Demonstration of high spectral resolution lidar (HSRL) measurements of aerosols and clouds using a coherent Doppler wind lidar

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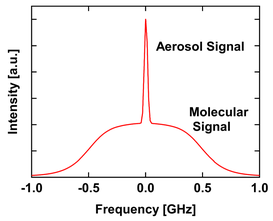
Introduction

Coherent Doppler Wind Lidar (CDWL)

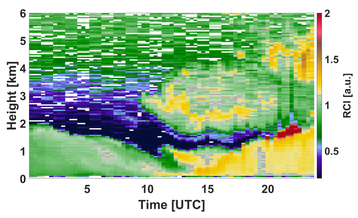
- measures wind speed based on Doppler shift of aerosol backscatter signal
- relies on spectrally resolving narrowband aerosol backscatter signal

High Spectral Resolution Lidar (HSRL)

- provides quantitative aerosol optical properties by independently measuring aerosol and molecular backscatter signals
- uses optical filters to separate aerosol and molecular signals



Conceptual aerosol and molecular backscatter spectral distributions



Aerosol backscatter strength measured by CDWL

Proposed Research:

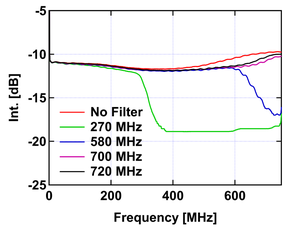
- make spectrally resolved measurement of molecular backscatter signal using a CDWL
- provides aerosol to molecular backscatter ratio needed for HSRL measurements

Advantages:

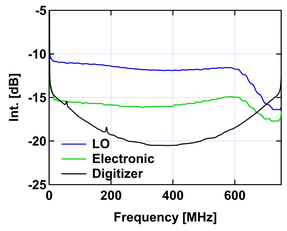
- simultaneous wind and aerosol measurements
- spectral separation in digital domain
- potential new aerosol/temperature lidar

Modification

- Replaced digitizer and detector for extended bandwidth measurement
- Modified LabVIEW data acquisition software to acquire data at 1.5 Gs
- Developed analysis software
- Characterized different noise sources



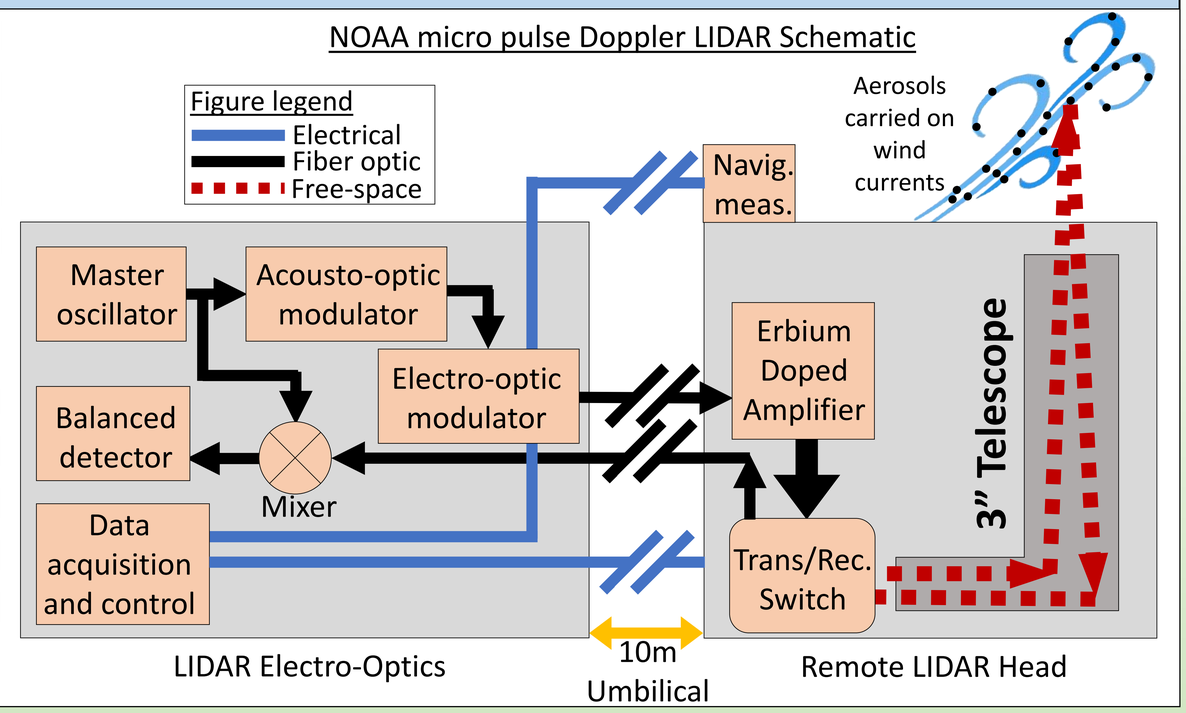
Instrument noise with different low pass filters



Different instrument component noise

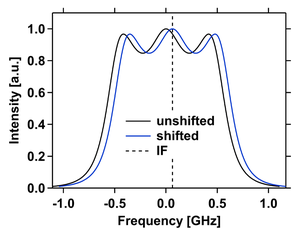
Compact and flexible coherent Doppler wind LIDAR

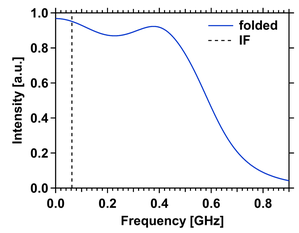
Lidar parameter	Specification
Wavelength (nm)	1543.00
Average power (mW)	800
Pulse Energy (μJ)	40
Pulse Length (ns)	166-1000
Range resolution (m)	25-150
Pulse repetition rate (kHz)	18-20
Maximum Range (km)	8.3-7.5
Beam rate (Hz)	1-10
Intermediate Frequency (MHz)	62.5
Sampling Rate (MHz)	250
All components are off-the-shelf	



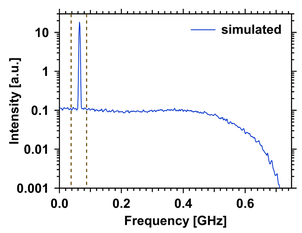
Simulation

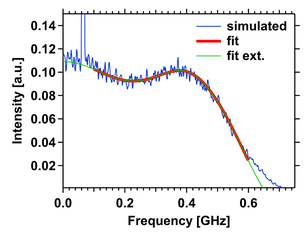
- Rayleigh-Brillouin spectrum at 1.5 μm



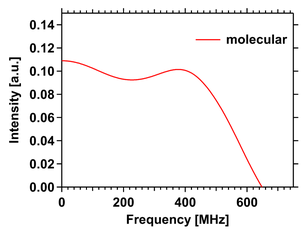


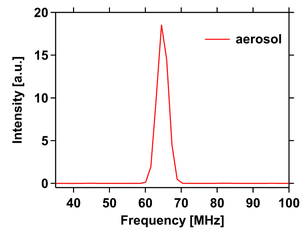
- Backscatter power spectrum at 750 MHz bandwidth





- Separated aerosol and molecular spectra

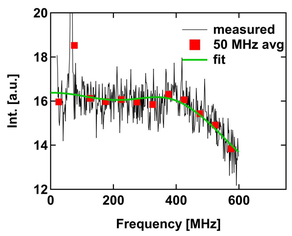




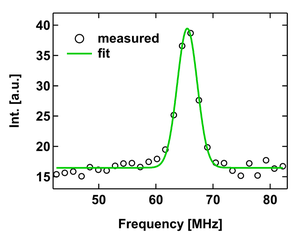
- Integrate aerosol and molecular backscatter spectra for quantitative aerosol backscatter coefficient

Results

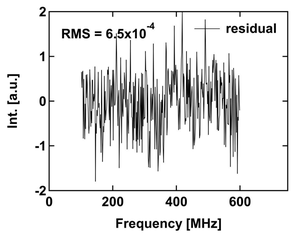
- Measured molecular and aerosol backscatter spectra from atmospheric return



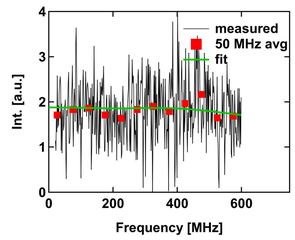
Molecular



Aerosol

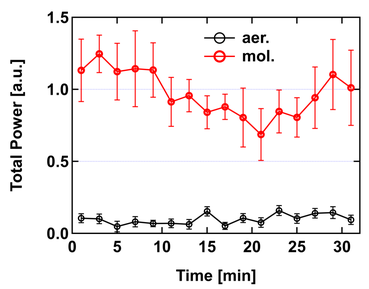


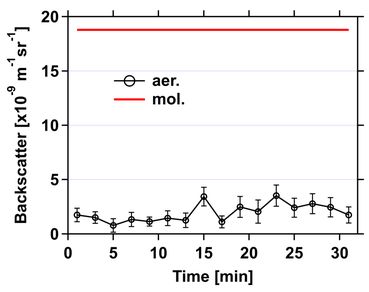
Residual



Null Case

- Retrieved aerosol backscatter coefficient





Summary and Future Work

- Successfully measured spectrally resolved atmospheric molecular backscatter signal using coherent detection technique.
- Demonstrated possibility for simultaneous wind and quantitative aerosol optical properties measurements.
- Perform further verification, validation and range resolved measurements.