REQUEST FOR EOL FACILITY SUPPORT
(C-130 WITH WCR, AND GAUS)
VOCALS REGIONAL EXPERIMENT (VOCALS-REX)
NCAR/EOL -NOVEMBER 2007 OFAP MEETING

Submitted on July 1st 2007

PART I: GENERAL INFORMATION

A. Corresponding Principal Investigator(s)

Name	**Robert Wood**
Institution	University of Washington
Address	Dept of Atmospheric Sciences, Box 351640 Seattle, WA 98195
Phone	206-543-1203
Email	robwood@atmos.washington.edu
Co-Investigator(s) and Affiliation(s)	Christopher Bretherton (U. Washington), Barry Huebert (U. Hawaii), C. Roberto Mechoso (UCLA), Robert Weller (Woods Hole Ocean. Institution)

B. Project Description

Project Title	**VOCALS Regional Experiment (REx)**
Location of Project	Northern Chile, Southeast Pacific
Start and End Dates of Field Phase	Oct 1-Nov 15 2008
NSF Facilities requested	C-130 including WCR, GAUS for Chilean land site and R/V José Olaya
Funding Agency and Program Officer	Coordinated by NSF, Walter Robinson
Proposal(s) affiliated with this request	Coordinating C-130 proposal by Wood and Bretherton (U. Washington), ~6-8 C-130 related proposals Approx. 30 PI proposals for entire VOCALS project, including modeling to be submitted July 15th 2007
Proposal Status	In preparation, to be submitted July 15th
Do you expect other, non-NSF support? If yes, from whom?	• NOAA Climate Prediction Program for the Americas (CPPA) • NOAA Atmospheric Composition and Climate Program (ACCP) • DoE Atmospheric Science Program • US Office of Naval Research (ONR) • International agencies (UK, Chile, Peru, Finland, Canada, Sweden)
Is this a resubmission of a previous request?	No
Is this a multi-year request or a request for continuation?	No

C. Abstract of Proposed Project

The **V**AMOS **O**cean-**C**loud-**A**tmosphere-**L**and **S**tudy - **R**egional **Ex**periment (VOCALS-REx) is an international field experiment designed to better understand physical and chemical processes central to the climate system of the Southeast Pacific (SEP) region. The climate of the SEP region is a tightly coupled system involving poorly understood interactions between the ocean, the atmosphere, and the land. VOCALS-REx will focus on interactions between clouds, aerosols, marine boundary layer (MBL) processes, upper ocean dynamics and thermodynamics, coastal currents and upwelling, large-scale subsidence, and regional diurnal circulations, to the west of the Andes mountain range. The field experiment is ultimately driven by a need for improved model simulations of the coupled climate system in both the SEP and over the wider tropics and subtropics.

VOCALS-REx will provide detailed and targeted observations of those processes that impact the SEP climate system and are amenable to study with a relatively short field program. The intensive field observations are a vital component of the broader VOCALS[¶] program and have been carefully designed to complement a suite of enhanced long-term observations. The long-term observations provide important context for the intensive observations. In addition, a major thrust of the VOCALS program is to provide coordination for modeling activities, which will benefit from the intensive observations in a poorly observed region where coupled ocean-atmosphere models exhibit strong biases in sea surface temperature. The coordination through VOCALS of observational and modeling efforts will lead to an improved pull-through for climate and regional forecasting agencies.

Multi-disciplinary intensive observational datasets will be obtained during VOCALS-REx from several platforms including aircraft, a research vessel, and a surface land site. These datasets will be used to test a coordinated set of hypotheses that are organized into two broad themes: (1) improved understanding of aerosol-cloud-drizzle interactions in the marine boundary layer (MBL) and the physicochemical and spatiotemporal properties of aerosols; (2) improved understanding of the chemical and physical couplings between the upper ocean, the land, and the atmosphere. The intensive observational period will be six weeks long and will take place during October-November 2008, chosen because it is the month during which the coverage of stratocumulus over the SEP is at its greatest, the southeast trade winds are at their strongest, and the coupling between the upper ocean and the lower atmosphere is at its tightest.

[¶] The Scientific Program Overview (SPO) for VOCALS, and other documentation about the program, can be found on the web at *www.eol.ucar.edu/projects/vocals/*

D. Experiment Design

Scientific Objectives

VOCALS-REx will collect datasets required to address a set of issues that are organized into two broad themes: (1) **aerosol-cloud-precipitation** interactions in the marine boundary layer (MBL) including the physicochemical and spatiotemporal properties of aerosols; (2) **coupled ocean-atmosphere-land** processes involving chemical and physical interactions between the upper ocean, the land, and the atmosphere.

A key VOCALS-REx goal is to use the observational datasets to critically evaluate the ability of a range of numerical models, from process models to GCMs, to simulate important aspects of the SEP climate system. VOCALS-REx will also provide important in-situ datasets to test current and future satellite cloud microphysical retrieval algorithms that are essential to understanding the indirect effects of aerosols upon clouds.

Hypotheses to be tested

Two sets of hypotheses, following the aerosol-cloud-precipitation and coupled ocean-atmosphere-land themes, will be tested using data from VOCALS-REx. These themes are directly linked to the themes of the VOCALS Modeling Program[§]. This strategy has been carefully designed so that the modeling makes best use of the REx data, and so that the models are used, from the outset, as an integral component of the field analysis at all stages from process studies through parameterization and model development. The specific hypotheses, broken down by theme are described below.

a. Aerosol-cloud-precipitation theme

The overarching goal for work in the first theme is a better understanding of processes that influence cloud optical properties (cloud cover, thickness, and particle size) over the SEP. We focus these goals using the following testable hypotheses:

[H1a] Variability in the physicochemical properties of aerosols has a measurable impact upon the formation of drizzle in stratocumulus clouds over the SEP.

[H1b] Precipitation is a necessary condition for the formation and maintenance of pockets of open cells (POCs) within stratocumulus clouds.

[H1c] The small effective radii measured from space over the SEP are primarily controlled by anthropogenic, rather than natural, aerosol production, and entrainment of polluted air from the lower free-troposphere is an important source of cloud condensation nuclei (CCN).

[H1d] Depletion of aerosols by coalescence scavenging is necessary for the maintenance of POCs.

A comprehensive suite of in-situ and remotely sensed cloud and boundary layer measurements will be made using the aircraft platforms and the ships (see hypothesis-testing strategies below) to address issues in this theme. It is becoming recognized that precipitation falling from stratocumulus clouds can have a profound impact upon the cloud structural, dynamical, and radiative properties (Stevens et al. 2005). Aircraft missions will focus upon understanding the processes that control precipitation, including the role of atmospheric aerosols, their transport from the land to the ocean, their formation, and their depletion by the clouds themselves. A key goal is to better link aerosol microphysical variability with the variability in the radiative properties of the clouds by performing closure studies that not only link cloud

---

[§] see http*://www.eol.ucar.edu/projects/vocals/documentation/VOCALS_Modeling_0906.pdf* microphysics with aerosol microphysics, but also link the cloud optical properties (measured with aircraft and satellite remote sensing) to the underlying aerosol variability.

b. Coupled ocean-atmosphere-land theme

The goals of the second theme aim to elucidate the roles that oceanic upwelling, mesoscale eddies and other transient upper oceanic processes, and the land play in determining the physical and chemical characteristics of the upper ocean across the SEP.

> *[H2a] Oceanic mesoscale eddies play a major role in the transport of heat and fresh water from coastally upwelled water to regions further offshore.*
>
> *[H2b] Upwelling, by changing the physical and chemical properties of the upper ocean, has a systematic and noticeable effect on aerosol precursor gases and the aerosol size distribution in the MBL over the SEP.*
>
> *[H2c] The diurnal subsidence wave ("upsidence wave") originating in northern Chile/southern Peru has an impact upon the diurnal cycle of clouds and provides a useful framework for analysis of numerical model performance on diurnal time scales.*
>
> *[H2d] The entrainment of cool fresh intermediate water from below the surface layer during mixing associated with energetic near-inertial oscillations generated by transients in the magnitude of the trade winds is an important process to maintain heat and salt balance of the surface layer of the ocean in the SEP.*

To address the issues in this theme, a ship towing the SeaSoar platform will be used, in conjunction with the NOAA Ronald H Brown (**RHB**) to conduct surveys of the mesoscale eddy field both in the eddy genesis region close to the coast, and much further offshore. Detailed measurements of the microscale variability of the upper ocean will be used to explore the connections between the ocean mixed layer and the ocean beneath. Chilean and Peruvian coastal components are expected to provide key data on the nature of the upwelling and the initiation of the mesoscale eddies. Links between the variability in oceanic upwelling and the biogenic production of important aerosol precursor gases (e.g. DMS) will be explored using DMS flux measurements. In addition, the role of the land in modifying the diurnal cycle of low clouds (Garreaud and Muñoz 2004) will be explored.

Previous experiments of similar type

Past subtropical marine boundary layer cloud experiments:

- Dynamics and Chemistry of Marine Stratocumulus (DYCOMS-I) (1985)
- First International Regional Experiment (FIRE) (1987)
- Atlantic Stratocumulus Transition Experiment/Marine Aerosol Gas Exchange (ASTEX/MAGE) (1992)
- Dynamics and Chemistry of Marine Stratocumulus – Phase 2 (DYCOMS-II) (2001)
- East Pacific Investigation of Climate (EPIC) (2001)

Past aerosol-cloud interaction experiments in the subtropical eastern oceans:

- First Aerosol Characterization Experiment (ACE-1) (1995)
- Second Aerosol Characterization Experiment (ACE-2) (1997)

Past experiments detailing upwelling and mesoscale ocean eddy structure in the tropics:

- Tropical Ocean-Global Atmosphere - Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE) (1992)
- East Pacific Investigation of Climate (EPIC) (2001)

References of published results from previous experiments

Albrecht, B.A., C.S. Bretherton, D. Johnson, W.H. Schubert and A.S. Frisch, 1995: The Atlantic stratocumulus transition experiment - ASTEX. *Bull. Amer. Soc.*, **76**, 889-903.

Bates, T. S., B. J. Huebert, J. L. Gras, F. B. Griffiths, and P. A. Durkee, 1998: International Global Atmospheric Chemistry (IGAC) project's first aerosol characterization experiment (ACE 1): Overview. *Journal of Geophysical Research-Atmospheres*, **103,** 16297-16318.

Bates, T. S., P. K. Quinn, D. S. Covert, D. J. Coffman, J. E. Johnson, and A. Wiedensohler, 2000: Aerosol physical properties and processes in the lower marine boundary layer: a comparison of shipboard sub-micron data from ACE-1 and ACE-2. *Tellus B*, **52,** 258-272.

Blanco, J.L., A.C. Thomas, M.-E. Carr, and P.T. Strub, 2001: Seasonal climatology of hydrographic conditions in the upwelling region off northern Chile, *J. Geophys. Res., 106*, 11,451-11,467.

Blanco, J.L., M.-E. Carr, A.C. Thomas, and P.T. Strub, 2002: Hydrographic conditions off northern Chile during the 1996-1998 La Niña and El Niño events, *J. Geophys. Res., 107(C3)*, doi:10.1029/2001JC001002.

Brainerd K. E., and M. C. Gregg, 1997: Turbulence and stratification on the Tropical **Ocean** Global Atmosphere Coupled Ocean-Atmosphere Response Experiment microstructure pilot cruise. *J. Geophys. Res.*, **102**, 10437-10455.

Bretherton, C. S., T. Uttal, C. W. Fairall, S. Yuter, R. Weller, D. Baumgardner, K. Comstock, R. Wood, and G. Raga, 2004: The EPIC 2001 stratocumulus study. *Bull. Amer. Meteor. Soc.*, **85**, 967-977.

Chaigneau A., and O. Pizarro, 2005*a*, Mean surface circulation and mesoscale turbulent flow characteristics in the eastern South Pacific from satellite tracked drifters, *J. Geophys. Res., 110*, C05014, doi:10.1029/2004JC002628.

Chaigneau A., and O. Pizarro, 2005*b*: Eddy characteristics in the eastern South Pacific, *J. Geophys. Res., 110*, C06005, doi:10.10.1029/2004JC002815.

Chen, G., D.D. Davis, P. Kasibhatle, A.R. Bandy, D.C. Thornton, B.J. Huebert, A.D. Clarke, and B.W. Blomquist, A study of DMS oxidation in the tropics: Comparison of Christmas Island field observations of DMS, SO2, and DMSO with model simulations, *J. Atmos. Chem.*, *37* (2), 137-160, 2000.

Clarke, A. D., D. Davis, V. N. Kapustin, F. Eisele, G. Chen, I. Paluch, D. Lenschow, A. R. Bandy, D. Thornton, K. Moore, L. Mauldin, D. Tanner, M. Litchy, M. A. Carroll, J. Collins, G. Albercook, 1998: Particle nucleation in the tropical boundary layer and its coupling to marine sulfur sources. *Science*, **282**, 89-92.

Colbo, K., and R.A Weller, 2007a. The accuracy of the IMET sensor package. *J. Atmos. Ocean. Technol.*, in review.

Colbo, K. and R. A. Weller, 2007b: The variability and heat budget of the upper ocean under the Chile-Peru stratus. *J. Marine. Res.*, in press.

Comstock, K. K., Wood, R., Yuter, S. E., and Bretherton, C. S., 2004: Reflectivity and rain rate in and below drizzling stratocumulus. *Quart. J. Roy. Meteorol. Soc.,* **130**, 2891-2919, 2004.

Dandonneau, Y., et al., 2003. Oceanic Rossby waves acting as a “Hay Rake” for ecosystem floating by-products. *Science*, **302**, 1548-1551.

Frisch, A. S., C.W. Fairall and J.B. Snider. 1995: Measurement of Stratus Cloud and Drizzle Parameters in ASTEX with a K_α-Band Doppler Radar and a Microwave Radiometer. *J. Atmos. Sci.*: **52**, 2788–2799.

Gallardo L., G. Olivares, J. Langner, and B. Aarhus, 2002: Coastal lows and sulfur air pollution in Central Chile. *Atmos. Env.*, 36, 3829-3841.

Garreaud, R. D., J. Rutllant, J. Quintana, J. Carrasco and P. Minnis. 2001: CIMAR–5: A snapshot of the lower troposphere over the subtropical Southeast Pacific. *Bull. Am. Meteorol. Soc.*, **82**, 2193–2207.

Garreaud, R. D., and R. C. Muñoz, 2004: The diurnal cycle in circulation and cloudiness over the subtropical southeast Pacific: A modeling study. *J. Climate*, **17**. 1699-1710.

Hoell, J. M., Davis, D. D., Jacob, D. J., Rodgers, M. O., Newell, R. E., Fuelberg, H. E., McNeal, R. J, Raper, J. L., Bendura, R. J., 1999: Pacific Exploratory Mission in the tropical Pacific: PEM-Tropics A, August-September 1996. *J. Geophys. Res.* **104** *, No. D5 , p. 5567 (1998JD100074).*

Huebert, B. J., A. Pszenny, and B. Blomquist, 1996: The ASTEX/MAGE experiment. *J. Geophys. Res*, **101,** 4319-4329.
Johnson, D. W., S. Osborne, R. Wood, K. Suhre, R. Johnson, S. Businger, P. K. Quinn, A. Wiedensohler, P. A. Durkee, L. M. Russell, M. O. Andreae, C. O'Dowd, K. J. Noone, B. Bandy, J. Rudolph, and S. Rapsomanikis, 2000: An overview of the Lagrangian experiments undertaken during the North Atlantic regional Aerosol Characterisation Experiment (ACE-2). *Tellus B,* **52,** 290-320.
Kollias, P., Fairall, C. W., Zuidema, P., Tomlinson, J., and Wick G. A., 2004: Observations of marine stratocumulus in SE Pacific during the PACS 2003 cruise. *Geophys. Res. Lett.*, **31**, No22110.
Lenschow, D., I. Paluch, A. Bandy, R. Pearson, S. Kawa, C. Weaver, B. Huebert, J. Kay, D. Thornton, and A. Driedger, 1988: Dynamics and Chemistry of Marine Stratocumulus (DYCOMS) Experiment. *Bull. Amer. Meteor. Soc.*, **69**, 1058–1067.
Moore, K. G., A. D. Clarke, V. N. Kapustin, and S. G. Howell, 2003: Long-range transport of continental plumes over the Pacific Basin: Aerosol physiochemistry and optical properties during PEM-Tropics A and B. *J. Geophys. Res.,* **108**, 8236.
McGillicuddy D. J., A. R. Robinson, D. A. Siegel and coauthors, 1998: Influence of mesoscale eddies on new production in the Sargasso Sea. *Nature*, **394**, 263-266, 1998.
McGillicuddy, D. J. et al, 2007. Eddy/wind interactions stimulate extraordinary mid-ocean plankton blooms. *Science* **316**, 1021-1026.
Petters, M. D., J. R. Snider, B. Stevens, G. Vali, I. Faloona and L. Russell, 2005: Accumulation mode aerosol, pockets of open cells, and particle nucleation in the remote subtropical Pacific marine boundary layer. *J. Geophys. Res.,* **111**, D02206, doi:10.1029/2004JD005694.
Raes, F., T. Bates, F. McGovern, and M. Van Liedekerke, 2000: The 2nd Aerosol Characterization Experiment (ACE-2): general overview and main results. *Tellus B*, **52,** 111-125.
Stevens, B., and 31 coauthors, 2003: Dynamics and Chemistry of Marine Stratocumulus - DYCOMS-II. *Bull. Am. Meteorol. Soc.*, **84**, 579-593.
Stevens, B., G. Vali, K. Comstock, R. Wood, M. C. van Zanten, P. H. Austin, C. S. Bretherton, and D. H. Lenschow, 2004: Pockets of open cells (POCs) and drizzle in marine stratocumulus. *Bull. Amer. Meteor. Soc*., **86,** 51-57.
Strub, P.T., J.M. Mesias, and C. James, 1995: Altimeter observations of the Peru-Chile countercurrent, *Geophys. Res. Lett.,* **22**, 211-214.
Tomlinson, J. M., Li, R., and D. R. Collins, 2006: Physical and chemical properties of the aerosol within the southeastern Pacific marine boundary layer. *J. Geophys. Res.* in press.
Vali, G., R.D.Kelly, J.French, S.Haimov, D.Leon, R.E.McIntosh and A.Pazmany. 1998: Finescale structure and microphysics of coastal stratus, *J. Atmos. Sci.*, **55**, 3540–3564.
Wijesekera H. W. and M. C. Gregg, 1996: Surface layer response to weak winds, westerly bursts, and rain squalls in the western Pacific Warm Pool. *J. Geophys. Res*. **101**, 977-997.
Wijesekera H. W, D. L. Rudnick, C. A. Paulson and coauthors, 2005: Upper ocean heat and freshwater budgets in the eastern Pacific warm pool. *J. Geophys. Res.*, **110,** C08004.

How proposed project goes beyond what has been done before:

Cloud-Aerosol-Precipitation

Past field studies of subtropical marine stratocumulus clouds, e.g. DYCOMS-I, FIRE, ASTEX/MAGE, DYCOMS-II, have focused upon the mean state and turbulent properties of the marine boundary layer, and their relationship with the radiative and surface forcings. These studies have all demonstrated the importance of entrainment for understanding energy, water, and chemical budgets. Although some precipitation measurements were made during these experiments, an understanding of the role that precipitation plays in determining the structure and cloud optical properties within the remote MBL was not the primary driving motivation. As such, several key hypotheses concerning both the impacts that precipitation has upon the cloud coverage and thickness *and* the impacts that aerosols (especially those of an anthropogenic origin) have upon this system remain poorly tested. Earlier studies have shown that the contained nature of the marine stratocumulus system makes it an ideal location to perform process-based studies of the interactions between aerosols, chemistry, and clouds.

The recent EPIC field study in 2001 demonstrated that (a) the quantity of precipitation falling from marine stratocumulus clouds over the SE Pacific (SEP) is tightly connected to the mesoscale organization and coverage of the clouds; (b) both microphysical (cloud droplet concentration) and macrophysical properties (vertically-integrated liquid water content) impact the formation of drizzle. EPIC also demonstrated the power of multi-instrument remote sensing for sampling MBL properties, clouds and precipitation. Both EPIC and DYCOMS-II have revealed the importance of precipitation in MBL clouds and have found tight links between precipitation, cloud cover, microphysics and morphology that VOCALS-REx will focus upon.

The Aerosol Characterization Experiments (ACE), particularly ACE-1 and ACE-2 provided an unprecedented dataset on the clean and polluted marine environments in regions dominated by low clouds. In particular, from these experiments new hypotheses were conceived regarding the sources of aerosols in the MBL (entrainment, new nucleation) that need to be generalized to different regions of the globe, particularly those regions with extensive low clouds. ACE-2 in particular demonstrated the importance of aerosol microphysics in determining the radiative properties of marine stratocumulus. However, the ACE studies did not focus strongly upon the tight connections between precipitation, aerosol removal and replenishment that our limited studies of the SEP show are important. The ACE experiments advanced column radiative and microphysical closure type experiments (both clear and cloudy) on a local airmass.

Existing studies that have carried out Lagrangian experiments (ASTEX/MAGE, ACE-1, ACE-2) where an airmass is sampled repeatedly by aircraft over several flights are of particular value for understanding processes. Measurements from a single point, while invaluable, are more easily put into context by Lagrangian studies.

New technology, especially improvements to remote sensing capabilities that can be deployed on aircraft and research vessels, has led to great improvements in our ability to simultaneously sample critical properties of clouds (e.g. precipitation, liquid water path, cloud boundaries) at the same time that in-situ measurements can be made of the dynamic and thermodynamic properties, cloud microphysical properties and aerosol properties. Recent improvements to cloud microphysical sensors will improve our ability to measure embryonic drizzle drops (drops 10-40 microns in radius) that are important for the onset of precipitation. Real-time aerosol speciation of aerosols using mass spectrometry will provide important information regarding the cloud activating properties of aerosols (solubility, organic content) and their spatial variability that have been difficult to obtain with existing methods. The combined sampling of the MBL with a research aircraft and a research vessel with scanning radar will provide critical new information to link the mesoscale precipitation and cloud fields, the turbulent and mesoscale dynamics, and the cloud and aerosol microphysical properties. Together, these new measurements will allow the testing of hypotheses linking the cloud optical properties to precipitation and precipitation to aerosols that are a major source of discrepancy in climate models.

Coupled-Ocean-Atmosphere-Land

Historical observations on the coastal area (18-24° S, 70-75° W) off northern Chile consist largely of Chilean fisheries observations, satellite altimetric and surface temperature observations, and World Ocean Circulation Experiment (WOCE) Surface Velocity Program (SVP) drifters. These observations have been used primarily to characterize regional mean and seasonal variability, the regional oceanic response to El Niño/Southern Oscillation (ENSO), and mesoscale variability. The historical observational data base is sparse over the SEP, particularly within 100 km of the coast for satellite and drifter data and on oceanic mesoscales for in-situ hydrographic data.

Blanco *et al.* (2001) have summarized climatological variability off northern Chile (18°-24°S) from the coast to 400 km offshore. They used hydrographic data collected by the Chilean national fisheries institute (Instituto de Fomento Pesquero (IFOP)) between 1964 and 1996. Typical along-shelf separations for IFOP transects are 1 degree in latitude, hence they do not resolve eddies. These data were sufficient to describe the mean and seasonal cycle of water properties and of the geostrophic circulation. Blanco *et* *al.* (2001) divided the data into four seasons, austral winter (July-December), spring (October-December), summer (January-March), and fall (April-June). Mean features include coastal upwelling with an equatorward nearshore surface current, a poleward undercurrent, an oxygen minimum near 250 m depth, and low-salinity subsurface water near 100 m in the offshore and southern area of the region. Seasonal cycles exist in upwelling, the poleward undercurrent, and the low-salinity subsurface water. Hydrographic data suggest each of these features is strongest in summer and weakest in winter. Satellite altimetric observations confirm the poleward undercurrent but suggest it is strongest in spring (Strub *et al.*, 1995).

More recent IFOP observations together with wind and coastal sea level measurements have been used by Blanco *et al.* (2002) to characterize the response to 1996-1998 ENSO events off northern Chile. The regional ENSO response propagated from the equator with maxima of about 4°C and 0.6 salinity. ENSO-related anomalies were strongest within 50 km of the coast and extended to 400 m. During ENSO peaks, the usual nearshore equatorward geostrophic flow weakened. In May 1998, following the end of the 1997-1998 ENSO events, sea surface temperature and equatorward flow near the coast returned to climatological conditions, but offshore salinity remained anomalously high due to a tongue of subtropical water extending southeast along the Peruvian coast.

WOCE SVP drifters in combination with satellite altimetry have been used to characterize mesoscale variability in the region (Chaigneau and Pizarro, 2005*a*; 2005*b*). Both drifter observations and satellite altimetry suggest eddies propagate west from the coastal zone past the STRATUS buoy at 20°S, 85° W. Typical eddy sizes estimated from drifters and altimetry range from 30 to 200 km diameter. Eddies at the lower end of this size range are difficult to resolve using altimetry alone. They are also smaller than the local Rossby radius, suggesting ageostrophic processes may be important. Both cyclonic and anticyclonic eddies are observed. Typical eddy propagation speeds are 3-6 cm/s with a latitudinal dependence in speed. Circulation velocities in the eddies are on the order of 14 cm/s with sea level variations on the order of 6 cm. Hydrographic data suggests eddies have a signature down to 2000 m. Estimations of single particle diffusivity combined with typical temperature gradients suggest eddy heat fluxes of 25 W/m^2 onshore. However, the lack of drifter data in the region means this calculation relies on a single estimate of single particle diffusivity from 10°S to 34°S and from 100°W to the coast. Thus, it can only be regarded as a crude estimate for the VOCALS region which is closer to the coast and in the northern part of the region analyzed by Chaigneau and Pizzaro (2005*a*). Another important weakness of the drifter and altimetric data is that they give no insight into eddy generation processes within 100 km or so of the coast. This is due to a lack of coastal drifter observations and difficulties interpreting altimetry data in the coastal region.

The historical work does provide sufficient background to characterize proposed VOCALS oceanographic observations in the context of seasonal variability and ENSO. It suggests that eddies generated near the coast may contribute significantly to the upper ocean heat balance. However, historical observations only scratch the surface in our understanding of regional oceanographic processes and their contribution to air-sea interaction in the VOCALS region. Historical observations provide no indication of how eddies form within the 100 km of the coast due to limitations on satellite altimetry and drifter numbers. They provide little insight as to the vertical structure of eddies due to the lack of mesoscale surveys. Historical in-situ observations also do not include sufficient measurements within eddies of biologically relevant properties such as chlorophyll, nutrients, and dissolved gasses. They also lack shipboard velocity measurements (acoustic Doppler current profiler (ADCP)). Nor do they include measurements of surface momentum and heat fluxes on the scales of oceanic mesoscale variability.

VOCALS-REx will contribute to an understanding of the effects on regional coastal ocean processes on air-sea interaction in the VOCALS region in several novel ways. We would describe in detail the horizontal and vertical physical and biochemical structure of mesoscale features, assess the effects these features have on air-sea interaction, and describe how these features change as they move offshore. We would do this using shipboard surveys including SeaSoar hydrographic measurements, acquisition of ADCP velocities, measurements of surface fluxes and atmospheric variables, and bio-optical and biochemical water sampling. The proposed measurements would be coordinated with Chilean scientists and distributed to fisheries scientists within IFOP.

The offshore SEP observational work to date is insufficient to rigorously identify the balance of physical processes that maintain the sea surface temperature field and set the vertical and horizontal structure of the upper ocean under the stratus. At the same time coupled models yield a warm bias in sea surface temperature over the same region. Proxy surface fluxes based on numerical weather prediction models and climatologies were known to have large errors under the stratus in this region. The Stratus buoy has provided an accurate, in-situ time series of air-sea fluxes and surface meteorology (Colbo and Weller, 2007a). A one-dimensional ocean forced with these fluxes becomes too warm and too salty, and preliminary work has pointed to an important role for fluxes of cool, fresh water associated with ocean eddies in maintaining SST in this region (Colbo and Weller, 2007b). This mixed layer is forced from above by net warmth and net evaporation and bounded below by a cool, fresh water mass, with lateral transports and mixing influencing SST. Mesoscale ocean features that propagate westward, identified by some as eddies and by others as Rossby waves are characteristic of the region, and do have a low salinity, cool water mass below the mixed layer (Weller, pers. Communication). Vertical mixing of this cool, fresh water into the layer and/or net offshore export of cooler, fresher coastal water may balance the surface fluxes. There is biological evidence for enhanced vertical mixing. Dandonneau et al. (2003) suggests that at this location they also play a role in mixing nutrients by Rossby wave-induced convergences. McGillicuddy et al. (2007) suggests, alternatively, that eddy-induced upwelling enhanced by interaction between eddies and the wind brings nutrients up that increase productivity.

Experimental Strategy: How the instruments/platforms requested will be used to test the hypotheses and address objectives.

Aerosol-cloud-precipitation interaction hypotheses

Instruments/Platforms: Data from two key platforms will be used to test the VOCALS aerosol-cloud-precipitation hypotheses: the **NSF C-130** aircraft and the NOAA R/V **Ronald H Brown (RHB)**, both of which will be equipped with a comprehensive suite of aerosol, cloud and precipitation sensors.

The **C-130** will characterize cloud and drizzle microphysics using in-situ measurements from standard scattering/shadow probes and potentially from new technology sensors (2D-S and fast-FSSP). A 95 GHz radar with zenith, nadir and backward-slant downward beams, will be flown to remotely sense cloud, drizzle and the mesoscale dynamics of precipitation/cloud fields. Cloud base height and liquid water path (LWP) will be obtained below cloud using zenith-pointing cloud lidar and a 183 GHz microwave radiometer.

The **C-130** will carry a comprehensive suite of aerosol sizing and high resolution composition measurements. An aerosol mass spectrometer (ToF-AMS) will characterize non-refractory size-resolved composition from 50-2000 nm and size spectra for volatile (e.g. sulfate) and refractory (e. g. sea-salt, soot) measurements over 120–5000 nm. DMA and volatility DMA size measurements (10–500nm) will be made at 15 s resolution. CN and Ultrafine CN concentrations will be measured. Together these provide rapid inferred size resolved compositional information that will be constrained by slower measurements of bulk chemistry. A fast size spectrometer (UHSAS) will provide sizing over the dominant CCN size range to provide context for changes in CCN during the slower volatility and composition measurements. Cloud nucleating ability of aerosols will be assessed with a continuous flow CCN diffusion chamber and a counterflow virtual impactor (CVI). Filter and impactor sampling for individual particle analysis by electron microscopy (SEM and TEM) will be conducted on both ambient aerosol and cloud droplet residues collected through an aerosol inlet, the CVI and the Giant Nucleus Impactor (GNI); this will provide composition, mixing state, and size data on non-volatile particles from 10-1000 nm by TEM and 50 nm up to 100 μm diameter by SEM. An aerosol lidar may be flown to provide important information on the vertical structure of aerosol layers above and in the MBL.

The **RHB** will make continuous remotely sensed measurements of cloud physical properties including cloud base, cloud top and LWP, in addition to a set of comprehensive in-situ aerosol microphysical measurements similar to those on the **C-130**. Cloud microphysical measurements will be obtained from the **RHB** using transmissivity/microwave-based retrievals. The **RHB** C-band scanning radar will provide essential measurements of the horizontal and vertical drizzle structure, and a combination of sensitive vertically-pointing radars (a 94 GHz pitch/roll stabilized radar, a 94 GHz bistatic radar, and a micro rain radar) and lidar ceilometer will provide estimates of the drizzle size distributions. Cloud boundaries will be provided by the 94 GHz radar and the ceilometer. Surface meteorological measurements and bulk-flux estimates will be made, and frequent (probably 6 per day) radiosonde launches will be made. A high resolution Doppler lidar will provide estimates of the horizontal and vertical wind field and the aerosol vertical profile that will permit assessment of the affects of aerosols upon cloud microphysics. Joint **C-130** and **RHB** sampling will provide an unprecedented characterization of the structure of drizzling stratocumulus.

Three other aircraft platforms are planning to participate in VOCALS REx: the ONR CIRPAS Twin Otter (contact: Bruce Albrecht, University of Miami), the DoE ASP G-1 (contact: Pete Daum, Brookhaven National Laboratory), the UK FAAM BAe-146 (contact: Philip Brown, The Met Office, United Kingdom). These three aircraft will primarily conduct operations within 500 km from the coast, but there will be opportunities to carry out flights in conjunction with the **C-130** or **RHB** platforms. Some logistical information concerning these aircraft deployments is given at the end of this document.

Aerosol-cloud-drizzle hypothesis testing strategies:

HYPOTHESIS 1A: VARIABILITY IN THE PHYSICOCHEMICAL PROPERTIES OF AEROSOLS HAS A SIGNIFICANT IMPACT UPON THE FORMATION OF DRIZZLE IN STRATOCUMULUS CLOUDS OVER THE SEP

The crux here is to build from the various VOCALS-REx ship and aircraft measurements a database containing collocated observations of cloud base precipitation rate P_{cb}, cloud thickness h and/or LWP, cloud droplet concentration N_d, aerosol properties below cloud and above the inversion (particularly the Aitken and accumulation mode size distributions that give rise to the aerosol concentration N_a). The **C-130** data will be obtained from each of the various different missions (described in Aircraft Operations in Part IV below). We will then determine the degree to which variability (both temporal and spatial) in P_{cb} is correlated with variability in these sizes as they relate to N_a. **If these relationships are weak, or it is clear that P_{cb} is much more closely correlated with the cloud macrophysical properties (h or LWP), then this would constitute a falsification of H1a.**

HYPOTHESIS 1B: PRECIPITATION IS A NECESSARY CONDITION FOR THE FORMATION AND MAINTENANCE OF POCKETS OF OPEN CELLS (POCS) WITHIN STRATOCUMULUS CLOUDS.

Dedicated **C-130** POC-Drift missions (see *Aircraft Operations* in Part IV of this request) will be used to study the dynamical and microphysical cloud and precipitation structure. Stacks of flight legs spanning the boundary between a POC and the surrounding unbroken stratocumulus will be used to contrast cloud/drizzle structure in the two regions. At night when POCs generally form, satellite 3.9-11 μm BTDs from GOES will be used to locate clouds susceptible to POC formation. Flights will be directed according to these forecasts. Observation of POC formation is a goal, but much will be learned about their structure by studying existing POCs over an extended time, and efforts will be made to sample the same POC on multiple flights (in conjunction with other aircraft), and to fly in POCs advecting over the **RHB**. **If POCs are observed that do not contain drizzle heavier than a few tenths of a mm day^{-1} then we can rule out precipitation as being a necessary condition, and consider H1b as falsified.** Based upon our findings from recent cruises, we expect that drizzle will accompany POCs. In this case, then our goal is to learn the mechanisms by which precipitation affects the mesoscale cloud structure.

Scanning C-band radar observations from EPIC indicate that drizzle cells frequently develop a complex layered mesoscale structure with extensive 5-10 km wide regions flowing into the center of the cells roughly at cloud base with outflow above this. It is an untested possibility that these mesoscale inflow regions are necessary to maintain the moisture supply to the cloud that would otherwise precipitate out within 30 minutes or less. The role of evaporating precipitation is also likely to be important, but evidence linking this with the mesoscale dynamics is so far lacking. The cloud radar on the **C-130** will be used in conjunction with the aircraft-derived flight level winds to determine the mesoscale dynamics of the individual cells within the POC and help elucidate the mechanisms responsible for their maintenance and longevity. The scanning C-band radar on the **RHB** will also provide important information on the horizontal and vertical structure of the POCs, and we plan to obtain at least one POC case where the **C-130** and **RHB** C-band radar will sample the same structures.

HYPOTHESIS 1C: THE SMALL EFFECTIVE RADII MEASURED FROM SPACE OVER THE SEP ARE PRIMARILY CONTROLLED BY ANTHROPOGENIC, RATHER THAN NATURAL, AEROSOL PRODUCTION, AND THAT ENTRAINMENT OF POLLUTED AIR FROM THE LOWER FREE-TROPOSPHERE IS AN IMPORTANT SOURCE OF CLOUD CONDENSATION NUCLEI (CCN).

Cloud microphysical properties on the **C-130** will be measured together with size-resolved aerosol physical and chemical properties. In both the MBL and the lower free-troposphere (FT), measurements will be made of the important aerosol precursor species including DMS, SO_2 and MSA. Using the DMS flux from the ocean surface, in conjunction with the physicochemical aerosol and precursor measurements, it will be possible to estimate the relative importance of different pathways for aerosol formation and growth in the MBL, and to attribute the aerosol to specific anthropogenic and/or natural sources. Aerosol size and composition measurements on the **RHB** and above and below the inversion on the **C-130** platforms will be used, together with DMS/SO_2 measurements, to estimate entrainment rates and assess the potential contribution of free-tropospheric aerosol/precursor sources. Airborne profiles of the SO_2 flux will be used to separate entrained vs. surface DMS-derived SO_2 and associated particles. Aerosol and cloud chemistry measurements, in conjunction with surface and upper-air (sondes) meteorological measurements, will also be made at land sites in the Chilean coastal range downwind of smelters in Northern Chile to determine characteristics of this air and the transport processes by which it advects over the SEP, and **C-130** flight legs will be dedicated to sampling the characteristics of elevated pollution layers in the FT, MBL, and close to land.

We will attempt to falsify H1c using aerosol-CCN-cloud microphysical closure studies using data from the **C-130**. These will focus upon determining correlations, both spatially and from flight-to-flight, between cloud droplet size distributions and concentration (and hence effective radius) and accumulation mode aerosol size distributions (and number concentrations) and physicochemical properties. Anthropogenic tracers such as CO and free-tropospheric SO_2 will be used to determine the anthropogenic impacts on the air in the MBL at different distances from the coast. **Falsification of H1c would require poor correlations between accumulation mode concentration, cloud droplet concentrations/radii, and anthropogenic indicators.** Aircraft remote sensing (lidar, radar and microwave radiometer) and simultaneous satellite overpasses will also be used to broaden the context of the aircraft dataset.

HYPOTHESIS 1D: DEPLETION OF AEROSOLS BY COALESCENCE SCAVENGING IS A MAJOR SINK TERM FOR CLOUD CONDENSATION NUCLEI OVER THE SEP.

We will use **C-130** observations to determine the magnitude of the CCN coalescence scavenging loss for stratocumulus, using (i) the cloud layer droplet concentration (N_d) budget and (ii) the subcloud layer accumulation mode aerosol budget. Theoretical, but untested, parameterizations suggest that loss rates in stratocumulus topped MBLs are in the range 10-200 cm^{-3} day^{-1}, and increase with precipitation rate. This is large enough to be estimated with reasonable accuracy over the course of 6-8 hour Lagrangian flights, and the potential for multi-flight, multi-platform Lagrangian flights will be explored. For (i), the total eddy-covariance N_d flux will be evaluated for in-cloud flight legs. DMS tracer measurements made in-cloud and above-cloud will be used to estimate the total water deficit due to entrainment, and when combined with a microphysics-entrainment model will give the deficit of cloud droplets due to entrainment-evaporation. Finally, the CCN scavenging rate will be evaluated by combining the rate of change of N_d measured during the flight with the total eddy-covariance droplet flux and the flux attributed to entrainment-evaporation. In POCs, the mesoscale inflow and outflow regions will be sampled together with the radar-derived mesoscale dynamics to provide an alternative means for assessing depletion rates. **Falsification of H1d would require derived CCN loss rates not to exceed 10-20 cm^{-3} day^{-1} even when substantial drizzle (~1 mm day^{-1}) is present.** These data will be used to develop improved parameterizations of the two way interactions between aerosols and warm clouds.

Coupled ocean-atmosphere land hypotheses

Instruments/Platforms: Three research vessels are the key platforms for testing the coupled ocean-atmosphere land hypotheses with a lesser, but still important, role played by the **C-130**.

The **RHB** and a second research vessel (a UNOLS Intermediate class such as the R/V Wecoma) will carry comprehensive suites of oceanographic instrumentation to sample the physical/chemical properties of the upper ocean. The **RHB** will make measurements of the sea surface temperature, along with vertical profiles of the upper ocean temperature and salinity at different locations with XBTs and CTDs. An ADCP, together with Modular Microstructure Profilers, will be used to measure the mean and turbulent kinematic and thermodynamic structure and diapycnal mixing across the base of the ocean mixed layer. Surface drifters will be released periodically and tracked from the **RHB**. Oceanographic measurements made from the Wecoma will focus upon mapping out the horizontal and vertical structure (to 300 m depth) of mesoscale ocean features using the towed SeaSoar platform, which will measure temperature, conductivity, pressure, dissolved oxygen and chlorophyll. A Peruvian research vessel José Olaya (contact: Carmen Grados, IMARPE, Lima, Peru) will carry out a mesoscale survey in the southern Peruvian waters and will measure a suite of upper oceanographic parameters including temperature, salinity, dissolved oxygen and CO_2, currents, nutrients and phytoplankton. Atmospheric measurements, including upper air measurements, will also be made from the José Olaya.

In addition to the atmospheric measurements on the **RHB** detailed in the Aerosol-Cloud-Precipitation theme above, measurements will be made of concentrations of important aerosol precursor gases SO_2 and DMS. Surface fluxes of these species will be estimated using eddy correlation.

HYPOTHESIS 2A: OCEANIC MESOSCALE EDDIES PLAY A MAJOR ROLE IN THE TRANSPORT OF HEAT AND FRESH WATER FROM COASTALLY UPWELLED WATER TO REGIONS FURTHER OFFSHORE.

A two-phase deployment of the **RHB**/Wecoma will be carried out to optimally sample mesoscale ocean eddies. For Phase 1, the **RHB** will make measurements for 6 days at each of the IMET (20°S, 85°W) and DART (20°S, 75°W) buoys, transiting between the buoys with a concertina pattern to sample mesoscale ocean variability, while the Wecoma carries out a survey of the eddy-genesis region close to the Chilean coast. For Phase 2, the Wecoma will survey oceanic mesoscale variability and its effects on the atmosphere around the **RHB**. Figure 1 in the Experiment Design (below) gives a summary of the overall platform sampling strategy. During each phase the Wecoma will tow the SeaSoar platform instrumented with a range of sensors to sample thermodynamics and nutrients, and will drop XBTs at hourly intervals when transiting. An ADCP on the **RHB** will determine eddy kinematics. Mapping the horizontal velocity and temperature fields will allow estimation of the advective transports associated with the ocean mesoscale variability, of the water mass characteristics of eddies, and of the change in water mass characteristics as the eddies move offshore. That change is an indicator of mixing with the surrounding water. Mapping of nutrient concentrations as well as heat and salinity will provide additional insight into relevant mixing and transport processes and into the strong productivity of the waters offshore. Since nutrient-induced phytoplankton blooms can affect the depth over which sunlight is absorbed in the ocean column, nutrients may even be somewhat active tracers. These blooms may also contribute to biological production of aerosols. Drifters, with thermistor chains extending below the mixed layer base, will be deployed to examine horizontal homogeneity and resolve smaller scale features and Lagrangian transports in the eddy field. Microstructure observations will provide useful constraints on the role of vertical mixing processes at selected locations within the eddy and current field. Altimetry will be used to put the SeaSoar and XBT sections into better spatial context. **Falsification of the hypothesis will require the observations to be placed into the broader context by comparison with long term data and eddy-resolving ocean simulations from which quantitative flux transport estimates will be obtained**. Coupled and regional ocean model simulations will also be used to understand the role of lateral ocean mixing and eddy transports in setting the regional SST distribution of the SEP.

HYPOTHESIS 2B: UPWELLING, BY CHANGING THE PHYSICAL AND CHEMICAL PROPERTIES OF THE UPPER OCEAN, HAS A SYSTEMATIC AND NOTICEABLE EFFECT ON AEROSOL PRECURSOR GASES AND THE AEROSOL SIZE DISTRIBUTION IN THE SEP

The primary test will be to examine the broad spatial and temporal variability of the aerosol physicochemical properties both in and above the MBL in combination with back-trajectory analyses from regional models. We will use correlations between the key aerosol precursor SO_2 and chemical tracers such as CO and methanesulfonic acid (MSA) to attempt to separate the anthropogenic contribution to the aerosol size distribution from the natural contribution (see also hypothesis 1c). Surface DMS fluxes and gas phase SO_2 will be measured on both the **C-130** and the **RHB**. Relationships between these fluxes, the wind speed, and the thermodynamic and nutrient structure of the upper ocean will be assessed using shipborne upper ocean measurements from the **RHB**, and SST and ocean color measurements from the **C-130** radiometers. These data will be used to assess the potential impact upon the aerosol size and concentration using complementary data such as satellite-derived upwind wind speed and SST (and hence upwelling) variability. Entrainment of aerosols from the FT will also be estimated (hypothesis 1c above). **Falsifiability of H2b would require evidence of dominance by anthropogenic sources or evidence of a dominant free-tropospheric source.**

HYPOTHESIS 2C: THE DIURNAL SUBSIDENCE WAVE ("UPSIDENCE WAVE") ORIGINATING IN NORTHERN CHILE/SOUTHERN PERU HAS AN IMPACT UPON THE DIURNAL CYCLE OF CLOUDS AND PROVIDES A USEFUL FRAMEWORK FOR ANALYSIS OF NUMERICAL MODEL PERFORMANCE ON DIURNAL TIME SCALES.

A key signature of the subsidence wave is the diurnal cycle of temperature, reflecting vertical motion, in the lower FT. Sonde observations taken 6 times per day from the **RHB** at different locations along 20°S during the three stationary deployment phases, together with similar measurements from the R/Vs Wecoma and José Olaya in the near-coastal zone, and from the Chilean land site, will be composited as a function of local time to determine the amplitude and phase of the diurnal cycle as a function of distance from the coast. Vertically-resolved satellite temperature data from the COSMIC/GPS profiles and from AIRS will provide longer-term constraints on the diurnal cycle.

Estimating the impact of the wave upon the diurnal cycle of cloud and MBL properties is more challenging. We will primarily use the diurnal cycle of liquid water path and cloud top from the **RHB** at three different distances from the coast. Model simulations indicate that the diurnal cycles should be measurably different owing to the distance-dependent amplitude and phase differences between solar absorption and the subsidence wave. Assuming that significant differences are observed, the measurements will be used as strong constraints to test process, regional, and global model simulations.

We will also use the model results and observations to determine the primary factors controlling the wave amplitude and phase, and attempt to more broadly address its role in modulating the diurnal cycle of cloud over the SEP**. Falsification of the hypothesis will require either that no significant differences in the diurnal cycle of MBL and cloud properties are observed at the two locations, *or* that the models are unable to accurately predict the impact of the subsidence wave upon the diurnal cycle of clouds and the MBL.**

HYPOTHESIS 2D: THE ENTRAINMENT OF COOL FRESH INTERMEDIATE WATER FROM BELOW THE SURFACE LAYER DURING MIXING ASSOCIATED WITH ENERGETIC NEAR-INERTIAL OSCILLATIONS GENERATED BY TRANSIENTS IN THE MAGNITUDE OF THE TRADE WINDS IS AN IMPORTANT PROCESS TO MAINTAIN HEAT AND SALT BALANCE OF THE SURFACE LAYER OF THE OCEAN IN THE SEP.

Variability associated with events in which the trade winds drop to 1-2 m s^{-1} for up to several days and its consequences will be observed. Wind data from the IMET buoy, the **RHB** and Wecoma, satellites, and the aircraft will provide information about the space/time variability of the surface wind field. The spatial structure of the ocean response to surface wind will be documented by the buoy, by drifting buoys with thermistor chains suspended below, and by the **RHB**. As the wind dies, the near-surface ocean re-stratifies, leaving a shallow, warm layer that is very sensitive to subsequent wind events. The strengthening wind accelerates the shallow layer, triggering near-inertial oscillations and, potentially, mixing with the fluid below. The mean vertical shear and the vertical temperature structure will be observed by the moored and drifting buoys. Microstructure profiling from the **RHB** will quantify the vertical mixing. These observations will quantify the contribution of this mixing term to the upper ocean heat budget during VOCALS-REx. Subsequent to the field work, modeling studies will be used to hindcast the evolution of the upper ocean layer with wind fields that both include and exclude the transients in the magnitude of the trade winds. This will further assess the importance of the mixing events generated by the temporal variability in the winds in the SEP. We anticipate that the observations will find strong near-inertial oscillations. **Falsification of H2d would require little significant correlation between the trade wind speed and the observed mixing into the shallow surface layers.**

Deployment logistics:

The multidisciplinary nature of the VOCALS-REx field program necessitates a multi-platform approach to observational data collection. In this section we describe deployment logistics. Two major platforms form the central core of our experimental design, are essential to the overall success of the program, and form the crux of the experimental strategy described above: (a) the **NSF C-130** aircraft; (b) the **NOAA R/V Ronald H Brown** (**RHB**). In addition, a number of other platforms will provide additional important datasets especially at the land-ocean boundary, and these are described below.

Figure 1 shows the overall sampling strategy for VOCALS-REx, which is proposed to take place in October and November 2008. The project will be based in Northern Chile and over the Southeast Pacific (SEP) Ocean, a region of strong coastal upwelling, cold SSTs and extensive low cloud cover. During September-November, upwelling is strong, the trade winds are at their strongest, and the low cloud cover reaches its maximum extent, making the chosen deployment period ideal.

We propose that the research aircraft will be based together, either in Arica or Iquique, Chile, both of which have runways suitable for the deployment. Site surveys by EOL and the VOCALS-REx organizers will be conducted during fall 2008 to ascertain the most suitable location. An operations center at the aircraft site (or at a nearby hotel) will be essential to maximize the efficiency of coordinating the platforms and to provide a base for scientific planning including forecasting and operations support. The NCAR EOL will continue to provide scientific, technical and administrative support services to VOCALS-REx for planning, organizing, and implementing the field campaign.

The US ships will port in Arica before and after the two phases described below. Three land-based sites will be set up in Northern Chile to make physical and chemical measurements of the airmasses that will be advected over the SEP.

We propose that the aircraft deployment takes place from October 15th to November 15th 2008:

Aircraft (Oct 15-Nov 15): The **NSF C-130** will make cross-sectional measurements along 20°S out to 85°W, and will also conduct POC-drift and multi-day Lagrangian flights (with other aircraft) to study the structure of POCs and the evolution of the MBL. Details of the **C-130** flight plans will be given in Part IV (Aircraft Operations) below.

Other aircraft (DoE G-1, CIRPAS Twin Otter, and the UK FAAM 146) will work mainly in the near-coastal zone to examine aerosol, cloud and precipitation variability.

The ship deployment (the **RHB** is already scheduled) will take place from October 1st to November 15th 2008, and will consist of two phases:

Ships Phase 1 (Oct 1-21): The NOAA Ronald H Brown (**RHB**) will make measurements for 6 days at each of the IMET (20°S, 85°W) and DART (20°S, 75°W) buoys, transiting between them with a concertina pattern to sample mesoscale ocean variability, while the Wecoma carries out a survey of the eddy-genesis region close to the coast.

Ships Phase 2 (Oct 23-Nov 15): The Wecoma will survey oceanic mesoscale variability (using SeaSoar) and its effects on the atmosphere around the **RHB** which will be situated on a mesoscale ocean feasture close to 20°S and between 75°W and 85°W (one possible pattern is shown).

The R/V José Olaya coastal cruise will sample oceanic upwelling and the MBL structure and will take place from October 25-November 7.

Three land sites situated at sea-level, in the upper MBL, and in the lower FT, at the Iquique (20°S) or the Antofagasta (23.5°S) latitudes, will be used to characterize atmospheric aerosols including cloud particle residuals, gas phase chemistry, aerosol optical depth (the NASA AERONET project has agreed to provide three sunphotometers), and associated meteorology including upper air measurements (sea-level site) to complete the characterization of the diurnal subsidence wave at different distances from the Andes.

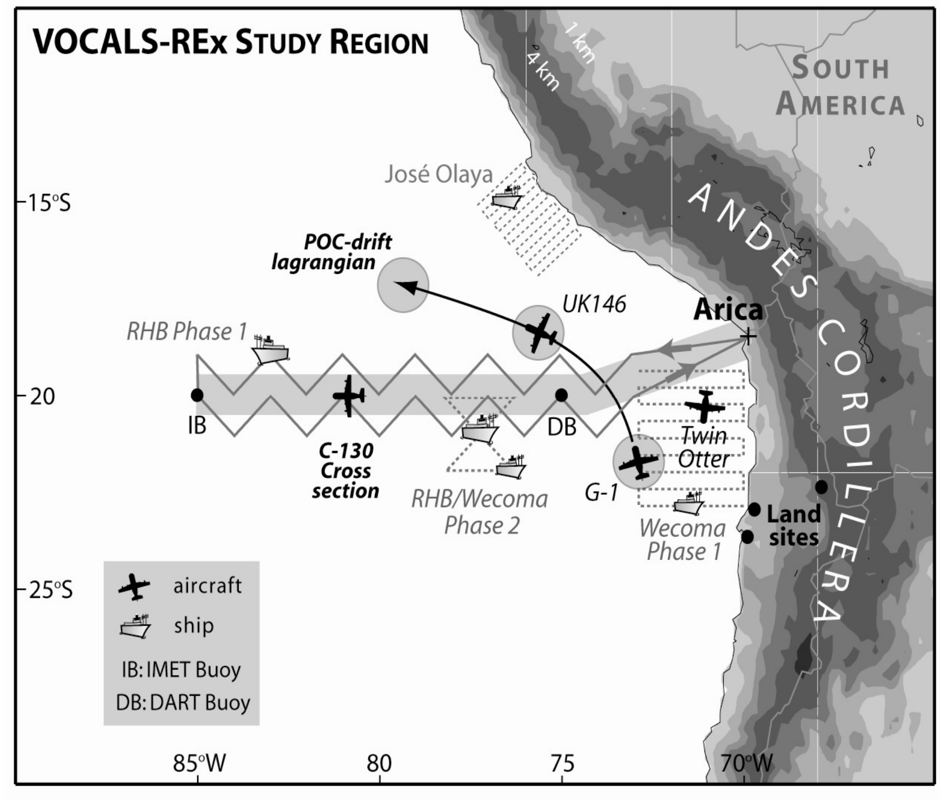


Figure 1: VOCALS-REx study region and key platforms/components

Meteorological Context

The VOCALS-REx study region is situated to the northeast of the subtropical SEP high pressure and experiences persistent southerly and southeasterly low level winds (see Fig. 2, with VOCALS-REx study region highlighted by the red rectangle) which drive strong ocean upwelling along the coast of Northern Chile and Southern Peru. This in turn maintains low SSTs over the region which, in combination with the warm free-tropospheric air aloft, is conducive to the formation of extensive marine stratocumulus clouds. The typical cloud cover during the Austral spring is 70-80% within the VOCALS study region. There is synoptic variability in the winds associated with the passage of low pressure systems to the far south, but this reduces in amplitude northwards, and by 20°S is quite weak.

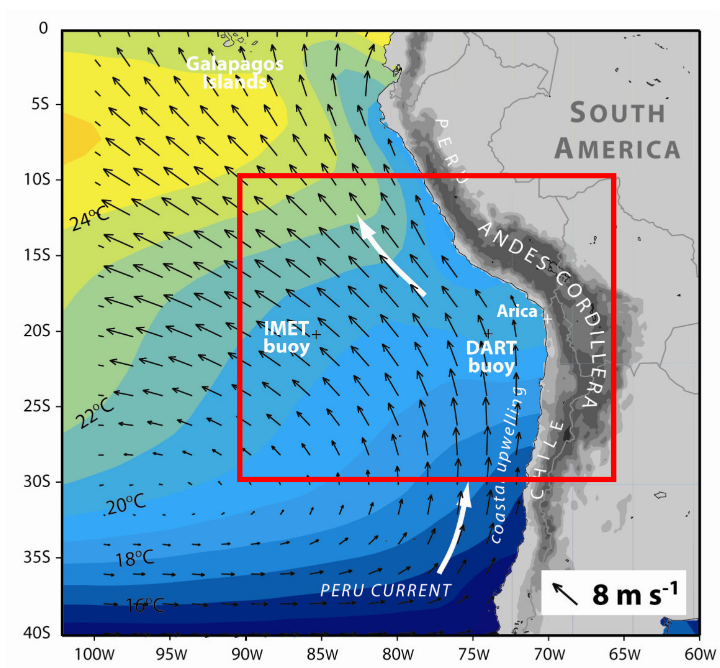


Figure 2: Mean sea surface temperatures (Reynolds) and surface wind vectors (Quikscat) for Sep-Nov.

PREVIOUS RESEARCH EXPERIENCE

Past EOL support for VOCALS PIs:

Atlantic Stratocumulus Transition Experiment/ Marine Aerosol Gas Exchange (ASTEX/MAGE)	1992
First Aerosol Characterization Experiment (ACE-1)	1995
Second Aerosol Characterization Experiment (ACE-2)	1997
East Pacific Investigation of Climate (EPIC)	2001
Aerosol Characterization Experiment – Asia (ACE-ASIA)	2001

Publications resulting from past EOL support:

Albrecht, B.A., C.S. Bretherton, D. Johnson, W.H. Schubert and A.S. Frisch, 1995: The Atlantic stratocumulus transition experiment - ASTEX. *Bull. Amer. Soc.*, **76**, 889-903.

Bandy, A., D. Thornton, F. Tu, B. Blomquist, W. Nadler, G. Mitchell, and D. Lenschow, Determination of the vertical flux of dimethyl sulfide by eddy correlation and atmospheric pressure ionization mass spectrometry (APIMS), Journal of Geophysical Research, 107 (D24), 4743 doi:10.1029/2002JD002472, 2002.

Bretherton, C. S., T. Uttal, C. W. Fairall, S. Yuter, R. Weller, D. Baumgardner, K. Comstock, R. Wood, and G. Raga, 2004: The EPIC 2001 stratocumulus study. *Bull. Amer. Meteor. Soc.*, **85**, 967-977.

Caldwell, P., C.S. Bretherton, and R. Wood, 2005: Mixed-Layer Budget Analysis of the Diurnal Cycle of Entrainment in Southeast Pacific Stratocumulus. *J. Atmos. Sci.*, **62**, 3775–3791.

Chen, G., D.D. Davis, P. Kasibhatle, A.R. Bandy, D.C. Thornton, B.J. Huebert, A.D. Clarke, and B.W. Blomquist, A study of DMS oxidation in the tropics: Comparison of Christmas Island field observations of DMS, SO2, and DMSO with model simulations, *J. Atmos. Chem.*, *37* (2), 137-160, 2000.

Clarke, A.D., Z. Li and M. Litchy, Aerosol Dynamics in the Pacific Marine Boundary Layer: Microphysics, Diurnal Cycles and Entrainment: Geophys. Res. Lett., 23, pg 733-736, 1996.

Clarke, A.D., J. L. Varner, F. Eisele, R. Tanner, L. Mauldin and M. Litchy, Particle production in the remote marine atmosphere: Cloud outflow and subsidence during ACE-1, Jour. Geophys, Res., 103, 16,397-16,409, 1998.

Clarke, A.D., D. Davis, F. Eisele, G. Chen, K. Moore, L. Mauldin, R. Tanner and M. Litchy, Particle nucleation in the marine boundary layer and its coupling to marine sulfur sources. *Science*, **282**, 89-92, 1998.

Clarke, A.D., F. Eisele, V.N. Kapustin, K. Moore, R. Tanner, L. Mauldin, M. Litchy, B. Lienert, M.A. Carroll, G. Albercook, Nucleation in the Equatorial Free Troposphere: Favorable Environments during PEM-Tropics, Jour. Geophys. Res, 104, 5735-5744, 1999.

Clarke, A.D., V.N. Kapustin, F. L. Eisele, R. J. Weber, P. H. McMurry, Particle Production near Marine Clouds: Sulfuric Acid and Predictions from Classical Binary Nucleation , Geophys. Res. Lett., 26, 2425-2428, 1999.

Colbo, K. and R. A. Weller, 2005: The variability and heat budget of the upper ocean under the Chile-Peru stratus. *J. Marine. Res.*, in press.

de Szoeke, S.P., and C.S. Bretherton, 2005: Variability in the Southerly Flow into the Eastern Pacific ITCZ. *J. Atmos. Sci.*, **62**, 4400–4411.

de Szoeke, S.P., C.S. Bretherton, N.A. Bond, M.F. Cronin, and B.M. Morley, 2005: EPIC 95°W Observations of the Eastern Pacific Atmospheric Boundary Layer from the Cold Tongue to the ITCZ. *J. Atmos. Sci.*, **62**, 426–442.

Comstock, K. K., Wood, R., Yuter, S. E., and Bretherton, C. S., 2004: Reflectivity and rain rate in and below drizzling stratocumulus. *Quart. J. Roy. Meteorol. Soc.,* **130**, 2891-2919, 2004.

Comstock, K.K., C.S. Bretherton, and S.E. Yuter, 2005: Mesoscale Variability and Drizzle in Southeast Pacific Stratocumulus. *J. Atmos. Sci.*, **62**, 3792–3807.

Faloona, I., D. Lenschow, Teresa Campos, B. Stevens, M. van Zanten, B. Blomquist, D. Thornton, Alan Bandy, Observations of Entrainment in Eastern Pacific Marine Stratocumulus Using Three Conserved Scalars, *J. Atmos. Sci.*, **62**, 3268-3285.

Huebert, B.J., D.J. Wylie, L. Zhuang, and J.A. Heath, Production and loss of methanesulfonate and non-sea salt sulfate in the equatorial Pacific marine boundary layer, Geophysical Research Letters, 23 (7), 737-740, 1996.

Huebert, B.J., S. Howell, P. Laj, J.E. Johnson, T.S. Bates, P.K. Quinn, V. Yegorov, A.D. Clarke, and J.N. Porter, Observations of the atmospheric sulfur cycle on SAGA-3, Journal of Geophysical Research, 98, 16985-16995, 1993.

Huebert, B.J., S.G. Howell, L. Zhuang, J.A. Heath, M.R. Litchy, D.J. Wylie, J.L. Kreidler-Moss, S. Coeppicus, and J.E. Pfeiffer, Filter and impactor measurements of anions and cations during the First Aerosol Characterization Experiment (ACE 1), J. Geophys. Res., 103 (d13), 16,493-16,510, 1998.

Nowak, J. B., Davis, D. D., Chen, G., Eisele, F. L., Mauldin, R. L., Tanner, D. J., Cantrell, C., Kosciuch, E., Bandy, A., Thornton, D. and Clarke, A., Airborne observations of DMSO, DMS, and OH at marine tropical latitudes, Geophys Res. Lett., 28, 2201-2204, 2001.

Petters, M. D., J. R. Snider, B. Stevens, G. Vali, I. Faloona and L. Russell, 2005: Accumulation mode aerosol, pockets of open cells, and particle nucleation in the remote subtropical Pacific marine boundary layer. *J. Geophys. Res.,* **111**, D02206, doi:10.1029/2004JD005694.

Raymond, D.J., G.B. Raga, C.S. Bretherton, J. Molinari, C. López-Carrillo, and Z. Fuchs, 2003: Convective Forcing in the Intertropical Convergence Zone of the Eastern Pacific. *J. Atmos. Sci.*, **60**, 2064–2082.

Raymond, D.J., S.K. Esbensen, C. Paulson, M. Gregg, C.S. Bretherton, W.A. Petersen, R. Cifelli, L.K. Shay, C. Ohlmann, and P. Zuidema, 2004: EPIC2001 and the Coupled Ocean–Atmosphere System of the Tropical East Pacific. *Bull. Amer. Meteor. Soc.*, **85**, 1341–1354.

Raymond D.J., Bretherton C. S., Molinari J., 2006: Dynamics of the intertropical convergence zone of the east Pacific. *J. Atmos. Sci.,* **63**, 582-597.

Russell, L.M., D.H. Lenschow, K.K. Laursen, P.B. Krummel, S.T. Siems, A.B. Bandy, D.C. Thornton, and T.S. Bates, Bidirectional mixing in an ACE 1 marine boundary layer overlain by a second turbulent layer, J. Geophys. Res., 102 (16), 16411-16432, 1998.

Stevens, B., D. H. Lenschow, I. Faloona, C-H. Moeng, D. K. Lilly, B. Blomquist, G. Vali, A. Bandy, T. Campos, H. Gerber, S. Haimov, B. Morley, D. Thornton, On Entrainment Rates in Nocturnal Marine Stratocumulus, Quart. J. Roy. Meteorol. Soc., 129, 3469-3493, 2003.

Stevens, B., D. H. Lenschow, I. Faloona, C-H. Moeng, D. K. Lilly, B. Blomquist, G. Vali, A. Bandy, T. Campos, H. Gerber, S. Haimov, B. Morley, D. Thornton, Dynamics and Chemistry of Marine Stratocumulus - DYCOMS-II, Bull. Amer. Meteor. Soc., 84 (5), 579-593, 2003.

Stevens, B., G. Vali, K. Comstock, R. Wood, M. C. van Zanten, P. H. Austin, C. S. Bretherton, and D. H. Lenschow, 2004: Pockets of open cells (POCs) and drizzle in marine stratocumulus. *Bull. Amer. Meteor. Soc.*, **86,** 51-57.

Thornton, Donald C., Alan R. Bandy, Fang H. Tu, Byron W. Blomquist, Glenn M. Mitchell, Wolfgang Nadler, Donald H. Lenschow, Fast Airborne Sulfur Dioxide Measurements by Atmospheric Pressure Ionization Mass Spectrometry(APIMS), Journal of Geophysical Research, 107 (D22), 4632 doi:10.1029/2002JD002289, 2002

Wijesekera H.W, and M. C. Gregg, 1996: Surface layer response to weak winds, westerly bursts, and rain squalls in the western Pacific Warm Pool. *J. Geophys. Res.,* **101**, 977-997

Zhuang, L., and B.J. Huebert, A Langrangian Analysis of the total ammonia budget during ASTEX/MAGE, *J. Geophys. Res*., 101 (D2), 4341-4350, 1996.

E. EDUCATIONAL ACTIVITES

A considerable outreach program for VOCALS is currently being developed (project led by Wood) and a draft white paper giving information on a suite of different opportunities is available on the internet at:

http://www.atmos.washington.edu/~robwood/VOCALS_Education_and_Outreach_Program.pdf

This document provides an overview of a range of education, outreach, and training opportunities of relevance 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 legacy of 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.

Opportunities for graduate and undergraduate students:

Dependent upon level of support from NSF, NOAA and other agencies, but we expect that this number will be of the order of 20-30 based upon the number of individual PI proposals being submitted to the VOCALS Panel Review.

There will be a number of different opportunities for graduate students to be involved in the field phase of VOCALS-REx, including instrument operations on the aircraft, the research ships, and at the Chilean land site. We will strive to involve the graduate participants in forecasting and mission planning activities at the operations center.

Undergraduates will be involved in various aspects of VOCALS-REx analysis through requests for Research Experience for Undergraduate (REU) support on individual PI proposals. 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 campaign.

Enhancement to university teaching:

VOCALS will collect numerous observational datasets that will be incorporated into classroom teaching and student projects in a senior undergraduate "Instruments and Observations" class at the University of Washington (taught by Wood) and other institutions.

Outreach/K-12 activities:

We plan to use the NSF supported Research Experience for Teachers (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). Additionally, we will apply for support from NOAA's Teacher at Sea Program 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 will be submitted in October 2007.

In addition, we plan to collaborate with the *Windows to the Universe* (W2U) project. W2U is an education and outreach program initiated in 1995, initially with funding from NASA, with subsequent additional sponsorship from NSF and other 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*, 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. Support for W2U activities will be sought from NSF and NOAA program funds.

PART II – OPERATIONAL CONSIDERATIONS & LOGISTICS

Approx. how many people will be involved in the field campaign? *Please specify number of participants and location(s).*	**Aircraft Operations Center**: Probably 60-80 in total including scientists, pilots, engineers, graduate students **Ships:** Approx. 35 **Land Sites:** Approx. 10
What other facilities/platforms outside the EOL suite will be deployed? Are any of them non-US facilities?	**Aircraft:** ONR CIRPAS Twin Otter DoE ASP G-1 UK FAAM BAe-146 (United Kingdom) **Ships:** NOAA R/V Ronald H Brown UNOLS R/V Wecoma (or similar) R/V José Olaya (Peru) Possibly R/V Abaté Molina (Chile) **Chilean Land Sites:** Sea-level site (ideally Iquique airport), Elevated site MBL (TBD), free-tropospheric site (TBD)
Are complex inter-facility or inter-agency permissions required for flight operations and/or other facility operations that would benefit from EOL leadership and experience?	Yes
Is there a need for integrated diplomatic arrangements? *(e.g., customs, immigration, focal point with local hosts/governments)*	Yes
If there are multiple instrumentation/operations sites, is there a need for operational coordination?	Yes
What kind of real-time data display and project coordination needs do you anticipate?	Real time communication between Ops Center and aircraft/ships where possible; Inter-aircraft communication may necessary for some flights. Communication between **C-130** and NOAA Ronald H Brown would be desirable
Is forecasting support required for project operations?	No. Forecasting expertise will be provided by the Chilean partners. Forecast output will be provided by collaborating operational centers such as NCEP, ECMWF, UK Met Office
What kind of communications capabilities do you expect on site? *(e.g., bandwidth)*	As fast as possible given reasonable resources. Most important is the ability to access satellite data and model forecast data in a timely manner
Will operations center and real-time display	Yes

[1] *A basic data/analysis center with LAN connections to the EOL computers and access to the Internet will be provided in the field by EOL. Support will include real-time communications links to the facility via "chat" and real-time display of selected variables via web site links. Access to forecasting tools and preparations of operational forecasts are not usually included as part of this service. These services are presently not supported by the NSF Deployment Pool. Funds to support its deployment currently must be obtained from separate sources, such*

and coordination services be required? [1]	
Will you require work space? *(e.g., office, lab and storage space)*	Yes. In the Operations Center: a meeting room for briefings including projection facilities. Lab, clean bench and storage space will be required for instrument calibration (see specific instrument requests below)
Will you require system administration support on site?	Yes, if necessary to maintain functioning operations center
Is there a need for coordinated shipping, lodging or transportation? *(especially if this is an international project)*	Yes
Will you be shipping hazardous/radioactive material?	• Small quantities of nitric acid/chloroform • 20-25 cylinders of compressed gas (nitrogen and air/CO2), usually sent by seatainer by EOL • Sealed radioactive isotope sources (3×15 mCi of Ni-63 and 1 mCi of Am-241)
Will you be shipping expendables? (e.g., radiosondes to local NWS offices)	Yes
Do you require assistance with various activities/services? *(e.g., organizing of workshops, meetings, site surveys, leases, permits)*	Yes, VOCALS Project Office has already been set up, coordinated by José Meitín, EOL.

PART III: DATA MANAGEMENT

What operational data do you need? *(e.g., satellite, upper air, radar, surface, oceanographic, hydrological, land characterization, model products)*	Access to near real-time GOES satellite data for VOCALS study region (all channels, not just images) is highly desirable (15 minute update for South America). Other satellite products such as MODIS (cloud top temperature and visible, NIR and TIR radiances), Microwave radiometers (liquid water, SST, water vapor), Quikscat, GPS/COSMIC Soundings, AIRS, CloudSat/CALIPSO
Do you have any specific real-time data needs to aid in your data collection activities?	Real-time GOES data (see above) and access to operational forecast products
Is there a requirement for a local satellite receiver to acquire local or real time polar orbiter or high resolution geostationary satellite data?	Probably not, but may be necessary if internet bandwidth availability at the Ops Center precludes rapid download of data from various archives
Beyond the EOL dataset, will you or your Co-PIs provide additional research data to the project?	Yes. Multiple datasets will be generated from all the research platforms and made available to participants after the project

as NSF Special Funds. For more information, please contact the CDS Facility Manager.

What data analysis products will you provide during the deployment?	To be decided among VOCALS PIs
What other research data and products do you need?	To be negotiated with EOL and VOCALS PIs
Is an EOL Field Catalog needed to provide real-time information management, reporting, decision dissemination, data exchange and resource monitoring?	Yes
Do you plan on moving a large amount of data back to your home institution during the project?	Not absolutely necessary. Only if available bandwidth permits**.**
What arrangements have been made for a comprehensive data archive, including the management and distribution of data from non-EOL platforms?	Under discussion with Steve Williams and EOL staff. Data policy to be determined at the Second VOCALS Preparatory Workshop (February 2008)
Do you intend to request restricted data access? [2]	To be decided at above meeting, February 2008

[2] *Please note that EOL policy will make all EOL data publicly available once the data are quality controlled. If a PI wants to have exclusive access to these data for the first year, s/he has to officially request such a restriction via email from the EOL Division Director (wakimoto@ucar.edu) eight weeks prior to the start of an experiment. The burden will fall on the requesting PI to request the restriction and also to "police" data distribution and access to the data once the restrictions are in place.*

PART IV: FACILITY-SPECIFIC REQUESTS

NSF/NCAR C-130

Contact: Dr. Jorgen Jensen
Email: jbj@ucar.edu, Phone: (303) 497-1028
http://raf.atd.ucar.edu/Aircraft/c130.html

AIRCRAFT OPERATIONS

Preferred flight period	Oct 15-Nov 15 2008
Number of flights required	14
Estimated duration of each flight	12 at 9 hrs, 2 at 6 hours
Number of flights per day	1
Preferred base of operation	Iquique or Arica, Chile
Alternate base	
Is JeffCo Airport (near Boulder) acceptable as your operations base?	No
Average flight radius from base	500 km
Desired flight altitudes(s)	Lowest possible to ~6 km [*Most legs confined to lowest 2 km, with profiles up to 4-6 km*]
Particular part(s) of day for flights	Flights will take place during both daytime and nighttime hours to capture open cell formation and time of maximum drizzle.
Statistically, how many days during specified period should be acceptable for flight operations?	Nearly all days
Number of scientific observers for each flight (max is 15)	14 but fewer if space is required for instruments

Scientific rationale for the use of this aircraft in the proposed project:

The **C-130** is required to carry the instrumentation necessary to achieve the project goals and has a sufficient endurance to carry out sampling activities in the remote marine boundary layer.

Description of desired flight pattern(s), priorities, and estimate number of flights:

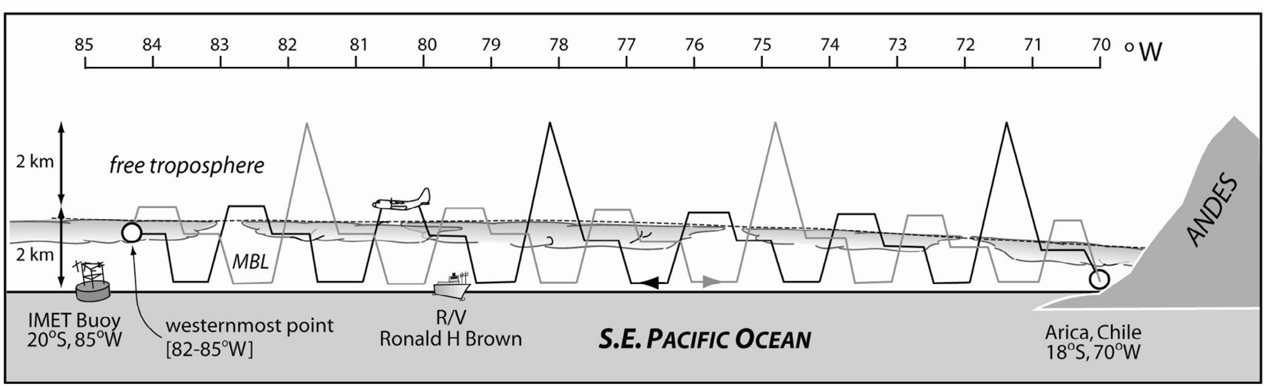
Two distinct **C-130** flight strategies will provide the range of sampling necessary to address the VOCALS-REx hypotheses: (a) **Cross-section missions** along 20°S latitude from the coast to the close to the IMET buoy at 85°W; (b) **POC-drift missions** which target either existing pockets of open cells (POCs) within overcast stratocumulus, or areas prone to POC development, and track these as they advect with the flow. In addition, subsections of the flights will be used to carry out coordinated sampling with the **RHB**, the Wecoma and/or the other aircraft. We plan to coordinate with other aircraft (most likely the UK 146 and G-1) to carry out one or two multi-flight Lagrangian missions formed from the combination of **POC-drift missions**, or missions with a very similar flight plan in a polluted airmass.

We anticipate that flights for both missions will require 9 hours, or the maximum permissible duration. In addition a number of test and intercomparison flights will be conducted with the **RHB** and/or with other aircraft. The table below gives an approximate breakdown of the flight hours.

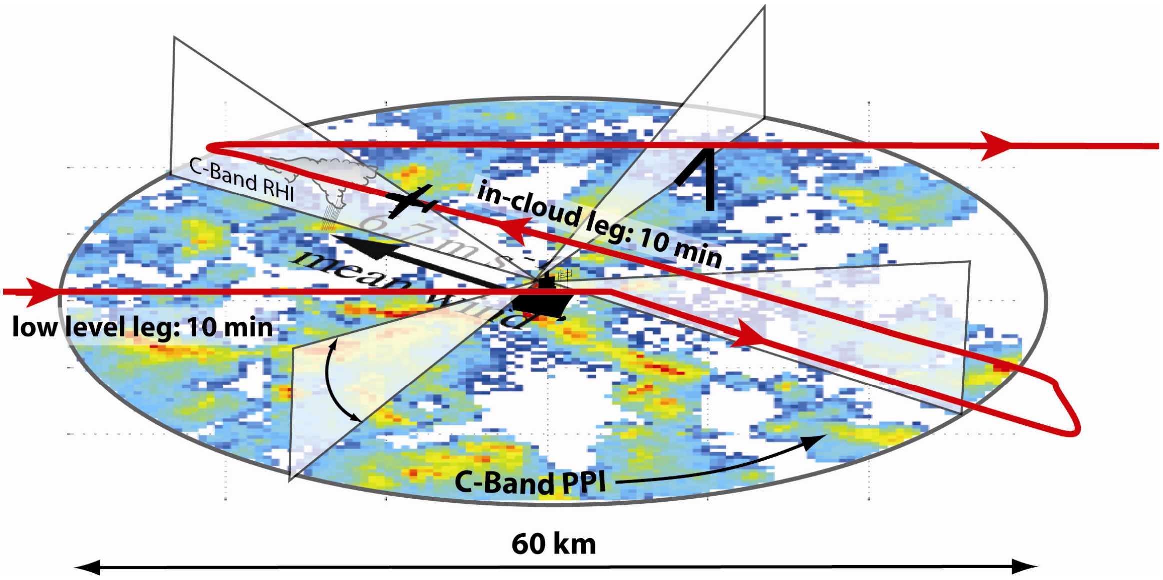
Total flight hours requested:	120 hours + ferry from NCAR and return
Flight plan breakdown:	• *Cross-Section* Missions: 5/6 flights at 9 hrs duration (total ~50 hrs) • *POC-Drift* Missions: 5/6 flights at 9 hrs duration (total ~50 hrs) • *Test/Intercomparison* Flights: 3/4 flights at 4 hrs duration (total ~20 hrs)

(a) Cross-Section missions: These flights are designed to sample contrasts in MBL thermodynamics, chemistry, aerosols and clouds between the South American coast and that in the remote SEP. Focus will be placed on good sampling of aerosol characteristics, MBL structure/depth, cloud morphology, microphysics, and drizzle. The aim is to generate a quantitative picture of the structure of the MBL and lower FT by combining data from 5 or 6 missions. To avoid aliasing diurnal variability, these flights will all take place at the same local time (probably depart 3am local, return 12 noon). There will be efforts made to coordinate some of these missions with satellite overpasses particularly Terra. On both the outbound and return sections, the mission will comprise a set of 10 minute straight and level runs below cloud (lowest possible flight level), in-cloud, and above cloud (1800 m AMSL) cloud, with science-quality climbs/descents of ~300 m min^{-1}. This will give roughly 6 sets of legs on the outbound and return portions. A number of profiles will be made up to 4 km to sample the FT aerosols and meteorology. An exact specification of the levels used and the leg-duration will be dependent upon the needs of the key participants. The above cloud runs will be used to sample the drizzle, cloud, and MBL structure using the WCR, and to characterize the free-tropospheric chemistry, aerosol and thermodynamic structure. Below cloud runs will aim to determine physicochemical properties of aerosols, to remotely sample the cloud and drizzle using the upward pointing 183 GHz microwave radiometer, the WCR and the lidar, and to determine lower boundary conditions (SST, surface thermodynamic and DMS fluxes, winds). This general type of flight plan was implemented very successfully during EPIC 2001 for studying southerly cross-equatorial boundary layer inflow into the East Pacific ITCZ.

An important component of the cross-section missions is to devote a portion of the flight (typically 30-40 minutes) to coincident sampling with the **RHB**. These coordinated sections (see **Coordinated C-130/RHB Pattern** figure below) will serve as a means of comparing instruments (particularly aircraft aerosol sampling and SST estimates) and will provide important *in-situ* context to remotely sampled cloud and drizzle properties from the **RHB**. In addition, these sections will be invaluable in helping to determine, using a combination of **C-130** and C-band radar measurements, the dynamical structures and mesoscale organization associated with POCs and mesoscale drizzle cells in general.



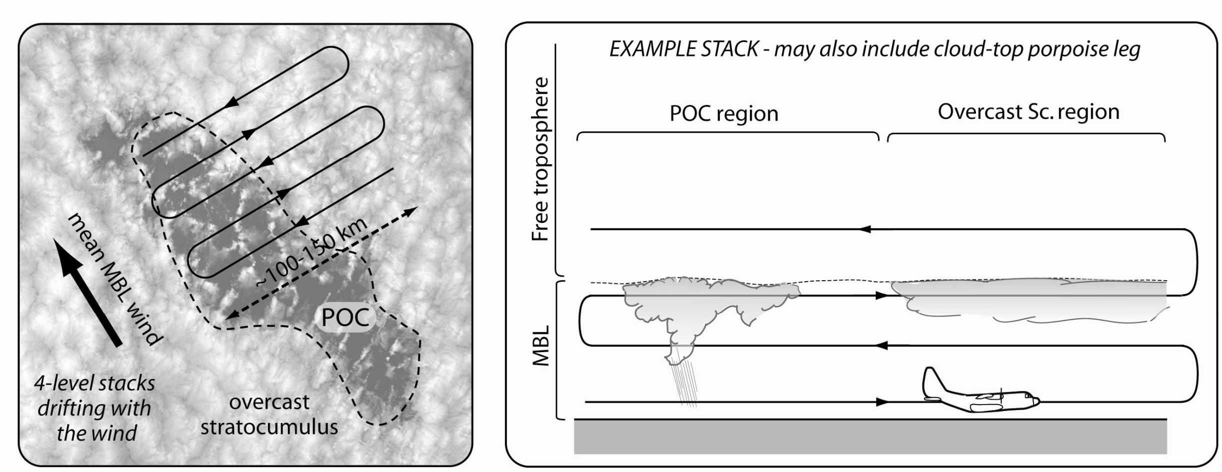
Flight plan for the **C-130 Cross-Section** missions.



Coordinated C-130/RHB Pattern: Cosampling during *Cross-Section* missions between **C-130** (red line) and **RHB** (center). A **RHB** C-band radar PPI scan is shown for context. The **C-130** enters region on a low level E-W leg, makes a turn at the **RHB**, and continues in the upwind direction for 30-60 km before climbing to the cloud level to make a 60-90 km run in-cloud passing over the **RHB**. The **C-130** will then resume its *Cross-Section* mission.

(b) POC-drift missions: These flights are designed specifically to examine microphysical and dynamical processes that occur in pockets of open cells (POCs) and in the surrounding cloud. POCs that are completely surrounded by overcast stratocumulus clouds are of the most interest, but broader boundaries between open and closed cellular convection may also be a focus of these missions. Of particular importance will be a characterization of the aerosol and cloud microphysical properties in the two regions. If possible, these flights will be coordinated with the **RHB**, whose scanning C-band radar will provide the mesoscale context for the **C-130** data, as well as aerosol and cloud characterization within the POC region. The idea is to use geostationary satellite imagery to locate POCs or regions prone to POC formation (using cloud microphysical retrievals to location regions of unbroken but clean clouds), and then to target missions accordingly. Once a POC boundary has been reached, the aim is to carry out across-wind stacks of five straight and level runs approximately 100 km in length below, in, and above cloud (with additional porpoising runs to characterize the cloud top and inversion layers). The aircraft will be allowed to drift with the MBL mean wind (i.e. with the advecting POC) to provide Lagrangian-type measurements of the temporal evolution of the POC. Efforts will be made to sample the same POC on two **C-130** flights, to conduct multi-aircraft Lagrangian missions with the **C-130** and the BAe-146 or G-1 aircraft, or to fly in a POC region that will ultimately advect over the ship.

In addition, a flight pattern similar to the POC-drift mission will be used to conduct a multi-aircraft, multi-flight polluted Lagrangian study originating in a polluted airmass near the Chilean coast to observe the processes affecting the aerosol and cloud evolution as the MBL advects downwind from the coastal to the remote SEP.



POC-Drift Mission flight plan for **C-130**. A boundary between open and closed mesoscale cellular convection will be located and this will be sampled with relatively long (100-150 km) runs spanning the boundary with approximately equal penetration into each region. The flight will consist of 3-4 stacks of straight and level legs (lowest feasible level, cloud base, in-cloud, above cloud) drifting with the mean MBL wind in a Lagrangian manner. Profiles in both regions will be obtained at regular intervals. In addition, one or two 100 km straight and level runs will be carried out in each of the two regions (not shown).

Will there be operations in foreign or military airspace?

Yes**,** Chilean and possibly Peruvian airspace

STANDARD EOL/RAF AIRBORNE SCIENTIFIC INSTRUMENTATION

Standard Measurements

The list in Appendix 1 shows RAF's standard measurements that are provided automatically when the C-130 is allocated for a project. For details about instrument type and performance, consult the RAF Bulletins on the RAF web site at http://raf.atd.ucar.edu/Bulletins/.

Additional instruments available upon request

Before requesting instruments in this section, please refer to Appendix 1 to see whether any are needed. Some of them require considerably more resources, may need special data handling and may require a dedicated, on-board operator. The number and/or combination of instruments may exceed RAF's personnel and/or hardware resource limits. (See Table 2 for explanations of the "Special Considerations.") Mark these extra, **Needed** *instruments with "yes."*

Description	Special Considerations	Data Rate(s)	Name	Needed
Radiometric Ambient Air Temperature (Ophir III) (in cloud)		Low	OAT	Y
Radiometric Sky Temperature		Low	RSTT	Y
TDL Laser Hygrometer	B,C,D	Low	TDL	Y
Gerber Probe (Liquid Water Content)		High	PVM-100	Y
Cloud Particle Size Distribution (0.5 - 47 µm)		Low, High	FSPP/SPP -100	Y
Cloud Particle Size Distribution (40 - 640 µm)		Low, High	OAP 260X	Lower priority
Aerosol Particle Size Distribution (0.1 – 3.0 µm)		Low, High	PCAS/SPP -200	Y
Aerosol Particle Size Distribution (0.3 – 20 µm)		Low, High	FSSP/SPP - 300	Y
PMS Cloud Particle Images (2-dimensional)	B	Auto	OAP 2D-C	Y
PMS Hydrometeor Images (2-dimensional)	B	Auto	OAP 2D-P	N
Fast-Response Chemiluminescence Ozone Concentration	A, D	High	O3FSM	N
Carbon Dioxide Concentration	C, D	Low, High	CO2C	Y
Carbon Monoxide Concentration	D, D	Low	COCAL	Y
TECO Ozone Concentration		Low	TEO3	Y
Radial Differential Mobility Analyzer (8 – 130 nm)	B, D	Low	RDMA	Y
Number of RAF Air Sample Inlet(s) (standard or solid diffuser)	*Solid diffuser, LTI, Standard inlets (number TBD), Venturis for aspirating inlets*			
VHS Video recording (fwd) with date/time				Y
VHS Video recording (side) with date/time				Y
VHS Video recording (down) with date/time				Y
Digital video recording (fwd or down) with date/time stamp	C, D			Y

Instruments available by special arrangement

The following instruments are not covered by NSF Deployment Pool Funds and require a separate funding source. They also require considerably more resources, often need special data handling and may require a dedicated on-board operator. The number and/or combination of instruments may exceed RAF's personnel and/or hardware resource limits. (See below for explanations of the "Special Considerations.") Mark these extra, needed instruments with "yes."

Description	Special Considerations	Data Rate(s)	Name	Needed
Multi-channel Cloud Radiometer	B, D	High	MCR	Not supported
Counter-flow Virtual Impactor	A, B, D	Low, High	CVI	Y
Cloud Particle Imager	A, B, C, D	High	CPI	N
Wyoming Cloud Radar	A, B, C, D, E	High	WCR	Y

A – Instrument requires a dedicated operator on board the aircraft.
B – Special software tools are required for routine processing, display and analysis of the data acquired by this instrument.
C – Data recorded on a separate data acquisition system, not on RAF's ADS.
D – Data acquired by this instrument requires unique post-processing.
E – This instrument requires filling out a separate request form (available in this document).

If you marked any of the instruments above as needed, please describe the scientific rationale for the use of the instrument in the proposed project:

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Wyoming Cloud Radar**
Primary Contact Name:	Samuel Haimov
Primary Contact Institution:	University of Wyoming
Primary Contact Phone:	(307) 766-2726
Primary Contact Email:	haimov@uwyo.edu
Individual weight of all components:	see note
Complete size dimensions of all components:	see note
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	see note
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	see note
Hazardous material required:	No
Radioactive sources or materials:	No
Power required (watts, volts, amps):	1000 W
Type of power (DC, 60 Hz, 400 Hz):	115 V, 60Hz
External sensor location (if any):	No, but will use the UPWARD aperture at FS687 and the downward aperture on the rear ramp of the C-130
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	No
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	No
Need IRIG time-code feed?	Yes
Special sensor calibration service required?	Yes
Need full-time operator during flight?	Yes
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

Will use WCR installation set up prepared for ICE-L. Some modifications may be required due to possible change in the WCR hardware (use of the new WCR2). Dimensions and weights will be available by Spring 2008. An Ethernet hookup will be needed.

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system?

Yes

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

Ethernet connection for communication between the radar computer and a display computer

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

25Hz aircraft data

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	2		1-2
Power (hrs)	2		1-2

Special support needs on flight and non-flight days:

Pre- and post-experiment calibration of the radar received power

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Wyoming Cloud Lidar**
Primary Contact Name:	Zhien Wang
Primary Contact Institution:	University of Wyoming
Primary Contact Phone:	(307) 766-5356
Primary Contact Email:	zwang@uwyo.edu
Individual weight of all components:	1: 20 lbs (lidar laser unit) 2: 93 lbs (Lidar 19" floor mount electronics rack, cables and tubing)
Complete size dimensions of all components:	1: Max dimensions, 4.25"W x 16.0"D x 18.5"H, mounted to optically clear window, pointing up. 2: 16.0"W x 19.41"D x 19.375"H
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	Yes, FAA approval pending, 2/7/07, standard seat rail mounted.
Hazardous material required:	Emits wavelength 355nm 0.16w avg. power
Radioactive sources or materials:	
Power required (watts, volts, amps):	790 watts, 110v, Max 8 amps.
Type of power (DC, 60 Hz, 400 Hz):	60 HZ
External sensor location (if any):	Upward window
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	NO
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	NO
Need IRIG time-code feed?	Could use NTP time service
Special sensor calibration service required?	Pre-project and interval validation checks
Need full-time operator during flight?	Yes - negotiable
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead*

time).
The WCL will be used onboard the C-130 in ICE-L. No changes in the WCL installation for VOCALS are anticipated.

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system? YES

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

Network connection if NTP is available.

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	20 min	20 min	
Power (hrs)	20 min	20 min	

Special support needs on flight and non-flight days:

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**183 GHz Microwave Radiometer**
Primary Contact Name:	Andrew L. Pazmany
Primary Contact Institution:	ProSensing Inc.
Primary Contact Phone:	(413) 549 4402 x11
Primary Contact Email:	pazmany@prosensing.com
Individual weight of all components:	G-band section: 22 lb, Control box: ~12 lb
Complete size dimensions of all components:	G-band (max.): 41"x6.25"x7" Control box: 3.5"(2U)x12"x19"
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	2U
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	No
Hazardous material required:	No
Radioactive sources or materials:	No
Power required (watts, volts, amps):	28 W (60 Hz AC), 126 W max. (~50 W ave.) (28 VDC)
Type of power (DC, 60 Hz, 400 Hz):	See above
External sensor location (if any):	PMS Canister with view upward
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	No
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	Yes
Need IRIG time-code feed?	No, but a 1 sec TTL heartbeat would be useful for absolute time stamping.
Special sensor calibration service required?	No
Need full-time operator during flight?	No
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

No

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system?

Yes

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*
RS-422 serial stream: 38400 bits per sec., 8 data bits, even parity, 2 stop bits, hardware flow control

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	0	0	
Power (hrs)	0	0	

Special support needs on flight and non-flight days:

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Wyoming Fine Nuclei System**
Primary Contact Name:	Jeff Snider
Primary Contact Institution:	University of Wyoming
Primary Contact Phone:	307 745 7540
Primary Contact Email:	jsnider@uwyo.edu
Individual weight of all components:	Wyoming CCN 27.5 lbs; TSI 3010 12 lbs; TSI 3025 25 lbs
Complete size dimensions of all components:	See table attached below
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	One half of one 19" C-130 instrument bay is requested for this measurement system (picture of recent Wyoming King Air installation attached below)
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	No
Hazardous material required:	N-butyl alcohol
Radioactive sources or materials:	No
Power required (watts, volts, amps):	435 W; 100/120 V ac; 4.1 A
Type of power (DC, 60 Hz, 400 Hz):	60 Hz
External sensor location (if any):	Aerosol is sampled at 6 alpm by this system. Formerly (DYCOMS-II), we sampled from the C-130 solid diffuser inlet, which was OK. The LTI is not required for this application.
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	Yes
If yes: Signal format (digital, analog, serial):	See table attached below
Full-scale Voltage:	7 channels analog and 1 channel of 8 bit digital (TTL compatible)
Range:	7 channels of -10 to +10 V analog
Resolution:	Minimum of 12 bit A/D resolution
Sample Rate (1, 5, 250 sps):	5 sps (5 Hz)
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	No
Need IRIG time-code feed?	No
Special sensor calibration service required?	No
Need full-time operator during flight?	Yes
Number of lap-top computers for on-board use:	1 (not included in power allocation)

Will NCAR support be required in preparing the instrument(s) for use on the aircraft

(other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system?

No

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

No

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	0.5	0.5	1
Power (hrs)	0.5	0.5	1

Special support needs on flight and non-flight days:

None

Instrument	Flow	Channel	Channel Description	Signal	External Connector
UWyo thermal diffusion CCN counter	2 alpm (450 mm Hg of vacuum required)	DTEMP	Top plate minus bottom plate temperature	-10 to 10 V analog	twin-ax
		TOPTMP	Top plate temperature	-10 to 10 V analog	twin-ax
		LPWR	Output power of laser diode	-10 to 10 V analog	twin-ax
		VDET	Laser light power scattered by activated droplets	-10 to 10 V analog	twin-ax
		ASTAT	Analog Status	-10 to 10 V analog	twin-ax
		DSTAT	Digital status	8 bit digital, TTL compatible	DB-9

Size – Width: standard 19” rack mount; Height: 11”; Depth: 15” (This instrument is a standard 19” rack mount)

Weight – 27.5 lbs

Power – 2 amp @ 115 V ac, 40 to 440 Hz

Recommended rate of data acquisition – 5 Hz (final data output desired by user)

User interface – RS-232, 9-pin, “D” subminiature connection to user-supplied laptop

Instrument	Flow	Channel	Channel Description	Signal	External Connector
TSI CPC 3010	1 alpm (sample) 2 alpm (total) (450 mm Hg of vacuum required)	CONC	Analog signal proportional to derived concentration	0 to 10 V analog	BNC

Size – Width: 8.5”; Height: 7.5”; Depth: 7.5” (19” shelf mount as shown in the attached picture)

Weight – 12 lbs

Power – 25 W, 100/120 V ac, 50/60 Hz

Recommended mode of data acquisition – 5 Hz (final data output desired by user)

Instrument	Flow	Channel	Channel Description	Signal	External Connector
TSI CPC 3025	2 alpm (internal pump)	CONC	Analog signal proportional to derived concentration	0 to 10 V analog	BNC

Size – Width: 15”; Height: 10”; Depth: 9.5” (19” shelf mount as shown in the attached picture)

Weight – 25 lbs

Power – 180 W, 100/120 V ac, 50/60 Hz

Recommended mode of data acquisition – 5 Hz (final data output desired by user)

- **University of Hawaii combined user-supplied payload description**

The overall request is for almost exactly the same instrumentation as for the PASE project. We expect to fully occupy two racks, one of which we will supply. In addition, one instrument (a nephelometer) will be mounted on a plate on the floor in front of one rack, another (a CCD camera) will be mounted under the floor, and we will need space for one large pump in the rear of the plane. Overall power use will be around 28 A of 60 Hz, and 5 A of 400 Hz.

This entire suite of instruments will be mounted on the C-130 this summer for PASE.

The complete list of instruments is

In one rack (which we will supply):

11. Aerodyne Time-of-Flight Aerosol Mass Spectrometer (AMS) [Clarke/Howell]
12. Long Differential Mobility Analyzer (LDMA) [Clarke/Howell]

The other rack (supplied by RAF) will contain

11. Optical Particle Counter (OPC) [Clarke/Howell]
12. Thermal pretreater for OPC (TOAD) [Clarke/Howell]
13. thermal/tandem radial Differential Mobility Analyzer (rDMA) [Clarke/Howell]
14. Particle Soot Absorption Photometer (PSAP) [Clarke/Howell]
15. hot/cold CN counters [Clarke/Howell]
16. ultrafine CN counter [Clarke/Howell]
17. f(RH) system (humidifier and 2 Radiance Research nephelometers) [Clarke/Howell]
18. Multi-Orifice Impactor (MOI) [Howell/Huebert]

Instruments elsewhere

11. 3 wavelength nephelometer (on floor in front of AMS) [Clarke/Howell]
12. Downward facing CCD camera (under floor in a belly port) [Clarke/Howell]
13. TAS (on the exterior of the fuselage plus a big pump somewhere) [Howell/Huebert]
14. Cloud Droplet Probe (wing mounted) [Clarke/Howell] This is replicated by some of the standard RAF instrumentation and might be dropped.

- There are some hazardous materials. The DMAs each use 3 small (500 μCi) ^{210}Po ionizers. Thd DMAs and each of the CN counters use n-butanol. There are Class 1 lasers in the CN counters and the OPC. There may be a Class 3? laser in the AMS if Aerodyne successfully adds an optical probe to the AMS. There are high voltages in the DMAs (10kV) and the AMS (4kV).

There will be 3 computers on the racks, two of which are laptops. All will need ethernet connections to the aircraft network. Two in-flight operators will be required to run everything.

We will be running our own data acquisition, but will supply 6 analog signals (0 to 10 V) to the aircraft data system and request 2 real-time serial feeds of aircraft data. In addition, we will need an isokinetic calculation added to the usual RAF data system (we've had them do this before; it seems to be no problem).

One facility request is for the Low Turbulence Inlet.

We will use a total of 3 lasagna pans: the LTI, the TAS, and a solid diffuser inlet. In addition, we'll use a belly port for the camera. We also need two exhaust venturis.

We will need 2 hours of access and power before each flight and about 30 minutes after. On non-flight days, we'll typically need 2 to 4 hours of power, though that will vary considerably depending on maintenance and calibration requirements.

Since everything will have been mounted the previous year, there will be little need for RAF support preparing the instruments. A little sheet metal work may be needed to make a shield for the AMS laser, if that actually exists.

- USER-SUPPLIED SCIENTIFIC PAYLOAD

*Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(*http://raf.atd.ucar.edu/Bulletins/bulletin3.html*), RAF Bulletin No. 13 (*http://raf.atd.ucar.edu/Bulletins/bulletin13.html*) and Design Guide RAF-DG-00-001 (*http://raf.atd.ucar.edu/Bulletins/Design_Guide.html*). Please provide the following information for each user-supplied scientific instrument:*

Instrument Name:	**UH Aerosol suite**
Primary Contact Name:	Steven Howell
Primary Contact Institution:	University of Hawaii
Primary Contact Phone:	808-956-5185
Primary Contact Email:	showell@soest.hawaii.edu
Individual weight of all components:	OPC: 40 lbs TOAD: 25 lbs rDMA: 80 lbs LAG chamber: 45 lbs PSAP: 15 lbs CN tray: 35 lbs UCN: 35 lbs f(RH): 30 lbs APS: 20 lbs MOI pump and control: 45 lbs? TSI neph: 73 lbs (including impactor) TSI neph power supply: 5 lbs Computer #1 (laptop): 15 lbs Computer #2 (laptop): 15 lbs AC Power strip: 3.8 lbs DC power strip: 2 lbs Ethernet hub: 2 lbs RS232 hub: 8.8 lbs AMS electronics: 7 lbs? AMS pump control: 7 lbs?

	AMS DC power supply: 8 lbs? AMS HV power supply: 50 lbs? AMS computer: 25 lbs? AMS UPS: 45 lbs AMS signal junction box: 4 lbs? AMS roughing pump: 12 lbs? AMS vacuum chamber: 150 lbs?
Complete size dimensions of all components:	OPC: 7 x 14.5 x 22 TOAD: 3.5 x 19 x 25 rDMA: 10.5 x 19 x 21 LAG chamber: 57" x 8 x 6 PSAP: 5.25 x 19 x 9.625 (11) CN tray: 7 x 17.5 x 24" UCN: 9 x 19 x 9.5 (11) f(RH): 6 x 19 x 25 APS: 7.5 (9.5) x14.5 x 12.5 (14) MOI pump and control: 16 x 10 x 10 TSI neph: 41.5 x 12 (18) x 10 (11) TSI neph power supply: 3.75 x 6.75 x 10.5 (15.5) Computer #1 (laptop): 2 (12) x 13 (18) x 11 (13) Computer #2 (laptop): 2 (12) x 13 (18) x 11 (13) AC Power strip: 1.75 x 19 x 4 (7) DC power strip: 2.75 x 11.75 x 1.25 (2.5) Ethernet hub: RS232 hub: 1.75 x 19 x 7.75 (10) AMS electronics: 3.5 x 19 x 9 (12) AMS pump control: 3.5 x 19 x 13 (17) AMS DC power supply: 1.75 x 19 x 11.5 (13.5) AMS HV power supply: 10.5 x 19 x 20 (24) AMS computer: 7 x 19 x 21 (26) AMS UPS: 3.5 x 19 x 19 (?) AMS signal junction box: 1.75 x 19 x 6 (9.5) AMS roughing pump: 6 (6.5) x 9 x 6.5 AMS vacuum chamber: 28.5 (34) x 7 (18) x 24 note: Dimensions are height x width x depth. Numbers in parentheses are the max dimension needed (typically clearance for connectors).
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	OPC: none (on top of rack) TOAD: 3.5" (2U) rDMA: 10.5" (6 U) LAG chamber: none (back of rack, overhangs 6") PSAP: 5.25" (3U)† CN tray: 7" UCN: 9"† f(RH): 6" APS: 8" (but overhangs 4.5") MOI pump and control: 10 " TSI neph: none (on floor plate) TSI neph power supply: 4.5"† Computer #1 (laptop): 12.5"† Computer #2 (laptop): 12.5"† AC Power strip: 1.75" (1 U)†

	DC power strip: none (mounts within rack) Ethernet hub: 1.75" (1 U)† RS232 hub: 1.75" (1 U)† AMS electronics: 3.5" (2U)† AMS pump control: 3.5" (2U)† AMS DC power supply: 1.75" (1 U)† AMS HV power supply: 10.5" (6 U) AMS computer:7" (4 U) AMS UPS: 3.5" (2U) AMS signal junction box: 1.75" (1 U)† AMS roughing pump: 6"† AMS vacuum chamber: 34" † Instrument does not occupy full depth, so can be back to back with another.
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	We will supply one rack (actually 2 HIAPER racks) for the AMS and use 1 RAF C-130 rack for everything else
Hazardous material required:	N-butanol in 5 CN counters
Radioactive sources or materials:	6 Staticmaster 500 uCi 210Po sources
Power required (watts, volts, amps):	28A of 60 Hz, 6A 400 Hz
Type of power (DC, 60 Hz, 400 Hz):	60 Hz, 400 Hz
External sensor location (if any):	3 lasagna pans, a belly port, possibly a wing mount
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	yes
If yes: Signal format (digital, analog, serial):	analog
Full-scale Voltage:	10 V
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	1 Hz is sufficient
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	Yes
Need IRIG time-code feed?	No
Special sensor calibration service required?	No
Need full-time operator during flight?	Yes, 2
Number of lap-top computers for on-board use:	2

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

- No

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

- **Will you be using your own recording system?**

Yes

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	2	0.5	2 to 4
Power (hrs)	2	0.5	2 to 4

- **Special support needs on flight and non-flight days:**

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**CSU Airborne Cloud Collector**
Primary Contact Name:	Jeff Collett
Primary Contact Institution:	Colorado State University
Primary Contact Phone:	970-491-8697
Primary Contact Email:	collett@atmos.colostate.edu
Individual weight of all components:	Cloud water collector, including PMS canister: 35 pounds Laptop computer and data acquisition system: 20 pounds
Complete size dimensions of all components:	Cloud water collector: 95 cm long by 16 cm diameter, mounted in PMS canister Laptop computer and data acquisition system: rack-mountable 19" panel space required
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	18" high x 25" depth for laptop computer and data acquisition system
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	no
Hazardous material required:	no
Radioactive sources or materials:	no
Power required (watts, volts, amps):	28 V DC, 1 amp for cloud water collector 115 V, 60 Hz for laptop computer and data acquisition system
Type of power (DC, 60 Hz, 400 Hz):	DC for cloud water collector, AC for laptop
External sensor location (if any):	Cloud water collector is housed in a PMS canister. Instrumentation pod is preferred mounting location.
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	no
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	Yes, real time measurements of liquid water content, pressure altitude, true air speed, and external temperature are needed (RS-232).
Need IRIG time-code feed?	no
Special sensor calibration service required?	no
Need full-time operator during flight?	yes
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

One 17 wire cable is required to interface the externally mounted cloud water collector to the data acquisition system (i.e. from instrumentation pod to cabin).

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system? Yes.

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	½ hour	½ hour	
Power (hrs)			

Special support needs on flight and non-flight days:

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Single-particle Streakers and Micro-impactors** (1 Streaker and 1 micro-impactor for CVI, 1 Streaker and 1 micro-impactor for ambient aerosol inlet)
Primary Contact Name:	Jim Anderson
Primary Contact Institution:	Arizona State University
Primary Contact Phone:	480-965-7139
Primary Contact Email:	janderson@asu.edu
Individual weight of all components:	44 lbs total
Complete size dimensions of all components:	2 micro-impactors @ 12h" x 5" x 12", 2 pumps @ 5"h x 5" x 7" , 2 Streakers @ 12h" x 6" x 6" , plus small flowmeters, valves, and small filters.
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	36" height of 19" rack space, standard depth.
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	no
Hazardous material required:	none
Radioactive sources or materials:	none
Power required (watts, volts, amps):	10 amps @ 120VAC, 1200 watts
Type of power (DC, 60 Hz, 400 Hz):	120 VAC, 60 Hz
External sensor location (if any):	no
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	no
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	no
Need IRIG time-code feed?	no
Special sensor calibration service required?	no
Need full-time operator during flight?	yes
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft

(other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).* No

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system? yes

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	1 hr	1 hr	2 hr (occasionally)
Power (hrs)	Not needed	Not needed	2 hr

Special support needs on flight and non-flight days:

None

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Ver2 CPI and 2D-S**
Primary Contact Name:	Dr. Paul Lawson
Primary Contact Institution:	SPEC INC
Primary Contact Phone:	(303)449-1105
Primary Contact Email:	plawson@specinc.com
Individual weight of all components:	CPI Computer: 48 lbs, 2D-S Computer: 19.4, 2D-S Power Supply: 14 lbs, Keyboard (2) 14.5 lbs each, LCD monitors (2) 16 lbs each. CPI sensor: 30 lbs, 2D-S sensor 19 lbs
Complete size dimensions of all components:	CPI computer: 23"x17"x7" (w/ 19" rack mount flanges), 2D-S computer: 12"x8"x7.5", 2D-S power supply: 9"x12"x3.5", Keyboards: 17"x23"1.5" each, LCD monitors: 19"x14"x2" on front rack panel. CPI sensor: 14"x25.5"6.25", 2D-S fits in standard PMS can, extends 10.3" from front of can.
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	45" Height, 19" Width, 23" depth, one full side of a high rack
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	No
Hazardous material required:	No
Radioactive sources or materials:	No
Power required (watts, volts, amps):	CPI: 2500 Watts, 115 V AC, 22 Amps 2D-S Computer 200 Watts, 115 V AC, 2 amps 2D-S Sensor 400 W 115 V AC 60 hz 4 amps and 112 Watts 28 V DC 4 amps
Type of power (DC, 60 Hz, 400 Hz):	115 V 60 hz AC and 28 V DC
External sensor location (if any):	Wing spearpod
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	No
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	Yes RS-232
Need IRIG time-code feed?	Yes
Special sensor calibration service required?	No
Need full-time operator during flight?	Yes
Number of lap-top computers for on-board use:	0

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time). No,*

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system? Yes, IDE Hard drives

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.) None*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	1	.5	6
Power (hrs)	1	.5	6

Special support needs on flight and non-flight days: None

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**FAST FSSP**
Primary Contact Name:	Jean-Louis BRENGUIER
Primary Contact Institution:	METEO FRANCE
Primary Contact Phone:	33 5 61 07 93 21
Primary Contact Email:	jean-louis.brenguier@meteo.fr
Individual weight of all components:	19 kg (fssp) 14 kg (DAS)
Complete size dimensions of all components:	Probe (same as FFSP Probe)
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	5U for the DAS
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	No
Hazardous material required:	no
Radioactive sources or materials:	no
Power required (watts, volts, amps):	DAS : 1 A 110 Vac PROBE : 0.5 A 110 Vac (400Hz) 2.8 A 110 Vac (deicing)
Type of power (DC, 60 Hz, 400 Hz):	
External sensor location (if any):	Under wing
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	no
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	no
Need IRIG time-code feed?	no
Special sensor calibration service required?	no
Need full-time operator during flight?	Yes
Number of lap-top computers for on-board use:	0 in normal operation

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time).*

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system?

Yes a 19'' rack mountable VME acquisition system

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	1 hour	¼ hour before shutdown power	1 hour
Power (hrs)	1 hour	¼ hour before shutdown power	1 hour

Special support needs on flight and non-flight days:

Lab space for calibration and maintenance (1.6x0.6 m workbench).

USER-SUPPLIED SCIENTIFIC PAYLOAD

Note: All user-supplied equipment must meet RAF safety and design specifications. Refer to RAF Bulletin No. 3(http://raf.atd.ucar.edu/Bulletins/bulletin3.html), RAF Bulletin No. 13 (http://raf.atd.ucar.edu/Bulletins/bulletin13.html) and Design Guide RAF-DG-00-001 (http://raf.atd.ucar.edu/Bulletins/Design_Guide.html). Please provide the following information for each user-supplied scientific instrument:

Instrument Name:	**Porter Lidar**
Primary Contact Name:	John Porter
Primary Contact Institution:	University of Hawaii
Primary Contact Phone:	(808) 956-6483
Primary Contact Email:	johnport@hawaii.edu
Individual weight of all components:	Laser power supply (34 pounds) Telescope and mount (~45 pounds) Laptop (~10 pounds)
Complete size dimensions of all components:	Power supply (24x24x10 in.) Telescope and mount (16x16x24 in.) Detector Package (12x12x12 in.) Laptop (14x14x12 in)
Rack-mountable 19" panel space required (Note: depth beyond 25" will overhang in back):	16 " width, 25" depth, 15" height
Supplying your own 19" rack (yes/no): (Note: racks must survive 9G crash load.)	no
Hazardous material required:	no
Radioactive sources or materials:	no
Power required (watts, volts, amps):	450 W
Type of power (DC, 60 Hz, 400 Hz):	120 V AC, 60 Hz
External sensor location (if any):	Lidar looking down
Are signal(s) to be recorded on RAF's Aircraft Data System (yes/no)?	no
If yes: Signal format (digital, analog, serial):	
Full-scale Voltage:	
Range:	
Resolution:	
Sample Rate (1, 5, 250 sps):	
Need real-time, in-flight, RAF-measurement, serial data feed (RS-232, RS422)?	Yes (serial RS232 output)
Need IRIG time-code feed?	Need time in serial feed
Special sensor calibration service required?	no
Need full-time operator during flight?	yes
Number of lap-top computers for on-board use:	1

Will NCAR support be required in preparing the instrument(s) for use on the aircraft (other than inspection, installation and power hook-up)? EOL/RAF can provide design

and fabrication support for hardware and electronic interfaces. *(If so, specify type and lead time). John Porter will build lidar mount.*

SPECIAL DATA RECORDING AND PROCESSING REQUIREMENTS

Will you be using your own recording system? Yes

What additional recording capability is needed? Please give us details on the number of signals, their characteristics, format, synchronous, fire-wire, ethernet, etc. *(We may not be able to accommodate any and all signals.)*

If nonstandard output formats and/or data rates are required, how often are the measurements needed? Note: The standard format for processed, RAF output data is net CDF. The standard output media are CD/DVD and ftp transfer. *(Nonstandard rates and/or formats will be considered as special processing requests.)*

PAYLOAD GROUND SUPPORT NEEDS FOR USER-SUPPLIED INSTRUMENTATION

	Preflight needs	Postflight needs	Routine Maintenance
	On flight days	On flight days	On non-flight days
Access (hrs)	None	None	2-4
Power (hrs)			450 W

Special support needs on flight and non-flight days:

I will need to carry out tests and alignment on down days. If the laser power supply gets too hot it will fail. This happened to me in the past. Therefore I will need some air conditioning air on the ground.

WYOMING CLOUD RADAR (WCR) AVAILABLE ON NSF/NCAR C-130

The Wyoming Cloud Radar (WCR) is maintained and operated by the University of Wyoming. To request a budget for WCR deployment, contact the Department of Atmospheric Science (UW DAS, 307-766-3246 or http://www-das.uwyo.edu/wcr/mmradar.wcrrequest.html). Use this request form for use of the WCR on the NSF/NCAR C-130. For WCR use on the UW King Air Research Aircraft go to the UW King Air request web page:http://flights.uwyo.edu/bulletin1.html

RADAR OPERATIONS

Scientific rationale for the use of WCR in the proposed project:

Because of its sensitivity to drizzle and its ability to depict the vertical-plane structure of the stratocumulus layer, the WCR is essential to the overall success of VOCALS.

Weather events during which collection is desired:

Marine Stratocumulus

Typical operations schedule:

Same as C-130 schedule.

Estimated number of radar hours:

~120. Same as # of C-130 flight hours.

Desired radar parameters:

PRFs (4 or 6-pulse packets): **TBD – depends on capabilities of WCR data system. Full Doppler spectra with resolution of < 0.2 ms^{-1} are also highly desirable.**
Gate Spacing along Beam (m): **15m or less (depends on capabilities of data system TBD)**
First Gate Location (min 75 m): **75m**
Number of Gates: **200 (max – 15m rgs)**
Minimum Sensitivity Needs (dBZ at 1 km): **better than -25 dBZ**
Antenna Configuration (pick one):
~~Dual antennas (single linear polarization): ____down-looking, ____ side-looking~~
~~Single antenna (dual linear polarizations): ____ down-looking, ____ up-looking~~
~~____ side-looking~~

We are requesting the 3-beam: 2-down + 1 upward looking beam configuration of the WCR that will be used during ICE-L.

Scientific rationale for desired radar parameters:

WCR reflectivity measurements will be used to depict the vertical-plane structure of the stratocumulus-topped boundary layer, and will be used to make quantitative estimates of the precipitation rate/profile and the coalescence-scavenging rate. Doppler velocities will be used to depict circulations within the cloud and sub-cloud layers (in the presence of drizzle) and identify regions where the cloud and subcloud-regions are decoupled.

RADAR DISPLAY AND COMMUNCATIONS NEEDS

Summary of radar display and communication needs:

The ability to have a 2nd display (in addition to that used by the WCR operator) available for use by the flight scientist is desirable, but not strictly necessary.

Summary of on-site radar data access and analysis requirements:

We would like to have preliminary, processed WCR data available within 24 hours after a flight.

SUPPORTING SERVICES

Multiple radar coordination requirements:

If WCR will coordinate with other radars (airborne or surface), please provide brief details

Coordination with the C-band radar onboard the NOAA RV Ron Brown may be attempted on some flights.

Is a WCR Scientific Project Manager needed for the project?

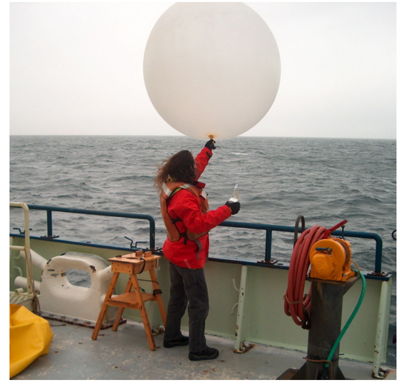
Yes.

Has a WCR scientist been consulted to help complete this request?

Consultation with WCR scientist is strongly encouraged before submitting this request.

Yes.

GPS ADVANCED UPPER AIR SYSTEM (GAUS) FIXED & MOBILE



Contact: Bill Brown
Email: wbrown@ucar.edu; Phone: (303) 497-8774
http://www.eol.ucar.edu/facilities/gaus.html

Operational Requirements:

Number of systems requested:	**2**
Location:	**1. Chilean low level land site (probably Iquique)** • Operator, system and expendables required. Additional sonde launches will be carried out by students from Chile and the US (contact Jose Rutllant, Universidad de Chile *jrutllan@dgf.uchile.cl*, or VOCALS-REx PI) **2. Peruvian R/V José Olaya** • System and expendables required. Operator will be provided by Peruvian scientists (contact Carmen Grados, IMARPE, Peru, *cgrados@imarpe.gob.pe*)
Do you need a mobile or fixed system(s)?	Land site: fixed Ship: mobile
Total number of sondes requested:	**Land site (Oct 15-Nov 15 2008)**: 6 per day for 30 days (180 total) **Ship site (Oct 25-Nov 7th 2008)**: 8 per day for 15 days (120 total)
Will you conduct Intensive Observing Periods (IOPs)? If yes, under which circumstances?	No, continual monitoring will be carried out during aforementioned periods.
How long does each IOP last?	N/A
At what frequency will sondes be released?	As above
Please specify your data access needs. Do you need data in real-time?	Real time data not necessary
How many of your staff will be available full time to help with GAUS operations?	To be negotiated. We will either provide students (Chilean or from the US) or students can be employed by NCAR.
Do you have any special requirements that pertain to EOL support?	No
Which EOL staff was consulted to help complete this request?	Bill Brown, Jose Meitin, Brigitte Baeuerle

APPENDIX I: NSF / NCAR C-130

NCAR/RAF Standard Airborne Scientific Measurements

I. TIME

Name	*Units*	*Description*
HOUR	hr	Raw ADS Time Component (UTC)
MINUTE	min	Raw ADS Time Component (UTC)
SECOND	sec	Raw ADS Time Component (UTC)
YEAR	yr	Raw ADS Time Component (UTC)
MONTH	mo	Raw ADS Time Component (UTC)
DAY	day	Raw ADS Time Component (UTC)
base_time	sec	Reference Start Time (UNIX time format, UTC)
time_offset	sec	Offset from Reference Start Time

II. INERTIAL REFERENCE SYSTEM

Name	*Units*	*Description*
LAT	degree_N	Inertial Latitude
LON	degree_E	Inertial Longitude
THDG	degree_T	Aircraft True Heading Angle
PITCH	degree	Aircraft Pitch Angle
ROLL	degree	Aircraft Roll Angle
ACINS	m/s2	Aircraft Vertical Acceleration
VSPD	m/s	IRS-Computed Aircraft Vertical Velocity
ALT	m	IRS-Computed Aircraft Altitude
GSF	m/s	Inertial Ground Speed
VEW	m/s	Inertial Ground Speed Vector, East Component
VNS	m/s	Inertial Ground Speed Vector, North Component

III. GLOBAL POSITIONING SYSTEM (GPS)

Name	*Units*	*Description*
GLAT	degree_N	GPS Latitude
GLON	degree_E	GPS Longitude
GVEW	m/s	GPS Ground Speed Vector, East Component
GVNS	m/s	GPS Ground Speed Vector, North Component
GALT	m	GPS Altitude
GMODE	none	GPS Mode
GSTAT	none	GPS Status

IV. ALTITUDE AND POSITION

Name	*Units*	*Description*
HGM232	m	Geometric (Radar) Altitude (APN-232)
PALT	m	NACA Pressure Altitude
PALTF	feet	NACA Pressure Altitude
GGALTC	m	GPS-Corrected Altitude
LATC	degree_N	GPS-Corrected Latitude
LONC	degree_E	GPS-Corrected Longitude

V. AIRCRAFT AND METEOROLOGICAL STATE PARAMETERS

Name	*Units*	*Description*
ATTACK	degree	Attack Angle, Reference
SSLIP	degree	Sideslip Angle, Reference
PCAB	mbar	Interior Cabin Static Pressure
PSX	mbar	Raw Static Pressure, Reference
PSXC	mbar	Corrected Static Pressure, Reference
QCX	mbar	Raw Dynamic Pressure, Reference
QCXC	mbar	Corrected Dynamic Pressure, Reference

TTH	deg_C	Total (Recovery) Temperature, Deiced
TTX	deg_C	Total (Recovery) Temperature, Reference
DPX	deg_C	Dew/Frost Point Temperature, Reference
DPXC	deg_C	Dew Point Temperature, Reference

VI. THERMODYNAMIC MEASUREMENTS

Name	*Units*	*Description*
ATH	deg_C	Ambient Temperature, Deiced
ATX	deg_C	Ambient Temperature, Reference
TASX	m/s	Aircraft True Airspeed, Reference
TASHC	m/s	Aircraft True Airspeed, Humidity Corrected
EDPC	mbar	Ambient Water Vapor Pressure, Reference
THETA	K	Potential Temperature
THETAE	K	Equivalent Potential Temperature (Bolton)
TVIR	deg_C	Virtual Temperature
RHUM	%	Relative Humidity
RHODX	gram/m3	Absolute Humidity, T-Electric, Reference
SPHUM	gram/kg	Specific Humidity
MR	gram/kg	Mixing Ratio, T-Electric

VII. WINDS

Name	*Units*	*Description*
UI	m/s	Wind Vector, East Component
VI	m/s	Wind Vector, North Component
WI	m/s	Wind Vector, Vertical Gust Component
WS	m/s	Horizontal Wind Speed
WD	degree_T	Horizontal Wind Direction
UX	m/s	Wind Vector, Longitudinal Component
VY	m/s	Wind Vector, Lateral Component
UIC	m/s	GPS-Corrected Wind Vector, East Component
VIC	m/s	GPS-Corrected Wind Vector, North Component
WIC	m/s	GPS-Corrected Wind Vector, Vertical Component
WSC	m/s	GPS-Corrected Horizontal Wind Speed
WDC	degree_T	GPS-Corrected Horizontal Wind Direction
UXC	m/s	GPS-Corrected Wind Vector, Longitudinal Component
VYC	m/s	GPS-Corrected Wind Vector, Lateral Component

VIII. RADIATION

Name	*Units*	*Description*
RSTB	deg_C	Radiometric Surface Temperature
IRB	W/m2	Raw Infrared Irradiance, Bottom
IRT	W/m2	Raw Infrared Irradiance, Top
IRBC	W/m2	Corrected Infrared Irradiance, Bottom
IRTC	W/m2	Corrected Infrared Irradiance, Top
SWB	W/m2	Shortwave Irradiance, Bottom
SWT	W/m2	Shortwave Irradiance, Top
SWTC	W/m2	Shortwave Irradiance, Top (Attitude-Corrected)
UVB	W/m2	Ultraviolet Irradiance, Bottom
UVT	W/m2	Ultraviolet Irradiance, Top

IX. CLOUD PHYSICS

Name	*Units*	*Description*
PLWCC	gram/m3	Corrected PMS-King Liquid Water Content
RICE	Volts	Raw Icing-Rate Indicator

XI. PARTICLES

Name	*Units*	*Description*
FCNC	vlpm	Corrected CN Counter Sample Flow Rate
CONCN	count/cm3	Condensation Nuclei (CN) Concentration

APPENDIX II: OTHER RESEARCH AIRCRAFT

Three research aircraft, besides the NSF C-130 are expected to participate in VOCALS-REx:

- Office of Naval Research (ONR) CIRPAS Twin Otter
- Department of Energy (DoE) ASP G-1
- United Kingdom Facility for Airborne Atmospheric Measurements (FAAM) BAe-146

Here we give the basic information regarding these aircraft, funding sources and status, expected number of participants in the team, contact personnel, estimated flight details and some information about power requirements where available.

ONR CIRPAS Twin Otter

Deployment status: Final approval to be made by ONR subject to proposals submitted summer 2007

Funding Source: Mostly ONR

Status of funding: TBA

Number of people in team (scientists/pilots/engineers/technicians etc): Approximately 10

Contact Person (logistics): Haf Jonsson (Naval Postgraduate School, *hjonsson@npl.edu*)
Contact Person (science): Bruce Albrecht (University of Miami, *balbrecht@rsmas.miami.edu*)

Logistics:

Approximate flight hours – 80 hours
Approximate duration of each flight – 4 hours
Arrival date in Chile – probably October 15th 2008
Departure date from Chile – probably November 15th 2008
Day/Night Flying? - mainly daytime
Ground requirements:
Power required/type on ground:

30A 110 VAC
20A 220 VAC
20A 220 VAC

DOE ASP G-1

Deployment status: Use of the G-1 for VOCALS has been approved
Funding Source: DOE Atmospheric Sciences Program
Status of funding: Funding has been approved
Number of people in team (scientists/pilots/engineers/technicians etc): Approximately- 8 Scientists; 2 Pilots; 3 Technicians

Contact Person (logistics): John Hubbe PNNL; john.hubbe@pnl.gov; ph.-509-372-6134
Stephen Springston BNL; srs@bnl.gov; ph. 631-344-4477

Contact Person (science): Peter Daum, email phdaum@bnl.gov; phone 631-344-7283

Logistics:

Approximate flight hours - Approximately 60-70 hrs
Approximate duration of each flight- 4 hrs

Deployment dates: October 15-November 15 timed to coincide with the arrival of the other aircraft.

Day/Night Flying?- Daytime flying only

Ground requirements: Parking space for aircraft; office/storage/lab space similar to what was available in the MILAGRO Campaign ie., about a 20 ft office trailer or the equivalent; space to put 1 Seatainer.

Power required/type on ground:

Three lines are required-
30A 110 VAC
20A 220 VAC
20A 220 VAC

We supply our own electrical distribution box if we can get a 220 power feed; call Springston for details

UK FAAM BAe-146

Deployment status: Use of the BAe-146 for VOCALS contingent upon a joint proposal between UK Met Office and UK University consortium to be submitted December 2007. Met Office commitment to the partnership is confirmed at this point.

Funding Source: Met Office
Status of funding: confirmed
Number of people in team (scientists/pilots/engineers/technicians etc): ~30 total

Contact Person (logistics): Bob Wells (FAAM - *rowel@faam.ac.uk*)
Contact Person (science): Phil Brown (Met Office - *phil.brown@metoffice.gov.uk*)

Logistics:

Approximate flight hours - 120
Approximate duration of each flight - 5.0-5.5 hours (depends slightly on choice of operating airfield).

Arrival date in Chile - 3 Nov 2008 [tentative]
Departure date from Chile - 26 Nov 2008 [tentative]
[Note that these dates are tentative and were scheduled before the NSF C-130 dates were firmed up. Discussions are now underway to align these dates more closely with those of the NSF C-130]

Day/Night Flying? – Both

Ground requirements:

Hangarage for aircraft - not essential
Office space for flight planning by aircrew
Office space for science contingent - routine data processing operations
Lab/workshop space for minor instrument rectifications, calibrations etc.
Storage space for aircraft and instrumentation spares and equipment

Power required/type on ground:

Ground Power Unit (GPU) for aircraft - 90 kVA