File Revision Date:
September 16, 2021

NDACC Mobile Aerosol and Temperature Lidar
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Data Products

Temperature - vertical profile from ground to >70 km
Aerosol products - vertical profile from ground - ~ 30 km at 351 nm, 532, nm and 1064 nm
Water Vapor – vertical profile ground to ~15kms.

Instrument Description

The GSFC Aerosol and Temperature Lidar is a combined Rayleigh-Mie, Raman backscatter lidar. Three wavelengths are transmitted, 1064, 532, and 355 nm (from a 50Hz, 1.0 J Continuum Nd-YAG laser) and 355 nm. The beams from the YAG laser are transmitted approximately 1-m from the receiving telescopes, a 36" Newtonian and a smaller 4” telescope (used for near-field returns). Five wavelengths are currently collected: 1064, 532, 408, 355, and 387 nm. The 1064 is recorded using analog detection, while the other wavelengths are all photon counted. Currently plans are in place to replace the analog channel with a PMT and go to photon counting for the 1064 nm as well. Spectral separation is accomplished using beam splitters and interference filters. Because of signal dynamic range issues, the 355 and 532 returns are further split - 5% of each is split into a second detector to make measurements at lower stratospheric altitudes. In addition, part of the 532 nm beam is sent via optical fiber to a monochromator where special filters allow the application of the Rotational-Raman temperature

retrieval technique. The system is currently is a 16 channel lidar (8 channels that are 355 related and 8 channels 1064/532 related).

Temperature is extracted from the Raman and elastic returns from the YAG laser, and also from the 532 signals via Rotational Raman technique. A relative density profile is constructed using the 355 nm returns above ~28 km, and the 387 nm return below. Together with the 4" telescope signals this allows retrieval of temperature from the ground to >70 kms. In addition, the Rotational Raman signals are used to retrieve temperature to ~30 kms. These retrievals are much less sensitive to the presence of clouds/aerosol layers.

Aerosol information is extracted from all the transmitted wavelengths. The ratio of the elastic return at 355 (532) nm to the normalized Raman return at 382 (607) are used. This is, in essence, the lidar ratio; no assumption of the extinction to backscatter ratio is required as in single wavelength techniques.

Water vapor is retrieved using the ratio of the 387 and 408 signals. After study of the results of the WAVES and MOHAVE campaigns, changes were made to the system to eliminate as much as possible 355 nm fluorescence effects from various optical components that might contaminate the 408 signal return.

This lidar instrument has been deployed to Table Mountain, Mauna Loa, and Beltsville for NDACC intercomparison campaigns.

Selected Measurement Campaigns

August, 1995 - February, 1996	MLO, Hawaii	NDSC/TOTE/VOTE/STRAT
February - March, 1997	Table Mountain, CA	STRAIT
Jun, 2005	Table Mountain, CA	3T-2005
Oct, 2006	Table Mountain, CA	MOHAVE-I
Jun-Aug, 2006	Beltsville, MD	WAVES-I
Jul-Aug, 2007	Beltsville, MD	WAVES-II
Oct, 2007	Table Mountain, CA	MOHAVE-II
Feb-Apr, 2008	Beltsville, MD	WAVES-III
Jan-Apr, 2009	Beltsville, MD	N-WAVES
Nov, 2011 – Feb. 2015	MLO, HI	NOJGIE

References - Technique

"Measurements of Stratospheric Aerosols with a Combined Rayleigh/Raman Lidar", M. Gross, T. J. McGee, U. N. Singh, and P. Kimvilakani , Appl. Opt., 34, 6915-6924, 1995.

"Temperature Measurements Made with a Combined Rayleigh-Mie/Raman Lidar," M. R. Gross, T. J. McGee, R. A. Ferrare, U. Singh, and P. Kimvilikani, Applied Optics, 24, 5987-5995, 1997.

References - Campaigns and Results

STRAIT '97: An aerosol lidar and backscatter sonde intercomparison campaign at Table Mountain Observatory during February-March 1997, G. Beyerle, M. R. Gross, D. A. Haner, N. T. Kjome, I. S. McDermid, T. J. McGee, J. M. Rosen, H.-J. Schaefer, and O. Schrems, In Press, J. Geophys. Res., March, 2000.

Beyerle, Georg, M. R. Gross, D. A. Haner, N. T. Kjome, I. S. McDermid, T. J. McGee, J. M. Rosen, H-J. Schäfer, and Otto Schrems. "A lidar and backscatter sonde measurement campaign at Table Mountain during February–March 1997: Observations of cirrus clouds." *Journal of the atmospheric sciences* 58, no. 10 (2001): 1275-1287.

Reichardt, Jens, Rudolf Baumgart, and Thomas J. McGee. "Three-signal method for accurate measurements of depolarization ratio with lidar." *Applied optics* 42, no. 24 (2003): 4909-4913.

Leblanc, T., McDermid, I.S., McGee, T.G., Twigg, L.W., Sumnicht, G.K., Whiteman, D.N., Rush, K.D., Cadirola, M.P., Venable, D.D., Connell, R. and Demoz, B.B., 2008. Measurements of humidity in the atmosphere and validation experiments (MOHAVE, MOHAVE II): Results overview.

Leblanc, T., I. S. McDermid, J. Howe, R. Aspey, T. D. Walsh, H. Vömel, T. G. McGee et al. "P1. 5 measurements of humidity in the atmosphere: Validation experiments (mohave) overview of the campaign and first results." *Meas. Tech. Discuss* 86 (2009).

McDermid, I. S., T. Leblanc, and T. D. Walsh. "Ground-based water vapor Raman lidar measurements up to the upper troposphere and lower stratosphere-Part 1: Instrument development, optimization, and validation, Atmos." *Meas. Tech. Discuss* 4 (2011): 5079-5109.

Leblanc, T., I. S. McDermid, and T. D. Walsh. "Ground-based water vapor Raman lidar measurements up to the upper troposphere and lower stratosphere for long-term monitoring." *Atmospheric Measurement Techniques* 5, no. 1 (2012): 17-36.

McGee, Thomas J., Laurence W. Twigg, Grant K. Sumnicht, Thierry Leblanc, and John Barnes. "Results of a Longer Term NDACC Measurements Comparison Campaign at Mauna Loa Observatory." In *EPJ Web of Conferences*, vol. 119, p. 05015. EDP Sciences, 2016.

McGee, Thomas J., Laurence W. Twigg, John T. Sullivan, Thierry Leblanc, John Barnes, Grant K. Sumnicht, and Stuart McDermid. "Lidar validation measurements at the NOAA Mauna Loa Observatory NDACC station." In *Lidar Remote Sensing for Environmental Monitoring XVI*, vol. 10779, p. 107790D. International Society for Optics and Photonics, 2018.