CRINSAR FOR LANDSLIDE DEFORMATION MONITORING: A CASE IN THREEGORGE AREA

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Although the conventional differential SAR interferometry (DInSAR) technique is matured now [1][2][3][4], the decorrelation factors and error factors still reduce the accuracy of its results, and sometimes will mask the true situation. By identifying temporarily stable natural reflectors or persistent scatterers (PS), Persistent Scatterers for SAR Interferometry (PSInSAR) technique [5] [6] [7] can analyze the corresponding pixels in SAR images, even suffering relatively serious decorrelation, to get high accuracy deformation measurements. Compared with the above methods, the method of DInSAR using corner reflectors (CRInSAR)[8] is potential for mapping ground deformation phenomena in such areas where the conventional DInSAR and thePSInSAR technique are unsuitable due to temporal decorrelation and lack of natural phase stable point targets.

In 2003, the level of the Yangzi River in front of the Three Gorges Dam has reached 175 meters, while before it was 135 meters. In recent years, the level of this part of the river has been controlled to vary from 145 meters to 175 meters so as to deal with the heavy rainfall. It's inferred that the variation of the level would reduce the stability of the landslides at the sides of the river. So the monitoring to the landslides in the Yangtze River Three Gorges has much more meaning. Considering that the landslides in this area are all heavily covered by trees, brushwood and meadow, CRInSAR is preferred to rather than other DInSAR methods.

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CRInSAR has been studied by some researchers. In this paper, the processing of CRInSAR is divided into these steps: 1) Basic data collection and field work; 2) data acquisition; 3) design ,make and deploy CR; 4)CR ground measurements; 5)CR locating and peak retrieve; 6) differential phase generation; 7) temporal differential phase analysis; 8) surface deformation analysis. Among them, step 3) to step 8) will be further discussed.

pyramidal corner reflector (PCR)   asymmetrical cubic corner reflector (ACCR)

Fig.1. The two types of CR deployed in Shuping landslide

Two types of CR, pyramidal corner reflector (PCR) and cubic corner reflector (CCR) have been made and deployed for CRInSAR application in Shuping landslide (Fig.1). After field work in company with geological researchers, 12 points are selected to deploy CR. Among the 12 CR, there are 10 PCR, which are traditional instrument for InSAR, and 2 ACCR, which are less used and for test.

After the deployment of 12 CR, their coordination data have been measured by GPS. Between March, 2005 and November, 2006, all the CR had been measured for 2 times to determine the deformation. And in the year of 2009, multi-times GPS and leveling measurements are being carried out.

During the course of CR location, 8-pixels radius is adapted to search the maximum amplitude value. For the peak retrieve, 8 points Raised Cosine interpolation kernel is used. Fig.2 shows the interpolated signals of all the 12 CR and their labels, among which ZRS4 and ZRS6 are ACCR, and ZRS11 and ZRS12 are thought to be stable.

To compare the CRInSAR results with the ground measured deformation between 2005 and 2006, 5 ENVISAT ASAR images are selected to make 7 interferometric pairs with short time baselines. While analyzing the differential phases of all CR from the 7 pairs, a simple phase model is assumed. In the simple model, all the phase components except for deformation phase are considered as a whole, named as the phase error, including phase parts derived from orbit error, height error, atmospheric disturbance and other noise. For the time series unwrapped differential phases of one certain CR, LS method [9][10] is used to get the the CR's time series movement along the look direction of SAR.

By selecting ZRS11 as reference, the other 11 CR's deformation history can be calculated. It is found that on 6 CR, the bias between CRInSAR and ground measurements are within 1 cm. But on the other 5 CR, the disagreement is remarkable.

After carefully discussion, we think that there should be remarkable errors in ground measurements. The most possible reason for the obvious difference may be the vapor above the Yangtze River. To effectively validate the results of CRInSAR, more carefully designed ground measurements are being carried out in this year.

Benefiting from the large number of ENVISAT ASAR from 2005 to 2009, PS-like technique introduced by [11] is also used to retrieve the deformation velocity and history of every CR. Fig.3 shows the deformation history plots of ZRS12. According to the experiences of the field workers, the deformation values in Fig.3 are reasonable.

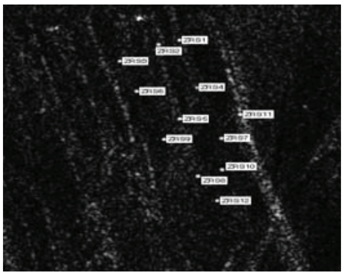

Fig.2 The signal of CR in the interpolated SAR image

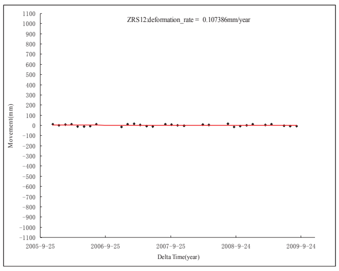

Fig.3 The deformation history plots of ZRS12

The conclusions below can be made: the method of CRInSAR has been completely implemented and applied. Both LS and PS-like technique are used to analyze the time series differential phases. ACCR can provide strong response signal while the SAR look angle varies in large range and it is especially fit for the multi-angle applications of DInSAR. Based on the numerical simulation of phase accuracy of 7 interpolation kernels, the 8 points Raised Cosine kernel is an ideal choice in practical SAR data processing.

In the future work, to deal with the possible nonlinear and fast deformation of landslide, it’s necessary to use multiplatform with higher acquisition frequency. It is important to further separate atmospheric phase from differential phase to get more accurate deformation measurements.

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