The VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-REx)

Presented by René Garreaud
Universidad de Chile
The overall goal of VOCALS is to develop and promote scientific activities leading to improved understanding, model simulations, and predictions of the southeastern Pacific (SEP) coupled ocean-atmosphere-land system, on diurnal to interannual timescales.

The science objectives of VOCALS include:

- Improving the understanding and simulation of aerosol-cloud-drizzle interactions in the marine PBL.

- Improving the understanding and simulating the ocean budgets of heat, salinity, and nutrients in the SEP.

- Characterizing, determining, and alleviating the systematic biases of atmosphere-ocean GCMs in the SEP.

- Elucidating and understanding interactions between the SEP climate and remote climates.
Major features of SEP climate

• Cold SSTs, upwelling
• Cloud-topped ABLs
• Influenced by and influential on remote climates (ENSO)
• Unresolved issues in heat and nutrient budgets
• Important links between aerosol and clouds
• Poorly simulated by atmosphere-ocean GCMs
• High biological production and DMS fluxes
AEROSOL-CLOUD-DRIZZLE HYPOTHESES

• Variability in the physicochemical properties of aerosols has a measurable impact upon the formation of drizzle in stratocumulus clouds over the SEP

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

• 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)

• Depletion of aerosols by coalescence scavenging is necessary for the maintenance of POCs.
COUPLED-OCEAN-ATMOSPHERE-LAND HYPOTHESES

• Oceanic mesoscale eddies play a major role in the transport of heat and fresh water from coastally upwelled water to regions further offshore.

• By changing the physical and chemical properties of the upper ocean, upwelling has a systematic and noticeable effect on aerosol precursor gases and the aerosol size distribution over the SEP.

• The diurnal subsidence wave (“upsidence wave”) originating in northern Chile/southern Peru has an impact upon the diurnal cycle of clouds that is well-represented in numerical models.

• 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.
VOCALS Overall Strategy

VOCALS-REx

Airborne
NCAR C-130
(and others)

Ship
Ron Brown
(and others)

Land Sites
(Paposo, Iquique)
& Satellite

VOCALS data meeting
July 2009, Seattle

Modeling: Atmos / Ocean
LES & Regional & Global
VOCALS Regional Experiment: Hypotheses and Initial Results

Robert Wood, University of Washington

C Roberto Mechoso, Chris Bretherton, Bob Weller, Bruce Albrecht, Phil Brown, Hugh Coe, Pete Daum, Chris Fairall, Rene Garreaud, Laura Gallardo, Carmen Grados, Geraint Vaughan

Mesoscale ocean eddies

Regional pollution

Aircraft, ships, and land sites

Stratocumulus clouds
Collaborating Institutions
C. R. Mechoso, Chair, VOCALS SWG
R. Wood, VOCALS-REx PI

Logistic Support: NCAR JOSS

Operational Centers
BMRC Australia
CPTEC Brazil
ECMWF Int.
JMA Japan
NCEP US
UKMO UK

Universities
Arizona State U.
U. Concepción, Ch
CSU
Drexel U.
U. Hawaii
U. Manchester UK
U. Miami
North Carolina State
Oregon State U.
U. Reading UK
U. Arizona
U. Chile
UCLA
U. Colorado
UCSD
U. Leeds UK
U. Washington
U. Wyoming

Research Labs
Brookhaven Nat.
COLA
CNRS/LMD
France
IMARPE
IPRC
LEGOS
NASA GSFC
NASA JPL
NCAR
NOAA/CIRES
NOAA/GFDL
NRL
Pacific Northwest
Woods Hole
VOCALS-Rex: Oct.-Nov. 2008

- NSF C-130
- NOAA Ronald H Brown
- Paposo
- IMARPE José Olaya
- Iquique
- NERC Dornier 228
- CIRPAS Twin Otter
- DoE ASP G-1
- UK FAAM BAe-146
Ops. Center @ Arica-Chile. Hand-on meeting early in Nov.2008
VOCALS Data Sets

Data Set Name (Responsible Group/PIs shown in parentheses) | Date Posted | Info
---|---|---
VOCALS Facility Status Reports [NCAR/EOL] | 2008-12-11 |
VOCALS Photography [Bretherton] |

Aircraft: CIRPAS Twin Otter

CIRPAS Twin Otter Navigation and State Parameters |
CIRPAS Twin Otter 3 CPCs Data |
CIRPAS Twin Otter 94 GHz Doppler FMCW Radar |
CIRPAS Twin Otter CCN-200 |
Unprecedented observations of cloud and precipitation structure

OPEN CELLS

CLOSED CELLS

MODIS visible image
[250 m resolution]

RADAR

LIDAR

POC Edge

Boundary Cell

2km

Dave Leon, University of Wyoming
PAPOSO
25°S, 70.3°W; 690m altitude (upper site)

Antofagasta (180 km)
Paranal (45 km), 2600 m.a.s.l

Laura Gallardo, U de Chile
Boundary layer depth [all 20°S missions]

remarkable synoptic variability

Wyoming cloud radar – widespread drizzle
Diurnal cycle of temperature anomalies... upsidence wave observed & simulated
NOAA Ronald H Brown, Mesoscale Ocean Eddy Sampling

30 CTD (conductivity, temperature, depth) profiles (to 1000-2000m) were collected in eddies, fronts and the boundary currents.

300 Underway CTD profiles (to 300-700m) were collected to map the large-scale, mesoscale and submesoscale structure of the upper ocean.

Surface Drifters and Profiling SOLO floats were deployed in the center of eddies.

VMP (vertical microstructure profiles) were collected to quantify mixing.
Ronald H Brown Leg 2 track and eddies sampled

Fiamma Straneo, WHOI
Coastal Upwelling Region and source of Eddies:

Figure shows an underway CTD section up to the coast of Chile.

- Cyclonic eddy with a warm salty sub-surface core
- Boundary current with same properties as the eddies’ core
- Upwelling of fresh and cold waters of subpolar origin to the surface
Peruvian R/V Jose Olaya

15 day cruise

atmospheric, hydrographic, biogeochemical and fishery acoustic observations, glider and zooplankton experiments

Carmen Grados, INMAR
PreVOCA

GOAL: Assess the forecast skill and biases of global/regional model simulations of SE Pacific boundary-layer clouds and aerosols on diurnal and longer timescales.

WHAT? Daily hindcasts for October 2006 over the SE Pacific.

WHY? Learn how to optimally use REx, satellite and cruise data for model assessment and improvement.

WHO? 14 modeling groups using regional and global models, including climate models run in forecast mode.

WHEN? Data submission is complete; analysis in progress, journal submission early 2009.

www.atmos.washington.edu/~robwood/PreVOCA/index.html
Oct 2006 10 m vector wind (m s\(^{-1}\)) - models agree fairly well
Mean Boundary Layer Depth Along 20S
Conclusions from PreVOCA

• Much scatter in PBL/Sc properties, esp. among the regional models: an issue for aerosol-cloud interaction?
• UKMO and ECMWF models perform best overall, correctly capturing most geographic variations in PBL depth/structure and cloud cover.
• Sharpness of inversion challenges even the highest-resolution models.
• Cloud variability and aerosol feedbacks are cutting-edge challenges to the best global and regional models.
• VOCALS SE Pacific datasets are wonderful tools for assessing and improving cloud and aerosol simulations.
# Papers in AMS database (all journals)

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