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Insights into dome deformation processes from optical camera and seismic data: Results from Mount St. Helens

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Morphological changes and intermittent destabilization of volcanic domes can lead to rockfalls and pyroclastic flows, significant volcanic hazards. We study short term dome deformation associated with earthquakes and tremor at Mount St. Helens, recorded by permanent optical cameras and a seismic monitoring network. We use Digital Image Correlation (DIC) to compute the displacement field between successive optical images,and compare the results to the occurrence and characteristics of seismic events during a 6-week period of dome growth in 2006. The results reveal that upward dome growth at Mount St. Helens was interrupted by short-term meter-scale downward displacements of the dome surface. The displacements were associated in time with low frequency, large magnitude (M>1) seismic events followed by a broadband tremor-like signal, starting between 10 and 40 seconds after the onset of the main event. This latter signal was only recorded by the seismic stations closest to the dome. We find a correlation between the amplitudes of the displacements and the spectral amplitudes of the associated tremor, larger displacements being associated with stronger tremor. We derive the 3D-displacements for a representative seismic event by reprojection of the DIC results from two cameras onto the topography, revealing a segmentation of the dome into areas of distinctive displacements. Based on the three-dimensional deformation field, we conjecture that the tremor is recording the gravity-driven response of the upper parts of the dome to depressurization associated with the leading earthquake, as well as mechanical disintegration controlled by clearly defined internal dome structures. The distribution of such features may have significant implications for the structural integrity of the dome and the potential for collapse. Our results highlight the potential of new techniques, which can also be applied to existing datasets, for revealing details of the dome growth process and the relationships between shallow seismic and deformation signals.