Applications of blind source separation for analysing volcanic deformation in satellite radar

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Résumé

The relationship between distinct volcanic deformation signals can provide more information than the inversion of each signal in isolation. Deformation in different locations may be related by common responses to regional stress or pore fluids changes, by hydraulic connectivity in the shallow crust, or connection to the same deep reservoirs. Methods that provide tests of the signal independence therefore have potential as an exploratory analysis tool in volcano geodesy, and particularly for Interferometric Synthetic Aperture Radar (InSAR). I apply Independent Component Analysis (ICA) to both synthetic cases of volcanic deformation, and to Sentinel-1 time series for recent episodes of volcanism. ICA describes random variables as a linear combination of statistically independent components. Mixed signals are decomposed using the assumption that each constituent component has a non-Gaussian probability distribution. Deformation sources that do not share a causal mechanism will generate independent displacement patterns, and will therefore be decomposed into separate components. Exploratory analysis requires a reliable method for assessing the statistical significance of the ICs. I achieve this by dividing InSAR datasets into independent groups and using a cluster analysis of the spatial patterns identified as independent components. This approach for analysing deformation signals likely to be particularly useful for interrogating the large volumes of satellite radar imagery, such as the Sentinel-1 archive, ALOS-2 or future NISAR archives.

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