Sarah Anderson 8/15/18-7/31/20 $16,885

Elizabeth Hiroyasu

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National Science Foundation 1747562

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**Doctoral Dissertation Research: Using Prospect Theory and Human Perceptions of Wildlife to Predict Support for Invasive Species Management**

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Invasive species are one of the most important drivers of environmental change and declines in global biodiversity (Chapin et al., 2000; M. C. Mack & D'Antonio, 1998). Invasive species are estimated to cost $120 billion annually in management and mitigation costs in the US (Pimentel et al. 2000; Pimentel, Zuniga, and Morrison 2005), making this a salient issue for land and wildlife managers. Despite this, little is known about how to frame the management of invasive species in a way that facilitates public support. Prospect theory would suggest that the public will respond more strongly to frames that communicate possible losses from invasive species. Further, invasive species impacts are an example of an environmental problem that has not become politicized, thereby providing a useful test of prospect theory in the environmental arena where costs are often concentrated and benefits diffuse (Leung et al. 2002; Finnoff et al. 2007). Invasive species cover a range of species, and human perception of them may interact with how the public perceives the potential gains or losses from the presence of the species. Prospect theory can provide important insights to how the public perceives the risks of invasive species and whether this perceived risk is consistent across species.

The primary objective of this project is to assess how prospect theory applies to environmental problems that are not yet politicized. Additionally, this project has practical implications for how managers can frame and message about invasive species to garner public support for management. To test the role of prospect theory in invasive species management, an online panel survey will be conducted with a two by two factorial design, measuring levels of support for invasive species management when it is framed in terms of the ecological or economic risks associated with the gains or losses of management. A single survey will be conducted for each species, for a total of four surveys conducted. The results will be pooled once all surveys are conducted.

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Ralph Archuleta 10/1/17-3/31/18 $49,747

Chen Ji

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California Department of Conservation 1017-561

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Strong Ground Motion from Earthquakes on Multiple Faults

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InSAR image and geological surveys demonstrate that Kaikoura earthquake resulted in slip on multiple (>12) fault segments (https://info.geonet.org.nz/display/quake/2016/12). InSAR cannot conclusively determine that all of these segments ruptured co-seismically. We propose a two-step approach to constrain the co-seismic rupture.

We first investigate the co-seismic moment rate distribution using strong motion records with the multiple double-couple (MDC) approach discussed above. We assume each potential fault segments as one double-couple point source and invert for its seismic moment, centroid location, centroid time, and rupture duration for each fault segment using teleseismic and far-field strong motion waveforms. The results will provide the spatial moment distribution and temporal distribution of point sources.

When the causative fault segments are constrained, we conduct finite fault inversion on a fault geometry with predefined fault segments using broadband seismic data as we did for 2008 Wenchuan and 2016 Kumamoto earthquakes. As the seismic data with higher frequency is included, the fault slip is refined.

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Ralph Archuleta 1/1/15-12/31/15 $38,006

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National Science Foundation 1449275

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**Numerical Modeling of Earthquake Motions: Waves and Ruptures**

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Numerical simulation of rupture propagation and seismic waves is an essential tool for investigating earthquake physics and refining the velocity structure of the Earth. The physics of earthquake ruptures is a complex phenomenon involving the constitutive law for sliding friction (with many different processes, e.g., temperature, pressure, slip and slip rate, affecting the friction) along with a medium that may behave elastically or plastically. The fault itself has an inherent roughness at all scales. There is simply too few data by which one can constrain the physics of an earthquake rupture. The earthquake rupture, being complex, produces a complex radiated field which is poorly sampled by the arrays of seismic instruments. Because one cannot directly observe an earthquake – the complex evolution of slip on a fault, which is buried within the Earth to depths of 100’s of kilometers – a primary question is what data can constrain the numerical models? Thus the participants in the workshop will be considering both forward modeling of earthquakes and inversion methods by which properties of the earthquake source are inferred. The approaches are complementary; both depend on the elastic and attenuation properties of the Earth. Because of uncertainties in the properties of the Earth as well as the spatial-temporal distribution of stresses on the fault, there are tradeoffs between what is considered a property of the source and what is a property of the Earth. The discussion in a focused workshop allows those who have experience with these problems to discuss how the different methods might lead to better constraints on the source and propagation. This would lead to better numerical simulations and hence more realistic ground motion estimates from future earthquakes.

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Ralph Archuleta 9/1/12-8/31/17 $359,859

Chen Ji

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National Science Foundation EAR-1215769

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**Improving Resolution of Finite Inversions With Increasing Bandwidth.**

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This project will develop new methods of inverting observations to provide more resolved and robust estimates kinematic rupture models. Without direct measurements of the fault during an earthquake the spatio-temporal evolution of the slip on the fault must be inferred from seismic, geodetic and geologic observations. While the representation theorem provides the link between the spatio-temporal evolution and the observations, the inverse problem has been a quagmire. The number of parameters needed to infer the details of a rupture is much larger than the number of available data, i.e., the inverse problem is underdetermined. By itself that is a problem. When coupled with the fact that the temporal variables (rise time and rupture time) are not linearly related to the observations, additional complexities arise in the methods for inverting the observations. Nonetheless, models of the spatio-temporal evolution of slip, i.e., the source process, can be found. The quality of these models needs to be quantitatively assessed.

High-frequency seismic data exists but has not been fully exploited. These data provide important constraints on stress drops and variations in rupture velocity. By using these data in concert with low-frequency seismograms, GPS and InSAR, the resulting kinematic models will be better resolved and more robust. Two methods are proposed for exploiting the high-frequency data. First using back projection, areas on the fault that produce high-frequency radiation are identified. Using a multiscale inversion, the parameters are resolved on a finer scale and used as constraints on the inversion at a larger scale. Second, derivatives of the acceleration envelope function are inverted to determine regions of high-frequency radiation. These regions will also be subject to multi-scale inversion to constrain the overall inversions. In combination the two methods will improve the resolution and robustness of the inverted rupture model.

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Ralph Archuleta 6/1/17-11/30/17 $33,000

Chen Ji

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University of California 00009589

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**Modeling of Ground Motion from Intermediate-Depth Earthquakes**

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The current GMPEs have three source terms: magnitude, stress parameter and focal mechanism. For intraslab events, which are dominated by normal fault events, we will use magnitude, stress parameter, and nodal plane as three basic parameters. We will investigate the following three questions:

1) In modeling the intermediate earthquakes do we need abnormal high/low stress parameter?

2) Is there a significant radiation difference between rupture on sub-horizontal fault plane and rupture on a sub-vertical fault plane? (Up-dip directivity)

3) Will the GMPEs show a break in scaling of PGA and PGV at some large magnitude? There are known width limitations:

* Subducted oceanic crust ~10 km.
* Plate unbending model: neutral plane ~ half of slab width: 15-30 km given limits on the width.
* Slab width is strongly dependent on the age of the subducted plate: width is about 30 km for a young subduction zone like Cascadia and about 50-60 km for an old subduction zone, Japan trench. If the earthquakes occur on a reactivated outer-rise fault (~ 45o relative to slab interface), the corresponding critical widths are 14, 21-42, 42-84 km, depending on the age of the subducted slab.

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Ralph Archuleta 2/1/19-1/31/20 $27,000

Chen Ji

Toshiro Tanimoto

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University of Southern California

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**UCSB Broadband Kinematic Rupture Simulation With A Double Corner Source Spectrum**

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Statement of Work

1. In the current UCSB broadband simulation method (Schmedes et al., 2013; Crempien and

Archuleta, 2016) there is an explicit constraint: the final moment-rate spectrum should

approximate an Aki-Brune single corner spectrum that has an a priori corner based on an

assumed stress drop. (The temporal parameters related to the rupture time and the slip-rate

functions of each subfault are continuously adjusted in an inner loop until the spectrum of

source moment-rate function approximates a specified Aki-Brune spectrum.) As shown by

the Allmann and Shearer (2009) spectrum, this will lead to underestimation of the

acceleration high frequency spectral level. The first priority is to replace the single corner

spectrum with a double corner spectrum based on Ji and Archuleta (2018).

2. While we will continue to use spatial correlation for slip (𝑘−2), we will replace the regions of

high correlation with crack-like asperities (Boatwright, 1988). These regions will still

produce slip with 𝑘−2wavenumber and thus 𝑓−2 spectral decay (Herrero and Bernard, 1994).

This is similar to what is done by Irikura and Miyake (2011). However, the location of the

asperities will be randomly selected through the von Karman spatial correlation pattern,

which itself is randomly generated with a given correlation length (Mai and Beroza, 2002).

3. We will explore how the asperities will fail in time. Initially we will be guided by the work

of Das and Kostrov (1983, 1985), Fukuyama and Madariaga (2000) and Dunham et al.

(2003). The dynamic solutions indicate that rim of the asperity breaks first and then collapses

inward. The timing of the overall rupture front and the timing of the asperity have to be

coordinated.

4. We will re-run the SCEC broadband validation problems (Goulet et al., 2015).

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Ralph Archuleta 9/1/13-8/31/14 $47,000

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University of Southern California 10113445

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**SCEC4 Participation, Project F: Broadband Modeling of Earthquake Ground Motions**

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The scope of UCSB’s involvement is to ensure the correct implementation of the UCSB’s broadband modeling modules (Schmedes et al., 2012) in the validations and forward simulations. Once the validations are complete, the UCSB module will be made available on the SCEC Broadband Platform. UCSB is only one of several modeling techniques that will be developed and fined tuned during the calibration phase of the validation project. The first validations will run through January 2013 for earthquakes that are modeled with a single plane and through February 2013 for earthquakes involving more than one fault plane.

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Ralph Archuleta 2/1/14-1/31/15 $30,000

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University of Southern California 10202846

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**SCEC4 Partcipation, Project F: Broadband Modeling of Earthquake Ground Motions**

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In this research project, we will modify the UCSB broadband method to use a homogeneous velocity structure above the Moho for high frequencies propagation combined with a Boore & Joyner (1997) quarter wavelength amplification. In the current UCSB BB method the Green’s functions are critical to a realistic estimate of the ground motion because they are used for both the high- and low-frequency wave propagation. We will modify the specified velocity structure for propagating high frequencies (f ≥ ~1.0 Hz). The low-frequency computation will remain the same. For the high frequencies we will eliminate the near-surface velocity structure. A constant-velocity, anelastic medium will be used for depths to the deepest part of the fault. The shear wave velocity will be selected such that it has almost the same travel time as for the original structure. The Green’s functions will be adjusted in time so that the S waves align. After modifying the UCSB BB method, we will verify the modifications by recomputing all the ground motions in the validation exercise of June 2013 and will continue with larger broadband platform research.

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Ralph Archuleta 2/1/16-1/31/20 $30,000

Jorge Crempien

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University of Southern California 10436016

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**SCEC4 Participation, Project V: Simulation of Kinematic Rupture for Multi-Segment Faults Based on Dynamic Rupture**

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The ability of earthquake rupture to jump across faults, or to propagate on complex faults with multiple bends is of great importance to determine plausible earthquake magnitudes in specific regions (Wesnousky, 2006). The sub-discipline of earthquake rupture dynamics has been quite productive in determining the physics of these phenomena, which have been observed in many earthquakes such as: The 1992 Mw7.2 Landers (Hart et al., 1993) and 1999 Mw7.1 Hector Mine (Oglesby et al., 2003)

Not only is the rupture physics of these earthquakes important, but also the near field ground motion they can produce, to better inform the engineering community and to properly estimate earthquake hazard and risk. This is a priority for GMP: “Develop and implement simulation methods for the modeling of bending faults and multi-segment ruptures. The highest priority need is for kinematic rupture generators for implementation of the UCSB method (Crempien and Archuleta, 2015) on the Broadband Platform (BBP).”

Our goal is to determine plausible rupture prescriptions when generating ground motions from kinematic scenarios involving multiple fault segments or bending faults. Once the rules for simulating kinematic rupture on multiple-segment faults are specified, we will validate the model within the realm of the Broadband Validation Exercise (Goulet et al., 2015; Dreger et al., 2015). Specifically, for this proposal, we will produce kinematic models for the 1992 Landers Mw7.3 and the 1999 Hector Mine Mw7.0 earthquakes. We will use the metrics of the Broadband Validation Exercise in comparing synthetic ground motions with observations.

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Ralph Archuleta 6/1/16-5/31/17 $35,000

Jorge Crempien

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University of Southern California 10450329

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**SCEC4 Participation, Project U: High Frequency Path and Source Parameters Determined from Recorded Ground Motion in Central California**

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The Central California Seismic Project (CCSP) highlights “Use observations of ground motion from local earthquakes, and dense recordings of ground motion (where available) to characterize the ability to predict the intensity of strong ground motion and its variability.” One of the most critical factors affecting ground motion is attenuation, both regional and site specific. To our

knowledge, there have been no systematic attempts to determine the attenuation parameterized by κ (explained in the next paragraph) in Central California (CC), a region that hosts vital infrastructure such as the Diablo Canyon Nuclear Power Plant and several dams, all of which are vulnerable to high-frequency ground motion (Muto, 2015).

The effective attenuation of seismic waves has been approximated by Futterman (1962) and Knopoff (1964) with the following equation A(r,f) = exp(-πfr/βQeff), where r is distance away from the fault, f is frequency, Qeff is effective seismic quality factor of S-waves, and β is S-wave velocity of the medium. There are many causes for seismic attenuation of waves, but the two

main recognized physical processes of attenuation have been pointed out to be anelasticity (Qin) and scattering (Qscat) (Dainty, 1981), where the effective attenuation can be written as 1/Qeff = 1/Qin +1/Qscat. This relationship shows the difficulty in determining the relative contributions of anelasticity and scattering to the effective attenuation. In spite of this difficulty, it has long been

recognized that Qscat is frequency dependent (e.g., Jin et al., 1994). If the contribution of scattering to effective attenuation is significant, then Qeff should also be frequency dependent. Cormier (1982) proposed a model for attenuation based on the integration along a ray path such that A(f) = A0exp(-πt\*f), with t\* = ∫path dr/(βQeff). As the waves come to the surface, the waves experience a major increase in t\*, an argument that inspired Anderson and Hough (1984) to

propose a model based on a linear decrease of the log-amplitudes of the Fourier amplitude Spectrum (FAS) of ground motion. They called the slope of this decay κ, such that A(f) = A0exp(-πκf), which implies that Qeff is frequency independent. They also concluded that κ increases with distance away from the fault, which is interpreted as the regional anelastic attenuation modeled as κ(r)= κ0 + mr, where κ0 is the intercept of κ at zero distance, and m is the

slope of κ(r) as a function of distance.

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Ralph Archuleta 2/1/12-1/31/17 $25,000

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University of Southern California 20121443

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**SCEC4 Participation, Project E: Dynamic Ruptures with Off-Fault Dissipation Processes: Constraints on Energy Partition, Size-Dependent Levels of Prestress and Ground Motion Predictions.**

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We propose to critically investigate the different modes of energy partition in earthquakes and the relevant implications on ground motions, rupture speed and levels of prestress by doing self-consistent dynamic rupture simulations. The primary focus is to estimate the relative contribution of on and off-fault dissipation mechanism to the total energy budget. We will start by investigating the conditions under which a steady slip pulse can propagate on a velocity- weakening friction interface embedded in an elasto-plastic bulk. Steady propagation will allow us to examine the relationship between the width of the plastically deforming zone surrounding the fault and the constant width of the slip pulse. Because steady propagation does not emit radiated energy, accurate bounds can be placed, in this case, on the energy dissipated in the inelastic and frictional processes. Steady propagation will also allow us to investigate, in a more systematic way, the effect of perturbations in the material properties, material response, and prestress on the rupture dynamics including variability in rupture speed, maximum slip rate and ultimately rupture arrest.

We will also address several seismologically-relevant questions. For example, we will be examine the effect of off-fault plasticity on seismic observables like rupture speed, acceleration to limiting speed in sub-shear ruptures, transition to super shear and slip rate functions (in terms of the maximum and the average values of slip rates). Moreover, we will also be able to assess the impact of off-fault dissipation on the high frequency content of ground motion. This is relevant for developing physically-based models for ground motion prediction.

The project will accomplish the following tasks:

a. Quantify the magnitude of on- and off-fault dissipation and their relative contribution to the earthquake energy budget for different friction laws (rate and state law/slip weakening law).

b. Constrain the absolute levels of prestress consistent with the different modes of ruptures (cracks vs pulses) with and without the presence of off-fault dissipation mechanisms.

c. Investigate the effect of off-fault dissipation on high frequency ground motion.

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Ralph Archuleta 1/1/15-3/31/15 $8,500

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University of Southern California 57443669

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**SCEC4 Participation, Project M: Broadband Modeling of Earthquake Ground Motions**

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This effort will simulate high-frequency ground motions for the eastern United States using the UCSB Broadband Method (Crempien and Archuleta, 2014). In particular we will focus on reproducing the ground motions from the 1988 Saquenay M 5.8 earthquake, the 2011 Mineral, Virginia M 5.6 earthquake and the 2005 Riviere du Loup M 4.9 earthquake.

1. We will investigate the likelihood that stress drop in the eastern US is depth dependent.

2. We know that the 1-D Green’s functions fail to produce the temporal signature found in the data. To correct this we will be adding scattering coda to the time histories by convolving scattering functions with the Green’s functions for a 1-D velocity structure.

Jin et al. (1994) and Mayeda and Walters (1996) show that at different frequency bands, the coda energy envelopes exhibit different durations for different tectonic regions. Thus we first have to determine for the scattering parameters for the eastern US before convolving with the Green’s functions.

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Ralph Archuleta 5/1/17-9/30/18 $18,000

Jorge Crempien

Toshiro Tanimoto

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University of Southern California 94315251-D

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**SCEC5, 17234: Estimating Path and Source Parameters in the Southern Sierra Nevada Using a Non-Parametric Approach and Special Source Constraints**

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Engineering site parameters such as have not been estimated in the Southern Sierra Nevada (SSN) region. We will use a non-parametric approach (Andrews, 1986; Castro et al, 1990) to estimate simultaneously source and path parameters for the SSN region. To reduce the variability of observations, we propose to incorporate additional constraints into the method of Andrews (1986) and Castro et al. (1990) by using the ratios of ground motion spectra produced by two earthquakes whose hypocenters are close to each other and recorded at the same site. This additional constraint should eliminate the path and site conditions allowing us to isolate source effects. We will apply this new approach for the CC coastal dataset that we have already analyzed to see if we can improve on the estimates of the source parameters.

Several networks in SSN record strong ground motion with stations maintained by both Northern and Southern California Earthquake Centers (NCEC, SCEC), the USGS and the California Geological Survey (CGS). Because we will be working with a limited dataset in the Sierra Nevada, we first want to test the proposed method with datasets that are more extensive as well as datasets that include recordings in deep boreholes, in order to better estimate the site conditions. The ideal place to do such work is with arrays that are maintained by Dr. Steidl at UCSB: Hollister downhole array (HEO), Garner Valley downhole array (GVDA) and Borrego Valley downhole array (BVDA). These data are available at: http://nees.ucsb.edu/data-portal. Once we have estimated all parameters, we will compute stress drops, apparent stress, radiated energy, and other source related parameters.

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Ralph Archuleta 5/1/17-9/30/18 $25,000

Jorge Crempien

Toshiro Tanimoto

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University of Southern California 94315331-B

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**SCEC5, 17247: Validation of the UCSB Multi-Segment Kinematic Rupture Ground Motion Code Against Recorded Ground Motion for Several Events**

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Our objective is to compute large ensembles of earthquake simulations for central California sites that are suitable for probabilistic seismic hazard analysis (PSHA). Compare the simulation results with those from ground motion prediction equations (GMPEs). Use this modeling to understand the aleatory variability encoded by the GMPEs and to assess the epistemic uncertainties in the simulation-based PSHA.

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Ralph Archuleta 2/1/12-1/31/17 $25,000

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University of Southern California Y86552-D

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**SCEC4 Participation, Project D: 1987 Superstition Hills Earthquake: A Triggered Event with a Complex Nucleation and Rupture Dynamics.**

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The basic goals of this research are as following:

*1. Dynamic rupture model for Elmore Ranch earthquake.*

Although the Elmore Ranch Fault (ERF) earthquake is relatively simple (most researchers have treated it as a point source), we want to construct a more comprehensive stress model for the ERF earthquake. We want to construct the initial stress on the ERF fault first, using existing methods (e.g., Hauksson, 1994), considering its local tectonic context and fault geometry and also taking into account the aftershock sequence of the ERF earthquake during the 12 hours preceding the Superstition Hills Fault (SHF) earthquake.

*2. Evaluate the stress perturbation on the SHF due to the Elmore Ranch earthquake*

Based on the results from Step 1, as well as the location and focal information of the aftershock sequence of the ERF earthquake, we will evaluate the stress perturbation on the main SHF. We will account for the fault geometry with great care to insure the relative accuracy of the Coulomb stress change estimates. It is obvious that the MW 6.2 ERF earthquake will have a major influence on the SHF nucleation.

*3. Dynamic rupture model for Superstition Hills earthquake.*

We are going to combine the results from first two steps as outlined and previous research to constrain our stress model. We will take into account the heterogeneous velocity structure such as variable basement depth, material property contrast across the fault, as well as the non-planar feature of the fault (gradual fault strike changes, segment stepover). We wish to integrate as much previous research as possible to construct our rupture dynamics model. We want to construct an initial stress field that could produce the key rupture patterns obtained from the observations. The relocated aftershock dataset gives us a chance to look at the possibility of stress transfer and triggering. The strong motion waveforms and the surface rupture measurements place strong constraints on the stress conditions in the upper kilometers, which have almost no aftershocks in the double difference catalog. In particular we will analyze the stress conditions for the dynamic rupture model paying specific attention to the emergent nucleation and the partitioning of the seismic radiation into and high- and low-frequency energy.

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Ralph Archuleta 2/1/13-1/31/17 $25,000

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University of Southern California Y86552-H

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**SCEC4 Participation, Project H: Incorporating Roughness and Supershear in UCSB Broadband Modeling**

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A puzzling observation of recorded borehole ground motion at very close hypocentral distances from faults reveal a great deal of incoherency in high frequency (HF) seismograms from direct body waves. Because of their arrivals, and the closeness of the recording station to the fault, one can deduce that the level of scattering of these waves is not that meaningful. Scattering increases in a diffusive way with distance, and travel time (Zeng et al., 1990), making it difficult for CODA to show up at such short distances. Therefore a plausible assumption is that there must be complexity at the rupture fronts of earthquakes for very small scales (Gusev, 2012). With these important observations, it is necessary to study in detail the rupture front complexity and to answer the question: Is the rupture front continuous and smooth across the fault? If we find that rupture front is not smooth or continuous across the fault, then a natural follow up question would be how will this complexity at smaller scales affect ground motion intensity measures (GMI’s), such as PGA, PGV and Arias Intensity? If we find that the rupture front is not continuous or smooth, then the effect of the irregularity in the rupture front must be included into current kinematic ground motion simulation techniques such as Schmedes et al. (SAL, 2010).

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Ned Bair 10/1/18-9/30/21 $213,968

Karl Rittger

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National Aeronautics and Space Administration 80NSSC18K1489

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**Fusion of MODIS, VIIRS, and Landsat snow cover data to create high spatial and temporal resolution estimates of snow water equivalent in a well-instrumented and austere basin**

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About 1/6th of the world’s population relies on water from snow and ice melt. Snow cover and now albedo are important properties used to estimate snow water equivalent (SWE) and snowmelt. Daily observations of snow cover and snow albedo are available from MODIS Terra and Suomi NPP VIIRS at a resolution of 500 m and 1 km respectively, but snow properties vary at an order of magnitude smaller scales. Finer scale observations at 30 m from satellites such as Landsat 5, 7, and 8 are available but only at 16-day intervals. By fusing MODIS and VIIRS snow cover retrievals together with Landsat, we will create a multi-decadal time series that can also be used as input for retrospective modeling and forecasting of SWE. We will focus on two regions: the well-instrumented Colorado River basin in the Rocky Mountains and the austere upper Indus River basin in the Himalaya-Hindu Kush.

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Ned Bair 10/1/18-9/30/20 $59,519

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National Oceanic and Atmospheric Administration NA18OAR4590380

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**Improving subseasonal water supply prediction across the Western United States through assimilation of remotely sensed snow cover snow albedo, and snow water equivalent in the NOAA National Water Model**

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Water managers must balance competing demands for water supply, hydropower, recreation, habitat, and flood protection. Information that can improve early season decision-making therefore benefits a wide range of end-users. In the Western U.S., where snow accounts for a large fraction of the annual water budget, one of the largest sources of uncertainty in subseasonal to seasonal water forecasts is snowpack. The NOAA National Water Model (NWM) includes a subseasonal (30-day, aka "long-range") forecasting module, which predicts precipitation, snowpack water storage and release, and streamflow. This particular NWM product is currently underutilized by water managers and resource planners, in part due to unfamiliarity with the system, high uncertainties in the estimates, and lack of grounding in the observational datasets commonly used by managers.

We propose to address these current deficiencies by assimilating a new, near-real-time suite of remote-sensing-based snow products into the NWM. The foundation of our methodology is a post-processing algorithm developed by NSIDC to create daily, spatially and temporally consistent estimates of fractional snow-covered area, clean snow albedo, and dust radiative forcing, products which perform better than traditional MODIS snow products. UCSB will expand this product suite in high-priority target regions with near-real-time snow water equivalent (SWE) estimates derived by a novel machine-learning algorithm trained on the NSIDC remote-sensing suite and a historical SWE reconstruction model. To bring this rich data suite into the NWM, NCAR has devised an ensemble particle-filter assimilation method to winnow the long-range forecast ensemble set to "optimal" combinations of model parameters and forecasts that best replicate the snow observations. To test the new framework, the team will conduct a system-level demonstration of the NWM long-range forecast configuration for the 2018-2019 period with weekly regional snow state and parameter updates, including full computational benchmarking and feasibility assessment for U.S.-wide implementation.

The long-range configuration is ideally suited for our data-model fusion approach. Its simpler process representation and faster computational speeds allow parameter and forcing ensembles to become computationally tractable, permitting seamless assimilation of high-quality, high-impact observations like the NSIDC snow suite. With modest effort, we believe this expanded system will make substantial improvements in the accuracy and relevance of the NWM seasonal forecasts to water resource managers.

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Ned Bair 3/1/18-2/28/21 $85,489

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The Regents of the University of Colorado 1556287

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**Optimizing the Indus Basin Irrigation System and reservoir operations using remotely sensed snow surface properties in the ParBal model**

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This project will use sophisticated research algorithms to create essential water variables (EWVs) for snow and glacier ice. The EWVs will be analyzed as indicators to long-term trends in the Indus River basin that spans the countries of Pakistan, Afghanistan, India, and China, presenting transboundary issues.

The UCSB component of this work will focus on the implementation of the ParBal model and development of a Real-time SWE prediction model.

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Kelsey Bisson 5/15/17-6/30/19 $50,000

David Siegel

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National Academies Keck Futures Initiative NAKFI DB53

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**Project ROAM: Rendering Oceanography in Artistic Mediums**

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Science and art are both avatars of human examination and creativity, but only rarely are they coupled on seagoing expeditions for their mutual benefit. To this end, ROAM (Rendering Oceanography in Artistic Mediums) aims to bring four artists aboard R/V Sally Ride on a graduate student led science expedition to produce creative, artistic narratives from science at sea. By translating science experiences through art, ROAM will build empathy and wonder for our ocean and, ultimately, spark a commitment to marine stewardship. The ROAM team will include a creative writer, a videographer, an illustrator, and a musician. These individuals will collaborate with each other and with the scientists aboard to produce poetry and creative prose, illustrations, music, a short animated film, a short documentary-style video, photos, and likely many unforeseen creative endeavors that will undoubtedly transpire from this dedicated cross-disciplinary engagement. The overall goal is to leverage the strengths of art and science to motivate a love for the deep ocean across a range of communities. Following the weeklong expedition, this material will be available through numerous artistic publications, a cruise website, and an art-science installation in Santa Barbara, California. The online efforts will make the ocean more accessible to people who live far away from the ocean, creating a proximal connection despite the distance. This in turn will breed concern for ocean health, stimulate interest in the deep ocean, and perhaps inspire others to pursue a career in oceanography.

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Carol Blanchette 6/13/19-3/15/21 $506,800

Marion Wittmann

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California Department of Forestry 5GA18206

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Valentine Reserve Fuel Reduction

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Valentine Reserve is an ecological reserve and research station owned and operated by the University of California. The Reserve is located at the wildland urban interface (WUI) between the resort Town of Mammoth Lakes and the Inyo National Forest. Wildfire has been suppressed on the Reserve for approximately 150 years. Historical records show that average fire recurrence intervals before that time at the Valentine Reserve were as frequent as 15 years. Very high loading of fuel has accumulated, and the forest is in a very unhealthy condition with excessive stand density (up to 900 stems/acre). We propose a hazardous fuels reduction project on 50 acres of high-density forest within the reserve to increase the health and resilience of the forest and to reduce potential future wildfire severity and protect developed infrastructure in the Town of Mammoth Lakes, CA.

Having a large, natural forest preserve in such proximity to a tourist-based semi-urban community requires special attention to both the work prescribed and the methods employed for performing the work. The WUI at Valentine Reserve will require a mixture of approaches in order to achieve fuels reduction goals oriented around preservation, conservation and wildfire safety. This includes the establishing of sustainable tree spacing, the maintenance and preservation of a diversity of tree age and tree species, and a sensitivity to wildlife habitat. This project will incorporate forest treatment prescriptions oriented around the following: selective thinning of small conifer trees by hand felling; selective removal of dead trees; removal of trees infested with bark beetles; pole saw work (raising) in some densely forested areas in order to reduce ladder fuels; and finally some raking in areas of excessive ground fuel accumulation. Treatment of the fuels material will likely be a mixture of on-site chipping, complete removal to be processed and chipped at a remote green-waste facility, and some minimal piling and burning. A variety of equipment types will be used in order to move the material out of the area. A minimal impact approach on the landscape will be followed as much as practical and possible throughout the project. Finally, all commercially viable and useable material will be removed and processed locally for either firewood or building material.

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Joseph Blankinship 6/1/15-2/29/16 $9,255

Joshua Schimel

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UC Center for Water Resources/UC Riversi SA11-885-NIWR-BLANKINSHIP

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**Using soil exopolysaccharides (EPS) to make California grapes more drought-adapted**

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As highlighted by the current historic drought and forecasts for future climate change, California agriculture will only be sustainable by adapting to drought. For example, in order to support the rapid expansion of grape vineyards, Californians need to develop water conservation strategies from the “ground up.” I propose a soil-based solution for drought adaptation. If water retention and nutrient availability can be improved in dry soils, it may be possible to conserve large amounts of water by reducing irrigation frequency during drought. Various synthetic soil surfactants and hydrogels are commercially available to increase water infiltration and retention, but these products can have toxic effects in the environment and they are not intended to increase nutrient diffusion to plant roots. As an alternative, we propose to amend vineyard soils in the greenhouse with an exopolysaccharide (EPS), xanthan gum, which is naturally secreted by soil bacteria and commercially available in bulk quantities as an FDA-approved food additive. When mixed with soil, xanthan is known to be both a superb “sponge” for long-lasting water retention and “highway” for the diffusion of resources. However, there are no studies that have investigated the potential benefits of soil EPS for plants. Does more soil EPS mean greater water and nitrogen (N) availability for plants? An undergraduate researcher and I will grow grape plants in a greenhouse with varying levels of xanthan and water to see whether soil EPS can maintain N supply and plant health while reducing the need for irrigation.

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Joseph Blankinship 3/1/16-2/28/17 $12,396

Joshua Schimel

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UC Center for Water Resources/UC Riversi SA15-2997-CA358B

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**2016CA358B: Using soil exopolysaccharides (EPS) to make California grapes more drought-adapted**

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As highlighted by the current historic drought and forecasts for future climate change, California agriculture will only be sustainable by adapting to drought. For example, in order to support the rapid expansion of grape vineyards, Californians need to develop water conservation strategies from the “ground up.” I propose a soil-based solution for drought adaptation. If water retention and nutrient availability can be improved in dry soils, it may be possible to conserve large amounts of water by reducing irrigation frequency during drought. Various synthetic soil surfactants and hydrogels are commercially available to increase water infiltration and retention, but these products can have toxic effects in the environment and they are not intended to increase nutrient diffusion to plant roots. As an alternative, we propose to amend vineyard soils in the greenhouse with an exopolysaccharide (EPS), xanthan gum, which is naturally secreted by soil bacteria and commercially available in bulk quantities as an FDA-approved food additive. When mixed with soil, xanthan is known to be both a superb “sponge” for long-lasting water retention and “highway” for the diffusion of resources. However, there are no studies that have investigated the potential benefits of soil EPS for plants. Does more soil EPS mean greater water and nitrogen (N) availability for plants? An undergraduate researcher and I will grow grape plants in a greenhouse with varying levels of xanthan and water to see whether soil EPS can maintain N supply and plant health while reducing the need for irrigation.

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Jim Boles 2/1/10-6/30/15 $287,219

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Department of Energy DE-SC0003676

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**Fault-Related CO2 Degassing, Geothermics, & Fluid FLow in Southern California Basins---Physiochemical Evidence & Modeling**

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In this renewal proposal, we advance our studies of the geohydrology and geochemistry of active faults and young petroleum reservoirs in southern California, including the South Ellwood field in the Santa Barbara basin (SBB), the Newport-Inglewood Fault zone (NIFZ) in the Los Angeles basin, and the Lost Hills field in the San Joaquin basin (SJB). Subsurface core samples, outcrop samples, well logs, reservoir properties, pore pressures, thermal gradients, formation fluid compositions and structural-seismic sections are being studied to characterize the geohydrologic/diagenetic history and degree of compartmentalization for these known fault networks in a transpressional tectonic setting. We are also investigating the isotopic and trace elements signatures in calcium carbonate minerals, including vaterite, that characterizes rapid CO2 degassing, as observed in scales from production well tubing in several petroleum and geothermal reservoirs. These data provide the constraints for our geohydrologic models that are being developed to predict fluid pressures, multiphase fluid saturations, rates and patterns of deformation and fluid flow, subsurface temperature, geothermal heat flow, and fluid geochemistry associated with large fault systems. In past DOE-sponsored research, we mathematically modeled reactions associated with the transport of petroleum SBB-sourced methane and meteoric groundwater mixing in faulted submarine reservoirs, which are partially uplifted along coastal Santa Barbara. This fluid mixing simulation resulted in carbonate mineralization along the Carneros-Refugio fault, as observed in outcrops. We have also recently developed basin-scale models that incorporate coupled processes of poroelastic deformation and fluid flow, as well as field-scale models of multiphase flow for the NIFZ and Long Beach fields. We are currently developing a new coupled flow-heat-poroelastic deformation model, TUFTS2D-FE, and a multiphase flow model, TUFTS2D-FV, and reactive flow applications for the NIFZ in the Los Angeles basin. This renewal proposal requests support for additional three years of work, and details the field and modeling studies scheduled for these fascinating faults, reservoirs, and sedimentary basins. One new aspect will be a first time study in the LA basin of the helium isotopic composition of deep natural gas in the basin, which is an indicator of degree of connection to the mantle. Our past collaborative research has been very productive, and this new work will make new and important geologic contributions to understanding the leakage behavior of active faults in sedimentary basins. As these types of reservoirs become the primary targets for anthropogenic carbon sequestration, we feel we are making fundamental contributions to science and an important contribution to society.

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Derek Booth 9/21/12-9/30/14 $104,893

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DA Army Engineers/Vicksburg District, Corps of W912HZ-12-2-0016

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**Web-Based Conceptual Model for Urban Stream Systems**

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The restoration of any complex environmental system requires broad understanding of the causal mechanisms of degradation, clear diagnosis of the specific processes of degradation occurring at a given place and time, and a set of tools or techniques that can effectively address those processes of degradation. For the restoration of streams and their watersheds, successful implementation also requires clear recognition of the contextual framework in which the degradation is occurring, so that tools and “lessons learned” from prior efforts can be applied, but only where appropriate; and a realistic understanding of what restoration outcomes are feasible, given both watershed context and preexisting social and economic constraints.

“Stream restoration” is thus a complex and multi-dimensional enterprise, and so there should be little surprise that examples of successful stream restoration are few. Practitioners typically embark on project analysis with a limited geographical and thematic scope, thus inviting treatment of local symptoms of degradation rather than underlying causes; using a static body of knowledge without application of the most current scientific findings and engineering approaches; and bringing a narrow geographic range of practice, which encourages the application of tools developed in one hydro-geo-eco-climatic region that may be completely inappropriate in another. Project design is similarly crippled by an overly narrow set of outdated and potentially inappropriate tools and techniques. Finally, the articulated expectations of stream restoration are typically burdened with platitudes about lofty desired outcomes that have little or no chance of ever being achieved, by virtue of either legacy disturbances left uncorrected, overly limited scope of actions, or simply inadequate technical and financial resources.

The goal of this project has been to support the overall EMRRP effort to enhance the capacity and capability of the national stream restoration community of public and private practitioners, with an explicit focus on urban streams throughout the varied climatological and physiographic regions of the United States. Its products are also intended to promote improved understanding of the impacts of urbanization on aquatic ecosystems for the myriad federal, state, and local agencies tasked with protecting or restoring those resources.

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Derek Booth 7/1/15-6/30/20 $850,034

Thomas Dunne

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National Park Service P15AC01121

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**Yosemite Valley Merced River Restoration**

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The purpose of this project is to provide scientific and design support to Merced River restoration efforts in east Yosemite Valley being considered or implemented by the National Park Service (NPS). This work is occurring in an area of both great natural resources and intensive human activity, with complex and potentially conflicting goals articulated by the Merced Wild and Scenic River Final Comprehensive Management Plan and Environmental Impact Statement, issued in February 2014.

Since the initiation of this project, the work accomplished has comprised field data collection, data compilation, channel-migration modeling, in-stream project design and construction monitoring, stakeholder outreach, and preparation of a comprehensive report on scientific activities to date. As a result of this work we have developed and completed a map-based characterization of channel attributes throughout the study area, contributed to the in-progress geologic map of the valley, participated in multiple stakeholder meetings, and provided engineering design and construction oversight on two in-stream projects constructed in the valley since initiation of the project. Research questions have been framed relating to the past and future behavior of this river, given a range of potential management prescriptions for riparian areas and under potential climate-change scenarios.

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Erin Bray 12/1/14-12/31/15 $64,785

Thomas Dunne

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UC Sea Grant College Program

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**How Hydrologic Processes, Geomorphological Processes, and their Interactions in Gravel Rivers Sustain the Extent and Quality of Chinook Salmon (Oncorhynchus tshawytscha) Spawning Habitat During Managed Flow Regimes**

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This research will investigate how bedform morphology controls the distribution of hydrologic fluxes across gradients of elevation, topography, climate, discharge, and hydraulic conductivity in gravel rivers. We will first quantify bedform-flux interactions using high-resolution derived terrain, discharge information measured at multiple gauging sites, and climate information in distinct bar-bend reaches. This high-resolution data will also be used to inform and evaluate a two-dimensional subsurface hydrologic model in channel bedforms where the spatial distribution of hydraulic conductivity is measured in situ. Our goal is to investigate the effects of bar morphology, patterns of streambed hydraulic conductivity, and the physical parameters controlling bedform morphology on the hyporheic flow. We will document their influence on patterns of subsurface flow and quantify physically based adjustments on the magnitude and extent of infiltration and seepage, intragravel flow velocity, the residence time distribution, and the mean hyporheic depth. We quantify and compare these physical measures for a natural, engineered, and flow-modified river reach at spatial and temporal scales critical to Chinook salmon (O. tshawytscha) early life stages.

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Mark Buntaine 3/1/17-4/30/20 $208,269

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University of California 00009574

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**Citizen Monitoring of Urban Waterways in Jiangsu, China**

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In collaboration with UCSB, Nanjing University will design and carry out a randomized field experiment that tests whether citizen monitoring of urban pollution and the public or official dissemination of that information improves the management of urban pollution. This effort includes:

1. Baseline survey / water quality audit: We will implement baseline household surveys and water quality audits of the urban waterways in our sample prior to assigning any of the waterways to treatment. The baseline survey will assess resident attitudes about water pollution in their neighborhoods and their willingness to take action.

2. Implementation of treatments: We will assign our urban waterways to treatment conditions that include citizen monitoring or no citizen monitoring. For those waterways that are assigned to citizen monitoring we have a further experimental arm that will dissemination the monitoring information directly to government offices or release it publicly on social media platforms.

3. Endline survey / water quality audit: We will implement the same survey and water quality audit that was take at baseline after one year, with the goal of being able to identify any changes that are caused by our planned monitoring and information dissemination treatments.

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Douglas Burbank 7/1/08-7/31/14 $280,000

Bodo Bookhagen

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National Science Foundation 0819874

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**Collaborative Research: Orogeny, orography, and unsteady erosion: evolution of the Himalaya**

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Many aspects of climate-erosion-tectonic interactions remain unresolved. This research attempts to understand how Himalayan rates of erosion vary as a function of space and time and what drives such changes. Some detrital cooling-age data suggest that, irrespective of how spatially irregular erosion may be at short time scales, erosion rates become much steadier at longer time scales. This research will test that contention. The PIs hypothesize that, at decadal to millennial scales, spatial variations in rainfall distributions modulate differences in erosion rates. Specific stream power (the product of discharge and channel gradient) is hypothesized to provide a reliable proxy for modern erosion rates. To underpin tests of these hypotheses, the PIs have developed and calibrated the highest resolution, remotely sensed data on rainfall currently available for the Himalaya. When combined with digital topography, rainfall is routed through the Himalayan landscape and predicts pronounced along-strike variations in stream power. To test whether stream power successfully predicts variations in erosion rates, the PIs will collect 50 detrital cosmogenic nuclide samples within 10 catchments that exhibit strong contrasts in stream power. With judicious placement of sampling sites, this large new data set should also permit testing of a much-debated question: is the rate of erosion controlled by large trunk rivers or by the erosive power of much smaller catchments (<20 km2) that cover most of the landscape?

In order to assess the extent to which erosion rates change at longer time scales, the PIs will collect relief transects of bedrock samples in each of the CRN-sampled catchments and will measure ~100 cooling ages each for apatite, zircon, and muscovite, representing closure temperatures of ~80°, ~200°, and ~375°C, respectively. Reflecting different times and depths of cooling, these ages will be analyzed using thermokinematic models to create reliable reconstructions of temporal changes in erosion rates at each of 10 catchments.

Furthermore, the PIs’ current analysis suggests that topographic relief exerts a fundamental control on the distribution of Himalayan rainfall and that valleys of large rivers “guide” moisture into the orogen. At time scales for which Himalayan topography and climate are “constant”, spatial variations in rainfall, stream power, and, hence, erosion are, therefore, envisioned to remain steady. The Himalayas, however, are an active collisional orogen in which rocks advect laterally faster than they move vertically. The PIs hypothesize that topography also advects laterally, especially in the rain shadow north of the Himalayan peaks where erosion rates appear lower. Moreover, this advection is hypothesized to cause major re-organization of Himalayan drainages and related topography. If so, new avenues for rainfall to move into the orogen will open, old ones will close, and, as a consequence, new patterns of erosion should emerge. As advection leads to stream capture and creation of new Transhimalayan rivers with greatly enhanced erosive power, other trunk channels will be beheaded, thereby losing power. Such changes in stream power should be expressed by changes in both erosion rates and topographic relief. The PIs propose to test these novel ideas by reconstructing changes in topographic relief using bedrock cooling ages both from their relief transects and from equal-elevation transects. Such dynamic Transhimalayan channels would stand in contrast to the persistence of rivers at the Himalayan “indentor corners”. Despite the challenges presented by Himalayan landscapes, they provide a propitious setting: stark lateral variations exist in rainfall, erosion, and topography; cooling ages are almost ubiquitously reset, and strong signals of differential erosion should rise above the inevitable geomorphic and tectonic noise

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Douglas Burbank 8/1/11-7/31/17 $275,006

Bodo Bookhagen

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National Science Foundation 1050070

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**The Pamir Frontal Thrust System: Rates, Style, and Controls on Deformation.**

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Our goals include defining how, where, and at what rates shortening has been accommodated within the Pamir-Tian Shan structural corridor, and exploring the extent to which erosion by an axial river modulates shortening rates on faults proximal to the river. We will focus our work along the axis of the structural corridor where we can examine a rich suite of along- strike structural variability in the style, orientation, and (likely) rate of deformation. The Pamir Frontal Thrust (PFT) is the leading edge of the Pamir orogen. In reality, some apparently Pamir-related faults occur to the north of the PFT, including nearby faults that ruptured in the 1985 M7.4 Wuqia earthquake [Feng et al., 1988]. Within the study area, the PFT tends to be localized within lower Paleogene gypsum beds, and it typically carries the entire Cenozoic stratigraphic succession (up to 8 km thick) in its hanging wall. Where the PFT is exposed in the Bozi Tage Range near the Kezilesu River, it tends to be a low-angle thrust dipping from 0° to 15°. Ongoing slip on the PFT is evidenced by offset talus slopes that show fresh scarps. Typically, the PFT slices across the Xiyu conglomerate, an upper Cenozoic, time-transgressive fluvial conglomerate that ranges in age from 16 to 0 Ma within the foreland [Heermance et al., 2007], but which is less than 1.6 Ma where it has been paleomagnetically dated a few kilometers north of the PFT in the corridor [Chen et al., 2005]. On the eastern margin of the Mayikake Basin, the PFT cuts nearly horizontally across a 50°-dipping, 3-km-thick panel of Xiyu conglomerate for about 4 kilometers.

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Douglas Burbank 5/15/12-4/30/16 $143,370

Bodo Bookhagen

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National Science Foundation EAR-1148268

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**Collaborative Research: Reconstructing Mid-Miocene-to-Recent Paleo-Erosion Rates in the Eastern Andes, Northern Argentina**

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This project will focus on the analyses required to characterize long-term erosion rates throughout the entire section, while also gaining insight into how erosion rates may respond to variations in climate at sub-100 kyr timescales. We plan to use ~30 10Be analyses to undertake a low-resolution sampling of the 1-12 Ma portion of the section, at a density of ~1 sample per 330 Myr. We plan to use several 10Be samples on modern sediment, and divide the remaining 10Be samples between two sections of the stratigraphy that show the best opportunity for developing a high-resolution record of paleo-erosion rates. Such sections will be characterized by well-resolved paleomagnetic reversals, anchored by new tephrachronology with high-resolution U- Pb zircon ages. As mentioned above, we will likely focus on a 1.2-Myr interval between 7.4 – 6.2 Ma, which is currently bracketed by two ashes and contains 7 reversals. Nine additional samples in this interval would provide a resolution of ~1 sample per 100 kyr, capable of resolving 400-kyr cyclicity. An additional 11 samples would then be collected from a ~100 kyr long interval, allowing a nominal resolution of ~8.3 kyr per sample, capable of resolving variations as short as 23 ka. For comparison, we would like to repeat the above sampling strategy on a ~ 1-Myr-long interval in the late Pliocene/early Pleistocene, after the onset of northern hemisphere glaciation at ~ 2.8 Ma. The 20 additional 10Be samples focused on this interval would be paired with 26Al and 21Ne analyses in the same samples, in an effort to implement the full 3-isotope approach described above. 5-10 of these 21Ne analyses will be paired with 10Be samples to develop a cross-calibration and compute nucleogenic 21Ne, whereas the remaining 10-15 21Ne samples will be used to extend the low-resolution record back as far as 12 Ma.

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Cathy Busby 3/30/14-2/28/15 $99,778

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Consortium for Ocean Leadership T350A44

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**U.S. Science Support Program**

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Co-Chief Scientist of Leg 350, International Ocean Discovery Program

This NSF-funded program has been in existence for over 45 years. Its mission is to explore the history and structure of the Earth as recorded in seafloor sediments and rocks, through ocean drilling for research purposes. Each expedition lasts two months and involves about 45 scientists and about 45 crew and technicians. The science party is supervised by three people: a staff scientist who has a full-time job at IODP, and two Co-Chief Scientists selected for their expertise in the type of rocks or sediments to be targeted, as well as their ability to supervise research and write/edit scientific reports and journal articles.

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Cathy Busby 3/1/14-2/28/18 $137,042

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National Science Foundation EAR-1347901

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**Collaborative Research: The Rosario Segment of the Cretaceous Alisitos Oceanic Arc (Baja California, Mexico): An Outstanding Field Analog to the Izu Bonin Arc**

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The Rosario segment of the Cretaceous Alisitos arc in Baja California is an outstanding field analog for the Izu-Bonin-Mariana (IBM) arc, which is under intense study by IODP. The Rosario segment is structurally intact, unmetamorphosed, and has superior three-dimensional exposures of an upper- to middle-crustal section through an extensional oceanic arc. Previous mapping of this 60-km-long segment of the Alisitos arc, done in the 1990’s (Busby et al., 2006), will provide a framework for the proposed study; however, that study focused mainly on field descriptions of the volcanic rocks, with limited geochronology, and no geochemistry. The proposed study will determine in detail the relationships between plutonic, hypabyssal, and volcanic rocks, using field, geochemical, and geochronological data. These data will be used to construct an “Island Arc Crust Virtual Field Model” to be used by scientists as a reference model for IBM drilling outcomes.

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Cathy Busby 8/1/14-7/31/17 $116,048

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National Science Foundation EAR-1358130

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**REU Site: Collaborative Research: Field-Based Research on the Gulf of California Rift Margin Basins, Baja California Sur (Mexico)**

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The Baja Basins Research Experience for Undergraduates (REU) site seeks to provide students with a unique U.S.-Mexican collaborative research opportunity that combines digital field mapping techniques with state-of-the-art laboratory analytical work on the tectonic evolution of the Santa Rosalia basin area in the Gulf of California rift. Few places in the world expose volcanic and marine sedimentary sequences and large uplifted Quaternary terraces that can be used to understand the processes involved in the progressive stages of continental breakup. Because of the rapid tectonic motion in the Gulf of California rift (e.g. Umhoefer, 2011), the Santa Rosalia basin is a site where the stratigraphic history and processes of rifting can be studied in detail with exceptional exposures and accessible outcrops. Furthermore, the Santa Rosalia basin hosts large Cu-Mn-Co deposits that are not present elsewhere in the Gulf of California rift (Conly, 2003; Conly et al., 2005, 2006). The tectonic controls on hydrothermal emplacement of these ores are not well known. Many open questions reamin about the rapid tectonic uplift and active faulting, the volcanic processes in the arc-rift transition, and the style and history of deformation. For over a decade, the NSF MARGINS program funded a major effort to understand the process of continental rifting through shipboard and field studies of the Gulf of California. While a great deal of offshore research has focused on the central segment of the Gulf of California, particularly in the Guaymas rift, field studies on the Baja California Peninsula have largely focused on the northern and southern segments. Relatively little is known about the geology onshore of the Guaymas rift in the Santa Rosalia area, because it has not been mapped in over 50 years. We propose to carry out the first modern basin analysis study of the Santa Rosalia area, by gathering and integrating stratigraphic, volcanological, structural, and geomorphic data combined with petrographic, mineralogical, sedimentological, geochemical, and geochronological laboratory analyses.

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Jean Carlson 2/1/12-1/31/17 $20,000

Ralph Archuleta

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University of Southern California 20121441

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**SCEC4 Participation, Project C: Implications of Physical Dissipation Mechanisms for Dynamic Faulting and Structural Resilience.**

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This project will accomplish the following tasks:

\* Construct an integrated view for different weakening mechanisms through the extension of STZ constitutive laws describing plasticity to include additional geophysical mechanisms for dissipation such as granularity, breakage and thermal effects.

\* Develop better models of friction in fault gouge through reformulation of the STZ theory in terms of concepts more appropriate for strictly granular systems (perfectly hard spheres) in which there is no intrinsic energy scale, to extract the broad spectrum of transition rates and trapping volumes and to capture inherent variability arising from the broad range of grain sizes in fault gouge.

\* Develop a multi-scale approach to the dynamic rupture problem through the resolution of dynamics that arise from these constitutive laws and the material properties of the fault gouge to obtain predictive results for dissipation and fracture from laboratory to tectonic scales.

\* Assess the heat flow paradox through the analysis of energy balance and thermal heating during large earthquakes based on general thermodynamic principles as well as specific information regarding the materials and failure mechanisms that occur in faults.

\* Design control techniques, for improving seismic response of engineering structures, that are motivated by our better understanding for the role of entropic deformation in dissipating energy and increasing toughness in systems like fault gouge and abalone shells.

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Jean Carlson 2/1/12-1/31/17 $76,000

Ralph Archuleta

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University of Southern California Y86552-J

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**SCEC4 Participation, Project J: Compactivity, Comminution, Heating, and Disorder - The Physics of Granular Fault Gouge**

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We plan to apply our statistical-thermodynamic theory of granular systems – the Shear Transformation Zone (STZ) theory of local plastic rearrangements – to recent laboratory experiments, molecular dynamics simulations, and seismological observations involving granular fault gouge. Our focus is on three experimental paradigms that occur in shear flow--- compactivity, comminution, and thermally induced changes in material properties. Each of these is of interest to the SCEC Fault and Rock Mechanics community and each has become accessible theoretically based on advances in STZ theory made in the last year. Our goal is to provide a first-principles, quantitative interpretation of the great wealth of experimental data on fault gouge that to date has been treated phenomenologically. The advantage of a physics-based approach is that it enables extrapolation from the lab to the field.

In the first project, we will connect our theory of granular hard-sphere systems [Lieou and Langer, 2012] to the phenomenon of auto-acoustic compaction-- the suppression of shear dilatancy by means of internal acoustic vibration—in steady shear flows, which was recently observed in laboratory experiments [Elst, Brodsky, Bas, and Johnson, 2012]. We will examine how the STZ compactivity (which characterizes local volume fluctuations) is influenced by the shear rate and account for the apparent reduction in porosity due to acoustic vibrations generated at intermediate shear velocities.

In the second project, we will examine frictional weakening mechanisms associated with grain breakage. This involves augmentation of the original STZ theory to incorporate the effects of broad distributions of particle sizes and STZ transition barriers, as was done recently to characterize aspects of the glass transition [Langer, 2012], as well as physical mechanisms for granular fracture and wear [Mair and Abe, 2011]. In geophysical applications, the distribution of particle sizes may be responsible for frequency dependent response and variability in friction characteristics [Marone and Scholz, 1989]. Grain breakage is expected to lead to frictional weakening, and provides a significant pathway for energy dissipation that will help account for the lack of thermal heating during earthquakes.

In the third project, we will build on our recent work involving extensions of STZ theory that include thermally varying material properties [Elbanna and Carlson, 2012]. The next phase will focus on shear banding as an additional weakening mechanism in order to model more realistically the shearing response of gouge layers at high strain rates. We will compare our results with laboratory experiments of Sone and Shimamoto, [2009], that exhibit strain localization and rapid velocity weakening.

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Leila Carvalho 1/1/12-12/31/16 $450,000

Charles Jones

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International Potato Center (CIP) SB120184

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**Regional Climate Variability and Changes in the Central Andes**

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This collaborative work focuses on regional climate variability and changes over the central Andes with an emphasis on potential impacts on water resources and food security particularly potato crop productions and vulnerability. Research activities will be developed under the theme “Integration for decision making” and divided in the following objectives:

I. Analysis of climate variability and changes in the central Andes This objective will analyze atmospheric reanalysis to characterize climate variability and trends during 1948-present to identify key changes in the South American Monsoon System. In particular, we will develop several observational analyses to identify potential regional atmospheric changes over the central Andes. We will also analyze data from Coupled Model Intercomparison Project version 5 (CMIP5). CMIP5 model simulations are being used for preparation of the next Intergovernmental Panel on Climate Change (IPCC). We will analyze model simulations for the present climate and projections.

II. Development of climate downscaling methods

The specific research problem addressed in this objective will be the development of downscaling methods to properly represent the complex topography of the central Andes and the associated atmospheric variability particularly in precipitation and air temperature. The tasks will include analysis of conventional observations as well as regional climate model simulations. The Weather Research and Forecasting (WRF) model will be used to develop regional simulations over the central Andes. Conventional observations and regional climate model products will be used as inputs for multi-fractal downscaling at high resolutions over the Peruvian Andes.

III. Analysis of climate variability in South America and vulnerability assessments This objective will consist in summarizing the analysis of climate variability and changes in the South American Monsoon (Objective-I) and develop geo-referenced data that will be applied in vulnerability assessments over the central Andes.

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Leila Carvalho 8/1/10-7/31/15 $370,984

Charles Jones

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National Oceanic and Atmospheric Administration NA10OAR4310170

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An Integrated View of the American Monsoon Systems: Observations, Models and Probabilistic Forecasts.

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This project focuses on the interactions between the North American Monsoon System (NAMS) and South American Monsoon System (SAMS) and identification of common sources and limits of summer season predictability. The main theme of this proposal is to develop a unified view of the American Monsoon System (AMS). The project evaluates the ability of global models from the World Climate Research Program (WCRP) Coupled Model Intercomparison Project (CMIP) to simulate the variability of the AMS in the present climate. The project is comprised of four interconnected main goals. First, the project will investigate the extent to which the annual evolution of NAMS and SAMS and their temporal variability on ISI time scales can be represented with metrics that effectively describe changes in precipitation and atmospheric circulation in the Americas. Second, this will identify regional physical processes and teleconnections that control the interactions between NAMS and SAMS. Third, this project will evaluate the skill of WCRP CMIP coupled models in representing the observed variations in the AMS. Lastly, this project will implement diagnostic monitoring tools, identify sources of potential predictability and develop probabilistic forecasts of the AMS on subseasonal to seasonal scales.

Specific objectives are:

I. Develop and validate indices for a unified approach to monitor and forecast the variability of the monsoon systems in the Americas.

II. Investigate the associations between the two monsoon systems, the importance of regional processes and remote atmosphere-ocean variations on intraseasonal-to-interannual (ISI) time scales in explaining these linkages.

III. Examine the degree to which simulations from the WCRP Coupled Model Intercomparison Project (CMIP-3 and CMIP-5) realistically represent the AMS and associations between the monsoons in the Americas.

IV. Use NCEP Climate Forecast System (CFS) model outputs (reforecasts and operational) to develop probabilistic forecasts of the American Monsoon Systems on subseasonal to seasonal lead times. Identify potential predictability sources of the AMS on ISI time scales.

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Leila Carvalho 8/15/11-1/31/17 $563,506

Charles Jones

Bodo Bookhagen

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National Science Foundation 1116105

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**Climate Variability and Impacts on Regional Surface Runoff in High Asia Mountains.**

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The current state and future fate of the ‘High Asian water towers’ (i.e., freshwater reservoirs at high elevations) are of central importance for water, food, and power supply of densely populated regions in south, east, and central Asia. In addition to the highly seasonal summer rainfall, winter precipitation is important for snowmelt and discharge in the pre-monsoon (spring) season. Runoff from snow is especially significant in the central Asian and western Himalayan regions, where hundreds of millions of people reside, but observation, understanding, and prediction of terrestrial water storage and fluxes remain poorly understood. Quantification of seasonal amounts of rain, snow, glacial and snowmelt waters and associated physical processes are largely unknown, despite their importance to pre-monsoon and dry-season water for irrigation, drinking and power generation.

The main goal of this project is to advance our current understanding of climate processes on regional-to-continental scales and how they affect the water balance in the High Asia Mountains. The project focuses on multiannual-to-decadal variations in the Indian Summer Monsoon (ISM) and winter western disturbances (WD) and their impacts on rainfall, snow and runoff variability in High Asia. The project will focus on three specific objectives:

I. Characterize and investigate multi-annual-to-decadal variations in the Indian Summer Monsoon and western disturbances and their regional impacts on the surface water budget in the High Asia Mountains.

II. Examine the spatiotemporal variability of the surface water budget including changes in rainfall and snow and their relative roles in driving runoff variations in High Asia.

III. Develop case studies to investigate changes in Indian Summer Monsoon and western disturbances seasons and their influences on the long-term variability of snow and associated runoff in the High Asia Mountains. Changes in the Indian Summer Monsoon and western disturbances include extremely wet/dry monsoon seasons, high/low frequency and precipitation intensity of winter storms and teleconnections associated with warm/cold El Niño/Southern Oscillation (ENSO) phases.

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Leila Carvalho 8/1/17-7/31/20 $1,508,987

Charles Jones

Richard Church

Alan Murray

Dar Roberts

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National Science Foundation 1664173

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**PREEVENTS Track 2: Understanding Extreme Fire Weather Hazards and Improving Resilience in Coastal Santa Barbara, California**

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Frequent gusty downslope winds accompanied by rapid warming and decreased relative humidity are among the most significant fire weather conditions affecting coastal areas like Santa Barbara County (SB) in Southern California. Such conditions have affected the evolution of 15 major wildfires in SB (since 1955) responsible for loss of life, injuries, millions of dollars in property loss, and significant environmental impacts. The coastal communities of SB, with nearly 200,000 people, are particularly exposed to wildfire hazards as most of the population lives in a narrow zone between the mountains and the ocean. US-101 highway runs parallel to the coast and is the area most important evacuation route. SB Fire Department along with other agencies rely extensively on the National Weather Service (NWS) to provide accurate forecasts of wind direction and speed, onset and demise of windstorms in preparing for firefighting strategies. However, the current approaches are limited in scope, detail and how interacting mechanisms are taken into account. To enhance capabilities and understanding, an interdisciplinary team of experts in atmospheric sciences, fire-weather, ecosystem management, remote sensing, and transportation modeling propose to develop a framework that better accounts for mechanisms of downslope windstorms and fire spread regimes in order to derive probability risks of extreme hazards along this coastal region. This proposal contributes to PREEVENTS goals 1 and 2 by enhancing understanding, improving capabilities for modeling and forecasting hazards and increasing resilience. The following tasks are proposed: 1) use available observations and the Weather Research & Forecasting Model (WRF) at 1km resolution from 1979-present to investigate mechanisms and develop a climatology of significant downslope winds in the Santa Inez Mountains; 2) based on historical extreme events (task-1), use fire spread models (based on input from the WRF and observed fuels) assuming fire ignition in areas previously burned (validation) and in areas that presently have high density of vegetation fuels; 3) carry out fire weather risk assessment and determine the spatial probability of fire weather hazards affecting the greater SB region; and, 4) use transportation models and results from 1-3 to examine evacuation strategies and improve resilience.

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Leila Carvalho 4/1/16-3/31/18 $70,784

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Rutgers University 5898

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**The precipitation response to ENSO over Tropical South America: spatial and temporal heterogeneity and the role of the land surface**

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The rainfall anomalies associated with the El Niño/Southern Oscillation (ENSO) events frequently cause disruptive impacts on the populations, ecosystems, and economies of Tropical South America (TSA). An outstanding challenge for understanding—and in turn, developing more accurate forecasts—of ENSO impacts is the regional and seasonal heterogeneity inherent in the precipitation response to ENSO forcing. We propose here to analyze this spatiotemporally complex response in the context of land-atmosphere (LA) interactions. In pursuing this research, we are guided by the following hypotheses: (1) the physical characteristics of the land surface and LA interactions, including soil moisture, surface energy flux partitioning, and boundary layer characteristics, account for the regional and seasonal heterogeneity of the rainfall response to ENSO over TSA; (2) the spatial divergence in current generation model simulation of the TSA precipitation response to ENSO can be tied to errors in the simulation of specific land surface processes; and (3) LA interactions modulate how ENSO forcing affects the frequency, intensity, and duration of sub-daily/daily rainfall, which considered together lead to the seasonal-mean responses we associate with ENSO forcing.

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Kelly Caylor 11/17/17-7/31/20 $103,249

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Clark University 2A325-7533

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**Hazards SEES: Understanding cross-scale interactions of trade and food policy to improve resilience to drought risk in Zambia**

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This effort involves the integration of data and models for improved forecasting of hydrological hazards and agricultural production, and dissemination of forecast products. Part of this considers impact reduction focusing on identifying strategies to improve early warning of hydrological hazards through use of improved forecast products and their uptake, and improving resilience of local populations through improved access to resources, and development of policy recommendations that ensure availability and access to food. There is also a biophysical science aspect of this research, including the analysis and development of improved prediction systems for hydrological hazards and agricultural impacts.

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Kelly Caylor 1/1/18-12/31/19 $80,267

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Clark University SB180140

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**Developing and Scaling Up The Mapping Africa Active Learning Platform**

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UCSB will contribute to the following project tasks: 1) Porting the existing active learning code to a scalable parallel computing environment (AWS EMR cluster); 2) Adapting image pre-processing to handle irregular image boundaries and incomplete coverage by training data; 3) Converting external cython image feature extraction code into streaming Apache Spark Routine; 4) Adapting code to be image agnostic (i.e. can operate on PlanetScope, Sentinel, Landsat, etc.); 5) Integrating, testing, and demonstrating the complete active learning platform.

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Kelly Caylor 11/28/18-12/31/19 $100,000

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National Geographic Society NGS-57848R-18

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**Global maps of center pivot agriculture for improving estimates of crop yield and groundwater use**

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Agriculture is by far the sector with the highest demand for water, and increasingly, we are turning to non-renewable reservoirs such as groundwater to satisfy this demand. How resilient are food systems that rely on groundwater extraction? To answer these and other land use/ land cover change questions, we will enhance components of a machine learning system we have already developed: 1) CloudFreePlanet: an algorithm for filtering clouds and downloading Planetscope imagery to cloud storage 2) CropMask: a python API that makes deep learning object segmentation methods easily applicable to extract agricultural features from medium to high resolution time series of satellite imagery (including Worldview, Planetscope, Landsat, and Sentinel-2) and 3) CropProfile: a python API for identifying agricultural categories with temporal features (e.g. planting dates) and spectral features (e.g. annual change in reflectance). We will use this toolset to map center pivot agriculture globally. Next, fields will be classified in two stages: they will be determine to be active, fallow, recultivated, or abandoned and then active fields will have crop type classified. This dataset will be used in an empirical model to estimate groundwater use continuously over time, for arable regions across the globe. All algorithms, models, apis, jupyter notebooks and datasets for this project will be open sourced, allowing researchers to apply pretrained models to identify land cover categories, train their own models using CropMask, and conduct their own regional analysis of groundwater use.

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Kelly Caylor 8/1/17-12/31/18 $481,730

Leila Carvalho

Matthew Hall

Greg Husak

David Siegel

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National Science Foundation 1659449

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**CC\* Networking Infrastructure: UCSB Network Upgrade to 100 Gigabit**

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This project will enhance the University of California, Santa Barbara network in order to enable global, high-performance, end-to-end access to dynamic network services that enable rapid, unimpeded movement of the diverse and distributed scientific data sets utilized by 120 research teams at UCSB, facilitating learning, science and research, and establishing greater accessibility of scientific and research data. The network enhancements will allow the UCSB Earth Research Institute (ERI) and Department of Geography researchers to effectively share data of world-wide importance and impact. This effort addresses current network saturation challenges and facilitates efficient movement of large data sets between the numerous research activities in Ellison Hall on the UCSB campus, home to both ERI and Geography, and the Alexandria Digital Research Library (ADRL), UC Santa Barbara Library’s home for collections of digital research materials, in the UCSB Library and in the North Hall Data Center on the UCSB campus. In addition, the network upgrades will also allow ERI and Geography collaborators who are located across the nation and world-wide to effectively access the data sets by increasing bandwidth from the CENIC network interface to the UCSB North Hall Data Center where increasing amounts of the data are stored.

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Kelly Caylor 2/1/17-2/29/20 $628,779

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National Science Foundation 1801251

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**WSC-Category 2 Collaborative: Impacts of Agricultural Decision Making and Adaptive Management on Food Security**

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Despite significant attention from governments, donor agencies, and NGOs, food security remains an unresolved challenge in the context of global human welfare. Both technical and conceptual limits have prevented the collection and analysis of rich empirical datasets with high temporal frequency over large spatial extents necessary to investigate how changes to seasonal precipitation patterns are affecting food security. This research project will transform both methodological and conceptual frameworks for assessing the sustainability of dryland agricultural systems. The research will bring new understanding of how dryland farmers adapt to within-season variability in climate and how those adaptations affect their current and future resilience to climate variability and climate change. Project findings will improve forecast models used to monitor and predict the sustainability of water-dependent agricultural systems. By marrying the simple idea of cell phone adoption with state-of-art research in data science, crop prediction, and environmental/social monitoring, the project will advance and accelerate scientific understanding of an important global sustainability problem.

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Kelly Caylor 8/1/16-8/21/17 $27,518

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Princeton University SUB0000189

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**Hazards SEES: Understanding cross-scale interactions of trade and food policy to improve resilience to drought risk in Zambia**

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This effort involves the integration of data and models for improved forecasting of hydrological hazards and agricultural production, and dissemination of forecast products. Part of this considers impact reduction focusing on identifying strategies to improve early warning of hydrological hazards through use of improved forecast products and their uptake, and improving resilience of local populations through improved access to resources, and development of policy recommendations that ensure availability and access to food. There is also a biophysical science aspect of this research, including the analysis and development of improved prediction systems for hydrological hazards and agricultural impacts.

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Jordan Clark 9/1/10-8/31/14 $185,621

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National Science Foundation OCE-1031352

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Collaborative Research: Large-scale, Long-term, Multi-directional, Cross-hole Experiments in the Upper Oceanic Crust Using a Borehole Observatory Network.

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This effort will support of multidisciplinary borehole experiments in oceanic crust, to assess hydrogeologic, solute and colloid transport, and microbiological processes and properties at multiple spatial and temporal scales (meters to kilometers, minutes to years). Results of these experiments will comprise a major advance in our understanding of hydrogeologic properties and fluid processes within oceanic crust, and will help to develop new tools and methods that can be applied in many settings. Earlier grants funded engineering design and testing in preparation for these experiments; the present proposal is for support of scientific activities that occurred after IODP Expedition 327, late summer 2010. IODP Expedition 327 drilled and deepened three basement holes and installed three new subseafloor, borehole observatory systems (CORKs). Expedition 327 included single and cross-hole hydrogeologic testing, to assess multi-scale formation properties, including the nature of hypothesized azimuthal and vertical crustal anisotropy. IODP researchers also initiated a single and multi-hole tracer experiments by injecting a mixture of tracers (including sulfur hexafluoride) during a 24-hour pumping test in one of the new basement holes (1362B), and monitoring for tracer arrival at holes 350 m to 2400 m away. We requested support for two dive programs, in Summer 2011 and 2012 (due to mechanical problems with the research vessel the 2012 expedition was delayed until 2013), followed by analytical and modeling work. The Summer 2011 and 2013 expeditions included: downloading pressure data and collecting borehole fluid samples from several observatories at multiple depth using valves and samplers at the seafloor, exchanging long-term wellhead OsmoSamplers and microbial fluid samplers, and attaching an autonomous flow meter to wellheads (1362B 2011-2013 and 1362A 2013-2014) that could be opened and closed with a ball valve. We fluid discharge from the naturally-overpressured formation was about 5 L/s. UCSB was responsible for analyzing OS copper coil samples for sulfur hexafluoride.

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Jordan Clark 6/1/13-5/31/17 $121,801

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National Science Foundation OCE-1260353

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**Collaborative Research: Completing single- and cross-hole hydrogeologic and microbial experiments: Juan de Fuca Flank.**

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Below the seafloor lies one of the biggest aquifers on Earth. Here bottom seawater is drawn into basaltic crust and flows vast distances before discharging, driven by Earth’s natural heat loss and associated differences in fluid density, and guided by permeable pathways and basement outcrops that link oceanic and crustal realms. The extent of oceanic hydrothermal flow rivals that from rivers to the oceans, influencing ocean chemistry, crustal properties, and a poorly-understood subseafloor biosphere. However, little is known about the nature of flow paths and rates of flow through the crust, how different crustal regions are connected laterally and vertically, and how this flow influences crustal microbial populations. We are completing a series experiments to resolve processes and characteristics of hydrothermal circulation in the ocean crust, using long-term borehole observatories (CORKs) as perturbation, monitoring, and sampling points. Experiments was initiated in 2010 during IODP Expedition 327 following ocean drilling operations to install observatory infrastructure and instrument systems deep below the seafloor.

We have combined a series of short-term and long-term pumping and discharge experiments, lasing hours to years, with a multi-tracer injection experiment, to quantify solute, dissolved gas, and particle flow velocities, directions, and crustal interactions. Hydrogeologic experiments like these have been performed on land, to elucidate conditions in hydrocarbon reservoirs and freshwater aquifers, but they have never before been attempted in the ocean crust. Using the same boreholes, we are monitoring natural pressure conditions and perturbations, the extent of isothermality in the upper crust, the chemical evolution of borehole and crustal fluids, and the nature and extent of microbial growth in incubators containing chips of rock and minerals.

Cross-hole pressure perturbations have been observed, and sparse wellhead sampling of fluids from one borehole has recovered tracers injected in a different borehole (hundreds of meters away), demonstrating that the hydrogeologic and tracer experiments are working. But the most complete multi-year records of experimental results remain; these samples were recovered during a 12-day ROV/submersible expedition in August 2014. Shore-based activities are on-going and include hydrogeologic and tracer analyses, microbial characterization, and integration of physical, chemical, and microbial data to constrain crustal conditions, properties, and processes. UCSB is responsible for analyzing OS copper coil samples for sulfur hexafluoride.

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Jordan Clark 10/1/10-12/31/14 $110,875

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WateReuse Association (Foundation) WRF-09-11

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**Development of New Tracers for Determining Travel Time Near MAR Operations.**

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The objective of the study was to evaluate two new tracers to determine subsurface travel times near manage aquifer recharge (MAR) sites, which could be used instead of sulfur hexafluoride (SF6) for compliance with the California Division of Drinking Water (DDW), formerly the Department of Public Health (CDPH), groundwater replenishment reuse project (GRRP) regulations.. The new tracers were boron-10 (as 10B enriched borate) and radio-sulfur (35S). A multi-tracer experiment with the conservative anion bromide (Br-), 10B, and heat was conducted at the test basin near the San Gabriel MAR operations (travel time of a few months), to evaluate the relative performance of the different tracers. This basin is managed by the Water Replenishment District of Southern California (WRD). The experiment showed that 10B and heat are not conservative during near field transport and therefore should not be used as a replacement for SF6. At two other southern California MAR facilities, WRD’s Rio Hondo Spreading Grounds and Orange County Water District’s Kraemer Basin, time series measurements were made for 35S. The significant result of this experiment is that S should be considered as a viable replacement for SF6. This study addressed issues critical to the operation and regulation of many water reuse projects in California, the United States, and elsewhere around the world by increasing the available tools for evaluating travel times and hydraulic connections near MAR operations. These data are critical for understanding water quality changes that occur in the subsurface and permitting (in California). Although the California Air Resources Board (CARB) is regulating emission of SF6, a provision was included to allow for exemptions if the researchers can demonstrate a method for the introduction SF6 into the recharge water that minimize its loss to the atmosphere. A new method was developed using a membrane contactor with a closed circulation system for SF6 to achieve the CARB requirement of minimal SF6 loss.

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Brian Clarke 9/1/12-8/31/15 $171,556

Douglas Burbank

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National Science Foundation 12272278

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Quantifying Near-Surface Patterns of Bedrock Fractures and Assessing Controls on Fracture Formation.

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Rock strength is a well recognized but poorly known variable in landscape dynamics. Such strength plays a key role in shaping landscapes, resisting erosive processes, and modulating landslide hazards. The key factor, however, is not the strength of intact rock, but rather the effective strength of the entire rock-mass at the surface where it interacts with climatic, topographic, and biotic variables. This effective strength is modulated by the development of fractures that weaken the rock mass and make it more susceptible to erosion, physical and chemical weathering, biologic activity, or collapse. We have recently developed a methodology using both shallow seismic refraction surveys bedrock outcrops and laboratory analyses of “intact” samples to delineate variations in fracture density in the shallow subsurface. These new data indicate two common fracture patterns versus depth: rock that is uniformly fractured (apparently by large-scale tectonic forces); and rock with a distinct fracture gradient in an upper layer (apparently due to geomorphic fracturing processes have damaged the near-surface) that overlies a much stronger, less fractured lower layer. Although very promising, this methodology needs to be refined, tested, and explored more thoroughly.

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Brian Clarke 9/1/13-8/31/16 $25,549

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National Science Foundation EAR-1324627

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**Collaborative Research: Differentiating Between Lithologic and Baselevel Controls on River Profiles: Canyons of the Colorado Plateau**

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We propose a study of the relative roles of lithology and baselevel fall in canyon formation to better elucidate the role of lithologic heterogeneity in landscape evolution in general. To accomplish this we will study erosion patterns in and around deep canyons on the Colorado Plateau in relation to channel steepness patterns and rock properties. Important to our approach is the concept that the spatial structure of short-term erosion rates in disequilibrium landscapes like the Colorado Plateau reflects the longer-term temporal history of mainstem river incision. Not only do the canyons and surrounding landscapes of the Colorado Plateau provide an excellent natural laboratory for this investigation, but their study also carries significant broader impact and public education potential because of the iconic status of the Grand Canyon and the recent, high profile debate over the antiquity of this dramatic landform (age estimates range from <6 Ma to >60 Ma).

Despite the fundamental, and long-recognized, importance of lithology in landscape evolution, it has received little attention in the quantitative studies of landscape evolution in recent decades. Partly this is because we have lacked the ability to quantitatively measure rock strength at the process scale and partly because until recently lacked firm theory to relate rock properties to river incision processes – limitations that can now be overcome. We address three fundamental problems of broad interest to Geologists and Geomorphologists: (1) the role of lithology in river incision and landscape evolution in general, (2) how lithologic variability affects, and limits, our ability to interpret river incision history from study of landforms and (3) the controversial incision history of river canyons in the Colorado Plateau. The back drop to our study is the enigmatic Late Cenozoic exhumation history of the Colorado Plateau, but although our results should contribute to solving this long-standing problem, it is not our focus. We frame our study around three testable hypotheses concerning the fundamental controls on landscape evolution encoded in canyon landscapes and the last ~1 Myr of river incision history.

Given the icon nature of the Grand Canyon and the vast number of tourists that visit the canyon each year, public education is essential, especially when geoscience educators use National Parks as case studies for teaching exercises. As part of this research we will pursue a geoscience education study (part of the graduate student’s time commitment) of the effectiveness of using field analogs to teach about geologic process and landscape evolution, specifically related to canyon incision and relief generation. Folks living on reservation land on the Colorado Plateau are a key target audience. In addition to our public outreach efforts, the proposed study will provide significant training for one graduate student and several undergraduates. All students will interact with the PIs and institutions providing educational experiences for each student that are not typical. Specifically, this research will enhance the opportunities for undergraduates for direct involvement in cutting-edge research. We will proactively recruit women and underrepresented minorities.

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Christopher Costello 9/1/14-8/31/17 $37,515

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Conservation International 1000487

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**Maintaining productivity and incomes in the Tonle Sap fishery in the face of climate change**

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Indiscriminate fisheries are fisheries that target multiple species and multiple size classes. These fisheries are very poorly understood relative to single-species target fisheries, yet they feed millions of people. Their response to human-driven changes in freshwater dynamics is almost completely unexplored. The goal of our research is to better understand indiscriminate fisheries and their response to climate change, using one of the largest and most dynamic indiscriminate fisheries in the world as a research testbed. The ecological and social implications of indiscriminate fisheries are particularly important for the world's poor. Major indiscriminate fisheries exist in inland freshwater systems in low-income countries where freshwater fish consumption is a very important part of nutritional security. Protein from large freshwater fisheries are of greatest importance in countries with annual GDP per capita of less than US$1000. Cambodia's freshwater fishery stands out as one of the largest contributors of animal protein to people living in poverty; major components of this fishery are indiscriminate. Here, we will focus on the Tonle Sap Lake of Cambodia, perhaps the world's largest indiscriminate fishery. The Tonle Sap system feeds approximately 3 million people directly and provides income for millions more. The productivity of the system relies on hydrologic dynamics that interact with land use dynamics, making for a complicated system that is impacted in many ways by human actions and will be vulnerable in many dimensions to climate change. As a result of recent ministerial decisions on fisheries management, the Tonle Sap represents a prime example of an indiscriminate fishery, as well as a model of community control and management of a freshwater fishery. These attributes make it a rich resource to inform management of other indiscriminate fisheries and improve the living conditions of communities that depend upon them.

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John Cottle 5/1/11-10/31/14 $133,321

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National Science Foundation 1050043

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**Collaborative Research: Improving the Accuracy and Precision of Monazite and Allanite Geochronology via ID Th-Pb Ages for Reference Materials.**

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The principal limitation for obtaining high-precision, accurate standard-based 208Pb/232Th ages from monazite and allanite is the lack of appropriate, well-characterized reference materials. Because both monazite and allanite are compositionally variable and SIMS, LA-ICP-MS incur instrumental mass-dependent fractionation, it is essential to closely match standards with unknowns. This proposal seeks to determine isotope dilution (ID) Th-Pb ages for the Th-rich accessory minerals monazite and allanite. Th-Pb ages currently exist for only one reference material that is commonly used-'554'. Consequently, all standard-based geochronologic measurements require an assumption that Th-Pb and U-Pb ages are equivalent. This assumption is unnecessary and, in many cases, invalid. By obtaining high-precision ID Th-Pb ages for a suite of well-characterized, community-wide reference materials, this research will provide a means of independently calibrating Th-Pb ages for minerals that can be linked to fundamental tectonic processes.

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John Cottle 9/1/15-8/31/19 $257,128

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National Science Foundation 1443296

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**Petrologic Constraints on Subduction Termination from Lamprophyres, Ross Orogen, Antarctica**

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This project proposes to systematically study a suite of lamprophyres, their xenoliths and

associated rocks, spanning c.1300km along-strike and emplaced during the latest stages of

the Neoproterozoic - Ordovician Ross orogeny, Antarctica. High-precision geochronology coupled with whole rock and mineral-scale elemental, isotope geochemical and petrologic analysis will elucidate: 1) the mechanisms for, and temporal and spatial scales over which, deep crustal foundering/delamination occurred and; 2) the processes responsible for the significant isotopic heterogeneities observed in these rocks.

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John Cottle 1/15/17-6/30/20 $86,426

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National Science Foundation 1650265

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**Collaborative Research: Andean plutonic perspectives on generation, storage, and eruption of rhyolite**

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This project will be an international collaboration to synthesize and integrate field observations,

geo- and thermochronology, and compositions of rocks and minerals, together with thermal modeling

of a young plutonic complex typical of the Andean orogen. The shallow emplacement, range of

compositions, and three-dimensional exposures make a superb target for investigating timescales

of epizonal pluton assembly, magma storage, and relationships to silicic volcanism in an active

subduction zone. Our approach includes hypothesis testing aimed to: 1) establish rates and

mechanisms of pluton assembly, 2) identify individual magma batches and assess interactions,

if any, between them, 3) determine the timescales of crystallization and cooling of individual

magma batches, and system-wide, 4) establish petrogenetic relationships between coeval, but

compositionally distinct plutons, and 5) evaluate whether eruptible rhyolitic melt formed.

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John Cottle 7/1/11-12/31/15 $311,385

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National Science Foundation ANT-1043152

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**Exploring the Significance of Na-Alkalkine Magmatism in Subduction Systems, a Case Study From the Ross Orogen, Antartica.**

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This research aims to map and study basement rocks exposed in the Royal Society Range (2011−2012 season) and the Darwin Glacier regions (2012−2013 season) of the TransAntarctic Mountains. The Royal Society Range lies approximately 90km ESE of McMurdo Station in the TransAntarctic Mountains while the Darwin Glacier area is 200 km SW from McMurdo Station, immediately north of the Byrd Glacier. I hypothesize that these two areas represent the northern and southern boundaries (respectively) of a geologically distinct segment within the southern Victoria Land sector of the 550−500 Ma Ross Orogen. I will test our hypothesis in the field by conducting detailed geologic mapping and sample collecting. In subsequent laboratory work we will determine the ages and chemistry of the basement rocks. These two datasets combined will thus build up a more complete picture of the geologic evolution of this part of the TransAntacrtic Mountains.

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John Cottle 7/1/11-6/30/16 $366,356

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National Science Foundation EAR-1119380

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**How Does the Mid-crust Accommodate Deformation in Large, Hot Collisional Orogens? Insight From the Himalaya-Tibet System.**

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This research involves target fieldwork aimed at lithotectonic and structural characterization, and specimen collection. Detailed structural mapping of faults and shear zones and analysis of spatial variations in strain paths followed by rocks within the Main Central thrust system will follow the approach previously applied by the P.I.’s to other structures in the Himalaya (e.g. Cottle et al. 2007, 2009a, b; Kellett & Godin 2009; Kellett et al. 2009, 2010; Larson and Godin, 2009; Larson et al. 2010a; Jessup & Cottle, 2010). Macro- scale structural mapping will include documentation of all standard fabrics with an emphasis on lineations, high-strain domains, melt-associated deformation as well as boudins, flanking structures and over-printing relationships. Shear sense and deformation temperatures will be characterized through both micro-structural analysis (following the methods of e.g. Hirth and Tullis (1992)) and through optical and electron backscatter diffraction (EBSD) analysis of crystal lattice preferred orientations (LPO) and the asymmetry of [c] and <a> axes patterns in quartz and feldspar grains (following e.g. Law et al. 1990 and Kruhl, 1998). Diffraction patterns will be collected using an FEI Quanta 400 FEG scanning electron microscope coupled with a HKL Nordlys 2 EBSD camera at UCSB.

Timing constraints on deformation within structures identified in the field will come from U(- Th)-Pb dating of 1) intrusive bodies that either cut or are deformed by the shear zones (Figure 3C); and 2) metamorphic monazite that can be texturally linked to pre-, syn-, and post-kinematic porphyroblasts (see thermobarometry and metamorphic ages sections).

The distribution of deformation domains will provide important information regarding the spatial variations in fabric development during the evolution of the Greater Himalaya series-Main Central thrust system and the relative importance of distributed versus focused (e.g., shear zone) deformation. Within the context of the models proposed, Hypothesis 1 predicts that deformation will be concentrated in the vicinity of the major thrust faults. Furthermore, deformation temperatures attained would be expected to decrease abruptly down structural section. In contrast, Hypothesis 2 predicts that deformation is pervasive throughout the rocks to be examined, and that all rocks were deformed at high temperatures; any change in deformation temperature should be gradational. Thus, understanding the distribution of deformation and its relative and absolute timing and duration of movement will provide a direct test of the competing models. In either case, this study will provide a detailed account of structures including microstructural characteristics and vorticity, both of which provide significant constraints on the structural evolution of the Himalayan front.

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John Cottle 2/28/12-7/31/14 $67,095

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US Geological Survey G12AP20049

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Evaluating Mechanisms for Rare Earth Phosphate Mineralization in the Proterozoic Pinto Gneiss, Music Valley, Eastern Mojave, California

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Music Valley lies immediately to the north and east of Joshua Tree National Park in the Mojave desert of eastern California. The study area lies within the Valley Mountain and Hexie Mountains 15’ quadrangles, mapped at 1:62500 scale by Dibblee (2008). The Twentynine Palms Mountain and Fried Liver Wash 7.5’ quadrangles provide 1:24000 topographic base for more detailed mapping and targeted sample collection. Field work will involve sample collection of at least 50 bulk rock and 20 alluvial samples from the several previously mapped deposits, including the U-Thor, Uranus 2-6, Baby Blue, and Hansen, and other deposits delineated by Evans (1964). GPS location, field relations, and photographs to indicate the precise location and context of the samples will also be collected. In addition, this study will employ a multi-faceted petrologic, geochemical, and geochronologic approach to determine the mechanism of rare earth phosphate mineralization. The proposed tools for this research include U-Th-Pb geochronology, in-situ Sm/Nd isotope geochemistry, trace element analysis, and chemical mapping of xenotime and monazite grains.

Sampling strategy: 50 bulk rock samples: host gneisses as well as leucosomes, inside and outside of the Th-anomaly, and at several of the deposits identified by Evans (1964) will be collected for further analysis during year 1 of the project. In addition, 20 alluvial samples will be collected in order to make a reconnaissance assessment over a wider to assess the likely spatial extent of the deposit. Analysis will begin with detailed petrographic thin section analysis of bulk rock samples. From this it will be determined which samples contain sufficient REE-phosphates for further study (we anticipate making detailed analyses of a subset of the most appropriate 25- 30 samples over the two year period).

Chemical Petrography: To characterize zoning patterns in xenotime and monazite, chemical mapping by two electron microbeam instruments will be carried out. Preliminary mapping of monazite and xenotime inclusions will be done on a FEI Quanta scanning electron microscope (SEM) equipped with a back-scattered electon detector (BSE). This will allow for the rapid location and identification of monazite and xenotime grains, as well as an initial view to the internal zoning patterns. Following this initial screening, x-ray maps of individual grains will be produced using a Cameca-SX100 electron probe micro analyzer (EPMA) equipped with five spectrometers to measure Y, Th, U, La, Pb and Nd zoning patterns. Distinguishing between zones of different chemical composition will be crucial for in-situ laser ablation. We expect the majority of chemical petrography to be complete by the end of year one.

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Carla D'Antonio 8/16/11-3/31/15 $600,000

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California Energy Commission 20111150

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**Quantifying the Impacts of Interactions Between Fire, Invasive Species, and Hydrologic Cycles.**

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We will examine on-going vegetation change in areas of high fire activity and subsequent changes to hydrologic cycles (e.g., timing and amounts of stream flow, nutrients in run-off) caused by fire in specific watersheds of California, where invasive species have come to dominate over portions of the watersheds or where type conversion is occurring. Our collaborators at UC Berkeley (Max Moritz and postdoc) will evaluate cover changes (trees to shrubs) and their consequences in Sierran watersheds while the UCSB group will focus on southern California coastal mountain ranges and eco-hydrological modeling. At UCSB, we will use a combination of historic aerial photos, GIS and fire occurrence records to evaluate factors contributing to watershed conversion in order to project areas vulnerable to future change. To study the consequences of land cover change, we will select relatively fine-scale study areas to be compared, stratified according to those that are dominated by native species and those that have largely been “type converted” into non-native invasive species. Local scale measurements of water infiltration, vegetation evapotranspiration, and soil surface conditions will be used to parameterize watershed scale models to predict changes in water yield and nitrate run-off relative to vegetation condition. Small scale measurements will be used to parameterize and test the ecosystem watershed model, RhesSys to evaluate the potential for largescale changes in water yield due to land cover change. RhesSys models will be developed for both the Sierran watersheds and a southern California watershed.

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Carla D'Antonio 9/1/16-2/28/18 $56,284

Dar Roberts

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University of California 00009434

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Restoration and Resilience of Endemic Bigcone Douglas-fir after the 2007 Zaca Fire

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UCSB will be responsible for interpretation of satellite imagery documenting location of BCDF stands and interpretation of environmental features affecting stand resilience. This effort will sponsor a graduate student who will work on the restoration of degraded stands of BCDF. This will involve overseeing seed collection, seedling rearing, experimental design and out-planting of BCDF seedlings.

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Carla D'Antonio 10/1/17-11/30/18 $19,763

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University of California SA17-3877-01

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Restoration and Resilience of Endemic Bigcone Douglas-fir after the 2007 Zaca Fire

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Focusing on bigcone Douglas-fir after the Zaca Fire using a science-based restoration project. The project will be mapping the forest stands and their condition, analyses of environmental factors important for regeneration, collection and propagation of local seed, outplanting, evaluation of survival in the field, and synthesis of findings for the long-term adaptive management of bigcone Douglas-fir.

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Frank Davis 10/1/15-9/30/18 $63,513

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National Science Foundation 1550653

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**Collaborative Research: EAGER-NEON: How do microscale biophysical processes mediate ecosystem shifts during climate change-driven drought?**

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The project team will use National Ecological Observatory Network (NEON) Airborne Observation Platform (AOP) data in synergy with their own microclimate measurements, experimental data on tree species establishment, and ecosystem models, to test the hypothesis that microenvironments exert a

strong influence on emergent macroecological patterns of forest dynamics. Research questions are: 1) How do microclimates (solar insolation, surface temperature, and soil moisture regime)

vary at fine spatial and temporal scales across the southern Sierra Nevada foothills and mountains of the Pacific Southwest NEON Domain? 2) How does the relationship between local microclimate and vegetation canopy cover change across the foothills to subalpine climate gradient that

occur within this region? 3) How does drought-induced tree mortality affect microenvironmental conditions, and how do patterns of mortality and canopy gap formation affect subsequent forest dynamics?

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Frank Davis 6/1/11-12/31/17 $2,328,985

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National Science Foundation EF-1065864

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**Collaborative Research: Do Micro-environments Govern Macro-ecology?**

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Lead Institution: UC Santa Barbara Collaborators: UC Riverside, UC Berkeley, UC Los Angeles, Arizona State University, Conservation Biology Institute, Desert Research Institute, Conservation International

This project examines the effect of microenvironments (i.e. areas of high habitat suitability for individual species on macroecological processes, including species distribution responses to climate change and consequent extinction risk. Microenvironments have played critical roles in rapid vegetation response to past climate change, such as the emergence from the last glacial maximum. This project tests the importance of these difficult-to-model features in vegetation response to future climate change. The overarching research question addressed is ""How does macroecological response to climate change emerge from finer scale climate and population processes?"

The project uses a combination of modeling and field experimentation to answer this question. A collaborative research team will model microenvironment impacts on species distribution, abundance and diversity under rapid climate change for four tree species across four study sites in the Sierra Nevada and Coast Ranges of California. This proposed research design is a novel combination of site trials, distribution models and population models, incorporating measured (rather than inferred) species' tolerances relevant to microenvironments at scales that vary over five orders of magnitude (30m-3000km). Analytical tools will include reciprocal transplant experiments, field surveys, species trait-based distribution models, population models and biogeographic models of climate change. Physical models of microenvironments are linked to models of tree species occupation of microenvironments, which in turn inform models of population-level responses. Climate change is simulated using Regional Earth Systems Models and statistical downscaling from global climate model simulations. Field experiments examine the response of establishment phase (seedling) dynamics, the life history stage most sensitive to altered climate, through transplanting protocols to lower (warmer) elevations. The frequency of fire in the landscape is projected using correlations of fire to landscape conditions under current climate. Establishment phase and fire information is then used in models of single species population responses and multi-taxa responses in complex landscapes. These population-level models will give clear indication of whether microenvironments change species dynamics in rapid climate change in ways that will dramatically change range-wide and continental-scale biological responses to climate change.

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Ranjit Deshmukh 1/1/19-12/31/20 $199,605

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Oxford Policy Management A0534A

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**Accelerating large-scale renewable energy deployment in Southern Africa by bridging analysis and application through decision support tools**

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This project aims to identify renewable energy resources and grid integration strategies

that are specific to the challenges, needs, and opportunities in Southern

African countries, specifically mainland member countries of the Southern

African Development Community (SADC)--12 member countries of the

Southern African Power Pool (SAPP). By doing so, this proposed project seeks

to extend existing studies in a way that is directly relevant for near-term

decision-making while considering long-term development ambitions.

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Duane DeVecchio 2/1/12-1/31/17 $6,500

Dylan Rood

Ralph Archuleta

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University of Southern California Y86552-K

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**SCEC4 Participation, Project K: Precise Fault Slip Rates on the Oak Ridge Fault: New age constraints on the Saugus Formation using 36Cl/10Be isochron burial dating**

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This project will begin the work of developing the chronology of an important Quaternary strain marker in Southern California, the Saugus Formation. The Saugus is variably deformed across numerous active faults in Los Angeles and Ventura Counties and its inferred age is commonly used to quantify fault slip rates. Yet because the formation is diachronous across the region and few absolute ages exist fault slip rates on many of the largest faults in Southern California are poorly constrained. Until recently the age of Saugus strata (0.2- 2 Ma) lay outside the range of applicability of existing Quaternary geochronological techniques. However, with the advent of recent advances in cosmogenic nuclide burial dating (36Cl/10Be isochron dating), which is capable of precisely dating (uncertainty <5-10%) strata of this age, a new opportunity exists to determine the age of these tectonically significant strata. The resulting chronology of the Saugus Formation will directly contribute to and reduce uncertainties in earthquake hazards assessments associated with the USGS Earthquake Hazard Program, UCERF3, and the proposed SCEC Ventura Special Fault Study Area.

The primary focus of this research is to resolve the two-fold uncertainty in the existing fault slip rate (5.9 mm/a and 12.5 mm/a) of the Oak Ridge fault (ORF), which extends for ~40 km through urbanized Ventura County. Rates are based on the inferred age of the Saugus Formation, with the 2-fold range in the rate reflecting the uncertainty in the upper age of Saugus strata (200-500 ka). Funds from this grant will be used to conduct fieldwork, including geologic mapping and identification of propitious sites for cosmogenic sampling of the top and the bottom of the Saugus Formation. Fieldwork will focus along a North-South transect from the across the Oak Ridge hangingwall north of Moorpark California, where a thick section of Saugus strata are preserved in the Happy Campy syncline.

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Timothy DeVries 9/1/18-8/31/19 $45,000

Michael Nowicki

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National Aeronautics and Space Administration 80NSSC18K1353

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**Improving satellite-based estimates of net primary productivity by assimilating oceanographic data**

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Accurately estimating oceanic net primary production (NPP) is imperative to increasing our understanding of the global carbon cycle, and improving our ability to attribute and predict changes in Earth's climate. Despite this necessity, current satellite-based NPP estimates have significant uncertainties, as evidenced by the wide variation between different satellite NPP products. This is due in part to a lack of adequate validation of model parameters used to produce these estimates. Efforts to validate models have been made, but the in-situ data used for validation has generally been too limited either spatially, temporally, or both to accurately extrapolate NPP estimates on a global scale. The work seeks to improve these NPP estimates through assimilation of global-scale in-situ oceanographic tracer data with satellite-based observations. The work will produce biogeochemically-consistent NPP estimates that can be applied to data from satellite-based sensors such as MODIS-Aqua, Suomi VIIRS, and the upcoming PACE mission, along with potential to support NASA projects such as the EXport Processes in the Ocean from Remote Sensing (EXPORTS).

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Timothy DeVries 7/1/16-6/30/19 $260,662

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National Aeronautics and Space Administration NNX16AI22G

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**Quantifying the ocean's biological carbon pump with remotely sensed and in-situ observations**

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Organisms in the ocean’s sunlit surface layer take up carbon at a globally-integrated rate 5 times faster than humans emit CO2 to the atmosphere. A substantial but highly uncertain portion of this organic carbon ultimately sinks into the deeper ocean, where it is sequestered for years to millennia, significantly affecting the Earth’s climate. This process, known as the ocean’s biological carbon pump, both governs and responds to changes in Earth’s climate on decadal to millennial timescales.

This project develops new mechanistic, observationally-constrained models to address substantial uncertainties surrounding the operation of the biological pump in the contemporary ocean, and its response to climate change. This project aims to: (i) Quantify how much carbon the biological pump delivers to the deep ocean on an annual basis, and how long this carbon is sequestered in the deep ocean; (ii) Develop mechanistic models relating biological pump processes to remotely sensed variables, so that the biological pump can be monitored from space; (iii) Quantify the environmental sensitivities of key biological pump processes, so that climate predictions can be improved; (iv) Develop a new framework for assimilation and integration of satellite and oceanographic data, to maximize the useful information from space-based and ocean observing systems. The primary novelty of this project is that it integrates both satellite and in-situ oceanographic observations in the context of a global ocean circulation and biogeochemistry inverse model. Each data source provides unique constraints on different important parts of the biological pump. Satellites sense surface biological properties such as productivity and ecosystem size structure, while oceanographic tracers integrate information on the rates and pathways of organic carbon decomposition. By combining the two, this project aims to develop models that have the potential to change how NASA resources will be used to monitor and quantify the ocean’s carbon cycle.

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Timothy DeVries 7/1/17-6/30/20 $274,355

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National Science Foundation 1658392

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**Collaborative research: Combining models and observations to constrain the marine iron cycle**

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Iron (Fe) is an important micronutrient for marine phytoplankton that limits primary productivity over much of the ocean. However, the major fluxes in the marine Fe cycle remain poorly quantified: ocean models that attempt to synthesize our understanding of Fe biogeochemistry predict widely different Fe inputs to the ocean, and are often unable to capture first-order features of the Fe distribution. The proposed work aims to resolve these problems using advanced data assimilation (inverse) methods to "teach" the widely used Biogeochemical Elemental Cycling (BEC) model how to better represent Fe sources, sinks, and cycling processes. This will be achieved by implementing BEC in the efficient Ocean Circulation Inverse Model (OCIM) and expanding it to simulate the cycling of additional tracers that constrain unique aspects of the Fe cycle, including aluminum, thorium, helium and Fe isotopes. In this framework, our inverse model can rapidly explore alternative representations of Fe-cycling processes, guided by new high-quality observations. Through this model-data synthesis, we will address three specific objectives: (i) To quantify the magnitude of each Fe source to the ocean; (ii) To better understand the loss of Fe by particle scavenging and quantify the lifetime of Fe in the ocean; (iii) To make new robust predictions of Fe cycling under future climate change scenarios, by coupling the improved BEC to an Earth System Model.

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Qinghua Ding 9/1/18-8/30/20 $297,938

Charles Jones

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National Oceanic and Atmospheric Administration NA18OAR4310424

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**Abrupt Arctic warming episodes driven by atmospheric circulation changes in the past 1150 years**

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Understanding the behavior and causes of multi-decadal variability in the Arctic is hampered by the shortness of the instrumental record and 20th century reanalyses, which only capture one or two cycles of low-frequency variability. Thus, the Last Millennium Climate Reanalysis (LMR) provides a good opportunity to build knowledge and understand how the global atmospheric circulation and Arctic climates were interlinked and how they evolved together on interdecadal to centennial time scales in the past millennium, especially due to changing natural and anthropogenic external forcing. Indeed, preliminary results offered in this proposal suggest that there exists an observed low frequency teleconnection between tropical SSTs and the Arctic in the past 60 years and a similar teleconnection could exist in a long integration of CESM that is not subject to external forcing. Thus, our working hypothesis is that in the past millennium, a low frequency SST variability in the tropics could generate and maintain a teleconnection pattern propagating toward the Arctic to cause an abrupt warming through changing the local circulation. In this project, we aim to test this hypothesis using LMR data and CESM, and develop a physical understanding of this tropical-Arctic linkage and its responses under changing natural and anthropogenic external forcing.

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Qinghua Ding 6/1/18-5/31/21 $341,590

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National Science Foundation 1744598

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**Collaborative Research: Arctic sea ice variability: Remote drivers and local processes**

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The goal of the research is to understand and quantify how the atmospheric circulation in the Arctic influences winds, cloudiness, water vapor, radiation and thereby sea ice variability. We will examine the dynamical mechanisms that link the Arctic circulation to remote drivers in the tropics. We will put circulation changes in the Arctic and the related climate shift over the last 40 years into a longer term, 117 years, context to better understand the relative contributions of anthropogenic and internal variability though analyses of observations and model simulations. We will then evaluate how well CMIP5/6 models reproduce the observed linkage between Arctic sea ice and tropical sea surface temperatures and diagnose potential failures, and how such failures might affect model based hindcasts and projections of Arctic sea ice and climate.

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Qinghua Ding 7/1/16-4/30/20 $113,422

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University of Washington UWSC10548

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**Collaborative Research: A high-sensitivity 10Be and extraterrestrial 3He record from an ice core at South Pole**

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Qinghua Ding (University of California, Santa Barbara) will work with the other project members in designing climate modeling runs to test the impact of large scale circulation changes on the deposition of 10Be to the ice surface in the Antarctic in the past 40,000 years. In the first year, runs will be conducted by Professor Ding using ECHAM5-HAMMOZ. In years 2 and 3, similar climate modeling runs will be further conducted by Professor Ding, using an updated ECHAM6-HAM2 climate model. The comparison of results from different climate models (NASA GISS) is fundamental to the project goals

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Qinghua Ding 8/1/16-7/31/19 $161,045

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University of Washington UWSC9314

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**CVP: Seasonal to interannual variability and predictability of Arctic summertime sea ice associated with tropically forced planetary wave patterns**

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Increases in economic, environmental, and security interests in the Arctic demand improved prediction capabilities. This project explores a new path towards improved predictions of Arctic sea ice. We are investigating how teleconnections between tropical sea surface temperatures (SST) and high latitude circulation patterns can be exploited for sea ice predictions. Recent climate change in the Arctic is generally attributed to anthropogenic drivers and related feedbacks between sea ice, the ocean, and the atmosphere. However, work by Ding et al. (2014) and others (e.g. Trenberth et al. 2014) suggest that tropical Pacific SST variability is important in modulating recent Arctic climate variability by influencing the high-latitude atmospheric circulation. So far, these papers have examined the teleconnection between tropical SSTs and Arctic circulation and surface air temperatures. One unresolved question is how much does this tropical-Arctic teleconnection affect sea ice variability and predictability? This project aims to fill that gap. Indeed, preliminary results suggest that these links with sea ice exist. This work will focus on the implications of this link for seasonal predictability of sea ice and explore how a hierarchy of models captures this link and can be used and improved to enhance Arctic sea ice prediction.

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Jeff Dozier 1/20/15-1/19/20 $150,215

Ned Bair

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DA Army Cold Regions Research and Engineering Laboratory W913E5-15-C-0003

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**Methods to Estimate and Validate the Spatial Distribution of Snow Water Equivalent (SWE)**

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Accurate estimates of snow water equivalent (SWE) in mountain watersheds pose a longstanding, unsolved problem. Operational models’ high uncertainty imposes costs for water users. For instance, April to July runoff forecasts for the American River in California’s Sierra Nevada have a median error of 18%, and sometimes exceed 100% [*Dozier*, 2011]. Uncertainty stems from the heterogeneous nature of mountain snow. Spectral mixing techniques using satellite-based imagery in the visible and near-infrared bands have been successful at mapping snow covered area (SCA) at sub-pixel resolution [e.g., *Rosenthal and Dozier*, 1996; *Painter et al.*, 2009]. The remotely sensed date of disappearance of snow from each pixel can be combined with a calculation of melt to reconstruct the accumulated SWE for each day back to the last significant snowfall [*Martinec and Rango*, 1981]. Successful examples of reconstructed SWE include large basins in the Rocky Mountains [*Molotch*, 2009] and the Sierra Nevada [*Rittger*, 2012; *Guan et al.*, 2013; *Girotto et al.*, 2014]. Reconstruction’s main advantage lies in its provision of spatially resolved SWE estimates without the need for ground based observations, but its biggest disadvantage is that SWE can only be calculated retroactively after snow disappears. Alternatively, passive microwave (PM) sensors offer real-time global SWE estimates but suffer from several issues, notably signal loss in wet snow [*Chang*, 2000], saturation in deep snow [*Kelly et al.*, 2003; *Takala et al.*, 2011; *Hancock et al.*, 2013], decreasing SWE with increasing forest fraction [*Nolin*, 2010; *Tedesco and Narvekar*, 2010], subpixel variability in the mountains owing to the large (~25 km) pixel size [*Vander Jagt et al.*, 2013], and SWE overestimation in the presence of large grains such as depth and surface hoar [*Derksen et al.*, 2005; *Durand et al.*, 2011]. ***Overarching goal:*** The proposed research uses reconstruction to validate and improve real- time passive microwave estimates of SWE, as well as validating reconstruction itself.

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Jeff Dozier 9/15/16-9/26/18 $387,268

Ned Bair

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DA Army Cold Regions Research and Engineering Laboratory W913E5-16-C-0013

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**Methods to Robustly Assess the Snow Water Resource in Remote Mountains**

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A billion people depend on melt water from snow and glaciers. As the climate warms, the timing and quantity of water from snow and glacial melt is changing. Little is known about the spatial distribution of snow over vast areas of the world. A few areas have relatively dense measurement networks or aerial snow surveys that provide estimates of basin wide snow water equivalent (SWE), which greatly aid runoff forecasts. Most mountain areas, i.e. almost all of High Mountain Asia, lack such measurements, and therefore have nonexistent or poor runoff forecasts. Additionally, there is no baseline in these areas, as accurate snow measurements are not available retrospectively either. In these austere areas, estimates of snow on the ground must be derived from different satellite measurements, all of which suffer from limitations.

We have developed a snowmelt energy balance model called the Parallel Energy Balance Model (ParBal) that is driven entirely by satellite-based measurements. ParBal is highly parallelized and optimized so that it can be run at resolutions that are an order of magnitude greater than current operational products, as well as for large areas (continents) over long time periods (decades). Recently, ParBal was used to build a snowpack in reverse with a technique called SWE Reconstruction. The reconstructed SWE was then validated using snow measurements from an aerial laser scanner and spectrometer in the Tuolumne Basin, CA. Results show that ParBal performed better than any other method tested, with no bias and very low (26%) mean absolute error (MAE) for basin-wide SWE. In contrast, the operational model used by the National Weather Service, The Snow Data Assimilation System, overestimated SWE in every year with a 33% mean Bias and a 65% MAE. SWE Reconstruction has several limitations: it is only available retrospectively after the snow melts; it can only estimate ablation; and it is only valid for regions with little accumulation during ablation. Because of these limitations, we will use reconstructed SWE as training data in machine learning techniques. We will use snow measurements that are available daily from optical- and micro-wavelength sensors aboard satellites as predictors. Machine learning allows for flexible utilization of these predictors since it is known that certain sensors are more effective in certain geographic areas and during certain times of the year. In this manner, we will generate models that can be used for near real-time SWE prediction, with the lags (i.e. a day or two) coming only from processing time.

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Jeff Dozier 11/30/17-5/31/19 $57,432

Ned Bair

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Jet Propulsion Laboratory 1591172

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**Spatial Dynamics of Grain Size, Radiative Forcing by Impurities, and Spectral Albedo from AVIRIS-NG Data in the Indian Himalaya**

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Glaciers in the Western Himalaya have generally retreated since the mid-1800s [Bhambri and Bolch, 2009; Gardner et al., 2013], yet large uncertainties persist about the scale of that retreat, its spatial variability, its causes, and the magnitude of the resulting contribution to sea-level rise [Mayewski and Jascheke, 1979; Kaab et al., 2012; Garde/le et al., 2013; Gardner et al., 2013]. Himalayan glacier retreat is commonly attributed to global warming, but air temperature and black carbon (BC) only began to increase appreciably about 40 years ago [Kaspari et al., 2011], whereas widespread increases in dust loading to the Himalaya in the last 150 years [Thompson et al., 2000; Conroy et al., 2013] have coincided with the sustained glacier retreat in the Himalaya. Recent in situ measurements, ice cores, and modeling of aerosol transport and radiative forcing in the Himalaya suggest that snow darkening, earlier exposure of darker glacier ice owing to more rapid snowmelt, and atmospheric heating from dust and BC may have at-surface radiative forcings 1 to 2 orders of magnitude stronger than those from all greenhouse gases [Qian et a., 2011; Nair et al., 2013; Kaspari et a/, 2014]. This evidence leads us to understand that a complex mix of forcings is changing this iconic region, beyond just radiative forcing from greenhouse gases. To explore this complex mix, we work under an overarching science goal: quantitatively understand physical processes that drive changes in the snow and ice of High Mountain Asia.

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Jeff Dozier 6/24/11-9/30/16 $1,425,210

James Frew

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National Aeronautics and Space Administration NNX11AK35A

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**Error Analysis of MODIS Fractional Snow-Covered Area and Snow Albedo in Mountain Regions.**

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With the significant maturation of Earth science products in the EOS era, we are on the verge of true quantitative integration of these high-resolution, spatially explicit data records into water resource management and research. Snowmelt runoff forecasting in mountainous areas, such as the western United States, has developed as empirical models forced by sparse, in situ measurements of snow water equivalent that lie primarily in subalpine regions. Not only do the seasonal forecast models already have large errors in some years, they rely on a data record that assumes stationarity, and, therefore, are theoretically ill suited for water manage- ment in a changing climate. Moreover, they are unable to accurately address water resources during extreme events, such as persisting spring snow or new snowfall in the alpine zone above almost all measurement sites.

In response to this need for better assessment of the snow resource in mountain areas, new Earth System Data Records that use MODIS data have become available. However, they have not been rigorously validated, and uncertainties and the possible presence of systematic error are not known. In this investigation, we propose to undertake this necessary validation, through four years because the products will evolve. The specific Earth System Data Records are:

· Daily MODIS fractional snow cover.

- MODIS fractional snow cover based on the normalized difference snow index originally developed for Landsat [Dozier, 1989; Hall et al., 2006], available from Terra (product MOD10A1) since 2000 and from Aqua (product MYD10A1) since 2002 [Salomonson and Appel, 2004, 2006].

- MODIS fractional snow cover based on spectral mixing [Painter et al., 2009], available for the Sierra Nevada since 2000 but produced on demand for any MODIS scene. The al- gorithm will be used for the NOAA/NOHRSC National Snow Model starting in water year 2010-11 and has been adopted for the GOES-R Advanced Baseline Imager (ABI), sched- uled for launch in the 2015 timeframe.

· Snow albedo of the fractional snow cover, based on choosing the snow endmember from spectral mixing that minimizes the residual error [Painter et al., 2009]. A snow albedo prod- uct is also available for the normal “binary” (snow vs no-snow) snow-covered area product [Klein and Stroeve, 2002], but it is usually applied to continuous snow cover.

· MODIS fractional snow cover and albedo, smoothed and interpolated across time and space to compensate for cloud cover, off-nadir viewing, and data dropouts [Dozier et al., 2008]. The analyses are available as monthly data cubes, during the snow seasons, for the Sierra Nevada since 2000.

The coupling presented here of fractional snow cover and the albedo of that snow provides water managers with spatially and temporally dense data records that populate modeling in- puts for forecasting and research. Their use in snowmelt models and reservoir operations would be advanced by our proposed investigation, which would validate the products, analyze the structure of errors, and advise users of caveats and likely accuracy. Of greatest interest is their potential combination with surface data and energy balance models to help estimate the

-1-spatial distribution of snow water equivalent (SWE). SWE can be interpolated in near real time from snow pillow and snow course measurements, constraining the surface measurements by satellite snow-cover estimates [Fassnacht et al., 2003]. In addition, SWE can be reconstructed from satellite snow-cover estimates and snow-depletion models [Martinec and Rango, 1981; Cline et al., 1998; Molotch, 2009].

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Jeff Dozier 4/1/12-9/30/17 $834,399

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National Aeronautics and Space Administration NNX12AJ87G

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**Assessing Water Resources in Remote, Sparsely Gauged, Snow-Dominated Mountain Basins.**

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Our objective is to estimate seasonal snow volumes, relative to historical trends and extremes, in snow-dominated mountains that have austere infrastructure, sparse gauging, challenges of accessibility, and emerging or enduring insecurity related to water resources.

To judge feasibility, the proposed effort looks at two regions, a validation case and a case representing the characteristics outlined above. For the validation case, we propose to use the Sierra Nevada of California, a mountain range of extensive historical study, emerging scientific innovation, and conflicting priorities in managing water for agriculture, urban areas, hydropower, recreation, habitat, and flood control. For the austere regional focus, we will examine southwest and south Asia, where some of the most persistent drought in the world causes food insecurity and combines with political instability, and occasional flooding, to affect US national security. Our approach will use a mix of satellite data and a spare modeling approach to present information essential for planning and decision making, ranging from optimization of proposed infrastructure projects to assessment of water resources stored as snow for seasonal forecasts.

We will combine optical imagery (MODIS on Terra/Aqua, VIIRS on NPP), passive microwave data (SSM/I, AMSR-E), retrospective reconstruction with energy balance calculations, and gridded feed-forward, uncoupled land surface modeling to establish retrospective context. Specifically, we will use the period spanning the decade-long record from Terra and Aqua to bracket the historical record. In the California Sierra Nevada, surface measurements have sufficient spatial and temporal resolution for us to validate our approach, which we will extend to the Hindu Kush of High Asia where surface data are sparse and where access presents significant difficulties. The world's mountains accumulate substantial snow and, in some areas, produce the bulk of the runoff. In ranges like Afghanistan's Hindu Kush, availability of water resources affects US policy, martial and humanitarian operations, and national security. The rugged terrain makes surface measurements difficult and also affects the analysis of remotely sensed data. The analysis would leverage several techniques developed from NASA-sponsored research and use NASA instruments. While using data from the Sierra Nevada for validation, the activity would also improve water resource assessment in that region where statistically based forecasts occasionally produce significantly errors. Partner organizations include the US Army Corps of Engineers and the NOAA Office of Hydrology, organizations that work together in the NOAA-led IWRSS (Integrated Water Resources Science and Services).

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Jeff Dozier 9/1/15-8/31/17 $239,066

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National Aeronautics and Space Administration NNX15AT01G

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**CAS-NASA Workshops on Snow and Glacier Change and Related Natural Disasters in High Mountain Asia**

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Quality of life in High Mountain Asia depends partly on an ability to understand and monitor the dynamics of the glaciers and seasonal snow, and to project plausible future scenarios for different predictions of future concentrations of greenhouse gases and aerosols. Because of rugged terrain, political instability, and the meager measurement infrastructure, remotely sensed measurements must play a crucial role. The proposal is to hold two follow-on workshops to the initial one in January 2015 in Kathmandu, which the NASA Earth Science Division and the Chinese Academy of Sciences (CAS) Institute of Remote Sensing and Digital Earth (RADI) co-organized with the assistance of the International Centre for Integrated Mountain Development (ICIMOD). Scientists in both the U.S. and China use satellite and field data provided by both, and carry out field work throughout High Mountain Asia. CAS has operated a glacier field station in the Tien Shan since the 1958 International Geophysical Year. Several U.S. scientists have worked in the region and published findings that analyze Chinese data. A face-to-face workshop allows us to fully characterize the data available, learn about ongoing work on snow, glaciers, and hazards in High Mountain Asia, and best specify how a Glacier Melt Tool will advance science worldwide. At the Kathmandu workshop, participants identified a set of priority themes and began to define specific collaborations that take advantage of strengths and resources of NASA and CAS that include satellite and airborne sensing, field measurements, and modeling. To further these collaborations, we established three working groups-- process research and modeling, data sharing and exchange, and validation--to begin work on a “Glacier Melt Tool” to support monitoring, process understanding, and future projections of glaciers and snow in High Mountain Asia. The two subsequent workshops--one in the U.S. and the next in Beijing--will provide more specific guidance about research needed to understand changing climate and implications of human impacts on glaciers and using Earth observations, how the changing cryosphere in High Mountain Asia alters the risks of hazards, and how societal impacts on communities in the region might be mitigated. The recent earthquake in the region illustrates how the combination of tremors, snow and ice, and avalanches has devastated villages, and raises the hope--indeed the expectation--that scientific and technological resources of NASA and CAS could help restore Nepalese communities and lessen the consequences of future events. The September 9-11, 2015 workshop at Mammoth Mountain, California will consist of a few keynote talks, invited presentations that build on the work presented in Kathmandu in January, posters that illustrate relevant recent work by the attendees and their students, and break-out meetings of the working groups. Invitations to attend will be extended to the participants in the January workshop along with a few others who were not able to attend that one. Because of lower costs associated with a meeting in the U.S. instead of Nepal, we will encourage attendance by some advanced graduate students also. We will cap attendance at 65 participants, with travel support for 31.

The third meeting in Beijing, to be scheduled in early 2016, will enable us to finalize all recommendations and formulate goals. At that meeting, we will conclude preparation of publishable papers that lay out strategies for future research. The Chinese Academy of Sciences will host that meeting. This proposal includes travel support for 25 U.S. attendees who are not Civil Servants.

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Jeff Dozier 9/1/16-8/31/19 $120,000

William Brandt

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National Aeronautics and Space Administration NNX16AO25H

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**Using the spatial variability of snow accumulation to evaluate the orographic effect in California's Sierra Nevada**

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California depends greatly on snow accumulation in high altitude watersheds in the Sierra Nevada for its annual water supply. Snowfall is typically generated by the topographic lifting of moist air advected to the region by powerful winter storms. Higher elevations tend to receive more precipitation that the lowland areas due to orographic effects. To capture this spatial variability we currently use a combination of rain gauges and snow pillows. However, the paucity of these stations, particularly at high elevations, makes the estimate of mountain precipitation error prone and hard to assess. This has large implications for the hydrologic modeling of these watersheds and therefore streamflow forecasting. In order to reduce the error around these forecasts, we need alternatives to surface stations that can truly capture the spatial patterns of precipitation. Remotely sensed snow depth and water equivalent, at a time scale that resolves storms, could offer a truly unique answer to this problem. Even though NASA’s Airborne Snow Observatory’s (ASO) primary mission objective is to measure snow depth and reflectivity for streamflow forecasting, it has recorded a number of storms in 2014 and 2015, and will again fly this year. This has presented a truly unique opportunity to study the spatial distribution of snowfall in the Tuolumne basin in California’s Central Sierra Nevada. Therefore, I will use ASO to first investigate the spatial structure of precipitation through changes in snow depth, and then use these observations to assess whether gridded precipitation products and surface station data can replicate these observed spatial patterns. Finally, I will analyze the regional atmospheric circulation patterns for the individual events, as this may be key to understanding the differences in snow accumulation between storms. Collection of the ASO data upfront and preliminary testing have demonstrated the feasibility of this study, thus minimizing the proposal risk, while also indicating the potential for considerable scientific reward. The proposed study directly supports the “Water and Energy Cycle” focus of NASA’s Earth Science Research program and the “Water Resources” focus area of NASA’s Applied Sciences Program. The work will provide valuable insights into to the distribution of water in mountain environments through an innovative and unique blend of NASA remotely sensed observations and models.

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Jeff Dozier 10/1/10-9/30/14 $33,972

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National Science Foundation EAR-1015057

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Rapid Quantitative Snow Stratigraphy for Avalanche Forecasting Using Near-Infrared Photography.

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Over two snow seasons, we made detailed time-series observations of snow stratigraphy and sintering throughout the depth profile of the snowpack. We used optical microscopy and scanning electron microscopy to measure snow grain geometry and chemical composition. Our findings agree with laboratory experiments and sintering theory. Because of the time required for sampling and microscopy, we sampled in just two locations. We now plan to extend our sampling to learn how stratigraphy and sintering vary spatially. Other studies we recently published examine how spatial variability is the driving mechanism that produces power laws in avalanche depth distributions. We will use a new method, near-infrared digital photography, for rapid quantitative stratigraphy and to cover the range of variability over a large mountain. We will apply this technique to snow stability evaluation and the general study of snow metamorphism. Since the measurement of snow properties with near-infrared photography is a new technique, it has not been widely used, and there are no peer-reviewed studies that apply it to snow stability. While the heterogeneity of grain sizes at the snow surface has been investigated with remote sensing, there are many fewer studies of the heterogeneity of snow properties in buried layers, especially at the slope scale. Our experience, extensive instrumentation, site accessibility, and large number of avalanche control records make our field location, Mammoth Mountain, an ideal site to test how near-infrared photography can be used for avalanche hazard evaluation. We will relate mechanical strength to specific signs of instability, called lemons, i.e. yellow flags. We propose that four of five common lemons can be identified with nearinfrared photography alone. We will also use spatial statistics and machine-learning techniques to classify stable and unstable near-infrared snow profiles. The funding requested will supply materials and travel expenses for one PhD student, who is supported by an ORISE fellowship through the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory.

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Jeff Dozier 3/1/18-2/28/20 $2,094,303

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University of California LFR-18-548316

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**Headwaters to groundwater: Resources in a changing climate**

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Climate change and greater water demand pose new challenges for managing water resources in California. To enable California to optimize future water infrastructure, legislation, and economy, scientists at 5 UC campuses, LLNL, and LBL will address measurement and modeling of water from headwaters in the Sierra Nevada, through rivers and reservoirs, to and through groundwater in California’s Central Valley. The goal is to provide scientific information to optimize water storage, quality, and groundwater sustainability as precipitation varies, temperatures warm, and population grows. To consider the range of headwater-to-groundwater systems, we focus on three river basins comprising different climatic, geologic, and socio-economic settings -- Shasta R (volcanic, northernmost, lowest and wettest), Kings R (granitic, southernmost, driest, highest, poorest), and the American R (metamorphic, wealthiest). Novel methods to monitor and model ongoing and future changes in rain and snowmelt in the headwaters will be coupled with process-driven modeling and measurement of evapotranspiration, groundwater recharge, and withdrawal in the lowlands. Models will consider changes in water policy and infrastructure, and resulting impacts on energy production and consumption. Collaboration between the campuses and Labs will build interdisciplinary teams that include faculty in all career stages who study aspects of the water cycle from remote sensing of precipitation to water policy. Collaborators from LLNL and LBL contribute capabilities and expertise in isotopic tracing of water, high-performance computer modeling of groundwater and surface water, and energy implications of water management. This proposal strengthens DOE’s mission, to ensure America's security and prosperity by addressing energy, environmental, and nuclear challenges through science and technology. Ultimately, the alliance between UC faculty, postdoctoral fellows, and students with scientists at LLNL and LBL will improve understanding of how changing climate and water demand will affect water resources through the middle to the end of this century. Our proposal will nurture a new generation of scientists in the nexus of climate, water, and energy. An advisory board of water practitioners will help target our findings to help water managers make the best decisions for California’s precious water resources.

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Thomas Dunne 11/15/07-11/30/17 $286,582

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California Department of Water Resources 460007708

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**San Joaquin River Restoration Program**

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This project involves field and computational research to assist the California Department of Water Resources (DWR) in providing Chinook salmon habitat in Reach 1 of the San Joaquin River. Completion will involve both field data collection and computer modeling activities designed to answer the question: "How will the form and bed conditions of the gravel bed reach of the San Joaquin River respond to an alteration of flow regime and to manipulation of the sediment within the reach, and how will the changes affect the quality of habitat for Chinook salmon?"

The project has supported two PhD theses on gravel mobility and hyporheic flows in gravel bars, and has installed a monitoring system to continue the study of gravel mobility in high flows of 2017 and future years.

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Zachary Eilon 8/15/17-7/31/21 $244,801

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National Science Foundation 1658214

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**Collaborative Research: Imaging small-scale convection and structure of the mantle in the south Pacific: a US contribution to an international PacificArray**

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This project is a collaborative seismological exploration of shallow Earth structure at two locations within the Pacific plate, over a four-year time frame. The primary target is to image putative small-scale convection beneath the oceanic plate that may give rise to distinctive gravitational lineations. Numerous secondary targets include: investigation of the poorly understood base of tectonic plates (the lithosphere-asthenosphere boundary); analysis of rock fabrics and anelasticity that can inform us about the distribution of melt and the deformation history of the plate; and refining our limited understanding of plate ageing processes. The two ocean bottom seismic instrument deployments will contribute towards an international effort to instrument better the Pacific ocean basin in order to improve global seismological coverage that currently limits community Earth models. The relatively remote field locations were selected to significantly expand existing instrumental coverage and to interrogate potential small-scale convection structures. UCSB will be one of three US institutions responsible for this portion of the international Pacific Array campaign; the other institutions are LDEO Columbia University and Brown University. International partners include teams from Japan, New Zealand, and Taiwan.

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Zachary Eilon 5/15/18-4/30/21 $179,944

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National Science Foundation 1723170

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**Collaborative Research: The context for rifting in East Africa - melt distribution and lithospheric removal imaged from axis to flank**

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Continental rifting is inherent to the process of plate tectonics and lies at the nexus of geodynamical, geochemical, geological, and seismological research. Rift zones exhibit marked variability in terms of extension rate, magmatism, pre-existing structure, and temporal evolution, and initial conditions and geologic idiosyncrasies likely play a key role in rift dynamics. Therefore, understanding the entire extensional system – from rift axis to flank – is critical. Our study will explore extensional deformation of mantle lithosphere and the crust: how strain varies with distance from the axis, whether along-axis heterogeneity is a function of time or pre-existing conditions, and how extension is accommodated at crustal versus mantle depths. This work will help us ascertain whether rifting is controlled by shallow or deeper processes, with an emphasis on the location of melt and its role in modifying lithospheric strength at different depths. This project entails seismic imaging in the Main Ethiopian Rift (MER) and Gulf of Aden (GoA) out to the rift margins. In addition to data from existing experiments since 2001, this project will utilize a new dataset collected by Keranen that extends seismic coverage of the MER to ~500 km off the rift axis. The wide aperture array is critical to constrain pre-rifted structure that may control rift dynamics, as well as to image the geodynamically-crucial transitional zone between rift and flank. By comparing the incipient MER and the more mature GoA, we will elucidate the time-dependency of lithospheric strain geometry. The proposed imaging comprises simultaneous inversion of P and S receiver functions with Rayleigh wave phase velocities within a Bayesian framework; this approach is ideally suited to constrain lithologic/seismic discontinuities, the presence of melt, and complex 3-D rift structure. Anisotropic body wave inversions and splitting studies will help constrain the locus of melt as well as the time-integrated strain history of this rift.

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Zachary Eilon 1/1/18-12/31/19 $183,537

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National Science Foundation 1753722

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**Collaborative research: Lithosphere-scale anisotropic imaging across the Eastern North America Margin's ocean-continent transition**

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The project is a new seismological analysis of the Eastern North American Margin (ENAM). The US east coast is an archetypical example of a passive continental margin, the remnant of a once-dynamic rifting system that enabled the breakup of the Pangean supercontinent and the earliest formation of the northern Atlantic Ocean at incipient seafloor spreading centers. This margin holds clues to the processes of continental breakup, encoded in the transitional region between continent and young ocean. New broadband seismological data from a 2014-2015 amphibious seismic deployment holds promise for a more detailed analysis of the ENAM region, particularly offshore, where little work has thus far been carried out using the newly available data set. Preliminary research in this region revealed unexplained patterns of seismic anisotropy (a directional dependence to seismic velocity, often linked to ancient flow and/or architecture of magmatic plumbing systems), and unclear linkages between crustal thickness, magnetic anomalies, and deeper structure of the tectonic plates. We propose an integrated analysis of the anisotropic seismic properties of this margin using a combination of different seismic data types. We propose using new codes developed by PI Eilon to conduct a joint inversion of surface and body waves for lithospheric velocity structure. This approach provides constraints on discontinuities and absolute velocity, including unprecedented lithosphere-asthenosphere boundary constraints.

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Erica Fleishman 2/1/10-12/31/19 $266,000

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BP Exploration - Alaska SB100049

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Cumulative Effects of Anthropogenic Underwater Sound on Marine Mammals.

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There are no standards for assessment of cumulative effects of underwater sound. Quantitative assessments typically consider a single source whereas qualitative assessments may include multiple sources but rarely identify response variables. As a step toward understanding cumulative effects of underwater sound, we are developing complementary quantitative and qualitative methods for assessing the aggregated sounds from multiple sources received by marine mammals. As a case study to refine the transferable methods, we are assessing sounds received by migrating bowhead whales (Balaena mysticetus) in the Alaskan Beaufort Sea during their 2008 autumn migration. The quantitative method models the sound field from multiple sources and simulates movement of a population through it. The qualitative method uses experts to assess responses of individuals and populations to sound sources and identify potential mechanisms. These methods increase the transparency of assessments. Results of this work were published in 2016: Ellison, W.T., R. Racca, C.W. Clark, B. Streever, A.S. Frankel, E. Fleishman, R. Angliss, J. Berger, D. Ketten, M. Guerra, M. Leu, M. McKenna, T. Sformo, B. Southall, R. Suydam, and L. Thomas. 2016. Modeling the aggregated exposure and responses of bowhead whales Balaena mysticetus to multiple sources of anthropogenic underwater sound. Endangered Species Research 30:95–108.

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Joan Florsheim 3/6/14-6/30/15 $100,000

Edward Keller

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Cal EPA Water Control Board 13-068-120

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**San Gregorio Creek Watershed Sediment Budget**

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The objective of this project is to quantify changes in sediment delivery and storage processes in the San Gregorio Creek watershed, San Mateo County, CA, over the historical period. We will map erosional and depositional landforms from recent aerial LiDAR images and historical aerial photographs into a GIS, and conduct field measurements and other analyses. Specific questions to address through development of a rapid sediment budget (Reid and Dunne, 1996) for various time periods, include: 1) what are the significant active geomorphic processes (e.g. gullies, slides, incision) that deliver sediment to channels? 2) how do current and/or historical landuse activities influence sediment delivery rates relative to pre-disturbance natural background rates? 3) have landuse activities caused significant changes in channel sediment storage and sediment supply in alluvial channel reaches, and or significant changes in the rate of sediment supply to the lagoon? 4) what are the relationships between grain size distributions in channels and bed mobility, pool filling, and sediment supply rate? Addressing these questions will increase our knowledge about the effects of anthropogenic and climate disturbances on geomorphic processes at the scale of a small coastal California watershed.

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Joan Florsheim 10/1/16-9/30/17 $13,943

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CSU San Diego State University SA0000537

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**Evaluating Potential Environmental Impacts from Channel Morphology and Habitat Changes to the Santa Ana River Downstream of Prado Dam**

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The primary goal of this study is to determine whether habitats within the Santa Ana River below Prado Dam are sustainable or subject to significant degradation due to anticipated changes in hydrology and geomorphic changes to riverbed characteristics. Habitats within the Santa Ana River are critical to numerous threatened and endangered species such as the Santa Ana Sucker and Least Bell’s Vireo, and other native aquatic and terrestrial species. The study includes two phases—the first phase will review existing models and reports to analyze current understanding and gaps in knowledge about the potential degradation of physical habitat downstream of the Prado Dam within Reach 9 of the Santa Ana River. The second phase work plan will be developed in coordination with SDSU and USACOE.

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Joan Florsheim 9/15/13-2/28/17 $22,866

Edward Keller

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National Science Foundation EAR-1359734

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**Collaborative Research: RAPID: Short-and Long-term Sediment Dynamics Following Wildfire in Chaparral Environments**

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Wildfire disturbs sediment erosion, transport, and depositional processes in profound ways. Because of the acute reduction in vegetation and organic matter, soils burned by fire lose cohesion and infiltration capacity. Along with enhanced soil water repellency, runoff and flooding potential are elevated years after fire. Post-fire hydrologic and sedimentologic responses are extremely complex, varying with burn severity, rainfall regimes, geophysical characteristics, and vegetation recovery. Although researchers have studied these processes for more than 70 years, predicting post-fire effects remains elusive, and physically-based models of post-fire runoff and erosion are not yet complete. Part of the difficulty is that temporal windows for observing post-fire effects are comparatively short, with direct measurements tending to span only part of the recovery period (typically less than three years). Equally important are longer-term perspectives, however, in regards to how wildfire impacts Earth surface processes in the context of landscape evolution. Developing predictive understanding of both short- and long-term effects is critical to the future of our planet, especially in an era of changing climates that have increased frequencies and magnitudes of wildfires. This proposed RAPID project focuses on production and delivery of dry ravel, a characteristic and immediate post-fire response on steep slopes in the western USA. Dry ravel is a dry-season erosion process whereby gravel sediment moving down hillslopes by gravity becomes trapped by vegetation. Burning vegetation releases this sediment, enabling its accumulation at margins of ephemeral channels. Dry ravel therefore provides a significant source of sediment into river channels after fire in chaparral environments. The investigators will quantify the volume of dry ravel sediment derived from the recent Springs Fire that burned Big Sycamore Canyon in southern California during May 2013 Using Terrestrial LiDAR scanning (TLS) augmented by field surveys. Additionally, the investigators have geomorphic data spanning over 25 years for Big Sycamore Canyon and two comparable basins nearby with different fire histories. Thus, comparing the dry ravel processes at these three sites will enable a compelling story of both short- and long-term sediment dynamics following wildfire in chaparral environments. These data are critical toward developing models of the dynamics of dry ravel for further development and testing.

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Joan Florsheim 11/21/16-6/30/20 $125,000

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Sonoma County Agricultural Preservation and Open Space Distr 1016

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**Biophysical Approach Toward Riparian Conservation and Floodplain Ecosystem Functionality**

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In collaboration with SCAPOSD, this project will develop a biophysical rationale for designation of spatial extent required for riparian corridor conservation and floodplain ecosystem functionality using available LiDAR data. This project will also develop a science (bio-physical)-based rationale to identify elements central to conservation of floodplain ecosystems.

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James Frew 8/1/13-7/31/19 $250,364

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National Science Foundation 1302236

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**III: Medium: Collaborative Research: Citing Structured and Evolving Data**

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Citation is an essential part of scientific and scholarly publishing: it is used to gauge the trust placed in published data and, for better or worse, is an important factor in judging academic reputation. Now that much scientific publishing – especially data publishing – takes place through a database rather than conventional journals, how should something that is found in a database be cited? More generally, how should digital data that is stored in a repository with internal structure and which is subject to change be cited? This is the case for the very large number of curated databases through which much scientific publishing now takes place; it is also true of most scientific data collections, which are seldom stable.

There has recently been substantial interest in the problem of data citation, and various organizations have proposed structures for the format and content of citations; however most proposals do not address issues of structure and change that are intrinsic to databases. The focus of this proposal is to develop a framework for data citation which takes into account the following issues: (1) the potentially very large number of possible citations; (2) citations should be both human and machine readable; and (3) citations must conform to specifications prescribed by both the publishers of the data and by the various standards that are being established. All these give rise to interesting computational challenges: citations must be generated automatically from the data; the source data must be guaranteed to support the generation of these citations; and the generated citations must be guaranteed to conform to the specifications. Of course, as with any computational problem, all this must be done efficiently.

Citation is also closely related to provenance and issues of reproducible results. Workflows, executable papers, and microcitations have all been proposed to support reproducible analysis of data. The work of this project will explore the connections between these ideas and, where possible, establish a common framework.

For many databases, the publishers and authors have a clear idea of how they would like their data to be cited, and there is enough information in the database to enable these citations to be generated once the right computational machinery has been developed. However, interesting questions arise when a set of data to be cited is arrived at by means of a query, in which case the query itself may need to be included (an actionable citation). In other cases the navigational structure needed for meaningful citation – such as in the case with linked open data or RDF, which are ostensibly large amorphous graphs – may be missing. The challenge here is to find techniques for discovering or adding that structure to provide the necessary basis for citation.

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James Frew 8/30/18-8/29/20 $233,470

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Rilee Systems Technologies 80NSSC18M0118-1

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**STARE: SpatioTemporal Adaptive- Resolution Encoding**

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UCSB will develop two implementations of a multiresolution snow mapping procedure using STARE-indexed MODIS swath data: one based on files of MODIS granules with ancillary STARE indices, and one based on swath data loaded continuously into ScIDB with internal STARE index support. We will use these implementations to evaluate (a) the effectiveness of STARE indexing as an adjunct to a traditional file-based workflow; (b) the performance of SciDB versus a file-based workflow; and (c) the extent to which a non-trivial Earth science workflow can be implemented in SciDB. UCSB anticipates NASA funding the proposed scope directly

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James Frew 10/1/12-9/30/18 $372,000

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University Industry Research Corporation SB130034

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**Intel Science and Technology Center for Big Data - ISTC-BD**

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This project focuses on constructing EarthDB, a SciDB database of primary Earth observation data. Primary data is original sensor outputs or human observations, not subject to any reformatting, reprojection, aggregation, or other transformations beyond those required to digitize and ingest them. SciDB will allow common Earth science analytical operations (e.g., coordinate transformations, aggregation, spatial algebra, etc.) or data fusion (e.g., joins across multiple heterogeneous data types and representations) to be expressed as database queries against original observations, providing heretofore unavailable flexibility and traceability. We will populate the EarthDB pilot with data sources that challenge both scalability and heterogeneity. We have already demonstrated the feasibility of managing and processing MODIS "level 1" swath data (the lowest-level digital representation of this Earth imaging satellite sensor) in SciDB.

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Phil Gans 7/1/13-9/30/15 $31,915

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Great Lakes Exploration SB140046

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**Exploration of the Rochford Area, Black Hills, South Dakota: An Integrated Geologic Mapping and Framework Study**

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The Black Hills of South Dakota have historically been very successful in terms of economic mineral deposits, including the Homestake Mine, which produced over 30 million ounces of gold throughout its operational history. It has been determined that the Rochford mining district, which lies just to the south of the Homestake district, is a promising new prospect for exploration. This area has been selected by Great Lakes Exploration due to 1) USGS maps reporting significantly anomalous gold values 2) similarity of mineralization to the Homestake mine, and 3) the relative lack of mining claims throughout the district.

Great Lakes Exploration has expressed a need for a more detailed geologic understanding of the Rochford area in order to continue their exploration, and this proposal outlines the goals, specific types of work, research plan, and anticipated results that we will aim for throughout the next two years.

We propose to undertake an integrated geologic framework study, with the goal of providing Great Lakes Exploration with a more comprehensive understanding of the stratigraphy, mineralization, and structural controls for the Rochford and surrounding areas. Our focus will be mainly on mapping the Rochford area geology, focusing on iron formation trends and structural features with a focus on identifying structural controls or influence on the gold occurrences.

Our overriding objective is to gain a better understanding of the geologic framework of the Rochford area, with the expectation that this understanding will clarify why the anomalous gold occurrences appear where they do, including how and when the mineralization occurred, and how much subsequent structural disruption there has been. We believe that this type of geologic framework study will significantly aid efforts to find any potentially economically valuable targets in the area and help guide efforts to extend these studies throughout the region.

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Phil Gans 4/1/14-5/31/15 $25,677

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US Geological Survey G14AC00080

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**Geological Mapping of the Southwestern Whipple Mountains and Eastern Mopah Range, Southeastern California: Unraveling the Eruptive and Structural History of a Synextensional Miocene Volcanic Center**

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The lower Colorado River Extensional Corridor (CREC) is a premier natural laboratory for investigating large-magnitude continental extension. This proposal requests funds to facilitate two graduate student geologic mapping projects within the breakaway region of the CREC in southeastern California. The primary goals of this project are to: a) produce publishable digital geologic maps – a context map at 1:24,000-scale and two inset maps at 1:10,000 - with cross-sections and supporting data, allowing us to answer important scientific questions in the process, and b) to train two graduate students in the making of high-quality geologic maps and conducting field-based geological research. The students will map two independent but complementary areas: Mary Kate Fidler (Ph.D.) will map a 80 km2 area of faulted and tilted volcanic successions in the SW Whipple Mountains and eastern Mopah Range with the goal of understanding the detailed eruptive and faulting history of the shallow levels of the core complex. Beau Gentry (MS) will map a 50 km2 area in the Whipple Mountains that includes an extensive Miocene dike swarm in the footwall of the core complex with the goal of assessing the amount of tilting and intrusive dilation. In addition, both students and PI will map the enveloping 200 km2 area at 1:24,000 to provide geologic context. Our proposed study area is being actively explored for detachment-hosted gold and rare earth element mineral deposits, and this new data will be invaluable to these efforts. The PI will train and mentor the two graduate students during all phases of the project, which will primarily involve detailed mapping and field based structural and stratigraphic analysis. The mapping will form the basis for two graduate theses that will also include extensive petrologic, 40Ar/39Ar and U-Pb geochronologic studies funded by other sources.

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Phil Gans 6/1/16-8/31/17 $42,715

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US Geological Survey G16AC00157

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**Geologic Mapping of the Snake Range Metamorphic Core Complex, Eastern Nevada: Unraveling the Creatceous-Paleocene History of Burial and Partial Exhumation of Footwall Rocks**

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The Snake Range in eastern Nevada is an exceptional natural laboratory to investigate the deep burial and partial exhumation that characterizes the early history of most Cordilleran metamorphic core complexes. This effort will facilitate two graduate and two undergraduate student geologic mapping projects in a portion of the footwall of the northern Snake Range Decollement (NSRD), where the Miocene extensional overprint is less pervasive and older structures and fabrics are well-preserved. The primary objectives of this project are: 1) Produce publishable digital geologic maps, including two maps of key areas at 1:10,000, and a compilation of new and existing mapping to complete Six Mile Canyon 7.5’ Quadrangle at 1:24,000, with accompanying cross-sections and technical reports, and 2) Train two graduate and undergraduate students in the making of high-quality geologic maps and conducting field-based research. The four students will map independent but complementary areas: one will map an approximately 30 km2 area at 1:10,000 of intensely-folded Cambrian to Ordovician marble and calc-schist that is cut by an Eocene (?) dike swarm in the northernmost part of the range. The goals are to document the fold geometry associated with Mesozoic shortening, the geometry, kinematics and timing of different tectonite fabrics, and degree of footwall rotation. Another student (MS) will map a 35 km2 area at 1:10,000 along the western flank of the range, focusing on the geometry of a recently discovered east-directed thrust fault system. Two undergraduate students will be selected to join the EDMAP mapping effort for the last 4 weeks of summer to help complete the Six Mile Canyon 7.5’ Quadrangle. Our study will shed new light on how older thickening and extensional(?) events influenced the Miocene detachment faulting history in this (and other) core complexes.

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Brad Hacker 6/1/16-5/31/20 $260,619

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Boise State University 6800-G

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**PIRE: ExTerra Field Institute and Research Endeavor (E-FIRE)**

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The rheology of quartzofeldspathic crust is not well understood, despite being a critical aspect underpinning geodynamic models. Measurements of U-Pb ages of titanite of subducted crust can provide a map of how extensively quartzofeldspathic rocks recrystallize at subduction-zone conditions. In this project, U-Pb ages and trace-element concentrations of titanite will be measured in situ by laser ablation split-stream ICP mass spectrometry to provide a nappe-scale map of strain in the Brossasco–Isasca unit of the diamond-bearing Dora Maira massif. In collaboration with T. Gerya, geodynamic models of subduction of quartzofeldspathic rocks at similar P-T conditions will be assessed for concordance with the implications of the titanite measurements. Methods: Detailed field study, chemical mapping of major elements, trace elements and U-Pb ages using EPMA and LASS.

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Brad Hacker 2/1/09-1/31/15 $227,664

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National Science Foundation 0838264

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**Collaborative Research: Testing Channel-Flow Models Using Middle-Crustal Rocks of North Himalayan Gneiss Domes**

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Recently formulated thermal-mechanical channel flow/extrusion models which postulate that the middle crust exposed in the high Himalaya and southern Tibet was a low-viscosity, ductile material, bounded above and below by coeval normal- and thrust-sense shear zones, respectively, that flowed and extruded to the south. In light of these provocative models, it is time to test the channel flow hypothesis by determining whether the predicted low-viscosity channel is exposed in the North Himalayan gneiss domes and whether it shows the expected combination of southward flow and vertical thinning.

Flow within a channel can range from pure Couette flow to Poiseuille flow, or be a combination of the two. Couette (or linear) flow develops between rigid plates moving relative to one another and is characterized by simple shear (high vorticity number) with the highest velocities toward the top or bottom of the channel. Poiseuille (or parabolic) flow develops between stationary rigid plates in which a horizontal gradient in lithostatic pressure produces the highest velocities in the center of the channel and decreasing, but opposite, shear velocities toward the top and bottom of the channel. Poiseuille flow is characterized by high vorticity number (simple shear) at the top and bottom of the channel, decreasing vorticity number (mix of simple shear and pure shear or general shear) toward the center of the channel, and low vorticity number (pure shear) at the center of the channel.

This project will document the deformation vorticities, finite strain, temperatures, and timing during ductile flow, combined with existing thermobarometric, geochronologic, and thermochronologic data, will provide a comprehensive spatial, thermal, and temporal history of deformation and flow in middle crustal rocks, southern Tibet. Furthermore, our studies, combined with similar published and ongoing studies in middle crustal rocks exposed in the high Himalaya, will provide an unprecedented view of middle crustal flow parallel to the transport direction over a distance of 50100 km. Characterization of deformation over a broad range of spatial, thermal, and temporal scales is critical to testing models of middle crustal channel flow/extrusion within a collisional orogen and will provide invaluable insight into the role of the middle crust in the geodynamic development of the HimalayanTibetaan orogenic belt, and orogenic belts in general.

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Brad Hacker 4/1/13-3/31/16 $75,489

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National Science Foundation 1249486

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**Collaborative Research: The Role of Fluids in Intermediate-Depth Seismicity and Wedge Anisitrophy: Case Studies for Cascadia and Alaska, With a Comparison to Japan.**

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Large amounts of fluid enter Earth’s mantle through subduction of hydrated oceanic sediment, igneous crust and mantle. During subduction, a series of progressive devolatilization reactions release fluid from the slab. Some of these fluids enter the overlying mantle wedge and trigger melting that in turn leads to arc volcanism. While it is clear that fluids play an important role in the dynamics of subduction zones the precise fluid pathways remain unclear. Details of the fluid budget, the location of dehydration events, and the precise role of fluids in triggering intermediate-depth seismicity also remain unquantified. Recent seismological work has provided important new insights into the position of intermediatedepth seismicity in the slab and the role of seismic anisotropy in the interpretation of seismic velocities. The first allows us to test whether fluids are responsible in generating intermediate-depth seismicity; the second leads to improvements in the seismological mapping of fluids and melts within the mantle wedge. The strong non-linear influence of fluids on material properties and wave propagation makes it essential to use a forward modeling approach, where we predict the physical state of wedge and slab by dynamical models that take into account the best constraints from mineral physics and petrology. By comparing the seismological expression of these models with the observations we can iteratively improve the dynamical/petrological models. In the research proposed here we will develop new high-resolution 2D/3D finite element models of the dynamics and thermal structure of subduction zones. We will use petrological and mineral physics constraints to guide the choices for rheology and to predict the seismological expression of these models; in particular for velocity anisotropy. Using seismological modeling we will compare the predictions with observations and use an iterative approach to develop a suite of models that satisfy the observations. We will use these models to study the dynamics and structure of the subducting slab and mantle wedge at two GeoPRISMS primary sites (Alaska and Cascadia) and the well-instrumented Japan subduction system to address three main questions: 1) Does intermediate-depth seismicity indicate the presence of fluids? 2) Can we constrain the composition and deformation of the mantle wedge from observations of seismic anisotropy? 3) Can we use improved predictions for the petrological structure of the slab and anisotropic structure of the wedge to improve the locations of subduction-zone earthquakes? The focus sites are well-studied “warm” and “cold” subduction zone end-members and provide excellent testing grounds for the main research hypotheses.

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Brad Hacker 2/15/16-1/31/20 $332,772

John Cottle

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National Science Foundation 1551054

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**Collaborative Research: Characterizing and Modeling Crustal Recycling**

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Recycling of continental crust into the mantle is among the most-important processes driving the chemical and physical evolution of Earth. Mechanisms of crustal recycling include arc subduction, sediment subduction, continent subduction, subduction erosion, and foundering. These processes dictate the rates and types of crustal chemical and physical evolution—and even more-fundamental issues such as the secular evolution of continental volume—but are only loosely understood. This limitation has led to a wide range of viewpoints on the efficiency of the recycling process. If, for example, 95% of continental crustal material that is ablated by subduction erosion is returned to the mantle [Scholl and von Huene, 2007], this process reduces the global continental volume at a rate of ~1.3 km3 /yr and the eroded material comes from all crustal levels. Alternatively, if crustal material removed by subduction erosion undergoes buoyancy-driven fractionation, the mafic material may return to the mantle, but the felsic material may be relaminated to the base of the crust [Hacker et al. , 2011; 2015]. Our understanding of crustal recycling comes chiefly from i) geodynamic models, ii) large-scale box models that use specific isotopic systems to quantify recycling rates [Coltice et al. , 2000; Simon and Lécuyer, 2005]; iii) exposed arc rocks [Kelemen et al. , 2003; Ducea et al. , 2013], from which one can infer the magnitude and timescale of lower crustal foundering; iv) geophysical images of foundering material [Zandt & Carrigan, 1993]; and v) xenoliths, which provide snapshots of processes at depth. Among these techniques, xenoliths provide our only actual samples of the physical and chemical materials and processes involved in crustal recycling, and constitute our only way to verify or “ground truth” inferences made from geodynamic models, box models, exposed arcs, and geophysical images. For example, xenoliths provided the spectacular record of foundering of the Sierra Nevada arc lower crust and upper mantle [Ducea & Saleeby, 1996; Chin et al. , 2013], and the foundation for interpreting seismic velocities as images of the recycling process [Zandt & Carrigan, 1993]. In spite of the tremendous insight that xenoliths afford our understanding of crustal recycling, basically all xenoliths from mantle depths are mafic or ultramafic—with two exceptions: one locality in the Pamir and one in Tibet. These unusual xenolith localities thus present a special opportunity to understand the chemical and physical processes that attend crustal recycling.

We propose to integrate geochemical constraints from the Pamir xenoliths with geodynamic models to address the following questions:

• What is the timescale of recycling: how rapidly did the crust sink, metamorphose and melt?

• How do typical continental crustal rocks reach mantle depths?

• What mineralogical changes occur during recycling?

• How do density and buoyancy evolve during recycling?

• Under what circumstances can part of a typical crustal section founder?

• To what extent does sorting occur during recycling? For example, can mafic or ultramafic rocks pull felsic rocks

down into the mantle? Or do the felsic rocks always manage to escape on the way down?

• Is crust in the process of being recycled differentiable from the surrounding mantle using seismic wavespeeds?

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Brad Hacker 9/1/18-8/31/21 $91,110

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National Science Foundation 1829426

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**Collaborative Research: Structure and dynamics of the Alaska mantle wedge**

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The Alaskan subduction system is one of the planet's archetypal subduction zones, and studies here are the basis of much first-order understanding of subduction dynamics. The Alaska Transportable Array combined with several dense portable broadband experiments (BEAAR, SALMON, MOOS, WVLF) achieves unprecedented sampling of seismic wave propagation in the Alaska subduction zone. This proposal takes advantage of these data to test fundamental hypotheses regarding subduction structure and dynamics. The proposed project integrates new seismic observations, state-of-the-art wavefield simulations, and petrologically consistent models of subduction-zone mantle structure to test these hypotheses. It focuses on three distinct corridors for which EarthScope and related projects provide unusually good sampling: (a) the Cook Inlet corridor where normal Pacific lithosphere subducts and the arc is robust; (b) the nearly amagmatic Denali corridor where the Yakutat oceanic plateau subducts and generates intermediate-depth earthquakes; and (c) the Wrangell Volcanic Field corridor where slab seismicity is nearly absent but there is very high-volume volcanism. Observations of seismic attenuation provide proxies for thermal structure and melt abundance, and observations of shear-wave splitting constrain the anisotropic fabric and its variation between hot and cold parts of the mantle wedge. Parallel observations of seismicity and high-frequency phases that interact with the slab surface then allow Inferences about the mantle wedge to be compared with slab dehydration. High-frequency wavefield simulations of split shear waves will assess the maximum depth of a supra-slab anisotropic slow layer, a probable signature of slab-mantle coupling depth.

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Brad Hacker 6/1/11-5/31/16 $266,136

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National Science Foundation EAR-1008760

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**Collaborative Research: The Suturing Process: Insight from the India-Asia Collision Zone.**

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The suturing of continental fragments following the subduction of intervening oceanic lithosphere is a fundamental process in lithospheric dynamics and the shaping and growth of Earth’s continents. However, our understanding of this fundamental process remains limited. Can we use geological observations in some particularly well-exposed suture zones to make general statements about how landscapes and sedimentary basins evolve during suturing? What geodynamic processes lead to decreases in plate convergence rate? Are Mediterranean-style rollback of remnant oceanic lithosphere and opening of marginal oceanic basins characteristic of all or most pre-climax collision zones? Do presuturing ophiolite obduction and intraoceanic arc–continental margin interactions leave predictable signatures in suture zones? How is the upper continental plate preconditioned by pre-suturing tectonism and how does the upper plate evolve during the transition from oceanic to continental subduction? Is there a predictable mode of deformation in the downgoing continental plate? And what do we expect the balance to be among continental subduction and erosive removal of mass from a collisional orogenic system? We propose to address such questions through a 4-year investigation of the archetypal India–Asia collision zone (IACZ) in southern Tibet that involves 19 investigators and 14 graduate students from 9 different institutions. Techniques to be employed include structural geology, stratigraphy, geochronology, thermochronology, stable and radiogenic isotope geochemistry, igneous and metamorphic petrology, paleomagnetism, and geodynamical modeling. We aim to determine the: (1) evolution of paleogeography and paleoelevation during the transition from oceanic subduction to mature continental collision; (2) geodynamic processes that caused marked decreases in India–Asia convergence rate; (3) role of Mediterranean-style opening and closing of marginal basins prior to terminal collision; (4) metamorphic evolution of lower-plate (Indian) rocks in response to ophiolite emplacement, possible intra-oceanic arc collision, and continent collision; (5) role of pre-collisional Andean-style magmatism and deformation in preconditioning the upper-plate lithosphere and how this Andean-style system evolved during continent collision; (6) paleogeography of the Neo-Tethys margins and the history of subduction, exhumation, thickening, and underthrusting/rollback of Greater Indian continental lithosphere; and (7) spatial pattern, magnitude, and history of erosion and sediment dispersal. Our aims are ambitious but feasible because of the presence of rich, but as yet untapped geological records of appropriate age (Cretaceous to Miocene) adjacent to and within the India–Asia suture zone. Geodynamical modeling of suturing processes will run in parallel with the geological studies; this vital effort will help guide the evolving project. Whereas the IACZ will be used as our lab, we expect that our project deliverables (3-D pre-, syn-, and post-suturing reconstructions at the lithosphere scale) will provide fresh, well-constrained, and testable ideas about the suturing process and its role in continental crustal genesis.

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Brad Hacker 7/1/12-6/30/16 $329,701

Andrew Kylander-Clark

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National Science Foundation EAR-1219942

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**What Determines Whether the Deep Continental Crust Flows?**

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Understanding why and how the deep continental crust flows at high temperature and pressure is central to understanding a broad range of geologic processes, including flow in response to gravitational potential energy gradients, seismicity, plate flexure, plate-boundary deformation, and so on. There is however, uncertainty about how to quantify the influence of many factors— including rock composition, temperature, grain size, strain, fluid activity, and/or degree of melting—on flow of the continental crust at high temperature and pressure. This proposal presents an unusual opportunity to test which factors permitted or inhibited the flow of continental crust at high pressure and temperature in a well-understood orogen.

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Brad Hacker 3/1/14-2/28/19 $304,644

Andrew Kylander-Clark

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National Science Foundation EAR-1348003

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**What Causes UHT Metamorphism: Lengthscales and Timescales**

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Four endmember hypotheses for the cause of UHT metamorphism--subduction beneath an arc, collisional thickening + plutonism, strain heating, and extreme collisional thickening—will be tested using Ti-in-zircon, Ti-in-quartz, and Zr-in-rutile thermometry and pseudosection modeling, in conjunction with laser-ablation split-stream U/Th-Pb dates and trace elements of monazite and zircon.

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Brad Hacker 9/1/14-8/31/17 $173,765

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National Science Foundation EAR-1419751

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**Collaborative Research: Did the Pamir gneiss domes and salient form by northward underthrusting of India or southward subduction and rollback of Asia?**

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The Pamir orogen is distinguished by a pronounced, northward-convex salient and a spatially extensive, orogen-parallel suite of gneiss domes. Both the salient and gneiss-dome suite are thought to have developed synchronously and largely since Miocene time. At depth, the thick crust (≥ 65 km) of the Pamir is underlain by a cold mantle lid, interpreted to be northward underthrust Indian lithosphere; it is bound in the north by a southward-dipping zone of intermediate-depth seismicity that has been attributed to intracontinental subduction of Asian lithosphere. We propose to test two end-member ‘tectonic drivers’ that may genetically link all of these features: (1) a lower-plate-driven, relatively rapid and short-lived phase of northward rollback/retreat of a southward-subducting slab of Asian lithosphere, during which the Pamir gneiss domes accommodated significant net horizontal extension (~150 km) and growth of the Pamir salient; versus (2) an upper-plate-driven, protracted northward underthrusting/indentation of Indian lithosphere, which forced vertical exhumation of Asian mid-crust above it and southward subduction of Asian lithosphere beneath it. These two end-member scenarios are not mutually exclusive in that they may have acted in concert or played varying roles in space and time. Nevertheless, they make contrasting predictions at the scale of the entire orogen that can be assessed with geologic investigations. We focus this project on testing end-member model predictions for the kinematic, metamorphic, and magmatic evolution of the gneiss domes. Our approach will integrate (i) metamorphic petrology and monazite U/Th-Pb geochronology and heavy REE analysis to quantify the history of prograde and retrograde metamorphism, (ii) geologic mapping and structural analysis to constrain the kinematics of gneiss dome exhumation; (iii) moderate- and low-temperature thermochronology to quantify the history of exhumation; and (iv) U-Pb geochronology and isotope analysis of zircon (Hf) and titanite (Nd) to quantify the history and sources of Cenozoic magmatism.

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Robert Heilmayr 7/1/18-5/31/19 $73,615

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Global Canopy 20181164

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**Trase for Indonesian Palm Oil**

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The proposed research will collect and analyze data on palm oil supply chains and their impacts on forests and rural communities in Indonesia through an expansion of the Transparent Supply Chains for Sustainable Economies (Trase) platform (www.trase.earth).

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Robert Heilmayr 4/1/18-3/31/19 $51,220

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University of Wisconsin 811K204

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**Deforestation impacts of the Amazon Soy Moratorium**

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In 2017, the Gibbs Land Use and Environment Lab (GLUE) and the Heilmayr lab began a research collaboration to use econometric methods to assess the impact of the Amazon Soy Moratorium. Preliminary research focused on existing datasets spanning the Brazilian regions of Matto Gross and Pará. Consistent with previous studies, we found remarkably few violations of the Soy Moratorium. However, we also found no evidence to indicate that the Soy Moratorium caused observed reductions in deforestation and soy conversion.

To control for differences in public policies across Brazilian states, and to take advantage of available datasets, our preliminary analysis chose to focus upon the states of Mato Grosso and Pará. However, prior assessments have highlighted contrasting rates of deforestation in the Amazon and the Cerrado portion of Maranhão, Tocantins, Piauí and Bahia (Matopiba) as evidence of the moratorium’s impact (Gibbs et al. 2015). The spatial scope of our research must be expanded to assess whether the null result found within Matto Gross and Pará holds across the Amazon.

In this proposed research, we will expand the spatial scope of our analysis to include Maranhão, Tocantins, Piauí and Bahia. Across this expanded study region, we will use quasi-experimental econometric methods to estimate the causal impact of the soy moratorium. Furthermore, we will explore spatial variations in impacts from the Soy Moratorium as a function of the stringency and enforcement of public policies, and the cleared land bank in each of these regions. In addition, we will explore the possibility of using the assembled datasets to contrast the effectiveness of the Soy Moratorium to the Cattle Moratorium.

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Laura Hess 1/6/12-10/5/16 $1,139,723

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National Aeronautics and Space Administration NNX12AD27G

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**Land and Resource Use on the Amazon Floodplain Under Evolving Management Systems and Environmental Change: Fish, Forests, Cattle, and Settlements.**

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We propose to carry out integrated remote sensing, field, and modeling studies in order to quantify key drivers of land cover and land use change on the lower Amazon floodplain. We will use existing and new satellite (ALOS PALSAR, Landsat TM), aerial (historic aerial photography and videography), and socioeconomic data sets to address the following questions:

1) What have been the main trends in land cover change in the Lower Amazon region over the last fifty years?

2) What are the economic strategies of the three main groups of resource users: ranchers, smallholders and commercial fishers?

3) What has been the impact of the settlement and co-management policies now being implemented on land and resource use and floodplain vegetation cover?

4) How might climate induced changes in the Amazon flood regime impact floodplain land and resource use and consequently vegetation cover?

The study area for the proposed work encompasses the Amazon floodplain from the western border of the state of Para, Brazil, downstream to the mouth of the Xingu River.

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Laura Hess 12/14/18-2/28/20 $35,837

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National Science Foundation 1851993

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**Balancing biodiversity conservation with development in Amazon wetlands**

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The overall objective of the project is to work with stakeholders to identify solutions enabling preservation of biodiversity and ecosystem services in Amazon floodplain environments under a variety of development scenarios, and to provide support for decision-making at local and regional scales. An international team of scientists from Brazil, Colombia, the U.S., France, Germany, Norway, and the United Kingdom will develop scenarios of biodiversity and ecosystem services for the extensive floodplains of the lowland Amazon basin, which support one of Earth's great reservoirs of biodiversity. The focus is on floodplains of "whitewater" rivers, which include the mainstem Amazon floodplain and tributaries such as the Juruá. Seasonally inundated by nutrient-rich sediments, these floodplains have historically been centers for human settlements practicing subsistence agriculture supplemented by fishing and hunting; whitewater floodplain districts are thus the most densely populated rural areas in central Amazonia.

To explore scenarios of Amazonian floodplain biodiversity and services in a rapidly changing socioenvironment, the project will: 1) Map spatio-temporal variability of floodplain habitats, providing a basis for scaling up existing biodiversity data sets and for evaluating the potential impacts of regional drivers such as climate, land use intensification, and dams upon wetland habitats. 2) Characterize interactions between local populations and their environment and how they may adapt to changes in regional drivers, including socio-demographic and socio-economic drivers. 3) Analyze how public policies and governance have contributed to wetland habitat protection and freshwater biodiversity conservation.

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Laura Hess 1/14/14-1/13/19 $529,966

John Melack

Thiago Silva

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Virginia Polytechnic Institute and State University 426670-19B03

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**Impacts of floods and droughts on aquatic macrophytes, forests, and fisheries of central Amazonian river floodplains**

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The annual flood of the Amazon River is the world’s largest inundation event, flooding about 300,000 km2 for six or more months each year, with water levels reaching as high as 15 meters. This seasonal inundation connects river channels to adjacent floodplains, driving immense biological and ecological productivity. The ecosystem services derived from this floodplain system provide food and livelihoods for local people. However, climate and land-cover changes are increasing the frequency and severity of extreme climate events such as droughts and intense rain, resulting in greater variability and decreased predictability of the annual flood. This disruption may adversely affect fishery yields and floodplain vegetation productivity. Despite the importance of Amazon inundation dynamics for both ecosystem health and local livelihoods, we know relatively little about the vulnerability of these systems to changing climate and extreme events. This project will increase our understanding of the mechanisms linking basin-wide hydrology, river-floodplain connectivity, and the productivity of floodplain ecosystems by 1) quantifying the relationship between flood extent and the productivity of fisheries and floodplain vegetation and 2) modeling the effects of deforestation and extreme climatic events on inundation dynamics under historic and alternative future scenarios. This work is funded by NASA's Interdisciplinary Research in Earth Science program.

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Patricia Holden 1/1/15-11/30/19 $1,987,869

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California Department of Water Resources 14-476-550

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**Microbial Source Tracking in the Santa Barbara Region**

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Coastal marine waters in human developments may be contaminated by fecal indicator bacteria whose presence signals fecal pollution that impinges on public health and coastal fisheries. New DNA-based technologies can assist in determining if fecal pollution is associated with human waste and thus human pathogens, or if other animal hosts or natural sources explain. Further, such technologies, if applied in a watershed context within a qualified field study design, can enable determining fecal sources, e.g. failed civil infrastructure whose repair by owners can remedy the pollution and restore water quality. To date, several beaches in the Santa Barbara area have been researched for fecal pollution since fecal indicator bacteria concentrations in coastal waters were chronically elevated. Three beaches in Santa Barbara remain a high priority as determined by the Clean Beach Initiative in CA: East Beach at Sycamore, Leadbetter Beach, and Goleta Beach. In this project, the lower watersheds of each beach will be characterized for sources of fecal pollution, including evaluating infrastructure location and age. Hypotheses will be developed regarding potential fecal sources that impinge on surf zone water quality. Hypotheses will be tested using state of the art approaches in microbial source tracking applied within a field sampling program for each beach. Results will be used to inform stakeholders, i.e. water quality and infrastructure managers in the region, regarding sources that can subsequently be remediated. This is a three year project that builds on expertise in the Holden Lab group previously demonstrated in various State of CA clean beach initiatives and in the Santa Barbara region.

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Patricia Holden 9/9/14-1/31/15 $24,991

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City of Santa Barbara 21400222

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**Verification Monitoring in Santa Barbara**

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This research is to perform verification monitoring (VM) in Santa Barbara. In the SB region, there are beaches for which microbial source tracking (MST) and fecal source remediation were previously performed. VM is needed to verify that human fecal contamination sources have been remedied, and that other controllable sources such as domestic dogs and faulty septic systems are not causing ongoing surface water contamination. The overall and long-term goal is to improve microbiological water quality and public health at Santa Barbara beaches, which are very popular recreational and tourism destinations.

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Patricia Holden 11/8/16-1/31/18 $29,999

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City of Santa Barbara 21700093

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**Research in New Source Detection**

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In urban coastal zones where cities have variably aged sanitary sewer and municipal separate storm sewer systems (MS4s), untreated sewage can migrate from sanitary sewer defects through subsoil and into nearby storm drains.Such subsurface communication between these separate pipe systems threatens coastal water quality, since storm drains discharge to creeks that flow to the ocean. There is some evidence that the proximity of leaking sanitary sewers to storm drains, including where sanitary sewers cross over storm drains, may influence sanitary sewer contamination to MS4s. We previously showed this by real time studies, using rhodamine WT dye released into sanitary sewers and probing dye fluorescence continuously in a nearby storm drain coupled with sampling and analyzing for molecular evidence of human waste. In a separate study, we showed that populating a pipe leakage algorithm with GIS-based sanitary sewer system information (i.e. pipe material, diameter, and depth)—for pipes with invert depths within 3 m of the shallow groundwater table—allowed for explaining wastewater contamination in shallow groundwater as originating from leaking nearby sewers. We have further shown that this approach can be predictive of groundwater contamination. The goal of this current research is to determine if a similar GIS-based modeling approach of sanitary sewer pipe exfiltration probabilities can be adapted for predicting where storm drains might be contaminated by human fecal material entering MS4s from nearby leaking sewers. Through modeling of municipal sanitary sewer and MS4 infrastructure, this project identifies storm drains for field sampling. Up to twelve samples will be analyzed for fecal indicator bacteria, DNA-based markers of human waste, and potentially chemical markers. The broader goal of understanding which storm drains may be impacted by human fecal contamination would be addressed, thus enabling the City to employ their management approaches to remedy contamination. The overall and long-term goal of this research is to improve microbiological water quality and public health at urban beaches. In conducting this research, transferable knowledge and approaches are to be generated and disseminated via the published literature, thus contributing to the general body of knowledge in environmental management of microbiological water quality.

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Patricia Holden 1/1/14-1/31/16 $194,209

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Southern California Coastal Water Research Project (SCCWRP) 9406

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**Determination of DNA-based Fecal Marker Aging Characteristics for Use in Quantitative Microbial Source Tracking**

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The goal of the proposed work is to understanding how aging of fecal pollution affects the ability of managers and policy makers to interpret results from microbial source tracking assays. Microbial source tracking assays have been developed that are highly sensitive and specific, and this is a great advancement in tracking sources of microbial pollution in recreational waters. Our team has evaluated modern assays for their specificity and sensitivity, and has applied well-performing assays to identifying sources contributing to regional microbiological water pollution. However, interpreting assay results likely depends on the source of pollution, when it was released, and how it changed, or “aged”, within the environment. The relative abundances of assay markers are expected to change significantly during pollution source aging in the environment, but the magnitude of those changes and the factors that contribute are unknown. This makes interpreting assay results from environmental samples very difficult. The overall goal of this project is to determine aging characteristics and contributing factors in the field, and in the lab.

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Patricia Holden 1/1/17-12/31/19 $209,151

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UC Irvine 2017-3429

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**Fighting Drought with Stormwater: From Research to Practice**

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In this project, researchers from the six southern California UCs will catalyze widespread adoption of natural treatment systems (in particular, biofilters) for capturing, treating, and reusing urban runoff. The faculty team will conduct collaborative research across the following themes: (1) Human and ecosystem benefits of biofilters (UCLA lead); (2) Microbial communities in biofilter sediments in relationship to nutrient and pathogen removal (UCSB lead); (3) Biofilter removal of metals and nanoparticles (UCR lead); (4) Multi-physics modeling of biofilter water budgets and treatment performance (UCI lead); (5) Tailoring biofilter hydraulics to minimize urban flood risk (UCI lead); (6) Ecosystem and human co-benefit modeling plus coordinating field sampling across five UC campuses (UCI lead); (7) Cost-benefit analyses to uncover the true value of biofilters (relative to conventional stormwater management approaches), and evaluating the effectiveness of existing economic tools to incentivize their adoption (UCSD lead); and (8) Institutional and governance barriers to biofilter adoption (UCI lead). A citizen science component, to facilitate technology information transfer beyond the borders of UC campuses, will be led out of UCLA. Because the six campuses will be utilized as experimental test beds, our project will inform UC’s aggressive systemwide water-saving goals, and leverage UC’s goal of aligning research and academics with campus operations in a functional ‘living laboratory’.

This multi-campus UC program will solve, through interdisciplinary research and education, the biophysical and social barriers that currently limit the capture, treatment, and reuse of urban runoff in Southern California. The center will focus on natural treatment systems, such as biofilters (also known as rainwater gardens) that simultaneously augment municipal water supply and provide myriad co-benefits, including: receiving water quality and ecosystem protection, flood mitigation, urban heat island mitigation, carbon sequestration, urban green space creation, and local community engagement. Our center will be unique in its tailoring of sustainable runoff harvesting and reuse to southern California’s semi-arid climate, and it will leverage a multi-million dollar NSF-funded Partnerships for International Research and Education (PIRE) project that supports an evaluation of natural treatment systems implemented in Melbourne (Australia) during their decade long Millennium Drought.

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Patricia Holden 7/1/18-12/31/19 $509,325

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University of California MRP-17-455083

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**Fighting Drought with Stormwater: From Research to Practice**

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Peter Homyak 6/1/17-5/31/18 $45,000

Joshua Schimel

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Ford Foundation SB170159

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**Evaluating paradigms in phosphorus (P) biogeochemical cycling: The paradox of high P**

**availability in ecosystems developing on P-poor parent material**

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Californians, and residents in many arid regions, depend on montane ecosystems for freshwater. Environmental changes that threaten the quality of montane water supplies, therefore, have social, economic, and ecological implications. For example, because dusts can transport nitrogen (N) and phosphorus (P), processes increasing dust inputs to ecosystems can degrade water quality. In drought-impacted regions like California, fallow agricultural fields may serve as fertilizer-rich dust sources. Because in the Sierra Nevada Mountains—California’s principal water source—P availability drives landscape development, understanding how dusts impact these ecosystems is critical from an ecological and water management perspective. A long-held paradigm in ecosystem science postulates that while N is derived from the atmosphere, P originates from the weathering of rock, where denudation processes control P supply during ecosystem development. Over time, these processes deplete P-bearing minerals, leading to a “terminal steady state” of profound P-limitation. Paradoxically, in high-elevation ecosystems of the Sierra Nevada, shifts from P- to N-limitation and enrichment of soils and lake sediments with P suggest that over time, P availability is not decreasing—rather it is increasing. In these P-poor granite-derived systems, increasing P enhances loss to streams and lakes, lowering water quality, and may be altering the balance ecosystem C:N:P ratios. Changes in nutrient stoichiometry can affect plant and microbial activity and diversity, altering rates of primary production and organic matter decomposition. Exceptional drought covered >50% of the state with conditions expected to worsen. (http://droughtmonitor.unl.edu) question: if rock-derived P is expected to decline over time, what mechanisms maintain P supply to both lakes and terrestrial ecosystems?

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Matthew Jackson 7/1/15-12/31/15 $15,143

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American Samoa Power Authority SB150139

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**A preliminary geochemical characterization of lavas from a 600 meter drill core in Tutuila, American Samoa**

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This research effort will describe, sub-sample, and geochemically characterize the drill core in Tutuila, which represents a revolutionary opportunity to constrain the evolution of a Samoan volcano and to advance geological research in Samoa. Work at the drill site will include: logging all rock material that is cored, describing the petrographic characteristics of the core, and subsampling the core to build a basic petrological understanding of the core. The samples will then be used to generate an important preliminary geochemical dataset to constrain future work on Tutuila.

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Matthew Jackson 7/1/16-6/30/19 $299,928

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National Science Foundation 1624840

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**Preservation of Hadean geochemical signatures in the Icelandic high 3He/4He mantle domain**

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Helium isotopes provide a powerful tool for tracing early-formed reservoirs in the Earth’s interior. Lavas erupted at the Baffin Island flood basalt province, which record the initiation of Icelandic hotspot volcanism at 62 Ma, host the highest know terrestrial mantle-derived 3He/4He (50 Ra, ratio to atmosphere). Mid-Miocene Icelandic lavas record the second highest 3He/4He globally (43 Ra). Unlike the Baffin Island lavas, the mid-Miocene Icelandic lavas were not emplaced through continental crust. Thus, the Icelandic lavas provide the best opportunity to evaluate the radiogenic isotopic composition of the highest 3He/4He mantle domain, free of continental assimilation.

A recent discovery identified large magnitude 182W anomalies in Baffin Island lavas with high 3He/4He (≥ 43 Ra). In the 182Hf-182W system, 182Hf decays to 182W (t1/2 = 8.9 Ma), thus all 182W/184W heterogeneity was generated during the lifetime of 182Hf (<50 Ma after accretion). Therefore, the discovery of 182W anomalies shows that early-Hadean signatures have survived for >4.5 Ga in the dynamic mantle. The preservation of Hadean 182W anomalies in the modern high 3He/4He mantle is an exciting discovery, and provides a key constraint for geodynamic models seeking to describe the time-scales over which geochemical heterogeneities are preserved in the mantle.

The discovery of Hadean-generated 182W anomalies in lavas sampling the modern (62 Ma)

mantle leads to several key questions regarding the 3He/4He mantle sampled by the Icelandic hotspot: 1. Are positive 182W anomalies associated with high 3He/4He ratios in mantle-derived lavas at other localities? 2. Does a moderately high 3He/4He lava from Iceland’s neovolcanic zone, which hosts a Hadean 129Xe/130Xe signature, also preserve a Hadean 182W anomaly? 3. Do 182W anomalies exhibit relationships with He, Sr, Nd, Pb and Os isotopes? Such relationships will provide insights into the geodynamic processes that preserve 182W anomalies in the mantle.

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Matthew Jackson 8/15/17-7/31/20 $299,756

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National Science Foundation 1736984

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**Origin of highly heterogeneous 87Sr/86Sr in melt inclusions from oceanic hotspot lavas**

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Whole rock geochemical analyses of ocean island basalts (OIB) have long been considered windows into the composition of the mantle. However, blebs of trapped melt in phenocrysts, called melt inclusions, complicate this picture; this is because melt inclusions from a single lava can exhibit highly heterogeneous 87Sr/86Sr ratios that span much of the variability observed in oceanic lavas globally. The origin of the isotopic diversity in melt inclusions remains a source of debate: Is it the result of mixing pristine magmas from different mantle sources, or the result of crustal assimilation? At the heart of this question is the origin of the geochemical diversity in oceanic lavas and their utility as windows into the mantle’s composition.

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Matthew Jackson 5/1/19-4/30/22 $98,714

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National Science Foundation 1900652

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**Collaborative Proposal:Deciphering the LLSVP-plume relationship**

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Amongst the most enigmatic aspects of the mantle are anomalously low shear wave velocity provinces (LLSVPs) whose origin, composition, dynamics and interaction with the mantle remain controversial. LLSVPs have been suggested to control the distribution and chemistry of hot spots. For example, it has been suggested that plumes form predominantly at the edges of LLSVPs and that entrainment from the edges of LLSVPs causes the distinct chemical asymmetry observed at many hotspots. Elucidating how LLSVPs control plume location and entrainment can explain both geochemical observations at hotspots and provide crucial information on the nature and composition of LLSVPs. We are proposing an

experimental fluid dynamical study to explore how three proposed LLSVP structures control and interact with mantle plumes. These three structures represent the range of LLSVP formation hypotheses so far proposed: a) purely thermal; b) dense and deformable; c) undeformable and uncoupled. We will use state-of-the-art visualization tools, including scanning particle image velocimetry and thermometry to measure the three-dimensional temperature and flow fields, laser induced fluorescence and Lagrangian analysis tools to locate plumes and quantify entrainment to very high spatial and temporal resolutions. We will use idealized and realistic LLSVP geometries derived from seismic tomography to make predictions about plume location and material entrainment. We seek to test both location control and whether entrainment at the edges explains the observed chemical asymmetry in hotspot lavas.

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Matthew Jackson 8/1/14-7/31/17 $37,702

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National Science Foundation EAR-1347377

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**Collaborative Research: The role of oxygen fugacity in calc-alkaline differentiation and the creation of continental crust at the Aleutian arc**

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Geochemical exchanges between the Earth’s surface and interior at subduction zones drive major changes in magmatic composition that potentially generate Earth’s continental crust. Among the key characteristics shared by bulk continental crust and some subduction zone magmas is calc alkaline affinity, a rapid draw-down in Fe concentration early in a magma’s cooling history. Most hypotheses for explaining calc-alkaline differentiation from a primary magma invoke a combination of the effects of elevated H2O and oxygen fugacity (fO2), both of which are common in arc magmas, on the early solid phase assemblage when arc magmas begin to crystallize. The relative importance of H2O, fO2 and magmatic bulk composition in generating calc-alkaline magmas, however, remains an outstanding and important question. Moreover, although the elevated H2O contents of arc magmas are generally thought to derive from the subducted lithosphere, no such consensus has been reached for the cause of elevated fO2 in arc magmas. Contrasting models link oxidizing processes either to an oxidizing flux from the subducted plate, concomitant with (though not directly caused by) the addition of H2O, or to an oxidizing process in the overriding plate (e.g., crystallization, degassing), through which magmas pass before eruption. Resolving the key roles that H2O, fO2, and magmatic bulk composition play will have important implications for models of how Earth’s continents initially formed and have grown through time. Lavas of varying calc-alkaline affinity, from strongly calc-alkaline to mildly tholeiitic, erupt along the Aleutian arc, making it an ideal natural laboratory for constraining the petrogenesis of these magma types. This study will provide critical new constraints on the fO2 of variably calcalkaline magmas in the Aleutian arc, and explore how fO2 is linked to magmatic H2O, contributions from the subducted plate, and various differentiation processes, through the combined study of melt inclusions, whole-rocks, and petrological experiments. To do this, we will measure dissolved volatiles, Fe3+/**Σ**Fe ratios, and isotopic signatures of melt inclusions and/or whole-rocks from the Eastern and Western Aleutians, and pair these natural studies with experimental constraints on the effects of H2O, fO2, and bulk composition on the phase equilibria of Aleutian parental magmas.

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Matthew Jackson 6/1/14-12/31/15 $111,566

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National Science Foundation EAR-1348082

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**Collaborative Research: Using sulfur isotopes to identify subducted Archean crust in modern oceanic hotspot lavas**

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A consequence of modern plate tectonics is that subducting ocean plates transport oceanic crust and sediment into the mantle. However, the fate of the subducted package--oceanic crust and sediment--in the mantle is poorly understood. A long-standing hypothesis maintains that subducted materials residue in the mantle for an extended, but unknown, period of time and are then recycled back to the Earth's surface in regions of buoyantly upwelling mantle and melted beneath hotspots. If this hypothesis is correct, ocean island basalts (OIB) erupted at hotspots should exhibit geochemical signatures associated with the crustal protoliths that were injected into the mantle at a subduction zone in the geologic past. However, it has been difficult to unequivocally detect geochemical signatures of ancient subducted materials in hotspot lavas. This project will use measurements of mass independently fractionated sulfur (MIF-S) isotope signatures--made using two complementary techniques--in key hotspot lavas to trace crustal cycling from the surface, through the mantle and back again.

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Matthew Jackson 9/1/14-12/31/19 $524,244

John Cottle

Brad Hacker

Matthew Rioux

Syee Weldeab

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National Science Foundation EAR-1429648

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**MRI: Acquisition of a Thermal Ionization Mass Spectrometer (TIMS) for high-precision research of the Earth's mantle, crust and oceans**

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The Earth Science Department at UCSB has maintained a core strength in radiogenic isotope geochemistry since the 1960s, from the Thermal Ionization Mass Spectrometry (TIMS)-based geochronology and geochemical advances of George Tilton and James Mattinson to the modern laser ablation split-stream (LASS) inductively coupled plasma mass spectrometer (ICP-MS) facility currently operated in the department. Four young PIs leading this project (Jackson, Cottle, Rioux and Weldeab) were trained on modern TIMS instruments and actively utilize TIMS-based measurements in their current NSF-funded research; the students and post-docs of PI Hacker also make extensive use of TIMS in their research. However, a modern functioning TIMS is lacking at UCSB. This project will replace the 30-year-old MAT261 TIMS at UCSB to enhance the success of the research programs of the PIs and their ability to teach and mentor graduate and undergraduate students. The arrival of the new instrument will coincide with the completion of a state-of-the-art, metal-free clean lab built as part of PI Jackson’s start-up. The new TIMS facility at UCSB will: 1) enable new fields of discovery by opening up new analytical avenues for research (e.g. ultra-precise 142Nd/144Nd, precise analyses of sub-nanogram quantities of Sr and Nd isotopes, and high-precision U/Pb ages on (sub-) single zircons); 2) transform UCSB’s analytical capabilities, permitting development of cutting edge new analytical techniques that combine high precision TIMS with in situ isotopic and elemental analyses using the laser ablation multi-collector (LA-MC)-ICP-MS and electron-probe microanalyzer (EPMA); and 3) carry the excitement for research and discovery in analytical geoscience to the next generation of researchers and teachers. The new TIMS at UCSB will enable transformative research in studies of the Earth’s crust, mantle and oceans.

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Matthew Jackson 9/2/13-1/31/15 $99,395

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National Science Foundation EAR-1430610

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**Isotopic diversity in Mangaia melt inclusions: Mantle source or crustal assimilation?**

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Olivine-hosted melt inclusions (“inclusions” hereafter) are trapped by growing phenocrysts in magma conduits at depth and provide “snapshots” of diverse melt compositions before complete melt aggregation. Inclusions reveal major and trace element diversity that is not clear from analyses of whole rock lavas alone and the origin of this diversity continues to be a source of vigorous debate. One end member hypothesis is that the diversity in inclusions reflects heterogeneity in mantle source compositions. Alternatively, the diversity of inclusion compositions may result from magmatic processes, including crustal assimilation.

In a groundbreaking discovery, extreme Pb-isotopic variability—spanning 50% of the range identified in global ocean island and MORB lavas—was measured in olivine hosted melt inclusions from a single lava collected from the island of Mangaia (Cook Austral Islands). While many of the Mangaia inclusions host a Pb-isotopic component similar to lavas from the island, a surprising result was that some inclusions host less radiogenic Pb-isotopic ratios never before seen in Mangaian lavas. The origin of the Pb isotopic diversity in these inclusions is not well understood and the discovery of isotopic variability gave rise to a host of fundamental questions. Why is it that the inclusions are not isotopically representative of the bulk magma? Is it because inclusions from a single lava trap melts from isotopically-diverse mantle sources? Or, does the isotopic diversity reflect assimilation of the lithosphere during magma ascent? Unfortunately, bulk abundances of elements most sensitive to crustal assimilation (like B, Cl and K) have never been paired with Pb-isotopic compositions in the same inclusions from Mangaia. As a result, it has not been possible to evaluate whether the Pb-isotopic variability in Mangaia inclusions relates to mantle source variability or crustal assimilation.

In an attempt to evaluate the origin of the isotopic variability in inclusions from Mangaia, the PI used start-up funds to undertake a pilot study with his student (Ms. Rita Cabral) in which 14 inclusions from Mangaia were analyzed for major, trace and volatile elements. The data from the pilot study are intriguing and hint at a possible role for crustal assimilation. However, the data are limited and robust conclusions cannot be drawn without additional data, and mantle source variability is possible. In particular, Pb-isotopic measurements on the inclusions are necessary to determine whether proxies for crustal assimilation relate to the Pb-isotopic variability. Thus, this proposal seeks funding to make additional measurements to test the following hypotheses:

1.) If the Pb isotopic diversity in Mangaia inclusions is a result of crustal assimilation processes, the Pb-isotopic compositions will correlate with indices of assimilation (e.g., high Cl and B).

2.) Alternatively, the isotopic diversity in Mangaia inclusions reflects diverse mantle sources beneath Mangaia that contribute isotopically-heterogeneous melts to inclusions.

To test these hypotheses, this proposal seeks funding to measure 87Sr/86Sr (which is also sensitive to assimilation of seawater and crustal materials) and Pb isotopic ratios and major, trace and volatile abundances in the same inclusions, and expand the study to include a larger suite of inclusions from three Mangaia lavas. The proposed measurements will constrain the relative roles of magmatic processes and mantle sources in generating heterogeneous inclusions, and will be important for understanding magma transport and emplacement processes in the lithosphere.

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Matthew Jackson 7/1/13-9/30/15 $184,293

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National Science Foundation OCE-1153894

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**Collaborative Research: Using the Rurutu hotspot to evaluate mantle motion and absolute plate motion models**

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Hotspot tracks have long been used as an absolute reference frame for absolute plate motion (APM) models. However, the two longest-lived Pacific hotspot tracks, the Hawaiian-Emperor and Louisville seamount chains, exhibit hard-to-explain differences in behavior prior to 45 Ma: (i) The Hawaiian-Emperor show a pronounced “kink” while the Louisville chain is gently curved, and (ii) while the Louisville hotspot likely remained geographically fixed (results of recent IODP Expedition 330), Hawaii drifted 15° south. Differences in hotspot fixity may arise from ridge capture and ridge-related flow modifying plume upwelling, the mantle wind tilting plumes, movement of the plume base, or large-scale reorganizations of tectonic plates affecting global mantle flow. As a result, these complicating processes diminish the accuracy of APM models for the Pacific Plate in particular, and our understanding of mantle dynamics in general.

We propose that adding a third, long-lived Pacific hotspot track can help to deconvolve the effects of plate versus plume motions. Recent evidence suggests that the Rurutu hotspot is long-lived (~100 Ma), follows a hotspot track midway between Hawaii and Louisville, and shows a pronounced 155° bend like Hawaii between 35-55 Ma. Combining Sr-Nd-Pb-Hf geochemical and 40Ar/39Ar age data will allow us to test the hypothesis that the Rurutu hotspot is both geochemically continuous and and possibly the longest-lived hotspot in the Pacific.

We propose to obtain new age and geochemical data for the critical region around the poorly characterized Rurutu hotspot bend. This data will help define a third Pacific hotspot track that will help deconvolve plate from plume motions between 40 and 80 Ma. Specifically, we propose to test the following two hypotheses: (1) The Rurutu hotspot is a long-lived, geochemically-distinct hotspot like the Hawaiian and Louisville hotspots; and (2) the Rurutu hotspot exhibits a pronounced bend, and the timing of the Rurutu bend matches the timing of the (pronounced) Hawaii-Emperor and (less pronounced) Louisville bends at ~50 Ma. To test these hypotheses we propose to: (1) Dredge 20 key volcanoes at the Rurutu hotspot bend--defined by the intersection of the Tuvalu and Samoa chains--to determine its precise location and timing; (2) Geochemically characterize 60 samples to evaluate a link to the modern-day Rurutu hotspot; (3) Compare the predicted Rurutu age progression from various APM models to 45 new 40Ar/39Ar ages to be measured from these seamounts.

This data from the Rurutu hotspot will allow us to trace the longest-lived hotspot in the Pacific and construct an APM model for the Pacific Plate that is less sensitive to plume motion.

The University of Texas at El Paso (UTEP) is a Hispanic Serving Institution and the only US research-intensive doctoral university with a Mexican-American majority student population. We will recruit the most promising undergraduate students from PI’s classes taught at UTEP, Boston University (BU) and Oregon State University (OSU). We will bring 9 nine undergraduate students on the cruise, including an IDES (Increasing Diversity in Earth Sciences) undergraduate student from OSU Furthermore, the project will support three graduate students, who will gain seagoing experience and will work on the sample suite at their respective home institutions. At sea we will organize four outreach activities: (1) run a real-time cruise website, (2) produce new bathymetric maps for the Seamount Catalog (http://earthref.org), (3) organize an at-sea seminar series for the further education of the nine undergraduate students, and (4) provide compositional analysis training for the undergraduates using a portable LIBS (Laser Induced Breakdown Spectroscopy) system. Finally, the nature of the research will foster the ongoing collaboration between the research programs at UTEP, BU and OSU, where the funding helps to support their analytical facilities. This project will also support 2 young investigators (Konter, Jackson).

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Matthew Jackson 3/15/17-8/31/17 $24,770

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University Corp For Atmospheric Research - Ucar Z17-28065

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**Climate Adaptation and Mitigation Program**

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Two major components of the NOAA OER mission are to prepare for and execute multidisciplinary scientific expeditions that integrate exploration, education, and outreach objectives, and to ensure that deliverables from these expeditions are generated and distributed. EX conducts expeditions that execute a new paradigm for systematic ocean exploration utilizing telepresence technology installed aboard the NOAA ship Okeanos Explorer (EX), a concept referred to as "remote science". One of the vessel's key capabilities is utilizing telepresence to engage scientists ashore. Through telepresence, scientists will participate from Exploration Command Centers on shore in Hawaii, Rhode Island, Oregon, Washington, New Hampshire, Massachusetts, Maryland, Silver Spring, and other remote locations using internet and telephone access. These scientists will monitor and guide the operations of the ship's technical team to accomplish mission objectives.

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Chen Ji 8/15/14-1/31/15 $54,630

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Total S.A. (France) SB150037

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**Collaborative Project Between Total and University of California, Santa Barbara: Developing and testing a method to simultaneously inverting moment tensor solutions and locations for micro-seismic events near a high velocity interface**

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Barnett CEDF project was conducted on May 2011, including nine stages of hydraulic fracturing experiments on two horizontal wells CEDF 5H and CEDF 8H. To achieve a better determination to the source depth, every stage was recorded by 2 down-hole arrays. However, this dataset has three known limitations. First, the two arrays were not synchronized. Second, the relative aperture of the observational arrays is small. If assuming the spatial interval of two geophones is 50 ft, the length of the vertical array is about 600 ft and that of the horizontal array is around 400 ft. Both of them are much smaller than the distances between the micro-seismic events and the closest geophones, which are up to 3500 ft. Third, the hydraulic fracturing treatments were conducted along two horizontal wells, which locate right above a high velocity layer. The first arrivals of induced seismicity then can be either direct Pd phase or head wave Pn phase. The error in phase identification leads to the error in locations. A better velocity structure is needed. Considering these limitations, the source locations based on only the P and S wave picks shall always include significant error, in particular the source depth. Here we conduct a synthetic experiment to explore the difference in observed waveforms caused by the source depth, relative to the high velocity interface. Analogous to the velocity structure found during Barnett project, in this synthetic experiment we let the P-wave velocity change from 3.5 km/s (14000 ft/s) to 4.5 km/s (18000 ft/s) across the interface.

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Chen Ji 2/1/13-1/31/17 $25,000

Ralph Archuleta

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University of Southern California Y86552-I

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**SCEC4 Participation, Project I: Developing and testing Realtime finite fault inversion and ground motion prediction algorithms using ShakeOut synthetic datasets**

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The Great Southern California Shake-Out (www.shakeout.org) is a NEHRP-coordinated, multihazard response exercise based on an Mw 7.8 rupture scenario of the southern San Andreas fault (Jones et al., 2008) in order to improve public awareness and readiness for the next great earthquake in southern California. Several kinematic and dynamic rupture scenarios (Graves et al., 2008; Olsen et al., 2009) had been created to artificially break a 305 km long segment of the San Andreas fault, from Bombay Beach, on the Salton Sea, to Lake Hughes, 20 km northwest of Palmdale. Multiple groups have preformed the deterministic ground motion modeling for low frequencies (<1Hz) using SCEC CVM4 velocity structure and some of results were in good agreement (Bielak et al., 2010). Graves et al. (2008) also generated the broadband (0–10 Hz) ground motion simulations, which combines a 3D deterministic approach at low frequencies (<1 Hz) with a semi-stochastic approach at high frequencies (>1 Hz). Currently, this unique dataset has been used yearly for the ShakeOut earthquake drill, which had 8.6 million participants this year. Here we propose to use it as a benchmark to test algorithms of quick finite fault inversion and ground motion prediction. We propose to address the following questions:

1) How quick can we determine the focal mechanism, seismic moment of this scenario earthquake using the new MDC approach?

2) How quick can a finite fault source model based on current algorithm be available?

3) What is the spatial-temporal resolution using current strong motion and high rate GPS stations?

4) Can we improve the results with additional stations? If so, where are their locations? Note that the previous simulations produced the waveforms at dense surface grids, allowing us to address this subject without additional expensive forward calculations.

5) How well will the predicted strong ground motion be? Considering the limited waveform information used to constrain the realtime finite fault, the quick solution might not be very precise. Then what is the quality of the predicted ground motion parameters such as PGV and intensity?

In the end, as suggested by committee, efforts will focus on internally operating this

realtime system in UCSB and USGS Pasadena office. We also attempt to incorporate the

USGS realtime GPS data flow into the system.

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Chen Ji 2/1/12-1/31/17 $30,000

Ralph Archuleta

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University of Southern California Y86552-R

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**SCEC4 Participation, Project R: Characterization of induced micro-seismicity associated with one hydraulic fracturing experiment near the San Andreas Fault, Central California**

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With an agreement between UCSB and Venoco, we are able to access micro-seismic observations of one multi-stage hydraulic experiment. The experiment was conducted on a site only 8 km away from the San Andreas fault in Central California. This will allow the following three research activities: 1) Improve the location and detecting limitation of microseismic events using a linear array of receivers. All research activities rely on precise event locations. Due to cylinder symmetry, we cannot locate earthquakes using only the travel-time information collected by such a sub-vertical array; the polarity information must be used. Most uncertainties in locations result from the relatively large uncertainties in polarization analysis. We expect that the multiple path effects of a cluster of events shall be similar, the relative locations of these events shall be much better. The relocate earthquake catalog will be used to track the migration of micro-seismic events during the post-stages periods. 2) Focal mechanisms. A single-azimuth data set (as in single well monitoring) in the far field cannot resolve the dipole perpendicular to the plane of stations and the hypocenter [Vavrycuk, 2007]. However, we could exclude the unresolvable moment tensor (MT) component in a suitable coordinate system and determine the class of MTs constrained by the data [Jechumtalova and Eisner, 2008]. As the initial attempt, we will specially focus on the events with single-phase. 3) Stress drop of seismicity induced by hydraulic fracturing. For small magnitude events, reliable determination of corner frequency requires accurate knowledge of Qp and Qs, which can be constrained using spectral ratio derived from perforation shots [Eaton et al., 2014]. A better constraint to stress drop may help us to distinguish the events directly associating with hydraulic fracking and induced tectonic earthquakes along the fault.

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Chen Ji 2/1/12-1/31/17 $11,000

Ralph Archuleta

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University of Southern California Y86552-S

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**SCEC4 Participation, Project S: M 7.x SIV-Benchmark Simulations for greater L.A. Region**

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This collaborative project will develop the specifications and synthetic data for the next Source Inversion Validation (SUV) benchmark problem (2015/2016). The overall action plan, time line, and roles of each team are as follows:

• April 2015, Teams Caltech/ UCSB: define macroscopic rupture specification, in consultation with SCEC’s Community Fault Database, previously generated scenario ruptures (e.g. Cybershake) and the SIV-requirements in terms of complexity of the rupture and its radiated spectral contents

• May 2015, Teams KAUST / Prague: develop the complete space-time description of the finite-fault rupture model, based on the above specifications; small-scale variability in slip, rupture speed, rise time will be included using the k2-square‐model or pseudo‐dynamic source simulations; we will examine whether spontaneous dynamic rupture simulations are feasible, and preferable over kinematic scenarios

• June 2015, Team UCSB: compute initial set of teleseismic synthetics using the “standard” approach by the UCSB group (same as in the USGS finite-fault inversion approach) • June 2015, Team Caltech: generate regional-scale synthetics and teleseismic data for back- projection analysis

• June‐July 2015, Teams KAUST / Prague: generate local synthetics (seismograms and GPS) in 1D, and 3D model, including multi-scale random perturbations in the velocity structure

• July 2015, Team KAUST: Generate near-field data set and synthetic GPS; disseminate synthetic data for inversion validation, computed in a fully deterministic velocity structure (e.g. “no noise” synthetics)

• August 2015, Team KAUST: Generate and distribute various datasets, computed with multi-°©‐scale random variations in near‐source velocity structure (e.g. “noisy” synthetics)

In particular, the UCSB team will be involved in the following tasks:

Task 1. Define the source model In coordination with the Caltech team, we will help to defining the source for the benchmark scenario, a hypothetical large rupture in Southern California based on the following general characteristics: Magnitude between 7 and 7.4, such that the teleseismic data clearly show finite-fault effects; thrust-faulting mechanism, potentially on a buried fault; location in the greater L.A. region.

Task 2: Generating the Synthetic Data for finite fault Source Imaging In coordination with Caltech team, we will generate synthetic seismograms for the benchmark of finite fault source imaging methods. Two sets of synthetic data will be produced. The first set of data is constructed precisely using 1D earth model. The data noise caused by scattering-attenuation in earth crust structure will be included in the second set of synthetic data.

Task 3: Finite fault inversion using local and teleseismic waveforms Finite fault inversions using local and teleseismic data will be conducted. The impact of inaccurate Green’s functions will be investigated.

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Charles Jones 7/15/11-6/30/16 $466,314

Leila Carvalho

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National Science Foundation AGS-1053294

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**The Madden-Julian Oscillation and Predictability of Extreme Precipitation in the United States**

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Extreme precipitation events are among the most devastating weather phenomena and are oftentimes associated with loss of life and property. The Madden-Julian Oscillation (MJO is the most prominent form of tropical intraseasonal variability in the climate system and has significant influences on the occurrence of extreme precipitation and forecast skills in the medium-to-extended ranges. The main goal of this proposal is to advance our understanding of the influence of the MJO on the predictability of extreme precipitation in the contiguous United States on lead times of 1-14 days during boreal winter. The specific objectives are:

I. Examine how the amplitude of the MJO modulates the predictability of extreme precipitation.

II. Investigate the relationships between the life cycle of the MJO and predictive skill of extreme precipitation.

III. Study the mechanisms by which the MJO influences the predictability of extreme precipitation.

The project has two main elements: 1) develop a detailed analysis of the relationships between the MJO and its impact on the predictive skill of extreme precipitation, 2) Investigate teleconnection mechanisms by which distinct properties of the MJO may have different impacts on the predictability of extreme precipitation. The proposal will test the hypothesis that variations in the characteristics of the MJO (e.g., amplitude, duration and eastward propagation speed, primary and successive events, phase evolution and El Niño /Southern Oscillation- ENSO state) have different influences on the predictability of extreme precipitation.

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Arturo Keller 6/16/14-8/31/15 $109,921

Sangwon Suh

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Cal EPA Toxic Substances Control, Department of 13-T3804

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**Chemical Life Cycle Database and Visualization Tool**

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Many consumer products contain chemicals that are known to be detrimental to human health and the environment. However, due to the current lack of regulation, chemical content disclosure and consumer awareness, most manufacturers have little incentive to replace chemicals-of-concern (COCs) with safer alternatives. Assembly Bill 1879 requires DTSC to develop the Safer Consumer Products Regulations that establish a process to identify products that pose high risk to humans and the environment. Once identified, the regulations require manufacturers to evaluate safer alternatives to COCs in those products by following an AA protocol and considering the impacts of the COCs and alternative formulations from life cycle (LC) perspective. By integrating LC thinking into the AA, manufacturers can avoid shifting environmental burdens and making environmentally unfavorable substitutions. California State regulations permit DTSC to compile a list of 1,200 candidate COCs. The list of candidate chemicals can be found at http://www.dtsc.ca.gov/SCP/ChemList.cfm. DTSC must identify consumer products containing COC’s and compile guidance for AA. The regulations apply to any COC – containing product sold, distributed, supplied or manufactured for sale in California. In March of 2014, DTSC issued a list of 3 high-priority products of concern. DTSC is researching other specific product/chemical combinations of interest. The newly established Chemical Life Cycle Network (ChemLCNet) project at the Bren School, UCSB, will be developing a toolkit to assist manufacturers, governments and researchers to determine the life cycle environmental implications of existing and new chemicals. The toolkit will be instantiated as an open-access, interactive web-based tool that implements a parametric life cycle assessment (LCA) model of chemicals production, use, and end of life.

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Arturo Keller 4/23/15-6/30/16 $93,500

Roland Geyer

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Cal EPA Toxic Substances Control, Department of 14-T3952

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**Pilot Study on Alternatives Assessment**

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Many consumer products contain chemicals that are known to be detrimental to human health and the environment. However, due to the current lack of regulation, chemical content disclosure and consumer awareness, most manufacturers have little incentive to replace chemicals-of-concern (COCs) with safer alternatives. Assembly Bill 1879 requires DTSC to develop the Safer Consumer Products Regulations that establish a process to identify products that pose high risk to humans and the environment. Once identified, the regulations require manufacturers to evaluate safer alternatives to COCs in those products by following an AA protocol and considering the impacts of the COCs and alternative formulations from life cycle (LC) perspective. By integrating LC thinking into the AA, manufacturers can avoid shifting environmental burdens and making environmentally unfavorable substitutions.

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Arturo Keller 10/1/13-7/31/14 $9,995

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Electric Power Research Institute 00-10001423

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**Publication on "Use of InvEST to evaluate ecosystem services"**

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This research is related to generating a peer-reviewed publication from the work done by Dr. Keller’s team at UCSB for EPRI, using the InVEST model to evaluate ecosystem services. The Natural Capital Project’s InVEST toolkit is the result of a collaborative effort between Stanford University, World Wildlife Fund, and The Nature Conservancy (www.naturalcapitalproject.org). The InVEST tool consists of the following models:

1. Biodiversity: Habitat Quality & Rarity

2. Carbon Storage and Sequestration

3. Reservoir Hydrologic Balance

4. Water Purification: Nutrient Retention

5. Sediment Retention Model: Avoided Dredging and Water Quality Regulation

6. Managed Timber Production Model

7. Crop Pollination

Modeling of proposed landuse changes at an AEP property was completed in December 2012, with a final report to EPRI submitted at that time. The current work will transform that final report into a peer-reviewed publication.

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Arturo Keller 11/1/11-2/28/15 $83,554

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Electric Power Research Institute EP-P42069/C18398

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**Modeling Nutrient Credit Calculations in Ohio River Basin**

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The scope of this research includes the following tasks:

1. WARMF model simulations to support credit estimation

UCSB will provide supporting information from available WARMF model simulations to assist in calculating credit values between credit suppliers and identified coal-fired power plant buyer facilities. These efforts will also include updated assessments of credit needs based on WQT drivers applicable to each potential buyer.

2. Participate in two ORB committee meetings

UCSB will participate in two ORB committee meetings to share WARMF model simulation results and integrate findings or their assessments into other tasks being addressed by the project team.

3. Evaluate pilot trades and test an interstate trading framework

UCSB will run WARMF simulations to assess the potential water quality outcomes of proposed trades.

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Arturo Keller 9/15/15-2/29/16 $2,479

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National Science Foundation 1554142

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**International travel to participate as reviewer for the third joint transnational call of the ERA-NET SIINN**

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International travel to participate as reviewer for the third joint transnational call of the ERA-NET SIINN on innovative transnational research proposals focused on manufactured nanomaterials, held in Lisbon, Portugal. Provide expert advice on proposal selection for the third joint transnational call of the ERA-NET SIINN on innovative transnational research proposals. Increase collaboration between US (NSF) and European research agencies, promoting high quality research that benefits citizens in both continents.

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Arturo Keller 8/1/17-7/31/18 $25,000

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National Science Foundation 1748352

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**Sustainable Nanotechnology Conference**

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The Sustainable Nanotechnology Conference will be held in November 5 - 7, 2017 in Marina del Rey, California, supported in part by National Science Foundation resources. The 2017 conference will cover the following topics: Green Synthesis, Life Cycle Assessment, Water Treatment, Fate and Exposure, Nanotoxicology, Sensors & Measurement, Education and Social Aspects, and Food & Agriculture. All of these topics will address the sustainable use of nanotechnology to achieve societal goals.

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Arturo Keller 5/15/19-4/30/22 $389,981

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National Science Foundation 1901515

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Developing and Integrating "-Omic" Tools to Elucidate Nanoparticle Transport Mechanism and Responses in Agricultural Crops

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Overview. The tunability of the surface properties of engineered nanomaterials (ENMs) continue to broaden the range of their applications in food, agriculture and environmental protection. In agriculture, ENMs are used in biosensing, enhanced nutrient transport, and improved pathogen protection by controlling size, surface charge, polarity, and electronic properties. However, their proposed applications and associated responses are mostly based on assumptions that ENMs are taken up by terrestrial plants via diffusion of constituent ions through stomatal openings on leaves, root epidermis or tissue injury. The dissolved ions or bio-transformed ENMs are anticipated to move through the apoplast to reach the plant vascular system, following the established route of mineral nutrients through ion channels. There is limited understanding and no conclusive evidence yet on the mode of entry of ENMs and subsequent transport in plants. Advanced spectroscopic and microscopic techniques have been used to locate ENMs and transformed species within plants; however, despite the depth and precision of these powerful techniques, they are limited by resolution, sampling bias, analytical costs, high exposure concentrations and sample preparation artefacts.  In addition, the current literature is contradictory with regards to the transport kinetics, and reported mechanisms differ with plant species, exposure conditions, as well as growth medium. This gap in the understanding of nano-plant interaction limits utilizing ENMs in agricultural applications at their utmost potential. Sensitive endpoints at a molecular level are needed to identify the biomarkers associated with ENM cellular transport. We propose to use -omic approaches to elucidate the mode of uptake of metal based nanoparticles (MNPs) by crop plants. Our primary objectives are to: (1) characterize MNPs in natural exposure conditions and in vivo; (2) apply discovery proteomic tools to identify plasma membrane and apoplastic proteins involved in cellular uptake and transport of MNPs in plants; (3) apply untargeted metabolomics to identify metabolite regulation in plant tissues involved with MNP uptake and localization; (4) validate the candidate biomarkers using targeted proteomics and metabolomics.

To address these objectives, we propose root and foliar exposure of three crops (soybean, corn, and lettuce), grown in artificial soil medium. The plants will be exposed to MNPs such as Cu(OH)2, MoO3, Mn3O4, and CeO2 at environmentally relevant concentrations. Plant plasma membrane proteins (IMPs) and apoplastic proteins (APs) are critical candidates for this study as they participate in communication between cells and extracellular environment, ion transport, protein translocation/integration, and signal transduction. To achieve our goal, the IMPs and APs in roots and leaves from respective root and foliar exposures will be selectively enriched in our sample pool, which will then be used for discovery proteomics. The tissue metabolites will also be collected and fractionated into hydrophilic and hydrophobic components for untargeted metabolomics. Advanced high-throughput liquid chromatography-mass spectrometry (LC-MS) will be employed for the untargeted proteomics and metabolomics. Upon initial screening, the candidate proteins and metabolites will be validated and quantified using targeted approaches across different exposure period and concentrations, followed by meta-data integration to identify universal biomarker of MNP exposure. This workflow has been shown to be effective for drug development and targeted delivery in humans; thus it is a logical approach for elucidating MNP transport and effects mechanisms in plants.

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Arturo Keller 8/1/13-7/31/14 $45,000

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National Science Foundation CBET-1343638

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**Second Sustainable Nanotechnology Conference (2013)**

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The Sustainable Nanotechnology Conference will be held in November 3 - 5, 2013 in Santa Barbara, California, supported in part by National Science Foundation resources. The 2013 conference will build on the previous year’s focus on lifecycle assessment, green synthesis, green energy, industrial partnerships, and environmental and biological fate, and will include additional emphasis on economic and societal aspects of nanotechnology. In particular, sessions on Sustainable Manufacturing, Tools for Achieving Sustainable Nanotechnology, Nano-economics, and Nano science and engineering in agriculture and food systems will serve to provide more emphasis to these aspects of sustainability.

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Arturo Keller 9/1/08-8/31/14 $8,250,820

Patricia Holden

Hunter Lenihan

Barbara Harthron

Galen Stucky

Roger Nisbet

Bradley Cardinale

Joshua Schimel

William Freudenburg

Ed McCauley

Sangwon Suh

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National Science Foundation SB090050

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**CEIN (2008-2014) Predictive Toxicological Assessment and Safe Implementation of Nanotechnology in the Environment.**

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The UC Center for Environmental Implications of Nanotechnology (UC CEIN) studies the effects of nanomaterials on a range of biological systems in terrestrial, freshwater, and marine environments. From this research, the UC CEIN will design a comprehensive risk-ranking model, based on the potential toxicity, mobility, and persistence of the nanomaterials. With the rapid development of nanotechnology, little is known about the possible environmental, health, and safety impacts of nanomaterials.

UC CEIN research is primarily conducted at UC Los Angeles and UC Santa Barbara, with several important partner institutions. Within the UC CEIN, UCSB takes the lead on fate and transport, ecotoxicological, and risk perception studies, collaborating primarily with researchers at UCLA, UC Davis, UC Riverside, University of Texas at El Paso, Columbia University, and University of British Columbia.

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Arturo Keller 9/1/13-8/31/20 $5,384,336

Patricia Holden

Hunter Lenihan

Galen Stucky

Joshua Schimel

Roger Nisbet

Sangwon Suh

Robert Miller

Barbara Harthorn

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National Science Foundation SB140059

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**CEIN (2013-2018) Predictive Toxicological Assessment and Safe Implementation of Nanotechnology in the Environment**

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The UC Center for Environmental Implications of Nanotechnology (UC CEIN) studies the effects of nanomaterials on a range of biological systems in terrestrial, freshwater, and marine environments. From this research, the UC CEIN will design a comprehensive risk-ranking model, based on the potential toxicity, mobility, and persistence of the nanomaterials. With the rapid development of nanotechnology, little is known about the possible environmental, health, and safety impacts of nanomaterials. UC CEIN research is primarily conducted at UC Los Angeles and UC Santa Barbara, with several important partner institutions. Within the UC CEIN, UCSB takes the lead on fate and transport, ecotoxicological, and risk perception studies, collaborating primarily with researchers at UCLA, UC Davis, UC Riverside, University of Texas at El Paso, Columbia University, and University of British Columbia.

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Arturo Keller 3/31/11-3/30/16 $103,713

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Ohio Water Development Authority SB110060

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**Water Quality Modeling of the Ohio State Component of the Ohio River Basin Water Quality Trading Program.**

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We will implement the WARMF model for the two sections of the Ohio River,

(USGS HUC 0503 and 0509) that run through Ohio, as well as the Great Miami River (HUC 0508) watershed (Figure 2). For hydrological connectivity, small sections of surrounding states will also be modeled. For those major tributaries that are not yet modeled (e.g. HUC 0502, Monongahela) and that drain into this section of the Ohio River, we will use the ORSANCO monitoring data as a placeholder for the flows and loads from these watersheds. This proposed project will benefit from our existing efforts funded by USEPA, since we have already established the connections with Ohio EPA and ORSANCO to obtain the needed point source and observed water quality information. Implementing the model involves obtaining a number of datasets such as topography (digital elevation model), hydrologic network and observed hydrology from USGS; land

use data from the 2001 National Land Cover Dataset, supplemented with the 2008 Cropland Survey for Ohio from USDA; point source and water quality observations data from Ohio EPA; ORSANCO monitoring data. The TWG project has allowed us to develop a number of software tools and algorithms for processing these large datasets to more rapidly implement each new watershed. If we did not have these tools, the cost of implementing the model for these three HUCs (0503, 0508 and 0509) would be approximately twice the proposed budget, given the large area considered. The watersheds will be modeled at the 10-digit HUC level, as shown in Figure 2. For practical purposes, the models are implemented as distinct subwatersheds that can be run independently or together in a master project. Thus, if someone needs to run a scenario for a small section within a watershed, it is not necessary to run the entire master model. Data set collection and incorporation into the model will take approximately 3 months. Once the model is implemented and calibrated, the model will be used to develop the “trading coefficients” for the entire state of Ohio. This involves evaluating the effect of a load reduction in a given location, and its impact on the rest of the downstream watersheds. A matrix of the trading coefficients will be generated, for use in the broader WQT program. The matrix will also be displayed graphically using ArcView or any other accepted Geographical Information System software. A number (approx. 20) of trading

scenarios within Ohio will be evaluated, to illustrate the use of the model for WQT. The final report will detail the model implementation, calibration, analysis of the WQT scenarios, and an explanation of the trading coefficient matrix. A proposed water quality monitoring program in support of the WQT program for the state of Ohio will also be included in the final report.

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Arturo Keller 7/1/18-12/31/19 $7,980

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University of California SB190022

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Magnetic permanently confined micelle arrays (Mag-PCMAs) for the elimination of emerging contaminants from environmental samples from Lake Chapala

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We propose the use of Mag-PCMAs for the elimination of emerging organic contaminants from natural waters of Lake Chapala, México, focusing on the adsorption of PPCPs, which represent a threat to the organisms living in the lake and the surrounding communities. Initially, batch treatments will be conducted to determine the removal efficiency of the most abundant contaminants found in the water samples. We also propose the dispersion of Mag-PCMAs within alginate-based hydrogels to evaluate their suitability and efficiency to remove contaminants from water when embedded in a 3D matrix. A filter will be designed and tested at laboratory scale to demonstrate the suitability of this novel platform for the removal of contaminants of emerging concern from water. This ultimately might lead to the development of large scale engineered filters for the supply of clean water.

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Edward Keller 5/1/17-6/30/18 $2,840

Daniel Morel

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Evolving Earth Foundation SB170164

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**Chronology and Deformation of the Gaviota Coast near Santa Barbara, California**

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The main goal of this research project is to resolve the terrace chronology across the SBSYF. OSL is an ideal geochronometer for this study for a number of reasons. Fossil corals on the Gaviota Coast are sparse, making U-series dating impractical. There are occasional mollusk shell beds, but radiocarbon dating cannot be relied upon completely because the terrace ages may be beyond the upper limits of radiocarbon dating (~45-50 ka without isotopic enrichment; Walker, 2005). West of the SBSYF, this is almost certainly the case. Fortunately, marine terrace quartz sands are abundant and have ideal characteristics for OSL dating, i.e. a depositional environment and texture (fine-medium grain size, well-sorted) that suggest a high degree of bleaching (Nelson et al., 2015). These characteristics mitigate potential concerns with OSL dating. Moreover, local terrace sands have been shown to be amenable to OSL (Gurrola et al., 2014), further affirming the method’s utility in this coastal setting. Lastly, the upper limits (~150-200 ka depending on dose rate) and resolution of OSL (± 5-10%; Rhodes, 2011) are sufficient to date and distinguish between the expected terrace ages of ~45 ka and ~80 ka.

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Edward Keller 1/19/16-12/30/16 $9,264

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UC Sea Grant College Program R/HCME-31PD-F

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**The Impact of Sea-Level Rise on Coastal Erosion: Using the Coming 2015-2016 El Niño as a Surrogate for 50-100 years of Expected Sea-Level Rise in Central California**

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California has the third largest population living within a meter of sea level in the United States (Strauss 2012). A major impact of climate change with rising sea levels is increased coastal erosion of beaches and sea cliffs. Billions of dollars of property are at increased risk if coastal erosion accelerates (Ryan et al. 1999). The last powerful El Niño in 1998 raised local sea levels in Central California by as much as 20-30 cm (Huyer et al., 2002). This rise is equivalent to the projected sea-level rise in Central California near the end of the 21st century (Cayan et al. 2008, 2009; NRC, 2012). The 2015-16 El Niño is shaping up to be a very strong event that will likely bring higher sea levels in California. Tidal records in Santa Barbara suggest that it has already risen about 15 cm as of mid-October, 2015. Mean sea level rise for Santa Barbara in recent decades is 0.73 ± 1.2 mm/yr (NOAA, 2015). For Southern California, considering tectonic processes, the rate is 1.5 to 2.4 mm/yr (Reynolds and Simms, 2015). Projected global rise in sea level is 18-48 cm by 2050 (Board of Earth Sciences and Resources, 2015).

The purpose of the proposed research is to quantify the extent of coastal change in beaches and sea cliffs as a result of both the expected El Niño storms during the winter of 2015- 2016 and the rise in sea level as a result of El Niño. We intend to use a combination of existing 2006, and 2009-2011 high-resolution airborne LiDAR (Light Detection and Ranging), as well as new terrestrial LiDAR data, which we will obtain from equipment available at the University of California, Santa Barbara.

Higher waves and sea levels will increase rates of coastal erosion along beaches and sea cliffs (Sallenger et al, 1998; Komar, 1998). However, very little work has quantified these changes over a particular time period and at particular places. The 2015-2016 period provides a unique opportunity to observe changes attributable to higher sea levels, and perhaps, to more intense storms with higher waves. These may then be compared with existing 2006 and 2009- 2011 LiDAR airborne results to visualize and measure changes (Rosser et al. 2005; Young et al. 2006). The research will continue after the El Niño into 2016, to determine if erosion rates return to pre-El Niño values.

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Bruce Kendall 8/1/11-7/31/15 $260,763

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National Science Foundation DEB-1120865

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**Collaborative Research: Demographic heterogeneity in landscapes and communities**

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Variation in phenotypic traits occurs within all populations. This, in turn, creates variation in demo- graphic traits — the propensity to survive more or less, or to have more or fewer offspring (contrast with the actual life history an organism experiences — its demographic fate; see Kendall & Fox 2003), as well as individual growth and dispersal rates. While ecologists do use models (like linear matrix models) that classify individuals by age, stage or size, and sex, most assume that in doing so they have captured suffi- cient variation, so that further variation is simply noise of small amplitude. This is not necessarily the case. This variation in traits occurs even when within categories such as age, stage, size, or sex. We use the term “demographic heterogeneity” to refer collectively to the variation in birth, death, growth and dispersal rates among individuals in an age, stage, or size class.

Demographic heterogeneity can be produced by various mechanisms including genetic variabil- ity(Yashin et al. 1999, Ducrocq et al. 2000, Gerdes et al. 2000, Casellas et al. 2004, Isberg et al. 2006),spatial heterogeneity in the habitat(Gates and Gysel 1978, Boulding and Van Alstyne 1993, Menge et al. 1994, Winter et al. 2000, Franklin et al. 2000, Manolis et al. 2002, Bollinger and Gavin 2004, Landis et al. 2005), unequal allocation of parental care(e.g., Johnstone 2004; Manser&Avey 2000), seed heter- omorphisims(e.g., Silvertown 1984; Venable &Burquez M 1990), maternal family effect (Fox et al., 2006), learned feeding preferences (Bolnick et al. 2003) and social rank (e.g., von Holst, Hutzelmeyer, &Kaetzke 2002). Demographic heterogeneity is taxonomically widespread. For example, heterogeneity in survival has been found in crocodiles (Isberg et al. 2006), baboons (Bronikowski et al. 2002), birds (Wintrebert et al. 2005, Fox et al. 2006), wild plants (Beckage and Clark 2003, Landis et al. 2005), domestic ani- mals(Ducrocq et al. 2000, Casellas et al. 2004), and humans(Yashin et al. 1999, Garibotti et al. 2006), including British aristocrats(Doblhammer and Oeppen 2003).

Demographic heterogeneity has been shown to have a variety of effects on population dynamics. Heterogeneity in survival and reproduction can change the population variabliltydue to demographic sto- chasticity, often reducing it relative to a homogeneous population with the same average rates. Hetero- geneity in survival, if it persists throughout the life cycle, creates cohort selection, which in turn increases the asymptotic population growth rate and equilibrium population densities. Finally, heterogeneity in dispersal ability can increase the rate at which an invading population spreads.

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Roland Knapp 3/23/17-10/31/19 $92,862

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California Department of Fish and Wildlife P1620105

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Three crucially important conservation actions to recovery R. sierrae in the northern Sierra

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This effort aims to inform recovery of Federally Endangered Sierra Nevada yellow-legged frogs. Actions will be undertaken to re­establish three Rana sierrae populations in the portion of the Desolation Wilderness managed by the Lake Tahoe Basin Management Unit. This work will continue efforts conducted during 2013-2016, that included translocations of adults and egg masses from the Rivendell source population (Eldorado National Forest) to Lake Lucille and/or Jabu Lake in 2013 and 2014, collection of eggs and/or metamorphs from the Rivendell source population in 2013 and 2014 for captive rearing at the San Francisco Zoo, and reintroduction of captive-reared adults to Lake Lucille and/or Tamarack Lake in 2014, 2015, and 2016. Insufficient time has elapsed to determine the outcome of these efforts. During the current project (11/1/2016-10/31/2019), we will continue efforts to establish self-sustaining R. sierrae populations at Jabu Lake, Lake Lucille, and Tamarack Lake. This will be accomplished via translocalions, and reintroductions of captive-reared frogs. All populations will be intensively monitored using capture-mark­recapture (CMR) methods. On completion, this project will provide key insights into the feasibility of restoring R. sierrae to this portion of the Desolation Wilderness, allow comparisons of the success of frog translocation versus captive rearing/reintroduction, and make recommendations regarding recovery methods that should be considered in future R. sierrae recovery efforts both in the Desolation Wilderness and across the species' native range.

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Roland Knapp 9/30/18-9/30/23 $96,601

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National Park Service

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Restoring Genetic Diversity of Endangered Mountain Yellow-legged Frogs in Extirpated Watersheds

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Recovery of the endangered Sierra Nevada Yellow-legged frog is dependent upon reintroductions of gnetically appropriate source populations to historically occupied habitats. Currently, large portions of formerly occupied watersheds are now completely extirpated due to human-induced factors such as fish stocking and the importation of disease. Even when these factors are reversed or stabliized, remnant yellow-legged from populations are often too small and at risk of local extinction to act as sources fro reintroduction. In order for the Park Service to fulfill its mission of recovering this listed species, a ground-breaking new approach is being proposed to preserve as much genetic diversity as possible while there is still time. Should this effort prove successful through a culmination of partnerships with researchers and close collaboration with the U.S. Fish & Wildlife Service, the results could be far reaching beyond park boundaries and set the course for reintroductions and ercovery range-wide.

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Roland Knapp 6/10/15-6/10/20 $10,325

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National Park Service P15AC01412

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**Restoring rare frogs in Yosemite National Park**

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This project focuses on the restoration of rare frogs in Yosemite National Park. Work includes site visits and follow-up assessments at nine SNYF populations using visual encounter survey (VES) at: Galllson Lake, Unicorn Basin, Conness Pond, East Merced Pass Lakes, Breeze Lake, No. Lyell Basin Lakes, Kuna Basin Lakes, Obelisk Lakes and Clark Ford Lakes. Continue to assess past SNYF translocation success at six sites, using capture-mark-recapture (CMR); translocate SNYF into six locations.

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Roland Knapp 9/30/16-9/30/21 $44,703

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National Park Service P16AC01701

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Critical Restoration Efforts to Recover Endangered Mountain Yellow-legged Frogs in Sequoia and Kings Canyon National Parks

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In this collaborative effort, UCSB will focus on assessing one high-priority persisting Mountain Yellow-legged Frogs (MYLF) population using visual counts, translocate adults to augment or re-establish MYLFs in a separate waterbody, and assess translocated frogs using CMR; assess one reintroduced MYLF population using CMR (translocating frogs to separate waterbodies if large enough to safely allow and assess translocated frogs using CMR); perform sex determinations and install PIT tags in all translocated frogs prior to being moved; conduct disease assays in all waterbodies containing reintroduced or translocated frogs.

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Roland Knapp 12/31/99-00/00/00 $0

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National Park Service P19AC00789

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**Assess Condition and Habitat of Parkwide Endangered Mountain Yellow-legged Frog Populations in SEKI and YOSE to Inform Design of Recovery Strategies**

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This condition assessment is critically needed for effective planning and implementation of recovery actions undertaken on behalf of the federally endangered mountain yellow-legged frog in Sequoia, Kings Canyon, and Yosemite National Parks (SEKI and YOSE). To provide this assessment, the results of numerous frog recovery actions undertaken in SEKI and YOSE during the past ten years will be rigorously analyzed to quantify their effectiveness. These actions include (1) disease treatments conducted with early frog life stages (tadpoles and juveniles), (2) disease treatments conducted with adult frogs, (3) frog translocations, and (4) frog reintroductions. Data to be included in these analyses include those from repeated visual encounter surveys, capture-mark-recapture surveys, and disease assays. Results from each action will be critically reviewed to assess their effectiveness and feasibility, and form the basis for a prioritization of future actions.

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Roland Knapp 4/1/18-3/31/19 $4,372

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San Francisco Zoo SB170145

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Disease Assays For Frog Captive-Rearing Program – San Francisco Zoo

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The San Francisco Zoo participates in a broad range of public outreach and public service programs, including supporting the recovery of endangered amphibians in California by rearing animals in captivity. For the past five years, the Knapp research group at the Sierra Nevada Aquatic Research Laboratory has been assisting the zoo in their efforts related to recovery of the endangered mountain yellow-legged frog (Rana muscosa, Rana sierrae). During this time, we have collected early life stage animals for captive rearing and reintroduced captive-reared animals back into the wild. One of the major threats to the mountain yellow-legged frog is the amphibian chytrid fungus (Batrachochytrium dendrobatidis; Bd). This novel pathogen has been spread worldwide by global commerce and has caused the decline or extinction of hundreds of amphibian species. Given the high susceptibility of mountain yellow-legged frogs to this pathogen, as part of the captive-rearing protocol animals are frequently screened for the presence of Bd. Because the Bd assay requires highly specialized and expensive equipment that the zoo does not have access to, the zoo requires assistance in analyzing these samples. Sample analysis entails extraction of DNA from skin swabs, and the use of real-time quantitative PCR to estimate Bd concentration. Sample results will be provided to the zoo in digital form, and additional interpretation and analysis of the results will be provided as necessary to aid the zoo in making husbandry decisions.

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Roland Knapp 9/22/15-7/31/20 $46,464

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USDI Fish and Wildlife Services F15AC00500

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Treatment and prevention of infection by Bd in two species of mountain yellow-legged frogs

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This research focuses on 1) completing a range-wide assessment of Mountain Yellow Legged Frog genetic diversity and 2) understanding specific factors that may confer resistance to an invasive fungal pathogen. The Rosenblum Lab at the University of California, Berkeley is responsible for conducting molecular lab work and molecular data analysis for the project. Specifically, the Rosenblum Lab will be genotyping frog samples using several custom genotyping assays we have developed. In year 1, we will run a custom Fluidigm assay on swab samples. In year 2, we will run a restriction site associated DNA sequencing "RAD-seq" assay and an Exon capture assay on tissue samples. The Rosenblum Lab will work collaboratively PI Knapp on data synthesis, manuscript preparation, and translating findings for conservation managers.

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Gary Libecap 1/1/15-12/31/17 $283,780

Christopher Costello

Andrew Plantinga

Olivier Deschenes

Paulina Oliva Vallejo

Kyle Meng

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UC Office of the President MR-15-328650

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**Legal Economic Data and Analysis of Environmental Markets**

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New initiatives in environmental and natural resource management are based on property rights that assign resource ownership directly or use rights in specified ways. This rights-based approach can be more effective than traditional regulation. Rights-based management helps California meet environmental goals in innovative ways, and joint legal/economics analysis of such approaches places the University of California at the forefront of new environmental approaches. Establishing property rights is necessary for markets that create incentives and facilitate transactions to enhance resource value and provide environmental quality. Examples are individual transferable quotas in fisheries, tradable development rights and mitigation banks in land use, habitat credits for endangered species, water rights and water quality trading, and conservation banking for ecosystem protection. Knowledge of how these rights must be structured and how the resulting markets function to achieve environmental and other goals is incomplete. Comprehensive empirical research requires information bases that have not been assembled. We propose a Planning Award for this research infrastructure through efforts by scholars in economics and law and to make it available to the UC System and California. Legal scholarship is needed for understanding which aspects of property rights enable transactions, for showing how legal institutions affect creation of property rights, and for identifying how uncertainty, monitoring problems and asymmetric information are addressed. Economics scholarship is needed to understand how property rights affect incentives, resource use and social value. This project consists of economists and law faculty in the UC System. This Planning Award project has the goal of defining research agendas and assembling data bases on property rights and market transactions to solve environmental problems. These databases would include registries of transactions for use rights associated with fisheries, water, and land. Ultimately, we will use the data assembled by the Planning Award for drafting a Program Award for collaborative efforts in empirical research aimed at understanding why property rights can be used in some situations but not in others, and why markets arise easily and function smoothly in some environmental resource settings, but not for others. California policy questions motivate the databases compiled, including over-exploitation of fisheries, inefficiencies in water use, conservation of endangered species, and ecosystem protection.

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Francis MacDonald 9/1/18-8/31/20 $91,191

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National Science Foundation 1916698

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Collaborative Research: Did the Formation of the Great Unconformity Trigger Oxygenation and the Cambrian Explosion?

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This proposal aims to constrain the timing, magnitude, and spatial heterogeneity of erosion that lead to

development of the Great Unconformity (GU) to test hypotheses for oxygenation and the Cambrian

explosion. The GU is one of the most geologically significant and largest temporal gaps in the rock

record, marking the boundary between Precambrian and Phanerozoic time. It has been proposed that

erosion below the GU delivered bio-limiting phosphorous to the ocean, which spurred organic carbon

burial, oxygenation of the ocean-atmosphere system, and the rise of animals. Determining when the GU

developed (whether during Rodinia mantle upwelling, early Rodinia breakup, the Cryogenian Snowball

Earth glaciations, or Late Ediacaran rifting) and deciphering the size of the last erosion event preceding

GU formation (whether km's or 100s of m) are critical for identifying viable mechanisms for evolutionary

change during this pivotal interval of Earth history. However, because the temporal gap across the GU is

so substantial, the timing and magnitude of erosion under the GU are largely unconstrained. Recent

advances in (U-Th)/He thermochronology allow access to the thermal histories required to unravel the

history of this iconic feature. This proposal outlines a strategy to acquire zircon and titanite (U-Th)/He

data for samples along two regional transects characterized by minimal post-GU burial overprinting from:

(1) the Superior Craton eastward across the Appalachian margin; and (2) the Kalahari craton westward to

the Gariep belt. These transects are designed to capitalize on the PIs' collective experience working in

these regions. Study sites will be targeted to fully exploit Neoproterozoic and Cambrian geologic

constraints, which will be vital for narrowing the range of viable thermal histories to enable

discrimination between GU formation models. The results will dramatically improve constraints on the

Neoproterozoic cooling history of each margin, which will be used to test competing models for GU

development and significance.

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Francis MacDonald 11/1/18-5/31/20 $77,882

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National Science Foundation 1927851

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COLLABORATIVE RESEARCH: Testing proposed rapid true polar wander in the Neoproterozoic Zavkhan Volcanics of Mongolia and the Banxi Group of South China

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Finalize paleomagnetic and geochronologic analyses. Extend geochemical analyses from both China and Mongolia to better assess the tectonic environment of magmatism. Additional field studies in Mongolia to expand data set and test hypotheses generated with initial dataset.

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Sally MacIntyre 9/1/09-8/31/15 $407,061

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National Science Foundation DEB-0919603

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Collaborative Research: Arctic to the Amazon: Physical Processes Controlling Gas Exchange from Freshwater Ecosystems.

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Despite the small overall surface area of lakes, reservoirs, streams and rivers, estimates of carbon dioxide and methane emissions indicate aquatic ecosystems play an important role in regional carbon balances (Richey et al., 2002; Melack et al. 2004). Further, lakes are anticipated to be sentinels of climate change, with the balance between autotrophic growth and respiration in lakes anticipated to change with increased anthropogenic activity in their watersheds and with climate change. Studies have been and are being conducted worldwide to assess the role of lakes and reservoirs in regional and global carbon cycles and efforts are underway to estimate metabolic activity in lakes. Essential to both efforts are accurate estimates of gas fluxes at the air-water interface.

The gas transfer coefficient, used in the calculation of fluxes, depends upon turbulence at the air-water interface, but in most biogeochemical studies either a fixed conservative value is used or one based on wind speed alone. Other processes which cause turbulence are neglected. We estimate that regional carbon budgets are in error by at least a factor of two and likely higher in warm water lakes due to incorrect parameterization of the gas transfer coefficient. The error is unknown in cold water lakes. The surface renewal model takes into account the various processes which induce turbulence in near-surface waters yet has never been validated for lakes. We propose to combine direct air-water flux measurements of carbon dioxide using eddy covariance techniques with *in situ* measurements of the water-side CO2 concentration profile, turbulence and energy fluxes to evaluate and improve upon the surface renewal model of the gas transfer coefficient. We further propose studies using SF6 in lakes too small for EC studies with measurements taken on time scales of events which drive gas flux. We propose studies in an arctic, temperate zone, and tropical lake to capture the latitudinal variations in physical forcing which affect turbulence near the air-water interface. Our overarching goal is a formulation of the gas transfer coefficient which can be readily applied in ecosystem studies of lakes at any latitude.

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Sally MacIntyre 9/1/09-8/31/15 $7,494

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National Science Foundation DEB-0919603

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**Collaborative Research: Arctic to the Amazon: Physcical Processes Controlling Gas Exchange from Freshwater Ecosystems**

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Efforts to obtain gas transfer coefficients in small lakes have been based on tracer approaches or full lake carbon budgets (Cole and Caraco 1998; Cole et al. 2010) which provide average values over several days. Estimates using eddy covariance techniques, which provide 30 minute averages, are difficult because the footprint over which measurements are made can extend over land. In our proposed work (DEB-0919603), we suggested using sulfur hexafluoride (SF6) and sampling in response to changing meteorology. However, both Vachon et al. (2010) and Cole et al. (2010) use chamber methods which they indicate can be or are corrected for the chamber induced accentuation of turbulence at the air-water interface. Using these chambers, and sampling over short intervals over diel cycles, opens the door for diel assessments of k600 using inversion techniques as in MacIntyre et al. (in press). Our approach for developing valid equations for k600 in small lakes over diel cycles will be to combine these short interval flux measurements with diel measurements of temperature, meteorology, surface currents, and pCO2.

Given the predicted importance of global warming in the Arctic for mobilizing carbon stores, and previous evidence that freshwaters contribute significantly to terrestrial carbon budgets in the Arctic (Kling et al. 1992), our measurements in summer 2011 will be performed in two small arctic lakes near the Toolik Field Station. Lake N2, has a surface area of 1.6 ha, is 10 m deep, and seasonally stratifies, and Lake E6 is polymictic, 1.9 ha in surface area, and maximally 3 m deep. We will obtain time series temperature and meteorological measurements, measurements of currents with acoustic Doppler profilers and acoustic Doppler velocimeters, measurements of exchange of SF6 introduced near bottom or in the metalimnion and the epilimnion as a proxy for green house gases, measurements of pCO2 concentrations in surface waters and air using a LiCor 820 and equilibrator, and measurements of gas concentrations in chambers. We will obtain profiles to compute turbulence using the self-contained autonomous micro- profiler (SCAMP). We have experience with all but the chamber measurements and willdevelop that expertise before leaving for the field. The research team includes the PI, the co-PI Jordan Clark who is an expert with SF6, and two postdoctoral fellows with experience in physical limnology and physical-biological coupling. Within the overarching goal of quantifying the physical limnology of small lakes and developing equations for the gas transfer coefficient for these lakes, intermediate goals include determining the extent of damping of turbulence during windy periods with heating; quantifying turbulence during periods of cooling; quantifying current speeds, the shear induced, and the persistence of these currents; and validating predicted shear stresses and heat loss from sheltered lakes.

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Stéphane Maritorena 8/12/15-9/30/19 $144,592

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Bermuda Institute of Ocean Sciences (BIOS), Inc. 154444UCSB

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**CORAL: COral Reef Airborne Laboratory**

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UCSB will contribute to the development, implementation and refinement of the benthic production and calcification algorithms. In addition, UCSB will participate in several Productivity and Calcification field experiments and will perform validation analyses of the Level-4 data products (Production and Calcification). Specifically, this work includes: 1) the conception and implementation of the benthic production and calcification algorithms and the associated processing flows; 2) the benthic community productivity and calcification field experiments in Key West and Guam; 3) the benthic community productivity and calcification field experiments in Hawaii and Moorea; 4) the comparison of the production and calcification in situ measurements with the products derived from the PRISM measurements; 5) performing individual and/or collaborative data analyses to address the project objectives; 6) refinement and modification of the production and calcification algorithms and processing flows as dictated by the comparison analyses.

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Stéphane Maritorena 2/1/19-1/31/20 $12,819

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California State University - San Marcos 92329/85142

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**Carbon-based phytoplankton size classes using multi-platform ocean color observations and Earth System Models: satellite algorithm development and interannual variability**

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As part of the proposal entitled “Carbon-based phytoplankton size classes using

multi-platform ocean color observations and Earth System Models: inter-annual

variability and trend power analysis”, in answer to NASA Program Announcement

“THE SCIENCE OF TERRA, AQUA, AND SUOMI NPP ” (NNH17ZDA001N-TASNPP ), I will help in the development and testing of the non-spherical particles and two component PSD models in collaboration with Dr. Kostadinov (Years 1 to 3). I will

also help in developing the error propagation scheme that accounts for

uncertainties in the merged multi-platform remote sensing reflectance and in the

IOP model (Year 2 and Year 3).

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Stéphane Maritorena 12/1/18-9/30/19 $124,164

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Jet Propulsion Laboratory

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**CORAL {Coral Reef Airborne Laboratory}**

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As part of the proposal entitled CORAL (COral Reef Airborne Laboratory), in answer to NASA Program Announcement “Earth Venture Suborbital-2”, I will contribute to the development and implementation of the algorithms for the benthic community productivity and calcification L4 products. The productivity estimates will be derived following the light-use efficiency approach used in land productivity studies and adapted to coral reefs by Hochberg & Atkinson (2008). The approach uses a combination of incident irradiance, light absorption and a community-based light use efficiency factor to calculate gross primary productivity. Except for the light-use efficiency factor, all variables used in the algorithm can be obtained from remotely sensed data (benthic community, incident light, community absorption). Approaches to derive these variables will be tested in collaboration with colleagues working on the atmospheric and optics components of the project. The calcification product cannot be derived directly from measurements made above a reef and thus will be based on the documented relationships between productivity and calcification for various organisms or communities. I will also contribute to the U.S.-based field campaigns for Cal/Val of the productivity and calcification products by participating in the gradient flux experiments and Eulerian DIC measurements.

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St̩phane Maritorena 2/8/11-2/7/15 $487,545

David Siegel

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National Aeronautics and Space Administration NNX11AE87G

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**From UV to Fluorescence, a Semi-analytical Ocean Color Model for MODIS and Beyond.**

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We propose to develop the GSM model which is a well documented and vastly used multispectral semi-analytical ocean color model that we have developed at UCSB. We propose to modify the GSM model so it can account for fluorescence which should help better constraint the model and improve Chlorophyll and phytoplankton absorption retrievals in both oceanic and coastal waters. Although MODIS does not have UV bands, we also propose to extend the GSM model into the UV region to help discriminate better between phytoplankton and colored dissolved organic matter (CDOM) absorption which are not well separated by the current 412 nm band in ocean color sensors. In upgrading GSM, we also plan on making it fully hyperspectral so it can be adapted and applied to MODIS and other sensors. Model development and later tests and validations of the different components of the model will performed using existing in situ data from our field campaigns and other existing public data sets. The model will be adapted to the MODIS bands and applied to the satellite data. In parallel, we will conduct a complete error and uncertainty analysis of the model and data as we have done in the past.

In summary, our objectives are to:

- Develop and add a fluorescence module for the GSM model

- Investigate and add a UV component to the GSM model

- Make the GSM model hyperspectral and adaptable to multispectral sensors like MODIS

- Develop a complete end-to-end error budget (inputs, model, outputs)

- Apply the model and error budget to the MODIS data

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St̩phane Maritorena 5/15/13-5/14/18 $956,638

David Siegel

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National Aeronautics and Space Administration NNX13AK22A

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**Creating Unified Ocean Color Data Records with Uncertainties.**

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The generation of unified satellite data records through the merging of ocean color data from multiple sensors has proven beneficial to the science users community at various levels. First, merged products offer improved coverage of the ocean at daily to monthly time scales, which reduces the uncertainties in estimates derived from those products for both local and global studies. Second, merged data products often have lower uncertainties than the same product from any single sensor. Last, data merging has also proven a powerful tool to identify inconsistencies among the different data sources or issues with the sensors’ radiometry. In all, data merging benefits both the ocean color and biogeochemistry science that uses its data and the inter-sensors calibration/validation activities. Here, we propose to continue the development of unified and coherent ocean color time series through the merging of data from multiple sensors. We will continue the development of merged ocean color products from the GSM semi-analytical model. This model merges data at the Remote sensing reflectance level and derives several biogeochemically relevant data products simultaneously along with uncertainty estimates at each pixel. In addition, we will also generate merged products from higher level data (e.g. chlorophyll-a concentration) as such products are no longer available to the science community. We will also develop new merged ocean color products. In particular, we will develop a merged remote sensing reflectance product that will allow users to work with a data set with improved spectral resolution and lower uncertainties. Last, uncertainty estimates for all merged products will be generated on a pixel-by-pixel basis. All products and uncertainty estimates will be validated through matchup analyses. The merged records will cover the time span over which multiple ocean color sensors are or will be available (SeaWiFS, MODIS, MERIS, VIIRS, OLCI,…). Both global (9-4 km resolution from level-3 data) and regional (1-4 km resolution from level-2 data) merged products will be developed.

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St̩phane Maritorena 11/25/14-11/24/18 $364,386

David Siegel

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National Aeronautics and Space Administration NNX15AC65G

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**How useful will the PACE UV bands be for IOP retrievals and atmospheric correction?**

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Several prospective ocean color sensors such as PACE will have spectral bands in the UV in addition to those in the visible and those designed for atmospheric correction in the NIR and SWIR regions. The expected usefulness of the UV bands for ocean color sensors is two-fold: 1) they should allow a better discrimination between phytoplankton and CDOM -through their inherent optical properties, IOPS-in the ocean and 2) they can help in the atmospheric correction when absorbing aerosols are present. They PACE UV bands are expected to help mostly in coastal and turbid waters where both high amounts of CDOM and the presence of absorbing aerosols are frequent. Because both CDOM and absorbing aerosol show increased absorption toward short wavelengths, confounding effects may limit the ability of the UV bands to discern the role of CDOM and aerosols in the remote sensing signal. Here, we propose to test the use of the PACE UV bands for both IOP retrievals and atmospheric correction. We will test the performance of a semi-analytic ocean color algorithm (an upgraded version of the GSM model) for the retrieval of IOPs using available in situ data that cover the UV and visible domains. Using simulated data, we will also test how perturbations in the NIR and SWIR atmospheric bands affect the spectral IOP retrievals (from UV to the green wavelengths). Last, we will test if the UV bands can be used to better constrain the aerosol path radiance and improve atmospheric correction. Some of these analyses will also be considered with the HICO data.

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Robin Matoza 8/1/15-7/31/20 $220,000

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National Science Foundation 1446543

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**Characterizing fault zones at Kilauea & Mauna Loa volcanoes by large-scale mapping of earthquake stress drops and focal mechanisms**

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The analysis and interpretation of seismic sources from within Earth’s mantle up to the surface plays a key role in understanding how volcanoes work. Hawaii Island is one of the most tectonically, volcanically, and seismically active regions on Earth. The USGS Hawaiian Volcano Observatory (HVO) operates a seismic network that has recorded over 260,000 earthquakes since 1986, but this rich dataset has not been fully exploited. This project supports collaboration between HVO and U.C. San Diego to apply a number of new large-dataset processing methods to learn more about seismic activity on Hawaii and its relationship to faults and volcanoes. It also supports the educational program at the Scripps Institution of Oceanography and U.C. San Diego by providing funds for graduate student support. The results from this study are expected to yield a sharper and more comprehensive view of fault zone characteristics as well as generate public databases of high-resolution information on seismicity characteristics, suitable for other researchers in their studies of Hawaiian geology, tectonics, and volcanism. This research will lead to improved descriptions of seismicity and tectonics for Hawaii, which will improve our ability to monitor and characterize volcanic and earthquake hazards.

By performing systematic and comprehensive analyses of seismicity recorded by HVO, this work will improve earthquake location precision, provide robust estimates of the patterns of earthquake stress drops, and compute more reliable earthquake focal mechanisms on Hawaii. Integrating these results will better characterize crustal and mantle fault zones and magma conduits in and around Kilauea and Mauna Loa volcanoes, and will help to resolve the relationships between seismicity, volcanic activity, and strain transients. Our results will address the following questions: (1) Relocated microearthquakes in Hawaii align along resolvable fault and conduit structures—what do these structures reveal about tectonic and volcanic processes? (2) What is the origin of recently discovered seismicity rings in Hawaii? (3) How do the stress drops of Hawaiian earthquakes compare to other regions? Are there variations in earthquake stress drops that can be used to characterize stress field heterogeneity and identify regions of stress concentration? (4) Can focal mechanisms be improved for small earthquakes in Hawaii and what do they reveal about the faulting process and stress state? (5) Can repeating earthquakes with nearly identical waveforms be used to resolve temporal variations in seismic velocity associated with tectonic and volcanic activity? (6) How do the characteristics of long-period (LP, 0.5-5 Hz) seismicity at Kilauea volcano relate to redistributions of magma and stress within its magma supply system?

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Robin Matoza 5/11/15-7/31/16 $63,493

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National Science Foundation 1546139

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**Collaborative Research: Constraining Volcanic Jet Dynamics with Infrasound Using Numerical and Empirical Models**

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Explosive volcanic jets produce eruption columns that often form buoyant ash clouds and may fully or partially collapse to form pyroclastic density currents, dangerous fast-moving lateral flows of hot ash and gas. These natural hazards directly threaten surrounding communities and global air traffic. Our ability to mitigate these risks is restricted by our inability to safely measure volcanic jets or monitor them co-eruptively. Infrasound (acoustic signals with frequencies below that of human hearing) provides a means to detect the atmospheric oscillations from volcanoes at distances of meters to thousands of kilometers from the source. This project aims to use these signals to constrain the physics of volcanic jets and measure them in real-time. These measurements may be used as input parameters for aviation safety ash-cloud prediction models and toward assessing the hazard presented to local communities by a given eruption. Additionally, this work will provide constraints on eruptive parameters and physics for numerical and experimental studies.

Recent infrasound recordings of volcanic jets have frequency spectra similar to the acoustic signal produced by man-made jets (jet noise). For the past 60 years, aeroacoustics has studied the relationship between the flow properties of man-made jets and the acoustic signal produced. Our long-term objective is to reverse this concept by determining the flow properties of volcanic jets based on the infrasound signal produced by the eruption. This work represents a first step toward this long-term goal. We begin by building a catalog of infrasonic jet noise observations to determine characteristic volcanic jet noise features and determine any correlations between these features and known eruptive parameters. This process includes searching existing infrasound databases using new signal processing tools and empirical and theoretical propagation modeling. We will then use analytical and numerical models of volcanic jets to adapt established empirical models of man-made jet noise to volcanic systems.

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Robin Matoza 6/1/16-5/31/20 $261,778

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National Science Foundation 1614855

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**Collaborative Research: Quantifying explosive volcanism in Alaska using seismo-acoustic wavefields recorded by USArray**

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Alaska is home to 130 potentially active volcanoes, of which more than 50 have been active in historical times. On average 2 volcanoes are in a state of eruption every year. Volcanoes in the Aleutian Islands, Alaska Peninsula, and Cook Inlet are capable of sudden, explosive, ash-cloud forming eruptions, which are potentially hazardous to passenger and freight aircraft along this heavily travelled air corridor. Many of Alaska’s volcanoes are in remote locations with harsh environments. Monitoring these volcanoes represents a formidable challenge and many of the volcanoes are not instrumented. Infrasound (acoustic waves with frequencies below the 20 Hz hearing threshold of the human ear) is a rapidly developing technology to understand and monitor explosive volcanic eruptions. Modest-sized explosive eruptions produce powerful infrasound signals that propagate efficiently over thousands of kilometers in the atmosphere. However, to date, these signals have been recorded by sparse infrasound sensor networks, limiting our understanding of their source generation and propagation through the atmosphere. The EarthScope Transportable Array (TA) is currently being deployed in Alaska, bringing the densest ever combined seismic and infrasonic network to one of the world’s most active volcanic regions. Exploiting this novel dataset, this project will advance the capability of acoustic early warning systems of volcanic eruptions for aviation safety and will assess the potential contribution of large sensor networks such as the TA to volcano monitoring. At the end of the project, an operational volcano-acoustic monitoring system resulting from this work will be implemented at the Alaska Volcano Observatory.

This work will capitalize on the unprecedented seismo-acoustic dataset starting to become available as the TA records Alaska’s routine explosive volcanism with dense spatial wavefield sampling. Volcano seismo-acoustics is a rapidly advancing research field, where basic questions remain on the source mechanisms, source directionality, atmospheric propagation, and seismo-acoustic coupling from explosive volcanic eruptions. This project will focus on detection, discrimination, and location of the signals using novel methods; quantifying the seismo-acoustic wavefield; investigating the source mechanisms; quantifying seismo-acoustic wave coupling; and understanding infrasound propagation in the spatio-temporally varying atmosphere. Through a combination of data analysis and modeling, we will characterize and quantify diverse seismic and infrasonic signals recorded at a range of distances and directions from the explosive eruption source. We will address the following questions: (1) How do observed acoustic and seismic signals from explosive volcanic eruptions vary with distance and azimuth to the source? (2) How does acoustic propagation differ for various types of explosive eruptions? (3) What kind of volcanic source information can be determined from long-range seismo-acoustic data? (4) What are the wavefield sampling limitations in previous volcano infrasound studies? (5) What other infrasound sources are present in Alaska? Our team will work with the EarthScope National Office at the University of Alaska Fairbanks to help highlight this research and its impacts. Multi-media products illustrating seismo-acoustic wavefields from volcanic eruptions in Alaska will be distributed via the web for use in public information packets and education and outreach. Event catalogs and related data products will be publically available, with notable infrasound events uploaded to the IRIS TA Infrasound Reference Event Database (TAIRED).

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Robin Matoza 3/1/17-2/29/20 $290,000

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National Science Foundation 1620576

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**Investigating the seismic signatures of volcanic unrest and eruption: Spatiotemporal distribution and source origin of tiny long-period seismicity**

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Seismicity generated during volcanic unrest and eruption plays a central role in our understanding of how volcanoes work. Long-period (LP, 0.5-5 Hz) seismicity, a particular type of volcanic seismicity, is used routinely by volcano monitoring scientists to forecast and assess eruptions and mitigate hazards, but its source origin remains controversial. This project will perform detailed investigations into the origin of an intriguing and largely overlooked additional type of volcanic seismicity: numerous tiny-amplitude LPs (LP subevents) that accompany the regular LPs. Tiny LP subevents have apparently been recorded at multiple volcanoes worldwide, but their origin remains mysterious. Millions of tiny LP subevents were exceptionally well recorded by a dense seismic network during the 2004-2008 eruption of Mount St. Helens (MSH), but were not cataloged or analyzed. These LP subevents contain rich, unexploited information that has the potential to better elucidate the processes generating volcanic seismicity. This project will utilize novel computationally intensive processing methods adapted from studying regional seismicity in Southern California and Hawaii. This research will map the spatiotemporal distribution and source mechanisms of millions of tiny LP subevents to high precision and determine their relation to other volcanic seismicity and eruptive activity. The primary dataset is from MSH, but additional datasets from Mammoth Mountain, CA, Kilauea Volcano, HI, and other volcanoes will be exploited for comparative analyses and hypothesis testing across multiple volcanic systems.

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Robin Matoza 6/1/19-5/31/24 $387,073

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National Science Foundation 1847736

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**CAREER: Seismo-acoustic signatures of volcanic unrest and eruption: Local. Regional, and Remote**

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This CAREER (Faculty Early Career Development Program) project would support a 5-year comprehensive research program integrated with a range of undergraduate and graduate educational activities led by Prof. Robin Matoza at the Department of Earth Science, University of California, Santa Barbara (UCSB). This is the first and last attempt at an NSF CAREER proposal by PI Matoza given the eligibility criteria. I propose a comprehensive research program on the source, propagation, and remote detection and quantification of the seismo-acoustic signatures of volcanic unrest and eruption. We will collect next-generation, multi-parametric, seismo-acoustic geophysical field data from active volcanoes in Vanuatu, Mexico, and Chile at local (15 km), regional (15–250 km), and remote (>250 km) distances from the source. In tandem, we will develop an array of computationally intensive data processing methodologies and modeling and inversion strategies to systematically mine large volcano seismo-acoustic datasets and test multiple scientific hypotheses about the source and propagation of these wavefields.

Intellectual Merit

This project will focus on the seismo-acoustic signatures of explosive eruptions (Strombolian, Vulcanian, Plinian), including pre-eruptive, co-eruptive, and post-eruptive seismicity and infrasound. Specifically, we will investigate: (1) Source directivity of volcanic explosions; (2) Seismo-acoustic wave partitioning, conversion, and coupling; (3) Non-linear infrasound propagation; (4) The influence of topography and atmospheric structure on infrasound propagation from volcanic explosions; and (5) the capability of regional and remote seismo-acoustic networks to detect, locate, characterize, and catalog explosive eruptions. We will work toward these goals using a combination of new and existing data. Existing data includes growing volumes of continuous seismo-acoustic waveform data available, e.g., at the IRIS Data Management Center (DMC). New data will be collected in targeted local and regional multi-parametric field experiments at Yasur and Ambrym volcanoes, Vanuatu; and Popocatépetl volcano, Mexico. We will also deploy a new regional infrasound array in Chile. Our Vanuatu field deployments will combine ground-based broadband seismic and infrasonic networks in tandem with multiple novel airborne infrasound tethered-balloon (aerostat) acquisition systems together with 3D aerial (“drone”) imaging and other multi-parametic data. All data from our experiments will be made publicly available, e.g., at the IRIS DMC.

Broader Impacts

Undergraduate and graduate education, training, and mentorship are integral and central to this research project. Each geophysics field experiment team will include up to five undergraduates and two graduate students from UCSB and the experiments will involve significant international collaboration with multiple researchers and graduate students from the US, New Zealand, Vanuatu, Mexico, and Chile. These field experiments will represent the capstone experience of the geophysics undergraduates at UCSB. The students will prepare for this field research experience through a series of classes and a special new graduate seminar series “Field studies in geophysics” taught by the PI. Funds are requested to support two graduate students, and to support undergraduate summer research projects analyzing the field data. Data examples and results from this research will be integrated into computer practicals, lectures, section exercises, and readings in lower and upper division undergraduate and graduate classes offered by PI Matoza. In the field, we will collect geo-referenced video data from novel 360˚ (virtual reality capable) cameras, unmanned aerial vehicles (“drones”), and other systems, allowing us to create rich immersive material for virtual field trip exercises that will share the excitement of volcano geophysics fieldwork and scientific discovery to General Education (GE) undergraduate students at UCSB and elsewhere. This work is focused on understanding the geophysical signatures of volcanic unrest and eruption, with application in monitoring and mitigating volcanic hazards.

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Robin Matoza 7/1/18-12/31/19 $13,553

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University of California SB190021

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Seismic and infrasonic signature of explosive eruptions at Popocatépetl volcano, México

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This collaboration brings together volcano geophysicists from the US and Mexico to refine our understanding of how volcanoes work and potentially improve monitoring methods for active volcanoes in both countries. Seismology and acoustics are complementary methods for quantifying volcanic eruption processes. Seismic data form the backbone of most volcano monitoring systems. Seismic signals at erupting volcanoes capture subsurface magma transport and degassing associated with explosive eruptions. Infrasound (acoustic waves with frequencies below 20 Hz) is a newer technology; infrasound data record subaerial degassing and allow physical quantification of explosive eruption mechanisms. Popocatépetl is the most active volcano in Mexico and a prodigious source of explosive activity, making it an ideal target to combine seismic and infrasound investigations. We have collected the first continuous infrasound and seismic data ever at Popocatépetl.

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Robin Matoza 12/31/99-00/00/00 $0

Toshiro Tanimoto

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University of Southern California

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**SCEC5 Participation, Project H: Shallow Elastic Structure from Co-located Seismic and Pressure Sensors**

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This project is related to a novel approach of deriving shallow structure of the Earth based on co-located seismic and pressure data. The project consists of two tasks. 1.  Analyze thirteen co-located station data in Southerna California that existed between 2000 and 2010. 2. Conduct a pilot observational study by installing portable seismometer and infrasound sensors (pressure sensors) for 3-6 months and apply our inversion method for shallow structure. The location of observation will be determined in a few weeks. We expect to begin collecting data this summer.

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Douglas McCauley 10/1/17-9/30/18 $20,200

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National Geographic Society WW-151R-17

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**Deploying next-generation remote sensing technologies to understand collective behavior in animal groups at multiple scales**

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Animal aggregations provide some of the most visually compelling examples of biological self-organization in the natural world. From a school of anchovies avoiding a shark to a swarm of locusts engulfing a cornfield, these impressive displays afford a unique opportunity to directly observe fundamental ecological processes in real time. While the biology of aggregating behaviors is relatively well studied in model species of small animals (e.g., minnows, locusts), the challenge of observing groups of large bodied animals in the wild has hindered our understanding of this most basic phenomenon in ecosystems worldwide. However, recent advancements in remote sensing technologies like unmanned aerial vehicles (UAVs) and very high-resolution satellite imagery (VHRS) have opened up exciting new pathways for studying aggregating behaviors of large vertebrates in situ and at unprecedented spatial scales. We propose to use novel remote sensing technology and automated image analysis to experimentally test the ecological causes of aggregation behaviors in migratory wildebeest in the Greater Serengeti Ecosystem of Tanzania. Specifically, we aim to identify the social and environmental processes that give rise to the spatial patterns observed in wildebeest herds across the landscape. By establishing this link, we hope to advance our understanding of the ecology of collective decision making in animals and provide conservation partners in Tanzania with a new methodological framework for remotely monitoring the behavior of large, mobile species across this flagship ecosystem.

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John Melack 1/1/10-12/31/14 $357,736

Laura Hess

Sally MacIntyre

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National Aeronautics and Space Administration NNX10AB66G

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Analysis and Synthesis of Carbon Dynamics on Amazon Floodplains.

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Our research on the ecology, hydrology and biogeochemistry of Amazon wetlands under the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA-ECO) addressed important aspects of the regional carbon dynamics of the Amazon basin, combining remote sensing and field measurements to calculate evasion of methane and carbon dioxide from rivers and wetlands. Our proposed work synthesizes newly available remote sensing datasets and analyses, recently completed field measurements, and recent modeling advances with past results in order to target important remaining uncertainties regarding carbon dioxide and methane dynamics on Amazonian floodplains. This work will contribute to understanding of tropical riverine and wetland systems in the global context of greenhouse gas emissions and carbon dynamics. Furthermore, recent studies have indicated that lakes and wetlands make a significant contribution to the global carbon budget because of the high rates of carbon uptake and metabolism in these systems. Therefore, our research in the large and productive Amazon basin is likely to be quantitatively important globally.

About 20% of the Amazon basin is seasonally inundated, and these wetlands are sites of intense biological activity that can have a strong influence on the regional carbon dynamics. Understanding the effects of these dynamics on air-water exchanges of CO2 and CH4 is of critical importance if we are to estimate the net contribution of Amazon wetlands to greenhouse gas emissions. To quantify this influence it is necessary to improve estimates of the fluxes and balance of carbon, incorporating the principal sources of spatial and temporal variability and developing numerical models to simulate and integrate their effects. Hence, we propose to study the organic carbon dynamics and its influence on the net emissions of CO2 and CH4 on central Amazon floodplains.

We propose to examine three unresolved issues:

1. The role of aquatic herbaceous macrophytes and litterfall from flooded forests as sources of organic carbon fueling the outgassing of carbon dioxide and methane from wetlands and rivers.

2. The regional, seasonal and interannual variations in evasion of methane and carbon dioxide.

3. The inundation dynamics of floodplains on multiple scales, and their function as a physical template for biogeochemical processes.

To resolve these issues and to advance predictive capability and understanding of how the carbon balance of Amazon floodplains will respond to environmental changes requires several coordinated activities. Hydrological and hydrodynamic models will be integrated with biogeochemical analyses and models and with remotely sensed-based estimates of plant growth and phenology.

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John Melack 5/3/17-5/2/20 $859,009

Sally MacIntyre

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National Aeronautics and Space Administration NNX17AK49G

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Methane fluxes from tropical aquatic systems: Integration of measurements, hydrological and biogeochemical models and remote sensing

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Tropical aquatic systems, including floodplains and other wetlands, lakes and rivers, are major sources of methane to the atmosphere. The considerable uncertainty about the estimated fluxes of methane stems from the large seasonal and inter-annual variations in ecological conditions and inundation typical of floodplains and other wetlands. In this proposed project, we will combine results from our field measurements, hydrological simulations and advances in remote sensing to develop mechanistic models that couple floodplain inundation dynamics to the production and emission of methane. Our work will quantify and reduce uncertainty associated with estimates of methane fluxes and expand understanding of their temporal and spatial variability. Our results will provide necessary inputs to regional atmospheric models of methane fluxes derived from airborne campaigns and satellite retrievals, and provide key improvements in the tropics for models applied globally. Among tropical river systems, the Amazon basin is the largest and has the most extensive floodplains. Hence, our analyses will focus on aquatic systems in the Amazon basin, and be extended to tropical systems elsewhere based on modeling and remote sensing. Remote sensing of inundation and vegetative dynamics will be combined with recent results from in situ measurements of methane fluxes, related physical processes and hydrological models to provide regional estimates of methane fluxes. We will utilize existing datasets complemented by focused field studies to develop and validate a model of methane evasion tailored to tropical aquatic systems with strong seasonal and inter-annual variations in inundation, water depths and vegetative cover.

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John Melack 7/1/18-6/30/21 $564,136

Sally MacIntyre

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National Science Foundation 1753856

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**Aquatic metabolism and carbon dioxide flux: Linking physical and biological processes in Amazon floodplains**

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Recent syntheses of carbon processing and evasion of carbon dioxide to the atmosphere in inland aquatic ecosystems have revealed the disproportionately large contribution, relative to their area, that these ecosystems make to carbon cycling. Tropical systems are under-represented in these analyses, and floodplains are often the largest aquatic ecosystem in these regions. Among tropical river systems, the Amazon basin is the largest and has extensive floodplains. To advance understanding of carbon cycling within the Amazon, we will combine data on CO2 and O2 concentrations from representative habitats, air-water fluxes, and aquatic plant inputs of carbon with interpretation extended via new measurements of hydrodynamics and remote sensing.

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John Melack 9/1/12-8/31/19 $182,476

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National Science Foundation DEB-1242594

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**LTREB Renewal-Collaborative Research: Responses of High Elevation, Aquatic Ecosystems to Interannual Climate Variability**

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Three decades of investigation of high-elevation Emerald Lake and neighboring lakes and watersheds in the Sierra Nevada (California) have transformed our understanding of how interannual changes in snowmelt and rates of atmospheric deposition have modified the timing and magnitude of hydrological and chemical fluxes, and thereby modulate the ecology of high elevation ecosystems. Experiments, both in the field and laboratory, have added mechanistic understanding of biogeochemical processes of Sierran lakes and watersheds. Comparative studies of biological and hydrochemical aspects of lakes, conducted from 1982 to the present, provide a regional context for examination of Sierra-wide conditions and responses to global change. Recent paleo-investigations at Emerald Lake and companion lakes have provided a multi-century context for the 31-year dataset from Emerald Lake. In our LTREB renewal, we propose to complete our decadal research plan to test the hypothesis that altered climate, changing snow regime and changes in atmospheric composition are driving biogeochemical and ecological changes in high elevation ecosystems. We propose to continue long-term study of the Emerald Lake watershed, Tokopah Valley and nearby catchments in order to test conceptual hypotheses regarding drivers of environmental change in high-elevation aquatic ecosystems. The primary foci of the proposed study are: i) continued assessment of the response of lake phytoplankton to changing atmospheric deposition and ii) continued study of the coupling between climate variability and N and P biogeochemistry. These questions will be answered through the continuation of on-going watershed measurements; additional study of lake metabolism; enhanced measurements of atmospheric deposition; and paleolimnological study of lake sediments. Climate conditions have a strong influence on potential N&P source areas, on the incidence of fires, on transport and deposition, and lake ecology. Hence, as a consequence of the considerable interannual variability in California’s Mediterranean climate, it is essential to conduct these studies for at least ten years.

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John Melack 9/1/13-8/31/18 $411,216

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Pennsylvania State University 4916-USB-DOE-0620

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**Scale-aware, Improved Hydrological and Biogeochemical Simulations of the Amazon Under a Changing Climate**

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About 20% of the Amazon basin is seasonally inundated, and these wetlands are sites of intense biological activity that can have a strong influence on the regional carbon dynamics. Understanding the effects of these dynamics on air water exchanges of CO2 and CH4 is of critical importance if we are to estimate the net contribution of Amazon wetlands to greenhouse gas emissions. To quantify this influence it will be necessary to improve estimates of the fluxes and balance of carbon, incorporating the principal sources of spatial and temporal variability and developing numerical models to simulate and integrate their effects. To do so, we propose to combine hydrological and biogeochemical modeling with analysis of existing data.

The overarching question of our proposed research is: How do the overall CO2 and CH4 cycles and carbon pools in the Amazon, including catchment and aquatic systems, respond to the changing climate, especially significant changes in the water cycle? To address this question, the UCSB aspect of the proposed research will enhance the modeling capabilities of Community Land Model by adding an aquatic ecosystem module that includes multi-scale carbon and methane biogeochemistry.

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John Melack 11/1/18-9/30/19 $15,130

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Tahoe Regional Planning Agency 19C00008

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**Decision Support Framework (DSF) for the Upper Truckee River Watershed – Phase I**

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Peer reviewers of the 2011 and 2015 threshold evaluations encouraged a more ecosystem-based approach to threshold evaluation and resource management. This is particularly important when considering projects that are expected to produce environmental benefits across multiple resource categories and spatiotemporal scales.

Hence, a project have been conceived by the Tahoe Scientific Advisory Council that will contribute information and tools relevant to objectively evaluating landscape-scale projects purporting to provide multiple benefits in a changing environment. This project will initiate the assembly of the structural elements necessary to develop a decision support framework for the largest watershed in the Tahoe Basin.

The project will: 1) provide a decision support framework for objectively evaluating the benefits of multi-resource projects, and 2) provide tools for the identification of meaningful metrics for monitoring.

The Council convened a workshop of scientists and agency representatives to review and document the scope of environmental and management components relevant to the Upper Truckee River (UTR) watershed (Figure 1). This information will be used to describe important drivers, linkages and outcomes (D-L-O) of environmental processes and management actions within a set of linked or nested conceptual models. The conceptual models will include written narratives, references and performance characteristics along with graphical representation of the system components that together communicate the D-L-O characteristics to a broad stakeholder audience.

Draft conceptual models will be presented to the Upper Truckee River Watershed Advisory Group (UTRWAG) for review and input. This feedback will be incorporated and used to refine selected sub-models of identified importance, and to identify a draft set of indicator metrics. The conceptual models and indicator metrics will be integrated into a decision support framework following the approach of DiGennero and others (San Francisco Estuary and Watershed Science, 2012, v10). The utility and efficacy of the resulting DSF will be tested using a sample set of potential UTR watershed projects selected by UTRWAG from the existing Environmental Improvement Program project list. The approach and tools will be provided to UTRWAG for further evaluation and feedback. These tools, results and the lessons learned will be documented along with the final conceptual models and sub-models.

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Joel Michaelsen 1/1/16-4/30/20 $997,095

Lisa Stratton

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Cal Department of Fish and Wildlife P1696006

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**North Campus Open Space Coastal Wetland Restoration Project**

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The full North Campus Open Space (NCOS) Restoration Project will restore 90 acres of diverse coastal habitat that will provide important ecological and hydrological benefits to Santa Barbara County through excavation of 350,000 cy of fill from the former extent of Devereux Slough on property owned by the University of California, Santa Barbara (UCSB) and restoration of diverse habitats and estuarine processes which will provide multiple benefits (Figures 1 & 2 Location maps, Figure 3 a& b Restoration Plans). These include reduction in flood risk to habitats and property currently within 100 year flood zone and vulnerable to projections for 3 feet of sea level rise, provision of long-term support for diverse threatened and endangered species, improvements in water quality, greenhouse gas sequestration and the provision of educational and public access benefits for students and members of Isla Vista, a disadvantaged community in Santa Barbara County.

Funds will support the implementation of the majority of the wetland-related restoration components of the full project. CDFW Proposition 1 grant funds will specifically fund the: a) removal of approximately 40,000 cy of the 300,000 cy that will be removed with other, secured funding, b) implementation of fine grading and restoration actions to support the conservation of 18 acres salt marsh habitat in the face of sea level rise, and 3) construction and restoration of habitat features in support of federally endangered tidewater goby, migratory shorebirds and special status birds and plants. The project’s impact will be expanded through monitoring and reporting to EcoAtlas and interpretive signage that will complement public access components of the larger project.

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Joel Michaelsen 1/19/17-11/1/20 $2,449,000

Lisa Stratton

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Cal Department of Transportation 05-6300F15

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**UC Santa Barbara, North Campus Open Space Multi-Modal Trail Project**

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The project site is on a 64-acre property donated to the University of California Santa Barbara (UCSB) by the Trust for Public Land on 04/30/2013 to restore the site and incorporate public access through trail installations. UCSB supports the establishment of multi-modal public trails on the site, but has no dedicated resources for this development. Through an ongoing community-based planning process, it became clear that the community has a strong desire for trails and public access across the land for wildlife and open space appreciation and passive recreation, including walking, cycling, jogging, and as a safe route to school. With funding from the Active Transportation Program, the trail would provide both educational opportunities and access to bus stops, public schools and UCSB, and to trails located on Ellwood Mesa and other portions of the adjacent 652-acre preserve (part of the Ellwood Devereux Open Space).

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Joel Michaelsen 6/30/15-3/1/20 $999,989

Lisa Stratton

Jennifer King

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California Department of Fish and Wildlife P1496006

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**North Campus Open Space Wetlands Restoration**

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The North Campus Open Space (NCOS) Wetlands Restoration Project Phase 1 will restore 34 acres of diverse coastal wetlands and 20 acres of upland habitat in coastal Santa Barbara County. The project is projected to sequester 549 metric tons (t) of carbon over the first 100 years of establishment and to contribute to the science of quantifying the greenhouse gas (GHG) sequestration potential of intermittently tidal coastal estuary systems through a research and monitoring program. Anticipated fish and wildlife co-benefits include supporting recovery plan recommendations for federal and state threatened and endangered species by providing expanded and improved habitat for the Tidewater Goby (TWG), Western Snowy Plover, California Least Tern, California Red-legged Frog, Ventura Marsh Milk Vetch and Belding’s Savannah Sparrow. In addition, expanded habitat for migratory shorebirds and waterfowl and resident wetland and upland bird species will be created. Ecosystem benefits include reducing localized flooding problems and disturbance associated with flood control management activities, improving downstream water quality through expansion of wetlands and bioswale systems within the urban to wetland interface, and supporting expanded carbon sequestration, denitrification and other microbial processes. Educational benefits from this project are significant because of its location on the University of California Santa Barbara (UCSB) campus with its rotating student body of 20,000 students, active academic research, and hands-on restoration implementation and training program run by the Cheadle Center for Biodiversity and Ecological Restoration (CCBER). In addition, the project site borders a relatively dense urban area (City of Goleta and the community of Isla Vista) and 652 acres of recently protected coastal open space. A trail system will be developed through the restoration project site which will connect the community to the recreational amenities of this protected open space and the beach.

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Joel Michaelsen 7/1/17-6/30/25 $391,250

Lisa Stratton

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California Department of Parks and Recreation C0232033

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**North Campus Open Space: Trailhead Interpretive Area and Amenities Project**

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The University of California Santa Barbara campus dedicates 340 of its 1,000 acres to open space conservation and facilitates public access, especially for educational purposes. The 136 acre North Campus Open Space Restoration Project is underway and is unearthing 40 acres of wetlands buried in the 1960’s and restoring historic land forms and a diversity of native plant communities and wildlife habitat using only locally sourced native plant material. The project includes 2.5 miles of trails and four wetland crossings funded by CalTrans Alternative Transportation Program under contract now. The crucial need, now, is for an interpretive trailhead area with benches, shade, plantings and interpretive signage, as well as trailside amenities such as benches and signage to enhance the educational value of the site for the diverse users of the area. An exhibit case that can support changing exhibits and a native ethno-botanical garden supported by downloadable audio pod-casts with Native American stories, chants and songs will supplement traditional signage to keep the facility current and living. The project site forms a gateway to a larger coastal open space by connecting people via bus routes, bike and walking paths, student residences, and community members from median income and disadvantaged neighborhoods. Funded primarily by grants with a long term management commitment by the university, this project will provide valuable educational and experiential learning opportunities regarding California’s natural resources and the value of wetlands to the State’s future leaders and voters. UCSB’s Cheadle Center for Biodiversity and Ecological Restoration is uniquely suited to implement the project and multiply its value into the future.

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Joel Michaelsen 5/1/17-1/1/21 $350,000

Lisa Stratton

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California Natural Resources Agency E13613-0

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**North Campus Open Space Coastal Habitat Enhancement Program**

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The North Campus Open Space (NCOS) Coastal Habitat Enhancement Project, located in Santa Barbara County adjacent to the City of Goleta and within University of California’s campus, is the third phase of a larger project to restore 136 acres of degraded coastal habitats through excavation of 350,000 cubic yards of fill from a former golf course created in 1965 when soil from adjacent uplands were bulldozed into an estuary. The full NCOS project will provide hydrologic and tidal connectivity to Devereux Slough and its tidewater gobies by restoring the former upper arms of this estuary and the adjacent historic coastal terrace landform. More than 40 acres of wetland and 60 acres of upland and transitional habitat will be actively restored on the graded landforms and another 36 acres of habitat will be protected and enhanced through active invasive species control and enhancement planting. EEM funds are for the fourth phase of the larger North Campus Open Space project representing 20 acres of degraded habitat to be enhanced with weed control and selective planting adjacent to the re-created coastal terrace restoration area.

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Joel Michaelsen 5/1/15-12/31/18 $1,000,000

Lisa Stratton

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California Natural Resources Agency U59316-0

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**North Campus Open Space Restoration**

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The North Campus Open Space Restoration Project will restore nearly 50 acres of coastal wetland and approximately 50 acres of upland habitat that will provide an important community green space to this densely populated area. The trails and boardwalks to be created will invite people to intimately experience a unique, seasonally variable wetland ecosystem and provide connectivity between residential areas, schools, commercial areas, and adjacent coastal open space. This project will restore the hydrologic function lost in 1965 when nearly 500,000 cubic yards of soil were moved from adjacent uplands into a once functioning estuarine system. Opportunities to work on this scale in developed southern California cities are very limited, and this project provides an unprecedented local opportunity in a region that has lost more than 80% of its coastal wetlands and has experienced a significant loss of public access to open space areas. By restoring a natural system, this project will improve water quality, increase flood capacity, support wildlife and enhance regional adaptation to projected sea level rise by providing room for the migration of habitats.

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Joel Michaelsen 9/1/16-11/30/19 $1,000,000

Lisa Stratton

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California Ocean Protection Council P01-1-07

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**North Campus Open Space Coastal Wetland Restoration**

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The North Campus Open Space Restoration Project is a project to restore 90 acres of degraded cut and fill areas, including the former Ocean Meadows Golf Course, to a matrix of estuarine, palustrine, transitional and upland habitats characteristic of the Devereux Slough ecosystem through excavation of fill from the former upper arms of Devereux slough. The property to be restored is located on UCSB campus, adjacent to the main campus and immediately north of UCSB’s Coal Oil Point Reserve. The project site encompasses the interface of four tributaries to the Devereux Slough, and is south of the City of Goleta.

The larger project will return the channelized Devereux Creek to an estuary and restore the 64 acre invasive plant-dominated former private golf course to wetland and upland habitat. It will provide stormwater capture and flood control benefits, expanded rare species and migratory bird habitat, and create 1.2 miles of trail connecting adjacent residential neighborhoods and the protected lands to the California Coastal Trail. This grant will fund a portion of the second phase of the project, specifically restore 8 acres of wetland and transitional habitat along the western side of the restored estuary.

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Joel Michaelsen 7/27/16-6/30/20 $3,820,000

Lisa Stratton

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California Wildlife Conservation Board WC-1589DC

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**Upper Devereux Slough Restoration**

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The Wildlife Conservation Board grant for the Upper Devereux Slough Restoration will support restoration of portions of the historic northern extent of the Devereux Slough primarily on the former Ocean Meadows golf course property and adjacent borrow site (South Parcel) that will expand slough, wetland, transitional and upland habitats (Project) on approximately 136 acres of land commonly known as the North Campus Open Space, located in Santa Barbara County, California. Project supports grading, restoration and project management components of the project.

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Joel Michaelsen 12/21/15-6/30/20 $923,718

Lisa Stratton

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Land Trust for Santa Barbara County SB160090

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**North Campus Open Space Devereux Creek Flood Plain Restoration Project**

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In coastal Santa Barbara County a 60+-acre floodplain at the junction of Devereux and Phelps Creeks was filled with soil from the adjacent uplands in 1965 to create a golf course that left the creek in a narrow, channelized form, added 3-10 feet of fill and significantly reduced habitat for fish and wildlife, including the endangered tidewater goby. These impacts remain and contribute to localized flooding problems for Goleta City residents living adjacent to these creeks. The proposed project (Phase 1) will reverse these impacts by removing approximately 250,000 cubic yards (cy) of fill from the floodplain of these creeks (DWR funds support removal of 150,000 of the 250,000cy in the project). The project will provide flood control benefits to the residents living north and east of the project site, restore and protect riparian and diverse wetland and upland habitats by connecting the creek to the downstream estuary, thereby providing wildlife habitat for migratory and resident bird species, and estuarine fish, including the Tidewater Goby, Western Snowy Plover, and Belding's Savannah Sparrow which have been identified by federal and state governments as threatened or endangered. The project will also promote community involvement through public access trails and restoration activities, as well as educational programs and signage, that will benefit a rotating population of UC Santa Barbara students and community members for years to come.

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Joel Michaelsen 3/1/16-6/30/17 $18,000

Lisa Stratton

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Santa Barbara County SB170097

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**North Campus Open Space (NCOS) Public Access Design Project**

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This particular restoration project is extremely significant because it connects the upper and lower arms of the slough to each other and to adjacent areas of protected open space, including the Coal Oil Point Reserve and Expansion Area, Goleta Slough, the Sperling Preserve at Ellwood Mesa, and the Coronado Monarch Butterfly Preserve. Situated as such, the restoration of this site will have beneficial impacts to the entire estuary, for water quality and wildlife habitat, by providing wildlife connectivity, as well as important wetland habitat.

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Joel Michaelsen 1/1/17-12/31/41 $29,900

Lisa Stratton

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Southern California Wetlands Recovery Project 16-051

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**Whittier Channel Restoration**

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Restore 1.25 acres of wetland and riparian habitat with community volunteers in partnership with Kids in Nature II, Your Children’s Trees, Department of Water Resources, and the Land Trust for Santa Barbara County. We anticipate hosting: 6 school field trips (35 students/event), 6 weekend planting events, (10 to 30 participants), 3 volunteer tree planting events (20 per event), 30 morning greenhouse volunteer events (1 – 6 volunteers/event), 3 Birding/Educational Tours (20-30 participants), for a total of approximately 600 people participating.

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Joel Michaelsen 5/27/14-12/31/18 $869,300

Lisa Stratton

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State Coastal Conservancy 13-115

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**North Campus Open Space Restoration (previously named Upper Deveroux Slough) Project Planning Phase, UCSB**

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This work is associated with initial planning phase for the restoration of upper Devereux Slough in the area formerly used as Ocean Meadows Golf Course (63.8 acres) and adjacent open space area known as South Parcel (68 acres). The project involves interim management, planning including preliminary design, technical studies, environmental compliance documents, permitting and commencement of seed collection and propagation. Together the project area is part of the newly named North Campus Open Space (NCOS). The UC Regents, through UCSB and its partner The Trust for Public Land (TPL) will direct the planning phase for the Project.

The planning work will support the restoration goals of the project:

1) restore estuarine function to the upper arms of Devereux Slough by creating a diversity of wetland habitats (sub-tidal, mudflats, salt marsh, transitional freshwater marsh); 2) re-create a diverse set of upland habitats and vernal wetlands by returning a significant portion of the fill soil from the excavation of the slough arms to South Parcel; and 3) design a public access component of trails and, potentially, boardwalks which will connect to local and regional trail networks in adjacent open spaces. Benefits of the project include reduced localized flooding and enhanced habitat quality for threatened and endangered species currently or potentially using the area. These species include tidewater goby, western snowy plover, California least tern, California red-legged frog, Ventura marsh milk vetch and multiple species of special concern such as White-tailed Kite.

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Joel Michaelsen 5/27/15-3/31/18 $650,000

Lisa Stratton

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State Coastal Conservancy 13-115

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**North Campus Open Space Restoration (previously named Upper Devereux Slough) Project Planning Phase, UCSB**

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This award is associated with the planning phase for the restoration of North Campus Open Space in the area formerly used as Ocean Meadows Golf Course (63.8 acres),and the adjacent open space areas known as South Parcel (68 acres) and Whittier Parcel (3.7 acres). The project involves interim management, seed collection, and environmental planning. Environmental planning includes technical studies to support the preliminary design, environmental compliance documents (including existing conditions report, CEQA and NEPA documents), and technical work supporting permitting requirements.

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Joel Michaelsen 1/1/17-12/31/21 $980,000

Lisa Stratton

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State Coastal Conservancy 16-044

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**North Campus Open Space Vernal Pool Complex Restoration Project**

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This project supports restoration of 12 acres of rare wetland and upland habitat on the University of California, Santa Barbara's (UCSB's) South Parcel, including a 6-acre vernal pool complex, back dune swale, vernal marsh and salt marsh wetland habitats. The project site is adjacent to Devereux Slough within UCSB's North Campus Open Space (NCOS), part of the protected, 652-acre Ellwood Devereux coastal open space area. Historically, the upper Devereux Slough contained significant wetland values with both palustrine and estuarine habitat types and supported more than half of the coastal wetlands within the slough system. In 1965, wetlands in the upper slough were filled to create the Ocean Meadows golf course. Up to 500,000 cubic yards of soil were moved from adjacent lands causing severe degradation of the borrow sites and raising the elevation of the lower estuary between four and 10 feet. Filling reduced the flood capacity of the wetland, and significantly reduced habitat for estuarine and palustrine dependent wildlife, including fish, birds, insects and mammals of concern (Campopiano et. al, 2000). In 2011 and 2013, the State Coastal Conservancy (SCC) received two NCWCP grants for a total of $2 million; $500,000 for the acquisition of the Ocean Meadows/Upper Devereux Slough that occurred in 2013, and $1.5 million towards restoration of that wetland to its historic status. The restoration portions of those grants have been combined to fund a portion of Phase 1a of the larger restoration vision for this estuary. This project is for Phase 1b (12 acres), which forms an integrated and integral part of the larger project.

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Joel Michaelsen 1/1/17-12/31/21 $692,463

Lisa Stratton

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State Coastal Conservancy 16-044

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**North Campus Open Space Vernal Pool Complex Restoration Project**

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This project supports restoration of 12 acres of rare wetland and upland habitat on the University of California, Santa Barbara's (UCSB's) South Parcel, including a 6-acre vernal pool complex, back dune swale, vernal marsh and salt marsh wetland habitats. The project site is adjacent to Devereux Slough within UCSB's North Campus Open Space (NCOS), part of the protected, 652-acre Ellwood Devereux coastal open space area. Historically, the upper Devereux Slough contained significant wetland values with both palustrine and estuarine habitat types and supported more than half of the coastal wetlands within the slough system. In 1965, wetlands in the upper slough were filled to create the Ocean Meadows golf course. Up to 500,000 cubic yards of soil were moved from adjacent lands causing severe degradation of the borrow sites and raising the elevation of the lower estuary between four and 10 feet. Filling reduced the flood capacity of the wetland, and significantly reduced habitat for estuarine and palustrine dependent wildlife, including fish, birds, insects and mammals of concern (Campopiano et. al, 2000). In 2011 and 2013, the State Coastal Conservancy (SCC) received two NCWCP grants for a total of $2 million; $500,000 for the acquisition of the Ocean Meadows/Upper Devereux Slough that occurred in 2013, and $1.5 million towards restoration of that wetland to its historic status. The restoration portions of those grants have been combined to fund a portion of Phase 1a of the larger restoration vision for this estuary. This project is for Phase 1b (12 acres), which forms an integrated and integral part of the larger project.

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Joel Michaelsen 1/1/17-12/31/41 $1,203,126

Lisa Stratton

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State Coastal Conservancy 16-051

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**North Campus Open Space Wetland Transition**

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The goal of the project is to restore 12 acres of salt marsh and transitional habitat along the wetland side of the 1 mile long primary trail through the estuary. This area will be used for construction work through the project and a grant focused on specifically restoring this edge is vital to the final functionality and aesthetics of the restoration project. This zone will be part of the SLR transition zone and the challenging wetland to upland fringe that is the most challenging to restore.

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Noah Molotch 1/1/19-6/30/19 $42,208

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University of California 4600010378 AM-31

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Proposal for Expert Assistance with Snow Products, California

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The PI Noah Molotch has developed an algorithm to estimate daily melt-season snow water equivalent (SWE) over the Sierra Nevada mountains (85,000 km2), for the months March through August by two methods: reconstruction by combining remotely sensed snow cover images with a spatially distributed snowmelt model, and a blend of the reconstruction with snow sensor observations (blended product). The reconstructed data has a low bias, which is improvedby using the blended product, or can be quickly corrected with the local snow sensor data for the same time period. The State of California’s Department of Water Resources (CA DWR) would like to fully integrate spatial SWE into their water forecasts. Products produced by ERI for this study will be used by water forecasters in the state of California to integrate modeled spatial SWE into their forecasting operations. CA DWR forecasters and university researchers will also investigate using the modeled products as a bridge to extend the reach of the smaller-footprint dataset produced by the Airborne Snow Observatory (ASO) at the Jet Propulsion Laboratory (JPL), NASA.

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Kristin Morell 4/15/18-3/31/21 $285,581

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National Science Foundation 1756943

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**Collaborative Research: Permanent forearc strain partitioning in Northern Cascadia**

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We propose to evaluate the role of slab geometry and oblique convergence on the production and partitioning of permanent forearc deformation in a region of northern Cascadia where there are along-strike gradients in subduction obliquity, slab curvature, and geodetically-recorded strain. Specifically, this project will test the hypothesis that newly identified active crustal faults on Vancouver Island, British Columbia, Canada, accommodate right-lateral transpression and contribute to active oroclinal bending in response to the slab-parallel component of relative plate motion. To test this hypothesis, we will determine fault kinematics and the Holocene slip history of three prominent outer forearc structures using a combination of bedrock mapping and structural analysis, surficial mapping of offset Quaternary deposits, and exploratory paleoseismic trenches. This work will also provide the first constraints on the seismic hazard posed by crustal faults in populated areas of southern British Columbia and will train undergraduate and graduate students in the identification and characterization of active shallow faults.

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Kristin Morell 3/1/18-2/28/19 $20,470

Edward Keller

Thomas Dunne

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National Science Foundation 1830169

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The nature and physics of the Montecito debris flows of January 9, 2018, increasing community resiliency to debris flow hazards

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On January 9, 2018, three large debris flows in the village of Montecito, Santa Barbara County, California killed 21 people, destroyed or damaged over 390 homes and commercial buildings, and closed all local traffic for several weeks. The flows were caused by intense precipitation in the days following the Thomas Fire, the largest wildfire in California history. In this project we will: 1) document and analyze time-sensitive field evidence for the nature and physics of the Montecito debris flows; and 2) increase community resiliency by converting this knowledge into more accessible forms of public understanding and messaging about the risk of future debris flow damage. This program will be implemented as soon as possible, because key field evidence is rapidly degrading and research suggests the debris flow hazards posed by the Thomas fire may continue for two or more years.

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Max Moritz 12/31/99-00/00/00 $0

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National Fish and Wildlife Foundation 0806.18.059850

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**Restoration & Resilience of Endemic BCDF: Phase II**

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Restoration and management of BCDF, a key species of concern for LPNF, must incorporate its unique characteristics and environmental constraints on regeneration. This is particularly important in the context of climate change, which is likely to cause more frequent wildfires and more severe droughts. The massive Thomas Fire of 2017 only highlights the importance of severe events and the potential need for more active restoration in USFS Wilderness of southern California.

This project will utilize our detailed spatial characterization of BCDF stand sizes, locations, and post-fire survival status within the Zaca Fire perimeter, in conjunction with landscape-scale analyses of prioritization characteristics for restoration need and feasibility (e.g., mortality, climate sensitivity, accessibility). More local-scale analyses of factors associated with seedling survival (e.g., micro-topography, shading, nurse plant relationships) will then guide out-planting activities at chosen sites, which are likely to be outside wilderness areas. Seedlings from local BCDF populations will be used for out-planting into degraded stands. A comprehensive synthesis of what has been learned during this phase of the project will be provided to managers to guide the long-term resilience of BCDF.

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Max Moritz 3/1/18-2/29/20 $134,119

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University of California 20180192-04

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**Fire, Forest Dieback, and Climate Change in California**

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PI-Moritz and postdoc(s) will develop statistical analyses of historical and future fire patterns (e.g., frequency, severity, rates of spread) and their relationships to numerous biophysical causal factors (e.g., water stress in vegetation burned, weather conditions during fires, long-term climate variables controlling productivity and/or fire season length); human influences will also be examined (e.g., road densities, land development patterns). Management scenarios to mitigate both fire hazard and drought stress will be explored, with the goal of quantifying the degree to which they might have been able to alter recent impacts of drought across California; these will also be projected into future conditions. The “reversibility” of climate change scenarios will be examined by quantifying the habitat suitability requirements (i.e., environmental niche space) of mixed conifer forests, which should reveal how much of this important forest type may persist in the coming century and how much will no longer be able to survive in its current range.

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Max Moritz 2/6/18-12/31/19 $179,472

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University of California SA17-3881-01

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**Fire Probability Modeling for Avoided Emissions Projects**

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This project will produce updated projections of future wildfire activity across California. These will be provided to the California Department of Forestry and Fire Protection-Fire and Resource Assessment Program (CAL FIREFRAP) for use in greenhouse gas (GHG) accounting, resource allocation planning, and other activities. Our goal is to incorporate updates to base input data, regional statistical calibrations, and other refinements to produce maps of future fire probability under accepted climate change scenarios for California. This will be done in collaboration with Dr. Michael Mann at George Washington University, who has been instrumental in previous model development (i.e., Mann et al. 2016).

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Norm Nelson 8/9/13-8/8/15 $7,662

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East Carolina University A13-0184

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**A workshop on the laboratory measurement of the spectral absorption of color dissolved organic matter**

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We will carry out preliminary experiments in our laboratory using UltraPath and Shimadzu spectrophotometers. Dr. Nelson will travel to GSFC for the workshop, and will plan on conducting post-workshop activities back in the lab. Dr. Nelson will participate in data analysis and project report preparation, and will participate in any manuscript preparation led by the workshop participants for publication in peer-reviewed journals.

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Norm Nelson 3/27/18-3/26/21 $579,527

David Siegel

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National Aeronautics and Space Administration 80NSSC18K0736

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**Bermuda Bio-Optics Project: Data for MODIS Algorithm Maintenance**

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Continuing the over 22-year time series of in situ optical data needed to maintain MODIS remote sensing reflectance, chlorophyll, and absorption IOP algorithms, using observations from the Bermuda Atlantic Time-series Study site in the northwestern Sargasso Sea. We plan to collect high quality data for MODIS ocean products including remote sensing reflectance spectra, chlorophyll a concentration and inherent optical properties, and to compare them to the corresponding MODIS data sets. Component absorption spectra will be determined on samples shipped 3x yearly to UCSB for analysis.

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Norm Nelson 2/8/11-2/7/15 $732,936

David Siegel

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National Aeronautics and Space Administration NNX11AE99G

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**Bermuda Bio-Optics Project: Enhancement of Measurements for New Ocean Color Applications.**

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This project will revitalize ongoing time-series of high quality optical measurements in the field at the Bermuda time-series site. New applications for ocean color (algorithms, etc) will require novel and enhanced existing measurements of radiometric and inherent optical properties. This project will apply and test against field data, prospective algorithms addressing aspects of community structure and carbon flux, taking advantage of our time-series data records and ongoing related research at the site. We intend to introduce and test evolutionary improvements to techniques for measuring radiometric optical properties at the site. In particular the beginning part of the project will include development of an autonomous free-floating profiling optical buoy system (the Near-Surface Profiling Buoy, NSPB). The NSPB is a flexible, easily deployed, and is a cost-effective alternative to long-term, moored optical buoy installations. The NSPB eliminates the need to address biofouling and extrapolation to the sea surface from discrete fixed depths, which complicate data analysis from long-term moored optical buoy data. This approach also avoids modeling of upwelling radiance from the reflected sky radiance, which bedevils above-water approaches. We believe a global network of short-term, autonomous profile systems, patterned after the system proposed here, would change how ocean color satellite vicarious calibration is performed. The NSPB system will also make direct and diffuse incident irradiance determinations which will be useful for assessing aerosol and cloud optical properties and incident spectral irradiance at the sea surface. BBOP will provide a proving ground for this instrumentation which will replace currently-conducted handheld optics profiles.

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Norm Nelson 3/26/14-3/25/17 $439,579

David Siegel

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National Aeronautics and Space Administration NNX14AG24G

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Ocean Color Observations on CLIVAR: Opportunities in 2014 and 2015

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Since 2003 we have been participating in U.S. CO2/CLIVAR Repeat Hydrography expeditions, studying the distribution and dynamics of CDOM in the global ocean, and collecting a global database of particulate and CDOM absorption, radiometric profile measurements, phytoplankton pigments via HPLC, and related data for ocean color validation and algorithm development. Recently we have added an automated system that measures surface particulate backscattering, spectral particle absorption and attenuation, and particle size distribution to our suite of measurements, allowing us to study the impact of plankton community structure on the remotely-­‐sensible optical properties. Uncertainty in ship availability and scheduling for CLIVAR expeditions has in recent years made planning ahead for cruises through the conventional grant process challenging. We have an opportunity to participate in two expeditions in the Pacific in 2014 and 2015, and are submitting a Rapid Response proposal accordingly. We propose to analyze CDOM samples collected by the GSFC field team on the P16S expedition to the South Pacific and Southern Ocean in early 2014, and to mount a full effort with our own field team on the early 2015 P16N expedition to the equatorial and North Pacific along the 152W line. Our continuing research will contribute to understanding the effect of phytoplankton community structure on inherent optical properties, and to the development of new ocean color algorithms thereof.

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Norm Nelson 7/1/14-7/1/18 $1,056,179

David Siegel

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National Aeronautics and Space Administration NNX14AM83G

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**Bermuda Bio-Optics Project: Continuation of Time-series and Retrospective Data Analysis**

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The subtropical Sargasso Sea southeast of Bermuda has been and continues to be a model system for oceanographers studying earth system processes in the open ocean, in particular elemental cycles involving organic carbon and nutrients. The long-term studies being carried out at the U.S. JGOFS Bermuda Atlantic Time-series Study (BATS) site (Steinberg et al. 2001) are providing a decade-scale view of the current state of the ocean climate and its changes, while the hydrographic measurements at Hydrostation S provide a record of ocean climate change over the last half century. The long baseline of these time series reveals patterns and processes that are not visible within shorter studies. In particular, the BATS record of the inorganic carbon system (Bates et al, 2012; Figure 1) shows a strong trend in increasing CO2 and decreasing pH and aragonite saturation state. This trend may be a strong driver of the biological community that we can detect and analyze using bio-optical techniques. Our research within this time series context has focused on developing and applying methods for extending the reach of in situ time-series of oceanographic studies by using optical and remote sensing data to provide novel information and spatial context. Our past and ongoing research efforts have been oriented toward analyzing the linkages between ocean optical properties (as measured in situ and from spaceborne sensors) and biogeochemical processes such as CDOM cycling and primary productivity as modulated by seasonal cycles and mesoscale processes.

Previous and ongoing studies have also made use of BBOP in situ data in combination with imagery and other sensor data from EOS and related platforms in both algorithm development, validation, and in answering science questions. BBOP has also contributed significantly to data records required for deriving new products from ocean color data, and toward the validation of current spaceborne radiometric sensors and algorithms. Our goals for this project are to continue the time series of high quality observations at the BATS site, carry out studies of the long-term data set, transition to the new platform, and reprocess and quality control the historic data set using new community derived standards.

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Nicholas Nidzieko 6/1/17-12/31/17 $81,865

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AMPAC, Inc. AMPAC0180-17-012

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**Test of bi-static underwater optical imager from an autonomous underwater vehicle**

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UCSB will provide NAVAIR access to a Kongsberg-Hydroid REMUS 600 for the purpose of demonstrating a NAVAIR-provided bistatic LIDAR system, including initial testing in the coastal ocean near UCSB and a demonstration at Patuxent NAS.

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Nicholas Nidzieko 7/1/16-7/31/17 $11,657

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National Science Foundation 1745258

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**Collaborative Research: Circulation and mixing in a coastally trapped river plume**

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The purpose of the research funded under this award was to make novel measurements of turbulent mixing at the spreading edges of a buoyant coastal plume. Such observations are exceedingly rare, with the majority of our knowledge and understanding of plume dynamics based on numerical simulations. We successfully conducted an extensive field campaign, capturing the leading edge of a plume with ship-based observations and the offshore edge of the plume with an AUV.

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Nicholas Nidzieko 7/1/16-9/30/16 $188,794

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Northrop Grumman Corporation 8200199216

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**Annual Naval Technology Demonstration**

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The Annual Naval Technology Exercise, hosted by the Naval Undersea Warfare Center in Newport, RI, is an opportunity for industry and academia to demonstrate emerging technology and areas of research to the naval community. UCSB is collaborating with Northrop Grumman to demonstrate cross-domain autonomy using autonomous/unmanned underwater, surface, and aerial vehicles using the UCSB REMUS 600.

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Ryan Niemeyer 6/1/18-5/31/20 $164,977

Christina Tague

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US Department of Agriculture 2018-67012-28046

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**Forest thinning in dry forests: improving the resilience of forest health and streamflow in the Pacific Northwest**

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People in the interior Pacific Northwest depend on dry forests for timber, healthy ecosystems, and reliable streamflow. However, these forests are denser than historical forests, leaving them unhealthy and at risk for drought and wildfire. Forest thinning can increase forest health but the mountainous terrain of the Pacific Northwest makes it difficult to know where thinning will maximize forest resilience. Forest owners and managers have identified the need for management-relevant scientific information at the appropriate scale. The goal of the following integrated postdoctoral fellowship is to identify forest thinning strategies that maximize dry forest resilience through research and extension with forest owners. The integrated project has two over-arching objectives within research and extension: a) assess the ability of forest thinning strategies to reduce drought vulnerability and increase streamflow resilience; b) increase understanding of forest thinning impacts and implementation of thinning strategies among forest owners and managers. I will simulate forest hydrological and ecological processes in three watersheds in Washington and Idaho. I will establish three longitudinal workshop groups with forest owners in each of the watersheds. These groups will be consulted throughout the project to increase model applicability to forest owners.

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Roger Nisbet 8/8/12-8/7/15 $176,584

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University of California UCSCMCA 13-008

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From the Watershed to the Ocean: Using NASA Data and Models to Understand and Predict Variations in Central California Salmon.

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This project will focus on the development and testing of dynamic energy budget models for Chinook salmon. Characterization of the physical and biotic environments that determine the forcing functions for the model will come from the three physical models and the biogeochemical model described in the proposal and provided by other investigators. Since DEB model development and testing has to be performed in parallel with development of these other models, the first year of research will be committed to developing a prototype “full life cycle” DEB and estimating the parameters from literature data. The primary task in year 2 will be coupling the DEB model to the different forcing functions and resolving issues relating to matching of spatial scales. This is likely to involve experimentation with different stochastic variants on the basic model. The priority for year 3 will be integration of the components from individual investigators to meet the broader aims of the research.

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Roger Nisbet 10/1/10-9/30/15 $278,486

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University of California UCSCMCA-11-008

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**Investigations in Fisheries Ecology.**

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Dynamic Energy Budget (DEB) theory uses systems of differential equations to describe the rates at which individual organisms assimilate and utilize energy and elemental matter from food for maintenance, growth, reproduction and development. These rates depend on the state of the organism (age, size, sex, nutritional status, etc.) and on the state of its environment (food density, temperature,etc.). The objective of the research is to develop a DEB model for Chinook salmon that links the available knowledge on all stages from eggs to mature adult, and opens the way to future modeling of the complex salmon dynamics in space and time. Characterization of the physical and biotic environments that determine the forcing functions for the model will come from models provided by other investigators. The primary product will be a prototype

“full life cycle” DEB with parameters estimated from literature data. By the end of the project, the model will be available for coupling different forcing functions; this will involve resolving theoretical issues relating to matching of spatial scales. Components of the work will include:

• Initial selection of state variables for each life stage

• Literature search for empirical guidance on the “maturity” variable characterizing the transitions between stages

• Formulation of submodel for feeding

• Model parameterization from literature – first cut

• Preliminary model testing and refinement as needed

• Evaluation of implications of environmental forcing at different spatial scales

• Preparation of peer‐reviewed papers

• Attendance at project meetings

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J. Carter Ohlmann 11/30/18-10/14/19 $57,873

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Arete Associates AZ-401259

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**Ocean of Things Float Development**

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UCSB will work with Arete scientists to jointly develop a test plan for both float and associated sensor performance using the following approach: Develop a thorough understanding of sensor specifications and performance; develop a series of in situ tests that that can be used to ensure sensors meet their stated performance specifications over a wide range of environmental conditions; consider the role of small scale variations in sensor observations and necessary smoothing for meaningful sensor data; develop a thorough understanding of vertical shear in ocean currents within the upper meter of the ocean; develop a series of in situ tests that allow evaluation of water following capabilities and positioning (i.e. accuracy and lag in GPS positioning) of float prototypes both naked and instrumented. UCSB will also perform a series of float deployments in the coastal ocean and evaluate both float performance and sensor data following the Float Test Plan developed in Task 1. Float and sensor performance will be evaluated through a series of test deployments off the Southern California coast. For the first set of test deployments, floats will be deployed in the morning and retrieved before sunset (daily deployments). This will occur on roughly five separate days, over a range of environmental conditions, in month three of the project. The second type of test deployment will involve deployment of roughly 5 floats for a period of 24 to 48 hours. This test deployment will be used to demonstrate the float performance metrics indicated in Section 1.4.1 of the BAA. Microstar drifters will be deployed alongside floats to ensure tracking and recoverability of each float during its test phase. Large spatial gradients in oceanographic conditions (i.e. winds and waves) typically exist in Southern California waters (due to pronounced headlands, islands, and a curved coastline) and will be taken advantage of to ensure testing in a range of conditions.

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J. Ohlmann 9/1/15-8/31/16 $102,637

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City of Los Angeles 4500318931

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**Monitoring the Fate and Transport of the Diversion Effluent Plume from the Hyperion Treatment Plant (City of Los Angeles, Bureau of Sanitation)**

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An oceanographic study is being proposed to directly measure the horizontal

advection and mixing of effluent plume waters as they move from the shallow

outflow diffuser (hereafter “shallow outflow”) during the Fall 2015 diversion.

At the shallow outflow discharge location, fresh (i.e. buoyant compared with ambient ocean saltwater) plume waters are expected to quickly rise to the ocean surface (top few meters). Drifters drogued at 1meter depth provide a direct measure of transport pathways taken by surface water parcels. CTD measurements following drifter motion give a direct measure of effluent plume dilution as fresh plume waters mix with ambient saltwater. Primary goals of the proposed study are: 1. Make repeated direct measurements of effluent plume pathways from the diffuser location with water-following drifters. 2. Make repeated direct measurement of plume concentration (via salinity) following plume (drifter) motion. 3. Identify where (and if) plume waters (as tracked with drifters) reach the offshore edge of the surf zone and indicate corresponding plume concentration. 4. Provide an independent ocean current data set that can be used to evaluate numerical ocean circulation model performance.

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J. Ohlmann 3/15/11-2/28/15 $252,733

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Oregon State University S1364A-A

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**DYNAmics of the Madden-Julian Oscillation / DYNAMO Subsurface Fluxes.**

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Solar radiation plays a primary role in the diurnal (mixed layer) stratification process influencing both daytime EKE dissipation and setting up nighttime convection (e.g. Simpson and Dickey 1981, Price et al. 1986, Brainerd and Gregg 1993, Hosegood et al. 2008). Direct measurement of the in-water solar flux divergence, or radiant heating rates, allows variations in solar forcing of stratification, that can be significant, to be accurately quantified (e.g. Ohlmann et al. 1996, Ohlmann et al. 1998, Ohlmann et al. 2000, Hosegood et al. 2008). Solar attenuation depends primarily on upper ocean chlorophyll biomass concentration in open ocean waters. Chlorophyll biomass depends (to first order) on the availability of light and nutrients. When measured together, these data inform on bio-physical feedbacks. This statement of work describes the proposed measurement of surface irradiance and in water solar flux profiles during the Dynamo field experiment. Collecting solar flux profiles allows upper ocean stratification, an important component of upper ocean mixed layer evolution, to be quantified. It is also proposed that water samples be collected for laboratory analysis of chlorophyll biomass and nutrients. These data are necessary to understand why the in-water solar flux divergence varies, and the sampling adds little cost to the project. Upper ocean models work with solar transmission, defined as solar flux at depth relative to the incident value just above the surface. Surface irradiance will thus be sampled with a radiometer mounted on the ship’s mast. The complete data set, to be collected throughout the MJO-evolution cruises, will provide the necessary solar transmission information for accurate quantification of upper-ocean mixing, and will allow the bio-physical influence on stratification/dissipation to be better understood. Profiles of downwelling irradiance and upwelling radiance in 11 spectral bands (~300 to ~700 nm) will be measured using a Satlantic Profiler II Radiometer (www.satlantic.com/profiler). The radiometer is a long (122 cm) slender (9 cm in diameter) hand-deployed freefalling instrument (retrieved using a small winch) that eludes ship motion and shadow. Coincident measurements of downwelling spectral irradiance and total solar radiation incident at the surface will be made so that solar transmission profiles can be computed. It is estimated that solar flux profiles will be made to ~40 meters every few hours each day. It is possible that profiles in the morning and evening hours, when total solar energy is reduced, can be made shallower. Water samples at discrete depths will be collected once each day with the ship’s CTD/Rosette system and analyzed for chlorophyll concentration and nutrients. The noontime CTD/Rosette casts will be performed to ~150 meters so that the deep chlorophyll maximum and nutricline are resolved. The radiometer primarily resolves the visible portion of the entire solar spectrum. This is sufficient to resolve the solar flux at depths beneath ~5 m as energy in the ultra-violet and near-infrared spectral regions is completely attenuated in the top few meters of the ocean.

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Ryoko Oono 9/1/18-8/31/20 $199,779

Katja Seltmann

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National Science Foundation 1841715

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**EAGER: Does host specificity drive species diversification of fungal endophytes?**

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Foliar fungal endophytes are one of the most speciose and phylogenetically diverse guilds of microbial symbionts, living cryptically and ubiquitously in the photosynthetic tissues of every major plant lineage in the world. A better understanding of their host associations and ecological functions has important and far-reaching implications for medicine, industry, agriculture, multiple ecosystem functions (e.g., decomposition), and conservation of species diversity. A growing body of exploratory studies suggests that some of these fungi are host-specific and have adapted to a unique life history in which they reproduce during a critical period of host senescence. This project will test how host-specific adaptations, such as their ability to degrade and reproduce in host litter, may drive their species diversification. This project develops a model endophyte system by generating phylogenetic, genomic, and transcriptomic data from a global representation of the Lophodermium-Pinus symbiosis to understand the molecular mechanisms underlying diversification of fungal endophytes. The goal is to understand significant endophyte adaptations across diverse host lineages and assess the evolutionary history of the adaptive trait within a phylogenetic and genomic framework of the endophyte. Aim 1 is focused on community and phylogenetic diversity of the associations at a global scale and includes the development of a potentially transformative cyber-platform for the synthesis of systematic data. In Aim 2, the project integrates taxonomic, genomic and transcriptomic dimensions by identifying key genetic changes across multiple Lophodermium lineages correlating with changes in host-specificity. A transcriptomic analysis of endophyte tissues embedded within the host, complemented with novel in situ tools, will help push the boundaries of molecular and microscopic tools for the study of fungal endophytes.

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Ryoko Oono 9/1/18-8/31/20 $9,000

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National Science Foundation 1841715

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**EAGER: Does host specificity drive species diversification of fungal endophytes?**

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REU supplement that would help fund two female undergraduatestudents, Miss Yesenia Cardenas and Miss Helen Chang, to participate in research over the summer and fall quarters of 2019. Miss Cardenas is a Hispanic, first-generation college student, who has been working in our lab since January 2019. Miss Chang is a Chinese-American first-generation student who has been working in our lab since August 2018. This REU will supplement the current NSF EAGER grant 1841715 “Does host specificity drive species diversification of fungal endophytes?”, which explores species diversity of fungi living inside of plant tissues by combining high-throughput sequencing, culturing, and host plant metadata. The EAGER project has, so far, isolated hundreds of fungal strains, indicating various levels of host specificity, from diverse conifer species from China and Europe. The REU project lead by Miss Cardenas will further explore the enzymatic diversity of the fungi collected during the EAGER project using a microplate spectrophotometer. Her work will test the hypothesis that host-specific fungi harbor enzymes to decompose plant material, such as lignin. Additionally, while the original EAGER project proposed to focus on a particular pine-specific genus, the Lophodermium, the REU project lead by Miss Chang will focus on the many other fungal genera that were unexpectedly and commonly found across our plant samples. Both students will be invited to continue participating in research during the fall academic quarter of 2019 and encouraged to present their findings at local and regional conferences as well as participate in the preparation of manuscripts summarizing results from the EAGER project.

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Susannah Porter 5/1/13-4/30/15 $40,000

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National Science Foundation EAR-1251959

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**Collaborative Research: Estimating the Tempo of the Cambrian Explosion**

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Due to recent advances in geochronology, stratigraphy, and paleontology, the broad pattern of the Cambrian explosion is now known, but details of this event remain unclear, including the rate of diversification, the order of appearances of major clades, and the number and timing of pulses of origination. The goal of the work proposed here is to generate a statistically rigorous timeline for the appearances of skeletal animals during the first ~25 million years of the Cambrian (Nemakit-Daldynian and Tommotian stages). It will build on earlier work by PIs Maloof and Porter and their collaborators that used radiometrically calibrated carbon isotope chemostratigraphy to reconstruct the pattern of appearances through this interval at two million year resolution. That work suggested that the diversification of skeletal animals began early and extended throughout this interval, with pulses of appearances ca. 540–538 Ma, 534–530 Ma, and 524–522 Ma. However, it is not clear to what extent preservational biases and uncertainties in correlation and dating have influenced these patterns.

This research effort will use recently developed statistical methods to address these concerns. In particular, it will (1) use a new method developed by PI Wang and colleagues to estimate a confidence interval for the duration of the diversification (and thus provide an estimate of its rate), and (2) use both a randomization procedure and a new method developed by Wang and an undergraduate student to identify the most likely number of pulses of origination and their timing. As a side benefit, this work will also provide estimates of the time of origination for the skeletal genera in the database, as well as estimates of recovery potential and diversity curves. Finally, this work will fund ongoing efforts by PIs Maloof and Porter and graduate student Moore to augment the dataset, currently composed of 150 skeletal genera from 24 sections in China, Mongolia, and Siberia, with the eventual goal of extending coverage to later Cambrian time.

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Susannah Porter 9/1/14-8/31/19 $421,588

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National Science Foundation EAR-1411594

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**Collaborative Research: Toward a global timeline of biological and ocean geochemical change during the early Cambrian**

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Global correlation of the lower Cambrian has been difficult to achieve. Biostratigraphic correlation has been hampered by the provinciality of many early animal groups, including trilobites, and the inevitable diachroneity of fossil first appearance datums (FADs). Likewise, deriving correlations based only on qualitative ‘wiggle matching’ of chemostratigrapic records such as carbon (**δ**13C) or strontium (87Sr/86Sr) isotopes usually is ambiguous, and can be distorted by disconformities and carbonate diagenesis. Furthermore, without U-Pb zircon ages from interbedded tuffs and volcaniclastic rocks, even stratigraphy that is well correlated in relative time will not constrain the rate and duration of important biological and geochemical changes. The PIs will construct a comprehensive database of animal fossil occurrences, litho- and chemostratigraphy, and U-Pb zircon geochronology of interbedded volcaniclastics. Multiproxy records of variable diversity and completeness from around the globe will be correlated using the CONOP seriation software. The resulting composite stratigraphy will place each local record in relative and absolute time, based not on one variable, like FADs or **δ**13C, but rather on all available stratigraphic observations simultaneously. In addition, we will improve on the CONOP algorithms by adapting statistical techniques that compute uncertainties in stratigraphic correlation by taking into account variables such as curve-matching ambiguity and facies control on fossil preservation. The result will be a first-of-its-kind timeline of early Cambrian animal evolution and ocean geochemical change with quantitative uncertainties. We will use this timeline to constrain a new Earth-system model that tracks C, O, S, Mg, Ca, ALK, P, Sr, U and Mo in sea water and sediment pore-fluid.

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Margarita Portnykh 8/1/14-3/31/17 $192,692

Gary Libecap

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Donors Trust 73346928

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**Essays on Adaptation to Climate Change**

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The main focus of this research is the analysis of the economic effects of climate change. Climate change is perceived to be quite costly, there is a growing literature, which presents estimates of the costs of rising temperatures in different countries. However, at the moment adaptation mechanisms, especially provided by means of free-markets are studied much less. While there are some studies indicating that adaptation is likely to help, the exact scope and the magnitudes of the effect of various adaptation mechanisms on climate change costs are not well understood. This research will help fill in this gap in the literature. Prior research on migration as an adaptation mechanism allowed for the assessment of the efficacy of migratory responses as a means of adapting to rises in temperature. In this effort, I found that migration, while having a somewhat small effect on average, will be very helpful in reducing the costs for the areas which are extremely hit hard by the climate change (notably Florida and some currently densely populated areas on the East Coast). That paper provided a methodological contribution by constructing a discrete choice model, which explicitly accounts for general equilibrium effects. This model takes into account that while population density might affect individual migratory decisions it is also a function of those same individual decisions on the aggregate level. Currently, my research accounts for general equilibrium effects for population density only. One might expect that wages might change as a result of both migration (due to change in labor demand) and climate change (supply side shocks). These will be the next steps in my research.

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Simone Pulver 1/1/16-8/31/20 $349,308

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National Science Foundation 1534976

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**Egregious Polluters: A socially-structured explanation of disproportionality in the production of pollution**

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Rankings of firm environmental performance consistently reveal that the production of pollution is uneven. There are some facilities whose pollution burden on the environment is egregious compared to peer facilities. Freudenburg (2005) termed this pattern disproportionality in the production of pollution. Disproportionality as a measure to characterize inequality in the production of pollution is gaining ground in organizational research on society and the environment. Studies of disproportionality have been conducted for the primary metals industry (Freudenburg 2005), the dairy industry (Collins 2012), the electric utility industry (Grant et al. 2013), and comparatively across a range of industries (Collins forthcoming), and they all confirm the disproportionality pattern. However, such studies take a cross-sectional approach, analyzing disproportionality at one point in time. This research proposes a longitudinal, comparative, mixed-methods approach, investigating the social structures and contexts that affect if, how, and under what circumstances disproportionality changes over time. The research focuses on three questions: 1) How does disproportionality in the production of pollution change over time? 2) What drives those changes? and 3) What factors account for the persistence of egregious polluters? These questions are answered by analyzing facility-level toxic chemical emissions data reported to the US EPA's Toxics Release Inventory from 1988 to 2012 for three industry classifications- pulp and paper milling (NAICS 3221), printed circuit board manufacturing (NAICS 334412), and PVC pipe manufacturing (NAICS 326122).

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Matthew Rioux 8/1/16-7/31/20 $210,557

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National Science Foundation 1636678

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**Collaborative Research: The four-dimensional distribution of magmatism during the growth of lower oceanic crust: High precision U-Pb dating of IODP Hole U1473A, Atlantis Bank, SWIR**

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Recent application of high precision U-Pb zircon geochronology to samples of lower ocean crust has begun to provide unprecedented insight into the spatial and temporal distribution of magmatism during accretion, providing key constraints for the development of robust petrogenetic models. In this proposal, Cheadle, John, and Rioux propose to use integrated Secondary Ion Mass Spectrometry (SIMS) zircon trace element analysis and high precision isotope dilution-thermal ionization mass spectrometry (ID-TIMS) U-Pb dating to study the formation and cooling rates of the lower oceanic crust cored by the new deep IODP drill hole (Hole U1473A; 789.2 meters below sea floor). Cheadle, a shipboard scientist, collected over 90 samples from the core providing high spatial resolution. Previous work by the PIs on samples from Ocean Drilling Program (ODP) Holes 1105A and 735B, yielded analytical uncertainties for single zircon U-Pb dates as low as +/-0.011 Ma, and weighted mean uncertainties of +/-0.004 to +/-0.009 Ma for the most precisely dated samples. These data permitted the recognition of individual intrusive events, placing constraints on the constructional dimensions and history of lower oceanic crust.

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Matthew Rioux 4/15/17-3/31/20 $231,072

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National Science Foundation 1650407

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**Formation of the metamorphic sole of the Semail ophiolite: High-precision U-Pb dating of the preserved remnants of a subducted slab**

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The Semail (Oman-United Arab Emirates) and other Tethyan ophiolites are underlain by a thin sole of amphibolite- to granulite-facies metamorphic rocks. As preserved remnants of the underthrust plate, sole exposures can be used to better understand the formation and obduction of ophiolites. In two previous projects, PI Matt Rioux and his collaborators have used high-precision isotope dilution-thermal ionization mass spectrometry (ID-TIMS) U-Pb zircon dating to study the timing of ophiolite formation and the development of subduction below the ophiolite. New data from two large exposures of the metamorphic sole yielded surprising results, indicating that that the earliest sole metamorphism was synchronous with or pre-dated formation of the ophiolite crust and that metamorphism was diachronous along the length of the ophiolite, spanning ≥1.3 Ma, contrary to current models. To better understand the implications of these results to the origin of ophiolites, Rioux proposes to carry out high-precision dating at exposures of the metamorphic sole throughout the Semail ophiolite.

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Matthew Rioux 2/1/13-1/31/16 $218,043

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National Science Foundation EAR - 1250522

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**Timescales of development of sub-ophiolite subduction: High precision U-Pb dating and geochemical characterization of late magmatism and metamorphism in the Oman-U.A.E. ophiolite**

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The Oman-United Arab Emirates (U.A.E.) ophiolite is the largest sub-aerial exposure of oceanic lithosphere on Earth and has played an important role in our understanding of both the structure of the crust and the processes of crustal growth at mid-ocean ridges (MOR). The structure of the ophiolite makes it clear that the crust formed in an extensional environment similar to modern fast-spreading mid-ocean ridges, making it an invaluable resource for studying MOR processes. However, many researchers have also highlighted important differences between the Oman-U.A.E. ophiolite and modern ridges, including geochemical differences between MOR basalts and extrusive lavas in the ophiolite and the presence of multiple generations of plutonism and volcanism within the mantle and crust. To determine how observations from the ophiolite can be applied to modern spreading centers, it is necessary to understand the tectonic setting during formation and emplacement of the ophiolite.

The Principal Investigator recently completed an extensive U-Pb zircon geochronology and Nd isotope study of the ophiolite. The results from this study, together with previous work by other researchers, suggest that the age and composition of magmatism that post-dates formation of the ophiolite crust can provide important new insight into the tectonic history of the ophiolite. The proposed research would target three series of rocks: silicic sills and dikes in the mantle with Nd isotopic ratios that are distinct from the ophiolite crust; intrusive and extrusive rocks in the crust that post date the main phase of crustal growth; and leucocratic melts and amphibolite to granulite facies metamorphic rocks from the metamorphic sole. The distinct isotopic and geochemical compositions of the first two series are likely related to development of a thrust fault or subduction zone below the ophiolite. Initial U-Pb zircons dates from these rocks are <0.1–0.25 Ma younger than the ophiolite crust. Further high precision geochronology and geochemical analyses, including Nd and Hf isotopic analyses, will map out the spatial and temporal development of subduction or thrusting along the length of the ophiolite. High-precision U-Pb zircon geochronology and geochemistry of the metamorphic sole will provide complementary information on conditions in the under thrust slab. This project will provide fundamental new insight into the tectonic development of the Oman-U.A.E. ophiolite and place direct temporal constraints on models of ophiolite genesis.

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Matthew Rioux 2/15/12-7/31/14 $35,046

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National Science Foundation OCE-1144648

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**Collaborative Research: Plutons as ingredients for continental crust: Pilot study of the differences between intermediate plutons and lavas in the intra-Aleutian arc**

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We propose a pilot study of Paleogene and Neogene plutonic rocks, together with a limited number of the volcanic and volcanoclastic rocks intruded by these plutons. Our work will focus on collection of full whole rock major element, trace element and radiogenic isotope data and geochronologic data on plutonic rocks and a few older volcanic samples, for comparison with the much larger existing data set for Holocene volcanic rocks. Our main goals are constraining (a) the systematic chemical differences between plutons and volcanic rocks, (b) the origin of these differences via melting of different sources and/or different crustal differentiation processes, (c) the presence or absence of an age progression in the composition of Aleutian magmatic rocks.

We will analyze existing samples from three islands, Atka, Umnak, and Unalaska. We will use published XRF and/or K/Ar data as a guide to sample selection, but in most cases we may need to choose spatially related samples, rather than those previously analyzed, in order to ensure that we have enough material for our proposed work. Samples will undergo zircon U/Pb and 40Ar/39Ar geochronology, XRF and ICP-MS whole geochemistry, and Sr, Nd, Pb and Hf isotope analyses.

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Karl Rittger 6/1/18-12/31/19 $331,195

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California Department of Fish and Wildlife

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**High Resolution Snow Cover Maps for Quantifying Winter Habitat for Wildlife**

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Optical remote sensing can accurately provide much needed information on snow cover and snowpack; specifically, we can derive snow cover and snow albedo from these instruments. Since March of 2000, the Moderate Resolution Imaging Spectroradiometer (MODIS) has provided daily images of the entire Earth’s surface. Historically, MOD10 snow cover and albedo, based on simple algorithms such as the Normalized Snow Difference Index (NDSI), have been used. However, NDSI uses only parts of the electromagnetic spectrum available from Earth observing satellites while recent developments in modeling snow properties utilize innovative algorithms that take advantage of the full spectrum. Unlike NDSI, these modern algorithms, in this case MODIS Snow Covered Area and Grain Size (MODSCAG), maintain their performance over a broader range of land surfaces, especially mountainous terrain, during accumulation, and in spring and summer when snow is most heterogeneous (Rittger et al. 2013). The proposed work includes adapting and introducing statistical methodology for fusing Landsat and MODIS satellite data. In particular, the blended product will be daily optimal statistical estimates of snow cover at the 30m Landsat resolution, but that are consistent with the coarse 500m MODIS estimates.  This will be accomplished by utilizing generalized additive models, robust feature engineering techniques from machine learning, and spatial stochastic modeling that accounts for uncertainty in the fused products.

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Leonel Romero 9/18/15-2/29/20 $1,692,209

J. Ohlmann

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Centro De Investigacion Cientifica De Ensenada CICESE SB160037

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**Inner-Shelf Near-Surface Horizontal Dispersion**

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This proposal is part of the SENER-CONACYT/Hydrocarbons project to quantify horizontal dispersion over the inner shelf. This will be achieved with a series of field experiments in the Gulf of Mexico off the coast of Brownsville, TX. The project performance is 4.5 years, which is divided in three periods: Period 1 (9/11/2015 – 2/28/2017), Period 2 (3/1/2017 – 2/28/2019) and Period 3 (3/1/2019 – 2/28/2020). In the 1st Period UCSB will deliver a preliminary report of dispersion analysis and flow characteristics. In Period 2 UCSB will deliver a report with analysis of coastal dispersion with respect to background flow structures, as well as wind and wave forcing conditions. In Period 3 UCSB will deliver the final report with scale dependent diffusivity analysis with respect to distance from the shore, bathymetry, and forcing, including the characterization of background flow structures. The final deliverable will enable comparison with deep‐water dispersion studies and modeling efforts to be carried out by other members of the SENER‐CONACYT/Hydrocarbons project.

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Leonel Romero 7/1/16-6/30/19 $259,538

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Office of Naval Research N00014-16-1-2936

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**Numerical Modeling of Wave-Current interactions in the Presence of Submesoscale Ocean Features**

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This project studies wave-current interactions in the presence of oceanic submesoscale features such as fronts, filaments, and eddies. The work will investigate feedbacks on submesoscale processes due to wave-current interactions. The Regional Ocean Modeling System (ROMS) will be coupled to a wave model to study realistic wave-current interactions over the mid and inner continental shelf. The wave model will be validated in conditions with significant wave-current interactions, including both current-induced refraction and direct forcing by surface currents, against existing field observations. Coupled simulations will be carried out to investigate wave-current interactions and feedbacks over regions of elevated submesoscale activity. The coupled model will be validated against field observations collected during the DRI. The simulations will enable investigation of the importance of vortex forces on submesoscale processes. The resulting coupled model will provide a numerical framework for future capability expansion to incorporate additional effects of waves on currents such as modulation of the surface stress, and mixing due to breaking and non-breaking waves.

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Leonel Romero 6/17/15-10/31/15 $26,856

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University Corp for Atmospheric Research Z15-13065

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**Numerical Modeling of Non-Equilibrium Wind-Waves in the Southern Ocean**

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This subcontract to the National Center for Atmospheric is for the modeling of surface waves in the Southern Ocean for idealized and realistic wind scenarios. The work is in collaboration with Peter Sullivan at NCAR and William Large at NCAR’s Climate and Global Dynamics Division for a DOE SciDAC award: Southern Ocean Uptake in Model for Prediction Across Scales (MPAS). The goal is to investigate effects of surface waves on upper-ocean dynamics, mixing and deepening of the mixed layer due to wave-induced Langmuir circulation. Broadband directional wind-wave spectra will be simulated under different wind forcing conditions, including growing and decaying winds of different rates. Simulated wave spectra will enable full computations of Stokes drift. Time evolving Stokes drift will allow P. Sullivan to force Large Eddy Simulations of upper ocean turbulence with wave effects beyond wind-wave equilibrium. Wave simulations will be carried out using in-house modifications of the wave model WaveWatch III. Wave solutions will be made available on NCAR’s supercomputer Yellowstone and, if needed, on Department of Energy (DOE) machines located at National Energy Research Scientific Computing Center.

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Dylan Rood 9/15/11-8/31/15 $89,382

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National Science Foundation 1103532

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**Collaborative Research: Synchronizing ther North American Varve Chronology and the Greenland Ice Core Record Using Meteoric 10-BE-Flux.**

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This project will investigate the systematics of 10Be concentrations in glacial and nonglacial varved sediments from the NAVC, with the goal of determining how best to extract a record of 10Be fallout variations. Second, we will use the information gained in this first part of the project to plan and carry out a sampling and measurement scheme most likely to yield a record of centennial variability in 10Be fallout flux that can be matched to the 10Be flux record from the Greenland ice cores.

Measurement of bulk 10Be in NAVC sediments: The specific analytical tasks in this project include locating and obtaining samples of NAVC sediments, subsampling them for 10Be analysis, and measuring 10Be concentrations by accelerator mass spectrometry (AMS). Our primary source of samples will be an extensive archive of cores of NAVC sediments that PI Ridge has collected over many years and that are stored at Tufts University. One important aspect of this part of the project, however, is to ensure that subsamples are not cross-contaminated, or contaminated with modern 10Be, during collection. This requirement may restrict use of archived cores that are highly fractured or otherwise difficult to sample cleanly. If we can not obtain the samples we need from this archive, we will revisit source outcrops and collect new samples, typically by collecting short cores from outcrops using a hammered-PVC-pipe procedure that Ridge has employed for many years. Ridge will have primary responsibility for locating archived and new sample material and correlating it to the NAVC, although students will also be closely involved in this process and all project personnel will participate.

10Be concentrations are measured by an isotope dilution method in which a 9Be carrier is added to the sample, the entire sample is digested and the Be extracted, and the Be isotope ratio is measured by accelerator mass spectrometry (AMS). All aspects of this process are proven, reliable, and efficient. We will carry out Be extraction from sediments in a purpose-built chemistry laboratory at the University of Vermont (see Facilities and Resources), using a total-fusion method described by Stone (1996) and further refined during the past few years by Balco, Bierman, and Bierman’s students. At the 10Be concentrations we expect to measure in this project (> 107 atoms g␣1), AMS measurement is rapid (a few minutes per sample) and precise (␣1-2% analytical uncertainty).

Research focus 1: systematics of 10Be deposition in varved sediments. We will use several strategies in the first part of the project. First, we will investigate how 10Be is delivered to glacial and nonglacial varved sediments. We hypothesize that 10Be deposition is seasonally focused due to effects such as more effective scavenging by fine sediment during winter, suppression of fallout 10Be delivery to the lake during winter due to snow and ice cover, and the strong overall seasonality of sediment transport and deposition. We will investigate this by characterizing 10Be concentrations and their variability within both summer and winter layers to investigate seasonal effects, as well as laterally within a single varve to investigate the effect of sediment source variation between direct glacial sediment and runoff from the landscape. Understanding which, if any, of these processes are important may suggest means to preferentially sample fallout 10Be rather than recycled 10Be. Second, we will determine whether or not short-period solar variability, in particular the diagnostic 11-year Schwabe cycle, is present. As noted in many ice-core studies (Beer et al., 1994; Yiou et al., 1997; Steig et al., 1998), observing the 11-year cycle in a 10Be concentration record clearly shows that 10Be fallout variations are recorded (the reverse is not necessarily true: if we did not observe the 11-year cycle, it could signal only that it was suppressed by a multi-year residence time for fallout 10Be in the lake and catchment, which would not affect recording of centennial-scale variability). Analytical work for this part of the project will require approximately 90 10Be measurements, including paired summer and winter analyses on a number of glacial and nonglacial sections (approx. 40 analyses) and analyses of at least two short continuous sections at a resolution adequate to observe the 11-year period (e.g., two-year spacing over a 50-year period; 50 samples).

Research focus 2: generating a long 10Be flux record suitable for correlation. In the second part of the project we will choose a section of the NAVC from which to generate a long 10Be record with resolution appropriate to matching the centennial-scale variations in 10Be flux observed in the Greenland ice cores, and then generate this record. At present, absent any new information we may gain from the first part of the project described above, we think the nonglacial varve section at Newbury is the most likely section of the NAVC to yield such a record, for three reasons. First, varves are relatively thin, which limits dilution of the fallout signal. Second, centennial-scale variations in 10Be flux during this time interval are suitable for correlation at the needed precision, as demonstrated by Muscheler et al. (2008). Third, this section is one of the longest continuous sections in the NAVC, which permits us to generate as long a record as possible from a single site: this avoids any potential complications related to patching together 10Be records from multiple locations within the lake system.

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Dylan Rood 9/15/11-8/31/16 $150,017

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National Science Foundation 1114436

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**Collaborative Research: Deciphering Connections Among Land Management, Soil Erosion, and Sediment Yield in Large River Basins.**

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This research is a systematic, multidisciplinary study of the relationship between land-use and fluvial sediment transport in a mountainous region of western China. In this region, a unique hydrological dataset provides a framework to relate sediment transport changes to land-use, in the context of rapid urbanization and climate change. We will use hydrological observations and isotopic measurements to estimate sediment transport over a variety of temporal and spatial scales, determine the sources and sinks of the sediment, and tie our findings to regional land-use history. We anticipate these efforts will demonstrate that understanding the source and fate of sediment is important as it will allow us to unravel the effect of land-use on sediment transport in sensitive mountain regions undergoing population expansion, provide critical information for development and environmental conservation projects, and better allow us to use sediment flux measurements on a variety of time scales to estimate geological-time-scale rates of mass export from the landscape.

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Dylan Rood 5/1/17-9/30/18 $22,000

Toshiro Tanimoto

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University of Southern California 94315363-C

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**SCEC5 Participation, Project: Testing fault geometry and interaction models using high-precision slip rates on the San Cayetano and Ventura-Pitas Point Faults**

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The primary goal of this work is to use cosmogenic isotope dating techniques to precisely date important and poorly-dated Quaternary strain markers, which are variably deformed across two major structures in the Western Transverse Ranges (WTR): the San Cayatano and Ventura Pitas Point faults. These important structures are potentially linked by a fault section (the Southern San Cayetano fault), for which slip rates do not currently exist. Developing the first radiometric chronology of deformed deposits will directly contribute to and reduce uncertainties in earthquake hazards assessments associated with the SCEC5 research priorities, WGCEP goals, and the USGS National Seismic Hazard Mapping Program. First, we will develop precise ages for multiple river terraces and alluvial fans, which are differentially deformed across and along strike of the San Cayetano and Pitas Point fault systems. We will, in turn, use these ages to develop high-resolution deformation rates on these hazardous, but poorly understood, faults where current greater than two-fold uncertainty on rates exists. Finally, we will use the spatial distribution of slip rates along strike and between adjacent faults to test controversial subsurface fault geometry (ramp versus non-ramp models) and fault interaction models.

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Dylan Rood 6/1/14-5/31/15 $27,406

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US Geological Survey G14AP00055TDD

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**Differential Uplift and Incision of the Yakima River Terraces: Collaborative Research with WWU, UVM & State Agricultural College, and UCSB**

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We request funding for a collaborative effort to define and relate rates of fluvial incision along the Yakima River to surface deformation and earthquake activity along reverse faults and folds in the Columbia Basin of Washington State. This project combines lidar and field-based investigation of fluvial terraces along the Yakima River with cosmogenic radionuclide geochronology of terrace cover deposits to define spatial and temporal patterns of river downcutting over potentially active structures in the Yakima Fold and Thrust belt (YFTB).

The primary question we seek to address is whether incision of the Yakima River reflects differential uplift in response to late-Quaternary growth and development of the Yakima folds. Increasing recognition that reverse faults and folds of the YFTB represent potential earthquake sources underscores the need to resolve the contribution of geologically young deformation to the topographic development of these structures. The Yakima River terraces between Kittitas Valley and Roza Gap represent ideal landforms for reconstructing this history. Intact surfaces and exposed gravel cover deposits suggest a rich archive of sustained fluvial downcutting over three fault-cored anticlinal ridges, Manastash Ridge, Umtanum Ridge, and Selah Butte, from north to south. Preliminary mapping, field reconnaissance, and downstream correlation of terrace remnants reveals multiple generations of surfaces spanning these structures, as well as sufficiently thick cover deposits for 10Be/26Al burial dating of capping gravels based on the isochron method.

Specific questions that data collected by this project can address include: 1) whether downcutting of the Yakima River reflects late-Quaternary growth of YTFB anticlines (as expressed by uplifted terraces) occurred in response to recent slip and related uplift on the underlying reverse faults, 2) how spatial and temporal patterns of fluvial incision reveal the locus of surface deformation along the Yakima River, and 3) the relationship among incision and folding of the Yakima River terraces to slip on the underlying reverse faults. Investigation of these topics will shed light on the rate, timing, and magnitude of surface deformation along the Yakima River canyon, and improve our understanding of how contemporary shortening is partitioned among individual structures within the YFTB.

Reducing losses from earthquakes. This project will contribute to reducing losses from earthquakes in the Pacific Northwest by characterizing surface deformation and fault activity for structures with an unknown late-Quaternary history of deformation. The YFTB represents a priority target area for understanding earthquake hazards in Washington State due to proximity to critical facilities at the nearby Hanford Nuclear site.

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Roberta Rudnick 9/1/16-8/31/19 $140,000

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Arizona State University/Tempe EAR-1338810

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**FESD Type 1: The Dynamics of Earth System Oxygenation**

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Because Mo abundances in black shales remains the most important proxy for the rise of atmospheric oxygen, it is imperative that the behavior of Mo during crust formation and evolution (e.g., during magmatic differentiation and weathering) be determined. Attempts to use Mo abundances in black shales as an oxybarometer for the atmosphere have rested on the assumption that Mo is mainly contained within sulfides (particularly pyrite) in the upper continental crust, and that increased pyrite dissolution rates at higher pO2 results in greater release of Mo. The work to be carried out seeks to test this assumption.

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Roberta Rudnick 2/15/17-1/31/20 $394,453

John Cottle

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National Science Foundation 1650260

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**U-Pb thermochronology of lower crustal xenoliths -- estimating Moho temperature in order to constrain crustal heat production**

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This project will focus on developing methods that will allow crustal heat production to be ascertained from in-situ U-Pb thermochronology of lower crustal xenoliths combined with surface heat flow data. We will focus our initial efforts on a large and well-characterized suite of granulite-facies xenoliths from northern Tanzania, followed by similar studies of well-characterized lower crustal xenoliths from the Siberian Craton (Udachnaya kimberlite) and the Superior Craton (Attawapiskat kimberlites). The methods developed here can be applied to other suitable xenolith suites in order to develop global constraints on the proportion of heat producing elements that reside in the continental crust.

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Roberta Rudnick 2/1/18-1/31/20 $138,655

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National Science Foundation 1757313

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**Chalcophile Element Geochemistry**

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The funding will support the research of a PhD candidate, who will use the abundances and, in some cases, isotopic compositions (e.g., Mo) of variably chalcophile elements in three projects related to chalcophile element geochemistry of the crust-mantle system. The first project investigates the causes of the systematic depletion in Mo (relative to Ce and Pr – which have similar bulk partition coefficients) that the student discovered in many granitic suites through study of the Mo inventory in common crustal rocks. This depletion may be caused by i) loss of Mo to a magmatic vapor phase (MVP) during late-stage differentiation, ii) loss of Mo during crystal fractionation in the crust due to its partitioning into Ti-bearing phases, and/or iii) loss of Mo to a Ti-bearing phase (e.g., rutile) in subducted oceanic crust. To evaluate these possibilities, we will i) determine the Mo abundances and partitioning in xenolithic eclogites from the Man Shield, Sierra Leone that have been interpreted to be residues of Archean oceanic crust trapped within the cratonic mantle, and ii) analyze a calc-alkaline differentiation suite to determine whether Mo is lost to Fe-Ti oxides. The second project seeks to understand the systematic change in Mo isotopic composition of the upper continental crust that the student discovered through analyses of glacial diamictite composites. We hypothesize that the trend to lower ä98Mo seen in diamictites deposited from the Archean to the Paleozoic results from retention of isotopically light Mo within Fe and Mn hydroxides developed in the regolith following the GOE. To test this hypothesis, we plan to analyze Mo isotopes in two well-characterized weathering profiles developed on basalt and a diabase, for which mineralogy, major and trace elements, and Li and Mg isotopes have previously been determined. If our hypothesis stands, we expect the basalt profile to exhibit a lighter Mo isotope signature, as it contains abundant Fe-Mn oxides and hydroxides relative to the diabase profile. These data, in combination with the Mo isotope data for the glacial diamictites, may allow us to track the onset of oxidative weathering of the continents. The final project evaluates the degree to which variably chalcophile elements, like Mo, partition into sulfides in the mantle through a study of well characterized massif peridotites. In addition to determining chalcophile element partitioning behavior, we seek to provide additional constraints on the abundances of these elements (many of which are moderately to highly volatile, e.g., As, Cd, Ga, In, Sn, Tl) in the primitive mantle. For this work we will analyze a wide array of chalcophile elements in both whole rocks and minerals of well-characterized peridotites from the Pyrenees. By determining the behavior of these elements during mantle melting, we will provide additional constraints on their abundances in the primitive mantle and, from this, their partitioning into the core.

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Alyson Santoro 7/20/18-7/19/21 $351,478

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National Aeronautics and Space Administration 80NSSC18K1431

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**Surface versus subsurface controls on microbial attenuation of sinking particulate flux in the mesopelagic ocean**

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The goal of this research is to develop a mechanistic link between microbial attenuation of sinking particle flux and surface ocean properties, with the following objectives: 1. Measure, in situ, the magnitude of microbial respiration as a sink for carbon throughout the upper mesopelagic during the two EXPORTS field campaigns. 2. Refine the existing conceptual model of the relationship between surface ecosystems, subsurface biogeochemical characteristics, microbial respiration, and transfer efficiency of carbon through the mesopelagic. 3 Develop a predictive subsurface particle remineralization model that can be incorporated into EXPORTS data products.

To accomplish these objectives, we will deploy replicated sets of particle capture devices equipped with oxygen optode-based respiration chambers throughout the mesopelagic during the EXPORTS field campaigns. These systems, known as RESPIRE traps, allow for the in situ capture of sinking particles and subsequent tracking of oxygen consumption. We will compare respiration rates to subsurface ecosystem and biogeochemical characteristics including particle sinking rates, geochemical characterization of particles, and microbial community structure. We will further compare our results to remotely-sensed properties such as net primary production, phytoplankton community composition, and particle size spectra to determine the mechanistic basis for the relationship between surface ocean properties and subsurface activity. This research will determine the importance of microbial processes relative to other potential sinks, such as zooplankton particle consumption.

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Joshua Schimel 1/1/18-12/31/19 $60,000

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Community Environmental Council SB190053

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**Healthy Soils Demonstration Project**

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Joshua Schimel 5/1/12-4/30/16 $607,635

Patricia Holden

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National Science Foundation DEB-1145875

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**Collaborative Research: Controls over C Sequestration: Physiology vs. Physics**

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In this project, we will focus on an annual grassland to evaluate the mechanisms that regulate the fate of C. Grasslands in California cover over 10 million hectares (Jackson, 1985), are dominated by annual grasses, and are important ecosystems in the State. However, we have found comparable microbial dynamics in California grassland and Bishop pine forest, so we have confidence that the mechanisms we evaluate occur in other ecosystem types as well.

The research will take place at the UCSB Sedgwick Reserve, which is located 50 km from the coast in the Santa Ynez Valley (43o42 ́30 ́ ́N, 120o2 ́30 ́ ́W). The climate is Mediterranean and characteristic of interior California, with hot dry summers and cool wet winters. Average rainfall is 380 mm/yr, but varies widely; El Niño years are notably rainy. The soils are pachic argixerolls in valley bottoms and typic argixerolls on slopes. The vegetation is dominated by Mediterranean annual grasses including Bromus diandrus, B. hordaceous, and Avena fatua. Our main site will be in the Figueroa watershed previously studied by Schimel and Holden.

Analyzing the mechanisms involved requires controlled microcosm experiments that will be described below, but to explore how these mechanisms regulate how varying plant C inputs and moisture influence soil C storage, we propose a field experiment in which we modify: 1) plant C- inputs during the growing season (by thinning), and 2) the length of the dry season (by watering & rainout shelters). We will establish 3 blocks of 16 plots each (1 m x 1m) and establish a factorial design in which we create gradients of plant inputs and the length of the summer drought. We will use modeling to integrate between the micro- and macro-scales.

To modify plant inputs we will thin plots by hand to remove either 1/3, 2/3 or all the biomass (plus a control). Plots will be established initially after plants germinate in the fall of 2012 and new sprouts will be removed weekly or as necessary to maintain these approximate proportions. Soil moisture is likely to vary as transpiration losses will be lower in the thinned plots, but surface evaporation may partially compensate. Importantly, annual grasses senescence and die shortly after seed-set, not when the soils dry out. Thus, at the beginning of the summer, there will be a suite of plots with different amounts of dead roots to serve as substrate within the soils, with relatively similar moisture conditions (depending on the timing of spring rainfall). Dry-down after senescence will be purely by evaporation.

Moisture manipulations will include control, lengthened summer drought, shortened drought, and no drought. To extend the drought, we will build rainout shelters to prevent rewetting during the winter following the thinning treatments. To shorten the drought, we will use weekly drip irrigation. The goal is not to keep soils constantly wet, but to mimic episodic precipitation and prevent soils from drying fully. The short-drought treatment will be irrigated into July, then allowed to dry normally, roughly halving the length of the typical drought. The no-drought treatment will be watered into October. We will regularly weed the watered-plots during the summer to remove new sprouts.

Soil moisture will be monitored continuously (using soil moisture probes and dataloggers) in the experimental plots. Soil samples will be collected from all treatments to analyze C dynamics at four points through the year: 1) At peak live plant biomass late in the growing season (April/May), 2) early summer (just before the short-drought watering ends; late June), 3) midsummer (August), and 4) the end of the dry season (October or early January for the extended drought treatment). We will collect samples from the top 10 cm and analyze the essential C pools, including roots, light and heavy fraction OM, microbial biomass, etc. As these measures will be coupled to the work specifically testing the research hypotheses, we describe the details of those analyses in those sections. The field sampling will assess how environmental factors (C-supply and moisture) regulate C-pools and microbial activities, and the begin identifying the mechanisms connecting them. We will couple these to laboratory incubation studies to tease apart the specific mechanisms.

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Joshua Schimel 7/1/14-6/30/19 $704,320

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National Science Foundation PLR-1417758

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**Does E. vaginatum take up organic N?**

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Twenty years ago, Chapin et al. (1993) showed that Eriophorum vaginatum, the plant species that dominates arctic tussock tundra, not only can use organic N-sources, but actually grows better with amino acids as a sole N-source than with inorganic N salts. This catalyzed a cascade of research that transformed our vision of the plant-soil N-cycle; small N-containing organic compounds have replaced NH4+ as the centerpoint of the N cycle. A challenge of this shifting view however, is that no one has actually quantified, for any plant species growing in the wild, let alone for E. vaginatum-- how much of its total N demand is met by organic N-sources! The challenge to answering this question has been methodological; standard 15N isotope tracer methods show that many plants can take up amino acids, but without accounting for dilution of the 15N tracer into the native N pools as they rapidly turn over, they can not assess how much of the native compounds are taken up by plants. This project would overcome this problem and answer the question "Do plants really use organic N?" The project would use a combination of methods integrated through simulation modeling. The key novel method is microdialysis, in which a probe the size of a root is inserted into the soil, a carrier solution flows through it, and small molecules diffuse into it. If water is used as the carrier, it creates a diffusion gradient, while if a dextran solution is used, it draws water into the probe and so creates mass flow. Thus, this can indicate which substrates in soil are moving to the root surface. Microdialysis will be coupled with intact root uptake kinetic studies, isotope partitioning, and analyzing diffusion and transport of amino acids, NH4+ and NO3- through soil to parameterize a root uptake model that will be used to synthesize and integrate the results. This will allow evaluate the actual N sources used by E. vaginatum. The first phase of the work will be done under controlled conditions in the greenhouse; then having refined the methods and assessed model parameters, we will move into the field to assess seasonal patterns of N uptake and how it is affected by environmental manipulations.

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Joshua Schimel 10/1/16-9/30/17 $41,122

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University of California 00009485

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**Carbon sequestration potential of rangeland soils**

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Dr. Schimel's lab at UCSB will undertake to do a series of soil incubations to measure microbial biomass and nitrogen mineralization rates as an overall contribution to the project evaluating the effects of using compost applications to enhance soil C sequestration in grasslands around California.

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Joshua Schimel 3/1/16-2/28/17 $50,000

Joseph Blankinship

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USGS Powell Center G16AC000053

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**What lies below? Improving quantification and prediction of soil carbon storage, stability, and susceptibility to disturbance**

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Terrestrial carbon (C) dynamics and the fate of the soil C reservoir recently emerged as one of the largest sources of uncertainty in global C cycle models (Cannadell et al., 2007; Mishra et al., 2013; Scharlemann et al., 2014). Soils contain more C than the atmosphere and aboveground vegetation combined (Ciais et al., 2013), and will undeniably play a major role in determining future climate conditions. However, due to the complexities of biogeochemical processes governing soil C storage, it is largely unknown whether the role of soil will be to sequester C or instead to contribute further to rising atmospheric carbon dioxide (CO2) concentrations. Defining the stability of this highly relevant C pool and predicting its behavior under future climate scenarios is imperative for understanding and mitigating global climate change. This challenge cannot be overcome without better constraining the primary controls of soil C dynamics across ecosystem types. Improving knowledge of the primary controls of soil C storage requires measurements of distinct soil C pools that are repeatable and comparable across different soil and ecosystem types. However, a consistent set of methodologies assessing the fundamental biogeochemical processes governing soil C storage is currently lacking (Jandl et al., 2014). Datasets are often collected using entirely different methodologies or at vastly different resolutions (molecular- to ecosystem-scale), limiting our ability to integrate process-level understanding into terrestrial ecosystem models. Overcoming this challenge begins with the careful evaluation of existing datasets, calibration and standardization of methodologies for future data collection, and data integration into models.

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Katja Seltmann 6/27/16-6/30/18 $40,000

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California Coastal Conservancy 15-124

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**Kids in Nature Explore the Coast (KIN2)**

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The KIN2 program is designed to provide twenty 4-6th grade classrooms in our local area with one educational activity to one of the coastally focused KIN sites, which include UCSB Storke Wetlands, Coal Oil Point Reserve (COPR), North Campus Open Space and Arroyo Hondo Preserve. In addition, one follow-up classroom visit will be provided: KIN2 staff will work in small groups to complete the specially designed activities.  KIN2 will provide opportunities for teachers and students to explore the coast. We will:  Update 18 activity boxes; Provide funding for bus transportation for 20 5th grade teachers to bring their classes (approximately 600 students) to one of our coastal locations—Storke Wetlands, COPR and Arroyo Hondo;  Provide funding for each classroom to receive one follow-up visit from the KIN2 staff to work through the post field-trip activities; Expand opportunities for UCSB students to serve as mentors through the KIN2 program; Provide professional development  (incorporated into each fieldtrip); Promote the use of 18 previously developed coastally focused activity boxes that accompany each fieldtrip. The KIN2 program will engage graduate and undergraduate students to serve as mentors for the 4-6th grade students. Along with other scientists, these UCSB students will provide engaging and challenging activities, structured lessons and supportive interactions both in class and in the field.

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Katja Seltmann 10/1/16-9/30/19 $112,749

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The Institute of Museum and Library Services IMLS MA-30-16-0387-16

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**Upgrade of the historical Wenner insect collection: Utilizing collection data in Restoration Ecology**

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The Wenner insect collection represents an uncommon historical record of insects in endangered coastal California habitats. Dr. Adrian Wenner developed the collection as part of a UCSB general entomology course that he taught from 1961 until he retired in 1993. The majority of the specimens were collected on UCSB campus and the UCSB Natural Reserve System habitats; consequently, he created an important natural history archive that is valuable to ongoing regional ecological restoration research initiatives. In this project we propose to: 1) curate, barcode, image, database, and georeference the existing 9,000 insect specimens in the collection, 2) disseminate the information broadly to national and international specimen data resources, 3) develop an insect curation skills course as part of the already established and successful Curation of Natural History Collections course offered by the Cheadle Center for Biodiversity and Ecological Restoration, 4) create a manual on contemporary practices for curating and digitizing insect collections for small museums, and 5) provide workshops on insect identification and insect biodiversity.

The project will be devoted to the moving of the insects into new cabinets and taxonomic identification for reorganization of the collection; barcoding, imaging, and label transcription to database the specimens; and finding decimal geographical coordinates that match the specimen locality labels. Concurrent to these activities, we will develop and teach the Curation of Natural History Collections course on insect curation skills and recruit student interns to work in the collection. The course will be offered in winter quarter 2017 and fall quarter 2017. In winter quarter 2017 and 2018 we will provide workshops on insect identification and biodiversity for CCBER restoration staff, UC Santa Barbara Natural Reserve System staff, and other interested university staff, faculty and students.

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David Siegel 1/1/13-3/31/15 $30,424

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Columbia University 3 (GG006565-09)

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Atmospheric Correction Over Coastal Oceans using Hyperspectral Imaging and Scanning Polarimetry (ACOCO-HISP)

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This proposal addresses the NASA 2012 ROSES A.32 solicitation for research on improving atmospheric correction capability in remote sensing of coastal waters. The common approach for atmospheric correction is to use top-of-the-atmosphere (TOA) radiance in the near infrared (NIR) or short-wave infrared (SWIR) to select a ‘standard’ aerosol model, and to then use this model to calculate the TOA atmospheric radiance in the visible (VIS). This approach suffers from limitations that severely restrict the accuracy of water-leaving radiance retrievals especially in coastal regions covered by absorbing aerosols. We propose using radiance observations in the near ultra-violet (NUV) and O2 A-band as well as polarized multiangle radiance measurements in the VIS-NIR-SWIR to improve the efficacy of atmospheric correction for remote sensing of coastal waters. We will mostly utilize currently sponsored flights of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) onboard an ER-2 (high-altitude) aircraft to obtain the requisite NUV and O2 A-band over the coast of California. We will provide the Research Scanning Polarimeter (RSP) onboard the ER-2 at minimal cost to obtain the requisite multiangle VIS-NIR-SWIR polarized radiance. We will expand existing inversion algorithms to include these radiance data, and expand our ocean model to include independent variations for underwater-light scattering and absorption. Validation of atmospheric correction results will be performed by comparing the resulting water-leaving radiance with ship-based measurements from the NASA Plumes and Blooms (PnB) ocean color project. We will compare our ocean color retrievals with those retrieved from coincident satellite observations, and perform extensive sensitivity studies, to evaluate the benefits to atmospheric correction of adding NUV radiance, O2 radiance, and multiangle VIS-NIR-SWIR polarized radiance to the common suite of VIS-NIR-SWIR ocean color observations. The proposed research is the first to date to examine in detail and quantify the anticipated improvement in atmospheric correction when such measurements are included. The need for NUV radiance measurements to achieve this objective has been recognized in the recent formulation of threshold requirements for the NASA Pelagic and Coastal Ecosystem (PACE) mission. The PACE mission also advocates the contemporaneous use of multispectral and multiangle polarized radiance and of O2 A-band radiances to improve atmospheric correction. The results of the proposed research will also benefit other planned NASA missions, such as the Geostationary Coastal and Air Pollution Events (GEO-CAPE) and the Hyperspectral Infrared Imager (HyspIRI) missions, which add UV (and O2) bands and also require improved atmospheric correction algorithms. Analyzing the AVIRIS, RSP and ship based measurements is a highly complex undertaking that requires a multidisciplinary team of specialists. Dr. Chowdhary has worked for over a decade on the simultaneous retrieval of aerosol and ocean properties from RSP measurements. He developed a state-of-the-art radiative transfer program for polarized underwater light, and is a member of the Glory Science Team (GST) and the PACE Science Definition Team (PSDT). Dr. Alexandrov, Dr. van Diedenhoven, and Dr. Knobelspiesse have worked extensively on developing state-of-the-art inversion algorithms for RSP and APS data, and are also members of the GST. Mr. McCubbin has been part of the AVIRIS team at JPL for 15 years, and has extensive flight operation experience with AVIRIS and the ER-2. Dr. Cairns is the instrument scientist for the RSP and APS instruments, a member of the PSDT and the GST, and has overseen analyses of RSP data from all previous field campaigns. Dr. Siegel is a member of the PSDT, has overseen the PnB project for more than 15 years and is a developer of recent satellite ocean color analyses that use spectral inversion algorithms.

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David Siegel 5/1/18-4/30/21 $2,003,894

Nicholas Nidzieko

Daniel Reed

Norm Nelson

Robert Miller

Thomas Bell

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Department of Energy DE-AR0000922

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**Scalable Aquaculture Monitoring System - SAMS**

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Giant kelp (Macrocystis pyrifera), one of the most productive organisms on Earth, depends on nutrients supplied from the surrounding water column to maintain its photosynthetic apparatus and maximize growth rates. Recent advances in macroalgal biofuel production techniques have spurred action to develop offshore kelp farms to utilize natural pools of available nutrients and produce kelp biomass as a novel US energy production stream. To maximize kelp biomass yields, managers must be able to monitor the progression of the kelp farm, starting at outplant and continuing through the growth cycle to harvest, with information on biomass, productivity and physiological status, as well as the environmental conditions that control its near-term production. The rapid growth rate of this species, along with the everpresent potential of biomass losses due to frond senescence, herbivory, and fouling amplify the requirement of real time, autonomous monitoring data to assist in optimizing the operation of a giant kelp aquaculture farm. The Scalable Aquaculture Monitoring System (SAMS) addresses these needs by continuously assessing underwater and floating kelp biomass, physiological condition, and production along with the environmental factors known to affect kelp growth, all while delivering relevant information to the farm manager in real time. SAMS is composed of aerial and underwater autonomous vehicles and sensors, tested and validated to provide the most efficient suite of instruments delivering the required metrics at the plant scale, while maintaining the scalability to monitor multiple giant kelp farms simultaneously.

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David Siegel 8/1/17-9/17/21 $4,263,668

Norm Nelson

Uta Passow

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National Aeronautics and Space Administration 80NSSC17K0692

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**Synthesizing Optically- and Carbon Export-Relevant Particle Size Distributions for the EXPORTS Field Campaign**

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Giant kelp (Macrocystis pyrifera), one of the most productive organisms on Earth, depends on nutrients supplied from the surrounding water column to maintain its photosynthetic apparatus and maximize growth rates. Recent advances in macroalgal biofuel production techniques have spurred action to develop offshore kelp farms to utilize natural pools of available nutrients and produce kelp biomass as a novel US energy production stream. To maximize kelp biomass yields, managers must be able to monitor the progression of the kelp farm, starting at outplant and continuing through the growth cycle to harvest, with information on biomass, productivity and physiological status, as well as the environmental conditions that control its near-term production. The rapid growth rate of this species, along with the ever- present potential of biomass losses due to frond senescence, herbivory, and fouling amplify the requirement of real time, autonomous monitoring data to assist in optimizing the operation of a giant kelp aquaculture farm. The Scalable Aquaculture Monitoring System (SAMS) addresses these needs by continuously assessing underwater and floating kelp biomass, physiological condition, and production along with the environmental factors known to affect kelp growth, all while delivering relevant information to the farm manager in real time. SAMS is composed of aerial and underwater autonomous vehicles and sensors, tested and validated to provide the most efficient suite of instruments delivering the required metrics at the plant scale, while maintaining the scalability to monitor multiple giant kelp farms simultaneously.

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David Siegel 3/27/18-3/26/21 $574,858

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National Aeronautics and Space Administration 80NSSC18K0735

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**Plumes and Blooms MODIS Algorithm Maintenance**

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We will continue the fieldwork and data analysis tasks needed to maintain the Aqua MODIS ocean remote sensing reflectance, phytoplankton pigment and inherent optical property (IOP) algorithms using observations from the Santa Barbara Channel (SBC). Satellite algorithm maintenance requires the comparison of remote sensing data products with both coincident field observations as well as satellite data products from similar sensors. The SBC and its surrounding waters is an excellent location for this task due to the inherent large spatial and temporal variations in ocean and atmospheric optical properties.

We propose to quality assure the MODIS Aqua ocean color algorithms using observations in a complex coastal system. Of particular relevance are algorithms for remote sensing reflectance spectra, chlorophyll a concentration and inherent optical properties. MODIS ocean color data products are operationally produced by the NASA GSFC ocean color data processing group and are used regularly by the ocean sciences community. Maintenance of satellite algorithm requires quality assessment of MODIS Aqua satellite data products with both field observations as well as relevant satellite data products from other platforms (VIIRS, OLCI, etc.). We will analyze MODIS Aqua Level-2 satellite data products for the SBC and its surrounding waters through matchups to field observations and their intercomparison with (Henderikx Freitas et al. 2016). The integration of field and satellite observations provides quality assure the MODIS Aqua ocean color algorithm maintenance in a complex coastal ocean.

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David Siegel 7/7/11-7/6/15 $825,000

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National Aeronautics and Space Administration NNX11AL94G

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**Evaluating NPP Ocean Color Data Products in a Complex Coastal Environment: The Plumes and Blooms Program.**

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This effort will continue the Plumes and Blooms (PnB) satellite ocean color observational and analysis program and will use theses observations to understand the quality of NPP data products in the complex coastal environments. The scientific aim of the PnB program is the understanding of the dynamics of sediment plumes and phytoplankton blooms in a complex coastal ocean using satellite, ship and bio-optical glider observations. This aim is well suited for evaluating and creating new NPP ocean color data products. Specifically, we propose to:

¥ Continue the PnB monthly field sampling program of optical, biological, biogeochemical & hydrographic parameters in the Santa Barbara Channel,

¥ Use PnB data to evaluate NPP ocean color data products & algorithms,

¥ Supplement the PnB observational program with bimonthly, month-long oceanographic

glider deployments of physical and bio-optical parameters,

¥ Understand how phytoplankton functional type (PFT) regulates ocean color and inherent optical property (IOP) variability,

¥ Investigate the relationships among the particle size distribution (PSD) and IOP’s and develop methods for the robust assessment of PSD using NPP-VIIRS ocean color imagery,

¥ Use the coupled PnB ship, glider and satellite observations to investigate the dynamics of phytoplankton blooms and sediment plumes in a complex coastal ocean.

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David Siegel 9/1/11-8/31/14 $90,000

Fernanda Henderikx-Freit

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National Aeronautics and Space Administration NNX11AQ26H

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**Bio-optical Variability of Plumes, Blooms and Relaxations in the Santa Barbara Channel: How Biased are our Current Assessments?**

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Coastal waters are dynamic systems influenced by numerous atmospheric, marine and terrestrial processes that control the distribution of water column constituents in different temporal and spatial scales. Wind relaxation events, plumes and blooms are some of the mechanisms responsible for the mixing and transport of organic and inorganic materials such as larvae, nutrients, pollutants and sediments along the continental shelf. In the Santa Barbara Channel (SBC), California, these mechanisms cause dramatic changes in the color of the ocean on time scales of days to weeks. The variability of ocean color on short timescales has not been well characterized or accounted for by satellite remote sensing due to revisit time and sampling issues, which makes such observations impossible. Moreover, many ocean processes tend to develop under overcast conditions, when no imagery or in situ data is being collected, biasing the assessment of those systems to clear sky conditions. Underestimation of ocean productivity is also expected because phytoplankton pigmentation adapts to changes in light availability, and we might be biasing satellite observations of phytoplankton biomass to high light, clear sky conditions.

My research objective is to characterize the variability of bio-optical properties on time scales of days to weeks in the Santa Barbara Channel and account for the observations that have been missed by satellite systems due to unfavorable meteorological conditions. An electric glider will be used to make repeated bio-optical and physical measurements of the water column during plumes, blooms and relaxation events at excellent temporal and spatial resolutions, nearly independent of weather conditions. An extensive set of in situ data will be synthesized and used to complement NASA satellite ocean color data. The characterization of ocean color variability in the SBC in finer time scale will provide new insights about how the ocean responds to physical disturbances, what are the ecological implications of rapid changes in bio-optical properties of the water, and how the current under sampling influences how much we know about coastal marine ecosystems and primary productivity. This research will help answer questions related to bias and aliasing of remote sensing data, providing a new perspective about ocean dynamics in the SBC.

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David Siegel 9/1/12-8/31/15 $90,000

Thomas Bell

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National Aeronautics and Space Administration NNX12AO05H

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**Hyperspectral Remote Sensing of Kelp Condition in the Santa Barbara Channel.**

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Giant kelp ecosystems are highly productive and provide habitat structure for a diverse assemblage of biological and economically important species. Recent studies using Landsat multispectral imagery have successfully assessed changes in kelp biomass at temporal and spatial scales once deemed infeasible. This proposed study would extend this work and use hyperspectral images (AVIRIS) of giant kelp forests in the Santa Barbara Channel to determine the age structure and condition of kelp fronds and relate changes in frond demographics to physical and environmental variables already measured by the Santa Barbara Coastal Long Term Ecological Research (SBC LTER) project at UCSB. Measurable differences in the in vivo reflectance spectra of giant kelp fronds at different life stages have been confirmed by earlier studies. Giant kelp blades of known age will be collected once per month and photosynthetic characteristics will be measured in the laboratory through the use of oxygen evolution and fluorescence spectroscopy. The proposed project will help assess how the impacts of a changing environment impact nearshore nutrient cycling and biodiversity. AVIRIS images of SBC LTER kelp forests from 1997 to present are available for our use. We are in possession of all equipment to be used for analysis of giant kelp in vivo reflectance spectra and photosynthetic characteristics and are in a position to immediately begin work. The proposed project supports the NASA 2010 Science Plan objective of “Advance(ing) Earth System Science to meet the challenges of climate and environmental change” for a keystone ecosystem species with important economic value.

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David Siegel 10/1/12-11/12/14 $102,158

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National Aeronautics and Space Administration NNX13AC35G

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Controls on Open Ocean Productivity and Export eXperiment - COOPEX

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The determination of rates of net community production (NCP) and export production (EP) is important for many global ocean problems including understanding the role of the biological pump on atmospheric CO2 levels and thereby climate as well as the predicting the impacts of fossil fuel CO2 emissions on ocean ecosystems and biogeochemical cycles. The determination of EP and NCP on regional to global space scales and seasonal to interannual time scales is central for the rationale for NASA’s up-coming Pre-Aerosol-Cloud-Ecosystems (PACE) mission. However, our ability to assess these important carbon cycle parameters from satellite data remains quite limited and new approaches and data sets are desperately needed.

We propose the development of a major field campaign focused on a process level description of NCP and EP to provide progress toward the prediction of important carbon cycle parameters on local to global scales. This field campaign we have coined (for now) as: “Controls on Open Ocean Productivity and EXport – COOPEX”. The overarching question for COOPEX is How do upper ocean processes control net community production and carbon export in the open ocean and the sequestration of exported carbon to depth? A major field campaign focused on controls of carbon cycling parameters is needed to elucidate the underlying mechanisms controlling NCP and EP in the open ocean and provide the necessary data and models to assess changes in these parameters that can be measured by satellite observations. There are many recent technical advances in remote sensing science, ocean biogeochemistry, bio-optics, autonomous sampling platforms and coupled physical-ecological-biogeochemical numerical modeling that make this vision a possibility – and one that needs to be accomplished now.

Here, we request support from the NASA Ocean Biology and Biogeochemistry program to develop an implementation plan for COOPEX. Funds are requested for a small scoping workshop of domain experts (~25) to be held at UC Santa Barbara to scope and formulate the COOPEX implementation plan. The scoping workshop and the implementation plan writing will be led by Dave Siegel (UCSB) and Ken Buesseler (WHOI). Assisting them is a team of domain experts that will help steer the project forward and will assist in the writing of the implementation plan.

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David Siegel 7/7/14-7/6/18 $840,001

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National Aeronautics and Space Administration NNX14AL94G

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**Plumes and Blooms: A Multi-Decadal Coastal Bio-Optical Time-series and Retrospective Data Analysis**

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The focus of the Plumes and Blooms (PnB) program is to understand, predict and utilize changes in ocean color in the complex coastal waters of the Santa Barbara Channel (SBC), California. The core element of the PnB program is the monthly, day-long sampling of 7 stations across the Santa Barbara Channel. At each station, a full suite of bio-optical and oceanographic measurements is sampled and nearly 80 stations are completed each year. Coupled with the highly dynamic nature of the SBC, the PnB data are incredibly useful for answering coastal ocean color science questions and for validating satellite data products. PnB field observations started in 1996 and they have continued continuously to the present.

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David Siegel 3/1/15-2/28/20 $1,280,934

Norm Nelson

St̩phane Maritorena

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National Aeronautics and Space Administration NNX15AE72G

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**North Atlantic Aerosol and Marine Ecosystem Study (NAAMES)**

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The UCSB In Situ Ocean Optics & Ocean Color Modeling Team will support the NAAMES field project by: 1) making in situ ocean optics profiles of downwelling and upwelling spectral irradiance and upwelled radiance spectra at each daylight station during the four scheduled field deployments; 2) collecting and analyzing discrete water samples for inherent optical property determinations (cf., ag(λ), aph(λ), adet(λ)), 3) archiving reduced and quality-checked data within four months after each deployment; 4) develop, validated and implement next generation biooptical models for retrieving ocean properties using NAAMES radiance spectra determinations; 5) participating in project planning and science discussions and meetings; 6) conducting individual/collaborative data analyses to address project objectives; and 7) presenting results at national/international meetings and in peer-reviewed journals in accordance with project schedules.

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David Siegel 9/1/15-8/31/18 $105,000

James Allen

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National Aeronautics and Space Administration NNX15AN87H

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**Retrieval of Phytoplankton Size Distribution from Satellite Imagery**

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Knowledge about the size, composition, and distribution of particles in the global ocean has led to breakthroughs in understanding surface ecosystem dynamics as well as the ocean’s role in the Earth’s carbon cycle. Remote sensing has recently become a powerful tool for characterizing the global particle size distribution (PSD) and phytoplankton size composition on relevant spatiotemporal scales through the use of two distinct optical modeling approaches. Spectral backscattering models perform well in oligotrophic marine regions due to the lack of terrestrially derived particles, while spectral absorption models work well in productive regions due to their ability to key into the flattening of spectral absorption features in larger particles due to the package effect. However, these models often fail because they do not address the bio-optical complexity of the ocean. The proposed work will improve on current studies by developing a novel algorithm that merges PSD information from both particle backscattering and absorption spectra. These new models, as well as existing techniques, applied to remotely sensed imagery from SeaWiFS, MODIS-Aqua, and Suomi VIIRS will be validated with available PSD field data. This allows for a detailed analysis of model sensitivities to changes in input variables while providing the ability to reconcile phytoplankton vs. particle size distributions. The power law size distribution assumption will also be reassessed in favor of a two-component model made up of fine and coarse modes following approaches used by the atmospheric aerosol community.

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David Siegel 9/1/16-8/31/20 $120,000

Dylan Catlett

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National Aeronautics and Space Administration NNX16AO44H

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**Linking Ocean Optical Properties with Marine Microbial Diversity Assessed by Next-Generation Sequencing**

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Understanding global patterns and distributions in marine microbial diversity is imperative in developing knowledge of global primary production, biogeochemical cycling, and ecosystem structuring. Given the excessive time and cost required to study these distributions on significant temporal and spatial scales, developing the use of ocean color remote sensing as a means to monitor these distributions is of great interest to oceanographers. Thus, many efforts have been made to develop relationships between optical properties, such as remote sensing reflectance and spectral absorption and backscattering coefficients, and phytoplankton community structure, which is generally characterized in these efforts by High Performance Liquid Chromatography (HPLC). Recent advances in the use of next-generation sequencing (NGS) as a taxonomic method have provided a new way to characterize microbial community structure and diversity in situ, but its utility in studies linking optical signatures with diversity has yet to be examined. The goal of the proposed research is to further elucidate the two-way linkage in in situ optical signatures and phytoplankton community structure and to develop a relationship between these optical signatures and the non-photosynthetic microbial community by employing a combination of HPLC and NGS.

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David Siegel 8/25/16-8/24/20 $762,291

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National Aeronautics and Space Administration NNX16AR49G

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**Data Mining Global Ocean Ecosystem & Carbon Cycling Observations for EXPORTS Planning & Synthesis**

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The biological carbon pump is thought to export ~10 Pg C each year from the surface ocean to ocean’s interior largely in the form of settling organic particles. The monitoring and prediction of global carbon export and time scales for its sequestration remain important unknowns of the ocean’s carbon cycle. To attack this problem, NASA is implementing the EXport Processes in the Ocean from RemoTe Sensing (EXPORTS) field campaign. The goal of EXPORTS is to gain a predictive understanding of the export and fates of global ocean net primary production (NPP). The EXPORTS Science Plan focuses on quantifying the pathways in which NPP is exported from the upper ocean and is sequestered at depth. The EXPORTS field campaign as planned will likely observe maybe eight distinct ecosystem / carbon cycling states; yet its plan is to answer its science questions by performing longitudinal analyses of observations made across a range of states. Unfortunately, the statistical confidence in these results may be quite poor as only a small number of realizations may be afforded from the field program alone. The good news is that there are many sites where high-quality ecosystem / carbon cycling observations are available from online repositories and literature accounts from previous and ongoing research programs. Because of the available of these data, the “data mining” of available observations is an integral part of the EXPORTS Science Plan and likely critical to its success.

This pilot study will assess how to address the EXPORTS Science Questions by “data mining” previous observations. Specifically, our objectives are to: 1) Collect and collate available global ocean ecosystem and carbon cycling field observations useful for addressing the EXPORTS Science Questions; 2) Construct EXPORTS data products and “wiring diagrams” from available data and distribute and publish them for their wide use, and; 3) Evaluate the use of the mined data products for assessing the EXPORTS Science Questions and developing advanced satellite algorithms and numerical models.

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David Siegel 1/1/11-12/31/14 $765,235

Norm Nelson

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National Science Foundation 1040502

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**MRI: Development of Novel Profiling Buoy Technology for Satellite Ocean Color Calibration and Data Product Validation.**

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The Near Surface Profiling Buoy system is a floating/profiling optical sensor system that will enhance the calibration and validation of ocean color data from satellite instruments, enabling the collection of long-term climate data records of the ocean biosphere. Intellectual Merit: We propose to develop and evaluate the performance of a novel profiling buoy system for the calibration of satellite ocean color observations and the validation of their data products. This measurement capability is essential for creating longterm satellite climate data records of the ocean biosphere – but the costs of building and deploying existing moored buoy systems are excessive ($M’s to build & ~$1M/y to deploy for each site). Our system, the Near Surface Profiling Buoy (NSPB), will autonomously collect 100’s of high-quality, near-surface irradiance / radiance profiles during each multi-day deployment as part of a standard oceanographic research cruise. The NSPB is built upon recent advances in optical profiling instrumentation designed for turbid water environments that is adapted to the calibration and validation of ocean color satellite data. The NSPB system is aimed at making day-long to week-long deployments improving the likelihood of high quality match-ups with satellite data than is possible with conventional profiling techniques. This will alleviate wire time constraints for shared research cruises, maximizing the return on research vessel time (often >$50K/day). The NSPB will be a cost-effective alternative to long-term, moored optical buoy installations for satellite ocean color sensor calibration and eliminates the need for addressing biofouling and extrapolation of subsurface signals to the sea surface, which are the major sources of uncertainty for long-term moored systems. We will test and deploy the NSPB system in both coastal and open ocean conditions as part of on-going UCSB research projects in the Santa Barbara Channel (PnB) and the Sargasso Sea (BBOP). System performance will be assessed and compared with traditional long-term moored buoy systems and conventional ship-based spectroradiometry profiling. All radiometric measurements will be fully characterized and tied to NIST standards and system radiometric performance will be monitored at UCSB. Broader Impacts: This equipment development will help reenergize long-term field research programs conducted by the UCSB group. More importantly, it will help solve a national need for a low-cost, high-performance, flexible buoy system for the calibration and validation of satellite ocean color observations. This development project has the potential to greatly improve the accuracy of present and future satellite ocean color sensors, which will have impacts far beyond this instrumentation development request. It will also involve a significant collaboration between academic researchers and the private sector that will advance the state of the art in optical technology and facilitate acquisition of quality data and instrumentation for long-term records of the ocean biosphere.

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David Siegel 2/1/12-1/31/16 $370,141

Rachel Simons

Bruce Kendall

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National Science Foundation OCE-1155813

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**Quantifying the importance of biological factors in the estimation of**

**larval connectivity and population dynamics in the coastal ocean.**

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Larval connectivity, which quantifies the intensity and pathways of connections among populations through the dispersal of larvae, is a critical factor in marine population dynamics and has broad reaching consequences for marine spatial planning and fisheries management. Biophysical models, consisting of ocean circulation models combined with Lagrangian particle tracking, are now widely used to provide insights into the spatial and temporal dynamics of larval connectivity that remain unobtainable through empirical approaches. However, many of the biological assumptions used to characterize larval life history in these models are quite general and the impacts of these assumptions have yet to be rigorously tested. Our goal in this proposal is to quantify How important are the details of larval biology in estimates of connectivity and long-term population dynamics? To answer this question, we propose to study the spatial and temporal impacts of larval biological factors on site-to-site connectivity and long- term population growth using a biophysical model for nearshore species in the Southern California Bight (SCB). Four major, larval biological factors will be investigated: (1) temperature effects on larval growth, maturation and mortality, (2) vertical swimming behavior, (3) spatial/temporal variability in larval production, and (4) role of habitat on settlement. Using a biophysical model of the SCB, differences in larval connectivity due to the biological factors will be assessed statistically by comparing connectivity estimates that incorporate the additional biological factors to a baseline of connectivity estimates calculated from passive, neutrally buoyant particles. We will also employ a spatial demographic model, driven by the connectivity estimates, to quantify the influence of biological factors on long-term population dynamics. The proposed work will generate significant insights into the various aspects of larval biology that are critical for determining larval connectivity and for projecting population dynamics into the future. The results of this project will improve the credible application of biophysical modeling approaches to scientific studies of coastal species as well as to marine spatial planning and -fisheries management.

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David Siegel 6/30/14-6/29/17 $223,248

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Oregon State University NS257A-A

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**MODIS-based phytoplankton carbon and photoacclimation: responses to climate variability**

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On this collaborative project, the focus of the UCSB work will be comparing the MODIS-Aqua particulate backscatter coefficient (bbp) retrievals with LIDAR-based retrievals bbp from the CALIOP lidar. The UCSB group will work with global data from two ocean color algorithms; the Garver, Siegel and Martiorena (GSM) model (Maritorena et al. 2002, 2010; Siegel et al. 2013) and the Quasi-Analytical Algorithm (QAA; Lee et al. 2002). In particular, we will make refinements to the Garver, Siegel and Martiorena (GSM) algorithm based upon these comparisons and will develop uncertainty estimates for the bbp retrievals.

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David Siegel 10/1/16-9/30/17 $69,233

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University of Connecticut 137828

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Water Quality Monitoring Enhancements to Support the Hypoxia Management in Long Island Sound

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Long Island Sound (LIS) is one of the largest urban estuaries in the world with highly diverse, physically dynamic and optically complex water. Variability in inherent and apparent optical properties, as well as biogeochemical properties such as sediment and chlorophyll concentrations, is exceptional across the region (Aurin et al. 2010, Aurin & Dierssen 2012). Recent research has shown that the waters are “optically complex” and other constituents besides phytoplankton play an important role in light absorption and scattering within the estuary. Namely, colored dissolved organic matter (CDOM) and suspended sediment are flushed into the estuary from rivers and these substances serve to absorb considerable amounts of blue light (400-500 nm) and also backscatter light across the visible spectrum. Because of this optical complexity, the standard NASA open ocean algorithms for assessing chlorophyll are not intended to be used and are highly inaccurate. Semi-analytical models can be used to retrieve the absorption and backscattering properties of dissolved and suspended materials of coastal environments and Aurin et al. (2010) has already optimized a semi-analytical ocean color algorithm for the dynamic and optically complex LIS estuary. The model provides a means to estimate the contributions of absorption and backscattering coefficients of each component (cdom, nap, and phytoplankton) and these derived optical properties can then be used to estimate biogeochemical parameters such as total suspended material (TSM) and chlorophyll (Chl). This tuned model, however, has not yet been regularly applied to imagery from the current ocean color satellites NPP VIIRS, and MODIS Aqua and Terra. Because of the challenges in accurately retrieving biogeochemical properties in complex estuaries, little work has been done assessing the spatial patterns of biomass and the relationships between temperature and chlorophyll in this region. This work aims to improve the standard satellite image processing to retrieve more accurate measures of phytoplankton biomass. With application of new algorithms, we are now poised to assess the long-term relationship between surface temperature and chlorophyll and begin to tackle questions related to how LIS has changed over the last 15 years in response to climate and anthropogenic forcings.

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Alex Simms 1/1/13-8/31/16 $100,000

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American Chemical Society 52790-ND8

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**Hyperpycnal Subaqueous Fans of the Northern Santa Barbara Channel, Central California, USA**

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The importance of hyperpycnal flows in cross-shelf transport of sand has only recently been widely recognized. Attempts at creating a facies model for hyperpycnal flow deposits are based on either ancient examples where their presence can only be inferred from sedimentary characteristics or modern studies that sample the flows themselves but not necessarily their deposits. The study of Quaternary systems bridges the gap between modern processes, which provide predictive metrics of sedimentary characteristics, and ancient deposits representing petroleum reservoirs. The few existing Quaternary examples of deposits produced by hyperpycnal flows focus on the broad scale of deposition and rarely describe individual geomorphic features resulting from hyperpycnal flows. A recent marine bathymetric survey of the northern Santa Barbara Channel continental shelf by the United States Geological Survey (USGS) revealed the presence of shallow-water submarine fans immediately offshore of several small mountainous streams. Based on observations of modern discharges from these and similar systems in the northern Santa Barbara Channel, we hypothesis that these geomorphic features represent the deposits of hyperpycnal flows and dense bedload-dominated underflows emanating from steep mountain catchments. The purpose of this proposal is to characterize these features using high-resolution seismic profiles, sediment grab samples, underwater camera operations, and shallow cores. The characterization of these deposits will allow an evaluation of their potential for reservoir quality sands and provide one of the few modern examples of a subaqueous fan delta from a semi-arid setting.

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Alexander Simms 9/1/17-8/31/21 $260,571

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National Science Foundation 1644197

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**Collaborative Research: New Constraints on Post-Glacial Rebound and Holocene Environmental History along the Northern Antarctic Peninsula from Raised Beaches**

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The purpose of this research is to use optically stimulated luminescence to date a series of newly discovered raised beaches along the eastern Antarctic Peninsula and an already known, but only preliminarily dated, series of raised beaches in the South Shetland Islands. Data to be collected include the age and elevation of raised beaches, ground-penetrating radar profiles through the raised beaches, and the roundness of cobbles and the lithology of ice-rafted debris found on those raised beaches. With this data we will test three hypotheses: (1) uplift rates have increased in modern times relative to the late Holocene across the Antarctic Peninsula, (2) the sea-level history at the northern tip of the Antarctic Peninsula is distinctly different than that of the South Shetland Islands, and (3) cobble roundness and the source of ice-rafted debris on raised beaches varied systematically through time reflecting the climate history of the northern Antarctic Peninsula.

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Alexander Simms 2/1/12-1/31/17 $56,700

Ralph Archuleta

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University of Southern California Y86552-L

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**SCEC4 Participation, Project L: Collaborative Research: Documentation of Tsunami Deposits in the Carpinteria and Goleta Slough Estuaries: A signal of Great Earthquakes on the Pitas Point Thrust**

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Large earthquakes and their associated tsunamis including recent earthquakes and tsunamis in Sumatra (2004) and Japan (2011) have brought into sharp focus the hazards associated with convergent margins. The Transverse Ranges is southern California’s version of a convergent margin and recent work between Ventura and Carpinteria has demonstrated that the Ventura Avenue Anticline (VAA) and associated Pitas Point – Ventura thrust have produced large uplift events. The amount of inferred uplift, on the order of 7-8 m per event, likely results in the production of a sizable tsunami along the Santa Barbara – Ventura County coastline, although until recently no one has looked for tsunami deposits in this region. Prior work in Carpinteria Salt Marsh has identified a potential tsunami layer and a stratigraphy suggesting the presence of subsidence events within the marsh. In this coming year, we propose two primary tasks to test whether a coseismic subsidence signal is present and provide more support for a tsunami origin for the deposits. First, we will need to create a metric within Carpinteria Salt Marsh to test for sudden subsidence events. This will be done by conducting a survey of modern microfossils (foraminifera and diatoms) in order to establish transfer functions for high-resolution sea-level index points to be used to quantify subsidence. Second, we propose to duplicate this study in nearby Goleta Slough to determine if a similar record of proposed tsunami deposits is present.

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Alexander Simms 2/1/12-1/31/17 $12,000

Ralph Archuleta

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University of Southern California Y86552-T

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**SCEC4 Participation, Project T: Testing Model Predictions of Large Tsunamis Associated with Great Earthquakes on the Pitas Point Thrust using Ground-Penetrating Radar**

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Model predictions of motion along the Pitas Point Thrust-Ventura Avenue Anticline (PPT-VAA) call for tsunamis with peak amplitudes of 6-9 m along the Santa Barbara and Ventura coasts (Ryan et al., 2015; Kie Thio et al., 2014; and Lotto and Dunham, 2014; Fig. 1); amplitudes similar to the tsunami generated by the Tohoku-earthquake. However, the fault motion and geometry used as a source for these model predictions has been called into question (Nicholson et al., 2015). To date, evidence for such large tsunamis is lacking. However, the only viable archive along this coastline that has been examined is Carpinteria Slough, which appears to be undergoing large environmental shifts at the same time as the purported large earthquakes, potentially masking any potential tsunami deposits within the slough (Reynolds et al., 2015). Most of the coastline of the Santa Barbara Channel is marked by cliffs or sandy beaches, with very few marshes like Carpinteria Slough to preserve evidence for tsunami inundation. However recent work along other coastlines known to have experienced large tsunamis (>6 m) like those predicted to have struck the Santa Barbara Channel coast have shown that sandy beach ridges also provide a record of past tsunami inundation and erosion (Meyers et al., 1996; Gouramanis et al., 2015; Simms et al., 2015). The purpose of this project is to determine if such erosional surfaces can be found in Ground Penetrating Radar (GPR) profiles along the coastal beach plain of Ventura and Oxnard, California. Their presence/absence provides a test for tsunamis hypothesized to have been created by earthquakes events along the PPT-VAA.

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Alexander Simms 8/1/14-7/31/15 $19,508

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US Geological Survey G14AC00277

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**Geologic Controls on Karst in western Oklahoma**

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Western Oklahoma is host to over 1200 feet of interbedded shales, sandstones, and gypsums. The gypsums of western Oklahoma provide natural resources for local economic development but also pose a risk to transportation and other infrastructure. The area is prone to karst and similar to the neighboring Texas Panhandle, the age and geologic controls on karst are still relatively poorly understood. During a mapping project of the Washita National Battlefield in western Oklahoma, the PI and a former undergraduate student noted the development of inverted topography from karst. The purpose of this proposal is to expand the limited mapping (<35 km2) conducted as part of that project in order to better understand the distribution of karst landforms in the region and gain better insights into the timing and controls on karst formation in western Oklahoma. Our central hypothesis is that karst follows the major late Quaternary drainages of the region. If this is true it suggests a tie between river incision and karst in the region. However, this leaves unresolved whether the karst controlled river development or river incision lead to karst formation. The relationship between karst and the other Cenozoic stratigraphic units (e.g. Neogene Ogallala Formation, Quaternary Terraces) will allow for this differentiation. In order to test our central hypothesis we will map the surface geology of two quadrangles in western Oklahoma. We expect to find that the inverted topographic features within our study area created due to karst are only found along the major stream courses and the karst cross-cuts the Ogallala Formation but not the Quaternary terraces. If our hypothesis is correct that would suggest that karst in this region is no older than the stream courses.

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Michael Singer 9/19/18-9/19/22 $569,285

Kelly Caylor

Dar Roberts

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Department of Defense Strategic Environmental Research Devel W912HQ18C0068

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**Understanding and Assessing Riparian Habitat Vulnerability to Drought-Prone Climate Regimes on Department of Defense Bases in the Southerwestern USA**

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Our project will provide a toolkit and quantitative support for land/water conservation management plans to ensure the sustainability and resilience of riparian forest ecosystems in arid and semi-arid landscapes. This work will focus on drought-prone ecosystems, where prolonged dry periods affect riparian habitat quantity and quality, thereby limiting their role as thermal and moisture refugia for many threatened and endangered (T&E) species such as passerine songbirds and amphibians. Drought stress affects the extent, functioning, and sustainability of riparian habitats for T&E species, which are of great management concern on DoD bases. However, there are currently limited tools available for developing sustainable, long-term riparian habitat management plans that are responsive to changes in the mean state and variability of climate. Our project will detect and assess the responses of sensitive riparian forests to drought stress over recent decades, and will generalize these responses through modeling of a warming/drying climate punctuated by variable rainfall.

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Michael Singer 8/1/17-7/31/20 $396,566

Kelly Caylor

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National Science Foundation 1700555

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**Collaborative Research: Impacts of Dynamic, Climate-Driven Water Availability on Tree Water Use and Health in Mediterranean Riparian Forests**

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We propose an integration of methods to quantify and clarify how seasonal and annual variability in water sources influence tree water use, growth, and health, and how these processes are recorded within tree ring isotopic signatures. Our project combines: 1) field-based measurements of climate, soil hydrology, and tree water use, water sampling and laboratory analysis of oxygen isotopes from all potential tree water sources; (2) contemporary and retrospective analysis of oxygen and carbon isotopes in annual tree-rings to investigate recent climate-driven fluctuations in tree water use and water use efficiency; (3) seasonal (intra-annual) analysis of oxygen isotopes via high-resolution 'micro-slicing' of annual tree rings to assess seasonal fluctuations in tree water source use during the project period; and 4) improvement and application of a climate-driven numerical ecohydrology model that includes dynamic water fluxes into the floodplain, isotopic fractionation/mixing, and tree water uptake and cellulose preservation. Using this model and collected data, we will compare the ecohydrologic responses to climatic fluctuations and trends in water availability at forest sites along a strong climatic gradient in SE France.

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Michael Singer 1/1/13-12/31/16 $96,466

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National Science Foundation EAR - 1226741

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Collaborative Research: Establishing Process Links Between Streamflow, Sediment Transport/Storage, and Biogeochemical Processing of Mercury.

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This research effort is an investigation that ties together fluvial geomorphology and biogeochemistry in a manner that will a) identify critical locations in fluvial systems where the risk of mercury (Hg) input to food webs increases and b) elucidate the processes by which this occurs. The proposed research will develop new understanding of the interplay between hydrology, sediment transport/storage, and biogeochemistry. The project is designed so that this new knowledge can be generalized and readily transferred to a wide range of fluvial systems beset by sediment-adsorbed contaminants. The study will focus on the longitudinal (downstream) transport and biogeochemical processing of sediment-adsorbed Hg derived from hydraulic gold mining in the Sierra Nevada and mercury mining in the Coast Ranges within and through the Yuba-Feather-Sacramento River system of Northern California, USA. It will document the primary sources (Coast Range v. Sierra Nevada) of Hg contamination to lowland ecosystems in the Sacramento Valley and Bay-Delta and the relative contribution and risks of each. It will challenge conventional wisdom by assessing how Hg bioavailability changes along sediment transport pathways, irrespective of total Hg concentrations, and by identifying/quantifying the controlling processes at the intersection of sedimentation/inundation and biogeochemical modifications of Hg speciation. The proposed work will: 1) mathematically model flood inundation in river corridors to identify areas of high potential of oxidation/reduction; 2) identify preferential zones of sedimentation through numerical modeling of eventbased washload transport and interpret relative sediment deposit age via a detailed and spatially extensive library of sedimentary histories from prior work; 3) identify distinct contamination sources to lowlands by conducting Hg stable isotopic analysis of sediment; and 4) investigate Hg speciation and reactivity in conjunction with changes in Hg species isotopic signatures, associated with redox conditions, sediment source, and ambient chemistry.

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Michael Singer 4/1/17-12/31/20 $302,235

Dar Roberts

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State University of New York (SUNY) 550-1142143-79134

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**Linking basin-scale, stand-level, and individual tree water stress indicators for groundwater-dependent riparian forests in multiple-use river basins**

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This research project will develop a suite of water-stress indicators at several scales to assess the health of riparian ecosystems in response to sustained groundwater decline. This project will address a topic of scientific and societal importance, namely how to evaluate and help prevent negative impacts of drought and human-induced water shortages on vulnerable, high-value riparian ecosystems. It will integrate advanced methods in two rapidly emerging fields, hyperspectral remote sensing and isotope dendroecology, to develop a more holistic understanding of water stress at multiple scales of resolution. The project will compare water stress indicators that vary in their timing, strength, and rates of change, and it will facilitate the evaluation of warning signs and time lags among physiological water stress, reduced growth, and dieback in individual trees as well as synoptic forest decline evident throughout a river corridor. This project has the potential to influence groundwater management practices throughout California and in water-limited, multiple-use basins elsewhere. In partnership with The Nature Conservancy and other project collaborators, the investigators will integrate project findings with statewide guidelines for protecting groundwater-dependent riparian ecosystems mandated under California's recently implemented Groundwater Sustainability Management Act. The investigators will interact with groundwater conservation and management efforts in river basins through workshops for managers and stakeholders. They will mentor early-career environmental scientists, including women in STEM fields, and they will conduct outreach activities for elementary and secondary school students to increase regional environmental awareness in the study region.

Riparian forests and woodlands are hotspots of biodiversity, and they support key functions and habitats within river corridors, but they are particularly sensitive to large changes in water supply. This project will take place in the Santa Clara River in southern California, where sustained groundwater pumping for irrigation during a severe drought has had negative impacts and allows for study of riparian woodland response to changing environmental conditions over both short and longer terms. The investigators will assess the signals and thresholds of water stress over the last decade using high-resolution aerial imagery and tree-rings to develop predictors of long-term impairment and collapse. They will capitalize on extensive groundwater well records to link water-table dynamics with changes in plant water status detected at two different scales through the use of basin-wide, high-resolution aerial imagery taken seasonally during the drought and annual growth and carbon isotope data from tree rings covering the same period.

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Michael Singer 2/26/18-6/15/19 $31,371

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The Nature Conservancy 07282017-4691

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**Assessing Riparian Forest Water Sources in the Santa Clara River Basin**

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Dynamic partitioning of water in the floodplain directly controls water availability to riparian trees rooted at different depths. We propose to collect detailed datasets at several field installations in the Santa Clara River Basin, which will enable us to ascertain: a) the evolving access to subsurface water by riparian trees; b) the relative magnitude of their use of groundwater, particularly during stressful periods; and c) their corresponding growth responses. Notably, it will allow us to assess the groundwater dependency of riparian forests in this basin, which has experienced marked declines in water tables and subsurface soil moisture due to the recent drought.

The data from this study will provide new understanding of water availability to riparian forests and their use of this water. These results will be relevant to surface water management efforts including developing aquifer recharge strategies and timing that benefit riparian forest ecosystems. Specifically, we will: 1) fingerprint distinct differences between potential endmember source waters to trees; 2) assess what water Salix and Poplulus spp. are using in the Santa Clara basin on annual and seasonal timescales, including likely depths of water access to roots and water source switching; and 3) quantify the growth response of these trees to fluctuations in water availability. Collectively, these data will indicate the patterns of groundwater use by keystone riparian trees. Due to the ubiquity of the focal species and similar ecohydrological responses of closely-related taxa, the results are projected to be applicable to riparian systems throughout California and other dryland regions.

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Michael Singer 2/26/18-1/31/20 $37,300

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The Nature Conservancy 07282017-4691

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**Assessing Riparian Forest Water Sources in the Santa Clara River Basin**

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Christopher Sorlien 10/1/15-9/30/18 $87,059

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National Science Foundation 1537719

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**Collaborative Research: The North Anatolian Fault system in the Marmara Sea, Turkey - Insights from the Plio-Quaternary evolution of a multi-stranded transform**

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A continental transform is expected to originate as a distributed network of small faults with complex geometries that, with continued slip, gradually coalesce and simplify into a through-going fault. The North Anatolian Fault (NAF), a young continental transform, has been proposed as a prime example of this process. In the Marmara Sea, however, the NAF splits into several branches and forms a transtensional basin. Most of the strain is associated with the Northern Branch, which spawned three 1200-m deep basins. It has been proposed that the strain is focusing on the Northern Branch and that the Central and Southern branches are being abandoned. However, recent multichannel, sparker, and chirp seismic reflection and multibeam bathymetry data demonstrate continued activity of the Central Branch. These new data collected in 2013 and 2014 image the stratigraphy and numerous individual fault strands on the southern shelf of the Marmara Sea. We will use these data, in combination with a large suite of available previous data, to map the stratigraphy and faulting related to the Central Branch of the NAF. We propose to extend our published stratigraphic age model covering the past 0.5 Ma to greater depth and age. Earliest Pliocene fill of Messinian (~5 Ma) erosional valleys dated on land will be projected short distances to our near-shore reflection data to provide a base to the age model. Based on this stratigraphic framework, we will evaluate fault kinematics of many strands over the southern Marmara Sea during the last several million years. We will test the age model using sequence stratigraphic modeling. Basin modeling will be used to separate the effects of sediment loading, compaction and tectonic subsidence and test the extension estimates.

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Christopher Sorlien 1/1/14-12/31/17 $170,539

Bruce Luyendyk

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National Science Foundation PLR-1341585

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**Subsidence, Tilting, Sedimentation, and Oligocene-middle Miocene paleo-depth of Ross Sea**

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It has been proposed that the Ross Embayment and much of West Antarctica was a high elevation plateau supported by thick crust before rifting commenced 104 Ma, and has extended and subsided since then. As extension waned towards the end of the Cretaceous (east) or the Paleogene (west), the Ross Embayment lithosphere continued to subside creating the proto Ross Sea. A seismic-stratigraphic and modeling study is proposed to address the transition from basement rock near and above sea level across most of the future Ross Sea region in early Cenozoic time, to sedimentation in shallow water by the end of Oligocene time and into the early Miocene. Paleo-depths and the nature of the sea floor/subaerial surface through time will be quantified, providing models for Oligocene-early Miocene paleo-topography and tests for hypotheses for extension in the Ross Embayment. This work affects modeling of West Antarctic ice volumes, including large early Miocene volume fluctuations.

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Christopher Sorlien 2/1/15-1/31/16 $21,000

Ralph Archuleta

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University of Southern California 15098

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**SCEC4 Participation, Project N: Offshore South-Central California for the Community Fault Model**

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This project aims to produce digital depth‑converted 3D fault representations of many faults in western Santa Barbara Channel and offshore south‑central California for the Southern California Earthquake Center Community Fault Model (SCEC CFM). This will be done via geologic interpretation of a vast amount of multichannel seismic reflection data (MCS), using age and stratigraphic information from several dozen wells. A 3D velocity model will also be produced of western Santa Barbara Channel and part of offshore south‑central California based on velocity surveys in well logs, water depth, and a burial depth and age velocity relationship between wells. This model will include the sedimentary section offshore south‑central California and the uppermost part of the metamorphic basement rock. This model will be provided to the SCEC Community Velocity Model, probably to Harvard, as time‑depth charts at wells. For areas of

Santa Barbara Channel where seismic stratigraphic interpretation is completed, the 3D velocity model will also be provided as 3D grids of stratigraphic horizons in both time and depth. Surfaces in both time and depth define a 3D interval velocity for the rock volumes in between.

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Christopher Sorlien 1/1/14-6/30/15 $55,713

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US Geological Survey G14AP00012

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**Post-1 Ma Deformation History of the Pitas Point-North Channel-Red Mountain Fault System and Associated Folds in Santa Barbara Channel, California**

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Evidence for 6 to 8 meter uplift events west of Ventura have been linked to proposed paleo-quakes approaching Magnitude 8.0. The north margin of rapidly-shortening, rapidly-subsiding offshore and onshore Ventura Basin is comprised of major N-dipping faults. These faults extend 200 km between Pt. Conception and the east end of the Santa Susana fault. Vertical motion is partly across a narrow fold scarp in Ventura and the near offshore. This local fold dies out farther offshore and is replaced by broad forelimb tilting. Such tilting implies a continuously variable, but predictable, pattern of subsistence and uplift. Fault representations in the SCEC Community Fault Model (CFM) indicate discontinuities in the shallow faulting that may limit the M<=6.7 for 20th century quakes on this system. M6 1/2 quakes can be disastrous enough, and because they are much more frequent for the same shortening than major quakes, their hazard is high. However, tsunami hazard is much less for a M6.5 than a M7.5 thrust quake, and whether a particular building, bridge, or mountainside will collapse is also affected by the duration of strong ground motion. Does the development of, and shortening across the regional fault system over the last 1 My suggest multiple segment ruptures and major quakes?

Multiple grids of 2D industry, USGS, and academic seismic reflection data and eight 3D surveys have recently become publicly available. Nine horizons, precisely dated between 975 ka and 120 ka, have only been integrated with all these data across the central 40 kn of the offshore part of the fault system. A series of published well cross sections will also be incorporated. The existing 3D velocity model from sonic logs and checkshot surveys will be extended to the east and west and to greater depth. Data integration will be accomplished using an industry seismic and well interpretation software. Three dimensional kinematic modeling will include unfolding stratigraphic horizons and reassembling them across faults, and/or trigonometric modeling of tilt and imaged fault 3D attitude vs. slip direction and magnitude, and/or use of volumes in hanging-wall anticlines above footwall basin references.

Products from this study will include revised and new 3D representations of fault surfaces and stratigraphic horizons, and new estimates of fault slip rates and slip directions. The digital fault representations will be provided to the SCEC Community Fault Model and to U.S.G.S. researchers, and the digital stratigraphic grids in time and depth will be supplemental data to a publication. Implications include strong ground motion duration and tsunami hazard between Oxnard-Ventura and Santa Barbara-Goleta. Work will also include part of the Pitas Point-North Channel fault system west of Pt. Conception, where it interacts with NNW-striking faults including the southernmost Hosgri fault.

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Frank Spera 2/15/16-7/31/19 $251,997

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National Science Foundation 1551056

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**Collaborative Research: Thermodynamics of magma mixing**

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We propose to utilize the Magma Chamber Simulator (MCS), a thermodynamic model that describes open system evolution of magma bodies subject to heat and matter exchange in a composite system to study the thermodynamics of multicomponent-multiphase magma mixing. MCS defines thermal, mass, and compositional (major/trace element and isotope) characteristics of melt ± minerals ± fluid phase in a magmatic system undergoing recharge (magma mixing), assimilation, and crystallization. The goals of our proposed work are to (1) Finalize MCS for general release to the petrologic community by early 2017 based upon feedback obtained from beta users in the last year. Streamlined input and output, automated trace element and isotope calculations, web-based tutorials, workshops, and YouTube videos will allow a spectrum of scholars to use MCS in their own studies. (2) Building on successful development of the exploratory (i.e., toy) binary eutectic model, develop three new toy models that sequentially incorporate known thermodynamic features of natural systems (peritectic, solid solution, ternary). These will provide insight into the thermodynamics of magma mixing. (3) Apply MCS to volcanic (Karymsky, Llaima) and plutonic (Kiglapait and Bushveld intrusions) suites that show indisputable evidence of magma mixing. (4) Extend MCS capabilities to include reaction of cumulates with magma melt, eruption, and the rhyolite MELTS H2O-CO2 solubility model. These new versions of MCS will be released. (5) Develop a magma mixing taxonomy by using toy and MCS results and observations from natural systems to identify and group dominant characteristics of mixed magma products and evaluate if these are associated with diagnostic initial conditions.

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Jamison Steidl 10/1/11-9/30/15 $75,012

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Northeastern University 501947-78052

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**Induced-Partial Saturation Through Transport and Reactivity for Liquefaction Mitigation.**

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UCSB, as an equipment site within the NSF George E. Brown, Network for Earthquake Engineering Simulation program, provides assistance to researchers in using the NEES@UCSB field sites for conducting experiments related to earthquake engineering. In this proposal, UCSB will be working as a subcontractor to Northeastern University, the lead institution.

UCSB will be providing scientific expertise and technical assistance in the planning, deployment of instrumentation and the induced partial saturation delivery system, and experiments using active mobile shakers from UT Austin, all taking place at the NEES@UCSB Wildlife Liquefaction Array facility. UCSB will work as an advisor to the project PI and co-PI’s in order to help assure that the experiments are successful and are conducted without affecting the existing permanent instrumentation at the facility. Technical assistance will be provided during the field work and experimentation at the facility.

The NEES@UCSB field site will provide access to the facility, and assistance with the integration of the collected data into the NEEShub for this project. No charge for the data telemetry and IT services are being charged in this subcontract, as these will be covered by the NEES@UCSB operations contract with NEEScomm at Purdue. In addition, NEES@UCSB student lab assistants who work on the operations contract may assist in the field work, depending on the schedule.

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Jamison Steidl 5/1/15-9/29/17 $532,627

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Nuclear Regulatory Commission NRC-HQ-60-15-C-0001

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**Observations and Analysis of Geotechnical Array Data**

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This project is to provide observations from the densely instrumented geotechnical array field sites associated with the University of California at Santa Barbara (UCSB) monitoring program for use in confirmatory research and in the development of regulatory guidance at the U.S. Nuclear Regulatory Commission. These field sites, the Wildlife Liquefaction Array, the Borrego Valley Downhole Array, the Garner Valley Downhole Array, the Hollister Earthquake Observatory, the Seattle Liquefaction Array, and the Delaney Park Array, are geographically distributed throughout the most hazardous part of the United States, including three sites in southern California, one site in central California, one Pacific Northwest site in Seattle, and one site in Anchorage Alaska. The design objective of these sites was to capture the penultimate earthquake in each region and instrumental observations of the earthquake effects associated with such events. The broader objective is to capture a suite of earthquakes covering a range of ground motions and strain levels at each of these sites, to enable calibration of ground motion prediction models that include the effects of the near-surface geology from linear through nonlinear behavior. The California sites are operated solely by UCSB, while the Seattle and Anchorage sites are operated by the Pacific Northwest Seismic Network (PNSN) and the United States Geological Survey (USGS) respectively, with some assistance from UCSB. The data from all six of these facilities flows in real-time to UCSB and is disseminated along with the relevant metadata at the UCSB geotechnical array data portal (http://www.nees.ucsb.edu/data-portal). Contributing to the development and validation of models for site response, liquefaction initiation, ground displacements and settlement, and soil-foundation-structure interaction effects, are the primary goals of this observation and analysis effort.

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Jamison Steidl 10/1/09-11/30/14 $2,613,461

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Purdue University NEES-4101-31902

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NEES Consortium Operations: 2004-2014.

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The NEES@UCSB facility consists of permanently instrumented geotechnical test sites designed to improve our understanding of the effects of surface geology on strong ground motion. The instrumentation at these sites includes surface and borehole arrays of accelerometers and pore pressure transducers designed to record strong ground motions, excess pore pressure generation and liquefaction that occurs during large earthquakes. An instrumented structure is also monitored to improve our understanding of soil-foundation-structure interaction (SFSI) effects.

Located in the Imperial Valley of Southern California within the Imperial Wildlife Management Area, the Wildlife Liquefaction Array is a fully instrumented site in an area that has historically produced significant ground motion and liquefaction effects. The Garner Valley Array is a thoroughly characterized strong-motion monitoring site with surface accelerometers, borehole pore pressure transducers and accelerometers, and an extensively instrumented SFSI test facility. Both the Garner Valley and Wildlife Field Sites records earthquakes on a daily basis, and are used in active testing experiments.

Data from these field sites is recorded continuously in real-time on a 24/7 basis, and 100’s of earthquakes are segmented out of the continuous stream and included in a web-based data dissemination portal. These event data are also transmitted to NEEShub and stored in the NEES Project Warehouse database. Serving the experimental research community that use these facilities for active testing, and analysis of the data these sites produce, is our primary goal for this project. The operations and maintenance of these field sites, to ensure that the next “Big One” is recorded and all sensors are operational is another primary goal of this project.

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Jamison Steidl 2/1/15-1/31/20 $30,000

Ralph Archuleta

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University of Southern California 10358789-A

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**SCEC4 Participation, Project P: SCEC Borehole Instrumentation Program**

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The Portable Broadband Instrument Center (PBIC) will continue to support individual PI project driven deployments of the older style RefTek and the newer next generation real-time data acquisition systems. The new systems use commercial grade cellular VPN routers or other available Internet based telemetry that allows for continuous transmission of data back to the USGS/Caltech component of CISN. Ongoing projects using PBIC equipment include: real-time deployment of the PBIC stations along the Elsinore fault zone; array deployment of 10 RefTek stations at Pinon Flat to monitor potential tremor activity in the region; and use of the broadband CMG-40T sensors at stations in the Anza regional network.

In addition to support of field deployments, the PBIC project will continue to maintain the existing pool of older instruments including the long-term loan equipment from the IRIS PASSCAL instrument center and newly acquired RefTek 72A series instruments from the DOE. Heavy involvement of undergraduates is an important part of the PBIC operations as these student laboratory assistants perform the majority of the routine maintenance work under the supervision of the PI and/or engineering staff at the Earth Research Institute. These students also participate in deployments getting hands-on training in the use of the PBIC seismic monitoring equipment and software processing tools. Outreach demonstrations and presentations to local K-12 schools is also a regular activity for the PBIC and will continue.

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Jamison Steidl 2/1/15-1/31/18 $18,000

Ralph Archuleta

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University of Southern California 10358789-B

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**SCEC4 Participation, Project Q: The SCEC Portable Broadband Instrument Center**

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The PBIC was established in 1991 by Prof. Ralph Archuleta through funding from SCEC to provide a "pool" of digital seismic recording equipment for use in post earthquake response and on individual PI driven research experiments within southern California. The PBIC is currently managed at the Earth Research Institute (ERI) by Dr. Jamison Steidl with support from undergraduate student laboratory assistants from the department of geological sciences and electrical and computer engineering.

The ability for SCEC to respond rapidly to a major southern California earthquake with the deployment of seismographs in the near-source region was a catalyst for the creation of the PBIC and is a critical asset of SCEC earthquake research community. This has been highlighted recently by the successful deployment of PBIC equipment in the 2010 El Mayor–Cucapah earthquake as well as the 2008 shakeout experiments along the southern San Andreas. Other PBIC successful RAMP deployments occurred in conjunction with the 2004 Parkfield and 2003 San Simeon earthquakes, as well as the four major earthquake sequences in the previous decade (1992 M6.1 Joshua Tree and M7.3 Landers, 1994 M6.7 Northridge, and 1999 M7.1 Hector Mine). The ability to conduct individual PI driven research experiments in between these major earthquake sequences using PBIC equipment is another very important asset. One of the main goals of the PBIC is to facilitate research in the earthquake community by providing readily accessible seismic monitoring stations for deployment in the southern California region.

This year, the Portable Instrument Center is starting to upgrade the data acquisition technology to current real-time systems, capable of integrating directly with the SCSN operations. Over the course of SCEC3, using its two newer real-time stations, the PBIC has demonstrated the capability to deploy and integrate its stations into the regional network, providing high-quality observations that are being used for earthquake locations and shake map applications. These stations have proven to be dependable and require very little maintenance. The previous generation of SCEC portable equipment is now coming up on two decades of operations. This older equipment is no longer completely reliable or cost-effective to deploy, as it requires regular site visits and post-processing efforts. Data recovery is about 75% in the winter months and as low as 50% in the summer months due to the age of the equipment, and failure of the older SCSI hard drives in the warmer summer temperatures. This year equipment will be added to provide a third modern real-time station to be used by the SCEC community, as well as maintenance and operations of the other two currently deployed stations.

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Jamison Steidl 7/1/16-6/30/19 $200,000

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University of Southern California 10456511

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**Central California Special Project: Temporary Seismic Deployment**

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This component of the Central California Special Project is to collect broadband (40 seconds to 100 Hz) seismic data from both ambient and earthquake sources in a temporary network of 50 stations. The goal is to provide additional data to improve our understanding of seismic hazard. In particular, improving our understanding of the crustal structure and path effects that affect the seismic hazard in the central California region.

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Jamison Steidl 2/1/19-1/31/20 $9,000

Toshiro Tanimoto

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University of Southern California 118063069-I

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SCEC5 participation, Project I: Verification and Validation of 3D Nonlinear Physics-based Ground Motion Simulations: Phase I

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The UCSB specific task for the 2019 proposal is to compile the datasets of both temporary deployments (2004, 2007-2008, 2014) and the permanent station data across the Garner Valley basin into a single dataset. These will be used to examine depth to basement using HVSR techniques and drive the following years new deployment by identifying gaps in the dataset where additional data is needed to define the basin 2-D and 3-D structure.

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Jamison Steidl 2/1/19-1/31/20 $35,000

Toshiro Tanimoto

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University of Southern California 118063069-J

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SCEC5 participation, Project J: Borehole Instrumentation Program

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The borehole instrumentation program at UCSB is a continuing collaborative data

gathering effort between SCEC and other agencies. We help to maintain the existing network of

borehole stations in California, to facilitate the integration of this data into the regional seismic

networks and the Southern California Earthquake Data Center (SCEDC), and to improve the

dissemination of this data to the research community world-wide. We also seek targets of

opportunity for collaborations that will augment the number of borehole stations providing

publicly available data in Southern California. In the past, this program has been heavily

leveraged through major funding from a single agency, with the NSF Engineering Directorate for

more than a decade (2002-2014), and more recently, the Nuclear Regulatory Commission

(NRC) from 2015-2017. The past two years, the program has been “in-between” funding from a

large major sponsor, and currently the leverage is spread out across multiple

agencies/organizations at a significantly smaller level.

The real-time data from the SCEC borehole sites is made available online to the public

and research community, both through the SCEDC and the UCSB borehole-specific data portal.

Some of the organizations the SCEC borehole instrumentation program continues to collaborate

with include Caltech/USGS, ANSS/NSMP, the California Geological Survey, the UC San Diego

HPWREN program, the NSF EarthScope PBO program at UNAVCO, and the UC San Diego

Anza network of shallow borehole sensors along the San Jacinto fault. Stations from these

various collaborators are shown in Figure 1 below.

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Jamison Steidl 2/1/19-1/31/20 $23,000

Toshiro Tanimoto

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University of Southern California 118063069-K

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SCEC5 participation, Project K: Portable Broadband Instrument Center

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The PBIC was established more than 2 decades ago through funding from SCEC to provide a

pool of digital seismic recording equipment for use in post-earthquake response, and in

individual PI driven research experiments within southern California. While the uses of the PBIC

equipment remain unchanged over the years, the PBIC is now in the process of modernizing its

broadband instrument pool with posthole form factor sensors to adopt this more recent style of

station deployment.

The ability for SCEC to respond rapidly to a major southern California earthquake with the

deployment of both weak- and strong-motion instruments in the near-source region was a

catalyst for the creation of the PBIC and remains an important asset of SCEC seismology

infrastructure and earthquake research community. This has been highlighted by successful

deployments of PBIC equipment following previous earthquakes. The southern California region

has been relatively quiet in recent years, with the last RAMP deployment during the 2010 El

Mayor–Cucapah earthquake. This event was the first post-earthquake response using the

modern real-time capable PBIC equipment, with stations deployed and data delivered directly

back to UCSB and then relayed to the regional seismic network (SCSN). Two of the PBIC

stations remained deployed through June of 2014, providing data to the network for more than

four years after the mainshock, without requiring a site visit.

Other successful RAMP deployments include the 2008 shakeout exercise along the

southern San Andreas, the 2004 Parkfield and 2003 San Simeon earthquakes, as well as the

four major earthquake sequences in the previous decade (1992 M6.1 Joshua Tree and M7.3

Landers, 1994 M6.7 Northridge, and 1999 M7.1 Hector Mine). The ability to conduct individual

PI driven research experiments in between these major earthquake sequences using PBIC

equipment is another very important component of the PBIC program. The PBIC continues to

modernize and provide the SCEC community with modern seismic monitoring stations to

facilitate individual PI research.

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Jamison Steidl 5/1/17-9/30/18 $30,000

Toshiro Tanimoto

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University of Southern California 17246

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**SCEC5 Participation, Project A: SCEC Borehole Instrumentation Program**

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The borehole instrumentation program at UCSB continues to be a collaborative effort between SCEC and other agencies to maintain the existing network of borehole stations in California, to facilitate the integration of this data into CISN and the Southern California Earthquake data center (SCEDC), and to improve the dissemination of borehole data. The borehole program is highly leveraged, taking advantage of the resources of other programs and agencies that are active in monitoring southern California earthquake activity. This data is made available online to the public and research community, both through the SCEDC and the UCSB borehole data portal. Organizations the SCEC borehole instrumentation program collaborates with include Caltech/USGS, ANSS/NSMP, and the California Geological Survey. Other collaborators include the UC San Diego HPWREN program, the NSF EarthScope PBO program at UNAVCO, and also a NSF funded project to image the San Jacinto Fault zone, which has been leveraged along with USGS funding to include the installation of additional shallow borehole sensors along the San Jacinto fault, which are now part of the Anza Network. In 2015, the SCEC borehole program began a new collaboration with the U.S. Nuclear Regulatory Commission, in support of the UCSB Geotechnical Array Monitoring Project, previously funded by the NSF NEES program. The NRC provides continued support for the web-based data dissemination portal, and real-time continuous monitoring operations and data processing software, an important leveraged component of the SCEC borehole program.

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Jamison Steidl 2/1/12-1/31/17 $116,000

Ralph Archuleta

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University of Southern California Y86552-A

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**SCEC4 Participation, Project A: SCEC Borehole Instrumentation Center**

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The SCEC borehole program continues to be a highly leveraged and collaborative effort between SCEC and other agencies to maintain the existing network of borehole stations in California and to facilitate the integration of this data into CISN and the SCEC data center. The borehole program is highly leveraged, taking advantage of the resources of other programs and agencies that are active in monitoring southern California earthquake activity. This data is made available online to the public and research community.

As has been the case for many years, joint monitoring efforts continue between SCEC and the US Geological Survey and Caltech through ANSS, NSMP, and CISN, and the California Geological Survey to maintain the existing network of borehole stations. Other collaborators include the NSF funded NEES and HPWREN programs, as well as an NSF funded project to image the San Jacinto Fault zone, which has been leveraged to include the installation of additional borehole sensors along the San Jacinto.

In 2012, the SCEC borehole program will continue to maintain the existing borehole stations in the southern California region, and also continue the collaborations with; the NEES program through processing and data dissemination of the SCEC borehole data; the SCEC/EarthScope Plate Boundary Observatory borehole strainmeter program that includes pore pressure observations, and both weak- and strong-motion seismic monitoring in the Anza region; and the strong-motion borehole sensors being installed as part of a new NSF funded study of the San Jacinto fault zone.

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Jamison Steidl 2/1/12-1/31/17 $89,000

Ralph Archuleta

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University of Southern California Y86552-B

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**SCEC4 Participation, Project B: The SCEC Portable Broadband Instrument Center**

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The SCEC Portable Broadband Instrument Center (PBIC) was established to provide researchers in southern California with year-round access to a "pool" of portable seismic recording equipment. The PBIC maintains this equipment and also serves as a RAMP facility in the event of significant earthquakes. At other times PBIC equipment is used on projects related to SCEC science and data gathering goals.

Instrumentation consists of Quanterra 6-channel 24-bit data loggers and Kinemetrics 8-channel 24-bit data loggers, all with real-time capabilities through cellular or internet telemetry. Sensors consist of high output velocity transducers to record very small ground motion and force balance accelerometers designed to stay on-scale for the strong ground motion expected from very large earthquakes (up to +/- 2G). A broad dynamic range of recording is obtained by pairing both types of sensors with a single 6-channel recorder. These include Mark Products L4C-3D 1Hz velocity transducers, Guralp CMG 40T broadband sensors, and Kinemetrics FBA-EST accelerometers.

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Samantha Stevenson 9/15/18-9/14/21 $105,178

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Georgia Institute of Technology RK586-G1

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**Evaluating mechanisms of Pacific decadal variability in ESMs and their sensitivity to external forcing**

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setup and implementation of simulations with E3SM and the analysis of output from E3SM and other CMIP6-class models. In the first year, the PI will recruit a postdoctoral researcher and facilitate the interaction of that researcher with the other PIs and DOE scientists through collaborative visits and attendance at DOE PI meetings. In the second year, the PI and postdoctoral researcher will participate in performance and analysis of simulations in collaboration with the Georgia Tech and NOAA PIs, as well as DOE investigators.

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Samantha Stevenson 7/1/18-6/30/20 $341,402

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National Science Foundation 1805143

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**Collaborative Research: A Model/Proxy Synthesis of Walker Circulation Trends During the Last Millennium**

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The Pacific Walker circulation alters weather and climate extremes around the world, but its sensitivity to external climate forcings remains unknown. In particular, observational estimates of 20th century trends in the Walker circulation provide conflicting results, with some suggesting a strengthening and others a weakening or no trend, complicating the attribution of these trends to any specific forcing. Paleoclimate records can improve the detection and attribution of trends by providing longer-term context, but their use has been hindered by the lack of multi-proxy synthesis products and climate model simulations covering the last millennium. We propose to create new quantitative reconstructions of multiple Walker circulation metrics using the recently constructed PAGES Iso2k database, and to evaluate the mechanisms for variability and trends in these metrics using the Community Earth System Model Last Millennium Ensemble (LME) and new simulations with its isotope-enabled complement (iLME). The proposed research applies these new tools to answer one central question: What are the mechanisms underlying Walker circulation variability and trends from the Last Millennium through the 20th century, and what are the relative roles of external forcings and internal variability?

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Andrea Stith 4/1/19-7/31/19 $20,000

Kelly Caylor

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University of California LFR-19-645741

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2019 UC Lab Fees Workshop on Wildfire-related Research

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This proposal is to request support for the 2019 UC Lab Fees Workshop on Wildfire-related Research. The workshop will take place in Santa Barbara, on the campus of UCSB, April 12-13, 2019. The primary aim of the workshop is to identify exciting and compelling research problems in the area of wildfire-related research and to initiate inter-institutional research teams that will submit compelling proposals to the 2020 UC Lab Fees grant program.

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Lisa Stratton 8/1/17-12/31/19 $75,000

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Goleta West Sanitary District SB180076

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**North Campus Open Space (NCOS) Public Access Implementation Project**

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The goal of the NCOS Restoration Project is to restore the upper arms of Devereux Slough that were filled in 1965 to create Ocean Meadows Golf Course using fill soil from the adjacent uplands, including South Parcel to the south west of the golf course. The restoration project includes restoring more than 135 acres of diverse habitats, including a tidal connection to Devereux Slough, intermittently flooded mudflats, plover breeding habitat, salt marsh and a variety of upland and freshwater habitats, including vernal pools, freshwater marsh, native grassland, coastal sage scrub and back dune swale woodland habitat. The project also includes excavation and placement of approximately 350,000 cubic yards of fill on the former borrow site on South Parcel, which is within the NCOS project area. The project includes a trail system with bridges and boardwalks that supports safe routes to school and a diversity of users with a variety of trail sizes and functions. The trail design was developed through a community based planning process in 2013-14 that included 4 public meetings and an opportunity to vote on alternatives in person and on-line.

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Lisa Stratton 1/1/14-1/31/15 $10,000

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Outhwaite Foundation SB140075

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**Ellwood-Devereux Connecting the Community & Nature**

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In 2004 the Ellwood-Devereux open space area was created which protected 652 acres of coastal open space in Goleta. A key puzzle piece, however, was the 64 acre privately owned Ocean Meadows golf course property which limited public access to the larger open space and created a legacy of adverse wetland impacts resulting from the filling of the upper arms of Devereux Slough with soil from the adjacent uplands. Thanks to the work of The Trust for Public Land, the former golf course was purchased and donated to UCSB. The goal of the larger project is to return this golf course to its original wetland status and incorporate public access and education in the process.

During the next one to two years, UCSB will be working on the permitting process and preparing proposals to fund the restoration component. This time span provides a window of opportunity to engage the community in the process and to develop a stewardship role for the neighboring families and Goleta residents. The goal of this effort is to provide a year of monthly, family-oriented, educational and engaging weekend events, which will connect local residents to this newly acquired property and to our organization. Benefits to the community members include the opportunity to learn about our local ecology, to participate in the restoration vision and process and to work as a community in the Ellwood-Devereux open space that is being restored and preserved for future generations. Funding from Outhwaite Foundation would be used to create an educational program that will become a regular part of people’s lives and develop a community of environmental stewards.

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Lisa Stratton 2/1/15-11/30/15 $6,500

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Outhwaite Foundation SB150075

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**Ellwood-Devereux Connecting the Community with Nature**

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This project funded a monthly community outreach program which provided a three hour outing, suitable for families and individuals, with parallel tracks. The focus on the program was on the ecology, hydrology and restoration plans for the newly designated North Campus Open Space that includes the former Ocean Meadows Golf Course and South Parcel. This 136 acre area will be restored to its former function as wetlands and coastal terrace with a diverse array of habitats, wildlife support and public access components. This outreach program built on the community based planning process that was part of the initial design basis and helped community members appreciate the value of the site and to understand the motivation for the restoration.

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Lisa Stratton 3/1/16-5/31/18 $18,000

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Santa Barbara Foundation SB160074

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**Restoration of the Eastern Mesa Top at Campus Point Along the CA Coastal Trail**

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This project will restore the eastern mesa top at Campus Point along the CA Coastal Trail, at the top of recently constructed public access stairway. This high profile site provides educational and hands on opportunities for UCSB students, elementary school students and community members to participate and learn from this restoration of the degraded Campus Point coastal bluff site.

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Lisa Stratton 10/1/12-9/30/17 $59,800

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US Fish & Wildlife Service F12AC00683

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**Recovery Activities for Nipomo Lupine**

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Lupinus nipomensis (Nipomo lupine) is a small annual plant in the pea family (Fabaceae). Historically and currently, the species is known only from the southwestern corner of San Luis Obispo County, California, scattered over an area of approximately 2 miles wide and 2 miles long. Lupinus nipomensis is restricted to one extended population of a few hundred individuals. The species is faced with a high risk of extinction due to the extremely low number of individuals and an intense degree of threats. The species may face extinction within the next 5 years.

To reduce the risk of extinction, we propose to implement the following recovery actions: Task 1: introduce populations to suitable habitat in the Guadalupe-Nipomo Dunes region. Suitable habitat may include lands managed by the U. S. Fish and Wildlife Service at Guadalupe-Nipomo Dunes National Wildlife Refuge, California State Parks, the Land Conservancy of San Luis Obispo County, and private lands; Task 2: conduct a seed bank analysis at the existing and historical occurrences, and Task 3: Undertake population enhancement though supplemental watering of existing occurrences.

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Sangwon Suh 7/15/14-6/30/19 $466,517

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City University of New York (CUNY) 40E48-A

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**WSC-Category 3: A National Energy-Water System Assessment Framework (NEWS): Stage I Development**

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This effort focuses on the development of a multi-sector dynamic model for energy deployment, which will be integrated to energy-climate-water model to be developed by CUNY. The model should reflect technology development, and changes in energy demand over time considering both direct and indirect relationships between sectors of an economy.

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Sangwon Suh 3/15/13-2/28/15 $99,795

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National Science Foundation 20130851

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**Impact of shale gas on renewable energies**

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In this project, we will examine (1) the effects of rising shale gas production on the deployment of renewable energy technologies in the short and long run; and (2) the effect of potential policy measures, existing or new, on energy mix change under the presence of shale gas in the U.S. Drawing on the insights from previous studies, our proposed work will concentrate on the energy sector in the U.S. at finer temporal and technological scales using process level information and system dynamics models. We will also test a broader range of technology and policy scenarios and identify policy instruments that help promote renewable energy technologies. Our first step is to build an integrative model centered on a system dynamics framework, coupled with life cycle inventories (LCIs) of various renewable and other low-carbon energy technologies. In so doing, we will capitalize on our previous USDA/DOE project, in which we integrated system dynamics model with life cycle assessment (LCA) to identify cost-effective pathways to achieving the national Renewable Fuel Standard (see http://forio.com/simulate/umn/rfs2/simulation). Another major source of data will be our ongoing project on low-carbon energy technologies including wind, photovoltaics, concentrated solar power, geothermal, hydropower and carbon capture and storage. Under this project LCIs of renewable energy technologies and other low-carbon energy technologies are compiled, and they are connected to different policy scenarios that mitigate greenhouse gas emissions from 2010 to 2050. This model accounts for technology change and changing energy mix over time, but the model does not currently interact with policy interventions. Coupling the data and results acquired from this project with a system dynamics model will enable us to simulate different policy and technology scenarios. The data and the model that have been compiled so far do not include those of shale gas development. Therefore, after construction of the integrative model, we will add the component of shale gas and develop an array of technology and policy scenarios to simulate potential influences that rising shale gas production would exert on the rest of the energy sector, particularly on renewable energy technologies. Furthermore, the scenario development will help us identify policy measures that can lead to least cost, least greenhouse gas (GHG) emissions. A preliminary list of scenarios worth exploring include (1) continuous increase in shale gas in the mid to long run (baseline), (2) nation-wide implementation of a California’s low carbon fuel standard (LCFS), (3) carbon tax on fossil energy, (4) federal and state subsidies and credits for low-carbon technologies, and (5) relief of control over natural gas export largely to emerging countries like China and India to replace their coal combustion, which would boost U.S. economy but likely bring domestic natural gas prices back pre-shale gas situations.

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Sangwon Suh 1/1/19-12/31/20 $10,071

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University of California 2019-3702

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**Maximizing the Environmental Utility of Battery Storage**

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Building on the previous workshop at UCD, this workshop aims to further the discussion on life cycle modeling focusing on consequential approaches. LCA has been used largely as a tool to quantify the environmental impacts of existing technologies based on historical data. The retrospective perspective of conventional LCA exhibits a clear limitation when applied to emerging technologies such as large-scale battery storage. For such technologies, understanding their life cycle impacts requires modeling potential changes that the technology in question will introduce to the economy and the environment. In particular, the following questions and potential modeling approaches to address them will be discussed during the workshop: (1) The problem of curtailment in high-renewable electricity grid, (2) The role of battery storage in mitigating curtailment and peak-shaving, (3) Understanding the concept of marginal technologies, (4) Modeling approaches to grid-response to large-scale battery storage, and (5) Economies of scale and learning effects. For each of the topics, relevant background and current literature will be presented, followed by each group's brief intervention on the knowledge and data that the group can provide to advance the topic. As consequential modeling requires insights from multiple domains of science, it is important for the participants to share their expertise during the workshop. To better facilitate the process, the organizer will circulate a pre-workshop packet describing the type of data and knowledge needed to operationalize consequential modeling.

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Samuel Sweet 8/15/16-12/31/17 $46,778

Christopher Evelyn

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Department of Agriculture 2016-CS-11052007-086

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**Conservation Status of California Amphibians and Reptiles**

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The purpose of this agreement is to compile all available data from literature, reports, museum records and other related information on each of the taxa. Information to be included is on current and historic distributions with respect to National Forest lands, life history information, identified risks to their populations and habitat, dispersal capabilities, abundance within the Pacific Southwest Region, population and habitat trends, vulnerability of their habitats to degradation and loss, and life history and demographic conditions that relate to effective management of National Forest lands where each species occurs.

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Samuel Sweet 6/10/09-6/9/19 $29,914

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Department of the Air Force FA4610-09-P-0102

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California Tiger Salamander Survey

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This project will provide an updated inventory of California tiger salamanders (Ambystoma californiense). California tiger salamanders are known to occur off of VAFB along Hwy 246 and near Casmalia. Surveys for CTS on VAFB in 2001 and 2003 were inconclusive because of the dry weather during the survey years. During dry years, CTS may not emerge and breed in pools. In 2008, the habitat capability of pools for CTS were assessed by a member of the Recovery Team, Professor Samuel Sweet of the University of California, Santa Barbara. Sweet assessed the pools based on ecological requirements of the species. For pools to be suitable, they must remain wet for a prolonged period, long enough to develop a prey base for the larval CTS. For pools to be occupied, they need to have surrounding habitat through which salamanders can disperse. The probability of occupancy increases in pools within 2 miles of occupied habitat off base. Suitable dispersal habitat needed microenvironments which were cool or shaded with gradual slopes down to the pools. The surrounding area of the pools needed friable soils or burrows which could shelter adult CTS during the nonbreeding season or years. In 2008, hoop-net and seine net samples of pools were conducted after pools had been inundated for about a month. No CTS were observed by these methods although samples were only taken once at each pool. The pools with suitable dispersal habitat had drift nets and pittraps installed; the drift nets will channel approaching CTS towards the pit traps. These traps were installed during the dry season and kept closed. Coverboards were also placed in areas with suitable dispersal and breeding habitat. Locations of coverboards and pools with driftnets were noted on GIS. Also, in 2008, surveys near VAFB noted whether the introduced barred salamander were present. Barred salamanders were noted in many areas, including the penitentiary pond and near Rucker Road next to La Purisima Mission. The close proximity of the barred salamanders highlights the conservation concerns for CTS. Barred salamanders may also be present on VAFB.

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Samuel Sweet 6/1/12-6/1/17 $12,013

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US Fish & Wildlife Service F12AC01020

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**Research and Restoration at Casmalia Landfill: Ecosystem Evaluation and Restoration for Species Recovery.**

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The Casmalia Landfill Superfund Site is located approximately 10 miles southwest of the city of Santa Maria in Santa Barbara County, California. The site was owned and operated by Casmalia Resources and accepted approximately 5.6 billion pounds of waste between 1973 and 1989. Waste disposal units at the site included: 6 landfills for pesticides/solvents, metals, caustic/cyanides, acids, and non-liquid polychlorinated biphenyls; 43 surface impoundments; 15 evaporation pads; 2 non-hazardous waste spreading areas; 6 oil field spreading areas; 11 shallow injection wells; 7 disposal trenches; 1 drum burial unit; and 6 landfills.

The site supports five stormwater ponds that may serve as an attractive nuisance to wildlife. The federally endangered California tiger salamander (Ambystoma californiense) and federally threatened Calfornia red-legged frog (Rana draytonii) have been detected at the site. In 2001 the U.S. Fish and Wildlife Service (Service) entered into an agreement with EPA to extend a covenant not to sue for Natural Resource Damages to potentially responsible parties as part of a de minimis settlement. The Service received $178,250 in settlement funds in exchange for the issuance of the covenant not to sue. The Service intends to use these funds to conduct restoration that will benefit the California red-legged frog, California tiger salamander, and other trust resources.

Biological surveys were conducted in the late 1990s and early 2000s in support of EPA’s ecological risk assessment and remedial investigation. Updated surveys are necessary in order to determine current usage of the site by our trust resources, and to best guide the use of the limited settlement dollars available to conduct restoration.

The Ventura Fish and Wildlife Office proposes to use the requested funding to conduct surveys for the California red-legged frog and California tiger salamander in strategic locations within the site and surrounding habitats to determine current usage of the site by these species. Surveys for California red-legged frogs were previously conducted in 1998, 1999, 2001, 2002, 2003, and 2004. Surveys for California tiger salamanders were conducted in 2002/2003, and 2004/2005. California red-legged frogs were detected in all survey efforts with the exception of 2004. California tiger salamanders were detected during drift fence surveys in 2004/2005.

Because California tiger salamander surveys have never been replicated at the site in the six years since the species was detected, and because the species is so acutely imperiled within Santa Barbara County, information about presence or absence of the species at the Casmalia Resources site would be invaluable. In addition, previous surveys for California tiger salamanders established presence of metamorphosed individuals in upland habitat, but the extent of California tiger salamander breeding in aquatic resources at the site remains unknown. The trend in observations of California red-legged frogs throughout the 1998 to 2004 study period demonstrated a rapid decline from over 50 individuals detected in 1998 to no individuals detected in 2003 or 2004. The absence of California red-legged frogs in 2003 and 2004 is suspected to be associated with low water levels in the stormwater ponds due to pumping of water for the construction of a landfill cap, and increasing total dissolved solids (TDS) in the stormwater ponds. The water level in all ponds is currently high relative to 2003/2004, however TDS remains high and the use of the ponds by California red-legged frogs and California tiger salamanders is unknown. It is likely that the high TDS is creating an attractive nuisance for the California tiger salamanders and California red-legged frogs attempting to breed at the site. This project will evaluate the need for (through aquatic and upland surveys) and feasibility of, creating additional breeding ponds at the site to provide suitable breeding habitat away from areas with high TDS. Ponds will subsequently be created as deemed appropriate and monitored in subsequent years.

The proposed surveys will assist the Service in providing technical assistance to EPA during the remedial process, and implementing restoration for the California red-legged frog and California tiger salamander. Updated information about the use of the site by California tiger salamanders and California red-legged frogs will support the Service’s effort to work with EPA in evaluating and selecting a remedy that would provide maximum habitat for trust resources and understand the use of the site be these species. The study will be conducted in phases to achieve the overall objectives of the study.

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Christina Tague 11/15/18-3/31/22 $609,970

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California Wildlife Conservation Board WC-1750BC

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**From Snow to Flow: Targeted Forest Management Strategies to Increase Streamflow For Ecosystems and People in the Tahoe-Truckee Basin**

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Snowmelt in mountain forests is critical for generating streamflow in much of the Sierra Nevada.  The forest distribution and structure (i.e. height and density of the trees and their location and orientation) can have profound effects on the distribution of snow.  In coordination with the 59,000 acre interagency Lake Tahoe West Project ([LTWP](https://www.nationalforests.org/who-we-are/regional-offices/california-program/laketahoewest)) led by the U.S. Forest Service, we propose expanded scientific studies and modeling in the Tahoe-Truckee Basin that develop watershed-scale forest thinning strategies to enhance streamflow within a critical area for water and threatened species.  The primary goal of this project is to develop actionable information for managers to retain snow on the landscape in ways that delay the stream hydrograph and improve the quantity and quality of summer low flows when aquatic ecosystems are most stressed.  We will use three project objectives to meet this goal and achieve streamflow enhancement in numerous watersheds: 1) Determine optimum watershed-scale forest thinning strategies for the LTWP to enhance streamflow by retaining snow in key parts of the landscape, 2) Provide baseline streamflow monitoring and develop tools to quantify the effects of forest treatments on streamflow and limiting factors for ecology across diverse watersheds, 3) Develop 25- and 50-year forest management strategies in key watersheds to ensure streamflow enhancement gains under the combined effects of climate change, drought, and forest disturbance.

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Christina Tague 9/1/15-8/31/20 $1,724,821

Sarah Anderson

Andrew Plantinga

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National Science Foundation 1520847

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**Hazards SEES: Land Management Strategies for Confronting Risks and Consequences of Wildfire**

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A team consisting of natural scientists and social scientists from U.C. Santa Barbara, U.C.

Extension, and U.W. Seattle proposes to identify land management strategies that will mitigate

the risk and the impacts of wildfires. Federal and state agencies apply fuel treatment techniques

such as thinning and controlled burns. Fuel treatments often generate unintended consequences

for humans and ecosystems because neither the agencies nor the research community fully understands the interactions among fire, vegetation, and ecosystem services. Furthermore, agency decision makers may make decisions about fuel treatments on the basis of economic and political dynamics, rather than on the basis of the best science. To assess the consequences of current fuel treatment decisions and facilitate alternative strategies, the proposing team will integrate an empirical socio-economic analysis of agency decision making with RHESSys, a premier physical model of the linkages between ecological and hydrological processes.

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Christina Tague 9/1/12-8/31/14 $79,542

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University of California, Merced 20121104

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**The California Critical Zone Observatory.**

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Funding from the CZO is currently supporting Phd candidate Khongho Son. Support for an additional 1/2 year will allow him to complete his integration of CZO hydrologic data and coupled eco-hydrologic modeling of climate responses for the CZO watersheds (see papers in prep 1 through 4). Results from previous modeling analysis demonstrate shifts between temperature and water limited responses to climate warming across a combination of micro-climate, drainage-position and soil depth gradients defined by the CZO. We would like to extend this analysis to a broader regional scale. A large spatial extent would cover a larger elevational gradient and includes shifts in dominant conifer species. Results from this work will link analysis done at the CZO to a broader Southern Sierra context and several ongoing initiatives (NEON, and a recent NSF funded study to look at climate-forest establishment in this region).

Recent studies across the Western US and elsewhere document increasing rates of background mortality and drought related forest dieback (Allen et al., 2010). We expand our data-model integration to examine how site specific geoclimatic characteristics mediate the vulnerability of forests to these disturbances. We build on recent work demonstrating the application of RHESSys for a Ponderosa Pine forest in New Mexico where model accurate estimated spatial patterns of dieback during the early 2000s drought. We will estimate spatial patterns of drought-related mortality in the Southern Sierra CZO and examine where and under what conditions threshold responses are most likely to occur. This work will build on prior modeling and data collection at the CZO. We seek to fund a second PhD student for 1/2 year. By providing overlap between past-CZO student, Khongho Son, in the Tague Ecohydrology Lab and a new student we facilitate technology transfer. Key tasks in this analysis will be a) improved data assimilation of existing vegetation data sets, including LIDAR data, flux tower, and allometric measurements into the model to provide a more realistic baseline of existing vegetation carbon stores and b) parameterization of RHESSys estimates of vegetation drought responses across a range of species and soil characteristics within the CZO. We link this project with another ongoing USGS project - the Western Mountain and incorporate tree-ring and C13 isotope measurements in the Southern Sierra region as additional data to validate and parameterize our model. To drive RHESsys we use state-of-the art downscaling of GCM scenarios from Flint et al (2010) to 800m. GCM scenarios include downscaled NCAL, GFDL and PCM models. We further downscale data to account for topographic drivers, based on our analysis of micro-climate patterns in the CZO.

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Christina Tague 10/1/13-9/30/19 $348,546

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University of California, Merced EAR-1331939

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**Southern Sierra Critical Zone Observatory**

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The Southern Sierra CZO is a community platform for research on critical-zone processes along a steep elevation gradients that spans the rain-snow transition and ecosystems from the oak savannahs to subalpine forests in Southern Sierra Nevada. The characteristic spatial differences along these gradients offer the opportunity to substitute space for time, making the CZO an excellent natural laboratory for studying how critical-zone processes respond to perturbations. This project continues the previous 5 years of work at the Sierra CZO. The overarching goal is to use a combination of measurements and modeling to advance our mechanistic understanding of the bi-directional links between longtime-scale geophysical processes and ecosystem structure/function and material (water, carbon, nutrient) fluxes. This work addresses both fundamental science questions about how landscape structure and function coevolve and applied questions about how the critical zone influences ecosystems services and material fluxes and their sensitivity to intentional (land management) and unintentional (climate, disturbance land use) drivers of change.

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Christina Tague 7/1/15-7/31/16 $74,366

Andrew Plantinga

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University of Maryland Z3708011

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**Wildfire Management, Ecosystem Dynamics, and Climate: The Role of Risk Salience in Driving Ecological Outcomes**

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This project contributes to development of a new approach for examining the inter-connections between fire management actions (e.g. fuels treatments), fire risk and post-fire effects (e.g. risks to water resources and other ecosystem services). Salience theory, which predicts that management actions will be more responsive to salient wildfire events, will be used to guide data-driven analysis of previous public fire-management decisions. These results will then be linked to RHESSys, a spatial model of ecosystem dynamics, hydrology and fire risk. Results of this work are expected to improve understanding of wildfire risk and help land managers more effectively target limited management resources.

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Christina Tague 5/15/10-6/30/15 $365,554

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US Geological Survey G10AC00309

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**The Western Mountain Initiative: Vulnerability and Adaptation to Climate Change in Western Mountain Ecosystems.**

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Climate warming is affecting Western mountain ecosystems, directly through changes in water dynamics and indirectly through altered disturbance regimes. The Western Mountain Initiative (WMI; http://www.cfr.washington.edu/research.fme/wmi) team explores the effects of climate change on ecological disturbance, responses of forest vegetation, mountain hydrology, and the coupled hydro-ecological responses that determine vulnerability of Western mountain ecosystems to change. Extensive data sets, empirical studies, surveys, and monitoring programs are linked via models to hindcast and forecast the effects of changing climate on forest dynamics, distribution, and productivity; fire occurrence and insect outbreaks; recovery of vegetation after disturbance; hydrologic changes and glacier dynamics; and the consequences of an altered water cycle for terrestrial and aquatic ecosystems and chemistry. We will address the extent to which climate drivers are mediated by regional- or watershed-scale controls on ecosystem processes, thus quantifying vulnerability to climate change in mountain ecosystems. Region-specific results and emergent West-wide patterns will be shared with resource managers through workshops and a comprehensive web-based toolkit on climate-change science and adaptation management. WMI seeks to understand climate-ecosystem interactions, forecast ecological change, and provide adaptation information for managers. We build on the foundation of our ongoing research program, which includes hundreds of publications, long-term datasets, and a mature network of collaborators. WMI addresses Ecosystem and Climate Change goals of the USGS Global Change Science Strategy, and Goals 4 and 5 of the U.S. Climate Change Science Program Strategic Plan. Both the National Park Service and US Forest Service are developing science-based management approaches for adapting to climate change, and WMI will collaborate directly with both agencies to ensure scientific consistency in the implementation of adaptation strategies.

In the preceding phase of WMI research, we used RHESSys to model ecosystem processes and hydrology in five forested montane watersheds representing diverse conditions across the western U.S. (sites in MT, CO, NM, CA, WA) (Christensen et al. 2008). In addition, ongoing RHESSys applications as part of other projects include a range of watersheds throughout the West (Tague et al. 2008; Tague et al. in review). Analysis at the scale of these sites (<800 km2) is critical given that management of resources takes place at small watershed scales where process-based interactions are determined by gradients in snow, temperature, and radiation; spatial distribution of moisture; vegetation structure and pattern; and disturbances (fire, insects, mass movements). This abundant RHESSys model output is ready to be carried to the next level of interpretation. Tague role in the WMI project will be to continue the refinement and application of RHESSys, as a coupled eco-hydrologic model for use in hypothesis generation and scenario development.

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Christina Tague 8/1/15-7/31/16 $70,000

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US Geological Survey G15AC00359

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**The Western Mountain Initiative: Vulnerability and Adaptation to Climate Change in Western Mountain Ecosystems**

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U.S. Geological Survey’s (USGS) Fort Collins Science Center solicits research on “Western Mountain Initiative - Central Rocky Mountains,” as part of the USGS integrated Western Mountain Initiative (WMI). The goal of this research is to increase process understanding explaining how hydrologic and ecosystem structure and function respond to climate variability and change, and land use/land cover changes in mountain environments in the Western US. Results from this work are communicated through peer-review publications, and through interactions with stakeholders - including land managers and the public. A key focus of this sub-proposal is the development of process-based spatial models as tools for both scenario generation and to integrate findings from field-based research by collaborators within the WMI initiative and elsewhere. Our ongoing model development with RHESSys (Regional Hydro-Ecological Simulation System) is made available to the larger science community through publically available code and regular training sessions.

There is a long-standing collaborative partnership between USGS and University of California, Santa Barbara researchers to explore the effects of climate change on water resources, ecosystem structure and function, and disturbance regimes. Results contribute to improving understanding of how Western U.S. landscapes will respond to climate variation and change, and identifying key vulnerabilities and the consequences of land management options. For example, we have used model-based scenarios to quantify the contributions of underlying watershed geologic characteristics to the sensitivity of forest water use and streamflow to drought (e.g Tague and Peng, 2013). Our continued development of informatics tools provides improved techniques for assessing the impacts of thinning and fuel treatments on forest drought, fire risk, and water resources (eg. Tague et al., 2013). By providing a coupled eco-hydrologic perspective, our model scenarios provide information about the interactions among climate, forest management practices, and water resources that are needed for effective climate change adaptation planning. The connection with the UCSB Bren School of Environmental Science and Management’s professional Master’s program also provides an opportunity to communicate research findings to young environmental leaders and professionals. The Bren program is specifically designed to train environmental professionals for careers in environmental problem solving in government, industry, and non-profits, and has a very active outreach program to these societal groups.

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Christina Tague 4/1/11-3/31/17 $410,984

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Washington State University (Pullman, WA) 115320 G002931

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**Collaborative Research: Type 2: Understanding Biogeochemical Cycling in the Context of Climate Variability Using a Regional Earth System Modeling Framework.**

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One of the greatest science & engineering challenges of the 21st Century is managing nitrogen (N) in the environment to maximize agricultural productivity while minimizing negative environmental effects. Developing a clear understanding of climate & human-induced changes in environmental N cycling in tightly coupled atmospheric, terrestrial, & aquatic systems & understanding how these changes feed back into the climate system are critical to addressing this challenge. In the Pacific Northwest (PNW), the interactions among N, carbon (C), climate & human activities are complex. The region has extensive & diverse agricultural lands surrounded by pristine natural ecosystems, interspersed with heavily populated urban areas. The topography of the area is diverse, & the terrain is drained by extensive river systems, including the vast Columbia River Basin (CRB). Storm patterns are closely tied to the jet stream position & sensitive to long-term circulation patterns including the El Niño Southern Oscillation (ENSO) & Pacific Decadal Oscillations (PDO). Given this complexity, a challenge is to understand & quantify the interactions & feedbacks between N & C cycling in coupled atmospheric, terrestrial, & aquatic systems as they are affected by the climate system at inter-annual to decadal time-scales over the PNW region. The overarching goal of this project is to improve understanding of the interactions among C, N, & H2O at the regional scale in the context of global change to inform decision makers’ strategies regarding natural & agricultural resource management. The approach will create a regional modeling framework by integrating and/or linking a network of state-of-the-art process-based models that are currently in existence & that are undergoing continuous development & evaluation, & to do so in collaboration with stakeholders. The Bio-EASM framework includes: WRF for meteorology, CMAQ for atmospheric chemistry & transport, VIC for hydrology, CropSyst for agricultural dynamics, RHESSys for natural ecosystem dynamics, NEWS for aquatic nutrient transport & CREM for economic interactions. Subcontract PI is the principle developer of RHESSys. The subcontract allows PI expertise to integrate RHESSys within the EASM framework & contribute to application of the integrated modeling framework to improving understanding of environmental change. With this framework, UCSB will be involved in integration process: simulations in a series of steps with increasing model integration & coupling to address questions related to 1) how climate variability affects regional biogeochemical cycling with specific focus on N & C, 2) how do regional N & C cycles feed back to climate in terms of greenhouse gas fluxes in the context of landuse change & inter-annual variability, & 3) how do land use & agricultural production decisions affect the interactions of N, C & climate & how do these interactions interplay with economic drivers. PI will supervise a post-doctoral scholar who will work on the RHESSys evaluation for a series of focus study sites, & RHESSys integration into Bio-EAsSM. Evaluation of RHESSys will include set-up, calibration & sensitivity analysis of RHESSys carbon, nitrogen & hydrologic estimates at the focus study sites with particular emphasis on evaluation the nitrogen cycling component. UCSB will undertake any necessary refinements to RHESSys based on retrospective, site-specific analysis. PI will work with other PIs to decide on appropriate data sets for retrospective, & N-deposition & climate change scenarios for stand-alone RHESSys modeling, and will work with other PIs to develop papers on these off-line RHESSys model applications. PI will work with the other Bio-EaSM modelers to embed RHESSys within VIC & contribute to analysis of coupled modeled results; & will work with the Bio\_EaSM team in the design & application of the fully coupled model & participate in developing papers, presentations & outreach.

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Toshiro Tanimoto 3/1/16-2/29/20 $197,763

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National Science Foundation 1547523

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**Extreme Interaction Between Atmosphere and Solid Earth: Understanding the Forcing Mechanism by Hurricanes and its Application for Monitoring**

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Hurricanes generate strong ground motions in the solid earth that are one of the strongest cases of mechanical coupling between the atmosphere and the solid earth. This in turn suggests that seismic data may be used for monitoring the hurricane intensity, if its seismic-wave excitation mechanism could be understood. The Earthscope network unexpectedly recorded hurricane data in the last five years and exactly provide such information for understanding the atmosphere-land interaction. Our investigation on Hurricane Isaac (2012) has demonstrated that the Earthscope data do provide new important information on the seismic-wave excitation process. The primary goal of this project is to apply our current approach to other hurricanes from the Earthscope data and test the stochastic, seismic-wave excitation theory that has been developed. This knowledge will then be applied to monitoring the intensity changes of hurricanes while they are still in the oceans. If such a monitoring becomes possible, it may become a useful tool for hurricane-hazard mitigation.

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Toshiro Tanimoto 7/1/15-12/31/17 $15,037

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University of California SB160023

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**Monitoring Hurricanes by the US and Mexican Seismic Networks**

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Developing a new approach for monitoring hurricanes would be useful for mitigating hurricane hazards in the US and Mexico. We propose to develop a new seismic approach for the dual purpose of (i) improving our understanding of the hurricane dynamics and (ii) developing a new monitoring methodology for predicting the intensity of incoming hurricanes so that warning may be issued.

This new seismological approach will utilize seismic networks that have become available in the United States and Mexico in the last 10 years now allow us to monitor hurricanes from seismic ground motions. The intensification of hurricanes is associated with strong pressure changes at the Earth’s surface that in turn lead to larger excitation of seismic ground motions. While progress by aircraft, radar and satellite observations in the atmospheric sciences has brought great progress to our understanding of hurricanes in the last 50 years, these seismic data will provide a fresh, new perspective because continuous streams of seismic data provide completely different views of a hurricane, views from the ground. The first goal of this project is to improve our understanding of the hurricane dynamics. The second goal is to develop a practical scheme to monitor the intensification of hurricanes by seismic data. This is useful for hazard mitigation, especially if the intensity changes can be monitored remotely, while a hurricane is still in the ocean. We have done this line of work using seismic data only from the US so far. Addition of seismic data from the Mexican National Seismic Network will broaden the area of this study and is advantageous as some hurricanes hit Mexico before reaching the US. Our primary motivation for this project is the addition of the Mexican National Seismic Network data to the analysis and focus on studying hurricanes that pass through Mexico. We expect that there will be many features that we were not able to discover only with the US data.

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Toshiro Tanimoto 2/1/18-1/31/20 $35,000

Jamison Steidl

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University of Southern California 104714023-E

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**SCEC5 Participation, Project E: SCEC Borehole Instrumentation Program**

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The borehole instrumentation program at UCSB is a continuing collaborative data gathering effort between SCEC and other agencies. We help to maintain the existing network of borehole stations in California, to facilitate the integration of this data into the regional seismic networks and the Southern California Earthquake Data Center (SCEDC), and to improve the dissemination of this data to the research community world-wide.

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Toshiro Tanimoto 2/1/18-1/31/20 $35,000

Jamison Steidl

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University of Southern California 104714023-E

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**SCEC5 Participation, Project F: SCEC Portable Broadband Instrument Center (PBIC)**

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The ability for SCEC to respond rapidly to a major southern California earthquake with the deployment of both weak- and strong-motion instruments in the near-source region was a catalyst for the creation of the PBIC and remains an important asset of SCEC seismology infrastructure and earthquake research community. This has been highlighted by successful deployments of PBIC equipment following previous earthquakes. The southern California region has been relatively quiet in recent years, with the last RAMP deployment during the 2010 El Mayor–Cucapah earthquake. This event was the first post-earthquake response using the modern real-time capable PBIC equipment, with stations deployed and data delivered directly back to UCSB and then relayed to the regional seismic network (SCSN). Two of the PBIC stations remained deployed through June of 2014, providing data to the network for more than four years after the mainshock, without requiring a site visit.

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Toshiro Tanimoto 2/1/13-10/30/16 $25,000

Ralph Archuleta

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University of Southern California 39073248

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**SCEC4 Participation, Project G: Modeling high-frequency seismic waves in Southern California**

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During the period 2/1/2013-1/31/2014, the PI, his student and his Japanese collaborator Dr. Taro Okamoto will perform waveform modeling of monochromatic high-frequency (1.12 Hz and 1.64 Hz) shaking data in the Los Angeles Basin. There were multiple sequences of shaking experiments that lasted 4-6 hours between 2000 and 2002 and were recorded by more than 100 stations in the regional seismic network. These data have not been modeled as the available computers were not fast enough to do modeling work until recently.

Through computer modeling, we will create a better attenuation model which will explain observed amplitudes on the average. We will also perform analyses, based on the adjointoperator approach, that will clarify the nature of seismic waves in the shaking wavefield. The wavefield is essentially a standing wavefield and should contain (equivalent) body waves and surface waves. This analysis will bring new information on the attenuation structure for highfrequency waves. We expect to learn how an attenuation model should be and how the SCEC CVM may need modifications. The two main goals of this project for the coming year will be:

1. Decipher the nature of harmonic signals and improve our understandings of high-frequency

wave propagation

2. Derive a better attenuation model that explains the shaking data.

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Toshiro Tanimoto 2/1/17-1/31/22 $0

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University of Southern California G17AC00047

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**SCEC5 Master**

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Jennifer Thorsch 6/10/14-9/30/15 $25,000

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California Coastal Conservancy 13-078

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**Kids in Nature Explore the Coast**

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The Kids in Nature (KIN) program at the University of California will provide opportunities for teachers and students to explore the coast. The goals of the program include reconnecting children to nature and engaging underserved children in activities that will develop an appreciation for and stewardship of the local coastal environment. The program will include classroom studies and student/teacher field trips to local coastal areas. In addition, coastal focused activity boxes and lesson plans will be developed, a two-day institute for local 4-6th grade teachers to highlight the local coastal regions and the resources available will be offered, and funding for bus transportation for the teachers to bring their classes to one of the coastal locations will be provided. The program will also expand opportunities for UCSB students to serve as mentors through the KIN program.

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Jennifer Thorsch 9/1/10-8/31/15 $214,305

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National Science Foundation DBI-0956281

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**Collaborative Proposal: Harnessing the Power of Herbarium Specimens to Understand the Changing Flora of a Biodiversity**

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The Consortium of California Herbaria (CCH) proposes to database 338,600 specimens and georeference 500,000 specimens of California plants to support the national effort to predict, understand, and monitor the effects of climate change. Taxa targeted for databasing and georeferencing are dominants in California habitats and those that are most imperiled by threats to biodiversity (including climate change). The nineteen partner institutions participating in this collaborative project will make available databased and georeferenced records providing tangible benefits to the public, students of all levels, and the research community.

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Jennifer Thorsch 8/1/11-7/31/14 $80,655

Samuel Sweet

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The Institute of Museum and Library Services IMLS MA-05-11-0256-11

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**Vertebrate Collections Management Project.**

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The Cheadle Center for Biodiversity and Ecological Restoration (CCBER), will utilize IMLS funding for a two year Vertebrate Collection Management project to complete the curation, documentation, cataloging, and databasing of its 24,875 herpetological, ornithological, and mammalian specimens. With the exception of UC Berkeley’s Consortium of Natural History Museums, CCBER is unique in its multiple roles of 1) curating, under one administrative structure, diverse biological research collections that are integrated into the teaching and research missions of the University of California; 2) directing ecological restoration projects that rely on the collections for biodiversity data; and 3) offering specimen-based K-12 education, scientific workshops, and evening seminars open to the public. Although our vertebrate collections are modest in size, they represent both a thorough synoptic collection for specimen based teaching and strong regional collections for research in evolution, ecology and biogeography. The vertebrate collections have been used for research purposes mostly by students associated with the curators. They are used by academic personnel in several departments both at UCSB and elsewhere for teaching, by the general public for conservation-based education, and for our K-12 environmental education program, Kids in Nature. The herpetology collection (over 13,000 catalogued specimens of amphibians and reptiles) was started in 1977 to serve both research and teaching needs. The UCSB herpetological collections are focused on southwestern California, a region that is significantly underrepresented elsewhere, yet contains the contact areas for most of the state's main zoogeographic regions (i.e., the Coast Ranges, San Joaquin Valley, Sierra Nevada, Mojave Desert, Transverse Ranges, and southern coastal plain). Southwestern California is at the hub of rapid tectonic and regional climate changes that are driving phylogeographic patterning in a majority of the resident species. The collection has had two primary foci. From 1977-1990 the primary emphasis was on collection-building, targeting remote areas, ecotones, relict populations, and areas soon to be alienated as natural habitat. Targeted work was directed at intergrade zones in a number of reptile taxa and isolated habitat areas with unusual species compositions, as well as towards building useful series of hard-to-collect species. Since about 1990 the emphasis has shifted to documentation of the distributions and life histories of regionally declining, threatened, and endangered species. Life history materials, particularly for amphibians, are seldom well represented in western North American collections, and the CCBER collection has strength in this area. Some of the most compelling arguments for federal listing of amphibian and reptile species in southern California have depended on the vouchers and data housed in CCBER, and in the current regulatory environment, these vouchers have been invaluable to state and federal agencies. Herpetological specimens were used in providing some of the biological and distributional data that resulted in the official listing of the California Tiger Salamander (Ambystoma californiense) and the Arroyo Toad (Bufo microscaphus californicus) as endangered species by the US Fish and Wildlife Service (see Sweet, 1991 1993, and Jennings 1994). Dr. Sam Sweet regularly uses the collection in his upper division courses at UCSB and to educate agency biologists regarding species of critical concern for this region and for general identification workshops. Most of the specimens are preserved in 70% denatured ethanol, and some in 10% in formaldehyde.

The CCBER ornithology collection (6245 catalogued specimens) and mammal collection (1,745 specimens) are important regional collections that will exhibit modest, targeted growth in the future. The collections were started by Drs. Mary Erickson and Barbara DeWolfe, former faculty members in the department of Ecology, Evolution, and Marine Biology (EEMB). The mammal collection includes 172 addition, our website contains images and information on the collections, and the library and archives are used by campus and community members. Our award winning “Kids in Nature” program (received 2007 Governor’s award in Environmental Education) with over 100 5th graders enrolled as well as other K-12 classes visit our museum several times each year and participate in hands-on activities with various collections. The Vertebrate Collection Management Project fulfills several goals in our five-year strategic plan. For the past two years, we have focused on improving collection usage and collection management procedures such as documentation, data accessibility, and preservation of our collections through museum best practices. As part of our strategic plan, in 2008 we asked an external review panel of university faculty from across the country to meet with our faculty curators, our directors and key staff (Goal 8). Their invaluable experience with university natural history collections similar to ours provided us with recommendations in several key areas: improving staffing and storage space for all collections, databasing of all biological specimens and uploading them to appropriate federated databases, and increasing faculty use of the collections campus-wide. We also successfully established a formal curator title on the UCSB campus (a two-year process) that will acknowledge the contributions of the faculty curators during their merit review process and appointed three new adjunct curators and three affiliates to CCBER.

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Jennifer Thorsch 10/1/13-9/30/14 $99,374

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The Institute of Museum and Library Services IMLS MA-30-13-0466-33

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**Digitization of the UCSB Vascular Plant Collection**

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The Cheadle Center for Biodiversity and Ecological Restoration (CCBER), a center under the Office of Research at UCSB, is requesting $99,374 for a one-year collections stewardship grant to image 71,600 specimens in our vascular plant collection, in order to improve databasing workflows, increase efficiency and speed, and to complete data entry of 57,295 of those specimens.

Natural history collections represent the irreplaceable documentation of life on Earth. The Digitization of the UCSB Vascular Plant Collection project will provide UCSB faculty, students, CCBER staff, environmental consultants and the general public with access to these valuable and historically significant collections but also contribute to a larger effort worldwide to digitize millions of biological specimens as quickly and efficiently as possible. The project will also provide the opportunity for student interns to learn new skills and increase their interest in the work to pursue employment or advanced degrees in museum studies or collection management.

The Cheadle Center's lack of funding for steady employment of a data entry technician coupled with current data entry protocols indicate a best case scenario of over seven years to complete the databasing of the remaining mounted 57,295 specimens. Our challenge is to make the data available in the most timely way. This will be done by adopting new workflows to capture label data from digital images and using optical character recognition software that can be entered directly into our database, thus reducing keystrokes and improving our hourly rates of data entry. The project goals and activities will be accomplished in one year by hiring an imaging technician who will take digital images of all catalogued sheets and enter specimen data, a project manager who will process images, enter data, and manage image and data uploads into a Specify database, and student interns who will do data entry. In addition, a taxonomist will oversee the curation, mounting, and cataloging of an additional 6200 backlogged specimens and will begin georeferencing completed records. At the end of the project, images and specimen data will be available through a Specify web portal on our web site. Completed California specimen records will also be uploaded to the Consortium of California Herbaria database, while additional specimens that are subsequently georeferenced will also be available to export to additional federated databases, such as the Global Biodiversity Information Facility (GBIF) to be repurposed for use in floras, species lists, and historical distribution studies.

The intended results of this project are: 1) improved databasing protocols and increased output leading to completion of the vascular plant collection 2) 71,600 herbarium sheet images available for online identification and assistance in refining loans to relevant specimens 3) increased preservation of specimens by reduced handling over time 4) availability of new data sets for regional and statewide biodiversity studies and 5) increased potential workforce by retaining and educating interns. Additional benefits include improved loan management and tracking and safer long-term backup for images and data. We will evaluate and measure the success of our project through daily statistics, quality checking and modification of protocols as needed to accomplish our goals, monthly review of project activities and progress, and yearly performance evaluations.

The Cheadle Center's primary collection management goals are to prepare, organize, and catalog collections for greater accessibility and to make specimen data available online for all of our audiences. This project strengthens our ability to serve our audiences more effectively by supporting these goals and advancing the university's mission of Education, Research, and Outreach.

Natural history collections represent the irreplaceable documentation of life on Earth. CCBER’s botanical collections contribute to discovering, understanding, and documenting biodiversity and to informing public policy on such issues as invasive species, species extinction, and climate change.