Sun and Aureole Measurements (SAM) During the DOE CLASIC and CHAPS Field Campaigns

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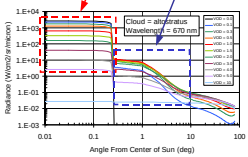
1 Introduction to SAM [1]
Sun and Aureole Measurement

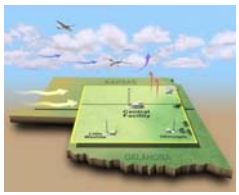
- Ground-based measurement of cloud optical properties
  - Cloud optical depth from solar disk radiance
  - Particle size distribution from aureole radiance profile



2 DOE CLASIC and CHAPS Campaigns
June 2007, Oklahoma

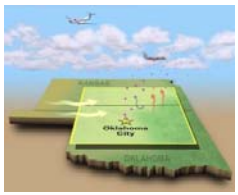
CLASIC [2]

Cloud and Land Surface Interaction Campaign



CHAPS [3]

Cumulus Humilis Aerosol Processing Study

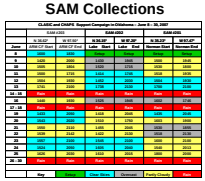


6 Conclusion

- SAM measurements were collected during CLASIC and CHAPS
- SAM data are available for analysis [4]
- Opportunities exist for algorithm development

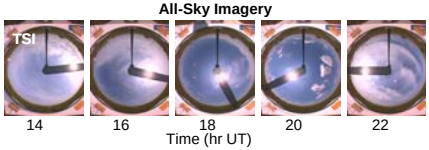
SAM Locations

SAM Collections

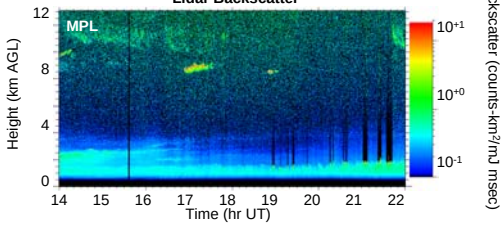


3 12 June 2007

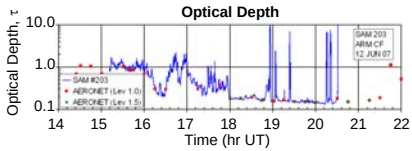
All-Sky Imagery



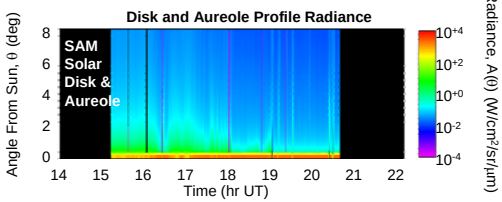
Lidar Backscatter



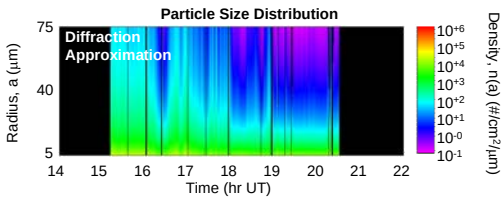
Optical Depth



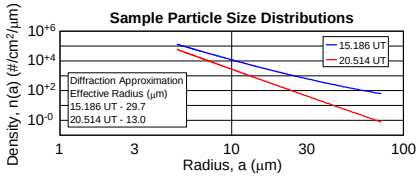
Disk and Aureole Profile Radiance



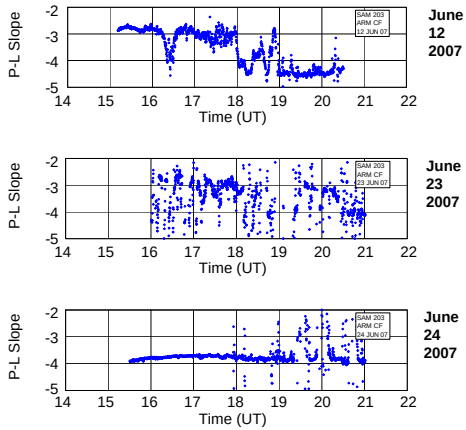
Particle Size Distribution



Sample Particle Size Distributions



4 Power-Law Slope of the Particle Size Distribution



5 Particle Size Distribution Using a Diffraction Approximation

Optically Thin Case: The aureole profile, $A(\theta)$, is related to the particle scattering pattern, $P(\theta)$ as follows:

$$A(\theta) \simeq \frac{P(\theta)}{4\pi\mu_s^2}\,\tau F_\odot \propto P(\theta)$$

where τ is the optical depth (vertically) through the layer, $F_\odot$ is the irradiance of the Sun (W cm$^{-2}\mu$m^{-1}), and μ_s is the cosine of the solar zenith angle.

Diffraction approximation: We approximate the forward scattering pattern with a Heaviside (or rectangular) function. The differential contribution to the composite phase function at scattering angle θ due to particles of radius between a and $a + da$ (μm) is:

$$dP(\theta < \lambda/a) \;\propto\; n(a)\,\frac{\sigma(a)}{\Delta\Omega_a}\,da$$

where $n(a)$ is particle size probability distribution (μm^{-1}), $\sigma(a)$ is the cross section (μm^2), and $\Delta\Omega_a$ is the solid angle of the diffraction pattern (sr). Integrate over particle size to find $P(\theta)$:

$$P(\theta) \;\propto\; \int_0^{a(\theta)} n(a)\,\frac{\sigma(a)}{\Delta\Omega_a}\,da$$

where from simple diffraction theory $a(\theta) = \lambda/\theta$. Approximate the cross section with twice the geometric cross section which is appropriate in the limit of large particles:

$$\sigma(a) = 2\pi a^2 \qquad \Delta\Omega_a = \pi\,\frac{\lambda^2}{a^2}$$

Substitute the relations above into the equation for $P(\theta)$:

$$P(\theta) \;\propto\; \frac{1}{\lambda^2}\int_0^{a(\theta)} n(a)\,a^4\,da$$

Solving for the size distribution: Differentiate with respect to θ:

$$\frac{dP}{d\theta} \;\propto\; \frac{1}{\lambda^2}\,\frac{da}{d\theta}\,n(a)\,a^4$$

$$n(a) \;\propto\; \frac{dP}{d\theta}\,\frac{\lambda^2}{\left(\frac{da}{d\theta}\right)a^4}$$

Using $\theta = \lambda/a$ and $(da/d\theta) = -\lambda/\theta^2$ the equation for $n(a)$ becomes:

$$n(a) \;\propto\; -\frac{dP}{d\theta}\,\frac{\theta^6}{\lambda^3}$$

Given $dP/d\theta$ as a function of θ based on SAM measurements, $n(a)$ can be determined from the equation above.

REFERENCES:

[1] http://www.visidyne.com/SAM/SAMhome.htm
[2] http://science.arm.gov/clasic
[3] http://asp.labworks.org/
[4] http://www.arm.gov/acrf/fc.stm

ACKNOWLEGEMENTS:

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