VOCALS REx:
Aerosol Physics
at the Ocean Surface
On the NOAA RV Ronald H. Brown
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VOCALS REx GOAL

Better understand aerosol, clouds and precipitation as interactive processes that in turn influence cloud properties - cloud cover, thickness and particle size and optics over the South East Pacific.

Hypotheses we are addressing – two of many.

1a. “Variability in the physico-chemical properties of aerosols has a measurable impact upon the formation of drizzle in stratocumulus clouds over the SEP.”

1c. “The small effective radii measured from space over the SEP are primarily controlled by anthropogenic, rather than natural, aerosol production; entrainment of polluted air from the lower free-troposphere is an important source of cloud condensation nuclei (CCN).”
Panama Canal, entry from the Atlantic
Instrument Summary

Optics: light scattering and absorption coefficients
nephelometer and absorption photometers, 3 wavelength, humidified nephelometer

Chemistry: 12 to 24 hour impactor, filter samples for major ions.

Physics: number-size distribution 20nm to 10μm diameter
DMPS, Differential Mobility Particle Sizer, 20 to 800nm
APS, Aerodynamic particle sizer, 800nm to 10μm

Cloud Condensation Nuclei Concentration
DMT, Thermal Gradient CCNC
0.10, 0.15, 0.20, 0.30 and 0.60% SS.

DMPS is a differential measurement 5 minute time resolution
CCNC is an integral with 60 minute resolution.

In order to relate the two:
Integrate DMPS number-size distribution from 800nm to critical diameter,
for a given CCNC supersaturation assuming a chemical composition - eg., ammonium sulfate.
Integral (over size) of particle number concentration from DMPS vs. droplet concentration from CCNC at 0.2% and 0.6% supersaturation

Chemical assumption: Ammonium sulfate

0.2% supersaturation
R = 0.987
Intercept = -15 ± 4
Slope = 1.14 ± 0.015

0.6% supersaturation
R = 0.980
Intercept = -11 ± 6
Slope = 1.15 ± 0.018
Generic marine number-size distribution

Classical marine features

Some influence from urban industrial sources in region 500 km, several days upwind

Combustion

Biomass burning

Copper smelter SO$_2$

CCN = C * (SS$\%$)$^K$, Twomey and Squires, 1959
Coastal, continental aerosol

Dominant accumulation mode

Minor Aitken mode (shoulder)

Strongly influenced by urban industrial sources in region 500 km, several days upwind

Combustion

Biomass burning

Copper smelter SO₂
Remote marine aerosol

Dominant accumulation mode

Minor Aitken mode (shoulder)

Strongly influenced by urban industrial sources in region 500 to 1000 km or more upwind
Mixing ratio of species SH-SO2t at 200 m asl for age class 0 - 10.00 DAYS

Latest analysis time 20081108. Actual time 20081121. 0
Mean value 0.111E+00 Maximum value 0.494E+01 Minimum value 0.000E+00
Distance of grid lines 5.0 deg

FlexPart model SO₂ conc. at 200m
Accumulation mode is depleted in all cases. Within the more active POC region the Aitken mode is depleted as well.
POC 28 Oct 2008

Post POC 28 Oct 2008
Summary:

Aerosol number-size distribution is consistent with past results in the SEP in terms of relation to POCs, i.e. depleted accumulation and Aitken mode concentrations.

A spatial relation between number-size distribution features and POCs is evident, but a causal relationship is not yet clear.

At times the effect of continental, pollution, aerosol extends far to the west of the continent into the SEP stratus field.

Evidence for new particle formation in the MBL is minimal, it occurs in a very small volume fraction.

The chemistry implies a relatively soluble aerosol. I.e. size, not chemistry, is the main controlling factor in terms of effective CCN.
FlexPart model 8 day back-trajectory and SO$_2$ probable source region contribution at 200m
Figure 3: Accumulation mode aerosol concentration (top), and aerosol size distribution (bottom) measured on the R/V Roger Revelle over the SEP during November 2003. The red horizontal bars indicate periods where satellite imagery revealed pockets of open cells (POCs) over the ship. At these times there is strong reduction of the accumulation mode.
27 Oct 2009,
Satellite and RHB camera images
Summary:

Aerosol number-size distribution is generally consistent with past results in the SEP in terms of relation to POCs, i.e. depleted accumulation mode concentration.

At times the effect of continental, pollution, aerosol extends far to the west into the stratus field.

POC-like aerosol fields are extensive in time and space in the SEP MBL.

Evidence for new particle formation in the MBL is minimal, it occurs in a very small volume fraction.

The source of gas phase compounds for mass growth of Aitken mode to effective CCN size seems to be marine DMS and organic compounds, as well as SO$_2$ and organic compounds advected from the continent.

The chemistry implies a highly soluble aerosol. I.e. size, not chemistry, is the controlling factor in terms of effective CCN.
Summary:

Aerosol number-size distribution is generally consistent with past results in the SEP in terms of relation to POCs, i.e. depleted accumulation and Aitken mode concentrations.

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