INVESTIGATION ON THE APPLICATIONS OF DECORRELATION ANALYSIS IN POLARIMETRIC SAR INTERFEROMETRY

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ABSTRACT

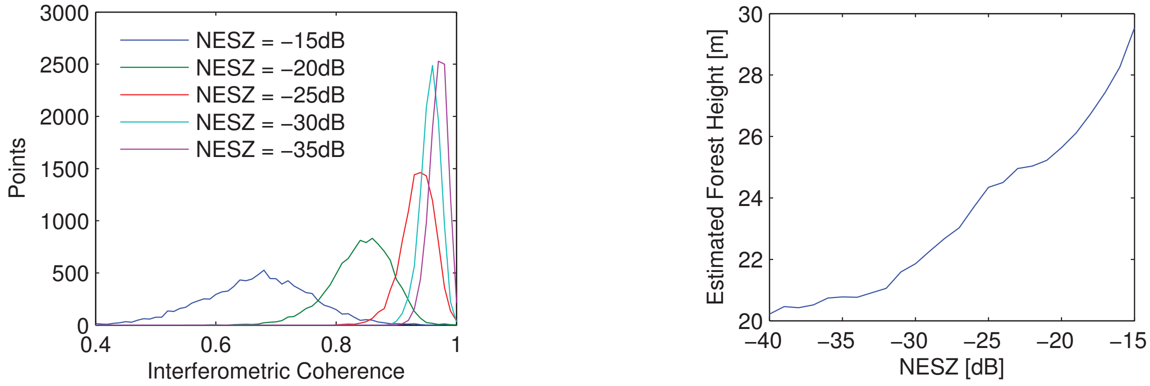
Decorrelation has been analyzed in many literatures. In this paper the emphasis is on two applications of the decorrelation analysis in polarimetric SAR interferometry. One is the derivation of Pol-InSAR requirements, which is based on quantitative expressions of the decorrelation as a function of system and processing parameters. The other application is compensation of the decorrelation wihch can not be minimized by optimizing system and processing parameters.

Polarimetric SAR Interferometry (Pol-InSAR) is the technique that combines SAR interferometry and SAR polarimetry and has already shown its effectiveness and sensitivity to volumetric structures [1]. The interferometric coherence (also called correlation) of two SAR images, which are acquired from the spatially separated sensors at either end of a baseline, is ideally equal to 1. However, in practical the coherence is usually decreased (named decorrelation) by the decorrelation sources, such as volume scatterers, instrument settings, processing errors, etc. The investigations of decorrelation sources have been demonstrated its use in (1) quantitative assessment of the Pol-InSAR performance, since coherence is a key quantity in estimation of interferometric phase [2], (2) estimation of vegetation parameters, such as vegetation height, extinction, since volume decorrelation is a function of the vegetation parameters [3]. This paper will show its use in (i) derivation of the Pol-InSAR requirements for system and processing parameters, and (ii) compensation of the decorrelation effects that can not be minimized by optimizing system and processing parameters.

Firstly, basic concepts and models of the various decorrelation are introduced. These decorrelation effects can be classified into three types. First is the decorrelation relates to scatterers, e.g., volume decorrelation which is used to estimate vegetation parameters. Second is the ones that can be quantitatively described as a function of system and processing parameters, such as thermal noise decorrelation. Third is the ones that can not be quantitatively described, such as temporal decorrelation.

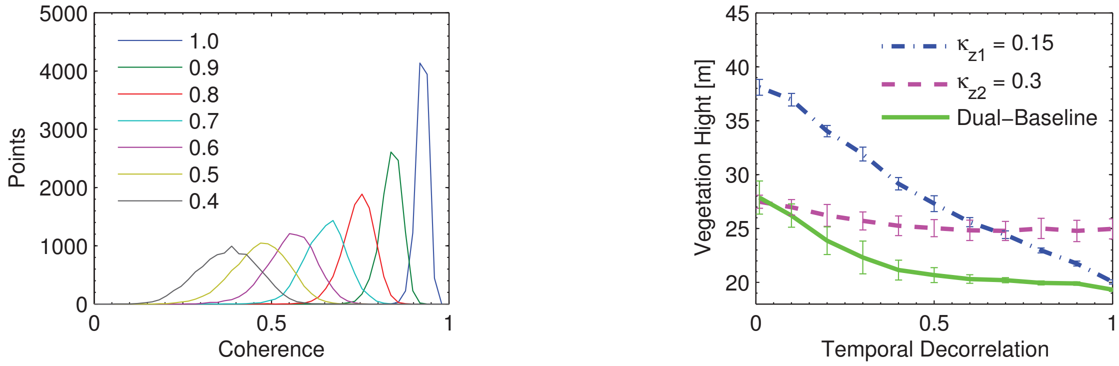
Then, based on the second type of decorrelation, a simple and effective method is presented to derive Pol-InSAR requirements of system and processing parameters. The derivation of NESZ requirement is shown as an example. Firstly, Pol-InSAR data are simulated based on the RVoG model, Fig. 1(a) shows the coherence of the simulated HV channel data. With decreasing NESZ (–15dB to –35dB), the observed coherence become higher and higher. The three-stage inversion method is then performed to invert forest height with the simulated Pol-InSAR data. Fig. 1(b) shows the estimated height. We can see that with increasing NESZ, the estimated forest height bias from the reference forest height (20m). If the accuracy requirement of forest height is 10%, the requirement for NESZ is less than –30dB.

Furthermore, based on the third type of decorrelation, a compensation method is presented. According to the geometrical interpretation of the decorrelation in the complex plane, the position of the volume coherence point is pulled toward the origin along the radial line. In order to compensate the effect of decorrelation, we need to shift the volume coherence point by contraries. In single-baseline Pol-InSAR, due to limited number of observables, we do not know what extent to shift the coherence point. However, it can be achieved via the dual-baseline Pol-InSAR approach. In order to validate the method, dual baseline Pol-InSAR data are firstly simulated with decorrelation effect [4, 5]. Fig. 2(a) shows the the coherence of the simulated HV channel data. With the increasing temporal decorrelation (γ_{Temp}: $1 \rightarrow 0.4$), the observed coherence become lower and lower. Fig. 2(b) shows the estimated height. The blue dashdot line ($\kappa_{z1} = 0.15$ rad/m) and magenta dotted line ($\kappa_{z2} = 0.3$ rad/m) are the individual estimation results of each baseline without compensating the temporal decorrelation. With the increasing temporal decorrelation levels, estimation results of each baseline become more and more overestimated. The



(a) (b)

Fig. 1. (a) Coherence histograms of simulated Pol-InSAR data for different NESZ level (HV channel). (b) Estimated forest height as a function of NESZ (reference height: 20m).



(a) (b)

Fig. 2. (a) Coherence histograms of simulated Pol-InSAR data for different temporal decorrelation level (HV channel). (b) Estimated forest height as a function of temporal decorrelation (reference height: 20m).

green solid line shows the estimated result using the dual-baseline data. Overestimation is not totally compensated but much close to the true value, especially at high temporal decorrelation level. Height standard deviation is large at low coherence.

This method does not need to know what extent the decorrelation is, but has a cost of more Pol-InSAR data. To date, the available spaceborne full-polarization SARs operate in the repeat-pass mode and the decorrelation, such as temporal derivation, are key facts that influences the Pol-InSAR applications. The method presented in this paper will help to solve the decorrelation problem.

Index Terms— Polarimetric SAR interferometry, decorrelation, system design, forest height estimation, RVoG model

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