Data assimilation strategies for volcano geodesy

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Ground deformation observed using near-real time geodetic methods, such as InSAR and GPS, can provide critical information about the precursory uplift caused by the injection of new magma prior to volcanic eruption. With the advancement of numerical modeling capabilities, a number of finite element models have been developed to understand the connection between ground deformation associated with magma injection and the potential for volcanic eruption. However, without robust model-data fusion techniques, the array of data volcano monitoring observations cannot be fully utilized for improving modeling approaches. In this study, we conducted a series of sensitivity tests to optimize the Ensemble Kalman Filter (EnKF) sequential data assimilation strategies for combing synthetic geodetic observations with geodynamic models to investigate volcanic unrest. The results show that (1) applying additional iterations of the EnKF step between the observation time series results in a faster convergence and more accurate model predictions, (2) the number of ensembles has little effect on the accuracy and convergence speed of the results, (3) when the mean values of the initial ensemble parameters are closer to the true values, the convergence speed is faster and accuracy of the results increases, and (4) the standard deviation of the initial ensemble parameters rarely affects the modeling outcomes. These results indicate that the EnKF methods can be greatly improved by adding more inter-EnKF iteration steps. This strategy is far less computationally expensive than adding more finite elements in the ensembles, which requires 100 – 1000 times more computing than conducting additional iterations. In addition, if the initial parameters, such as the depth and geometry of the magma chambers, can be better constrained by other observations such as geochemical indicators and seismic tomography, the EnKF method provides a more accurate result faster.