COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)		
EAR - EARTHSCOPE		1147435

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EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS ☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
956006144		

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
University of California-San Diego Scripps Inst of Oceanography	8602 La Jolla Shores Dr Univ of California-San Diego LA JOLLA, CA 92093-0210
AWARDEE ORGANIZATION CODE (IF KNOWN) 0013177010	
NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
UCSD Scripps Inst of Oceanography	UCSD Scripps Inst of Oceanography CA ,920930210 ,US.

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TITLE OF PROPOSED PROJECT **Collaborative Research: Strain Rate and Moment Accumulation Rate along the San Andreas Fault System from InSAR and GPS**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 258,842	36 months	01/01/12	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ________ or IRB App. Date ________
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Inst. of Geophysics & Planetary Physics	8795 Biological Grade, Room 1104 La Jolla, CA 920930225 United States
PI/PD FAX NUMBER 858-534-2902	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME David T Sandwell	PhD	1980	858-534-7109	dsandwell@ucsd.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

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(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

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(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Ann F Dunbar**	**Electronic Signature**	**Jul 13 2011 4:15PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
858-534-1293	**adunbar@ucsd.edu**	**858-534-9642**

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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NSF 11-535 07/16/11	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) EAR - EARTHSCOPE	1147427

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746000813	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
University of Texas at El Paso	University of Texas at El Paso Room 209 ElPaso, TX. 799680587
AWARDEE ORGANIZATION CODE (IF KNOWN) 0036616000	

NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
University of Texas at El Paso	University of Texas at El Paso TX ,799680001 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
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REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 200,938	36 months	01/01/12	

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____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Geological Sciences	500 W. University Ave. El Paso, TX 799680555 United States
PI/PD FAX NUMBER 915-747-5073	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Bridget R Smith-Konter	PhD	2005	915-747-6118	brkonter@utep.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

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(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Tom W Osteen	Electronic Signature	Jul 13 2011 3:45PM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
915-747-7359	tosteen@utep.edu	915-747-6474

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

PROJECT SUMMARY

Intellectual Merit

The San Andreas Fault System (SAFS) is a natural laboratory for investigating the physics of the earthquake cycle along a major continental transform boundary. Two of the key parameters that can be used for seismic hazard assessment are seismic moment accumulation rate and strain accumulation rate. Better estimates of these parameters will translate directly into one of the main goals of the EarthScope program - *"the ability to better forecast and respond to hazards and mitigate the associated risks"*. The GPS component of the Plate Boundary Observatory (PBO) provides accurate vector velocities (< 1 mm/yr accuracy) at a spacing of 10 to 20 km along the SAFS. However, the velocity gradient (strain rate) varies most rapidly within 20 km of the major faults, so strain rate is not well resolved by the GPS data alone. Radar interferometry (InSAR) provides deformation maps at 100 m spatial resolution, although factors such as temporal decorrelation and atmospheric path errors have made it difficult to achieve this full resolution with sufficient precision to improve upon the GPS measurements. The L-band data provided by the ALOS satellite (JAXA) retains phase coherence over longer time intervals than the prior C-band missions. *This improvement, combined with stacking techniques to reduce atmospheric errors, now makes it possible to image the entire SAFS using InSAR with unprecedented spatial coverage and resolution.*

<u>The primary focus of this proposed research is to construct high spatial resolution vector surface deformation measurements by combining the high accuracy point measurements provided by PBO GPS data with the high spatial resolution InSAR measurements available through WInSAR from foreign and domestic SAR missions</u>. We have already developed a successful technique to optimally combine vector GPS and LOS InSAR to construct a high-resolution surface deformation field. The new research we propose here has four main objectives:

- Resolve secular plate boundary deformation using new GPS and InSAR measurements provided by EarthScope (PBO and WInSAR). This research will involve the development of community software to preprocess the new data streams to be provided by the ALOS-2 and Sentinel-1 InSAR satellites (2013 launch).
- Use an integrated GPS-4D model-InSAR technique to better constrain fault slip rates and determine the depth of the locked/creeping transition on active faults of the SAFS.
- Generate high-resolution estimates of strain rate and seismic moment rate along major faults of the SAFS.
- Explore methods for isolating non-tectonic deformation contributions common in both InSAR and GPS data.

Broader Impacts and Data Management

These proposed research activities will contribute to the objectives of NSF's EarthScope Initiative by further advancing our understanding of fault system crustal dynamics, earthquake hazards, and data synthesis. The fundamental earthquake science to be explored by this research has substantial societal relevance, as earthquake cycle strain rate estimates are poised to help mitigate seismic hazards. Funding from this grant will support two Ph.D students at SIO and UTEP (a Hispanic Serving Institute) and will be used for further development of undergraduate and graduate courses. We will also develop a "How InSAR Works" module for use in IRIS's *Active Earth* interactive kiosks on disply around the country. Funding will also be used to move the GMTSAR software into the GMT distribution system where it will be available to 15,000 users worldwide. We will distribute all high-resolution vector deformation data and maps to the scientific community and archive the results at UNAVCO.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

1. Science Objectives and Relation to EarthScope Priorities

The San Andreas Fault System (SAFS) is a unique and well-instrumented natural laboratory for investigating the physics of the earthquake cycle along a major continental transform boundary. In particular, the absence of a major earthquake over the past three centuries along the southern SAFS, a region home to over 10 million people and the site of large earthquakes in the past, provides ample motivation for studying the loading conditions of an active plate boundary. Moreover, a critical goal of the EarthScope project is *"The ability to better forecast and respond to hazards and mitigate the associated risks"* [*Williams et al.,* 2010]. Directly aligned with this goal, the primary objective of our research is to use space geodetic tools to measure the present-day near-fault velocity and strain accumulation rate (Figure 1) and to convert this measurement to earthquake hazard quantities of seismic moment rate and stress accumulation rate using a physical model [i.e., *Smith-Konter and Sandwell*, 2009].

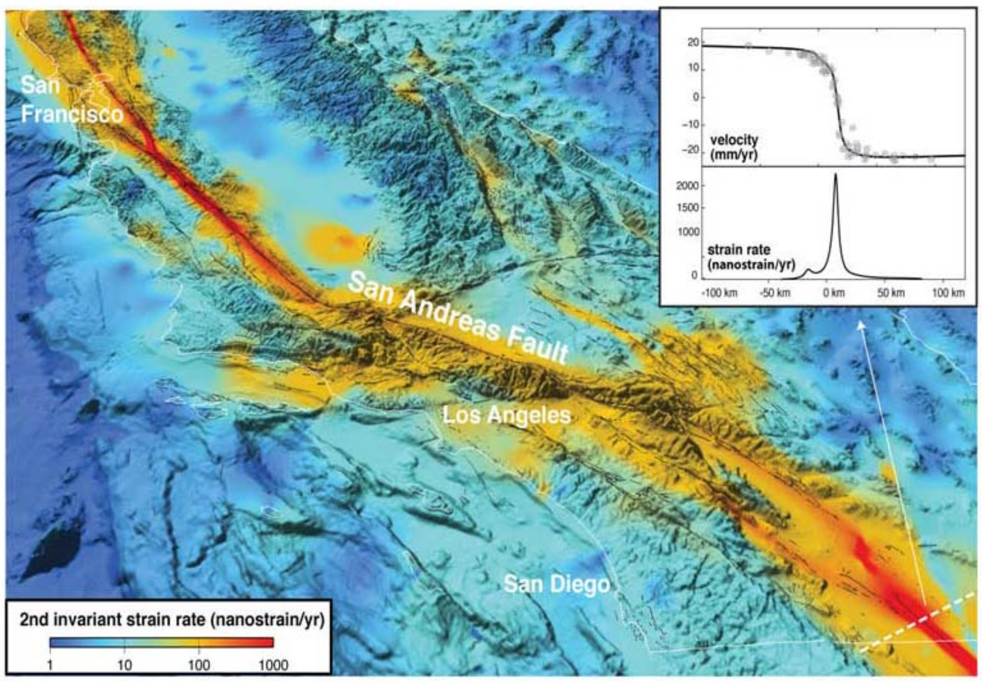


Figure 1. Strain rate of the SAFS from a geodetically constrained analytical model. Deep slip occurs on 41 fault segments consisting of hundreds of sub segments needed to accurately follow the fault trace. In this model approach, the geologic slip rate is applied and locking depth is varied along each fault segment to best fit to the GPS data. Inset: (top) Velocity model profile (black line), EarthScope PBO GPS data (gray circles), and (bottom) modeled strain rate across the Imperial fault (white dashed line). From *Smith-Konter et al*. [2010].

EarthScope has now accumulated a wealth of InSAR and GPS data to image vector surface deformations over the entire transform plate boundary. Identified in the 2010 EarthScope Science Plan as critical data for assessing seismic hazards, these data "*can constrain fault slip rates and determine the depth of the locked/creeping transition on active faults; the product of these two quantities is proportional to the long-term earthquake moment rate, which drives hazard calculations"* [*Williams et al.,* 2010]. The Plate Boundary Observatory component of EarthScope operates nearly 700 permanent GPS sites along the transform plate boundary that are able to recover vector deformation rates at mm/yr accuracy. However, the spacing of the GPS sites is insufficient to fully resolve the strain rate, especially within 20 km of the major faults where seismic moment accumulates most rapidly. Moreover, some of the GPS sites have large annual and secular signals that are unrelated to tectonics and could reflect motions of fluids in the porous crust [e.g., *Bawden et al.,* 2001]. A recent comparison of strain rate maps of Western North America, produced by 16 different research groups (see Figure 2 caption) using primarily the same GPS velocity measurements, reveals that modeled strain rate can differ by factors of 5 to 8 times, with the largest differences occurring along the most active faults [*Hearn et al.,* 2010] (Figure 2). These large differences in estimated strain rate are not related to the errors in the vector GPS measurements but are due to the differences in methods used to interpolate a high resolution model using sparse GPS data sampling (~10 km). Therefore, to achieve high spatial sampling requires either a dramatic densification of the GPS velocity measurements or the use of a higher resolution technique, such as interferometric synthetic aperture radar (InSAR). Thus integrating GPS and InSAR velocities may be key to improving strain rate accuracy and resolution and one of the main recommendations of the EarthScope Science Plan is to: *"Provide InSAR deformation products (interferograms and tools to facilitate time series analysis) for improved spatial resolution of the strain field*" [*Williams et al.,* 2010].

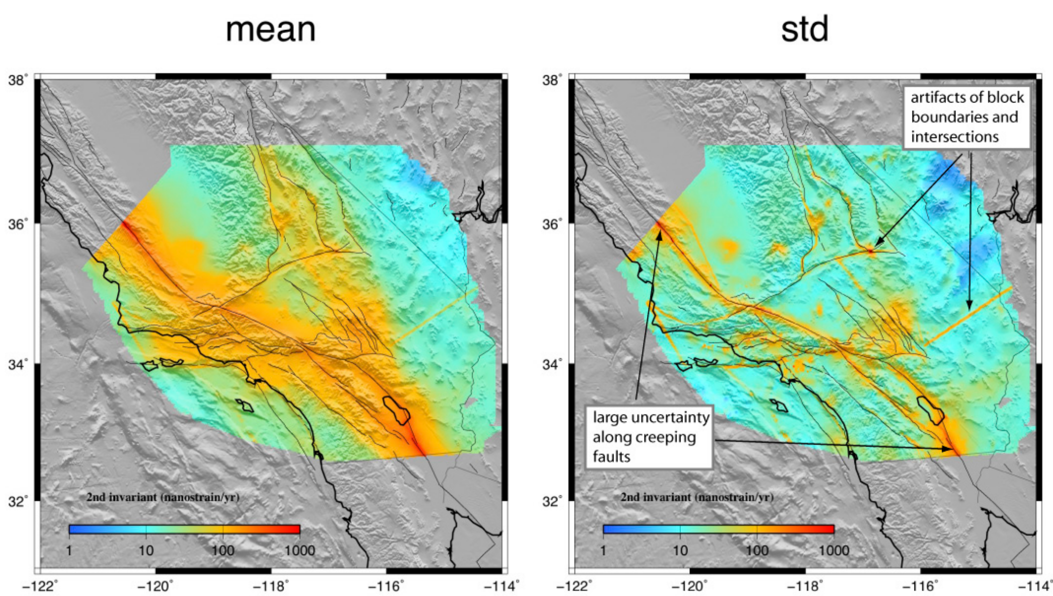


Figure 2. Mean and standard deviation of strain rate for 16 models contributed by the research community [*Hearn et al.*, 2010]. The disagreements among the models, shown as the standard deviation, provides a quantitative measure of what is known and unknown about strain rate. Large strain rate uncertainties of 300 to 1000 nanostrain occur within 20 km of the major faults, especially the creeping sections. In addition, several models have strain artifacts along block boundaries and at block intersections. All 16 strain rate models [the published models include - *Bird*, 2009; *Freed et al.,* 2007; *Hackl et al.,* 2009; *Kreemer et al.,* 2009; *McCaffrey,* 2005; *Meade and Hager,* 2005a and 2005b; *Parsons,* 2006; *Platt et al.,* 2008; *Platt and Becker,* 2010; *Shen et al.,* 1996; *Smith-Konter and Sandwell,* 2009; *Tape et al.,* 2009] were based on largely the same GPS vector velocity measurements so differences among models reflect differences in interpolating the velocity field between the GPS sites. The main approaches to interpolating the

GPS data are spline interpolation of velocities, imposing velocities on a viscoelastic/plastic sheet, and block models with backslip along block boundaries (our approach).

Since strain rate can be transformed into stress accumulation rate if the rheology is known, improving the resolution and accuracy of the near-fault velocity field is critical for improving stress accumulation models. Vector surface deformation measurements combined with geologic estimates of fault locations and slip rates, as well as paleoseismic information on earthquake rupture history, provide the information needed to estimate the 4-D stress accumulation within the seismogenic crust. An example of a 4-D stress model is shown in Figure 3. A number of groups are developing 3- and 4-D models [*Williams and Richardson,* 1991; *Johnson and Segall*, 2004; *Hetland and Hager,* 2005; *Pollitz et al.,* 2010] and as described here, the surface deformation data from GPS, InSAR, and strain meters will provide an important time-dependent boundary condition that must be matched by all the models.

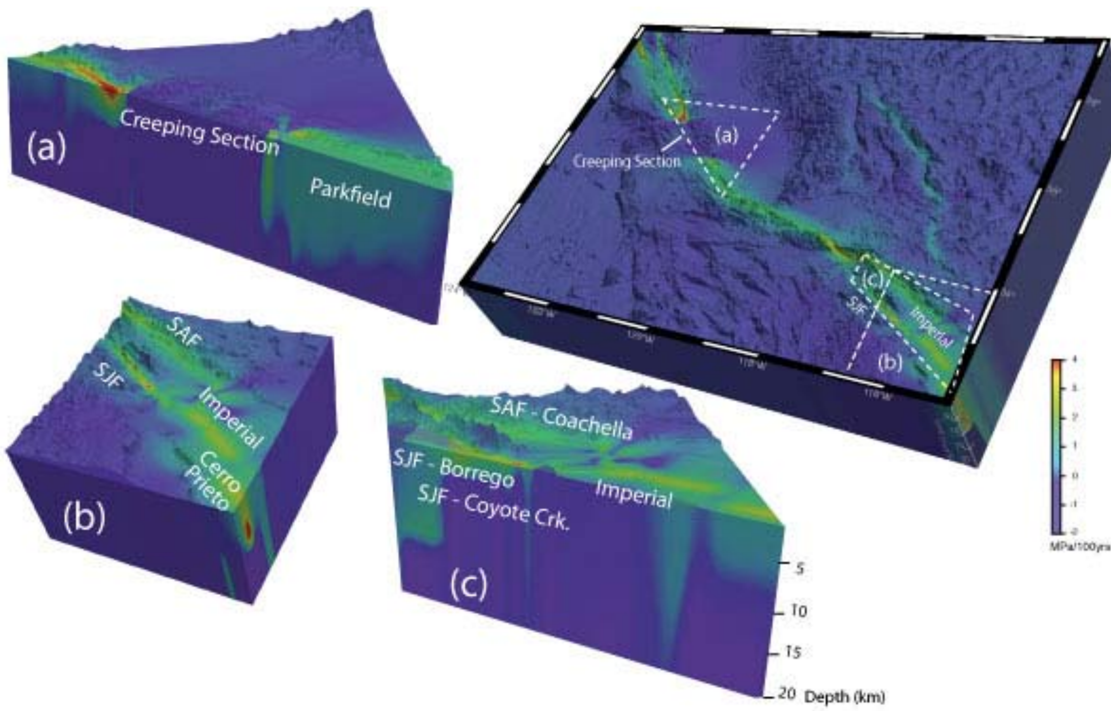


Figure 3. 4-D Coulomb stress accumulation rate models of the SAFS (from *Smith-Konter and Del Pardo*, 2011]. (a) Sliced view of the SAF (looking east) along the Creeping Section and Parkfield segment. (b) Zoomed view of the southern SAFS, revealing a high pocket of stress at depth along the Cerro Prieto segment. (c) Sliced view of the San Jacinto Fault (SJF) (looking east) along the Borrego and Coyote Creek segments.

In addition to strain rate, high-resolution geodetic data can be used to estimate the seismic moment accumulation rate per unit length of fault $\dot{M}/L = \mu VD$ where V is the slip rate, D is the effective thickness of the locked zone, and μ is the shear modulus. (Note that the model-dependent shear modulus can be omitted from this equation to calculate the potency rate.) The slip rate can either be estimated from geologic slip rate data or geodetic velocity data far from the fault. Similarly, the thickness of the locked zone can be estimated from microseismicity depth [*Nazareth and Hauksson,* 2004] or geodetic velocity data near the fault [*Smith-Konter et al.*, 2011 and Figure 4]. Since slip rate and the thickness of the locked zone are highly correlated in inversions where only geodetic data are used, we propose to use all relevant data types in inversions for moment (or potency) rate.

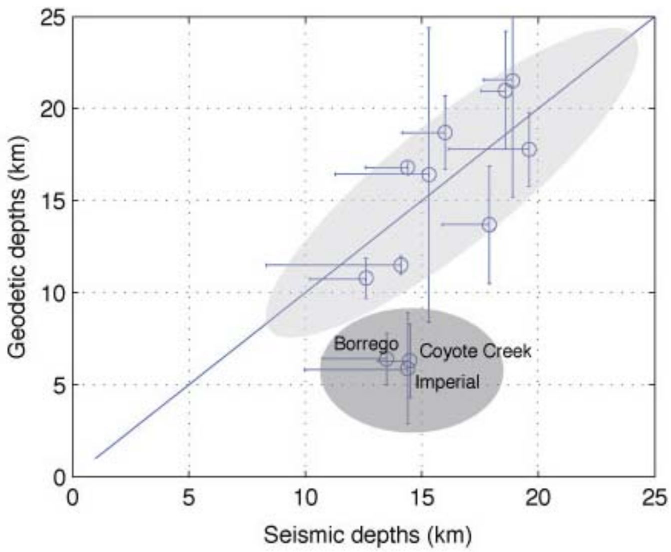


Figure 4 Comparison of seismogenic thickness (depths) estimated from 99% seismicity depth and geodetic locking depths corrected for creep depth (vertical axis) [*Smith-Konter et al.*, 2011]. Uncertainty estimates in geodetic depths and seismogenic depths (approximated from 90% - 99% seismicity cutoff depth estimates) are also plotted. Light grey oval represents data that cluster around the 1:1 match in depths shown by the diagonal line. Dark gray circle represents outliers where seismicity suggests much deeper fault depths than geodesy.

The long-term science questions identified in the EarthScope Science Plan [*Williams et al.,* 2010] that can be addressed through well-constrained physical models are:

- *What is the 3D rheology of the lithosphere and asthenosphere at active plate boundaries, and how does it relate to earthquake cycle deformation, plate boundary forces, and other stresses that drive large-scale, long-term deformation of the continent?*
- *How much elastic vs. permanent strain occurs adjacent to the San Andreas and other strike-slip faults? Does this proportion change along the length of these faults?*
- *What is the stress distribution in the lithosphere and how does stress accumulate, get transferred through the lithosphere, and get released during the earthquake cycle?*

These are broad scientific questions that can hopefully be answered over the next decade. Here we propose to address the following more specific but related science questions by integrating GPS and InSAR data with a well-tuned physical model:

- *How does the strain rate vary along all segments of the SAFS?* As demonstrated in Figure 2, there is a significant uncertainty amongst community strain rate models along many segments of the SAFS. Furthermore, the zone of highest strain rate does not always coincide with the surface trace of the SAFS [*Platt and Becker*, 2010]. High-resolution deformation observations from InSAR can improve strain rate accuracy and resolution.
- *What is the seismic moment accumulation rate along all segments of the SAFS?* In particular, is the "Creeping Section" of the SAF completely free to slip or are there asperities that can be resolved by the high resolution geodetic data as proposed by *Titus et al.* [2005], Ryder and Burgmann [2008], and *Rolandone et al.* [2008]? This has major implications for earthquake hazard models and can provide constraints on the probability of a through going rupture during a major earthquake.

- *How do we isolate non-tectonic signals that contaminate GPS and InSAR data?* The surface deformation field consists of earthquake-cycle related deformation, as well as deformation related to the migration of crustal fluids (e.g., groundwater and oil). Moreover the GPS data show seasonal variations whose origin is still not completely understood [*Watson et al*., 2002; *Prawirodirdjo et al.*, 2006].

The main focus of this proposed research is to construct high spatial resolution vector surface deformation measurements by combining the high accuracy point measurements provided by the GPS data from PBO with the high spatial resolution InSAR measurements available through WInSAR from foreign and domestic SAR missions. Existing SAR data along the SAFS include 1600 scenes of ERS, 1300 scenes of Envisat and 1200 scenes of ALOS. Currently there are no research satellites operating but two new satellites will be launched during this 3-year investigation (Sentinal-1 and ALOS-2). As we show next, the L-band SAR data provided by ALOS-1 are transforming our understanding of near-fault deformation because of the superior temporal correlation properties of L-band SAR. The shorter 14-day repeat cycle and 4 look directions of ALOS-2 will further enhance the vector deformation measurements [*Kankaku et al.*, 2009]. As discussed in the Data Management Section (see Supplemental Documents), these corrected line of sight (LOS) InSAR deformation data will be made available to the research community through UNAVCO. We will use these combined InSAR and GPS data to invert for locking depth and slip rates along all the major faults of the SAFS to estimate 3-D crustal strain accumulation rate and moment accumulation rate.

2. Pilot Study: Integrating vector GPS and LOS InSAR

With NASA Geodetic Imaging funds we developed an approach to optimally combine vector GPS and LOS InSAR to construct a surface deformation field using a **remove/filter/stack/restore** technique [*Wei et al.,* 2010] (Figure 5). This approach considers signal, tropospheric noise, GPS site spacing, and instrument noise characteristics of each system. The main assumption of this approach is that the GPS-based model, which is removed and restored to each interferogram, is accurate at length-scales greater than 20 km. An example of this approach is shown in Figure 6 where it is clear that the LOS stack provides shorter wavelength LOS information not captured by the GPS-based model.

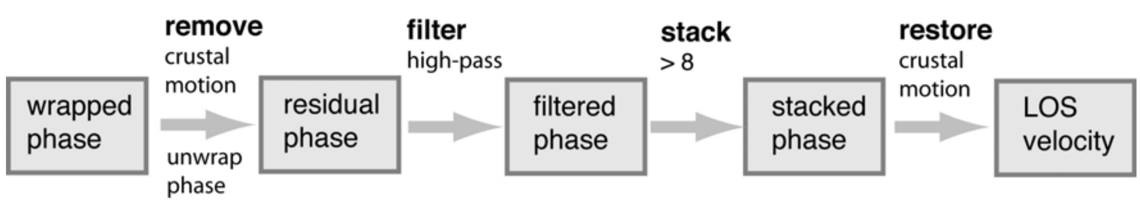
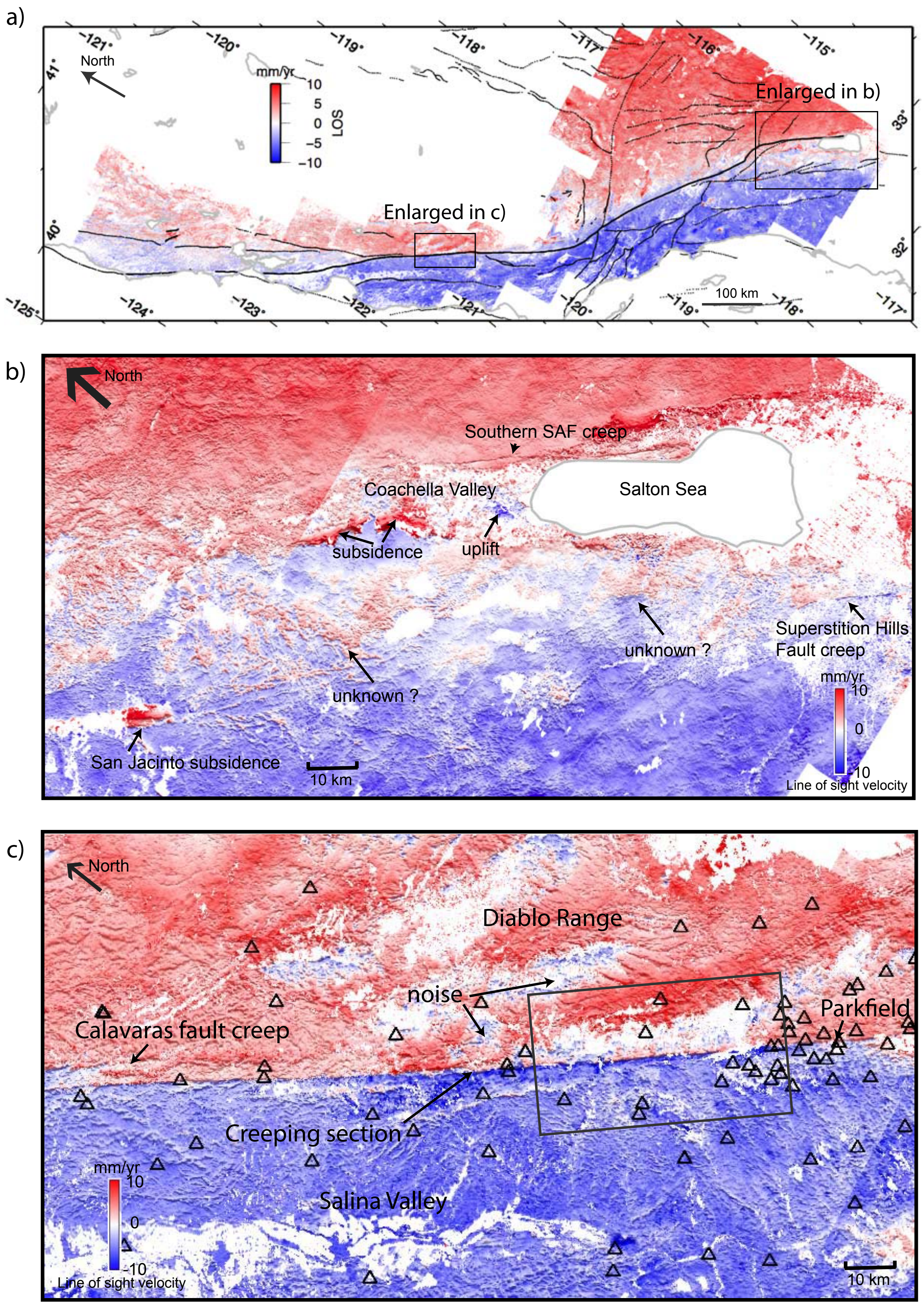


Figure 5. Diagram of the **remove/filter/stack/restore** approach for combining InSAR data with a GPS-based dislocation model. The first step is to use a tropospheric phase delay model provided by SIO/JPL collaboration [*Moore et al.,* 2010] to partly correct the interferograms for atmospheric effects. Preliminary tests of this troposphere model show promising results although models are not available along the entire SAFS over the full time intervals of ERS, Envisat, and ALOS. The second step is to project an interseismic velocity model based on the GPS measurements (e.g., *Smith-Konter and Sandwell* [2009]) into the line-of-sight of the interferogram and **remove** this model from each interferogram. The phase of the residual interferograms is unwrapped using the snaphu algorithm [*Chen and Zebker,* 2000] and the

interferograms are high-pass **filtered** with a 0.5 gain at a half-wavelength of 20 km. This wavelength was selected based on the average wavelength-dependent noise characteristics of the tropospheric phase delay, as well as the characteristic spacing of the GPS sites [*Wei et al.,* 2010]. The third step is to **stack** at least 10 residual interferograms keeping track of the total time span of the stack to compute a line-of-sight (LOS) velocity. This stacking will enhance the signal to noise ratio because, for example, the residual tropospheric noise is uncorrelated for a time span longer than 7 days [*Hanssen,* 2001; *Emardson et al*., 2003]. The fourth step is to add the GPS-based model (**restore**) back to the filtered stack to recover the full LOS velocity.

While GPS/InSAR integration has been performed in many previous studies [*Petlzer et al*., 2001; *Fialko,* 2006; *Walters et al.,* 2011] part of the major improvement in this approach is to use L-band (23 cm wavelength) SAR data from ALOS (Figure 6) which retains coherence better than C-band (5.8 cm wavelength) in vegetated areas [*Rosen et al*., 1996; *Wei and Sandwell*, 2010]. For example, over the highly vegetated Northern California forests in the Coast Range area, ALOS (L-band) remained remarkably well correlated over a two-year period, while an ERS interferogram (C-band) with a similar temporal and spatial baseline lost correlation. In Central California near Parkfield, *Wei and Sandwell* [2010] found a similar pattern, which enables the recovery of a fault creep signal at L-band that was not always apparent at C-band. In the Imperial Valley of Southern California, ALOS had higher correlation in the urban areas and lightly irrigated areas. In general L-band interferograms with similar seasonal acquisitions have higher correlation than those with dissimilar season. This improved coherence of L-band over C-band improves phase unwrapping accuracy and overall facilitates the analysis of large stacks of interferograms for the recovery of near-fault interseismic deformation.

In addition to the new use of L-band interferometry, our research group has developed community software tools to pre-process the ALOS PALSAR data, as well as a complete InSAR processing system that is designed for time series analysis of large stacks of interferograms [*Sandwell et al*., 2011]. This software, called GMTSAR, is an open source (GNU General Public License) InSAR processing system designed for users familiar with the GMT [*Wessel and Smith*, 1998]. GMT is used to display the products as postscript files and keyhole markup language overlays for Google Earth. A set of C-shell scripts has been developed for standard 2-pass processing as well as image alignment for stacking and time series. ScanSAR processing is also possible but requires a knowledgeable user. The software, satellite orbits, and custom digital elevation model generation are freely available at http://topex.ucsd.edu/gmtsar. A tutorial and algorithm document is available at the same site. The documentation includes appendices on the basics of SAR and InSAR and is suitable for an upper division undergraduate or graduate level class. While other community InSAR tools are available (e.g., ROI_PAC and Doris), GMTSAR was specifically designed to automatically align large stacks of radar images in the natural radar coordinates with little or no human interaction. Stacking or time series in radar coordinates, instead of geographic coordinates, enables one to retain the shortest possible lengths scales in the data to resolve sharp deformation gradients at creeping faults. While the funding for the ALOS preprocessing code was provided under a NASA Geodetic Imaging grant (07-ESGIC07-0001), no federal funds were used in the development of GMTSAR; funding for this task came from Conoco/Phillips and the State of California. *A unique feature of GMTSAR is the GNU public license, which provides truly open access for anyone to copy, modify, and redistribute the code.*


a)
North
mm/yr
10
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0
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LOS
Enlarged in b)
Enlarged in c)
100 km
b)
North
Southern SAF creep
Coachella Valley
Salton Sea
subsidence
uplift
unknown ?
Superstition Hills
Fault creep
San Jacinto subsidence
10 km
mm/yr
10
0
-10
Line of sight velocity
c)
North
Diablo Range
noise
Parkfield
Calavaras fault creep
Creeping section
Salina Valley
mm/yr
10
0
-10
Line of sight velocity
10 km

Figure 6 (previous page) (a) Interseismic deformation of the SAFS derived from integrating the GPS observations with ALOS radar interferograms (2006-2010) using a remove/filter/stack/restore approach [*Wei et al.,* 2010; *Tong et al.,* 2011]. The positive value (red color) shows the ground moving away from the satellite (81˚ azimuth, 37° from vertical). The shading highlights the gradient in the velocity field. The areas with low coherence and large standard deviation (> 6 mm/yr) are masked. This is a preliminary version based on the analysis of 800 ALOS L-band SAR images. (b) Southern part of the SAFS shows the broad transition in velocity across the San Andreas and San Jacinto faults that is well resolved in previous studies [e.g., *Fialko,* 2006, *Lundgren et al.,* 2009] as well as shallow creep across the San Andreas near the Salton Sea [*Lyons and Sandwell*, 2003]. Many regions of subsidence due to groundwater extraction are apparent (e.g., Indio, CA, *Sneed and Brandt* [2007]). (c) Central part of the SAFS shows the sharp velocity gradient across the Creeping Section. GPS sites are shown as triangles.

A full resolution version of this LOS velocity map and its relationship to faults and cultural features can be downloaded as a KML-file for Google Earth from the following site. We encourage all reviewers of this proposal to explore the remarkable detail of this data set.

ftp://topex.ucsd.edu/pub/SAF_models/insar/ALOS_ASC_masked.kmz

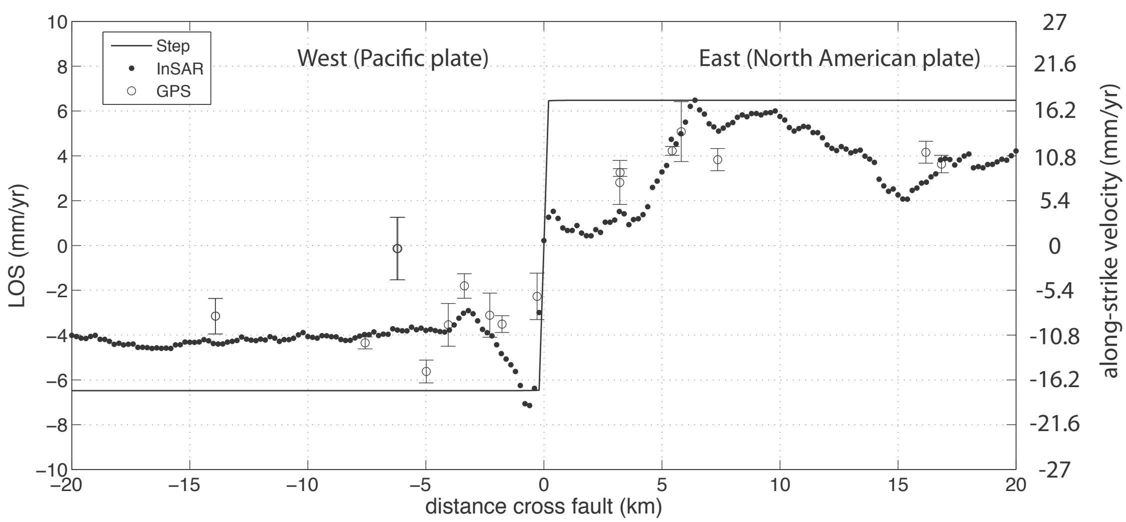


Figure 7. Average line of sight velocity profile across the Creeping Section (sample region shown as a box in Figure 6c) of the SAFS. For this section of fault, the scale factor between LOS velocity and strike-slip velocity is 2.7. The sharp step in LOS velocity directly on the fault agrees with the 22-24 mm/yr rate observed at creepmeters [*Wisely et al*., 2008]. Away from the fault, the LOS velocity roughly matches the vector GPS velocities mapped into LOS. The velocity step shown in the figure corresponds to a 35 mm/yr strike-slip velocity projected into the LOS. The measured LOS velocity is consistently smaller than the step. This improved coverage from L-band InSAR combined with the proposed analysis of other InSAR look directions will enable us to investigate deviations from the velocity step, for example, predicted from a top-to-bottom creeping fault at 35 mm/yr.

Key preliminary results. We have conducted a preliminary analysis of all the ascending ALOS data using this approach as shown in Figure 6. This represents the automated analysis of 800 radar images and the integration with the 4-D GPS-based dislocation model. This is version 1 so we are addressing some technical issues related to frame boundary mismatch and occasional phase unwrapping errors, however we are very pleased by the overall success of this work and the incredible detail of our integrated data set. Below we summarize two aspects of our results that warrant further investigation:

- This combined InSAR/GPS deformation map reveals a variety of deformation patterns related to deep dislocations, shallow creep, and groundwater/oil extraction and recharge. While most of these deformation features have been studied previously [e.g., *Bawden et al.,* 2001; *Schmidt and Burgmann,* 2003; *Sneed and Brandt*, 2007], the comprehensive overview suggests ways of identifying GPS sites and InSAR regions where there is contamination of the tectonic signal by other processes. These contaminated geodetic data will be down weighted in the next model inversion.
- One important preliminary result is that the ALOS data seem to show that the creeping section may have an intermediate-depth zone that is partially locked (see Figure 6c, Figure 7, *Titus et al.*, [2005] and *Rolandone et al.* [2008]). Since this ascending ALOS data are mainly sensitive to vertical motions, a more complete analysis of both the GPS data and the descending tracks from other InSAR satellites (e.g. ERS and Envisat) is needed to provide accurate estimates of the depth and locations of the asperities. Along other faults such as the Banning section and the west Garlock section we are investigating areas of high deformation gradient not always associated with active faults [*Platt and Becker*, 2010].

3. Proposed Research

We propose to construct high spatial resolution (100 m) vector surface deformation measurements by combining the high accuracy point measurements provided by the GPS data from PBO with the high spatial resolution InSAR measurements available through WInSAR from foreign and domestic SAR missions. We will use these integrated data to invert for locking depth and slip rate along all the major faults of the SAFS to estimate 3-D crustal strain accumulation rate and moment accumulation rate. Our science objectives follow:

Science Objective #1: Resolve secular plate boundary deformation using GPS and InSAR measurements provided by EarthScope (PBO and WInSAR).

InSAR component: We will first refine our pilot study ALOS InSAR analysis using longer frames and improved phase unwrapping techniques to minimize frame boundary discontinuities. We will also process InSAR data on available descending passes to provide a second look direction to separate the near-fault deformations into strike-slip and vertical motions. Since there are not enough descending ALOS scenes to achieve better than 6 mm/yr velocity precision, we will use an automated PS-InSAR approach [*Ferretti et al.,* 2001; *Colesanti et al*., 2003; *Lyons and Sandwell*, 2003] to process all the ERS and Envisat data on descending passes across the SAFS. We will also prepare for the launch of ALOS-2 in mid-2013 and Sentenel-1 in June 2013 by writing preprocessors for both data streams. We have been asked by JAXA to write a proposal to request ALOS-2 acquisitions along the SAFS using four look directions (see letter of support from Masanobu Shimada). Both the ALOS-2 and Sentinel spacecraft are optimized for InSAR studies because they have shorter repeat intervals than their predecessors and better controlled orbits for shorter interferometric baselines.

GPS/Model component: We will utilize our newest version of 4-D dislocation modeling code (based on *Smith and Sandwell* [2004; 2006]) to generate a starting model of the SAFS interseismic velocity field. Incorporation of the most up-to-date geodetic and geologic measurements is a major priority of this proposed research; we will use the most recent unified GPS velocity field compiled by T. Herring and will adopt geologic slip rate estimates provided to the UCERF3 modeling community by R. Weldon and T. Dawson. We proposed to increase the spatial resolution of the 4-D dislocation model (currently operating at 1 km) to 500 m to better resolve the sharp deformation gradients at creeping faults. We will also extend the dislocation model spatial domain to encompass fault segments of the Gulf of California using new dense campaign GPS data across the Cerro Prieto and Imperial faults being collected in collaboration with scientists at CICESE, Ensenada, Mexico.

Science Objective #2: Use integrated GPS-4D model-InSAR technique to better constrain fault slip rates and determine the depth of the locked/creeping transition on active faults of the SAFS.

Based on the integrated GPS-4D model-InSAR technique of our pilot study, we will extract the tectonically relevant geodetic data and feed this back into the high resolution (500 m) deformation model to refine deep and shallow slip rates, as well as locking depths, for all appropriate fault segments. A rigorous inversion of fault locking depths and slip rates will be used to tune subsequent models using our 4-D dislocation modeling code. We will include the non-secular post-seismic signals from Landers, Hector Mine, and the El Major-Cucapah earthquakes into the model using published postseismic parameters. This work will compliment ongoing community slip rate inversions that will be used to define the UCERF3 deformation models. Completion of this task will be particularly important in assessing new moment accumulation rates, as these are evaluated at seismogenic depth and thus depend on well-resolved locking depth estimates for each fault segment. We will also compare geodetic locking depths to seismicity depths with a focus on faults that are creeping near the surface. Our prior work has shown that faults with the largest seismic vs. geodetic depth discrepancies are typically those also associated with observed creep (Figure 4).

Science Objective #3: Generate high-resolution estimates of strain rate and seismic moment rate along major faults of the SAFS

Using the new high-resolution (500 m) deformation model we will estimate strain and moment accumulation rate along all the major strands of the SAFS. Along the Creeping Section, this analysis will help to distinguish between the two hypotheses proposed by *Titus et al.,* [2005] to explain the 14 mm/yr slip rate deficit near the fault with respect to the far-fault slip rate. They proposed that either the Creeping Section is partially locked at intermediate depth or there is accommodation by slip on parallel faults 35 km away from the SAF. Both hypotheses have significant implications for earthquake hazard.

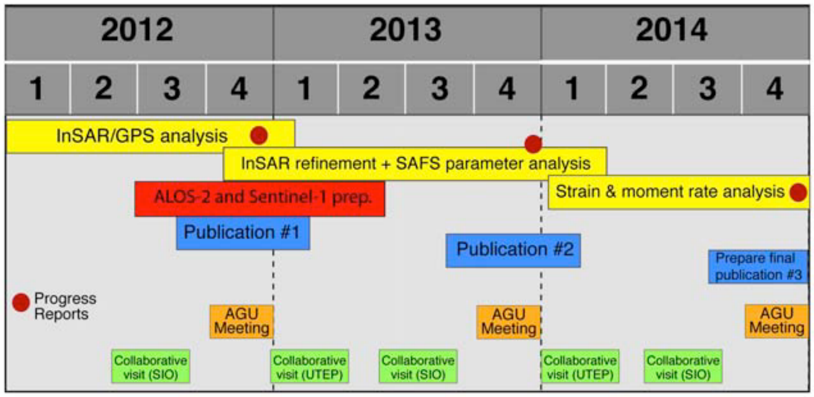
Science Objective #4: Explore methods for isolating non-tectonic deformation contributions common in both InSAR and GPS data

As seen in many previous InSAR studies and as well as our pilot study, non-tectonic deformation can sometimes dominate the geodetic velocity signal with both seasonal and secular contamination. Preliminary work comparing subsidence/uplift rates from 103 wells in southern California to local GPS vertical velocities suggests a ~15% improvement in model-data residuals when GPS data are corrected for groundwater effects [*Thornton and Smith-Konter*, 2011a,b]. We propose to visually examine all the InSAR LOS maps in relation to regional land use and locations of wells to identify geodetic data (both GPS and InSAR) that should be down weighted or not used in model inversions. This will be facilitated through the use of Google Earth where all the relevant data can be easily investigated and flagged. Our current ALOS analysis provides an example of the utility of this approach and we have already made preliminary notations on the LOS maps at ftp://topex.ucsd.edu/pub/SAF_models/insar/ALOS_ASC_masked.kmz.

4. Research Plan and Management

While the four science objectives detailed above may seem like an overly ambitious research effort for a 3-year investigation, we have already developed and tested both the modeling and the InSAR/GPS integration codes needed for the first objective. We have significant experience in the analysis of large complex data sets, including retracking all of the radar waveforms of ERS-1 and Geosat to construct a global marine gravity grid (V18, March 2009) and assimilating this model with diverse global depth soundings to construct a global bathymetry grid (V14, June 2011). These products are freely available at http://topex.ucsd.edu, and are used by hundreds of scientists, educators, and corporations. This proposed InSAR, GPS, and model integration is slightly less challenging than the gravity/topography projects and so we believe that we can make substantial progress on these efforts in 3 years.

We have developed a combined work plan that focuses on specific yearly milestones and is consistent with our previous collaborative scientific endeavors. The ALOS InSAR data processing and analysis will be performed chiefly at SIO, using desktop computers running the newly-developed GMTSAR processing package that is optimized for analysis of large stacks of SAR images. The InSAR analysis will be primarily performed by David Sandwell (PI) and SIO graduate student Xiaopeng Tong. The GPS data assimilation and 4-D physical modeling will be primarily performed at UTEP by Bridget Smith-Konter (PI) and graduate student Teira Solis. Strain rate and moment accumulation models will be developed and analyzed by both groups. PIs and students will primarily communicate electronically. In-person meetings will be scheduled around existing scientific meetings, such as the AGU, when possible. Smith-Konter and student will also visit SIO each summer to focus on the integration aspects of this work and Sandwell will visit UTEP once each year. Results will be presented at national scientific meetings and published in peer-reviewed journals.



Year 1 – During the first year, we will refine the ALOS InSAR analysis using longer frames and improved phase unwrapping. We will refine an automated PS-InSAR approach to process all the ERS and Envisat data on descending passes across the SAFS. We will increase the spatial resolution of the 4-D dislocation model to better resolve the sharp deformation gradients at creeping faults. The models will be refined from our current 1 km resolution to 500 m resolution, which will require a 4-fold increase in computer memory and time. We have conducted several benchmark exercises at this resolution and preliminary testing of our entire model grid (a 1000x2000 km region) indicates that our current computational infrastructure is capable of efficiently operating at this increased resolution. We will also optimize our current model inversion algorithms in preparation for locking depth and slip rate estimations to be performed in Year 2.

Year 2 – During the second year, we will prepare for the launch of ALOS-2 in mid-2013 by writing a preprocessor and making it available to the InSAR community. We will also work on tasks involving the full integration of GMTSAR into the GMT distribution. We will add dipping fault geometry [*Fuis et al.,* 2011] and associated deformation mechanisms to the 4-D dislocation model and invert all available geodetic data for slip rate and the thickness of the locked zone. This particular work will leverage present efforts from Smith-Konter's Career grant (EAR-0847499) to develop an enhanced suite of second-generation deformation models. We will compare locking depths to seismicity depths with a focus on faults that are creeping near the surface.

Year 3 – During the third year, we will use the updated 500 m resolution deformation model to estimate strain and moment accumulation rate along all the major strands of the SAFS. We will establish an upper bound on the moment accumulation rate on the Creeping Section of the SAFS. We will also extend the dislocation model all the way to the Gulf of California using dense campaign GPS data across the Cerro Prieto and Imperial faults.

5. Broader Impact

These proposed research activities will contribute to the objectives of NSF's EarthScope Initiative by further advancing our understanding of fault system crustal dynamics, earthquake hazards, and data synthesis. Subsequently, the fundamental earthquake science to be explored by this proposed research has substantial societal relevance, as earthquake cycle strain rate estimates are poised to help mitigate seismic hazards.

Distribution of InSAR Tools - We will continue the development of the GMTSAR InSAR processing system now being used by more than 160 researchers worldwide (http://topex.ucsd.edu/gmtsar). Under this proposal, the GMTSAR code will be fully integrated into the GMT software distribution so users will no longer need to separately install GMTSAR. GMT has a user base of 15,000 researchers worldwide, so after the code is fully integrated; all of these users will have the tools to perform InSAR processing. The documentation provided with the software can be used as a book for teaching InSAR theory and application. In July 13-15, 2011 we are offering a GMTSAR workshop and plan to continue these workshops in collaboration with UNAVCO. We also plan to continue our ongoing efforts to share all computer source code and documentation that results from this research with the scientific community. These materials are currently available for download at http://topex.ucsd.edu/body_force. Moreover, we also expect to engage in a collaborative exchange of data and models with active members of UCERF3.

K-16 Outreach and Education – In an effort to improve public awareness of earthquake hazards in California, all strain rate and seismic moment rate maps and products developed under this proposal will be used as educational tools for K-12 Earth Science educators and students. We also propose to develop a "How InSAR Works" module for use in IRIS's *Active Earth* kiosk displays around the country. Smith-Konter is an active collaborator with members of IRIS and the EarthScope National Office on this front; a key portion of her Career grant educational funds have supported the construction of several touch-screen kiosk exhibits modeled after the IRIS Active Earth display. Her research group is currently designing custom kiosk module content for the Rio Grande Rift with a bilingual (English and Spanish) emphasis. Under this proposal, we will expand our involvement with Active Earth kiosk development through the creation of an InSAR-themed interactive kiosk page.

Graduate Education and Training - Funding for this project will support the thesis research of one graduate student at both Scripps Institution of Oceanography (SIO) and the University of Texas at El Paso (UTEP). As UTEP is a major Hispanic Serving Institute (HSI), the research, education, and outreach activities proposed here will both influence and recruit traditionally underrepresented minorities into the geosciences. Funding for this proposed research will also provide an opportunity for the graduate students to participate and present scientific results at national workshops and meetings, a significant aspect of a student's professional development activities. Coinciding efforts to incorporate instruction of earthquake physics, literature reviews, crustal deformation modeling exercises, and data assimilation into advanced undergraduate and graduate courses will also take place at both SIO and UTEP.

6. Results from Prior NSF support

Total publications from our combined NSF earthquake cycle dynamics-related grants over the last decade: 50^+ meeting abstracts, 18 papers. Meeting abstracts and published papers acknowledging these grants can be found at *http://topex.ucsd.edu/sandwell* and *http://www.geo.utep.edu/pub/bkonter*.

A description of our most recently funded grants follow:

6.1 *Observations and Modeling of Shallow Fault Creep Along the San Andreas Fault System; Sandwell;* EAR 0811772*;* $298,000; 7/1/2008 - 6/30/2012

Funding from this grant was used to support graduate students Meng Wei and Xiaopeng Tong for InSAR investigations of the San Andreas Fault System as well as investigations of coseismic slip from the 2008 Wenchuan China earthquake, the 2010 Maule Chile Earthquake (Figure 8), and the 2011 El Major Cucapah Earthquake in Mexico. Meng Wei received his Ph.D. in January of 2011. Funding provided full or partial support for the following publications:

Wei, M., D. T. Sandwell and Y. Fialko, A Silent M4.7 Slip Event of October 2006, on the Superstition Hills Fault, Southern California, *J. Geophys. Res., 114*, B07402, doi:10.1029/2008JB006135, 2009.

Wei, M., D. T. Sandwell, and B. Smith-Konter, Optimal Combination of InSAR and GPS for Measuring Interseismic Crustal Deformation, *J. Adv. in Space Res.* doi:10.1016/j.asr.2010.03.013, 2010.

Wei, M., and D. T. Sandwell, Decorrelation of L-band and C-band interferometry over vegetated areas in California. *IEEE Trans. Geosci. Remote Sensing*, 10.1109/TGRS.2010.2043442, 2010.

Wei, M., D. T. Sandwell, Y. Fialko, and R. Bilham , Slip on faults in the Imperial Valley triggered by the 4 April 2010 Mw 7.2 El Mayor-Cucapah earthquake revealed by InSAR, Geophysical Research Letters, 38, L01308, doi:10.1029/2010GL045235, 2011

Tong, X., D. T. Sandwell, and Y. Fialko, Coseismic Slip Model of the 2008 Wenchuan Earthquake Derived From Joint Inversion of InSAR, GPS and Field Data, *J. Geophys. Res., 115,* B04314, doi:10.1029/2009JB006625, 2010.

Tong, X., D. Sandwell, K. Luttrell, B. Brooks, M. Bevis, M. Shimada, J. Foster, R. Smalley Jr., H. Parra, J. C. Báez Soto, M. Blanco, E. Kendrick, J. Genrich, and D. J. Caccamise II, The 2010 Maule, Chile earthquake: Downdip rupture limit revealed by space geodesy, *Geophys. Res. Lett.,* 37, L24311, doi:10.1029/2010GL045805, 2010.

Smith-Konter, B., D. Sandwell, and P. Shearer, Locking depths estimated from geodesy and seismology along the San Andreas Fault system: Implications for seismic moment release, *J. Geophys. Res., 116*, doi:10.1029/2010JB008117, 2011.

6.2 *CAREER: An integrated geologic, geodetic, and paleoseismic study of plate boundary stress evolution and geoscience education utilizing the EarthScope database*; *Smith-Konter*; EAR-0847499; $501,048; 6/1/09 - 5/13/14

This project is aimed at investigating the relationship between plate boundary stress evolution and the spatial/temporal occurrence of seismicity through computationally efficient time-dependent models of fault system deformation constrained by geologic, geodetic, and paleoseismic data that span 1000's of years. This work has contributed several important model-based observations, amongst these: 1) stress accumulation rates along the San Andreas Fault System vary between 0.5-7 MPa per century and 2) fault depths derived from seismicity and geodesy are well-correlated except in areas where fault creep is significant (i.e., *Smith-Konter and Sandwell*, 2009; *Smith-Konter et al.*, 2011). One recent highlight of this work has been the construction of a model that utilizes paleoseismic data extending as far back as 2000 years, generating a first-of-its-kind 3-D time-series simulation of earthquake cycle stress evolution. With three years remaining on this grant, we are beginning to use these tools to assess uncertainties in stress rates and to compare paleoseismic-derived stress drop to model-derived simulations spanning at least 12 earthquake cycles (*Solis and Smith-Konter*, 2011).

6.3 *Integrating geologic, geodetic, and coastal tide gauge observations with 100-year vertical deformation models of California earthquake history; Smith-Konter*; EAR-0838252; $230,773; 1/1/09 - 12/31/11

The primary goal of this project is to investigate time-dependent vertical earthquake cycle deformation using a comprehensive set of vertical measurements (geodetic, geologic, and coastal tide gauge) of surface deformation along the SAFS. The first stage of this project involved an investigation of the relationship between vertical geologic data from the SCEC Vertical Motion Database and PBO GPS data. Using several surface and triangulation techniques for optimal analysis of the data, our results show that the relationship between geologic and geodetic vertical data is not 1:1, and in several locations the observations are even anticorrelated, suggesting that the respective timescales of the data play an important role (*Thornton and Smith-Konter*, 2011a, 2011b). Since anthropogenic effects contaminate some of the geodetic data signal, we also use a vertical velocity model of the SAFS (*Smith-Konter and Sandwell*, 2009, *Wei et al.,* 2010) to help identify locations where tectonic motions should dominate the data signals. The second stage of this project is currently focused on an integration of vertical deformation from tide gauge data along coastal California.

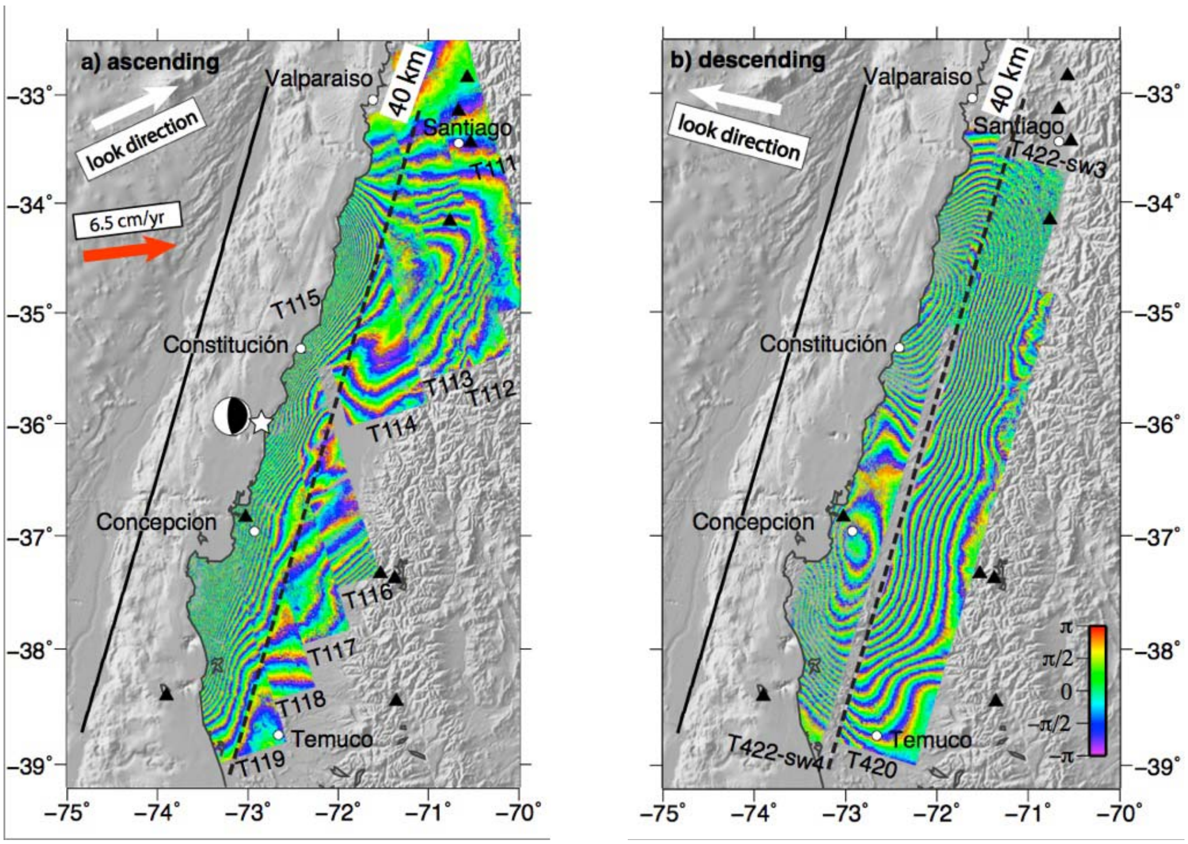


Figure 8. ALOS interferometry for the 2010 Maule Chile processed with GMTSAR [*Tong et al.*, 2010]. (a) Nine tracks of ascending interferograms (FBS-FBS mode) and (b) two tracks of descending interferograms (two subswaths of ScanSAR-ScanSAR mode and ScanSAR-FBS mode, and one track of FBS-FBS mode). The black triangles show the locations of the 13 GPS sites used in the inversion. These LOS data were hosted on the UNAVCO supersite (http://supersites.earthobservations.org/chile.php) and have been used in two other publications [*Lorito et al.,* 2011 and *Pollitz et al.*, 2011].

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southwestern United States from inversion of GPS, seismological, and geologic data, *J. Geophys. Res*., 110, B07401, doi:10.1029/2004JB003307, 2005.
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David T. Sandwell

Contact Information:

Scripps Institution of Oceanography dsandwell@ucsd.edu
La Jolla, CA 92093-0225 (858) 534-7109

Present Position: Professor of Geophysics, Scripps Institution of Oceanography

Professional Preparation:

Ph.D. 1981 University of California at Los Angeles, Geophysics and Space Physics
M.S. 1978 University of California at Los Angeles, Geophysics
B.S. 1975 University of Connecticut, Major Physics, Minor Mathematics

Appointments:

1989 – 93 Scripps Institution of Oceanography, Associate Professor
1985 – 89 University of Texas at Austin, Research Scientist
1982 – 85 National Geodetic Survey, Research Geophysicist

Publications: Related and Significant

Sandwell, D. T. and W. H. F. Smith, Marine Gravity from Geosat and ERS-1 Altimetry, *J. Geophys. Res.*, 102, 10039-10054, 1997.

Sandwell, D. T. and E. J. Price, Phase gradient approach to stacking interferograms, *J. Geophys. Res., 103*, 30183-30204, 1998.

Fialko, Y., D. Sandwell, D. Agnew, M. Simons, P. Shearer, and B. Minster, Deformation on Nearby Faults Induced by the 1999 Hector Mine Earthquake, *Science, 297,* 1858-1862, 2002.

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Luttrell, K., D. Sandwell, B. Smith-Konter, B. Bills, and Y. Bock, Modulation of the earthquake cycle at the southern San Andreas fault by lake loading, *J. Geophys. Res., 112*, B08411, doi:10.1029/2006JB004752, 2007.

Wei, M., D. T. Sandwell and Y. Fialko, A Silent M4.8 Slip Event of October 3-6, 1 2006, on the Superstition Hills Fault, Southern California, *J. Geophys. Res., 114*, B07402, doi:10.1029/2008JB006135, 2009.

Wei, M., D. T. Sandwell, and B. Smith-Konter, Optimal Combination of InSAR and GPS for Measuring Interseismic Crustal Deformation, *J. Adv. in Space Res.* doi:10.1016/j.asr.2010.03.013, 2010.

Tong, X., D. Sandwell, K. Luttrell, B. Brooks, M. Bevis, M. Shimada, J. Foster, R. Smalley Jr., H. Parra, J. C. Báez Soto, M. Blanco, E. Kendrick, J. Genrich, and D. J. Caccamise II, The 2010 Maule, Chile earthquake: Downdip rupture limit revealed by space geodesy, *Geophys. Res. Lett., 37*, L24311, doi:10.1029/2010GL045805, 2010.

Smith-Konter, B., D. Sandwell, and P. Shearer, Comparison of locking depths estimated from geodesy and seismology along the San Andreas Fault System, *J. Geophys. Res.*, 116, B06401, doi:10.1029/2010JB008117., 2011.

Synergistic Activities:

PI on two ALOS Investigations

Developed undergraduate and graduate classes: Satellite Remote Sensing, Geodynamics; Synthetic Aperture Radar.

Distributed global gravity and topography data for research and education: http://topex.ucsd.edu

President of the Geodesy Section of the AGU

Served twice as Chair of Western North America InSAR Consortium (WInSAR)

Awards and Memberships:

5/11	Member of the US National Academy of Sciences
4/08	Fellow of the American Academy of Arts and Sciences
11/04	George P. Woollard Award and Fellow of the Geological Society of America
12/97	Fellow of the American Geophysical Union
12/95	Bowie Lecture American Geophysical Union
9/98	Society for Exploration Geophysics
6/77	American Geophysical Union

Collaborators and Other Affiliations Outside of SIO:

Benjamin Brooks
Gidi Baer
Robert Cheney
James Foster
Graham Kent
Larry Lawver
Dave McAdoo
Rob Mellors
Paul Rosen
Masanobu Shimada
Walter Smith
Paul Wessel

Graduate Advisors and Postdoctoral Sponsors:

Bruce Douglas
Gerald Schubert

Thesis Advisor and Postgraduate-Scholar Sponsor:

Sylvan Barbot
Joseph Becker
Y. John Chen
Catherine Johnson
Bridget Smith-Konter
Dan Levitt
Suzanne Lyons
Karen Luttrell
Bill Moore
Dietmar Mueller
Evelyn Price
Jean-Yves Royer
Lydie Sichoix
Christopher Small
Mara Yale
Meng Wei

BIOGRAPHICAL SKETCH

BRIDGET R. SMITH-KONTER

ADDRESS: University of Texas at El Paso
Department of Geological Sciences
500 W. University Ave.
El Paso, TX 79968-500

PHONE: 915 747 6118
EMAIL: brkonter@utep.edu
http://www.geo.utep.edu/pub/bkonter

PROFESSIONAL PREPARATION

Northern Arizona University	B.S., Physics & Astronomy	1999
University of California, San Diego	Ph.D., Earth Science/Geophysics	2005
University of California, San Diego	Postdoctoral researcher, Geophysics	2005-2007
JPL, California Institute of Technology	Postdoctoral researcher, Planetary Ices	2007-2008

APPOINTMENTS

University of Texas at El Paso	Assistant Professor	2008-
JPL, California Institute of Technology	Postdoctoral Scholar	2007-2008
Scripps Institution of Oceanography, UCSD	Postdoctoral Scholar/Lecturer	2005-2007
Scripps Institution of Oceanography, UCSD	Graduate Student Researcher	1999-2005

PUBLICATIONS*

*Note: B. Smith is now B. Smith-Konter

PUBLICATIONS RELATED TO THIS PROPOSAL

1. Smith-Konter, B., D.T. Sandwell, and P. Shearer (2011), Locking depths estimated from geodesy and seismology along the San Andreas Fault System: Implications for seismic moment release, *J. Geophys. Res*., 116, B06401, doi:10.1029/2010JB008117.
2. Smith-Konter, B., D.T. Sandwell, and M. Wei (2010), Integrating GPS and InSAR to resolve stressing rates of the SAF System, *EarthScope inSights*, Summer 2010.
3. Wei, M., D.T. Sandwell, and Smith-Konter, B. (2010), Optimal combination of InSAR and GPS for measuring interseismic crustal deformation, *J. Adv. in Space Res*., doi: 10.1016/j.asr.2010.03.013.
4. Smith-Konter, B., and D.T. Sandwell (2009), Stress evolution of the San Andreas Fault System: Recurrence interval versus locking depth, *Geophys. Res. Lett*., 36, doi:10.1029/2009GL037235.
5. Smith, B., and D.T. Sandwell (2006), A model of the earthquake cycle along the San Andreas Fault System for the past 1000 years, *J. Geophys. Res*., 111, doi:10.1029/2005JB003703.

OTHER SIGNIFICANT PUBLICATIONS

1. Del Pardo, C., B. Smith-Konter, C. Kreemer, G. Blewitt, W. Hammond, and L. Serpa (2011 in review), Interseismic deformation and stress evolution of the Death Valley Fault Zone, submitted to *J. Geophys. Res*., doi:10.1029/2011JB008552.
2. Olgin, J., B. Smith-Konter, and R.L. Pappalardo (2011), The limits of Enceladus's ice shell thickness from tidally driven tiger stripe failure, *Geophys. Res. Lett*., 38, doi:10.1029/2010GL044950.
3. Smith-Konter, B. and R.T. Pappalardo (2008), Tidally driven stress accumulation and shear failure of Enceladus's tiger stripes, *Icarus*, 198, doi:10.1016/j.icarus.2008.07.005.
4. Luttrell, K., D.T. Sandwell, B. Smith-Konter, B. Bills, and Y. Bock, Modulation of the earthquake cycle at the southern San Andreas fault by lake loading, *J. Geophys. Res*.,112, doi:10.1029/2006JB004752, 2007.
5. Wdowinski, S., B. Smith-Konter, Y. Bock, and D.T. Sandwell (2007), Spatial characterization of the interseismic velocity field in southern California, *Geology*, doi:10.1130/G2938A.1.

BIOGRAPHICAL SKETCH

SYNERGISTIC ACTIVITIES

1. *NSF EarthScope Speaker Series* invited presenter (2011-2012)
2. Development, construction, and installation of *Active Earth Kiosk* in UTEP Centennial Museum and Hueco Tanks State Park (2009-2011)
3. Development of UTEP Earth Science Week promotional video and flyer (http://www.geo.utep.edu/esweek) (2009-2010)
4. Development and distribution of new earthquake-related teaching tools Earthquakes in Action (K-12 classroom demonstrations, lab exercises, and activity sheets) for UTEP MAT Program, Pathways to Geosciences Program, and SIO Visualization Center Earthquake Education Workshop (2006-2010)
5. Development of 3-D semi-analytic elastic and viscoelastic fault model, code made freely available for application of earthquake deformation and stress analyses (2001-present)

SELECTED AWARDS AND FELLOWSHIPS

University of Texas System Regents' Outstanding Teaching Award, UT System	2011
College of Science Distinguished Achievement Award for Teaching, UTEP	2011
Office of Research and Sponsored Projects Outstanding Research Award, UTEP	2009
Outstanding Postdoctoral Research Award, NASA Jet Propulsion Laboratory	2007
Outstanding Undergraduate Teaching Award, Scripps Institution of Oceanography	2005
Outstanding Geodesy Student Paper Award, AGU Meeting	2004
1st Place, SIO Visualization Contest, Scripps Institution of Oceanography, UCSD	2004
E. Frieman Director's Prize for Outstanding Graduate Research, SIO, UCSD	2003
NASA Earth System Science Fellowship	2003-2005
National Science Foundation Graduate Fellowship	1999-2002

SERVICE TO THE PROFESSION

PEER REVIEWER: *NSF – Geophysics, NSF – Tectonics, NSF – EarthScope, NSF – Frontiers in Earth System Dynamics, NASA – Outer Planets Research*
PEER REFEREE: *J. Geophys. Res., Geology, Earth Planet. Sci. Lett., Tectonophysics, Geophys. J. Int.*

COLLABORATORS & OTHER AFFILIATIONS

COLLABORATORS: Geoff Blewitt (UNR); Zane Crawford (JPL); Robert DeGroot (SCEC); Diane Doser (UTEP); Ann Gates (UTEP); V. Gonzalez (UTEP); Eric Hagedorn (UTEP); Bill Hammond (UNR); Ben Hooks (UTM); Jose Hurtado (UTEP); Debi Kilb (SIO); Cornee Kreemer (UNR); Jasper Konter (UTEP); Karen Lutrell (SIO/USGS); Kate Miller (UTEP/Texas A&M); Francis Nimmo (UCSC); Robert Pappalardo (JPL); T. Pavlis (UTEP); R. Romero (UTEP); David Sandwell (SIO); Laura Serpa (UTEP); Peter Shearer (SIO); Xioapeng Tong (SIO); Aaron Velasco (UTEP); Meng Wei (SIO/WOI); Y. Zeng (USGS).

GRADUATE ADVISORS AND POSTDOCTORAL SPONSORS: David Sandwell (SIO/UCSD, graduate advisor and postdoctoral sponsor), Robert Pappalardo (JPL/CalTech, postdoctoral sponsor)

THESIS ADVISOR AND POSTGRADUATE-SCHOLAR SPONSOR: Amanda Nahm (UTEP, postdoctoral sponsor), Benjamin Hooks (UTM, postdoctoral sponsor), John Olgin (UTEP, thesis advisor), Cecilia Del Pardo (UTEP, thesis advisor), Garrett Thornton (UTEP, thesis advisor), Teira Solis (UTEP, thesis advisor).
Total graduate students advised: 4 Total postdoctoral scholars sponsored: 2

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-San Diego Scripps Inst of Oceanography

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
David T Sandwell

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. David T Sandwell - Professor	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				26,715	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (1) OTHER				3,123	
TOTAL SALARIES AND WAGES (A + B)				29,838	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				23,097	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				52,935	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				4,080	
TOTAL OTHER DIRECT COSTS				4,080	
H. TOTAL DIRECT COSTS (A THROUGH G)				60,015	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC as of July 2012 (Rate: 55.0000, Base: 18459) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				20,212	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				80,227	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 80,227	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME	FOR NSF USE ONLY		
David T Sandwell	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
Ann Dunbar			

1 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147435

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

**** I- Indirect Costs**
MTDC before July 2012 (Rate: 54.5000, Base 18459)

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY					
PROPOSAL NO.			DURATION (months)		
			Proposed	Granted	
AWARD NO.					

ORGANIZATION
University of California-San Diego Scripps Inst of Oceanography

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
David T Sandwell

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. David T Sandwell - Professor	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				28,050	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (1) OTHER				3,279	
TOTAL SALARIES AND WAGES (A + B)				31,329	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				26,565	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				57,894	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				4,080	
TOTAL OTHER DIRECT COSTS				4,080	
H. TOTAL DIRECT COSTS (A THROUGH G)				64,974	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 55.0000, Base: 38410)					
TOTAL INDIRECT COSTS (F&A)				21,126	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				86,100	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 86,100	$

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME
David T Sandwell

ORG. REP. NAME*
Ann Dunbar

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

1147435

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-San Diego Scripps Inst of Oceanography

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
David T Sandwell

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. David T Sandwell - Professor	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				29,453	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (1) OTHER				3,443	
TOTAL SALARIES AND WAGES (A + B)				32,896	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				30,552	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				63,448	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				4,080	
TOTAL OTHER DIRECT COSTS				4,080	
H. TOTAL DIRECT COSTS (A THROUGH G)				70,528	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 55.0000, Base: 39976)					
TOTAL INDIRECT COSTS (F&A)				21,987	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				92,515	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 92,515	$

M. COST SHARING PROPOSED LEVEL $ 0 — AGREED LEVEL IF DIFFERENT $

PI/PD NAME
David T Sandwell

ORG. REP. NAME*
Ann Dunbar

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

3 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: **University of California-San Diego Scripps Inst of Oceanography**	FOR NSF USE ONLY: PROPOSAL NO.	DURATION (months) Proposed	Granted		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **David T Sandwell**	AWARD NO.				

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **David T Sandwell - Professor**	0.00	0.00	0.00	$ **0**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	**0**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**3**) GRADUATE STUDENTS				**84,218**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**3**) OTHER				**9,845**	
TOTAL SALARIES AND WAGES (A + B)				**94,063**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**80,214**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**174,277**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**9,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**12,240**	
TOTAL OTHER DIRECT COSTS				**12,240**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**195,517**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**63,325**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**258,842**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **258,842**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **David T Sandwell**	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: **Ann Dunbar**	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

1147435

SIO BUDGET JUSTIFICATION

We request salary support and tuition for a graduate student and 0.5 mo./year to support for a Research Project Assistant.

Salary recharge rates are calculated for actual productive time only (except for non-faculty sick leave, which is charged as direct). The rates include components for employee benefits, provisions for applicable merit increases and range adjustments in accordance with University policy.

Salary support for Research Project Assistant are for tasks that will specifically benefit this project, will be assigned by the Principal Investigator, charged on a time reported basis, and will not exceed the percent of effort requested. These tasks normally include library searches, data entry, copying project literature, researching and procuring project materials, making travel arrangements, computer file maintenance, computer searches, preparation of camera-ready manuscripts and coordination of efforts between project participants.

The travel budget includes one trip/year for one of the researchers to attend the Fall AGU meeting and one trip/year for Sandwell to travel to UTEP to work with Smith-Konter and students.

Project specific costs that include telephone tolls, voice and data communication charges, photocopying, faxing, postage are also requested. We also request funds each year for computer and networking services, which are for expenses that specifically benefit this project and are reasonable and necessary for performance of this project. UCSD applies a direct charge equivalent exclusion calculating the D.A. indirect costs, as required in the draft interpretations of A-21 section F.6.b.

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION: University of Texas at El Paso	FOR NSF USE ONLY				
	PROPOSAL NO.	DURATION (months)			
		Proposed	Granted		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Bridget R Smith-Konter	AWARD NO.				

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Bridget R Smith-Konter - Assistant Professor	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				21,114	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				21,114	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,945	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				25,059	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) equipment item 1 $ 0					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				5,300	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				5,508	
TOTAL OTHER DIRECT COSTS				9,508	
H. TOTAL DIRECT COSTS (A THROUGH G)				39,867	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 49.5% Modified total direct (Rate: 49.5000, Base: 39867)					
TOTAL INDIRECT COSTS (F&A)				19,734	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				59,601	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 59,601	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Bridget R Smith-Konter	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: Tom Osteen	Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

1147427

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION: University of Texas at El Paso		FOR NSF USE ONLY			
		PROPOSAL NO.	DURATION (months)		
			Proposed	Granted	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Bridget R Smith-Konter		AWARD NO.			

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Bridget R Smith-Konter - Assistant Professor	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				21,748	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				21,748	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,950	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				25,698	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) equipment item 1 $ 0					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				7,300	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				5,673	
TOTAL OTHER DIRECT COSTS				9,673	
H. TOTAL DIRECT COSTS (A THROUGH G)				42,671	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 49.5% Modified total direct (Rate: 49.5000, Base: 42671)					
TOTAL INDIRECT COSTS (F&A)				21,122	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				63,793	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 63,793	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME: Bridget R Smith-Konter	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: Tom Osteen	Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **University of Texas at El Paso**	**FOR NSF USE ONLY** PROPOSAL NO. / DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Bridget R Smith-Konter**	AWARD NO.

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Bridget R Smith-Konter - Assistant Professor	0.00	0.00	1.00	$ 8,260	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	8,260	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				22,400	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				30,660	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,066	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				36,726	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) equipment item 1 $ 0					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				5,300	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				5,843	
TOTAL OTHER DIRECT COSTS				9,843	
H. TOTAL DIRECT COSTS (A THROUGH G)				51,869	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) 49.5% Modified total direct (Rate: 49.5000, Base: 51869)					
TOTAL INDIRECT COSTS (F&A)				25,675	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				77,544	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 77,544	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $
PI/PD NAME **Bridget R Smith-Konter**	**FOR NSF USE ONLY** INDIRECT COST RATE VERIFICATION
ORG. REP. NAME* **Tom Osteen**	Date Checked / Date Of Rate Sheet / Initials - ORG

3 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Texas at El Paso

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Bridget R Smith-Konter

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Bridget R Smith-Konter - Assistant Professor	0.00	0.00	1.00	$ 8,260	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	8,260	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (3) GRADUATE STUDENTS				65,262	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				73,522	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				13,961	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				87,483	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 0					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				17,900	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				6,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				6,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				17,024	
TOTAL OTHER DIRECT COSTS				29,024	
H. TOTAL DIRECT COSTS (A THROUGH G)				134,407	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				66,531	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				200,938	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 200,938	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Bridget R Smith-Konter

ORG. REP. NAME*
Tom Osteen

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

UTEP Budget Justification

A. Senior Personnel: Smith-Konter (UTEP PI) will lead the overall UTEP research effort proposed here, and will be responsible for ensuring quality scientific work and for reporting research results in major peer-reviewed journals. She will oversee the effort of a UTEP geophysics Ph.D. student researcher. While Smith-Konter is planning to devote a considerable amount of her research time to this project, only 1 month of summer salary is requested for Smith-Konter in year 3, which will support her efforts to complete the strain and moment rate analyses and prepare these final results for publication submission. Personnel salary rates include provisions for applicable range adjustments and merit increases in accordance with University policy.

B. Other Personnel:

Graduate Student: A significant portion of the cost of this proposal is for full salary support (12 months per year) for a UTEP geophysics graduate student researcher. Personnel salary rates include provisions for applicable range adjustments and merit increases in accordance with University policy.

C. Fringe Benefits: UTEP approved faculty fringe benefit rates for summer support are estimated at $630/month plus 17.93% of gross wages. UTEP approved fringe benefit rates for graduate students are estimated at $315/month plus 0.78% of gross wages, which include health benefits.

D. Domestic Travel: Domestic travel costs will cover transportation and per diem (at government rate) expenses for 2 people to attend the annual AGU Meeting for 5 days ($1500 per person) and to travel to SIO once a year (for 5 days) to participate in collaborative research with SIO PI Sandwell and graduate student ($1150 per person). In year 2, an additional allocation is requested to cover transportation and per diem expenses for 2 people to attend the 2013 EarthScope National Meeting (costs estimated for round-trip travel to Phoenix, AZ, $1000 per person).

E. Other Direct Costs: Direct costs include materials and supplies, publication costs, and graduate student tuition. Materials and supplies expenses are anticipated at $2000 each year. Publication expenses are estimated to cover 1 publication per year (UTEP's contribution) and are based on publication costs (~$2000 per manuscript, with color figures) relevant to major journals. Three years of graduate student tuition are requested at a base rate of $5508 for year 1 (2 semesters), with inflationary adjustments for years 2 and 3.

F. Indirect Costs: Standard UTEP indirect costs are computed at a rate of 49.5%.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: David Sandwell

Other agencies (including NSF) to which this proposal has been/will be submitted.
none

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Observations and Modeling of Shallow Fault Creep Along the San Andreas Fault Zone
UCSD 2008-1732

Source of Support: NSF EAR 0811772

Total Award Amount: $298,000 Total Award Period Covered: 07/01/08-06/30/11*

Location of Project: SIO *NCE thru 6/30/12

Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Geodetic Imaging and Modeling of the San Andreas Fault System
UCSD 2008-1269

Source of Support: NASA NNX09AD12G

Total Award Amount: $386,471 Total Award Period Covered: 12/15/08-12/14/11

Location of Project: SIO

Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: High-Resolution Gravity, Topography, and Seafloor Roughness
UCSD 2008-2549

Source of Support: NSF OCE 0825045

Total Award Amount: $166,505 Total Award Period Covered: 09/01/08-08/31/10*

Location of Project: SIO *NCE thru 8/31/11

Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: X Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Deformation Models for Use in UCERF3
UCSD 2011-0693

Source of Support: USC/SCEC PO#149731

Total Award Amount: $12,000 Total Award Period Covered: 01/01/10-12/31/11

Location of Project: SIO

Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: X Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Study of postseismic deformation due to the 2010 M7.2 El Mayor (Mexico) earthquake
UCSD 2011-0112

Source of Support: NSF EAR 1053627

Total Award Amount: $288,997 Total Award Period Covered: 05/01/11-05/31/13

Location of Project: SIO - Fialko PI

Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: David Sandwell

Other agencies (including NSF) to which this proposal has been/will be submitted.
none

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: SGRUMB: Studying Gravity Rolls Using Magnetotellurics and Bathymetry

Source of Support: NSF MGG 1060148
Total Award Amount: $563,866 Total Award Period Covered: 01/01/11-12/31/13
Location of Project: SIO
Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Incorporating Geodetic Surface Data into UCERF3: Strain Rate
UCSD 20113484
Source of Support: USC/SCEC
Total Award Amount: $15,000 Total Award Period Covered: 02/01/11-01/31/12
Location of Project: SIO
Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: A Factor of 2 Improvement in Global Marine Gravity from Cryosat, Jason-1, and Envisat
UCSD 20112620
Source of Support: NSF
Total Award Amount: $458,375 Total Award Period Covered: 9/1/11- 9/30/14
Location of Project: SIO
Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Cryosat altimetry, arctic gravity enhancements, investigation of ice freeboard Measurements and InSAR code development (UCSD 20113985)
Source of Support: ConocoPhillips
Total Award Amount: $120,000 Total Award Period Covered: 01/01/11 - 12/31/13
Location of Project: SIO
Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: Strain Rate and Moment Accumulation Rate along the San Andreas Fault from InSAR and GPS (UCSD20120019)
Source of Support: NSF EAR- THIS PROPOSAL
Total Award Amount: $258,842 Total Award Period Covered: 01/01/12-12/31/14
Location of Project: SIO
Person-Months Per Year Committed to the Project Cal: 0 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Bridget Smith-Konter

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Investigating along-strike depth variations of seismicity along the San Andreas Fault System to better resolve geodetic locking depths

Source of Support: Southern California Earthquake Center

Total Award Amount: $ 15,000 Total Award Period Covered: 02/01/11 - 01/31/12

Location of Project: University of Texas at El Paso

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Acquisition of Cyber-ShARE Collaborative Visualization System

Source of Support: NSF Major Research Instrumentation

Total Award Amount: $ 699,671 Total Award Period Covered: 05/01/09 - 04/30/12

Location of Project: University of Texas at El Paso

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CAREER: An integrated geologic, geodetic, and paleoseismic study of plate boundary stress evolution and geoscience education utilizing the EarthScope database

Source of Support: NSF Career

Total Award Amount: $ 501,048 Total Award Period Covered: 06/01/09 - 05/13/14

Location of Project: University of Texas at El Paso

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.40

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Integrating geologic, geodetic, and coastal tide gauge observations with 100-year vertical deformation models of California earthquake history

Source of Support: NSF Tectonics

Total Award Amount: $ 230,773 Total Award Period Covered: 01/01/09 - 12/31/11

Location of Project: University of Texas at El Paso

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Geodetic imaging and modeling of the San Andreas Fault System

Source of Support: NASA EarthScope

Total Award Amount: $ 386,471 Total Award Period Covered: 01/01/09 - 12/31/11

Location of Project: University of California San Diego

Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Summ: 2.00

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Bridget Smith-Konter

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Three-dimensional semi-analytic viscoelastic earthquake modeling as applied to faulting processes on Enceladus and Europa

Source of Support: NASA Outer Planets Research
Total Award Amount: $ 268,529 Total Award Period Covered: 07/13/09 - 07/12/12
Location of Project: University of Texas at El Paso
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 1.50

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Collaborative Research: Strain Rate and Moment Accumulation Rate along the San Andreas Fault System from InSAR and GPS

Source of Support: NSF EarthScope - This Proposal
Total Award Amount: $ 200,938 Total Award Period Covered: 01/01/12 - 12/31/14
Location of Project: University of Texas at El Paso
Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.33

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

SIO Facilities, Equipment, and Other Resources

Software and Data – As described in the proposal we have developed a full InSAR processing system called GMTSAR (http://topex.ucsd.edu/gmtsar). As developers of the system, we have an intimate knowledge of the inner workings of the software and can develop custom procedures for large-scale processing. Both SIO and UTEP are members of the WInSAR consortium so we have access to all the ERS, Envisat, and ALOS-1 data for western North America. Smith-Konter and Sandwell have developed and published 4-D viscoelastic modeling code that will be used for the proposed research (http://www.geo.utep.edu/pub/bkonter/research/index.html#Res1).

General Computing Equipment – The Sandwell Lab at SIO maintains state-of-the-art workstations, tape drives, and disk facilities for processing all types of satellite radar data including satellite altimetry and InSAR. We have access to a 30-terabyte mass storage system for backup and archival of results.

ALOS 1 and 2 coverage of the San Andreas Fault System - Sandwell was the PI on the original WInSAR ALOS-1 proposal and has been continually requesting SAR acquisitions along both ascending and descending passes along the San Andreas Fault System. In addition, we have installed and maintain three radar corner reflectors at the Pinon Flat Observatory (PFO). The radar corner reflectors were used for geometric calibration of the ALOS-1 PALSAR. JAXA imaged the corner reflectors on most of the over flight so this section of the SAFS now has 22 acquisitions on ascending passes and 12 acquisitions on descending passes. JAXA plans to use these corner reflectors for calibration of ALOS-2 and we have been asked to write a proposal for ALOS-2 data acquisitions over the entire SAFS. Since ALOS-2 has only a SAR instrument and no optical cameras as were on ALOS-1, we will request imagery along both ascending and descending passes on a 14-day repeat interval. Over the nominal 5-year lifetime of the spacecraft, this could result in 130 repeats from each look direction – nearly an order of magnitude more data than provided by ALOS-1. While part of this effort is beyond the proposed funding period, it is important to help develop the ALOS-2 plan at least one year prior to the launch of ALOS-2 in mid 2013.

UTEP FACILITIES, EQUIPMENT, AND OTHER RESOURCES

The Department of Geological Sciences at the University of Texas at El Paso (UTEP) has a large collection of computing facilities accessible to Smith-Konter and the UTEP graduate student working on this proposed project. Computational infrastructure is available through the PACES facility (Pan American Center for Earth and Environmental Studies), a NASA-funded cross-disciplinary research center located within the Departments of Geological Sciences, Engineering, and Computer Science at UTEP. PACES continues to facilitate both fundamental research and educational objectives, with a particular commitment to support the development of skilled minority scientists and engineers. The PACES facility includes several Sun workstations, a cluster of Windows PCS, an 8-node Sun server used for data processing and mass storage, and a wide variety of licenses for both mathematical software packages with modeling and mapping capabilities (i.e., MATLAB, Mathematica, GMT) and remote sensing/GIS software packages (i.e., ENVI, ArcGIS). The Department's computer system administration support will also be available for this project.

In addition to the existing facilities at UTEP, Smith-Konter operates a tectonics and visualization laboratory. This computational facility is housed within the Department of Geological Sciences and consists of 4 Mac Pro quad-core workstations, 3 iMac dual-core machines, and 4 MacBook Pro laptops each running a variety of software packages for mathematical modeling, mapping, and 3D visualization applicable to this project. Smith-Konter and the graduate student will utilize the Mac Pro workstations for model computation activities and the laptop computers primarily for small-scale modeling research, word processing, graphic design, and manuscript preparation.

The University of Texas at El Paso is the largest institution within the continental United States with a Hispanic student body majority, and total university enrollment is estimated at more than 25,000 students for the 2011 academic year. UTEP has a moderate-sized geology and geophysics Ph.D program that provides both personalized and high-quality education and research opportunities for graduate students. The Department of Geological Sciences at UTEP is located in a large remodeled building that houses teaching, laboratory, research, and conference facilities for department affiliates. The Department will provide office space for the PI and graduate student. Both offices and Department meeting spaces provide sufficient space and infrastructure to facilitate interaction with other academic researchers and for interaction with collaborators.

Data Management Plan

All of the raw GPS and InSAR data are available at UNAVCO, and the Alaska Satellite Facility. Under this investigation we will construct secular line of sight (LOS) deformation rates at 100 m postings for one look direction of ALOS-1, a second look direction from ERS/Envisat, and perhaps additional look directions from ALOS-2 and Sentinel-1. We will provide these data as longitude, latitude, LOS_unit_vector, LOS_rate, and LOS_rate_uncertainty for specific time intervals. These files will be distributed on our web site topex.ucsd.edu and also distributed/archived at UNAVCO (see approval below). We have already worked with UNAVCO to host our line of sight (LOS) InSAR data derived from ALOS interferometry of the 2010 Maule Chile Earthquake. These LOS data were used in our publication [*Tong et al.*, 2010] as well as two subsequent publications [*Lorito et al.,* 2011 and *Pollitz et al.,* 2011].

UNAVCO has accepted your request for support.
We have the following information concerning your project:
Project Name: Archive of InSAR/GPS integration
Request Date: 7/5/2011 5:58:00 PM
Primary Contact: David Sandwell
Contact Phone: 858 573 0152
Contact Email: dsandwell@ucsd.edu
Contact Address: 1102 IGPP
Scripps
La Jolla, CA 92093-0225
Contact Affiliation UCSD/SIO
Project Type: Other
Other Project Type:
Support Type: GPS Time Series and Velocities,InSAR
Other Support Type:
Project Description: We are proposing to create a 100 m resolution grid of line of sight (LOS) deformation from InSAR data along the entire San Andreas Fault Zone. We will propose to make these data available through our web site but need a long-term archive to complete the data management aspect of our NSF proposal. We expect the total size of the compressed data files to be less than 10 Gbytes.

Prof. David T. Sandwell
IGPP 0225
Scripps Institution of Oceanography
La Jolla CA 92093-0225
USA

Re: Strain Rate and Moment Accumulation Rate along the San Andreas Fault System from InSAR and GPS

Dear David,

We are pleased that the L-band PALSAR data provided by the ALOS-1 satellite mission has improved the understanding of the earthquake potential of the San Andreas Fault system. The recent failure of ALOS-1 has increased the urgency for the launch of ALOS-2 and we are on track for a launch date of mid-2013. The announcement of opportunity for scientific participation in the ALOS-2 program will be published in July 2012. One of the duties of the PI's for ALOS-2 will be to advise JAXA on the planning of global SAR acquisitions. In addition we hope that you and your colleagues will develop new software for preprocessing of the ALOS-2 data.

I hope that your proposal to the US National Science Foundation for ALOS-1 and 2 InSAR analysis is successful and I look forward to your proposal for the exploitation ALOS-2 data.

Sincerely,

Masanobu Shimada

Dr. Masanobu Shimada
ALOS Science Manager
Japan Aerospace Exploration Agency

July 13 2011