A41E-0166: Measurements of the Statistical Relationship between Cloud Base Aerosols and Cloud Droplet Concentrations

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Objective

To better understand precipitation formation, airborne measurements from recent field projects in Saudi Arabia, North Dakota and Mali are analyzed to determine the relationship of below cloud base aerosols to above cloud base droplets.

In-Situ Airborne Measurements

A King Air 200 (Saudi Arabia), Cessna 340 (North Dakota) and a Cheyenne II (Mali) aircraft were used to obtain in-situ measurements of aerosol and cloud properties during recent weather modification projects.

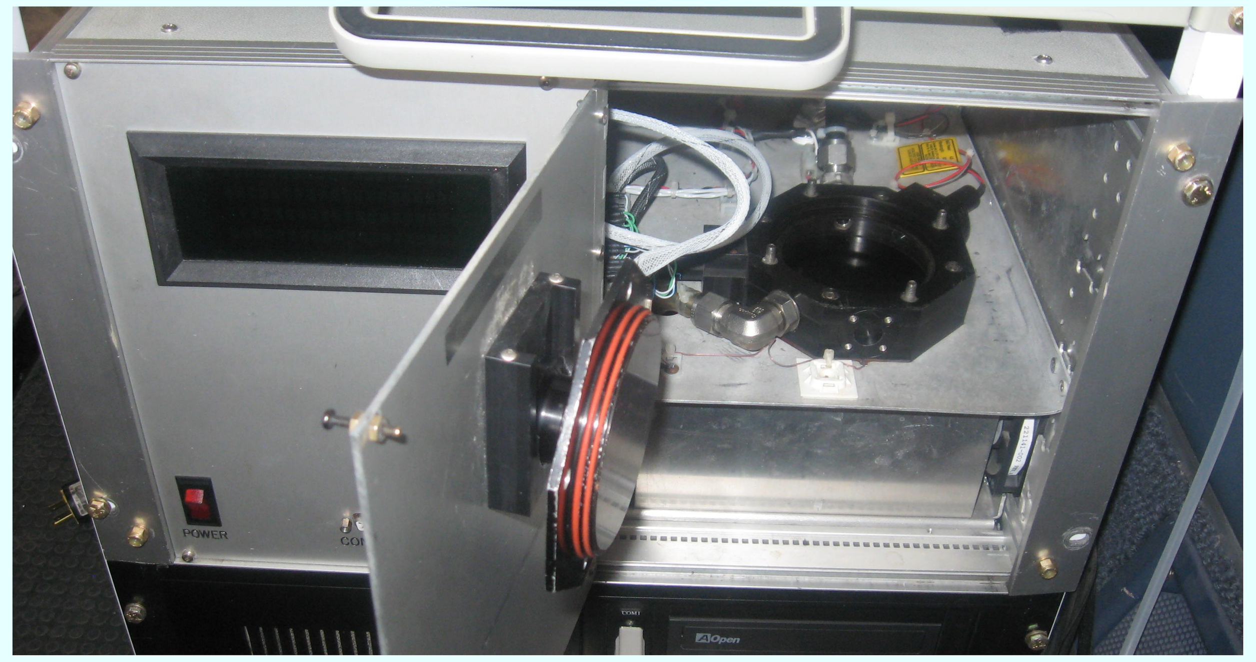
Passive Cavity Aerosol Spectrometer Probe (PCASP)

An optical particle counter that measures the aerosol size spectrum between 0.1 and 3.0 μm in 15 channels at a frequency of 1 Hz.

Forward Scattering Spectrometer Probe (FSSP)

Light scattering probe that measures the droplet spectrum between 3.0 and 50 μm in 20 channels at a frequency of 10 Hz.

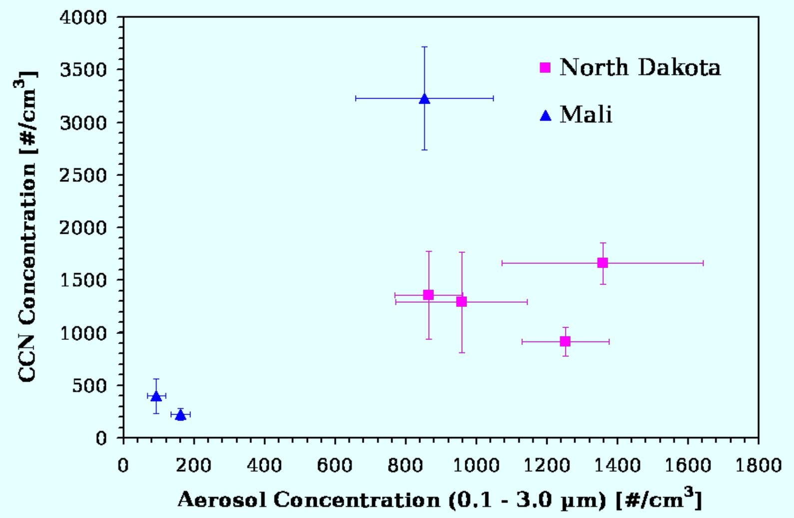
Cloud Condensation Nuclei Counter (CCNC)



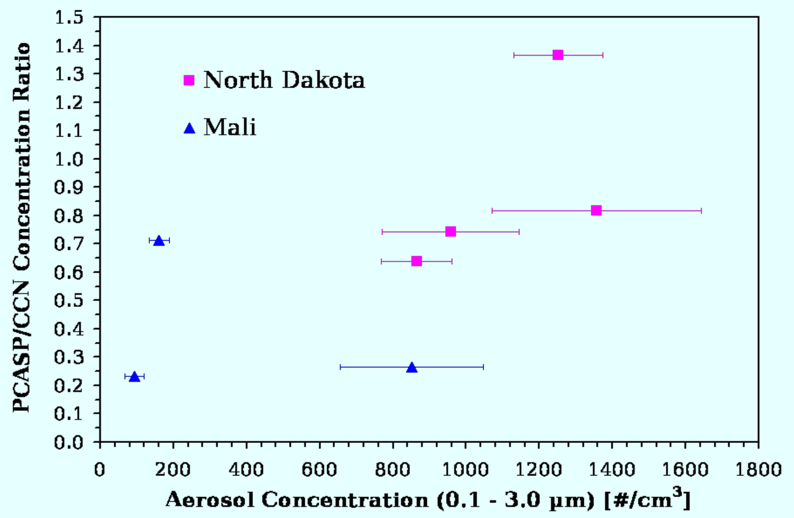
Static thermal gradient diffusion chamber that measures particles that activate at 1% supersaturation at a frequency of 0.033 Hz.

Location	Date	Start Time	End Time	PCASP
	[YY/MM/DD]	[HH/MM/SS]	[HH/MM/SS]	[#/cm^3]
Saudi Arabia	07/12/21	10:40:00	10:43:00	611
Saudi Arabia	08/01/10	14:33:00	14:39:00	748
Saudi Arabia	08/03/13	13:05:00	13:10:00	721
North Dakota	08/06/19	21:45:00	21:50:00	864
North Dakota	08/06/26	22:26:40	22:36:40	1357
North Dakota	08/07/09	20:08:20	20:16:40	958
North Dakota	08/07/11	20:11:40	20:20:00	1252
Mali	07/09/08	18:30:00	18:35:00	161
Mali	07/09/09	15:15:00	15:21:20	93
Mali	07/09/14	16:37:30	16:42:40	852

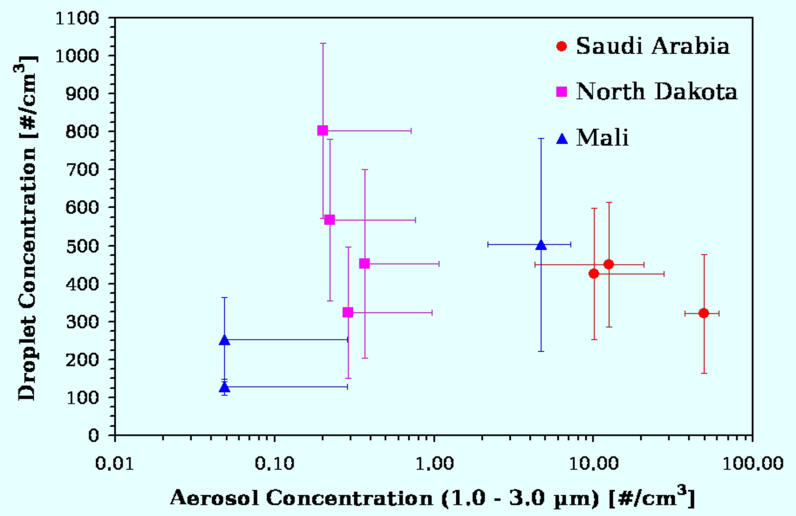
Details of airborne measurements conducted below cloud base. All cloud parameters presented were filtered to only include 1 Hz FSSP total concentrations above 100 #/cm^3 at standard temperature and pressure. Developing, non-precipitating cumulus clouds were sampled in each case. All concentration measurements are corrected to standard temperature and pressure.



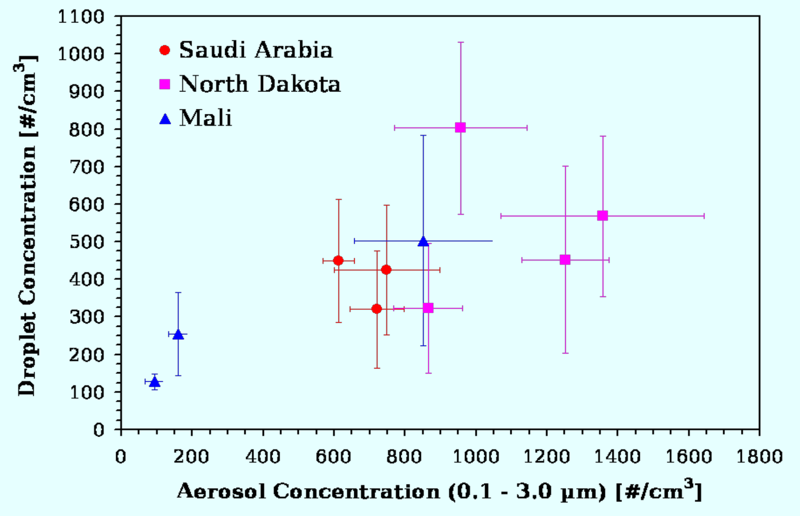
Mean total aerosol concentration measured by a PCASP below cloud base versus mean CCN concentration measurements at 1% supersaturation during the same period. Data point bars give the standard deviation of the mean.



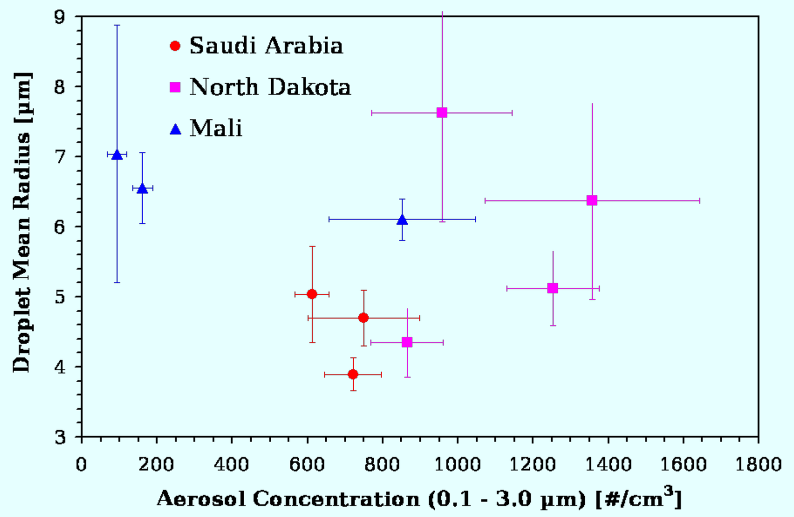
Mean total aerosol concentration measured by a PCASP versus PCASP/CCN$_{1\%}$ ratio. The ratio was calculated from the time segment means since the measurements were made at different frequencies.



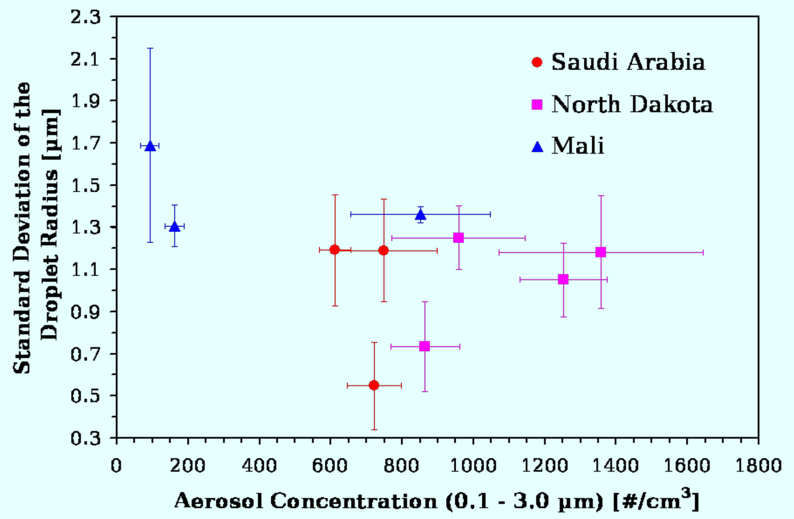
Aerosol concentration between 1.0 and 3.0 μm versus the total cloud droplet concentration measured by a FSSP. The FSSP were conducted shortly after the aerosol measurements at a single altitude slightly (500-1000 ft) above cloud base.



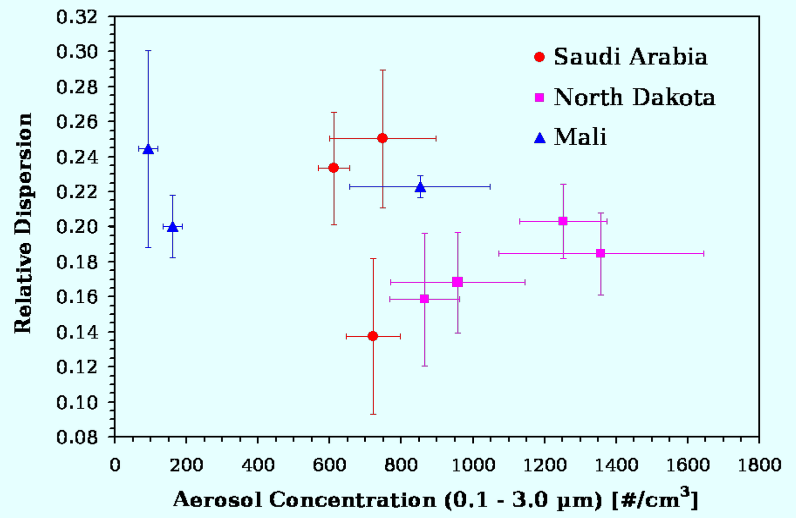
Mean total aerosol concentration from the full size range of the PCASP versus the total cloud droplet concentration measured by a FSSP. FSSP measurements were conducted shortly after aerosol measurements at a single altitude slightly (500-1000 ft) above cloud base.



Mean total aerosol concentration versus the mean droplet radius measured above cloud base. Time segments are the same as all the other plots.



Mean total aerosol concentration versus the standard deviation of the 1 Hz FSSP droplet spectrum. The mean and standard deviation are based on the 1Hz droplet size spectrum (20 size intervals).



Mean total aerosol concentration versus the relative dispersion of the droplet distribution. The relative dispersion is defined to be ratio of the standard deviation to the mean droplet radius.

Conclusions

- Measured aerosol and cloud droplet concentrations during the 2007 rainy season in Mali were generally lower than in North Dakota and Saudi Arabia and likely resulted in differences in participation formation.
- A few days during the 2 month long 2007 Mali field program had high aerosol and cloud concentration, likely due to long range transport of smoke or dust.
- Saudi Arabia has high aerosol concentration, lots of dust (> 1 μm), and higher cloud droplet concentrations than summer time measurements in North Dakota; however, the cloud spectrum parameters analysis have similar values.

Future Work

- Analyze more airborne measurements from current dataset.
- Collect more airborne measurements in upcoming years.
- Determine how frequently high aerosol concentration events affect Saudi Arabia and southern Mali using MODIS optical depth data.
- Investigate further how the aerosol and cloud concentration affect the shape of the cloud droplet spectrum.
- Conduct more accurate 3-dimension wind measurements to obtain cloud base update velocity.
- Use statistical analysis to relate changes in aerosol and cloud properties to radar derived precipitation measurements.