Overview of Aerosol Measurements from the DC-8 during NASA GRIP

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Introduction

- NASA GRIP (Genesis and Rapid Intensification Processes) took place in August/September 2010, in part to characterize the role of aerosols on storm development in the Atlantic basin.
- The vertical distribution of absorbing aerosol (i.e., black carbon (BC) and dust) can influence storm intensity, radiative forcing [*Zarzycki and Bond*, 2010] and cloud dynamics [*Koch and Del Genio*, 2010].
- Aerosols can alter storm dynamics through activation as cloud condensation nuclei [*Zhang et al., 2009*]; better characterization of inflow regions is necessary to constrain models
- Observations of aerosol physical, chemical, and optical properties were made during GRIP aboard the NASA DC-8 to characterize the upper troposphere and potential inflow regions to tropical storms during various stages of development.

Conclusions

- Minimal shift in African dust size distribution compared to NAMMA observations
- BC concentrations of 0.4-10 ng m^{-3} in upper troposphere, thinly coated, in conjunction with cirrus cloud
- Minimal aerosol extinction observed during Earl

Future Work

- Assess ice nucleation pathways for cirrus penetration
- Further explore changes in aerosol characteristics during repeat transects through intensifying storm (e.g., Flight 10), repeat analysis for Hurricane Karl
- Assess f(RH) relationship and lidar ratios for CALIPSO comparison case
- Evaluate cloud probe data to explain new particle formation occurrence
- Are number concentrations enough to alter storms?

Objectives and Impacts

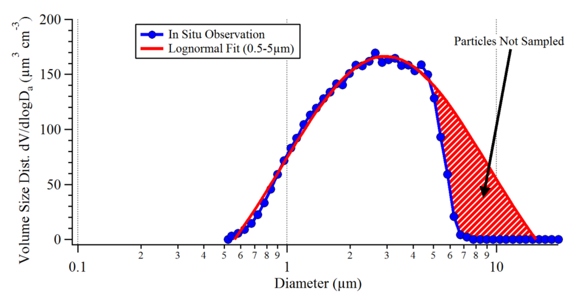
- Provide a survey of inflow-region aerosol properties, including BC and dust
- Assess the distribution of aerosols during tropical storm evolution
- Compare with observations during NAMMA and by CALIPSO

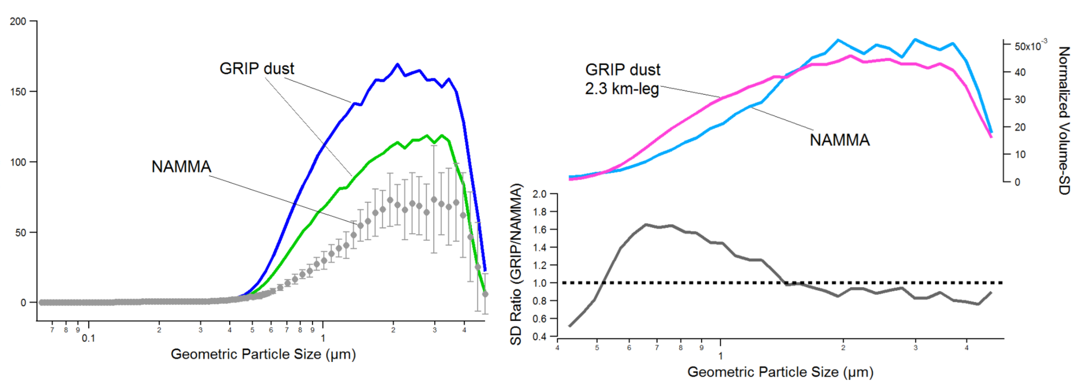
LARGE Measurements, Relationship to NAMMA

Measured Parameter	Instrument	Size Range (mm)	Response time (sec)	Approximate Precision
Aerosol Number Concentration	TSI 3025, TSI 3010	>0.003	1	10%
Particle Size	TSI SMPS	0.01 – 0.3	60	20%
	DMT UHSAS	0.08 – 1.0	1	20%
	MetOne OPC	0.3 – 10	1	20%
	TSI 3321	0.5 – 20	1	20%
Cloud Condensation Nuclei Spectra	Scanning Flow CCN	<10	1	NA
Scattering at 450, 550, and 700 nm	TSI 3563	<10	1	5e-7 m^{-1}
Absorption at 467, 530, and 660 nm	PSAP	<10	5 – 60	5e-7 m^{-1}
Black Carbon Mass, Size	DMT SP2	0.1-0.6	1	NA
Water-soluble Ion Composition	Filter/IC	>0.003	600	NA

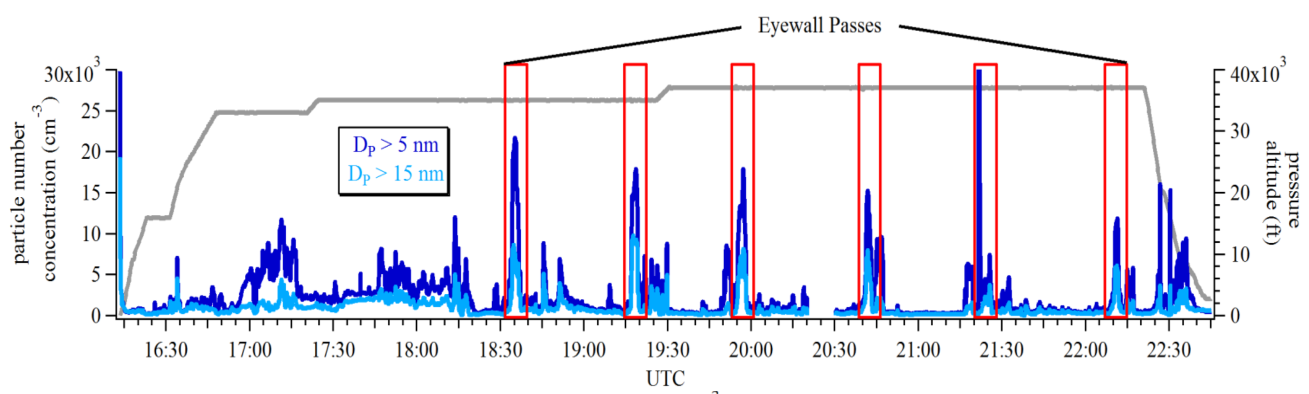
- Measurements made with UNH aerosol inlet
- Scattering and absorption coefficients also provided with 1-µm size cut
- Contamination issues with IC analysis

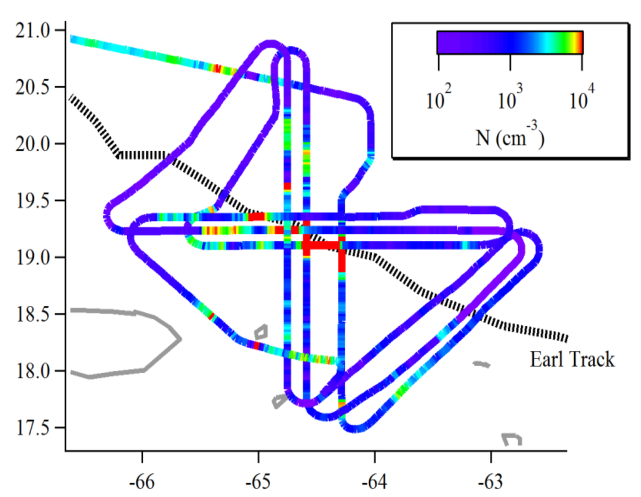
- Inlet allows sampling of dust aerosol up to approximately 5-µm diameter
- African dust size distributions very similar for NAMMA and GRIP
- Shift towards smaller sizes is consistent with deposition during transport across Atlantic

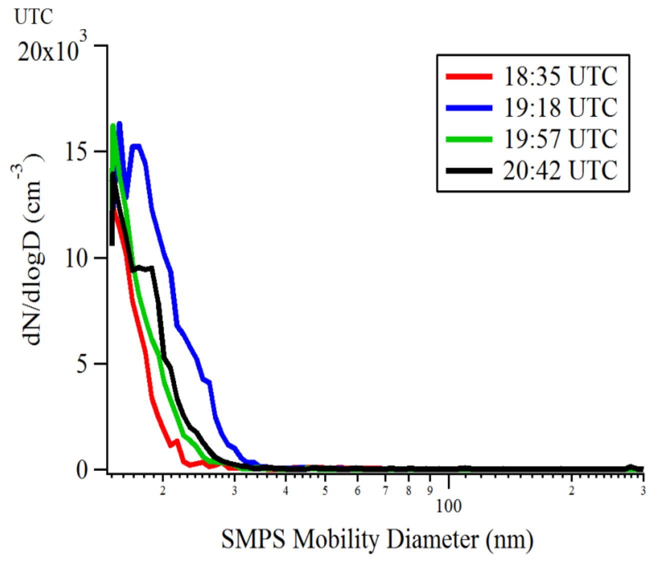




New Particle Formation in Earl's Eye

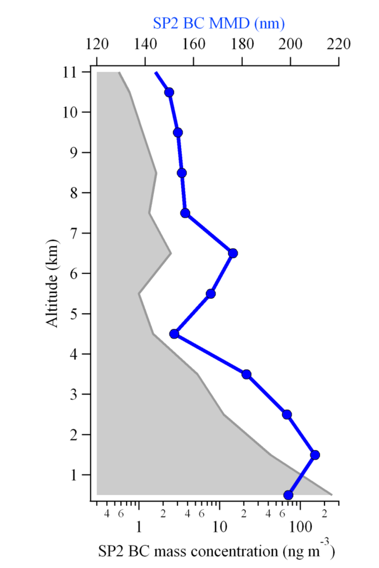


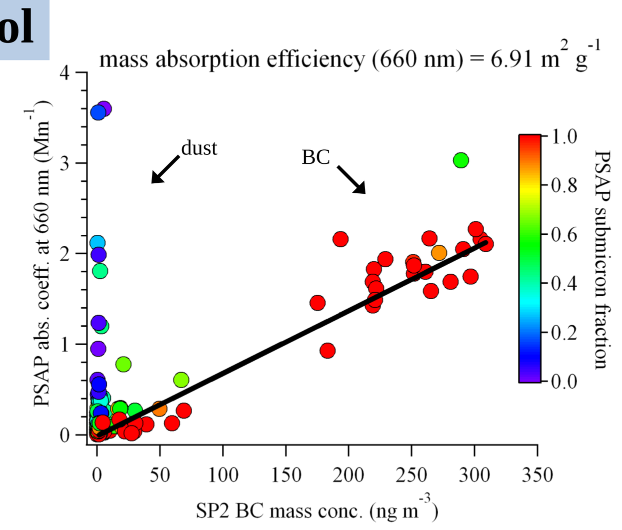




- Observations during intensification of Earl from Cat-3/Cat-4 (8/30/11)
- High concentrations and small size (<30 nm) suggest new particle formation
- Likely associated with eyewall penetration
- New particle formation typically requires a source of condensable gases and sunlight; may be linked to updrafts and clear conditions inside the eye
- Modeling necessary to confirm mechanisms

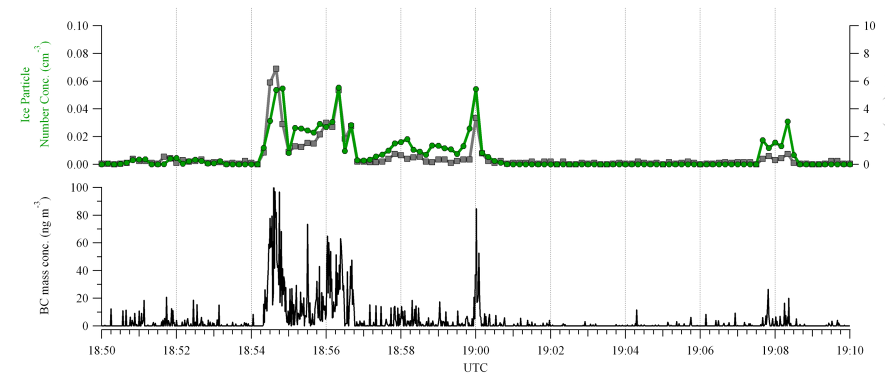
Black Carbon Aerosol





- BC measurements taken from the Palmdale-Florida transit flight
- Mass concentration and particle size decrease with altitude

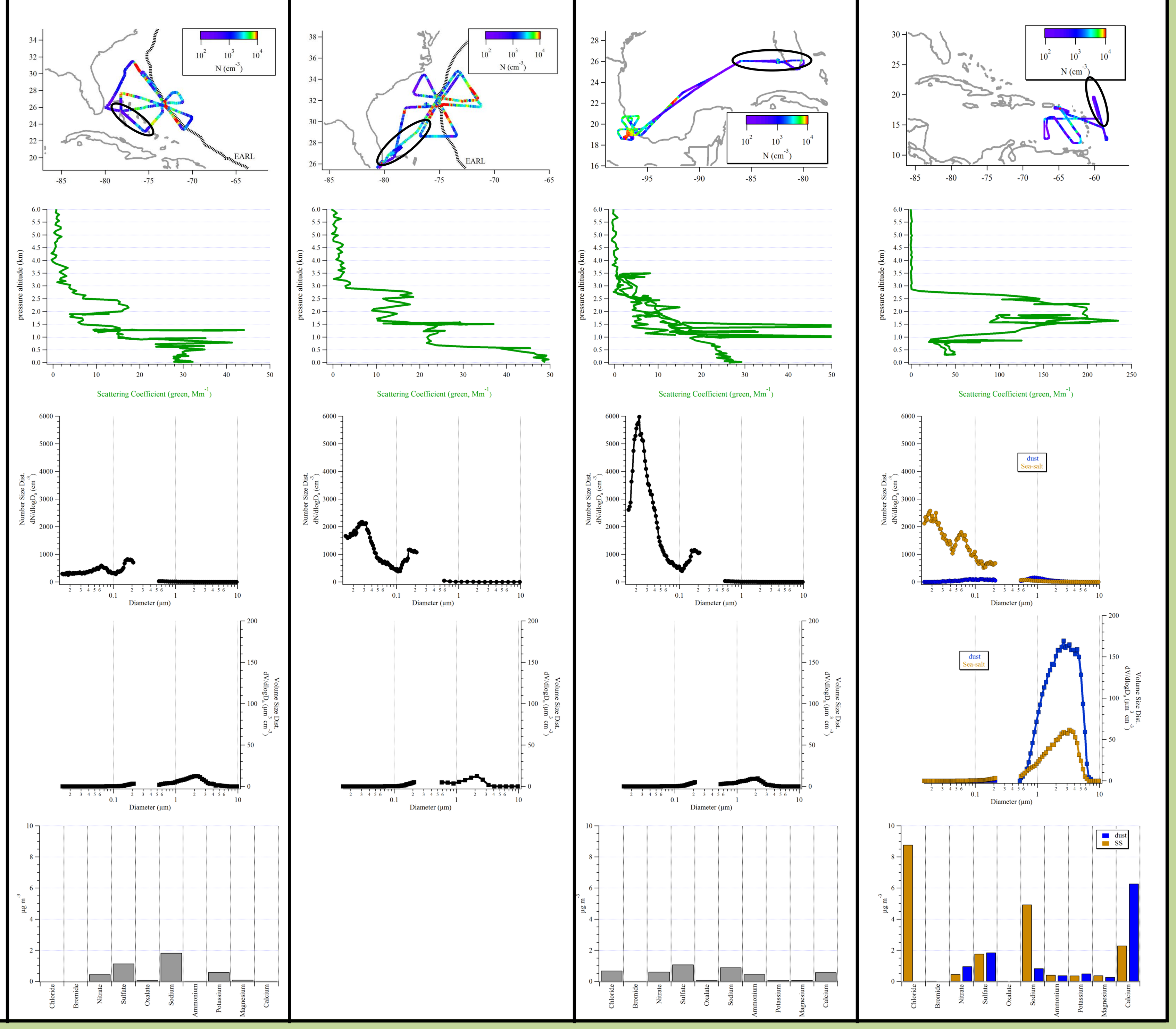
- Mass absorption efficiency is an important input for global/regional modeling; measured here using PSAP absorption coefficient (660 nm) and SP2 mass
- 6.9 m^2 g^{-1} is consistent with 'uncoated' soot
- SP2 is not sensitive to super-micron dust
- BC highly correlated with cloud particle number concentration during a cirrus cloud penetration at 12 km



Input-Region Aerosol Properties	Earl-1 (9/1/10)	Earl-2 (9/2/10)	Karl-1 (9/17/10)	African Dust	Sea-Salt
Location	SE of Ft. Lauderdale, marine	NE of Ft. Lauderdale, marine	W of Ft. Lauderdale, marine/cont.	NE of Lesser Antilles, marine	
Altitude (km)	1.3	1.5	1.2	2.3 (2.5±0.9)	0.9
Average N (>5 nm, cm^{-3})	1014	2484	4138	273 (350±78)	4147
Single Scat. Albedo (SSA)	0.92	0.97	0.95	0.99 (0.97±0.01)	0.99
Scat. Angstrom Exponent (AE)	1.09	1.52	1.61	0.10 (0.009±0.08)	0.33

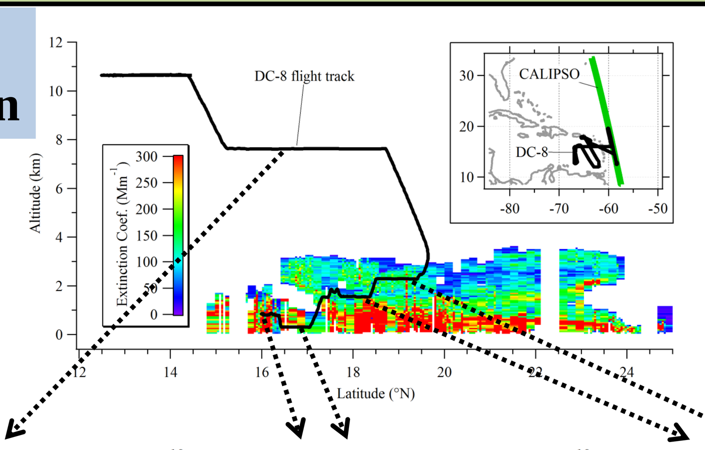
** for African dust, NAMMA shown in parentheses **

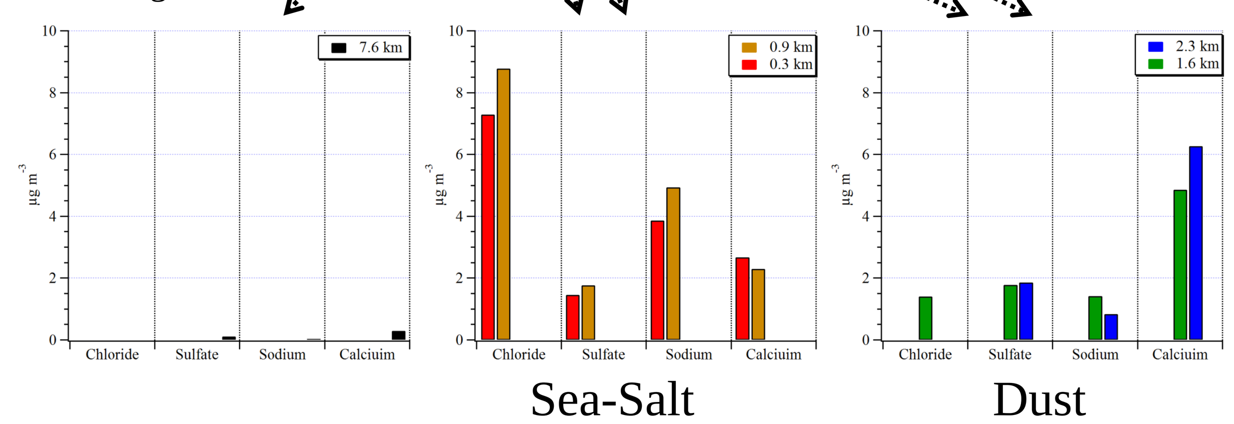
- Three cases were identified by enhanced scattering at low altitude, < 4 km
- Number-mode at diameter < 0.1 µm
- Volume-mode consistent at ~ 2 µm
- Low concentrations of super-um aerosol compared to dust case
- Filters showed little evidence of dust during Earl/Karl, AE is consistent

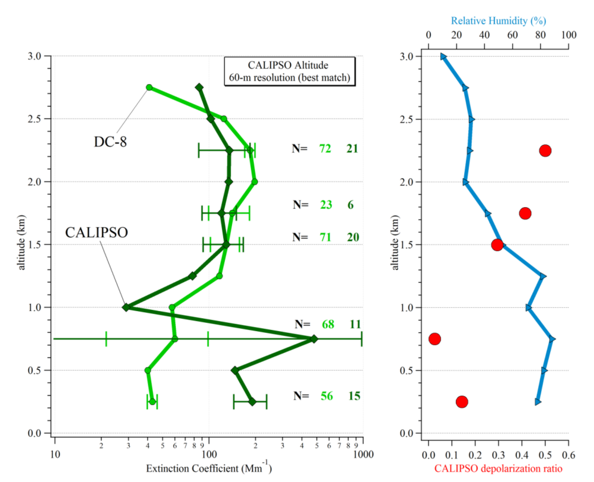


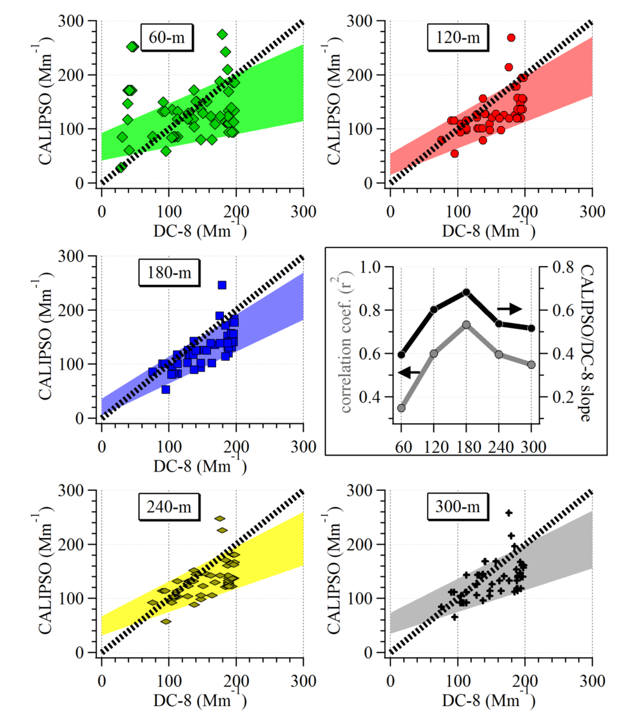
CALIPSO Intercomparison

- Very successful CALIPSO underpass allowed statistical sampling of dust and sea-salt aerosol with four level legs
- CALIPSO level-2 profile product used for comparison



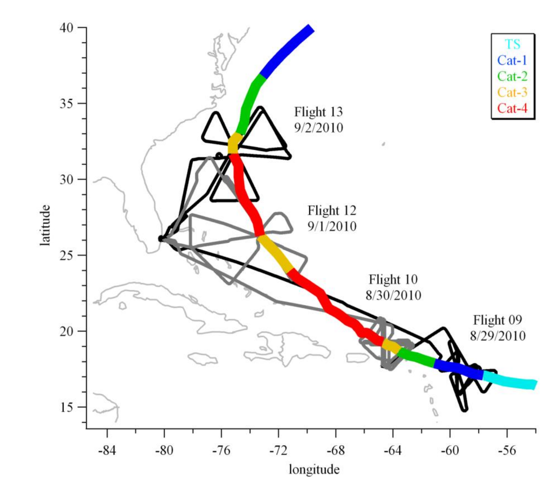


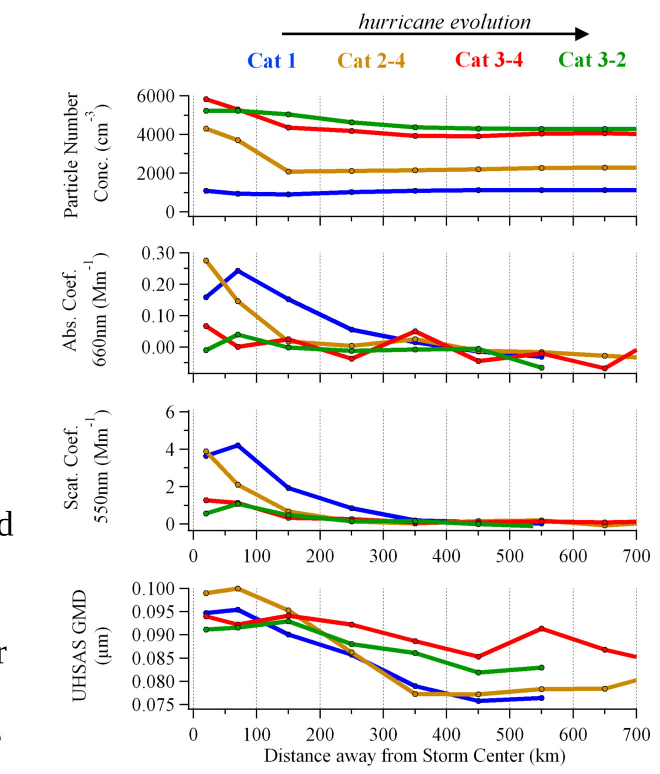




- Agreement observed for dry dust layer from 1-3 km
- Water uptake and miss-typing may account for low-level discrepancy
- Sensitivity study showed that averaging CALIPSO extinction to 180-m vertical resolution improved the comparison

Spatial Variability during Earl's Lifecycle





- Particle number concentration increased with storm age
- Scattering and absorption low throughout, slightly elevated near center during early stages
- Consistent trend in accumulation-mode particle size consistent with deposition away from storm center

** all observations at altitude > 9 km **