High Resolution Spectra of Atmospheric Water Vapor in the Near IR Using a Raman Shift Alexandrite Laser

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Abstract

We report the successful development of a tunable narrow line laser transmitter for near-infrared water vapor bands in the 730, 820, 940, and 1140 nm regions. The source laser is a flashlamp pumped alexandrite ring laser seed injected with a tunable diode laser. As a first test of the platform we measured the atmospheric transmission of the water vapor spectrum near 1140 nm from which the line strengths and air-broadened halfwidths for 15 lines were determined. These measurements were made to support the development of a water vapor/temperature lidar adaptable to a wide range of atmospheric humidities. The water vapor band was accessed through the first Stokes Hydrogen Raman conversion of the alexandrite laser. The diode laser, fiber optically coupled to the alexandrite, was also used to independently observe oxygen A-band rotational lines. The Raman-shifted oxygen wavelengths provided convenient references for the water vapor spectrum. The alexandrite laser linewidths are 10 MHz (765 to 770 nm) and 20 MHz (i.e., <0.001 cm^{-1}) at 1140 nm. The measured linestrengths and linewidths are compared to the HIgh-resolution TRANsmission database (HITRAN-2000). Relative to this database, our observed line strengths are larger by a factor of 1.28 (±13%) on average, and the line widths by 1.13 (±21%). Precisions vary from line to line, so these are only representative comparisons to HITRAN-2000. In Figure 1, an example absorption coefficient spectrum is shown from which linestrengths and halfwidths were measured. In Figure 2, these are compared with HITRAN and recent theoretical predictions from Nasa Ames Research Center. This research is supported by the U.S. Army Research Office under Contract No. DAAG-55-97-1-0297. Purchase of the alexandrite laser was made possible by a grant from the National Science Foundation.

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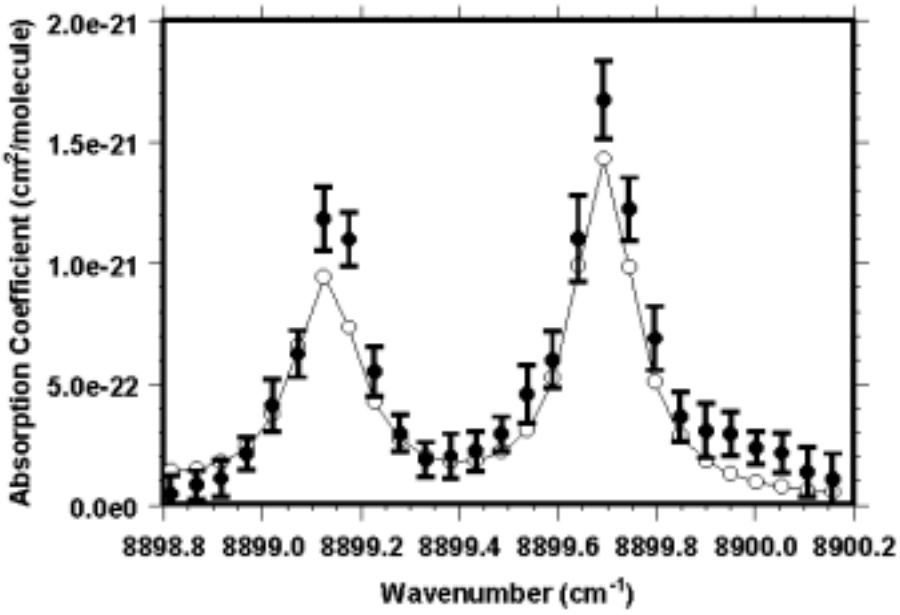

Figure 1. Measured absorption coefficient of water vapor near 8899 cm^{-1} (solid circle) compared with Voigt prediction using HITRAN-2000 database.

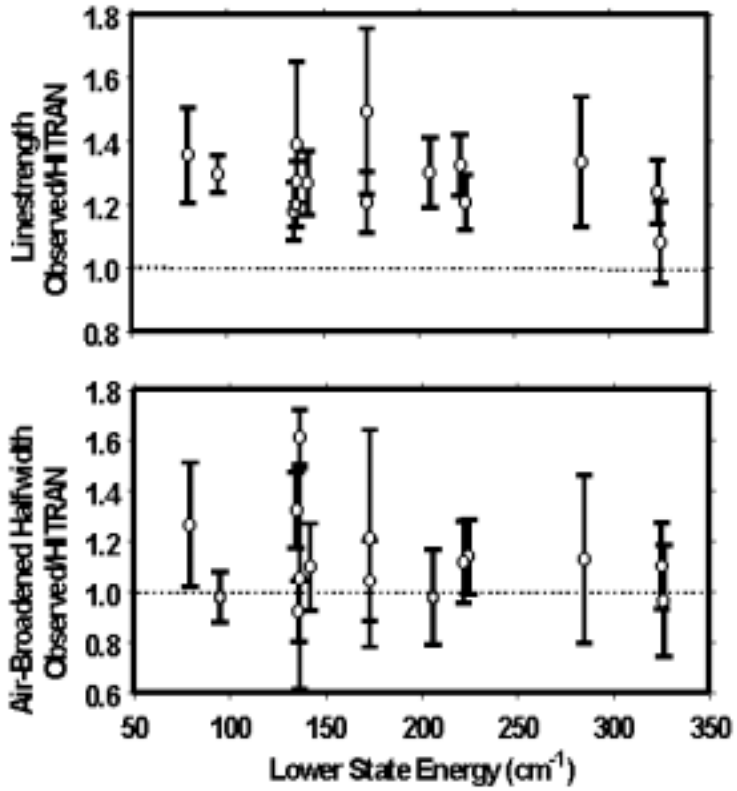

Figure 2. The ratio of measured linestrengths (top) and measured air-broadened halfwidths (bottom) with HITRAN-2000 as a function of lower state energy.