GPS at CTO: Geodetic Arrays and Data Processing

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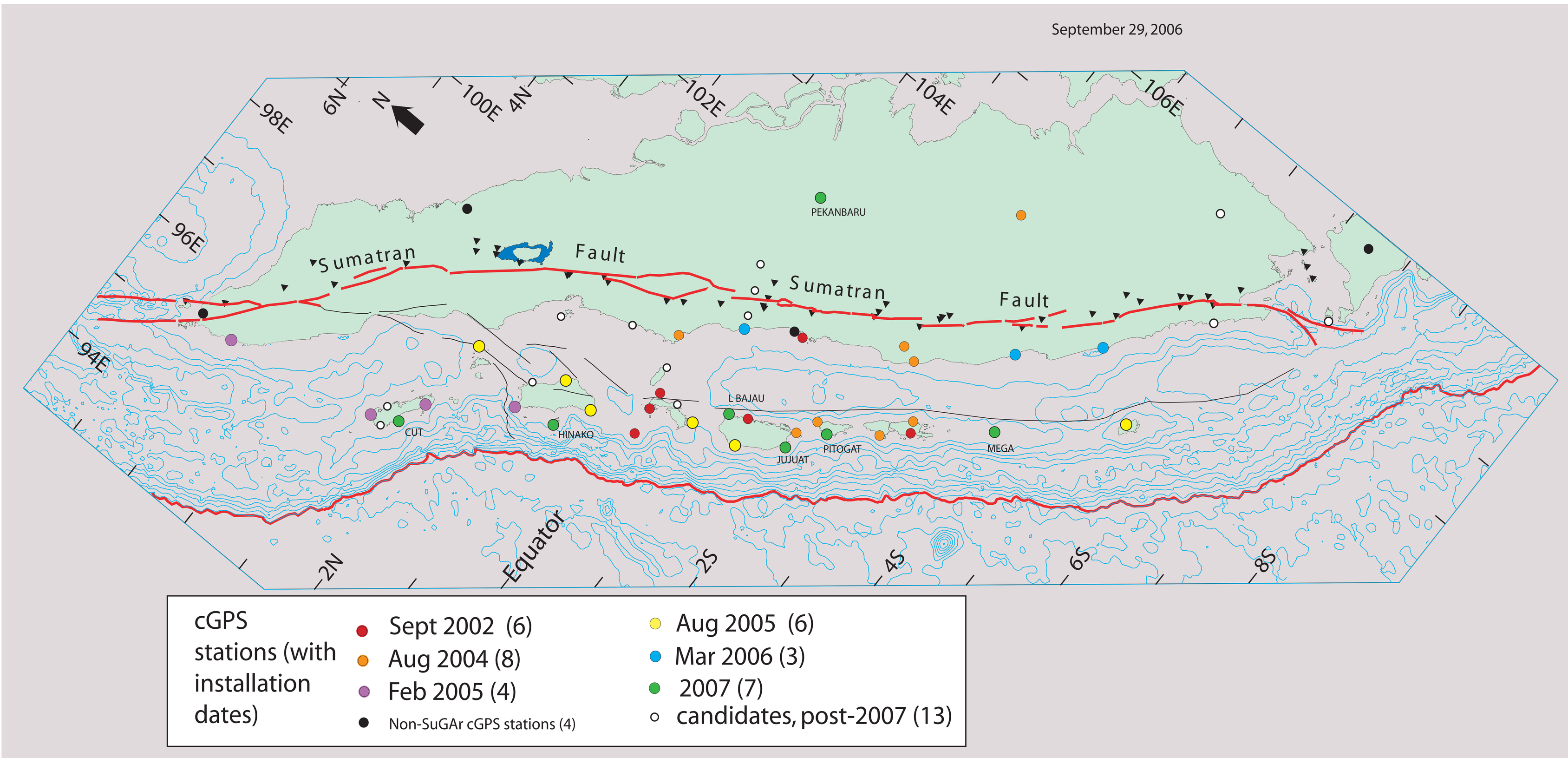

Figure 1. Map location of existing and future SuGAr sites in Sumatra.

Introduction and Current Status

CTO operates 4 medium size GPS geodetic arrays at or near plate boundaries. Two arrays are located near prominent subduction zones, a third monitors deformation in a continent-continent collision setting, and a forth measures displacement in an extentional environment. Established in 2002, the 27-station Sumatra GPS Array (SuGAr) occupies the Sumatran forearc from Enggano in the South to small islands north of Simeulue (Figure 1). With measurements starting in 2005, 11 stations of the Central Andean GPS Array (CAGA) span northern Chile from the Peruvian border to Antofagasta (Figure 2). Since 2004, data from 9 CTO stations in Nepal (Figure 3) add substantially increased spatial resolution to measurements from 3 pre-existing permanent sites in the area. The 71-site Basin and Range Geodetic Network (BARGEN) has been a collaborative project between Caltech and Harvard since 1996. Recent CTO efforts focus on a 31-station subset of BARGEN (Figure 4). CTO also contributed 3 stations in tectonically important, hard-to-access locations of the Central Range to the Taiwan GPS Network.

Station Design

Basic station design is similar for all networks (Figures 5 and 6). A tripod, formed by welded stainless steel tubing resting in drill holes, is anchored to the subsurface by epoxy and supports the radome equipped GPS choke-ring antenna. A 30 m coaxial cable carries the L-band satellite signals from the preamplifier (located at the base of the antenna) to the GPS receiver. The receiver is housed in a steel equipment box together with ancillary electronic and electrical equipment (Figure 7). The station is powered by 2 50-80 W-rated solar panels that charge 2 deep cycle, 70-100 Ah-rated gel cells. Where feasible, communications with the receiver is facilitated by radio links.

Data Retrieval

Data from SuGAr sites are downloaded in daily batches to a central internet hub in Batam, Indonesia, through low bandwidth serial port modems of a regional communications satellite. Several CAGA sites have internet links by long range Ethernet radio bridges terminating at internet hubs of local universities (Arica and Antofagasta) or of municipal administrations (Putre). The Nepal network, located in a challenging environment, currently relies exclusively on periodic on-site manual downloads.

Future Development

Site Augmentation

A major addition of sites is scheduled for all CTO-run networks. For SuGAr, a densification in certain key areas (Figure 1) will help to account for research activities related to the different stages of the seismic cycle for different parts of the network. For CAGA, targeted new sites near the coast and the Andean foothills will narrow the wide spacing of the existing array, while expansion into southern Peru and western Bolivia and Argentina will capture a much larger area of the plate margin. Near-future developments of the Nepal array call for a major deployment of new sites in the western half of the country. A trans-Himalayan expansion is currently underway with several sites in Tibet.

Real time Data Streaming

If site measurements can be transmitted in near real time to central processing facilities, GPS geodetic networks located near plate boundaries will potentially yield important contributions to natural hazards early warning systems, Three CAGA sites (ATJN, PCCL, PTRE) currently have internet links. Links to two additional sites (JRGN, MCLA) have been tested successfully. Near real time data links for SuGAr have been explored earlier this year at the central facility of the satellite communications provider (ACeS) in Batam. Using existing (low bandwidth) modems, data stream with a sampling interval of about 5 sec. were forwarded to CTO with a latency of several seconds. Employing a higher bandwidth satellite Ethernet radio bridge yielded subsecond latencies for data streams of 1 or 2 Hz. Efforts to expand real-time connectivity are underway for all CTO networks.

Data Processing

The displayed time series of station positions (Figures 8 and 9) show a long term, approximately linear trend that reflects crustal motion. This tectonic signal is superimposed by noise from a variety of sources. Depending on their origin, there are temporally correlated aperiodic and periodic components with annual, semi-annual, or diurnal contributions. Local- (multipathing), regional-, and reference frame-induced errors produce additional, spatially correlated noise. Eliminating or reducing these contributions with the help of suitable models and filters will be a significant part of future work.
With an increasing number of on-line data streams, it will also become necessary to develop proper tools for near real time data processing and analysis.

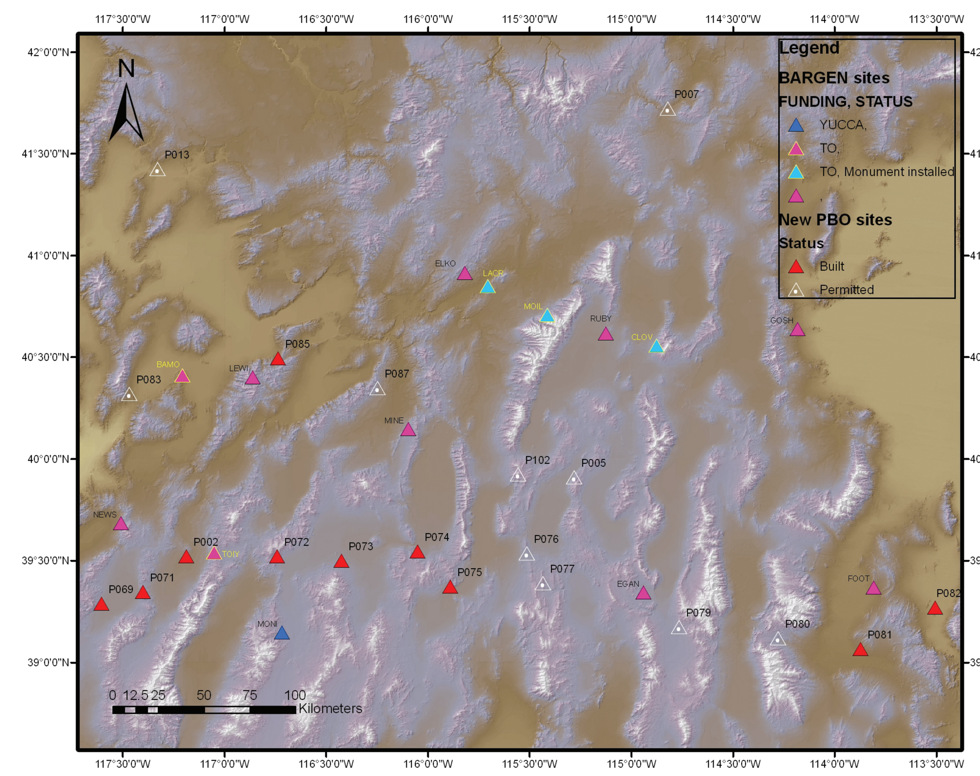

Figure 4. Map location of CTO subnetwork of BARGEN.

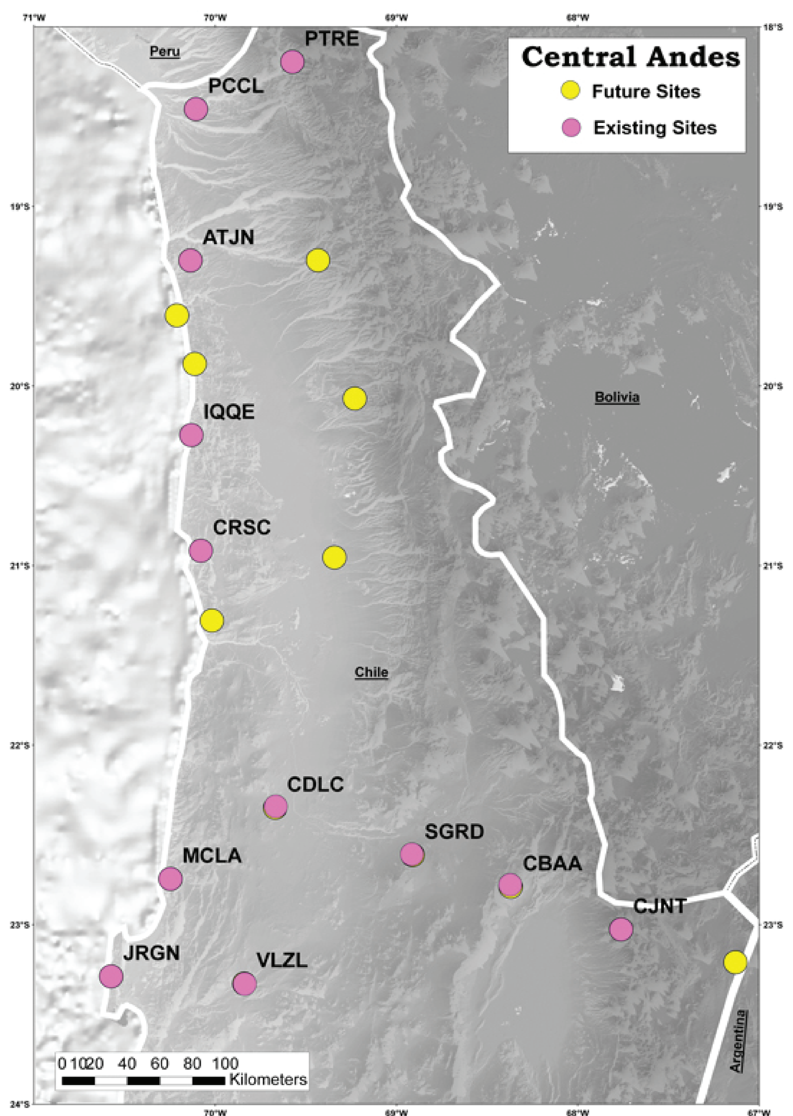

Figure 2. Map location of existing and future CAGA sites in northern Chile

Figure 5. CAGA station ATJN in northern Chile. Equipment box, solar panels, and ethernet link radio antenna in the foreground, GPS tripod and antenna in the background.

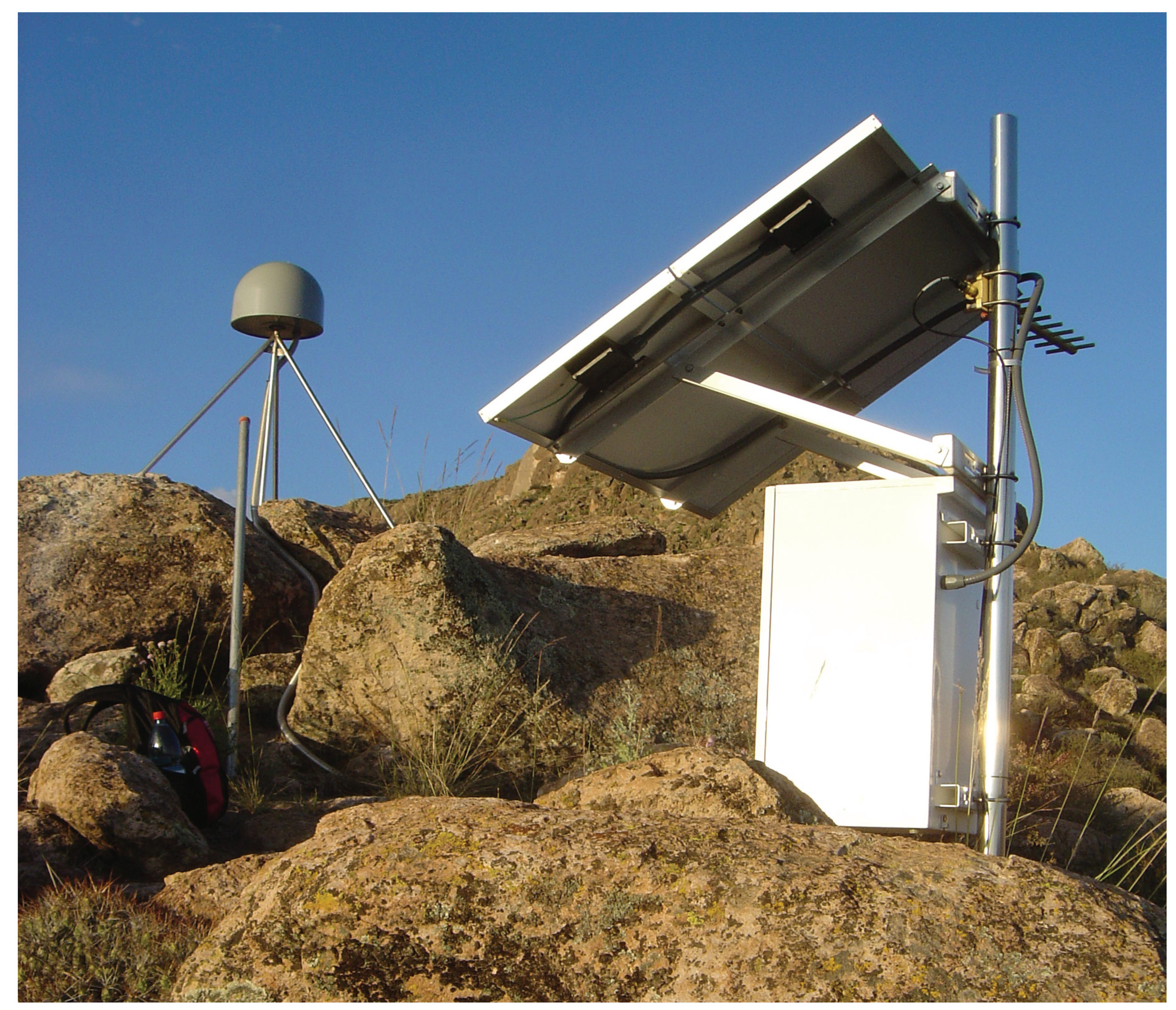

Figure 6. CAGA station PTRE.

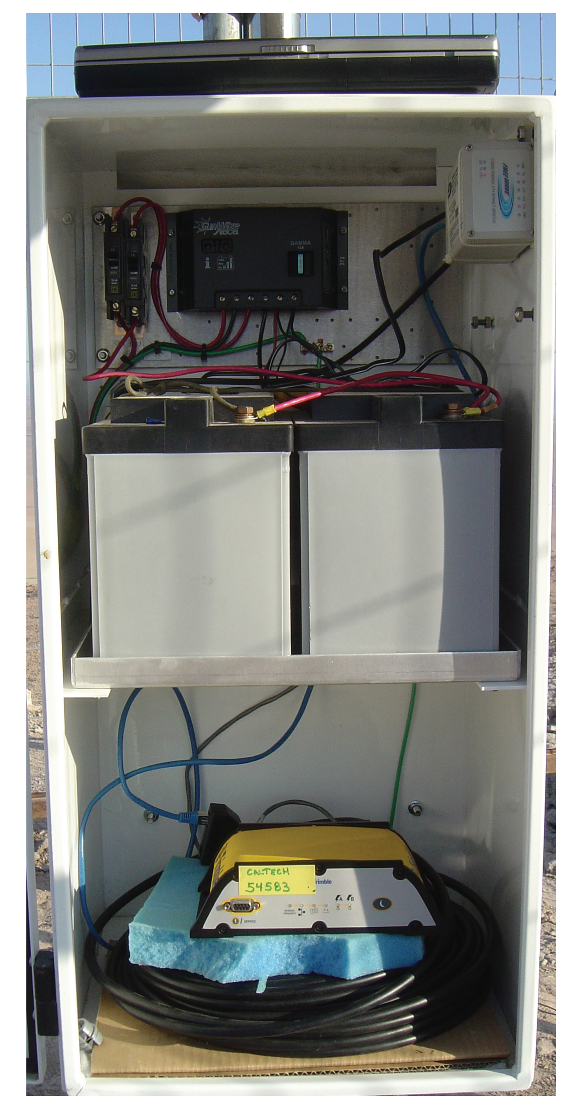

Figure 7. Interior of equipment box for station PCCL. Solar panel control unit and ethernet radio located above batteries, GPS receiver below.

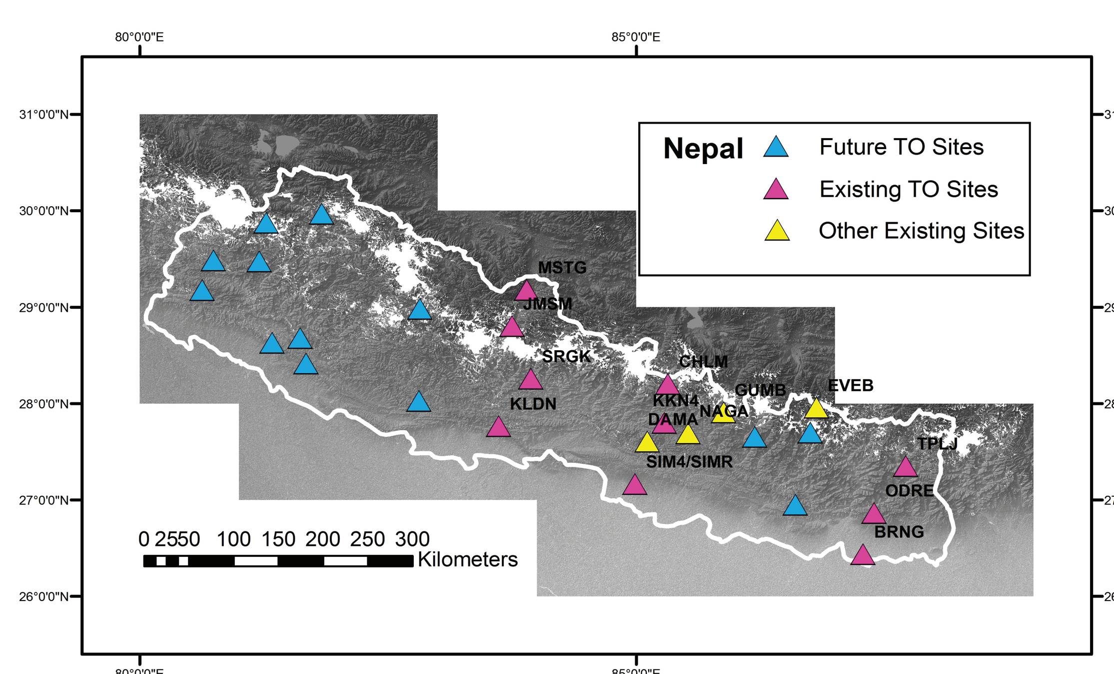

Figure 3. Nepal GPS network. Map location of existing and future sites.

Data Processing

For each 24 hour time period, all available raw receiver image files are converted to Ascii Rinex format. Using the GAMIT software package, local Rinex files are processed with corresponding phase observations from nearby global reference stations to yield daily station positions with respect to a loosely constrained global reference system. Refined ITRF 2000 daily positions are then computed by a Kalman Filter (GLOBK) with the help of solutions from several global (IGS) networks. North-, east- and up-components of the daily station positions are displayed on network specific web pages (Figures 8 and 9).

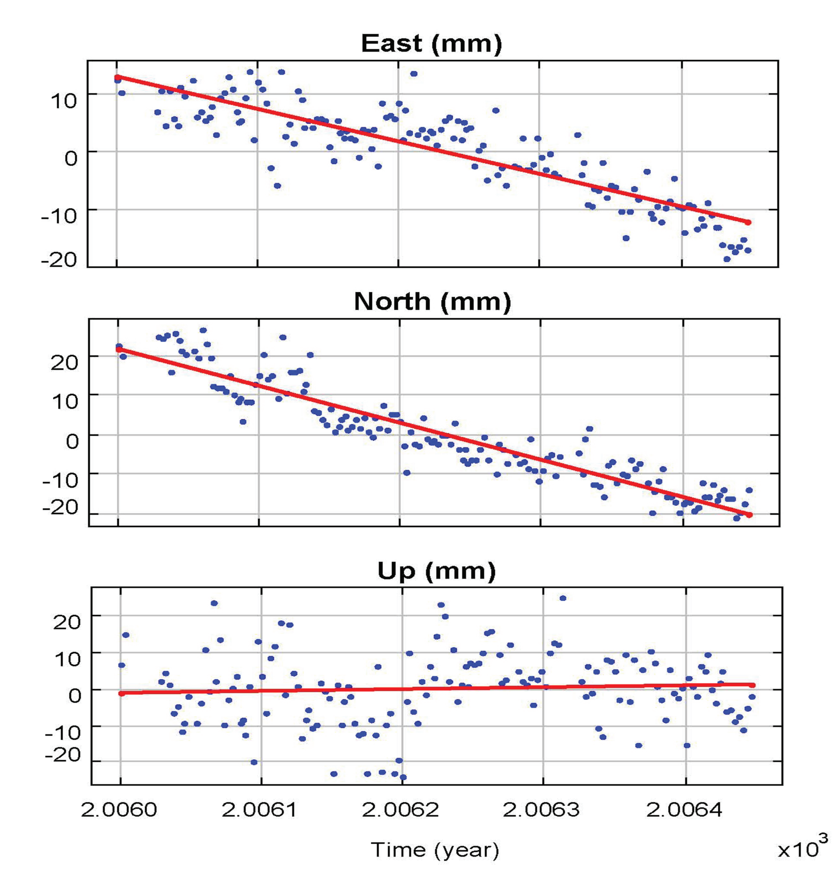

Figure 8. East-, north-, and up components of daily positions for SuGAr site LEWK in ITRF2000.

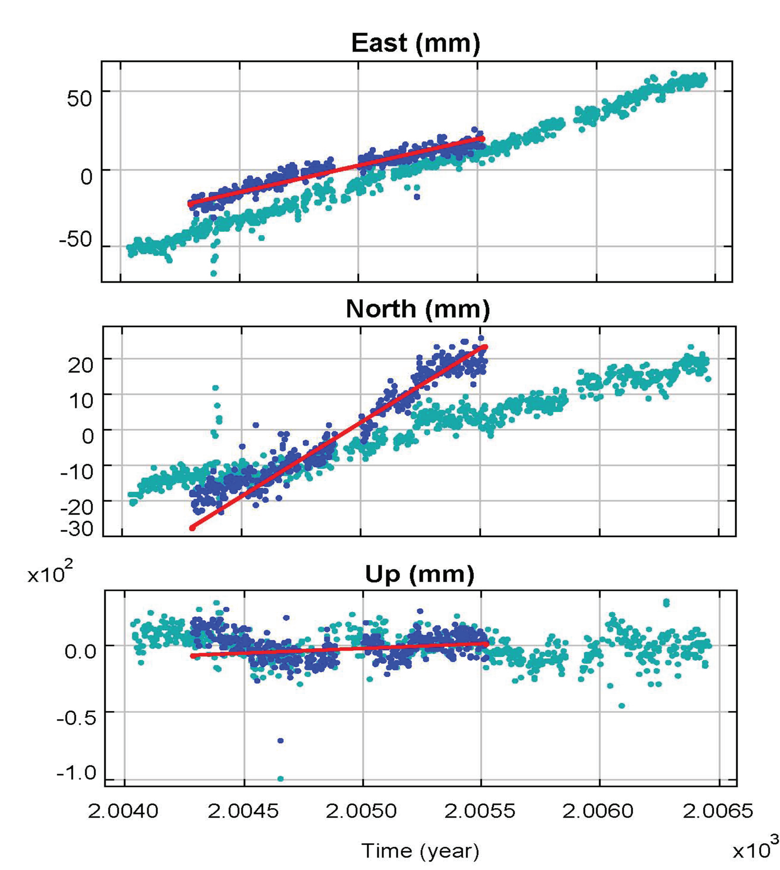

Figure 9. East-, north-, and up- components of daily positions for Nepal site KLDN (blue) and global reference site LHAS (green) in ITRF2000.