

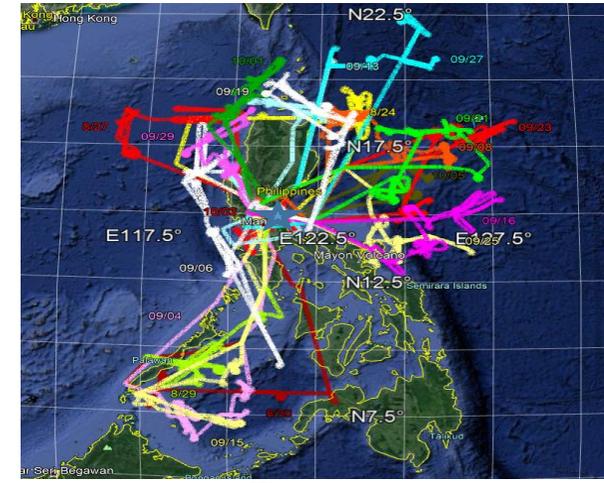


# Airborne High Spectral Resolution Lidar Measurements of Aerosol Distributions and Properties during the NASA CAMP2Ex Mission

NASA LaRC HSRL-2 Team - Rich Ferrare, Chris Hostetler, Sharon Burton, Marta Fenn,  
Dave Harper, Tony Cook, Amy Jo Scarino, Marian Clayton, John Hair, Joe Lee

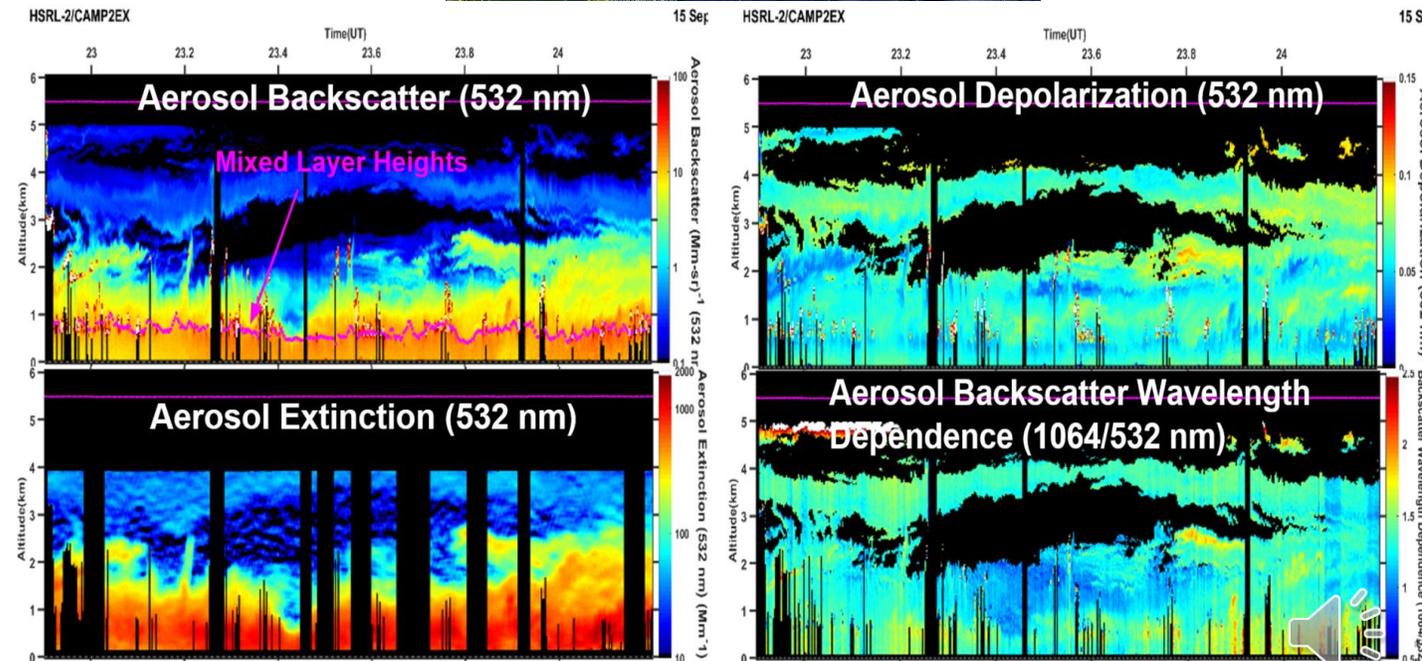


- CAMP2Ex addresses three NASA focus areas
  - Aerosol and cloud microphysics
  - Cloud and aerosol radiation
  - Aerosol and cloud meteorology
- NASA LaRC HSRL-2 deployed on P-3B aircraft for nadir viewing measurements
- P-3B, based at Clark Air Base, conducted 19 science flights between Aug. 24 and Oct. 5, 2019



## HSRL-2 Available Data Products

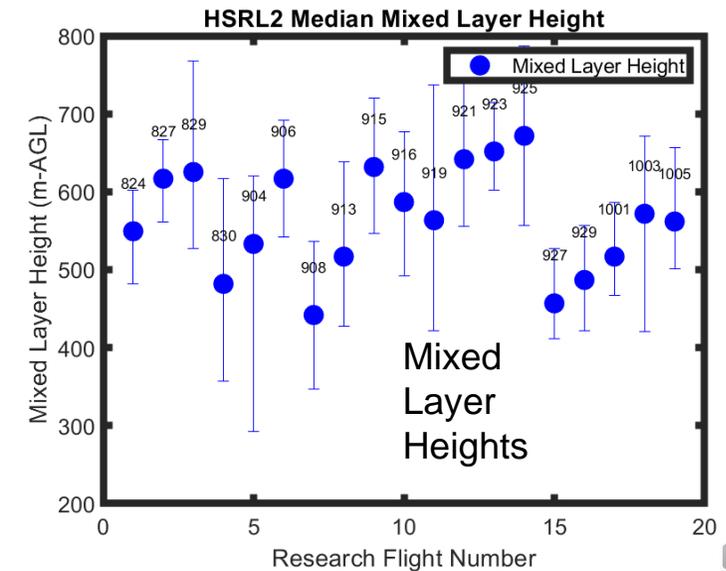
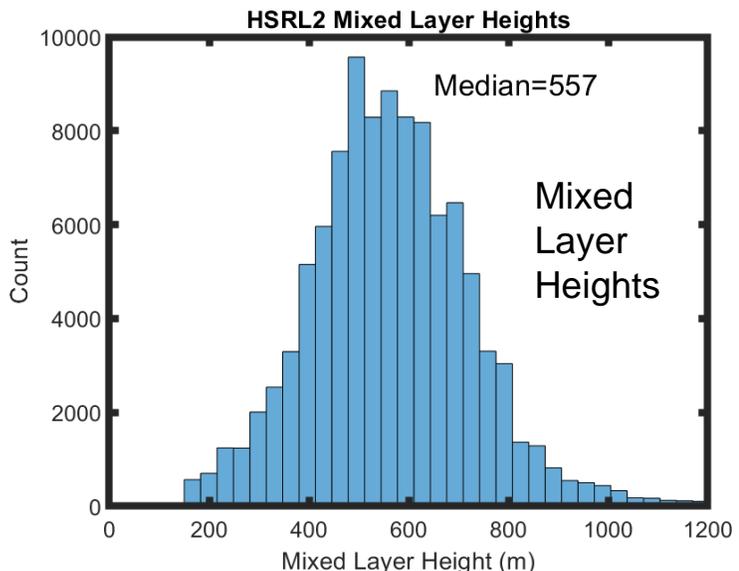
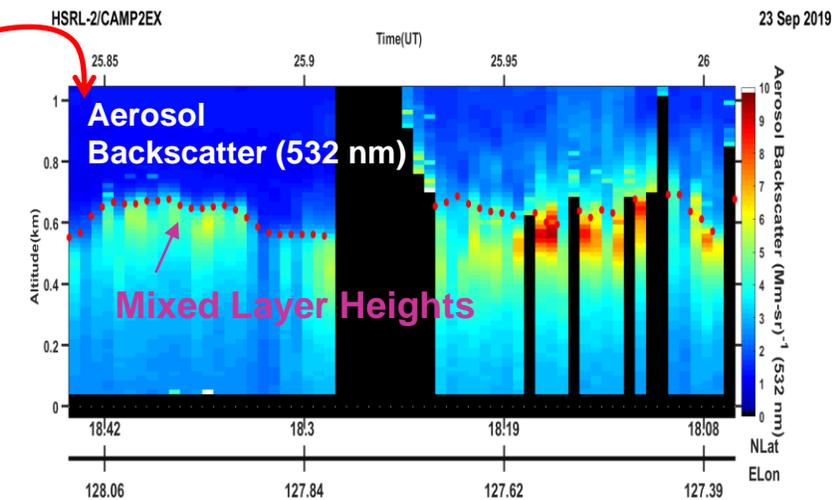
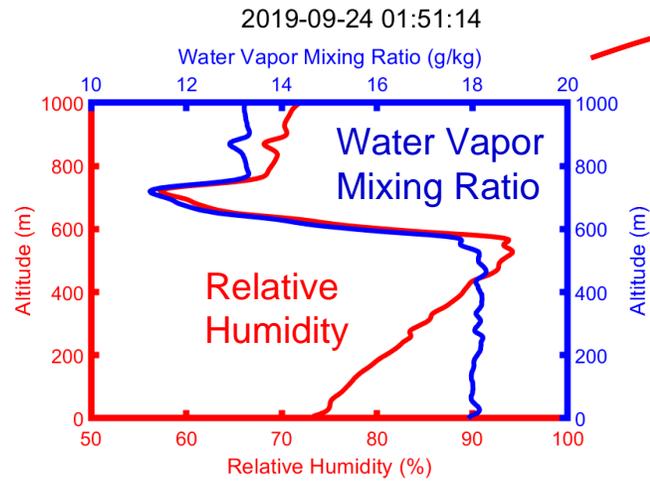
- Aerosol Extensive Measurements
  - Particulate backscatter profiles (355, 532, 1064 nm)
  - Particulate extinction profiles and AOT (355, 532 nm)
- Aerosol Intensive measurements
  - Particle depolarization profiles (355, 532, 1064 nm)
  - Extinction-to-backscatter ratio profiles (355, 532 nm)
  - Angstrom exponent profiles
    - Extinction: 355-532
    - Backscatter 355-532, 532-1064
- Aerosol Type
- Mixed Layer Heights



HSRL-2 data from CAMP2Ex data at <https://www-air.larc.nasa.gov/cgi-bin/ArcView/camp2ex#HOSTETLER.CHRIS/>

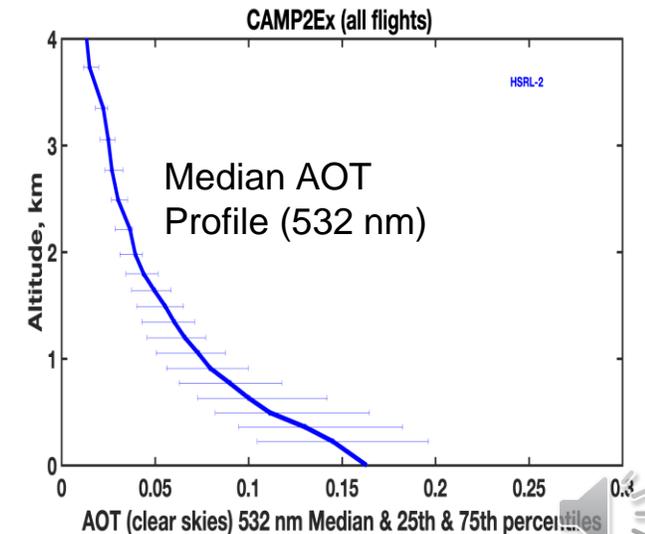
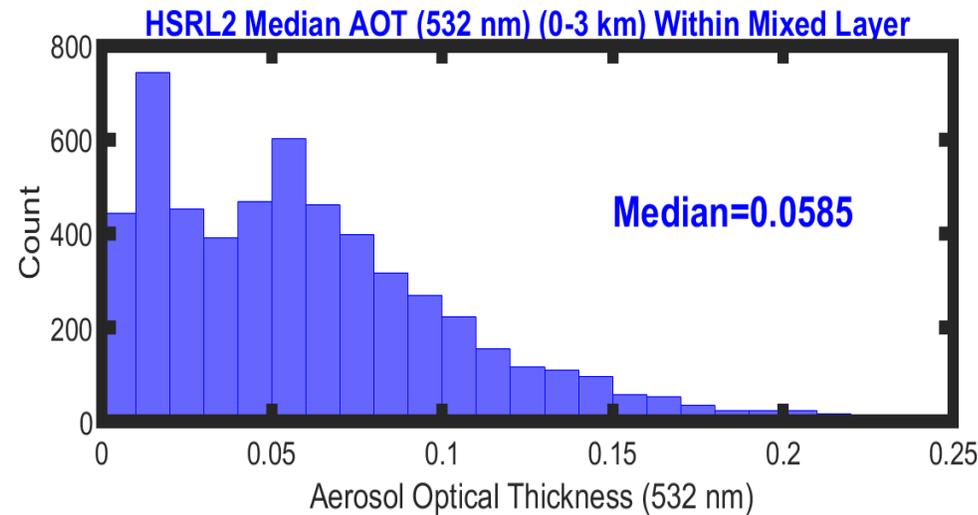
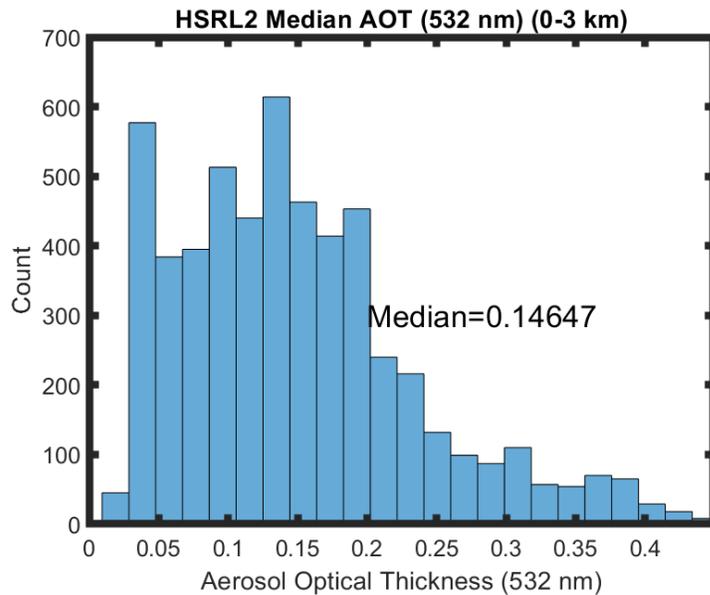
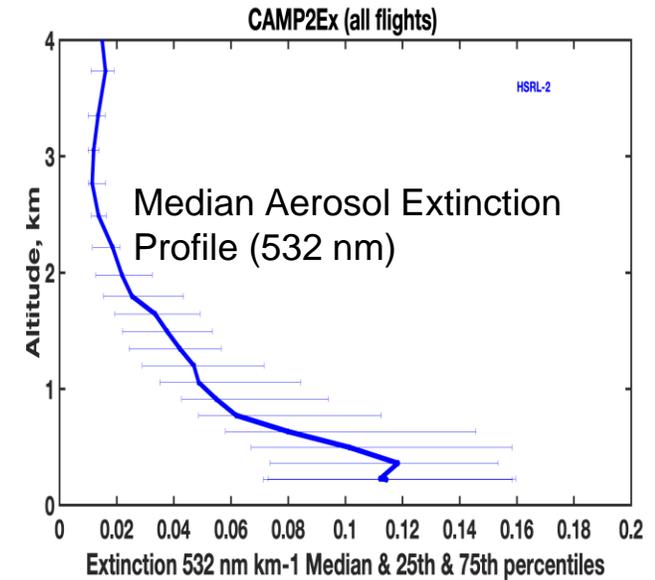
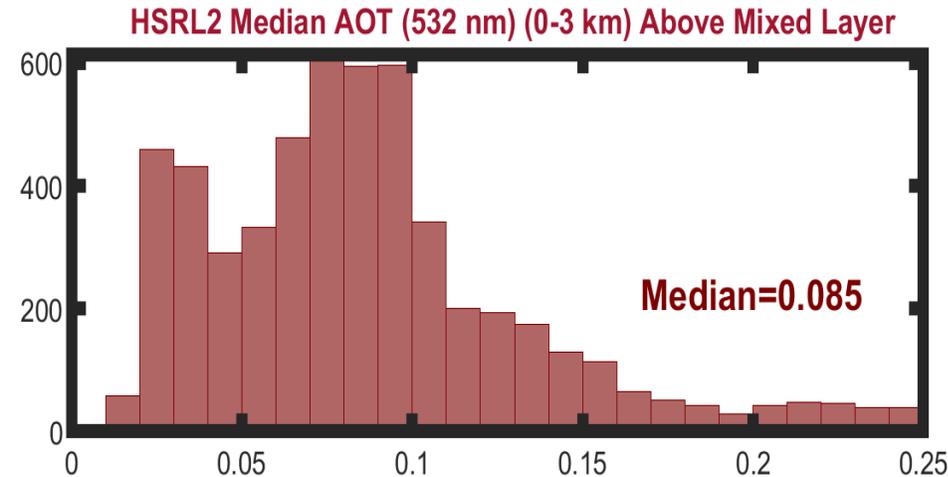
- Mixed Layer (ML) heights derived from cloud-screened aerosol backscatter profiles
- ML heights can be a good proxy for daytime PBL heights
- Technique uses a Haar wavelet covariance transform with multiple wavelet dilations to identify sharp gradients in aerosol backscatter (adapted from Brooks, JAOT, 2003)
- Automated HSRL algorithm chooses ML from among aerosol gradients with input from manual inspection where necessary (Scarino et al., 2014, ACP)
- During CAMP2Ex, median MLH = 557 m

Dropsonde data from Sue van den Heever (CSU)

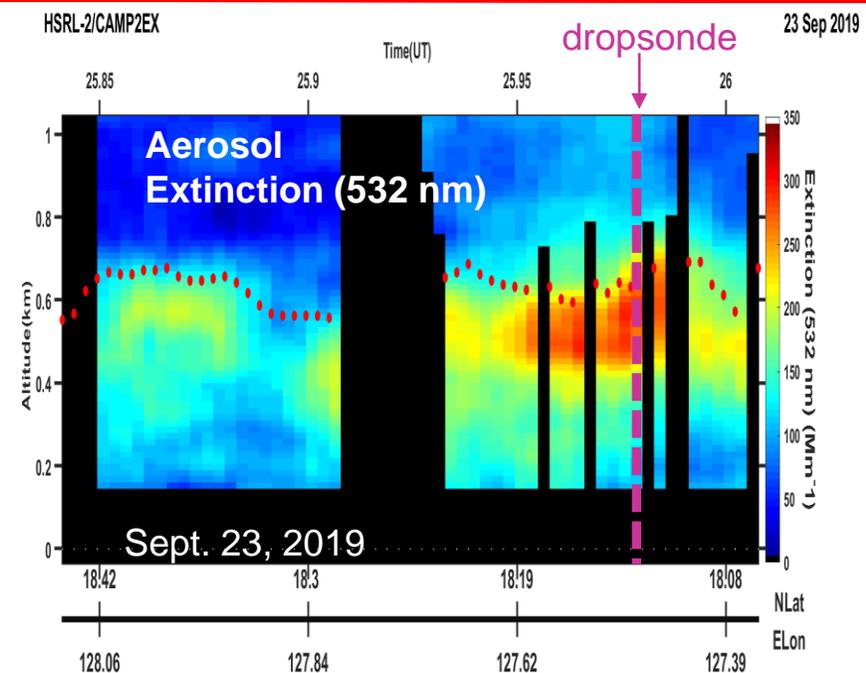
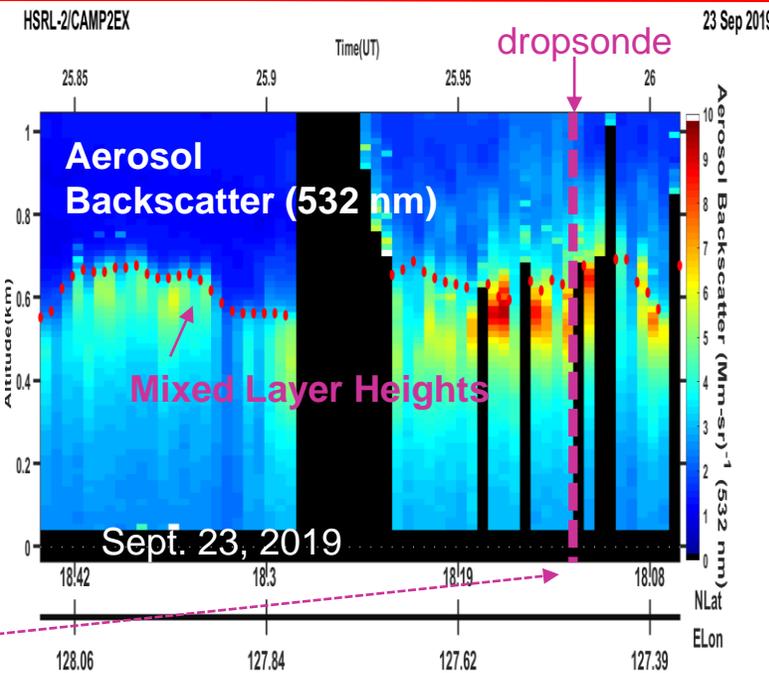
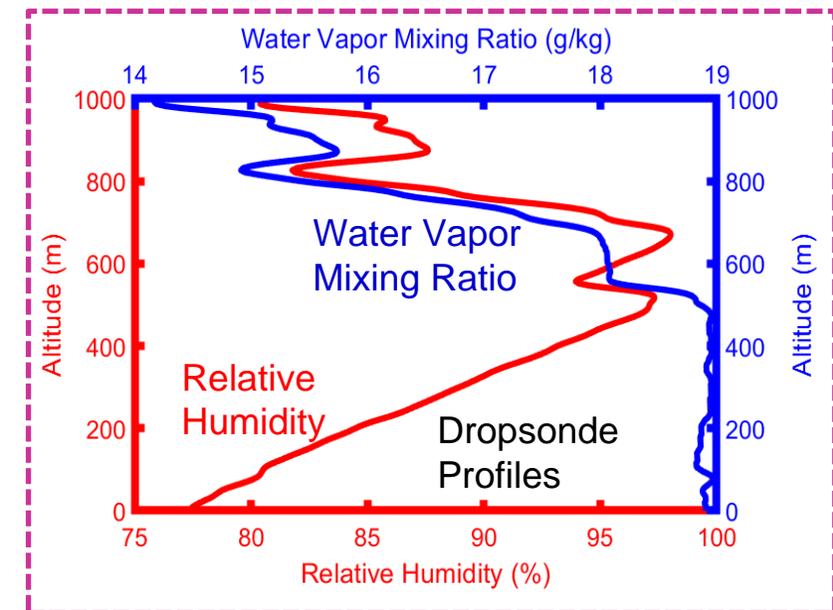


# HSRL2 Measurements of Aerosol Optical Thickness (AOT) During CAMP2Ex

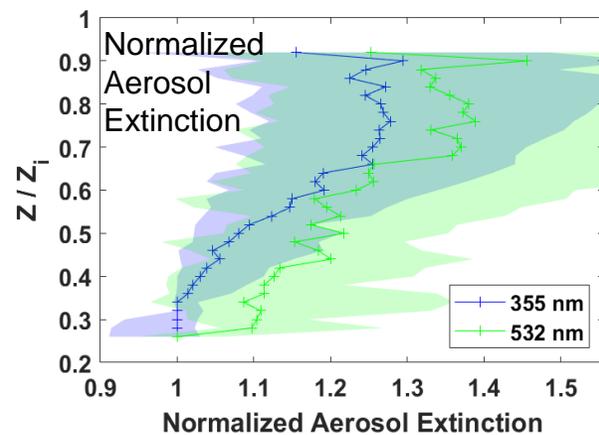
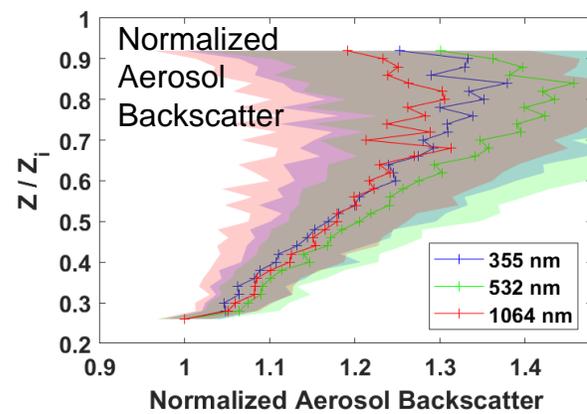
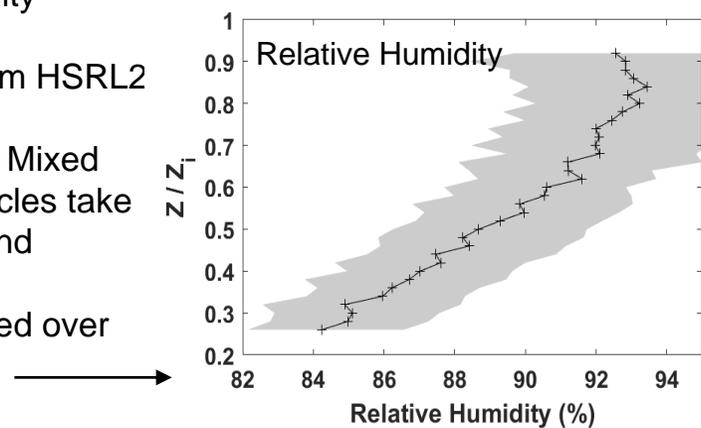
- Median AOT (532 nm) within the 0-3 km layer ~ 0.15
- About 60% of AOT above Mixed Layer
- About 40% of AOT within Mixed Layer



# Aerosol Backscatter and Extinction Increase with Height in Mixed Layer associated with Increase in Relative Humidity (RH)

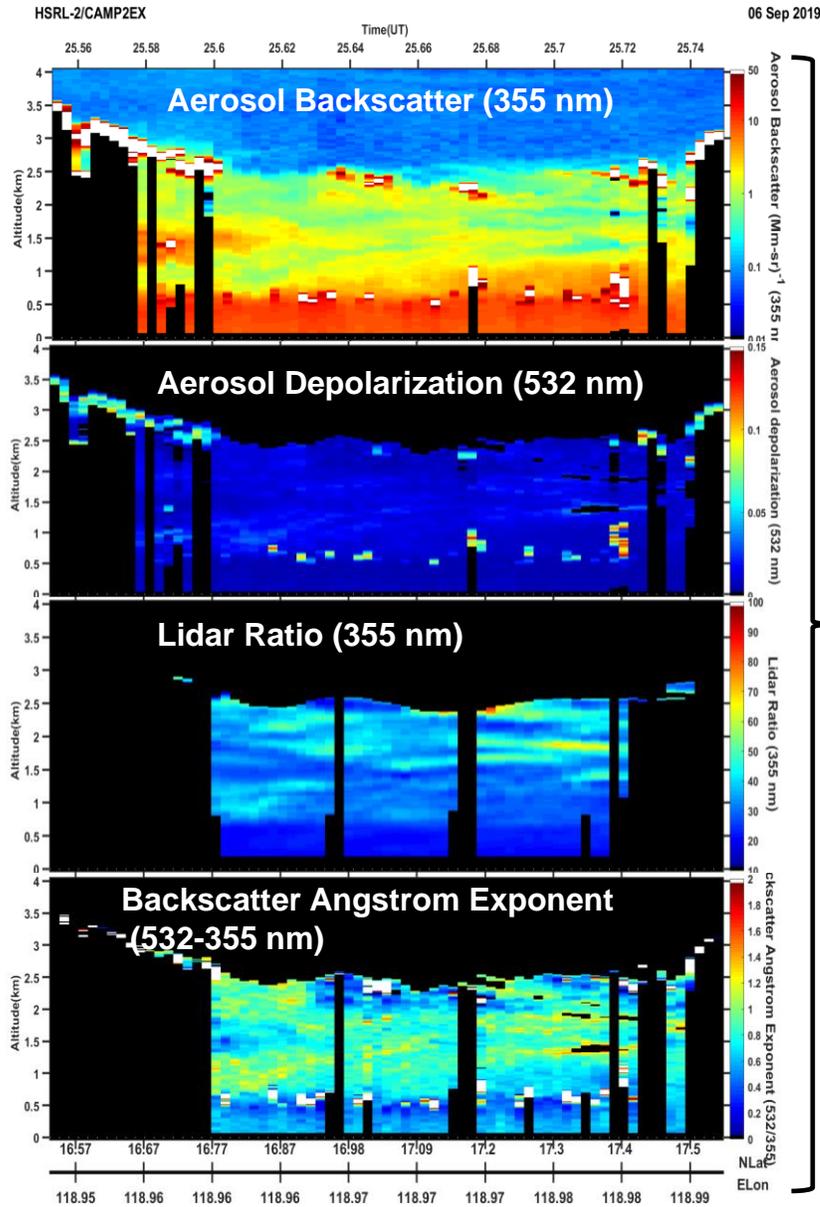


- Dropsondes provide relative humidity profiles
- Mixed Layer Height ( $Z_i$ ) derived from HSRL2 aerosol backscatter profiles
- As RH increases with height within Mixed Layer, fine mode hygroscopic particles take on water, so aerosol backscatter and extinction increase.
- These plots show behavior averaged over all of CAMP2Ex

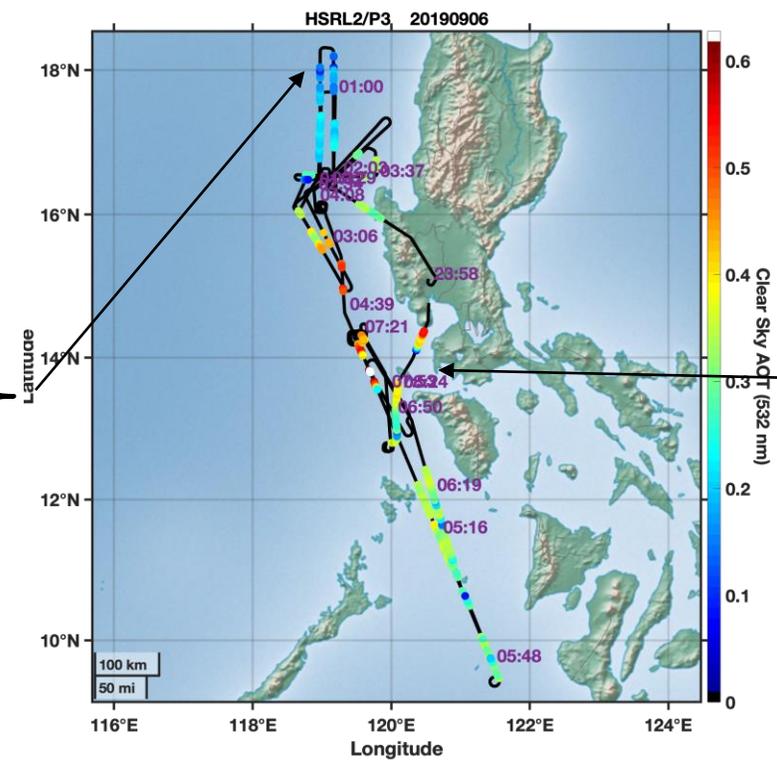


Recording may be in progress - By joining this telecon, you automatically consent to such recording.

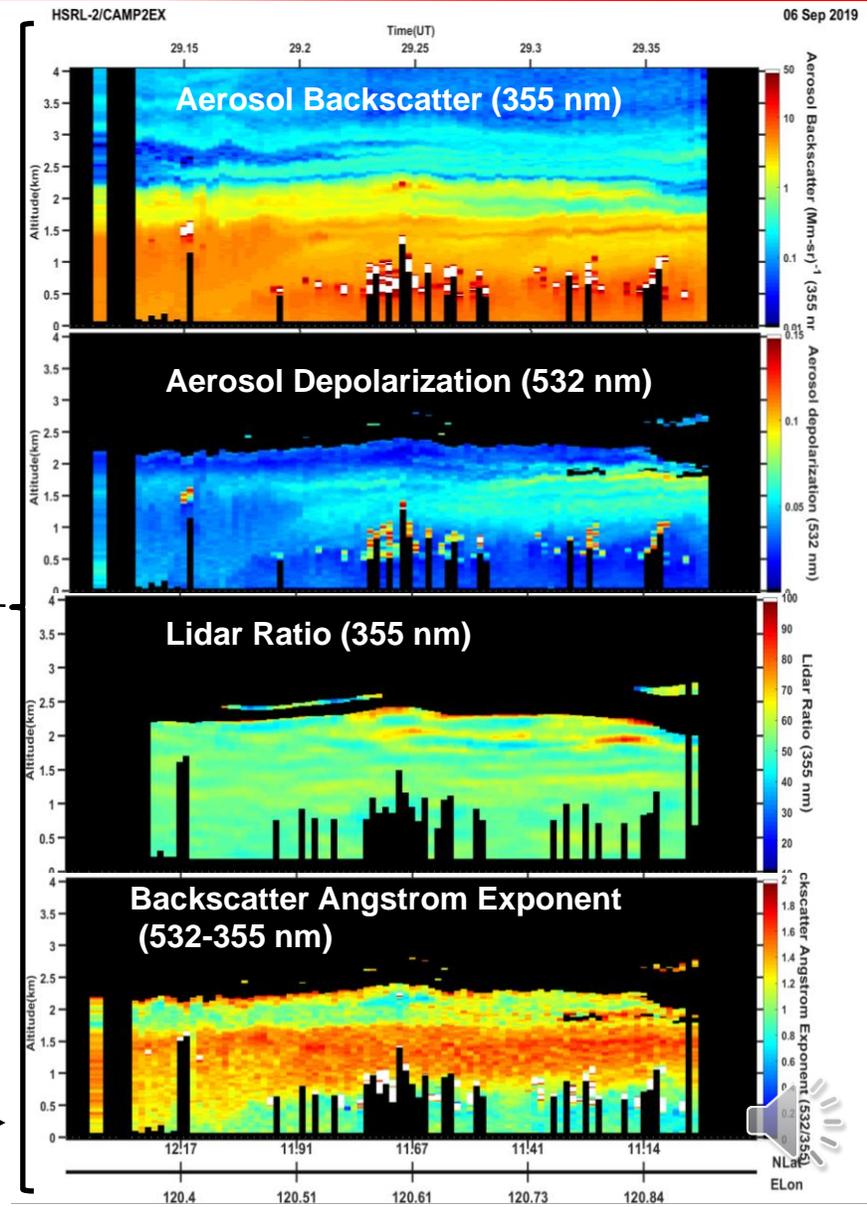
# HSRL-2 Reveals Horizontal and Vertical Variability of Aerosol Properties



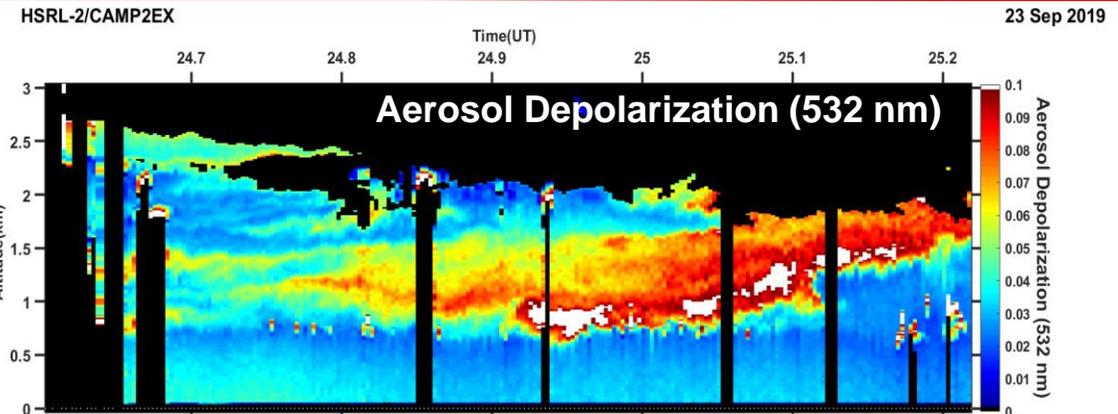
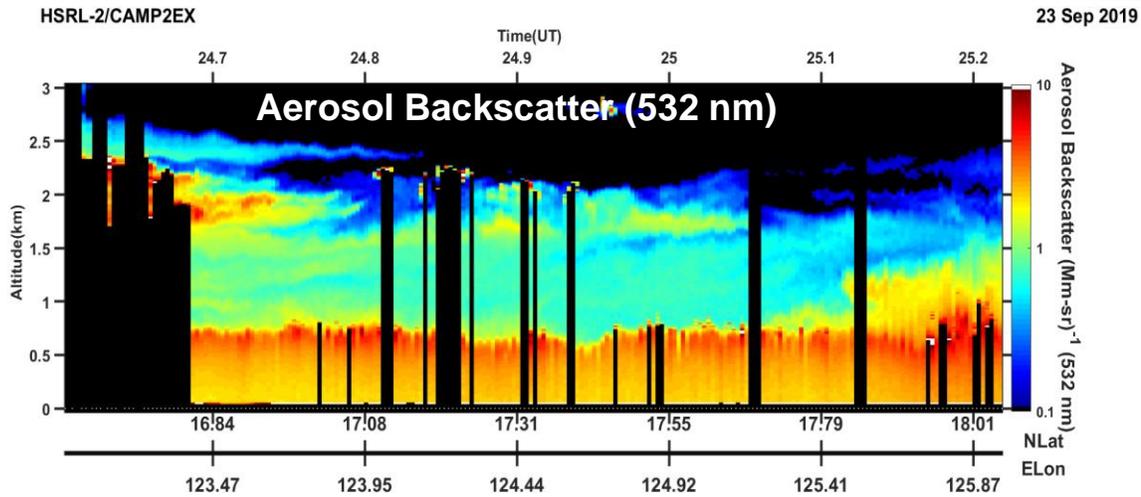
WNW of Luzon – larger, maritime (sea-salt) aerosol near surface



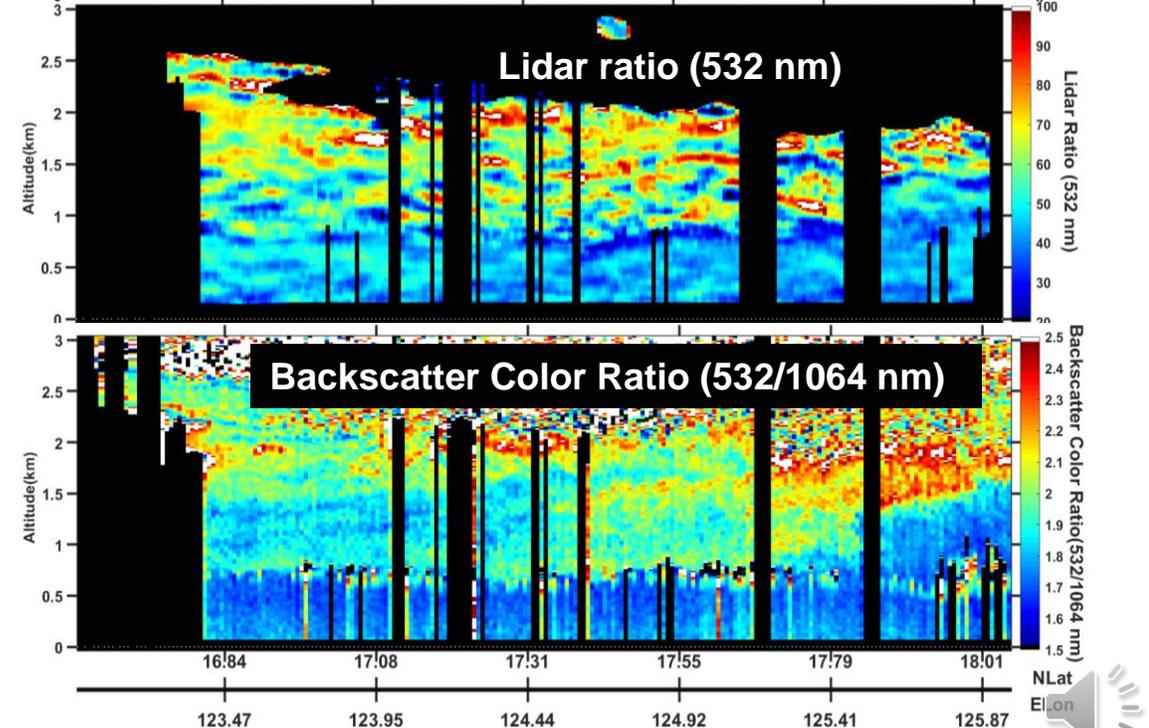
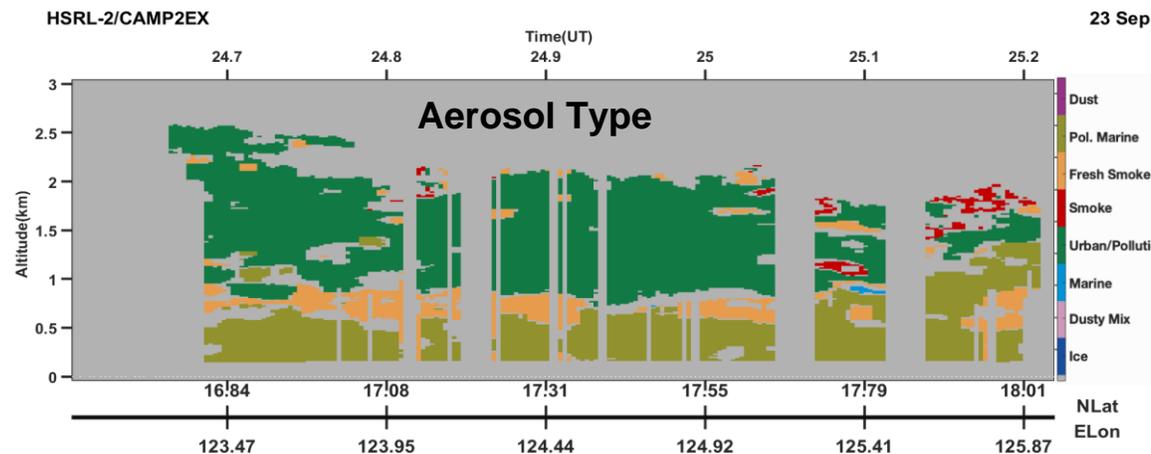
SSW of Manila – smaller particles (pollution/smoke) near surface, small, slightly nonspherical smoke aloft



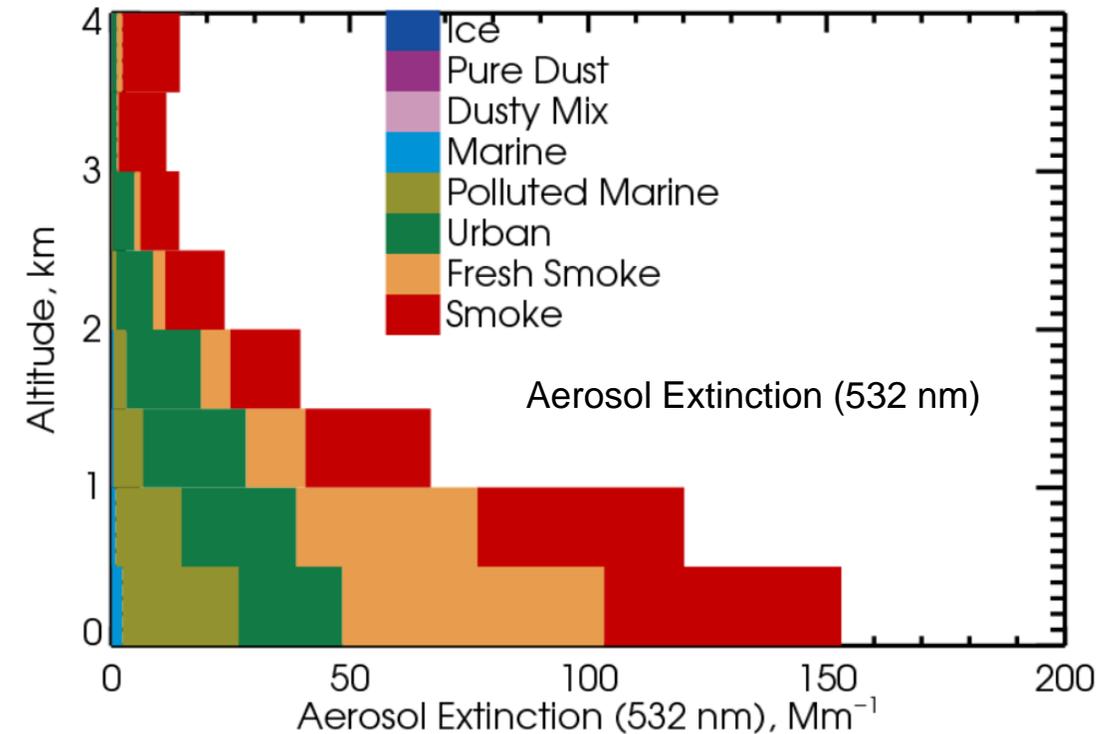
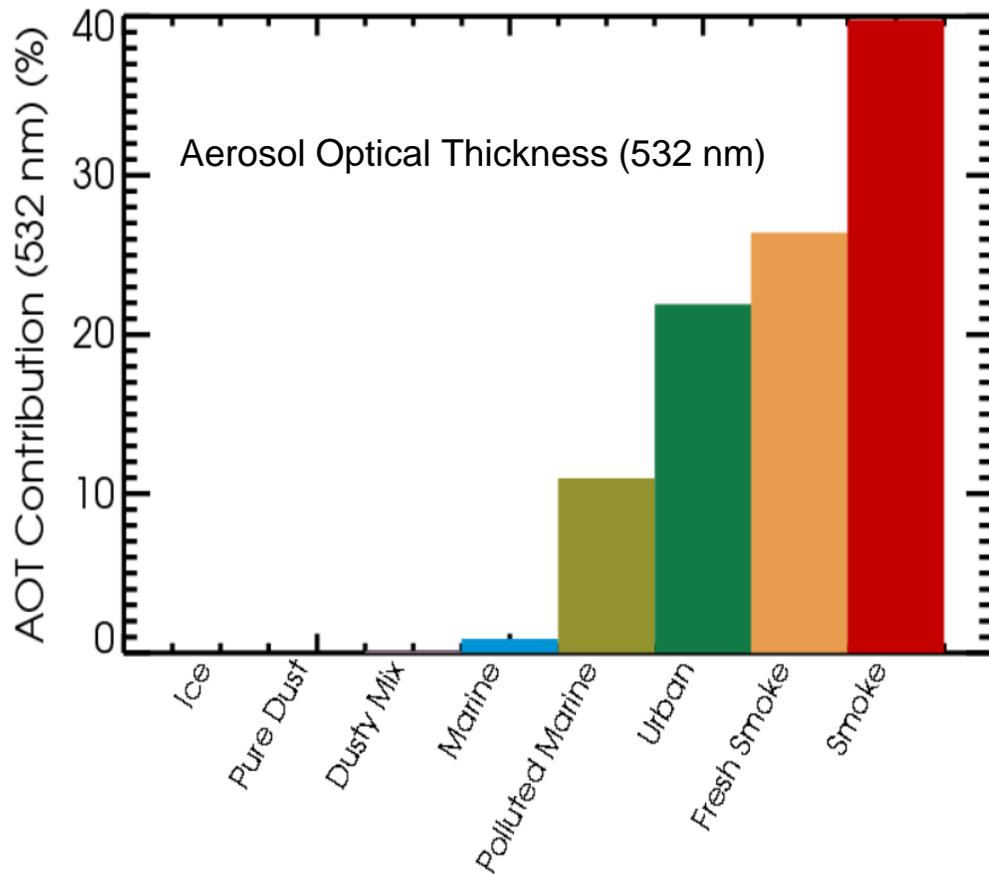
# HSRL2 Measurements used to Infer Aerosol Type



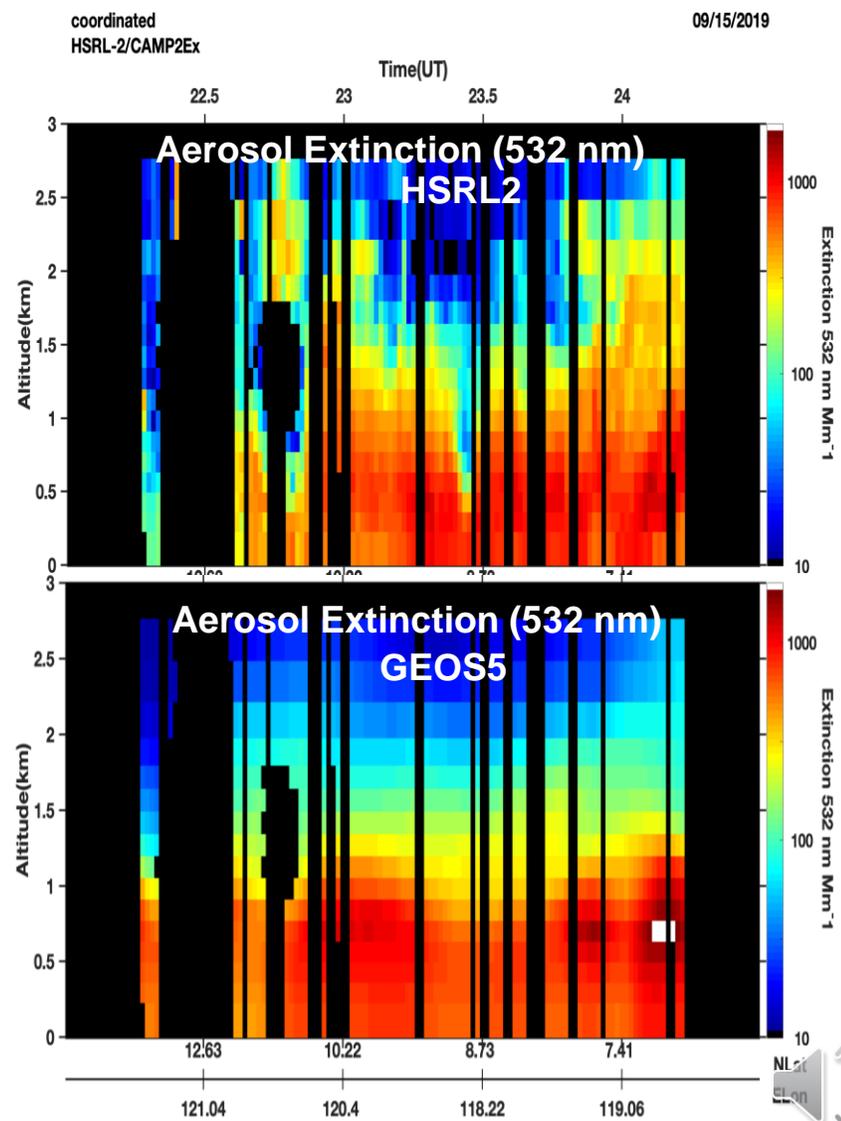
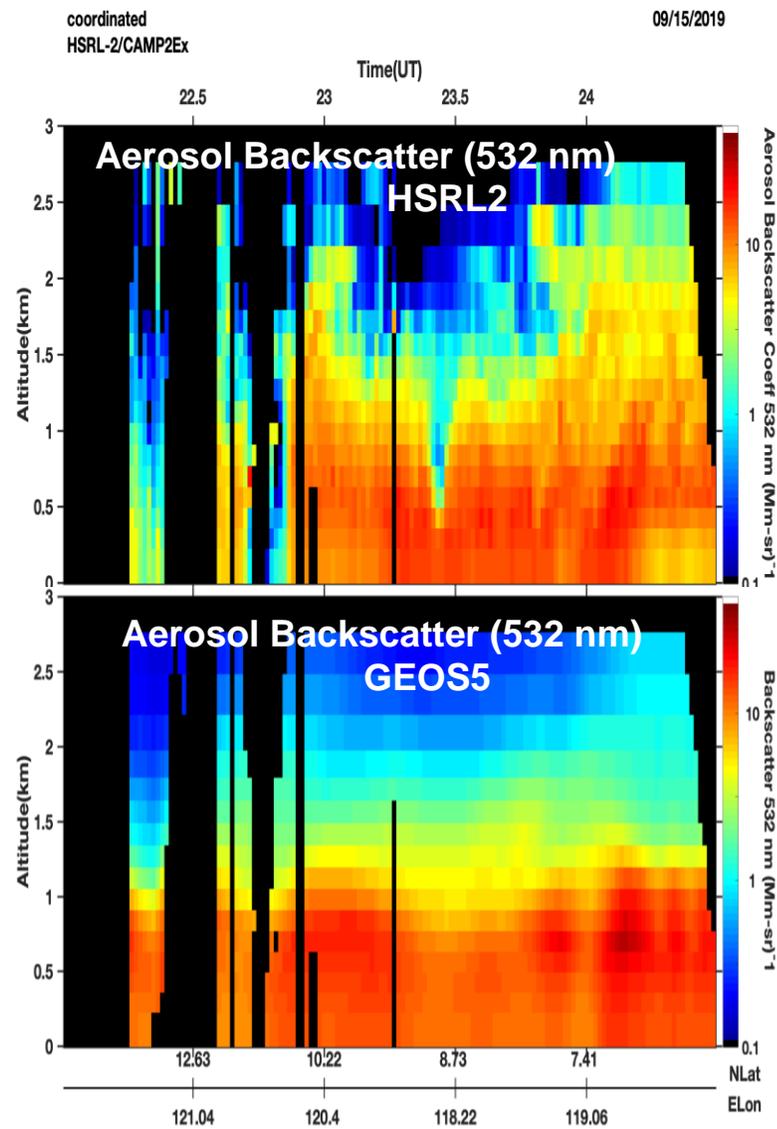
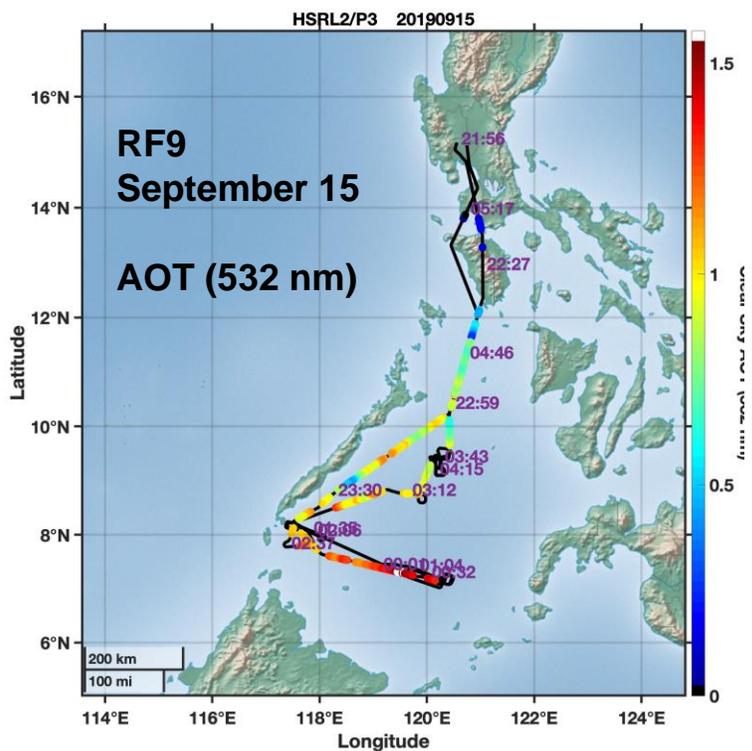
Aerosol type inferred from measurements of aerosol intensive parameters (Burton et al., 2012, AMT)



Majority of AOT and aerosol extinction classified using HSRL2 data during CAMP2Ex attributed to smoke



# Example: HSRL-2/GEOS-5 Comparison of Aerosol Extensive Parameters for Sept. 15

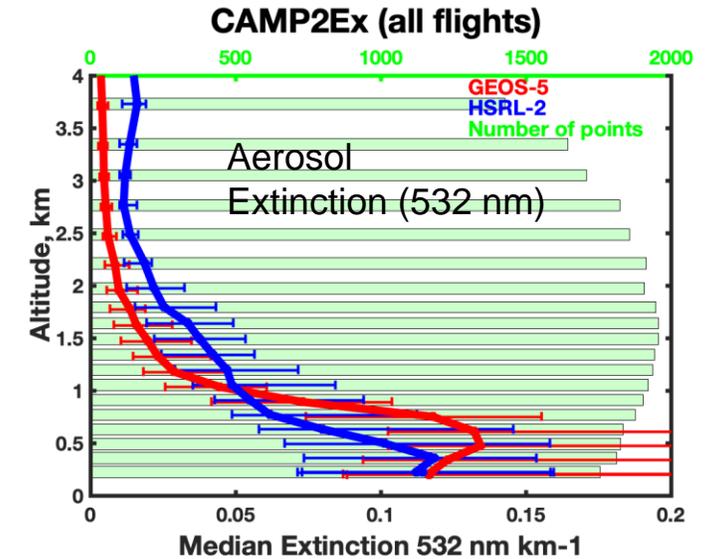
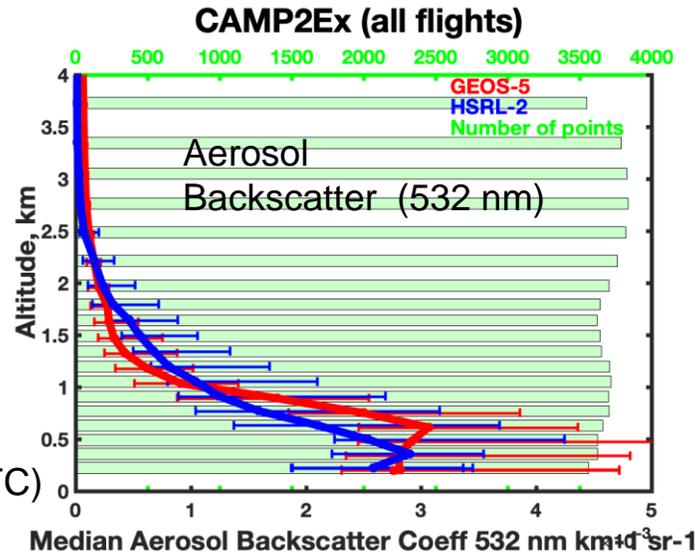


GEOS-5 Simulations provided by  
Arlindo da Silva (GSFC)

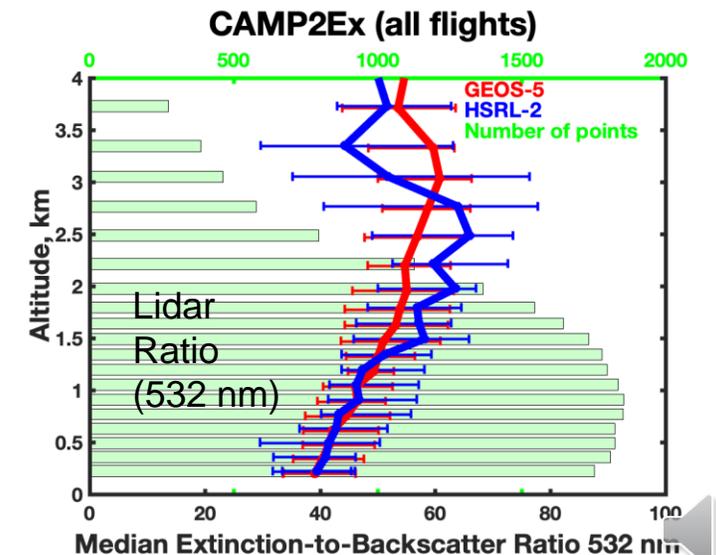
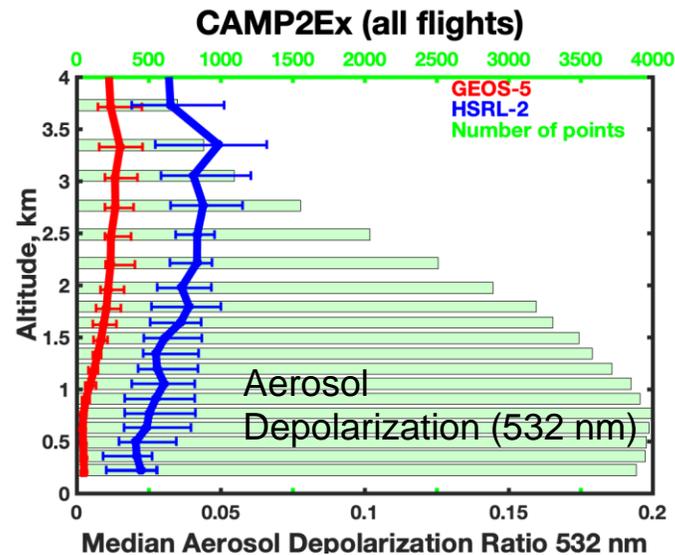
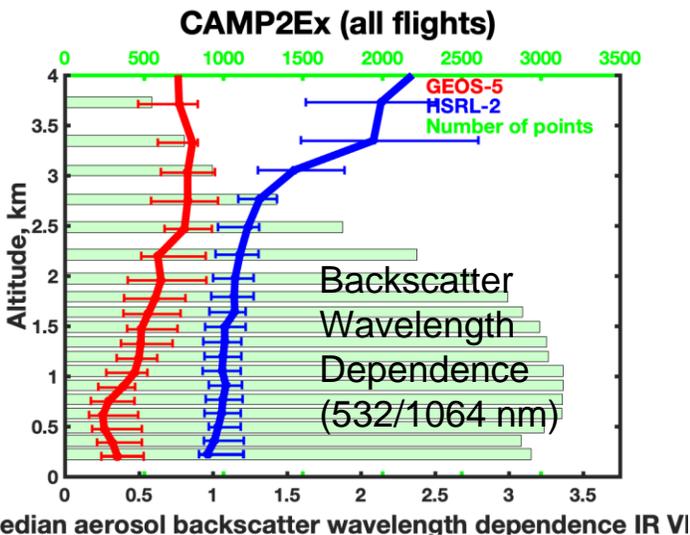


# HSRL- 2/GEOS-5 Comparison of Median Aerosol Profiles for all of CAMP2Ex

Median Profiles for all of CAMP2Ex flights  
**HSRL-2**  
**GEOS-5**



GEOS-5 Simulations provided by Arlindo da Silva (GSFC)



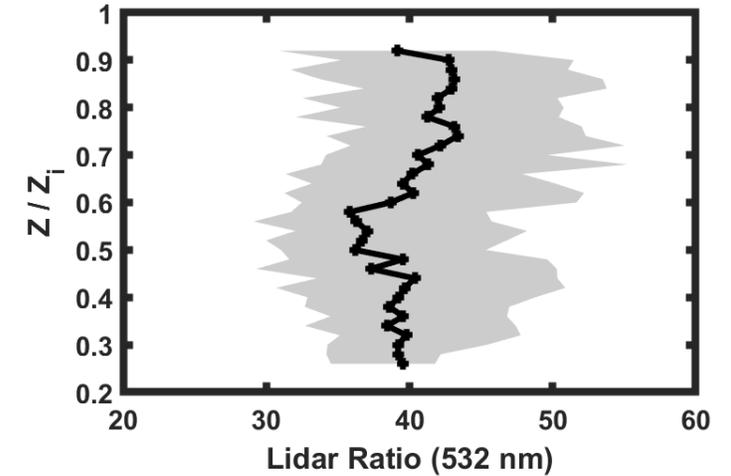
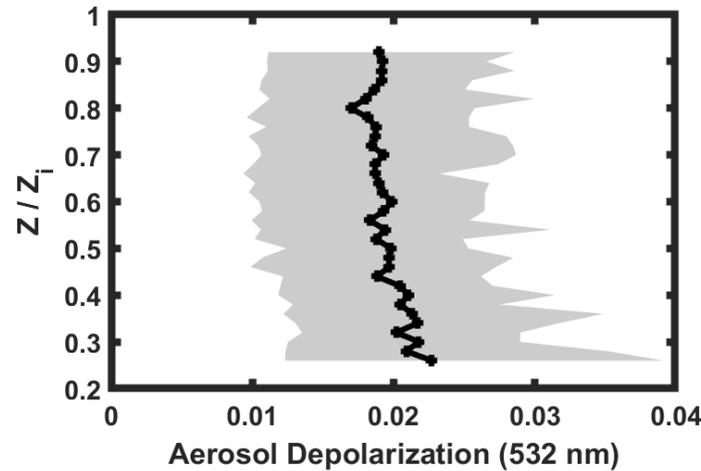
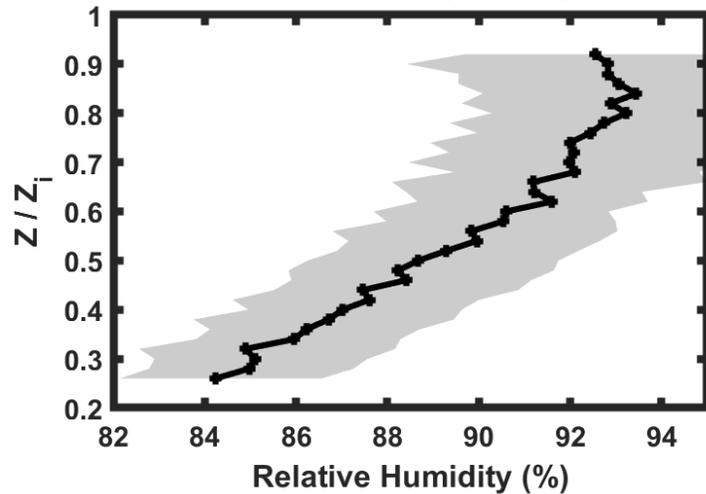
# Summary and Future Work

- Deployed from the NASA P-3B aircraft, the NASA LaRC airborne HSRL-2 measured profiles of aerosol extensive and intensive properties during all 19 CAMP2EX science flights
  - Aerosol backscatter and depolarization (355, 532, 1064 nm)
  - Aerosol extinction and aerosol optical thickness (AOT) via HSRL technique (355, 532 nm)
  - Additional products include aerosol type and mixed layer heights
- Median mixed layer height was about 560 m
- Associated with the increase in RH near the top of the mixed layer, HSRL2 measurements reveal:
  - Aerosol backscatter and extinction are systematically larger by about 30-40% near the top of the mixed layer due to the increase in fine mode scattering and fine mode particle size associated with increased RH
  - Slight decrease in aerosol depolarization associated with particles becoming more spherical due to water uptake
- About 40% (60%) of AOT was within (above) the mixed layer
- Majority of AOT and aerosol extinction classified by HSRL2 attributed to smoke
- HSRL2 data are being used to evaluate:
  - GEOS-5 simulations of aerosol distributions and properties
  - Variability of aerosol distributions and properties associated with cold pools
- Future work to include lidar-only and combined lidar+polarimeter retrievals of aerosol physical and optical properties



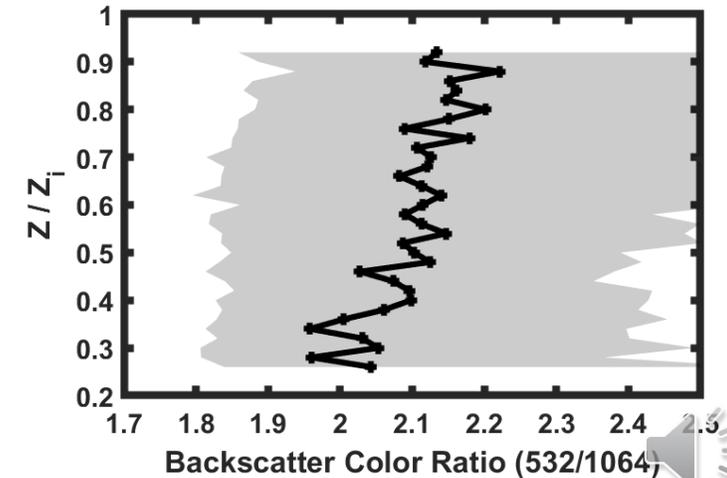
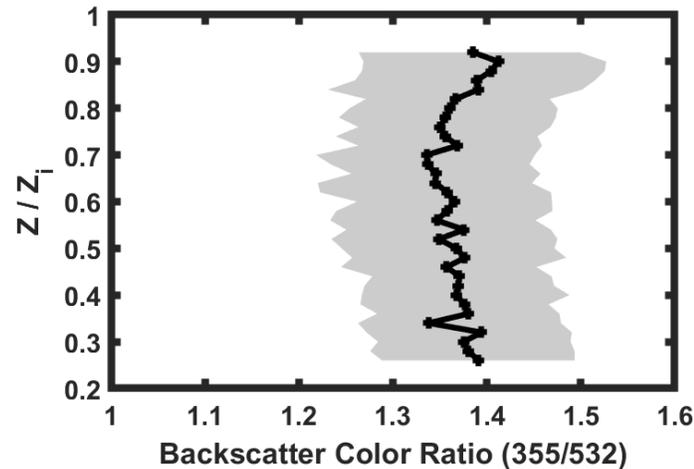
# Median Variability of Aerosol Intensive Parameters Within the Mixed Layer

$Z_i$  = mixed layer height

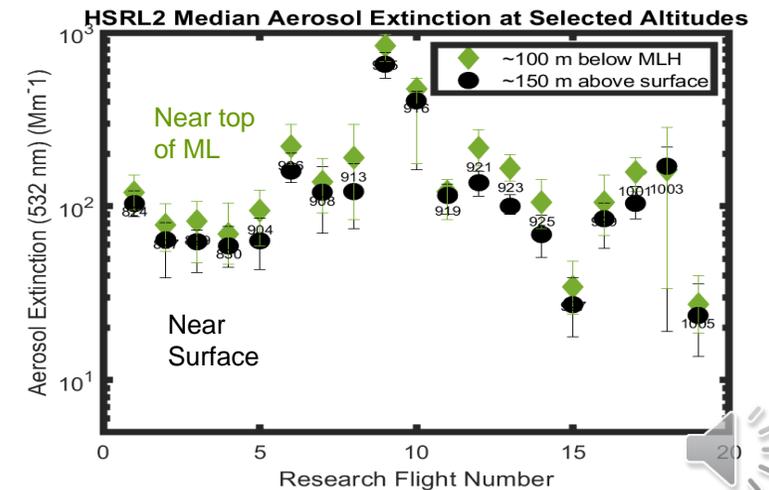
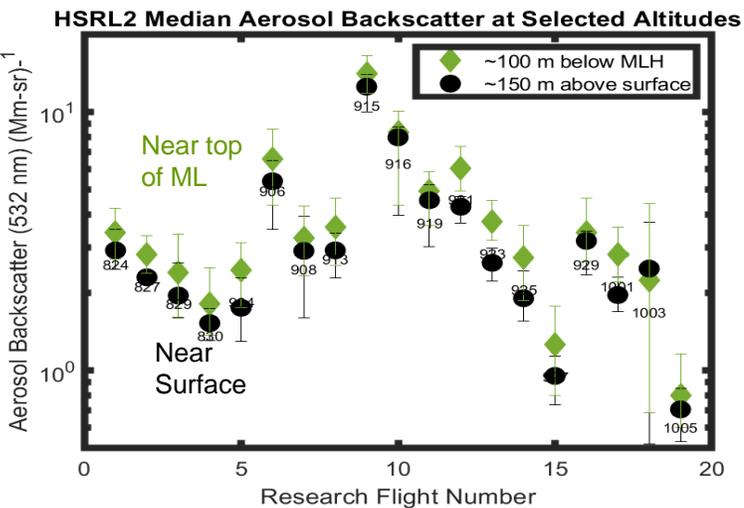
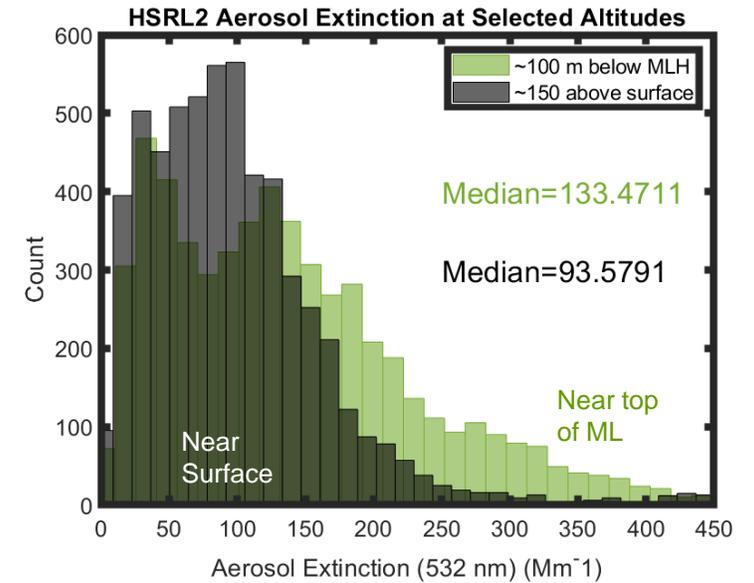
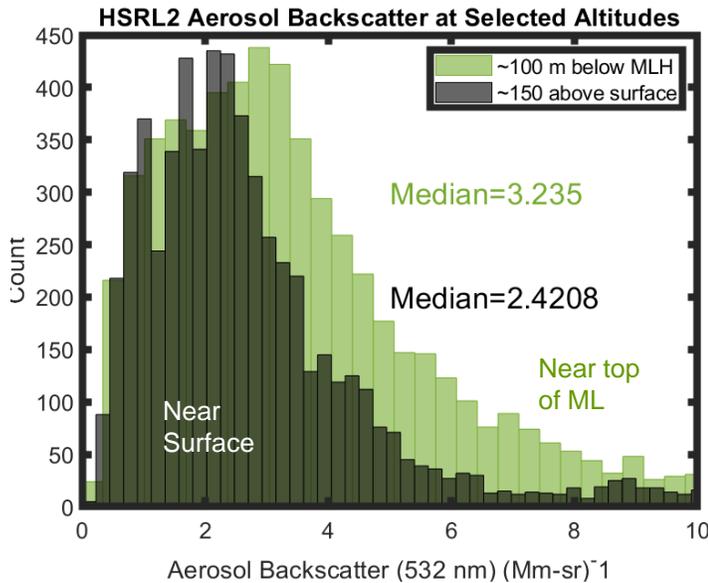
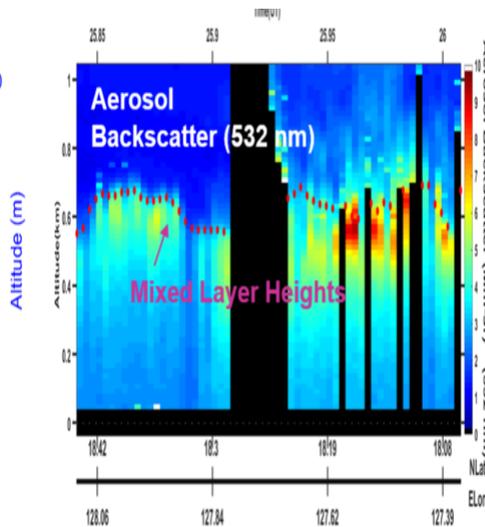
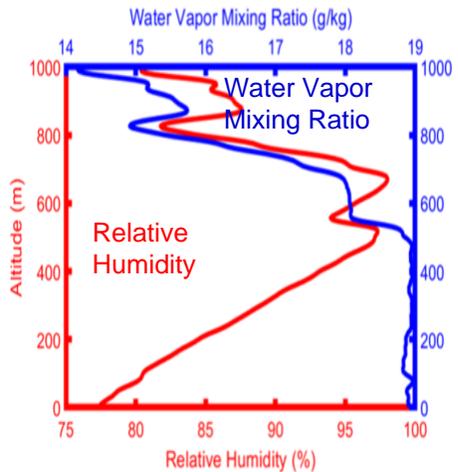


Analysis using entire CAMP2EX dataset; as RH increases near the top of mixed layer:

- Slight decrease in aerosol depolarization as particles become more spherical so particulate depolarization decreases
- Increase in fine mode particle scattering so backscatter color ratio (532/1064) increases
- Slight increase in fine mode size so backscatter color ratio (355/532) decreases
- Very little change in lidar ratio

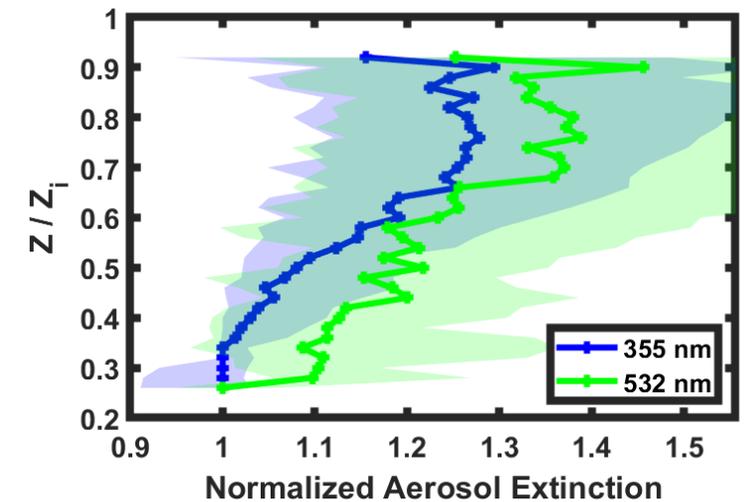
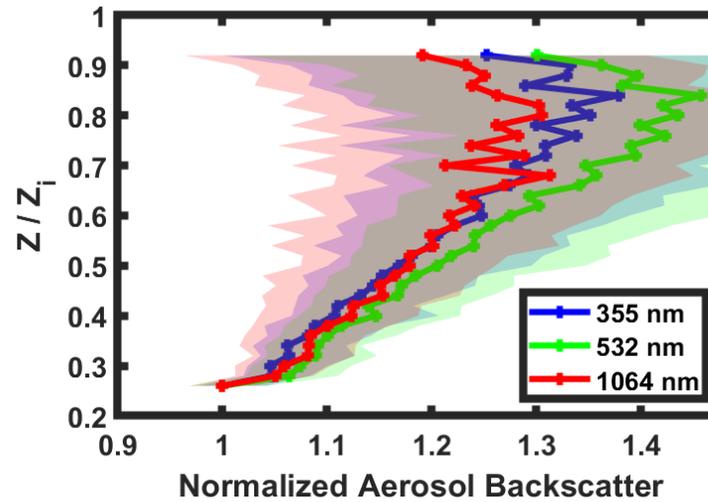
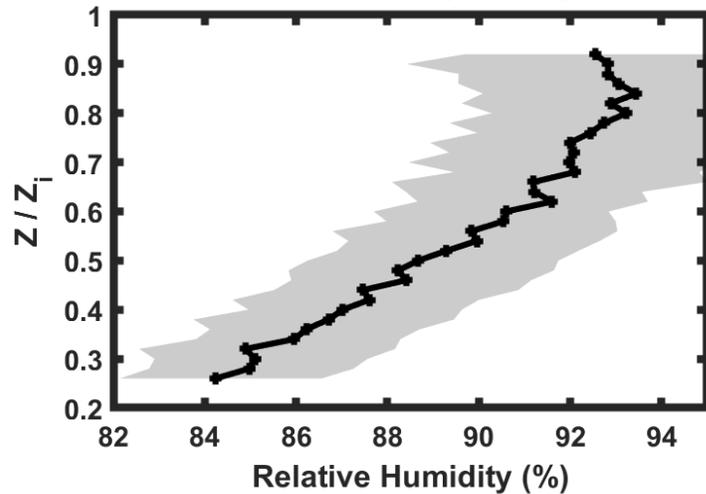


# Systematic Vertical Variability of Aerosol Backscatter and Extinction within the Mixed Layer Due to RH



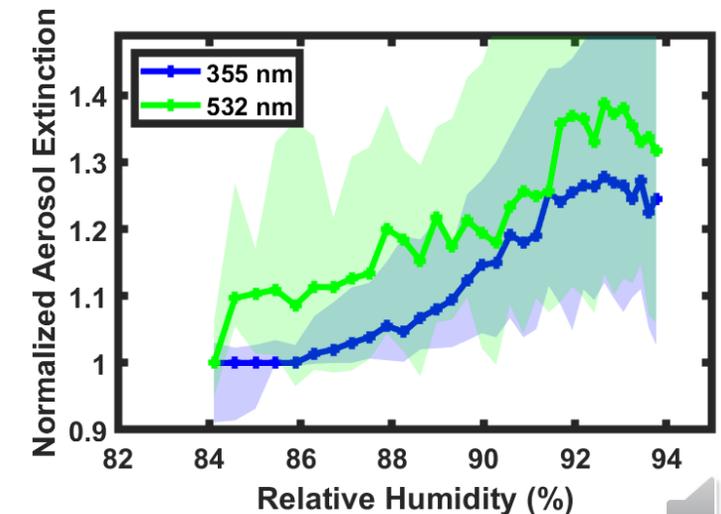
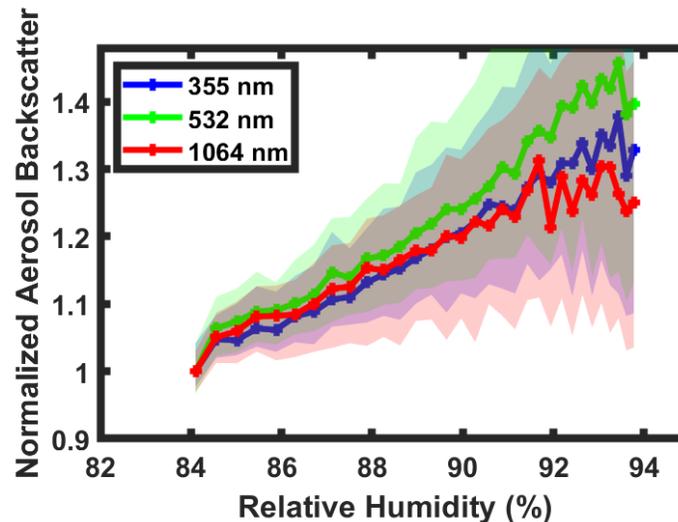
Aerosol backscatter and extinction are systematically larger during all of CAMP2Ex near the top of the Mixed Layer due to the increase in fine mode scattering and fine mode particle size associated with increased RH

$Z_i$  = mixed layer height

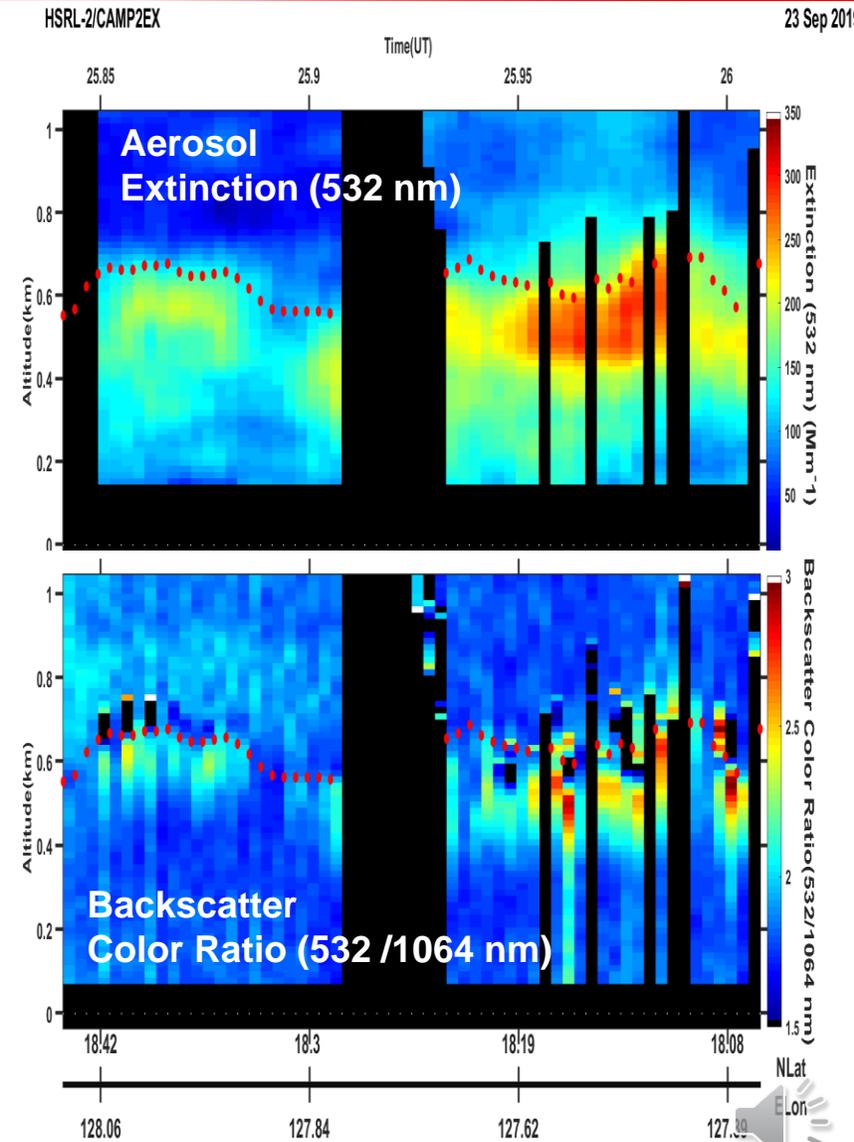
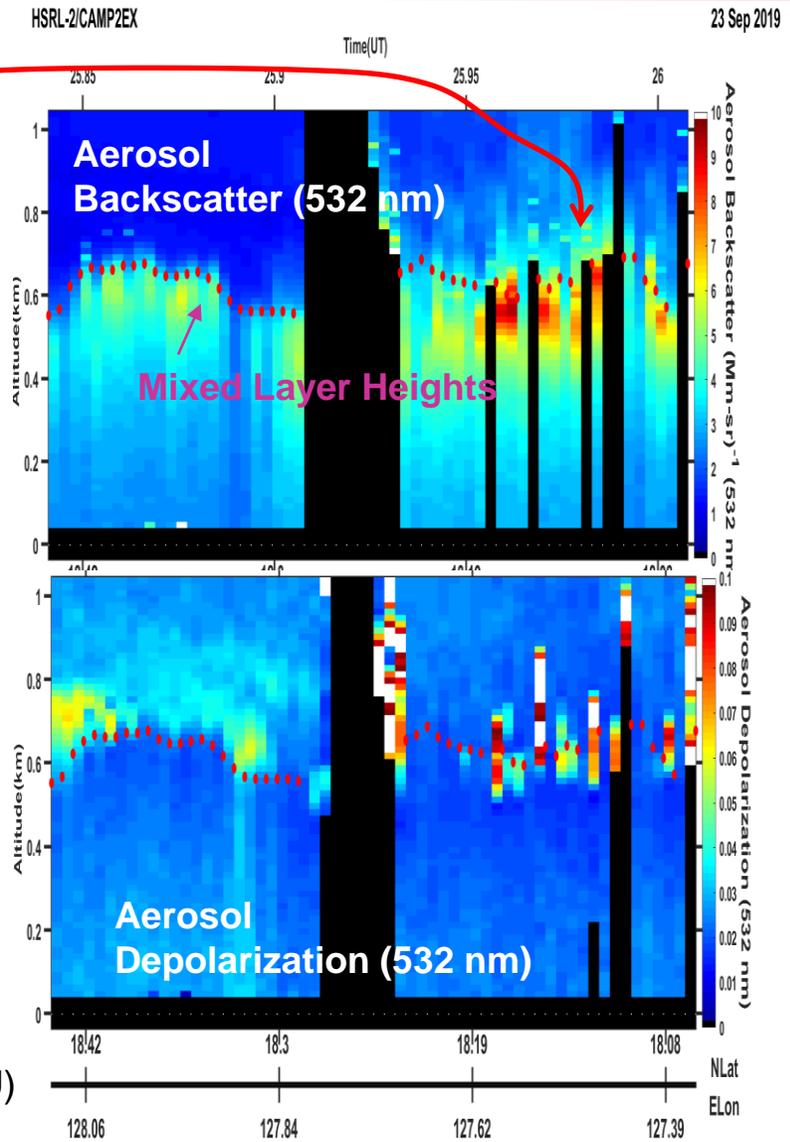
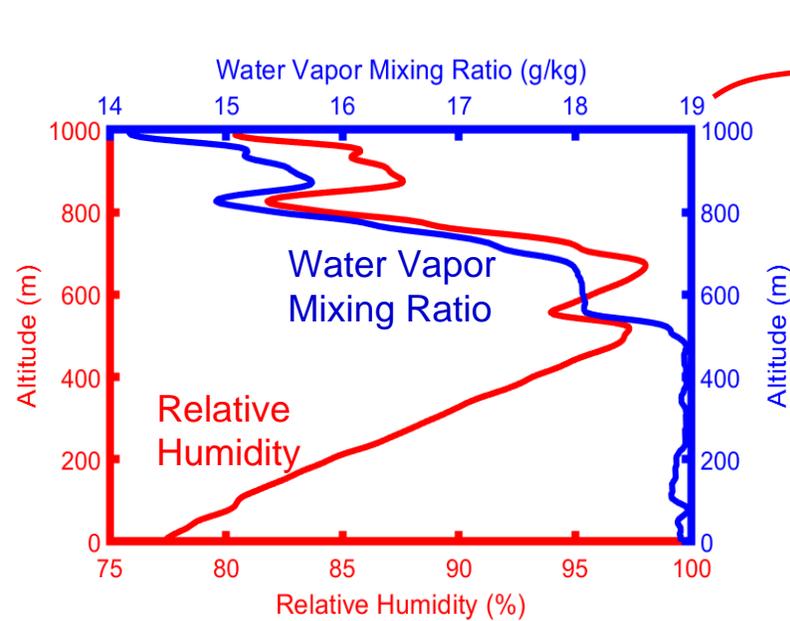


Analysis using entire CAMP2EX dataset reveals systematic increases in both backscatter and extinction with altitude within mixed layer

- RH from coincident dropsondes
- Cases selected such that water vapor mixing ratio is nearly constant in mixed layer so that vertical variability in aerosol properties is mostly likely due to RH
- Backscatter and extinction normalized to unity near surface



# Vertical Variability of Aerosol Properties within the Mixed Layer Associated with Relative Humidity (RH)

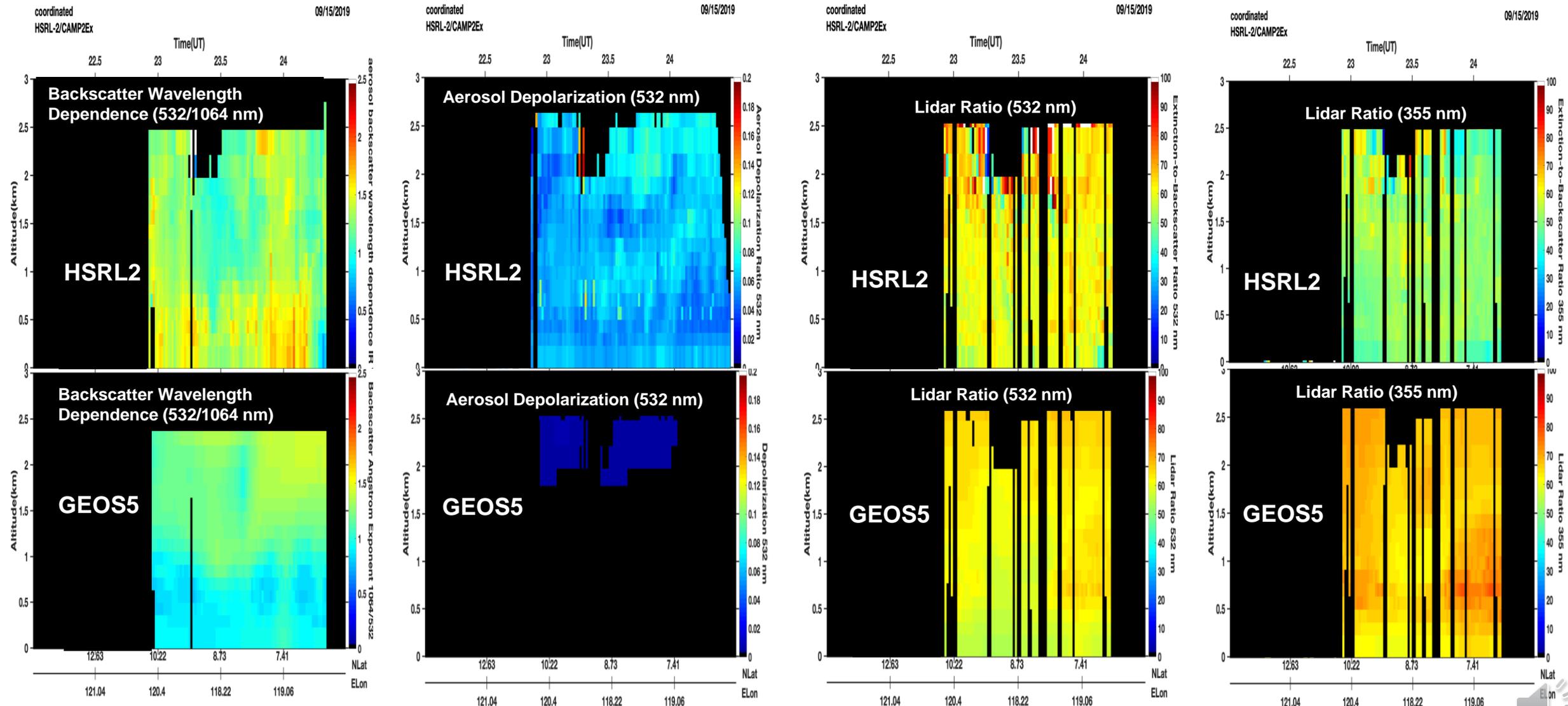


- As RH increases near top of Mixed Layer, fine mode hygroscopic particles take on water
- Aerosol backscatter and extinction increase
  - Particles become more spherical so particulate depolarization decreases
  - Increase in fine mode particle scattering so backscatter color ratio increases

Dropsonde data from Sue van den Heever (CSU)



# Example: HSRL-2/GEOS-5 Comparison of Aerosol Intensive Parameters for Sept. 15



GEOS-5 Simulations provided by Arlindo da Silva (GSFC)

