COMPACT REMOTE RAMAN, FLUORESCENCE, AND LIDAR MULTI-SENSOR INSTRUMENT FOR CHARACTERIZATION OF PLANETARY SURFACES AND ATMOSPHERE FROM ROBOTIC PLATFORM. M.N. Abedin[1], C.S. Garcia[2], T.F. Refaat[2], S. Ismail[1], A.T. Bradley[1], S.K Sharma[3], A.K. Misra[3], B. Robinson[4], and J. Hibberd[4], [1]NASA Langley Research Center, Hampton, VA 23681 (**m.n.abedin@nasa.gov**), [2]Old Dominion University, Norfolk, VA 23529, [3]University of Hawaii, Honolulu, HI-96822, [4]Science Systems Applications, Inc, Hampton, VA 23666.

Lidar measurements from the Phoenix Mars Lander [1-2] of precipitating ice clouds demonstrated the usefulness of lidar systems in planetary missions. NASA Langley Research Center (LaRC) in collaboration with University of Hawaii is developing a compact combined remote Raman/Fluorescence spectroscopy and Lidar instrument for measuring surface mineralogy, surface organic materials and atmospheric constituents from planetary rovers and landers. This instrument is based on inelastic (Raman) and elastic (Mie-Rayleigh) light scattering active remote sensing system. Mineralogical and surface organic information were obtained by using the instrument in the Raman-Fluorescence mode and results presented [3-4]. Atmospheric aerosols and cloud distributions are obtained by operating the instrument in the lidar mode and experimental results are reported here at the first time. In this study, the combined instrument uses a Photomultiplier Tube (PMT) for 532 nm atmospheric lidar operations and an intensified CCD detector for measuring remote Raman-Fluorescence spectra of materials on the surface. The laser excitation source for the combined instrument is a Compact Space-Qualifiable Laser Optics Module (mini Nd: YAG pulsed laser with three laser lines, 355-, 532-, and 1064-nm) with active Q-switch procured from Fibertek. The laser head has a volume of about 1600 cm^3 and a mass of 2.1 kg when the mechanical components are fabricated from aluminum. The laser follows the heritage of successful development of space-qualified Nd: YAG laser for the CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) mission at NASA LaRC. In this paper, we only emphasize the lidar technology. Lidar return signals are reported in this article, which were detected at two different times. Figures 1 and 2 show lidar range corrected return signals that were recorded on October 9, 2008, in the evening of the cloudy sky and on August 20, 2010, in the morning of the shiny sky without any cloud at NASA LaRC.

Laser beam was pointed vertically to collect atmospheric returns through PMT. The return signals from thin clouds and aerosols were detected by the PMT with 4-inch telescope and 532 nm laser with a pulse energy of 27 mJ at 20 Hz repetition from Big Sky Laser, Inc. Lidar system was aligned using low-level clouds in the cloudy sky at 2.7 km thin cloud as target, as specified in signal profiles for both return signals and color images in Figures 1a and 1b. The signals presented in this figure were analyzed with range correction $((S - B)*R^2$, where S is the signal, B is the background and R is the range. The atmospheric return signals and images in Figure 1 are represented by the signal (a.u.) in the vertical axis and the range (km) in the horizontal axis. Figure 1a shows two-layer thin cloud signals at 2.7 km and 4.8 km distances using the PMT along with the near-field boundary layer signals. Figure 1b shows return signal images from two-layer thin clouds at 2.7 and 4.8 km and near field boundary layer aerosol distributions at ~0.2 km distances. It was observed that small amplitude signal from top cloud layer was detected by the PMT, but relatively large signals from the bottom layer cloud target were monitored by the same PMT.

Figure 2 shows background range corrected atmospheric features of the return signals with the PMT, 4-inch telescope, and Fibertek space-qualifiable laser (used only 532 nm laser line with 16 mJ/pulse at 20 Hz repetition). The range spans between 0.0 to 7 km altitudes in Figure 2. The atmospheric signal profile and color image represent the backscattered range corrected signal. The time scale represents the time span between 0- to 7000-sec, which corresponds to the data collection time. Results show near-field aerosol boundary layer features from <0.1 to 3 km, but significant noise is observed beyond 4 km due to low signals and range square effects..

We will discuss integrated remote Raman, Fluorescence, and Lidar instrument, which can be used for studying minerals, ices and organic compounds on the surface of Mars, Moon, Titan, Europa, and other icy satellites of outer planets and for characterizing the distribution of dust and aerosols as appropriate.

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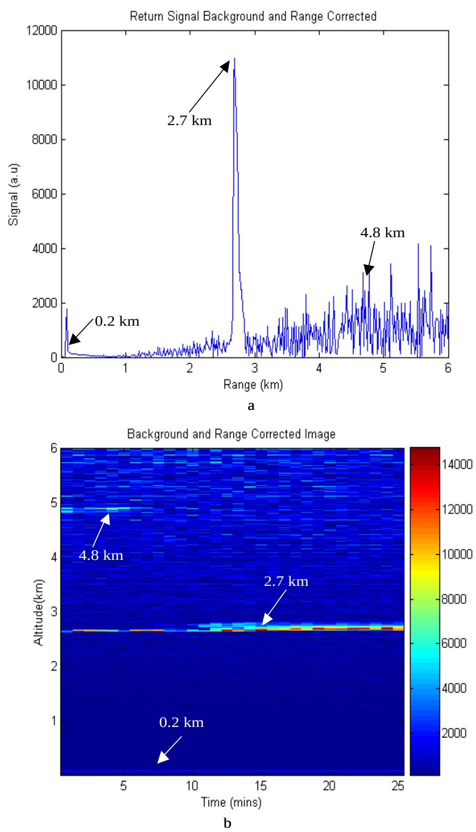

Figure 1. Atmospheric return signal profile (a) and return signal images (b) with 1 sec average (20 shot averages). Lidar return signals were recorded on October 9, 2008, in the evening of the cloudy sky at LaRC.

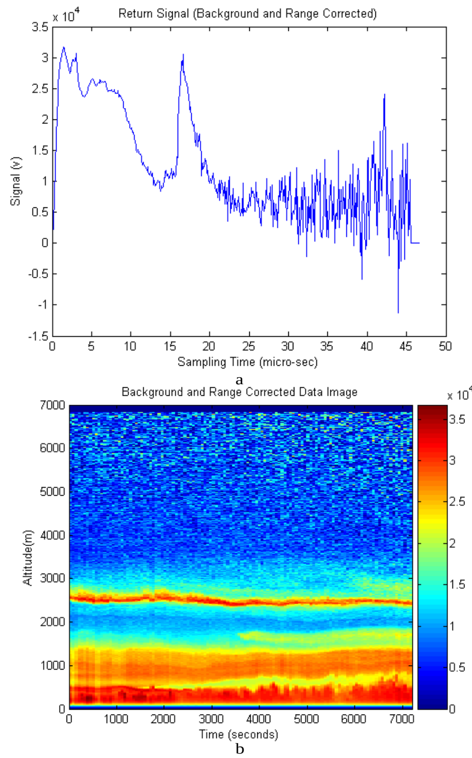

Figure 2. Atmospheric range corrected signals obtained on August 20, 2010 during 10:00 to 11:57 AM local time showing several layers of aerosols including a low level boundary layer over 0.0 to 0.5 km, an aerosol layer above the boundary layer over 0.5 to 1.3 km altitude, and a narrow plume in the free troposphere at ~2.5 km altitude ; (a) average profile of all data collected over 0-7 km; (b) image of data collected with 1 minute (1200 shot) averaging to reduce noise.