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InSAR Fringe Frequency and Deformation Gradient. Application for Geophysical Modelling

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Since more than 20 years Differential SAR Interferometry (DInSAR) is successfully exploited from the geoscientists to model geophysical phenomena. Its capability to detect and measures movements has been largely employed in the field of tectonics, glaciology and geology in general. The estimation of large scale deformation maps from the SAR acquisitions, without any in-situ deployment of instrumentation, is the main advantage of this technique. Many outstanding results have been produced using DInSAR deformation estimations as an input for geophysical modeling. However several source of errors such as geometric and temporal de-correlation or atmospheric delays can spoil the generation of accurate deformation fields limiting the usability of the interferometric data. The accuracy of the phase unwrapping in particular is hampered by the limited quality of the phase, as far as the noise induced errors in solving the ambiguities propagate trough the gradient integration up to the final estimations. People working in the field of SAR interferometry invested lot of efforts in finding methods that could avoid the problem of spatial phase unwrapping. The main objective of this study is to propose a way to reduce the impact of the phase unwrapping moving the attention from the interferometric phase to the local fringe frequencies. The idea is that the local fringe frequencies have also a geophysical meaning. Therefore instead of having the deformation relative to a reference point, as is normally done in DInSAR, an absolute estimation of the deformation gradient can be used. Then the measures of the estimated frequencies can be transformed and compared to the differential of the deformation model avoiding any spatial integration. This should extend the range of exploitation of the SAR interferograms as far as it removes the constrain that impose the interferogram pixels to be spatially connected, permitting also isolated but coherent areas to take part to the model inversion. These features can be particularly interesting in the case of the burst modes such SCANSAR and TOPSAR. In presence of large displacements the phase between different burst can be spatially inconsistent due to the change of LOS direction. This will make the unwrapping and the modeling of the phase considerably more difficult. Therefore the possibility to have estimations that can be independently handled in space would be strongly recommendable. In the first part of the paper the rationale of the method will be presented, showing first the link between the fringe frequencies and the derivatives tensor. Finally the feasibility of the technique is tested using some simulated examples. The full reconstruction of the deformation gradient tensor is shown using different observation geometries. Then two largely employed geophysical models, have been used for ”model-based”' case studies. The Mogi source, used to describe volcanoes deformations and the Okada source used to model the movements of tectonics faults.