CHAPTER 3

ESTIMATES FOR MID-LATITUDE OROGRAPHIC REGIONS

Precipitation in orographic regions can be divided into two types: that resulting from the movement of precipitation weather systems, called convergence components or convergence rain; and that resulting from orographic effects, called orographic components or orographic rain.

In estimating probable maximum precipitation (PMP) in a particular watershed or performing generalized PMP estimation for a particular area in an orographic region, data on transposed storms needs to be corrected. This enables the use of data from large storms that occurred in orographic regions and plains in the meteorological homogeneous zone. Depending on the method used to process the influence of orography on precipitation, methods for estimating PMP in orographic regions can be divided into three categories. The first category is the storm separation method. The second category is the method of orographic correction of PMP in non-orographic regions. The third category is the method of direct, detailed correction of PMP in orographic regions. The first two categories are introduced in Chapters 3, 5 and 6 and the third category is introduced in Chapter 7.

3.1 PRECIPITATION IN MOUNTAINOUS REGIONS

3.1.1 Orographic influences

The effects of topography on precipitation have been studied for many years. Observations of precipitation and runoff in mountainous terrain in many parts of the world show a general increase in precipitation with elevation. Several features of this increase can be distinguished.

First, there is the increase on windward slopes due to forced lifting of air over mountains. The magnitude of the effect on precipitation varies with the direction and speed of the moist airflow, and with the extent, height, steepness and regularity of the mountain barrier. Breaks in ridges or passes reduce the amount of lifting. Other factors are the extent and height of lower mountains or hills upwind of a slope.

Concomitant with increased precipitation on windward slopes is the decrease on lee areas. Immediately to the lee of ridges is a spillover zone, where precipitation produced by the forced ascent of moist air over windward slopes can be as great as on the ridge. Because of the relatively slow fall velocity of snowflakes, spillover extends much farther beyond the ridge for snow than it does for rainfall. Beyond the spillover zone, significant reductions can occur in precipitation due to sheltering effects.

A second feature of orographic precipitation, indicated by theory and supported by observations, is that first slopes or foothill regions are preferred locations for the initiation of showers and thundershowers. This effect results from stimulation of convective activity in unstable air masses by an initial and relatively small lift. Observational data are often too sparse to verify this phenomenon because of the more obvious effects of higher slopes nearby. Coastal station observations sometimes exhibit the effects of small rises in elevation. For example, a comparison of rainfalls at San Francisco, California, United States of America, and the Farallon Islands, approximately 40 km off the coast west of San Francisco Bay, showed that in major storms, rainfall is about 25 per cent greater at San Francisco. This effect was taken into account in a PMP study for the north-western United States (United States Weather Bureau, 1966).

Another effect noticed in orographic regions is sometimes referred to as a funnelling effect. Where there are narrowing valleys or canyons parallel to storm winds, the winds can experience horizontal convergence and resultant vertical lift, initiating or increasing rainfall. For this to occur, it is necessary that mountains adjacent to the valleys or canyons be relatively unbroken and at least moderately high.

3.1.2 Meteorological influences

Experience has shown that general storm precipitation resulting from atmospheric systems that produce convergence and upward motion is just as important in orographic regions as on the plains. Reports of thunderstorms and passages of weather systems during large-area storms in high mountain ranges are indicators of the dual nature of precipitation in orographic regions. Radar, for example, has tracked bands of precipitation moving across the coastal hills and central valley of California into the high Sierra Nevada (Weaver, 1966).