Three Years of Airborne Observations during NASA ACTIVATE: A Statistical Summary of Chemical, Optical, and Microphysical Aerosol Properties over the Western North Atlantic Ocean

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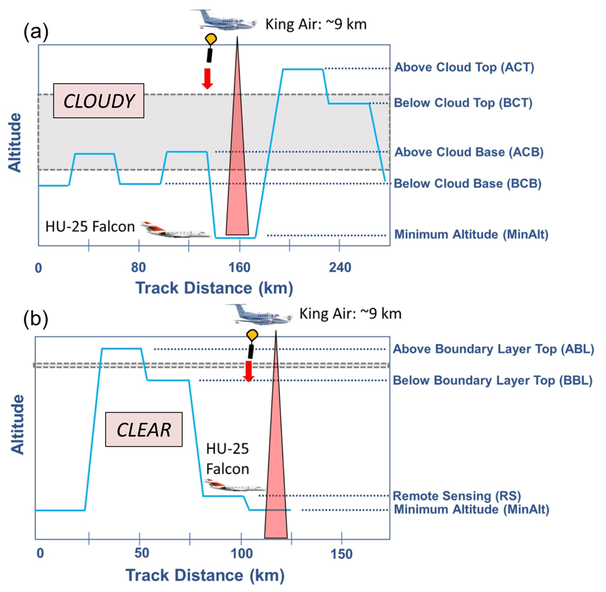
1. Operations

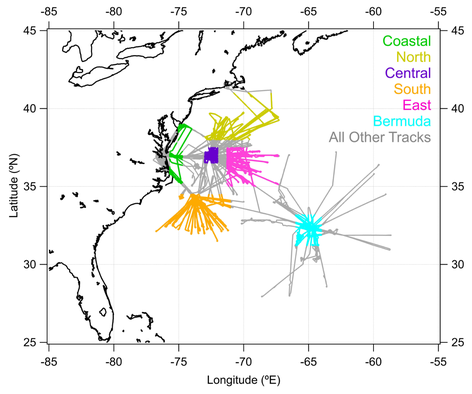


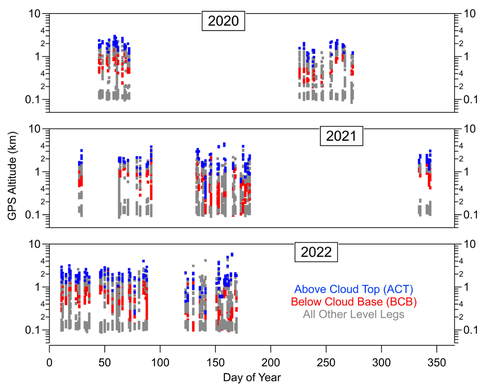
- ACTIVATE had 179 coordinated flights from Hampton, VA USA over 3 years

HU-25 FALCON → In-situ measurements

King Air → HSRL-2, RSP, and dropsondes

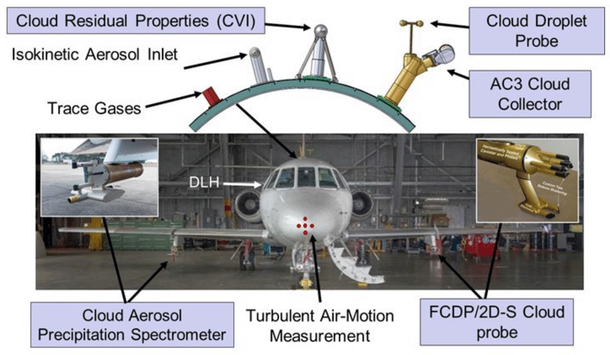
- In situ flight time was split between CLOUDY and CLEAR ensembles





- The flight domain was segregated into 6 regions and 2 time periods (March and May) for this analysis
- Flight time was relatively evenly distributed to allow statistical comparisons between legs and seasons

2. Measurements

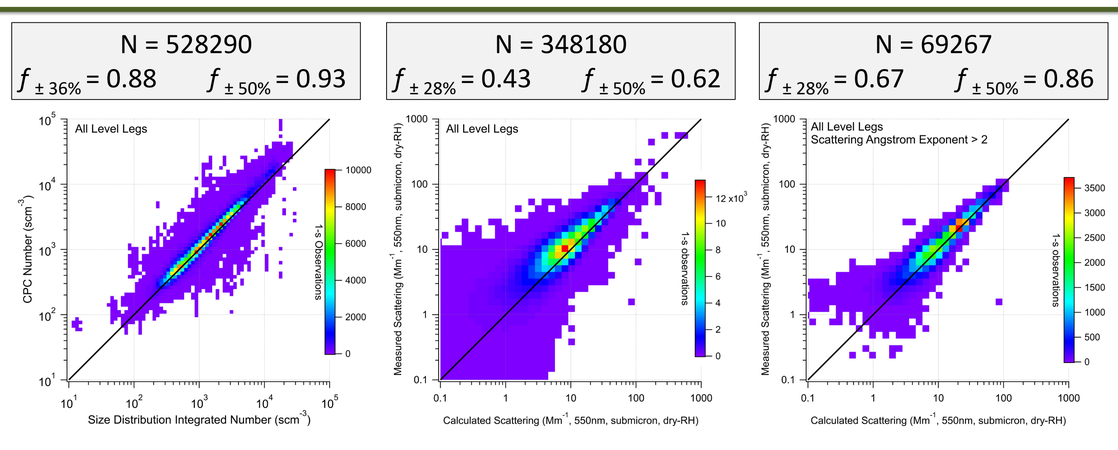


Measured Aerosol Parameter	Instrument	Uncertainty	Size (μm)	Time Response (s)
Total Particle Concentration	TSI-3776 CPC	10 %	> 0.003	1
Particle Concentration	TSI-3772 CPC	10 %	> 0.01	1
Nonvolatile (350°C) Particle Concentration	TSI-3772 w/ thermal denuder	10 %	> 0.01	1
Dry Aerosol Size Distributions	TSI SMPS	N/A	0.01 – 0.1	60
	TSI LAS	N/A	0.1 – 5	1
Dry Scattering Coefficient (450, 550, and 700 nm)	TSI-3563 Nephelometer	1 Mm^{-1}	< 1	1
f(RH) for Scattering (450, 550, and 700 nm)	TSI-3563, w/ 80% humidification	15%	< 1	1
Aerosol Absorption (470, 532 and 660 nm)	PSAP	0.5 Mm^{-1}	< 1	1
Non-refractory chemically-resolved mass concentration	Aerodyne HR-ToF-AMS	20%	0.06-0.8	10
CCN Concentration and Spectra	DMT CCN spectrometer	10%	< 5	1
Water-Soluble Aerosol Chemical Composition	PILS collection coupled to offline IC	<20%	<5	300
Cloud Water Chemical Composition	AC3 Cloud Water Collector and offline chemistry	<20%	>8 (drops)	f(LWC)

- The payload was designed to characterize aerosol and cloud properties, with limited trace-gases (CO, CO_2, CH_4, O_3)
- Aerosol measurements were switched between an isokinetic and CVI inlet for ambient and cloud-residual measurements, respectively

3. Data Quality Control

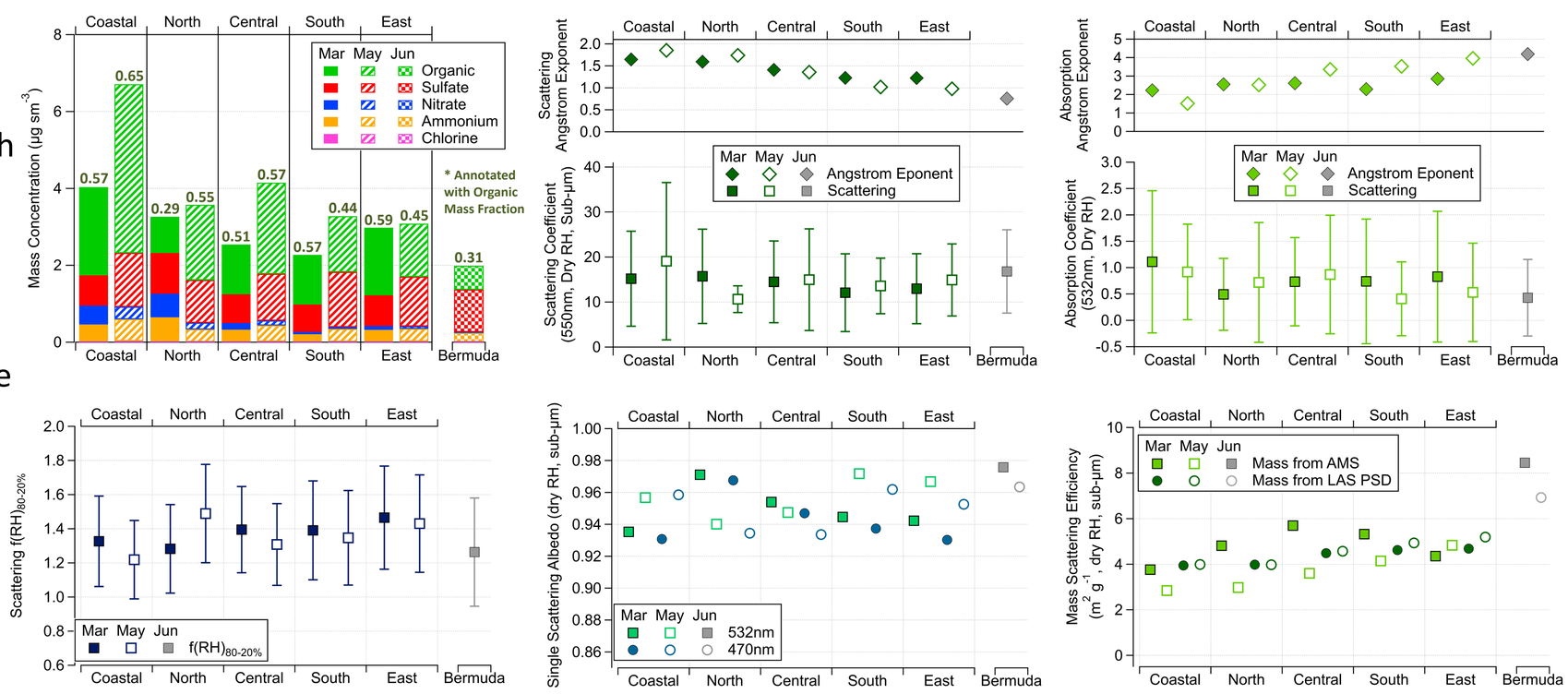
- Size distributions are a fundamental aerosol property critical to understanding ACI and radiative forcing
- After stitching SMPS and LAS size distributions, excellent number-closure was obtained with CPC measurements
- Scattering coefficients were calculated from measured size distributions using Mie-theory (RI = 1.52)



- A systematic scattering bias was observed, although minimized for populations dominated by small particles (using AE >2)

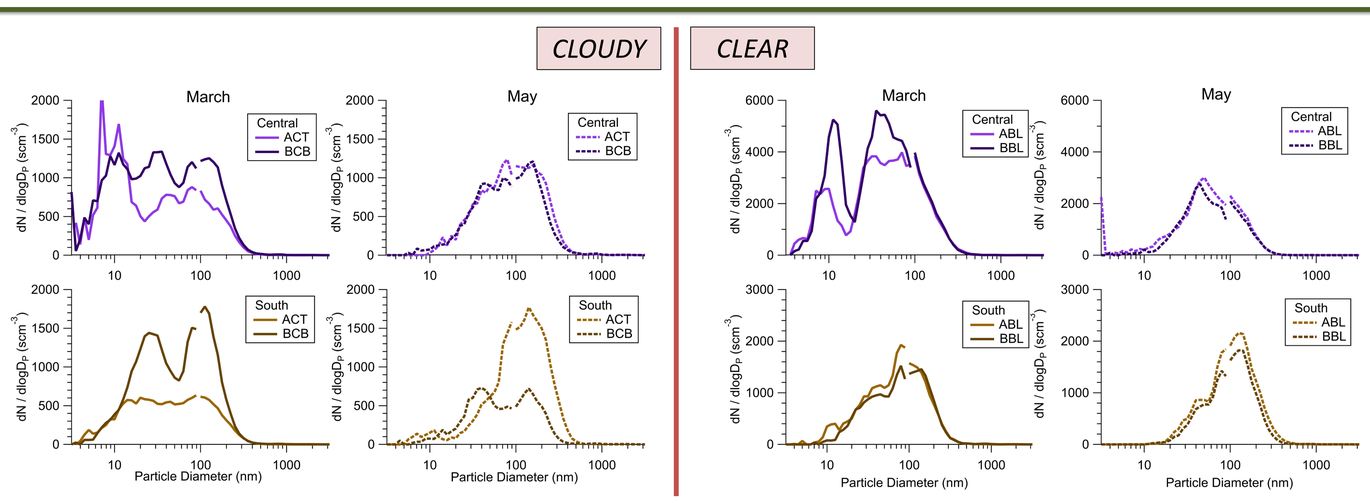
4. Spatial Variability

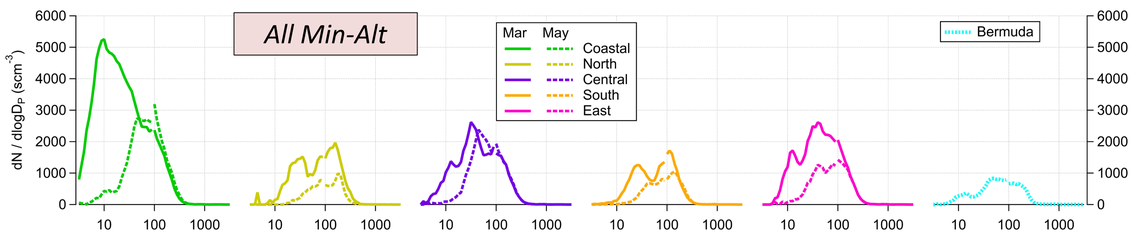
- The non-refractory aerosol composition showed generally higher mass in May, and more nitrate-rich particles in the Coastal and North regions
- No coherent spatial trend was observed in scattering, absorption, or SSA (532nm or 470nm)
- Optical wavelength dependence (as Angstrom Exponents) suggested particles are larger and more absorbing at shorter wavelengths to the south and east away from the continent, especially in May
- Two methods were used to calculate mass scattering efficiency (MSE), with good agreement
- Hygroscopicity values (as f(RH)) were lower than expected and generally increased away from continental sources



5. Particle Size Distributions

- Number size distributions at Min-Alt were generally characterized by two populations of varying relative abundance:
  1) 100nm D_P mode and, 2) 10-50nm D_P mode
- A nucleation-mode is only prominent near the coast in March, suggesting a stronger ultrafine sink than source over the ocean





- Cloudy size distributions at BCB showed a fairly consistent mode separation at 50-70nm D_P (i.e., the Hoppel minimum)
- This cloud effect is not observed at ACT, suggesting that interactions are occurring below cloud
- The Hoppel minimum was not observed in clear conditions

- Size distributions were similar below and above the MBL in clear conditions
- Transport of aerosols is most evident in May, when the concentrations of accumulation-mode particles (> 100nm D_P) were larger above clouds than below