

Shipborne Atmospheric Extinction Lidar

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Shipboard Atmospheric Extinction Lidar (SAEL)

- **Mission**

- Elastic backscatter lidar monitors **extinction** around ship
- **Supports operation of LWS by providing environmental awareness and laser weapon effectiveness range** to ship's tactical team

- **CONOPS**

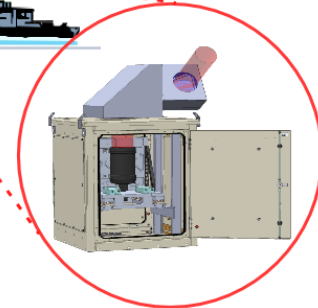
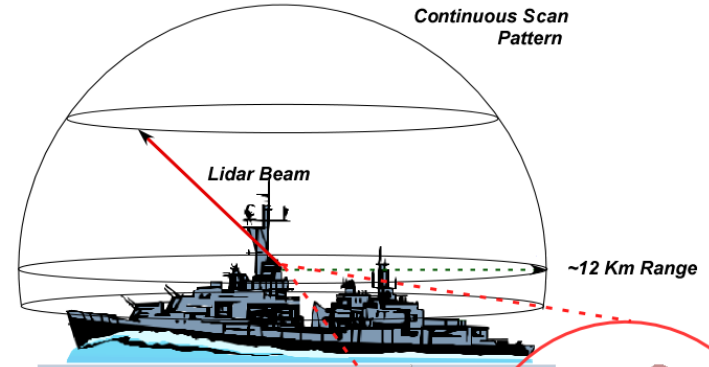
- Continuous ~hemispherical coverage around ship
- 12-14 km range provides **coverage to horizon**
- Azimuth range is 0-360 deg
- Elevation range is -5 to 60 deg
- Display updated at 15 min intervals

- **MicroPulse Lidar (MPL) design**

- Low power (10s-100s μ J), high rep rate (1 kHz) laser
- Eye safe (Class 1M)
- **Single photon detection** with Si g-APDs (2 channels)
- Uniaxial design - stabilized Tx/Rx optics train

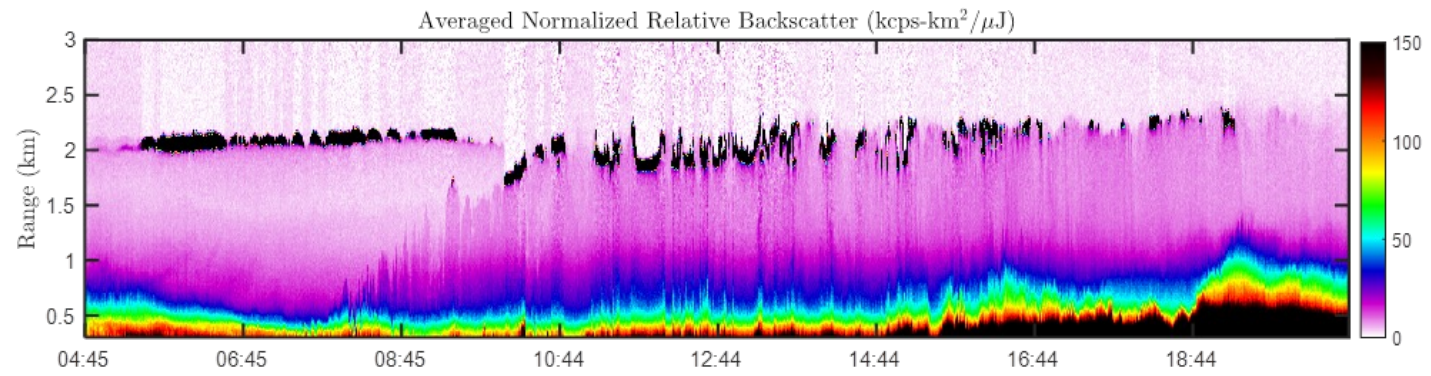
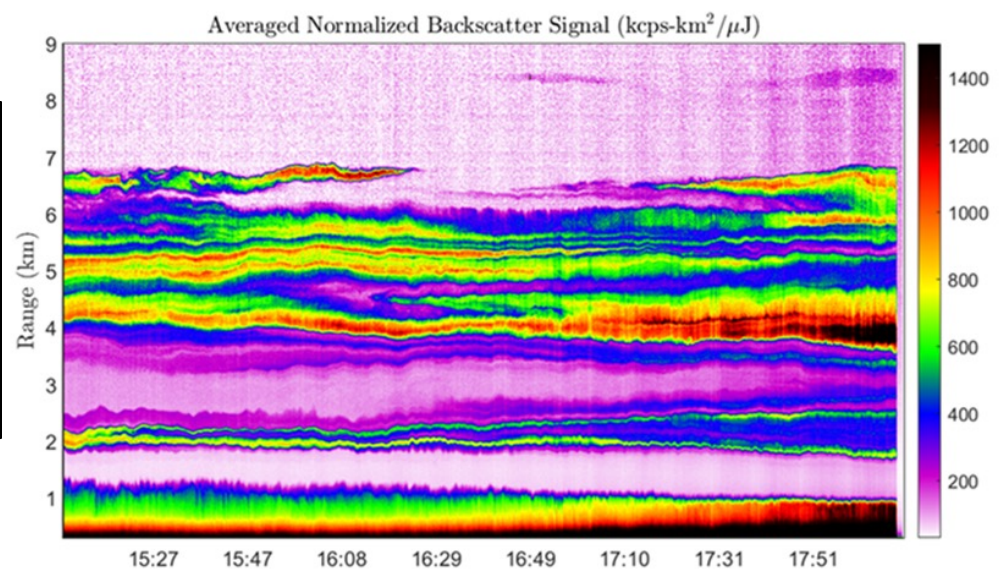
- **Extinction retrieval algorithm**

- **Enhanced Klett/Fernald algorithm yields range-resolved atmospheric extinction**
- Additional data from sunphotometer



Example of Performance Temporal and Spatial Resolution

- *Range-Time-Intensity plot of NRB, Andover, MA, 16 September 2020 (Time is local).*
- *Aerosol layers from particulates from California and Oregon forest fires.*
- *The time resolution ~6 sec and vertical spatial resolution is ~7 m.*



16 Hour data set showing evolution of boundary layer
24 May 2021 Andover, MA USA
Time is local time (UTC - 4hr)

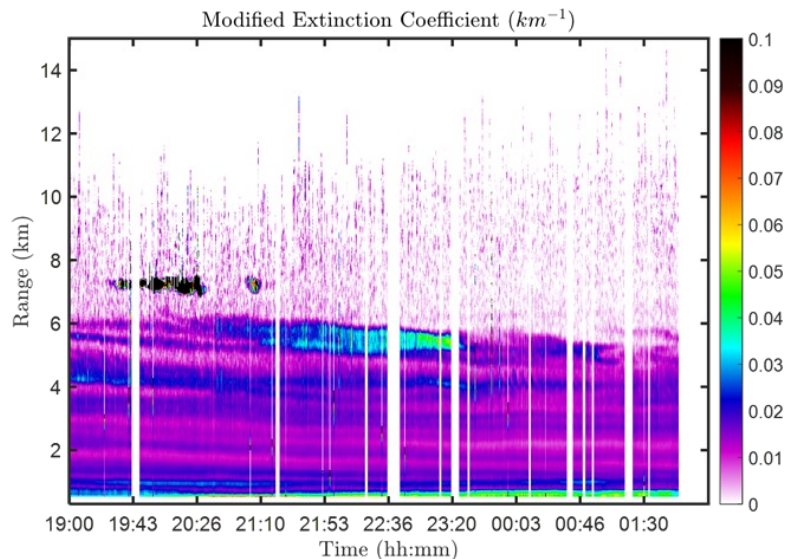
Example Data Products - Extinction

9 July 2021 Monterey

- **DATA PRODUCTS:**

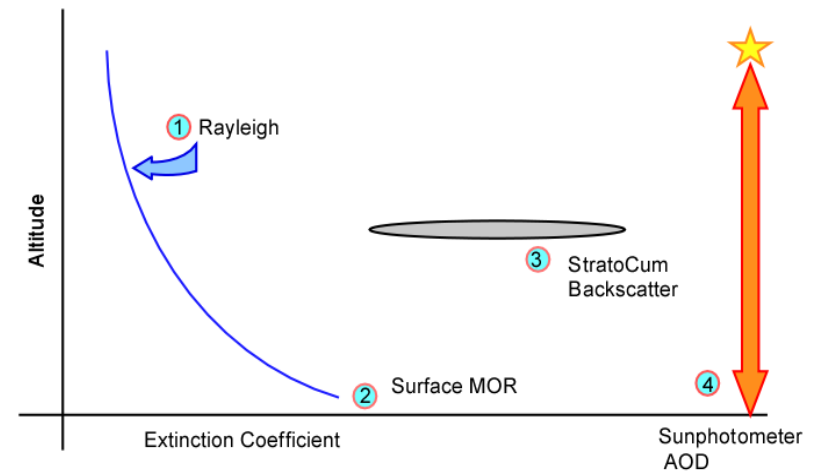
- Normalized relative backscatter (NRB)
- Extinction coefficient
- Transmission

- (Below) Retrieved extinction coefficient vs range (altitude) and time.
- All times are UTC (= PDT + 7).
- Vertical white bars are LCH “no shoot” windows.
- Extinction calculated via Klett inversion, enhanced



- **Techniques for aerosol extinction retrieval.**

- Rayleigh scattering regime
- Liquid stratocumulus cloud backscatter
- Surface MOR (requires extrapolation with wavelength)
- Sunphotometer AOD (Aeronet)



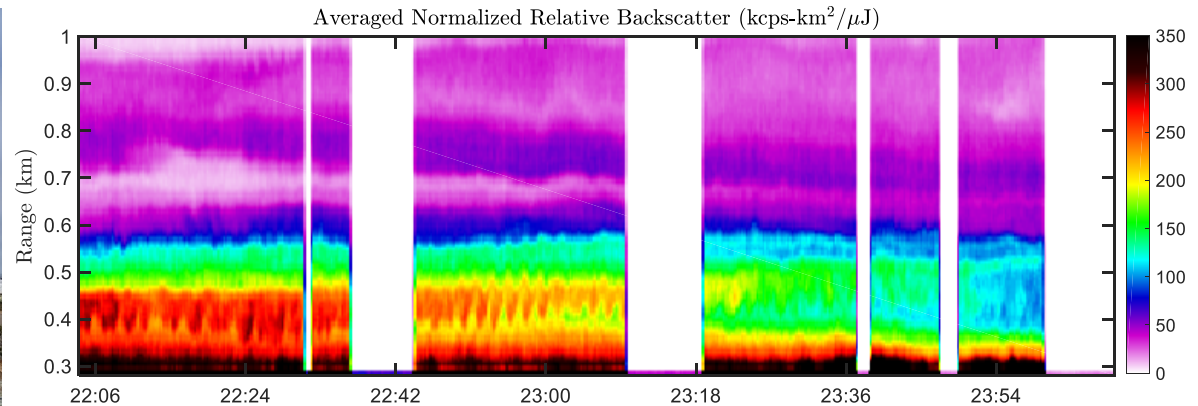
1. Sufficient range to measure Rayleigh scattering, need surface P & T
2. Surface MOR -> vis extinction -> NIR extinction
3. Thick cloud backscatter coefficient known
4. Sunphotometer measures AOD = integral of extinction profile

Deployments

- CABLE-TRAX/EAST - Shuttle Landing Facility, Kennedy Space Center, June 2017
- CABLE-TRAX/WEST - Naval Air Station Pt. Mugu, August 2018
- NRL Coastal Environmental Observation Station, Monterey, CA, July 2021
- HELIOS FDT activity at SCSC, Wallops Island, VA, October 2021

- System availability >90% integrated over all 4 deployments

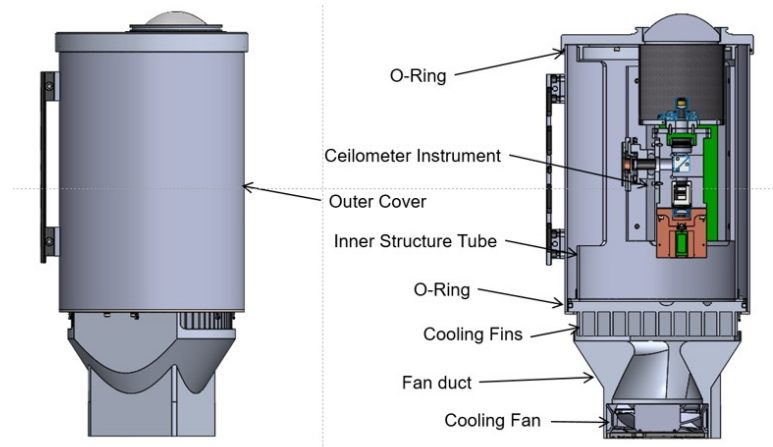
Development → **TRL = 7**



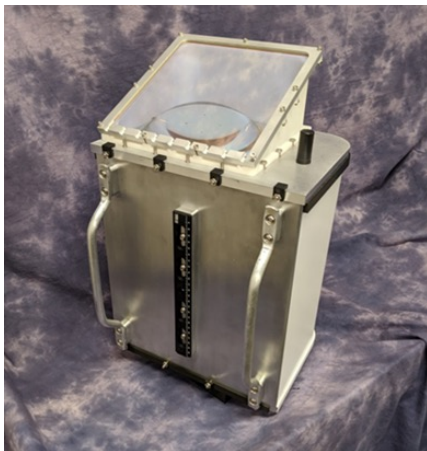
Compact Laser Ceilometer Engineering Prototypes Specialized for Network Deployment

Daniel Stover SBIR I/II/IIIA DE-SC0017167

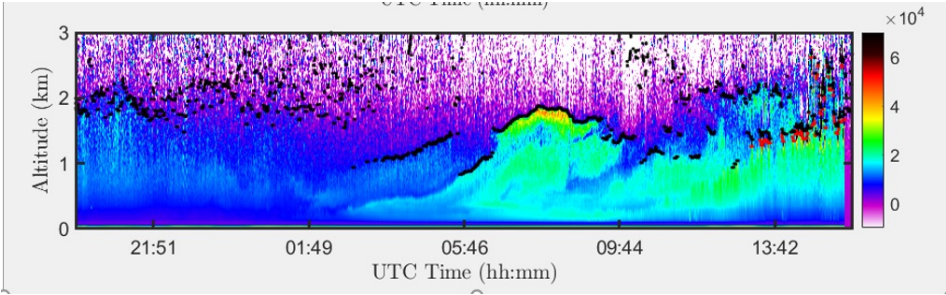
- Operation at 1.55 μm eye-safe wavelength.
 - **System is Class 1M at aperture.**
- Utilizes telecom-matured & ruggedized fiber laser.
- Utilizes temperature-stabilized InGaAs APD.
- Fiber-coupled, field-replaceable laser & detector.
- 6 inch diameter aperture.
- Uniaxial design. Shared transmit and receive axes maximizes thermo-elastic stability.
- Thermal management strategy derived from aerospace techniques.
- Full overlap from 100 m.
- Custom low SWaP system electronics.
- **Design includes attention to integration with site power & data streams.**



Gen2 Ceilometer



Gen1 Ceilometer



Normalized relative backscatter as a function of altitude vs time for 20 July 2022.

Parameter	Value	Requirement	Achieved
Size [linear cm]	95	100	√
Weight [kg]	9.5	10	√
Power [W]	21	20/100	~√