Celebrating 20 Years of Earth System Science at UC Irvine

“Collectively, we have found that it is possible to get international cooperation on a global scientific problem on the basis of scientific observation and consensus. Perhaps [this] can be a harbinger of the future; science and technology must play major roles in solving the problems we see all around us, and we all must continue to tell this not just to our colleagues, but to our representatives and to the general public, and we must be prepared to do it over and over again because the understanding is necessary. And it is still the most exciting game in town.”

F. Sherwood Rowland
June 11, 1993
Welcome

Air pollution. Deforestation. Drought. Melting ice caps. Ocean acidification. Ozone depletion. Global warming. These and other worsening environmental issues remind us of humanity’s increasing impact on Earth’s climate and ecosystems. In many cases, work to characterize and explain current changes is well underway. We understand, for example, that burning fossil fuels affects air quality, freshwater availability, and extreme weather. We now attribute past and project future effects of human activity. For example, our use of supercomputers can simulate a hypothetical world where carbon dioxide emissions are sequestered in the deepest ocean. We probe to see how our simulated Earth reacts. Scientists of the Earth system are working together to understand problems and develop solutions to some of humanity’s most pressing and shared challenges.

One property that makes Earth so intriguing is its tendency to change in response to new conditions and forcings. In ESS, we explore how all spheres in the Earth system interact. Not only do we posit explanations for observations that initially puzzle us (see At the Core… Publication Highlight for an example), we also train future researchers, educators, and leaders who will probe more deeply into human effects on the environment than we can. In September, we welcomed the 2011 cohort of Graduate Students. In this first year of their graduate careers, they are studying atmospheric chemistry, computer modeling, oceanography, terrestrial processes, geophysical fluid dynamics, global biogeochemistry, and climate change. They’re learning the science of the Earth as a system in order to answer questions no one else has yet answered. ESS is always looking for intellectually curious and engaged scientists to join us. If you’re interested in a Ph.D. program focused on the near-term changes affecting Earth, its composition, climate, and ecosystems, then I encourage you to visit http://ess.uci.edu/grad. Applications for next year are due in January.

Imagine what we can learn together...

Charlie Zender
Vice Chair of Graduate Studies, and
Professor of Earth System Science

In this issue

Refresh, then Read ....................................................2
Real Understanding. Proven Inspiration ........................3
Featured Dynamics: Crisis? What Crisis? .................4
At the core: Publication Highlight .............................5
UCI researchers chart long-shrouded glacial reaches of Antarctica ...............8
Two Decades of Influence and Innovation ..................9
Guiding the Future of International Science ..........10
Did you know.........................................................11
Engaging Future Leaders ........................................11
What on Earth? ......................................................12

Contributors
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Refresh, then Read

Did you see Professor Randerson’s interview about the recent successful satellite launch? Summer 2011 was busy for the Druffel Lab – did you know they’ve designed a new filter holder? Professor Johnson posted some amazing pictures of her research group exploring speleothems in caves. The Saltzman/Aydin Research Group has some incredible pictures of “life at sea”. Looking for interesting publications? Each of the ESS research group provides access to groundbreaking articles. You can find all of this and more research group websites.

ESS has been working on updating our research group websites! You can find links at http://ess.uci.edu/research. Watch our Facebook and Twitter pages for announcements of newly updated sites!
Real Understanding. Proven Inspiration.

It’s one of the oldest questions heard every September – What did you do over the summer? For a group of nine undergraduates, from across the nation and Europe, this year the answer is “Research in sunny Southern California.” Each of the students was selected during a competitive application process, and matched with an ESS faculty mentor. For eight weeks, they lived on campus, and experienced life as an academic researcher. A majority of the students will also present the results of their research at a scientific conference in the coming months. Hear more about the summer, in their own words, below.

Jonathan Nye
Can trace element ratios in Olivella biplicata shells from California be used to reconstruct Paleoclimate?
Dr. Kathleen Johnson (Mentor)
You can record these paleo-temperatures from these shells on very, very high resolution – much higher than I had ever really seen before. I’m used to hearing you can get the temperature for a decade, and with these shells, we were able to find daily or weekly resolution.

Jordan Samuel Thomas
Carbon cycling in soils at the top of the world
Dr. Claudia Czimczik (Mentor)
My experience was really nice, because I got to spend some time with other groups. There were a couple of groups I went with for a couple of days doing water samples, a couple of groups doing oil samples, and I was doing mostly air samples. It was really interesting – I got to see what kinds of samples I really liked working with.

Kirstina LaBoy
Global atmospheric composition and chemistry – model simulations for the IPCC 2012 Assessment
Dr. Michael Prather (Mentor)
Keep an open mind about your work. Your project might start one way, and end up another. You should always be prepared for that.

Nick Kelley
Microbial response to environmental change in the southern California coastal ocean
Dr. Adam Martiny (Mentor)
[One of the great things about the full-time research experience is that you’re able to] make your own hours. Depending on what you’ve accomplished, you might not have to show up at a certain time, or stay for a specific time...

Madeleine Campbell
Reconnaissance-level projection of ice sheet outlets
Dr. Todd Dupont (Mentor)
It’s important to not just predict, but use the computer models as a tool to show some of the possible scenarios. For some people who won’t trust the models, I would point to the models as the possible realities that we will face.

Matthew Ware
Remote sensing, ocean biogeochemistry, and marine primary productivity
Dr. Keith Moore (Mentor)
I was working to analyze satellite data. I’ve read a bit about it, and talked to a few people who have worked on it in the past, but this is the first time that I’ve been able to actually do it.

Charlotte Alster
Response and adaptation of microbial processes to climate change
Dr. Steve Allison (Mentor)
My favorite part was being part of a large lab. There were so many people around to ask different questions about things, and always people around to talk about your work. It was a really fun environment to work in.

Allison Moreno
Response of ocean bacteria to global climate change
Dr. Adam Martiny (Mentor)
[When I talk to my friends about climate change, I’m going to say] don’t just think about one thing – think about a lot of things. Usually people just focus on one thing, like “oh, it’s climate change, it’s just CO₂”, but I want to say no, it’s not just CO₂ – there’s a lot to think about.

Elizabeth Fosse
Trace gases in polar ice cores
Dr. Eric Saltzman (Mentor)
I’ve worked with a graduate student in Eric Saltzman’s Lab. It was interesting because Prof. Saltzman had three students in his lab – one who just finished his Ph.D., one who just started his fourth year, and one who just started her second year – so I got to pick everyone’s brain. It was interesting to hear how they got to where they are, but they all took different paths.

[The REU program] is definitely worth it, as far as the connections you make and your experience, and the value going forward.

For more information about the Research Experience for Undergraduates (REU) program, see http://ess.uci.edu/reu
Not surprisingly, this is the perspective most Americans have with respect to water. We turn on the tap, and our expectation is that out will flow a clear, crisp stream of cool (or heated to our desired temperature) fresh water. But suppose this were not the case? Can you imagine a life in which instead, when you opened your faucet, out came a stinky, erratic sputter of brown fluid? Or nothing at all? Unfortunately, this is the case in much of the developing world, where well over a billion people do not have routine access to clean, potable water for their household and agricultural needs. Sadly, emerging estimates suggest that this number, in reality, is far greater than one billion.

Don’t think it can’t happen in the United States. Wells are already running dry in California’s Central Valley, the most productive agricultural region in the country. Our Native American reservations have historically been water deprived. Large groundwater contamination plumes underlie virtually every major industrial center in the country, and in some cases, are responsible for localized cancer clusters and related health issues.

Hydrology Research Group Addresses World Water Issues

How much fresh water is available on our planet? Surprisingly, we don’t know! How will it change in the coming decades? What about the impacts of population growth and climate change? In short, will there be enough water to go around in the future?

Society would like to think the answer is a resounding ‘yes.’ However, research suggests that equitable distribution of water will simply not happen without new paradigms for global-scale, peaceable, trans-boundary water sharing, use, reuse and transfer. To ensure a secure water future for humanity, a tremendous amount of difficult work is ahead.

The ESS Hydrology Research Group has embraced the challenge of addressing these and a host of related issues, which will ultimately contribute to science-based, sustainable water management. We use advanced satellite methods like NASA’s GRACE mission to track water storage changes and groundwater depletion around the globe. We actively contribute to the science and design of emerging satellite missions like the NASA’s SMAP satellite for soil moisture and the US-French SWOT sensor for mapping river flows and lake levels. Several of our group members are developing new modules for land components of climate models, with a view towards making future water predictions more realistic and reliable. Still others are devising innovative approaches for analyzing and synthesizing these and other datasets to quantify how the water cycle, and with it, freshwater availability, is changing.

As a team, we have also accepted the responsibility for capacity building and training, as well as for communicating key results to environmental policy and decision makers. We travel globally offering UNESCO workshops on quantifying groundwater depletion. Most recently, we’ve been to Tunisia, the Dominican Republic, Austria and Italy. We’ve partnered with the American Museum of Natural History in New York City (think ‘A Night at the Museum’) to offer professional development workshops for middle and high school science teachers based on our research. And through our UC Center for Hydrologic Modeling (a UCOP-funded, multi-campus center that focuses on California water issues), we engage the community through outreach events such as “The Bridge” forum with Congresswoman Grace Napolitano (D-CA) in April, 2010, and our “Sustainable Water Solutions” meeting with Central Valley farmers in August of that year.

If you’re wondering how you can help manage our global water crisis in your daily lives, think seriously about lifestyle changes such as skipping car washing, or one shower on the weekends. How about reducing red meat consumption? Few people realize this, but all those expensive designer jeans that we wear are not meant to be washed, at all! So, don’t feel guilty about putting them back in the closet after a hard day at work. Importantly, begin cutting back on your home irrigation and reducing your landscape watering needs – far and away the biggest use of residential water.

- James Famiglietti, Professor of Earth System Science, and Civil and Environmental Engineering
What causes variability in atmospheric methane concentration?

The pursuit of groundbreaking science is rarely straightforward, and often involves debate and controversy. Just imagine the intense deliberation about whether the world was round, or flat. The science of the Earth as a system has progressed drastically since the Galilean debates in history, but some of the biggest questions still remain. For example, the challenge of understanding what caused the slow down of atmospheric methane growth during the last decade is one of the great puzzles in atmospheric chemistry. In August, 2011, two different studies from ESS were published in the journal Nature – both approached the problem from a different perspective, and reached a different conclusion.

Methane, a potent greenhouse gas, is the second largest contributor to climate change. In the last decade, levels of methane in the atmosphere stabilized, though recent observations indicate it might be on the upswing again. The growth and consequences of greenhouse gases, when studied as part of the science of the Earth as a system, involves atmospheric chemistry, biogeochemical cycles and global climate. Each area approaches the topic from a unique standpoint, utilizes different tools, and sometimes reaches controversial conclusions. When faced with a dichotomy of well-proven but contradictory results, scientists from differing research groups explore the results, and work to build an even stronger conclusion.

Continued on next page

Global Position of Scientists

Originally from Germany, Claudia might call Southern California an exotic destination... When she’s not enjoying sunny California, her research activities take Claudia to ecosystems in the high latitudes (arctic tundra and boreal forest). These field sites in northwestern Greenland and Alaska represent areas currently undergoing rapid changes in temperature and / or precipitation regimes.
At the Core (continued)

**A Biogeochemical Approach**

From careful, sustained measurements of methane and its chemical composition, the Randerson Research Group showed that water efficiency and heavier commercial fertilizer use in the booming Asian farming sector provided less fertile ground for soil microbes that create methane. The application of nitrogen fertilizers may have slowed the growth rate of methane, while concurrently contributing to the rapid rise of N2O.

“Approximately half of the decrease in methane can be explained by reduced emissions from rice agriculture in Asia over the past three decades, associated with increases in fertilizer application and reductions in water use,” said lead author Fuu Ming Kai, who wrote his UC Irvine doctoral thesis on the work and is now with the Singapore-MIT Alliance for Research & Technology.

**An Atmospheric Chemistry Approach**

The Saltzman/Aydin Research Group investigated the history of fossil-fuel emissions of methane, based on measurements of another hydrocarbon, ethane, in air trapped in the polar ice sheets in Greenland and Antarctica. The ancient air resides close to the surface, within the perennial snowpack, and can be used to study changes in the atmosphere during the twentieth century.

“Fossil fuels are a common source of both ethane and methane. Methane has many other sources, but we know most of the ethane in the atmosphere today is from fossil fuels. If ethane changes, it is easier to figure out the cause” said Aydin. “This research was conducted to track ethane and to see what it could tell us about methane. We found that ethane emissions declined at the same time as the rise in methane dramatically slowed, suggesting a common cause.” At the end of the 20th century, methane and ethane were deemed valuable energy resources. Collected and consumed as natural gas they are converted to carbon dioxide. The researchers’ results indicate that the leveling off in atmospheric methane in recent years is likely linked to this change in energy use.

**An outside perspective...**

Martin Heinmann, lead author on the Nobel Prize-winning Intergovernmental Panel on Climate Change reports, provided a third-party review of both papers. The publication of conflicting explanations from the same organization in the same issue provides a rare glimpse into the process of science. An excerpt from the review is included below.

*Can these conflicting inferences on the recent slowdown of global methane growth be reconciled? ...The different scenarios are plausible and compatible with their respective observations. The challenge now is to bring the different lines of evidence together, perhaps by using a more advanced modeling framework and improved bottom-up inventory information on the various methane-source categories. More extended observations will help too — particularly the mapping of atmospheric methane concentration by current and upcoming satellite missions.*

*These studies illustrate the importance of high-precision, long-term observations of methane concentration and isotope composition, and of auxiliary trace gases such as ethane, in distinguishing between the contributions from different sources. But more insight is needed to solve the enigma of the recent methane budget if the evolution of this important greenhouse gas over the twenty-first century is to be predicted.*

For more information, visit http://ess.uci.edu/~jranders or http://ess.uci.edu/~esaltzma
Watching local weather forecasts in Orange County, we rarely see a mention of a tropical cyclone. Wei Mei (Graduate Student) searches for these types of weather patterns in the open ocean. His research is focused on the interactions between tropical cyclones and the ocean.

Wei explores how changes in sea surface temperature affect the tropical cyclone intensity, and how tropical cyclones influence the ocean heat content. This will have both short- (weather timescale) and long-term (climate timescale) implications. Wei anticipates the development of a much better prediction of the Atlantic hurricane activity. He predicts we will be able to forecast hurricane activity more than a year in advance.

Global Position of Scientists
One of Wei’s most memorable travel destinations is Shanghai. It’s somewhat ironic, as the word Shanghai literally means “upon the sea.”

Congratulations to Christa Marandino (Ph.D. in Earth System Science, 2007), who was recently appointed a Helmholtz Young Investigators Group. This appointment will support the establishment of a research group, focused on an innovative technique, which was designed by Dr. Marandino. “With this project, we will provide a better understanding of the physical and chemical basis for the exchange processes between ocean and atmosphere. The method is called ‘eddy correlation technique.’ Simply put, we measure vertical wind speeds, the changes of gas concentrations, and bring the two together. The measurements have to be extremely fast and high-precision on a fluctuating measurement platform, like a research vessel.”

Dr. Marandino went on to describe the device, called the “atmospheric pressure chemical ionization mass spectrometer (APCI-MS),” which was deployed during her time in Earth System Science at UC Irvine, and will be utilized in pioneering ways by the newly formed research group.
A vast network of previously unmapped glaciers on the move from thousands of miles inland to the Antarctic coast has been charted for the first time by UC Irvine scientists. The findings will be critical to tracking future sea rise from climate change.

“This is like seeing a map of all the oceans’ currents for the first time. It’s a game changer for glaciology,” said UCI earth system science professor Eric Rignot, lead author of a paper on the ice flow published online today in Science Express. “We’re seeing amazing flows from the heart of the continent that had never been described before.”

Rignot, who is also with NASA’s Jet Propulsion Laboratory, and UCI associate project scientists Jeremie Mouginot and Bernd Scheuchl used billions of points of data captured by European, Japanese and Canadian satellites to weed out cloud cover, solar glare and land features. With the aid of NASA technology, they painstakingly pieced together the shape and velocity of glacial formations, including the huge bulk of previously uncharted East Antarctica, which comprises 77 percent of the continent.

Like viewing a completed jigsaw puzzle, Rignot said, the men were stunned when they stood back and took in the full picture. They discovered a new ridge splitting the 5.4 million-square-mile landmass from east to west. They found unnamed formations moving up to 800 feet each year across immense plains sloping toward the Southern Ocean - and in a different manner than past models of ice migration.

“These researchers created something deceptively simple: a map of the speed and direction of ice in Antarctica,” said Thomas Wagner, a cryospheric program scientist with NASA’s MEaSUREs program, which funded the work. “But they used it to figure out something fundamentally new: that ice moves by slipping at its bed, not just at the coast but all the way to the deep interior of Antarctica.”

“That’s critical knowledge for predicting future sea-level rise,” he added. “It means that if we lose ice at the coasts from the warming ocean, we open the tap to the ice in the interior.”

The work was completed during a period called the International Polar Year, and is the first such study since 1957. Collaborators working under the aegis of the Space Task Group were NASA, European Space Agency, Canadian Space Agency, Japanese Aerospace Exploration Agency, as well as the Alaska Satellite Facility, and MacDonald, Dettwiler & Associates Ltd.

“To our knowledge, this is the first time that a tightly knit collaboration of civilian space agencies has worked together to create such a huge dataset of this type,” said Yves Crevier of the Canadian Space Agency. “It is a dataset of lasting scientific value in assessing the extent and rate of change in polar regions.”

- Janet Wilson, University Communications

For more information, see http://ess.uci.edu/~erignot
Scientific advances have coincided with some of the greatest challenges to our society. It takes curiosity, training, and resources to move beyond the current boundaries of knowledge, which is essential to address these threats to civil society and our well-being. For the past two decades, the Department of Earth System Science (ESS) at UC Irvine has engaged the expertise and imagination of leading faculty, researchers and graduate students in groundbreaking research and teaching. As ESS reached the milestone of 20 years of science, we invited faculty, staff, students, and former departmental members to join ESS for a two-day celebration. The Department talked about the original intellectual basis of ESS, and how the science has both changed, and stayed the same. ESS discussed how we are training future generations, and the skills these leaders will need. As we discussed the novel Bachelor of Arts degree offered by ESS, founding faculty remarked at how extraordinary this program really is. Two decades ago, this kind of B.A. degree was unthinkable - now, enrollment in this program is steadily increasing.

The Department also explored grand challenges of the past and future, and the science that goes with them. ESS was invited to envision what would be possible with unlimited resources. This prompted interesting discussions of the wide-ranging scientific questions faculty, researchers, and students in ESS could answer. Some of the research questions that emerged were the following:

- How do we accurately simulate the ocean’s role in the Earth system?
- What processes and feedbacks produced observed 20th century abrupt climate changes?
- How does land use influence atmospheric composition and climate?
- What is the response of glaciers to greenhouse gases?
- How do we allocate water among humans, environment/ecology, and industry?

In addition to the scientific and academic discussions, ESS celebrated 20 years of memories. We talked about a time-capsule for future generations. Traditions were observed (i.e. a liquid nitrogen ice-cream party), and new traditions were started (i.e. “The Case for the Missing Methane” presented by ESS Graduate Students).

The event gave ESS an opportunity to imagine the future of Earth system science, and the inspiration to continue making a difference in the decades to come. For more information, please visit http://ess.uci.edu/celebrate20
ESS Involved in Guiding the Future of International Science

Earth System Science knows no boundaries - it involves research on global systems and it is a multinational effort. So, how do we coordinate such a complex endeavor? One way is through international “Projects” designed to bring together scientists from many nations to discuss, plan, and facilitate global science. One of these is SOLAS, the Surface Ocean – Lower Atmosphere Study, which comprises over 1,900 scientists in 75 countries (http://solas-int.org).

SOLAS science is focused on the biogeochemical interactions and feedbacks between the surface ocean and lower atmosphere. This covers a wide range of topics - from oceanic emissions of nitrous oxide to the global uptake of CO₂ and ocean acidification. SOLAS is aimed at understanding the complex interactions between ocean and atmosphere that will influence how climate evolves.

Dr. Eric Saltzman was recently elected chair of the SOLAS international Scientific Steering Committee. The committee works to identify high priority science questions, facilitate research by connecting experts around the world, and train the next generation of SOLAS scientists.

One of the challenges SOLAS has taken on is understanding air/sea gas exchange. The air/sea interface is physically and chemically complex, and it is notoriously difficult to sample. The Saltzman/Aydin Research Group at UC Irvine has developed new methods of directly measuring gas fluxes at sea using chemical ionization mass spectrometers deployed aboard research vessels. Other major SOLAS science questions include the oceanic uptake of carbon dioxide and the production of greenhouse gases in Eastern boundary oxygen minimum zones.

SOLAS organizes the International SOLAS Summer School, held biannually in Corsica, France. The SOLAS Summer School has trained more than 350 graduate students and postdoctoral scholars from both developed and developing nations. UC Irvine alumni of the SOLAS Summer School include Christa Marandino, Mike Lawler, Shanlin Wang, and Tom Bell. Dr. Saltzman has lectured at all 10 of the Summer Schools on a variety of topics. SOLAS also holds biannual Open Science Conferences. This year’s conference is in Washington State in May, 2012 (www.solas-int.org/OSCregistration).

The SOLAS community welcomes new members from all scientific disciplines. “Delivering a hundred year climate prediction means understanding how oceanic and atmospheric systems will evolve in response to changing climate and anthropogenic activities. At the end of the day, it will be research scientists who will answer the big questions in Earth system science. SOLAS can help them design research strategies and observational capabilities, and to build the good old-fashioned human interactions that move our science forward.”

For more information about Saltzman/Aydin Research Group visit http://ess.uci.edu/~esaltzman

The International Surface Ocean-Lower Atmosphere Study (SOLAS) Project works to achieve quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and atmosphere, and of how this coupled system affects and is affected by climate and environmental change.

Julie Ferguson (postdoctoral scholar) conducts research in the Keck Carbon Cycle Accelerator Mass Spectrometer (AMS) lab. Julie is working on reconstructing seasonal-resolution climate information using the chemical and isotopic composition of mollusk shells collected by humans over the last 10,000 years and found in archaeological sites in California. We have surprisingly little knowledge about seasonal aspects of climate in the past but such information is important if we are to understand long-term climate variability and test existing climate models. In addition to working in the Keck AMS lab Julie teaches one of the largest Earth System Science Undergraduate Course (EarthSS 5: The Atmosphere). When Julie manages to escape the lab, she loves exploring and camping in the mountains and National parks of California. You can also find Julie singing in the UC Irvine university choir.

Global Position of Scientists

Originally from England, Julie has explored many beautiful Southern California locations (see photo). As a postgraduate, her fieldwork was carried out on Gibraltar where there are fantastic cave sites where Neanderthals and early humans have lived for the past 120,000 years.
Did you know…

According to a recent survey published in the Wall Street Journal, the unemployment rate of Environmental Science majors is only 5%. Based on the 2010 Census data, the journal reported an average of $52,000/year for Environmental Science professionals. It’s a great time to be a student in Earth System Science.

Best College Majors for a Career - WSJ.com

Global Position of Scientists

Murat’s research takes him to a variety of amazing locations. One of his most memorable trips was to the South Pole.

Engaging Future Leaders

By now, you’ve heard about the degree options available in Earth System Science at UC Irvine (including B.A., B.S., and Ph.D), but do you know what kinds of courses ESS students take?

In the 2011-2012 year, Undergraduates can enroll in a variety of courses, including Geology, Fundamental Processes in Earth & Environmental Studies, Global Climate Change, Data Analysis, Catastrophes, Ocean Biogeochemistry, Paleoclimate, GIS for Environmental Scientists, Atmospheric Chemistry, Global Environmental Issues, Environmental Controversies, Marine Geochemistry, ESS Field Methods, and much more!

Graduate Students in the Earth System Science Department will enroll in newly updated courses, including Geoscience Modeling, Atmospheric Chemistry and Physics, Ocean Processes, Land Surface Processes, Geophysical Fluid Dynamics, Climate Change, and Global Biogeochemistry.

With courses like these, it’s not surprising that enrollment in Earth System Sciences continues to increase!

What on Earth?

This is the view looking down on the rain forest canopy from the top of the kilometer 83 eddy flux tower, which was constructed by the Goulden Research Group (http://ess.uci.edu/~goulden) This tower was part of the Large-Scale Biosphere Atmosphere (LBA) Experiment in Amazonia, near Santarem, Para, Brazil in the Tapajos National Forest.

Special thanks to Greg Winston for submitting our first “What on Earth?” photo (Volume 1, Issue 1).
What on Earth?

Faculty, Researchers and Graduate Students in the Department of Earth System Science at UC Irvine often find themselves in unique locations, undertaking extraordinary feats. In our first issue, we showed you a picture from Greg Winston (Specialist, Goulden Research Group). Do you have any idea what this picture captures?  
**Hint:** This picture was submitted by Dr. Kathleen Johnson (Faculty, http://ess.uci.edu/~kathleej).