**Proposed work:** Retrieval and evaluation of Aerosol Above Cloud (AAC) properties with combined polarimeter, Lidar and spectrometer observations

Kirk Knobelspiesse1, Meloë Kacenenbogen2, Matteo Ottaviani3, K. Sebastian Schmidt4

1 NASA Ames Research Center, Moffett Field, CA kirk.knobelspiesse@nasa.gov; 2 Bay Area Environmental Research Institute / NASA Ames Research Center Meloe.s.kacenenbogen@nasa.gov 3 Stevens Institute of Technology, Hoboken, NJ mottavia@stevens.edu; 4 Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Boulder, CO, Sebastian.schmidt@lasp.colorado.edu

Atmospheric aerosols play a potentially large, but highly uncertain, role in the global climate. Much of this uncertainty is due to the difficulty of observing aerosols and modeling their effects. A particularly challenging scenario is the case where aerosols have been left stratified above clouds (Aerosol Above Cloud, AAC). AAC have the potential for large positive (warming) radiative forcing, since the brightness of clouds magnifies the impact of aerosol absorption. Active instruments, such as Lidars, can detect AAC, but often are unable to determine the amount of aerosol absorption. Passive instrument algorithms for AAC have only recently been developed and require assumptions about most aerosol optical properties. However, it may be possible to determine the climate relevant properties of AAC more accurately if active and passive observations are combined – particularly if the passive instrument has sensitivity to linear polarisation. Since the measurement of aerosols in cloudy regions has not been recognised as highly uncertain, we will attempt this with newly acquired field observations. The SEACARs field campaign included active and passive polarimetric sensors in aircraft that overfly AAC in North America. We intend to build a merged dataset and retrieval algorithm for AAC using data from the Research Scanning Polarimeter (RSP), the Differential Absorption Lidar (DIAL), and the Solar Spectral Flux Radiometer (SSFR). Each method can access to different types of information, which we will leverage to produce an AAC retrieval that exceeds the capability of the different instruments independently.

Our goals are to (1) create an accurate algorithm to retrieve AAC optical and microphysical properties, (2) validate these results with comparisons to auxiliary airborne and satellite observations, (3) classify AAC type and compare to aerosol classification from other instruments, (4) improve our understanding of the radiative and climate impact of AAC, and (5) recommend future instrumentation designs. Ultimately, we hope to reduce observational insensitivity to AAC, and make it as regularly scrutinized as other types of aerosols.

**Aerosol Above Cloud product generation and analysis**

- **Data**
  - RSP: multi-angle (<150°), multi-spectral (VIS-SWIR), polarimetrically sensitive scanner
  - has been used previously (Knobelspiesse et al., 2011) to retrieve AAC properties. But could be far more successful with accurate constraints of cloud and aerosol optical depth and vertical distribution.
  - on the ER-2 for SEACARS

- **Retrieval Algorithm**
  - RSP reference channel
  - single scattering albedo
  - band ratios (multipolarization)
  - single scattering albedo
  - extinction coefficient
  - Cloud property
  - aerosol optical properties

- **Retrieved products**
  - Aerosol optical properties
  - Aerosol optical depth
  - Cloud top altitude

- **Analysis**
  - aerosol optical depth (with 2 pm modes)
  - aerosol type classification
  - aerosol reflective scattering

- **Derived products**
  - aerosol optical depth
  - Aerosol optical depth
  - Aerosol optical depth

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**Examples of a SEACARS research flight which successfully sampled significant AAC. The imagery is from a nearly simultaneous overflight of MODIS-Aqua. The high-altitude ER-2 aircraft (marked by the red cross) was coordinated in this portion of the flight with the DC-8, which contains the DIAL and SSFR and is shown sampling in the lower clouds.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Satellites nearby</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>August 6</td>
<td>Oregon coast</td>
<td>A-Train (21,32)</td>
<td>PARASOL (23,58)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderately absorbing smoke over ocean, variable cloud albedo</td>
</tr>
<tr>
<td>August 12</td>
<td>Alabama/Florida</td>
<td>A-Train (19,13)</td>
<td>PARASOL (21,21)</td>
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<td></td>
<td>coastline</td>
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<td>Pollution/haze</td>
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<td>PARASOL (21,21)</td>
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