MicroPulse Differential Absorption Lidar (MPD): A Network Deployable Ground Based Thermodynamic Profiler

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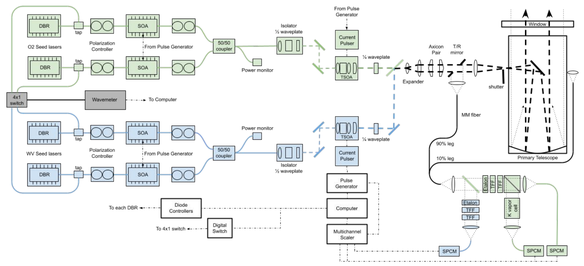
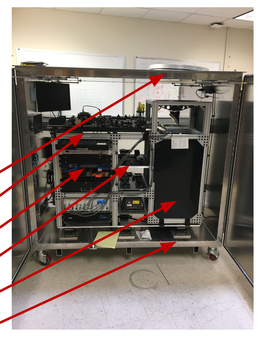
MPD Instrument, Network, and Testing

- Diode-laser-based design permits ***eye-safe*** and ***autonomous*** operation
- Leverages ***quantitative*** techniques: Differential Absorption Lidar (DIAL) and High Spectral Resolution Lidar (HSRL)
- MPD design: Combined water vapor DIAL, oxygen DIAL, and potassium based HSRL
- 5 unit testbed
- Data availability and resolution:
  - Range: typically to 4-6 km (WV), 3 km (Temperature), 8-10 km (HSRL) or cloud base
  - Time: typically 5 minute (WV), 20 minute (Temperature) and 1 minute (HSRL)



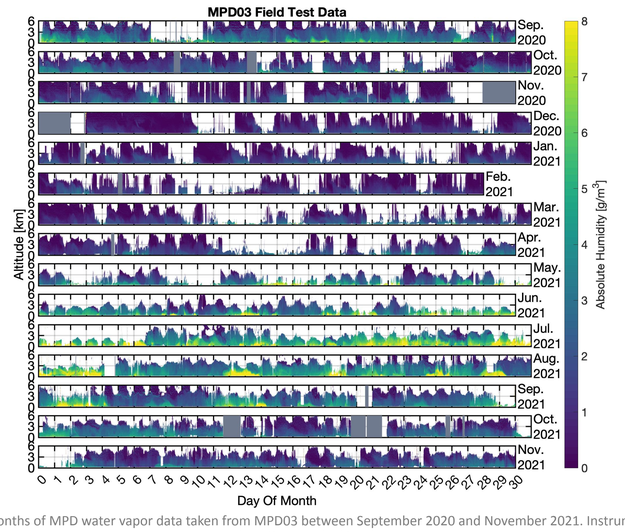
Block diagram of MPD systems (Blue: parts needed for water vapor, Green: parts needed for temperature measurements)

MPD field enclosures before deployment (2019)



MPD instrument in field enclosures (2019)

- Long term field testing at Marshall Mesa, Boulder, CO
- Total uptime: 98% (10,438 operational hours of 10,944 possible hours)

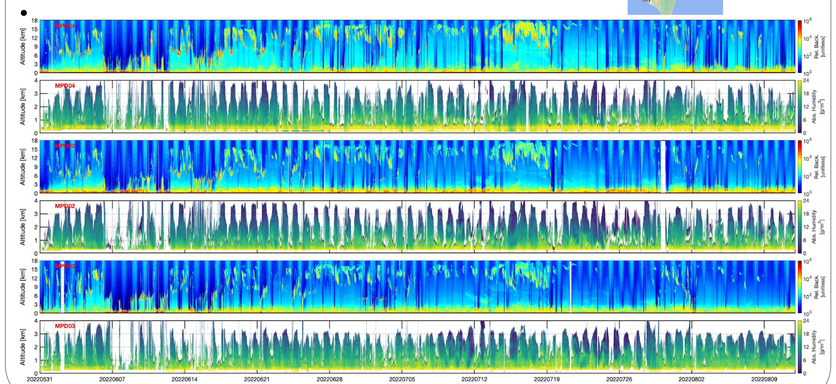


15 months of MPD water vapor data taken from MPD03 between September 2020 and November 2021. Instrument downtime marked in gray

Network Deployment: PRECIP (2022)

- First international deployment of MPD network
- Continuous operation for ~2.5 months with each > 99% uptime
- Only water vapor measurement capability deployed

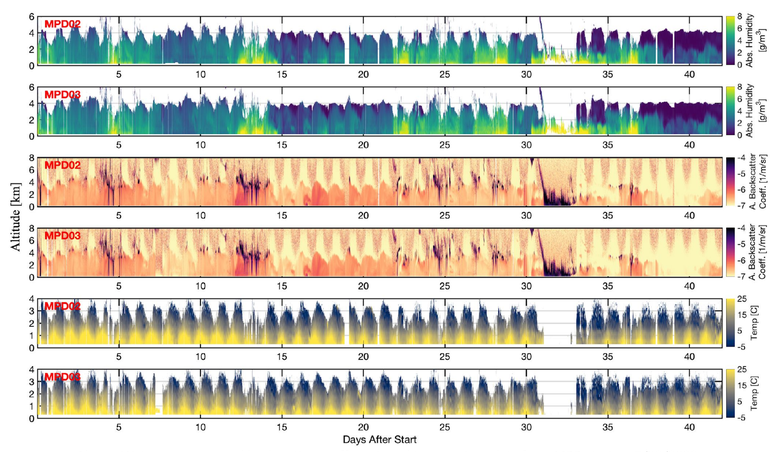
Location of the deployed MPD systems for PRECIP



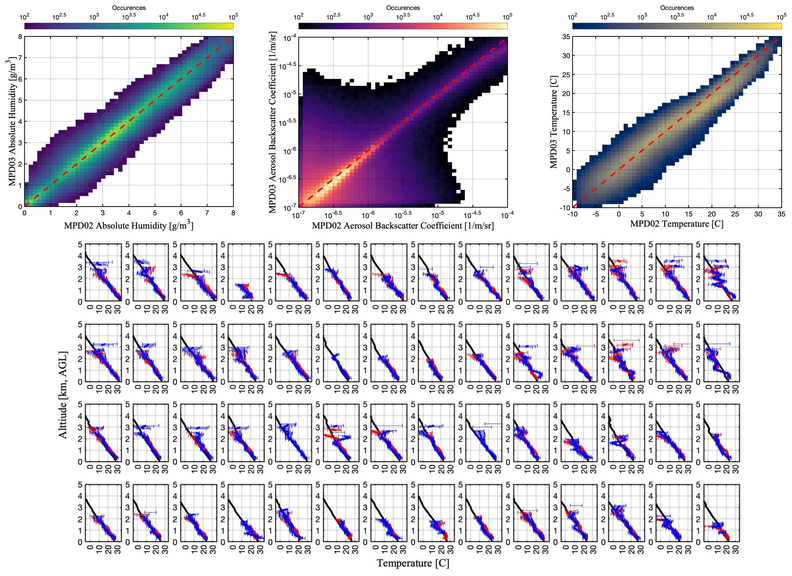
Time series of relative backscatter and absolute humidity from the 3 MPD systems deployed to the PRECIP field campaign

Thermodynamic Profiling: M2HATS (2023)

- Ongoing deployment of 2 collocated MPD systems to Tonopah, NV
- Full thermodynamic profiling capability deployed



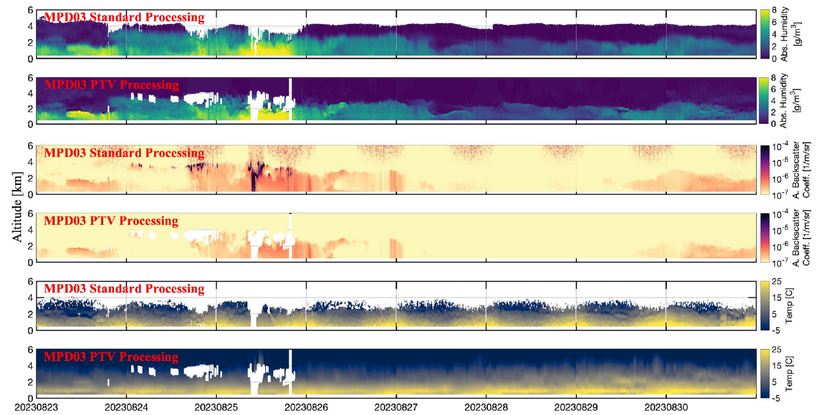
Above: Water vapor, aerosol backscatter coefficient, and temperature data from MPD starting 7/20/2023
Below: Comparisons of data from 7/20/2023 to 8/30/2023



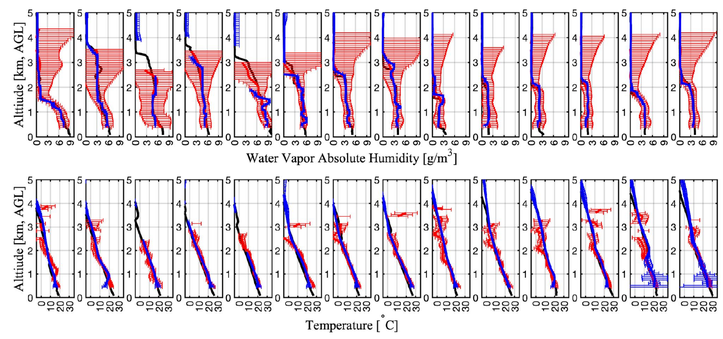
First month of Radiosonde temperature comparisons for MPD02 and MPD03. Launches done at ~10am and ~3pm local time

Advanced Retrieval Algorithms

- Data processing techniques that dynamically adjust to observed environment
- Major ***ongoing development effort*** to better leverage information content from signals
- Poisson Total Variation (PTV):
  - Forward model method used to simultaneously retrieve and denoise data products
  - Water vapor observations and a global retrieval for thermodynamic profiling



One week of data from MPD03 processed with standard methodologies and with PTV demonstrating both denoised and enhanced observational capability. Clouds are removed from PTV processing



Comparisons of Radiosondes, Standard Processing, and PTV for absolute humidity and temperature for 8/23/2023 to 8/29/2023

Ongoing Developments and Testing

- Technical readiness levels of measurements are currently assessed as: Water Vapor (8-9), HSRL (7-8), and Temperature (5-6)
- Currently finishing upgrades of all systems from water vapor to full thermodynamic profiling
- Temperature measurement field testing, co-location studies, and validation is ongoing or planned
- Component hardening is ongoing to improve reliability and overall instrument deployability
- Advanced algorithm development shows promise but is undergoing initial testing

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  - PRECIP: https://data.eol.ucar.edu/project/PRECIP (doi: 10.26023/JEV6-838G-180R)
  - M2HATS: https://data.eol.ucar.edu/project/M2HATS (doi: Not yet created, Ongoing)

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