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Persistent scatterer interferometric synthetic aperture radar for crustal deformation analysis, with application to Volcán Alcedo, Galápagos

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[1] While conventional interferometric synthetic aperture radar (InSAR) is a very effective technique for measuring crustal deformation, almost any interferogram includes large areas where the signals decorrelate and no measurement is possible. Persistent scatterer (PS) InSAR overcomes the decorrelation problem by identifying resolution elements whose echo is dominated by a single scatterer in a series of interferograms. Existing PS methods have been very successful in analysis of urban areas, where stable angular structures produce efficient reflectors that dominate background scattering. However, man-made structures are absent from most of the Earth's surface. Furthermore, existing methods identify PS pixels based on the similarity of their phase history to an assumed model for how deformation varies with time, whereas characterizing the temporal pattern of deformation is commonly one of the aims of any deformation study. We describe here a method for PS analysis, StaMPS, that uses spatial correlation of interferogram phase to find pixels with low-phase variance in all terrains, with or without buildings. Prior knowledge of temporal variations in the deformation rate is not required for their identification. We apply StaMPS to Volcán Alcedo, where conventional InSAR fails because of dense vegetation on the upper volcano flanks that causes most pixels to decorrelate with time. We detect two sources of deformation. The first we model as a contracting pipe-like body, which we interpret to be a crystallizing magma chamber. The second is downward and lateral motion on the inner slopes of the caldera, which we interpret as landsliding.

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1. Introduction

[2] Volcán Alcedo is one of six volcanoes located on Isla Isabela in the Galápagos Archipelago (Figure 1). Alcedo is unusual in that it is the only active Galápagos volcano known to have erupted rhyolite as well as basalt [*Geist et al.*, 1994]. The last known eruption occurred in late 1993 from the south caldera wall [*Green*, 1994]. Deformation of the caldera was detected by *Amelung et al.* [2000], who carried out interferometric analysis of synthetic aperture radar (SAR) data acquired over Alcedo between 1992 and 1999. However, they found the correlation to be too low to determine the deformation signal on the volcano flanks and were therefore unable to draw any conclusions about the source of the deformation. No measurements of surface displacement have been made on Alcedo by any other means, and displacements inferred from SAR data are therefore all we can currently use to constrain the movement of subsurface magma and volatiles. Conventional interferometric SAR (InSAR) fails on the upper flanks of Alcedo because a significant amount of vegetation is present and this leads to temporal decorrelation for most pixels in the image.

[3] When a SAR image is formed, even at the highest possible resolution, the value for each pixel remains the coherent sum of the returns from many scatterers on the ground. If these scatterers move with respect to each other between satellite passes, as is expected to be the case when many scatterers are vegetation, the phase of the return will vary in a random manner which leads to decorrelation. If, however, a pixel is dominated by one stable scatterer that is brighter than the background scatterers, the variance in the phase of the echo due to relative movement of the background scatterers will be reduced, and may be small enough to enable extraction of the underlying deformation signal (Figure 2). *Hooper et al.* [2004] identified this type of pixel as a persistent scatterer (PS) pixel. Physically, these stable scatterers might be a tree trunk or a single large rock or facet amongst the vegetation.

[4] Methods to identify and isolate these PS pixels in interferograms have been developed by several groups [e.g., *Ferretti et al.*, 2001; *Crosetto et al.*, 2003; *Lyons and*

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