



Natural Resources
Canada

Ressources naturelles
Canada



Volcano Risk Reduction in Canada

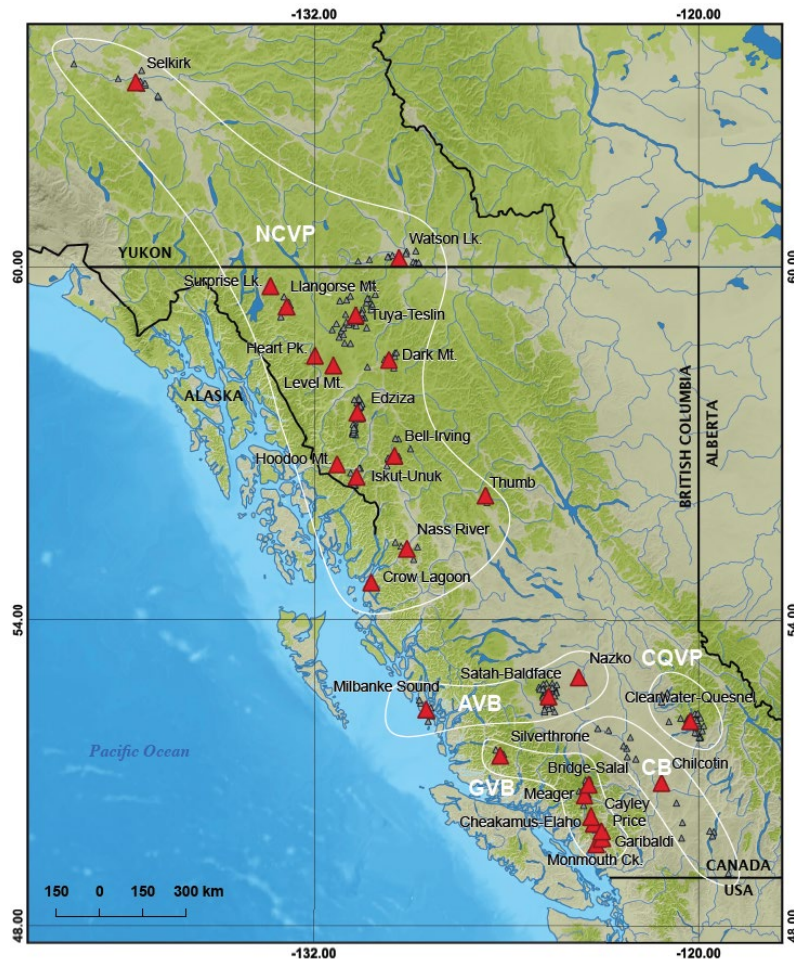
Monitoring Canada's Volcanic Threat with InSAR

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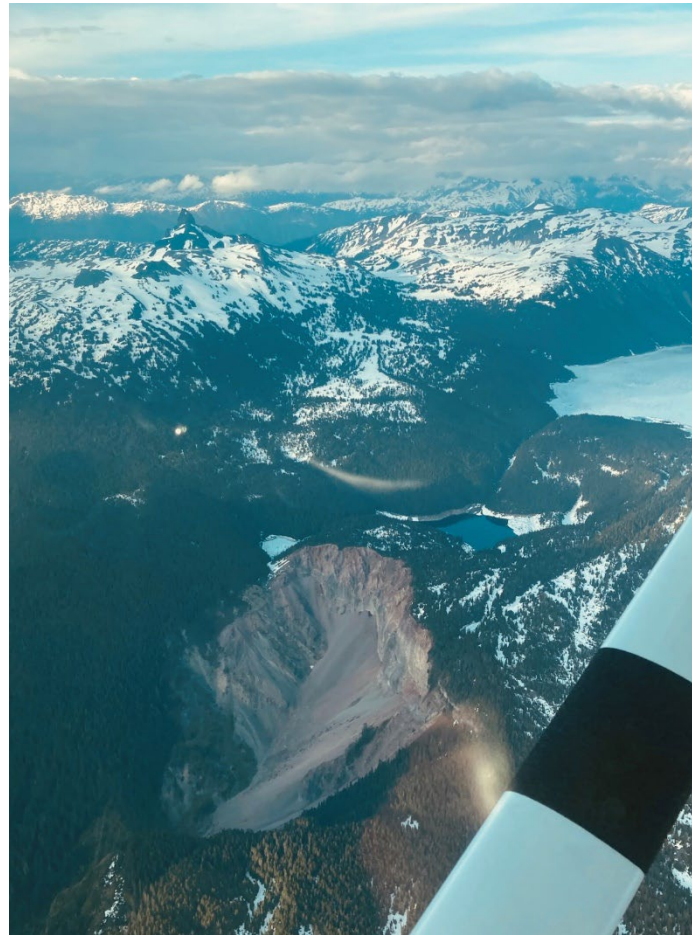
Canada

Volcanism in Canada



Map showing location of Canadian vents (small grey triangles), lumped volcanoes used for this study (large red triangles) and volcanic belt/province divisions. GVB – Garibaldi volcanic belt; CG – Chilcotin group; AVB – Anahim volcanic belt; CQVP – Clearwater-Quesnel volcanic province; NCVP – Northern Cordilleran volcanic province.

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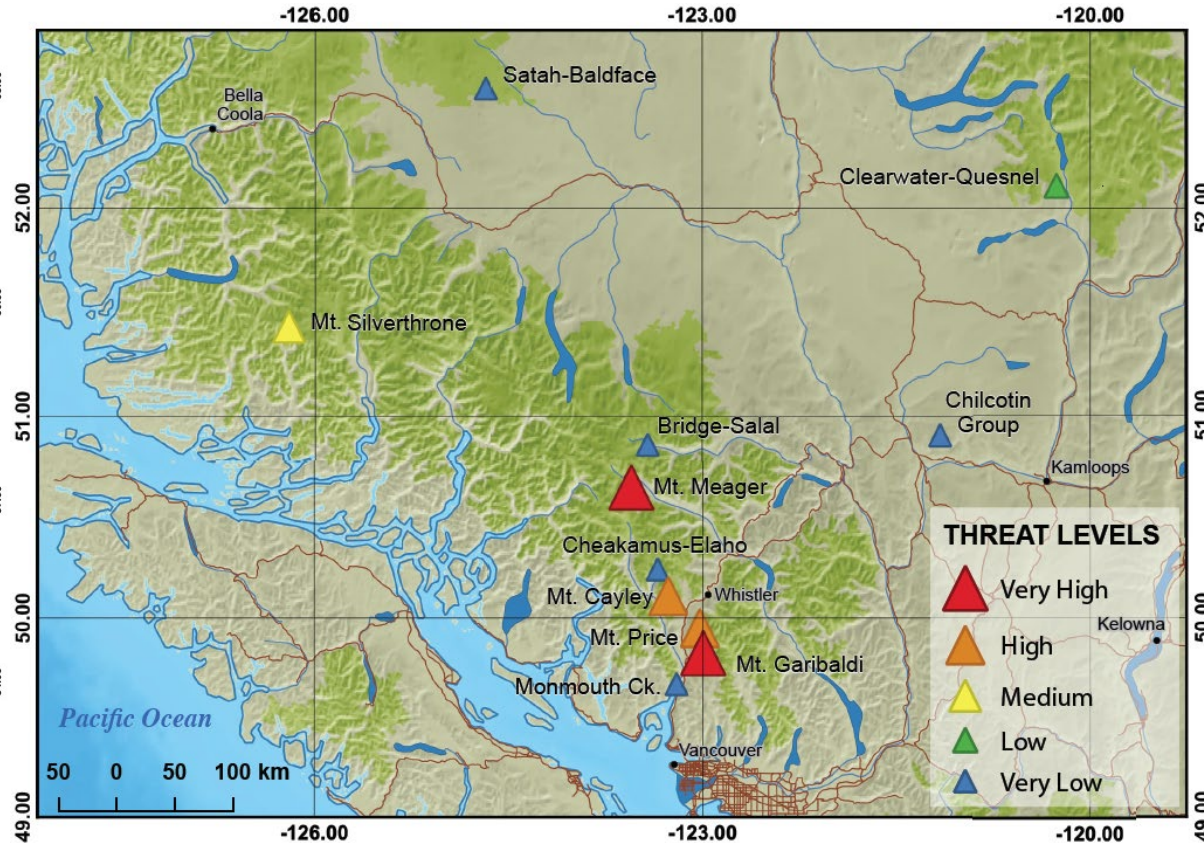
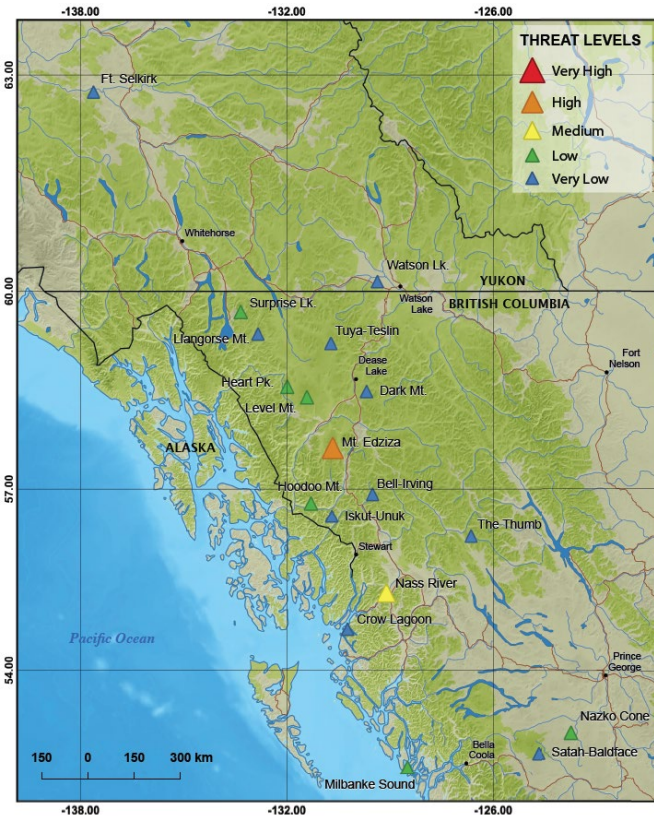


Aerial view of prominent volcanic features around the Garibaldi Volcanic province. The barrier, a volcanic flow feature emanating from Mt Price with significant lava-ice interaction features and. The Black Tusk

- Threat of Volcanism is thought to be commonly underestimated
 - No Major eruptions in living memory
 - Lack of monitoring, no observations of unrest events
 - Most Canadian Volcanoes aren't shaped like classic volcanoes due to glacial interactions
- 348 Known vents Pleistocene age or younger, 54 known to be active during the Holocene
- Notable events:
 - 220BP eruption of Tseax Cone
 - 2360BP eruption of Mt Meager
 - 2007-2008 Seismic swarm at Nazko Cone
- based on evidence of past eruptions, annual probability has been estimated at 1/200 for any eruption, and 1/3333 for a major explosive eruption (Stasiuk et al., 2003)



Volcano Threat Ranking



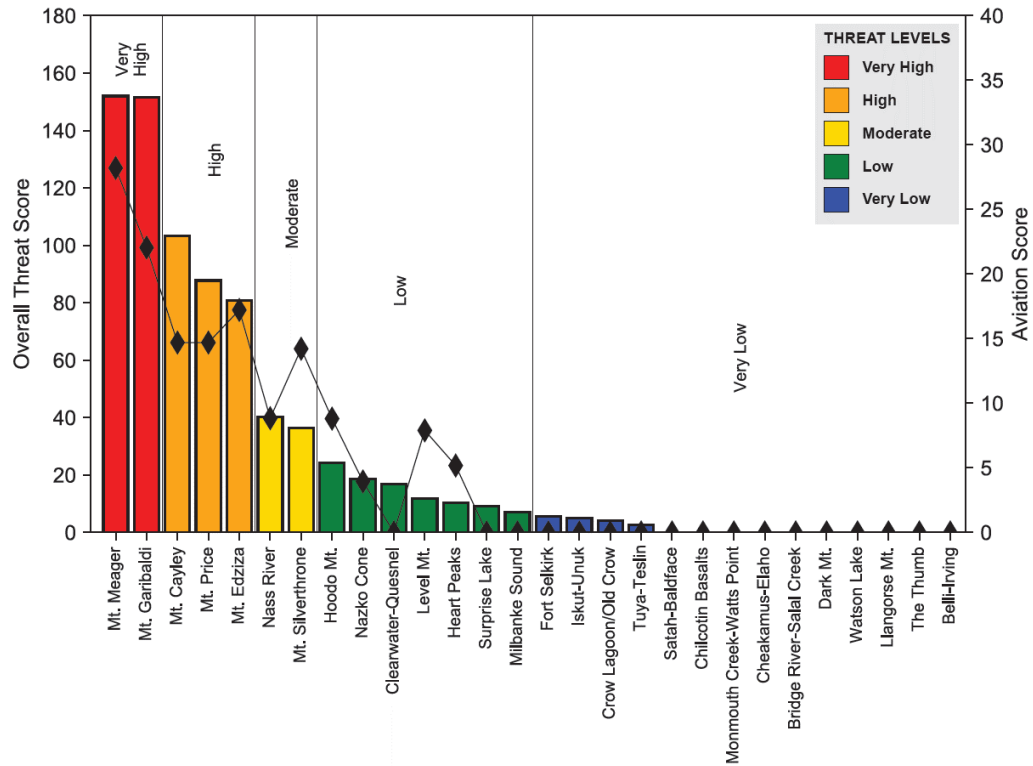
Known vents lumped into 28 volcanic fields/complexes

Threat scores assigned based on the methodology developed by the United States Geological Survey (USGS) as part of a National Volcano Early Warning System (NVEWS) (Ewert et al., 2005; Ewert, 2007; Ewert et al., 2018)

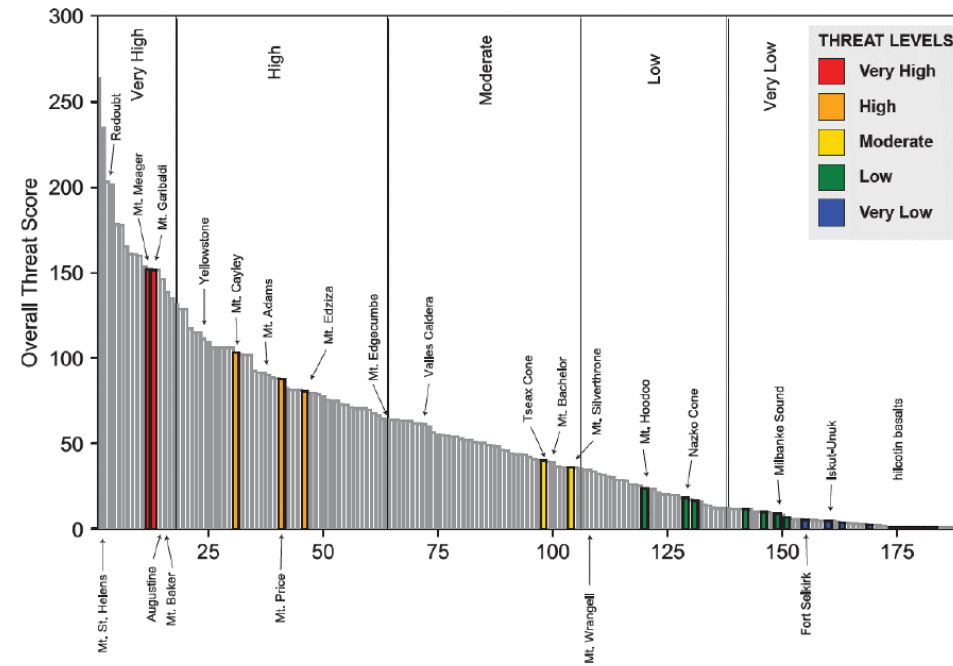
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Volcano Threat Ranking



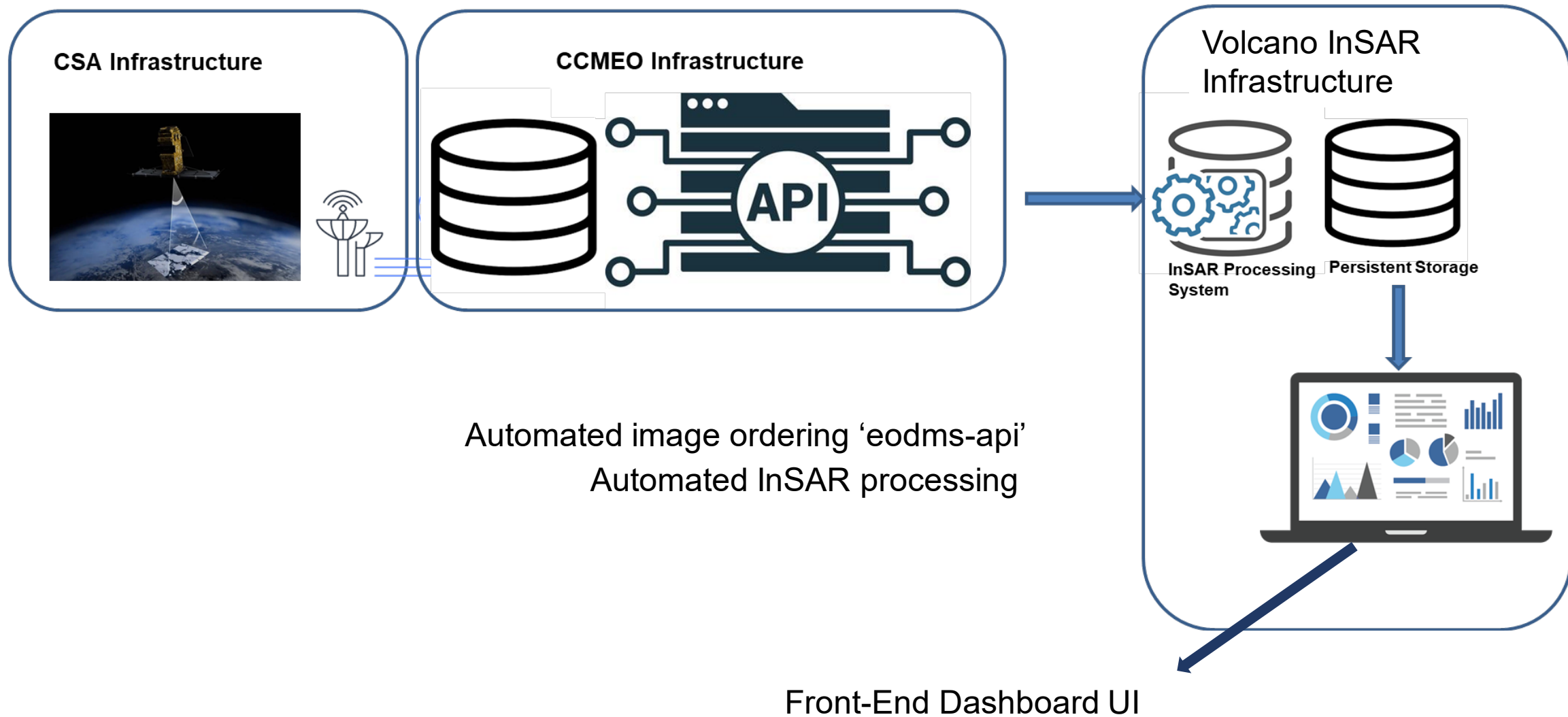
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USGS recommendations minimally a remote sensing approach for volcano threats low and above

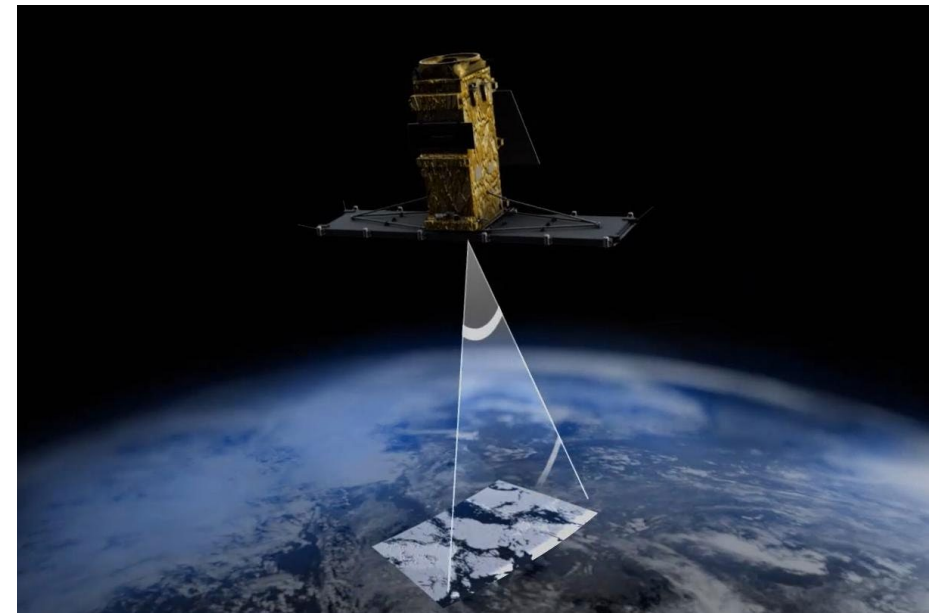


Volcano InSAR monitoring system



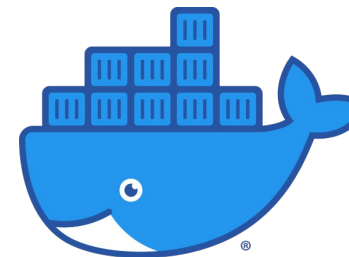
RADARSAT Constellation Mission (RCM)

- RCM is a constellation of 3 identical Synthetic Aperture Radar (SAR) satellites
- 3rd Generation of the RADARSAT-1 & RADARSAT-2 programs
- Launched June 12, 2019
- C-band 5.55cm wavelength
- Typically collect 3-5m strip-map mode with repeat passes varying from 4-12 days
- Owned and operated by Canadian Space Agency
- Dedication to Federal Government Scientific and Security Purposes

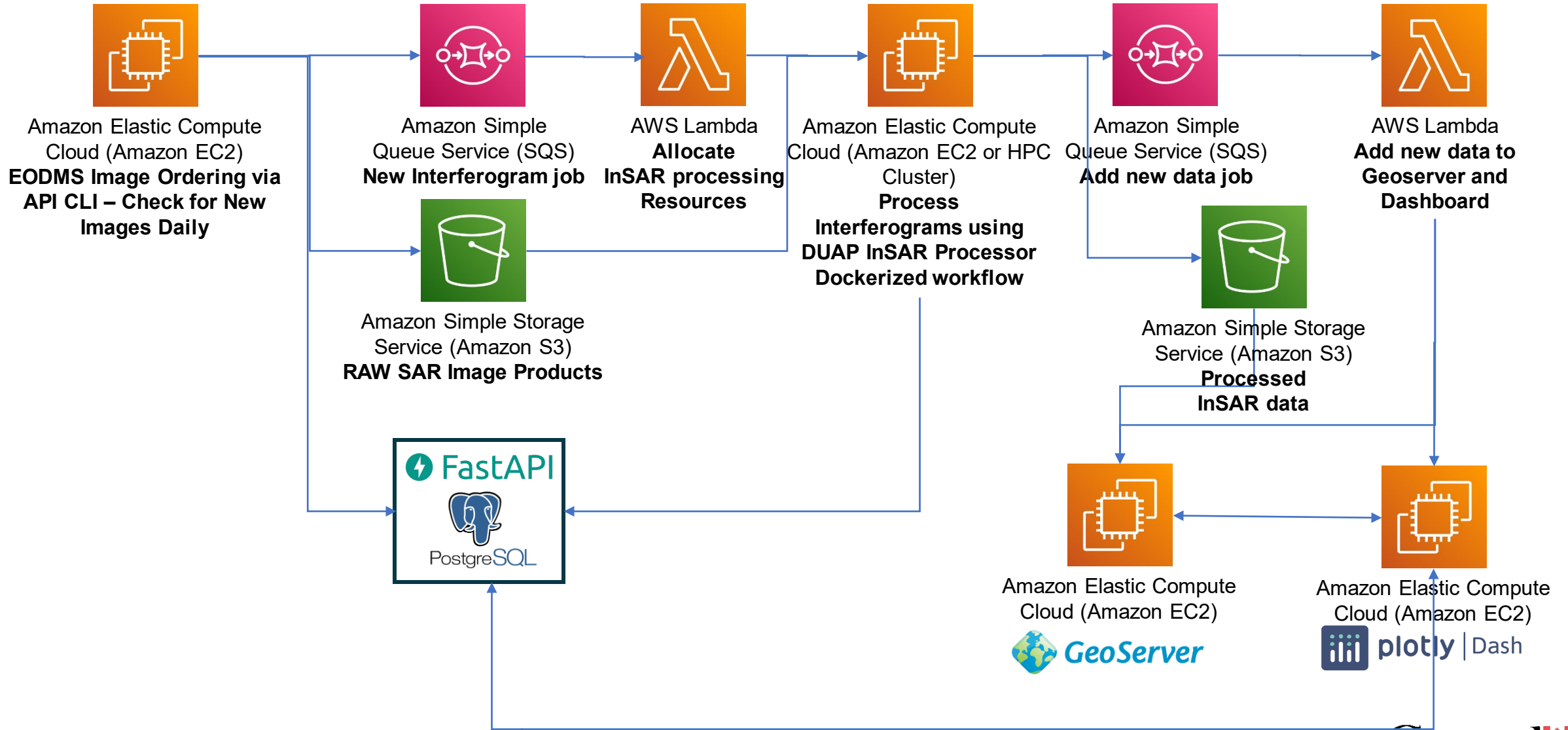


Guiding Scientific and Development Principles

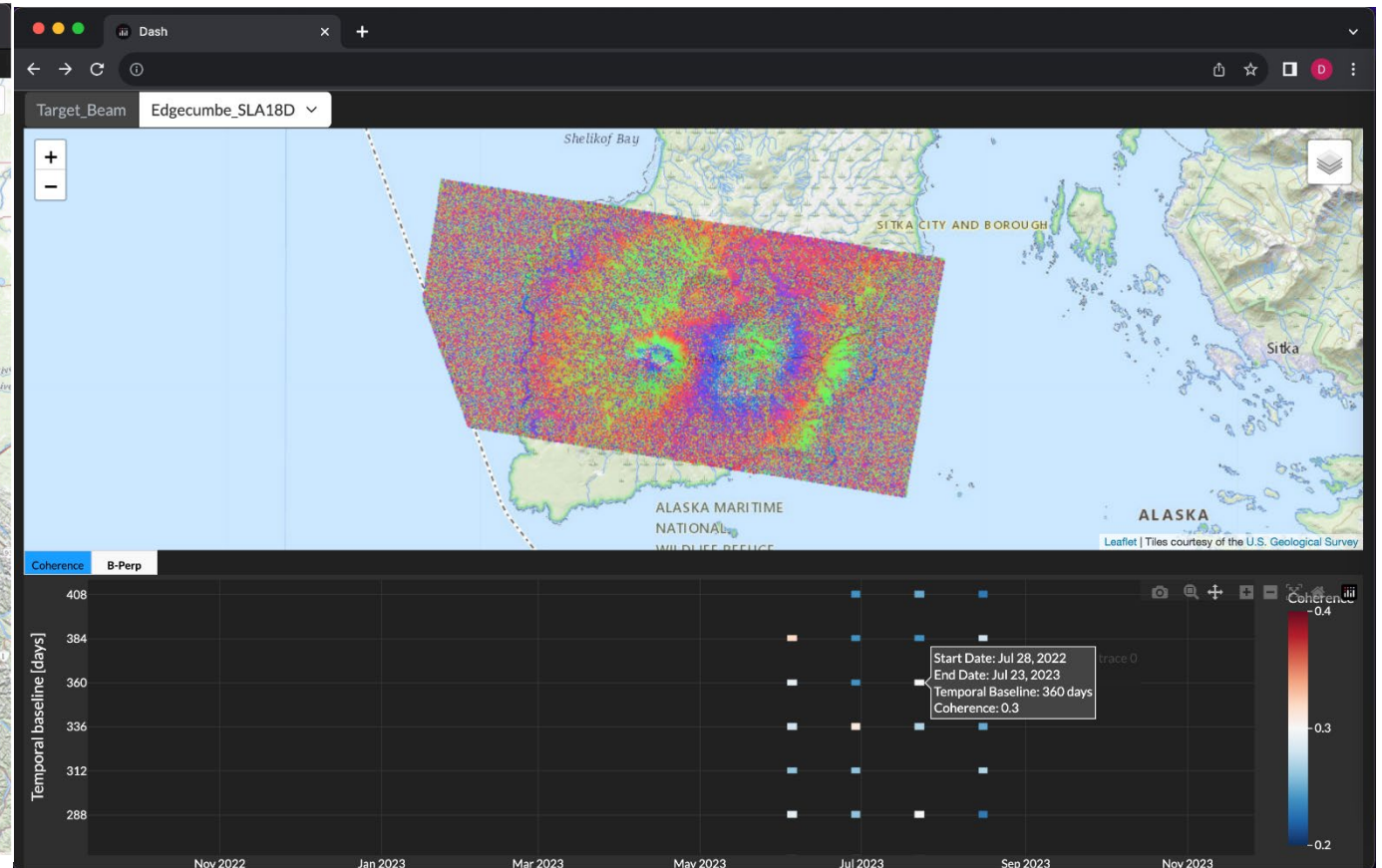
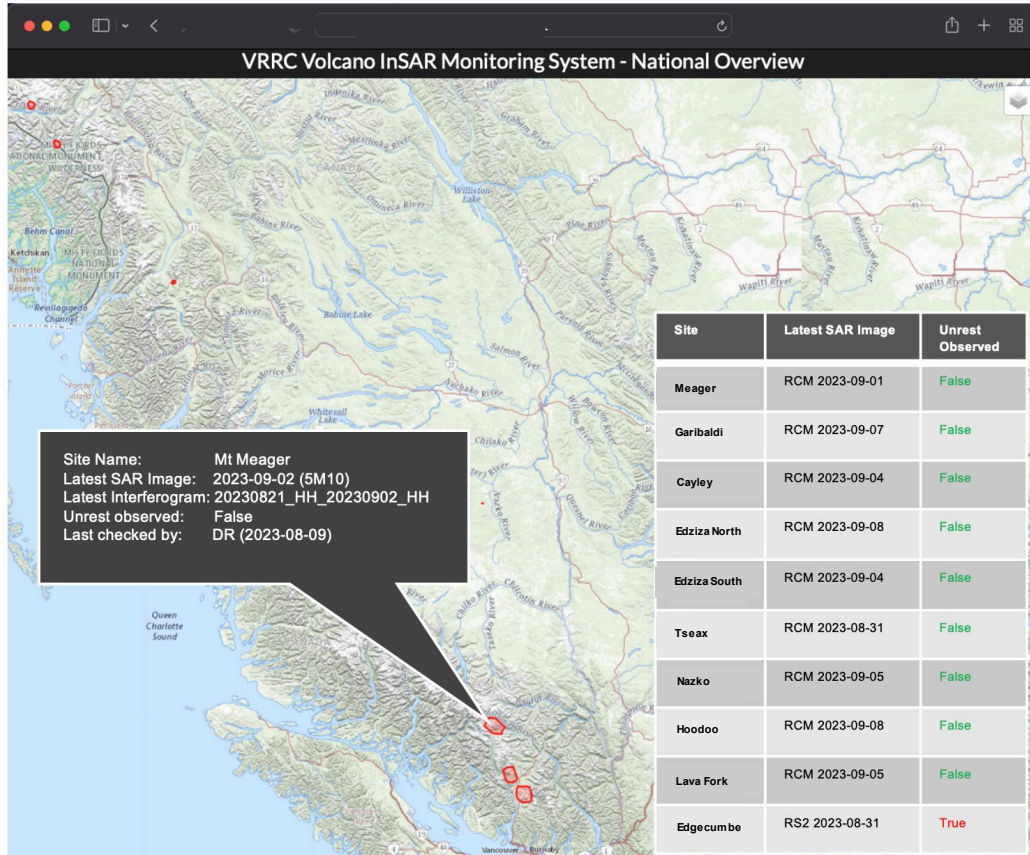
- Align as closely as possible with the principles of Open Science and Open Government as defined by the Treasury Board of Canada Secretariat (TBS)
- Cloud Native but portable
- Sensor Agnostic
 - Build around RCM but maintain flexibility to handle RADARSAT-2, TerraSAR-X, Sentinel-1, NISAR and even commercial SAR Sensors
- Iterative development principals



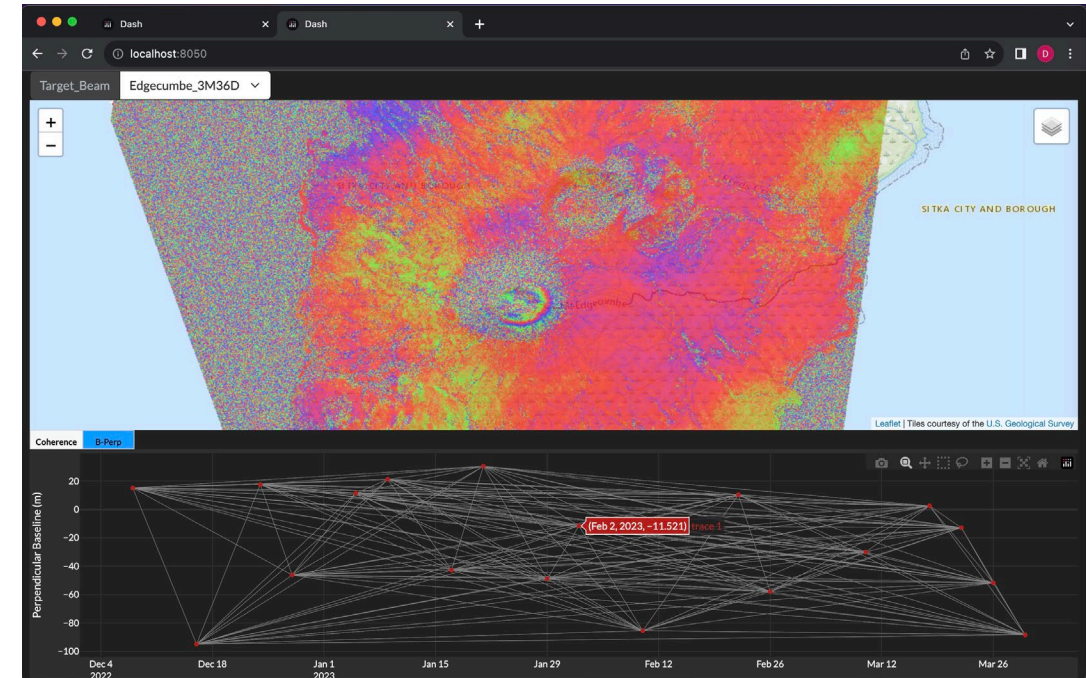
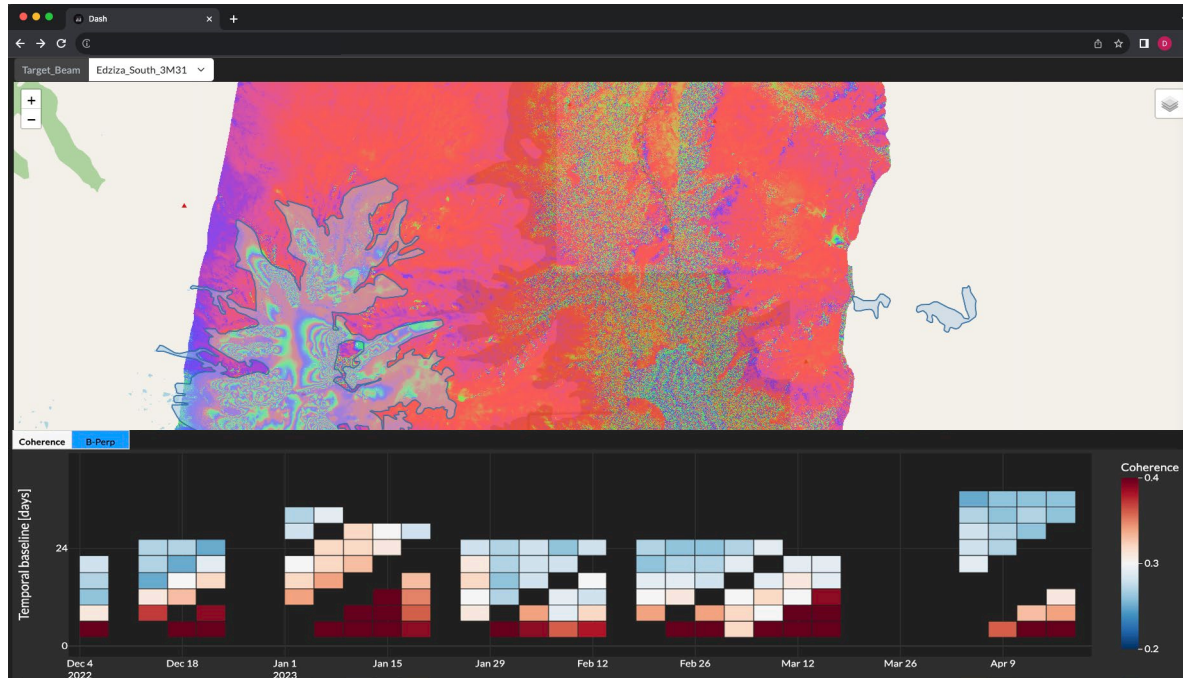
Cloud Native Architecture



Routine Monitoring – Highest Threat Volcano Sites



Routine Monitoring – Highest Threat Volcano Sites

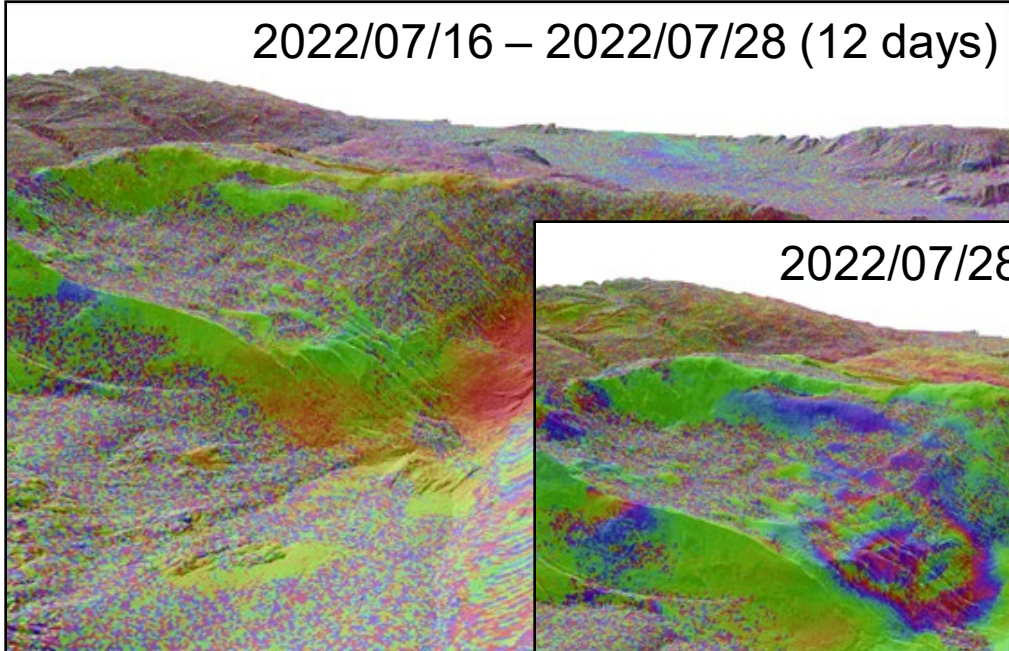


- Over 5000 interferograms and counting over 10 sites processed fully automatically this year
- Testing atmospheric modelling/correction with commercial tools as well as weather model and GNSS informed models

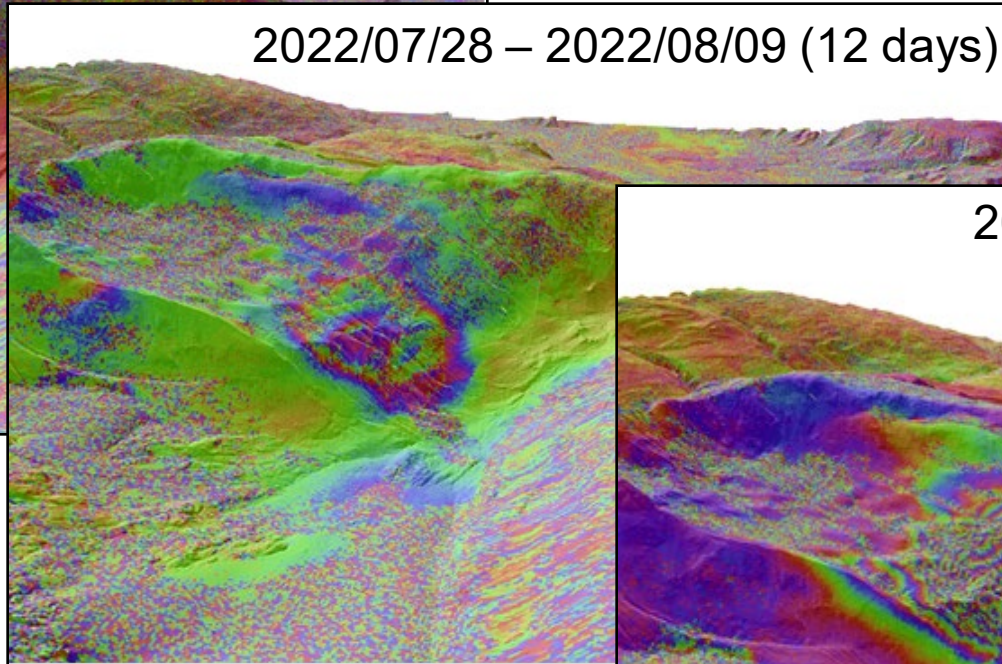


1st Year of observations – Slope Deformation at Mt Meager

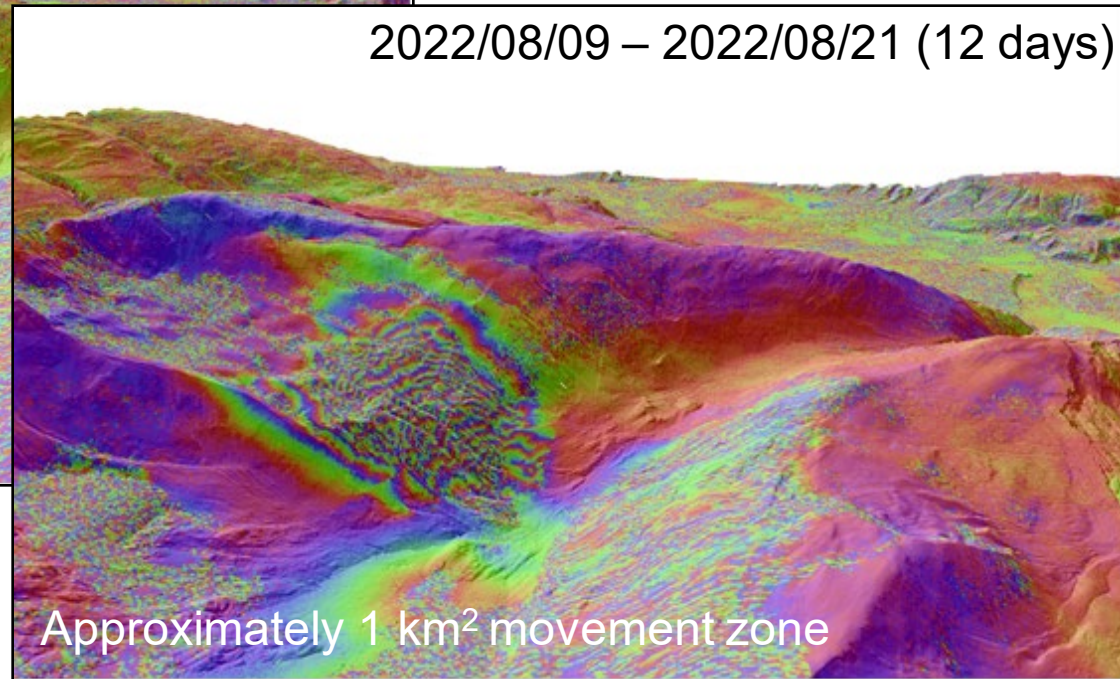
2022/07/16 – 2022/07/28 (12 days)



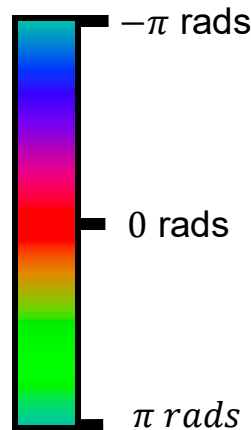
2022/07/28 – 2022/08/09 (12 days)



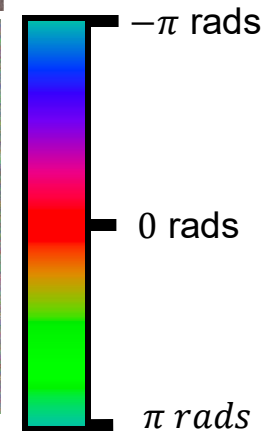
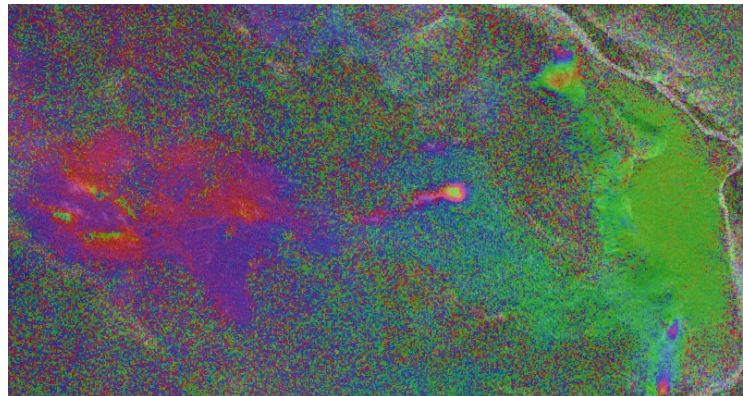
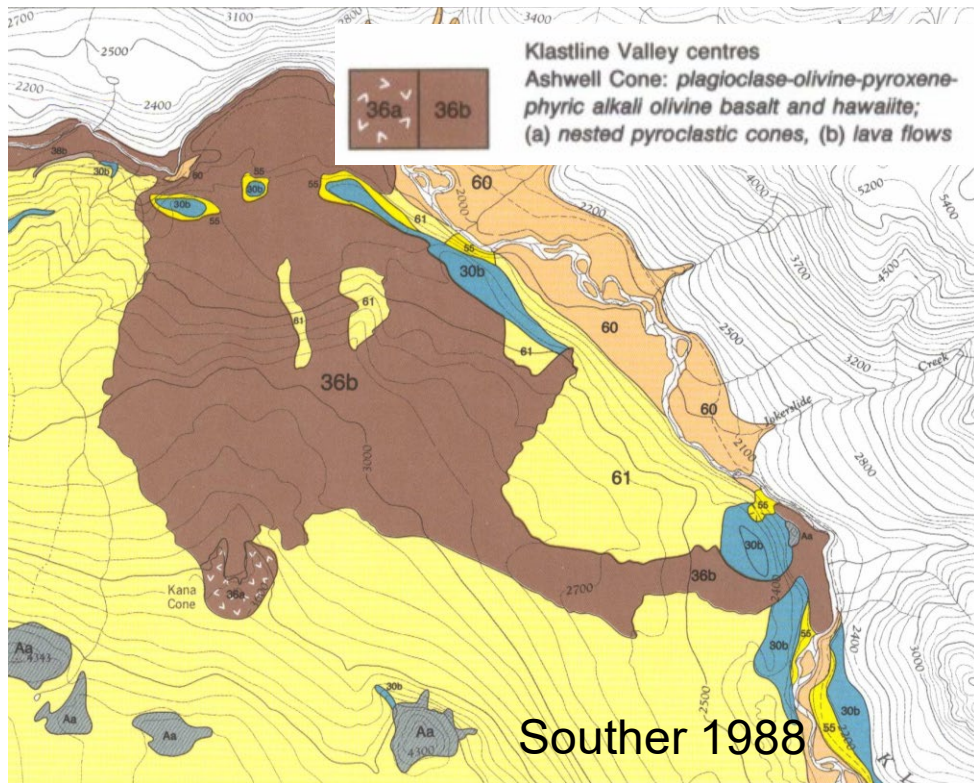
2022/08/09 – 2022/08/21 (12 days)



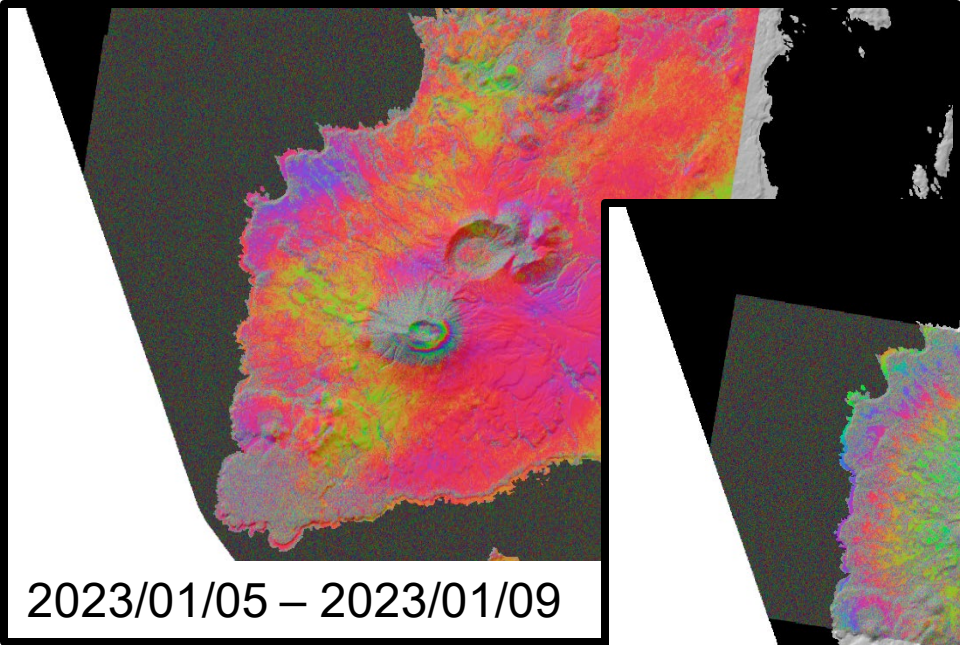
Approximately 1 km² movement zone



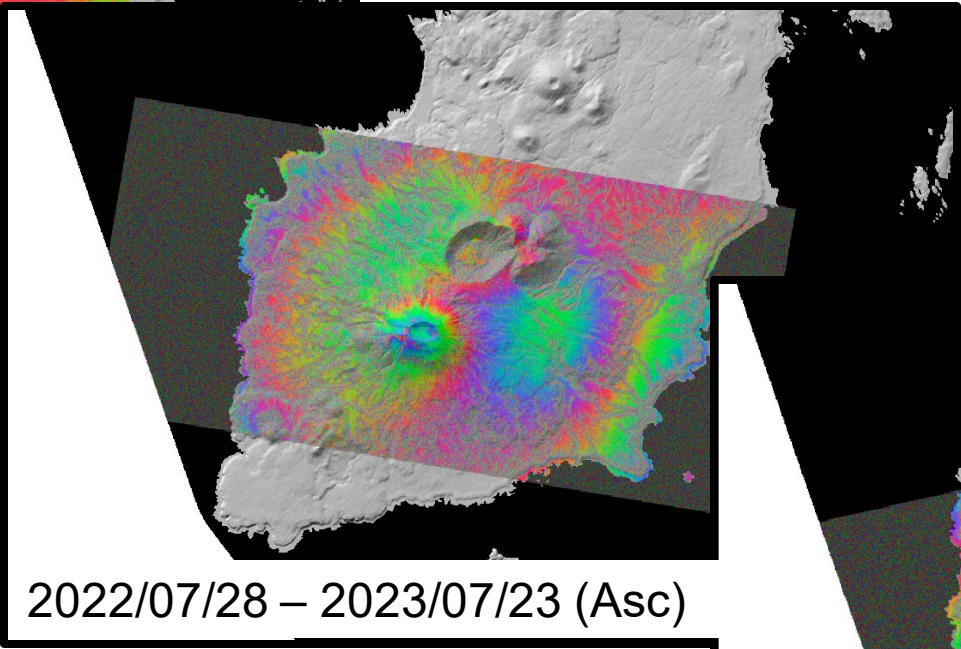
1st Year of observations – Subsidence of potential lava tubes - Mt Edziza



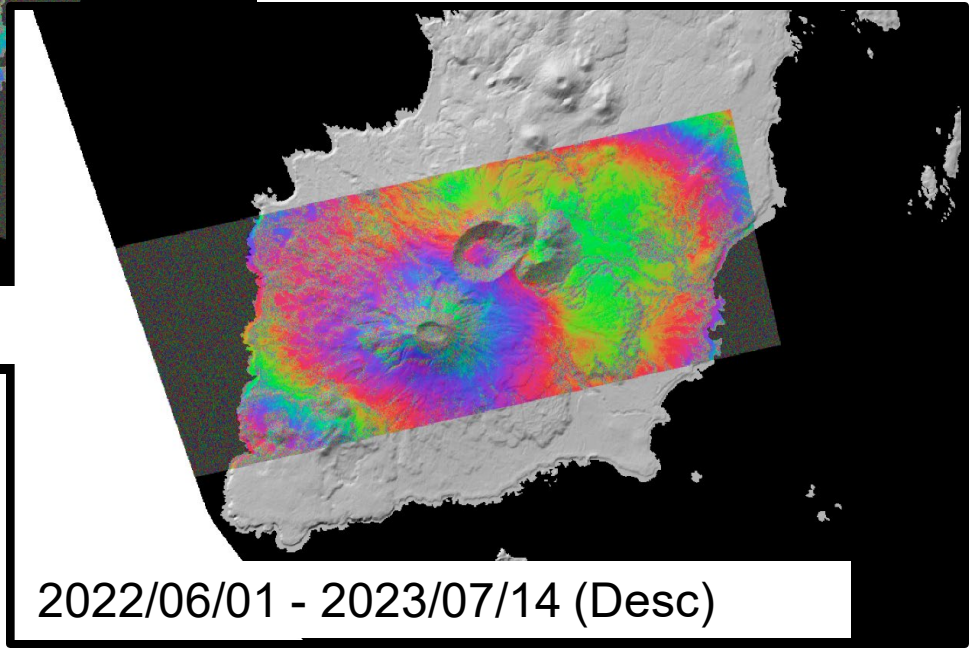
1st Year of observations –Magmatic Unrest at Mt Edgecumbe



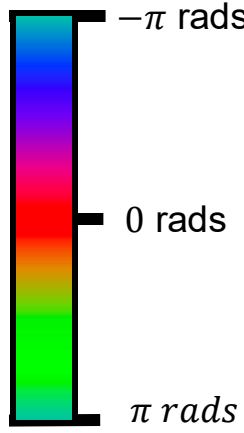
2023/01/05 – 2023/01/09



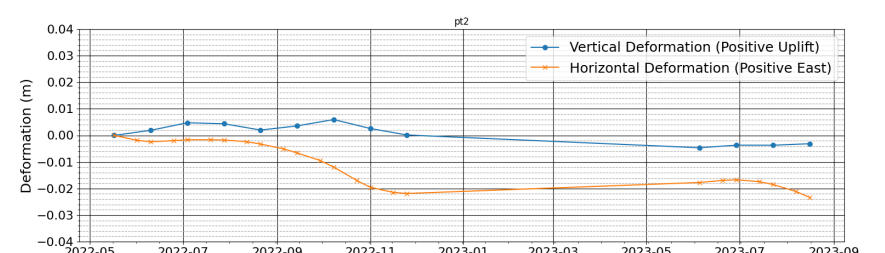
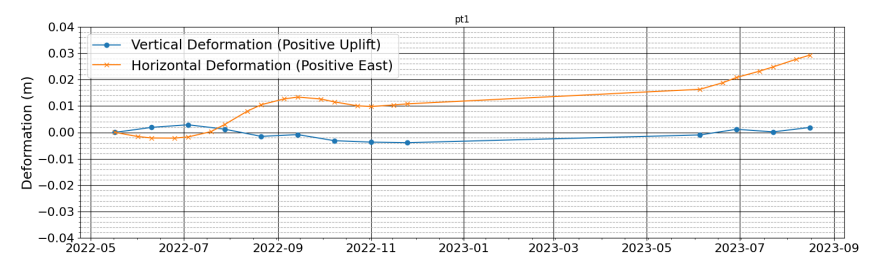
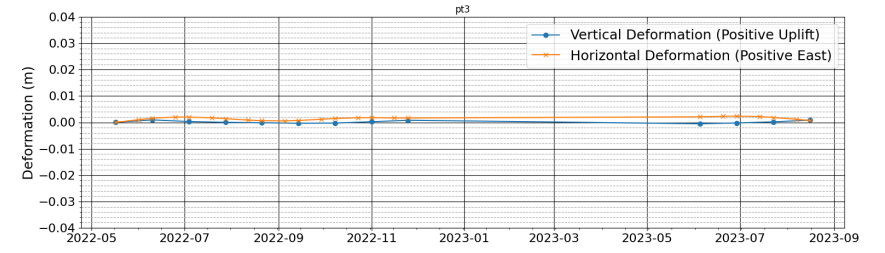
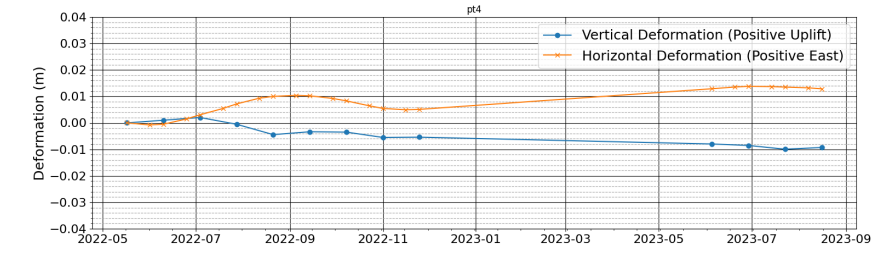
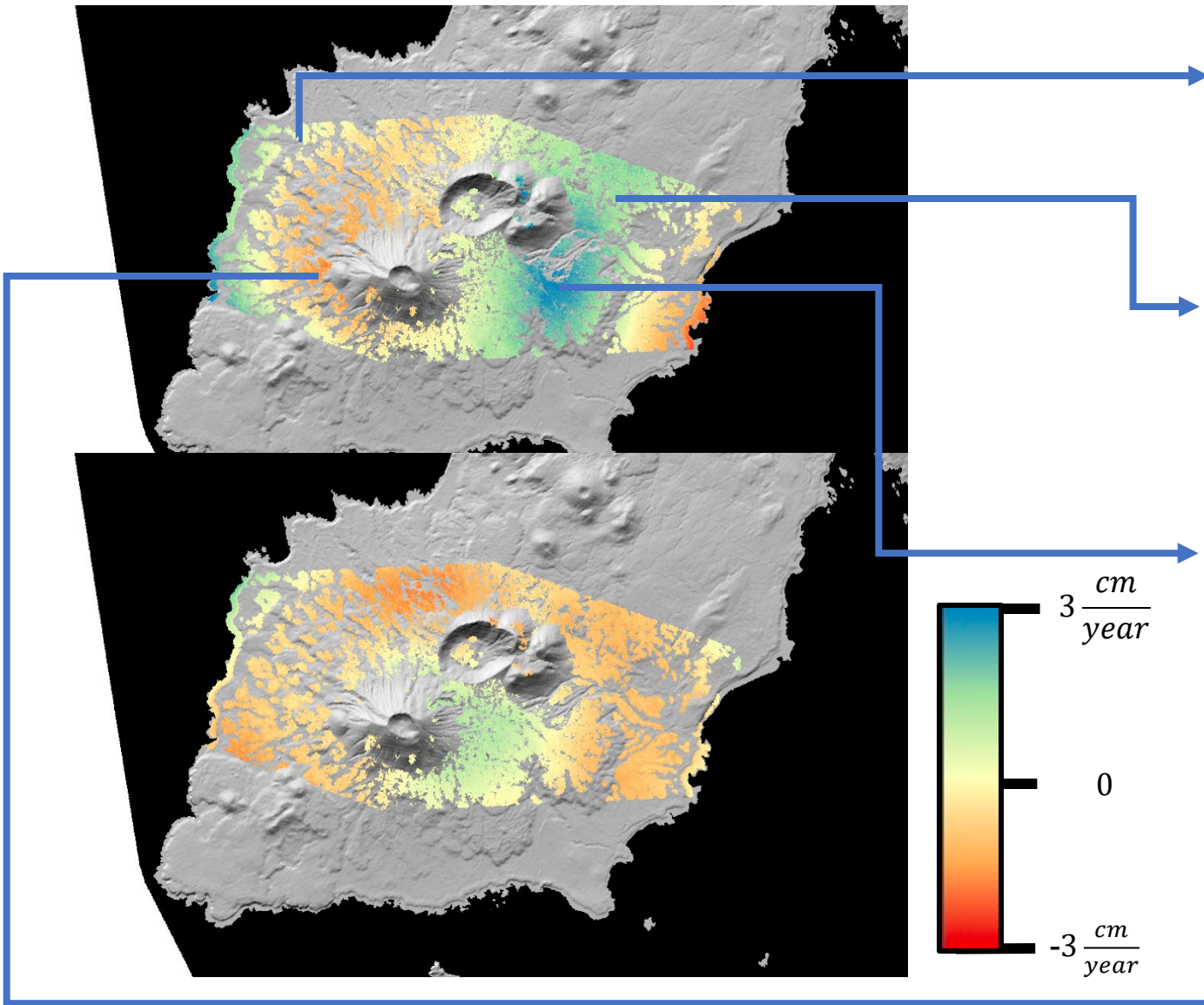
2022/07/28 – 2023/07/23 (Asc)



2022/06/01 - 2023/07/14 (Desc)



1st Year of observations –Magmatic Unrest at Mt Edgecumbe

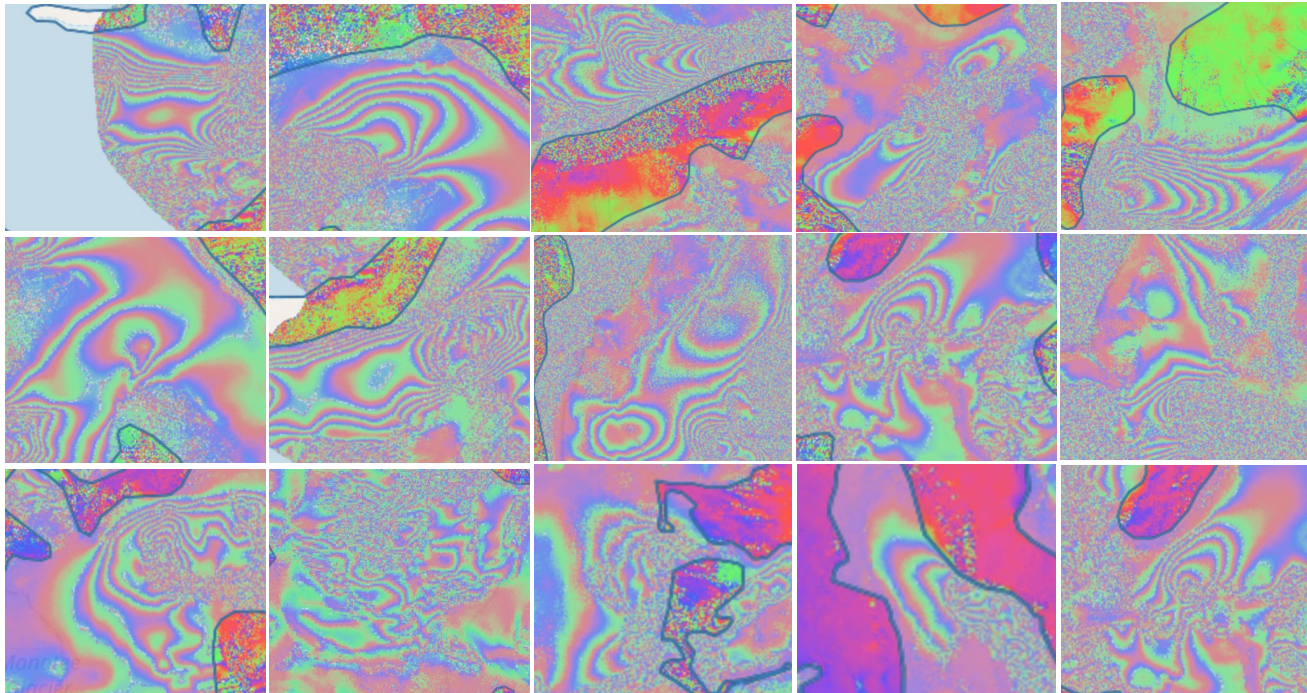


Conclusions

- VRRRC InSAR monitoring system running fully automatically, generating new InSAR measurements daily
- Deformation phenomena observed within the 1st year of operation
- Work remains in better atmospheric corrections, automated detection and deformation test cases

Future Directions

Growing training dataset of natural fringes

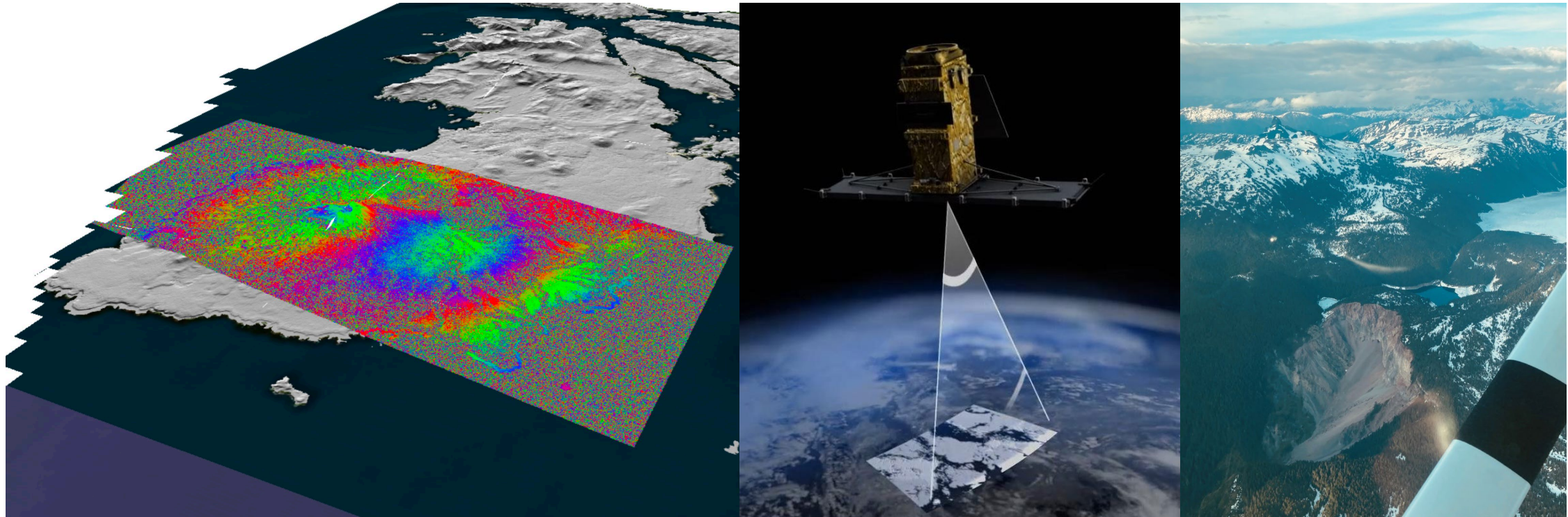


Growing number of volcano sites globally



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- ❖ Sergey Samsonov and Jonathan Dudley – Canadian Center for Mapping and Earth Observation
- ❖ Canadian Space agency



References:

- Dudley, J.P. Samsonov, S.V. 2020. The Government of Canada automated processing system for change detection and ground deformation analysis from RADARSAT-2 and RADARSAT Constellation Mission Synthetic Aperture Radar data: description and user guide, Geomatics Canada, Open File 63: 65
- Ewert, J.W., 2007. System for Ranking Relative Threats of U.S. Volcanoes; *Natural Hazards Review*, v. 8, p. 112-124.
doi:10.1061/(ASCE)15276988(2007)8:4(112)
- Ewert, J.W., Diefenbach, A.K., and Ramsey, D.W., 2018. 2018 Update to the U.S. Geological Survey National Volcanic Threat Assessment; United States Geological Survey, Scientific Investigations Report 2018-5140, 40 p. doi:10.3133/sir20185140
- Ewert, J.W., Guffanti, M., and Murray, T.L., 2005. An assessment of volcanic threat and monitoring capabilities in the United States: framework for a National Volcano Early Warning System (NVEWS); United States Geological Survey, Open-File Report 2005-1164, 62 p. doi:10.3133/ofr20051164
- Grapenthin, R., Cheng, Y., Angarita, M., Tan, D., Meyer, F. J., Fee, D., & Wech, A. (2022). Return from dormancy: Rapid inflation and seismic unrest driven by transcrustal magma transfer at Mt. Edgecumbe (L'ux Shaa) Volcano, Alaska. *Geophysical Research Letters*, 49, e2022GL099464.
<https://doi.org/10.1029/2022GL099464>
- Samsonov, S V. 2019. User manual, source code, and test set for MSBASv3 (Multidimensional Small Baseline Subset version 3) for one- and two-dimensional deformation analysis. Geomatics Canada, Open File
- Souther, J G. Geology, Mount Edziza volcanic complex, British Columbia; Geological Survey of Canada, "A" Series Map 1623A, 1988, 2 sheets,
- Stasiuk, M. V, Hickson, C.J., and Mulder, T., 2003. The vulnerability of Canada to volcanic hazards; *Natural Hazards*, v. 28, p. 563–589.
doi:10.1023/A:1022954829974

