



Combined Lidar Measurements of Methane, Aerosols, and Planetary Boundary Layer Heights over Urban and Rural Environments with the NASA High Altitude Lidar Observatory

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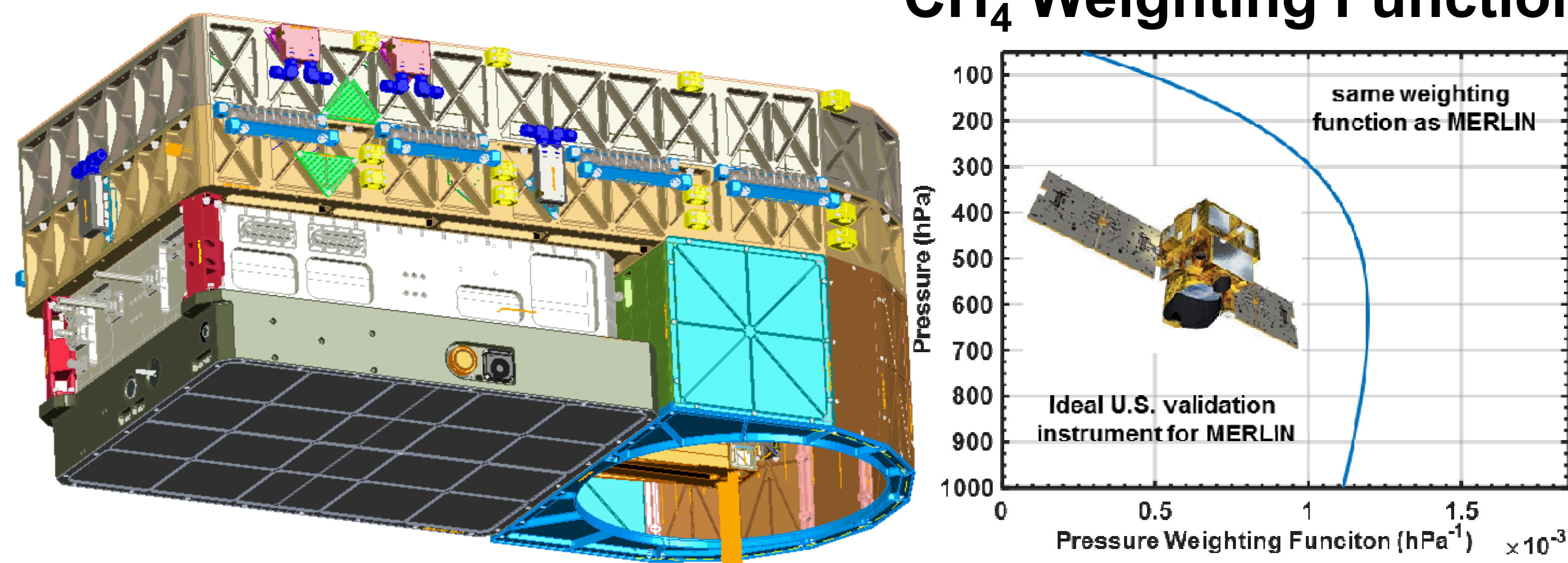
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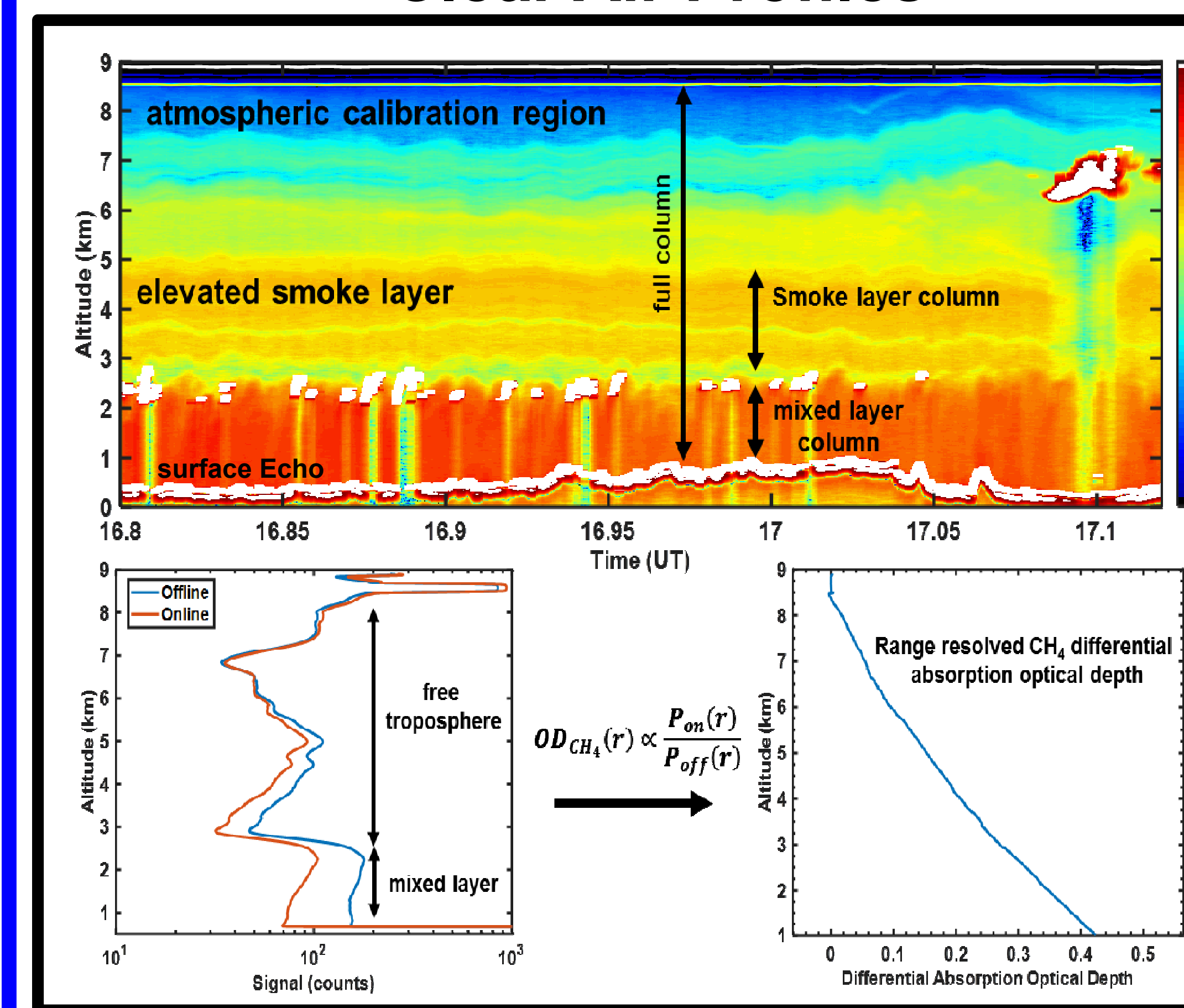
Introduction

- NASA LaRC is developing a combined DIAL and HSRL (HALO) to enable new observations of atmospheric H₂O, CH₄, aerosols, clouds, and ocean profiles.
- HALO employs a “plug & play” transmitter approach that extends measurement capabilities beyond those of a single laser transmitter:
 - The first transmitter enables simultaneous differential absorption lidar (DIAL) methane (1645 nm) and high spectral resolution lidar (HSRL) measurements of aerosols and clouds (532 and 1064 nm)
 - The second transmitter enable simultaneous measurements of DIAL water vapor profiles (935 nm) and HSRL measurements of aerosol and clouds
- In addition to H₂O and CH₄ DIAL, HALO's multi-wavelength receiver also enables simultaneous measurements of aerosols, clouds, and ocean profiles
- We have demonstrated for the first time an airborne DIAL/HSRL capable of simultaneously measuring CH₄ columns and aerosol/cloud profiles
- The initial deployment of HALO occurred in June-Sept. 2018 in the Long Island Sound Tropospheric Ozone Study (LISTOS) air quality mission

CH₄ Weighting Function

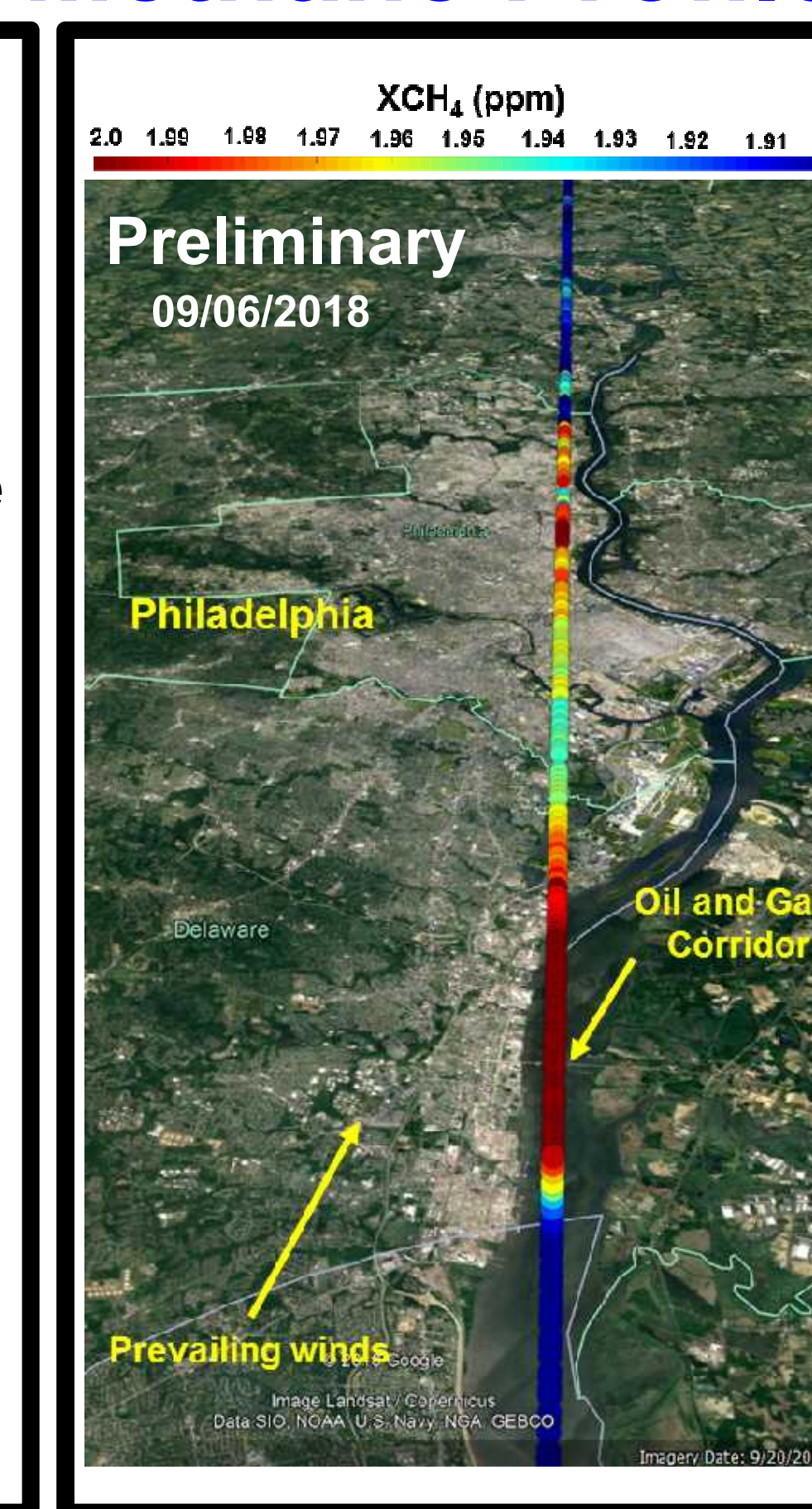


Clear Air Profiles

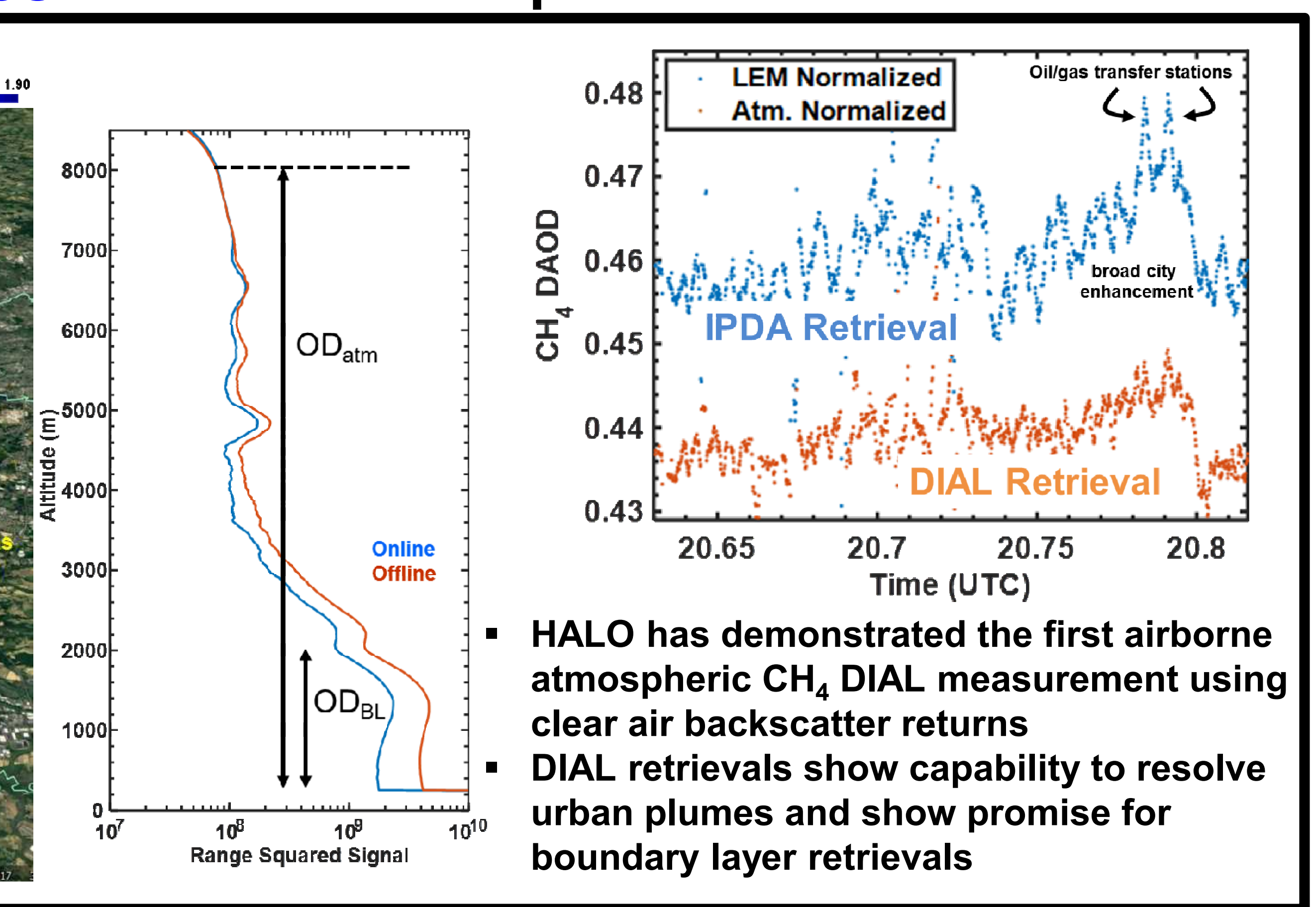


Self Calibrating Methane Profiles

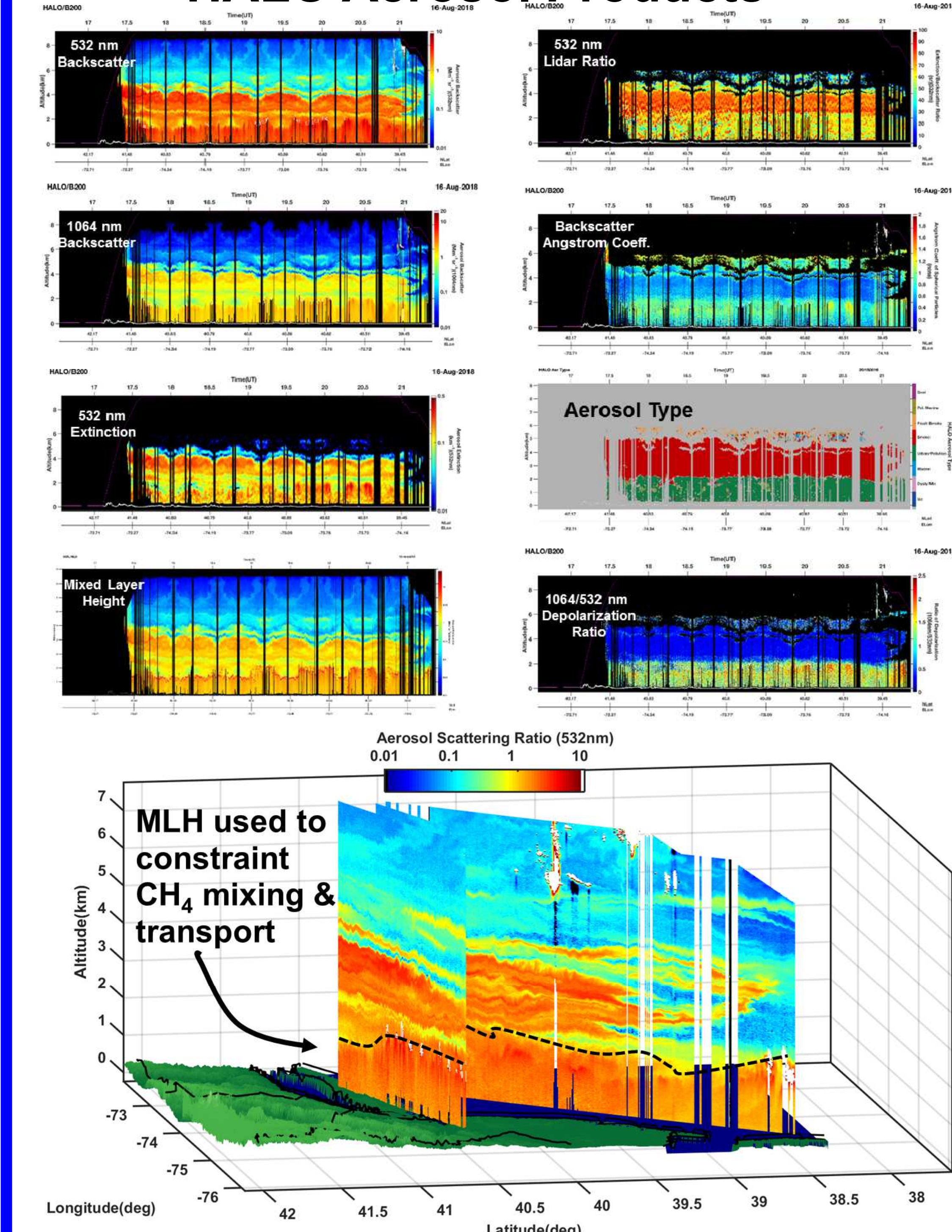
- HALO architecture enables direct retrievals of XCH₄ using the self calibrating DIAL technique
- HALO has demonstrated the first airborne DIAL measurements of atmospheric methane from the NASA B200 King Air
- Measurements of backscatter profiles enable apportionment of boundary layer and intermediated columns from the total column in clear and cloudy scenes



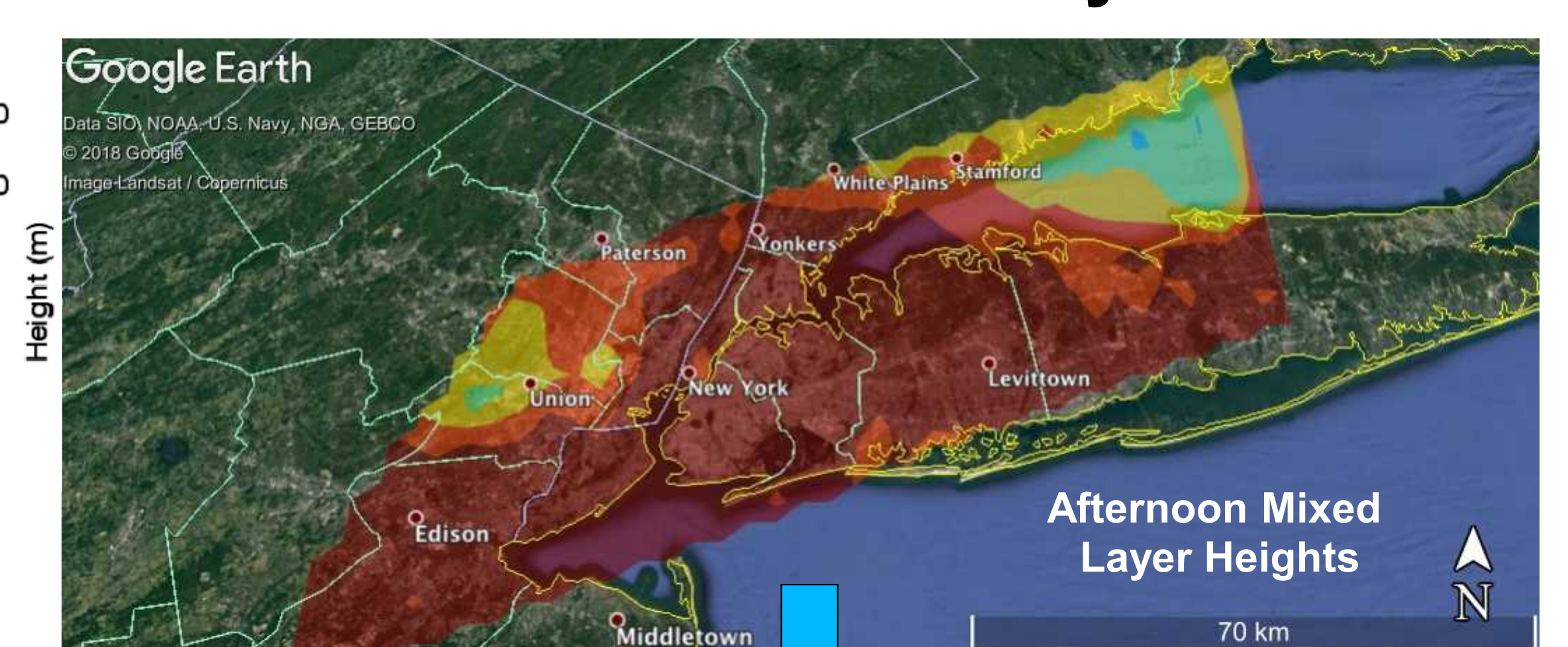
Philadelphia Urban Plume



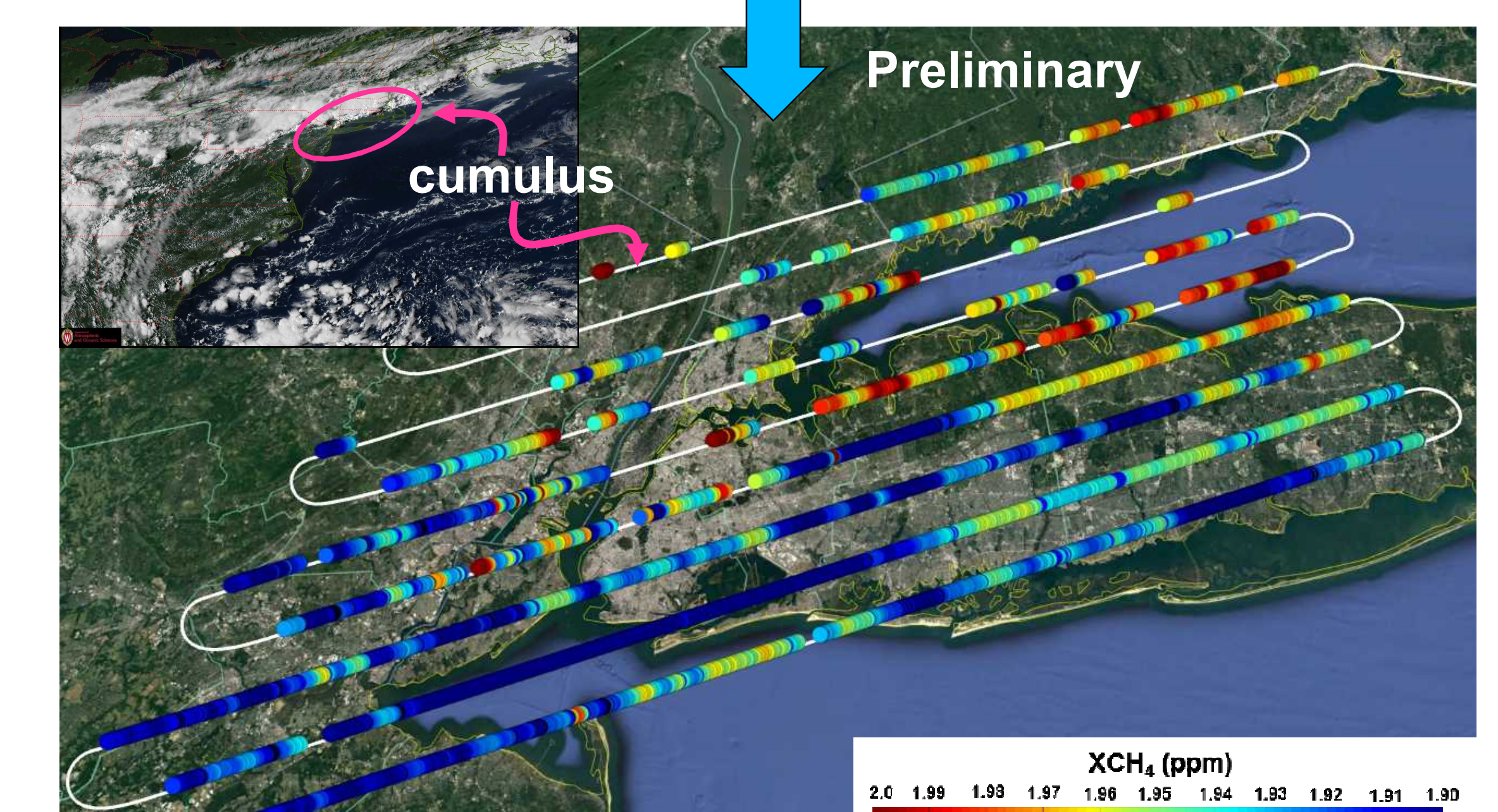
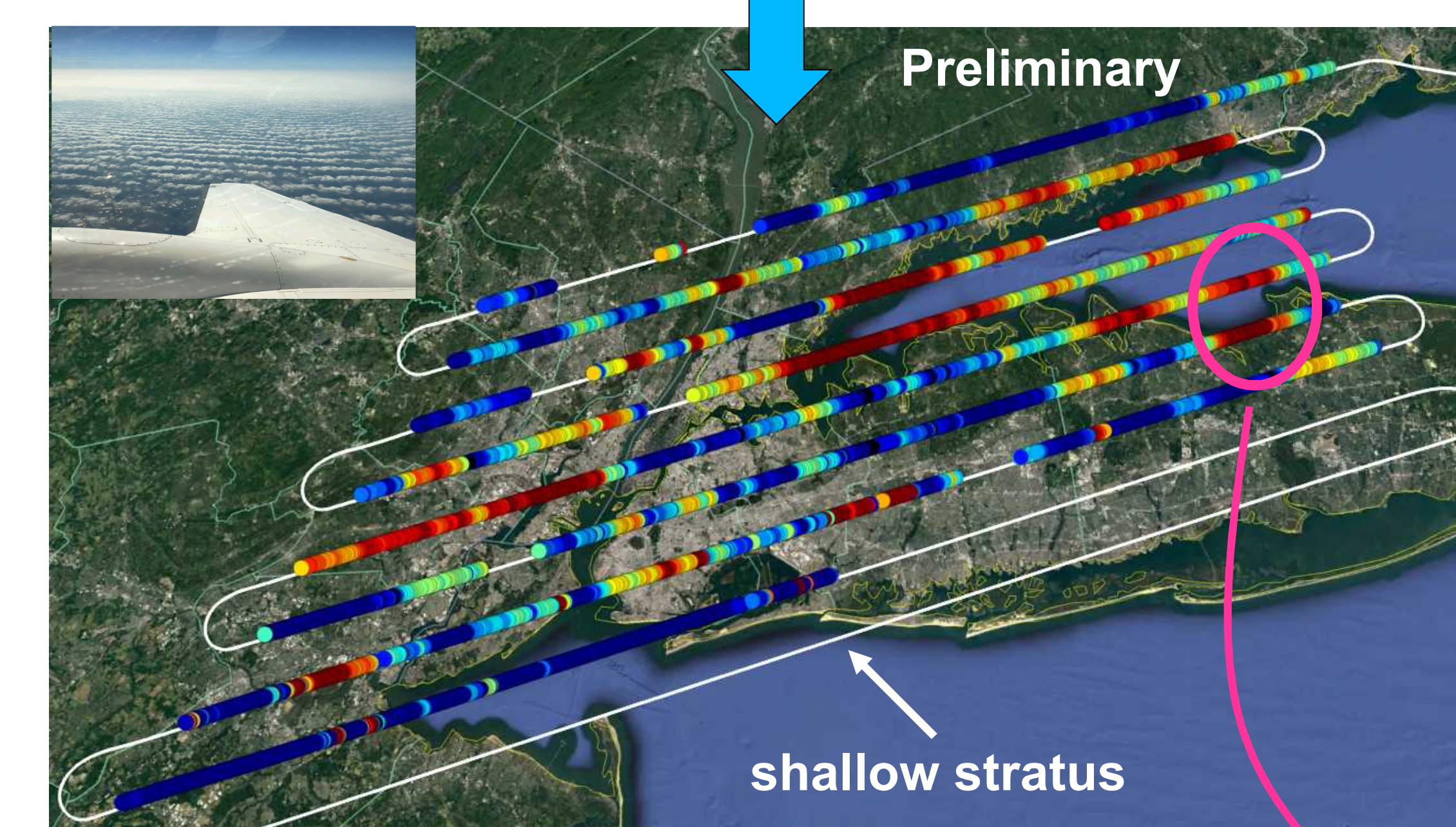
HALO Aerosol Products



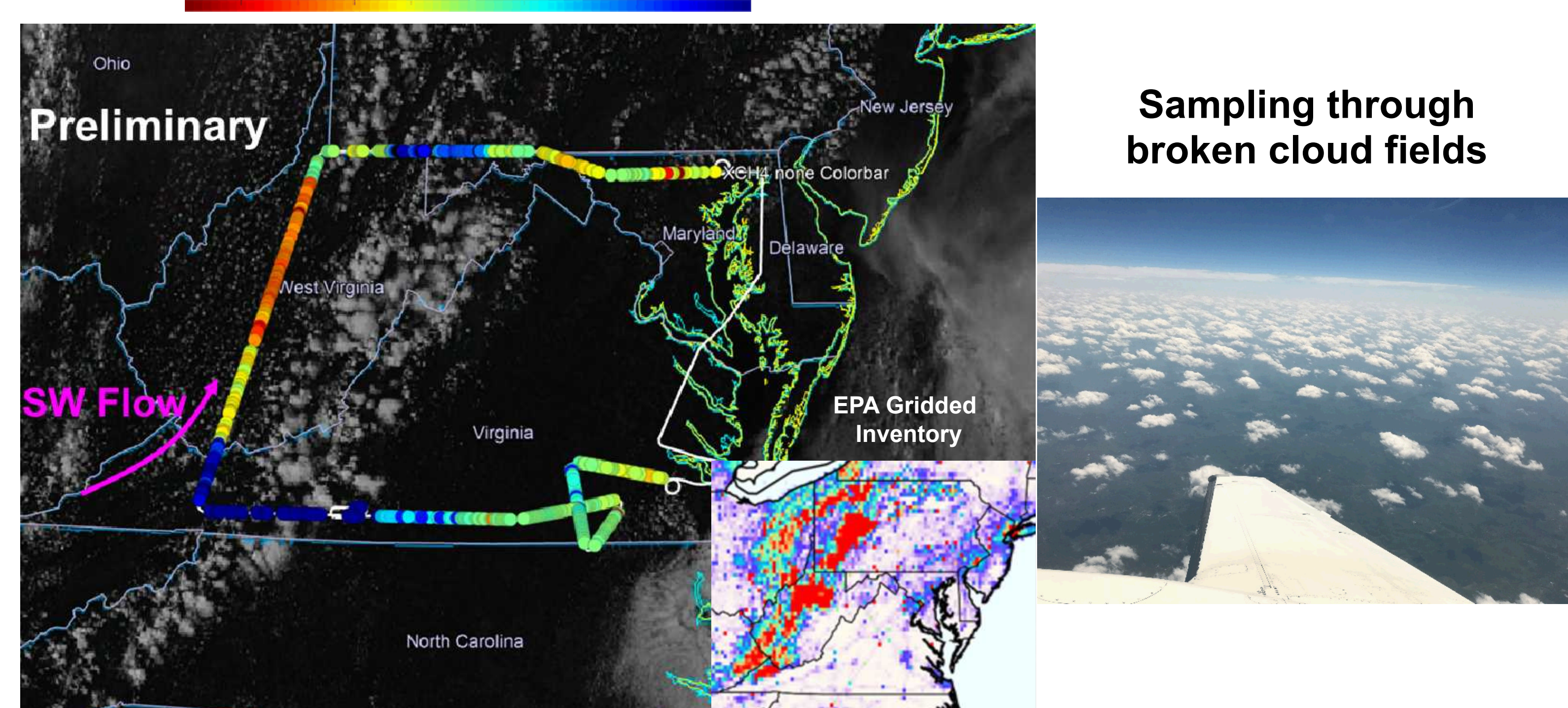
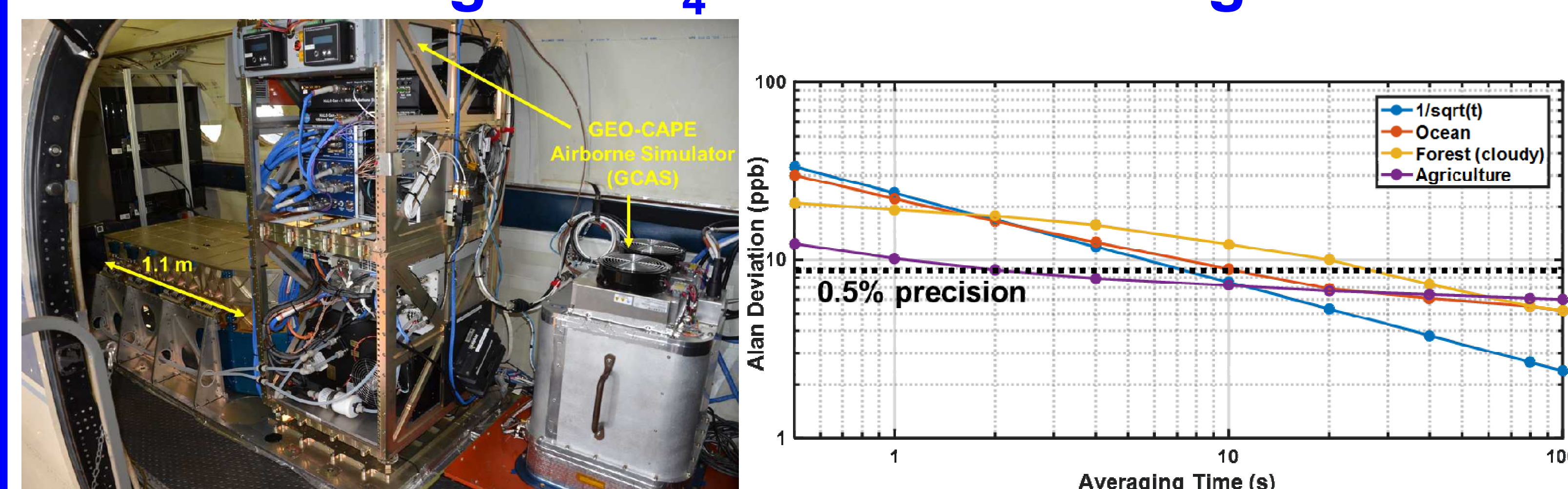
Long Island Sound Aerosol and Methane Distributions



Higher CH₄ concentrations/variability observed during stable conditions



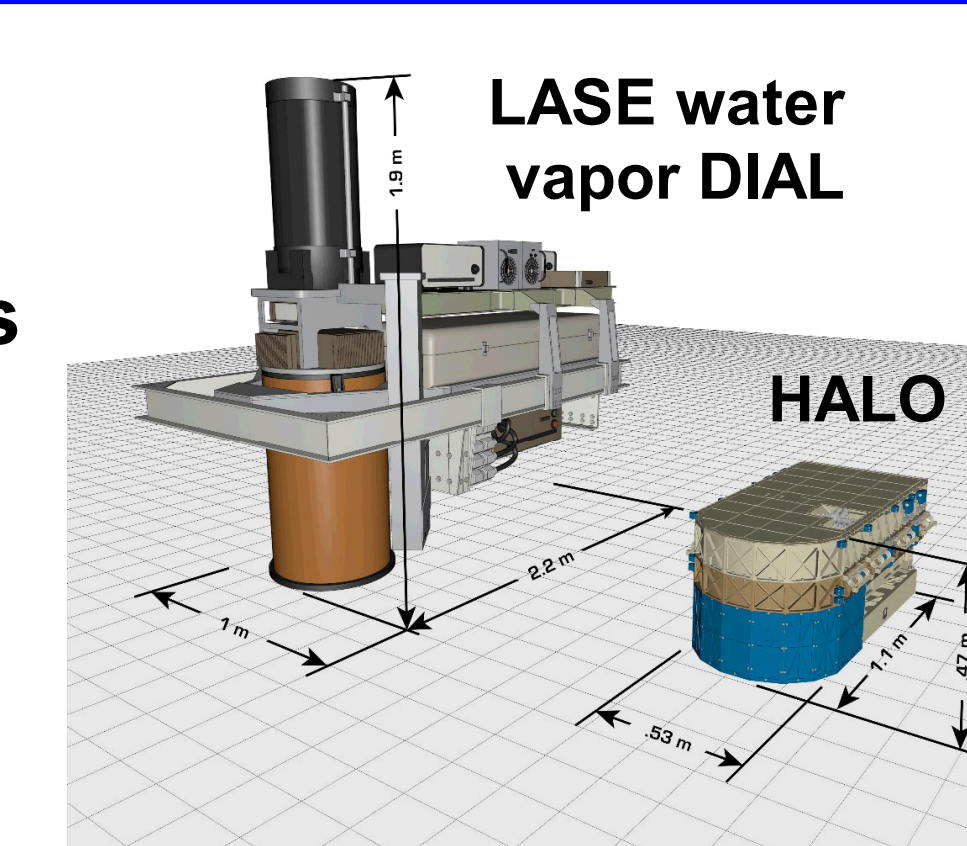
First Light- CH₄/HSRL Check Flights



- The HALO CH₄/HSRL configuration was deployed on the NASA UC-12 aircraft for initial test/demonstration flights in May 2018
- HALO sampled various geographic and atmospheric conditions over two test flights including flights targeting oil/gas activity over the WV Marcellus formation
- Validation flights were coordinated with the ACT-America EVS mission
- HALO preliminary CH₄ results demonstrate <0.5% precision with <200 m resolution
- Test flight shows significant CH₄ enhancement in WV that agree well with 2012 EPA oil and gas gridded inventory

Summary

- HALO successfully demonstrated simultaneous CH₄/HSRL measurements during the HALO and LISTOS flight campaigns with precisions < 0.5% with ~200 meter spatial resolution
- HALO demonstrated the first airborne DIAL measurements of atmospheric methane in clear air conditions
- Significant methane enhancements were measured over the Marcellus formation and Long Island sound during the HALO and LISTOS field missions, respectively



Future Activities

- Use DIAL retrievals to calculate absolute calibration for IPDA
- Continue development for advanced retrieval of boundary layer methane mixing ratios
- Assess improvement of boundary layer XCH₄ retrievals with advanced HgCdTe detector
- Integrate water vapor laser into HALO system and carry out test flights in spring 2019

Acknowledgments

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