GPS observations of the postseismic crustal deformation, associated with the 2001 Gujarat, India earthquake

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It has been reported that the Gujarat, India earthquake (Ms7.9) of January 26, 2001 caused really the worst damage (20,005 fatalities, 166,000 wounded and 370,000 razed houses) in the India's recorded history. This earthquake was a major intraplate event in the Indian plate, which is moving in the north-northeastern direction to collide with the Eurasian plate. The hypocenter has been determined at 23.40 N, 70.32 E, and depth of 23.6 km (IRIS, 2001). Indian Meteorological Department has classified this region as one of the most seismically active zones (Zone-5).

It is very important to investigate the mechanisms for preseismic, coseismic and postseismic crustal deformations in order to understand the total process of the major earthquake. In such a view, we have started GPS observations around the source region to detect the postseismic crustal deformation and investigate its mechanism.

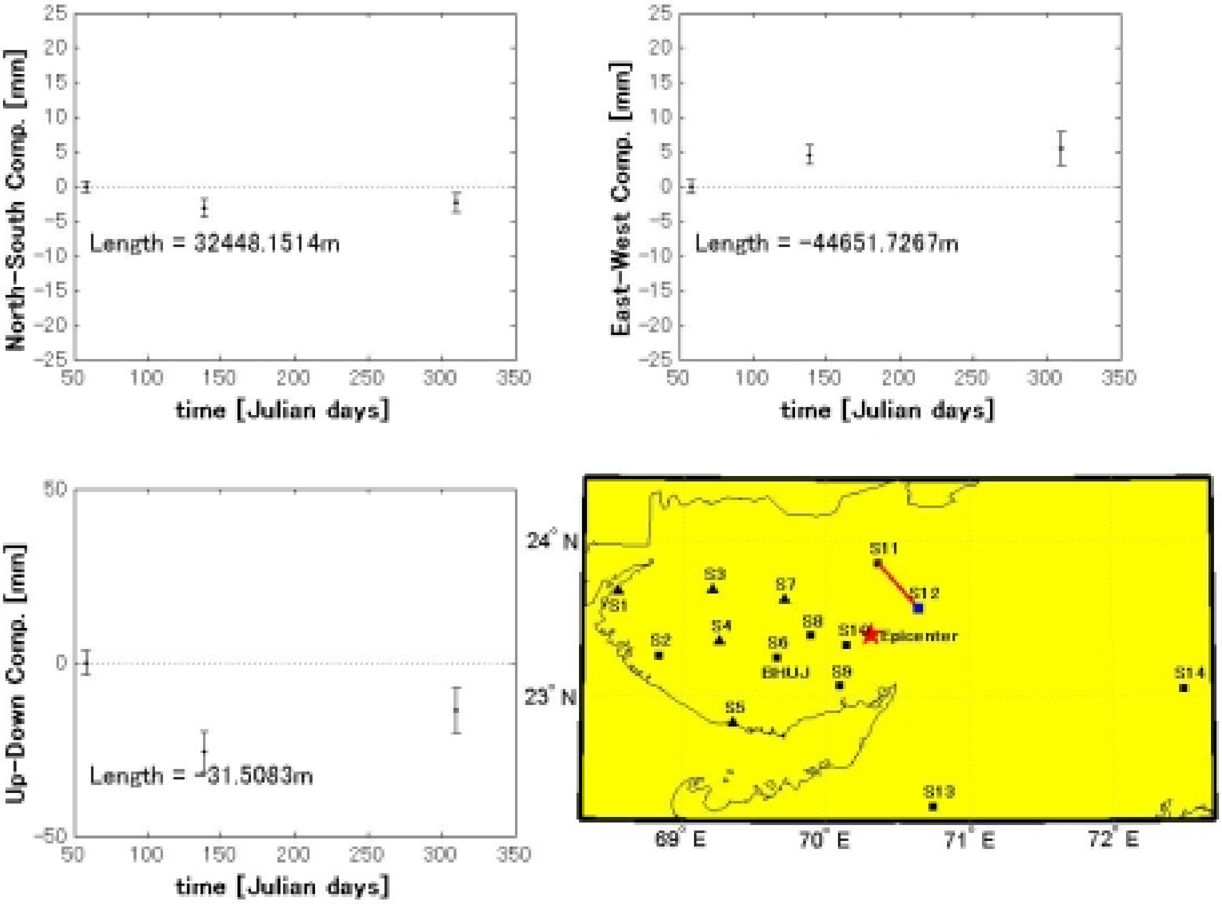
Figure 1d shows the GPS network, which was established two weeks after the earthquake occurrence. The network consists of 14 observation stations, where GPS antennae are mostly set up on roof-tops of the undestroyed buildings. The average station interval of the network is around 25 km. The first campaign of GPS observations was held during a period from Feb. 22 to Mar. 5, 2001, the second one from May 13 to 23, 2001, the third one from Nov. 2 to 11, 2001, and the fourth campaign shall be conducted during a period from Feb. 26 to Mar. 15, 2002.

We have not yet obtained the data about the coseismic crustal deformation. However, we could get some information of the earthquake fault plane from the results of body wave inversion (Yagi and Kikuchi, 2001) and aftershock observations (Negishi et al., 2001). Based on these studies, we depicted the following fault model: (N, E)=(23.4 N, 70.0 E); d=10 km; L=66 km; W=35 km; dip=45; strike=N78 E; slip=81 ; U=4.18 m. According to the model, the maximum uplift amounted to 243 cm, and the maximum horizontal displacement 165 cm. We could also expect from the model that the baseline vector between S11 and S12 (Fig. 1d) changed as follows: its E-W, N-S and U-D components increased -1.29, -18.8 and 23.4 cm, respectively. It should be noticed that S12 is located on the hanging-wall side of the fault plane, but S11 on the foot-wall side.

We analyzed the GPS data from the first, second and third campaigns of GPS observations by using the GAMIT/GLOBK software. We also used the data from the IGS fiducial sites around the network, i.e., Lhasa, Kitab, Diego and Bahrain. These IGS sites were constrained to vary within 3-5 mm horizontally and 5-10 mm vertically from their a priori coordinates in the ITRF96 reference frame. Baseline solutions for each campaign were obtained by combining daily solutions.

Figures 1a, 1b and 1c show the changes in the north-south (N-S), east-west (E-W) and up-down (U-D) components of the baseline vector, S11-S12 (Fig. 1d) near the source region during a period from the first campaign to the second or the third campaign. We could see that the site of S12 was uplifted about 2.6 cm with respect to S11 during a postseismic interval of 80 days, and was subsided about 1.2 cm during the next 180 days. Concerning the baseline vectors around the source region, the earlier postseismic deformation pattern was similar to the coseismic one, while the later postseismic one was slightly reverse to the earlier one.

We could detect the postseismic crustal deformation associated with the 2001 Gujarat earthquake from three campaigns of GPS network observations. However, we should have several more campaigns in order to clarify the mechanism of the postseismic process.


North-South Comp. [mm]
Length = 32448.1514m
time [Julian days]
East-West Comp. [mm]
Length = -44651.7267m
time [Julian days]
Up-Down Comp. [mm]
Length = -31.5083m
time [Julian days]
24° N
23° N
69° E
70° E
71° E
72° E
S1
S2
S3
S4
S5
S6
BHUJ
S7
S8
S9
S10
S11
S12
S13
S14
Epicenter