A FILTERING APPROACH TO IMPROVE DEFORMATION ACCURACY USING LARGE BASELINE, LOW COHERENCE DINSAR PHASE IMAGES

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1. INTRODUCTION

Synthetic aperture radar interferometry (InSAR) is a robust technique widely used in high resolution topographic mapping [1], [2]; measurement of ice and glacier movement [3], [4]; tree-height estimation[5], [6]; and ground deformation monitoring related to earthquakes [7]-[9] and mining and oil exploration [10]. Differential interferometry (DInSAR), constructed using three repeat-pass SAR acquisitions, or two repeat-pass SAR acquisitions and a digital elevation model (DEM), has the ability to measure millimeter-scale surface deformation in the line-of-sight. However, the accuracy of InSAR products (e.g., DEMs, ground deformation maps) are hindered by the presence of interferometric phase noise, which is caused by thermal, temporal, geometric, and Doppler Centroid decorrelation [11]. Several techniques have been developed to reduce the phase noise at different levels in the InSAR processing chain; for example, multilooking (which reduces the noise by averaging neighboring pixels at the cost of spatial resolution), mean/median filtering [5], the Lee filter [12], the De Grandi filter [13], and the Goldstein filter [14], etc. However, none of these filters enhances or recovers the signal, but rather, degrade image detail to some extent while reducing the noise. The objective of this paper is to develop a method that reduces noise in phase images derived from large baseline tandem pairs with low temporal decorrelation, and recover the lost coherence that is crucial to the next step in the InSAR processing chain.

2. METHOD

The Goldstein filter is one of the most commonly used interferogram filters. In recent years, modifications have been made to the Goldstein filter that take into account the coherence values between tandem pairs [15], and the number of looks used in the multilooking process [16]. It is true that the suggested alpha value should vary between 0 and 1. However, when used with these general settings and parameters, the filter fails to identify detailed fringe patterns, particularly with an image pair characterized by low temporal coherence and large baseline. In addition, with a strong filtering parameter, the resultant coherence image saturates or desaturates very quickly, and the value of every pixel becomes either 1 or 0. This creates fundamental issues for finding ground control points to be used in the next level of processing for topographic or crustal deformation mapping.

This paper explores the potential approach to minimizing the information loss during phase filtering and proposes a method for improving the estimation accuracy of ground deformation in low temporal coherence and large baseline scenarios, by identifying suitable Goldstein filter parameters based on the coherence map and the interferogram phase. Over the coherent areas in an interferogram image, the alpha values are set to vary linearly according to the corresponding coherence value, from the alpha min value where coherence = 1 to the alpha max value where coherence =0. However, the Goldstein filter with these settings did not provide any results that are much different than the Boxcar filter where the coherence is very low. Therefore, an alpha max value greater than 1 is indentified to emphasize the signal. Next, a strong filtering is applied to the noisy portion of the image to maximize the removal of phase noise. Since the filtering is aggressive, as in our case, and the processing parameters are set to dramatically reduce the phase noise, most of the pixels in the resulting coherence image are saturated to 1. Then, a combination of linear and non-linear filters is used to estimate and reconstruct the coherence information lost during the strong phase filtering. Therefore, the reconstructed coherence image is associated with the filtered phase image to generate deformation maps.

3. INITIAL RESULTS AND SUMMARY

The filter parameters in Table 1 were identified for Goldstein interferometric filters using the proposed method, and applied to an ALOS-based Phased Array type L-band Synthetic Aperture Radar (PALSAR) image pair collected over the Sichuan earthquake zone on March 5 and June 5, 2008. The phase shift and baseline information is shown in Table 2.

As can be seen Fig.1, interferogram fringes are almost invisible in Fig. 1A, except in the upper right corner of the image. Fig. 1B shows a filtered interferogram with the same parameters, and Fig. 1C is the coherence map associated with the Goldstein filter. It is clear that the coherence is saturated in most areas of the interferogram.

Table 1 Improved filter parameters

Window size:	512
Intensity Window Size:	5
Alpha Min Value:	0.3
Alpha Max Value:	4
Low Pass percentage:	50
Window Overlap Percentage:	80

Table 2 Baseline and shift information of the test data

Time span:	92 days
Measured baseline:	293.650 m
2 PI Ambiguity height:	197.036 m
Range Shift:	-43.725 m
Azimuth Shift:	44.374 m
Doppler Centroid Difference:	-41.819 m

zone with values of 1 (the red color in the Fig. 1C). Fig. 1D presents the reconstructed coherence image using the proposed technique.

Although further analyses are required to reach a definitive conclusion, our initial results indicate that the method is effective in removing phase noise while minimizing the signal loss due to the strong phase filtering that is necessary for large baseline and low temporal decorrelation scenarios. Further tests and validation of the proposed method for its accuracy in the determination of surface deformation are ongoing.

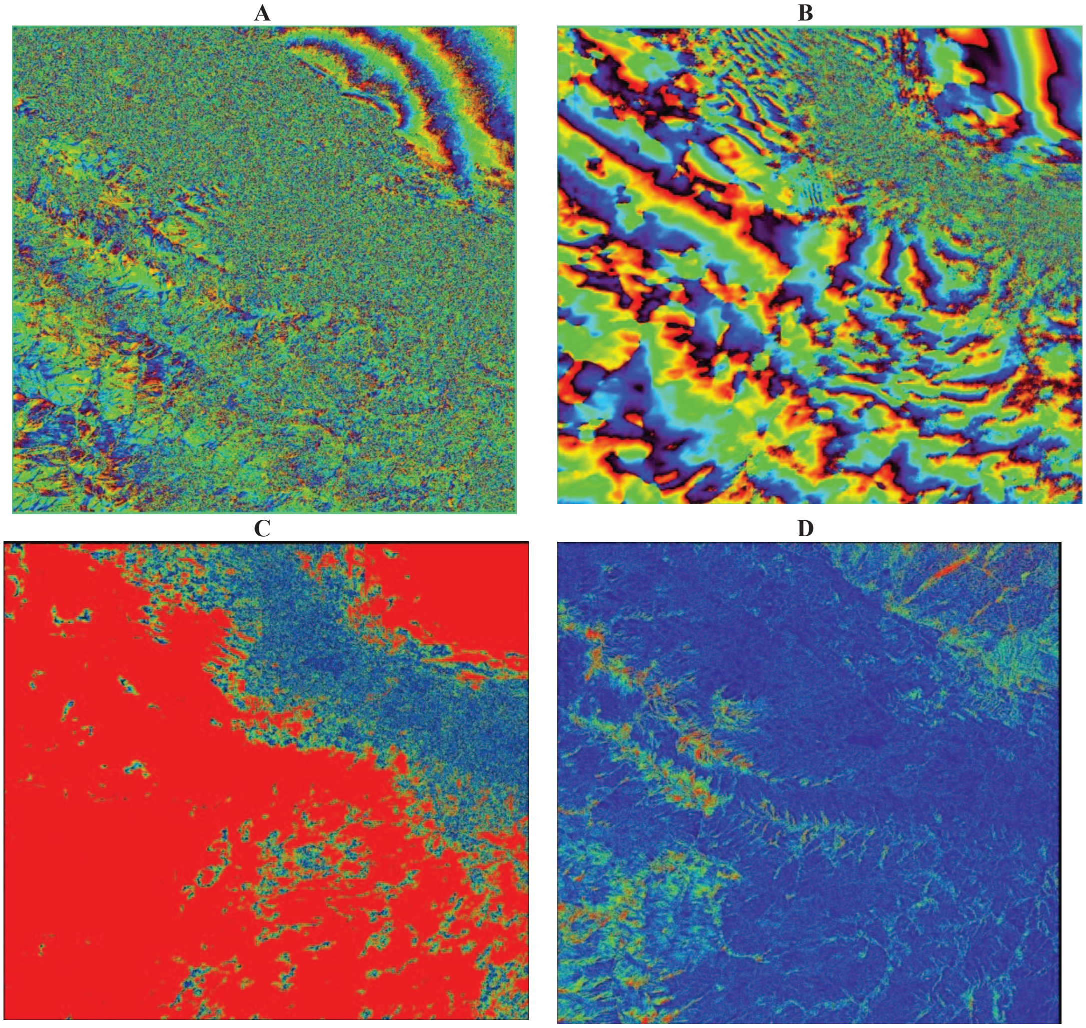

Fig.1 Phase filtering results from the proposed method. A is initial filter by default settings, B represents the Goldstein filter with the improved filter parameters, C is the

coherence image associated with the Goldstein filter and D is the reconstructed coherence image.

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5. REFERENCES

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