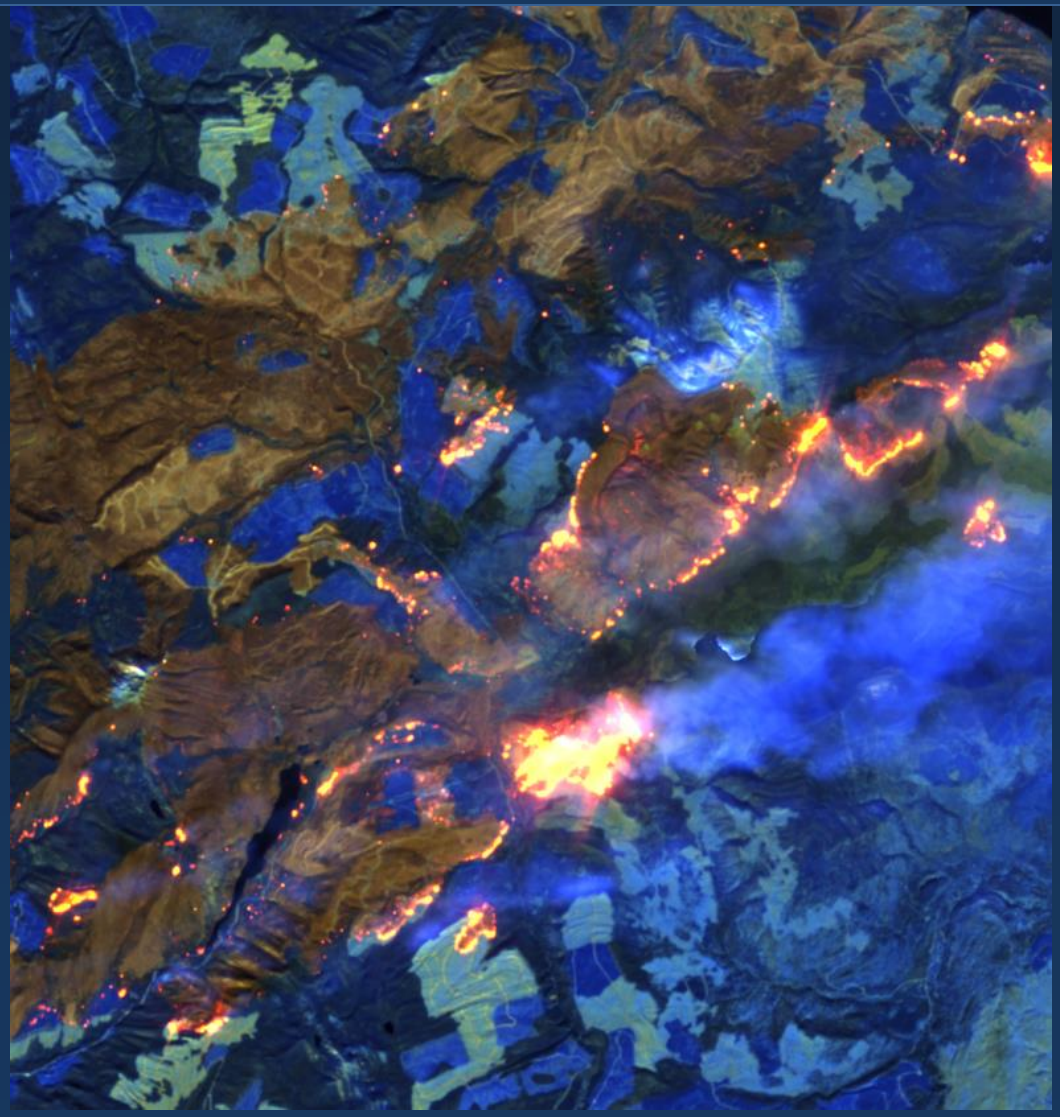
AI Fire Perimeter Mapping

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

- Opportunity to monitor remote areas where active suppression is not a priority
  - 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 (we tried Landsat and Sentinel-3)

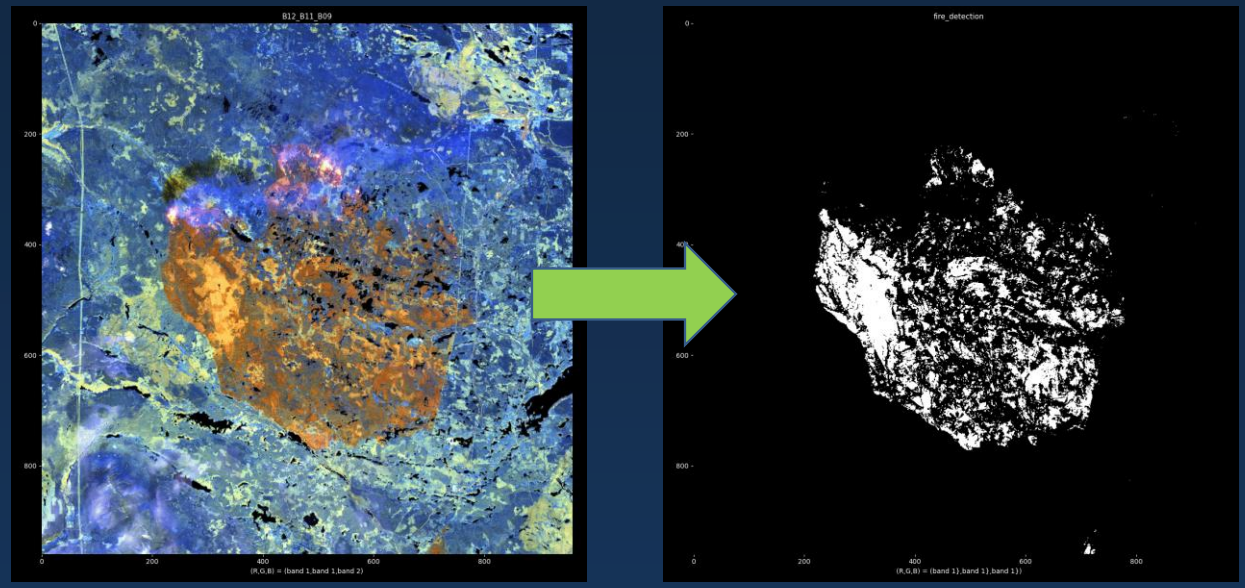
Why is this method unique?

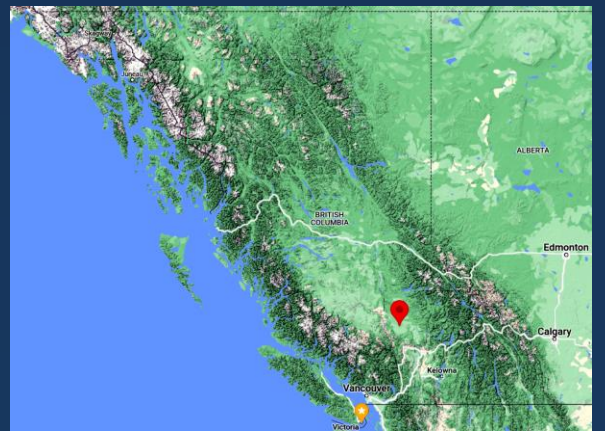
- Unconventional:
  - Not a retrospective pre/post veg comparison
    - Single-date imagery req'd
    - NBR / dNBR not used
  - Thermal IR band not req'd
  - Not a hotspot detection
    - Can catch v transient fires
- Accessible:
  - no math/stats required
  - Free/open-source software and open data 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)

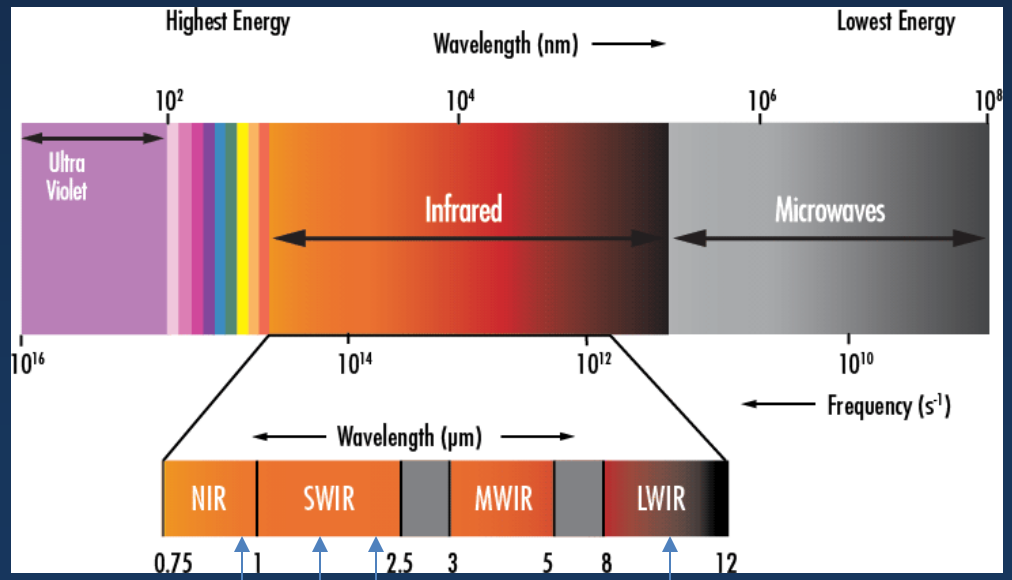
https://github.com/bcgov/wps-research/blob/master/py/binary_polygonize.py

1. False color coding

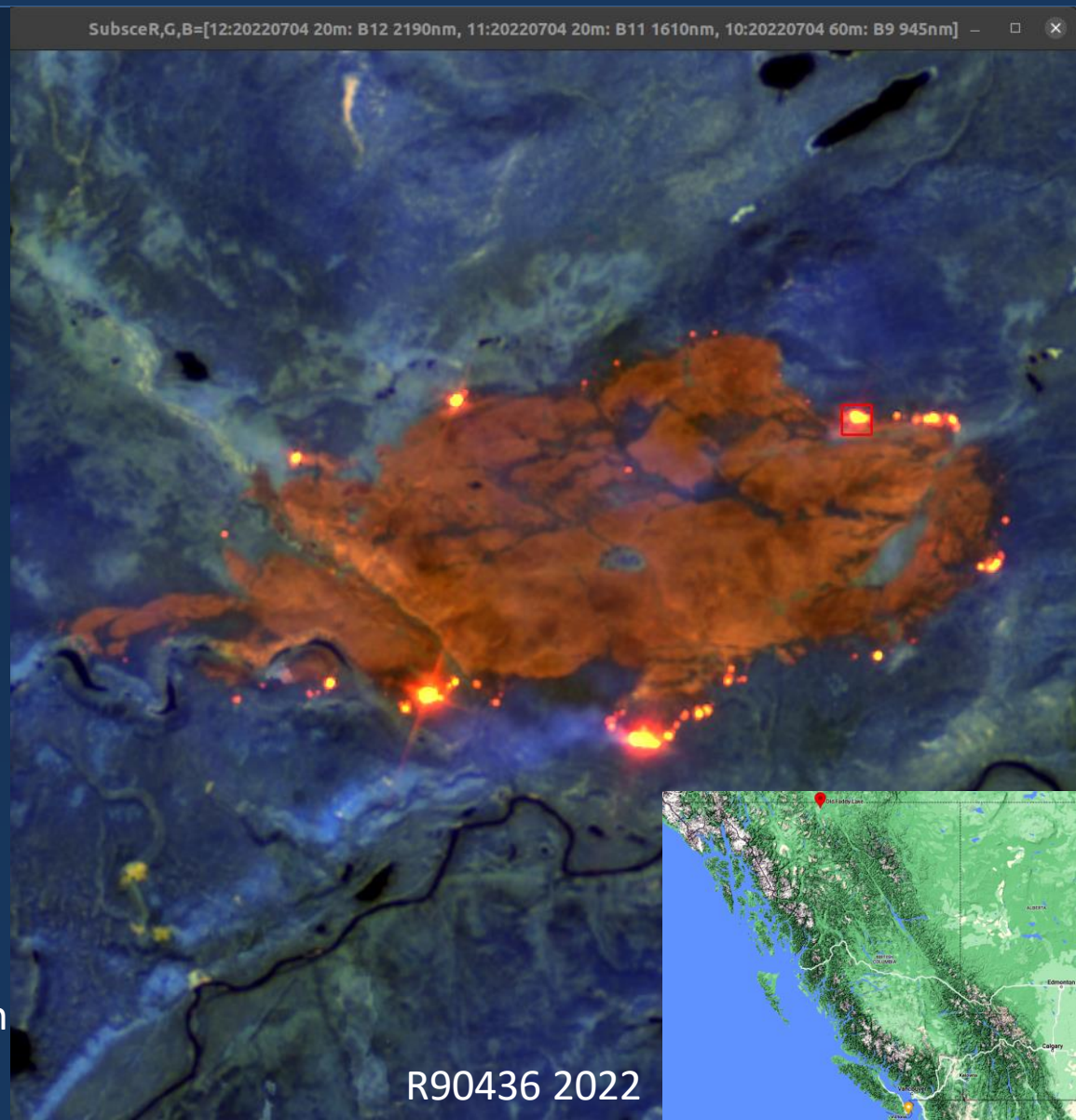
- Color encoding to generate map at right:
  - Red: "B12" 2190 nm = 2.2 µm
  - Green: "B11" 1610 nm = 1.6 µm
  - Blue: "B9" 945 nm = 0.95 µm

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?

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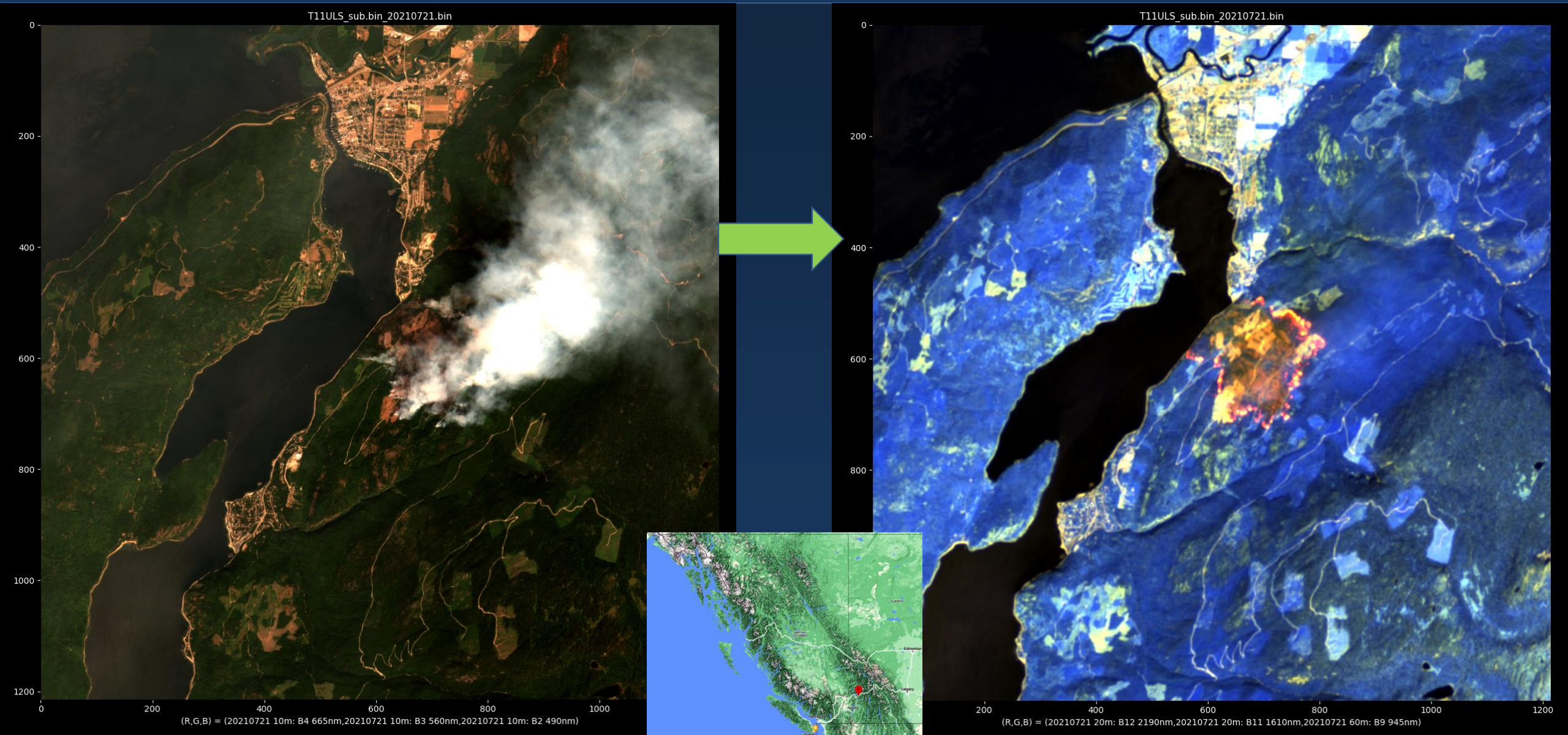
RGB = RGB (visible) Sicamous 2021

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

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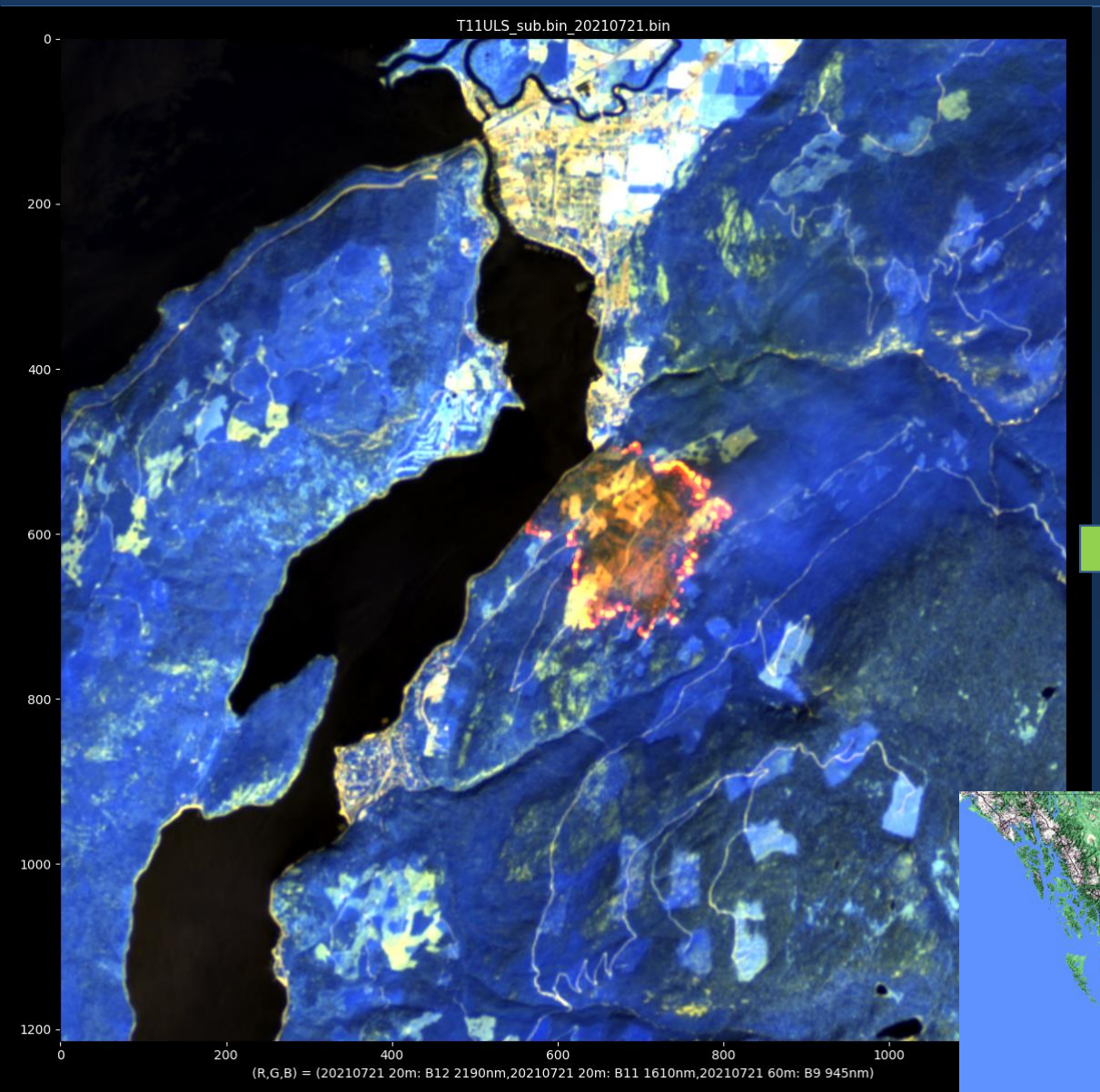
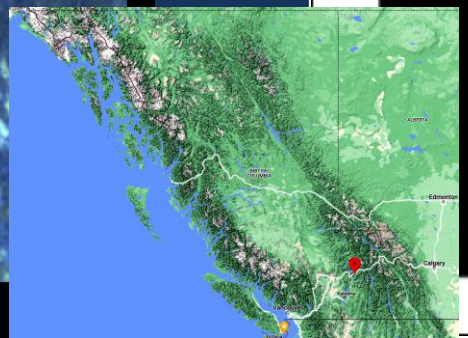
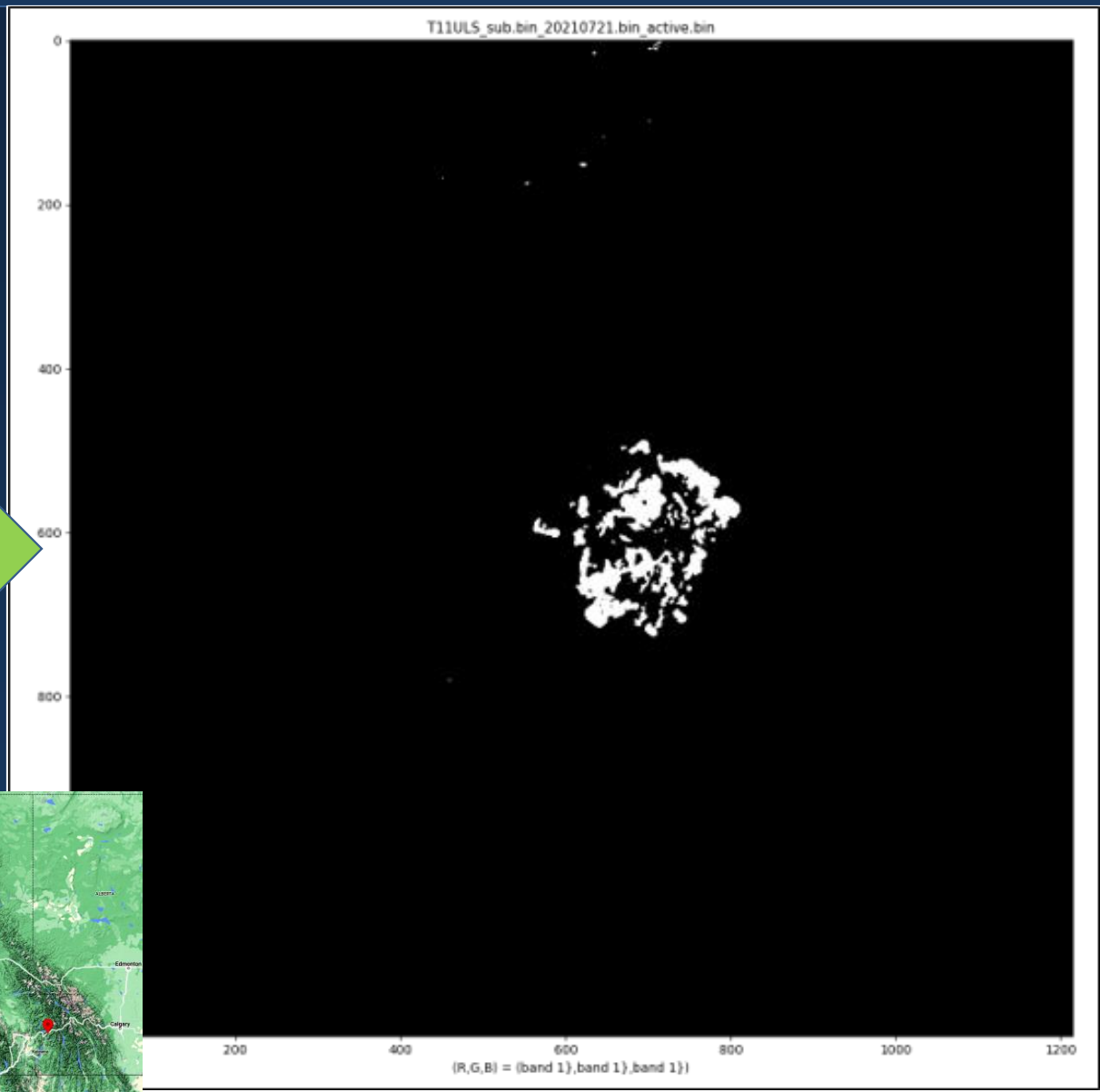


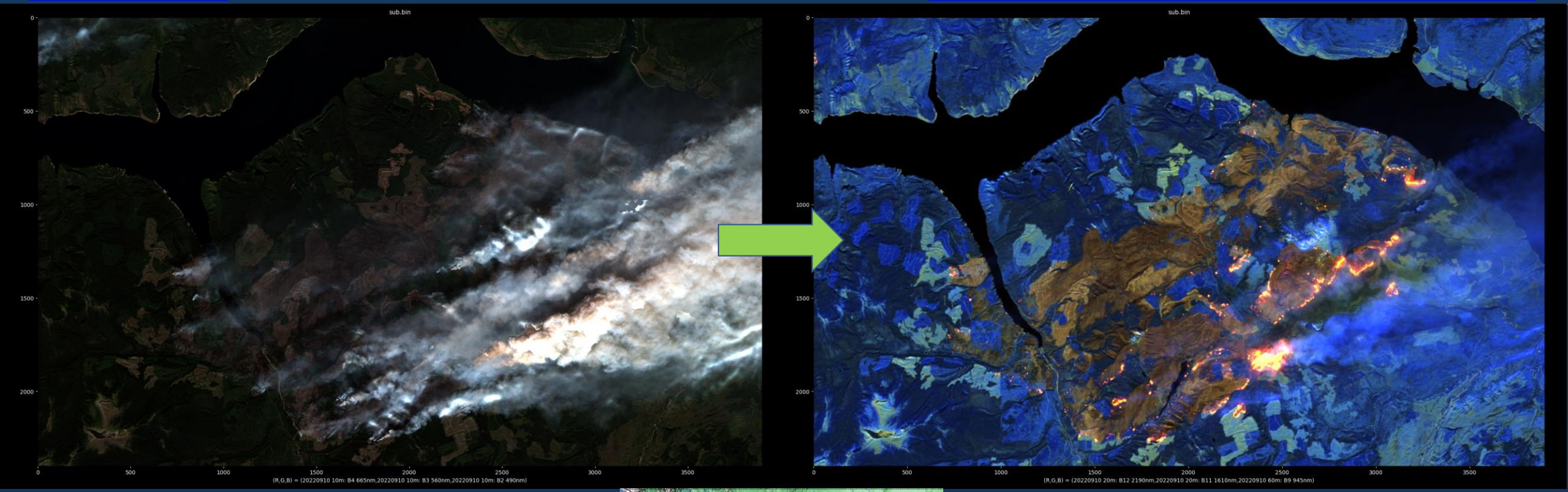


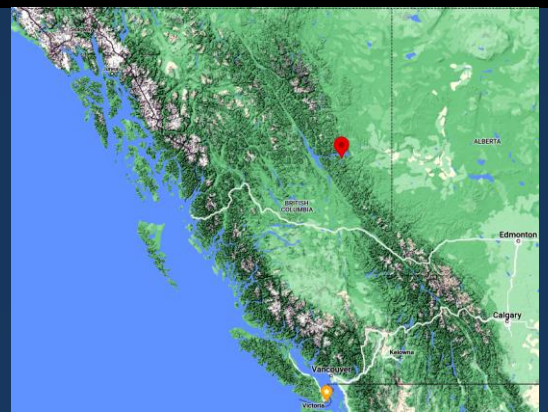


1) SWIR false-color encoding

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

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





Battleship mountain (G72150) 20220910

2) Threshold

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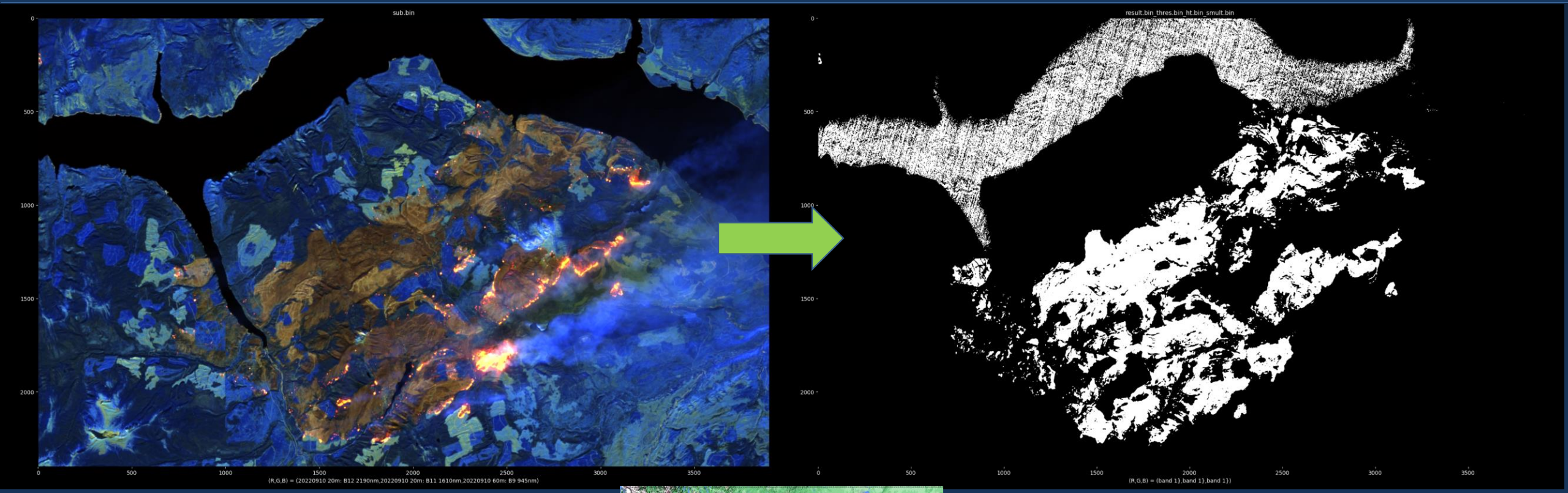
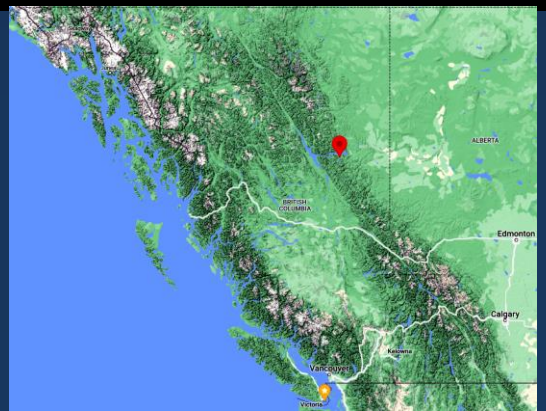


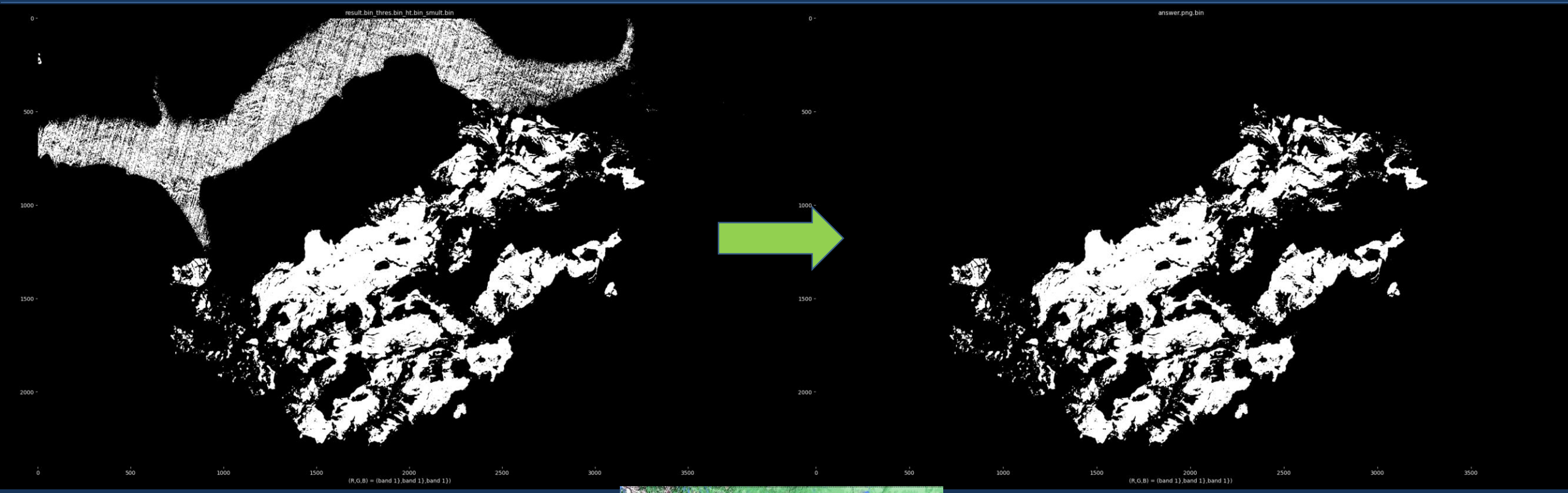


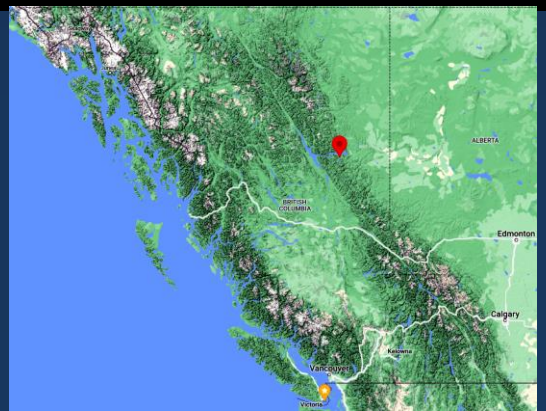
Battleship mountain (G72150) 20220910

(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

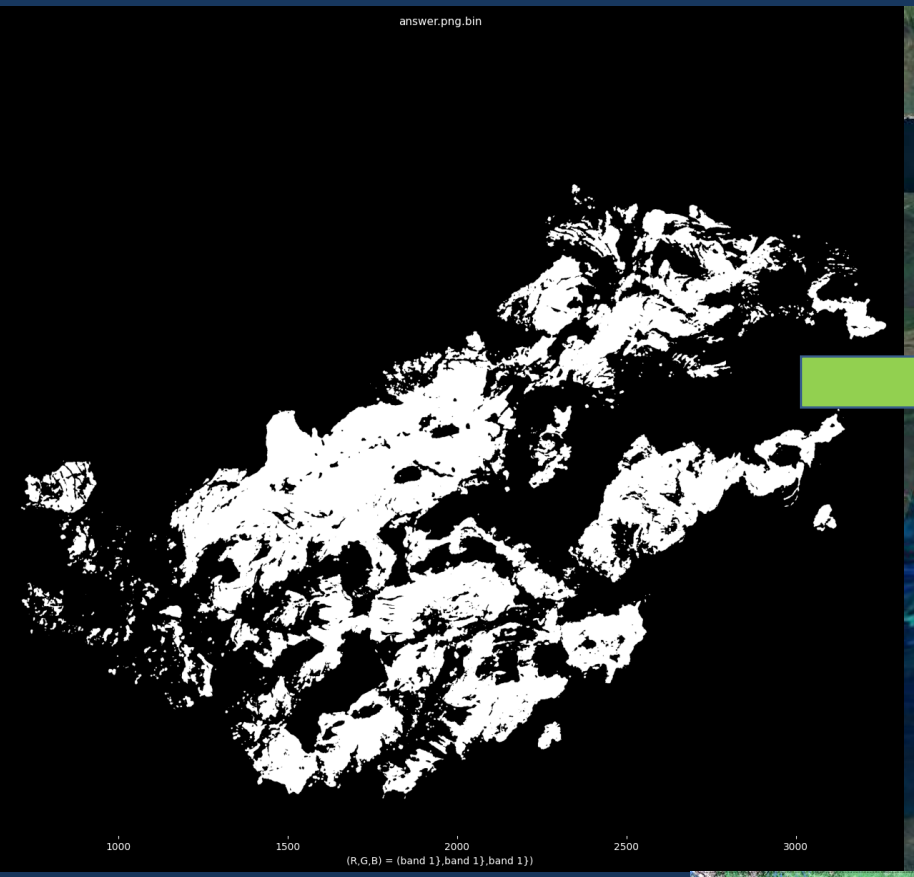


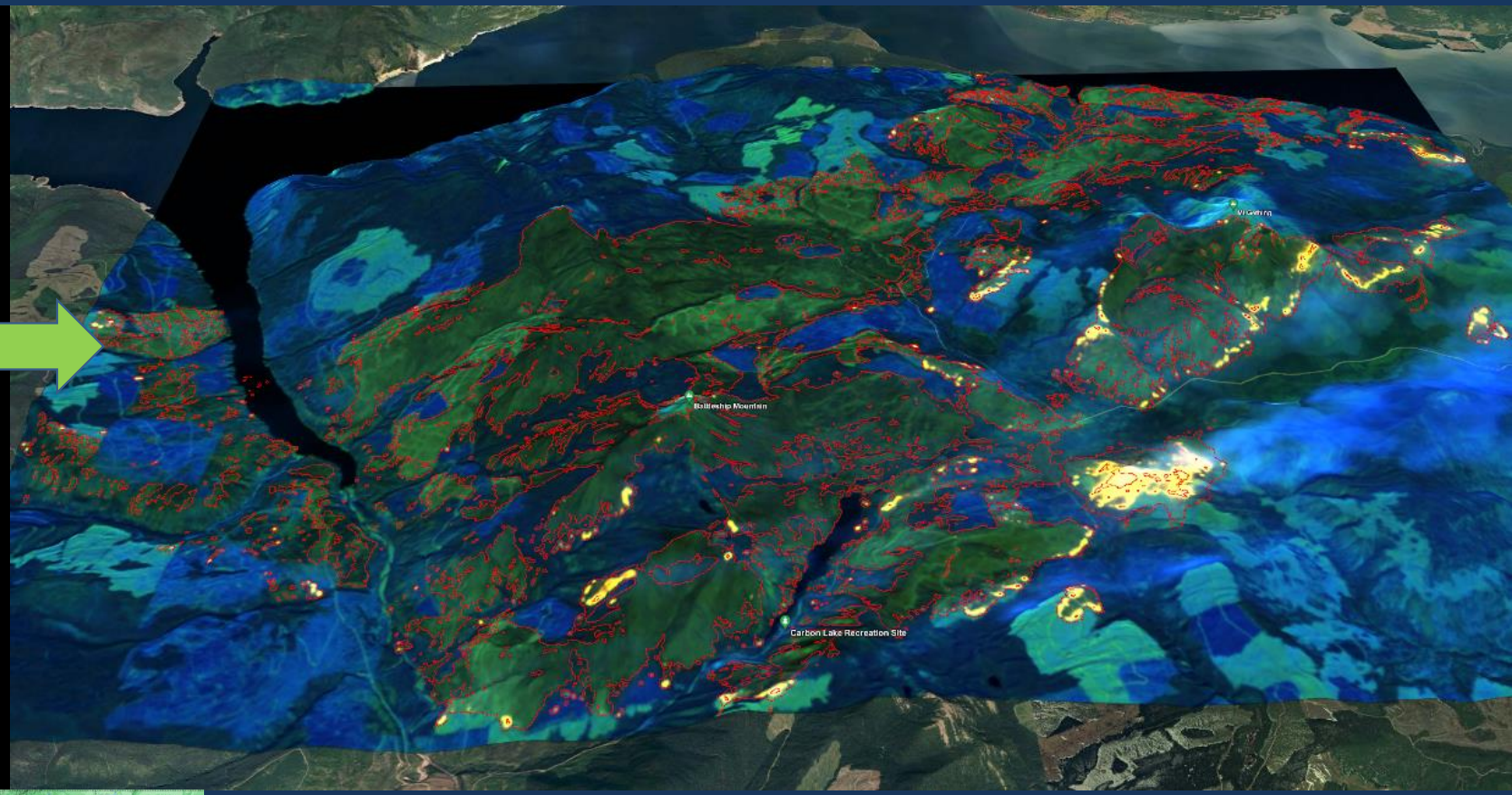


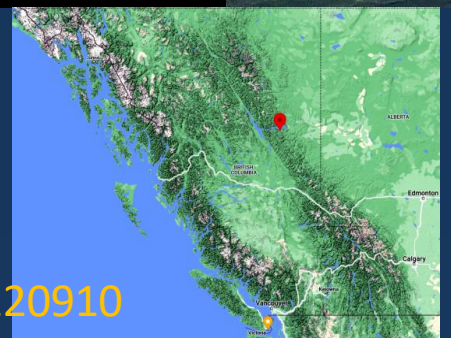
- Remove water areas
- GIMP used for manual scrubbing
- Weather, illumination or other image quality issues could necessitate more scrubbing

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!

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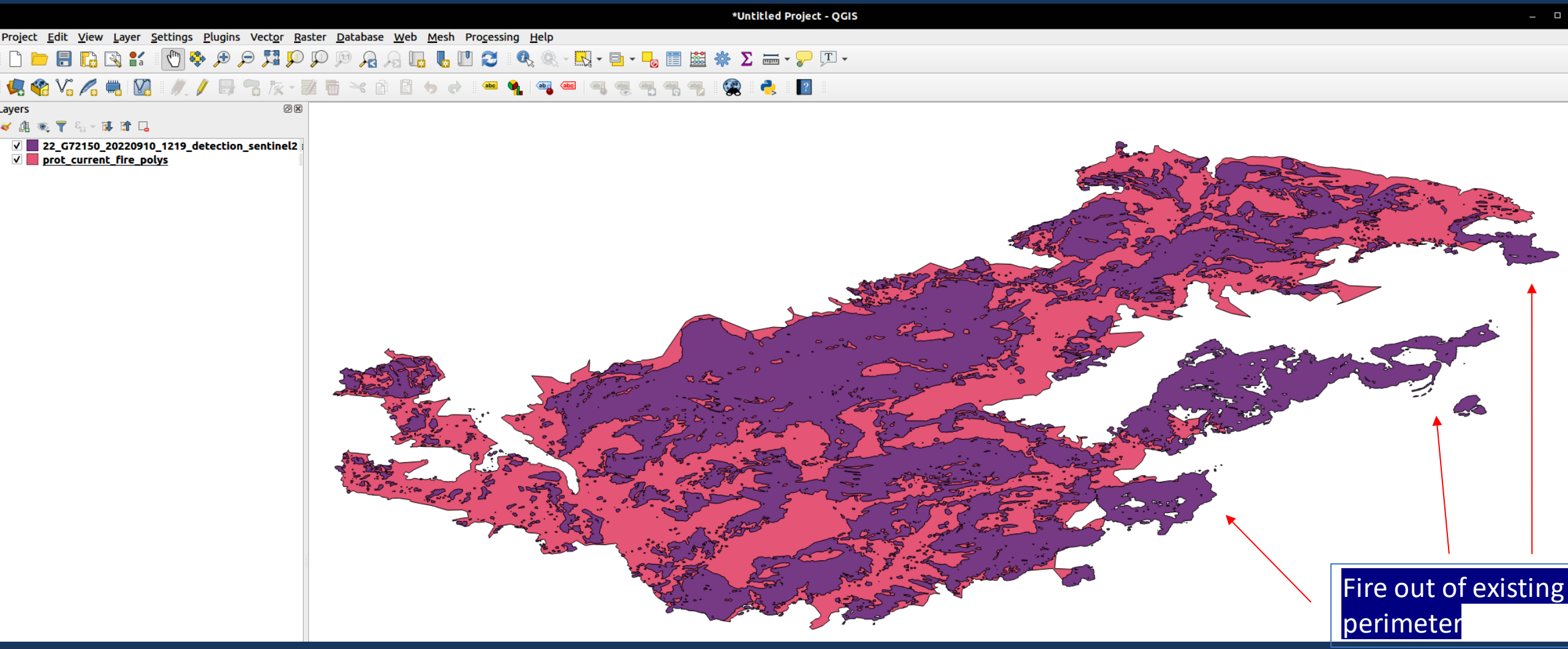
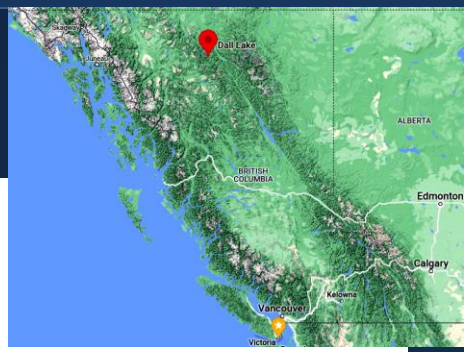


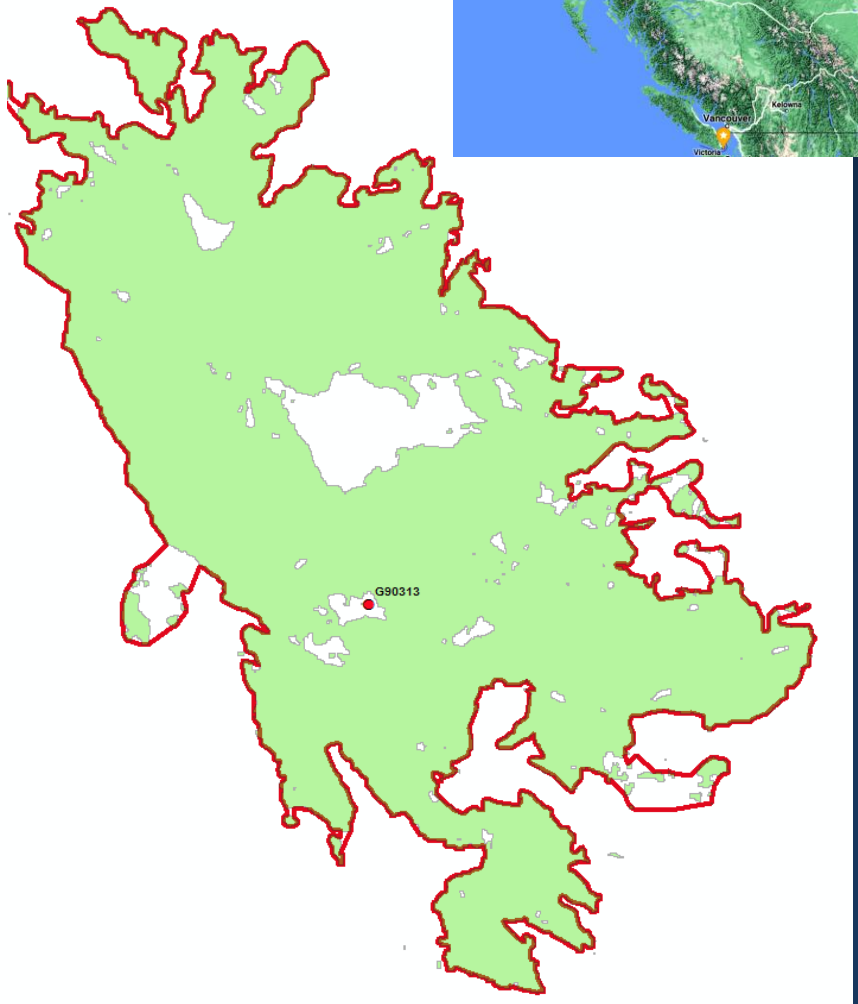
Battleship mountain (G72150) 20220910 Poly data 2022091021 (9-10pm)

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

5. Post processing

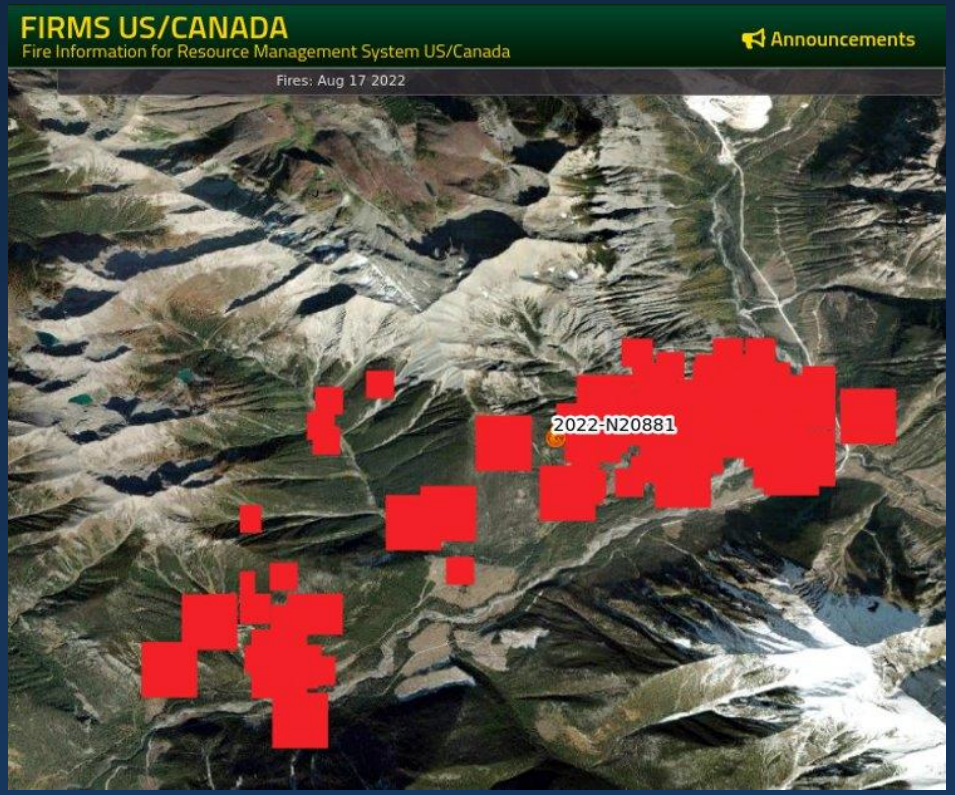
- Post processing completed in conjuction with current perimeter, Plans Chief and GIS Specialist
- Left: Sentinel2 derived detection. Middle: Generalized shape Right: comparison



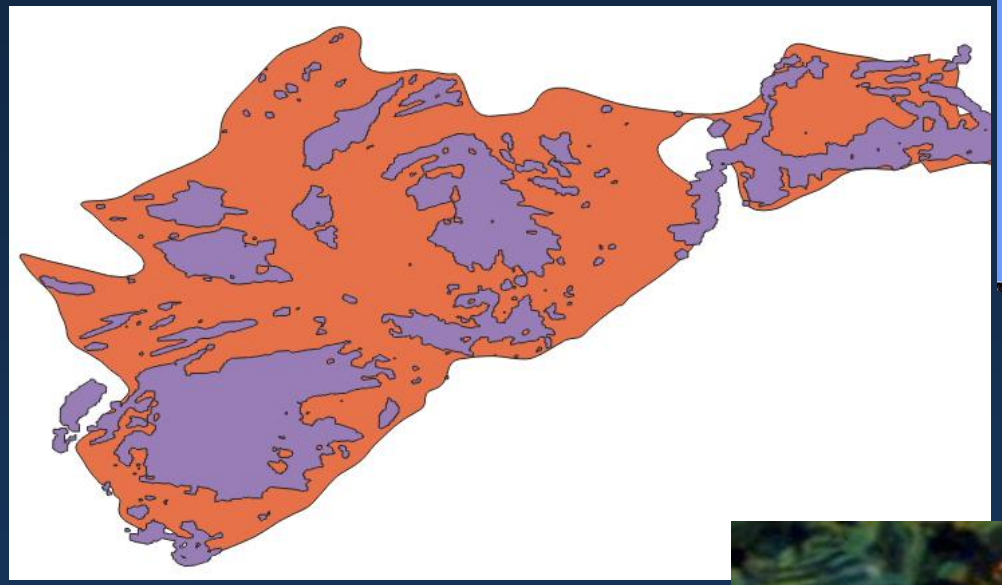


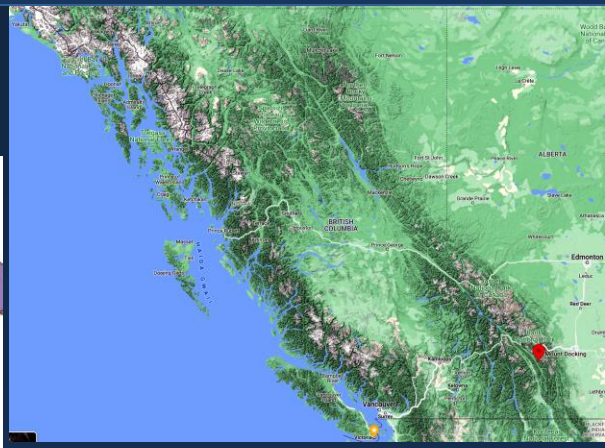
Comparing Sentinel2 result (right) with Firms

NASA Firms (MODIS and VIIRS) detection Aug 17

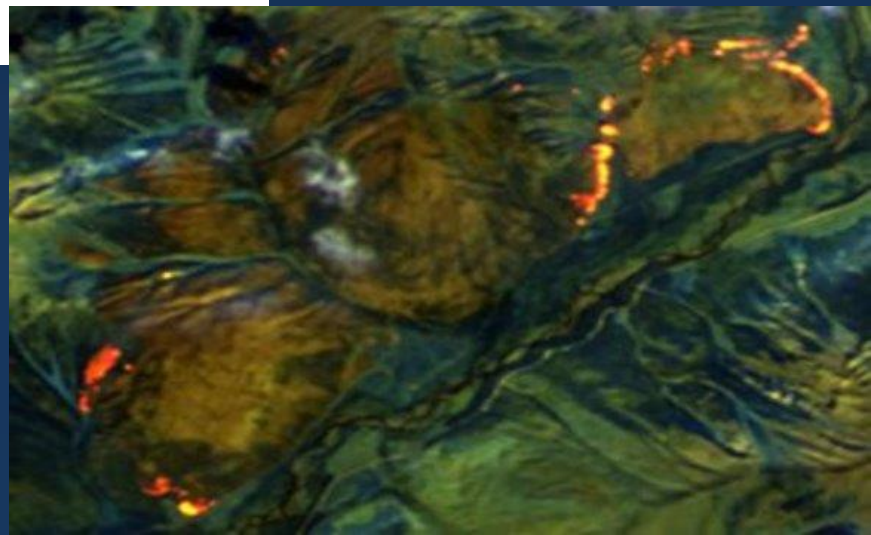


Purple – Sentinel-2 detection Aug. 17th
Orange – public perimeter as of 20220819





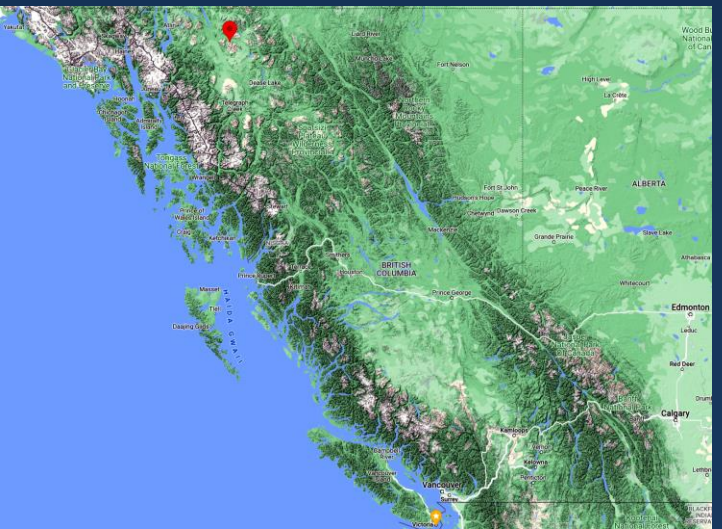
SWIR false color

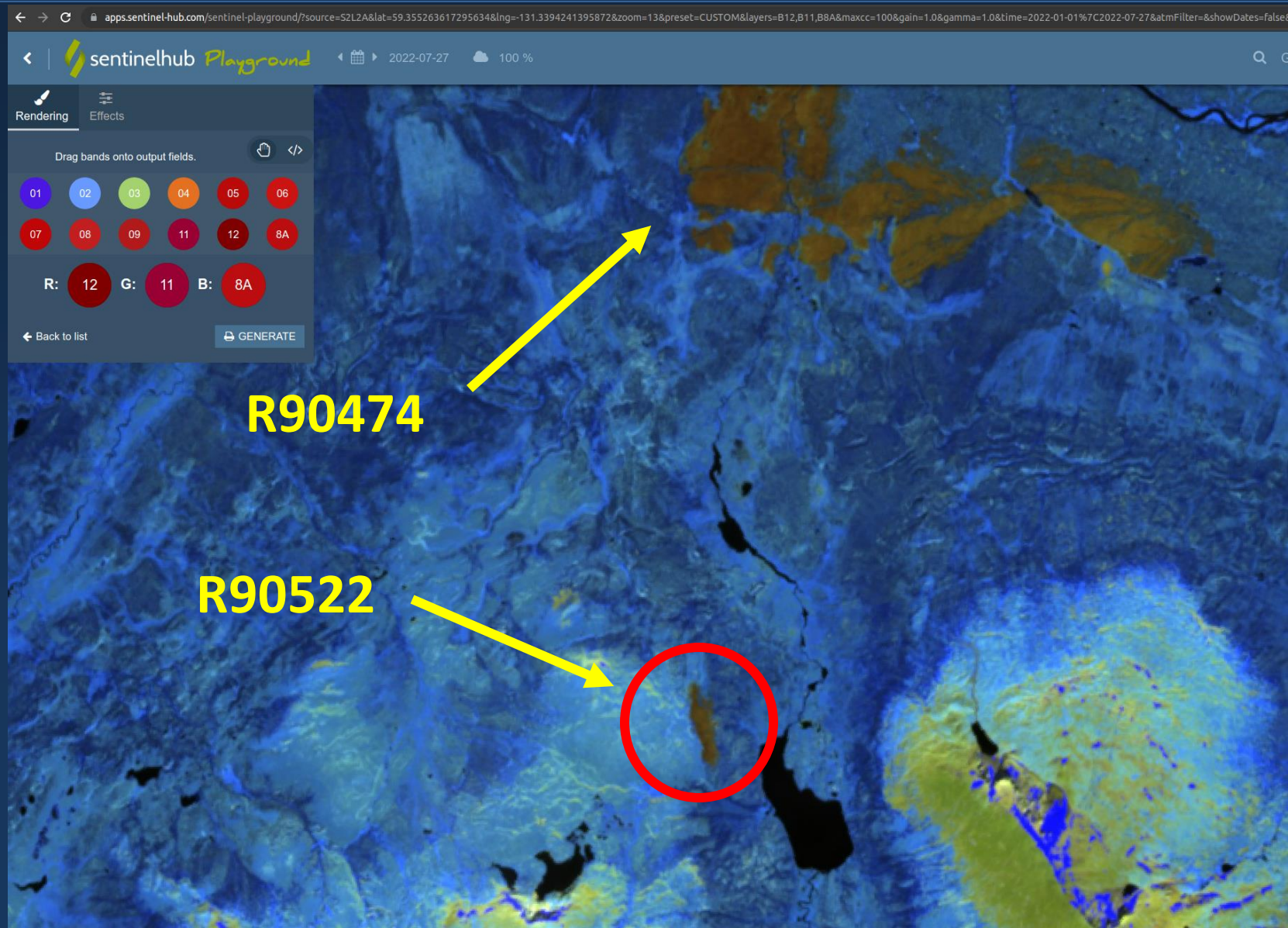


Fire: N20881 Date: 20220817

Finding unknown fires

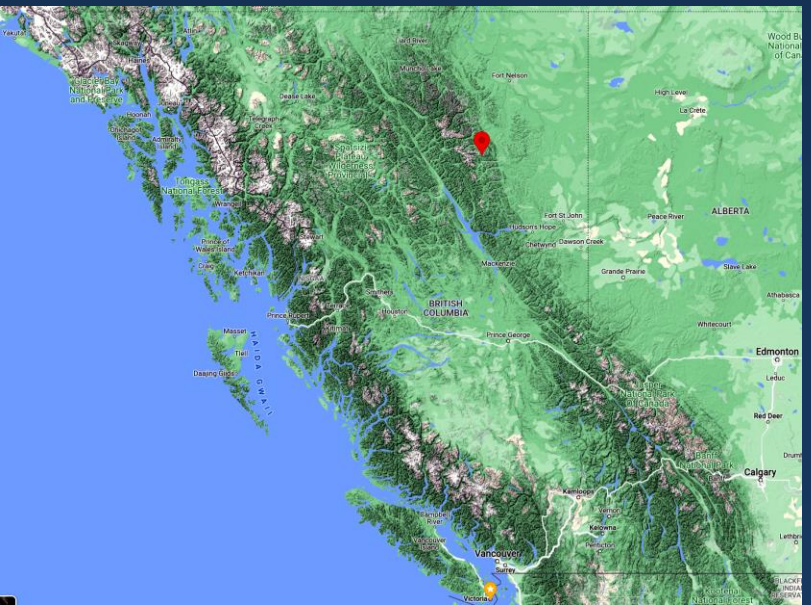
- Found on July 28 from Jul 27 imagery
- Aug 20 we confirmed it was assigned a fire number (status out)
  - R90522 / Tahoots Lake

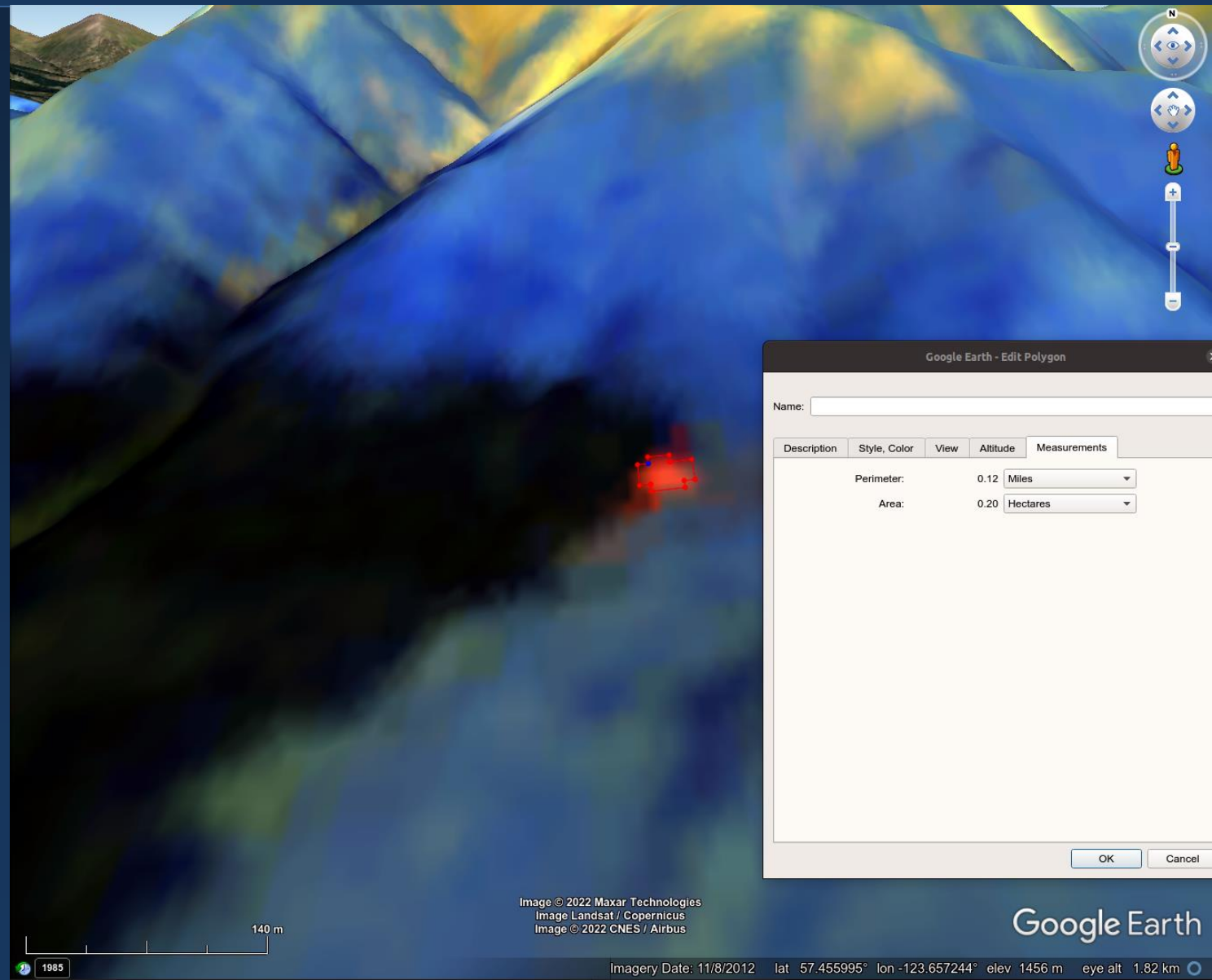




Small fires detected

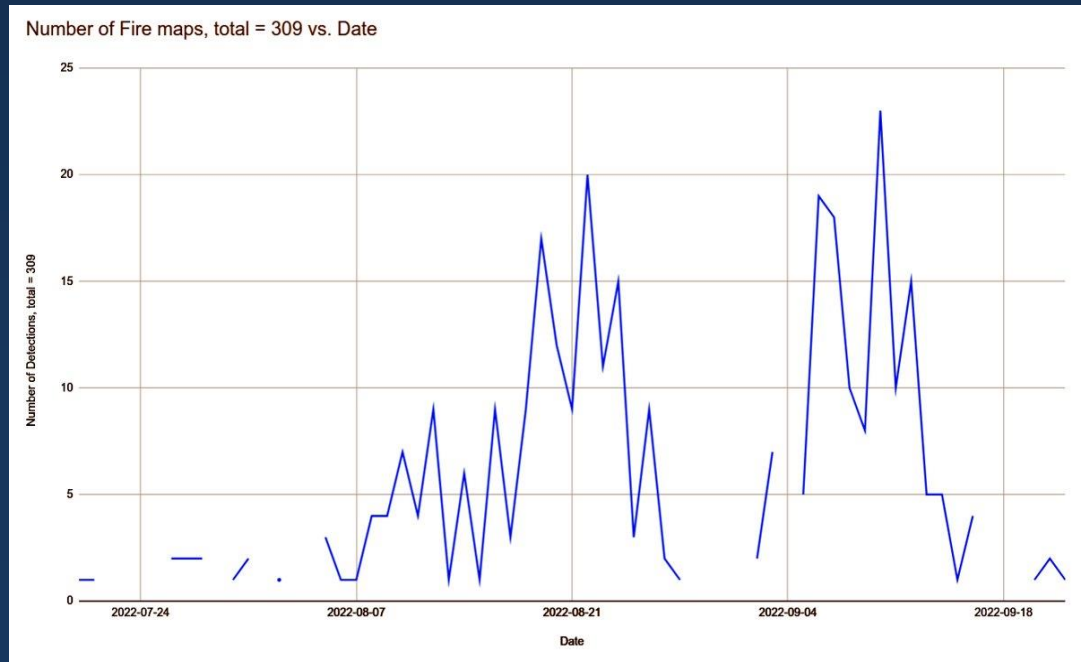
- Sub-hectare fires observed
- Fire: G82427
- Date: 20220913
- Size: 0.20 ha (Google Earth)





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 →

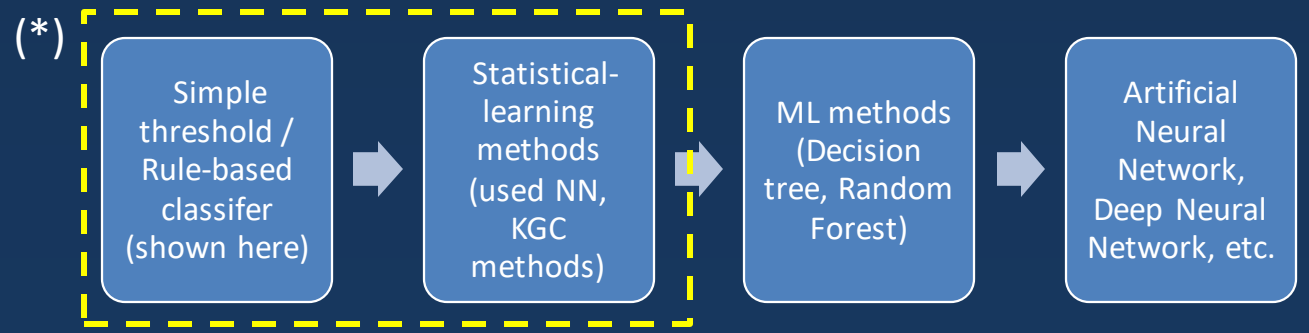
More automatic, generalize-able, flexible →

More modern / trendy →

← More accessible / explainable

← More human intervention

(*)



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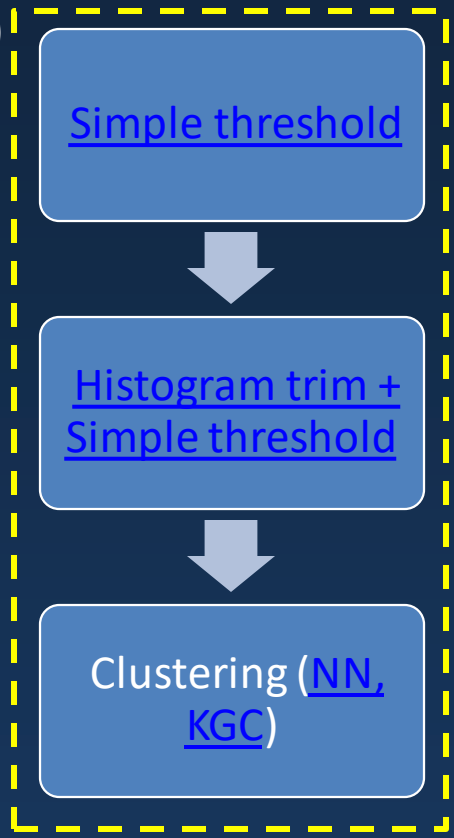

Next: ***find the sweet spot between automatic vs explainable/accessible!***
Want to be a little more "AI"-like than (*)

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