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# Fast, sensitive, and large dynamic range hygrometer for HIAPER using a vertical cavity surface emitting laser

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Water vapor exhibits great influences on the Earth's climate and atmospheric dynamics by absorbing longwave radiation, altering both shortwave and longwave fluxes through cloud formation, and determining latent heat fluxes. Despite its ubiquitous importance at all levels of the atmosphere, water vapor is rather poorly characterized. For example, in the tropopause region accurate levels of water vapor are needed to assess stratospheric trends of water vapor, mechanisms of stratosphere-troposphere exchange, and the presence of metastable forms of ice such as cubic ice or nitric acid coated ice. In the lower troposphere, fast and accurate water vapor measurements will help assess latent heat fluxes from the boundary layer to the free troposphere. The NSF/NCAR HIAPER Gulfstream-V aircraft is a unique platform that can help address these issues in the troposphere and lower stratosphere. However, no existing water vapor instrument exhibits the large dynamic range (five orders of magnitude in absolute concentration) necessary for the troposphere and lower stratosphere while still maintaining high sensitivity and fast response times.

To this end, a hygrometer is being developed for HIAPER using a vertical cavity surface emitting laser (VCSEL) operating near 1854 nm. VCSELs have much broader spectroscopic tuning ranges than existing laser-based hygrometers. The wide tuning range of the 1854 nm VCSEL allows for two bands of water vapor to be probed: a weak line at 1853.37 nm for moist conditions and a strong line at 1854.03 nm for low levels of water vapor. In combination, the entire range of tropospheric and lower stratospheric water vapor can be measured. An open-path, multiple pass (n=24) optical cell will reside outside the aircraft boundary layer, thereby minimizing the influence of instrument surfaces on the measurement. Drag on the aircraft is being reduced by using a pair of small (1.9 cm diameter) and thin (0.95 cm wide) mirrors with a

separation of 14 cm and by housing the laser and other electronics inside the aircraft. A fiber optic directs laser light to the external, open-path cell and prevents residual water vapor (e.g. inside the aircraft) from interfering with the ambient measurements. The laser light is collected by an extended wavelength InGaAs detector that is mounted in one of the optical cell mirrors. Laboratory spectra and calibrations, especially at the ppmv levels, will also be discussed. Overall, the HIAPER hygrometer will probe water vapor at a frequency of 25 Hz and have an accuracy of 5%.