



## VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS) CLIVAR Process Study Brief

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**Duration:** 2003 – 2010, with intensive field phase in October 2007  
**CLIVAR Panel:** Pan American (U. S.); VAMOS (Intl. CLIVAR)

### 1. Objectives and Relevance

The overall goal of VOCALS is to develop and promote scientific activities leading to improved understanding, model simulations, and predictions of the southeastern Pacific (SEP) coupled ocean-atmosphere-land system, on diurnal to interannual timescales. Our two leading concerns are (1) the physical processes affecting the radiative and microphysical characteristics of the persistent stratocumulus clouds of this region, and (2) the ocean budgets of heat and other constituents, and how they determine the sea-surface temperature (SST) throughout this region.

### 2. Plans

VOCALS integrates (a) an extensive SEP-focussed atmospheric and oceanic modeling and model improvement program, including its feedbacks on ENSO and the mean climate of the Pacific and the Americas, (b) synthesis and analysis of existing SEP observations and select extended-term observational enhancements, and (c) an intensive 'Radiator Fin' (RF) field program in October 2007 coupling atmospheric and oceanic measurements of critical small-scale physical processes in the SEP.

Atmospheric and coupled modeling and parameterization development have been ongoing since informal VOCALS planning begun in 2001, and will continue through 2010. They will attract more participants and be better able to use SEP observational data if VOCALS gets explicit CLIVAR endorsement and agency support. SEP buoy-maintenance cruises are also ongoing under NOAA funding, with extensive atmospheric remote sensing and aerosol measurements added as a VOCALS pilot project. These should also continue through 2010. U. S. VOCALS-related modeling and extended-time data analysis/gathering are currently funded in a piecemeal fashion by NSF and NOAA. They perhaps amount to on the order of \$1M/yr each, but each need to grow by at least 50% to make efficient progress and optimal use of the data being gathered and analyzed. Major new funding (an additional \$5M+ in PI support and equipment costs) will be required to conduct the RF field program in 2007 and analyze the data in 2007-2010, with costs depending on its ultimate scope and especially the extent of its oceanographic component). In addition, several major U. S. facilities (the *Ron Brown* and another ship, the NCAR C-130, and the ARM Mobile Facility) will be requested. NOAA and NSF (through U. S. CLIVAR) would be the core funding agencies, though we believe that the clouds, aerosol and radiation aspects of the RF study will also prove quite attractive to the DOE ARM program and NASA investigators. Coastal oceanographic measurements coordinated with the RF study are being planned by Chilean, Ecuadorean, and Peruvian scientists, to be funded mainly by those countries.

### **3. Observational Elements**

A major VOCALS goal is integration, enhancement, and effective analysis of existing extended-term observations in the SE Pacific with the goal of usefully comparing them with model predictions. Key existing measurements come from 12 TAO buoys from 95-125 W and 0-8 S, the WHOI stratus IMET buoy at 20S 85W, San Felix Island at 27S 81W and the Galapagos islands, coastal stations, buoy maintenance cruises, and a wealth of new satellite products relevant to SEP boundary layer clouds, aerosol distributions, and upper ocean processes. In additions to the current NOAA/ETL atmospheric measurement enhancements to the WHOI buoy maintenance cruises, we propose addition of radiation sensors on the TAO buoys and high-resolution XBT sections on maintenance cruises. In addition, more funding is needed for the challenging task of analyzing, interpreting and integrating this data and making comparisons with regional and global model output.

The one-month RF field study will focus on the region from 0- 1500 km offshore of the Peru-Chile border during the season of lowest SST and most persistent boundary layer cloudiness. It aims to document relationships between SEP aerosol, cloud structure, and cloud radiative properties across the diurnal cycle, and mapping ocean eddy and current structures to better understand lateral eddy transports and heat/salinity budgets between the coastal upwelling region and the WHOI stratus buoy at 20S 85W.

### **4. Modeling Elements**

A loosely-organized VOCALS modeling component has already begun, inspired by EPIC observations and long-standing biases in clouds and coupled-model SST distributions in this region. Participants include IPRC and U. Chile regional models, and UCLA and NCAR coupled GCMs. Modeling goals include (a) comprehensive observational comparisons of modelled SEP clouds, SST, and surface heat budget with SEP observations, (b) improvement of forecasts on daily, seasonal-interannual, and climate timescales by improvement of parameterizations important for cloud-topped boundary layers, including modeling of the aerosol indirect effect on climate, and ocean mixing/upwelling processes, and (c) sensitivity studies of ENSO, seasonal cycles and mean biases to cool-ocean physical processes and the coupling to the neighboring South American continent. UCLA, Oregon State University, and S. American partners plan (d) regional ocean modeling of the SEP upwelling region to understand the small-scale dynamics, SST variability, and heat/salt/nutrient transport processes, given additional funding.

### **5. Feasibility/Readiness**

VOCALS has had five years of international information-exchange and planning meetings at the annual VAMOS planning meetings (VPMs). Results from the EPIC stratocumulus cruise, other field studies such as DYCOMS-II in the Northeast Pacific, and advances in regional modeling of stratocumulus, have informed and refined the atmospheric component of VOCALS. In the last two years, the VPMs led to the plan for the RF field study and links to regional ocean modeling, solidified by a final planning meeting in Corvallis in November 2004, out of which the current VOCALS Science and Implementation Plans have emerged.

All the major observational platforms (C-130, *Brown*, ARM Mobile Facility) have been informed of the possible timing of the RF study and are still uncommitted at that time. The NASA CloudSat/Calypso mission will soon be launched, providing another important new data source that the RF experiment and the planning leading up to it is timed to exploit. Thus we believe we are scientifically ready for VOCALS and that the RF is feasible and well-timed. Furthermore, our scientific goals are very timely given the current strong community interest in improving simulation of clouds and cloud-aerosol interactions, and reducing cool-ocean SST biases in large-scale models.

## **6. National and International Links and Partners**

VOCALS is already well integrated into the International CLIVAR VAMOS program and participates in its annual meetings. Drs. Garreaud and Rutland of Chile and Cornejo of Ecuador have been important South American scientific partners in defining VOCALS plans. VOCALS is tightly linked to the regional/global observational and modeling community. Drs. Weller, Fairall, and Cronin are involved in flux buoy and shipboard atmospheric sensing observations worldwide and are actively involved in U. S. and international CLIVAR. As previously mentioned, VOCALS includes several leading modeling groups – IPRC (Xie), UCLA/OSU (Mechoso/Stevens/McWilliams/Samelson), U. Washington/NCAR (Bretherton), and U. Chile (Garreaud). Key VOCALS scientists play leading roles in other related national and international programs. For instance, Dr. Bretherton is head of the GCSS boundary layer cloud working group (which is currently doing model intercomparisons of cloud-drizzle-aerosol interaction), lead PI on the Climate Process Team (CPT) on low-latitude cloud feedbacks on climate sensitivity (which is aiming to better understand and improve simulation of clouds in three leading U.S. GCMs), and on the NCAR CCSM scientific steering committee. We are also planning to work with the NOAA Climate Testbed and DOE CAPT projects on parameterization testing improvement using short-range forecasts with climate-oriented models, and to deploy the ARM Mobile Facility to make cloud and radiation measurements for Sept.-Nov. 2007 on San Felix Island. Dr. Rob Wood has close liaisons to the NASA CloudSat program. Dr. Barry Huebert is actively involved in SOLAS, which is interested in aerosol production processes. We think these linkages provide an impressive basis for VOCALS to fruitfully engage the broader scientific community.