Department of Earth System Science
2017/2018 Strategic Plan - v. 05/10/2018

1. Mission

To contribute through research and teaching to a fundamental scientific understanding of the Earth as a coupled system, to train the next generation of scientists, to provide environmental science relevant to society, and to engage the public about global change.

2. Vision

A society that values scientific discovery and uses this knowledge to make informed decisions about the future of the planet.

Twenty five years into its making, our department remains unique in its interdisciplinary nature, with broad and exceptional research strengths~~,~~ and coherent degree programs. We aim to consolidate our activities to enhance connections between Earth system science and the impacts of global change on people's lives and the environment in the following directions:

(1) Discovery and attribution of rapid Earth system change. We seek to use an increasing stream of quality observations to discover rapid changes, e.g. climatic and hydrologic extremes, sea level rise, wildfires, drought, ocean acidification, environmental degradation, growing season, ~~etc.~~and use new methods to attribute these changes.~~, e.g. climatic and hydrologic extremes, sea level rise, wildfires, drought, ocean acidification, environmental degradation, growing season, etc.~~

(2) Impacts of global change on human and environmental systems. We seek to improve our understanding of Earth system function through a continued expansion of role human activities play in the system, including the concept of Planetary Health, which links environmental and human health issues with climate and other global change~~s~~ drivers on multiple levels.

(3) Projections of and adaptive strategies for Earth system change. We seek to integrate across physical processes operating on a variety of spatial and temporal scales using models to project the evolution of the Earth system, including sea level rise and coastal erosion, ~~how altered biodiversity~~ influences of altered biodiversity on ~~the rate and trajectory of recovery from disturbance in~~ ecosystem recovery~~s~~, climate and hydrologic extremes, ~~impacts of~~ climate and environmental changes on food security, air and water quality, and how best as a society we might adapt to this Earth system evolution. ~~etc.~~

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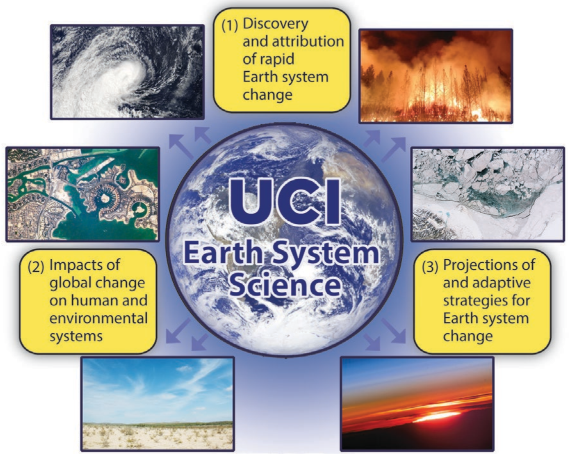

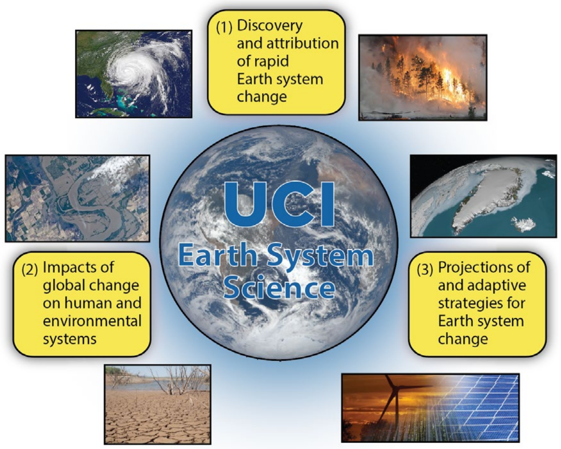

3. Background

The UCI Department of Earth System Science (ESS) is the first U.S. university department to carry the name of "Earth System Science" and to be dedicated exclusively to understanding the Earth as a coupled system. Current departmental research is focused on key areas of environmental and climate science including biogeochemistry of the land, ocean and atmosphere, climate dynamics, atmospheric science, glaciology and cryosphere science, and the global water cycle. In the past five years, the department has strategically grown in the research area of examining human systems and their interaction with natural systems. In addition to research and teaching, we work to engage policy makers and the community on a range of issues that affect the local and global environment.

ESS offers students B.S. and Ph.D. degrees in Earth System Science and a B.A. degree in Environmental Science; the B.A. program is joint program with the Department of Urban Planning and Public Policy, School of Social Ecology. As part of the UCI CalTeach program, we offer a concentration

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in Geosciences Education with a Secondary Teaching Certificate for both of our undergraduate majors. In terms of diversity, our undergraduate and graduate student populations are both close to 40% female / 60% male, and our Hispanic undergraduate population enrollment percentage has grown significantly to 38%, up from 8% ten years ago.

Over the last two decades, ESS has earned a reputation as one of the most influential academic departments in the nation devoted to studying the Earth as a system. The latest National Research Council (NRC) survey ranked the department among the top five geoscience programs out of 142 nationally. We currently have three members of the National Academy of Sciences, seven American Geophysical Union Fellows, two American Association for the Advancement of Science Fellows, and two faculty contributed to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report which was rewarded with the 2007 Nobel Peace Prize.

4. Goals

ESS was granted department status in 1995 and, being the newest department in the School of Physical Sciences, is still maturing to its full potential. The following goals promote an ambitious 10-year plan for ESS that encompasses our degree programs, strategic research vision, and infrastructure – a plan that grows faculty, students, staff, funding, and space accordingly, and aligns with the strategic vision of UCI. ~~The overarching goal is to maintain leadership in Earth system science education and research, strategically evolving to a department of the future.~~

Goal 1 – Research: Strategically invest in a set of targeted high impact research initiatives to study the Earth system. Each initiative aligns with our department's vision.

Goal 2 – Undergraduate and Graduate Programs: Successfully launch and grow the new interdisciplinary B.A. in Environmental Science and Policy. Double undergraduate enrollment in ESS classes over the next 10 years and increase climate literacy and sustainability awareness on the UCI campus. ~~Double the number of undergraduate student enrolled in ESS classes within 10 years by growing our B.A. major and offering new electives.~~ Double our enrollment of Ph.D. students within 10 years to 3 Ph.D. students per faculty member. Maintain excellence in our programs and improve the diversity of our students.

Goal 3 – Faculty Size: Increase departmental faculty to 35 in 10 years to meet the needs of our targeted high impact research initiatives and educational programs. Focus on increasing diversity will be done by following hiring best practices.

Goal 4 – Partnerships and Research Infrastructure: Invest in several strategic partnerships to expand the breadth and impact of ESS per alignment with our vision. Create ESS endowed positions to support the department's research and training goals. Continue to invest in and expand current facilities.

Goal 5 – Community Engagement and Communication: Strengthen existing initiatives in ESS and expand the department's communication efforts to engage local stakeholders, the State of California, and the public. Provide new internship opportunities for ESS undergraduate students.

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Appendix A. Implementation Plan

Our process for developing our 10-year strategic plan included a survey of faculty about climate, inclusive excellence, and the road ahead; an online survey on strategic initiatives; a one-day retreat with senate faculty; SWOT (Strengths, Weaknesses, Opportunities and Threat) analyses of potential research initiatives; and feedback from faculty, staff, students, and stakeholders on campus and in the community.

A1. Research

Goal: Strategically invest in a set of targeted high impact research initiatives to study the Earth system and the impacts of global changes on human systems and our environment. Each initiative aligns with our departmental vision and is as inclusive as possible of ESS faculty. ~~Below we describe the initiatives, their science goals, our strengths, opportunities for each initiative, what internal and external funding opportunities will be sought to fund these initiatives, what new FTE positions will be required to achieve our goals, and how we will measure success in implementing them. The suggested hires for each initiative have substantial overlap across them. The initiatives are not organized by rank or priority. While investing in these research initiatives, we will also pursue a balancing act of maintaining our core strengths and investing in our growing linkage with human systems.~~

A key concept at the department's founding was to study global change on the sub-seasonal, seasonal, decadal, and centennial timescales of a human lifetime. In recent years, there has been a growing appreciation of global change impacts on human systems over shorter time scales through the impacts of climatic and hydrologic extremes, and providing motivation for prediction on sub-seasonal to seasonal time scales. Recent discoveries also highlight how decisions we make regarding resource use over the next several decades will affect the evolution of Earth's physical and biological systems for centuries and even millennia. Exploration of deeper time horizons is needed to identify tipping points that might make it more difficult to sustainably manage Earth's life support systems. Thus, a broadening of the time horizons of departmental research has occurred naturally, and further broadening is viewed as a necessary step toward remaining on the cutting edge of research in many Earth system science disciplines.

The complexity of the Earth system and making the explicit linkages across disciplines demands increasingly sophisticated tools to manage and process the rapidly growing observational datasets on land, in the oceans, and in the atmosphere, coupled with massive new data streams from the satellite sensors in orbit. Analyzing these datasets and using them to assess and improve our models of climate and biogeochemistry require new geospatially oriented approaches and tools. We see expertise in these areas as critical for making progress understanding many complex Earth system interactions, including some associated with land use change, hydrology, biodiversity, biogeography, and disturbance (for example wildfires, coral bleaching events).

~~Our vision remains focused on understanding the Earth as a coupled system, drawing on lessons from the past and current system functioning, with more emphasis on providing guidance on the impacts of climate warming and other global change processes on Planetary Health.~~ Below we describe the initiatives, their science goals, our strengths, opportunities for each initiative, what internal and external funding opportunities will be sought to fund these initiatives, what new FTE positions will be required to achieve our goals, and how we will measure success in implementing them. The suggested hires for each initiative have substantial overlap across them. The initiatives are not organized by rank or priority. While investing in these research initiatives, we will also pursue a balancing act of maintaining our core strengths and investing in our growing linkage with human systems.

Initiative A. Global Environmental Change and Planetary Health

Vision: To improve the understanding of the links between global change processes and the health of the planetary biosphere, with the latter encompassing both human and ecosystem health.

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Overview: Global environmental change threatens to limit the substantial progress that has been made in advancing human health over the past several decades. Climate change and extreme weather events, air pollution, water quality, marine plastic pollution, food security (agriculture and fisheries), harmful algal blooms, conflict/migration, and disease (both agricultural and human) are mechanisms through which global change has immediate and substantial impacts on human well-being. The sustainability of fisheries will be strongly impacted by global change, ocean acidification, and fisheries management decisions. This emerging nexus of issues has been termed "Planetary Health," and attention is growing from various funding bodies (e.g. Rockefeller Foundation), academic organizations (e.g. UC Global Health Institute), and scientific societies (e.g. AGU's newest section, formed in 2018, is Geohealth with the explicit aim of creating a home in the geosciences for planetary health). Planetary Health is framed to encompass a vision that is inclusive of ecosystem health alongside human health.

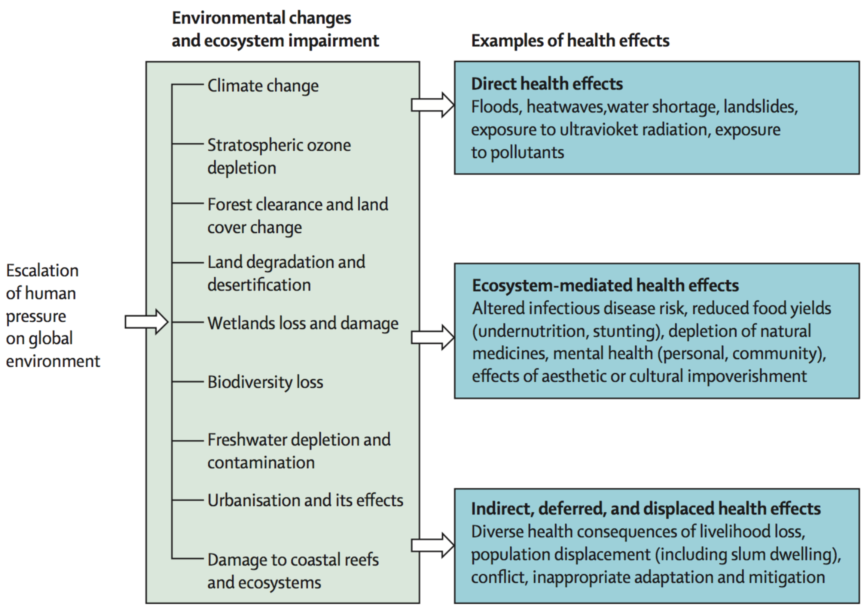

Figure 1. Health effects from environmental change. Reproduced from the Millenium Ecosystem Assessment via Rockefeller–Lancet report, which articulated a vision for Planetary Health.

Opportunities: ESS has strong expertise in physical climate processes, atmospheric chemistry, land use change, and human systems. The strongest current connections with Planetary Health themes revolve around food security (Mueller, Davis), climate change impacts on ecosystem productivity and sustainability (Moore, Martiny, Mackey, Primeau, Randerson, and many others), seasonal to subseasonal climate predictability (Magnusdottir, Pritchard, Yu), land use change (Randerson, Goulden, Velicogna, Mueller, Davis), and atmospheric chemistry (Guenther, Kim, Prather, Zender, Davis, Czimczik, Randerson, Saltzman). Several ~~faculty~~faculties (Mueller, Davis, Randerson) have worked or are working on studies with explicit health outcomes, but none have a primary focus on health and global environmental change.

A number of institutions are increasing expertise on this topic – many affiliated with the Planetary Health Alliance established by Harvard University and the Wildlife Conservation Society. UCSB and UCD

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have established "Planetary Health Centers of Expertise" via partnership with the UC Global Health Institution. Some contain more Earth science expertise. Others are public policy / public health researchers. UCI has unique expertise that bridges the gap between Earth science, human systems and health.

Opportunities: ESS has expertise in physical climate processes, atmospheric chemistry, land use change, and human systems. The strongest current connections with Planetary Health themes revolve around food security (Mueller, Davis), climate change impacts on ecosystem productivity and sustainability (Moore, Martiny, Mackey, Primeau, Randerson, and many others), seasonal to subseasonal climate predictability (Magnusdottir, Pritchard, Yu), land use change (Randerson, Goulden, Velicogna, Mueller, Davis), and atmospheric chemistry (Guenther, Kim, Prather, Zender, Davis, Czimczik, Randerson, Saltzman). Several faculty (Mueller, Davis, Randerson) have worked on studies with explicit health outcomes, but none have a primary focus on health and global environmental change. ESS has no coverage in fisheries and ecosystem health/services.

Growth in this area would support the development of human systems in ESS, which has been a long-standing goal. This initiative aligns closely with the goals for the new Interdisciplinary Science and Engineering Building (ISEB) building, which has a theme of "Healthy Planet, Healthy People."

Partnerships at UCI and beyond: Several connections exist across campus, particularly in the Department of Ecology and Evolutionary Biology (EEB). Infectious disease and air pollution connect with Public Health within the UCI College of Health Sciences (although no expertise in nutrition), with hydrology groups in the Department of Civil and Environmental Engineering (CEE) and with development / public policy researchers in the Department of Urban Planning and Public Policy (UPPP).

Funding: Foundation support (e.g. Rockefeller and Gates), NIH National Institutes of Environmental Health Sciences, UC Global Health Institute (small awards), NASA Applications, Land Cover Land Use Change, and Ecological Forecasting Programs, and EPA.

Hiring timeline: 1 FTE on ecosystem approaches for marine resource management (sustainable fisheries, harmful algal blooms, marine protected areas for conservation and ecosystem health), 1 FTE on air pollution impacts on ecosystem and human health, 1 FTE on climate/health relationships by means of infectious disease or heat-driven mortality (includes connections to extremes theme and S2S predictability), 1 FTE on biodiversity, land use, ecosystem services, and human health / well-being, and 1 FTE on fisheries. 1-2 FTEs for ESS could be achieved via a cluster or joint (50%) hires with EEB, Public Health, CEE, and/or UPPP.

How do we measure success?: Increasing funding levels, Ph.D. enrollment, electives that enrich undergraduate and graduate curriculum, floor space in ISEB Building. Recognition of ESS as a research leader indicated by publications and leading international initiatives or developing widely used models and approaches.

<u>**Initiative B**: Sea Level Rise and Impacts</u>

Vision: To make UCI a world leader for studying sea level rise from melting ice and glaciers to understanding its regional to global impacts on people, ecosystems, and biogeochemical cycles. Our goal is to provide society with practical knowledge and to engage partnerships, the public, and medias in our quest to address the issue of sea level change.

Overview: Sea level rise will affect millions of people in the coming decades, displace large populations, and involve economic costs in trillions of dollars for adaptation. The World Climate Research Program included "Melting Ice and Global Consequences" and "Regional Sea Level Change and Coastal Impacts" as two of its top seven grand challenges. NRC Decadal Survey 2017-2027 listed a top priority in Earth science as "How much will sea level rise, globally and regionally, over the next decade and beyond, and

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what will be the role of ice sheets?". Sea level is rising because of climate change. Oceans are warming and expanding. Ice sheets and glaciers are melting. Ocean expansion is affected by natural oscillations in the climate, e.g. El Nino. Similarly, the melting of ice sheets lowers sea level near the source of melt because of crustal rebound and changes in the gravity field, while sea level rises faster away from the ice sheets and glaciers, e.g. along the eastern and western coastal U.S. At the regional level, sea level change depends on tectonic movement, land subsidence associated with oil or water extraction, post glacial rebound, land erosion, waves, tides, winds, and other effects. The impact of sea level rise varies with storm surges, vulnerability to coastal inundation, sediment loading and compaction, and wave height.

Growing populations and development along the coasts increase the vulnerability of coastal ecosystem to sea level change. Development will alter the migration of wetlands, the sediment yield on deltas, or accelerate erosion. Rising sea levels affect drinkable water and many aquatic plants and animals. As seawater reaches farther inland, it will cause erosion, wetland flooding, and rapid loss of habitat for fish, birds, and plants.

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Major issues include how much will regional sea level rise in the future as a result of melting ice sheets, what will be the impacts on ecosystems, human systems and natural resources, what will be the economic impact in the U.S. and worldwide. There is not an institution that regroups the ensemble of expertise needed to address issues ranging from cryosphere science, climate modeling, and physical oceanography to assessment of impacts of sea level change on coastal and human systems.

Opportunities: ESS has expertise in ice sheet observations (Morlighem, Velicogna, Rignot), sea level fingerprint (Velicogna), ice sheet modeling (Morlighem, Rignot), ocean modeling (Primeau, Moore, Rignot), atmospheric modeling (Magnusdottir, Yu, Pritchard), the impact on ecosystems (Randerson, Moore, Mackey, Martiny, Primeau), and economic costs (S. Davis). CEE has expertise in flood models (Sanders) and coastal systems (K. Davis), and EEB in coastal oceanography (J. Martiny). Gaps in expertise include physical oceanography (aka David Holland), coastal erosion (aka Vitousek), data assimilation and projection of ocean heat content and variability (aka Josh Willis), impact of storm surges, weather extremes on coastal environments, and assessment of impacts on biological and human systems. Other UC campuses have not moved aggressively on this topic. UCI is well poised to stakeout a leadership positive within the State of California.

Partnerships at UCI and beyond: We will establish partnerships with CEE and EEB at UCI. We have partnerships with NASA's JPL Virtual Earth System Laboratory (vesl.jpl.nasa.gov); UCI/JPL Ice Sheet System Model (ISSM); the ECCO (Estimating the circulation and climate of the ocean) project; regional climate modeling at the University of Utrecht, Netherlands and the University of Liege, Belgium. We will seek partnership with cities and counties (Los Angeles, Orange, San Francisco, San Diego) and the State of California.

Funding: Opportunities to build capacity on sea level rise exist at NASA, NSF, and private foundations. We will propose a Science and Technology Center (STC) to NSF to raise $40M in 10 yr. Infrastructure would include floor space in the ISEB.

Hiring timeline: 1 FTE in physical oceanography with an interest in high latitude processes, 1 FTE on sea level impacts erosion and coastal geomorphology, 1 FTE on ocean heat content, and 1-2 FTE on sea level effects on coastal ecosystems and human systems.

How do we measure success?: NSF STC funded; participation in national and international Sea Level Change Teams; recognition of ESS as a research lead in sea level change via publications, international initiatives and widely used approaches; a new campus-wide initiative focused on sea level; a new physical center in the ISEB building; and new partnerships with city and state agencies to plan sea level adaptation.

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<u>Initiative C</u><u>: Climate Change and Prediction Over Multiple Timescales</u>

This component includes three sub-components that focus on 1) climate and hydrologic extremes, 2) seasonal to sub-seasonal prediction and predictability, and 3) longer timescale changes.

i. Hydrologic and Climate Extremes

Vision: To understand extreme phenomena in hydrology and climate and the links with the Earth system in order to prepare society for climate change impacts and to engage the media and public when events occur.

Overview: Hydrological and climate extremes are unusual events that often inflict disproportionate damages to ecosystems and society. Important examples of recent extremes include floods, droughts, heat waves, hurricanes, wildfires, forest dieback, and intense air pollution episodes. Increasingly, the dialogue regarding climate change at national and international levels focuses on extremes, their impacts, and the problem of attribution. Identifying the contribution of climate change to the intensity or behavior of individual events, or the aggregated statistics of multiple events is a nascent, emerging field of science that is increasingly shaping the public's perception of climate change (NAS, 2016)[1]. Over the next several decades, displacement of people (climate refugees) and the loss of ecosystems are likely to be closely tied to new extremes in the hydrological cycle and surface air temperature. These events will have profound geopolitical consequences and The World Climate Research Program has identified "Weather and Climate Extremes" as one of seven Grand Challenges.

Opportunities: An initiative in extremes would elevate UCI's profile at national and international levels building on current department strengths: the fluctuating position of the jet stream (Magnusdottir), heat waves in India (Davis, AghaKouchak), changing El Nino behavior (Yu), the isotopic signature of monsoons (Johnson), forest dieback across California (Goulden), and Indonesian wildfires (Randerson). Important disciplinary gaps that are essential for building a world-class program in this area include the study of changes in the global hydrological cycle, including the mechanisms influencing changes in the frequency and intensity of droughts and floods. This disciplinary theme is especially important in California. Other important areas include the study of storms, including for example, hurricanes, atmospheric rivers, thunderstorms, and the thermodynamic and dynamical mechanisms regulating precipitation extremes. Interdisciplinary hires could target early career scientists working on statistics and attribution challenges, providing "glue" for interdisciplinary collaboration with existing and new faculty that are more focused on disciplinary mechanisms. Finally, impacts of extremes on ocean and terrestrial biological systems is a critical new dimension of earth system extremes that has the potential to feedback on longer-term earth system changes.

Partnerships at UCI and beyond: An important part of this initiative is to increase research infrastructure for workshops and science communication within ESS. A strong partnership with the Schools of Engineering, Information and Computer Sciences (ICS) and Biological Sciences is essential. Important non-traditional partners include insurance and re-insurance companies that are interested in changing risk to residential and commercial properties in the U.S. and worldwide.

Funding: NASA, NSF, State of California, Private Foundations.

Hiring Timeline: 1 FTE focused on hydrology and hydrologic extremes (aka flooding or drought, response of hydrological systems to climate and other global change drivers), 1 FTE focused on storms, atmospheric extremes (aka heat waves or changing precipitation), and 1 FTE with emphasis on statistics and geospatial data analysis to study the underlying mechanisms of climate and hydrologic extremes.

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[1] National Academies of Sciences, Engineering, and Medicine. 2016. *Attribution of Extreme Weather Events in the Context of Climate Change*. Washington, DC: The National Academies Press. https://doi.org/10.17226/21852.

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How do we measure success?: Attaining a large climate impacts center grant from NOAA or another federal agency, greater coverage by local national news organizations, and increased graduate enrollment. Universities and U.S. National Laboratories are building research capacity around this theme. The Calibrated and Systematic Characterization, Attribution, and Detection of Extremes Project at Lawrence Berkeley Laboratory is an example of a significant U.S. Department of Energy investment, whereas Columbia University's Initiative of Extreme Weather and Climate is an example of an academic center funded in part by private foundations and companies in the financial sector.

<u>ii. Seasonal Timescale Earth System Prediction and Predictability (S2S)</u>

Vision: To improve our understanding and ability to predict Earth system dynamics on seasonal to sub-seasonal timescales.

Overview: Progress on seasonal time scales is of great societal importance, but is a major scientific challenge. Numerical weather prediction covers the time scale of hours to two weeks. Progress has been steady with improvements in weather forecast models and computational platforms, Earth observations, data assimilation, and improved diagnostics. Prediction on seasonal time scales lies beyond the capability of numerical weather prediction and requires consideration of the entire Earth system. Climate modeling involves time scales of a year to decades and an atmosphere and a land surface model, coupled to ocean, sea-ice, and land-ice models. Lately, the atmospheric models have become high-top, meaning they resolve stratospheric processes. Climate models have seen explosive improvements in recent years especially in terms of capabilities at higher resolution; current global climate models resolve phenomena that required regional climate models only a few years ago.

In between weather and climate modeling resides the area of sub-seasonal to seasonal (>15 days, but <10 month) Earth system projection, an area that is not only developing rapidly but it is important for safety and security of the nation and the international community. This time scale is critical for disaster mitigation efforts (e.g. Gulf states, Florida and the eastern sea board), to manage water resources in California (e.g. is the coming winter going to be an active atmospheric river season?), for emergency officials for wildfire preparation, or to improve projections of the impact of seasonal variability on food production. Bridging the two time scales will require immensely data intensive analysis to search for patterns on the relevant time scales both in experimental modeling efforts and in the vast database of "hindcasts" that has been assembled with a collection of state-of-the-art Earth system models that are now becoming "unified" or the same component model is used across scales.

Opportunities: This scale of Earth system prediction is an important growth areas of Earth system science. The analysis lends itself to probabilistic methods including machine learning, an approach that has strong expertise in ICS and Applied Mathematics. The physical-science expertise required is knowledge of the dynamical systems in play, an area that is present but needs strengthening in ESS. This area ties into a long-standing identified intellectual gap in ESS in regional climate modeling and dynamical and statistical downscaling.

This initiative would strengthen all three tracks of the BS program. We are about able to fulfill the AMS' requirements for a BS in atmospheric/earth system science with our BS curriculum. This will not only break that barrier but also increase the visibility of our graduate program to highly qualified graduates from other Universities. Obvious synergies with other departments and educational programs will strengthen our position in terms of the usual measures of success.

Partners at UCI and beyond: There is synergy in this area with Engineering (i.e. CEE) and Biology (i.e. EEB) but also ICS and Social Ecology (i.e. UPPP). This area complements the recent human systems focus within ESS and our efforts for stronger partnerships with JPL and UCANR.

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Funding: ESS could lead a campus-wide effort to integrate this forecasting capability with biological systems, infrastructure, policy, social justice, etc. for a large center proposal (e.g. NSF STC, USDA grant, or NOAA collaborative institute). Outside partners would include state, federal and local management agencies; NGOs; and UCANR. This area has major implications for national security and could be of interest to U.S. defense agencies.

Hiring Timeline: 1 FTE in ESS, possibly as part of a cluster hire across Schools, either a physical scientist, ecologist, or human system person involved in S2S prediction.

How do we measure success?: New faculty hire, campus-wide effort.

<u>iii. Humans, Climate, and Biogeochemistry over Longer Timescales</u>

Vision: To improve our understanding of longer term climate impacts on humans and the Earth system by developing Earth system simulations that encompasses the centennial to the millennial timescale.

Overview: Continued high levels of greenhouse gas emissions by humanity is initiating a large perturbation of Earth's climate that will last a thousand years or more, before the climate eventually cools back close to today's levels. At that point, most of the anthropogenic greenhouse gases will have been removed from the atmosphere, with the anthropogenic CO_2 mostly absorbed by the oceans (acidifying the oceans). To fully encompass global change impacts on the Earth system, Earth system simulation will need to consider longer timescales, from the centennial (to year 2100) to the millennial timescale. Paleo-climate and paleo-biogeochemistry provide observational constraints for model testing under different climate regimes, and conceptual frameworks for understanding future global change impacts on the coupled Earth system.

Opportunities: Building on existing strengths in Earth System modeling and paleoclimate, ESS could maintain leadership in this research area with a few targeted FTEs and funds for new hardware dedicated to longer timescale, coupled Earth System Model (ESM) simulations. A larger push along these lines could lead to UCI-led simulations for CMIP7 with a ten-year goal of a coupled ESM simulation extending from the LGM to year 4,000 that accounts for ice sheet dynamics, changing sea levels and a shifting land-sea boundary over time, including the impacts and feedbacks with terrestrial and marine ecosystems, biological productivity, and global biogeochemistry. Emphasis on this research area would build on existing department strengths in Earth System modeling, isotope biogeochemistry, paleo-climate, and paleo-biogeochemistry, and would strongly complement the W.M. Keck AMS facility.

Partnerships at UCI and beyond: The hires will build critical linkages between researchers and students in ESS and EEB and national and international research groups by encouraging new research avenues in interdisciplinary fields, such as climate modeling, aquatic biogeochemistry, microbial ecology, aerosol and trace gases, paleoclimate, stable isotope analysis, and human systems.

Funding: As funding agencies are increasingly recognizing the value of interdisciplinary research approaches such as these, we anticipate that the new hires will increase research funding significantly by facilitating large-scale, multi-collaborator research projects.

Hiring timeline: 2 FTEs in the areas of paleoceanography and marine biogeochemistry. These hires will leverage the world-class expertise of our faculty in studying the physical climate and biogeochemical cycling in the Earth system today, and will extend these efforts to understand key climate change impacts in the past. These advances will enable us to improve the Earth System models that we use to predict how physical climate and biogeochemistry will evolve in the future.

How do we measure success?: New hires, funding.

<u>**Initiative D**: Geospatial Data Science to Study the Earth System</u>

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Vision: To make UCI a world leader in the use of Geospatial tools to address the impact and management of global environmental change on humans, ecosystems, and natural resources. The emphasis is on both 1) identifying, diagnosing and attributing the ongoing impacts, and 2) evaluating the response options.

Overview: Global environmental change is impacting the terrestrial biosphere, with marked increases in wildfire, forest dieback, biodiversity loss and extinction, and hydrologic variability. We need to understand what is causing these shifts, whether they will accelerate in the future, and how we can manage their impact. Our field has become data rich in the last 20 years, but we have not figured out how to fully use this huge volume of satellite and in-situ network data to better address global environmental change. A new class of biogeoscientists is needed who understands and integrates information from numerous data streams to derive and apply fundamental theory. These scientists will have a strong understanding of the underlying physical, chemical and biological mechanisms, and will be fluent in a wide array of data types and methodologies.

New techniques in data science such as deep learning are enabling pattern recognition and information extraction, while advances in cloud computing are allowing analysis at scales that were previously unimaginable. Expanding portfolios of public and commercial satellites offer unprecedented views of the changing Earth, while networks of in-situ sensors and observations (genomics, etc), and near- (drones) and sub-surface (geophysical) imaging, offer unprecedented views of local mechanisms. The bottleneck is no longer the availability of data but the development of creative approaches for distilling, fusing and interpreting these data. A suite of critical questions is just becoming answerable; our goal is to develop the faculty expertise to train a new generation of terrestrial biogeoscientists to answer these questions.

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Opportunities: This initiative would expand educational opportunities at UCI, and is well aligned with workforce needs. Two new UCI NSF Graduate Training Grants underscore the demand (Data Science led by ICS and Ridge 2 Reef led by EEB). Additional educational opportunities will be explored over time, starting with the creation of Geospatial Data Science tracks in the existing ESS B.S. and Ph.D. programs, followed by an undergraduate minor, and ultimately a new B.S. and/or M.S.

This initiative is written to focus on the land, but similar issues apply elsewhere. ESS could make a major contribution to this area, but recent hires have not emphasized the use of geospatial tools to address the terrestrial impact and management of global change. This field is just starting to accelerate, and a focused hiring initiative is needed to ensure ESS is a central player. Additionally, we envision joint hires with ICS in environmental data science, with the aim of building cross-school geospatial and environmental core in the new IESB.

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Partnerships at UCI: Excellent colleagues in CEE, ICS and EEB offer complementary but distinct perspectives. There is great interest in this area among outside partners, and especially state, federal and local management agencies; NGOs; and UCANR.

Funding: Secured funding includes seed support from UCI, the usual collection of federal science agencies plus nascent collaborations with state, federal and local management agencies and NGOs. Pending proposals include the Cap and Trade climate change program administered by CA's Strategic Growth Council. Planned proposals include state and local agencies, Foundations and possibly a NSF STC.

Hiring timeline: 2 FTEs with additional hiring overlaps with the other initiatives. Areas of interest include: 1) biodiversity, biogeography and the distribution and abundance of organisms; 2) hydrology and the availability and use efficiency of fresh water; 3) land use, land management, and the rates of land conversion; 4) extremes, disturbance, and the resilience and recovery of land surfaces. Candidates will be selected based on outstanding contributions to the underpinning natural science, and potential to contribute to the Geospatial Data Science initiative.

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How do we measure success?: Excellence and success of faculty. Collaboration with and adoption of findings by managers; Number and success of students trained.

A2. Undergraduate and Graduate Programs

i. Undergraduate Program

Goal: Successfully launch and grow the new interdisciplinary B.A. in Environmental Science and Policy. ~~Double the number of undergraduate student enrolled in ESS classes within 10 years by growing our B.A. major and by offering new electives for this major; maintain excellence in both the B.A. and B.S. programs.~~ Increase climate literacy and sustainability awareness on the UCI campus; we aim to double undergraduate enrollment in ESS classes over the next 10 years. Review the current B.S. curriculum to identify new directions or potential gaps that would help students within the major reach their research/career goals.

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Our B.S. program provides students with a fundamental understanding of the oceanographic, atmospheric, and terrestrial sciences. This program of study prepares students for careers in science, research, or technical fields. Students are exposed to the physical, chemical, biological, and mathematical principles that govern the Earth system. Additionally, our program emphasizes the skills needed to succeed in research or industry, such as data collection and analysis, programming, and writing. In 2013/14, three optional specializations were created: (1) atmospheric science, (2) hydrology and terrestrial ecosystems, and (3) oceanography. These specializations allow students to identify a career and/or academic focus and to follow a set curriculum in their chosen area.

The new B.A. program in Environmental Science and Policy, approved to start in Fall 2018, is a joint degree program with the Department of Public Planning and Design (PPD), School of Social Ecology. As a result, the existing B.A. in Environmental Science will be phased out over the next 4 years. This new major integrates scientific understanding of environmental problems with an understanding of the socio-economic causes of the problems and the ways that environmental planning and policy may successfully intervene. Such an integrated and interdisciplinary understanding is necessary to successfully address many of the major environmental issues facing humanity, and the B.A. is designed to provide students with this broad systems perspective as well as the analytical and research skills necessary to engage environmental policymaking.~~Our BS program provides students with a fundamental understanding of the oceanographic, atmospheric, and terrestrial sciences. This program of study prepares students for careers in science, research, or technical fields. In the freshman year, students learn fundamental sciences (physics, chemistry, and mathematics). In the sophomore year, students are introduced to the major processes and systems governing the Earth's climate in a three course series focusing on a key subsystem of the Earth system (the oceans, the atmosphere, and the terrestrial biosphere). In the junior year, students begin to complete their upper division elective requirement, including a required data analysis course and a laboratory and field methods course where students learn methods to collect/analyze data and interpret results in the context of scientific theory. In the junior and senior year, students have the freedom to define their own area of focus by choosing from a large number of upper division electives to fulfill the final seven required courses. In 2013/14, three optional specializations were created: (1) atmospheric science, (2) hydrology and terrestrial ecosystems, and (3) oceanography. These specializations allow students to identify a career and/or academic focus and follow a set curriculum in their chosen area. Given the broad nature of our interdisciplinary degrees, the opportunity to specialize in a particular area is proving to be popular. Since the implementation of the optional specializations, 23% of BS graduates have completed a specialization.~~

~~The BA program prepares students interested in environmental problem-solving by linking an understanding of natural science with socioeconomic factors and public policy. The curriculum combines a quantitative understanding of environmental science, chemistry, and biology with studies of social science~~

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~~and policy to provide a foundation for careers in environmental policy, resource management, education, environmental law, and related fields. The required classes consist of the fundamental science series in biology and chemistry; a three course sequence in the fundamental processes of the Earth, local and regional environmental issues, and global environmental issues; a two course sustainability sequence taught by the Department of Public Planning and Design (PPD); and an ESS field methods course. Once the core course work is completed, students are encouraged to focus on a particular area within environmental science and to choose electives that build a coherent core of knowledge. To allow this flexibility, students choose electives from a variety of departments including in areas of biology, chemistry, physics, mathematics, social sciences, planning policy and design, economics, and sociology.~~

~~Major obstacles to growth include: 1) lack of staffing for a larger advertising and recruitment effort; 2) lack of staffing to establish connections to the local community for job/internship possibilities; 3) limited number of faculty members able to teach BA elective courses; and 4) uncertain growth in the number of TA positions.~~

Implementation Plan:

Goal #1: Successfully launch and grow the new interdisciplinary B.A. in Environmental Science and Policy.

1) Create new electives suitable for students in the B.A. (e.g. ocean sustainability, ecosystem services, economics of the environment).
2) Ensure our curriculum teaches relevant skills that will allow students to succeed once they have graduated (e.g. GIS, Matlab, writing/communication).
3) Increase external job/internship opportunities for students.
4) Increase research opportunities within the department for students.
5) Exploring interdisciplinary connections to other departments to expand course offerings.
6) Recruit new faculty who can fill teaching gaps and offer leadership and vision in developing this new program.

Goal #2: Increase climate literacy and sustainability awareness on the UCI campus. We aim to double undergraduate enrollment in ESS classes over the next 10 years.

1) Increase offerings of GE courses in climate change and related topics.
2) Explore opening up relevant upper division electives to upper division students from other majors (e.g. Chemistry, Engineering, and/or Ecology and Evolutionary Biology).
3) Increase recruitment efforts both on campus and from community colleges to increase the number of majors in both degree programs, paying particular attention to increasing diversity of students participating in the geosciences.
4) Revise the minor in Earth and Atmospheric Science to consider relevance and new course offerings.

Goal #3: Review the current B.S. curriculum to identify new directions or potential gaps that would help students within the major reach their research/career goals.

1) Create groups that review the curriculum within each specialization and identify gaps or opportunities for improvement
2) Develop internship/job opportunities to both assist our current students and aid in the recruitment and retention of new students (particularly underrepresented minorities).
3) Identify gaps (e.g. hydrology) and recruit faculty who can teach these core concepts within the major.

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Major obstacles to the implementation of these goals include: 1) limited number of faculty members able to teach specific B.A./B.S. elective courses; and 2) uncertain growth in the number of TA positions; 3) lack of staffing required to develop these programs in areas such as: web development/maintenance, marketing and recruitment, alumni/community outreach and relations, identifying job/internship possibilities, etc.

1) Comprehensively assess the entire program and develop new learning outcomes for each degree
   Offer more GE classes in climate change to promote undergraduate enrollment, and optimize current offerings.
2) Improve advertisement of our program through web and social media.
2) Recruit transfer students from local CSUs and community colleges.
2) Explore new electives for the B.S./B.A., e.g. a) Atmospheric Science with American Meteorological Society (AMS); b) Geospatial Data Analysis in collaboration with ICS.
2) Capitalize on the new BA coming online with UPPP.
2) Increase diversity, e.g., Link job/internship possibilities to local communities, and continue to focus on retention.

ii. Graduate Program

Goal: Double our enrollment of Ph.D. students within 10 years (30-35 FTE with 3 Ph.D. students per FTE) using internal (growth of TAships) and external (grant, fellowship, and private donors) funding while improving the quality of students and faculty mentoring and the diversity of our students. A doubling will bring our Ph.D. to faculty ratio to the level of the most outstanding science departments in the nation.

Over the past 10 years ESS has made a concerted effort to increase the graduate population while continuing to enroll high quality students. These efforts have included revamping the ESS website and individual faculty webpages, promoting our program at AGU and AMS, increasing our presence on social media: promoting our NRC rankings, listing awards and publications, and most recently creating google ads to increase our application pool. This has resulted in a 51% increase in the graduate student population while maintaining a five-year GRE average of 159.3/170 (qualitative) and 156.5/170 (verbal). Even with this growth, we need more targeted efforts to grow our graduate enrollment to faculty FTE ratio to 3 to 1. With the addition of new FTE hires (Goal 2), these equates to doubling our Ph.D. enrollment to about 100 students within the next 10 years.

Major obstacles to growth include: 1) quality of applicants; 2) funding uncertainties; 3) uncertain growth in the number of TA position; 4) capacity of faculty to manage 3 Ph.D students on average; 5) the low number of under-represent minorities in our applicant pool; and 6) inability to adapt our research training program to reflect that graduate alumni career is 56% in industry and research labs vs 44% in academia.

Implementation Plan:

1) Promote our PhD program across the nation and abroad at key undergraduate institutions to increase quality of enrollment. Prepare standard packet of slides and do recruitment talks – make sure to specifically address the undergraduate population.
2) Advertise at undergraduate conferences (AMS & SACNAS), advertise our tracks, and the career options (where do our alumni go)
3) Develop collaborative programs with other departments to increase graduate recruitment and training.
4) Look at applicant fee costs – is this fee deterring people from applying? Should block funds be used to waive this?

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5) Block a set of TA per faculty to cover one PhD student in full per faculty.
6) Encourage faculty to average 3 PhD students by enhancing its importance in Academic Placement, offering teaching incentives for large groups (4 and above) versus small groups (0-1), and offering increasing TA support for graduate students.
7) Offer more graduate electives to enrich our graduate curriculum, allow more flexibility in our program, and attract more STEM students of the highest caliber.
8) Develop a Master's program (state funded) to increase enrollment in the graduate program, support additional graduate level electives, and improve applicant quality for the PhD program.
9) Evaluate time to degree, are we using best practices to graduate students in 5 years?
10) Expand job positions that we place PhD graduates, including academia, industry, and research labs.

Immediate goals are to open our Master's program, revamp our web site, review and strengthen our graduate curriculum, establish a teaching policy linked to the number of Ph.D. students, and guarantee TA support for one Ph.D. student per faculty.

A3. Faculty Size

Goal: Increase departmental faculty FTE to 35 in 10 years to meet the needs of our targeted high impact research initiatives and educational programs. This expansion of approximately 11 FTE will require a hiring rate of 1-2 faculty per year above replacement, and will be accomplished, in part, through hiring partnerships with other departments and schools on campus; focus on increasing diversity will be done by following hiring best practices and working with the School's Equity Advisor. These hires are necessary to move into new research frontiers described below, and to maintain integration across the department. Our hiring plan will be presented to the School and University Leadership to fund these positions.

In the past ten years (Fall 2008-2017), senate faculty FTE has gone from 19.0 to 23.7, an increase of less than 0.5 FTE/year. During the same time frame, enrollment in the B.S. major has gone from 79 to 109 and in the Ph.D. program from 37 to 53; the biggest growth has been the number of B.A. majors with an enrollment of 125 in 2018, a number that has doubled in four years. Since its inception, ESS has been a campus leader in terms of gender diversity of its faculty, with founding members Professors Ellen Druffel and Sue Trombore. Currently there are nine female senate faculty members in the department, making up 35% of the department's FTE.

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Over the last decade, we have made important gains hiring in glaciology, physical climate, and human systems research, but our growth has been slow and non-optimal to maintain leadership in Earth System Science. Future hires will focus on building our research strengths to address societal challenges critical to the future of the planet, with human systems research integrated in with our more traditional groupings of atmospheric chemistry, biogeochemistry, and physical climate. These hires will align with our research goals and the targeted high impact research initiatives. Additionally, stronger formal interactions with other departments will be pursued with split appointments and without salary appointments.

Implementation Plan / FTE hiring timeline: 1-2 FTE/yr

Initiative A calls for 6 FTEs with 4 top priority; B for 5 FTEs with 3 top priority; C with about 7 FTEs (counting overlap) with 4 top priority; and D with 2 FTEs and 1 top priority, i.e. 20 FTEs with 12 top priority FTEs. The hiring timeline below is a guideline. The department plans to continue to fill FTE based on faculty input, seminars, educational needs, outstanding individual, etc. in addition to these initiatives.

<u>Top Hires for next 6 years:</u> 7 FTEs (incl.~~uding~~ hydrology replacement position)

- Initiative A: 1 Fisheries, 1 Biodiversity;
- Initiative B: 1 Physical oceanographer; 1 Coastal impact;
- Initiative C: 1 Hydrology, 1 Climate extreme;
- Initiative D: 1 Geospatial data analyst for land systems joint with ICS.

<u>Beyond 5-6 years:</u> TBD

<u>FTE for centers/facilities/partnerships:</u>

- <u>(KCCAMS) Facility</u>: 1 FTE (C)
- NSF STC Center or equivalent: 1 FTE (A or B)
- UCANR: 1 FTE (A or C)

A4. Partnerships and Research Infrastructure

Goal: Invest in several strategic partnerships, e.g. JPL's Strategic University Research Partnership (SURP) program and UC Agriculture and Natural Resources (UCANR), to expand the breadth and impact of ESS

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per alignment with our vision. Establishing these partnerships will require approval and support at the highest level of the University Leadership. Create ESS endowed positions for chairs/professorships, graduate fellowships, and a postdoctoral and visiting scholars program to support the department's research and training goals. Continue to invest in and expand current facilities, such as the W.M. Keck Carbon Cycle Accelerator Mass Spectrometer (KCCAMS) facility.

ESS hosts three endowed Chairs: the Fred Kavli Chair, the Donald Bren Chair, and the Ralph J. and Carol M. Cicerone Chair. The department's research expenditures are approximately $8M per year (i.e., $8.10M in 2016-17). As an overview, grant funding for the past five years (July 2012-June 2017) ranges from $7.0 to $10.2M per year; federal funding makes up 65-95% of the total funding with NSF and NASA/JPL being the department's major research funders. Other grant support includes foundation support, in particular from the Betty and Gordon Moore Foundation, national laboratories, and international agencies/institutes.

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We have identified a number of infrastructural initiatives that will help boost our funding resources, collaborations, and FTE priorities while aligning with our mission and vision statements.

i. JPL Strategic University Research Partnership (SURP) Program

Goal: UCI is interested in a strategic partnership with JPL to become the fourteenth university that is part of the Strategic University Research Partnership (SURP) program. This partnership is advantageous for both UCI and JPL, and would foster stronger research collaborations and student engagement. This partnership would enable the following goals:

- Strengthen existing relationships and provide a framework for initiating new projects to increase both UCI's and JPL's research portfolios, and to develop new science and technology opportunities in the space and Earth sciences
- Enhance students' research experiences and employment opportunities by having joint UCI/JPL advised research projects, promoting the JPL summer internship program to UCI's diverse undergraduate student body, and creating a pipeline for employment of UCI's students at JPL
- Secure additional extramural research funds and expand funding access by partnering and applying for funding opportunities which might otherwise not be available to the separate institutions

To advance these goals, UCI envisions (1) organizing meetings and workshops around mutual interest topic areas; (2) promoting visits between researchers at either JPL or UCI; (3) developing proposals for joint funding opportunities; and (4) facilitating student exchanges both at the undergraduate and graduate student levels.

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Strengths: A proposal for UCI to join the JPL Strategic University Research Partnership (SURP) Program has been submitted to JPL in March 2018. The proposal identified the current partnership strengths across the School of Physical Sciences and the School of Engineering. UCI has many unique connections to JPL via faculty in the Departments of ESS, Physics & Astronomy, and Mechanical and Aerospace Engineering. Our survey identified 16 faculty members with ongoing UCI-JPL collaborations, with 4 from ESS.

Opportunities: The SURP program will facilitate UCI students to research topics of interest to JPL and participate in relevant programs as well as for UCI students to build relationships with JPL staff for future employment. As a SURP university member, we will work with JPL to recruit our best undergraduate science and engineering students to apply for summer internship at JPL. Additionally, UCI has a strong undergraduate research program that enables students to work in research labs during the academic year or summer for credit or pay; JPL partnerships with UCI faculty can include these students. UCI is an HSI and working directly with our undergraduate students will pave the pathway to diversity for JPL and

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NASA. UCI is also committed to graduate education, and research partnerships with UCI faculty almost always include involvement and mentorship with graduate students.

Partnerships at UCI: UCI is a leader in a number of areas – with faculty partners in the Samueli School of Engineering, School of Physical Sciences, and Program in Public Health – that are strategic to JPL's mission. It would be beneficial for both entities to establish a more formal partnership. The JPL SURP program is a great opportunity that would help jumpstart new collaborations as well as push existing collaborations into new and exciting areas. We identified several potential new areas of research for collaboration, with more to come. Examples include propulsion and guidance, astrophysical observations with large aperture systems, smart manufacturing and materials, and Earth science from satellite observations and remote sensing techniques.

Funding: The SURP program provides many opportunities for funding, including research grant, student support, and increasing our competitiveness for NASA funding.

Next step: Obtain approval from the University Leadership and the Director of JPL to establish UCI as a SURP.

<u>ii. UC Agriculture and Natural Resources (ANR) Partnership</u>

Goal: We will seek partnership with ANR at the highest level on campus. We will identify partners on campus, negotiate at the Provost level, and identify strategic needs for ESS. The long-term proposal is for UCI to become a member of UC ANR. The UC ANR strategic plan includes several areas of strategic interest to ESS including:

- Sustainable Food Systems
- Sustainable Natural Ecosystems
- Water Quality, Quantity, and Security

Strengths: ESS faculty expertise in climate change, land use, and human systems makes a natural connection to UC ANR.

Partnership at UCI: Several other groups across UCI campus also have expertise in these strategic areas, notably CEE, EEB, and UPPP. Although not explicitly mentioned in the ANR strategic plan, air quality issues are of increasing importance to CA agriculture. Both ESS and CHE have strengths in this area.

Opportunities: The opportunities are: 1) To gain access to ANR FTE and funding (joining ANR would enable UCI PIs to lead research grants); 2) To better connect to and serve CA state stakeholders and diverse communities, and 3) to enable partnerships between UCI, ANR, and federal agencies (USDA) to promote inclusive excellence.

Next step: Hold discussions across UCI among faculty, with Chairs, Deans, VCR, and VPAED&I to develop a plan for partnership of UCI with ANR.

<u>iii. W.M. Keck AMS (KCCAMS) Facility</u>

Vision: To maintain leadership in the KCCAMS facility at the national level. The KCCAMS facility aims to maintain its excellence in Earth Science and plans to extend research activities in Environmental Science and Ecology. Key Research areas are: Monitoring human impacts on the C cycle, tracing organic matter cycling from soils to sea, paleoclimate (incl. glacial-interglacial variability of pCO_2~~2~~), understanding sources and fate of carbonaceous aerosol in air pollution and albedo of snow- and ice-covered surfaces, coastal ecology and oil spill remediation, and ecology of marine mammals.

The KCCAMS aims to acquire more capacity for the analysis of ultra-small (~~μ~~micrograms of~~g~~ C) samples. This would allow the KCCAMS facility to (1) fulfill the increasing need for the expedited analysis

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of ultra-small bulk samples and specific compounds, (2) allow for higher throughput of organic and inorganic samples to sustain and expand the leading role of U.S. researchers in Earth and Environmental Science and Ecology, and (3) strengthen the resilience of the existing KCCAMS laboratory to analyze what we consider regular-sized samples (100 micrograms to 1 milligram C), and thus provide sustained or additional ^{14}C analysis capability and training opportunities to U.S. researchers. One way to achieve this goal is to acquire a MIni CArbon DAting System (MICADAS), a 200-kV accelerator mass spectrometer (AMS), for high throughput radiocarbon (^{14}C, a natural and thermonuclear bomb-produced radioisotope) analysis of ultra-small to regular-sized samples (>3 micrograms to 1 milligram C / sample) in the form of carbon dioxide (CO_2) gas or graphite.

Hiring timeline: 1 additional FTE and replacement of outgoing FTEs. Areas of hiring: Paleoceanography, Isotope and Carbon Cycle Modeling, Organic Geochemistry

Funding: Faculty Hiring via Leveraged Research Excellence Initiative, Keck AMS Facility, NSF, USGS, NOAA, etc. Leverage new MICADAS with School and University funding

iv. UCI Interdisciplinary Science and Engineering Building (ISEB)

The ISEB will have a convergent focus on Grand Challenges in Health and Environment. ESS will seek floor space for three of its initiatives, i.e., A. Global Environmental Change and Planetary Health, B. Sea Level Rise and Impacts, and D. Geospatial Data Science to Study the Earth System, to participate in the Health and Environment focus.

A5. Community Engagement and Communications

Goal: Strengthen existing initiatives in ESS and expand the department's communication efforts (e.g., website, social media, brochures) to engage local stakeholders and the public. Provide new internship opportunities for ESS undergraduates (B.A. and B.S. majors). Work with the State of California on optimizing its investment of Cap and Trade funds and other relevant initiatives/programs.

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Appendix B. Financial and Infrastructure Implications

B1. Staff Hiring

As part of the department's strategic plan, it is important to consider our staffing needs. Non-academic staffing levels have not changed in 10 years and are not appropriate for our current faculty numbers and expected growth. Even at our current configuration in 2018 with 25 faculty members, 51 graduate students and 227 undergraduate majors, we are in need of 1 additional staff member ASAP. This position will assist with our increasing student affairs demands as the department launches its new B.A. program and modifies its Ph.D. program. There has also been a sharp increase in the number of events hosted by the Department. The need for event coordination, advertisement, and website design are in high demand for ESS and can be felt today.

If we consider growth of the department over the next ten years, we will need a second additional staff member to assist with pre-award procedures (i.e. contract and grant proposals) and payroll administration. In many other departments payroll is done separately for graduate students and academic titles. As ESS continues to grow its graduate program, we will need someone devoted to the funding and payroll procedures for our graduate students. Our current payroll employee handles all of the payroll for our graduate students, faculty, staff, and numerous research positions. This will not be sustainable over time. The same applies to our pre-award procedures. ESS has a very active extramural funding agenda. Each faculty member is extremely diligent and focused on applying for extramural funding opportunities. Therefore, the level of pre-award items processed is extremely high. In total, we will need an additional minimum of 2 staff members in ESS to support our strategic plan.

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B2. Space / IT support

ESS has been running out of floor space in the Croul Hall Building and also uses office space in Rowland Hall. It is critical for ESS to receive space allocation in new buildings, including ISEB, in order to accommodate our departmental growth and strategic initiatives.

IT support is critical along the lines of increasingly sophisticated data analysis, model simulations, data and model visualization, emerging trends in cloud computing, and big data analysis. ESS computing resources are not on par with that required for a leading research institution. ESS will need enhanced support from the School for IT support, including high quality system managers, networkers, that could maintain and managed a growing computing resources. ESS shall seek partnerships with other departments (aka Greenplanet) and Schools to increase our access to sophisticated computer resources.

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B3. New Revenue Sources

We will seek to boost core funding for ESS by about 30% through increased research funding, including large center grants (e.g. NSF STC, NOAA collaborative institute), private donations, and state funding. In addition to more research funds to increase the number of graduate students to reach a level of about 3 PhD per faculty, we will seek to increase our core number of TAs by increasing enrollment of undergraduates in our programs.

We will remain proactive on outreach program (web site, visit of local campuses, flyers about our program, presence at conferences, linkage with Alumni, etc.) to promote our department, engage private donation and sponsorships, and report on the planning and successes of our department.

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Appendix C. Alignment with School of Physical Sciences Strategic Plan and UCI Strategic Plan

The UCI strategic initiative is built upon the four pillars of 1) Growth that makes a difference; 2) First in class; 3) Great partners, and 4) New Paths for our brilliant future.

Our strategic plan contributes to 1) via an increase in number of faculty (35 by 2027) and their impact on society (research initiatives), increase in research expenditures (bring in faculty with high potential for funding, consolidate activities in overarching research initiatives), contribute to UCI strategic goals in health (Health and Environment Initiative), create programs for interdisciplinary, problem-based scholarship and teaching (all research initiatives are interdisciplinary in nature), e.g. for convergence science (Big Data Geoscience Initiative), and develop/support/promote new comprehensive research initiatives to shed light on social problems and address regional and global grand challenges.

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Our plan contributes to 2) through a doubling of our undergraduate and graduate enrollments, improving the quality of applicants, providing improved curriculum to our students, with internships, training in developing sectors (e.g. geospatial data), and increasing diversity among faculty and students.

We will contribute to 3) with the building of relationships with community college, local organization ((UC ANR) and research labs (JPL), provide output products of interest to the community (e.g. sea level, hydrologic and climate extremes), improve communication of our research to the public (web site, press releases, outreach).

We will contribute to 4) by aligning our strategic plan with a sustainable financial plan, opening a master program, doubling our student enrollment, improve our efforts for fundraising, and explore options to acquire the physical and technology infrastructures required to support our emerging activities.

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