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New compound dislocation models (CDMs) for volcano deformation analyses, applied to the 2015 Calbuco eruption

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Volcano deformation caused by magmatic and hydrothermal processes are one of the most important precursors of the succeeding volcanic eruptions. Modern geodetic techniques such as InSAR and GPS can detect and monitor the deformation in high spatial and temporal resolutions, respectively. Fast deformation models that can be used in a source-inversion procedure are crucial for volcano hazard assessment. We present a compound dislocation model (CDM) that is composed of three mutually orthogonal tensile dislocations. The CDM is an analytical model that can represent both planar intrusions in the near field and volumetric pressurized sources of any geometry in the far field. We apply the CDM to the 2015 Calbuco eruption displacement field observed by the Sentinel-1A satellite in both ascending and descending acquisitions. The inferred deformation source is a deflating vertical lens-shaped source centered beneath the Calbuco volcano. We validate the deformation source model using GPS and tilt data. We then use the inferred source parameters to estimate the stress change and Coulomb failure stress (CFS) at the epicenters of the volcano-tectonic earthquakes associated with the eruption. We discuss that the relation between the abundance of the earthquakes in the areas that undergo an increase in the CFS provides new information on the subsurface geological features near the Calbuco volcano. The Calbuco case study shows the efficiency of the CDM in rapid source inversion and deformation data interpretation, which are necessary for a near real-time understanding of the deformation source characteristics, particularly in rapid response monitoring systems and early warning.