Evaluation of High Resolution Data for LCLUC Science

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Project Title: **Prototyping Multi-Source Land Imaging (MuSLI) Canopy Chlorophyll (MuSLI Chl) for the Assessment of Vegetation Function and Productivity**

Objectives (O)

Goal: *evaluate the ability of commercial very high resolution (VHR) imagery to* develop approaches for remote sensing of canopy chlorophyll content (Chl), and evaluate the uncertainties, as they vary among different vegetation types and structures and in response to seasonal and environmental changes.

- O1: evaluate the radiometric stability of the VHR commercial imagery containing red edge bands (WV-3, -4 and RapidEye), as compared to ground measurements of stable targets
- Q2: test the VHR data ability to provide consistent VIs to develop stable, transferable algorithms and derive TOC Chl estimates

➢ *The accuracy of the estimates will be compared to satellite (L-8 and S-2) and field TOC Chl estimates across the phenology for crops and forests.*

➢ *We will assess the ability of the Planet SkySat constellations to provide accurate characterization of canopy topography and structural BRDF parameters.*

- Expected data usefulness and benefits:

Objectives (O)

Expected data usefulness and benefits:

The research will evaluate the potential to generate VHR multi-temporal maps of TOC Chl at a resolution that exceeds Global Climate Observing System (GCOS) Land ECV by a factor of 10x when using VHR.

Successful mapping of chlorophyll content at higher spatial resolutions (1-10 m) has applications to support precision agriculture as well as being able to delineate characteristics of smaller fields found in developing countries. Further, spatial variability in chlorophyll can identify the change in productivity of natural ecosystems at the scale of tree crowns, useful information for describing forest phenology and biodiversity.

The commercial satellite data have the potential to directly address Decadal Survey 2017 and NASA Ecosystem science and application questions by quantifying the distribution of functional traits such as TOC Chl and canopy BRDF spatially and over time, and potentially contributing for generating high temporal resolution maps, by combining observations from multiple satellites.

Technical Approach - Comparisons

Research FOCUS

Field data

Leaf:

SPAD readings *many*

Samples *select*

SPAD to Chl conversion

Chl extracts

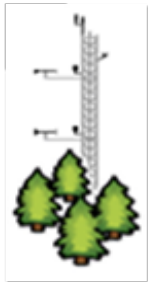
Chl content

Canopy:

% PV, NPV, Shade, Soil

CO2 flux Temperature

LAI



Measured Canopy Chl *Leaf Chl x LAI*

Error assessment

Chl x VI Algorithms

Chl Maps for Crops and Forests
Chl Dense Phenology Time Series

Satellite data

L-8 S-2

HLS Processing
Radiometric adjustment
Atmospheric correction
Geometric resampling
BRDF Adjustment

HLS reflectance (30m)
TIRS1 temperature

Canopy Fractions CFs 30 m

VIs 30 m

VHR: DG WV-3, PL RE

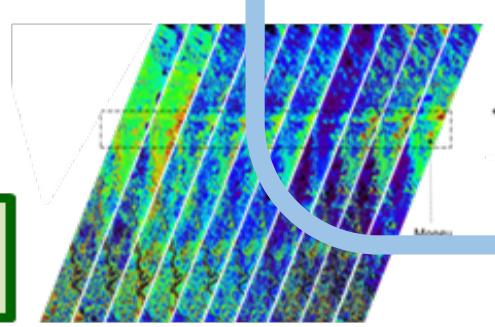
VHR Processing (team)
Radiometric adjustment
Atmospheric correction
Ortho-rectification and
Geometric resampling

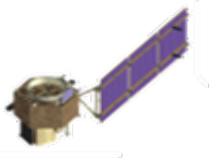
VHR reflectance
Scenes & DEMs

Canopy Fractions CFs 2 m

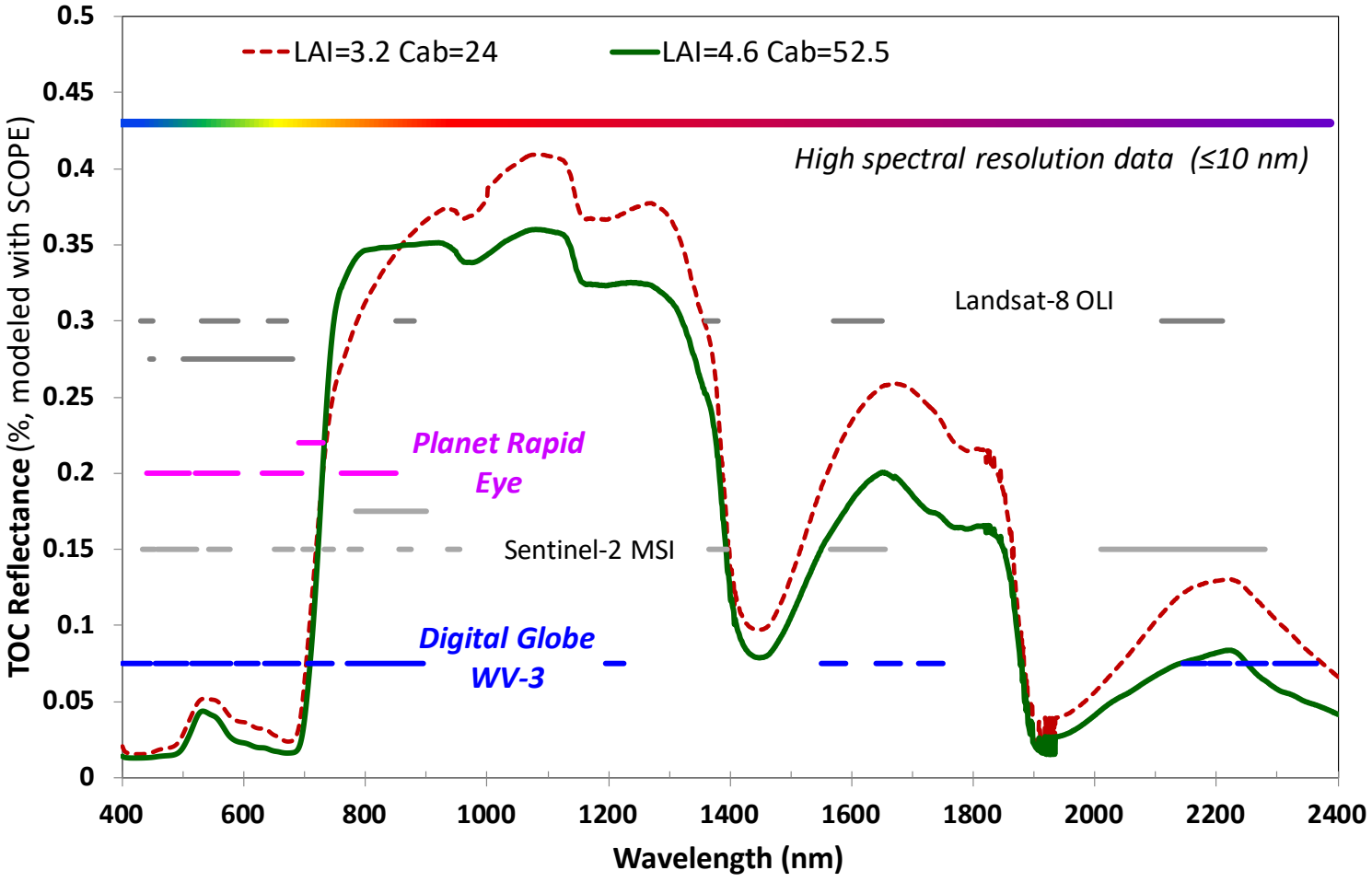
VIs 2 m

Normalize canopy structure
validate





Technical Approach – Calibration and Validation



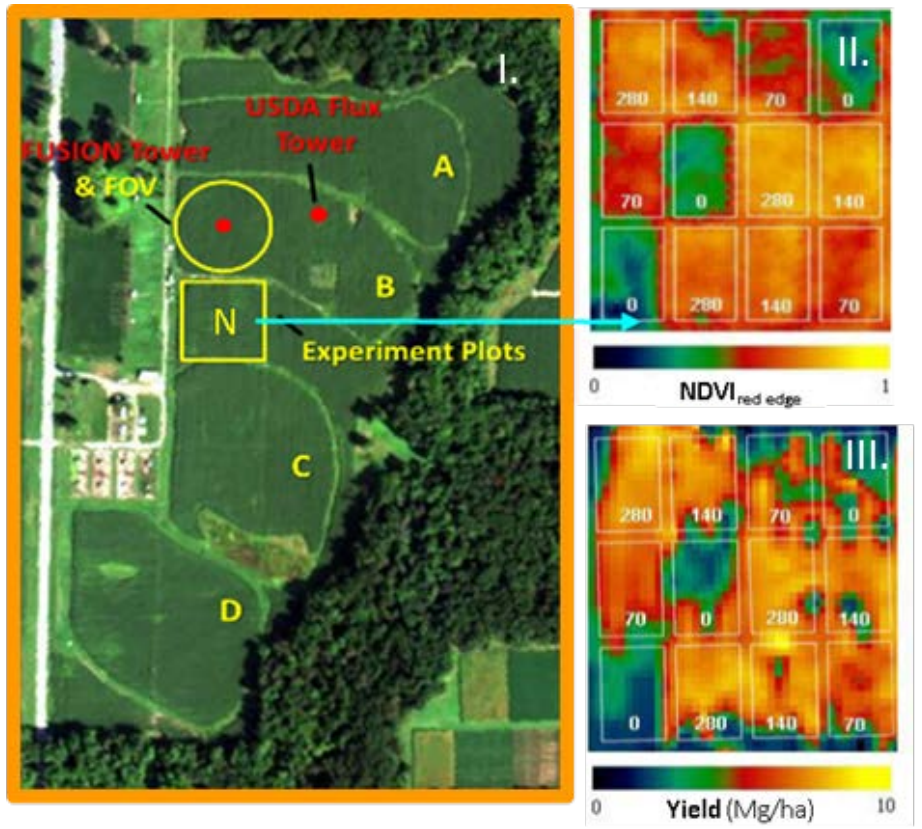


Figure 1. The OPE3 watershed (I. A, B, C and D) and the N plots (Corp et al. 2010). The $NDVI_{red\ edge}$ index was calculated using ~ 1m airborne imaging spectrometer (AISA) data (II.). $NDVI_{red\ edge}$ is indicative of canopy chlorophyll, distinguished the N treatments, and was indicative of crop productivity and grain yield (III.).

Data Requested and Status

- *Study Sites and Region*

	Study areas	Vegetation cover type(s)	Location (ID, center lat/lon)	Ground data collections
1	OPE3[1,2] USDA, MD, USA • Watershed – present award • N **Experiment plots** – ***NEW***	Maize (N treatments)	OPE3 (39.030686, -76.84546)	weekly
2	SERC [3], MD, USA	Mixed hardwood forest	SERC (38.889359, -76.556269)	monthly
3	Mead, NE, USA: Ne1/Ne2[1] irrigated/not	Maize-Soybean rotation	Ne2 (41.1649, -96.4701)	bi-weekly
4	Czech Republic (agriculture, tundra, forest[1,5])	Agricultural crops Alpine tundra Norway spruce forest (BK1) Beech forest, ForestGEO	CZ_K_S (50.194215, 15.145881) CZ_Tun (50.723796, 15.694413) CZ_BK1 (49.502115, 18.539068) Cz4GEO (34.978994, 32.731402)	seasonal
5	Paphos forest[4], Cyprus	Deciduous forest	PF (34.978994, 32.731402)	seasonal

[1]Fluxnet, http://fluxnet.ornl.gov/site_list ; [2]Long Term Agricultural Research (LTAR); [3]National Ecological Observatory Network (NEON), [4]SpecNet, http://specnet.info; [5]Czech Globe, http://www.czechglobe.cz/en/home

Data Requested and Status

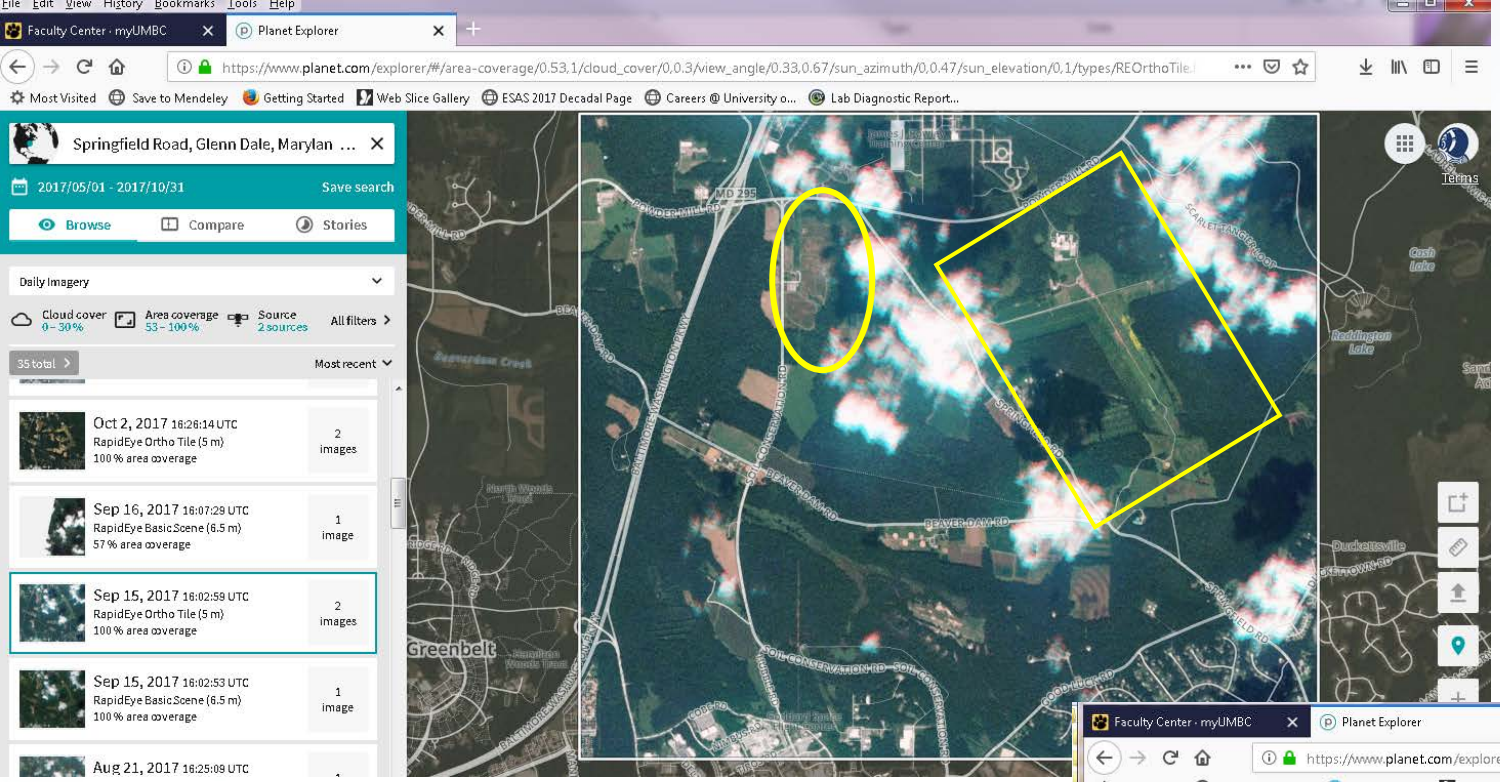
- Data download status and plans:
  - Data type: DigitalGlobe WV-2,-3 and -4, SkySat and RapidEye – specifics on next chart
  - Amount of data:
    - May-October, 2015-2019 including
    - Downloaded 2017 for primary sites
    - Going over 2015 and 2018 images to select

- Issues or challenges in downloading the data:
  - Cloud cover obscuring the sites
  - Issue extracting the files – cannot open the *.zip files (36.4 %)

Data Requested (Specifics)

- *VHR Data Requests – existing and new acquisitions (2019)*

Provider	Platform	Dataset	Frequency	Evaluation / Products
Digital Globe	WorldView-2 WorldView-3 WorldView-4	L1B (4 and 8 band bundles, red-edge key; VNIR, WV-3 SWIR, and CAVIS)	weekly	1. Radiometric stability and geolocation accuracy 2. VIs (TOC Chl and dry matter, ECVs included NDVI & NDWI) 3. Stereo-pairs: TOC topography, canopy density, sun/shade, DEMs 4. LCC due to water and nitrogen availability, and phenology
Planet Labs	RapidEye constellation	RapidEye (6.5 m)	weekly	1. Radiometric stability and geolocation accuracy; 2. Red-edge VIs for estimation of TOC Chl
	SkySat constellation	SkySat-(4-13) stereo-pairs	bi-weekly	1. Point-clouds, canopy surface topography, sun/shade green/brown fractions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Cloud cover 0 – 30%
Area coverage 53 – 100%
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All filters
35 total
Most recent
Oct 2, 2017 16:26:14 UTC
RapidEye Ortho Tile (5 m)
100 % area coverage
2 images
Sep 16, 2017 16:07:29 UTC
RapidEye Basic Scene (6.5 m)
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Terms
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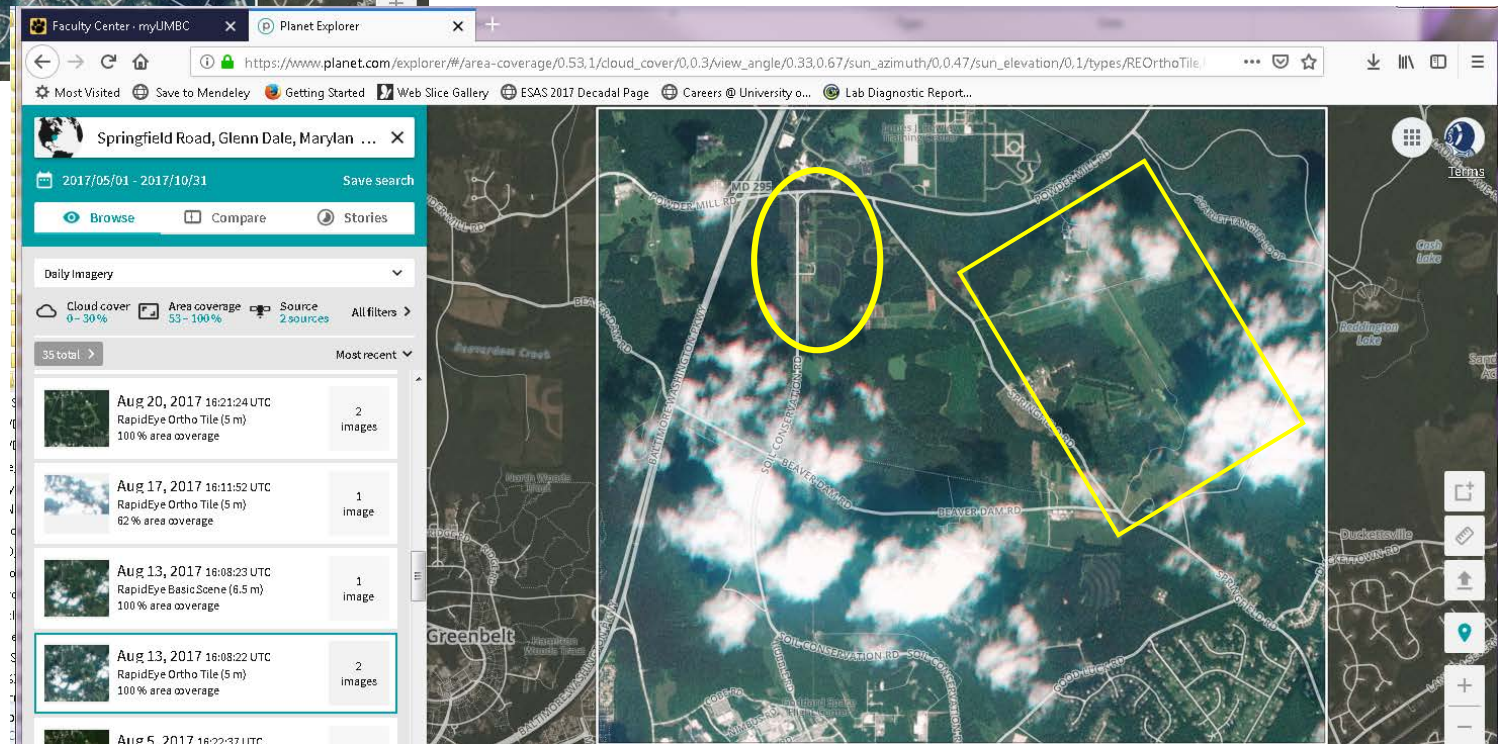
Duckettsville
Reddington Lake
Cash Lake
MD 295
BEAVER DAM RD
SOIL CONSERVATION RD
SPRINGFIELD RD
GOOD LUCK RD
POWDER MILL RD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Terms
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Duckettsville
Reddington Lake
Cash Lake
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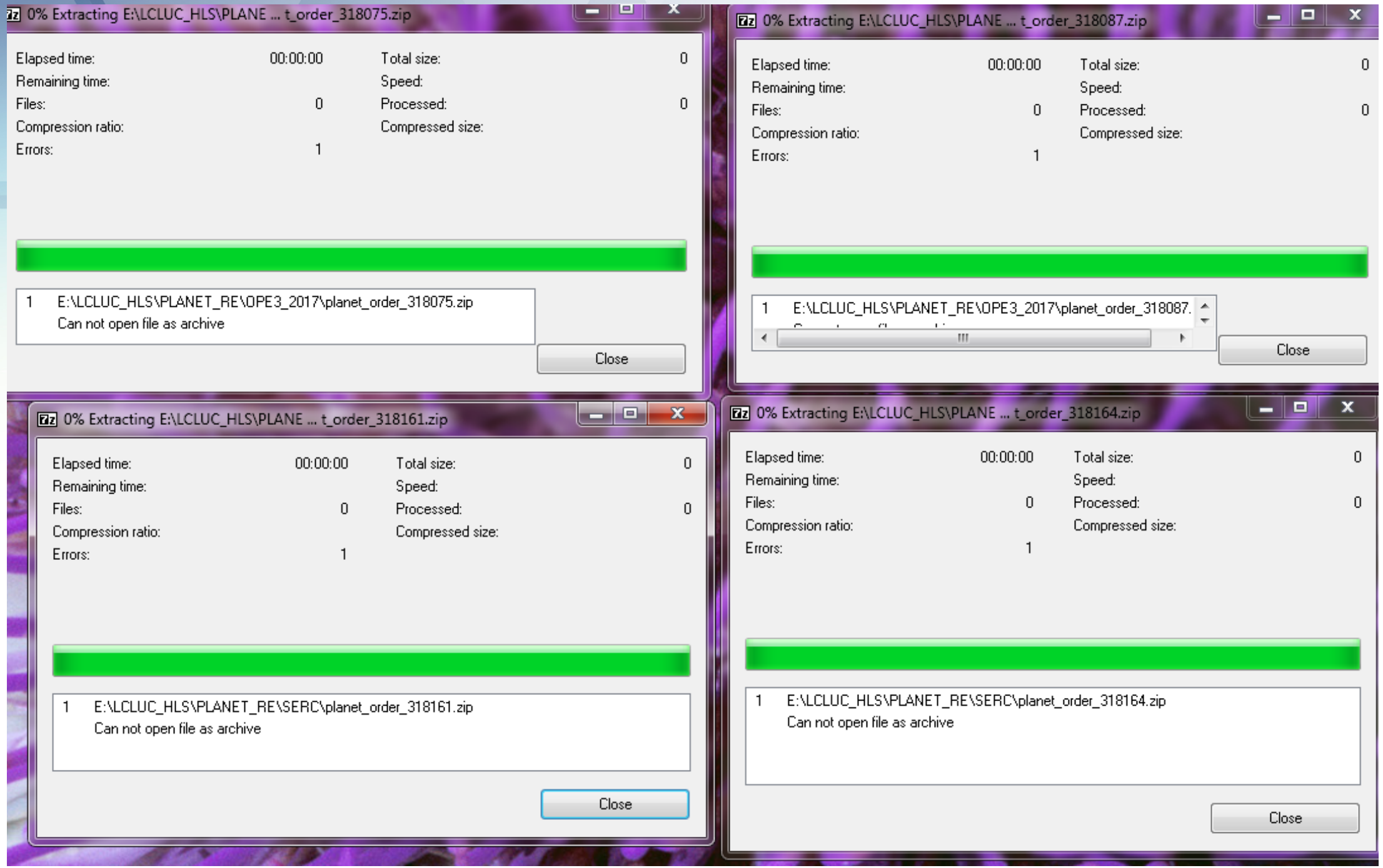
POWDER MILL RD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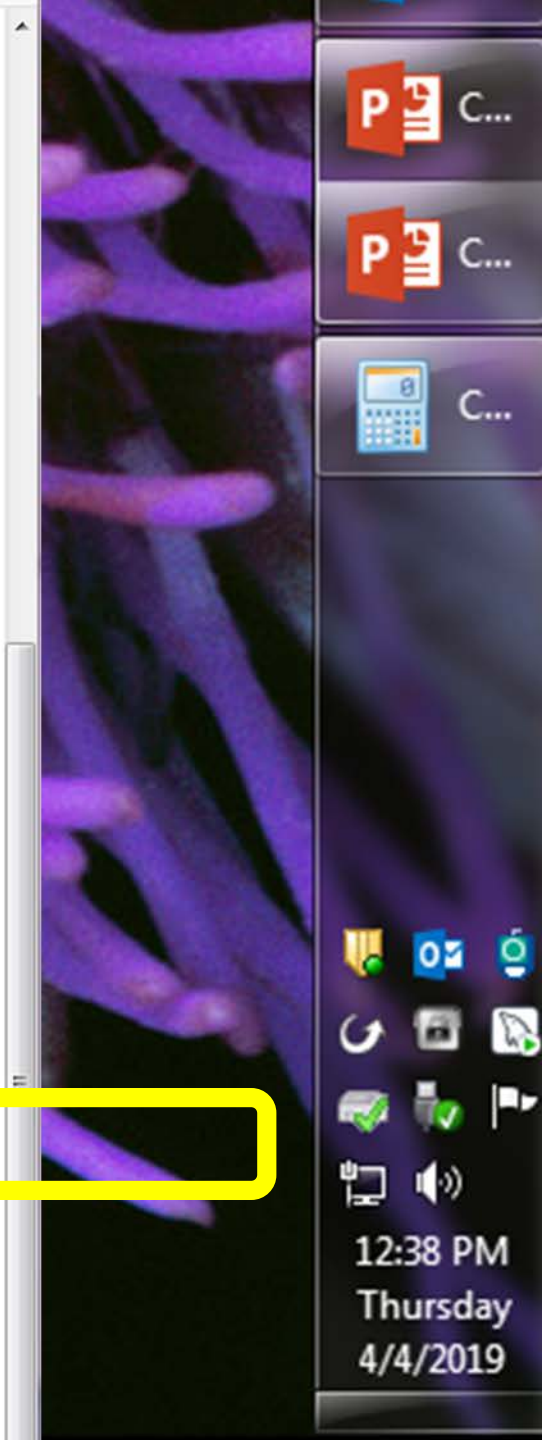

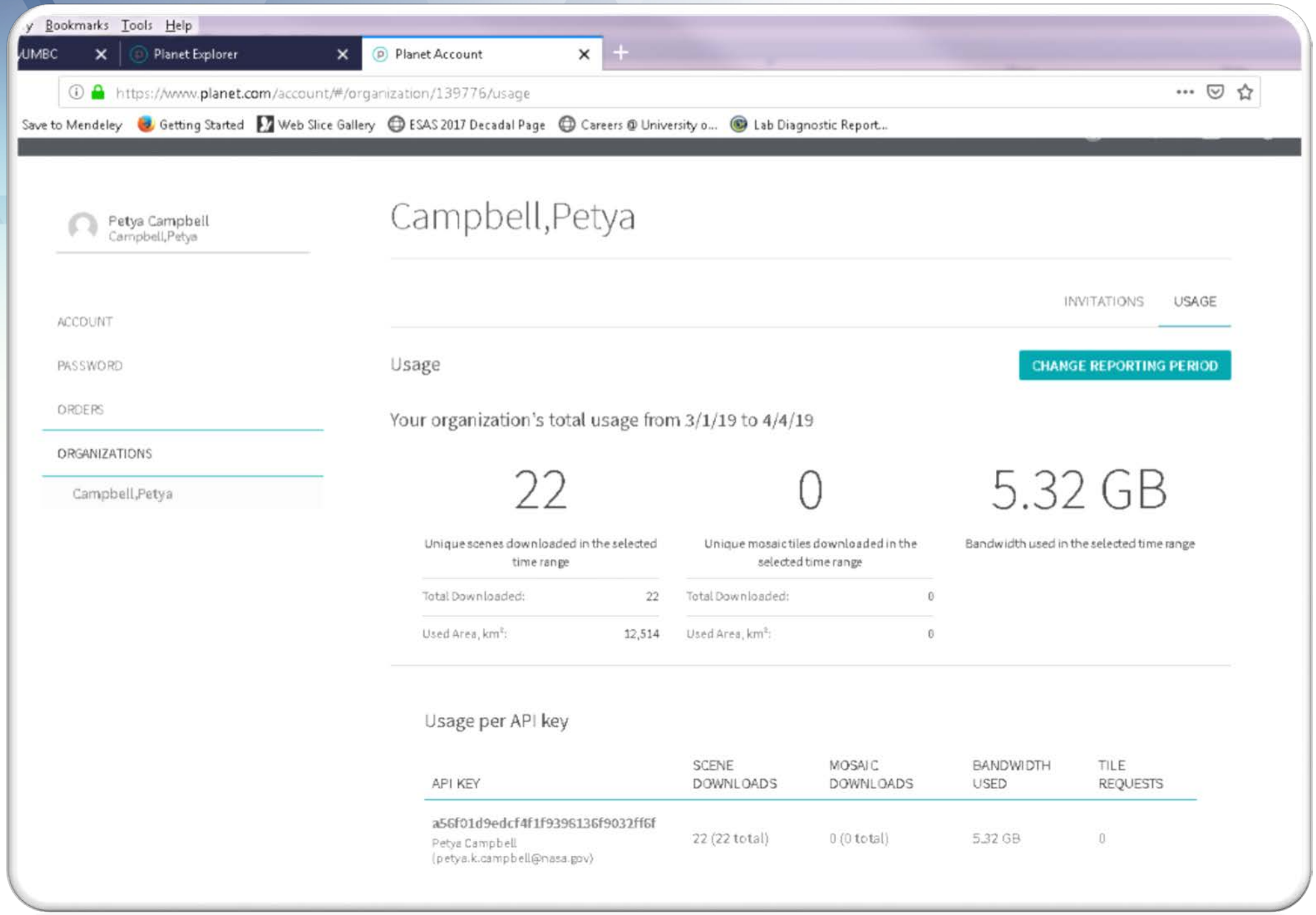
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INVITATIONS
USAGE
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CHANGE REPORTING PERIOD
Your organization's total usage from 3/1/19 to 4/4/19
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Total Downloaded: 22
Used Area, km²: 12,514
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Total Downloaded: 0
Used Area, km²: 0
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Bandwidth used in the selected time range
Usage per API key
API KEY
SCENE DOWNLOADS
MOSAIC DOWNLOADS
BANDWIDTH USED
TILE REQUESTS
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Petya Campbell
(petya.k.campbell@nasa.gov)
22 (22 total)
0 (0 total)
5.32 GB
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Preliminary Results

- Preliminary data evaluation: Clred = n/re - 1

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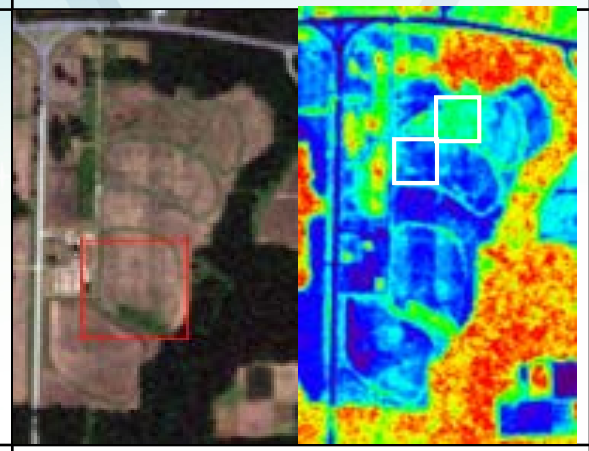
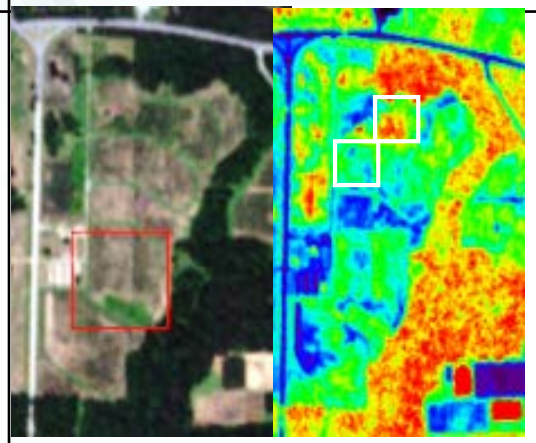
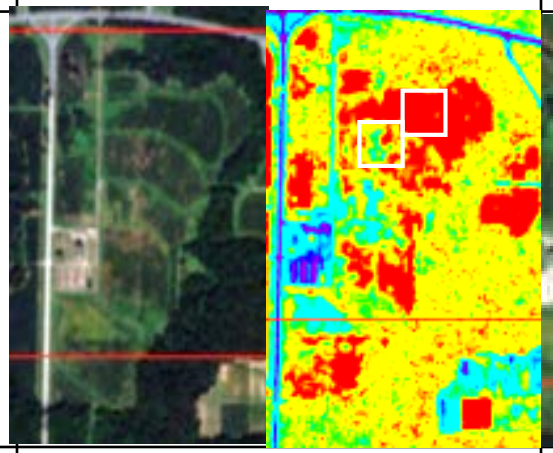
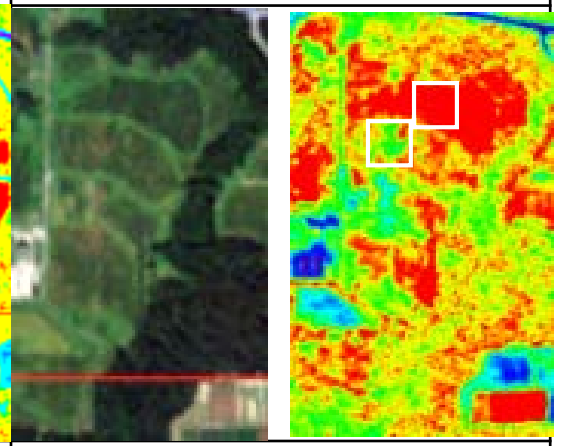
2016				
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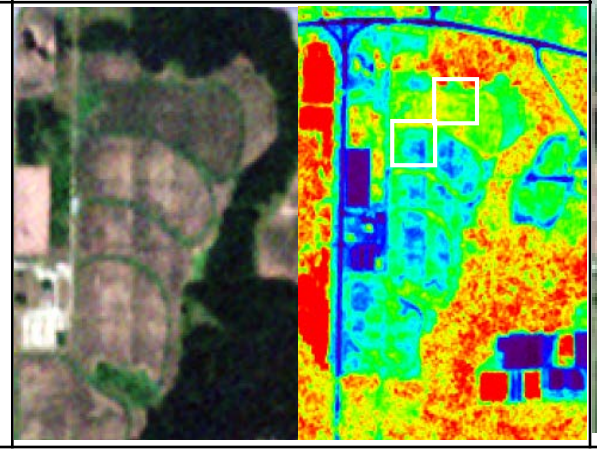
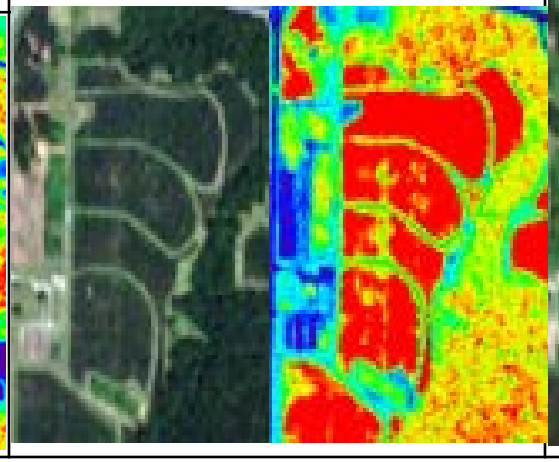
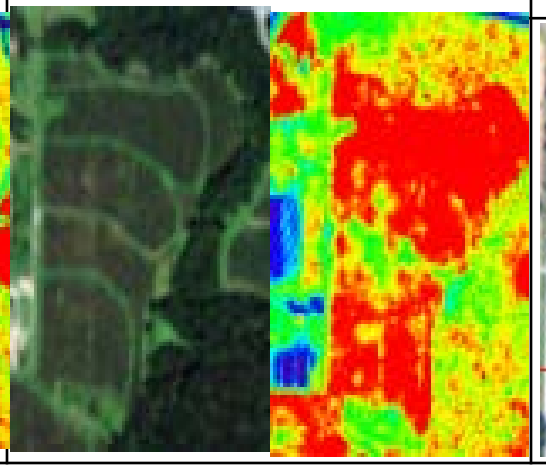
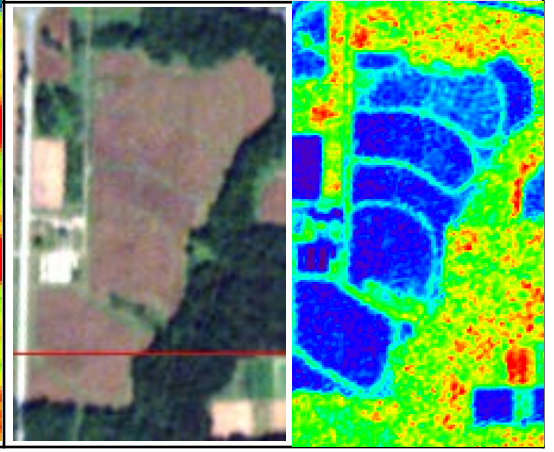
2017				

Next Steps

Tasks	Q1	Q2	Q3	Q4
Task 1. Tasking and assembly of satellite VHR data	XXX	XXX	XXX	
Task 2. Collection and assembly of field data	X	XXX	XXX	X
Task 3. VHR data processing and corrections to surface reflectance	XX	XXX	XXX	
Task 4. Generating VHR DEMs, characterization of canopy structure				
4.1 WV-2,-3, RapidEye - using established approaches and available GSFC tools	X	XXX	XXX	
4.2. SkySat constellation – using 'structure from motion' approach		XX	XXX	X
Task 5. Evaluation of radiometric stability and geolocation accuracy	X	X	X	X
Task 6. Algorithm development and implementation		XX	XXX	X
Task 7. Assessment of uncertainties	X	X	X	X
Reporting		X	X	XX

Next Steps

- Data analysis
  - *Spectral analysis*
  - *Spatial analysis*
- Algorithms
  - *Calculate VIs*
  - *TOC Chl calibration*
  - *Transferability*
- Validation
  - *Evaluation against field data*
  - *Evaluation against TOC Chl estimates from HLS*
- Enhancing LCLUC science

Index	wl	fwhm	expr	convolution
NDVI	800;670	10;10	(a-b)/(a+b)	mean
PRI	531;570	2;2	(a-b)/(a+b)	mean
MTCI	754;709;681	7;10;7	(a-b)/(b+c)	mean
EVI	800;670;480	10;10;10	2.5*(a-b)/(a+6*b-7.5*c+1)	mean
REP	670;800;700;740	10;10;10;10	700+40*((a+b/2)-c)/(d-c)	mean
TCARI	700;670;550;670	5;5;5;5	3*(a-b-0.2*(a-c)*a/d)	mean
REDCI	785;725	15;5	a/b-1	mean
mCRI	510;725;785	5;5;15	c/(a-b)	mean