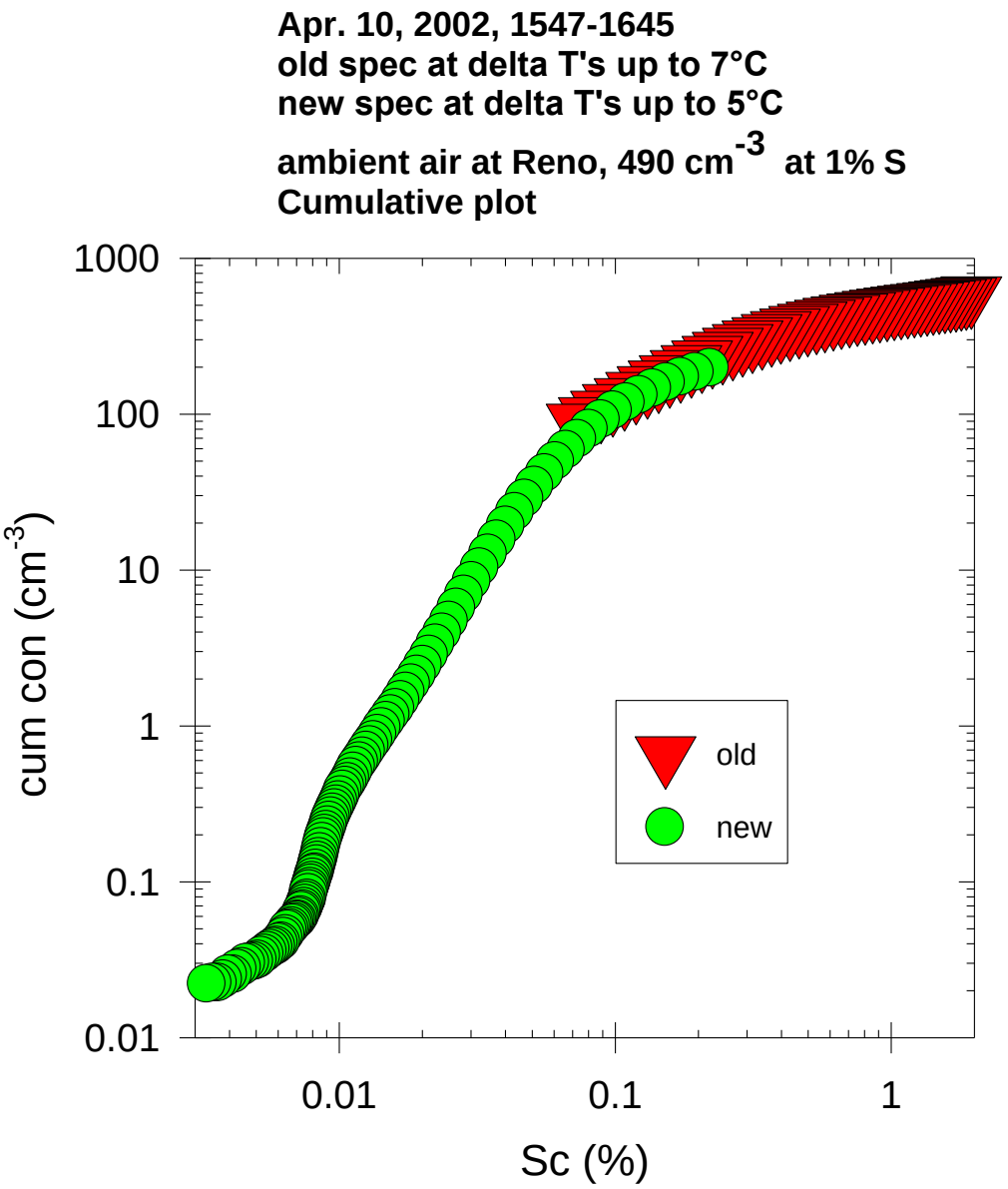
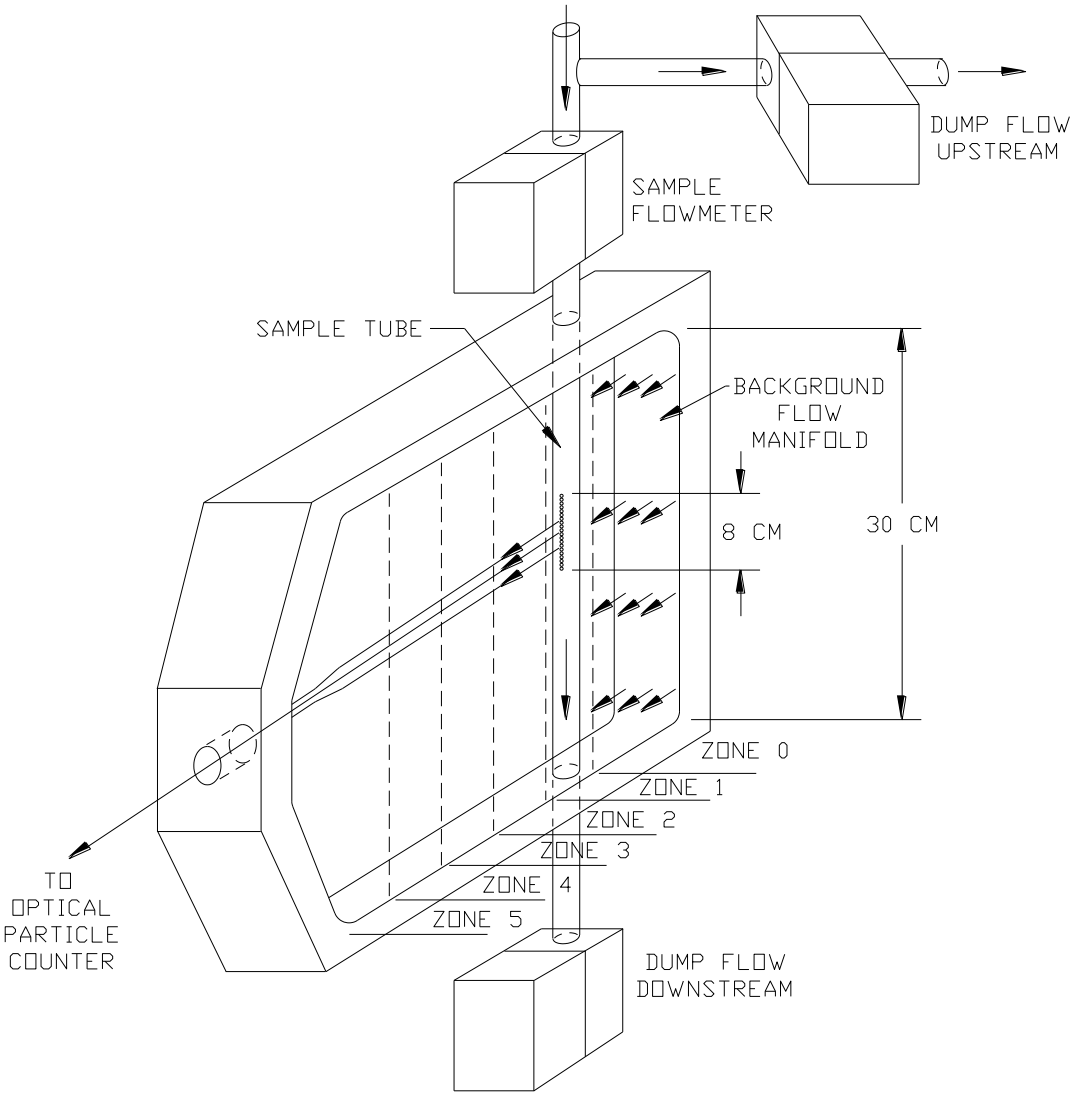
Direct ambient CCN measurements and CN (total particles)

On the airplane and perhaps at the surface.

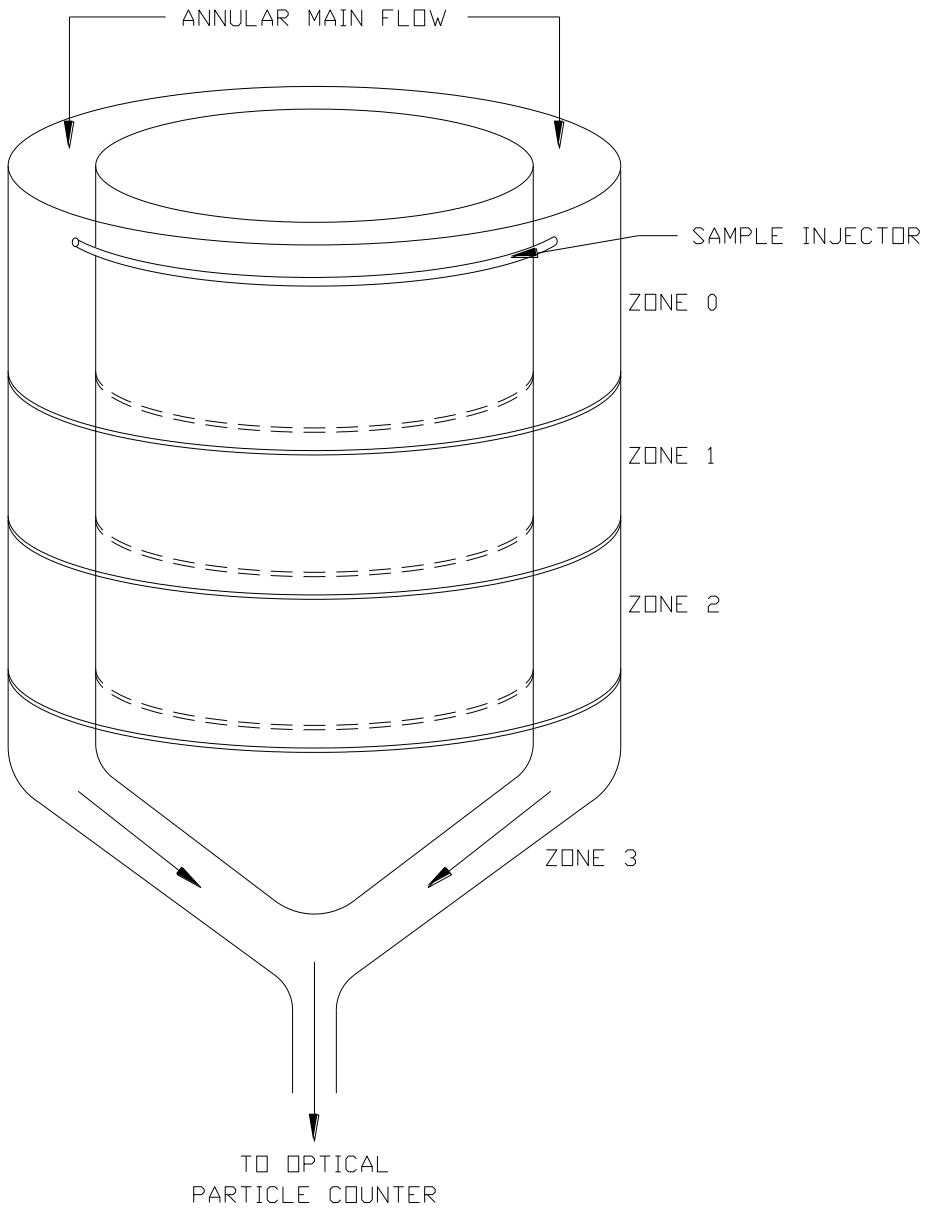
Coverage of both the traditional Aitken CCN range (S > 0.1%; dry soluble diameter > 0.1 μm = 100 nm) and the Large Nuclei (LN) range (S 0.1-0.003%; dry soluble diameter 0.1-1 μm= 100-1000 nm) requires two CCN spectrometers.

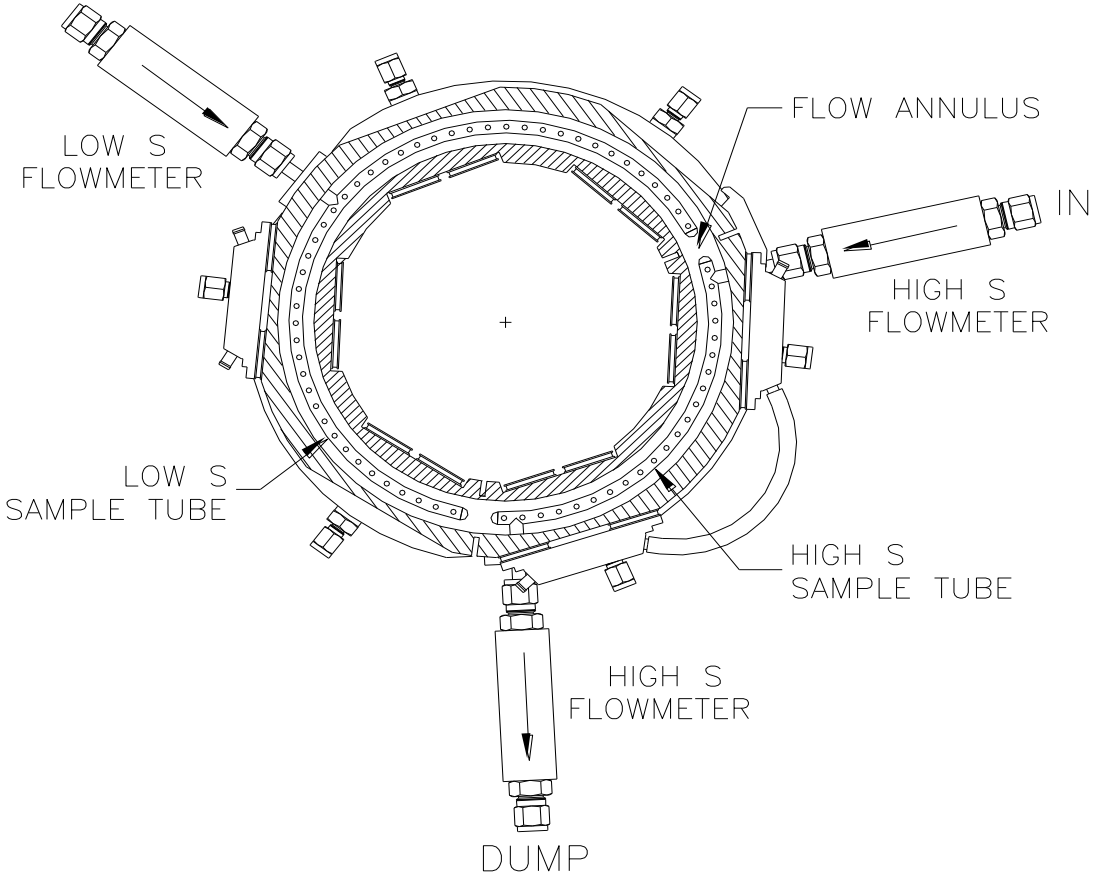

Apr. 10, 2002, 1547-1645
old spec at delta T's up to 7°C
new spec at delta T's up to 5°C
ambient air at Reno, 490 cm-3 at 1% S
Cumulative plot
1000
100
10
1
0.1
0.01
cum con (cm-3)
0.01
0.1
1
Sc (%)
old
new

DRI has two rectangular CCN spectrometers that have been used in 25 aircraft projects including 7 on the NCAR C-130, 6 both instruments; most recently in AIRS2 in November-December, 2003.


DUMP FLOW
UPSTREAM
SAMPLE
FLOWMETER
SAMPLE TUBE
BACKGROUND
FLOW
MANIFOLD
8 CM
30 CM
ZONE 0
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
TO
OPTICAL
PARTICLE
COUNTER
DUMP FLOW
DOWNSTREAM

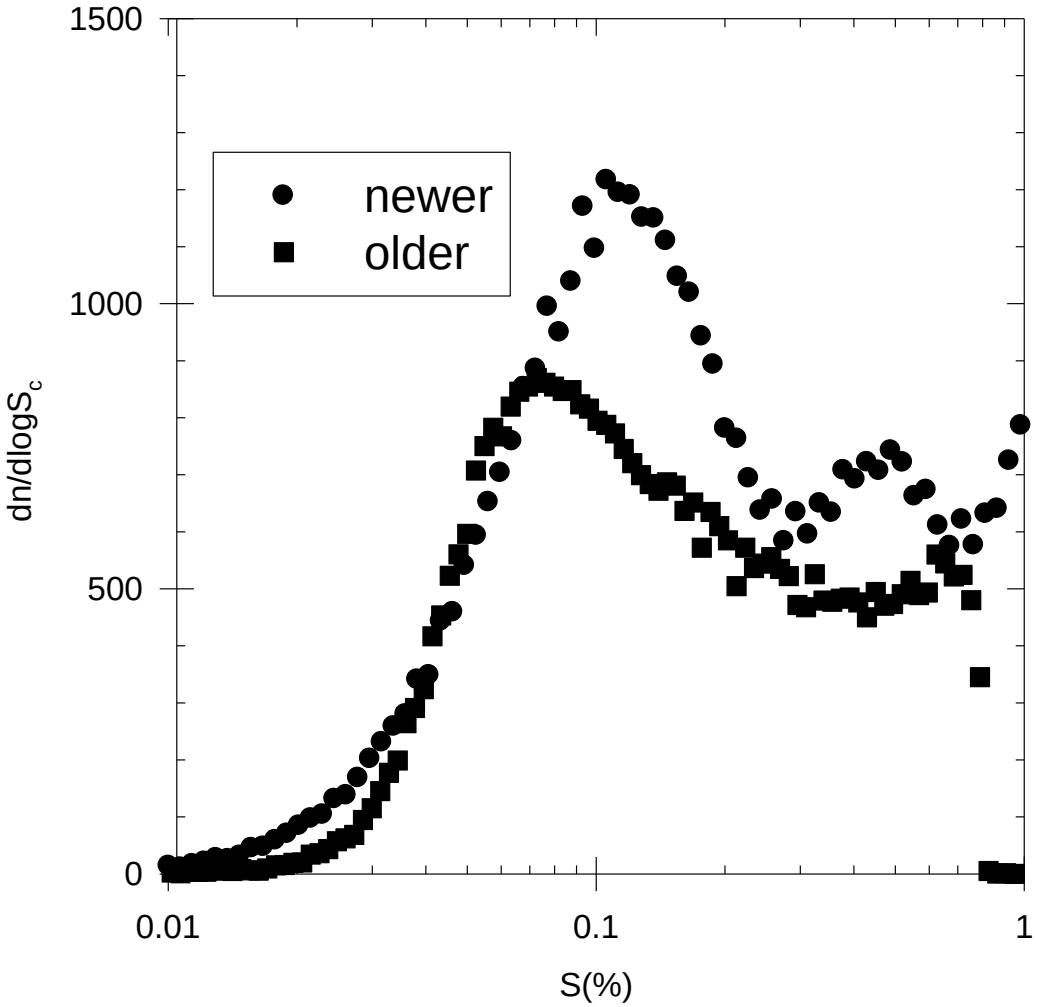
A new double track cylindrical chamber may (should) barely be ready for RICO but only for surface measurements.


ANNULAR MAIN FLOW
SAMPLE INJECTOR
ZONE 0
ZONE 1
ZONE 2
ZONE 3
TO OPTICAL
PARTICLE COUNTER


LOW S
FLOWMETER
FLOW ANNULUS
IN
HIGH S
FLOWMETER
LOW S
SAMPLE TUBE
HIGH S
SAMPLE TUBE
HIGH S
FLOWMETER
DUMP

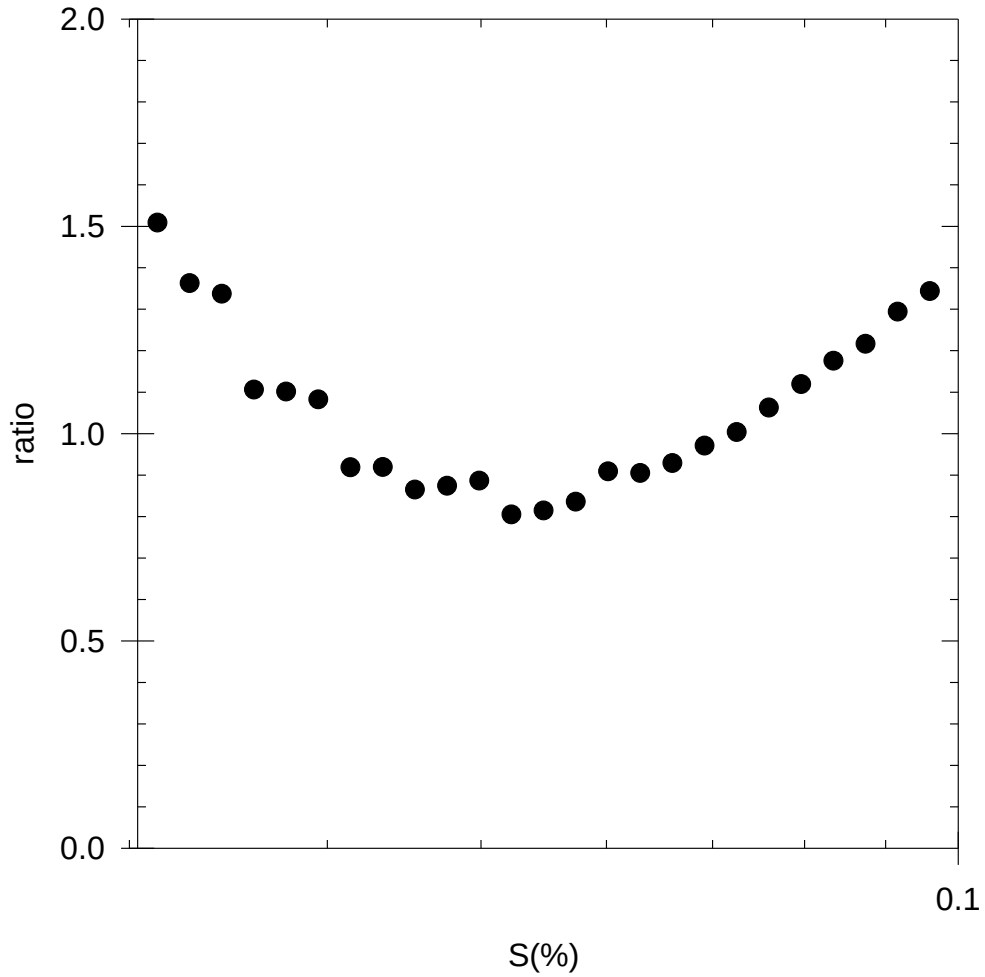
One single instrument cannot cover the entire S range, mainly because of the large dynamic range of CCN concentrations. Low LN concentrations require higher sample flows to obtain sufficient statistics. But such high sample flows produce too many coincident pulses and broadening of the high concentrations of Aitken CCN (esp. at highest S). This causes false LN concentrations that can be comparable to or overwhelming of the true LN concentrations.

May 25, 2003, 0015-0030 CDT;
differential concentrations
for both CCN spectrometers



May 25, 2003, 0015-0030 CDT;
ratio of concentrations
from new spec divided by old spec.
for the S_c intervals of the old spec.

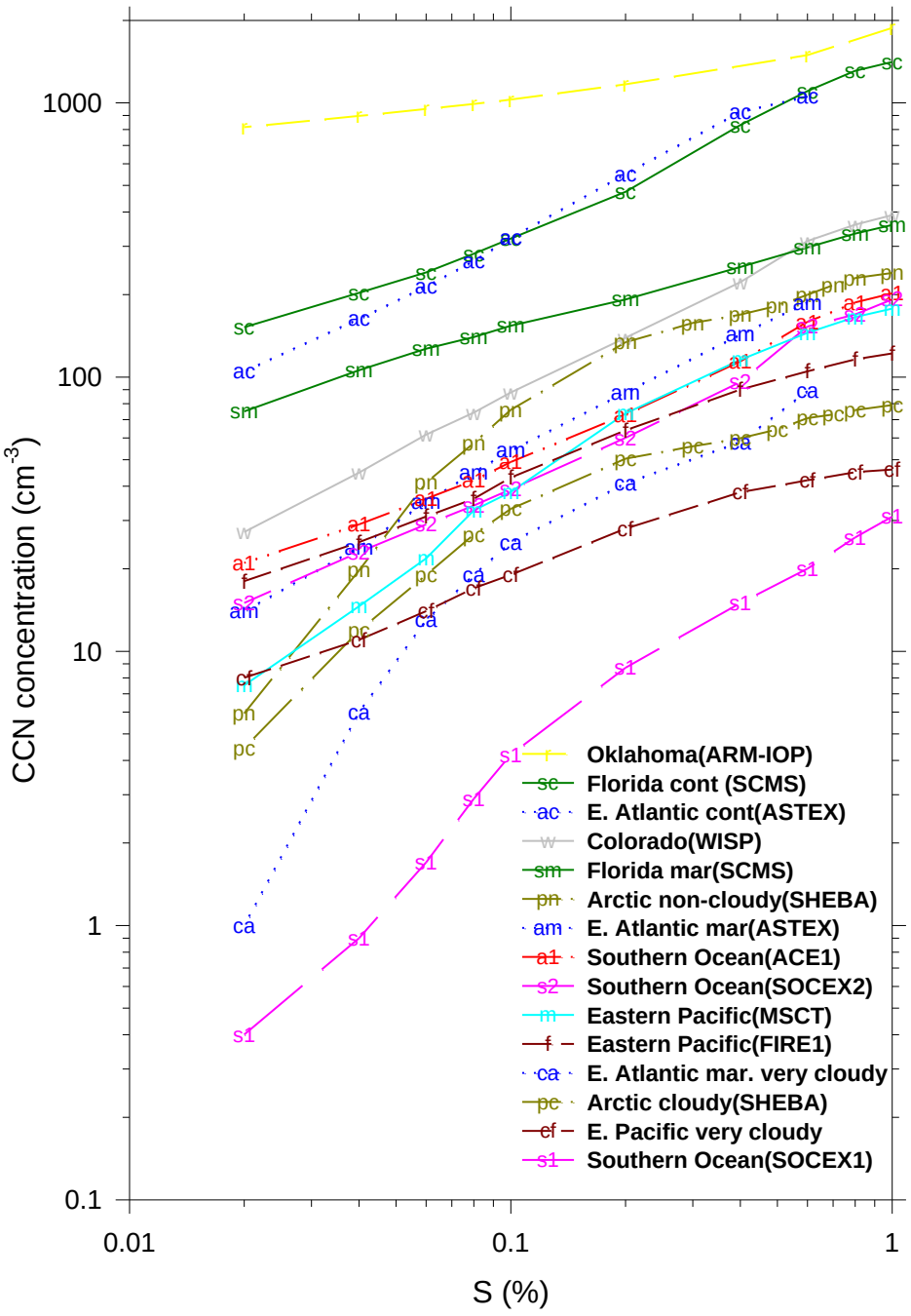
where data from new has been trans-
cribed to old intervals.



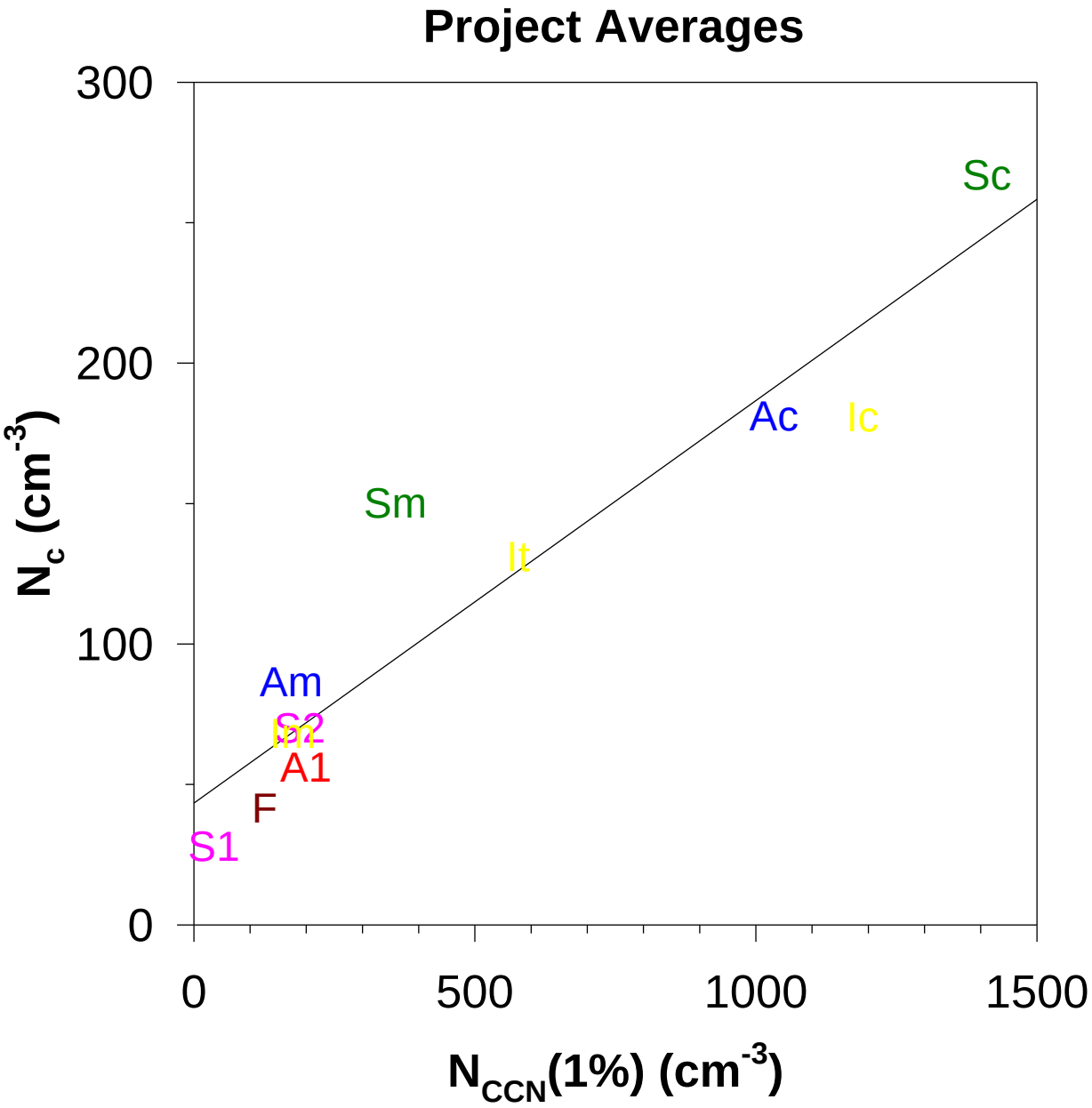
An overlapping S yields confidence in the method. With more channels CCN spectra can be plotted differentially as well as the traditional cumulative plots. Comparisons are best done differentially. This is especially the case since broadening and coincidence cause false LN concentrations for the instrument operating at higher S.

Research goals:

How much variability is there in CCN and LN concentrations? Spatial and temporal throughout the project.


CCN spectra from various projects
CCN concentration (cm-3)
S (%)
1000
100
10
1
0.1
0.01
0.1
1
Oklahoma(ARM-IOP)
Florida cont (SCMS)
E. Atlantic cont(ASTEX)
Colorado(WISP)
Florida mar(SCMS)
Arctic non-cloudy(SHEBA)
E. Atlantic mar(ASTEX)
Southern Ocean(ACE1)
Southern Ocean(SOCEX2)
Eastern Pacific(MSCT)
Eastern Pacific(FIRE1)
E. Atlantic mar. very cloudy
Arctic cloudy(SHEBA)
E. Pacific very cloudy
Southern Ocean(SOCEX1)

How does this variability compare with total cloud droplet concentrations?


Project Averages
300
200
100
0
N_c (cm^{-3})
0
500
1000
1500
N_{CCN}(1%) (cm^{-3})
Sc
Ac
Ic
Sm
It
Am
S2
In2
A1
F
S1

Large cloud droplet concentrations?
Drizzle drop concentrations?
Giant Nuclei (GN) concentrations?

Since GN are more numerous in clean air and Aitken CCN are more numerous in continental air what about LN? There should be a crossover size (LN) where maritime and continental concentrations agree.

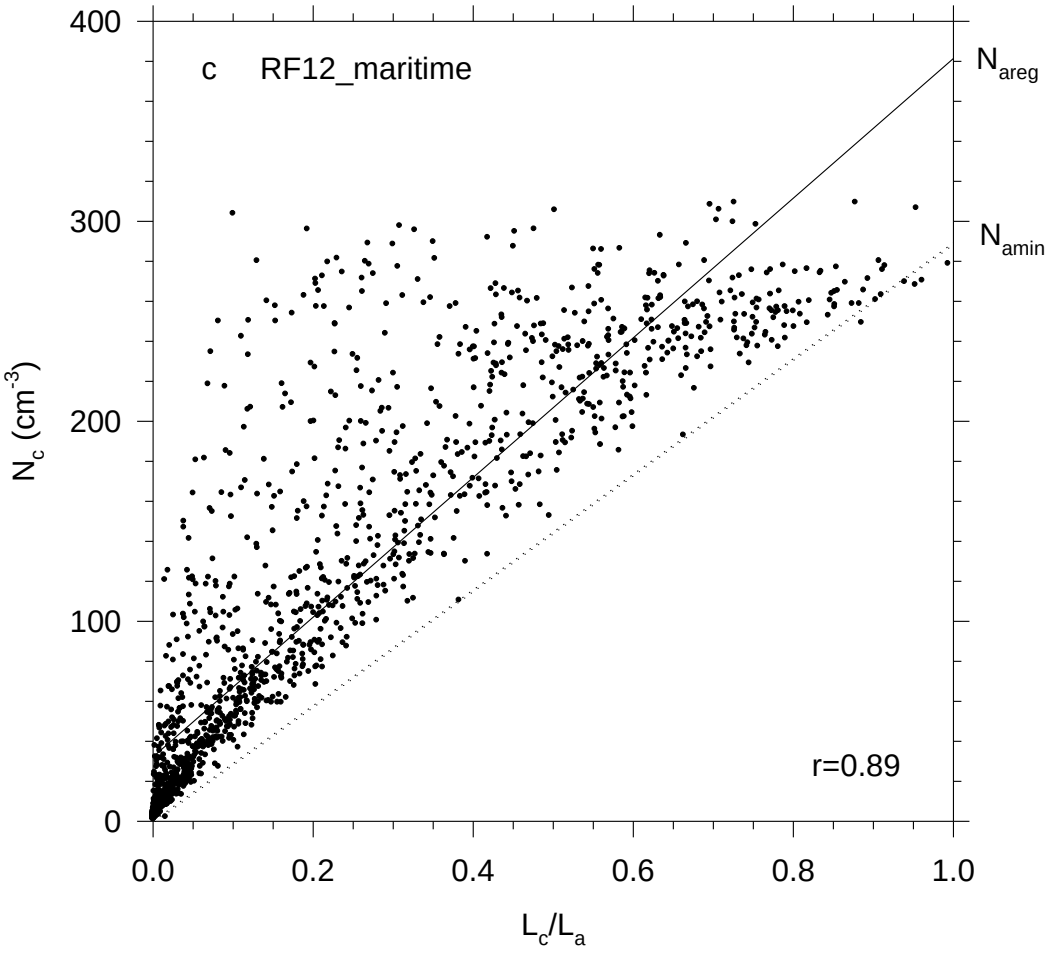
1) Some clouds, form in lower updrafts, which produce maximum cloud S < 0.1%.

2) Cloud droplet spectral width, may be sensitive to CCN spectra.

3) LN bridge the gap between CCN, which have a climatology and GN, which do not.

4) 1^{st} or static CCN closure--predictions of CCN spectra from measured aerosol size-resolved chemistry and measured CCN

5) 2nd or dynamic closure—predictions of cloud droplet concentrations from CCN spectra and updraft velocity and measured cloud droplet concentrations.


c RF12_maritime
N_{areg}
N_{amin}
r=0.89
N_c (cm^{-3})
L_c/L_a
0
100
200
300
400
0.0
0.2
0.4
0.6
0.8
1.0

6) More accurate size-S_c measurements. because the variability in ambient compositions causes wider CCN spectra even for size resolved CCN measurements.

7) LN more likely to be embryos for larger cloud droplets, which can coalesce or be coalesced.

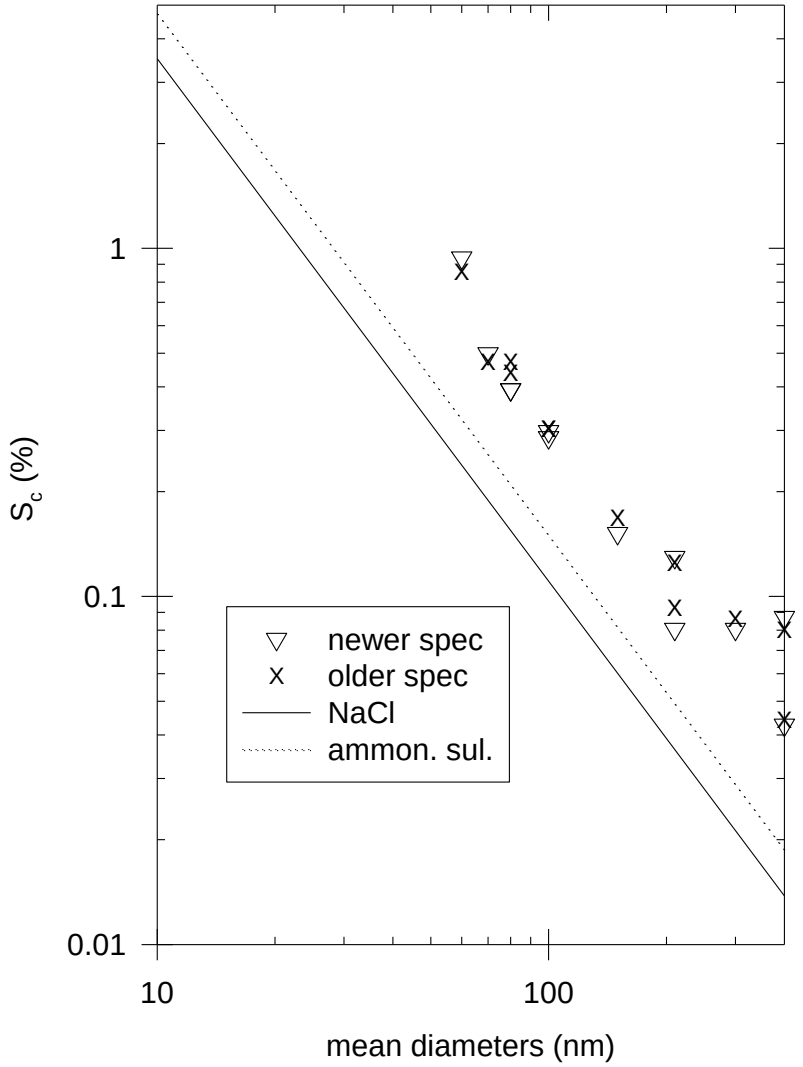
8) Preclude extrapolation of S when there are many particles with S_c below the S range of an instrument; lowest S_c particles into the last channel.

Measurements

1) regular ambient measurements for comparisons with cloud microphysics and other measurements, mainly aerosol measurements.

2) size versus S_c measurements; sample through DMA then CCN spectrometer. CCN sizes help infer composition.

March 29, 2002, 841-1011
mean S_c of ambient monodisperse aerosol at Reno from both CCN spectrometers and the NaCl relationship



3).Tests of Kohler theory

4) volatility measurements; sample heated to various temperatures of few hundred degrees; helps infer composition, especially NaCl

5) cloud droplet residue from the CVI; establishes which CCN are within cloud droplets; compare ambient and CVI residue spectra. Classically the lower S_c particles (e.g., LN) should be preferentially within droplets.

Compare cloud effective S from :

A) Comparisons of total adiabatic cloud droplet concentrations with CCN spectra to determine cloud S.

B) Predictions of cloud droplet concentrations from CCN spectra and updraft using adiabatic model and measured adiabatic cloud droplet concentrations.

C) CVI residue spectra.