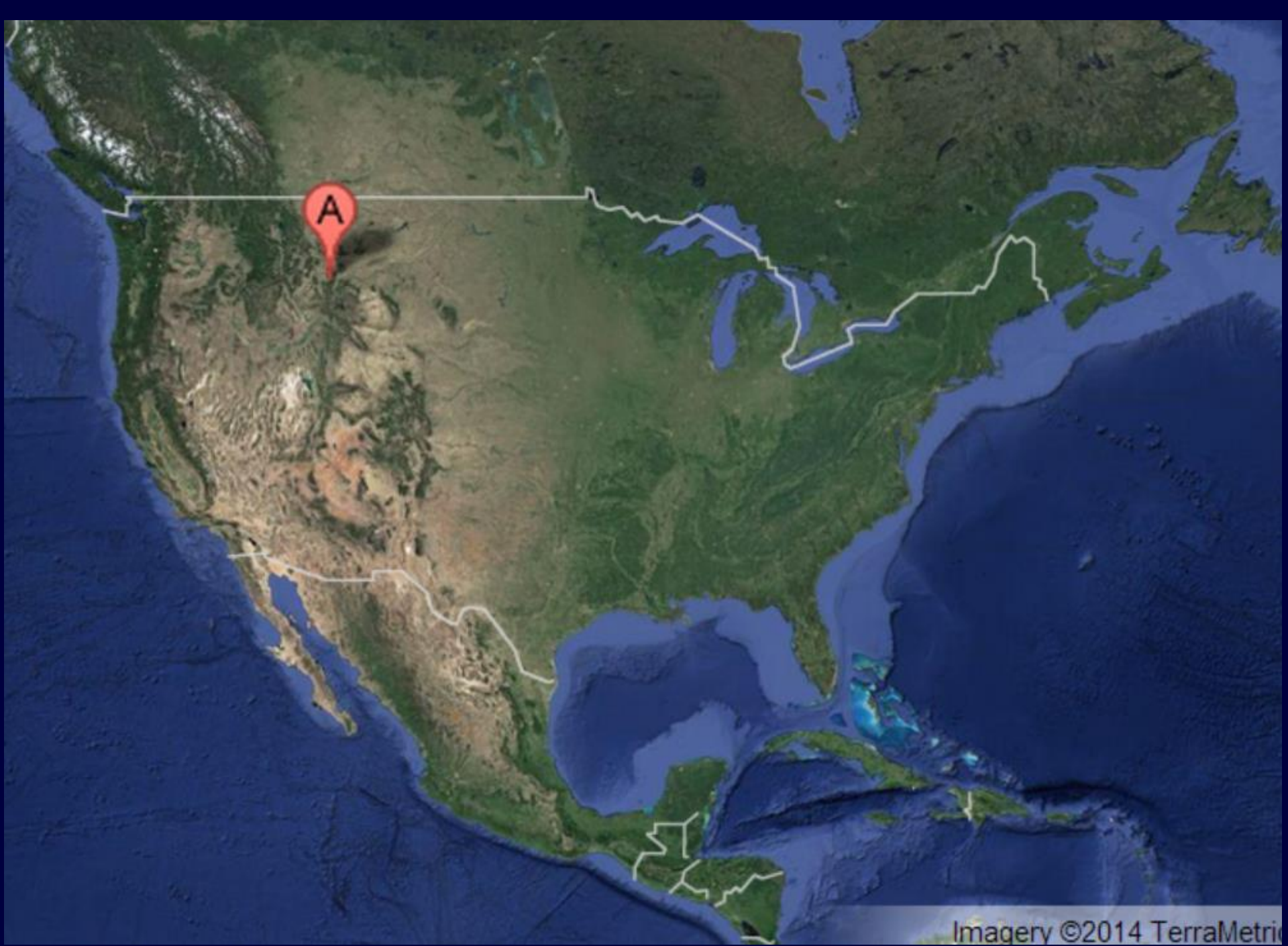


All-Sky Polarization Imaging with Spatially & Temporally Variable Aerosols

Joseph A. Shaw
Montana State University
Bozeman, Montana USA



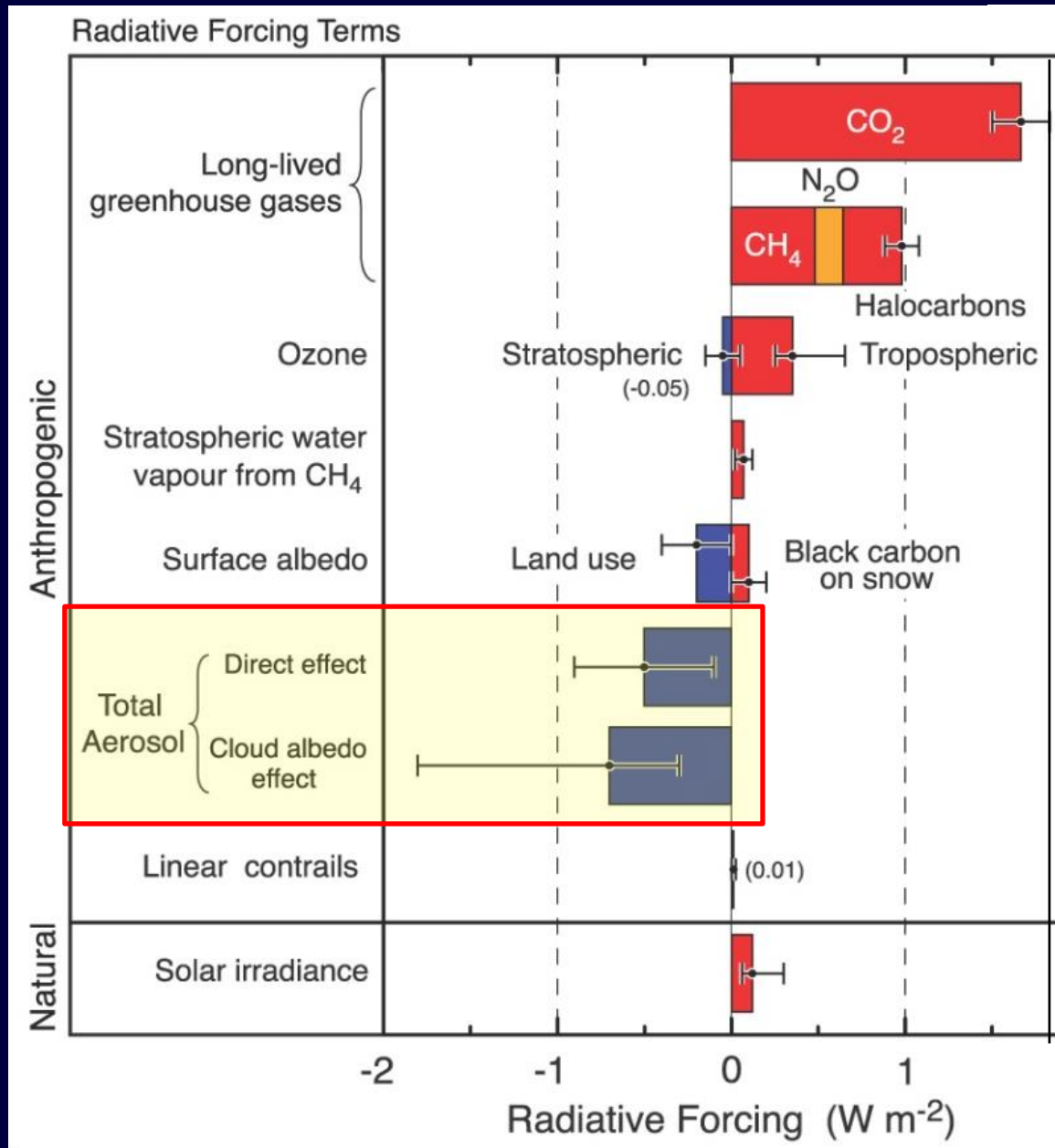


J. A. Shaw



J. A. Shaw

Largest climate uncertainties = clouds & aerosols

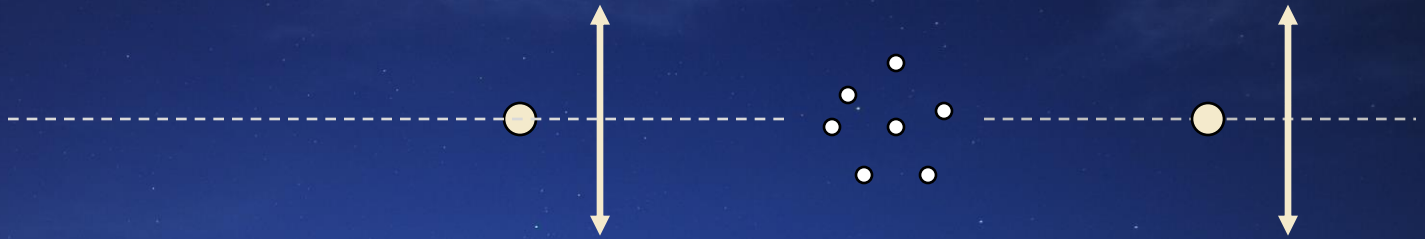


Sunlight is partially polarized by scattering

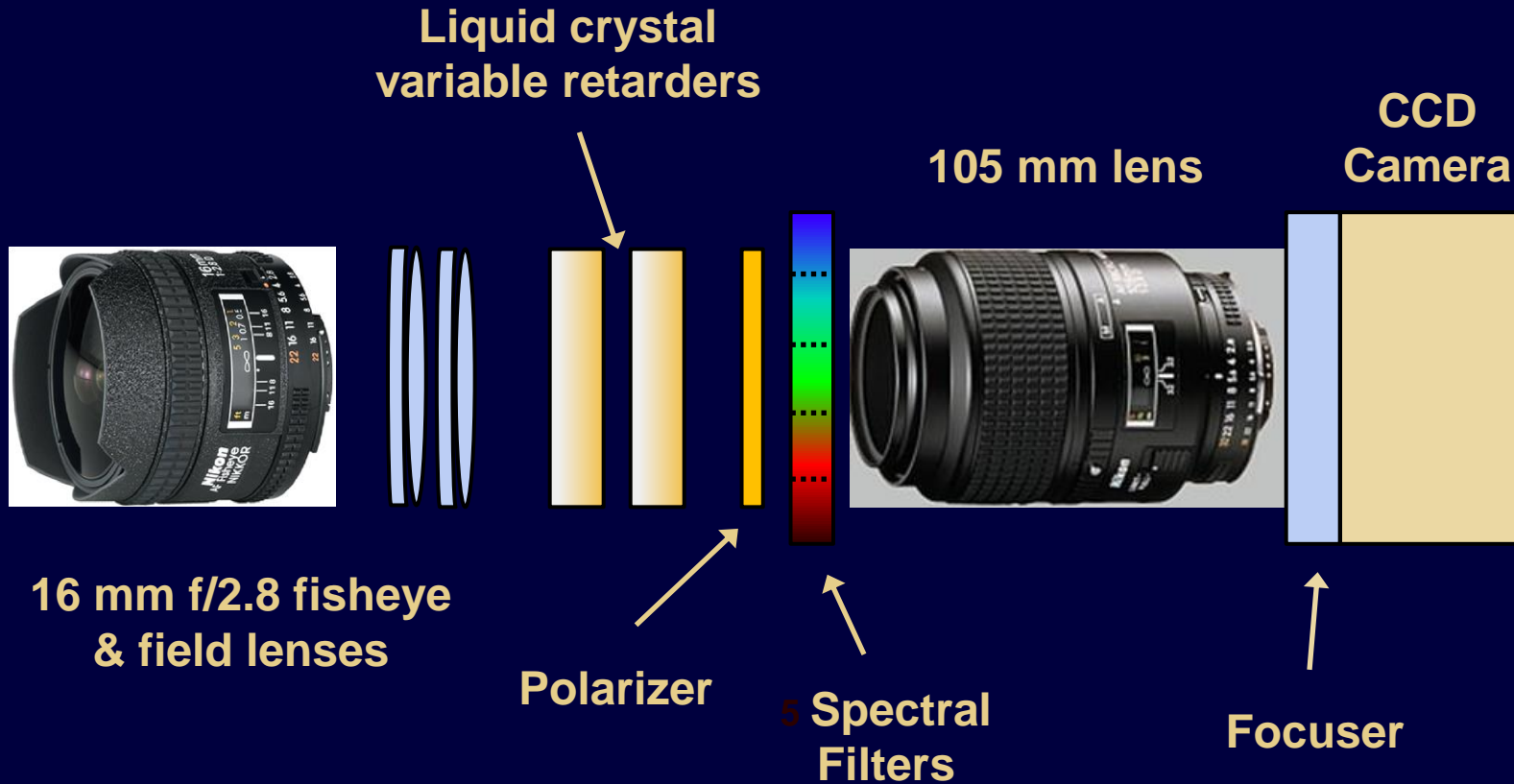


J. A. Shaw

Rayleigh scattering predicts 100% polarization 90° from the sun

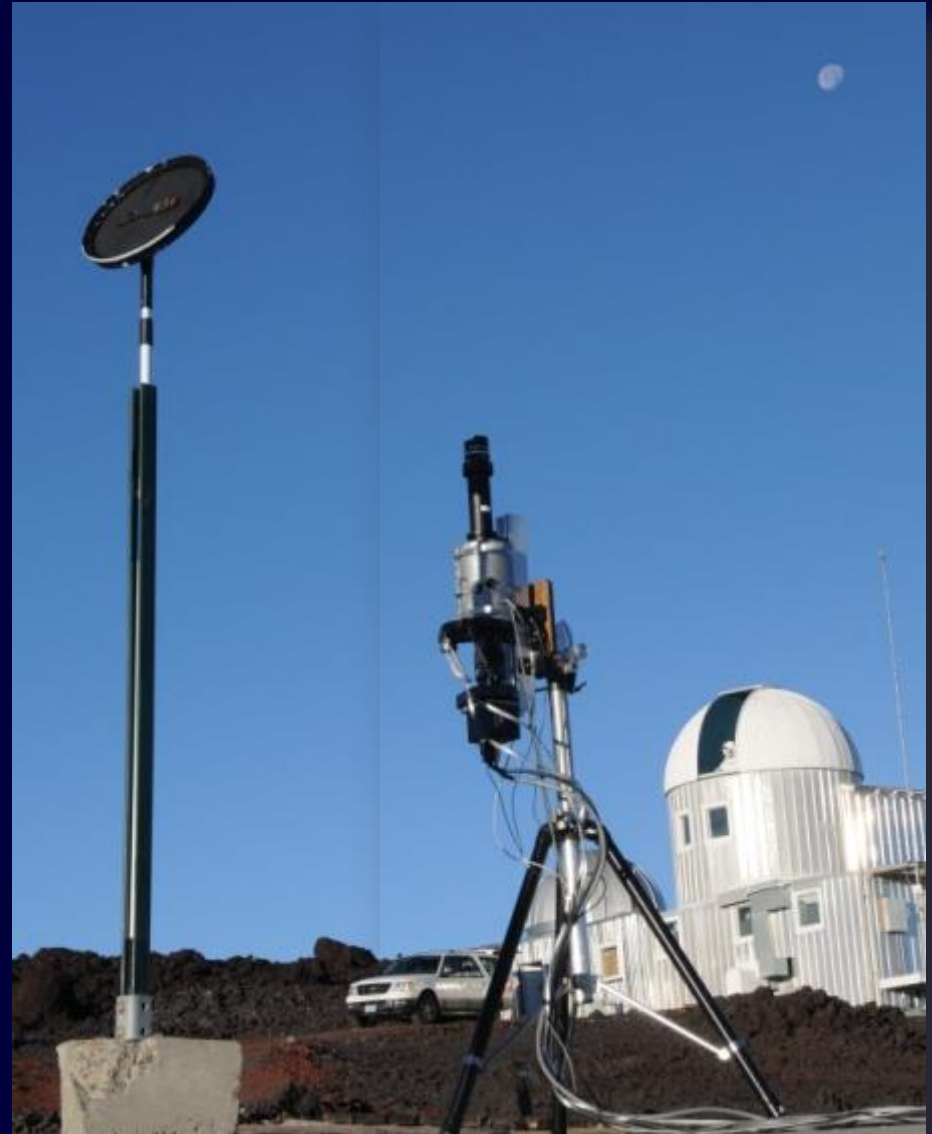


All-sky polarization imager



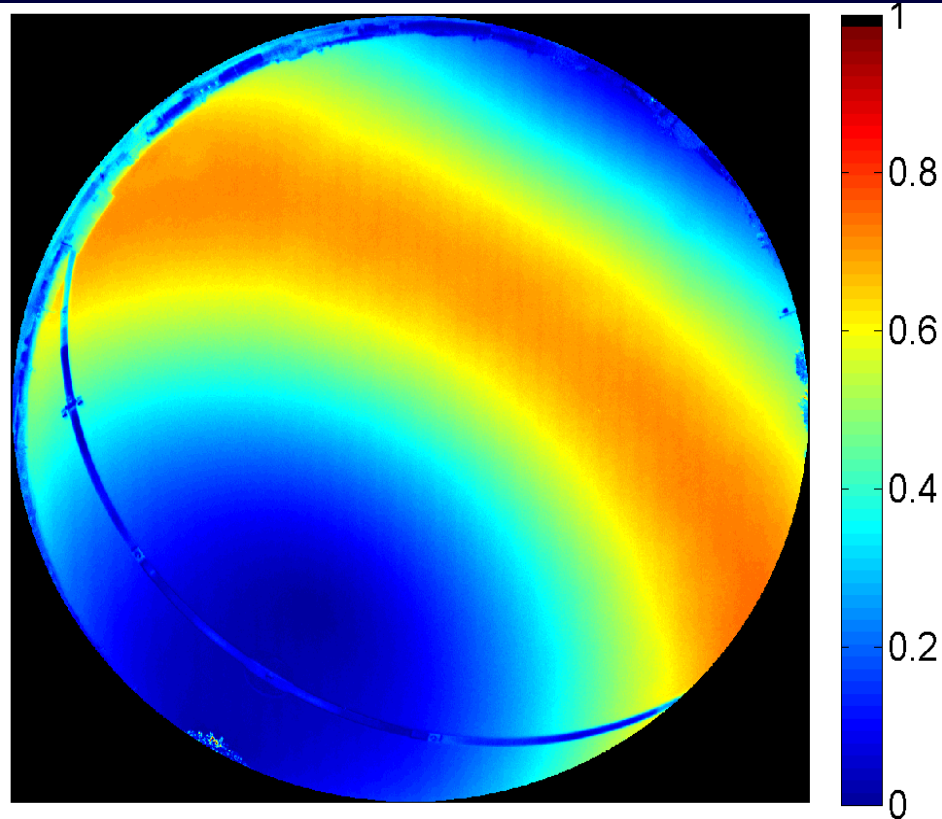
Wavelengths: 450, 490, 530, 670, 780 nm

Deployment at Mauna Loa

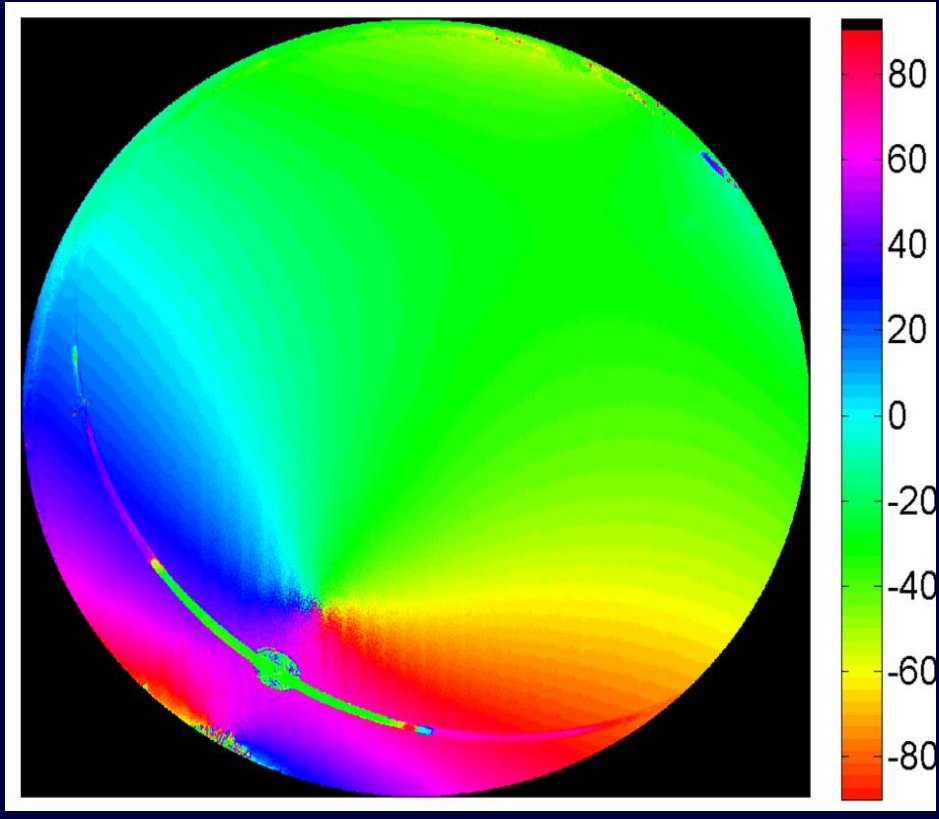


All-sky polarization images

Degree of Polarization



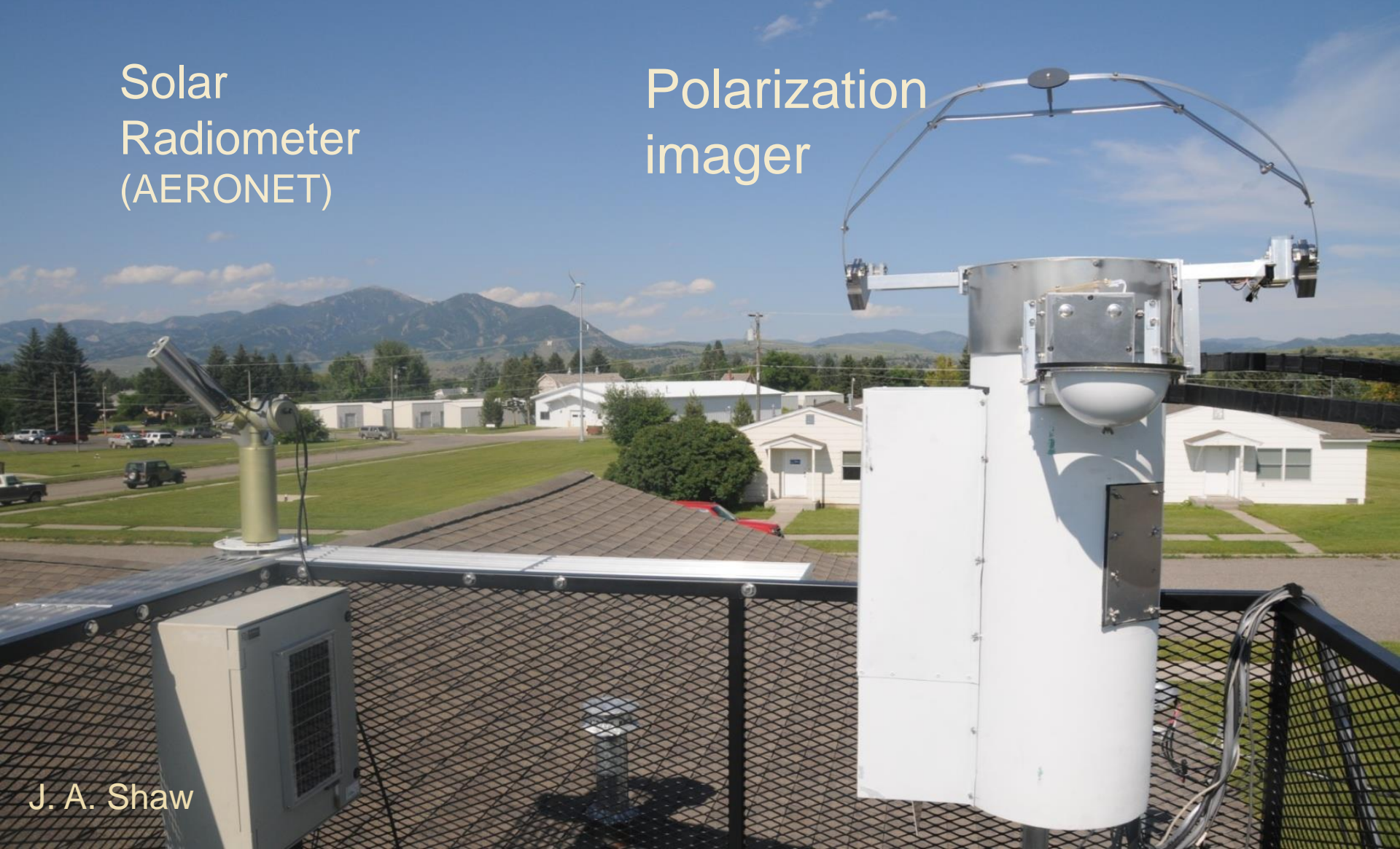
Angle of Polarization



All-sky polarization imager with automated sun occulter

Solar
Radiometer
(AERONET)

Polarization
imager



J. A. Shaw

Aerosol measurements

Size distributions

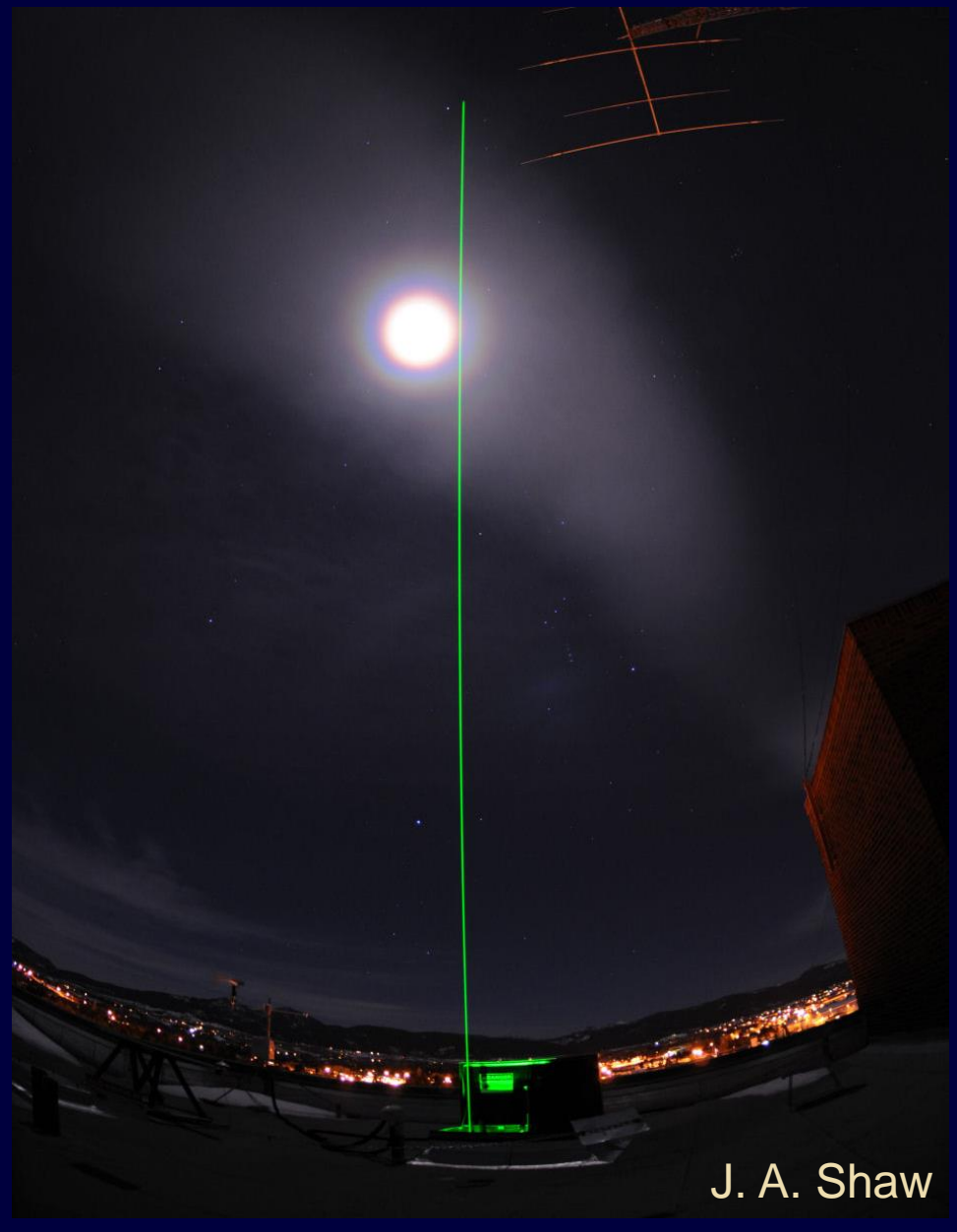
- $10 \text{ nm} \leq D \leq 0.5 \text{ }\mu\text{m}$
- $0.2 \text{ }\mu\text{m} \leq D \leq 20 \text{ }\mu\text{m}$

Scattering (3λ)

Extinction (3λ)



Cloud imager, dual-polarization lidar, ...

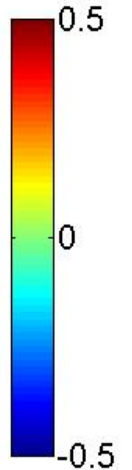
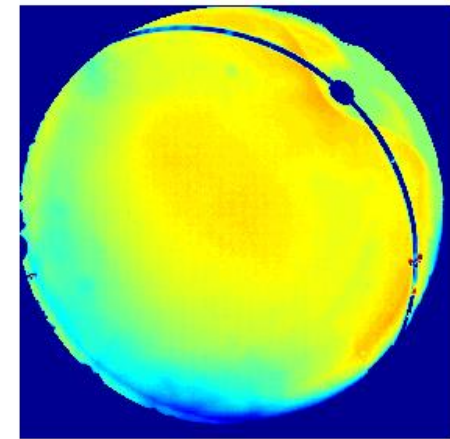
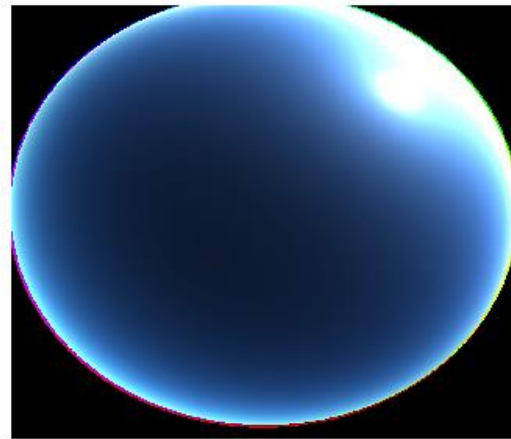
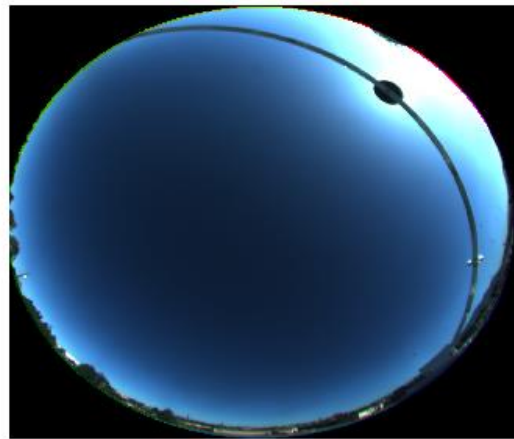


Measured and modeled sky polarization

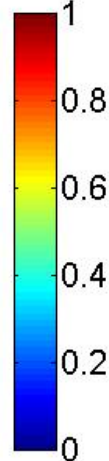
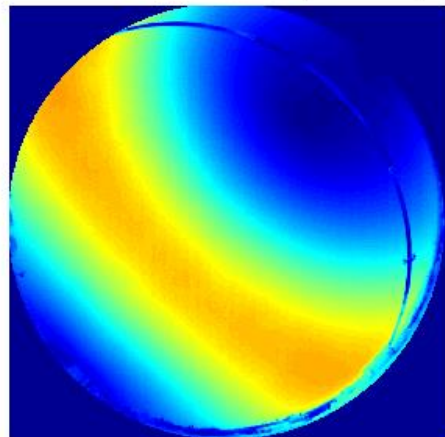
Local Time: 2009-09-02 09:32 Sun Zenith: 62.3°
SOS Model Radiance

450 nm
Radiance Error

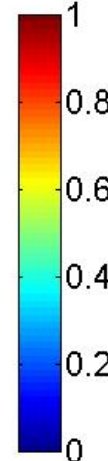
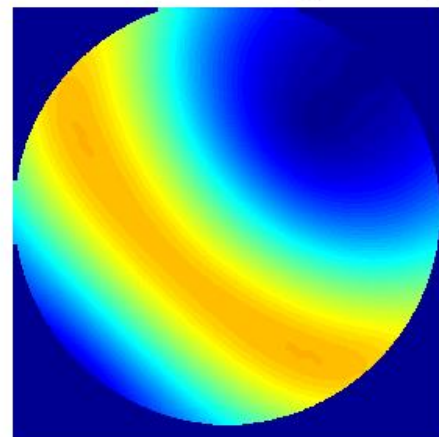
Polarimeter Radiance



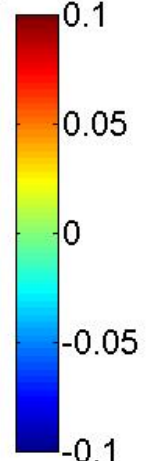
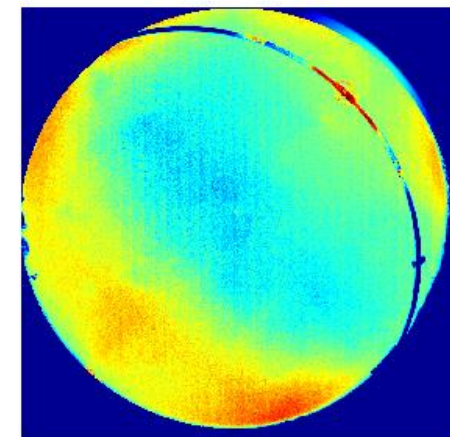
Polarimeter DoLP (450 nm)



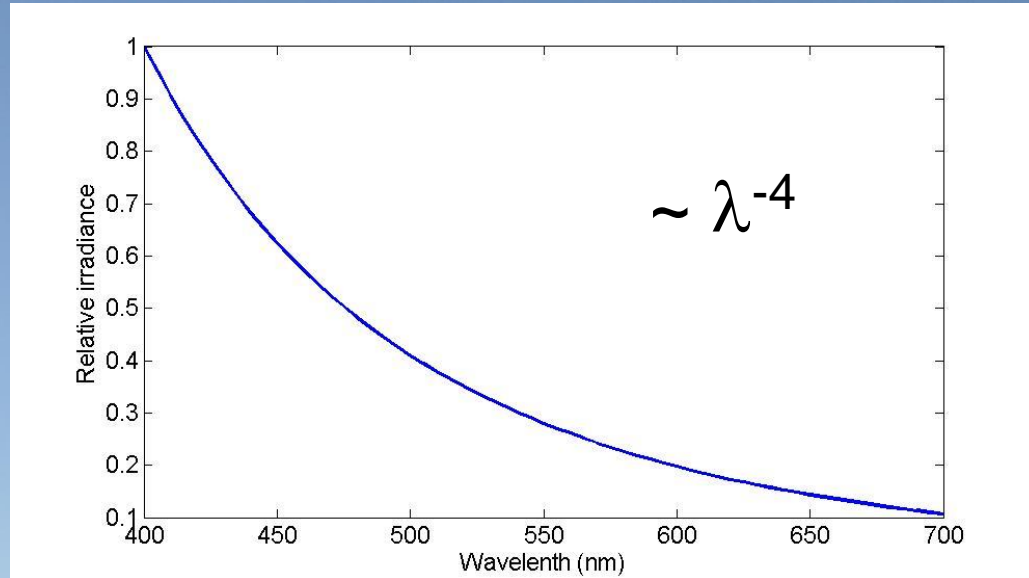
SOS Model DoLP (450 nm)



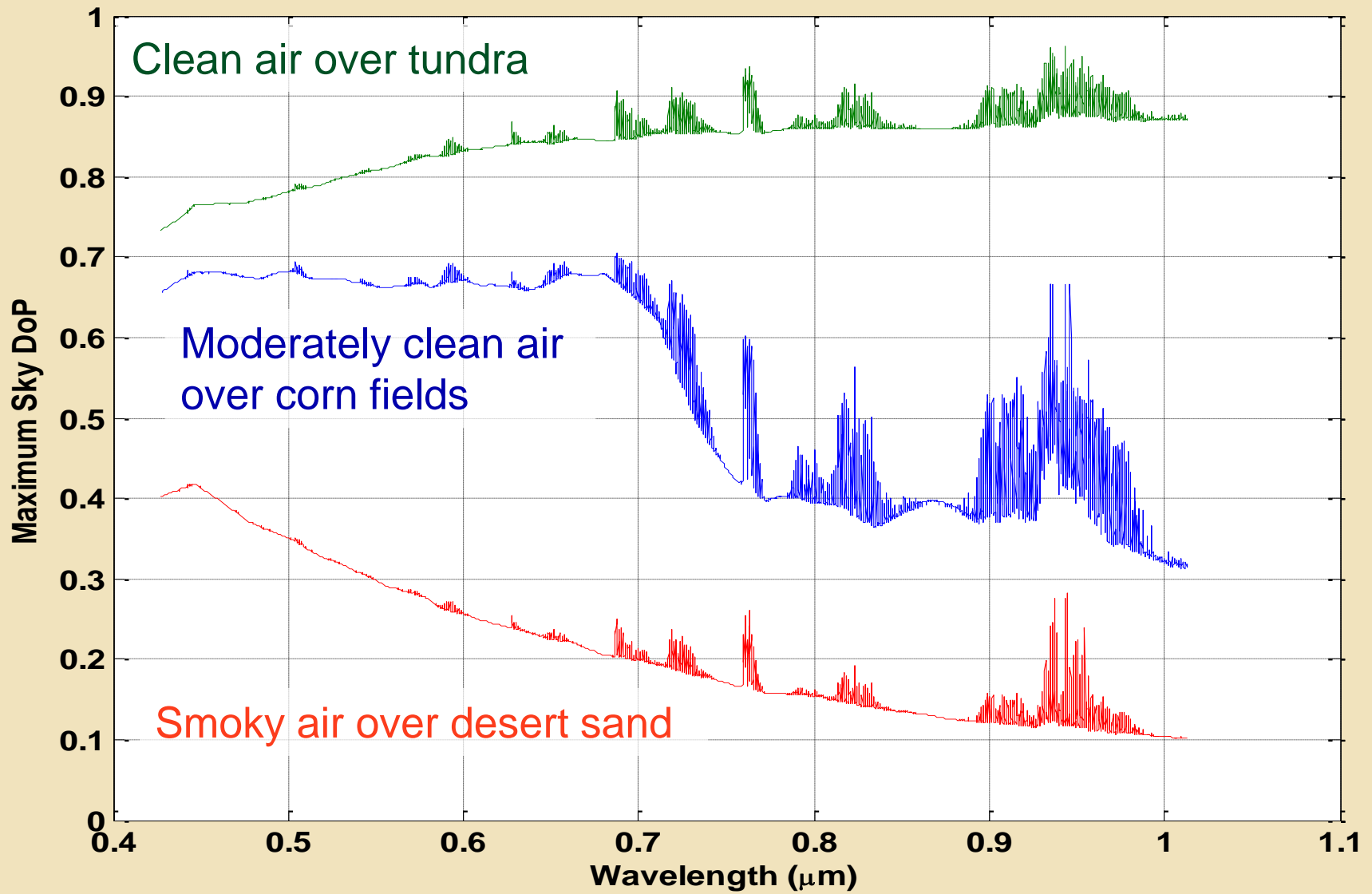
DoLP Error (Observed - Model)



Rayleigh scattering by gas molecules



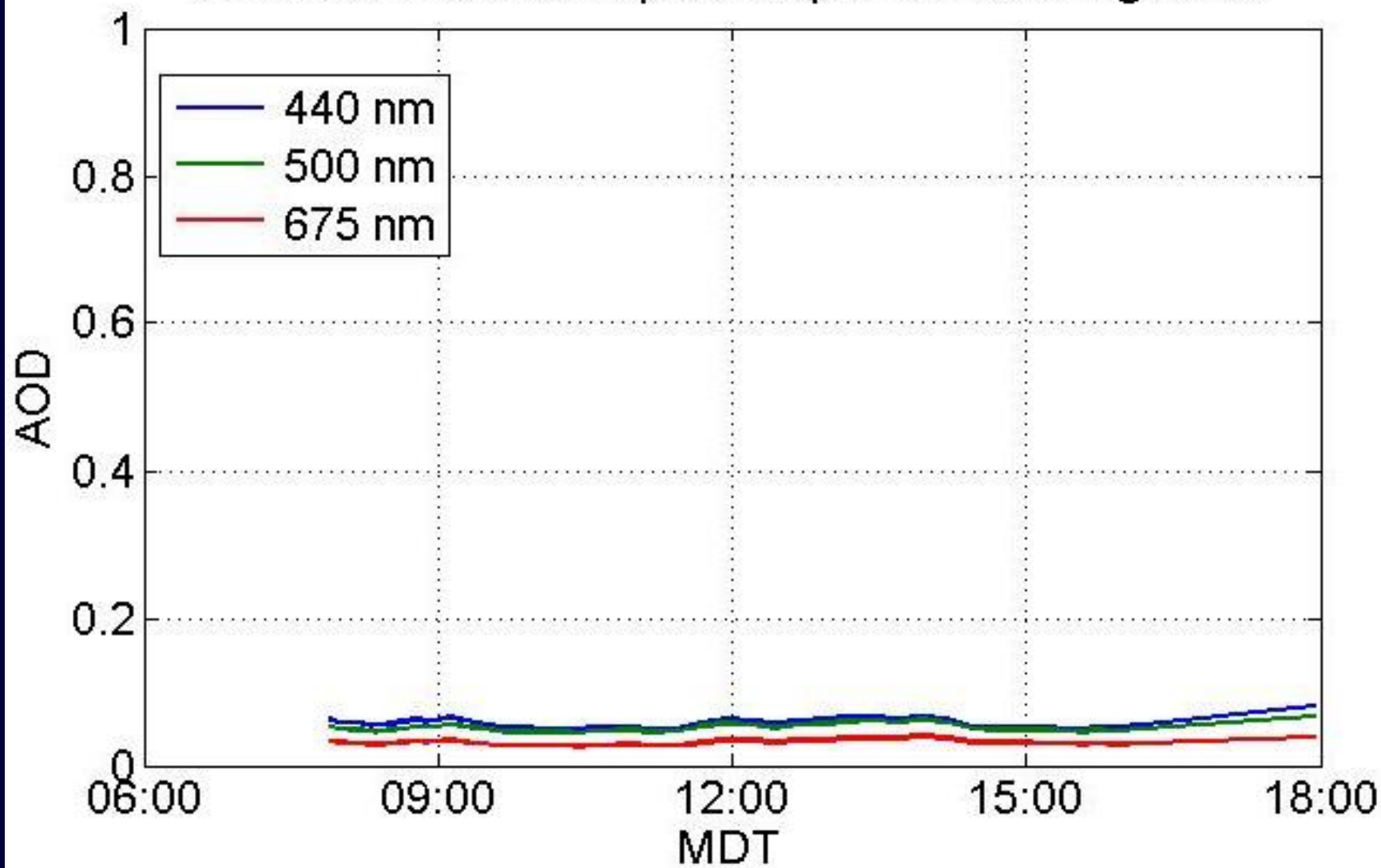
Skylight polarization spectra



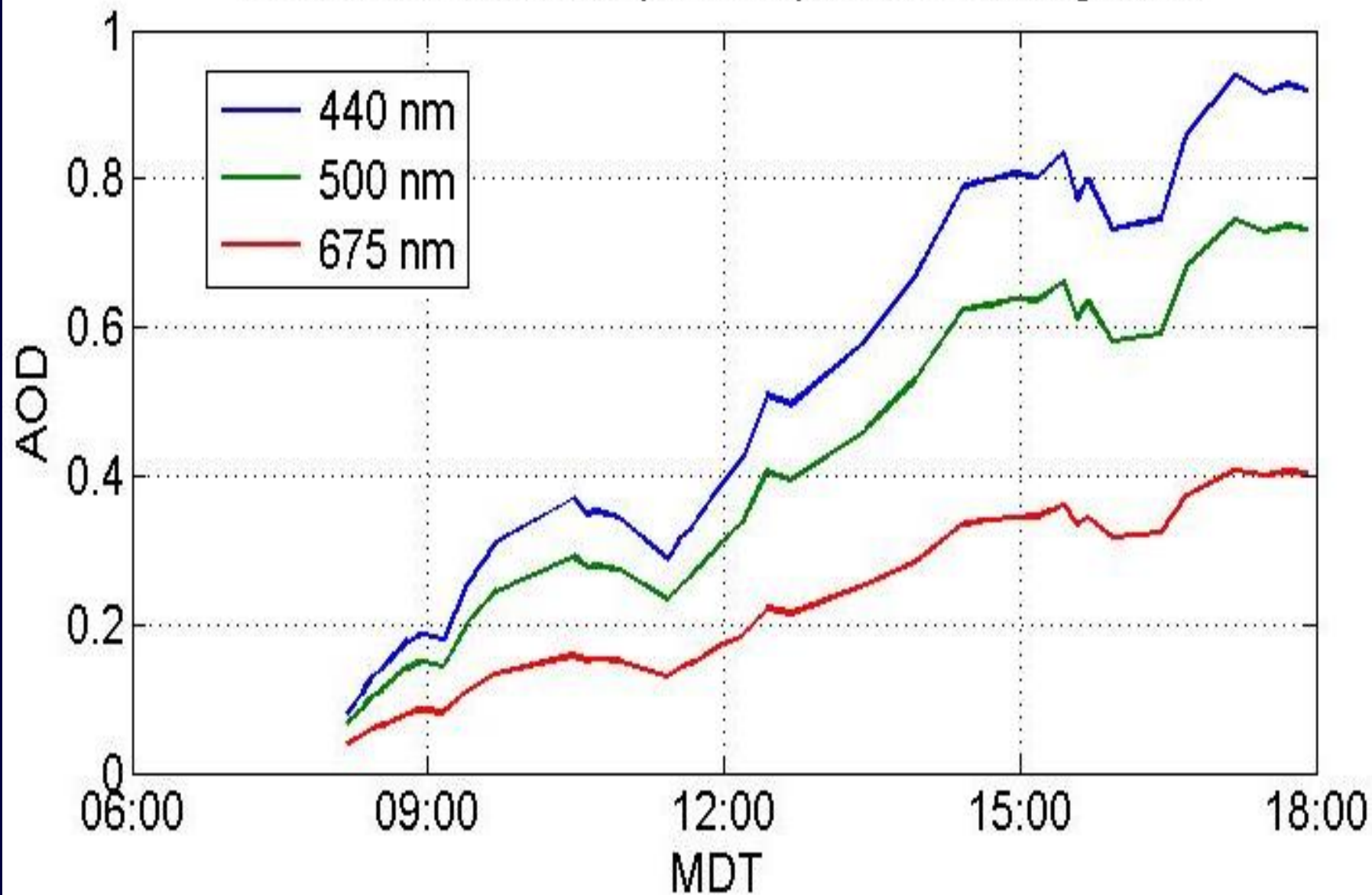
Wildfire smoke



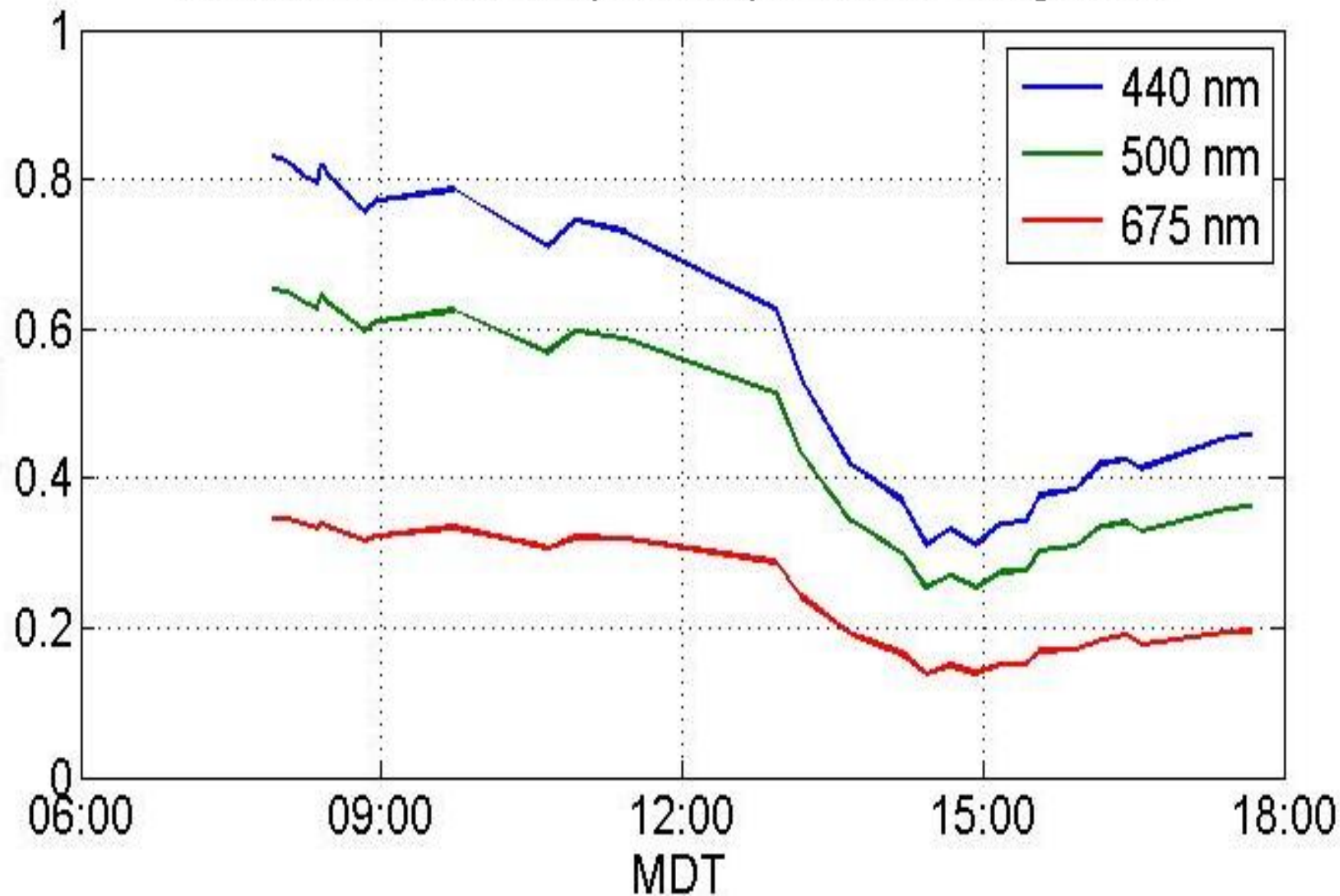
AERONET aerosol optical depth from 28-Aug-2012



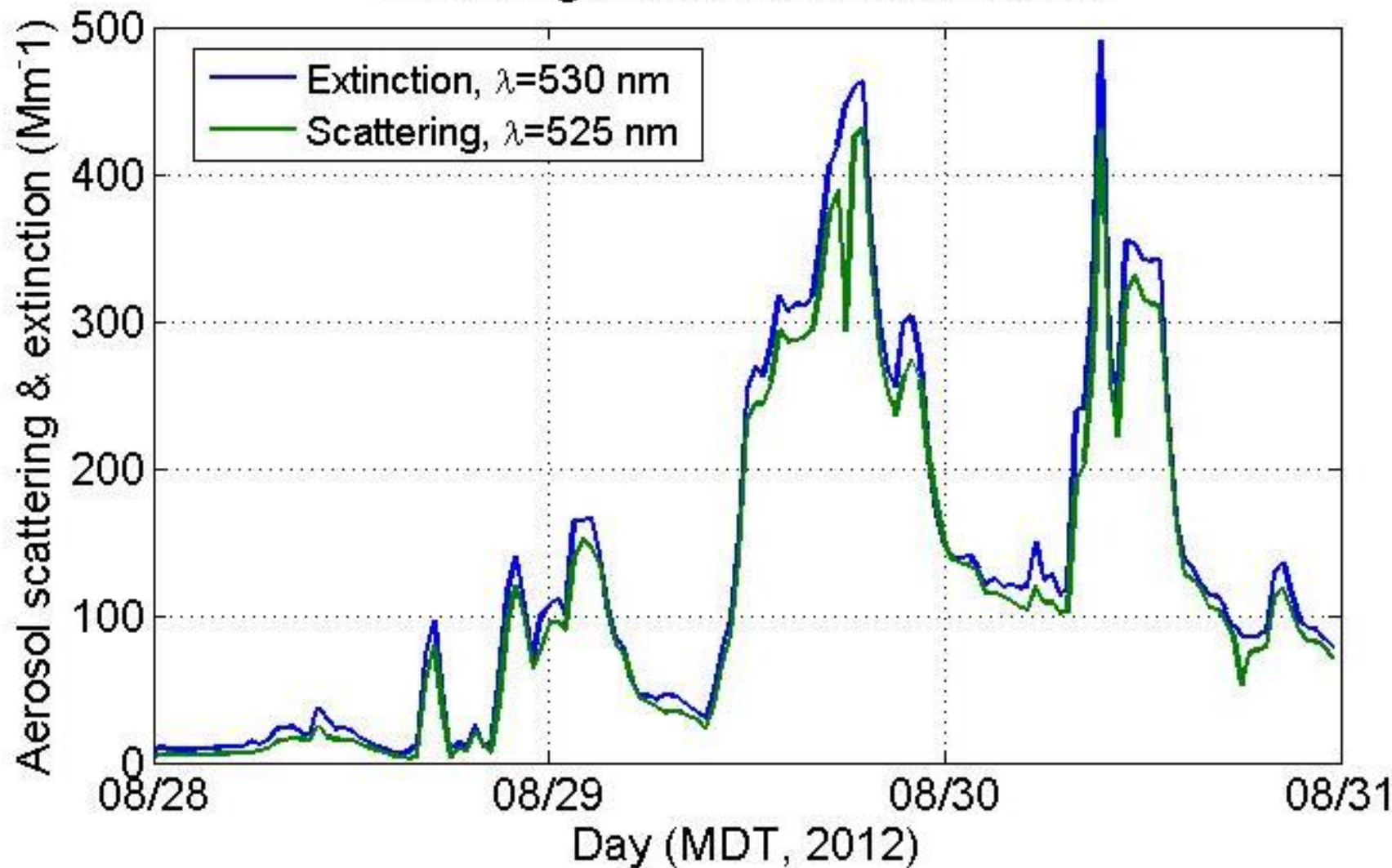
AERONET aerosol optical depth from 29-Aug-2012



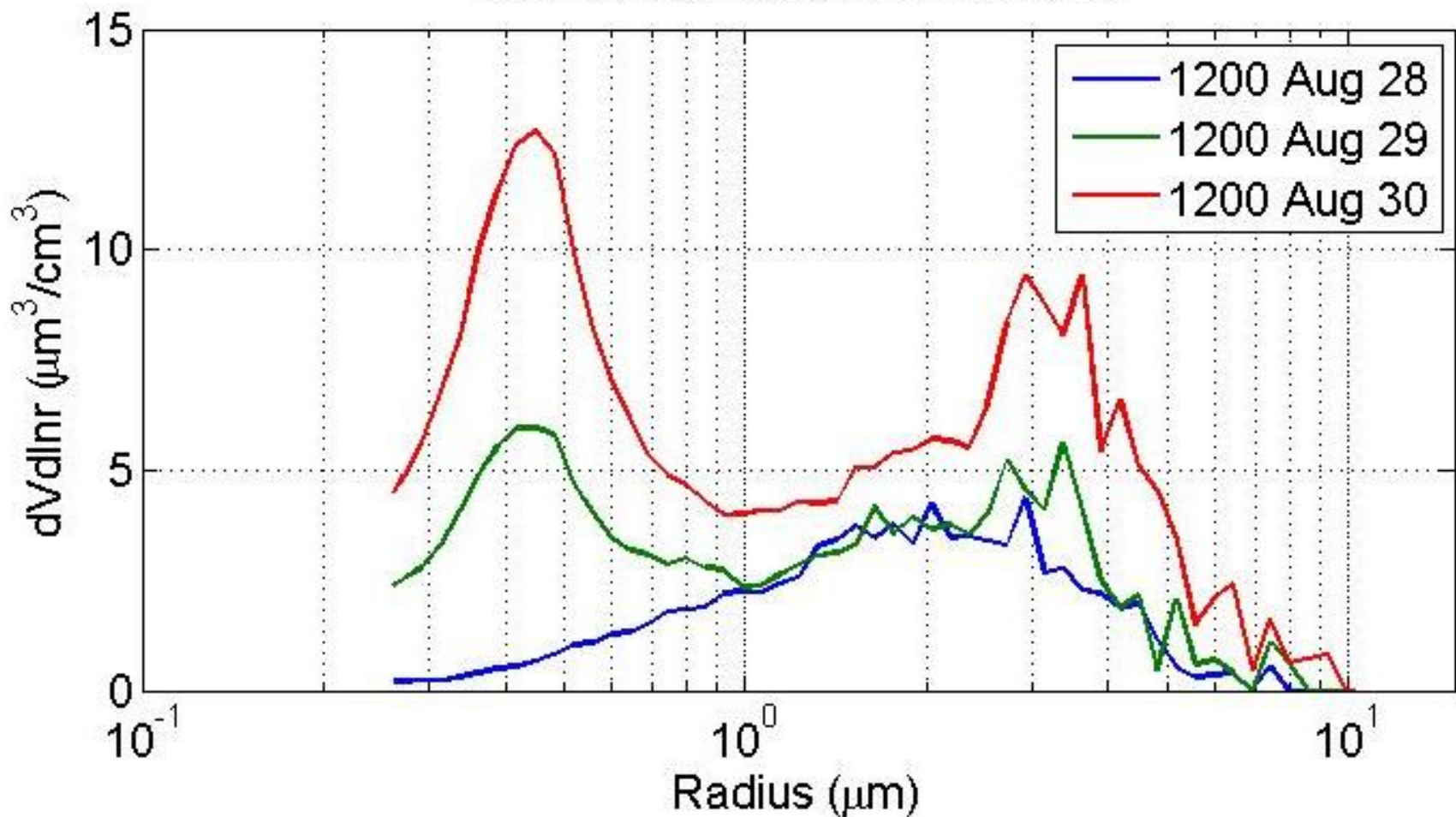
AERONET aerosol optical depth from 30-Aug-2012



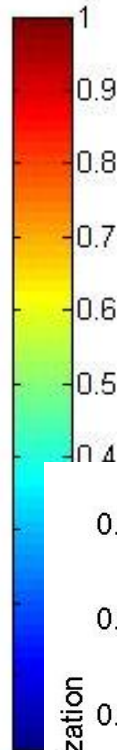
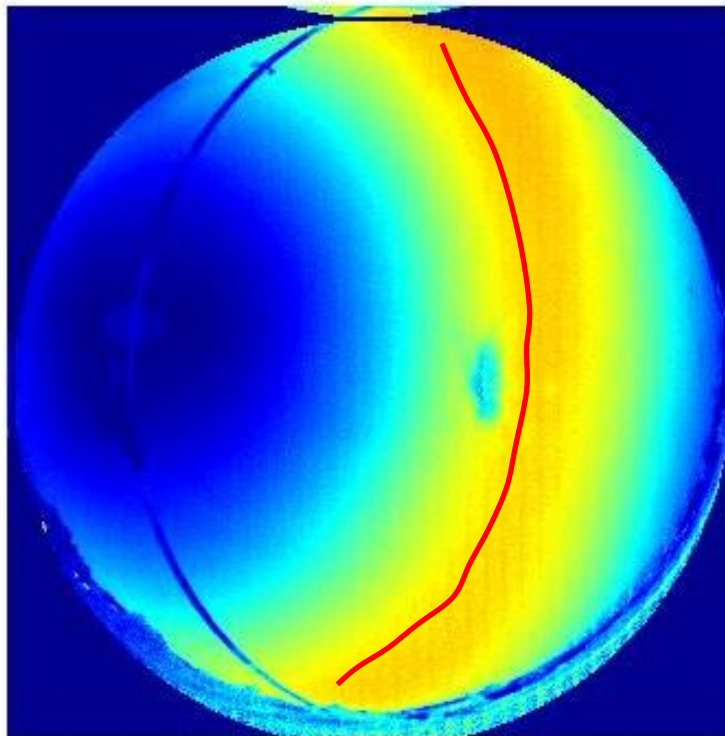
Scattering and extinction coefficients



Volume Distribution of Aerosols

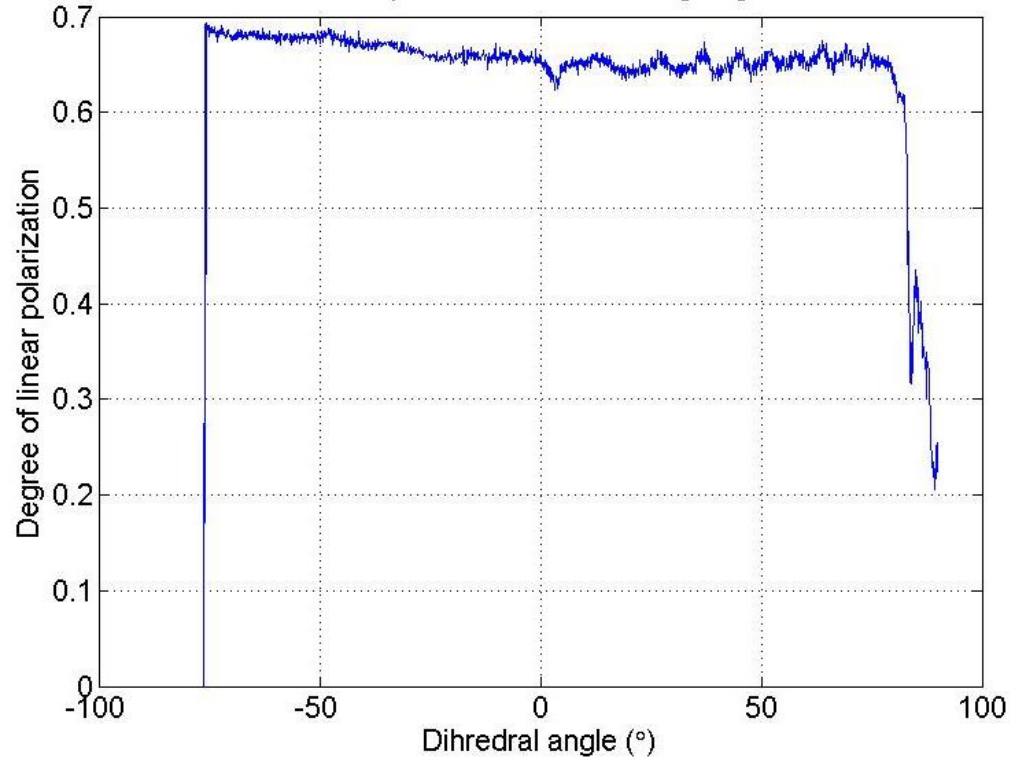


Degree of linear polarization
28 Aug 2012 16:00 0.45 μm

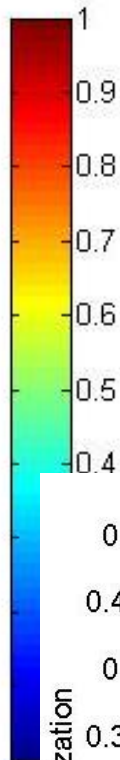
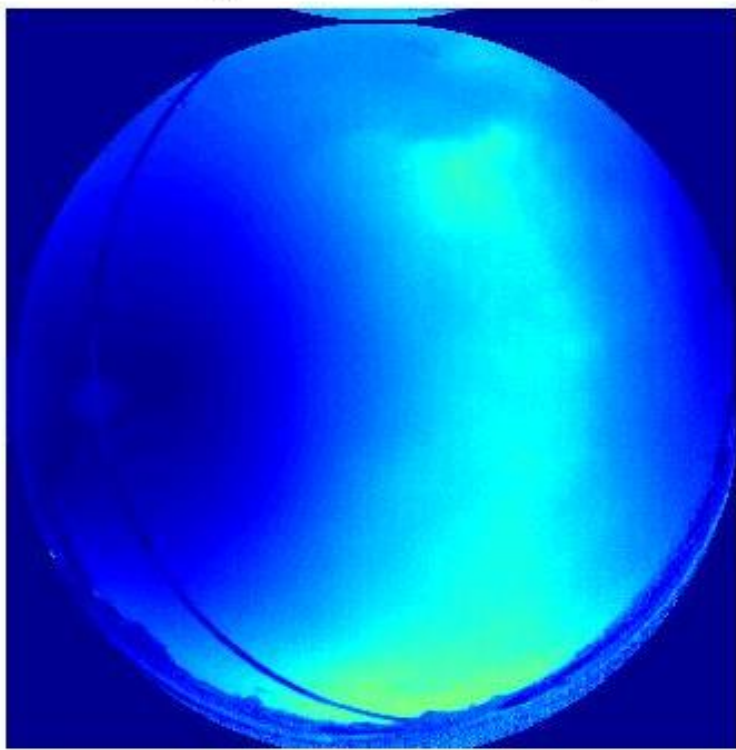


Before the plume

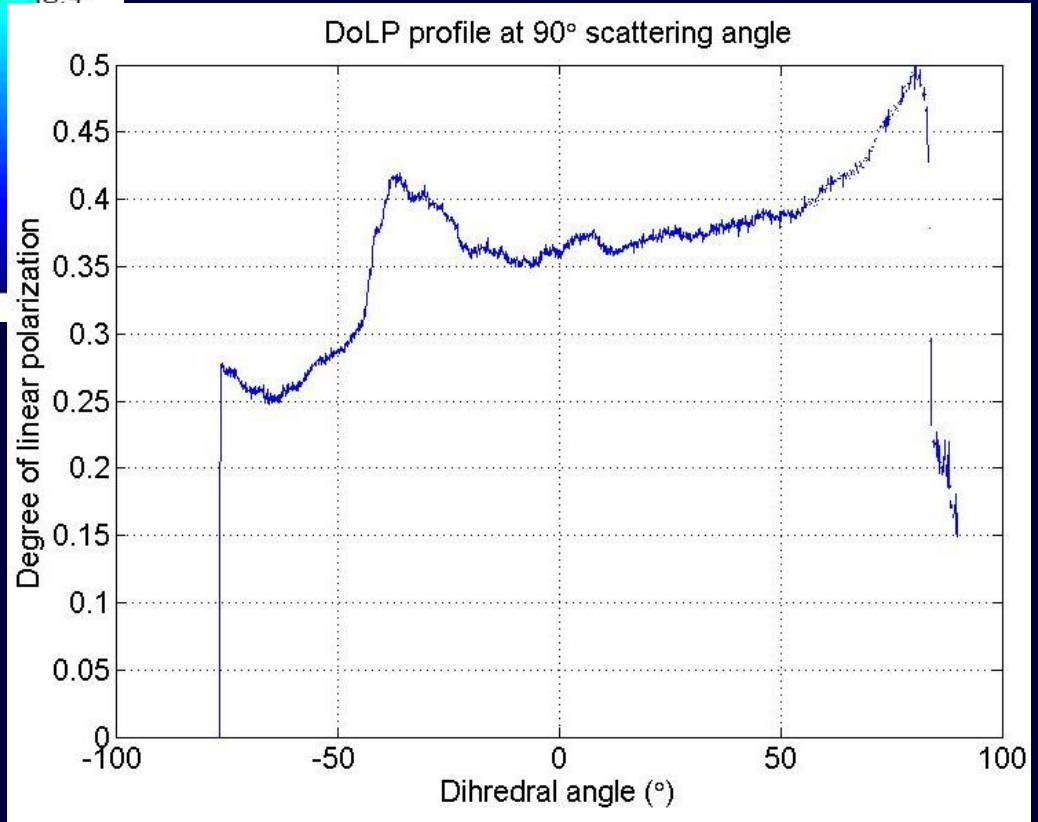
DoLP profile at 90° scattering angle



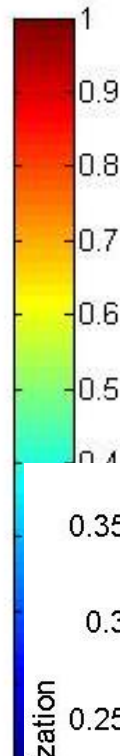
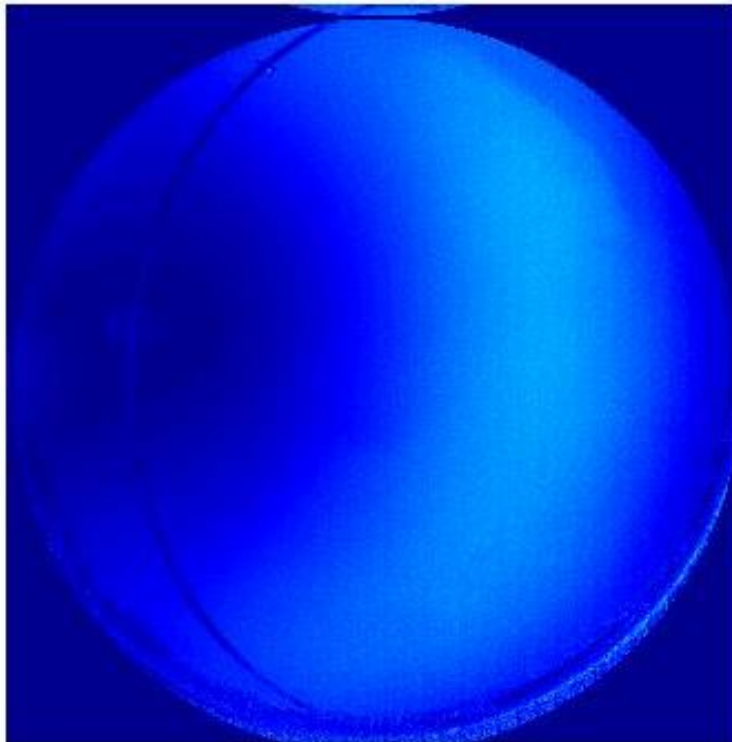
Degree of linear polarization
28 Aug 2012 17:02 0.45 μm



Increasing smoke

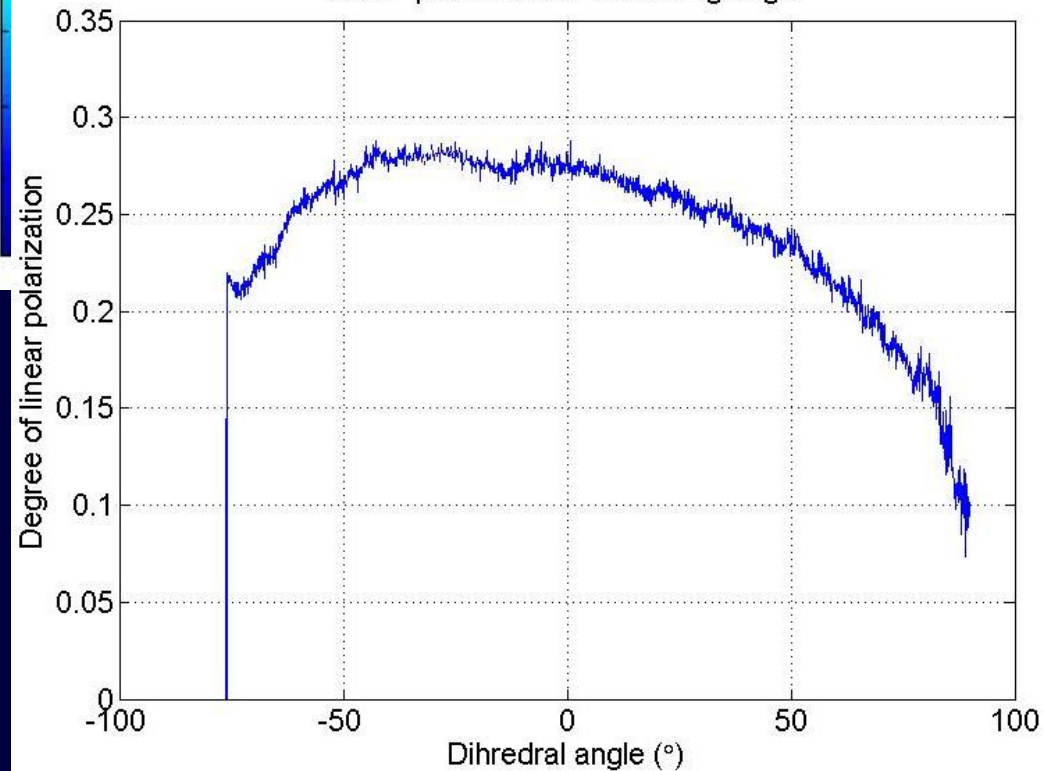


Degree of linear polarization
29 Aug 2012 15:59 0.45 μm

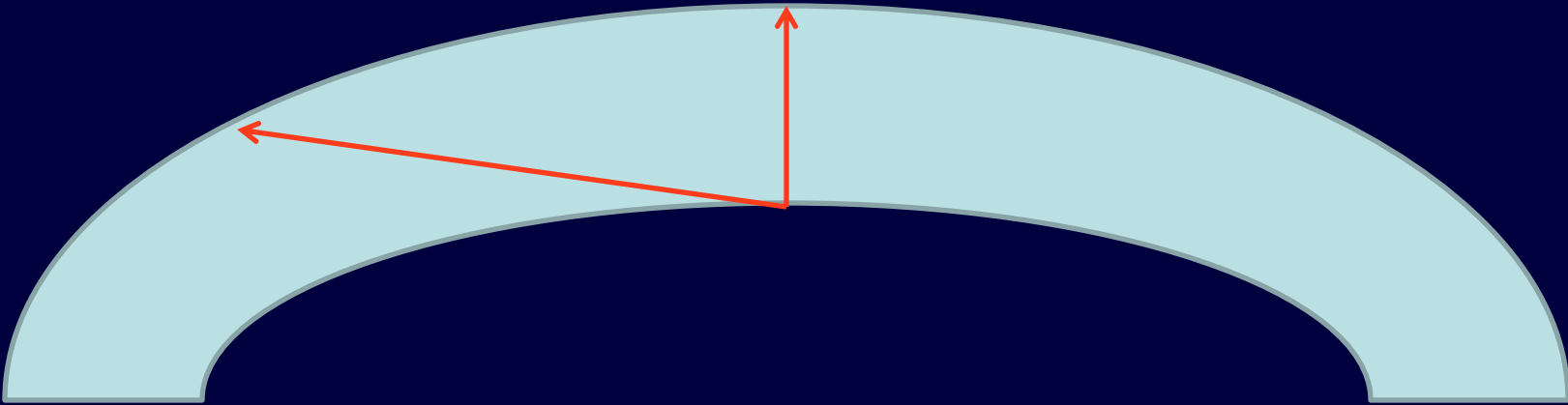


Thick smoke

DoLP profile at 90° scattering angle



Optically thick but physically thin smoke layer



Conclusions

- Aerosols produces highly variable skylight polarization
- Continuously deployed instruments provide valuable data for measuring atmospheric polarization in varying conditions;
- Ongoing research includes aerosol & cloud retrievals
- We welcome collaborations!

We acknowledge funding from AFOSR

Thank you to the workshop organizers ...