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Constraints on geothermal reservoir volume change calculations from InSAR surface displacements and injection and production data

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Continual production of geothermal energy at times leads to significant surface displacement that can be observed in high spatial resolution using InSAR imagery. The surface displacement can be analyzed to resolve volume change within the reservoir revealing the often-complicated patterns of reservoir deformation. Simple point source models of reservoir deformation in a homogeneous elastic or poro-elastic medium can be superimposed to provide spatially varying, kinematic representations of reservoir deformation. In many cases, injection and production data are known in insufficient detail; but, when these are available, the same Green functions can be used to constrain the reservoir deformation. Here we outline how the injection and production data can be used to constrain bounds on the solution by posing the inversion as a quadratic programming with inequality constraints and regularization rather than a conventional least squares solution with regularization. We apply this method to InSAR-derived surface displacements at the Coso and Salton Sea Geothermal Fields in California, using publically available injection and production data. At both geothermal fields the available surface deformation in conjunction with the injection and production data permit robust solutions for the spatially varying reservoir deformation. The reservoir deformation pattern resulting from the constrained quadratic programming solution is more heterogeneous when compared to a conventional least squares solution. The increased heterogeneity is consistent with the known structural controls on heat and fluid transport in each geothermal reservoir.