VOCALS Field Experiment
Coastal Component

René Garreaud* and José Rulllant

Departamento de Geofísica
Universidad de Chile

Contributors: Oscar Pizarro, Rodrigo Nuñez, Laura Gallardo, Ricardo Muñoz, Ken Takahashi, and many others..

(*) www.dgf.uchile.cl/rene
VOCALS Field Experiment
COASTAL COMPONENT

• The region
• Key atmospheric / oceanic features
• Scientific questions / Working hypothesis
• General Objective
• Experimental design overview
• Platforms – instrumentations
The nearshore strip off the tropical and subtropical west coast of South America is the longest and perhaps the most productive area of the world’s ocean in terms of pelagic fisheries. It accounts for ~20% of the worldwide marine fish catch.

Monthly composites of surface chlorophyll (SeaWIFS data, provided by Ted Strub)
Key atmospheric features over the coastal SEP

- ITCZ
- SCu deck
- Subtropical High
- Coastal jet
- Andes
- SAM
- Continental plume
Key oceanic features over the coastal SEP

- Coastally trapped Oceanic Kelvin waves
- Coastal jet
- Ocean eddies source
- CO2 – DMS Source
- Coastal Upwelling
Surface wind climatology (u,v,ws): QSCAT 2000-2003 / 0.25°
QSCAT also reveals some meso-scale details and insights on the diurnal cycle.
Simulated (MM5) structure of the coastal jet

$V > 18 \text{ m/s}$
Jet events (dark shaded) typically a week long (3-15 days).

More frequent, stronger and longer in spring and summer.

Time-latitude cross section of the surface meridional wind along the coast.
1-Point correlation map. \( V(33S/73W) \) regressed upon

- U,V elsewhere (vectors)
- WS elsewhere (contour)
- Cloud elsewhere (colors)

Jet events associated with: Stronger anticyclone / Reduced Sc near the coast / Increased Sc off the coast / Sea surface cooling at and downstream the jet
A few relevant scientific questions

1a. How do synoptic-scale features influence the Atmospheric MBL circulation (coastal jet), structure, and clouds within the coastal area?

1b. How well are these effects simulated by regional numerical models?

1c. How the coastal-jet/-upwelling system will evolve in a different climate change scenarios?

2a. On what time and space scales does continental heating and mechanical forcing impact on the AMBL clouds and structure in the coastal area?

2b. What are the feedback scales between upwelling plumes (SST gradients, current shear), mesoscale eddies over the AMBL clouds and structure in the coastal area?

3a. Do natural (DMS, sea-salt, mineral dust) and anthropogenic (SO2 emissions) aerosols significantly modulate AMBL clouds (cloud cover, droplet radii, etc.)?

3b. Are aerosols and low SST’s in the offshore region controlled by offshore transport by eddies generated by instabilities in the coastal ocean upwelling jet, particularly at 30 and 15 °S?
**Working Hypotheses**

H1a. Coastal jet events forced by migratory anticyclones crossing southern Chile.

H1b. Distinctive cloud pattern associated with the jet (clear core / cloudy downstream) due to zonal flow atop the AMBL.

H1c. Enhanced shear-driven turbulence during coastal jet foster upwelling and ocean eddy activity on time scales of hours.

H2a. Strong diurnal cycle of alongshore winds at the coast due to a reversal in cross-shore flow forced by continental heating/cooling.

H2b. Diurnal coastal clearing instigated by heating/cooling of the Andean slope via changes in the low-level divergence field along the coast.

H2c. Areas of persistent clouds / clear-skies associated with mechanically-driven, mesoscale, standing eddies forced by coastal topography

H3a. Mean low-level flow conducive for the formation of a “continental plume” (CP) extending several hundreds km. offshore.

H3b. CP is greatly enhanced during coastal low episodes, including pockets of continental air moving thousands of km. offshore.
The VAMOS Ocean-Cloud-Atmosphere-Land Study - Regional Experiment (VOCALS-REx) is an international field experiment designed to better understand physical and chemical processes central to the climate system of the South East Pacific (SEP) region...the field experiment is ultimately driven by a need for improved model simulations of the coupled climate system.

In the Coastal Component of VOCALS-REx we focus our study in the air-sea-land-cloud interactions explaining time-space variability of the nearshore (0-100 km) stratocumulus cloud deck and associated atmosphere-ocean upwelling dynamics and climate.
SHOA has scheduled an institutional cruise for October 2007 to acquire coastal hydrographic data along north-central Chile. Let’s take advantage of that opportunity:

- The Oceanography group at U-Concepción will pay 20 extra days to tend their sub-surface current-meter mooring at 30° and 21°S (10-12 days in each grid), and perform a number of CTD stations. CTD data will be complemented with XBT, ship mounted ADCP, and continuous, along track obs. of pCO$_2$ and pN$_2$0, and 5 satellite-tracked surface drifters will be released in each area.

- The Meteorology group at U-Chile will perform on-board radiosonde observations (4/day) and continuous, along track meteorological observations. Ceilometer/Wind profiler will be nice but need to be borrowed ETL. Emphasis in the day-to-day variability.
• Simultaneous with the ship at 30ºS, a light aircraft (Chilean AirForce Twin Otter) equipped with a basic meteorological package will sample the AMBL and capping inversion within the 0-100 km offshore area, aiming to better define the diurnal cycle.

• Cloud and aerosol size distribution and chemical properties will be sampled at a coastal land-site (Antofagasta, 22ºS). See more in Laura Gallardo presentation.

• Both realistic simulations and idealized process studies with regional atmosphere (MM5, WRF) and coupled ocean-atmosphere models of the coastal zone will be useful in providing a context for analysis of the observations and methods to examine the roles of specific physical mechanisms of interest.
CTD-O stations along the intensive study regions.

Red dots: 4000 m CTD casts. Green: 1000 m CTD casts
Proposed Twin Otter Flight Patterns

- Diurnal cycle / coastal topo.
- Jet / cloud pattern
- Jet / upwelling / ocean fronts

La Serena (30ºS)
<table>
<thead>
<tr>
<th>Platform</th>
<th>Instruments</th>
<th>Observations</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilean Airforce Twin Otter aircraft</td>
<td>AIMMS20 AQ instrument suite</td>
<td>Temperature, humidity, winds, turbulence</td>
<td>Gallardo (Universidad de Chile)</td>
</tr>
<tr>
<td>SHOA R/V Atmosphere</td>
<td>Radiosondes, surface meteorological package, NOAA wind profiler</td>
<td>MBL structure and dynamics</td>
<td>Rutllant/Garreaud (Universidad de Chile)</td>
</tr>
<tr>
<td>SHOA R/V Ocean</td>
<td>CTD-O, ADCP and thermostalinograph, water sampling</td>
<td>Upper ocean physical and chemical structure</td>
<td>Pizarro (Universidad de Concepcion)</td>
</tr>
<tr>
<td>Antofagasta (land site)</td>
<td>Counterflow virtual impactor (CVI), bulk filter measurements, Differential mobility analyzer (DMA)</td>
<td>Cloud and aerosol size distribution and chemical properties, cloud droplet residual properties</td>
<td>Gallardo (Universidad de Chile) and Krejci (MISU, Sweden)</td>
</tr>
<tr>
<td>Modeling</td>
<td>PSU/NCAR MM5 regional atmospheric model</td>
<td>MBL/coastal jet structure and variability, diurnal subsidence wave generation</td>
<td>Garreaud (Universidad de Chile)</td>
</tr>
</tbody>
</table>
## Coarse budget estimates

- 40-50 flight hours: US$80,000
- AIMMS20 AQ airborne meas. package: US$50,000
- Radiosondes (RS80) Antofagasta: US$10,000
- Shipboard obs: Helium, balloons, technician: US$20,000
- Aerosols and Stratus (El Tofo obs. site): US$60,000
- Equipment to borrow from NOAA-ETL: RS80 receiver, PRT, ceilometer, wind profiler: US$20,000

**TOTAL:** US$240,000
Critical Tasks – Schedule

• May 2006: Secure realization in SHOA cruise

• May 2006: Secure collaboration of Air Force

• June 2006: Secure funding from UConcepción to extend SHOA Cruise

• June 2006: Submit proposal to FONDECYT including support for Met/Chem observations

• July 2006: Secure collaboration from ETL