GEOG 457/657 – Advanced Remote Sensing – Winter 2024

Alex Bevington bevington@unbc.ca

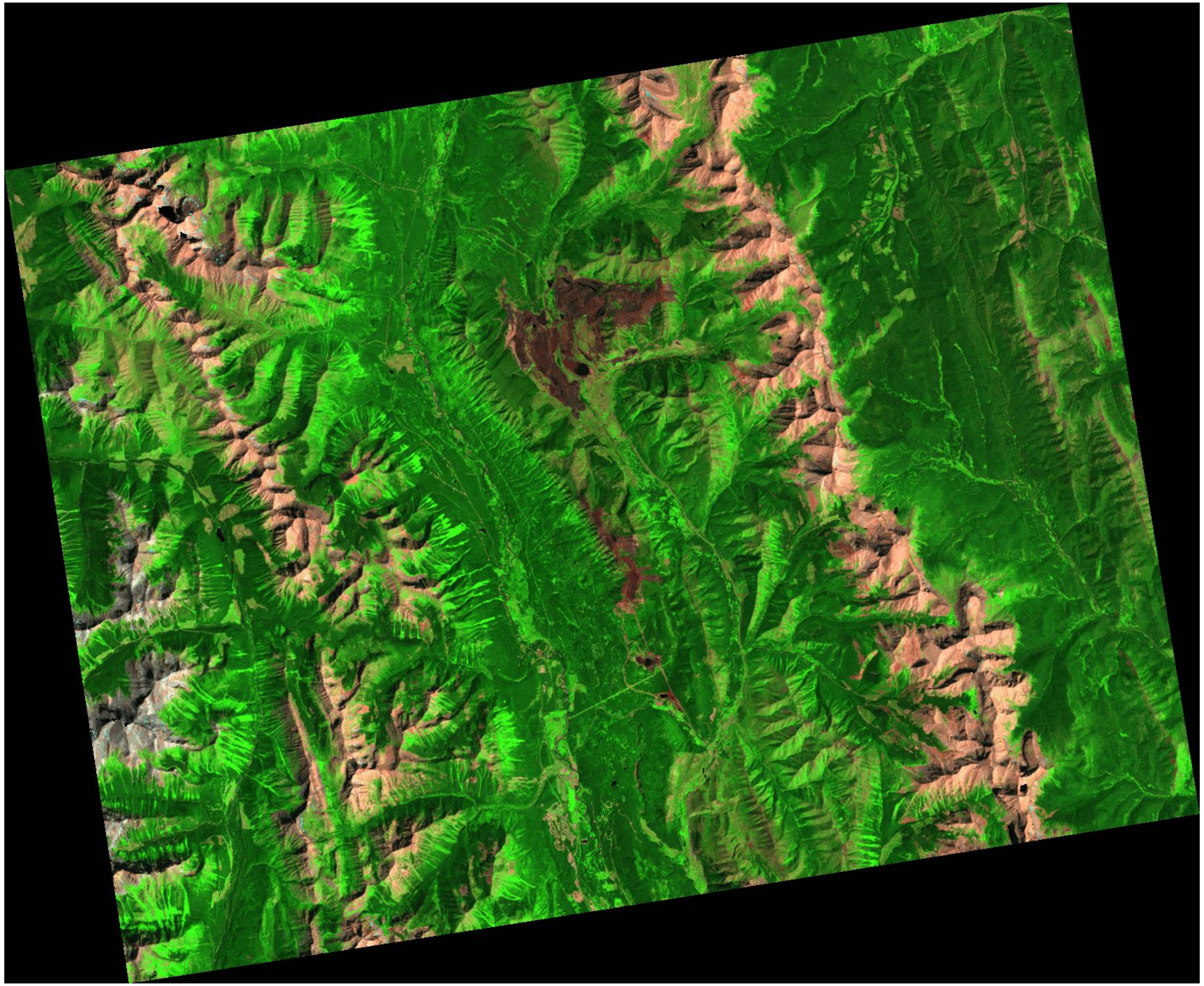
GEOG 457/657

- **Instructor**
  - Alex Bevington
    bevington@unbc.ca
- **Class website**
  - https://gis.unbc.ca/
- **Location and hours**
  - Tuesday 8:30-9:20 - Lecture (10-4072)
  - Tuesday 11:30-2:20 - Lab (GIS Lab 8-125)
  - Thursday 8:30-9:20 - Lecture (10-4072)
- **Office hours**
  - Tuesday from 10:30-11:30 in the GIS Lab
- **Undergraduate/graduate students**
  - This is a split course. Requirements for this course will be higher for graduate students.

https://code.earthengine.google.com/146f42d6ba635c4a0ae1155464c17d22

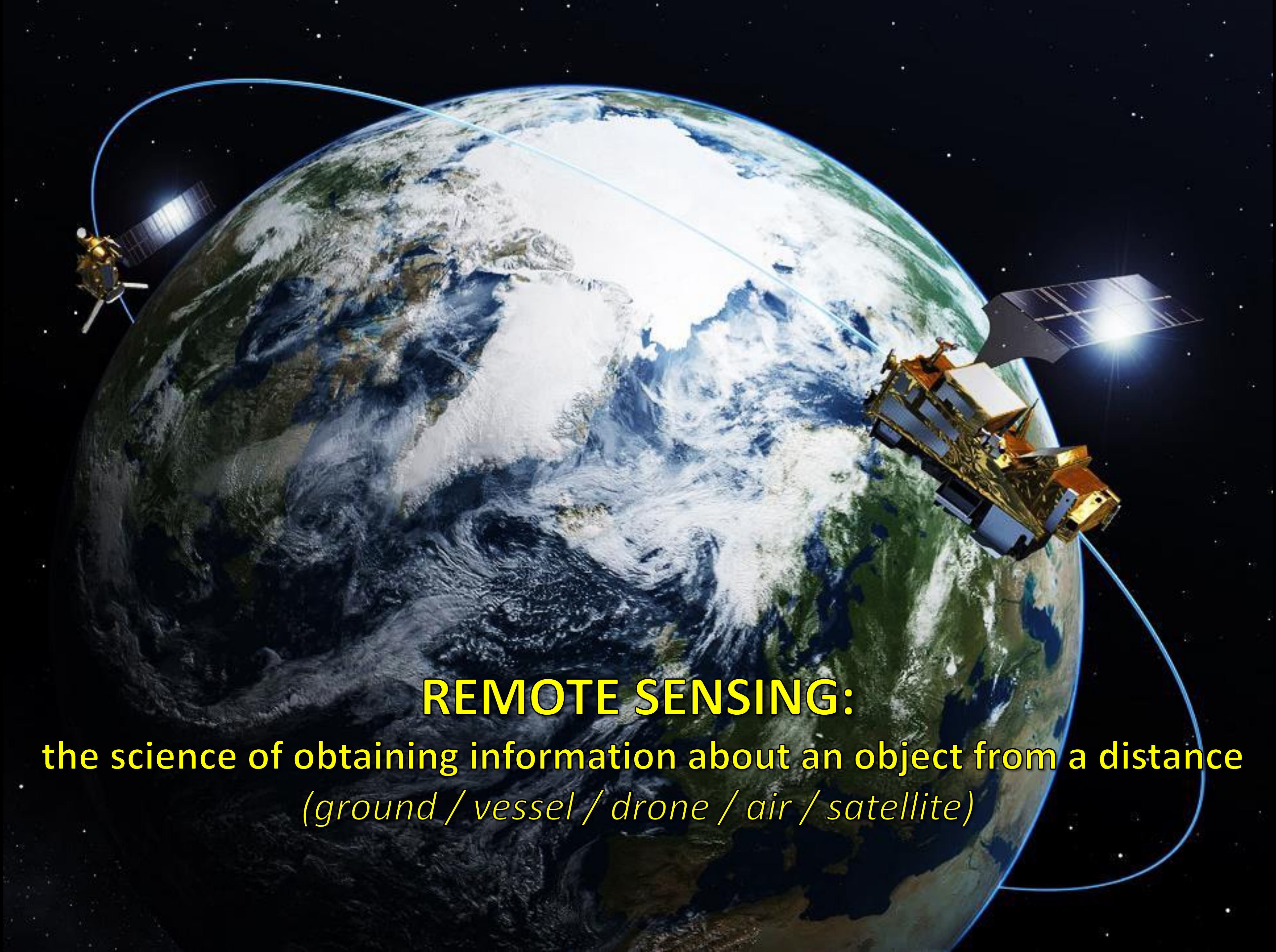
GEOG 457/657

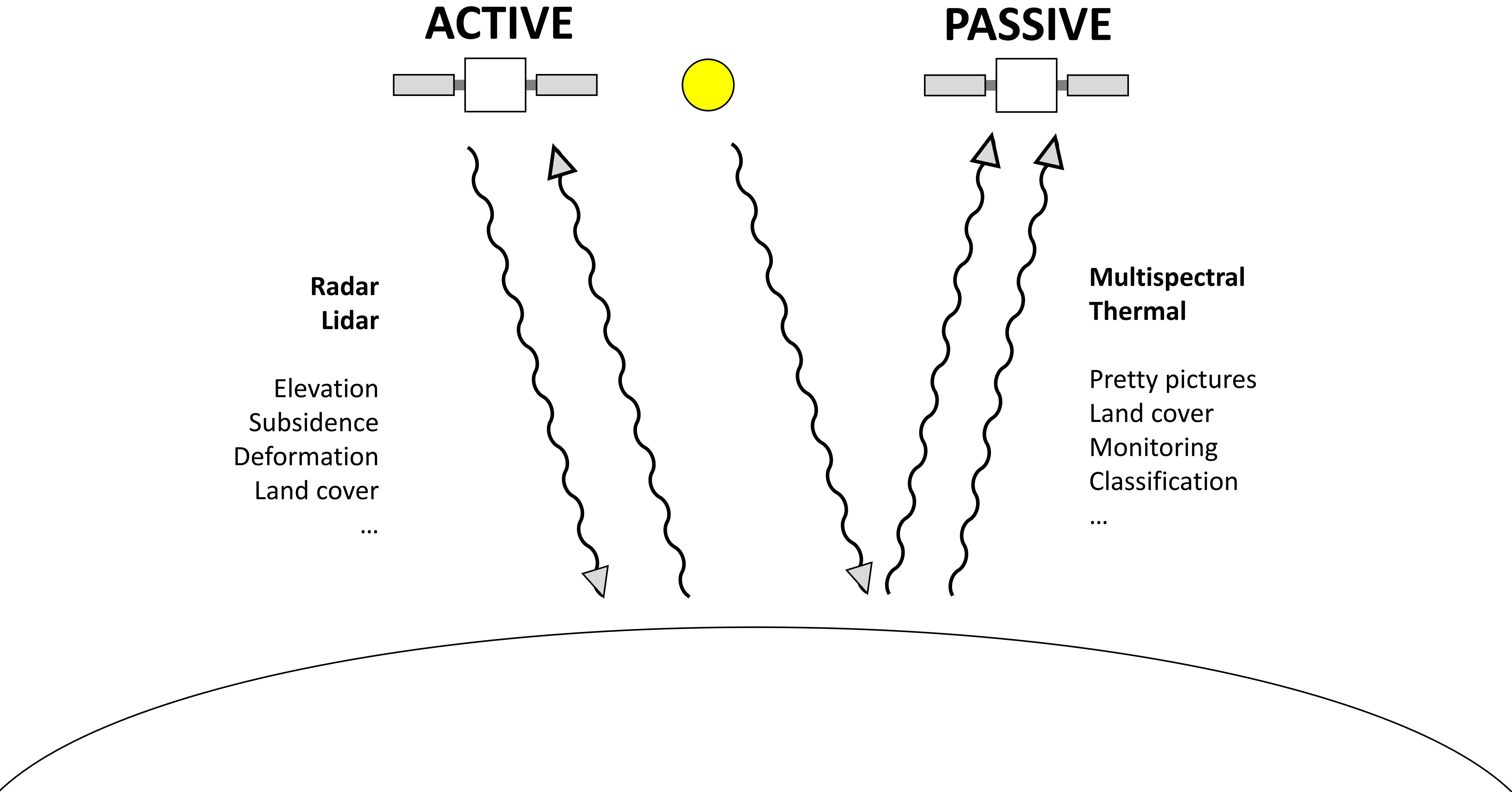
- **Grading**
  - 10 Labs (40%)
  - Presentations (10%) Feb 6 & Mar 14
  - Midterm exam (15%) Thu, Feb 15
  - Final exam (15%) Tue, Mar 26
  - Final project (20%) Thu, Mar 28
- **Required accounts**
  - Github https://github.com/
  - Gmail https://www.google.com/gmail/about/
  - Google Earth Engine https://code.earthengine.google.com/

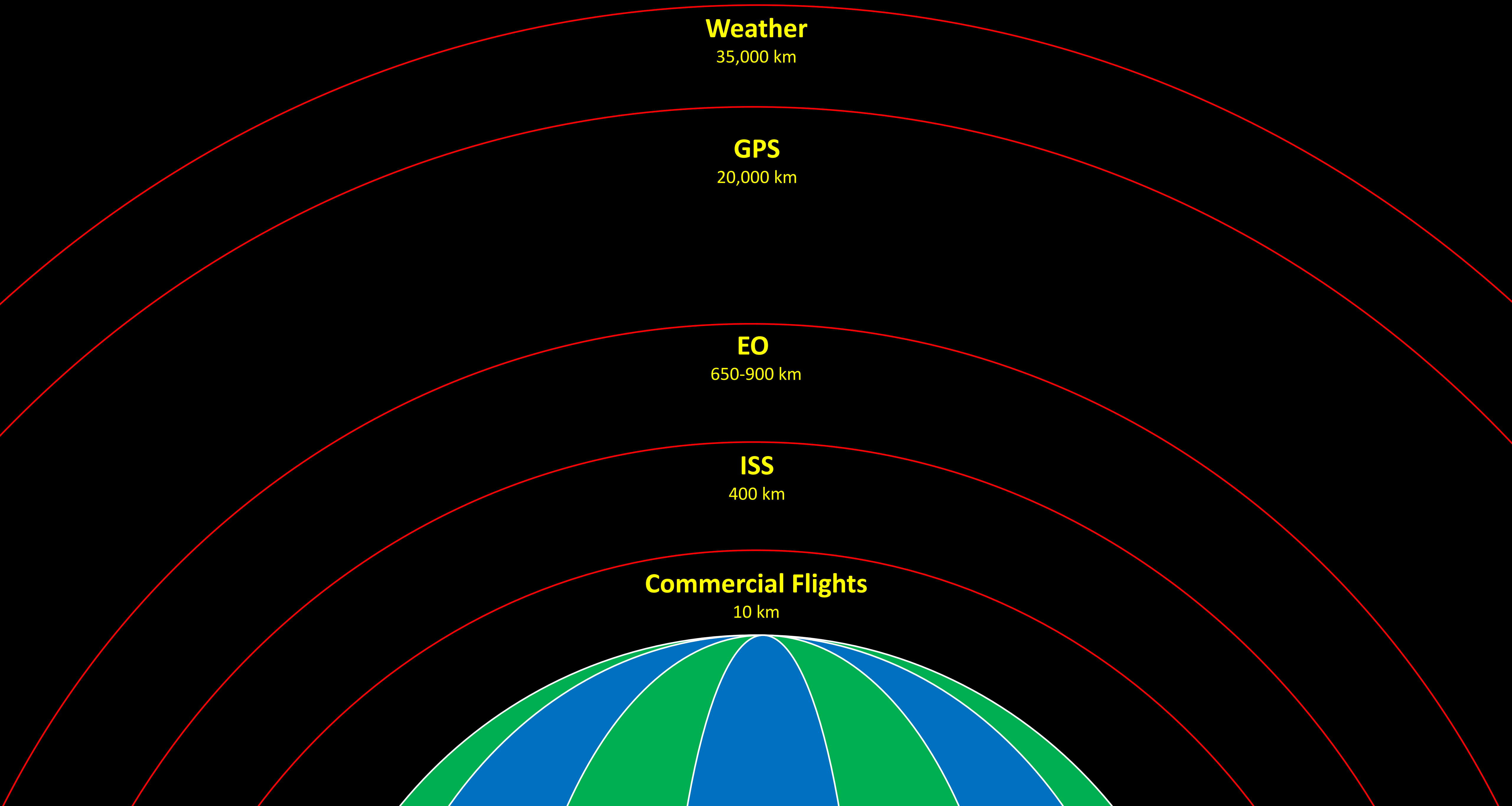


Date		Lecture	Lab	Reading
Thu, Jan 4		Intro		Hansen et al. 2013
Tue, Jan 9		Optical - Fundamentals	Lab 1: Google Earth Engine	Gorelick et al. 2017
Thu, Jan 11		Optical - Applications		
Tue, Jan 16		Radar - Fundamentals	Lab 2: GEE SAR Flooding	Howell et al. 2021
Thu, Jan 18		Radar – Applications		
Tue, Jan 23		Lidar - Fundamentals	Lab 3: lidR and LidarBC	Coops et al. 2021
Thu, Jan 25		Lidar – Applications		
Tue, Jan 30		Drones - Fundamentals	Lab 4: Drones	Kattenborn et al. 2019
Thu, Feb 1		Drones - Applications		
Tue, Feb 6	1	*Class Presentations (5%)*	Lab 5: Other sensors	
Thu, Feb 8		Other Sensors		
Tue, Feb 13	2	Extraterrestrial RS / Review	Lab 6: Building websites	
Thu, Feb 15	3	*Mid Term (15%)*		
Tue, Feb 20		*BREAK*		
Thu, Feb 22		*BREAK*		
Tue, Feb 27		Classification, ML	Lab 7: Random Forest in GEE	Mahdianpari et al. 2020
Thu, Feb 29		Classification, ML		
Tue, Mar 5	4	Time Series Analysis	Lab 8: Trends in indices	Pasquarella et al. 2022
Thu, Mar 7		Time Series Analysis		
Tue, Mar 12		Terrain Analysis - Fundamentals	Lab 9: Segmentation	Sykes et al. 2023
Thu, Mar 14	5	*Class Presentations (5%)*		
Tue, Mar 19		Pixel Tracking – Fundamentals	Lab 10: Image velocimetry	Pearce et al. 2020
Thu, Mar 21		Ground-based RS		
Tue, Mar 26	6	*Exam (15%)*	Project time	Mark et al. 2019
Thu, Mar 28	7	*Field Trip – Drones*		
Tue, Apr 2	8	*Project Presentations*	Lab 11: Timelapse camera	
Thu, Apr 4	9	*Project Presentations*		
Tue, Apr 9	10	Careers in remote sensing	No lab	

Introductions..


REMOTE SENSING:
the science of obtaining information about an object from a distance
(ground / vessel / drone / air / satellite)

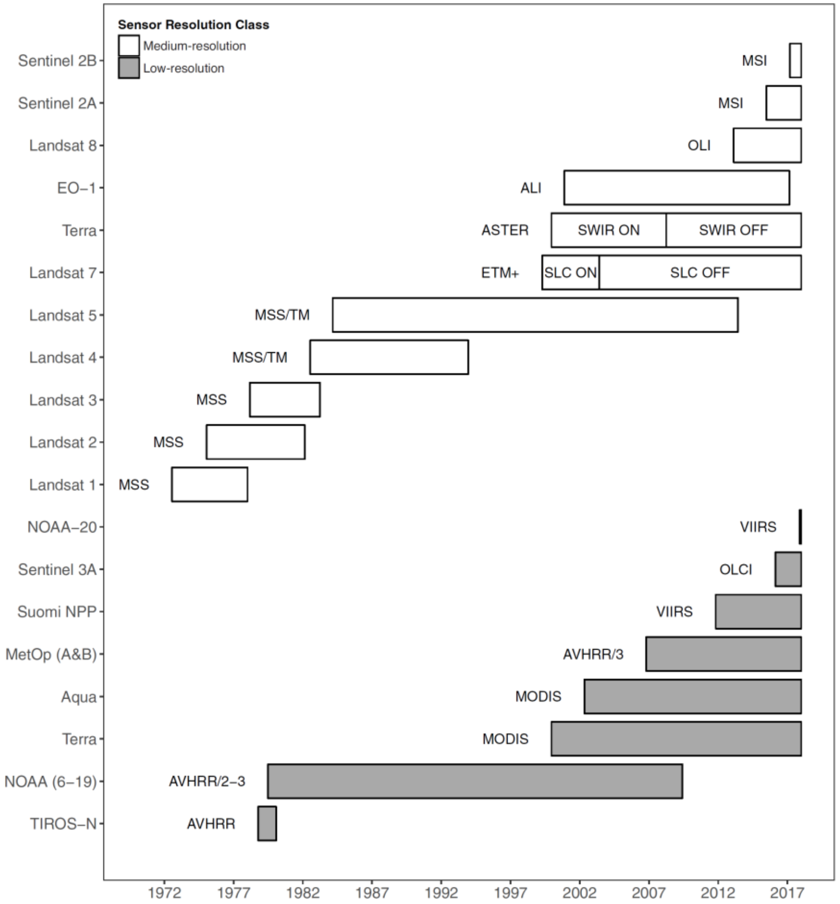

ACTIVE
PASSIVE
Radar
Lidar
Elevation
Subsidence
Deformation
Land cover
...
Multispectral
Thermal
Pretty pictures
Land cover
Monitoring
Classification
...

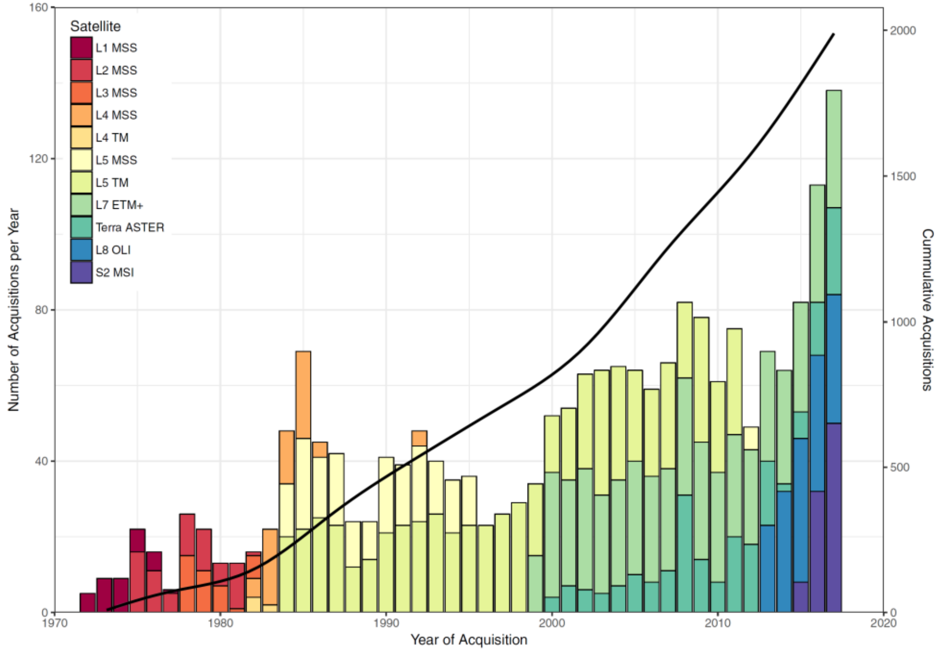


Weather
35,000 km
GPS
20,000 km
EO
650-900 km
ISS
400 km
Commercial Flights
10 km

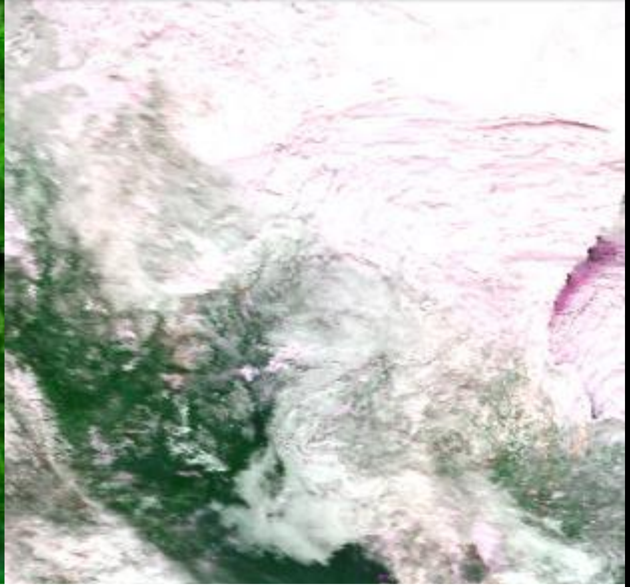
A Review of Free Optical Satellite Imagery for Watershed-Scale Landscape Analysis

Alexandre Bevington, Hunter Gleason, Xavier Giroux-Bougard, & Tyler de Jong

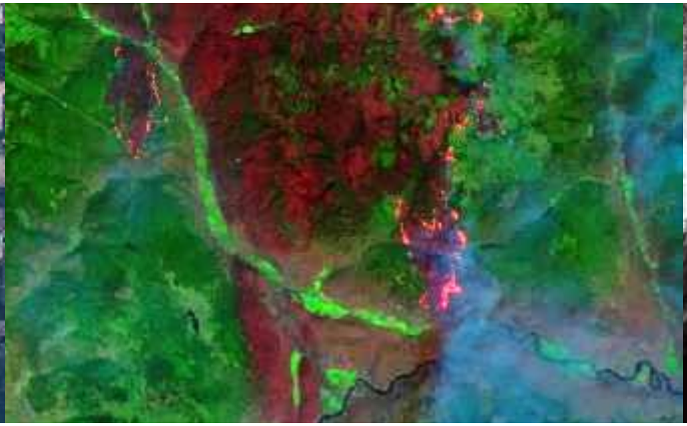
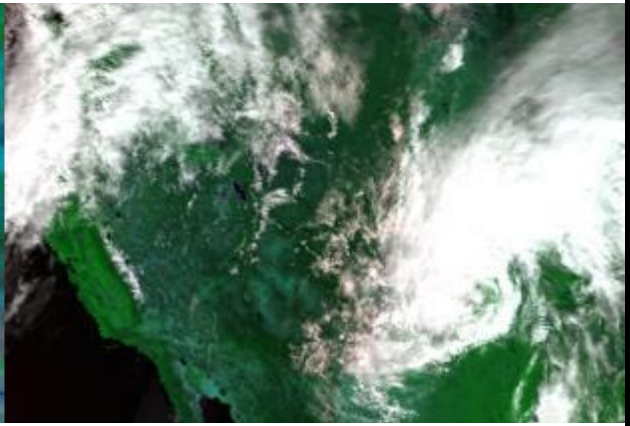








RESOLUTION IS THE SOLUTION

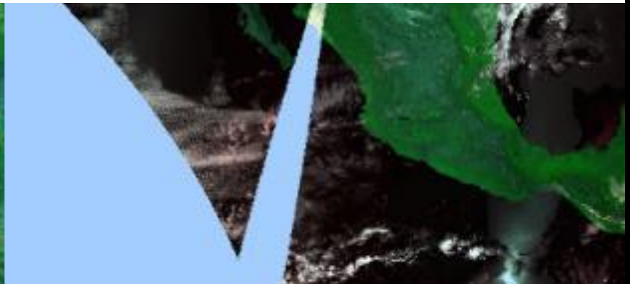




SPATIAL

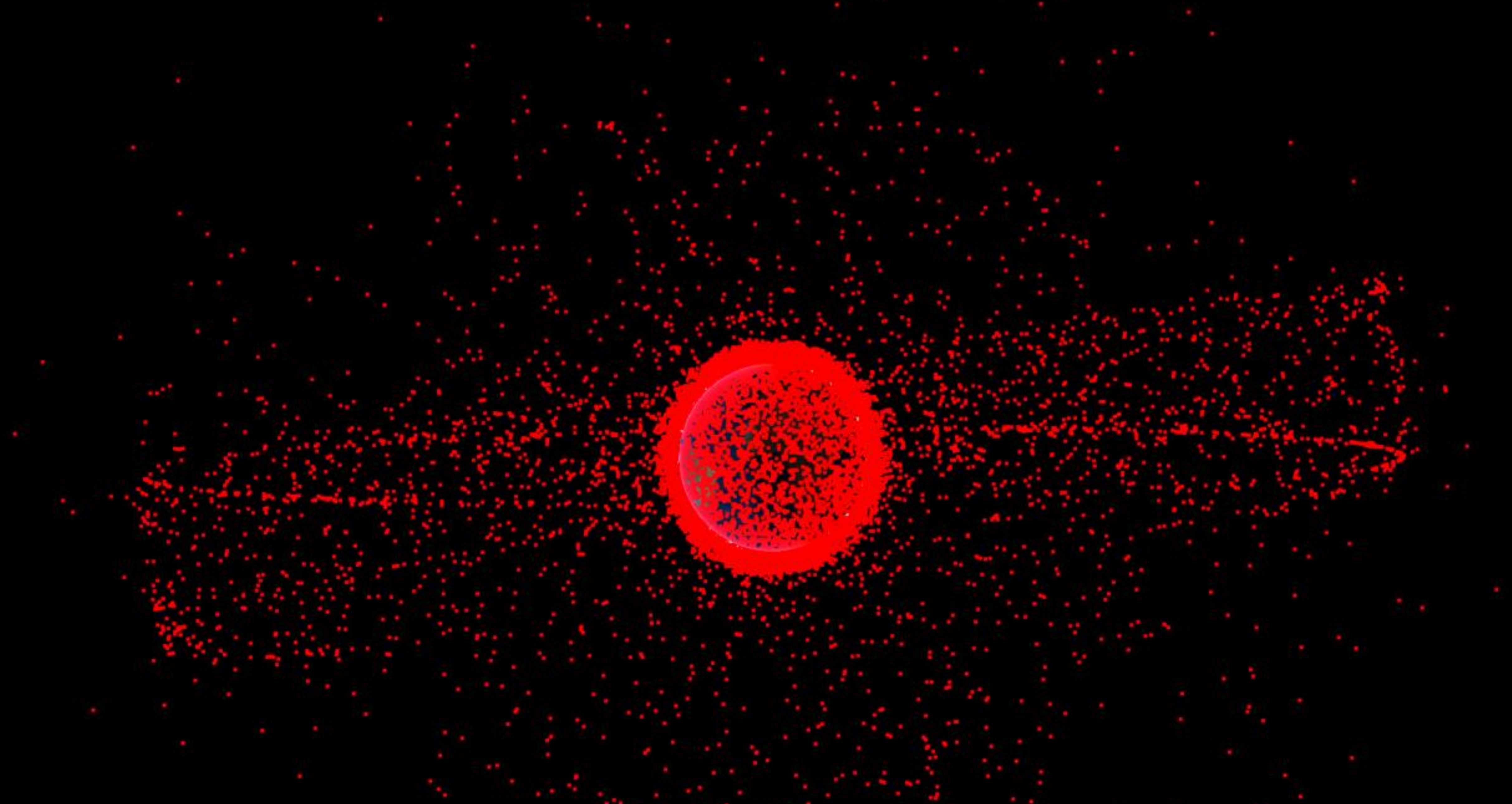
SPECTRAL

TEMPORAL



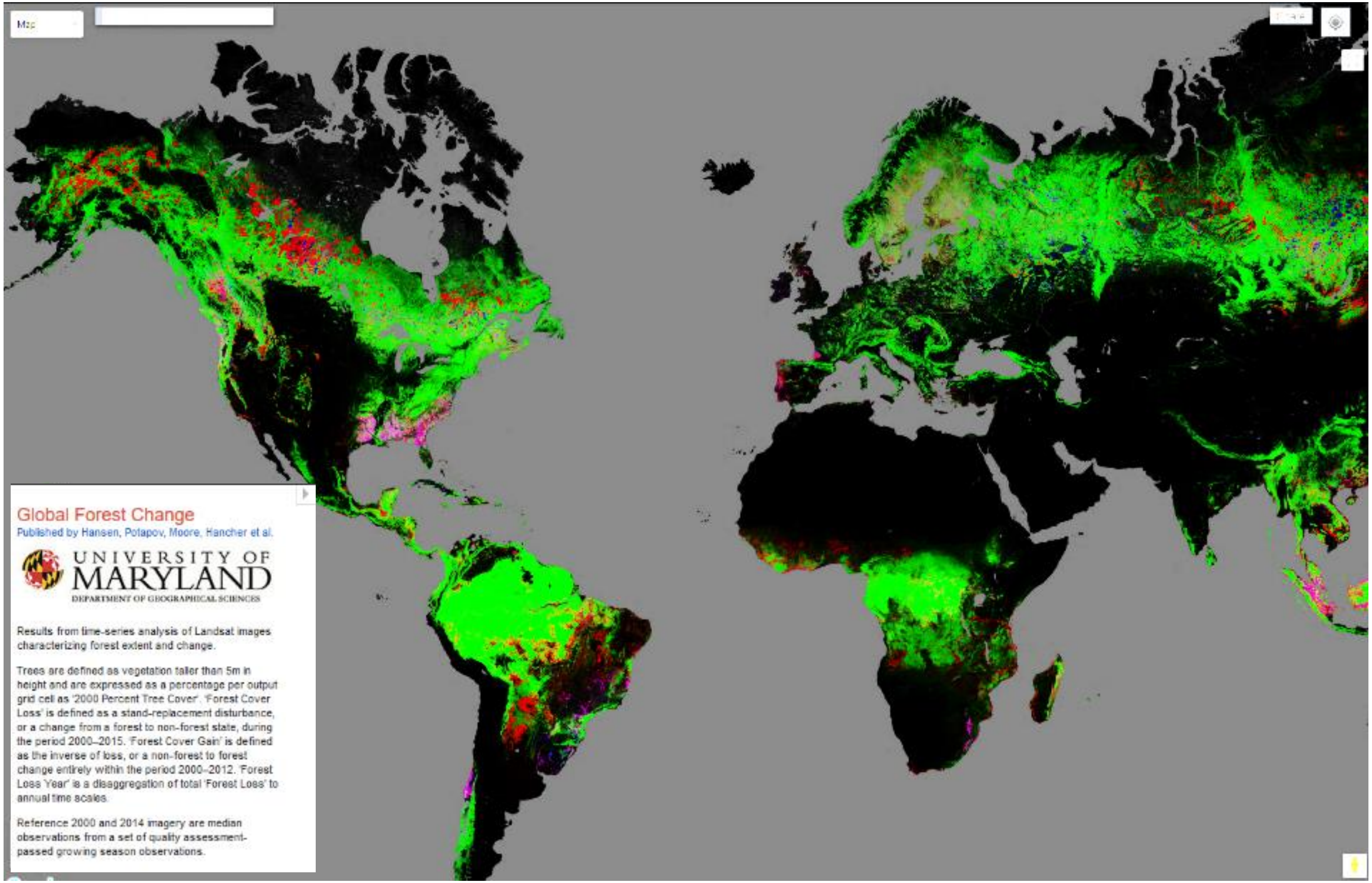


Sentinel 2A imagery of Aleppo, Syria acquired July 25, 2016 – August 1, 2016 (ESA 2016)

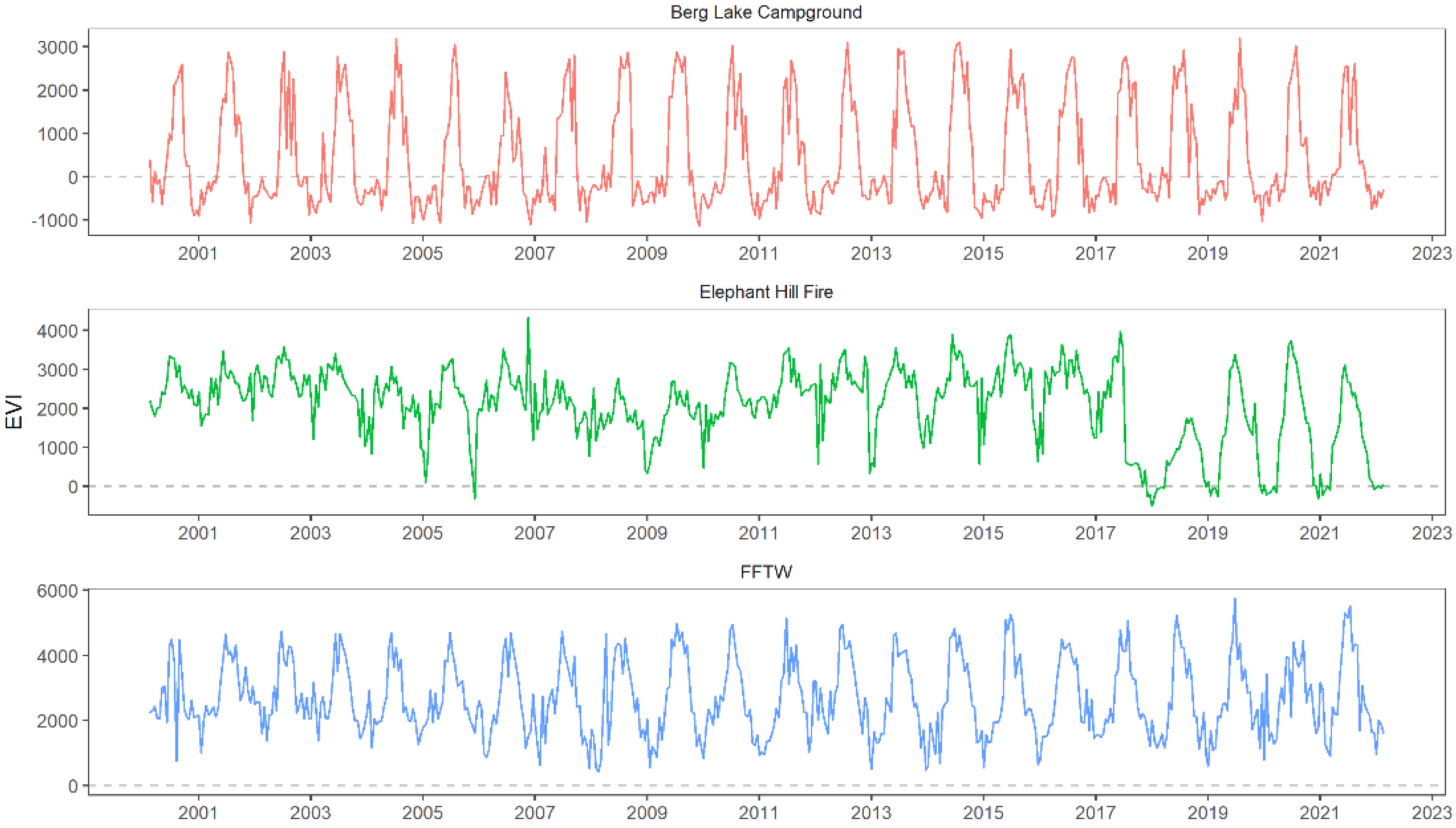


1960 1970 1980 1990 2000 2010 2018

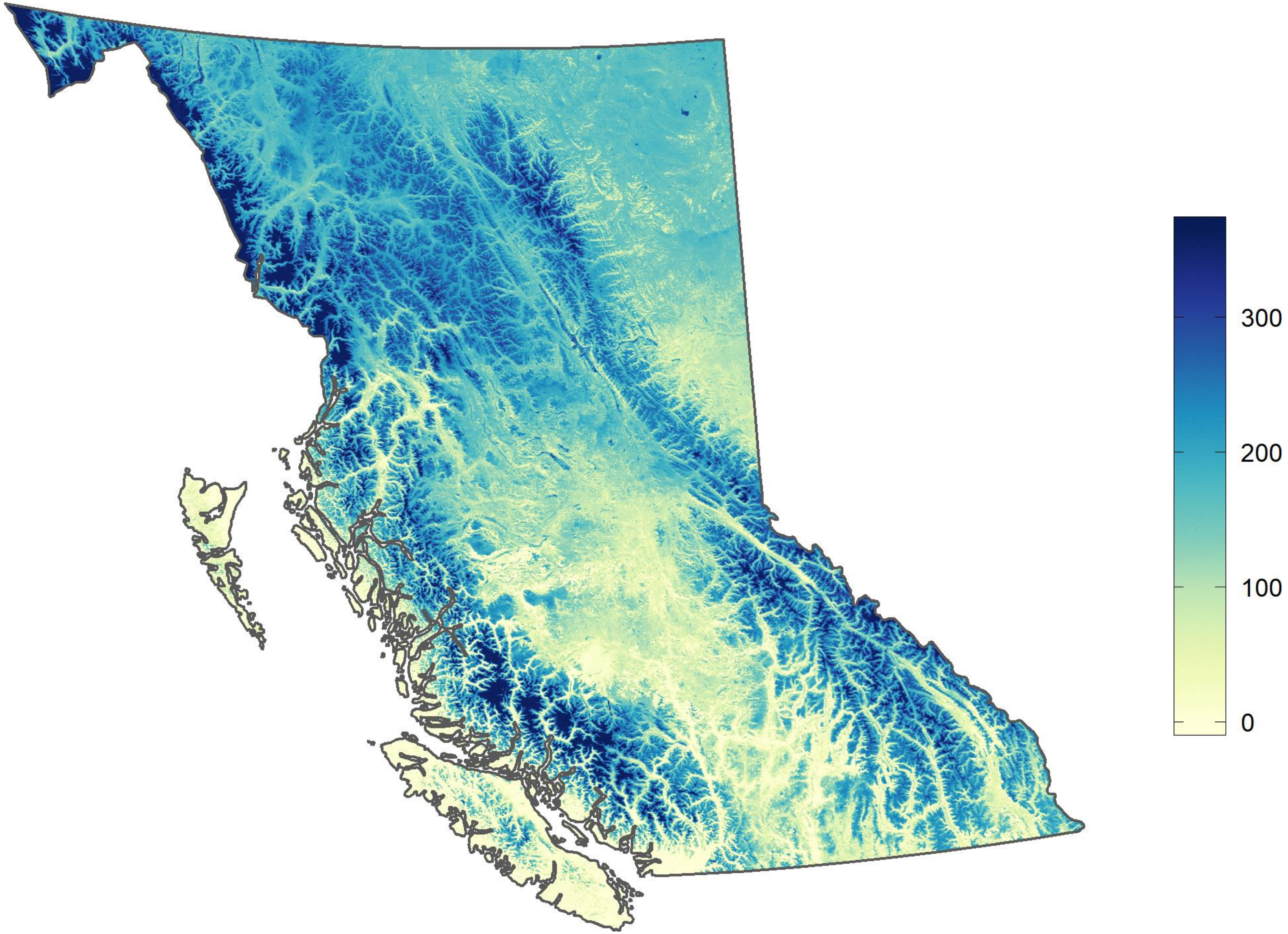
http://richiecarmichael.github.io/sat/index.html#



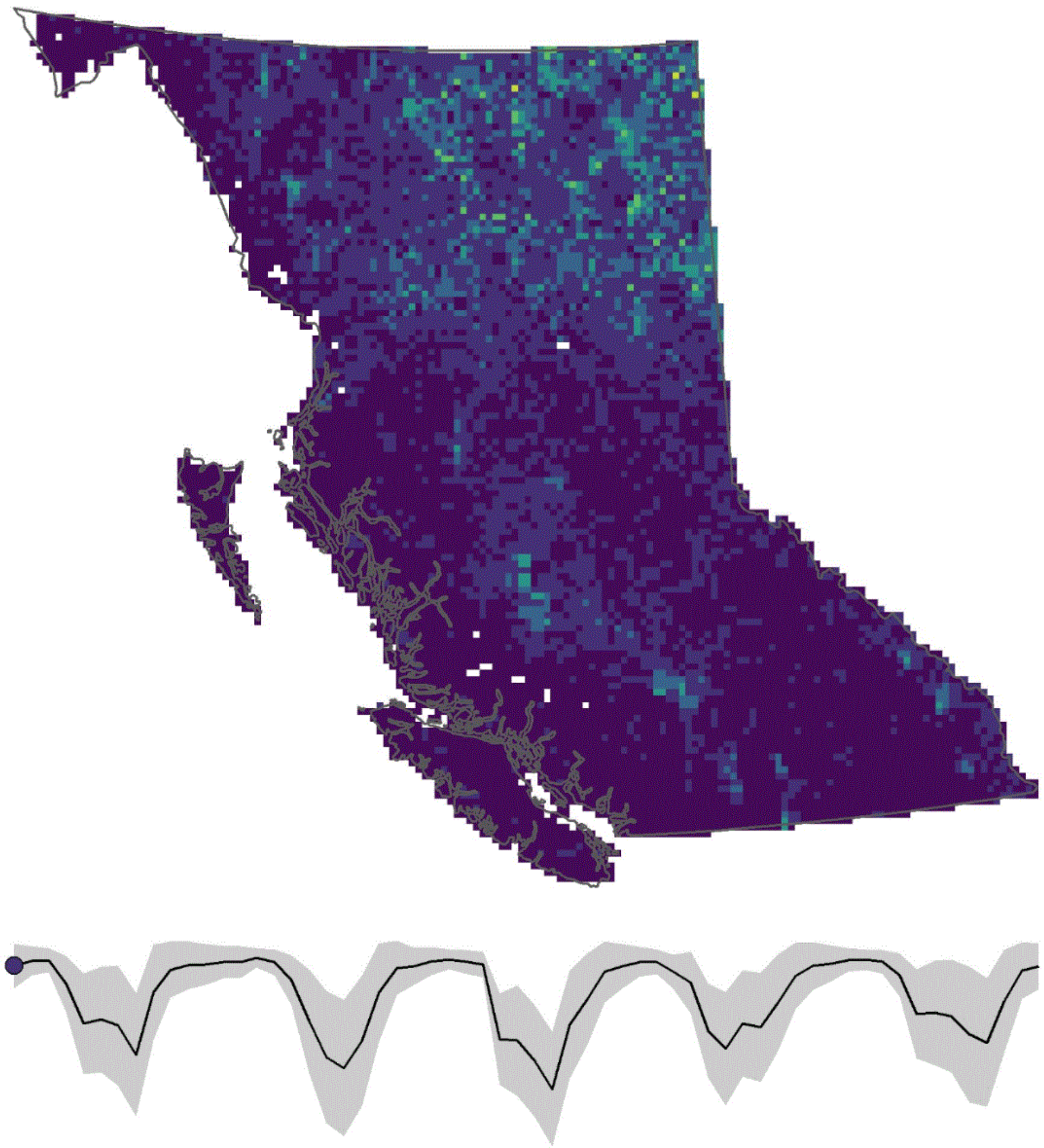
https://glad.earthengine.app/view/global-forest-change

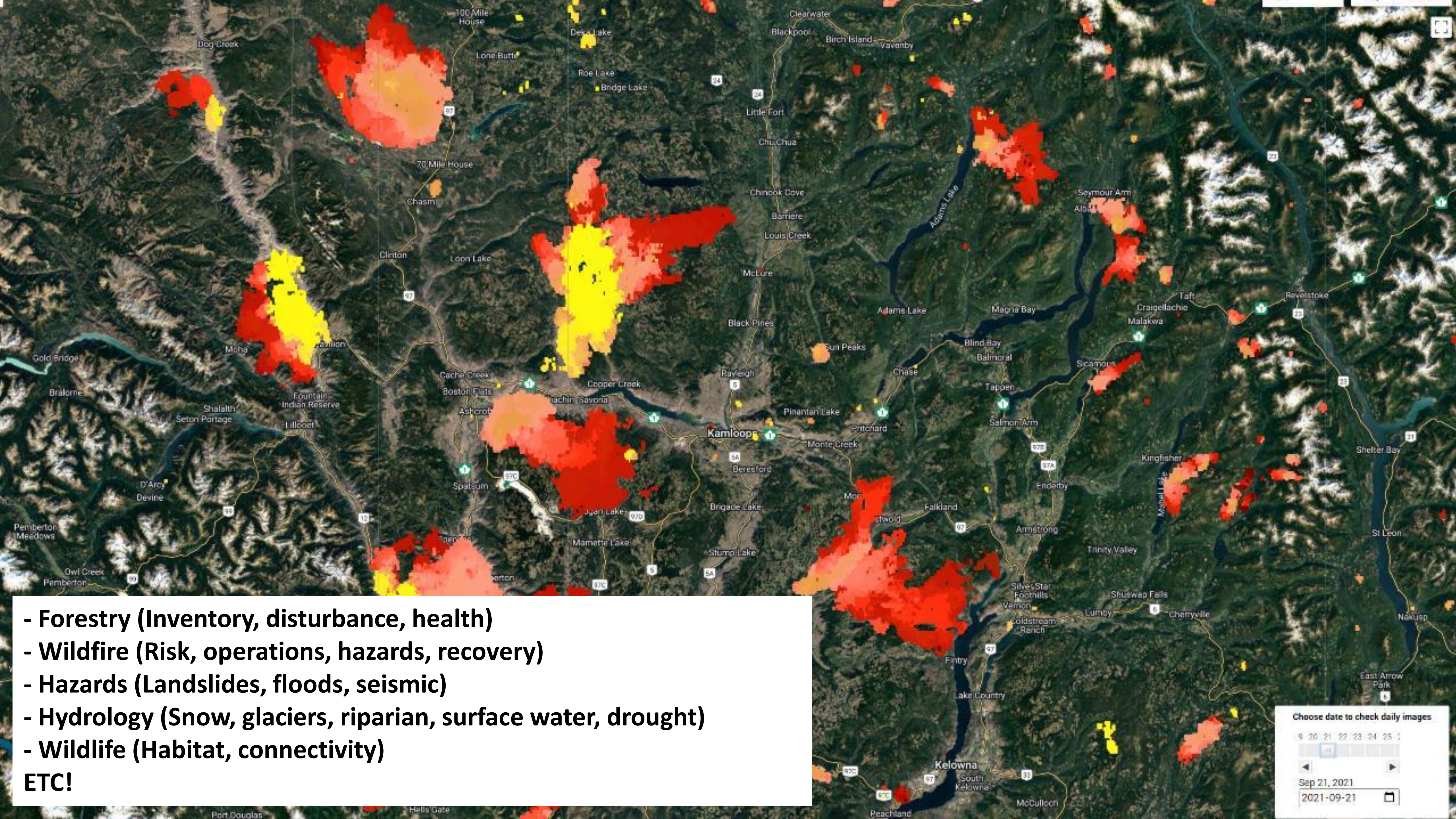

Berg Lake Campground
3000
2000
1000
0
-1000
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
Elephant Hill Fire
EVI
4000
3000
2000
1000
0
FFTW
6000
4000
2000
0

2002



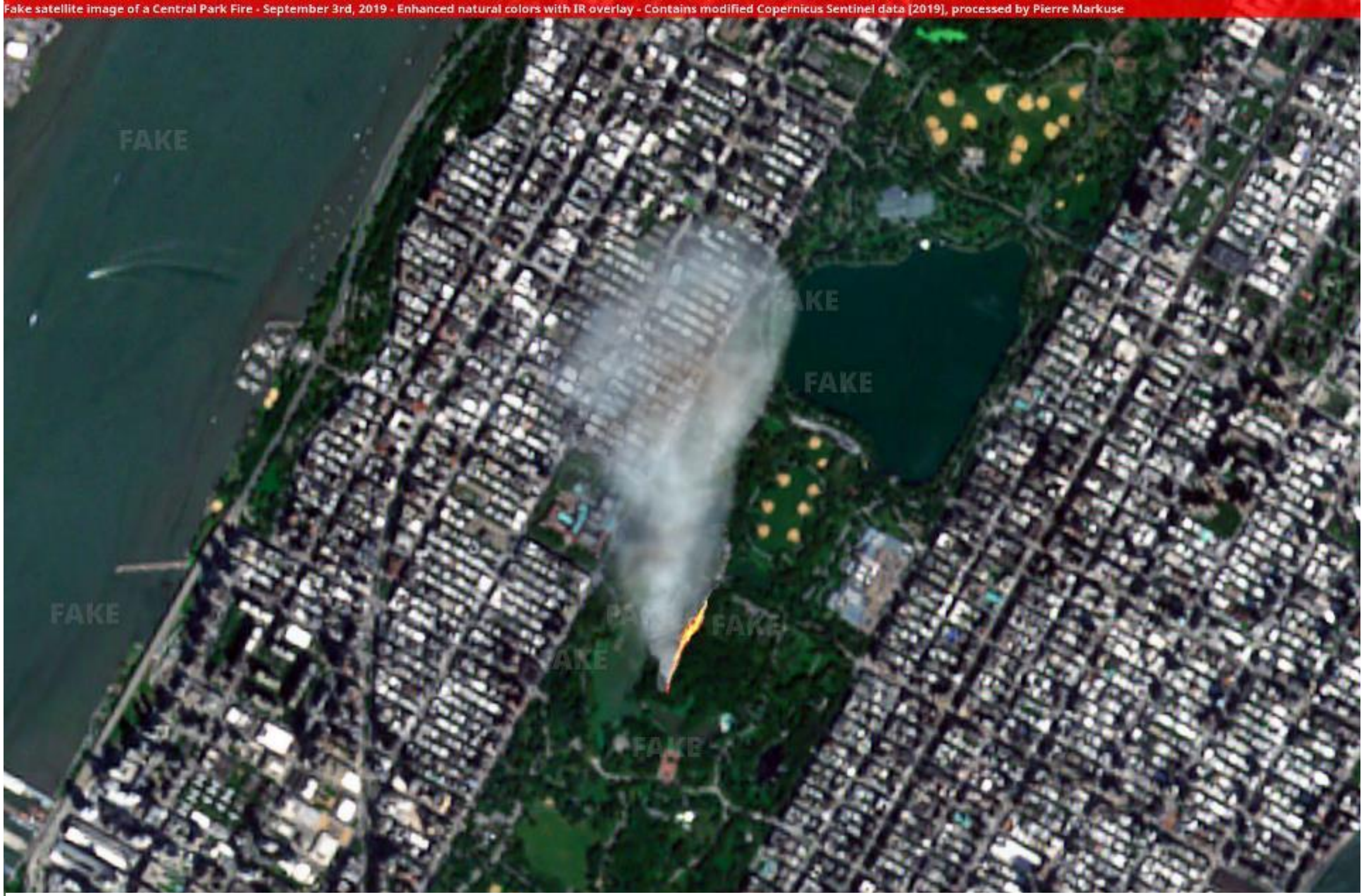
2016 January





- Forestry (Inventory, disturbance, health)
- Wildfire (Risk, operations, hazards, recovery)
- Hazards (Landslides, floods, seismic)
- Hydrology (Snow, glaciers, riparian, surface water, drought)
- Wildlife (Habitat, connectivity)

ETC!

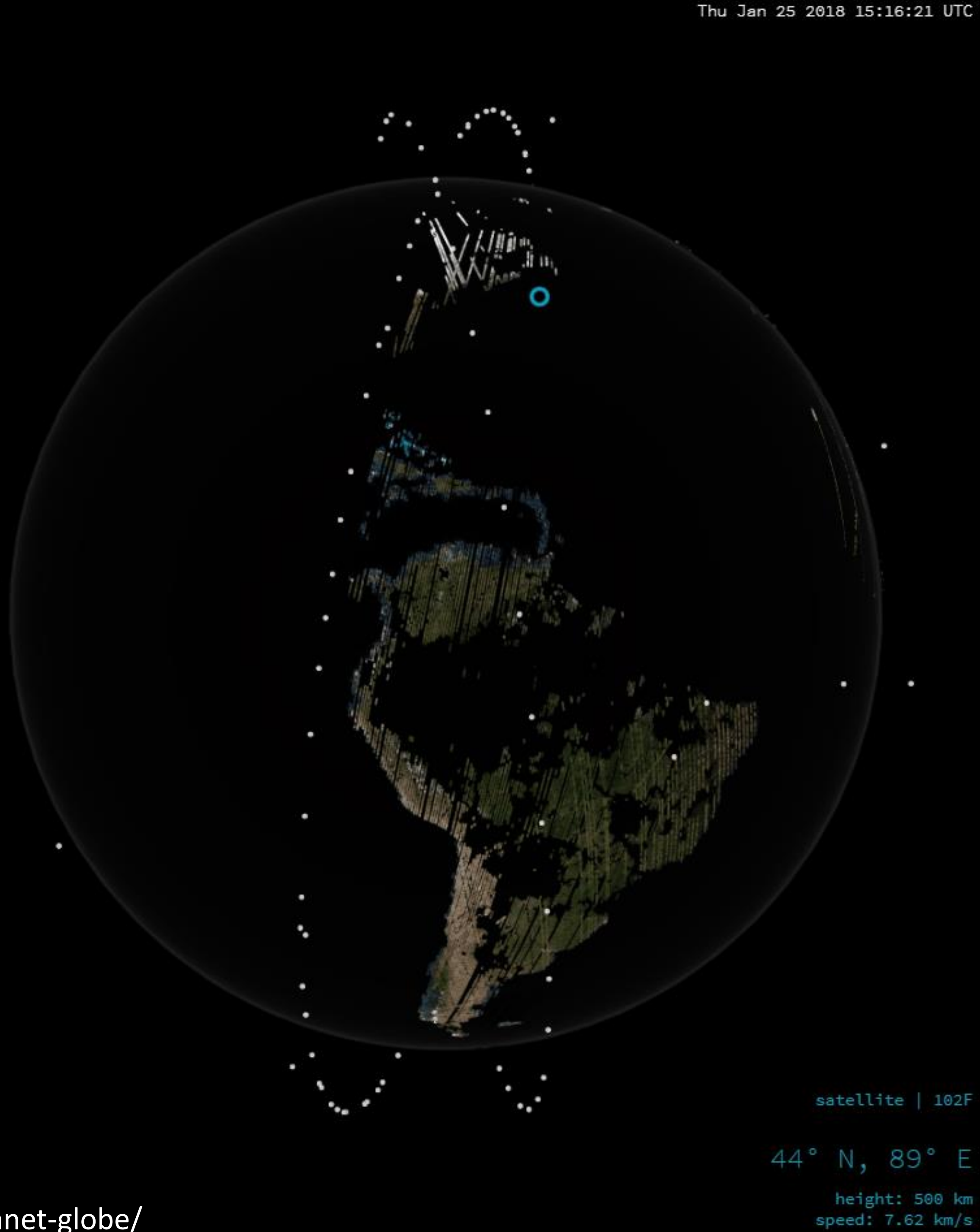


- AI is great, how else will we mine these massive datasets?
- but! satellite deep fakes are starting to proliferate..

Why don't we seen widespread use:

- Training
- GIS vs Remote Sensing
- Rapid change in technology
- Relevance at the plot level
- Sometimes asking the wrong questions
- Or maybe it is already widespread…..

Historical archive
Real time opportunities
Large area scalability
Value added analysis
Moving towards an IoT



https://nbremer.github.io/planet-globe/

High-Resolution Global Maps of 21st-Century Forest Cover Change

M. C. Hansen,[1]* P. V. Potapov,[1] R. Moore,[2] M. Hancher,[2] S. A. Turubanova,[1] A. Tyukavina,[1] D. Thau,[2] S. V. Stehman,[3] S. J. Goetz,[4] T. R. Loveland,[5] A. Kommareddy,[6] A. Egorov,[6] L. Chini,[1] C. O. Justice,[1] J. R. G. Townshend[1]

Quantification of global forest change has been lacking despite the recognized importance of forest ecosystem services. In this study, Earth observation satellite data were used to map global forest loss (2.3 million square kilometers) and gain (0.8 million square kilometers) from 2000 to 2012 at a spatial resolution of 30 meters. The tropics were the only climate domain to exhibit a trend, with forest loss increasing by 2101 square kilometers per year. Brazil's well-documented reduction in deforestation was offset by increasing forest loss in Indonesia, Malaysia, Paraguay, Bolivia, Zambia, Angola, and elsewhere. Intensive forestry practiced within subtropical forests resulted in the highest rates of forest change globally. Boreal forest loss due largely to fire and forestry was second to that in the tropics in absolute and proportional terms. These results depict a globally consistent and locally relevant record of forest change.

Changes in forest cover affect the delivery of important ecosystem services, including biodiversity richness, climate regulation, carbon storage, and water supplies (*1*). However, spatially and temporally detailed information on global-scale forest change does not exist; previous efforts have been either sample-based or employed coarse spatial resolution data (*2*–*4*). We mapped global tree cover extent, loss, and gain for the period from 2000 to 2012 at a spatial resolution of 30 m, with loss allocated annually. Our global analysis, based on Landsat data, improves on existing knowledge of global forest extent and change by (i) being spatially explicit; (ii) quantifying gross forest loss and gain; (iii) providing annual loss information and quantifying trends in forest loss; and (iv) being derived through an internally consistent approach that is exempt from the vagaries of different definitions, methods, and data inputs. Forest loss was defined as a stand-replacement disturbance or the complete removal of tree cover canopy at the Landsat pixel scale. Forest gain was defined as the inverse of loss, or the establishment of tree canopy from a nonforest state. A total of 2.3 million km^2 of forest were lost due to disturbance over the study period and 0.8 million km^2 of new forest established. Of the total area of combined loss and gain (2.3 million km^2 – 0.8 million km^2), 0.2 million km^2 of land experienced both loss and subsequent gain in forest cover during the study period. Global forest loss and gain were related to tree cover density for global climate domains, ecozones, and countries (refer to tables S1 to S3 for all data references and comparisons). Results are depicted in Fig. 1 and are viewable at full resolution at http://earthenginepartners.appspot.com/science-2013-global-forest.

The tropical domain experienced the greatest total forest loss and gain of the four climate domains (tropical, subtropical, temperate, and boreal), as well as the highest ratio of loss to gain (3.6 for >50% of tree cover), indicating the prevalence of deforestation dynamics. The tropics were the only domain to exhibit a statistically significant trend in annual forest loss, with an estimated increase in loss of 2101 km^2/year. Tropical rainforest ecozones totaled 32% of global forest cover loss, nearly half of which occurred in South American rainforests. The tropical dry forests of South America had the highest rate of tropical forest loss, due to deforestation dynamics in the Chaco woodlands of Argentina, Paraguay (Fig. 2A), and Bolivia. Eurasian rainforests (Fig. 2B) and dense tropical dry forests of Africa and Eurasia also had high rates of loss.

Recently reported reductions in Brazilian rainforest clearing over the past decade (*5*) were confirmed, as annual forest loss decreased on average 1318 km^2/year. However, increased annual loss of Eurasian tropical rainforest (1392 km^2/year), African tropical moist deciduous forest (536 km^2/year), South American dry tropical forest (459 km^2/year), and Eurasian tropical moist deciduous (221 km^2/year) and dry (123 km^2/year) forests more than offset the slowing of Brazilian deforestation. Of all countries globally, Brazil exhibited the largest decline in annual forest loss, with a high of over 40,000 km^2/year in 2003 to 2004 and a low of under 20,000 km^2/year in 2010 to 2011. Of all countries globally, Indonesia exhibited the largest increase in forest loss (1021 km^2/year), with a low of under 10,000 km^2/year from 2000 through 2003 and a high of over 20,000 km^2/year in 2011 to 2012. The converging rates of forest disturbance of Indonesia and Brazil are shown in Fig. 3. Although the short-term decline of Brazilian deforestation is well documented, changing legal frameworks governing Brazilian forests could reverse this trend (*6*). The effectiveness of Indonesia's recently instituted moratorium on new licensing of concessions in primary natural forest and peatlands (*7*), initiated in 2011, is to be determined.

Subtropical forests experience extensive forestry land uses where forests are often treated as a crop and the presence of long-lived natural forests is comparatively rare (*8*). As a result, the highest proportional losses of forest cover and the lowest ratio of loss to gain (1.2 for >50% of tree cover) occurred in the subtropical climate domain. Aggregate forest change, or the proportion of total forest loss and gain relative to year-2000 forest area [(loss + gain)/2000 forest], equaled 16%, or more than 1% per year across all forests within the domain. Of the 10 subtropical humid and dry forest ecozones, 5 have aggregate forest change >20%, three >10%, and two >5%. North American subtropical forests of the southeastern United States are unique in terms of change dynamics because of short-cycle tree planting and harvesting (Fig. 2C). The disturbance rate of this ecozone was four times that of South American

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