# Mapping surface displacement using a pair of interferograms: a comparative study

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**Résumé**

Interferometric analysis of Synthetic Aperture Radar satellite images (InSAR) measures only one component of ground deformation, in the satellite line-of-sight direction. To fully resolve the three dimensional (3D) ground displacement field, InSAR images acquired with different imaging geometries have to be complemented by other data sets or techniques. However, nowadays and despite the increase in the number of SAR missions, an area is most frequently imaged by a pair of interferograms, one inteferogram from an ascending satellite track and another one from a descending configuration. Such a pair defines an under-determined system with respect to the 3D displacements and is not directly invertible, hence several approaches have been used that we compare.
First, we use a model resolution matrix approach for a pair of interferograms, to quantify the ability to reconstruct the components of the deformation field for any combination of viewing geometries. The approach shows that the reconstructed components can be expressed as a linear combination of all true components, providing insight on uncertainties of retrieved components from a pair of interferograms. The east and vertical components are almost fully retrieved but also influenced by the north component, that is, on the contrary, poorly solved, capturing only up to 7.4% of the true north component. The reconstruction of the vertical component is slightly reduced with the obliquity of the incidence angles of the two interferograms.
We propose to solve the under-determined system using a decomposition approach, in particular the Singular Value Decomposition (SVD) algorithm. We compare results from the SVD algorithm with two widely used techniques, the linear combination (LC) method and the two-component linear inversion based on the removal of one to two horizontal components. The comparative study is applied to two areas in Iceland: the Reykjanes Peninsula and the NW-Vatnaj́okull area with the Bárdarbunga volcano, where different deformation processes occur. We complete these two examples with tests and modelling performed on synthetic data. We show that when the deformation is mostly vertical, all solutions are relatively similar (residuals $<$ 1cm), especially between the two-component inversion results and those resulting from the SVD. In case of a deformation field dominated by horizontal displacement, the results from LC method and the two-component linear inversion differ from SVD-based method in amplitude, up to few cm for both reconstructed components,

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and to a minor extent, in the pattern distribution. Simulations made using a known deformation field complete these results and show better solutions for the SVD-based method and the two-component linear inversion. The results of the SVD are slightly better and show that including the north component, even poorly constrained by the geometry of acquisition, seem to make the inversion more stable.