A Proposal for Interferometric Time Series Product with Reduced Stochastic and Systematic Phase Errors

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Abstract

Through extensive analysis of Sentinel-1 data, we observe a systematic, yet temporally inconsistent, error source in the multilooked interferograms which especially compromises the reliability of InSAR-derived deformation velocity maps. The observed error is attributed to the systematic variation in the scattering properties of the sub resolution scatterers [1]. The phenomenon can be explained, for instance, by moisture variation, vegetation growth etc. A relevant research direction is on-going to interpret the physical source and model the interferometric phase of such systematic signals. Complementary to the latter, this work sheds light on other aspects of the problem. Here we initially demonstrate:

- the presence of the systematic effects in interferograms;
- the propagated error to the deformation velocity maps;
- the effect of processing algorithms on mitigating the error.

More importantly we introduce an efficient processing scheme and propose an intermediate InSAR product which significantly reduces the observed effects.

For the initial demonstrations, a four-year archive of Sentinel-1 over Sicily-Italy is chosen. Showing the presence of the systematic errors, we explore the relation between the average phase bias of the interferograms to their temporal baseline. From this study, we conclude that the shorter temporal baseline interferograms are more error prone. Note that the InSAR community mostly exploits these interferograms for Big Data processing. We further experiment the propagation of bias to the deformation velocity estimation by including different subset of interferograms in the analysis. Starting from inclusion of up to 30-day interferograms we observe a deformation bias of 6.5 mm/yr. The bias decreases to 3 mm/yr when including up to 60-day interferograms. It further reduces to 0.25 mm/yr if all possible interferogram pairs within the data stack are exploited.

Our recommendation for mitigation of the errors is to exploit all the possible interferograms and reconstruct the consistent phase component in a data adaptive manner. The reconstruction is performed by imposing the simple model of phase triangulation [2]. This constraint insures that the reconstructed signal is invariant to the choice of interferogram pair within the time series. It shall be stressed that the major role in the reduction of the error source is played by the inclusion of the long temporal baseline

interferograms in the estimation. To address the demand for Big Data processing, we further introduce our efficient phase estimation scheme [3].

Based on the experiments, we recommend a new intermediate product level for InSAR, namely the reconstructed consistent interferometric phase series. The envisioned product would:

• contain the consistent physical signals such as, but not limited to, atmospheric variations and surface displacements;
• significantly reduce the interferometric phase bias and variance;
• reduce the amount of interferometric data from the original pairwise interferograms within the data stack to a time series of higher quality and, optionally, subsampled interferograms;
• ease the data transfer and provide a unified input to the user community;
• enhance the reliability of InSAR for displacement analysis specifically for the retrieval of deformation velocity maps.

[1] De Zan et al. 2015: https://ieeexplore.ieee.org/document/7147797
[2] Monti-Guarnieri and Tebaldini 2008: https://ieeexplore.ieee.org/document/4685949
[3] Ansari et al. 2017: https://ieeexplore.ieee.org/document/8024151

Keywords - Processing algorithms