Thermodynamic, Cloud, and Radiative Heating Profiles over Ascension Island During the 2016 and 2017 Biomass Burning Seasons

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

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

ASR Atmospheric System Research

GMAO Global Modeling & Assimilation Office

Background and Motivation

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

Methodology

- Observed thermodynamic and cloud profiles from the AMF1 deployment at Ascension Island are used in conjunction with MERRA-2 aerosol properties as input for idealized simulations using the Rapid Radiative Transfer Model (RRTM) during August and September 2016 and 2017

Experiment
1. Control (T and RH profiles only)
2. Aerosols (1 plus all species in MERRA-2)
3. No black carbon (2 minus black carbon)
4. Clouds (1 plus cloud properties)
5. Aerosols and Clouds (2 + 4)
6. Aerosols, Clouds, No black carbon (3 + 4)

RRTM Input Profiles

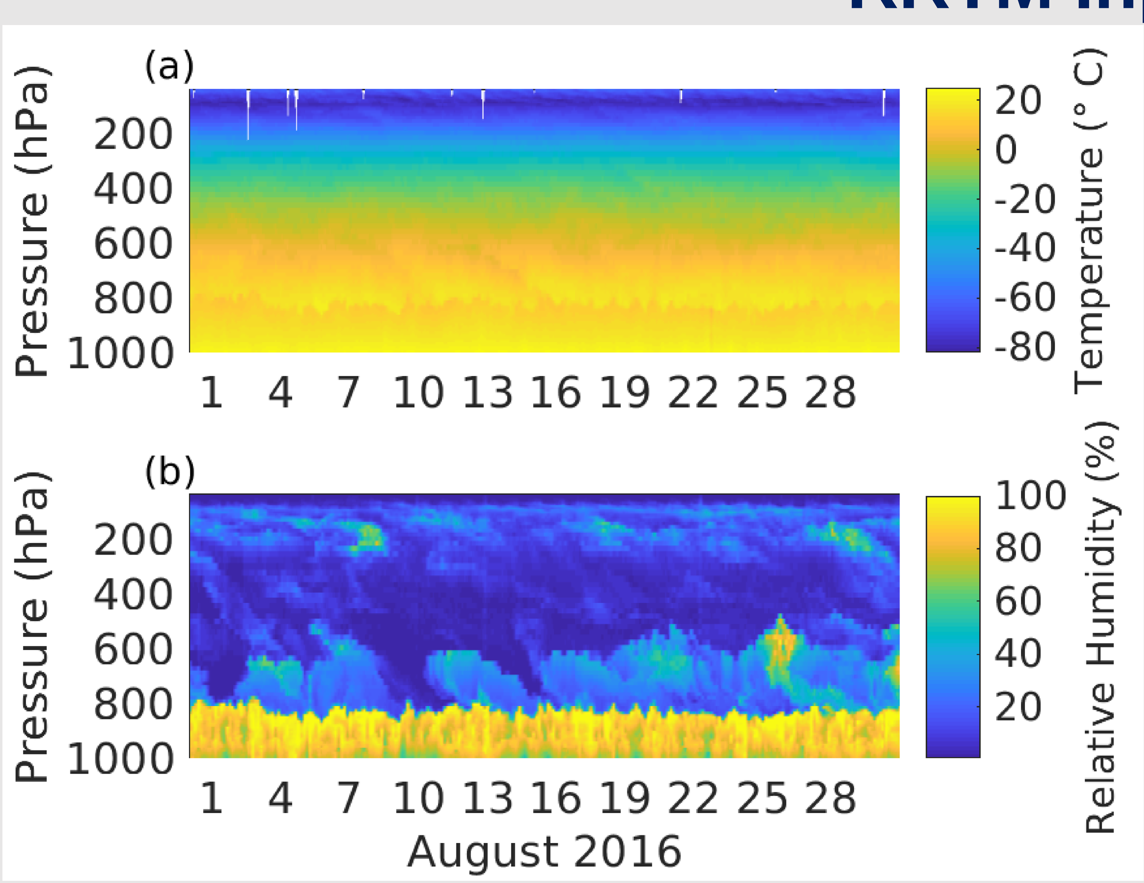


Figure 1: Hourly (a) temperature and (b) relative humidity profiles over Ascension Island during August 2016 using the INTERPSONDE VAP

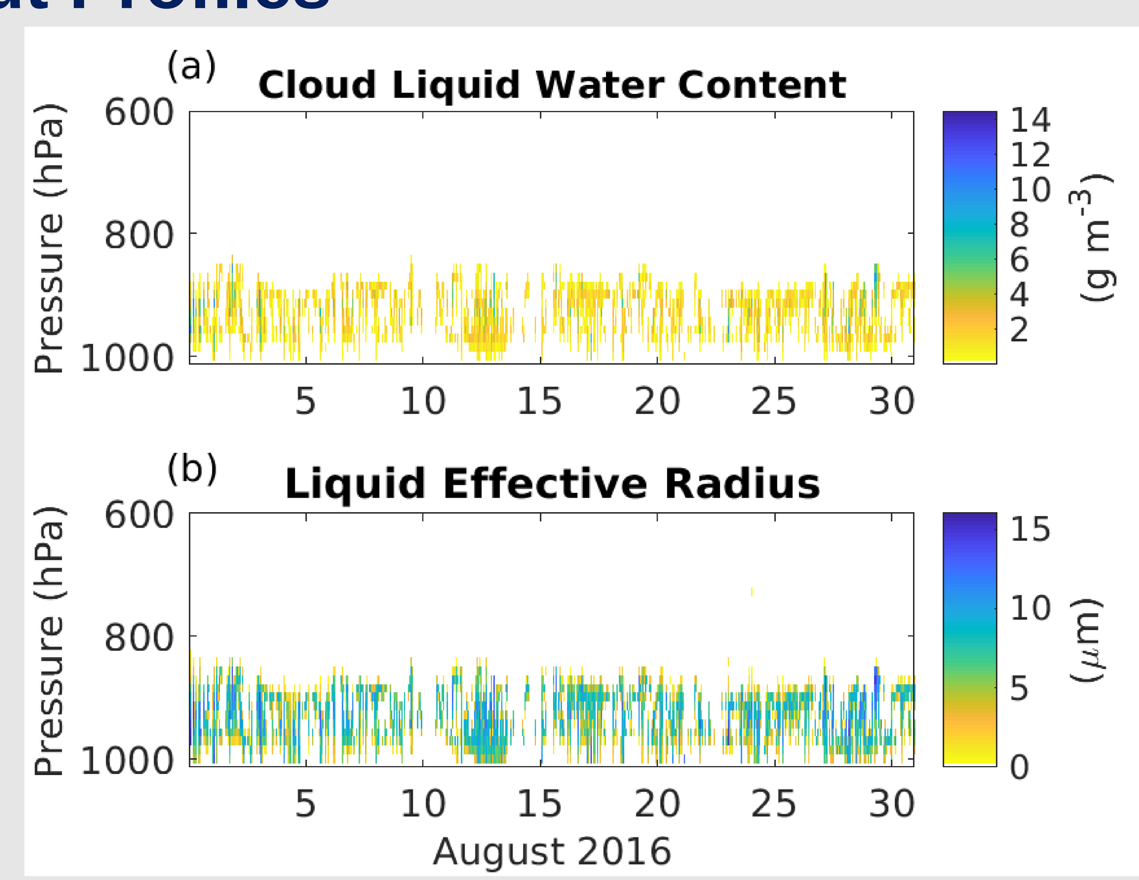


Figure 2: (a) Cloud liquid water content and (b) effective radius over Ascension Island during August 2016 computed using the MICROBASE algorithm

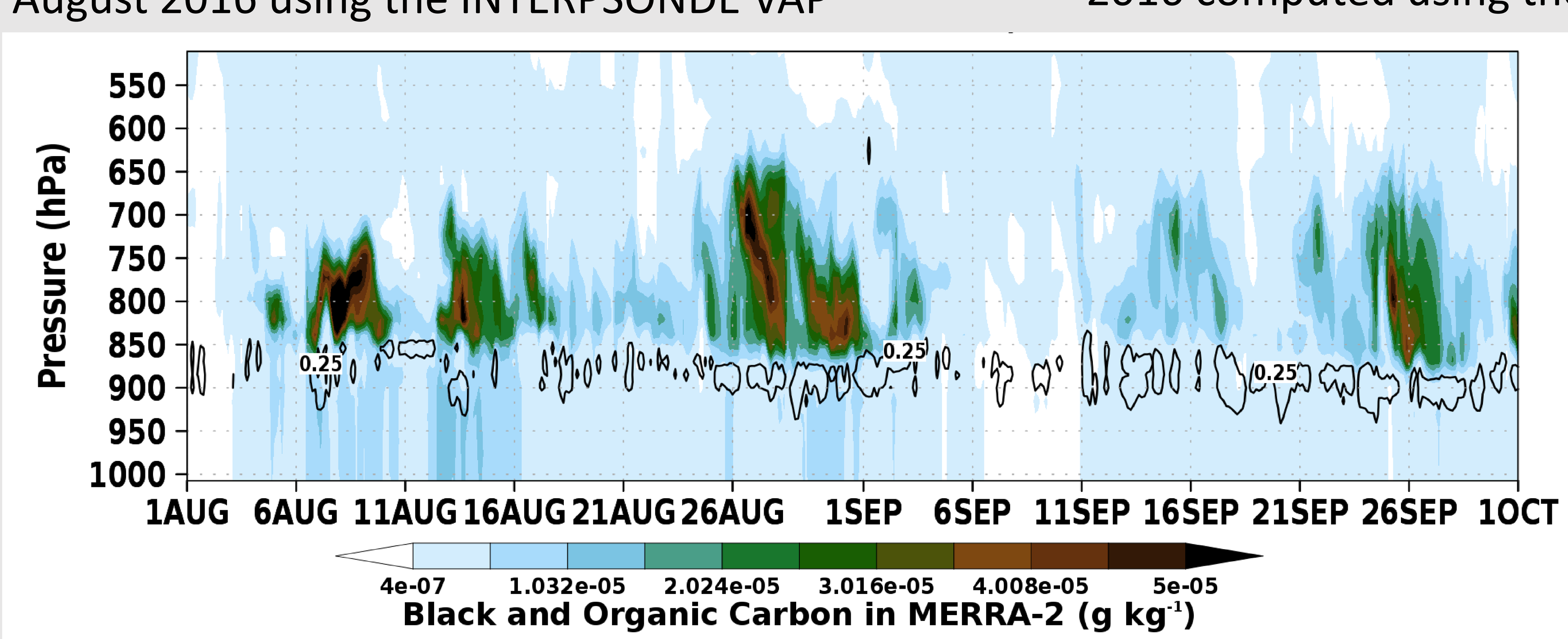


Figure 3: Vertical profile of the mixing ratio of black and organic carbon from MERRA-2 in grid box above Ascension Island during August and September 2016

Results

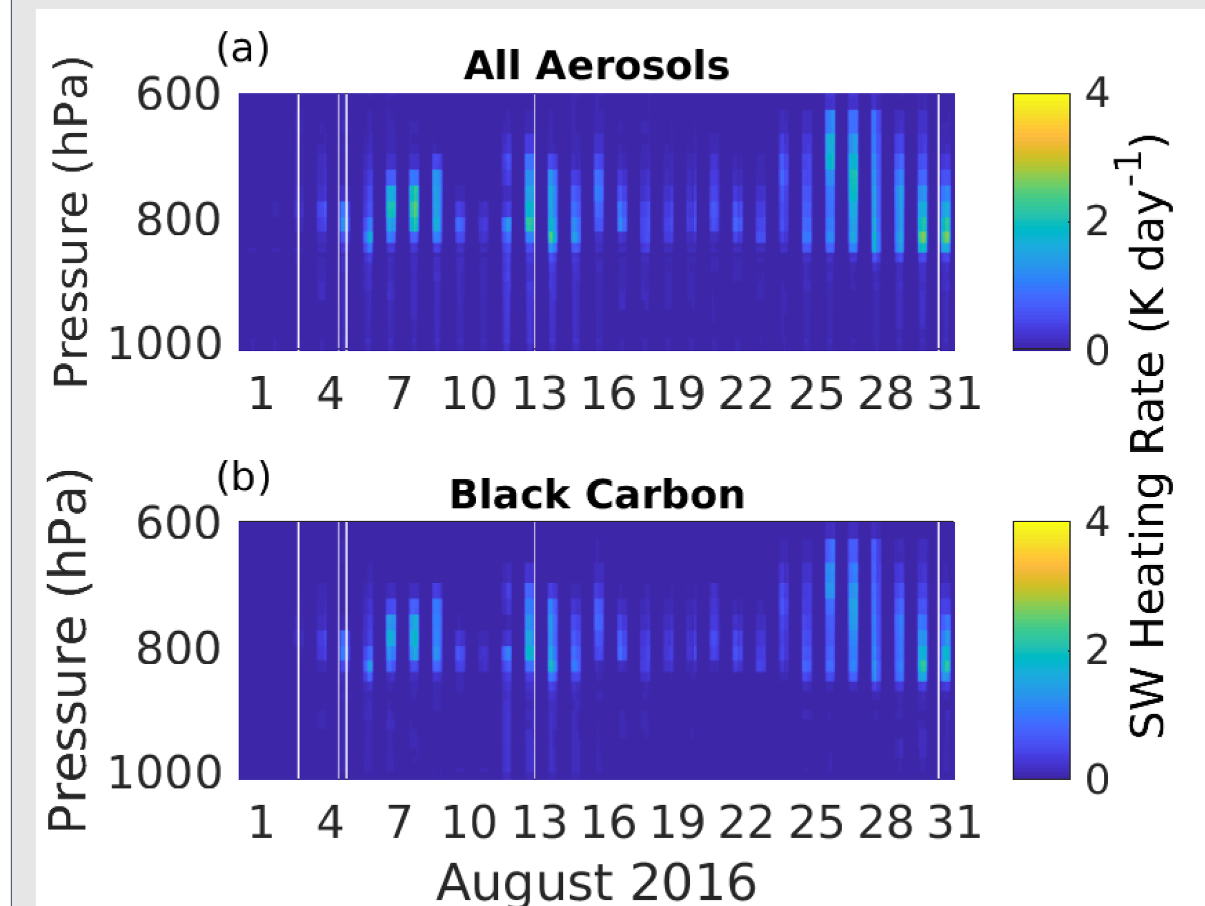


Figure 4: SW heating rate due to (a) all aerosols and (b) only black carbon over Ascension Island during August 2016

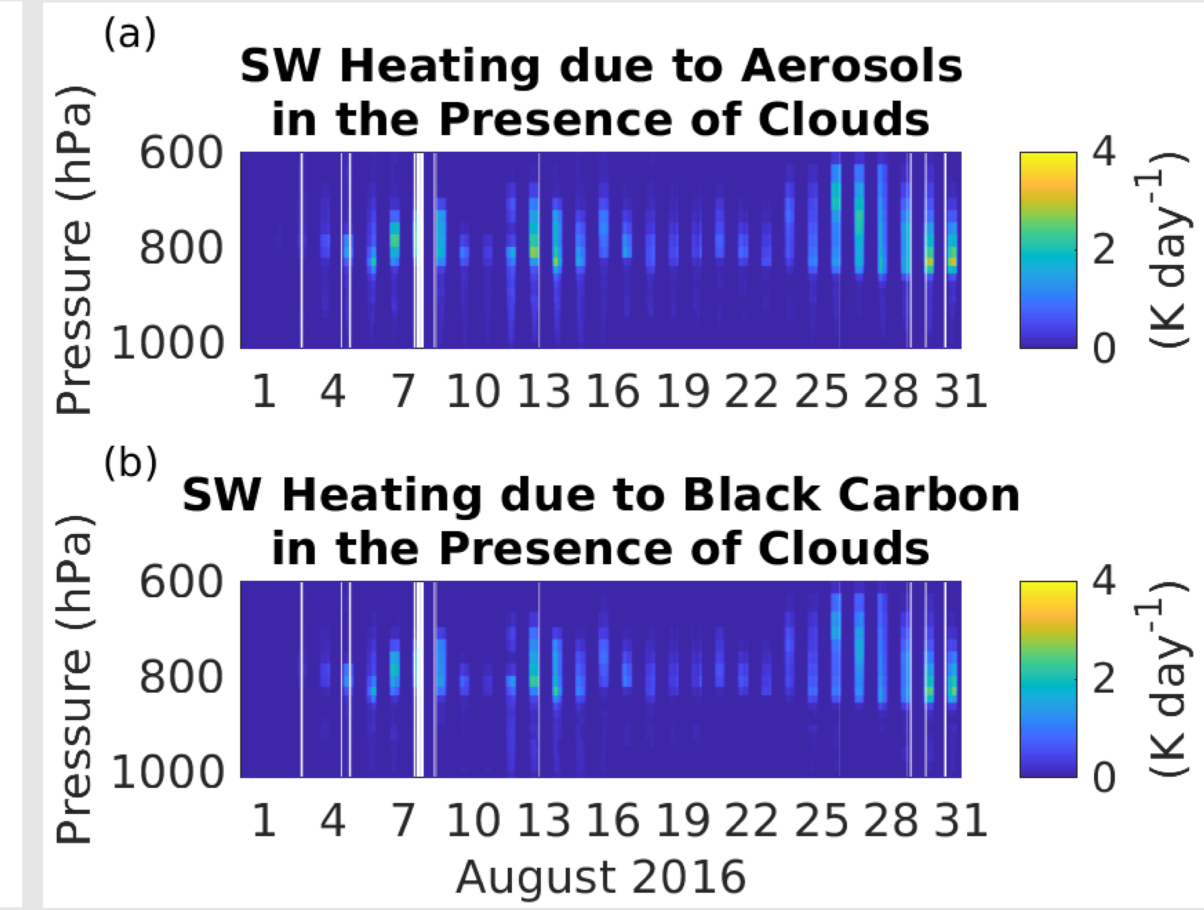
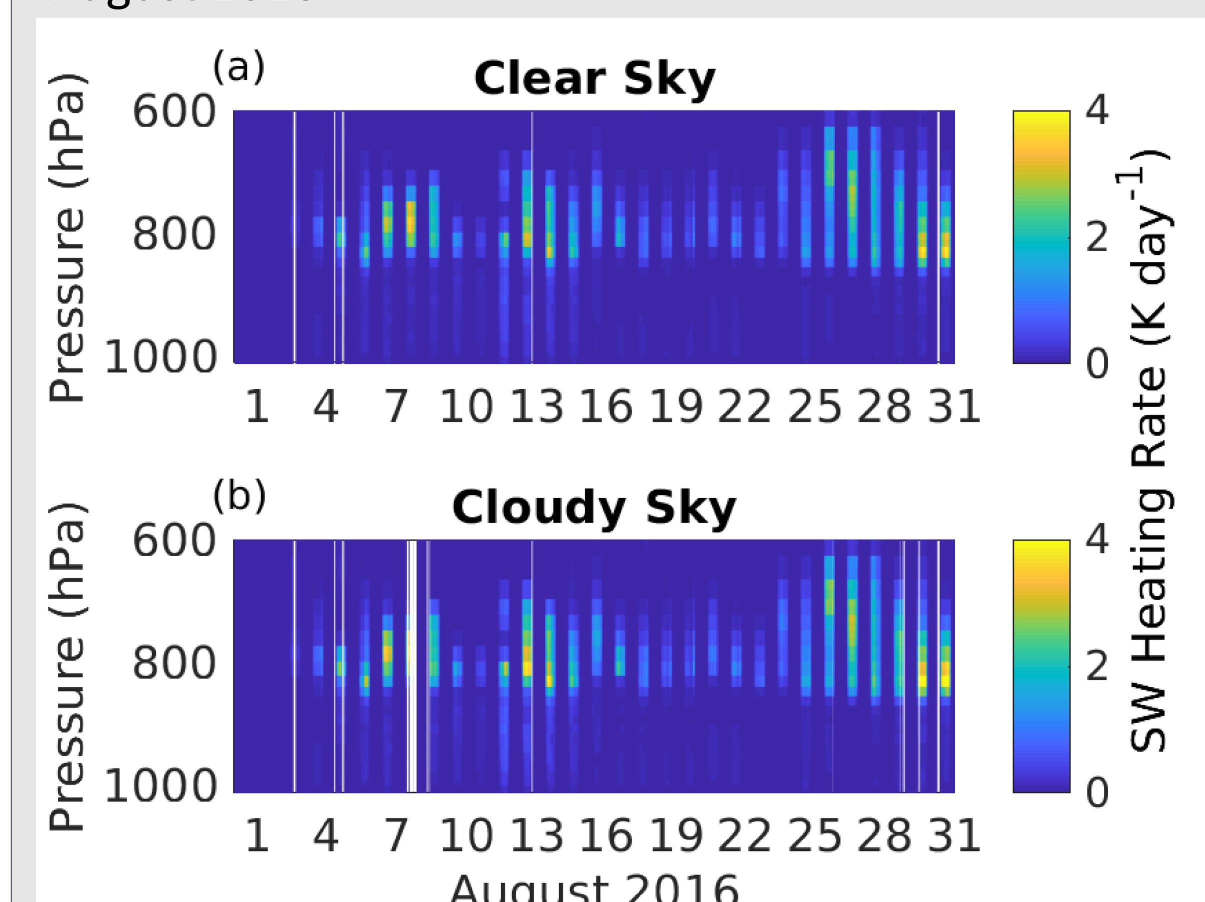


Figure 5: SW heating rate due to (a) all aerosols and (b) only black carbon in the presence of clouds over Ascension Island during August 2016



- The single scatter albedo (SSA) in MERRA-2 is ~15% higher than the observations presented by Zuidema et al. (2018)
- Comparisons between ORACLES observations and GEOS show similar results however flights near the African coast are in good agreement with GEOS (not shown)

Figure 6 (left): Additional SW heating due to all aerosols under (a) clear and (b) cloudy skies when the SSA for black carbon is reduced by 15%

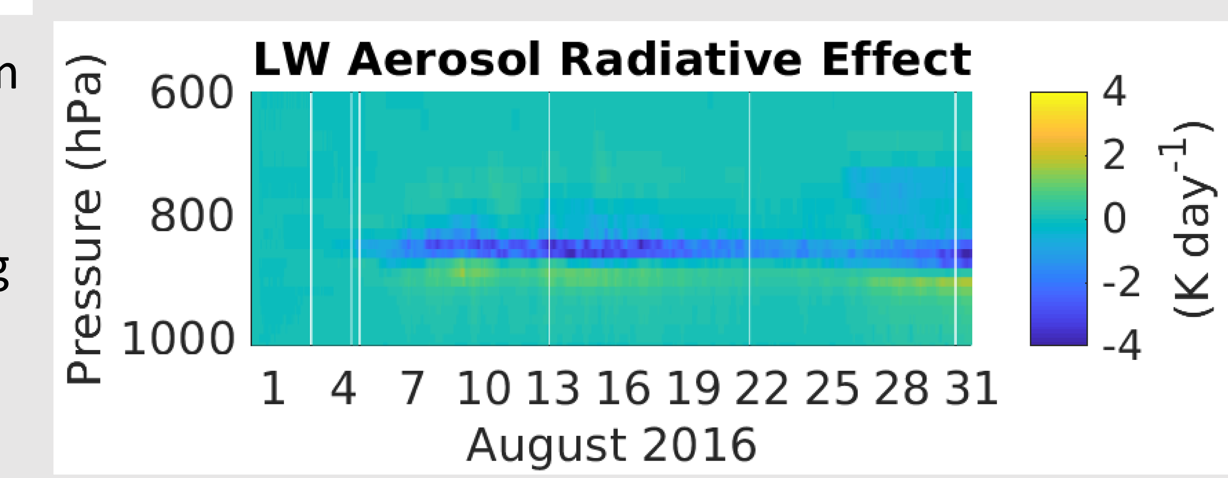


Figure 7 (right): LW heating rate due SW warming from aerosols under clear sky conditions. Temperature profiles were iteratively adjusted each hour using the SW aerosol radiative effect from the experiment using the reduced SSA. Any residual heating not accounted for by LW cooling was allowed to persist through the next hour.

Conclusions

- SW heating over Ascension Island due to MERRA-2 specified aerosols is ~2 K
- Sensitivity experiments suggest SW heating may be double above (MERRA-2 SSA is too high)
- Additional LW cooling cannot account for the SW heating due to aerosols
- Biomass burning aerosols alter the thermodynamic profile and can likely impact clouds below

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

RUTGERS THE STATE UNIVERSITY OF NEW JERSEY   USRA   National Aeronautics and Space Administration   NASA