Application of Solar Aureole for Atmospheric Monitoring

Pi-Huan Wang and Adarsh Deepak
- Taksha Institute -

- Outline -

I - **Solar Aureole (SA)** Almucantar radiance scan for retrieving columnar aerosol size distribution (CASD)

II – **Solar Aureole (SA)** constant-altitude multi-angle limb scattering system for retrieving profile of aerosol properties (Concept and theory development; Feasibility investigation)

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)

SOLAR AUREOLE METHOD
Atmospheric Almucantar and
Limb Remote Sensing

Pi-Huan WANG and Adarsh DEEPAK

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)
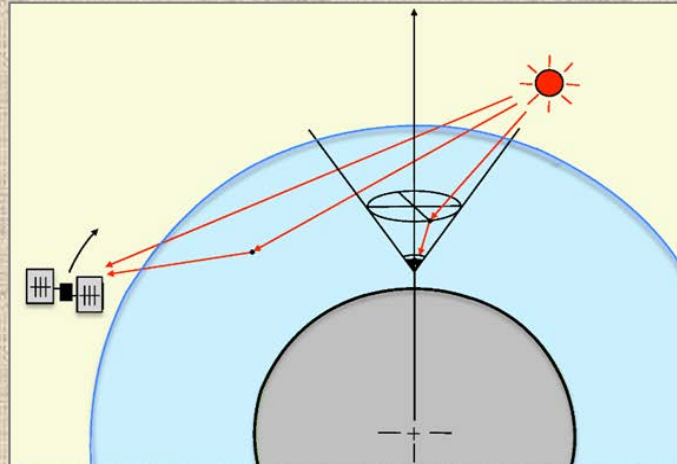
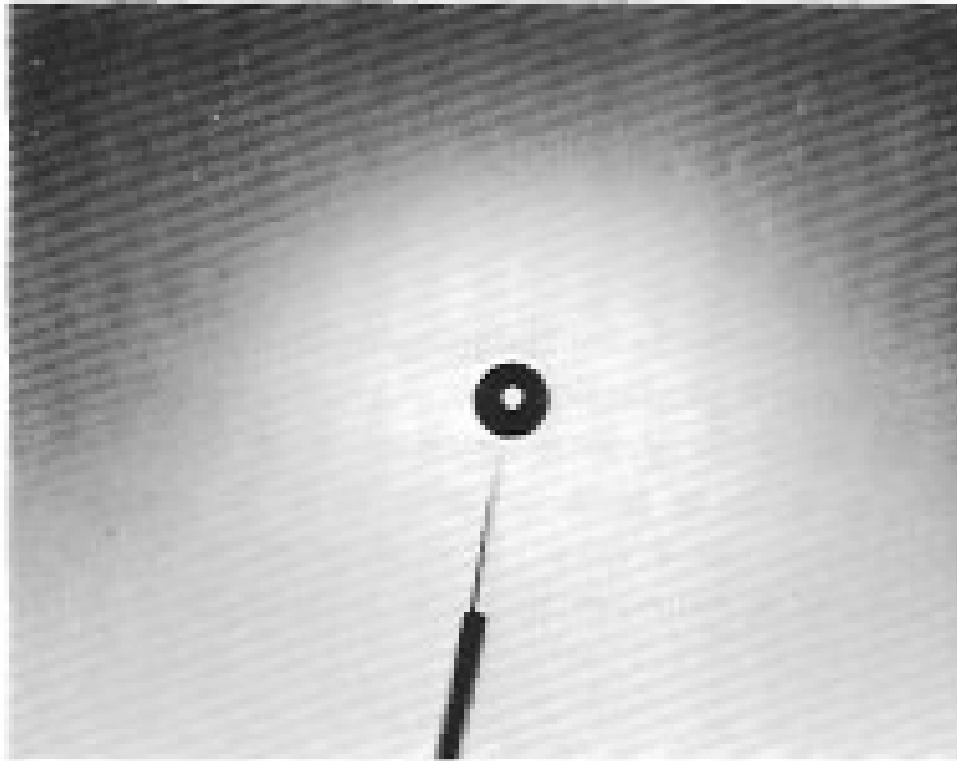**Solar Aureole (SA)** is the bright region near ($\lesssim 15°$) the
sun's disk as shown in the photograph
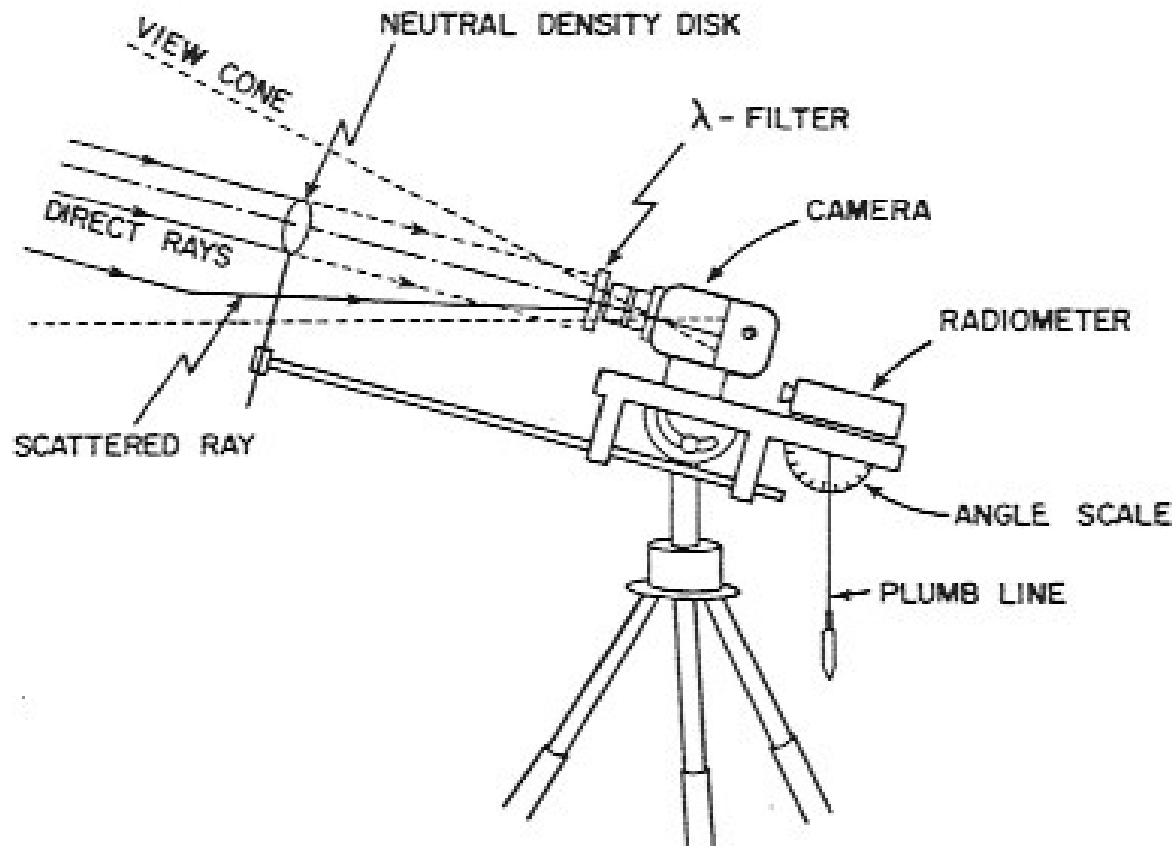- **SA** contains **86%** of total aerosol forward scattering energy

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)
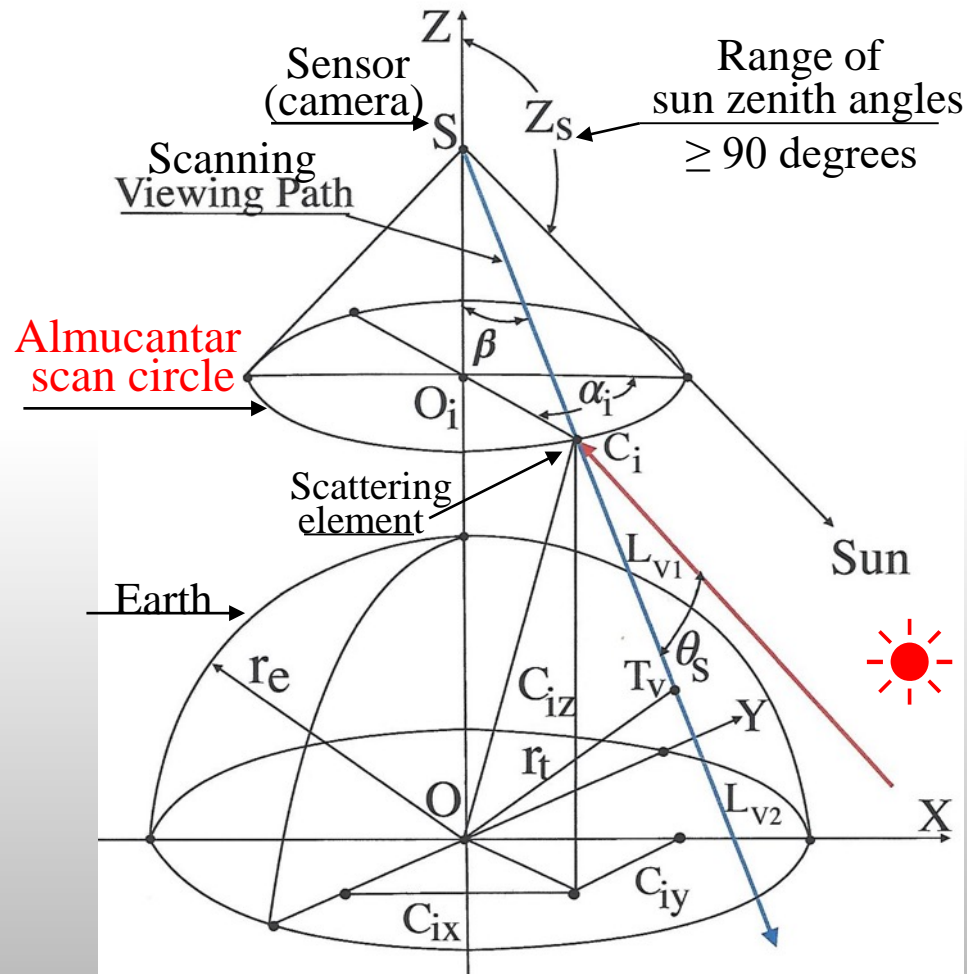
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A Portable Solar Aureole Photography System

- Can provide accurate columnar aerosol size distribution (CASD)
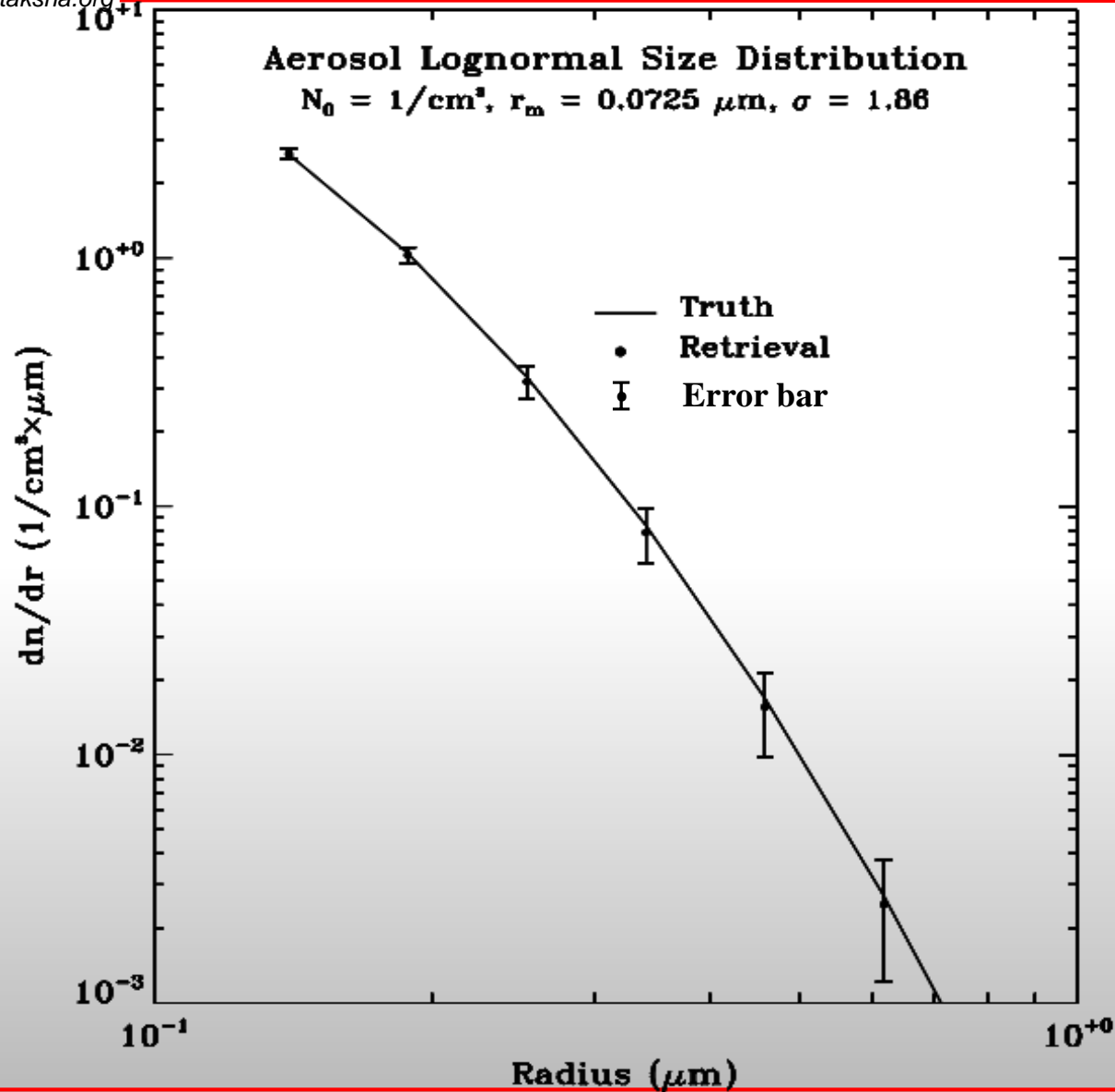- Is inexpensive with potential for global and planetary applications

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)

Almucantar is the sky scan circle around the local vertical with its track zenith angle equal to sun zenith angle (Z_S).
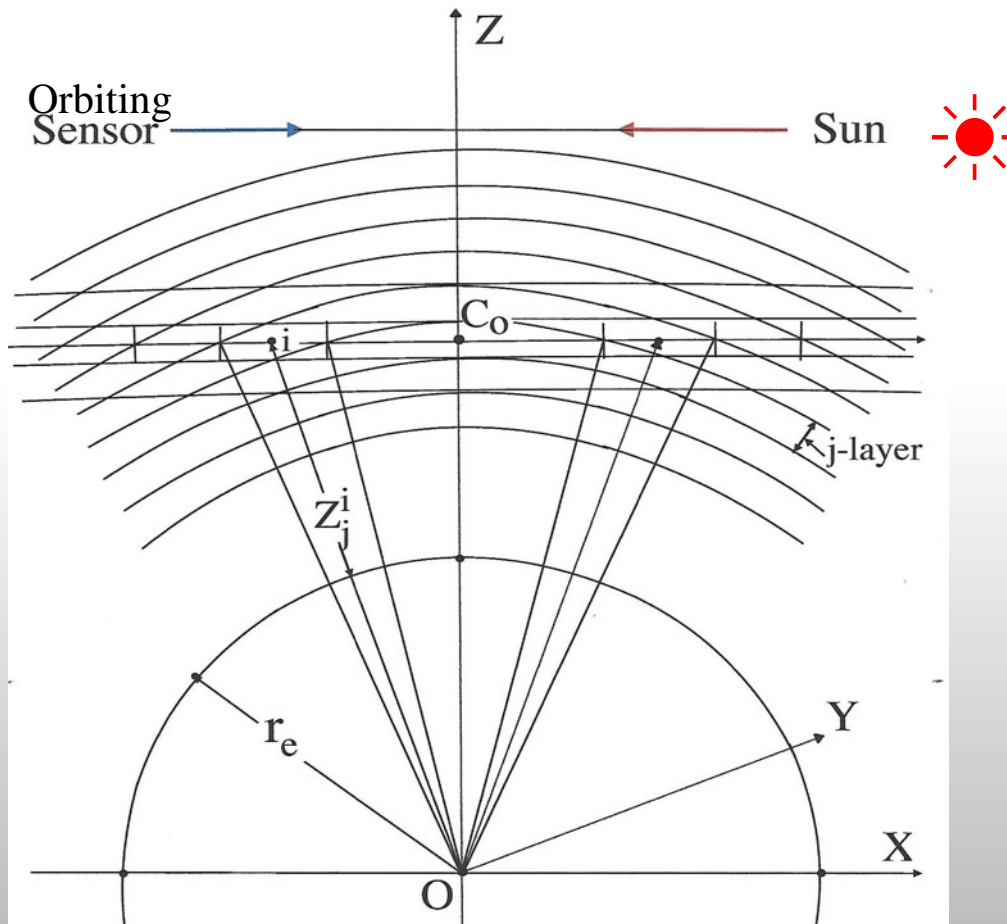
(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)

Atmospheric Limb Scattering Method (ALSM)

(1) Special Case: Solar Occultation (scattering angle = 0°)
(sensor viewing path is also sunlight trajectory)
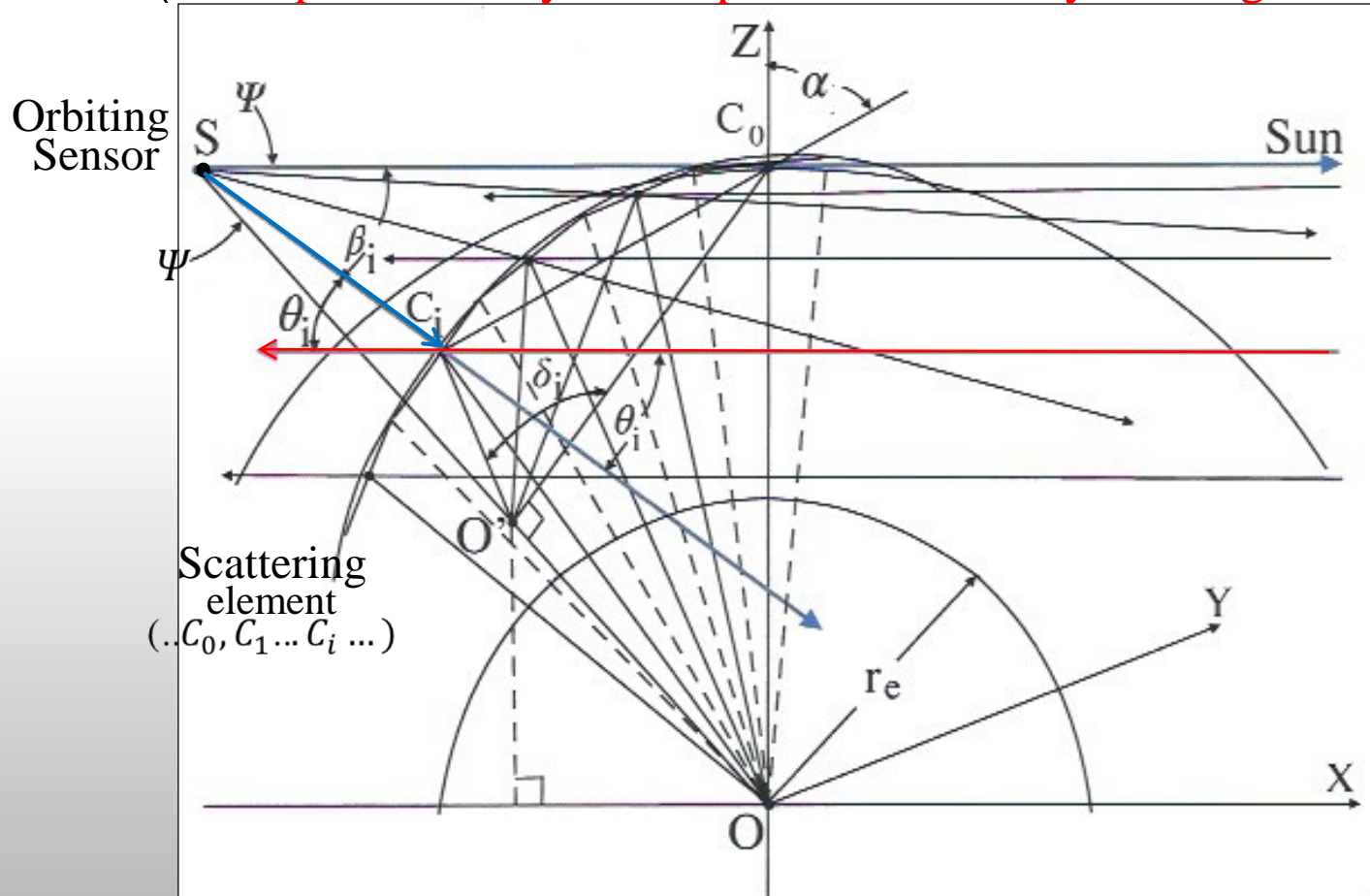

Atmospheric concentric shell structure

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)

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Atmospheric Limb Scattering Method (ALSM)

(2) Constant-Altitude Multi-Angle Limb Scattering (CAMALS) System
(scattering angle > 0°)
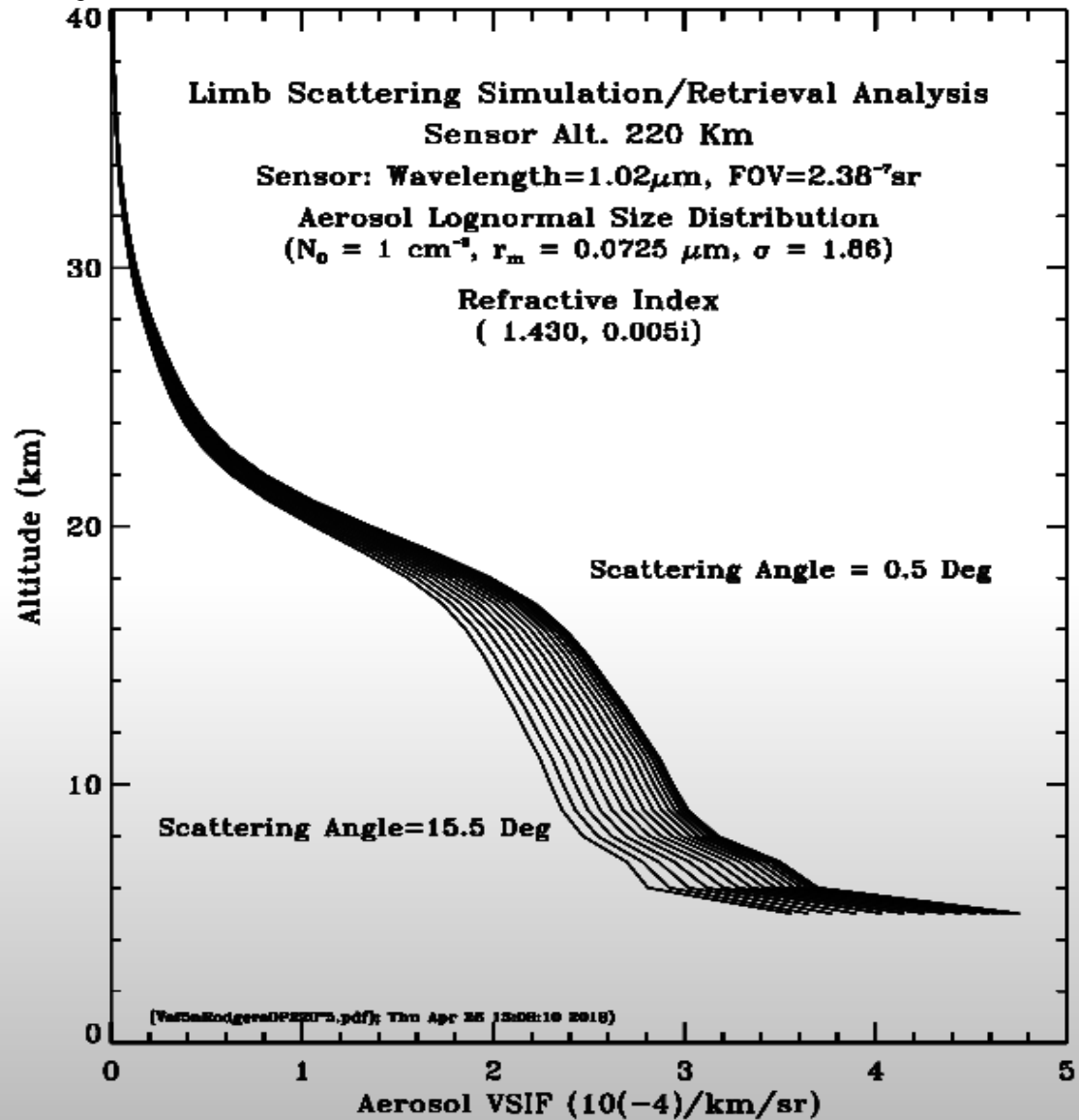(Concept and theory development; Feasibility investigation)

Limb Scattering Simulation/Retrieval Analysis
Sensor Alt. 220 Km
Sensor: Wavelength=1.02μm, FOV=2.38^{-7}sr
Aerosol Lognormal Size Distribution
(N_0 = 1 cm^{-3}, r_m = 0.0725 μm, σ = 1.86)
Refractive Index
(1.430, 0.005i)

Scattering Angle = 0.5 Deg

Scattering Angle=15.5 Deg

(1) A Comparison of Aerosol Number Density Profile

Limb Scattering Retrieval Analysis

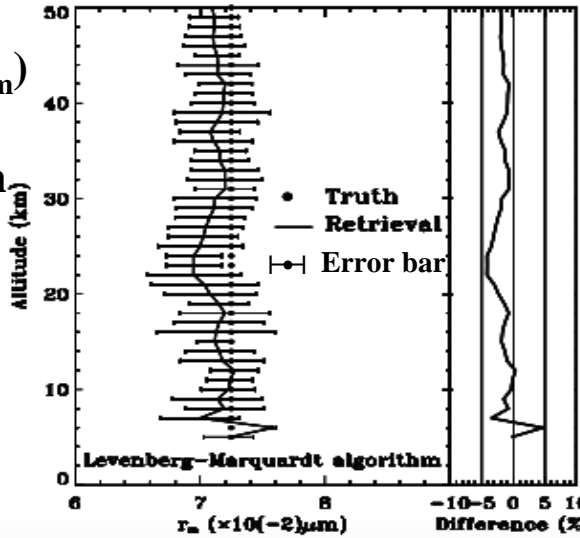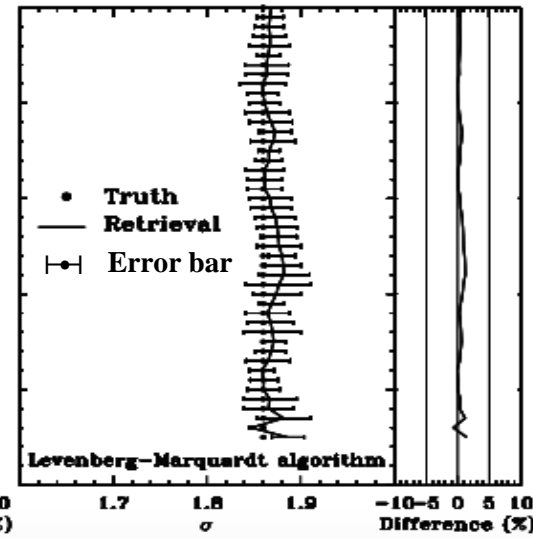**(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)**
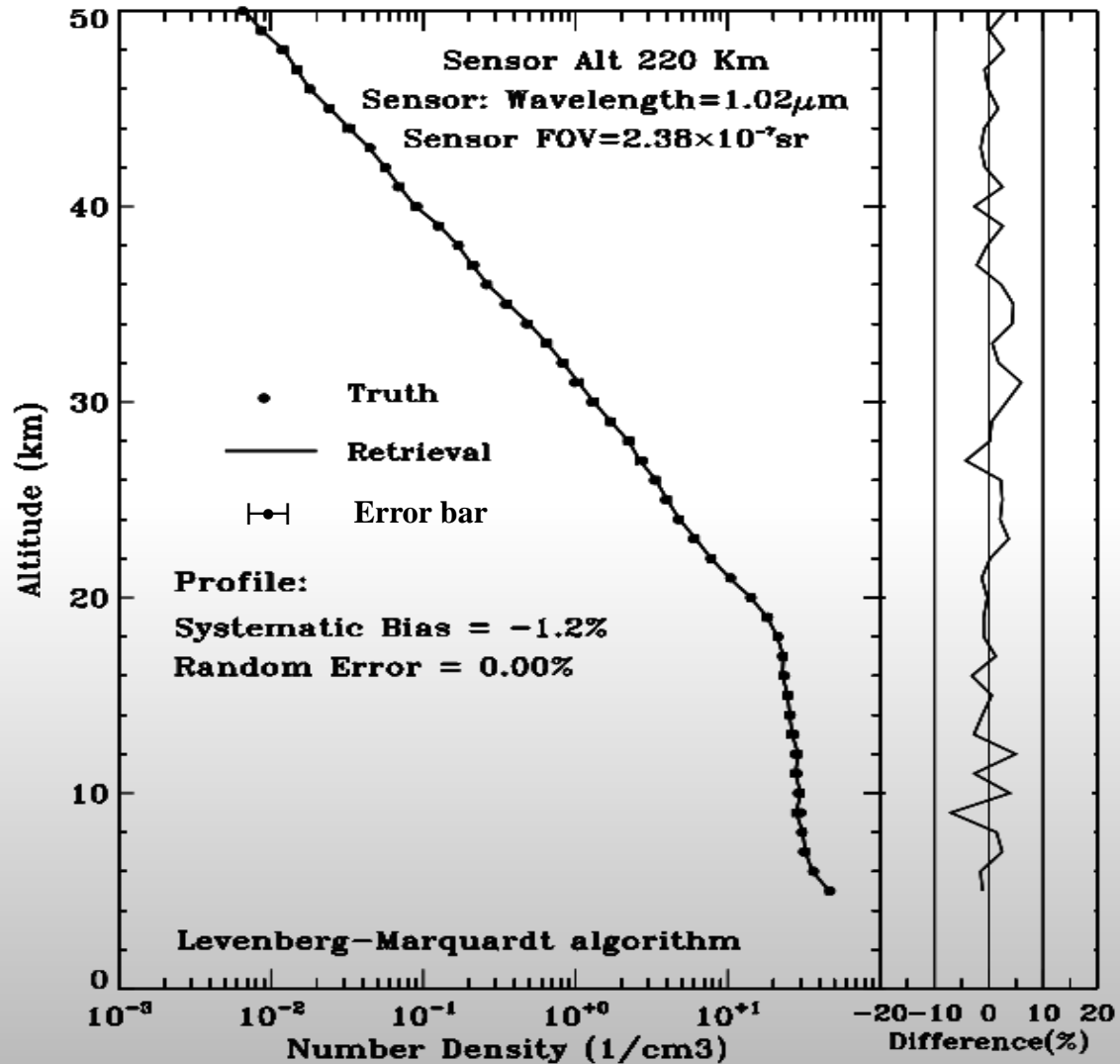
(2) Retrieved Aerosol Size Distribution and Complex Refractive Indices
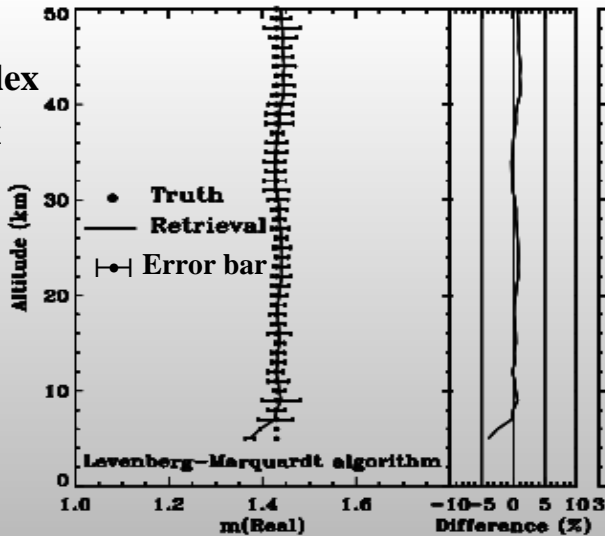

Limb Scattering Retrieval Analysis

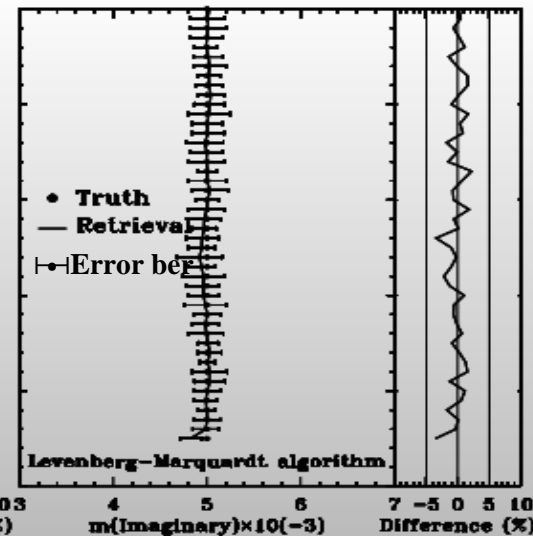**Mode radius (r_m) of log-normal size distribution**

Spread (σ) of log-normal size distribution

Real part of complex refractive index

Imaginary part of complex refractive index

**(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)**

- <u>Summary</u> -

- Using spherical symmetric atmospheric model, the analysis of **Solar Aureole** (**SA**) Almucantar radiance is suitable for all sun zenith angles;

- Columnar aerosol size distribution (CASD) can be retrieved from **Solar Aureole** (**SA**) Almucantar radiance data;

- Methodology for acquiring **Solar Aureole** (**SA**) constant-altitude multi-angle limb scattering (**CAMALS**) profile data is formulated;

- Aerosol size distribution and complex refractive index can be retrieved by using a single-λ ($1\mu m$), constant-altitude multi-angle limb scattering radiance data;

- With combination of **Solar Occultation (SO)** and **Limb Scattering (LS) system,** the atmospheric monitoring can be benefited by fully utilizing **Solar Aureole Method (SAM)** during **sunrises** and **sunsets**, for the **Earth**, **Moon** and **Mars**.

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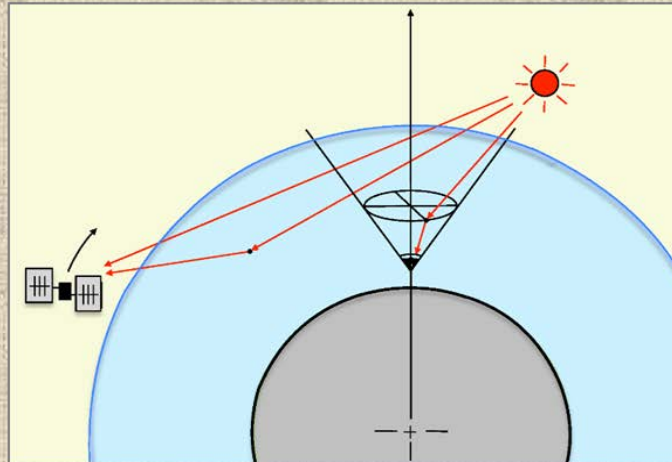
- <u>Future Effort</u> -

- To incorporate the effects of (1) atmospheric refraction, (2) multiple scattering, and (3) aerosol scattering polarization;

- To include other sunlight λ(s) for retrieving vertical profile of **atmospheric gases**, such as the wavelength at **0.6-μm** for **O$_3$**.

(Wang & Deepak, GMAC, May 21-22, 2019, Boulder Co.)