THREE-DIMENSIONAL DEFORMATION FIELD CAUSED BY THE GAIZE EARTHQUAKE BY MULTI-LOS DINSAR MEASUREMENT TECHNOLOGY

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1. INTRODUCTION

One of the limitations of deformation measurements made with interferometric synthetic aperture radar (InSAR) is that an interferogram only measures one component of the surface deformation—in the satellite's line of sight (LOS). But we need more the three-dimensional (3D) deformation caused by earthquake in order to reveal the focal mechanism. And this paper will use the multi-LOS DInSAR measure method to provide the 3D deformation field caused by the Gaize earthquake in China Tibet.

2. METHODOLOGY

According to Fialko et al. (2001) and Wright et al. (2004), suppose that the dE, dN, dU represents three orthogonal components of displacements in the local coordinate system (e.g. east, north, and up), dLOS represents displacements in the LOS direction. If they belong to the same reference frame, the transformation formula from dE, dN, dU to dLOS can be expressed as

$$dLOS = \sin\theta(dE \bullet \cos\alpha - dN \bullet \sin\alpha) - dU \bullet \cos\theta \qquad (1)$$

where α is the azimuth of the satellite heading vector (positive clockwise from the north), and θ is the radar incidence angle at the reflection point. Customarily we define upwards as positive for dU, whereras increase in the radar range are positive for dLOS..Given displacements acquired from no less than three directions, a complete 3-D displacement field can be inverted by the least-squares method.

3. RESULTS

For the Gaize earthquake, the ascending and descending orbit of ENVISAT satellite provide three different LOS directions observation which are shown in Table.1. The SAR raw images are processed with the two-pass DInSAR method and the GAMMA software. The 3 arc second DEM data from the

Shuttle Radar Topography Mission (SRTM) is used to remove the topographic phase. Precise DORIS orbits are used in processing the data to reduce errors associated with image co-registration and flat earth phase removal. And the three different LOS directions coseismic interferogram are obtained as shown in Figure 1.

Tab.1 the three different LOS direction measure by ENVISAT satellite

Orbit-Pattern	Data	Orbit	Track	Frame	$B_\perp$	Mode
Descending	20071123(M)	29961	2348	2961-2979	-	IS2-D
	20080201(S)	30963	2348	2961-2979	8m	
Ascending	20070809(M)	28451	2341	639-657	-	IS2-A
	20080131(S)	30956	2341	639-657	-74m	
	20070328(M)	26533	6427	621-639	-	IS6-A
	20080206(S)	31042	6427	621-639	110m	

(M is the mater image; S is the slave image; $B_\perp$ is the vertical baseline distance)

For the ENVISAT satellite, the incidence angle θ is vary from 19.2 to 26.7° and from 39.1° to 42.8 ° respectively for IS2 and IS6 mode, and the α is constant for the same orbit. For the Gaize earthquake deformation field, the average incidence angle θ of IS2-A, IS2-D and IS6-A mode is respectively about 25.8°, 21.4° and 41.8°. The constant α of IS2-A, IS2-D, IS6-A mode is respectively 348°, 192° and 350°. If we ignore the small change of incidence angle in different image pixels, the equation(1) is expressed as:

$$\begin{pmatrix} d_{LOS-IS2A} \\ d_{LOS-IS2D} \\ d_{LOS-IS6A} \end{pmatrix} = A \cdot \begin{pmatrix} d_E \\ d_N \\ d_U \end{pmatrix} = \begin{pmatrix} \sin(25.8°)\cos(348°) & -\sin(25.8°)\sin(348°) & -\cos(25.8°) \\ \sin(21.4°)\cos(192°) & -\sin(21.4°)\sin(192°) & -\cos(21.4°) \\ \sin(41.8°)\cos(350°) & -\sin(41.8°)\sin(350°) & -\cos(41.8°) \end{pmatrix} \cdot \begin{pmatrix} d_E \\ d_N \\ d_U \end{pmatrix} \quad (2)$$

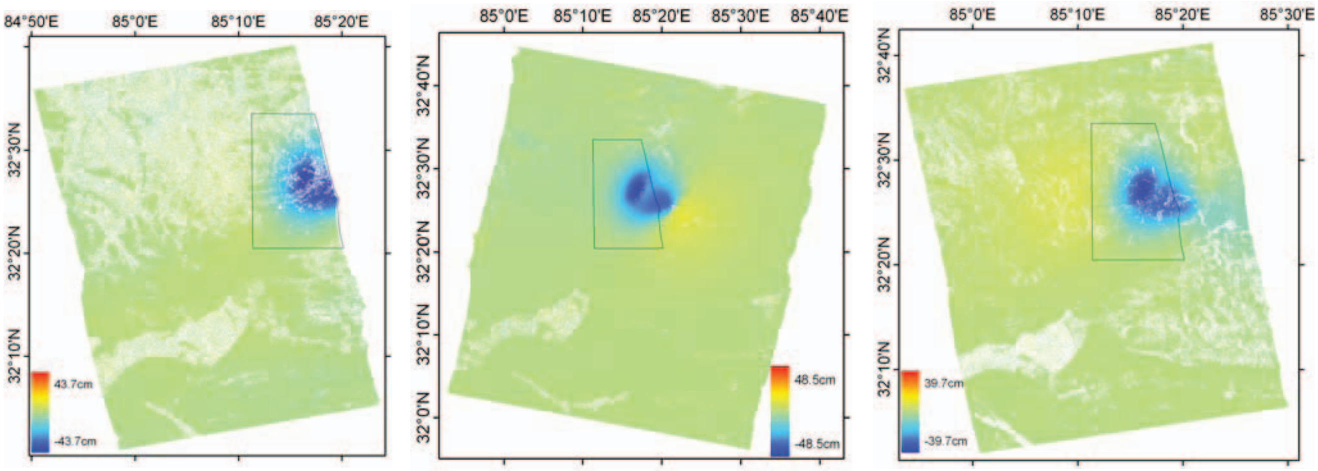
$d_{LOS\text{-}IS2A}$ is the deformation value of IS2-A mode, $d_{LOS\text{-}IS2D}$ is the deformation value of IS2-D mode, and $d_{LOS\text{-}IS6A}$ is the deformation value of IS6-A mode. And equation(2) can be transferred to equation (3):

$$\begin{pmatrix} d_E \\ d_N \\ d_U \end{pmatrix} = A^{-1} \cdot \begin{pmatrix} d_{LOS-IS2A} \\ d_{LOS-IS2D} \\ d_{LOS-IS26} \end{pmatrix} \quad (3)$$

And by the equation (3), the 3D deformation field can be calculated out, as are shown in Fig.2.

4. CONCLUSIONS

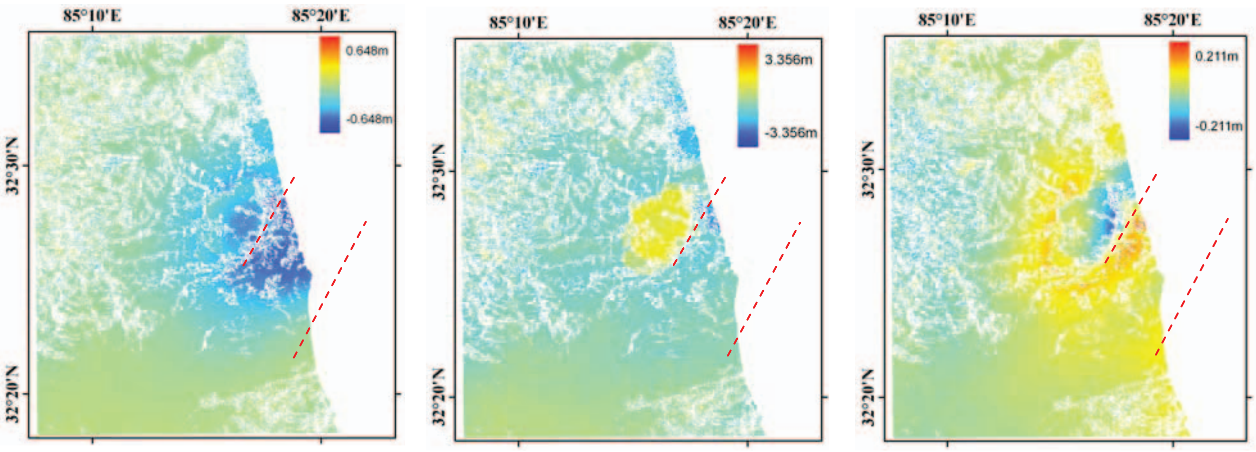
We obtain the 3D deformation field of Gaize earthquake by the multi-LOS DInSAR measurement. The northwest plate of east seismic fracture move toward to down in vertical direction (dU), and move toward to south (dN) and east (dE) in horizontal direction. And the northwest plate of west fault fracture



(a)IS2-A (b) IS2-D (c)IS6-A

Fig.1 the multi-LOS deformation field of Gaize earthquake

(the black rectangle is the resolving region of 3D deformation field)



(a)dU (b)dN (c)dE

Fig.2 the preliminary 3D deformation of Gaize earthquake

(the east and west dotted red lines are the fault fracture respective by the Ms6.9 mainshock and Ms6.0 aftershock)

move toward to down in vertical direction also, but move toward to north (dN) and west (dE) in horizontal direction. It can be judged that the east and west both fault fracture zone (maybe buried) are produced respectively by 9th Jan 2008 Ms 6.9 mainshock and 16th Jan 2008 Ms6.0 aftershock. Both of the faults are NE-trending and NW-dipping. The mainshock and aftershock successively give birth to the east and west both subsiding-centers. The 3D deformation result show the mainshock is major normal and left-striking fracture, but the aftershock is typical normal fracture. The obtain of 3D deformation fields give the better restriction and information for the next hypocenter mechanism simulation.

5. REFERENCES

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