The Relationship Between Total Atmospheric Water Vapor and Surface Dew Point on a Mean Daily and Hourly Basis

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1. Introduction

In a recent issue of the *Journal of Applied Meteorology*, Reitan (1963) described excellent correlation between mean monthly total atmospheric water vapor and mean monthly dew point. He derived the following equation:

$$\ln W_T = -0.981 + 0.0341 t_d, \quad (1)$$

where t_d = mean monthly dew point temperature in degrees Farenheit, and W_T mean monthly total atmospheric water vapor in cm.

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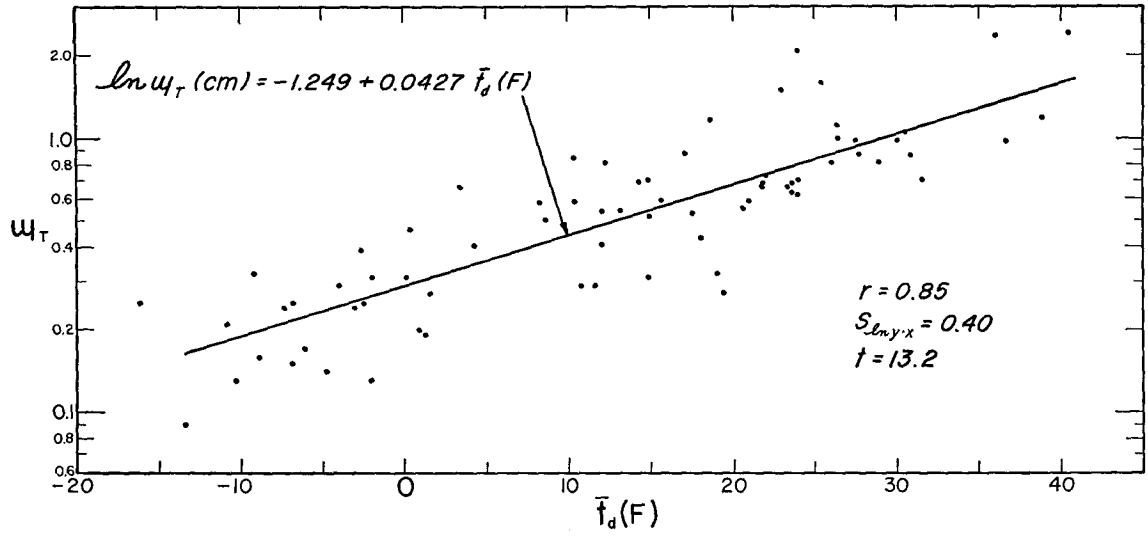

FIG. 1. Scattergram showing relationship between mean daily surface dew point and total atmospheric water vapor.

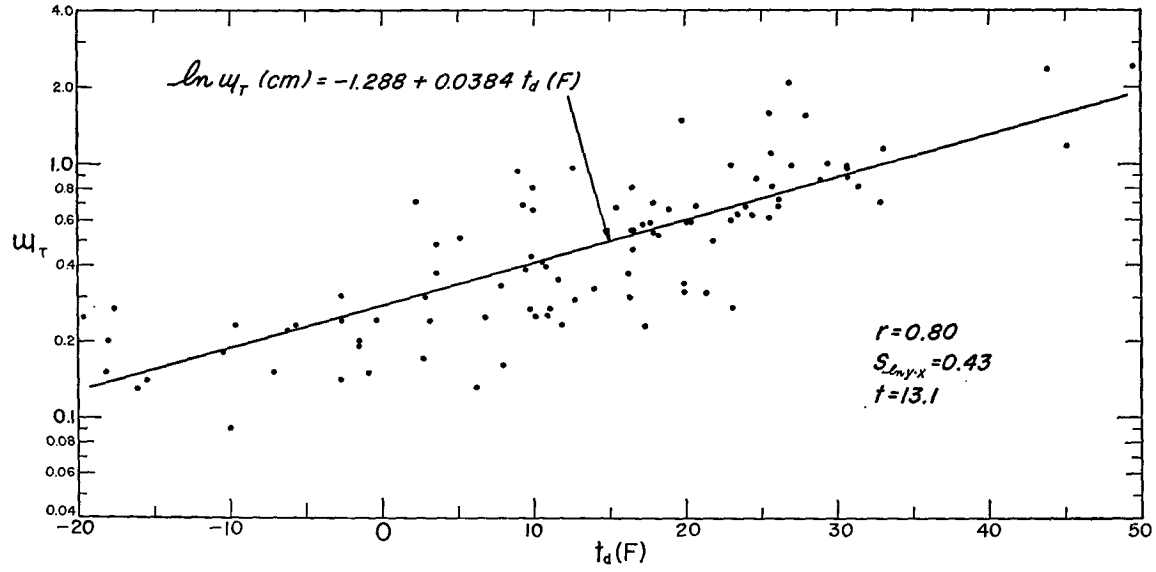

FIG. 2. Scattergram showing relationship between hourly surface dew point and total atmospheric water vapor.

Reitan implies that the same basic relationship could be expected between mean daily water vapor and dew point, but he did not investigate this point.

This study, which was prompted by Reitan's paper, had a twofold purpose: 1) to determine the degree of correlation between mean daily surface dew point and total atmospheric water vapor, and 2) to investigate the possibility of a dew point–total water vapor relationship for hourly data, i.e., when single values of dew point and water vapor are observed within the same hour. It should be emphasized that Eq. (1) was calculated by Reitan for data from the entire United States pooled together. His result may be somewhat biased when the water vapor–dew point relationship is represented for a particular geographical location such as the one to which the other data here apply.

The measurements were made sporadically from February to April 1963 and from November 1963 to March 1964 near Lebanon, New Hampshire (43°37′N, 72°18′W). Atmospheric water vapor was computed from soundings made at various times ranging between 0800 and 1600 EST. The U. S. Army Signal Corps Meteorological Team at Hanover, N. H., performed these measurements using a carbon humidity element.

2. Relationship between mean daily surface dew point and total atmospheric water vapor

A scattergram of the 72 pairs of data for mean daily dew point and total water vapor is shown in Fig. 1. Each dew-point value represents the average of 24 hourly values beginning at 0000 EST. Total water vapor is usually represented by one value per day. Water vapor values were averaged when more than one observation was made per day. The regression equation for the data was

$$\ln W_T = -1.249 + 0.0427 \bar{t}_d, \tag{2}$$

where $\bar{t}_d$ = mean daily dew-point temperature in degrees Fahrenheit. The correlation coefficient and standard error of estimate were 0.85 and 0.40, respectively.

3. Relationship between hourly surface dew point and total atmospheric water vapor

A scattergram of the 97 pairs of data is shown in Fig. 2. Hourly dew point is given by one measurement made a few minutes prior to the radiosonde release for water vapor measurement. The regression equation derived was

$$\ln W_T = -1.288 + 0.0384 t_d. \tag{3}$$

The correlation coefficient and standard error of estimate were 0.80 and 0.43, respectively.

4. Analysis

Table 1 contains values of correlation coefficients (r) standard errors of estimate ($s_{\ln y \cdot x}$), intercept constants (a), and slope constants (b) for the mean monthly water vapor-dew point relationship found by Reitan, and for the mean daily and hourly relationships found here. The magnitude of the correlation coefficients indicates that the same basic relationship was present in each case. However, the degree of relationship was less for mean daily and hourly values than for mean monthly values. Coefficients of determination show that about 96% of the differences in water vapor are related to differences in dew point for mean monthly values, 72% for mean daily and 64% for hourly values.

TABLE 1. Correlation coefficients, r, standard errors of estimate, $s_{\ln y \cdot x}$, intercept constants, a, and slope constants, b, obtained by Reitan for mean monthly values of dew point and water vapor and in this study for mean daily and hourly values of these factors.

	r	$s_{\ln y \cdot x}$	a	b
Mean monthly	0.98	0.18	−0.981	0.0341
Mean daily	0.85	0.40	−1.249	0.0427
Hourly	0.80	0.43	−1.288	0.0384

The standard error of estimate was 0.40 for mean daily values and 0.43 for hourly values. Both of these values were higher than Reitan's standard error of estimate for mean monthly values (0.18). Since the standard error is a measure of the general reliability of estimates calculated from regression equations, it follows that the reliability of water vapor values calculated from the mean daily and hourly equations is less than the reliability of values calculated from Reitan's mean monthly equations.

5. Conclusions

This study shows, as Reitan theorized, that the same basic relationship he found for mean monthly water vapor and dew point exists for mean daily values of these factors. However, the degree of relationship and reliability of estimates were lower for mean daily values than for mean monthly values. The same basic relationship also exists between hourly water vapor and dew point, but the degree of correlation and reliability of estimates is lower than for mean daily values.

The equations derived are given to demonstrate their similarity to Reitan's equation for mean monthly values. In order to eliminate regional variations in the coefficients, which Reitan (1963) describes, exact equations should be derived for the geographical areas being studied. This study provides only a general idea of the degree of correlation between hourly and daily dew point and water vapor. Much additional work is needed before these relationships can be satisfactorily evaluated.

REFERENCE

Reitan, C. H., 1963: Surface dew point and water vapor aloft. *J. Appl. Meteor.*, **2**, 776–779.