



Servicio Nacional de Geología y Minería

Red Nacional de Vigilancia Volcánica

Observatorio Volcanológico de Los Andes del Sur- OVDAS

Monitoring Chilean Volcanoes From ground and space by OVDAS...

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- Gabriela Pedreros

GEOVOLCANOLOGIA, OVDAS

Nevados de Chillan, 2017



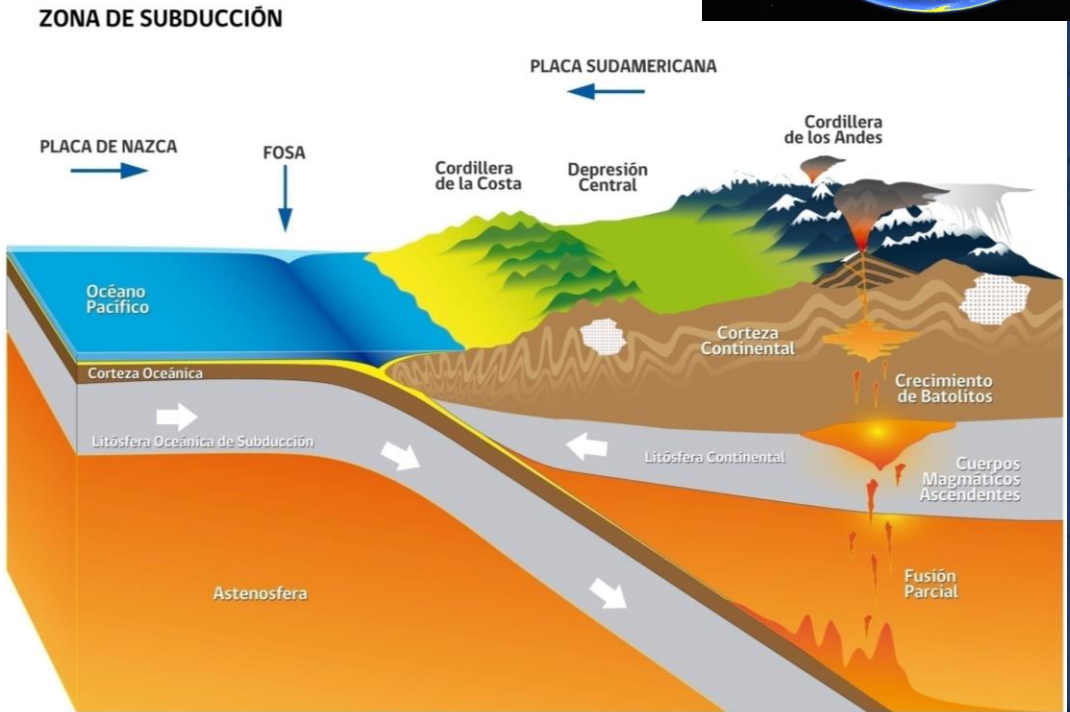
OUTLINE

- **Introduction:** Geological context. Creation of the **National Volcanic Surveillance Network** (RNVV) and the **Observatorio Volcanológico de los Andes del Sur** (OVDAS).
- **Monitoring techniques:** State of art at the Chilean Volcano Observatory OVDAS and how do we monitor volcanoes.
- **Crisis Response:** Monitoring surface and deformation changes during a crisis.
- **Improving volcano monitoring :** Comments about lack of data, useful data/online services and data policy





Chile: A country along a subduction zone, in the Pacific fire ring



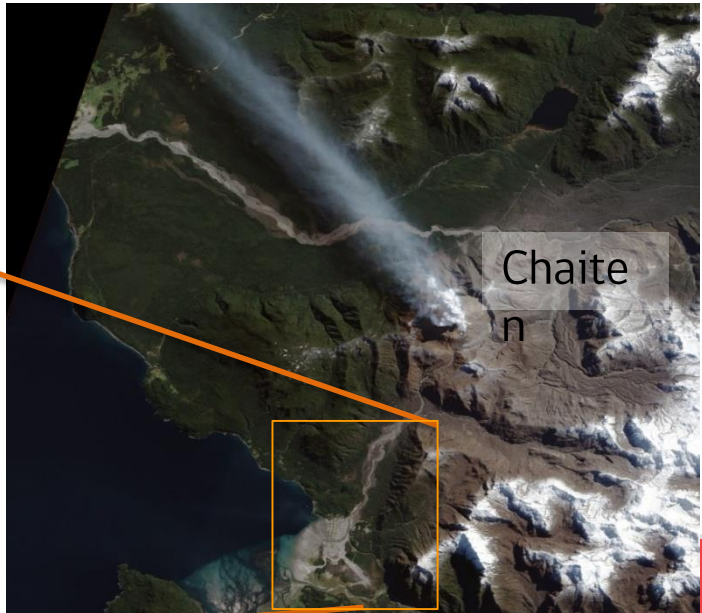


Creation of the **National Volcanic Surveillance Network**

(Red Nacional de Vigilancia Volcánica, RNVV)

In 2008 Chaitén and Llaima volcanoes erupted, with mayor impacts. These 2 volcanic emergencies triggered the creation of the RNVV, in January 2009.

OVDAS, the **Observatorio Volcanológico de los Andes del Sur** is part of RNVV.



Introduction

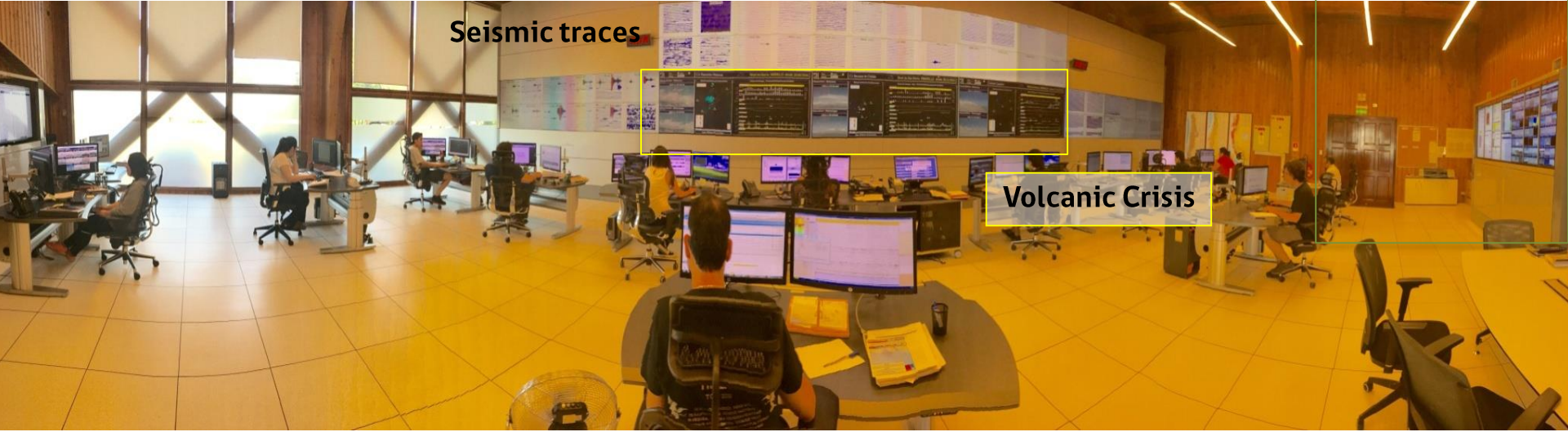
<http://www.sernageomin.cl/red-nacional-de-vigilancia-volcanica/>



After 12 years of the Project **OVDAS** has installed more than **200** stations of monitoring

Deformation, DOAS, and Cameras

Network Control



OVDAS is located in Temuco, 700 km south of Santiago



Which volcanoes are active?



Eastern Island



Lascar 2015



Villarrica 2015



Cordon Caulle 2011



Calbuco 2015



Isla Decepcion 1967

El 4 de diciembre de 1967 emergió un volcán en el mar y sus erupciones de lava y piedras destruyeron las bases allí instaladas. 27 miembros de la FACH, y los efectivos de la base inglesa fueron rescatados en medio de un verdadero caos.

Central Volcanic Zone

Southern Volcanic Zone

Austral Volcanic Zone

92 Active Volcanic systems
Continental Chile, Islands, Antarctica
Variety of tectonic settings, and a diversity of eruptive styles

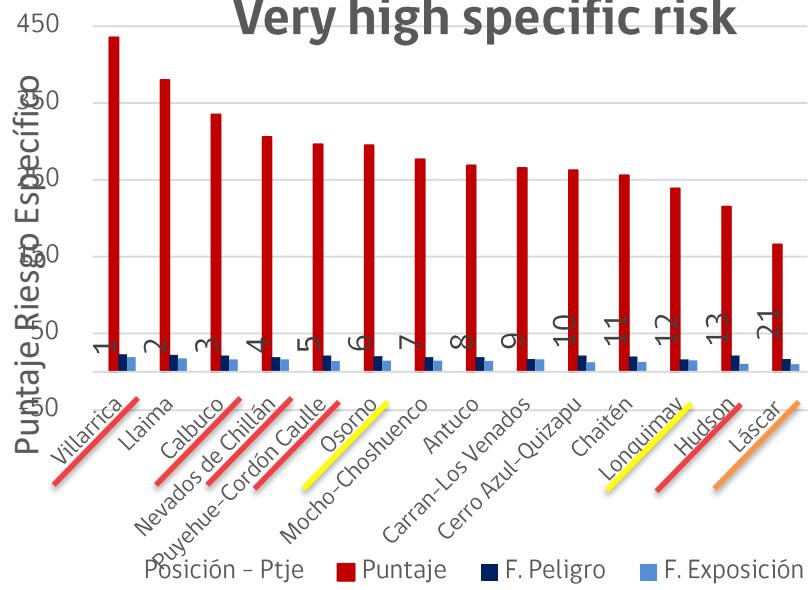


2019 Ranking of Relative Threats of Chilean volcanoes

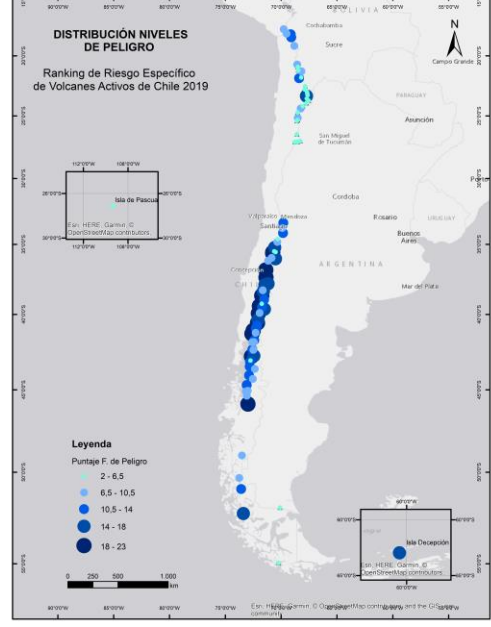
Result: 92 active volcanoes scored. Classified on 5 groups.

Group I:

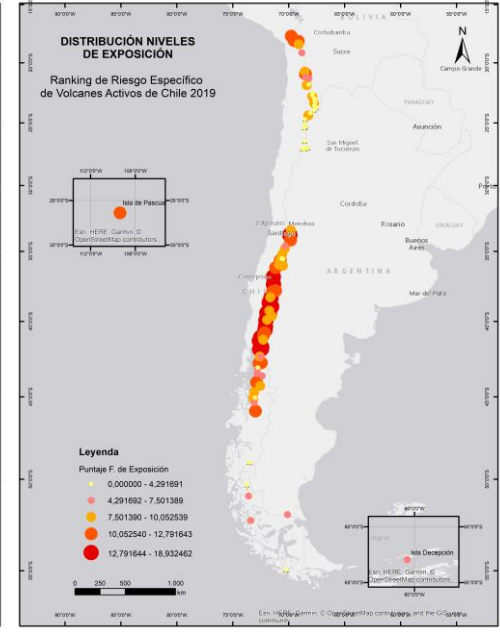
Very high specific risk



Hazard distribution



Exposure distribution



Ranking is the baseline to prioritize and define the volcanic networks (which type and how many instruments).

- Methodology modified from Ewert (2007) to fit to Chilean geological context.
- 13 hazard factors. 12 exposure factors.



The most 45 hazardous volcanoes are monitored (from good to very poor instrumental networks)



¿How do We monitor a volcano?

Fluids:

DOAS/ Direct sampling

Satellites



Infrasound:

Microphones



Surface Activity

Cameras (visual/termal), overflights, photogrammetry, **satellites**, and fieldwork.



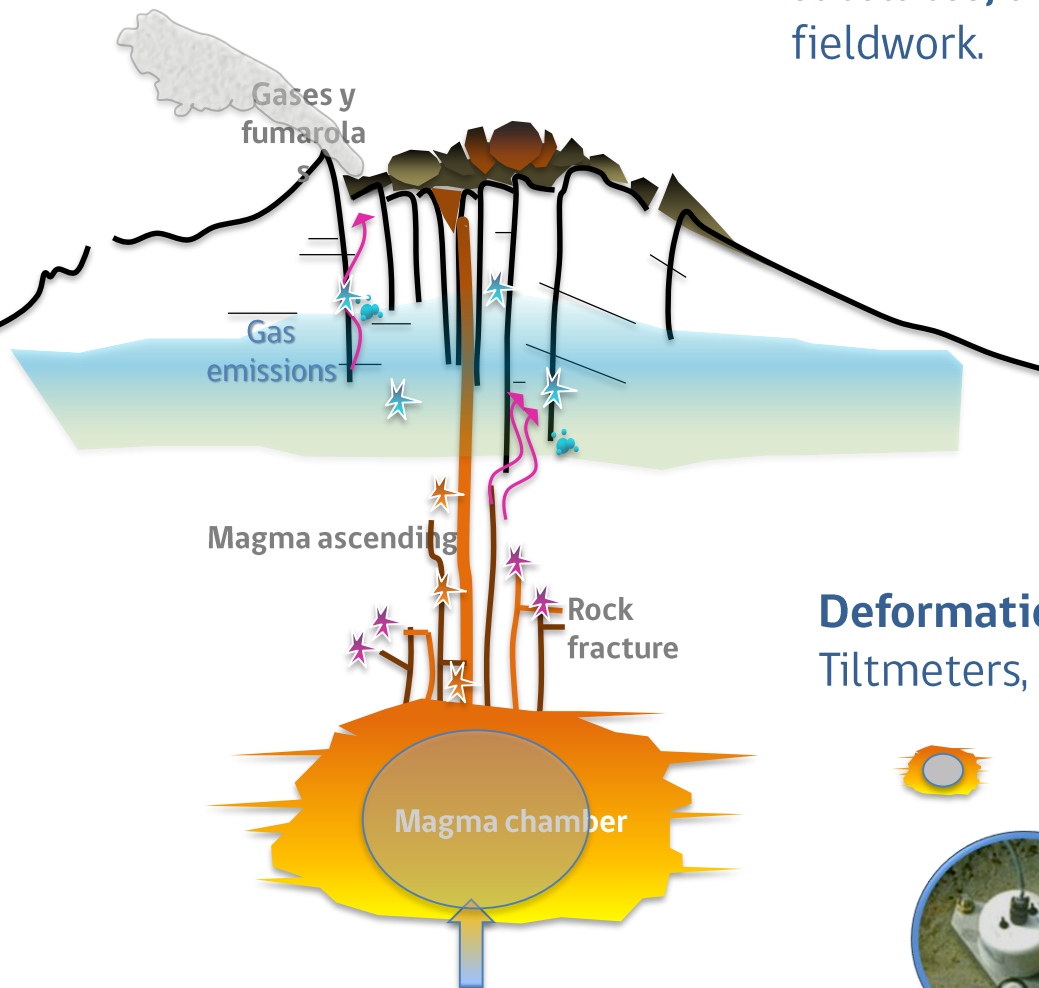
Seismicity:

Sismometers



Deformation:

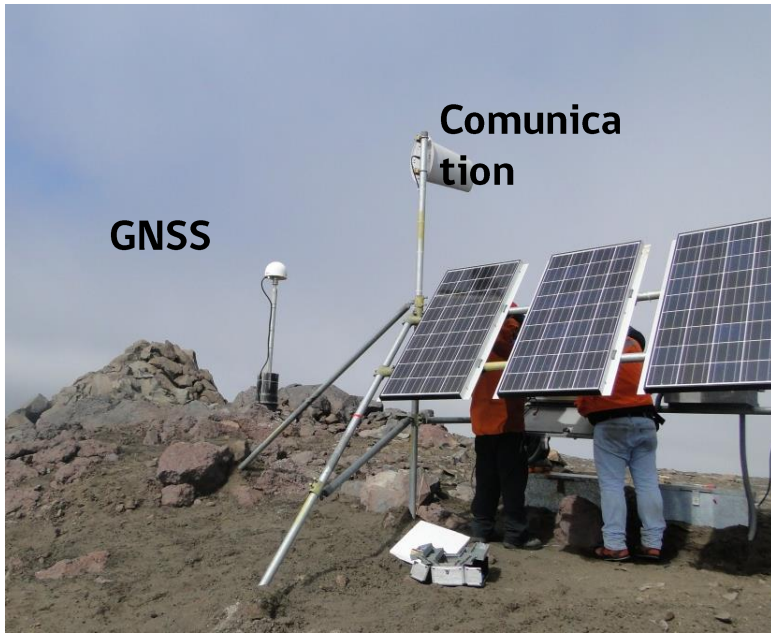
Tiltmeters, GNSS, **InSAR**



Modificado de Hincks et al (2014)



Some of our stations... and challenges



Our Challenge: More than 200 Stations working 24/7 the entire year, but Winter is hard in the Andes. High altitude and no ground Access for most of them.



Both instruments, installed on holes, at 0,5- 1 mt depth





Superficial activity



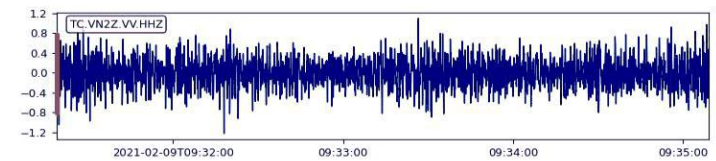
Emisión de ceniza. 320 m de altura. Dispersión NE.



Emisión de ceniza. 500 m de altura. Dispersión oeste.



2021-02-09T09:31:19 - 2021-02-09T09:35:09



05 de febrero del 2021 - 05:10 UTC



07 de febrero del 2021 - 08:02 UTC



Monitoring SO2

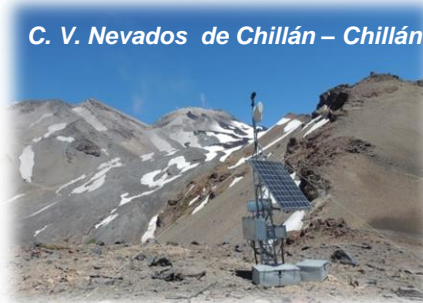
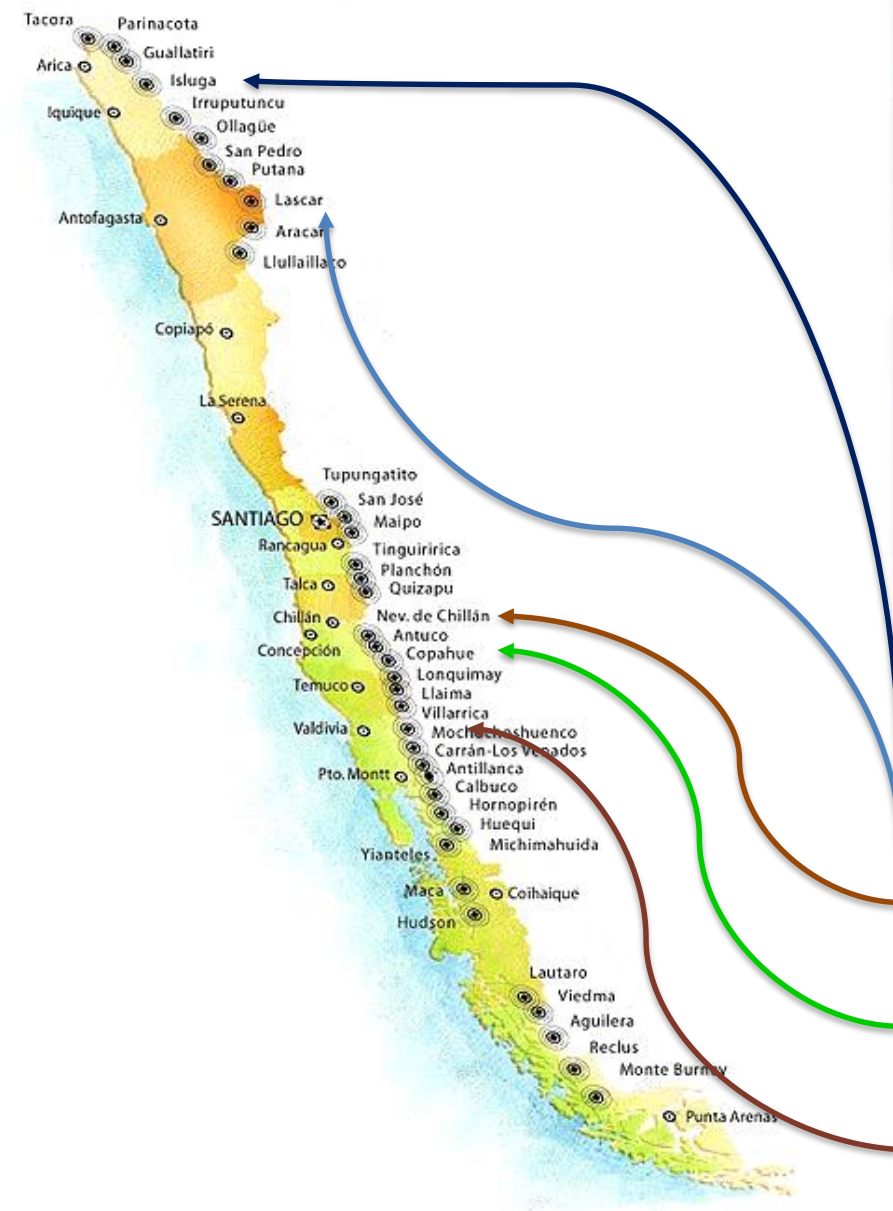
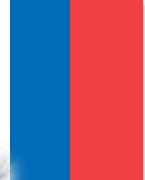


Tabla 2. Información estaciones DOAS instaladas

Volcano	Station	Distance to crater (km)
1. Isluga	Isluga	7,5
2. Lascar	Emu	7,0
3. Nevados de Chillán	Chillán	3,0
4. Copahue	Phillipi	1,5
5. Villarrica	Hito	5,5
	Mellizas	5,0
	Tralco	6,0
	Los Nevados	10



Emissiones SO₂ - OMI



<https://so2.gsfc.nasa.gov/>

NASA National Aeronautics and Space Administration
Goddard Space Flight Center

Atmospheric Chemistry and Dynamics Laboratory (Code 614)
Global Sulfur Dioxide Monitoring Home Page

Home News Publications Personnel Links

Latest SO₂ eruption alerts NOAA-NESDIS, SACS_BIRA, IASI-ULB.
SO₂ Near Real-Time Images: NASA(DR), FMI(DR), NASA(NRT), NOAA(NRT), AIRS(NRT), SACS(NRT).

SO₂ climatology from satellite instruments

Historic TOMS images | AIRS images | OMI images | OMPS images | TROPOMI images

Red = daily volcanic regions, green = daily pollution regions, blue = long-term pollution images

Source type:
● Oil and gas
● Power plant
● Smelter
▲ Volcano

Archived daily OMI/OMPS/TROPOMI images

Select Region
May 2014
submit

NASA Official: Nickolay A. Krotkov (Nickolay.A.Krotkov AT nasa.gov)
Web Content: Keith D. Evans (UMBC/JCET) (evans AT umbc.edu)
Last Updated: 2020-01-12

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NASA National Aeronautics and Space Administration
Goddard Space Flight Center

Flight Projects | Sciences and Exploration

Central Chile (OMI)

Jan 01, 2020 Jan 02, 2020 Jan 03, 2020 Jan 04, 2020 Jan 05, 2020 Jan 06, 2020
Jan 07, 2020 Jan 08, 2020 Jan 09, 2020 Jan 10, 2020 Jan 11, 2020

previous month OMPS imgs TROPOMI imgs next month

Time series plot

[Return to image selection page](#)


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Emissiones SO₂ - OMI

 National Aeronautics and Space Administration
Goddard Space Flight Center


Central Chile (TROPOMI)

Jan 01, 2020 Jan 02, 2020 Jan 03, 2020 Jan 04, 2020 Jan 05, 2020

[previous month](#) [OMPS imgs](#) [OMI imgs](#)

[Time series plot](#)

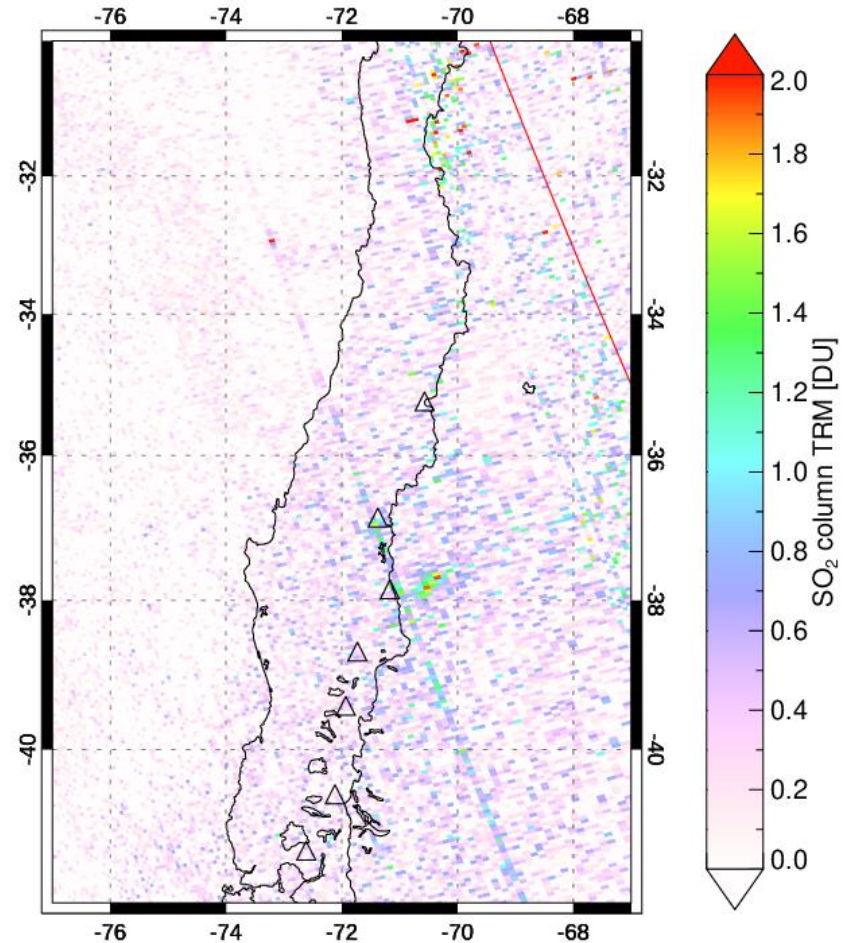
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 *Goddard*
SPACE FLIGHT CENTER

NASA Official: Nikolay A. Krotkov (Nikolay.A.Krotkov AT nasa.gov)
Web Content: Keith D. Evans (UMBC/JCET) (evans AT umbc.edu)
Last Updated: 2020-01-12

Sentinel-5P/TROPOMI - 12/08/2019 17:42-19:26 UT

SO₂ mass: 0.0369 kt; Area: 927 km²; SO₂ max: 18.85 DU at lon: -73.21 lat: -32.94 ; 19:25UTC



Data: BIRA-IASB/DLR/ESA/EU Copernicus Program

For many of Chilean volcanoes the SO₂ monitoring is based on satellite data. Daily check and incorporated to our Volcanic Activity Reports (RAV).

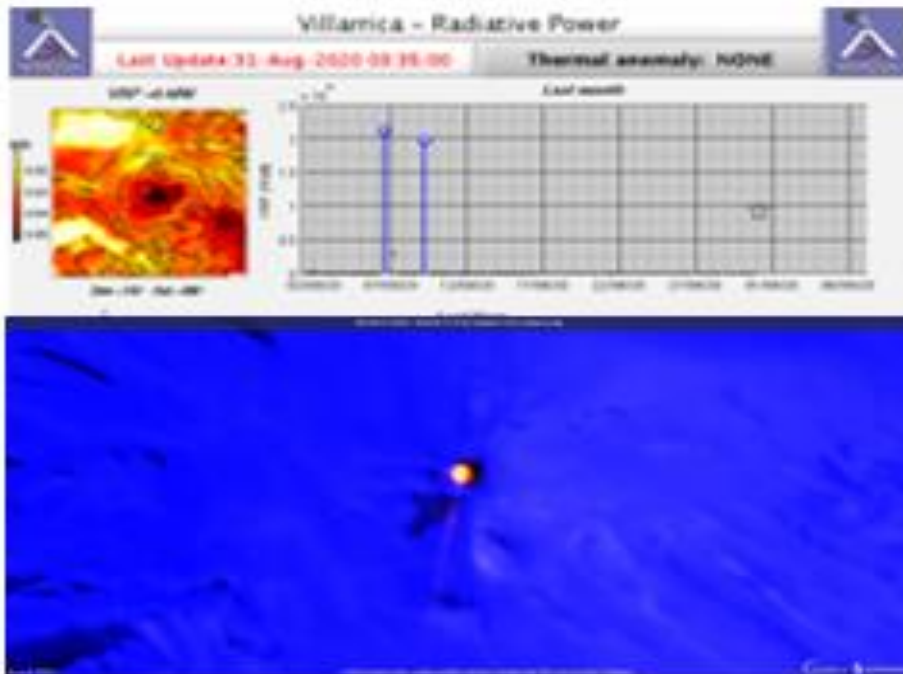




Thermal images from satellites (Infrared) MIROVA and Sentinel2- L2A

MIROVA Daily analysis of available data. Information for around 10 of our 45 monitored volcanoes is available.

[VOLCANOES](#)
[NRT](#)
[COUNTRIES](#)
[LATEST MEASURES](#)
[G-MAP](#)
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Latest HotSpots for Chile

ID	COUNTRY	NAME	POWER (MW)	DATE
357100	Chile	Lonquimay	0	2020-10-08 15:40
357110	Chile	Llaima	0	2020-10-08 15:40
358040	Chile	Minchinmávida	0	2020-10-08 15:40
357130	Chile	Mocho-Choshuenco	0	2020-10-08 15:40
357150	Chile	Puyehue-Cordón Caulle	0	2020-10-08 15:40
357040	Chile	Planchón-Peteroa	0	2020-10-08 15:40
358020	Chile	Calbuco	0	2020-10-08 15:40
358057	Chile	Hudson, Cerro	0	2020-10-08 15:40
358041	Chile	Chaitén	0	2020-10-08 15:40
357091	Chile	Callaqui	0	2020-10-08 15:40

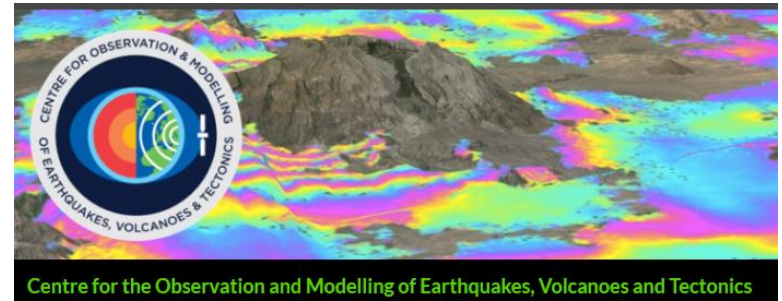
Volcanic Radiative Power Scale



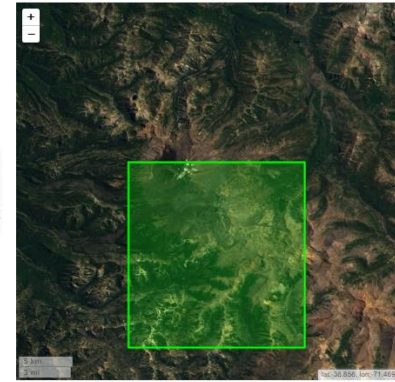
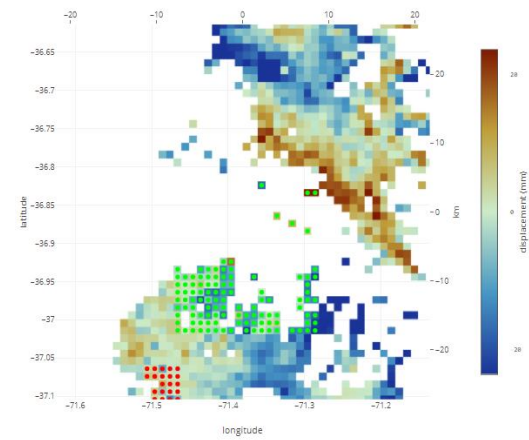
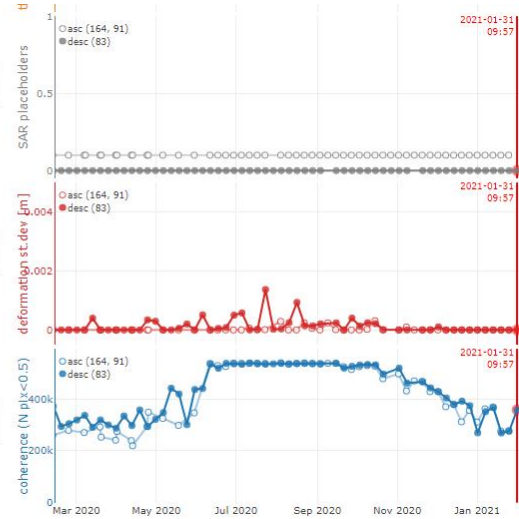
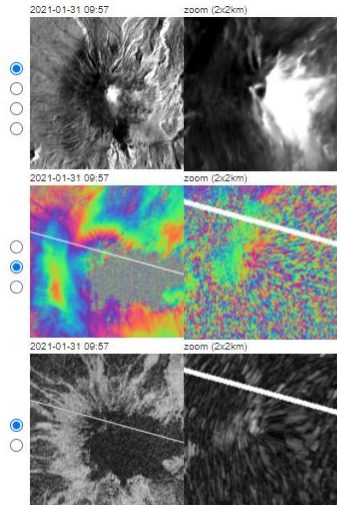


<http://www.mounts-project.com/timeseries/357120>

ID	NAME	COUNTRY	SO2 MASS* [tons]	THERMAL ANOMALIES* [npix]	DEFORMATION* std. dev [m]	LATEST product
332010	Kilauea	United States	60	1209	0	2021-02-01 20:59 S2
341040	Colima	Mexico	0	0	0	2021-02-01 19:44 S5P
341090	Popocatepetl	Mexico	579	33	0	2021-02-01 19:44 S5P
342030	Santa María	Guatemala	0	5	0	2021-02-01 19:44 S5P
342090	Fuego	Guatemala	0	38	9.9e-05	2021-02-01 19:44 S5P
344040	Telica	Nicaragua	0	7	0	2021-02-01 19:44 S5P
344090	Momotombo	Nicaragua	0	7	0	2021-02-01 19:44 S5P
357120	Villarrica	Chile	0	0	0	2021-02-01 19:24 S5P
352010	Reventador	Ecuador	0	0	0	2021-02-01 17:59 S5P
360050	Soufrière Hills	United Kingdom	0	1	0	2021-02-01 17:59 S5P
354006	Sabancaya	Peru	1999	4	0	2021-02-01 17:54 S5P
354020	Ubinas	Peru	2306	0	0	2021-02-01 17:54 S5P
355100	Láscar	Chile	0	7	0	2021-02-01 17:49 S5P
357070	Chillán, Nevados de	Chile	0	0	0	2021-02-01 17:49 S5P



<https://comet.nerc.ac.uk/>



displacement coherence
 points to plot reference area
 save data as csv surface plot

plot sentinel-2 map
 time series profile
 save data as csv

Map tiles from Sentinel-2 courtesy of ESA/ESA Services GmbH (Contains modified Copernicus Sentinel data)



<https://sarviews-hazards.alaska.edu/>
Nevados de Chillan (and Laguna del Maule)



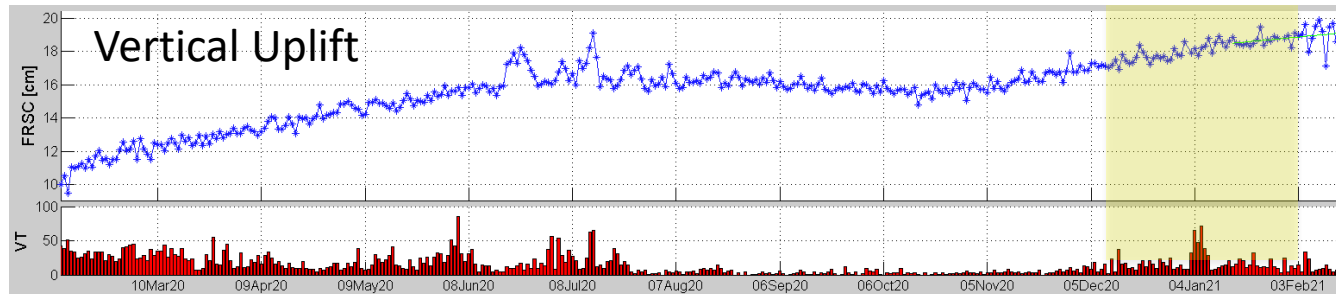
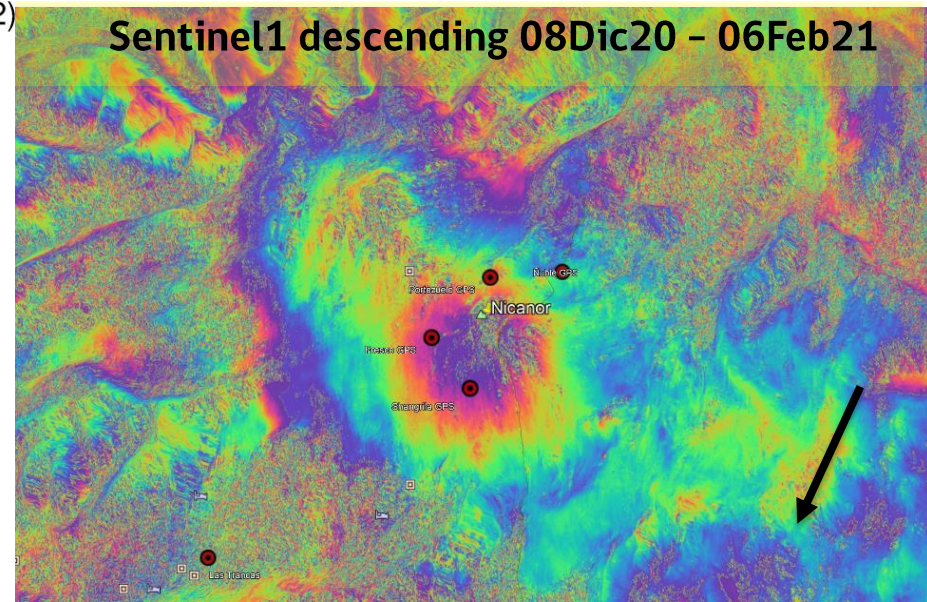
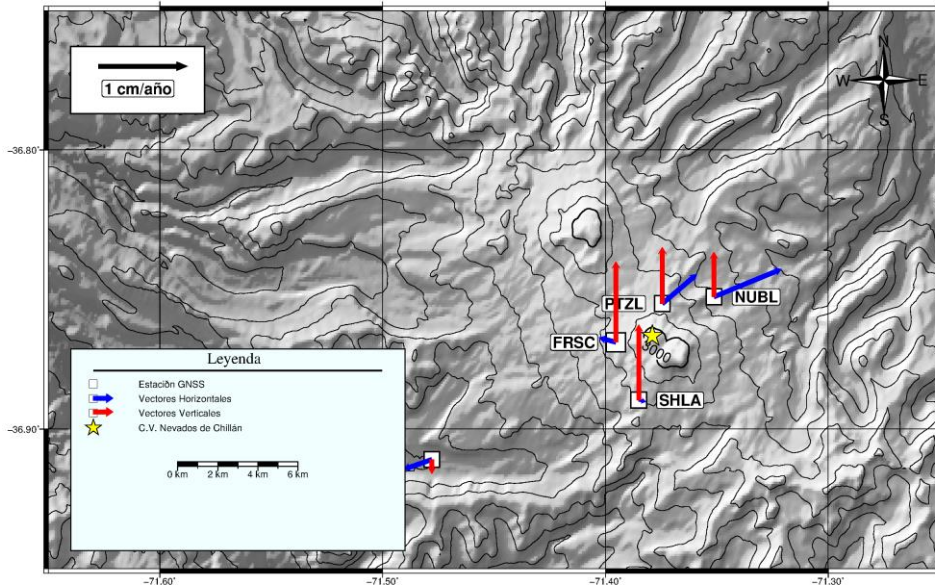
Key points about InSAR platforms:

- Updated for monitoring.
- Time series helps a lot to check if there is or not deformation.
- Temporal baseline for isolated interferograms. Usually very short (6 days) doesn't detect slow rates of deformation, ex Nev.de Chillan.



- 45 GNSS stations installed in 14 volcanoes and 9 tiltmeters working in 5 volcanoes.
- Sentinel1A/B data has been processing regularly, in priority volcanoes, using SNAP (snap2stamps, -StAMPS)

Vectores de desplazamiento C.V. Nevados de Chillán (15/01 al 15/02)

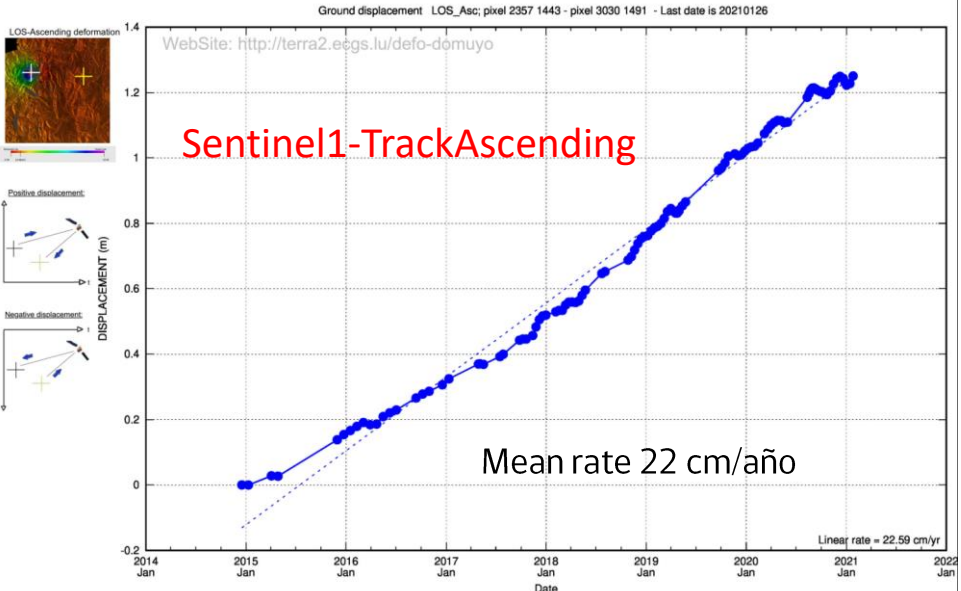
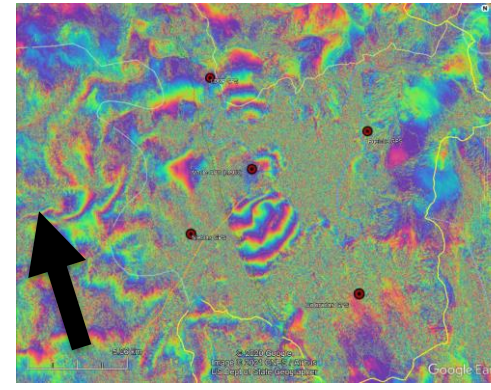
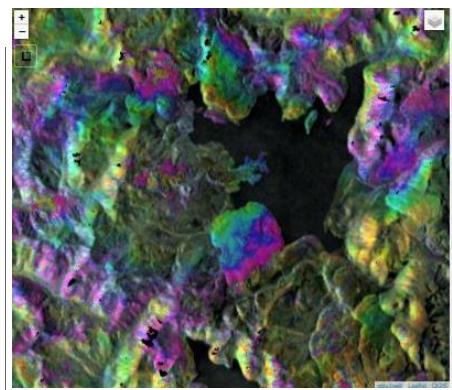




- Laguna del Maule
- Domuyo

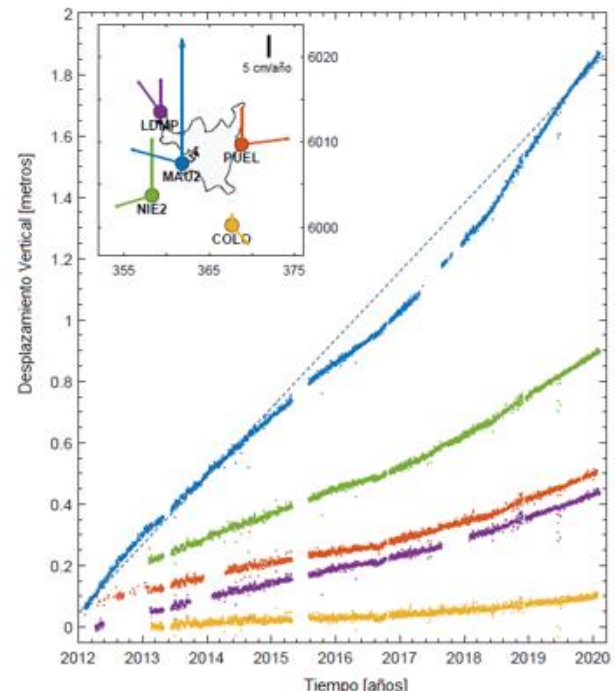
Last 3 months:
Asc_15Dic20-13Feb21

Last year:
Asc_20Mar20-07Feb21



LOS displacement from Sentinel1 available in <http://terra3.ecgs.lu/defo-domuyo/#8/-36.497/-70.369>

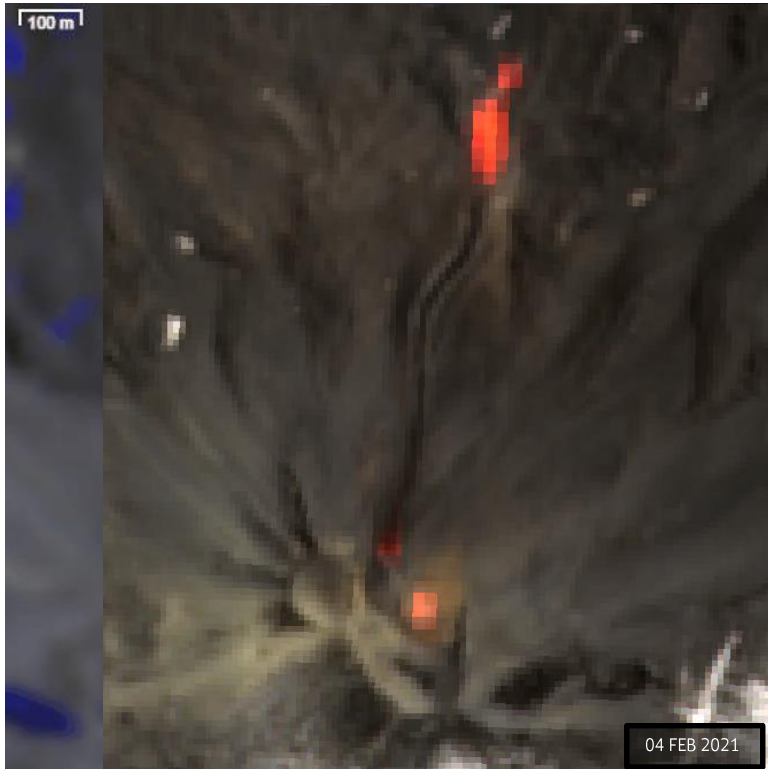
- Increase of seismic activity last months
- Deformation pattern without significance variation during the last years (2018-2020).
- Maximun uplift near to MAU2, (>1,8 meters since instalation in 2012).
- INSAR shows low coherence along Troncoso Fault.



GNSS time series at LDM

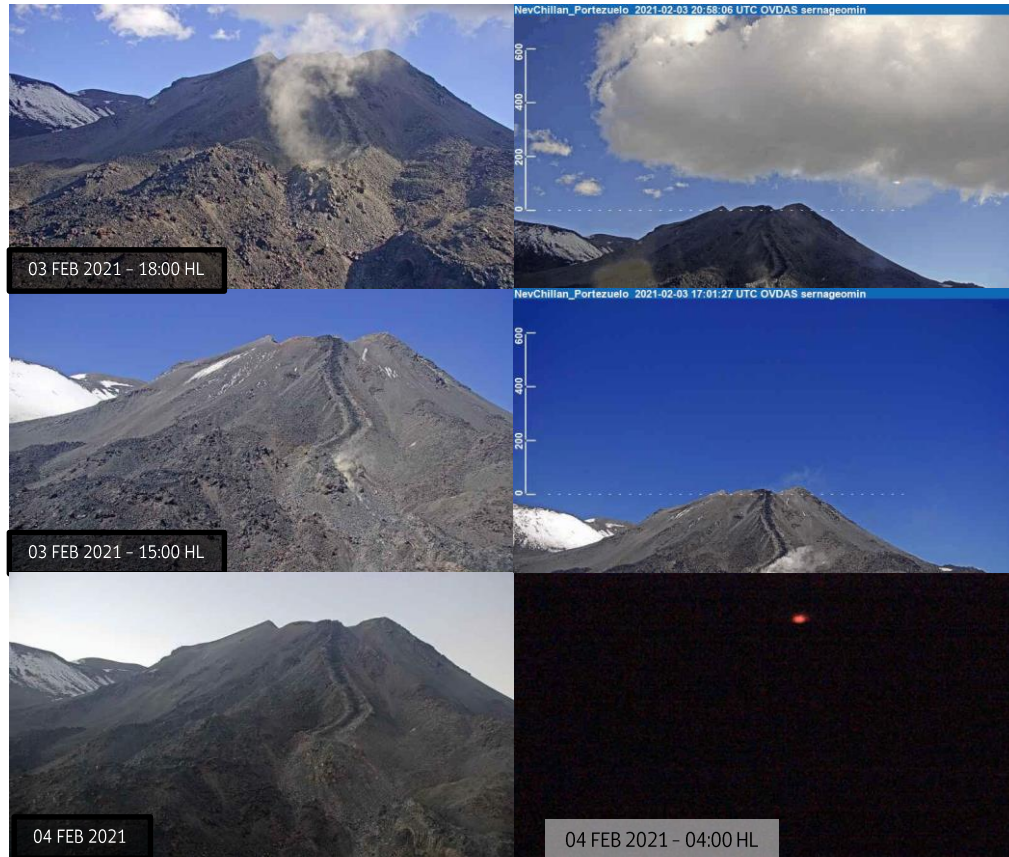


Efusive activity and Sentinel2-L2 A



Nuevo peak de radiancia térmica en frente de lava L5 visible en imágenes Sentinel L2 A, los días 23 y 25 de enero. Máximo peak el día 04 feb 2021.

Peak de AT en frente muestra un alto dinamismo con variaciones abruptas.



Nevados de Chillan Volcano Complex : 2016- ?



Captura Colada desde el 01 a 15 FEB 2021



Se mantiene la desgasificación continua y anómala desde frente de L5, se destaca el mayor desarrollo del canal central en cuanto a su ancho y extensión. Se observa un avance del frente de forma "compacta" y además, en bloques. Esta evolución es coherente con el aumento de tasa de emisión y cambio reológico reportado la quincena anterior.

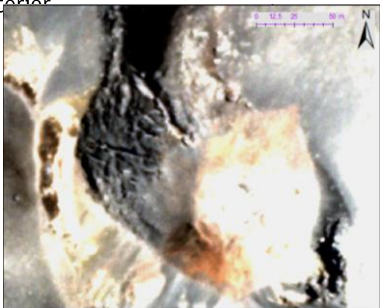


Imagen Skysat 09.12.2020

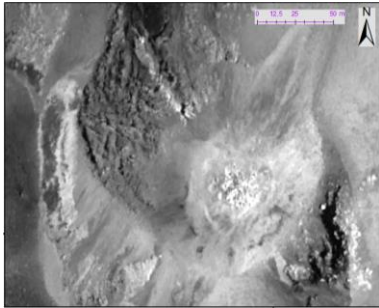


Imagen Pleiades 01.01.2021

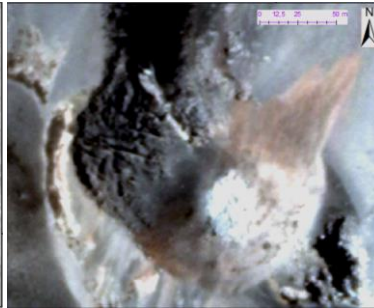
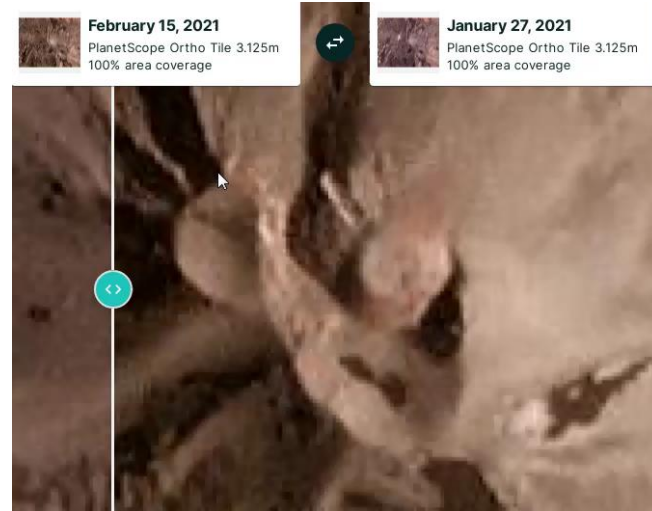
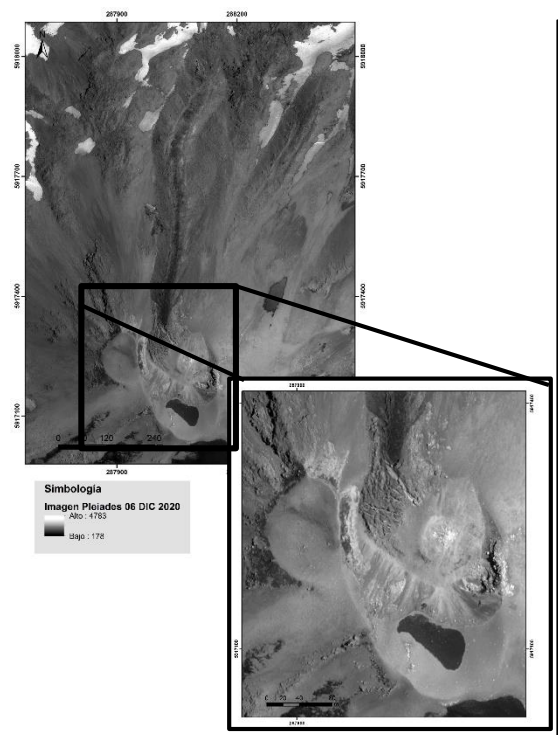
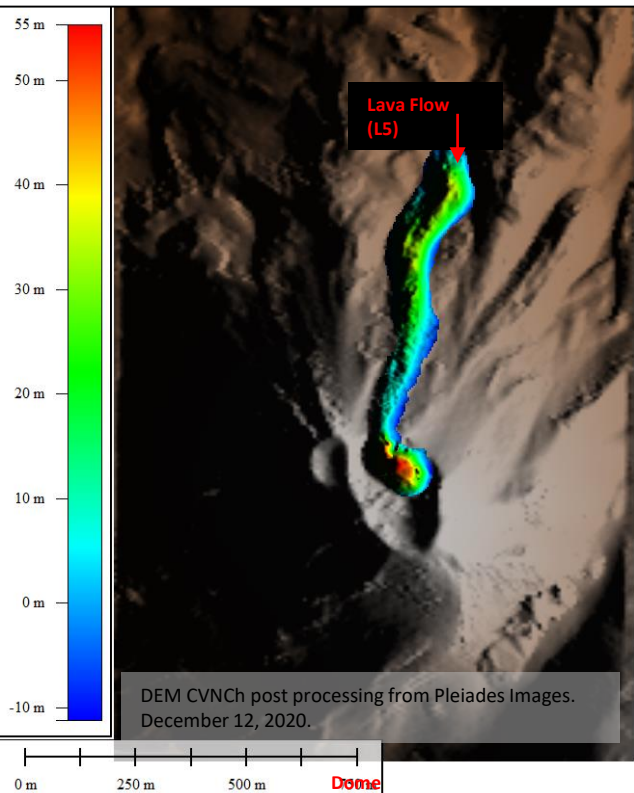


Imagen Skysat 10.01.2021



Nevados de Chillan Volcano Complex: 2016- ?



Remotes Sensing contribution to track CVNCh activity

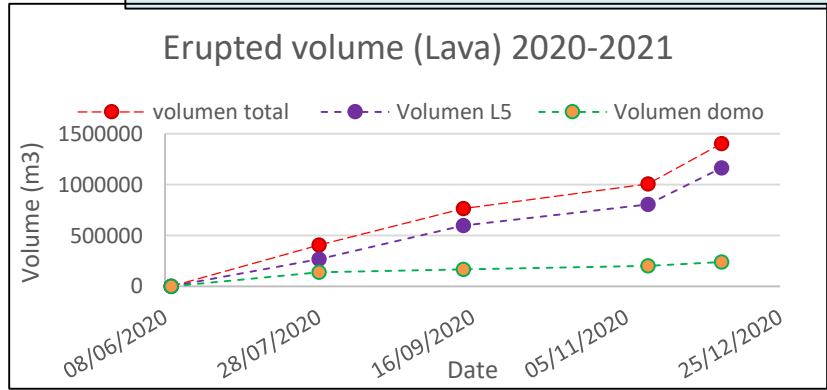
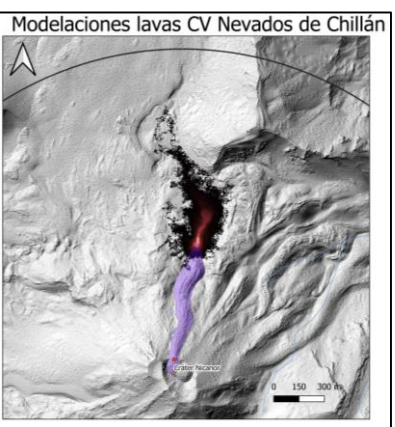
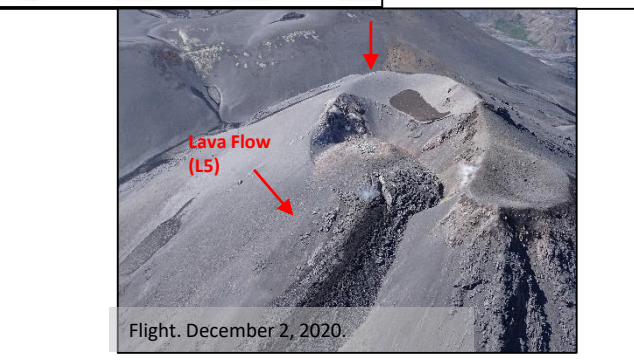
Sources:

- Skysat y Planet Scope
- Pleiades Images-World View
- DEMs from post procesing Pleiades and World View images

(Support from Volcano Demostrator Program and VDAP)

Results:

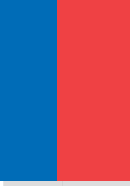
- ✓ Morphological evolution
- ✓ Mapping lava flows
- ✓ Volume estimations
- ✓ Eruptive rate tracking and changes on regime.
- ✓ Volcanic hazards modelling.



Comments about lack of data, useful data / online services

- More people and resources/instruments are needed (about 30 people for 45+ volcanoes). And continue the installation program.
- Would be great to **improve gas detection**, since there are only 5 volcanoes monitored by ground instruments (DOAS).
- A good way to face a volcanic emergency has been a **multiparametric monitoring**.
- **Optical high resolution images** (spatial and temporal), allows to track the process and improve our forecast and risk assesment, are still not open (as Sentinel1, for instance). We dream this kind of data could be **available online with expeditious access** in order to give a quick response (excellent parters CEOS Projects Supersites, Volcano Demonstrator/VDAP)

Comments about lack of data, useful data / online services



- **Online platforms** and **open satellite** data allow to monitor volcanos without instruments and complement our ground monitoring, following active volcanoes with anomalies, that are not erupting (not priority for ground instrumentation e.g., Isluga, Lastarria, etc). But there are priority volcanoes (type I) not included in them.
- We are open to share data and work under Cooperation Agreements (specific projects and general studies), in order to improve our knowledge about our volcanic systems.
- **THANK YOU!**

