MODULE DESCRIPTION
18. Aerosol/Cloud Droplet Measurement Module

Principal Investigator: Bob Black

Links to IFEX Goal 3: Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle;

The concentration, mass content, and size distributions of the precipitating particles in hurricanes remains a critical component necessary for improving the ability of the numerical hurricane models to properly characterize the storm environment. The precipitation is also the result of the vertical heat flux realized in the storm, another critical parameter in the numerical models. Measurement of these particles has not been done in a systematic manner since the 1980's and early 1990's (Black and Hallett, 1986, 1999), (Black et al, 1994), and those measurements were accomplished using probes that were incapable of recording all of the particles present. Worse, the early measurements included no measurements of the microphysical critical cloud droplets, particles with a diameter < ~50 μm.

The recent acquisition of the DMT CCP, CAS and PIP probes has finally removed these limitations, but these probes have never been exposed to the full brunt of the precipitation in the hurricane, especially above the melting level. Therefore, their capabilities remain potential, rather than confirmed. The CCP includes a 25μm resolution (0.025 - 1.6 mm) imaging probe and a 3 - 47μm cloud droplet probe (CDP). The CAS has a different sampling geometry from the CDP, producing cloud droplet spectra in the range 0.61 - 50μm, plus having the ability to distinguish aerosol particles that are either solid or liquid. The PIP has performed well in recent seasons, and measures precipitating particles in the size range 0.1 - 6.4 mm. Neither of the imaging probes are Greyscale, but this limitation is significant only for the smaller (< 0.5 mm diameter) ice particles.

To address this deficiency in our knowledge, I propose that the WP-3D aircraft resume standard "Rotating Figure-4" flight patterns <u>without</u> avoiding the convection for normal HFIP operations. These passes should be done at several altitudes, including above the melting level, AOC willing. Should the DMT probes perform adequately in the rain (there is potential for inadequate de-icing power at cold temperatures with them since they use 28 VDC de-icers), we should do an intensive study of the convection. To this end, a series of radial flights (Fig. 17-1) through the heaviest precipitation should be done. These passes should be accomplished at several altitudes from 2 km - 4 km MSL (1-km vertical separation) to document the evolution of the rainfall spectra with altitude, and to extend to higher rain rate values the conditions into which the DMT probes have been exposed. Each pass will require 10 - 15 minutes to execute, and while it would be best for these to be consecutive, multiple altitude penetrations made at any time are appreciated. In the current database, the highest rain rates the DMT probes have been exposed to is only 38 dBZ, and this must be extended to higher rates. Should AOC relent and allow the highly sought after passes at and above the melting level, I'd like to extend them to 6.0 km, such as we did prior to 1993, because good hurricane precipitation measurements above the melting level have not been obtained since then.

Aerosol/Cloud droplet measurement module
The sub-cloud aerosol determines the cloud base droplet concentration, which in turn controls the rate of precipitation formation. Recent work (Rosenfield et al, 2007) has shown that pollution aerosol might have a significant suppression effect on the hurricane intensity through the introduction of large quantities of aerosols in the form of cloud condensation nuclei (CCN). The

mechanism Rosenfield et al propose for weakening a hurricane works by suppressing the warm rain process in the outer rain bands and eyewall.

In 2010, only one aerosol pass was obtained because N43 was on a night schedule for most of the season. Analysis of these data has commenced, but no details are available.

In order to properly assess the likelihood of this scenario, it is necessary to determine the natural range and number concentrations of the sub-cloud aerosol in hurricanes that are far from land, unaffected by pollutants. These pristine oceanic aerosols are thought to be primarily sea-salt aerosol created by spray and ammonia salts with organic origins. The measurement of the sub-cloud and low-level cloud base aerosol and droplet spectra in the hurricane has not been heretofore accomplished. However, since the purchase of new droplet spectra probes, as well as a new cloud liquid water meter in 2009, this measurement has finally become possible. In addition, might be possible to once again obtain a new Droplet Measurement Technologies (DMT) dual-chamber CCN counter and a new fast-response hygrometer in time for hurricane season. These devices offer the ability to measure the concentration of the cloud - active parts of the aerosol. This information, along with accurate, fast-response hygrometer data will enable us to determine the fraction of the aerosol that is CCN.

While these new devices cannot determine the aerosol composition, they can determine the number concentration and activity spectra of these aerosols, and the new cloud droplet probe can measure the activated cloud base droplet spectra. This latter measurement is crucial to determining if the mechanism proposed by Rosenfield et al has any chance of operating. In order to do this, it will be necessary to fly the properly equipped WP-3D aircraft in the sub-cloud zone in several areas in various wind conditions, from benign trade wind to weak tropical storm strength through hurricane strength.

In the non-storm environment, it would be sufficient to fly in the sub-cloud layer at 1200' or a bit lower (if they'll do it, depending on circumstances) for 10 minutes, climbing 500', flying for another 10 minutes, then flying just above the trade-wind cumulus cloud base, to penetrate (non-precipitating) trade-wind Cu to obtain the low cloud droplet concentrations. In the Saharan Air layer (SAL) area, passes should also take place in the dry layer to determine the cloud-active proportion of the SAL aerosol. In a hurricane, such passes (Fig. A-1) should take place in non-precipitating cloud both inside and outside the rain bands. The final pass through the low cloud base should take place in the nearest rain band. Outside the eyewall, passes like these should end with a pass just above the nearest cloud base altitude. Should there be a will, a radial penetration of the eyewall at 1.5 km radar altitude would be desired to obtain the low level cloud number concentrations and water contents.

REFERENCES

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Rosenfield, D**,** A. Khain, B. Lynn, and W. L. Woodley, 2007: Simulation of hurricane response to suppression of warm rain by sub-micron aerosols. Atmos. Chem. Phys., **7**, 3411–3424.

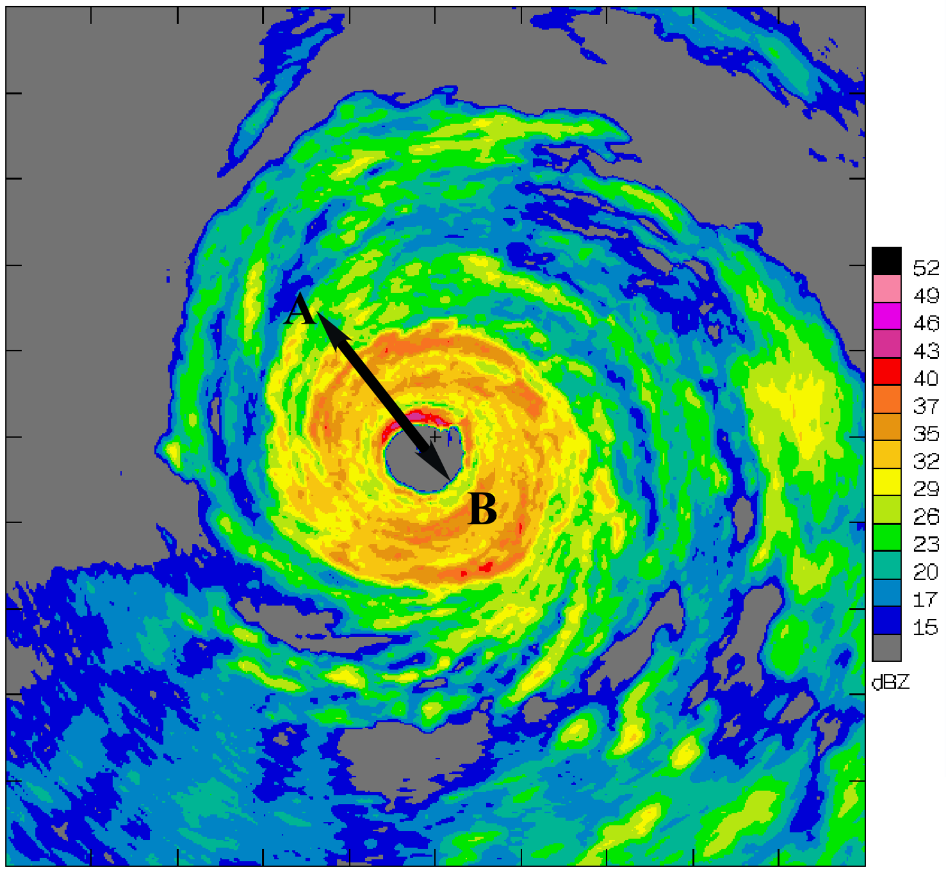

Figure 18-1: Radial microphysical passes should be obtained along a line such as A-B. These can be done at any altitude from 2 - 6 km, so long as the strongest reflectivity is sampled.

LOW-LEVEL AEROSOL/CLOUD DROP PATTERN

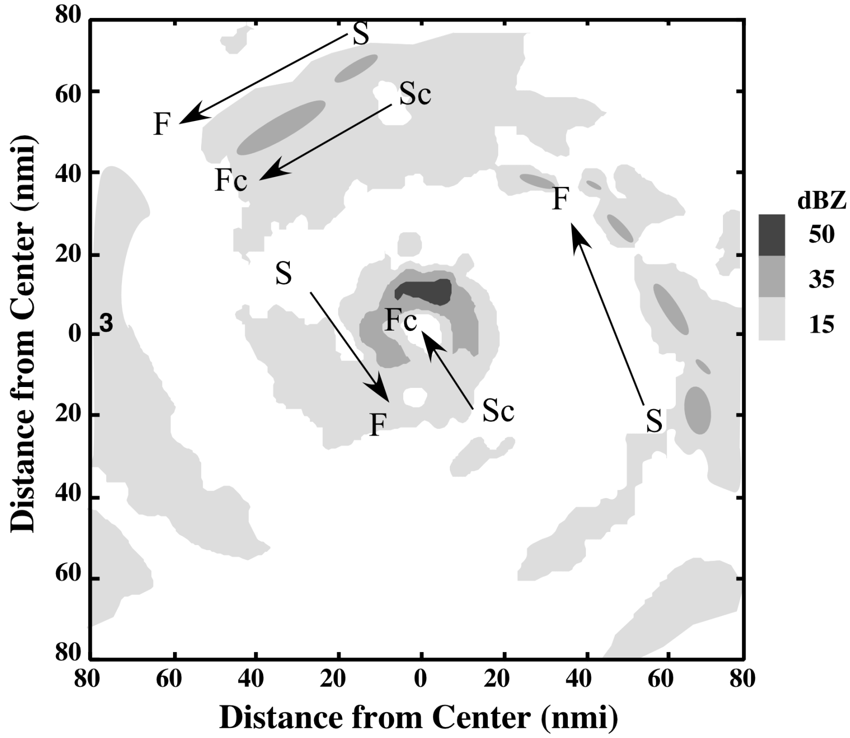

Fig. A 1. Aerosol/cloud droplet measurement flight pattern.

- Note 1. The pattern may be flown along any compass heading.
- Note 2. Fly S - F at 1,200 ft (0.4 km) in rain-free areas. Path is mor-or-less straight for 5 min, then increase elevation by 500 ft & continue until cloud base elevaton is reached.
- Note 3. After performing one or more passes, make one pass through cloud base nearest to end point (e.g Sc - Fc)
- Note 4. Pattern should be repeated as often as possible at various radii and horizontal wind velocities.