STROZ Lidar Results at the MOHAVE III Campaign, October, 2009, Table Mountain, CA

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Abstract

During October, 2009 the GSFC STROZ Lidar participated in a campaign at the JPL Table Mountain Facility (Wrightwood, CA, 2285 m Elevation) to measure vertical profiles of water vapor from near the ground to the lower stratosphere. On eleven nights, water vapor, aerosol, temperature and ozone profiles were measured by the STROZ lidar, two other similar lidars, frost-point hygrometer sondes, and ground-based microwave instruments made measurements. Results from these measurements and an evaluation of the performance of the STROZ lidar during the campaign will be presented in this paper. The STROZ lidar was able to measure water vapor up to 13-14 km ASL during the campaign. We will present results from all the STROZ data products and comparisons with other instruments made. Implications for instrumental changes will be discussed.

Introduction

The Measurements of Humidity in the Atmosphere and Validation Experiments (MOHAVE) 2009 campaign took place at the JPL Table Mountain Facility (TMF) on October 12-26, 2009. MOHAVE 2009 was an extended version of the MOHAVE and MOHAVE-2 campaigns held at TMF in October 2006 and 2007. These campaigns allowed a thorough evaluation of the Raman Lidar measurements throughout the troposphere by comparing to RS92 radiosonde and Cryogenic Frost-Point Hygrometers profiles.

The MOHAVE 2009 hosted the same instruments as in 2006 and 2007, but also three additional instruments and/or techniques, leading to the correlative measurement of temperature and water vapor from the ground to the mesopause, and ozone from the ground to the stratopause. Three primary goals of the MOHAVE 2009 campaign were to:

- Identify and quantify UT Humidity (UTH) changes associated with transport processes in the vicinity of the Sub-Tropical Jet
- Estimate the capability of the Raman lidar in detecting such UTH changes
- Provide continuous water vapor profiles from the ground to the mesosphere by combining the measurements of the various participating instruments and techniques, including sonde, lidar, and microwave.

In order to achieve these goals, simultaneous and co-located measurements included the following:

- 4 water vapor Raman lidars (JPL/Leblanc, GSFC/McGee(STROZ and AT lidars) and GSFC/Whiteman) [0-20 km]
- 15 CFH launches (JPL/Leblanc and GSFC/Whiteman) [0-30 km and total column]
- 3 NOAA Frost-point Hygrometer (FPH) launches (NOAA/Hurst) [0-30 km and total column]
- 50 RS92 launches (JPL/Leblanc and GSFC/Whiteman) [0-12 km and total column]
- 2 improved microwave radiometers (NRL/Nedoluha and Univ.

Bern/Kampfer) [20-80 km and total column]
- 1 FTIR (JPL/Toon) [total column]
- 2 GPS receivers (JPL/Leblanc, NOAA/Gutman and Whiteman/GSFC) [total column]

To optimize the lidar range, the core of the campaign was centered near Oct 19 at the occurrence of the new moon. Additional high priority nights (i.e., selected timing and increased density of the measurements and balloon launches) corresponded to the Aura MLS, Aura TES, Aqua AIRS, ACE, and MIPAS best coincidence with TMF. The campaign operations were adjusted in real time following the most favorable atmospheric conditions. High-resolution PV analysis and forecasts from the MIMOSA transport model (Hauchecorne/CNRS) supported the measurement planning.

The GSFC AT lidar had serious laser problems and was not able to provide scientifically useful data during the campaign, but the STROZ lidar was operational on 10 of the 14 campaign nights providing ozone, water vapor temperature and aerosol profiles. Data is currently being analyzed and preliminary results were presented at a campaign workshop in February. As the STROZ instrument had not participated in the earlier MOHAVE campaigns, this represented the best opportunity to demonstrate the capabilities of the STROZ lidar at a site which is well situated for upper troposphere/lower stratosphere water vapor measurements.

STROZ Lidar and Results

The GSFC STROZ Lidar is a mobile instrument developed as a traveling intercomparator within the Network for the Detection of Atmospheric Chemical Change (NDACC). The instrument has been operational since 1989, and recently underwent modification to add five detection channels for the measurement of tropospheric water vapor and aerosols. The modifications also included a more powerful YAG laser. The instrument had made measurements at GSFC and Beltsville, MD during the WAVES campaigns, but the MOHAVE 2009 campaign was the first effort from a high altitude, dry site where the tropopause could be reached. During the campaign, the STROZ was operated in two different modes: for water vapor, the XeCl excimer laser used to provide stratospheric ozone data was not fired; at the same time the field of view of the instrument was closed down to 1 mRad, reflecting the substantially better divergence of the YAG laser output. On nights when an ECC sonde was flown with a water vapor sonde, an ozone measurement was made, generally prior to the sonde launch. When this was done the FOV of the telescope was set to 2.3 mRad, to maintain a full overlap with the XeCl beam. Water vapor data is also retrieved in this configuration, but the upper altitude is limited by the increased ambient background. It was also noted early in the campaign that the STROZ lidar suffered from the same fluorescence contamination that had been seen in the JPL, AT, and SRL lidars during previous MOHAVE campaigns. Because of this fluorescence, a filter blocking the 355 backscattered radiation was placed in front of the telescope collimating lens, thereby removing almost all of the interference. For the periods when the blocking filter was not in place, the upper altitude data was empirically corrected by determining a scaling factor based on the 387 nm lidar return.

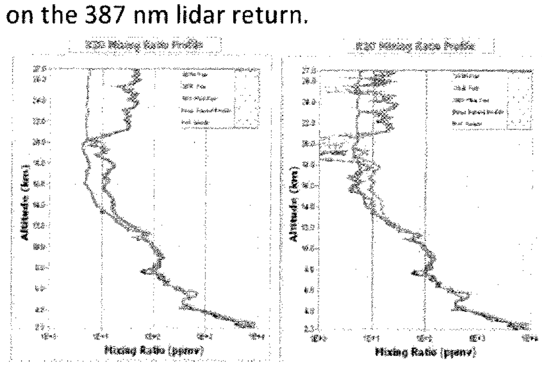

Figure 1. The water vapor profile retrieved during the night of 10/16/2009. The left panel shows the FPH sonde (purple) along with uncorrected STROZ lidar data. The wet bias is clearly visible above 12 km; the corrected data is in the right panel.

After 10/16, water vapor data was acquired at the reduced FOV, and with the blocking filter in place during the period after the sonde launch. Figure 2 shows the "curtain" plot of water vapor data for the night of 10/19/2009, showing dry air entering the troposphere from the stratosphere. The center part of the plot is data collected with the blocking filter in place, while the left and right regions are data without the filter, but corrected to remove the fluorescence contamination.

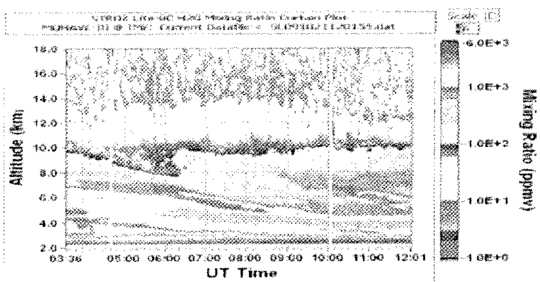

Figure 2 A "curtain" plot of water vapor above TMF on October 19, 2009. Data at the left and right ends of the panel have been corrected for fluorescence.

Figure 3 shows the average of the MOHAVE 2009 STROZ water vapor data with respect to the ALVICE water vapor data during the campaign in the left panel, while the right panel shows the average of the daily differences between the two datasets. The STROZ data

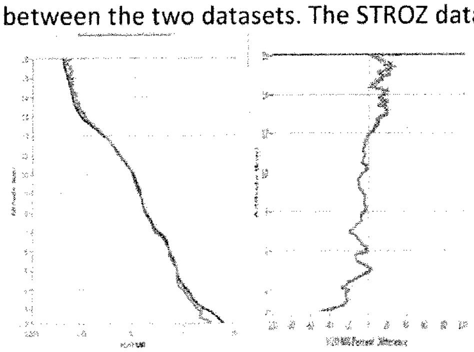

Figure 3 A comparison of the average of STROZ water vapor measurements (Red) during MOHAVE 2009 with ALVICE results (Blue) showing a STROZ dry bias near the ground and a wet bias above 12 km.

show a definite slope with respect to the ALVICE data – wet at the top and dry at the bottom. Currently the causes of these differences are being investigated and the results will be shown at the Conference.

The STROZ lidar also retrieved vertical profiles of temperature, ozone and aerosols during the campaign and many of those results will also be presented at the conference. As an example the results of the ozone measurements with respect to the JPL lidar ozone profiles are shown in Figure 4 below. The average of each instrument is shown in the left panel, and the average of the differences of each night's measurements is shown on the left. As in the past there is good agreement between the instruments and the disagreements can mostly be explained by differences in time of measurement, vertical resolution, and signal-to-noise.

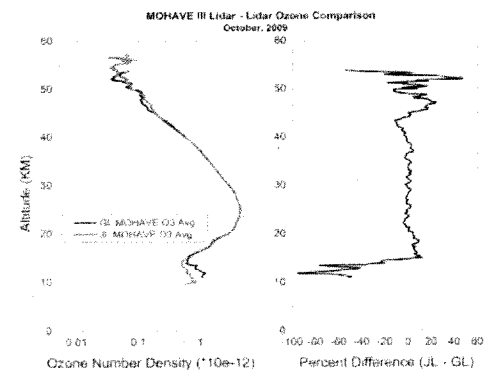

Figure 4 Comparison of ozone profiles retrieved by the STROZ lidar (black) and the JPL Ozone Lidar (red). The right panel shows percent difference of the ozone measurements.