

Investigating Spaceborne L-Band Polarimetric SAR for Operational Wildfire Mapping in BC

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Natural Resources
Canada Ressources naturelles
Canada

Canada

Our Application

Application:

NRT Fire mapping in heavy cloud/smoke cover conditions,
to improve situational awareness for firefighters,

better understand
fire behaviour in cloud / smoke cover,

improve safety etc.

Concern

Is there a technical problem to be solved through innovation, or a data issue? Or other support required

Goal: invite collaboration

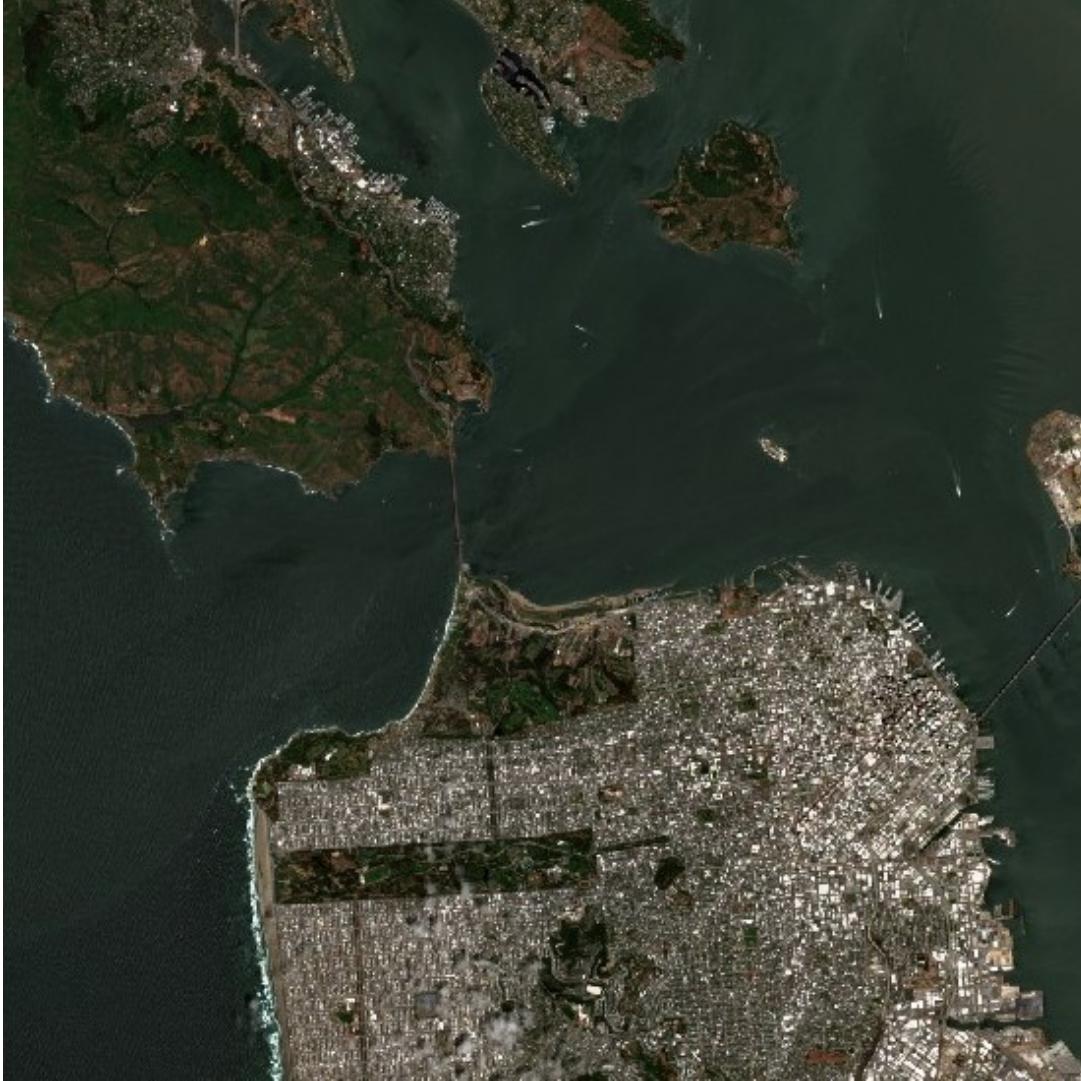
Is there a technical problem to be solved through innovation, or a data issue? Or other support required

Aim: Look for more opportunities to collaborate!

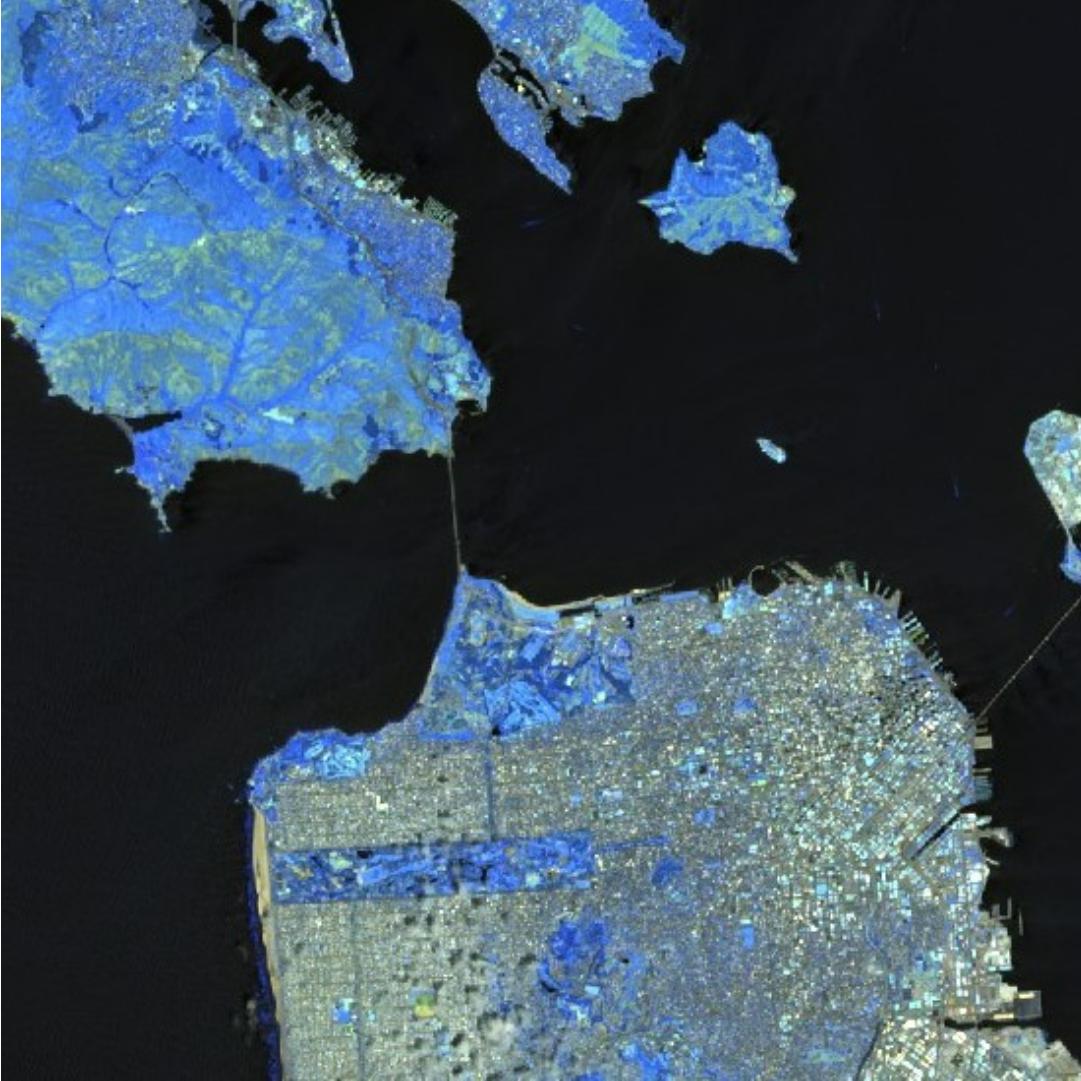
What does Polarimetric SAR data look like?



Optical: RGB



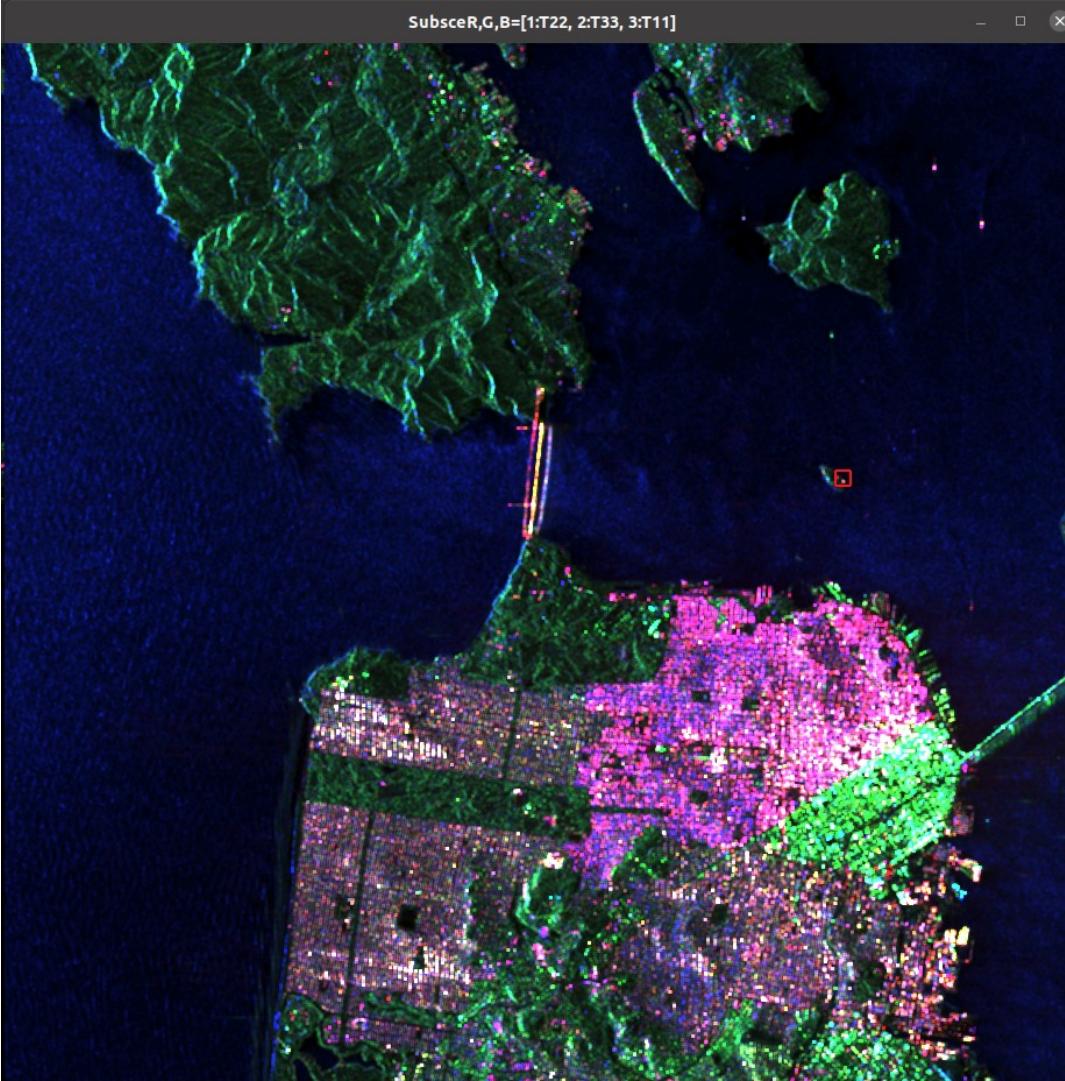
Optical: (SWIR)
R,G,B
= (B12, B11, B9)



Quad-pol
SAR:

Looks foreign
relative to RGB..

..But does it look
wierder than SWIR?





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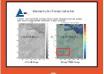
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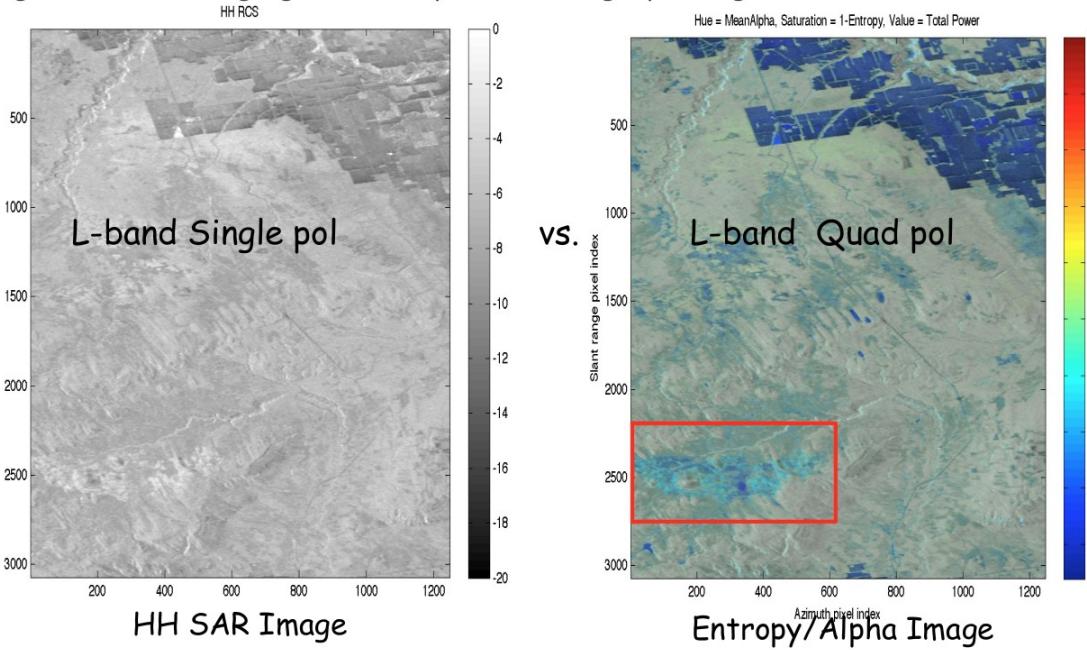
13

Radar Polarimetry for Forestry Applications: ALOS and Radarsat-2 studies in Canada, ForestSat, Lugo, Spain, Sept 2010



Polarimetry for Firescar detection

2 issues ...how to establish automatic detection and then understand why quadpol gives such a strong signature not present in single pol image...



Possible discussion points

Proposed solution: use quad-pol SAR data. Does this make sense?

Could use feedback on where to go next!

1) Recap some results presented at this meeting 10 years ago!

* Seems Possible to get operationally viable results at C or L band.

* What ways forward are there to develop this and related applications?

a) L-band is better than C?

2) Are there ways to work w commercial SAR providers to access their past/historical data to support developing the case for monitoring using commercial satellite services in future?

Particularly interested in quad-pol data (more flexible)

3) Could other application areas benefit from similar data? Fast/frequent/ cloud-penetrating/ multiple channels to support PolSAR/InSAR/PolInSAR/PolTomoSAR etc.

4) What steps need to be taken in organizations to maximizing the opportunity from satellites like NISAR, Rose-L and Sentinel-1 NG. What are some ways to start collaborating sooner?

5) Are there opportunities for Canada to collaborate more directly with ESA on missions like Rose-L and Sentinel-2 programs to increase continuity, interoperability and repeat? Other questions I missed?

The screenshot shows a presentation slide titled "Quad-Pol Analysis for Forestry". The slide has a header with the title and a small map of a forested area. Below the title is a bulleted list of points:

- Quad-Pol analysis for forestry (and other applications)..
- Several issues:**
 - Understanding the physical meaning of decomposition parameters.
 - Visualization (challenging in 5 or more dimensions).
 - *** **Effective classification*****
- Present work by University of Victoria (UVic) and Canadian Forest Service (CFS, NRCAN) seeks to address these issues through new algorithms R&D:
 - Information retrieval for fire scars and biomass.
 - Real-time interactive data visualization.**
 - Data Driven Classification.**

At the bottom of the slide, there are logos for Natural Resources Canada and the Canadian government, along with the word "Canada".

Recap some past results..

Activities Document Viewer Jun 22 00:43 •
1 of 22 2013-CSRS_V03.ppt
2012-CSRS-Richardson.pdf 67.8%

Hierarchical Unsupervised Nonparametric Classification of Polarimetric SAR Data

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²Department of Computer Science, University of Victoria
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ashy@uvic.ca

34th Canadian Symposium on Remote Sensing (CSRS 2013), Victoria, BC, Canada
August 29, 2013

Natural Resources Canada University of Victoria Canada



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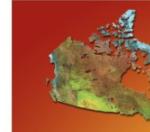
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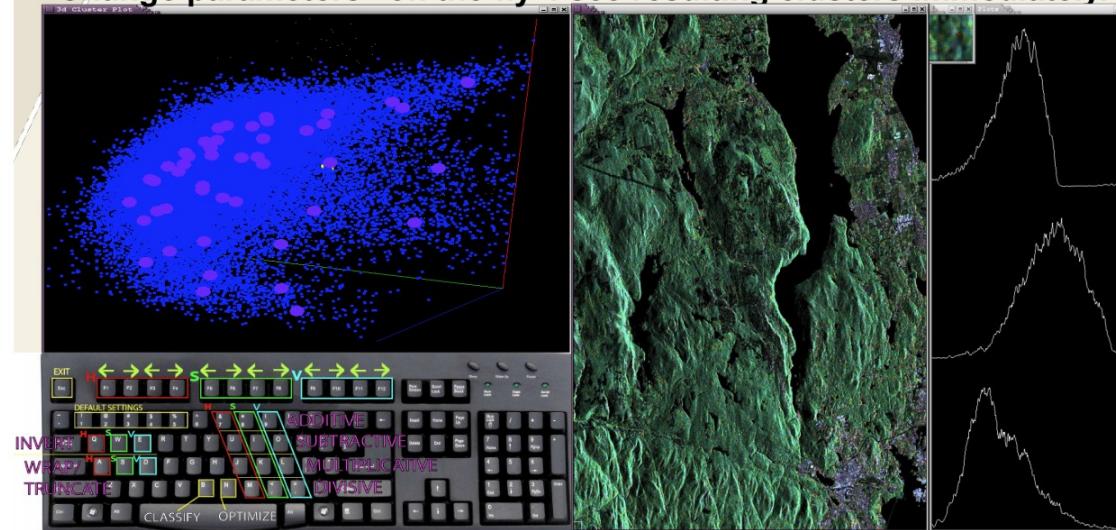


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Rapid visual data exploration

- Essential for data understanding
- Explore the discrimination potential of the data!
- Interactive 3-d scatter, decomposition parameter & classification display, histogram modification (below).
- Change parameters “on the fly”: see resulting clusters immediately.





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KGC method: description

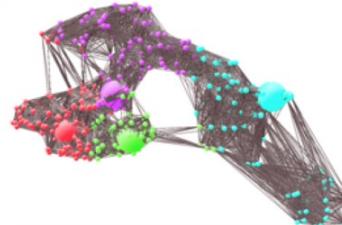
1) Construct the K-NN graph.. Compare everything to everything else!!

2) Estimate density at each point on the KNN graph.

$$\rho(x) = \frac{1}{\frac{1}{K} \sum_{n \in N} d(x, n)}$$

- x is a data point, K is the number of nearest neighbors of x , and N is the set of nearest neighbors of x
- Density taken as reciprocal of average neighbour-distance

3) Climb the density upon the K-NN graph to find peaks



- Method: "If my density is higher than my neighbours', I'm a peak! Otherwise, climb up! (traverse to my highest-density neighbour)"
- Associate peak with a basin of attraction: A peak and the data points which "climb up" to that peak.. are given the same color (class label).
- Left: example with 4 classes! (K-NN graph in 3-d..K=40) PALSAR data sub-area
- Data points: small spheres. Peaks: large spheres.

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Canada



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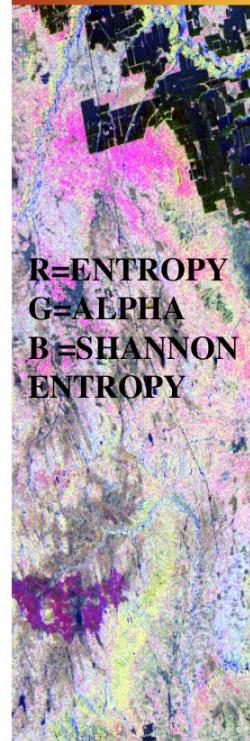
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2010 Result – (L-band) ALOS PALSAR



- 2009 ALOS-PALSAR - nominal swath 30km.
 - Faraday rotation compensation applied.
 - Multi-look (5x in row), followed by box filter (3x3) & multi-look (5x5) - resulting image size 737x249.
 - KGC tested in three dimensional feature space (H, Alpha, Shannon Entropy).
-
- Forests, urban development, and a ***prominent burned area*** (bottom left) from the 2002 Key River fire.



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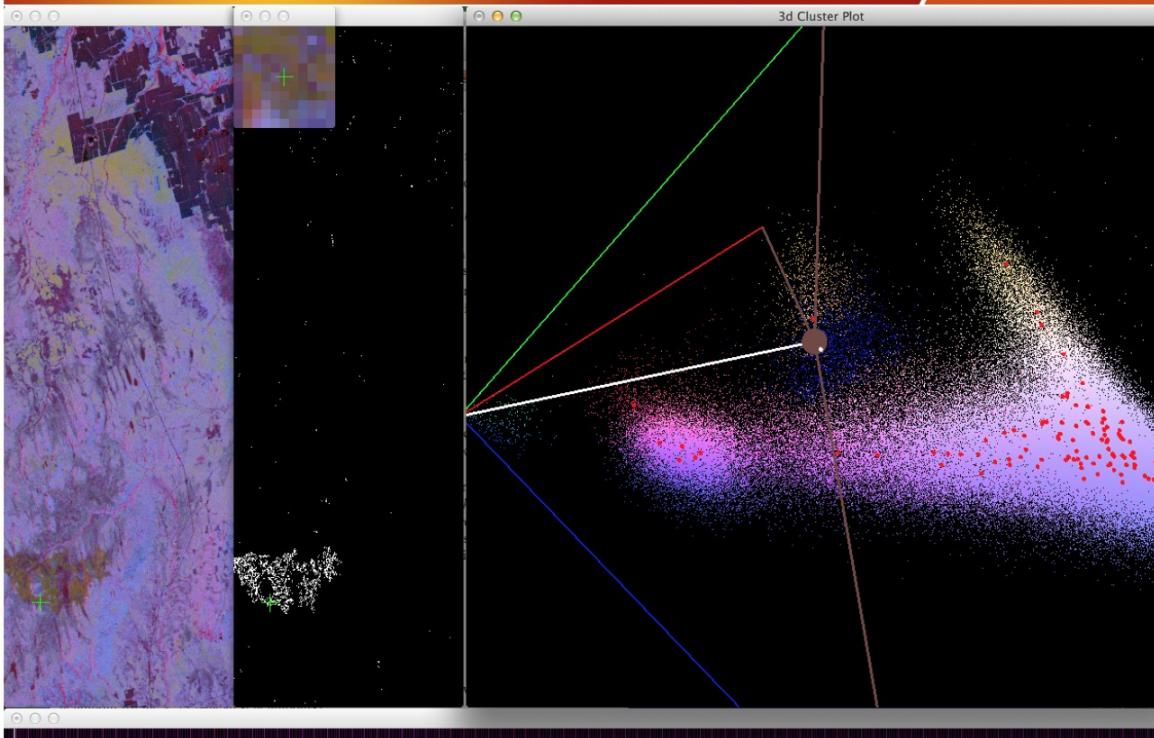
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Interactive Node Selection

L-band ALOS near Keg River





17 of 22



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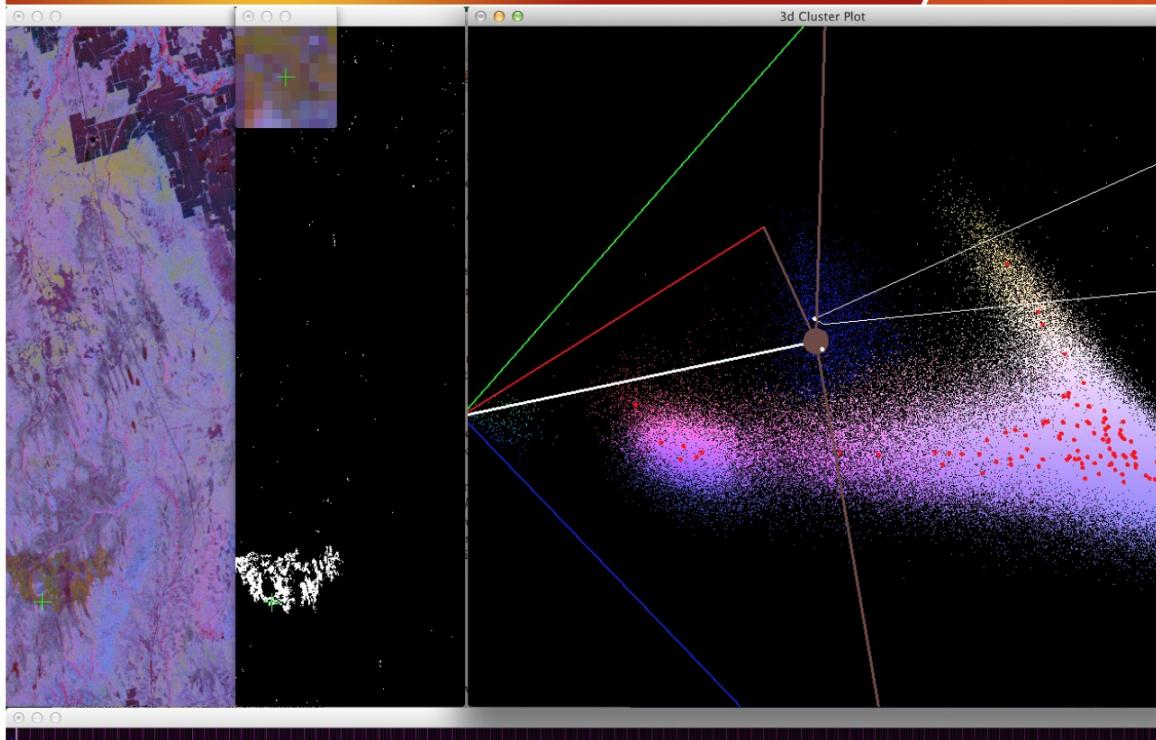
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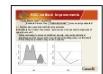
Interactive Node Selection

L-band ALOS near Keg River





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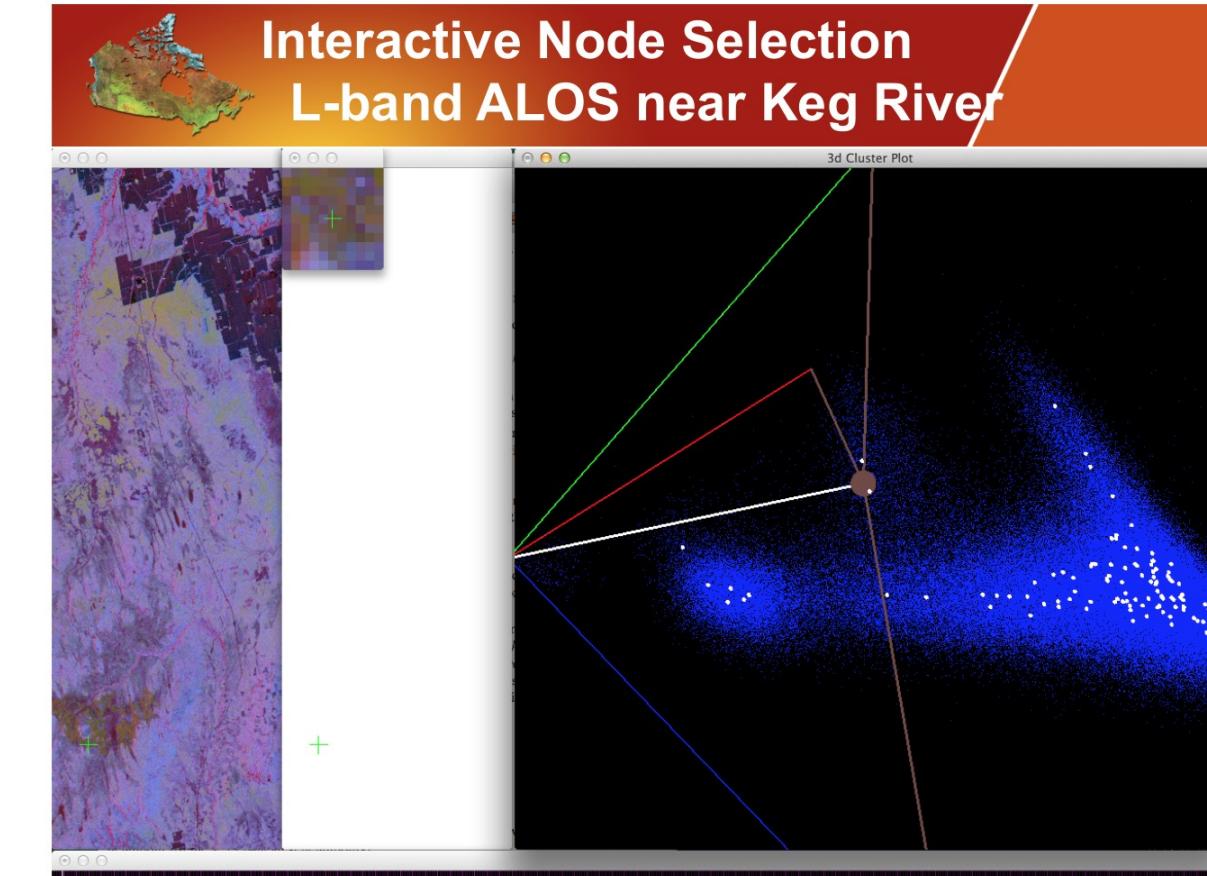
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2013 KGC Result – RADARSAT-2 (C-band)

RS2-SLC-FQ17-DES-01-Mar-2011_14

R = Entropy
G = Alpha1
B = Alpha2

3x2 multilook, 5x5 box filter, 5x5
multilook

KGC Binary Classification Result



Parameters used: Entropy, Alpha1,
Alpha2, Shannon-Entropy

- Good separation of burned area with 1 scene only.
- Boundary matches ALOS PALSAR (L-band) result,

and GIS fire polygon. **Canada**



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Visit some fires..

Where we have example data..

Some of these data are already analyzed/processed, many of them are not..

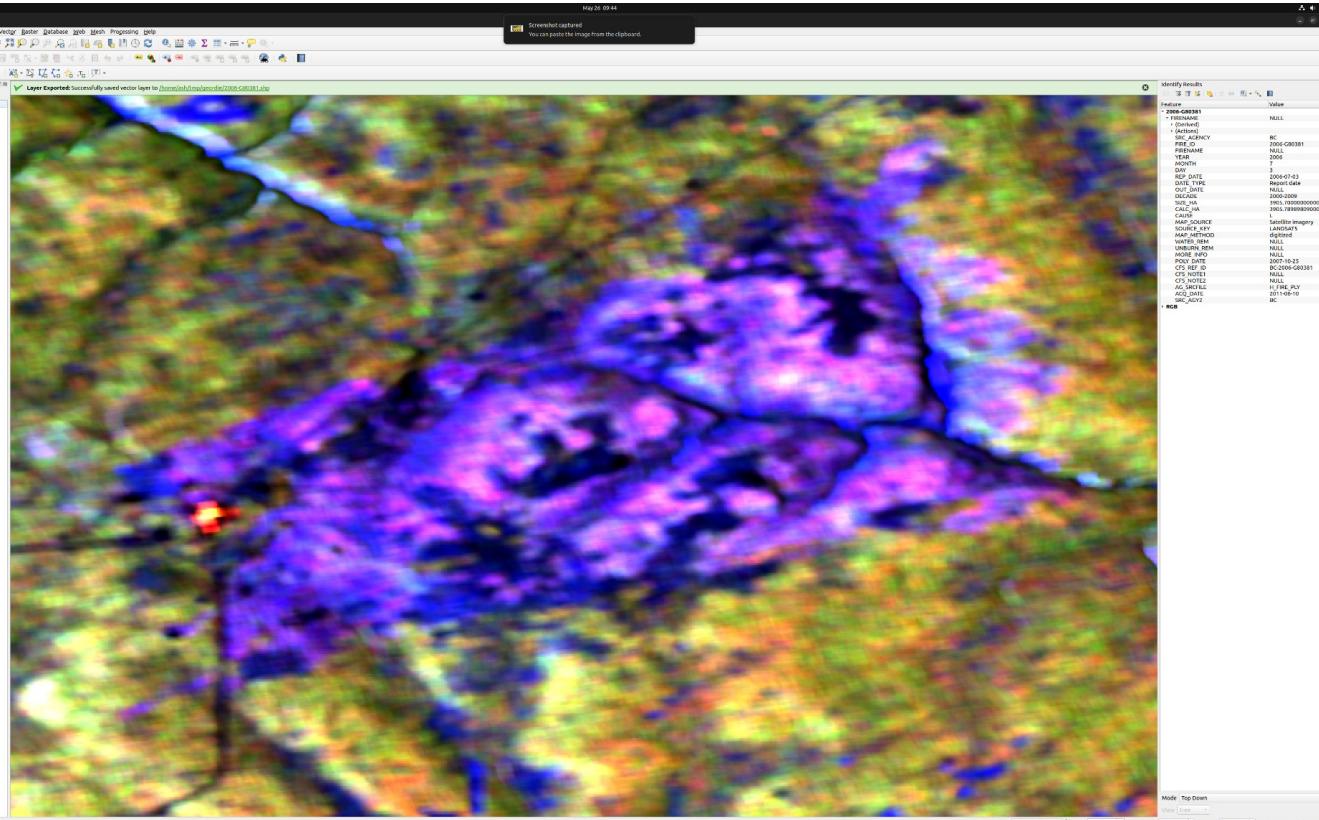
What methods would generalize to all the cases?

Is it necessary to use a trained approach?

Is data access an issue for operationalization?

2006-G80381

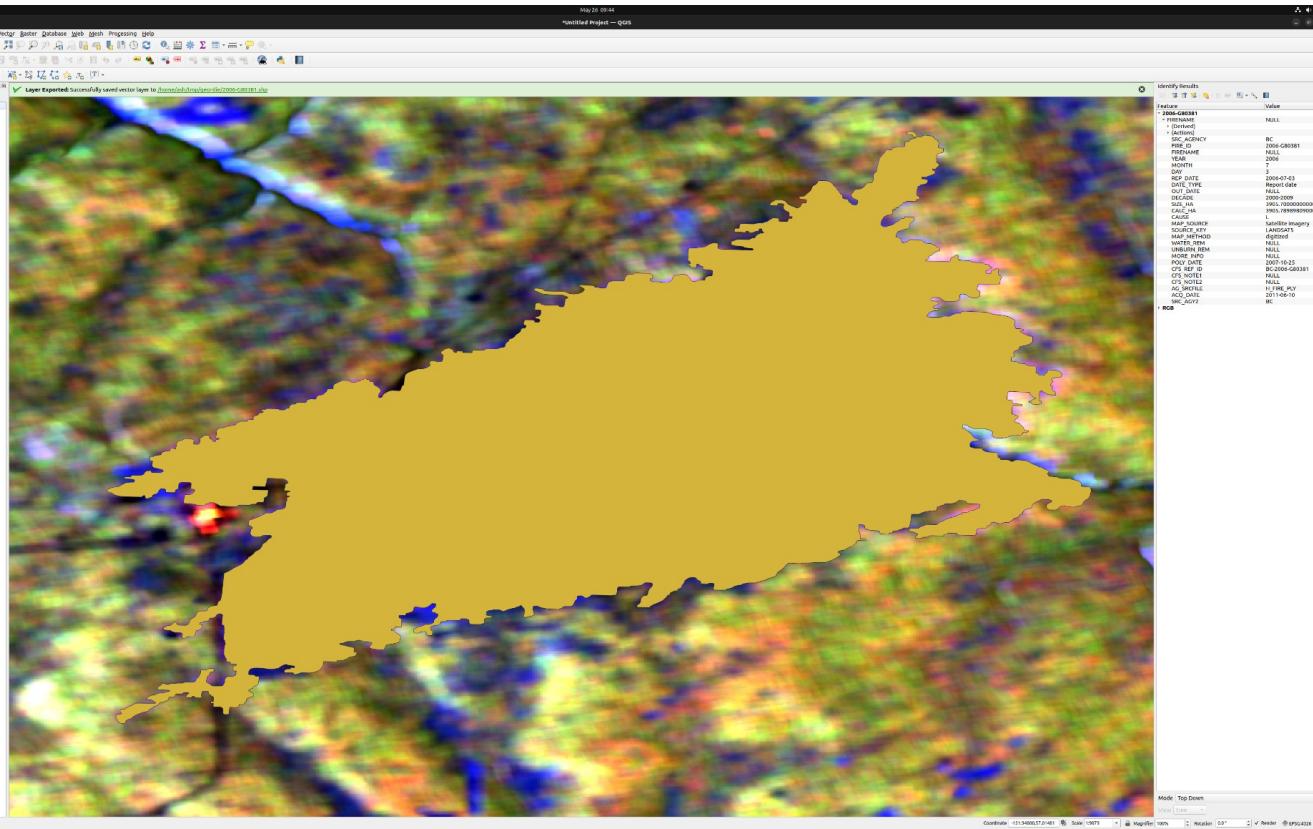
good overlap w CNFDB; 2009-Jun6 ALOS-1



This one is
analyzed in
Geordie
Hobart's
Masters
thesis!

2006-G80381

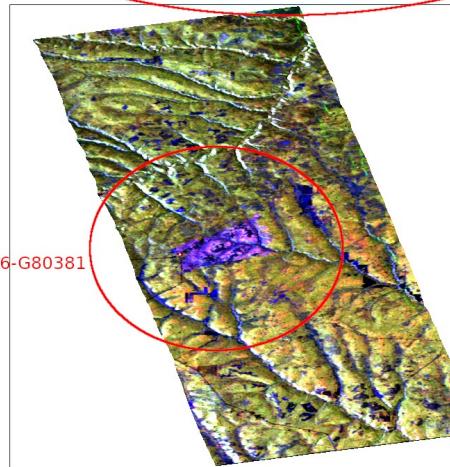
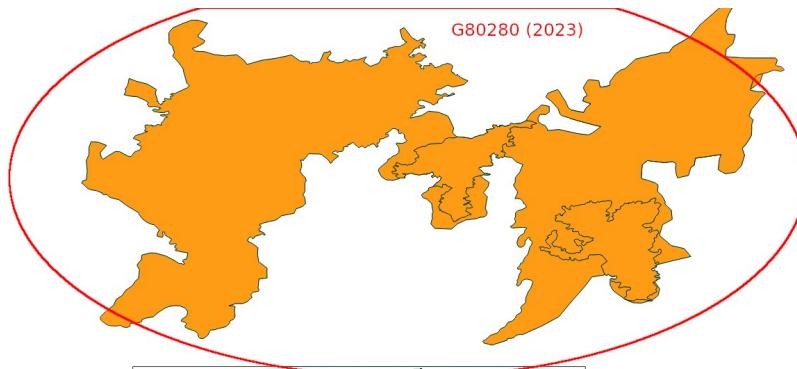
good overlap w CNFDB; 2009-Jun6 ALOS-1



Found the de-skewing button finally, comfortable to analyze the old data further

Note: calibration could also be an issue.

Current context: G80280 May 26th 2023. Could have reburned by now..





Search

ex. NYC

Get Directions History

Places

My Places

Sightseeing Tour

Make sure 3D Buildings

layer is checked

Temporary Places

AP_17930_PLR_F11...

Layers

Primary Database

Announcements

Places

Photos

Roads

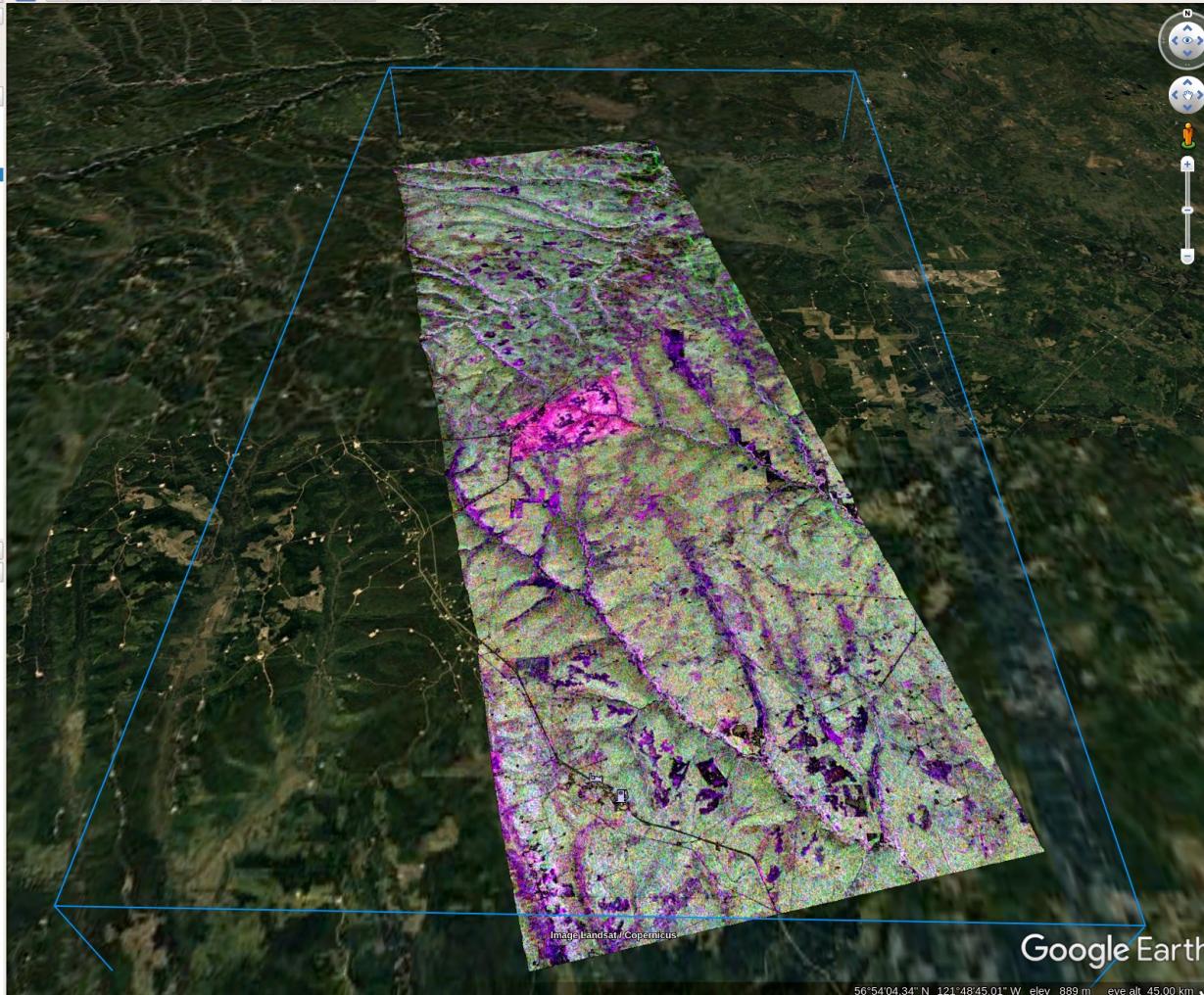
3D Buildings

Weather

Gallery

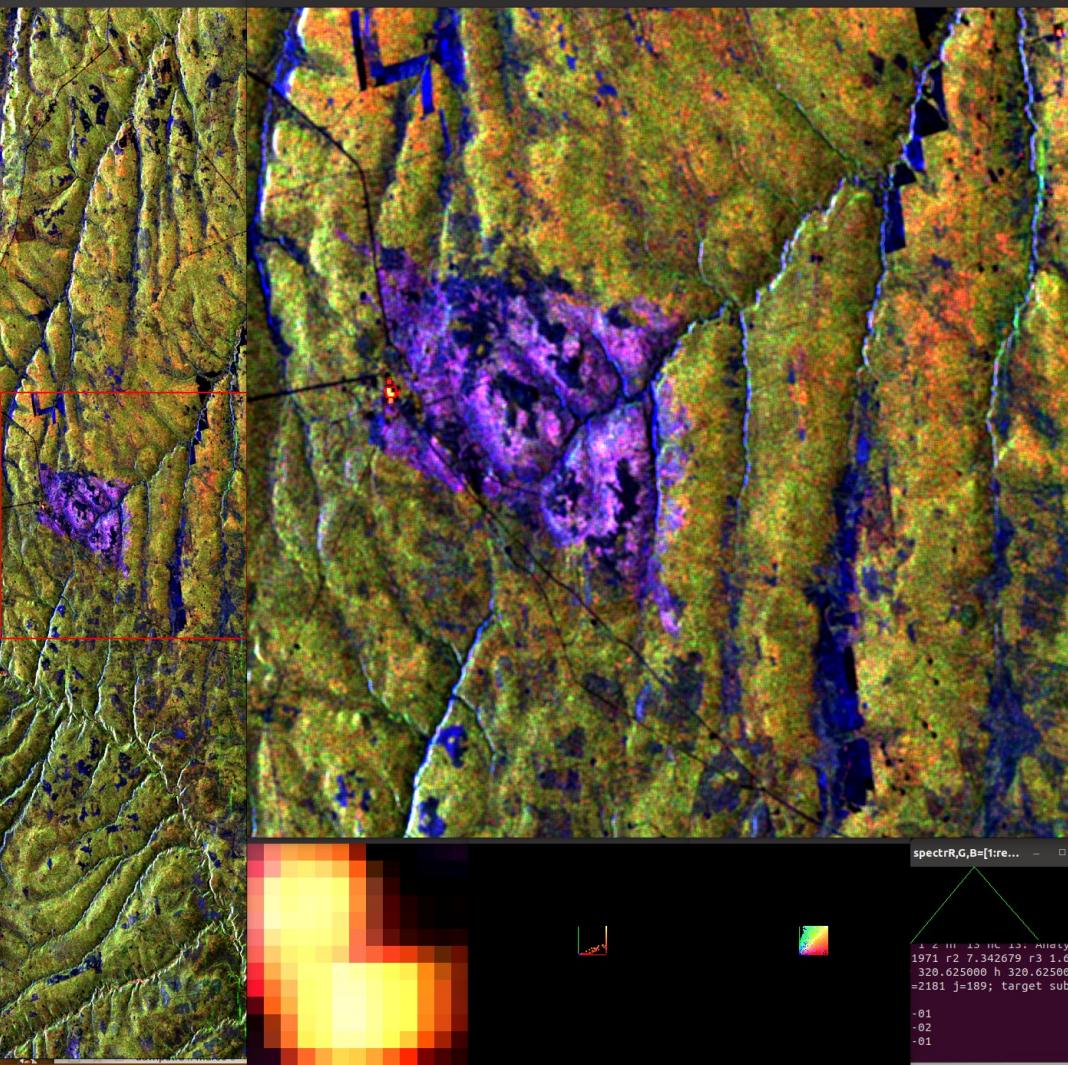
More

Terrain

Default
vis

Scene R,G,B=[1:red, 2:green, ...

SubscR,G,B=[1:red, 2:green, 3:blue]

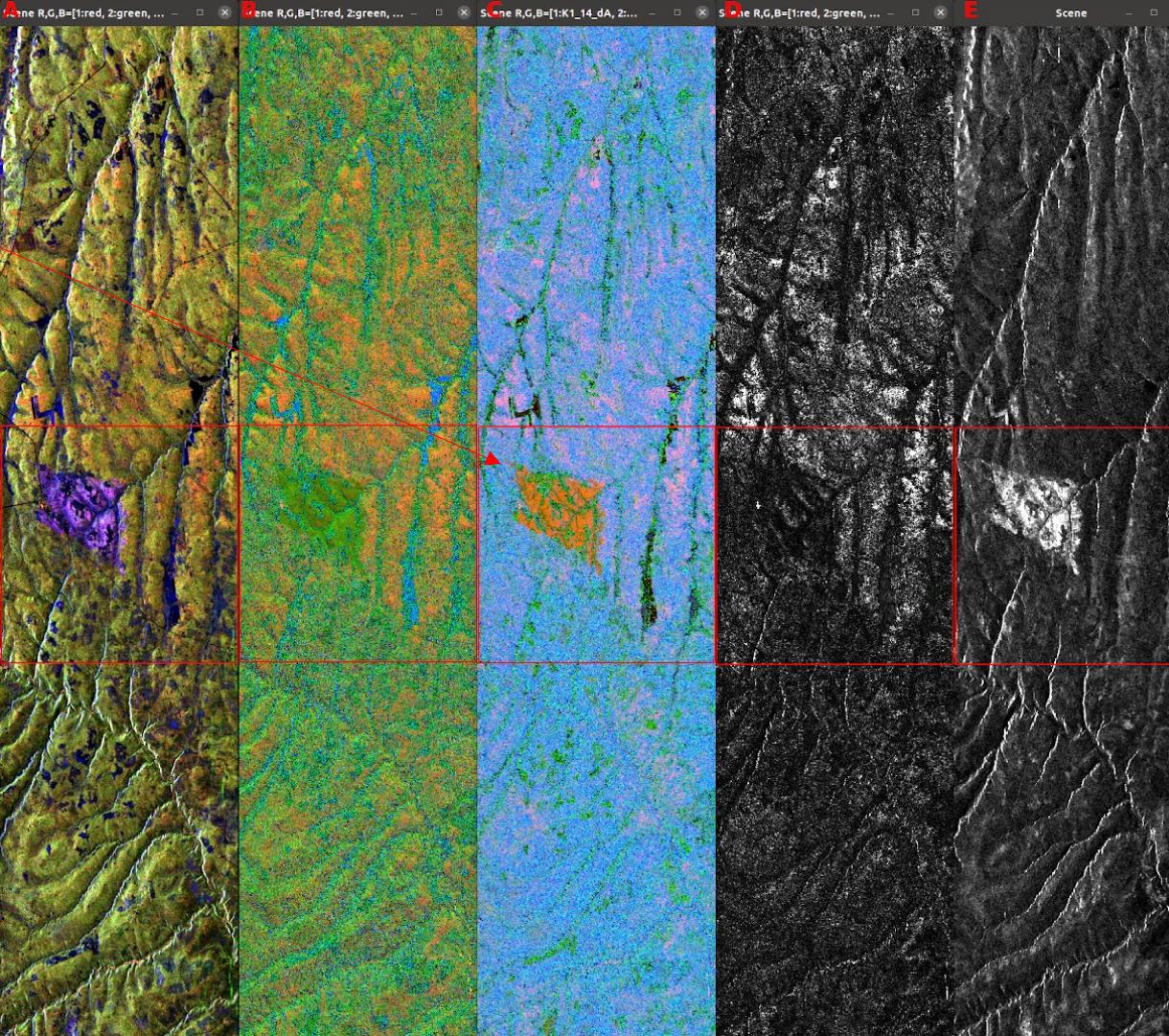


spectrR,G,B=[1:re...

I 2 III 15 NC 15. Alalyan
1971 r2 7.342679 r3 1.650
320.625000 h 328.625000
=2181 j=189; target subl
.01
.02
.01

Some
Complex
Math /
Models

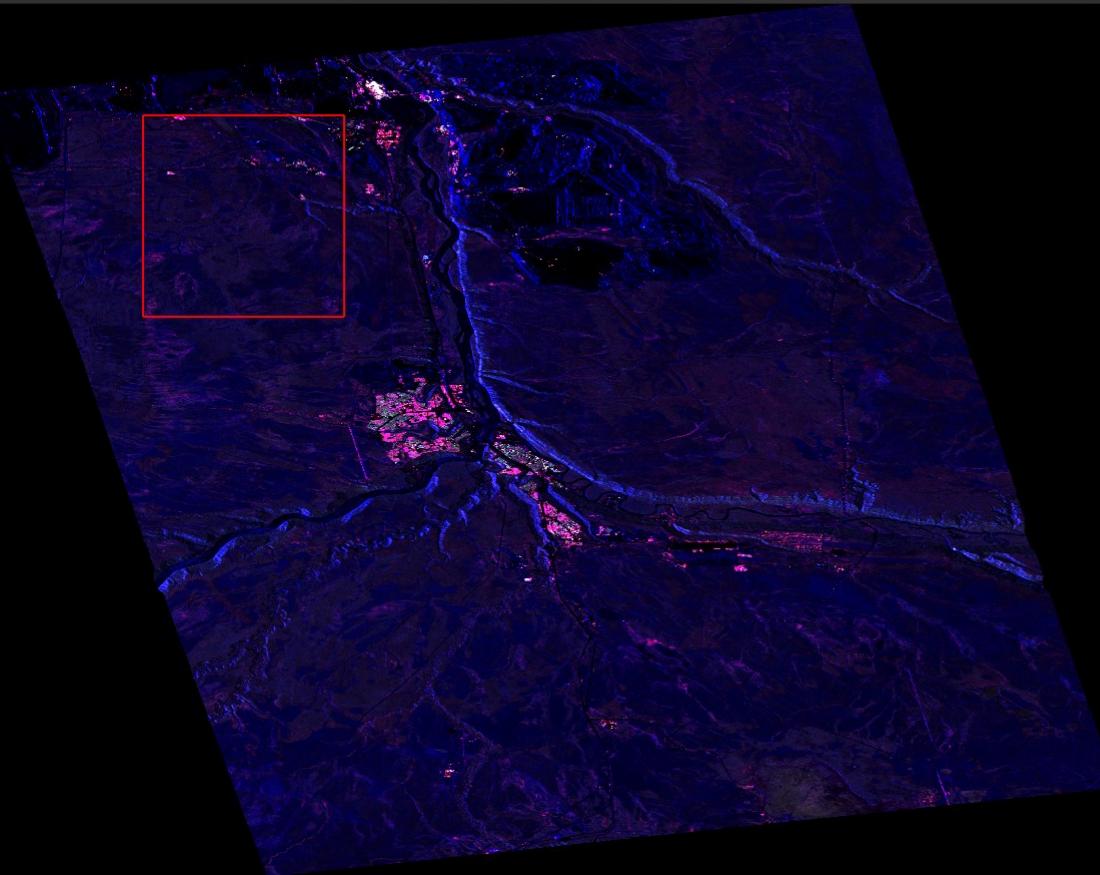
Needed to
Get over
to here..



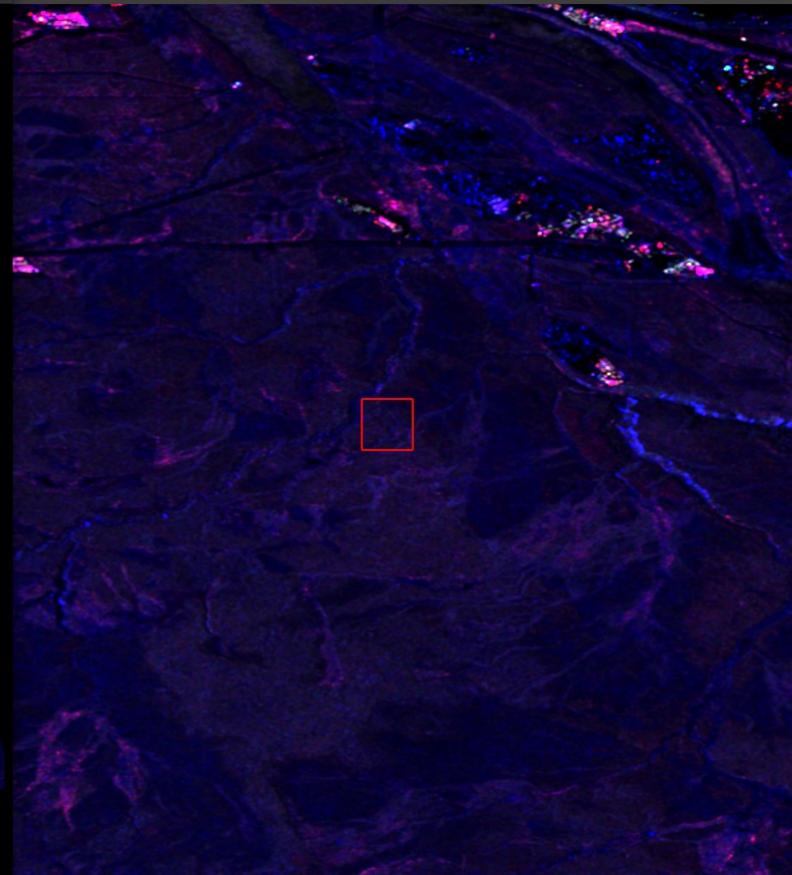
Horse River Fire 2016 L-band JAXA data

- Apr 4, 2015
- May 4, 2016
- May 18, 2016

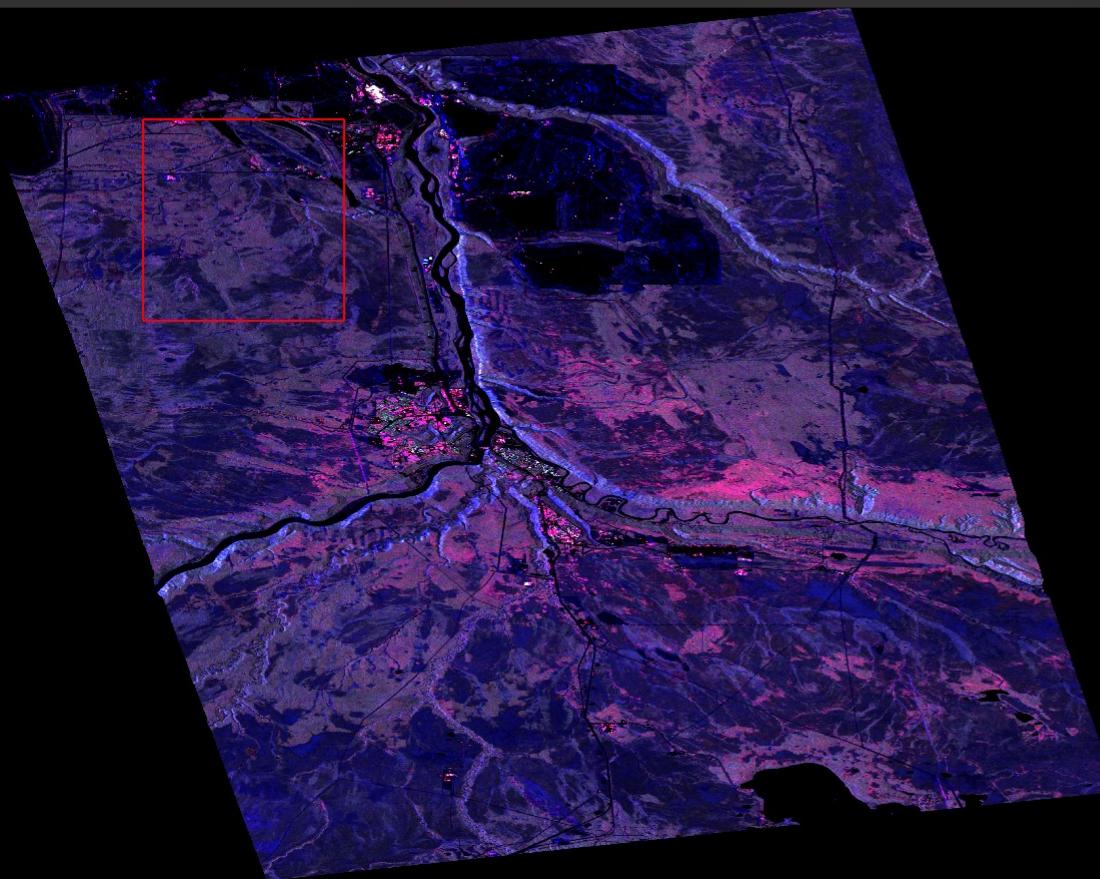
Scene R,G,B=[1:150404 T22, 2:150404 T33, 3:150404 T11]



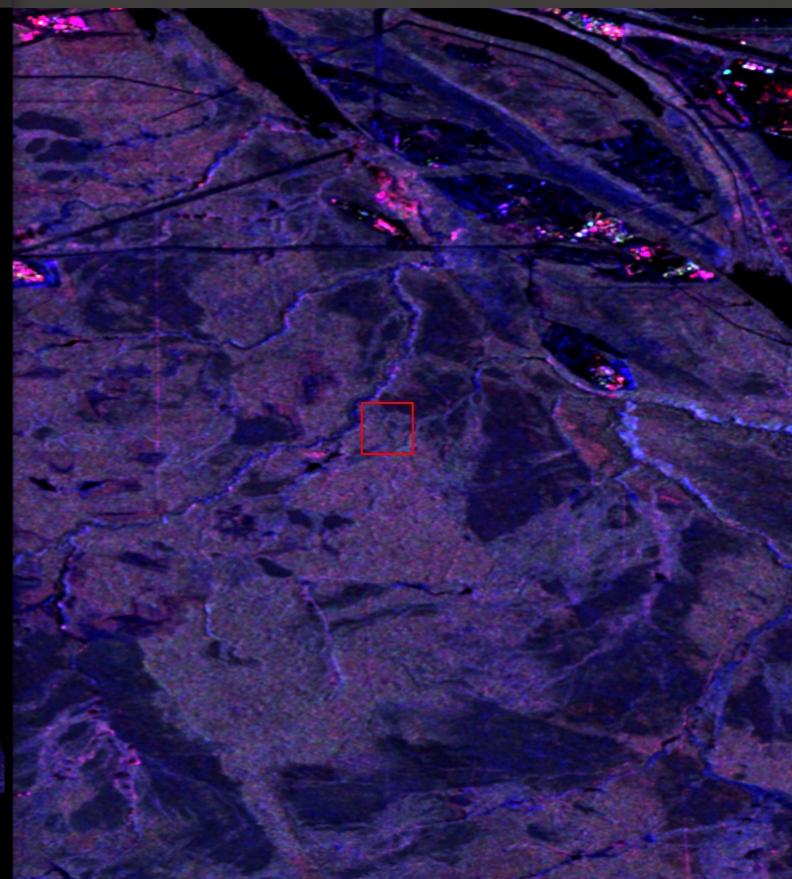
SubsceR,G,B=[1:150404 T22, 2:150404 T33, 3:150404 T11]



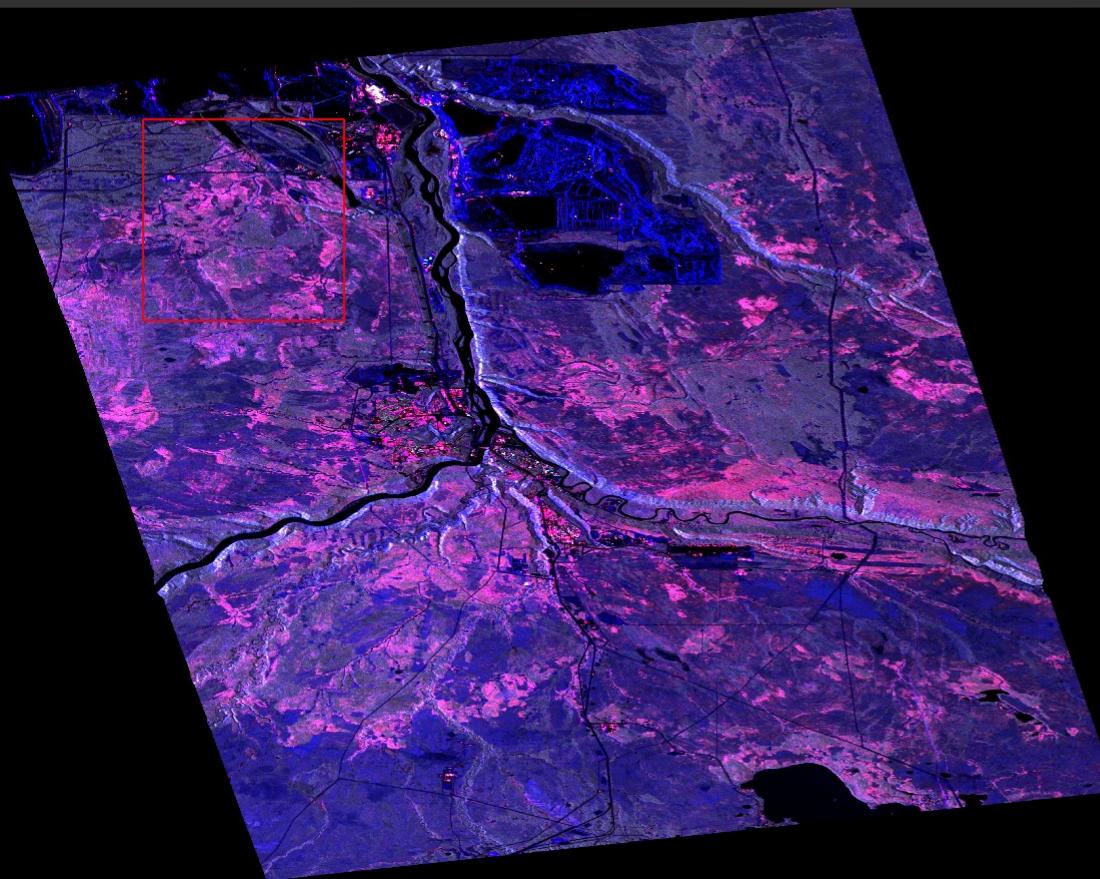
Scene R,G,B=[4:160514 T22, 5:160514 T33, 6:160514 T11]



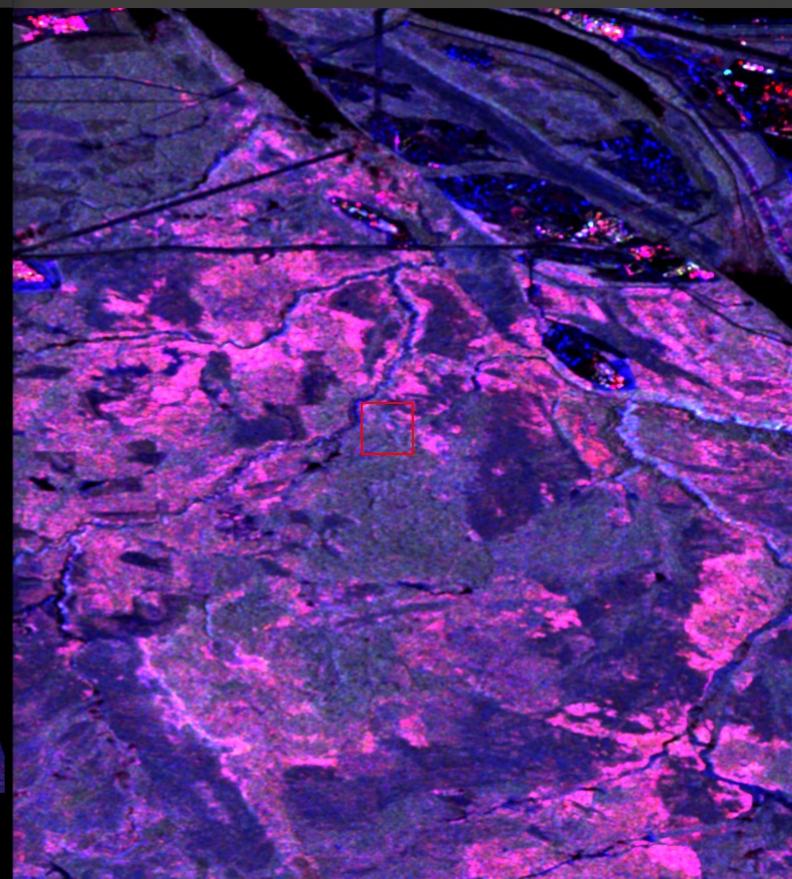
SubsceR,G,B=[4:160514 T22, 5:160514 T33, 6:160514 T11]



Scene R,G,B=[7:160528 T22, 8:160528 T33, 9:160528 T11]



Subscene R,G,B=[7:160528 T22, 8:160528 T33, 9:160528 T11]

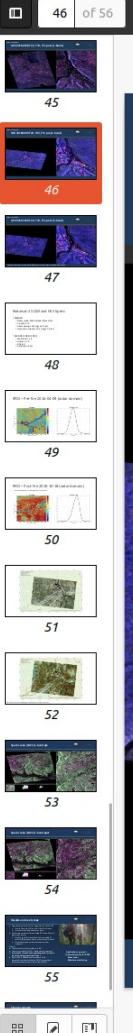


Is L-band required?

Maybe, however we already got some results with C-band

Let's revisit with more modelling?

Can physical models / extra parameters help?

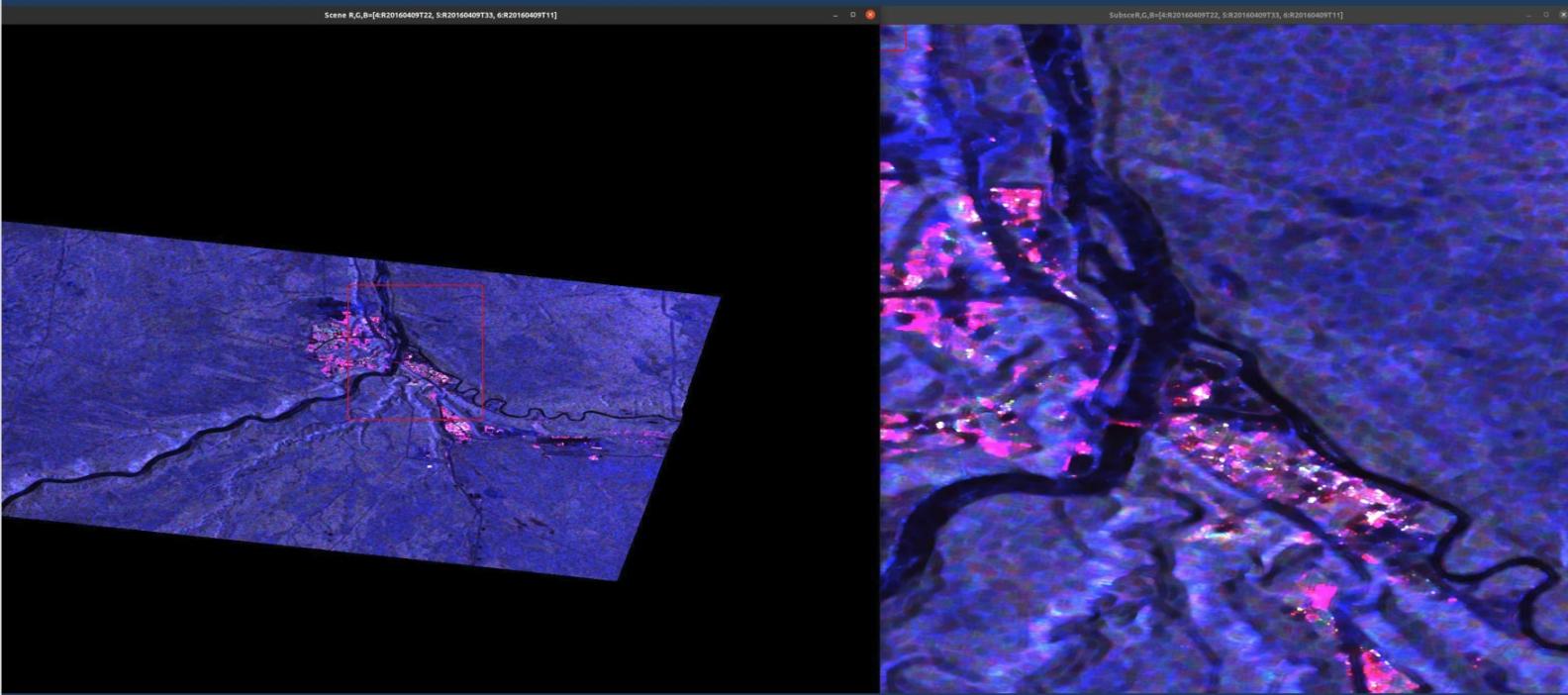


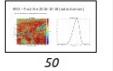
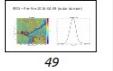
Compare with C band

RS2 20160409 T22, T33, T11 pre (C band)



BC Wildfire
Service



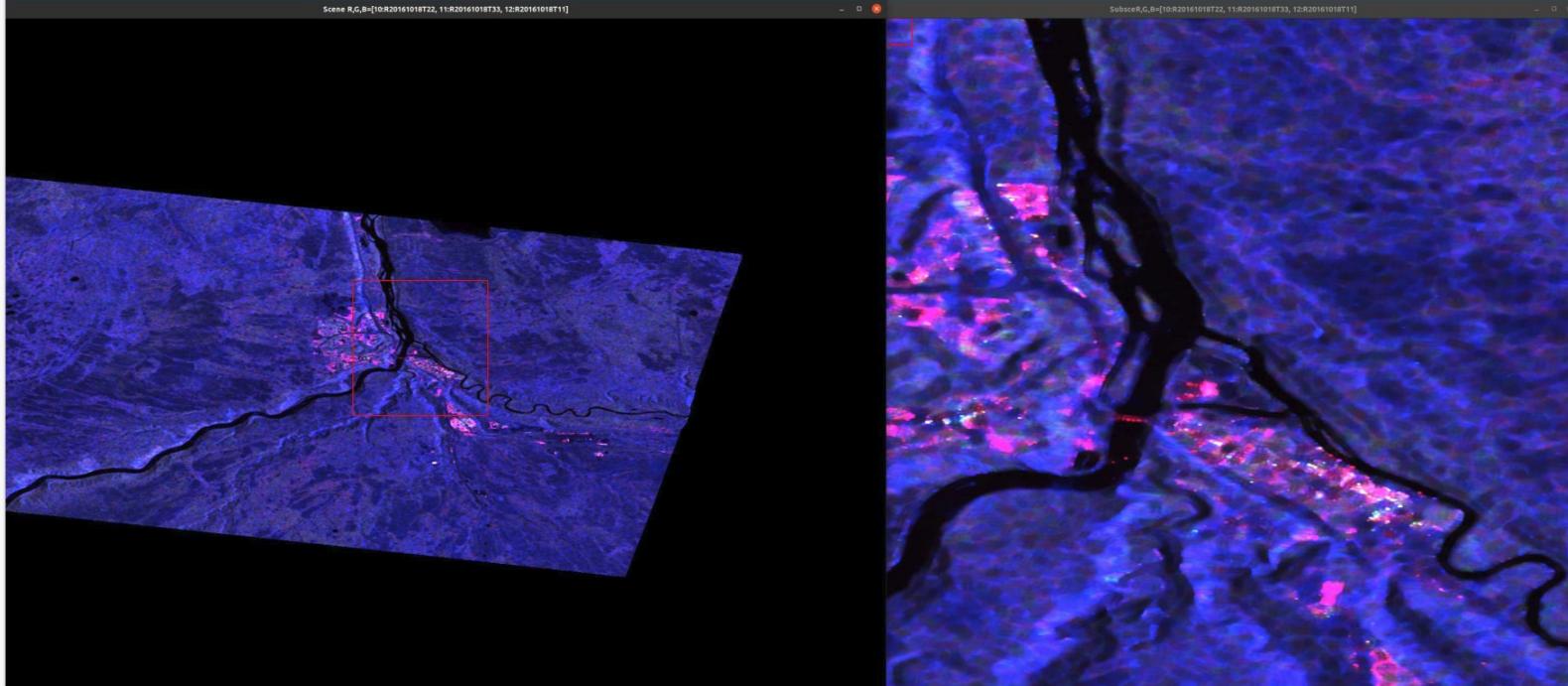


Compare with C band

AP2 20161018 T22, T33, T11 post (C-band)



BC Wildfire Service



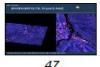
Changes are harder to see in C-band: But they are still there! Physics-based models needed



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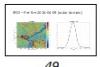
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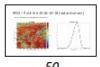
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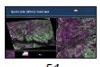
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Radarsat-2 SQW and HSV Specs

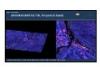
- SQ16W
 - Beam mode: Wide Standard Quad-Pol
 - Product: SLC
 - Pixel spacing: 11.8 (rng) x 5.5 (az)
 - Nominal resolution: 13.5 (rng) x 7.6 (az)
- HSV (CSI / RFDI / RVI)
 - Multilook: 1 x 4
 - Boxcar: 5 x 5
 - ENL: 63
 - Resolution: 30 m



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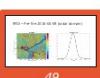
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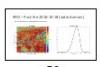
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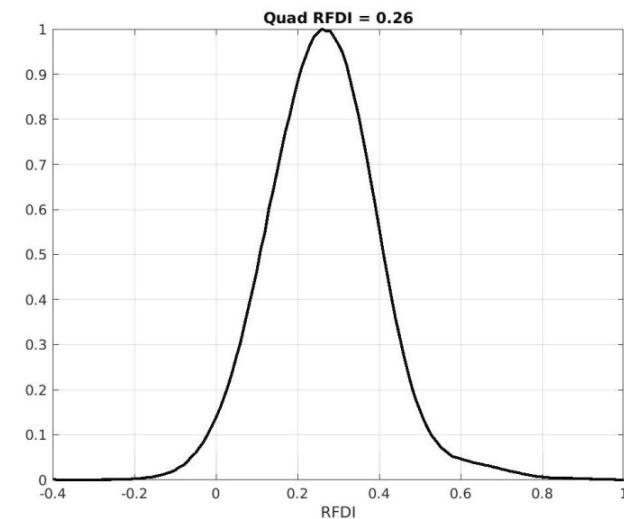
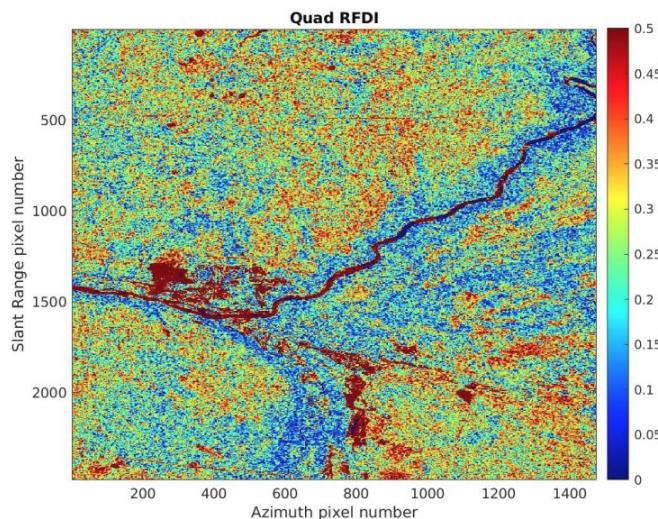


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RFDI – Pre-fire 2016-04-09 (radar domain)





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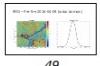
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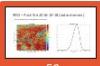
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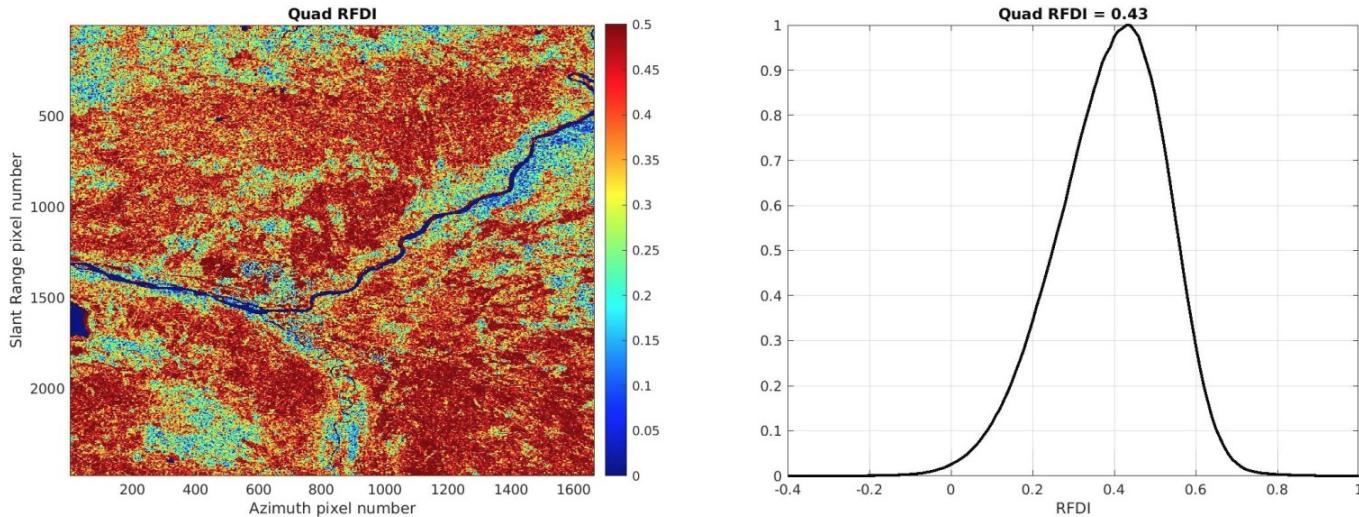
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RFDI – Post-fire 2016-10-18 (radar domain)

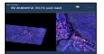
- An effective indicator for fire degraded forest structures



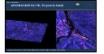
51 of 56



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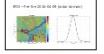
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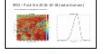
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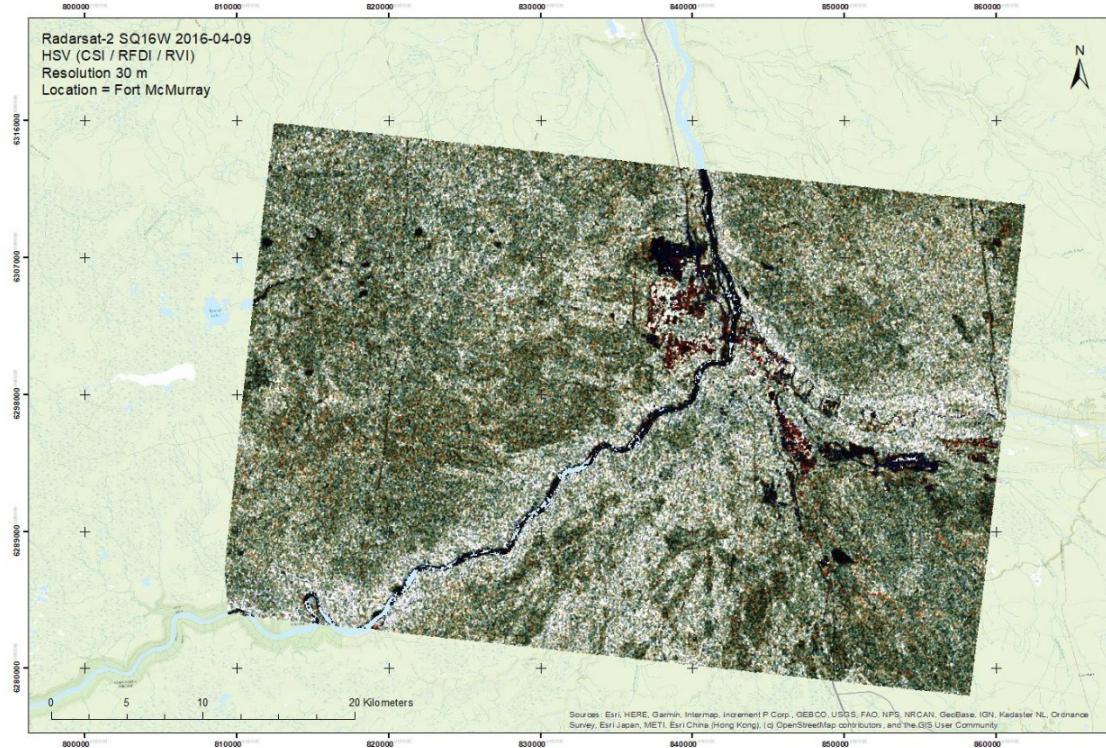
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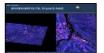




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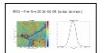
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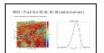
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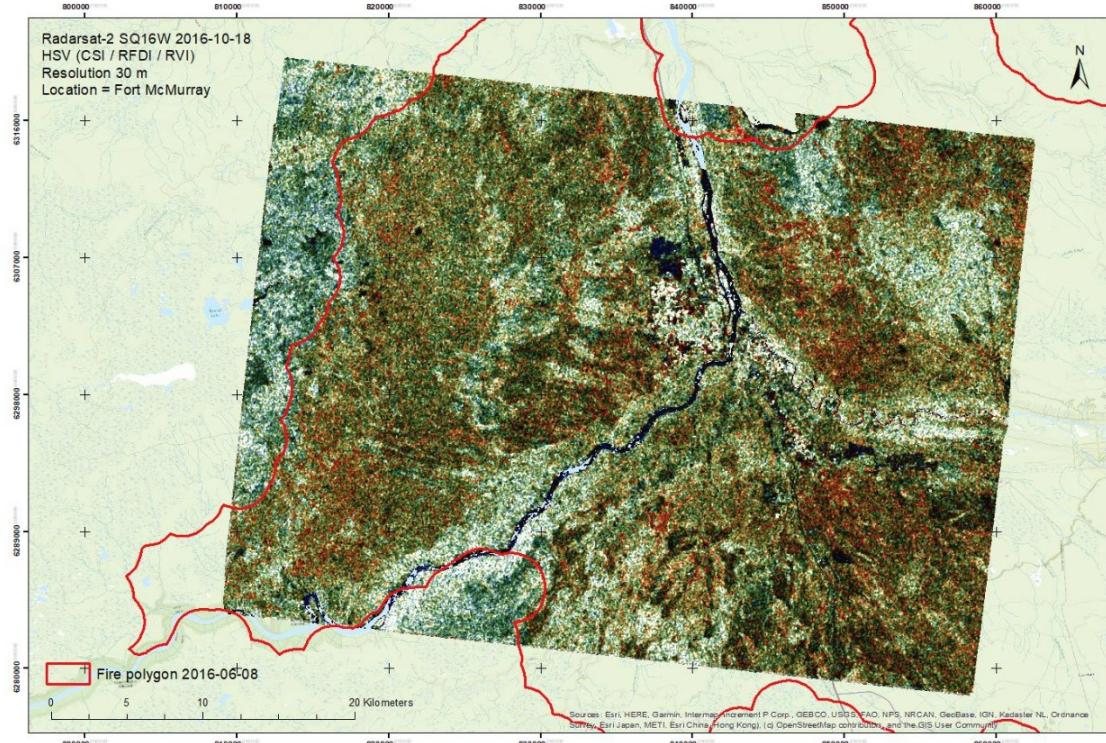
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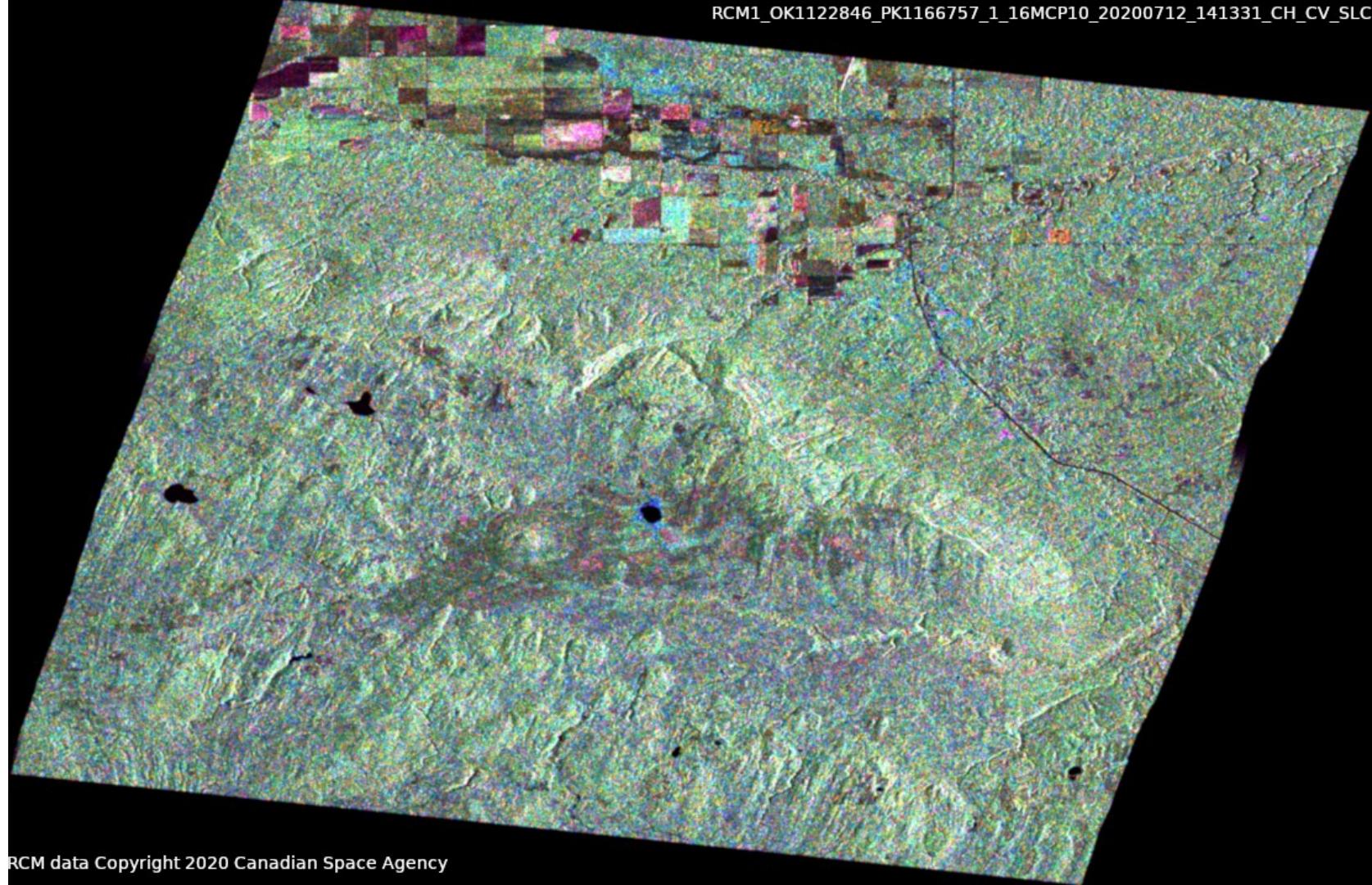
Hao Chen's group are extending these parameters to Compact-pol mode!

Even C-band Results look potentially useful for operational intelligence (so far) when clouds are in the way.....

- Quad-pol data is hard to get. Should it be?
- Need a Quad-pol (fully-polarimetric) model for change detection that uses phase
- Also interested in Dual-pol models to stay compatible and use existing / planned Dual-pol
- Open to suggestions on which models!

CP-Pol
Keg river fire

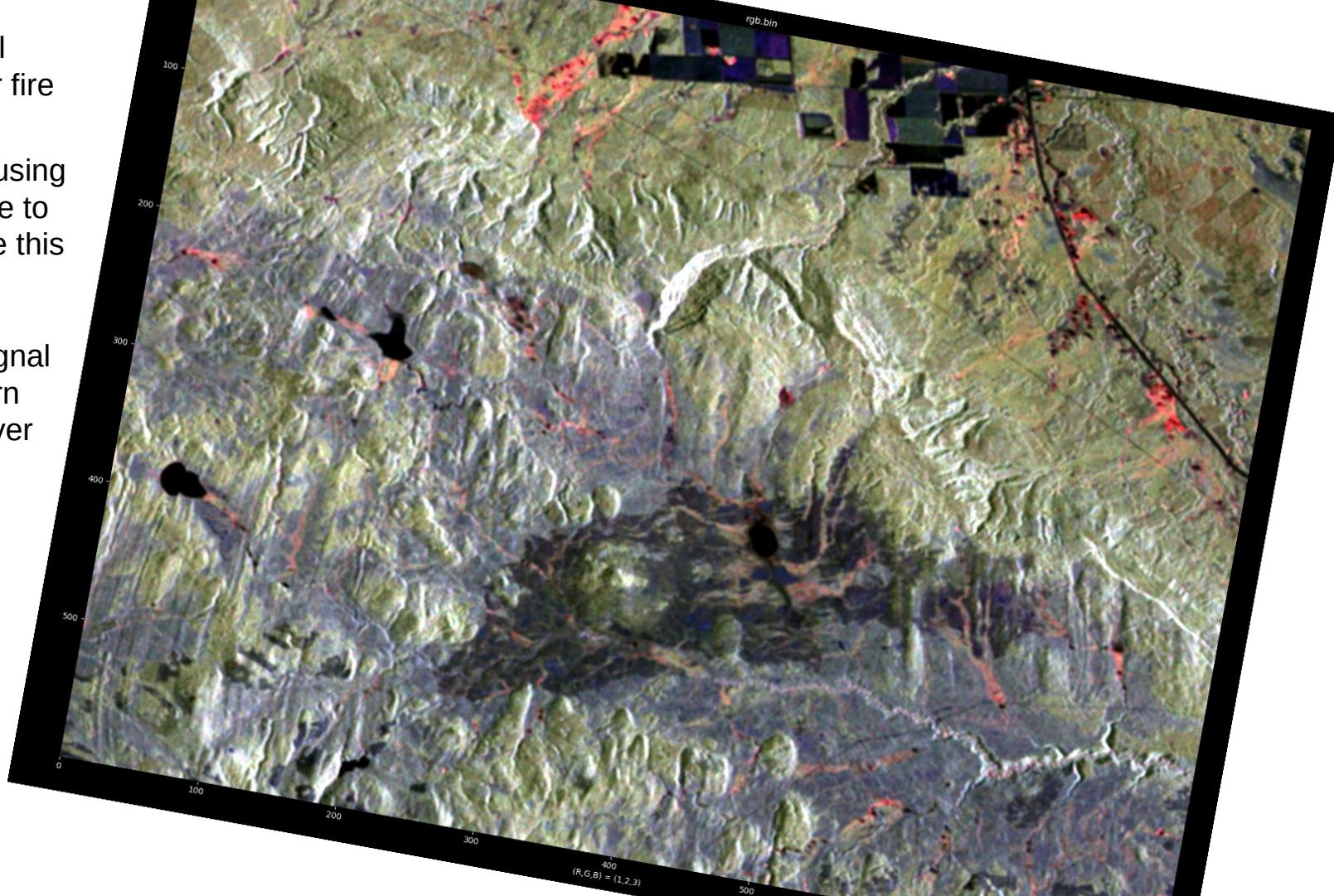
RCM1_OK1122846_PK1166757_1_16MCP10_20200712_141331_CH_CV_SLC



Quad-pol
Keg river fire

Despite using
Multi-date to
Generate this
Image,

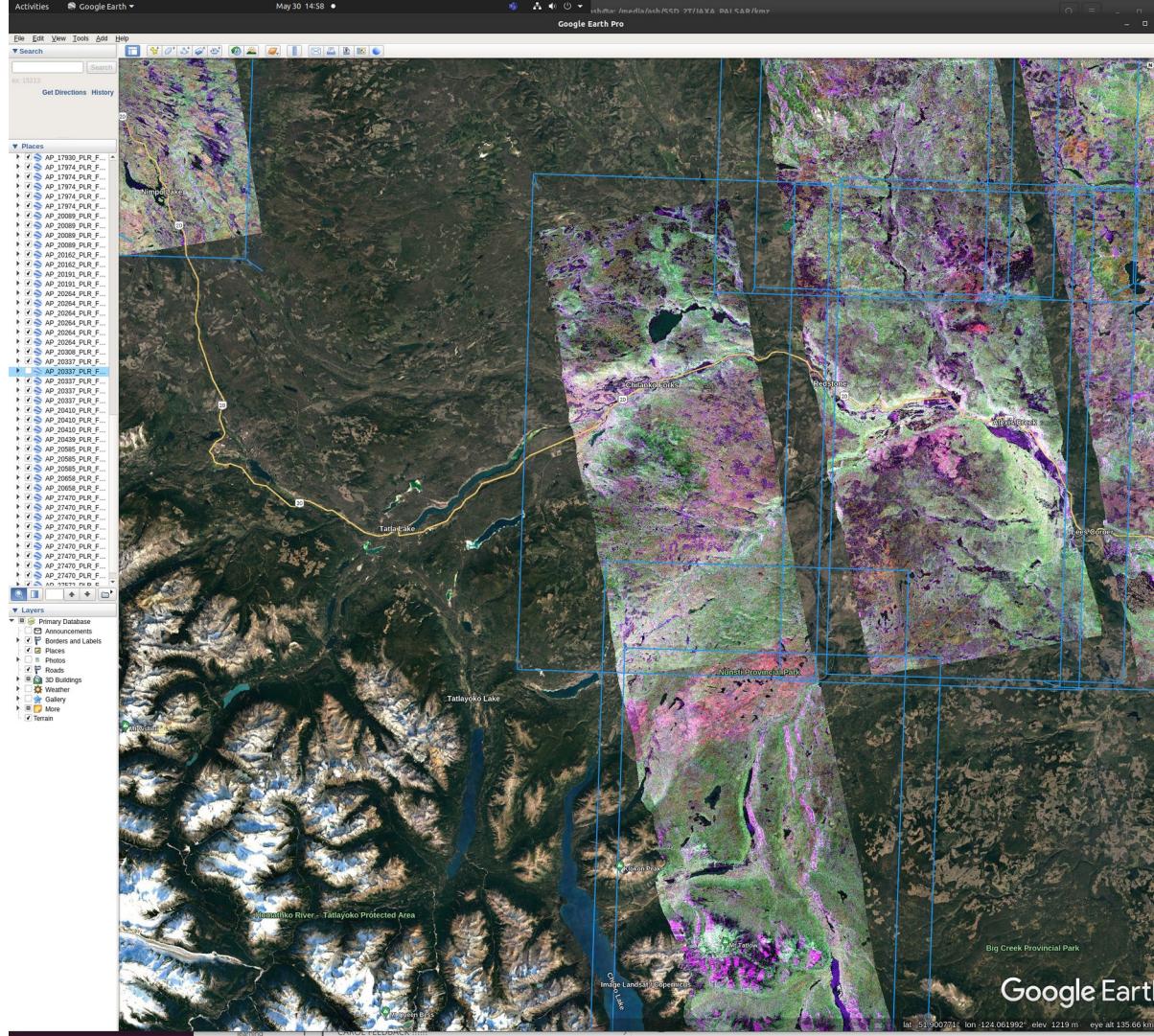
Better signal
To discern
Land-cover
types



Possible work-flow for quad-pol time series (RS2, ALOS-1, ALOS-2) what is more standard?

1. For each date:
 - } Calibrate (“write complex”)
 - } ALOS Deskew (for ALOS-1)
 - } Multilook to approx. Square pixel
 - } Box filter (window size 3, 5, or 7?)
 - } Convert to T4 matrix
 - } Range-doppler terrain correct
2. Coregistration “write stack”
3. Home made unstacking tool: dates back to T4 matrix (PolSARPro format)
4. Suggestions?

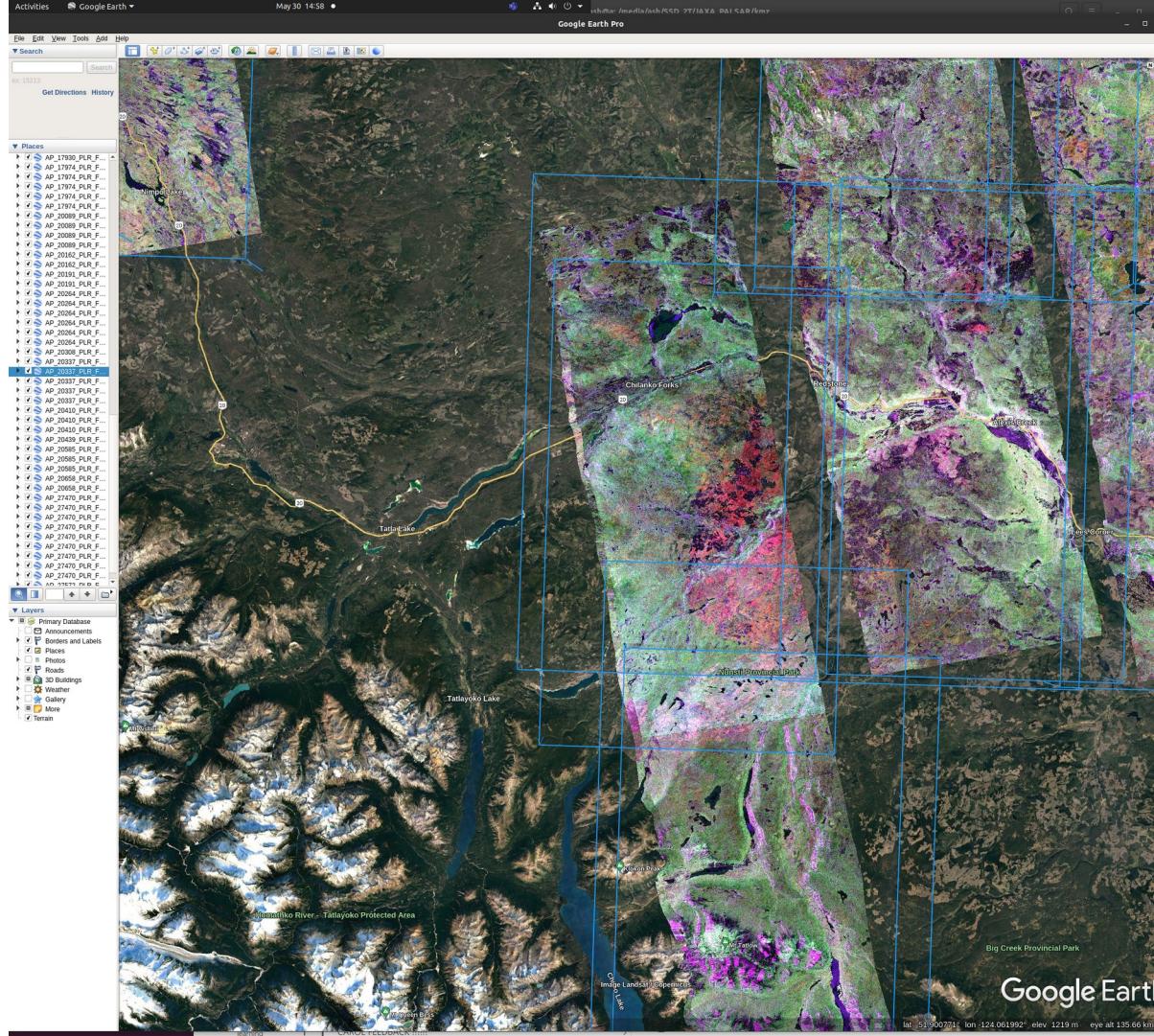
ALOS-1 Quad-pol



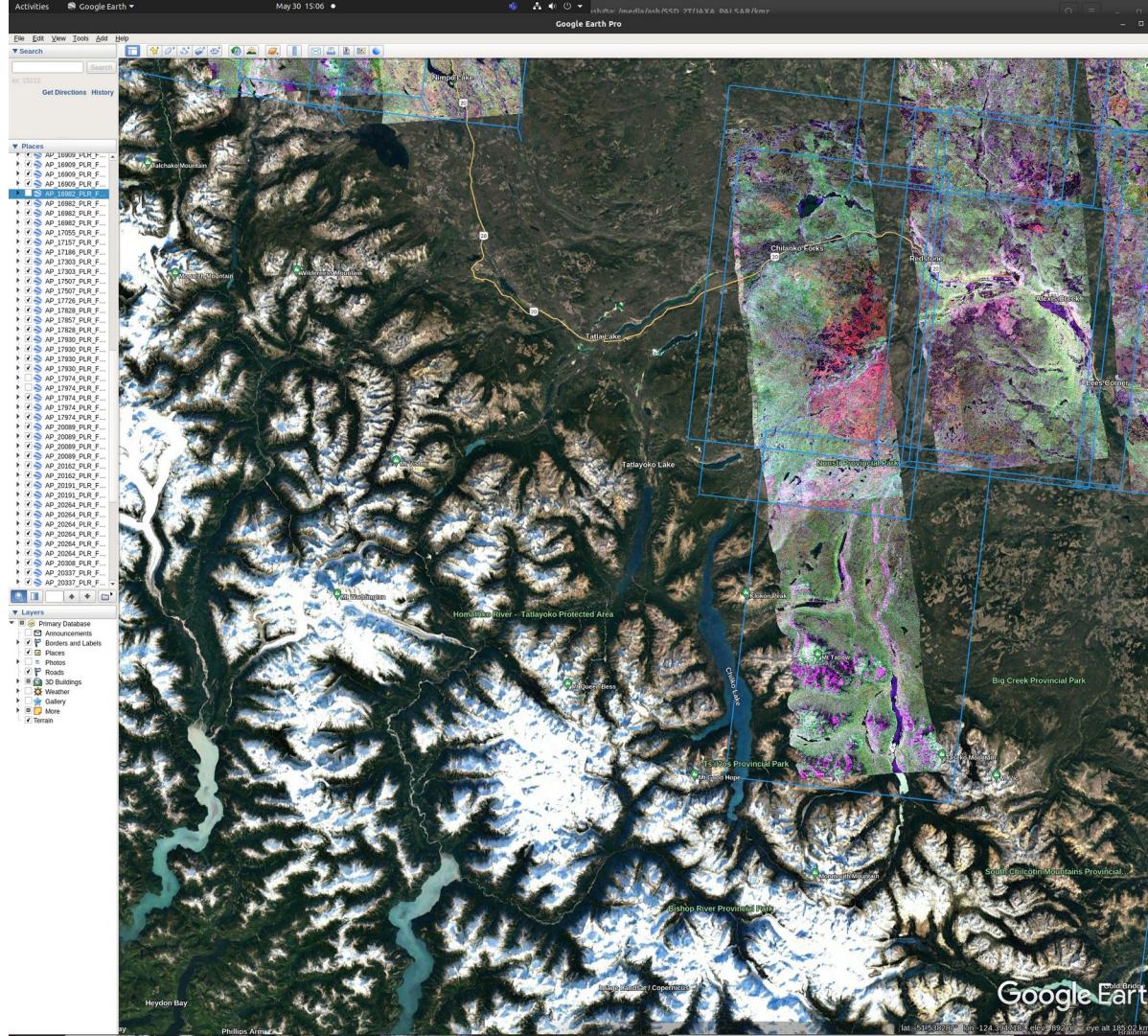
Google Earth

lat 54.9007°N lon -124.061992° elev 1219 m eye alt 135.66 km

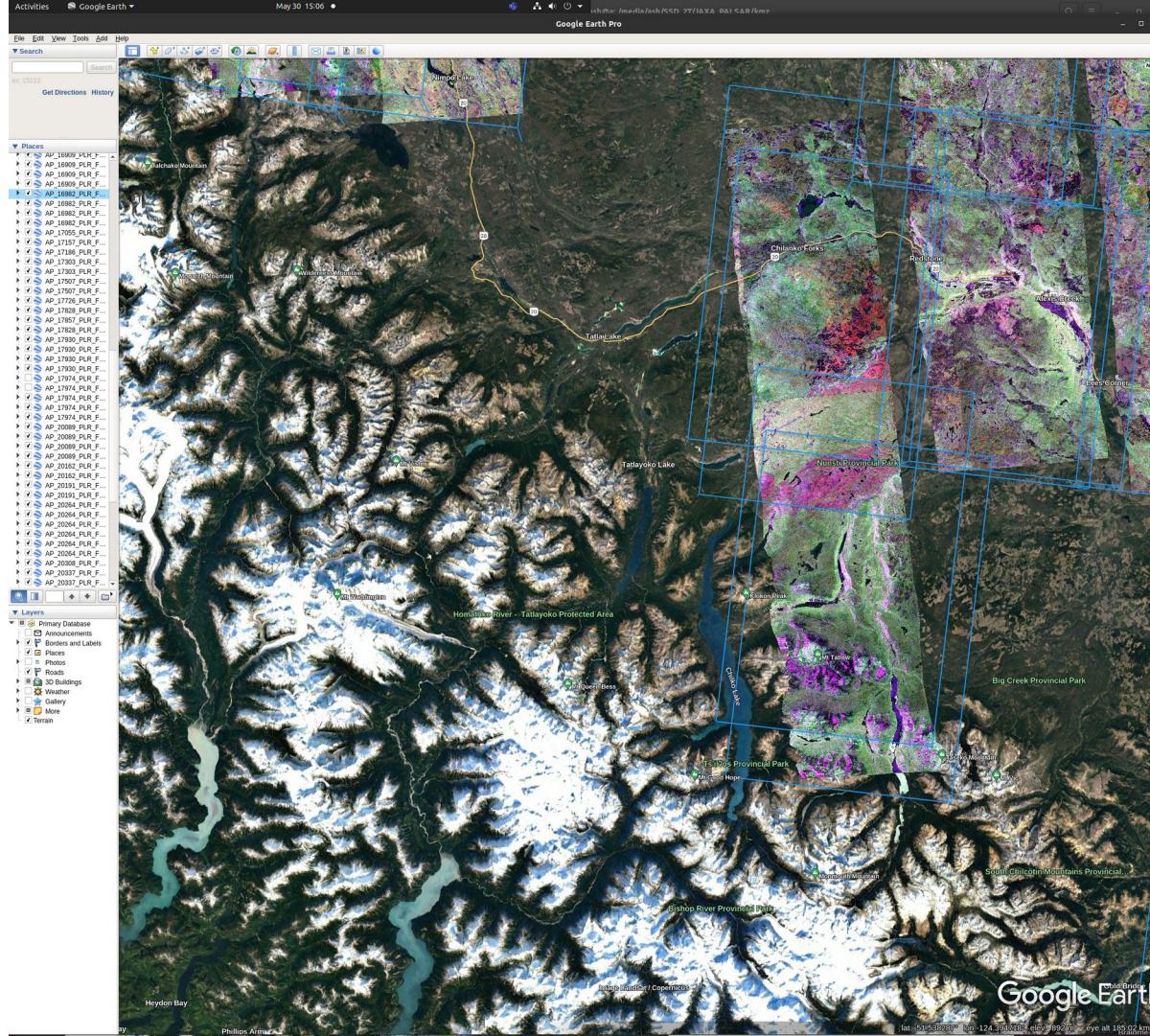
ALOS-1 Quad-pol



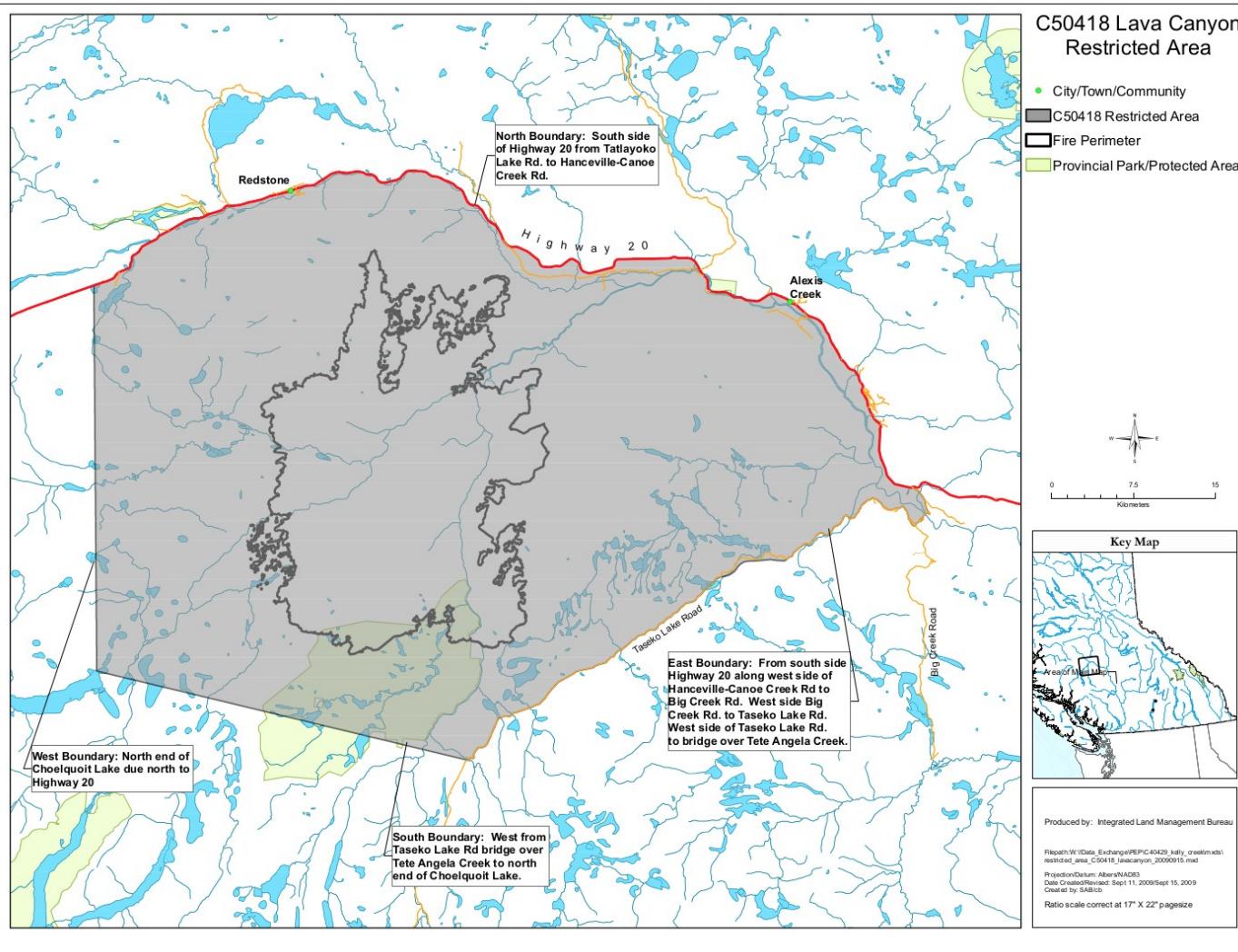
ALOS-1 Quad-pol



ALOS-1
Quad-pol

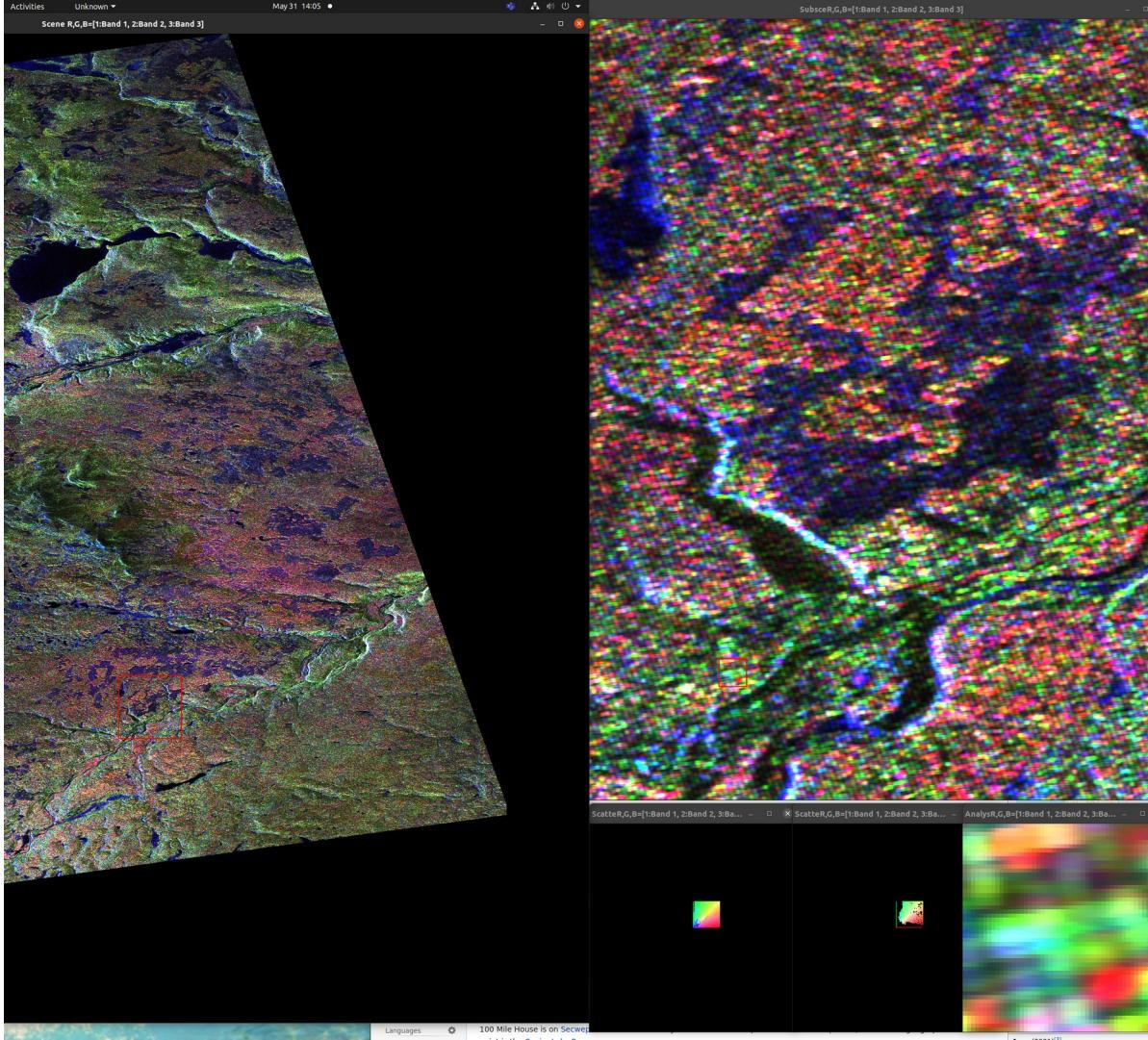


2009 Lava Canyon Fire

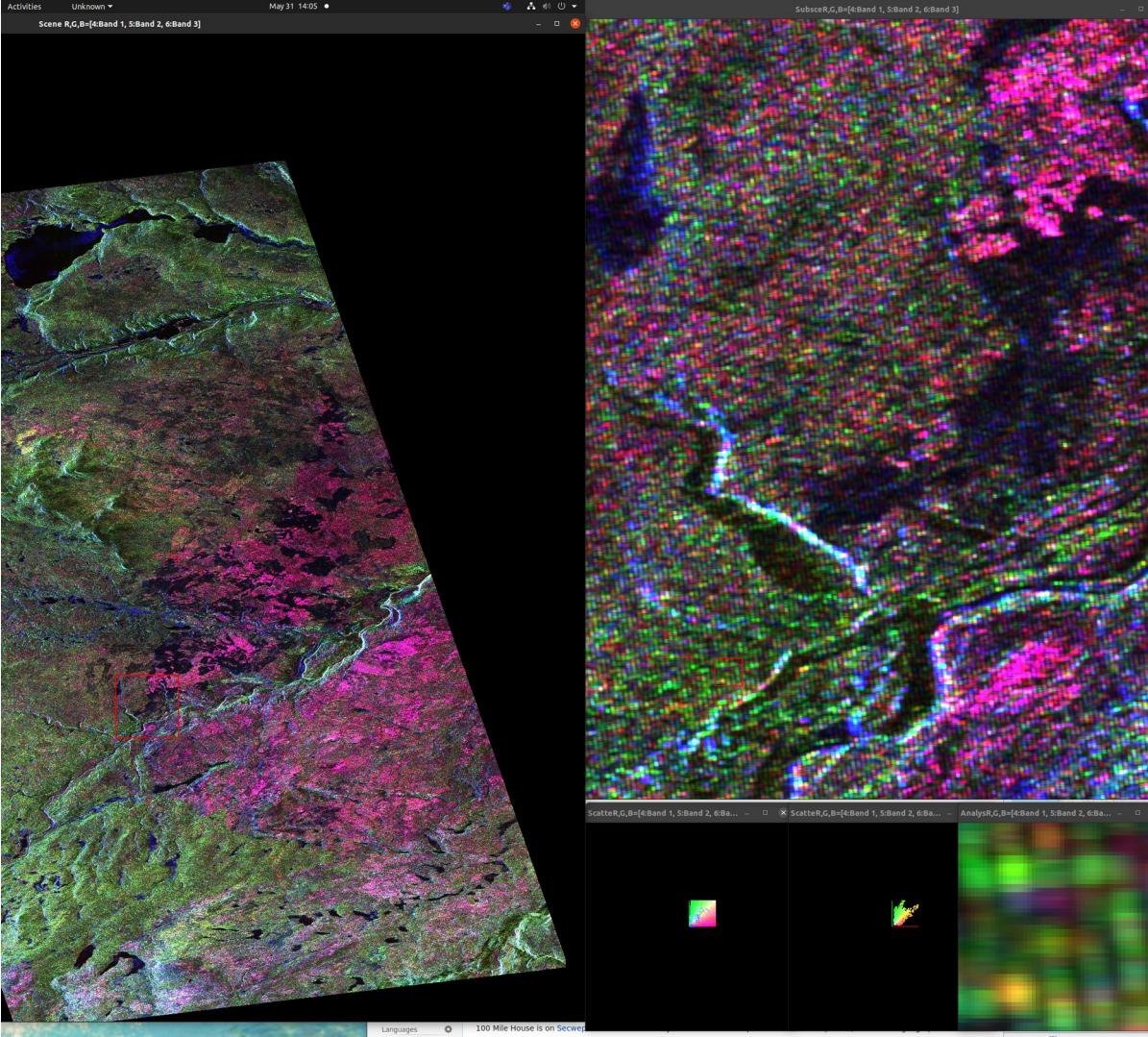


ALOS-1 Quad-pol

Pre



ALOS-1 Quad-pol post



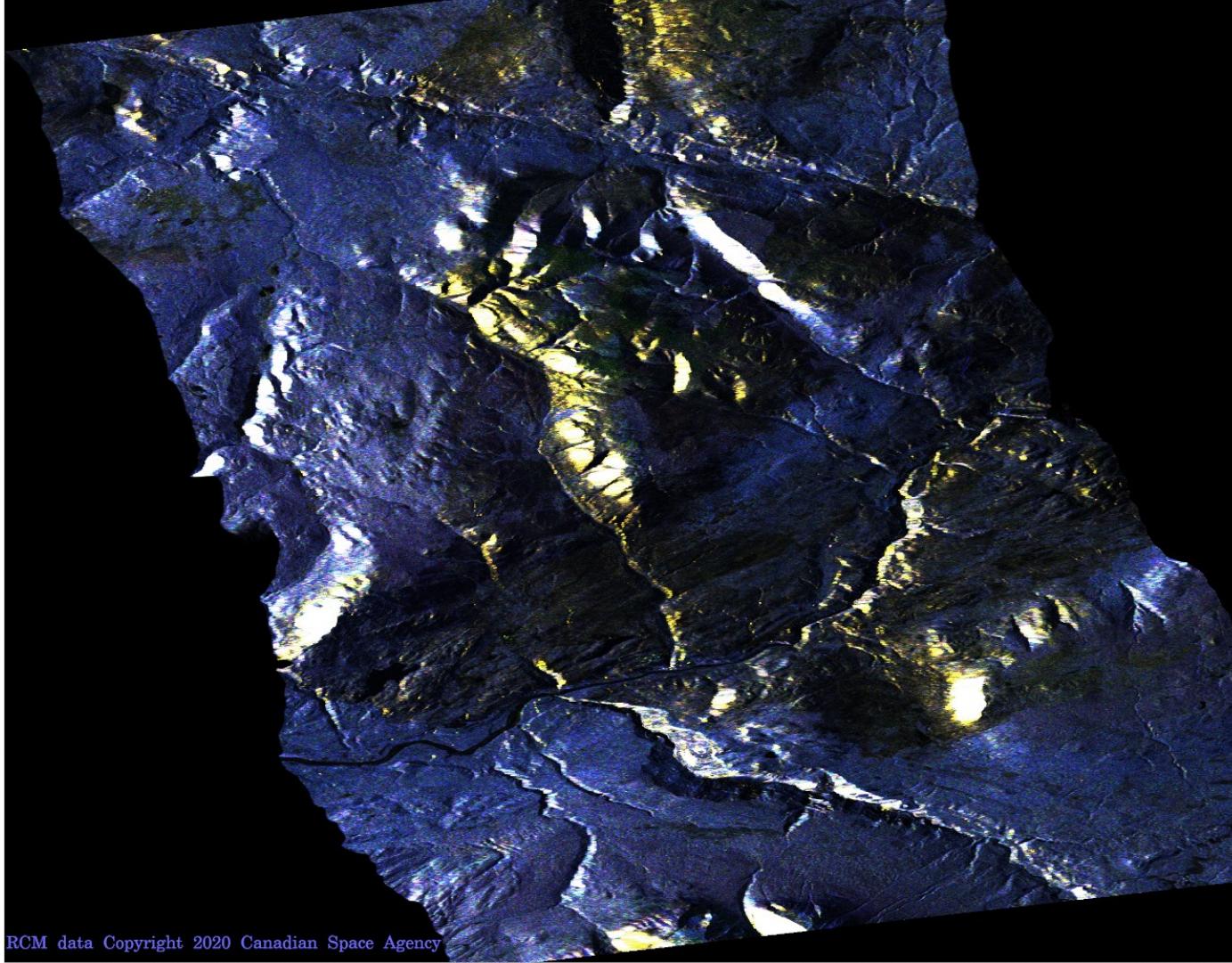
Sentinel-2
RGB

Telegraph
Creek fire



RCM
Quad-pol

Telegraph
Creek fire



Vis:
AFT group
“scm”
method

Despite
strong
terrain, fire
pattern still
visible in
quad-pol
single-
frame

Thanks

All feedback welcome!

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