Design of an Autonomous Polarized Raman Lidar for Arctic Observations

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Introduction
- Understanding microphysical properties of clouds and aerosols is crucial to understanding large-scale weather processes
- A dearth of high vertical and temporal resolution measurements in the Arctic contributes to modeling uncertainty which directly inhibits understanding of cloud radiative and precipitation impacts on the surface environment
- The Summit Polarized Raman (SuPR) lidar will be deployed to Summit, Greenland to measure water vapor, temperature, and polarization profiles
- Calibration will be done with radiosondes and ancillary instrumentation

Objectives
Primary Objectives (10 minute integrations with 7.5 meter resolution)
- Measure temperature with 10% precision to 20 [km]
- Measure depolarization with 5% precision to 30 [km]
- Measure water vapor number density to 10% precision to the tropopause
Secondary Objectives (10 minute integrations with 7.5 meter resolution)
- Measure Mueller matrix properties of clouds to 5% precision to 30 [km]

Theory
- Raman scattering is an inelastic scattering process
- One can use spectroscopic fingerprints to identify species

Design
- Simulations
  - Full Stokes vector treatment (Equation 1) [Hayman]. Note the box color around the figure corresponds to color coding in the equation or equation piece
  - Atmospheric data from MSIS or radiosonde
  - Background counts taken from UV spectrometer at Summit
  - Temperature dependent scattering cross sections (Stokes vectors) [Weitkamp]
  \[ \rho = \frac{\text{M}_\text{r}}{\text{M}_\text{r}} \left( \frac{\epsilon(r)}{\sigma} \Delta \text{R} \right) F \text{Atm}(k_r, r) F(k_i, k_r, r) F \text{Atm}(k_r, r) M \text{r}_r S I + S \rho (1) \]
- Simulated Retrievals
  - Using modeled photons, retrieval algorithms can be tested for accuracy
  - Seasonal variations in precision exist due to variations in sunlight and geophysical differences

Calibration
- By taking ratios of different signals, many terms of the lidar equation directly cancel
- An example of one such ratio is given for temperature retrieval (Figure 11)

Expectations
- SuPR will be constructed in Boulder, CO in 2014-2015 for testing
- SuPR will be deployed in 2016 for 3.5 years of atmospheric measurement
- The design is optimized for the weakest signal, water vapor

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References