Evaluation of Mali, West Africa Airborne Measurements to Access the Potential of Enhancing Precipitation using Hygroscopic Seeding

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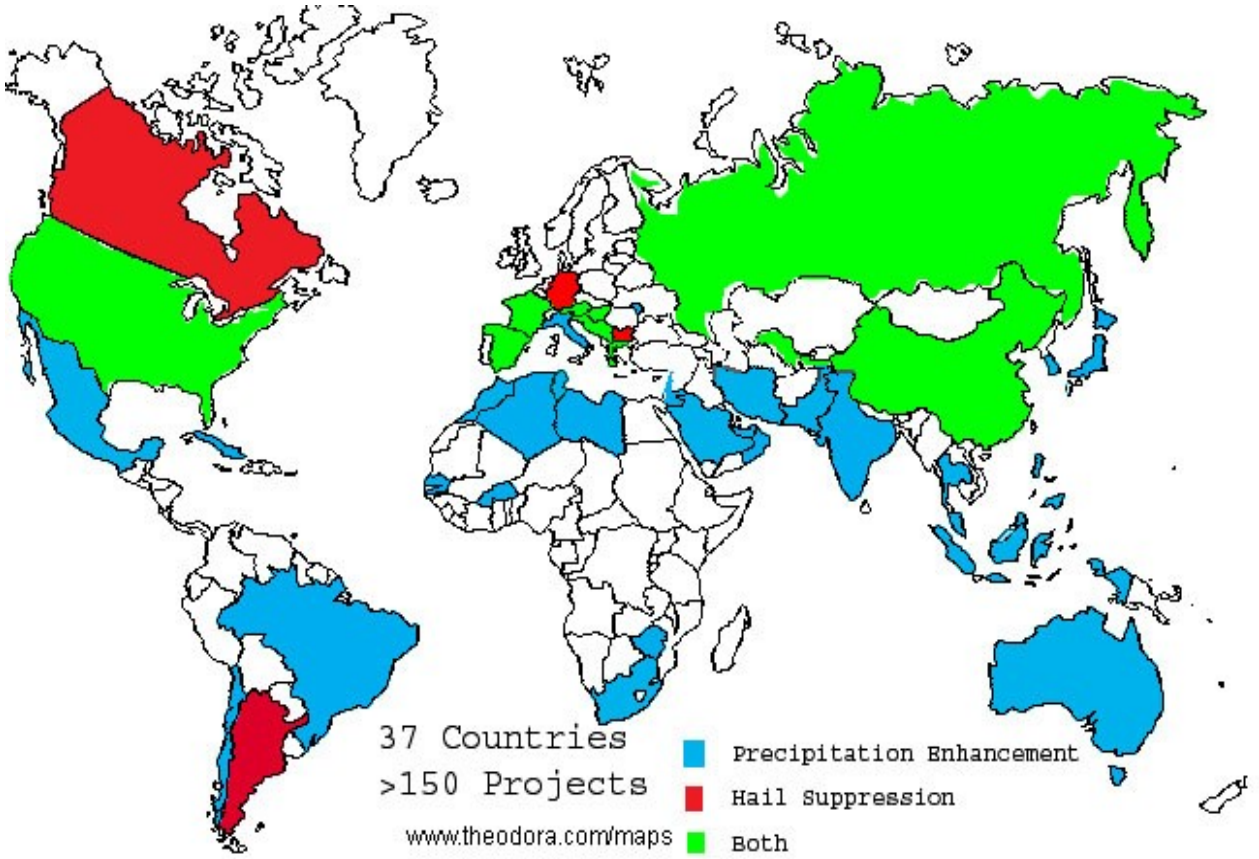
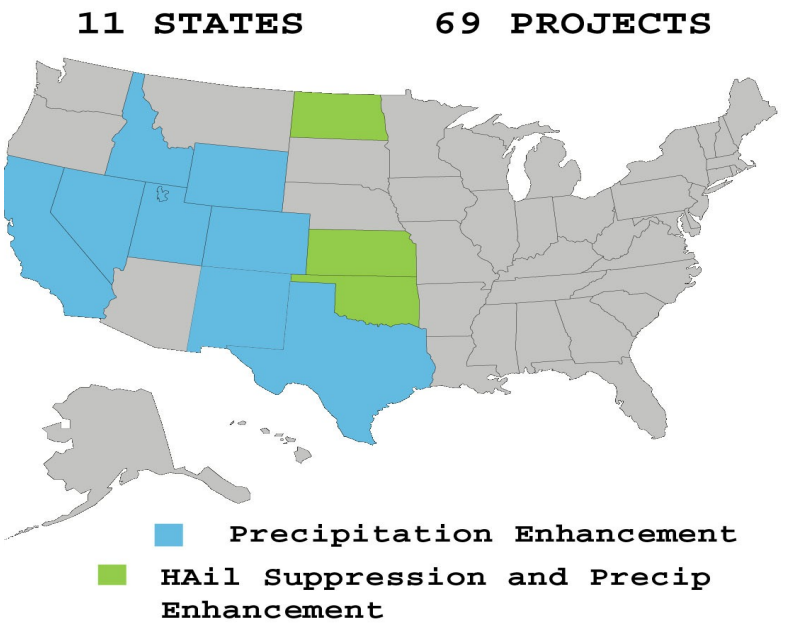
Research Modification

- Worldwide Water Resource Stresses
- Severe Weather Hazards
- New Observational, Computational, Statistical Technologies
- Operational Programs with Little Scientific Basis
- Population and Demographic Changes
- Inadvertent Weather Modification

Scope of Operational Programs

- Operational programs in more than 37 countries worldwide
- At least 69 programs in 11 U.S. states in 2001.





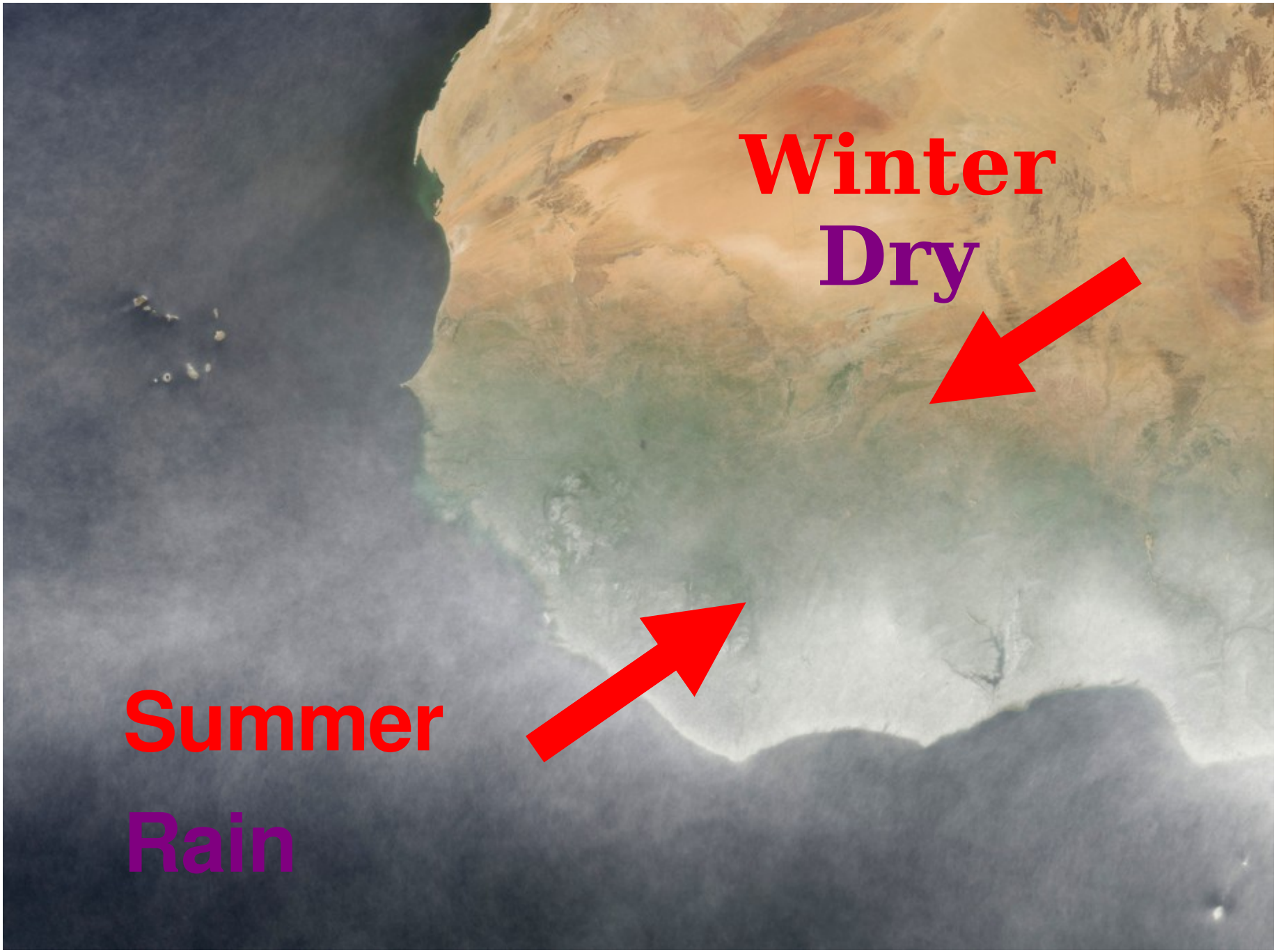
Measurement Objectives

- Determine if cloud seeding in Mali could be beneficial.
- Help determine what is the optimal seeding method for enhancing precipitation in the Mali region.

Measurement Importance

- The potential to enhancing precipitation is strongly dependent on the natural microphysics and dynamics of the clouds that are being seeded.
- Cloud properties can vary significantly from one geographical region to another and with the time of year in the same region.

Sahelian Trade Winds



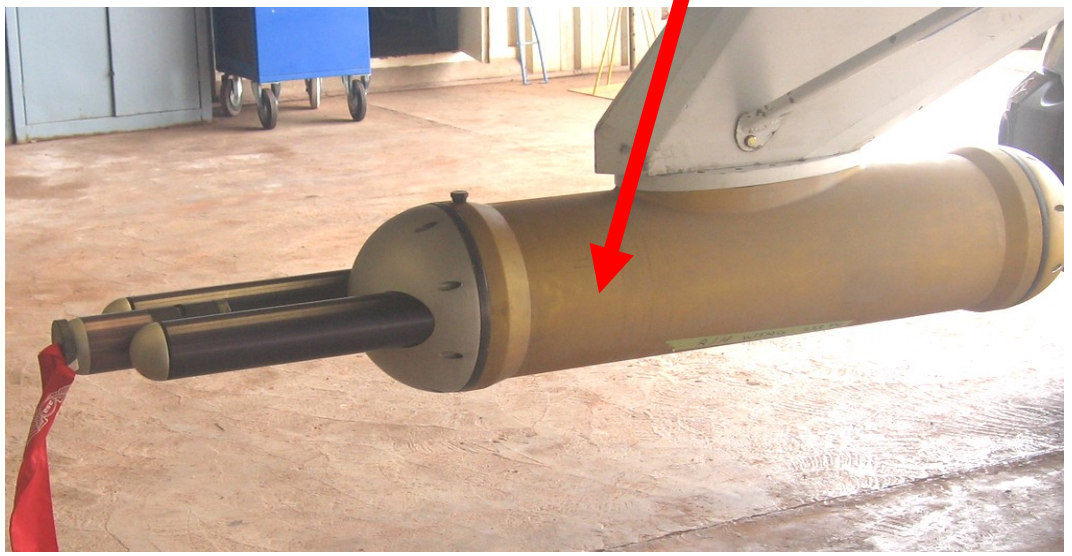
Lower Aerosol Concentrations

- The natural processes of rainfall formation is more efficient.
- Effects from hygroscopic cloud seeding are less effective.

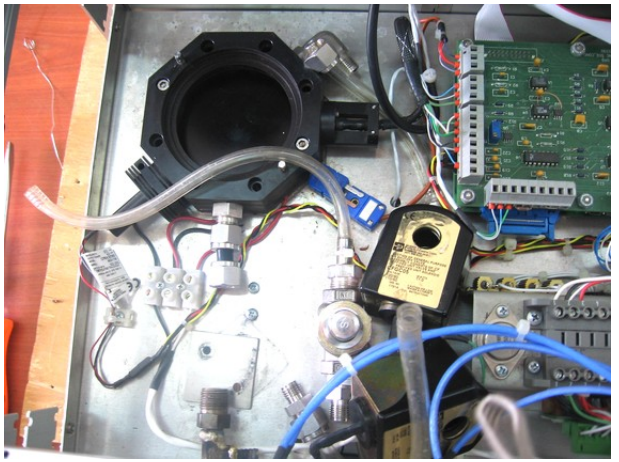
High Dust Concentrations

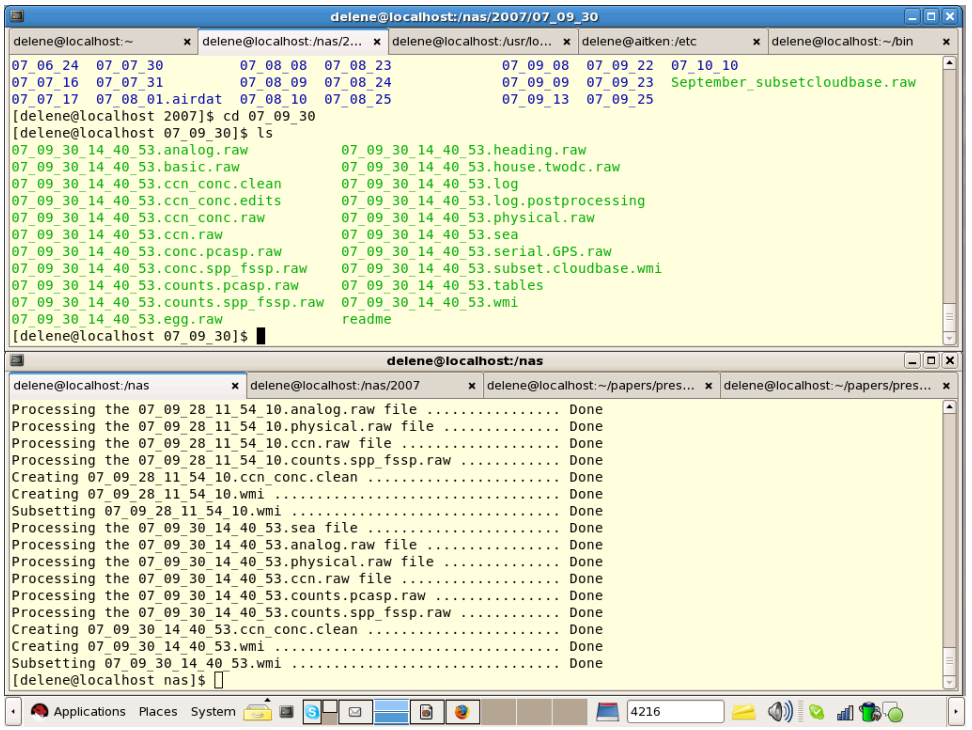
- The natural processes of rainfall formation is more efficient
- Effects from glaciogenic cloud seeding are less effective.

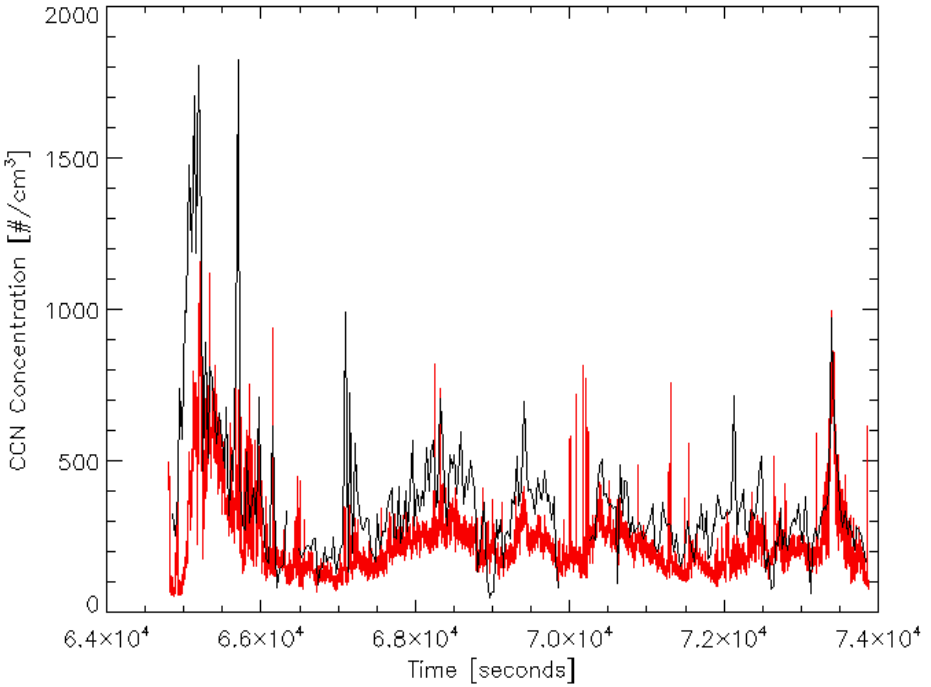
Aircraft Instruments

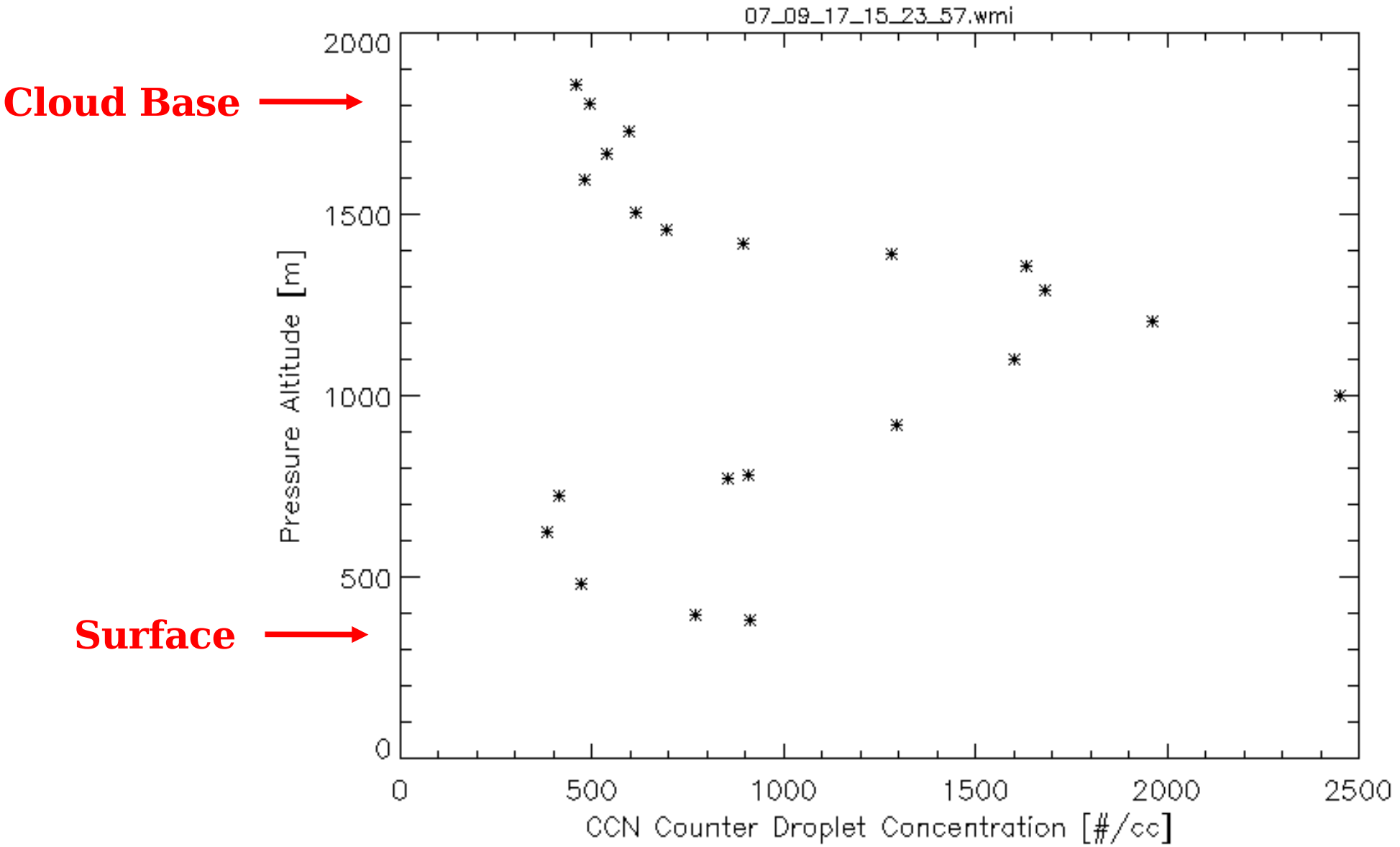


Quality Control
Quality Assurance

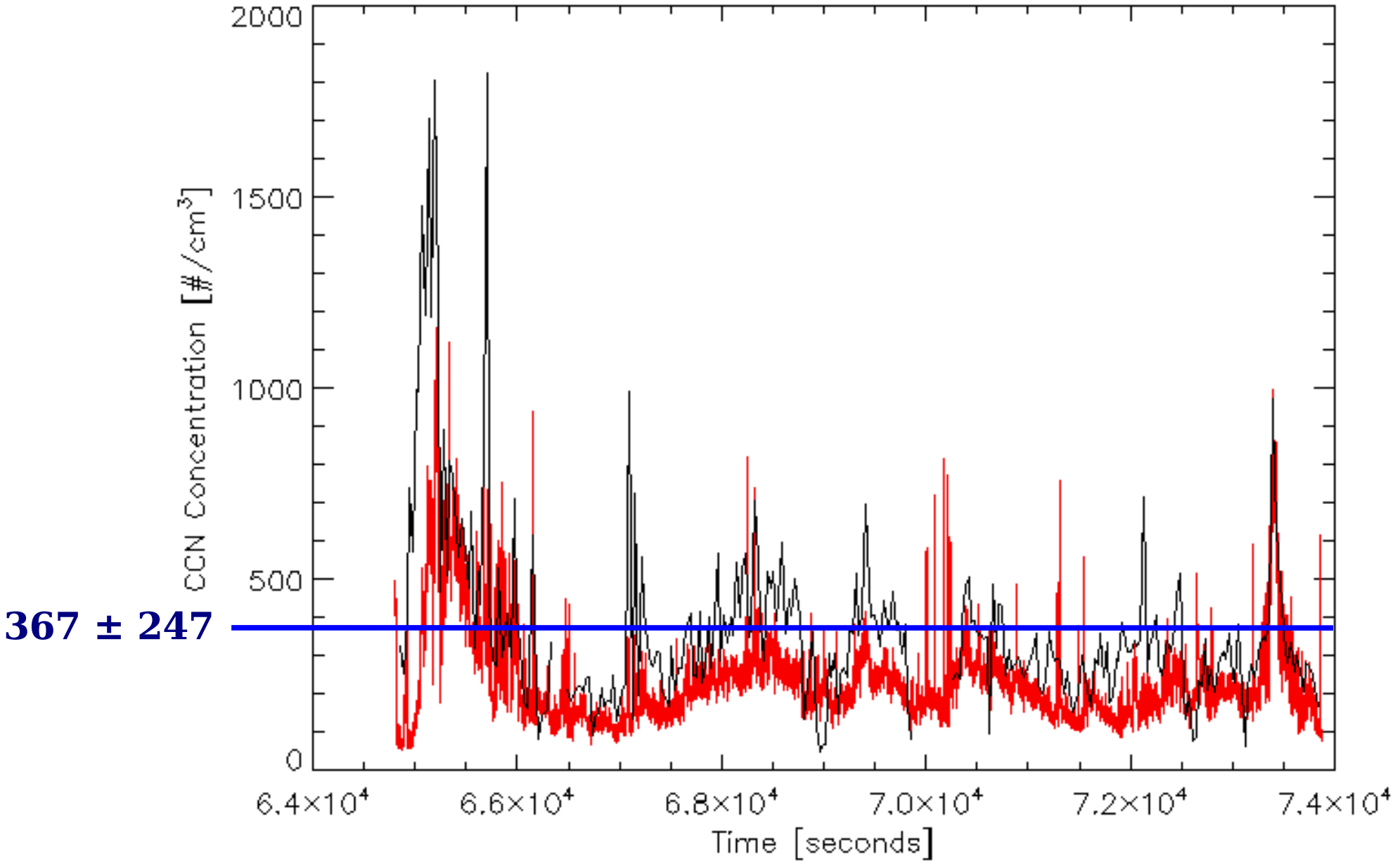








Cloud Condensation Nuclei (CCN) concentrations versus Pressure Altitude measured during decent into Bamako on the September 17, 2007 flight.



Cloud Condensation Nuclei (CCN) concentrations (black line) and Optical Particle Counter (OPC) concentrations measured East of Bamako on September 8, 2007 just below and above cloud base.

CCN Measurements

Location	Time of Year	CCN Concentration
Wyoming, USA*	Winter	146 ± 20 #/cm^{-3}
Wyoming, USA*	Summer	445 ± 157 #/cm^{-3}
New Zealand*	Summer	964 ± 17 #/cm^{-3}
Bamako, Mali	09/08/07	367 ± 247 #/cm^{-3}
Bamako, Mali	Sep. 2007	509 ± 453 #/cm^{-3}

Cloud Condensation Nuclei (CCN) concentrations at 1% supersaturation measured by a University of Wyoming CCN counter in the lower troposphere at various locations.

*Source: Delene, D. J. and T. Deshler, Vertical profiles of cloud condensation nuclei above Wyoming, Journal of Geophysical Research - Atmospheres , 106, 12579-12588, 2001.

CCN Measurements

Location	CCN Concentration
Australian Cost	120 #/cm^{-3}
North Atlantic Ocean	145-370 #/cm^{-3}
High Planes, Montana	290 #/cm^{-3}
Australia, Africa, USA	600 #/cm^{-3}
High Planes, Montana	2000 #/cm^{-3}
Buffalo, New York	3500 #/cm^{-3}
Texas, USA	3000-5000 #/cm^{-3}

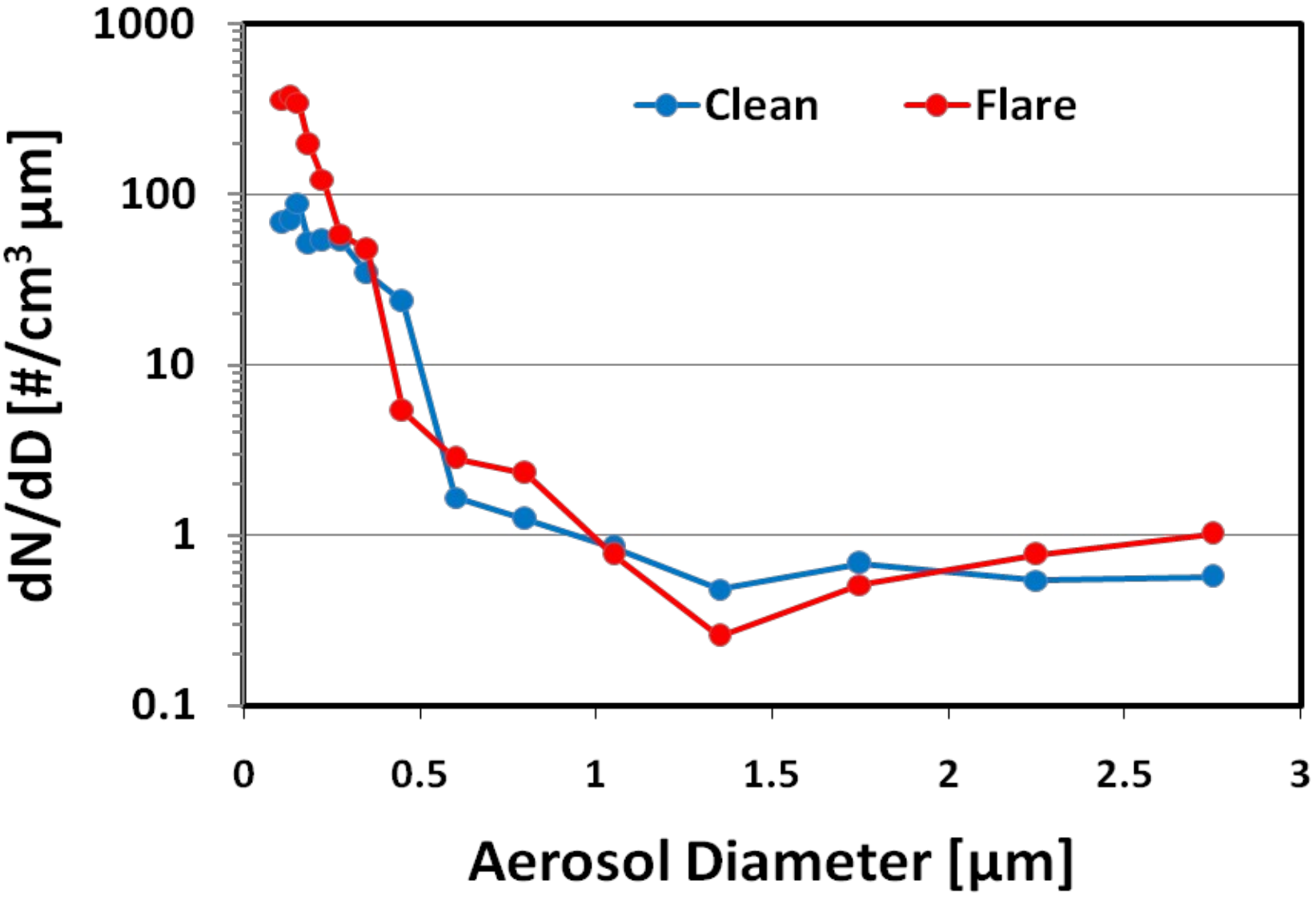
Cloud Condensation Nuclei (CCN) concentrations at 1% supersaturation measured at various locations. Data taken from Pruppacher, H. R., and J. D. Klett, Microphysics of Clouds and Precipitation, pp. 287-289, Kluwer Acad. Norwell, Mass., 1997.

Conclusions

- Cloud base CCN measurements in Mali during September 2007 show mostly clean continental conditions.

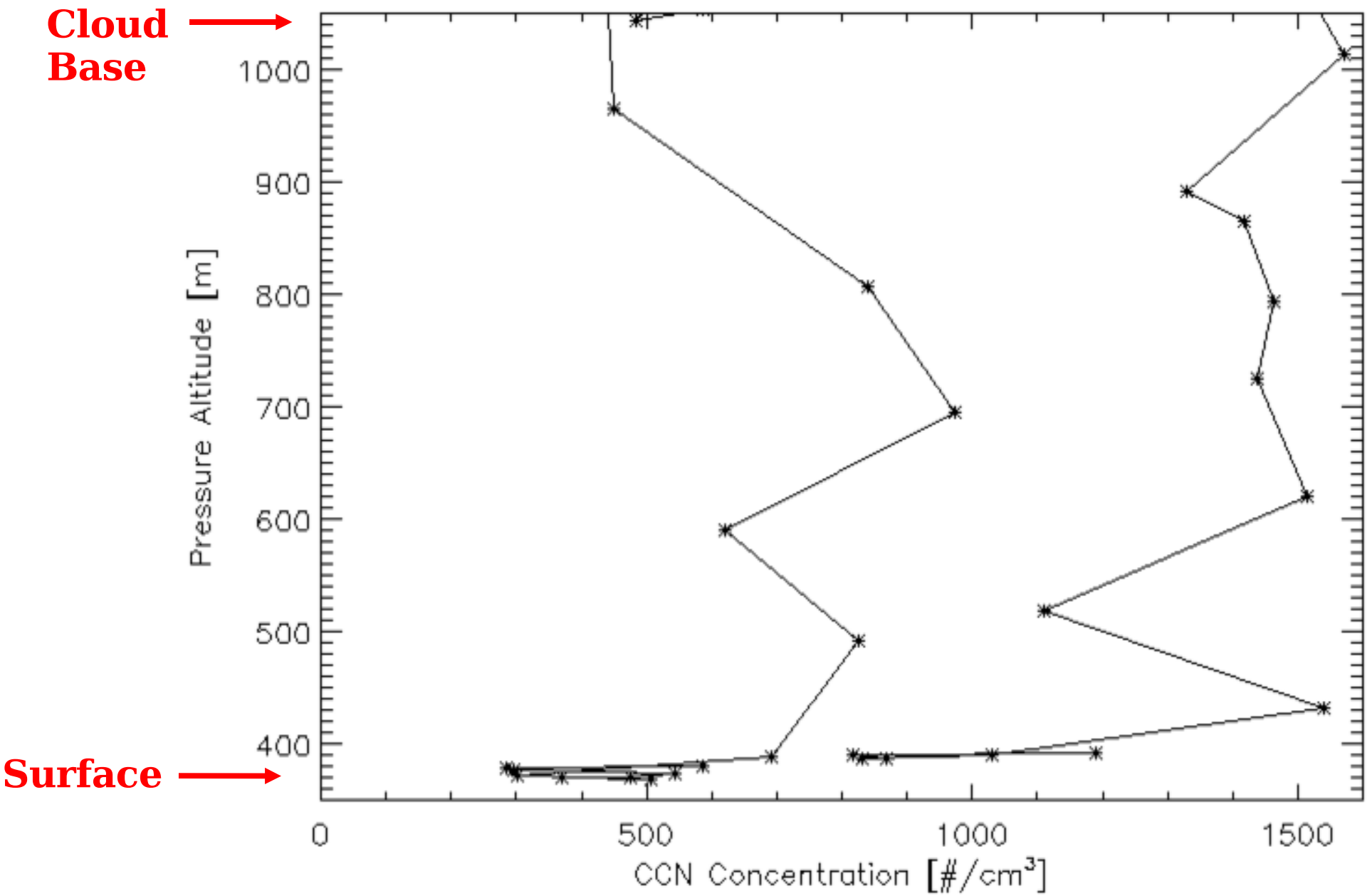
- On many operational cloud seeding days, cloud base CCN concentration are often low in Mali; hence, the natural rainfall formation process is efficient and hygroscopic cloud seeding may have no effect.

Future Work



Aerosol spectrum measured with a PCASP on September 30, 2007 in Mali. The “Clean” (Blue) spectrum is background aerosol measured between time index 57900 and 57999. The “Flare” (Red) spectrum is a flare plume sampled between time index 58008 and 58012

Any Questions?



Cloud Condensation Nuclei (CCN) profile over Bamako, Mali on September 18, 2007 over Bamako, Mali. The low concentration profile (left) was measured on ascent (14:30 UTC) and the high concentration profile (right) was measured on descent (17:00).