Advanced Lidars for ARM: What Would We Get?

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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

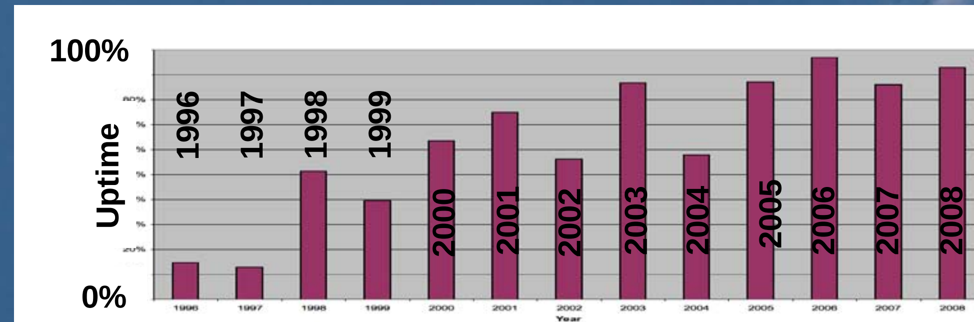
What is an "Advanced Lidar?" (2)

- 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

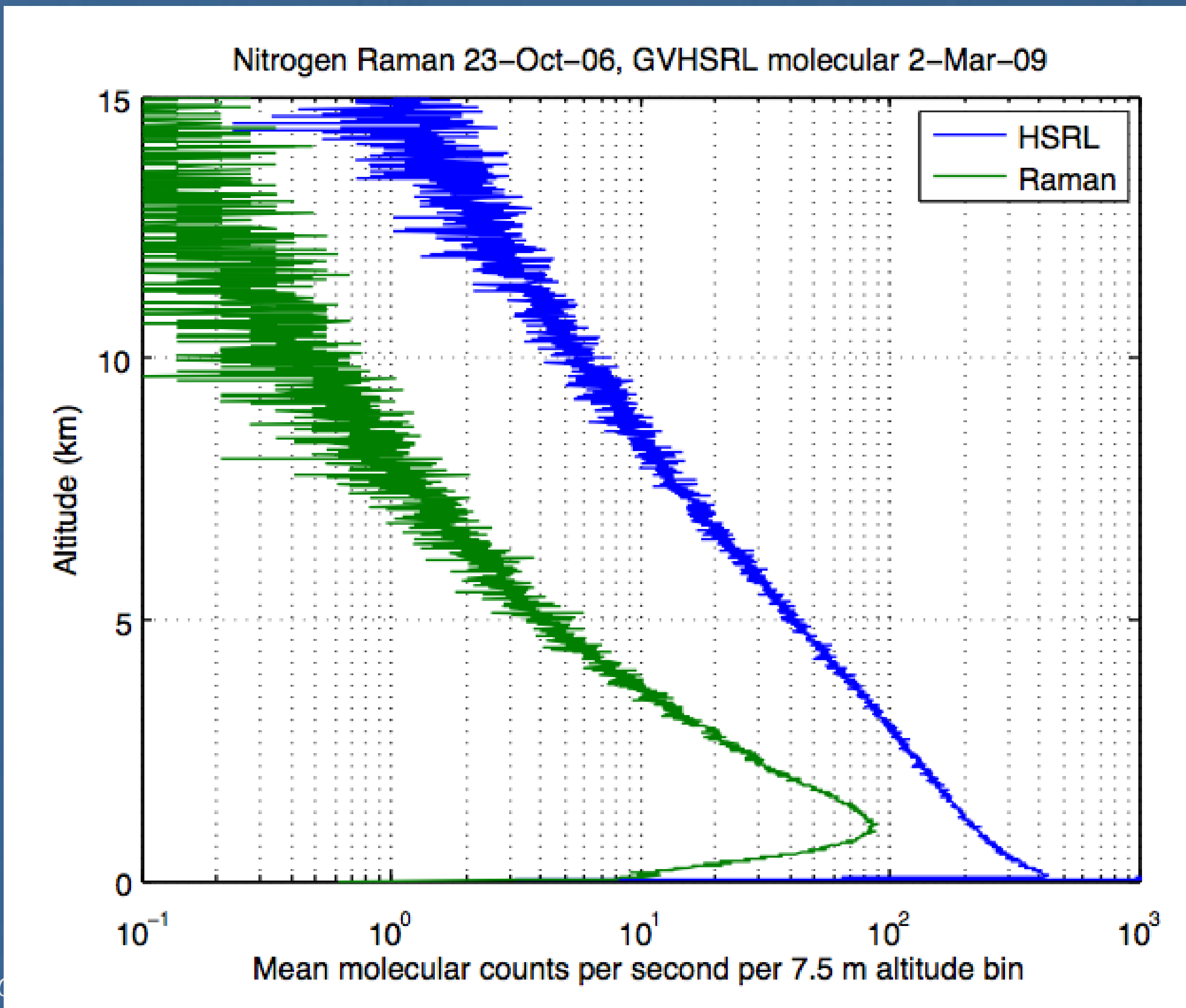


- SGP Raman lidar
  - Operational since 1998
  - VAPs developed to produce profiles of water vapor mixing ratio, RH, aerosol backscatter and extinction, linear depol ratio, cloud optical depth
  - Profile WV throughout the trop during the night (10-15 min resolution), and up to 5 km during the day
    - 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

30 Mar 2009

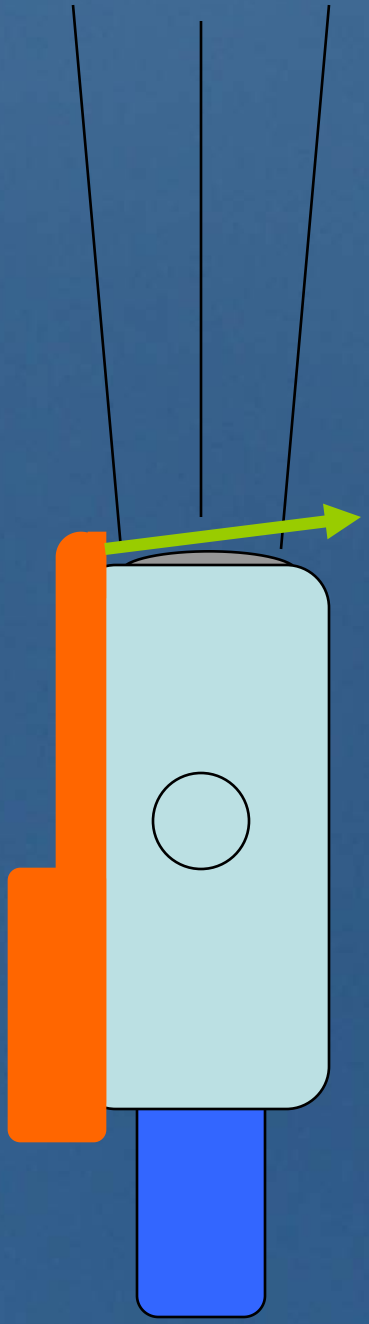
Two Problems Occur in Rain

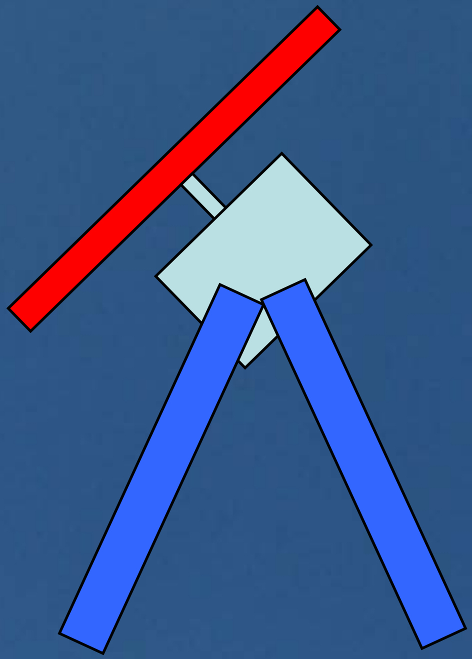
1. Rain hits and stays on the window, leading to an artificial signal

2. Signal saturates (atmosphere becomes opaque)

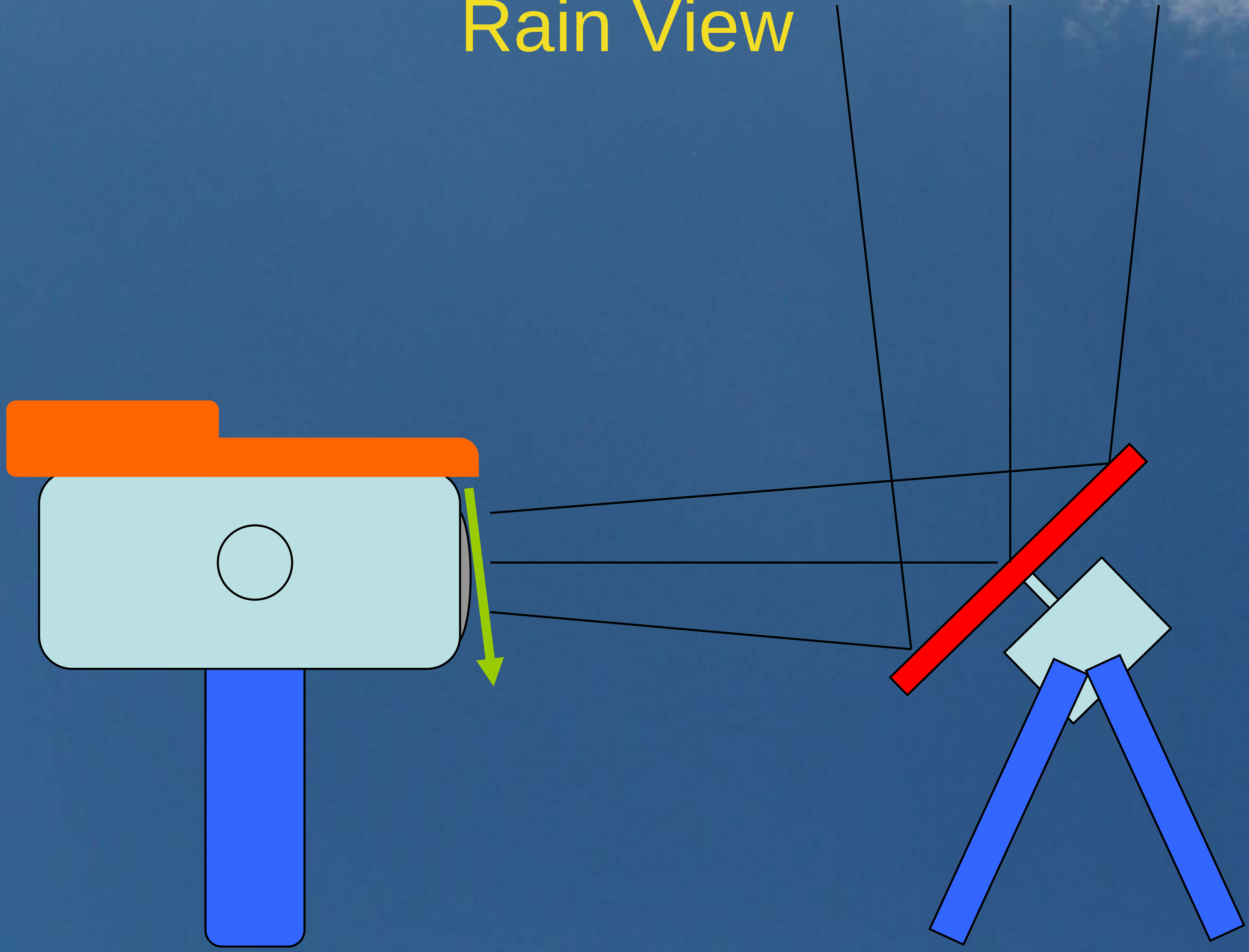
- Unable to do anything about #2 with our frequencies (need to use lower, less attenuating frequencies)
- Desire a (simple) solution for #1
  - Typical approach is to blow (warm) air across the window
  - A rotating mirror can be used (blantant copy of CU design)

Normal View





Rain View



Summary of Rain Mitigation Idea

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