Sensitivity experiment of aerosol retrieval for GEOCAPE

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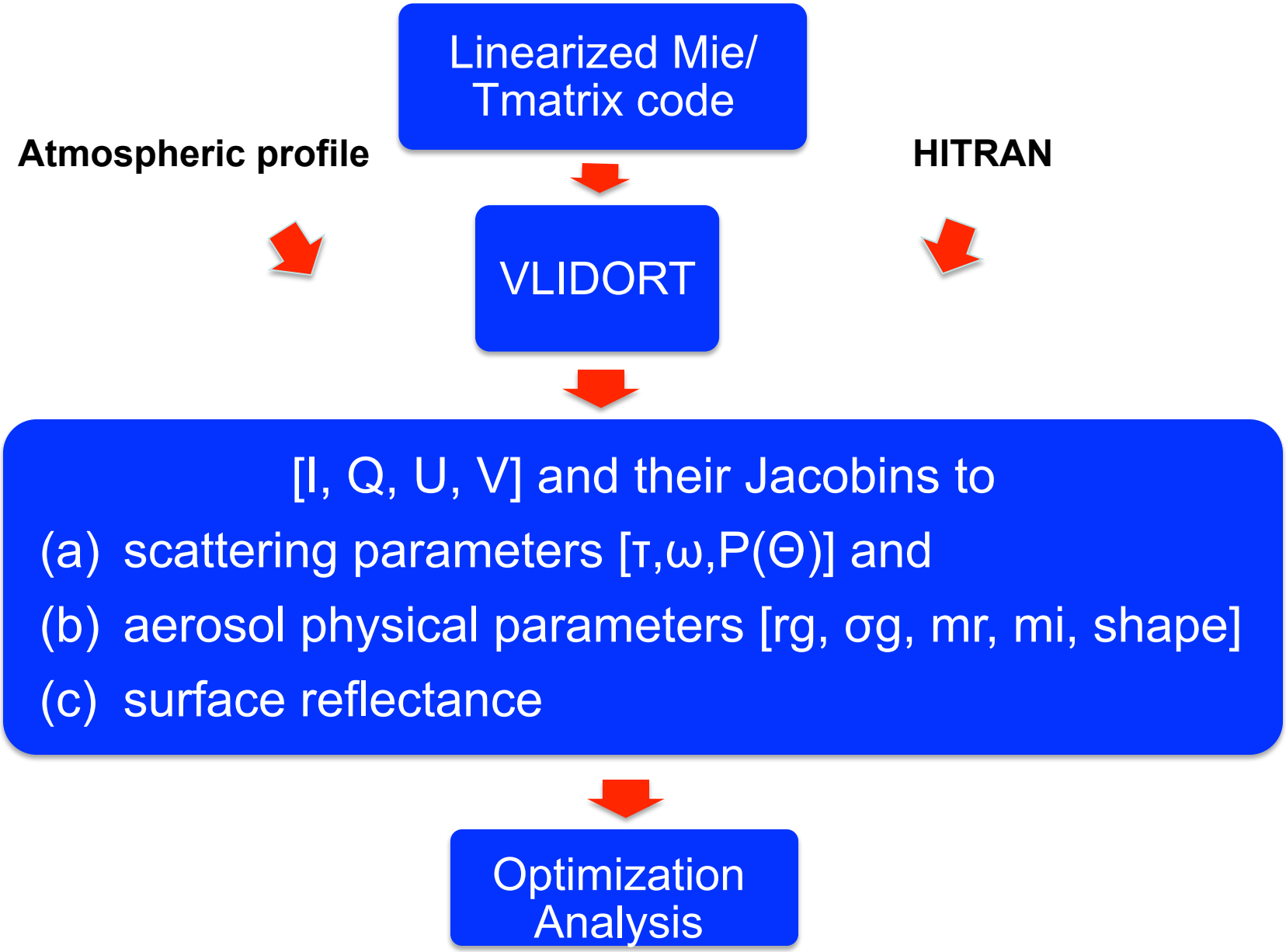
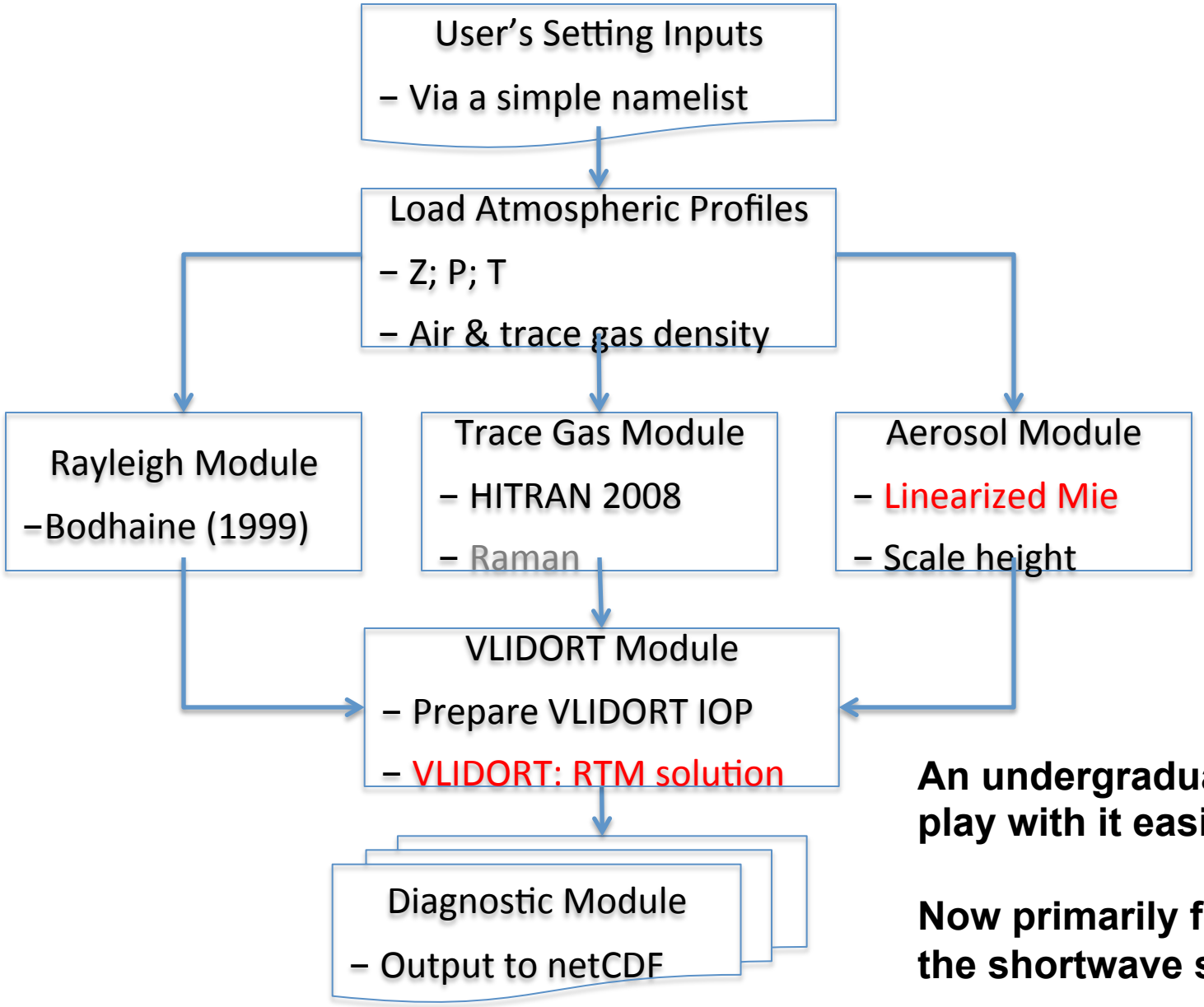
Radiative Transfer Modeling Tools



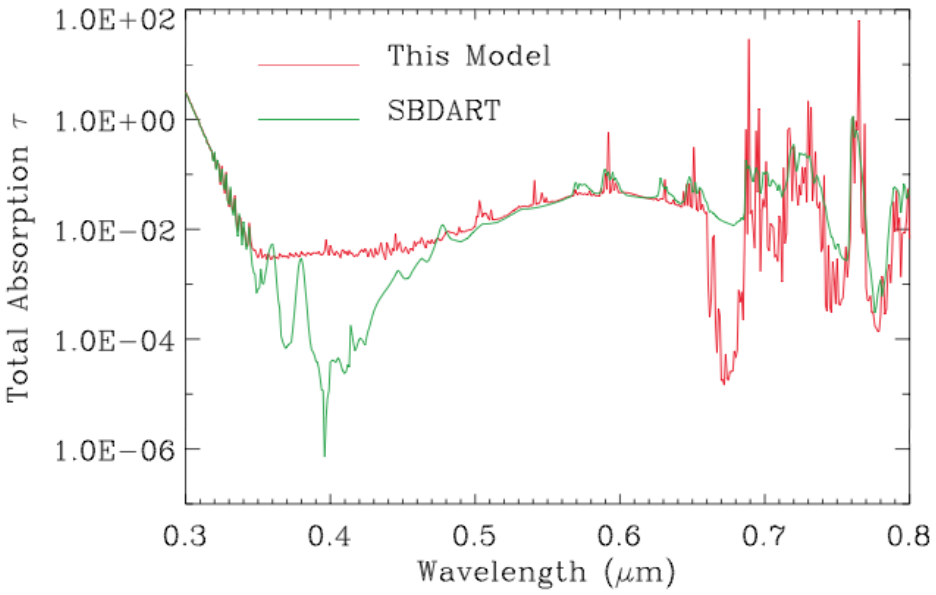
Model Structure

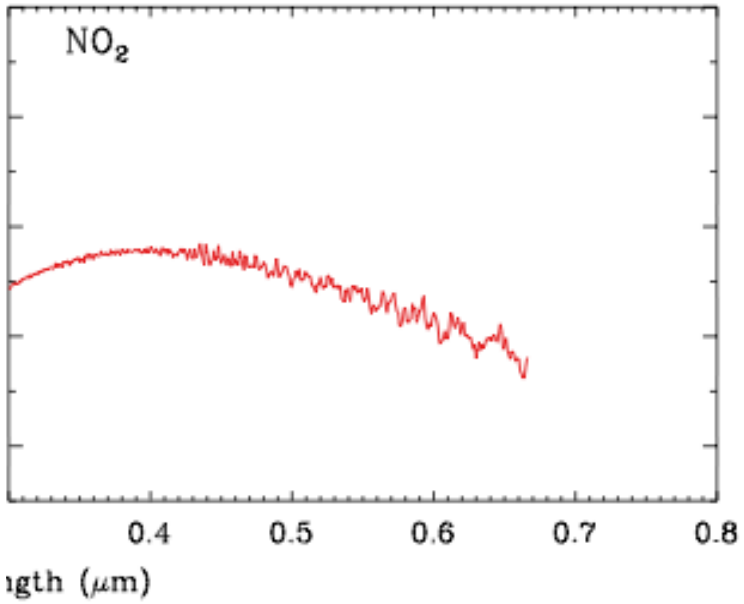


An undergraduate can play with it easily.

Now primarily focus on the shortwave spectrum

Gas Absorption Lines



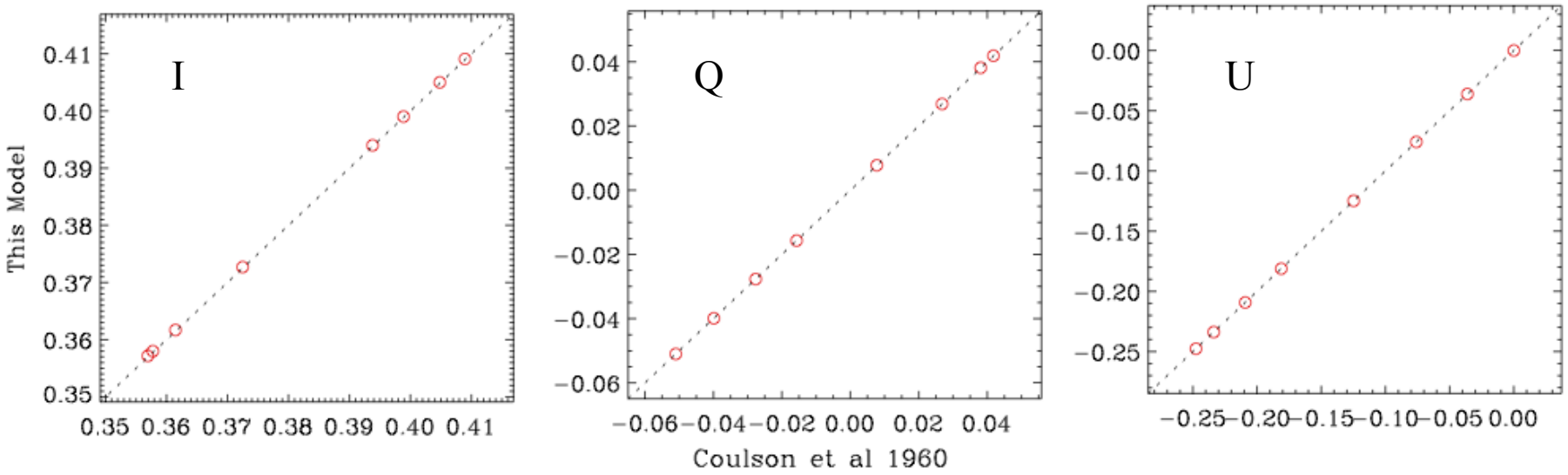


SBDART (Santa Barbara DISORT Atmospheric Radiative Transfer), Ricchiazzi,P., 1988, BAMS. It uses LOWTRAN with spectral resolution about 5 nm in uv-visible spectrum.

Validation: Pure Rayleigh Atmosphere

- Evans and Stephens (1991)
  - τ = 1.0
  - Upwelling at TOA
  - surface ρ = 0.25
  - $\cos\theta_0$ = 0.8
  - 8 difference θ

	Average Error		
	I	Q	U
Evans and Stephens	2.1E-4	9E-5	7E-5
This Model	1.9E-4	2E-5	4E-5
Relative Error (This model)	0.05%	0.14%	0.03%



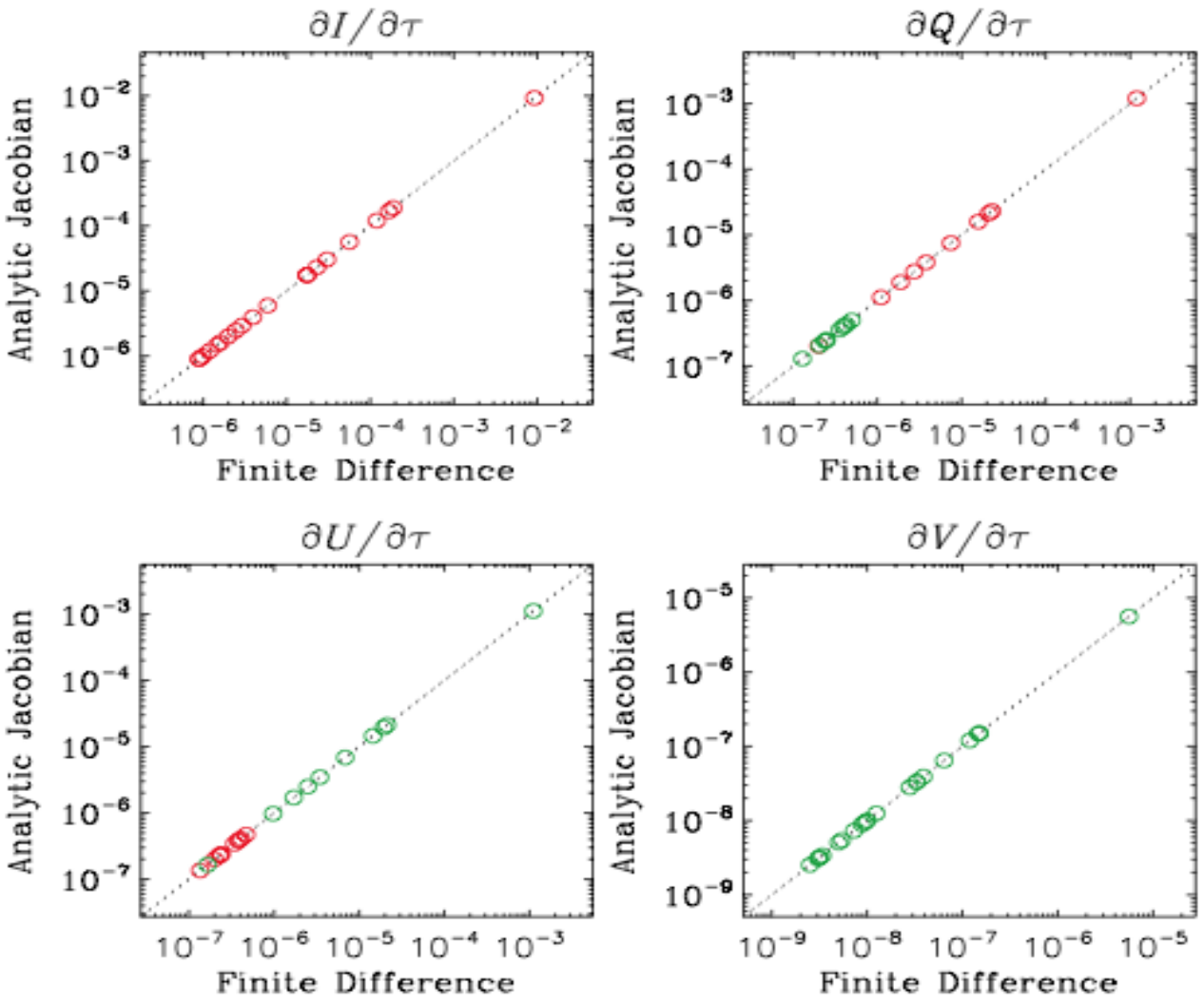
Compare with Coulson et al (1960)

Validation: VLIDORT Jacobians w.r.t. AOT

Input parameter:

mid-latitude summer
τ = 1.0
scale height: 2.0 km
λ: 550nm
Θ_0=30°, 45°
Θ: 10°-80° with 10° interval
ϕ: 90°
m = 1.53 + 0.001 i

Log-normal size distribution
R_g = 0.1 μm
σ_g = 1.6 μm

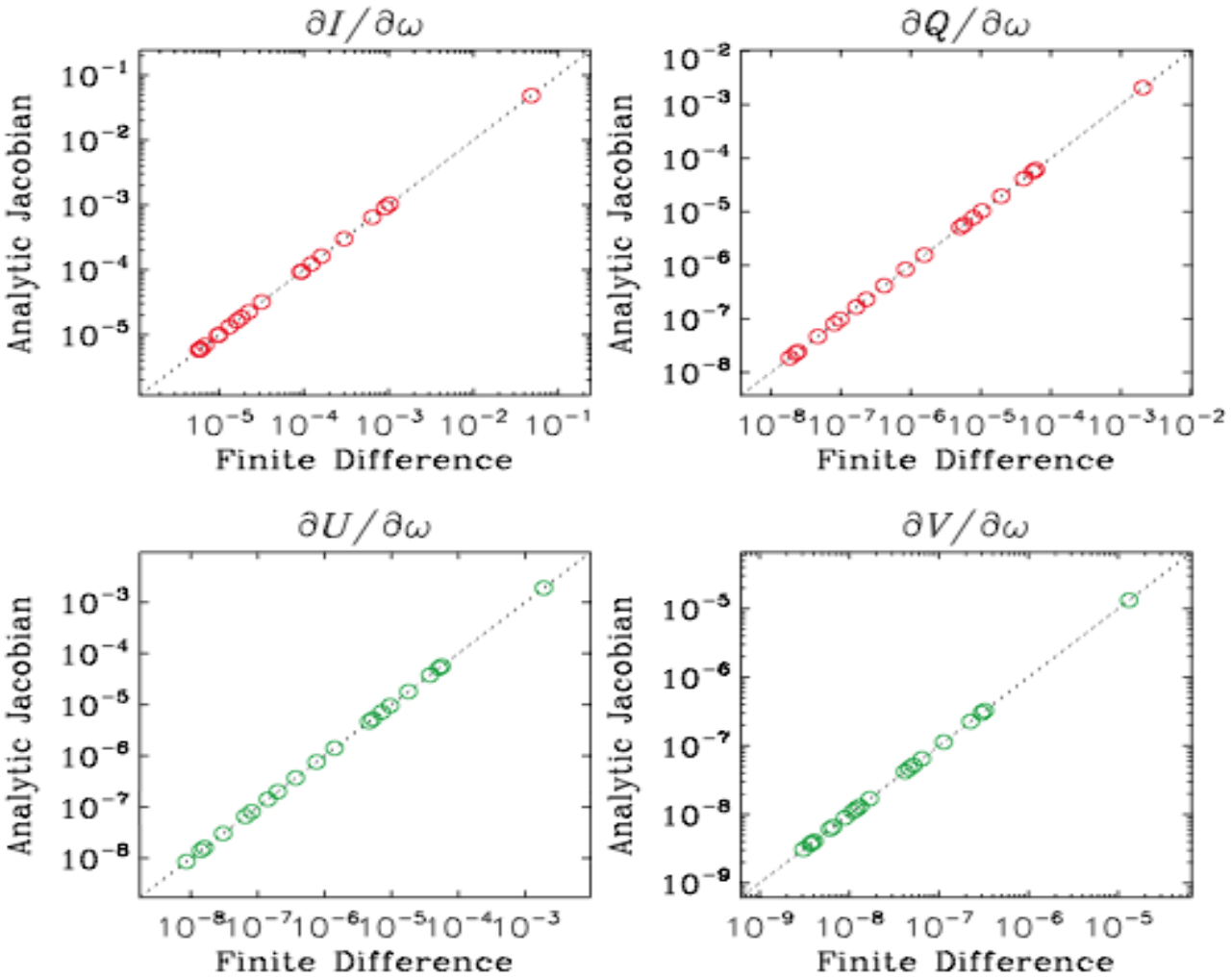


- Red: positive values
- Green: Negative values

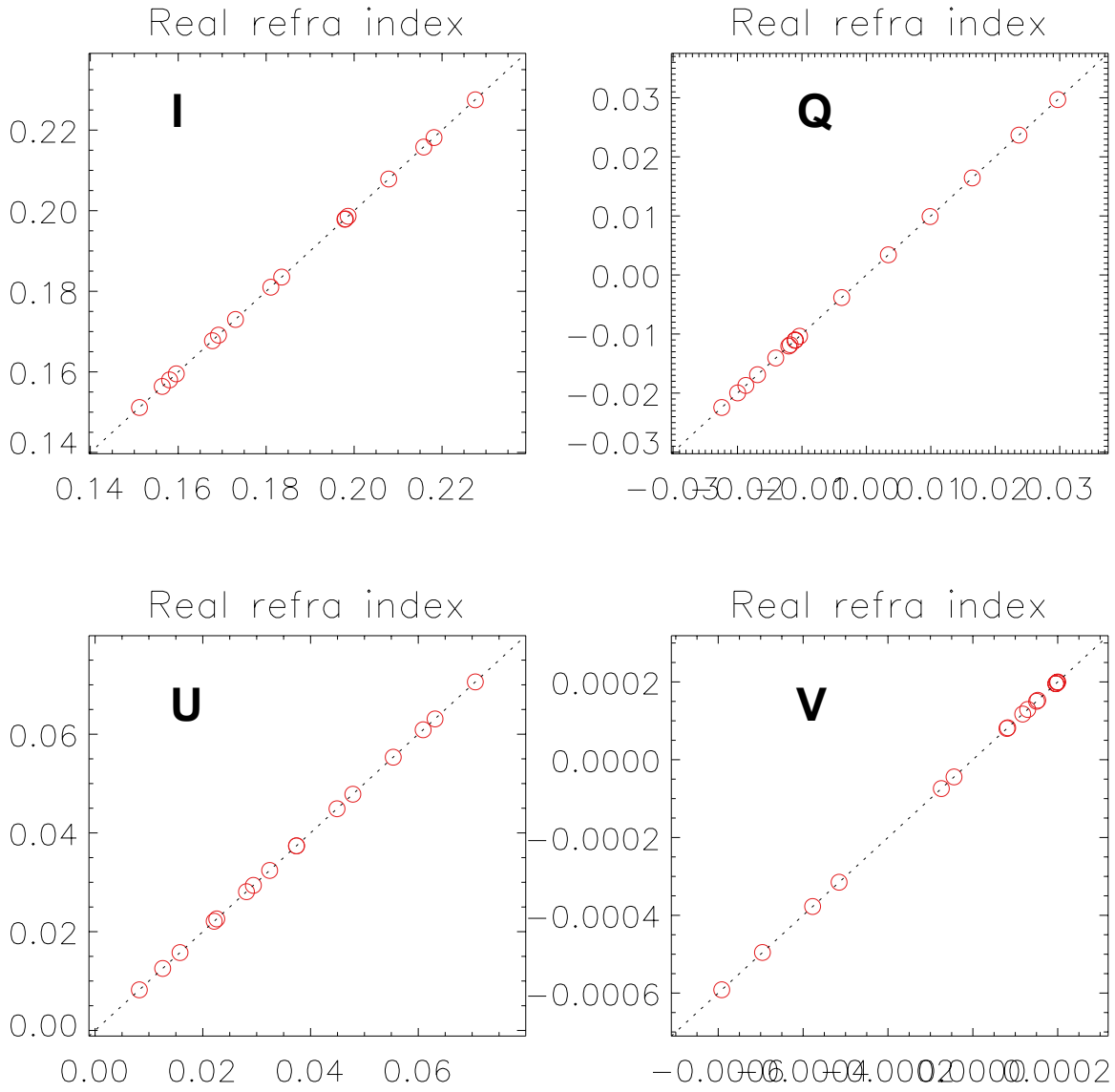
Validation: VLIDORT Jacobians w.r.t. ω

- Jacobian of Stokes parameters with respect to aerosol single scattering albedo (ω)

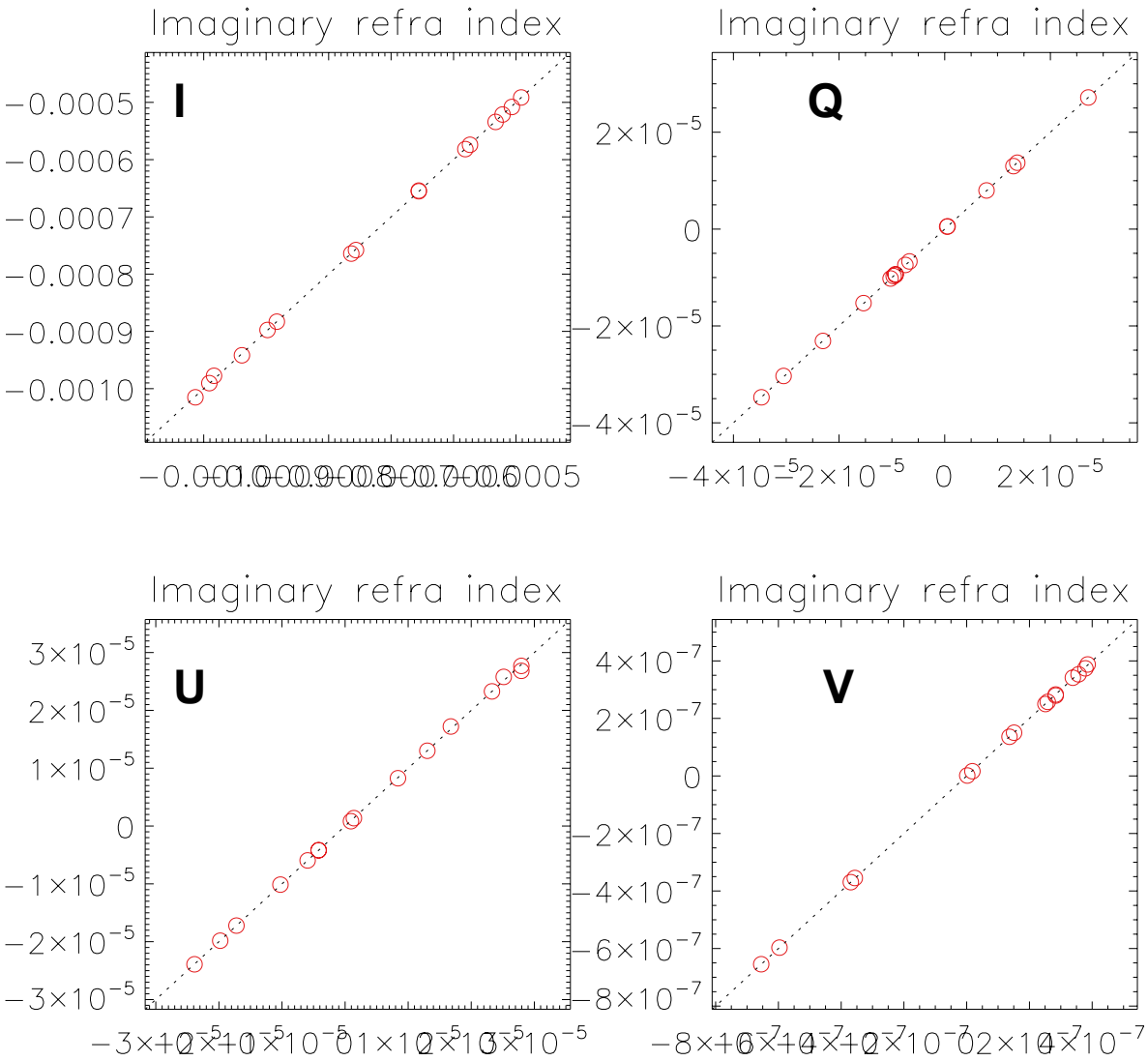
- Red: positive values
- Green: Negative values



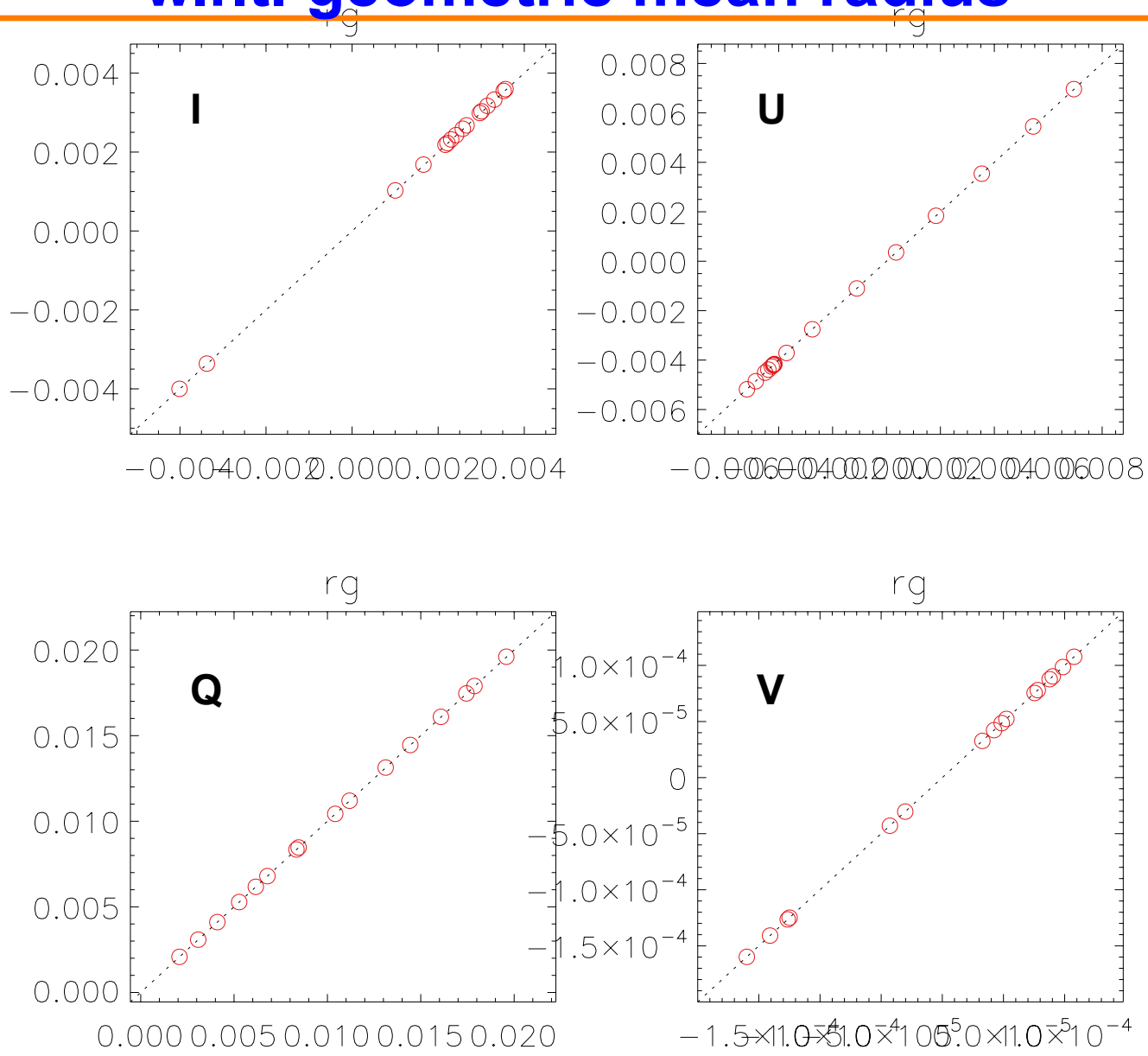
Validation: Jacobians of Stokes parameters w.r.t. real part of refractive index



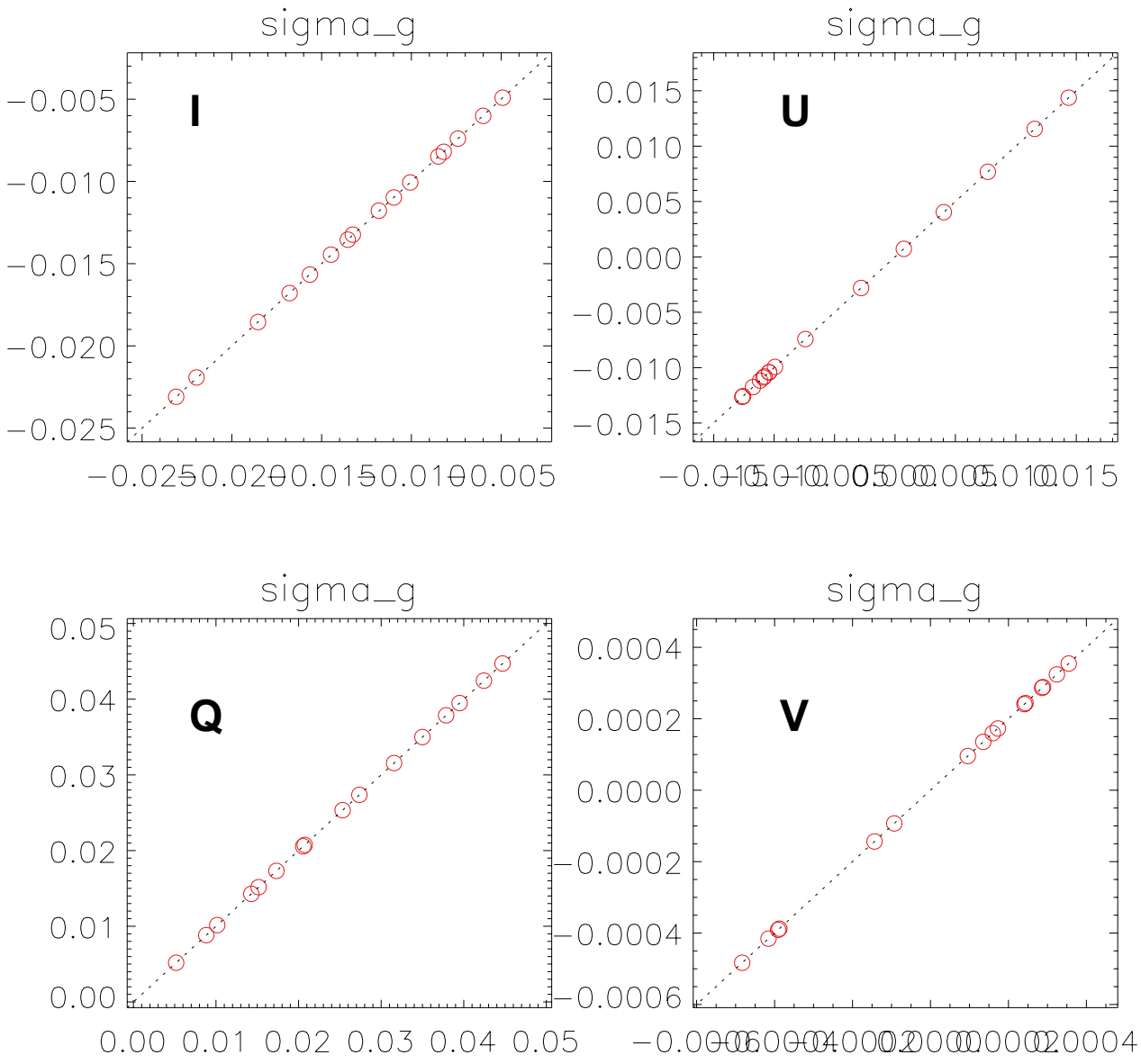
Validation: Jacobians of Stokes parameters w.r.t. imaginary part of refractive index



Validation: Jacobians of Stokes parameters w.r.t. geometric mean radius



Validation: Sensitivity of Stokes parameters w.r.t. geometric standard deivation

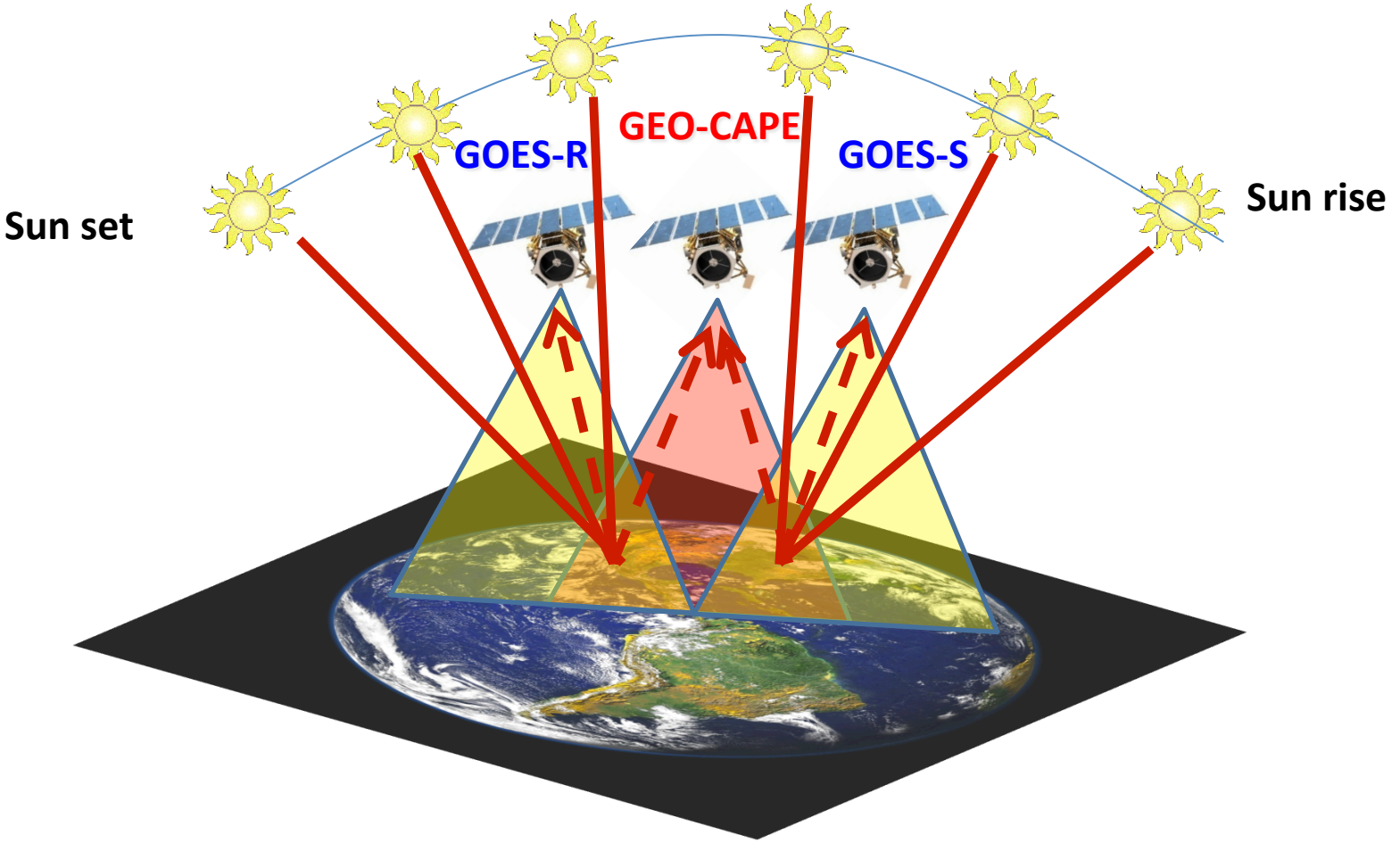


Applications to GEO-CAPE

Joint retrieval from observations collected from dual view angles and multiple scattering angles to:

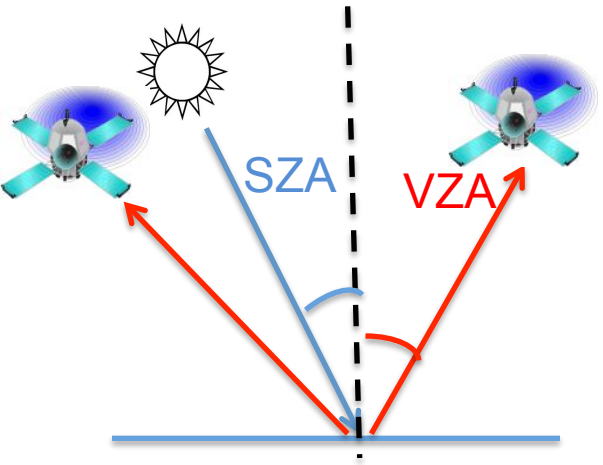
(1) characterize aerosol properties beyond the optical thickness. Size, Refractive index

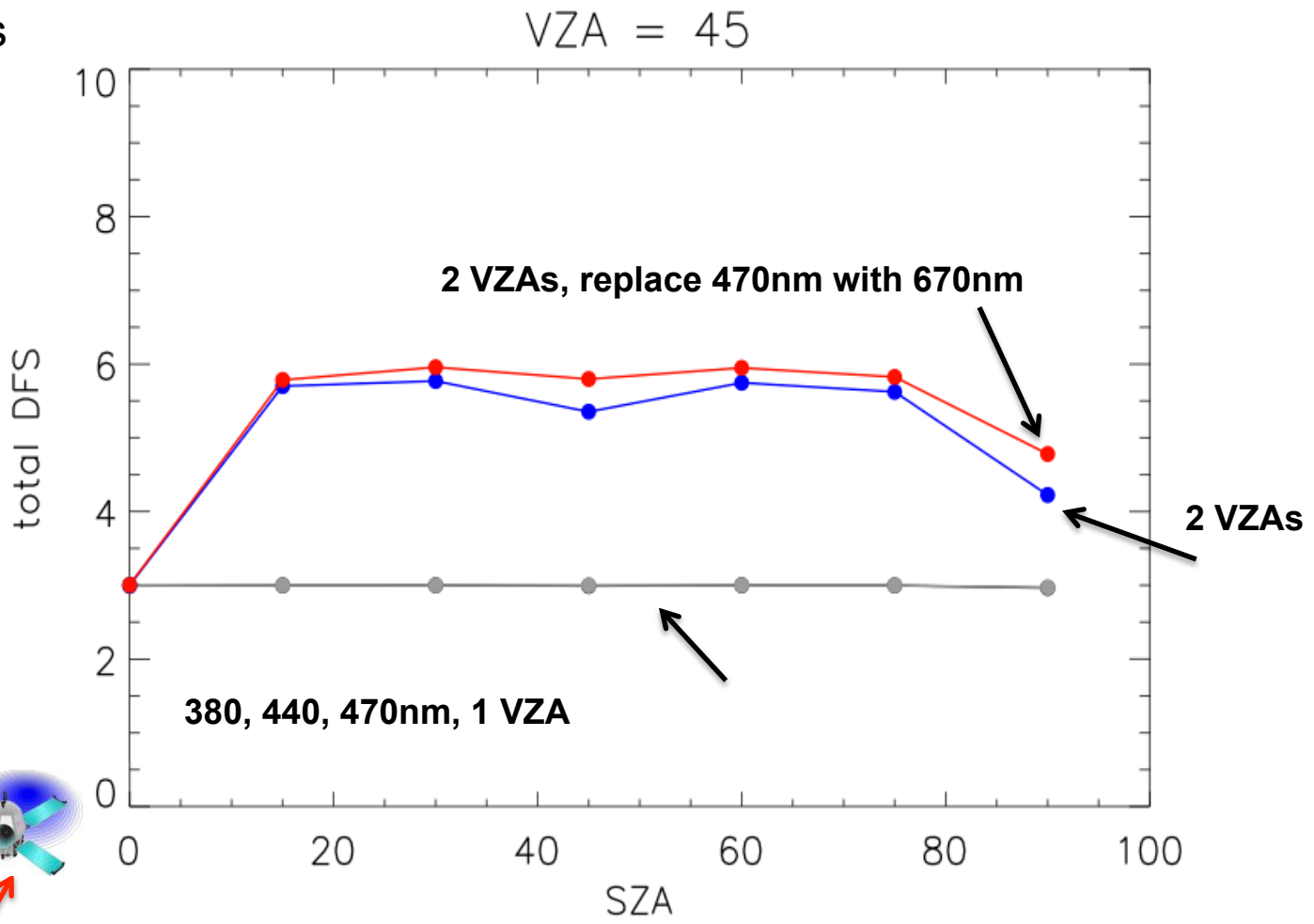
(2) derive the wind speed and stereo height of aerosol plume.



Experiments: 2 VZAs

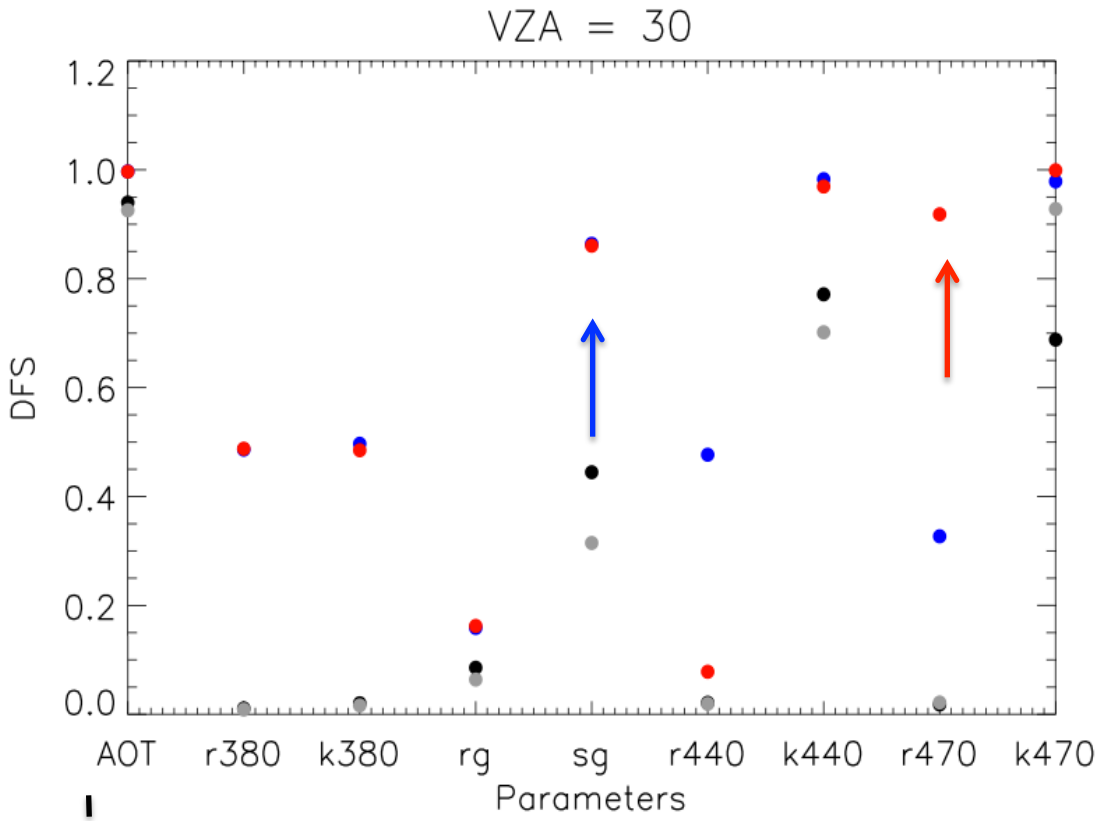
Two symmetric VZAs



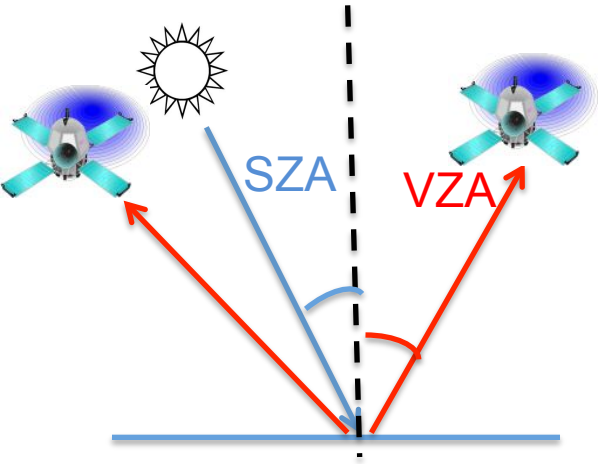


Input: dust-like particles from Hess et al., 1998, grassland surface, AOT scale height 2km, mid-lat summer
Assumptions: surface reflectance is perfectly known

Experiments: 2 VZAs

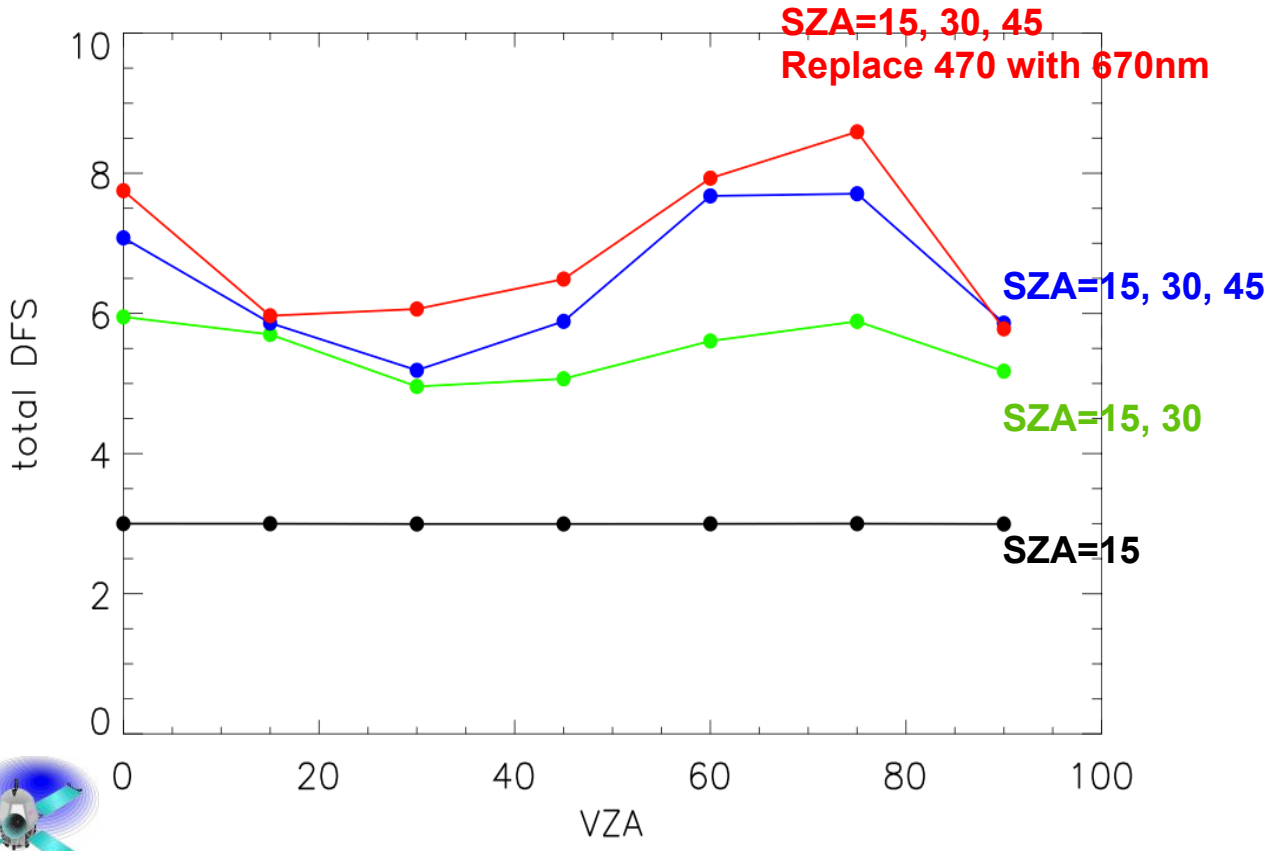


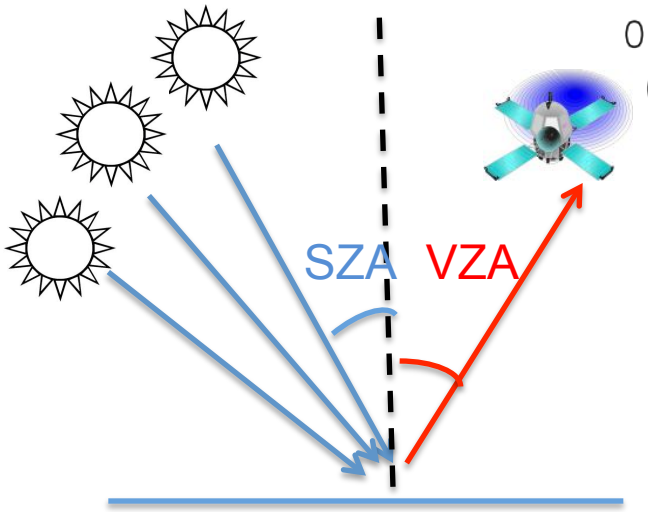
380, 440, 670nm, 2VZAs
380, 440, 470nm, 2VZAs
380, 440, 670nm, 1VZA
380, 440, 470nm, 1VZA



Particle size has a big impact on phase function particularly at the backscattering angles.

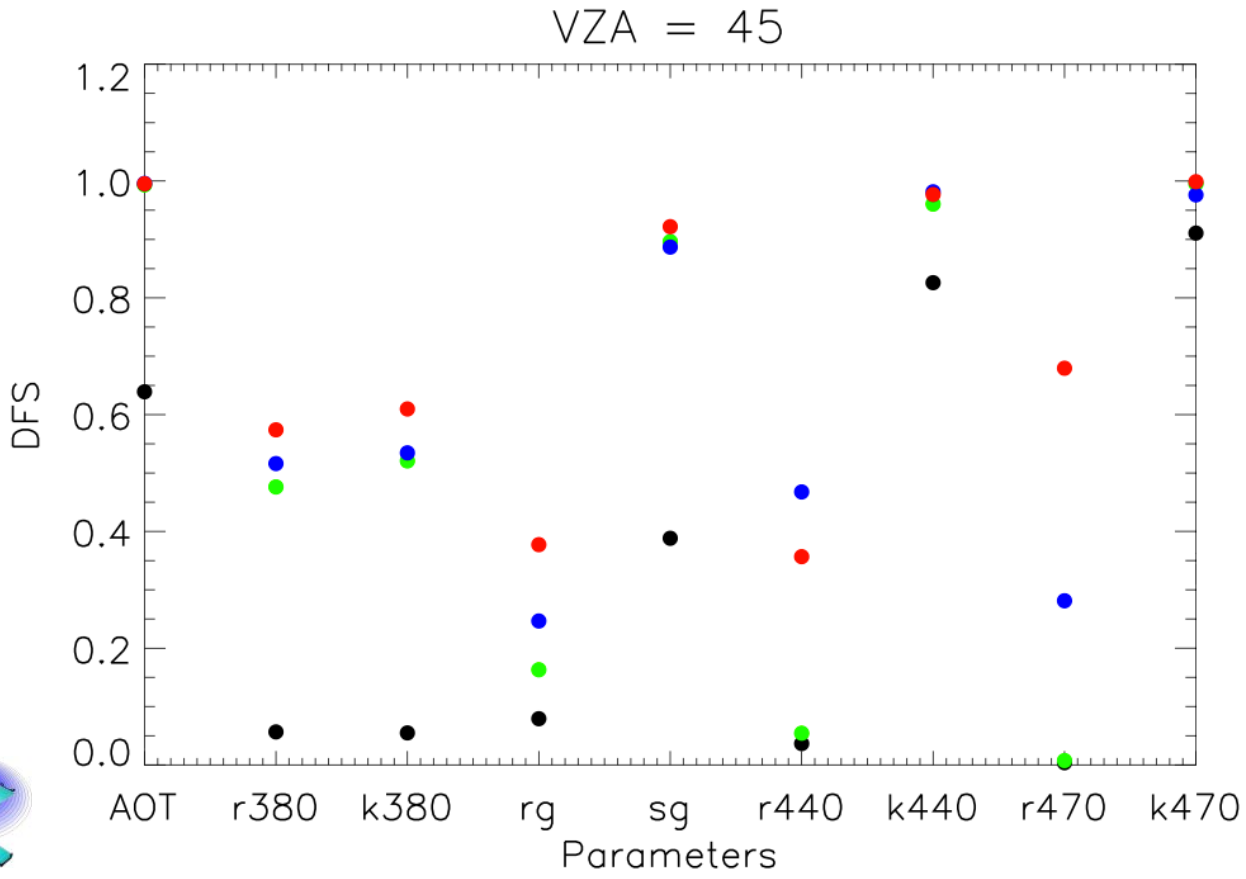
Experiments: 1 VZA & 3 SZA

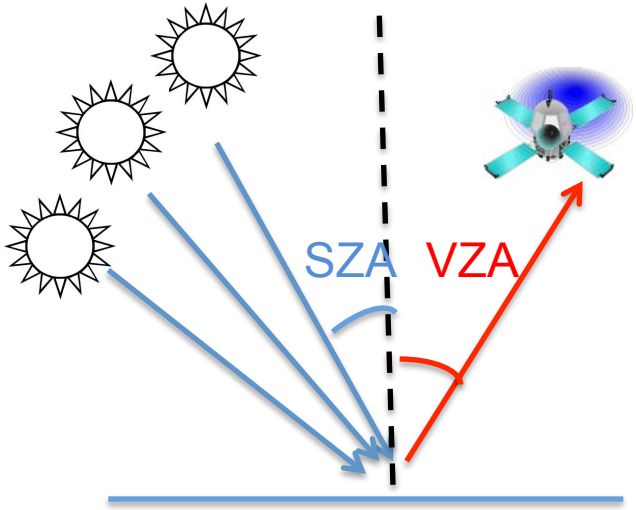




Experiments: 1 VZA & 3 SZA

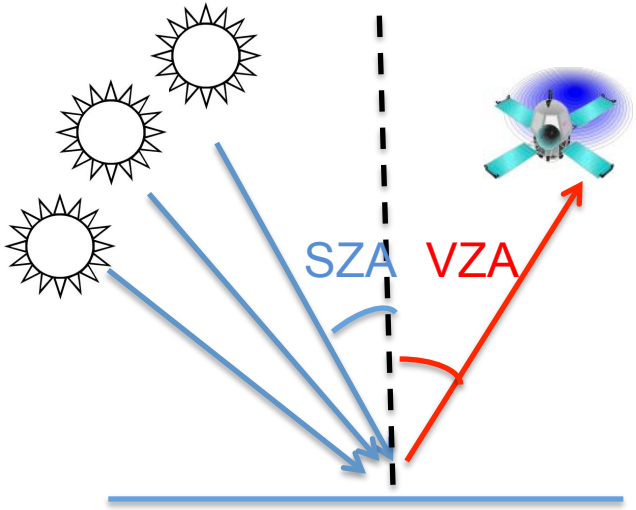
wavelength	SZA
380, 440, 670nm	15, 30, 45
380, 440, 470nm	15, 30, 45
380, 440, 470nm	15, 30
380, 440, 470nm	15

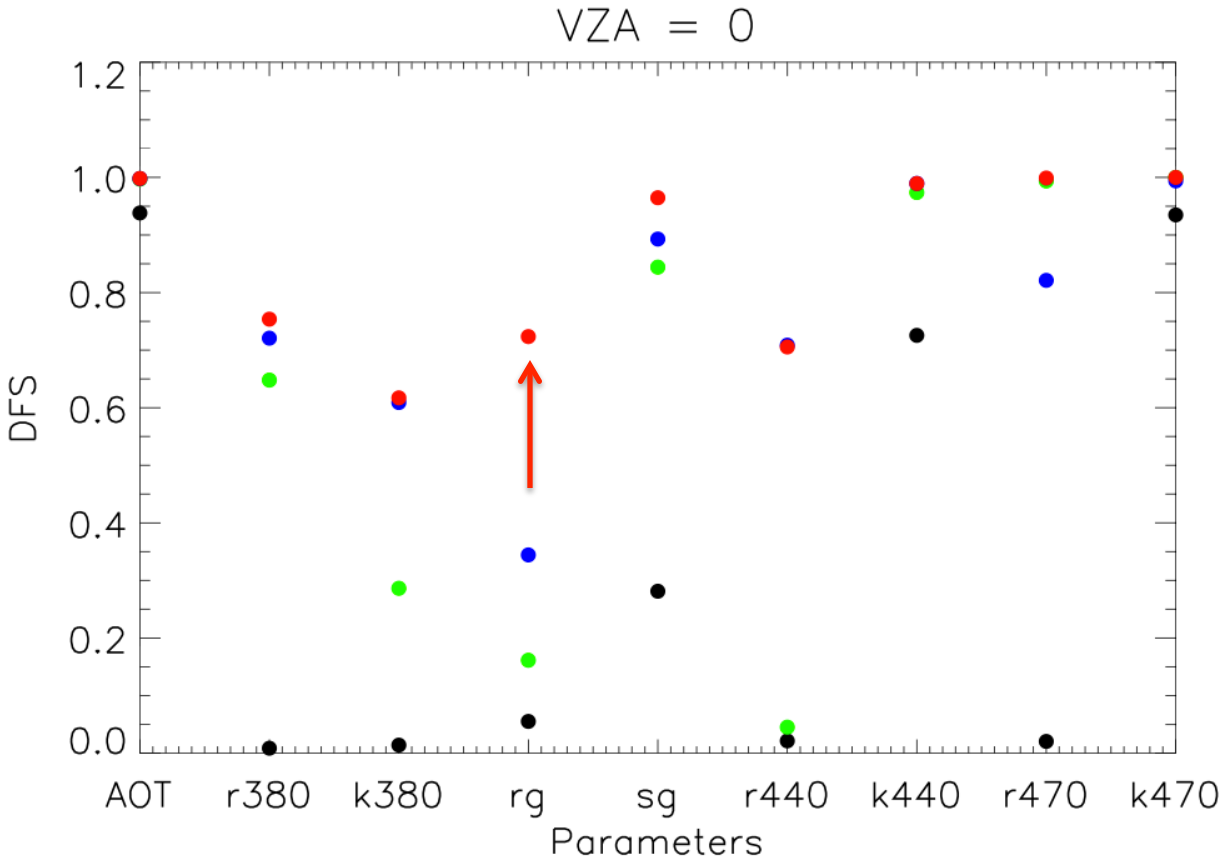




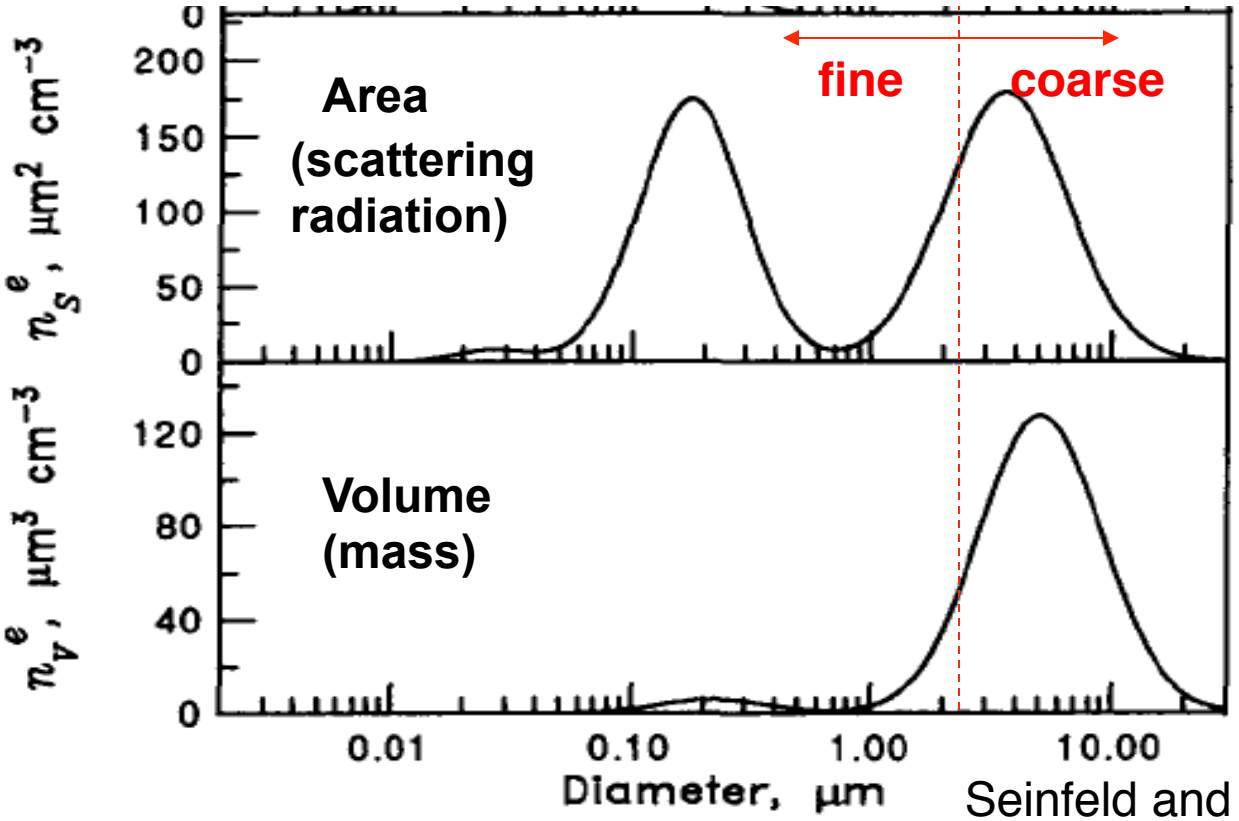
Experiments: 1 VZA & 3 SZA

wavelength	SZA
380, 440, 670nm	15, 30, 45
380, 440, 470nm	15, 30, 45
380, 440, 470nm	15, 30
380, 440, 470nm	15





Aerosol size is important…



AOT =
area per column * extinction efficiency

Seinfeld and Pandis, 2006.

Contributions of PM2.5 to total aerosols mass and optical thickness can be very different depending on the size.

Summary

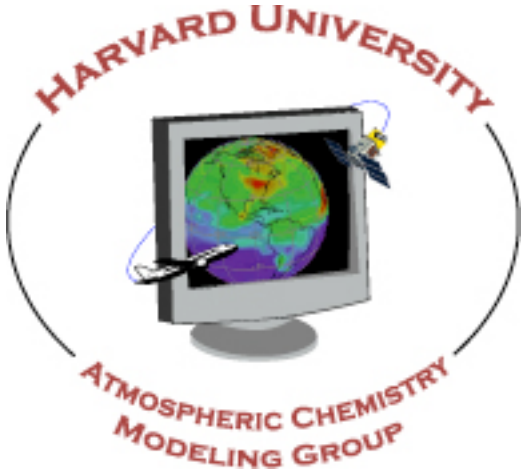
- A modeling framework is developed to study the information content for aerosol retrievals using multispectral and multiangle observations.
- First results show that the dual view angles offer the opportunity to retrieval more aerosol parameters beyond AOT, which enhances GEO-CAPE's synergy with other geostationary satellites.
- First results show that the retrievals with from three continuous observations (or at three solar zenith angles) offer the unique opportunity to retrieval more aerosol parameters beyond AOT, which indicates that GEO-CAPE can offer what polar-orbiting satellites can not offer to monitor temporal evolution of aerosol properties.
- Assumption that aerosol optical properties are nearly constant within 1-2 hours is reasonable. Note: the AERONET retrieval assumes constant aerosol properties during a full scan of skylight that takes ~0.5-1 hour.
- Adding longer wavelength in the visible will help to retrieve aerosol size parameters.

Next Steps

1. Include surface effect.
2. Study the retrieval of aerosol plume height
3. Thorough study with more modeling/observation data
4. Collaboration with gas retrieval group

Thank you !

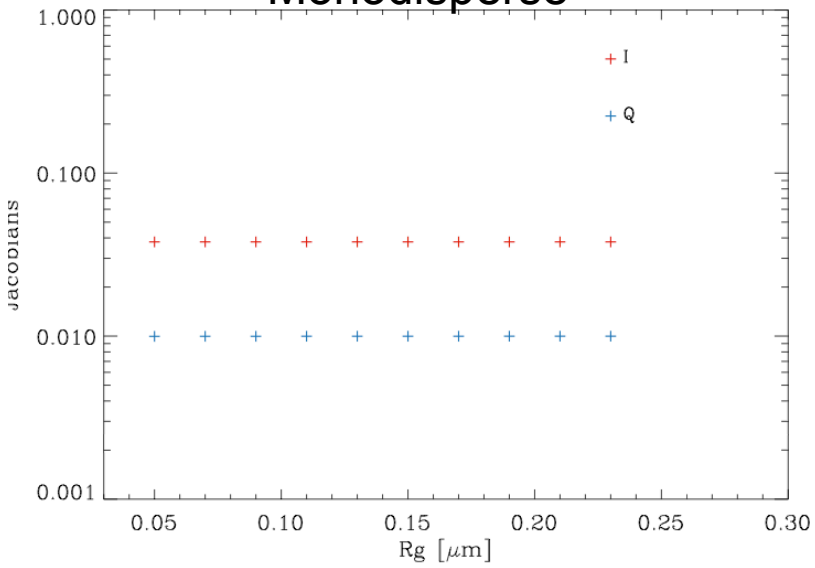

NASA


HARVARD UNIVERSITY
ATMOSPHERIC CHEMISTRY
MODELING GROUP

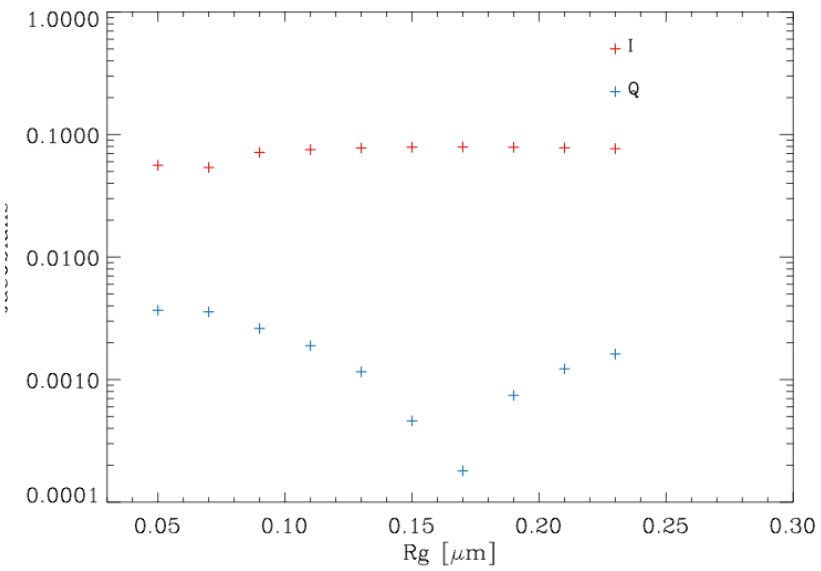
Single wavelength retrieval is most sensitive to AOT

$$\frac{\partial[I,Q]}{\partial\tau}\tau$$

Monodisperse



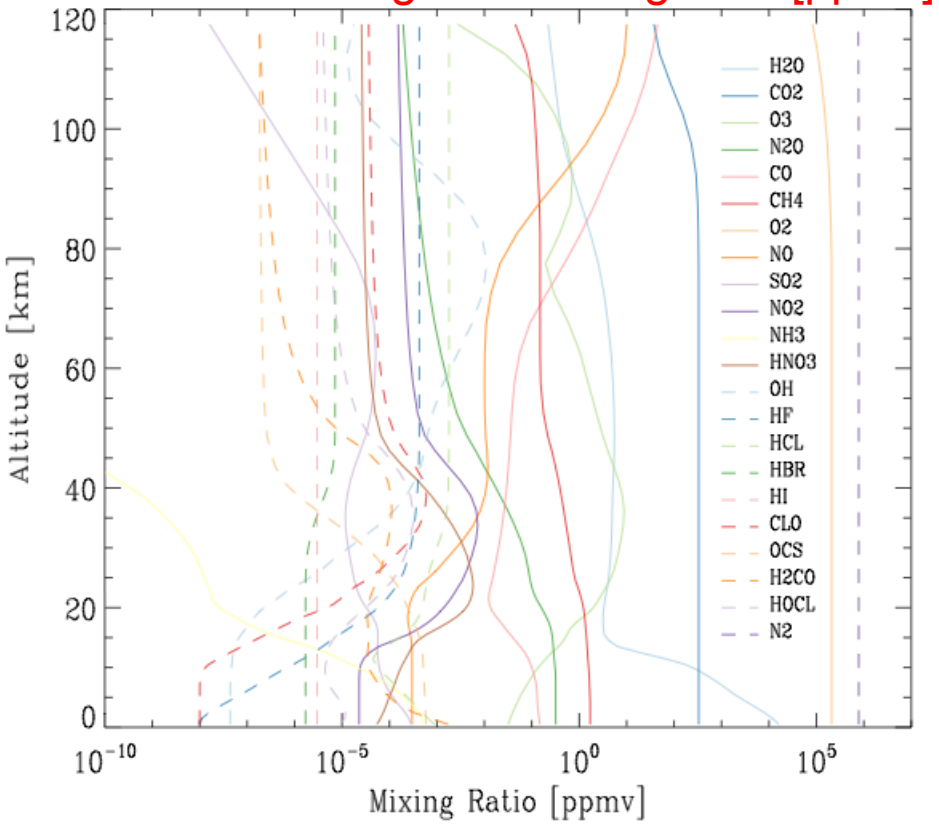
Log-normal



Assume monodisperse size distribution, moderate absorbing (mr=0.005)
lamda = 0.67 μm , sfc_ref = 0.07

Model Structure

Profile of trace gases mixing ratio [ppmv]



Scientific Questions

Air quality applications require knowledge of:

- Dry (RH < 30-50%)
- particle mass
- size (diameter) less than 2.5µm
- near the surface (~2-10 m)

Satellite remote sensing offers:

- Ambient (RH < 30-50%)
- particle extinction
- at all sizes
- integrated in a column

Climate studies require: