Characterizing Differences in the Aerosol Plume and Cloud Structure over Ascension Island During the 2016 and 2017 Biomass Burning Seasons

Allison B. Marquardt Collow[1,2] and Mark A. Miller[3]

[1] Universities Space Research Association, [2] NASA Code 610.1, [3] Rutgers University

GMAO Global Modeling & Assimilation Office

Background and Motivation

- Marine boundary layer clouds are poorly represented in models and the underlying physical processes and not well understood
- Aerosols in the SE Atlantic likely impact the microphysical and macrophysical properties of stratocumulus and trade cumulus in this region, but this has yet to be quantified
- Goal: to determine the impacts of these aerosols on boundary layer and cloud structure

Methodology

- The Modern Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) is evaluated using observations from the ARM Mobile Facility (AMF) over Ascension Island for the 2016 and 2017 biomass burning seasons
- HYSPLIT, forced with MERRA-2, is used to calculate back trajectories for the aerosol plume over Ascension Island
- Sub-cloud turbulent kinetic energy is calculated based on Doppler Lidar observations using w ($w' = w - \overline{w}$) and $TKE = 0.5\,\overline{w'w'} = 0.5\,\overline{w'^2}$ where 30 minute averages are subtracted from the one second observations. Clouds base must be above 200 m to be included.

Results: Aerosol Properties

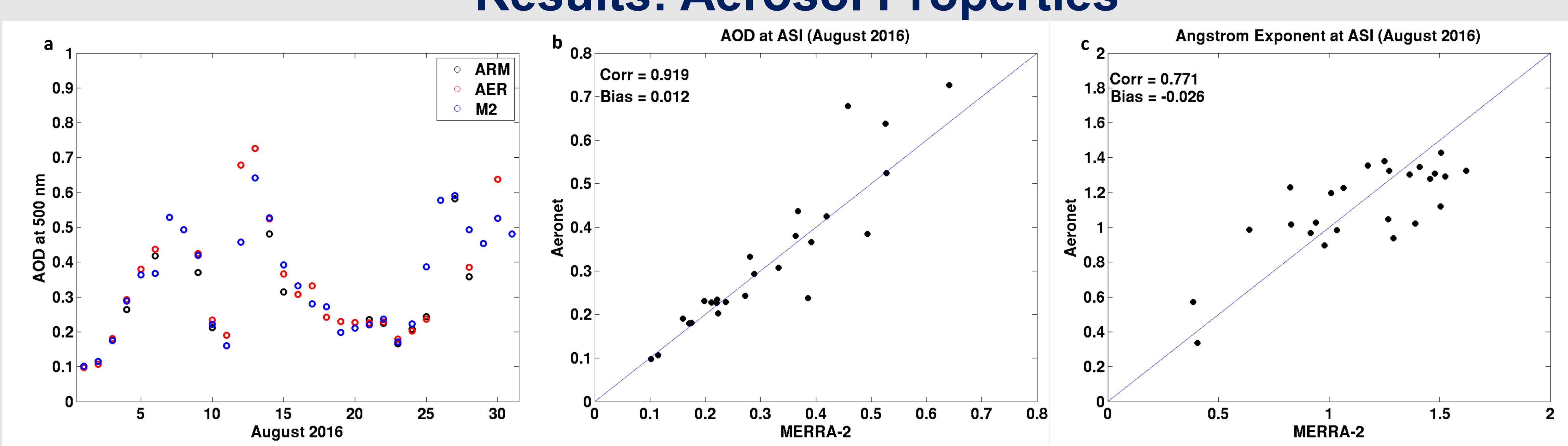

Figure 1 (above): (a) Daily aerosol optical depth from the AMF (ARM), Aeronet (AER), and MERRA-2 (M2) during August 2016 at Ascension Island ; (b) aerosol optical in MERRA-2 versus that observed by Aeronet; (c) Angstrom exponent in MERRA-2 versus that observed by Aeronet

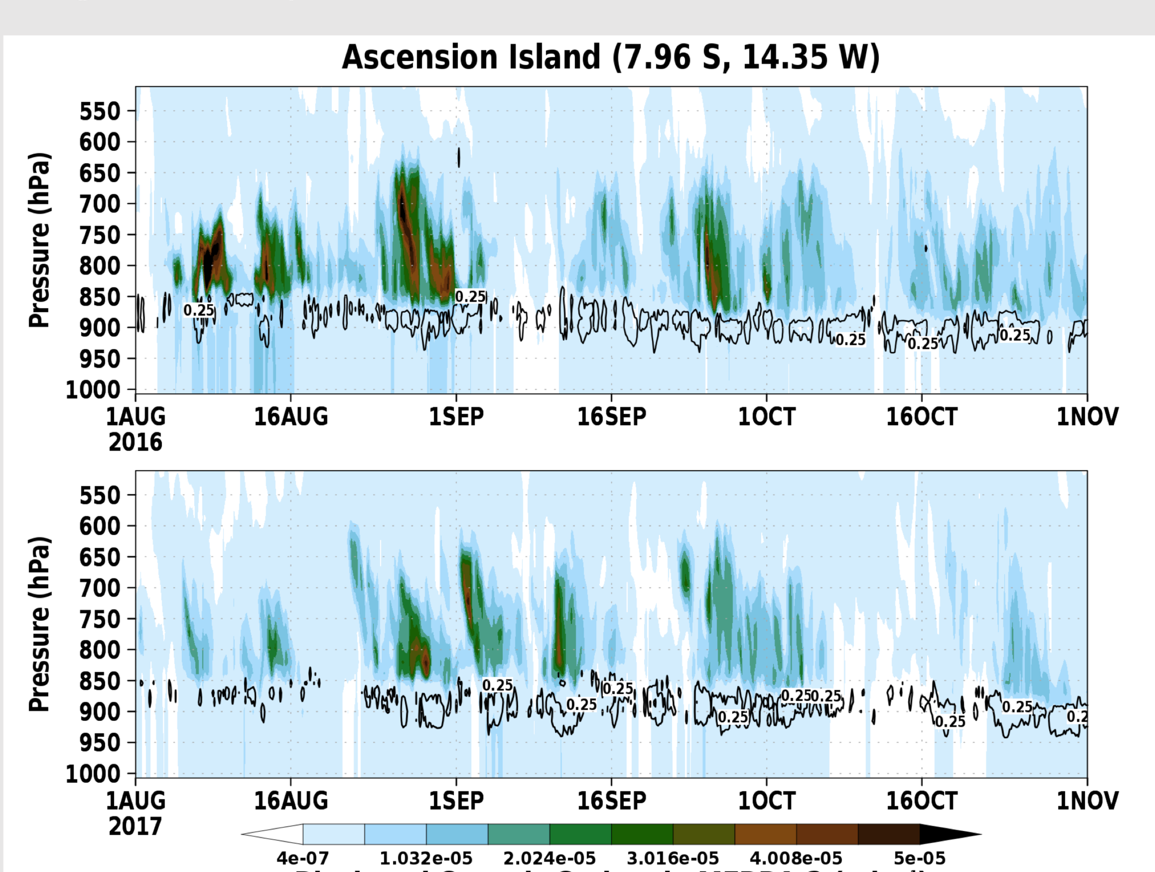

Figure 2 (left): Mixing ratio of black and organic carbon in MERRA-2 during August, September, and October of (a) 2016 and (b) 2017 over Ascension Island. Black contours indicate a cloud fraction of 0.25.

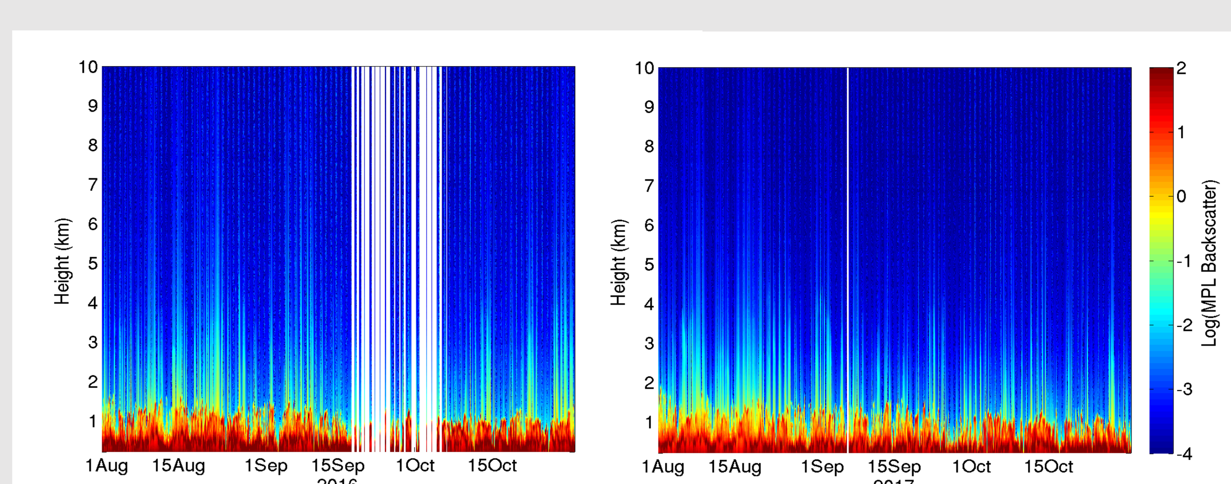

Figure 3 (above): The log of the MPL backscatter over Ascension for August through October 2016 and 2017

Key Points

- MERRA-2 accurately represents aerosol optical depth over the SE Atlantic
- Aerosol loading over Ascension Island is higher in 2016 due to a weaker subtropical high
- A shallow internal boundary layer is present as indicated by Doppler Lidar and wind profiler observations, with a sharp cutoff at a normalized height of 0.3 below cloud base
- Wind direction is remarkably consistent, limiting the impact of island effects

Results: Back Trajectories

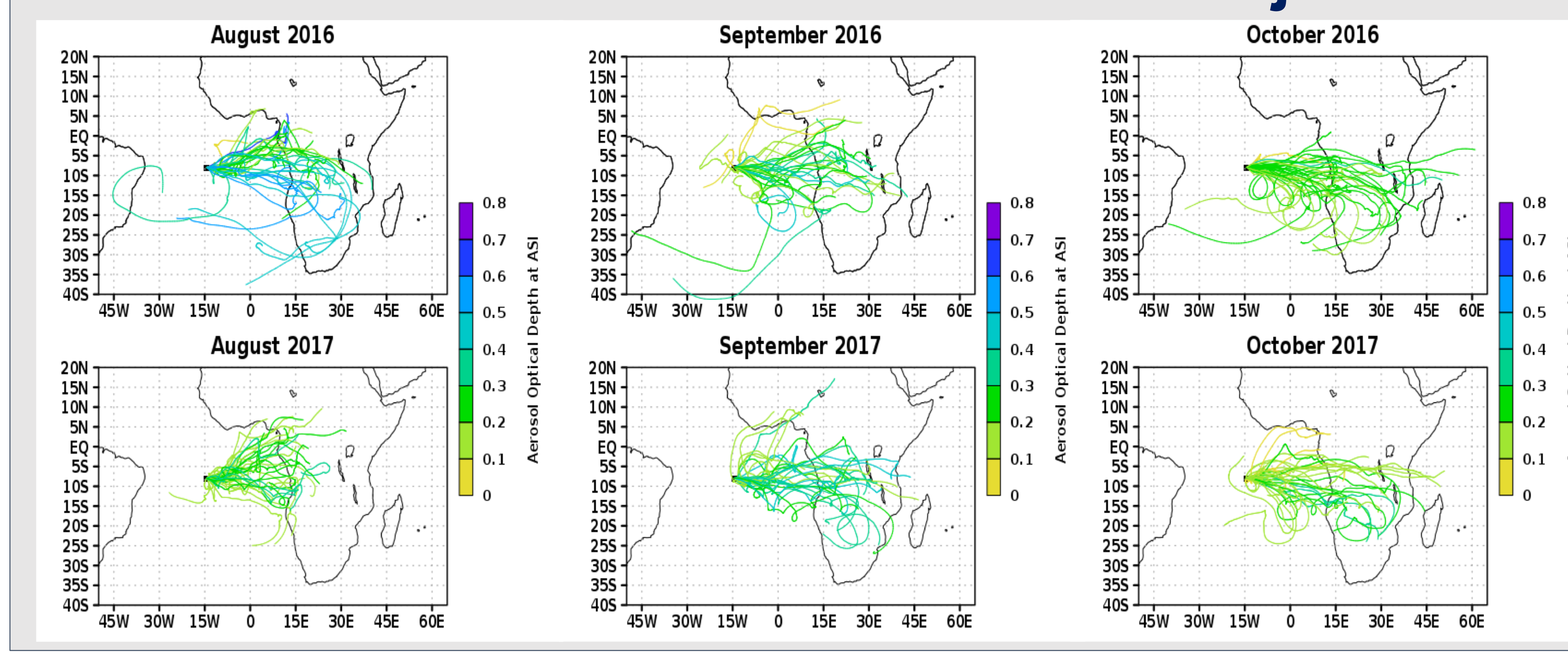

Figure 4 (left): 10 day back trajectories of a parcel originating at 2 km over Ascension Island color coded based on the AOD on the start date for (a) August, (b) September, and (c) October 2016 and 2017

Results: Sub-Cloud Turbulent Kinetic Energy and Island Effects

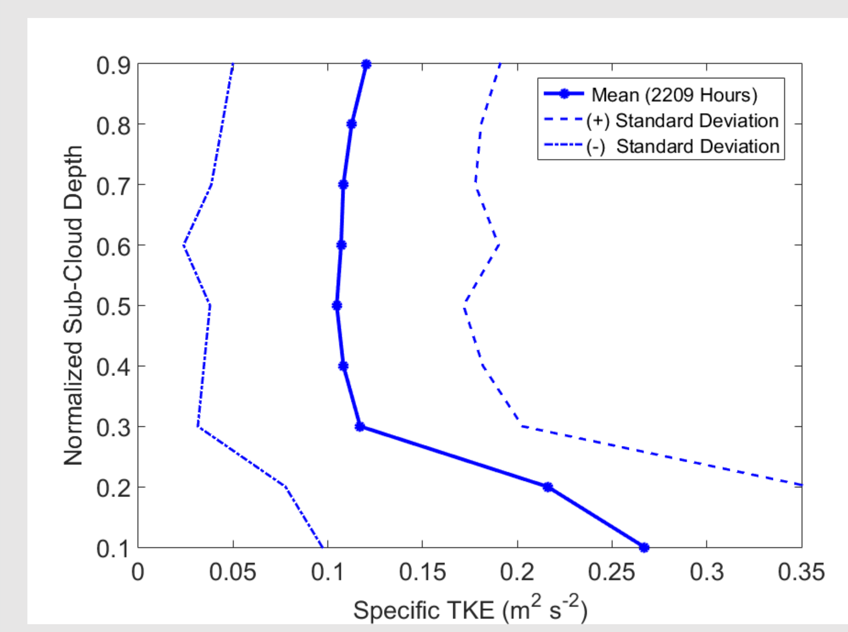

Figure 5 (left): Measurements of the profile of the vertical component of the sub-cloud specific Turbulent Kinetic Energy (TKE/m), where m is mass, from the Doppler Lidar on Ascension Island for the months of August-October 2016 and 2017. The heights were normalized such that they range between 0 and 1, where 1 equals the cloud base height. Also plotted are plus and minus one standard deviation from the mean.

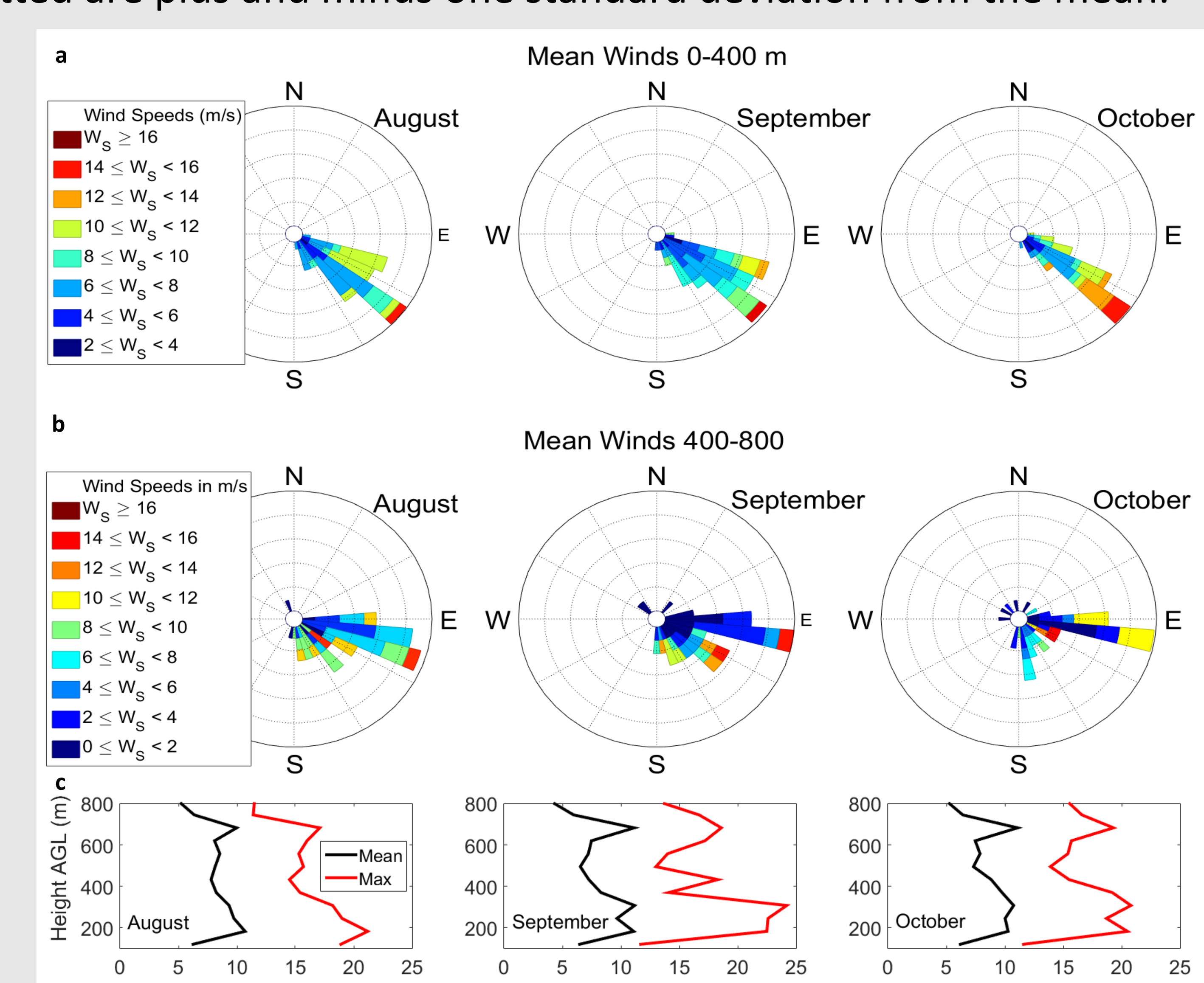

Figure 6 (right): (a) Wind roses depicting mean winds below 400 m as observed by the wind profiler above Ascension Island for the months of August, September, and October 2016 and 2017. (b) Same as in (a) except for 400 to 800 m above ground level. (c) Vertical profile of mean and maximum wind speed above Ascension Island for the months of August, September, and October 2016 and 2017.

E-mail: allison.collow@nasa.gov | *Web:* gmao.gsfc.nasa.gov

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