

Aerosol Particle Spectrometer with Polarization Detection (APSPD)
ICE-T Data Report
October 14, 2013
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1. File and Data Description

There are two data files created for each of the 13 research flights. No files have been produced for the ferry flights but are available upon request. The data files are labeled “RFnAPSPDstats.txt” and “RFnAPSPDspec.txt”, where “n” is the flight number, “stats” and “spec” refer to the types of information in the data file and is described below.

The data files contain tab delimited text, each line of data is a one second sample. The first line of each file is a header that describes the data found in each column.

The APSPD is an optical spectrometer that measures side scattered light from individual aerosol particles that pass through a focused laser beam, in the optical equivalent diameter range from 0.5 to 20 μm . The term optical equivalent diameter is used here to remind the user that Mie scattering theory is being used to derive a diameter from the measured scattered light assuming the particles are spherical with known refractive index. Since these are aerosol particles that are likely aspherical and with unknown refractive index, the diameter that is reported is for a sphere with index of refraction of water that would have produced the measured scattered light.

In addition to the side scattered light, there are two additional components of the scattered light that are measured, backscattered light with polarization that is perpendicular to the incident light and backscattered with no polarization. These two components are used to generate a polarization ratio from which information about the particle shape and possible composition can be derived.

In the data files there are concentrations reported of various types of dust or biogenic composition. These components are derived from laboratory measurements that have been made of different types of dust and pollen; hence, what is reported as Azores Dust only means that it has a signature that comes closest to being matched by the Azores dust that was measured in the laboratory. **This does not mean that the particles were actually dust from the Azores.**

1.1 RFnAPSPDstats.txt files

The data in these files are a combination of parameters extracted from the C-130 one second data files and parameters derived from the APSPD measurements. In Table I below, each column of this data file is described.

Table I
Parameters in Statistics File

Parameter	Units	Description
UTCTime	Seconds	UTC time of the day
Altitude	Meters	GPS altitude from NCAR C-130 archive file
AvgTemperature	Celsius	Ambient temperature from NCAR C-130 archive file
CVIstate	None	Counter-flow virtual Impactor state 0, 1 or 2
CldConc	cm ⁻³	FSSP droplet concentration from C-130 archive
PCASPConc	cm ⁻³	PCASP concentration from C-130 archive
qaFlag	None	Data quality flag: 0=good data, 1=suspect data
AvgConc	cm ⁻³	APSPD total number concentration
AvgVol	µm ³ cm ⁻³	APSPD total volume concentration
AverageDiameter	µm	APSPD average diameter
VolumeDiameter	µm	APSPD volume weighted diameter
AvgBtoS	None	Average ratio of back to side scattering
AvgDtoB	None	Average ratio of polarized back to non-polarized back
Bio	cm ⁻³	Number Concentration of biogenic-like particles
Ash	cm ⁻³	Number Concentration of ash-like particles
AzoresDust	cm ⁻³	Number Concentration of Azores Dust-like particles
Urban	cm ⁻³	Number Concentration of urban-like particles
IronOxide	cm ⁻³	Number Concentration of Iron Oxide-like particles
Other	cm ⁻³	Number Concentration of other aspherical particles
BioMVD	µm	Median Volume Diameter of biogenic-like particles
AshMVD	µm	Median Volume Diameter of ash-like particles
AzoresDustMVD	µm	Median Volume Diameter of Azores Dust-like particles
UrbanMVD	µm	Median Volume Diameter of urban-like particles
IronOxideMVD	µm	Median Volume Diameter of Iron Oxide-like particles
OtherMVD	µm	Median Volume Diameter of other aspherical particles

1.2 RFnAPSPDstats.txt files

The data in these files are 60 channel size spectra of number concentration, average shape factor, and number concentration of aspherical particles. The columns are labeled `psd[[0]-psd[[59]`, `sfPSD[[0]-sfPSD[[59]` and `asphPSD[[0]-asphPSD[[59]` to designate the three types of size distribution.

The shape factor is a relative value that is derived from the ratio of the polarization to backscattering intensities:

$$\text{Shape Factor} = 1 + \text{Polarization/Backscatter}$$

The farther the value is from 1, the more aspherical the particle.

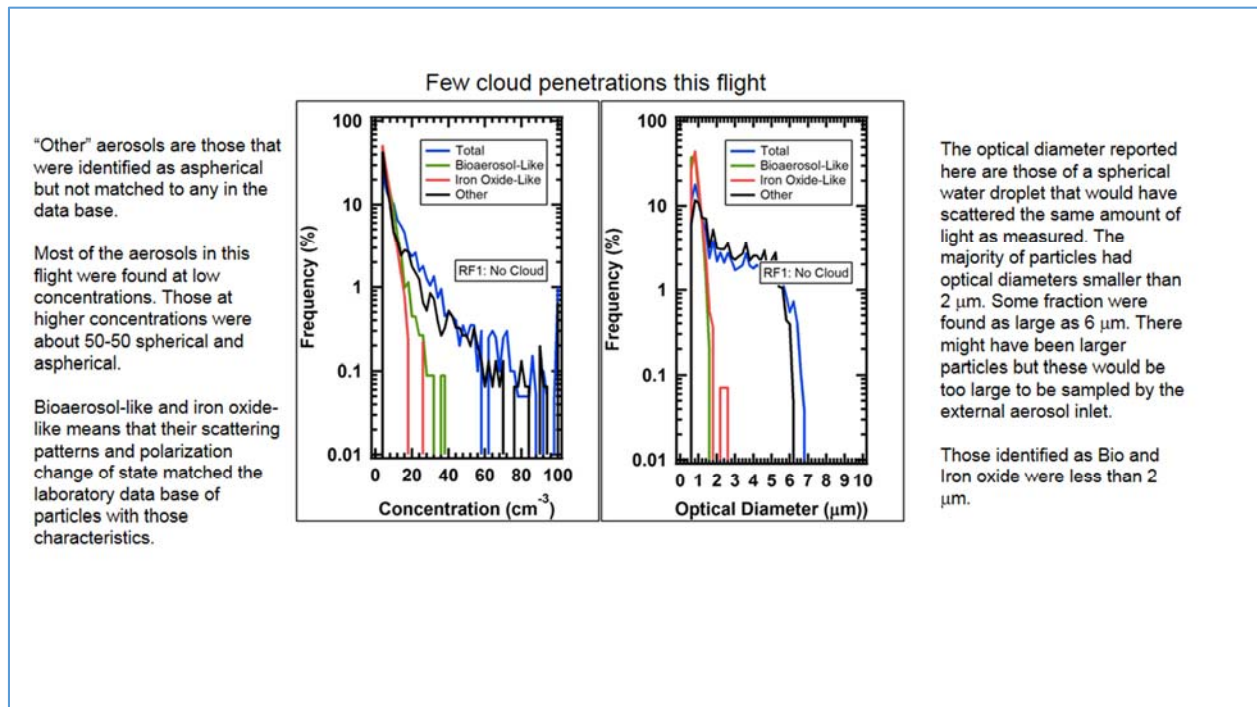
2. Caveats

Due to a suspected leak somewhere in aerosol delivery system of the aircraft, the measurements above 3000 m cannot be trusted and all these data points are flagged as bad. Below 3000 m the results are usually in good correlation with those from the PCASP suggesting that the APSPD measurements are not contaminated with cabin air.

The data have been quality checked by comparing with the PCASP and any data points when the APSPD does not track with the PCASP are flagged with the qaflag=1.

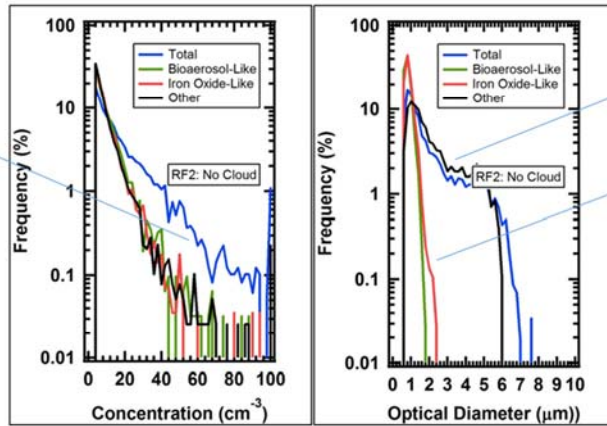
3. Flight summary figures

The following 13 figures give a brief summary of interesting features seen in the APSPD measurements for each flight.



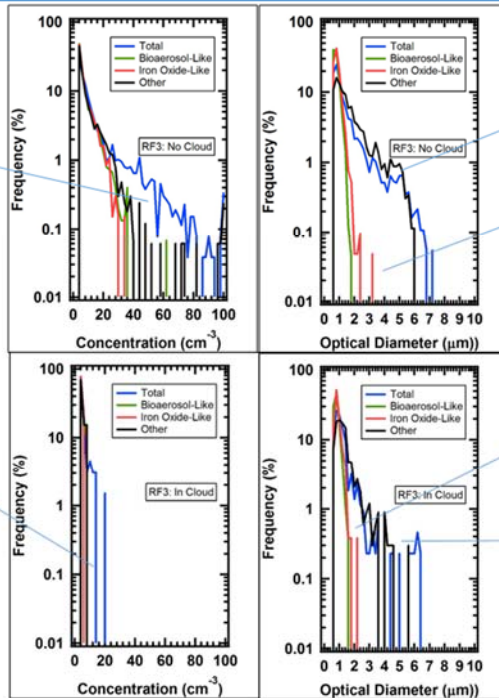
Few cloud penetrations this flight

Many more aspherical particles this flight as shown by the bio, iron-oxide and other aspherical histograms extending out to 60 cm^{-3} . This was a flight where a dust layer had been identified.



The largest particles were spherical. The larger aspherical particles could possibly be sea salt, particles that have not yet been tested in the laboratory.
The iron oxide particles have a slight tail towards particles larger than 2 μm .

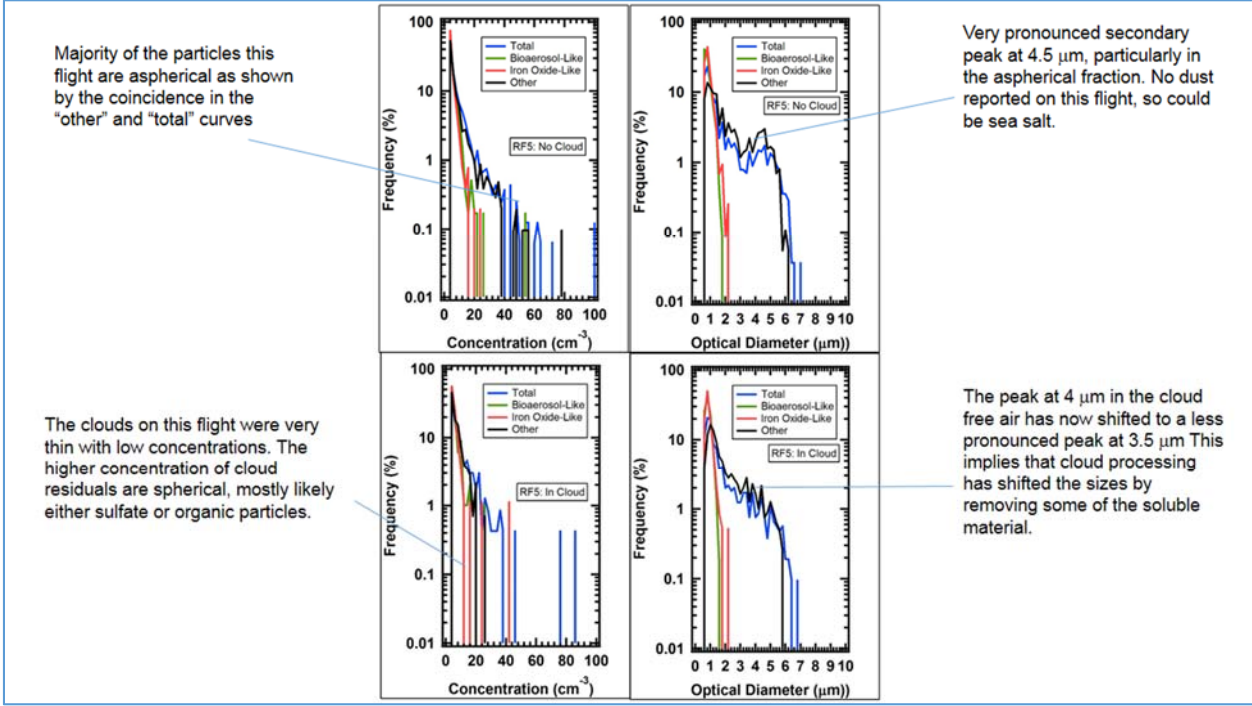
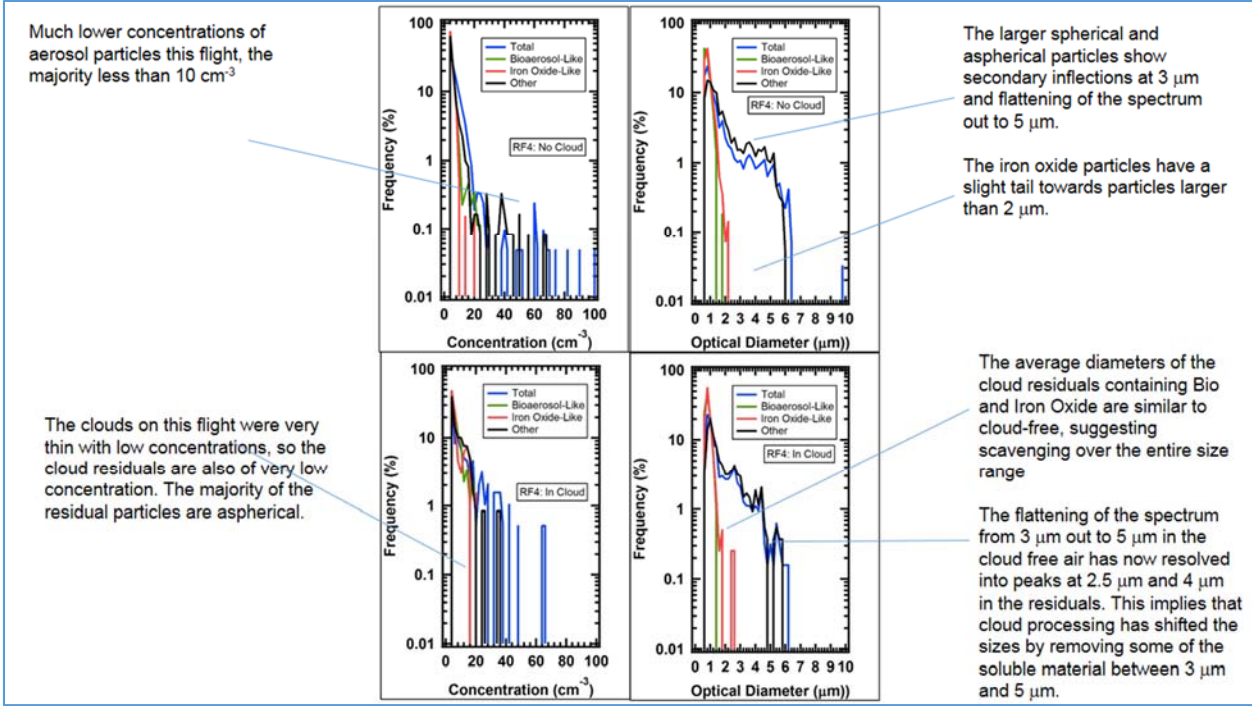
Many more aspherical particles this flight as shown by the bio, iron-oxide and other aspherical histograms extending out to 40 cm^{-3} . This was a flight where a dust layer had been identified.



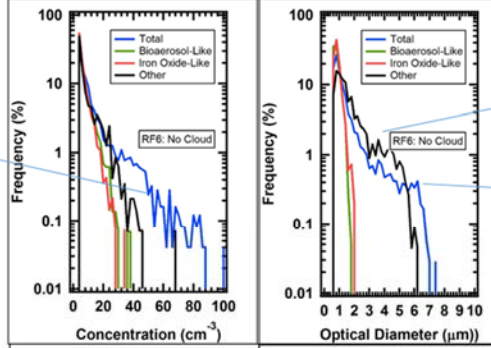
The larger spherical and aspherical particles show secondary inflections at 3 and 5 μm .
The iron oxide particles have a slight tail towards particles larger than 2 μm .

The clouds on this flight were very thin with low concentrations, so the cloud residuals are also of very low concentration.

The average diameters of the cloud residuals containing Bio and Iron Oxide are similar to cloud-free, suggesting scavenging over the entire size range.
The particles at 5 μm , seen in cloud-free air, are not seen in the cloud residuals. There are particles at 3 μm suggesting that the 3 μm particles were better CCN or IN than the 5 μm particles.

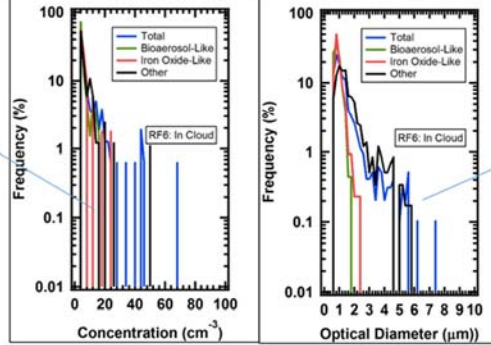


This flight occurred during a day where a dust layer had been identified. The concentration of aspherical particles are somewhat higher than non-dust days, but not as high as flights 2 and 3, the other two "dust" days. As shown in the blue curve, the majority of events with higher concentrations were aspherical particles.



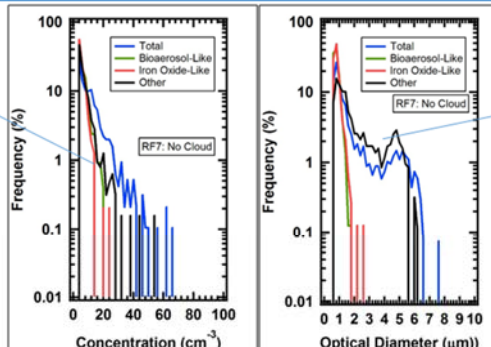
Broad secondary peak centered at 4 μm in the aspherical "other" fraction. Although not identified as one of the dusts in the data base, as this was a "dust" day, these are likely dust particles. The spherical fraction show a secondary peak at 6 μm. These most likely are deliquesced sea salt.

The clouds on this flight were very thin with low concentrations. The higher concentration of cloud residuals are aspherical, mostly likely either sulfate or organic particles.



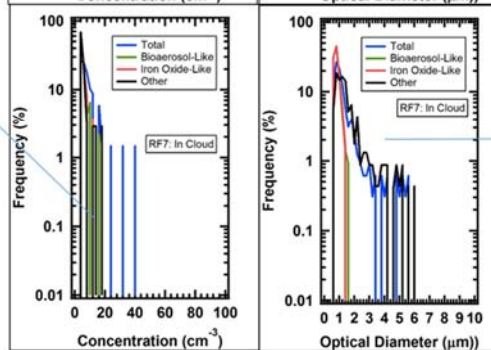
Distribution of cloud residuals is the same for bio, iron oxide and "other" aspherical particles but narrower for the spherical particles where the 6 μm peak is gone suggesting removal of some of the soluble material.

The concentration of aspherical particles is much less than the dust days



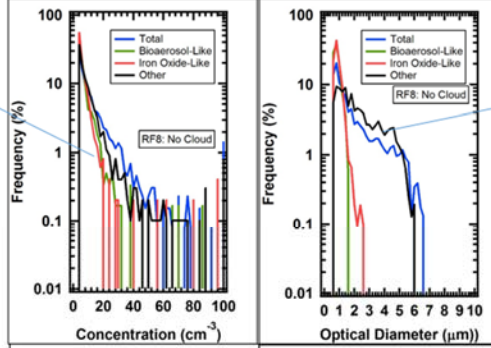
Very pronounced secondary peak centered at 5 μm in the aspherical "other" fraction.

The clouds on this flight were very thin with low concentrations.



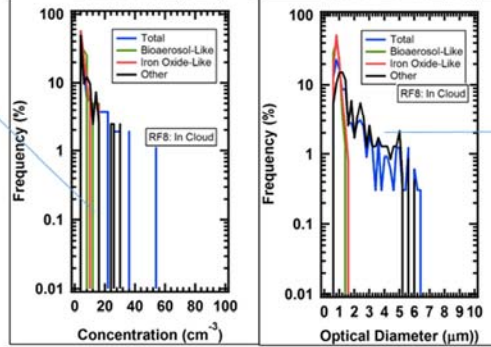
The very pronounced secondary peak centered at 5 μm in the aspherical "other" fraction in cloud-free air is not seen in the cloud particle residuals, suggesting that these particles were not good cloud nuclei or that the soluble material has been removed and what is left is the smaller, non-soluble core.

This day was flown downwind of Puerto Rico. Many more high concentration events of aspherical particles.



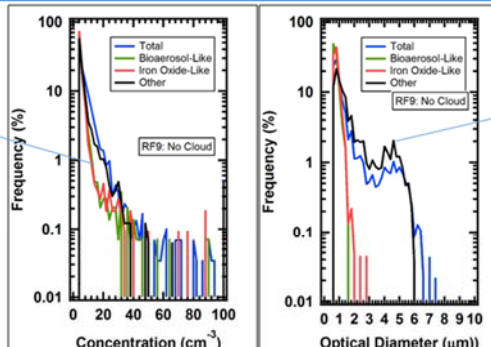
Slight inflection centered at 5 μm in the aspherical "other" fraction now dominate the larger particles that could be anthropogenic given that the flights are downwind of the island. Unlike previous flights the iron oxide particle sizes now extend to almost 3 μm.

Somewhat higher concentrations in the cloud residuals.



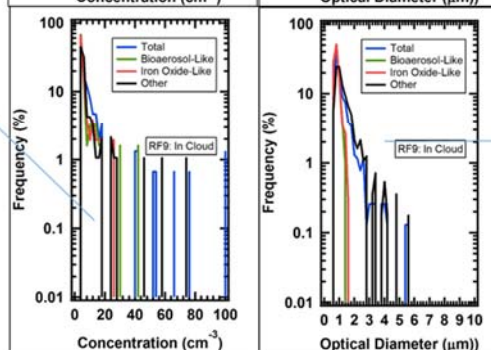
The inflection centered at 5 μm in the aspherical "other" fraction in cloud-free air is now a more pronounced peak at the same diameter in the cloud particle residuals, suggesting that these particles were good cloud nuclei.

The concentration of aspherical particles, particularly bio and iron oxide, is much like the dust days, except no dust was reported this day.

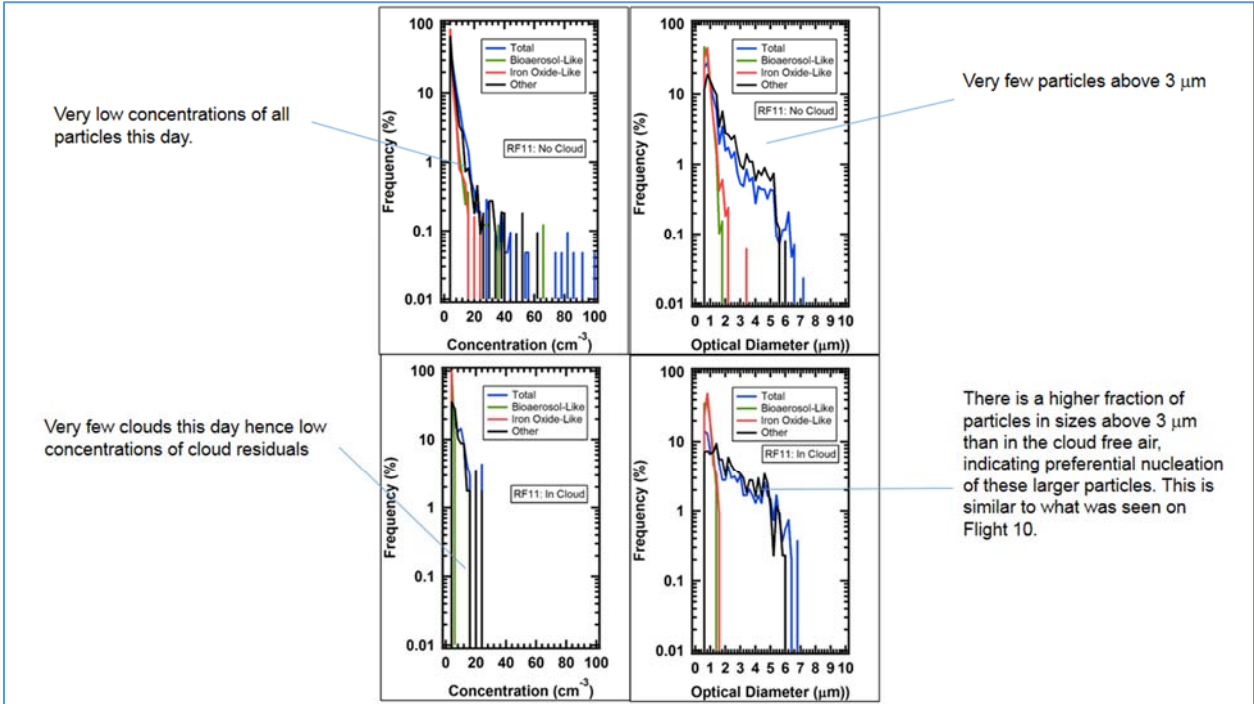
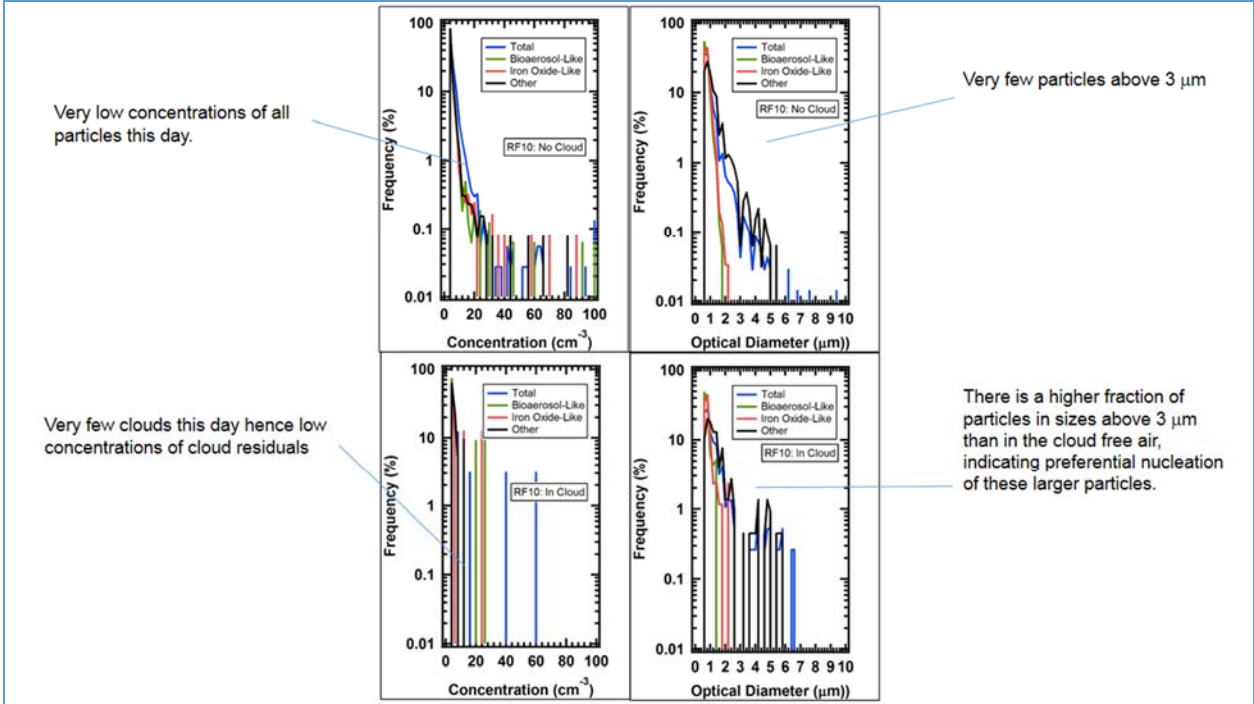


Very pronounced secondary peak centered at 5 μm in the aspherical "other" fraction in cloud-free air is now a more pronounced peak at the same diameter in the cloud particle residuals, suggesting that these particles were good cloud nuclei.

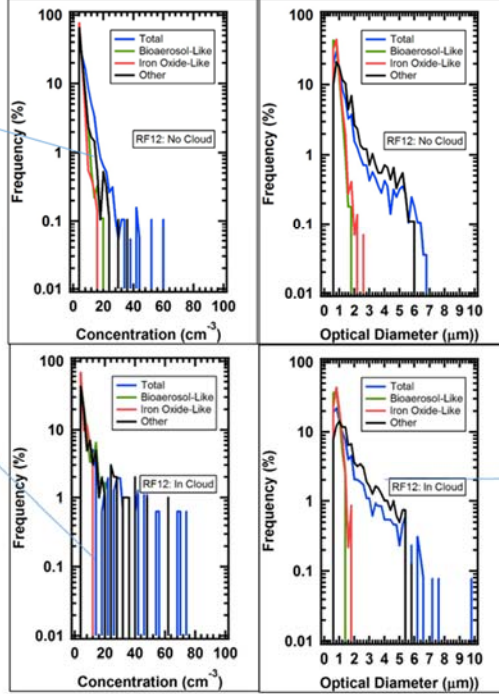
More, higher concentration clouds on this flight, many with aspherical particles in their residuals.



The very pronounced secondary peak centered at 5 μm in the aspherical "other" fraction in cloud-free air is not seen in the cloud particle residuals, suggesting that these particles were not good cloud nuclei or that the soluble material has been removed and what is left is the smaller, non-soluble core. This is similar to what was seen in Flight 7.



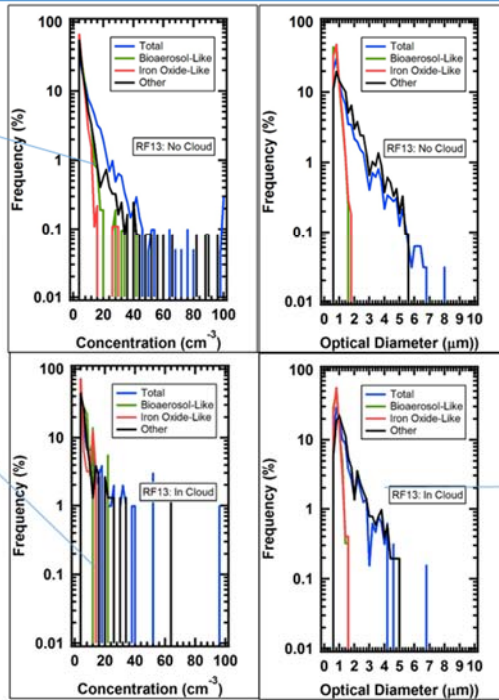
Very low concentrations of all particles this day.



More clouds this day with higher concentrations and hence higher concentrations of cloud residuals

The size distribution of cloud residuals appears very similar to the out of cloud size distributions suggesting that the majority of the particles were cloud nuclei

Frequency distribution show periods of much higher concentrations of bio and iron oxide particles.



More clouds this day with higher concentrations and hence higher concentrations of cloud residuals

The size distribution of cloud residuals appears very similar to the out of cloud size distributions suggesting that the majority of the particles were cloud nuclei