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Impacts of systematic errors on the DEM error estimation in InSAR: in a mathematical perspective

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Separation of topographic residual, induced by inaccurate digital elevation model (DEM), is important in accurate retrieval of surface deformation using interferometric synthetic aperture radar (InSAR). By employing the DEM error as a parameter in function models, multi-temporal InSAR (MTInSAR) techniques obtain the estimation of topographic parameter together with deformation. However, MTInSAR models can not promise an accurate estimation of DEM error due to multiple factors, e.g., network configuration, baseline threshold and deformation model. It is clear that erroneous perpendicular baseline in the design matrix and discrepancy between the model and practical displacement can deteriorate the estimation of topographic residual. Though the impacts of these two errors, classified as systematic errors, have been analyzed by several synthetic tests, there is a lack of investigations in a mathematical perspective.

In order to understand impacts of systematic errors on estimation of DEM error quantitatively, we derived the propagation formulas of the errors based on MTInSAR framework. We computed biases and explored that the errors of perpendicular baseline are almost negligible while the unmodeled deformation errors can contaminate the retrieval of topographic residual significantly. The biases induced by them are sensitive to the scale of baseline network. According to the theoretical analysis, we suggest selecting interferograms with large scale of perpendicular baselines to partially reduce the impacts of systematic errors. In addition, if the probabilistic approach is adopted to select realistic deformation model, sufficient amount of interferograms need to be guaranteed for high reliability. Several simulation experiments are conducted to validate the derivation. Furthermore, this contribution proposes the necessity to develop the optimal interferogram selection strategy or non-parametric estimation method to overcome the bias caused by systematic errors.