

Biennial report for Permanent Supersite/Natural Laboratory

Ecuadorian Volcanoes Supersite

History	http://geo-gsnl.org/supersites/permanent-supersites/ecuadorian-volcanoes-supersite/
Supersite Coordinator	<i>Patricia Mothes, Escuela Politécnica Nacional, Instituto Geofísico, Ladrón de Guevara E11-253, Quito Ecuador</i>

1. Abstract

The Ecuadorian Volcanoes Supersite is an initiative which has slowly gotten access to satellite images for use in InSAR processing. There are more than 35 potentially active volcanoes in continental Ecuador and several are often in eruptive state. Cotopaxi, which is probably one of the most dangerous volcanoes in all of the Americas, because of the high probability for producing huge lahars (debris flows), had a mild awakening in 2015, and while it quieted down and is now basically sleeping, could awaken at any time. With the capability of processing the satellite images the Instituto Geofísico of the Escuela Politécnica Nacional in Quito, which has a government mandate to perform volcano and tectonic monitoring, has been able to efficiently make interferograms of the restless volcanoes. These images and their respective interpretation are shared with the National Secretary for Risk Management as well as being given broad diffusion through social media for the public at large.

We consider that the use of satellite images as now a vital part of our volcano and tectonic monitoring because of the wide coverage area, the rapidity of repeat times and the facility to now process these images with new and innovative programs. The Ecuadorian Supersite has facilitated use of the satellite imagery and also learning by practitioners of the many applicable uses for the imagery.

2. Scientists/science teams

<In the table below please list all scientists/science teams who used/received data >

Researcher/team 1	<i>Patricia Mothes, IGEPN, Quito Ladrón de Guevara E11-253, pmothes@igepn.edu.ec, https://www.igepn.edu.ec/personal-vulcanologia/114-mothes-patricia</i>
Researcher/team 1	<i>Santiago Aguaiza, IGEPN, Quito Ladrón de Guevara E11-253, sagaiza@igepn.edu.ec, https://www.igepn.edu.ec/personal-vulcanologia/115-aguaiza-santiago</i>
Researcher/team 1	<i>Marco Yépez, IGEPN, Quito Ladrón de Guevara E11-253, myopez@igepn.edu.ec.</i>

Scientists/science teams issues

At present we are monitoring more than 10 volcanoes by remote sensing with SENTINEL data. In the next 6 months we will use COSMO SKYMED and TerraSar-X data for monitoring volcanoes Chiles, Sangay and Cotopaxi. Probably we will need more staff and computational resources for downloading, processing and interpretation of data.

One limitation has been lack of personnel to make downloads of data. We also manage the 115 stations geodesic network.

1. In situ data

<In the table below please list all in situ data types available for the Supersite>

Type of data	Data provider	How to access	Type of access
<i>e.g. seismic waveforms, GPS time series, gas measurements, etc.</i>	<i>Link to data repository or description of procedure for data access</i>	<i>E.g. unregistered public, registered public, limited to GSNL scientists, etc.</i>
GPS time series	IGEPN	Data of 22 stations at UNAVCO	--
Tilt time series	IGEPN	Upon request	--
Broad band seismic waveforms	IGEPN-JICA	https://www.igepn.edu.ec/cotopaxi-sismogramas	--
Short band seismic waveforms	IGEPN	Data of 20 stations at IRIS	--
Gas measurements	IGEPN	Upon request	--
Thermal monitoring	IGEPN	OMI, Firms and upon request	--

Gravity measurements	IGEPN	Upon request	--
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In situ data issues

We provide data upon request and wish to have collaborations with other scientists who use our data.

2. Satellite data

<In the table below please list all satellite data types available for the Supersite>

Type of data	Data provider	How to access	Type of access
TerraSAR X.	DLR,	Updated 2yr license-Feb19	Limited to licensed user
COSMO-SkyMed,	ASI,	Updated 2yr license-Feb19	Limited to licensed user
Radarsat 2	CSA	Updated 2yr license-Feb19	Limited to licensed user
Sentinel 1	ESA	Continuously accessible...	...Open access

Satellite data issues

Imagery from 4 space agencies is available. What is limited is the time and personal to download it.

3. Research results

<Should contain an overview of the scientific achievements. Please try to provide some pictures and enough information for a non-specialized audience so that the CEOS can use it also for dissemination purposes. If this part is too long, you can place it in an Annex. >

Publications

<In this subsection please list all publications obtained using datasets (in situ and EO) obtained through the Supersite initiative>

Peer reviewed journal articles

-Morales Rivera AM, Amelung F, Mothes P (2016). Volcano deformation survey over the Northern and Central Andes with ALOS InSAR time series. *Geochemistry Geophysics Geosystems*, June. DOI: 10.1002/2016GC006393.

-Ebmeier SK, Elliott JR, Nocquet JM, Biggs J, Mothes P, Jarrín P, Yépez M, Aguaiza S, Lundgren P and Samsonov SV (2016). Shallow earthquake inhibits unrest near Chiles–Cerro Negro volcanoes, Ecuador–Colombian border. *Earth and Planetary Science Letters*, Volume 450, 15 September 2016, Pages 283–291.

-Morales Rivera, AM, AMF Amelung, P. Mothes, S.-H. Hong, J.-M. Nocquet and P. Jarrin (2017). Ground deformation before the 2015 eruptions of Cotopaxi volcano detected by InSAR, *Geophys. Res. Lett.*, 44, doi:10.1002/2017GL073720.

-Arnold, DWD, Biggs, J. Wadge, G. and P. Mothes, 2018. *Using satellite radar amplitude imaging for monitoring syn-eruptive changes in surface morphology at an ice-capped stratovolcano. Remote Sensing of Environment*, Volume 209, May 2018, Pages 480-488. <https://doi.org/10.1016/j.rse.2018.02.040>

-C. Mueller, Juliet Biggs, Susanna K. Ebmeier, Patricia Mothes, [Mario Ruiz](#). Temporal Evolution of the Magmatic System at Tungurahua Volcano, Ecuador, detected by geodetic observations, November 2018, *Journal of Volcanology and Geothermal Research* 368 DOI: 10.1016/j.jvolgeores.2018.11.004, License [CC BY-NC-ND 4.0](#),

-D.W.D. Arnold, J. Biggs, H.R. Dietterich, [...], S. Vallejo Vargas, P. Mothes, *Lava flow morphology at an erupting andesitic stratovolcano: A satellite perspective on El Reventador, Ecuador, Feb 2019 • Journal of Volcanology and Geothermal Research*, 372 DOI: 10.1016/j.jvolgeores.2019.01.009

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Conference presentations/proceedings

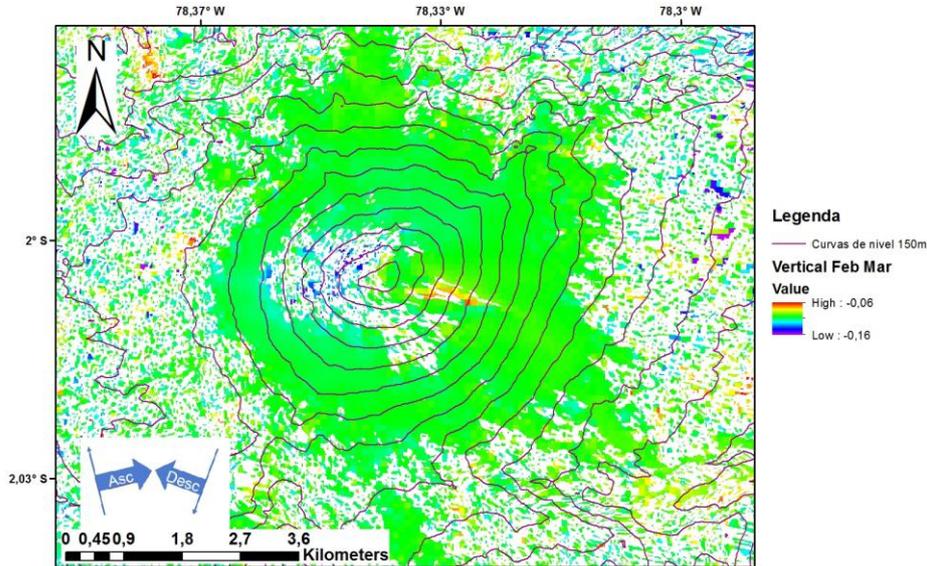
-Observing Volcano Deformation with Ecuadorian Volcano Supersite SAR Imagery and Future Applications. *Patricia A. Mothes, Falk Amelung, abstract-2018 Cities on Volcanoes 10, Napoli Italy, July 2018.*

-Snapshot of Heterogeneous Post-Seismic Deformation Following the 2016 Mw 7.8 Pedernales Earthquake, coastal Ecuador. Patricia A Mothes, Frederique Rolandone, Jean-Mathieu Nocquet, Paul Jarrin and Falk Amelung. Abstract/presentation at: sciencesconf.org:wegener2018:218965, in Grenoble France- Sept., 2018.

Research products

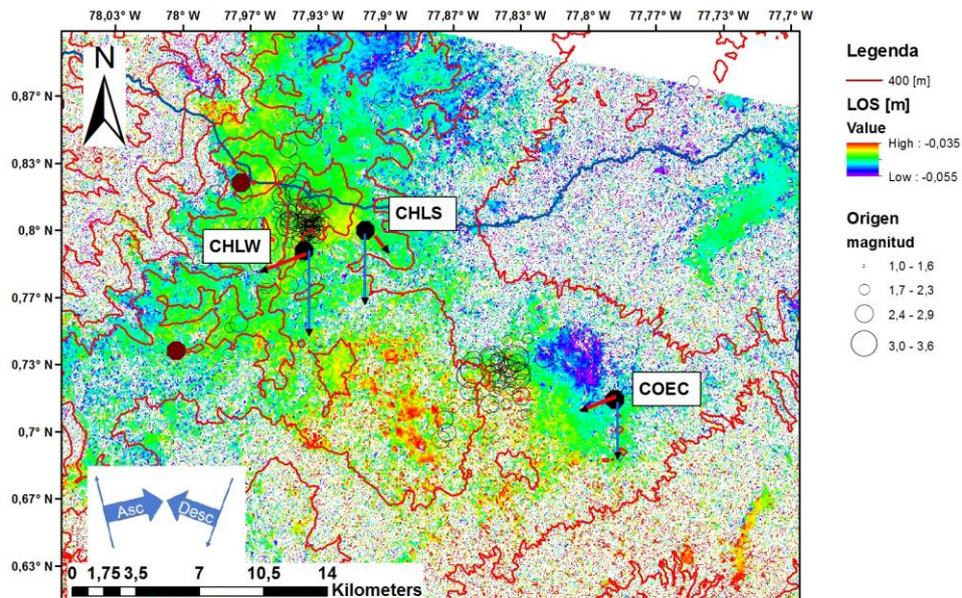
Type of product	Product provider	How to access	Type of access
<i>e.g. ground deformation time series, source model, etc.</i>	<i>Name of scientist(s)</i>	<i>Link to publication, research product repository or description of procedure for access</i>	<i>E.g. public, registered, limited to GSNL scientists, etc.</i>
<i>Ground deformation time series.</i>
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Deformación registrada en Sangay 3 Febrero - 23 Marzo 2019



Interferogram of mild deformation on Sangay volcanoes E side, as a result of renewed eruptive activity. Sentinel imagery.

Deformación registrada en Chiles Enero-Marzo 2019



Interferogram of minor deformation around Chiles volcano, Ecuador in first 3 months of 2019.

Research product issues

The Sangay imagery (above) will be posted on the IGEPN's webpage along with a report of the beginning of eruptive activity.

Dissemination and outreach

The Supersite leader has attended IAVCEI, Wegener, UNAVCO and AGU where results of the Supersite were displayed. Now that we have a better processing routine, more products will be produced and also distributed on the IGEPN's website.

4. Funding

Funding for the IGEPNs technical staff and all computational and instruments of the IGEPN is achieved through a SENPLADES program of the Ecuadorian government and through the University. At the moment, except for collaborations with INGV, the Universities of Miami and Bristol, and Geovol, there is no other funding.

5. Stakeholders interaction and societal benefits

The main stakeholders are the citizens who live in the wake of volcanic activity, particularly the path of lahars from Cotopaxi volcano. The IGEPN's instrumental monitoring results—from the seismic, geodetic and gas-monitoring networks are combined with the InSAR interferograms to create a coherent package of information which is discussed with the technical team of the IGEPN, with external experts, if necessary, and then discussed with the Secretary of Risk Management, who would make a statement on the state of a volcano (volcano watch). The IGEPN would also publish a Special Report on the Webpage (www.igepn.edu.ec) and then also on social media. The idea is that there is an early warning before onset of eruptive activity.

Conclusive remarks and suggestions for improvement

I believe that the Supersite is a great opportunity to have access to satellite imagery from which to see developing situations around/beneath a volcano. I hope that my small team in the present year will be able to more adequately exploit the potential of all the imagery we have access to, since we are receiving more in-depth training at several workshops during the first part of 2019. It is also very helpful to have an annual meeting of Supersite coordinators at a main meeting, to facilitate sharing of criteria and practices.