Deformation caused by the 2011 Puyehue-Cordón Caulle eruption

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Introduction

The Puyehue-Cordón Caulle volcanic complex in southern Chile began an eruptive phase on June 4th, 2011. The volcano has a history of eruptions with the previous large eruptive event in 1960, just 2 days after the 9.5 Valdivia Earthquake. The recent event is a plinian eruption with an ash cloud that reached a height of up to 10 km in the first days.

Optical satellite images

Fig. 1 shows ASTER satellite images (15 m resolution) taken before and after the start of the recent eruption. The ash plume covers its own base and complicates the mapping of the new vent.

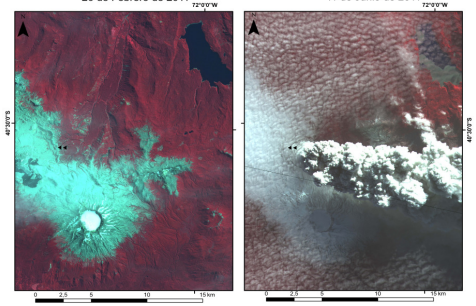

Figure 1. ASTER images taken on Feb 26th , 2011 and June 11th, 2011.

Radar remote sensing

The C-band radar signal of the Envisat ASAR instrument with a wavelength of 5.3 cm penetrates most of the ash cloud even in an image taken just 3 days after the start of the eruption allowing to locate the new vent (Figure 2 left). In Envisat images taken in the following months the extent of the lava flow can be mapped due to its high brightness in comparison to the surrounding ash-covered areas (Figure 2 right).

Synthetic aperture radar interferometry

SAR interferometry has demonstrated to be a powerful tool to monitor volcano deformation. Fournier et al. (2010) measured an inflation rate, to 19.8 cm/yr between January 2007 and February 2008 based on data from the Japanese ALOS satellite.

We analyzed synthetic aperture radar data from the European satellite Envisat to map the new volcanic features and to interferometrically determine surface deformations caused by the eruption. The interferometric analysis of image pairs taken 30 days apart reveals the evolution of the deformation during the eruption.

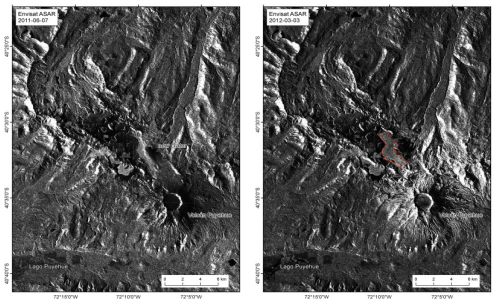

Figure 2. Envisat ASAR images before and after the eruption.

Deformation from GPS

Two GPS sites were occupied by the University of Concepción starting about 10 days after the beginning of the eruption. Preliminary results (Figure 5) indicate that both stations show a strong horizontal movement towards the eruption center (about 3 cm to the North for Pajaritos and 4.6 cm to the NE for LINC) in the time span that is covered by the second interferogram. The eastern station shows a subsidence in the order of 15 cm during the interferogram time span that continues another 10 cm until August.

Deformation from InSAR

While interferograms before the incept of the eruption do not show any deformation related signal, an interferogram between ASAR data taken on May 8th and June 7th, 2011 exhibits a 30 km long zone all along the volcanic complex that is affected by deformation with several foci (Figure 3). The deformation amounts to 1.5 m in the line of sight away from the sensor, and thus can be interpreted as subsidence if the deformation is assumed to be purely vertical. This deformation is expected to be a lower bound, because coherence is lost in the center due to high deformation rates.

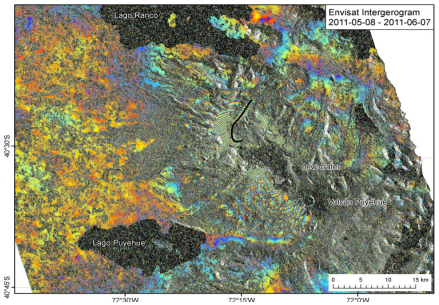

Figure 3. Envisat ASAR interferogram covering the initial phase of the eruption.

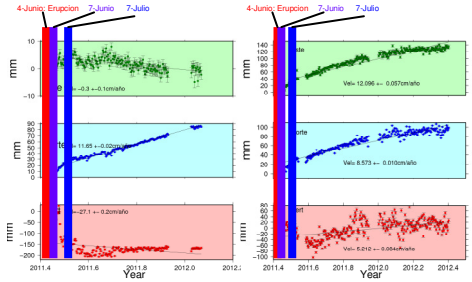

Figure 5. GPS time series for Pajaritos (left) and LINC (right).

Deformation at Cordón Caulle

The following interferogram covering June 7th to July 7th shows less coherence and a lower but more widely spread downward deformation with a maximum of 0.7 m (black profile in Figure 4).

An interferogram built from scenes from July 7th to August 8th shows very low coherence in the higher reaches of Cordón Caulle probably due to snow cover.

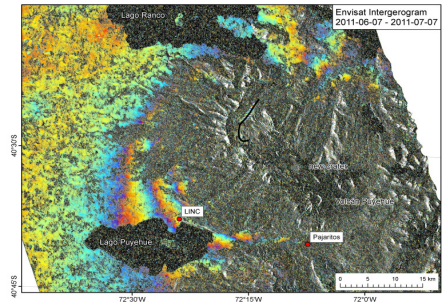

Figure 4. Envisat ASAR interferogram from June 6th to July 7th.

Acknowledgments

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References

Fournier, T. J., M. E. Pritchard, and S. N. Riddick (2010), Duration, magnitude, and frequency of subaerial volcano deformation events: New results from Latin America using InSAR and a global synthesis, *Geochem. Geophys. Geosyst.*, 11, Q01003, doi:10.1029/2009GC002558.

Pritchard, M. E., and M. Simons (2004b), An InSAR-based survey of volcanic deformation in the southern Andes, Geophys. Res. Lett., 31, L15610, doi:10.1029/2004GL020545.

Low resolution satellites images, for instance from the MODIS sensor which are available on a semidaily basis, can help to monitor the evolution of the ash cloud, but depend on weather condition (se Figure 2).

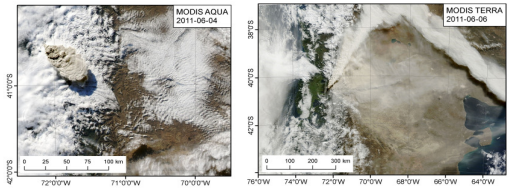

Figure 2. MODIS images taken on June 4th , 2011 and June 6th, 2011.