# LOCAL, NONLINEAR ADAPTIVE CO-REGISTRATION OF MASTER AND SLAVE INTERFEROMETRIC SAR COMPLEX IMAGE DATA FOR HIGH QUALITY DIGITAL ELEVATION MAP GENERATION

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## 1. INTRODUCTION

Interferometric synthetic aperture radar (InSAR) is a key technology in geoscience [1] [2] [3]. In the generation of a digital elevation map (DEM), the elimination of singular points (SPs) is the most important process besides the phase unwrapping (PU). A SP means a point where the phase rotation is not zero in the interferogram obtained by InSAR [4] [5] [6] [7]. What yields the SPs? One reason is a big cliff actually existing in the observation region. Empirically, such cliff-generated SP pairs (positive and negative SPs) are located at a distance from each other. Contrarily, other SP pairs, which make up the majority of the SPs, emerge closely to each other. Such close pairs arise from the autointerference caused by the diffraction in electromagnetic-wave propagation including the local permittivity fluctuation effect related to moisture vapor density in the air and other effects. We call the former the global SPs, while we do the latter the local SPs [6].

That is, the local SP pairs does not reflect real landscape, but originate from incidental phenomena in the electromagnetic propagation. We have distortion in the pixel values at the local SPs and their vicinity. Based on this idea, we previously proposed a method to reduce the distortion at around the local SPs and, eventually, to eliminate the local SPs [7].

In this paper, we go one step further. We propose a method to mitigate the distortion in the co-registration process. In our new method, when we co-register two complex image data (master and slave, hereafter) to obtain an interferogram, we adjust the relative position very locally and nonlinearly to reduce the harmful distortion. As a result, we eliminate local SP pairs, while preserving global SPs, which construct natural cliffs. Accordingly we obtain a high quality DEMs.

## 2. THE LOCAL AND NONLINEAR ADAPTIVE CO-REGISTRATION METHOD

A typical conventional co-registration process is as follows. We have a pair of master and slave complex image data. We prepare a window of $64\times64$ pixels, for example, to calculate correlation, and we determine the spatial correspondence between the master and slave windows in a sub-pixel preciseness such as 1/32 pixels. By repeating this process, we obtain a set of correspondent points (tiepoints). Based on the tiepoints, we determine an affine transform assuming a bilinear or biquadratic function for the global co-registration. That is, we rearrange the slave image against the master. Then we multiply the master pixel values by the conjugate slave values, pixel by pixel, to obtain the interferogram. Afterward, we apply the earth ellipsoid compensation to cancel the earth surface curvature, if needed.

Then the interferogram includes the following information: (i)earth surface landscape, (ii)local distortion generated by autointerference in the propagation explained above, and (iii)landsurface movement in the time interval between master and slave observations, if any. We neglect (iii) in this paper. We eliminate the effect of (ii) by using our method.

In our proposal, we compensate the distortion in the co-registration process locally and nonlinearly after we obtain a temporal interferogram with the typical co-registration mentioned above. First, we calculate the rotation value to mark local SP pairs in the interferogram. Then we focus one or a few of the SP pairs at once, and prepare a small window that contains the pair at the center. We interpolate the master and slave data in the window to obtain an interpolated data represented with sub-pixel coordinates. In the sub-pixel coordinate in the slave, we modify the pixel position, locally and nonlinearly, in an adaptive manner that the center pixels move largely, while the edge pixels move only slightly, so that the local SP pair vanishes in the local sub-pixel interferogram. Then we reconstruct an ordinary (1-pixel) -coordinate interferogram from the local-SP-free sub-pixel interferogram. We repeat this local modification process over the whole image, and finally obtain a compensated global interferogram that is free from the local SPs.

The authors thank Dr. Masanobu Shimada of EORC/JAXA for supplying the InSAR data.

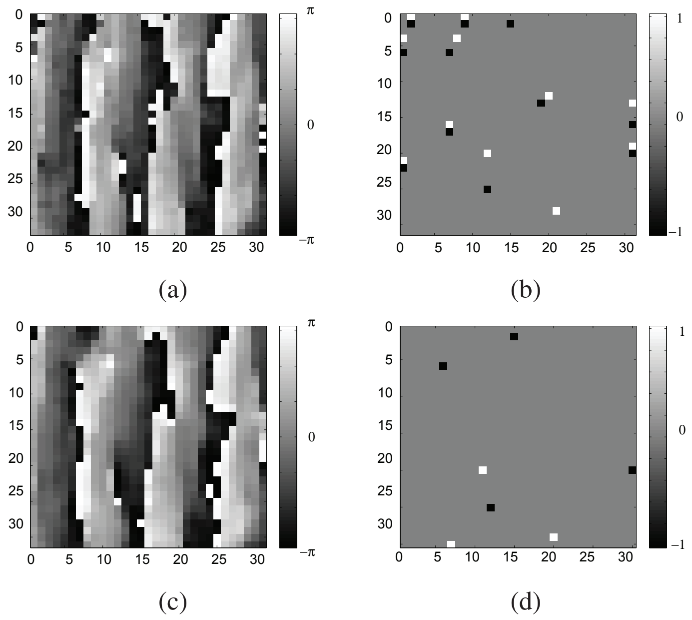


**Fig. 1**. Example of original (a)interferogram and (b)SP map, and corresponding (c)interferogram and (d)SP map after two iterations of the distortion compensation using the local and nonlinear adaptive co-registration. In the interferograms, the hue shows phase values. In the SP maps, white and black points indicate positive and negative SPs, respectively.

We are successful in reducing the number of local SP pairs in the interferogram by employing the local, nonlinear adaptive co-registration. Figure 1 shows an example of interferograms and SP maps with and without the method for JERS-1 complex-amplitude image data. Examining signal-to-noise (SN) ratios of resulting DEMs, we find that the process realizes the elimination of propagation-related distortion without loosing / modifying the landscape information.

## 3. SUMMARY

We have proposed a local, nonlinear co-registration method to eliminate the local SP pairs and related distortion. In the presentation, we show the obtained DEMs and discuss the quality by presenting SN ratios and other quantitative DEM data.

## 4. REFERENCES


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