Challenges Coping with Biomass Burning Aerosols in our Global Models

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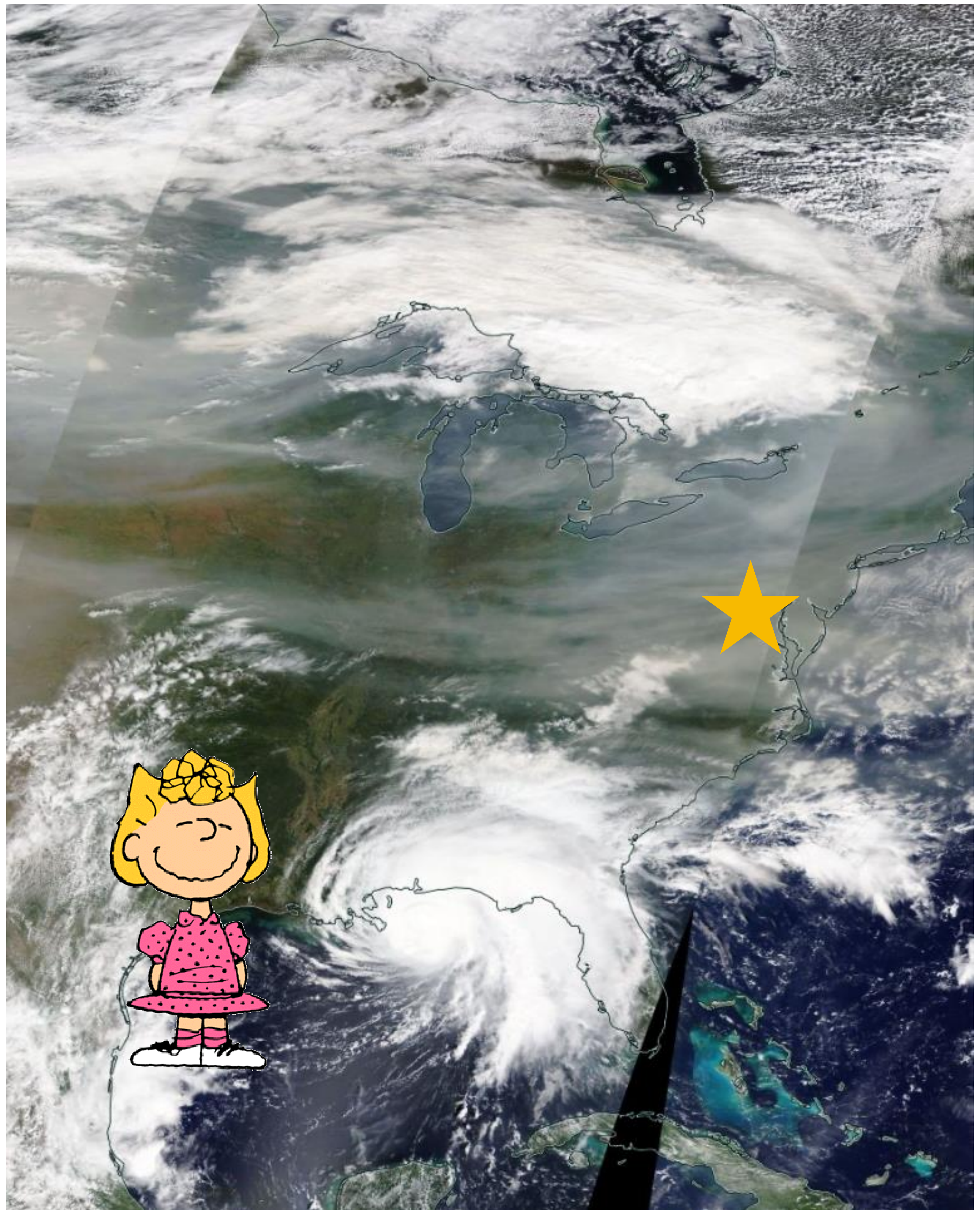
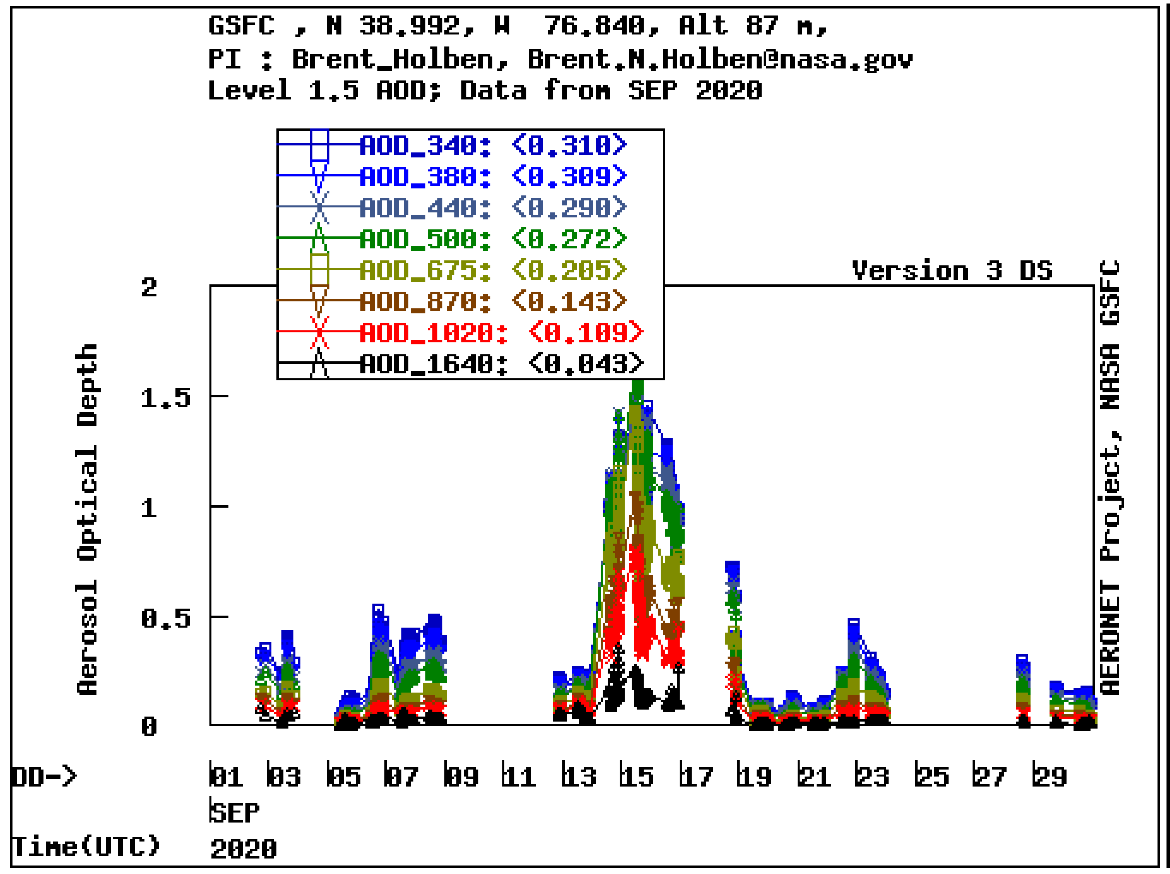
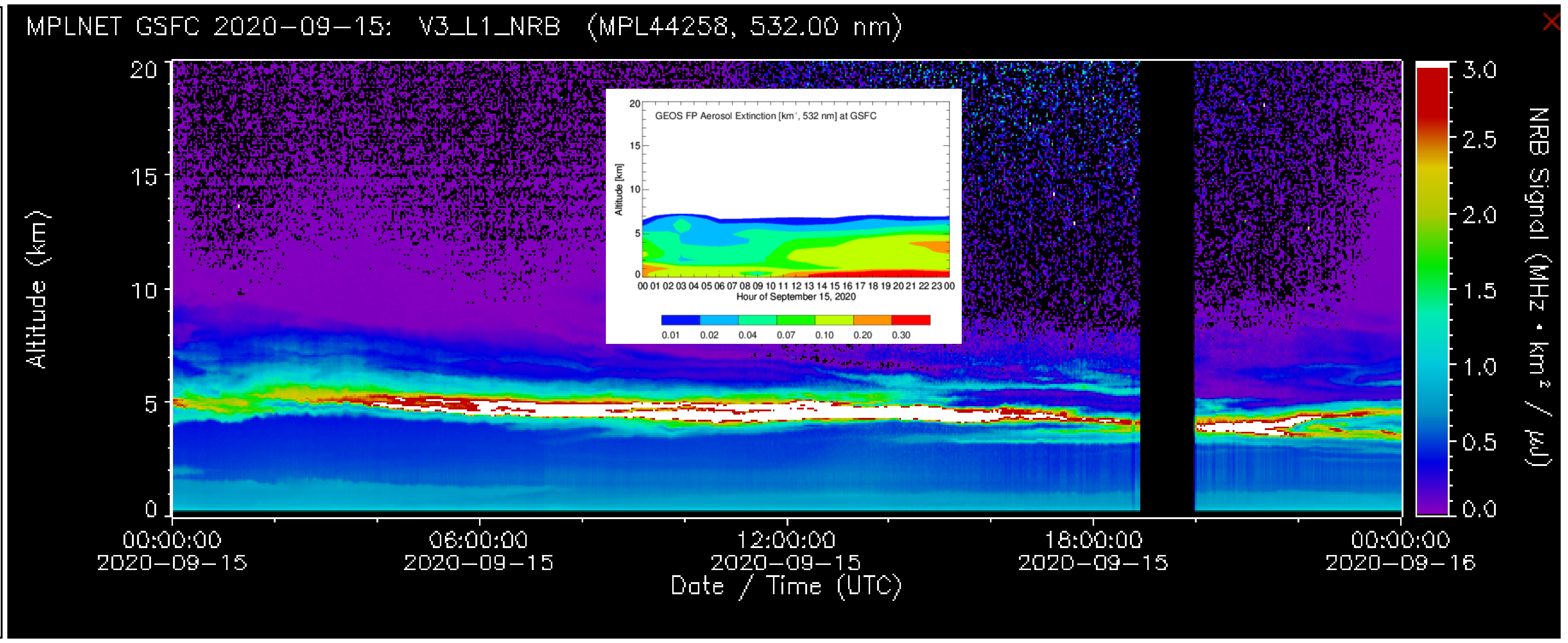
Was it cold in Maryland on September 15 because of California smoke?



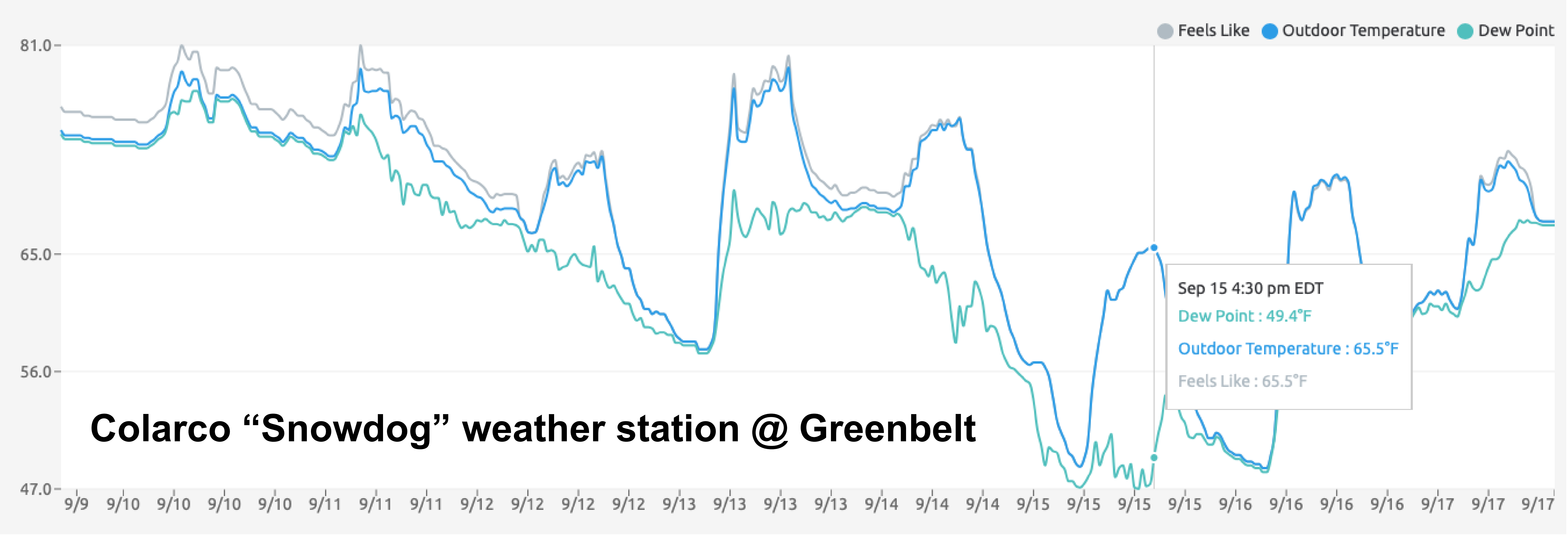
MODIS Terra RGB
9/15/2020



AERONET AOD @ GSFC



MPLNET Backscatter @ GSFC



Colarco “Snowdog” weather station @ Greenbelt

Challenges

There's a lot captured on previous slide

- Do we inject smoke (aerosol, VOC, other…) to right altitudes over the source regions?
- What is the composition and size of the material and how does it evolve?
- How does it interact with meteorology as it is transported? Does evolution of the vertical profile agree with observations?

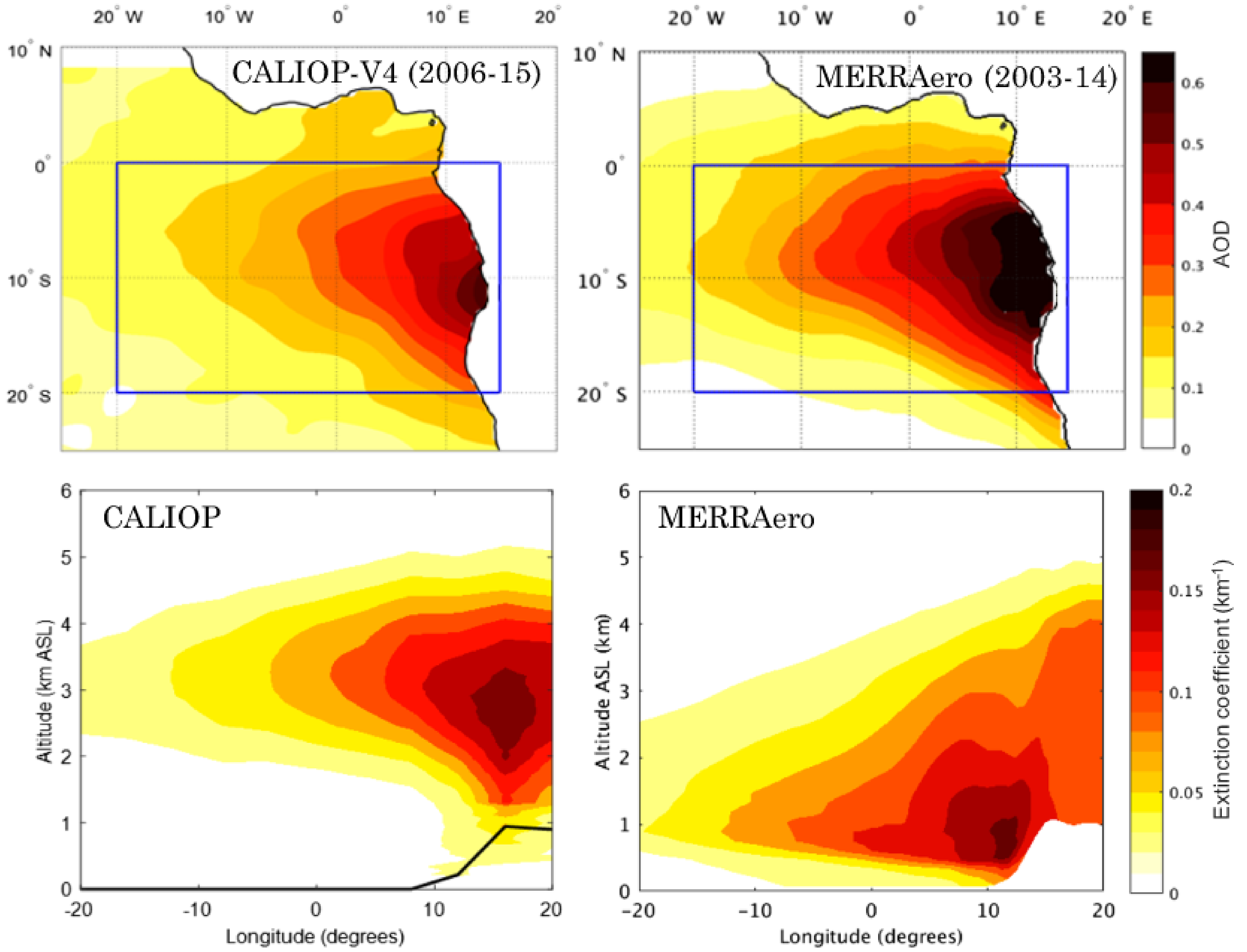
GEOS-FP / GOCART assumptions:

- QFED (MODIS FRP-based, biome tuned) emissions assign partitioning of smoke to BC and OC components
- material injected into boundary layer on a prescribed diurnal cycle
- prescribe a fixed OA:OC ratio
- "chemistry" is done with a time scale to convert hydrophobic -> hydrophilic

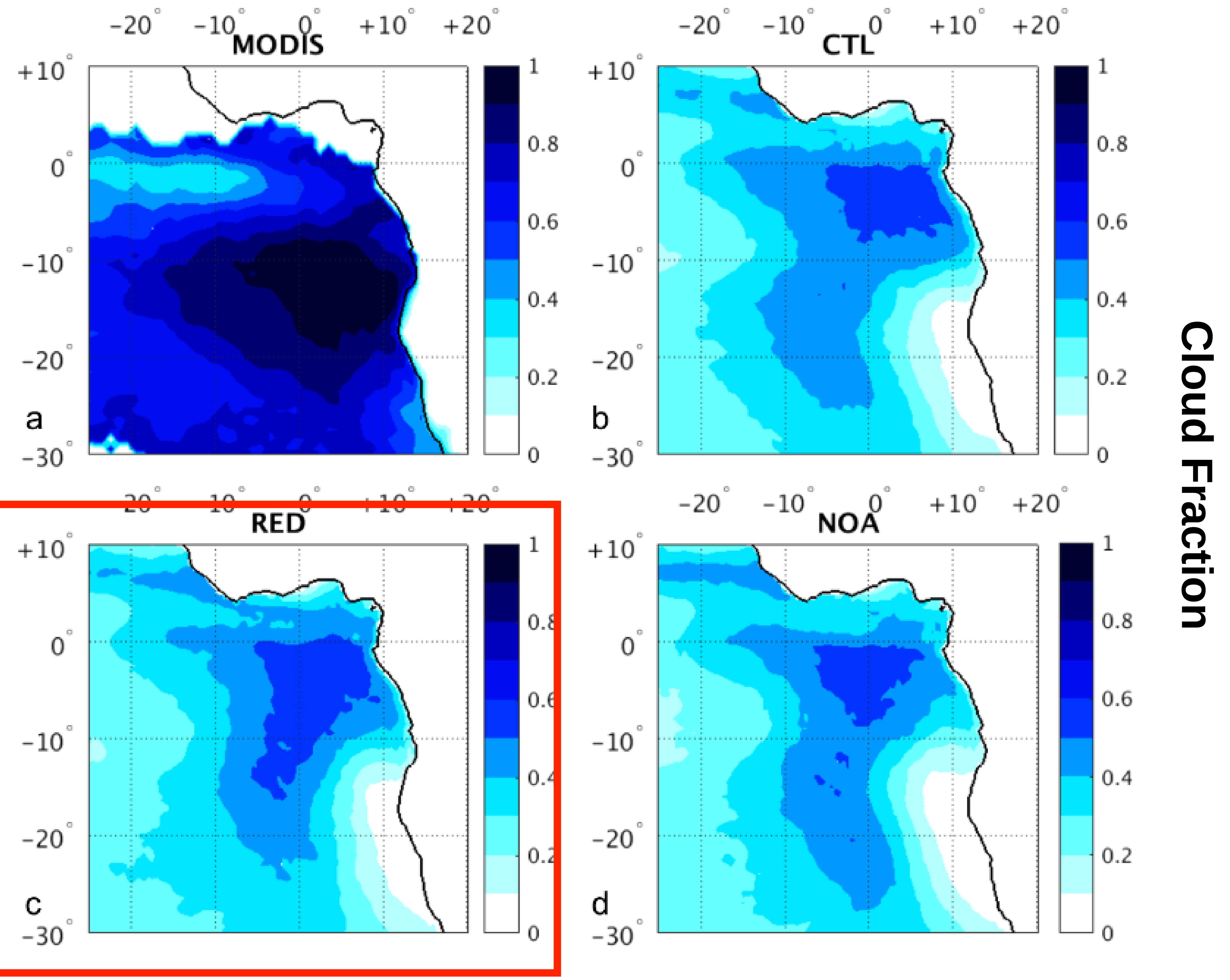
GEOS-FP / GOCART updates coming:

- Adjusted OA:OC ratio based on ATom
- Added VOC-produced SOA based on CO emissions
- Assign biomass burning organic aerosol optical properties more like brown carbon (that is, spectrally varying absorption)

Impacts of Smoke on Clouds



Even models well constrained in the total aerosol loading (AOD) still have trouble with the vertical profile of smoke in the highly dynamic SE Atlantic Ocean

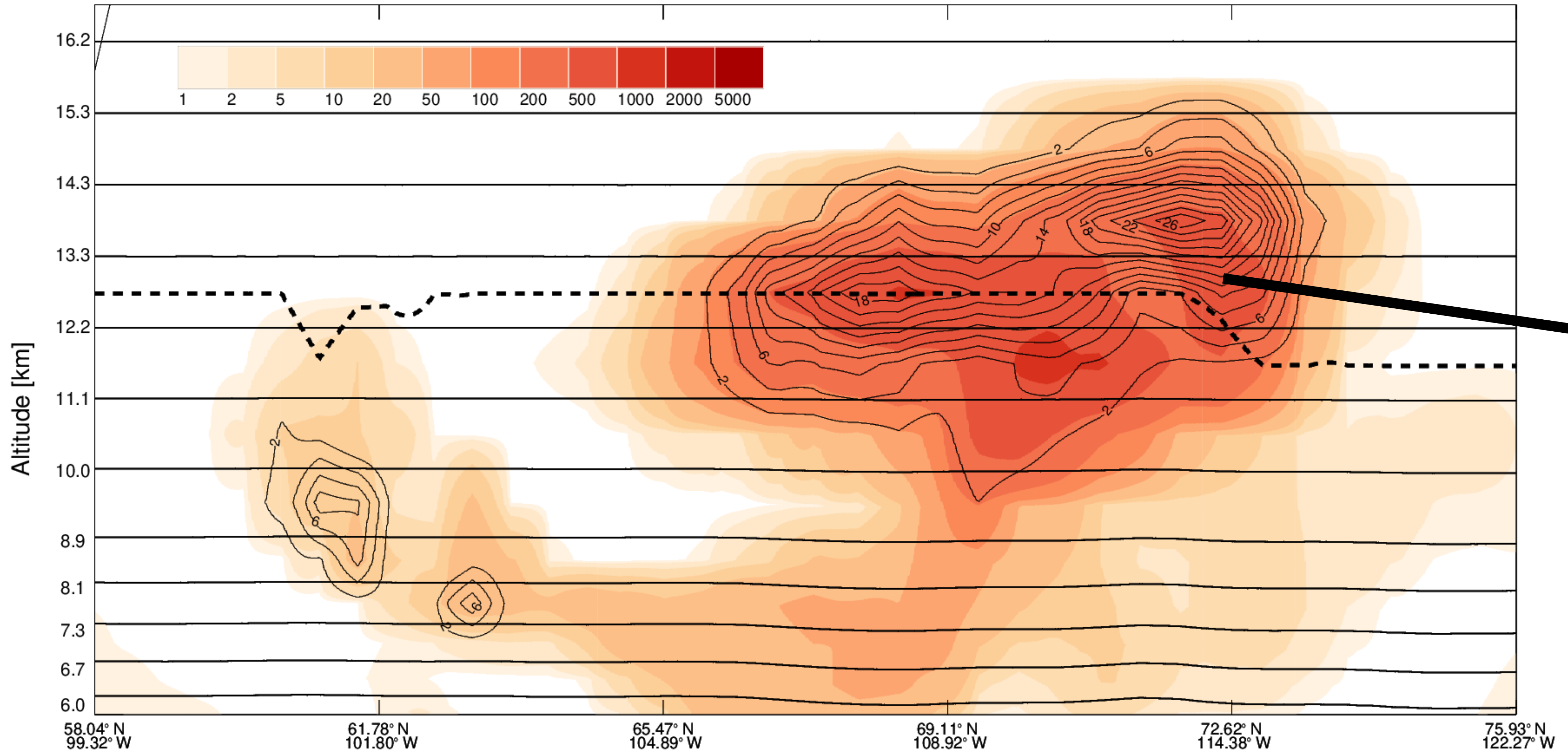


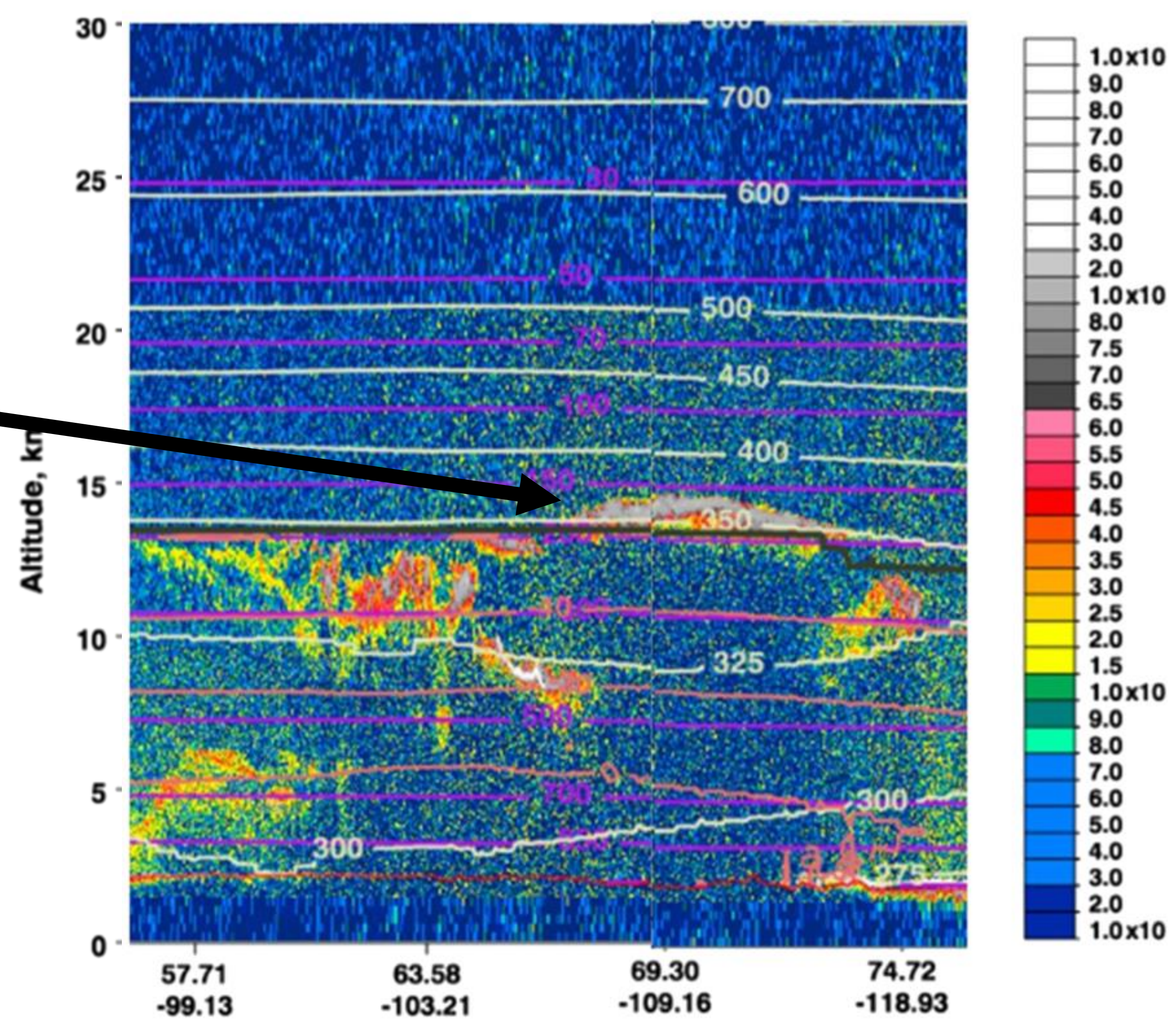
Constraints on the vertical profile—here, imposing it with CALIOP observation (RED)—result in small improvement in simulated cloud fraction in this region

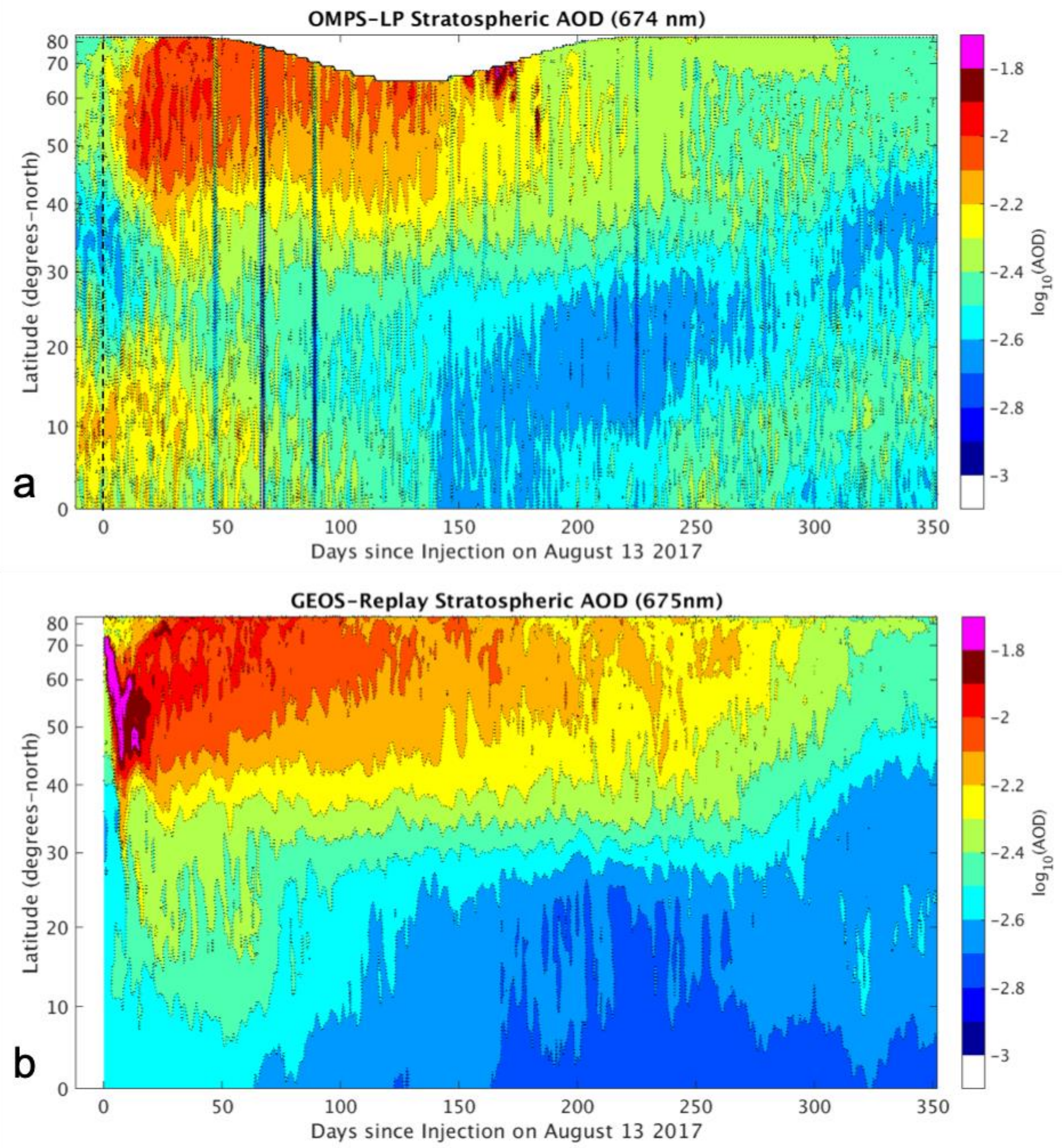
Das, S., Colarco, P., Harshvardhan, H. (2020). The Influence of Elevated Smoke Layers on Stratocumulus Clouds Over the SE Atlantic in the NASA Goddard Earth Observing System (GEOS) Model Journal of Geophysical Research: Atmospheres 125(6)https://dx.doi.org/10.1029/2019jd031209

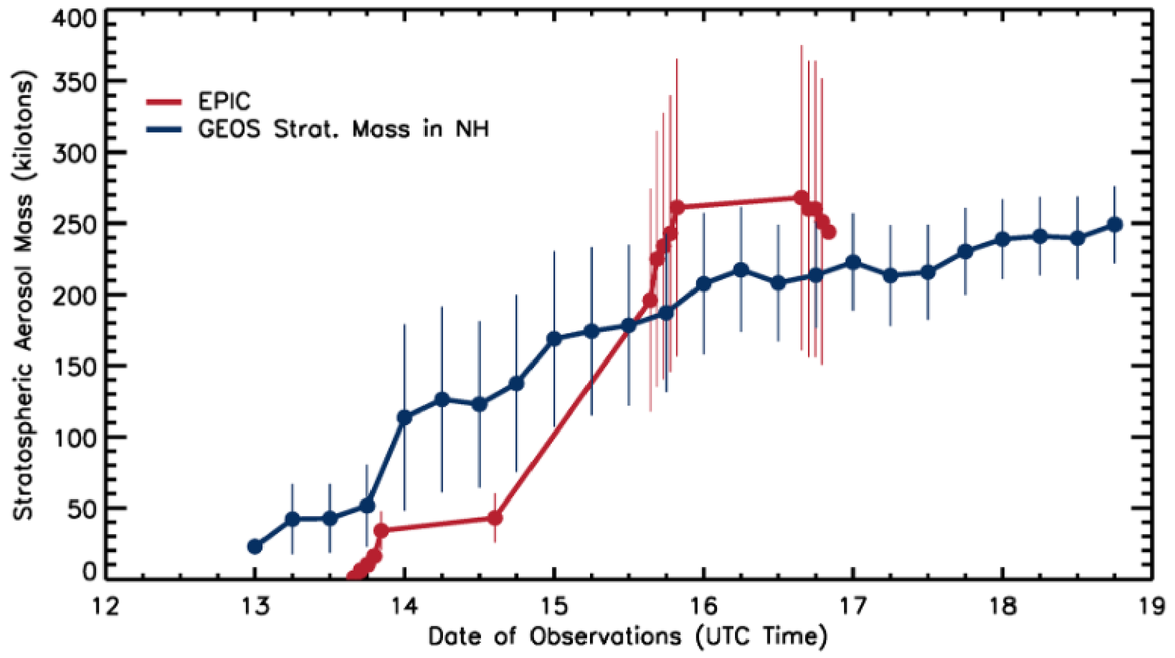
PyroCb as an extreme case

GEOS includes radiatively active black and brown carbon aerosols from wildfire pyroCb injections and simulates the observed vertical transport of smoke from the 2017 British Columbia pyroCb event.









Top: GEOS CCM-simulated aerosol extinction profile along the August 14, 2017 CALIOP track over Canada, compared to the CALIOP backscatter profile.

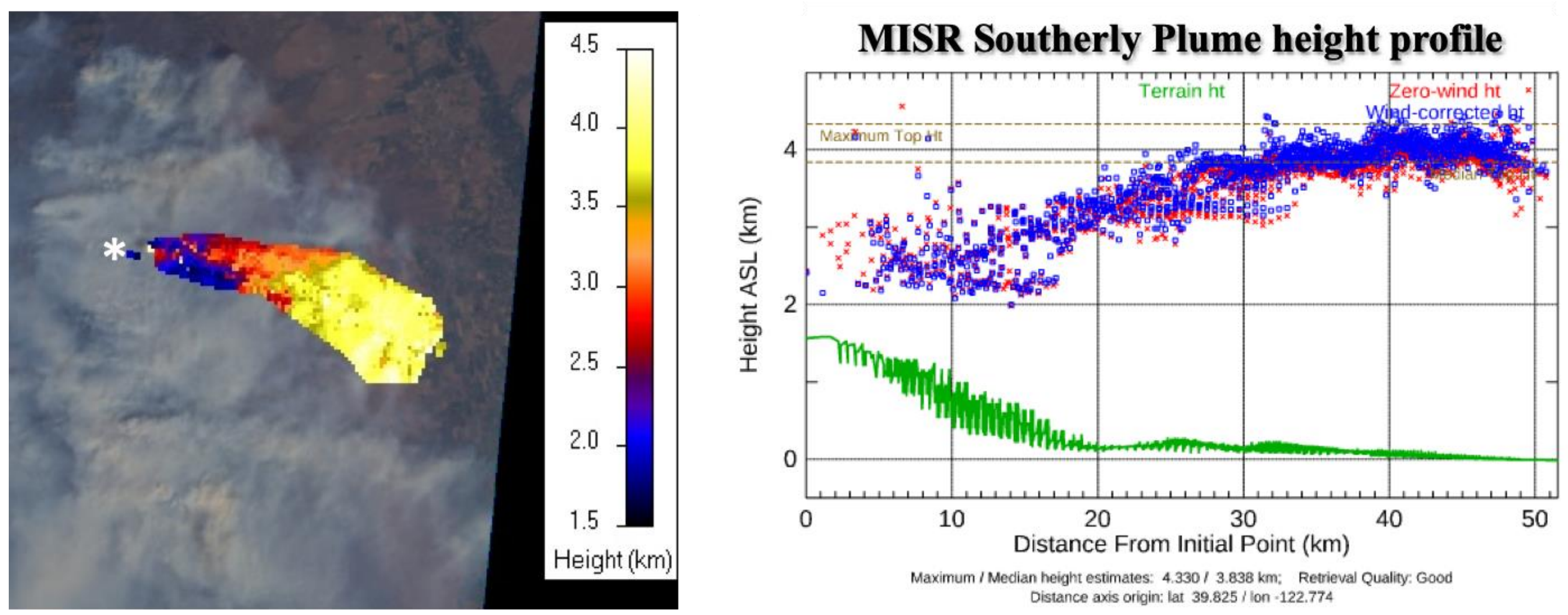
Left: Comparison of GEOS CCM stratospheric smoke aerosol mass to estimate from EPIC observations.

Above: Accounting for smoke radiative effects and we simulate longevity and horizontal extent of plume in excellent agreement with observations

Torres, O., Bhartia, P., Taha, G., Jethva, H., Das, S., Colarco, P., Krotkov, N., Omar, A., Ahn, C. (2020). Stratospheric Injection of Massive Smoke Plume From Canadian Boreal Fires in 2017 as Seen by DSCOVR-EPIC, CALIOP, and OMPS-LP Observations Journal of Geophysical Research: Atmospheres 125(10)https://dx.doi.org/10.1029/2020jd032579

Das, S., et al. in preparation

Prospects

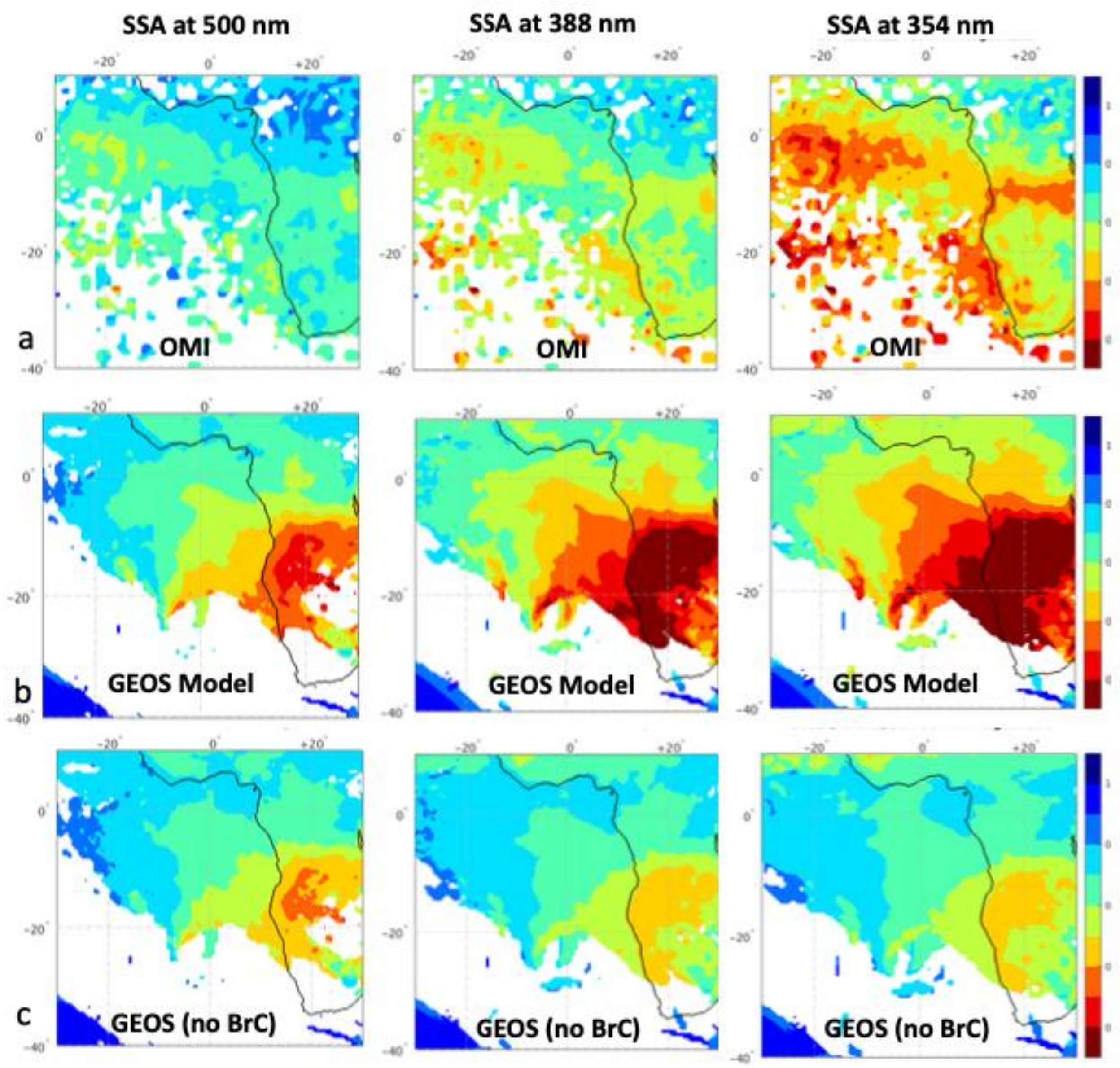


MISR stereo-height observations of smoke plume altitude for August Complex Fire (August 31, 2020, California). Product can be used for case studies/retrospective simulations or validation. MISR also retrieves important particle property information.

Emissions

- Coupling to LSMs for more fine grained, vegetation dependent emission factors
- Exploiting GEO observations (and high latitude, high-repeat LEO obs) to better calibrate diurnal cycles
- Use satellite thermal contrast methods in conjunction with thermodynamic profile-driven plume rise models to better inform vertical distributions

Simulate the OMI aerosol products en route to tuning the aerosol absorption



Particle property evolution

- Guided by field observations derive simple aging parameterizations for dynamic OA:OC to better represent composition
- Exploit data and microphysical models to tune particle size and mixing state assumptions
- Evaluate and improve absorption representation by engaging satellite observations (e.g., OMI/OMPS)