during the 6-hour period of the test. This valley precipitation (the convergence component of total precipitation), which is sometimes reduced for elevation, is attributed to atmospheric processes not directly related to orography. In the test case described, however, there was no appreciable valley precipitation so no deduction was made from observed precipitation.

3.2.3.8 Sources of error

Differences between precipitation computed by the model and observed orographic precipitation (total precipitation minus convergence component) can be attributed to two main sources: (a) errors of input to the model; and (b) sparsity and unrepresentativeness of precipitation data for checking model computation.

3.2.3.8.1 *Input to the model*

Usually, no more than two upper-air observations are made daily. Despite utmost care in interpolating for a particular storm period by referring to the more frequent surface synoptic charts, the question remains as to the representativeness of instantaneous wind and moisture values for even a short period of a few hours. Such inaccuracies lead to errors in computed amounts of precipitation.

In the example given, no allowance was made for the fact that the upper-air sounding station (Oakland) is approximately 160 km from the test area, and moisture and wind values were taken directly from the sounding. Attempts to adjust for wind travel time (averaging less than 2 hours) did not improve results.

3.2.3.8.2 *Observed orographic precipitation*

The uneven distribution of storm precipitation, with respect both to time and to space, the sparseness of the precipitation network, and the usual errors of gauge measurements make it difficult to obtain reliable averages of storm precipitation on slopes. Also, most gauges in orographic regions are located in narrow valleys or on relatively flat sites unrepresentative of nearby elevations or the generalized ground profile. Their measurements, while perhaps acceptably representative of actual precipitation at the gauge sites, are unlikely to represent with any great accuracy the average precipitation falling on the general slope. These various factors make it difficult to obtain reliable values of observed storm precipitation on a slope for comparison with model computations.

3.3 APPLICATION OF A LAMINAR FLOW MODEL IN THE OROGRAPHIC SEPARATION METHOD FOR ESTIMATING PMP

Reference was made earlier to the fact that precipitation in mountainous regions consists of two components: (a) orographically induced precipitation (orographic precipitation), and (b) precipitation produced by atmospheric processes unrelated to orography (convergence precipitation). PMP is computed, therefore, by maximizing and adding the two precipitation components. Caution must be exercised to avoid over-maximizing. Caution must also be used and this model applied only where the assumption of laminar flow is realistic (sections 3.2.1, 3.2.2, 3.4.1 and 3.5.2). In other regions, procedures discussed in section 3.4 or Chapters 5 and 6 may be more appropriate.

3.3.1 Orographic PMP

The procedure used in applying the orographic model for computing the orographic component of PMP is the same as that used in testing the model (section 3.2.3) with the exception that inflow winds and moisture are maximum values.

3.3.1.1 Maximum winds

If there is a long record of upper-air winds, say 30 years or longer, an envelope of the highest recorded speeds for winds from critical directions for each month or part of the month is usually adequate. The probability of occurrence of any of the envelope values is determined by statistical analysis. Such analysis may be used also to estimate high wind speeds, say for a 50-year return period, when the record is so short as to introduce doubt as to its maximum values being representative of those that would be obtained from a longer record. If the record is so short as to preclude reliable frequency analysis, say less than 10 years, maximum wind speeds may be estimated from surface pressure gradients between suitably located stations. Maximum surface winds so determined may then be used to estimate upper-air wind speeds by means of empirical relations (United States Weather Bureau, 1961*a*).

Figure 3.7 shows the maximum wind speed profile used for the coastal region of California. The variation with duration (Figure 3.8) was based on that of geostrophically derived winds and of 900 hPa winds at Oakland during selected storm periods.