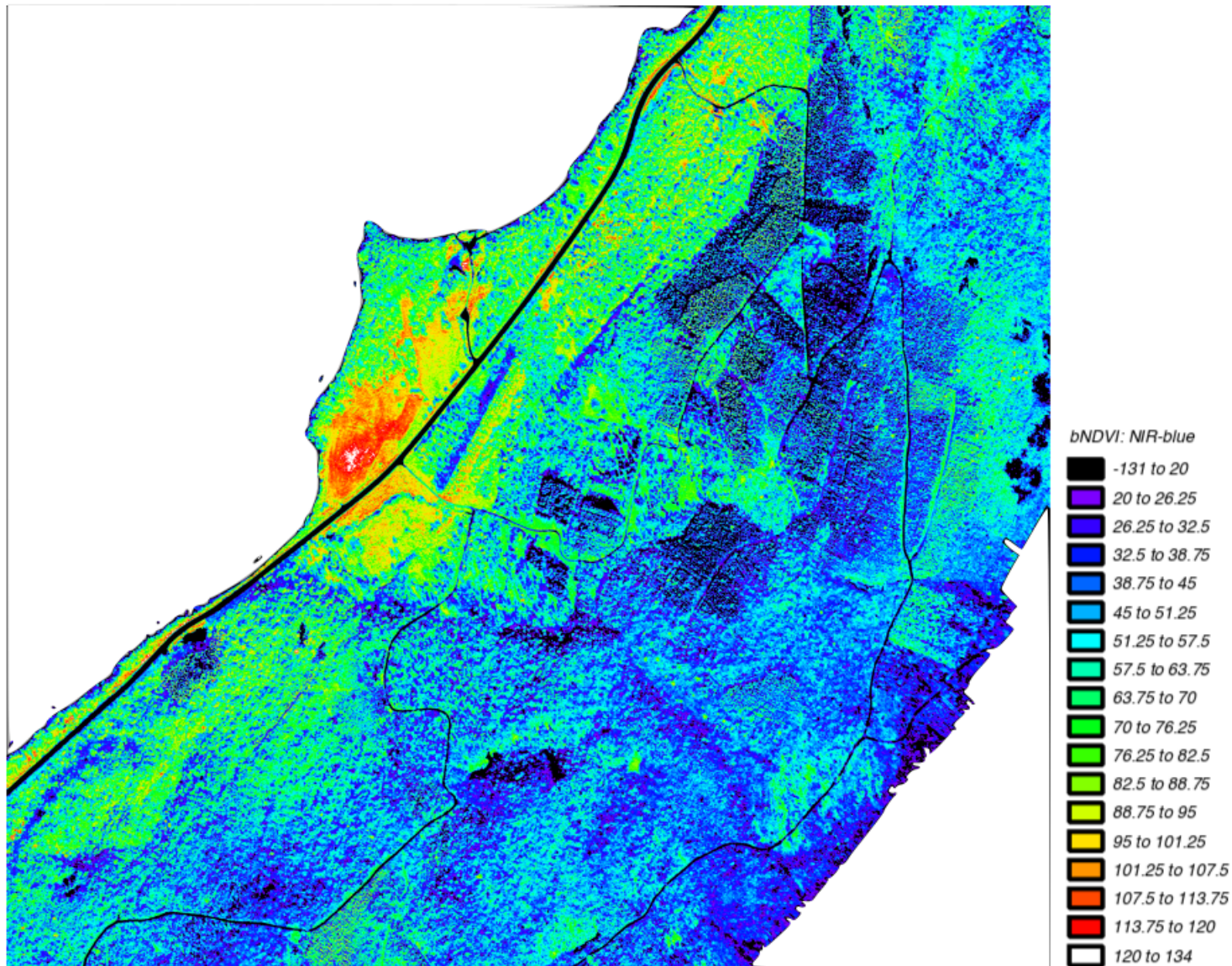
Some 2015 Iceland Results

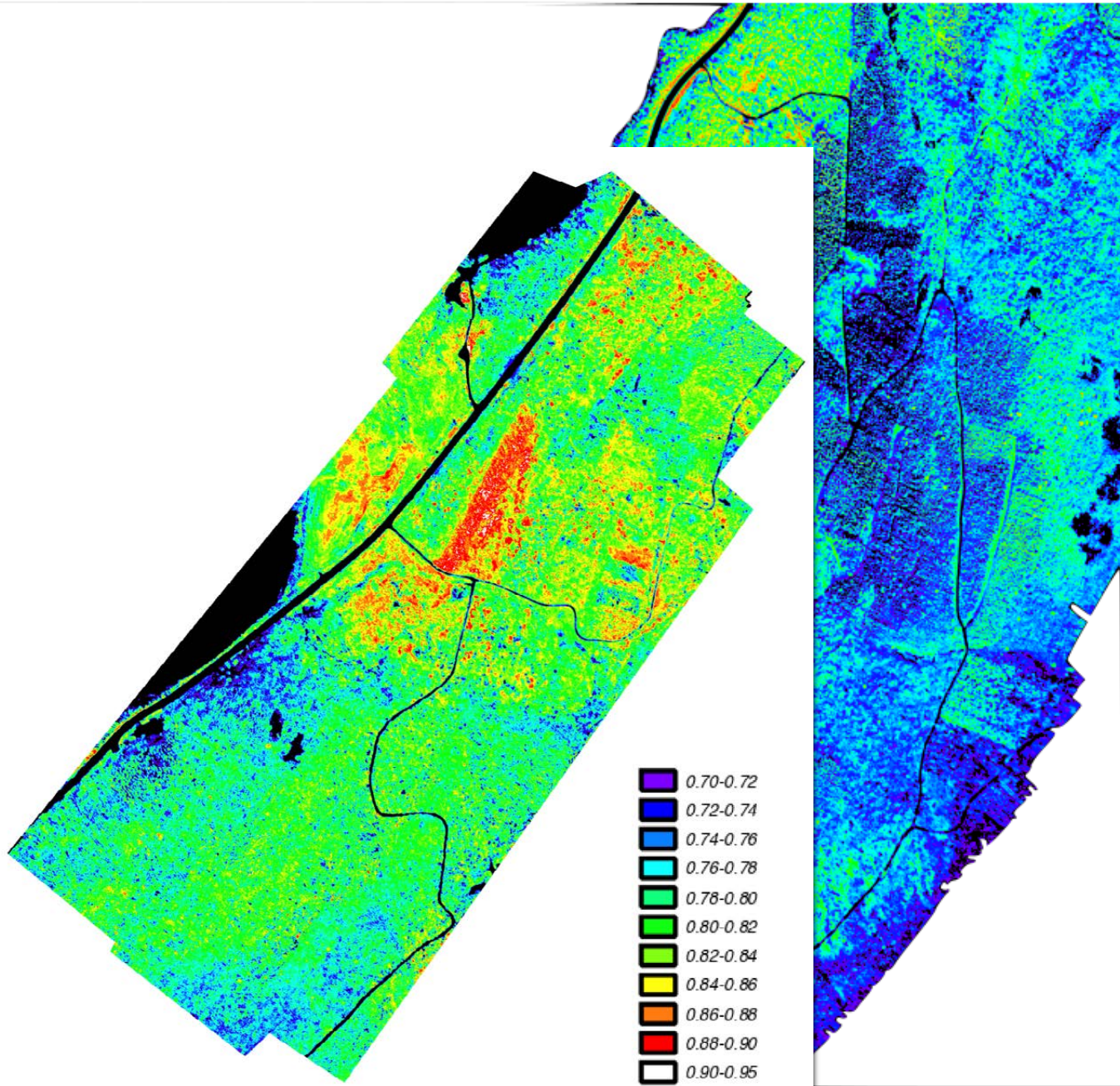





NDVI Hyperspectral Camera





















Blue NDVI Camera





-  0.70-0.72
-  0.72-0.74
-  0.74-0.76
-  0.76-0.78
-  0.78-0.80
-  0.80-0.82
-  0.82-0.84
-  0.84-0.86
-  0.86-0.88
-  0.88-0.90
-  0.90-0.95

- bNDVI: NIR-blue*
-  -131 to 20
 -  20 to 26.25
 -  26.25 to 32.5
 -  32.5 to 38.75
 -  38.75 to 45
 -  45 to 51.25
 -  51.25 to 57.5
 -  57.5 to 63.75
 -  63.75 to 70
 -  70 to 76.25
 -  76.25 to 82.5
 -  82.5 to 88.75
 -  88.75 to 95
 -  95 to 101.25
 -  101.25 to 107.5
 -  107.5 to 113.75
 -  113.75 to 120
 -  120 to 134



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- ***Develop new methodologies and technologies for remote sensing from unmanned aircraft.***
- ***Contribute to increased safety and security in search and rescue, fire and police operations***
- ***Collaborate with commercial partners and contribute in the development of new commercial applications and services and the establishment of a commercial unmanned aircraft industry in Norway***
- ***Contribute to coordination of unmanned aircraft activities across the Arctic, provide education and training for unmanned aircraft pilots, operators, and analysts.***
- ***Contribute to the development of certification and licensing of equipment and personnel***

- ***Director: rune.storvold@norut.no, Ph.: +47 934 16 169***

- ***Will be open for new partners and affiliates.***

Thank you!

ASUE



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