maximizing observed storm rainfall to estimate PMP involve moisture adjustments, storm transposition and envelopment. These are discussed in the following sections.

2.2 ESTIMATION OF ATMOSPHERIC MOISTURE

2.2.1 Assumption of a saturated pseudo-adiabatic atmosphere

Since many of the extreme, or major, recorded storms occurred before extensive networks of upper-air temperature and humidity soundings had been established, any index of atmospheric moisture must be obtainable from surface observations. Even today, current upper-air observational networks are too sparse to adequately define the moisture inflow into many storms, especially those limited to areas of the size considered in this manual.

Fortunately, the moisture in the lower layers of the atmosphere is the most important for producing precipitation, both because most atmospheric moisture is in the lower layers and because it is distributed upward through the storm early in the rainfall process (Schwarz, 1967; United States Weather Bureau, 1960). Theoretical computations show that, in the case of extreme rains, ascensional rates in the storm must be so great that air originally near the surface has reached the top of the layer from which precipitation is falling within an hour or so. In the case of severe thunderstorm rainfall, surface air may reach the top in a matter of minutes.

The most realistic assumption seems to be that the air ascends dry-adiabatically to the saturation level and thence moist-adiabatically. For a given surface dewpoint, the lower the level at which the air reaches saturation, the more moisture a column of air will contain. The greatest precipitable moisture occurs when this level is at the ground. For these reasons, hydrometeorologists generally postulate a saturated pseudo-adiabatic atmosphere for extreme storms.

2.2.2 Surface dewpoints as a moisture index

Moisture maximization of a storm requires identification of two saturation adiabats. One typifies the vertical temperature distribution that occurred in the storm to be maximized. The other is the warmest saturation adiabat to be expected at the same time of year and place as the storm. It is necessary to identify these two saturation adiabats with an indicator. The conventional label in meteorology for saturation adiabats is the wet-bulb potential temperature, which corresponds to the dewpoint at 1 000 hPa. Tests have shown that storm and extreme values of precipitable water may be approximated by estimates based on surface dewpoints, when saturation and pseudo-adiabatic conditions are assumed (Miller, 1963; United States Weather Bureau, 1960).

Surface dewpoints that represent the moisture inflow into the storm can be used to identify the storm saturation adiabat. The moist adiabat corresponding to either the highest recorded dewpoint observed over a period of 50 years or more for the location and season, or the dewpoint for a specific return period, for example, 100 years (see section 2.2.5), is considered sufficiently close to the probable warmest saturation adiabat. Both storm and maximum dewpoints are reduced pseudo-adiabatically to the 1 000-hPa level (Figure 2.1), so that dewpoints observed at stations at different elevations are comparable. This permits construction and use of tables showing atmospheric moisture as a function of the 1 000-hPa dewpoints (Tables A.1.1 to A.1.3, Annex 1).

2.2.3 Persisting 12-hour dewpoints

As moisture inflow has an appreciable effect on storm precipitation, the moisture must be the type that persists for hours rather than minutes. Also, any single observation of dewpoint could be a considerably inaccurate value. Consequently, dewpoint values used to estimate probable maximum and storm moisture should be based on two or more consecutive measurements separated by a reasonable time interval, or a continuous automatic record of dewpoint over a period of time. The so-called highest persisting 12-hour dewpoint is generally used. Other alternatives include the maximum average 24-hour dewpoint, an average 12-hour dewpoint or a 24-hour persisting dewpoint. The highest persisting dewpoint for some specified time interval is the value equalled or exceeded at all observations during the period.

Table 2.1 shows a series of dewpoints observed at 6-hour intervals. The highest persisting 12-hour dewpoint for this example series is 24°C, which is obtained from the period 1800 to 0600. However, if the air temperature had dropped below 23°C during the period 0000 to 0600, the highest persisting 12-hour dewpoint would then be 23°C, which is obtained from the period 1200 to 0000. If available, hourly dewpoints may be used, but such records are sparse. They also add a great deal of work to the surveys for persisting values, especially in the case