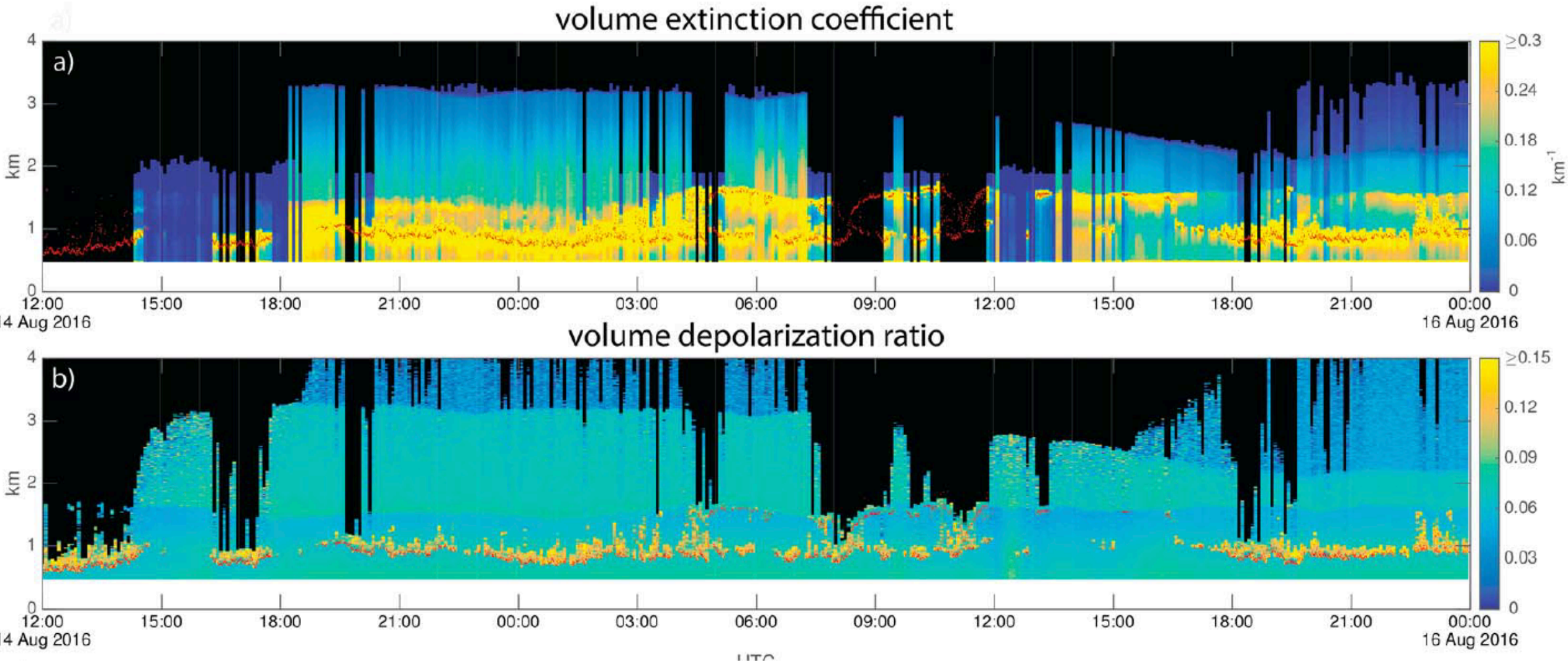
The micro pulse lidar at Ascension Island:

what **quantitative** information can we derive from it on the aerosol vertical structure?



Paytsar Muradyan (instrument mentor), Paquita Zuidema, Rodrigo Delgadillo, Jianhao Zhang

LASIC MPL timeline

Operations - good

- The micro pulse lidar operated for the entire LASIC time period
- No issue with lidar window
- On-site technicians created monthly after-pulse and dark-count calibration files, kept window clean

Calibration - good

Overlap correction: this accounts for differences in the field-of-view with range. It is instrument-specific. Correction factor was determined post-deployment at SGP site, ***comparison to the SGP Raman Lidar relatively good.*** Possible degradation Over time below 1km

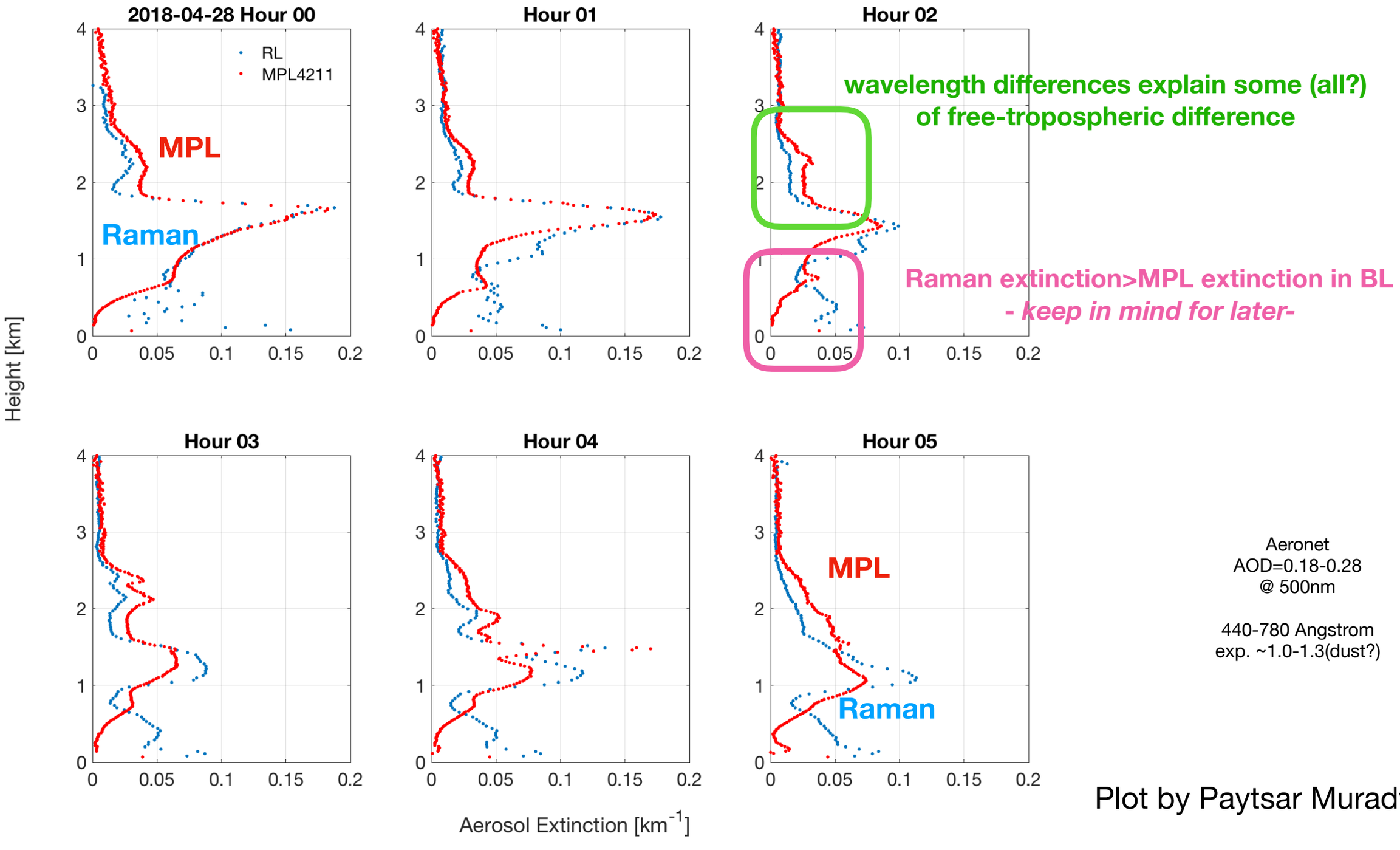
Extinction Retrievals

- MPL measures back-scattered intensities only and the physically-relevant extinction profile is under-determined. Two independent sets of extinction retrievals have been done (DOE Klett, UM Fernald), one using the AERONET aerosol optical depth as a constraint (UM), the other more of an optimal estimation for which the AERONET AOD can be used as an independent assessment (DOE).The two retrieval sets compare relatively well (share same use of a column-average lidar ratio assumption).
- An evaluation against Raman lidar/aircraft measurements of extinction suggests….

Little confidence below 1km, possibly worse with time

post-deployment assessment at SGP

A new overlap function was derived, different from the pre-deployment manufacturer-produced overlap function applied during the campaign. New DOE extinctions retrievals compare “well” to those from a Raman 355 nm lidar at SGP. Differences include an MPL overestimate above 2 km (consistent with wavelength difference), and underestimate below ~600 m



Aeronet
AOD=0.18-0.28
@ 500nm

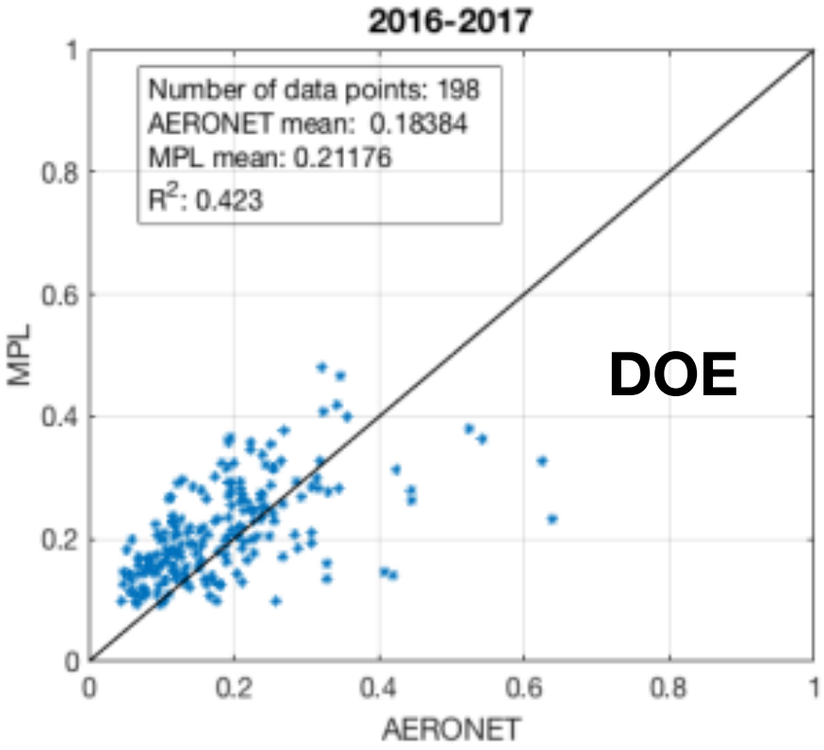
440-780 Angstrom
exp. ~1.0-1.3(dust?)

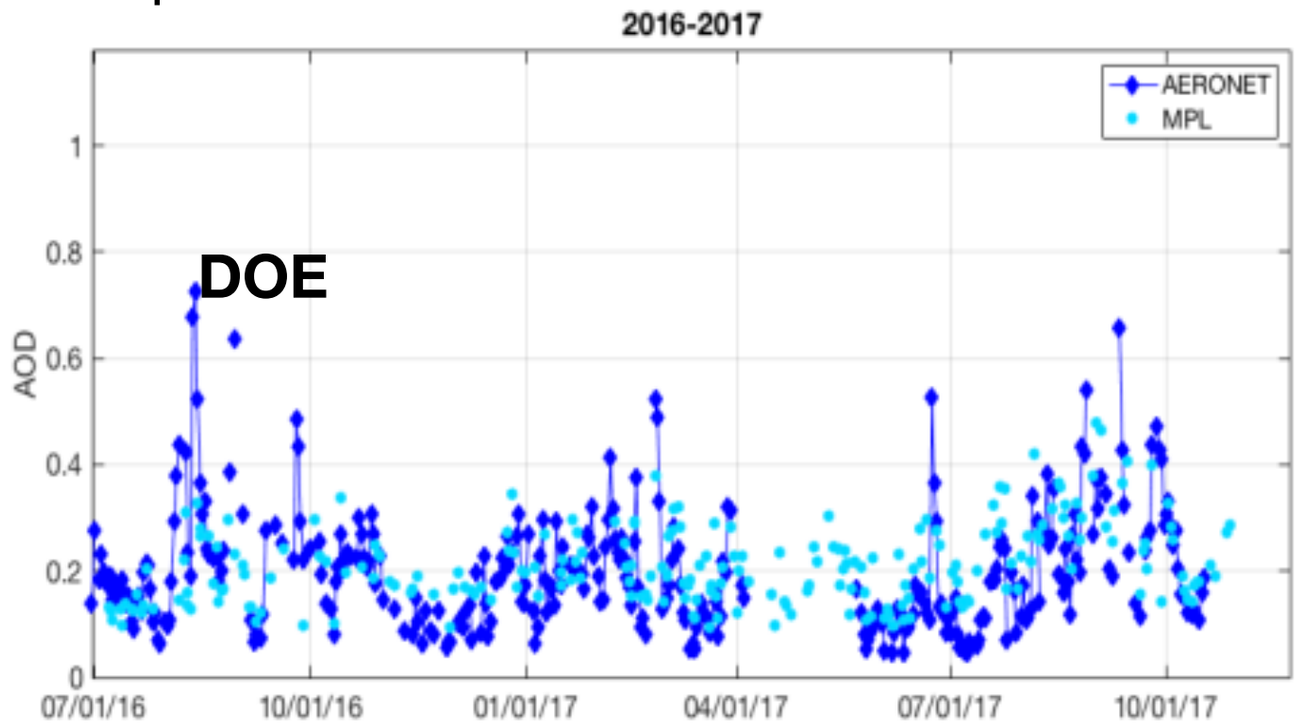
Plot by Paytsar Muradyan

UM extinction retrievals incorporate AERONET AOD as a constraint, DOE retrievals don't

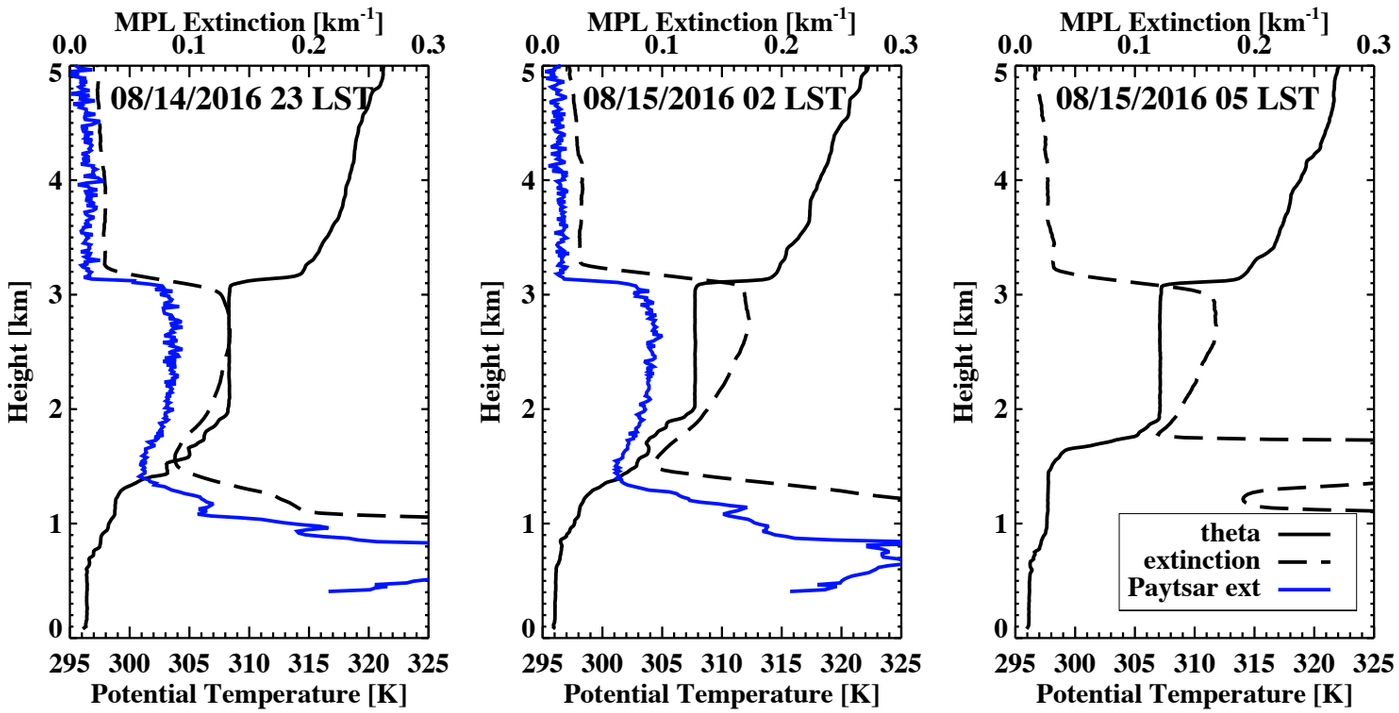
Top plot below indicates DOE extinction retrievals are slightly higher than UM's, judging by slight overestimate compared to AERONET AOD

But not for the time period shown on the bottom





Distinctive example, AERONET AOD 0.5-0.7, free-tropospheric AOD ~0.2



Two other independent assessments have been done, using NASA ORACLES HSRL2 532 nm data and UK CLARIFY in-situ extinctions, both at Ascension

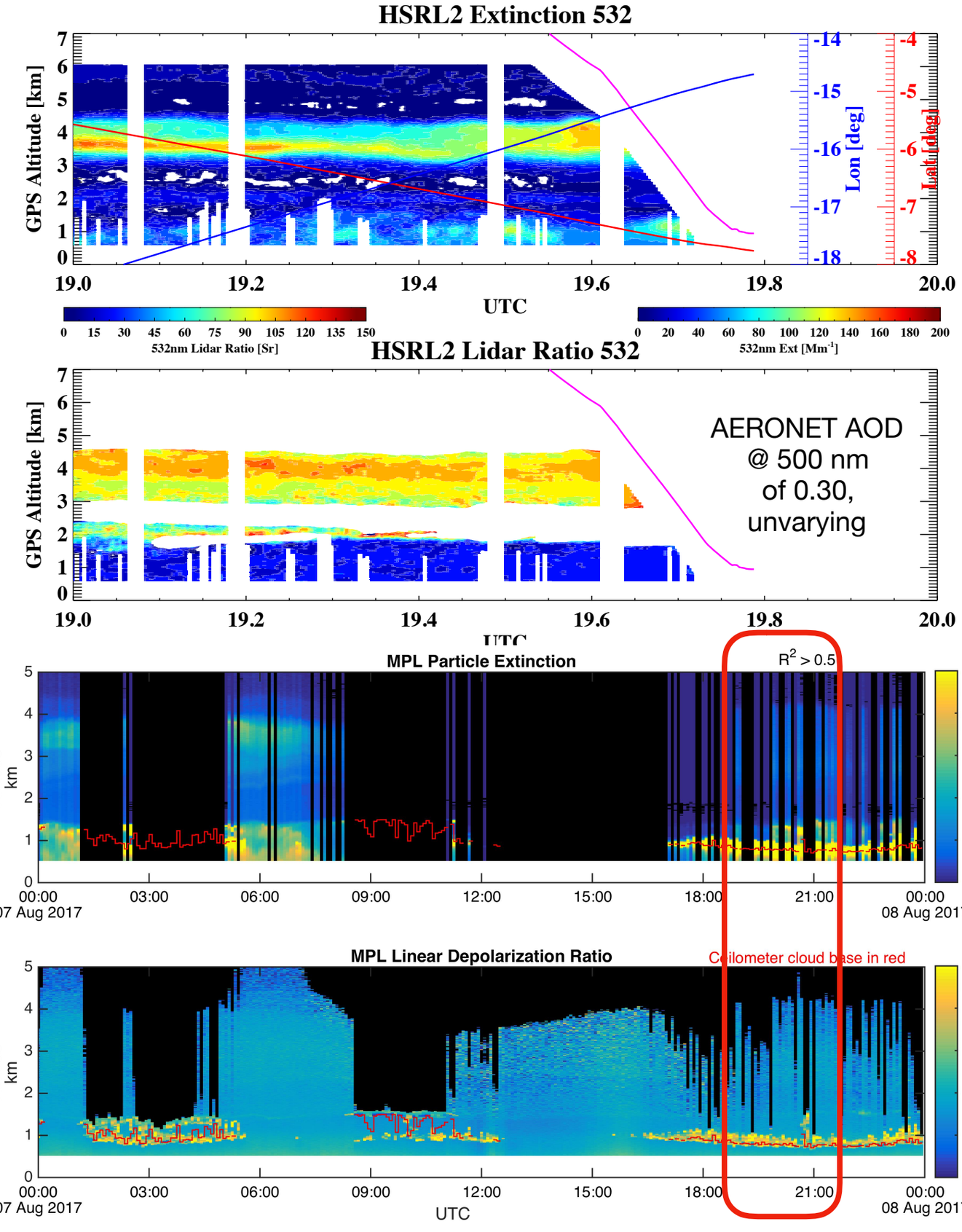
Met Office

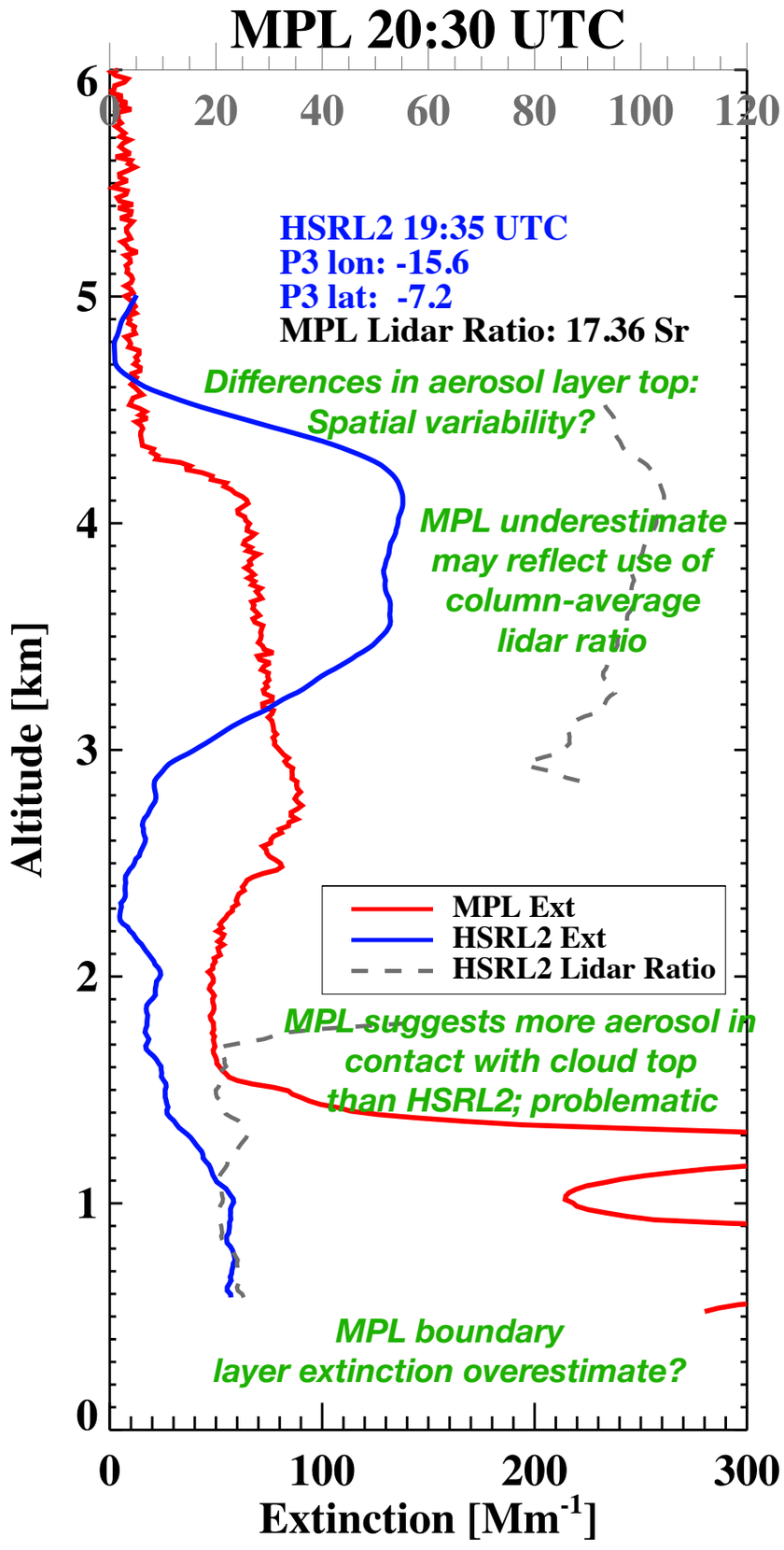
EXSCALABAR measurements

Measurement	Technique	Sample conditioning	Wavelengths (nm)		
Extinction	CRDS Cavity Ring-Down Spectroscopy	Dry	405	662	
		Humidified: 70%, 90%	405	405	
		Gas reference	405		
Absorption	PAS Photo-acoustic Spectroscopy	Dry	405	515	662
		Thermally denuded	405	~~662~~	

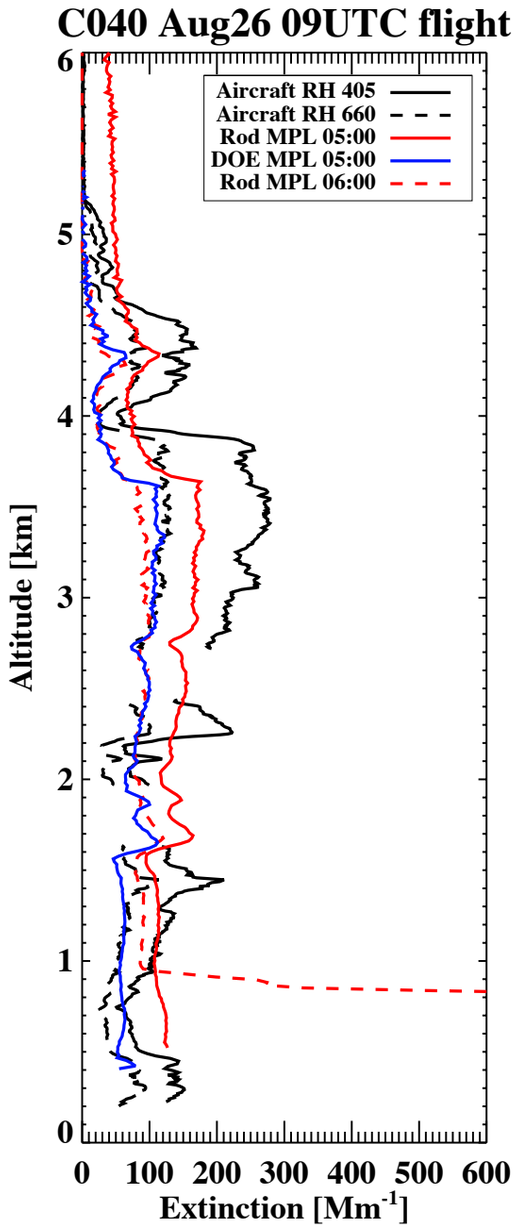
- 1 μm impactor
- Dry measurements have RH < 30%
- Activated Carbon scrubber removes Ozone, NO_2
- Aerosol filter for background check

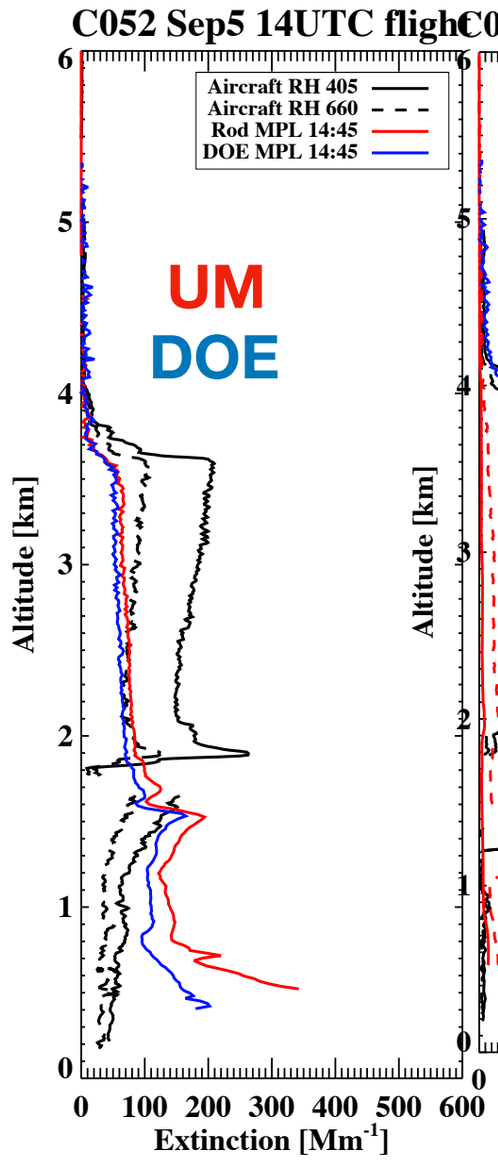
The best comparison case to the ORACLES HSRL2 lidar is August 7, 2017, Barbados -> Ascension

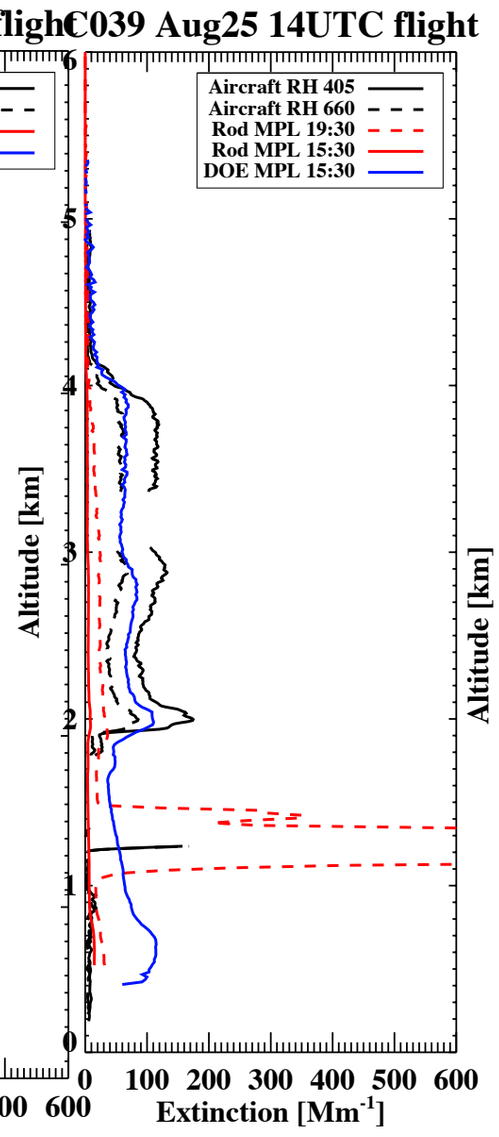


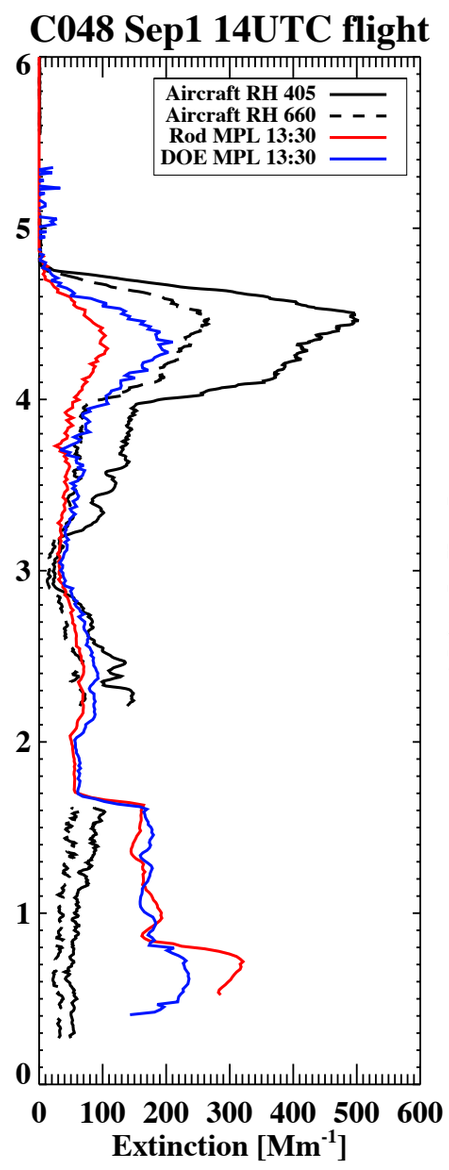


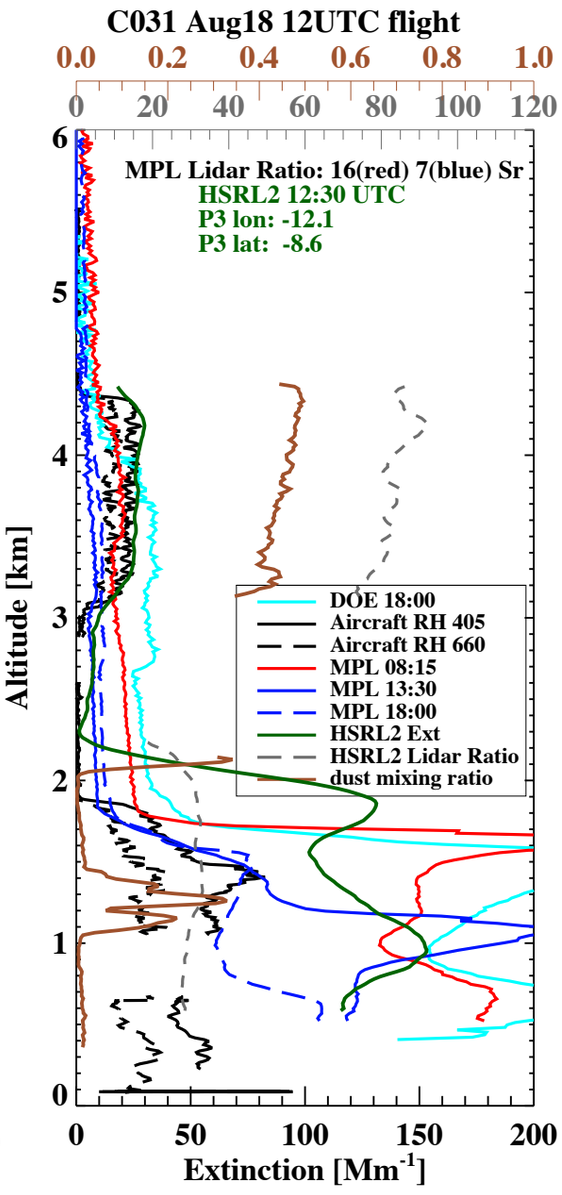
Comparison to EXSCALABAR extinctions









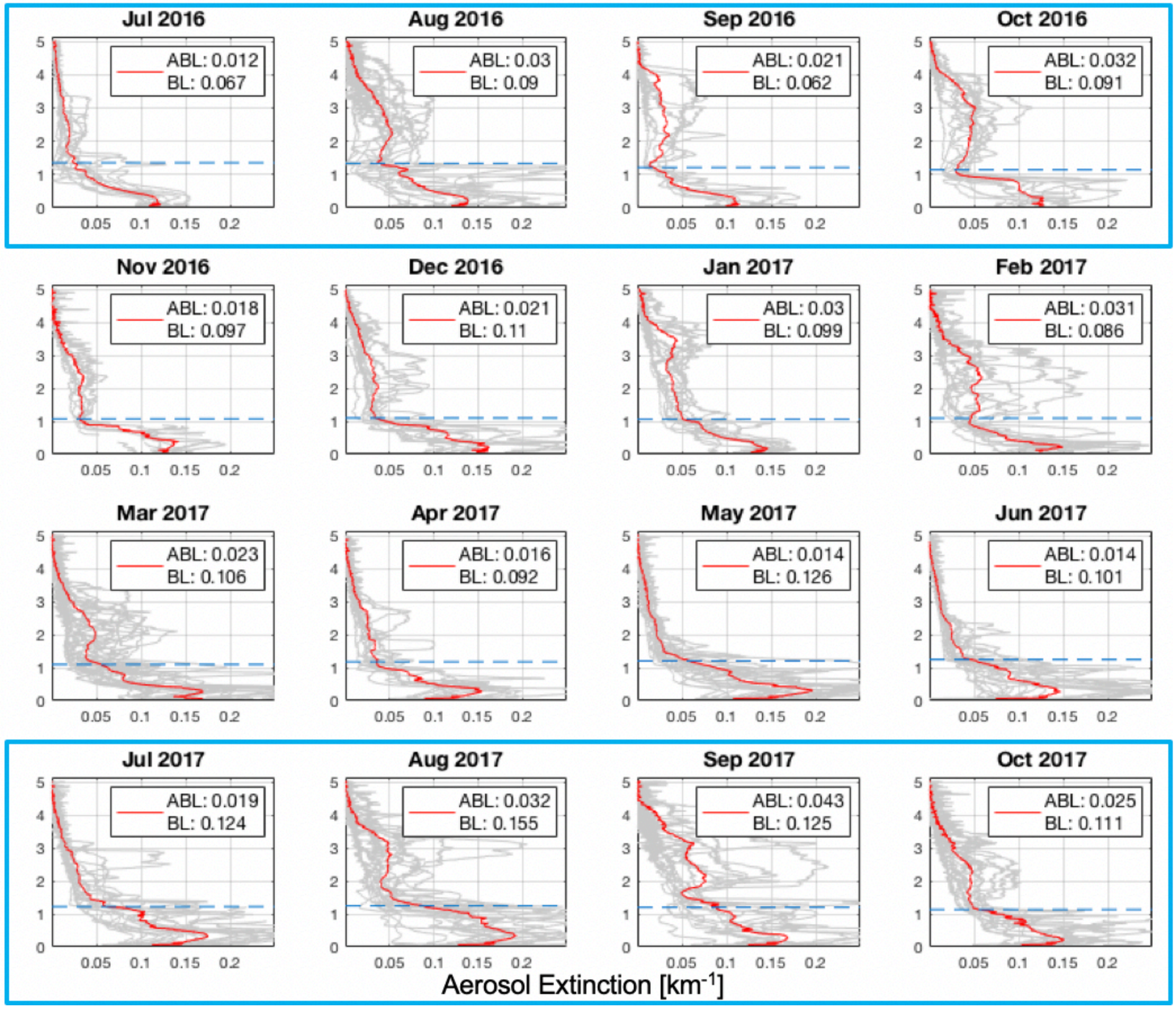


Some Science !

All from Paytsar

Monthly MPL Extinction Profiles

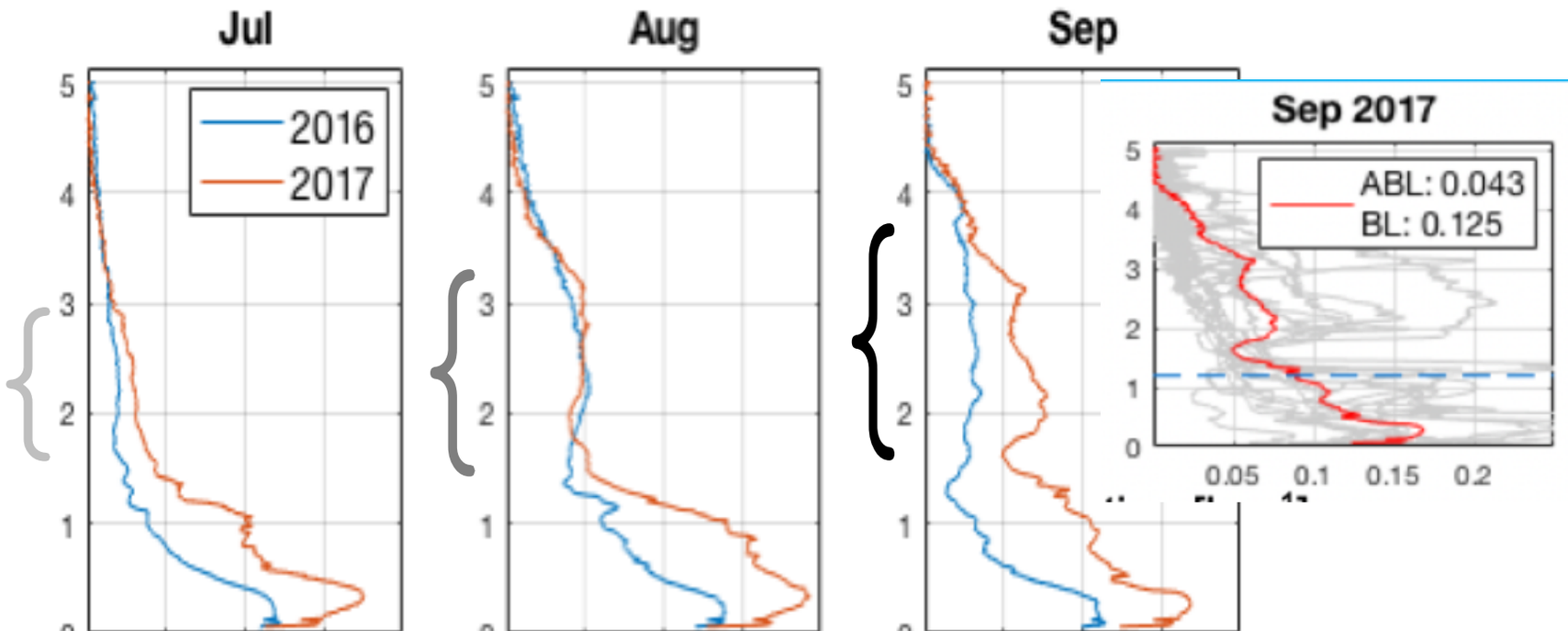
- Biomass Burning (BB) season extends from late June to October, but fewer "smoky days" evident in June and July
- Larger above boundary layer (ABL) mean extinctions in BB months (Aug, Sep, Oct), with smoke layer on occasion extending up to 4 km
- High ABL extinction in Mar and Feb 2017
  - > 0.1 km^{-1} ABL extinctions (Feb 2017) may be indicative of dust layers

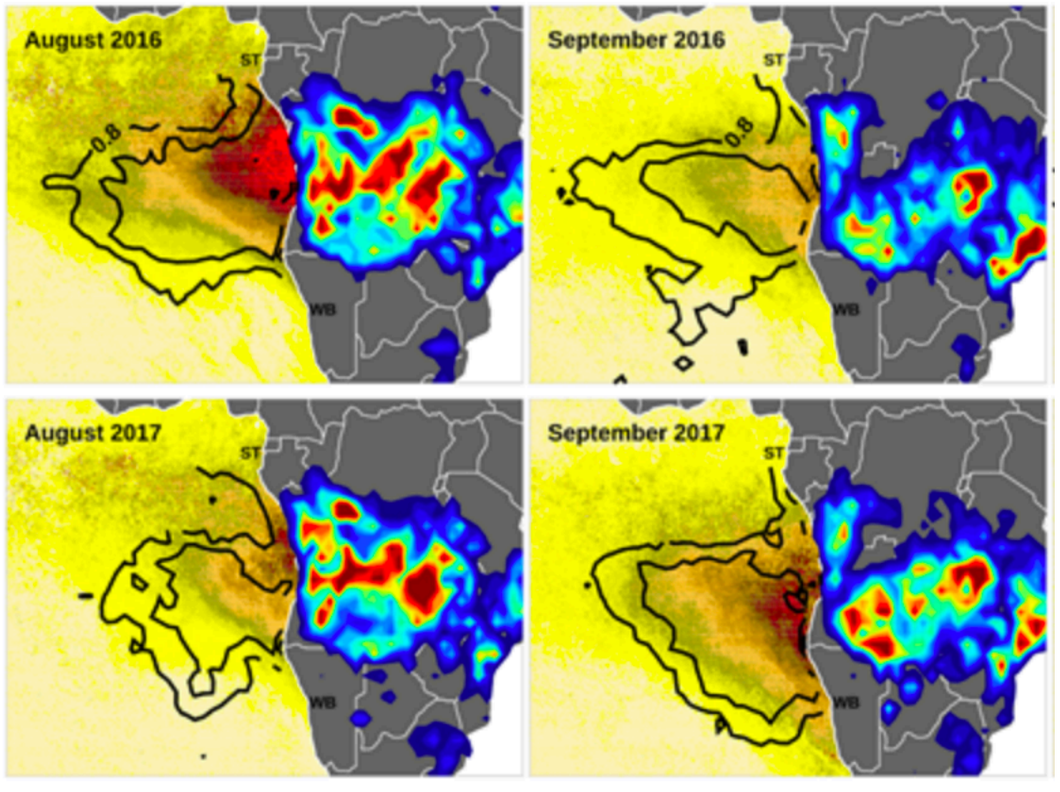


Free-tropospheric layer heights increase similarly from July to September for both years

More FT aerosol in September 2017 than September 2016 - consistent w/ satellite

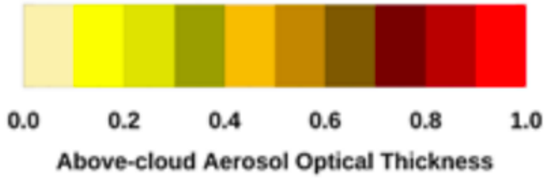
LASIC in-situ datasets indicate more boundary layer aerosol in August 2016 than 2017. Relative humidity profiles are similar; sampling similar. **Lidar degradation in optical alignment?** Not sure

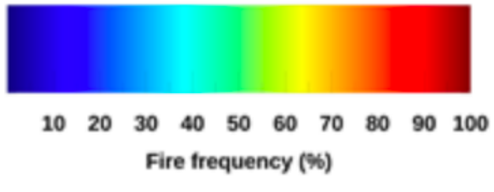




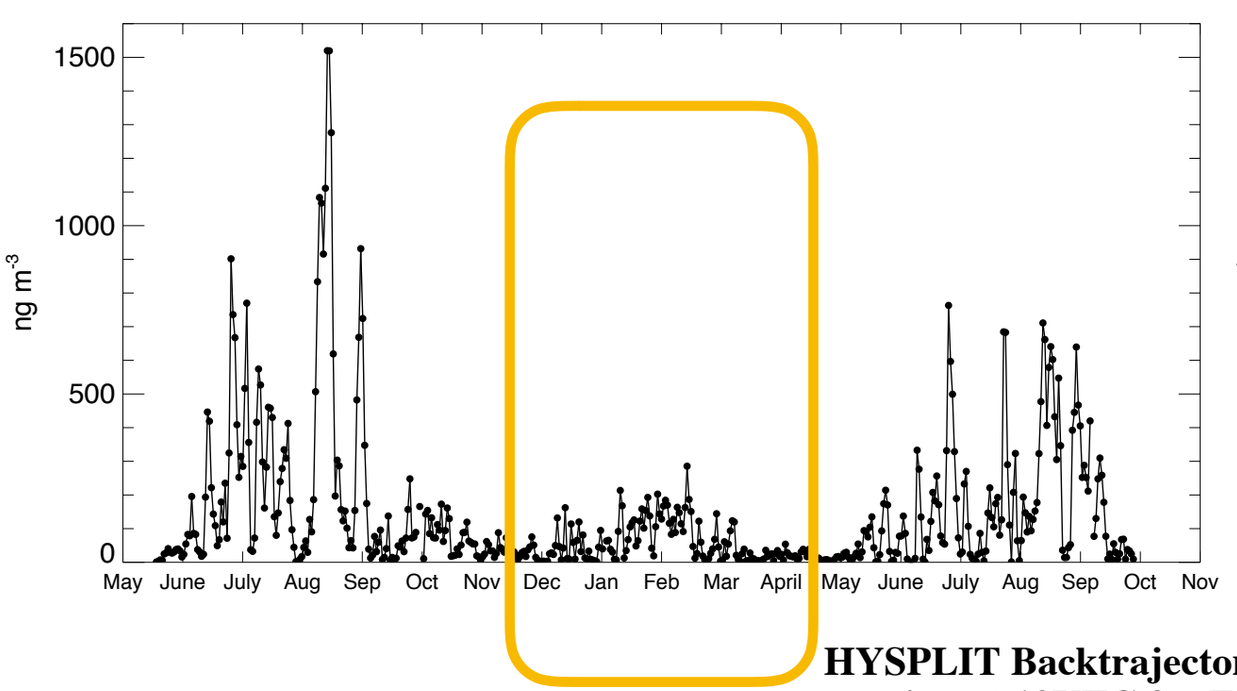
MODIS above-cloud AOD retrieval (Meyer et al., 2014)

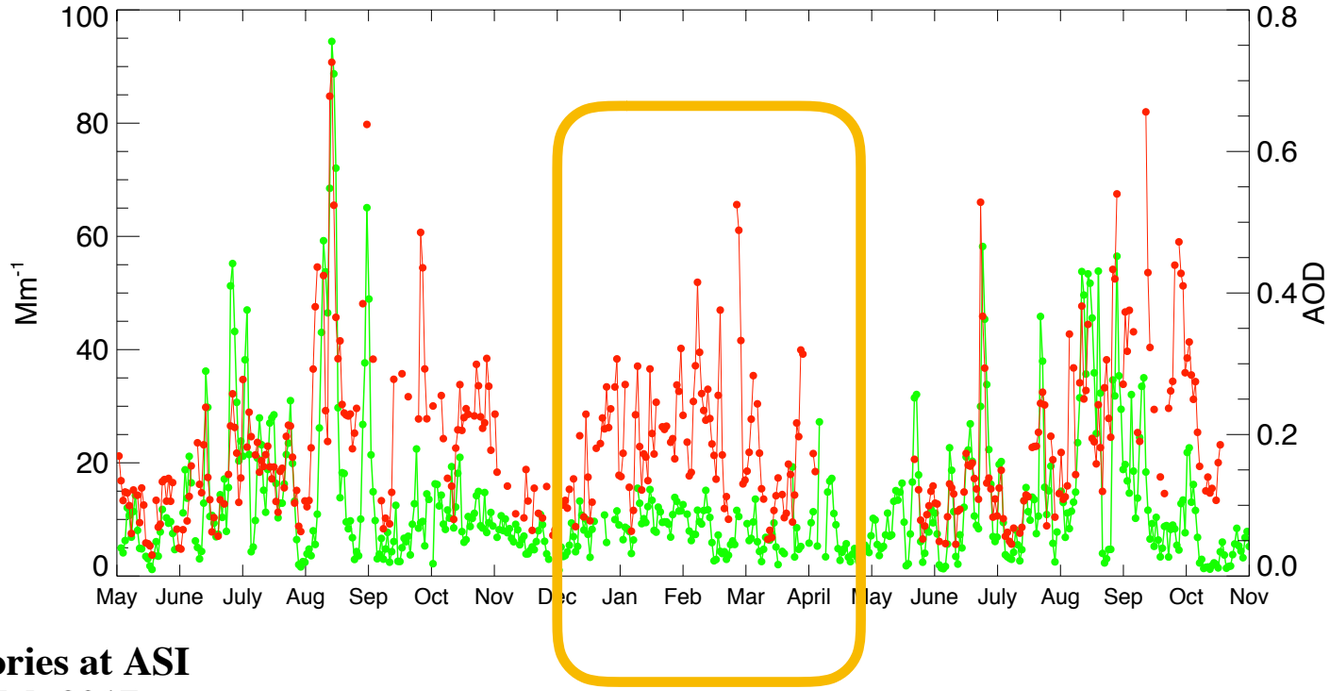
Plot by Ian Chang, black Contours are cloud fraction



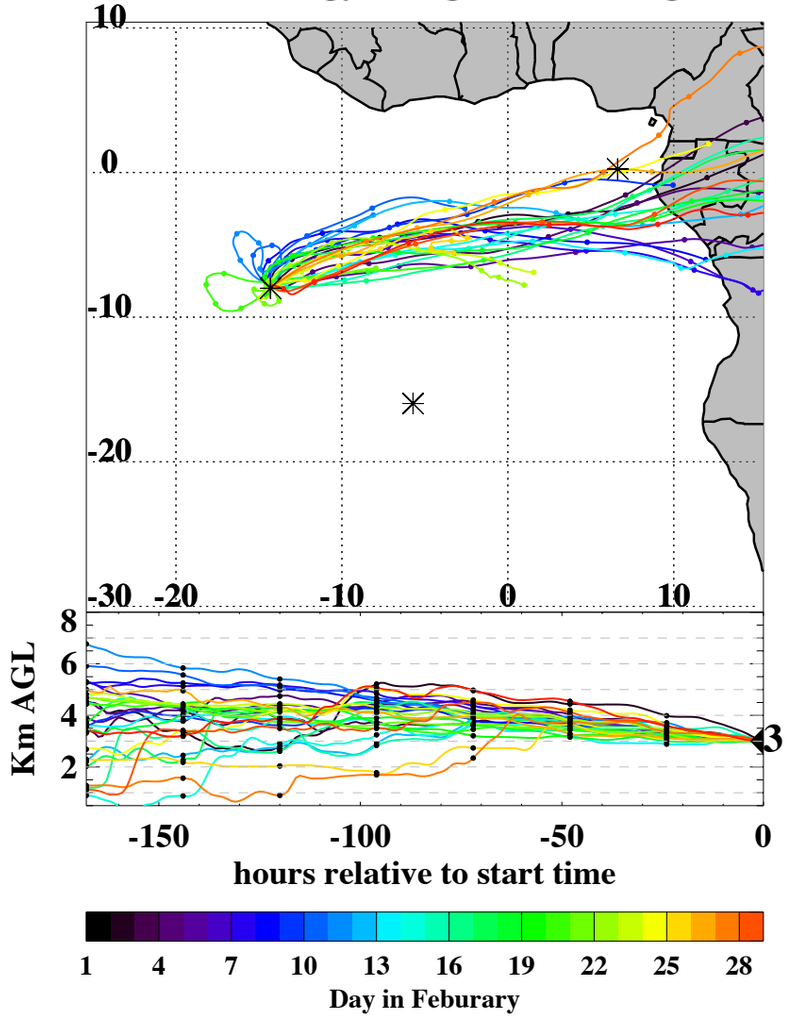


An interesting aspect of the seasonal cycle: another peak in February-March

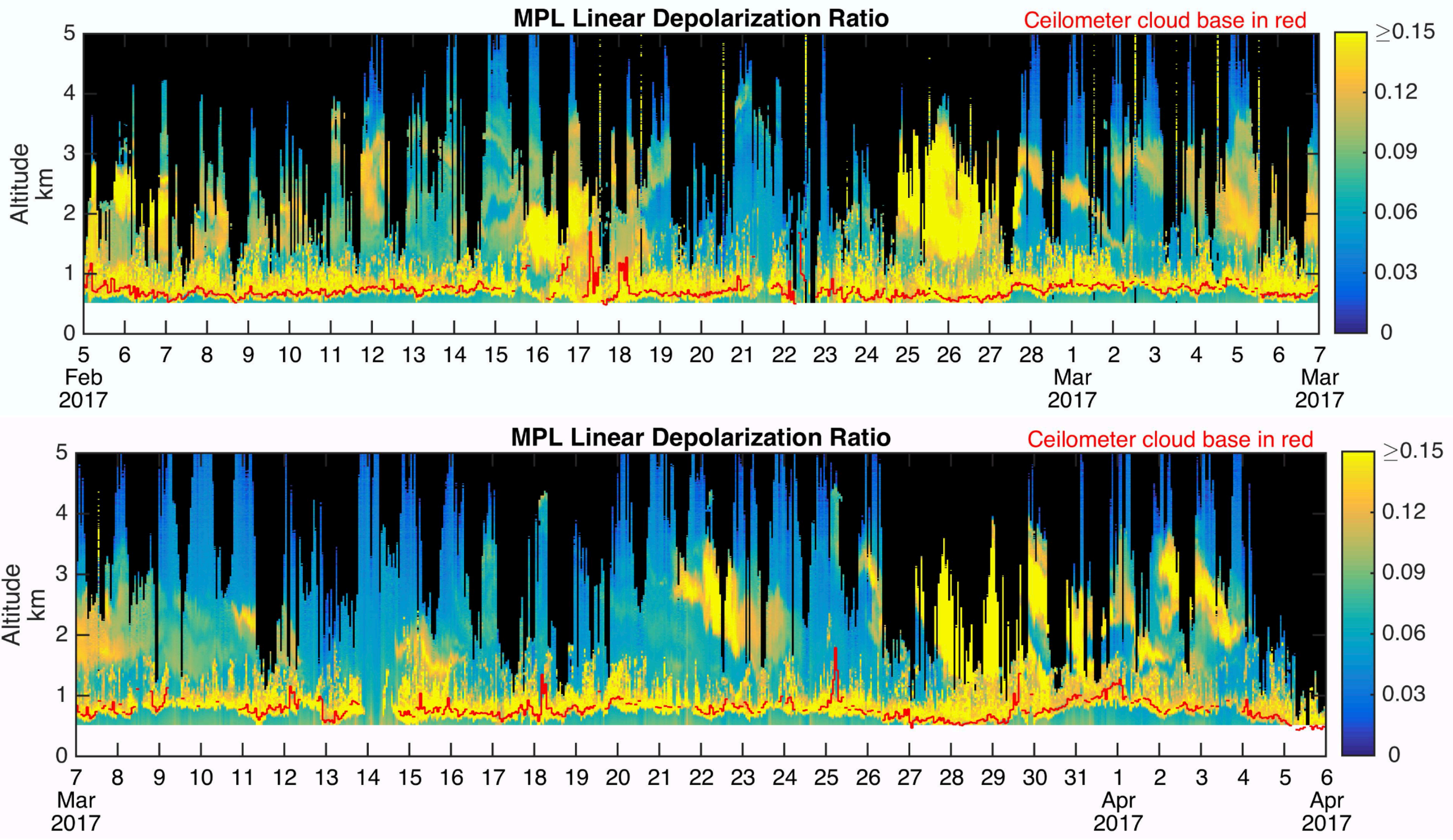




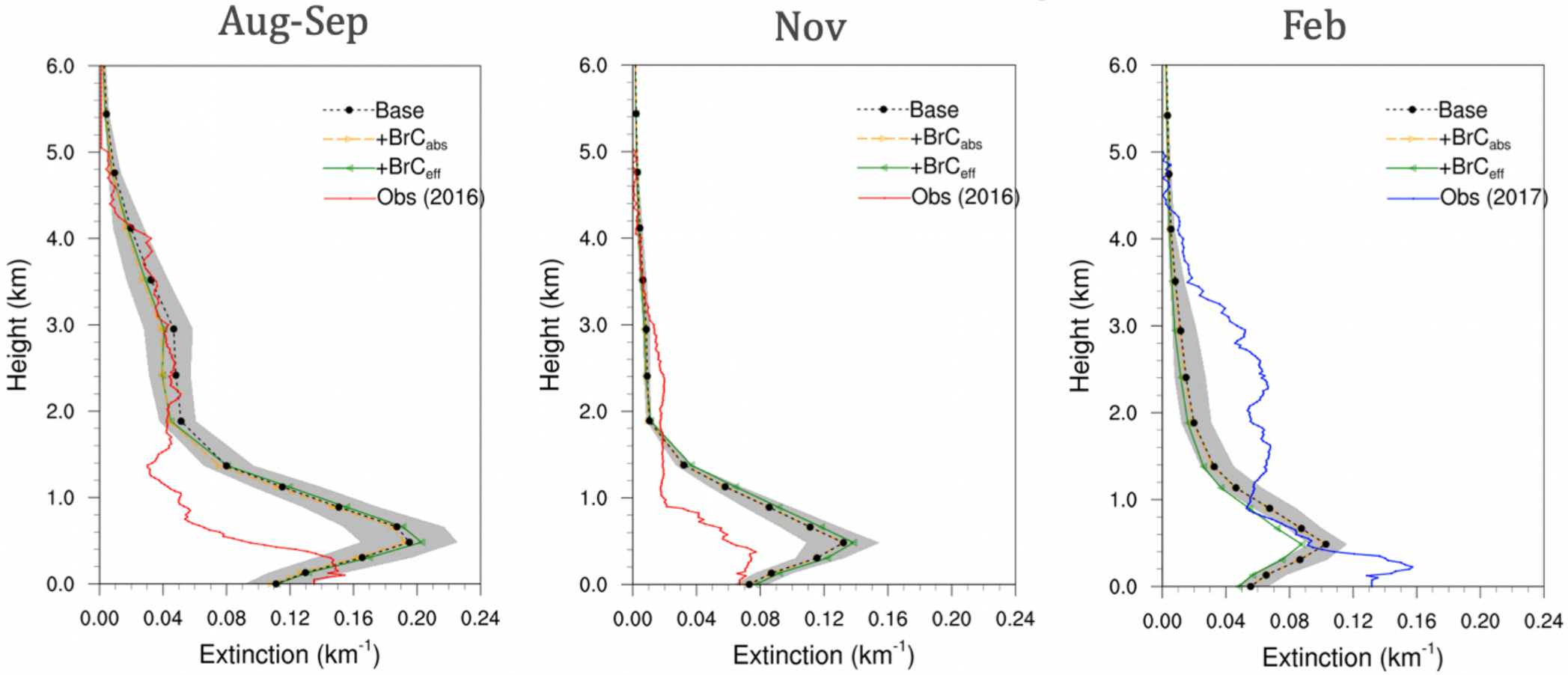
HYSPLIT Backtrajectories at ASI starting at 12UTC for Feb 2017 Meteorology using GFS 0.5 degree



In-situ + Lidar depolarization ratio indicates this is mixed dust/smoke



MPL Extinctions vs Community Atmosphere Model (CAM-5)



- **Aug - Sep:** Model agrees well with MPL retrievals in ABL and overestimates BL extinctions
- **Nov:** Model agrees with MPL observations in ABL but overestimates extinctions in BL
- **Feb:** Model agrees well with MPL from 0.5 to 1 km but underestimates ABL extinctions

Summary

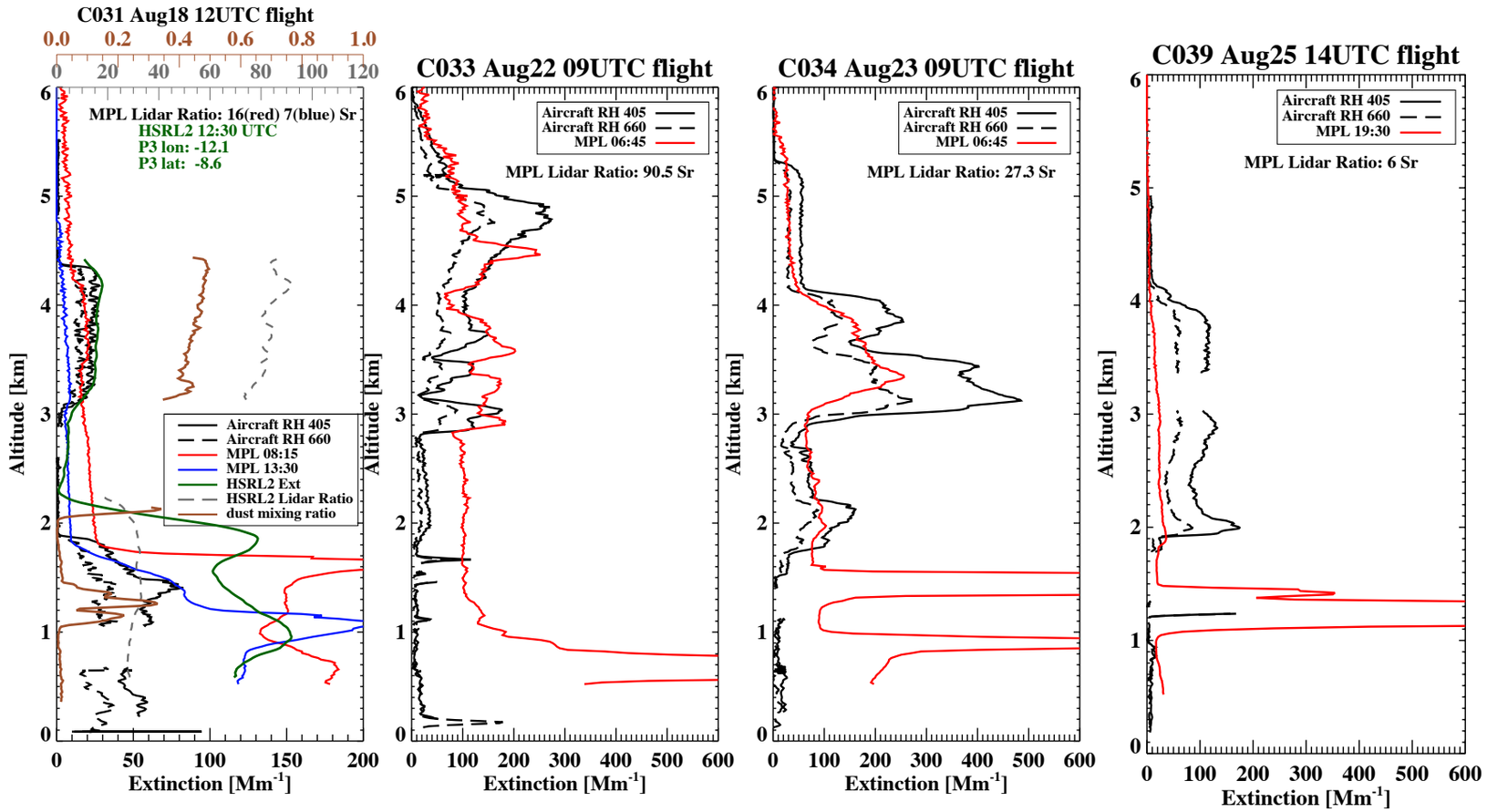
Paytsar: high quality calibrations are critical in attempting extinction retrievals with the MPL. After our "best attempt" with the calibrations, the retrieved extinctions are generally in good agreement with the in-situ humidified extinctions at 405 nm. In 2 out of 6 available comparison cases there is good agreement within the BL as well (Aug 26 and Sep 5). For the cases of large BL extinction differences between the MPL and EXCALABAR (e.g. Aug 24, Aug 25) it's difficult to put confidence in the in-situ measurements as well showing <20Mm-1 extinctions in 80-90% RH conditions. MPL extinction comparison with the RL shows agreement above ~600 m. However, RL itself has challenges in the near-field, therefore it's difficult to quantify the MPL performance in this comparison as well. All in all, the ASI MPL extinctions provide great insight into the variations of the smoke layer depth over Ascension, with representative above cloud AODs.

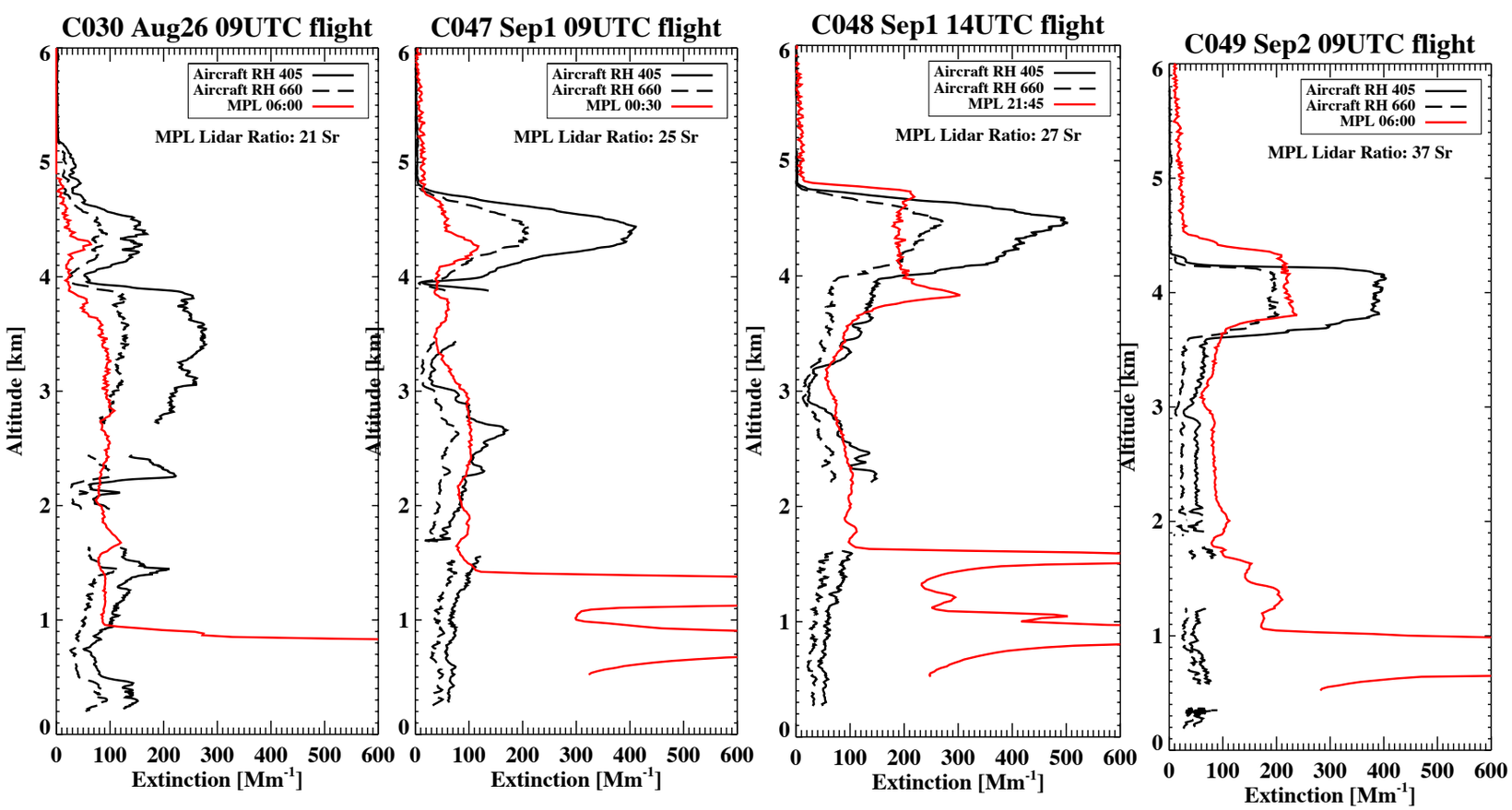
Paquita: the lidar imagery may be primarily valuable as pretty pictures providing context; much of the AOD is likely from aerosol hygroscopic swelling as opposed to free-tropospheric smoke. Application of a column-average Lidar ratio a real limitation, and optics may not have behaved consistently over time. The best science nugget: detection of FT aerosol layer top is good.

Future work

A paper based on our combined knowledge/work
Extinctions as PI products on ARM archive

Extra



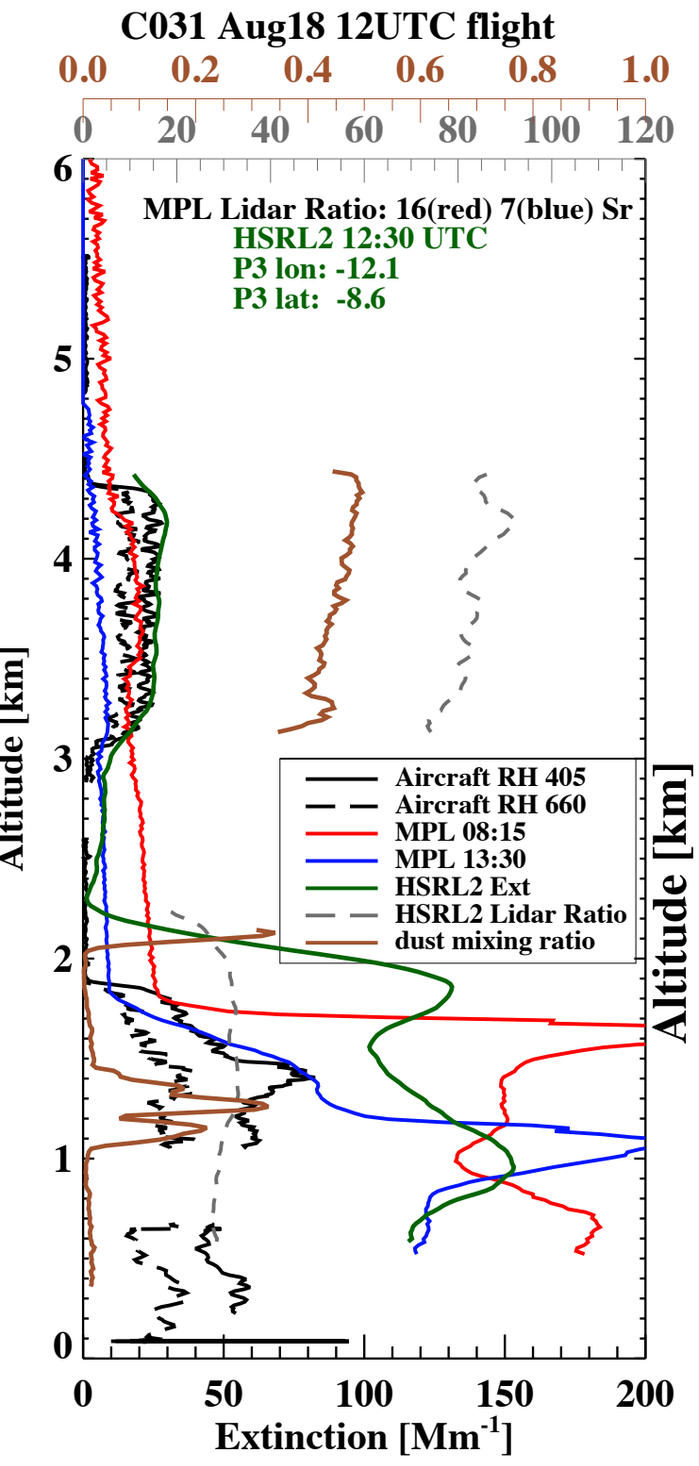


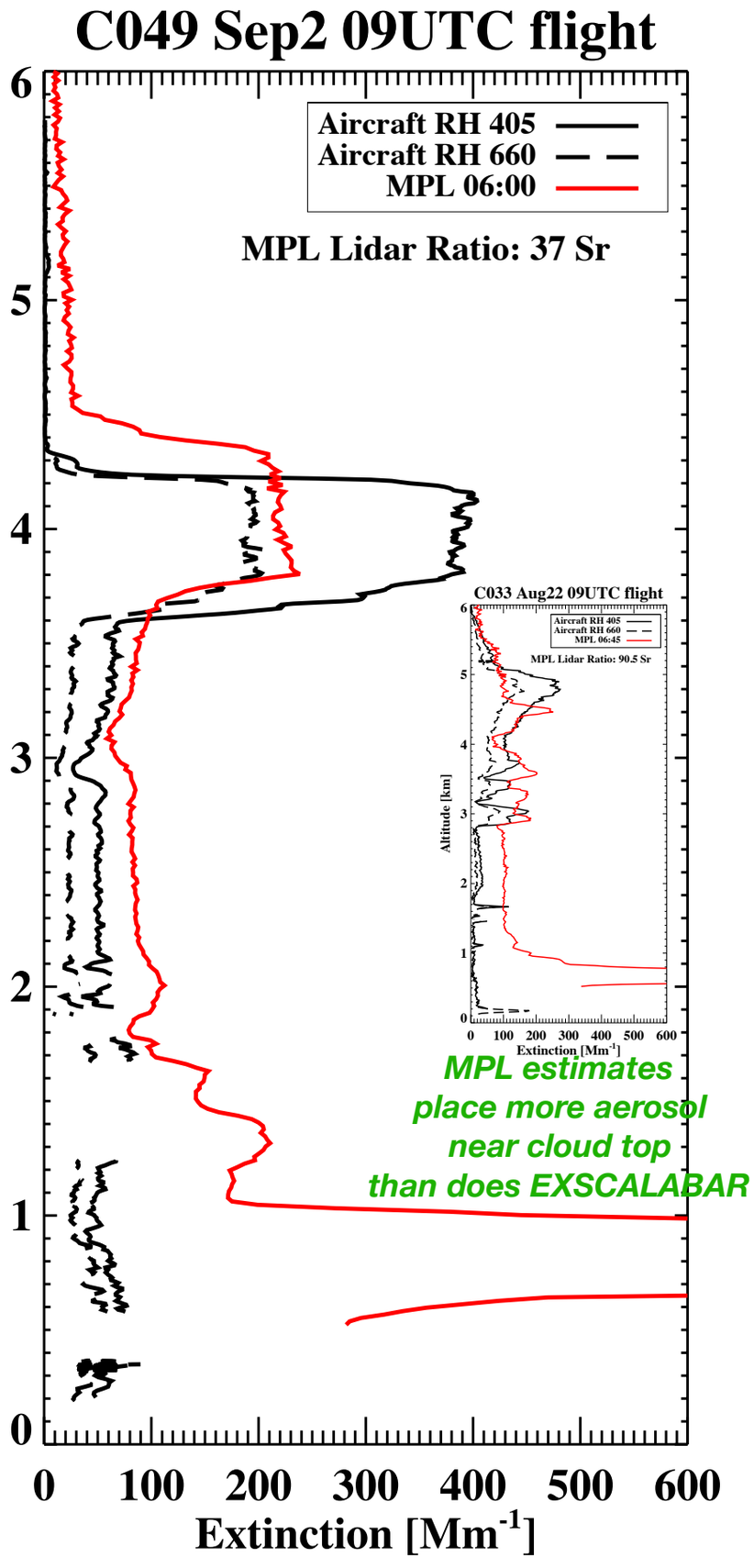
The full set of comparisons

UM retrievals

Plots by Jianhao Zhang

Comparison to EXSCALABAR extinctions





Probable MPL boundary layer extinction overestimate

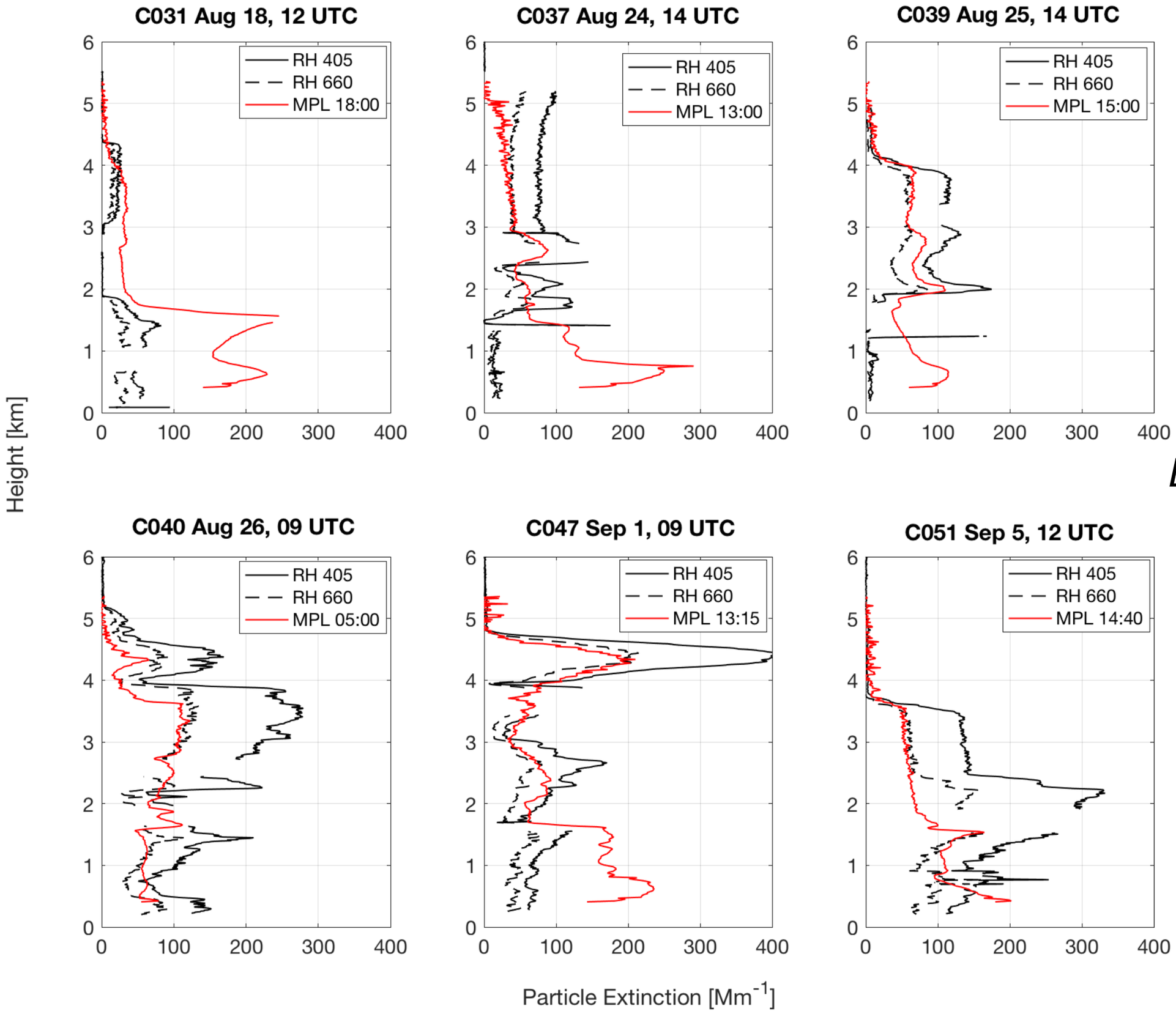
MPL estimates place more aerosol near cloud top than does EXSCALABAR

UM retrievals throughout

Plots by Jianhao Zhang

Our takeaways:

- Identification of aerosol layer top OK
- HSRL2 also perceives much higher extinctions in boundary layer than does EXSCALABAR, similar to the MPL
- MPL at times places more aerosol just above the cloud top (e.g. 18Aug,22Aug,23Aug,2Sep) than does the aircraft, need to not overinterpret MPL
- The column-average MPL lidar ratio typically < HSRL2's vertically-resolved smoke layer value, but, using HSRL2 value to correct found to generate discrepancies of equal magnitude => not worth it



DOE retrievals