Retrieval of Aerosol properties using GRASP from AirHARP observations

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ABSTRACT

Multi-angle multispectral polarimetric imaging of Earth's atmosphere can be used to retrieve microphysical parameters of clouds and aerosols[1]. AirHARP (Airborne Hyper-Angular Rainbow Polarimeter) is an aircraft instrument with the hyper-angular imaging capability of 60 viewing angles at 0.670um, and 20 viewing angles at other wavelengths 0.44, 0.55, 0.870um across the full 114° (94°) along-track (cross-track) field-of-view. AirHARP can measure I, Q, U elements of Stokes vector at all four wavelengths. GRASP (Generalized Retrieval of Aerosols and Surface Properties) is a versatile algorithm to retrieve aerosols and surface properties using various remote sensing and satellite observations[2,3].

Here we report the preliminary retrieval of aerosol properties using GRASP from the AirHARP data collected during the Aerosol Characterization from Polarimeter and Lidar (ACEPOL) NASA mission in 2017. The retrieved aerosol products include Aerosol Optical Depth (AOD), angstrom exponent, aerosol volume concentration and single scattering albedo (SSA).

AirHARP

Airborne Hyper-Angular Rainbow Polarimeter is a novel remote sensing hyper angular polarimeter developed in Laboratory for Aerosol and Cloud Optics in UMBC. It measures light at three polarizations 0º , 45º and 90º and thus measuring I, Q, U of stokes vector for the scene.

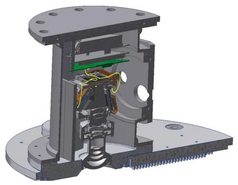


Fig. 1: Cross Section image of AirHARP

Wavelength (nm)	No. of Viewing angles
440	20
550	20
670	60
873	20

Table 1: No. of viewing angles for individual wavelength channels in AirHARP

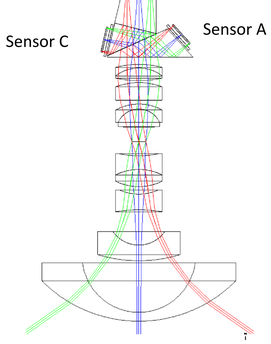


Fig. 2: Wide FOV Lens and Prism

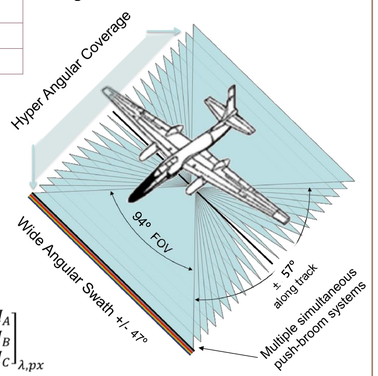


Fig. 3: Illustration of multi angle observation from an aircraft over a scene

Calculation of I, Q, U

$$\begin{bmatrix} I \\ Q \\ U \end{bmatrix}_{\lambda,px} = \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix}_{\lambda,px}$$

Selected Scenes from ACEPOL campaign

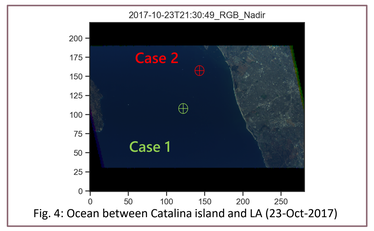


Fig. 4: Ocean between Catalina island and LA (23-Oct-2017)

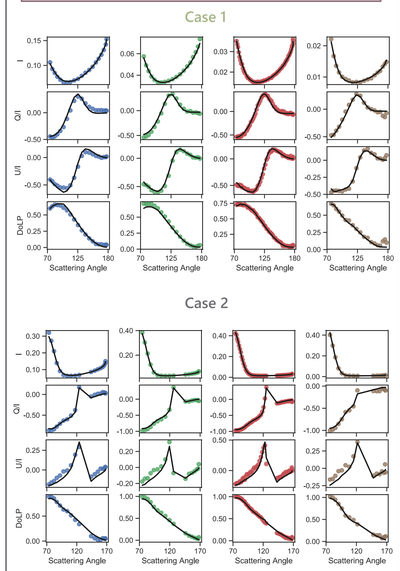


Fig. 5: GRASP Fit for off glint (case 1) and peak sun glint (case 2) pixels are plotted above. Solid circles are AirHARP data and Solid line is GRASP fit. 440, 550, 670 and 873nm bands are marked by blue, green, red and brown markers respectively.

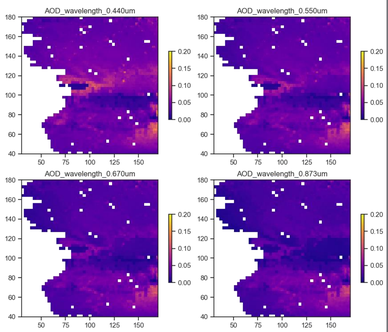


Fig. 6: Retrieved Aerosol Optical Depth(AOD) over the ocean area shown in the Figure 4

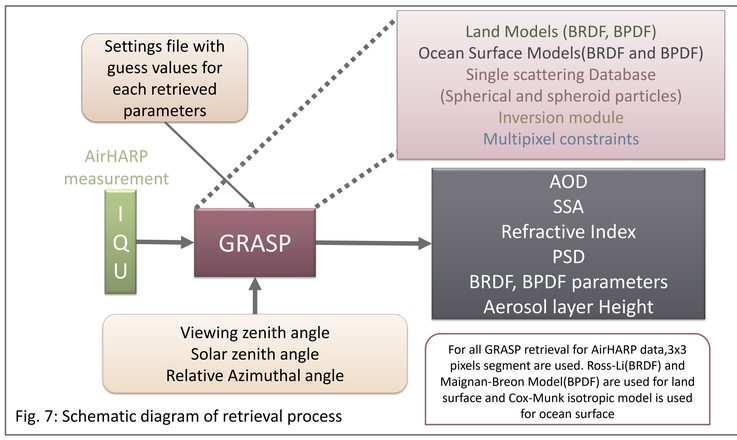


Fig. 7: Schematic diagram of retrieval process

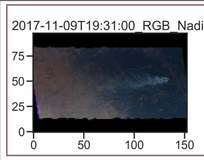
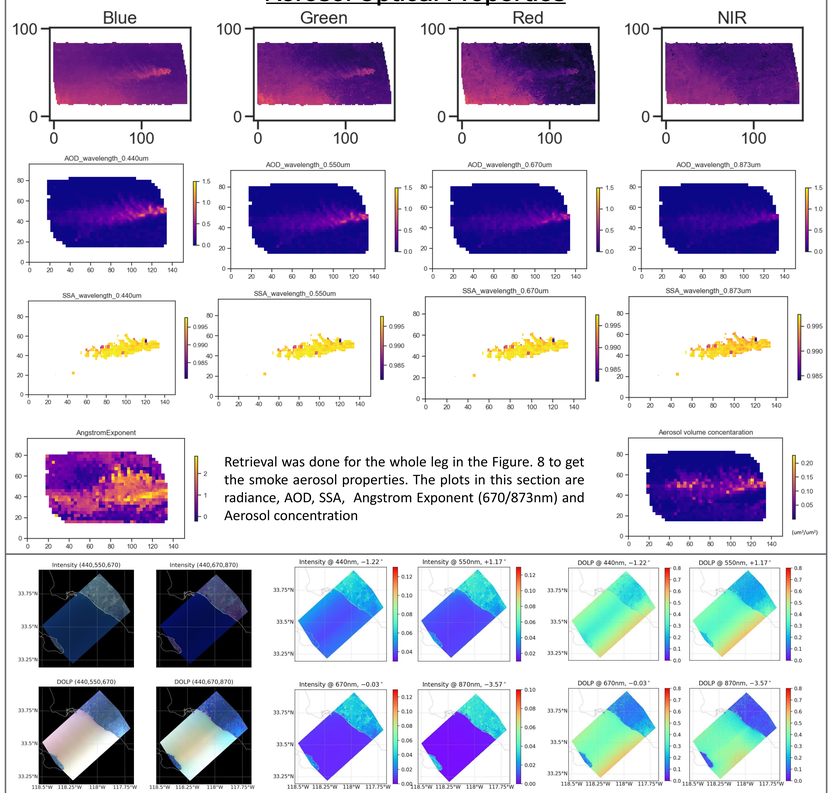


Fig. 8: Forest Fire on 09th November 2017 in Mogollon rim, AZ. Retrieved AOD, SSA, Angstrom Exponent and Aerosol volume concentration are plotted below

Aerosol Optical Properties



Retrieval was done for the whole leg in the Figure. 8 to get the smoke aerosol properties. The plots in this section are radiance, AOD, SSA, Angstrom Exponent (670/873nm) and Aerosol concentration

Projected RGB , RGNIR images of I and DoLP

Projected reflectance of each bands at a viewing angle

Projected DoLP of each bands at a viewing angle

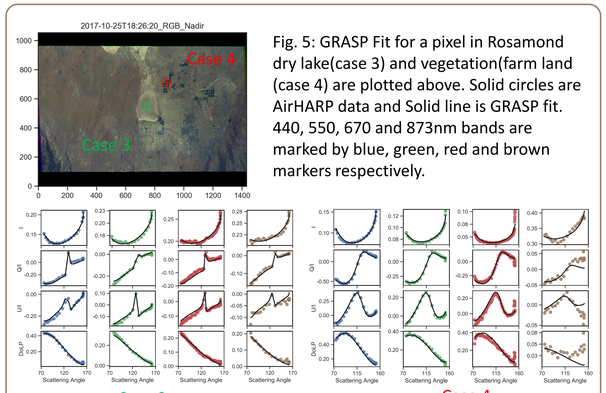
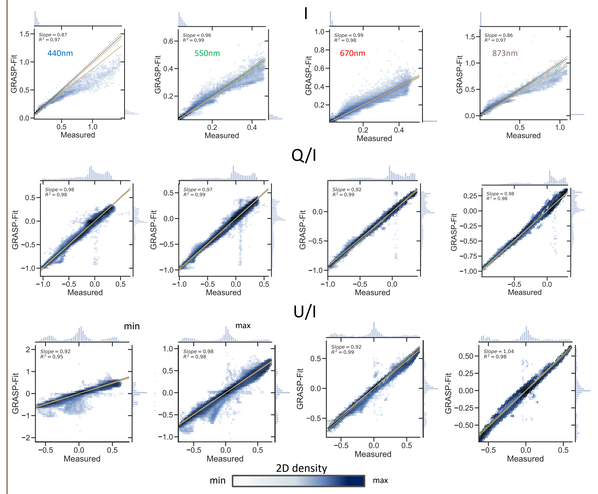


Fig. 5: GRASP Fit for a pixel in Rosamond dry lake(case 3) and vegetation(farm land (case 4) are plotted above. Solid circles are AirHARP data and Solid line is GRASP fit. 440, 550, 670 and 873nm bands are marked by blue, green, red and brown markers respectively.

Case 3 Case 4

Statistics on ocean pixels in Fig.4



Summary

- Retrieved aerosol properties for some scenes from the ACEPOL campaign using the AirHARP data and GRASP
- Developed an automated retrieval scheme using GRASP for HARP like observations
- More research is needed to improve the quality of retrieval for complex terrains
- Further research is needed to utilize the temporal data to constrain the land models to improve the accuracy of aerosol retrievals

References

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Acknowledgement

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UMBC ESI EARTH AND SPACE INSTITUTE

LACO Laboratory for Aerosol and Cloud Optics