Using glaciers to identify, monitor and predict volcanic activity

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Objective

- Our study for the first time tests the potential of using mostly **freely available optical and radar satellite imagery** (SAR) to detect the types and timing of **volcanic impacts on glaciers** on a world wide basis
- Based on the gained knowledge, this study also focuses on the development of a **predictive tool** for imminent eruptions

Background/Methods

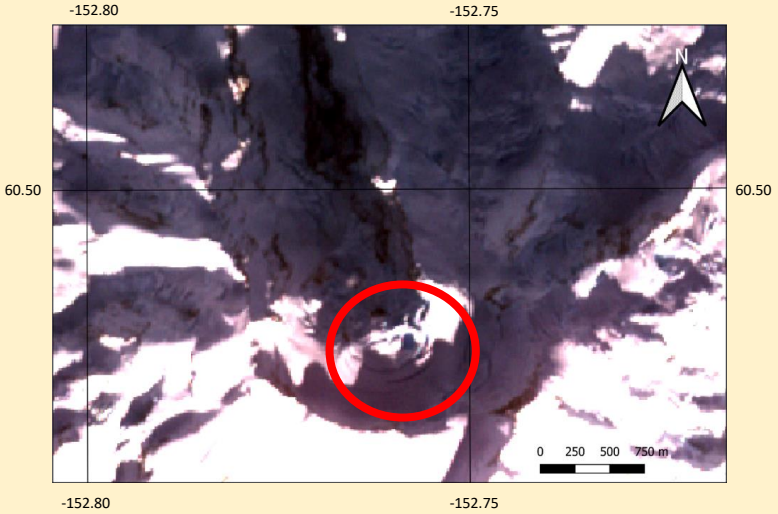
Background

- About ~ 250 volcanoes on earth are ice-clad[2]
- Possible ways that volcanoes and glaciers interact include[1]: Subglacial melt/enhanced geothermal heating, Supraglacial floods/lahars/lava flows, Supraglacial tephra/debris deposition
- Hazards associated with ice-volcano interactions include floods and lahars[3,4] due to increased melting and intense tephra production[5]

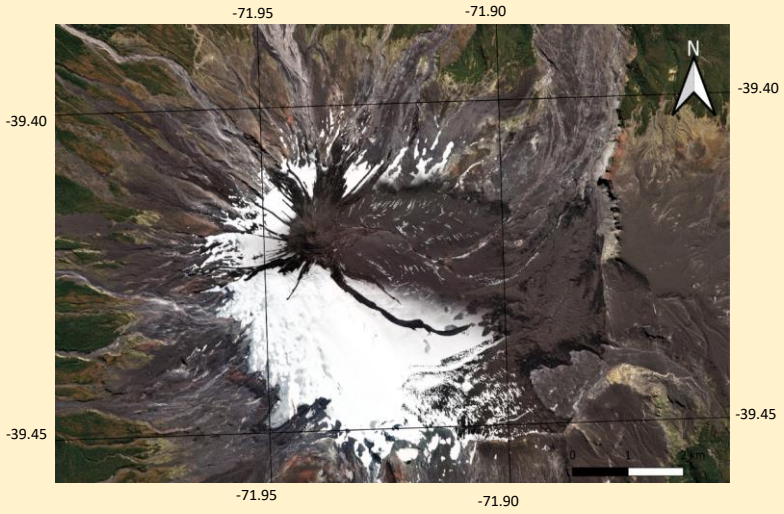
Methods

- **Systematic search of mostly freely available satellite remote sensing data** for the past ~30 years
- This study builds upon Barr et al. 2018, who reviewed volcanic impacts on glaciers since 1800 AD[1] and a dataset of Benjamin Edwards with locations of ice-clad volcanoes around the globe[2]
- Software/search machines: ArcGIS, QGIS, SNAP/google earth engine, planet

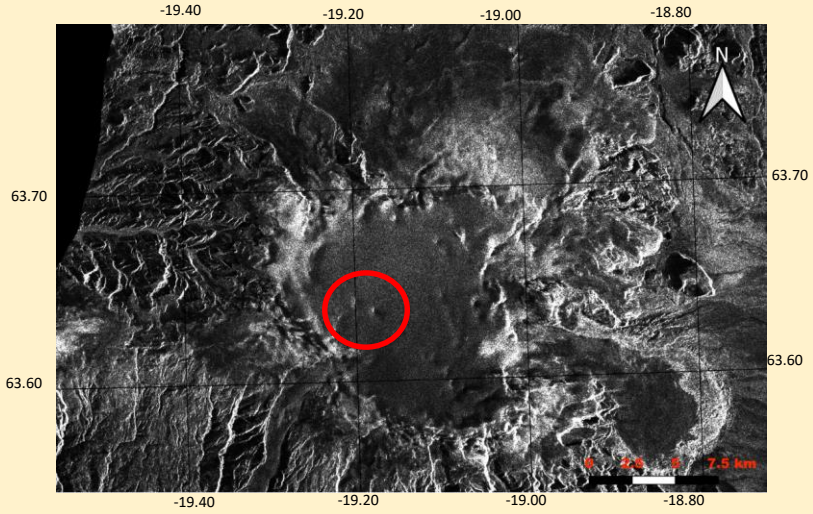
Results



Mount Redoubt (Alaska) seen from ASTER satellite with ice cauldron and crevassing (red circle) before start of eruption on March 22nd 2009



Vólcan Villarrica (Chile) seen from RapidEye satellite with black tephra cover after the eruption of 3rd March 2015



SAR ENVISAT-ASAR image of Mýrdalsjökull (Iceland) revealing circular depressions (red circle) due to geothermal heating

Conclusions

- Common indicators of interactions between glaciers and volcanoes (based on our remote sensing work):
- ➢ Circular depressions (with crevasses), cauldrons, meltwater lakes, tephra deposition
- Fast processing of Landsat/ASTER imagery in google earth engine allows us to view a large number of images in a short time
- Independence of SAR imagery from clouldcover/daylight supports the search process
- Outlook: Knowledge of detectability of features could act as a **basis for automatization techniques** such as machine learning approaches

References

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[4]Waythomas, C.F., Pierson, T.C., Major, J.J., and Scott, W.E., 2012, Preliminary observations of voluminous ice-rich and water-rich lahars generated during the 2009 eruption of Redoubt, Alaska: U.S. Geological Survey Open-File Report 2012-1078, 42 p.
[5]Edwards, B. R., Gudmundsson, M. T. and Russell, J. K. (2015) 'Glaciovolcanism.' *In The Encyclopedia of Volcanoes*. Elsevier, pp. 377–393.