CHAPTER 8
WEATHER RADAR PRECIPITATION DATA AND THEIR USE IN HYDROLOGICAL MODELLING

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1. Introduction

Most variables in the hydrological cycle show large and frequent spatial variations, and often exhibit rapid temporal variations. Of particular importance is precipitation, and it is often necessary in many hydrological process studies and applications to monitor precipitation continuously at as many points as possible.

Point measurements are insufficiently representative of sub-catchment scales, and hence it is difficult to understand and model hydrological processes using such data. The basic measurement requirement of hydrology is for areal measurements albeit over sometimes very small, as well as very large, areas.

The hydrological requirement for measurements of precipitation is shown in Table 8.1, where the maximum, minimum and most usual values for resolution, frequency of observations and accuracy (freedom from bias) are given. Clearly which requirement value is appropriate will depend upon the application to which the measurements are put.

The precision with which measurements should be made refers to their reproducibility in space, time and quantity. Precision is expressed quantitatively as the standard deviation of results from repeated trails under identical conditions. Hence a measurement may be quantitatively accurate, but imprecise and vice-versa. The reasons for this depend upon the inter-relationship between resolution, frequency and numerical accuracy (see for example, Chatfield, 1983). A measurement from a raingauge is spatially precise, but may be imprecise in time and quantity. Hence in Table 8.1 we have added requirements for precision where this quantity is taken as the standard deviation about the mean requirements for resolution, frequency and accuracy. It is therefore a tolerance within which the requirement stated must be met.

2. Use of precipitation measurements in distributed hydrological models

Lumped models attempt to represent the relationship between the characteristics of the hydrograph and its physiographic factors as a simple relationship between excess rainfall and direct runoff. The main criticism of the lumped models is that they require an assumption that the rainfall input is uniformly distributed over the catchment, or at least, that the spatial distribution is constant. This is an unrealistic assumption. Semi-distributed models consist of a system of interconnected cell units, each cell representing a definite portion, or area unit, of the catchment (see for example Diskin and Simpson, 1978) Figure 8.1 shows how sub watersheds (sub-catchments) 8 and 11 of the Walnut Gulch (Arizona) Experimental Catchment are divided into model cells.

All cell units receive rainfall excess input which is variable with time, but assumed to be uniform across each area unit. Two types of cells are recognised, exterior or interior. Exterior cells without any channel inflow, have only one input, namely the rainfall excess input. Interior cells are cells receiving channel inflow from upstream cells in addition to the rainfall excess input. As shown in Figure 8.1 the interconnections between the cells form a branching tree-like structure which approaches the form of the main drainage pattern of the catchment.

This modelling approach may be extended to formulations of many partial differential equations governing various physical processes and equations of continuity for surface and soil water flow. The SHE model (Abbott et al 1986a, b) is an example. The equations are applied to grids as small as 250m x 250 m. Unfortunately experience has shown that, even with the adequate calibration data in the form of flow records, these fully distributed models may still fail to provide consistent improvements in forecast accuracy. This is because rainfall inputs need to be provided with a spatial scale close to that of the model grid, and this can only be achieved using radar data (see for example, Anderl et al, 1976, Moore, 1987). However, Obled et al, (1994) found that, for a rural medium-sized catchment (71 km$^2$), the sensitivity of a range of model formulations to the spatial variability of rainfall, although important, is not sufficiently organised in time and space to overcome the effects of smoothing and dampening caused by the model formulations. They conceded that this might not be the case for smaller urban catchments or over larger rural catchments. Nevertheless, in general hydrological models may act as a broad band filter to enable a certain level of error in the input data to be tolerated. This is important since, as we shall see, the error characteristics of radar estimates of precipitation maybe variable in time and space. This does not mean that errors in input data are unimportant, but rather that consistency in error characteristics is as important as absolute error.