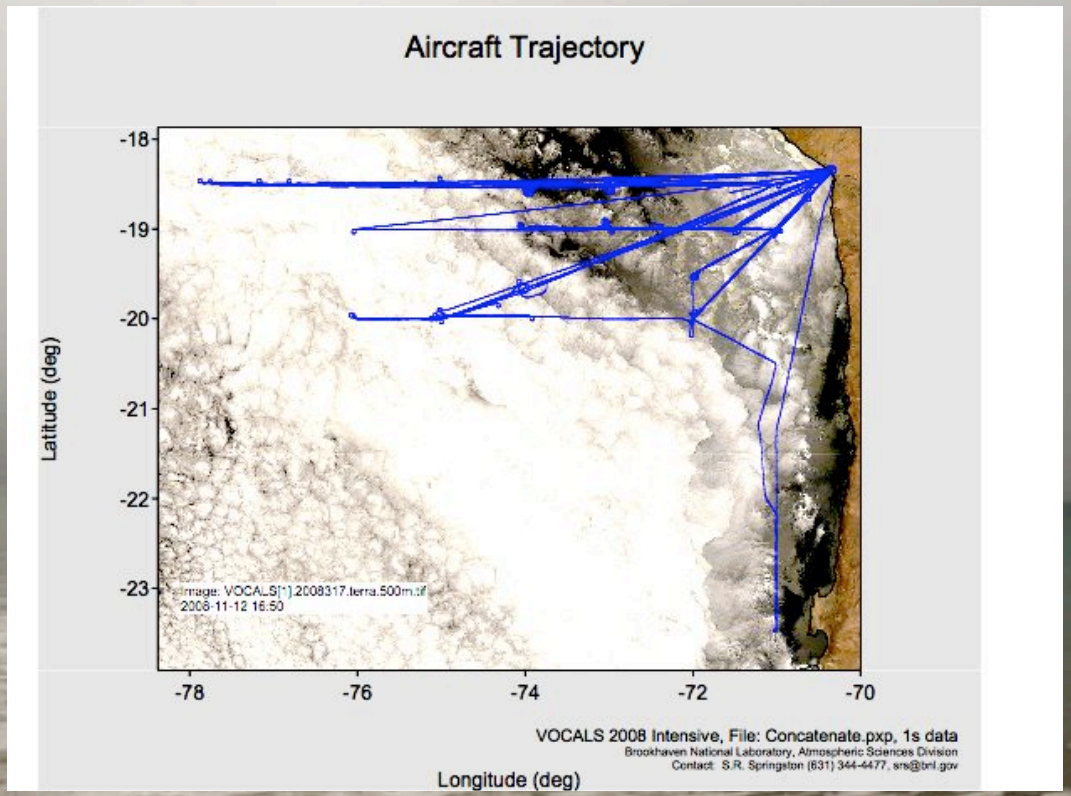
VOCALS G-1 Flight: Preliminary Observations

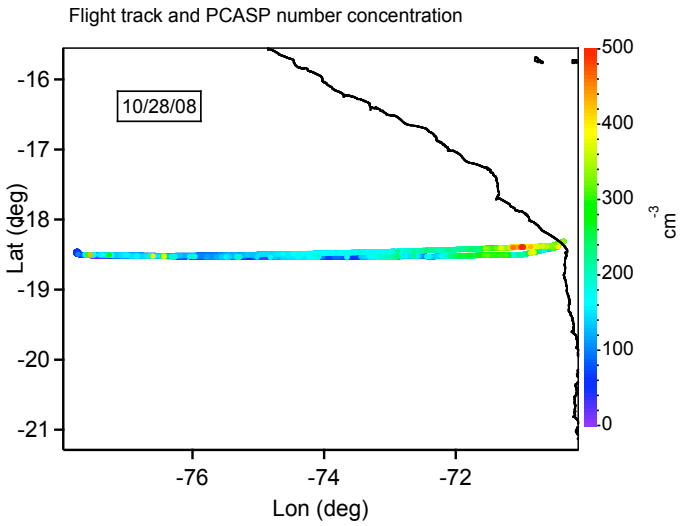
Peter Daum
Brookhaven National Laboratory



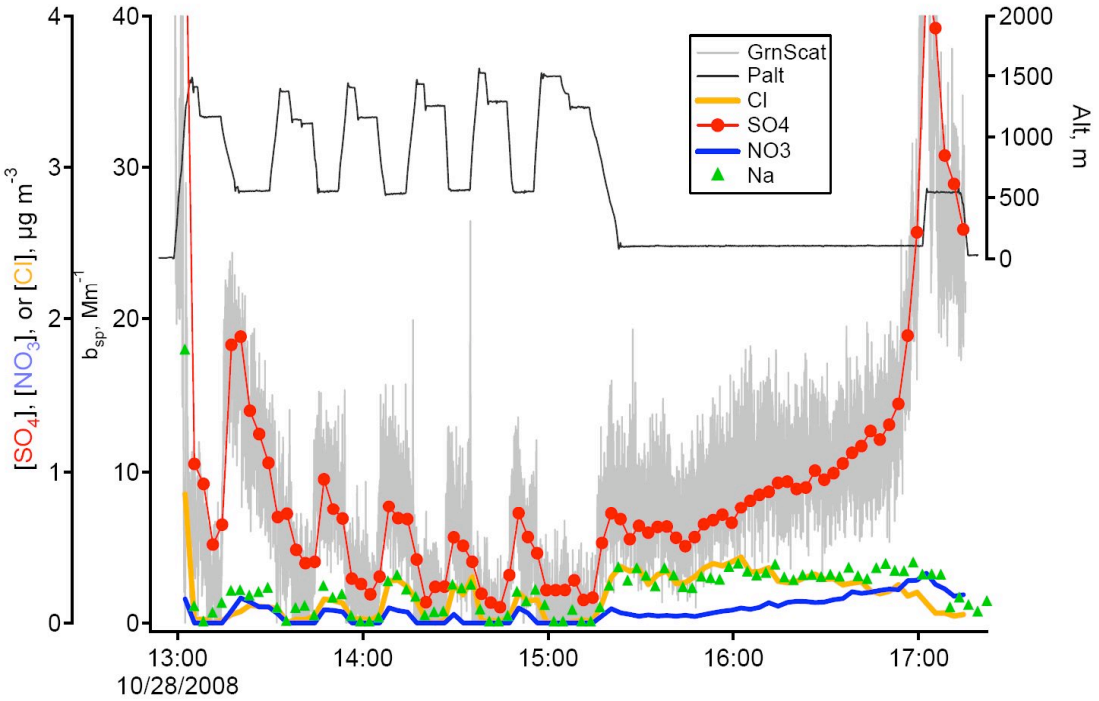
Seventeen flights during the program, mostly E-W to examine gradients in cloud and aerosol properties.

Aerosol composition

- ***SO_4^{2-}*** *dominated, decreasing with distance from land*
- ***NaCl*** *was comparable to* ***SO_4^{2-}*** *away from the coast*
- ***Organics, NO_3^-, and NH_4^+*** *were minor, all less than 10% of* ***SO_4^{2-}***
- ***$CH_3SO_3^-$*** *was only occasionally observed, but always below 0.1 µg/m³*
- ***K^+ and Ca^{2+}*** *were nearly always below 0.15 µg/m³*

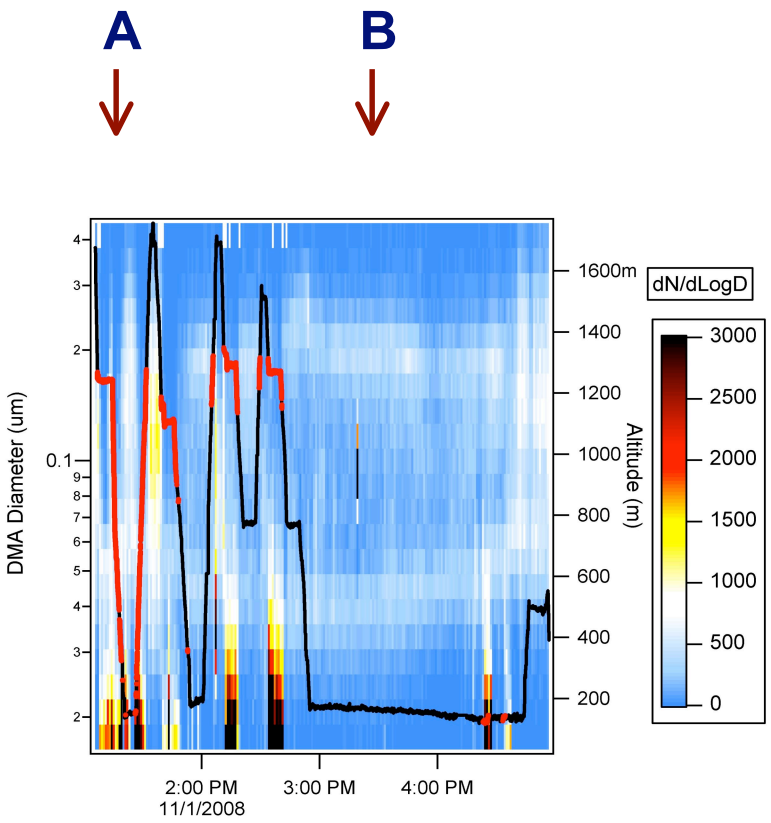


Flight Track

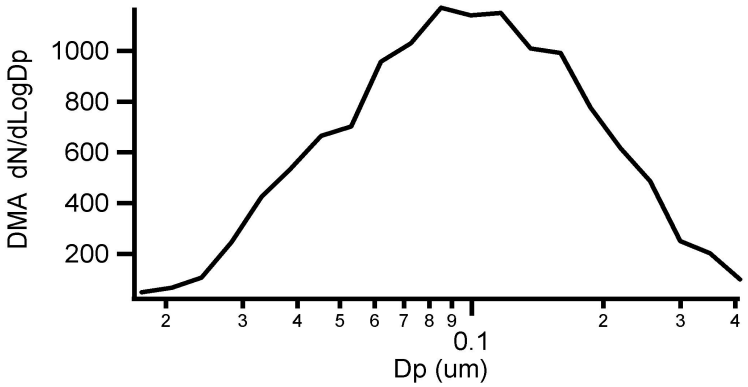


Aerosol composition

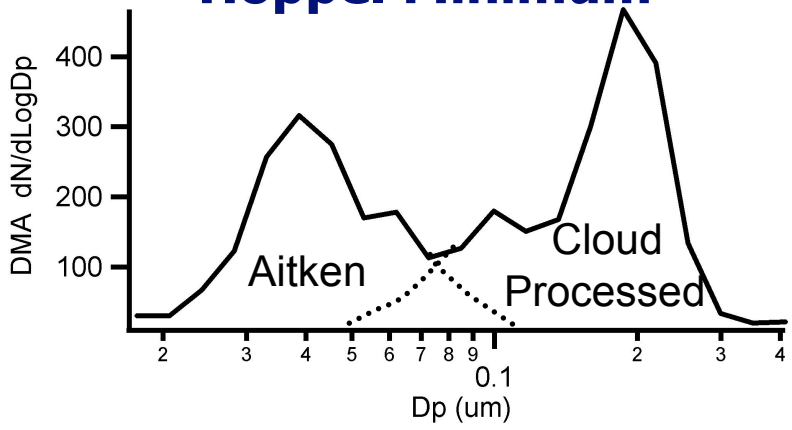
Typical Above and Below Cloud Aerosol Number Distributions



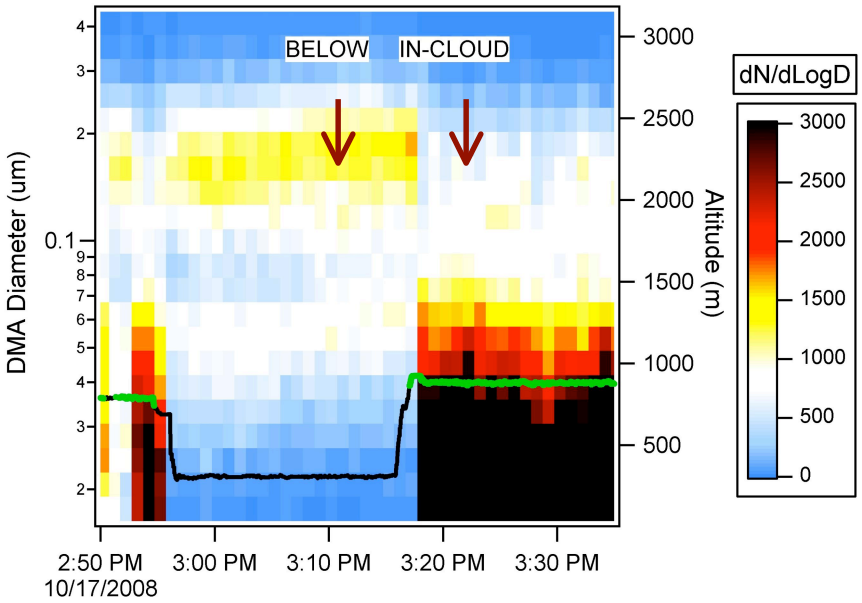
Point A. Above inversion pollution layer

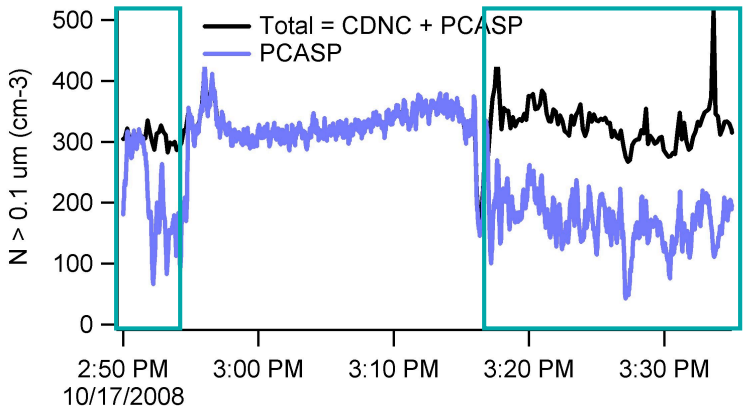


Point B. Below cloud Hoppel Minimum

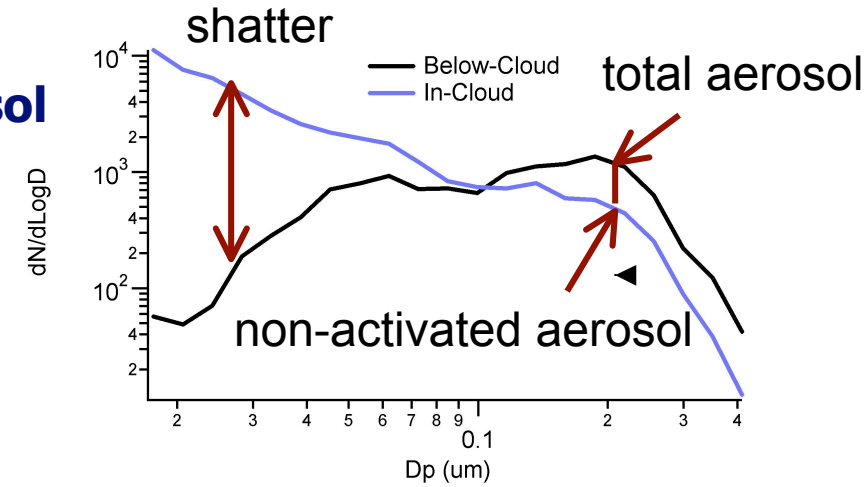


In-Cloud and Below-Cloud Aerosol Size Spectra

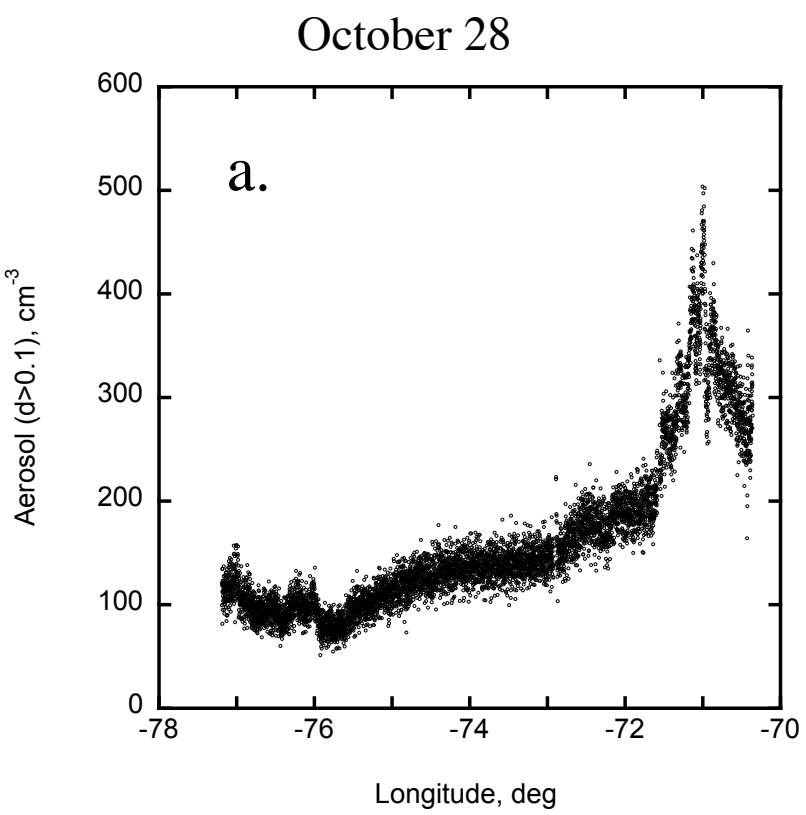


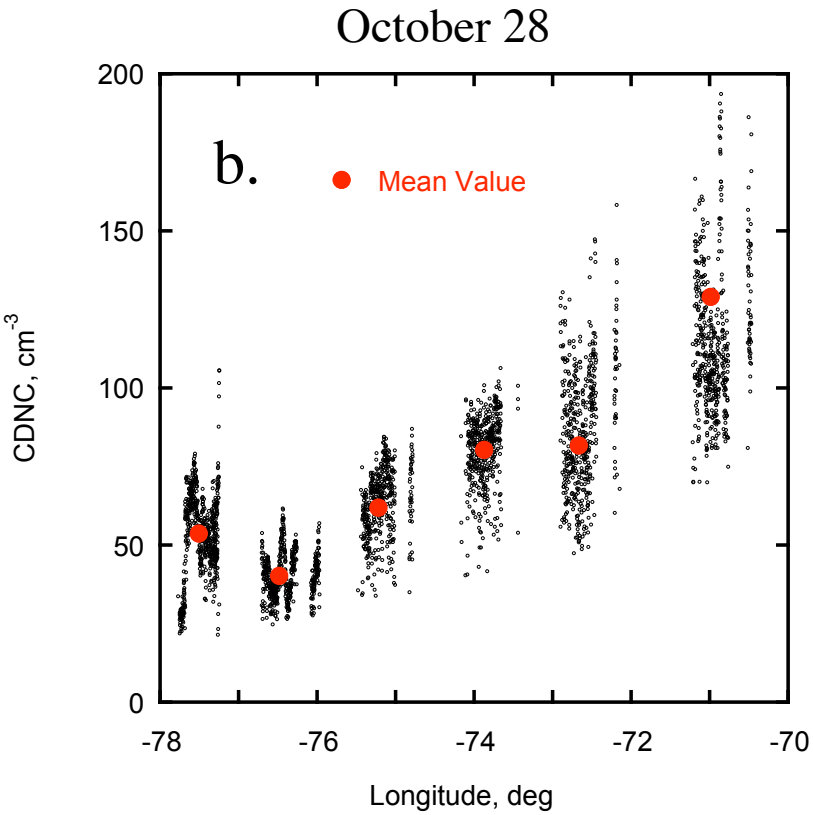


- **Cloud droplets + interstitial aerosol = below cloud aerosol**
- **~ 50% particles > 0.1 µm not activated**



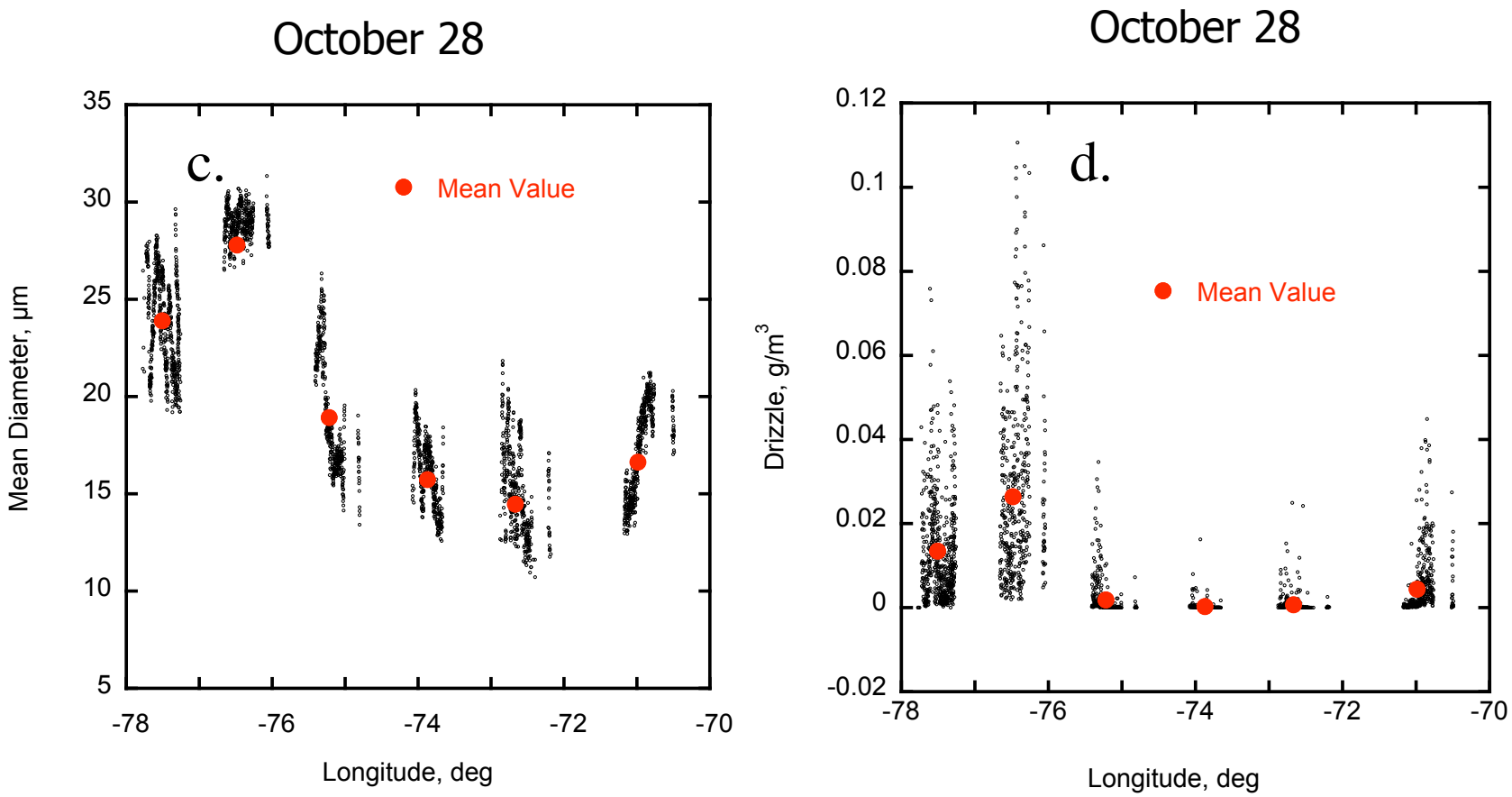
Typical Response of Clouds to Aerosols





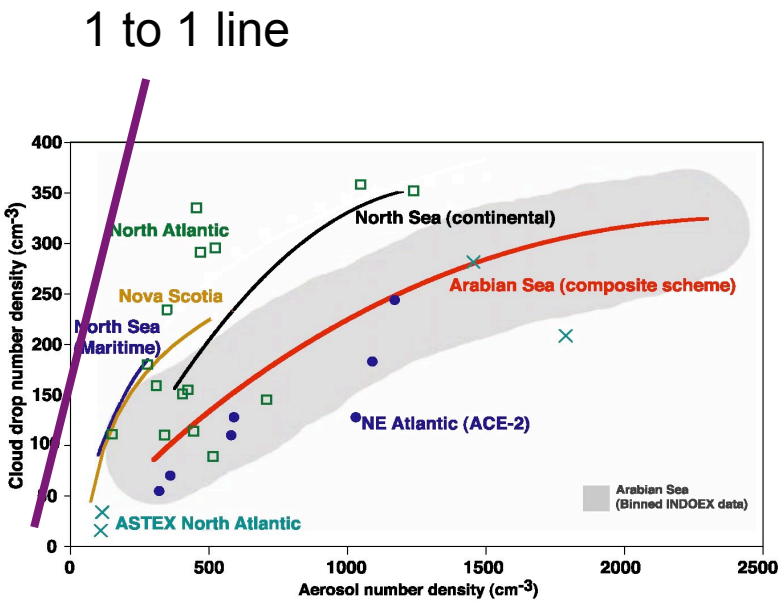
Aerosol concentration typically decreased with distance offshore (a.), and was associated with a decrease in droplet concentration (b).

Typical Response of Clouds to Aerosols, Cont'd

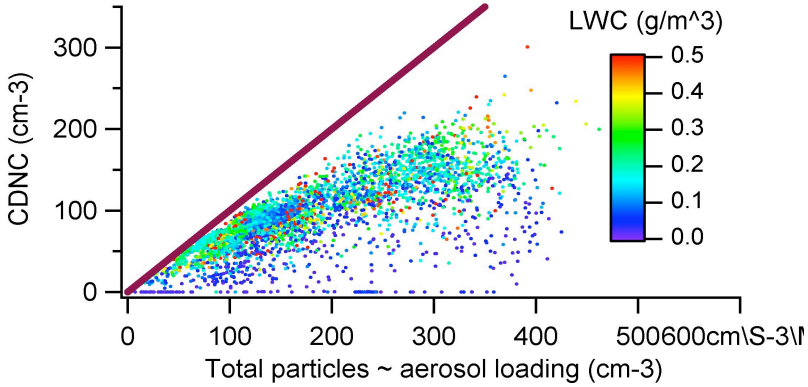


Decrease in aerosol concentration also accompanied by an increase in droplet size (c), and the formation of drizzle (d).

Fraction of Aerosol Activated



Ramanathan et al., *Science*, 2001



Significant fraction of aerosol with D_p > 0.1 μm are not activated

FAAM BAe146 UK

H. Coe, U. Manchester, Lead PI

VOCALS-UK

PIs:	Hugh Coe (Manchester) and Phil Brown (Met Office)
Manchester:	Tom Choularton; Grant Allen, James Dorsey, Gordon McFiggans; Paul Connolly; Keith Bower; Jonathan Crosier; Mike Flynn, Martin Gallagher; Lorenzo Labrador, Hugo Ricketts, Geraint Vaughan, Paul Williams
Leeds:	Mark Bart, Alan Blyth; Alan Gadian; Patricia Krejcl, James McQuaid
Reading:	Julia Slingo; Len Shaffrey; Thomas Toniazzo
Met Office:	Steve Abel, Paul Barrett
Berlin:	Thomas Ruhtz

BAe: Aerosol and Cloud Measurements: Bulk

LWC: Johnson Williams, Nevzerov LWC, Nevzerov TWC

Total Water Content: Liquid + Ice + Vapour (Lynman-α absorption hygrometer)

CCN: Dual channel continuous flow

VACC: Size distribution as a function of thermal volatility

Condensation Particle Counter: TSI-3025A Aerosol concentration > 3 nm

Aerosol Mass Spectrometer: Mass of non-refractory components of aerosol particles as a function of size (50 – 500 nm)

Single Particle Soot Photometer (SP2): Black carbon mass (single particle basis)

Filters: Sub and Supermicron

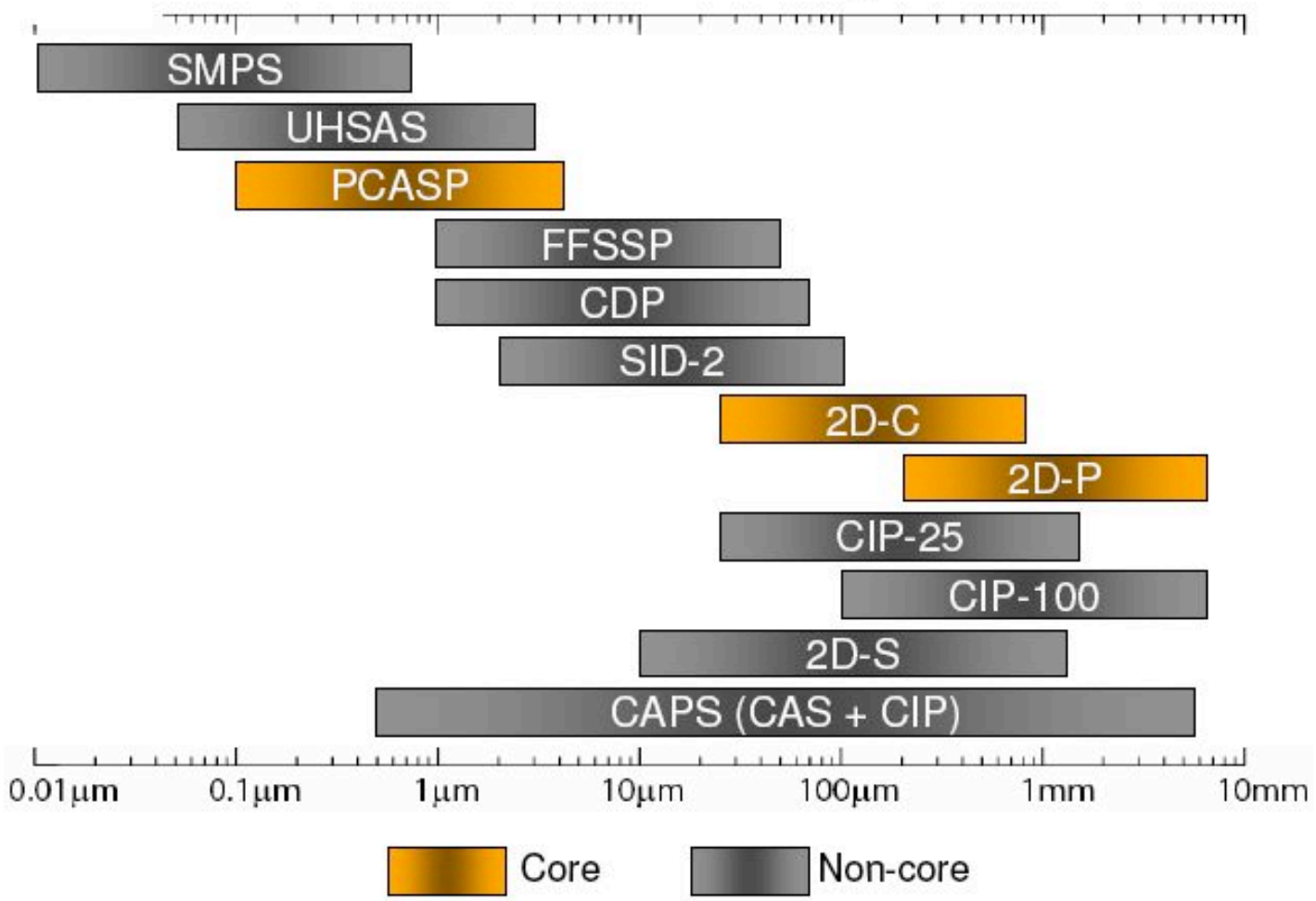
CVI: Counter Flow Virtual Impactor (Residual particle & vapour from cloud drops)

Nephelometer: Aerosol scattering (dry) at λ = 450,550,700 nm

Wet Nephelometer: Aerosol scattering f(RH) at λ = 450,550,700 nm

PSAP: Aerosol absorption at λ = 567 nm

146 – Cloud Physics



FAAM BAe-146 Additional Instrumentation

In addition to this instrumentation (see next slides) the aircraft will be fitted with

- Core chemistry: CO, O_3, NO_x, SO_2
- PAN
- Thermodynamics: Temperature, Humidity, Pressure……
- Dynamics: Turbulence probe
- Sondes
- Video Cameras: Upward, Downward, Forward, Rear

3Ae-146 FAAM Radiation Instrumentation

Microwave Radiometer (MARSS): Upward and downward pointing (+40 to -40 deg)
5 channels 89-183 GHz
Derive LWP, T + q structure

Shortwave Spectrometer (SWS): Pointable high resolution spectrometer measuring radiance across spectral range 0.3 – 1.7 μm
MODIS type retrievals of cloud properties

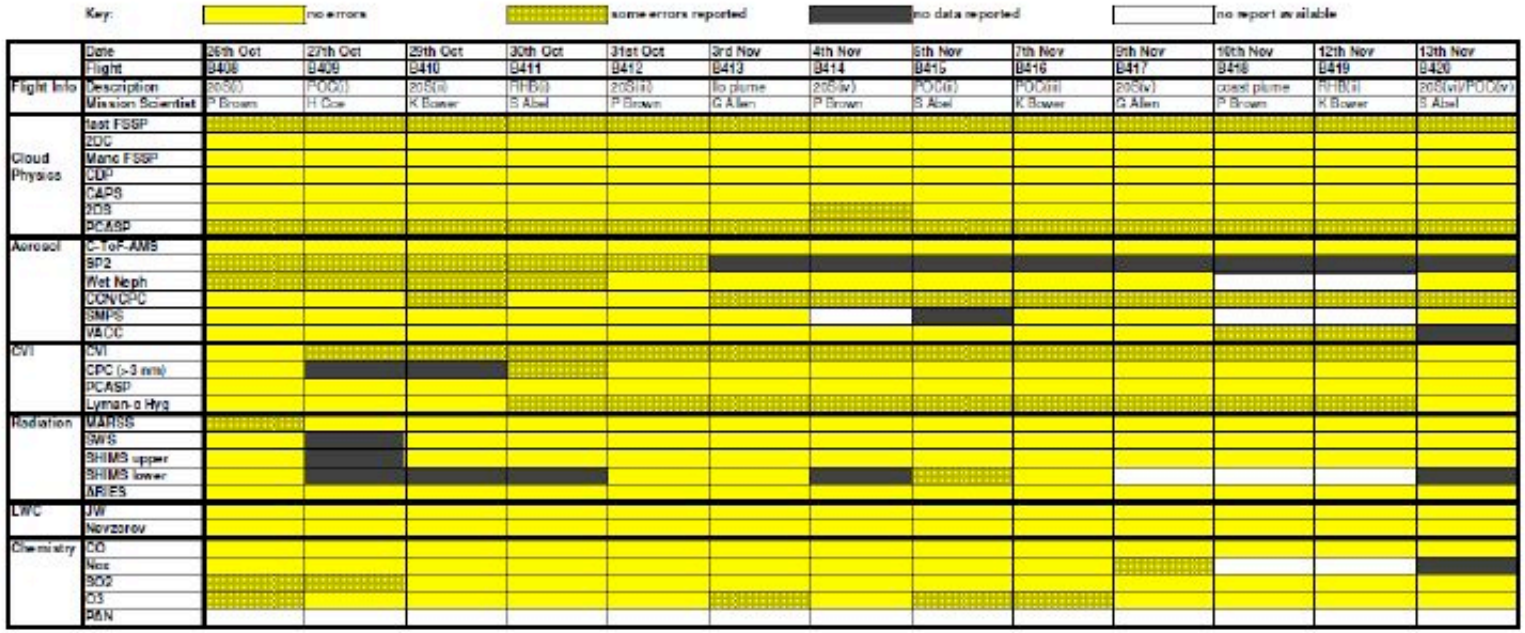
Spectral Hemispheric Irradiance Measurement (SHIM): As SWS but hemispherically integrating. Mounted on top and bottom of aircraft.
Derive cloud optical depth

Broad Band Radiometers: Derive cloud optical depth

Heiman Radiometer: Sea surface temperature

Airborne Research Interferometer Evaluation System (ARIES): Interferometer producing high resolution spectra 18 – 3.3 μm. Retrieve profiles of gases (CO_2, H_2O, O_3 etc) and sea surface temperature. Cloud info incl cloud top temp……

BAe 146 Flights and Data Status



BAe 146 Flights :

- 20-South cross sections
  B408(26/10); **B410**(29/10); **B412**(31/10); **B414**(4/11); **B417** (9/11); **B420** (13/11)
  - All with different characteristics in terms of:
    - Well-mixed and decoupled boundary layers
    - Homogeneity of stratocumulus
    - Drizzle occurrence
  - Several intercomparisons with C-130
  - Several low-level returns
  - Several high-level sonde-dropping

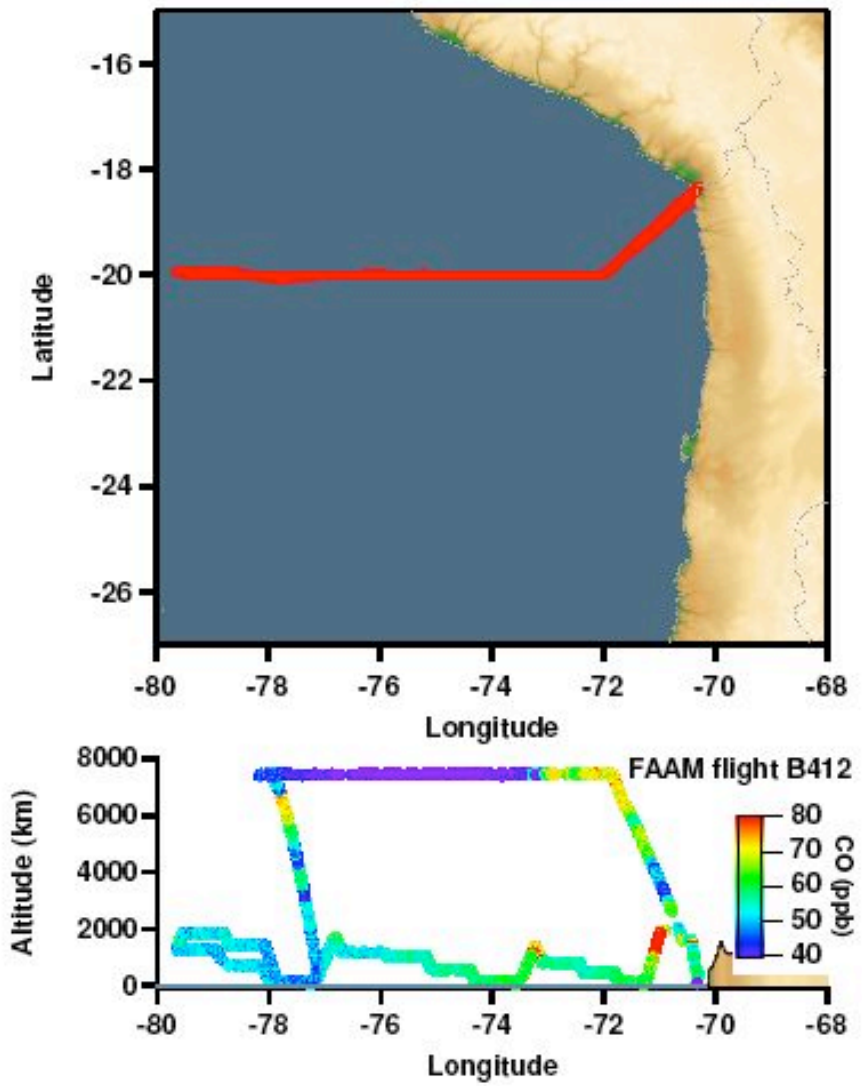
- POC studies
  - 4 completed (**B409, B415, B416, B420**)
  - one sampled subsequently by C-130 (quasi-Lagrangian) (**B409**)
  - Different times of day: eg One at sunset (**B409**) and one at sunrise (**B415**)
  - One combined with 20S cross section (**B420**)

- Pollution plumes (**B413** and **B418**)
  - **B413** Coastal survey in vicinity of Ilo smelter. Speculation that it had been turned off were later found to be true!
  - **B418** Antofagusta plume and coastal survey to south of Arica

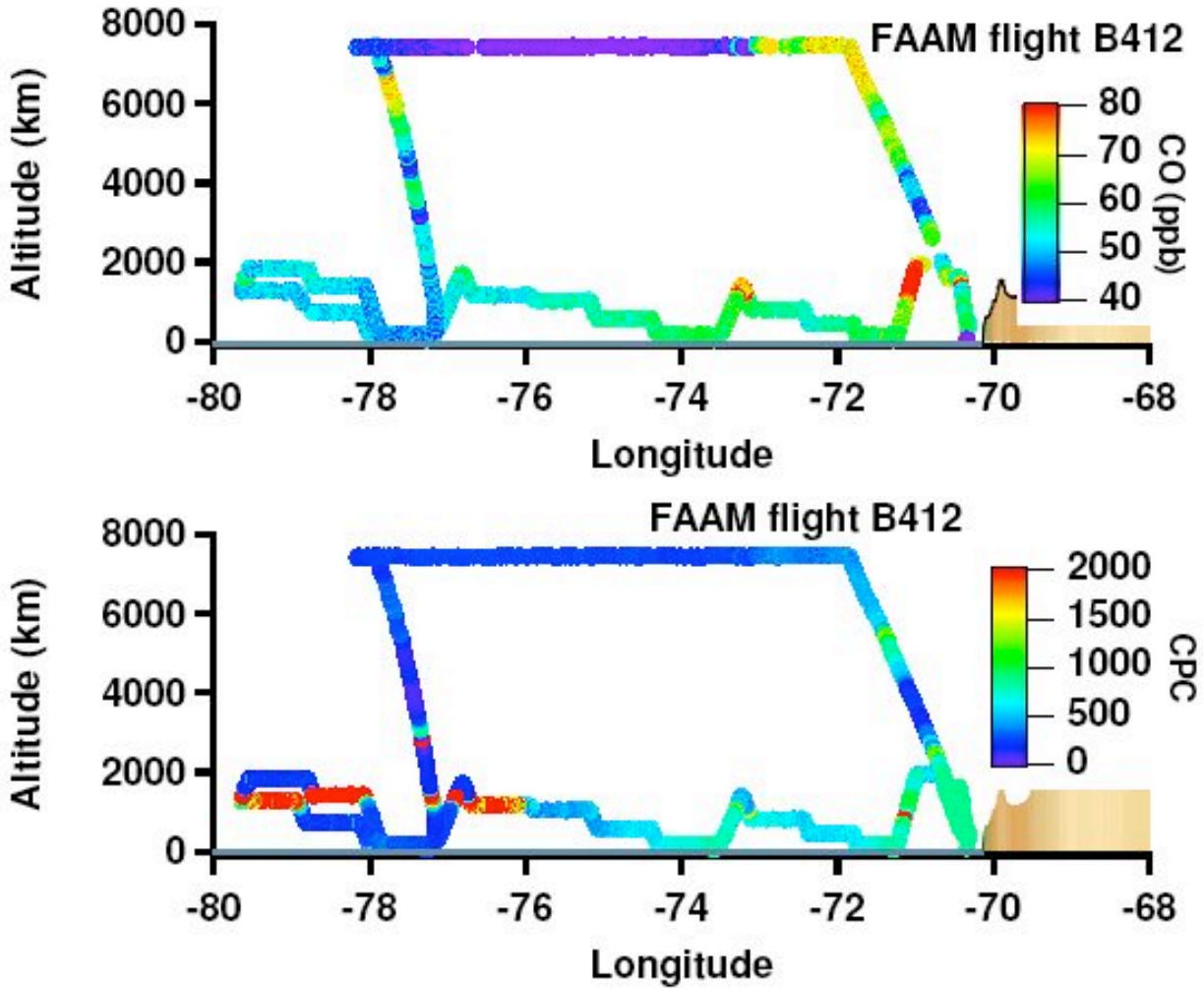
- Ron Brown Overflights (**B411** and **B419**)
  - Light drizzle on B419, none on B411, multiple legs below, in and above cloud

- Several intercomparison flights were conducted with other aircraft

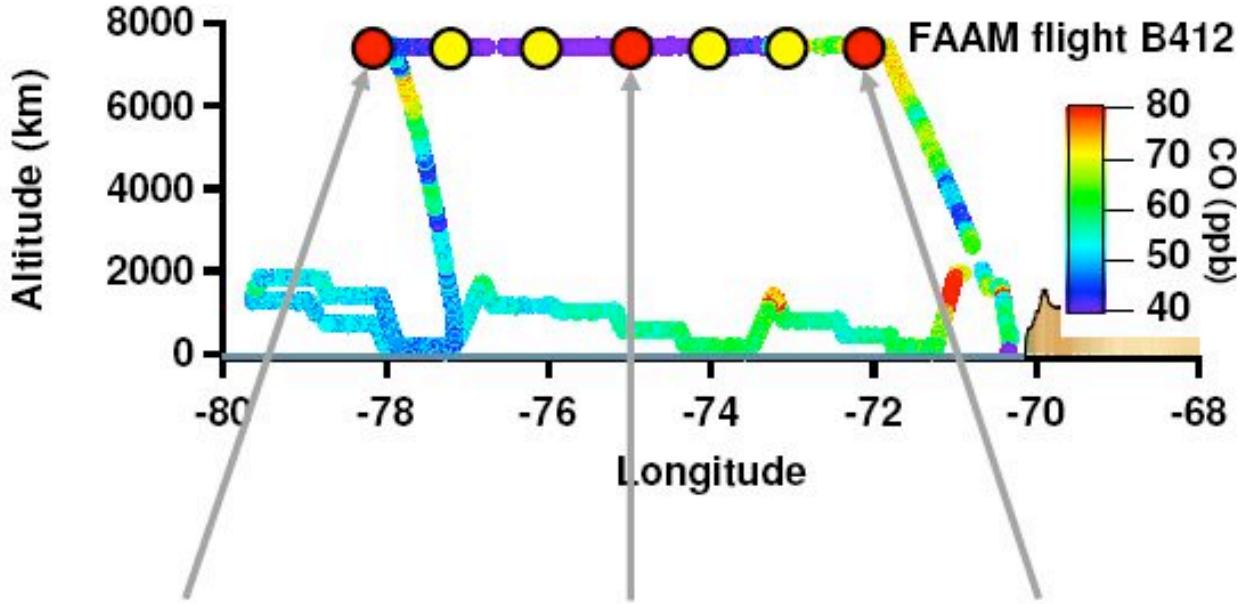
Data Highlights: An Example of a 20S Cross-Section

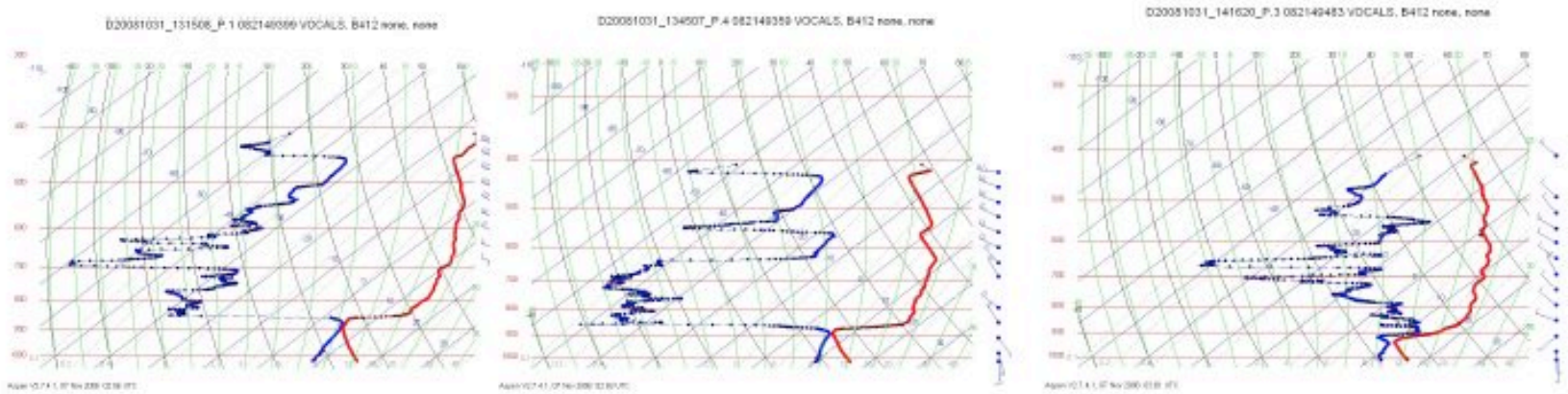


Data Highlights: An example of a 20S Lagrangian (B412)

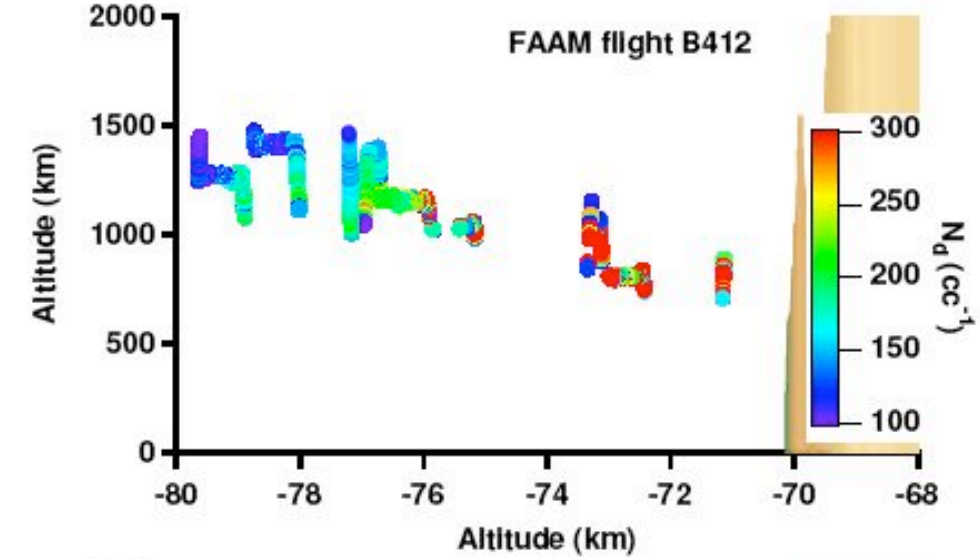


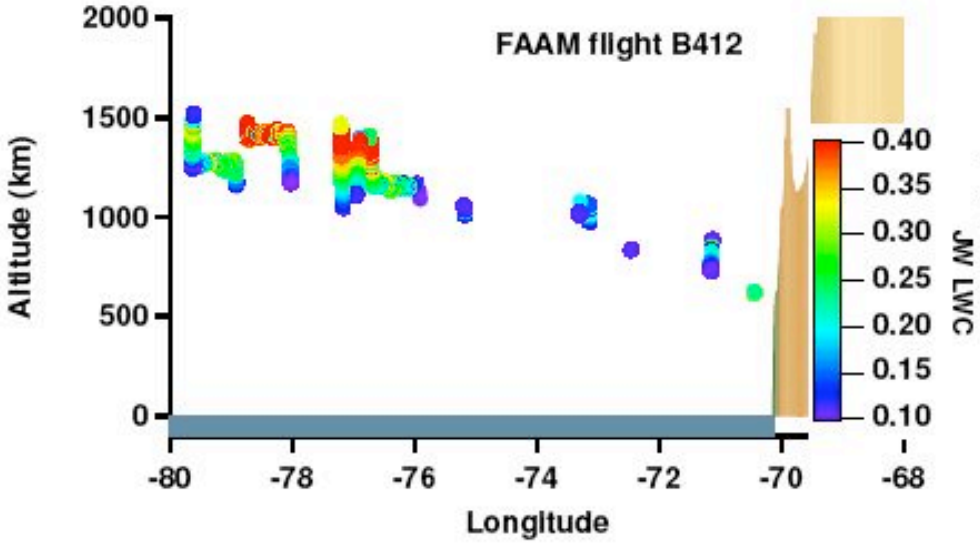
Data Highlights: An example of a 20S Lagrangian (B412)

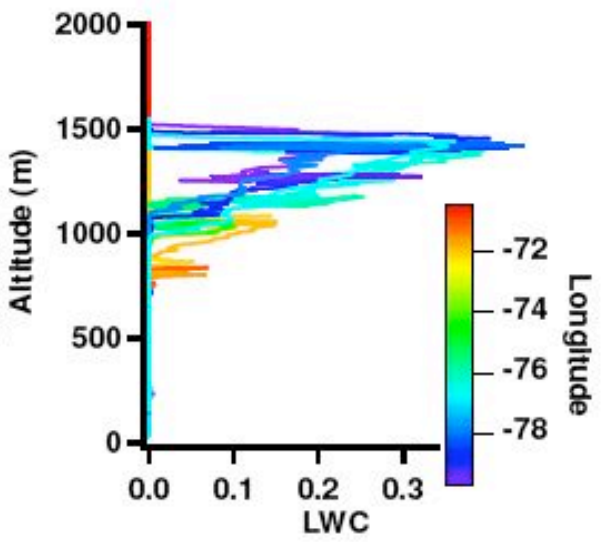




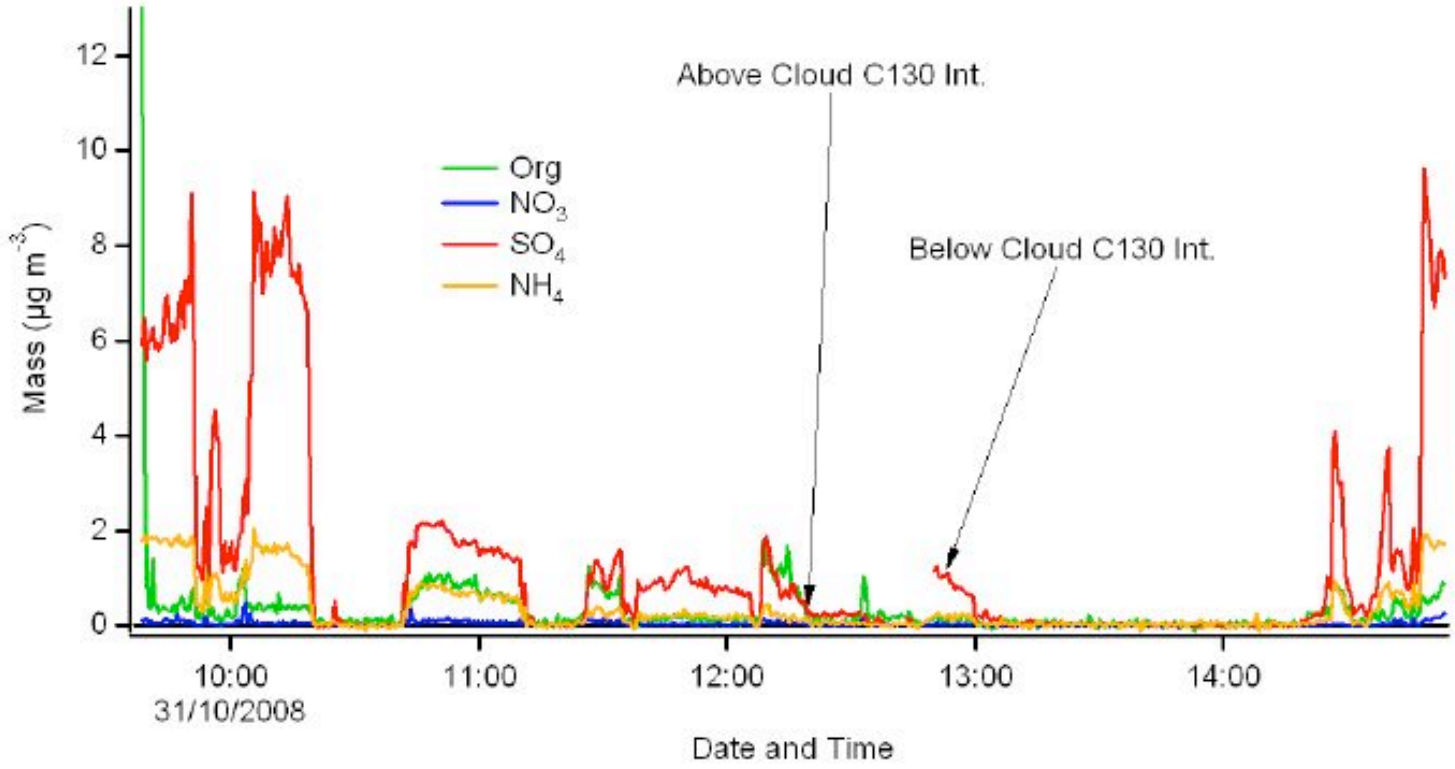
Data Highlights: An example of a 20S Lagrangian (B412)



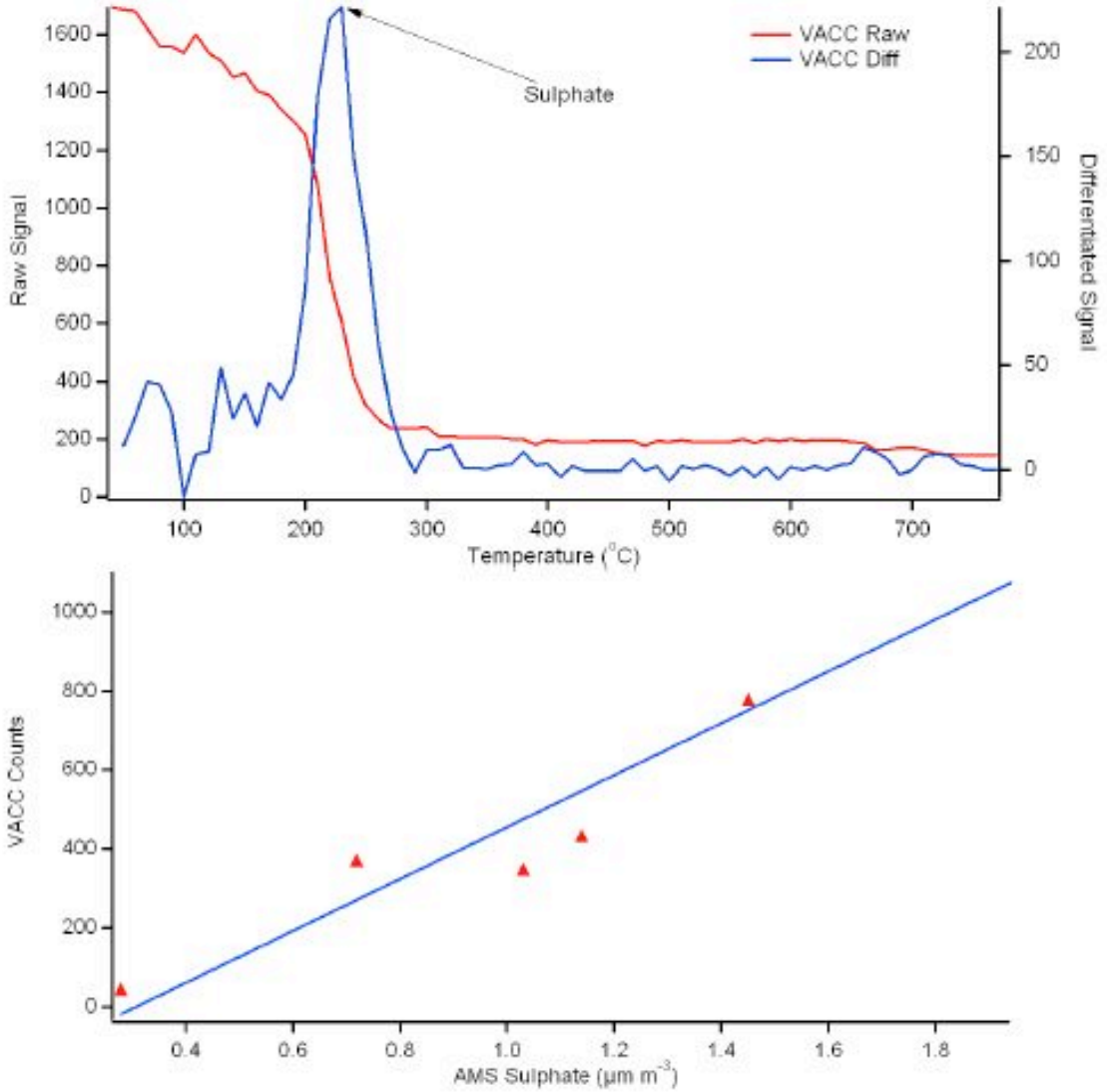




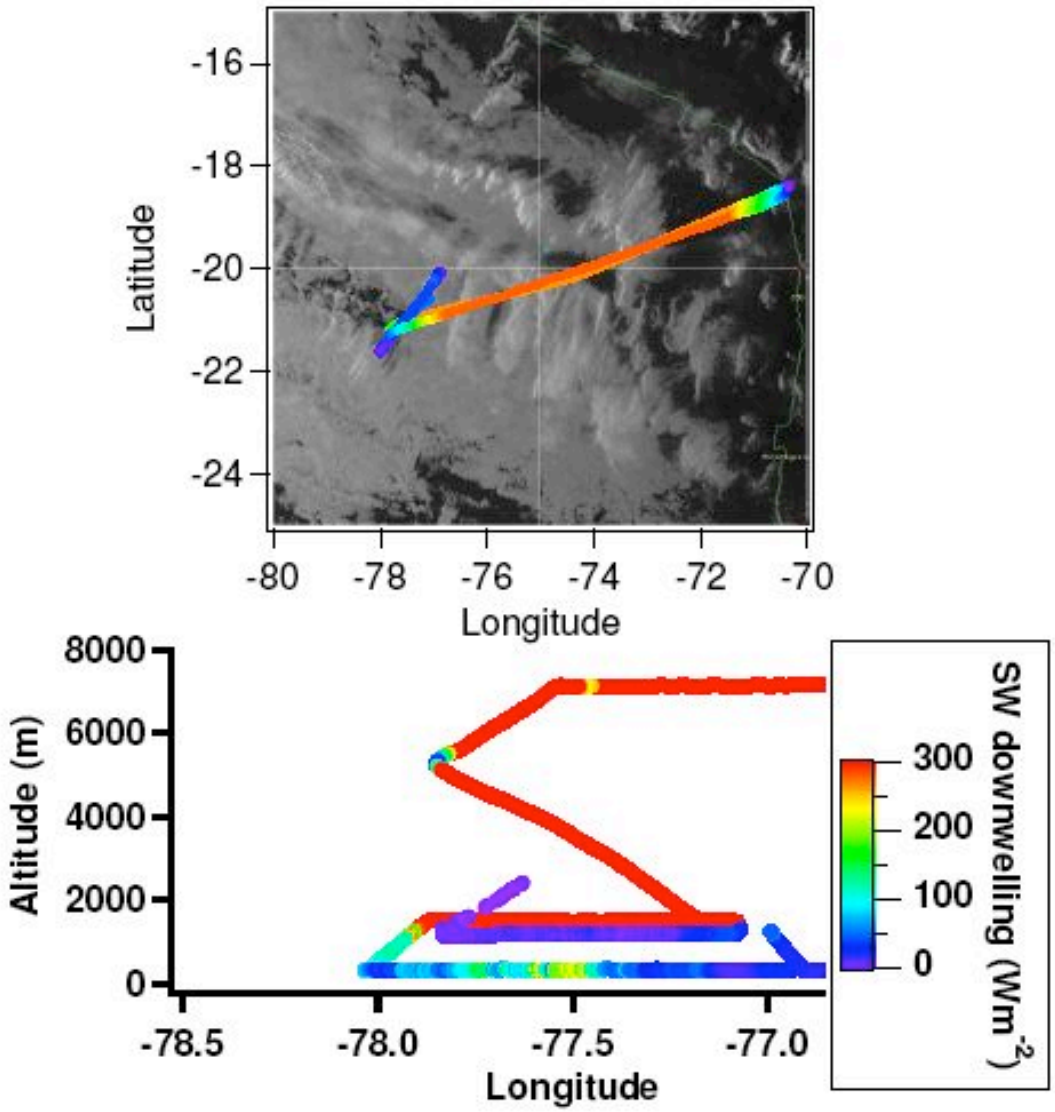
Data Highlights: An example of a 20S Lagrangian (B412)



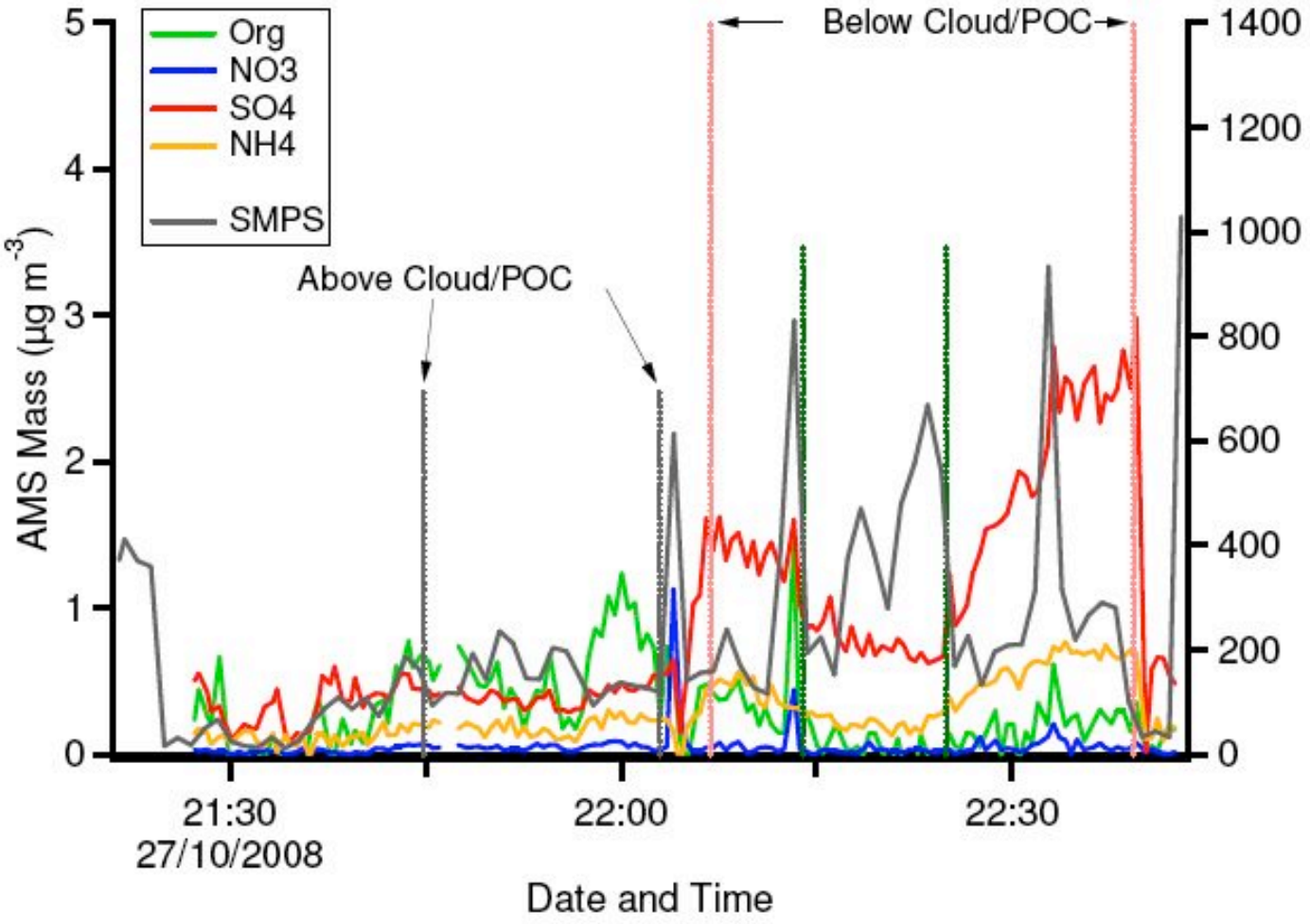
Data Highlights: An example of a 20S Lagrangian (B412)



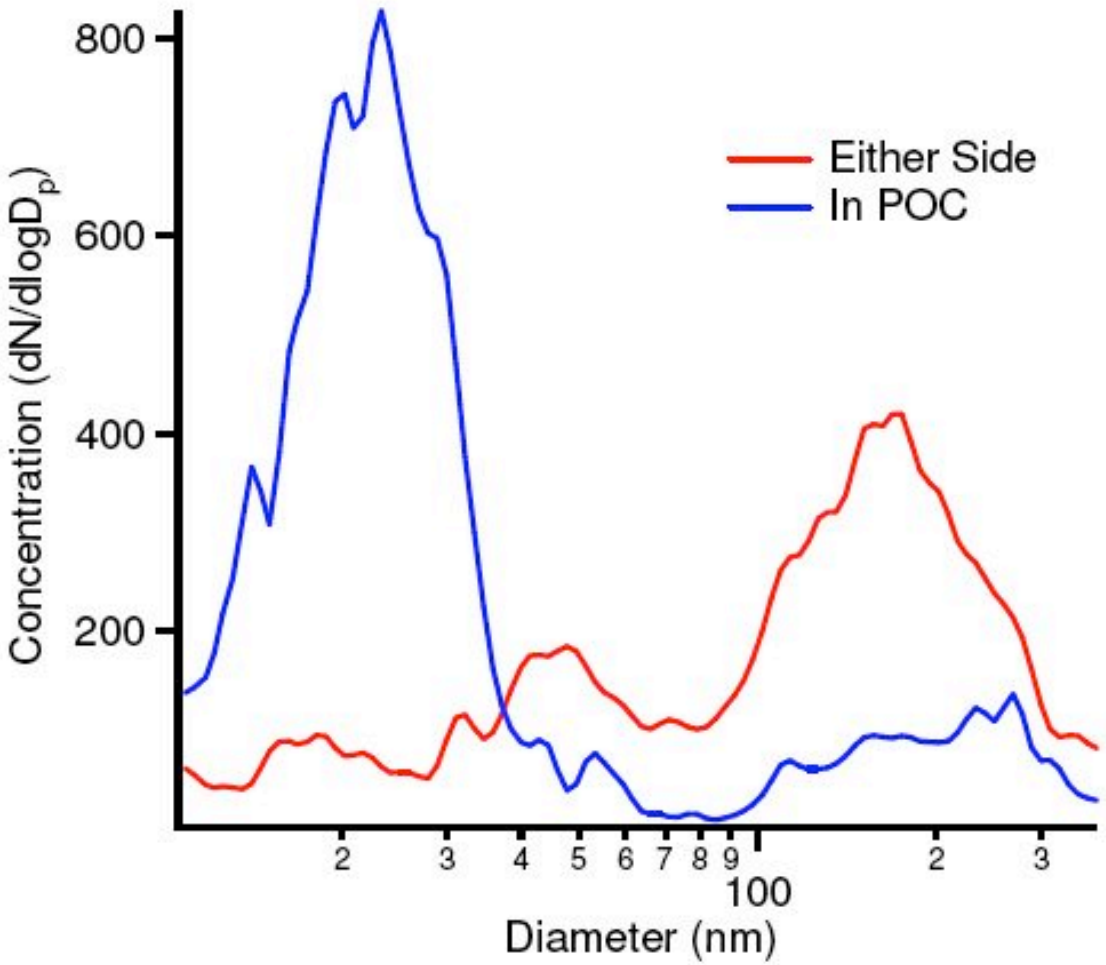
Data Highlights: An example of POC mission (B409)

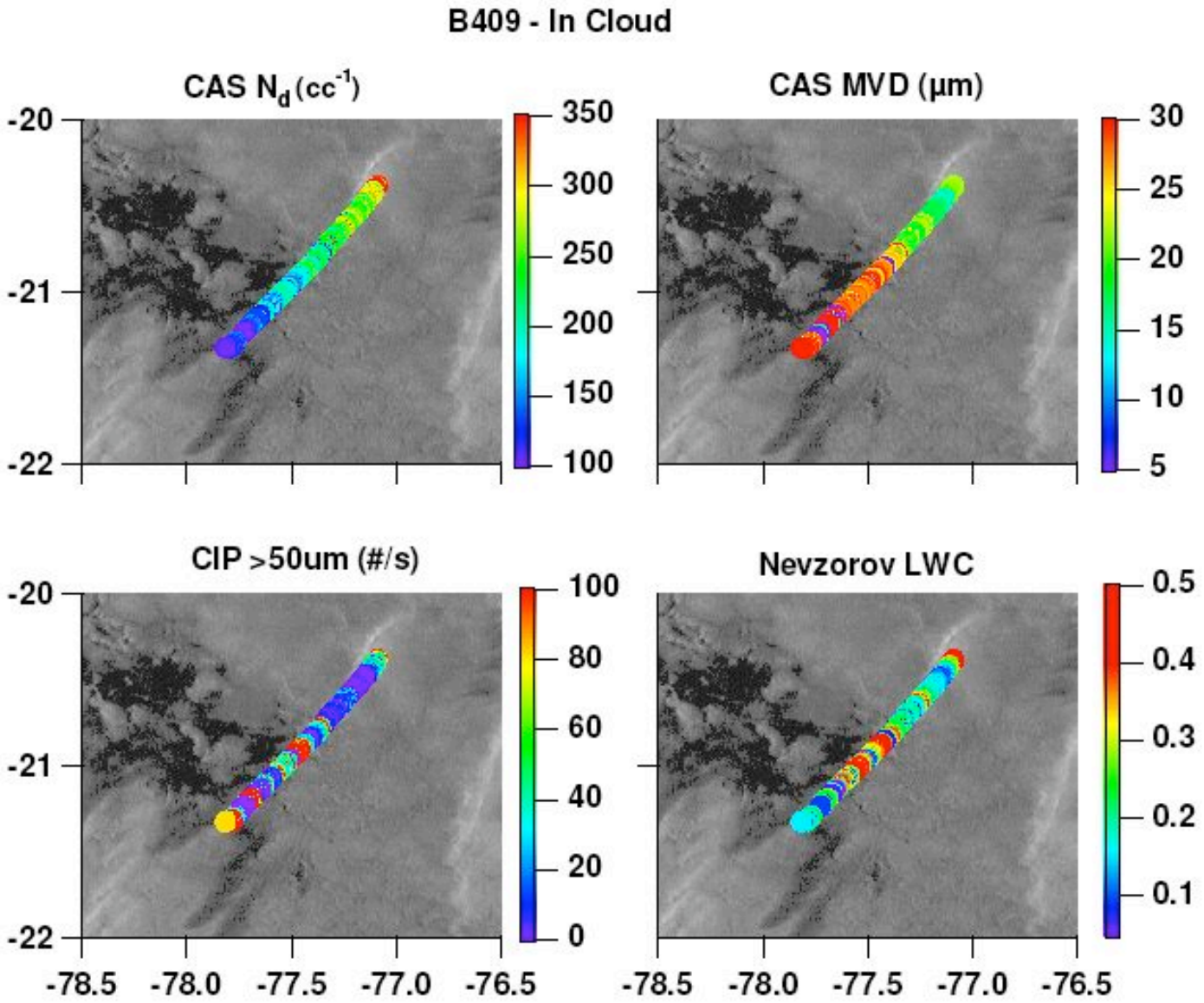


Aerosol composition below cloud during POC mission B409



Aerosol size distribution below cloud during POC mission B409




B409 - In Cloud
CAS N_d (cc^{-1})
350
300
250
200
150
100
CAS MVD (µm)
30
25
20
15
10
5
CIP >50um (#/s)
100
80
60
40
20
0
Nevzorov LWC
0.5
0.4
0.3
0.2
0.1
-20
-21
-22
-78.5
-78.0
-77.5
-77.0
-76.5

Remote sensing measurements with the NERC Dornier 228

Instruments

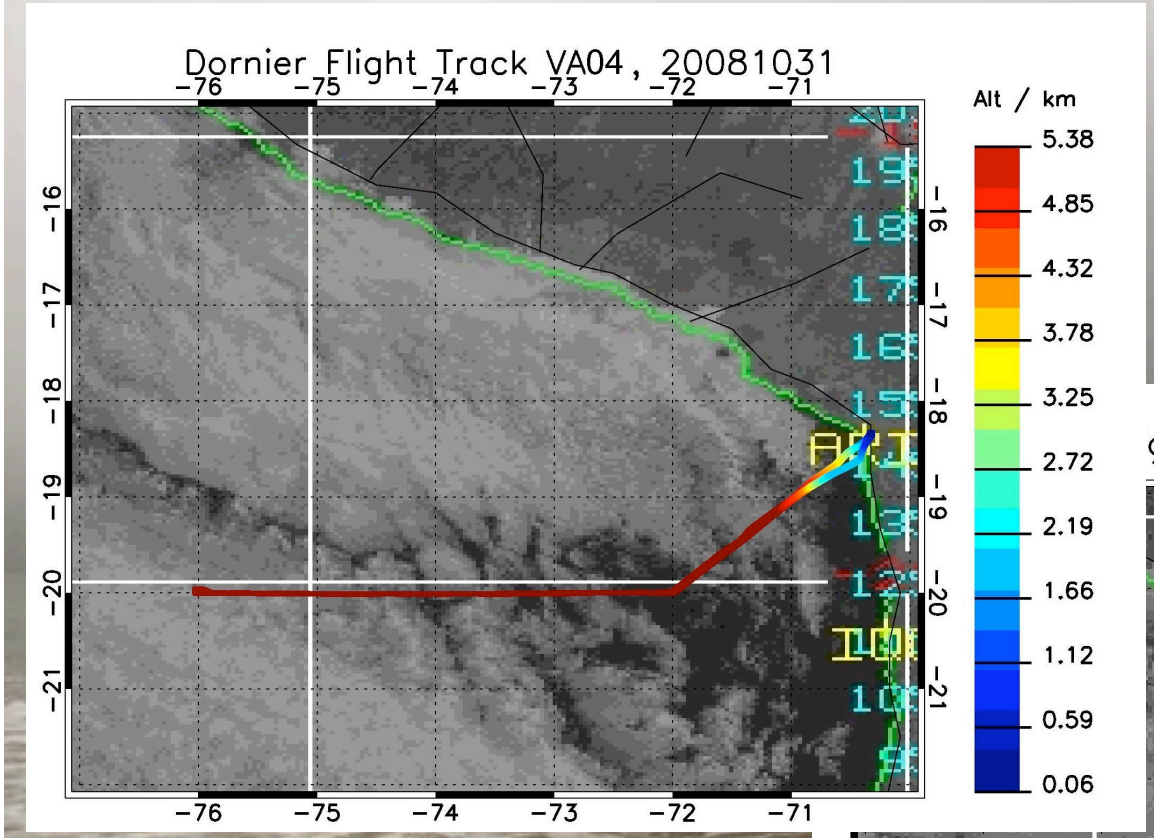
- Eagle and Hawk Hyperspectral Imager
- Leosphere aerosol-cloud lidar
- AMSSP Polarimeter
- UV spectrometer
- AIMMS meteorological probe
- APPLANIX GPS
- GRIMM aerosol spectrometer
- PCASP aerosol spectrometer
- FSSP aerosol and cloud probe

AIMMS-20

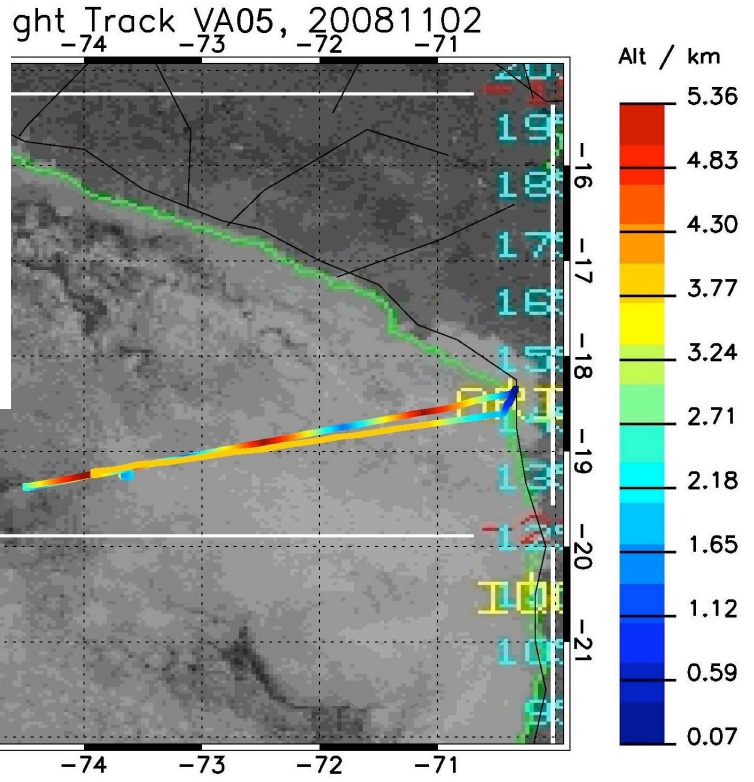
Flights

			Take off UT	Land UT	Duration hours
26-Oct	VA01	test	14:16	17:27	3:11
27-Oct					
28-Oct	VA02	test	12:49	14:30	1:41
29-Oct					
30-Oct	VA03	Ron Brown overflight	11:38	15:48	4:10
31-Oct	VA04	20°S	11:30	15:26	3:56
01-Nov					
02-Nov	VA05	Profiling	11:54	15:11	3:17
03-Nov	VA06	Pollution gradient	13:00	16:36	3:36
04-Nov	VA07	20°S	11:31	15:43	4:12
05-Nov	VA08	Profiling S	13:00	16:11	3:11
06-Nov	VA09	Lidar test	18:35	20:14	1:39
07-Nov					
08-Nov					
09-Nov	VA10	20°S	13:39	17:52	4:13
10-Nov	VA11	Pollution gradient	11:23	15:23	4:00
11-Nov					
12-Nov	VA12	Ron Brown	11:35	12:19	0:44
13-Nov	VA13	146 intercomparison	10:05	11:45	1:40
13-Nov	VA14	20°S	12:45	16:48	4:03
14-Nov	VA15	Profiling S	13:15	16:51	3:36
	Test flights				
	High-level (15000') remote sensing flights, usually with other aircraft beneath				
	Aerosol profiling flights, between cloud top and 15000'				
	Intercomparison of wing probes with 146 at low level				

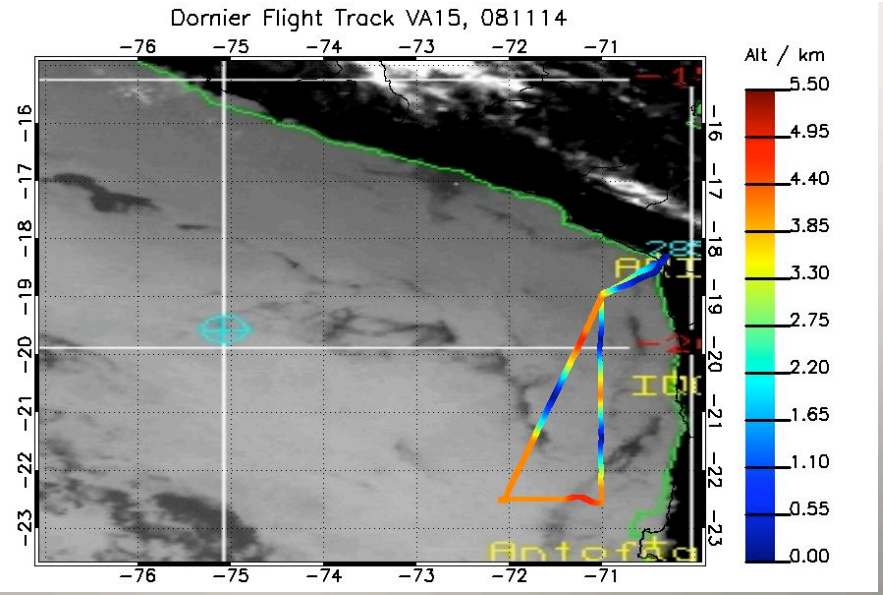
Example flights



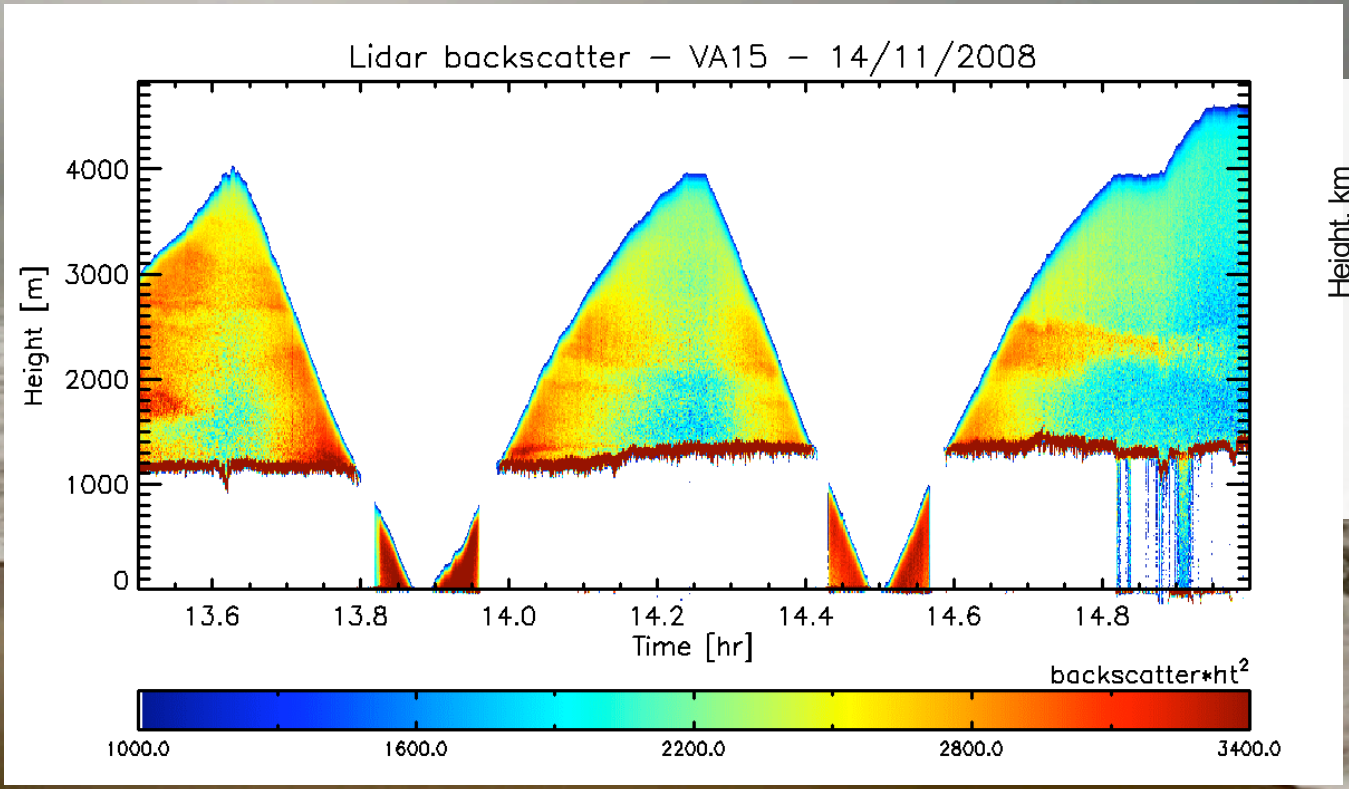
20° S flights – altitude 13000 – 15000 ft for remote sensing

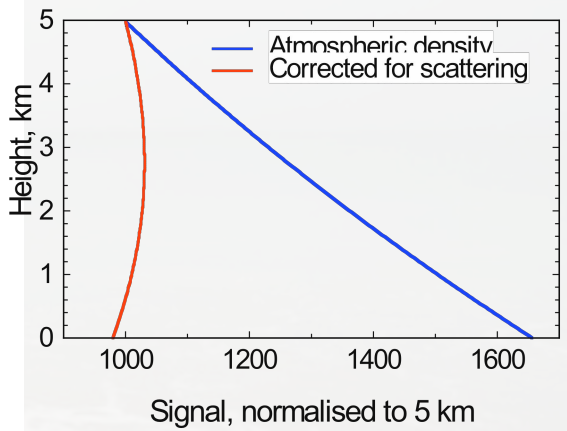


Example of lidar backscatter profiles



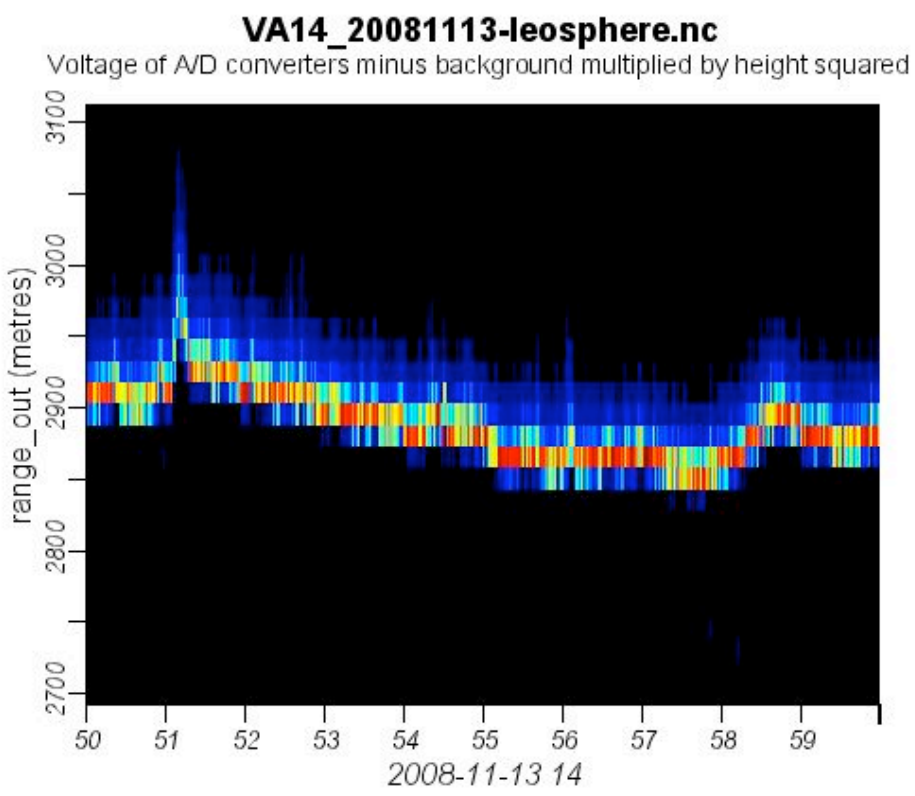
Profiling flight south of Arica on 14 Nov – track superimposed on GOES Channel 4

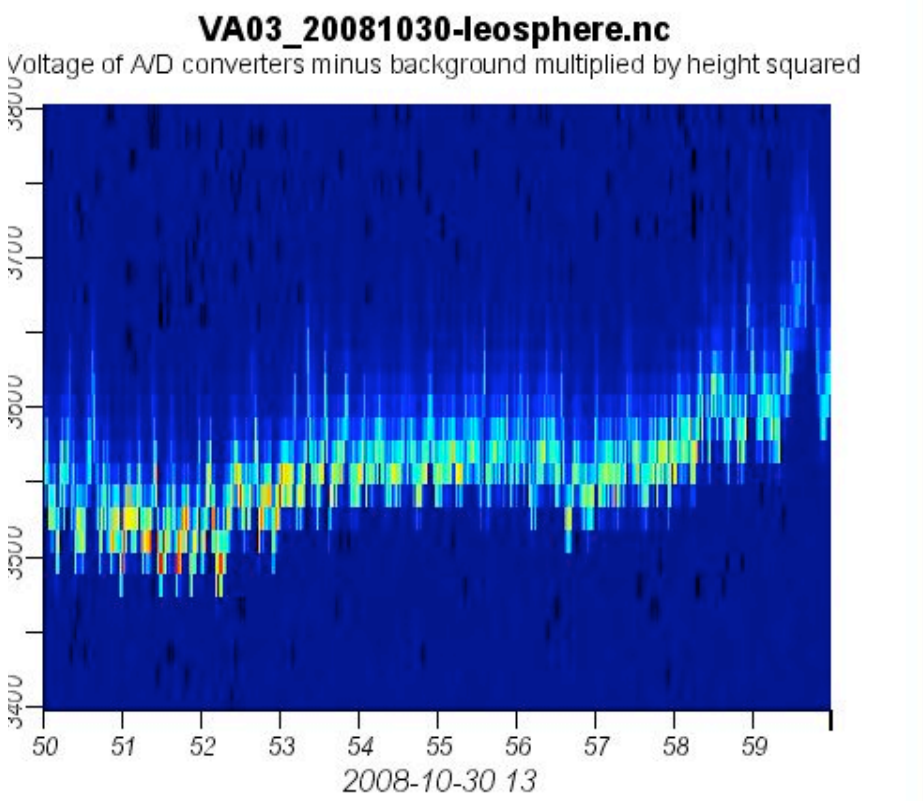


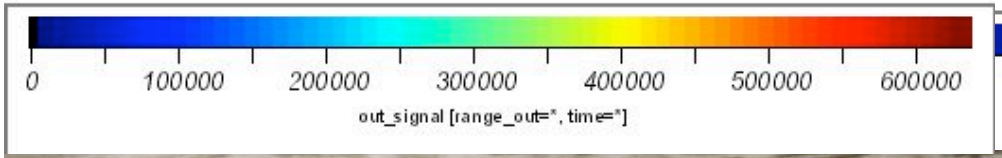


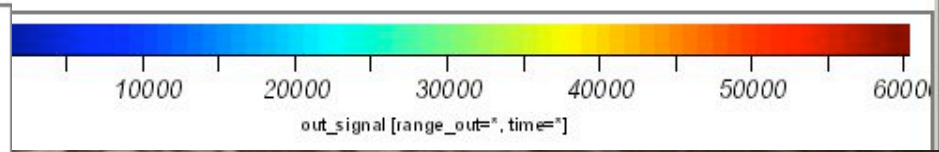
Background signal attenuated by scattering of 355 nm radiation – see above

Cloud top height: 10-min sections from VA14 and VA03 showing signal variation







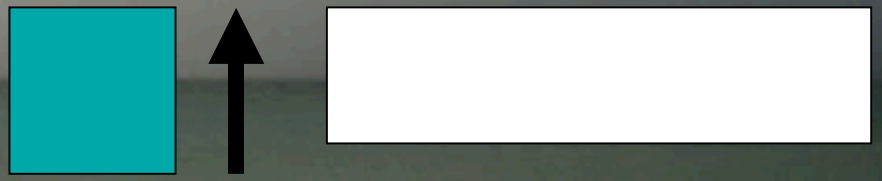


Lidar aligned

Lidar not aligned: high noise but distinguishes CTH well

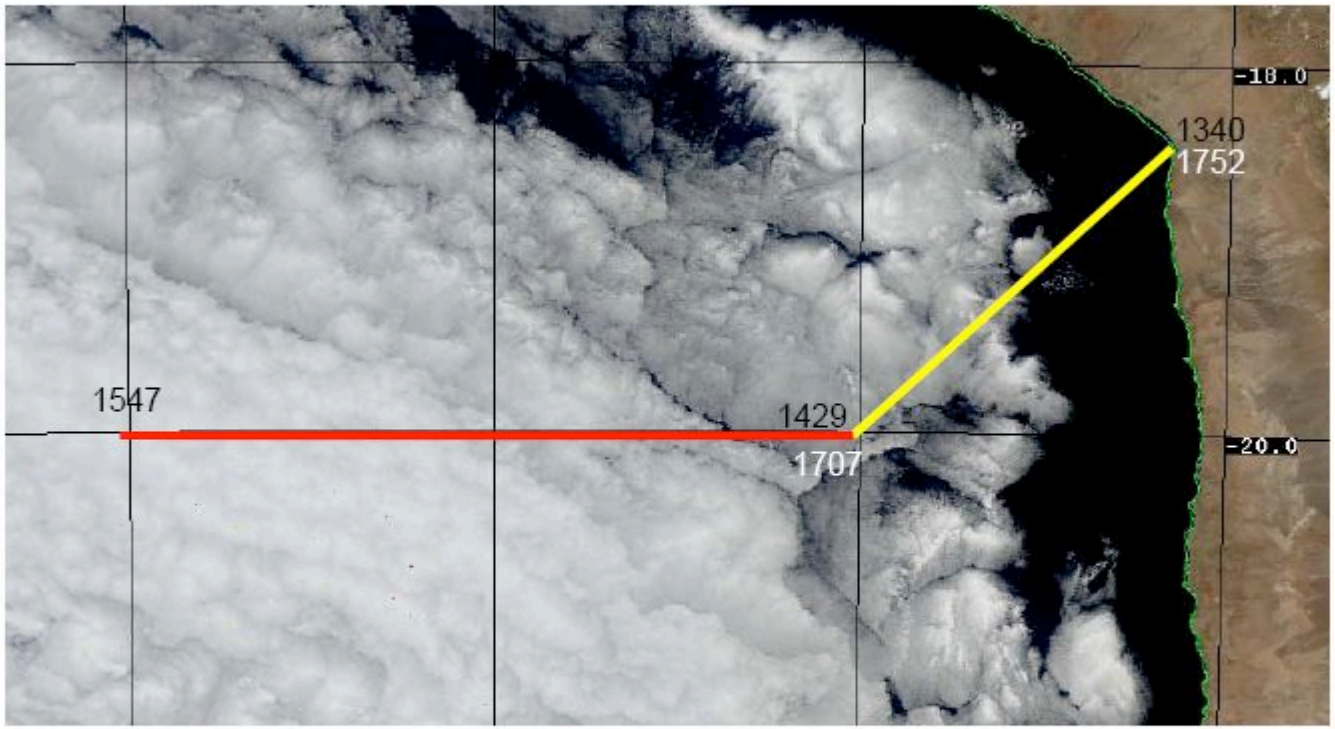
Y axis is distance from lidar – these have not been corrected for aircraft height

Eagle and Hawk Hyperspectral imager, preliminary data, VA02_081028



Eagle pixel	Hawk pixel
2.8 x 2.4 m	1.6 x 4.6 m
1024 pixels	320 pixels
400-970 nm	1000 - 2400 nm
Δλ = 2.9 nm	Δλ = 8 nm

VOCALS Nov 9 2008 – VA10



Terra MODIS overpass at 1440 UTC

Rendezvous with BAe146 west of 20S 72W during the outbound leg

Courtesy Harshvaradan, Purdue University