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Geohazard Supersites and Natural Laboratories

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The San Andreas Fault 'Supersite'

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USGS science for a changing world

Abstract. An expanded and permanent Supersite has been proposed to the Committee on Earth Observation Satellites (CEOS) for the San Andreas Fault system, based upon the successful initial Group on Earth Observations (GEO) Geohazard Supersite for the Los Angeles region from 2009-2013. As justification for the comprehensive San Andreas Supersite, consider the earthquake history of California, in particular the devastating M 7.8 San Francisco earthquake of 1906, which occurred along the San Andreas Fault, as did an earthquake of similar magnitude in 1857 in southern California. Los Angeles was only a small town then, but now the risk exposure has increased for both of California's megacities. Between the San Francisco and Los Angeles urban areas lies a section of the San Andreas Fault known to creep continually, so it has relatively less earthquake hazard. It used to be thought of as capable of stopping earthquakes entering it from either direction. Transitional behavior at either end of the creeping section is known to display a full range of seismic to aseismic slip events and accompanying seismicity and strain transient events. Because the occurrence of creep events is well documented by instrumental networks such as CISN and PBO, the San Andreas Supersite can be expected to be especially effective. A good baseline level of geodetic data regarding past events and strain accumulation and release exists. Many prior publications regarding the occurrence of geophysical phenomena along the San Andreas Fault system mean that in order to make novel contributions, state-of-the-art science will be required within this Supersite region. In more recent years, the 1989 Loma Prieta earthquake struck adjacent to the San Andreas Fault and caused the most damage along the western side of the San Francisco Bay Area. More recently, the concern has focused on the potential for future events along the Hayward Fault along the eastern side of San Francisco Bay. In Southern California, earthquakes struck in 1992 (Landers), 1994 (Northridge) and 1999 (Hector Mine) as well as the 2010 El Mayor – Cucapah (EM-C) earthquake (just south of the US-Mexico border). Of these four notable events, all produced extensive surface faulting except for the 1994 Northridge event, which was close to the Los Angeles urban area on a buried thrust fault. Northridge caused by far the most destruction, topping $20B (US) and resulting in 57 fatalities due to its location under an urban area. The Landers, Hector Mine and EM-C events occurred in desert areas away from major urban centers, and each proved to be a new and unique test-bed for making rapid progress in earthquake science and creative use of geodetic imagery. InSAR studies were linked to GPS deformation and mapping of surface ruptures and seismicity in a series of important papers about these earthquakes. The hazard in California remains extremely high, with tens of millions of people living in close proximity to the San Andreas Fault system as it runs past both San Francisco and Los Angeles. Dense in-situ networks of seismic and geodetic instruments are continually used for research and earthquake monitoring, as well as development of an earthquake early warning capability. Principles of peer review from funding agencies and open data availability will be observed for all data. For all of these reasons, the San Andreas Fault system is highly appropriate for consideration as a world-class permanent Supersite in the GEO framework.

Supersite description and justification

The earthquake history of California, in particular the devastating 1906 San Francisco earthquake, is well known worldwide and will be summarized, but can be found in more detail here:

http://earthquake.usgs.gov/earthquakes/states/california/history.php

The 1906 earthquake of M 7.8 occurred along the San Andreas Fault, as did an earlier earthquake of similar magnitude in 1857 along the southern San Andreas Fault. Between the San Francisco and Los Angeles metropolitan regions lies a section of the San Andreas Fault known to creep continually, and it has relatively less earthquake hazard as a result. Transitional behavior at either end of the creeping section is known to display a full range of seismic to aseismic slip events and accompanying seismicity and strain transient events. Because the occurrence of these events is exceedingly well documented by extensive instrumental networks, the supersites proposal would potentially be especially effective in California. The baseline level of information regarding past events and the strain accumulation and release process is very well known, as compared with many other parts of the world. The wealth of publications regarding the occurrence of various geophysical phenomena along the San Andreas Fault system means that the scientific bar has been set very high. In order to make novel contributions, state-of-the-art science is required. In more recent years, the 1989 Loma Prieta earthquake struck adjacent to the San Andreas Fault and caused the most damage along the western side of the San Francisco Bay Area, although the current concern is more related to the potential for future events along the Hayward Fault along the eastern side of San Francisco Bay. In Southern California, earthquakes struck in 1992 (Landers), 1994 (Northridge) and 1999 (Hector Mine) as well as the 2010 El Mayor – Cucapah earthquake that occurred just south of the US-Mexico border. Of these four notable events, all were above M 7 and produced extensive surface faulting except for the 1994 Northridge event, which was close to the Los Angeles urban area and was M 6.7 on a buried thrust fault. Nevertheless, Northridge caused by far the most destruction, topping $20B (US) and resulting in 57 fatalities. The Landers, Hector Mine and EM-C events occurred desert areas away from major urban centers, and each proved to be a new and unique test-bed for making rapid progress in earthquake science. InSAR studies were linked to GPS deformation and mapping of surface ruptures and seismicity in a series of important papers about these earthquakes. The hazard in California remains extremely high, with tens of millions of people living in close proximity to the San Andreas Fault system as it runs past both San Francisco and Los Angeles. Dense in-situ networks are used for earthquake monitoring, as well as development of an earthquake early warning capability.

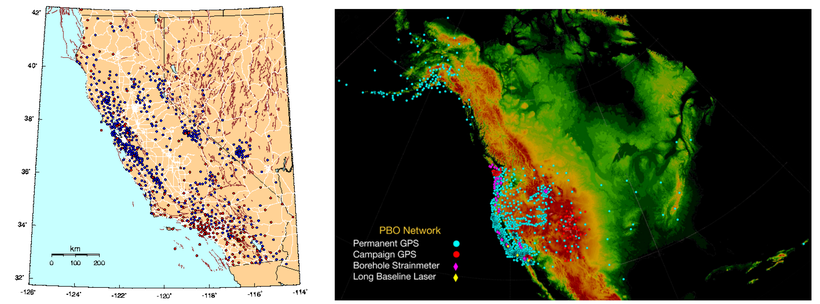

Figure 1. **The instrumental infrastructure of the project partners in the San Andreas Fault region.**

CISN source: http://www.cisn.org/instr/ **PBO source: http://pbo.unavco.org/**

The San Andreas Fault Supersite

The San Andreas Fault Supersite covers most of the state of California, as shown in Figure 1. The area of interest for imagery acquisition is the trace of the San Andreas fault system, extending from a point at the northern tip of the Gulf of California in northern Baja California, Mexico through the state of California diagonally past Los Angeles and San Francisco to Cape Mendocino where the fault runs offshore. Detailed TerraSAR-X acquisition areas have been acquired for the past year under a WInSAR background tasking project, shown below along with examples of areas of special interest.

Core Supersite Team and Organization

The supersite team for the San Andreas Fault is a group of collaborating scientists from the USGS, the Jet Propulsion Laboratory and many academic institutions, and represented by collaborative projects through UNAVCO, Inc., led by Meghan Miller and the Southern California Earthquake Center, led by Tom Jordan. The collaborative environment is typified by research projects funded by USGS, NSF, NASA and sometimes other agencies of the federal or state governments. Competitive grant programs run by these agencies award small to medium sized groups of investigators the funds required to conduct research in a competitive framework in which proposals and papers are evaluated through a rigorous peer-review process. Data are typically openly available, as are validated computer codes for processing, analysis and modeling of the data. As such, within the San Andreas Fault Supersite, we are able to provide an enormous quantity of extremely high quality data from in-situ networks such as the California Integrated Seismic Network and the Plate Boundary Observatory (Fig. 1). Data are available from the Northern and Southern Earthquake Data Centers, as well as from IRIS and UNAVCO, Inc. and the USGS. We propose that the full supersite team for the San Andreas Fault Supersite should therefore not be decided ahead of time, except for the "core" team that will provide input to space agencies, but rather be an evolving team whose research is funded and published through the existing competitive processes. In our work environment, free access to openly available data is the expectation and the norm, and we offer this to all because of our belief that open data are an important aspect of scientific repeatability, which is of fundamental importance. Through the San Andreas Fault Supersite, we will make all in-situ data and products available from GPS, seismic (broad-band, strong-motion, etc.), and borehole strain networks that are state-of-the-art, very dense, and of high quality installation. Similarly, USGS will continue to provide products such as PAGER for global earthquakes and to serve US imagery through our role in International Charter activations through the USGS EROS Data Center in support of disaster response. USGS is open to further international cooperation, especially in the area of imagery and in-situ data, through this Supersite proposal. USGS and other US federal agencies can be counted upon to continue to fund the network and monitoring operations that provide these in-situ data, as well as the research projects that would make use of the data provided through the supersites and CEOS arrangements and we welcome continued international collaborations to study natural hazards and their effects and impacts.

The core team members will be finalized during AGU FM 2013 discussions.

Core team potential members (final list TBD):

Ken Hudnut, USGS; Leader
Ben Brooks, USGS
Falk Amelung, Univ. Miami
Eric Fielding, JPL
Rowena Lohman, Cornell Univ.
Roland Burgmann, UC Berkeley
Gilles Peltzer, UCLA

If you are interested in being a participant in the San Andreas Supersite proposal process, please talk with Ken Hudnut at this meeting

Open access to in-situ data is the policy of San Andreas Fault Supersite

Open access to in-situ data for the San Andreas Fault system region is provided through the existing data centers operated by UC Berkeley and California Institute of Technology, as well as by UNAVCO and IRIS and by the USGS. All data and meta-data are provided in openly described and standardized formats. In addition to abundant seismological and geodetic data, aerial photos and electro-optical imagery, also available are geological maps, airborne LiDAR and multispectral data, and a wide variety of other data types.

Representative links to these open data distribution sites are as follows:

http://www.ncedc.org/

http://www.data.scec.org/

http://www.unavco.org/

http://www.iris.edu/hq/

http://www.scec.org/

http://earthquake.usgs.gov/

http://earthquake.usgs.gov/research/data/

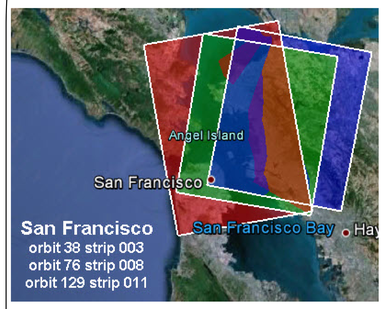

Figure 2. – Sample TerraSAR-X acquisition areas of interest currently via the WInSAR consortium

Source: https://winsar.unavco.org/tasking_tsx.html

The San Andreas Fault Supersite would require SAR data as follows; TerraSAR-X, COSMO-SkyMed, Radarsat-2, ALOS-2, as well as future missions and archival data. Several pre-existing arrangements exist among subsets of the user community, including WInSAR and others. The Supersites project would endeavor to consolidate requests and users into a more efficient structure for coordinate tasking requests, data acquisition and distribution. Landsat 8 data are openly available from USGS and will also be used extensively for future earthquakes.

TerraSAR-X: We would like to continue the previous WInSAR stripmap mode acquisitions shown in Figure 2, with some adjustments, and have the data products provided under the GEO Supersite.

COSMO-SkyMed: We would like to request a similar set of acquisitions over the sites shown in Figure 2 with COSMO-SkyMed stripmap mode scenes.

Radarsat-2: Our preferred coverage of Radarsat-2 data would be a set of three ascending tracks and five descending tracks in the wide fine or wide mode to provide an overview of the San Andreas Fault system at coarser resolution than the X-band satellites.

UAVSAR: The NASA UAVSAR L-band repeat-pass interferometry data is already available through the NASA open data policy, but we request coverage of the San Andreas Fault system at least twice a year.

The San Andreas Fault Supersite in-situ data are an in-kind contribution amounting to over $15M (US) per year and representing a long-term investment over the past several decades of well over $300M (US). Research funds through the peer-review competitive awards process amount to over $10M (US) per year through USGS, NSF and NASA programs, some of which are coordinated through the National Earthquake Hazard Reduction Program.

NEHRP http://www.nehrp.gov

If there is nobody at the poster and you have a question, text or call (626)672-6295

Schedule. The San Andreas Fault Supersite proposal is intended to begin a new phase of open data sharing to facilitate improved scientific research for the future. The satellite data access will be controlled by the GEO Geohazard Supersite data policy and archive systems as determined by the CEOS data providers. We anticipate beginning during the next three years the further establishment of a mutually agreed structure for obtaining and distributing imagery, perhaps similar to the WInSAR consortium approach in use by UNAVCO for many years, within a portal for the related in-situ data. This is one example of password-protected access to SAR imagery for research use by an approved list of scientists. Another example is the USGS EROS Data Center and its password-protected access for post-disaster emergency management use by an approved list of users. In either case, we have extensive experience with proper management of imagery in such a way that license agreements are honored and upheld while also facilitating distribution to those requiring the imagery in support of their research or disaster response efforts. To establish a comparable system specific to use in the supersite project would be possible within one month with existing staff, but only if not belabored by special restrictions or rules that could bog down the effort. USGS and other partners have numerous prior agreements as precedent such that any new agreements ought to be possible to arrange efficiently and without extensive new discussions. As much as possible, existing agreements should be utilized to expedite the process. Also, as much as possible, our goal would be to achieve a state much like with the in-situ data for the San Andreas Fault region, that is, open access to all data. If that is not immediately possible, we will work with CEOS partners to take reasonable steps in the next three years of this collaboration to work in this direction.