Efficient Interferometric Synthetic Aperture Radar Time Series Analysis Tailored to Big Data

Name: Homa Ansari
E-Mail: homa.ansari@dlr.de
Supervisor: Prof. Dr.-Ing. Richard Bamler
Chair of Remote Sensing Technology
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Efficient Time Series Analysis
Wide-swath Synthetic Aperture Radar (SAR) satellite missions with short revisit times, such as Sentinel-1 and the planned NISAR and Tandem-L, provide an unprecedented wealth of interferometric time series, opening new opportunities for systematic monitoring of the Earth surface. The processing of the emerging Big Data with the state-of-the-art Interferometric SAR (InSAR) time series analysis techniques is, however, challenging. The aim of this project is to migrate from the conventional approaches and propose new estimators for efficient processing of the Big Data. In the definition of efficiency two objectives are in mind: the computational cost of the estimator as well as its performance in terms of bias and variance of the estimation.

The Two Proposed Algorithms
Two estimators are proposed for the efficient processing of time series. Named Sequential Estimator [A], the first is a recursive estimator of the data covariance matrix with restriction on the data accessibility. It divides and compresses the chunks of data in order to avoid redundant computational cost. In constraining the performance loss, the algorithm retrieves the lost information due to batch processing by construction of artificial data among the compressed and streamed data chunks. Figure 1 provides an abstraction of the Sequential Estimator in exploitation of covariance matrix.

Coined Eigendecomposition-base Maximum-likelihood-estimator of Interferometric phase (EMI), the second proposed estimator [B] reformulates the conventional Maximum Likelihood Estimator (MLE) of phase into an optimization with equality constraint and employs the efficient method of Lagrange Multipliers in its solution. The latter method is efficiently solved via Eigendecomposition.
InSAR the retrieval of the geophysical signal is hampered by temporal noise. The aim of time series analysis techniques is to estimate the physically-induced phase from the noise-corrupted interferograms. Figure 2 depicts the phase screens before and after application of the proposed hybrid estimation method based on the Sequential and EMI estimators. Using the hybrid estimator, the SNR of interferometric signal is improved by 8 [dB]. This enhancement improves the sensitivity of InSAR to geophysical signals. The conventional approaches use 1171 interferograms to estimate the physical phase screen. The Sequential Estimator constructs and exploits 91 interferograms in total comprised of the observed and artificial data. The performance degradation of the Sequential Estimator compared to the conventional approaches is negligible [A, B].

**References**