High Altitude Lidar Observatory (HALO) Combined CH_4 DIAL and High Spectral Resolution Lidar

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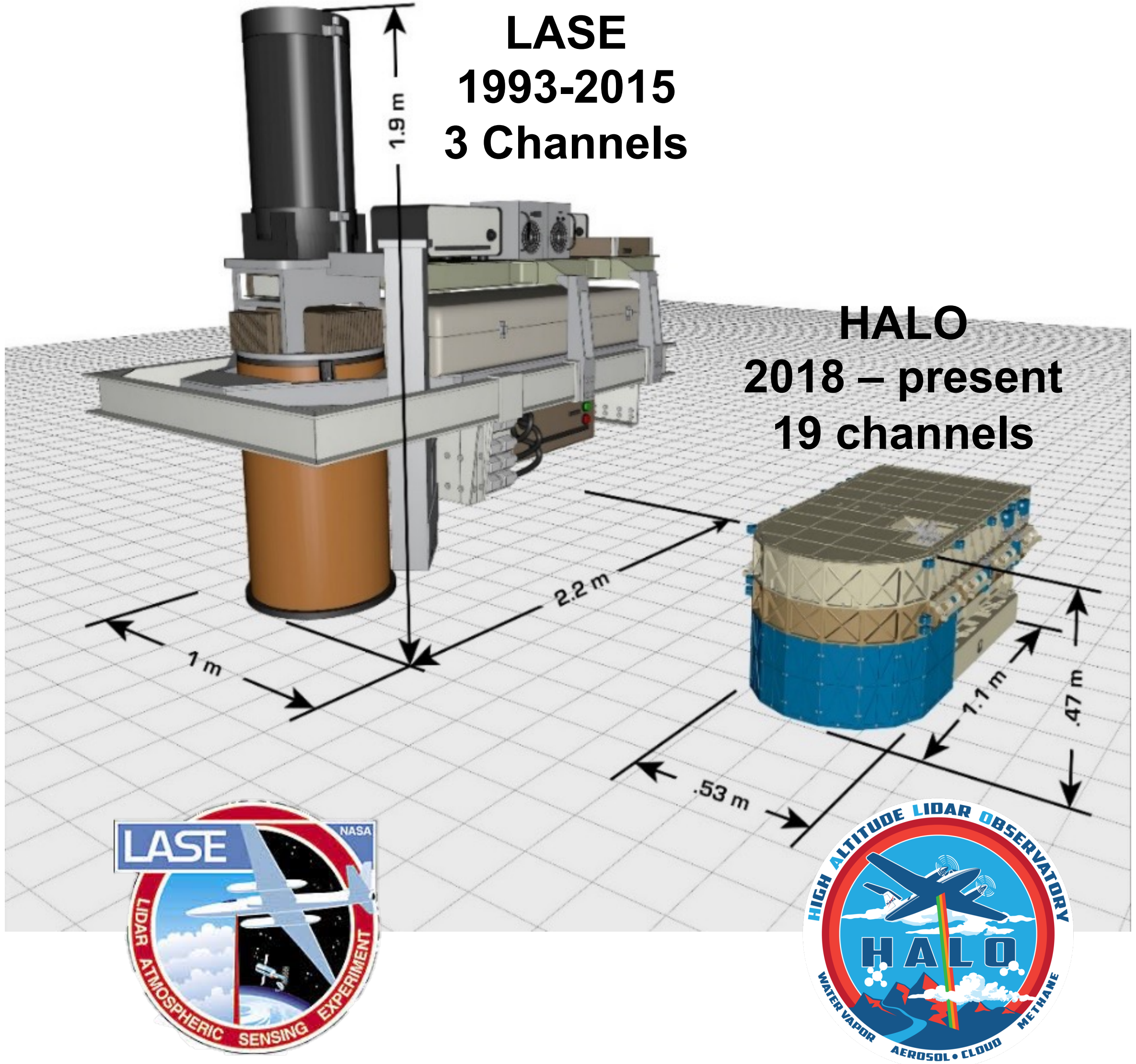
High Altitude Lidar Observatory (HALO)

- A more capable, robust, and operationally flexible replacement for the LASE water vapor DIAL
  - H_2O DIAL, CH_4 DIAL/IPDA, and HSRL
- Cross-cutting airborne lidar in support of weather and dynamics, atmospheric composition, radiation, and carbon cycle
  - Water vapor profiles
  - Aerosol/cloud/ocean profiles
  - Methane columns/profiles
  - Satellite calibration/validation
- Technology testbed for future missions



HALO Observables and Platform Compatibility

Three Measurement Techniques Enable Cross-Cutting Science

Differential Absorption Lidar
Water vapor DIAL

Integrated Path DIAL
Methane IPDA

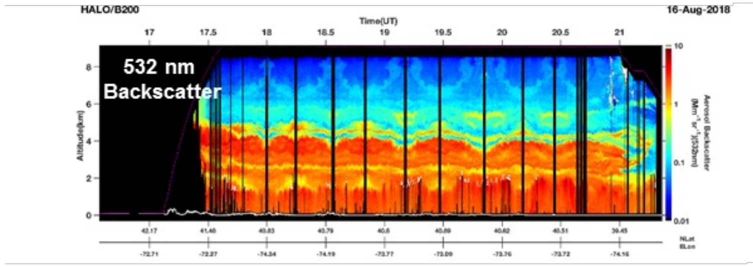
High Spectral Resolution Lidar
Aerosol/cloud HSRL

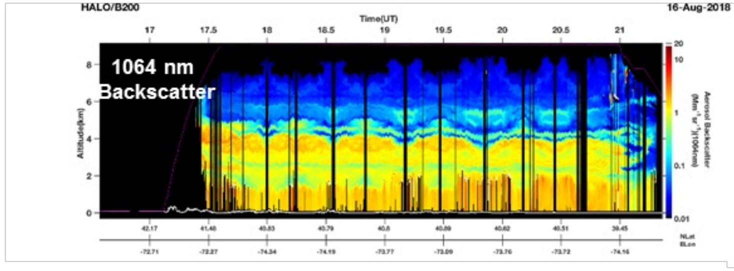
STAQS Observations

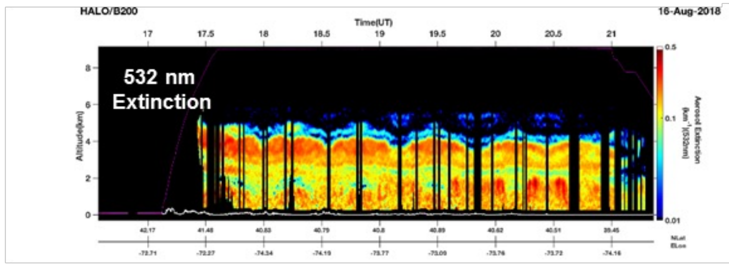
Parameter	Wavelength (nm)	Approximate Precision	Horizontal Resolution	Vertical Resolution
Water Vapor Mixing Ratio	935/820	5% or .001 g/kg	1-12 km variable	100-600 m variable
Methane Column	1645	<8 ppb	1 km	column
PBL height	532	< 50-100 m	200 m	N/A
Aerosol Backscatter	532/1064	$0.2\ Mm^{-1}sr^{-1}$	1 km	15 m
Aerosol Extinction	532	$0.01\ km\ sr^{-1}$	12 km	300 m
Depolarization	532/1064	0.01	1 km	15 m
Aerosol Type	N/A	Qualitative	12km	300 m

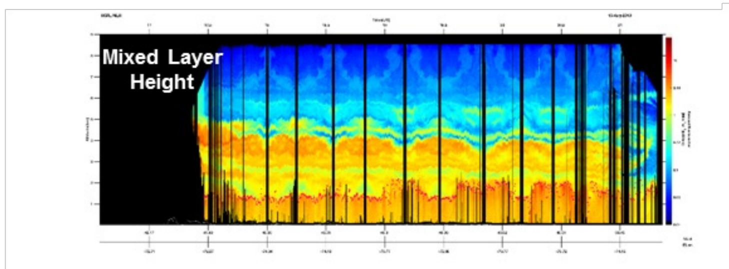
HSRL Products

Aerosol Extensive Products

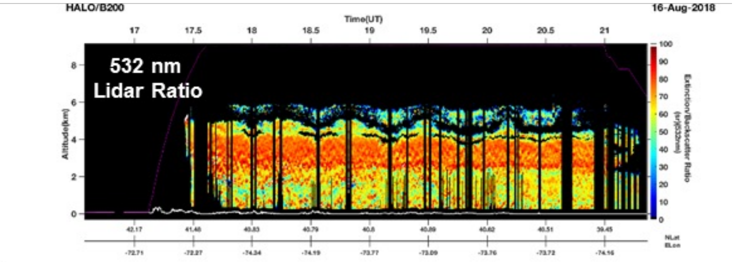


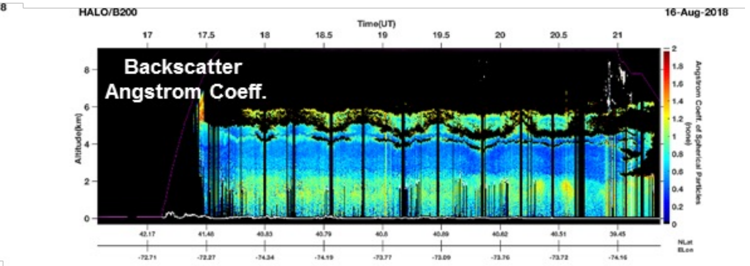


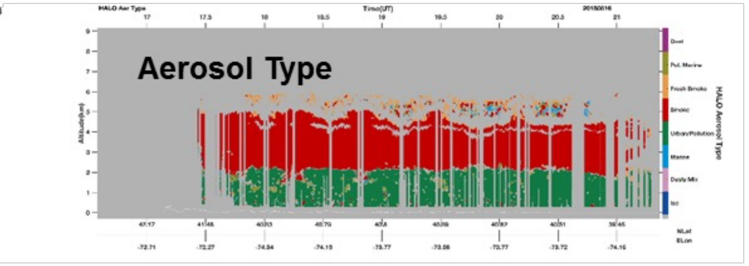


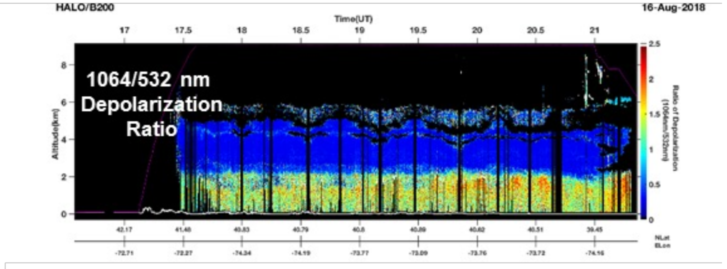


Aerosol Intensive Products



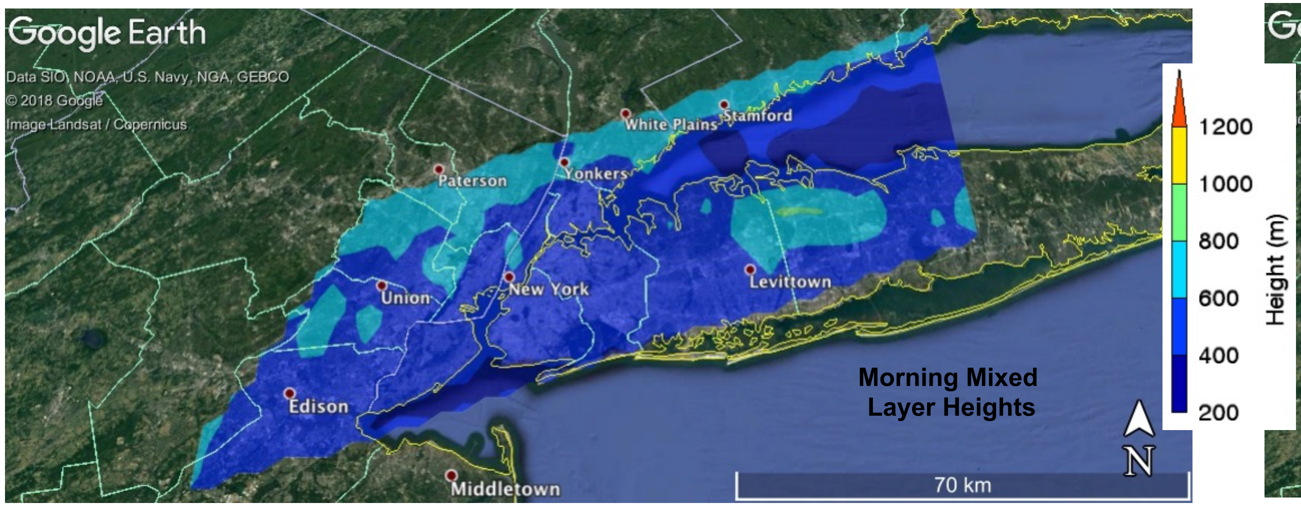




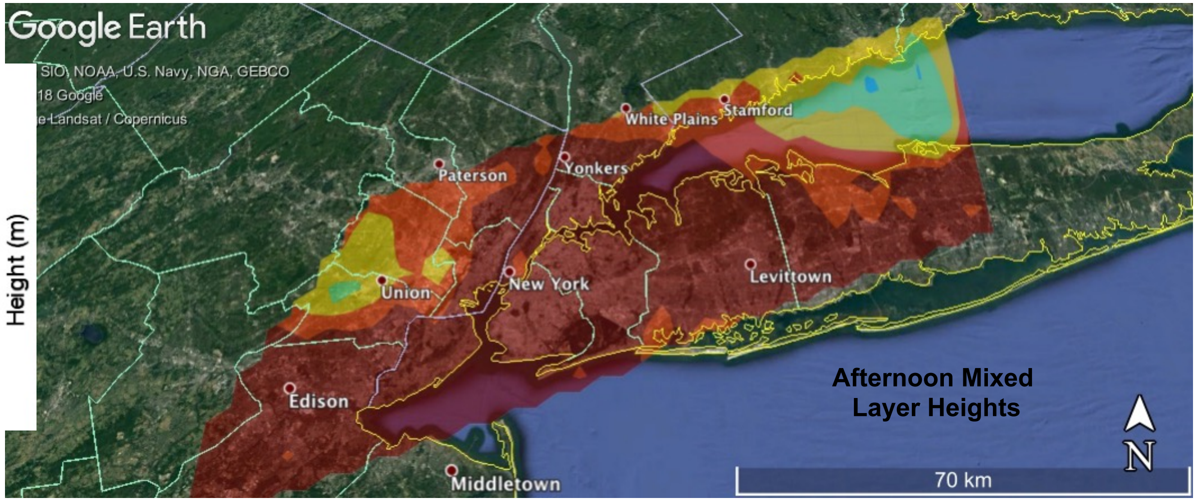


Evolution of PBL Height – Constrain Methane Fluxes

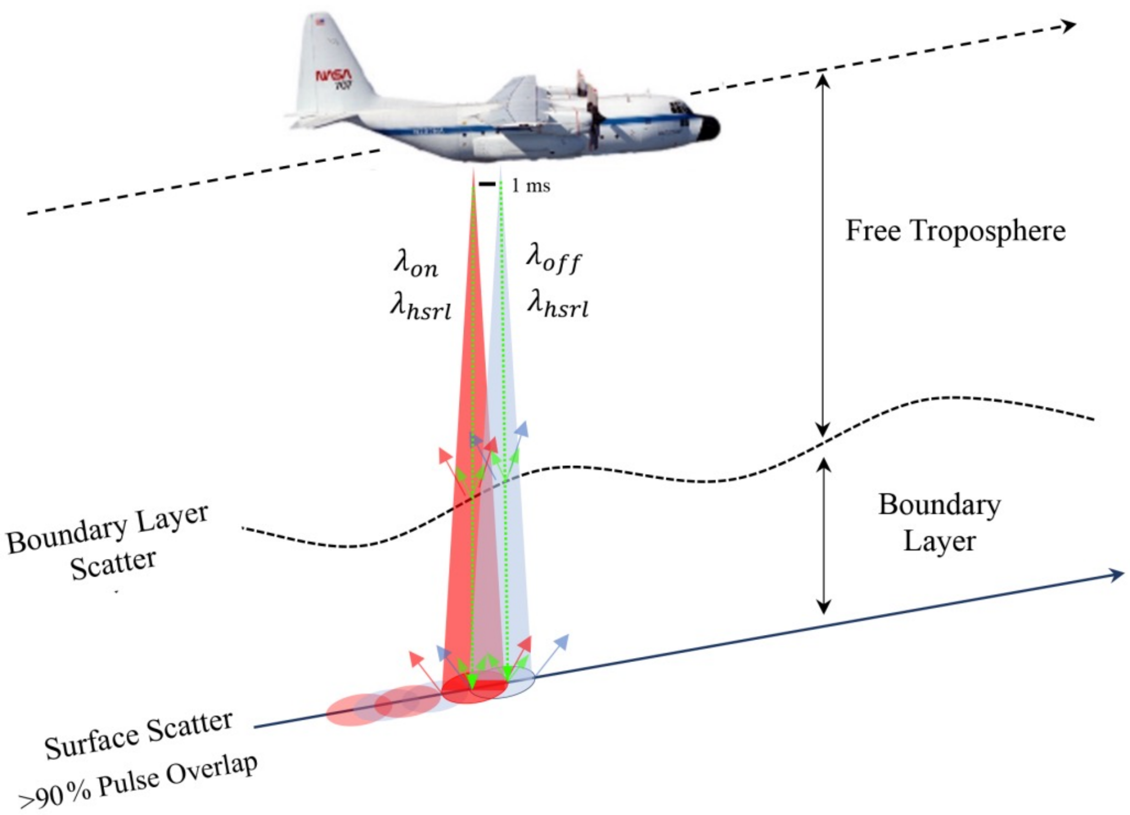
Morning Survey

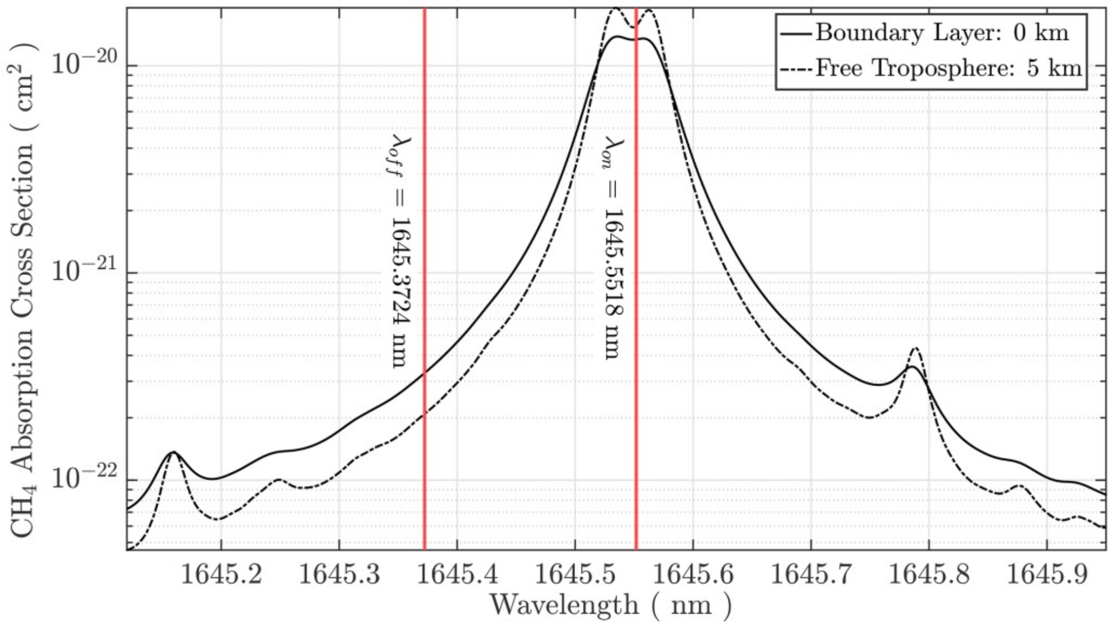


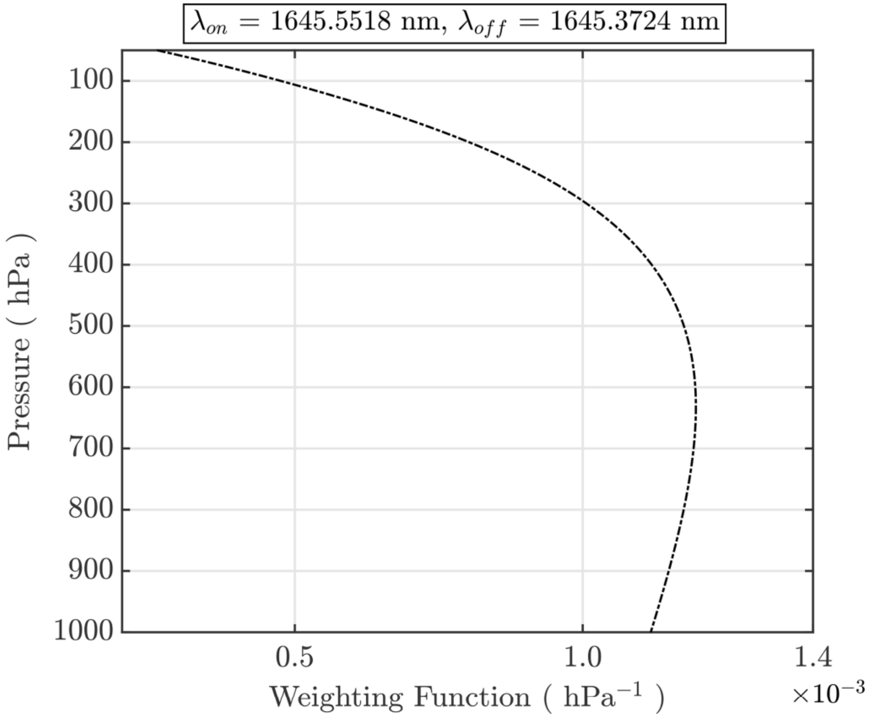
Afternoon Survey



CH4 IPDA measurement Technique

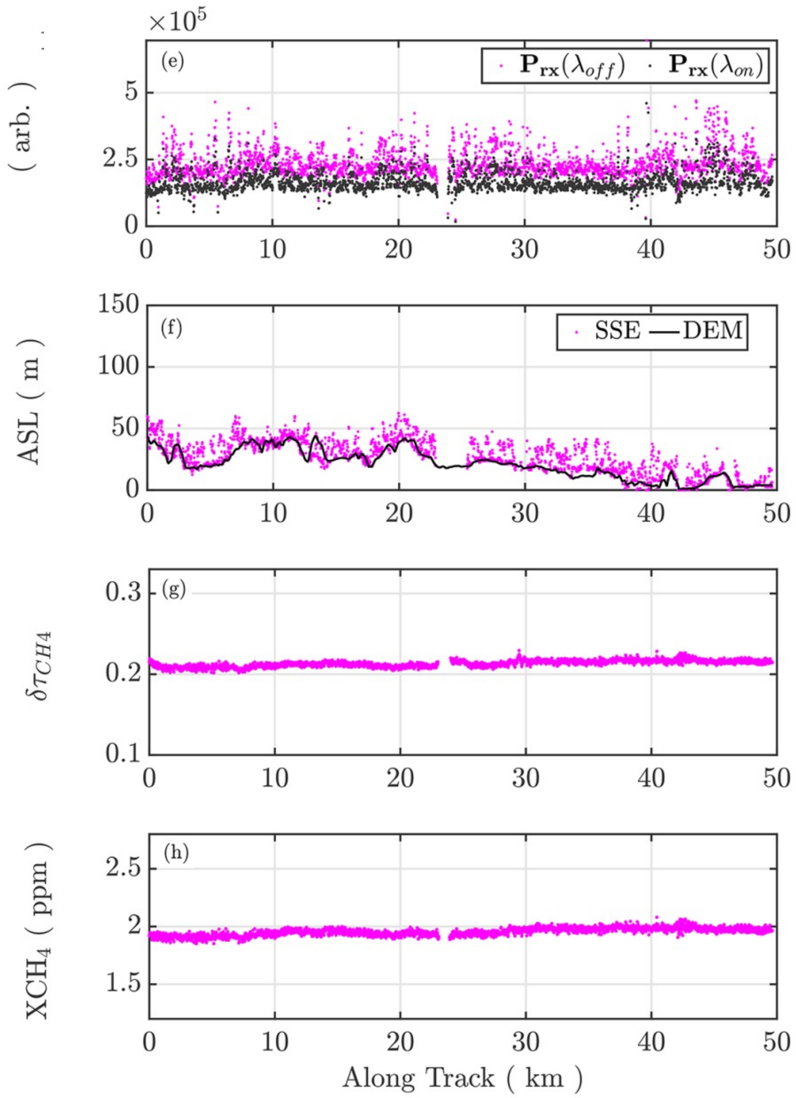






Barton-Grimley et al. 2022, AMT

Retrieval Methodology



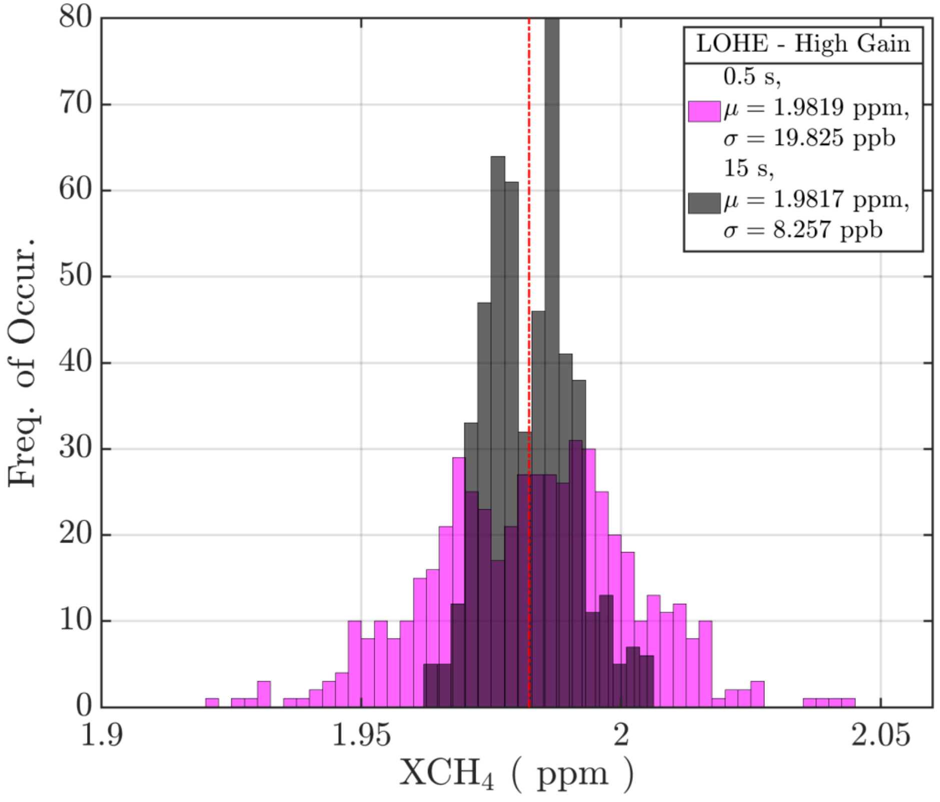
Detected Signals

Surface Scattering Elevation (including canopy)

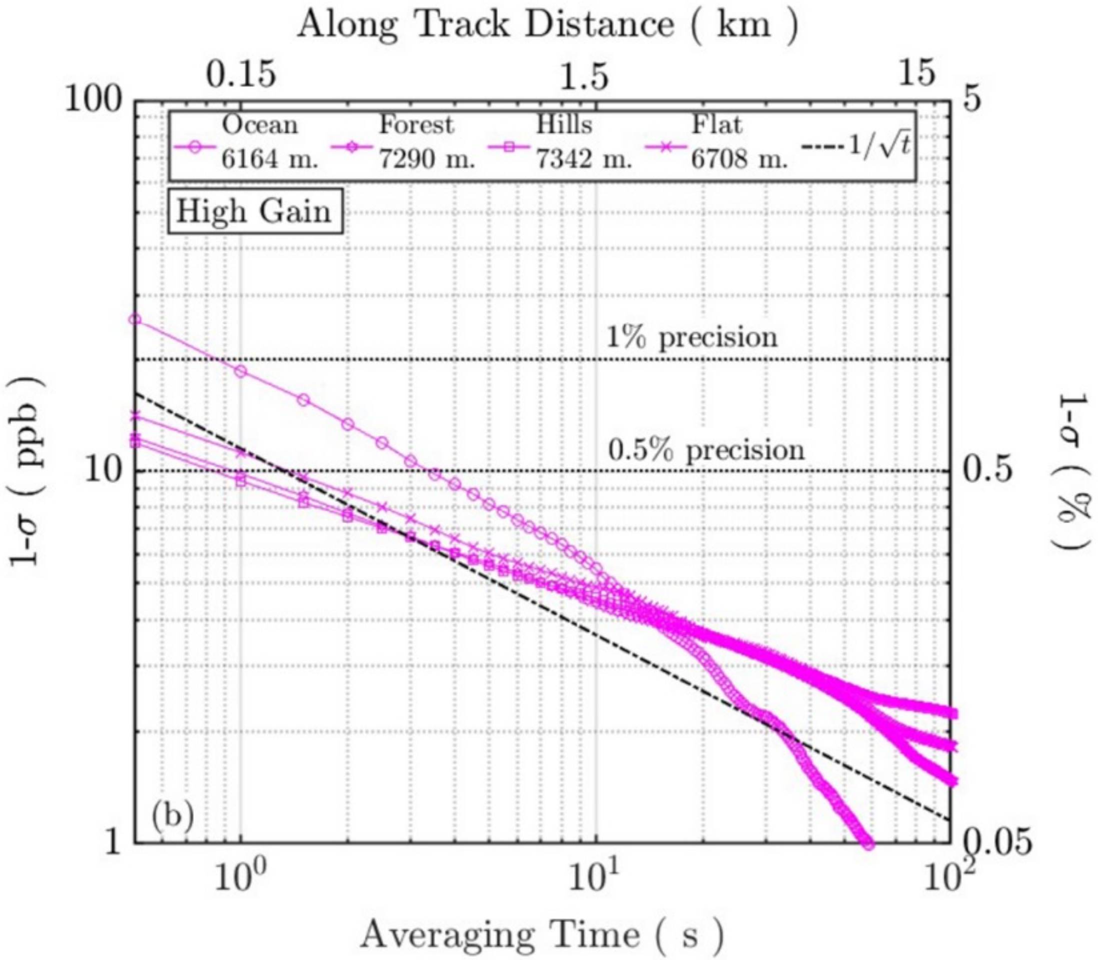
CH_4 Optical Depth

XCH_4

Precision



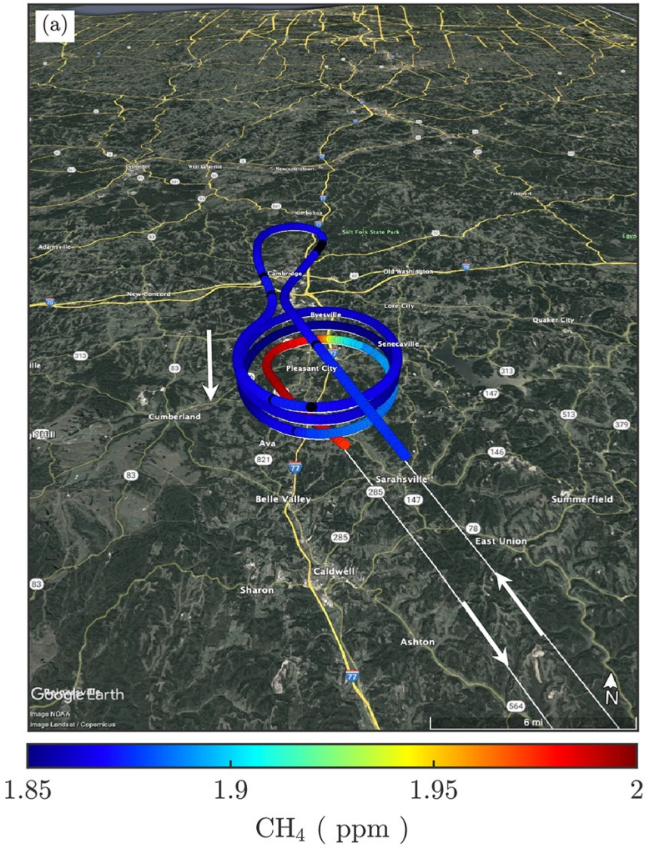
LOHE - High Gain
0.5 s,
μ = 1.9819 ppm,
σ = 19.825 ppb
15 s,
μ = 1.9817 ppm,
σ = 8.257 ppb
Freq. of Occur.
XCH$_4$ (ppm)



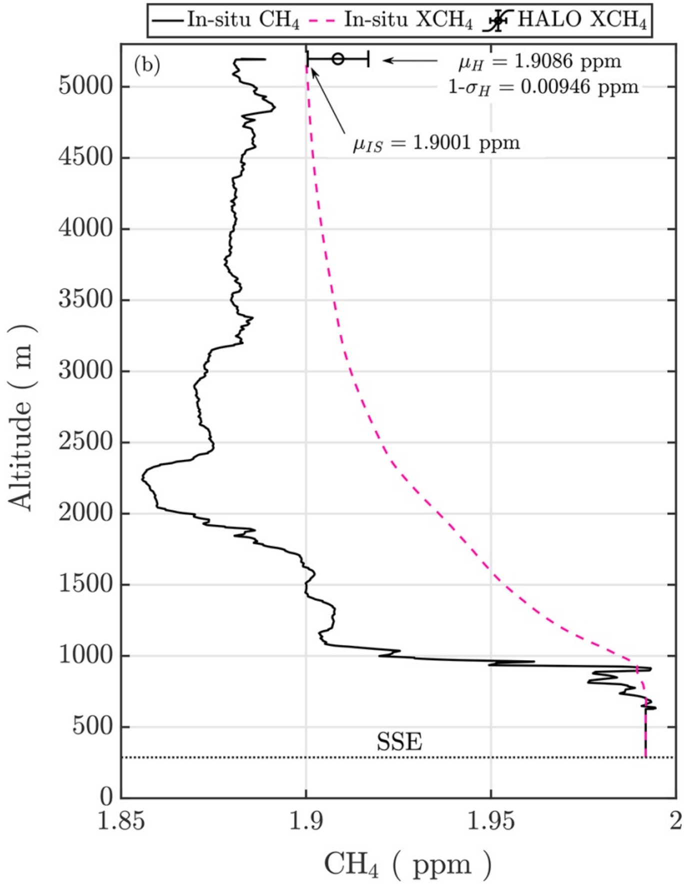
Along Track Distance (km)
Ocean 6164 m.
Forest 7290 m.
Hills 7342 m.
Flat 6708 m.
$1/\sqrt{t}$
High Gain
1% precision
0.5% precision
(b)
1-σ (ppb)
1-σ (%)
Averaging Time (s)

Validation

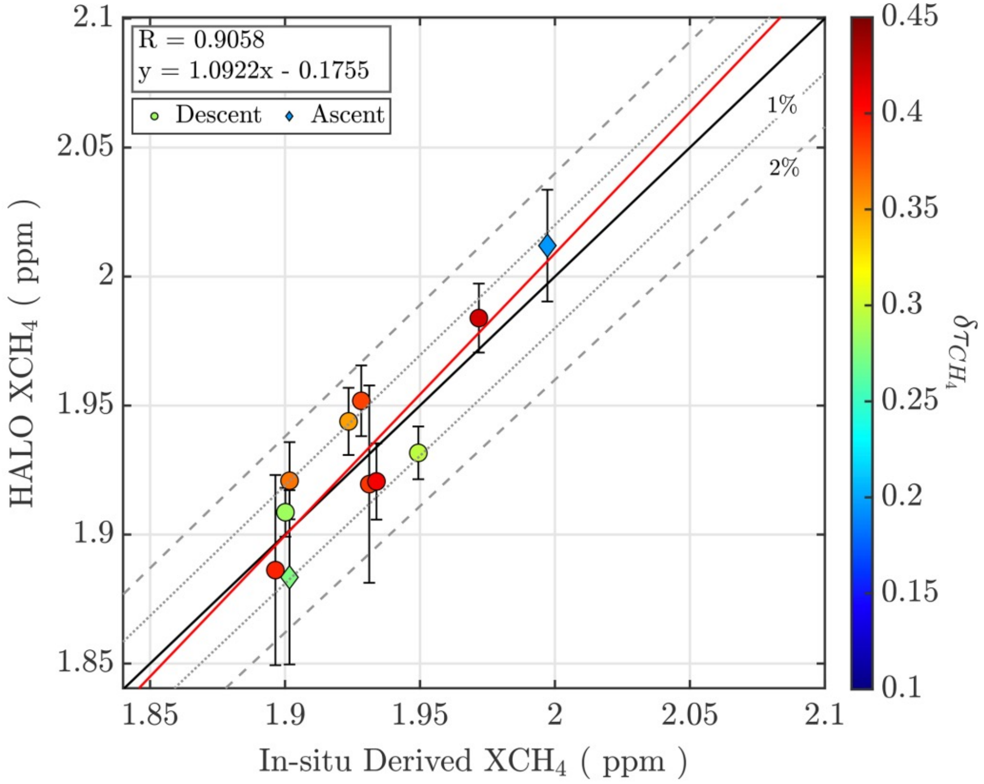
In Situ Spiral



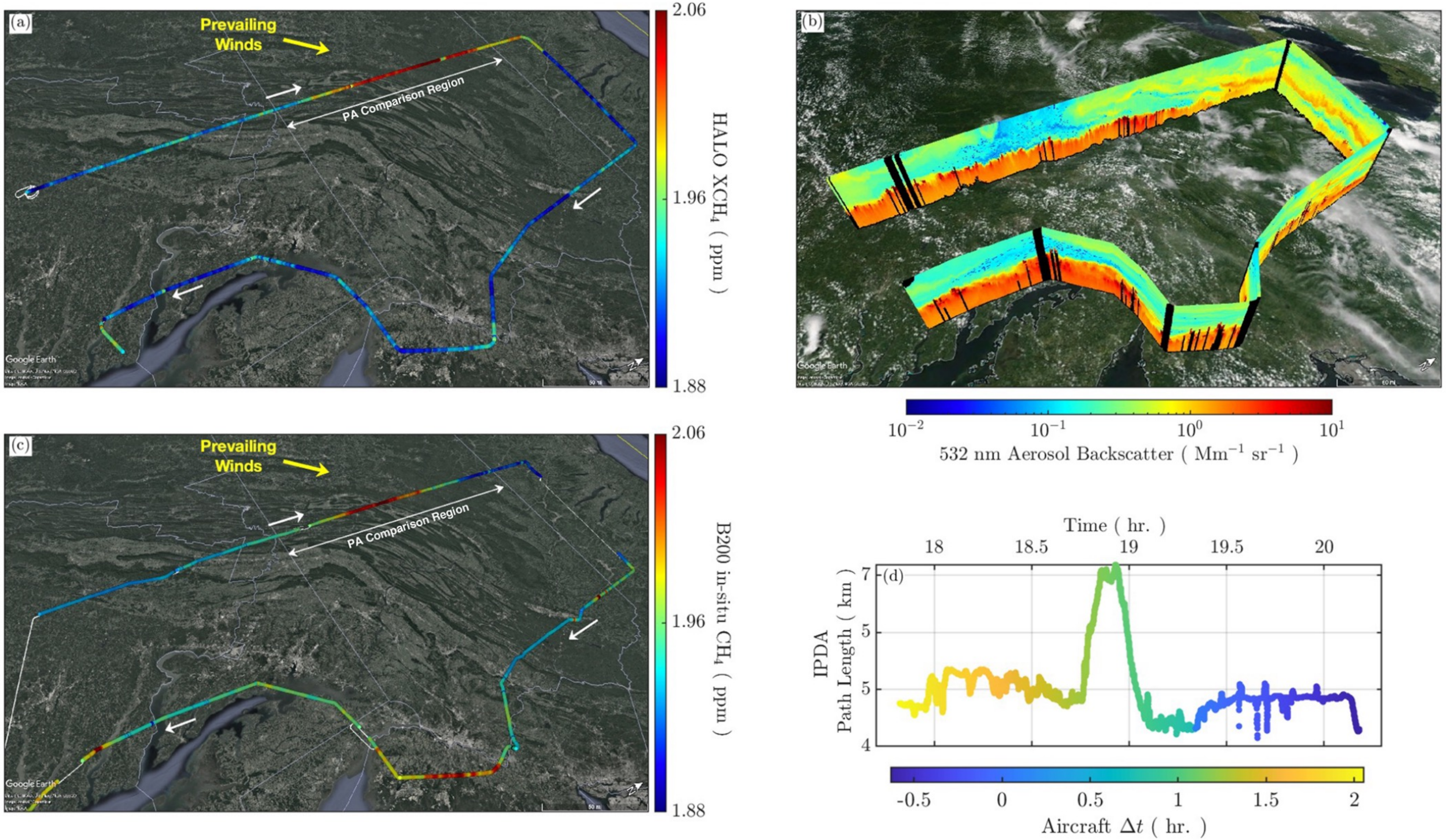
In-Situ Converted to XCH_4



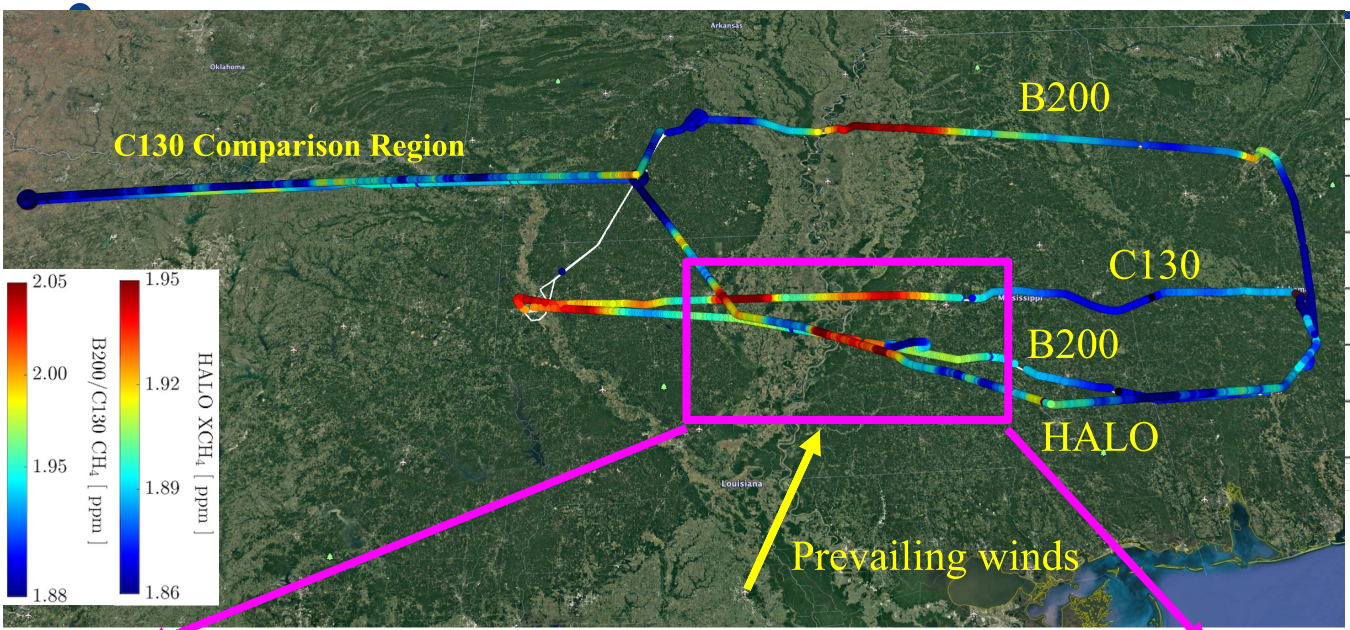
HALO validation against Picarro

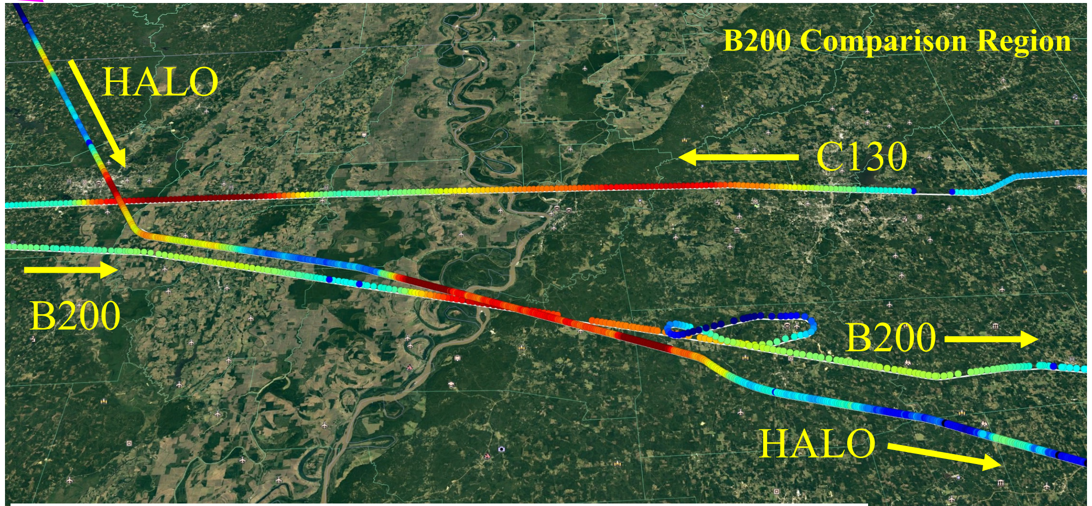


Data Example – Anthropogenic

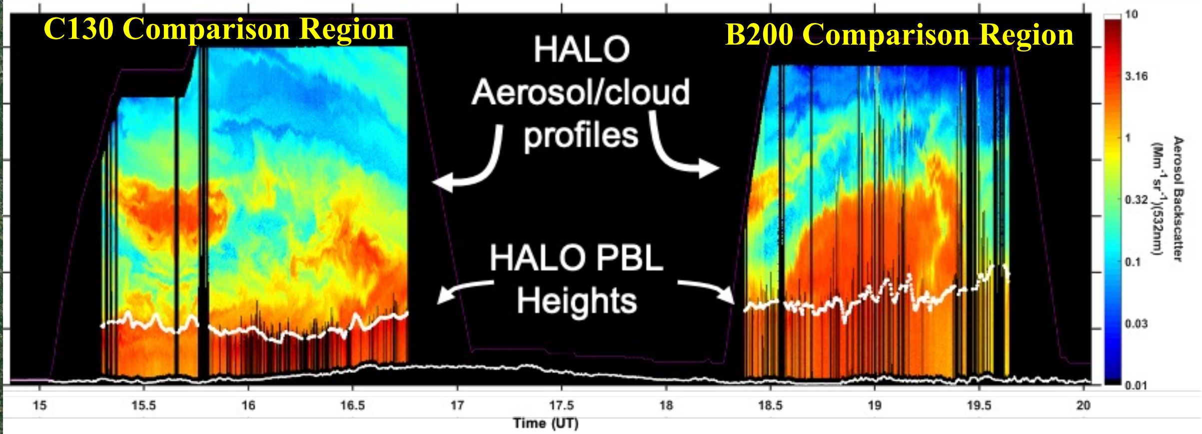


Data Example – Biogenic



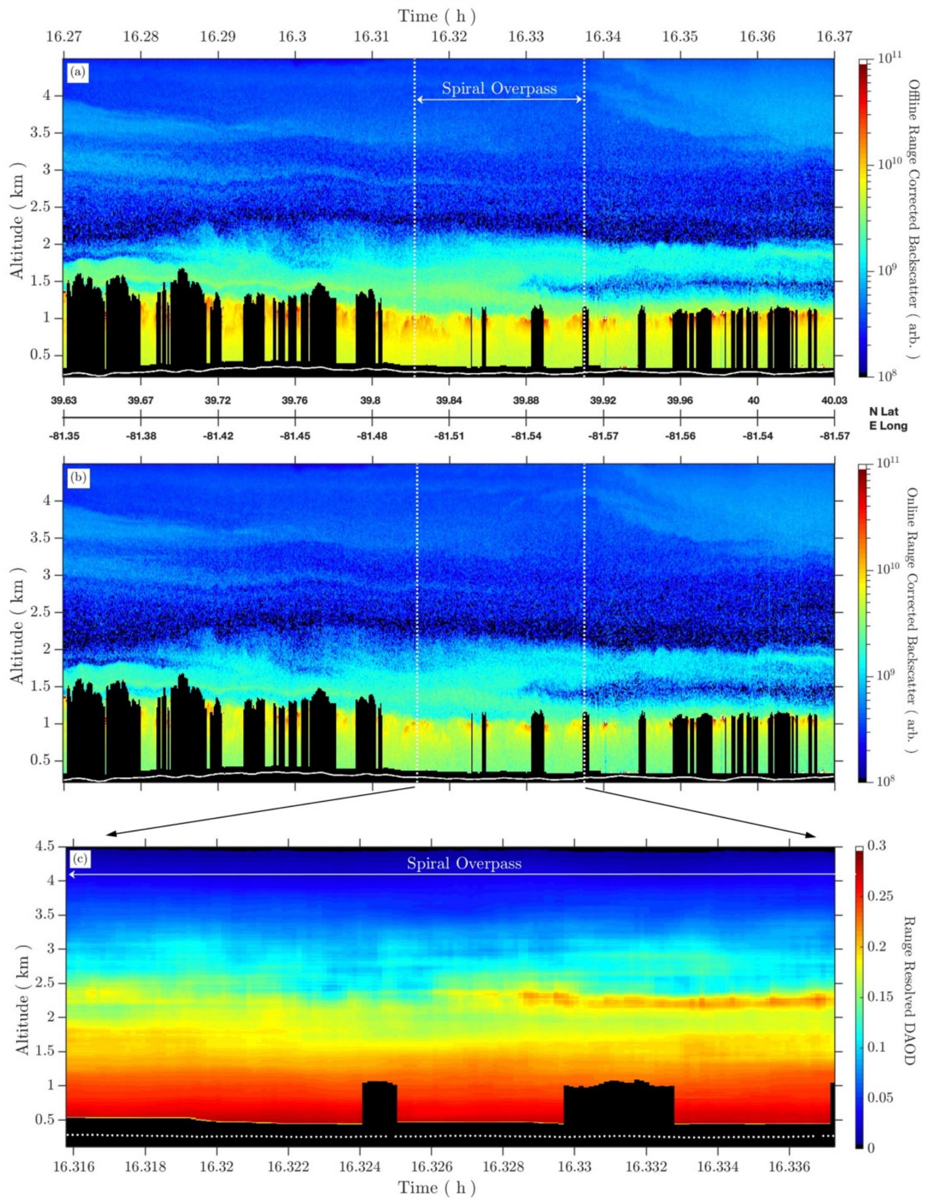


Lidar column covaries with PBL in situ measurements



- Multiple instrument comparison region: HALO XCH_4, C130 BL in situ CH_4, B200 BL in situ CH_4
- Cross-over points of the flight tracks show good agreement between all three sets of observations
- Demonstrates the utility of active columnar observations in capturing near surface CH_4 enhancements
- HALO's broad weighting function allows for quantification of both near surface fluxes as well as transport of upper tropospheric signals
- HALO HSRL aerosol observations provide context to the regional XCH_4 enhancements, showing for this case the boundary layer depth difference between the two comparison regions as the day progresses

Data Example – Column to profiling



- HALO measures weak atmospheric backscatter signal in addition to strong surface echo
- Atmospheric backscatter allow for direct measure of range resolved CH4 optical depth
- Current technology limits utility of profiling, however, new HgCdTe detector being implemented for STAQS to evaluate profiling capability
- Integration of PBL signals enables apportion of PBL XCH_4 from column XCH_4

Data Example – Column to profiling