Annual Report
Institute for Geophysics and Planetary Physics
University of California Irvine Branch
2003-2004

Susan Trumbore, Director
Elizabeth J. Ford, Administrator

W.M. Keck Carbon Cycle Accelerator Mass Spectrometer
Earth System Modeling Facility

IGPP @ UCI
Center for Global Environmental Change Research

Atmospheric Trace Gas Stable Isotope Facility
2003-2004 Annual Report
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Statement of UCI IGPP Branch Goals

The Institute for Geophysics and Planetary Physics is a Multi-Campus Research Unit (MRU) of the University of California established in 1946, with existing branches at the UCLA, UCSD, UC Santa Cruz, and UC Riverside campuses, and the Los Alamos and Livermore National Laboratories. The IGPP charter defines its mission: to promote and coordinate basic research on the understanding of the origin, structure, and evolution of the Earth, the Solar System and the Universe, and on the prediction of future changes, as they affect human life.

Research at the UCI IGPP branch addresses fundamental questions of global environmental change affecting the coupled system of atmosphere, ocean, and land, and occurring on the time scale of a human life.

Global environmental problems such as climate change and stratospheric ozone depletion involve complex interactions between atmosphere, ocean and land systems. UCI’s IGPP branch includes members of the Departments of Earth System Science, Chemistry, and Mathematics in the School of Physical Sciences and the Department of Mechanical and Aerospace Engineering in the School of Engineering. As a group, we take an integrated approach that combines field and laboratory measurements with modeling and theoretical studies. Understanding of the Earth as a coupled system of atmosphere, land and ocean is required to plausibly predict future changes in the Earth System.

The IGPP branch at UCI has three major goals:

1. promoting fundamental research on the workings of the earth as a coupled and complex system;
2. providing contributions to formal assessments needed by policy makers;
3. educating students and the public about scientific research in global environmental change.
Director’s Foreword: The Role of the IGPP at UC Irvine

The goal of the UCI Branch of the Institute for Geophysics and Planetary Physics is to enhance research in global environmental change at UCI and throughout the UC system. The UCI IGPP Branch, now in its third year, is attaining this goal in three ways. Support given to existing and new analytical facilities has fostered collaborations with UC and other campuses, and matching funds from IGPP for facility support are helping efforts to increase the multi-PI facilities on campus. Support given to UCI graduate students to begin their first major research projects helps foster research in Global Environmental Change and educates the next generation of scientists who study the Earth System. Support given for seminars and workshops fosters better communication and ultimately will lead to enhanced visibility for UCI IGPP.

The existence of world class research facilities at UC Irvine continues to stimulate collaborative research with other UC and Cal State campuses as well as internationally. These facilities have also helped UCI in its faculty, postdoc, and graduate student recruiting efforts. In the coming year, we will initiate support for a field-based ‘facility’ to support a multi-campus effort to determine the carbon balance of southern California.

As before, UCI uses its IGPP resources to carefully target areas of collaborative research, student research, and to sponsor visitors (including seminars and workshops). All of these activities add value to research in global environmental change at UCI.

Respectfully submitted

Susan Trumbore
Director UCI IGPP branch
UC Irvine IGPP Participants

Murat Aydin (trace gas biogeochemistry)
Donald R. Blake (measurement of trace gases in the atmosphere)
Ralph J. Cicerone (atmospheric chemistry; biosphere-atmosphere exchange of trace gases)
Donald Dabdub (mathematical modeling of air pollution dynamics)
Ellen R. M. Druffel (chemical oceanography and ocean carbon cycle dynamics)
Barbara J. Finlayson-Pitts (atmospheric chemistry -kinetics of gas phase and heterogeneous chemical reactions)
Carl Friehe (Turbulence and energy exchange between land and ocean surface and the atmosphere)
Jay Famiglietti (land surface hydrology and climate)
Michael Goulden (ecosystem ecology and exchange of energy, nutrients and water between land surface and atmosphere)
Gudrun Magnusdottir (atmospheric dynamics and global climate modeling)
Scott Miller (gas exchange and energy transfer between ocean, land and atmosphere)
J. Keith Moore (biogeochemistry of oceans)
Diane Pataki (plant physiology and isotope biogeochemistry)
Michael J. Prather (atmospheric chemistry; 3D atmospheric tracer transport models)
Francois Primeau (ocean circulation and climate)
James T. Randerson (biogeochemistry and the carbon cycle)
William S. Reeburgh (biogeochemistry, including methane)
F. Sherwood Rowland (trace gas chemistry of the atmosphere and stratospheric ozone depletion)
Edriss Titi (geophysical fluid dynamics)
John R. Southon (radiocarbon as a tracer for the global carbon cycle)
Kathleen Treseder (microbial ecology; global change biological)
Stanley C. Tyler (isotope biogeochemistry - stable isotope analyses of atmospheric trace gases and their sources)
Susan Trumbore (isotope biogeochemistry and global carbon cycle dynamics)
Jin-Yi Yu (coupled ocean-atmosphere climate modeling)
Charles S. Zender (atmospheric radiative transfer and global climate modeling)
## Major Research Facilities

### I. W.M. Keck Carbon Cycle Accelerator Mass Spectrometry Facility

The W. M. Keck Carbon Cycle Accelerator Mass Spectrometer (hereafter Keck CCAMS) was established as a facility to use radiocarbon measurements in support of research on the global carbon cycle. The facility was built with a $2 million grant from the W.M. Keck Foundation, matched by funds from UC Irvine’s Office of Research and Graduate Studies, the School of Physical Sciences, the Institute for Geophysics and Planetary Physics, and the A. W. Mellon Foundation. IGPP grants continuing facilities support of $25,000 per year to the facility, which is used to partially pay the salary of Dr. Guaciara dos Santos (Associate Specialist, ESS/IGPP).

The W. M. Keck Carbon Cycle AMS in a very short time has become a premier facility for measurement of radiocarbon at low cost to carbon cycle investigators. It is one of only five facilities in the US capable of measuring several thousand radiocarbon unknowns per year, and the only one dedicated to research in the carbon cycle. One of the other such facilities, LLNL’s Center for AMS (CAMS), also resides within the UC system and has had some association with IGPP. The two labs have cooperated on a number of levels, from technical (software support for data analysis at KCCAMS from CAMS/LLNL, and source comparison testing) to measurements (UCI collaborates on a multi-DOE lab project based at ORNL and LLNL, and the two labs are cooperating on intercalibration for high precision atmospheric $^{14}$CO$_2$ measurements).

The core of the KCCAMS facility is a 0.5 MV tandem accelerator system purchased from National Electrostatics Corporation. The AMS instrument was installed in July, 2002, and has been working on a reliable and routine basis since it passed acceptance tests in October, 2002. In July, 2003, the facility was successfully moved to its new home in Croul Hall. Over the past year, improvements in the ion source and the spectrometer have resulted in new major technical milestones:

1. We routinely now achieve high precision radiocarbon measurements (2-3‰) are routine for Modern samples.

2. The instrumental blank now is equal to or better than other AMS labs (70,000 years), as are our blanks for prepared graphite targets (57,000 years). Small (15 micrograms C) sample measurement capability has been demonstrated.

3. Sample throughput (including sample preparation) has reached the system’s present capacity, about 600 research unknowns per month. From October 2002 to June 2004 we have run over 5000 research unknowns (plus 3000 standards). The breakdown of samples for the past 6 months is roughly 40% in-house funded research, 20% research samples from universities and non-profits, and 20% commercial samples.
(4) The stable isotope facility is being augmented with an additional Finnegan Delta Plus isotope ratio mass spectrometer, purchased with start-up funds for Dr. Diane Pataki, who is newly affiliated with the Depts. of Earth System Science and Ecology and Evolutionary Biology at UCI. We expect the instrument to arrive in November 2004.

(5) In July 2004, the first short course on “Radiocarbon in Ecosystem and Earth System Science”, co-organized by Susan Trumbore and Ted Schuur, was held at UCI, with a total of 10 participants.

**W. M. Keck Carbon Cycle AMS Facility Personnel**

Dr. John R. Southon (Researcher ESS/IGPP)
Dr. Susan Trumbore (Professor, ESS)
Dr. Ellen R. M. Druffel (Professor, ESS)
Dr. Guaciara Macedo dos Santos (Associate Specialist, ESS/IGPP)
Dr. Xiaomei Xu (Specialist, ESS/IGPP)
Maya Mazon (hired June, 2003) (Junior Specialist)

**Associated Faculty:** Dr. Kathleen Treseder (joint appointment in ESS and Ecology and Evolutionary Biology), Dr. Diane Pataki (joint appointment in ESS and Ecology and Evolutionary Biology), Dr. James T. Randerson (ESS), Dr. William Reeburgh (ESS)

**Education/Outreach**

Education is a major part of the KCCAMS facility’s mission – so far, more than 30 people have been trained in the preparation of graphite materials and the fundamentals of radiocarbon. These include short course participants, graduate and undergraduate students who prepare their own research samples in the graphite laboratory.

**Postdocs (UCI ESS):** Dr. Claudia Czimczik, Dr. Tomoko Komada, Dr. Jeffrey Q. Chambers, Dr. Jeomshik Hwang


**Undergraduate students.**

Shala Ali, a double major in Chemistry and Physics at UCI worked to build the AMS with Southon and Santos, and on a carbon cycle project with Trumbore and Xu. She is now a doctoral student at Lamont, Columbia University. Maya Mazon, a student at California State University at Fullerton, has worked at the KCCAMS since March 2003; she is now a graduate student and continues her contributions to the lab, from preparing samples to operation and regular maintenance of the AMS. Kevin Druffel-Rodriguez, a student at Loyola Marymount University, helped set up the AMS and sample preparation labs, and works on various research projects with Southon, Druffel and S. Griffin. All three of these students have been coauthors on several publications. Several other undergraduate students, Shaun Evola, Diana Hsueh, Susana E. Gonzalez, Rachel Moore
and Sami Rifai, work on various aspects of AMS radiocarbon research. Santos is supervising these students in a new research program devoted to weekly monitoring of radiocarbon and stable carbon in seawater off the southern California coast.

Many ESS researchers have mentored undergraduates as a part of their research programs. Kelsey McDuffee did her honor's thesis research in the Druffel/Griffin lab, also did research with Ralph Cicerone, and is now working on a soils project with Trumbore. She graduated in 2003 magna cum laude, and won the top senior award in Physical Sciences, and was a Summer Student Fellow at Woods Hole Oceanographic Institution. She plans to enter a doctoral program in Fall 2005.

Leslie Roland worked with Druffel and Tomoko Komada for two years and won the award for best research in the ESS department during 2003-2004. She is now a doctoral student in the Dept. of Oceanography at U.C. Santa Cruz with Matthew McCarthy. Madelyn Luttgen is a sophomore ESS major who is working in Trumbore's group on isotopic analyses of soils.

Publications:

Radiocarbon Short Course
With funding from our NSF grant Trumbore and Schuur organized the first short course in “The uses of radiocarbon in Ecology and Earth System Science “, held July 11-18, 2004. The course had 10 participants in its initial year who received partial support for travel and living costs (the course web site can be found at http://ecology.botany.ufl.edu/radiocarbon04/), in future years we will expand to about 15 participants and we plan to submit an additional proposal for funding.

The purposes of the class were to expose students to the uses of radiocarbon in ecology and earth system science, and to educate them about past, present, and future changes in the global carbon cycle and their relationship to climate change. The course was organized to have both lecture and laboratory components, with students completing several original scientific projects during the course of the week. Students learned graphite preparation methods, and got experience at analyzing and interpreting radiocarbon data. At least two of the class projects (which investigated determining CO2 levels in the Los Angeles urban environment from the local radiocarbon ‘Suess effect’ as recorded in annual grasses, and which looked at diet as recorded in fingernails) are likely to be embellished and published. Funding to support the students was provided by an NSF Carbon Cycle grant to Trumbore, Schuur and Randerson, by the Keck CCAMS funds, and the Institute for Geophysics and Planetary Physics at UC Irvine.

Publications:

Cisneros-Dozal, L-M, S E Trumbore and P J Hanson, Partitioning Sources of Soil-Respired CO₂ and Their Seasonal Variation Using a Unique Radiocarbon Tracer submitted to Global Change Biology (Ecosystem respiration special section), June, 2004.


**Presentations at Meetings**

*Ecological Society of America (Savannah, GA, USA, August 2003)*

Using radiocarbon to partition autotrophic and heterotrophic soil respiration sources, S. Trumbore, LM Cisneros Dozal, X Xu, E A Schuur, J Chambers.

*International Radiocarbon Conference (Wellington, New Zealand, September 2003 (for publication in Radiocarbon)*

1. A radiocarbon dater's view of Greenland ice core chronologies. J. Southon


5. Radiocarbon in atmospheric CO$_2$ along a latitudinal transect of the Pacific Ocean in 2002, X. Xu, S. Trumbore, S. Tyler, H Agie


*American Geophysical Union (San Francisco, USA, December 2003)*

Czimczik, CI, S. Trumbore, Changing sources of respired CO$_2$ with time since fire in a boreal forests, Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract B22B-03, 2003


*Ocean Sciences Meeting of the American Geophysical Union (Portland OR, USA, February 2004)*


*2004 Joint Assembly of the American Geophysical Union and the Canadian Geological Society, Montreal Canada.*


*Other*


Hwang, J., $\Delta^{14}$C and $\delta^{13}$C of organic compound fractions of particulate organic carbon and temporal variability of biogeochemical properties of sinking POC in the NE Pacific, DISCO XVIII (Dissertations on Chemical Oceanography), 2003. (Sep, 2003).

**Honors**

Graduate student Jeom-Shik Hwang was awarded the Earth System Science Outstanding Graduate student award in the School of Physical Sciences in May 2003.

Kevin Druffel-Rodriguez used results from an experiment in graphite preparation methods at Keck CCAMS for an award-winning poster at the Orange County Science Fair, May 2003.

Kelsey McDuffee, an Earth System Science major and undergraduate working with Druffel and Trumbore, was awarded the Outstanding Earth System Science Undergraduate, and graduated Magna cum Laude from UCI in 2004.

Leslie Roland, an Earth System Science major and undergraduate working with Druffel and S. Griffin, won the award for best research in the ESS department during academic year 2003-2004.

Ellen Druffel received the Ruth Patrick Environmental Award from the American Society for Limnology and Oceanography in 2004.

John Southon was promoted to Research Step VI in July 2004, in recognition of his significant research contributions.

Sue Trumbore was elected and served as the first president of the new Biogeosciences Section of the AGU 2002-2004.

Ellen Druffel was elected and served as president-elect of the Ocean Sciences Section of the AGU 2002-2004, and is currently Section President (2004-2006).
II. The Earth System Modeling Facility

Charles Zender (Director, ESS)
Domingos Begali (Physical Sciences Computing)
James Famiglietti (ESS)
Steven D. Franklin (NACS)
Michael Goulden (ESS)
J. Keith Moore (ESS)
Scott Miller (ESS)
Gudrun Magnusdottir (ESS)
Michael Prather (ESS)
Francois Primeau (ESS)
James T. Randerson (ESS)
Susan Trumbore (ESS)
Jin-Yi Yu (ESS)

Post-Docs: J. Hsu
Undergraduates: S. Bamattre and others

The UCI Earth System Modeling Facility (ESMF) is a high-performance computer and storage system devoted to the integration, synthesis, and analysis of large models and datasets required to advance fundamental understanding of the coupled physical climate, chemistry, and biogeochemical cycles of the Earth system. THE EMSF supercomputer was delivered in December, 2003, and purchased with funds awarded through an NSF MRI. Additional funds have been awarded through NASA to connect the computer to high speed regional optical networks.

The ESMF will be used operationally (i.e., 100-year simulations) to address some outstanding questions about feedbacks anticipated with global change in the 21st century. These improvements will feed back into national climate modeling efforts. The ESMF represents a major enhancement in computational capability over the workstation-based and older shared-memory resources currently in use at UCI. It is tailored for the merging of ESM components (e.g., atmospheric chemistry, ocean biology, land hydrology) that normally consume the available computing resources of individual research projects. Although primarily a development facility for faculty and graduate researchers, the ESMF will produce the decade-long simulations of the coupled system that are needed for basic scientific studies.

Project descriptions of research initiated since January 2004 with the ESMF computing cluster include:
Emission and Long Range Transport of Large Mineral Aerosols: Current Biases and Climate Sensitivity, PI: Charlie Zender

Accurate representation of generation and long-range atmospheric transport of large particles is important for many aerosol species including mineral dust, soot, sea salt, and ice crystals. Large particles (e.g., D > 5 microns) usually account for a significant fraction of the aerosol mass distribution. All recent field studies show that models systematically underestimate concentration and deposition of large dust particles and correspondingly overestimate the presence of small dust particles. Consequently, remote regions, such as the Southern ocean, may receive inputs of dust-borne nutrients like iron much less regularly, and in much larger sized particles, than is currently thought. Moreover, direct radiative forcing by long range mineral aerosol is significantly biased, and causes excessive surface cooling.

We use the ESMF to probe the physical causes and biogeochemical and climate consequences of this large particle bias. The modeled mass median diameter of long range transported dust size distributions is typically 2.5 microns in models and 5 microns in reality. We found that about half of this discrepancy is due to neglecting complex physical processes which produce dust emissions. Driving the saltation-sandblasting process with realistic probability distribution functions of wind speed (SSPDF), rather than mean winds (CTL), comes much closer to observations (OBS) as shown in this figure, http://dust.ess.uci.edu/ppr/GrZ04/vfracmean.jpg from this paper, http://dust.ess.uci.edu/ppr/ppr_GrZ04.pdf. Simplistic advection schemes account for much of the remaining bias. Improving these processes does increase model run time and memory footprint substantially (about 50%). We will soon run coupled simulations to quantify the effect of these biases on climate and biogeochemistry. These new simulations will have less surface cooling, more atmospheric heating, and more variable dust fertilization of ocean biogeochemistry than current models. These simulations will strengthen dust radiative feedbacks in source regions and weaken them afar. We hypothesize these results will show that dust is more capable of drying out arid regions such as the Sahel (and generating more dust) than previously thought.

Relating Basin-wide and Inter-basin Interactions to Decadal Variability of ENSO, PI: Jin-Yi Yu

This project aims to explore hypotheses on mechanisms that give rise to decadal variability in ENSO (El Niño-Southern Oscillation) activity. We focus on the mechanisms that generate decadal variability through inter-basin interactions between the tropical Pacific and Indian Oceans and basin-wide interactions between the tropical and extratropical Pacific Oceans. For the basin-wide interactions, we focus on the hypotheses emphasizing ocean subduction mechanisms to those emphasizing atmospheric trade wind forcing mechanisms. For the inter-basin interactions, we focus on the relative importance of Indonesian Throughflow and the east-west atmospheric circulation mechanism in affecting ENSO behavior on decadal timescale. We use the ESMF to perform century-long simulations with coupled atmosphere-ocean general circulation models (CGCMs) to examine these mechanisms.
A modeling study of the intrinsic variability of the Gulf-Stream and Kuroshio Extension systems, PI: Francois Primeau

Satellite based observations of sea surface height in the regions of strong air-sea heat flux that flank the Gulf Stream and Kuroshio extension systems are beginning to reveal large-scale patterns of variability on inter-annual to decadal time scales. The dominant pattern of variability has a similar structure in both the Gulf Stream and Kuroshio Extension systems, and can be described as a low-frequency oscillation between a state with an elongated recirculation gyre and one with a contracted recirculation gyre. One of the striking results from these observations is the similarity between the observed variability and that produced in highly idealized wind-driven ocean models.

The purpose of this project is to test the hypothesis that the observed variability is a manifestation of intrinsic variability associated with the transitions between multiple equilibria of the wind-driven ocean circulation. To do this we apply recently developed methods of numerical bifurcation analysis to a hierarchy of ocean models with increasing realism to compute steady state solution branches and to analyse their stability. We use the ESMF to perform numerical bifurcation analysis of ocean models with O(100,000) degrees of freedom as well as to perform suites of multi-century ocean dynamic simulations with different Reynolds number.

The possibility that the observed large-scale patterns of low-frequency variability are the result of intrinsic variability is an exciting one because observations show that these current changes are significant contributors to the maintenance sea surface temperature anomalies (SSTA). Through the SSTA's effect on the atmosphere, the ocean's internal dynamics might be actively contributing to mid-latitude climate variability.

Global Atmospheric Nutrient Deposition and Ocean Biogeochemistry, PIs: Keith Moore and Charlie Zender

The biogeochemical cycles of silicon, nitrogen, phosphorus, and iron involve substantial transfer of materials from the continents to the oceans through atmospheric transport of natural and anthropogenic aerosols. We propose to study these important land-ocean links and their influence on ocean ecosystems and biogeochemical cycling, by coupling models of atmospheric chemistry and aerosol transport to a global ocean biogeochemical model. We will simulate the atmospheric deposition and dissolution in the oceans of the nutrients silicate, nitrate, ammonium, phosphate, and iron, and the crustal tracer aluminum. These key nutrients regulate phytoplankton growth rates, community structure, and primary production in the oceans. Their biogeochemical cycles are thus intimately linked with carbon cycling in the oceans and air-sea CO2 exchange. The ocean model includes an ecosystem model with several key phytoplankton functional groups and explicit treatment of the biogeochemical cycling of C, N, P, Si, and Fe. Mineralogy of both natural and anthropogenic aerosols will vary by source region and particle size, and the nutrient solubility will vary dependent on aerosol heterogeneous chemistry and aging during transport.
We will produce global maps of deposition to the oceans for each of these key nutrients. The mineral dust deposition of Fe, Si, and P will be constrained by oceanic observations of dissolved Al. We will estimate the impact of each nutrient on phytoplankton community structure, ocean biogeochemistry, biogenic carbon export out of surface waters, and air-sea CO2 flux at regional to global spatial scales. We will also examine how anthropogenic alterations of these biogeochemical cycles are influencing ocean biogeochemistry, and quantify the impact of variations in atmospheric nutrient deposition on ocean biogeochemistry and air-sea CO2 exchange over the next century.

III. Stable Isotope Facility for Measurement of Atmospheric Trace Gases

Personnel: Stanley C. Tyler (Researcher, ESS)  
Henry O. Ajie (Specialist, ESS)  

Graduate Students: Andrew McMillan, Allison Gotoh, Fu-Ming Kai  
Undergraduate Students: Ezekial Tostado  

Collaborators: UCI: Dr. Donald R. Blake, Dr. Michael Goulden, Dr. Susan Trumbore  
UC Berkeley: Dr. Kristie Boering, UC Davis: Dr. Mike Hare, LANL, Thom Rahn, IVIC, Venezuela: Dr. Tibisay Perez, King Mongut’s University of Technology Thonbury (Thailand) Dr. Amnat Chidthaisong  

With partial support from the IGPP, the stable isotope research lab (headed by Stanley Tyler) continues high precision measurements of stable isotopes on ambient concentrations of important atmospheric trace gases such as methane (CH4), nitrous oxide (N2O), hydrogen (H2) and carbon monoxide (CO). Studies underway include monitoring of the isotopic signatures of these gases in air on a monthly or bi-monthly basis, periodic transects spanning large latitude gradients, and upper air samples (free troposphere to lower stratosphere) taken from aircraft (in collaboration with Don Blake at UC Irvine Department of Chemistry). Recently, we have included high precision radiocarbon measurements in CO2 collected from a subset of these air samples.

IGPP funding allows this laboratory to do collaborative work; in particular we have collaborated with UC Berkeley scientists (Dr. Kristie Boering and co-workers) to analyze atmospheric CH4 from several recent high altitude (stratospheric) aircraft campaigns, and make isotopomer (positional dependence of 15N) in N2O.  

Collaboration with Dr. David Valentine in the Dept. of Geosciences at UC Santa Barbara on the isotope fractionation of bacteria under different conditions led to a successful NSF Biocomplexity proposal by Dr. Valentine, which provides funds for continued collaboration.

In each case, the collaboration has led to additional research funding for the stable isotope facility; hence the small ($25,000/yr) investment of IGPP is highly leveraged.
Publications resulting from collaborative work in 2003-2004


IV. A New Facility: Southern California Carbon Project

Initial Participants:
Michael Goulden (UCI ESS)
Phil Dennison (UCSB Geography)
Diane Pataki (UCI ESS and Eco. Ev. Biology)
Jim Randerson (UCI ESS)
Bill Riley (LANL)
Dar Roberts (USCB Geography)
Katy Suding (Eco. Ev. Biology)
Kathleen Treseder (UCI ESS and Eco. Ev. Biology)
Susan Trumbore (UCI ESS)

IGPP will provide ‘facility-level’ (ie.$25,000/year) support to enhance a recently funded interdisciplinary field study to better quantify and understand California's Carbon budget. This initiative builds on a project of the North American Carbon Program intended to better quantify California’s carbon budget. The overall project will synthesize collection of field data, remote-sensing observations, with existing data sets, develop mechanistic models, and build and run a data analysis framework that will produce a series of spatially resolved carbon budgets for the entire state of California.
Carbon budgets will incorporate all of the sources and sinks that are considered important, including those associated with natural ecosystems, agriculture, and fossil fuel combustion.

A second goal is to test ‘bottom up’ predictions of net CO₂ fluxed by comparing them with spatial gradients of atmospheric composition predicted by an atmospheric transport model with spatially and temporally comparable measurements of surface CO₂ and CO concentration. This will require building on existing gas sampling networks.

Many of the field measurements associated with this project will evaluate the various factors that control carbon exchange. In particular, we will consider the importance of interannual precipitation variability, fire emissions, insect mortality, recovery from disturbance (fire, logging, and disease), stand thickening with fire suppression, woody encroachment, land-use change, and agriculture as causes of interannual variation in net C exchange in California. To support this, a network of eddy covariance and field measurements sites spanning a range of climate and vegetation regimes will be established; IGPP funds will help to support this effort, which will both establish new sites and improve measurement networks at preexisting sites.

Clearly this new effort will be synergistic with efforts at other IGPP branches and UC as well as Cal State campuses – for example with efforts to model coastal California currents and regional air quality at UCLA, and fire modeling at LANL. Seed funding from IGPP will encourage these linkages, as well as support data collection efforts and small workshops for interested parties.

**Graduate Student Summer Research Program**

A major initiative of the IGPP has been to encourage first-year graduate student involvement in summer research projects. Students are required to do research related to global environmental change, and to obtain funding must submit a written proposal together with their research mentor. In summer of 2003, a total of 7 students received full or partial support from IGPP – their names and the titles of their projects are listed below. We will hold a symposium in November where students will present their results.

Leah Ray Necas (Mentor: Magnusdottir)
The effect of sea-ice trends on Arctic atmospheric circulation

Gopalakrishna Goteti (Mentor: Famiglietti)
The role of rivers and wetlands in biogeochemical cycling.

Nichole Nowinski (Mentor: Trumbore).
Effect of N deposition on below-ground carbon

Fuu-Ming Kai (Mentor: Tyler)
Using stable isotopes(del-D, del-13C) to constrain the CH4 budget.
Adrian Rocha (Mentor: Goulden)
Testing whether Net Primary Productivity is maximized by ecosystems

Fengping Sun (Mentor: Yu)
Monsoon-ocean interaction in Tropospheric Biennial Oscillation

Chris Doughty (Mentor: Goulden)
The effect of temperature on tropical forest photosynthesis

Other support
IGPP has paid to invite seminar speakers who give joint IGPP/ESS seminars (ESS itself has no funds to invite seminar speakers).

Budget Summary
Explanation of FY 2003-2004 Expenditures

Major expenditures in FY2003-2004 were for the W.M. Keck AMS facility, the Stable Isotope Facility, administrative and graduate student summer support. Again, the UCI IGPP branch does not have any line-item FTE support, instead it grants funds to facilities to be used at the discretion of the facility director (often to cover salary). Total salary (+ benefits) expenditures for 2003-2004 were $154,560, these were roughly distributed among facilities salary support, administrative support, and graduate student support, as detailed below. The remaining expenditures were $5165 for equipment (two LCD projectors to support workshops and seminars with IGPP sponsorship, and seminar speaker travel ($1240). Speaker travel costs were significantly under what was expected, because some charges were paid by the ESS Department.

W.M. Keck Carbon Cycle Accelerator Mass Spectrometry facility.
Funds granted to the AMS facility are counted as matching commitments toward the award from Keck; to help meet that matching commitment, we have spent a bit over the nominal $25,000 per year allotted per facility. This year IGPP gave partial salary support to Dr. Guaciara dos Santos (Associate Specialist). Santos is responsible for the UCI sample preparation lab, especially for training the many students and visitors who work in the lab preparing samples. In addition, she works with John Southon to continue improvement of the measurement accuracy and background of the AMS instrument.

Earth System Science Stable Isotope Facility
The stable isotope facility received funds this year in the form of three months of salary for Dr. Stanley Tyler, Researcher.

Earth System Modeling Facility
The ESMF funds are to be used to partly support a recently hired systems administrator; that person will not arrive until January, so this facility underspent its allotment this year.
**Administrative Support**
Partial salary was provided for selected administrative personnel in the Department of Earth System Science for continued support of IGPP payroll and accounting activities.

**Graduate Student Support.**
A major portion of IGPP’s annual budget is to be used to support research projects undertaken by first year graduate students on global change topics. That program supporting 11 students in the latter half of 2003 summer, and 6 students in the first half of summer 2004.

Other expenditures were in the form of travel reimbursements and associated expenses for visiting seminar speakers, and to purchase LCD projectors to support seminars.

**Explanation of carry-over funds and predicted budget expenditures for FY2003-2004**
IGPP spending has increased rapidly and in the coming year will exceed income. The UCI IGPP account has very little carryover, but the UCOP award has a relatively large carryover that derives from initially receiving year 1 allotment in the last month of the fiscal year, combined with slow spending growth as facilities that come on line (like ESMF) do not use their entire allotment in the first year. We expect a growth in facilities spending this year (as the ESMF and the new California Carbon Cycle Project begin to expend their allotted funds), as well as a reduction in income from both UCOP and UCI. We anticipate much of our carry-over will not survive the 2004-2005 year, especially given increases in student costs.

**Student Support Costs in 2004-2005 (estimated).** We do have a large carry-over from FY2002-2003, though a large portion of that is committed to be spent during summer 2003 by continued support of 11 graduate students this summer. Those costs are projected at $85,000 to finish the summer, and come to ~$100,000, if we include the start of a new summer research program in summer 2004. We have also decided to use IGPP funds to provide the unrestricted funds required by students who receive fellowships (such as NASA Global Change Fellowships) that require additional payment from unrestricted accounts. Those costs are estimated at $ for two foreign students this year.

**Facility Support.** In FY 2003-2004, we plan to continue supporting the three continuing facilities (UCI Stable Isotope Facility, W. M. Keck Carbon Cycle AMS Facility, and the Earth System Modeling Facility) in the amount of ~$25,000 each. The new California Carbon Cycle Initiative will also receive $25,000. Total expected facilities costs: $100,000.

**Administrative Support** will continue in the amount of $26,000/year. ($6,000 for Director support, $20,000 for administration)

**Seminar/Mini Workshop support** is expected to increase to ~$10,000 next year.
Total commitments in FY2003-2004 are thus estimated to be \(~236,000\), which is greater than our income is likely to be and will thus begin to erode the carry-forward funds from 2003-2004.

To get rid of the carry-forward, we will consider a one-time call for proposals (especially to fund postdoctoral researchers); we could fund 2-3 postdocs for a period of 2 years; we will meet with the advisory committee to determine the best way to run a selection process.