



The VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS)

Education and Outreach Program

The VOCALS Science Working Group

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Preamble

This document provides an overview of a range of education and outreach opportunities of relevance to the VAMOS[¶] Ocean-Cloud-Atmosphere-Land Study (VOCALS). It is intended to serve both as a guide for PI proposers wishing to connect into possible educational and outreach activities to address the broader impacts in their proposals, and also as a single reference point for the various sponsoring agencies that wish to learn more about the types of activities that are being pursued within the VOCALS Program. As VOCALS develops, this document will be updated and will eventually serve as a document that summarizes the educational and outreach achievements of the program. Some of the activities will be carried out as a collective effort that will develop as VOCALS develops. This document provides links and contacts for the various educational and outreach programs wherever possible.

[¶] VAMOS – Variability of the American MONsoon Systems, a CLIVAR program to study the American monsoons in the context of the global climate. Additional information at <http://www.clivar.org/science/vamos.htm>

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1. Scientific Background

Earth's climate is a fascinating and complex system of interconnected components involving the oceans, the atmosphere, and the land. Our ability to understand and predict natural and human-induced changes to this system depends upon understanding the processes occurring in each of these components *and* the interactions between them. Scientists understand that these interactions are the keys to the *feedback riddle*. In the climate system, feedbacks act to amplify or diminish the system's response to imposed changes, such as increases in greenhouse gases, sudden bursts of volcanic activity, or changes in the distribution of atmospheric aerosol particles.

Climate system science draws heavily upon a set of disciplines (e.g. atmospheric science, oceanography, hydrology) each of which primarily focuses upon one component of the Earth system. In their growing processes, each of these disciplines has devised ever more ambitious observational datasets and field experiments to critically evaluate theories and hypotheses, test models, and ultimately improve understanding. However, our increased realization that the couplings between components are as important as the components themselves has motivated a more holistic approach to our research strategies and programs. This holistic approach is a natural extension of the traditional, disciplinary, reductionist approach, and provides a complementary viewpoint to provide further avenues for insight into the behavior of Earth's climate system.

The Southeast Pacific coupled climate system

One of the most important and least well understood feedback systems in Earth's climate involves the interactions between low clouds and the upper ocean over the cold regions of the eastern subtropical oceans. The largest and most globally important of these subtropical eastern ocean climate systems is in the Southeast Pacific (SEP) Ocean. Here, winds along the ocean's surface are deflected equatorward by the Andes mountain chain and flow along the coast. In doing so, the winds lead to strong upwelling of cold, nutrient-rich deep water. As a result, sea-surface temperatures (SSTs) are colder along the Chilean and Peruvian coasts than at any comparable latitude elsewhere. The cold SSTs, in combination with warm and dry air aloft, support the largest and most persistent sheet of low clouds in the subtropics (its extent often exceeds that of the United States). The presence of this shallow (<1.5 km in altitude) cloud deck, by reflecting vast amounts of the sun's energy back to space, has a profound impact upon Earth's energy budget. Even small changes to the coverage of clouds could have dramatic implications for Earth's climate.

Collectively, the subtropical low cloud sheets are sometimes termed *Earth's radiator system* for their ability to effectively radiate away excess energy from the tropical and subtropical regions of Earth. Although it is unclear why, it appears that these climatic radiators are able to prevent a runaway greenhouse effect such as the one that has shrouded Venus in an insulating atmosphere and driven its surface temperatures up to 460 degrees Celsius. Within the SEP system itself, low level clouds cool the ocean surface temperature by reducing the amount of solar energy reaching the surface and by driving stronger winds which increases the evaporation rate of surface water. Thus, the clouds act as a positive feedback on the system which helps to maintain the cold ocean temperatures. The stronger winds also drive stronger upwelling of cold subsurface water, which constitutes an additional feedback mechanism. Our lack of understanding of the interplay between the atmospheric, oceanic and land-surface processes

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means that our state-of-the-art computer models used for climate prediction exhibit large errors in subtropical eastern ocean regions and particularly in the SEP region.

Our interest in a more complete understanding of these feedback mechanisms has motivated the development of the VAMOS (Variability of the American Monsoon Systems) Ocean-Cloud-Atmosphere-Land Study (VOCALS). This is a multi-disciplinary international program aimed to develop and promote scientific activities leading to improved understanding of the Southeast Pacific coupled climate system. The scientific direction and planning for VOCALS is carried out by the VOCALS Science Working Group¹ (SWG) which is chaired by C. Roberto Mechoso at UCLA. VOCALS involves teams of researchers from over 40 institutions in nine countries². The principal aim of VOCALS is to promote both holistic and reductionist perspectives of the climate system by coordinating disciplinary observational and numerical modeling strategies within a multi-disciplinary framework.

At the heart of the VOCALS³ Program is the VOCALS Regional Experiment (VOCALS-REx), an intensive observational field experiment in which several aircraft and research ships will take part in a coordinated observational strategy to answer key scientific questions related to the climate system of the SEP region. In addition, an extensive modeling program (VOCALS-Mod) will aim to improve understanding and numerical model simulations of seasonal-to-interannual timescale variability in the SEP climate system, and to better understand the physical processes central to this system and the interactions between them. The multi-year effort is funded by the National Science Foundation (NSF), The National Oceanic and Atmospheric Administration (NOAA), with major additional contributions from other US and international agencies.

2. Introduction to Education and Outreach opportunities

The multidisciplinary nature of VOCALS, and the combination of both field and modeling aspects, offers considerable opportunities for building a vibrant educational and outreach program involving students, educators, and the general public in the United States and internationally. This document represents an attempt to summarize our vision for the VOCALS Education and Outreach Program. Necessarily this will be a dynamic document which will evolve as the various components of the scientific research program themselves evolve.

It is important that, as a coordinated program, VOCALS addresses the broader impacts of the scientific research. A recent NSF report⁴ states that “...while most proposers have little difficulty responding to the criterion relating to intellectual merit, many proposers have difficulty understanding how to frame the broader impacts of the activities they propose to undertake.” We aim to build a small, dynamic team who will be responsible for coordinating the education and outreach opportunities within VOCALS. This team will design and build a central framework which will provide key themes and focus areas into which individual research teams and educators can tie their own education and outreach activities. This coordinated approach aims to provide a more efficient use of scientists’ resources and will provide a means for suitably framing the broader impacts of the scientific research.

¹ See Appendix 1 for list of VOCALS SWG members.

² See Appendix 2 for current list of participating institutions.

³ More information about VOCALS, including planning documentation for the various components of the program can be found at <http://www.eol.ucar.edu/projects/vocals/>

⁴ See www.nsf.gov/pubs/gpg/broaderimpacts.pdf

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We break down the program into an **educational component** and an **outreach component**. Together, these map onto the goals of the NSF Geosciences Educational Program⁵, which are to:

- improve the quality of geoscience education at all educational levels;
- increase the number and competency of Earth and Space Science teachers at K-12 levels;
- demonstrate the relevance of the geosciences by identifying and promoting traditional and non-traditional career opportunities in the field;
- increase the number of students enrolling in geoscience courses and degree programs at all educational levels;
- increase the number of students drawn from groups underrepresented in science, technology, engineering and mathematics (STEM) fields in geoscience courses and degree programs; and
- increase the public's understanding of geoscience-related issues.

The first five of the six key goals we broadly define as **educational**, with the final goal we consider to be **outreach**. Outreach component seeks to illuminate a broader section of the general public by providing opportunities to explore aspects of VOCALS, both directly and indirectly, using a wide range of media including the internet, the press, and broadcast media. There are of course many ways to facilitate exchange between these two areas.

3. Educational opportunities

We break down VOCALS educational activities into four categories. These are Opportunities for graduate students; undergraduate students; K-12 students; teachers. Each is addressed in turn.

a. Opportunities for graduate students

Graduate students are the lifeblood of most research-focused university departments and will form the next generation of research scientists and university educators. They are directly engaged in the research and to a large degree the success of programs like VOCALS can be directly attributable to the endeavors of graduate students. Many of the VOCALS PI proposals submitted to the various participating agencies/divisions⁶ will request support for graduate students. In addition to direct engagement in PI-led research projects, there will be a number of opportunities for graduate students to participate in the field program VOCALS-REx. These include instrument operator and data management roles on several platforms as detailed in Table 1. VOCALS presents an excellent opportunity for graduate students and other early career scientists to witness and participate in the unique activities that constitute a major field program in the geosciences. This early exposure to field programs is cited by many scientists as being a pivotal moment in their careers.

b. Opportunities for undergraduate students

It is important that undergraduate students from all backgrounds in the geosciences and physical sciences are given opportunities that can help to bridge the gap between the undergraduate and graduate levels in education. NSF has invested considerably in programs such

⁵ See the Geosciences Education webpage at www.nsf.gov/geo/adgeo/education.jsp

⁶ See Appendix 3 for details of the participating agencies/divisions

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as Research Experience for Undergraduates⁷ (REU) and the Significant Opportunities in Atmospheric Research and Science (SOARS). We will seek support from the REU in the form of supplemental requests to a number of the VOCALS individual PI proposals submitted to NSF divisions. We anticipate that several of these will involve participation in VOCALS-REx field program. In order to maximize the benefits for the undergraduates involved in REx, we plan to involve graduate students as “*field mentors*” to the undergraduates in the field. This combination of undergraduate and graduate student participation in the field was extremely successful during the recent RICO field campaign⁸.

Table 1: Opportunities for graduate student participation in the VOCALS-REx field program

Platform	Expected number	Roles
NOAA Ronald H Brown	4	Radiosonde launch and analysis; Photography; Radar quality control Labs?
NSF C-130 Aircraft	4	Dropsonde operators (2) CCN operator [ASK PARTICIPANTS for NUMBERS]
Aircraft Operations Center	2	Weather forecast/analysis support
Chilean Land Site		
NOAA R/V New Horizon		
CIRPAS Twin Otter Aircraft		
DoE ASP G-1 Aircraft		

c. Opportunities for teachers

Research Experience for Teachers

We plan to use the NSF supported Research Experience for Teachers⁹ (RET) program, which allows supplemental requests to be made on an NSF grant, to support participation of K-12 educators in VOCALS-REx. We anticipate supporting an educator to work in the field operations center and on the airborne platforms, and to help provide reports for outreach activities (see below). Typically these requests are limited to a budget of less than \$10,000 which includes a stipend, travel, and support for materials in the field. Additionally, we will apply for support from NOAA’s Teacher at Sea Program¹⁰ to permit one or two teachers to participate in VOCALS-REx on the NOAA R/V Ronald H Brown (RHB). Key VOCALS personnel on the RHB have considerable experience with the Teacher at Sea program during their recent cruises. Requests are submitted annually in October for cruises occurring during the following year.

⁷ Information on the Research Experience for Undergraduates Program can be found at www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517&from=fund

⁸ A manuscript (Rauber et al.), submitted to the Bulletin of the American Meteorological Society, reports on educational activities for graduates and undergraduates in the 2005 RICO field program.

⁹ See www.nsf.gov/pubs/2005/nsf05047/nsf05047.jsp

¹⁰ Information on NOAA’s Teacher at Sea Program is available at <http://teacheratsea.noaa.gov/>

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NOAA Adopt a Drifter Program

The National Oceanic and Atmospheric Administration (NOAA) Office of Climate Observation (OCO) established the Adopt a Drifter Program (ADP) in December 2004 for K-16 teachers from the United States along with international educators. This program provides teachers with an educational opportunity to infuse ocean observing system data into their curriculum. A drifting buoy (drifter) is a floating ocean buoy equipped with meteorological and/or oceanographic sensing instruments linked to transmitting equipment where the observed data are sent to collecting centers. A global array of 1250 drifting buoys is scheduled to be completed during 2005. Ongoing deployment of drifting buoys will be essential to maintain the array at its complete level.

The ADP invites schools from the United States to partner with international schools where they collaborate to mutually adopt a drifter to be deployed from a ship at sea. A teacher from each school may be on board the ship during deployment, although this is not a prerequisite for participation in the Program. An educational sticker or drawing from each school is adhered to the drifter before deployment and photos taken to document the activity. The teachers receive the WMO number of their drifting buoy in order to access data online from the school's adopted drifter. Participating teachers develop lesson plans to encourage their students to apply the drifting buoy data. Students in the teachers' classes receive a drifter tracking chart to plot the coordinates of the drifter as it moves freely in the surface ocean currents. Teachers and students can more easily make connections between the data accessed on line and other maps showing currents, winds, etc.

More information can be found on the ADP website at www.adp.noaa.gov and from Diane Stanitski (diane.stanitski@noaa.gov).

The GLOBE Program

GLOBE (Global Learning and Observations to Benefit the Environment) is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE's vision promotes and supports students, teachers and scientists to collaborate on inquiry-based investigations of the environment and the Earth system working in close partnership with NASA and NSF Earth System Science Projects (ESSPs) in study and research about the dynamics of Earth's environment.

GLOBE brings together students, teachers and scientists through the GLOBE Schools Network in support of student learning and research. Parents and other community members often work with teachers to help students obtain data on days when schools are not open. Further information on the GLOBE program can be found on the web at <http://www.globe.gov>.

3. Outreach opportunities

A number of outreach activities are planned for VOCALS. These include:

a. Windows to the Universe (W2U)

The *Windows to the Universe* project is an education and outreach program initiated in 1995, initially with funding from NASA, with subsequent additional sponsorship from NSF and other

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institutions. The project includes an extensive website (www.windows.ucar.edu) composed of over 7000 interlinked web pages spanning the Earth and space sciences, with interdisciplinary connections to arts, humanities, and other fundamental sciences. Content is available at 3 levels in both English and Spanish, and the project includes a professional development program for K-12 educators. The site received ~16 million visitors in 2006, corresponding to ~133 million page views per year, and continues to grow.

VOCALS will collaborate with W2U, under the coordination of Roberta Johnson at the National Center for Atmospheric Research (NCAR), to provide resources to support scientists working on the campaign to submit *Postcards from the Field*¹¹, so that their work can be shared with learners around the world through the Windows to the Universe website. We have also discussed the potential development of a VOCALS public portal on W2U, including supporting content describing the science of the campaign to the public.

Initial discussions with Roberta Johnson have generated two possible scenarios for VOCALS-W2U collaboration:

- 1) W2U staff trains 10 VOCALS scientists to submit postcards from the field during VOCALS-REx, with the assumption that they can be trained while on a visit to UCAR or on conference calls. W2U staff edits cards as they are submitted, translates them into Spanish also, and posts them on the site. If the collaborating scientists post ~15 postcards per month each, the budget would come to approximately \$14,000.
- 2) W2U staff develops approximately 40 web pages to support the VOCALS Program and science behind it (as well as brief informal biographies of the contributing scientists), linking also to content already available on the website. The content is also translated into Spanish. In addition, 10 scientists are trained to submit Postcards from the Field by our staff while on a visit to the field site at the beginning of the field campaign. The budget for this would be approximately \$65,000. This was used during the recent MILAGRO Campaign.¹²

b. COSEE

4. Training opportunities

VOCALS involves collaboration between international institutes in North America, South America, and Europe. One goal of VOCALS, and of its parent sponsoring programs (CLIVAR, WCRP), is to encourage the development of scientific research programs in South America. Previously, these activities have been supported by the US National Science Foundation International Programs, and we hope that this can continue in VOCALS. A great impact can be made through the provision of funds to support travel and exchange visits between US and South American research institutes. These visits will permit all scientists in VOCALS to become fully engaged in the scientific research, and will allow knowledge transfer so that the observational

¹¹ See www.windows.ucar.edu/tour/link=/people/postcards/postcards_menu.html

¹² See www.windows.ucar.edu/tour/link=/milagro/milagro_intro.html

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techniques developed in VOCALS can be continued in the future. VOCALS is aiming to partner with the Inter-American Institute for Global Change Research (IAI) an intergovernmental organization supported by 19 countries in the Americas dedicated to pursuing the principles of scientific excellence, international cooperation, and the open exchange of scientific information to increase the understanding of global change phenomena and their socio-economic implications. Further information is available at www.iai.int

Appendix 1: VOCALS Science Working Group, April 2007

Roberto Mechoso	UCLA, Los Angeles, USA (chair)
Chris Bretherton	University of Washington, Seattle, USA
Chris Fairall	NOAA/ESRL, Boulder, USA
Barry Huebert	University of Hawai`i at Manoa, USA
Jim McWilliams	UCLA, Los Angeles, USA
Oscar Pizarro	Universidad de Concepción, Chile
José Rutllant	Universidad de Chile, Santiago, Chile
Bob Weller	Woods Hole Oceanographic Institution, Woods Hole, USA
Hemantha Wijesekera	Oregon State University, USA
Robert Wood	University of Washington, Seattle, USA
Shang-Ping Xie	IPRC, Univof Hawai`i, USA
Carlos Ereño	International CLIVAR
José Meitín (ex officio)	NCAR EOL/VAMOS Office

Appendix 2: Research institutions participating in VOCALS

Appendix 3: Agencies/divisions participating in VOCALS