6. Weather and Climate

Temperature, humidity, wind, and precipitation are the most commonly measured meteorological parameters. Collectively, they are what most of us think of when we refer to climate. By monitoring them at Emerald Lake, comparisons can be made to other alpine watersheds where data may be available. Meteorological measurements in alpine locations are sparse [Barry and Van Wie, 1974], thus such comparisons can be only general in nature. More importantly, by monitoring meteorological parameters at several locations in the watershed, spatial similarities and variations can be evaluated that will allow understanding of the distribution of meteorological and energy transfer parameters.

TABLE 6.1: Micro-Meteorological Instrument Sites in Emerald Lake Watershed

Site	Elevation (m)	Location	
		UTM, Zone 11	Geodetic
1. Tower	2802	4,051,460 N 350,165 E	36°35'55" N 118°40'30" W
2. Inlet	2813	4,051,250 N 350,250 E	36°35'48" N 118°40'27" W
3. Pond	2962	4,050,975 N 350,520 E	36°35'39" N 118°40'16" W
4. Ridge	3085	4,051,325 N 350,830 E	36°35'51" N 118°40'03" W

Micro-meteorological monitoring in the Emerald Lake watershed is probably the most detailed in any alpine watershed in North America. Four sites are located on the topographic map presented in the previous chapter. Table 6.1 gives the elevation and coordinates of each site. Air temperature was monitored continuously at all four sites, humidity at the tower, inlet and ridge, wind speed at the inlet and the ridge, and snow and soil temperature at the inlet, pond and ridge during the 1986 snow season. The measurements were usually recorded at a time interval of 15 minutes, and were based on the average of 3 to 12 30-second samples. They were processed and integrated to one hour averages, at a consistent time step so that all sites and parameters could easily be compared.

Snow surface temperature, snow depth, and snow density were measured manually at regular intervals at several sites in the watershed. Snowfall was measured on snowboards at two or more sites, as soon after a deposition event as possible. Snow water equivalent (SWE) and temperature profiles were measured in monthly snow pits at several locations throughout the snow season. Less detailed surveys of SWE were made at a hundred or more sites four time during spring melt. All of these data were carefully evaluated to determine their reliability under a variety of conditions, relying on duplication of some measurements to help eliminate bad or spurious values. Particular care is given to data collected during snowmelt and runoff. The data presented represent our best estimate of each parameter.

Climatic conditions and local micro-climatic variation control the timing and magnitude of meltwater generation over the watershed. Snowmelt is initiated when the snowcover receives more energy than it loses over a period of time. Initially energy is utilized to increase the temperature of the snowcover to the melting temperature (0.0°C). Once this has been achieved additional input of energy will cause melt. Variations in measured meteorological parameters over time can be used to indicate when and at what rate energy transfer and melt will occur. This is a complicated process requiring not only detailed meteorological data, but information on the physical and thermal properties of the snowcover. Because these data are seldom available, most efforts to predict snowmelt and runoff have been based on the use of one or more easily measured meteorological parameters as an index to snowmelt that can be used to develop a regression against measured streamflow.

One of the first descriptions of this approach was presented by Horton [1915] who suggested that air temperature could be used as an index to the overall climate and therefore snowmelt. Collins [1934] defined the "degree-day" as a 24–hour period during which the average air temperature is 1.0°C above the melting temperature of ice (0.0 °C), and suggested that this parameter could be used as an index to overall energy exchange and snowmelt. Early investigations of the mechanisms and thermodynamics of snowmelt by Church [1941] and Wilson [1941b] recognized the complexity of the process, but recommended the statistical index approach for predicting snowmelt because of the difficulty in acquiring data for more deterministic methods. Light and Kohler [1943] developed and tested a statistical approach for forecasting seasonal snowmelt runoff using snow depth measured at selected sites as the index, and Linsley [1943] presented a method for forecasting daily snowmelt runoff using air temperature as the index. These early studies formed the foundation for virtually all of today's operational snowmelt runoff forecasting efforts. Anderson and Crawford [1964] showed that this type of model could be adapted to run on a digital computer, and the work of Anderson [1973] and Burnash et al. [1973] followed, defining operational snowmelt runoff forecasting for the most of the U.S. These models or variations on them are still in use today, as seen in the work of Tangborn [1980]. The most promising advancement was presented by Martinec [1975] who included spatial information on snow covered area (SCA) from satellite remote sensing data in the model regression equation. This technique was further tested by Rango and Martinec [1979]. Martinec [1980] conceded that there were limitations to using SCA in a temperature-index snowmelt model, but concluded that because it provided information on the depletion of snow volume from a drainage basin it was an improvement over air temperature alone [Martinec, 1982], and that it could also be used to estimate snow accumulation rates [Martinec, 1984] and depletion rates [Rango and Martinec, 1982].

All of these models are based on the premise that because climate and energy exchange could not be monitored adequately, a physically based snowmelt runoff model was not possible. More easily measured indices had to be established, and because the relationship