Advanced Lidars for ARM: What Would We Get?

Dave Turner, Ed Eloranta
University of Wisconsin - Madison

CMWG Breakout Session
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What is an “Advanced Lidar?” (1)

- Ceilometer
  - Max range ~7km, unpolarized, uncalibrated
- Micropulse lidar (MPL)
  - Sensitive to clouds & aerosols throughout troposphere
  - Small telescope, rep rate is 1.5 kHz, microjoules of power
  - Loses sensitivity to cirrus in upper trop during the day
  - Polarization sensitive
  - Uncalibrated
- Backscatter signals measured by both the MPL and the Ceilometer are convolutions of molecular and particle scattering events
  - Unable to determine particle extinction without significant assumptions
  - Main use by ARM has been to determine layer boundaries

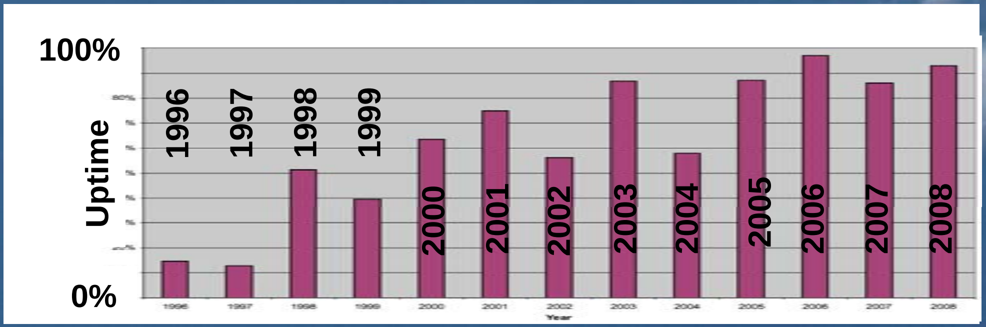
What is an "Advanced Lidar?" (2)

- Advanced lidars are able to directly measure the extinction due to particles directly
  - High-spectral resolution lidar (HSRL)
  - Raman lidar (RL)
- HSRL and RL measure backscatter from molecular targets
- Differences from a molecular density profile (computed from a temperature profile) indicate particulate extinction
- HSRL and RL extinction profiles are, by their nature, already calibrated

Additional Features

- HSRL and RL are both polarization sensitive
- Significantly larger signal-to-noise than MPL
  - Bigger lasers
  - Larger telescopes
- Able to detect cirrus throughout troposphere throughout the diurnal cycle
- RL is able to also measure profiles of water vapor (and temperature) throughout the boundary layer, and throughout the troposphere at night

Raman Lidar

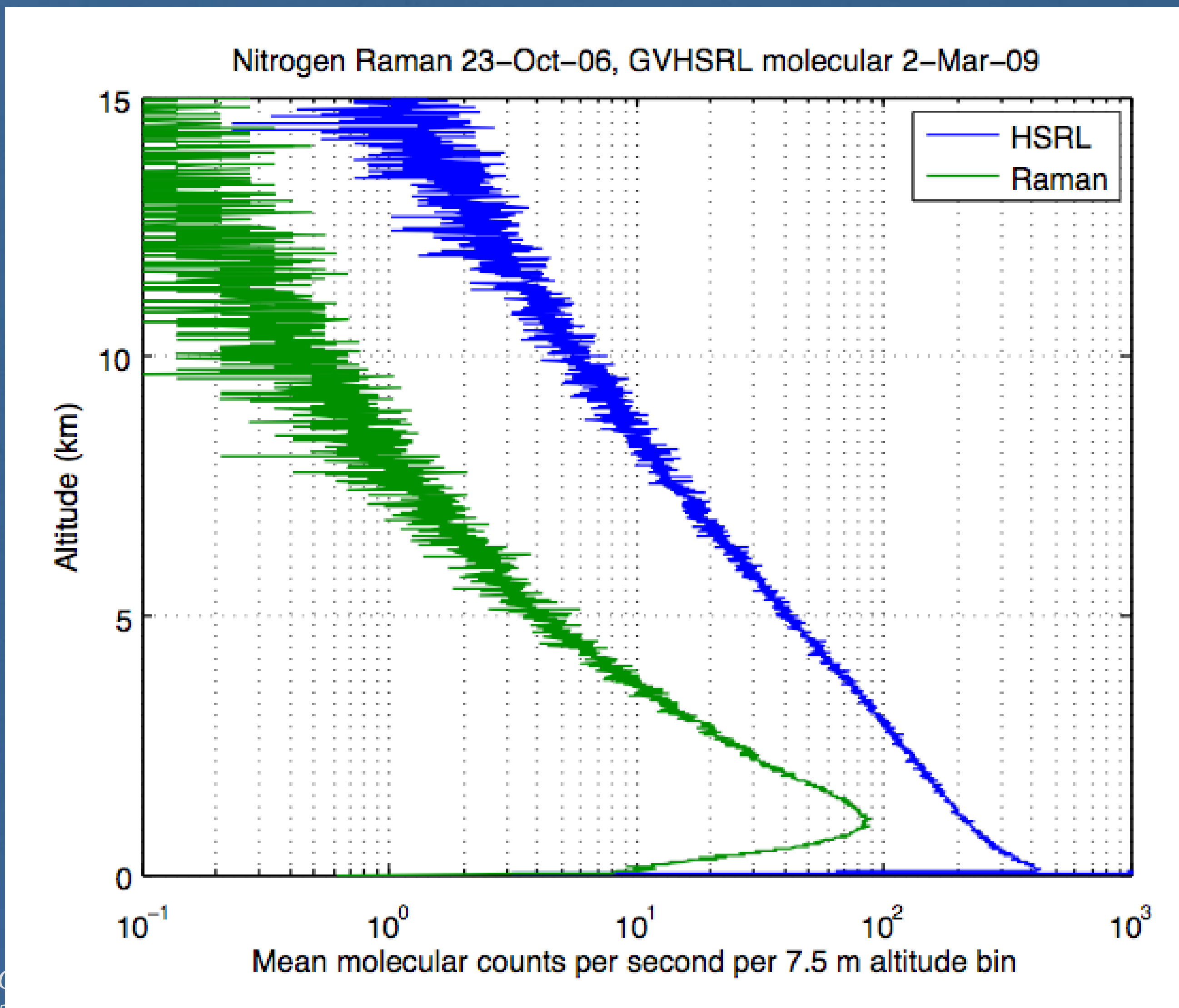


- SGP Raman lidar
  - Operational since 1998
  - VAPs developed to produce profiles of water vapor mixing ratio, RH, aerosol backscatter and extinction, linear depol ratio, cloud optical depth
  - Profile WV throughout the trop during the night (10-15 min resolution), and up to 5 km during the day
    - 10-s resolution on the water vapor and backscatter profiles in BL
  - 1-min resolution on the extinction profiles in the lower trop, 5-min resolution for extinction profiles in upper trop (< 15 km)
  - PIs have derived cirrus extinction and backscatter profiles, can be moved to operational VAPs in future
  - Has the capability to measure profiles of temperature (algorithm in development) -- anticipate range/resolution to be similar to the water vapor products

High Spectral Resolution Lidar

- Arctic HSRL developed for NOAA in 2003
  - Deployed to NSA site for M-PACE in Sep 2004 -- 2+ months of excellent operation
  - Relocated to NOAA SEARCH site in Eureka Canada in 2005
  - Uptime has been excellent, with only one period of downtime due to laser issues
  - Data (raw and processed) available from lidar.ssec.wisc.edu
  - Products are cloud optical depth, extinction, backscatter, and depolarization ratio
- Developing a new airborne HSRL for NCAR HIAPER
  - More robust, better temperature stability than A-HSRL
  - Better signal-to-noise then A-HSRL, better laser
- So how does the HSRL compare with the RL?

Strength of Molecular Return in Clear Skies: Raman vs. HSRL



- HSRL has > 10x the signal-noise ratio in molecular profile relative to RL
- ~10x better extinction profile

Advanced Lidar Summary

- HSRL extinction profile:
  - 10-s resolution in boundary layer (BL)
  - 1-min resolution in upper trop
  - Will be able to observe cirrus extinction up to 18 km
  - Polarization sensitive
- RL extinction profile
  - 1-min resolution in BL
  - 5-min resolution in upper trop
  - Will be able to observe cirrus extinction up to 15 km
  - Polarization sensitive
- Relative to MPL, both HSRL and RL
  - Have significantly larger S/N ratio than MPL
  - Directly measure the extinction profile with no assumptions
- RL is able to measure water vapor
  - Entire BL 24 hrs/day at 10-s resolution
  - Throughout the troposphere at night with 10-min resolution
  - Up to 5 km in day at 10-min resolution
- Algorithms exist to create these data products from both lidars

Approach to Measure LWP in Raining Conditions with the ARM MWRs

Dave Turner

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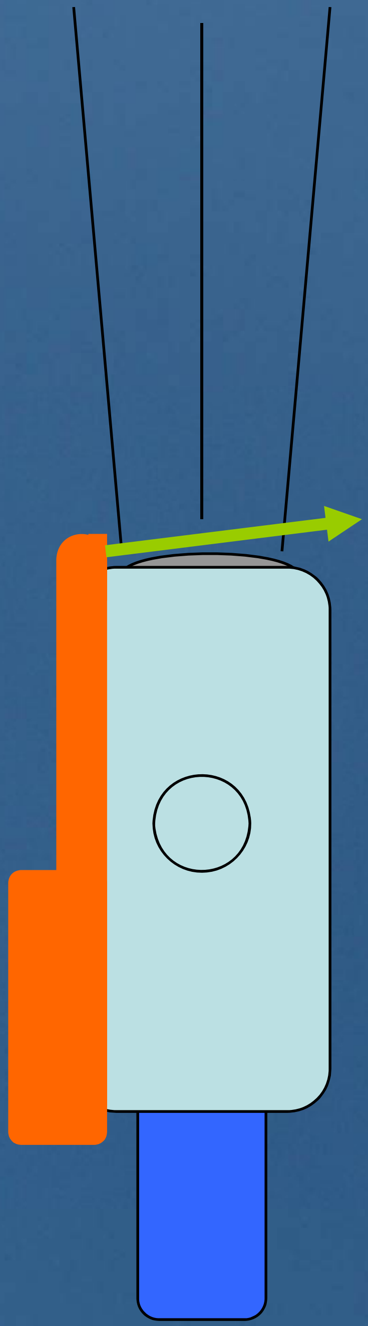
Two Problems Occur in Rain

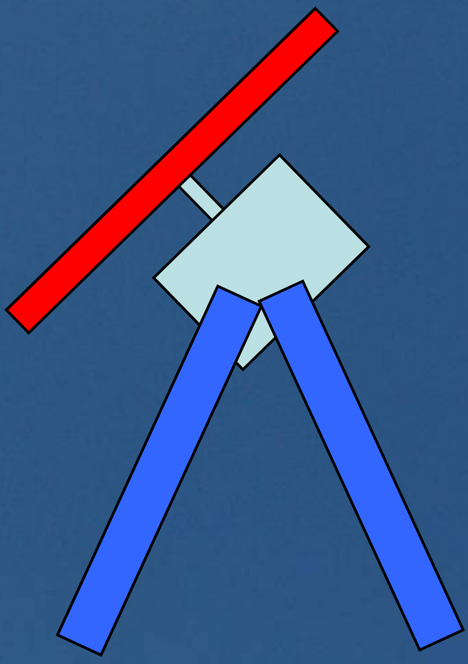
1. Rain hits and stays on the window, leading to an artificial signal

2. Signal saturates (atmosphere becomes opaque)

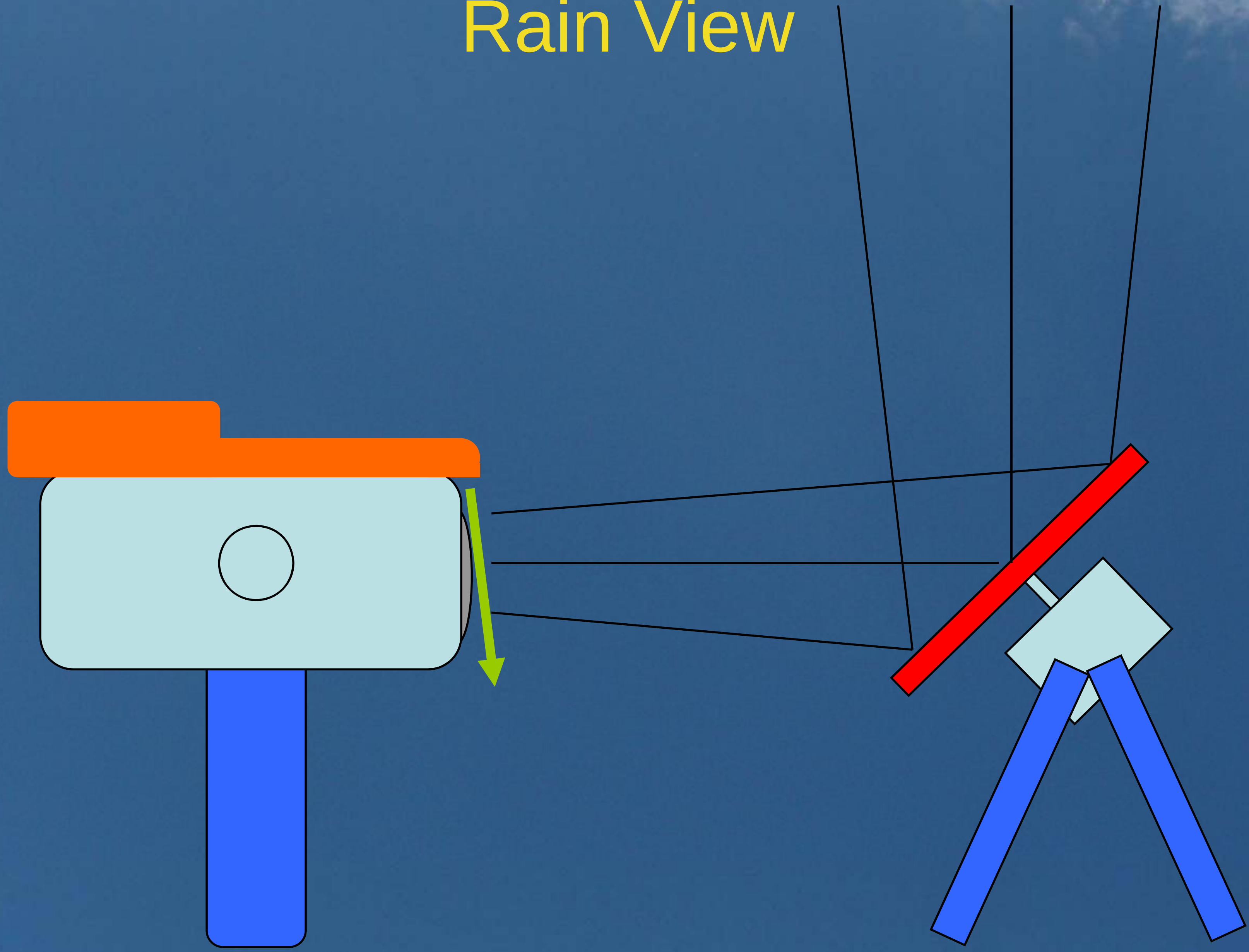
- Unable to do anything about #2 with our frequencies (need to use lower, less attenuating frequencies)
- Desire a (simple) solution for #1
  - Typical approach is to blow (warm) air across the window
  - A rotating mirror can be used (blantant copy of CU design)

Normal View





Rain View



Summary of Rain Mitigation Idea

- Simple engineering solution
- Inexpensive
- Should work well with the new 3-channel MWRs