Properties of Aerosols and Clouds Measured by the G-1 During VOCALs

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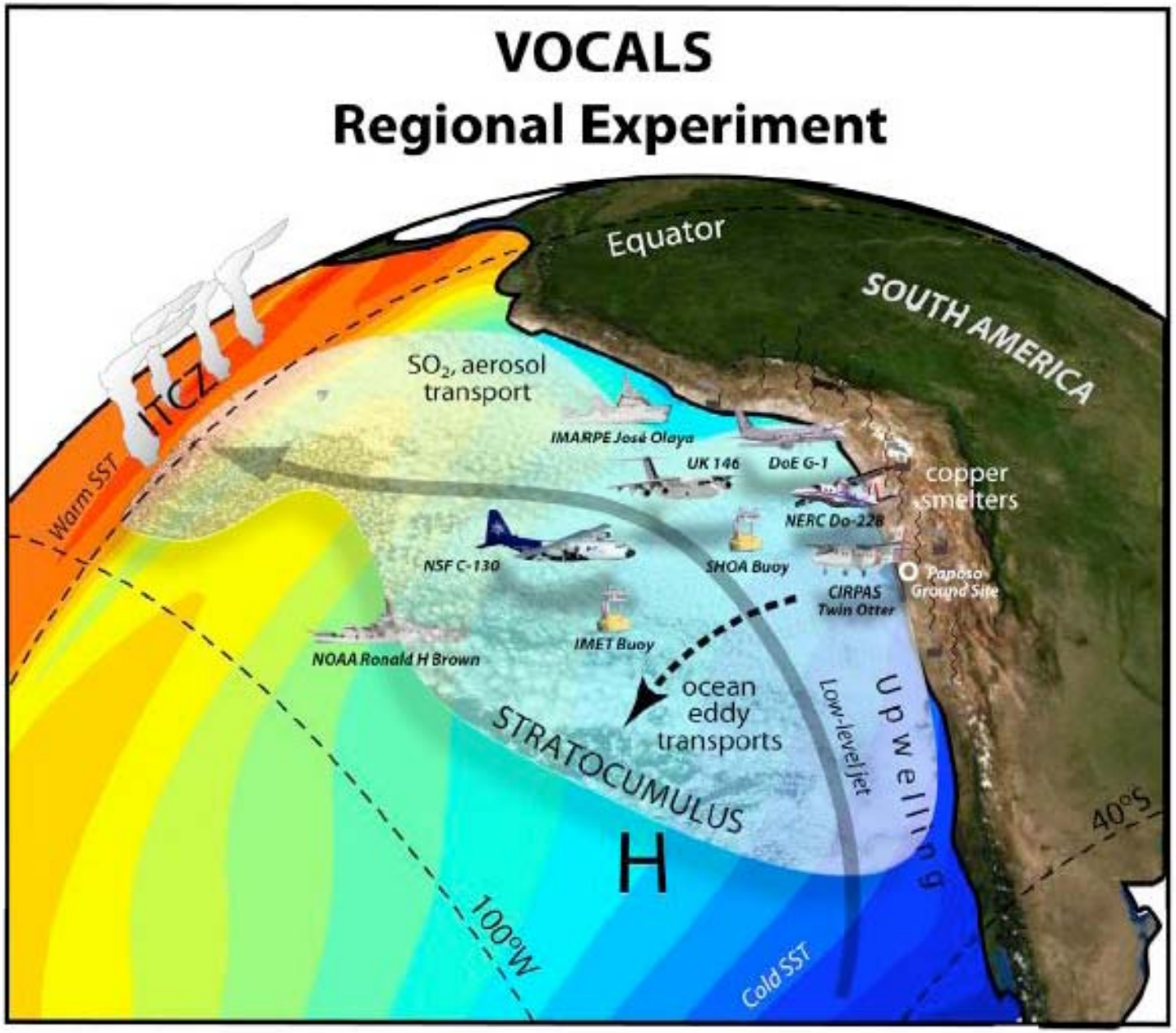
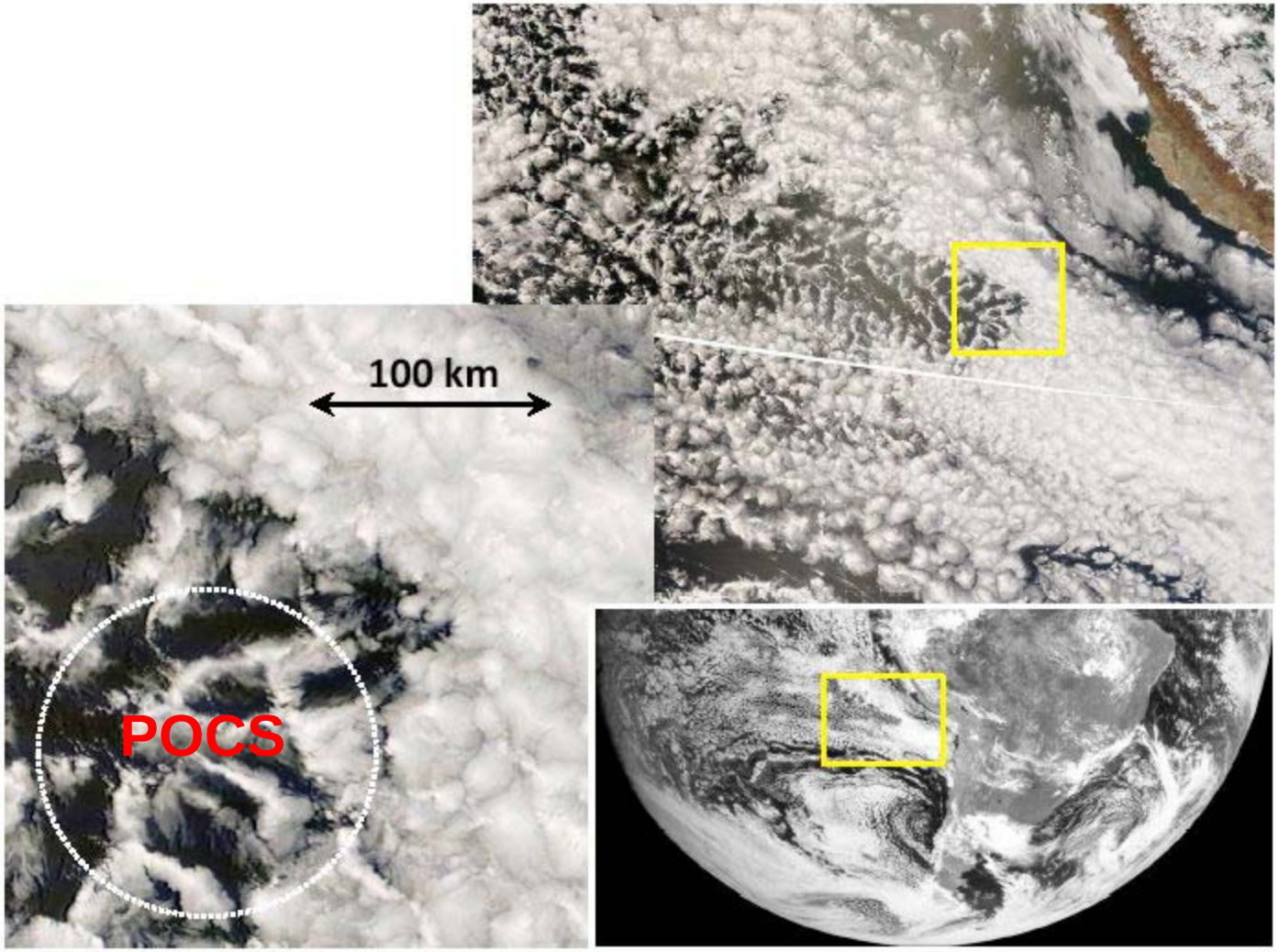
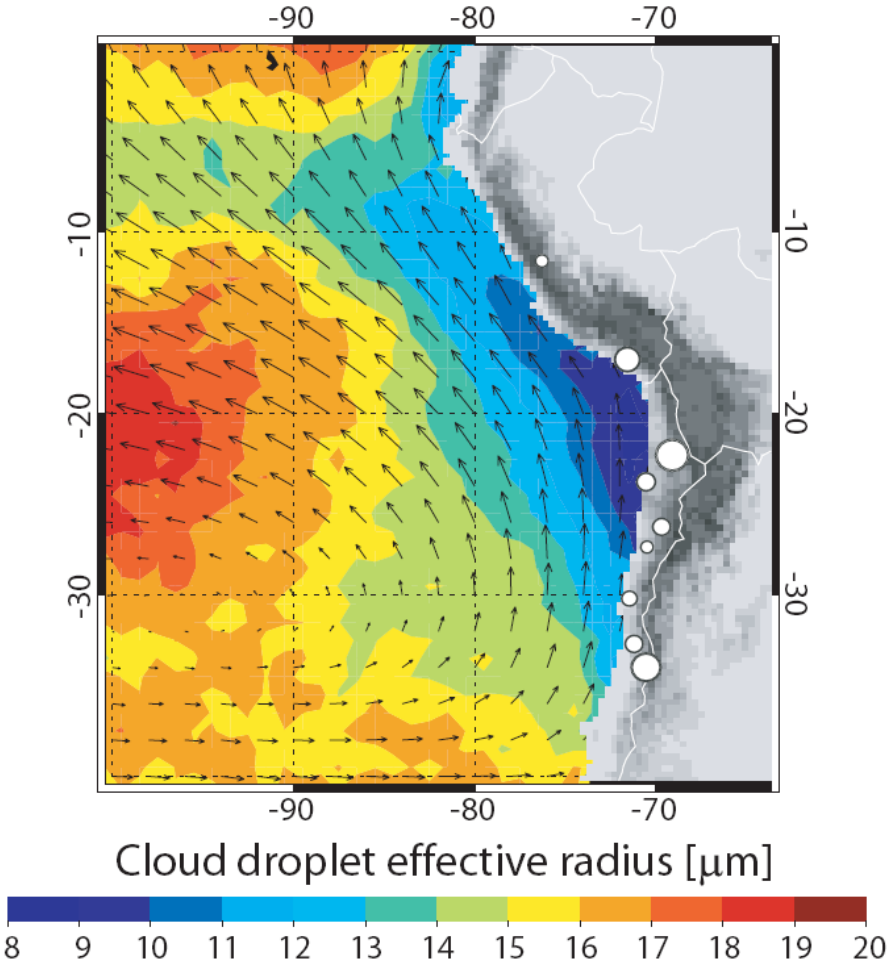

VOCALS
Regional Experiment
Equator
SOUTH AMERICA
ITCZ
Warm SST
SO_2, aerosol transport
IMARPE José Olaya
UK 146
DoE G-1
copper smelters
NERC Do-228
NSF C-130
SHOA Buoy
Paposo Ground Site
CIRPAS Twin Otter
IMET Buoy
NOAA Ronald H Brown
ocean eddy transports
STRATOCUMULUS
Low-level jet
Upwelling
H
100°W
40°S
Cold SST

VOCALS PLATFORMS

Pockets of Open Cells- Origin, persistence, influence of aerosols



Longitudinal Gradient in Cloud Properties



- DMS from upwelling near the coast?
- Advection of SO_2 and sulfate emissions from continental sources (smelters)?

VOCALS-REx Themes and Hypotheses

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)

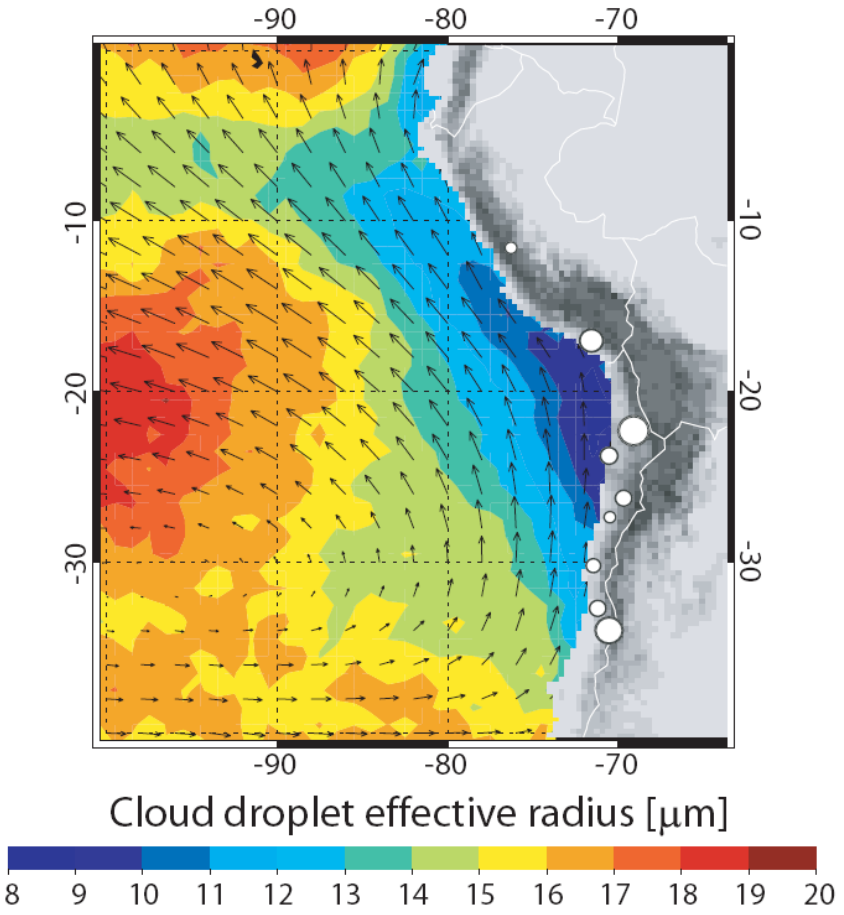
- Depletion of aerosols by coalescence scavenging is necessary for the maintenance of POCs.

G-1 Objectives

- **Identify sources of aerosols responsible for the longitudinal gradient in cloud microphysical properties observed by satellite.**

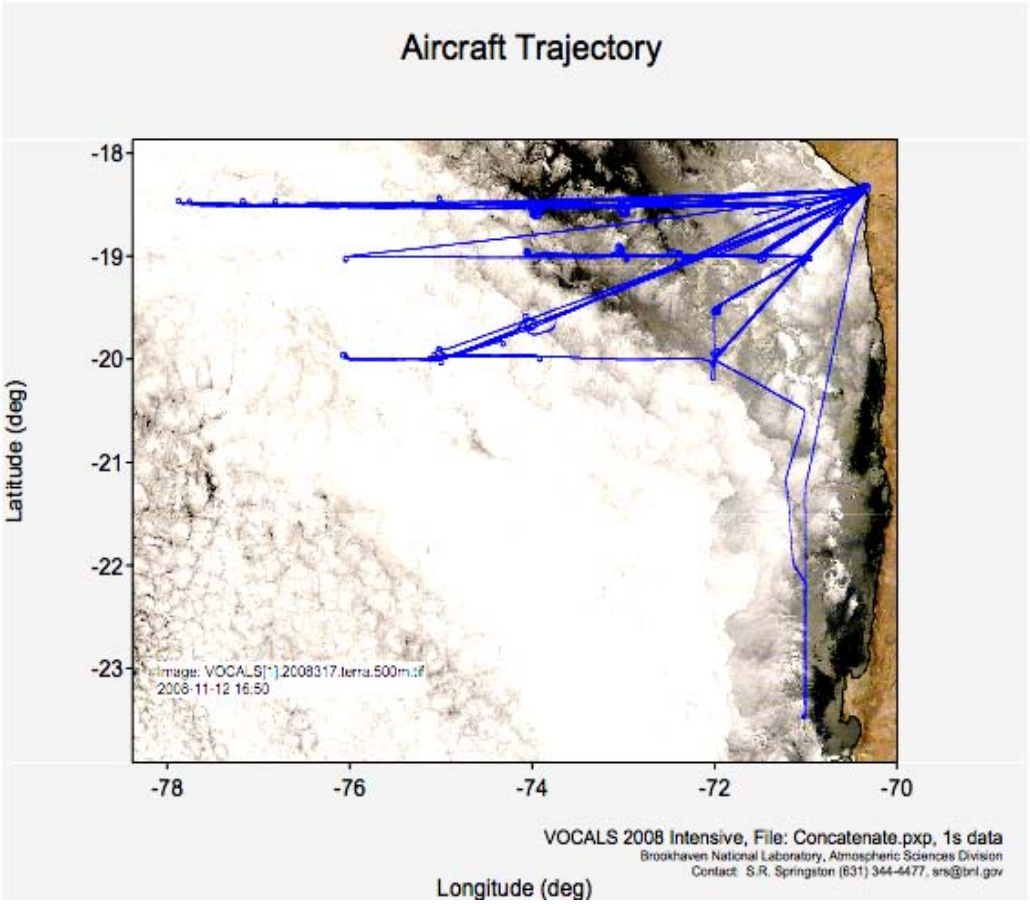
- **Characterize aerosol composition, size distribution, and CCN activity.**

- **Relate aerosol and cloud microphysical properties to drizzle formation.**



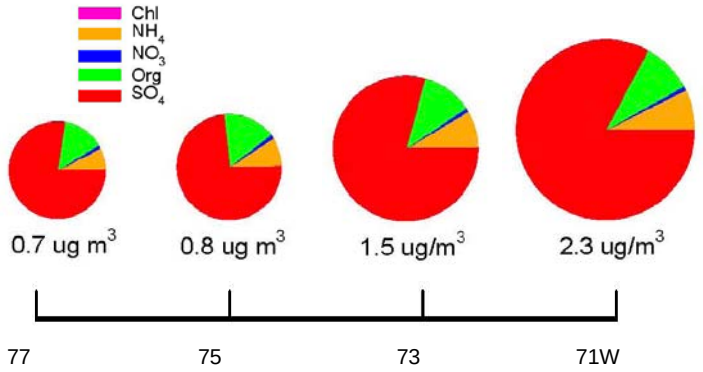
G-1 Flight Tracks

Seventeen flights during the program, mostly E-W to examine gradients in cloud and aerosol properties.



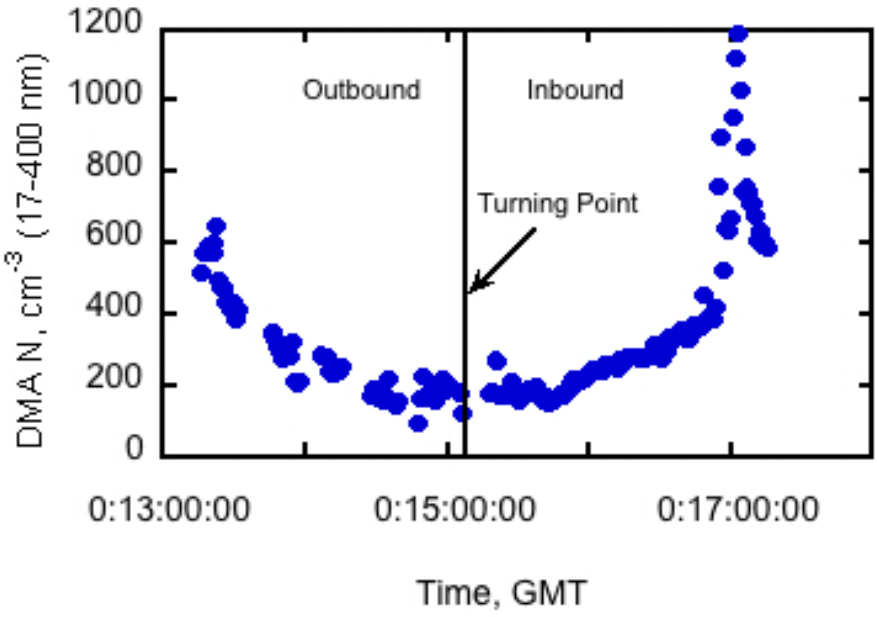
Aerosol composition and spatial distribution

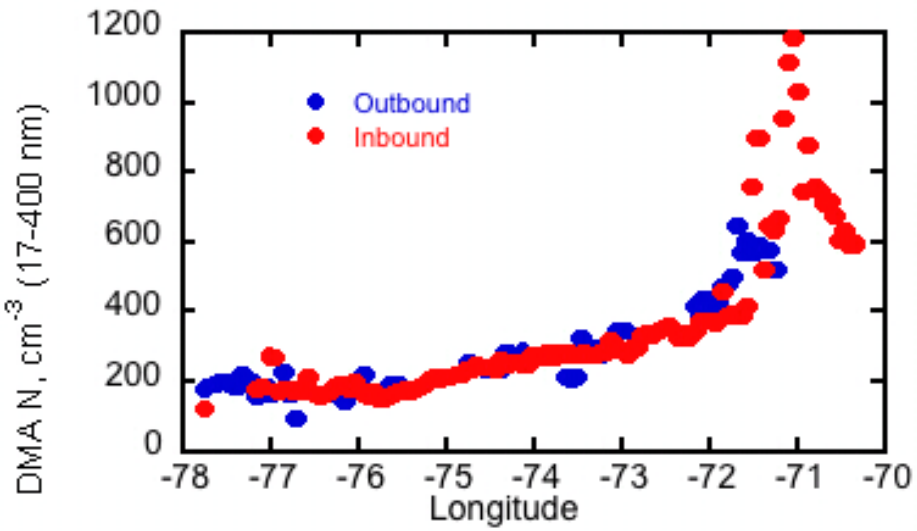
- Monotonic decrease in loading with distance from coast.
- Aerosol composition dominated by sulfate.
- Aerosol very acidic, ~20% neutralized.
- Composition implies only a small contribution from DMS



Average aerosol composition and loading as a function of distance from the coast.

Below Cloud Aerosol concentration



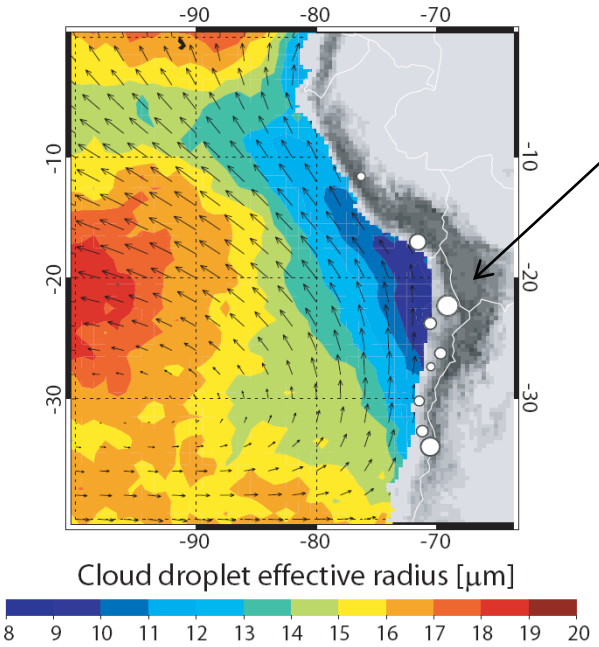


•Concentrations decrease by a factor of 3 in going from the coast to ~400 miles offshore.

•Right hand panel illustrates invariance of aerosol fields as outbound and in-bound concentrations virtually superimpose. Similar behavior noted on other days.

Aerosol Acidity

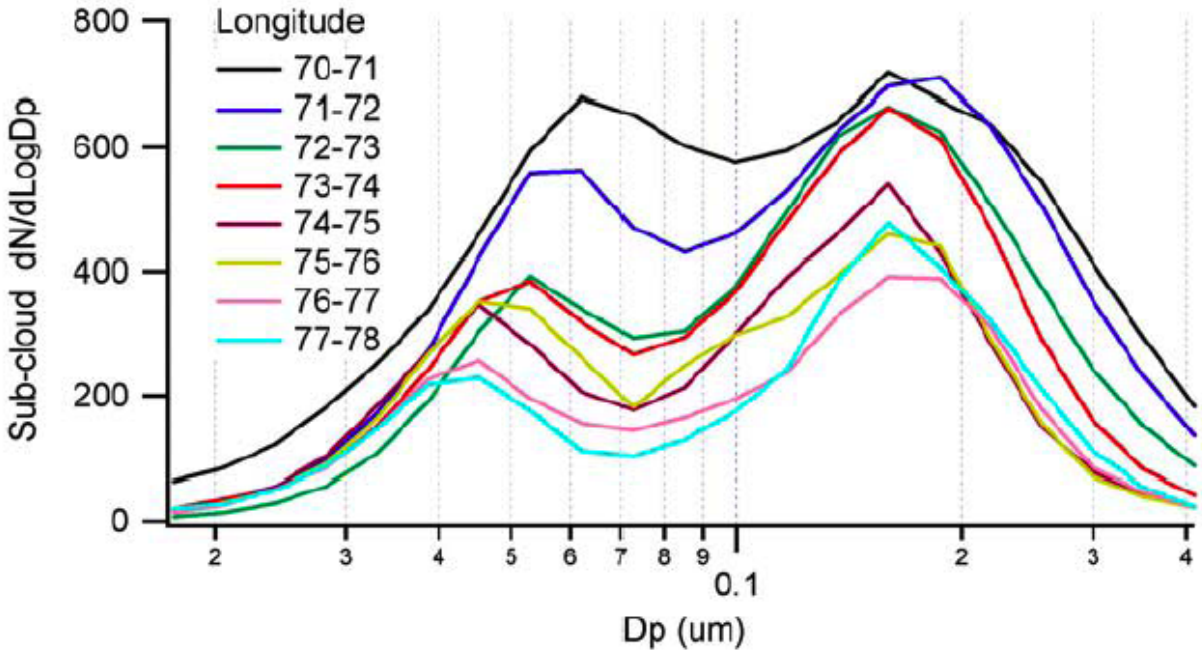
Is it reasonable that the aerosols would be so acidic?



Smelters

SO_2 thought to mainly originate from smelters located mainly in the desert. Because of very low population density of both animals and humans, no ammonia sources present to neutralize the H_2SO_4.

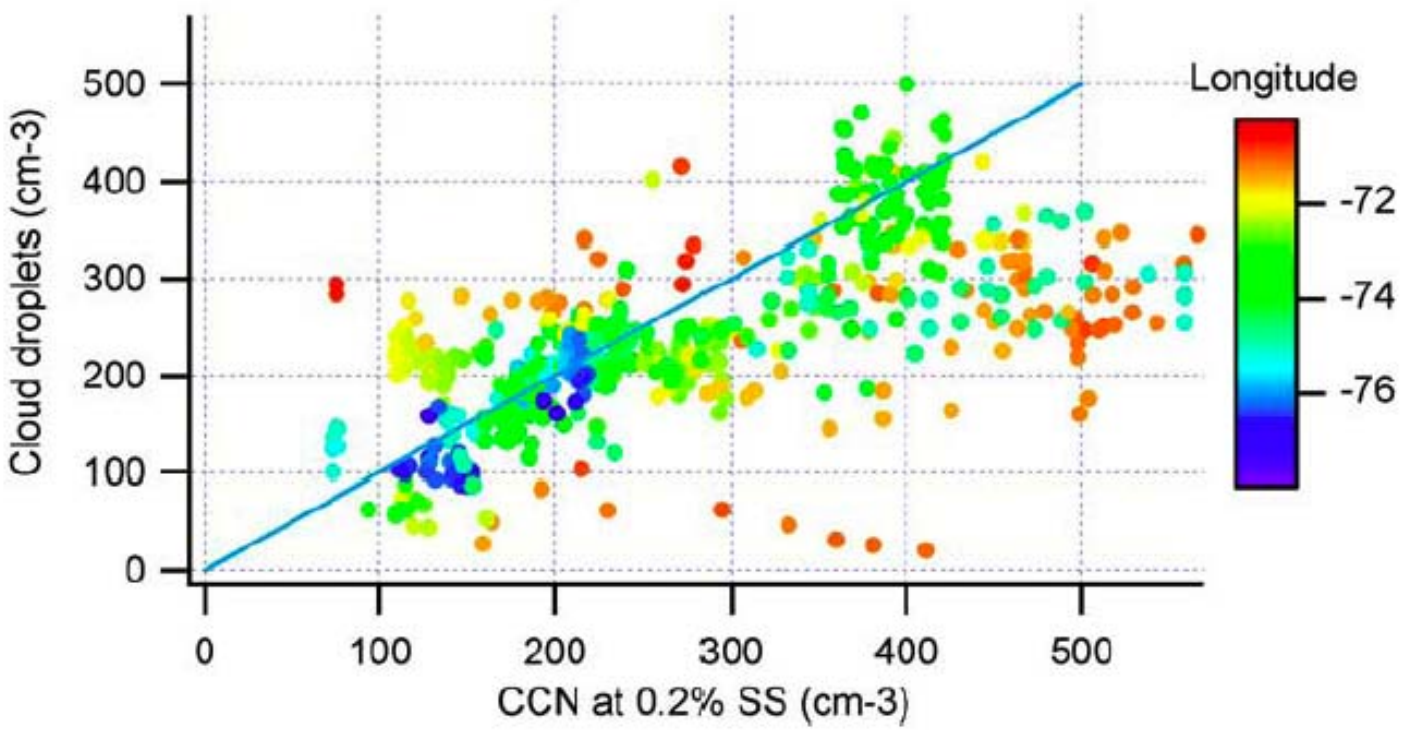
Aerosol microphysics



•Bimodal size distribution with a Hoppel minimum that shifts towards smaller sizes with distance from the coast.

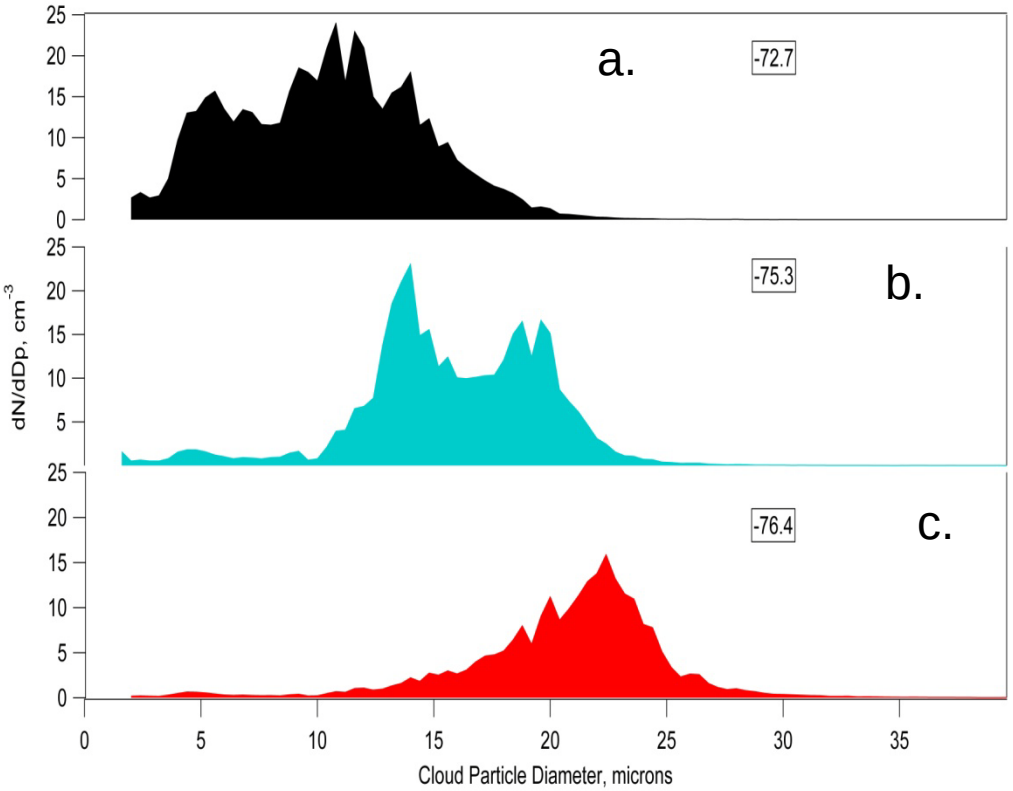
•Number concentration also decreases with distance from coast.

Activation of Aerosols to Cloud Droplets



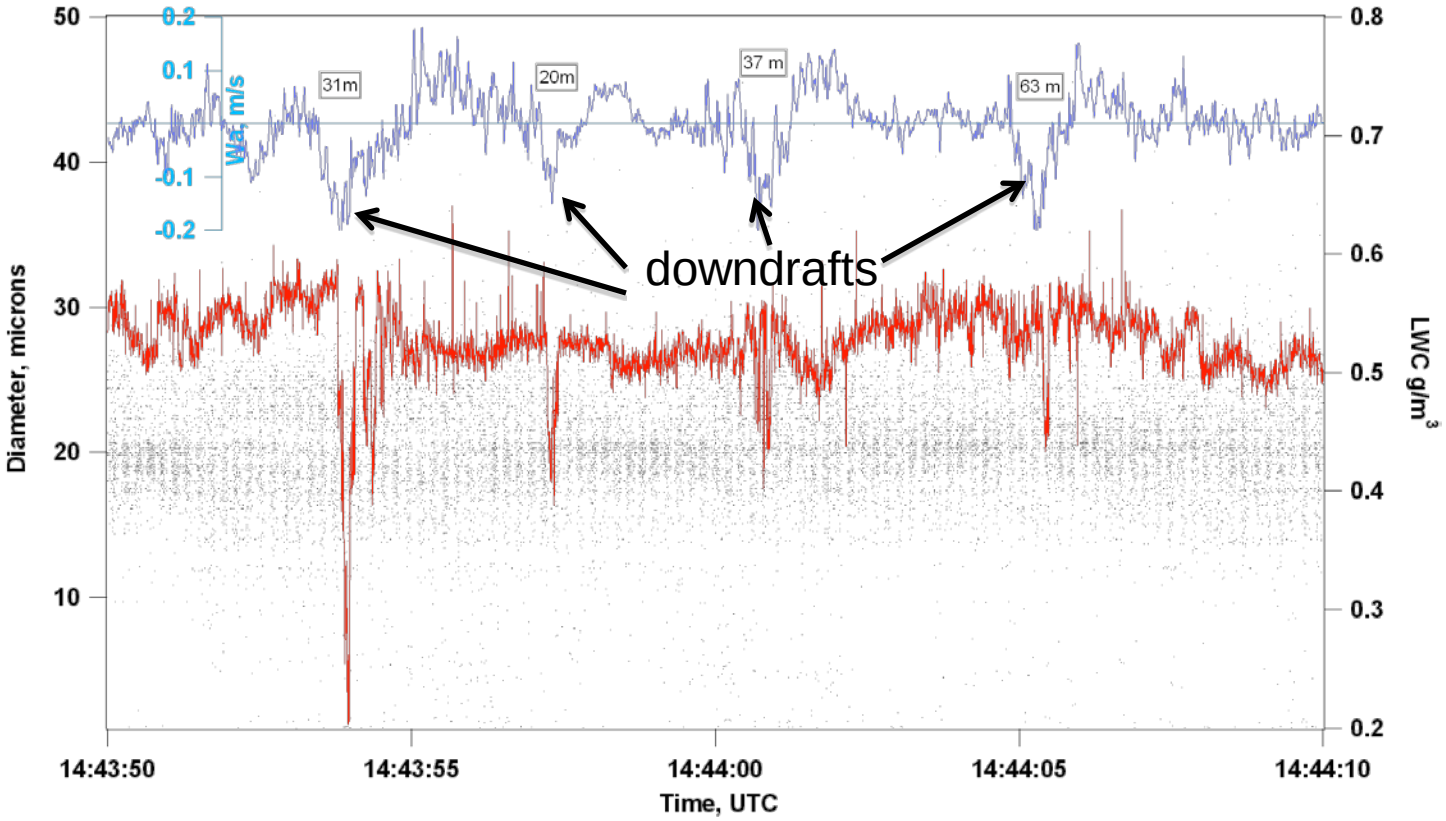
Cloud droplet concentration reasonably consistent with CCN @ 0.2%

Cloud Microphysics



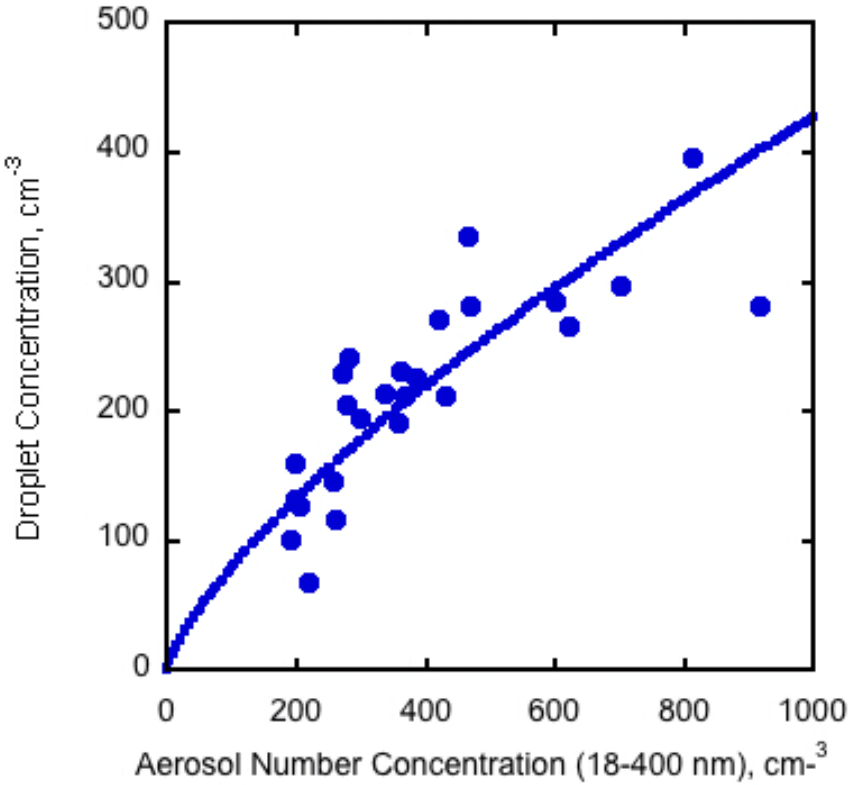
•Droplet number concentration decreases and size increases with distance from the coast. Drizzle mode appears in panel b, and is fully developed in panel c.

High speed cloud microphysical data



Narrow downdrafts from above cloud correlate with drying of cloud droplets.

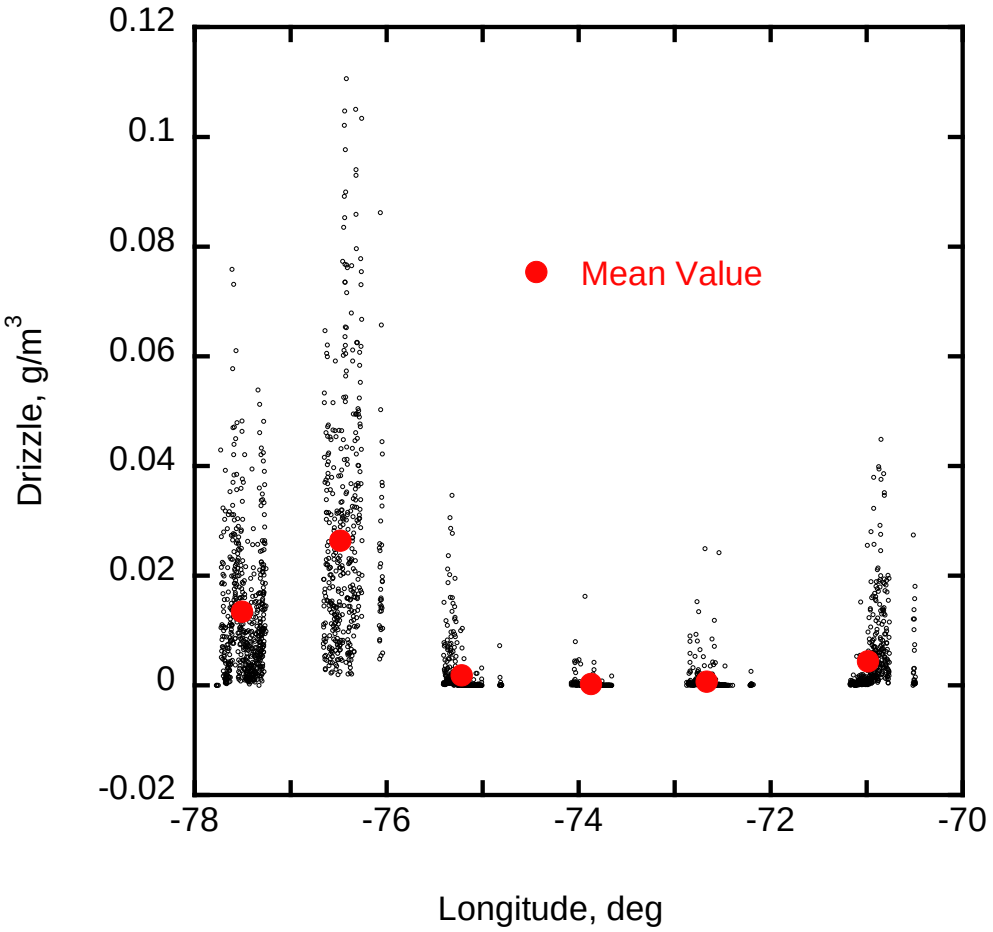
Aerosol vs Cloud Droplet Concentrations

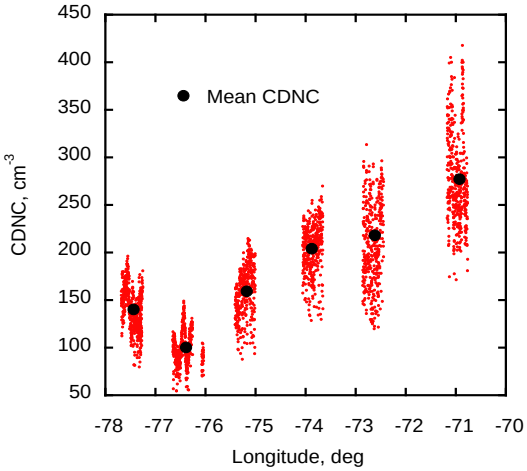


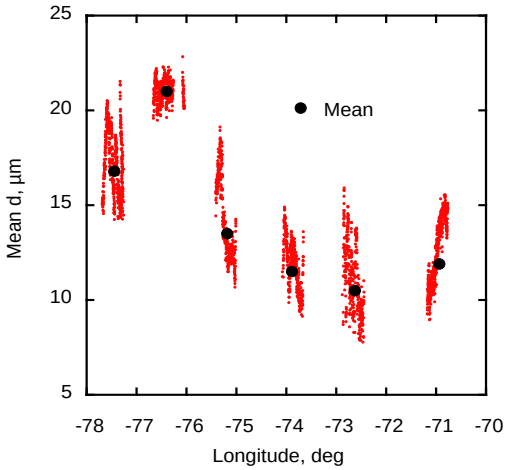
Leg average values of cloud droplet concentrations as a function of leg average below-cloud aerosol concentrations for all G-1 flights where below- and in-cloud flights were vertically stacked.

Dependence of droplet concentration on aerosol concentration similar to observations in other programs such as MASE.

Drizzle and cloud microphysics







Drizzle concentrations highest offshore where aerosol concentrations lowest and droplets largest.

Autoconversion Rate and the Threshold Function

(Liu, Daum, McGraw, GRL, 2005)

Autoconversion rate ($g/m^3/s$), $P = P_0 T_{LDM}$

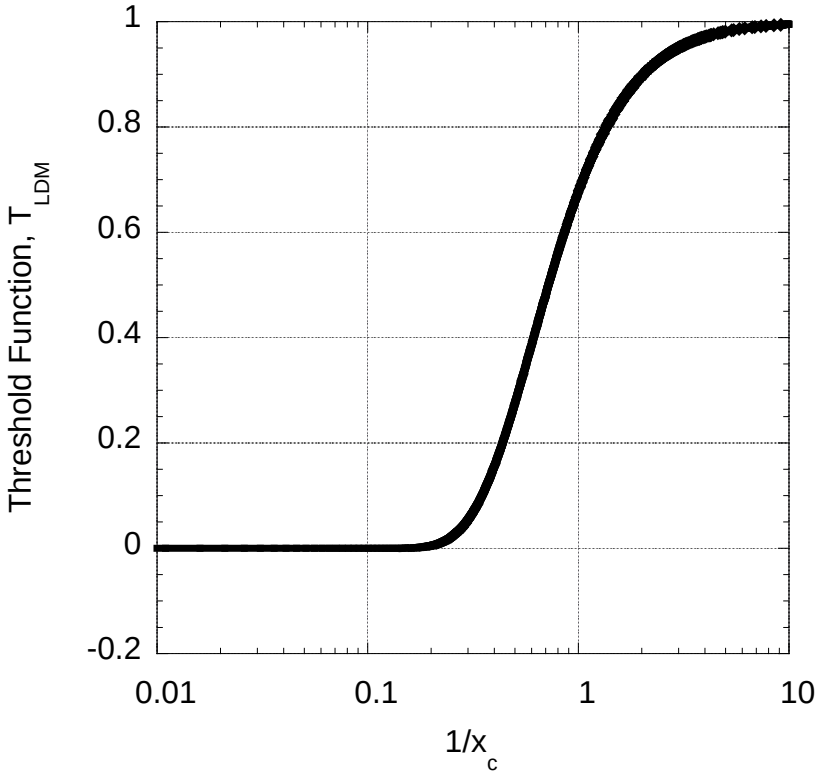
Where,

$T_{LDM} = 1/2(x_c^2 + 2x_c + 2)(1+x_c)\exp(-2x_c)$

Where,

x_c *is the ratio of the critical to mean mass*

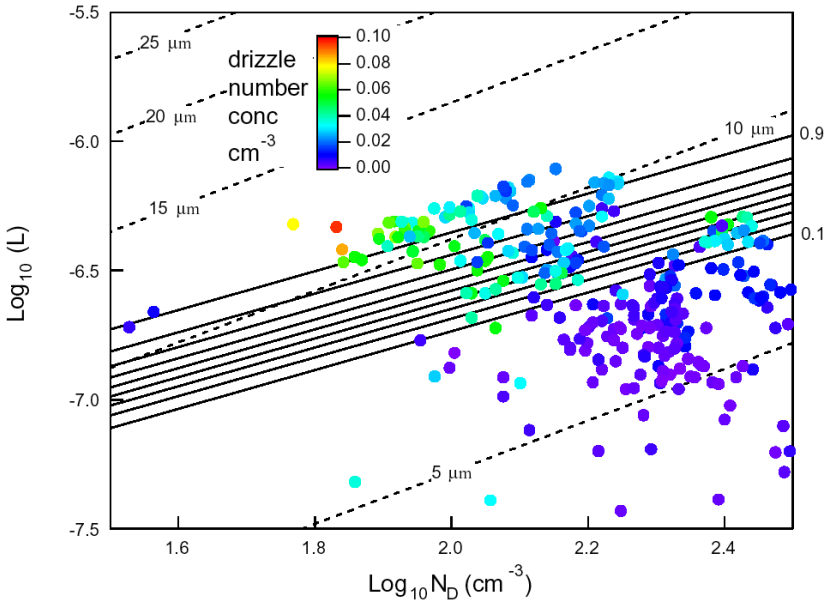
$x_c = 9.7 \times 10^{-17} N^{3/2} L^{-2}$



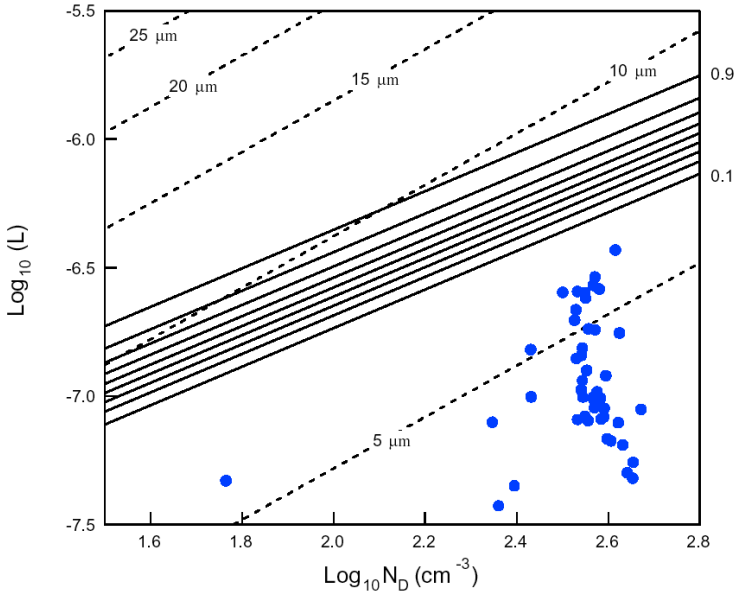
If $1/x_c >> 1$, $P = P_0$ and the cloud drizzles. If $1/x_c << 1$, $P = 0$ and the cloud does not drizzle. Transition region $0.3 < 1/x_c < 1.2$.

Examples From the VOCALS Measurements

Moderate Drizzle Day



Low Drizzle Day



Contours of the LDM threshold function and mean cloud droplet radius. Solid lines, LDM threshold function. Dashed lines, mean cloud droplet radius. Markers show cloud rainbow colored according to drizzle drop number concentrations

Conclusions

- Coastal MBL aerosols were dominated by sulfate.
- Aerosol number and mass concentrations decreased with distance from the coast.
- Cloud droplet number concentrations were correlated with below cloud aerosol concentrations, and also decreased with distance from the coast.
- Drizzle concentrations were highest when cloud droplet concentrations the lowest.
- LDM threshold function agrees with observations.

Data availability-http://www.eol.ucar.edu/projects/vocals/

Acknowledgements

- Scientists- Steve Springston, Gunnar Senum, Larry Kleinman, Yin-Nan Lee, John Jayne, John Hubbe, Liz Alexander, Alex Laskin, Art Sedlacek, Ryan Moffet
- Aircraft- Bob Hannigan, Dick Hone, Bill Svancara, Mikhail Pekour
- Doe- For funding the science and the aircraft
- Rob Wood and Chris Bretherton for formulating the idea for VOCALs and for leading the NSF effort with the C-130