DC-8 Aerosol Measurements for DC-3: Particle Transport and Aging in Deep Convection

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LARGE Measurements

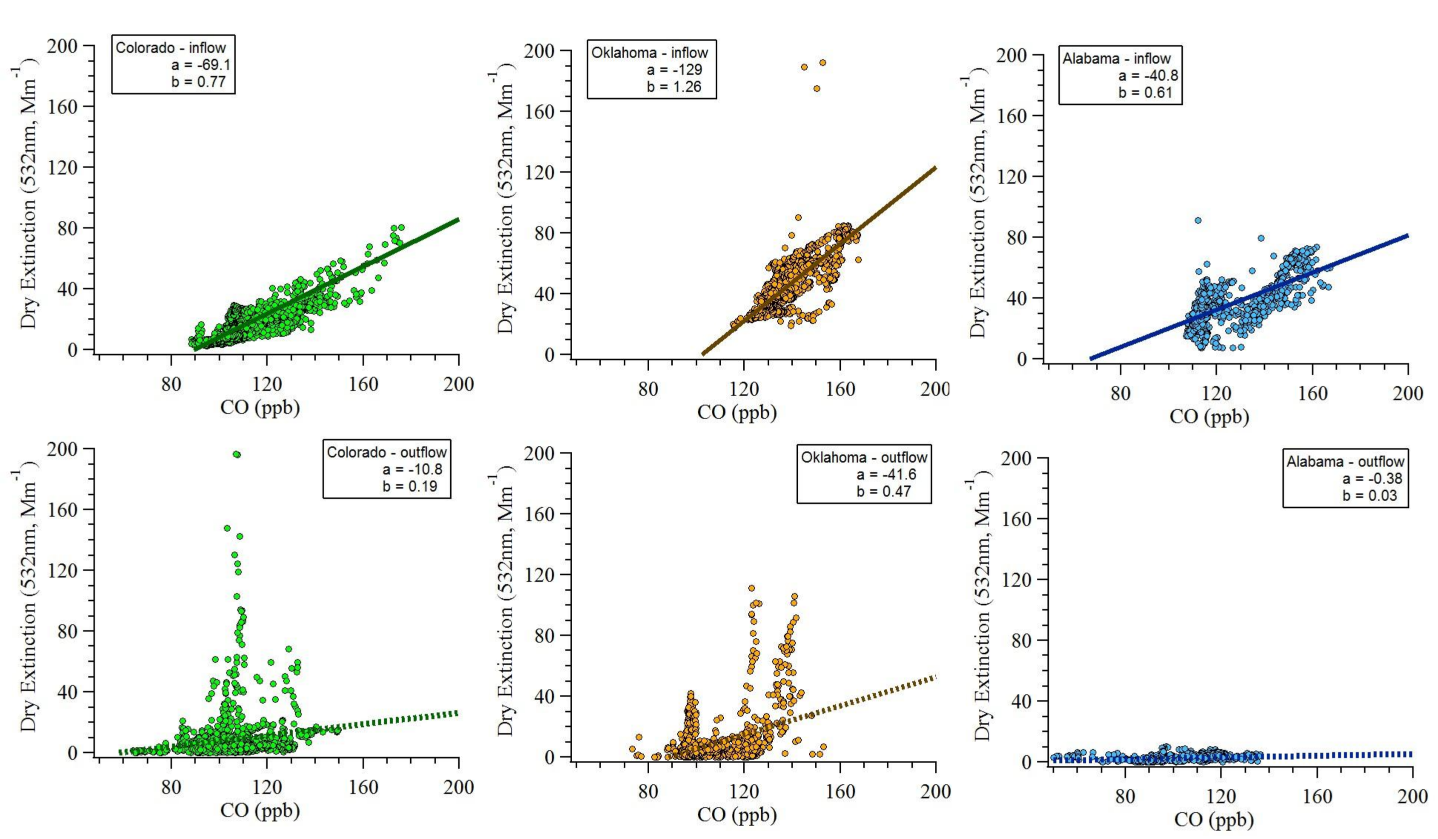
Number Concentration
Ultrafine – CPC_{3025}
Total – CPC_{3010}
$Total_{non-volatile}$ - CPC_{3010} (350C)

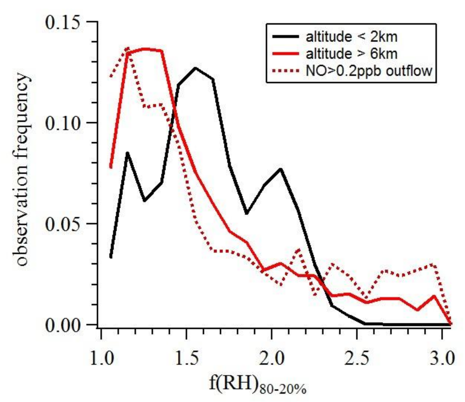
Size Distribution
SMPS: 10-320nm
UHSAS: 60-1000nm
LAS: 100-6000nm
APS: 500-6000nm

Optical
Total Scattering – TSI_{3563}
Sub-mircron Scattering – TSI_{3563}
Humidified Scattering – TSI_{3563}
Total Absorption– PSAP

Transport of Optically-Active Aerosol

- 1-sec data
- CO used as a conserved tracer for transport of BL-air into convective outflow
- BL = altitude < 1.5km agl
- outflow = altitude > 6km + exceeding 0.2ppb NO
- Transport Efficiency calculated from slope ratio

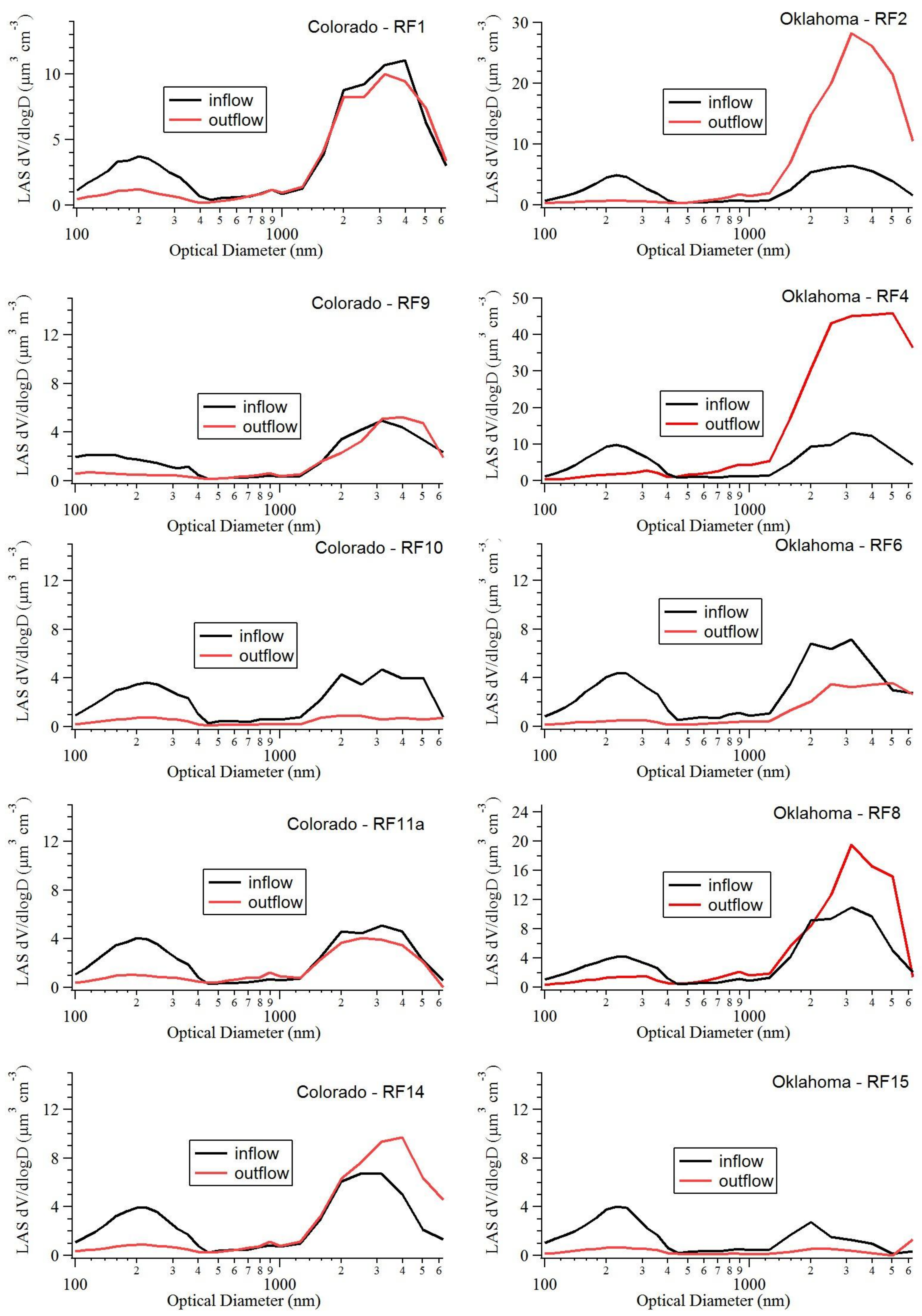




- cloud contamination observed for Colo. and Okla. outflows, fits are upper limits
- aerosol in outflow is less hygroscopic than in inflow region

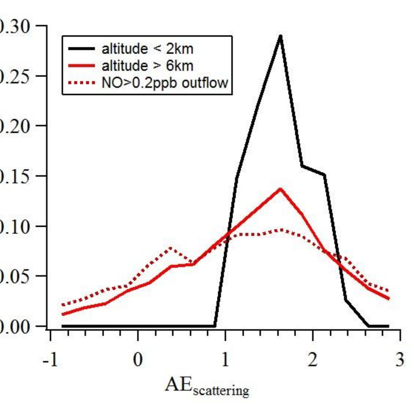
Extinction-Coefficient Storm Transport Efficiency $(Extinction/CO)_{outflow}$ / $(Extinction/CO)_{inflow}$	
Colorado	0.25
Oklahoma	0.37
Alabama	0.05

Transport Size Dependence

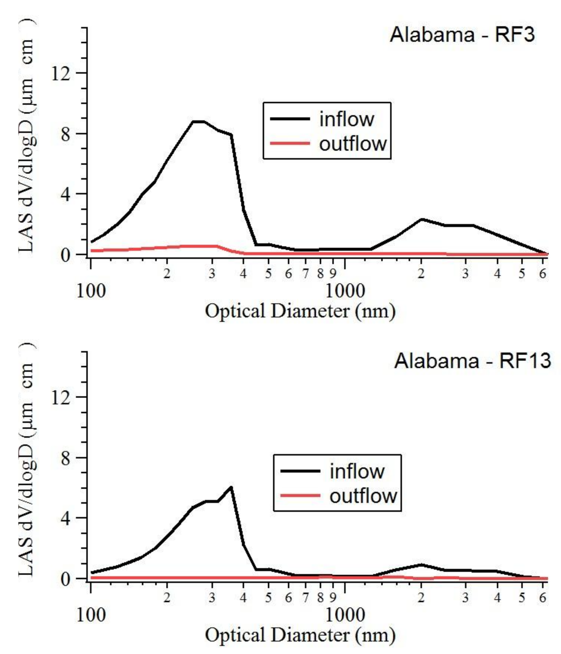


Volume Transport Efficiency		
Research Flight (RF)	Sub-micron	Super-micron
1	0.39	0.97
9	0.39	1.00
10	0.21	0.22
11	0.40	0.82
11	0.28	0.54
14	0.33	1.51
18	0.91	1.48
	0.42±0.23	*0.93±0.47*
2	0.34	4.02
4	0.45	4.25
6	0.15	0.56
8	0.51	1.57
15	0.19	0.37
	0.33±0.16	*2.15±1.87*
3	0.08	0.02
13	0.03	0.08

- 1-sec LAS
- outflow/inflow times from Dibb et al.



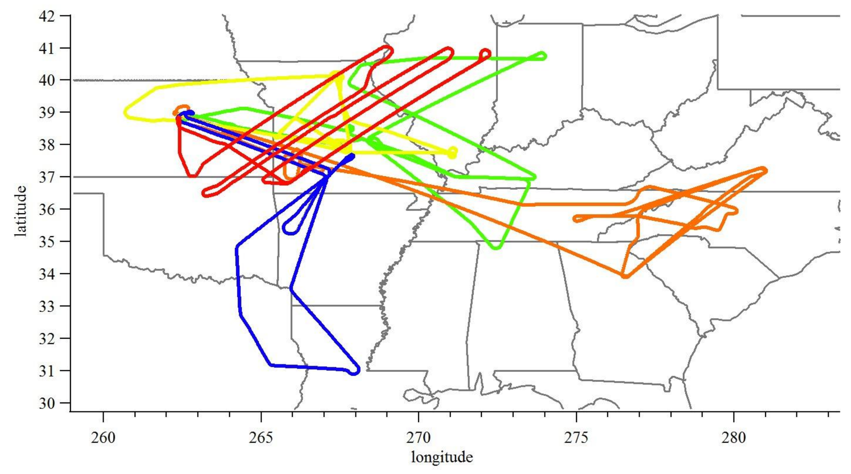
- sub-micron particles always decreased in outflow, more efficient removal



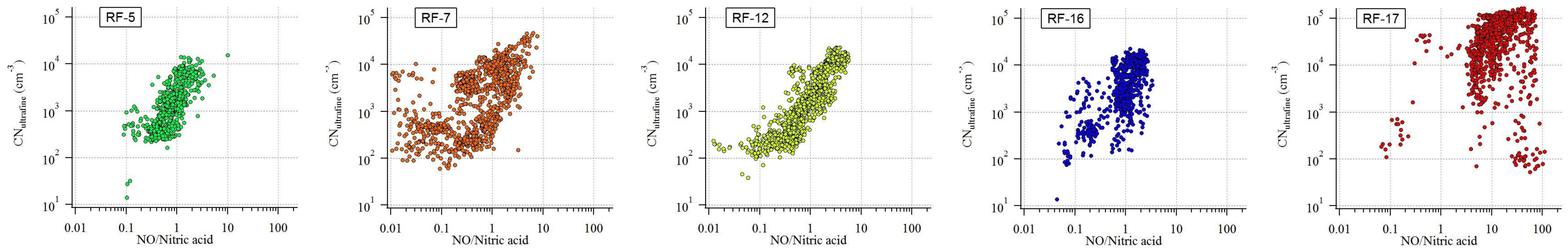
- coarse mode is present for CO and OK, less significant in AL
- coarse mode is less efficiently scavenged
- SD results are qualitatively consistent with optical AE_{scat}
- production of coarse-mode aerosol in outflow??
- potential effects of ice cloud contamination; residuals or interstitial aerosol?

New Particle Formation in Convective Outflow

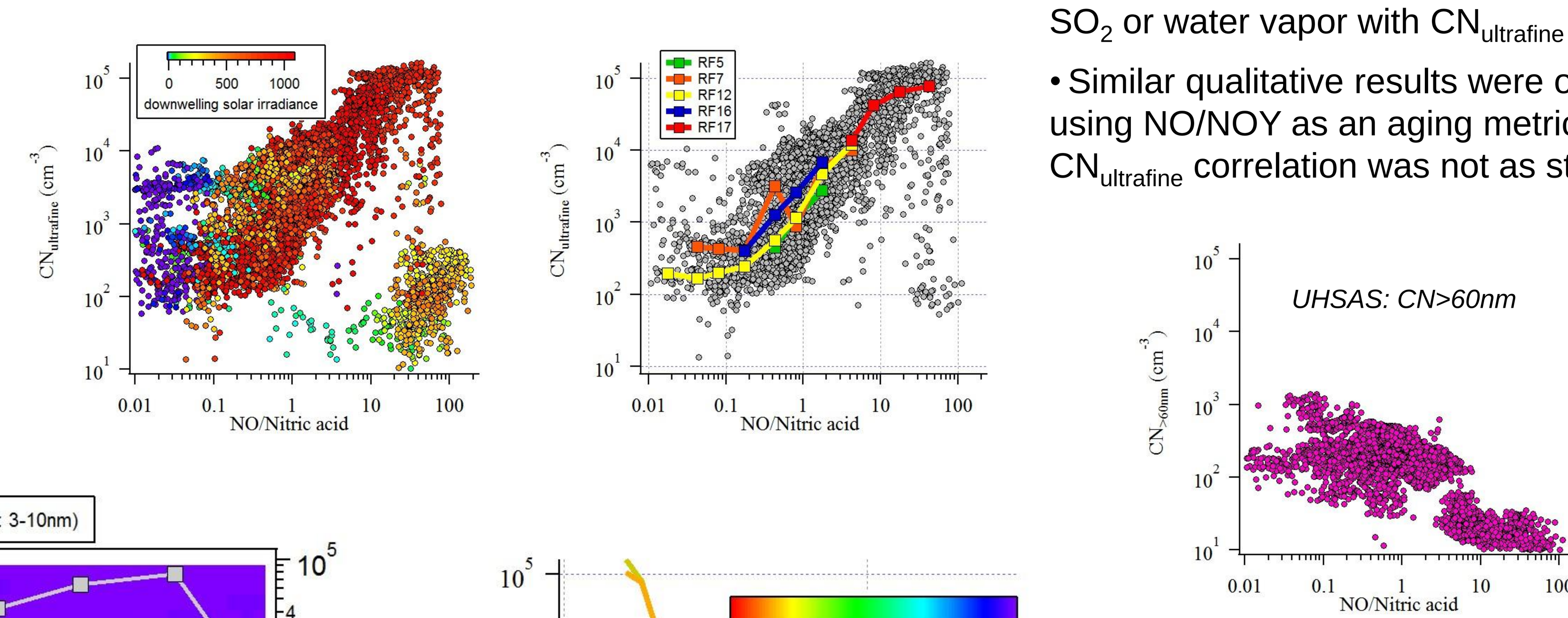
- Five flights were performed to specifically sampled outflow at various stages of aging after convection.
- Since much of the aerosol surface area is scavenged during convection, outflow regions are conducive to new particle formation
- Low temperatures, high RH, strong photochemistry, and transport of gas-phase precursors is also beneficial to formation of new particles in outflow regions



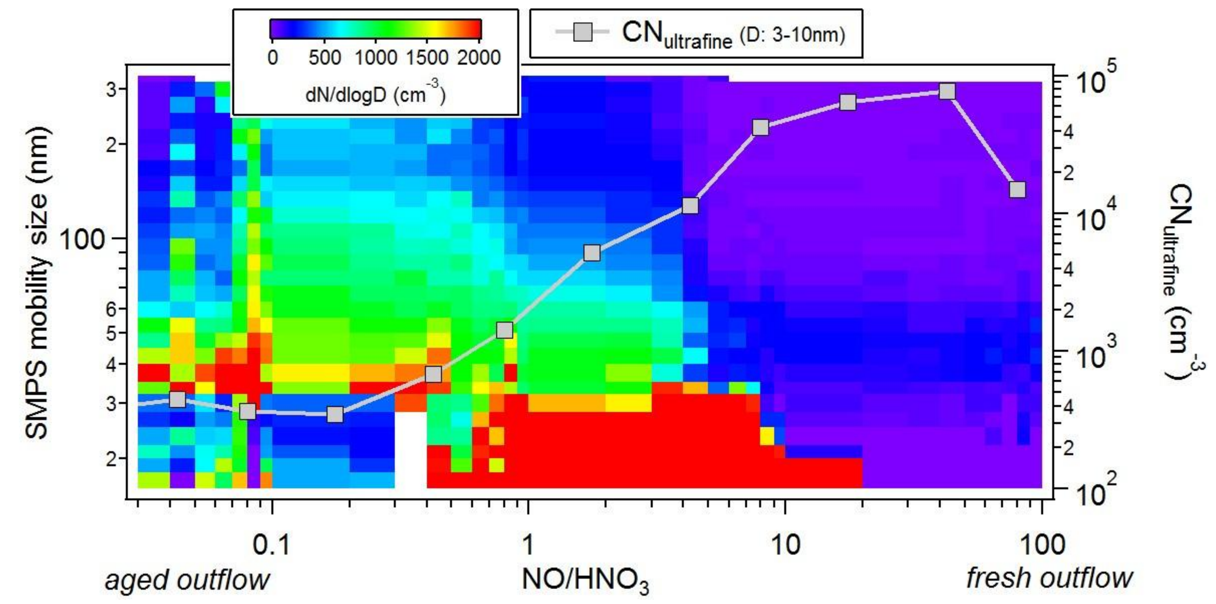
- 1-sec data
- New particle formation observed from $CN_{ultrafine}$ measurements (D: 3-10nm)
- altitude > 6km
- NO/HNO_3 used as an indicator of relative age after convection



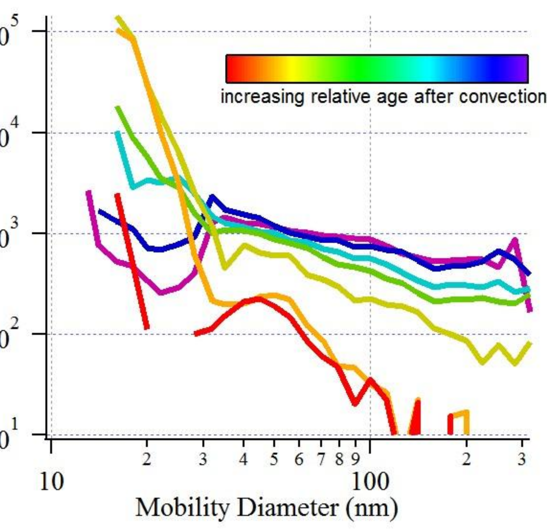
- data obtained early in the morning and in the late evening were removed based on a lack of solar irradiance (< 500 W m⁻²)
- A large range of airmass age was obtained by combining all 5 flights, RF17 was especially fresh and RF7 was aged
- Agreement in $CN_{ultrafine}$ indicates similar conditions were present between flights
- New particle formation observed in fresh outflow, $CN_{ultrafine}$ decreases with age.

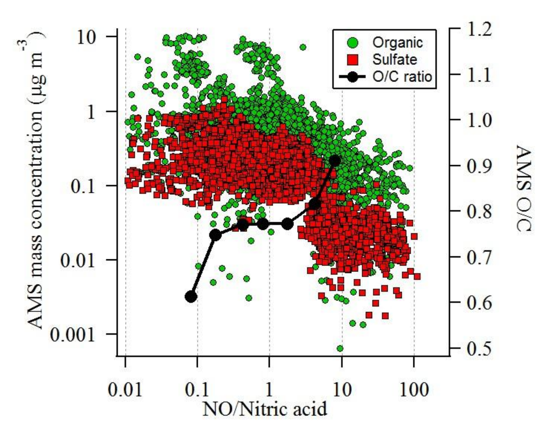


- No relationship was observed between SO_2 or water vapor with $CN_{ultrafine}$
- Similar qualitative results were obtained using NO/NOY as an aging metric, but $CN_{ultrafine}$ correlation was not as strong.



- size distributions were obtained with a SMPS at 1-minute resolution.
- weak 50-nm peak was present in fresh outflow after convection
- NPF observed with CPC, not detected in SMPS until particles had grown to D>10nm
- Consistent growth occurred as outflow aged, mode ~40-60nm



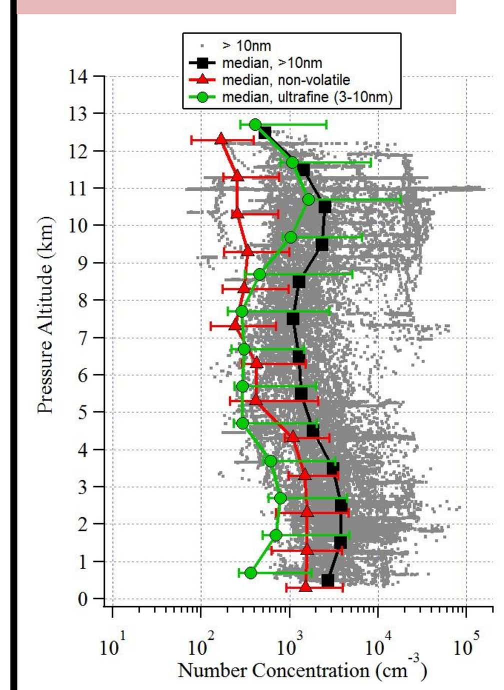


- quantitative clock is necessary to calculate particle growth rates
- CN>60nm (UHSAS) increased during aging as new particles grew, resulting in concentrations downstream of up to 10³ cm⁻³.
- AMS mass concentrations also increased with age, Org/SO4 ratio of 2-4 throughout → decreasing O/C??

DC3							
Flight		Date (2011)	T/O	T/O (sec)	Land	Land (sec)	General Notes
TF01	1	Fri-05-04	18:47:01	67621	23:12:47	83567	Palmdale
TF02	2	Tue-05-08	17:13:45	62025	21:03:01	75781	Transit to KS
TF03	3	Fri-05-11	15:20:28	55228	18:29:13	66553	
TF04	4	Mon-05-14	18:13:16	65596	23:38:05	85085	
RF01	5	Fri-05-18	19:03:51	68631	0:25:30	87930	CO Storm
RF02	6	Sat-05-19	21:03:08	75788	2:06:59	94019	OK Storm
RF03	7	Mon-05-21	16:00:22	57622	23:07:02	83222	AL Storm
RF04	8	Fri-05-25	20:10:52	72652	2:12:59	94379	OK Storm; GV IC
RF05	9	Sat-05-26	19:04:31	68671	2:14:30	94470	Outflow
RF06	10	Tue-05-29	19:54:18	71658	1:00:56	90056	OK Storm; L. Strike
RF07	11	Wed-05-30	18:33:21	66801	3:09:10	97750	Outflow; GV IC
RF08	12	Fri-06-01	19:39:15	70755	2:35:38	95738	CO PBL; OK Storm
RF09	13	Sat-06-02	18:18:44	65924	23:44:31	85471	CO PBL & Storm
RF10	14	Tue-06-05	20:00:38	72038	1:31:27	91887	CO Storm; GV IC
RF11	15	Wed-06-06	19:07:17	68837	1:11:34	90694	CO Storm
RF12	16	Thu-06-07	18:30:58	66658	0:27:07	88027	Outflow
RF13	17	Mon-06-11	15:57:07	57427	0:04:01	86641	AL Storm; Falc IC
RF14	18	Fri-06-15	18:08:50	65330	1:58:38	93518	CO PBL,Storm&Fire
RF15	19	Sat-06-16	21:07:48	76068	2:28:37	95317	TX/OK Storm
RF16	20	Sun-06-17	20:07:18	72438	0:30:00	88200	Outflow; GV IC
RF17	21	Thu-06-21	10:58:45	39525	17:25:34	62734	MCS
RF18	22	Fri-06-22	19:54:29	71669	2:52:21	96741	CO Fire, Storm & PBL

*All times are Zulu; Salina time is CDT (-5 hrs); Palmdale time is PDT (-7 hrs)

Conclusions



- Submicron aerosol is scavenged more efficiently than coarse mode aerosol consistently in convective outflows, what is the role of ice?
- new particle formation and subsequent growth resulted in significant concentrations of particles that are likely CCN-active and have a significant scattering coefficient