EarthCARE Calibration and Validation Using the NASA LaRC Airborne HSRL-2
Nighttime Bermuda Lidar Underflights of EarthCARE - NightBLUE

- **NASA LaRC (HSRL-2)**
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- **ESA and KNMI**
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  - Jonas Von Bismarck – ESA EarthCARE Campaign Validation Lead
  - Diko Hemminga – KNMI
  - David Donovan – KNMI
  - Gerd-Jan van Zadelhoff – KNMI
- **NASA HQ**
  - Annabelle Davis – Stanford graduate/intern
  - Kelsey Bisson – OBB Deputy Program Manager
- **NASA Flight Operations**
  - Pat Bookey, Taylor Thorson, Matt Elder, Chris Swanson, Brian Bernth – Pilots
  - Rob White and Elisa Warden – Aircraft crew

Photos from NightBLUE in Bermuda


Left to right: Matt Elder (RSD), Taylor Thorson (RSD, top), Diko Hemminga (KNMI), Jonas von Bismarck (ESA), John Hair (SD), and Taylor Shingler (SD)


Diko Hemminga (KNMI)

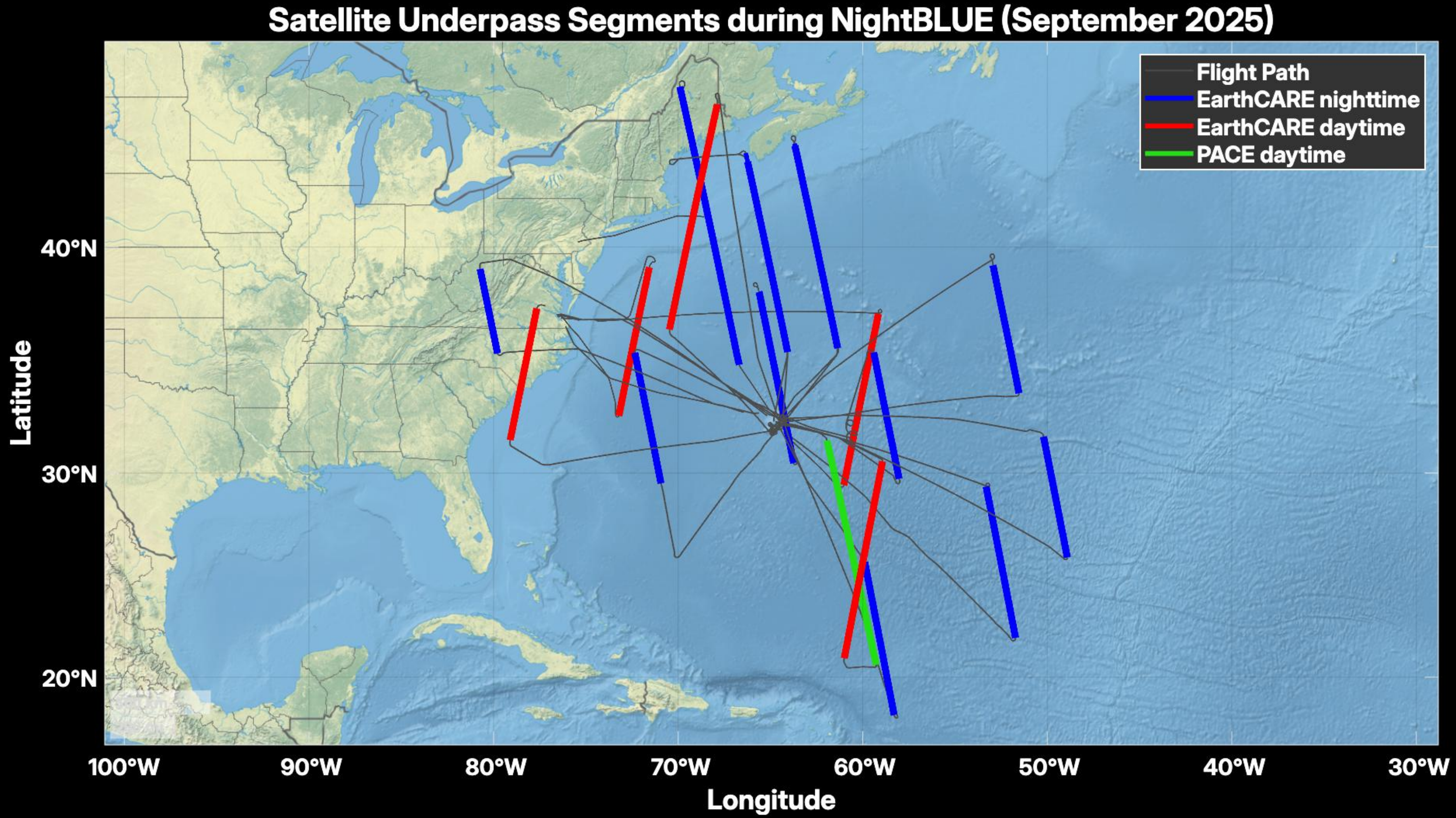

David Donovan (KNMI)


Annabelle Davis (Intern)

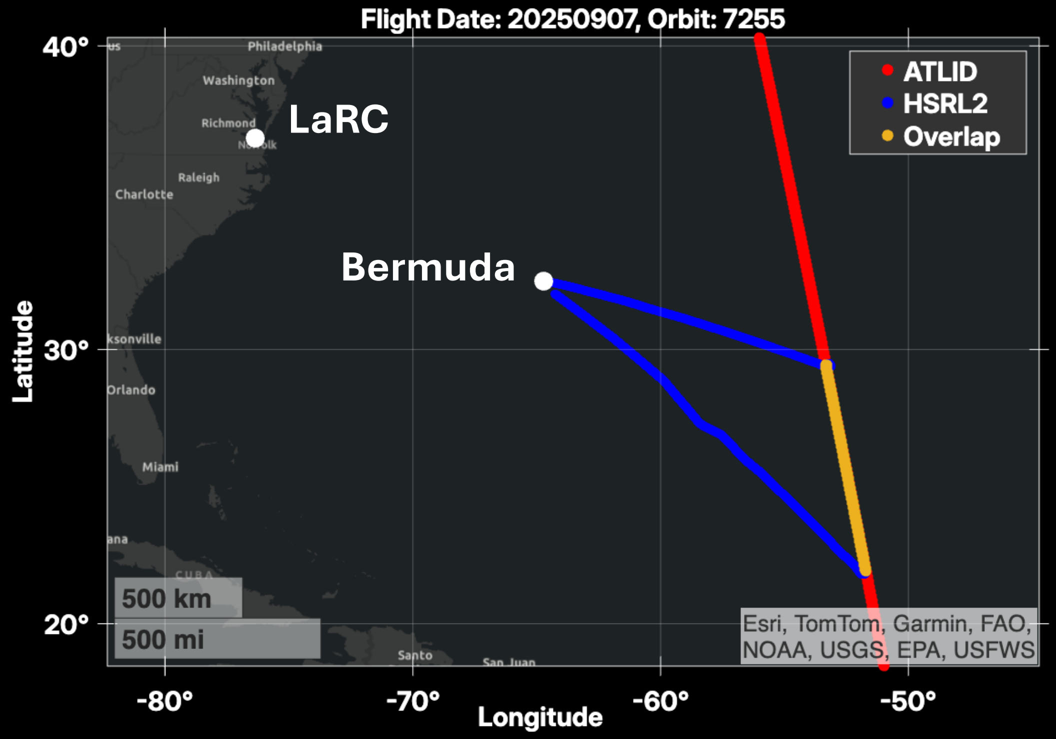

Bermuda Island

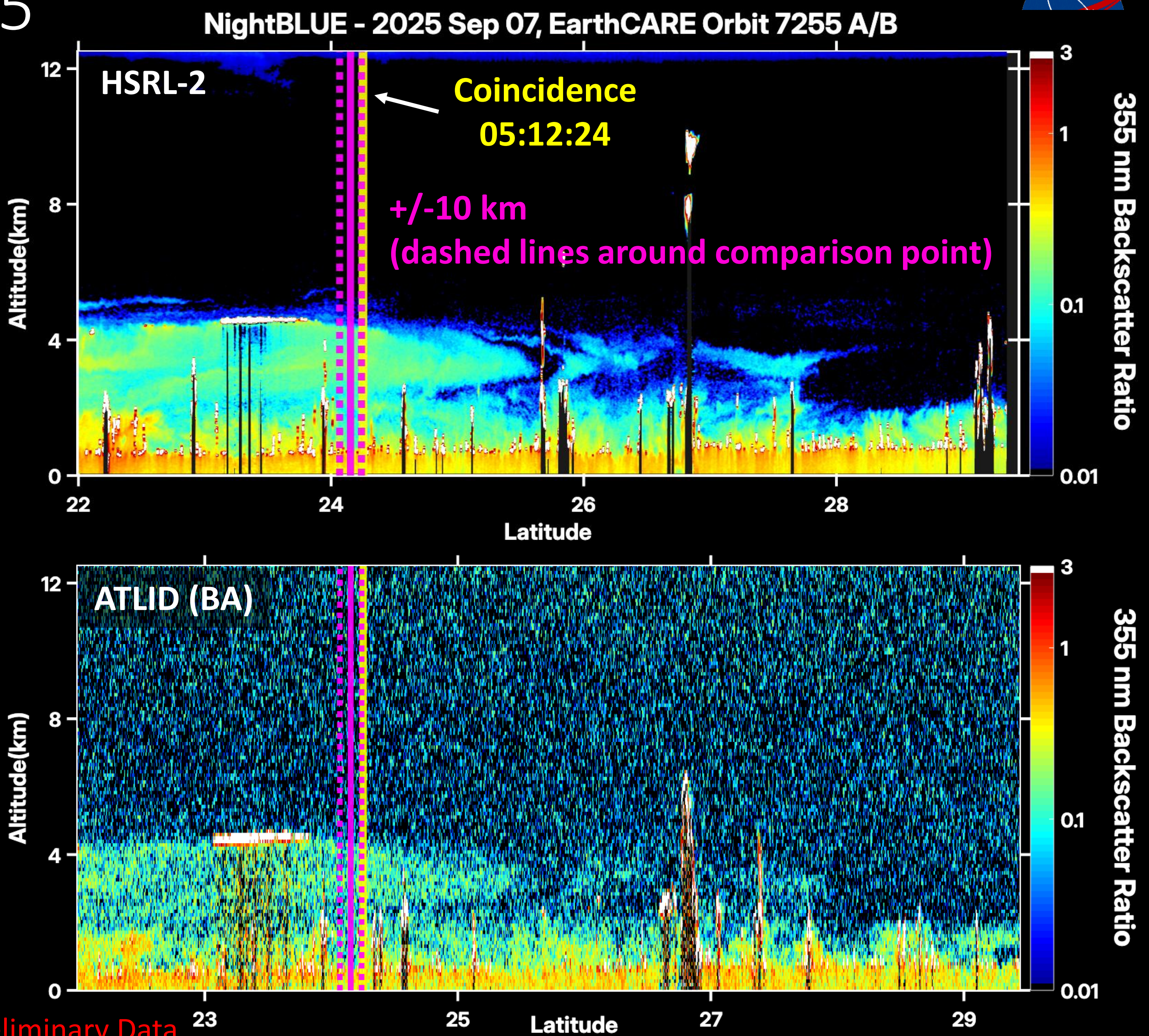

Left to right: David Donovan (KNMI), Chris Swanson (RSD), John Hair (SD), Pat Bookey (RSD, top), Taylor Shingler (SD), and Maddie Hetlage (SD)

Flight Tracks – 11 nighttime, 5 daytime



Flight Example: 07 Sep 2025



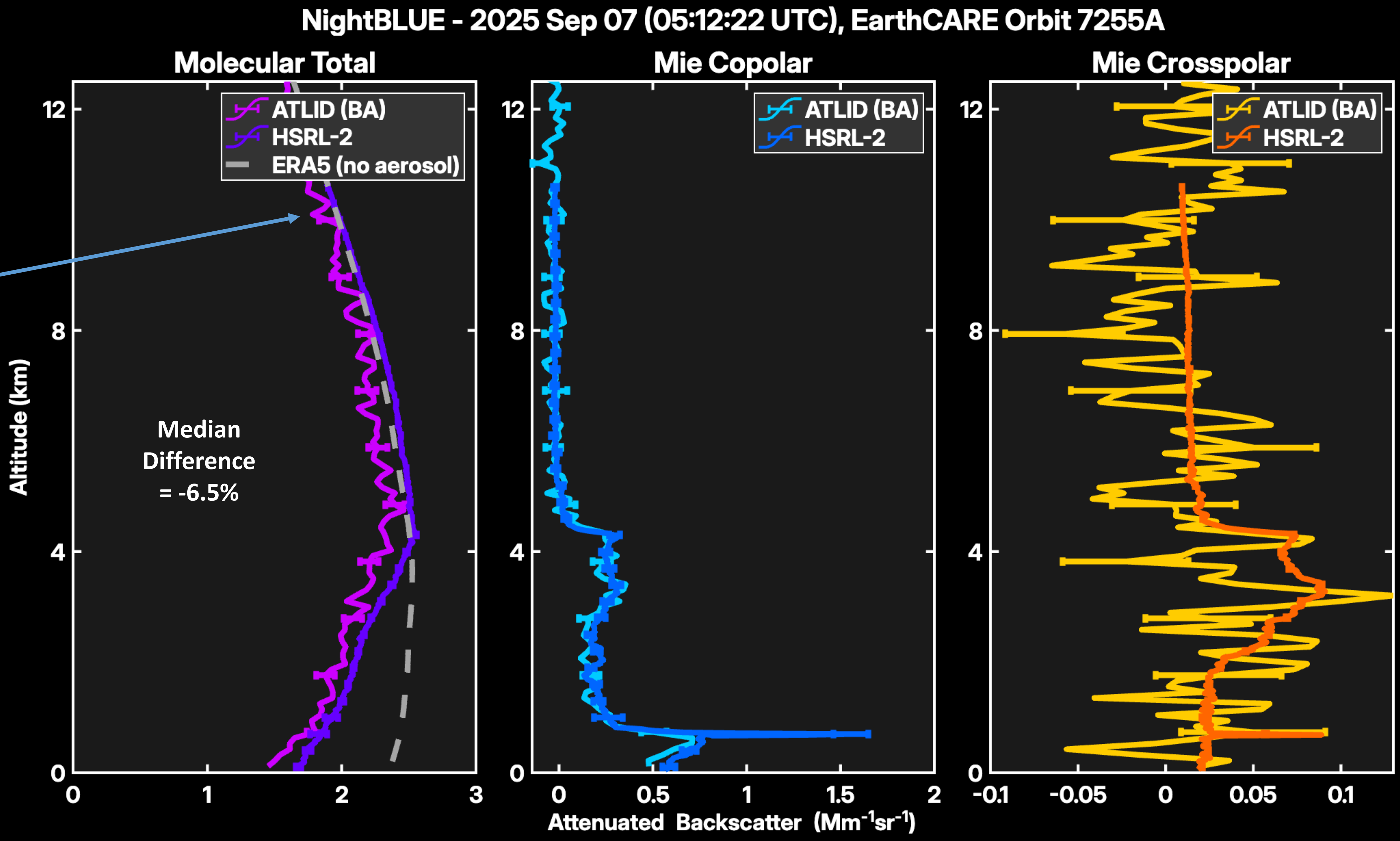


Preliminary Data

Nighttime L1 Signals: Attenuated Molecular, Mie, Cross

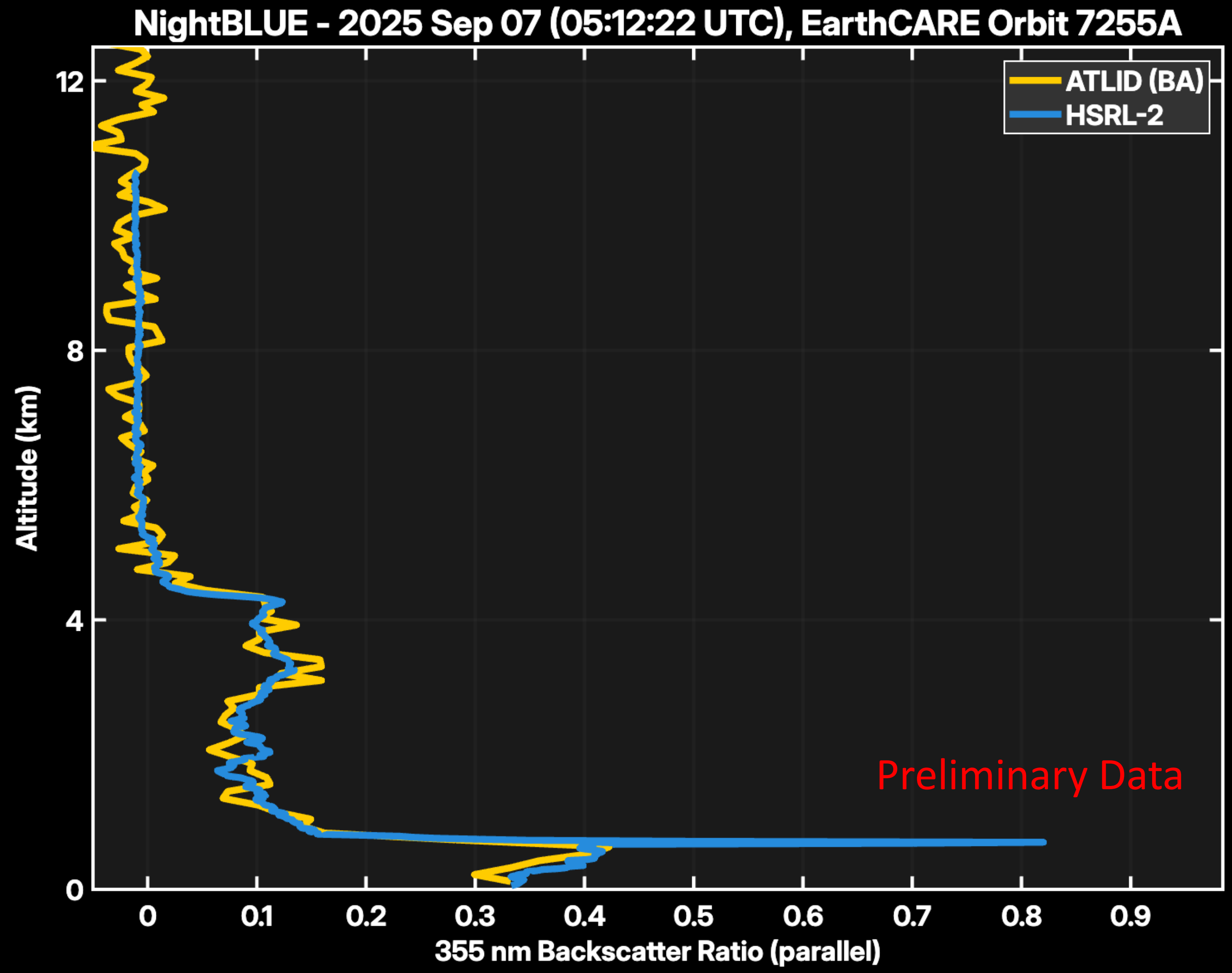
HSRL-2 is normalized 2.5 km below aircraft (~10.5 km altitude) using air density from the ERA5 reanalysis.

Account for molecular extinction and ozone absorption from 40 km to normalization altitude.



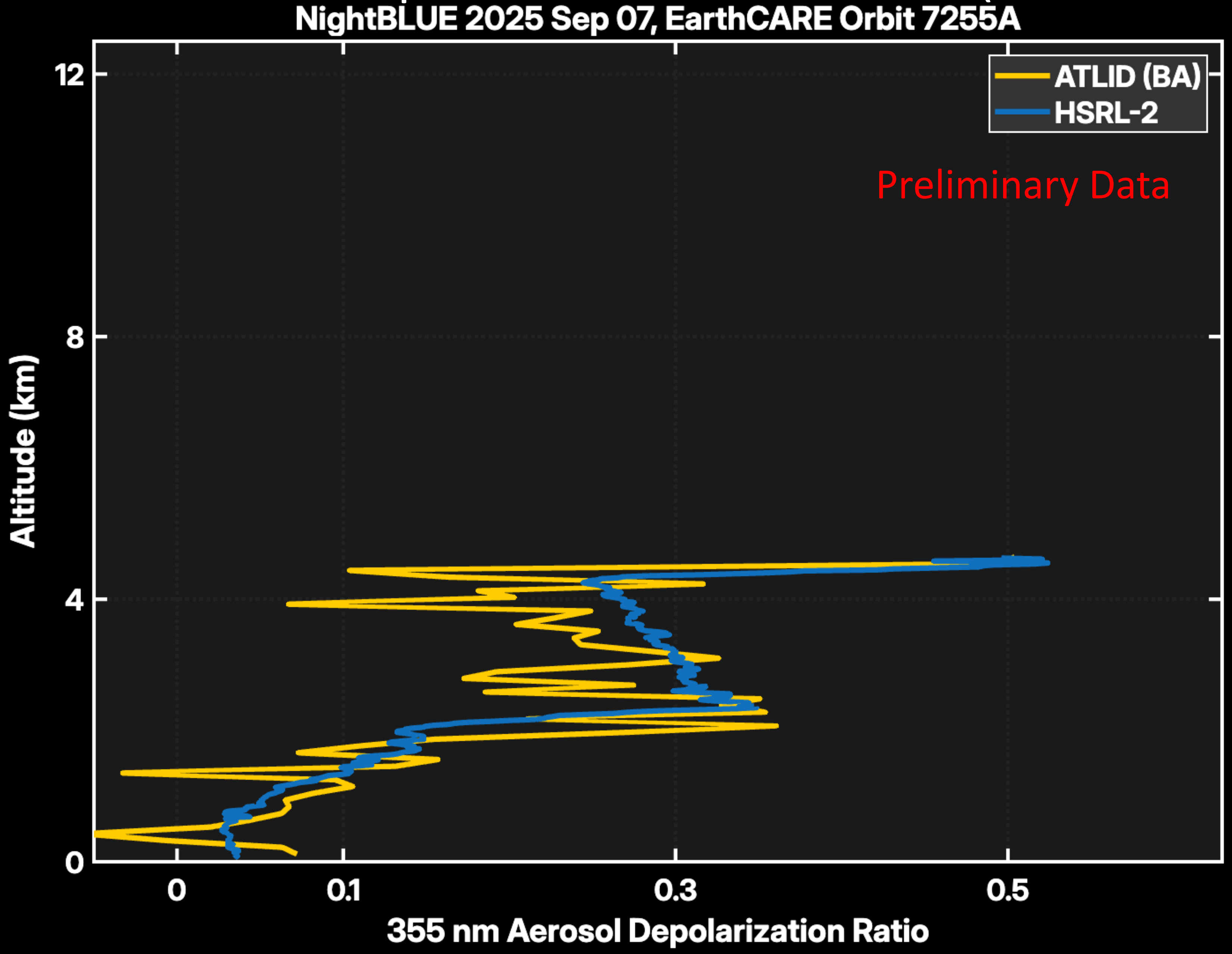
Preliminary Data

Scattering Ratio (parallel aerosol-to-molecular)



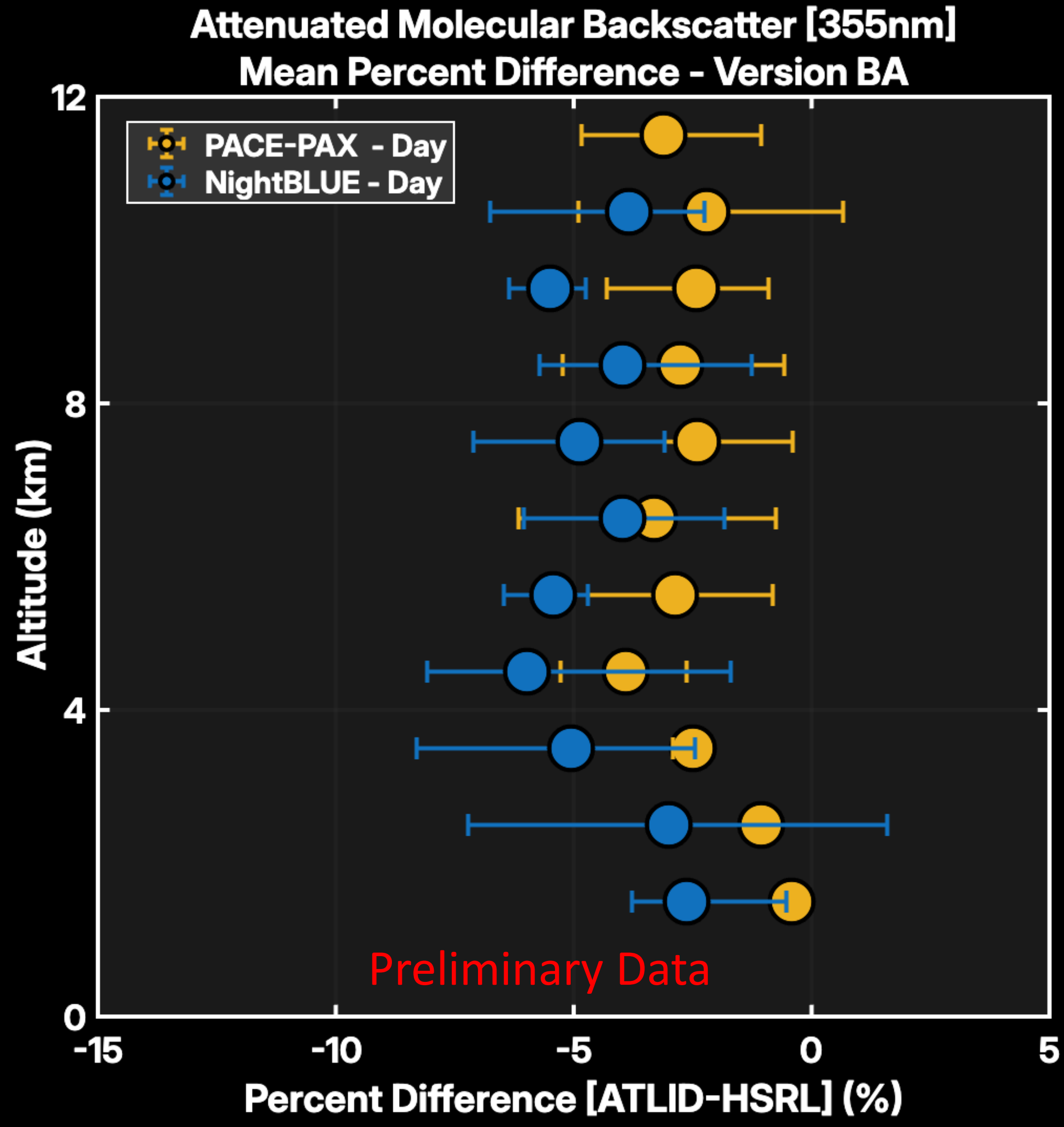
- **Backscatter matches well in dust layer**
- **Spatial sampling of water clouds results in differences**
- **Need to remove clouds for comparisons (next step)**
- **Offsets in L1 signals are not present in the ratio**

Particulate Depolarization Ratio (Cross to Parallel Mie)



- **Increased averaging to 80 km from 20 km**
- **There is an offset between the measurements in the dust layer (2-4 km).**

Daytime Molecular Profiles Differences (version BA) NightBLUE and PACE-PAX compare well



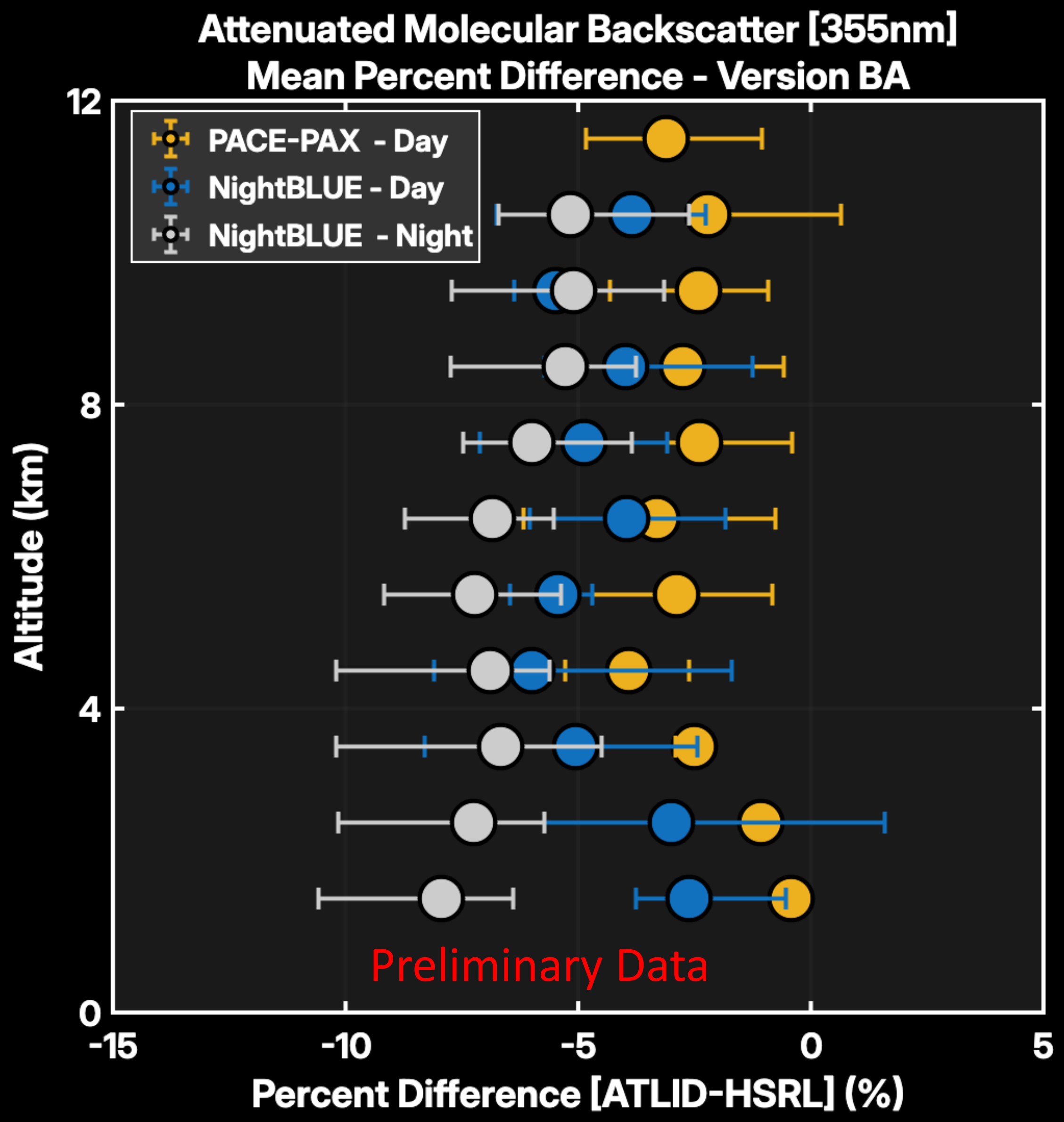
Data Averaging

- 1 km vertical
- 20 km horizontal
- 5 flights PACE-PAX and NightBLUE

Observations

- Comparison is NightBLUE with ~2-3% greater absolute difference than PACE-PAX
- Variation with altitude is similar between two campaigns

NightBLUE Day vs Night Molecular Profiles Differences are larger than between campaigns



Data Averaging

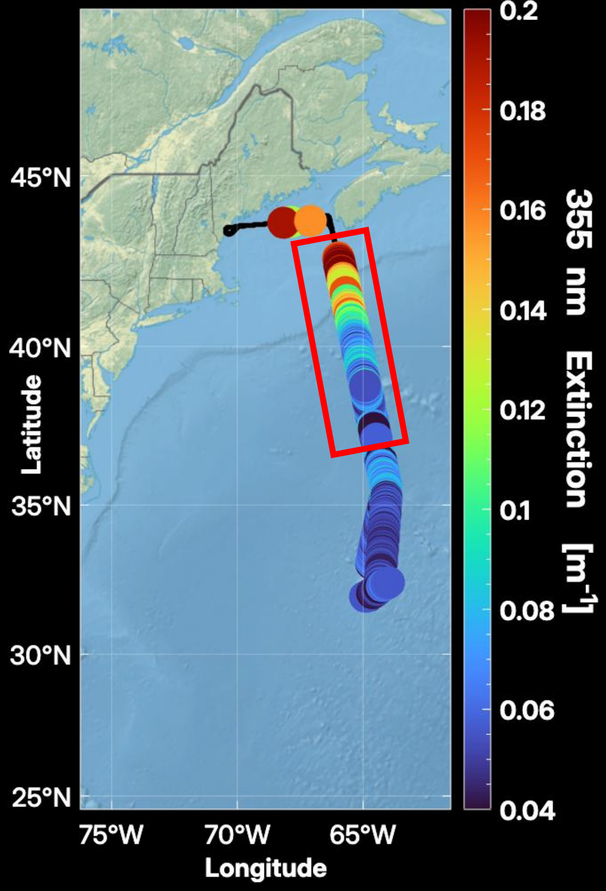
- 1 km vertical
- 20 km horizontal

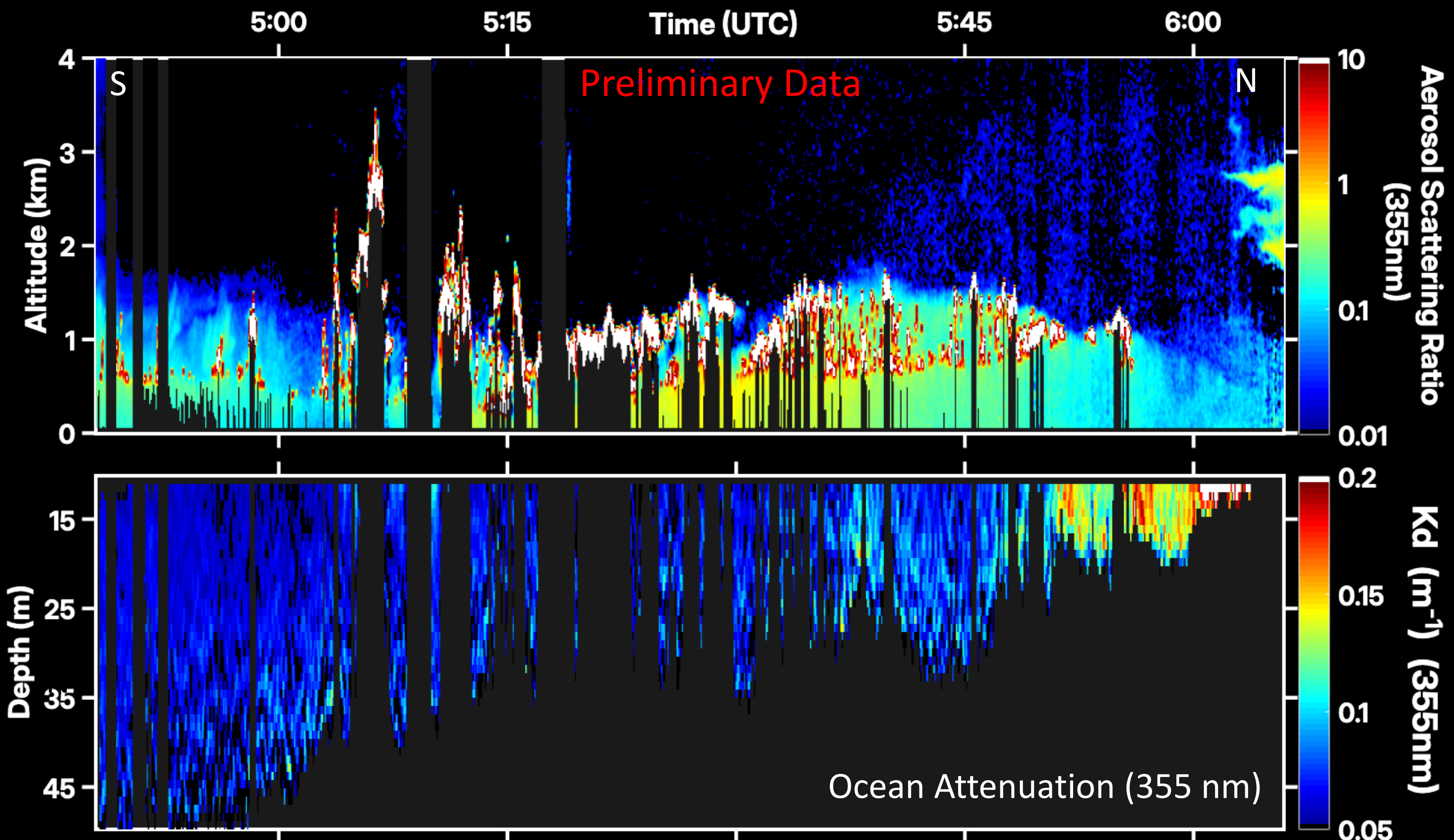
Observations

- NightBLUE has larger absolute nighttime differences (~6-7%) than daytime (3-6%)
- Difference is more pronounced at lower altitudes.

HSRL-2 Ocean Subsurface Measurements

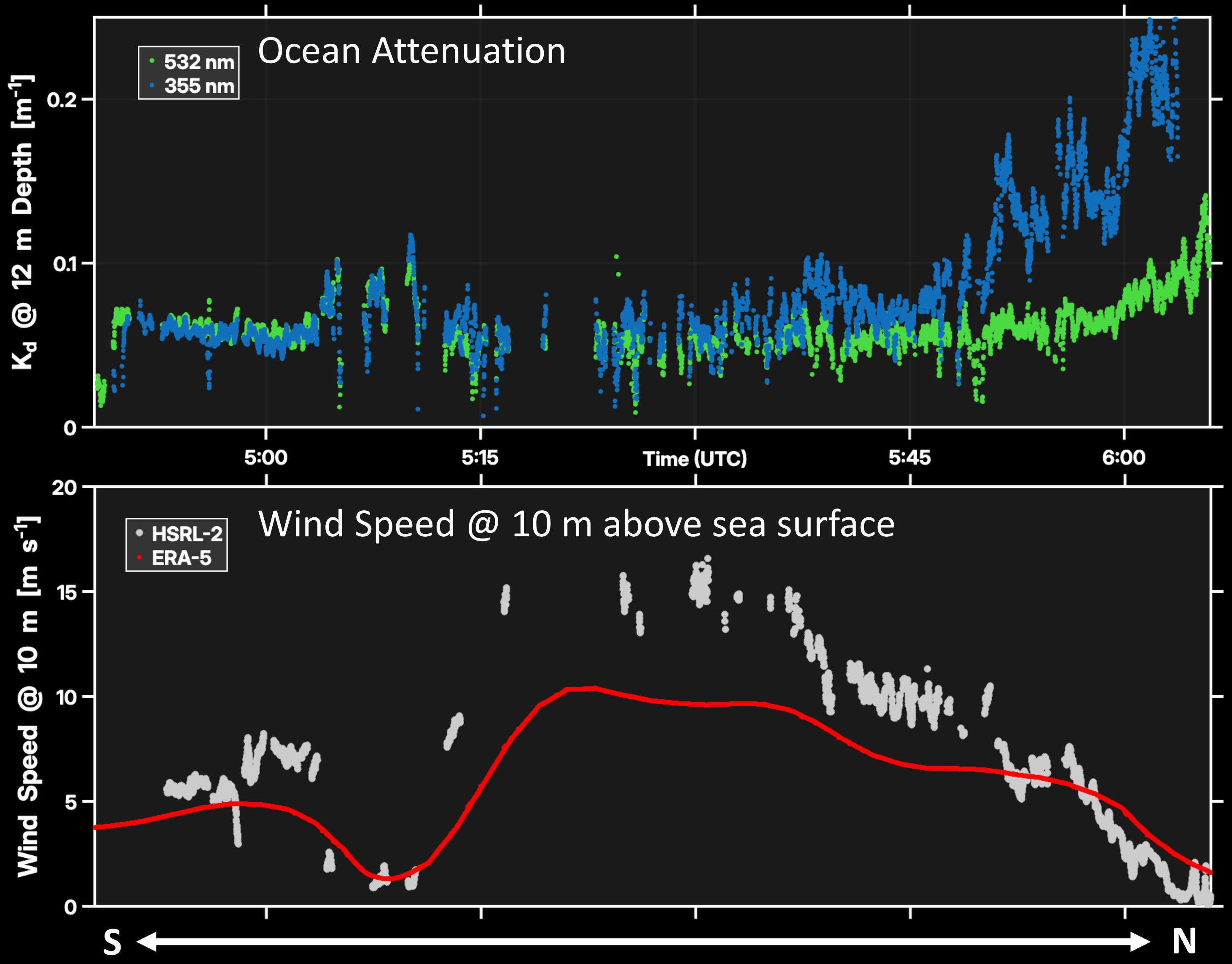
NightBLUE – 2025 Sep 17
EarthCARE Orbit 7411B





High vertical resolution (1 m) channels on HSRL-2 permits vertical profiles of ocean attenuation and backscatter at 532 and 355 nm.

HSRL-2 can be used to assess ATLID ocean retrievals (reference Gerd-Jan van Zadelhoff talk on Monday)



Preliminary Data

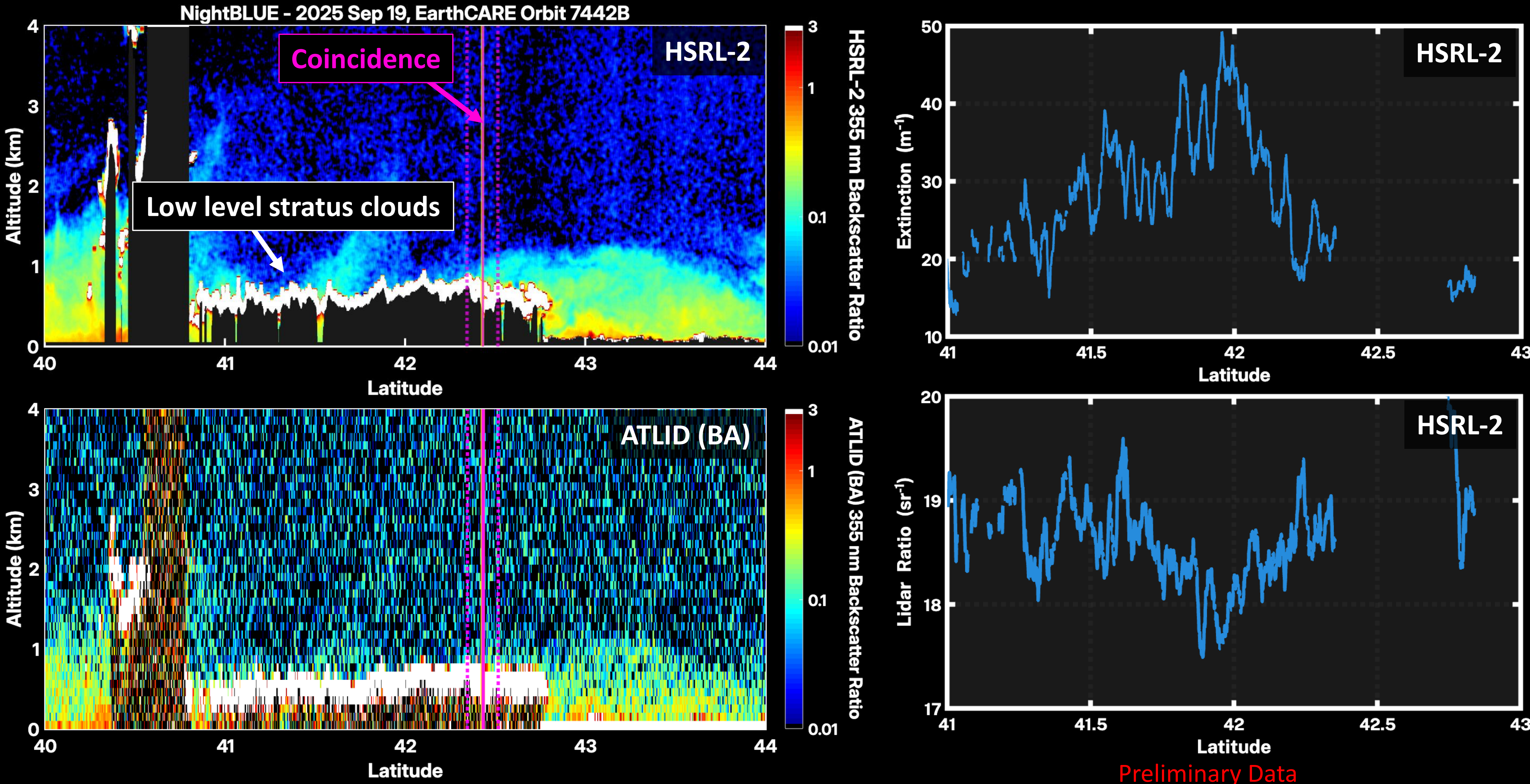
HSRL-2 was designed to be a high vertical resolution ocean profiling HSRL at 355nm and 532nm

HSRL-2 not only directly measures the ATLID data product (attenuation), but also an important input to the retrieval: the sea-surface reflectance.

Depth-integrated HSRL-2 product can also be produced as a more direct proxy for ATLID retrievals

ATLID global ocean products will be an important complement to new PACE UV products

Trends in Water Cloud Extinction and Lidar Ratio



Preliminary Data

Summary

- ATLID's Level 1B molecular and Mie channels still compare well!
  - e.g., the 355 nm attenuated molecular backscatter is within 5-6% of the HSRL-2 measurement in the 'clean' troposphere on average.
- HSRL-2 high vertical resolution data can be used to assess ATLID cloud top extinction data products.
- HSRL-2 ocean profiling capability provides a means to assess and build confidence in the ATLID ocean retrievals in the UV.
- Final archive: https://www-air.larc.nasa.gov/missions/earthcare-airbornelidar-underflights/index.html

Extra Info

EarthCARE Calibration and Validation Using the NASA LaRC Airborne HSRL-2

Nighttime Bermuda Lidar Underflights of EarthCARE - NightBLUE

Objective

Compare and assess the performance of EarthCARE's Atmospheric LIDar (ATLID) profiles of aerosols and clouds during nighttime when the signal-to-noise is largest.

1. Compare HSRL-2 355nm data products directly with L1B ATLID data products to evaluate gain calibration, filter coefficients, polarization calibration, and background subtraction
2. Compare HSRL-2 355nm data products to L2 aerosol backscatter, extinction, and depolarization ratio
3. Perform daytime under flights of PACE or in swath of PACE instruments and coordinate with underwater glider deployed near Bermuda by University of Delaware (Matt Oliver)