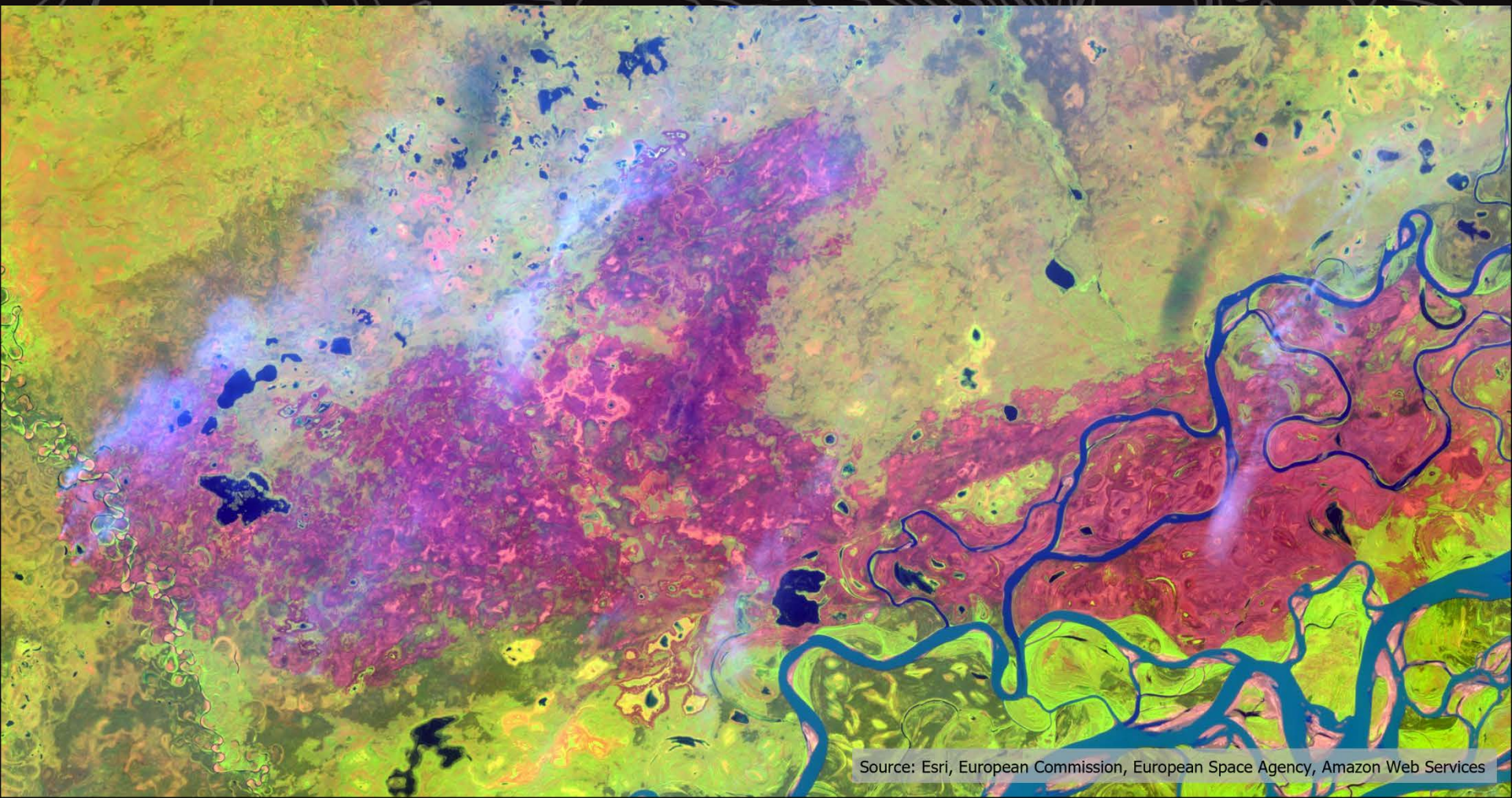
Remote Sensing for Wildland Fire

Pretty Pictures..or much more



Presentation Roadmap

- Framing the Issues and Opportunities
- Our Alaska Experience
- Current Resources in the Lake States
- New Platforms, Sensors, and Products
- Uses to Consider
- Conclusion/Closeout

Remote Sensing for Wildland Fire

What Qualifies?

- Platforms: Satellite, Aircraft, Drone, Fixed Platform, Crowd Source
- Sensors: The Spectral Band…
- Timing: DB, NRT, Historic
- Products: Unclassified Imagery, Modeled classifications

How do you use it?

- Weather Observations and Forecasts
- Landscape visualizations and classifications
- Values at Risk
- Fire and Smoke monitoring
- Fire Effects

Our Alaska Experience

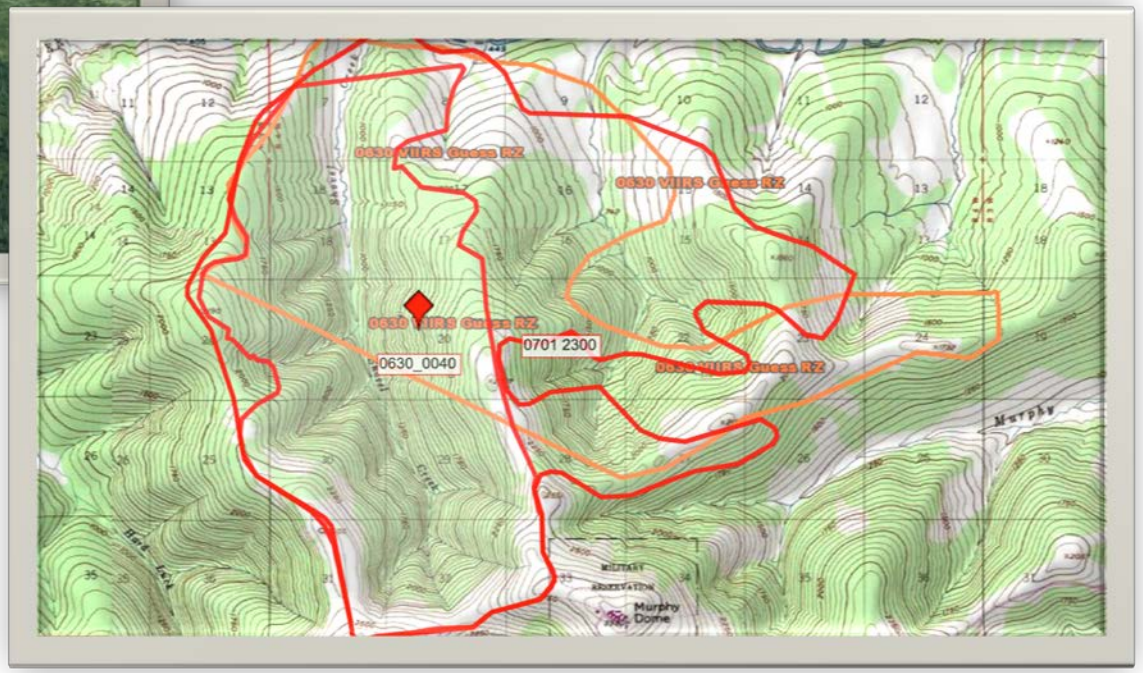
"With many remote, unstaffed fires…"

- Where are they?
- How big are they?
- How are they shaped?
- Where are they hot?
- What fuels have burned and what fuels are adjacent to the hot areas?

Which of these need to be current & accurate?

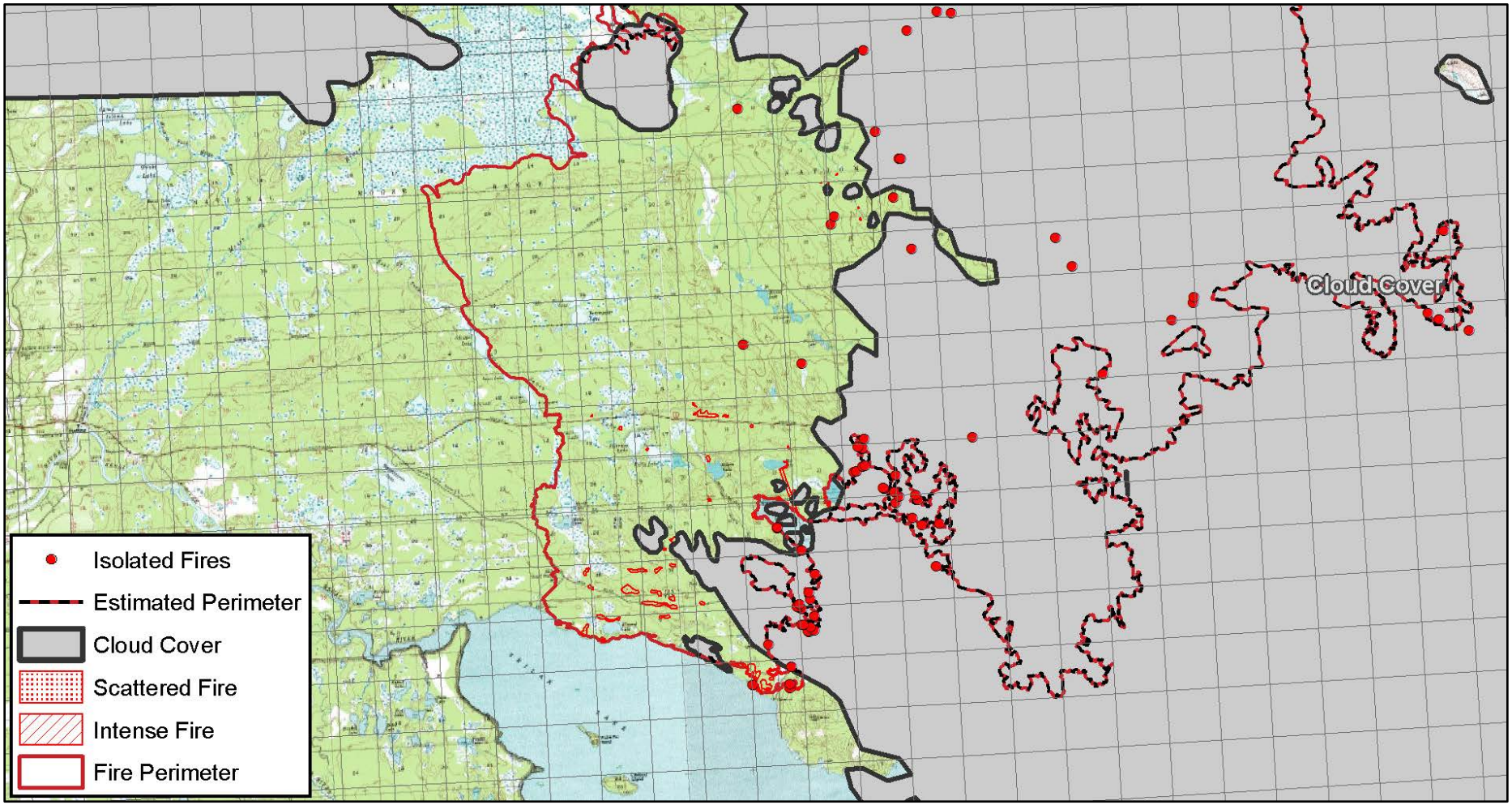
Recon Flights & Onscene Intel

But eyewitness observations can be crude approximations and with embedded bias and imprecision. Here is perimeter and ignition info I was provided for Fire 319, Shovel Ck.



There will always be a role for fireline observations. This picture shows fuels and fire behavior explicitly.

NIROPS Aircraft IR Intel



Cloudiness impacts thermal Remote Sensing products.

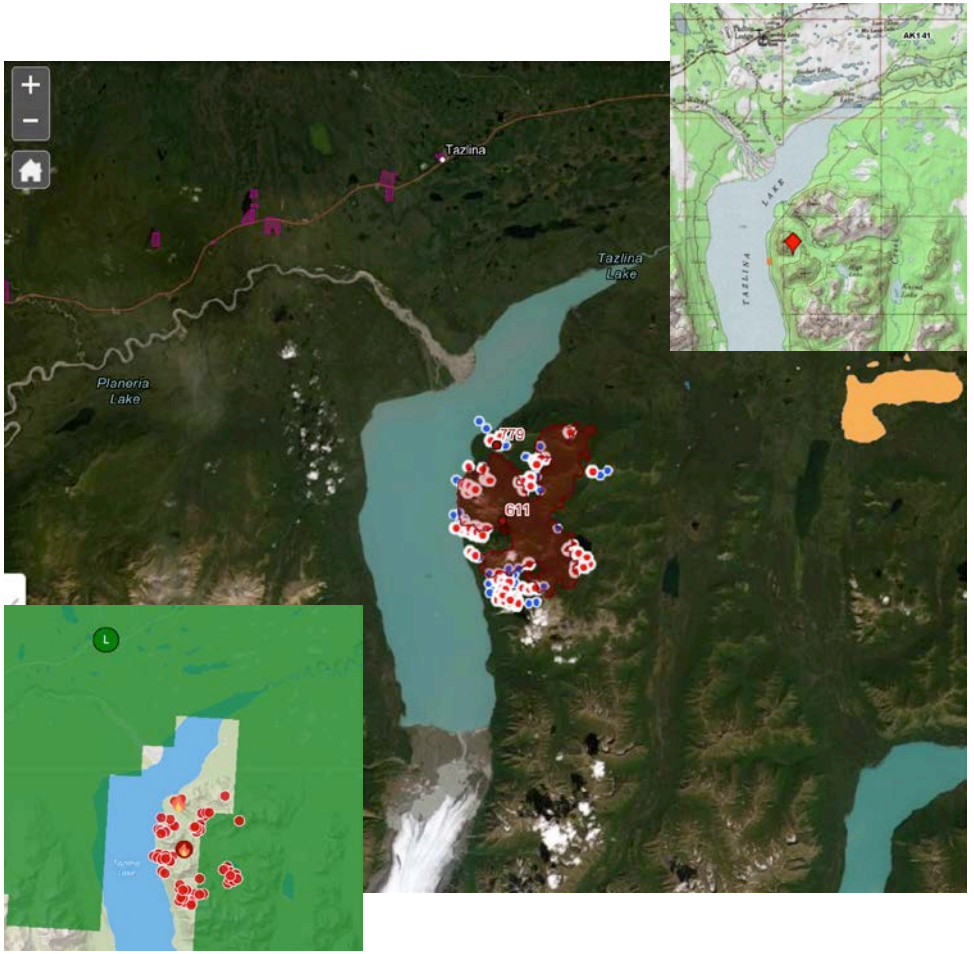
A New Paradigm

Monitoring fire activity and mapping perimeters has moved into the remote sensing realm.

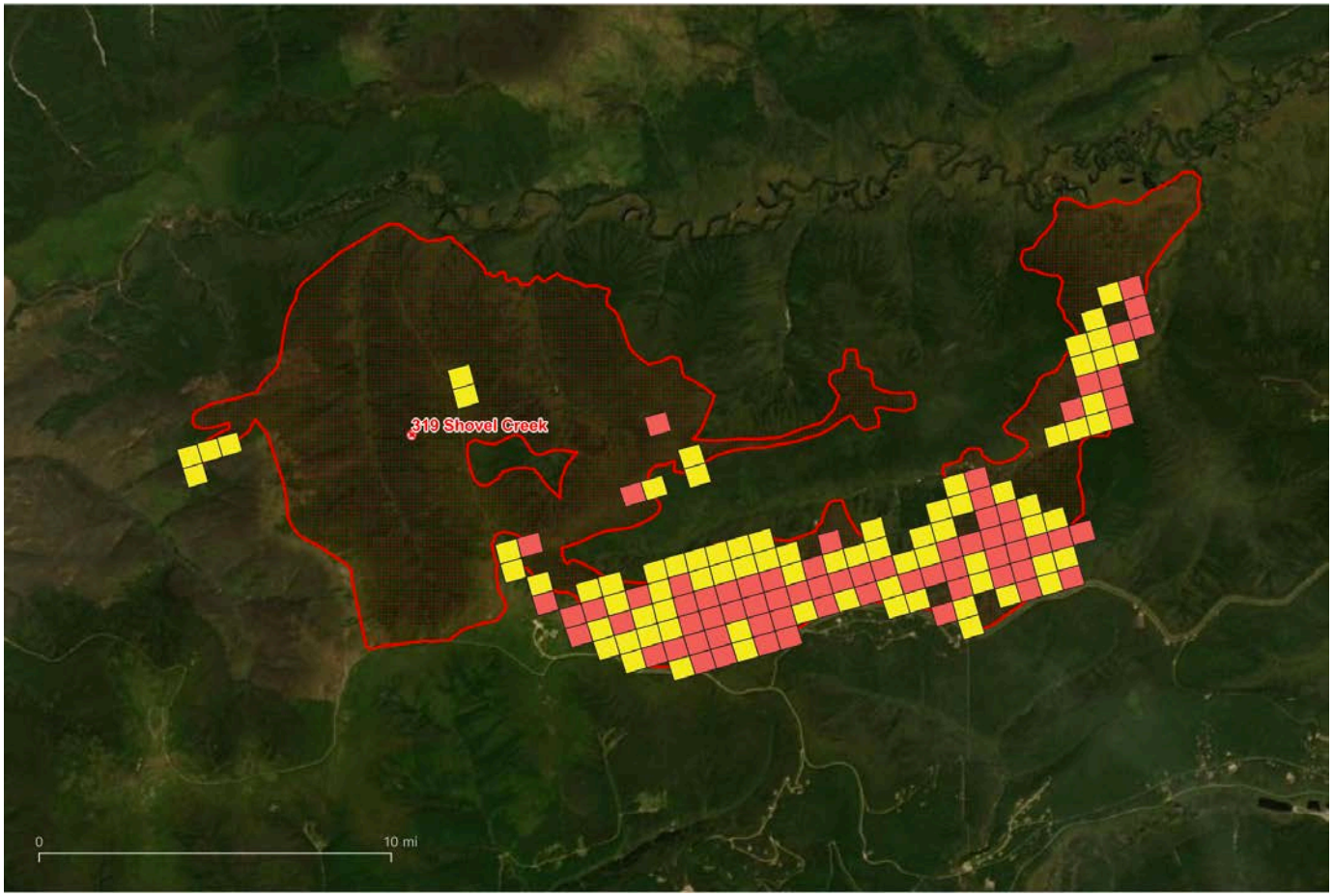
- MODIS, VIIRS and GOES for near real-time active fire monitoring.
  - Utility is not restricted to fire heat points.
  - Imagery designed to highlight fire activity also available
- LANDSAT 8 and Sentinel-2 for precise perimeter mapping.
- UAS imagery for real-time assessment and mapping in the most critical situations.

Satellite-based Fire Heat

- Near real-time
- VIIRS and MODIS Hot Spot Detections
- Integrated into many of our map environments
  - Alaska Wildland Fire Maps, AKFF, EGP, and WFDSS.
- Best source of fire growth history dating back to 2003 (MODIS)

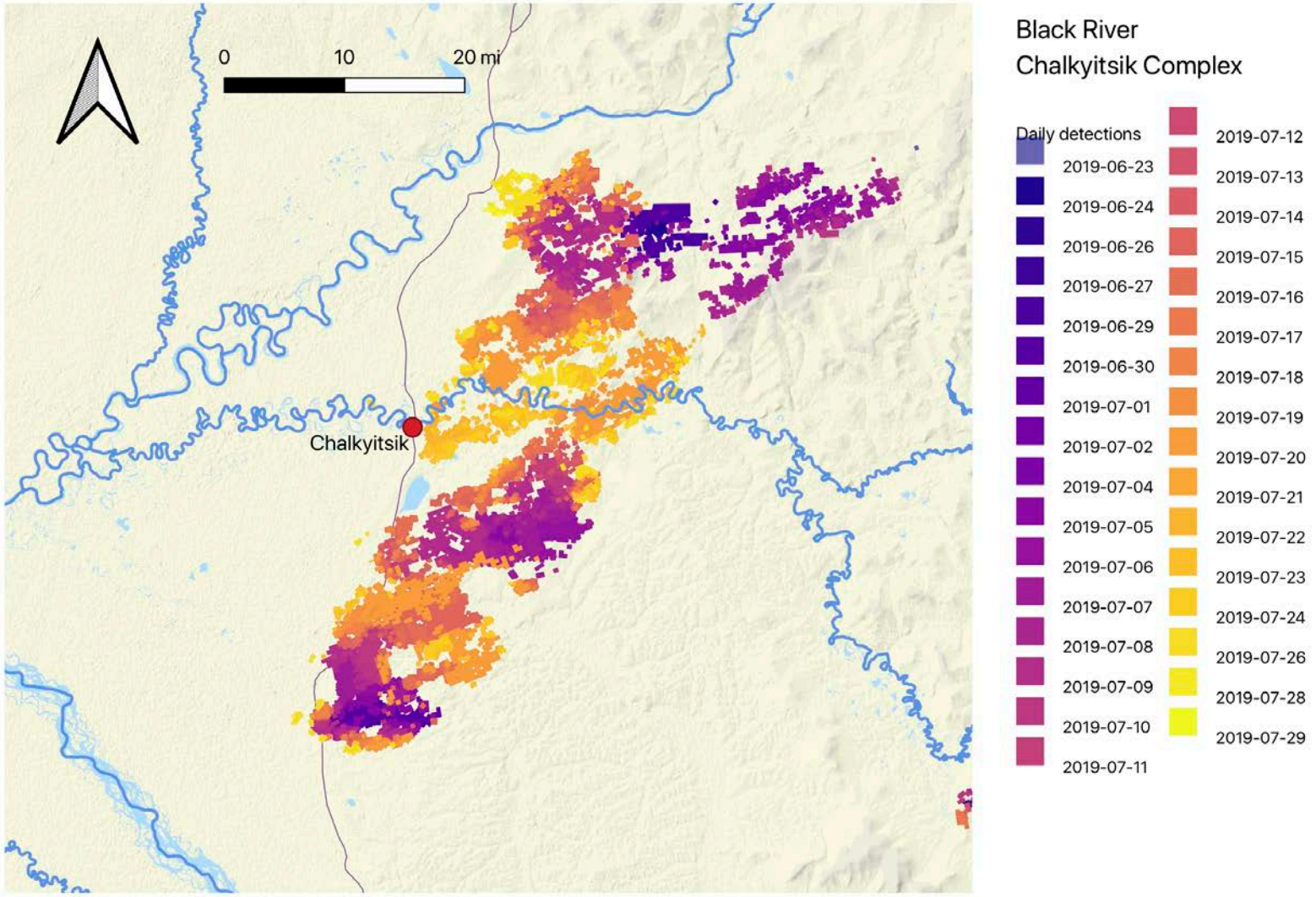


VIFDAHL: VIIRS fire detection algorithm for high latitudes
Can it help with tactical decisions? Historic analysis? Residual heat detection?



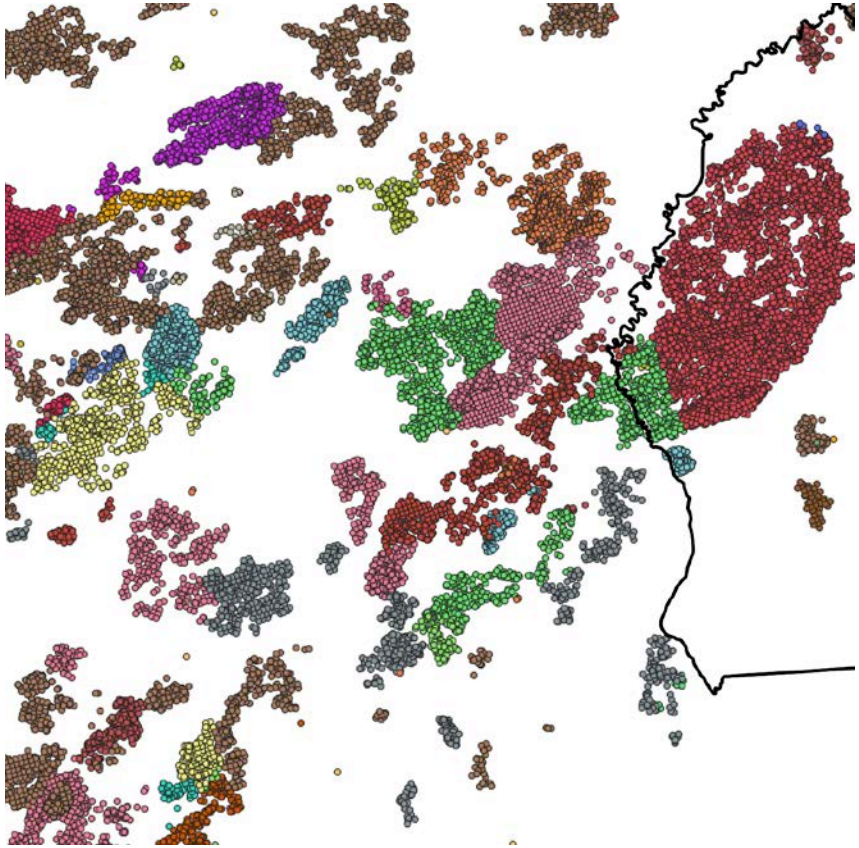
Shovel Creek fire, 2019-07-09, 16:16 and 17:59.
yellow: high intensity, red: low intensity
The smaller pixel size reflects the position of the pixel in the swath center.

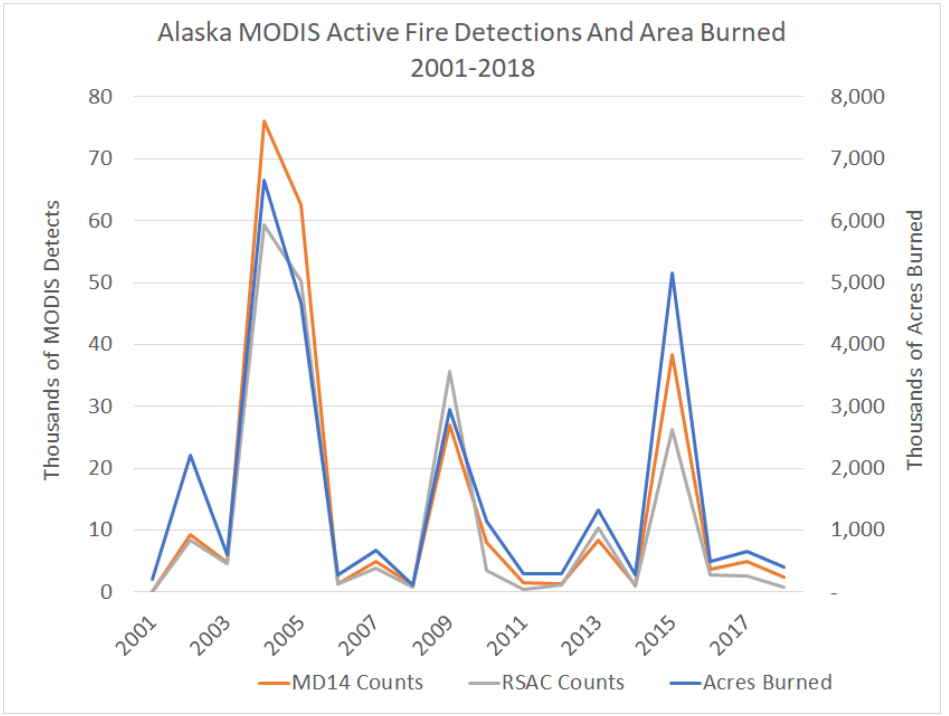
Time series/fire progression,

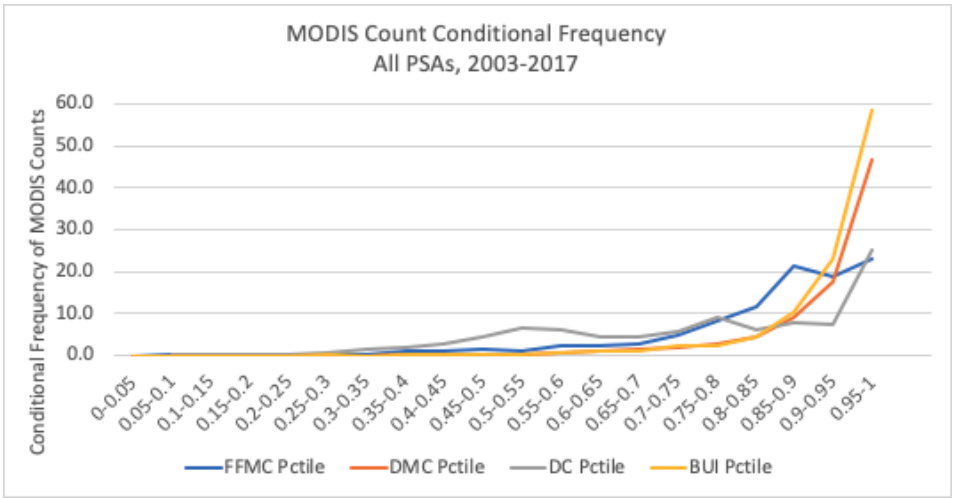


Fire History for Analysis Purpose

Nearing 300,000 MODIS Active Fire Detects in Alaska since 2003.

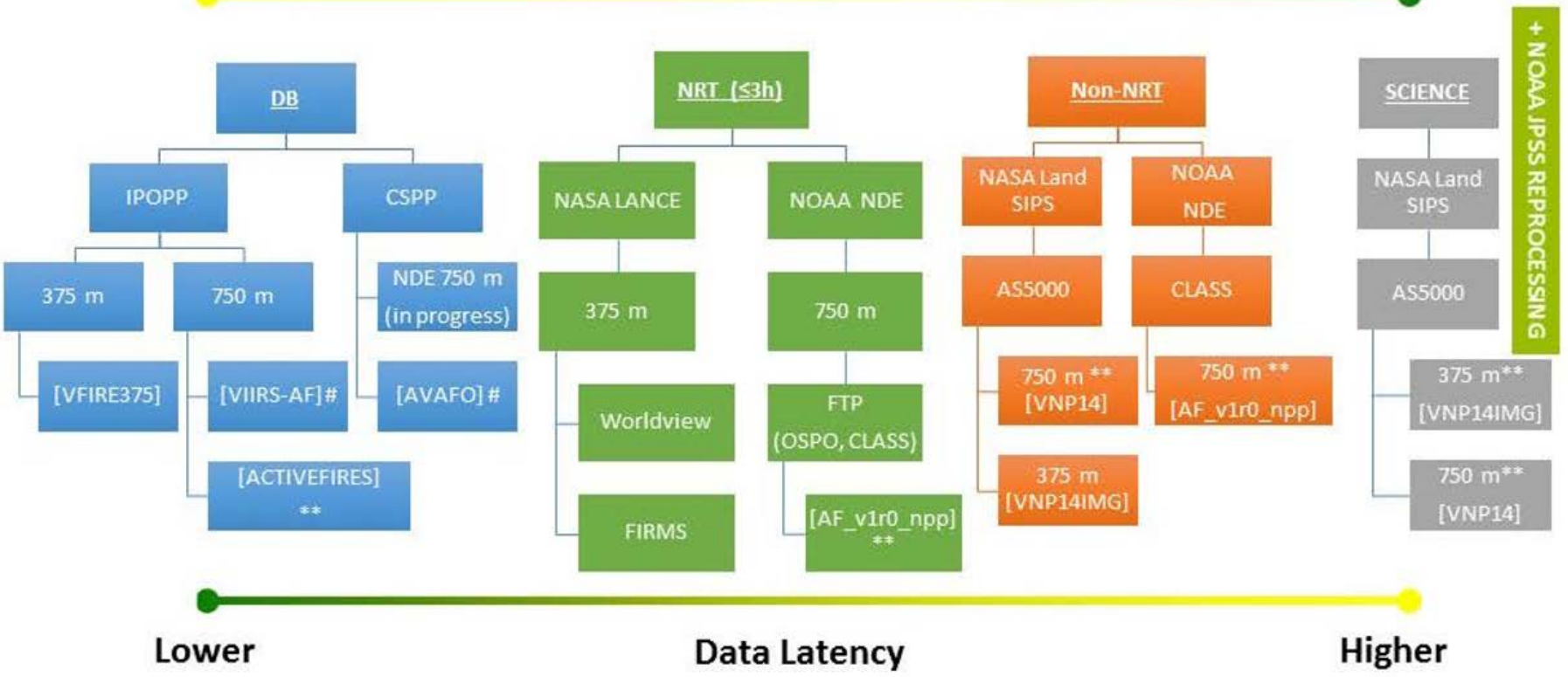






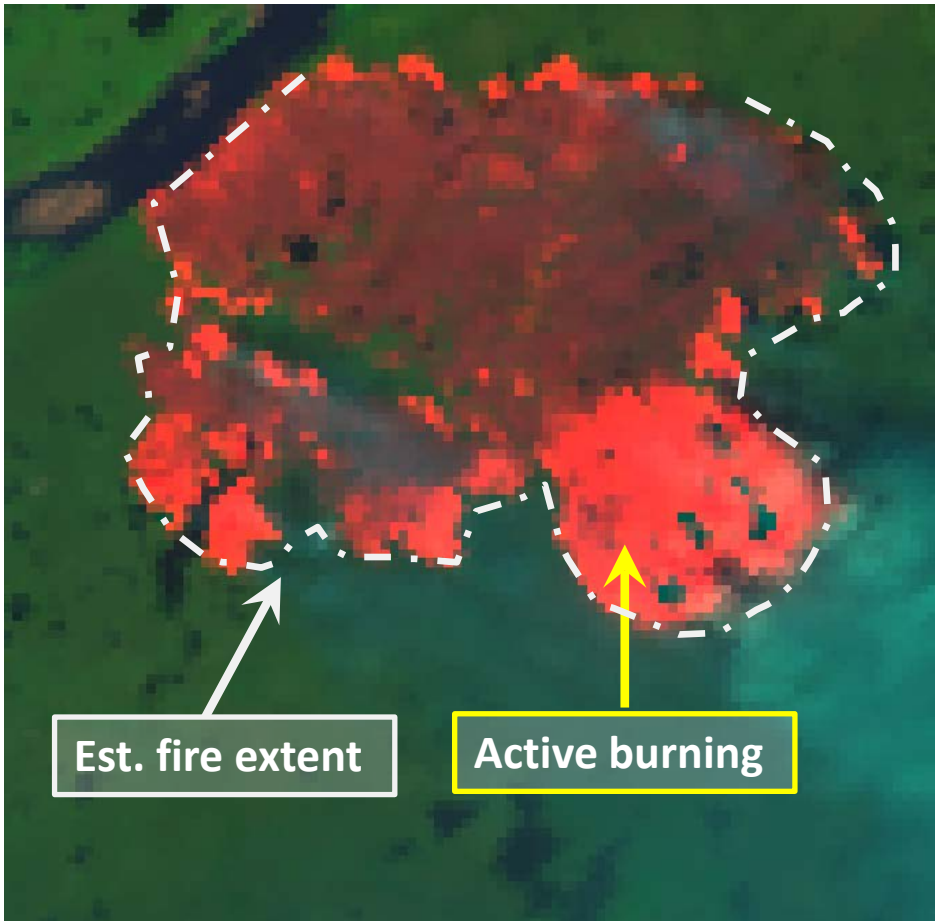
Data Quality & Latency

Figure 1: VIIRS Active Fire data access options



Satellite-based Fire Imagery

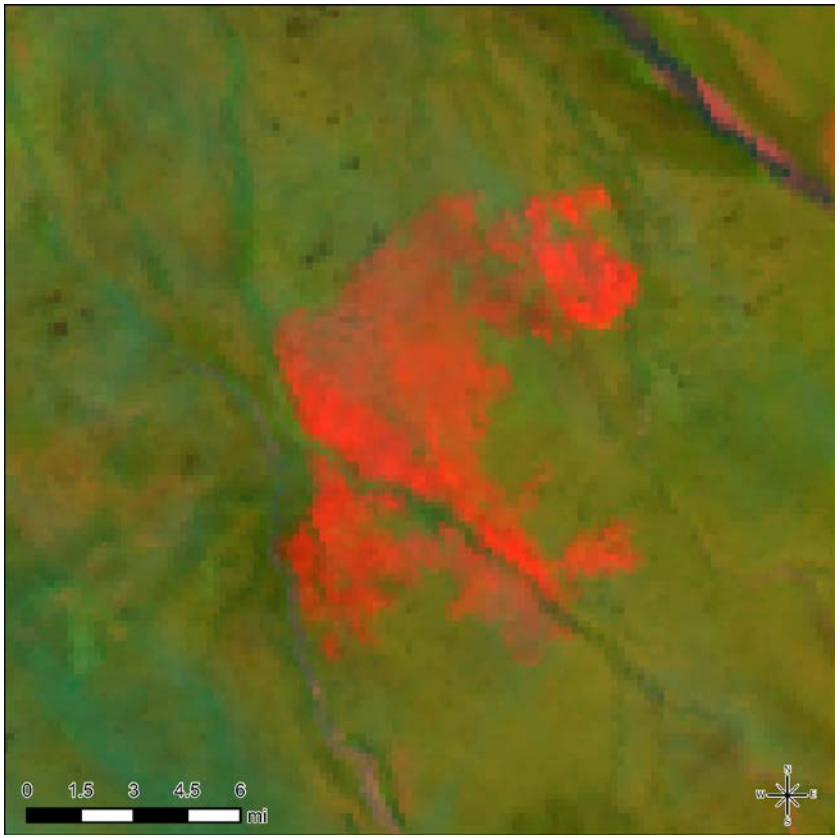
- 2 VIIRS satellites passing over AK makes for ***several passes a day***.
- Relatively coarse resolution imagery (375m) – yet provides a wealth of intel.
- Freely (for now) available for Alaska at GINA for download and use in GIS software.
- An underutilized resource.



Satellite Imagery for Perimeters

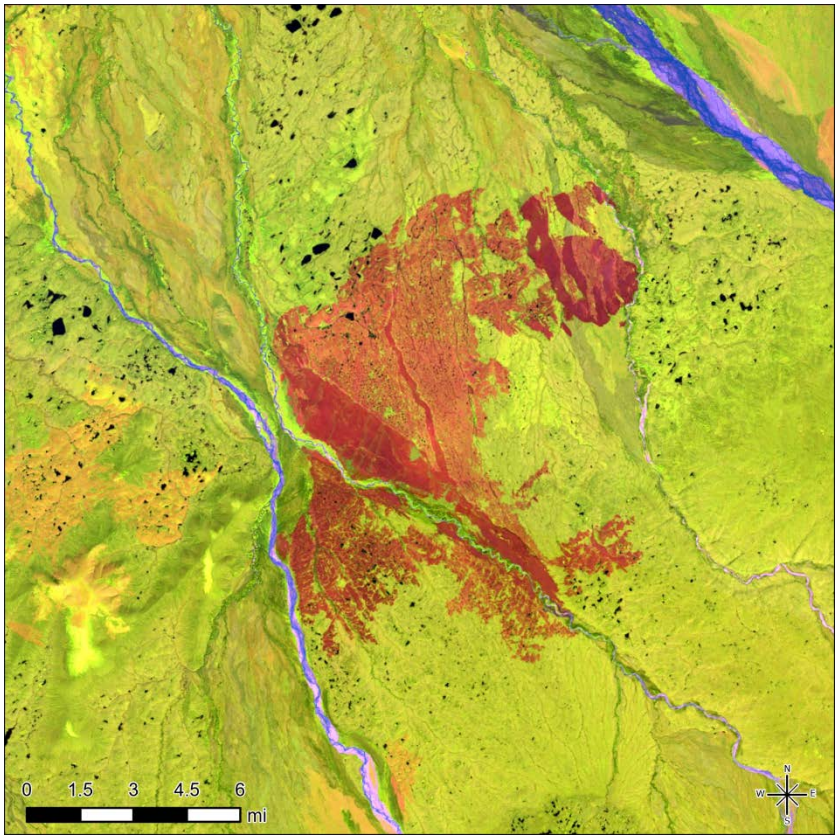
VIIRS RGB (375m)

Multiple passes per day



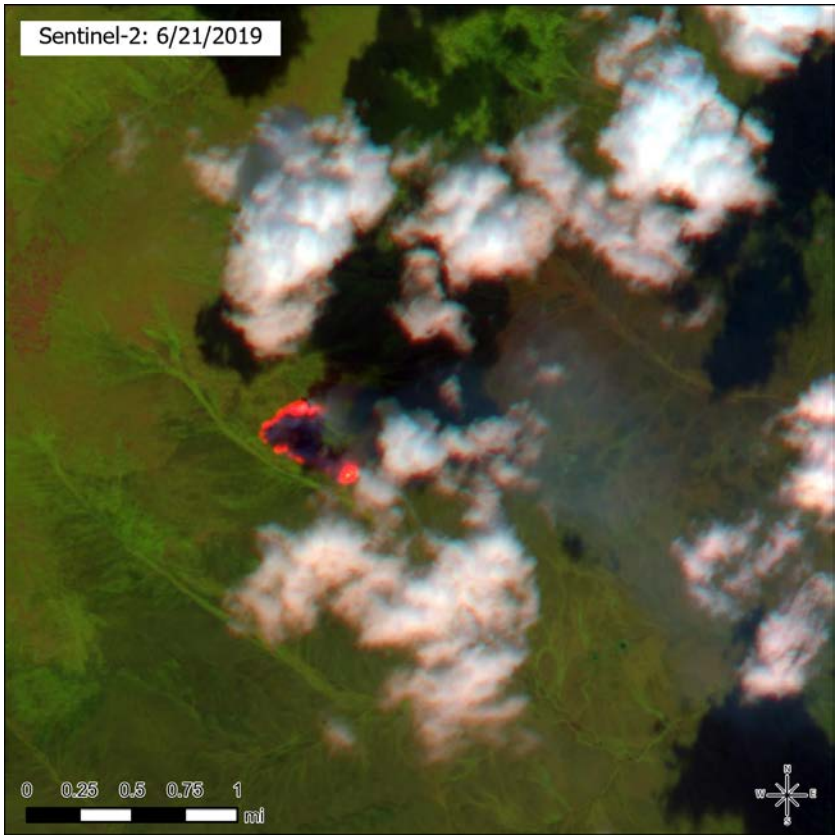
LANDSAT (30m)

One pass every 14 days

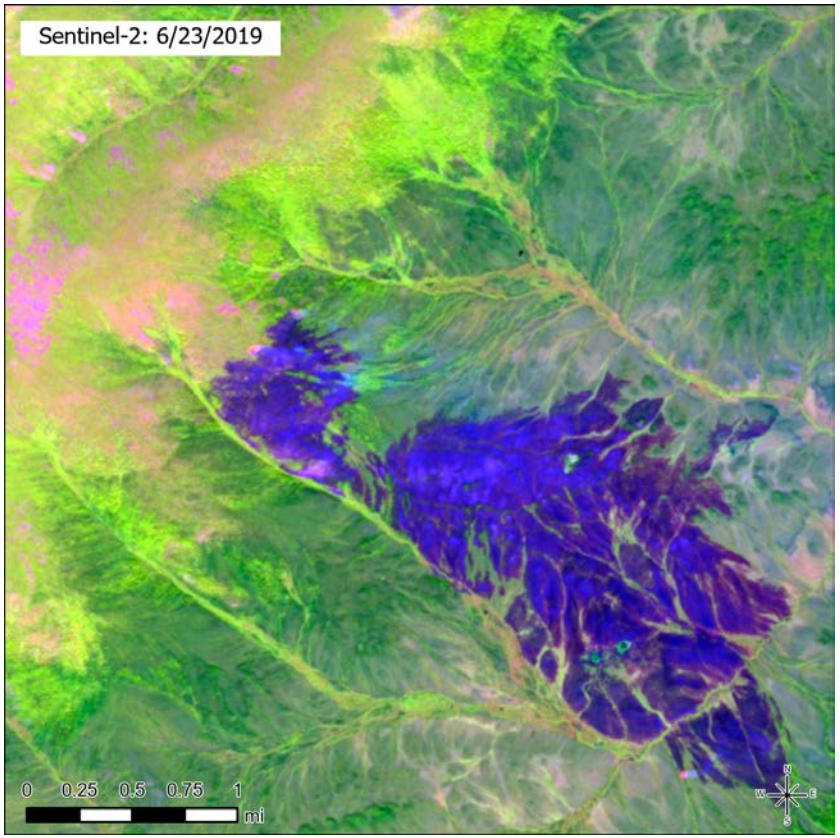


Satellite Imagery for Perimeters

Sentinel-2
6/21/2019

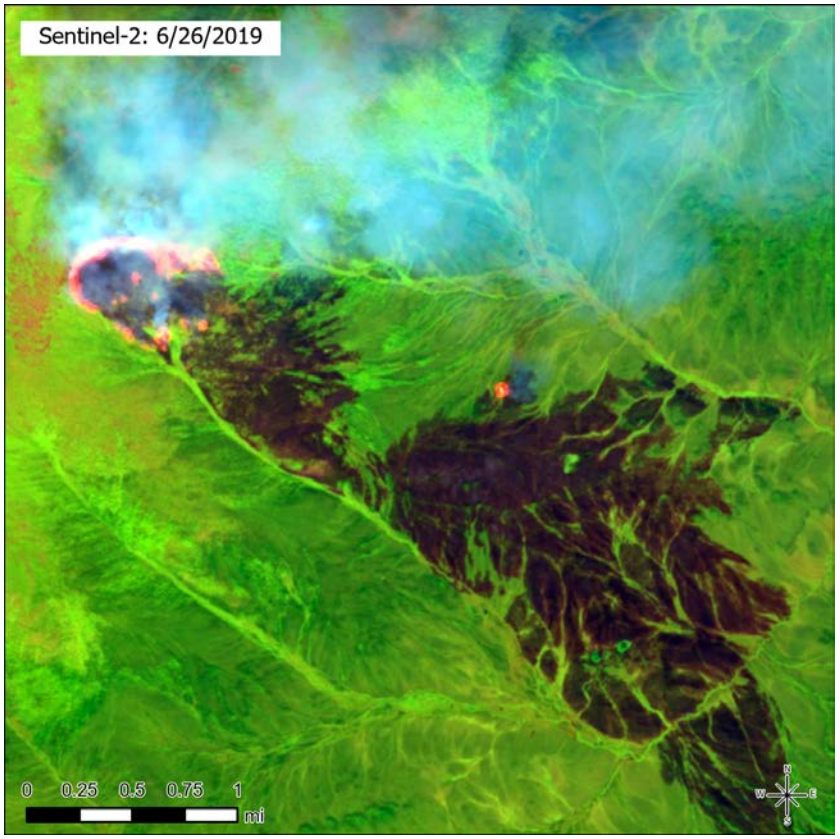


Sentinel-2
6/23/2019

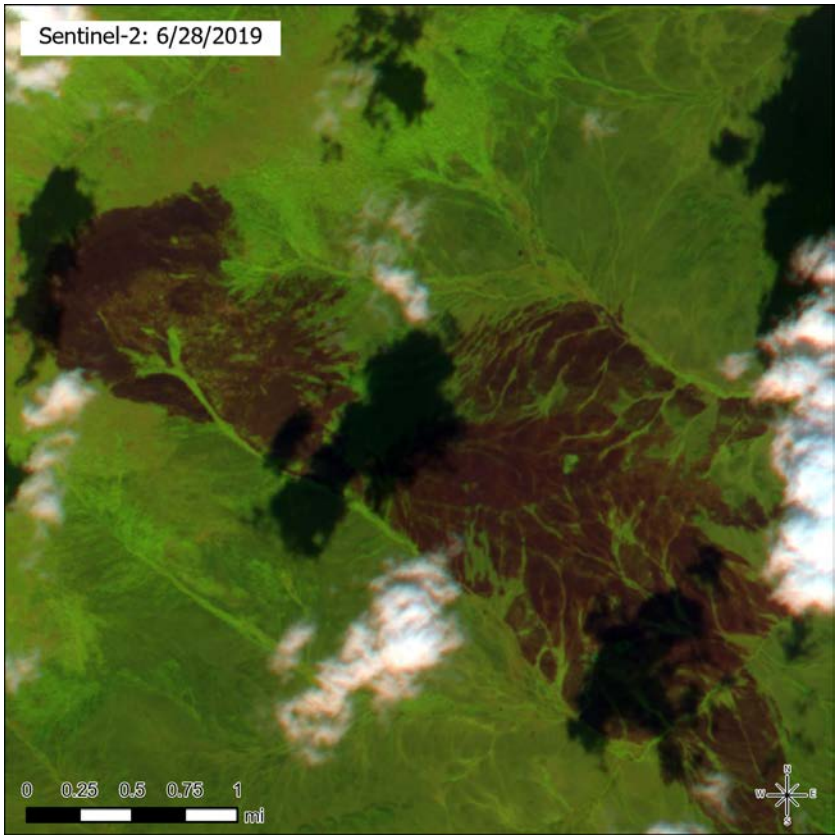


Satellite Imagery for Perimeters

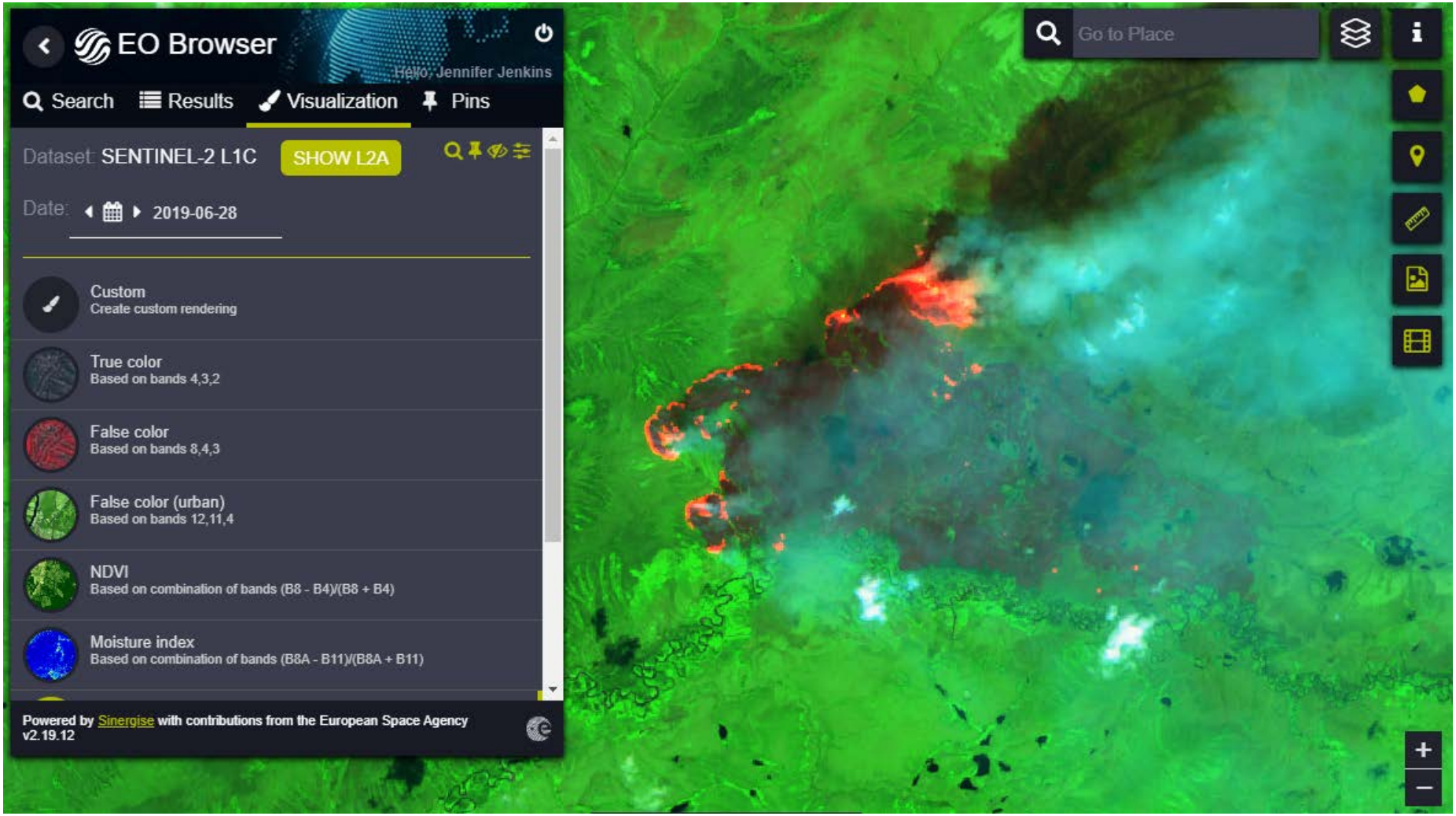
Sentinel-2
6/26/2019



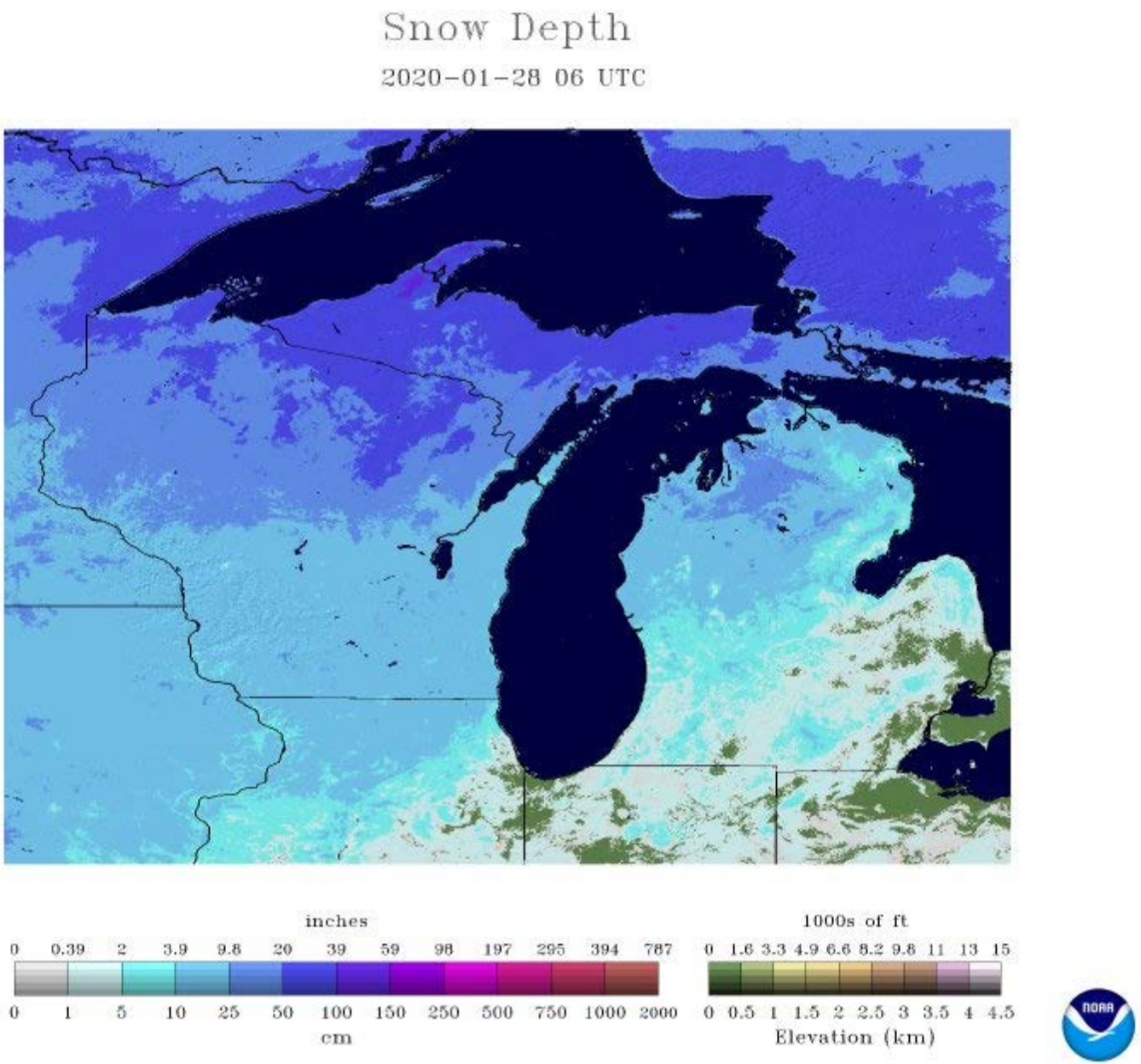
Sentinel-2
6/28/2019



Satellite Imagery for End Users



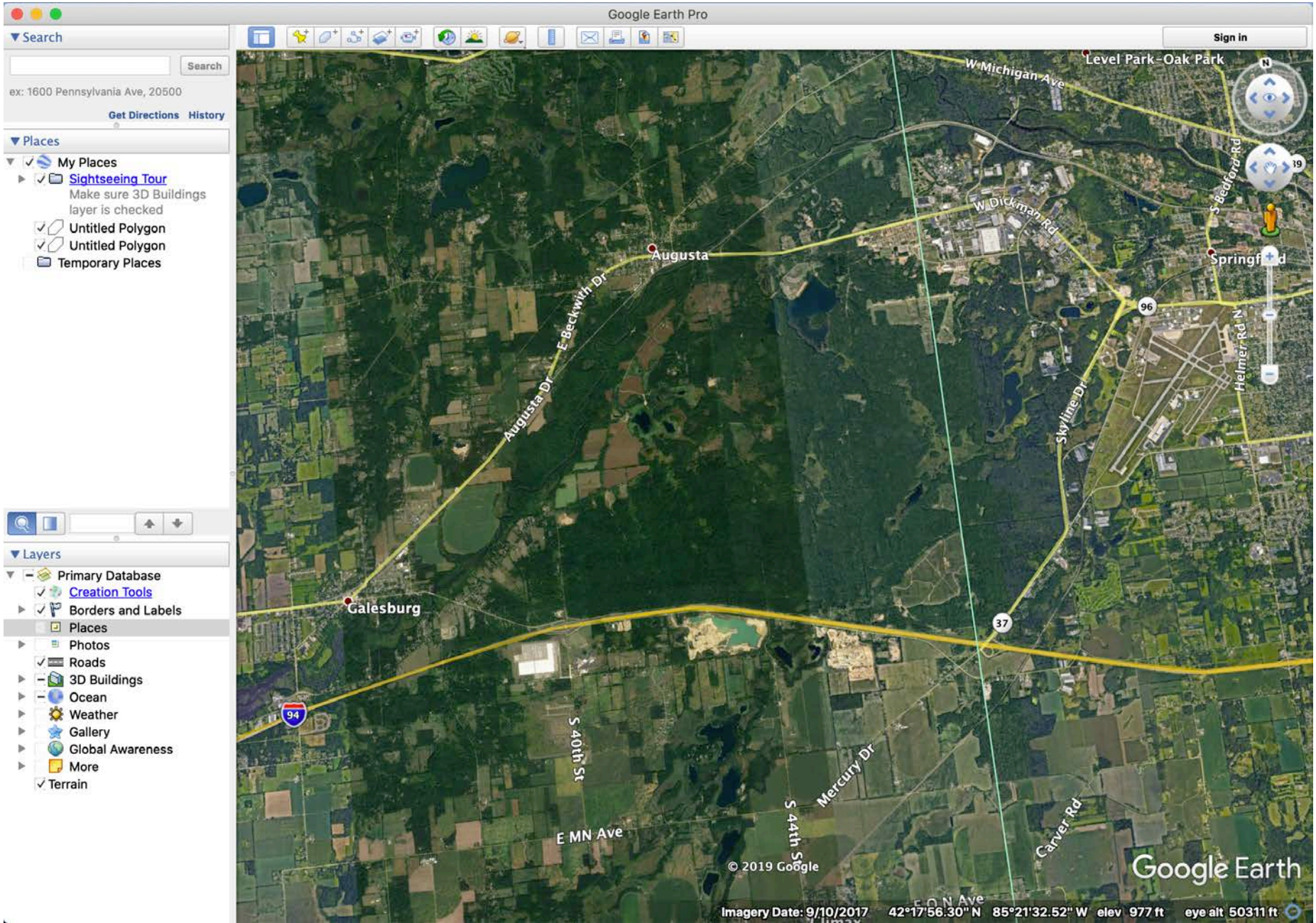
Current Resources in the Lake States



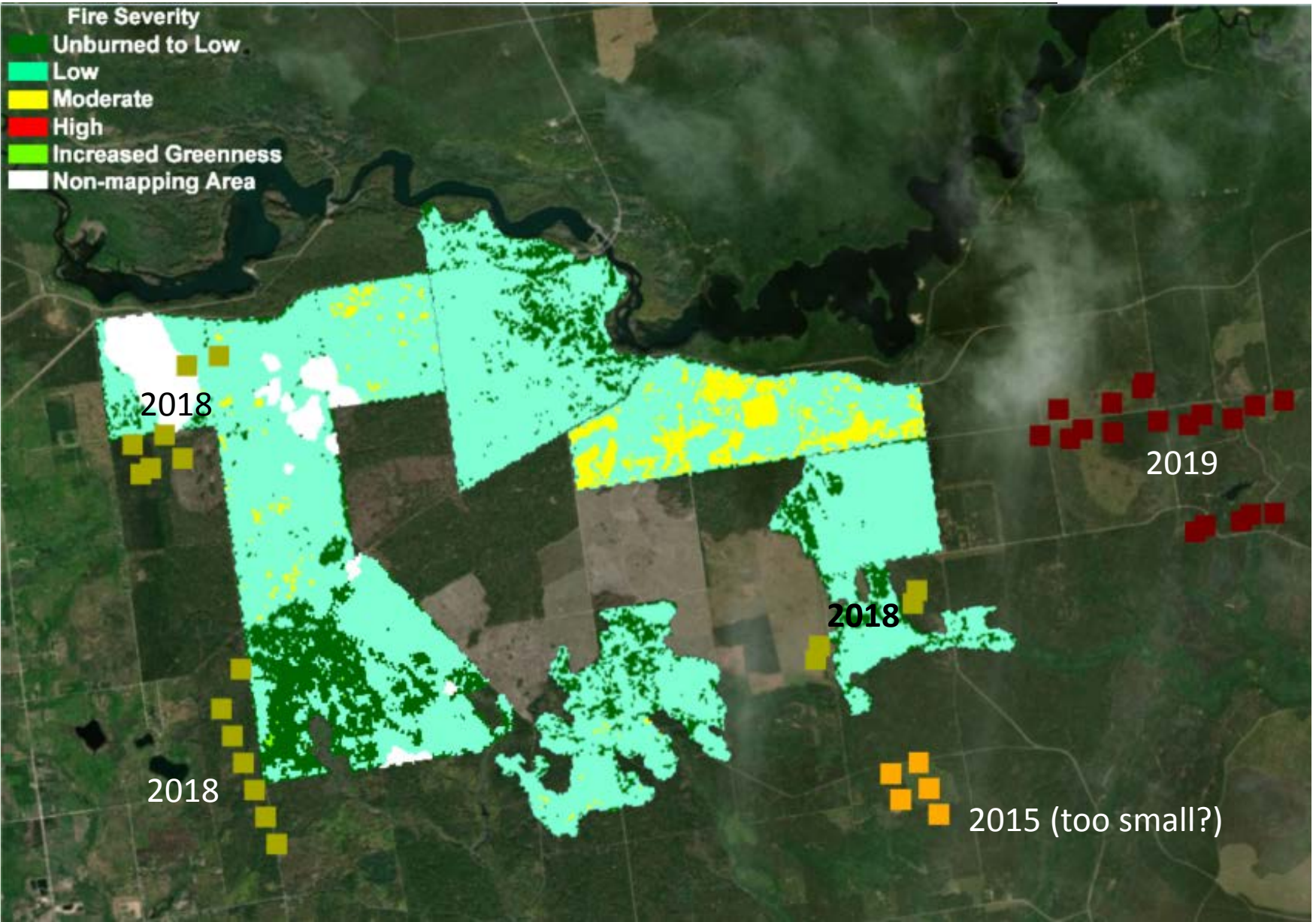
National Snow 2018-Analysis 2019

OWP | OFFICE OF WATER PREDICTION

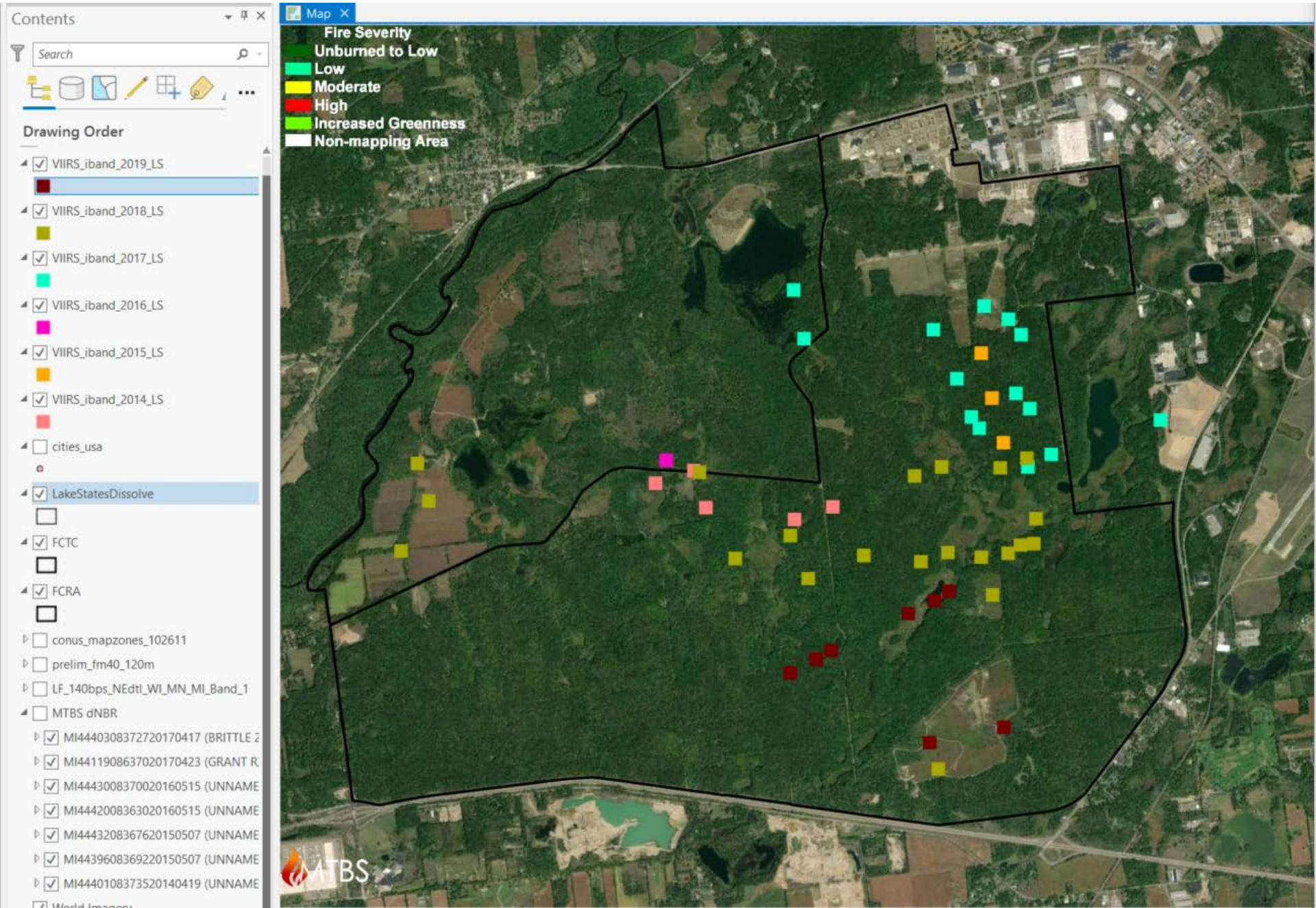
Google Earth and Avenza Maps



MTBS.GOV dNBR burn severity (thru 2017) & VIIRS i-band heat detections

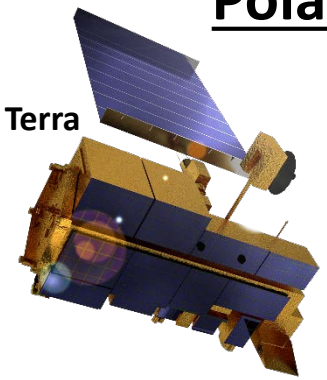


VIIRS iBand Active Fire Detections

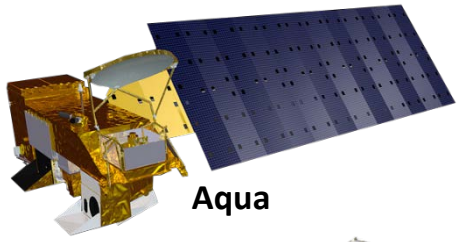


Environmental Satellites that Monitor Fire

Polar Orbiting



Terra

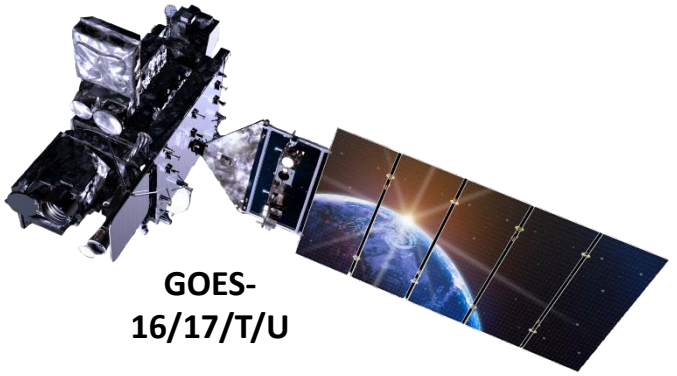


Aqua

NOAA 20
VIIRS

Suomi NPP
VIIRS

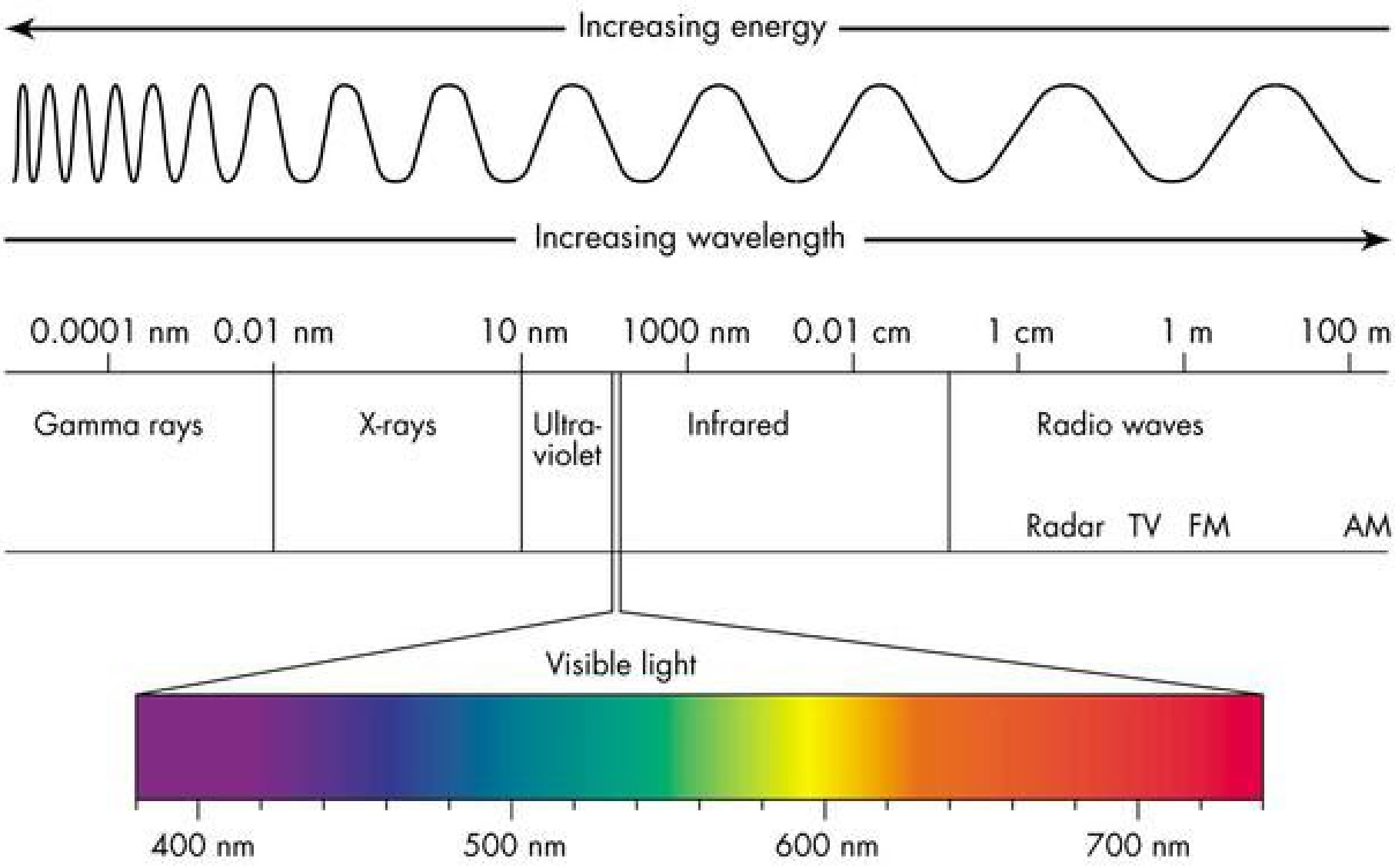
Geostationary



GOES-
16/17/T/U

Sentinel 2 (x 2)

Landsat 8


Increasing energy
Increasing wavelength
0.0001 nm
0.01 nm
10 nm
1000 nm
0.01 cm
1 cm
1 m
100 m
Gamma rays
X-rays
Ultra-violet
Infrared
Radio waves
Radar
TV
FM
AM
Visible light
400 nm
500 nm
600 nm
700 nm

LANDSAT 8, Sentinel 2 and GOES-R

LANDSAT 8 Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43-0.45	30
Band 2 - Blue	0.45-0.51	30
Band 3 - Green	0.53-0.59	30
Band 4 - Red	0.64-0.67	30
Band 5 - Near Infrared (NIR)	0.85-0.88	30
Band 6 - SWIR 1	1.57-1.65	30
Band 7 - SWIR 2	2.11-2.29	30
Band 8 - Panchromatic	0.50-0.68	15
Band 9 - Cirrus	1.36-1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.6-11.19	100
Band 11 - Thermal Infrared (TIRS) 2	11.50-12.51	100

Sentinel-2 Bands	Central Wavelength (μm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.49	10
Band 3 - Green	0.56	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.74	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.61	20
Band 12 - SWIR	2.19	20

GOES-R: ABI Band	Central Wavelength	Type	Nickname
1	0.47	Visible	Blue
2	0.64	Visible	Red
3	0.86	Near-Infrared	Veggie
4	1.37	Near-Infrared	Cirrus
5	1.6	Near-Infrared	Snow/Ice
6	2.2	Near-Infrared	Cloud particle size
7	3.9	Infrared	Shortwave window
8	6.2	Infrared	Upper-level water vapor
9	6.9	Infrared	Midlevel water vapor
10	7.3	Infrared	Lower-level water vapor
11	8.4	Infrared	Cloud-top phase
12	9.6	Infrared	Ozone
13	10.3	Infrared	"Clean" longwave window
14	11.2	Infrared	Longwave window
15	12.3	Infrared	"Drity" longwave window
16	13.3	Infrared	CO_2 longwave

MODIS & VIIRS Spectral Ranges

MODIS: Primary Use	Band	Bandwidth
Land/Cloud/Aerosols Boundaries	1	620 - 670
	2	841 - 876
Land/Cloud/Aerosols Properties	3	459 - 479
	4	545 - 565
	5	1230 - 1250
	6	1628 - 1652
	7	2105 - 2155
Ocean Color/Phytoplankton/ Biogeochemistry	8	405 - 420
	9	438 - 448
	10	438 - 493
	11	526 - 536
	12	546 - 556
	13	662 - 672
	14	673 - 683
	15	743 - 753
	16	862 - 877
Atmospheric Water Vapor	17	890 - 920
	18	931 - 941
	19	915 - 965
Surface/Cloud Temperature	20	3.660 - 3.840
	21	3.929 - 3.989
	22	3.929 - 3.989
	23	4.020 - 4.080
Atmospheric Temperature	24	4.433 - 4.498
	25	4.482 - 4.549
Cirrus Clouds Water Vapor	26	1.360 - 1.390
	27	6.535 - 6.895
	28	7.175 - 7.475
Cloud Properties	29	8.400 - 8.700
Ozone	30	9.580 - 9.880
Surface/Cloud Temperature	31	0.780 - 11.28
	32	1.770 - 12.27
Cloud Top Altitude	33	3.185 - 13.48
	34	3.485 - 13.78
	35	3.785 - 14.08
	36	4.085 - 14.38

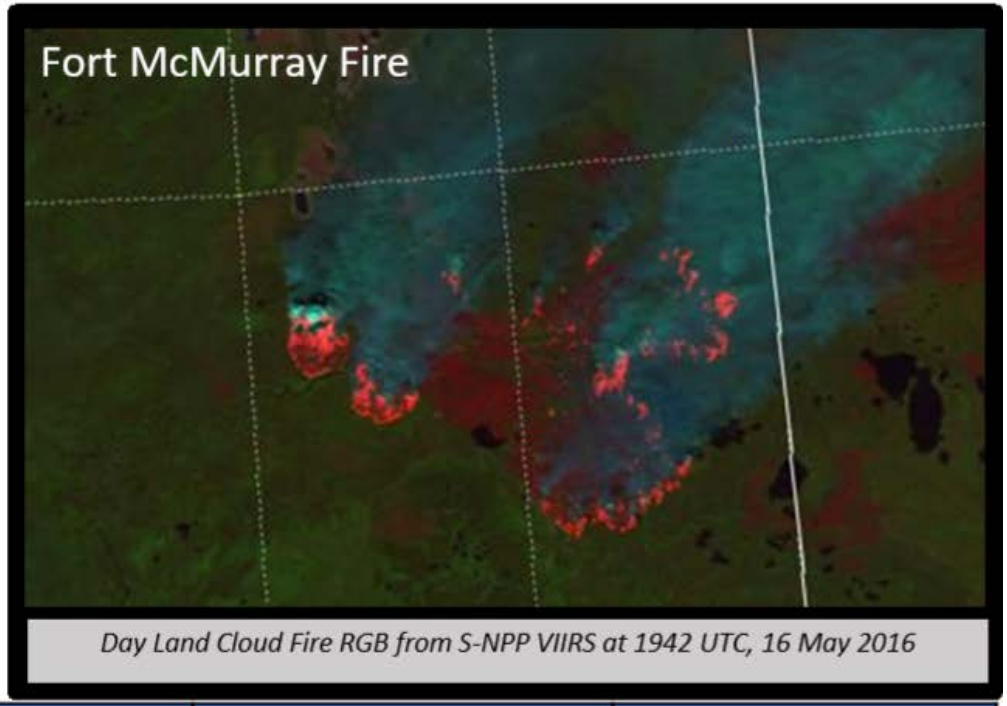
VIIRS: Primary Uses	Band Name	Center (microns)	Width (FWHM
Day/Night Band	DNB	0.7	0.4
Imagery band	I1	0.64	0.075
NDVI	I2	0.865	0.039
Binary Snow Map	I3	1.61	0.06
Imagery band Clouds	I4	3.74	0.38
Imagery band Clouds	I5	11.45	1.9
Ocean Color Aerosol	M1	0.415	0.02
	M2	0.445	0.02
	M3	0.49	0.02
	M4	0.555	0.02
Ocean Color Aerosol	M5	0.673	0.021
Atmospheric Correction	M6	0.746	0.021
Ocean Color Aerosol	M7	0.865	0.039
Cloud Particle Size	M8	1.24	0.02
Cirrus Cloud Cover	M9	1.378	0.02
Snow Fraction	M10	1.61	0.06
Clouds	M11	2.25	0.05
Sea Surface Temperature	M12	3.7	0.18
Sea Surface Temperature/Fires	M13	4.05	0.155
Cloud Top Properties	M14	8.55	0.3
Sea Surface Temperature	M15	10.763	1
Sea Surface Temperature	M16	12.013	0.95

VIIRS Day Land Cloud Fire RGB

Quick Guide

Why is the Day Land Cloud Fire RGB Important?

Also called "Natural Fire Color", this RGB combines three channels useful for fire monitoring. The 0.64 µm channel provides sensitivity to smoke, the 0.86 µm channel provides sensitivity to vegetation health and burn scars, and the 3.7 µm channel is sensitive to the hot spots from active fires. With VIIRS, we have the advantage that all of these channels are available at 375 m resolution, making it particularly useful for detecting small fires.



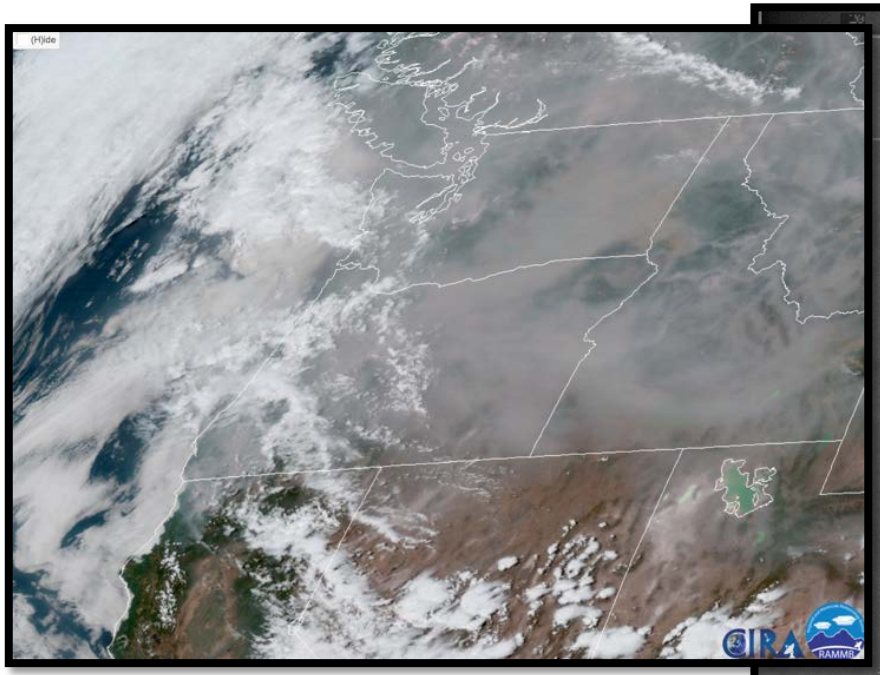
Day Land Cloud Fire RGB from S-NPP VIIRS at 1942 UTC, 16 May 2016

Day Land Cloud Fire RGB Recipe

Color	Band (µm)	Min-Max Gamma	Physically Relates to...	Small contribution to pixel indicates...	Large Contribution to pixel indicates...
Red	3.7	0 to 60 C 0.4	Temperature, clouds	Cold land surfaces, ice/snow, clouds	Warm land surfaces, hot spots (active fires)
Green	0.86	0 to 100% 1	Vegetation, land vs. water	Water, bare or rocky ground, burn scar	Healthy vegetation, snow/ice, clouds
Blue	0.64	0 to 100% 1	Smoke and clouds	Water, dark ground, burn scar	Smoke, snow/ice, clouds

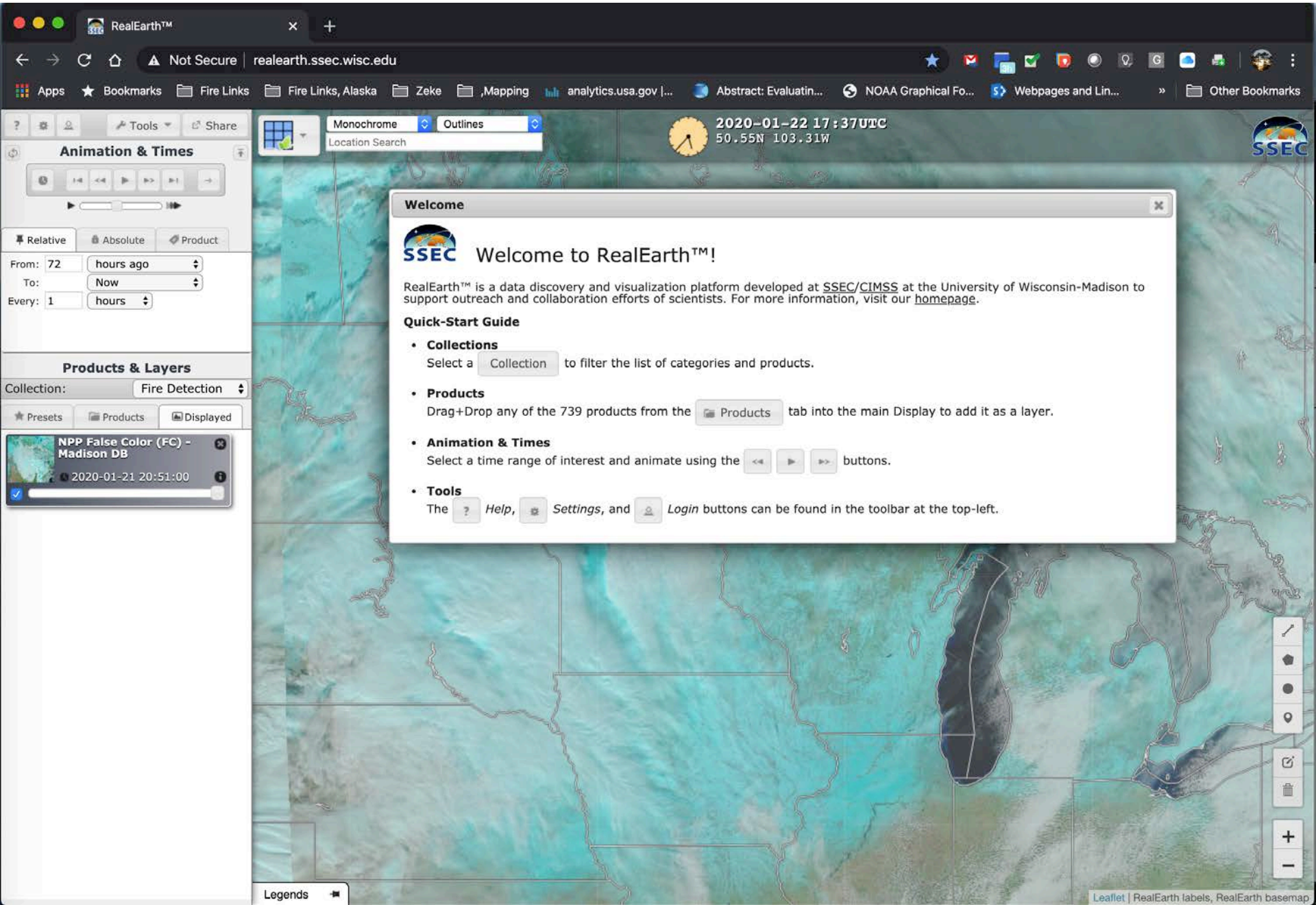
Near Real Time and…
Now Real Time

Real-time Visible Satellite Imagery via GOES-16/17:

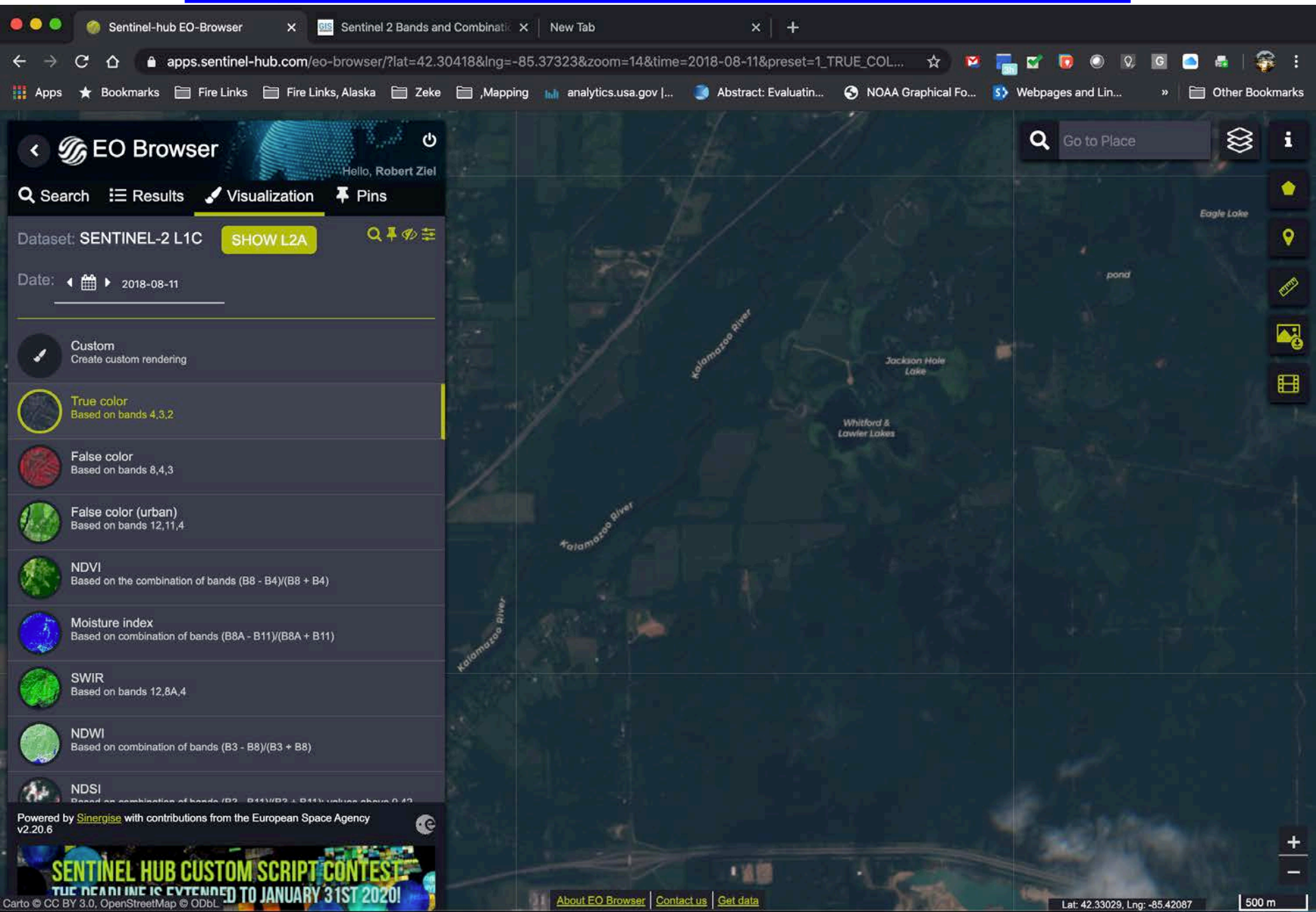


Still in early stages, but data updates every 15, 5, or even 1 minute in special cases.

http://realearth.ssec.wisc.edu/

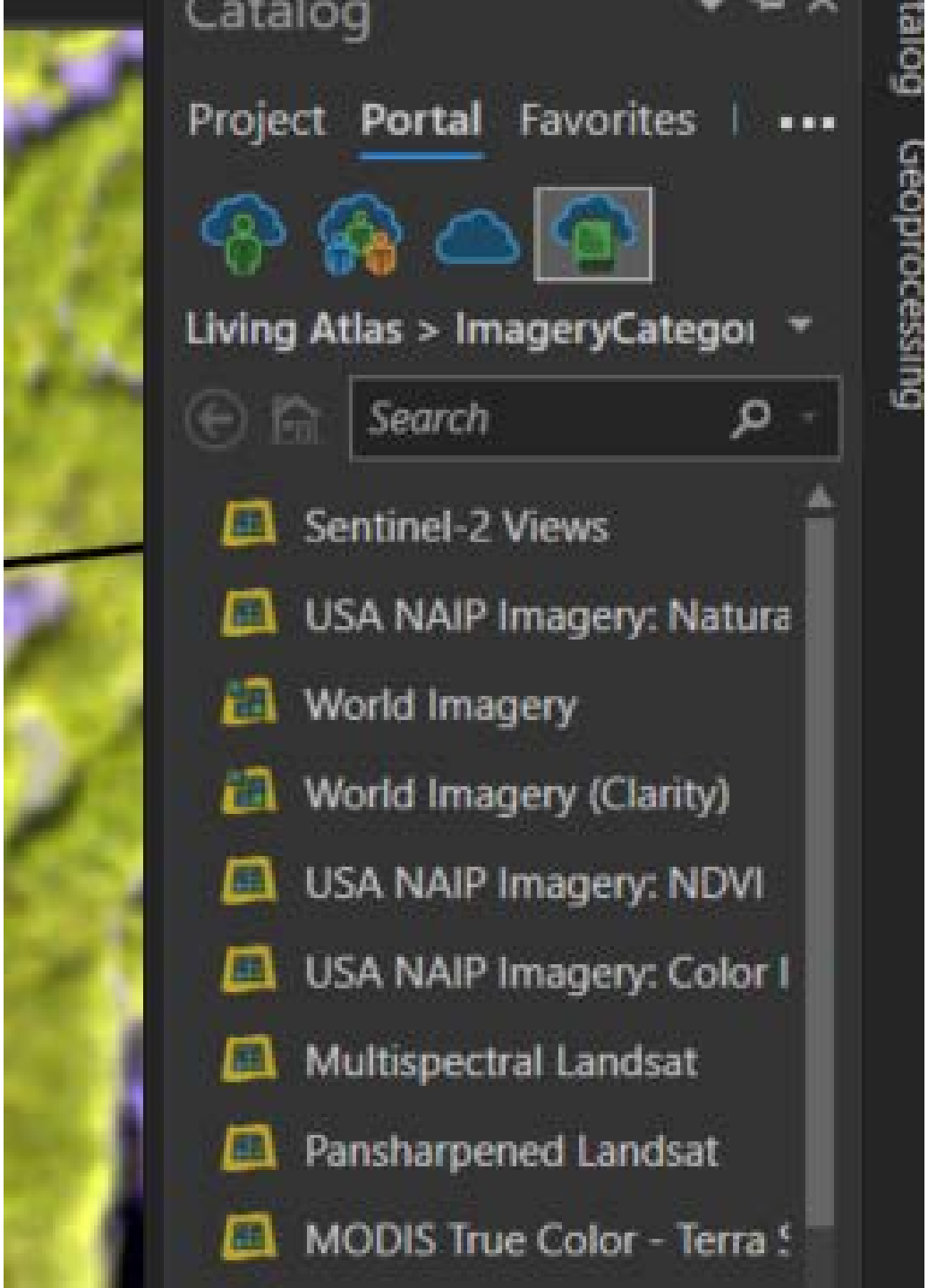


https://www.sentinel-hub.com/



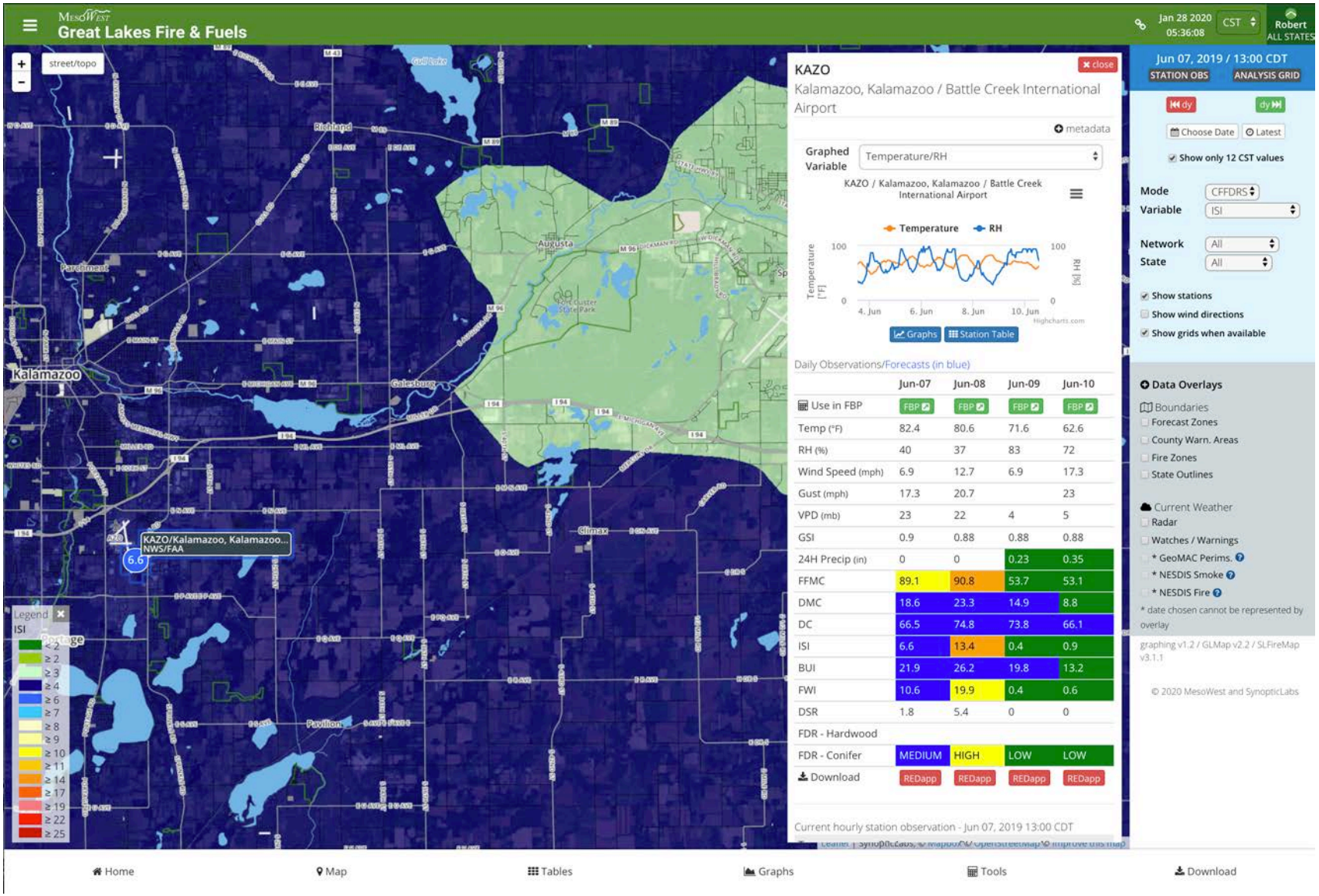
ESRI Living Atlas

- Integrated with ArcGIS Pro
- Updated with scenes in the middle of the night.
- Sentinel, Landsat, MODIS, many other products.



Data Integration for Analysis

https://glff.mesowest.org

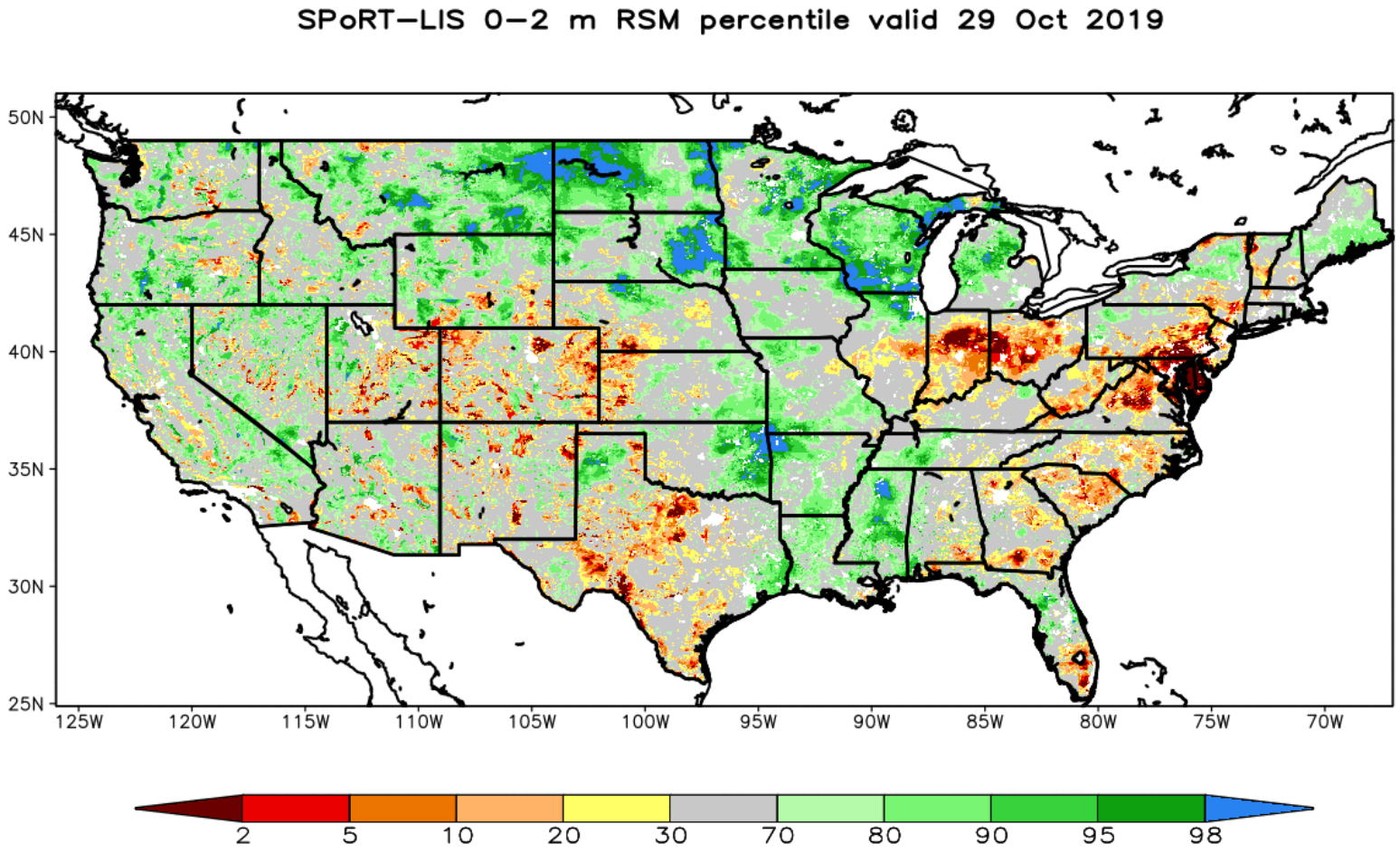


Data Integration for Analysis

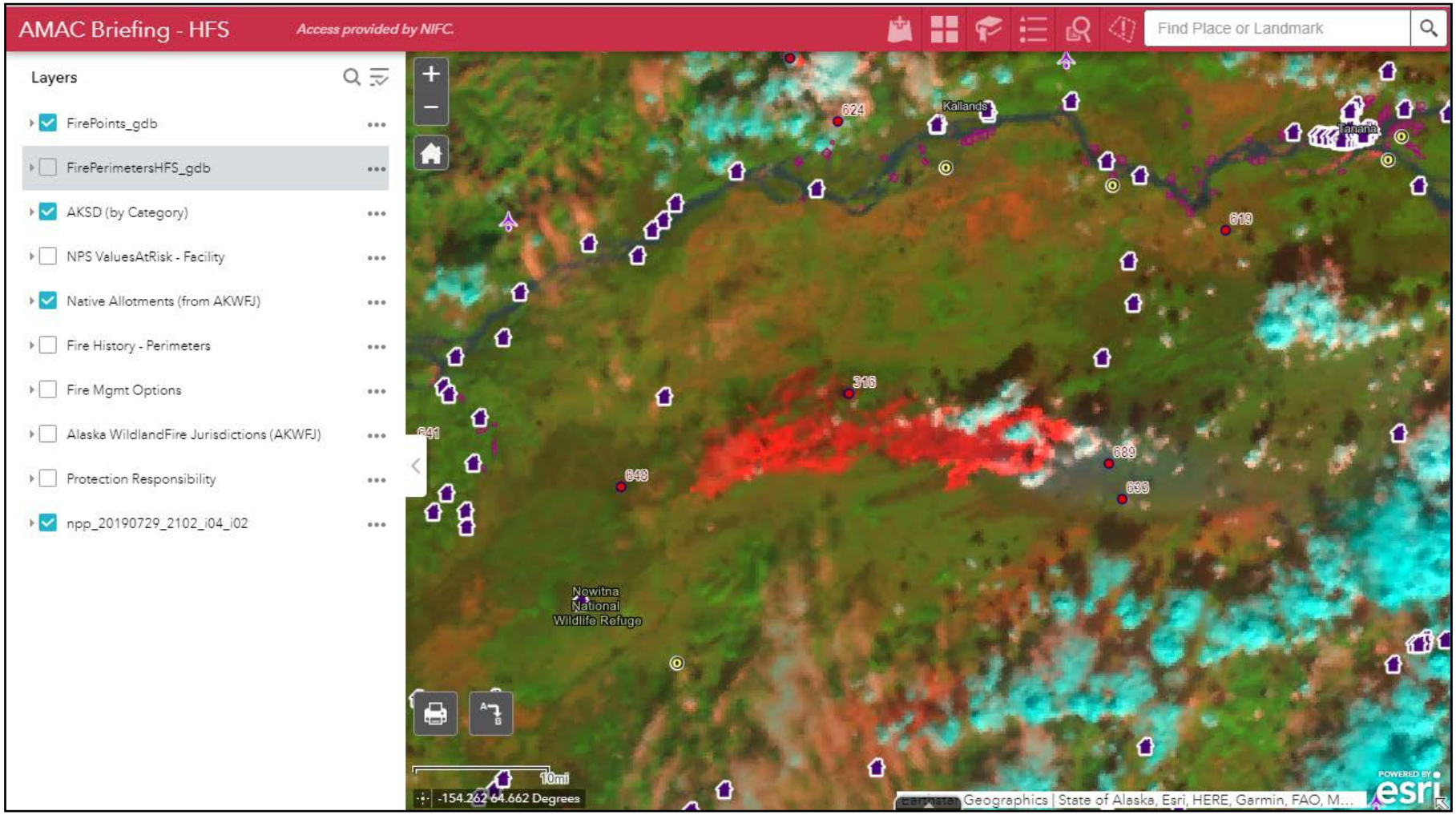
SPORT Short-term Prediction Research and Transition Center

NASA

https://weather.msfc.nasa.gov/sport/modeling/lis.html



GIS Integration



VIIRS Fire RGB image loaded into AGOL-based Web Mapping Application.

Questions/Closeout

- Remote Sensing has always been valuable…I started with aerial photographs
- LANDSAT got us thinking about current imagery as far back as 1972
- Expanding range of spectral range we can “see” changes the game
- Satellite data is accessible like never before
- How can current imagery make you a better manager? And what resolution is necessary?

Conclusions

- We’ve come a long way from the days of getting perimeters from fixed wing recon flights.
- The assortment of tools available to us may be confusing, but has promise to greatly expand our understanding of what is happening.
- Our task is daunting, monitoring and evaluating fire situations for sometimes well over 100 fires at a time.
- Some fires, like those with significant suppression effort, require more detailed approaches with less available tools.

Conclusions

- One of our critical monitoring assets, VIIRS RGB Fire Imagery, needs to be supported to provide near real time availability, easy access for fire management decision-makers, and archive retrieval for analysis purposes.
  - We’ve shown the path to better accessibility yesterday and today.
- All of this requires some planning and commitment of the agencies here in this room.