# AQRP Monthly Technical Report

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| **PROJECT TITLE** | **Sources and Properties of Atmospheric Aerosol in Texas: DISCOVER-AQ Measurements and Validation** | **PROJECT #** Project 14-005 | Choose an item. |
| **PROJECT PARTICIPANTS** | Sarah Brooks and Ping Yang | **DATE SUBMITTED** | 6/9/2014 |
| **REPORTING PERIOD** | **From:** May 1, 2015<br>**To:** May 31, 2015 | **REPORT #** | 5 |

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

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**Detailed Accomplishments by Task**

-- Data reduction and comparison of initial data products for time periods in which MODIS and in-situ CASPOL and AERONET data are collocated. Eight cloud-free Terra MODIS cases and four Aqua MODIS cases found be were available during times of 8 continuous hours of CASPOL data collected under a constant CASPOL type, i.e. Urban, Ship Channel, Ocean/Transported.

-- Data reduction and comparison of initial data products for time periods in which CALIOP and in-situ data are collocated. Four CALIOP cases were found to be compared to 8 hour CASPOL data segments.

**Preliminary Analysis**

Comparisons of MODIS aerosol optical depth (AOD) retrievals (Collection 6) and CASPOL aerosol settings are reported in Table 1.

Table 1. Collocated MODIS (Terra) and CASPOL Data

| Date | Time (CDT) | Terra AOD (Aerosol Optical Depth) | AERONET AOD | CASPOL Aerosol Type |
|---|---|---|---|---|
| 6 September | 12:30 | 0.262 | 0.233 | Ship Channel |
| 8 September | 12:20 | 0.278 | 0.105 | Transported |
| 13 September | 12:34 | 0.312 | 0.203 | Urban |
| 22 September | 12:29 | 0.098 | 0.050 | Transported |
| 25 September | 11:24 | 0.152 | 0.090 | Transported |
| 26 September | 12:04 | 0.133 | 0.060 | Transported |

Table 2. Collocated MODIS (Aqua) and CASPOL Data

| Date | Time (CDT) | Aqua AOD | AERONET AOD | Aerosol Type |
|---|---|---|---|---|
| 12 September | 15:05 | 0.100 | 0.103 | Ship Channel |
| 18 September | 14:30 | 0.146 | 0.103 | Transported |
| 25 September | 14:35 | 0.132 | 0.119 | Transported |
| 26 September | 15:20 | 0.137 | 0.086 | Transported |

Table 1. Collocated CALIOP and CASPOL Data

| Date | Latitude | Longitude | Distance (km) | CALIOP DPR | CASPOL DPR | CASPOL Backscatter Intensity |
|---|---|---|---|---|---|---|
| 11 Sep | 29.85 | -96.08 | 73.07 | 0.014 | 0.016 | 64.8 |
| 16 Sep | 29.81 | -94.95 | 39.33 | NA | 0.026 | 40.2 |
| 23 Sep | 29.51 | -96.38 | 102.89 | 0.013 | 0.005 | 60.1 |
| 27 Sep | 29.85 | -96.04 | 68.98 | 0.014 | 0.007 | 60.9 |

*NA is short for not available.

**Data Collected**

-- 3-km AOD retrievals from the Terra and Aqua MODIS Collection 6
-- AOD retrievals from the Univ_of_Houston site of AERONET
-- Volume depolarization ratios from the version 4.00 of the CALIPSO lidar level 1B product
-- Vertical feature masks from the version 3.30 of the CALIPSO lidar level 2 product

**Identify Problems or Issues Encountered and Proposed Solutions or Adjustments**

The current MODIS fine mode aerosol typing is based on location and season, and it was realized that all within our data set, all data are classified with the same fine mode aerosols The purpose of comparing MODIS to CASPOL optical types is to see if the current aerosol typing in MODIS could be improved. However, during the entire data set, there are only 2 ship channel cases and 1 urban case identified by CASPOL; all the remaining cases are Oceanic/Transported aerosol. As a proposed solution, we will modify our objective to use other CASPOL products.

In addition, there are not enough cases in which CASPOL data is available for 8 continuous hours centered on the CALIOP overpass. Therefore, no strong conclusions can be drawn from these data. However, the 8 hour time requirement was chosen to be consistent with the initial MODIS-CASPOL comparisons and is specifically required for the generation of CASPOL optical signatures. Since CASPOL depolarization ratios require less data points than CASPOL optical scattering signatures, we will attempt to compare CALIOP to shorter segments of CASPOL data. We hope that modifying this requirement will provide a larger number roof CASPOL-CALIOP cases for comparison. The next step for the CASPOL-CALIOP is to

determine whether reducing the CASPOL time requirement improves the number of co-located cases.

**Goals and Anticipated Issues for the Succeeding Reporting Period**

Reprocessing the CASPOL data and validate the MODIS and CALIOP aerosol retrievals using the data. Additional analysis will include comparison of the data CASPOL mean backscattering, mean depolarization ratio, particle size distribution, and fine mode fraction (which will be derived from the observed particle size distributions) to MODIS AOD and derived fine mode fraction.

For CALIOP, in the next reported period, we will determine whether reducing the CASPOL time requirement to 1 hour improves the number of co-located cases.

**Detailed Analysis of the Progress of the Task Order to Date**

The field campaign last from Sep. 5 to Oct. 1 in 2013 on the Moody Tower that is located at 29.7176° N and 95.3414° W. Ground-based AOD retrievals that were made adequately close to the Moody Tower are needed to assure that such retrievals and the corresponding CASPOL aerosol typing are representative of the conditions of the same air mass. In the Houston-Galveston area, AOD retrievals were available during the field campaign at two AERONET sites—Univ_of_Houston and UH_Coastal_Center, the locations of which are 29.7176° N and 95.3419° W and 29.7178° N and 95.0428° W, respectively. We therefore picked the AOD retrievals from the closest AERONET site, which is the Univ_of_Houston site on the Moody Tower. Then, we used AOD retrievals from this site to validate the 3-km AOD retrievals from the Terra and Aqua MODIS Collection 6 [*Levy et al.*, 2013], which is the latest version of the MODIS aerosol product. The Univ_of_Houston site AOD retrievals are available at 1640 nm, 1020 nm, 870 nm, 675 nm, 500 nm, 440 nm, 380nm, and 340 nm. We interpolated the AOD retrievals at 675 nm and 500 nm in a logarithmic manner to 550 nm, which is the wavelength of MODIS AOD retrievals.

In the Houston-Galveston area, urban aerosols, oceanic aerosols, and aerosols from the Houston Ship Channel (HSC) show distinct backscatter intensity and depolarization ratio features from the CASPOL measurements. There are 4 major sources of aerosols characterizing the air masses arriving at the Moody Tower. Sources include the Houston Ship Channel, a heavily industrialized area on the east side of Houston, the densely populated urban center of Houston, a marine source, which consists of transported aerosols from the Gulf of Mexico and potentially further (Goudie and Middleton, 2001), and aerosol from the less densely populated or semi-urban zones of Southwest Houston area. Conveniently, these sources come from four different wind directions relative to the Moody Tower. The NOAA, Atmospheric Resources Laboratories Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Draxler and Hess, 1997, 1998; Draxler et al., 1999) was used to create five day back trajectories with one hour intervals using Global Data Assimilation (GDAS) model data with 0.5 degree resolution for all CASPOL data. All CASPOL data was then classified as Ship Channel cases, Urban cases, and Oceanic/Transported aerosol type, according to the back trajectories. No Semi-Urban/Rural air masses were identified during the time period of the campaign.

A technique for identifying particle type by the patterns in plotted optical properties for ensembles of sampled particle was developed by Glen and Brooks (2013). To create the patterns, referring to here as scattering signatures, the backscatter intensity and depolarization ratio data for all particles observed in a time segment are first discretized. The depolarization ratio is plotted on the x axis, and the backscatter intensity on the y axis. Next, the frequency of particles that have intersecting values of depolarization ratio and backscatter intensity are placed at each intersection. In Figure 1, the composite scattering signatures of all of the data from each of the three sources are shown. The color of each intersecting value indicates the percentage of particles at that intersecting value. The Ocean/Transported case has the strongest backscatter intensity, approaching 400, and is the most depolarizing. The data collected under the Ship Channel conditions (Figure 1B) is slightly depolarizing but the backscatter intensity is around half of the Ocean data at around 210. The Urban data has an even lower backscattering intensity of 200 and is the least depolarizing at approximately 0.1 (Figure 1C).

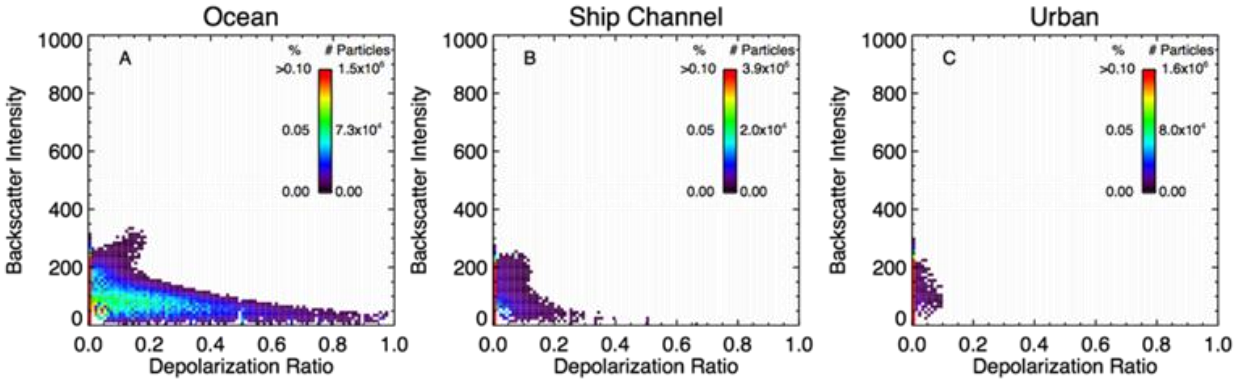


**Figure 1.** The scattering signatures for all of the data in the Ocean, Ship Channel, and Urban sources.

Each of these scattering signatures is unique in shape from the others. By using this scattering signature technique, the CASPOL can distinguish aerosol source regions in the Houston area. The CASPOL's ability to distinguish aerosol source shows that a potential exists for the CASPOL to be a useful tool in air quality monitoring. Provided that a significant number of particles have been detected (~$10^6$), an optical signature can be generated and the dominant aerosol type may be assigned. For each satellite comparison, the CASPOL data was sorted combing all data collected 4 hours before and after each satellite overpass time, and generating an optical plot from each data set. This ensures that a sufficient number of particles are available to generate high quality optical signature plots.

It has been shown that a comparison of spatial statistics of MODIS AOD to temporal statistics of AERONET AOD is more meaningful and uniform than a direct comparison of MODIS AOD at a single pixel to AERONET AOD at a certain time [*Ichoku et al.*, 2002]. *Ichoku et al.* [2002] suggest that an area of 50 x 50 $km^2$ may match a 1-hour sun-photometer measurements, and the correlations between the two statistics decay as the area enlarges [*Kovacs*, 2006]. We therefore adopted this comparison method, and compare domain-averaged MODIS aerosol retrievals with the averaged AERONET AODs 0.5 hour before and after the satellite overpassing time. AERONET Level 2.0 cloud-screened and quality-assured data were used.

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Submitted to AQRP by:

Principal Investigator:

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Submitted to AQRP by: [signature]

Principal Investigator: SARAH BROOKS