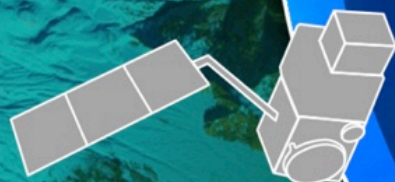lpve

→ LAND PRODUCT VALIDATION AND EVOLUTION 2018

27 February – 1 March 2018
ESA–ESRIN | Frascati (Rome), Italy

ESA UNCLASSIFIED - For Official Use

European Space Agency

A Hyperspectral Mission for Sentinel-2 Data Product Validation of a Northern Ombrotrophic Bog

Soffer R. J., Arroyo-Mora J.P., Kalacska M., White, H.P., Ifimov G., Leblanc G., Nazarenko, D.

- ➤ Interest in satellite-based remote sensing of northern ecosystems as these are going to be highly affected by climate change

- ➤ Upcoming campaigns such as the Arctic-BOreal VuInerability Experiment (ABOVE) and the Arctic –COastal Land Ocean inteRactionS (Artic-COLORS) campaigns would require baseline data

- ➤ With the launch of Sentinel 2A in June 2015, significant interest was expressed in being able to validate S2 data products at northern latitudes

- ➤ Due to the remote and challenging environment of most northern ecosystems, significant challenges are involved in undertaking airborne and field work in support of such validation work, the Mer Bleue Conservation Area identified as a surrogate site.

NRC·CNRC

Peatland distribution in Canada
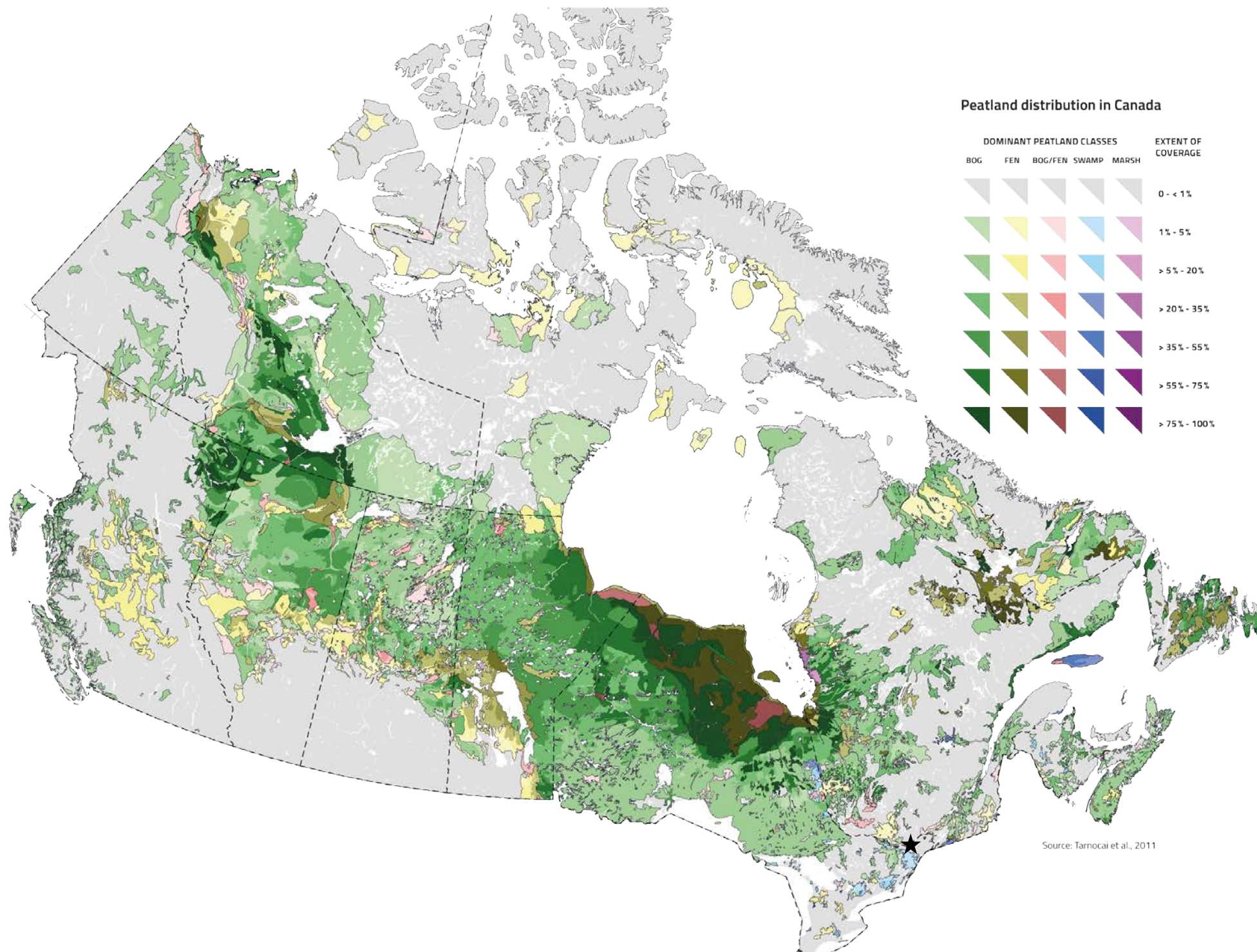
- Peatlands are wetlands with at least 40 cm of accumulated peat (3% global surface).

- Peatlands play a significant role in the global carbon cycle and climate regulation (30% C).

- Peatlands cover 113.6 M hectares in Canada (13% surface area)

- Response to climate change?

NRC·CNRC

Mer Bleue Bog – Its Suitability as an Arctic Peatland Surrogate (45.30°N, 75.61°W)

- Ombrotrophic Peatland(rain fed)

- Ramsar Site

- Representative of northern boreal peatlands

- 35 km² area suitable for Landsat 8/Sentinel-2 comparisons

- Proximity to NRC aircraft home base (13 km) and ground support teams

- Mer Bleue Peatland Observatory (MBPO)
  - Existing infrastructure and scientific interest
  - Boardwalk access
  - Flux tower
  - 150 scientific journal articles
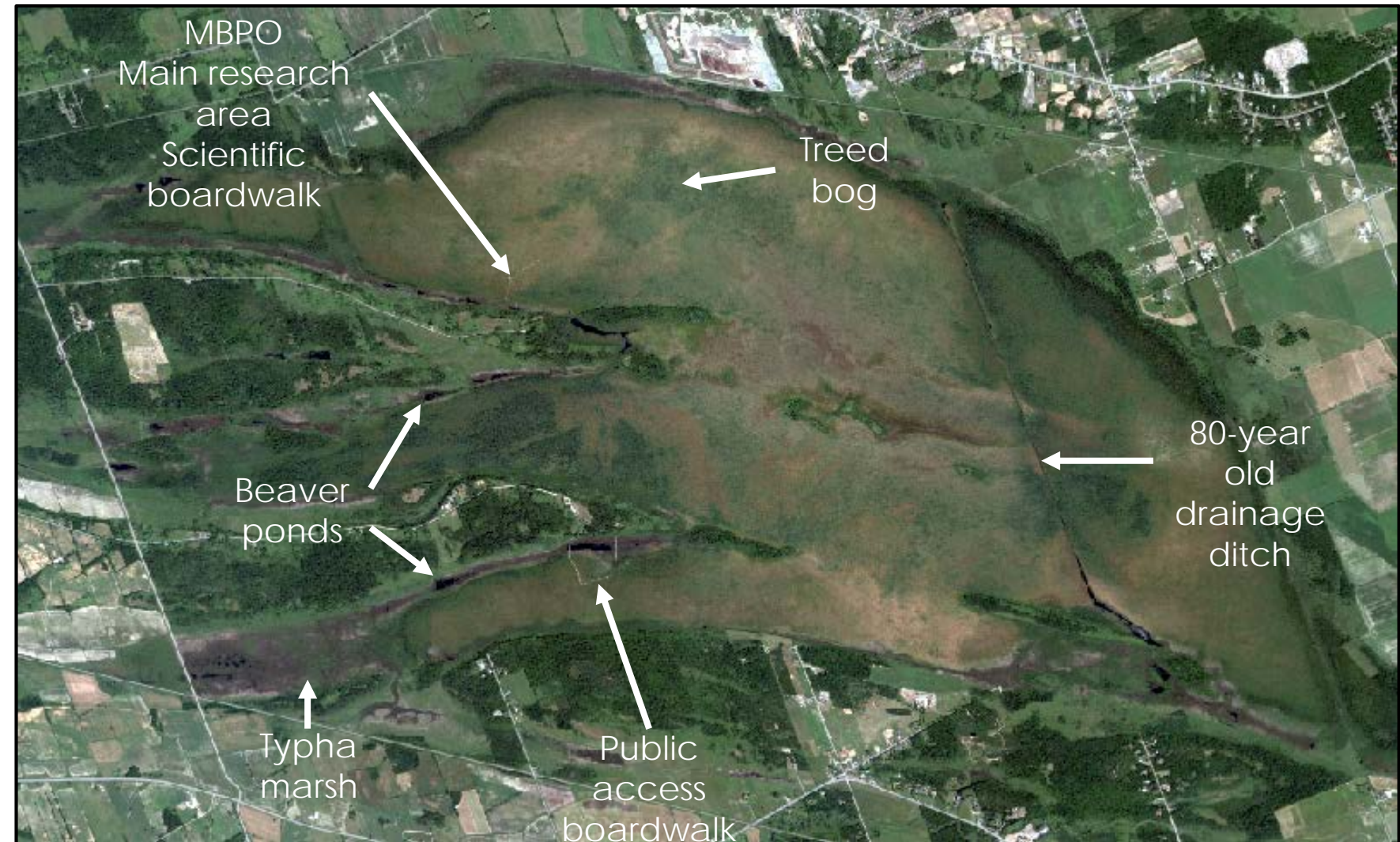
Mer Bleue Arctic Surrogate Simulation Site → MBASSS

ESA SPPA IDEAS+ Funded Project → MBASSS Sentinel-2 Data Product Validation Project

MBASSS Sentinel-2 Data Product Validation Project - Objectives

➢ Acquisition of clear sky, multi-temporal, high resolution airborne hyperspectral imagery of the Mer Bleue Peatland
- ➢ full mosaics as often as possible covering as much as possible of the growing season given project budget and time limitations
- ➢ additional acquisitions of primary flight line (MB-E)
- ➢ coincident with Sentinel-2 whenever possible

➢ Acquisition of field spectroscopy data of primary peatland plant physiognomies at the MBPO and public boardwalk.

➢ Acquisition of Airborne Hyperspectral Imagery & field spectra of a nearby cal/val site
- ➢ in coordination with the Mer Bleue flight lines and field work

➢ Optimization/validation of our field spectroscopy data results

➢ Simulations of S-2A imagery

➢ Validation of S-2A data products against data products derived from simulations

NRC·CNRC

Airborne Hyperspectral Imagery on NRC Twin Otter Turbo Prop

CASI-1500
Compact Airborne Spectrographic Imager

Vis/NIR (365 nm - 1050 nm)

Pushbroom

39.9° FOV

1.2 mrad IFOV

f3.5 - f18.0

1500 spatial pixels

288 spectral channels

2.4 nm SSI / 3.2 nm FWHM

14 bit

Variable Frame Rate

CMIGIT III GPS/INS

SASI-644
Shortwave Airborne Spectrographic Imager

SWIR (850 nm - 2500 nm)

Pushbroom

39.7° FOV

1.14 mrad IFOV

f1.8

644 spatial pixels

160 channels

~ 10.5 nm SSI / < 17 nm FWHM

14 bit

16.7 ms Frame Rate

CMIGIT III GPS/INS

SASI

CASI

NRC·CNRC

CASI
Red - 770 nm
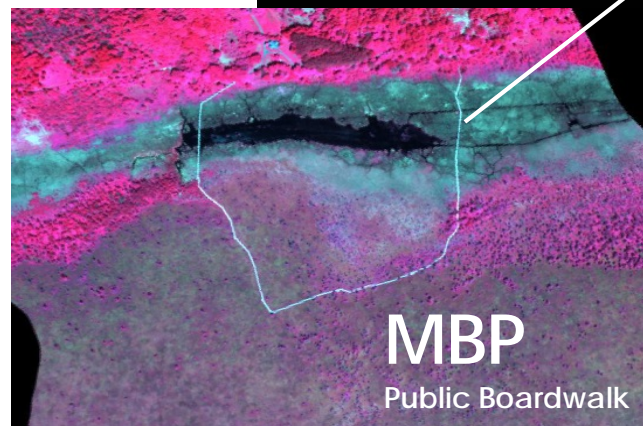Green - 688 nm
Blue - 551 nm
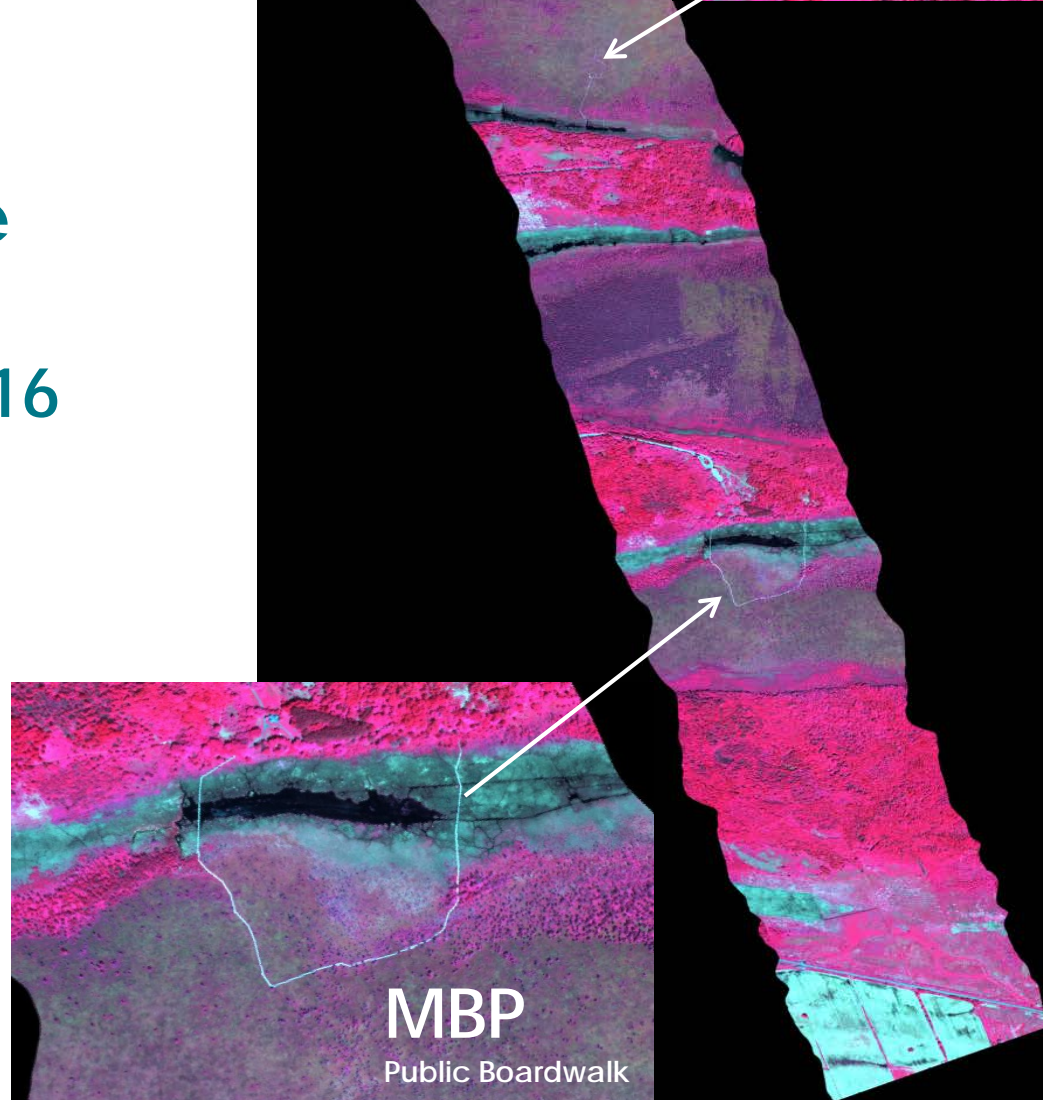
Original Pixel size
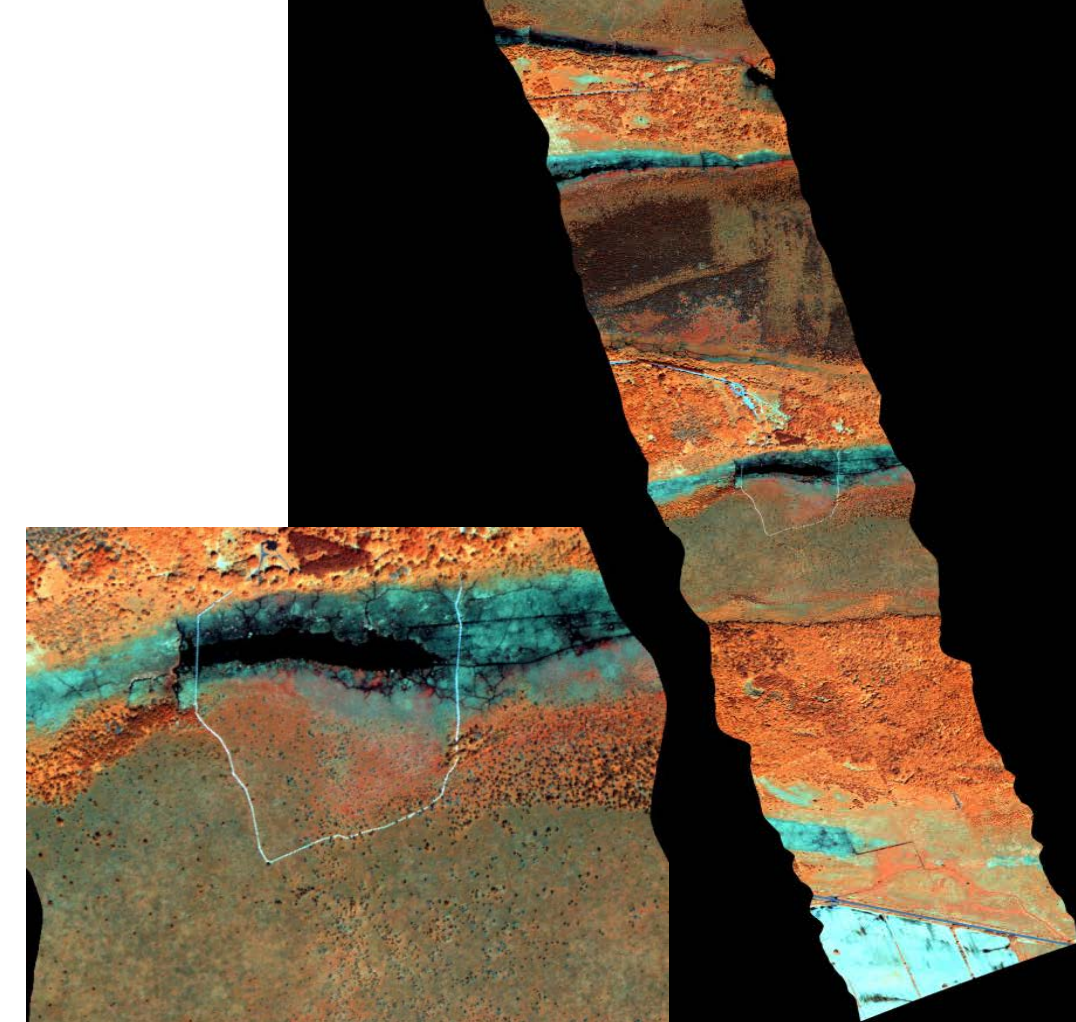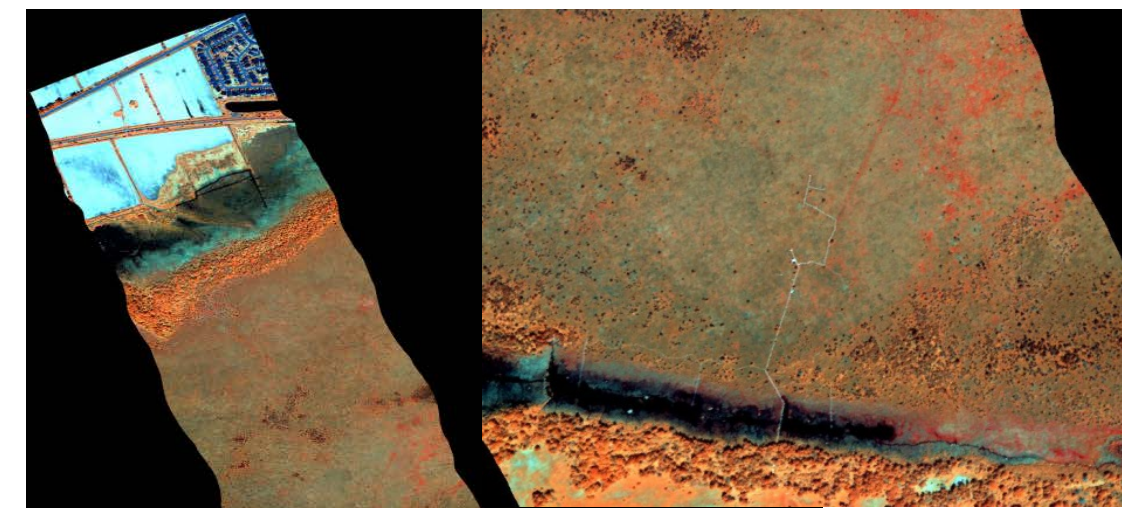~ 2.0 m x 0.5 m

Resampled Pixel Size
1.0 m x 1.0 m
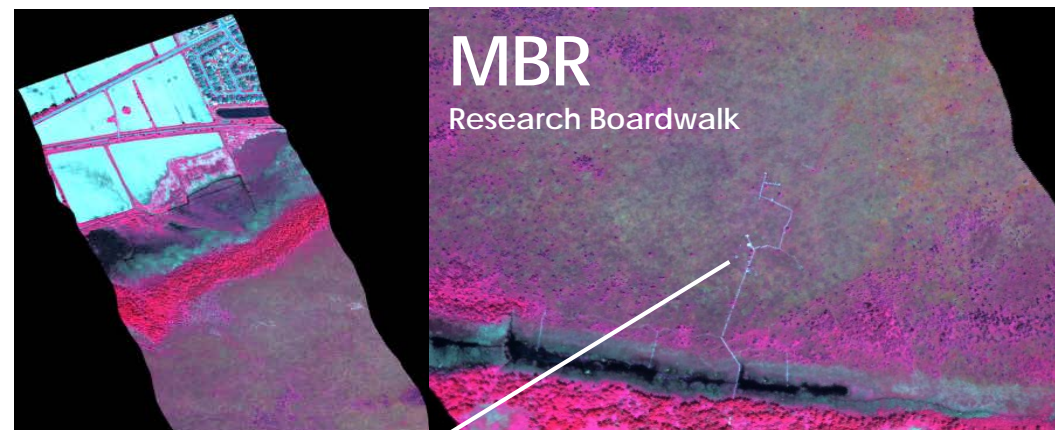
MBR
Research Boardwalk

Flight Line
MB-E
June 10, 2016

MBP
Public Boardwalk

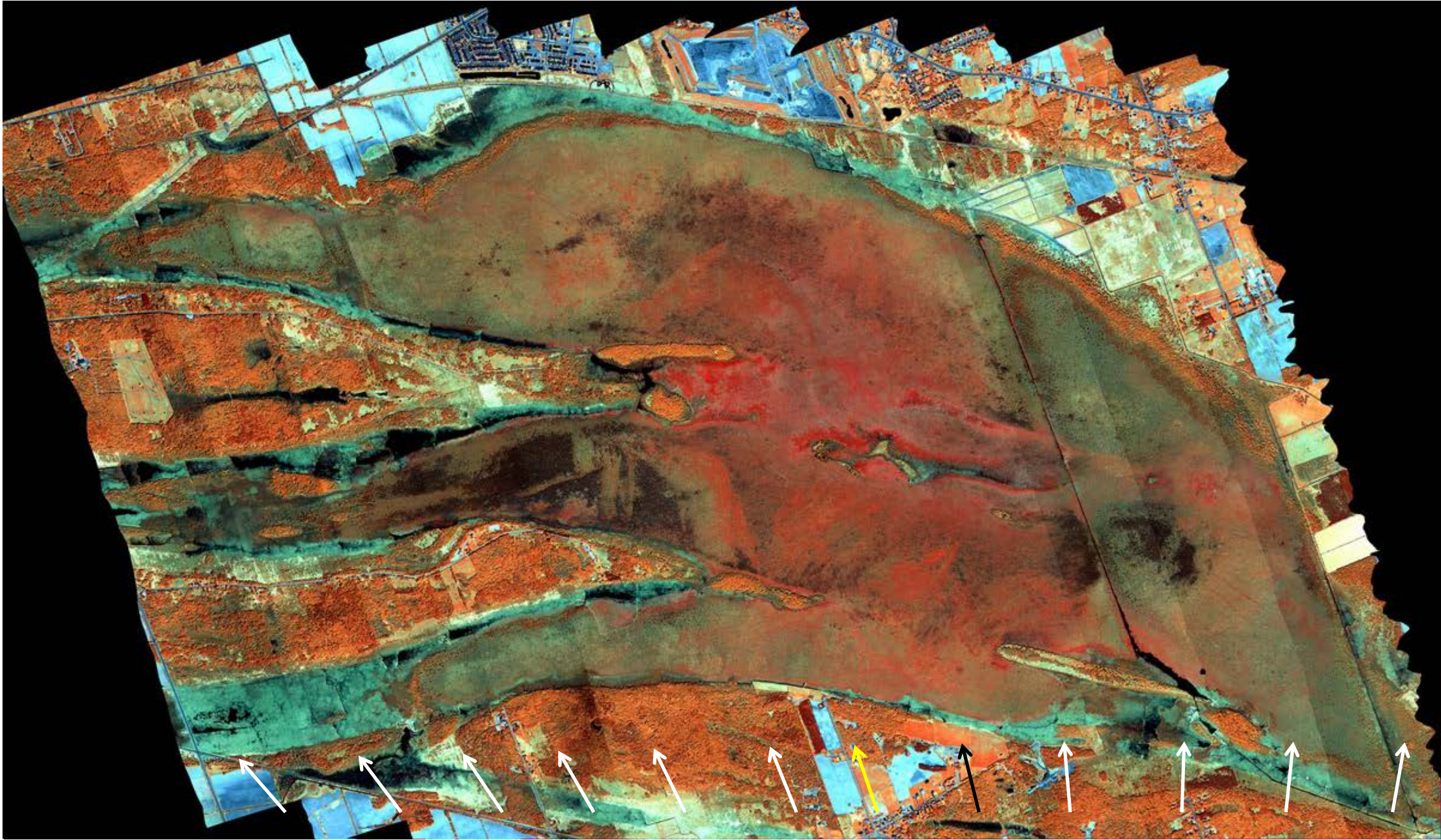SASI
Red - 1052 nm
Green - 1624 nm
Blue - 2122 nm

Original Pixel size
~ 0.7 m x 0.7 m

Resampled Pixel Size
1.0 m x 1.0 m

A Hyperspectral Mission for Sentinel-2 Data Product Validation of a Northern Ombrotrophic Bog – LPVE18

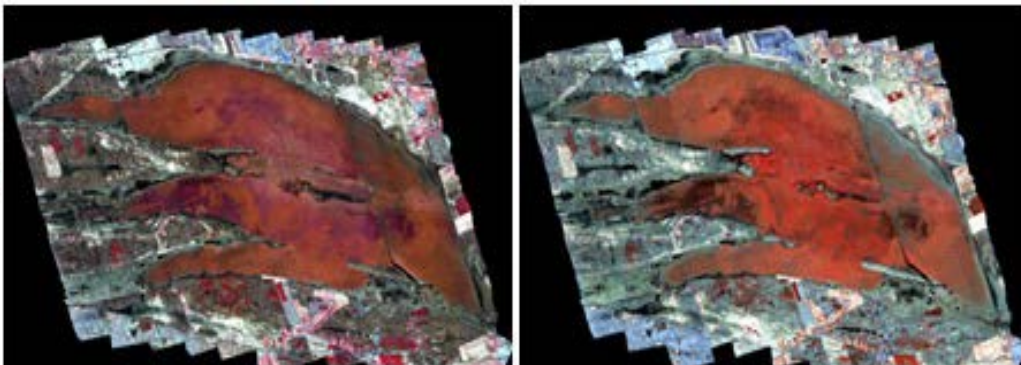NRC·CNRC

SASI

Mer Bleue Airborne Hyperspectral Mosaics

May 24th, 2016

→ SAA Flight Lines MB-A through MB-L   → SAA = FL Track   → Flight Line Time = S-2 Overpass (16:10 GMT)
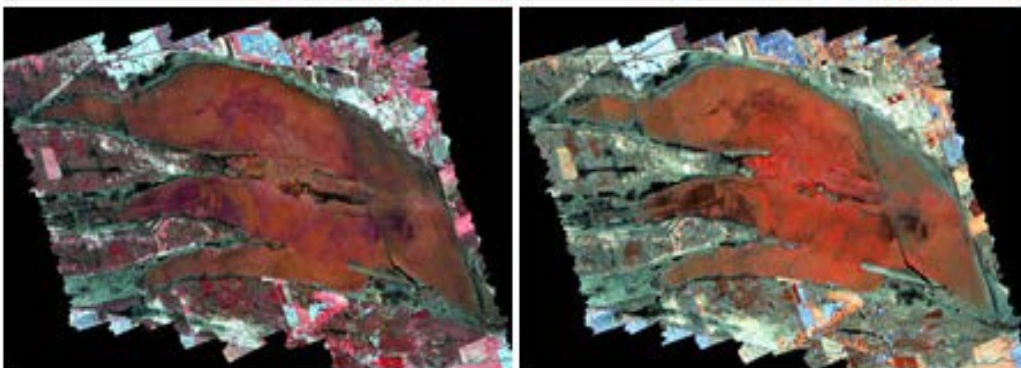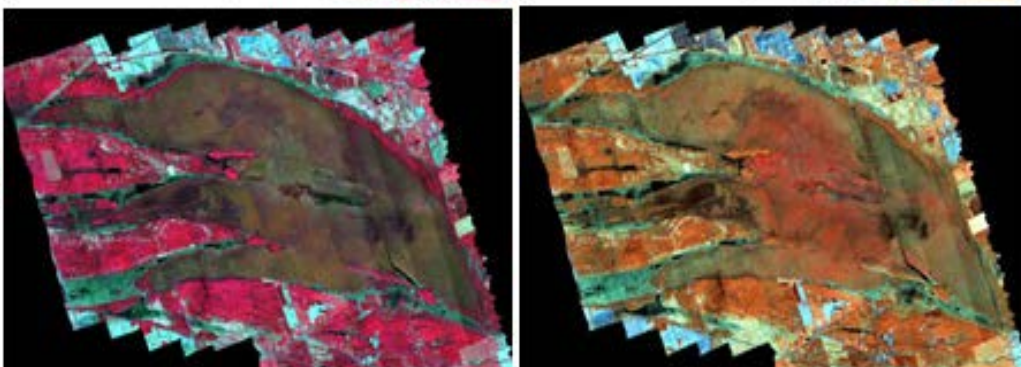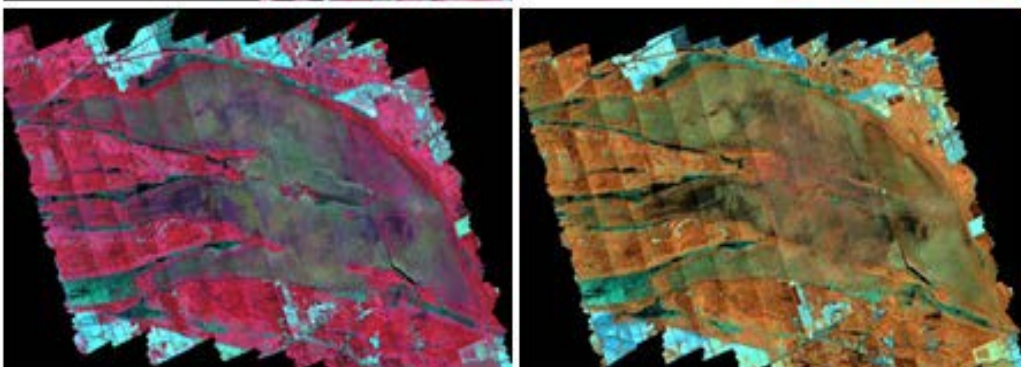
Generation of Mer Bleue
Airborne Hyperspectral Mosaics
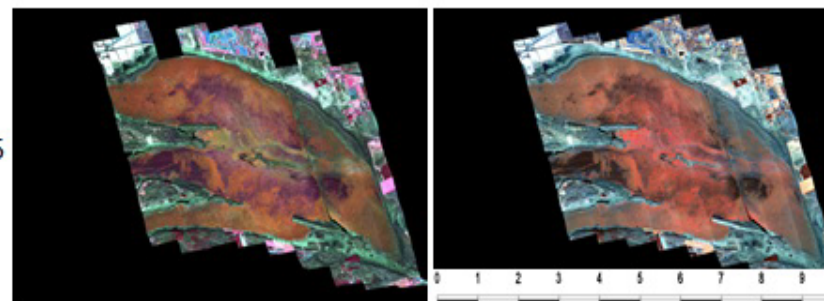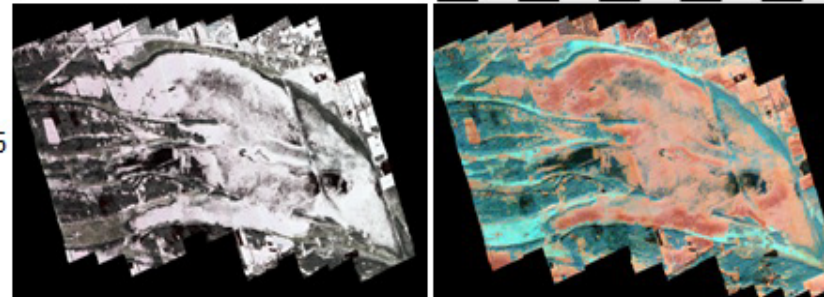
Mer Bleue
Field Work
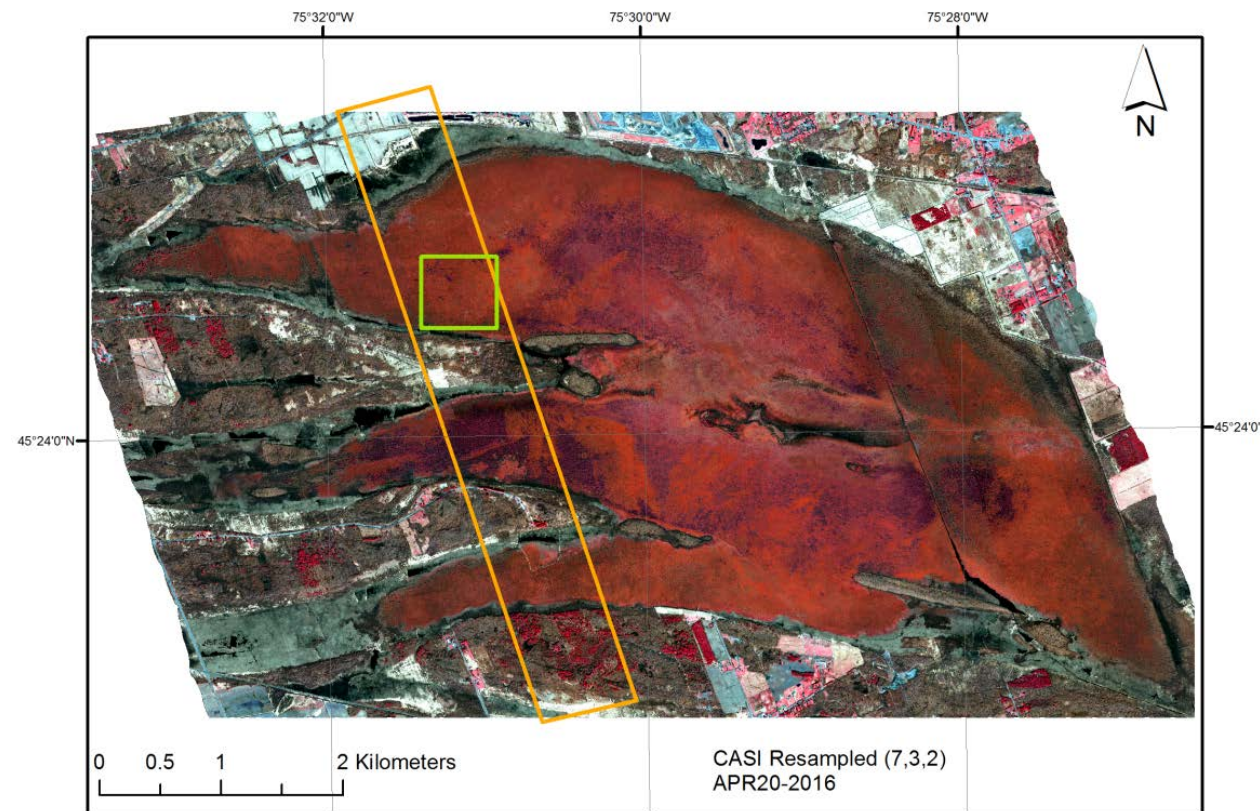
More detail
provided in later
LPVE18
presentations

CASI Resampled (7,3,2)
APR20-2016

Plot Vegetation Physiognomies

- BlueDome
- BogMargin
- Hollow
- Hummock
- OpenWater

Orthophoto. Source:
City of Ottawa (2005).

OW1

HO1

HU3
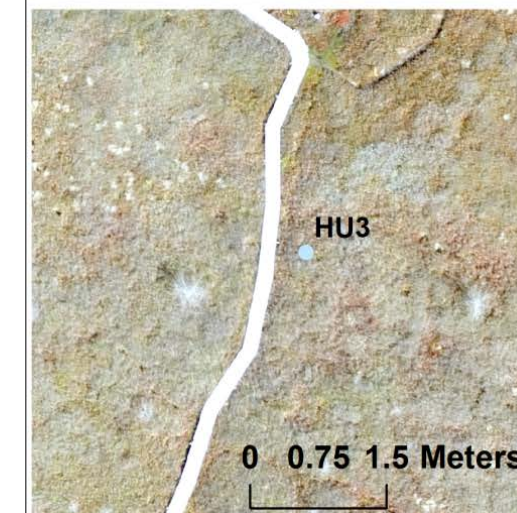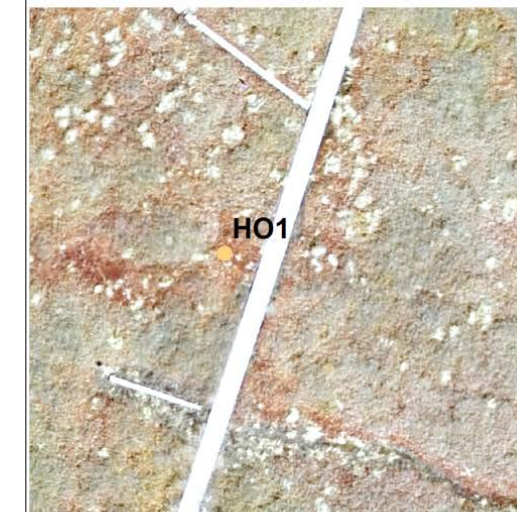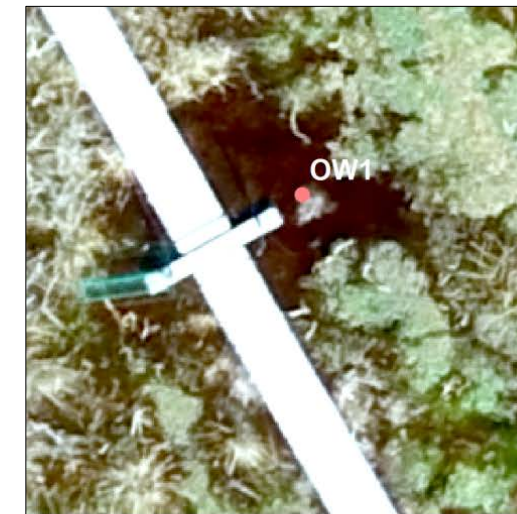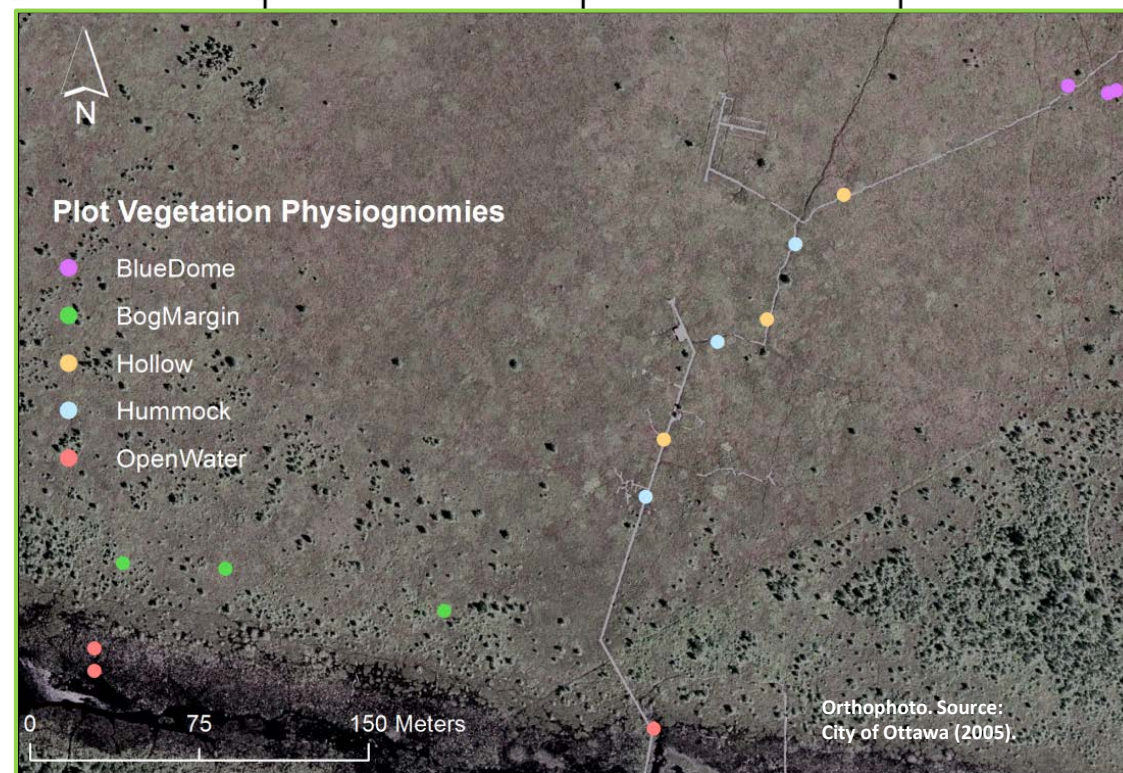
UAV Base Image
ARSL (McGill)

May 11, 2016

SVC HR1024i Spectrometer Setup

Diffuse Panel Measurement

Hemispherical Photos and SPN-1 Diffuse:Global Irradiance sensor

Sky Photos

Asphalt
Concrete
Grey Tarp
Black Tarp

Coodinate System: WGS 1984 UTM Zone 18 N
NRC - HAM, January 2017

NRC·CNRC
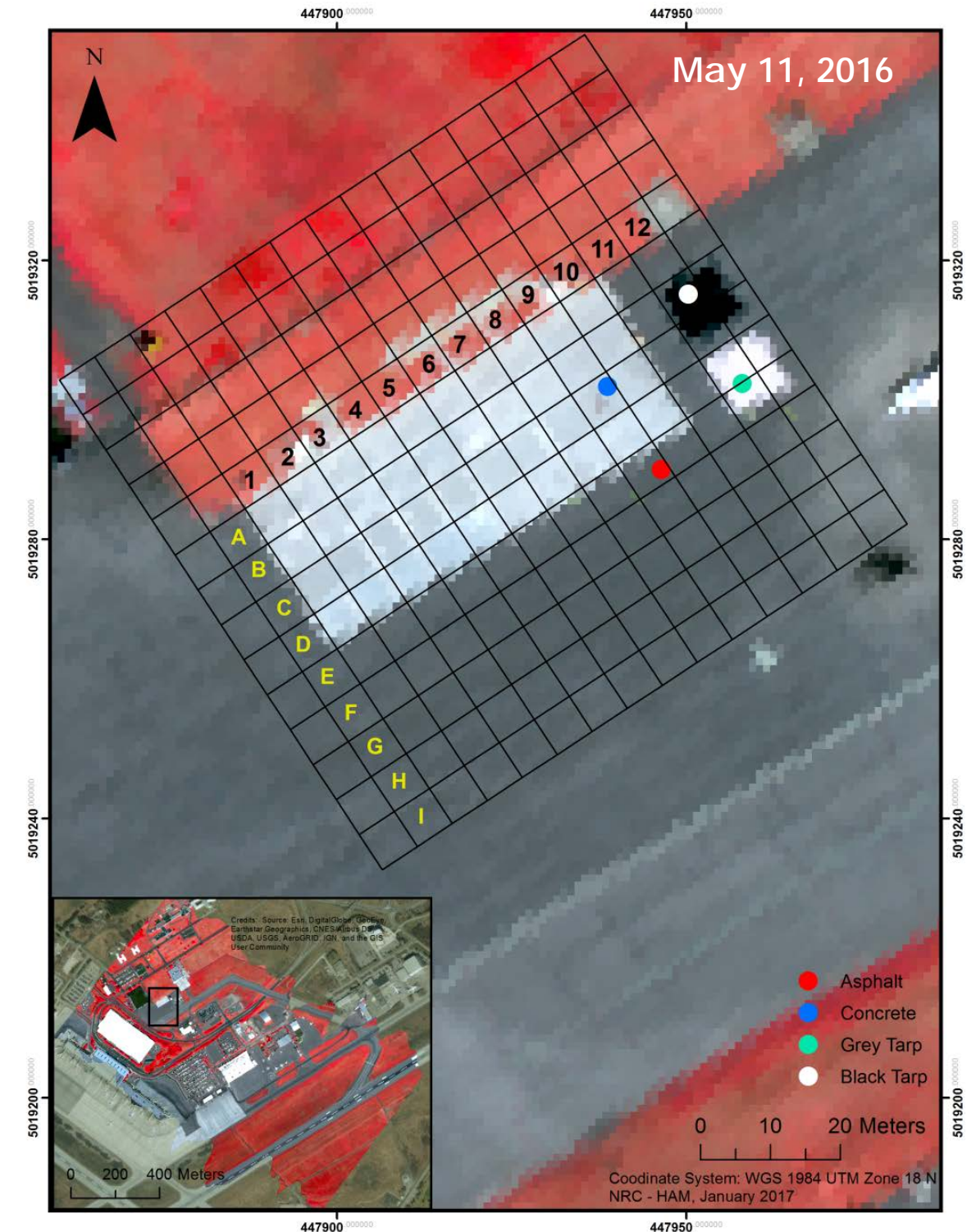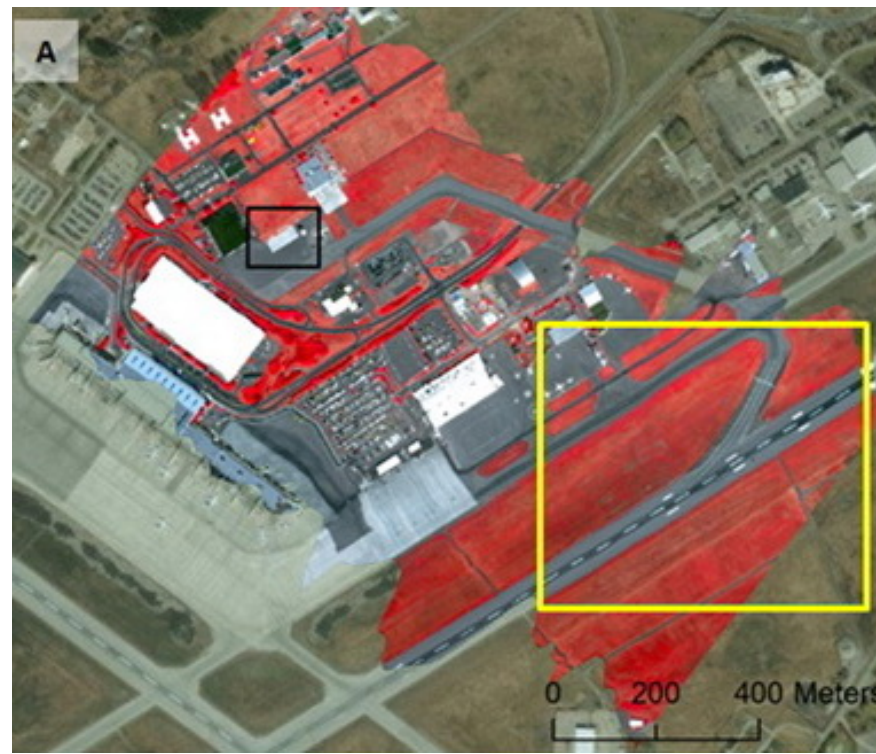
Sensitivity Flight Experiment: June 24th, 2016

➢ RAA Sensitivity Flight Lines

➢ SZA Sensitivity Flight Lines

➢ Xtrack Illumination Sensitivity Flight Lines

➢ Altitude Sensitivity Flight Lines

NRC·CNRC

RAA Sensitivity Flight Lines
June 24, 2016

- 7 Relative Azimuth Angles (RAA) (30° increments)
- Acquired over a period of 37 minutes
  - ΔSZA = 6.2°
  - ΔSAA = 6.4°

G
13:12:47 GMT
SZA = 51.5°
SAA = 94.8°
RAA = +90.2°

F
13:07.37 GMT
SZA = 52.5°
SAA = 93.8°
RAA = +58.2°

Common Area in all 7 RAA flight lines

E
12:58.47 GMT
SZA = 54.0°
SAA = 92.1°
RAA = +30.9°

D
12:52.58 GMT
SZA = 55.2°
SAA = 91.0°
RAA = +5.9°

C
12:47.41 GMT
SZA = 56.0°
SAA = 90.1°
RAA = -29.8°

B
12:42:19 GMT
SZA = 56.9°
SAA = 89.2°
RAA = -61.0°

A
12:37:36 GMT
SZA = 57.7°
SAA = 88.4°
RAA = -90.2°
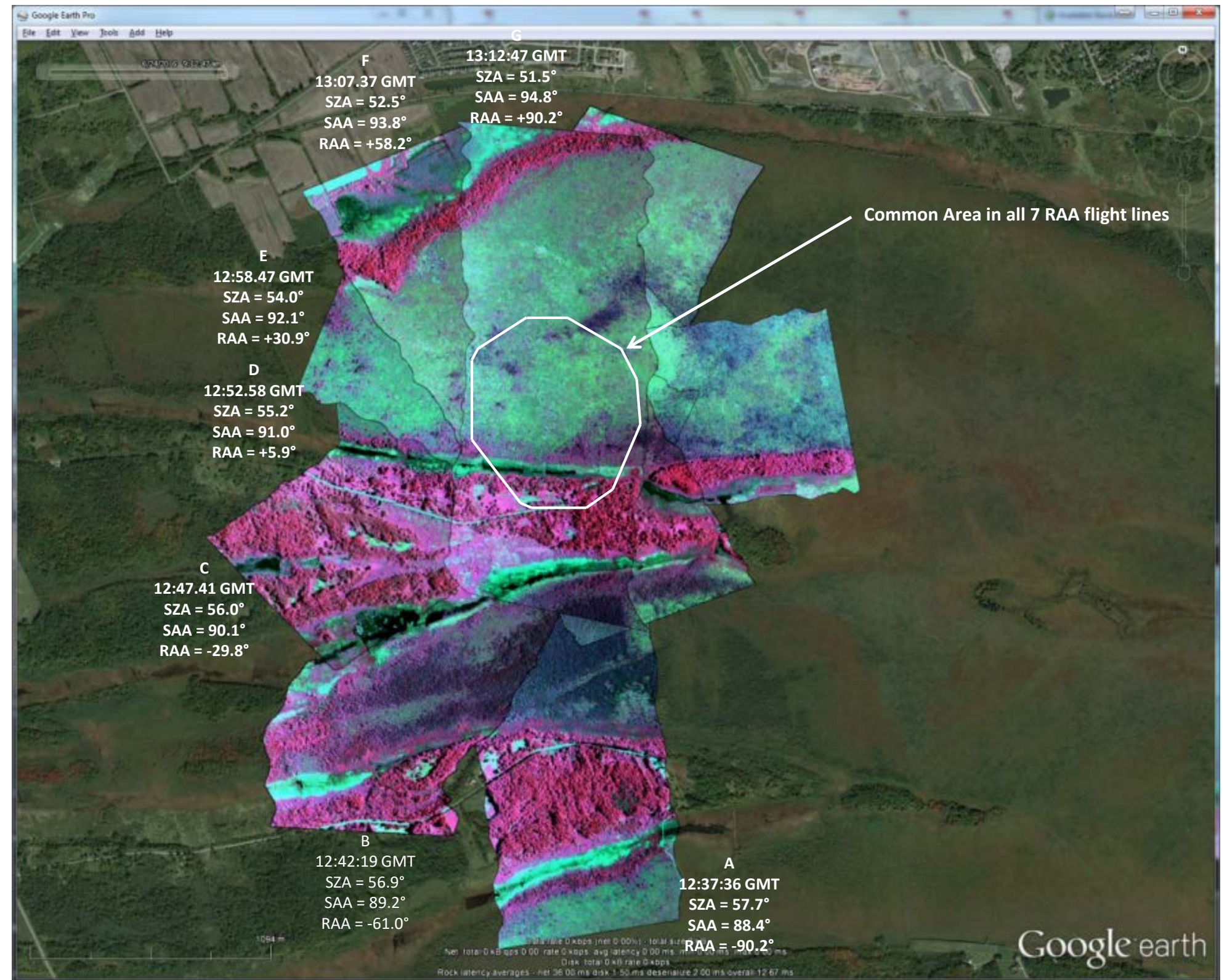
SZA Sensitivity Flight Lines
June 24, 2016

- SASI - 4 SZAs from 66.8 to 22.0°
- CASI - 3 SZAs from 55.2° to 22.0°

- Flown in the Solar Plane (RAA ~ 0°)
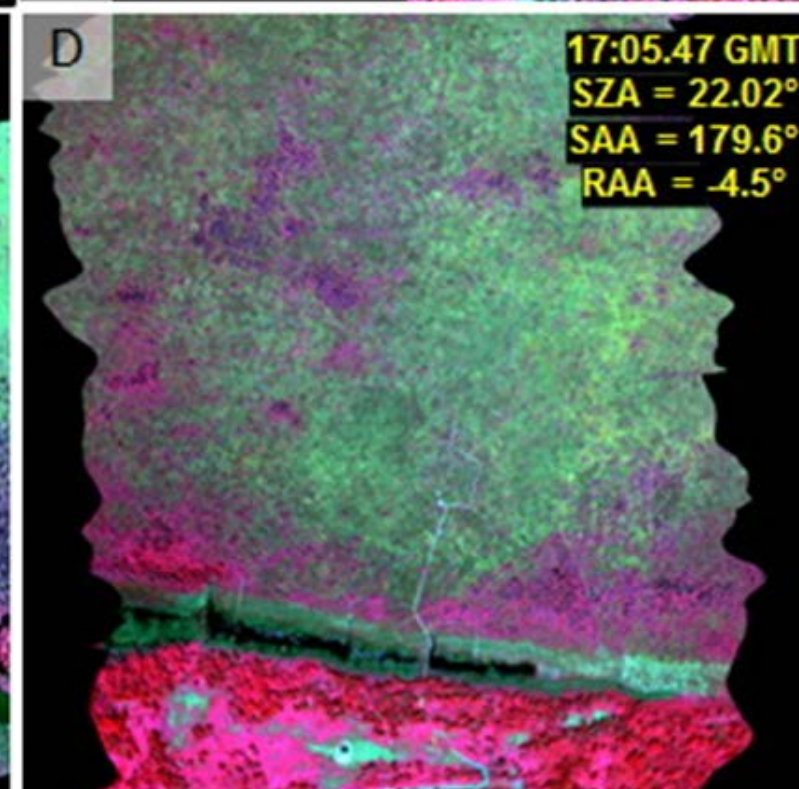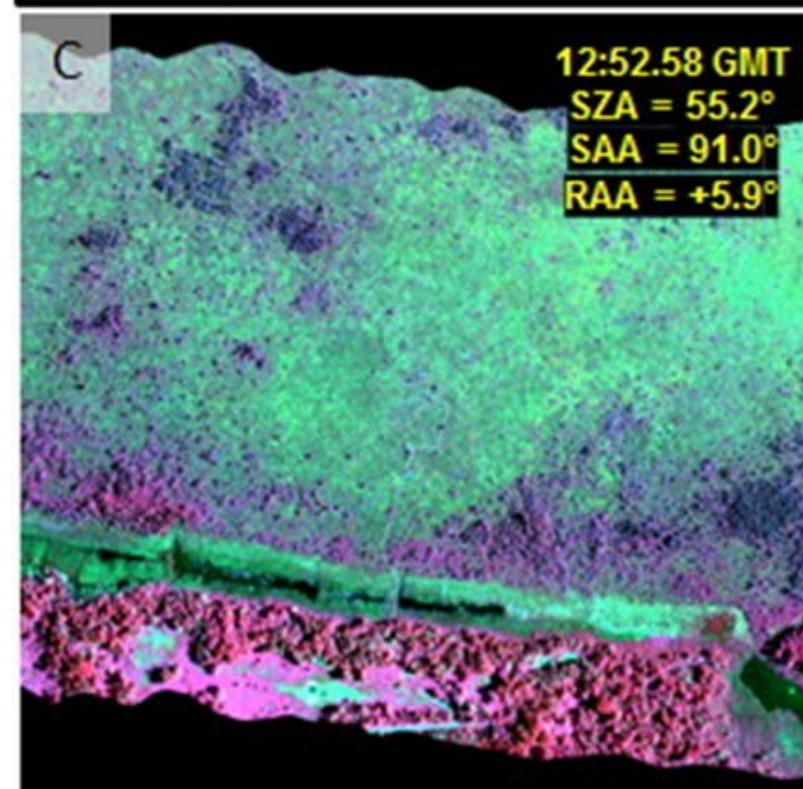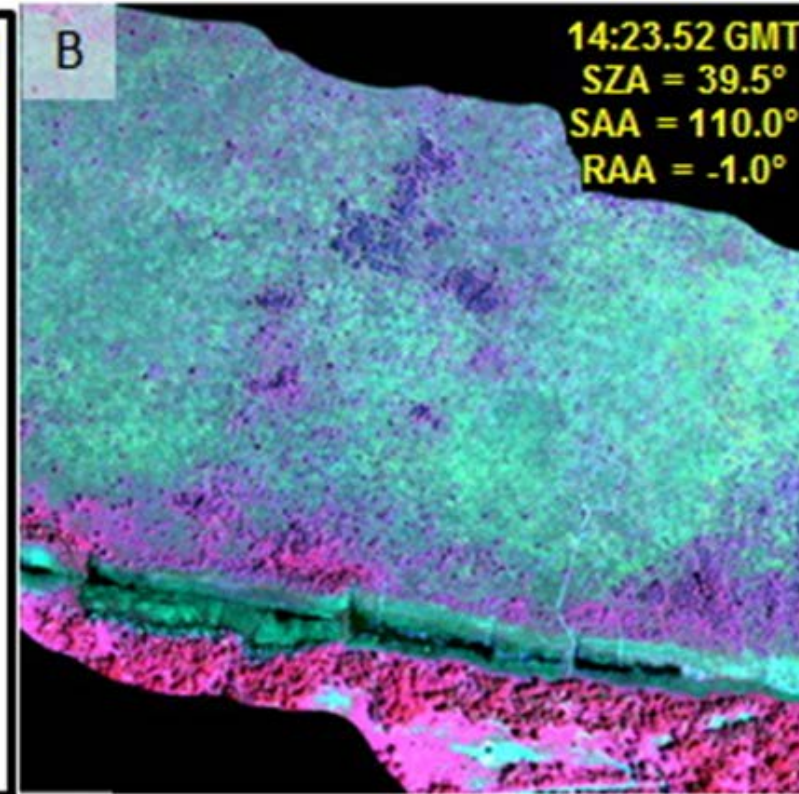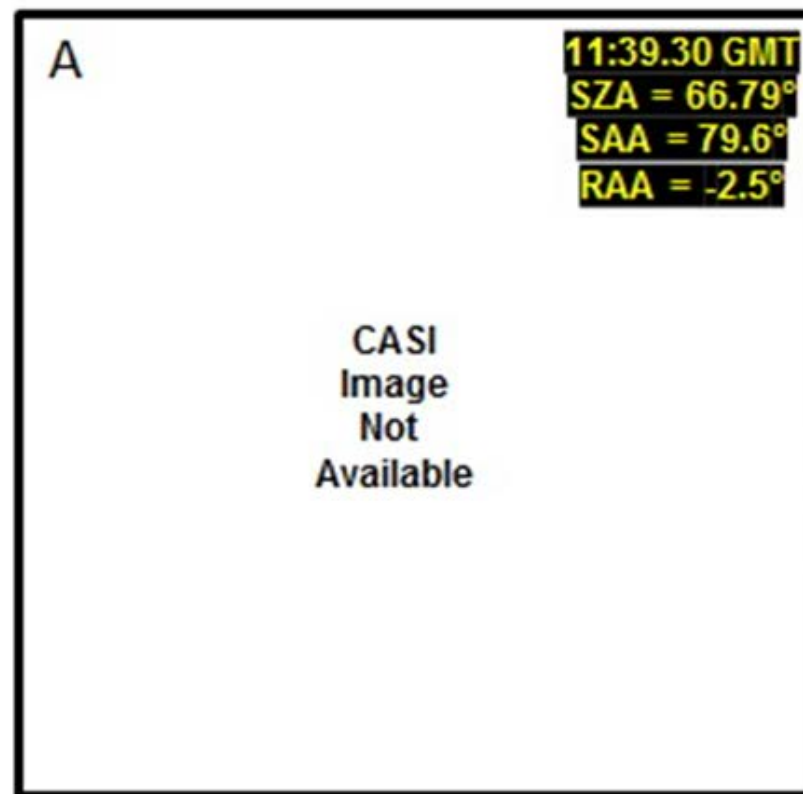
Xtrack Illumination Sensitivity Flight Lines
June 24, 2016

- 3 offset, parallel flight lines

- acquired over a period of 15 minutes

  - ΔSZA = 6.2°,

  - ΔSAA = 6.4°

Peatland Vegetation

NRC·CNRC
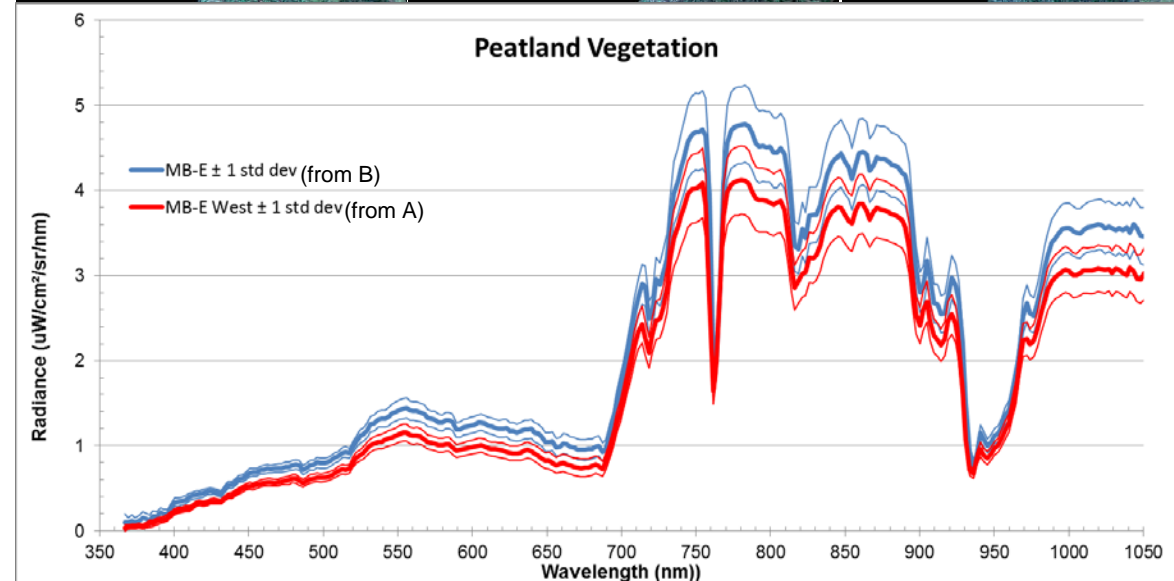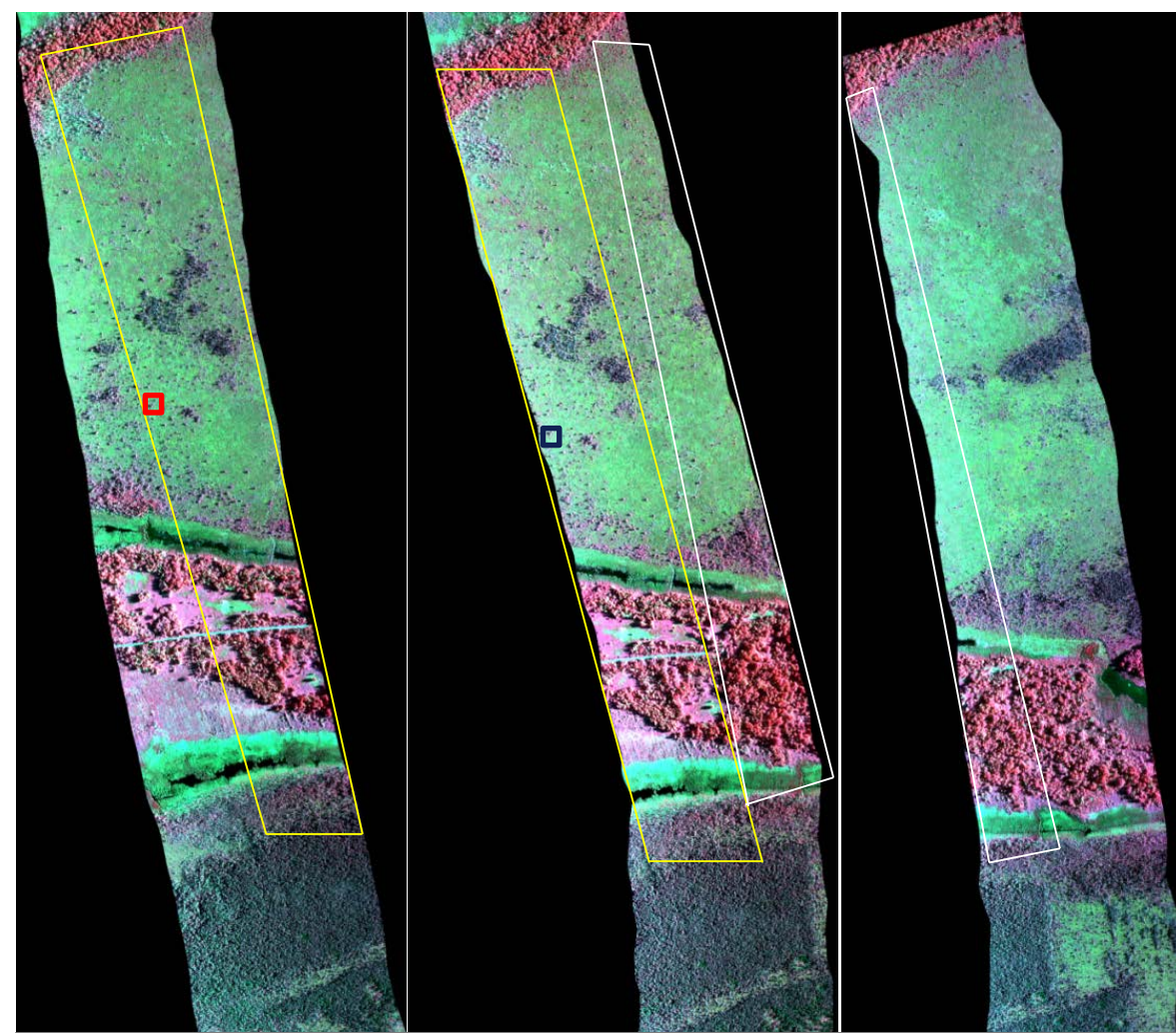
Altitude Sensitivity Flight Lines
(raw pixel resolution)
June 24, 2016

- 5 flight lines acquired a varying altitudes

- Acquired along the same flight line within 4.5° of the solar plane

  - acquired over a period of 32 minutes

    - ΔSZA = 5.3°

    - ΔSAA = 8.1°
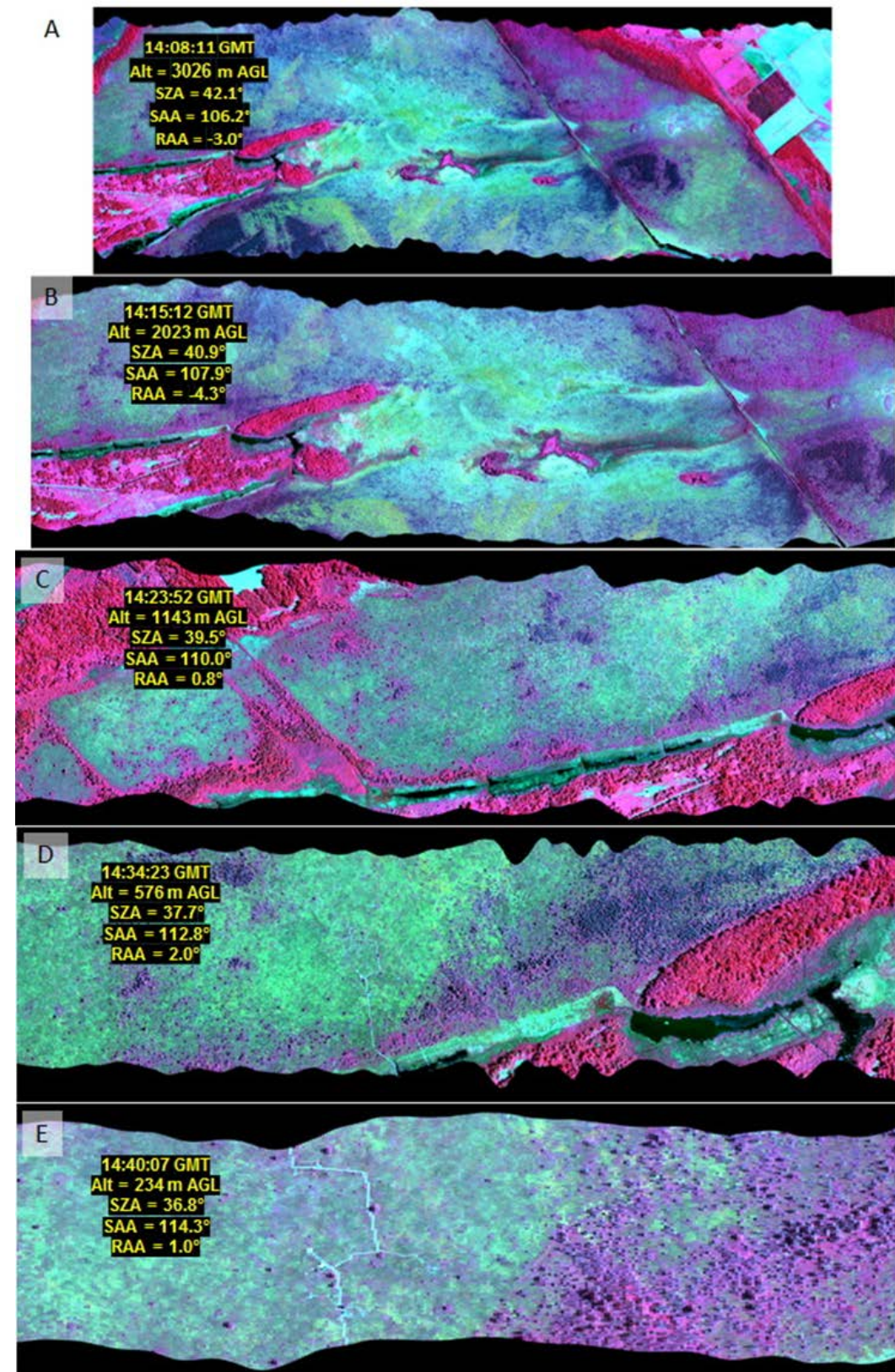
Optimization of Field Spectroscopy Results for Cal/Val Activities

➢ Establish a connection with a National Reflectance Standard

➢ Develop capability for cross-calibration Field Reference Panels against Lab Standard

➢ Determination of appropriate Field Panel Reflectance Factor

➢ Assess consistency of field spectroscopy results obtained by different field teams with various field spectrometers and field reference panels

NRC·CNRC

Lab standard now tied to NIST Reflectance Standard through University of Arizona Calibration facility

MBASSS Lab Reference Panel (NRC-03) Calibration Steps

R(0°:h) is fit to UofA data using a bilinear best fit:

$$C = \begin{cases} c_1 & , \lambda < 1600 \; nm \\ c_1 - c_2(\lambda - 1600), & \lambda > 1600 \; nm \end{cases}$$

where $c_1 = 1.0318$, $c_2 = 2.88 \times 10^{-5}$
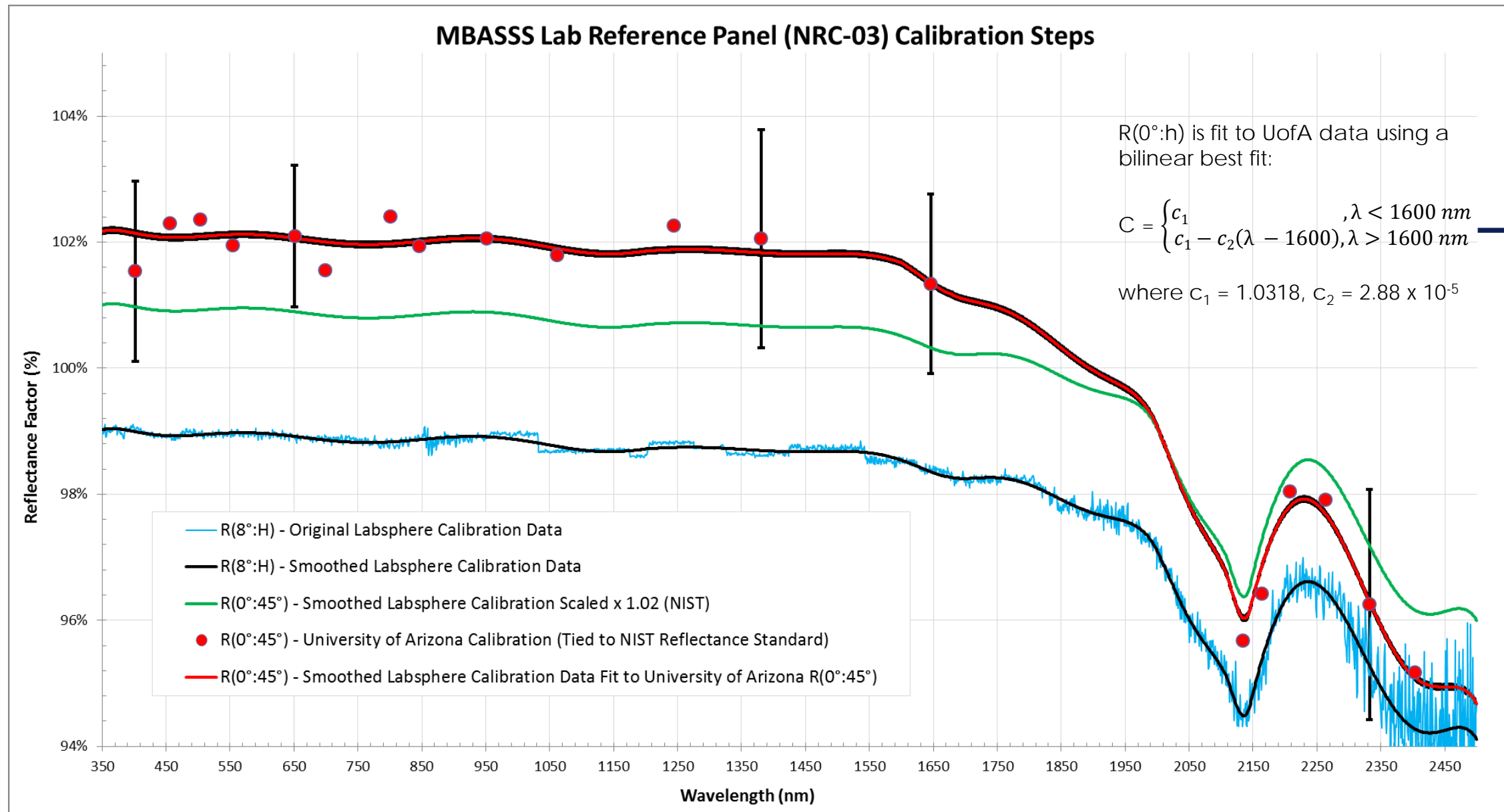
As implied in:

Cooksey, C. C., Allen, D. W., Tsai, B. K., & Yoon, H. W. (2015). Establishment and application of the 0/45 reflectance factor scale over the shortwave infrared. *Applied Optics, 54*(10), 3064-3071. doi:10.1364/AO.54.003064

Legend:
- R(8°:H) - Original Labsphere Calibration Data
- R(8°:H) - Smoothed Labsphere Calibration Data
- R(0°:45°) - Smoothed Labsphere Calibration Scaled x 1.02 (NIST)
- R(0°:45°) - University of Arizona Calibration (Tied to NIST Reflectance Standard)
- R(0°:45°) - Smoothed Labsphere Calibration Data Fit to University of Arizona R(0°:45°)

X-Calibration of MBASSS Field Reference Panels at NRC

R(0°:45°) only

Field panels now tied to NIST Reflectance Standard
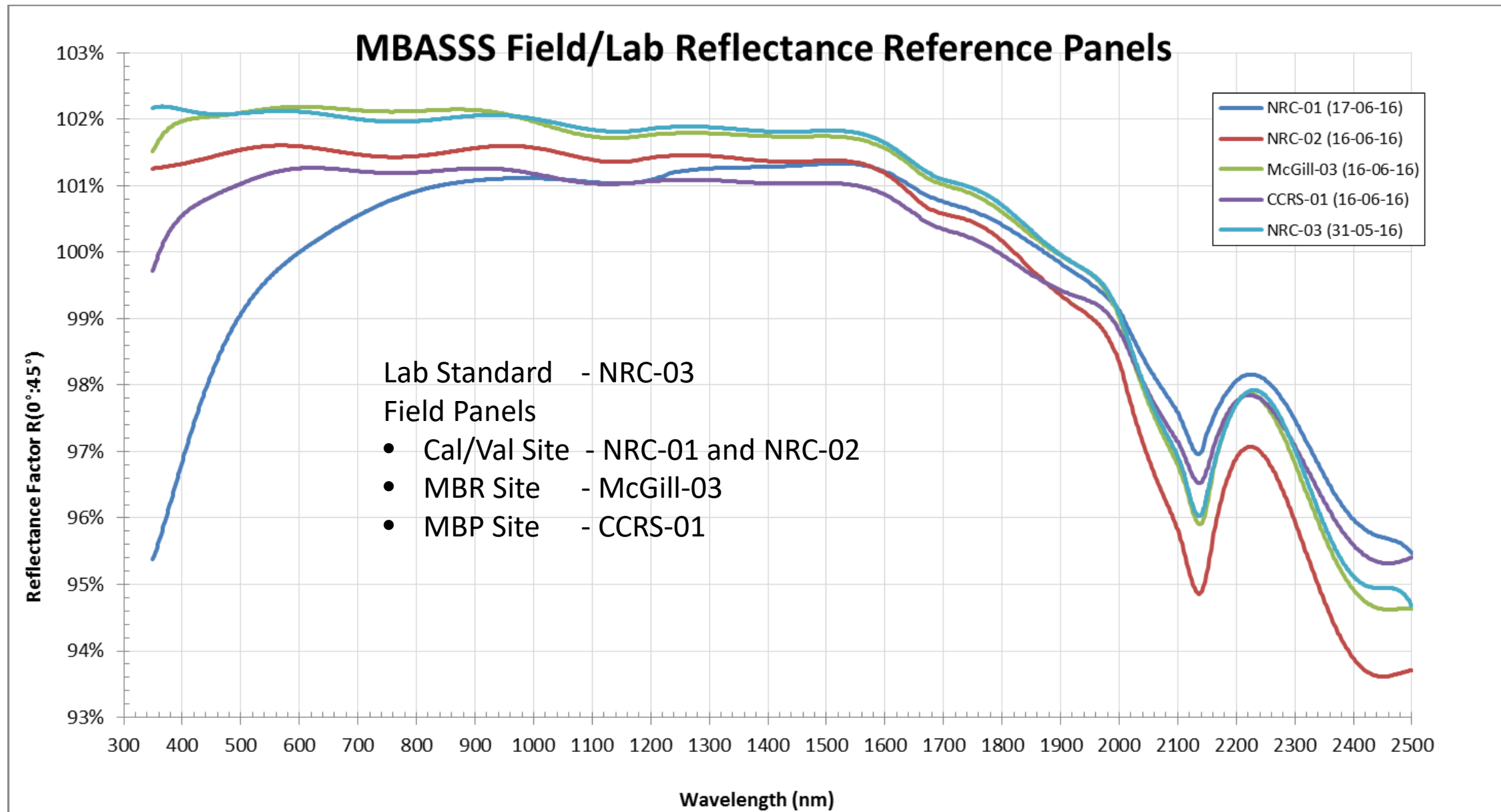
MBASSS Data Summary

- **Airborne Hyperspectral Imagery**
  - **120 Individua**l Flight Lines – 17 Days
  - **7 Mer Bleue Mosaics coincident** with S-2 or L8 (5 Complete, 2 partial)
  - **48 Hyperspectral U61 Cal/Val Site** Flight Lines - 20 days

- **Field Spectrometry Data** with auxiliary support data
  - **MBPO** – 11 Days
  - **Mer Bleue Public Boardwalk** – 11 Days
  - **U61 Cal/Val site** - 16 days (immediately preceding and following MB lines)

- **Corresponding Satelite Imagery**
  - **Sentinel-2 images** – 7 clear, 8 partially clear
  - **Landsat 8 images** – 17 clear, 11 partially clear

NRC·CNRC

Summary – Airborne Campaign

> A highly successful airborne campaign has been executed

> Extensive airborne data set acquired of Cal/Val site in support of airborne imagery

> Near coincident field spectrometer data acquired at both Mer Bleue and nearby Cal/Val site

> Field spectrometry data tied to NIST acquired of Cal/Val site

> Data will be made available shortly on the ESA Cal/Val Web site.

NRC·CNRC

› **Refinement of Atmospheric Correction** Process (CASI blue end (< 450 nm), SASI)

› Assessment and Correction of **Cross Track Illumination** issue

› **Further processing and analysis** of hyperspectral imagery
- SASI Imagery
- Sensitivity Flight Imagery

› **Further assessment of Cal/Val Field Spectrometry results**
- Sensitivity of results to field **spectrometer, panel, team**
- Evaluation of diffuse:direct weighted Reflectance Factor

› **Additional Satellite Simulations**
- SASI
- Alternate conditions

› Development of **hyperspectral UAV capability** to **replace/supplement field spectrometry** in order to address the spatial sampling issue and to allow coverage of difficult-to-access locations.

NRC·CNRC

Phenological Spectral Trends at the Mer Bleue Artic Surrogate Simulation Site
Pablo Arroyo-Mora et.al
Wednesday 16:10
Land Products III: Vegetation Parameters

Multi-Temporal Estimations of Peatland Net Ecosystem Exchange from Airborne and Satellite Imagery
Margaret Kalacska
Wednesday 16:30
Land Products III: Vegetation Parameters

From Airborne Hyperspectral to Space-borne Multispectral Optical Simulations: Demonstration of Sentinel-2 Simulations of a Northern Ombrotrophic Bog
H. Peter White
Wednesday 17:30
Poster Session 1: Approaches and Practices for Land Products Validation

NRC·CNRC

Thanks for your attention!

For more information visit the MBASSS Story Map at
http://bit.ly/merbleue

The MBASSS S2/L8 Data Product Validation Project was funded by European Space Agency as part of the Sensor Performance, Products and Algorithms (SPPA) element of the ESA Earth Observation ground segment.

We would also like to acknowledge the MBPO for their continued support and discussions as we develop and engaged our MBASSS campaign.

Raymond Soffer
Research Council Officer
National Research Council of Canada
Aerospace
1920 Research Rd
Ottawa ON
K1A 0R7
Ray.soffer@nrc-cnrc.gc.ca

NRC·CNRC