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HYR-SENSE Workshop
June 13, 2024

Scaling Remote Sensing Ground to Airborne to Satellite

+ Brief NEON Overview

1 This material is based upon work supported by NSF's National Ecological Observatory Network which is a major facility fully funded by the National Science Foundation

Land acknowledgement

The University of Colorado Boulder, the Mountain Research Station, and the people who participate in these institutions recognize that the university sits upon land within the territories of the Ute, Cheyenne, and Arapaho peoples. Further, we acknowledge that 48 contemporary tribal nations are historically tied to the lands that make up the state of Colorado.

Goals of this talk

- Discuss scaling up from ground to satellite data
- Explore tradeoffs of data collected at different scales/resolutions
  - Spatial, temporal, and spectral resolutions
  - Show examples of AOP & EMIT data resolution trade-offs at Niwot Ridge
- Brief overview of NEON (National Ecological Observatory Network) - complementary datasets to NASA EMIT, ECOSTRESS and SBG
- Provide some food for thought for further discussion, building off the first 3 days of the workshop

What do we mean by “scaling”?

In remote sensing (RS), scales are ranges of things we are trying to understand – e.g. space, time, matter.

With RS data, we think of scale in the following contexts:

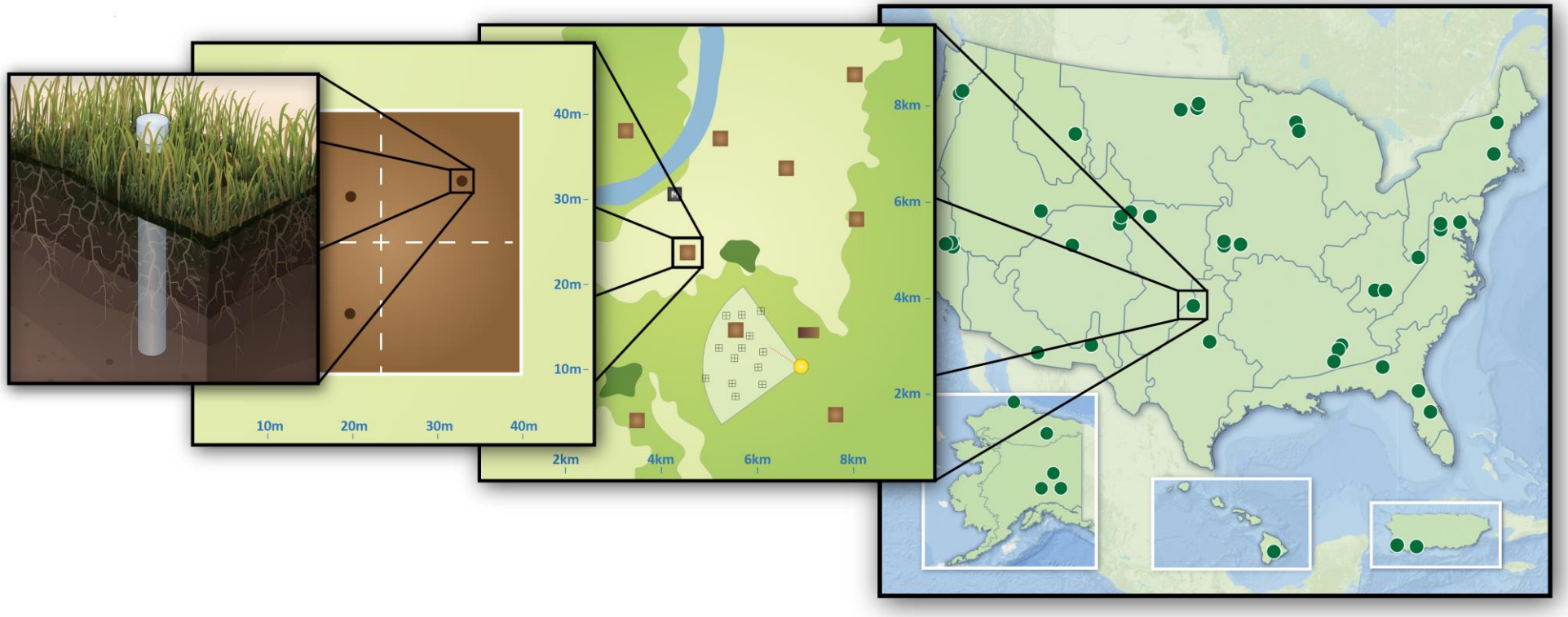
- **spatial** (area/land) – local, regional, global
- **temporal** (time) – day, year, decade, geological
- **spectral** (wavelength) - RGB, multispectral, hyperspectral

“Scaling up” means making inferences or approximations about what’s happening on the ground using data collected at a coarser scale – this is the essence of remote sensing.

Why care about remote sensing scaling?

- We care about what is happening on Earth, locally and globally
- Satellite & remote sensing data is great, but ultimately it is a tool for understanding what is happening on the ground, it is not “truth”
- Without context, or an understanding of processes, RS data is less meaningful
- Trade-offs: ground-based data takes time and effort to collect, which is often not feasible to do at large scales, but it is more accurate & meaningful
  - Uncertainty associated with remotely sensed data more, more so the further away from earth you get
  - Can use datasets collected at different scales to fill in some of these gaps

NEON – National Ecological Observatory Network
Continental Scale Ecological Monitoring



81

FIELD SITES

- 47 terrestrial
- 34 aquatic

Over

180

DATA PRODUCTS

NSF | neon Operated by Battelle

NEON's data collection methods

NEON's three systems

IS – Instrument System

Fixed sensors; e.g. meteorology, soil, surface water, eddy covariance (energy fluxes).

Terrestrial & Aquatic

OS – Observation System

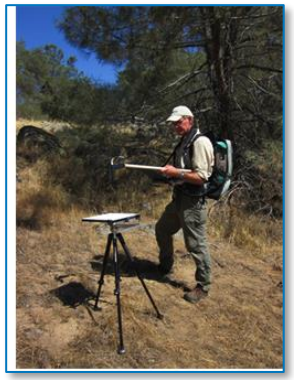
Terrestrial & Aquatic

Data are collected manually; e.g. taxa, biomass, chemistry, microbial sequencing, pathogens.

AOP – Remote Sensing

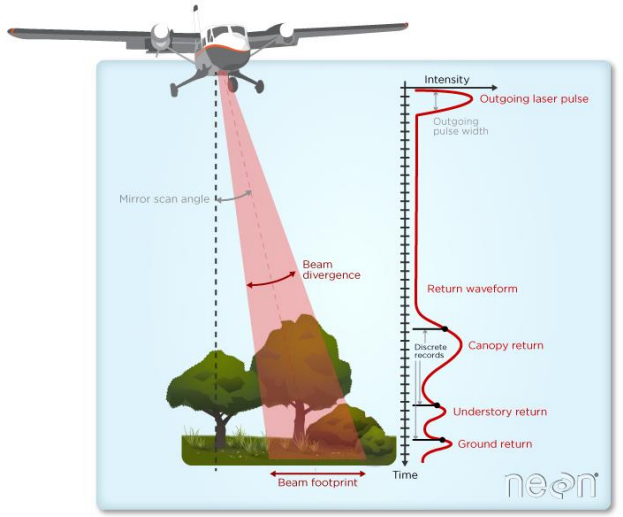
Airborne Platform

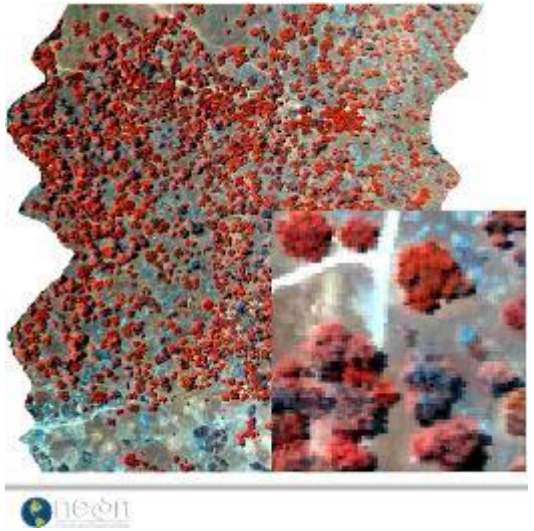
Mobile, airborne system; hyperspectral, lidar and camera data products for regional scale mapping.

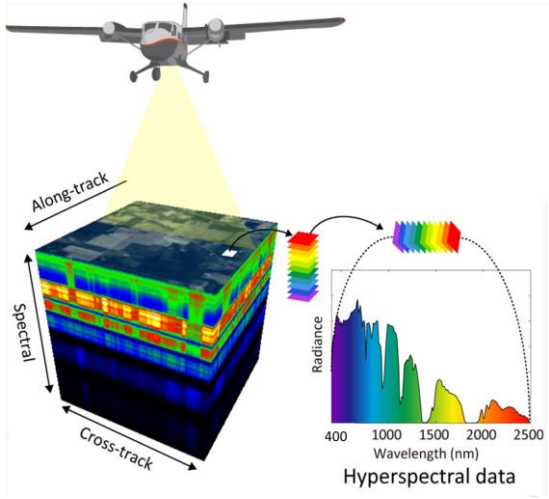


Airborne Observation Platform (AOP)

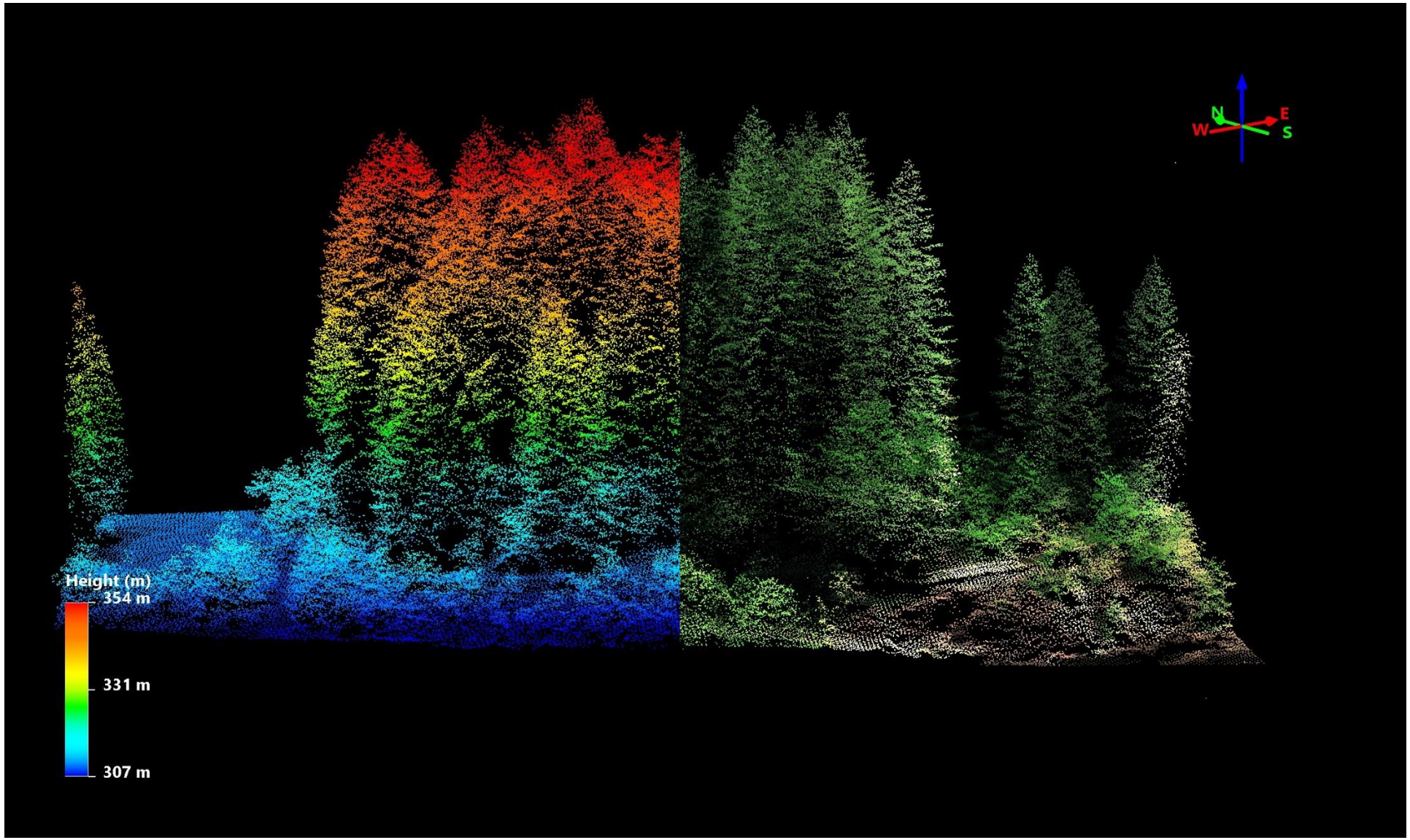
- Airborne remote sensing data
- Covers ‘regional scale’ areas (minimum 100 km^2)
- Data products generated at high spatial resolution (<=1 m^2)
- Discrete/Waveform Lidar, Hyperspectral and RGB camera



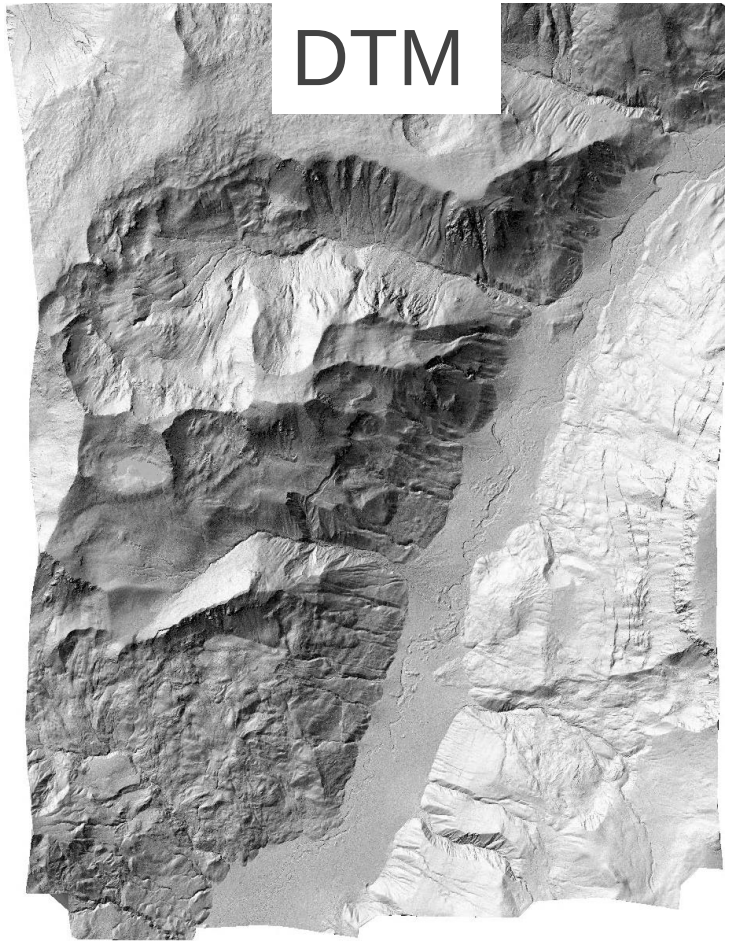


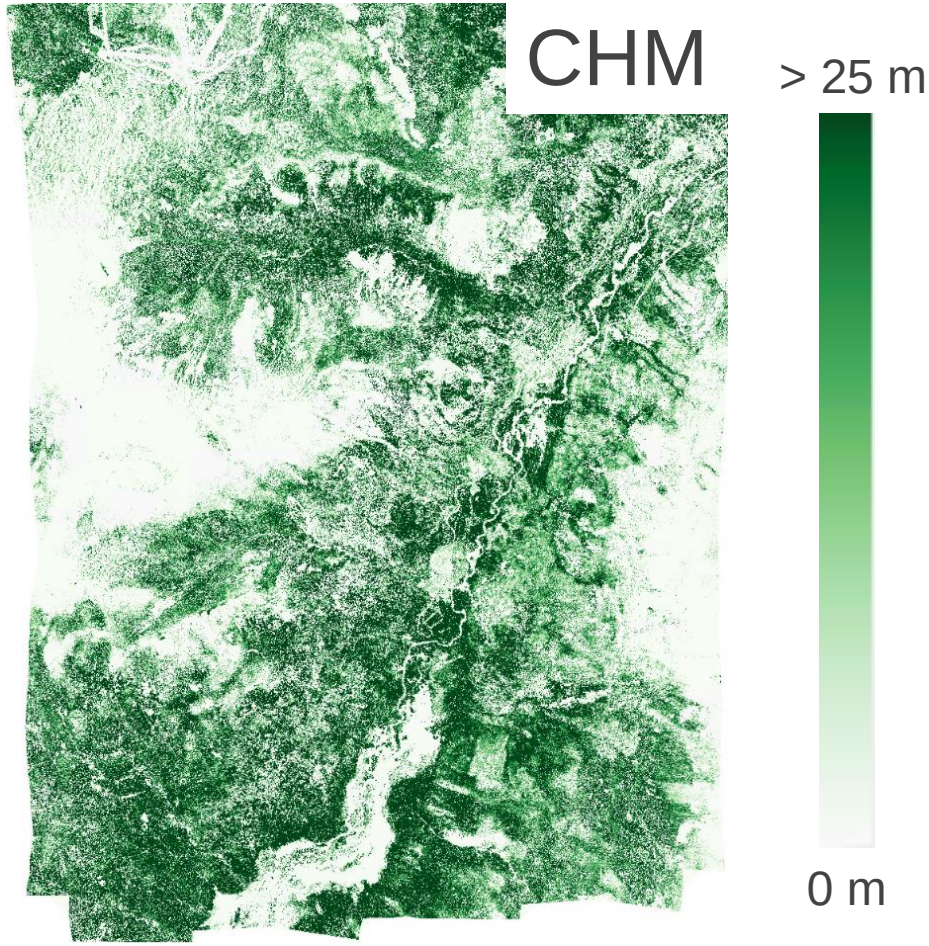


LiDAR – 3D Point Clouds and Models



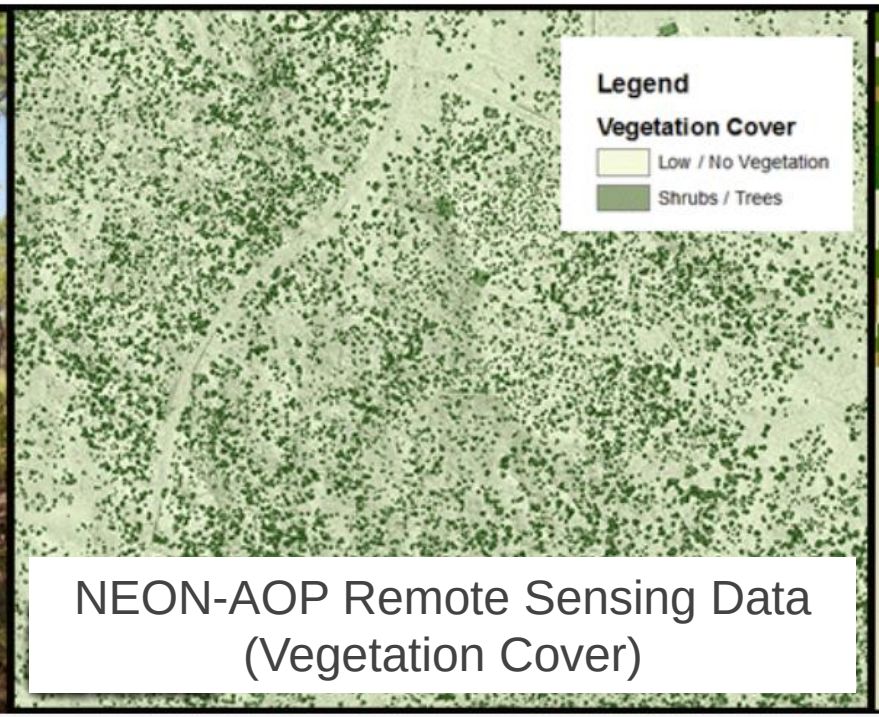
Lidar – Raster Data
Elevation Models, Canopy Height



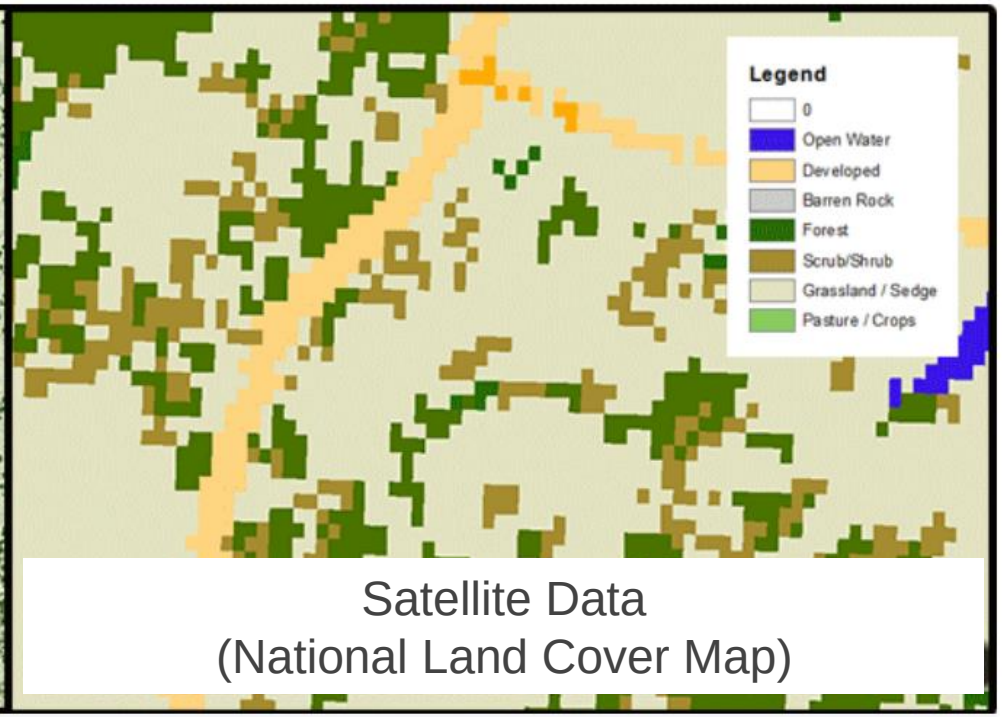


Bridging the gap between ground & satellite

In-situ data



NEON-AOP Remote Sensing Data
(Vegetation Cover)



Satellite Data
(National Land Cover Map)

Scaling Tradeoffs

seeing the forest
~~through~~ and the trees

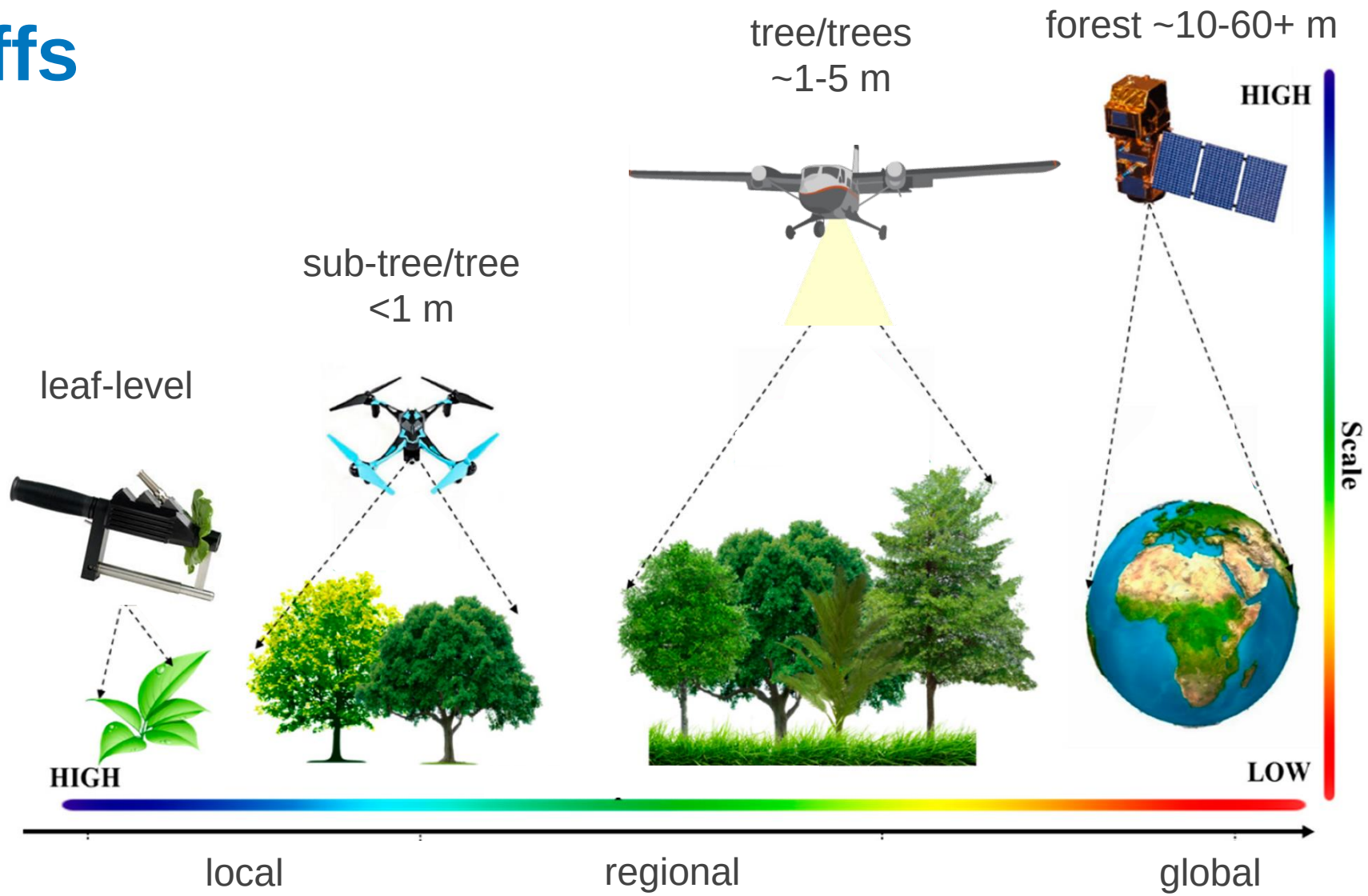
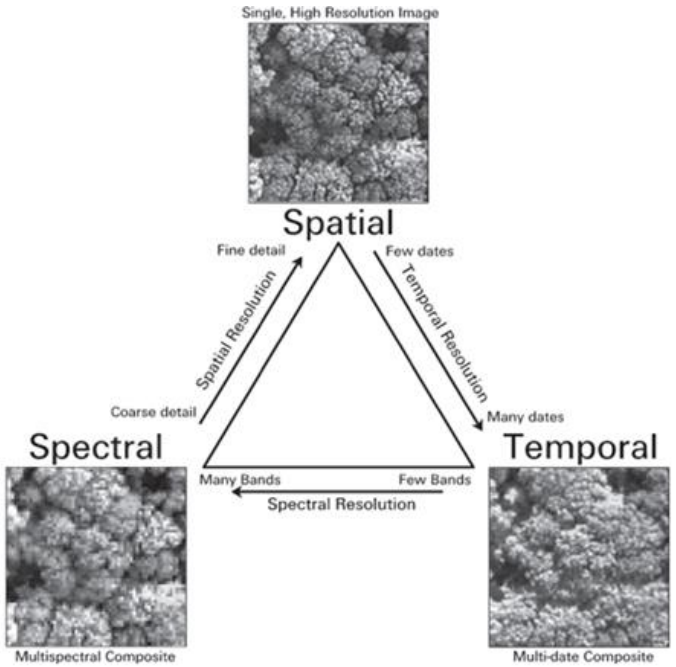
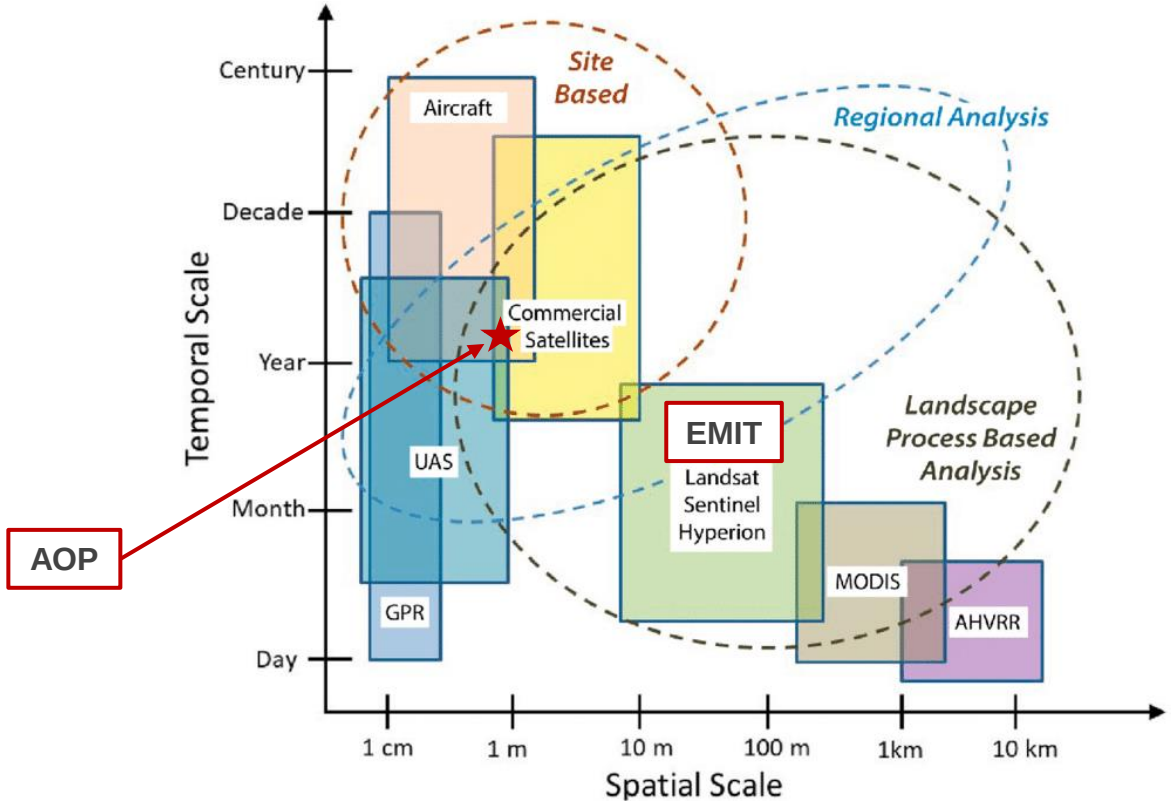


Figure modified from: https://www.mdpi.com/1424-8220/20/4/1144

Bandopadhyay, S.; Rastogi, A.; Juszczak, R. Review of Top-of-Canopy Sun-Induced Fluorescence (SIF) Studies from Ground, UAV, Airborne to Spaceborne Observations. *Sensors* **2020**, *20*, 1144. https://doi.org/10.3390/s20041144

Resolution Tradeoffs

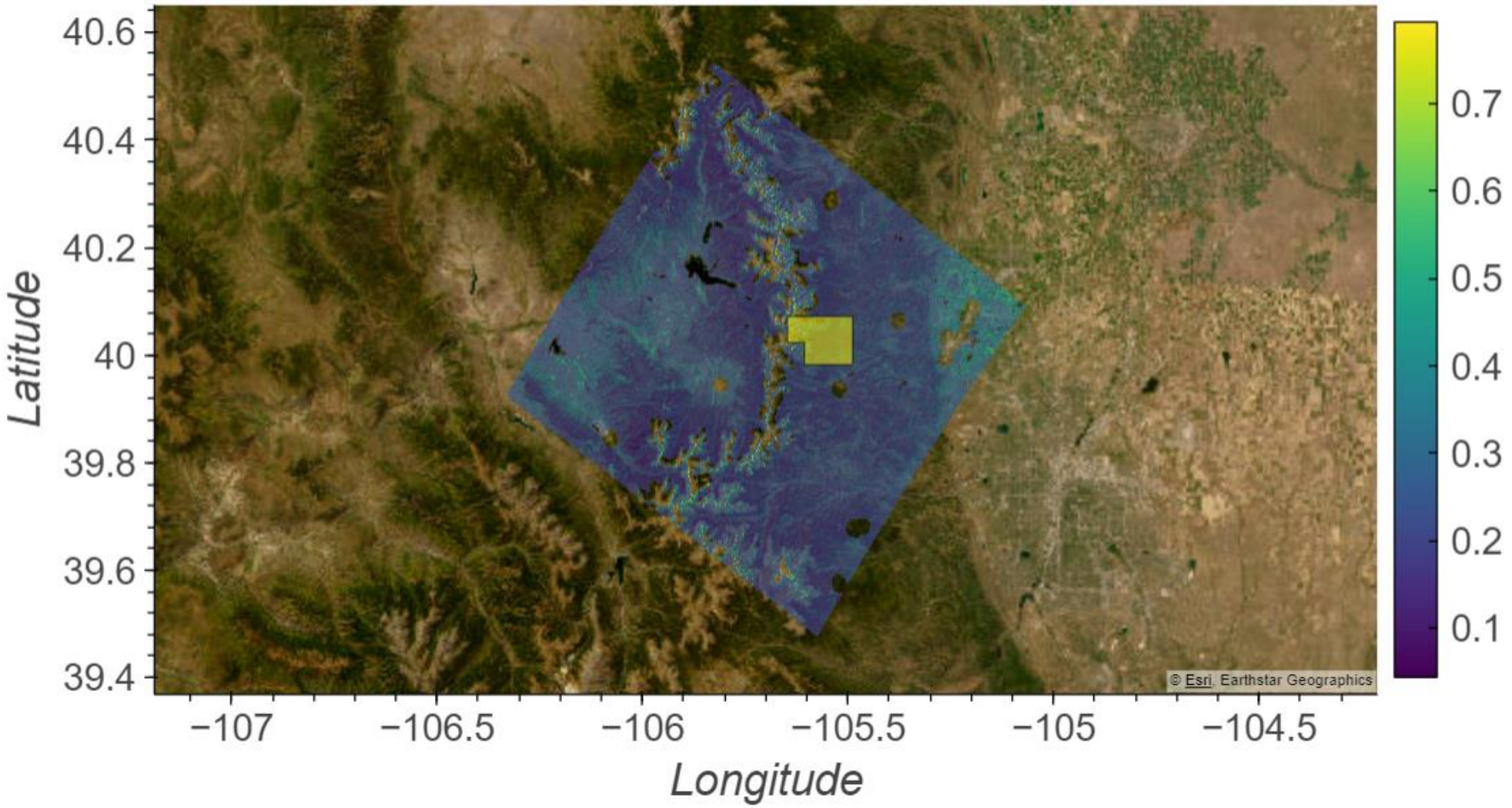




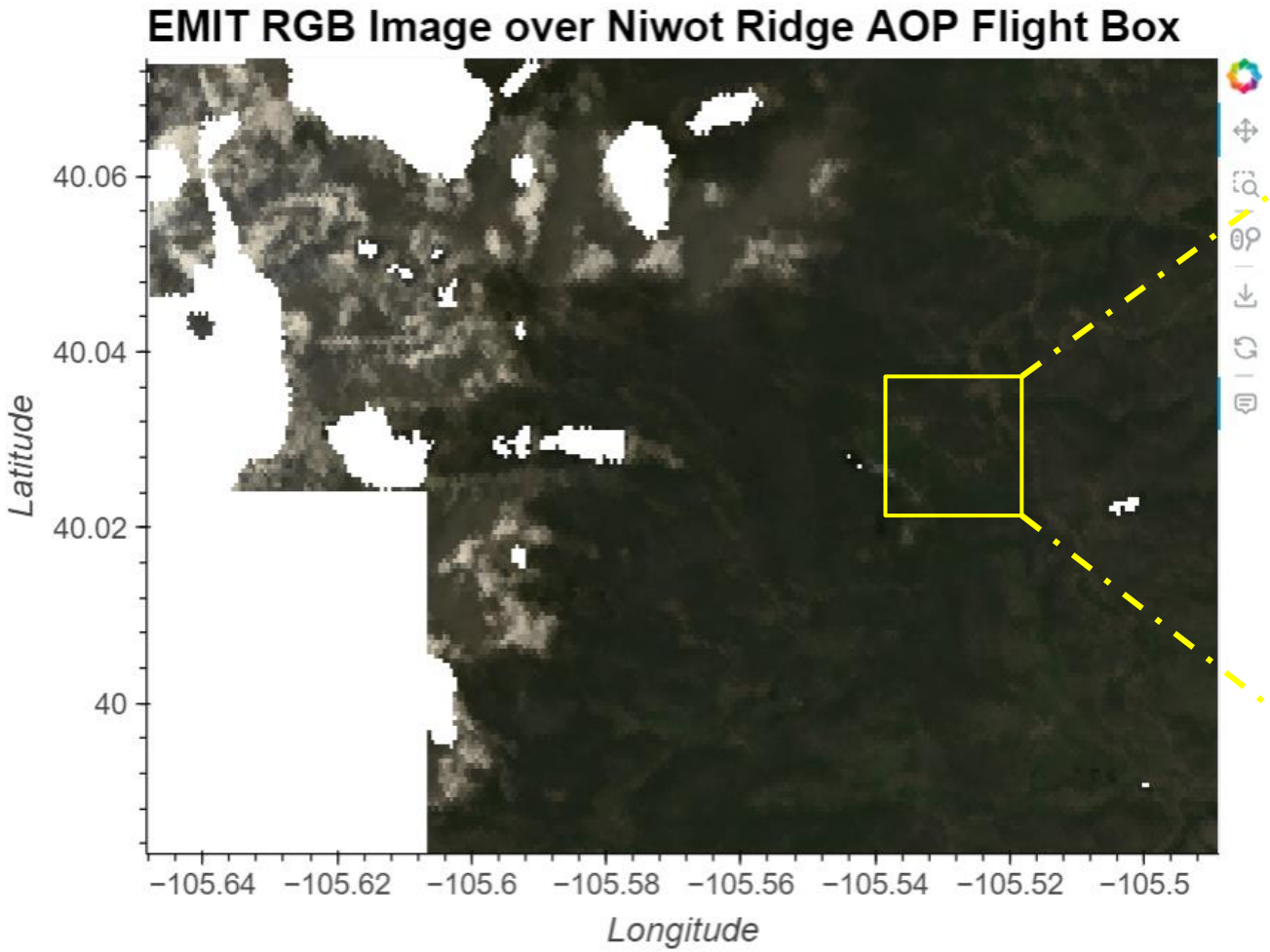
Dataset	Resolution			Coverage
	Spectral	Spatial	Temporal	Area
NEON AOP	426 bands	1m	Annual	10 x 10 km
EMIT	285 bands	60m	Variable	80 x 80 km
Landsat	7 bands	30m	Weekly	Global

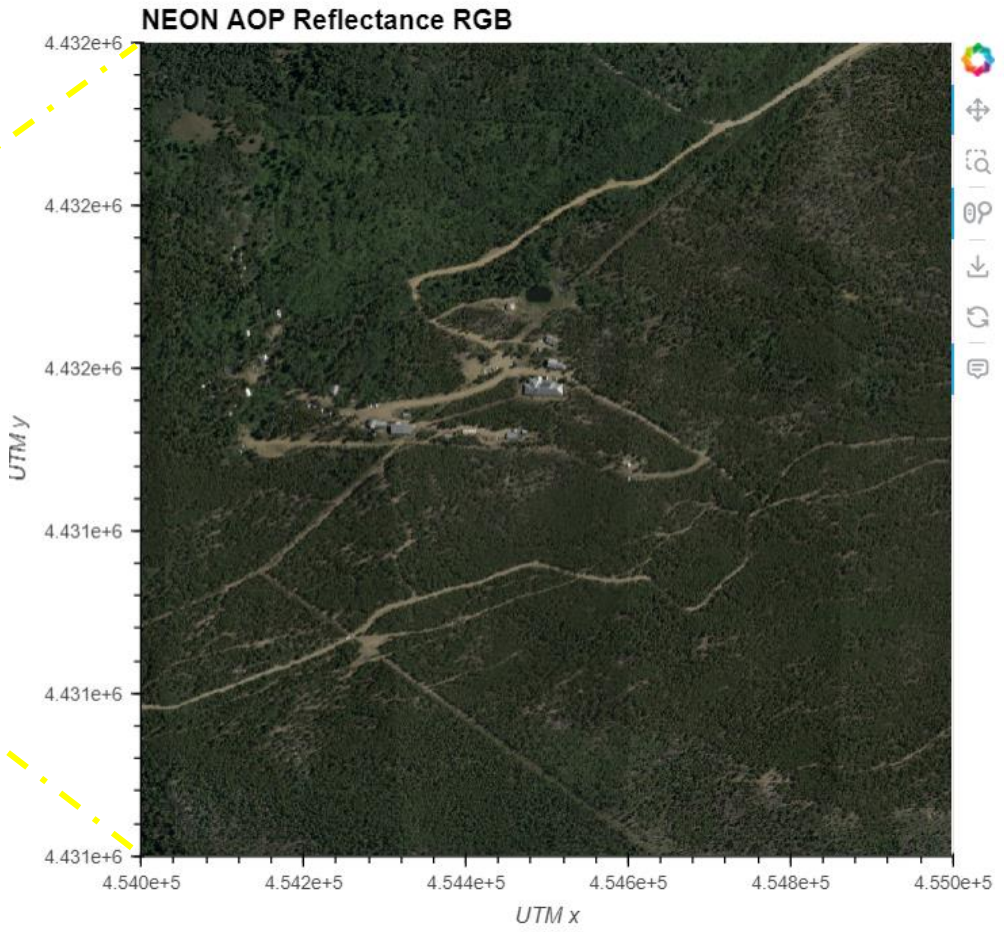
Figure Sources: 1) https://worldbank.github.io/OpenNightLights/tutorials/mod1_1_introduction_to_remote_sensing.html, 2) Remotely Sensed Big Data and Iterative Approaches to Cultural Feature Detection and Past Landscape Process Analysis - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/A-chart-of-the-relationship-between-an-array-of-remote-sensing-technologies-and-analytic_fig1_339217563 [accessed 11 Jun, 2024]

NEON AOP / EMIT Comparison - Examples @ Niwot Ridge

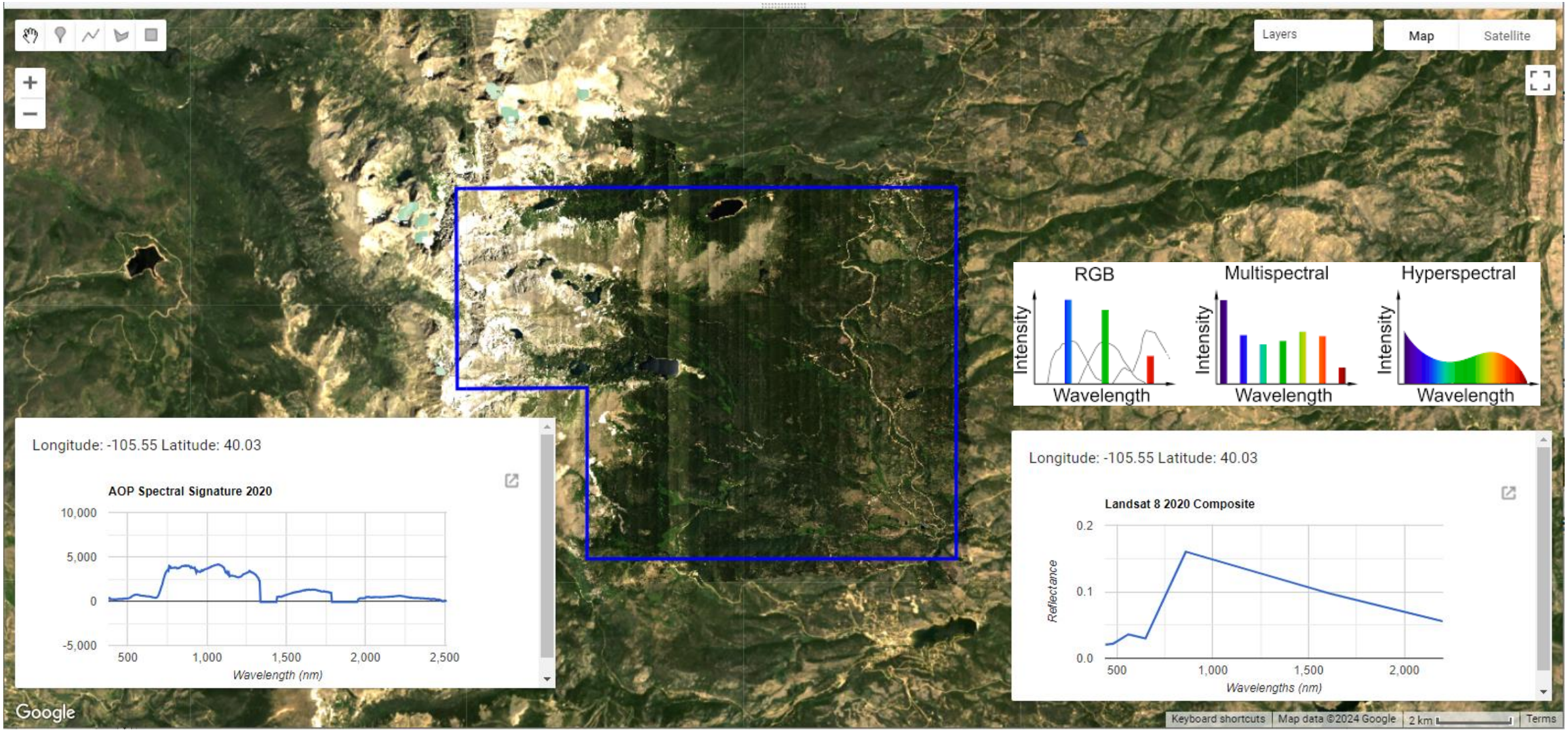


Resolution comparison – EMIT v. AOP



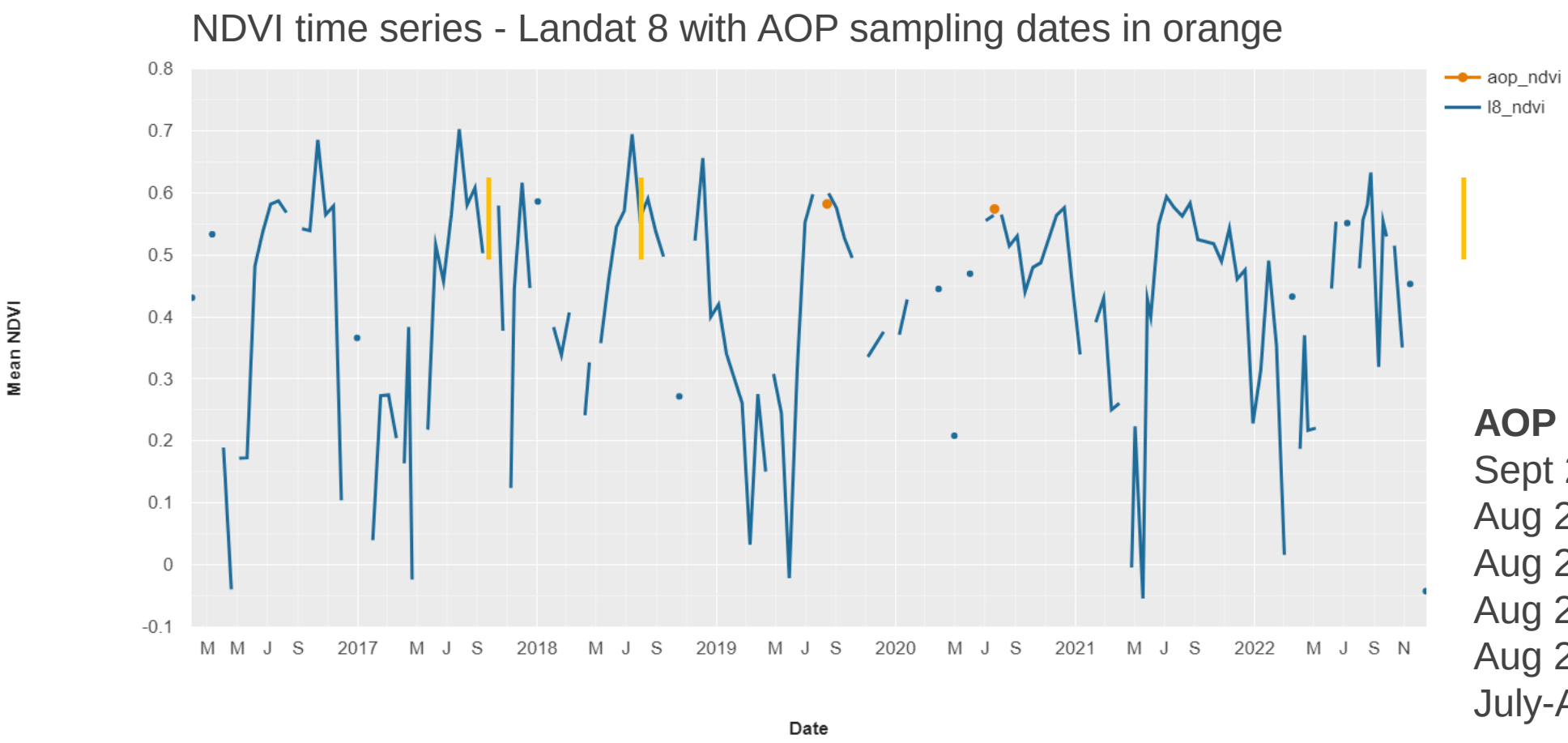


Spectral Resolution – Hyperspectral v. Multispectral



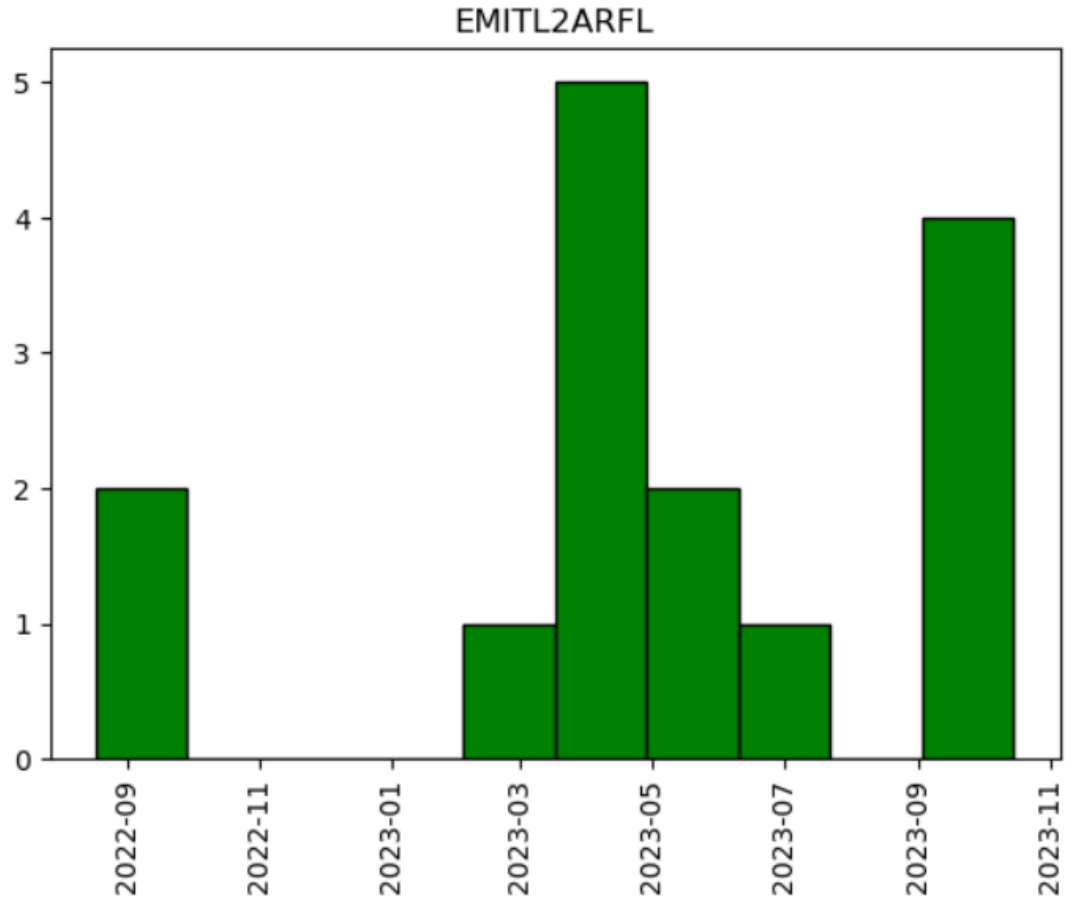
https://ee-bridgethass.projects.earthengine.app/view/niwo-spectra

Temporal Resolution Comparisons
AOP v. Landsat 8



AOP sampling dates:
Sept 2017
Aug 2018
Aug 2019
Aug 2020
Aug 2023
July-Aug 2024 (planned)

EMIT Temporal Resolution @ Niwot Ridge



Index: 6 - EMIT_L2A_RFL_001_20230406T181842_2309612_019

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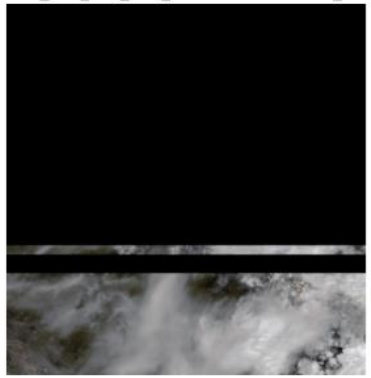
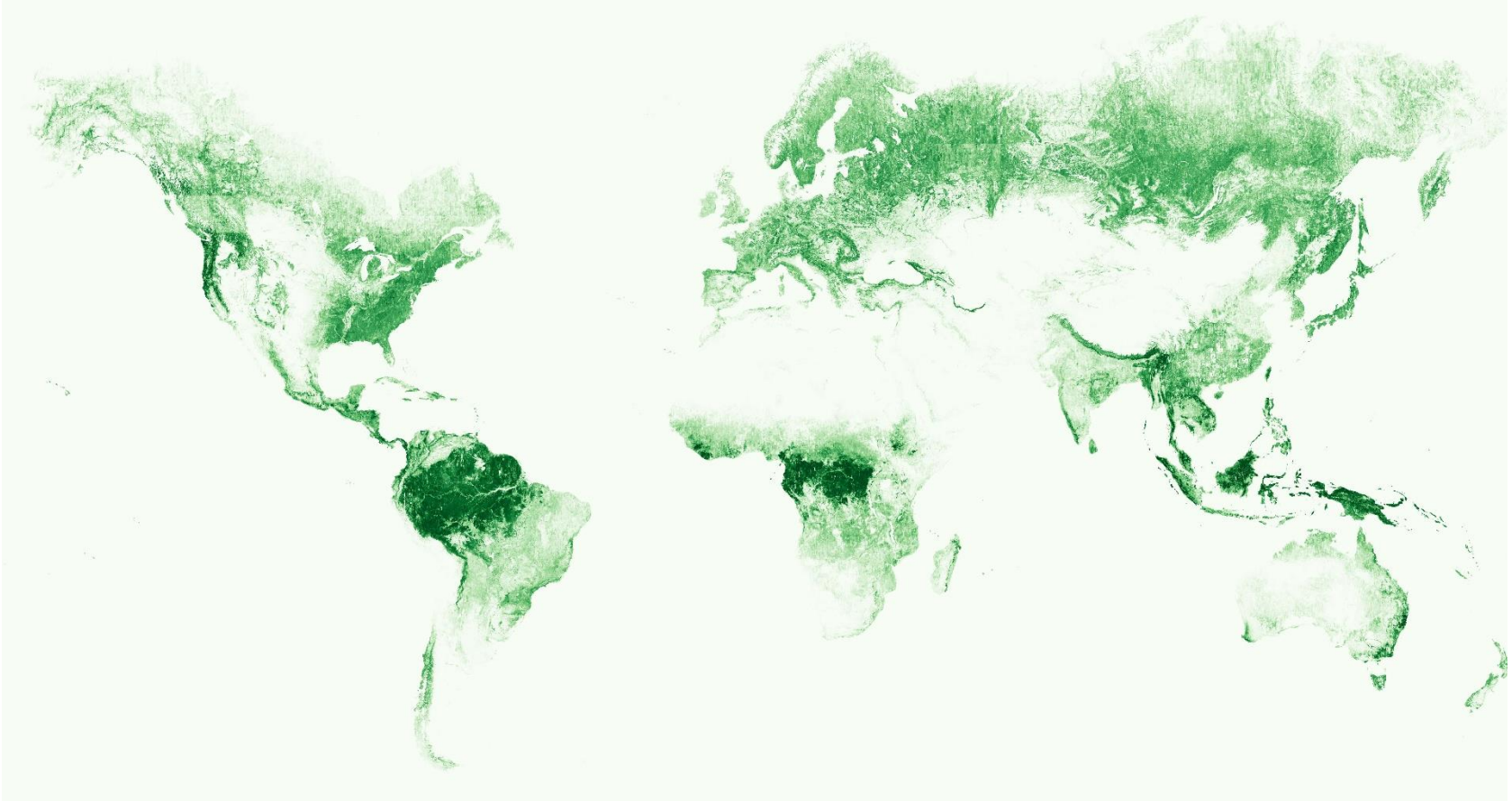
Index: 9 - EMIT_L2A_RFL_001_20230602T194051_2315313_018



Index: 10 - EMIT_L2A_RFL_001_20230625T170814_2317611_005

Scaling Research Example



AI model maps global tree canopy heights in hi-res, with carbon counting in mind

by **Abhishyant Kidangoor** on 30 April 2024

- *Scientists have used high-resolution satellite images to create a map of global canopy heights, and to also develop an AI model that can predict canopy heights.*
- *Tech company Meta collaborated with nonprofit organization World Resources Institute to develop the open-source map and model.*
- *While the map aims to establish and serve as a baseline for conservation initiatives, the AI model could be used to predict canopy heights in areas where high-quality data aren't available.*
- *Canopy height is an important indicator of forest biomass and aboveground carbon stock, and is used to measure the progress of forest restoration efforts.*

https://meta-forest-monitoring-okw37.projects.earthengine.app/view/canopyheight

Getting Started with NEON Data

- **NEON Learning Hub**
  - https://www.neonscience.org/resources/learning-hub

- **NEON – EMIT exploratory notebooks** on the HYR-SENSE repository:
  - https://github.com/CU-ESIIL/HYR-SENSE/blob/main/notebooks/neon-emit

- **NEON AOP Google Earth Engine Scripts / Apps**
  - https://ee-bridgethass.projects.earthengine.app/view/niwo-spectra
  - https://tinyurl.com/niwo-aop-gee-demo

Questions / Takeaways

What scaling applications would you like to explore?

What ground data or knowledge might you need to achieve this, and how might you link it to RS data?

- There are many, many data sources out there, available at various scales
  - NEON is one such openly-available resource that was designed to help bridge the gap between ground and satellite data, for regional to continental-scale ecological research in the U.S.

- Integrating local knowledge + incorporating multiple data sources can help create a bigger picture understanding of what's going on, locally to globally
  - You can have all the data you want, but ultimately need some context around it

Discussion / Questions + Contact Information

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