312 METHODOLOGY FOR THE VALIDATION OF WATER VAPOR PROFILE ENVIRONMENTAL DATA RECORDS (EDRS) FROM THE CROSS-TRACK INFRARED MICROWAVE SOUNDING SUITE (CrIMSS): EXPERIENCE WITH THE DOE ARM WATER VAPOR RAMAN LIDAR

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1. INTRODUCTION

Water vapor is a key component of the Earth's hydrologic cycle that plays an important role in the intensity of severe weather and hurricanes. Numerical weather prediction models are expected to show improved forecast skill when water vapor remote sensing observations are assimilated from operational weather satellites. Accurate water vapor vertical profiles retrieved from satellite radiances will also provide a valuable climate record for evaluation of NWP reanalysis products and for validating climate models.

NASA and NOAA are operating the NPP satellite with CrIS and ATMS in a PM orbit while the European METOP IASI sensor occupies an AM orbit. Radiance data and retrieval products from both these platforms will contribute to weather forecasts from NWP centers. This paper describes the methodology developed for validation of the water vapor vertical profiles from the CrIS and ATMS (CrIMSS) Environmental Data Records (CrIMSS EDRs). The approach uses ground-truth measurements from the Department of Energy Atmospheric Radiation Measurement sites; Southern Great Plains (SGP) and Tropical Western Pacific (TWP). In addition to Vaisala radiosonde profiles, a validation profile of water vapor mixing ratio profile will be obtained from a ground-based ARM Raman Lidar at the SGP and TWP sites. These Raman profiles obtain their absolute calibration from a ground-based Micro-wave Radiometer (MWR) operating nearby. Matchups of these data will be analyzed to make an independent assessment of the accuracy of the operational CrIMSS EDRs. The purpose of this study is to demonstrate a methodology for using ARM Raman lidar water vapor mixing ratio profiles in the validation of satellite retrievals. NASA AIRS science team Level 2 products are used as a proxy for the CrIMSS EDRs.

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2. DATA

2.1 ARM RAMAN LIDAR

The U.S. Department of Energy Atmospheric Radiation Measurement (DOE ARM) program has established several measurement sites in tropical, mid-latitude, and arctic climate zones (Ackerman and Stokes 2003). At two of these sites, Lamont, Oklahoma and Darwin, Australia, an automated Raman water vapor lidar has been installed (Turner et al. 2002). Figure 1 shows a photo of the Raman lidar trailer in Oklahoma. Figures 2 and 3 are mixing ratio cross-sections from the ARM SGP site.

Figure 1. DOE ARM Raman Lidar at SGP site.

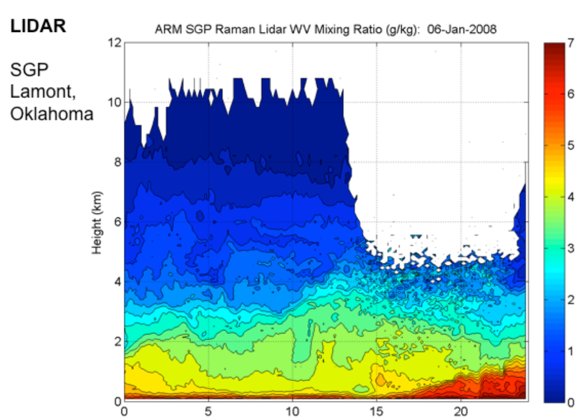

Figure 2. Raman lidar mixing ratio cross-section.

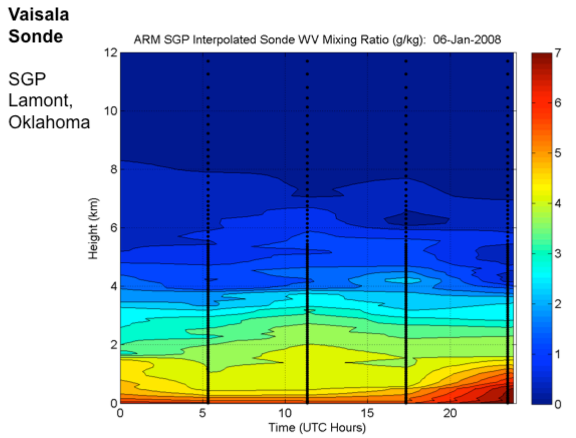

Figure 3. Radiosonde mixing ratio cross-section.

2.2 AIRS

The AIRS (Atmospheric InfraRed Sounder) instrument is a hyperspectral, scanning IR sounder aboard the A-train satellite Aqua (Aumann et al. 2003). It measures 2378 IR spectral channels over the range of 3.7 – 15.4 μm with a spatial resolution of 13.5 km at nadir, as well as 4 Vis/NIR spectral channels with a spatial resolution of approximately 2.3 km. AIRS attains complete global coverage daily using cross-track scanning, divided into granules of 6 minutes of calibrated radiance data containing 135 scan lines of 90 cross-track fields of view between ±49.5°. AIRS science team retrieval products (L2 v5) used in this study were obtained from the GES DISC.

3. METHODOLOGY

Overpasses from the sun synchronous Aqua satellite occur at local times at approximately 1:30 am and 1:30 pm about every three days. For each overpass an average Raman lidar profile was computed with a signal to noise ratio of 4:1 or more. Night-time Raman profiles were routinely obtained at the ARM SGP site to a height of more than 10 km as shown in Figure 4. However, day-time profiles could only be obtained with a 4:1 S/N ratio to about 5 km above the surface. Vaisala radiosondes are routinely launched from the ARM SGP site four times per day (Revercomb et al. 2003). A time interpolation of the radiosonde mixing ratio profiles was computed at each Aqua overpass time. These radiosonde profiles were also interpolated to the Raman lidar vertical height bins for consistency. AIRS L2 profiles were also interpolated to the Raman vertical height bins.

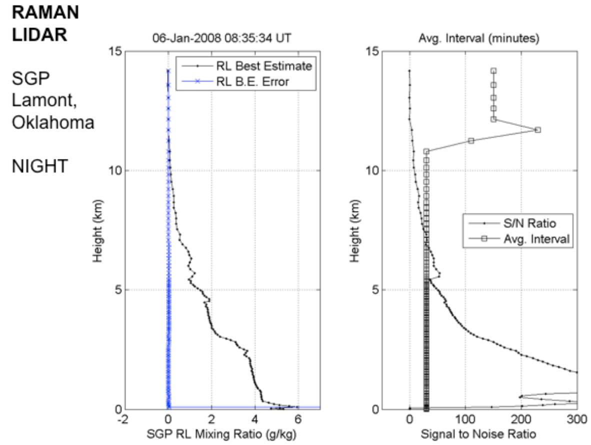

Figure 4. Night-time example of weighted mean Raman lidar mixing ratio profile (left) and averaging interval with corresponding signal to noise ratio (right).

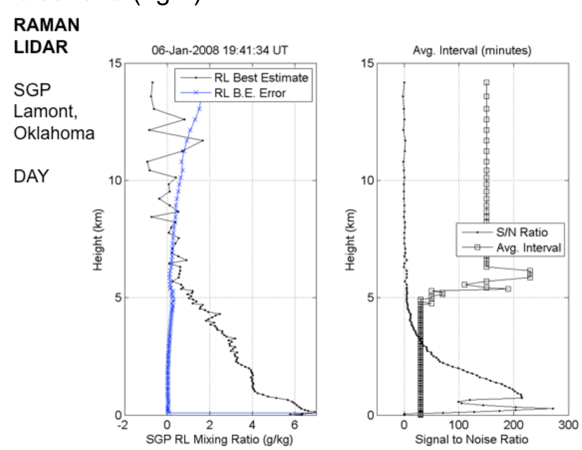

Figure 5. Day-time example of weighted mean Raman lidar mixing ratio profile (left) and averaging interval with corresponding signal to noise ratio (right).

4. RESULTS

Overpass times of the DOE ARM SGP site in the year 2008 were used to determine average Raman lidar profiles as shown in Figure 6. The profiles that extend above about 5 km are night-time Aqua overpasses. The largest mixing ratio values occur in the summer time in the atmospheric boundary layer. For each Aqua overpass, the difference profiles AIRS-RAMAN, AIRS-SONDE, and RAMAN-SONDE were computed. These difference profiles can be used to assess the accuracy of the satellite retrievals through comparison to two independent validation data types. Figure 7 illustrates these difference profiles for night-time winter and summer profiles.

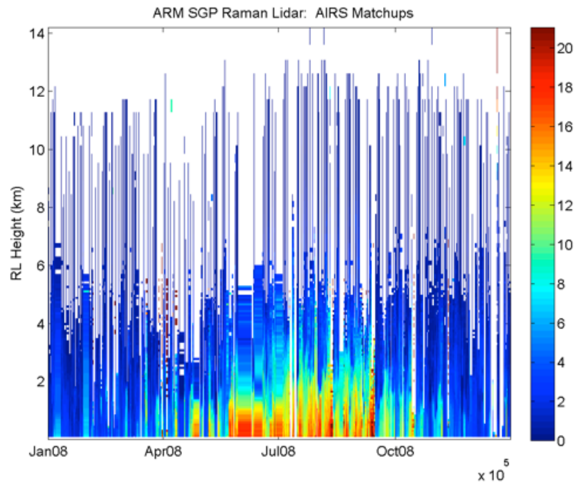

Figure 6. Raman lidar mixing ratio profiles for each Aqua overpass during 2008.

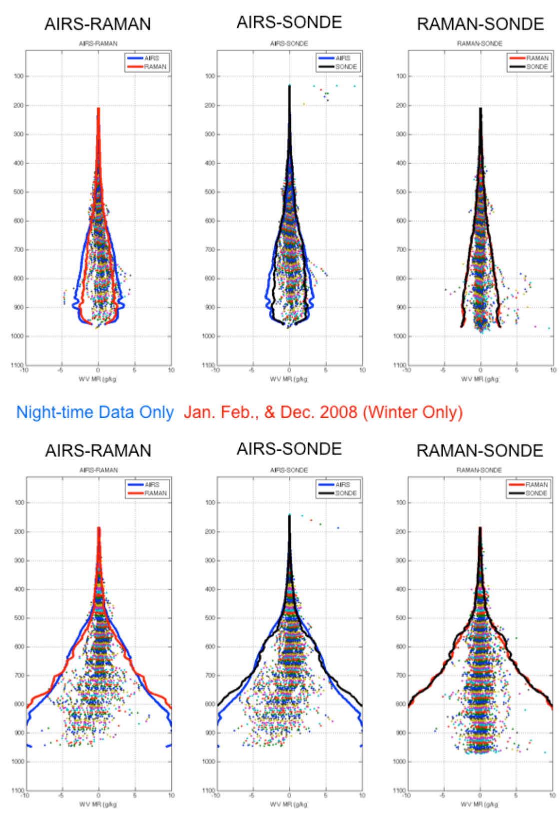

Figure 7. Mixing ratio difference profiles for each Aqua overpass during 2008; winter (upper panels) and summer (lower panels). The solid lines represent the standard deviation of the measurements for each data type.

The Raman and sonde measurements are in good agreement for both winter and summer showing zero mean, no height bias, and low variability. The AIRS retrievals show greater variability and a height dependent bias in the summer time.

5. CONCLUSIONS

Preliminary assessment has been performed of a methodology for using ARM Raman lidar and Vaisala radiosondes to validate NASA AIRS L2 retrievals. Results show a dry bias in AIRS L2 version 5 for summer, night-time observations in the Southern Great Plains. This is confirmed using time-interpolated radiosonde profiles. The result is consistent with Bedka et al. 2010 that showed a similar dry bias in PWV from MWR and ground-based GPS data. This method will be used for the assessment of accuracy of CrIMSS EDRs when they become available.

6. REFERENCES

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