Characterization of Water Vapor in the North American Monsoon with JLH and Aura MLS data

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ABSTRACT

Several NASA ER-2 flights during SEAC4RS sampled the UTLS region heavily influenced by the North American Monsoon (NAM). Here we present in-situ water vapor measurements from the newly improved JPL Laser Hygrometer (JLH) to characterize the NAM water vapor field during August and September 2013. Regional context is provided by the Aura Microwave Limb Sounder (MLS).

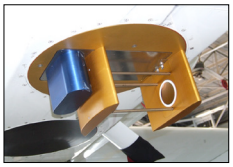

Fig. 1. The JLH Mark2 instrument mounted in the forward Q-bay camera port of the NASA ER-2 aircraft during the SEAC4RS mission.

New JLH features

- Athermal mechanical mounting.
- Aerodynamic mirror holders.
- Reduced noise on tunable diode laser (TDL) electronics.
- Direct absorption spectral fitting.
- HITRAN 2012 linelist.

Error Estimate

- Spectroscopic temperature dependence: 5%
- TDL wavelength tuning rate: 6%
- Spectral fitting in data analysis: 5%
- Absorption line strength: 3%
- Temperature and pressure: 1%
- Optical pathlength: 0.1%

Acknowledgements

JLH participation in SEAC4RS was funded by the NASA Upper Atmosphere Research Program. We thank Patrick Minnis for the use of cloud images, Laura Pan for helpful discussions, Jose Landeros for field support, and the aircraft crew for making these measurements possible. Part of this research was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

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Water Vapor in the Lowermost Stratosphere

Recent publications have highlighted the importance of convectively injected water vapor into the lowermost stratosphere [Anderson et al., 2012; Schwartz et al., 2013]. We examine UTLS water vapor measured over the continental U.S. during the SEAC4RS time period. Figure 2 shows Aura MLS H_2O at 100 hPa for July-August 2013. Individual events of H_2O > 8 ppmv (white circles) are likely due to local convection. The broad feature of H_2O > 5.5 ppmv is due to the NAM. Figures 3 and 4 compare Aura MLS H_2O from July-August 2013 with the decade 2004-2013.

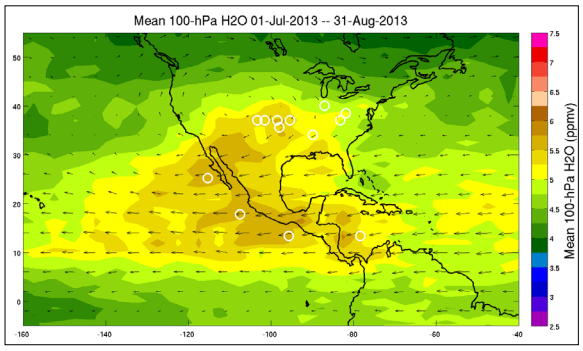


Fig. 2. Aura MLS 100-hPa H_2O (color scale), with superimposed MERRA horizontal winds (arrows) for July-August 2013 during the SEAC4RS time period. MLS observations of 100-hPa H_2O greater than 8 ppmv in this two-month period are shown by the white circles.

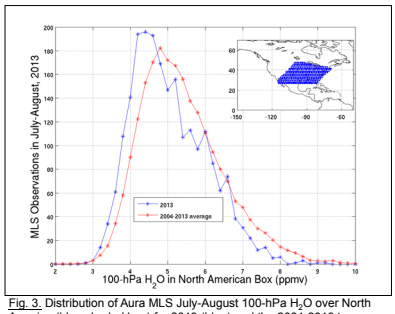


Fig. 3. Distribution of Aura MLS July-August 100-hPa H_2O over North America (blue shaded box) for 2013 (blue) and the 2004-2013 ten-year average (red).

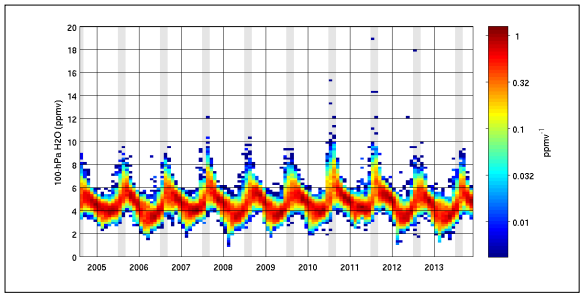
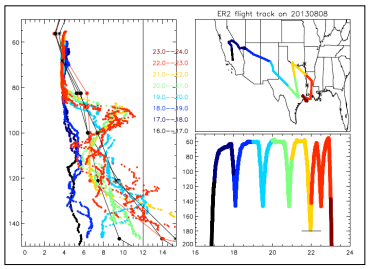


Fig. 4. Time series of Aura MLS 100-hPa H_2O over North America. Each monthly histogram is normalized to unity over mixing ratio. Dashed black vertical lines mark year boundaries, and gray-shaded areas denote July-August (after Schwartz et al., 2013).

NASA ER-2 profiles

Below are water vapor profiles measured by JLH during three NAM flights: 8 August, 14 August, and 16 August 2013.



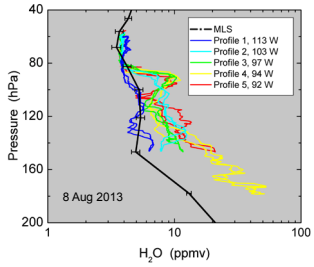
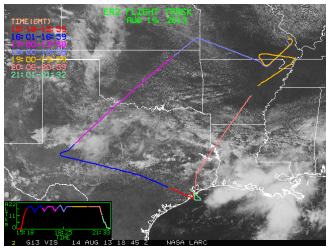


Fig. 5. 8 Aug 2013 observations of LS water vapor by JLH and MLS. **Left panel:** 8 Aug 2013 H_2O profiles from JLH (dots color-coded by profile), coincident MLS scans (lines with circles), and JLH with the MLS averaging kernel applied (line with asterisks). **Lower right panel:** time series of ER-2 pressure color-coded by profile. The MLS overpass and JLH data with averaging kernel applied are all from 22h UTC (yellow profile). **Upper right panel:** ER-2 flightpath (color-coded by profile) and MLS geolocations (asterisks).



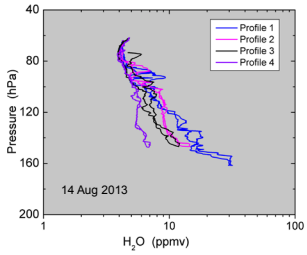
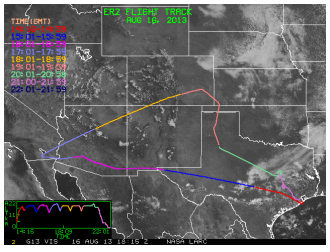


Fig. 6. 14 Aug 2013 flightpath (left) and JLH water profiles (right), color-coded by profile. The images were obtained from the NASA Langley Cloud and Radiation Research Group, http://angler.larc.nasa.gov/satimage/products.html.



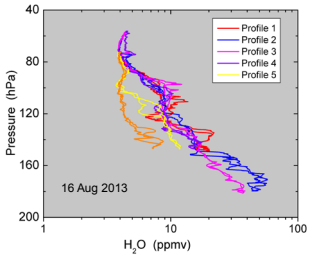


Fig. 7. 16 Aug 2013 flightpath (left) and JLH water profiles (right), color-coded by profile. The images were obtained from the NASA Langley Cloud and Radiation Research Group, http://angler.larc.nasa.gov/satimage/products.html.

SUMMARY

JLH provided UT/LS water vapor measurements from the NASA ER-2 during SEAC4RS. Aura MLS measurements indicate that the 2013 summer was slightly drier at 100 hPa than the average of 2004-2013 summers. MLS 100-hPa H_2O was observed to exceed 8 ppmv only nine times over the CONUS in July-August 2013. JLH frequently observed enhanced H_2O in the lowermost stratosphere between 160 and 80 hPa. On NAM ER-2 flights in August, the southern flight legs tend to have more UTLS moisture than the northern flight legs.