Reducing Model Biases in Aerosols and Clouds through Recent Airborne Field Campaigns

Allison Collow[1,2], Patricia Castellanos[2], Peter Colarco[2], Arlindo da Silva[2], Melanie Follette-Cook[3,2], Ravi Govindajaru[4,2], Edward Nowottnick[2], and Xiaohua Pan[5,2]

[1]Universities Space Research Association, Columbia, MD, [2]NASA GSFC, Greenbelt, MD, [3]Morgan State University, Baltimore, MD, [4] Science Systems and Applications, Inc., Lanham, Maryland, [5] ADNET Systems Inc., Bethesda, MD

Introduction

Field Campaign Data

- 15 Jul 2019 – 5 Sep 2019
- Two deployments: Boise, ID (wildfires) and Salina, KS (agricultural fires)
- NASA DC8 and ER2, NOAA Met and Chem Twin Otter
- Goal: Investigate air quality impacts of fire, relating fire emissions to fuel and fire conditions, downwind chemical transformation, and plume rise conditions.

- 24 Aug 2019 – 6 Oct 2019
- Spanned two monsoon phases
- Sampled Philippines and surrounding oceanic area
- P3 aircraft and Lear Jet observations complemented by ship-borne (PISTON) and satellite observations
- Goal: Untangle aerosol, cloud, radiation interactions

Model Data

- **Goddard Earth Observing System (GEOS FP)** version 5.22 used for flight planning
- GEOS 5.25 now "operational" and includes substantial physics upgrades
  - Switch from RAS to Grell-Freitas convection, introduction of UW shallow convection, switch from Chou-Suarez to RRTM-G radiation, new land scheme, among other updates
- Updated aerosol module on the way for future version of GEOS (experiment termed eFAQCPX); introduces brown carbon, SOA
- **Our Goal: Produce a mini-reanalysis using the best possible model configuration, assimilation techniques, and assimilated observations spanning the FIREX-AQ and CAMP²Ex campaigns**

Aerosol Backscatter and Extinction

- Evaluated using the Differential Absorption Lidar (DIAL) for FIREX-AQ and the High Spectral Resolution Lidar 2 (HSRL2) for CAMP²Ex
- Other wavelengths and fields also evaluated (eg. depolarization ratio, 1064 nm)

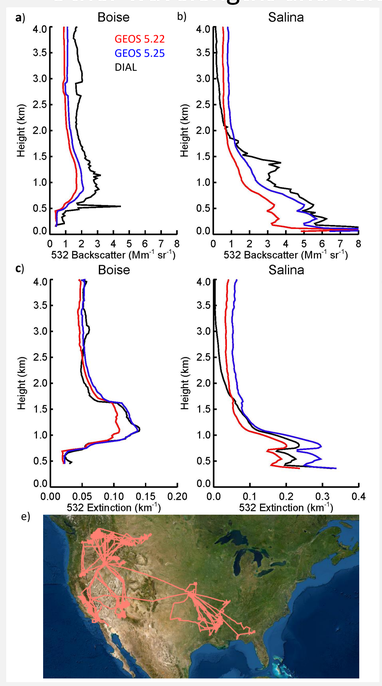


Figure 1 (left): Mean vertical profile of aerosol backscatter and extinction at 532 nm for FIREX-AQ flights originating from (a,c) Boise, ID and (b,d) Salina, KS as observed by DIAL and GEOS. (e) Tracks from the flights used to produce the backscatter and extinction in panels a-d.

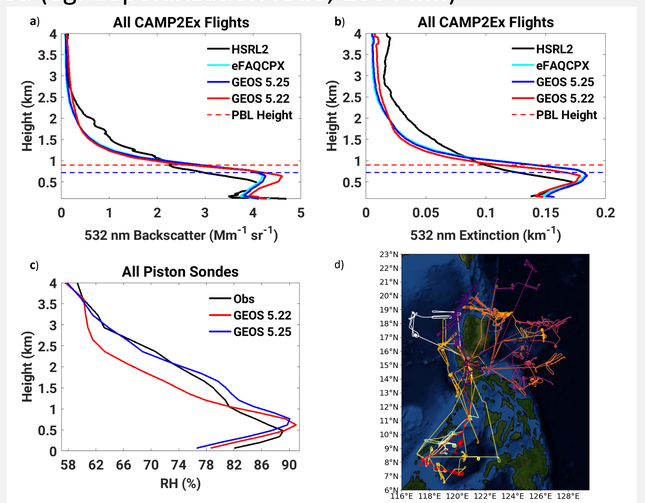
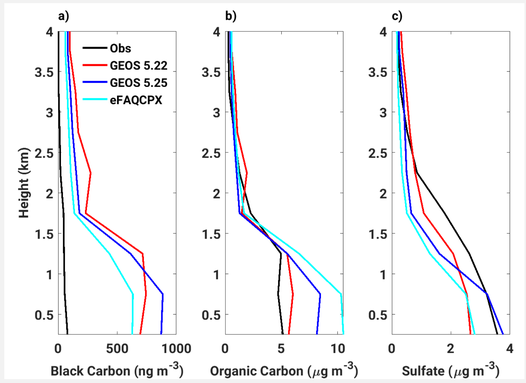


Figure 2: Mean vertical profile of (a) aerosol backscatter and (b) extinction at 532 nm as observed by the HSRL2 and in GEOS runs. Dashed lines indicate modeled PBL height. (c) Mean vertical profile of relative humidity as observed by radiosondes launched aboard the Sally Ride as part of Piston and in GEOS 5.22 and 5.25. Meteorology is the same in GEOS 5.25 and eFAQCPX. (d) Tracks from the 18 CAMP2Ex flights included in panels (a) and (b).

Aerosol Profile during CAMP²Ex

- Evaluated using observations from Langley Aerosol Research Group Experiment (LARGE) SP2 for black carbon and AMS for organic carbon and sulfate



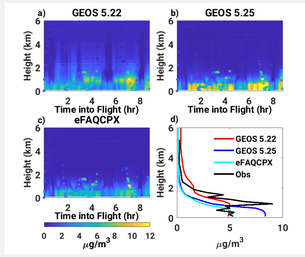
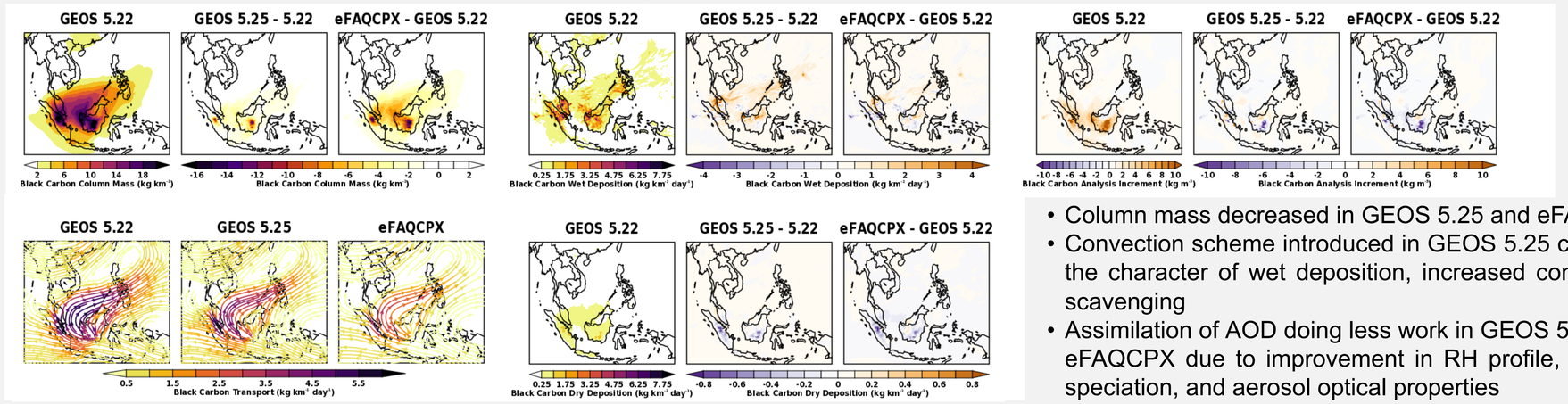


Figure 3 (above): Mean profiles of (a) black carbon, (b) organic carbon, and (c) sulfate from all CAMP²Ex flights.

Figure 4 (left): Vertical profile of sulfate from the flight on 1 October 2019, demonstrating boundary layer concerns in GEOS.

Black Carbon Lifecycle – 9 September 2019 to 22 September 2019



- Column mass decreased in GEOS 5.25 and eFAQCPX
- Convection scheme introduced in GEOS 5.25 changed the character of wet deposition, increased convective scavenging
- Assimilation of AOD doing less work in GEOS 5.25 and eFAQCPX due to improvement in RH profile, aerosol speciation, and aerosol optical properties

Recommendations for Future Improvement and Evaluation

- Decrease boundary layer height and improve decoupling
- Include peat and smoldering fires in biomass burning emissions
- Adjust vertical transport to improve aerosol vertical profile
- Investigate relationship between clouds and aerosol during CAMP²Ex

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

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