Polarized observations of aerosols and clouds

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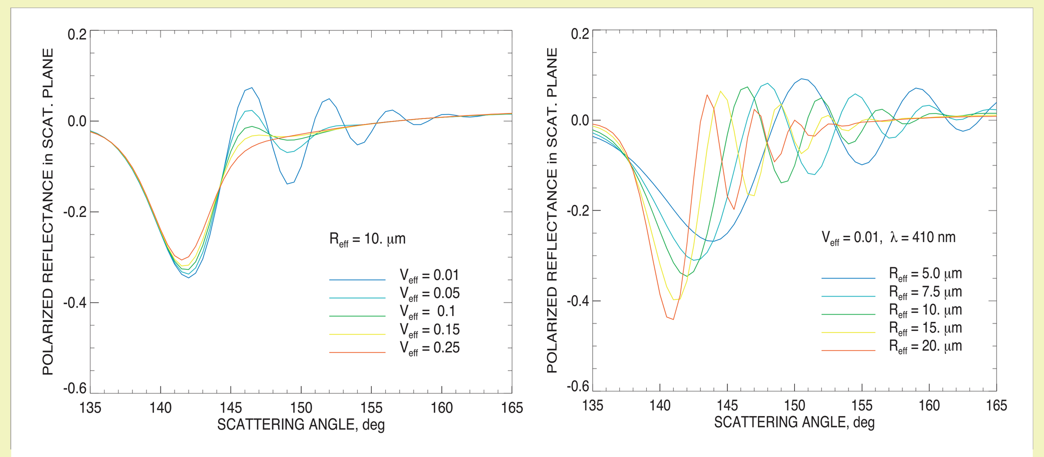
Introduction

The Aerosol Polarimetry Sensor (**APS**), a major component of the NASA Glory mission payload, has the potential to retrieve both cloud and aerosol properties because of its polarimetric, multiple view angle, and multi spectral observations. We present retrievals performed on data collected during recent campaigns, where several interesting cases of aerosol and cloud distributions were observed by the APS prototype (**Research Scanning Polarimeter, RSP**), currently deployed on the Langley B-200 King Air aircraft.

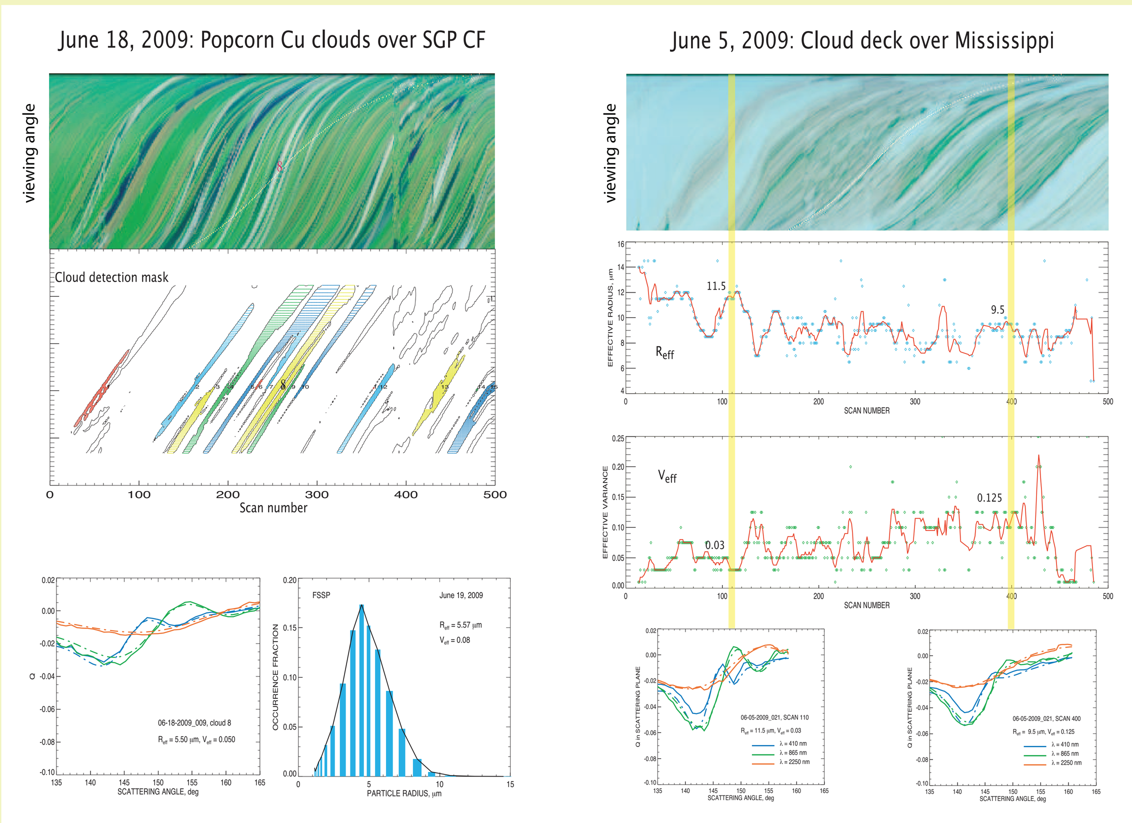
Clouds

Modeling the polarized reflectance in the rainbow region enables particle size retrievals



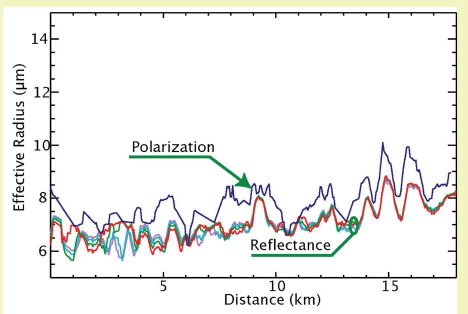
Sensitivity of polarized reflectance to effective radius (left) and variance (right) of cloud droplet size distribution.

From the **RACORO** campaign: in the RSP images (pseudo-true color), features at different altitudes appear with different slant angles as an effect of relative motion during along-track scanning.



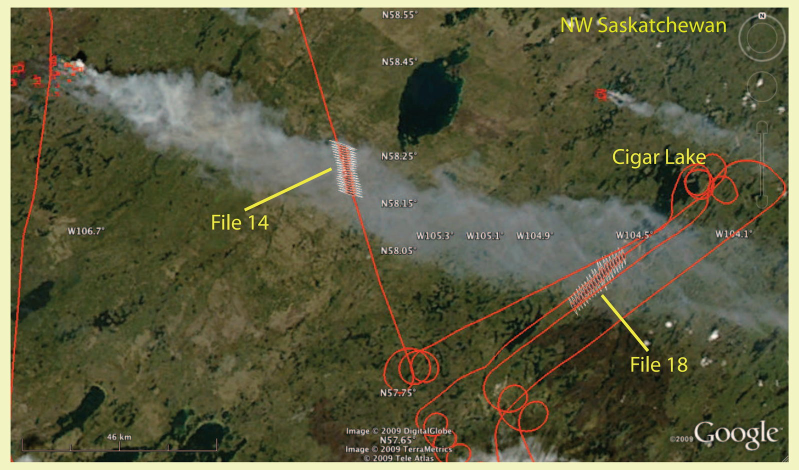
Left panel: retrievals on a selected cloud (no.8) and averaged cloud droplet size distribution from in situ (FSSP) measurements on June 19. Both show 5.5 μm effective radius and small effective variance (0.05-0.08). *Right panel and below*: The top of well developed clouds *usually* exhibit droplets larger effective radii and smaller effective variances.

Right: stratocumulus off the coast of Monterey, CA (**CSTRIPE** campaign). Polarization-based retrieval of cloud top droplet size and reflectance-based retrieval of in-cloud droplet size.



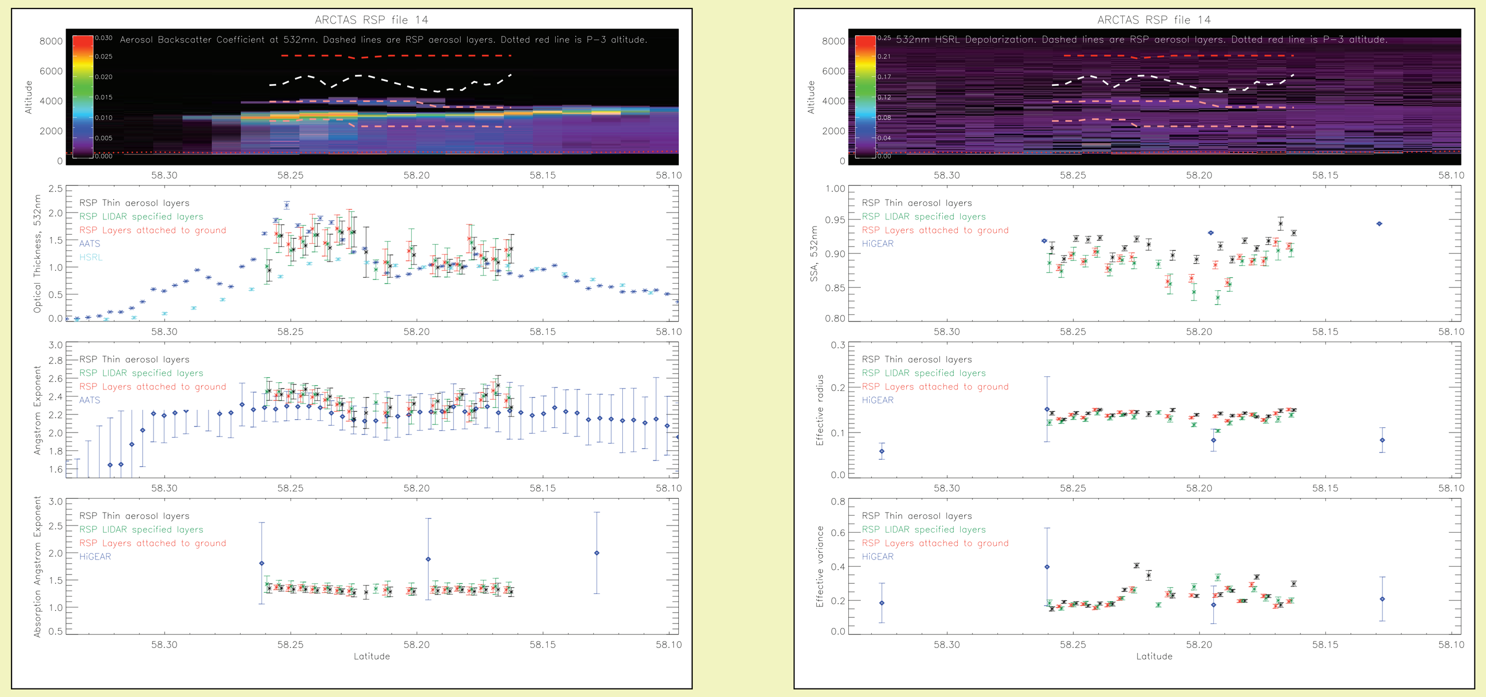
Smoke

During **ARCTAS**, the B-200 flew coordinated flights with the P-3 and DC-8 aircrafts scouting for wildfire smoke plumes in Canada.

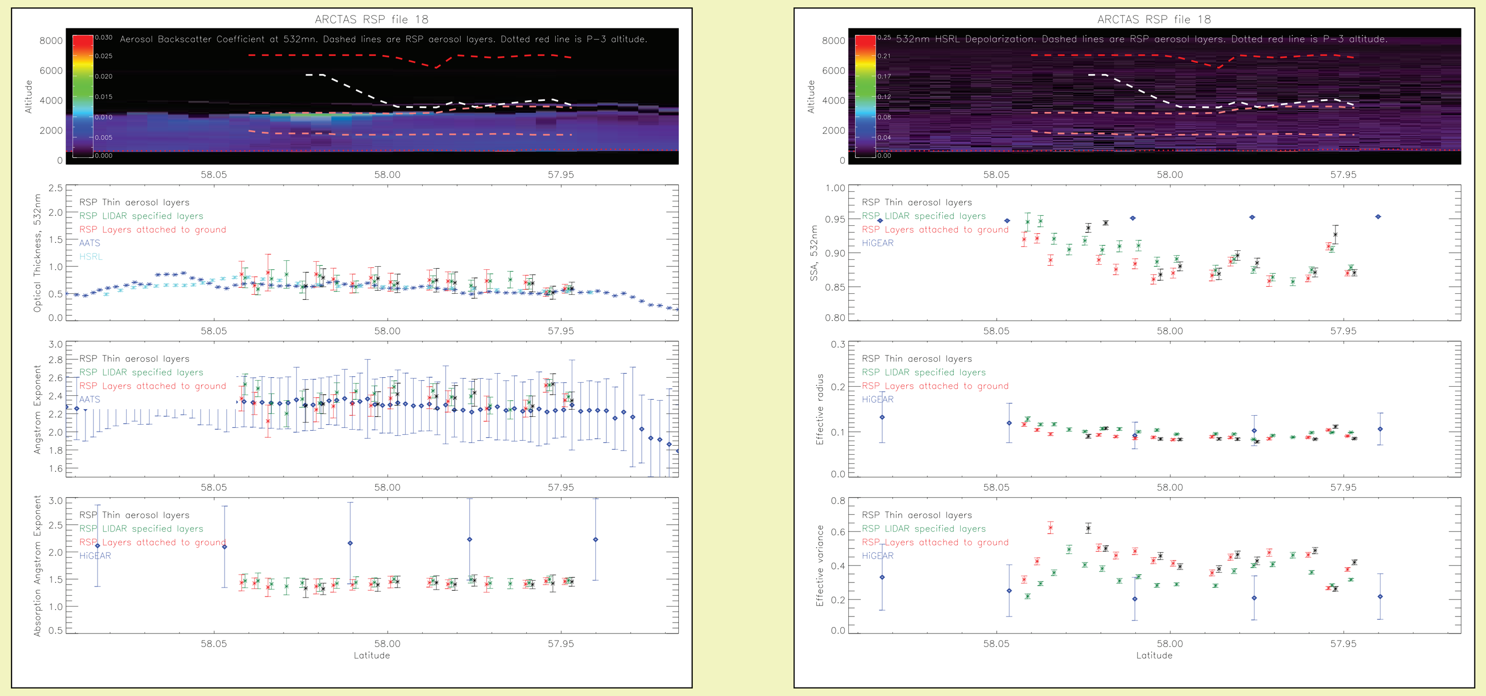


MODIS Aqua satellite fire imagery from 19:50 UTC, the time of the RSP observation in file 14. P-3 aircraft flight tracks are shown in red, while RSP data segments represent the area in the white diamonds. RSP file 14 data are close to the center of the image. File 18 data, from thirty minutes later, are farther to the south-east and downwind from the source.

Inverse (Levenberg-Marquardt) optimization techniques were used to retrieve aerosol microphysical parameters, in order to validate RSP data against in situ-measurements (AATS-14, HiGEAR).



The **HSRL** aerosol backscatter coefficient (co-located) product is used as a possible mean to constrain plume altitude.
The small radii, high refractive index, large absorption properties of soot particles are challenging to retrieve. Very good agreement is found for most properties.



Outlook

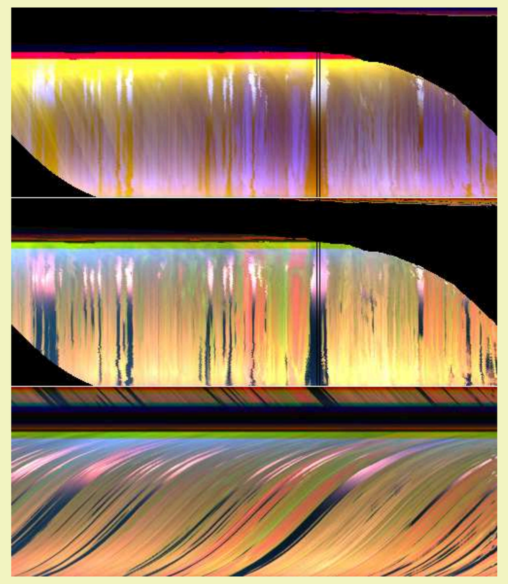
The richness of information contained in the angular behavior of the polarized reflectance of atmospheric particulates, and the capability of characterizing and removing the surface signal using the $2.2\mu m$ channel, successfully constrain the determination of optical and microphysical properties of atmospheric particulates in the radiative transfer modeling stage.

The RSP can benefit from the Langley High Spectral Resolution Lidar, also installed on the B-200, whenever accurate information is required about the vertical distribution and the extinction properties of the same particles.

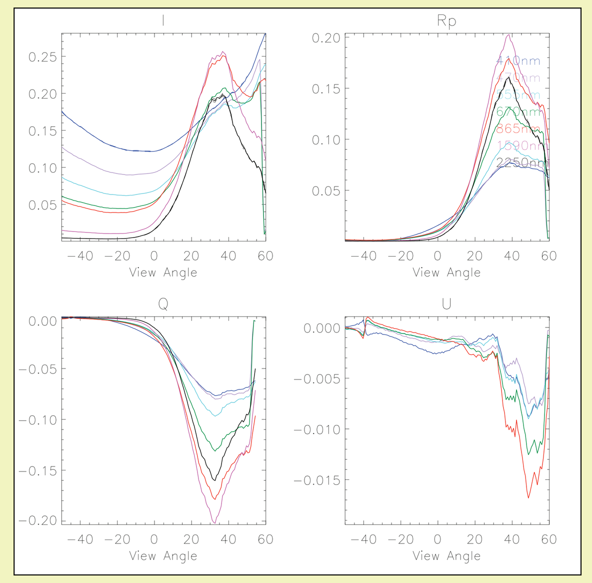
Other interesting studies

Sunglint

In presence of specular reflection over water bodies, the surface reflectance can be modeled using the $2.2\mu m$ channel to characterize the distribution of wave slopes. Sunglint radiances can be used to measure total extinction while off-glint measurements are used to characterize scattering.

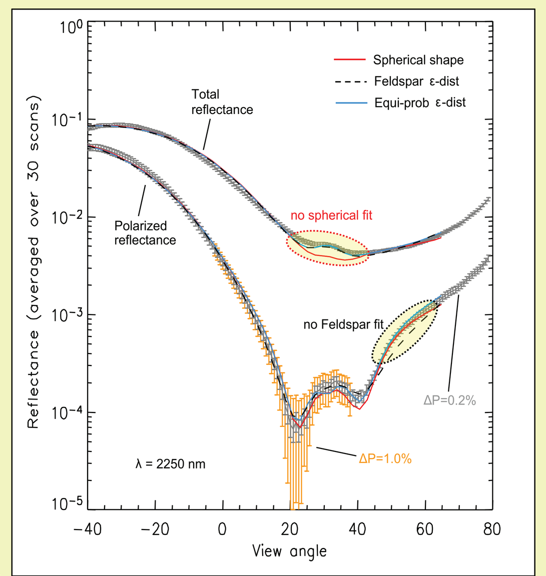


Left: Smoke on the water, with clear sunglint signatures over Northwest Territories (**ARCTAS** data). Bottom: RSP data, raw and corrected for aircraft attitude. Top: false color image enhancing the aerosol layer. *Right*: Stokes vector components originating from the sunglint-affected area between vertical bars.



Non-sphericity

The polarized reflectance is also impacted by non-sphericity as observed when retrieving large (**coarse mode**) sea-salt aerosols over the ocean.



RSP data at $2250nm$ from the **MILAGRO** campaign and corresponding fits. Grey and yellow error bars assume 0.2% and 1% polarimetric accuracy. Best fit is for particles with equi-probable aspect ratio distribution.