

NO. 159 CALIBRATION OF LOW H₂O METER

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ABSTRACT

An independent calibration is presented of the Low hygrometer, used extensively at this Laboratory during the past five years. For water-vapor amounts smaller than 3 mm, Dr. Low's calibration is confirmed. For larger amounts, a small systematic difference appears to exist which needs further investigation. Adequate allowance for the atmospheric pressure must be made in the interpretation of the measures.

Infrared astronomical observations require a knowledge of the atmospheric water-vapor absorption in the spectral interval of interest. The hygrometer developed by F. J. Low and A. W. Davidson (1965) is a very practical instrument, requiring no outside power supply, which enables the observer to make integrated water-vapor measures in daytime whenever required; and makes possible also convenient intercomparisons between different observatory sites, or even from aircraft (Kuiper, 1970). The purpose of this paper is to provide an independent calibration of the Low hygrometer used at this Laboratory during the past five years.

The detector in Dr. Low's device is a photodiode with a spectral response roughly equal to an S1 surface. Two narrow interference filters, coupled with a red filter cutting out all shorter wavelengths, isolate two narrow regions, centered on the 0.935 μ water-vapor band and on the nearby continuum at 0.89 μ ,

respectively. The ratio of the two readings defines the water-vapor absorption in the 0.935 μ water-vapor band.

Dr. Low calibrated the 935/890 ratio in terms of precipitable water vapor in the path. He obtained the zero water-vapor ratio from high altitude flights, with appropriate allowance for differential absorption in the aircraft window; and obtained the remainder of the relationship from data supplied by the U.S. Weather Bureau in Washington. The resulting calibration is found in *LPL Comm.* No. 158, Table A.

The new observations were made with the 1.4 μ water-vapor band as the intermediary, since with our laboratory setup it was more convenient to use than the 0.935 μ band. Solar spectra were obtained at the Catalina Observatory, Site I (elevation 8260 ft, $p = 740$ mb), using the A-spectrometer (Kuiper *et al.*, 1962). Simultaneously, water-vapor readings

in the solar beam were obtained with Dr. Low's hygrometer. Thereupon, laboratory runs were made with the same spectrometer, using the multiple-path 40-meter absorption tube at $p = 714$ mb for the longer path lengths; and the laboratory room itself, $p = 940$ mb, for the shorter path lengths. The amounts of H_2O were determined by measuring the moisture content of the laboratory air with the sling psychrometer. It is realized that some uncertainty is attached to such measures; the present recalibration is not considered definitive.

All spectra, solar and laboratory, so obtained, were measured with a planimeter for the derivation of the total absorption W of the 1.4μ band. The W values are plotted against the square root of the amounts of water vapor in Fig. 1. The closed circles give the relationship for the absorption-tube spectra, $p = 714$ mb; the open circles for the short-path laboratory spectra, $p = 940$ mb. It is seen that for H_2O amounts below 1 mm, the square root relation roughly applies. For larger values, the 1.4μ band approaches saturation (Kuiper, 1970, Fig. 9) and the further increase occurs more slowly.

The H_2O readings with the Low hygrometer are indicated by crosses. They appear to accord well with the open circles for values less than 1 mm H_2O , both calibrated essentially at $p = 1$ atm. For larger H_2O values, a divergence occurs with the $p =$

714 mb curve approximately, but not precisely, as expected from the pressure ratio. At $W = 70, 80, 90,$ and 100 , the (ratio)² between the curves in Fig. 1 are .79, .73, .67, and .62, respectively, whereas the slope for the Low points falls below the square root relation beyond $W = 90$. We may say, therefore, that for Low readings < 2.2 mm the values are confirmed and are still reasonably confirmed upward to 3 mm; but may require some scaling up beyond. However, the 1.4μ band is not very suitable for these larger H_2O amounts and a further calibration with the 0.935μ band itself is planned for them.

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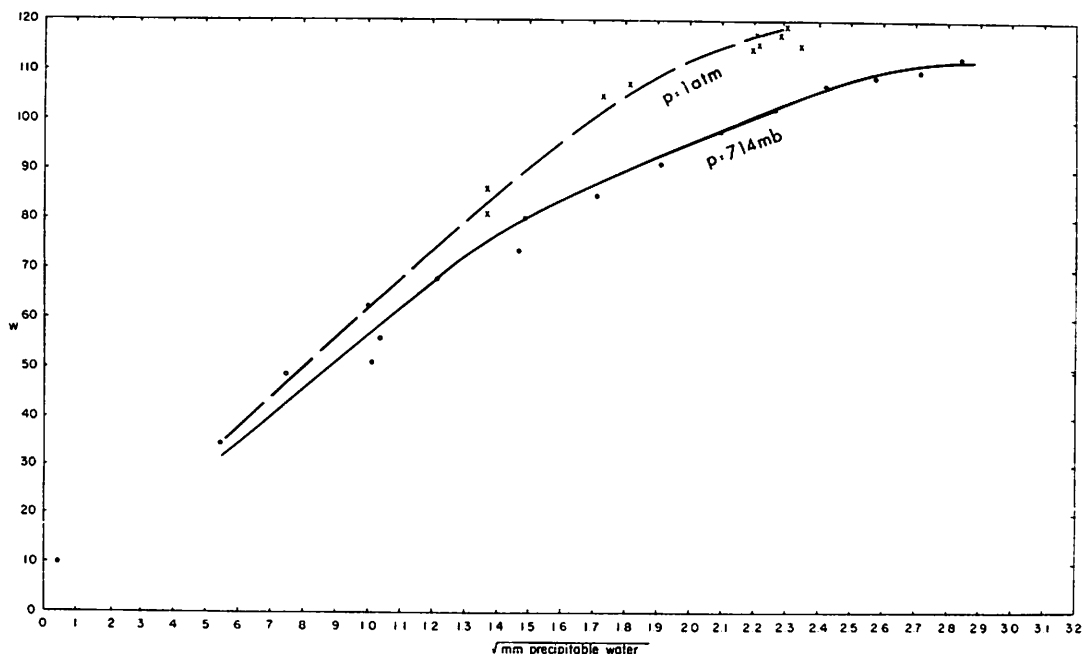


Fig. 1 Abscissae, square root of precip. H_2O in mm, obtained from air samples with measured H_2O contents. Ordinates: $W =$ total absorption in 1.4μ H_2O band (arbitrary units). Closed circles: air samples with $p = 714$ mb, using different path lengths in 40 m multiple-reflection absorption tube. Open circles: $p = 940$ mb, shorter path lengths. Crosses: W on solar spectra, Catalina Observatory, Site I, with H_2O values taken from Low hygrometer using his calibration.

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