All Hazards Application of RCM in BC

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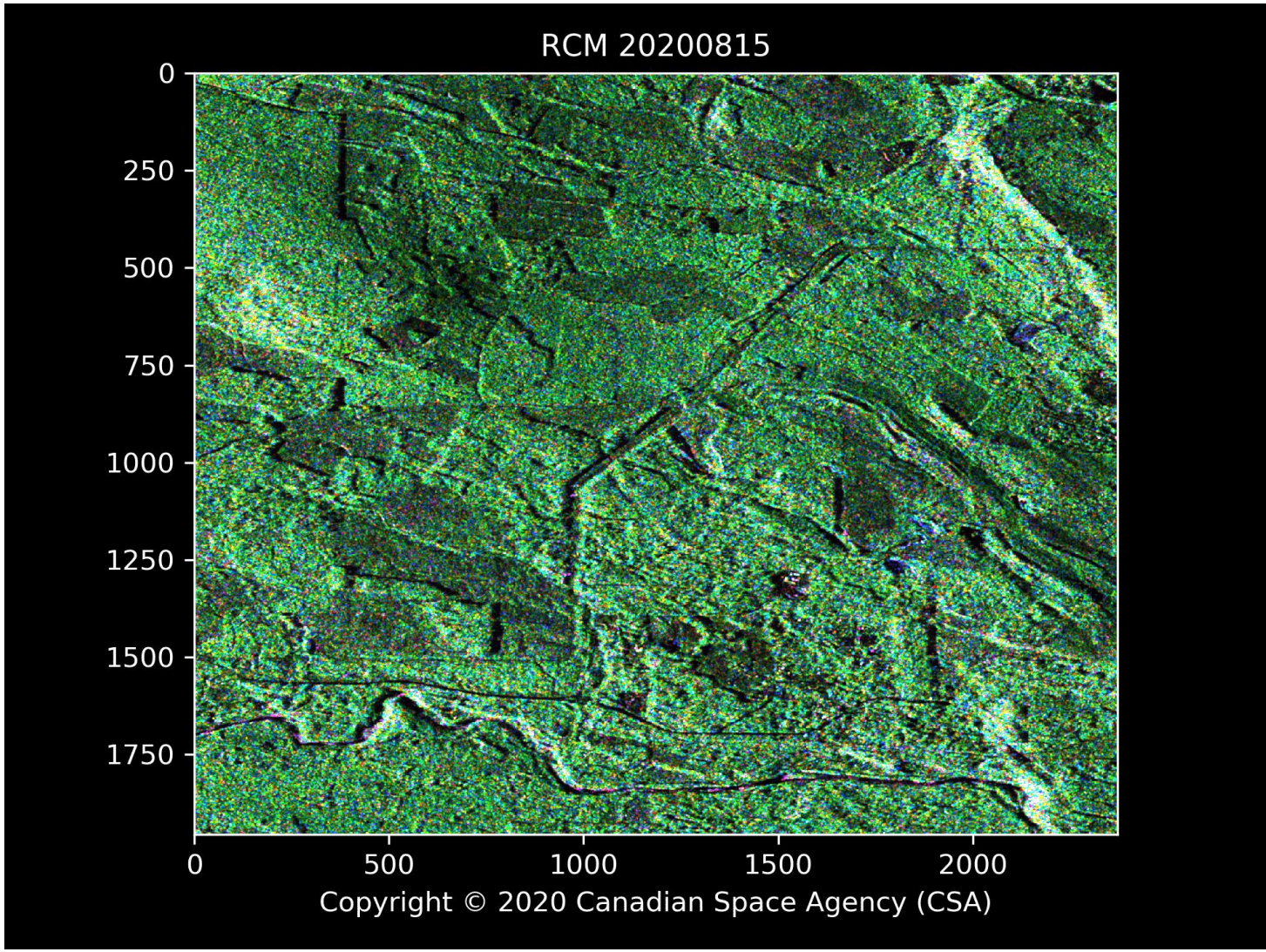
BC Wildfire Service (FLNRO)
Digital Platforms and Data Division (CITZ)

Canadian Space Agency (CSA) Radarsat Constellation Mission (RCM) Users' Group Meeting (Nov 25th, 2021)

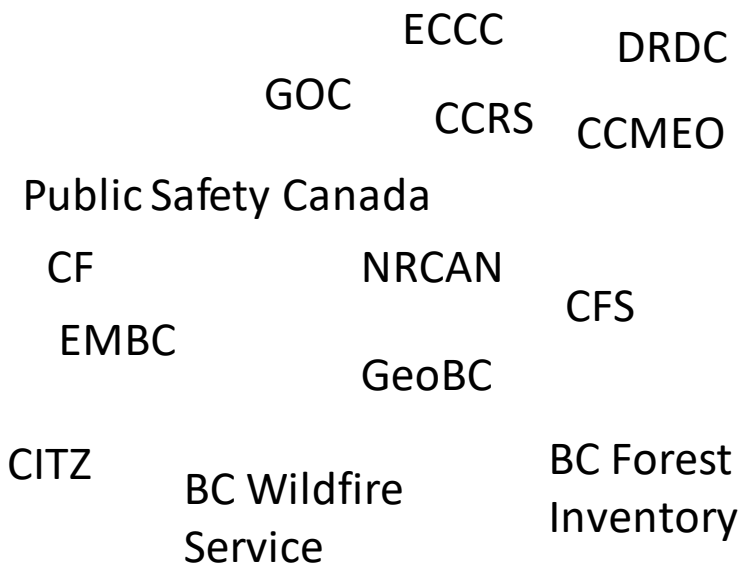
Roadmap

- Context
- Data Science approach
  - Partnerships and Capacity building
    - incl. GeoSci and RS
- BCWS Predictive Services Unit
  - Mandate and collaborations
- *RCM CP-Polarimetry 5m*
  - *Sparks Lake mega-fire (2021)*
- Outlook
  - Collaboration!



Context

- **EMBC leads for emergency response (PECC):**
  - All natural hazards
- MoH leads for Public health hazards (HECC)
- Wildfire mgmt branch is responsible for fires
- …



- Here to help build relationships with CSA and key partners

- Thanks for the opportunity to work with you
  - Feel free to task me Ashlin.Richardson@gov.bc.ca

BCWS Predictive Services Unit

- Report to Deputy Director, Wildfire Operations
  - Meteorologists
  - Fire Behavior Analysts
  - Agile Dev Team: software engineers, UX/UI, scrum-master
  - Data Science team: enhancing operational use of RS platforms
    - promoting continuously-updating geo-intelligence

Mandate:

- Daily and increasingly-proactive situational awareness to support Prevention, Preparedness, Response, Recover

07/27/201 How satellite information flows to Canadian decision-makers in case of wildfires and other disasters – SpaceQ
https://spaceq.ca/how-satellite-information-flows-to-canadian-decision-makers-in-case-of-wildfires-and-other-disasters/

File photo: How we monitor wildfires is about to change. Credit: Canadian Space Agency.

With the intensity of natural disasters and severe weather accelerating amid global warming, governments – including Canada – are working to speed up the satellite information flow as best as possible to the people on the ground – sometimes, literally, the wildfire firefighters holding the hose against the flames.

Data Science

- Math, stats, computing science, business acumen, domain expertise
- Transparent reproducible methods. Data-driven decisioning..
- Partnerships & capacity building.. DS CoP and RS CoP!
- Non-proprietary languages, scaleable systems..
- Work in open w cross gov teams
- Collaboration
- Speed of trust
- Key support for GBA+ in providing data-driven sights into differential impacts (and determinants) of public policy
- DS is one cheerleader for these things among many others..

Personal spin: emphasis on approaches that generalise across applications

Me

I like working on problems that are almost intractable!

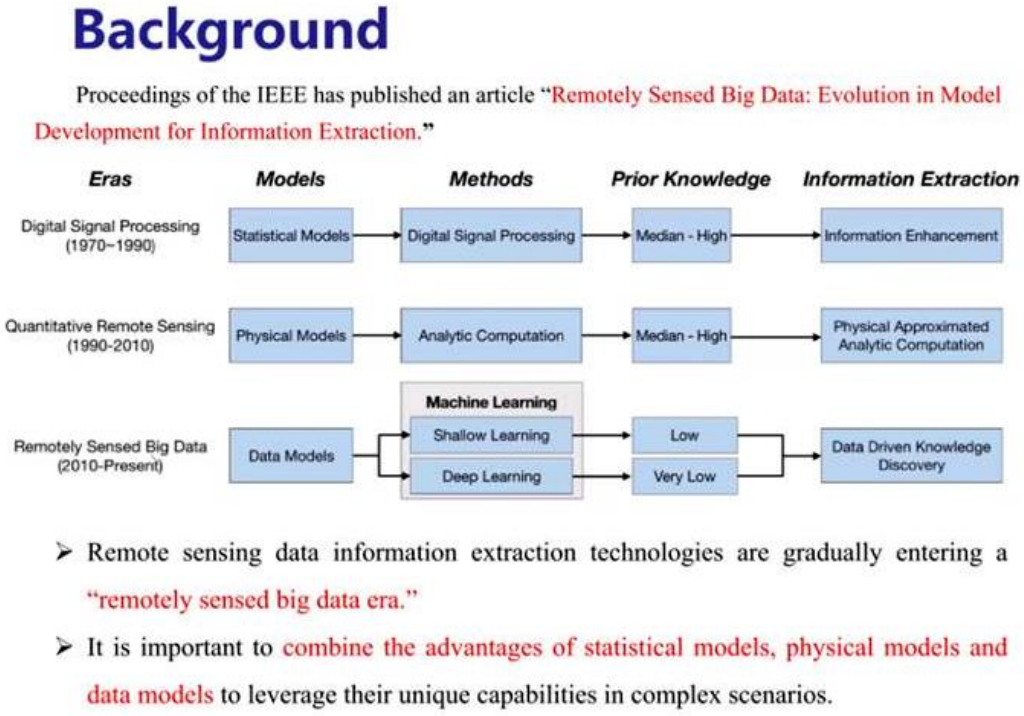
(BC Gov 2018-) concurrent projects:… **Data Integration**

- Data Innovation Program (DIP)
  - population scale --> longditudinal research on services and outcomes
    --> best outcomes for Citizens
    - Large multi-TB **tabular data**

- **Fuel Type Layer project (FTL)**
  - landscape scale data integration --> outcomes
    for ecosystem / landscape risks...!
    - **"big" Remote Sensing data**

…. real world:
Need statistical, physical and data models!

How to do this with tabular data and why does it matter?



Sep 21, 2020 Xing Mengdao (Zoom IEEE GRSS presentation

Answer: a story needs time and space!

une histoire a du temps et de l'espace

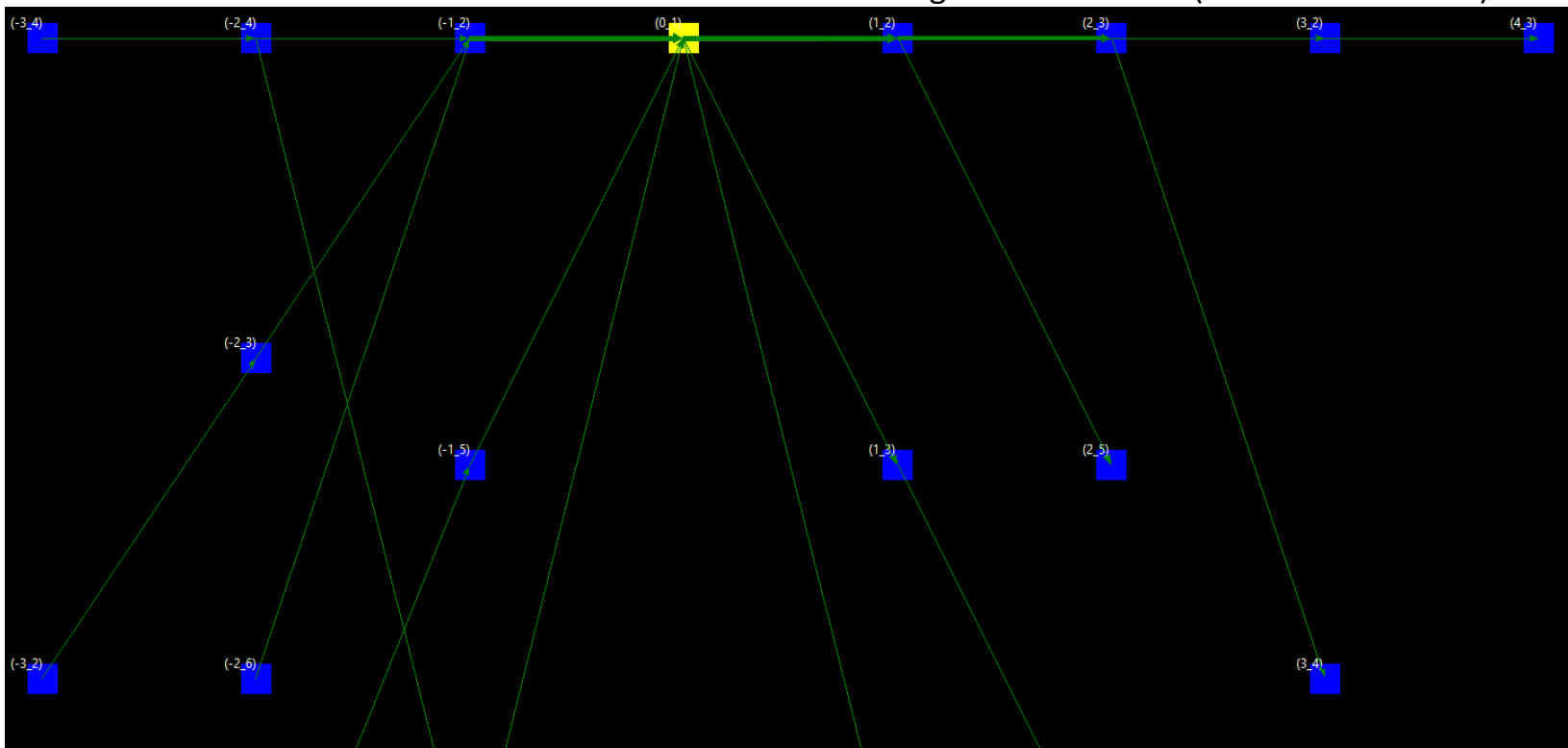
Hourglass / Sablier

- Not a black box
- An investigative tool
- Makes the invisibile, visible
- Hetero tabular data from complex arrays of services
- Highlights repeating patterns of outcomes and determinants, to provide critical info:
  - **where to target prevention or intervention**

..Has a built-in complexity knob
That serves as an approach to
The data anonymization
Problem :)

Also has a built-in redaction button

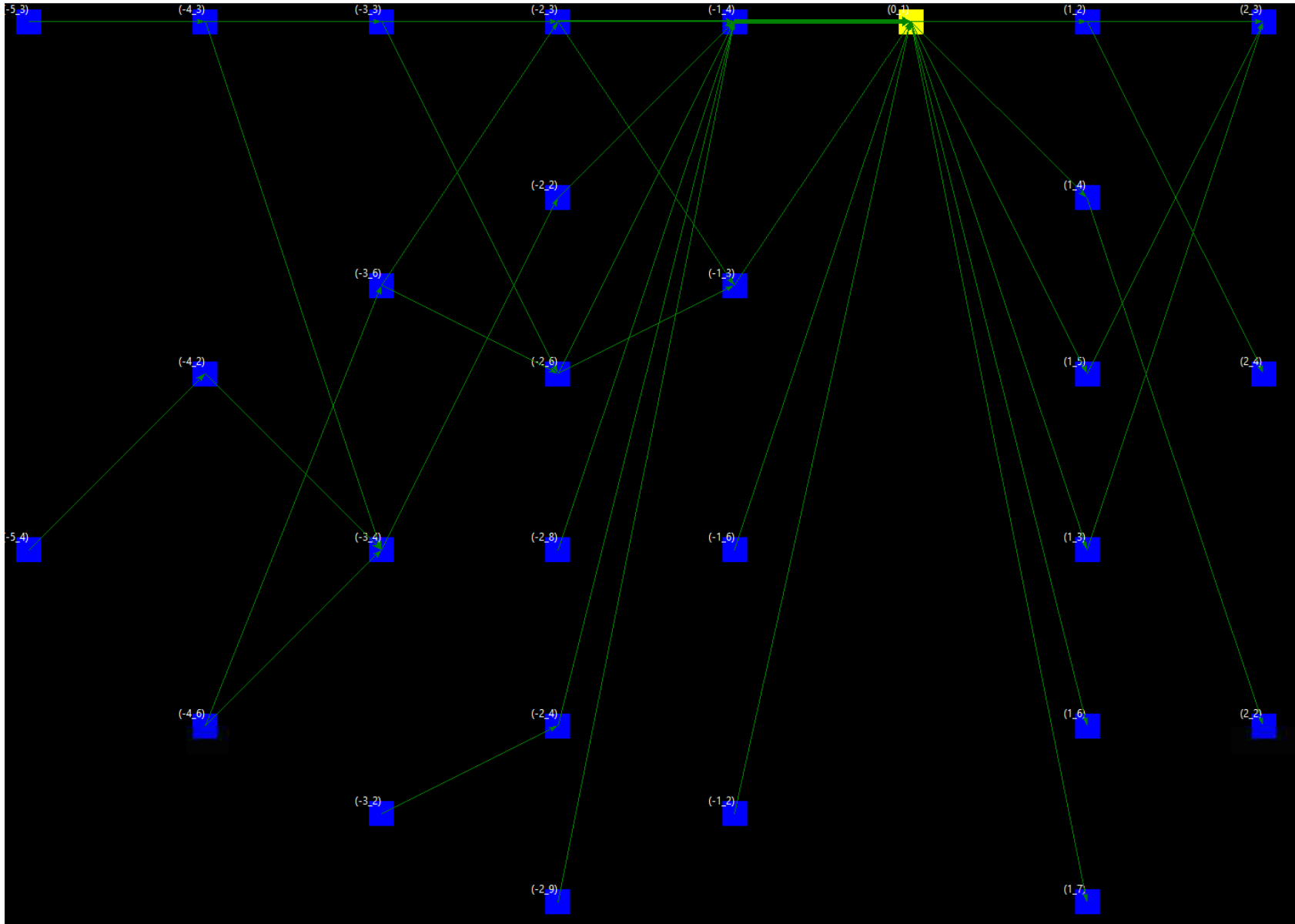
Indeterminate diagnosis is resolved (condition redacted)



Wanted to approach Machine Learning's goals in a transparent, accessible, non-subjective, way leading to a visual output that translates into words (withoutsophisticated math or stats)

Effect of a disease

- Differential risk profile
  - Exposure is not uniform
- Time asymmetry:
  - More info available about situations leading up to the Disease, rather than away from it
  - Disease inserts disorder into the patient journey
  - The hazard / risk landscape associated with the Disease outcome, changes depending on which direction in time we are looking



What does it have to do with Ecosystem monitoring?
"Easy"...
- 1) supposing we curate and discretize our remote sensing data appropriately, problem solved!

But not quite, still lots of work to do...

- 2) Also apparently the planet is sick and it needs help!

What about Space Mission planning for categorical inputs / outputs?

Can we map fire progression w CP-pol?

- Probably

scientific reports

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Article | Open Access | Published: 28 January 2020

Near Real-Time Wildfire Progression Monitoring with Sentinel-1 SAR Time Series and Deep Learning

Yifang Ban, Puzhao Zhang, Andrea Nascetti, Alexandre R. Bevington & Michael A. Wulder

Scientific Reports **10**, Article number: 1322 (2020) | Cite this article

Can. J. Remote Sensing, Vol. 37, No. 5, pp. 1–10, 2011

Mapping fire scars using Radarsat-2 polarimetric SAR data

David G. Goodenough, Hao Chen, Ashlin Richardson, Shane Cloude, Wen Hong, and Yang Li

Abstract. Climate change is increasing the frequency and size of wildfire events in Canada's forests. The size, distribution, and remoteness of boreal forest fire events make them a challenge to accurately monitor. Radarsat-2 is all-weather radar technology and offers high spatial resolution, cross polarization, polarimetric capabilities, and a wide swath width. In this paper, Radarsat-2 fine quad-pol data were analyzed utilizing the polarimetric phase information to map historical fire scars over two main study sites. The study demonstrated that historical fire scars, less than 10 years old and without strong topographic variation, had distinct polarimetric signatures with relatively higher quad-pol probabilities, leading to detection with low false alarm rates. By combining polarimetric decomposition and new classification approaches, fire scars were extracted; the resulting burned areas matched the true burned areas according to GIS polygons from the provincial forest fire database. Our new *K*-Nearest Neighbors Graph Clustering classifier, unlike the classical Wishart scheme, does not depend on backscatter intensity; it relies more on polarization information, and is more tolerant of topographic variations. These new approaches have revealed an exciting new application, mapping historical fire scars with polarimetric radar.

https://www.hatfieldgroup.com/projects/eo-for-r-bam/

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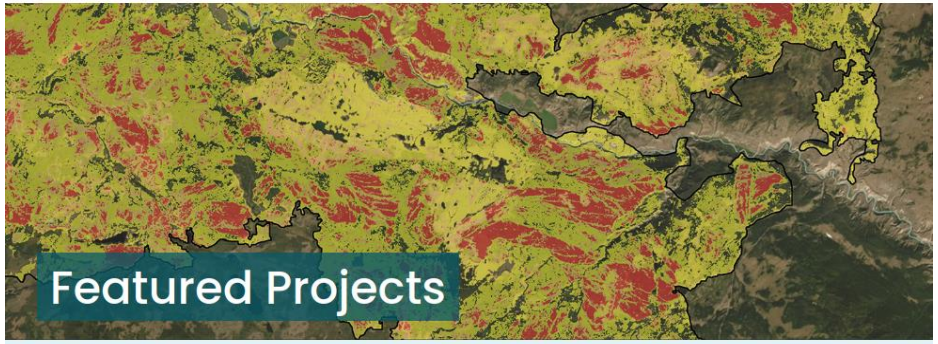

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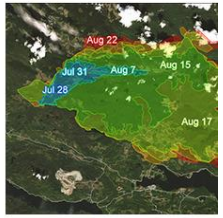
Earth Observation for Rapid Burned Area Mapping (R-BAM)



Client

Canadian Space Agency (CSA)

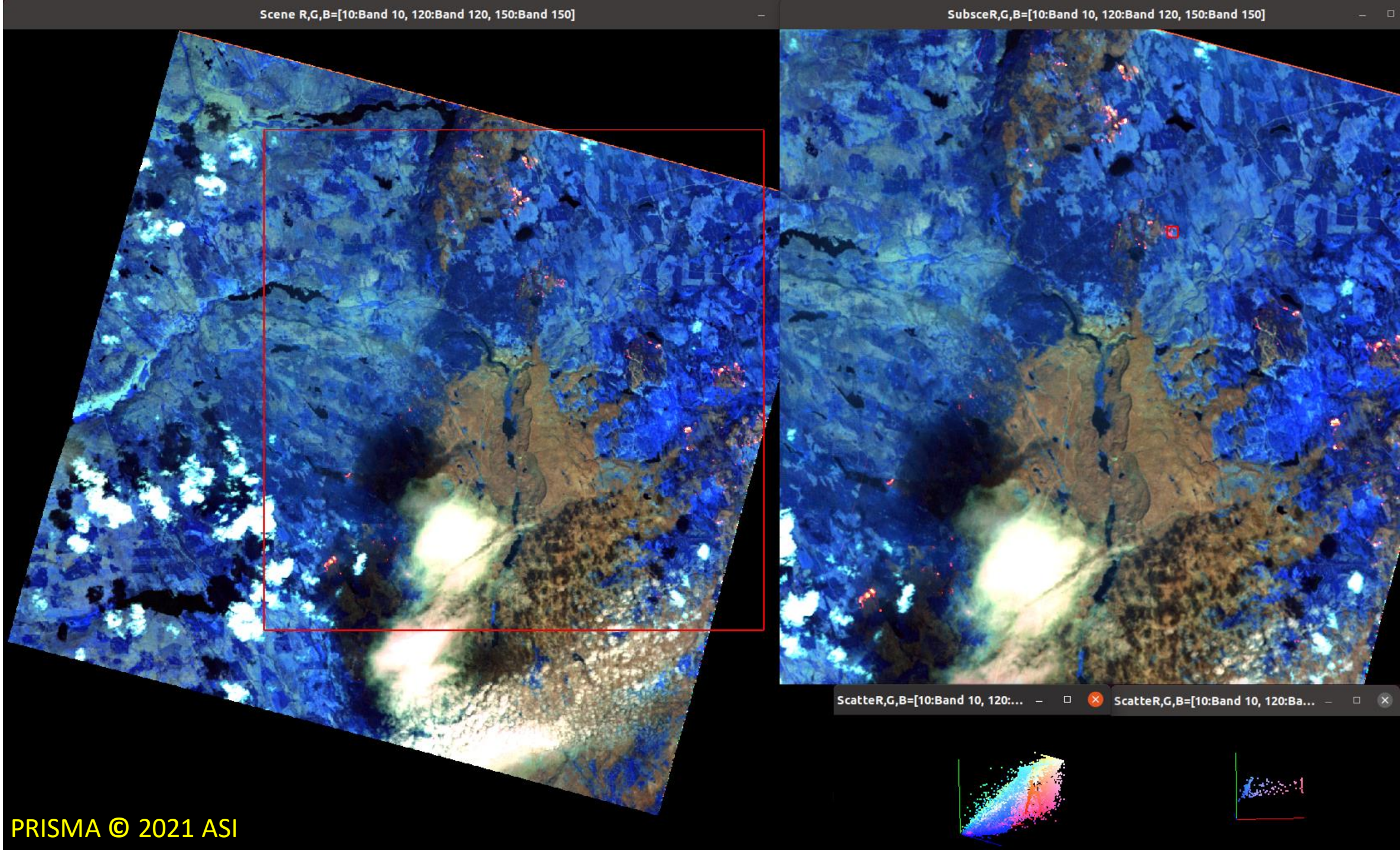
Location

Canada (various locations)

Project Duration

November 2016 - November 2018

Claims to fame 1) working with CSA 2) mapping fires from space 3) making an unsupervised kNN variant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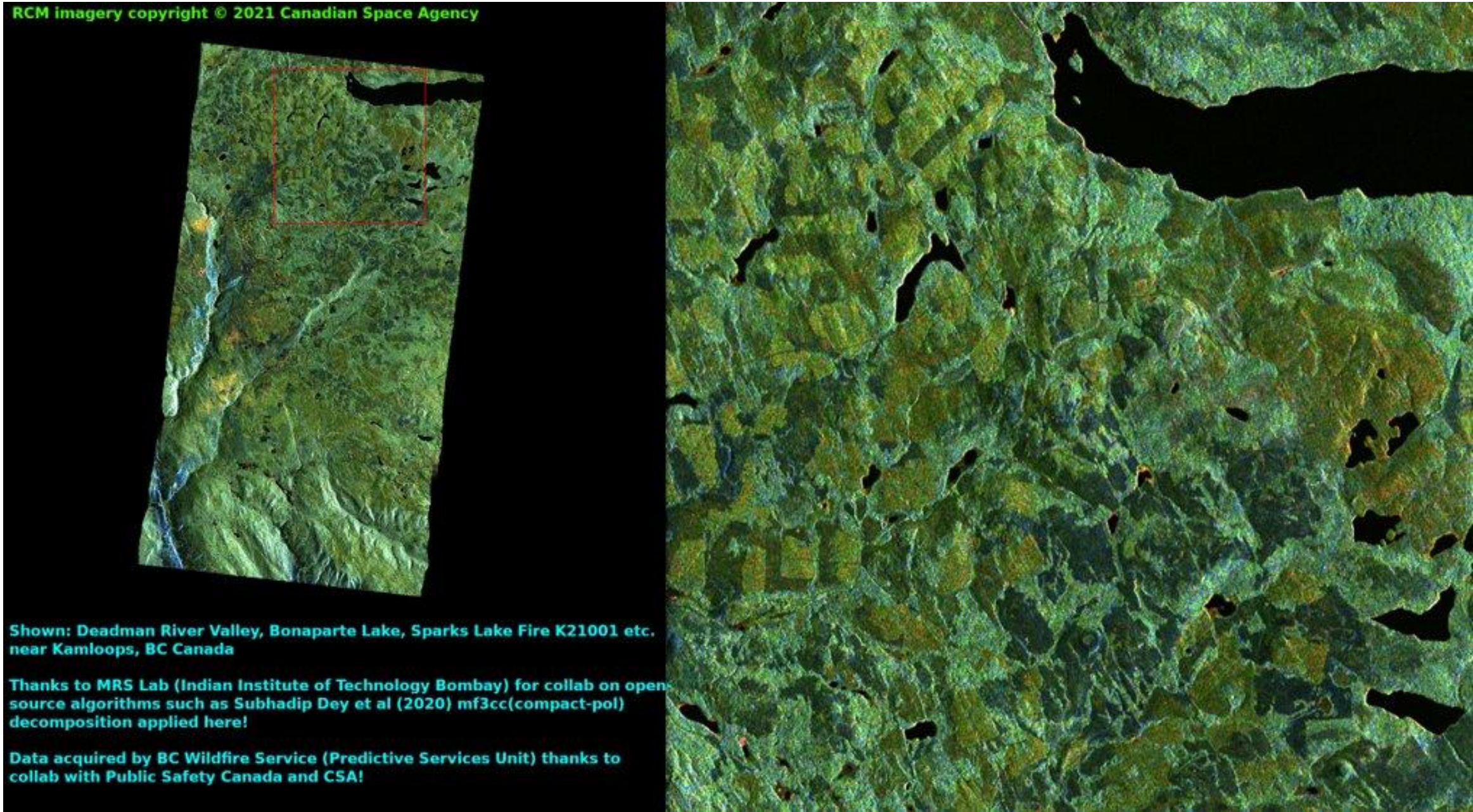
ScatteR,G,B=[10:Band 10, 120:Ba...
PRISMA © 2021 ASI

Compact pol modelling (thanks PSC / GOC and CSA)



Datasets

July	July	July	July	(*) = 5MCP18
08	x	16	20	5MCP7
x	x	x	x	
10	14	18(*)	22	5MCP19
x	15	19		5MCP13

- Sentinel2 (T09VUE)
  - 2021: 0626, 0629, 0714, 0719, 0729, 0813, 0907

RCM

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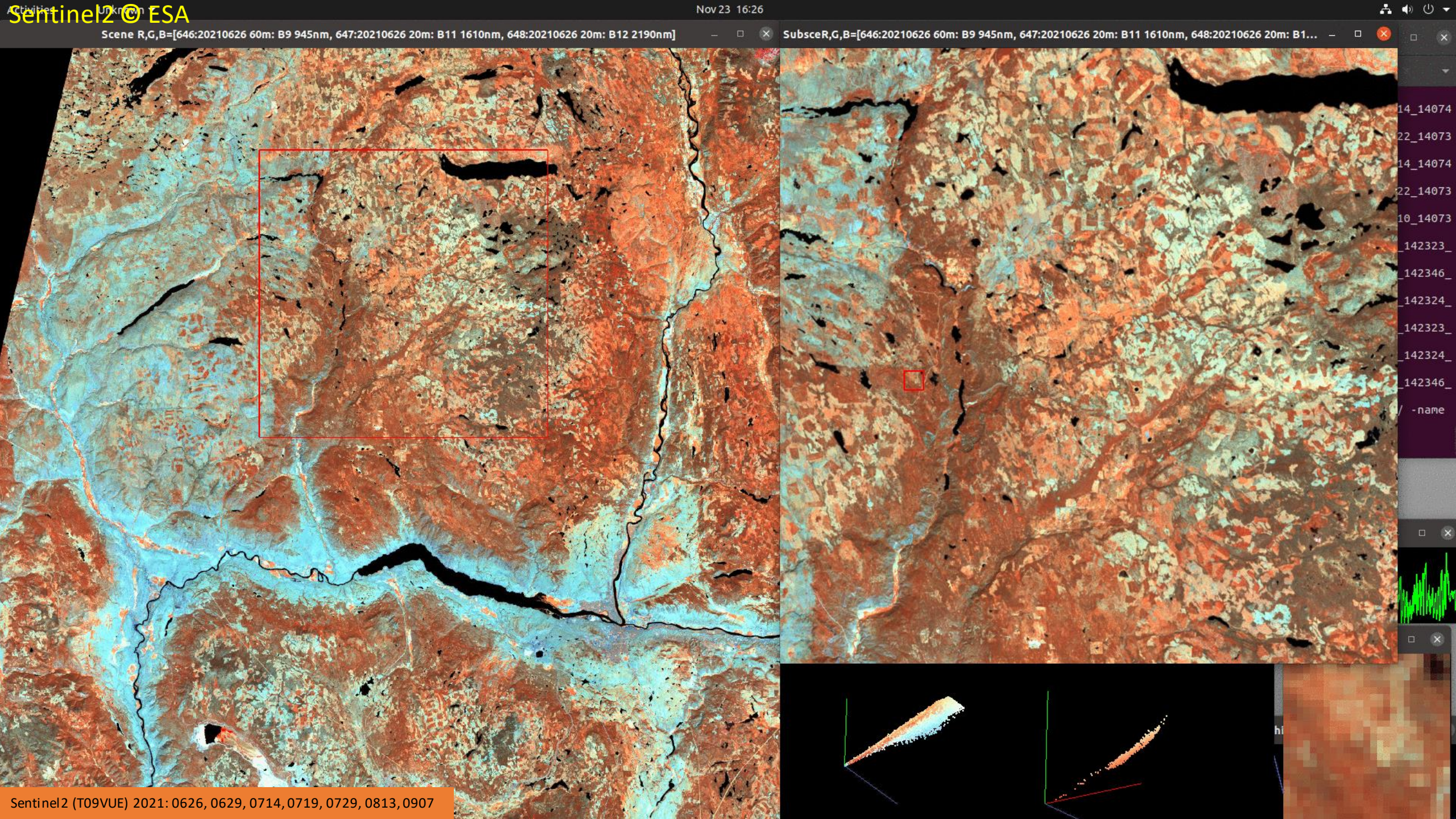
z


Sentinel2 © ESA
Nov 23 16:26
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14_14074
22_14073
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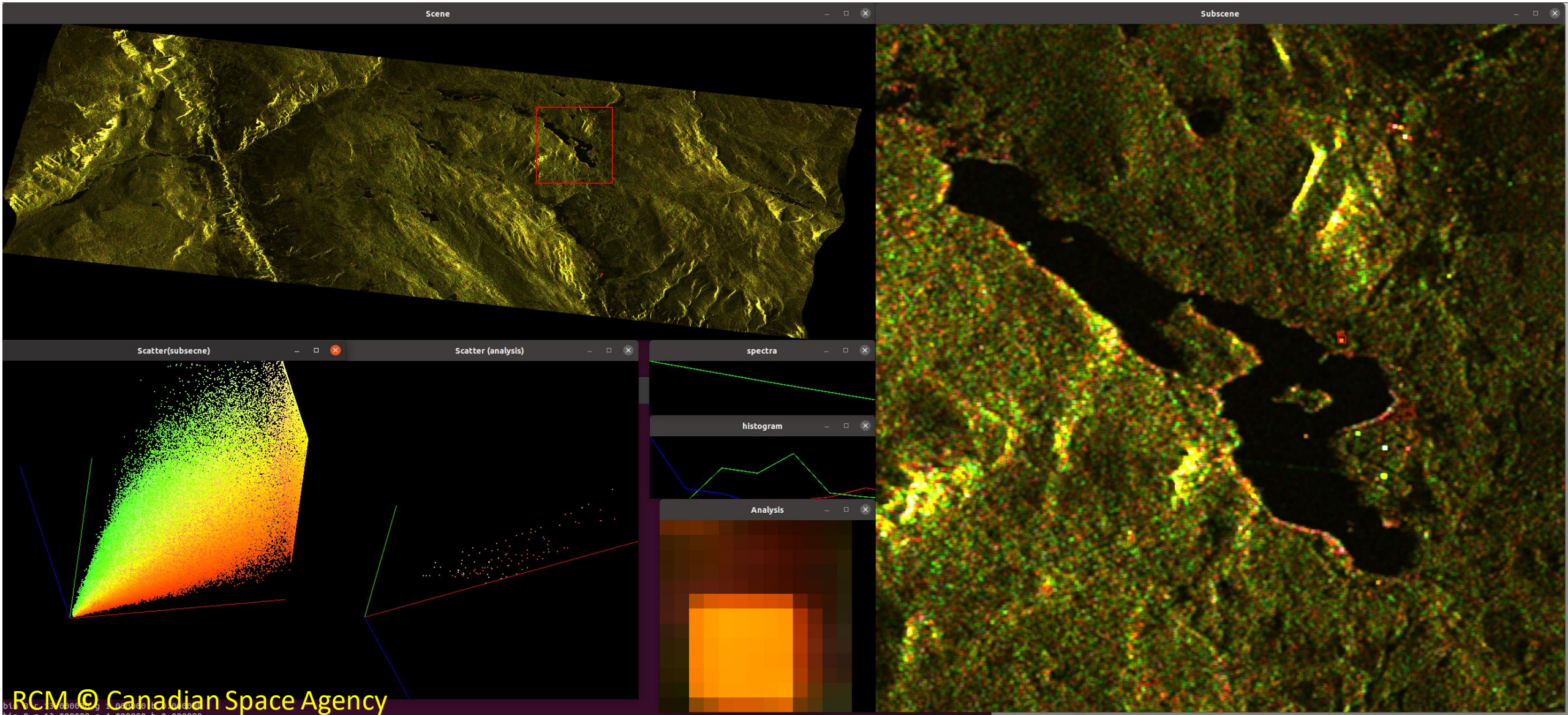
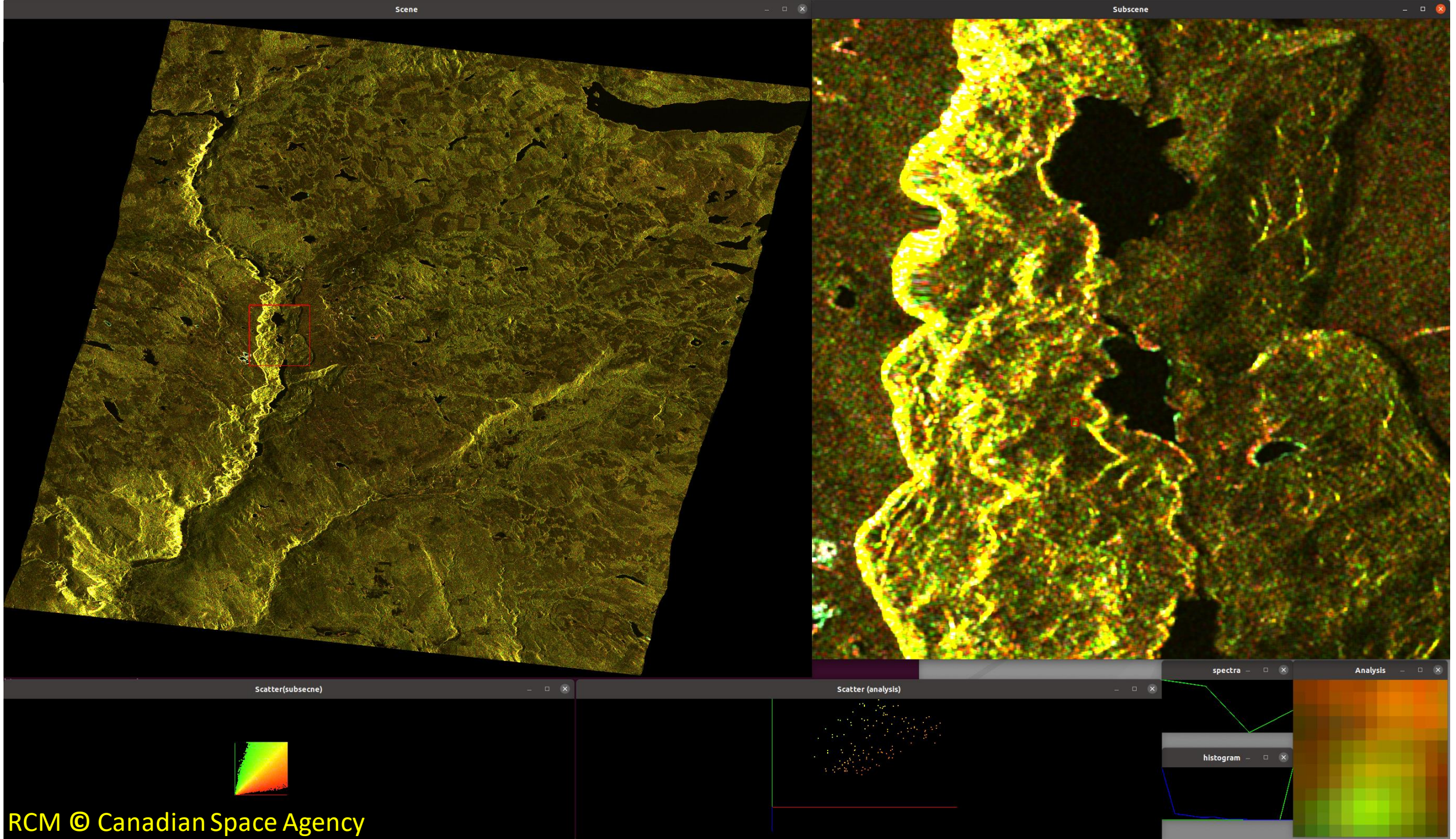
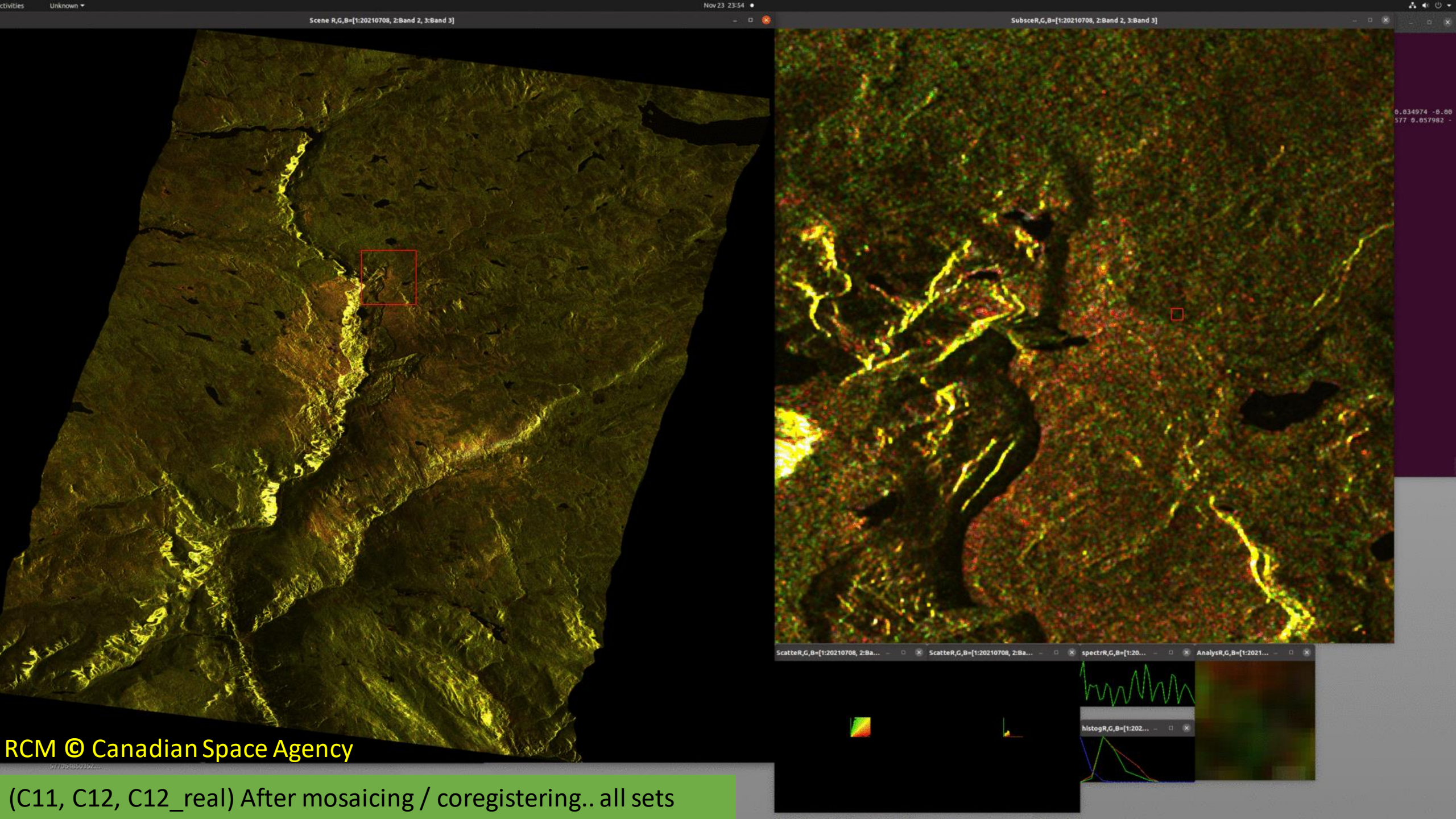
Sentinel2 (T09VUE) 2021: 0626, 0629, 0714, 0719, 0729, 0813, 0907

9 takes x 2 pieces…







(C11, C12, C12_real) After mosaicing / coregistering.. all sets

RCM steps

1. **Range / Doppler Terrain Correction,**
2. **Box Filter**
3. **mf3cc decomposition (double, volume, surface,** angle)
4. **Mosaic the 2 pieces together for each of the 9 dates..**
5. **Group by beam mode..**
6. **Calculate time diffs**

   (4 modes) … 5 differences total

   3x 5MCP7 = 2x differences
   1x 5MCP18 = 0x differences
   3x 5MCP19 = 2x differences
   2x 5MCP13 = 1x difference

Daily x14 same mode--> 13 differences..
Daily x14 in 4 modes: -->9 differences..

July	July	July	July	(*) = 5MCP18
08	x	16	20	5MCP7
x	x	x	x	
10	14	18(*)	22	5MCP19
x	15	19		5MCP13

[1] Dey, S., Bhattacharya, A., Ratha, D., Mandal, D. and Frery, A.C., 2020. Target characterization and scattering power decomposition for full and compact polarimetric SAR data. IEEE Transactions on Geoscience and Remote Sensing, 59(5), pp.3981-3998.

[2]. Dey, S., Bhattacharya, A., Frery, A.C., López-Martínez, C. and Rao, Y.S., 2021. A Model-Free Four Component Scattering Power Decomposition for Polarimetric SAR Data. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 14, pp.3887-3902.

[3]. Dey, S., Bhogapurapu, N., Homayouni, S., Bhattacharya, A. and McNairn, H., 2021. Unsupervised Classification of Crop Growth Stages with Scattering Parameters from Dual-Pol Sentinel-1 SAR Data. Remote Sensing, 13(21), p.4412.

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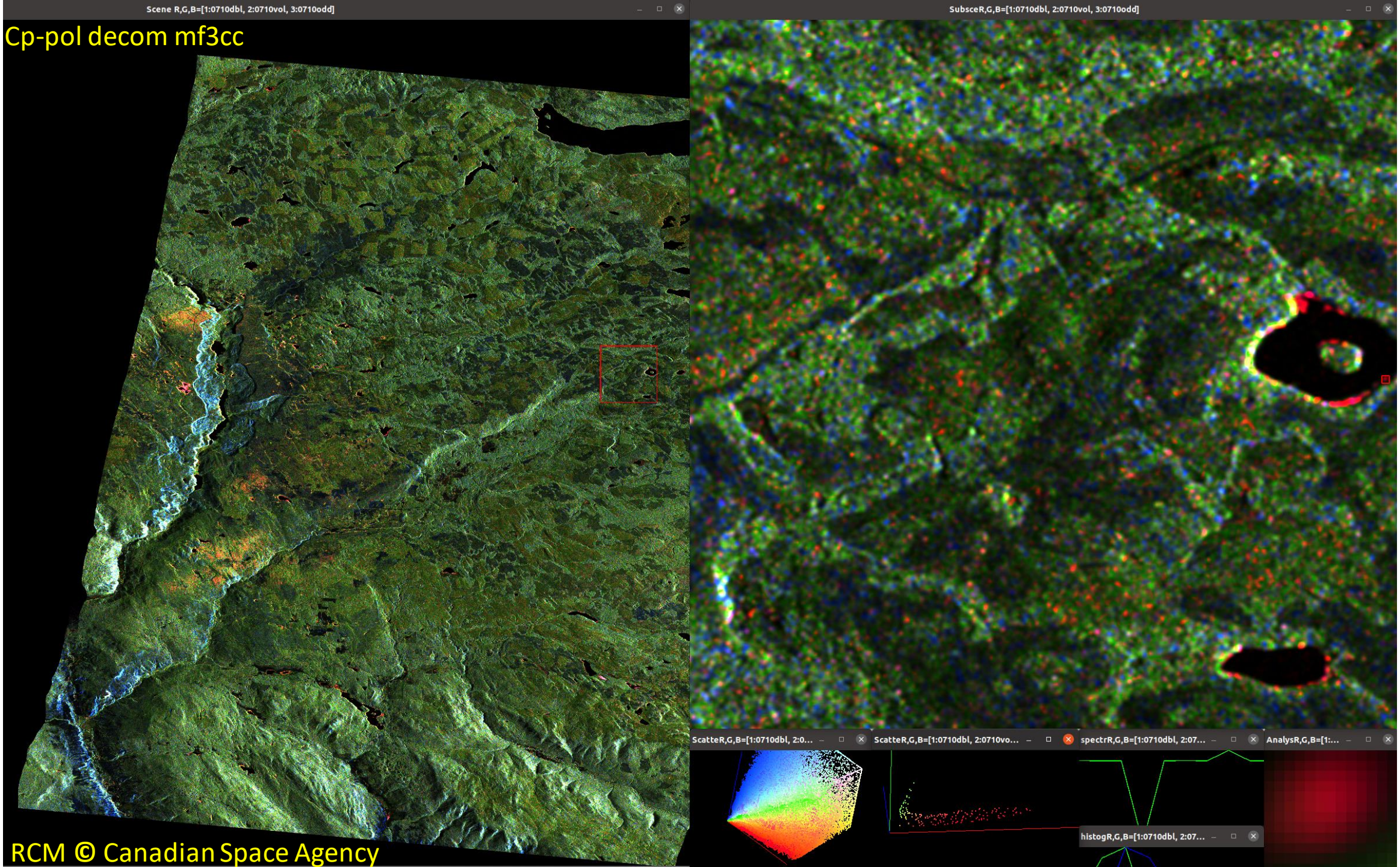
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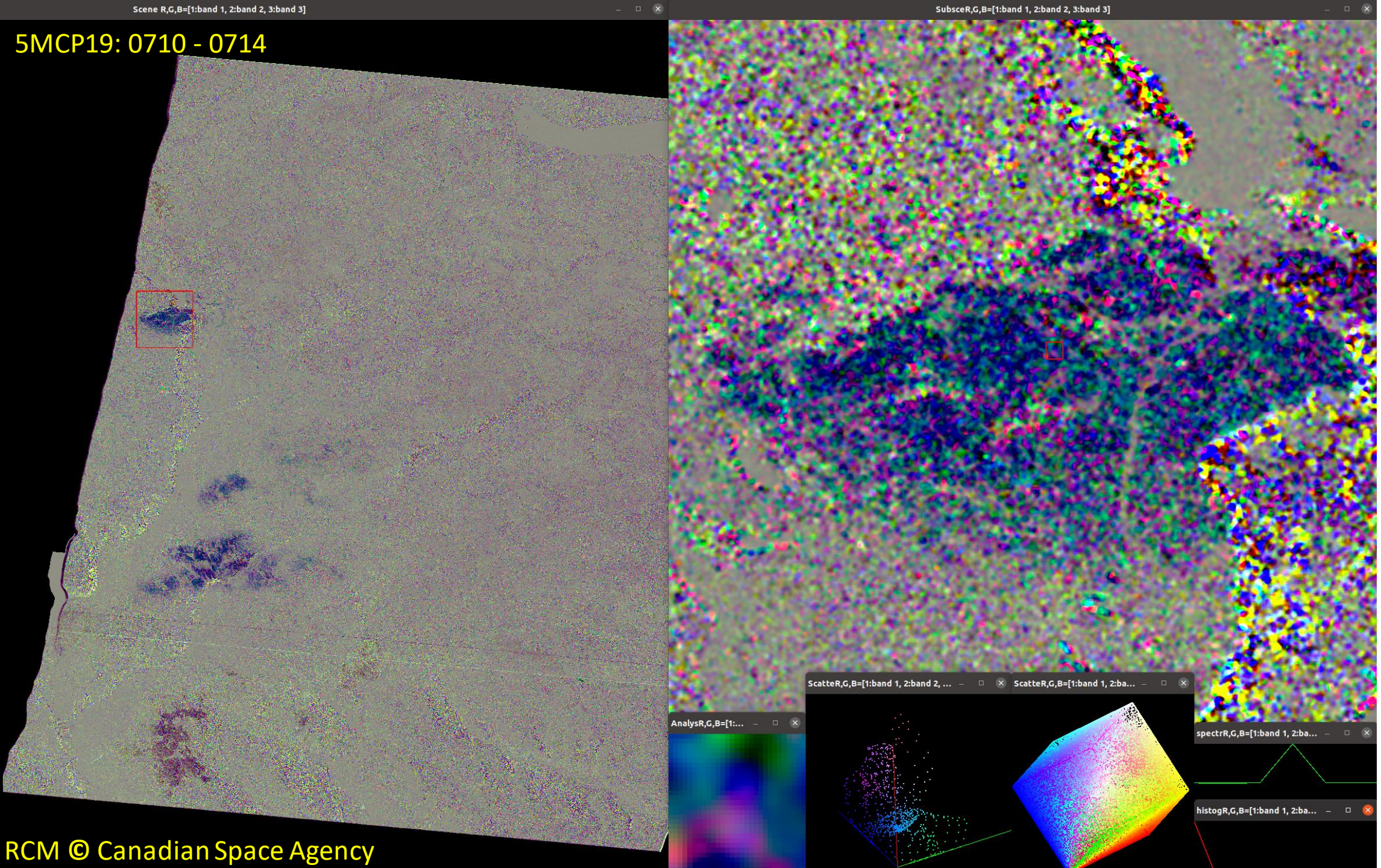
RCM © Canadian Space Agency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RCM © Canadian Space Agency
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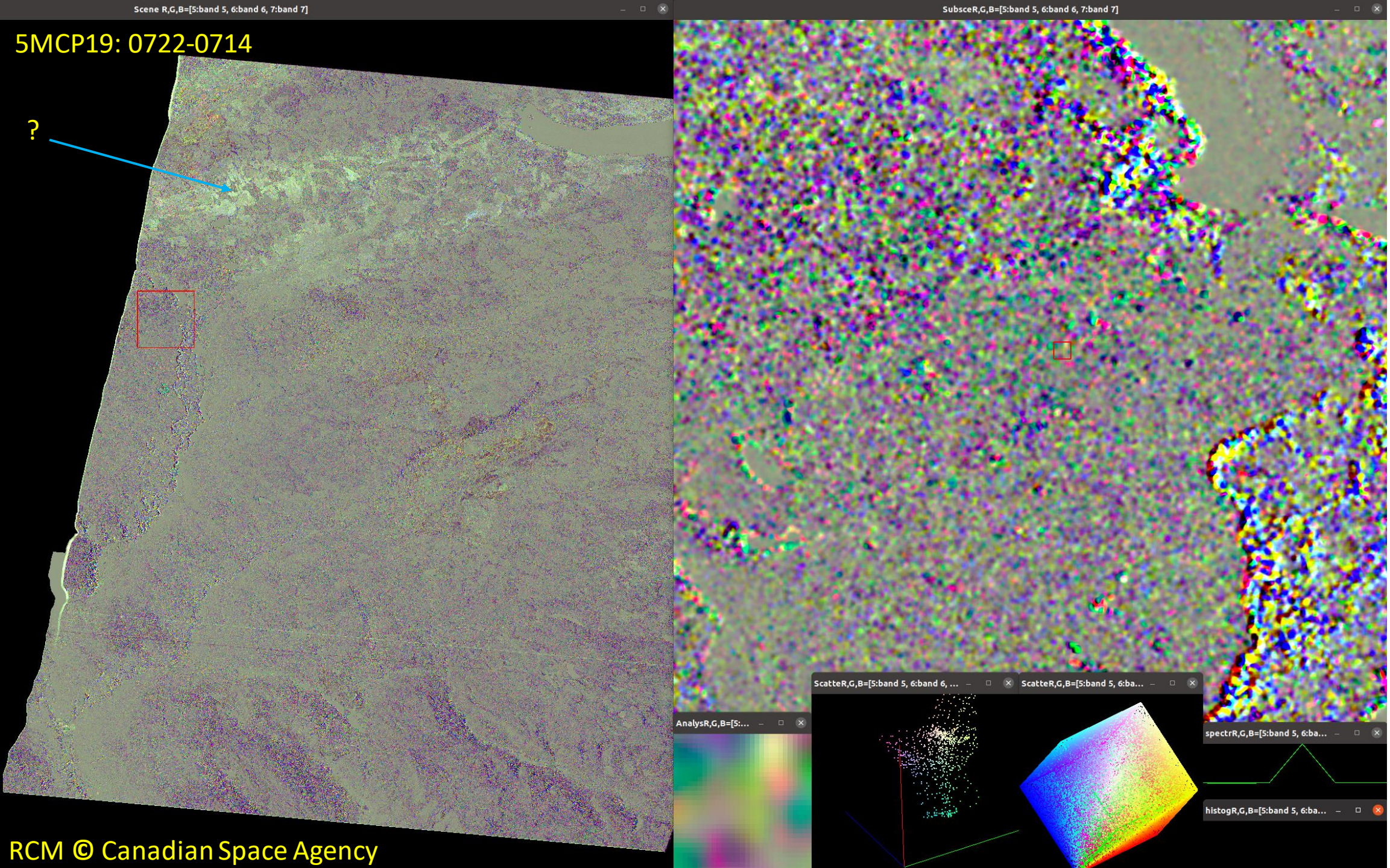
ScatteR,G,B=[1:band 1, 2:band 2, ...
ScatteR,G,B=[1:band 1, 2:ba...
spectrR,G,B=[1:band 1, 2:ba...
histogR,G,B=[1:band 1, 2:ba...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5MCP19: 0722-0714
?
RCM © Canadian Space Agency
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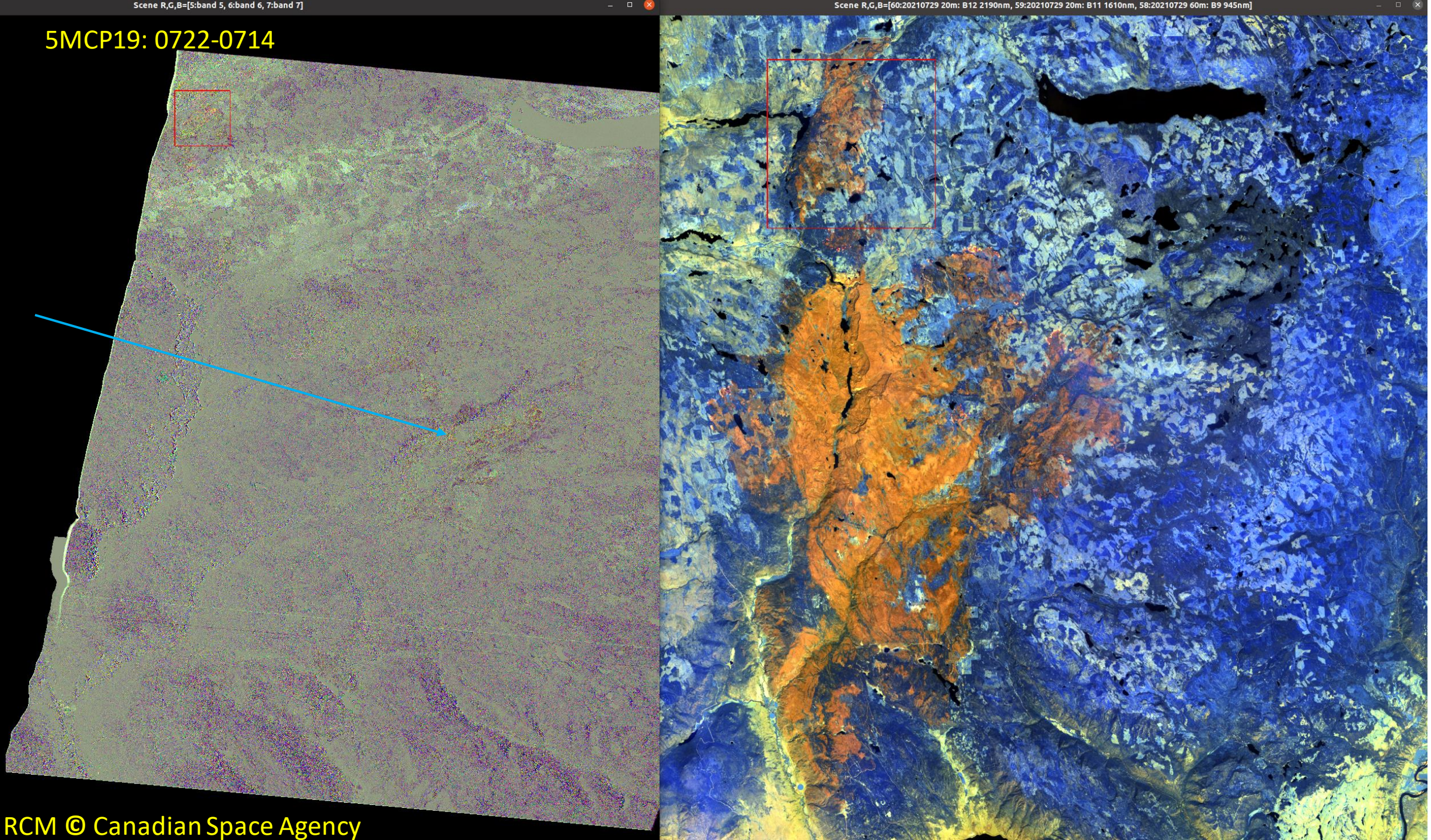
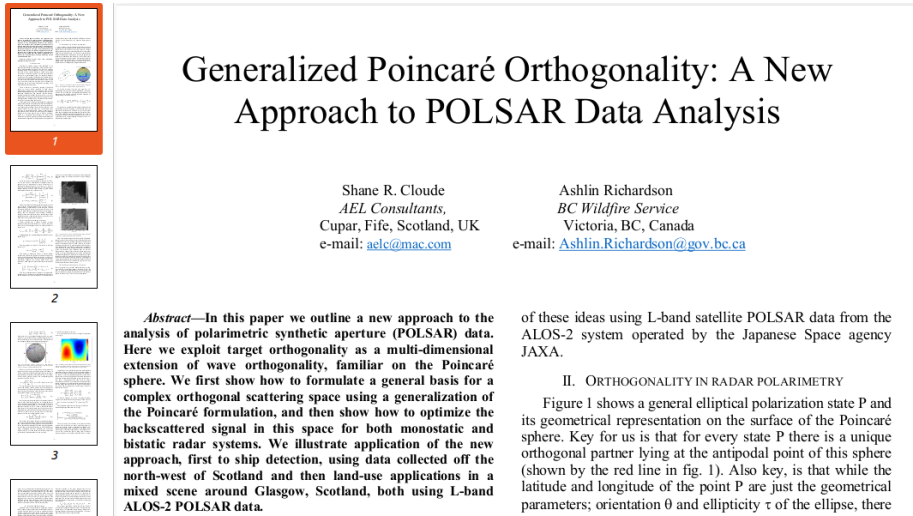

Scene R,G,B=[5:band 5, 6:band 6, 7:band 7]
Scene R,G,B=[60:20210729 20m: B12 2190nm, 59:20210729 20m: B11 1610nm, 58:20210729 60m: B9 945nm]
5MCP19: 0722-0714
RCM © Canadian Space Agency

Thanks

- CSA for the collaboration and Extraordinary data!
  - **Opportunity to improve consistency or quality of collections**
- For collab w CSA, CFS, NRCAN and partners on RCM and enhancing use of RS tech. Thanks Dr. Ake Rosenqvist for consultation
- ESA (Esp. Dr. Pottier) & NASA for RS training in 2021
- Dr. Cloude & Dr. Dey for mini collabs in open source!
- EGC / PSC for tasking. Thanks to Capella for a sample tasking
- Thanks A Beaudoin for S1 burn maps. Want to work with CFS on fires/fuel!

Next steps: Operational-integration engineering.

- Forest fuels study w Brad Martin, Senior Fire Protection Officer, present to BVRC Dec 8
- Pursue PolSAR, Multi & Hyperspec, LiDAR for fire and inter-related hazards, and ecosystem support
- Work with TRU on fire science
- **Collaborate with other application areas**
- Hope to work w JAXA, CFS and IITB on ALOS integration
- Aiming to exploit PolInSAR, quad-pol and dense series
- Working w BC gov RS and DS CoP to build capacity



Generalized Poincaré Orthogonality: A New Approach to POLSAR Data Analysis

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e-mail: aelc@mac.com

Ashlin Richardson
BC Wildfire Service
Victoria, BC, Canada
e-mail: Ashlin.Richardson@gov.bc.ca

***Abstract*—In this paper we outline a new approach to the analysis of polarimetric synthetic aperture (POLSAR) data. Here we exploit target orthogonality as a multi-dimensional extension of wave orthogonality, familiar on the Poincaré sphere. We first show how to formulate a general basis for a complex orthogonal scattering space using a generalization of the Poincaré formulation, and then show how to optimize the backscattered signal in this space for both monostatic and bistatic radar systems. We illustrate application of the new approach, first to ship detection, using data collected off the north-west of Scotland and then land-use applications in a mixed scene around Glasgow, Scotland, both using L-band ALOS-2 POLSAR data.**

of these ideas using L-band satellite POLSAR data from the ALOS-2 system operated by the Japanese Space agency JAXA.

II. Orthogonality in Radar Polarimetry

Figure 1 shows a general elliptical polarization state P and its geometrical representation on the surface of the Poincaré sphere. Key for us is that for every state P there is a unique orthogonal partner lying at the antipodal point of this sphere (shown by the red line in fig. 1). Also key, is that while the latitude and longitude of the point P are just the geometrical parameters; orientation θ and ellipticity τ of the ellipse, there