MicroPulse DIAL for Thermodynamic Profiling of the Lower Troposphere

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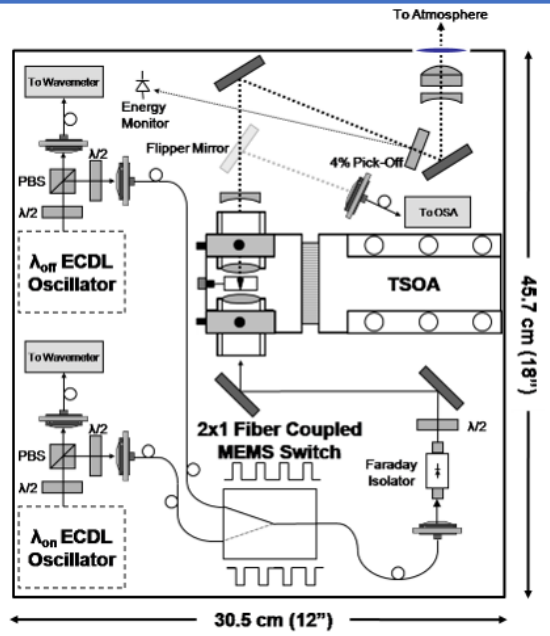
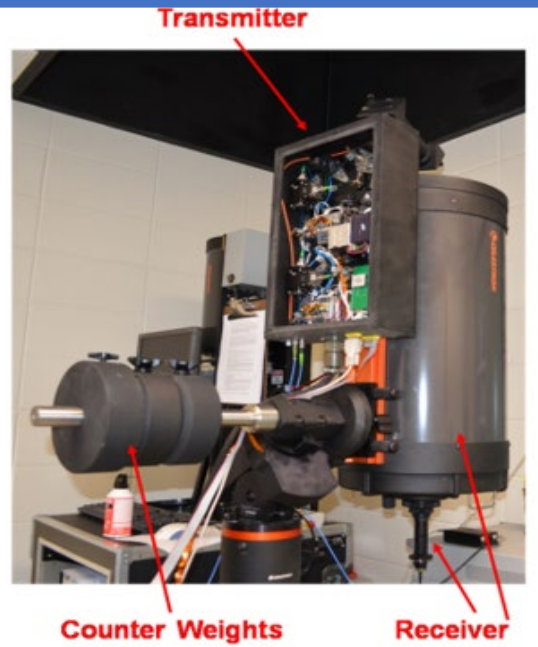
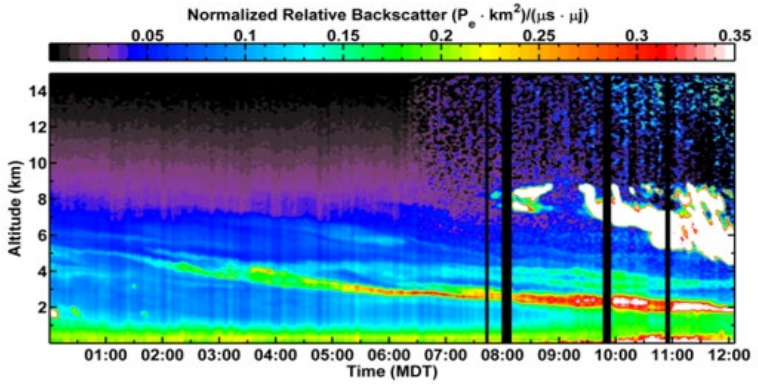
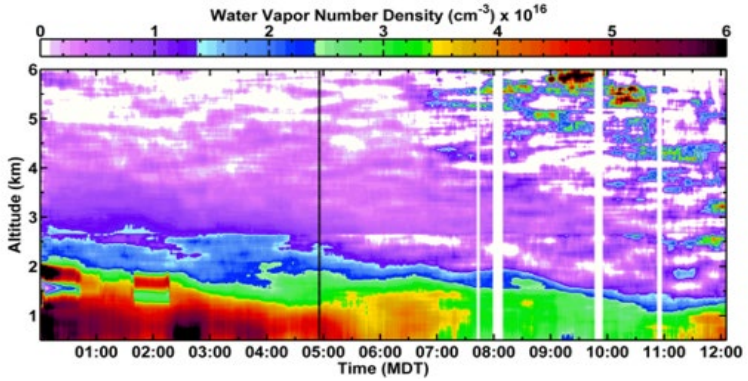
Diode-Laser Based Humidity Profiling

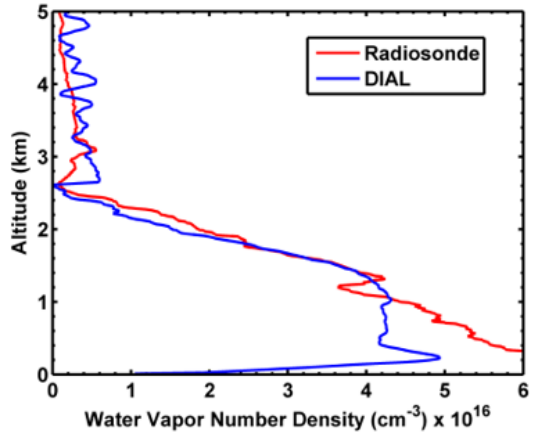




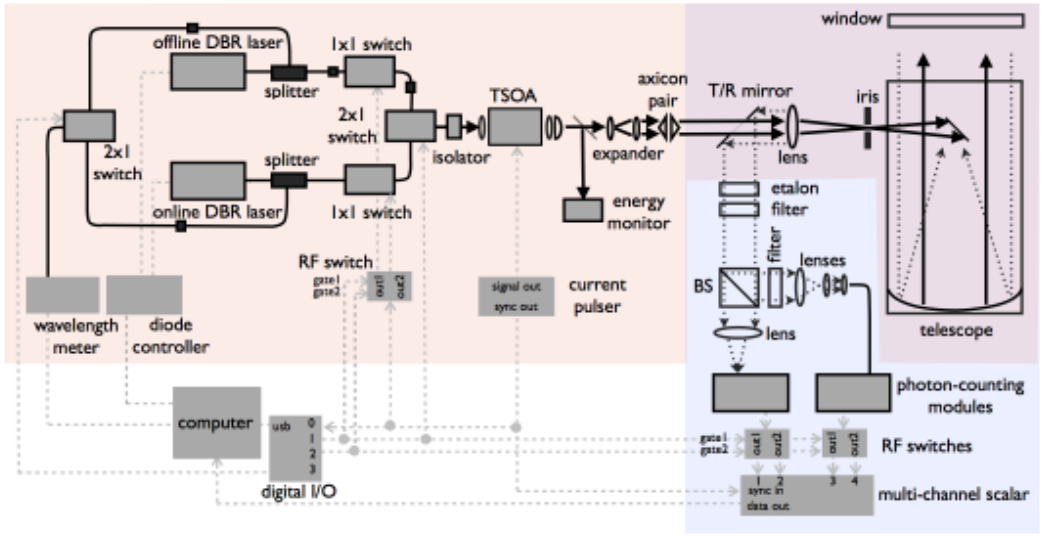


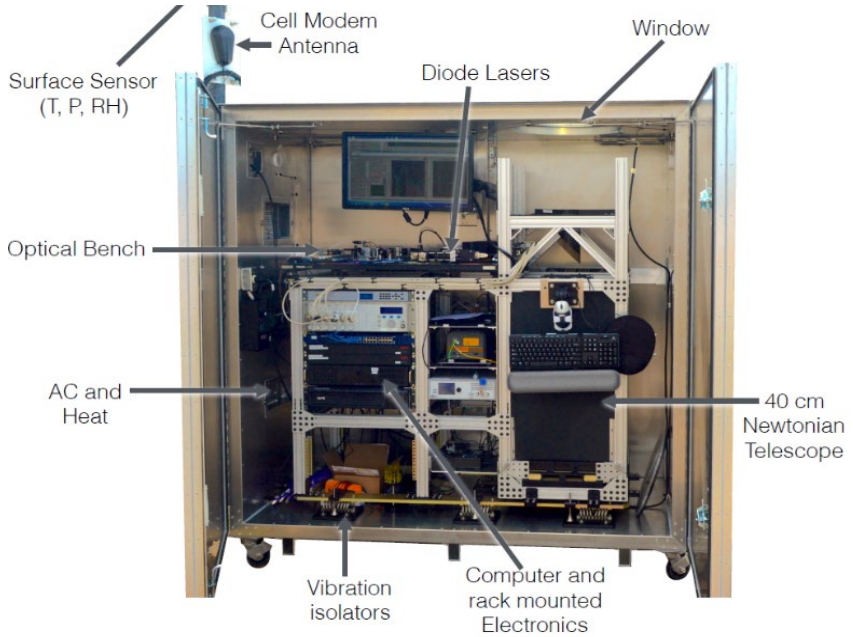


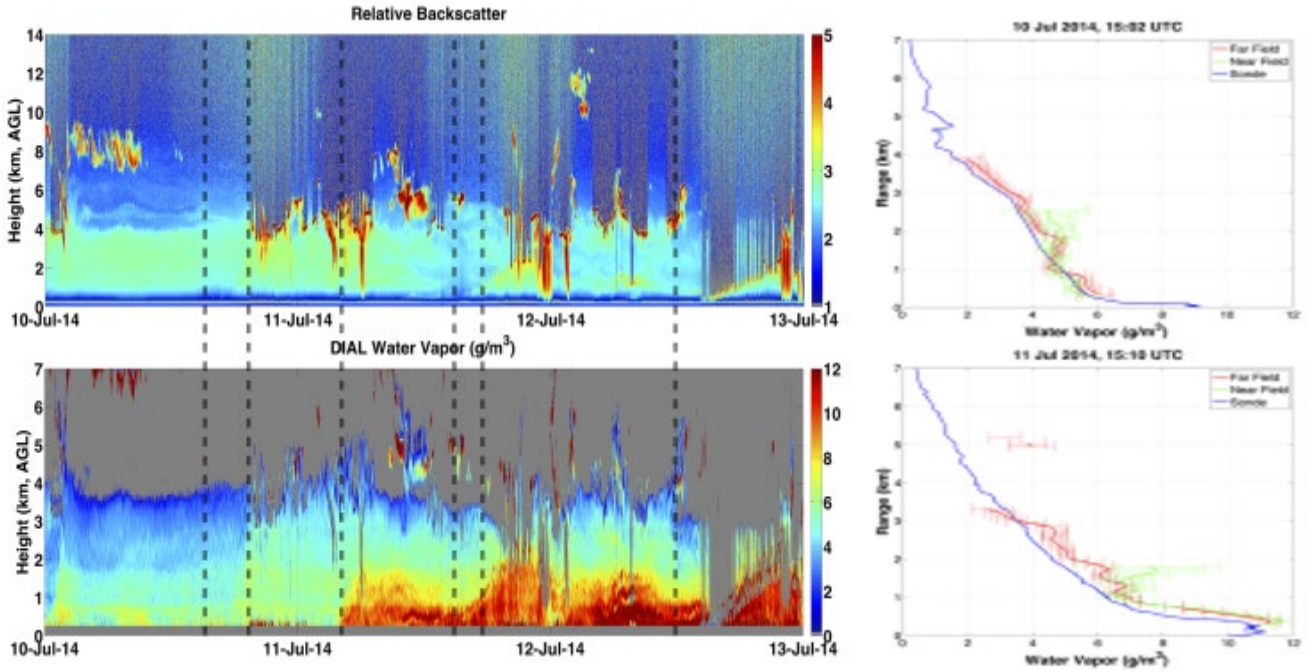
- Diode-laser-based transmitter and commercially available components provide a flexible cost effective architecture.
- Low pulse energy, high pulse repetition rate, and photon counting allow for eye-safe operation.
- MicroPulse differential absorption lidar developed at Montana State University for humidity profiling in 2008-2012 provided proof of principle for the technique.



Humidity Profiling

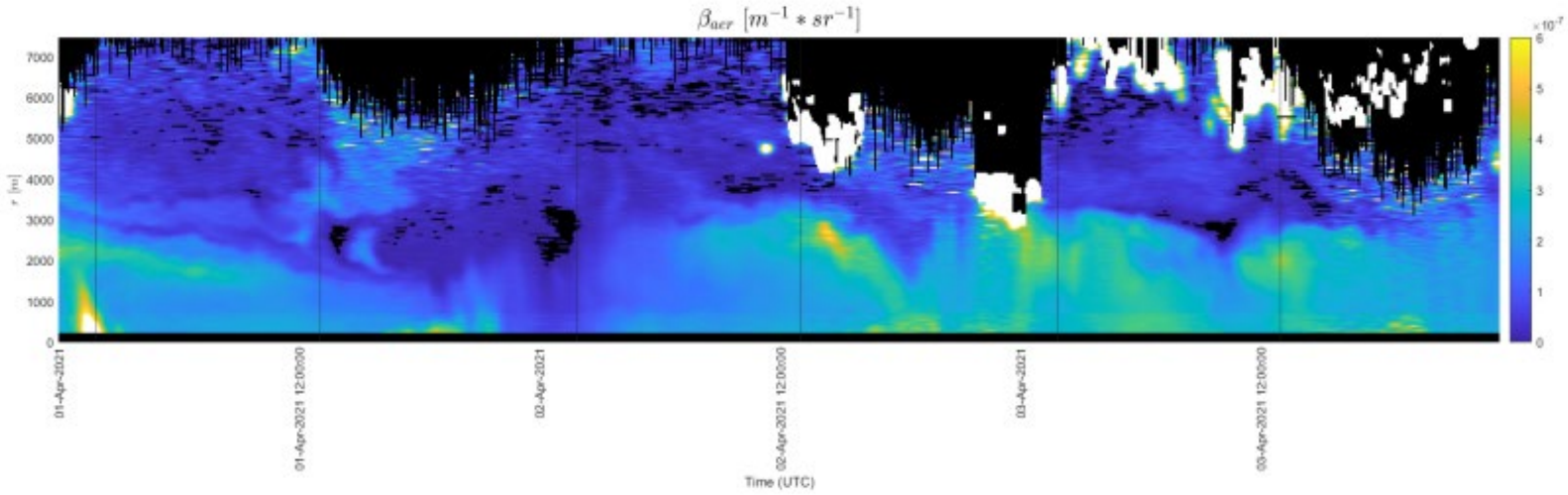


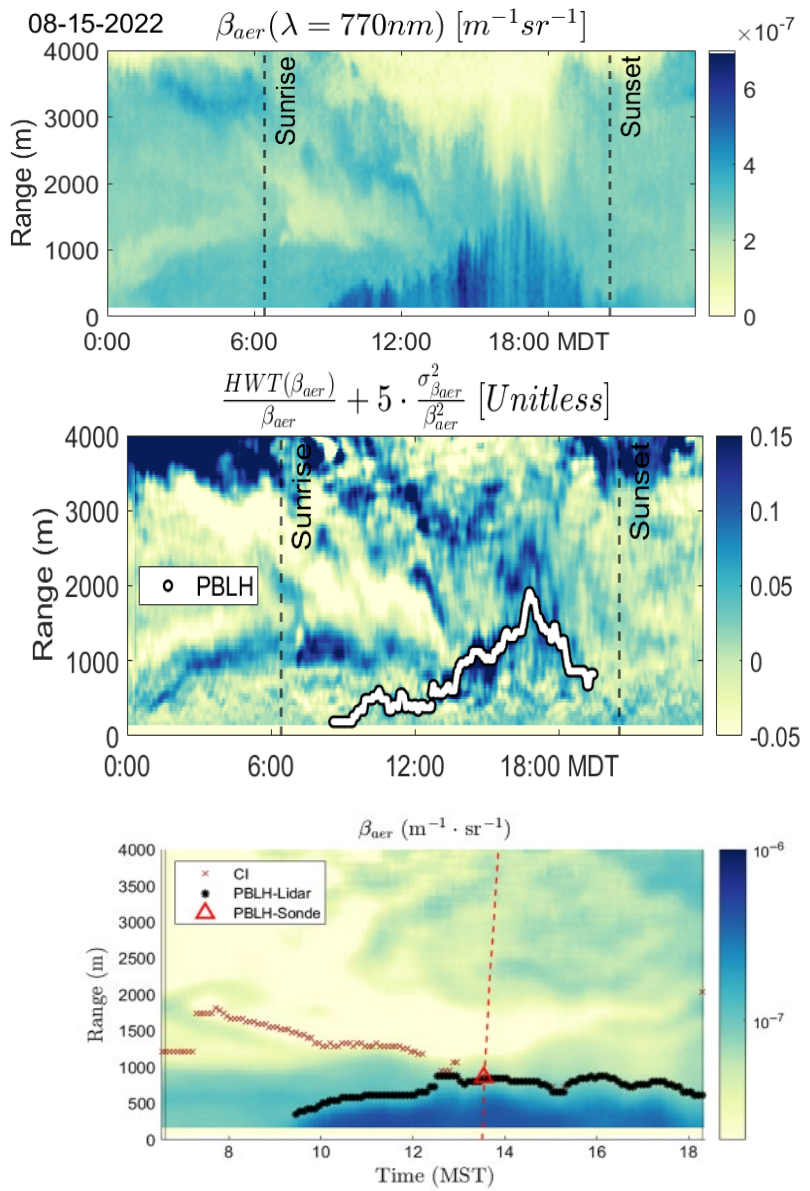




- A collaborative effort between MSU and NCAR began in 2012 and has led to the development of field deployable instruments for humidity profiling.
- Major improvements include DBR lasers, shared telescope design, and integration of an etalon for spectral filtering in the receiver.
- An environmental housing was developed by NCAR.
- A network of five MPD's was completed in 2020 and is available to the user community.

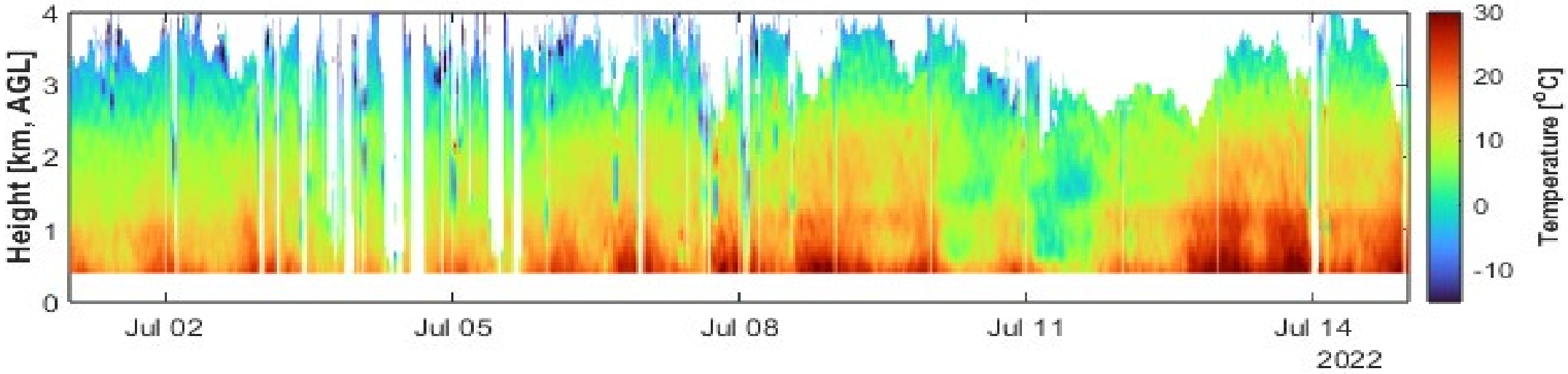
Calibrated Aerosol and Boundary Layer Height

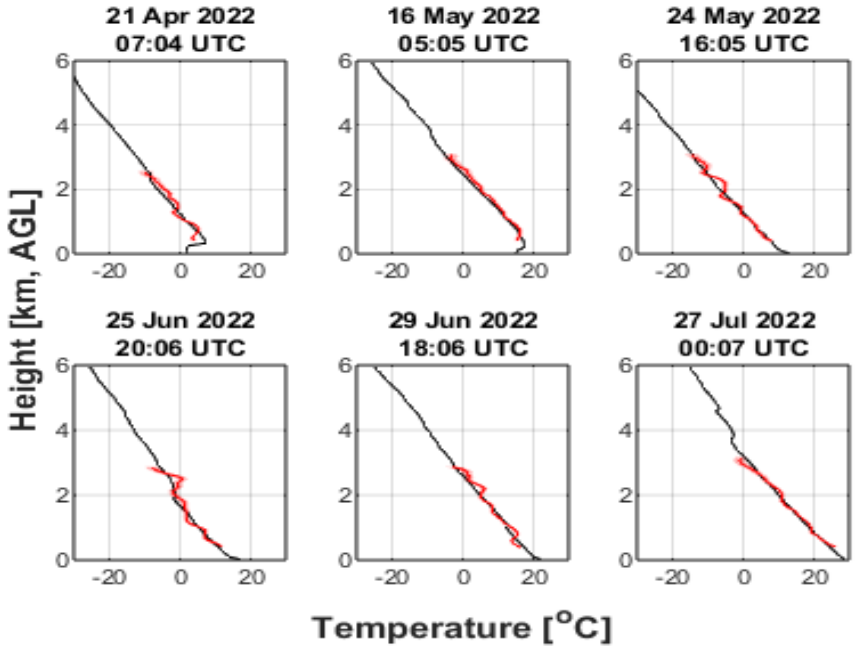




- Flexible diode-laser based instrument architecture allows the development of various lidar measurement capabilities.
- High Spectral Resolution Lidar (HSRL) for aerosol backscatter ratio was demonstrated in 2017 by NCAR.
- An atomic vapor cell is used in the receiver to block the aerosol scattered light.
- MSU had developed a Boundary Layer Height Retrieval
  - Haar Wavelet Transformation
  - Temporal Variance
  - Pathfinding Algorithm

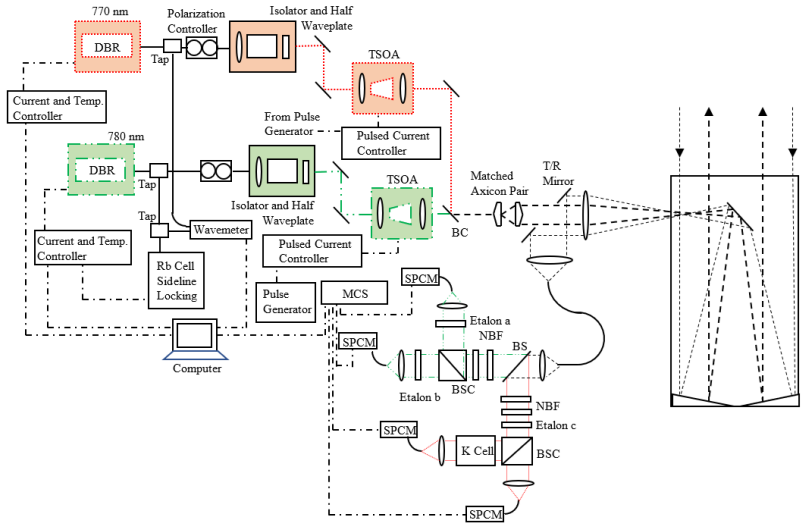
Temperature Profiling

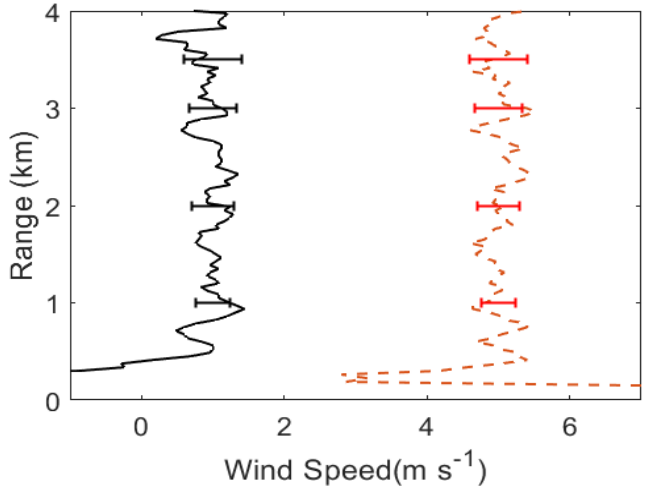


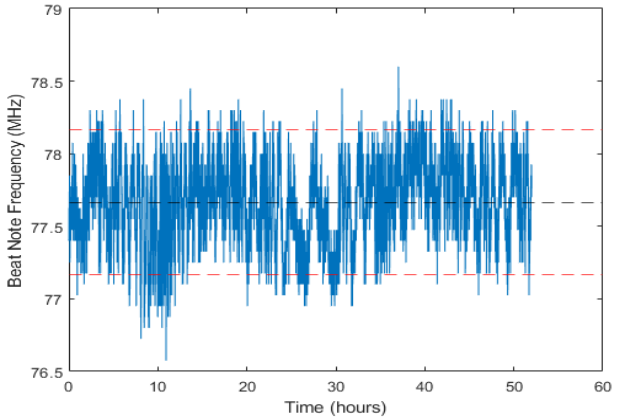


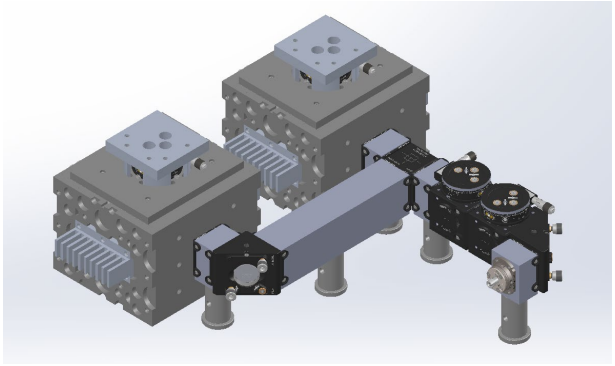
- Temperature profiling is possible via DIAL using a temperature sensitive O_2 absorption line.
- Auxiliary measurements of the water vapor and aerosol backscatter ratio are required to complete the temperature retrieval.
- A perturbative retrieval technique for the absorption coefficient was developed by MSU in 2018-2019.
- NCAR developed temperature profiling into all 5 of the MPD instruments in 2022-2023.
- Developments and improvements are ongoing.
- First field Campaign is currently in progress.

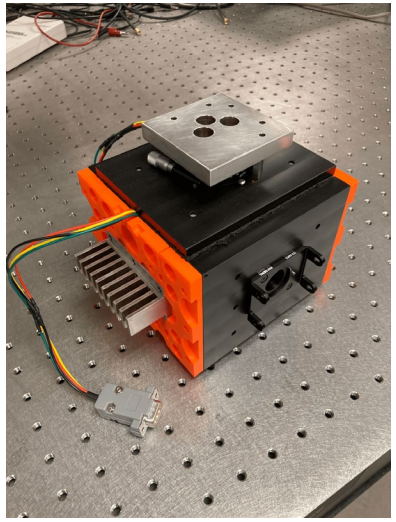
Doppler Wind Lidar







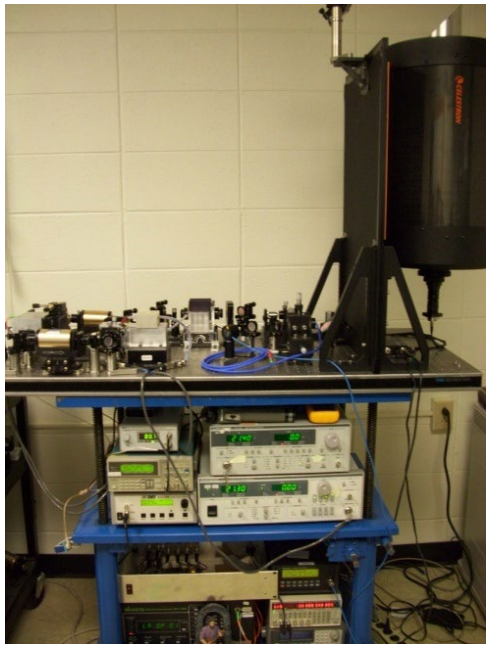




- A diode-laser-based Doppler wind lidar is under development at MSU.
- Modeling indicates that vertical wind profiling through the lower troposphere is feasible.
- A retrieval technique that utilizes an auxiliary measurement of the aerosol backscatter ratio to take into account the lineshape of the backscatter light has been developed.
- Initial testing will begin in early 2024.

Summary

- The collaboration between MSU and NCAR led to a network of five instruments for thermodynamic profiling of the lower troposphere
  - Humidity, calibrated aerosol backscatter, and temperature
  - Available for request to the user community through NCAR/NSF
- Continuing research efforts at MSU includes
  - Improvements to the hardware and retrieval for temperature profiling and long-term validation of the temperature profiling.
  - Inclusion of humidity profiles and a cost function and long-term validation of the boundary layer height retrieval.
  - Construction and testing of the Doppler wind lidar prototype.



Acknowledgments

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