Retrievals of Cloud Droplet Size from the RSP Data: Validation Using in Situ Measurements

Mikhail D. Alexandrov¹,², Brian Cairns², Kenneth Sinclair¹,², Andrzej P. Wasilewski³,², Luke Ziemb², Ewan Crosbie⁴, John Hair⁴, Yongxiang Hu⁴, Chris Hostetler⁴, Snorre Stamnes⁴

¹Columbia University, ²NASA Goddard Institute for Space Studies, ³Trinnovum LLC, ⁴NASA Langley Research Center

RSP on NAAMES Field Campaign
North Atlantic Aerosols and Marine Ecosystems Study (NAAMES) was based at St. John's airport, Newfoundland, Canada with the latest deployment in May - June 2016. RSP was onboard the NASA C-130 aircraft together with an array of in situ and other remote sensing instrumentation.

Research Scanning Polarimeter
Research Scanning Polarimeter (RSP) is airborne prototype to Aerosol Polarity Sensor (APS) built for NASA Glory mission.

Cloud droplet size retrieval algorithm
We utilize the scattering angle dependences of the polarized reflectances with the focus on the sharply defined rainbow structure within the scattering angle range between 137 and 165 degrees. The shape of the rainbow is determined mainly by single scattering properties of the cloud particles.

In situ validation during NAAMES field experiment
During NAAMES campaign a number of flight patterns were performed when C-130 flew along the same linear segment at one time at the cloud top making in situ measurements, and at another time above clouds where RSP could operate. We compare in situ droplet size distributions (DSD) retrieved from RSP data with in situ measurements made by the Cloud Droplet Probe (CDP). Distances between RSP and CDP ground tracks were about 200 m.

Comparisons for this segment are possible when C-130 is at cloud top. RFT inconclusive due to oscillations.

Deviations between RSP and CDP are due to a second DSD mode likely corresponding to another cloud layer.

Rainbow Fourier Transform (RFT)
Mie-theory-derived polarized reflectance $F(r, \gamma)$ as a function of reduced scattering angle (in the rainbow angular range) and the (monodisperse) particle radius appears to be a proxy to a kernel of an integral transform (similar to the sine Fourier transform on the positive semi-axis):

$$ F(r, \gamma) = \int_0^{\infty} n(r) F(r, \gamma) \, dr $$

This allows to retrieve the shape of the (area) droplet size distribution $n(r)$ by the application of the corresponding inverse transform to the observed polarized rainbow.

This non-parametric approach does not require any a priori knowledge of the droplet size distribution functional shape, no look-up tables, no fitting, computations are the same as for the forward modeling.

Acknowledgment
NAAMES field experiment and this research is funded by the NASA Earth Venture Suborbital Program.

RSP cloud retrievals are available from http://data.giss.nasa.gov/pub/rsp/