CHAPTER 1

VOCALS - Regional Experiment (REx) Operations Overview

1.1 Introduction to the VOCALS Regional Experiment (REx)

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 (Figure 1.1). 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[1] 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 five aircraft, two research vessels, and two surface land sites. 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.

[1] 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/*

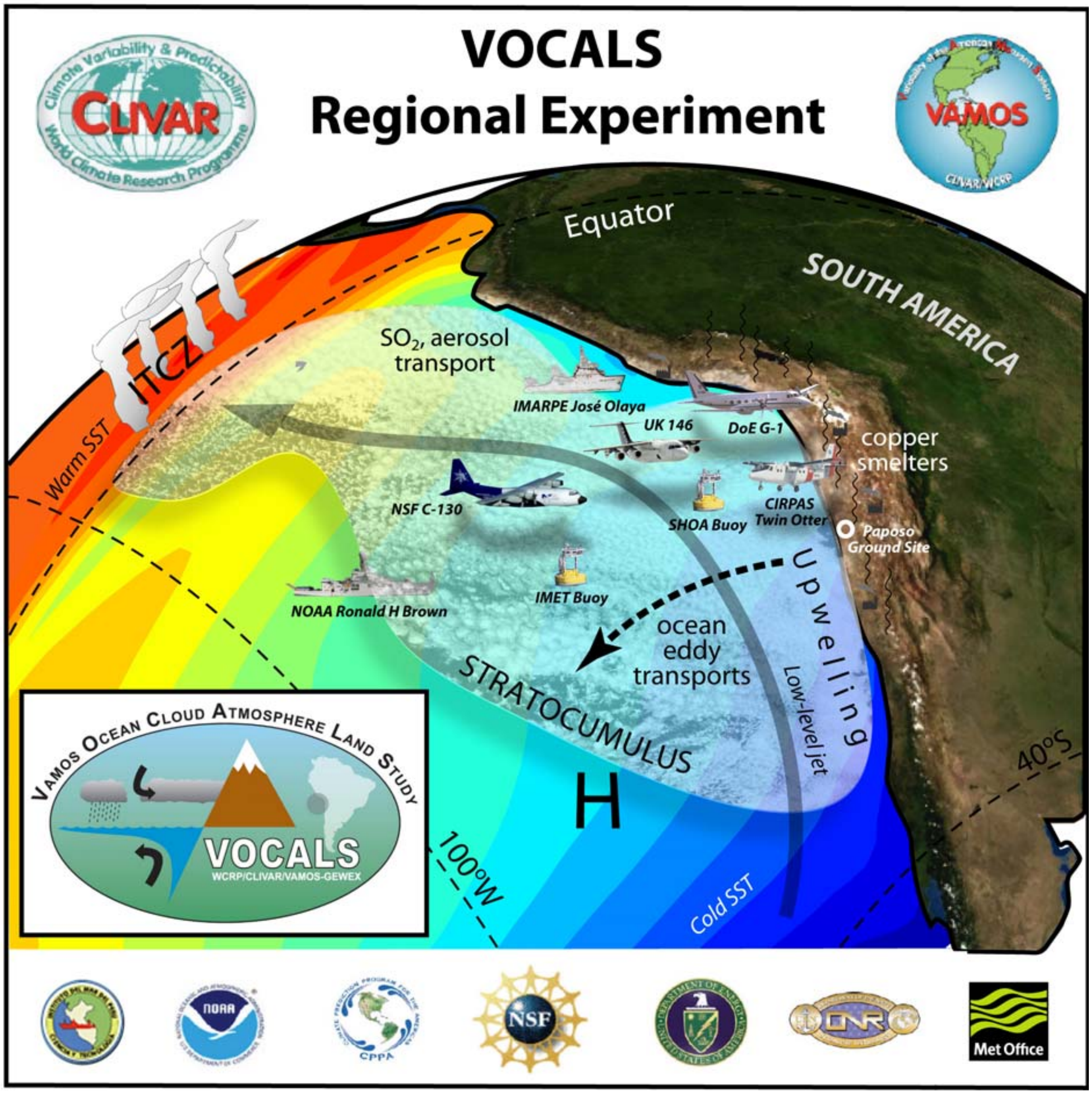

Figure 1.1: *Schematic showing major platforms and scientific foci for the VOCALS Regional Experiment.*

1.2 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.

1.2.1 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[2]. 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.

(1) 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 by 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.

(2) 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.

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[2] see http:*//www.eol.ucar.edu/projects/vocals/documentation/VOCALS_Modeling_0906.pdf*

[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.

1.3 VOCALS-REx Study Area

The main VOCALS study area focuses on the northern part of Chile and the southern part of Peru, stretching from approximately 15°S to 25°S and 85°W to 70°W.

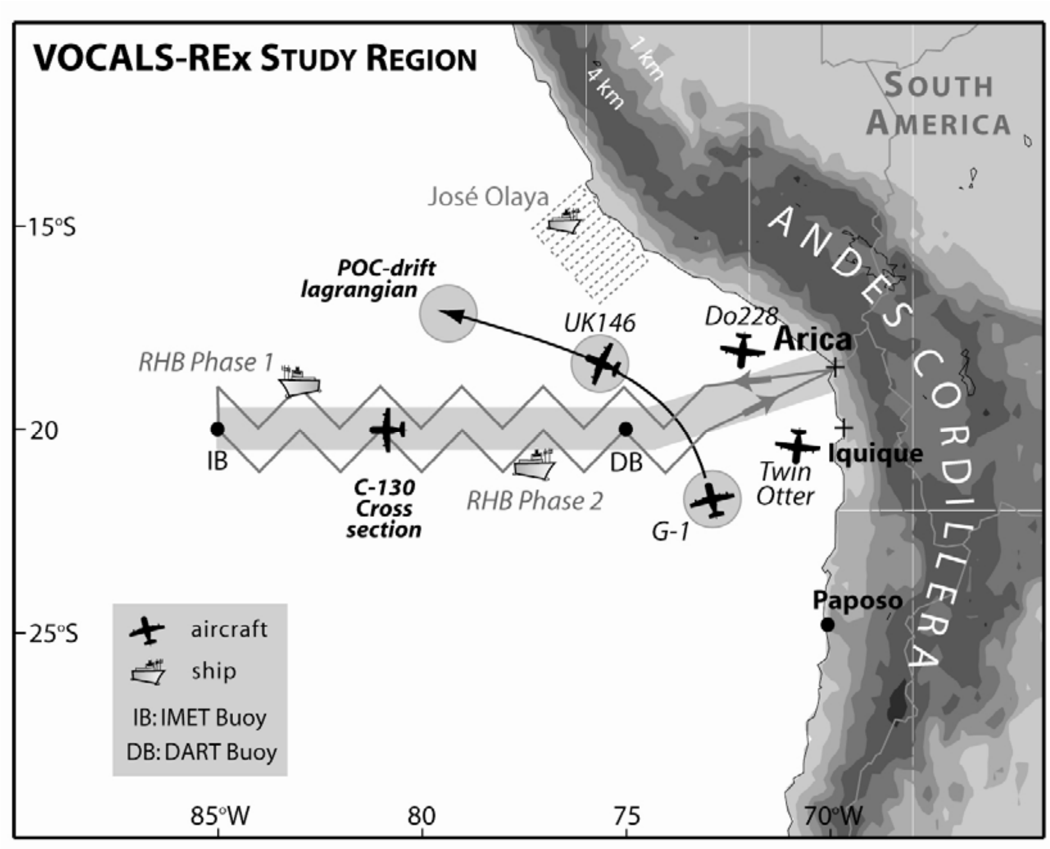


Figure 1.2: *Main VOCALS-REx Study Region*

Figure 1.2 depicts the VOCALS-REx study region. The majority of the VOCALS airborne facilities will be deployed in Chile's most northern city Arica. A fifth aircraft and one land based sounding system will be deployed in Iquique. A small number of instruments will be located in the small town of Paposo, south of Antofagasta. The NOAA R/V Ronald H Brown (RHB) will operate off-shore along the 20° S latitude and the Peruvian R/V José Olaya will conduct transects off shore of southern Peru near 15° S.

1.4 VOCALS Participating Facilities and Resources

VOCALS-REx was successful in securing significant airborne, shipborne and ground-based resources in support of documenting the coupling between clouds, aerosols, MBL processes, upper ocean dynamics and thermodynamics, coastal currents and upwelling, large-scale subsidence, and regional diurnal circulations. The allocated VOCALS research facilities, participating in the field campaign are listed in Table 1.1.

Research Facility	Type (location)	Number of flight hours / cruise days or expendables	Dates	No. of flights
NSF/NCAR **C-130**	Aircraft (Arica)	120 (research)	Oct 15-Nov 15	13
UK FAAM **BAe146**	Aircraft (Arica)	60 (research)	Oct 26-Nov 14	10
NERC **Dornier-228**	Aircraft (Arica)	50 hours	Oct 26-Nov 14	10
DoE **G-1**	Aircraft (Arica)	60 to 70 (research)	Oct 15-Nov 15	10-12
CIRPAS **Twin Otter**	Aircraft (Iquique)	80- 100 (research)	Oct 15-Nov 15	20
NOAA R/V **Ronald H Brown**	Ship	Leg 1: 17 days Leg 2: 20 days	Oct 15-Nov 3 (L1) Nov 07-Nov 28 (L2)	n/a
IMPARPE (Peru) R/V **José Olaya**	Ship	21 days	Oct 1-Oct 21	n/a
NCAR GAUS - Iquique	Land site (20.2°S, 70.2°W)	180 soundings, 6 per day	Oct 15-Nov 15	n/a
NCAR GAUS - R/V José Olaya	On R/V José Olaya	136 soundings, 6 per day	Oct 1-Oct 21	n/a
Paposo Land Site	Land site (25.0°S, 70.5°W)	Soundings, met obs, ceilometers, lidar, aerosol sampling	Oct 15-Nov 15	n/a

Table 1.1: *VOCALS Resources*

1.5 VOCALS Field Schedule and Timeline

The official start and end dates of the VOCALS field phase are **1 October and 28 November 2008** respectively. The various platforms/sites have dates of operation that fall within these dates, as detailed in Tables 1.2 and 1.3. The airborne and surface site intensive operations will primarily take place between

15 October and 15 November 2008, with the ship measurements extending outside of this timeframe.

1.5.1 Ship Component

VOCALS-REx is comprised of two phases which delineate the two legs of the RHB cruise (see Table 1.2). Between legs, the RHB will port in Arica before and after each of the two phases. The first leg of the RHB deployment is scheduled from 15 October to 3 November. During this phase the RHB will make measurements for six days at each of the IMET (20°S, 85°W, 19-24 October) and DART (20°S, 75°W, 28 Oct-3 Nov) buoys, transiting between them with a concertina pattern to primarily aimed at sampling mesoscale ocean variability. During the second phase, from 7 November through 28 November, the RHB will be situated on a mesoscale ocean feature close to 20°S and between 75°W and 85°W. The Peruvian R/V José Olaya coastal cruise will sample oceanic upwelling and the MBL structure and will take place from 1 to 21 October 2008.

1.5.2 Aircraft Component

The aircraft deployment will take place from 15 October to 15 November, 2008. The British aircraft have a slightly shorter deployment phase, starting on 26 October through 14 November. The NSF/NCAR 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. The DoE G-1, CIRPAS Twin Otter, and the UK FAAM 146 and Dornier 228 aircraft will work mainly in the near-coastal zone to examine aerosol, cloud and precipitation variability.

1.5.3 Landsite and Soundings Component

Two land-based sites will be set up in Northern Chile to make upper air measurements and physical and chemical measurements. One land site, situated at sea-level (Iquique, 20°S on the coast), will make regular radiosonde launches and collect standard meteorological data. The other site at Paposo (25°S) will be used to characterize atmospheric aerosols including cloud particle residuals, gas phase chemistry, aerosol optical depth, and associated meteorology including upper air measurements to complete the characterization of the diurnal subsidence wave at different distances from the Andes. GAUS operations in Iquique will start on 15 October and be carried out through 15 November 2008. Activities at the Paposo site will commence on 15 October and last through 15 November.

1.5.4 Operations Center

The VOCALS Operations Center will be located at the Hotel Arica in Arica, Chile. Infrastructure set-up of the Operations Center will begin on 8 October; preliminary operations will begin on 13 October to prepare for the first potential flight operations on 15 October and to test communications. The first daily planning meeting will take place on 13 October 2008. The VOCALS Operations

Center at the University Arturo Prat in Iquique will start operations on 13 October 2008. Forecasting support for VOCALS will begin on 12 October and continue through 15 November 2008. The daily planning meetings will take place once a day - always at 1530 South America/Santiago Time, which translates into GMT-4.

The deployment schedules of the major research facilities participating in VOCALS are listed in Table 1.2.

Research Platform	**Ferry / Transit / Set-up**	**Deployment Period**	**Ferry / Transit / Tear-down**	**Base of Operation**
NSF/NCAR C-130	Oct 10 – Oct 12	Oct 15 – Nov 15	Nov 18 – Nov 20	Arica
UK FAAM BAe146	Oct 21 – Oct 24	Oct 26 – Nov 14	Nov 16	Arica
NERC Do-228	Oct 21 – Oct 24	Oct 26 – Nov 14	Nov 16	Arica
DOE G-1		Oct 15 – Nov 15		Arica
CIRPAS Twin Otter		Oct 15 – Nov 15		Iquique
R/V Ron Brown	Oct 2 – Oct 13 Nov 6 – Nov 7	Oct 14 – Nov 03 Nov 08 – Nov 27	Nov 3 – Nov 5 Nov 27-Nov 30	Miami - Arica Arica – Arica
R/V Olaya		Oct 1/ - Oct 21		Lima – Lima
NCAR GAUS 1	Oct 10 – Oct 14	Oct 15 – Nov 15	Nov 16 – Nov 19	Iquique
NCAR GAUS 2	Sep 27 – Sep 29	Oct 1 – Oct 21	Oct 22 – Oct 24	R/V José Olaya

Table 1.2: *List of VOCALS platforms with their deployment periods and bases of operation.*

VOCALS Rex Platform Schedule

	Oct-08																																	Nov-08
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
RHB Status															Eddy Survey 1					IMET Buoy					Eddy Survey			SHOA Buoy						F
Olaya Status																																		
C-130 Status																																		
G-1 Status																																		
BAE 146 status																																		
Twin Otter status																																		
DOR 288 Status																																		
GAUS Iquique status																																		
Paposo status																																		

	Nov-08																											
Date	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
RHB Status	In port			F									Eddy Survey 3															
Olaya Status																												
C-130 Status																												
G-1 Status																												
BAE 146 status																												
Twin Otter status																												
DOR 288 Status																												
GAUS Iquique status																												
Paposo status																												

Legend:	(grey) Platform unavailable	RHB Activity:	Eddy Survey 1	westard from 75-85W
	(green) Platform available & operational		IMET Buoy	stationary at 20S, 85W
			Eddy Survey 2	eastward from 85-75W
			SHOA Buoy	stationary at 20S, 75W
			Eddy Survey 3	stationary near 20S,75-80 W
			F	Transit to/from Arica
			In Port	Arica

Table 1.3: *Summary of platform status for potentially interacting platforms during VOCALS-REx*

CHAPTER 2
VOCALS-REx Operations Centers

2.1. Arica Operations Center

2.1.1 Operations Center Location

The main VOCALS Operations Center is located at the Panamericana Hotel - Arica Inn and Resort in Arica, Chile. The hotel's address is Avda. Comandante San Martín 599, which is on the south side of town about 30 minutes from the airport. The Operations Center will occupy the hotel's two conference rooms on the second floor and will be equipped with tables, chairs, and basic conferencing and networking support. The Operations Center set-up will start on 10 October 2008 and will be operational by October 12, 2008, with daily briefings starting on 13 October. The support activities at the Arica Operations Center provided by the VOCALS Project Office are described below.

2.1.2 Operations Center Functions

The primary objective of the VOCALS-REx Operations Center is to conduct day-to-day operations during the field campaign as dictated by the VOCALS Science Working Group. It encompasses three major functions: (1) scientific planning, (2) operations control and mission implementation, and (3) real-time data display and data management activities.

(1) Scientific Planning: The Arica Operations Center will be the main base for the majority of the VOCALS-Rex scientist participating in the campaign. In addition to the members of the VOCALS Science Working Group, all VOCALS-REx investigators are invited and expected to be actively involved in the daily scientific planning process. Under the guidance of the Operations Director, investigators are encouraged to provide input to the mission selection process and operational procedures to be executed during the ensuing 24-72 hours.

(2) Operations Control and Implementation: Staff at the Operations Center will work with the VOCALS scientists and facility providers to assure efficient, effective and safe utilization of facilities operating within the limitations and operational constraints of the equipment and staff. The Operations Director will ascertain that mission plans conform to regulatory and safety standards and facility requirements, assure safety and integrity of in-flight changes to mission plans, and be responsible for timely notification of control agencies and facility project managers.

(3) Real-Time Data Display and Data Management: Several real-time data and communications tools including the EOL Field Catalog, Google Earth flight track displays, XCHAT, AEROS etc. will be available at the Operations Center. In addition, data management and archiving functions relevant to VOCALS-REx will be initiated by staff from EOL's Computing, Data and Software Facility (CDS). The various tools, datasets and real-time data streams have proven to be extremely valuable during aircraft missions as well as after the end of a project.

2.1.3 Operational Support

Operations center staff has overall responsibility for the conduct of day-to-day operations during the VOCALS field phase and will coordinate the following activities:

- Conduct of daily planning meetings;
- Conduct of regular science meetings incl. mid-project science review;
- Conduct of flight and mission planning meetings;
- Notification/information dissemination;
- Flight coordination and Air Traffic Control notification/interactions;
- Pre-flight briefings and mission debriefs;
- Generation of daily operations summaries, science summaries and other updates as required;
- Accommodation of PI preliminary data processing and data analysis work;
- Coordination of educational activities;
- Coordination of outreach/media activities.

2.1.4 Networking Support

The VOCALS Project Office will provide on-site systems administration support throughout the project. In addition to the hotel's WiFI set-up in all guest rooms, the bar and restaurant area, two EOL systems administrators will install a local area network (LAN) and telecommunications capabilities of adequate bandwidth to support the activities of all VOCALS participants in the Operations Center. This connection will be two **2 Mbps** lines with WiFi capabilities. In addition, the support set up will include the following:

- Linux network data server;
- 1 TB of mirrored storage (data storage access via NSF, Samba/CIFS and ftp);
- Network print services (1 Black & White and 1 Color Laserjet);
- 3 general access desktops/laptops for cybercafé set-up;
- 2 Mbps firewalled network, wired and wireless Ethernet with DHCP service;
- Intrusion Detection System (IDS);
- Skype support through the firewall.

The supported network protocol family will be TCP/IP. IP addresses and TCP/IP configurations will be assigned to participants' computers dynamically, via DHCP. If a participant's computer does not support DHCP, or if a particular computer has a need for a static numeric address, please contact Santiago Newbery (newbery@ucar.edu) for assignment of a static configuration. For security reasons, all machines connected to the firewalled VOCALS network must be running a vendor supported OS, with all software updates installed.

Additionally, all machines running Microsoft Windows must have a virus scanner installed, with updated virus signatures.

2.1.5 Administrative Support

The VOCALS Project Office will provide administrative support during the field campaign to help with the following activities:

- Liaison with hotel staff, coordination of hotel arrangements/reservations;
- Shipping and customs arrangements;
- General administrative support;
- Travel and flight arrangement changes;
- Rental car arrangements.

Figure 2.1 and 2.2: *Front side of the Hotel Arica and picture of the hotel's conference room that will serve as the Arica Operations Center*

Figure 2.3: *Geographic Map of Arica and surrounding area. The Operations Center will be located at the Hotel Arica. The Hotel El Paso and Hotel Azapa are overflow hotels to accommodate the large number of VOCALS PIs. The airport is about 18 km from the Hotel Arica.*

2.2. Iquique Operations Center

The VOCALS Iquique Operations Center is located at the University Arturo Prat in Iquique, Chile. The university is next door to the Iquique Radisson on Arturo Prat 2120. The Operations Center is located in the Study Hall on the 2nd Floor in the main building and accessible 24-hour/7 days a week. The set-up of the Iquique Operations Center will start on 12 October 2008 and will be operational by October 13, 2008 to allow participation in the first VOCALS Daily Planning Meeting on 13 October.

2.2.1 Operational Activities

The Iquique Operations Center will be the base for the CIRPAS Twin Otter crew as well as the operators for one of the NCAR GAUS systems. The following activities are scheduled to take place on the Arturo Prat campus:

- Remote participation in daily planning meetings and daily afternoon briefings via Skype;
- Remote participation in science planning meetings incl. mid-project science review;
- Conduct of flight and mission planning meetings;
- Flight coordination and Air Traffic Control notification/interactions;
- Pre-flight briefings and mission debriefs;
- Generation of daily operations summaries, science summaries and other updates as required;
- Accommodation of PI preliminary data processing and data analysis work;
- Daily radiosonde launches and collection of surface data.

2.2.2 Networking Support

The VOCALS Project Office through EOL will set-up access to the University Arturo Prat wireless network at the beginning of the project. Wireless internet access is available throughout the building (domestic 30 Mbps; international 6 Mbps). Daily communications with the Arica Operations Center will be through Skype (www.skype.com).

Figure 2.4: *Aerial View of Iquique and surrounding area. The Iquique airport is 25 miles south of the city.*

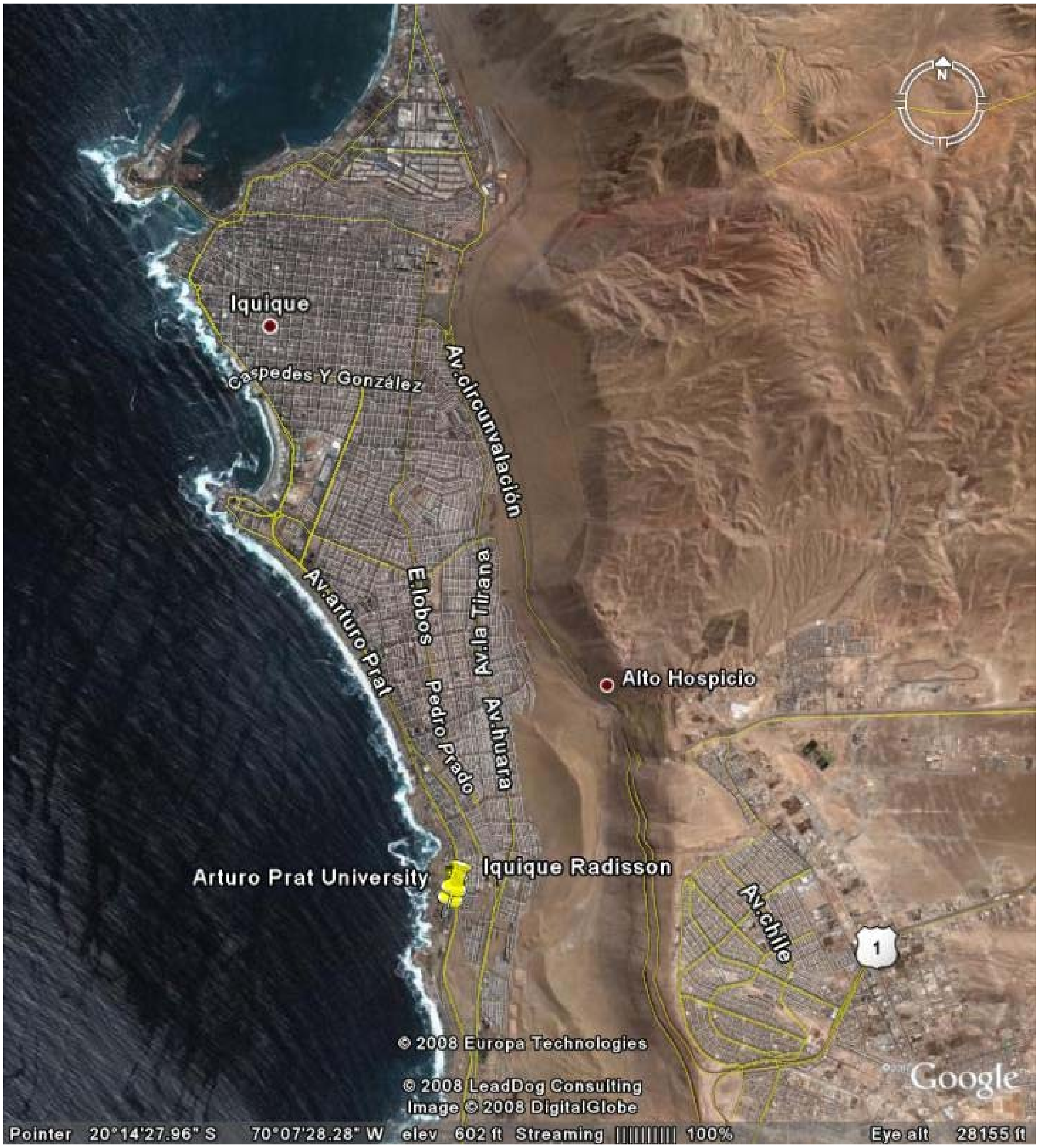


Figure 2.5: *Aerial View of Iquique*

Figure 2.6: *Aerial View of the Arturo Prat Campus*

2.3 Arica Operations Center Staff and Functions

During certain times of the project, VOCALS operations will require almost round-the-clock support from staff in the VOCALS Operations Center. The following positions and responsibilities were identified to support field campaign activities. It is important to point out that in some cases more than one of the key functions described below may be handled by a single individual, based on manpower availability and needs.

2.3.1 Key Roles and Responsibilities

Operations Director/Aircraft Coordinator

- Convenes and co-chairs VOCALS Daily Planning Meeting;
- Provides Status Report Summary to Daily Planning Meeting;
- Responsible for form and content of Daily Operations Summary;
- Assigns duties to Operations Center personnel;
- Implements the daily VOCALS Operations Plan;
- Acts as primary point of contact between Operations Center, on-board flight scientists and VOCALS Aircraft Facility Project Mangers;
- Coordinates ATC requirements–alerts, advanced notifications, etc.;
- Coordinates communications between Operations Center and research aircraft–flight track changes, data products transmitted to/from aircraft;
- Provides updated information to aircraft during flight operations;
- Works with flight scientists to update flight tracks as needed;
- Coordinates aircraft flight briefings and debriefings;
- Point of contact for outreach and media interactions.

Facility Status / In-Field Data Management Coordinator

- Monitors the status of all VOCALS facilities, including the use of all expendable resources;
- Responsible for monitoring and coordinating daily updates to the VOCALS Field Catalog;
- Presents a summary status briefing at the Daily Planning Meeting;
- Maintains an allocation/utilization account of flight hours and expendables;
- Responsible for implementation and updating of the VOCALS Field Data Catalog;
- Assists participants with submitting preliminary data products to the catalog;
- Monitors supplementary operational real-time data collection for VOCALS;
- Assures ingest and display of VOCALS specific satellite data and products;
- Supports exchange of special operational data products between Arica, Iquique and other sites;

- Assures timely and complete upload and download of data products between Arica and VOCALS aircraft during flight operations.

System Administrator / Communications Coordinator

- Manages, maintains and monitors VOCALS local area network and related computer support incl. printers;
- Assists VOCALS participants with set up of computer systems on the VOCALS LAN and provides general SA help;
- Responsible for computer and networking security;
- Primary point of contact with local Internet Provider and/or Hotel IT personnel;
- Establishes, monitors and maintains telecommunications (utilizing ICHAT, Skype or other tools) between the main operations center in Arica and the data analysis center during daily science, daily planning and other special meetings;
- Sets up, maintains and monitors chat links with all aircraft during flight operations.

Administrative Assistant

- Provides administrative support to all VOCALS participants
- Liaison to hotel management
- Assist in travel and rental car arrangements
- Responsible for shipping and logistics arrangements

FUNCTION	PARTICIPANT	SCHEDULE
Operations Director /Aircraft Coordinator	Jose Meitin Vidal Salazar	Entire time period Entire time period
Facility Status / In-field DM Coordinator	John Allison	13 – 27 October
System Administrator/ Communications Coordinator	Santiago Newbery Joe Vinson Jody Williams	Entire time period 10 -30 October 1 – 18 November
Education Coordinator	Brigitte Baeuerle Jacqueline Lim	Tbd tbd
Admin Assistant	Melanie Whitmeyer Kyle Terran	8 – tbd tbd

Table 2.1: *VOCALS Operations Center team members*

Chapter 3
VOCALS REx Mission Planning and Implementation

The following chapter describes the mission planning and implementation process during VOCALS. Due to the large number of participating facilities, scientists and agencies, a significant level of coordination is necessary to maximize resource utilization in addressing VOCALS hypotheses and scientific objectives.

3.1 VOCALS-REx Science Team

VOCALS-REx Science Team and Director: The VOCALS-REx Science Team is made up of all PIs participating in the project and includes the VOCALS Science Working Group, which is a mandatory committee for all CLIVAR/VAMOS projects. The Science Team is listed in Table 3.1. The VOCALS scientists are an international body associated with participating facilities, national research institutions, and government agencies, and have the collective responsibility to work together to accomplish the VOCALS research objectives. All scientists are encouraged to participate in and contribute to the development of the daily VOCALS scientific mission proposals. The Science Team is headed by the Science Team Director. His role is to act as chief scientific liaison at the Operations Center; to make the final decision (with consultation) on the deployment of facilities; to prepare relevant progress reports, and to co-chair the daily planning meetings.

FUNCTION	PARTICIPANT
Science Director	Rob Wood
C-130 Flight Scientist	Rob Wood, Chris Bretherton
BAe146 Flight Scientist	Hugh Coe, Phil Brown
G1 Flight Scientist	Pete Daum
Dornier Flight Scientist	Geraint Vaughan
Twin Otter Flight Scientist	Bruce Albrecht
Ronald H Brown Lead Scientist	Bob Weller
José Olaya Lead Scientist	Carmen Grados
All other VOCALS PIs	n/a
VOCALS Science Working Group (SWG)	Bruce Albrecht, Chris Bretherton, Hugh Coe, Tony Clarke, Chris Fairall, Jerome Fast, Laura Gallardo, Carmen Grados, Bill Large, C. Roberto Mechoso (Chair), Hualu Pan Yuqing Wang, Bob Weller, Rob Wood (Vice Chair) Paquita Zuidema, José Meitín and Carlos Ereño (ex officio)

Table 3.1 - ***VOCALS-REx Science Team***

VOCALS Mission Planning Team: A smaller sub-group of VOCALS investigators will make up the VOCALS Mission Planning Team. The Mission Planning Team consists of the chief scientists or representatives of each of the participating facilities (a maximum of two representatives for each facility, and often only one) who have a broad overview of the VOCALS objectives. This group will change during the field program reflecting changes in scientific goals, platforms and schedules. The Mission Planning Team will provide guidance and direction during the day-to-day execution of the campaign and be chaired by one of its members. Team members must be present in person at the respective Operations Centers and participate in Daily Planning Meetings during their rotation.

VOCALS Mission Scientists: VOCALS Mission Scientists for each aircraft are selected from the Mission Planning Team once a mission has been suggested. The Mission Scientists, in consultation with the Mission Planning Team, lead the mission planning discussion and decide the final deployment of each facility. He works with the Operations Director, flight scientists and facility representatives on the production of final flight plans and is responsible for making a go/no-go decision for a day's mission. Each Mission Scientist is responsible for real-time coordination of aircraft, monitors mission operations, and supports onboard flight scientists via chat and (where possible) image updating. He considers and approves mission changes and modifications that may be required during flight operations. The Mission Scientist participates in the aircraft post-flight debriefing and prepares the Mission Summary Report for inclusion in the VOCALS Field Catalog.

Weather Forecaster/Nowcaster Coordinator: Two forecasters from the Chilean Weather Service and the University of Chile will be available during the field campaign to provide forecasting support and updates to assist in mission selection. Their responsibilities include the following:

- Schedule daily operations support for forecasting and nowcasting including Pre-Flight Briefings;
- Prepare for and present of planning forecast information during the Daily Planning Meeting;
- Provide the daily forecast summary to be included in the Field Catalog;
- Prepare preflight briefing packages for all aircraft participating in a mission;
- Provide reports and products for the Aircraft Flight Scientists, as appropriate;
- Monitor weather conditions and short term forecasts during missions.

3.2 Daily Planning and Implementation Process

The VOCALS Mission Planning Team and VOCALS Science Group will have the day to day responsibility for selecting, developing, planning and executing the VOCALS mission objectives to address program science goals. The daily planning process involves several steps, including the preparation of weather forecasts, daily summaries and reports, the conduct of planning meetings and briefings, the preparation and finalizing of scientific mission proposals, followed by mission implementation and mission execution. These steps are described in detail below.

3.2.1 Daily Planning Meeting

While in the field, VOCALS planning meetings will be held daily to provide a forecast of the current and anticipated weather and synoptic situations, coordinate operations and scientific activities, keep track of facility status and resources, and plan missions to address VOCALS science objectives.

The **VOCALS Daily Planning Meeting**, which is co-chaired by the VOCALS Science Director and the VOCALS Operations Director, will be held daily at **1030 am** local time at the VOCALS Operations Center. Meetings will be conducted seven days a week throughout the field season including holidays, beginning **13 October 2008 thru 15 November 2008**. Meeting times will stay the same no matter whether VOCALS aircraft are operating in a daytime or nighttime mode. All project participants are encouraged to gather during the Daily Planning Meeting to discuss potential mission objectives for a specific day. The mid-morning schedule will provide sufficient time for the VOCALS forecasters to analyze weather conditions and prepare daily forecasts in preparation for the meeting, time for the VOCALS PIs to start initial mission planning discussions ahead of the meetings, and also allow for increased facility personnel participation during aircraft flight days. A Skype connection will allow VOCALS scientists at the Iquique Operations Center to actively participate in the deliberations. The timing of the decision making process is described at the end of this chapter.

The agenda for the Daily Planning Meeting will be the same each day and will include the following:

- Status of aircraft, research vessel, soundings and remote observing systems.
- Report on the status of scientific objectives and results of the last mission and/or update on the status of an on-going mission.
- Forecast discussion from 24-36 hours, special products; three day outlook (72 hours) to determine change over from day to nighttime operations and/or Lagrangian operations.
- Recommendations/proposals for next day's operations resulting in the selection of next day's operations (primary, alternate).
- Suggested schedule for aircraft operations (take-off time/PI participation).
- General announcements.

3.2.2 Mission Plan and Flight Plan Preparation

When there is a plan for a mission beginning the next day, a caucus of representatives from each aircraft (max 2) led by the designated VOCALS Science Director, will meet immediately following the Daily Planning Meeting to finalize the Mission Plan for the next 12-36 hours. This meeting may include other flight scientists or staff crucial to formulate the details of the Mission Plan. Multiple primary objectives may be possible depending on the location and availability of airborne facilities to conduct simultaneous missions in different regions of the VOCALS domain. The following items will be included in the final mission plan:

- Description of the primary and, if suggested, alternate mission, including a brief discussion of objectives and strategy and criteria for proceeding to the alternate mission.
- Weather forecast/nowcast support requirements
- Assignment of staffing for mission support for the next 24-36 hours.
- Preliminary Aircraft Operations Domain.
- Proposed aircraft flight plans.
- Schedule of operations:
    - Aircraft pre-flight briefing times
    - Aircraft take-off times
    - Debriefing schedule

Upon completion of the final mission plan, the aircraft mission scientists, Operations Director and the appropriate aircraft personnel prepare the operational flight plans and requirements.

3.2.3 Daily Facility Status Summary and Daily Operations Plan

A Daily Facility Status Summary and a Daily Operations Plan will be developed from the inputs to the Daily Planning Meeting and the Mission Planning Meeting. These two reports will be prepared by the Operations Director with help from appropriate staff and VOCALS participants. Both reports will be posted on the VOCALS-REx Field Catalog within three hours of the end of the Daily Planning Meeting.

The Daily Facility Status Summary will include the operational status of all research facilities incl. mission critical instruments. The Daily Operations Plan will include:

- Summary of ongoing and planned VOCALS operations and data collection;
- Proposed mission objectives for the upcoming mission;
- Schedule details for all aircraft and other special observations as appropriate;
- Other schedule highlights for the next 24 hours.

3.2.4 Facility Notification Procedure

Flight plan notifications and requirements will be communicated directly to all flight facilities at the end of the Daily Planning Meeting when mission planning has been finalized. Facility personnel will be notified by the Operations Director or a representative via phone as soon as possible to maximize crew duty rest requirements. All other VOCALS participants and interested parties will have access to these plans via the VOCALS Field Catalog. The Daily Operations Plan will be prepared once a day following the Daily Planning Meeting but will be updated by the Operations Director as changing plans warrant.

3.2.5 Air Traffic Control Notification Procedure

The preparation of aircraft flight tracks for submission to Air Traffic Control will be accomplished immediately after the Mission Plan has been finalized. The mission scientist of each aircraft facility will be responsible for preparing the flight plans for submission to the ATC. The advance notification will typically be 24 hours ahead of launch time with the provision for updating if required, and will be carried out by the Operations Director, who will assume Aircraft Coordinator responsibilities. Flight plans will be submitted to the air traffic agencies as required.

3.2.6 Go/No Go Decisions

During daytime missions, final go/no decisions are being made by 8 am before the aircrew leave for the airport. During a night time schedule, a final go/no decision is made at 15:00 PM local time on the previous day to allow for sufficient crew rest.

3.2.7 Pre-flight Planning Process

Pre-flight briefings for each aircraft are held 2 hours ahead of the scheduled aircraft take-off. These briefings are meant to provide any update in facility status, adjustments to flight plan, if possible, current observations, and short term weather forecast for the area of interest. The content will be similar for all facilities. The pre-flight briefing will be done by the mission scientist and take place at the airport.

3.2.8 Operations

Once mission plans are finalized and a decision to fly has been made, the responsibility for the conduct of operations shifts to the Operations Director. Each mission will have a dedicated Operations Director. Two Operations Directors will be in the field at all times, and will share operational responsibilities by alternating between missions. Each Operations Director will be responsible for all activities related to a specific mission starting with the daily planning meeting and ending with the debrief of the aircrew at the end of a flight day. Details about planned facility operations are described in Chapter4 through 6.

3.2.9 Aircraft Mission De-briefing

A representative of the aircraft flight crew and the flight scientist will participate in a de-briefing following each research flight. This will include aircraft facility and instrument status, a brief summary of flight operations and mission highlights, and aircraft availability for the next mission. Any operational or in-flight coordination issues will be brought up and discussed at this time. Debriefs will be kept short to allow crew and flight scientists to return the hotel as soon as possible after a long flight. Typically, the Operations Director and VOCALS Science Director will facilitate this meeting. The Mission Scientist will provide a mission summary within 24 hours of completion of a flight and submit it to the VOCALS Field Catalog.

3.3 Daily Operations Timeline

The table below illustrates the planning–implementation sequence of operational activities, emphasizing the scheduling of aircraft operations. Times are given relative to local time.

0600-1000	Forecasters supporting VOCALS operations will evaluate various current weather and forecast products; forecast preparation for Daily Planning meeting incl. submission to VOCALS Field Catalog
No later than 8 am	Go/No-go Decision for today’s daytime flight during daytime operations
By 1000	Various facility managers provide status update of all VOCALS facilities to VOCALS Field Catalog
1030-1130	Daily Planning Meeting
1130-1400	Preparation of Mission Plan for D+1
1130-1400	Preparation of Daily Briefing Report
1400-1600	Notification – facilities, ATC Centers, Field Catalog, R/V
1500	Go/No-go Decision for next day’s nighttime flight for nighttime operations

Table 3.2 – *Daily Operations Timeline*

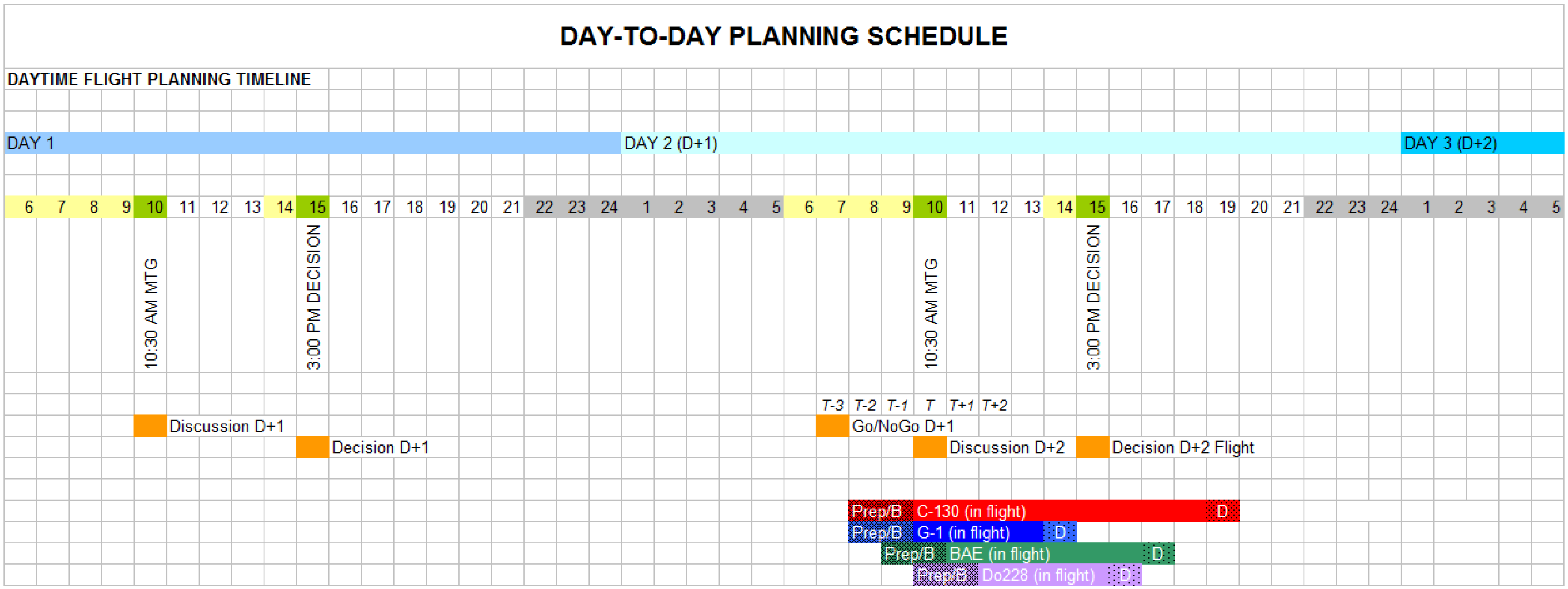


***Fig. 3.2** – Daytime Planning Timeline*

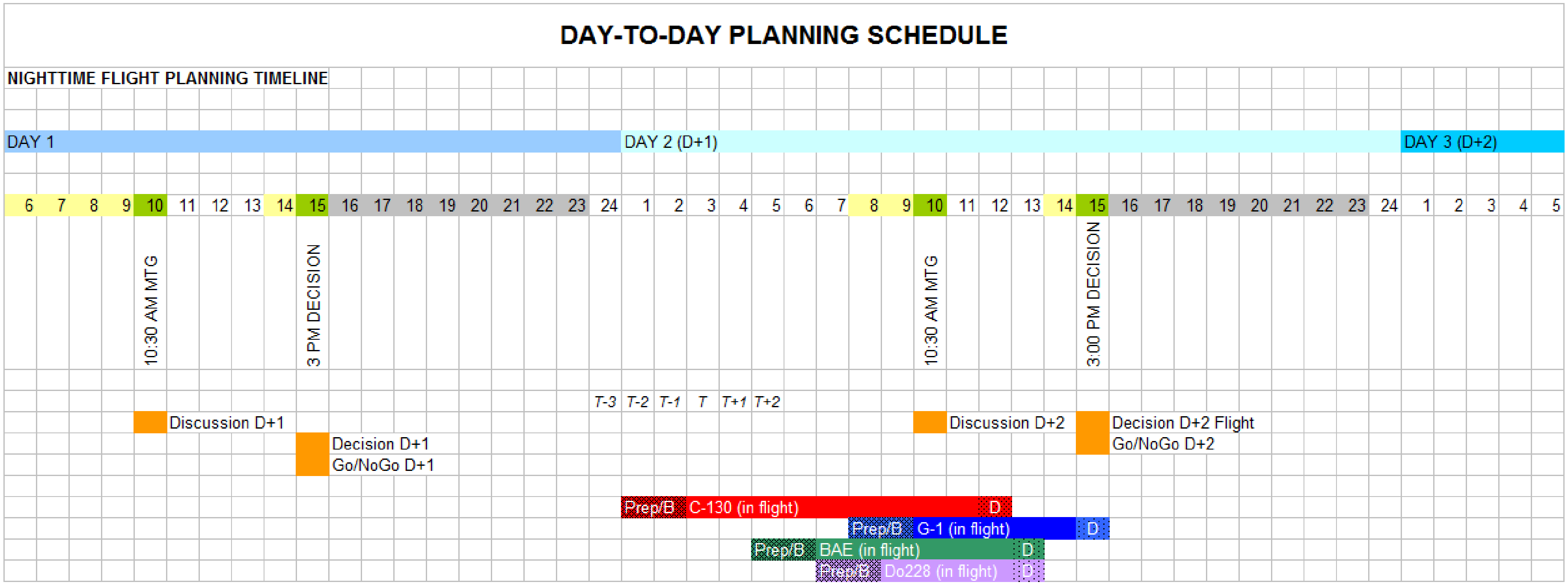


***Fig. 3.3** – Nighttime Planning Timeline*

3.4 VOCALS Project Communications

This section describes the key nodes and links in the VOCALS project to permit the flow of key data products and information among all participants. The communications network for VOCALS will involve several systems to assure reliable transfer of data, relay of information for facility coordination and updating of all project participants on project activities. The figure below provides a schematic overview of the variety of communications networks and systems that will be used in support of VOCALS operations.

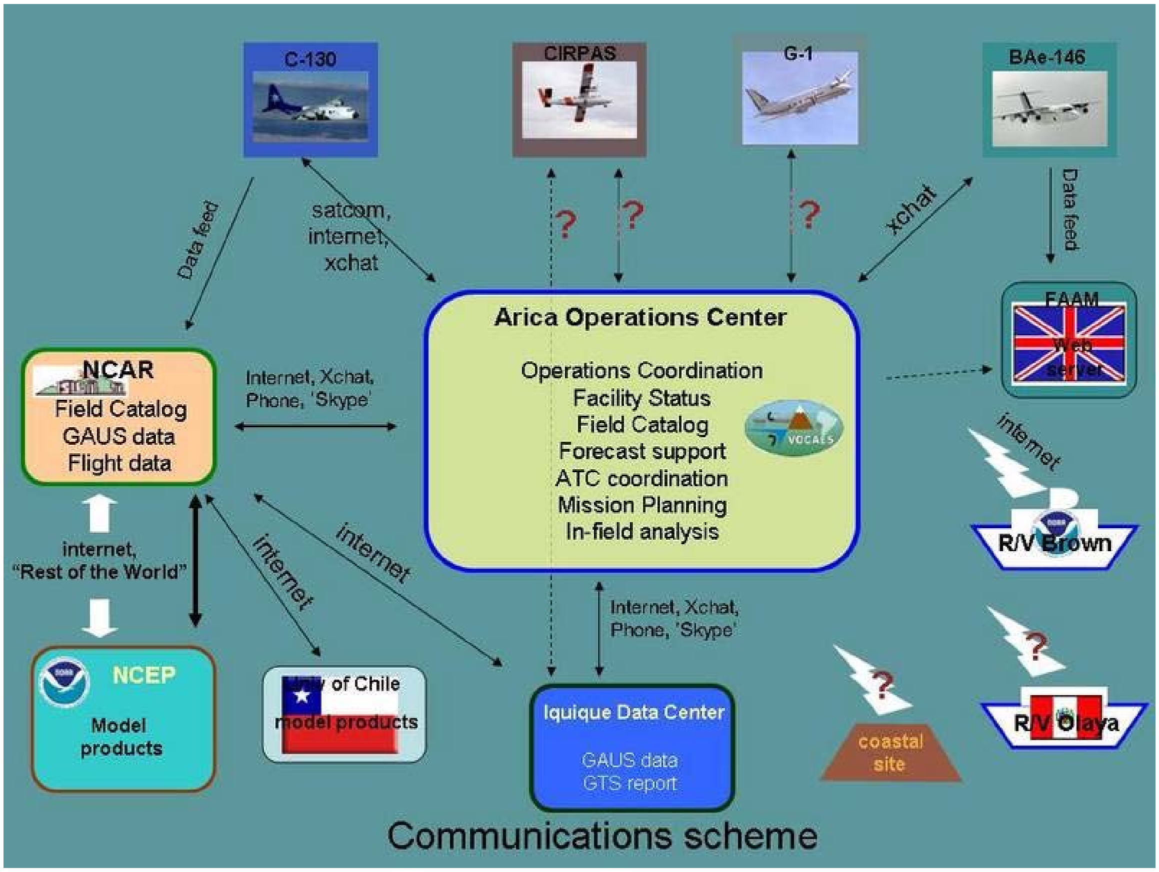


Figure XX: VOCALS Communications Diagram including critical links, paths and sources for information during the field phase

3.4.1 Capabilities of VOCALS Operations Center

The VOCALS Operations Center will be at the Hotel and Resort Arica. The hotel has full wideband Internet capabilities. The VOCALS Field Catalog will be updated from this site both automatically and manually to maximize information availability to the project participants. See Chapter 7 for more details on the Field Catalog.

The VOCALS Operations Center will connect to the Iquique Data Analysis Center utilizing either Skype or Ichat. Both systems will allow participants at locations other than Aria to join the daily meetings and participate via a Voice over IP link through the computer and with graphics in *Powerpoint* presentations. All discussion, questions and answers can be heard by all participants. The VOCALS Field Catalog will be accessible through the web.

Internet Relay Chat Capabilities: EOL will support Internet Relay Chat (IRC) capabilities for the Arica and Iquique operational locations, a subset of the VOCALS facilities and VOCALS participants on the ground, if they are interested. This is a real-time text message exchange protocol that will permit immediate messaging between centers and participants. This technology is currently used heavily by the EOL research aircraft and ground facilities, project scientists, engineers and technicians to relay information, debug instrumentation and provide updates during mission execution. It will also be possible for users to access chat archives to review previous messages. This tool will be particularly helpful to coordinate project operations across different research platforms and locations. EOL will support the server to host this software. Users need only install the free client on their own machine and log into the EOL chat server to participate. Instructions for downloading and operating the chat will be included in the VOCALS Field Catalog.

Aircraft Communications: All participating aircraft are equipped with several forms of communications that will permit the coordination needed to execute VOCALS observational strategies. Details of individual aircraft and ship communications capabilities are listed in Table XXX. These links will allow limited transmission of chat text messaging, aircraft-to aircraft voice contact, low resolution imagery and periodic relay of aircraft position and data. Satellite links are available for the transmission of data from and to the ground, including flight level and in-situ data. The satellite links also permit text messages to and from aircraft and the operations center.

Ship Communications: The VOCALS Chief Scientist or designated representative will have access to the RHB telecommunications systems. The ship's communications systems include:

- Inmarsat Mini-M: [1]
  - 011-874-761-831-360 or 011-874-761-831-361(Voice)
  - 011-874-761-831-362 (Fax)
  - 011-874-761-831-363 (Data)
- Inmarsat B: [1]
  - 011-874-336-899-620 (Voice)
  - 011-874-336-899-621 (Fax)
  - 011-874-336-899-622 (Data)
  - 011-874-336-899-623 (Telex)
  - 011-874-391-027-022 (HSD)

- Iridium: [3]
    - 011-8816-7631-5690 [3] (patched into PBX)
        - 808-659-5690

INMARSAT-B is used for high speed data transmission, including FTP, and high quality voice telephone communications. Costs are about $7.00 per minute for voice and $2.25 per minute for FAX.

INMARSAT-A is a backup for Inmarsat B. Costs are about $11.25 per minute for voice and $5.55 per minute for FAX.

INMARSAT STANDARD C is available for low speed store and forward telex messages, approximately 500 baud message transfer.

INMARSAT MINI-M is used for voice telephone communications and 2400 baud data transfer. Cost is about $3 per minute to the US. Mini-M coverage is by spot beam and may not be available in all the areas the ship may be working in.

IRIDIUM is available for voice communications. The cost is about $1.00 a minute.

An e-mail account will be established for each embarked personnel by the shipboard electronics staff.

Due to the escalating volume of e-mail and its associated transmission costs, each member of the ship's complement, crew and scientist, will be authorized to send/receive up to 15 KB of data per day ($1.50/day or $45/month) at no cost. Large data files (one megabyte or more), are blocked from transmission unless prior arrangement is made with the ET or the CO.

Chapter 4
VOCALS-REx Aircraft Operations

4.1 NSF/NCAR C-130

The NSF/NCAR C-130 Hercules, managed and operated by the National Center for Atmospheric Research in Colorado, is a four engine turboprop, that supports observational research studies of atmospheric chemistry, cloud physics, mesoscale meteorology, boundary-layer dynamics, air-sea interactions, oceanography, and other fields within the atmospheric sciences.

4.1.1 NSF/NCAR C-130 Specifications:

Max altitude	26,000 ft (7.925 km)
Range	1,800 nmi @1,000 ft 2,500 nmi @ 10,000 ft 3,100 nmi @ 20,000 ft
Speed	290 KTAS @normal cruise altitude 250 KTAS with instrument pods installed
Max endurance	10 hours
Gross weight	155,000 lbs
Payload	23,000 lb maximum
Owner:	U.S. National Science Foundation, Washington, D.C.
Registration Number:	N130AR
Destination:	Arica, Chile
Pilot Information:	Henry Boynton Captain ATP Cert # 2245308 Lowell Genzlinger Captain ATP Cert # 2069296 Edward Ringleman Captain ATP Cert # 28924391
Max Aircraft Crew	2 pilots, 1 flight engineer, 1 technician
Max Scientific Crew	15

4.1.2 NSF/NCAR C-130 Communications Capabilities

Basic communications capabilities on the NSF/NCAR C-130 involve voice, limited time-series data transfer (1 sample per sec), Google Earth display of flight tracks, and uploading/ downloading of low resolution imagery.

Iridium	Baud Rate	2400 baud
	Full Duplex	Up/down
	Reliability	Satellite coverage is uncertain
	Voice Phone #	011 8816-3146-8961 (direct dialing; between $2 - $7 per minute) 1-866-621-6057 followed by 8816-3146-8961 (toll free number to Iridium; $2.49 charged to Iridium Phone)
INMARSAT	Baud Rate	64 kbits/sec
	Full Duplex	Up/down
	Reliability	Drop outs in turns Satellite coverage is uncertain
	Voice phone cabin Voice phone cockpit	011-25-80093802 (direct dialing) 011-35-80093801 (direct dialing) 001-602-308-4641

4.1.3 NSF/NCAR C-130 Resource Allocation

The following resources were approved by NSF and allocated to the NSF/NCAR C-130:

Chief Scientist:	Dr. Robert Wood University of Washington robwood@atmos.washington.edu Phone: 206 543 1203
Total flight hours:	172 hours (120 research, 12 test, 40 ferry)
Total days in the field:	40 days
Total number of flights:	approximately 13 flights
Nighttime flights:	Yes
Funding Agency:	NSF

4.1.4 NSF/NCAR C-130 Overall Schedule

Instrument Upload	4 August – 28 September
Test Flights – RMMA	29 September – 9 October
Ferry to Arica, Chile	10 October – 12 October
Observation Period	15 October – 15 November
Ferry to RMMA	17 November – 19 November
Instrument Download	20 November – 27 November

4.1.5 NSF/NCAR C-130 Crew Rest and Flight Duty Limitations

Any 24-hour period	10 flight hours
Any consecutive 7 days	35 flight hours
Any 30-day period	110 flight hours
Consecutive working days	6 days
Crew duty period	14 hours
Minimum crew rest period	12 consecutive hours

The above mentioned limits may be exceeded for ferry purposes at project pilot's discretion. PIs are expected to follow the same crew duty rules as the crew.
It should also be noted that the C-130 pilot in command will always have the option of calling a no-flight day when consecutive flights are scheduled and crew fatigue is a factor.

4.1.6 NSF/NCAR C-130 Day to Night Time Operations Change-Over

The following tentative day and night time schedules are planned. Please note that a 24 hour notice to change from day flights to night flights and reverse is required. The change over effectively entails 36 hours: 12 hours crew rest after a mission/work day and 24 hour notification to adjust to a new sleep schedule. Please note that on no-fly days, the 36 hour period starts at the time of the notification; on flight days, the 36 hour period starts 1 hour after landing. Once on a night schedule, maintenance access is also only on night schedule.

Day-Time Schedule	7 am – 9 am	Warm up and pre flight
	9 am – 7 pm	Flight
	7 pm – 8 pm	Post flight
	12 hour rest	
Night-Time Schedule	0 am – 2 am	Warm up and pre flight
	2 am – 12 noon	Flight
	12 noon – 1 pm	Post flight
	12 hour rest	

4.1.7 NSF/NCAR C-130 Payload

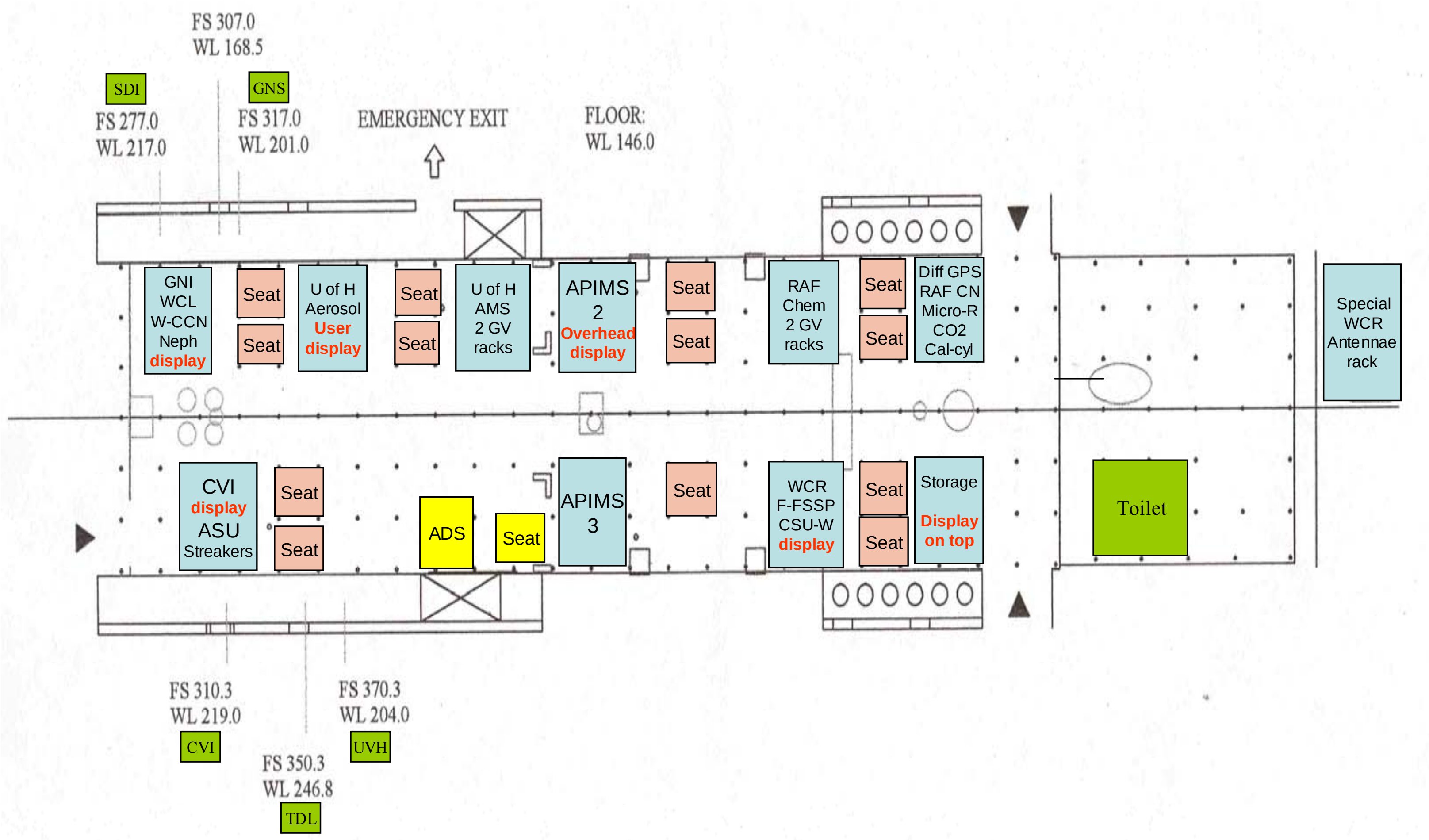
Instrument	Contact	University
Streaker on LTI, SEM, TEM	Jim Anderson	Arizona State
TSI 3010, 3025 CN counters	Howell & Clarke	U. of Hawaii
DMPS and APS	Howell & Clarke	U. of Hawaii
PSAP	Howell & Clarke	U. of Hawaii
3 wavelength TSI nephelometer	Howell & Clarke	U. of Hawaii
Real time AMS	Howell & Clarke	U. of Hawaii
Liquid Water Collector	Jeff Collett	CSU
Counterflow Virtual Impactor	Cindy Twohy	Oregon State
Giant Aerosol Impactor	Jorgen Jensen	NCAR
APIMS – SO_2	Alan Bandy	Drexel
APIMS – DMS	Alan Bandy	Drexel
UV Resonance Fluor. – CO	Teresa Campos	NCAR
TECO – O_3 (slow)	Teresa Campos	NCAR
NO chemiluminescence – O_3 (fast)	Teresa Campos	NCAR
Fast CO_2	Teresa Campos	NCAR
Wyoming Cloud Radar	Samuel Haimov	U. of Wyoming
Wyoming Cloud Lidar	Perry Wechsler	U. of Wyoming
Microwave Radiometer	P. Zuidema	U. of Miami
Wyoming CCN Counter	Jeff Snider	U. of Wyoming
PVM-100 Liquid Water	RAF	NCAR
SPP-100	RAF	NCAR
SPP-200	RAF	NCAR
SPP-300	RAF	NCAR
PMS-260X	RAF	NCAR
PMS-2D:C	RAF	NCAR
CDP Cloud Probe	RAF	NCAR
OPHIR Radiometric Temp	RAF	NCAR
Differential GPS	RAF	NCAR
RAF Remote Sfc Temp – Up	RAF	NCAR
French Fast FSSP	J.L Brenguier	Meteo France
TDL Hygrometer	RAF	NCAR
Wyoming CN Counters (2)	Jeff Snider	U. of Wyoming
UV Fast Hygrometer	RAF	NCAR
Standard Met Sensors	RAF	NCAR

4.1.8 NSF/NCAR C-130 Flight and Scientific Crew

The maximum crew compliment for the C-130 is 19, including the RAF flight crew. The current list of crew and operators for the NSF aircraft is 18:

1) Pilot
2) Pilot
3) Flight engineer
4) Mission scientist
5) ADS operator (RAF)
6) CVI operator (OSU)
7) Aerosol streaker operator (ASU)
8) CCN/CN operator (Wyoming)
9) GNI / Aerosol Stick operator (RAF)
10) Aerosol operator (U of Hawaii)
11) Aerosol operator (U of Hawaii)
12) SO_2 operator (Drexel)
13) DMS operator (Drexel)
14) Trace Gas Chemistry operator (RAF)
15) WCR/WCL operator (Wyoming)
16) Fast FSSP operator (France)
17) Liquid Water Collector operator (CSU)
18) Microwave Radiometer operator (Miami)

DRAFT C-130 LAYOUT FOR VOCALS
6/12/08



4.1.9 NSF/NCAR C-130 Real-Time and Post Flight Tools

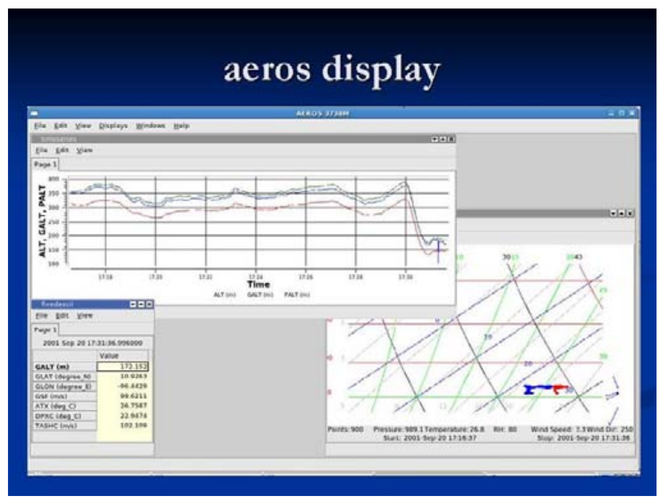
Real-Time Tools:

The following tools are available on the ground as well as onboard the aircraft

(1) Google Earth Flight Tracks with satellite image overlays

(2) Internet Relay Chat (IRC), which allows text communications with participants no matter where they are located.

(3) *Aeros Display Program*
For viewing of preliminary data on Windows XP and Unix/Linux



Post Flight Tools:

(1) Display Programs:
ncplot – general time series
ncpp - size distributions
xpms2d – PMS2D Image data

(2) Ascii Converters
N2asc – netCDSF to ASCII
Asc2cds – ASCII to netCDS

4.2 DOE ASP G-1

Stationed at Pacific Northwest National Laboratory in Richland, Washington State, the Battelle Gulfstream G-1 is a two engine turboprop, used to collect aerosol and other atmospheric data around the world.

4.2.1 DOE ASP G-1 Specifications

Max altitude	30,000 ft
Range	1,500 nmi
Speed	160-290 knots (cruise) 195 knots (sampling)
Max endurance	6 hours
Gross weight	36,000 lbs
Payload	2,500 lb maximum
Owner:	Battelle Memorial Institute, Columbus, OH, USA
Registration Number:	N701BN
Destination:	Arica, Chile
Pilot Information:	Robert V. Hannigan, Captain
Max Crew	2 pilots, 5 scientists

4.2.2 DOE ASP G-1 Communications Capabilities

Iridium	Baud Rate	19.2 K
	Full Duplex	n/a
	Reliability	90%
	Voice Phone	n/a

4.2.3 DOE ASP G-1 Resource Allocation

Chief Scientist:	Dr. Peter Daum Brookhaven National Lab phdaum@bnl.gov 631/344 7283
Total flight hours:	60 to 70 research hours
Total days in the field:	46
Total number of flights:	10-12 (4 hr flights)
Night flights	None
Funding Agency:	DOE Atmospheric Sciences Program

4.2.4 DOE ASP G-1 Overall Schedule

Instrument Upload	14 June - 1 August 2008
Test Flights	16 June – 5 August 2008
Ferry to Arica, Chile	5 – 8 October 2008
Observation Period	15 October – 15 November
Ferry to Houston, TX	18 November – 19 November
Instrument Download	20 November – 21 November

4.2.5 DOE G-1 Crew Rest and Flight Duty Limitations

Any 24-hour period	12 hrs
Any consecutive 7 days	12 hrs/day or following 24 hours off
Any 30-day period	12 hrs/day or following 24 hours off
Consecutive working days	12 hrs/day or following 24 hours off
Crew duty period	12 hrs
Minimum crew rest period	12 hrs

4.2.6 DOE G-1 Flight and Scientific Crew

The maximum crew compliment for the G-1 is seven, including the flight crew. The current list of crew and operators for the aircraft is as follows:

Robert V. Hannigan, PNNL	Pilot In Command,
J Richard Hone, PNNL	Copilot
E William Svancara, PNNL	Copilot
Gene Dukes, PNNL contractor	mechanic
John M. Hubbe, PNNL	Flight engineer & project manager
Mikhail Pekour, PNNL	Instrument scientist & ground support
Connor Flynn, PNNL	Instrument scientist & ground support
Stephen Springston, BNL	Flight scientist, data system
Gunnar Senum, BNL	Flight scientist for CAPS
Yin-Nan Lee, BNL	Flight scientist for AMS
Art Sedlacek, BNL	Flight scientist for PTI, FIMS and TSEMS
Peter Daum, BNL	Flight scientist
Larry Kleinman, BNL	Flight scientist

4.2.7 DOE G-1 Payload

AEROSOL and CLOUD MICROPHYSICS		
Parameter	**Instrument**	**Source**
Aerosol Size Distribution 0.1 – 3 µm	PCASP	PNNL
Aerosol Size Distribution 30 – 120 nm	FIMS	BNL
Aerosol Concentration D > 10 nm	TSI 3010	PNNL
Aerosol Concentration D > 3 nm	TSI 3025	PNNL
Cloud Droplet and drizzle size distribution	DMT CAPS	BNL
Cloud Liquid Water Content	Gerber Probe / CAPS Probe	PNNL/BLN

AEROSOL PROPERTIES		
Parameter	Instrument	Source
Aerosol Composition – soluble inorganic and organic species	PILS	BNL
Aerosol Composition	Aerodyne ToF-AMS (high resolution)	BNL/PNNL/Aerodyne
CCN	3 DMT CCN 1 dual, 2 single	BNL/PNNL
Aerosol extinction and backscatter	TSI 3ʎ Integrating Nephelometer	PNNL
Aerosol absorption	Photothermal	BNL

TRACE GASES		
Parameter	Instrument	Source
O_3	Thermo Electron 49-100	BNL
CO	UV Fluorescence	BNL
SO_2	Thermo Electron 43S modified	BNL
DMS/Organics	PTRMS	PNNL

4.3 DeHavilland Twin Otter (DHC-6)

The Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS), a research center at the Naval Postgraduate School in Monterey, California, operates this non-pressurized, two engine aircraft in support of the science community.

4.3.1 CIRPAS Twin Otter Specifications

Max altitude	18,000 ft (12,000 ft without oxygen)
Range	400 km
Speed	100 -150 kts
Max endurance	4 to 5 hours
Gross weight	13,500 lb (6,140 kg)
Payload	1,500 lb maximum
Owner:	Naval Postgraduate School/CIRPAS, USA
Registration Number:	762256
Destination:	Iquique, Chile
Pilot Information:	Mike Hubbell - Chief Pilot
Max Crew	2 pilots, 2 scientists

4.3.2 CIRPAS Twin Otter Communications Capabilities

Iridium	Baud Rate	2400
	Full Duplex	Yes – voice only
	Reliability	100% - clear view of sky
	Phone Number	TBA
INMARSAT	Baud Rate	11 kbps (transfer rate)
	Full Duplex	No - asymmetric
	Reliability	50%
	Phone Number	MPDS only

4.3.3 CIRPAS Twin Otter Resource Allocation

The following resources were approved by ONR and allocated to the Twin Otter:

Chief Scientist:	Bruce Albrecht University of Miami balbrecht@rsmas.miami.edu 305/421 4043
Total flight hours:	80-100 hours (20-25 hrs/week)
Total days in the field:	40
Total number of flights:	20 (4 hour duration)
Night flights:	Possible but mainly daytime
Funding Agency:	ONR

4.3.4 CIRPAS Twin Otter Overall Schedule

Instrument Upload	9-14 October 2008
Test Flights	None
Ferry to Iquique, Chile	5-8 October 2008
Observation Period	15 October – 15 November 2008
Ferry to Monterey, CA	19-23 November 2008
Instrument Download	16-19 November

4.3.5 CIRPAS Twin Otter Crew Rest and Flight Duty Limitations

Any 24-hour period	12 hours
Any consecutive 7 days	2 days
Any 30-day period	n/a
Consecutive working days	Work 3 – down 1 – work 2 – down 1
Crew duty period	12 hr/day
Minimum crew rest period	12 hr/day

4.3.6 CIRPAS Twin Otter Payload

INSTRUMENT	OBSERVATIONS/PURPOSE
Standard met	Winds, temp, dewpoint, cloud liquid water, sfc temp
Turbulence Probes	High speed wind, temp, and moisture (Friehe)
94 GHz Doppler FMCW radar	Cloud properties, in cloud turbulence
Chaff (Dropsonde) Dispenser (with radar)	Track air movements – entrainment, sub-cloud layer coupling, large eddies
3 CPCs	Ultrafine aerosols
PCASP	Aerosols 0.1 – 3 µm
FSSP	Clouds 2 – 40 µm
CIP	Drizzle 25-1500 µm
CCN-200	CCN (fast 2 point, slow 6 points)
Photoacoustic	BC absorption
Phased Doppler Interferometer	Cloud drizzle 2-600 µm
SP2-Black Carbon	BC mass and ratio to total particles

4.4 BRITISH AEROSPACE BAE-146-301

FAAM or the Facility for Airborne Atmospheric Measurements is the result of a collaboration between the UK Met Office and the Natural Environment Research Council (NERC). The modified BAE 146 aircraft is a four engine jet and is owned by BAE Systems and operated for them by Directflight. The home base is at Cranfield University, Bedfordshire in the UK. The aircraft has many uses including radiative transfer studies in clear and cloudy air, tropospheric chemistry measurements , cloud physics and dynamic studies and remote sensing.

4.4.1 BAe-146 FAAM Specifications

Max/Min altitude	35,000 ft / 50 ft
Range	1800 nautical miles
Speed	Research: 200 knots TAS, Cruise 230; Max 305
Max endurance	5 hours
Gross weight	93,000 lb (42,184 kg)
Payload	4000 kg maximum
Owner: Operated by: Operated for:	British Aerospace Systems (BAES) Directflight Ltd Facility for Airborne Atmospheric Measurements (FAAM), UK
Registration Number:	G-LUXE
Destination:	Arica, Chile
Pilot Information:	Latty Lathouwers
Max Aircraft Crew	3 Crew
Max Scientific Crew	17 Scientists

4.4.2 BAe-146 FAAM Communications Capabilities

INMARSAT Aero C	Baud Rate	600bps
	Full Duplex	Simplex
	Reliability	Good
	Phone Number	N/A, sends position reports to ground and send/receive text emails
Iridium Aero H	Baud Rate	10.5kbps
	Full Duplex	Yes
	Reliability	Reasonable – dependent on traffic & coverage
	Phone Number	00 871 52000 4032 – Please keep private
INMARSAT Swift 64	Baud Rate	64kbps data
	Full Duplex	Yes
	Reliability	Reasonable– dependent on traffic & coverage
	Phone Number	N/A, used to access internet, webmail etc.

4.4.3 BAe-146 FAAM Resource Allocation

The following resources were approved by the UK Met Office and allocated to the BAE FAAM:

Chief Scientist:	Phil Brown UK Met Office Phil.brown@metoffice.gov.uk 01392 886740
Total flight hours:	120 flight hours total (incl. ferry)
Total days in the field:	28 days
Total number of flights:	10 flights, 5 to 5.5 hours duration
Night flights:	Yes
Funding Agency	UK Met Office & NERC

4.4.4 BAe-146 FAAM Overall Schedule

Instrument Upload	16 October
Test Flights	17 – 20 October
Preparation & Ferry to Arica, Chile	21-24 October
Observation Period	26 October to 14 November
Pack up and Ferry to UK	15-19 November
Instrument Download	19 October

4.4.5 BAe-146 FAAM Crew Rest and Flight Duty Limitations

- A single day off will include 2 local nights and cover at least 34 hours;
- Crew members will not be on duty more than 7 consecutive days between days off;
- Crew members will have 2 consecutive days off in any consecutive 14 days following the previous 2 days off;
- Crew members will have a minimum of 7 days off in any consecutive 4 weeks;
- Crew members will have an average of at least 8 days off in each consecutive 4 week period, averaged over 3 such periods.

Maximum Flight Duty Periods

Local Time of Start	Number of Flights				
	1	2	3	4	5
0600-0659	13	12 ¼	11 ½	10 ¾	10
0700 – 1259	14	13 ¼	12 ½	11 ¾	11
1300 – 1759	13	12 ¼	11 ½	10 ¾	10
1800-2159	12	11 ¼	10 ½	9 ¾	9
2200-0559	11	10 ¼	9 ½	9	9

4.2.6 BAe-146 FAAM Day to Night Time Operations Change-Over

The following tentative day and night time schedules are planned.

Day-Time Schedule	Take-off – 4 hours	Warm up and pre flight
	0700-1200 (for 20S flights)	Flight
	2 hours post flight	Post flight
Night-Time Schedule	Take-off – 4 hours	Warm up and pre flight
	On an opportunity basis	Flight
	2 hours post flight	Post flight

4.2.7 BAe-146 FAAM Flight and Scientific Crew

The maximum crew compliment for the FAAM is 20, including the flight crew. The current list of crew and operators for the aircraft is as follows:

Science Crew	**Pilots**
Maureen Smith	Alan Foster
Doug Anderson	Alan Roberts
Steve Devereau	Luc Lathouwers
Jim Crawford	Ian Ramsey-Rae
Kate Turnbull	
Jamie Trembath	**Cabin Crew**
Guy Gratton	Gaynor Ottoway
Phil Brown	Dawn Quinn
Steve Abel	Tracie Wells
Paul Barrett	
James Bowles	**Ground Engineers**
Jeff Norwood-Brown	Dean Warrilow
Debbie O'Sullivan	John Kitchen
Martyn Pickering	Jason Smith
Stuart Rogers	Andy Boardman
Andy Wilson	
Martin Glew	**Ground Operations**
Hugh Coe	Peter Chappell
Keith Brower	Steven Douglas
James Allan	
Jonny Crosier	
James Dorsey	
Michael Flynn	
Martin Gallagher	
Paul Williams	
Geraint Vaughan	
Alan Gadian	
Jim McQuaid	
Mark Bart	
Grant Allen	

4.2.8 BAe-146 FAAM Scientific Payload

RADIATION MEASUREMENTS	
Microwave Radiometer (MARSS)	Upward and downward pointing (+40° to -40°) Five channels: 89-183 GHz Derive LWP, T + q structure
Shortwave Spectrometer (SWS)	Pointable high resolution spectrometer measuring radiance across spectral range 0.3 – 1.7 µm MODIS type retrievals of cloud properties
Spectral Hemispheric Irradiance Measurement (SHIM)	As SWS but hemispherically integrated. Mounted on top and bottom of aircraft. Derive cloud optical depth
Broad Band Radiometers	Derive cloud optical depth
Heimann Radiometer	Sea Surface Temperature
Airborne Research Interferometer Evaluation System (ARIES)	Interferometer producing high resolution spectra 18-3.3 µm. Retrieve profiles of gases (CO_2, H_2O, O_3 etc) and sea surface temperature. Cloud info incl. cloud top temperature

CLOUD AEROSOL PHYSICS –SIZE SPECTRA		
SMPS	Non-core	20-600nm (TBC)
UHSAS	Non-core	55-1000nm, 99 channels
PCASP	Core	0.1-3µm
FFSSP	Core	1-47µm
CDP	Non-core	2-50 µm (may not be available).
SID-2	Non-core	U/S
2D-C	Core	25-800µm (32 bins 25µm resolution)
2 D-P	Core	200-6400µm (32 bins 200µm resolution)
CIP-Greyscake	Non-core (test)	15-930µm (64 bins 15µm resolution)
CIP-100	Non-core (test)	100-6200µm (64 bins 100µm resolution)
2D-S	Non-core	10µm to > 2mm 2D imaging B&W
CAPS (CAS + CIP)	Non-core	CAS PbP 0.5-50µm CIP Greyscale 25, 25-1550µm 2D imaging grey

AEROSOL AND CLOUD MEASUREMENTS: BULK	
LWC	Johnson Williams, Nevzerov LWC, Nevzerov TWC
Total Water Content	Liquid & Ice & Vapor (Lyman-α absorption hygrometer
CCN	Dual channel continuous flow
Condensation Particle Counter	TSI-3025A Aerosol concentration > 3 nm
Aerosol Mass Spectrometer	Mass of non-refractory components of aerosol particles as a function of size (50-500 nm)
Single Particle Soot Photometer (SP2)	Black carbon mass (single particle basis)
Filters	Sub and Supermicron
CVI	Residual particle and vapor from cloud drops
Nephelometer	Aerosol scatterying (dry) at λ -= 450,550, 700 nm
Wet Nephelometer	Aerosol scattering f(RH) at λ = 450, 550, 700 nm
PSAP	Aerosol absorption at λ =567 nm

OTHER INSTRUMENTATION	
Core Chemistry	CO, O_3, NO_x, SO2
Thermodynamics	Temp, Humidity, Pressure
Dynamics	Turbulence Probe
Sondes	50
Video Cameras	Upward, Downward, Forward, Rear

4.5 NERC ARSF Dornier 228

The NERC Airborne Research & Survey Facility (ARSF, formerly Airborne Remote Sensing Facility), located at Oxford airport, Kidlington, manages a Dornier 228 twin turbo-prop powered, non-pressurized, shoulder-wing monoplane with rectangular-section fuselage and a double passenger/cargo door. The aircraft is used in the fields of optical remote sensing, oceanography, atmospheric and earth science research.

4.5.1 NERC ARSF Dornier 228 Specifications

Max altitude	15, 000 ft
Range	800 nautical miles (FL150)
Speed	200 KTAS (FL150)
Max endurance	4 hours
Gross weight	6000 kg
Payload	2202 kg
Owner:	NERC, UK
Registration Number:	D-CALM
Destination:	Arica, Chile
Pilot Information:	Carl Joseph David Davies James Johnson Lance Dutton
Max Aircraft Crew	2
Max Scientific Crew	3

4.5.2 NERC ARSF Dornier 228 Communications Capabilities

Iridium	Baud Rate	2400 bps
	Full Duplex	Up/Down
	Reliability	Satellite coverage is uncertain
	Phone Number	008816131450105

4.5.3 NERC ASRF Dornier 228 Resource Allocation

The following resources were approved by NERC and allocated to the Dornier aircraft:

Chief Scientist:	Prof. Geraint Vaughan (Geraint.vaughan@manchester.ac.uk)
Total flight hours:	50 science hours
Total days in the field:	22
Total number of flights:	~12 flights at 4 hours
Night flights:	No
Funding Agency:	NERC

4.5.4 NERC ASRF Dornier 228 Overall Schedule

Instrument Upload	29th Sep to 3rd October
Test Flights	24th October
Ferry to Arica, Chile	15th Oct – 22nd October
Observation Period	26th October – 14th November
Ferry to Oxford, UK	16th November – 23rd November
Instrument Download	25th November

4.5.5 NERC ASRF Dornier 228 Crew Rest and Flight Duty Limitations

Any 24-hour period	10 flight hours
Any consecutive 7 days	35 flight hours
Any 30-day period	110 flight hours
Consecutive working days	6 days
Crew duty period	14 hours
Minimum crew rest period	12 consecutive hours

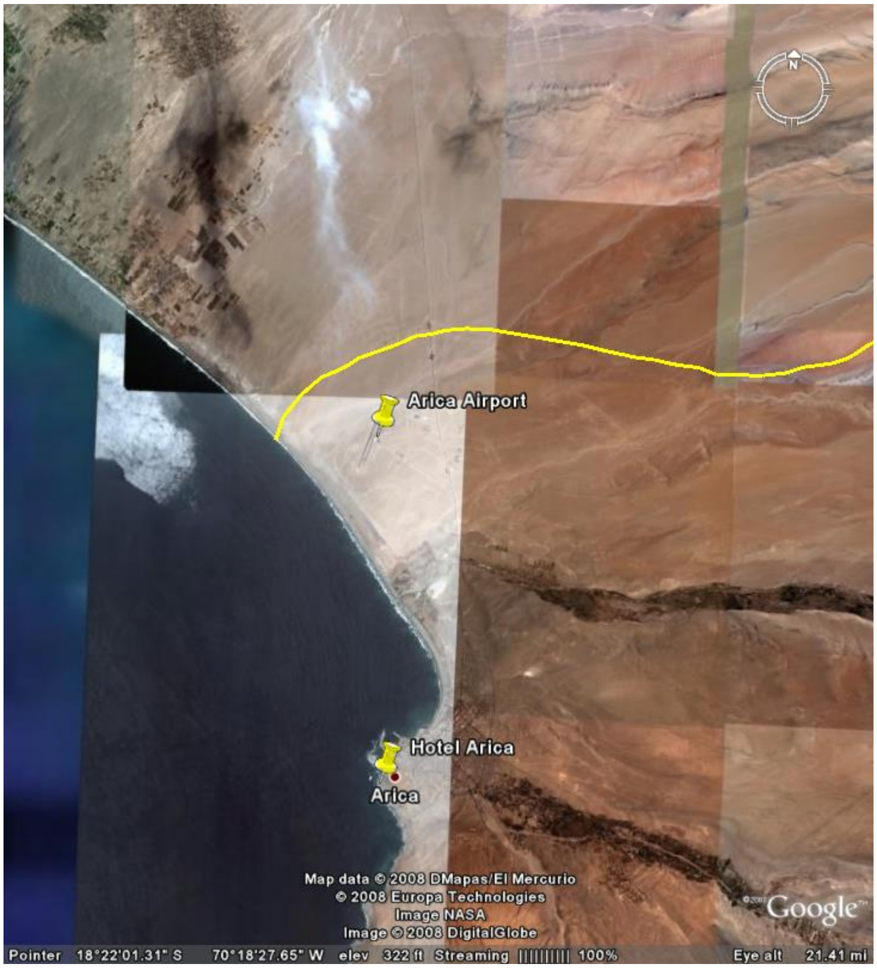
4.5.6 NERC ASRF Dornier 228 Payload

Instrument	Contact	Description
LIDAR	Hugo Ricketts, U. Man	Leosphere (ALS300) aerosol backscatter
FSSP-100	Martin Gallagher, U. Man	Particle Measuring Systems Inc. Forward scattering coarse-mode aerosol probe ($0.5<D_p<32$ µm, 42 channels)
PCASP-100	Martin Gallagher, U. Man	Passive Cavity Aerosol Spectrometer Probe. 20 size channels 0.1 – 3 µm
Grimm 1.108	Martin Gallagher, U. Man	Grimm Technologies Inc 1.108 Accumulation and coarse-mode Optical Aerosol Sizing Probe ($0.3<D_p<25$ µm, 15 channels)
Hyperspectral Imaging	Phil Goy, NERC ARSF Lorenzo Labrador, U. Man	Specim AISA Eagle and Hawk hyperspectral imagers (pushbroom systems): *Eagle:* Swath Width: 1000 pixel Visible and near IR spectrum 400-970 nm; Spectral resolution: 2.9 nm *Hawk:* Wavelength range: 970-2450 nm Pixels: 320 Spectral pixels: 244 Spectral resolution: 8 nm
AMSSP	Thomas Rühtz, U. Berlin	Airborne Multi- Spectral Sunphoto- & Polarimeter Full Spectral Range: 350 – 2400 nm, spectral resolution (VIS 10 nm, NIR, 20 nm), FOV – 1.5 deg
AIMMS	David Davies, ARSF	Thermodynamic and position data: RH, winds (no turbulence), temperature, pressure, GPS, aircraft configuration. 1 Hz logging frequency

Aircraft Contact Information

AIRCRAFT	Project Manager	Affiliation	Email	Phone	# of staff
BAe-146	Maureen (Mo) Smith	FAAM	masmi@faam.ac.uk		30 total
C-130	Al Schanot	EOL	schanot@ucar.edu	303/497-1063	
Dornier 288	Geraint Vaughan	U. Man	Geraint.vaughan@manchester.ac.uk	+44(0)1613063931	14 total (4 pilots, 2 techs, 4 scientists)
G-1	John Hubbe Stephen Springston	PNNL BNL	John.hubbe@pnl.gov srs@bnl.gov	509/372-6134 631/344-4477	13 total (2 pilots, 3 techs, 8 scientists)
Twin Otter	Haf Jonsson	NPS	hjonsson@nps.edu		10 total

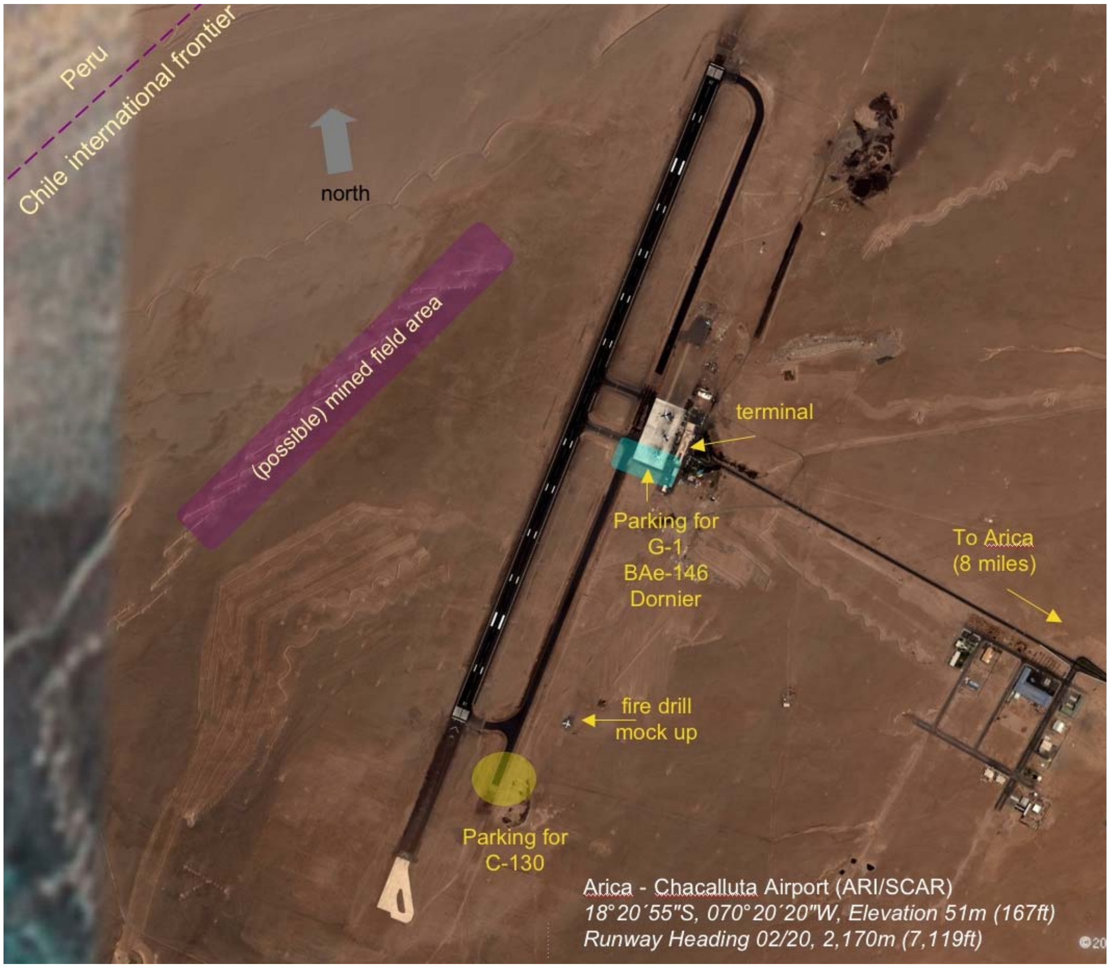
4.6 VOCALS Aircraft Operational Bases



4.6.1 Aeropuerto Internacional Chacalluta, Arica

Four of the five VOCALS aircraft will be based at the International Airport Chacalluta, Arica. The NSF/NCAR C-130, the UK BAe-146 FAAM, the NERC Dornier 228 and the DOE ASP G1 will conduct operations off-shore, spanning a radius up to 648 nmi or 1200 km.

ICAO code SCAR; /IATA code: ARI
Type: Airport (Aerodrome, Airfield)
Use: Public/Civil
Latitude: 18°20'55"S (-18.348531) Longitude:70°20'19"W (-70.338742) 1984
Elevation:167 ft (51 m)
Runways: 1 - 7119 × 148 ft (2170 × 45 m)



Limited parking space is available for the four aircraft at the Chacalluta Airport. The C-130 will be parked on the southern end of the taxiway, while the other three aircraft will parked in a row on the south end of the apron area. The apron area is about 100 x 200 meters. Access to the airport will be via the main gate on the south-east corner of the terminal and requires a VOCALS security badge. Vehicle access will be allowed so the C-130 crew will be able to drive to the C-130 location for pre-flight and maintenance tasks. All personnel driving on the airport will have to attend training that will be provided by the airport.

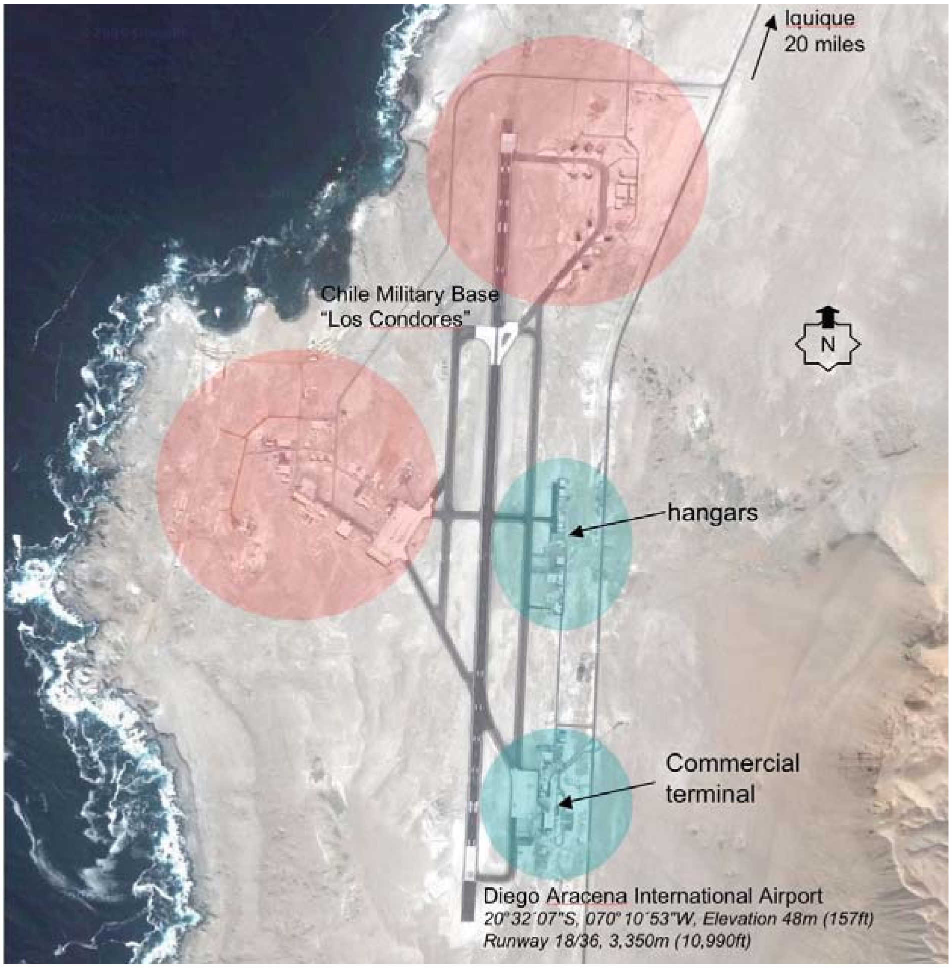
The existing infrastructure at Chacalluta is limited and no hangar, office or storage space is available through at the airport. Restroom facilities are available in the terminal and a limited number of chemical toilets near the C-130. How about electrical? Internet?

4.6.2 DIEGO ARACENA INTERNATIONAL AIRPORT, IQUIQUE

The CIRPAS Twin Otter will operate out of Diego Aracena International Airport, Iquique about 35 minutes south of downtown via Ruta 1 (25 miles). The positioning of the CIRPAS Twin Otter separate from the other VOCALS aircraft is intended to maximize the aircraft's on station time. The aircraft will normally conduct operations in off-shore of Iquique (approximately 950 nmi radius). The Twin Otter's primary mission is to support measurements to address aerosol-cloud-drizzle-turbulence interactions in boundary layer clouds.

ICAO code SCDA; /IATA code: IQQ
Type: Airport (Aerodrome, Airfield)
Use: Public/Civil, Military
Latitude: 20°32'07"S (-20.535222) Longitude:70°10'53"W (-70.181275)
Elevation: 155 ft (47 m)
Runways: 1, Longest: 10991 × 148 ft (3350 × 45 m)

The aircraft will be parked north of the main terminal to the east of the taxiway. Access to the airport will be via the main gate on the east side of the airport, and requires a VOCALS security badge. Vehicle access will be allowed so the Twin Otter crew will be able to drive to the aircraft location for pre-flight and maintenance tasks. All personnel driving on the airport will have to attend training that will be provided by the airport.



4.7 VOCALS Aircraft Missions

4.7.1 KEY MISSION STRATEGIES

The following key mission strategies will provide the range of sampling necessary to address the VOCALS-REx hypotheses:

1. **Cross-section missions** along 20°S latitude from the coast to the close to the IMET buoy at 85°W.
2. **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.
3. **Stacked cloud and radiation missions** in which two aircraft will simultaneously sample the same airmass at different levels with the upper aircraft primarily serving as a radiation/remote sensing platform.
4. **Coastal zone Point-to-Point and Gradient missions** in which a single aircraft (or multiple aircraft) samples an airmass either between fixed points or along a strong gradient in microphysical properties.
5. **Multi-flight quasi-Lagrangian missions** in which multiple aircraft are used to sample an advecting airmass sequentially over a time period of 12-36 hours.
6. **Test and intercomparison flights** will be conducted with the RHB and/or with other aircraft.

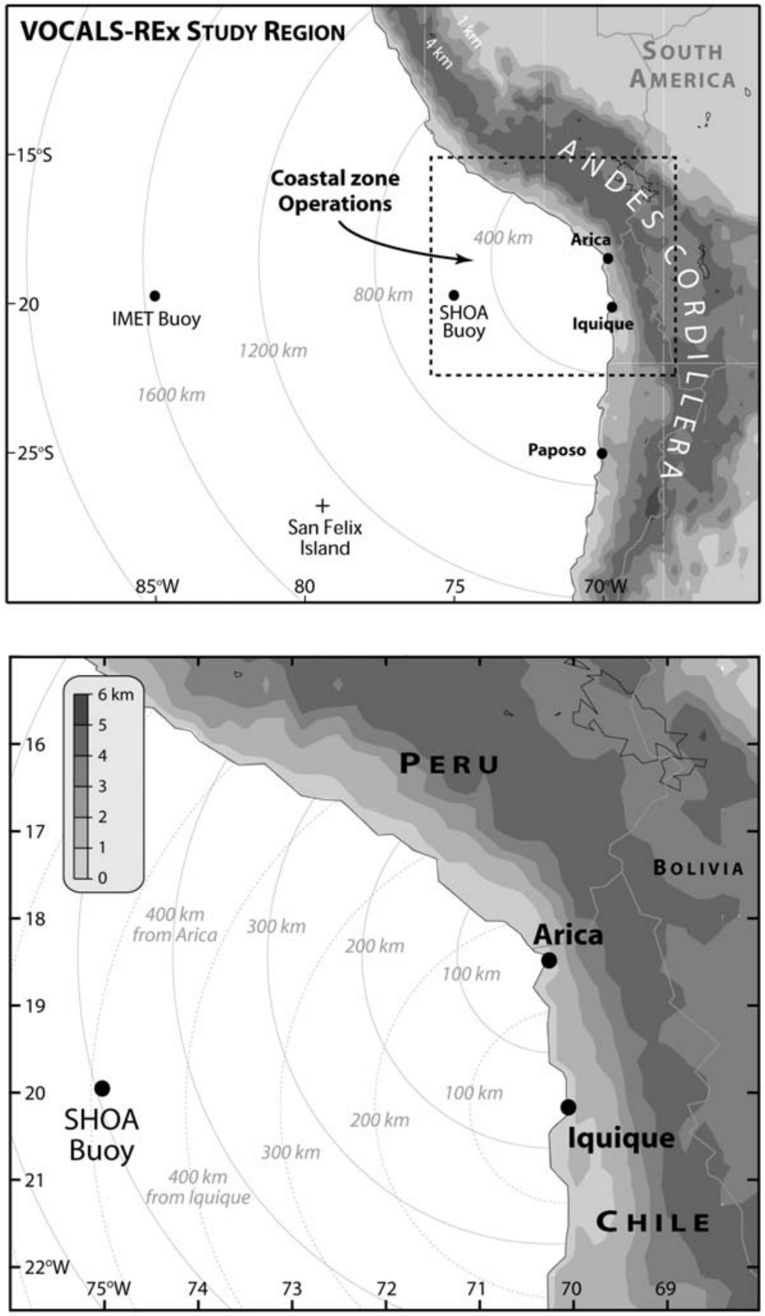


Fig 4.7.1: VOCALS-REX study region (top) and enlargement of the Coastal zone operations region (bottom). Distances from Arica are given in top panel; distances from both Arica and Iquique are given in the lower panel.

Table 4.7.1: Mission types and details

Mission type	Mission details	Aircraft and roles
Cross Section Missions (see also Figs. 4.7.3)	• 5 – 6 flights for C-130 (~50 research hours) • 9 hour duration (C-130) • 10 min legs (below, in and above clouds, approx. 12 each) • Profiles up to 4km • Night missions: **Take–off: 3-4 am**; **Land: noon-1pm** (local time) • Flight track: along 20°S (transit from Arica to 72°W, 20°S then along 20°S to 82-85°W) • Each C-130 flight to include RHB Co-sampling (30-40 minutes)	• C-130 alone • BAe-146 alone • C-130 and BAe-146 together • Dornier may cosample (overfly) during start or end of missions • G-1 may cosample during end of mission
POC-Drift Missions (see also Fig. 4.7.4)	• 5 – 6 flights for C-130 (~50 research hours) • 9 hour duration (C-130) • **Take-off: 10 am; Land: 7 pm** (local time) • Flight track: variable depending upon POC location	• Chiefly C-130 alone • Occasionally BAe-146 or G-1 but separately
Stacked cloud/radiation Missions (see also Fig. 4.7.5)	• Daytime flights only. • Flight track: near-coastal zone, horizontal legs between fixed points	• Chiefly BAe-146 and Dornier 228 • G-1 may also participate
Coastal zone cloud sampling Missions (see also Figs. 4.7.6)	• Single-aircraft missions • Mostly daytime flights • Flight track: Typically horizontal legs and some profiles sampling subcloud, cloud and FT	• Chiefly G-1 and Twin Otter • Some BAe-146
Multi-flight quasi-Lagrangian Mission (see also Fig. 4.7.7)	• Multi-aircraft (sequentially) • Flight track: as for POC-drift mission • Aircraft flights spaced by 6-12 hours (requires intense planning) • One crossing POC boundary; a possible second mission in polluted near-coastal airmass	• Twin Otter/G-1 (Flight 1); BAe-146 (Flight 2); C-130 (Flight 3)
Test/Inter-comparisons (see also Fig. 4.7.8)	• 3 – 4 flights (<20 research hours) • 4 hour duration • Flight track: In near-coastal region, subcloud (side-by-side), in-cloud (sequential), and FT (side-by-side) intercomparison legs	• Two or more aircraft • Cosampling between C-130 and RHB (as part of Cross-Section Missions)

1. Cross-Section missions:

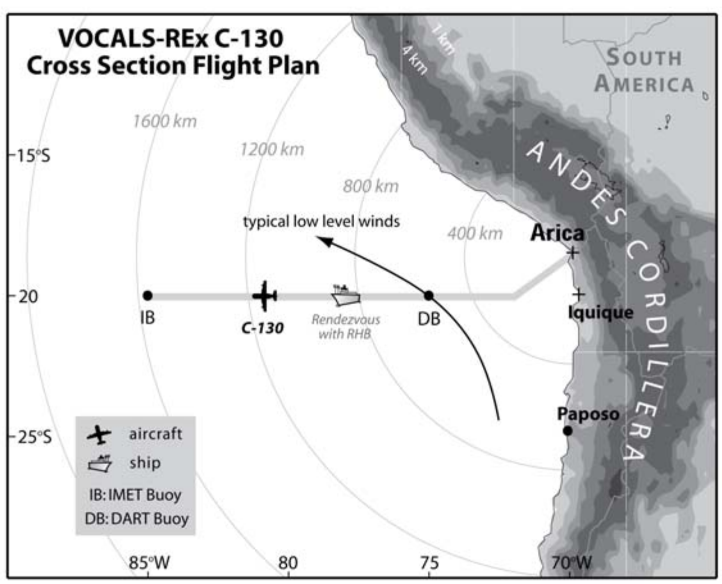
These flights are designed to sample contrasts in MBL thermodynamics, chemistry, aerosols and clouds between the South American coast and the remote SEP. Focus will be placed on good sampling of aerosol characteristics, MBL structure/depth, cloud morphology and thickness, aerosol and cloud microphysics, and drizzle. The aim is to generate a quantitative picture of the structure of the MBL and lower FT by combining data from a number of missions flown at the same local time of day (to avoid aliasing diurnal variability and to fly during maximum drizzle, these flights will occur during the later part of the night, Table 4.7.1). There will be efforts made to coordinate some of these missions with satellite overpasses particularly Terra.

The NSF **C-130 will be the primary aircraft undertaking Cross-Section missions**, but the **BAe-146 will also fly some missions** (either at the same time as the C-130 or on different days). During the near-coastal outbound and return parts of the missions, other aircraft (especially the Dornier 228) may cosample with the primary aircraft.

<u>C-130 Flight Plan for Cross-Section Mission</u>

On both the outbound and return sections, the C-130 mission (Fig. 4.7.1) will comprise a set of 10 minute straight and level runs *below cloud* (lowest possible flight level), *in-cloud*, and *above cloud* (approximately 200 meters above cloud top to ensure presence in the free-troposphere by close enough to cloud top to provide useful information on air subsiding into the MBL). Science-quality climbs/descents of ~300 m min^{-1} will enable frequent profiling albeit in sections. This will give roughly 6 sets of legs on each of 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.

Figure 4.7.2: Plan view of Cross-section mission flight plan for NSF C-130. The RHB will be located at some point between 75 and 85°W on (or very close to) 20°S.



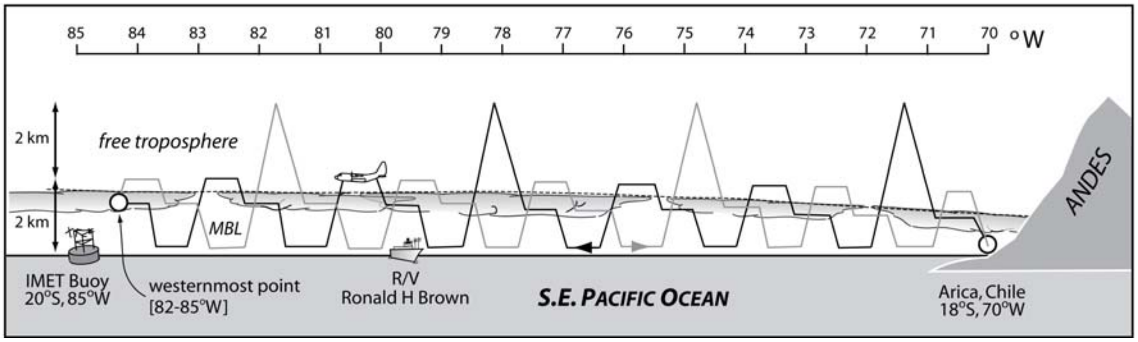


Figure 4.7.3: Cross-Section flight plan for the NSF C-130

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 and aerosol precursor gases (SO_2 and DMS), 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).

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.

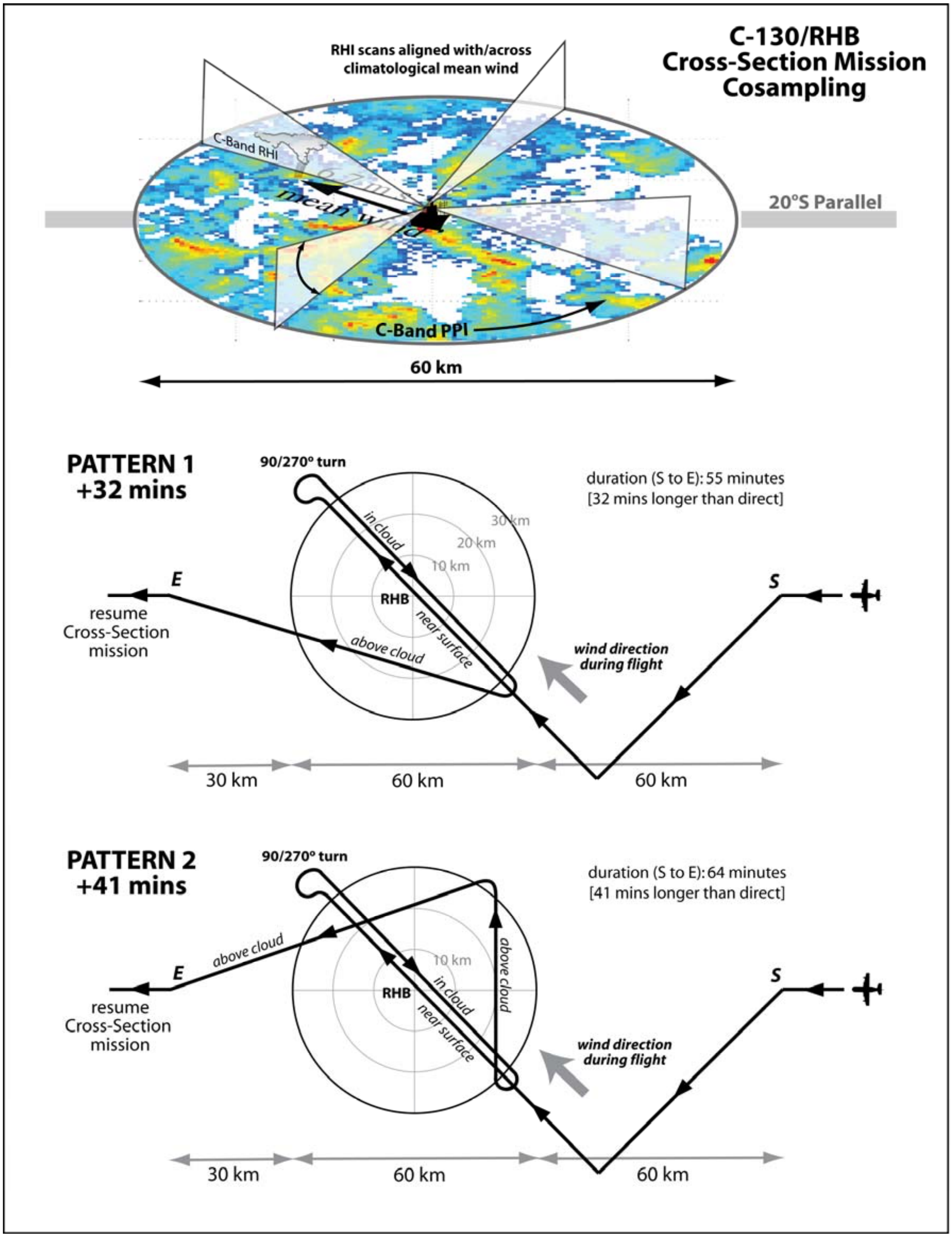


Figure 4.7.3b: Coordinated C-130/RHB Pattern: Co-sampling during Cross-Section missions between C-130 (red line) and RHB (center). A RHB C-band radar PPI scan is shown for context. The decision to fly either pattern 1 or 2 will depend upon available time, meteorological conditions, and the RHB location. Following the co-sampling, the C-130 will then resume its Cross-Section mission. Pattern 1 will add 32 minutes to the direct cross-section; Pattern 2 will add 41 minutes.

Multi-Platform Flight Plan for Cross-Section Mission

A multi-platform Cross-Section Mission (Fig. 4.7.3c) will be flown on some of the C-130 Cross-section missions. This will include the two UK aircraft (BAe-146 and Do-228). The idea is that the C-130 will conduct its standard Cross-Section mission but that the BAe-146 will also conduct an outbound low level flight pattern (take-off ~7 am local), and will rendezvous with the C-130 at 78-80°W before flying a high level (7-8 km altitude) radiation/remote sensing leg approximately above the C-130 on the return leg. In addition the Do-228 will conduct a high level (4-5 km altitude) flight along 20°S timed to approximately overfly the C-130 on the return portion. Figure 4.7.3c gives details of this three-aircraft mission.

An IDL script to aid flight planning for this mission has been developed by Rob Wood and will be used in the field to fine tune the mission and to provide more precise take-off times for the different aircraft.

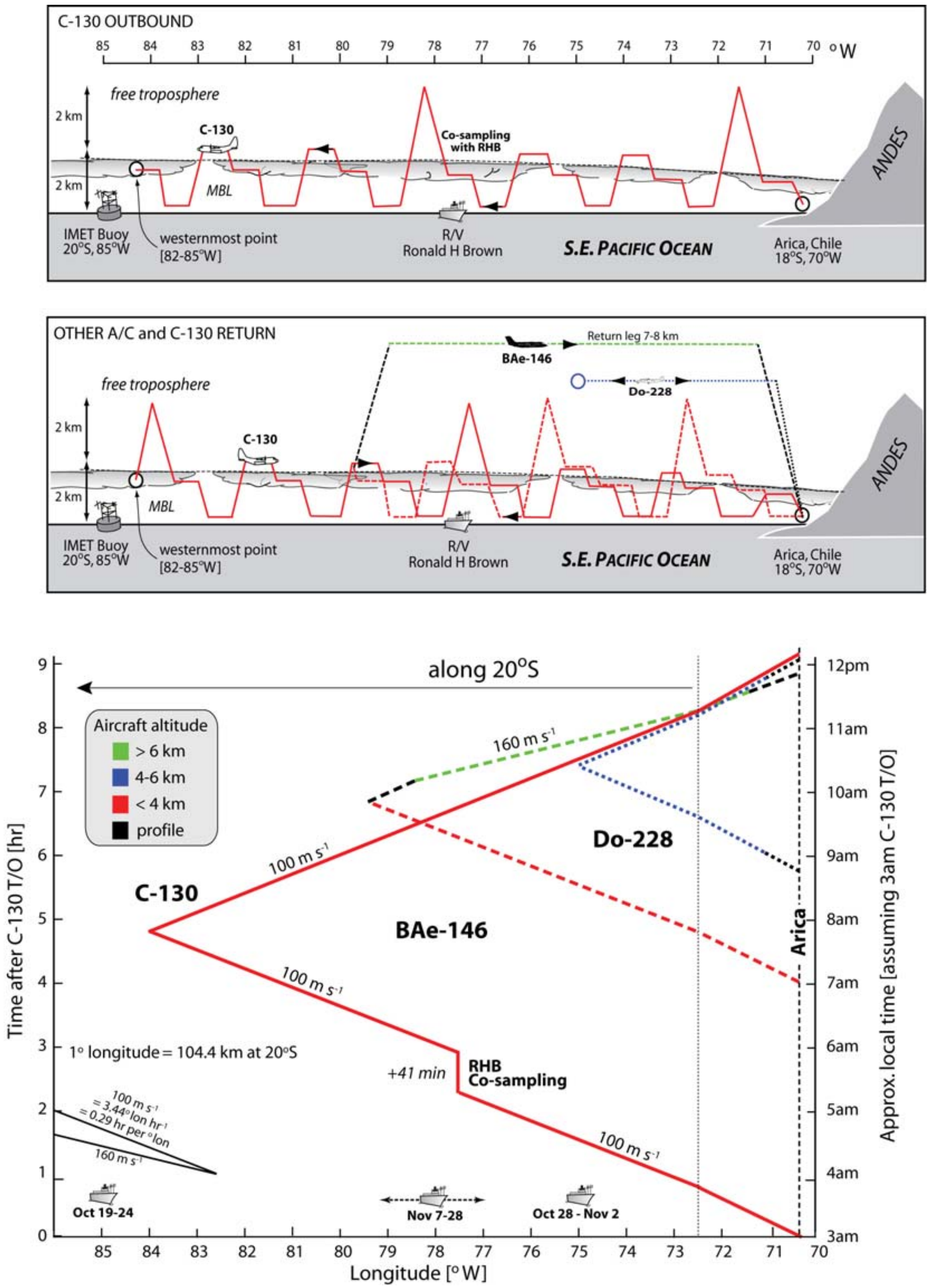


Figure 4.7.3c: Multi-platform flight pattern for Cross-Section missions: Top panel shows C-130 outbound leg (T/O 3 am local time). Second panel shows return C-130 leg plus flight plans for BAe-146 (dashed) and Do-228 (dotted). Colors shows flight altitude windows (key in lower panel). Lowest panel shows time-longitude diagram of the flight for the three platforms. Outbound C-130 leg will include co-sampling with the RHB (see Fig 4.7.3b above). On the return the BAe-146 will release dropsondes. The Do-228 flight will be timed to overfly the other aircraft during the return leg which occurs during the daytime (ETA at 75°W on the return is approximately 10-11 am local time). The return leg will also coincide with Terra overpasses.

2. 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.

Because POCs are typically located in the more remote parts of the SEP, we expect that these flights will primarily be conducted by the C-130, which will aim to make 5-6 mission of this type. However, if POCs happen to come within range of the other aircraft, it is likely that they too will undertake such missions.

If possible, these flights will be coordinated with the **RHB**, whose scanning C-band radar will provide valuable 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 100-150 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.

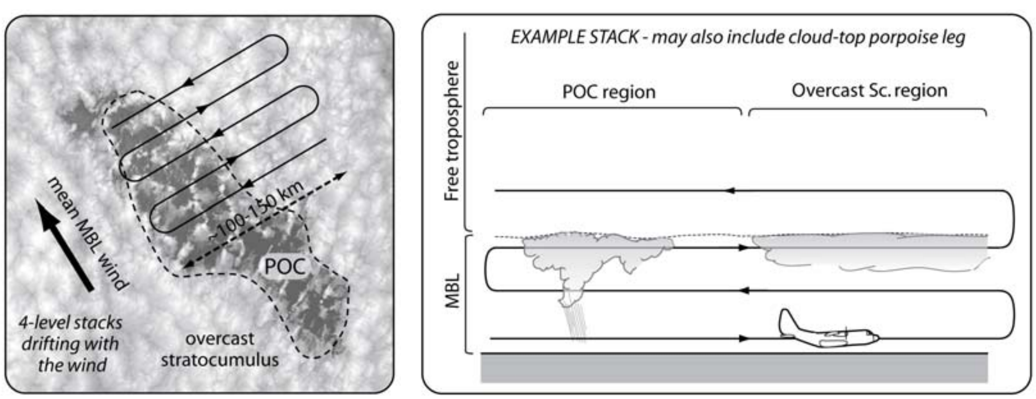


Figure X-4. POC-Drift Mission flight plan for **C-130**. A boundary between open and closed mesoscale cellular convection will be located and this will be sampled with relatively long (100-150 km) runs spanning the boundary with approximately equal penetration into each region. The flight will consist 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).

3. Stacked cloud and radiation missions

[Need input here from UK groups – primarily envisaging one aircraft overflying the other with the upper aircraft serving as a remote sensing platform and the lower one conducting in-situ observations of cloud and aerosol microphysics]

4. Coastal zone cloud sampling Missions

Two of the VOCALS aircraft (the DoE G-1 and the CIRPAS Twin Otter) will operate primarily in the coastal zone (within 600 km of the Chilean coast). Here, two primary types of mission will be flown:

(1) Point to point cloud sampling missions;
(2) Gradient missions.

(1) <u>Point-to-Point Missions</u>:

The Strategy of the point-to-point flight plan is to obtain statistically meaningful data on properties of clouds and the conditions under which they were formed by flying legs of approximately 100 km below, in and above cloud. Two aircraft could potentially conduct this mission with the aircraft flying at different levels.

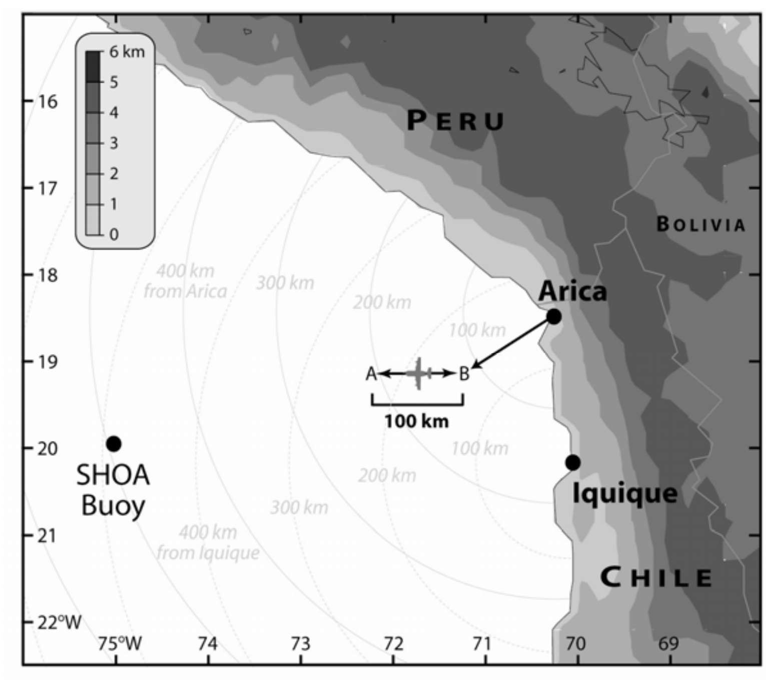


Figure 4.7.6: Flight plan for Coastal-Zone Point-to-Point Missions which will be undertaken primarily by the DoE G-1 and the CIRPAS Twin Otter. On occasion two aircraft may opt to fly this mission with one aircraft sampling in the MBL and the other performing remote sensing measurements above cloud.

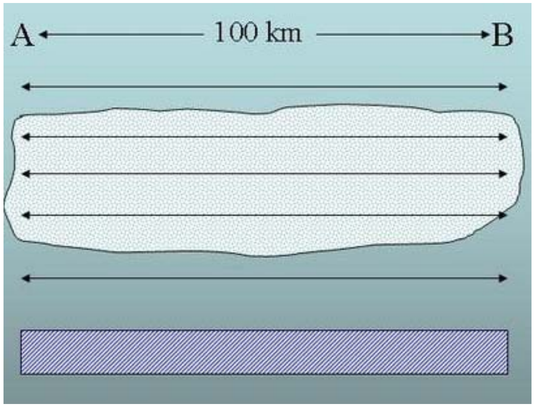


Fig 4.7.6b: Horizontal runs to be conducted during Point-to-Point G-1 missions.

(2) Gradient Missions:

These missions are intended to sample the offshore gradients in the persistent layer of marine stratus and stratocumulus clouds. Data from the missions will therefore help in examining how the chemical and microphysical properties of aerosol, and their ability to act as CCN differs between remote marine air masses and marine air masses that have been influenced by anthropogenic aerosols, and how these differences in aerosol loading and properties influence the properties of the clouds that form in these different environments.

The strategy is to make near-simultaneous measurements of cloud and aerosol properties at different distances offshore using the Twin Otter, G-1, Bae 146, Dornier, and possibly the C-130. This could be an independent mission, or flown as part of missions planned for other purposes. Multiple aircraft are desired to characterize this gradient since one aircraft by itself cannot provide measurements with the needed detail and spatial coverage during a single flight. As shown in the attached Figure 4.7.6c, aircraft would be spaced about 1° apart (~100 km) and would conduct a set of N-S transects about 100 km long consisting of a below cloud leg, multiple in-cloud legs and at least one above cloud leg. The Dornier (or possibly the BAe-146) would fly an above cloud leg from the location of its transects to the east to capture the gradient in cloud optical properties using primarily remote sensing. This flight plan could be modified to change the spacing between the transects of the aircraft, or to allow for the participation of a different number of aircraft.

Gradient Missions are designed to sample this gradient in cloud properties. The aircraft will fly as far as 500-700 km offshore to sample the desired gradient in cloud properties. The flight strategy is as follows: flights will include a *below-cloud leg* to measure pre-cloud aerosol properties (aerosol composition, size distribution, CCN spectra, vertical velocities and their variability); *in-cloud flights* at several altitudes to examine the relationships between pre-cloud aerosol properties, cloud dynamics and cloud droplet microphysics, and their variation with altitude, and sampling through and *above cloud top* to define the vertical dimensions of the cloud, to document the thermodynamic structure of the atmosphere, and to sample the properties of the above-cloud aerosols.

In addition, alternative sampling methodologies will be used to sample the horizontal gradients in cloud properties and, if elevated aerosol layers are observed to be subsiding into the MBL, sawtooth legs will be conducted to characterize chemical and microphysical properties of above cloud air. There is a specific interest to see whether the aerosol layer observed just above the cloud layer during a previous field campaign (MASE) is also seen in VOCALS.

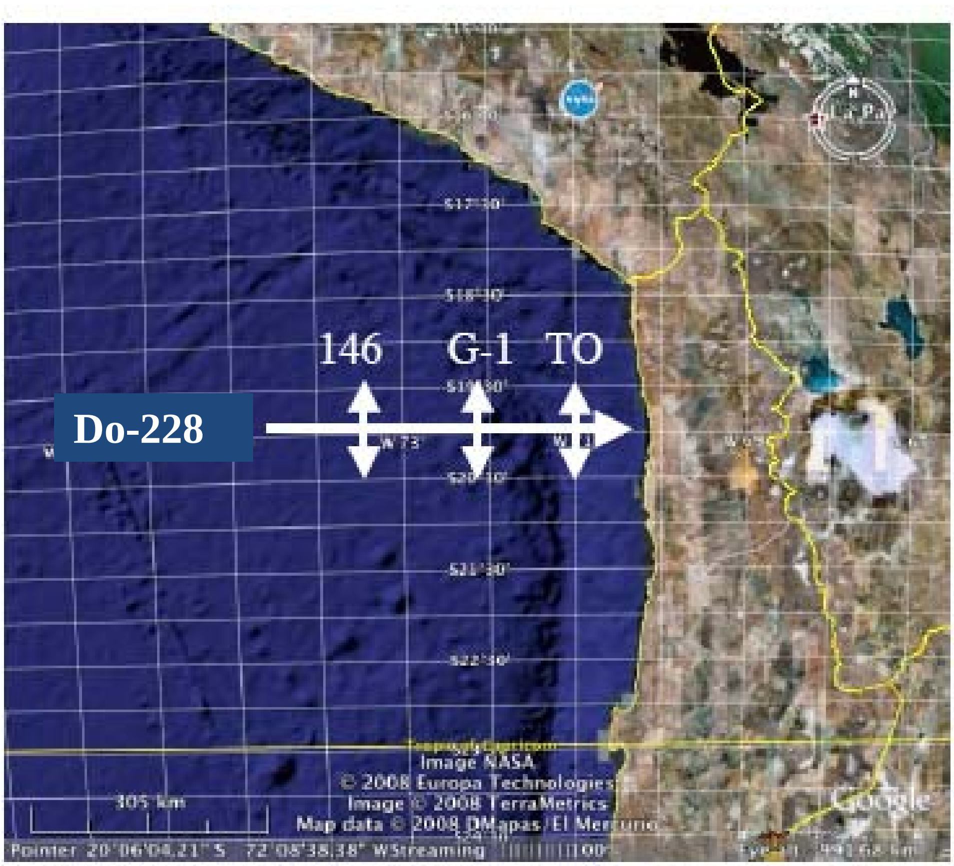


Figure 4.7.6c: Strategy for multi-aircraft gradient mission.

5. Multi-flight quasi-Lagrangian Mission

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.

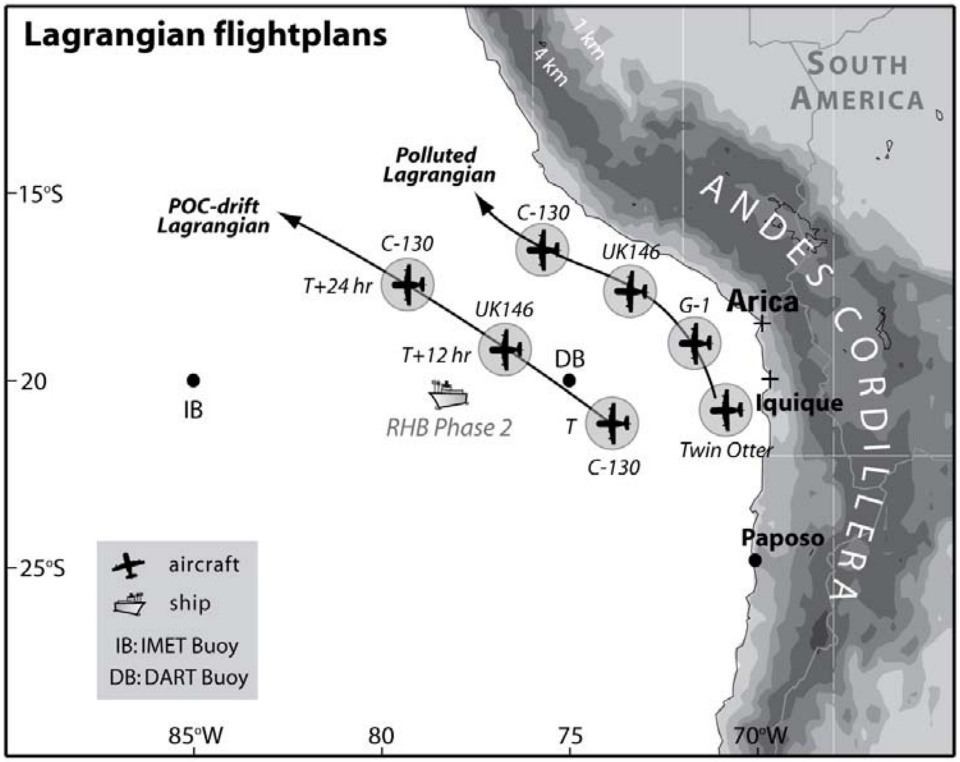


Figure X-7. Lagrangian Mission flight plan examples for POC-Drift and Polluted Lagrangian missions respectively. Exact configurations will vary depending upon desired start location, platform availability and wind conditions.

Two types of Lagrangians are possible, and are shown separately in Figure X-7:

1. **The Polluted Lagrangian** originating in, and likely remaining close to, the coast of northern Chile/southern Peru**;**
2. **The POC-Drift Lagrangian** which aims to track the evolution of a POC over two or three flights.

The easiest Lagrangian to plan is the Polluted Lagrangian because suitable conditions (a polluted near-coastal region in the vicinity of 20°S) are likely to occur more frequently than those required for the POC-Drift Lagrangian which requires the presence of a region of open cells within reach of both the C-130 and the BAe-146.

<u>The Polluted Lagrangian:</u>

This mission allows four aircraft (possibly 5 if Dornier works above another aircraft during one leg) to sample the same airmass sequentially over a period of approximately 36 hours. The four contributing aircraft missions would be organized hence:

Aircraft	Start location*	End Location*	Approx Sampling times
Twin Otter	20.5°S, 72°W	19.5°S, 72°W	Day 1, 08-12 LT
G-1	18.5°S, 72°W	17.5°S, 72.5°W	Day 1, 16-21 LT
BAe-146	17°S, 73°W	16.5°S, 73.5°W	Day 1, 01 LT: Day 2, 06 am
C-130	16°S, 74°W	15.5°S, 75.5°W	Day 2, 10-19 LT

*Locations based on approximate advection speed of 6 m s^{-1}

Test/Intercomparison Missions

Intercomparison flights are essential for determining errors in measurements, for establishing offsets that can help to homogenize data from the collaborative missions during VOCALS-REx, and for determining calibration constants for aircraft wind-measuring systems. Intercomparison flights will typically be 4 hours in duration.

The following are flight segments that will be conducted during the intercomparison missions.

<u>Two-aircraft intercomparison:</u>

Intercomparisons with two aircraft will be conducted (Fig X-8). Straight and level runs of **10-15 minutes** will be carried out in conditions of relatively homogeneous clouds. Out of cloud (well below or above cloud layers) **wing-tip intercomparisons** (side-by-side) will be conducted both below cloud and in the free-troposphere between the platforms that can fly at approximately 100 m s^{-1}. This identifies possible offsets between temperature, humidity, aerosol, and chemical measurements.

In addition, comparison legs will be flown for **straight and level legs in cloud using sequential passes** through the same cloud volume with the aircraft spaced as closely as possible allowing for safety considerations. The emphasis here will be for the aircraft to attempt to fly at exactly the same altitude during each pass. These runs will establish important potential differences in cloud and precipitation microphysical estimates including hydrometeor size distributions, liquid water content, and temperature/humidity measurements in cloud.

The set of the out of cloud and in-cloud intercomparison legs should be conducted between as many aircraft pairs as is possible/realistic during the campaign.

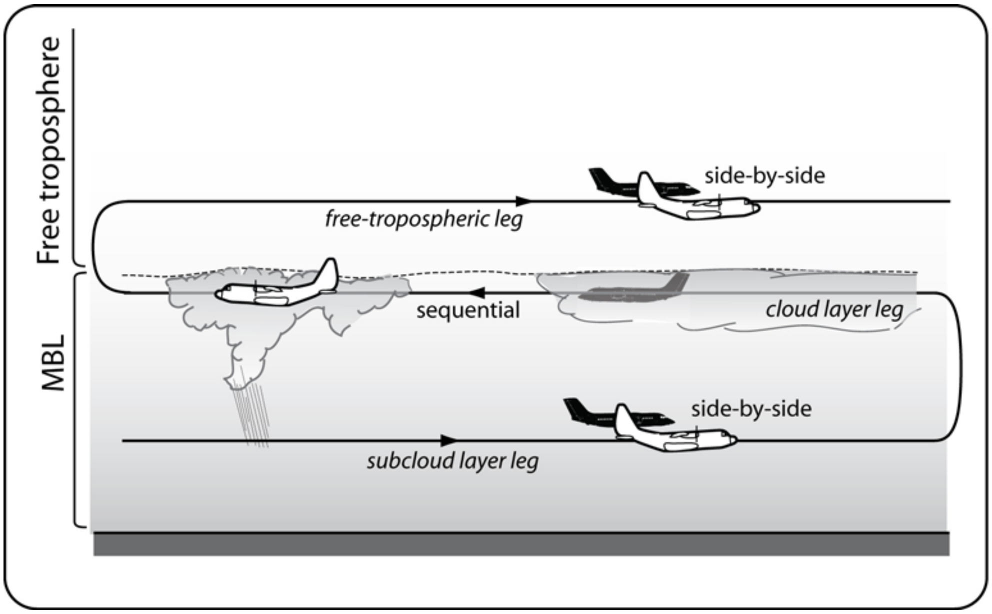


Figure X-8. Intercomparison flight example. Two aircraft fly 10-15 minute legs below cloud, in-cloud, and above cloud. Below and above cloud legs are side-by-side intercomparisons while in-cloud leg is conducted sequentially with minimum safe distance between aircraft.

Single aircraft maneuvers:

Lenschow maneuvers will be conducted during at least one C-130 flight during VOCALS-REx. These should be conducted in clear air above cloud in the free-troposphere during relatively homogeneous conditions with limited horizontal wind speed variance. These runs take approximately 15 minutes including aircraft positioning and are required to characterize the wind-measurement system.

These maneuvers will be done extensively in the test-flight period leading up to the field phase. We would like to conduct a scaled-back version of the maneuvers in the field, essentially to check that no changes have occurred with time. The proposed maneuvers cover a single reverse heading leg, consisting of two 3-minute legs separated by a 90-270 turn. The legs should preferably be done along the mean wind direction, but this is not an absolute requirement. Both pitch and sideslip maneuvers should be conducted.

Aircraft speed runs will be conducted in clear air conditions at a range of altitudes in and above the MBL. The runs can be conducted during transits on science missions if necessary to save time. These runs are used for (i) improved characterization of static pressure defects that impact on pressure, wind and temperature measurements, (ii) determination of a wet-bulb temperature sensor recovery factor.

Any aircraft will cause a disturbance of the ambient pressure field as the aircraft moves through the air. Measurement of static pressure is done on the skin of the aircraft in an area which is affected by pressure errors. Recent installation of differential L1/L2 GPS systems on both the NSF C-130 can, in conjunction with a ground-based station at Arica, give high accuracy measurements of aircraft altitude (0.5 m or better). A speed run, for which the aircraft pitches up at slow speeds and is more level at high speeds, will give different pressure error which can be determined using the aircraft GPS altitude and the hydrostatic equation. An additional error caused by aircraft engine torque may also be characterized. The flight plan calls for flight straight and level away from clouds. The aircraft should be steady at normal research speed at the beginning of the leg. After a run of one minute the speed is reduced and subsequently accelerated to cover a wide range, followed by another minute of straight flight at normal research speed.

Temperature and dewpoint offsets will be determined using the numerous passes through clouds during regular science missions. Dedicated runs are not necessary. **Radiometer zero calibrations** will be conducted using the night-time missions and do not require dedicated runs.

C-130 Flight Operations Timelines

Daytime Flight Planning		
Day	**Time (local)**	**Activity**
D-1	15:30	Flight plans to pilots for review
D (Research Day)	06:30	Last minute flight plan updates as needed
	06:30	All crew depart for airport
	07:00 – 09:00	Research instrumentation warm up & pilot flight prep
	09:00	Go / No-go decision – Access by telephone
	09:00-09:45	Taxi to fueling pit & fuel loading
	10:00	Take off
	19:00	Landing
	19:00 – 20:00	flight power for wrap up activities
	20:30	End duty day

Nighttime Flight Planning		
Day	**Time (local)**	**Activity**
D-1	08:00	Flight plans to pilots for review
	15:30	Go / No-go decision
	23:30	Last minute flight plan updates as needed / Ops center
	23:30	All crew depart for airport
D (Research Day)	00:00-02:00	Research instrumentation warm up & pilot flight prep
	02:00 – 02:45	Taxi to fueling pit & fuel loading
	093:00	Take off
	12:00	Landing
	12:00-13:00	flight power for wrap up activities
	13:30	End duty day

Chapter 5
VOCALS Soundings Operations

5.1 Iquique

One NCAR GPS Advanced Upper-Air Sounding (GAUS) system will be installed at the University Arturo Prat campus located in Iquique, Northern Chile. The GAUS system is a standard weather balloon launching system that uses Vaisala radiosondes to measure wind, pressure, temperature and humidity.

Location	University Arturo Prat Arturo Prat 2120 Iquique, Chile
Operations Period	Set-up: 10-14 October Operations: 15 Oct – 15 Nov Tear-down: 16-19 Nov
Total number of sondes	180 - 6 per day, 30 days
Daily launching schedule	4am, 8 am, 12 noon, 4 pm, 8 pm, midnight (local time)

The Iquique GAUS consists of two separate subsystems:

- One balloon-borne radiosonde navaid (GPS) sounding system
- One enhanced surface meteorological observing station; the enhanced surface observing station consists of one instrumented tower, which is 4 m high and measures pressure, temperature, wind speed, wind direction and humidity.

GPS Sounding System Specifications

Sonde Manufacturer & Type	Vaisala RS92-SGP
Transmitter frequency	403.5 MHz
Pressure sensor	BAROCAP Capacitive aneroid Range: 3-1060 mb Accuracy: 0.5 mb Data system resolution: 0.1 mb Sensor resolution: 0.1 mb
Temperature Sensor	THERMOCAP Capacitive wire Range: -90 to 60 deg C Accuracy: 0.25 C Data system resolution: 0.1 C Sensor resolution: 0.1 C
Humidity Sensor	HUMICAP thin film capacitor Range: 0 to 100% relative humidity Accuracy: 1.5 % relative humidity Data system resolution: 0.1 % humidity Time constant: 0.5 sec @ 6m/s flow, 1000 mb, 20 C

Surface Meteorological Surface Station Specifications:

Surface Pressure Measurements	Silicon capacitive pressure sensor CS 100 Setra 278 Barometric Pressure Sensor Pressure range: 600 to 1100mb Accuracy: +/- 0.5mb
Surface Temperature and Humidity Measurements	Contained in a Vaisala HMP35C instrument probe; Fenwal Electronics UUT5J1 thermistor Temperature sensor accuracy: +/- 0.4 degree C over range -33 to + 48 degrees C Vaisala Humicap capacitive relative humidity sensor Humidity sensor accuracy: approximately +/- 2%
Surface Wind Measurements	R.M. Young 05103 Wind Monitor propeller wind vane Wind speed threshold: 0.9 m/s Wind maximum: 60 m/s Wind direction measurement threshold: 1.0 m/s at 10 degree displacement 1.5 m/s at a 5 degree displacement

5.1.1 Staffing/Schedules and Crew Duty Guidelines:

The GAUS system will operate 24/7, assuming no unexpected problems or significant downtime for maintenance. Staff will be at the site every day monitoring and maintaining the systems and launching radiosondes as requested by the VOCALS PIs.

NCAR/EOL will provide two GAUS technicians at any one time during the entire length of the project; these technicians will be available to address data quality issues, perform maintenance and repairs, and train and oversee additional operators. Three sets of GAUS staff will be rotating in and out on a 16 day basis to cover the VOCALS operations period and the required 24/7 work schedule. Each GAUS operator will work 12 hour shifts with no days off. In addition, three Chilean undergraduate students will be hired through the University Arturo Prat to help with manning the GAUS.

Staff will be based at the Iquique Data Analysis Center in the “Study Hall”, which is located on the north side of the Arturo Prat campus. Staff will be staying at the Radisson Hotel in Iquique.

Personnel Schedule:
Below is the current list of operators and dates. Staffing schedules may be subject to change.

Name	Dates on Site	Phone	Email	Radisson room number*
Jose Meitin	10/2 – 10/8		vidal@ucar.edu	
Tim Lim	10/2 – 10/8 10/31 – 11/18		tdlim@ucar.edu	
Brad Lindseth	10/2 – 10/8 10/12 – 10/21		lindseth@ucar.edu	
Lou Verstraete	10/12 – 11/2		louver@ucar.edu	
Bill Brown	10/19 – 11/2		brownw@ucar.edu	
Laura Tudor	10/31 – 11/18		tudor@ucar.edu	

**Radisson Hotel Iquique:*
Phone: 56-57-381-188
Fax: 56-57-380-434

Daily Shifts:

Shift	Launch times	Shift duration
1	Midnight, 4 am, 8 am, noon	11 pm – 1 pm (12 hrs)
2	4 pm, 8 pm, midnight, 8 am	3 pm – 9 am (12 hrs)

GAUS operators will cover balloon launches in two 12 hour shifts. GAUS staff utilizes a "buddy" system in all operations, and will team up with one of the Arturo Prat students. The third student will rotate in and out to allow for days-off for the students.

5.1.2 Data Collection Procedures

(1) Preparations for a launch generally start about 45 to 60 minutes before scheduled launch time.

(2) Data collection at the land site will terminate once the balloon bursts (approx. 50 mb), which takes about 1.5 hours. If a balloon burst below 400 mb, a second sonde will be launched.

(3) Within two hours after each launch, the GAUS operator will upload the raw data products (un-qced sounding file) via the Internet onto the VOCALS Field Catalog, where a Skew T will be automatically produced. Data and plots will be available from the VOCALS data management website at http://www.eol.ucar.edu/projects/vocals/dm/. The GAUS personnel will also update the VOCALS Field Catalog, reporting on the GAUS operational status and entering the launch times. These preliminary data will not be quality controlled.

(4) Additional QC processing will be carried out on the sounding data post-project. The standard GAUS data products will be provided to the investigator within six months of the completion of the project. Data will be archived on DVDs/CD-ROMS and on the NCAR mass store facility. Data will be distributed via the web, and on DVD/CD-ROM if requested by the PIs.

5.2 R/V José Olaya

Location	Research Vessel José Olaya
Operations Period	Set-up: 27 Sep -29 Sep Operations: 1 Oct – 18 Oct Tear-down: 19 Oct – 21 Oct
Total number of sondes	136 – up to 8 per day for 21 days
Daily launching schedule	3 am, 6 am, 9 am, 12 noon, 3 pm, 6 pm, 9 pm, midnight (local time)

The shipborne GAUS system will only consist of the balloon-borne radiosonde navaid (GPS) sounding system:

Sonde Manufacturer & Type	Vaisala RS92-SGP
Transmitter frequency	403.5 MHz
Pressure sensor	BAROCAP Capacitive aneroid Range: 3-1060 mb Accuracy: 0.5 mb Data system resolution: 0.1 mb Sensor resolution: 0.1 mb
Temperature Sensor	THERMOCAP Capacitive wire Range: -90 to 60 deg C Accuracy: 0.25 C Data system resolution: 0.1 C Sensor resolution: 0.1 C
Humidity Sensor	HUMICAP thin film capacitor Range: 0 to 100% relative humidity Accuracy: 1.5 % relative humidity Data system resolution: 0.1 % humidity Time constant: 0.5 sec @ 6m/s flow, 1000 mb, 20 C

5.2.1 Personnel Schedule:

Soundings operations on the research vessel Olaya are assigned to an IMPARPE Project Scientist. Due to the ambitious schedule and the lack of a NCAR technician on site, it is anticipated that several soundings will be missed or will fail due to technical difficulties.

5.2.2 Data Collection Procedures

(1) Preparations for a launch generally start about 45 to 60 minutes before scheduled launch time.

(2) Data collection at the land site will be terminated at a minimum of 100 mb, which takes about 1.5 hours.

(3) The GAUS system will be equipped with a Iridium satellite communications system that will be used to transfer a subset of the data (temp message, significant level data only) to shore. An attempt will be made to send a temp message, Skew T Image and a daily summary at least once per day to the VOCALS Field Catalog. The timing of the data transfer is unknown at this point. Personnel at the VOCALS Operations Center will have to update the VOCALS Field Catalog accordingly to report on the GAUS operational status and to enter the launch times. These preliminary data will not be quality controlled.

(4) Additional QC processing will be carried out on the sounding data post-project. The standard GAUS data products will be provided to the investigator within six months of the completion of the project. Data will be archived on DVDs/CD-ROMS and on the NCAR mass store facility. Data will be distributed via the web, and on DVD/CD-ROM if requested by the PIs.

5.3 Paposo

Location	Paposo (70°27’W, 25°0’S)
Operations Period	Set-up: October 15th Operations: October 15th-November 15th 2008 Tear-down: November 16th See website at: *http://www.dgf.uchile.cl/VOCALS_PAPOSO/*
Total number of sondes	3 or 4 per day (TBD)
Daily launching schedule	Tentatively 7, 15, 23 UTC
Sonde Manufacturer & Type	n/a
Transmitter frequency	n/a
Pressure sensor	n/a
Temperature Sensor	n/a
Humidity Sensor	n/a

5.4 Antofagasta NWS

Location	Antofagasta (Cerro Moreno airport, 70° 26’ W, 23°26’ S)
Operations Period	October 15-November 30th 2008
Total number of sondes	90
Daily launching schedule	12 UTC and 18 UTC
Sonde Manufacturer & Type	n/a
Transmitter frequency	n/a
Pressure sensor	n/a
Temperature Sensor	n/a
Humidity Sensor	n/a

5.5 R/V Ronald Brown

Location	R/V Ron Brown – variable location
Operations Period	
Total number of sondes	
Daily launching schedule	
Sonde Manufacturer & Type	
Transmitter frequency	
Pressure sensor	
Temperature Sensor	
Humidity Sensor	

CHAPTER 6
VOCALS RESEARCH VESSELS

6.1. NOAA Ship RONALD H. BROWN,
The R/V Ron Brown (RHB) is NOAA's largest state-of-the-art oceanographic and atmospheric research platform. The ship was commissioned on July 19, 1997 in its homeport of Charleston, South Carolina. The vessel is 274 ft (83.5 m) long, has a cruising speed of 12 knots, a range of 11,300 nmi plus 30 days on station, and an endurance of 60 days. INMARSAT B (voice and fax) and INMARSAT Mini-M (voice) and Iridium (voice) communications are available aboard ship.

Registration/Hull Number: R104
Call Letters: WTEC
Captain's Name: tbd
Port of Call: Arica, Chile
Email: Noaa.Ship.Ronald.Brown@noaa.gov
Phone:

a) Inmarsat Mini-M
  011-871-761-831-360 or 011-874-761-831-361(Voice)
  011-871-761-831-362 (Fax)
  011-871-761-831-363 (Data)

b) Inmarsat B
  011-871-336-899-620 (Voice)
  011-871-336-899-621 (Fax)
  011-871-336-899-622 (Data)

c) Iridium:
  011-8816-7631-5690 (patched into PBX)
  808-659-5690

Messages can also be left with the Marine Operations Center, Norfolk, Virginia, by calling (757)441-6206.

Ron Brown Activities

Investigator	Activity
Fairall	Fluxes, cloud optical properties
Yuter	C-band radar, drizzle
Brewer	Scanning Doppler Lidar
Feingold	Lidar-cloud radar aerosl – LWP
Norman	Aerosol isotope analysis
Huebert/Matrai	DMS flux
Albrecht	Cloud drizzle/aerosol interactions
Covert/Bates/Quinn/Russell	Aerosol Characterization
Volkamer	Remote sensing of trace gases
Zuidema	Cloud Remote Sensing

Ron Brown Instrumentation

System	**Measurement**
Fast Turbulence Sensors	Direct covariance turbulent fluxes
Mean SST, air temp/RH	Bulk turbulent fluxes
Pyranometer/Pyrgeometer	Downward solar/IR radiative flux
Ceilometer	Cloud base height
0.92 GHz Doppler Radar Profiler	Cloud-top height, MBL Winds
Rawinsonde	MBL wind, T, RH profile
DMT CIP Precip Spectrometer	Drizzle droplet size spectra
94 GHz Doppler Cloud Radar	Cloud microphysical properties
Microwave Radiometer	Integrated water liquid/vapor
RHB C-band Radar	Precipitation spatial structure
RHB Satellite Receiver	Cloud and SST fields
MicroRainRadar (NCSU)	Profiles of drizzle
Lasair-II aerosol spectrometer	Aerosol size spectra
ESRL Scanning High Res. Doppler Lidar (HRDL)	Wind speed and direction, small scale mixing

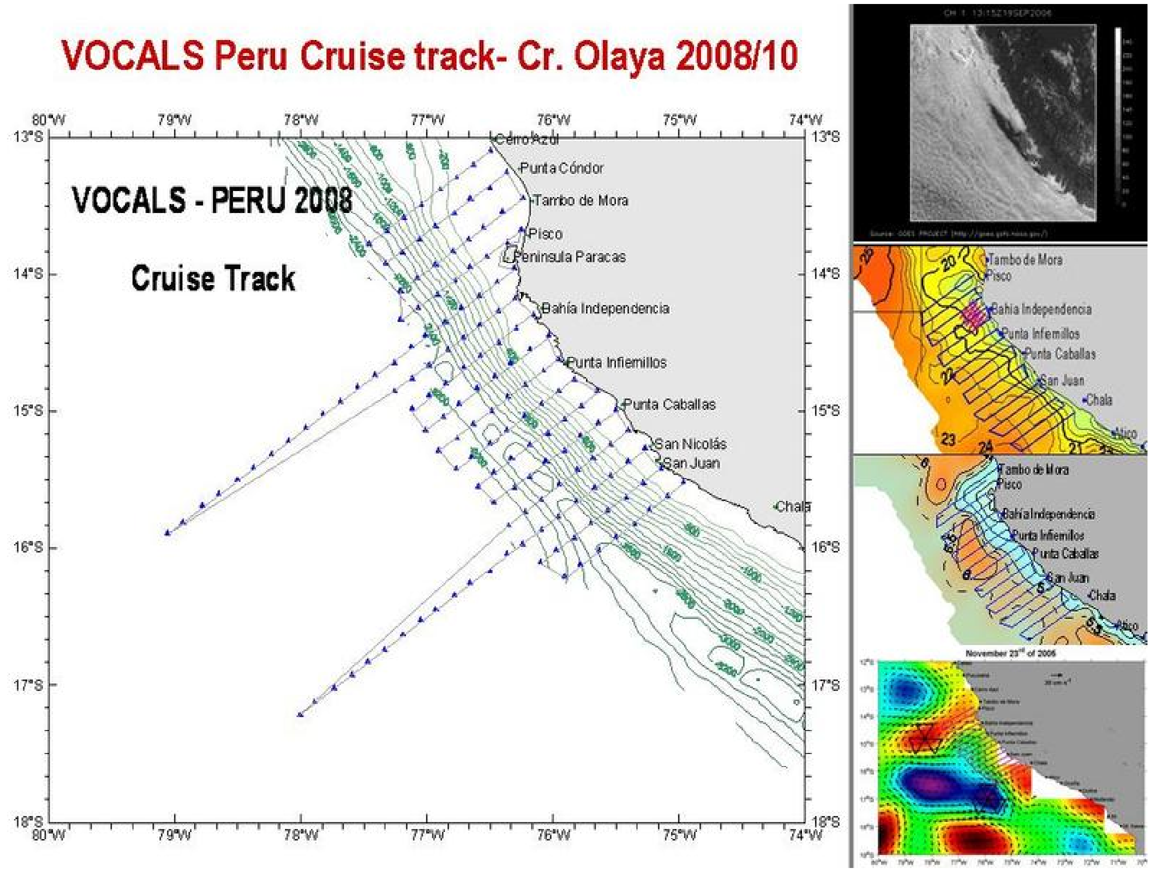
6.2. R/V José Olaya Balandra

The R/V José Olaya Balandra is one of the three research vessels operated by the Instituto del Mar del Perú (IMARPE) and owned by the Ministerio de la Producción, Perú. The ship is 41 m long and dedicated to assessment of oceanographic resources and surveys. Its home port is Lima, Peru.

Registration/Hull Number: CO-17706-EM
Call Letters:
Captain's Name: CdeF Raúl Rojas Turpaud
Port of Call: Callao, Peru
Email:
Phone:

The main objective of the Peru VOCALS Coastal Component is to investigate the meso and submesoscale ocean-atmosphere interaction in the upwelling cell off southern Peru (Pisco-San Juan) and to determine the associated biogeochemical responses. Two main hypotheses are considered:

(1) there is strong feedback/interaction between the variability of the atmospheric coastal wind, the upwelling cell and the instabilities of the associated thermic front and cloud clearing between Pisco-San Juan.
(2) Mesoscale eddies play an important role in the transport of coastal upwelled water properties to offshore regions.


VOCALS Peru Cruise track- Cr. Olaya 2008/10
VOCALS - PERU 2008
Cruise Track
80°W
79°W
78°W
77°W
76°W
75°W
74°W
13°S
14°S
15°S
16°S
17°S
18°S
Cerro Azul
Punta Cóndor
Tambo de Mora
Pisco
Peninsula Paracas
Bahía Independencia
Punta Infiernillos
Punta Caballas
San Nicolás
San Juan
Chala
Atico
November 23rd of 2008

Chapter 7
VOCALS DATA AND INFORMATION MANAGEMENT

7.1 Introduction

The development and maintenance of a comprehensive and accurate data archive is a critical step in meeting the scientific objectives of VOCALS. The overall guiding philosophy for the VOCALS data management is to make the completed data set available to the scientific community as soon as possible following the VOCALS-REx (Regional Experiment) in order to better understand physical and chemical processes central to the climate system of the Southeast Pacific region; namely interactions between the ocean, the atmosphere, and the land. The VOCALS data will be available to the scientific community through a number of designated distributed VOCALS Data Archive Centers (VDAC)s coordinated by the NCAR/EOL. The archive will include data from various NOAA Data Centers (e.g. NCDC, NODC), the DOE, NASA, DoD, WHOI, and various Chilean and Peruvian agencies. In addition, supporting data will be collected (or linked) from various sources and archives of satellite data and numerical model output/products from various Numerical Weather Prediction Centers.

The EOL coordination activities fall into three major areas: (1) determine the data requirements of the VOCALS scientific community and develop them into a comprehensive VOCALS Data Management Plan through input received from the VOCALS Scientific Working Group (SWG), project participants, and other tools such as the data questionnaire; (2) development and implementation of an on-line field catalog to provide in-field support and project summaries/updates for the Principal Investigators (PIs) and project participants to insure optimum data collection; (3) collection of real-time data for preliminary data analysis; and (4) establishment of a coordinated distributed archive system and providing data access/support of both research and operational data sets for the VOCALS PIs and the global scientific community. To accomplish these goals, EOL will also be responsible for the establishment and maintenance of the VOCALS Data Management Portal. These web pages provide "one-stop" access to all distributed VOCALS data sets, documentation, on-line field catalog products, collaborating project data archives, and other relevant data links. EOL will make arrangements to ensure that "orphan" data sets (i.e. smaller regional and local networks) will be archived and made available through the VOCALS archive. The EOL may also quality control and reformat selected operational data sets (e.g. atmospheric soundings or surface data) prior to access by the community as well as prepare special products or composited data sets.

Oversight of the VOCALS data management tasks will come from the VOCALS SWG, as well as coordination with the individual investigators, and other participating groups.

Figure 7.1 shows the planned VOCALS Data Management Timeline which includes all relevant data milestones (black), meetings (red), and documents (green). Further details on some of these activities are provided in the following sections.

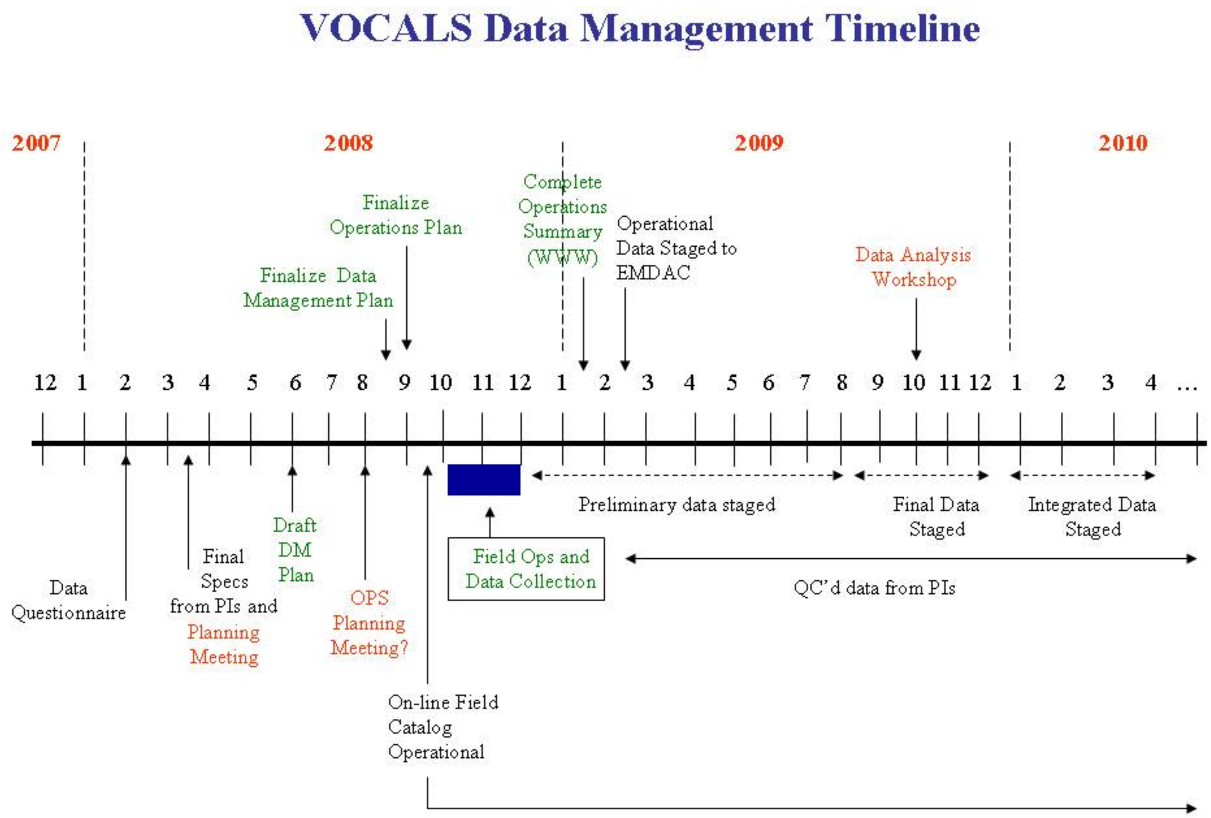


Figure 7.1 – VOCALS Data Management Timeline. Data milestones are denoted in black, meetings in red, and documents in green.

7.2 Data Policy

The basis for the VOCALS data policy is the World Meteorological Organization (WMO) Resolution 40 on the policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities. This resolution was adopted by the XII WMO Congress during June 1995 in recognition of the requirement for the global exchange of all types of environmental data and the basic responsibility of WMO Members and their national Meteorological Services in support of safety, security and economic benefits of their countries to adopt the following policy on the international exchange of meteorological and related data and products:

"As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, the WMO commits itself to broadening and enhancing the free and unrestricted

international exchange of meteorological and related data and products."

In general, users will have free and open access to all the VOCALS data, subject to procedures to be put into place at the various VOCALS Data Archive Centers (VDACs). The following is a summary of the VOCALS Data Management Policy by which all VOCALS participants, data collectors, and data users shall be requested to abide:

- All investigators participating in VOCALS agree to promptly submit their quality-controlled data to the appropriate VDAC to facilitate intercomparison of results, quality control checks and inter-calibrations, as well as an integrated interpretation of the combined data set.

  - Standard meteorological data such as synoptic observations, special rawindsonde observations, and satellite imagery shall be submitted to the appropriate VDAC within three months following the end of the field campaign (18 February 2008).
  - Special meteorological data such as Doppler wind lidar data, Differential Absorption Lidar (DIAL) data, and radar data shall be submitted to the appropriate VDAC no later than 6 months following the end of the field campaign (18 May 2009). EOL will coordinate with individual data sources regarding submission of partial datasets by this date.

- During the initial data analysis period (which is defined as 1 year following the end of the field campaign data collection), the VOCALS investigators will have exclusive access to the data. This initial analysis period is set to accommodate the amount of processing required for specialized data products, to provide an opportunity to quality control the combined data set, and to provide the investigators ample time to publish their results.

- During the initial data analysis period, the investigator(s) who collected the special data sets must be notified first of any intent to use the data. In particular, this applies if data are to be provided to other parties via journal articles, presentations, and research proposals. It is strongly encouraged that VOCALS investigators responsible for acquisition of data be invited to become collaborators and co-authors on any projects, publications, and presentations. If the contribution of the data product is significant to the publication, the VOCALS investigator responsible for generating a measurement or a data product should be offered the right of co-authorship or collaboration. Any use of the data should include an acknowledgment (i.e., citation). In all circumstances, the VOCALS investigator or data source responsible for acquisition of data must be acknowledged appropriately.

- All data shall be promptly provided to other VOCALS investigators upon request. All VOCALS investigators will have equal access to all data. A list of VOCALS investigators will be maintained by the VOCALS Project Office and will include the investigators directly participating in the field experiment as well as collaborating scientists who have provided guidance in the planning and analysis of VOCALS data. No data may be provided to a third party via journal articles, presentations, or research proposals without the consent of the investigator who collected or is responsible for the data.

- Following the end of the initial data analysis period (18 November 2009), all data shall be considered in the public domain. A data set within the VOCALS archive can be opened to the public domain earlier at the discretion of the data provider for their particular data set(s).

- The following VOCALS acknowledgment(s) is suggested: The (.....) data were collected as part of the THORPEX Pacific Asian Regional Campaign (VOCALS). In the United States, the primary sponsors of VOCALS are the U.S. National Science Foundation (NSF) and the Office of Naval Research. The involvement of the NSF-sponsored National Center for Atmospheric Research (NCAR) Earth Observing Laboratory (EOL) is acknowledged. The acquisition of the (...) data was carried out by Dr. (....) using the (....) instrument and was funded by (....) (if pertinent). The data were provided from the VOCALS Data Archive, which is maintained by NCAR's Earth Observing Laboratory (EOL) (or other appropriate archive center).

7.3 Data Management Strategy

The first step in organizing the VOCALS data management support is to determine what data are required from the various scientific components of the program. EOL has developed and distributed a data questionnaire to survey the VOCALS participants to document this information. This questionnaire information with input from other data sources, VOCALS investigators, and sample data sets will be used to obtain detailed information regarding the various data sets (e.g. data format, data set size, data frequency and resolution, real-time operational requirements, etc.). This will assist the EOL (and the collaborating Data Archive Centers) in handling and processing the data as well as identifying and developing any format converters necessary. The PIs (and data sources) will be requested to adequately document data sets in accordance with standard international metadata standards agreed upon by VOCALS and summarized in the Data Management Plan.

The EOL will have the primary responsibility to develop the VOCALS Data Management Plan. This document will contain details of the strategic and tactical data management implementation such as: (1) describing data policies and protocol, data compilation (including special data sets) and attribution; (2) providing details of the VOCALS data archive system and data submission/access; (3) identifying the sources of observations from existing and planned networks; and (4) providing details and assisting in the developing integrated data sets from existing observational systems and operational model output. The EOL will also collaborate with other VOCALS related programs such as the VAMOS, MESA, and other related regional projects.

Fig. 7.2 describes the VOCALS Data Flow. Operational and special research "preliminary" datasets/products will be ingested into the operations center and the field catalog (see Section 7.5.1). All processed and quality assured data/products will be submitted into the final archive (see Section 7.6) at EOL along with data from distributed data centers. In addition, the VOCALS archive will be linked to other VAMOS archives both at EOL and the Inter-American Institute (IAI) in Brazil.

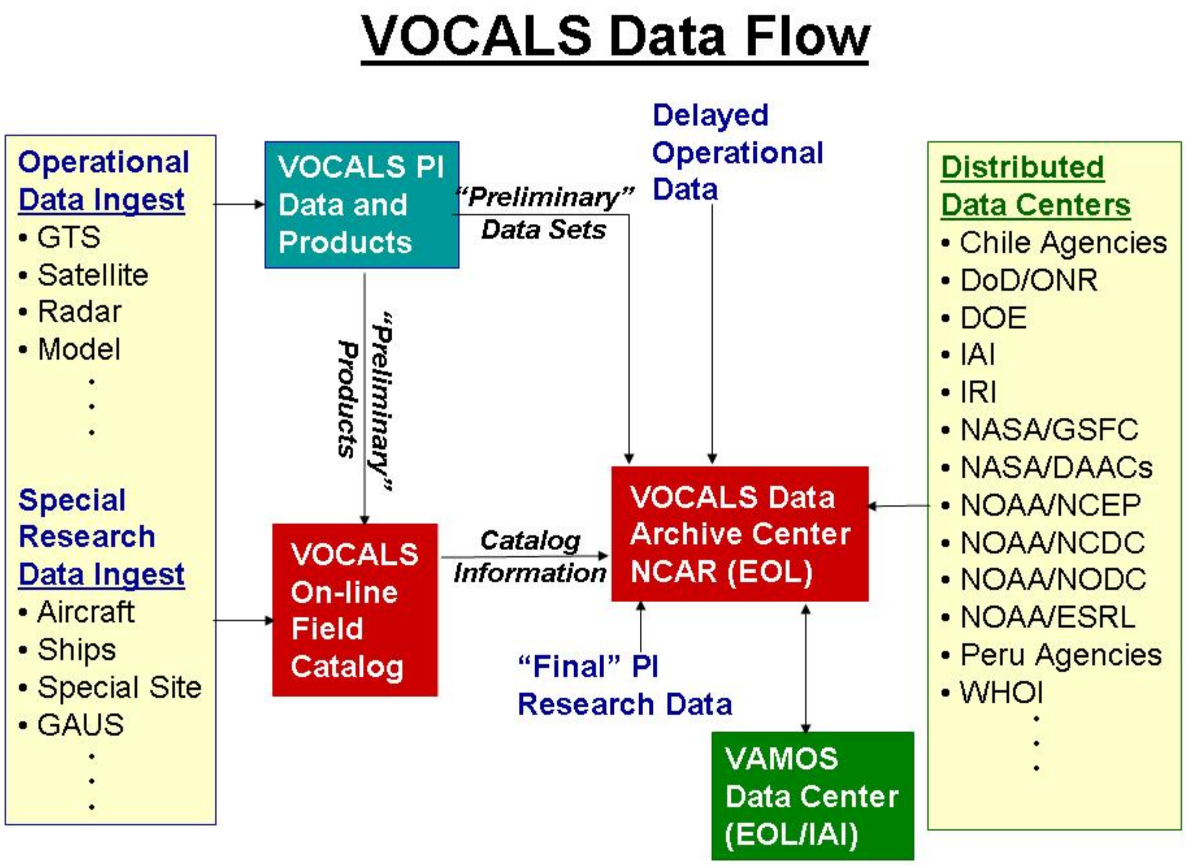


Figure 7.2 – VOCALS Data Flow.

7.5 Real-time Data Access

7.5.1 On-line Field Catalog

The EOL will develop and maintain an On-line Field Catalog that will be functional during and following the VOCALS Field Phase (REx). This catalog will be implemented using a web-based browser interface and will be operational at NCAR/EOL (Boulder, CO) and available at the VOCALS Operations Centers. Data collection information about both operational and research data sets (including metadata and overview documentation) will be entered into the system in near real-time beginning approximately one month before field operations commence. The catalog will permit data entry (data collection details, field summary notes, certain operational data etc.), updates of the status of platforms and instrumentation (on a daily basis or more), data browsing (listings, plots) and limited catalog information distribution. Daily summaries will be prepared and contain information regarding operations (aircraft flight times, major instrument systems sampling times, POES overpasses, etc.). It is important and desirable for the PIs to contribute graphics (e.g. plots in GIF or Postscript format) into the Field Catalog for in-field research instrumentation comparisons and evaluations. Preliminary data/information could be restricted to the VOCALS Operations Centers access only if needed. Public access to status information, mission summaries, and operational and selected research data sets will be available from http://catalog.eol.ucar.edu/vocals/ .

7.5.1 Real-time Data Displays

(to be provided by Chris Burghart)

7.6 Data Archive and Access

The VOCALS will take advantage of the capabilities at existing VDACs to implement a distributed data management system. EOL will provide "one-stop" single_point access (Portal) using the web for search and order of VOCALS data from VDACs operated by different nationalities/agencies with the capability to transfer data sets electronically from the respective VDAC to the user. Access to the data will be provided through a Data Management web page (http://www.eol.ucar.edu/projects/vocals/dm/) and also linked from the VOCALS "Home" page. These Data Management pages will contain general information on the data archive and activities on-going in VOCALS (i.e. documents, reports), data submission instructions and guidelines, links to related programs and projects, and direct data access via the various VDACs.

EOL will be responsible for the long-term data stewardship of VOCALS data and metadata. This includes ensuring that "orphan" datasets are properly collected and archived, verifying that data at the various VDACs will be archived and available in the long-term, and that all supporting information (e.g. field catalog) are included in the archive.

CHAPTER 8:
VOCALS Education and Outreach Program

This chapter provides an overview of a range of education and outreach opportunities of relevance to 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.

The multidisciplinary nature of VOCALS, and the combination of both field and modeling aspects, offers considerable opportunities for building a vibrant educational and outreach program involving students, educators, and the general public in the United States and internationally. It is important that, as a coordinated program, VOCALS addresses the broader impacts of the scientific research.

We break down the program into an **educational component** and an **outreach component**. Together, these map onto the goals of the NSF Geosciences Educational Program[1], which are to:

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

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

[1] See the Geosciences Education webpage at *www.nsf.gov/geo/adgeo/education.jsp*

8.1 Educational opportunities

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

8.1.1 Opportunities for graduate students

Graduate students are the lifeblood of most research-focused university departments and will form the next generation of research scientists and university educators. They are directly engaged in the research and to a large degree the success of programs like VOCALS can be directly attributable to the endeavors of graduate students. Many of the VOCALS PI proposals submitted to the various participating agencies/divisions[2] will request support for graduate students. In addition to direct engagement in PI-led research projects, there will be a number of opportunities for graduate students to participate in the field program VOCALS-REx. These include instrument operator and data management roles on several platforms as detailed in Table 1. VOCALS presents an excellent opportunity for graduate students and other early career scientists to witness and participate in the unique activities that constitute a major field program in the geosciences. This early exposure to field programs is cited by many scientists as being a pivotal moment in their careers.

8.1.2 Opportunities for undergraduate students

It is important that undergraduate students from all backgrounds in the geosciences and physical sciences are given opportunities that can help to bridge the gap between the undergraduate and graduate levels in education. NSF has invested considerably in programs such as Research Experience for Undergraduates[3] (REU) and the Significant Opportunities in Atmospheric Research and Science (SOARS). We will seek support from the REU in the form of supplemental requests to a number of the VOCALS individual PI proposals submitted to NSF divisions. We anticipate that several of these will involve participation in VOCALS-REx field program. In order to maximize the benefits for the undergraduates involved in REx, we plan to involve graduate students as "*field mentors*" to the undergraduates in the field. This combination of undergraduate and graduate student participation in the field was extremely successful during the recent RICO field campaign[4].

8.2 Outreach opportunities

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

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[2] See Appendix 3 for details of the participating agencies/divisions

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

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

8.2.1 Windows to the Universe (W2U)

The *Windows to the Universe* project is an education and outreach program that was initiated in 1995 with initial funding from NASA. Since then, W2U staff has received 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 three 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* (see http://www.windows.ucar.edu/tour/link=/people/postcards/postcards_menu.html) so that their work can be shared with learners around the world through the Windows to the Universe website. A VOCALS public portal on W2U will be developed that includes supporting content describing the science of the campaign to the public.

W2U staff will develop approximately 40 web pages to support the VOCALS Program and science behind it (as well as brief informal biographies of the contributing scientists), linking also to content already available on the website. The content will be translated into Spanish. In addition, 10 scientists will be trained to submit *Postcards from the Field* by NCAR staff while on a visit to the field site at the beginning of the field campaign.

Table 8.1 lists the VOCALS PIs and students who have agreed to send *Postcards from the Field*

PI/Student	**Affiliation**
Baeuerle, Brigitte	NCAR
Beem, Katie	Colorado State University
Chuang, Pat	UC Santa Cruz
Crouch, Jake	North Carolina State University
DeWitte, Boris	Institute for Research and Development, Peru
Fairall, Chris	NOAA
George, Rhea	University of Washington
Hawkins, Lelia	Scripps
Lee, Taehyoung	Colorado State University
Lim, Jacqueline	NCAR; University of Colorado
Matrai, Patricia	Bigelow Laboratory for Ocean Sciences
Mooiweer Bryan, Wisje	University of Wyoming
Painemal, David	University of Miami

Snider, Jeff	University of Wyoming
Twohy, Cindy	Oregon State University
Wood, Rob	U. of Washington
Zappa, Chris	Columbia University
Zuidema, Paquita	University of Miami

8.2.2 NCAR/EOL Field Tracks - VOCALS 2008

NCAR's Earth Observing Laboratory is working on a pilot educational and outreach pilot that uses an interactive Google map to tie VOCALS scientific questions to local meteorological and oceanographic features and the use of various observational facilities. In addition, the map shows various other waypoints in the surrounding area that are of general or cultural interest. Clicking on each icon will lead to various reports in the form of pod/video casts, movie loops, photos, narratives and texts.

Special attention will be given to narratives by undergraduate and graduate students who had a chance to actively participate in a scientific field study. By writing campaign blogs, first-person articles or producing little movie clips, students will be asked to describe their personal experiences while being in the field. Narratives are expected to be personal, insightful and fun to read. No restrictions will be imposed concerning the content of these narratives - we envision a wide range of subjects covering interpersonal, technical, scientific and cultural subjects. Stories will be compiled to allow students to share insights with their peers in the hope that these will offer avenues toward deeper scientific and cross-cultural understanding for students back home.

Working in collaboration with UCAR Media, several VOCALS-related interviews and podcasts will be made available for posting on Itunes-University.

Student Participation in VOCALS

Table 1: Graduate student participation in the VOCALS-REx field program
Mailing list: vocals-students@eol.ucar.edu

Student Name	Affiliation	Email	Advisors	Responsibility	Location	Time in the field
Wiesje Mooiweer	University of Wyoming	wmooiwr@uwyo.edu	David Leon Jeff Snider	Operation of aerosol instruments on C130; Analysis of aerosla nd possibly in situ cloud microphysics data	Arica	mid Oct - mid Nov
Rhea George	University of Washington	rheag@atmos.washington.edu	Rob Wood	Flight Planning, Aircraft scientist on C-130	Arica	entire period
tbd	University of Washington		Rob Wood		Arica	8-10 days
tbd	University of Washington		Rob Wood		Arica	8-10 days
Matthew Miller	North Carolina State U.	mamille4@ncsu.edu	Sandra Yuter	Ship radar scientist	RHB	Leg 1
tbd	North Carolina State U.		Sandra Yuter	Processing of ship radar data		
David Painemal	University of Miami	dpainemal@rsmas.miami.edu	Pacquita Zuidema	Cloud remote sensing	RHB, Arica	entire period
Donna Blackney	Drexel University	dmb98@drexel.edu	Alan Bandy	SO2 Instrument operation on C-130	Arica	5 weeks
tbd	Colorado State		Jeff Collett			
Dione Rossiter	UC Santa Cruz	dionelee@gmail.com	Patrick Chuang	Cloud microphysical measurements using a phase Doppler Interferometer	Iquique	entire period
Minxi Yang	U. of Hawaii	reelguy@gmail.com	Barry Huebert	DMS Fluxes on Ron Brown	RHB	November leg
Brad Barrett	U. of Chile	bbarrett@dgf.uchile.cl	Renee Garaud	Forecast/ops support, edu and outreach	flexible	flexible
Sean Coburn	U. of Colorado	sean.coburn@colorado.edu	Rainer Volkamer	MAX-DOAS measurements	RHB	second leg
Daniel Barahona	U. Conception, Chile	dbarahona@udec.cl	Oscar Pizarro	Physical oceanography	RHB	second leg
Carlos Castillo	U. de Chile	carcasti@ing.uchile.cl	Laura Gallardo Klenner	Aerosol and CCN measurements	Paposo	tbd