Volcano ground deformation caused by surface sediment loading

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Ground displacements at active volcanoes are often interpreted in terms of pressure changes at depth in the magmatic system. Numerical models may be used to estimate the elastic response of the crust - and thus the ground surface - to pressurisation at depth. Inversions of observed deformation often use such models to constrain location, size, shape, and volume or pressure change of magmatic sources. Such approaches require a number of simplifying assumptions and typically neglect the influence of complicating factors, such as compressibility of magma in the system, surface topography, inhomogeneity of crustal rheology, and the effect of surface loading of erupted material. We explore the extent to which volcanic ground deformation may be influenced by surface loading due to the accumulation of volcanogenic sediment during the eruption on Montserrat, West Indies.

The eruption at Soufrière Hills Volcano, Montserrat, has generated over a cubic kilometre of lava since 1995. Much of that material has moved offshore, but there remain substantial subaerial and submarine sediment deposits around the volcano's flanks. We measure the thickness of deposits emplaced around the volcano over 15 years by differencing topographic survey data and then derive a surface load estimate assuming typical density values. We use finite element modelling to estimate the crustal response to the deposit load, in terms of expected associated ground deformation. We show the sensitivity of loading-derived deformation to the model's elastic parameters for a range of plausible configurations, applying constraint for rock rigidity profiles derived from seismic survey data, Results are compared to continuous GPS timeseries data recorded on Montserrat throughout the eruption. We discuss the extent to which loading the volcano's flanks with erupted sediment has contributed to the observed ground deformation and how this contribution may mislead typical schemes for inverting measured displacements at volcanoes.