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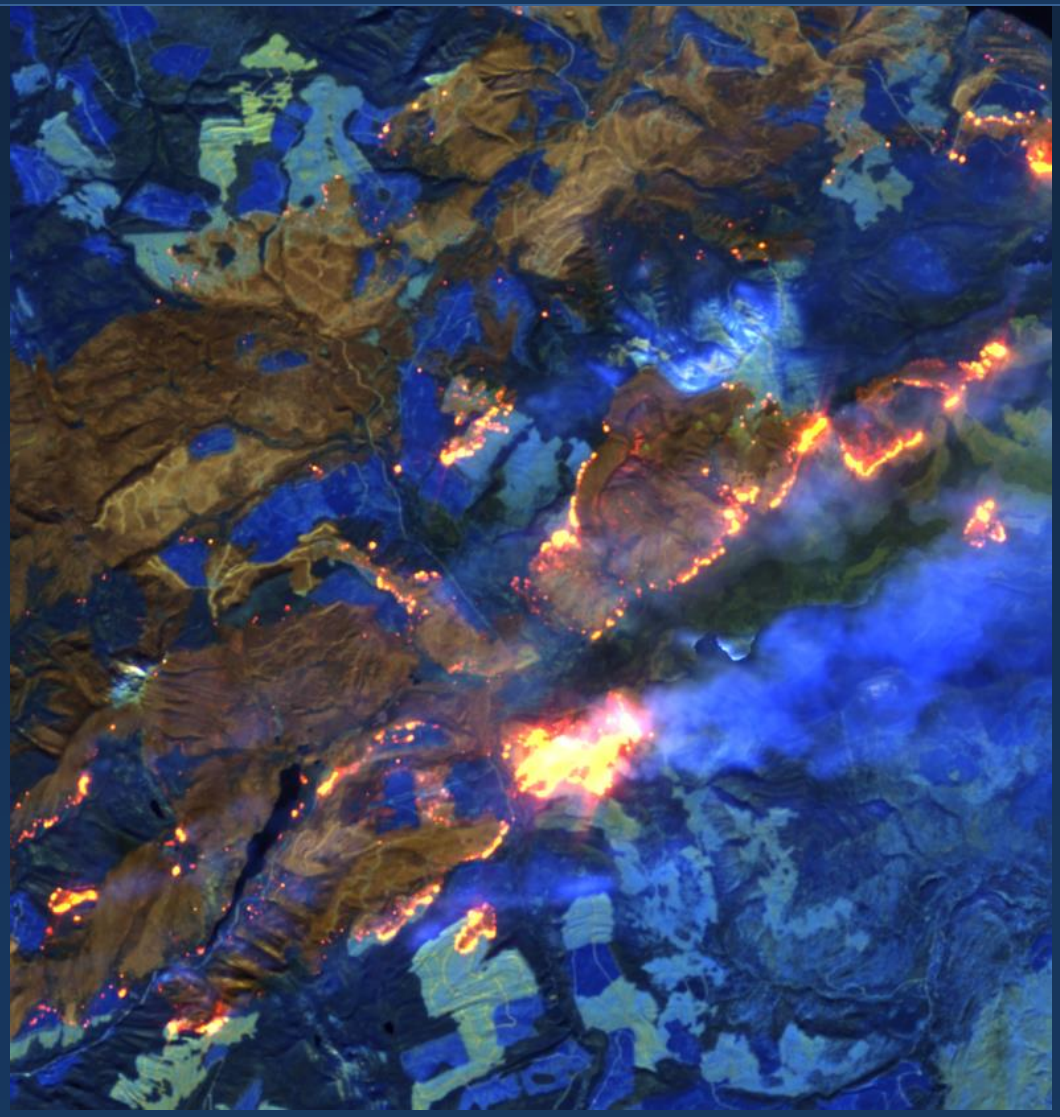
Satellite Fire Mapping: BCWS Operational Trial 2022

Ash Richardson
Senior Data Scientist
BCWS Predictive Services Unit

20221130

AI Fire Perimeter Mapping

BC Wildfire Service



CIFFC Geomatics Working Group, 12 Oct 2022 10:00

Ash Richardson, Predictive Services Unit

Operational trial 2022 (BCWS)

1. Goal: satellite fire perimeter mapping
2. Approach
    - A) Web prototype GEE data access (Sentinel2)
    - B) Direct data download:
        - ESA copernicus API (Sentinel2)
        - USGS web interface (Landsat 7/8/9)
    - Simple "A.I." Method(s)
3. What we learned
    - Wins
4. Next steps

BCWS Predictive Services
BCWS Geospatial Services

Satellite mapping of fires

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- Opportunity to monitor fire progression where active suppression is not occurring
  - Keeping situational awareness
  - Reduce high-risk flight requirements
- Complementary to existing methods
- Additional frequency and fidelity for perimeter updates
  - Better intel for growth projections & other predictive services products
- Stepping-stone, towards continuous fuels mapping

- How? Start with Sentinel-2 and add more (tried Landsat and Sentinel-3)

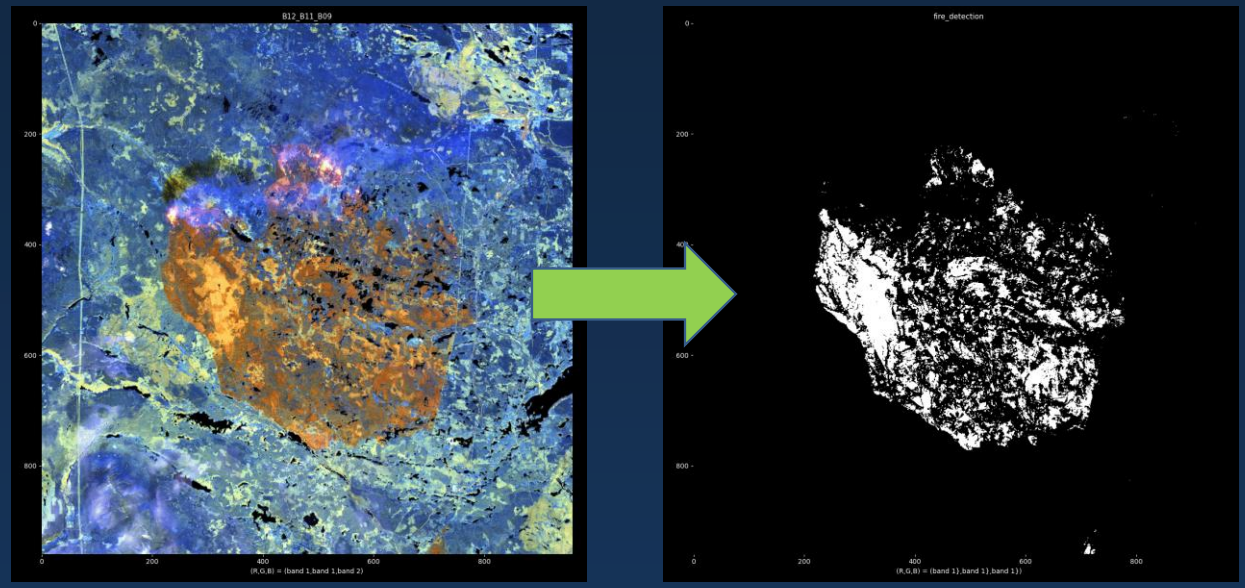
Why is this method unique?

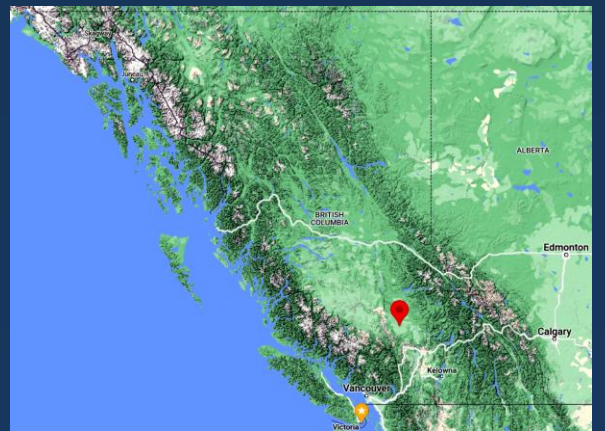
- Unconventional:
  - Not a retrospective pre/post veg comparison
    - Single-date imagery req'd
    - NBR / dNBR not used
  - Thermal IR band not req'd
  - Not a hotspot detection
    - Can catch v transient fires
- Accessible:
  - no math/stats required
  - Free/open-source software and open data used!
  - Can use a simple "band math" expression in your preferred Geomatics tool (Arc, ENVI, SNAP, PCI, QGIS, ..etc)

Private-cloud / GEE approach

- Collaborated w Predictive Services Unit (PSU) agile dev team
  - Web-based detection prototype
    - BC Gov internal private-cloud
  - Data from Google Earth Engine (GEE)
  - Detection queued automatically
    - from publicly BCWS fire locations
  - Issue: several days latency on Sentinel2 data access from GEE

Flat Lake Wildfire (2021)





https://github.com/bcgov/wps-fire-perimeter

Approach: direct "low latency" data access

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1. Prepare Sentinel2/Landsat data
   - Download, extract, band selection, crop
   - Copernicus faster than SentinelHub
   - Save ~2h by downloading L1 & process to L2
2. Binary fire classification
   - Two classes: Fire vs NA
3. Scrub false positives (using GIMP)
   - E.g. Water
4. Convert to Polygon (kml)
   - ***Record GeoTiff raster for QC/QA and analysis***
   - Use QGIS to compare w public perimeter data
5. Submit to BCWS Geospatial Services team
   - SME review (+ Post processing)

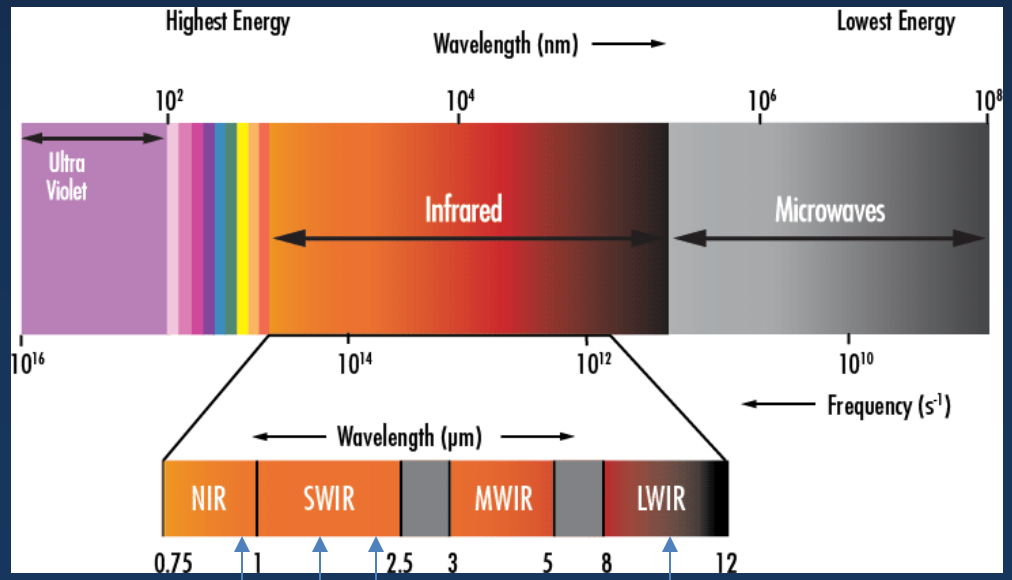
https://github.com/bcgov/wps-research/blob/master/py/binary_polygonize.py

1. False color coding

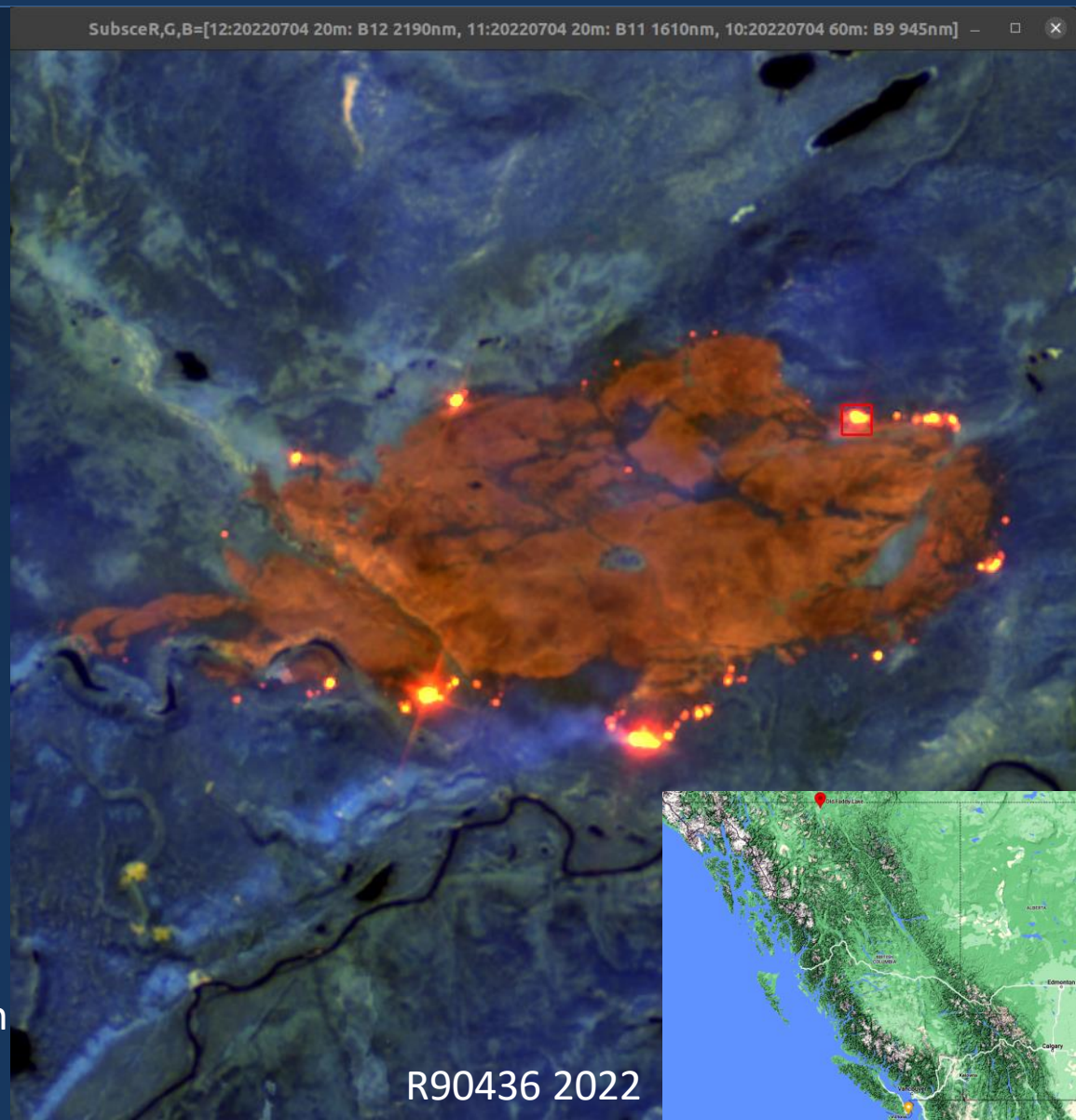
- Color encoding to generate map at right:
  - Red: "B12" 2190 nm = 2.2 µm
  - Green: "B11" 1610 nm = 1.6 µm
  - Blue: "B9" 945 nm = 0.95 µm

I.e. The B12, B11 and B9 are respectively plotted as Red, Green and Blue on the screen

- Vegetation is blue
- Hotspots are red
- Burned areas are orange



"Somewhere between visible and thermal"

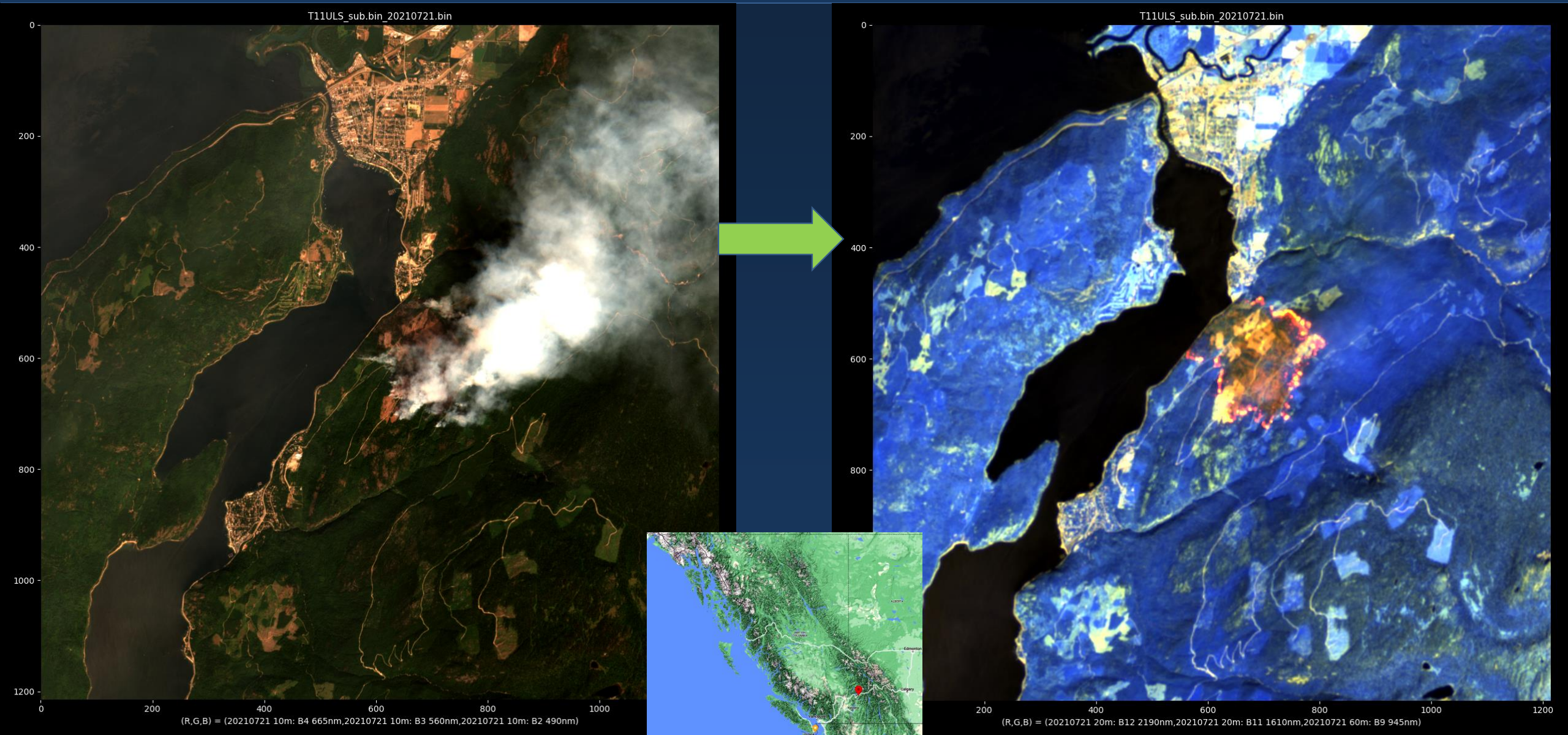


1) Sentinel2 data: Why use longest-waves?

BC Wildfire Service

RGB = RGB (visible) Sicamous 2021

RGB= (B12, B11, B9) shortwave IR. 3 longest-wave bands!

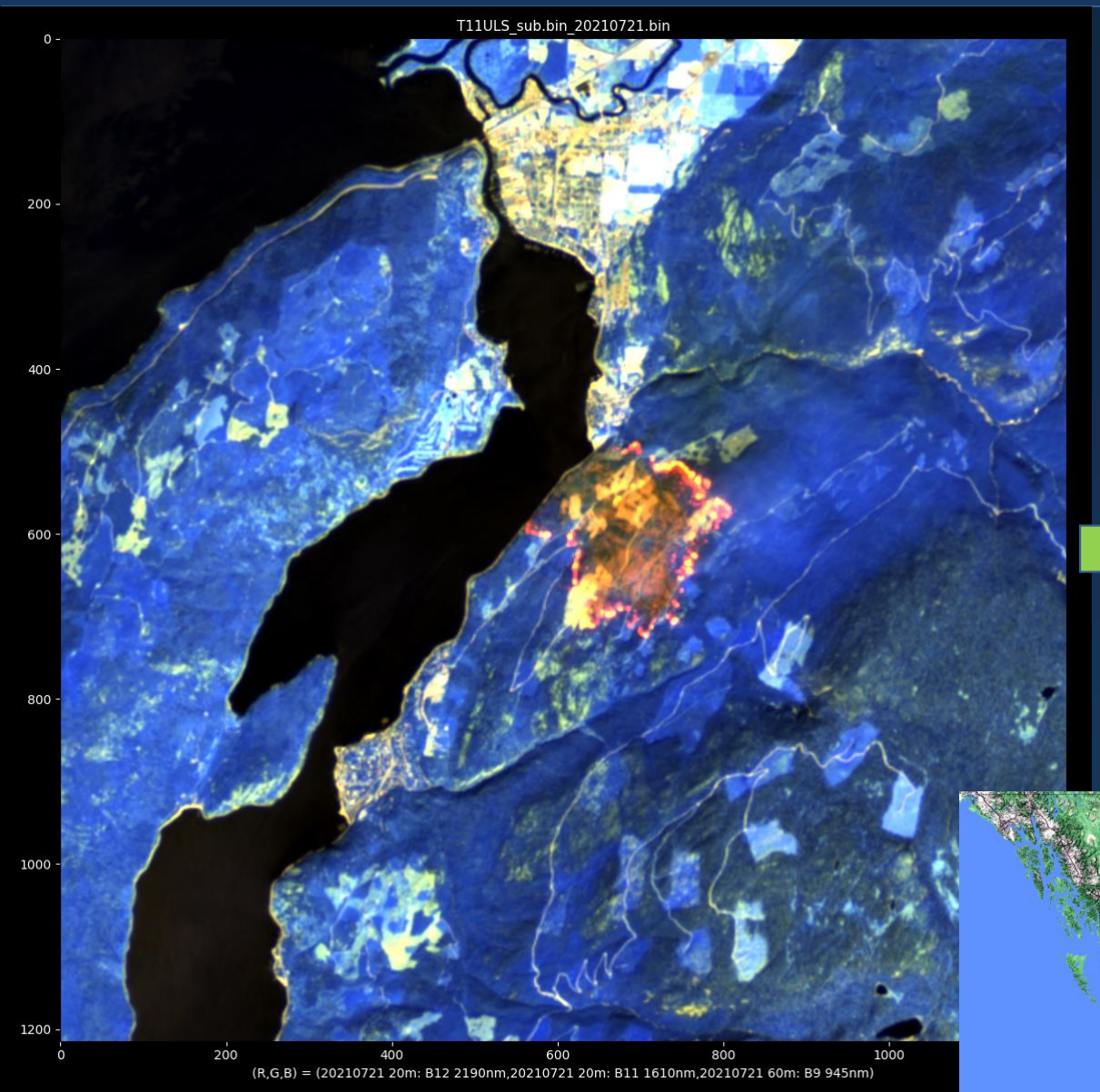


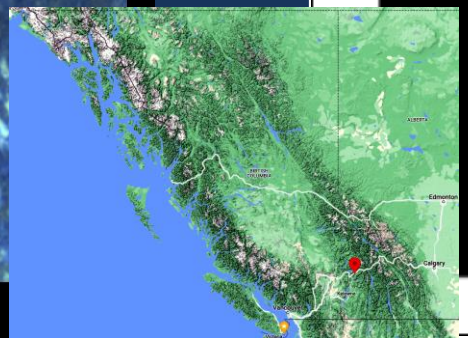
2. Threshold

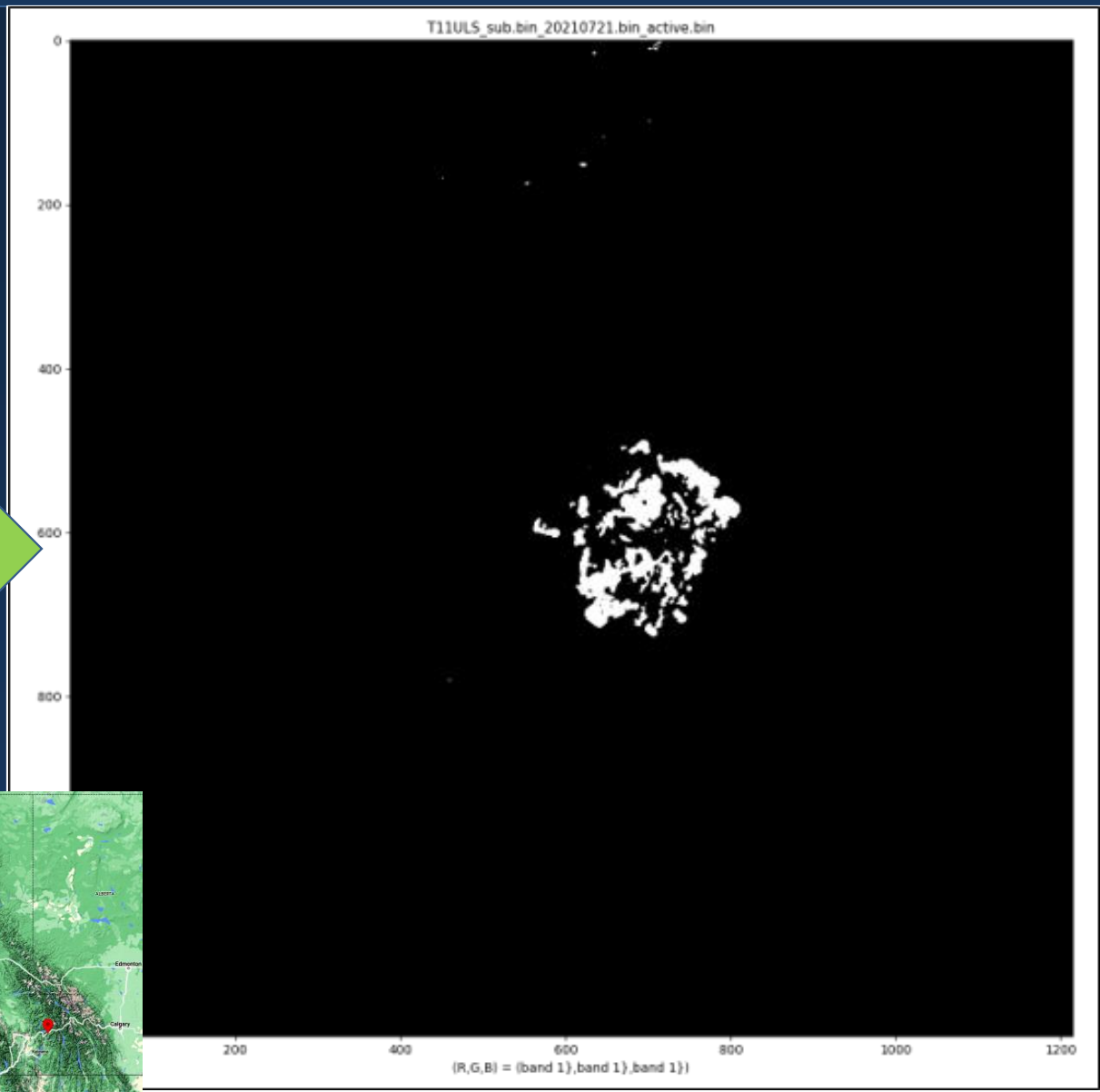
https://github.com/bcgov/bcws-psu-research/blob/master/cpp/sentinel2_active.cpp

(*) https://github.com/bcgov/wps-research/blob/master/cpp/raster_dominant.cpp

BRITISH COLUMBIA | BC Wildfire Service



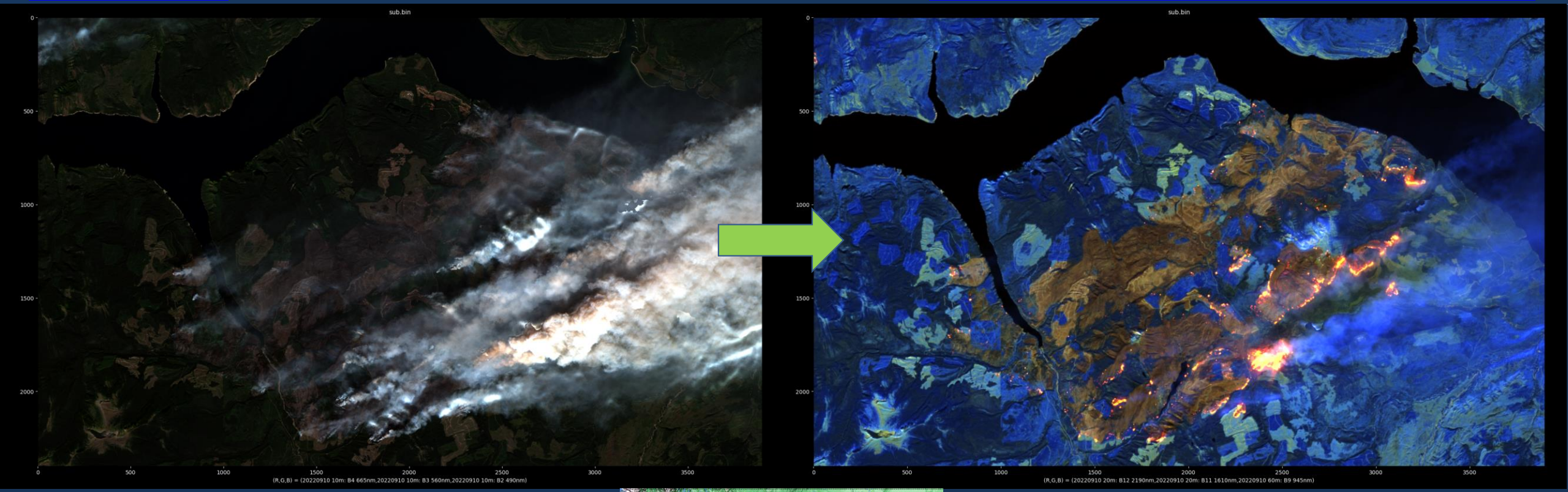


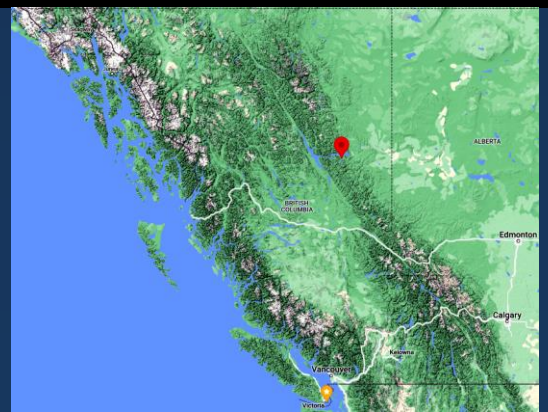


1) SWIR false-color encoding

RGB = RGB (visible) Battleship mountain (G72150) 20220910

RGB= (B12, B11, B9) shortwave IR. 3 longest-wave bands!



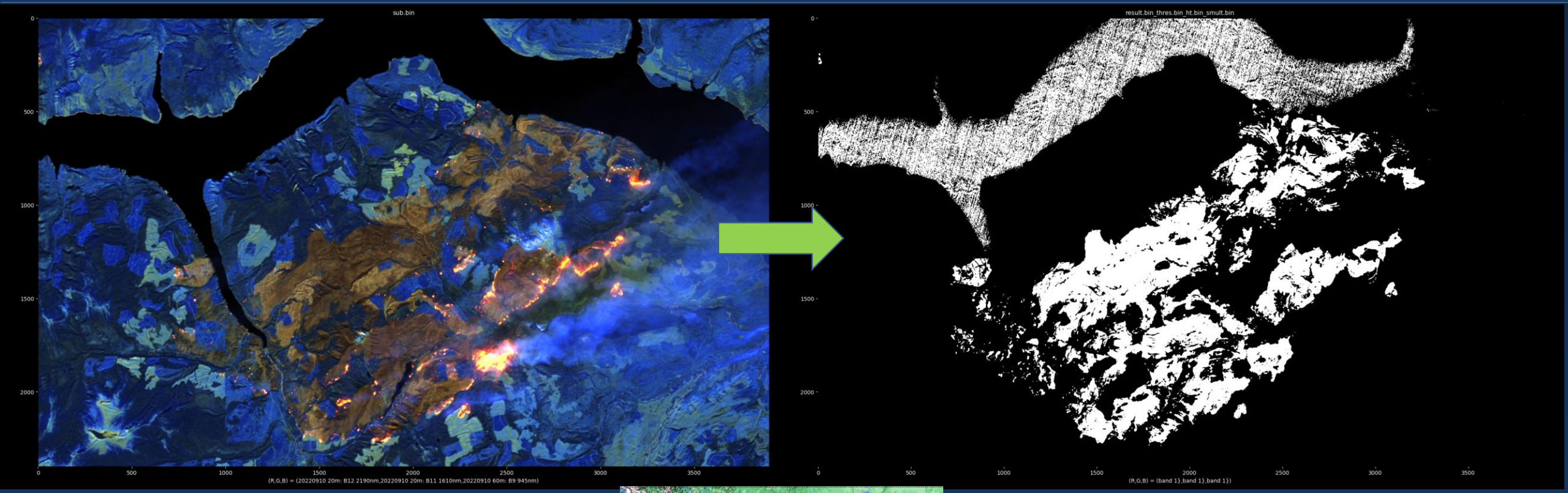


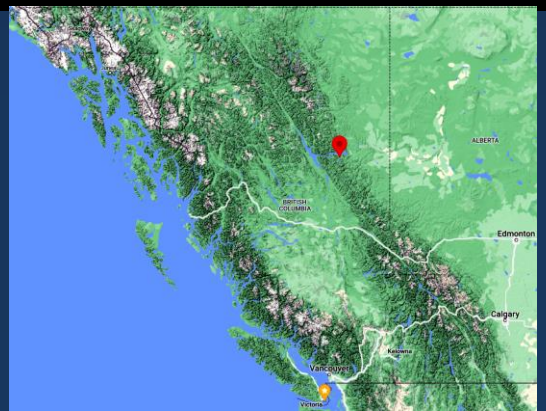
Battleship mountain (G72150) 20220910

2) Threshold

https://github.com/bcgov/bcws-psu-research/blob/master/cpp/sentinel2_active.cpp
https://github.com/bcgov/wps-research/blob/master/cpp/raster_dominant.cpp

BC Wildfire Service



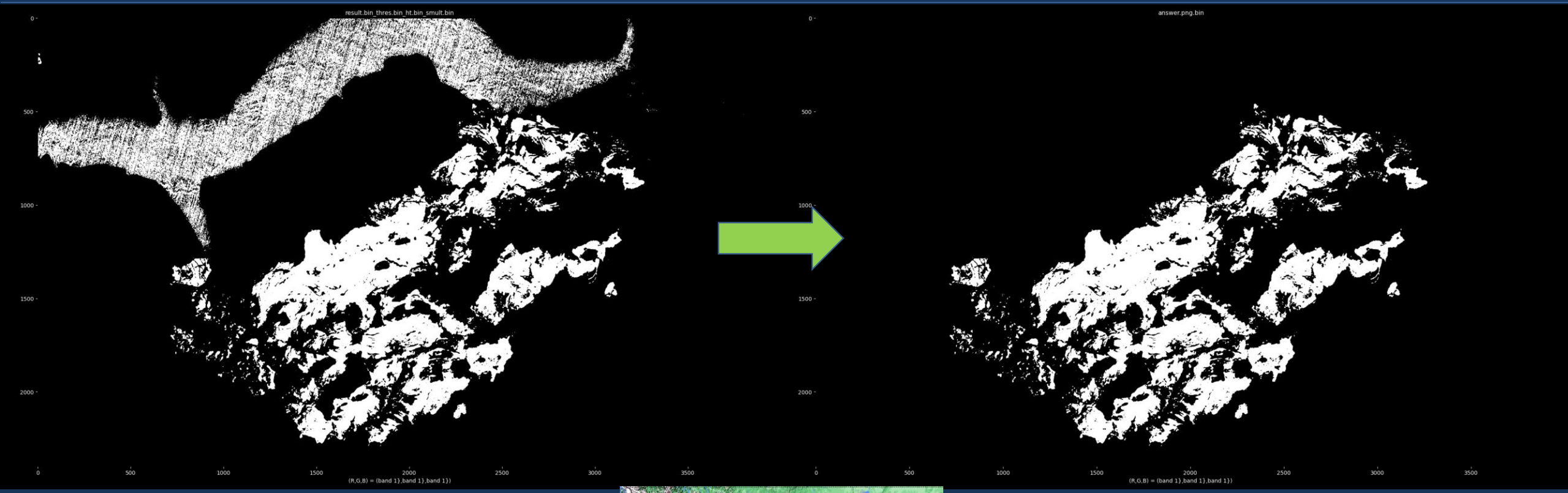


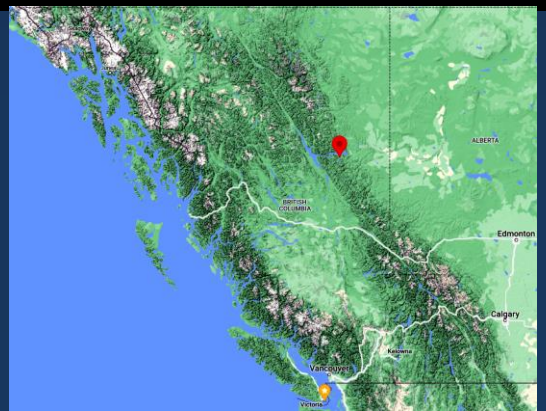
Battleship mountain (G72150) 20220910

(B12 > B11 && B12 > B9)

- Find image areas that are "more red"
- False positives incl. Reflection off water
- In-house private cloud app uses GEE land-cover to exclude water

3) Scrub

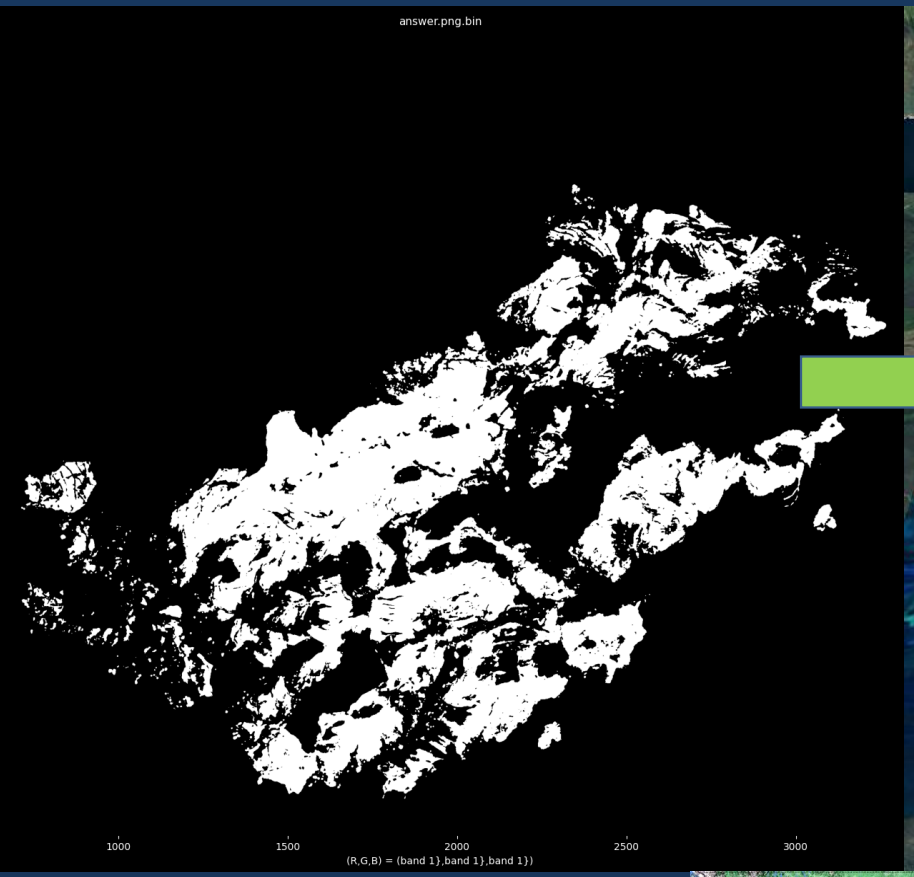


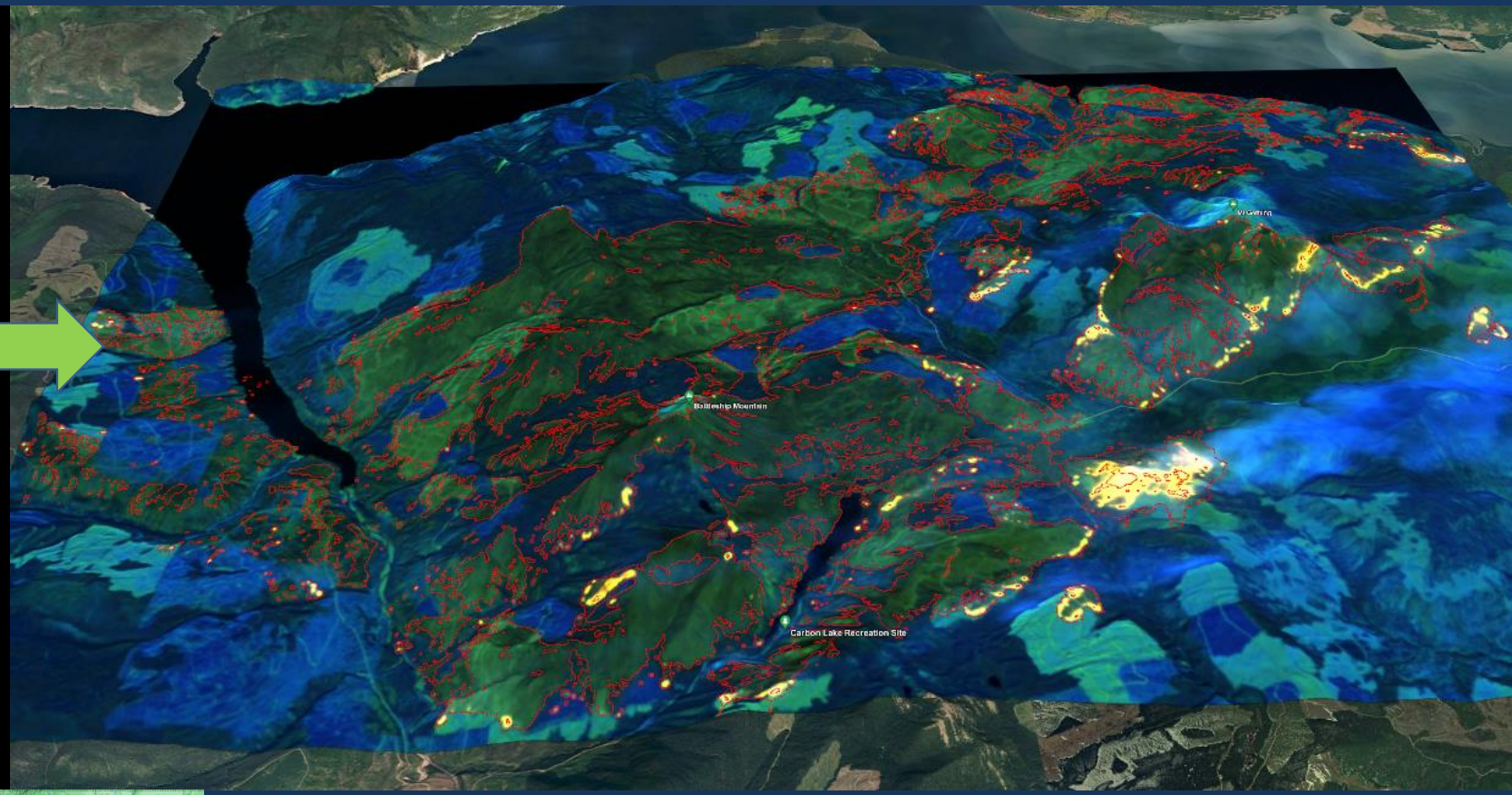


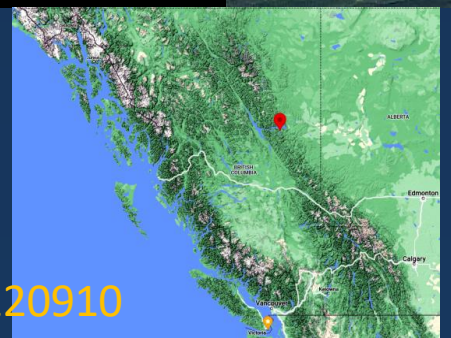
- Remove water areas
- GIMP used for manual scrubbing
- Weather, illumination or other image quality issues could necessitate more scrubbing

Battleship mountain (G72150) 20220910

4) Convert to polygon and compare





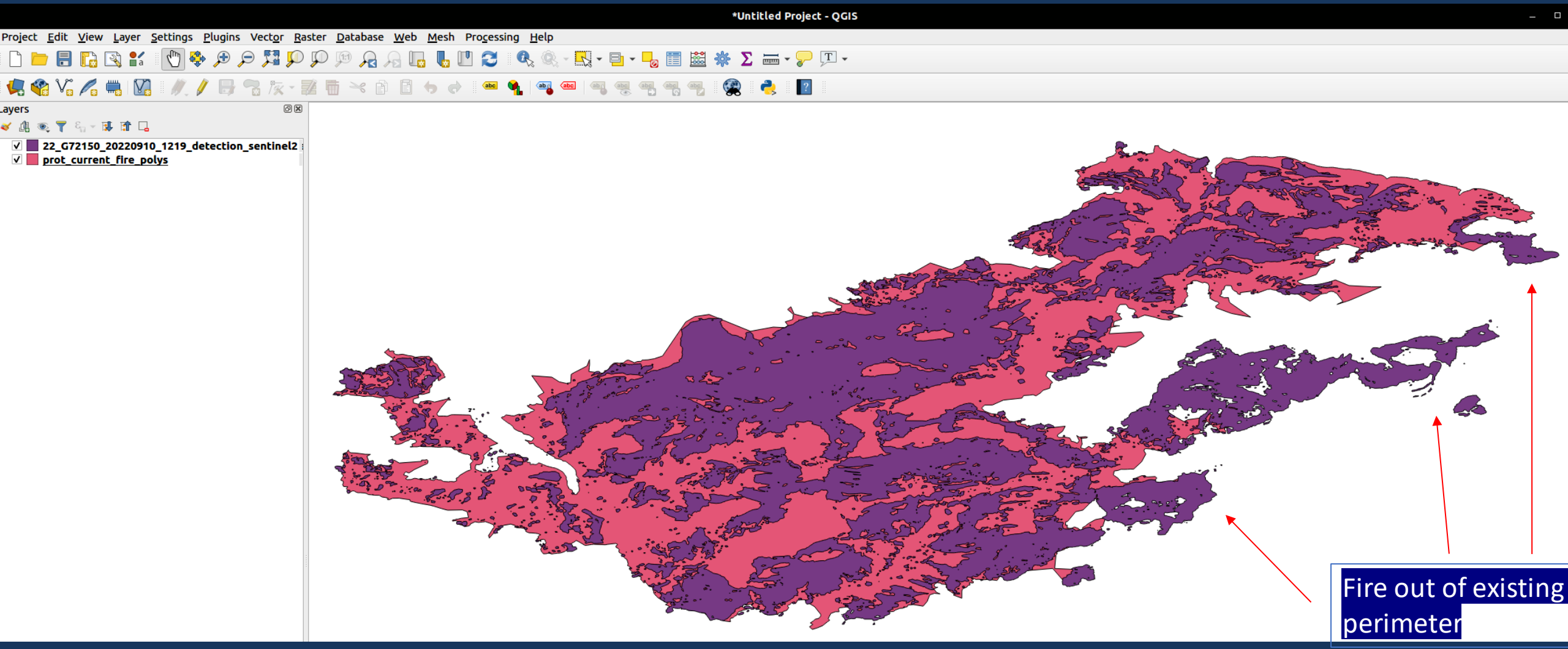


Battleship mountain (G72150) 20220910

- KML outline (RED) viewed in Google Earth
- SWIR band preview saved to TIFF
  - Scaled to 8-bit (each band)
- 5. SME post processing not shown

4. Polygon: compare w existing data!

BC Wildfire Service

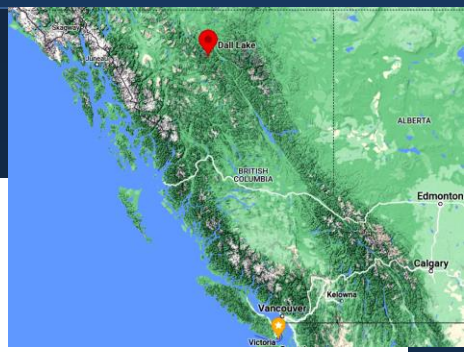


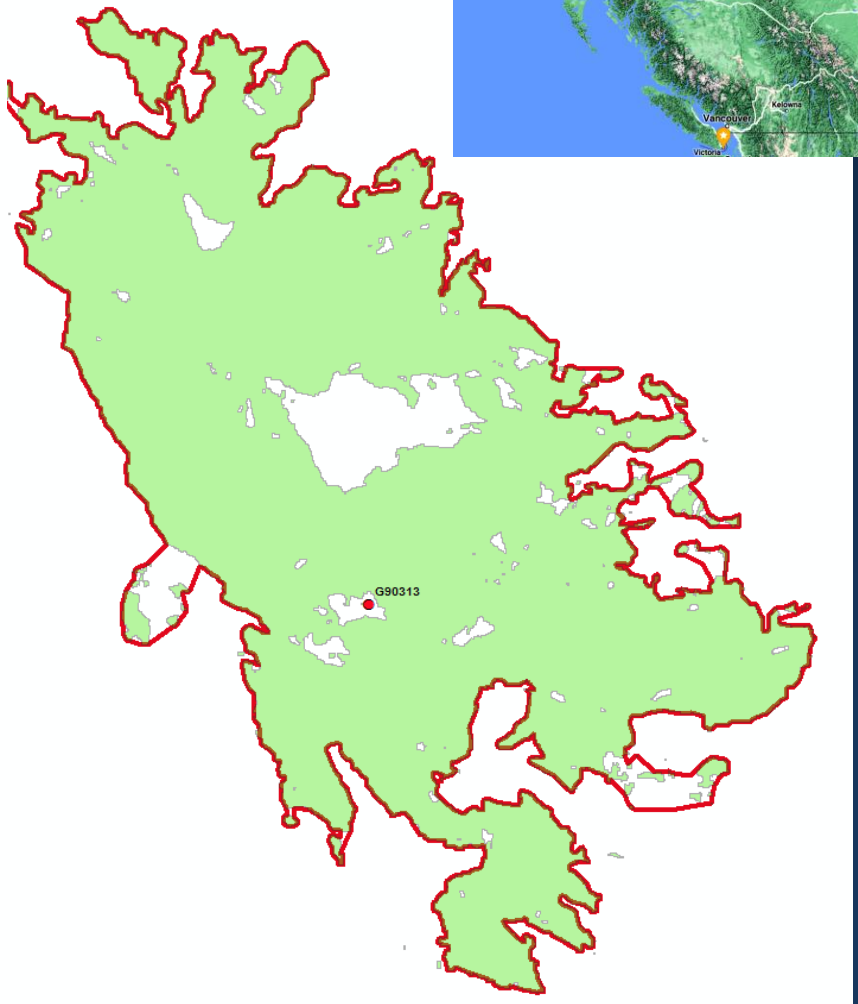
Battleship mountain (G72150) 20220910 Poly data 2022091021 (9-10pm)

Note: 12 Sep 2022 poly to boots on ground in 4h24m from image capture (approx noon)

5. Post processing

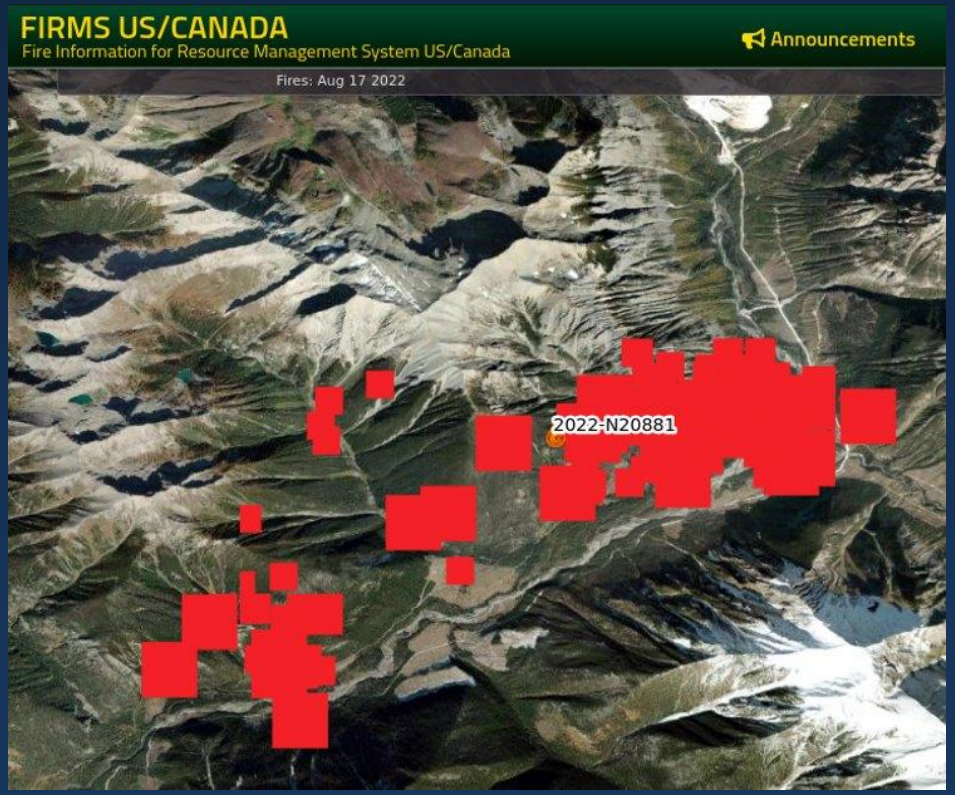
- Post processing completed in conjuction with current perimeter, Plans Chief and GIS Specialist
- Left: Sentinel2 derived detection. Middle: Generalized shape Right: comparison



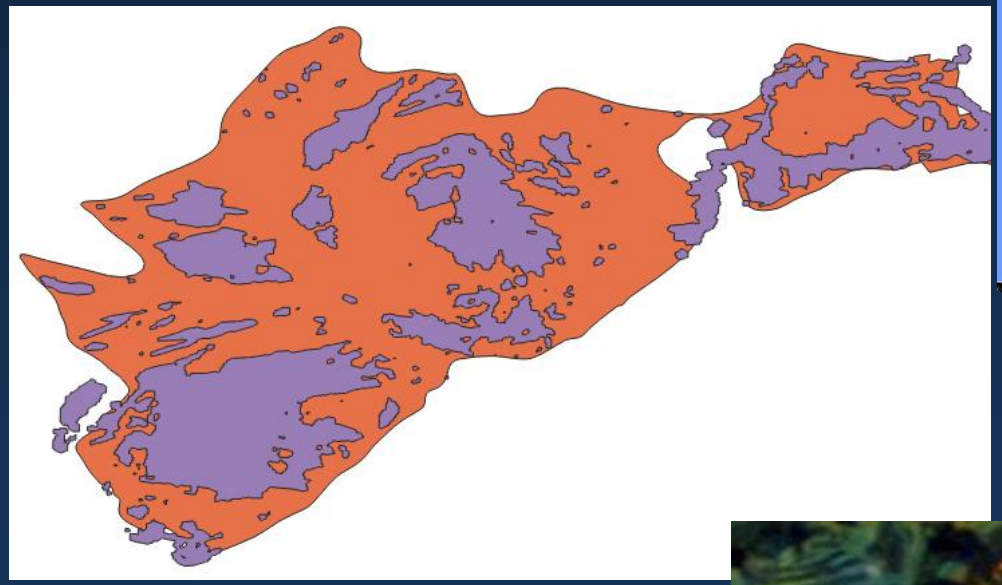


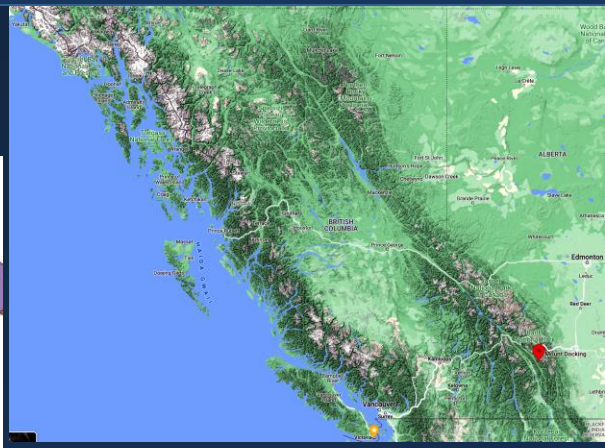
Comparing Sentinel2 result (right) with Firms

NASA Firms (MODIS and VIIRS) detection Aug 17

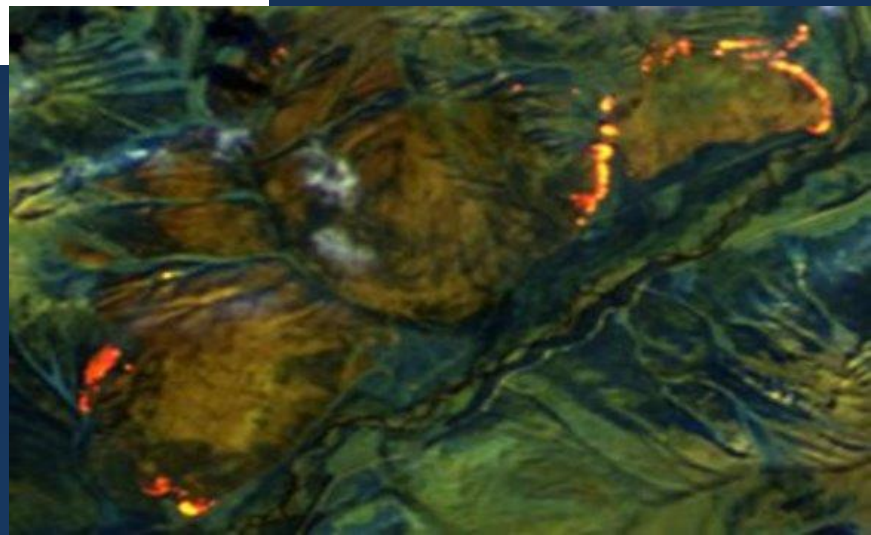


Purple – Sentinel-2 detection Aug. 17th
Orange – public perimeter as of 20220819





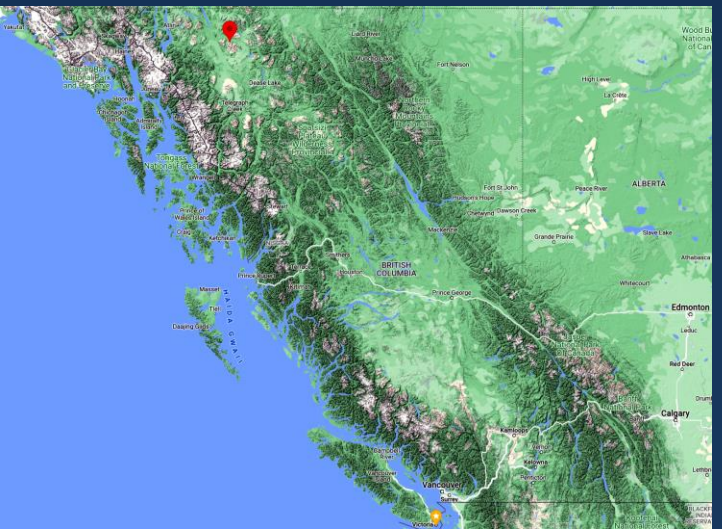
SWIR false color

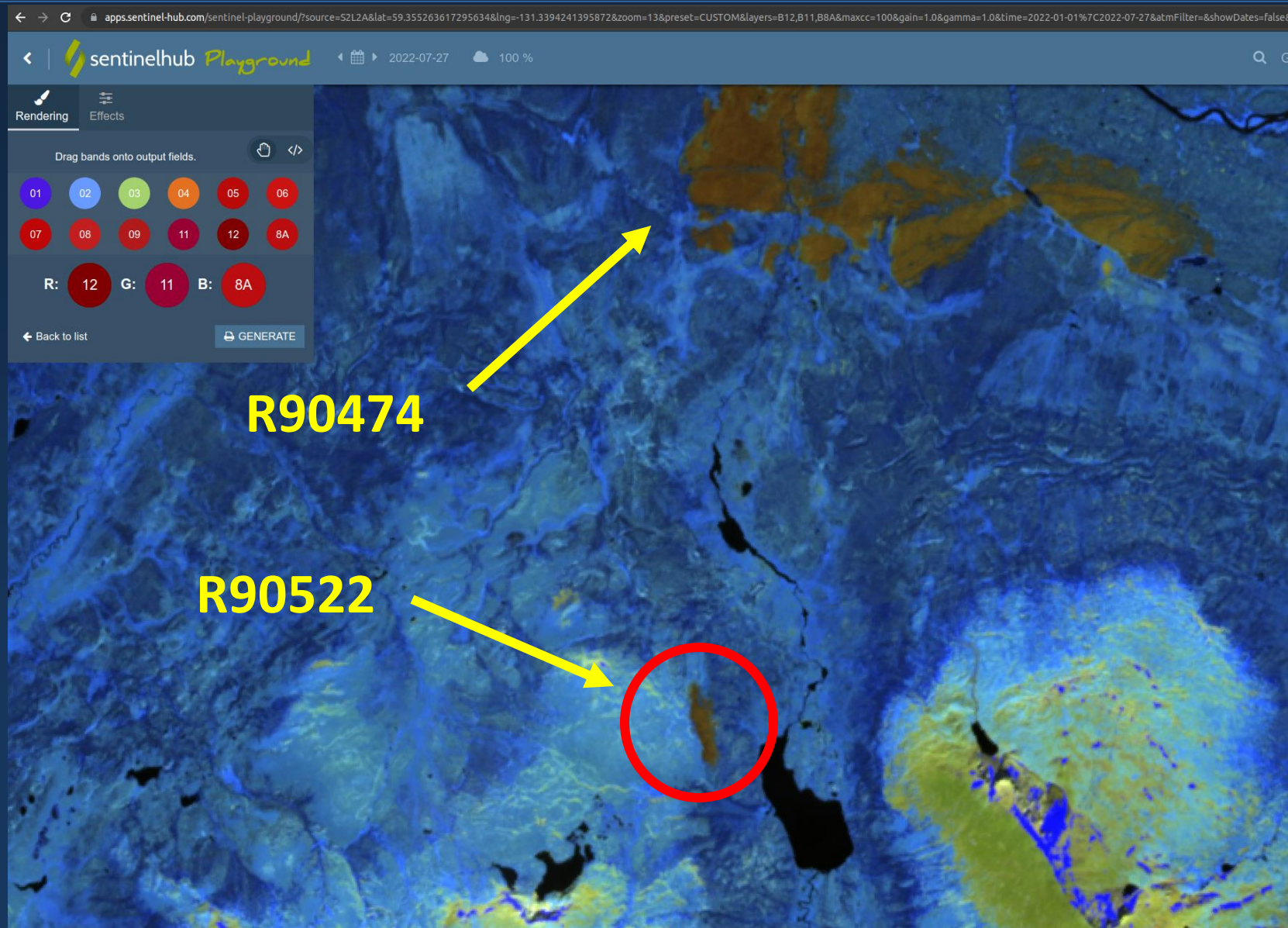


Fire: N20881 Date: 20220817

Finding unknown fires

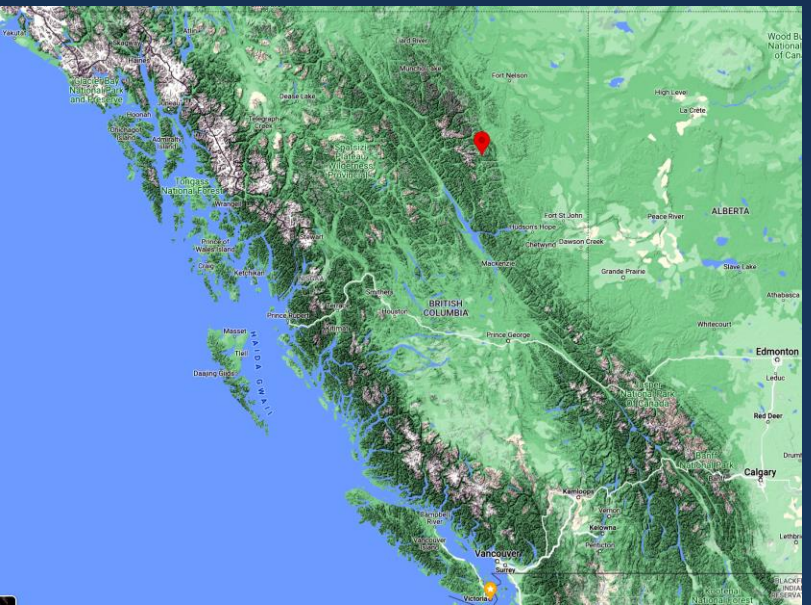
- Found on July 28 from Jul 27 imagery
- Aug 20 we confirmed it was assigned a fire number (status out)
  - R90522 / Tahoots Lake

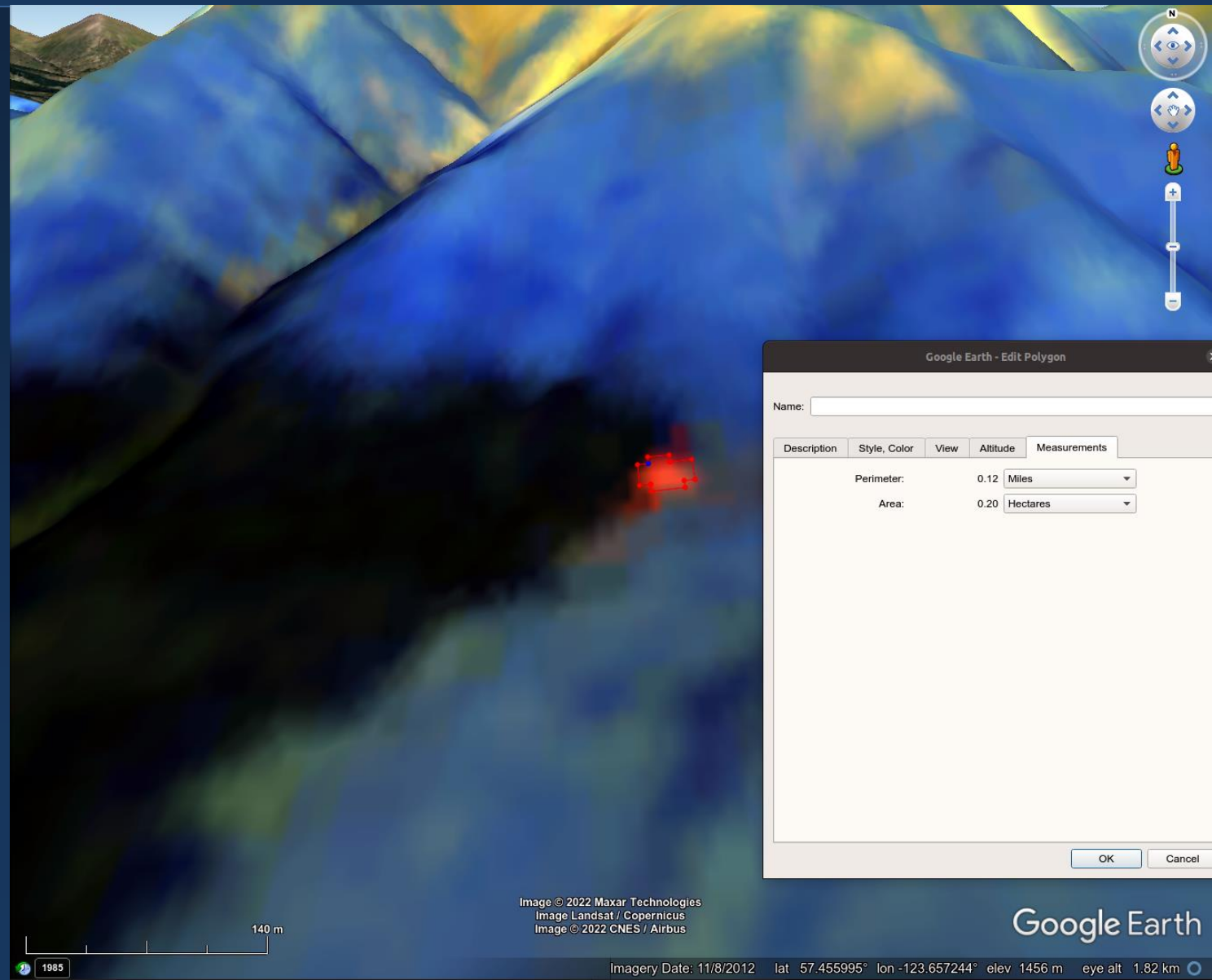




Small fires detected

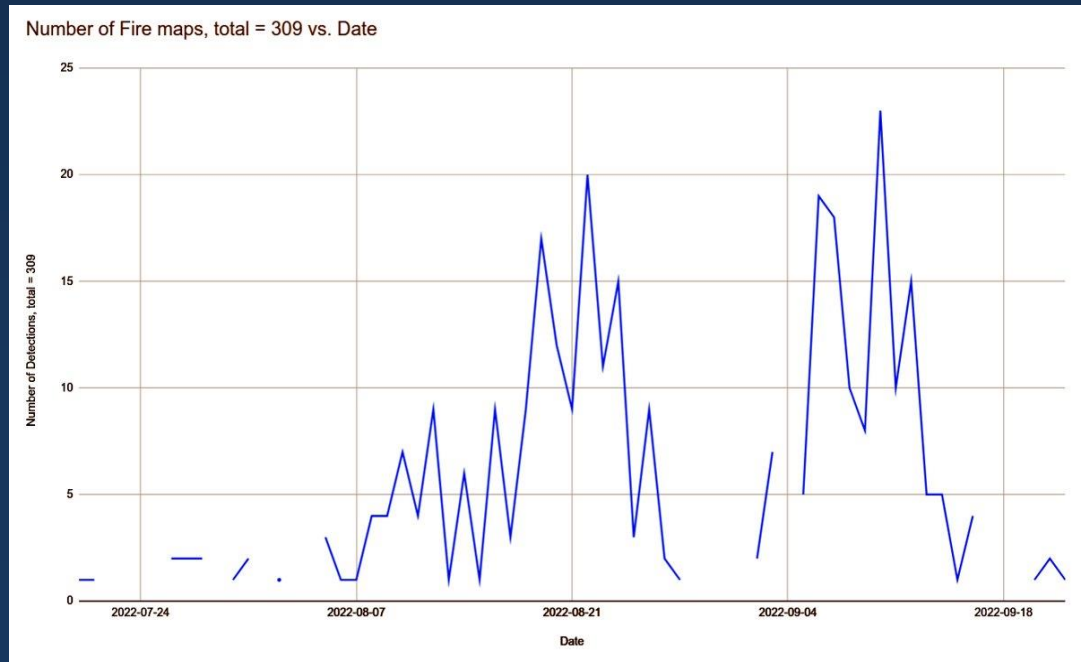
- Sub-hectare fires observed
- Fire: G82427
- Date: 20220913
- Size: 0.20 ha (Google Earth)





Wins

- More than 300 "low latency" fire mapping updates generated & vetted
  - Sentinel-2 (ESA) and Landsat (NASA)
  - Low latency: less than 12h possible
- Mapped small or unknown fires
- Mapped fires under smoke cover
- Value of the mapping recognized by front-line staff in 2022
  - Increasing number of requests from incidents for operational use



Limitations & Learnings

- Most significant issues: Frequency & Latency
  - 1-5 day repeat (Sentinel2), <= 9 day repeat (Landsat)
  - NRT access for Sentinel2 is possible (1-3 hours)
- Challenging cases:
  - Atmosphere, illumination, altitude, low-intensity fire, sub-canopy fire, data variation!
  - Multiple dates, more sophisticated algorithms needed to improve results
- Artificial Intelligence:
  - ***"Computer-based Decision Support Systems"*** (NRCAN PFC AFT group Definition)

IT resource usage →

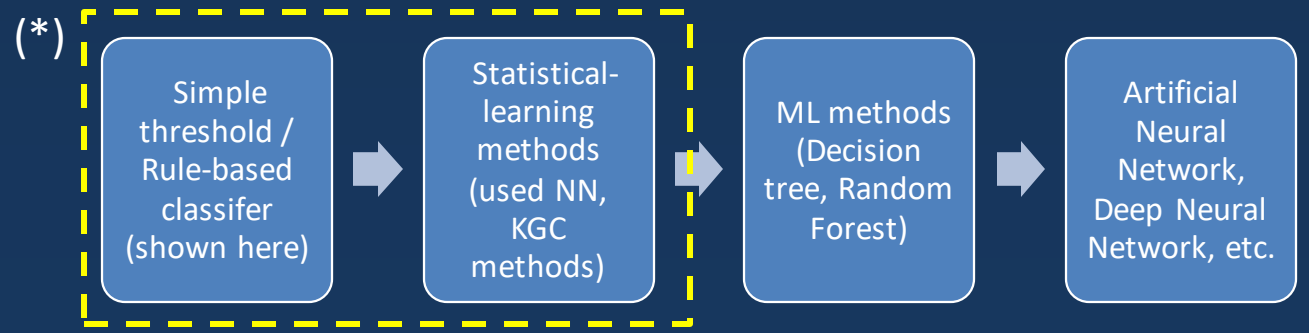
More automatic, generalize-able, flexible →

More modern / trendy →

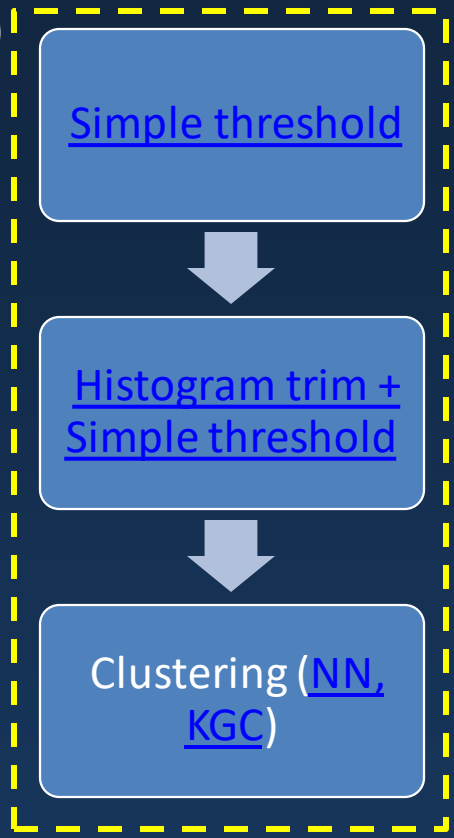
← More accessible / explainable

← More human intervention

(*)



(*)



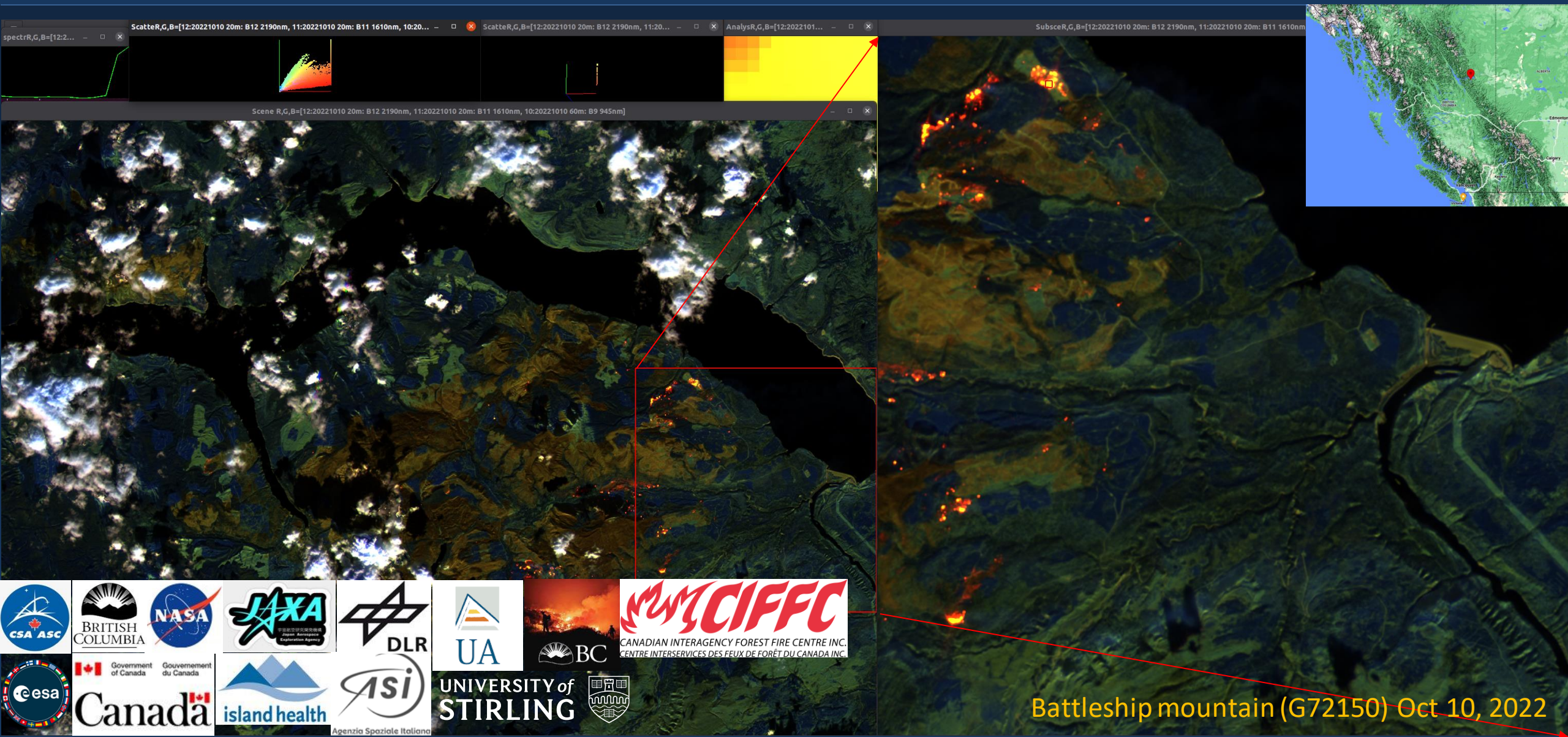
Next: ***find the sweet spot between automatic vs explainable/accessible!***
Want to be a little more "AI"-like than (*)

Next Steps

- Work w **BCWS Geospatial Services** to help capture missing end-of-year perimeters
- Explore sensor fusion / **energy modelling w WildfireSat team!**
- ***NRT/URT data access?***
- Automate & extend
  - Train "more-automatic" methods --> ***Reduce human intervention!***
  - Add terrain, geometry, climate variables?
  - Machine / API access for Landsat data
  - IT resources needed to scale up
- Extend to fuels mapping: multi-class classification:
  - Wildland Fire Canada Conference 2022 (Edmonton) Tues Nov 1, 11:10 AM
    Fuel Type Mapping with Remote Sensing and Machine Learning
- Continue work w CSA, BC Forest Inventory, NRCAN, JAXA, ESA, NASA, ASI & more partners
  - Cloud penetrating fire/ fuels mapping!

Thanks! Questions? Ashlin.Richardson@gov.bc.ca

BC Wildfire Service



WFS KE show and tell

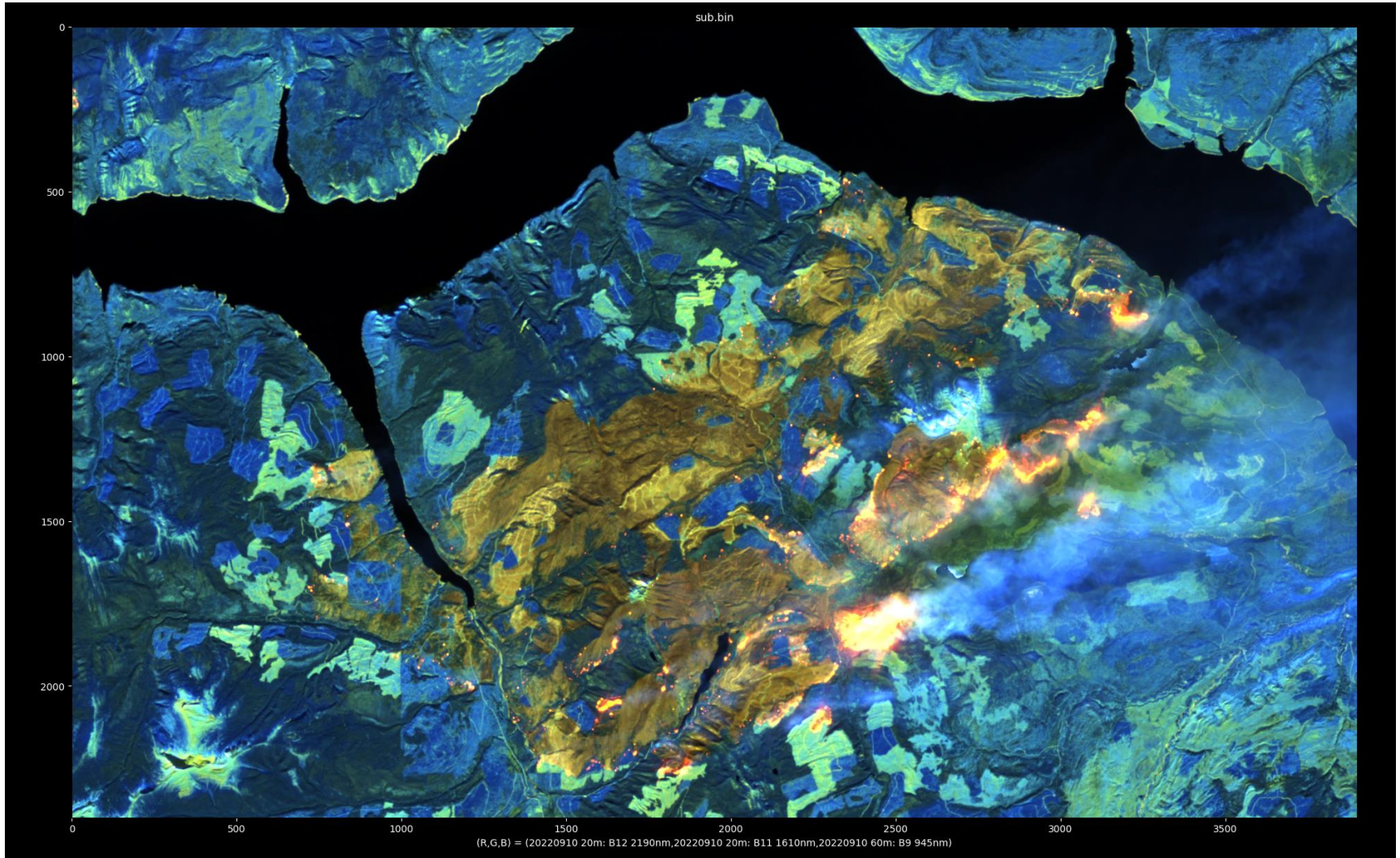
20221129

Show and tell

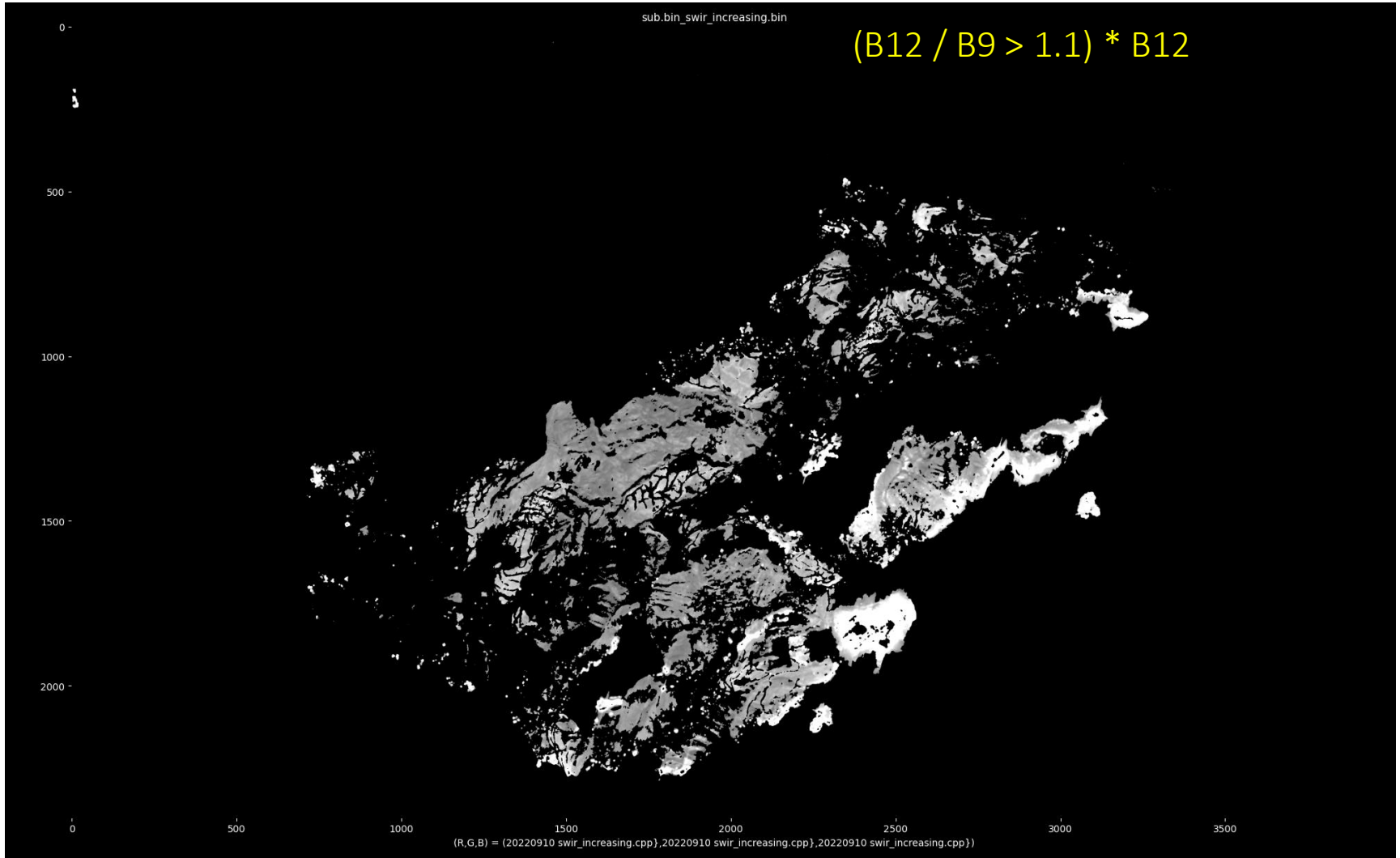
- Sentinel2 classification: old rule
  - Battleship Mtn(2022) BC
- Sentinel2 classification: new rule!
  - Battleship Mtn (2022) BC
  - V11746 (2022) BC
  - Херсо́н, Україна May 2022
  - Beaver Creek (2022) YT
    - Why we can't use the Sentinel-2 cloud mask
    - MODIS/ VIIRS C1,C2
- L-band SAR application

Thanks: Mike Smith for YT Fire Polygon!

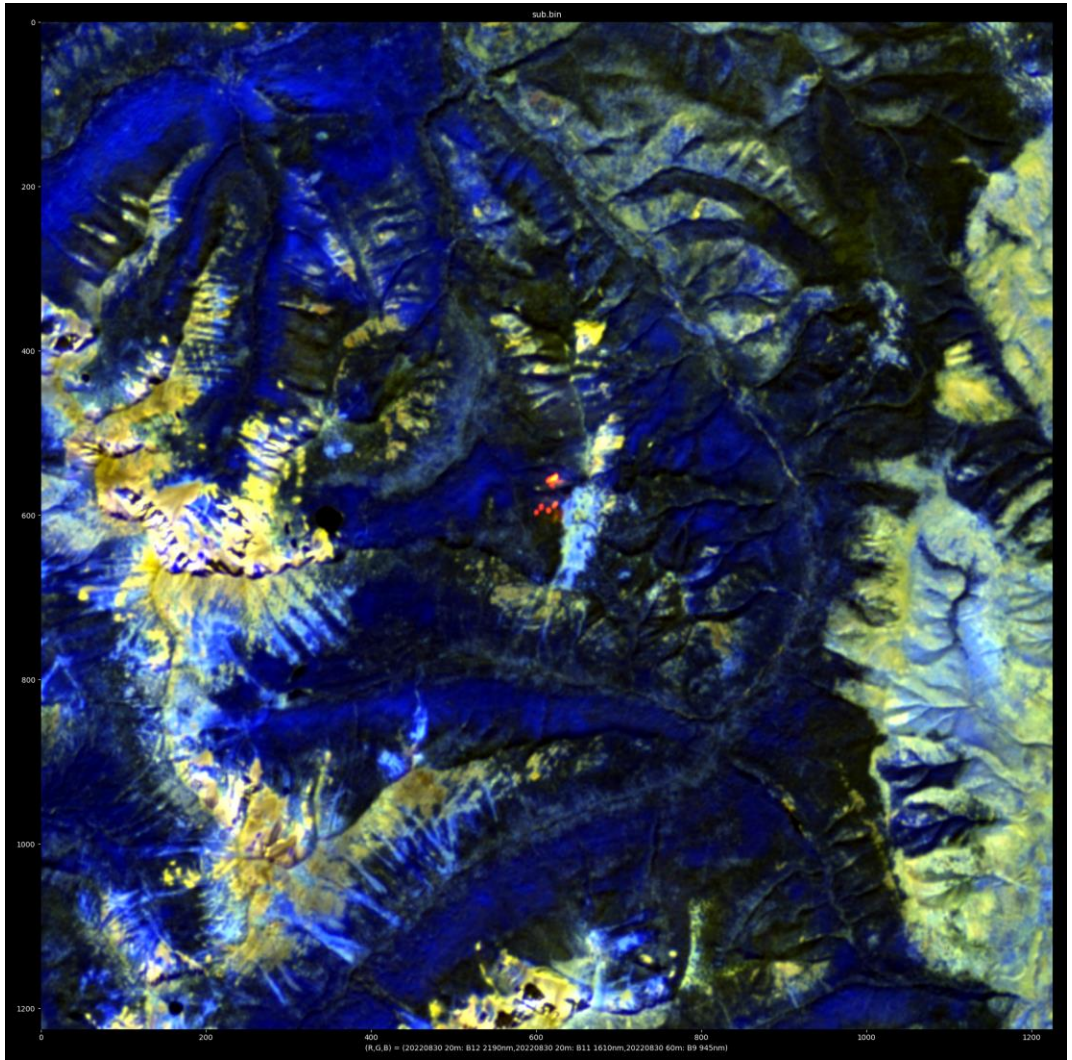
New rule: S2 rgb=b(12, 11, 9)



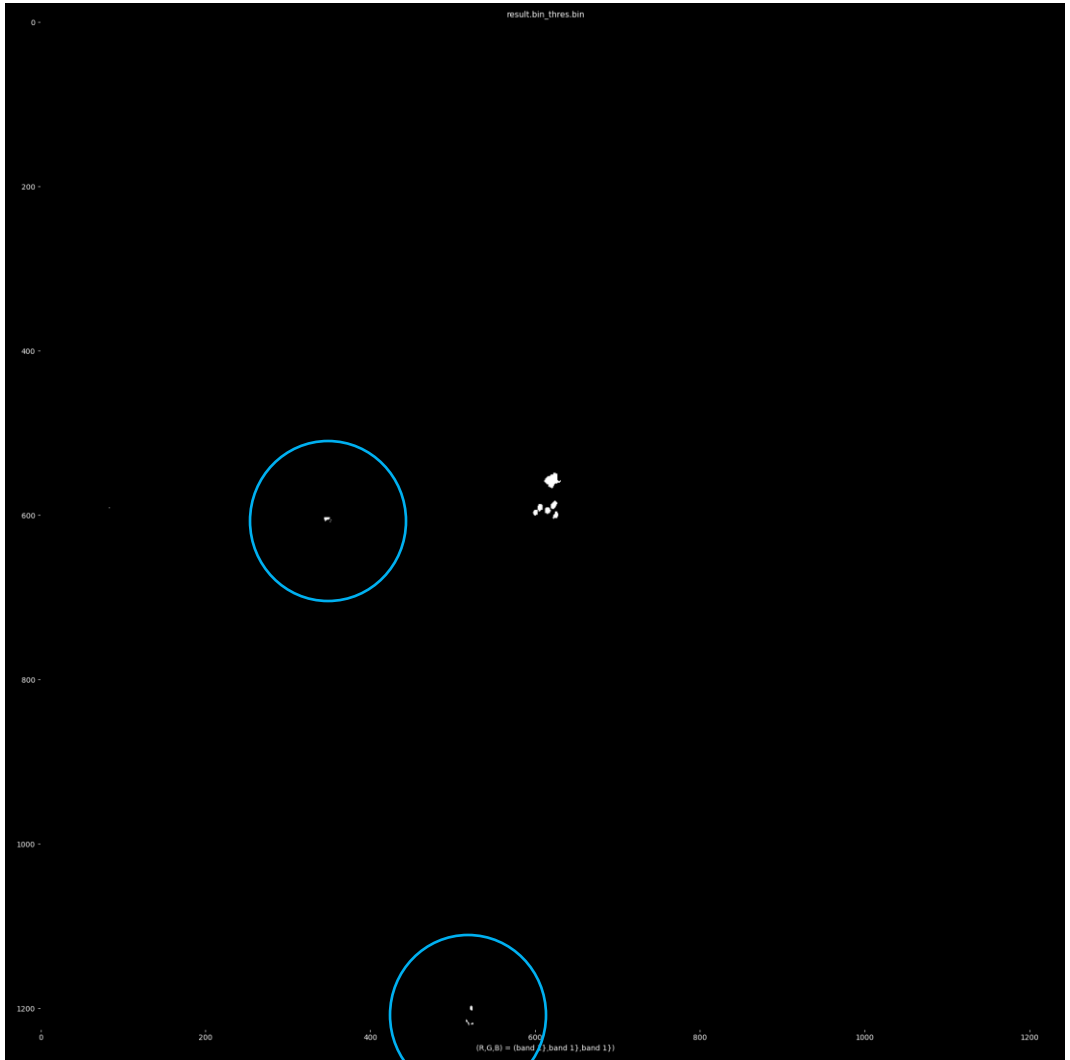
New rule: S2 rgb=b(12, 11, 9)



20220830 V11746

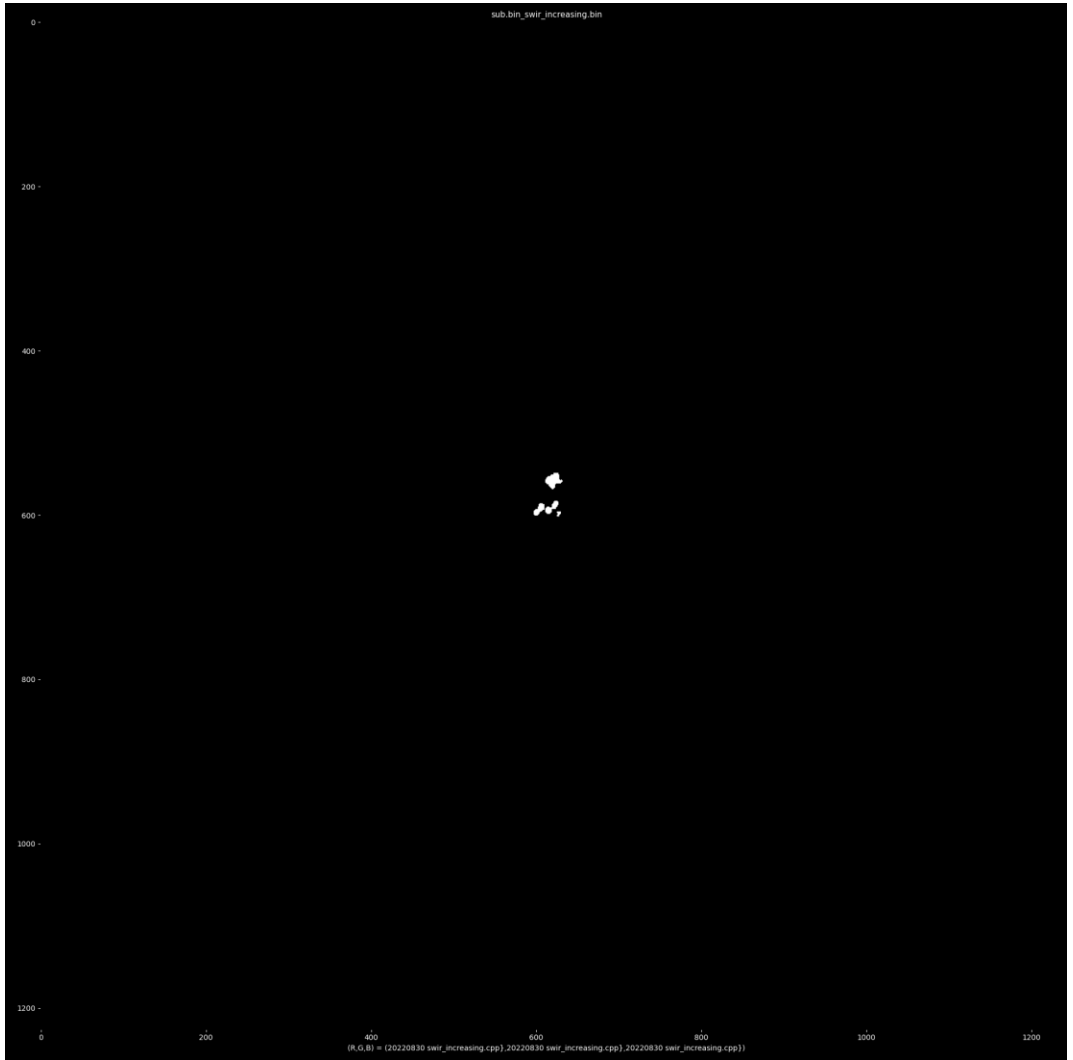


20220830 V11746 old rule



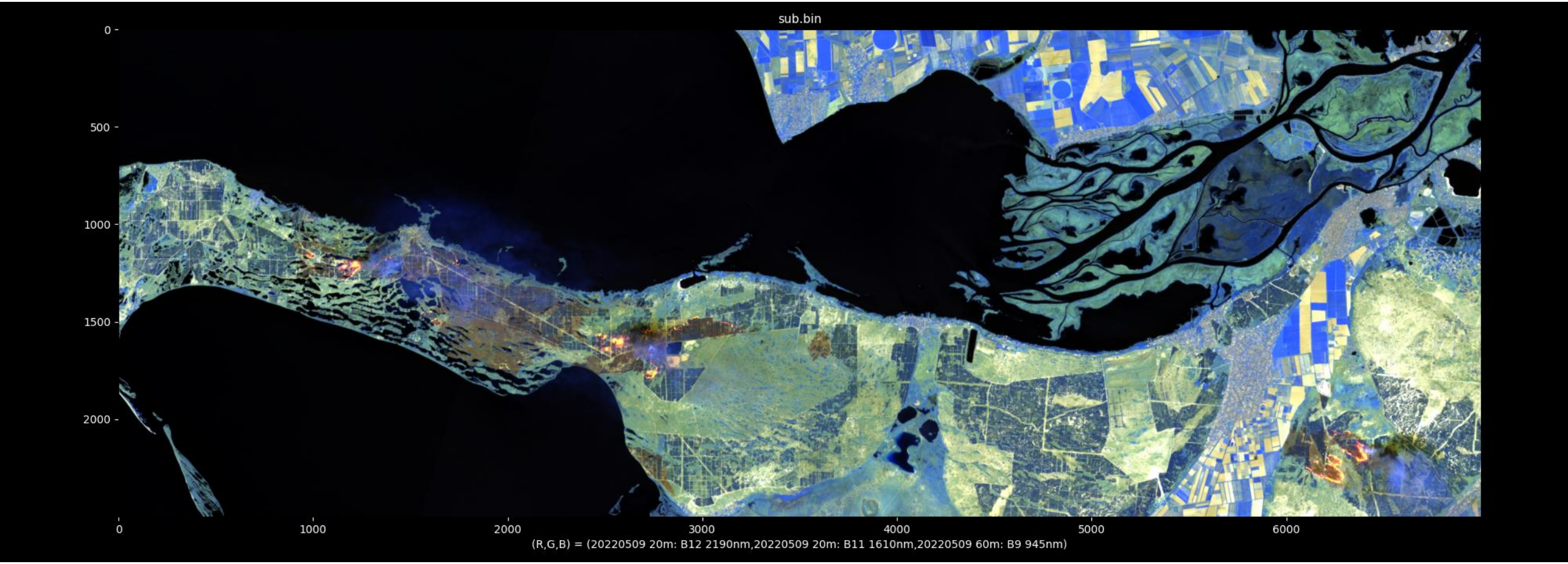
b12>b11
&&
b12>b9

20220830 V11746 new rule

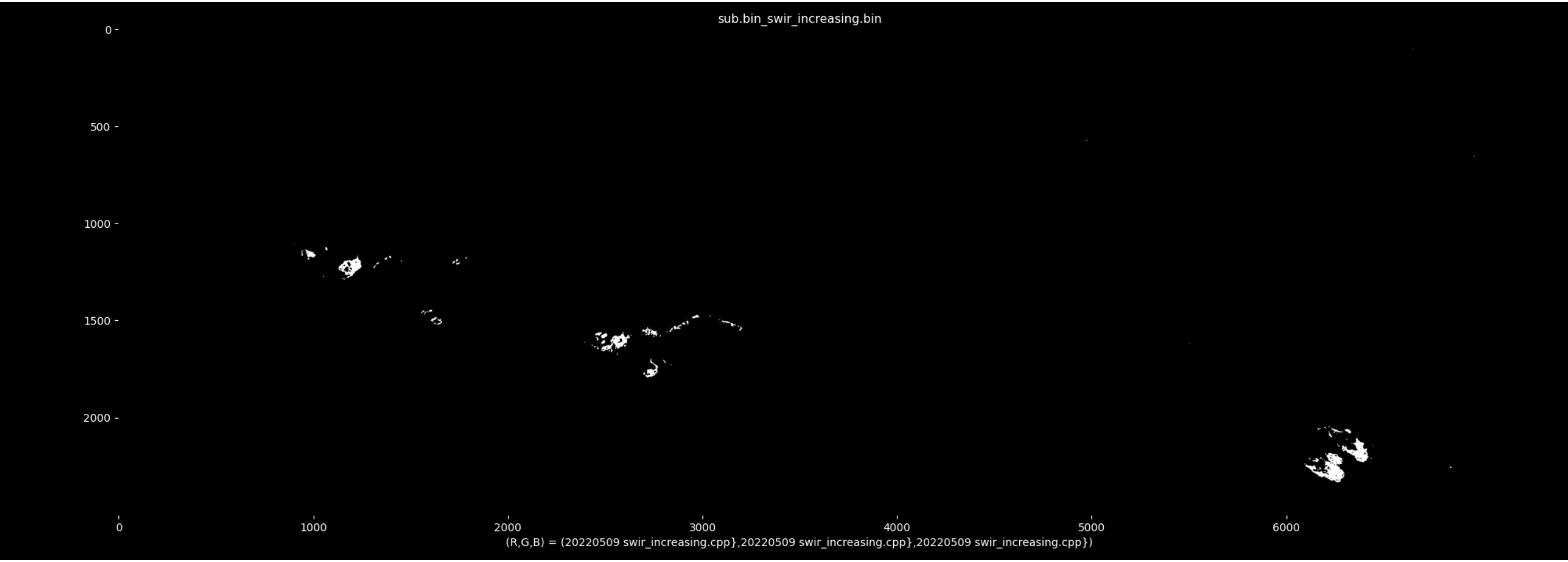


b12 > 1.1 * b9
&&
b12 > 1.1 * b10

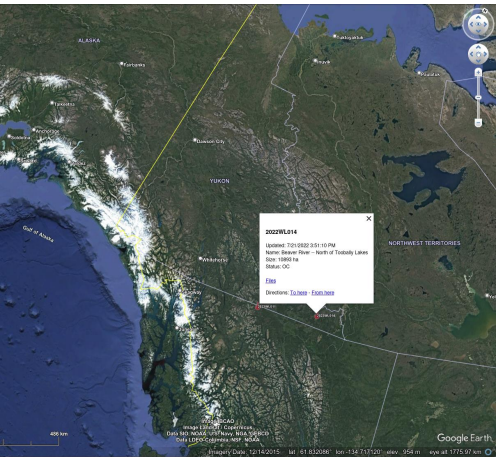
Херсо́н Україна 20220507



Херсо́н Україна 20220507 (new rule)



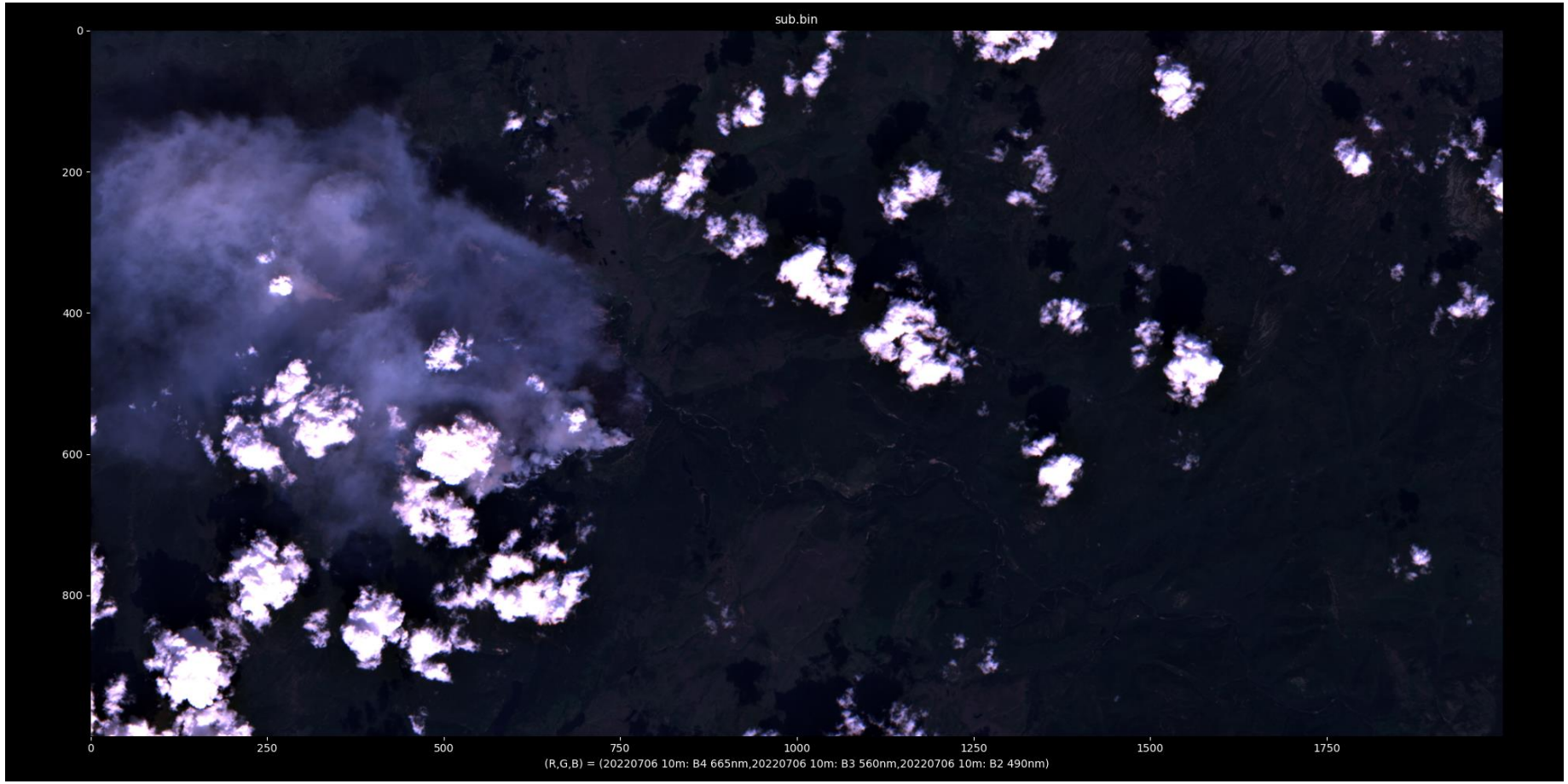
2022WL014 Beaver Creek YT



ALASKA
Fairbanks
Tuktoyaktuk
Inuvik
Paulatuk
Talkeetna
Anchorage
Soldotna
Seward
Valdez
Dawson City
YUKON
Gulf of Alaska
Whitehorse
NORTHWEST TERRITORIES
Skagway
2022WL011
2022WL014
Juneau
2022WL014
Updated: 7/21/2022 3:51:10 PM
Name: Beaver River -- North of Toobally Lakes
Size: 10893 ha
Status: OC
Files
Directions: To here - From here
Image IBCAO
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data LDEO-Columbia, NSF, NOAA
486 km
Google Earth
Imagery Date: 12/14/2015 lat 61.832086° lon -134.717120° elev 954 m eye alt 1775.97 km

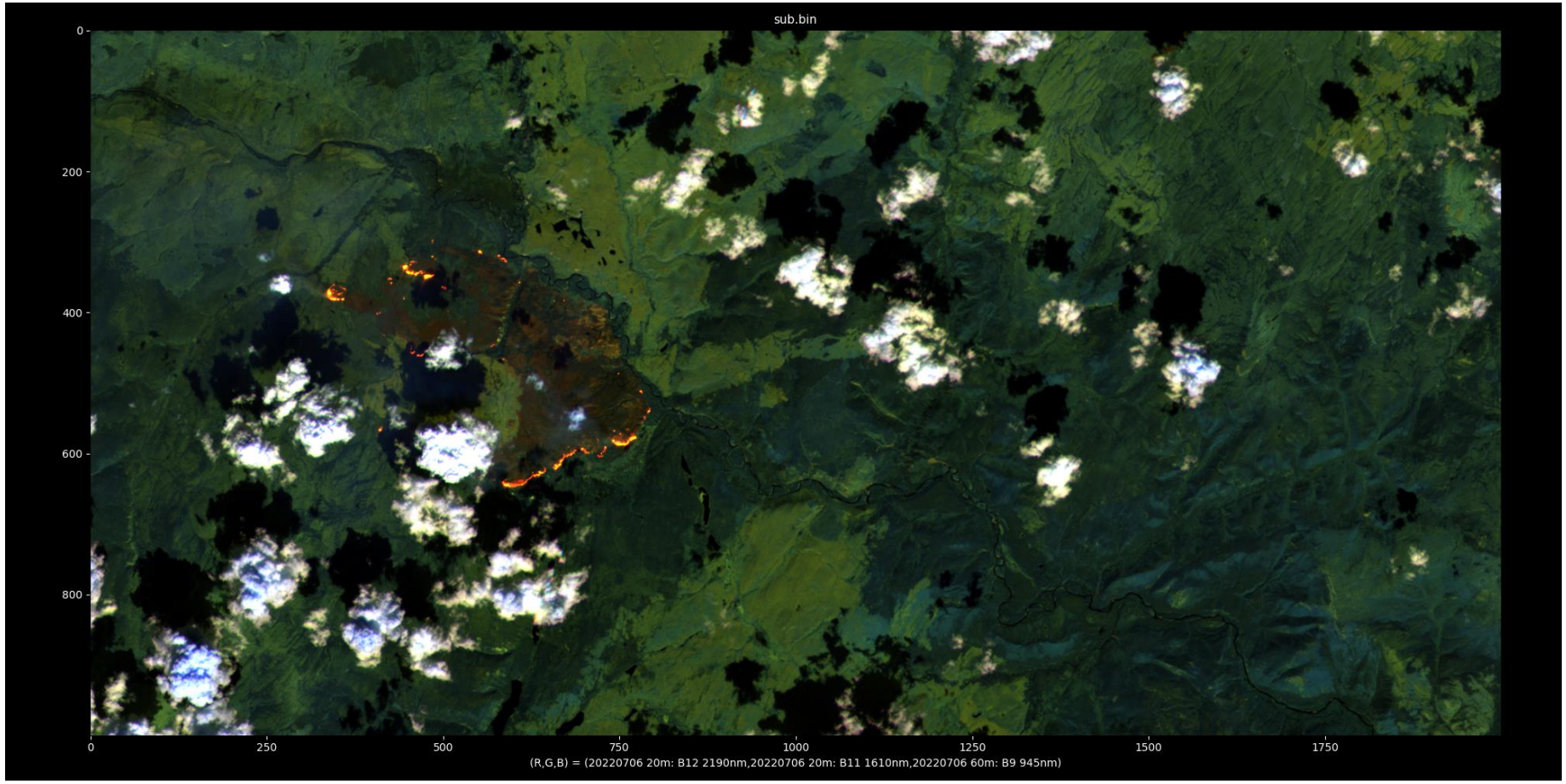
Why we can't use the built-in cloud mask

Sentinel2 Usual RGB



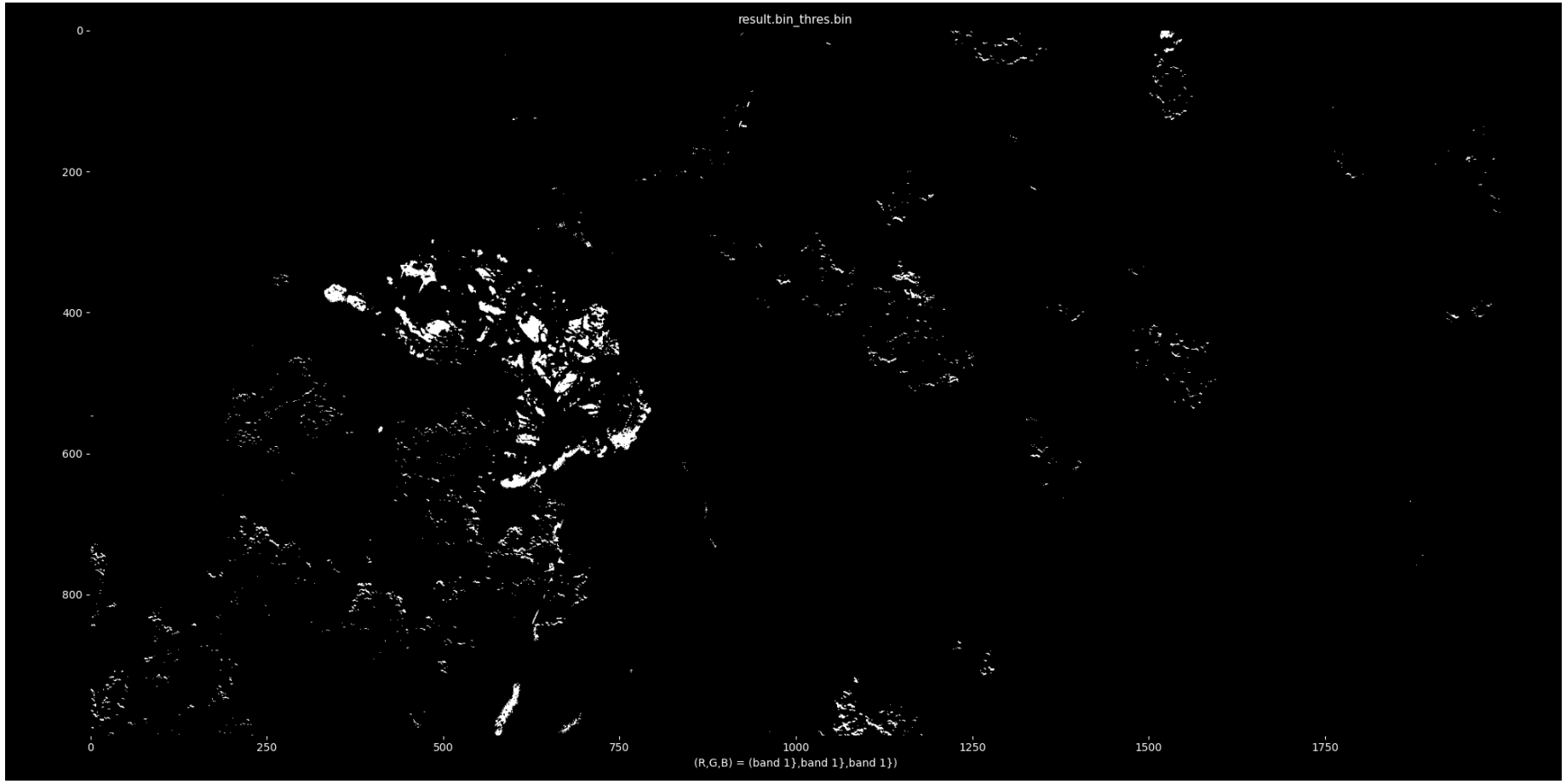
Why we can't use the built-in cloud mask

Sentinel2 rgb=b(12, 11, 9)



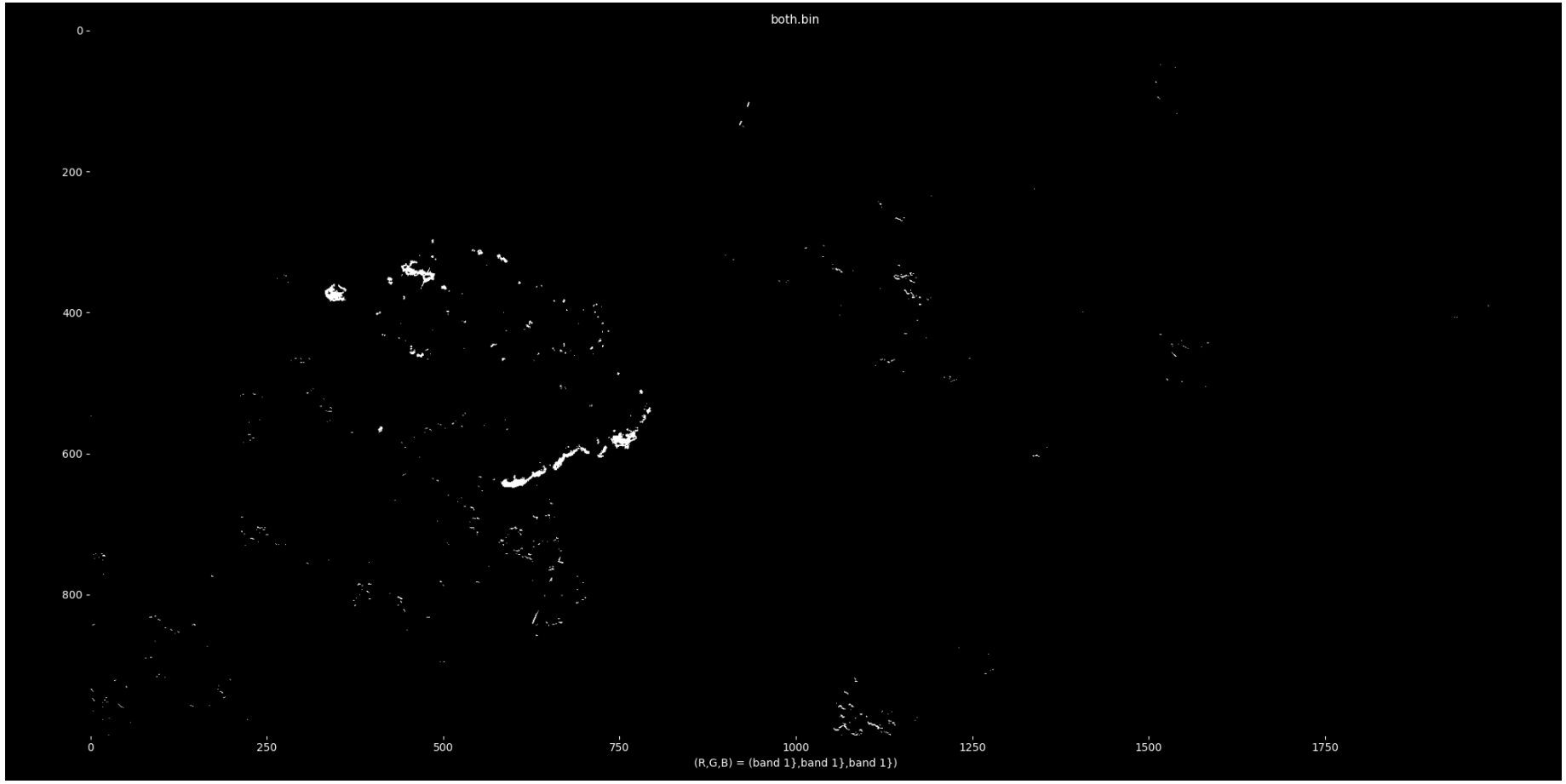
Why we can't use the built-in cloud mask

Sentinel-2 old rule



Why we can't use the built-in cloud mask

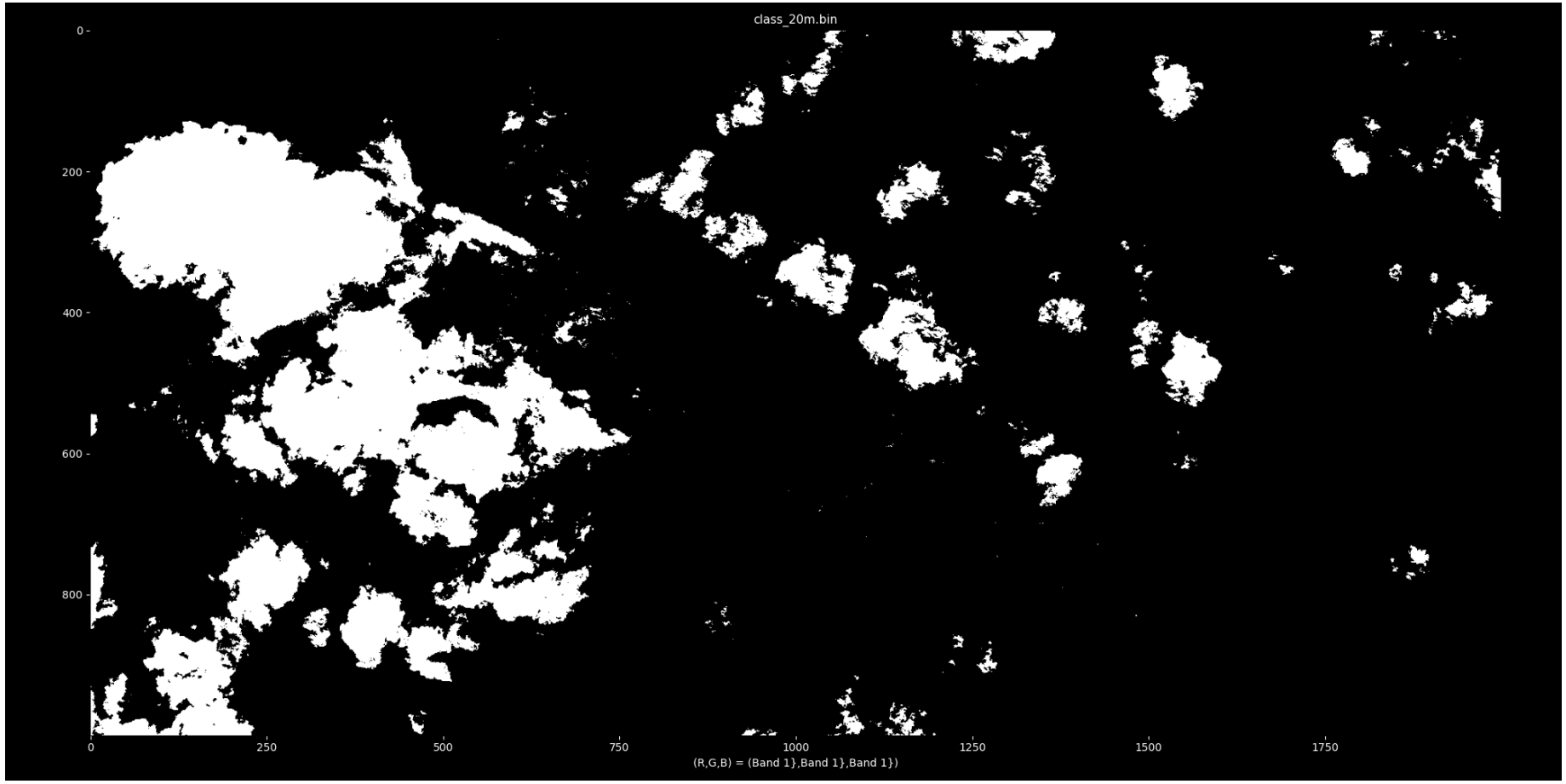
Sentinel2 new rule (less FP)



Can we use the built-in cloud mask to filter out cloud-related FP?

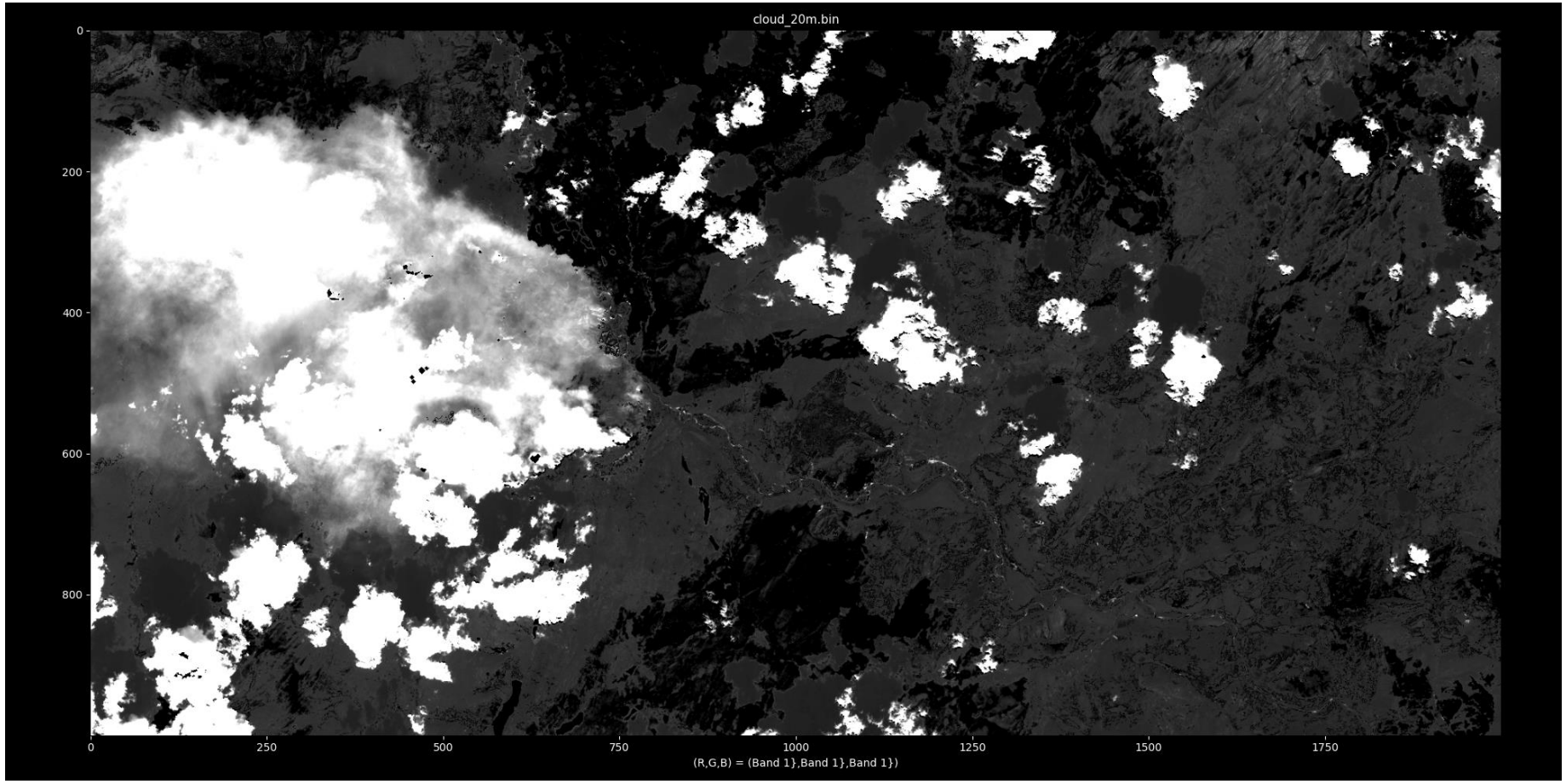
Why we can't use the built-in cloud mask

Sentinel2 sen2cor class map



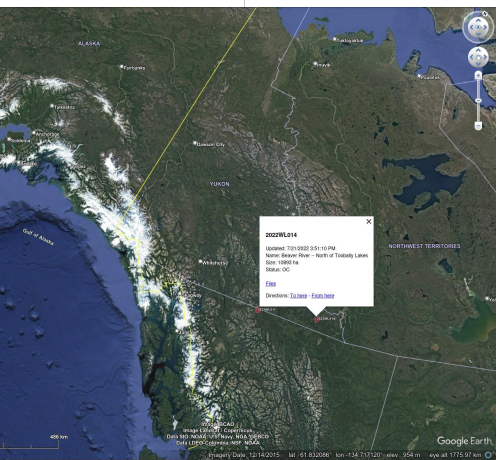
Why we can't use the built-in cloud mask

Sentinel2 sen2cor cloud probability

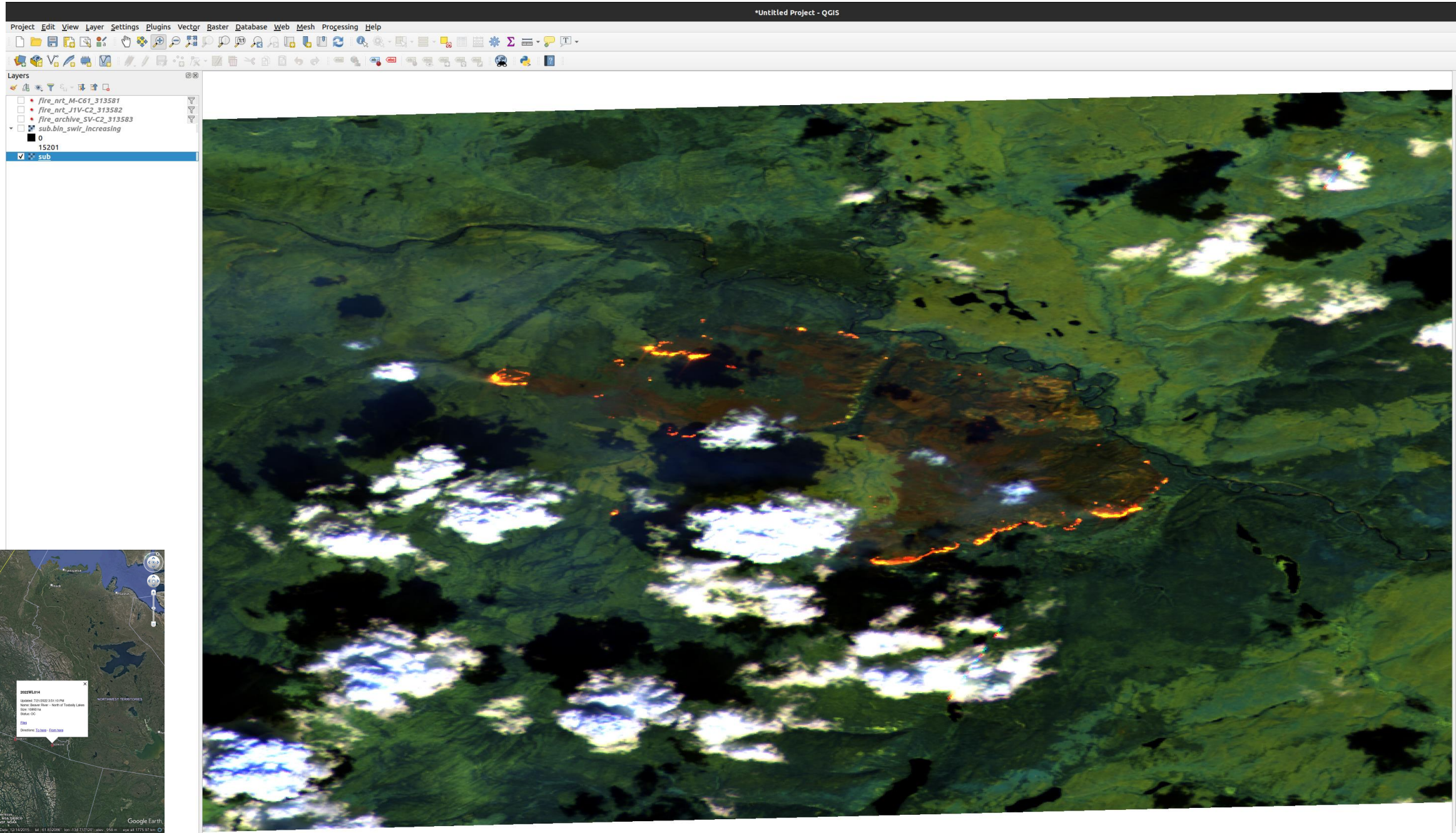


Sen2Cor L1C--> L2A tool cloud mask is not smoke penetrating, cloud/smoke/fire confused?

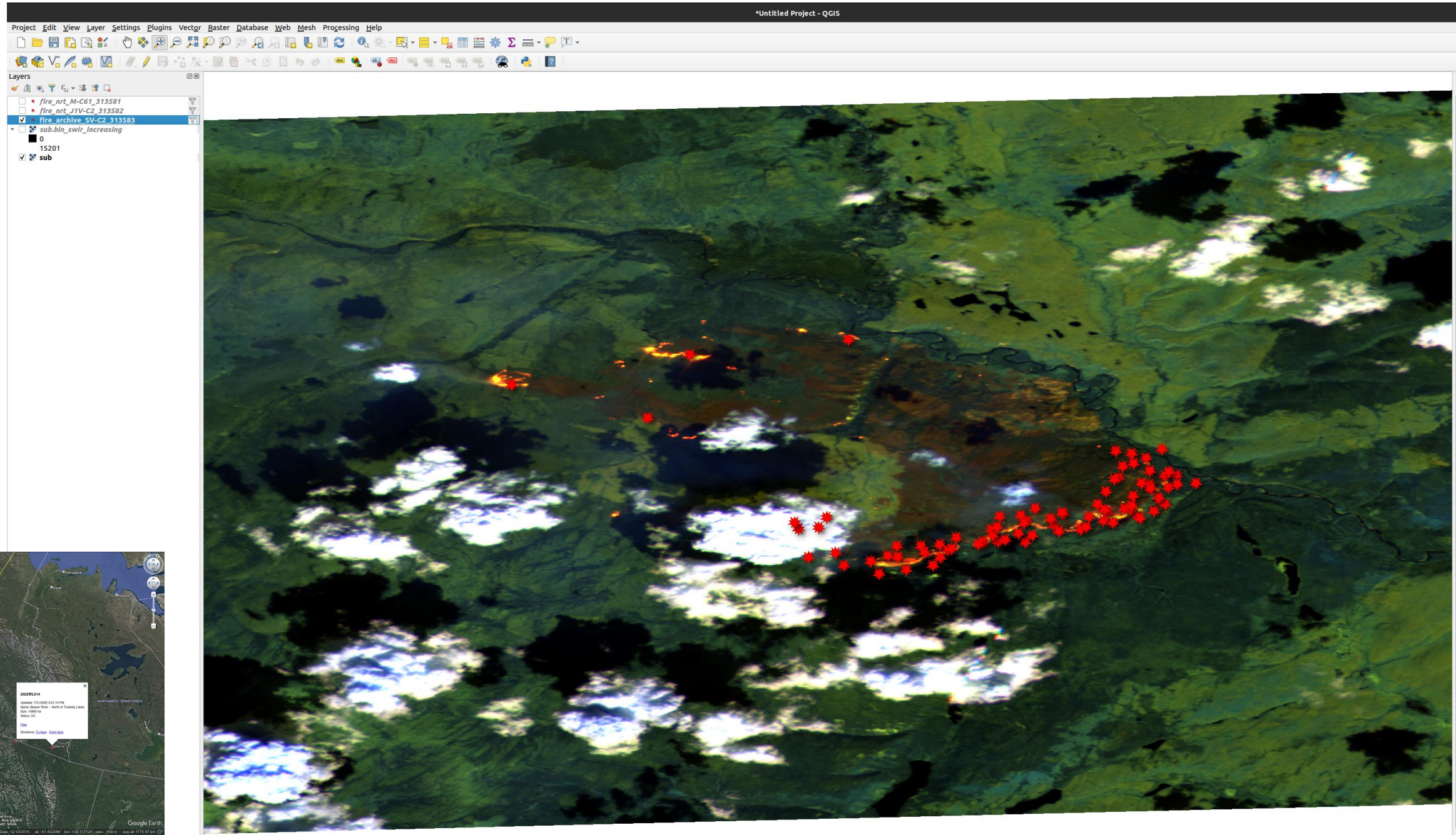
2022WL014 20220706 Sentinel-2 rgb=(b4, b3, b2)



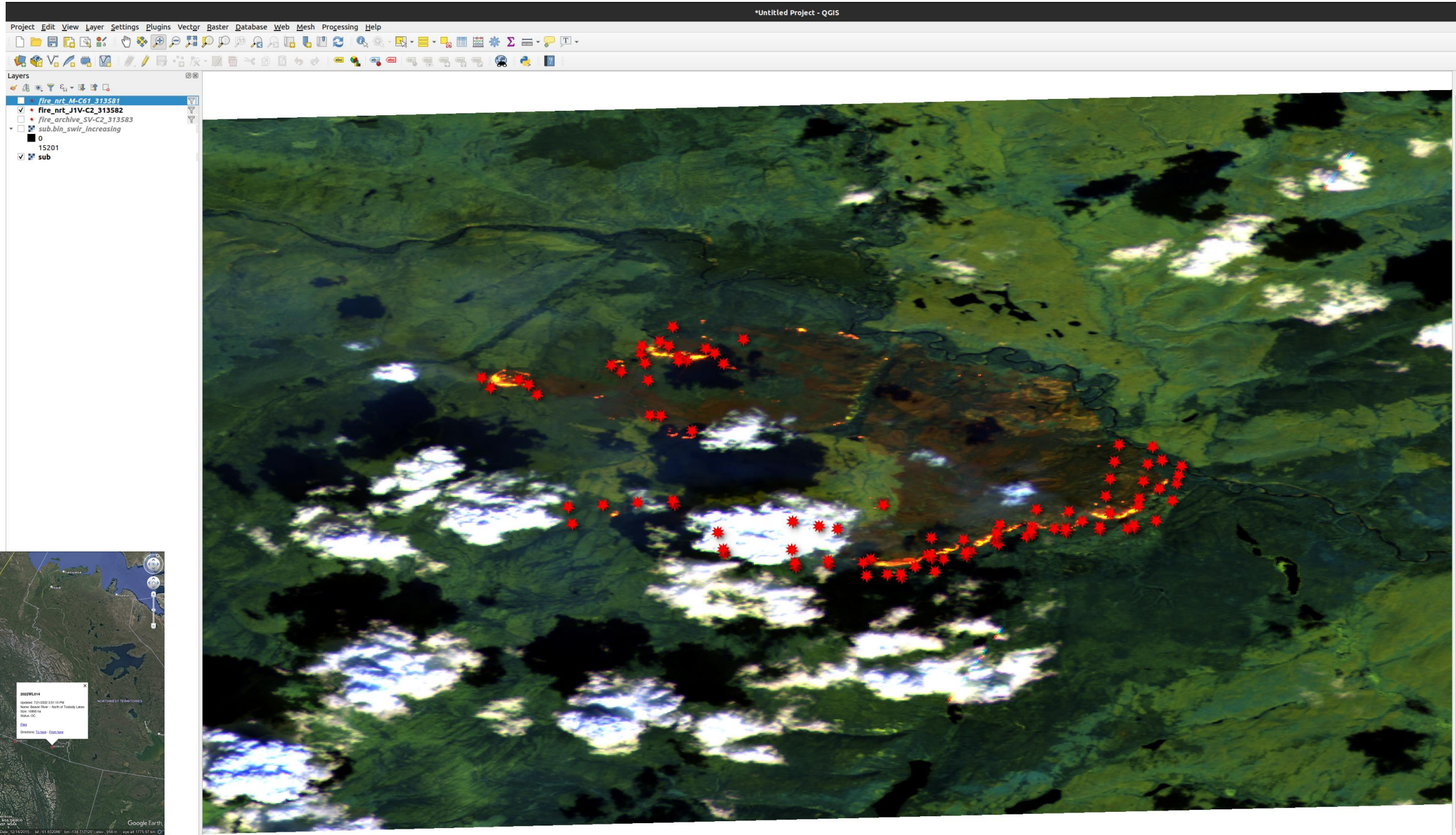
2022WL014 20220706 Sentinel-2 rgb=(b12, b11, b9)



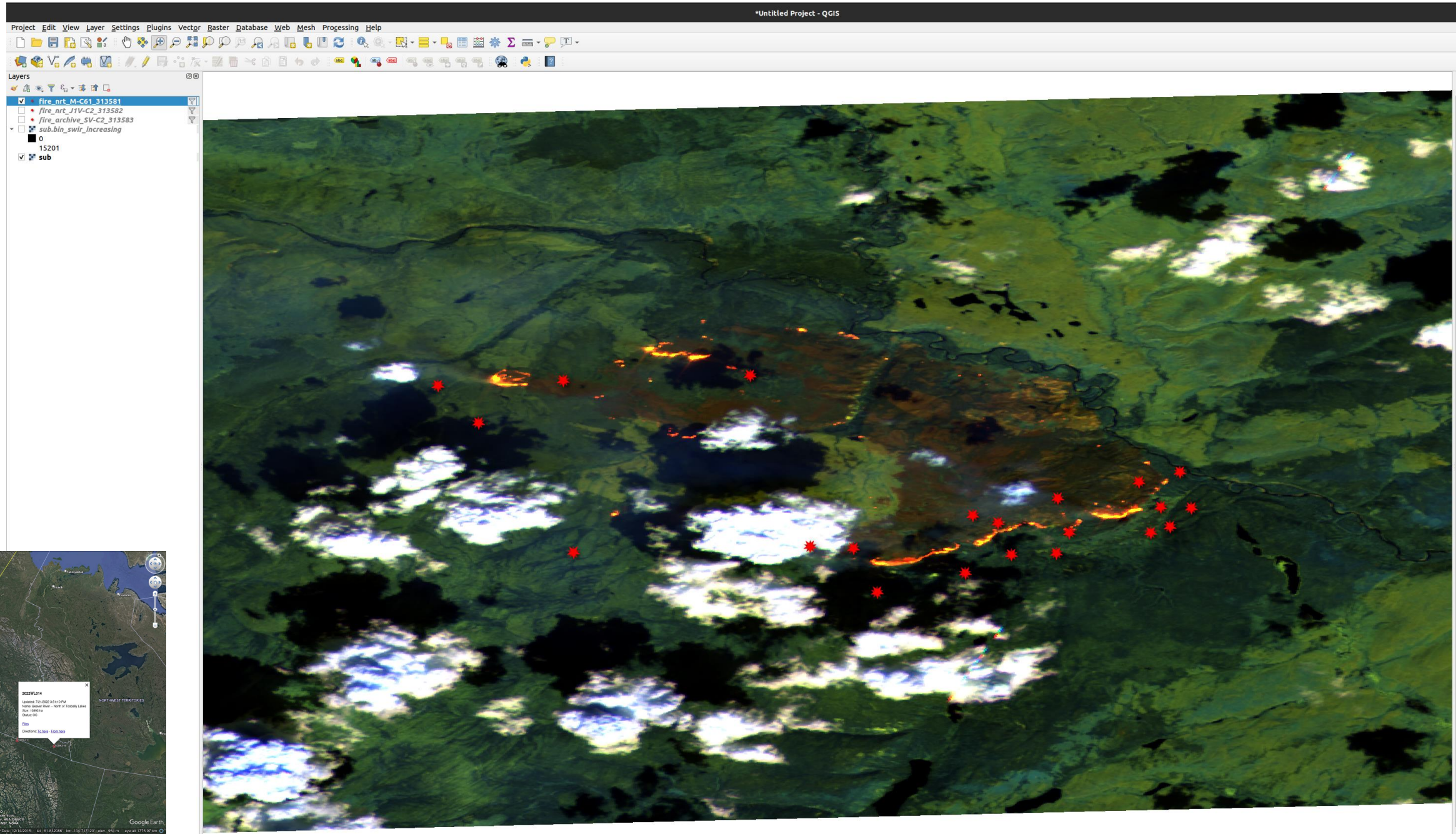
2022WL014 20220706 S2(b12,11,9) vs SUOMI VIIRS C2



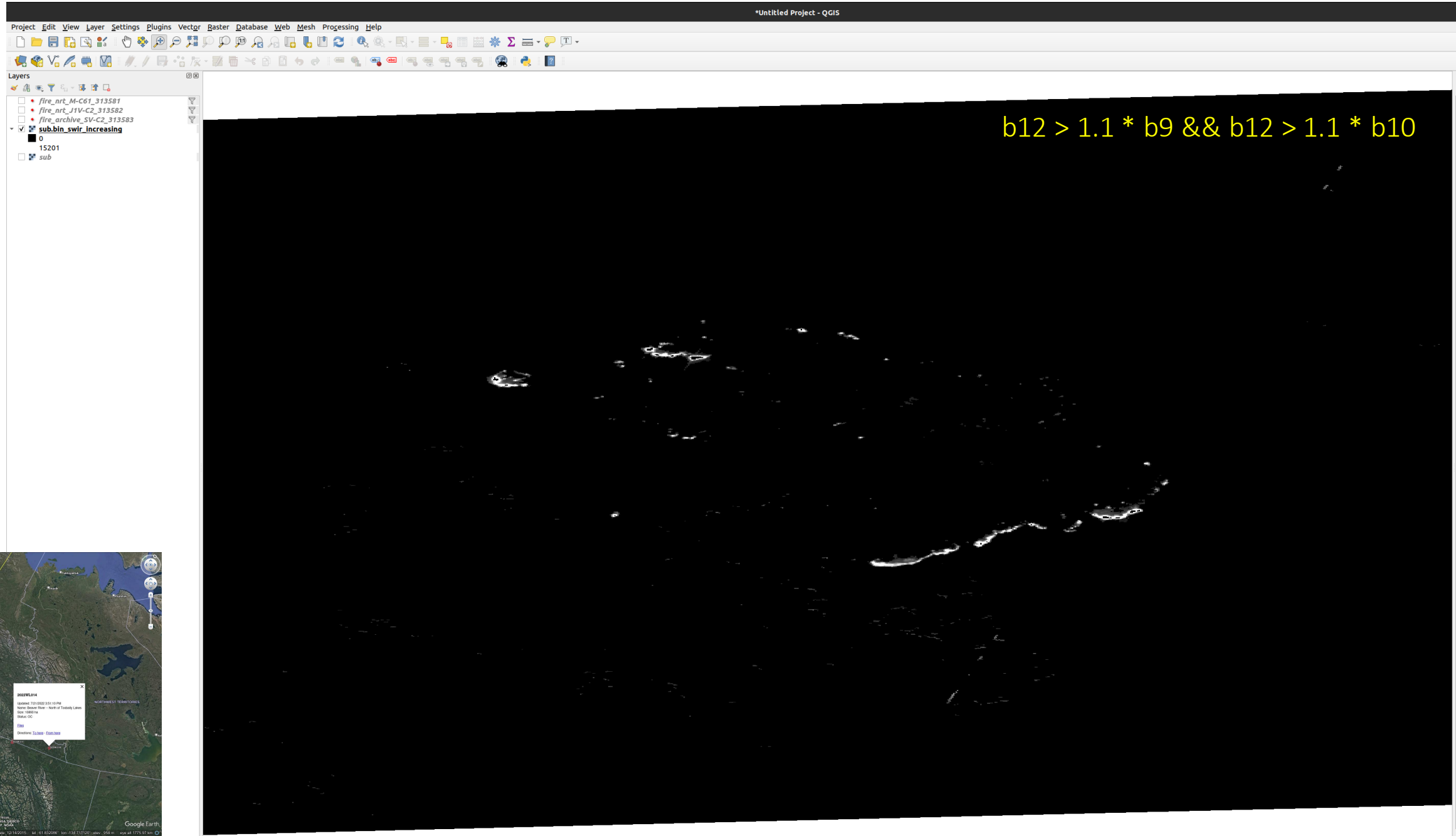
2022WL014 20220706 S2(b12,11,9) vs J1 VIIRS C1



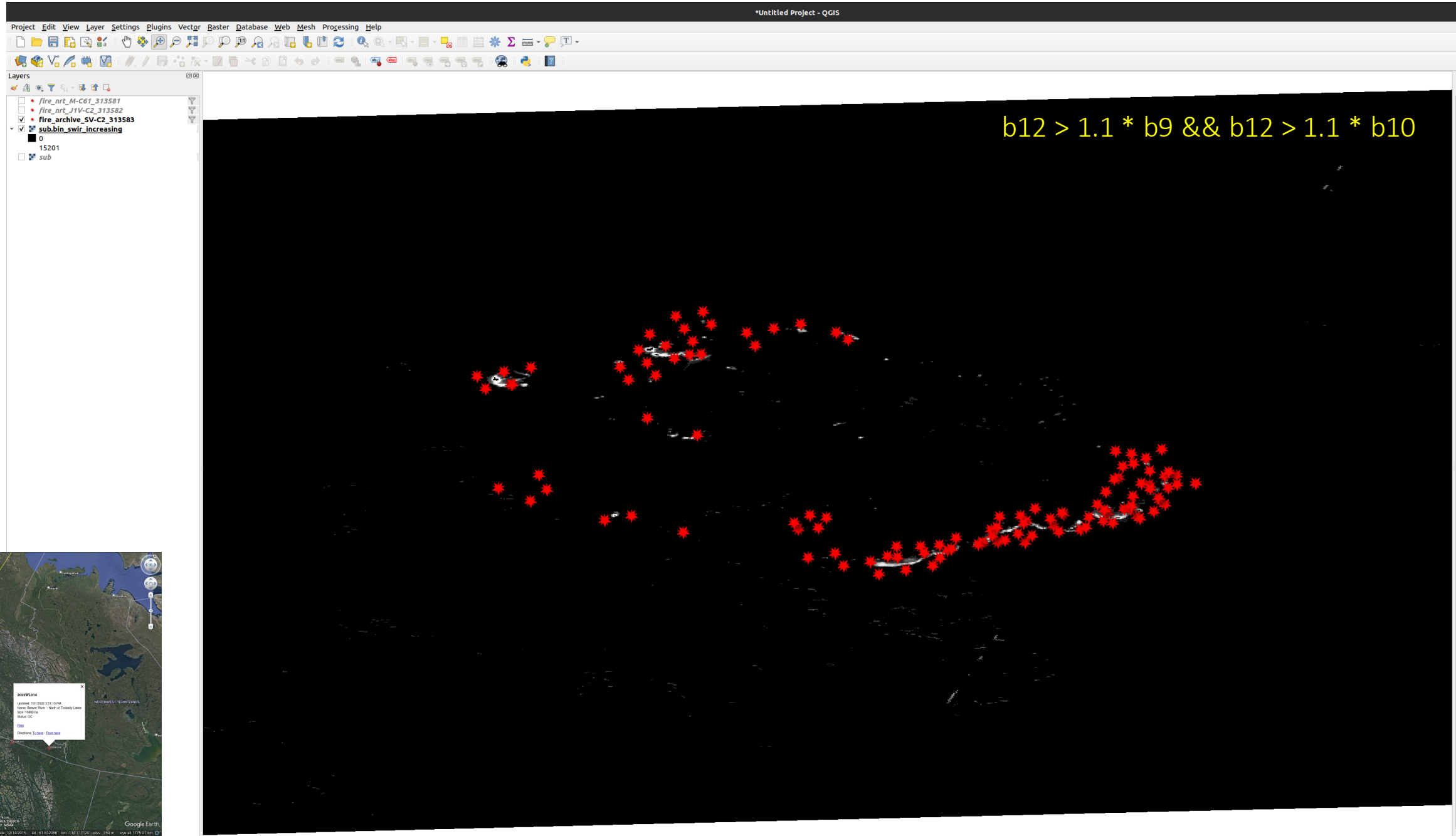
2022WL014 20220706 S2(b12,11,9) vs MODIS C6.1



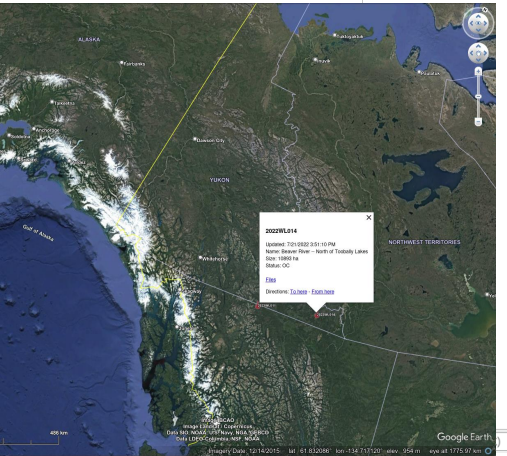
2022WL014 20220706 S2

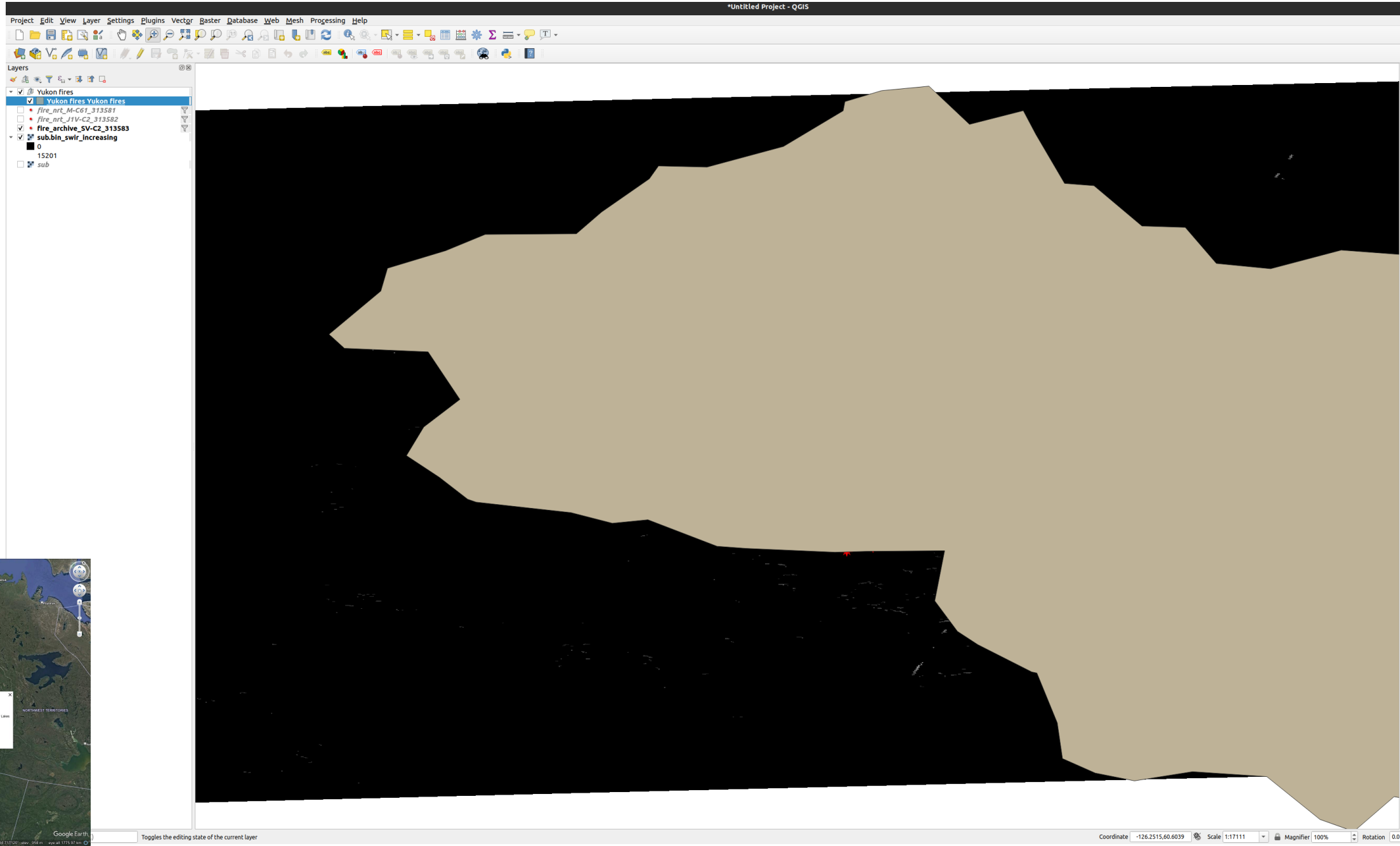


2022WL014 20220706 vs SUOMI VIIRS C2

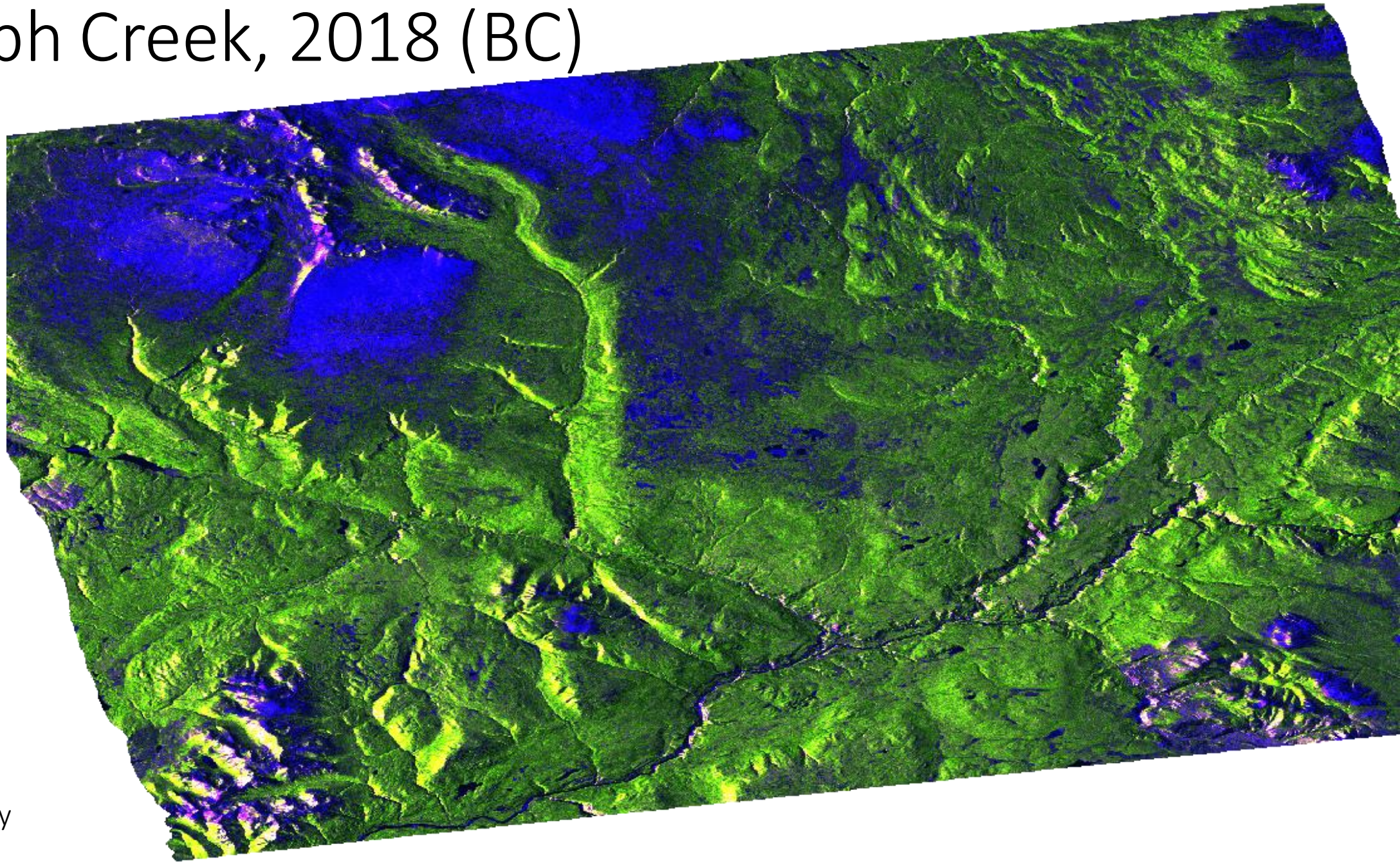


2022WL014 20220706 GIS poly



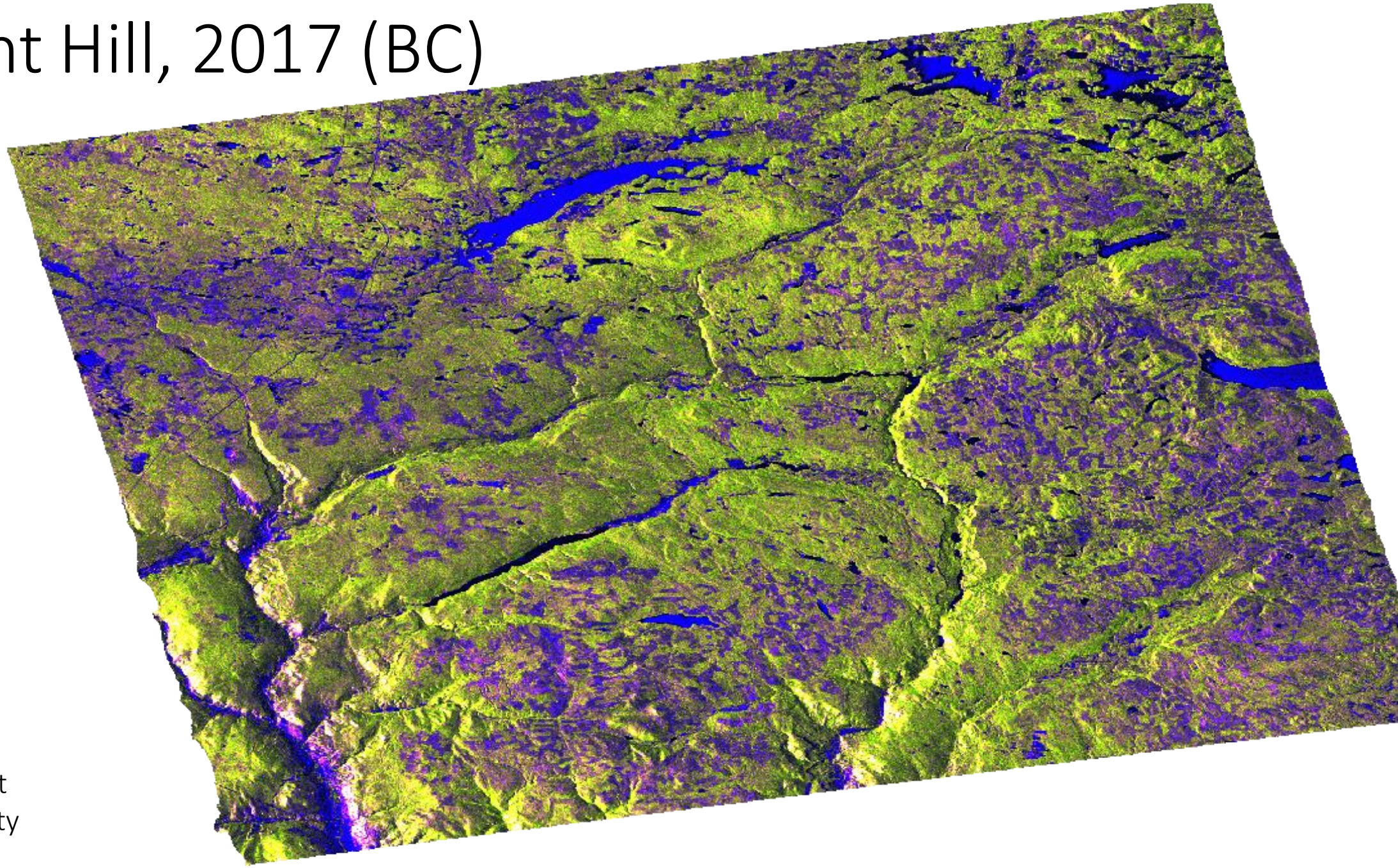


Telegraph Creek, 2018 (BC)



L-band SAR project
EORA-3 opportunity
Thanks JAXA!

Elephant Hill, 2017 (BC)



L-band SAR project
EORA-3 opportunity
Thanks JAXA!

GIS Community of Practice
Here, There, and Everywhere
Harnessing the Power of Place... Together

Thanks

Questions?

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