AQRP Monthly Technical Report

PROJECT TITLE	**Using Satellite Observations to Quantify Surface $PM_{2.5}$ Impacts from Biomass Burning Smoke**	**PROJECT #**	20-005
PROJECT PARTICIPANTS	Matthew Alvarado, Archana Dayalu, Qiang Sun (AER)	**DATE SUBMITTED**	10/08/2020
REPORTING PERIOD	**From:** 09/01/2020 **To:** 09/30/2020	**REPORT #**	3

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.

Detailed Accomplishments by Task for reporting period

We gathered TROPOMI UVAI data subset over Texas from January through July 2020. Based on a literature review that established a smoke threshold for the TROPOMI UVAI product, we applied a smoke and quality flag filter to obtain likely smoke pixels in the study domain. We refined our intercomparison of NOAA HMS and GOES smoke products and are in the process of incorporating the third smoke product (TROPOMI UVAI) into the assessment. We additionally processed the GOES smoke product by using their provided Data Quality Filter (DQF). We also ran the OMI Brown Carbon processor for April and May 2020 period; we will run the processor for additional dates in the coming weeks. We anticipate wrapping up Task 1 by the end of the October reporting period. We provide preliminary results using a case study for May 22, 2020 – a date where Texas was potentially impacted by the April/May agricultural fire season in the Yucatán Peninsula.

In addition, we began work on Task 2 where we explore the use of MAIAC plume height data for smoke events. Specifically, we explored a Summer 2020 publication that established a relationship between MAIAC-derived plume heights and aerosol optical depth (AOD) measurements.

Preliminary Analysis

As a preliminary test, we examined the three smoke products for a test date on May 22, 2020 which exhibited potentially extensive smoke intrusion in the Texas region.
Figure 1 displays the three smoke products (HMS, GOES, UVAI) for the May 22, 2020 test date. With a few exceptions, we see from Figure 1 that the NOAA HMS (Figure 1a) and TROPOMI UVAI (Figure 1b) smoke regions are largely the inverse of each other, particularly in the Texas region. We also see that in Figure 1c the GOES product, absent a quality filtering scheme, universally suggests significant smoke activity. In Figure 1c, we display NOAA HMS overlap with GOES for reference.

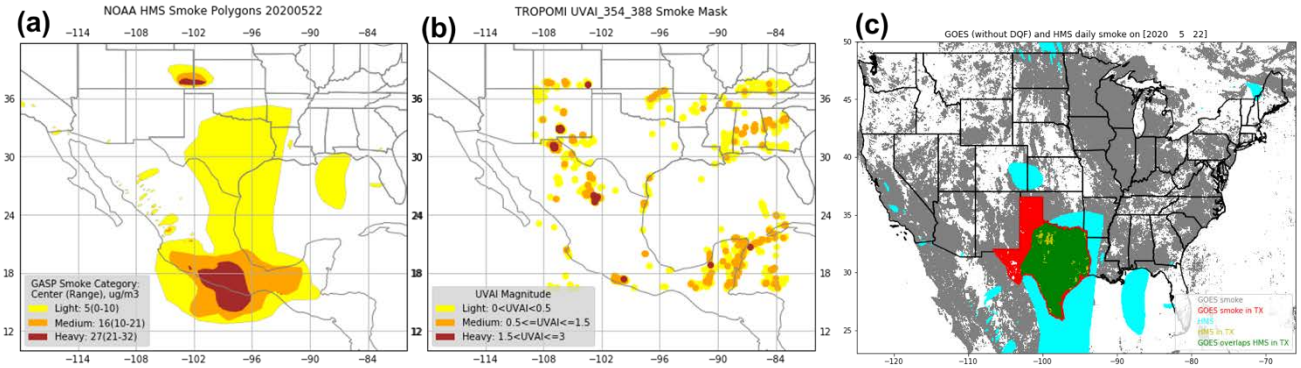

Figure 2. Comparison of three smoke products for Task 1 for a test date on May 22, 2020. (a) daily NOAA HMS product colored by smoke density; (b) TROPOMI UVAI binned by magnitude; (c) Unfiltered GOES aggregated 10-minute data slices with NOAA HMS overlap as reference. In panel (c), regions of GOES smoke are grey; overlap with HMS within TX are green; GOES-only in TX is red; and HMS only is yellow.

In Figure 2, we further explore the overlap between NOAA HMS and GOES for the May 22, 2020 test date. Figure 2a shows the same GOES product from Figure 1c, this time with data quality flags (DQF) applied. Application of the quality flags reduces a significant number of the smoke-identified GOES pixels. With the DQF, we find that GOES estimates 22% of Texas impacted by smoke; HMS scientists (derived primarily from the GOES satellite information) suggest a value closer to 80%. Overall, the agreement between GOES and HMS for this date ~21%. Qualitatively, it appears that TROPOMI UVAI smoke pixels (Figure 1b) tend to align more with DQF GOES (Figure 2a); we will quantify the relationship among all three smoke products, including aggregation across multiple days, in the upcoming reporting period.

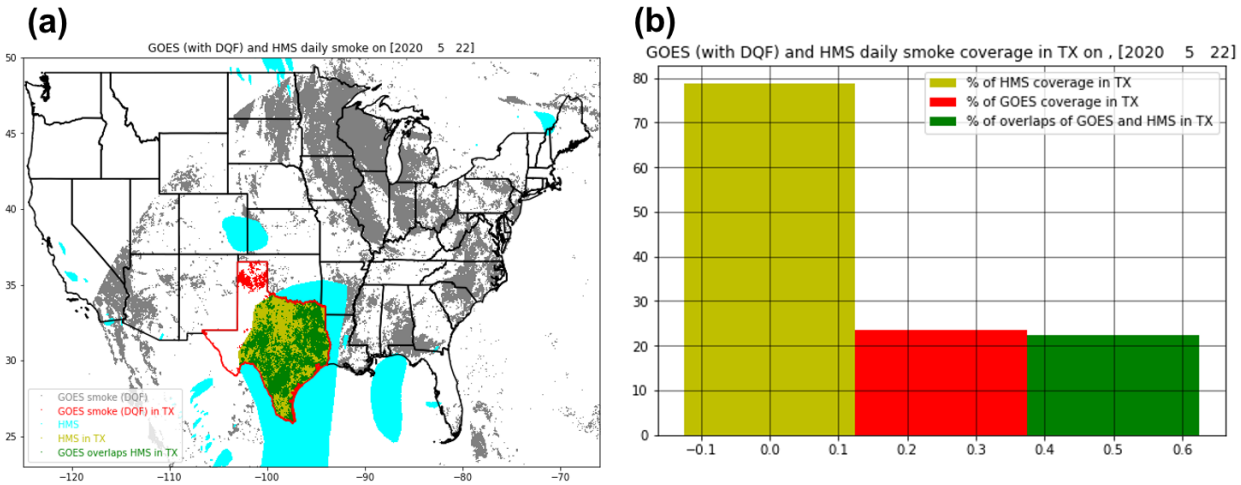

Figure 1. Comparison of NOAA HMS smoke polygons with quality-filtered GOES on May 22, 2020. (a) Spatial assessment of smoke and overlap; (b) quantification of overlap in Texas.

In Figure 3, we demonstrate an early comparison with our previously developed OMI Brown Carbon smoke evaluation product. Figure 3a shows Absorption Ångstrom Exponent (AAE; calculated from AAOD) vs. Extinction Ångstrom Exponent (EAE; calculated from AOD) for ~160 days in April and May from 2005 to 2020. As several previous studies suggest, the points in red indicate brown carbon dominance with Absorption Ångstrom Exponent (AAE) values between ~4 and 6. Comparison with Extinction Ångstrom Exponent (EAE) values enables filtration of other potential contributions to the signal (e.g., dust). Yellow cluster points suggest

brown carbon mixtures, and do not necessarily preclude smoke activity. Orange cluster points do not seem to indicate significant brown carbon presence and are possibly associated with other non-smoke contributions to AAOD and AOD. For the May 22, 2020 test date specifically, we map the pixels colored by AAE vs EAE regime (Figure 3b). We note overlap of red clusters in southwestern Mexico with HMS high smoke density polygon and medium to high magnitude TROPOMI UVAI (Figure 1a). Despite several missing pixels, we note that Figure 3b suggest brown carbon dominance in the Yucatán Peninsula, in agreement with the smoke presence suggested by TROPOMI UVAI and the known pattern of agricultural fires in the region during this time. Interestingly, NOAA HMS does not extend their smoke polygon to the tip of the Yucatán.

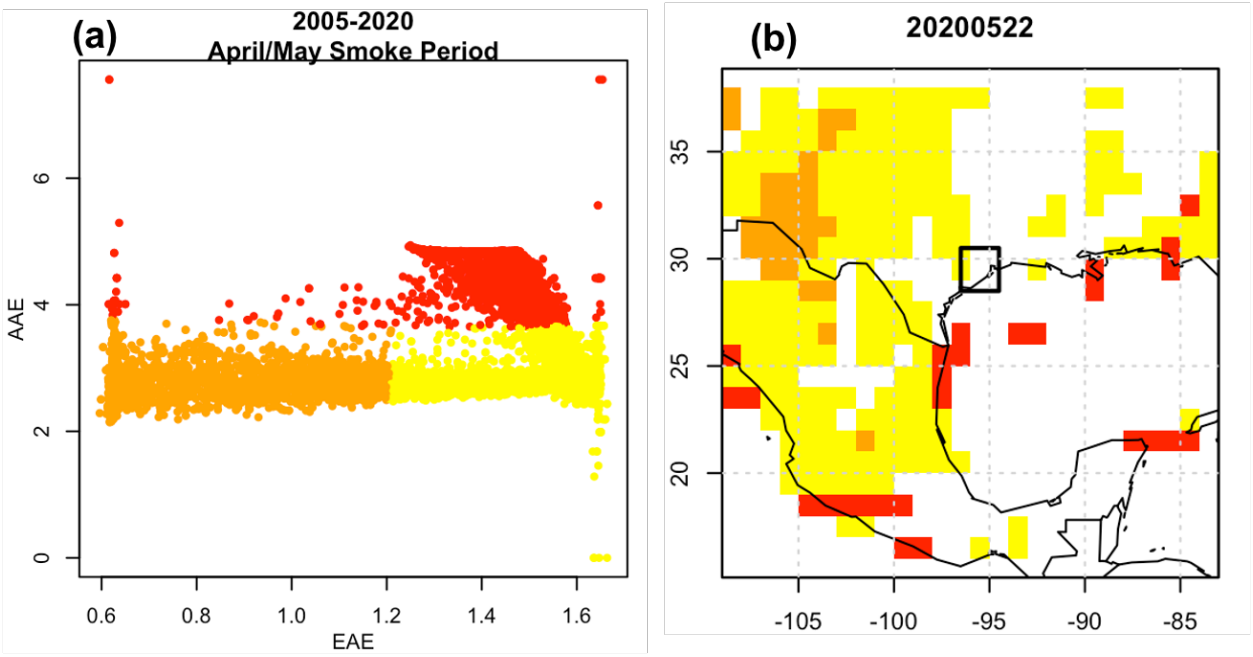

Figure 3. Results from OMI Brown Carbon processor. (a) ~160 April/May dates between 2005 and 2020 categorized by AAE and EAE regime using k-means clustering. (b) May 22 2020 pixels categorized by AAE vs EAE cluster ID in (3a). Red and yellow clusters indicate potential brown carbon presence, with red cluster suggesting brown carbon dominance. White areas are missing pixels, primarily due to cloud obstruction.

Data Collected

We gathered TROPOMI UVAI data for all dates from January through July 2020, specifically subset over the study domain. We gathered necessary driving data sets for April and May 20202 for the OMI Brown Carbon processor, namely 48-h averaged data for AOD, Absorption Aerosol Optical Depth (AAOD), carbon monoxide (CO), formaldehyde (HCHO), and nitrogen dioxide (NO_2).

Identify Any Problems or Issues Encountered and Proposed Solutions or Adjustments

Based on our literature review, we found that the UVAI associated with agricultural biomass burning is likely a smaller magnitude signal with weaker correlation than those associated with forest- or peat-type fires. We will consider this as we include UVAI in our comparison with HMS and GOES. Currently our UVAI smoke flag is binary: we flag smoke if $0<UVAI\leq3$. Going

forward, we will categorize our UVAI according to magnitude, and we will quantify strength of UVAI smoke signal both within and outside of overlap regions.

Goals and Anticipated Issues for the Succeeding Reporting Period

We will refine our incorporation of the UVAI-derived smoke product. We will continue our comparison of the three different smoke products with OMI AAOD/AOD, AIRS CO, and CrIS NH_3 data. We anticipate wrapping up Task 1 by the end of October. We will begin smoke plume height assessment beginning with MAIAC plume height data. Our initial goal for Task 2 is to apply the recently published relationship between MAIAC Plume Height and AOD.

Detailed Analysis of the Progress of the Task Order to Date

We have selected 93 dates between January and July 2020 with suspected smoke intrusions in the Texas area. For these dates:

- We are completing and refining our comparisons of three different smoke products, the first milestone of Task 1 from the task order. We will also incorporate time of measurement to further refine our comparisons.
- We have begun our comparison with OMI brown carbon estimates derived from AOD and AAOD measurements.
- We have also begun our comparison with AIRS CO and CrIS NH_3 data.

Do you have any publications related to this project currently under development? If so, please provide a working title, and the journals you plan to submit to.

☐**Yes** ☒ **No**

Do you have any publications related to this project currently under review by a journal? If so, what is the working title and the journal name? Have you sent a copy of the article to your AQRP Project Manager and your TCEQ Liaison?

☐ **Yes** ☒ **No**

Do you have any bibliographic publications (ie: publications that cite the project) related to this project that have been published? If so, please list the reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Do you have any presentations related to this project currently under development? If so, please provide working title, and the conference you plan to present it (this does not include presentations for the AQRP Workshop).

☒ **Yes** ☐ **No**

Identifying Smoke-Impacted Regions using the Optical Properties of Brown Carbon Aerosol, accepted for poster at AGU Fall Meeting

Do you have any presentations related to this project that have been published? If so, please list reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Have any personnel changes occurred that were not listed in the original proposal? If so, please include a detailed description of the personnel change(s) below.

☒ **Yes** ☐ **No**

We added AER Sr. Research Associate Qiang Sun to the project to help gather and process data for Task 1.

Are any delays expected in the progress of the research? If so, please include a detailed description of the potential delay below.

☐ **Yes** ☒ **No**

Describe any possible concerns/issues (technical or non-technical) that AQRP should be made aware of.

None

Are you anticipating using all the available funds allocated to this project by the end date? If not, why and approximately what is the amount to be returned?

☒ **Yes** ☐ **No**

Submitted to AQRP by
Matthew James Alvarado