VOCALS REx:
Aerosol Physics
at the Ocean Surface
On the NOAA RV Ronald H. Brown
October, November 2008

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Thanks to: Captain, Chief Scientist, Oceanographers, and the Crew of the Ron Brown

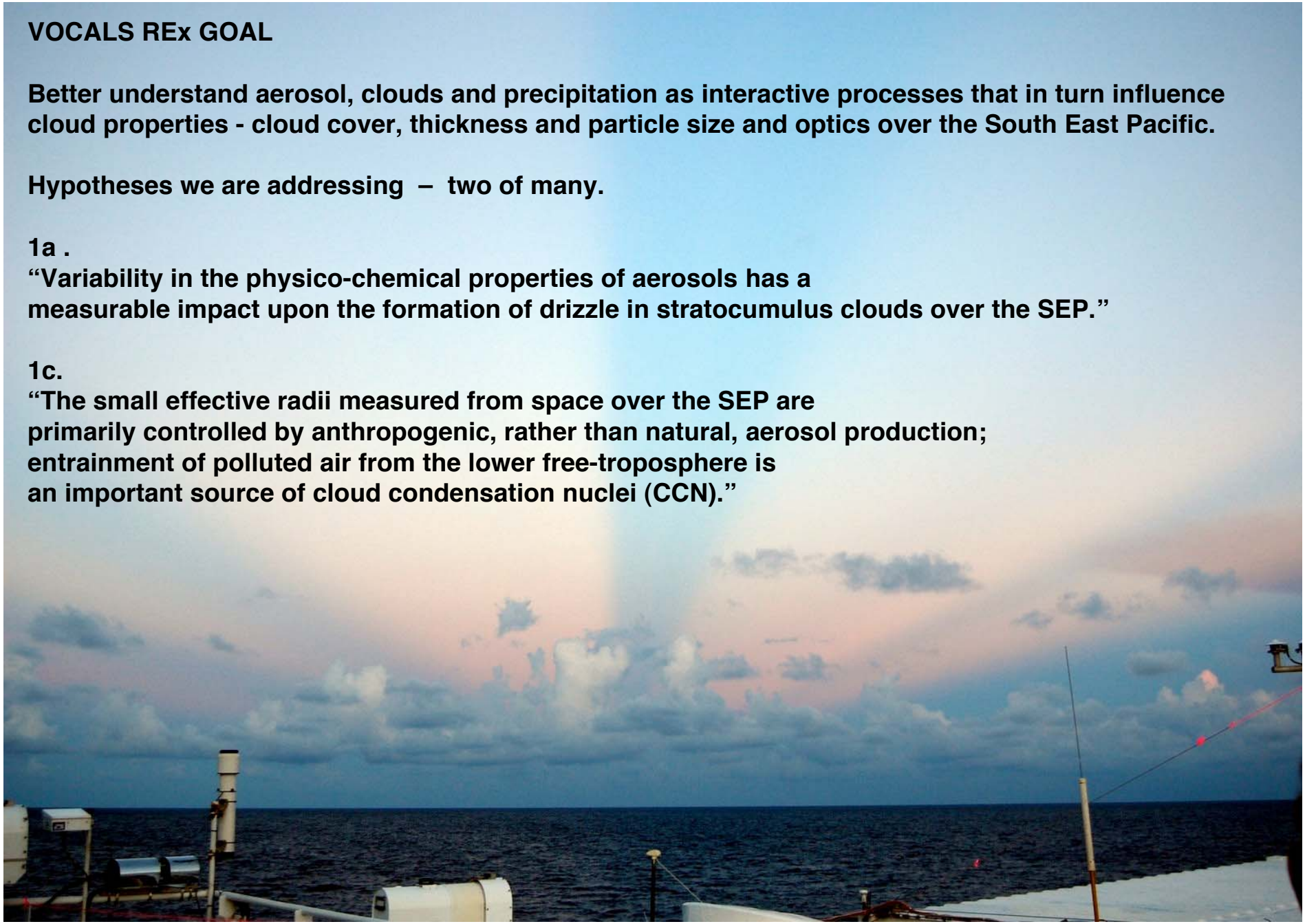
VOCALS REx GOAL

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.

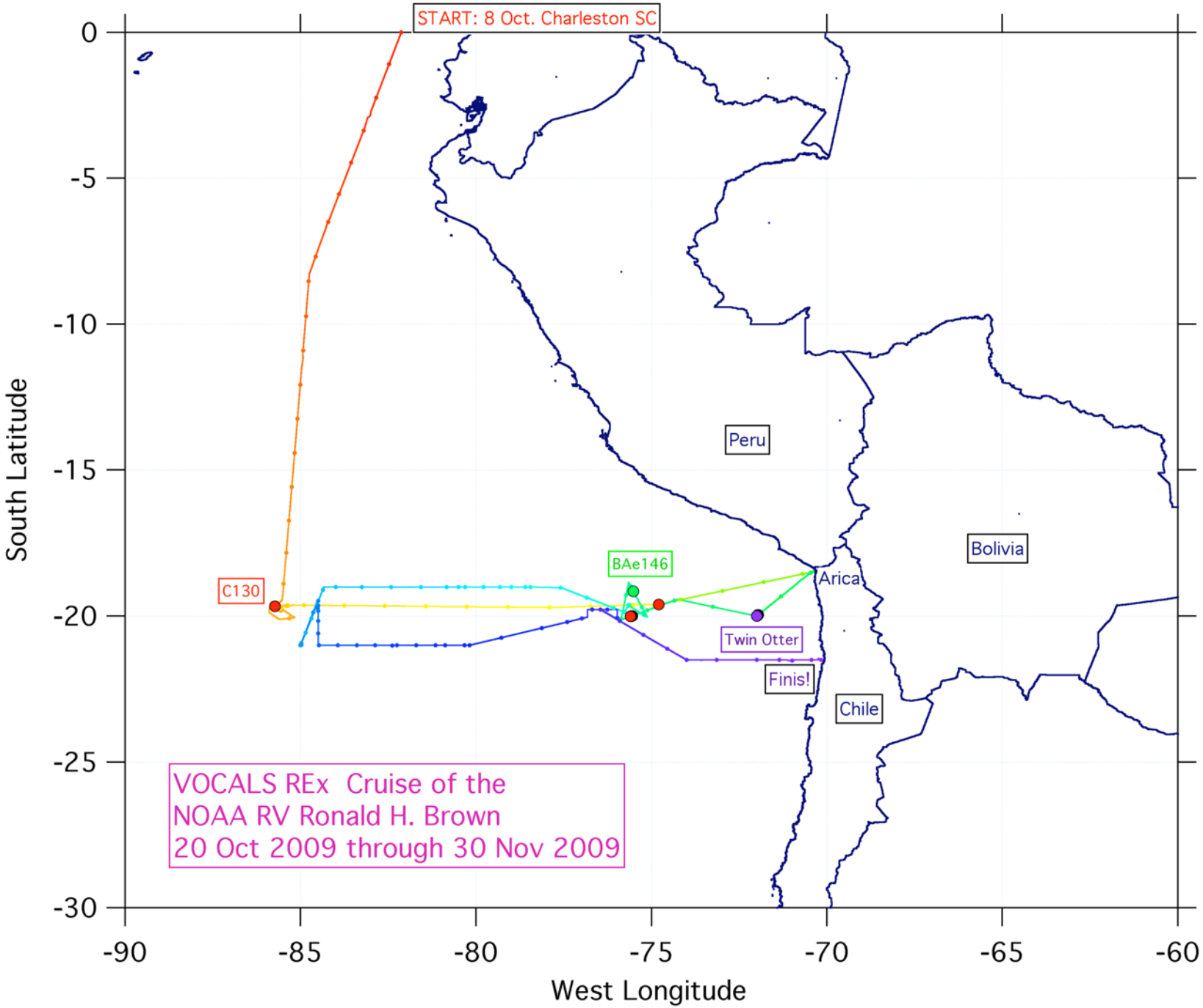
Hypotheses we are addressing – two of many.

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


START: 8 Oct. Charleston SC
C130
BAe146
Twin Otter
Finis!
Arica
Peru
Bolivia
Chile
VOCALS REx Cruise of the
NOAA RV Ronald H. Brown
20 Oct 2009 through 30 Nov 2009
South Latitude
West Longitude
0
-5
-10
-15
-20
-25
-30
-90
-85
-80
-75
-70
-65
-60

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

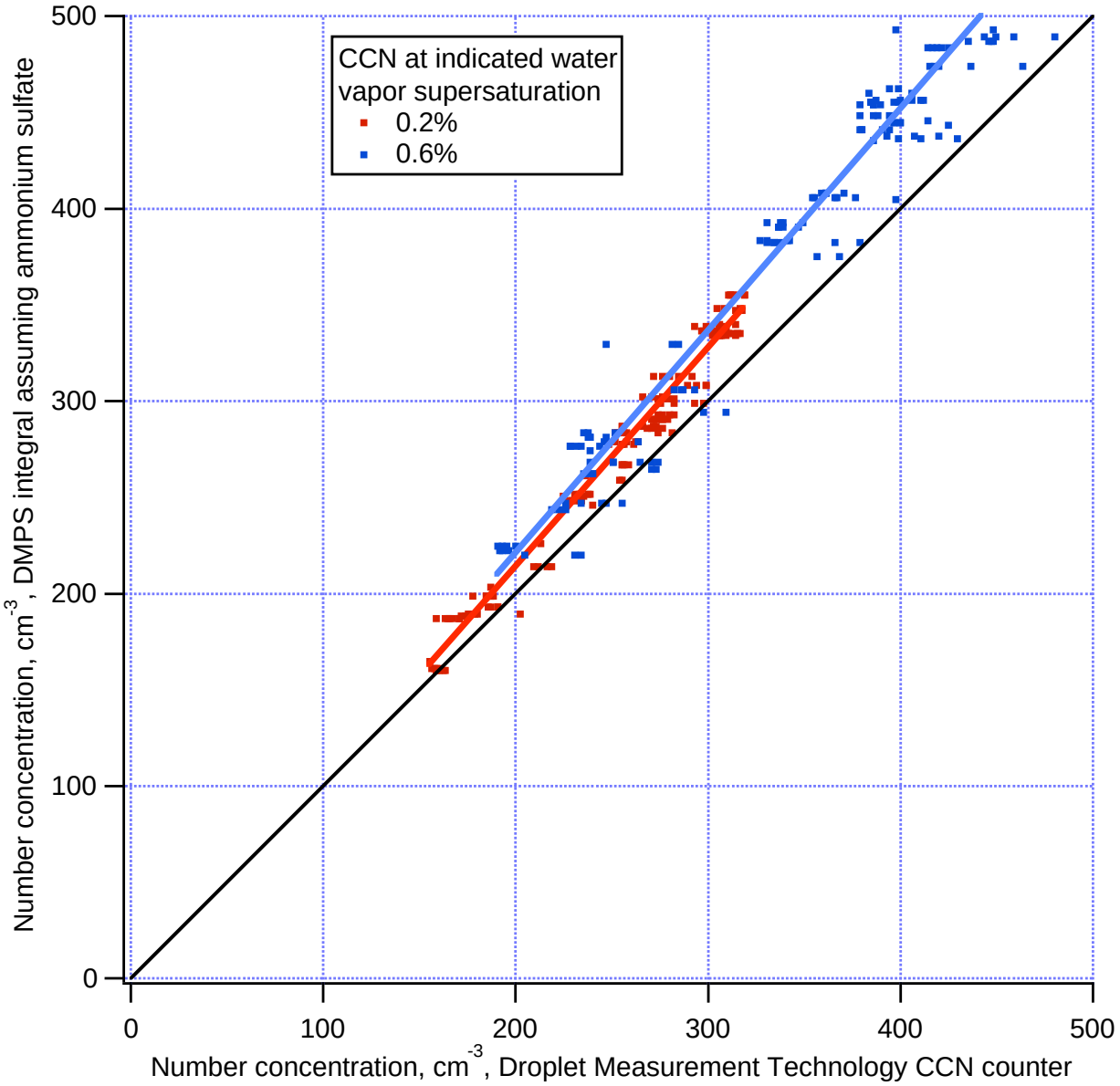
Cloud Condensation Nuclei Concentration
DMT, Thermal Gradient CCNC
0.10, 0.15, 0.20, 0.30 and 0.60% SS.

DMPS is a **differential** measurement 5 minute time resolution
CCNC is a **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.

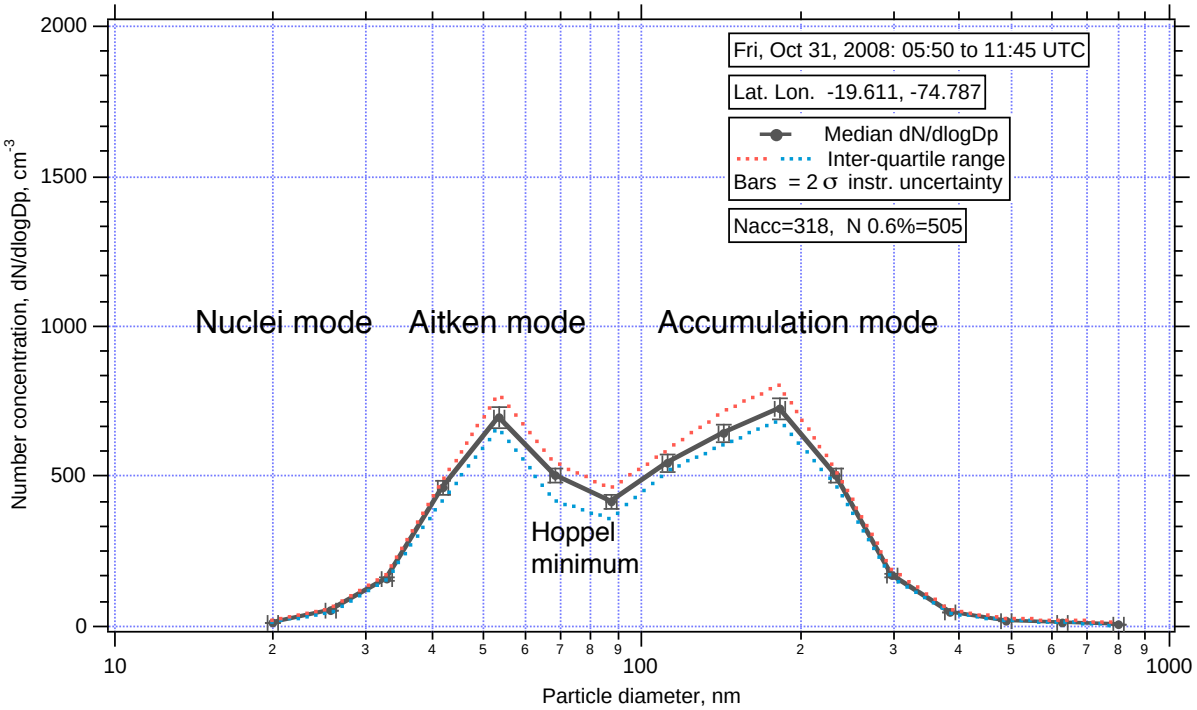
Integral (over size) of particle number concentration from DMPS
vs. droplet concentration from CCNC at 0.2% and 0.6% supersaturation

Chemical assumption: Ammonium sulfate



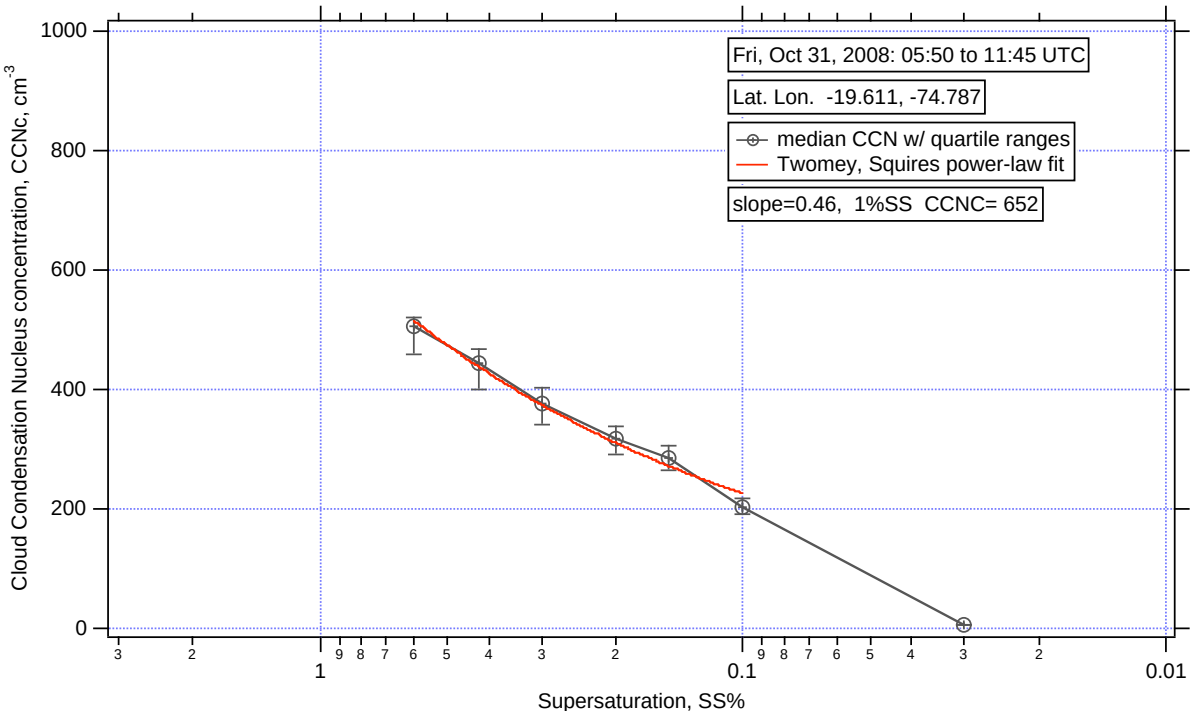
0.2% supersaturation
R = 0.987
Intercept = -15± 4
Slope = 1.14 ± 0.015

0.6% supersaturation
R = 0.980
Intercept = -11 ± 6
Slope = 1.15 ± 0.018

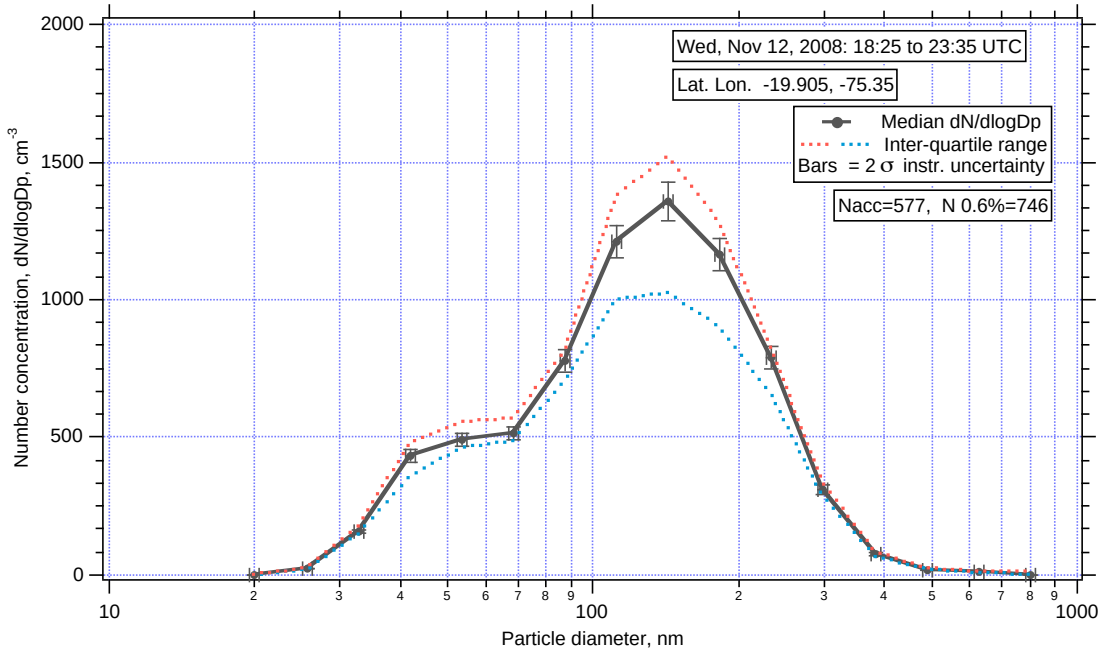


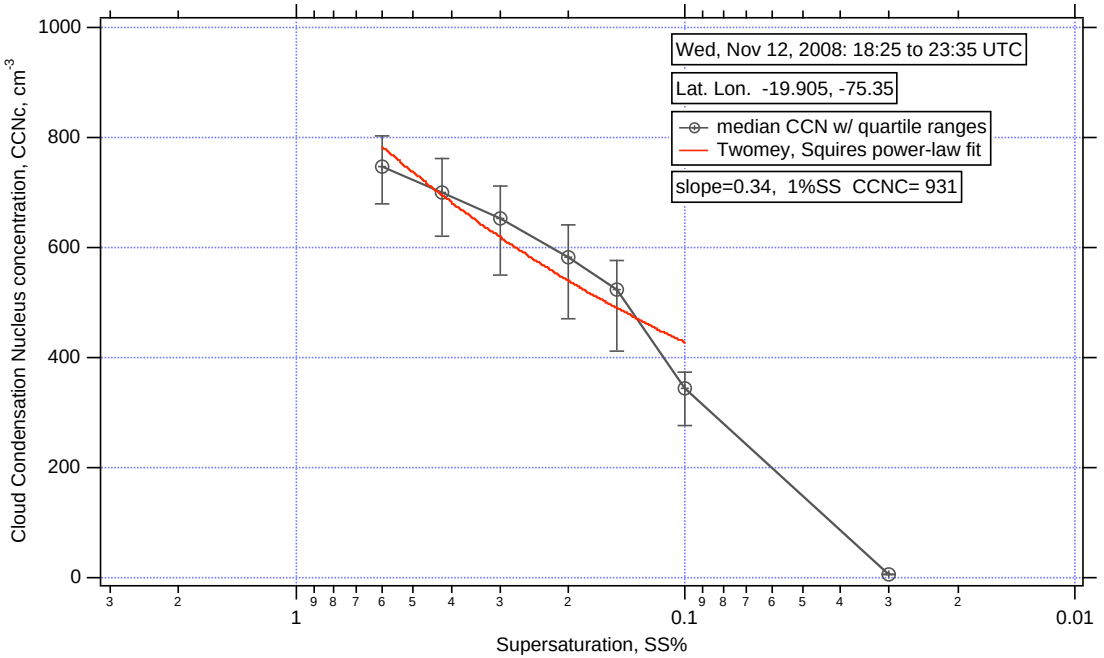
Generic marine number-size distribution

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

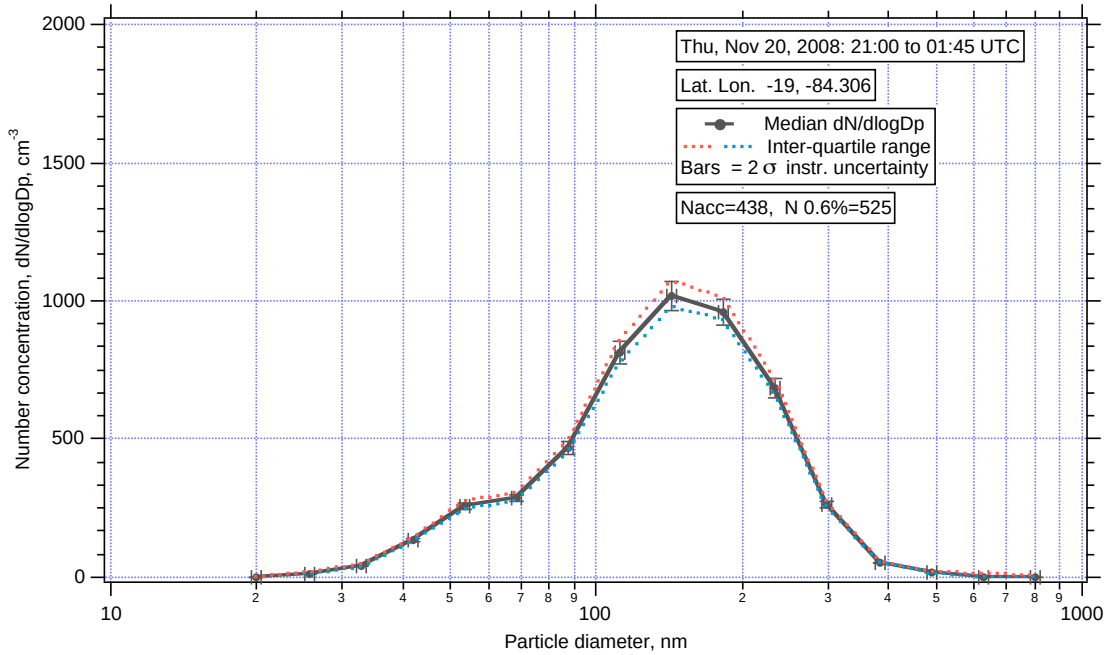


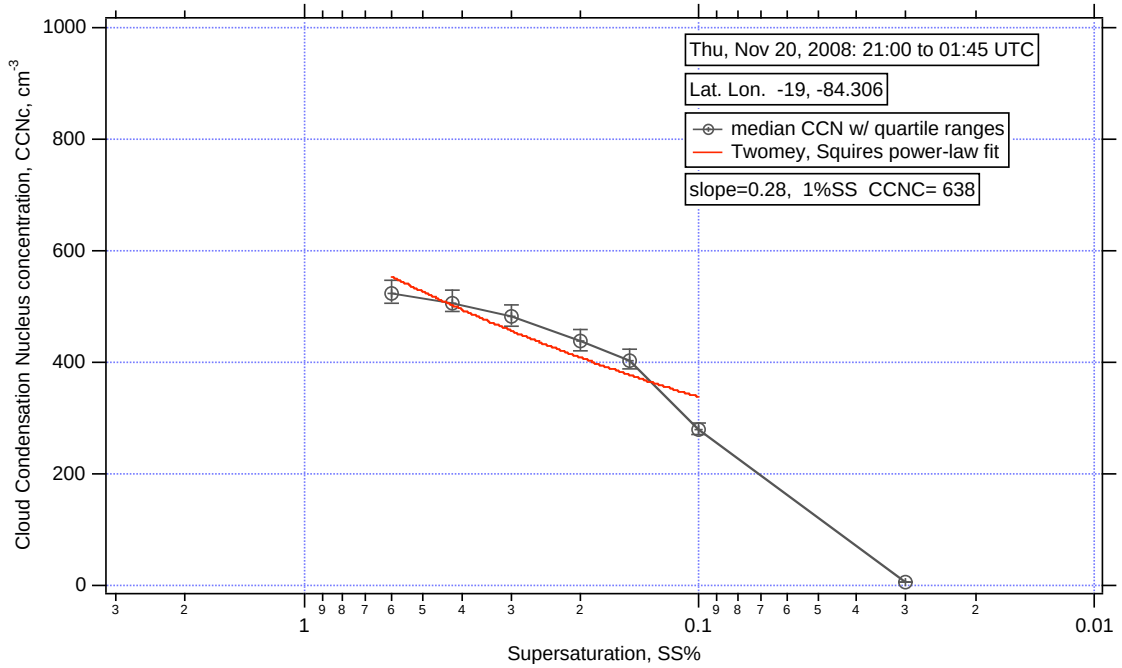


Coastal, continental aerosol

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 SO_2





Remote marine aerosol

Dominant accumulation mode
Minor Aitken mode (shoulder)

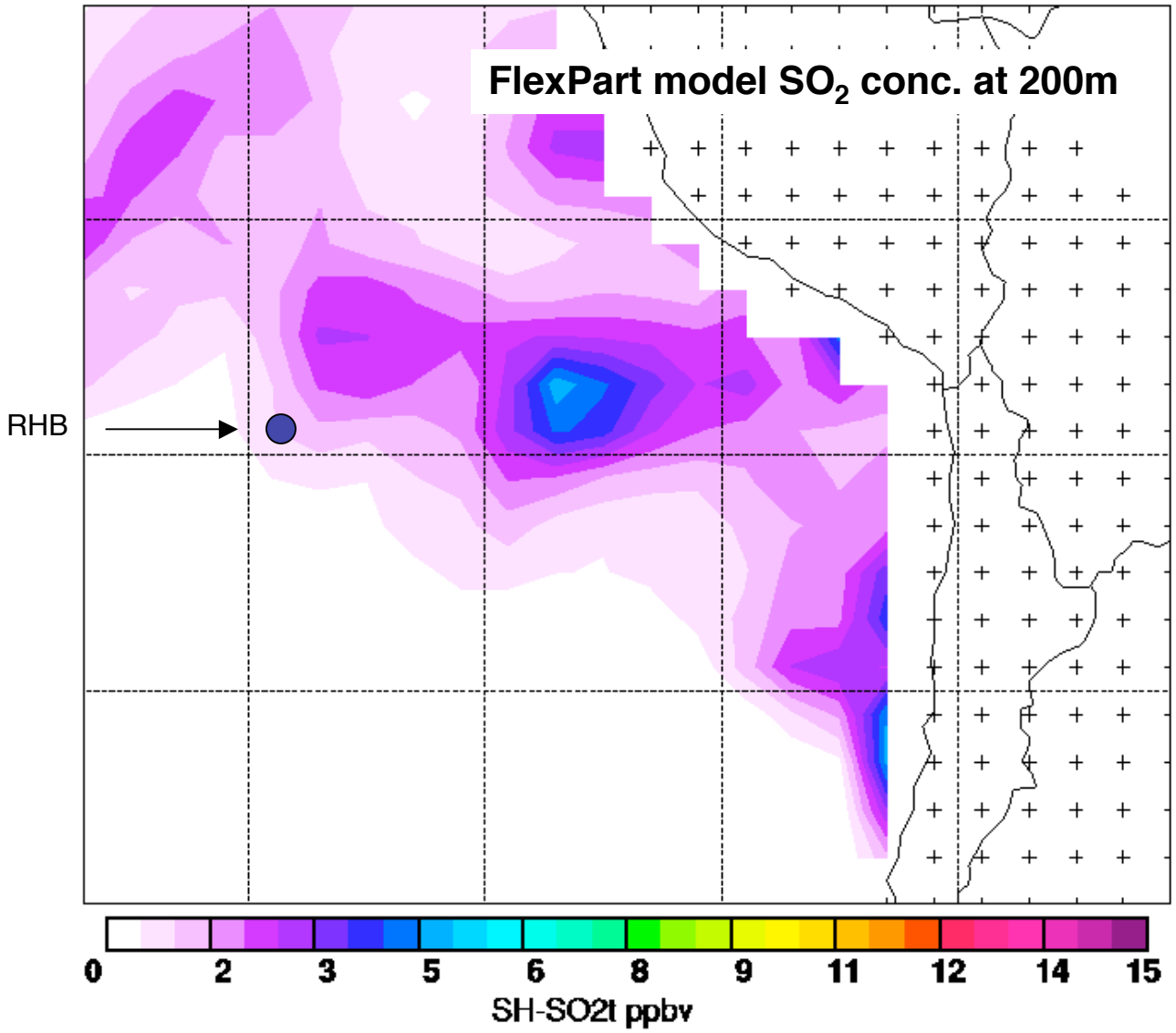
Strongly influenced by urban industrial sources in region 500 to 1000 km or more upwind

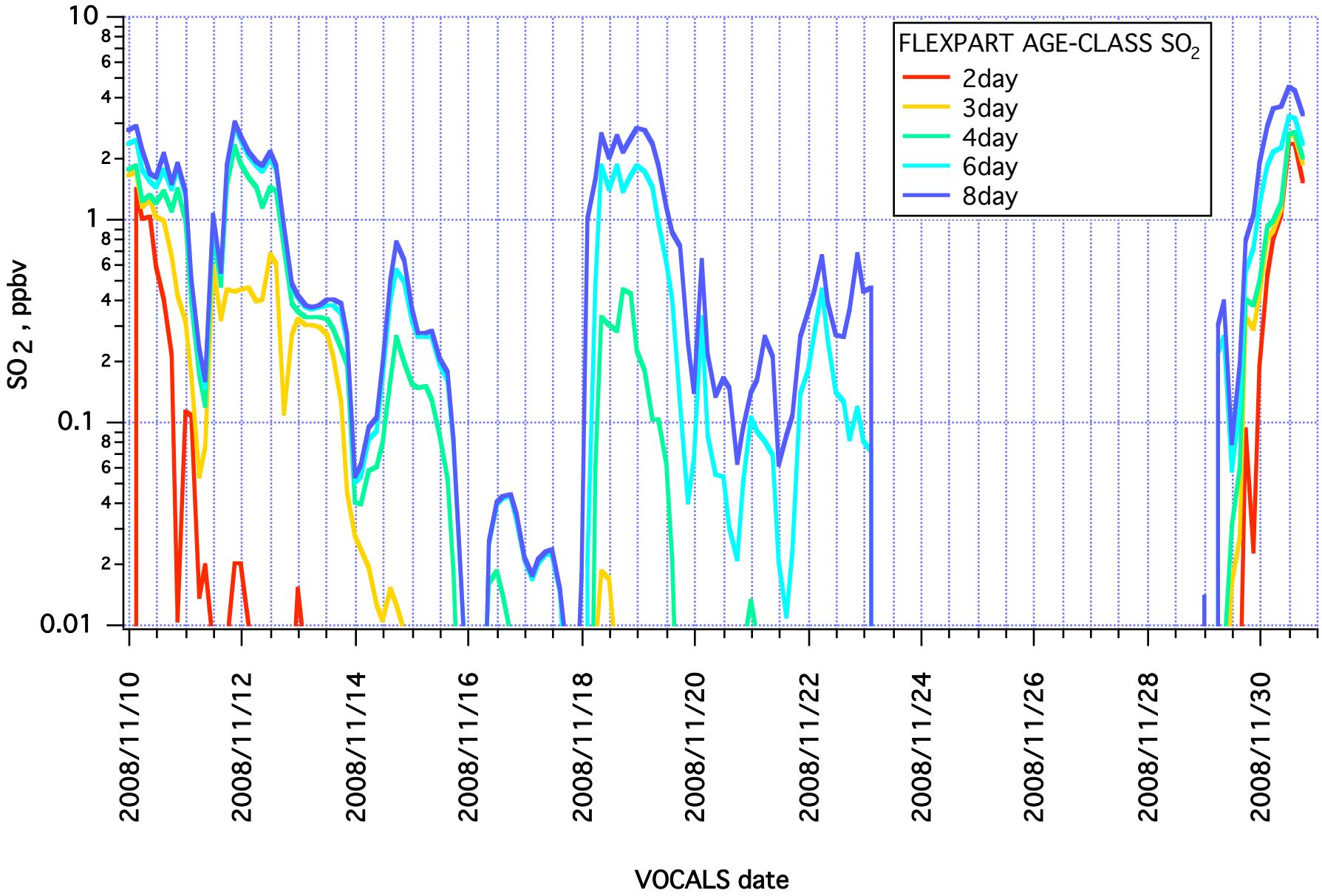
Mixing ratio of species SH-SO2t at 200 m asl for age class 0 - 10.00 DAYS

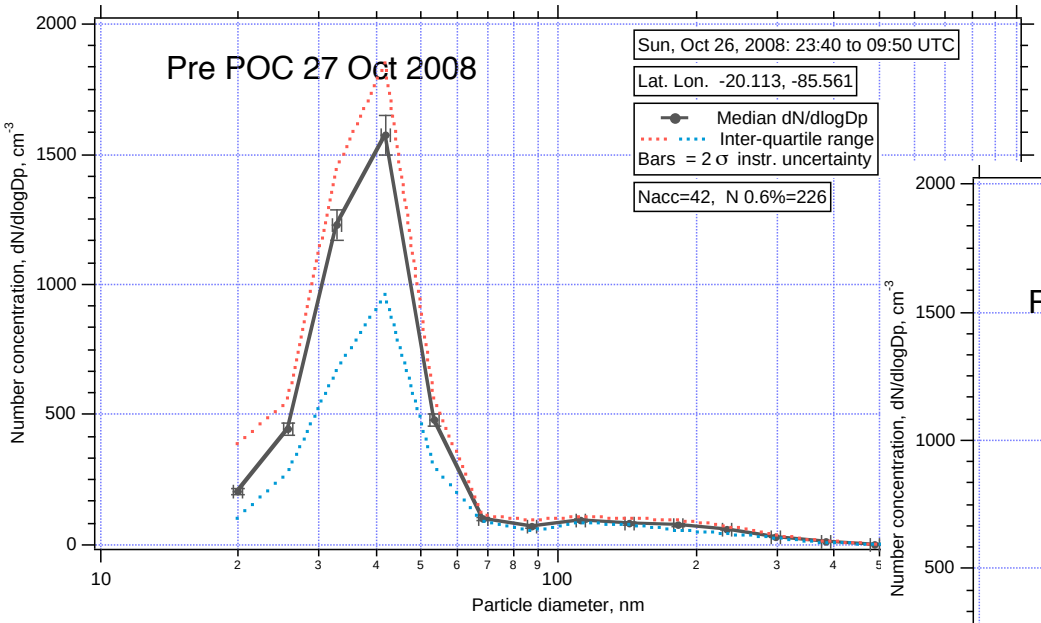
Latest analysis time 20081108. 0 Actual time 20081121. 0

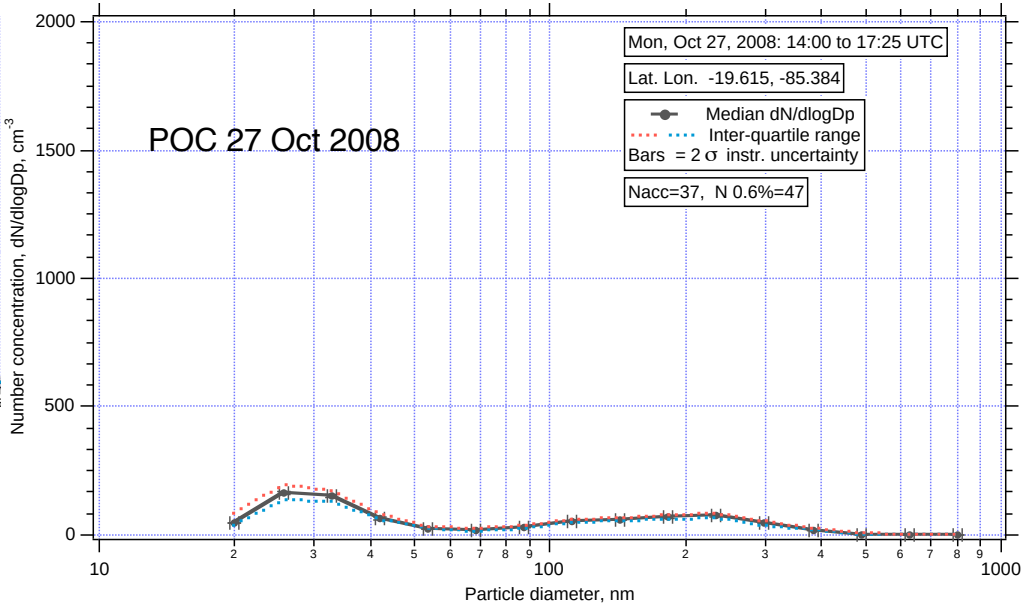
Mean value 0.111E+00 Maximum value 0.494E+01 Minimum value 0.000E+00

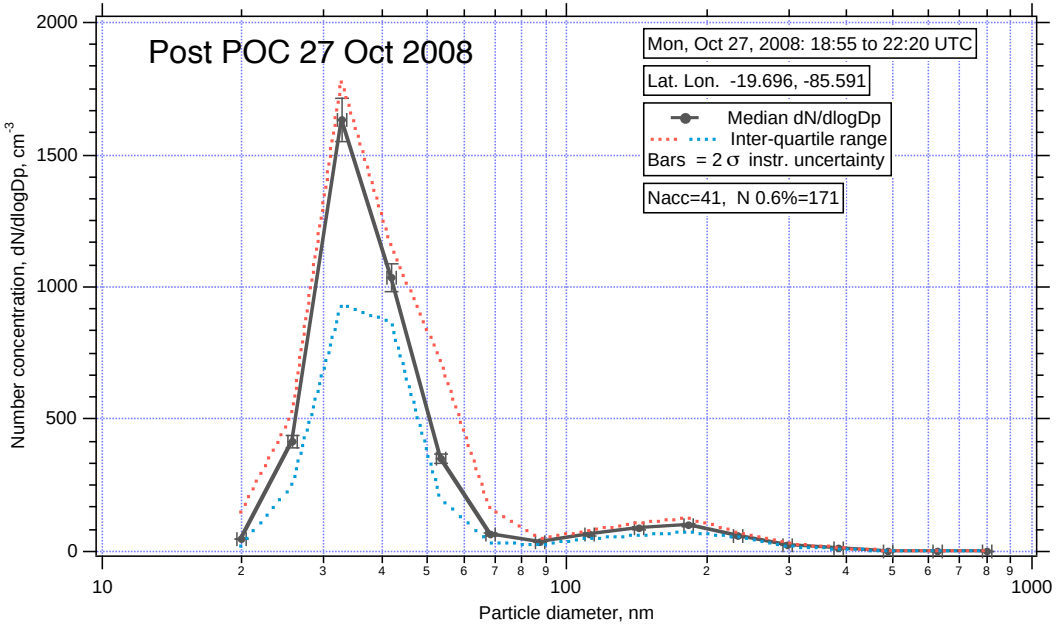
Distance of grid lines 5.0 deg




FLEXPART AGE-CLASS SO2
2day
3day
4day
6day
8day
SO2 , ppbv
10
8
6
4
2
1
0.1
0.01
2008/11/10
2008/11/12
2008/11/14
2008/11/16
2008/11/18
2008/11/20
2008/11/22
2008/11/24
2008/11/26
2008/11/28
2008/11/30
VOCALS date

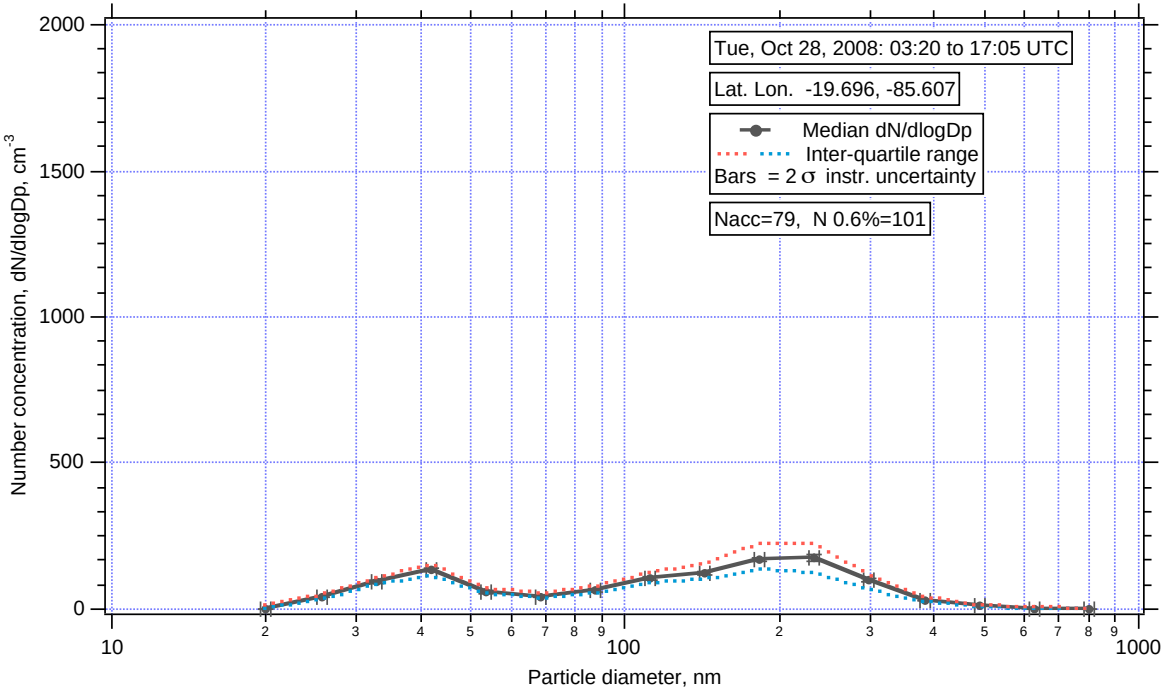




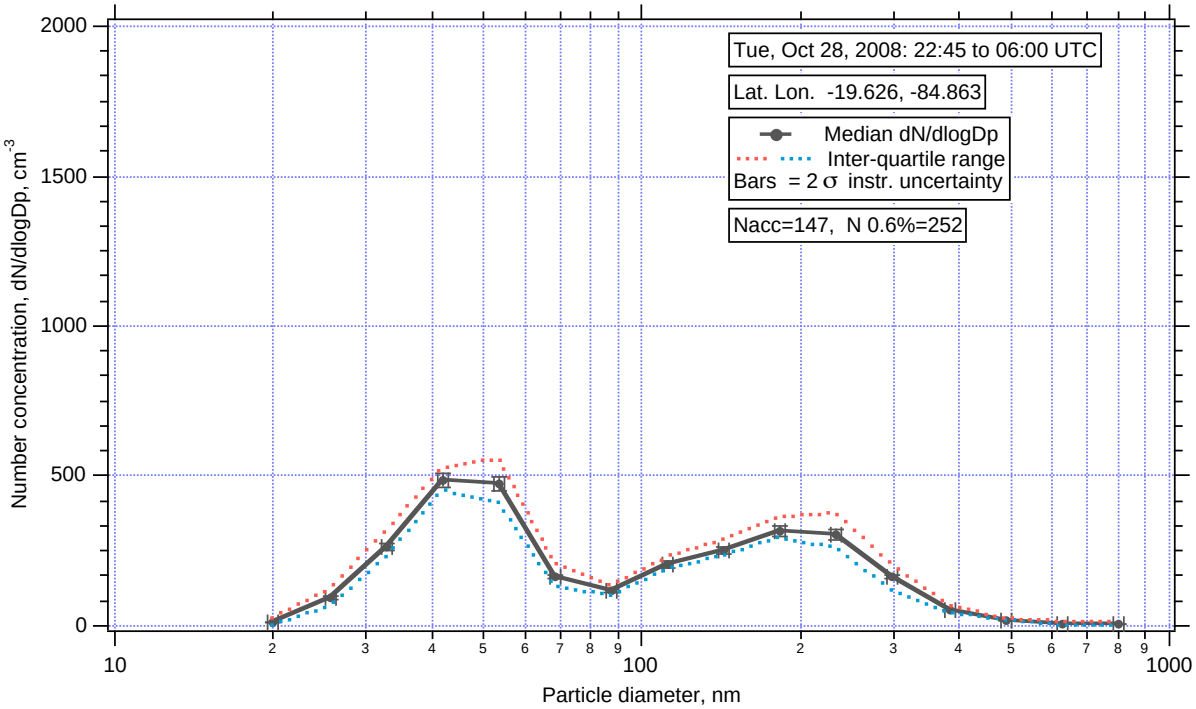


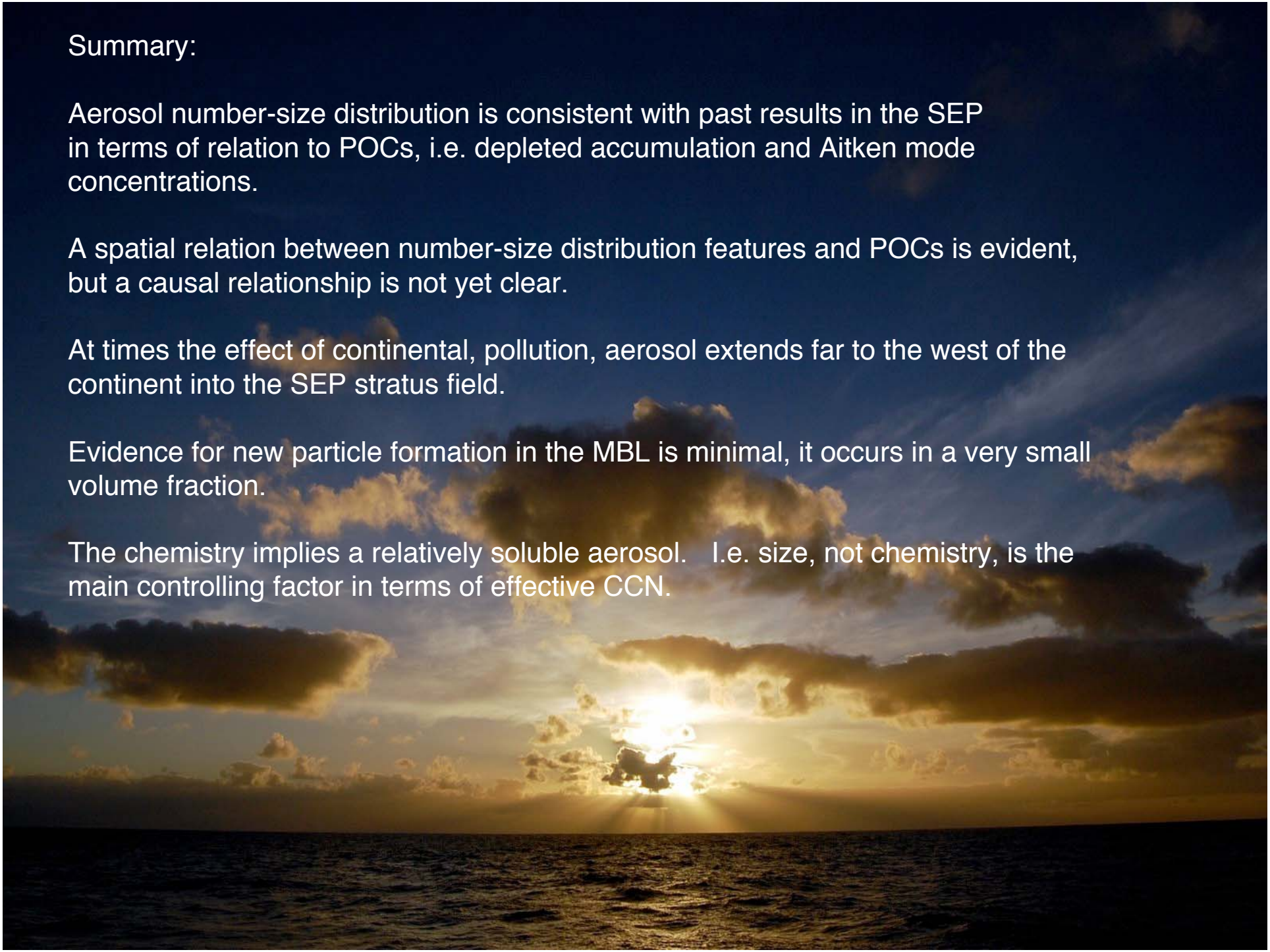
Accumulation mode is depleted in all cases.
Within the more active POC region
the Aitken mode is depleted as well.

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.

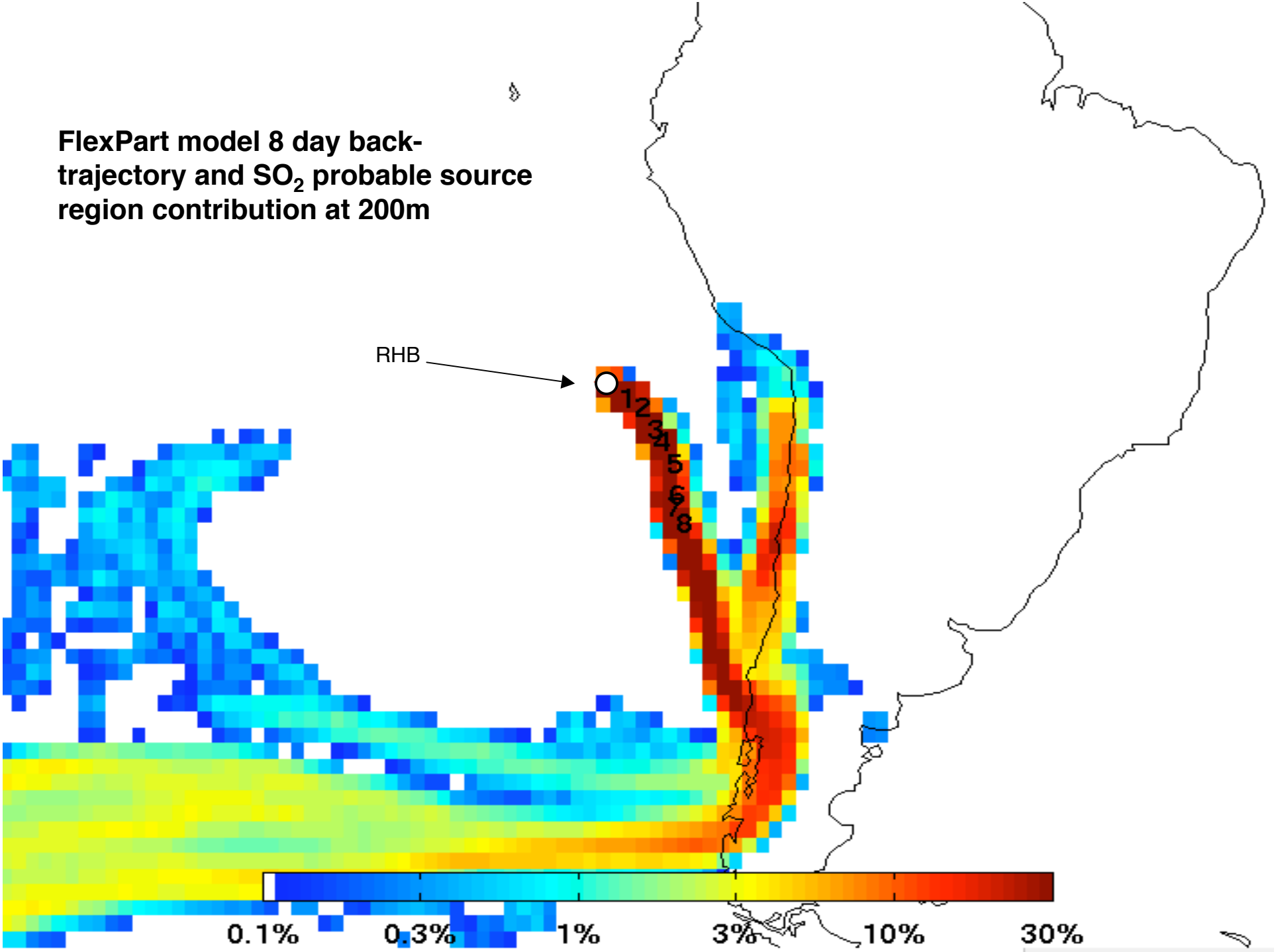
A spatial relation between number-size distribution features and POCs is evident, but a causal relationship is not yet clear.

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



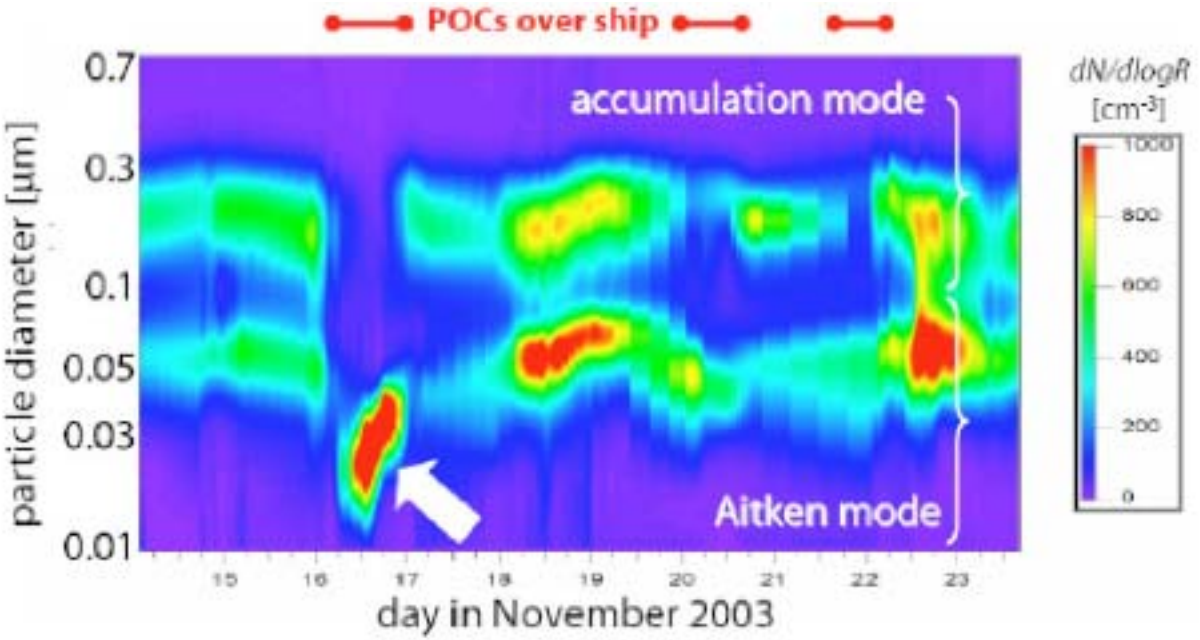
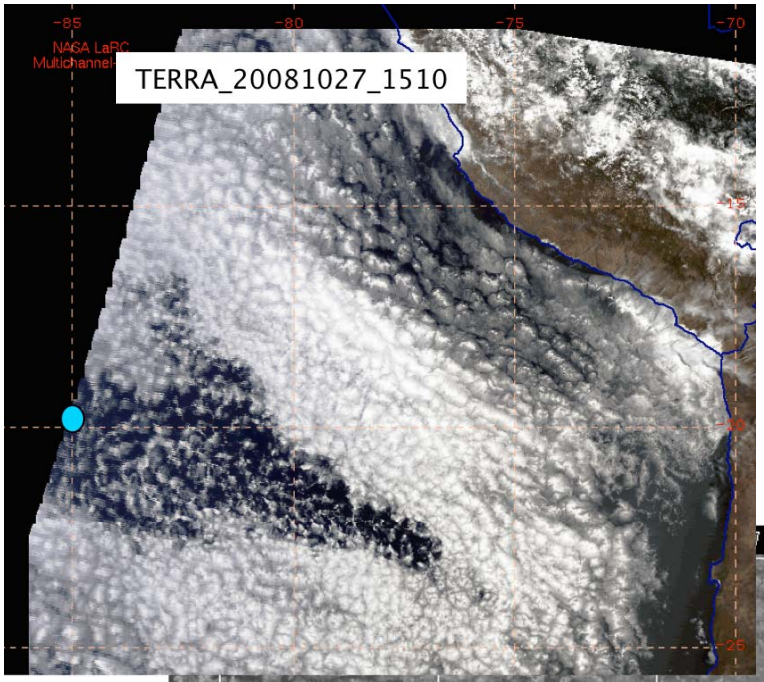
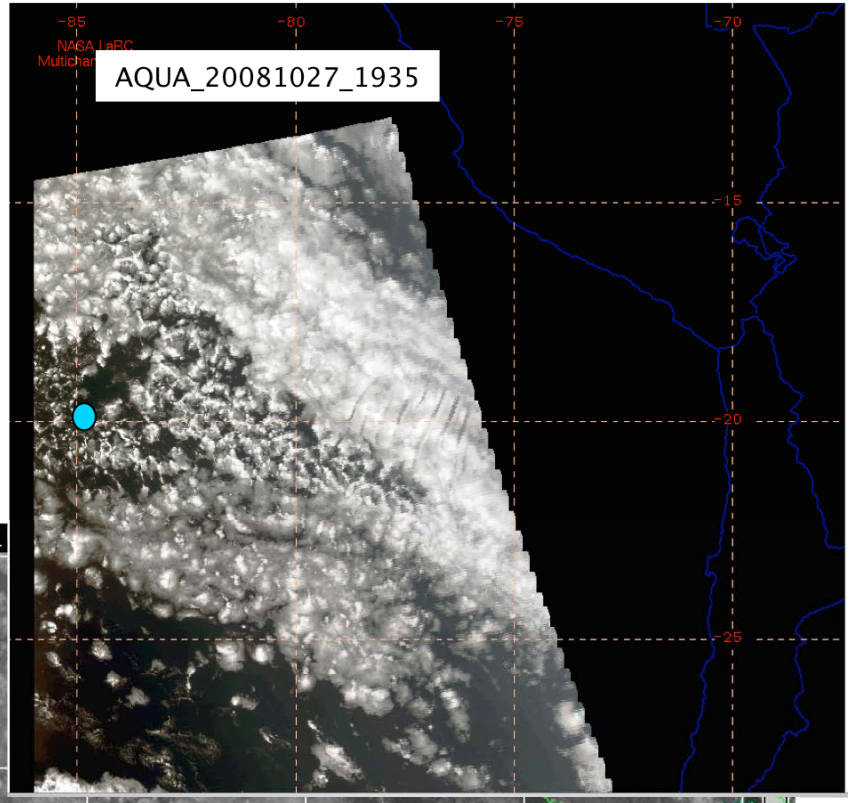
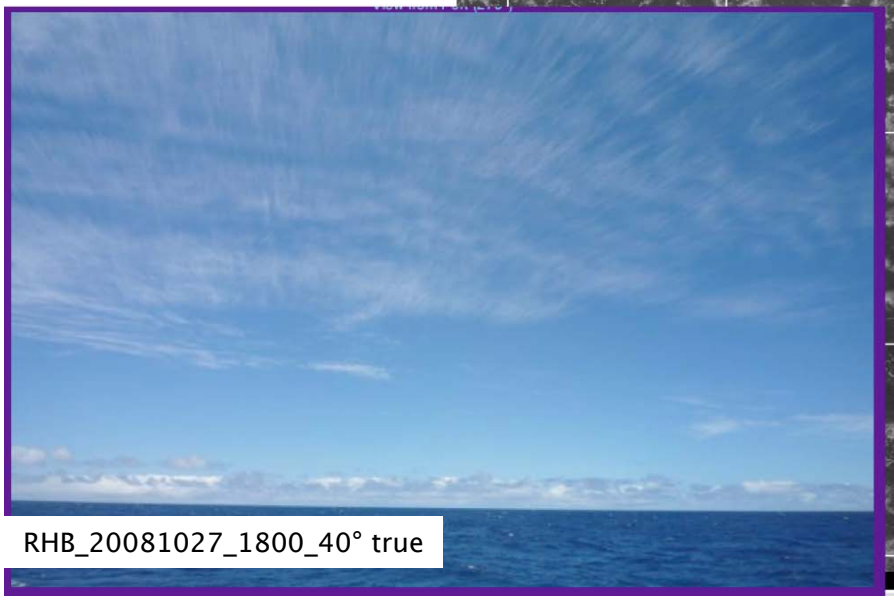


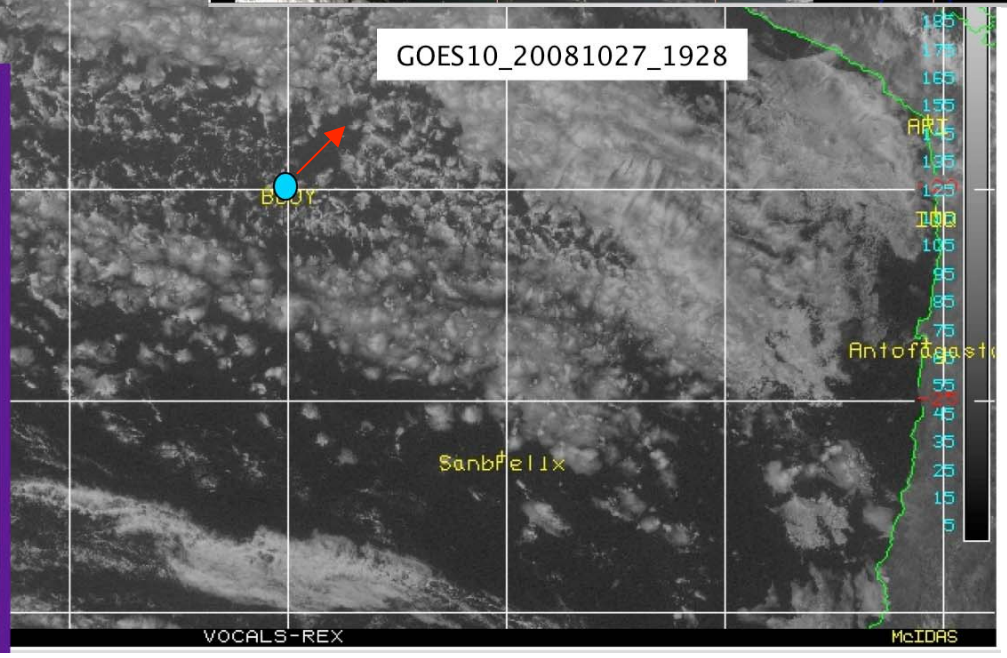
Figure 3: Accumulation mode aerosol concentration (top), and aerosol size distribution (bottom) measured on the R/V Roger Revelle over the SEP during November 2003. The red horizontal bars indicate periods where satellite imagery revealed pockets of open cells (POCs) over the ship. At these times there is strong reduction of the accumulation mode



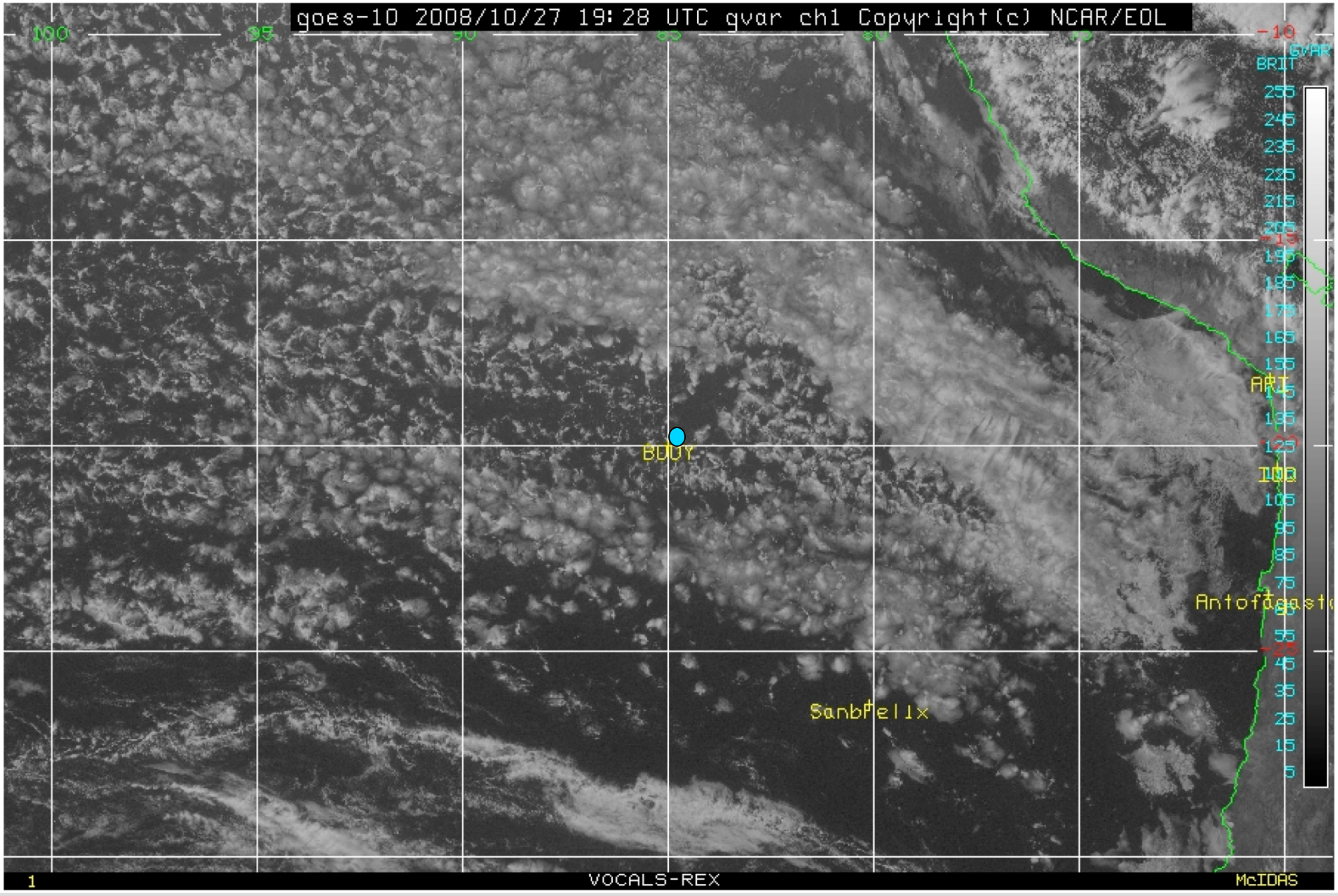


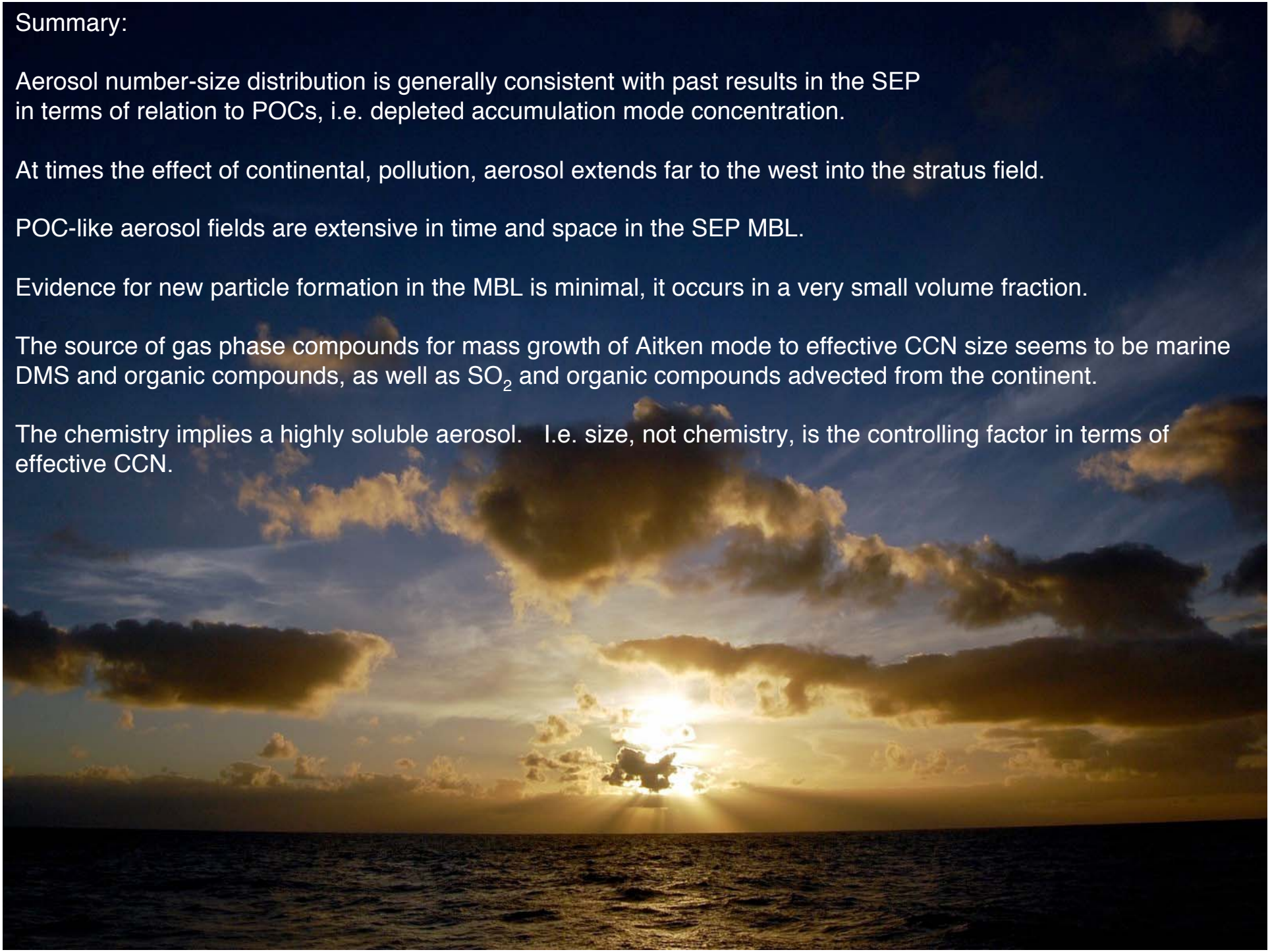
27 Oct 2009,
Satellite and RHB camera images





GOES, 27 Oct 08, POC





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.

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