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Application of Independent Component Analysis to volcanic signals in multi-temporal InSAR

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Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based method for the measurement of displacements of the Earth's surface and has great potential for monitoring deformation at active volcanoes. A major challenge in the analysis of InSAR data is the separation of real displacement signals from signals originating in variations in satellite position and atmospheric composition. Additionally, deformation signals caused by many different physical processes are often present at the same volcano, potentially obscuring the magmatic deformation most important for assessing hazard. Here, I present an application of a blind signal separation method to a) separate volcano deformation from noise and b) test the independence of different parts of volcanic deformation fields. I separate signals using Independent Component Analysis (ICA), which uses the statistical independence of signal components to produce a linear representation of nongaussian data and is widely used in the fields of remote sensing and medical physics. I use multiple groups of independent satellite images to identify statistically significant independent components and examine their spatial and temporal relationships. I present synthetic tests of the application of ICA to distinguish volcano deformation signals from noise and from other independent deformation processes. These methods are then applied to analyse deformation fields in Sentinel-1 images from volcanoes that potentially have multiple deformation sources, including subsiding lava flows at Parícutin, Mexico. The ability to provide a robust test for the independence or connectivity of multiple deformation sources makes ICA analysis potentially a powerful tool for analysing both remote sensing and time series monitoring data at volcanoes.