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Atmospheric precipitable water vapour over Manora Peak, Naini Tal

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Abstract. Precipitable water vapour is one of the variable atmospheric constituents and its short-term and seasonal variations may affect the infrared photometric observations. From the analysis of the measurements, made at Manora Peak, Naini Tal, 1981 November–1983 December, of the total precipitable water vapour content in the atmosphere, the relative-humidity, and the temperature at ground level, it is concluded that the precipitable water vapour content is maximum during the months of May and June; and a minimum of 2.5 to 3.5 mm of precipitable water vapour content is observed during the winter observing season from November to March. The precipitable water vapour (mm) shows a poor correlation with the ground absolute humidity (gm/m^3).

Key words : atmospheric precipitable water vapour—site testing

1. Introduction

A site survey program is being carried out in the Sivalik ranges to determine a suitable site for the installation of a large telescope. The three prospective sites at Gana-Nath (Almora), Chaukori (Pithoragarh) and Mornaula (Naini Tal) are being compared with the existing site of the Observatory at Manora Peak, Naini Tal. Kulkarni *et al.* (1977), from a few measurements of the total amount of precipitable water vapour content in the atmosphere at Manora Peak, have concluded that the existing site shows a good potential for infrared observations. The 18 observations of the total amount of precipitable water vapour at Manora Peak, taken by Kulkarni *et al.* (1977) were for the period 1976 November 9–December 5. It was therefore considered desirable to have more data for a final conclusion and then to compare the present site of the observatory with the other prospective sites under consideration.

From the study of the correlation between water vapour and extinction carried out by Roosen & Angione (1977), it is apparent that the extinction in the visible region also increases with the precipitable water vapour content in the atmosphere. Thus, for any observing site, it is desirable to have the knowledge of total amount of precipitable water content in the atmosphere.

2. Observations

The observations of atmospheric precipitable water vapour content over Manora Peak, Nainital (Long. 79°27′. 4E, Lat. 29°21′. 6 N, height 1951m) were made during the period 1981 November to 1983 December. The measurements of the precipitable water vapour were made with a meter kindly loaned by Dr J. A. Westphal of California Institute of Technology. Manufactured by John H. Ransom Laboratories Inc., Los Angeles, the meter operates with the sun as an extraterrestrial source. The meter compares the depth of the atmospheric water absorption band at 1.86μm to the continuum at 1.65μm. The meter readings are converted to millimeters of precipitable water using a calibration curve also supplied by Dr Westphal. The calibration curve for the meter used at Manora Peak, Naini Tal, is shown in figure 1, which can be expressed as :

$$W = -0.167 + 0.05125R - 0.000083R^2. \quad \ldots(1)$$

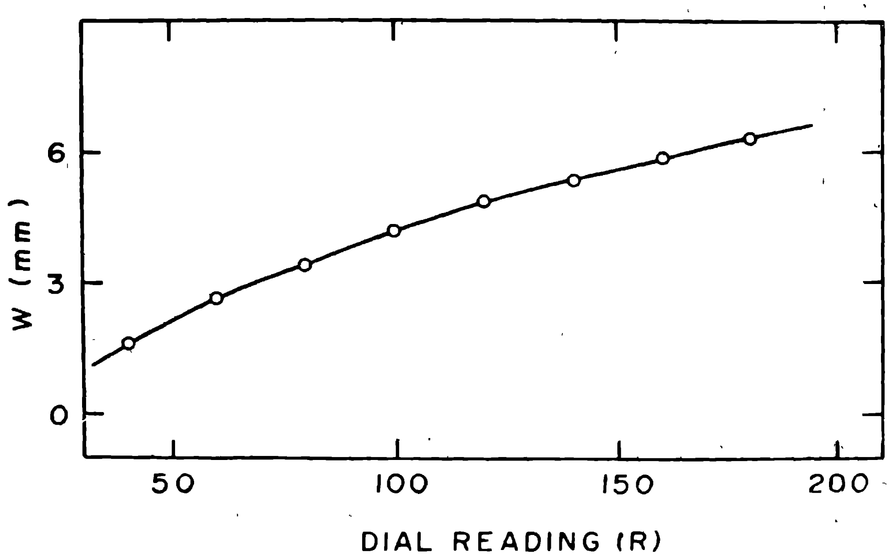

Figure 1. Calibration curve for the precipitable water vapour meter.

where W is the atmospheric precipitable water vapour content in mm and R the dial reading of the meter.

The precipitable water vapour was normally measured around 1100 IST and 1400 IST of each day together with cloud cover. The ground relative humidity (%) and the temperature (C) for the time of observations were read out from the continuous records of hygrograph and thermograph installed at the site. The water vapour measurements were not made during the monsoon season, from the middle of June to September. All precipitable water measurements W are reduced for the zenith.

3. Results

In the present analysis we have considered only those measurements which have been made on clear days. In figure 2 we have shown the variation of water vapour content in the atmosphere over the year and during the period 1981 November–1983 December. We find that at Manora Peak, the precipitable water vapour is maximum during summer months from April to middle of June. This is presumably due to higher air temperature which causes an increased amount of water evaporation and also a higher saturation vapour pressure. The average atmospheric precipitable water vapour data for the different months is given in table 1.

We find that the atmospheric precipitable water vapour over Manora Peak is appreciably lower on clear winter days than clear summer days and there is also

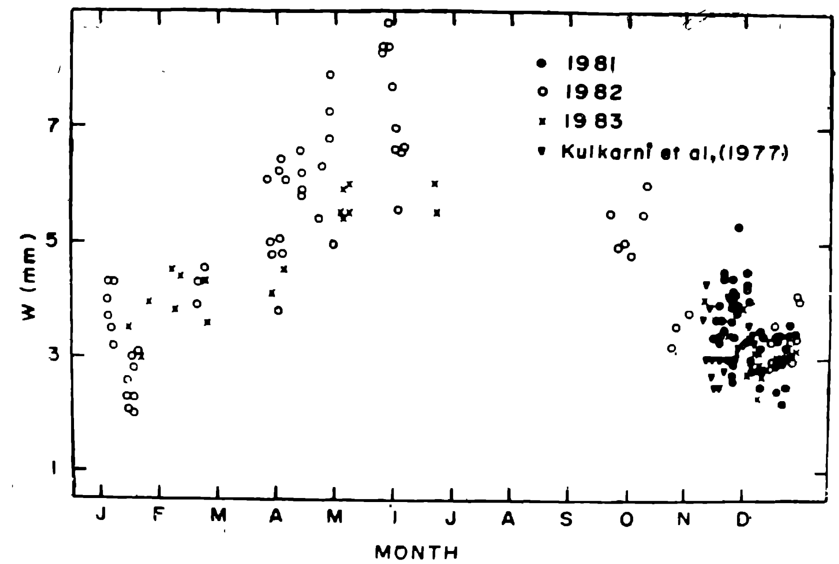

Figure 2. Atmospheric precipitable water vapour W at Manora Peak from November 1981 to December 1983. The filled triangles ▾ in the figure are the observations made by Kulkarni *et al.* (1977).

Table 1. Monthly average precipitable water vapour (mm) content in the atmosphere

Month	Average precipitable water vapour (mm)		
	1981	1982	1983
Jan	—	3.1	3.5
Feb	—	4.3	4.1
Mar	—	5.3	4.1
Apr	—	6.0	4.5
May	—	8.3	5.7
June	—	6.5	5.8
Jul	—	—	—
Aug	—	—	—
Sep	—	5.2	—
Oct	—	4.6	—
Nov	3.7	3.8	3.5
Dec	3.2	3.9	2.9

relatively a large scatter in the measurements for clear summer days. In figure 3 we have shown the distribution of number of observations (%) with the total precipitable water vapour for different seasons.

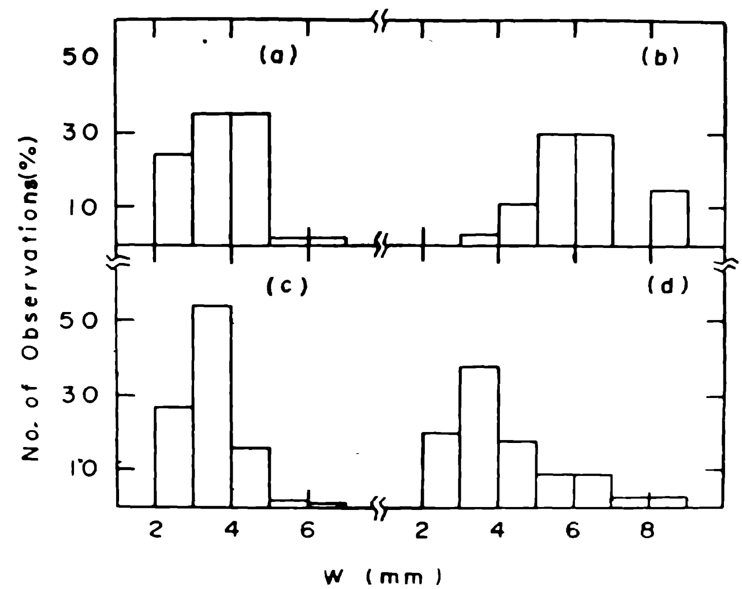

Figure 3. Distribution of atmospheric precipitable water vapour observations for the three seasons (a) January to March ; (b) April and May ; (c) October to December; and (d) the total observations made between 1981 November to 1983 December.

The major drawback of using the sun as an extraterrestrial source is that measurements can be made during day time only while for astronomical observations the measurements of precipitable water vapour during night time are more important. We have tried to find out the correlation between precipitable water vapour content in the atmosphere and the ground absolute humidity obtained from the relative humidity and temperature near the ground. The absolute humidity, χ (gm m^{-3}) is given by the relation

$$\chi = 2.17 \times e_a . R_H . T^{-1}. \qquad \ldots(2)$$

where R_H is ground relative humidity (%), T the surface temperature (K), and e_a the the saturation vapour pressure (mb). The values of e_a, corresponding to the surface temperature, are obtained from the Smithsonian's standard tables. The plot of χ against W in figure 4 shows a large scatter indicating that the correlation between χ and W is poor.

From the measurements of relative humidity during night time during the periods 1981 November to 1982 March and 1982 November to 1983 March it is roughly indicated that the atmospheric precipitable water vapour over Manora Peak is relatively low during night time.

4. Conclusion

From the monthly mean precipitable water vapour it is concluded that there is lower atmospheric water vapour during the winter observing season. The ground

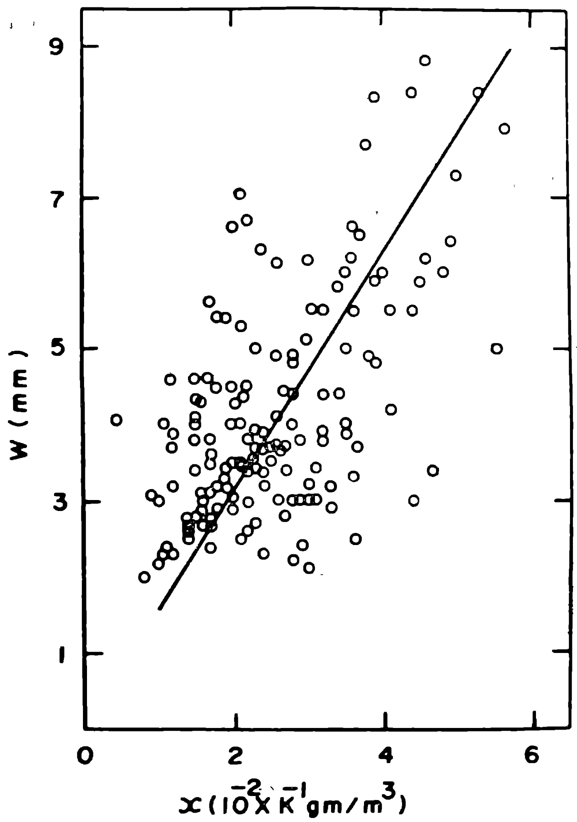

Figure 4. The correlation between the atmospheric precipitable water vapour W and the absolute humidity χ. The constant $K=1/217$.

absolute humidity shows a poor correlation with the precipitable water vapour content in the atmosphere. A relatively higher atmospheric precipitable water content is observed in summer months. The measurements of relative humidity roughly indicate that the average precipitable water vapour content in the atmosphere at Manora Peak during night time in the winter observing season from November to March is relatively low.

On the basis of the results obtained in this study and the atmospheric precipitable water vapour measured at different sites (Hansen & Caimanque 1975; Randiac & Kuiper 1970; Roosen & Angione 1977), it is concluded that the observatory site at Manora Peak shows a good potential for infrared observations during the period November to March and this is also the period of maximum number of photometric nights at Manora Peak.

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