Atmospheric phase screen-estimation for PSInSAR applied to TerraSAR-X high resolution spotlight-data

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Abstract

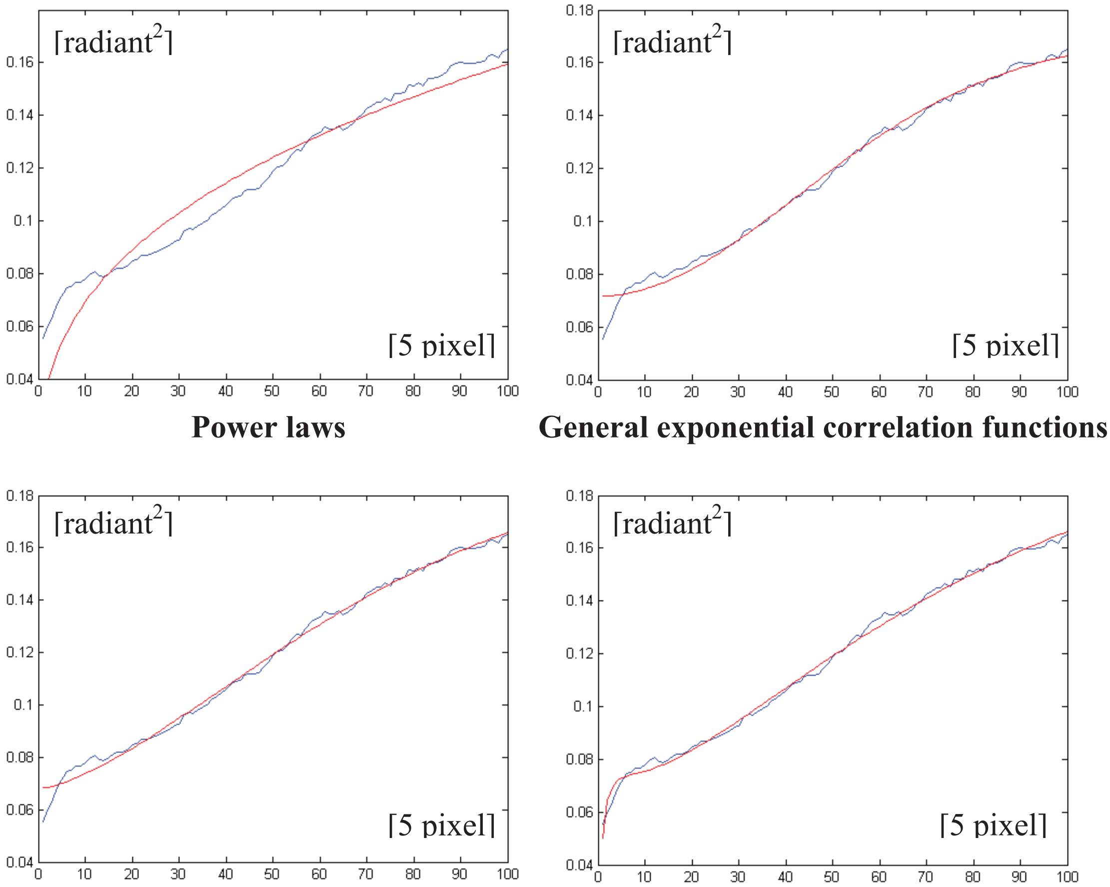
Ten years ago PSInSAR was invented by Ferretti et. al. [1], [2], [3]. Since than it has proven to be a valuable operational method for monitoring movements of the earths surface accompanying a variety of phenomena, like volcanic or tectonic activity, landslides, draining and refilling of aquifers, extraction of oil or gas, mining and other underground building activity. Corresponding to the plethora of applications, a lot of research took place since then, leading to great progress in the methods.

For example, the latter is true for the estimation of the APS (atmospheric phase screen), which is an important step in PSInSAR, as path delays in the order of several phase cycles may occur. Here development started from a rather simple filtering based on the assumption that the APS is correlated in space and uncorrelated in time [2]. Shortly afterwards spatial averaging was replaced by kriging interpolation [3], which minimizes the error variance in the least squares sense. Some years later two further steps were inserted [4], [5]:

1. filtering based on the assumptions of correlation in space and decorrelation in time
2. estimation and removal of a phase ramp, accounting for ionospheric delay and residual orbit errors
3. estimation and removal of stratified tropospheric delay, caused mostly be water vapour and assumed to be a linear function of elevation
4. kriging of the residual phase, which can now be interpreted as estimation of turbulent atmosphere with zero mean superposed on the stratified troposphere

In the kriging step a choice crucial for the quality of the estimation has to be made: fitting a theoretical variogram to the experimental variogram obtained from the data [6], [7]. Bounded variance of the data implies that the theoretical variogram is equivalent to a covariance function, what has to be observed when choosing the family of functions used for the fitting. A second important constraint is a good fit of the theoretical variogram to the data especially near the origin, because behaviour there corresponds to the greater or lesser regularity of the

spatial variation and therewith to a structural property of the real phenomenon. The most common classes of theoretical variogram functions proposed.in the literature are power laws [8], variograms equivalent to general exponential correlation functions [4] or equivalent to correlation functions of the Matérn-family [9].

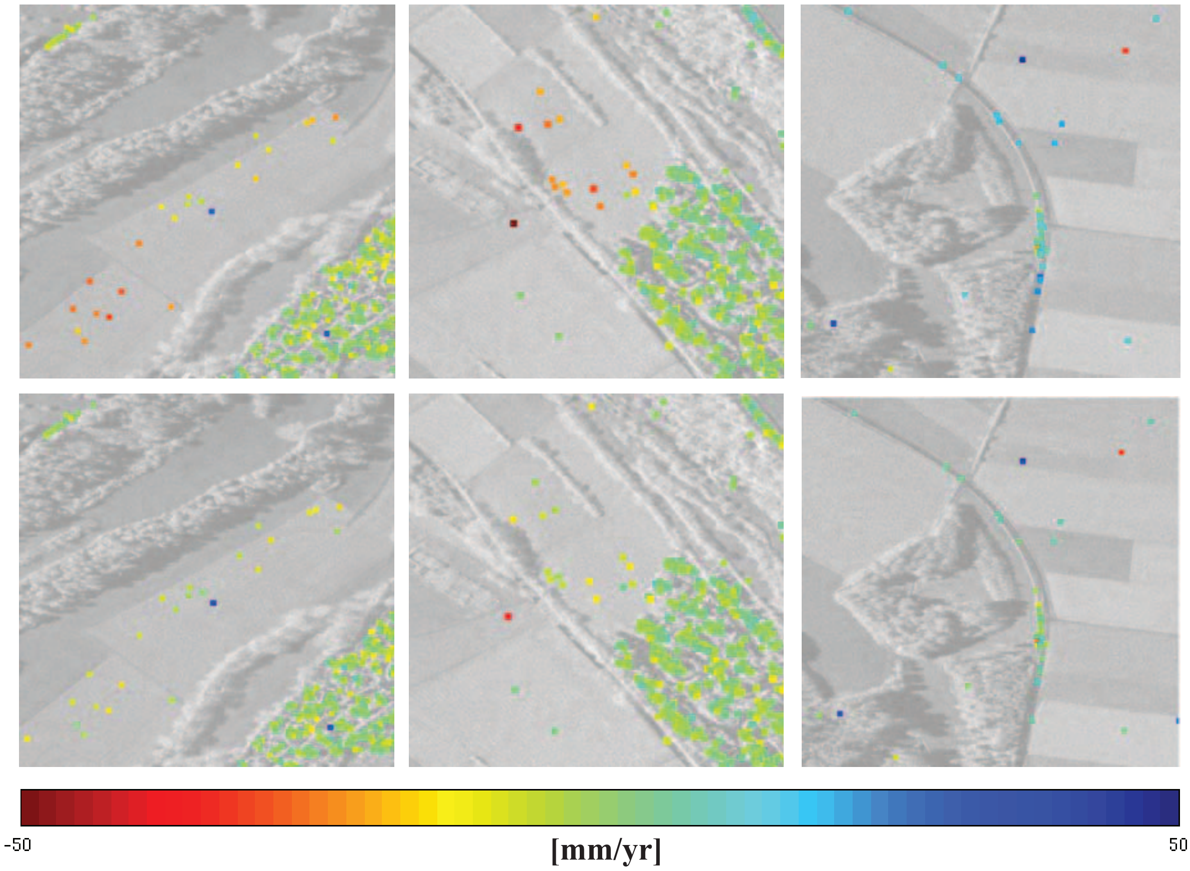


Power laws **General exponential correlation functions**

**Shkarofsky-family [10]
(spezializes to Matérn-family)** **Newly introduced variogram family**

To our knowledge APS-estimations with PSInSAR for high resolution spotlight-data are not found in the literature up to now. The steep slope of the experimental variogram on the first 50m, which prevents a good fit with commonly used variogram functions, seems to correspond to a regime of turbulence which will not be visible for lower resolved data because of the larger scale.

The change from the simple filtering to the above sketched algorithm which takes into account topography and via kriging the spatial statistics results in an improved APS-estimation. In the figure below details from the deformation velocity-plot are shown. Those in the upper row were engendered with the original algorithm using simple filtering. In the lower row the results from the augmented algorithm are displayed for the same details. As in these areas no cause for deformation is known to us we consider the change of the depicted PS-candidates towards zero velocity as a distinct improvement.



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