Lidar Based Cloud Droplet Concentration Retrieval in Supporting Aerosol-Cloud Interaction Study in Low Clouds

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Motivations

• Droplet number concentration is important, but with limited observations.

• Expensive to collect a large dataset with aircraft

• Ground-base lidar measurements allow us to better link aerosol and cloud droplet concentrations.

Vogelmann et al. 2012
The Approach

• Combining lidar derived extinction with adiabatic LWC to estimate number concentration with assumed log-normal size distributions

• Assumptions:
  – Vertical consistent N in stratiform clouds
  – Within~200 m of stratiform cloud base, cloud vertical properties (LWC and extinction) close to adiabatic profiles.

\[
N = \frac{2\sigma^3 e^3 \sigma_x^2 \rho_w^2}{9\pi q_l^2} = C \frac{\sigma^3}{q_l^2}, \quad C = \frac{2e^3 \sigma_x^2 \rho_w^2}{9\pi}
\]
Multiple Scattering Correction In Lidar Measurements

• Two approaches
  – Using linear depolarization as a measure of MS contribution in attenuated backscattering coefficients (Hu et al. 2007).
  – Iterate correction:
    • Initial extinction retrieval -> MS calculation with Eloranta (1998) method → correct MS effect in the original signals--extinction retrieval -> MS calculation with Eloranta (1998) method → ...
    • Two iterations is enough normally.
Evaluation

In-situ Remote Sensing

\[ y = ax \]
\[ a = 1.3 \]
\[ r = 0.8 \]
MPL-based Retrieval Examples

- **Azores**: Remote ocean
- **MAGIC**: Remote ocean and coastal regions
- **Hefei**: Continental high aerosol loading and different types of clouds
MAJIC Cases

magmplpolsM1.b1.20130601.230001.cdf

Height (km)

P (db)

N (cm⁻³)
Hefei Cases

(a) 20080831

(b)
Droplet Concentration: aerosol vs dynamics?
Statistics from Limited Cases

Strong Regional Difference as expected.
Summary

• Perform well with MPL measurements for warm clouds, **but** more coding work to be done to process large among data.

• Can be implemented with HSRL.

• Offer new capabilities to facilitate aerosol-cloud interaction study with ARM observations:
  • **Aerosol properties**—surface sampling and lidar measurements
  • **Vertical velocity**—Radar and Doppler lidar
  • **Cloud properties**—Lidar + radar+radiometer
Future

• Develop a data base for process study and model evaluation.
HSRL-based Retrieval Example