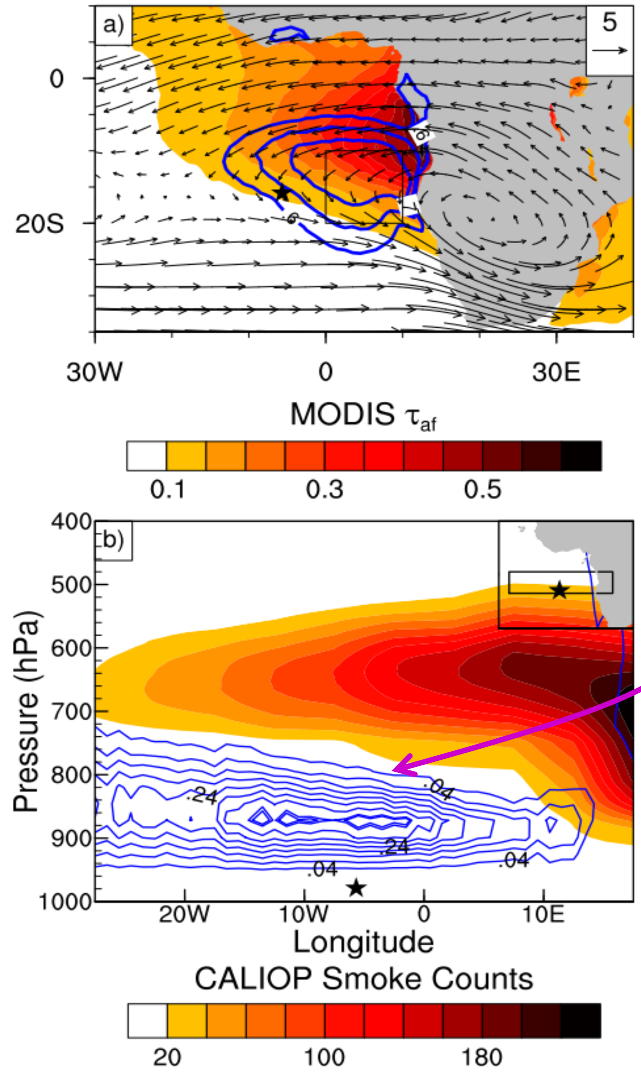
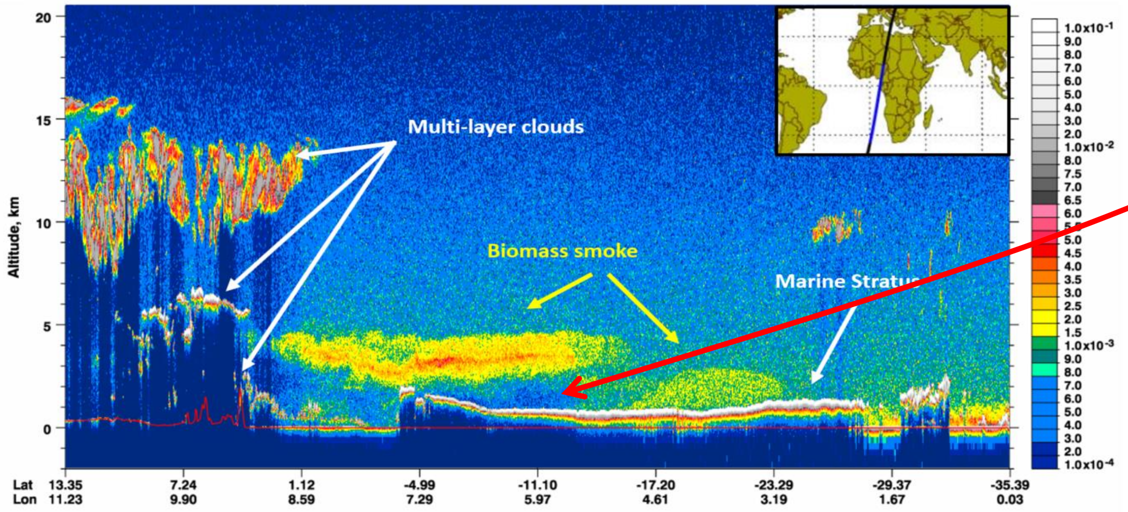
Background: V4 Operational CALIOP Measurements of Smoke above Clouds Over Southeast Atlantic Ocean Can Be Problematic



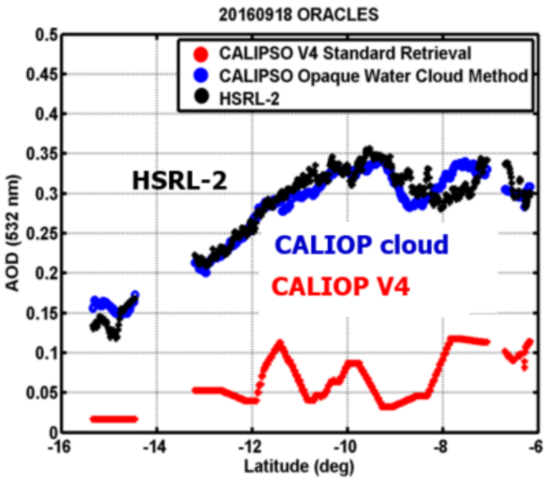
e.g. Adebiyi et al., 2015

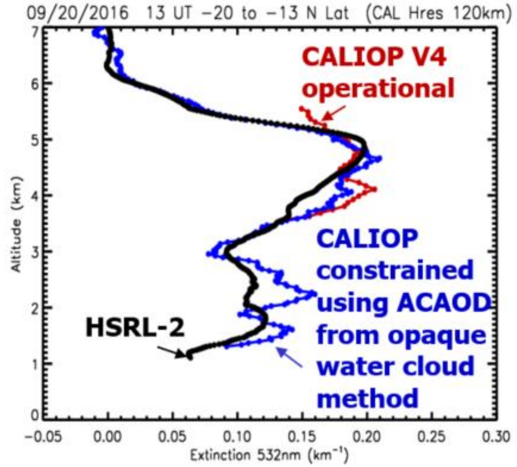
- Proximity of smoke to clouds impacts cloud drop size, cloud coverage, etc. and consequently cloud radiative impacts
- CALIOP aerosol profiles have been used to determine proximity of elevated smoke layers to underlying clouds
- <u>Problem: </u>CALIOP V4 532 nm aerosol layer detection often misses lower boundary of thick smoke layer due to strong attenuation of upper part of smoke layer (current V4 algorithm CALIOP 1064 nm penetrates further but uses 532 nm layer boundaries) resulting in:
  - Underestimate of above cloud AOD (ACAOD)
  - Overestimate in the size of the gap between smoke and cloud

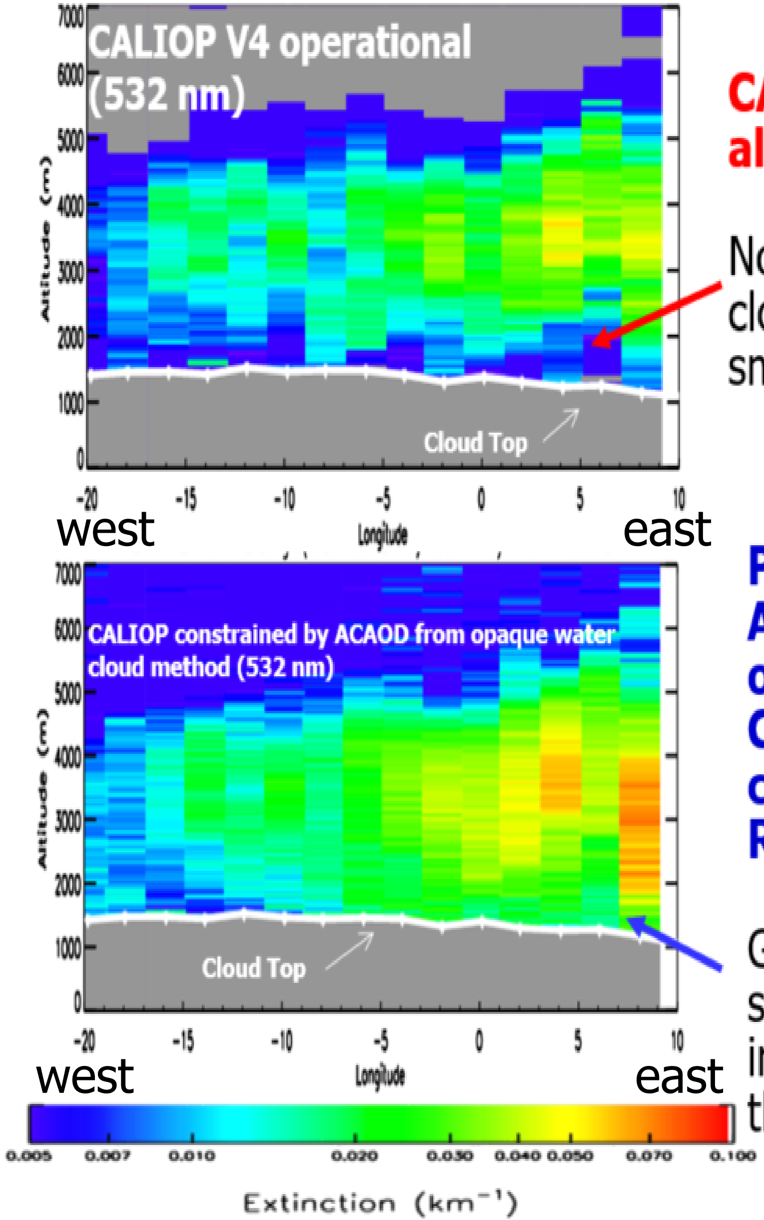


Solution: Opaque Water Cloud (“Depolarization Ratio Method”) Provides Alternative (and Better) Method to Derive Above Cloud AOD (ACAOD) and Aerosol Extinction Profiles

1. V4 Operational product uses
   - layer detection scheme
   - extinction retrieval algorithm
   - inferred lidar ratio
2. Opaque water cloud (“Depolarization Ratio” – Hu et al., 2007; Deaconu et al., 2017)) uses
   - Layer-integrated attenuated backscatter and depolarization of clouds
   - Assumed cloud lidar ratio (18.9 sr)







CALIOP V4 operational algorithm (532 nm).

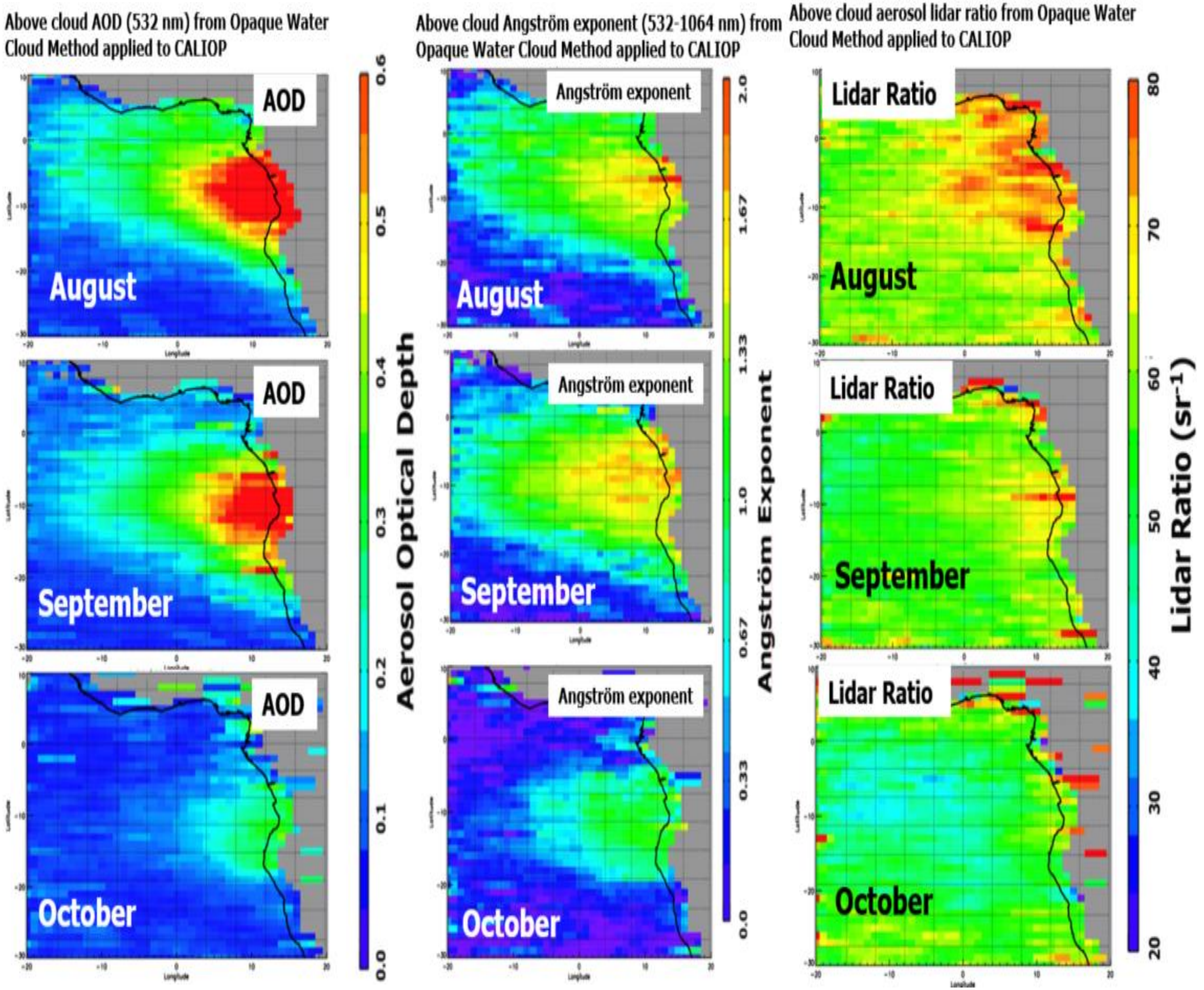
Note the gap between the cloud top and the bulk of the smoke layer.

Profiles derived using the ACAOD constraint obtained from the CALIOP opaque water cloud (“Depolarization Ratio – DR”) method.

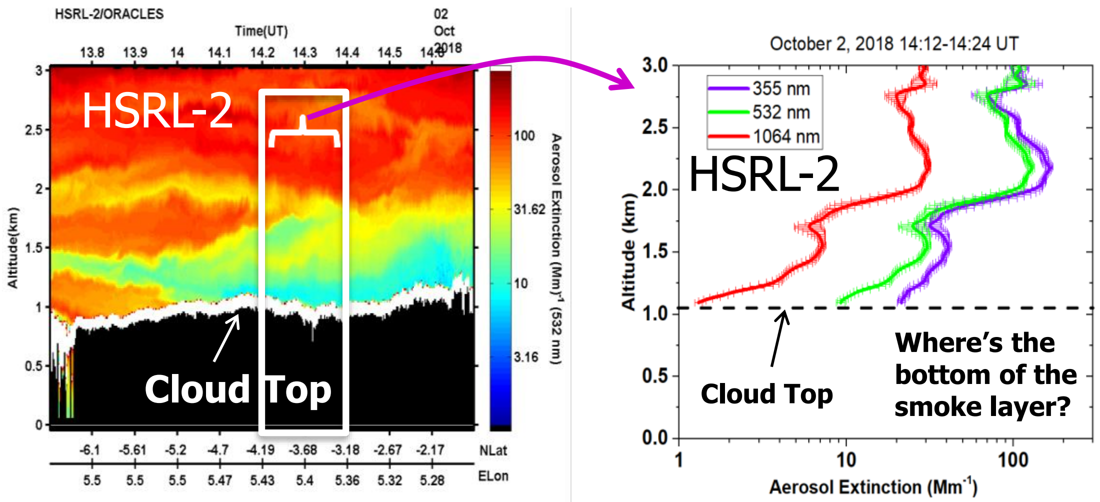
Gap has significantly reduced so that smoke and clouds are in close proximity most of the time.

Averaged ACAOD (532 nm), Aerosol Angström exponent (532-1064 nm), and Lidar Ratio computed using CALIOP ACAOD constraint (2006-2018)

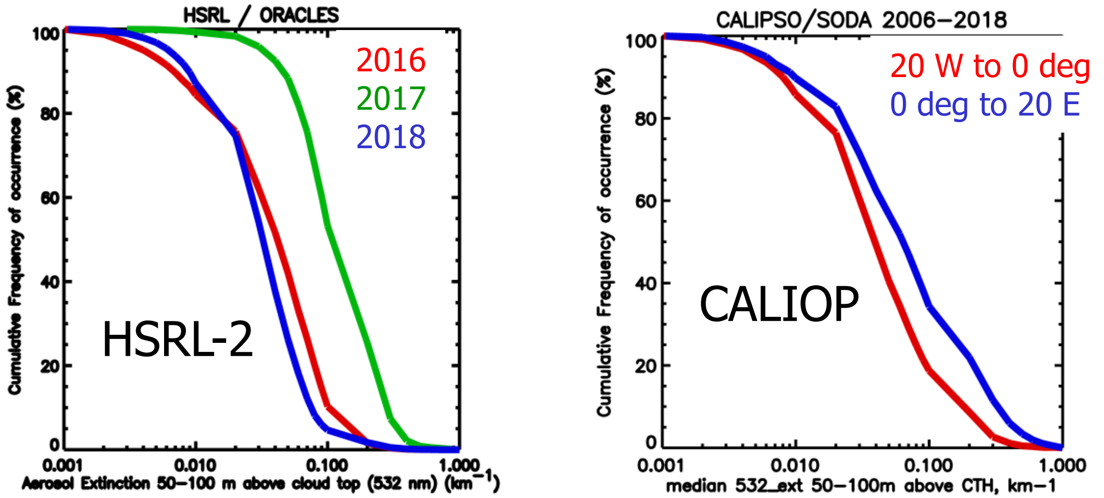
- CALIOP profiles (2006-2018), constrained by the CALIOP above cloud AOD derived using the return signals from the underlying clouds, show that moving west (away) from the African coast and from August to October:
  - Aerosol optical thickness decreases
  - Aerosol Angstrom exponent decreases (~ aerosol size increases)
  - Lidar ratio decreases (~ aerosol absorption decreases)
- Lidar ratio monthly trend is consistent with:
  - HSRL-2 profiles of lidar ratio
  - Decrease in aerosol absorption (increase in SSA) derived from AERONET and OMI (Eck et al., 2013, JGR)



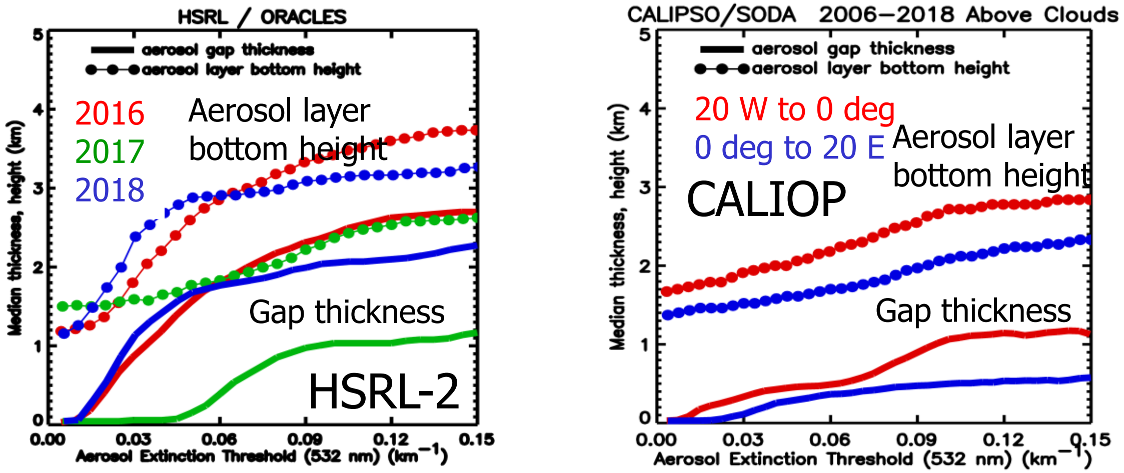
How large is the gap between clouds and smoke layers? (It depends…)



Q. Where's the bottom of the smoke layer?
A. It depends on threshold used to define the bottom.

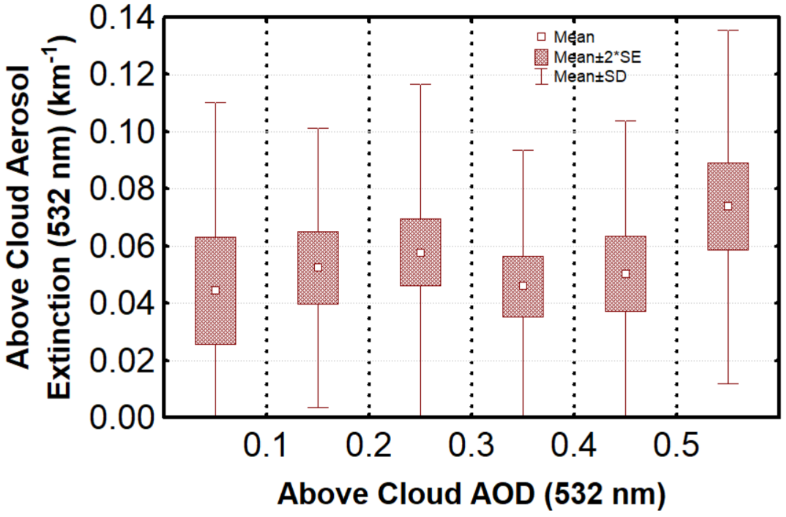


HSRL-2 and CALIOP data show similar distributions of aerosol extinction in the 50-100 m layer above cloud top



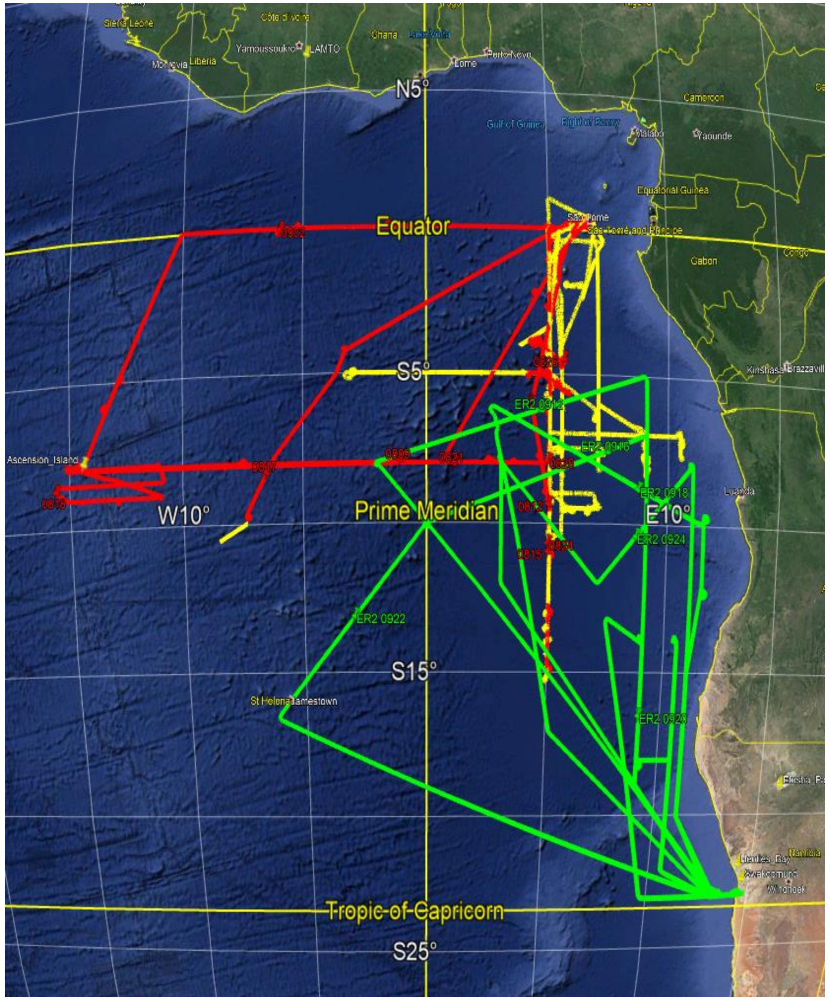
HSRL-2 and CALIOP data show how aerosol layer bottom and gap thickness depend on aerosol extinction threshold value

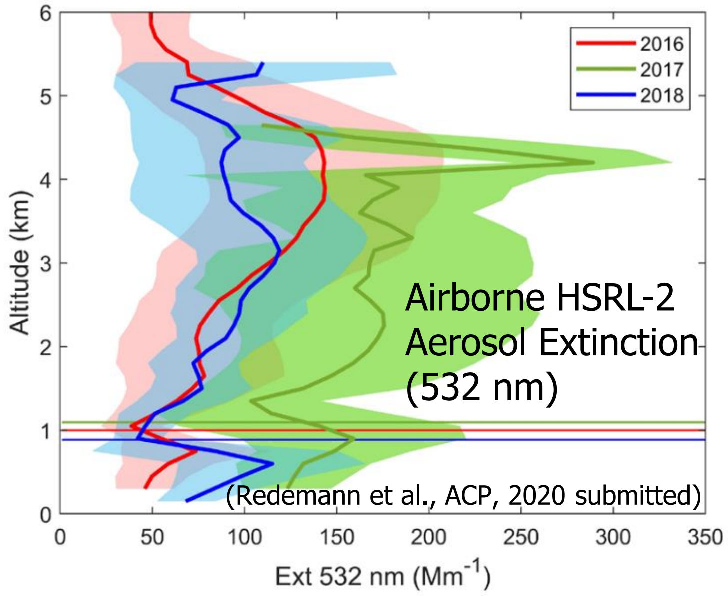
HSRL-2 data show no correlation between above cloud AOD and aerosol extinction just above cloud top

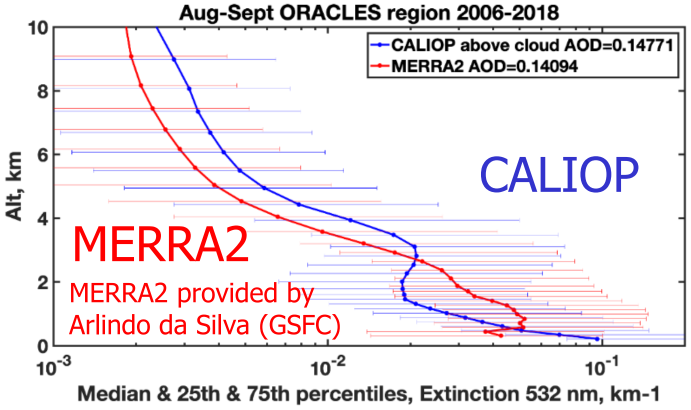


Airborne HSRL-2 Measurements and Retrievals from NASA ORACLES Mission Show Vertical Variability in Median Aerosol Parameters

Airborne HSRL-2 lidar deployed from NASA ER-2 (2016) and P-3 (2017, 2018)







Median CALIOP aerosol extinction profile (2006-2018) shows more aerosol near surface and aloft than MERRA-2 model

Airborne HSRL-2