Polarized Imaging Nephelometer Scattering Measurements from SEAC^{4}RS

W. Reed Espinosa, Lorraine Remer, F. Daniel Orozco and J. Vanderlei Martins

Department of *Physics and Joint Center for Earth Systems Technology , University of Maryland Baltimore County*

Motivation

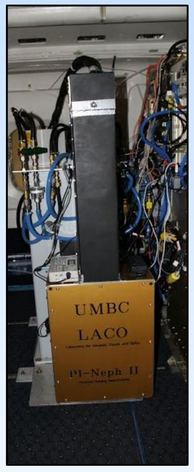
Aerosols, clouds, and their interaction play a key role in the climate of our planet. Space based remote sensing platforms have vastly contributed to our understanding of earth's atmosphere by providing data over large temporal and spatial scales but many of the microphysical retrieval algorithms used are based on assumptions that have not yet been well validated.[1] In situ measurements of the unpolarized and polarized angular dependence of scattered light are central to both the validation of remote sensors[2] as well as obtaining accurate radiative forcing estimates.[3]

$$\vec{S}' = \frac{\beta_S \cdot \Delta V(\theta)}{4\pi \cdot R(\theta)^2} \cdot \overline{\overline{P(\theta)}} \cdot \vec{S} \qquad \overline{\overline{P(\theta)}} = \begin{pmatrix} P_{11}(\theta) & P_{12}(\theta) & 0 & 0 \\ P_{12}(\theta) & P_{22}(\theta) & 0 & 0 \\ 0 & 0 & P_{33}(\theta) & P_{34}(\theta) \\ 0 & 0 & -P_{34}(\theta) & P_{44}(\theta) \end{pmatrix}$$

Polarized Imaging Nephelometer

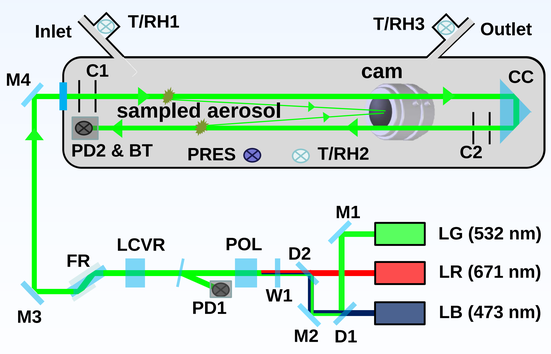
The Polarized Imaging Nephelometer (PI-Neph) is a novel polar nephelometer design that uses a high-powered laser and wide field of view CCD camera. Measured and derived products are:

- **Scattering Phase Function (P_{11})**
- **Polarized Phase Function ($-P_{12}/P_{11}$)**
- **Scattering Coefficient (β_{scat})**
- **Asymmetry Parameter (g)**



All products are produced at 473nm, 532nm and 671nm and are measured from *3° to 176° in scattering angle*.

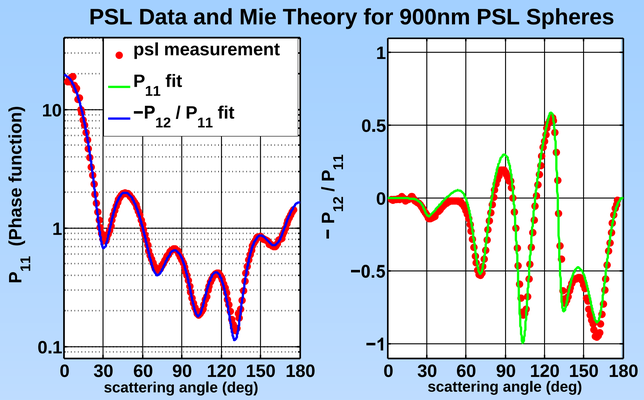
Additionally, microphysical retrievals can yield ***size distribution***, ***refractive index*** and ***degree of sphericity***.



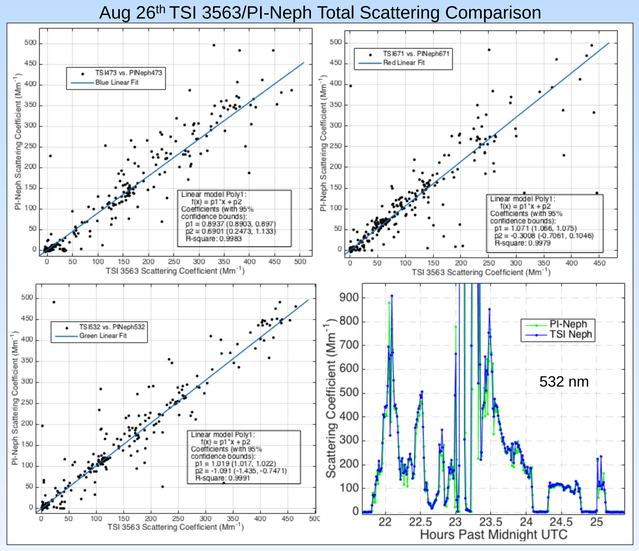
LR, LG, LB: red, green & blue laser heads
CAM: CCD camera
M1,2,3,4: laser alignment mirrors
D1,2: dichroic beam combiners
W1,2,3: windows
POL: Glan-Taylor calcite linear polarizer
PD1,2: photodiode detector assemblies

LCVR: liquid crystal variable retarder
FR: Fresnel rhomb
C1,2: beam collimator series
T/RH1,2,3: temperature & RH sensors
PR: pressure sensor
CC: corner cube retroreflector
BT: beam trap assembly

PI-Neph Validation

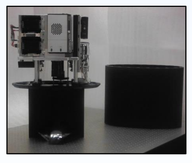


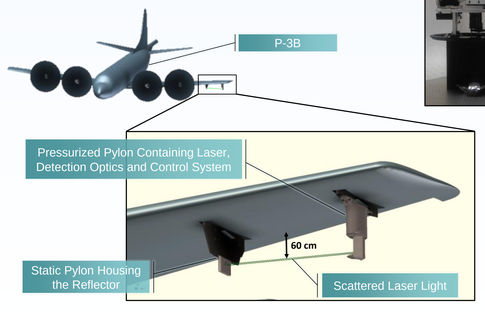
Aug 26th TSI 3563/PI-Neph Total Scattering Comparison



Open Imaging Nephelometer

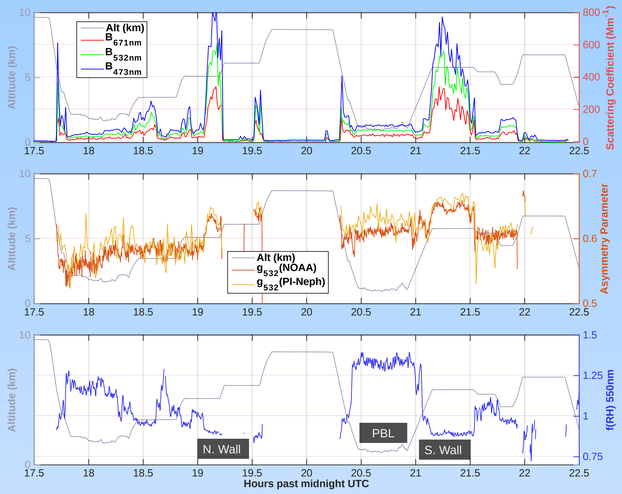
The Open Imaging Nephelometer (OI-Neph) improves upon the successes of its predecessor, the PI-Neph by removing the sample enclosure. This allows for airborne measurements of aerosols in their native state without the need for an inlet, tubing or chamber that can distort the size distribution and relative humidity of the sample.

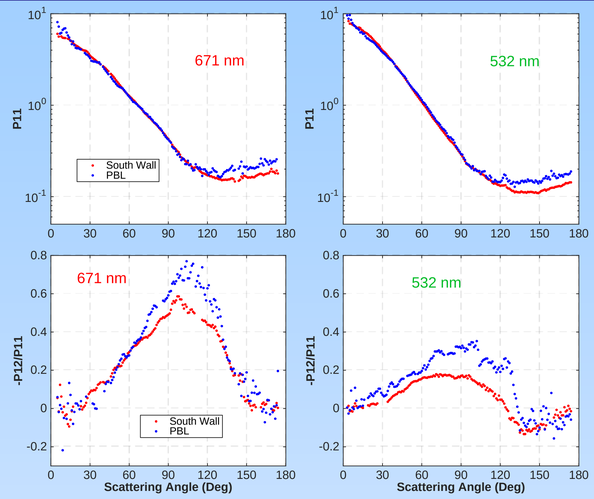


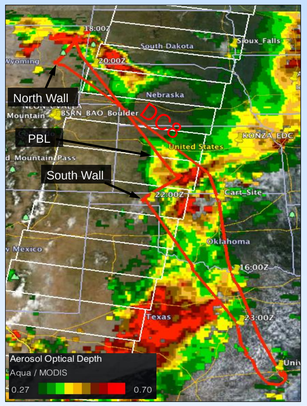


Ralph Kahn, Saide et al

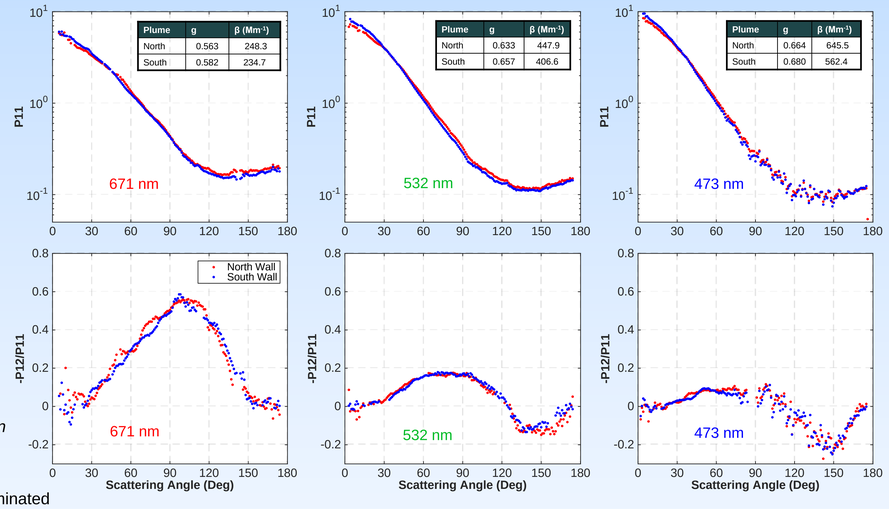
Angular Scattering Properties of Two Smoke Plumes – Aug 19th



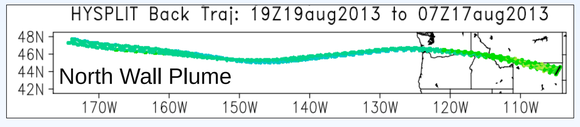


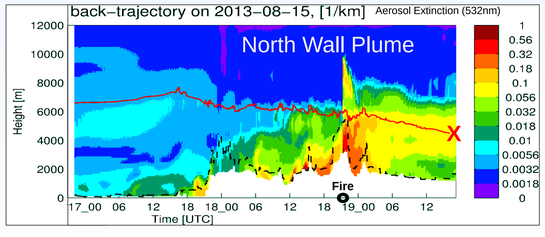


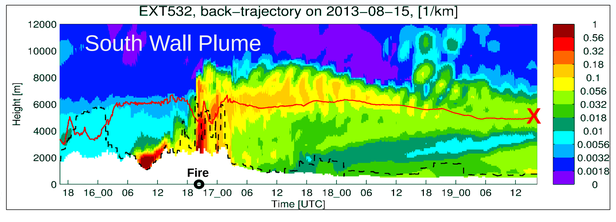
MODIS AOD & Flight Track by Ralph Kahn

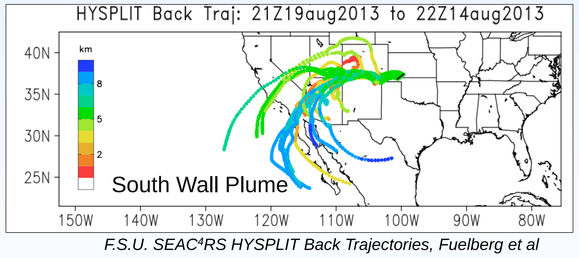


North Wall: Younger (<1day) Smoke
South Wall: Older (several days) Smoke
PBL: Continental Background, Sulfate Dominated









F.S.U. SEAC^{4}RS HYSPLIT Back Trajectories, Fuelberg et al

References

[1] Dubovik, O. *et al.* Accuracy assessments of aerosol optical properties retrieved from Aerosol Robotic Network (AERONET) Sun and sky radiance measurements. *J. Geophys. Res. Atmos.* **105,** 9791–9806 (2000).

[2] Mishchenko, M. I. *et al.* Accurate Monitoring of Terrestrial Aerosols and Total Solar Irradiance: Introducing the Glory Mission. *Bull. Am. Meteorol. Soc.* **88,** 677–691 (2007).

[3] Liou, K., Takano, Y. & Yang, P. *Light scattering and radiative transfer in ice crystal clouds: Applications to climate research. In Light Scattering by Nonspherical Particles: Theory, Measurements and Applications*. 417–449 (Acadamic Press, 1999).

[4] Hovenier, J. W., Volten, H., Mu, O., Zande, W. & Waters, L. Laboratory studies of scattering matrices for randomly oriented particles : potentials , problems , and perspectives. *J. Quant. Spectrosc. Radiat. Transf.* **80,** 741–755 (2003).