EarthScope Participates in Open Data Seismic Deployment Following 2010 Chile Earthquake

The global seismology community established a new model of international cooperation in response to the great Chile earthquake of February 27, 2010. The adoptable framework is geared to produce a high-quality, open-access data set of seismic waveforms collected in the wake of great earthquakes. Collection of the unprecedented Maule International Seismic Dataset (MISD) was supported by an NSF-RAPID award and used fortunately available EarthScope Flex Array (FAA) sensors; IRIS RASSCAL personnel and volunteers from the IRIS Community deployed and maintained 58 broadband seismic stations from April-September 2010. The FAA sensors constituted the IRIS RASSCAL (for Chile) MAMF network, the largest equipment contribution to the MISD. Three CHAMP stations transmitted continuous data to PASSCAL in Seattle. 

When great earthquakes strike, will we be ready to exploit all they can potentially tell us about the processes occurring at the end of the seismic cycle? Although the great 2004 Sumatra earthquake caught Earth scientists largely unprepared, when the M, 8.8 February 27, 2010, Maule earthquake struck – thanks in large part to a quick decision to use available EarthScope equipment, and to a flurry of negotiations between national groups responding to the crisis – the global seismology community did everything possible to collect unique seismic and geodetic data as they accrued following the event. The Maule earthquake damaged central Chile to a degree commensurate with its magnitude, mitigated by careful preparation by Chilean civil defense authorities and scientists. Rapid repair and restoration of critical infrastructure allowed seismologists from Germany, France, the United States, and Chile to coordinate sensor deployment, thus capturing aftershocks and other signals associated with this significant earthquake. In all, 91 broadband, 48 short period, and 25 accelerometer stations were installed. The CHAMP sites were deployed by the end of March and commissioned in late September 2010 to return equipment to a scheduled 125 project. The sixth CHAMP dataset – all data available from the IRIS Data Management Center (network code XX) – provides an unprecedented view of endoseismic cycle processes, including a detailed look at seismic tremor in the wake of a great earthquake.

Open data is a new model for international collaboration in affected states. One of the most important policies implemented at the inception of EarthScope established the immediate open-access to data recorded at the EarthScope facilities. Recognition that open access to all data collected following the Maule earthquake would ensure that it was maximum and timely use spurred IRIS leadership to negotiate an open data access agreement with other international groups deploying instruments. Cooperation allows for the most efficient use of equipment, stimulating redundant network design. The MISD will therefore contain data from a relatively uniform network covering virtually the entire armed earthquake region, some 30,000 km² at a nominal station spacing of ~30 km (Figure 1)

Figure 1: Location map of stations deployed to capture seismic inputs following the Maule earthquake. Blue: U.S. networks; green: Chilean networks. Blue triangle and pink triangle: near-arrivals. Red dot within the blue dot indicates the ISSN location.
Cascadia Initiative

The National Science Foundation received funding through the 2009 American Recovery and Reinvestment Act for facility-related investments to support multi-disciplinary EarthScope and GeoPRISMS (www.geoprism.org) science objectives. During its first phase, 2010-2015, the focus is on onshore/offshore studies of the Cascadia margin to better understand the nature of recently discovered, regularly occurring “Episodic Tremor and Slip” (ETS) events and how ETS is related to “normal” destructive subduction zone earthquakes. The ambitious Cascadia Initiative is one of only two NSF projects that has been selected as one of “100 Recovery Act Projects That Are Changing America.” Visit the EarthScope science highlight for additional information.

Installation of 27 new USArray TA seismic stations has been completed and over 75% of the 232 PBO GPS sites targeted for near real-time data transmission at 1 Hz sampling rate have been upgraded. Currently, 60 new Ocean Bottom Seismographs (OBS) are being built and tested for a first deployment in 2011. The Workshop report from the Cascadia Initiative Workshop in October 2010 outlines the OBS deployment plan. ■

PBO Status

A major Plate Boundary Observatory (PBO) activity in 2010 included its involvement in the UNAVCO response to the April 4th El Mayor-Cucapah earthquake in northern Baja California, Mexico (Star in Figure 1). The M=7.2 earthquake, which struck 40 miles south of the Mexico-US border, was the largest recorded earthquake in the area. PBO’s immediate response was to deploy 6 new GPS near-shore and 13 GPS near-shore and 15 GPS offshore stations within 48 hours that were then relocated to sites at close epicenter distances. High rate GPS were also used to support airborne Lidar and photography missions imaging the rupture zone. PBO’s standard 15-second GPS data helped to establish overall coseismic dislocations. Additionally, four EarthScope campaign GPS receivers provided geodetic control for terrestrial laser scanner measurements. A science highlight describes the UNAVCO/PBO response and has further links and results.

Figure 1: Location of new permanent GPS sites (green) and P485, P796 and P797 in Baja California (blue). Green (white) points represent extending the existing southern California CORS network (orange). Red dots are afterlocation markers.

PBO engineers Shawn Lawrence and Chris Hallis identified a slow slip signal at site P613 (Figure 2), possibly triggered by the earthquake. P613 is about 220 km north of the rupture and 10 km from the San Andreas Fault. Anomalously low north and west-directed slip of up to 1 cm amplitude occurred over a few months after the event. Although the transient may be caused by the Sidewinder deep-sea slide, it is a slow, low frequency earthquake that is well-recorded across the region. The PBO field team was able to deploy temporary high-rate GPS at the site, which record data for 10 days.

Uniform coverage of the Maule rupture region allows us to address some interesting questions. Episodic tremor, slow slip events, and low-frequency earthquakes (LFEs) have been observed at the down-dip edge of megathrust rupture zones in Japan, Cascadia, Costa Rica, Mexico and southern Chile, revealing a strong correlation between tremor and slow, aseismic basin subsidence of the forearc region that relieves stresses on the deeper parts of the interplate interface. Improvements in tremor locations have shown that tremors occur on or very near the interplate interface in both Japan, and Cascadia, and are part of a continuum of shear slip processes occurring at high fluid pressures that include seismic slip, slip producing tremor, LFEs and seismic slip. How ever the relationship between episodic tremor and megathrust earthquakes is not understood. Is tremor excited by megathrust ruptures, or is it suppressed or forced to migrate elsewhere in the system? Does tremor occur only along the boundary of the Maule slip region, or has it been suppressed for other subduction zones? If high-frequency tremor in the Maule rupture zone conforms to type, we expect to detect regions of slip that produce LFEs and tremor along the interplate interface. Identification of such regions may have implications for slip acceleration during rupture near the down-dip seismic limit.

Initial analysis of MDS data provides observations of LFEs (Figure 2), and indications of non-volcanic tremor activity (Figure 3) in central Chile (13.38°S). These are the first observations ever of tremor in the wake of a megathrust earthquake. A major challenge to detect tremor in the aftershock zone is the extreme frequency of high-amplitude “normal” aftershocks (Figure 3), which make identification of distinct tremor wave packets difficult. A preliminary search for tremor again began to operate. Given this observation, a more likely scenario is that tremor is currently generated during the slow, aseismic slip on the Slippery Shales that has been observed to follow other great earthquakes.

Figure 2: Spectrogram of an apparent low frequency earthquake (LFE) at station U09B (see Figure 3). Vertical Hokkaido is an area of high frequency (Hz) activity. The LFE was recorded on all three components. Some of which are visible on the seismogram above the spectrogram. Note the longer-duration normal aftershock and 30-40 Hz tremor.

Figure 3: Epicentral location of the Maule earthquake (star) located by the US National Earthquake Information Center, February 27 – October 1, 2011. Preliminary analysis of MDS data by its group at Imperial University and OSU Potsdam, Germany, has resulted in more than 30,000 located aftershocks. Ongoing and future studies of the MDS will certainly take us further towards resolving the presence of tremor and other issues concerning and seismic cycle processes. Thanks to EarthScope, IRIS and PASSCAL, and to our international collaborators, the global seismological community will have the opportunity to attack these problems with an unprecedented array of data.

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