

**CLIMATIC DATA FOR SHINGOBEE LAKE
AND WILLIAMS LAKE, HUBBARD COUNTY,
MINNESOTA, 1989-91**

By R.S. Parkhurst, D.A. Merk, D.O. Rosenberry, and T.C. Winter

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CONVERSION FACTORS

Multiply	By	To Obtain
centimeter	0.394	inch
kilopascal	0.010	standard atmosphere
millibar	0.015	pounds per square inch
kilometer per hour	0.622	mile per hour
calories per square centimer	25.913	watts per square foot

To convert degrees Celsius (°C) to degress Fahrenheit (°F) use the following formula:

$$^{\circ}\text{F} = 9/5(^{\circ}\text{C}) + 32$$

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ABSTRACT

Research on the hydrology of Williams Lake and Shingobee Lake, north-central Minnesota, includes the study of evaporation. Presented here in a graphical format are those climatic data needed for energy budget studies, including: air temperature, wind speed, radiation, humidity, and precipitation. Data were collected at raft and land stations on both lakes.

INTRODUCTION

Williams and Shingobee Lakes are located in north-central Minnesota near the town of Walker (Fig. 1). They were selected by the U.S. Geological Survey as field sites to conduct comparative research on two lakes having different residence times. Williams Lake has no surface water inlet or outlet and Shingobee lake, which lies three miles to the north, has inlet and outlet streams. The research effort, known as the Interdisciplinary Research Initiative (IRI), includes many aspects of the physical, chemical, and biological processes associated with the two lakes and their watersheds. Research is also being conducted on the Shingobee and Little Shingobee Rivers as well as on a number of wetlands within the headwaters area of the Shingobee River. As part of the interdisciplinary effort, climate stations were established on rafts on each lake and at land stations near the lakes. These data will be used to provide information for a variety of reasons; such as, calculating evaporation, watershed modeling, ground-water modeling, and a number of other determinations of chemical and biological characteristics of the environment.

Hydrologic studies of Williams Lake have been underway for more than a decade, and a number of climate data reports have already been published for 1982 through 1988. Climatic data from the 1982 and 1986 season are presented in Rosenberry and others (1988a, 1988b). Data collected in 1983, 1984, and 1985 are presented in Sturrock and others (1984, 1986a, and 1986b). Data collected in 1987 and 1988 are

presented in Parkhurst and others (1992). Williams Lake was originally selected as part of a nationwide network of comparative studies of lakes because of its climatic and hydrogeologic setting (Siegel and Winter, 1980). Studies of Shingobee Lake, Shingobee River, several wetlands, as well as comparative studies of the two lakes were initiated in 1989 as part of the IRI effort.

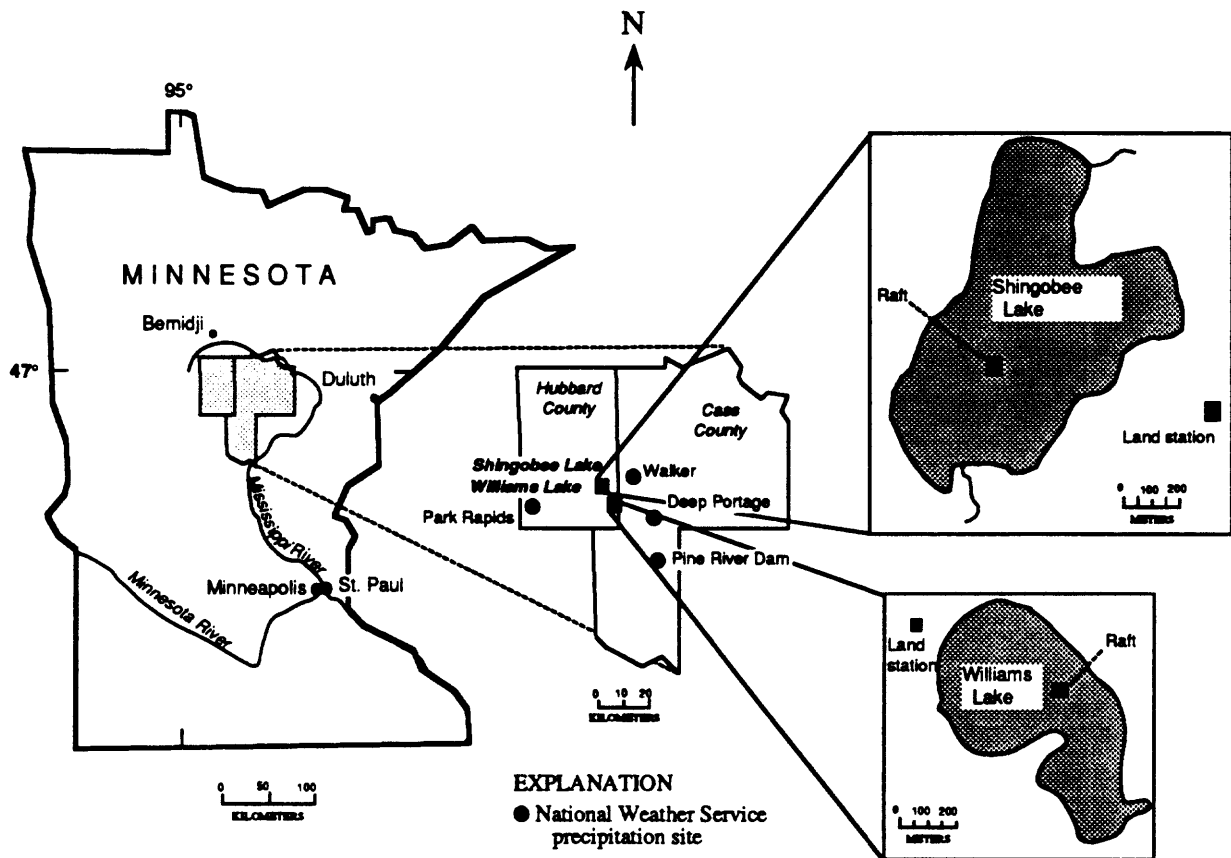


Figure 1.--Locations of Shingobee Lake, Williams lake, National Weather Service precipitation sites, and instrument stations.

The purpose of this report is to provide daily values of all climate data, and monthly values of selected data, in graphical form. The data are for 1989, when IRI was begun, through 1991. All daily data available are presented in this report. The initial phases of the IRI effort resulted in some sensors being discontinued and others initiated. Therefore, not all sensors were available at all location during this time period.

DATA COLLECTION AND PRESENTATION

Climatological sensors are located on rafts in the middle of the lakes, and at nearby land stations(fig. 1). Sensors on the rafts include anemometers, and an air temperature and humidity probe, all located 2 meters above the lake surface, and a surface-water temperature probe. There was an additional anemometer at 3 meters above lake surface at the Shingobee Lake raft station. Williams Lake raft station had a backup anemometer at 2 meters above the lake surface. Data from these sensors are recorded by digital data loggers located on the rafts. The data loggers scan the sensors every minute and calculate hourly and daily averages. In addition, for selected sensors, the daily output includes maximum and minimum values and the time they occur. Data from the raft station are for ice-free periods only. The period of record for 1989 is from April 27 (Julian day 117) to November 13 (Julian day 317) for Williams Lake. Data collection from the raft station at Shingobee Lake in 1989, started and ended the day after that of the raft station at Williams Lake. The period of record for data collection from both lakes in 1990 is from April 17 (Julian day 107) to November 14 (Julian day 318). The period of record for 1991 is from April 16 (Julian day 106) to November 3 (Julian day 307).

The land station at Shingobee Lake, located in a field 400 meters east of the lake, consists of long- and short-wave radiometers, an anemometer, a wind direction sensor, and an air temperature and humidity probe, all located at 2 meters above ground. Data from these sensors are recorded by a data logger, identical to that on the raft, which records hourly totals and averages, daily totals and averages, and selected maximum and minimum values and their associated times of occurrence. A weighing-bucket rain gage connected to an event recorder is also at this site. Additional backup sensors include an analog hygrothermograph and a standard 8-inch rain gage. Calibration checks are made with independent laboratory thermometers and psychrometers. Data from the land station were collected continuously starting on April 28, 1989.

The land station at Williams Lake, located in a field 135 meters northwest of the lake, consists of a weighing bucket rain gage connected to an event recorder and an analog hygrothermograph. A tipping-bucket rain gage connected to a data logger is located just east of the land station. The analog hygrothermograph measures air temperature and humidity,

which are used as backup data. The weighing-bucket rain gage and the hygrothermograph record the data on paper charts. Calibration checks are made with independent laboratory thermometers and a psychrometer every few days. In 1989 the land station also included long- and short-wave radiometers, and an air temperature and humidity probe located 2 meters above ground. The period of record for the land station in 1989 was March 22 (Julian day 81) to November 26 (Julian day 330). The period of record in 1990 and 1991 is about the same as for the raft station at Williams Lake. Precipitation data from National Weather Service sites (fig. 1) are used in conjunction with precipitation data collected at the site to provide a continuous record of precipitation throughout the year.

Data plotted in this report are daily values and monthly summaries of these values. Raft-station data together with land-station radiation and precipitation are considered primary. When the primary instruments were not operating properly, daily values were obtained by regression using data from backup sensors, if a satisfactory statistical relation could be established. Data used to establish regressions were selected so that they bracketed the period of missing or inadequate data. Estimated values for periods of missing data are summarized in table 1.

Table 1.--Estimated data for Shingobee Lake and Williams Lake atmospheric data and procedures used to fill in the data

Dates of missing data	Variable missing	Source of filled in data	Regression used	R squared
Williams Lake raft:				
4/17/90	air temperature	hygrothermograph	$Y=0.976X+.66$	0.991
4/17/90	humidity	hygrothermograph	$Y=0.993X+.477$	0.946
10/17/90-10/19/90	air temperature	hygrothermograph	$Y=0.976X+.66$	0.976
10/17/90-10/19/90	humidity	hygrothermograph	$Y=1.001X-2.228$	0.946
11/7/90-11/14/90	wind speed	backup anemometer	$Y=0.992X-.204$	0.999
Shingobee Lake raft:				
4/14/91-5/18/91	wind speed at 2m	anemometer at 3m	$Y=1.002X-.244$	0.991
Shingobee Lake land:				
6/20/89-6/24/89	Short-wave radiation	Williams Lake radiometer	$Y=0.993X+3.168$	0.991
6/20/89-6/24/89	Long-wave radiation	Williams Lake radiometer	$Y=0.929X+78.532$	0.977
4/7/90-4/15/90	Long-wave radiation	Brunt's equations (Koberg, 1964)	$Y=0.846X+120.593$	0.995

Y=missing data, X=data from back-up instrument

Table 1.--Estimated data for Shingobee Lake and Williams Lake atmospheric data and procedures used to fill in the data.

Temperature data include the average, maximum, and minimum daily air temperature at the raft stations (figs. 2-5) and land stations (figs. 6-7). Monthly averages for these temperature data are shown in figures 8 and 9. Average daily surface water temperatures and a comparison of average monthly air and surface water temperatures at the raft stations are shown in figures 10-13. Humidity data include average daily humidity at the raft stations (figs. 14-15) and land stations (fig. 16). Average monthly humidity are shown in figures 17 and 18. Average daily vapor pressure and vapor pressure deficit at Williams Lake land station for 1989 is shown in figure 19. This is the only vapor pressure and vapor pressure deficit data collected for 1989-1991. Wind data include the average, maximum, and minimum daily wind speed at 2 meters above the raft stations (figs. 20-21), at 3 meters above the Shingobee Lake raft station (fig. 22) and at 2 meters above the Shingobee Lake land station (fig. 23). Average monthly wind speeds are shown in figures 24 and 26. Radiation data include daily total short-wave and long-wave radiation at the Shingobee Lake land station (figs. 27-28) for 1989-1991, and daily total short-wave and long-wave radiation at the Williams Lake land station for 1989 (fig. 29). Precipitation data includes monthly total precipitation at Shingobee Lake and Williams Lake gages (fig. 30) and the National Weather Service gages at Deep Portage, Park Rapids, Pine Rive Dam, and Walker (fig. 31). Although only daily and monthly values are shown here, hourly values also were recorded. Daily and hourly values are available for all or part of the period of record on request.

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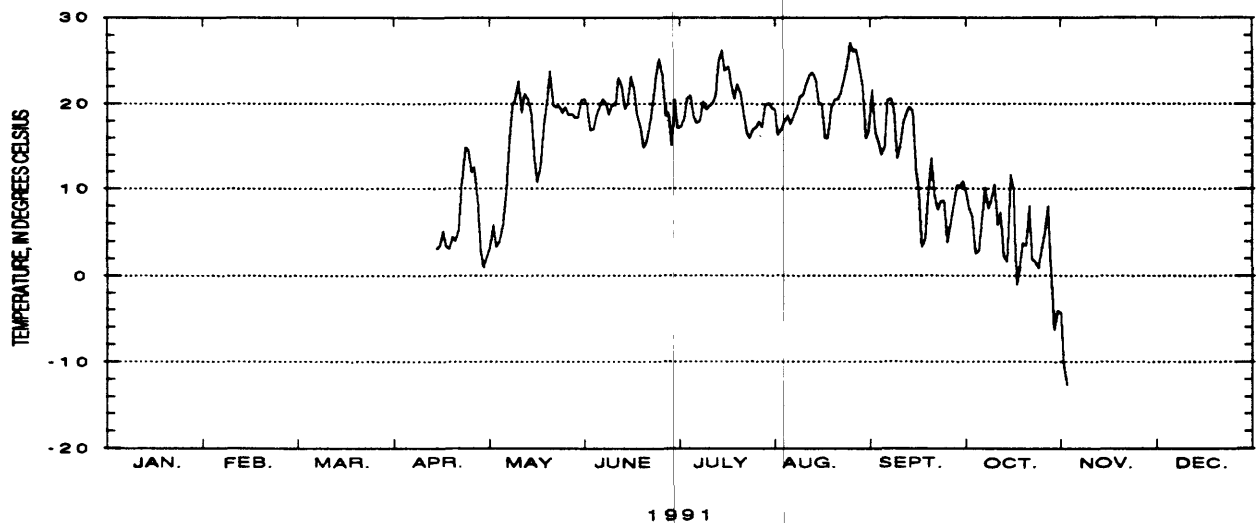
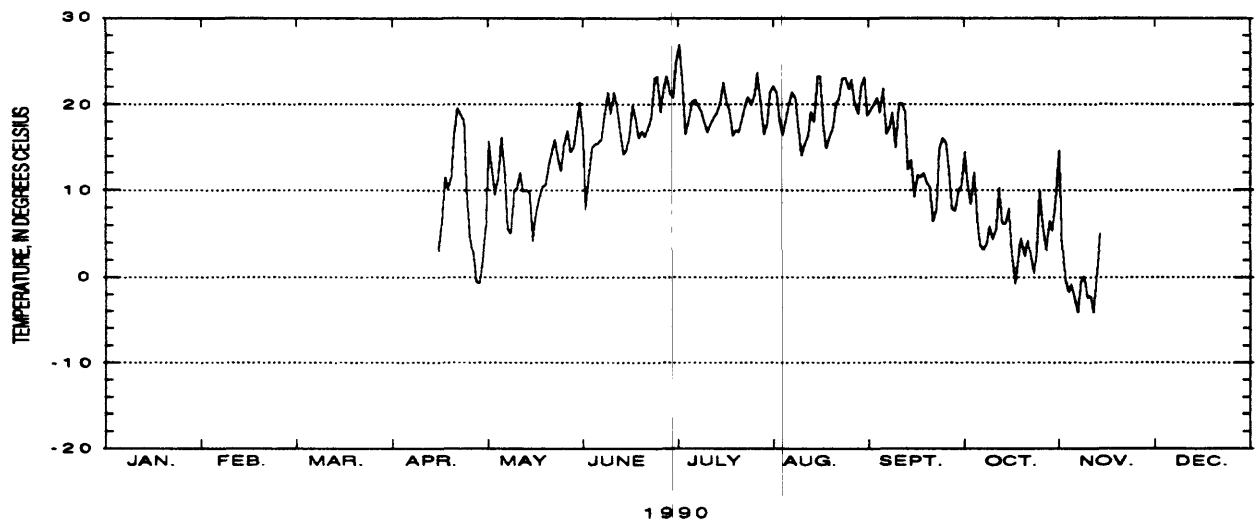
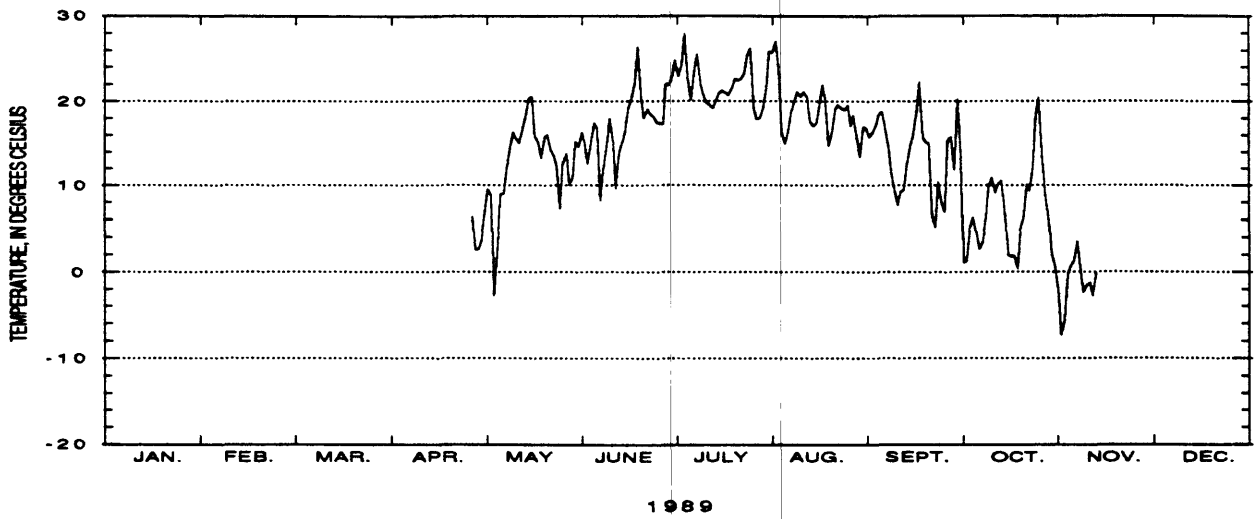
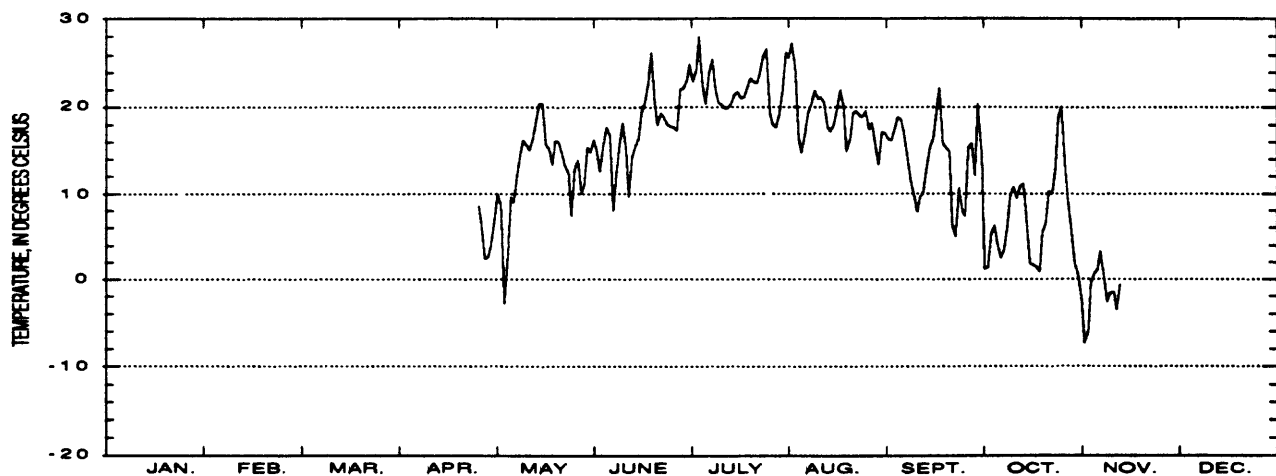
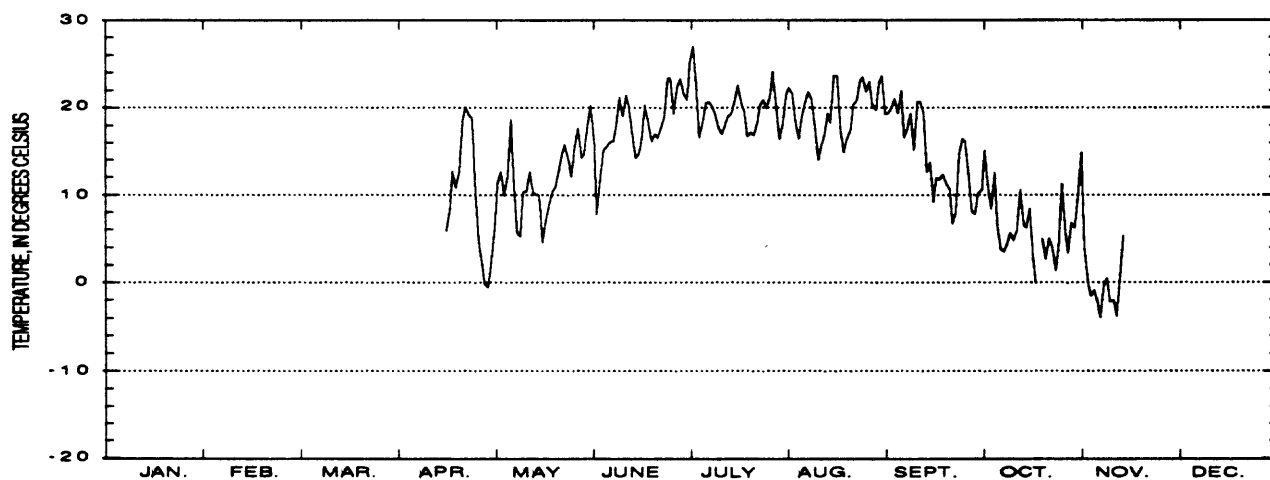


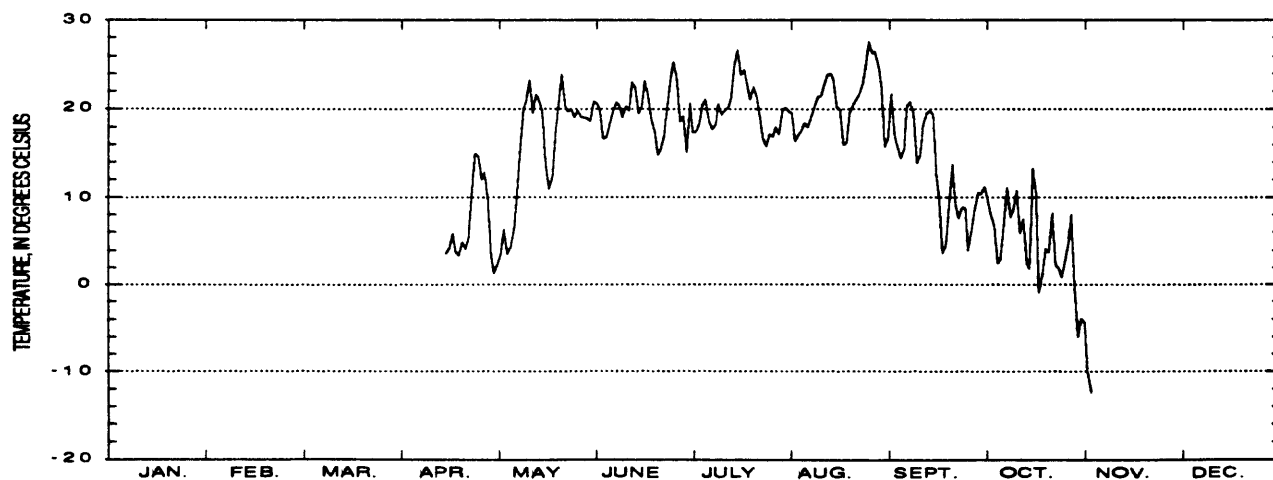
Figure 2.--Average daily air temperature at Shingobee Lake raft station, 1989-91



1989



1990



1991

Figure 3.--Average daily air temperature at Williams Lake raft station, 1989-91

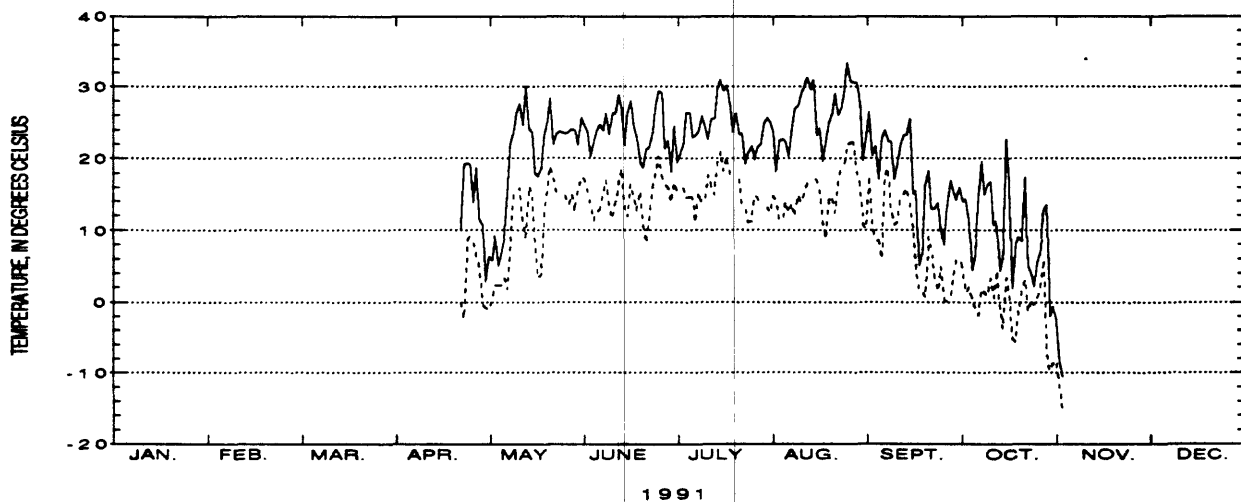
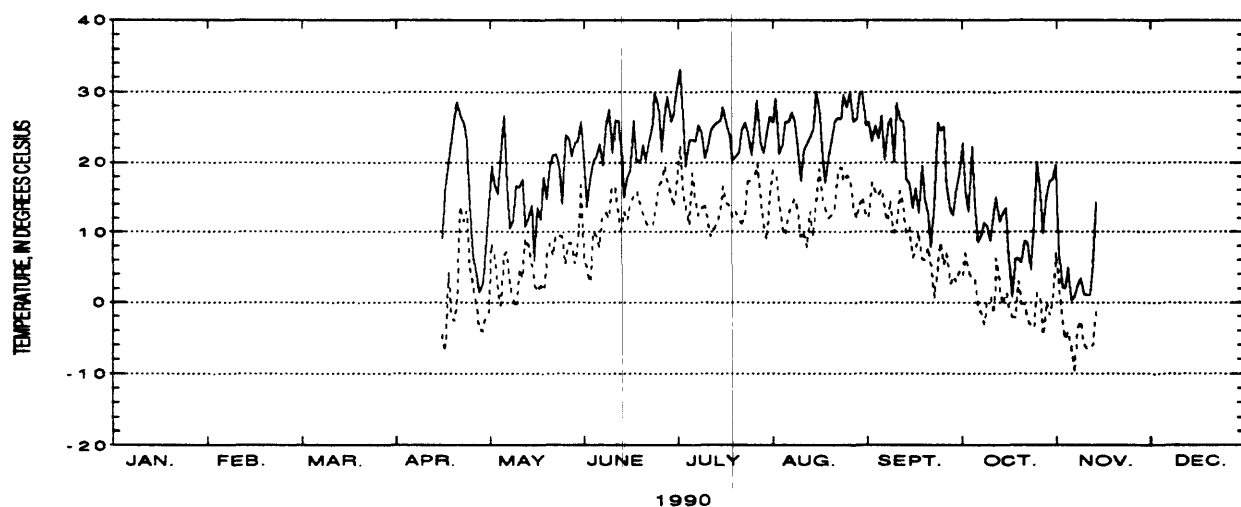
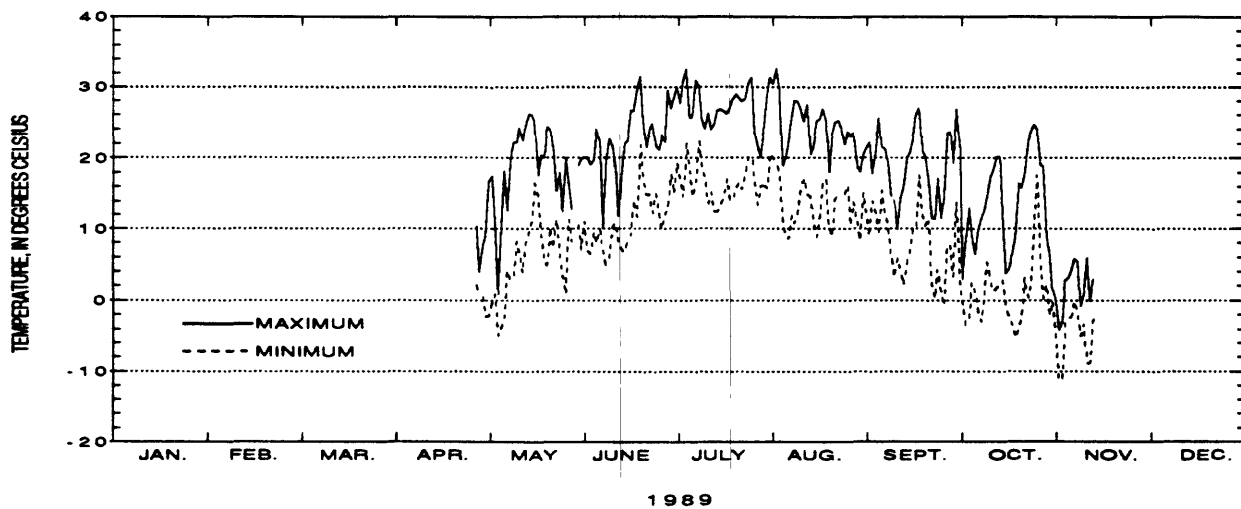


Figure 4.--Maximum and minimum daily air temperature at Shingobee Lake raft station, 1989-91

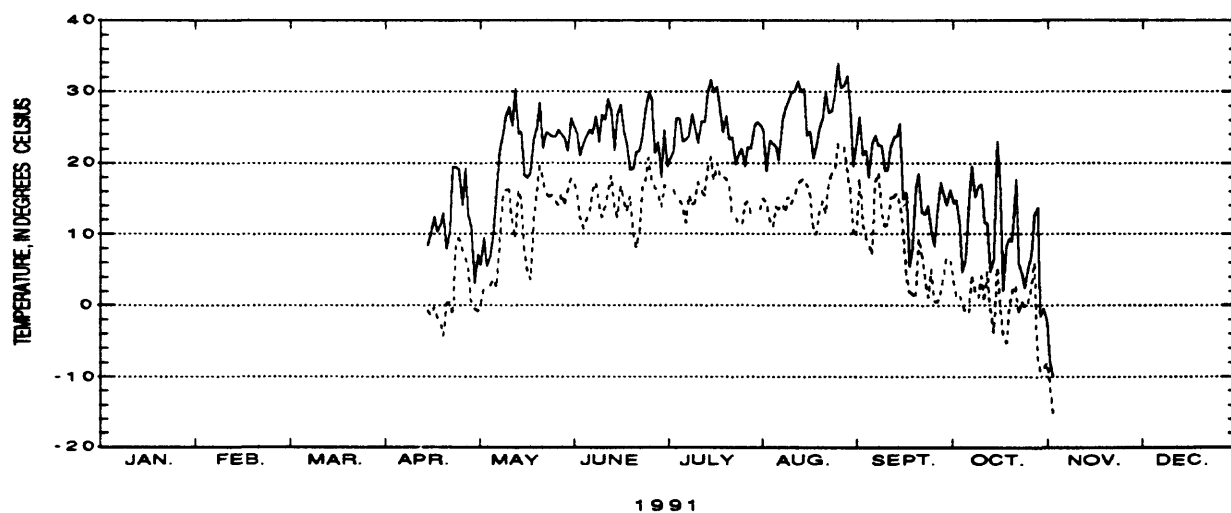
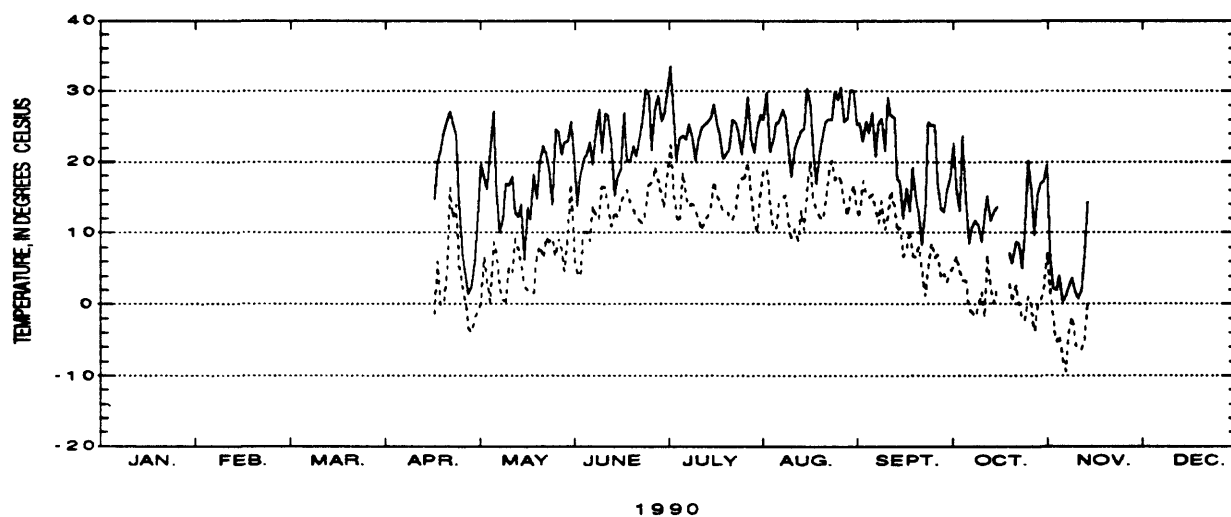
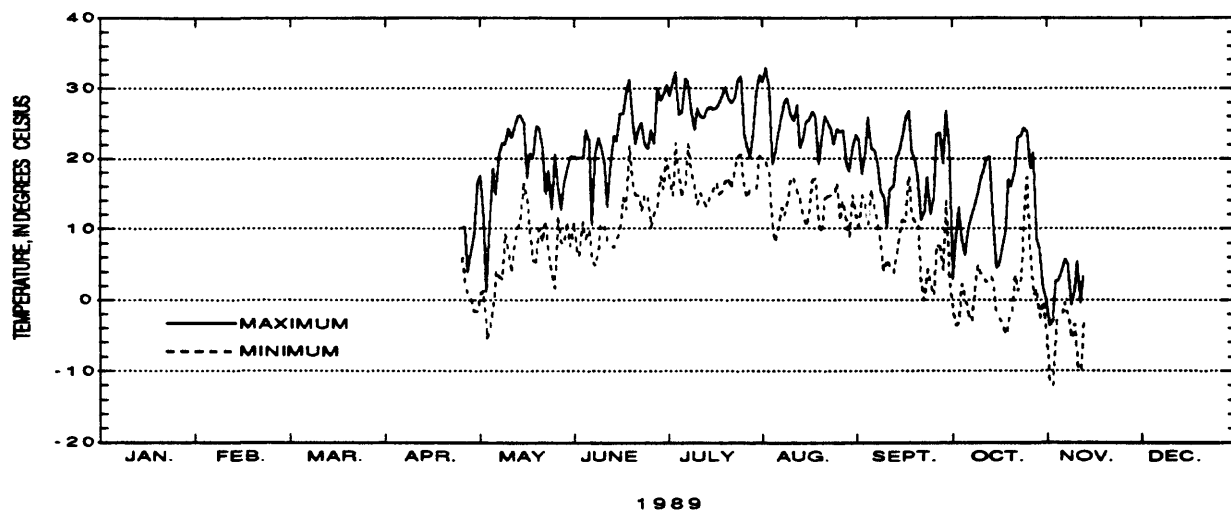


Figure 5.--Maximum and minimum daily air temperature at Williams Lake raft station, 1989-91

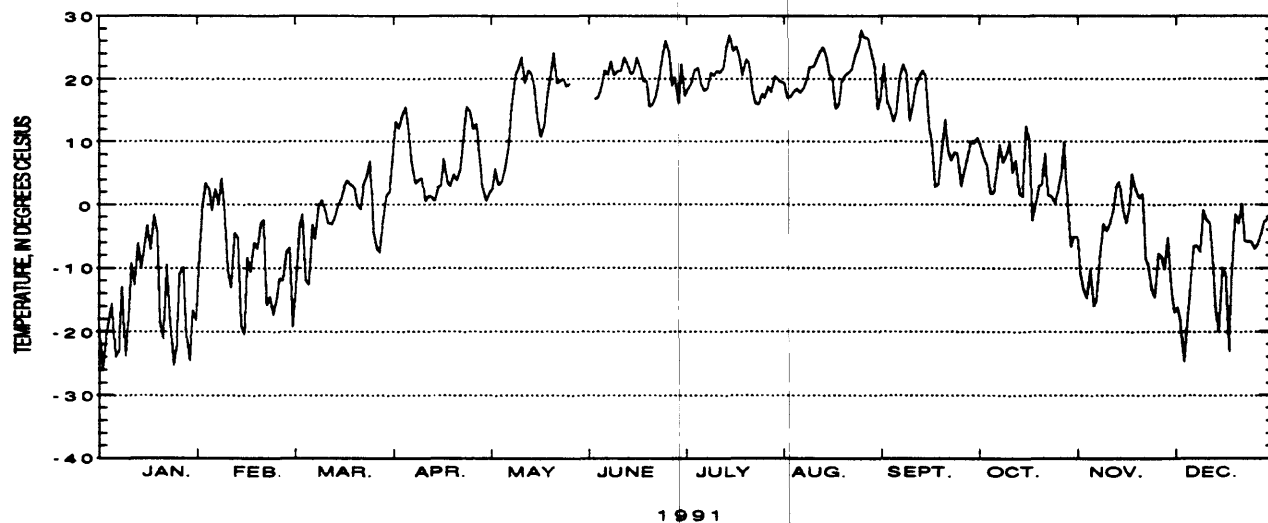
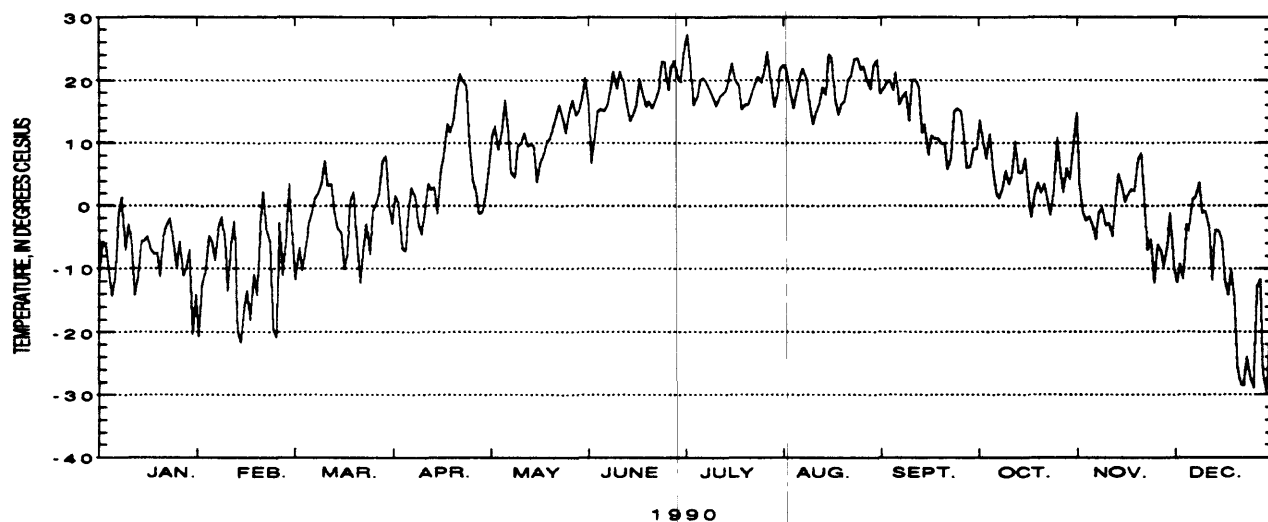
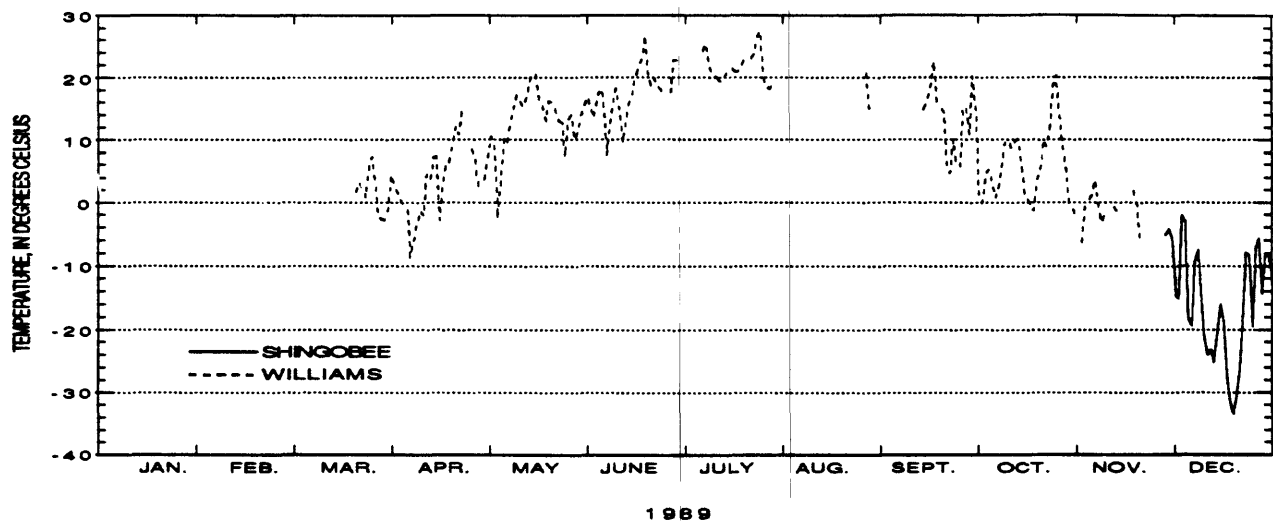


Figure 6.--Average daily air temperature at Shingobee Lake and Williams Lake land stations, 1989-91

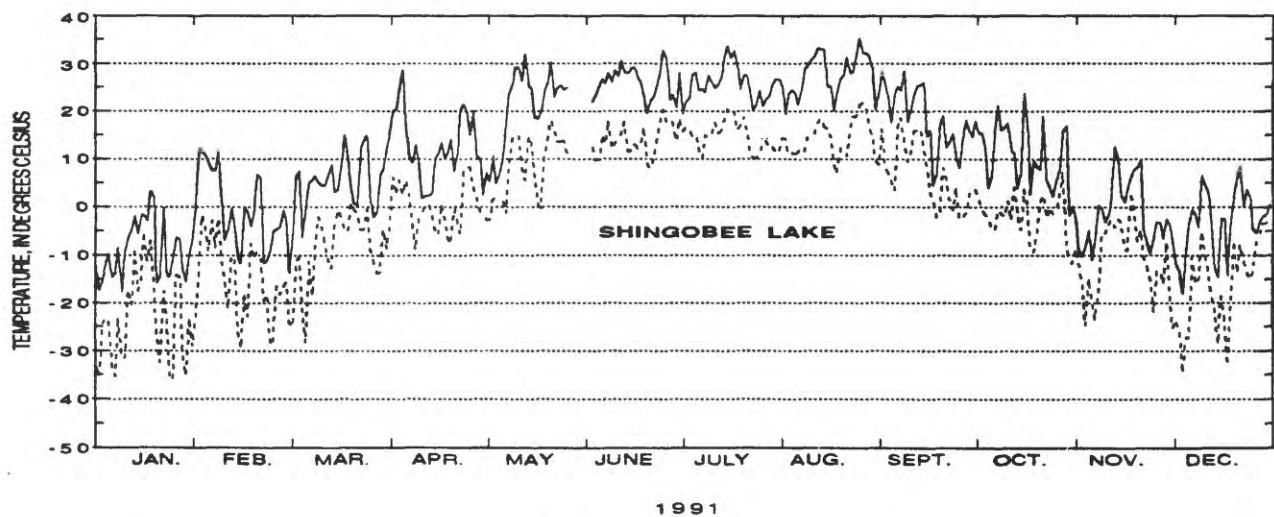
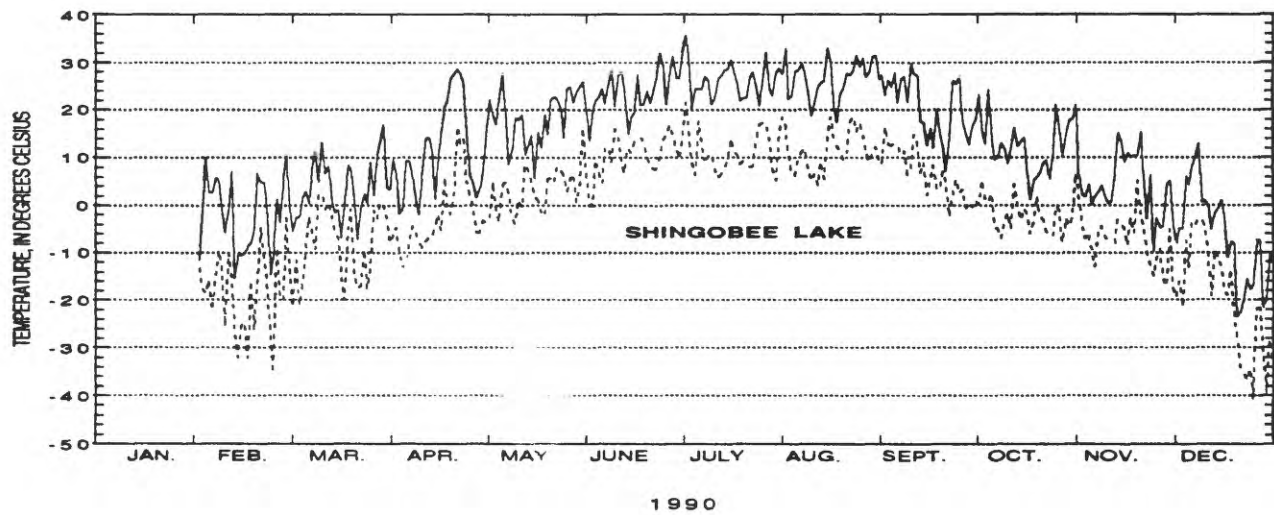
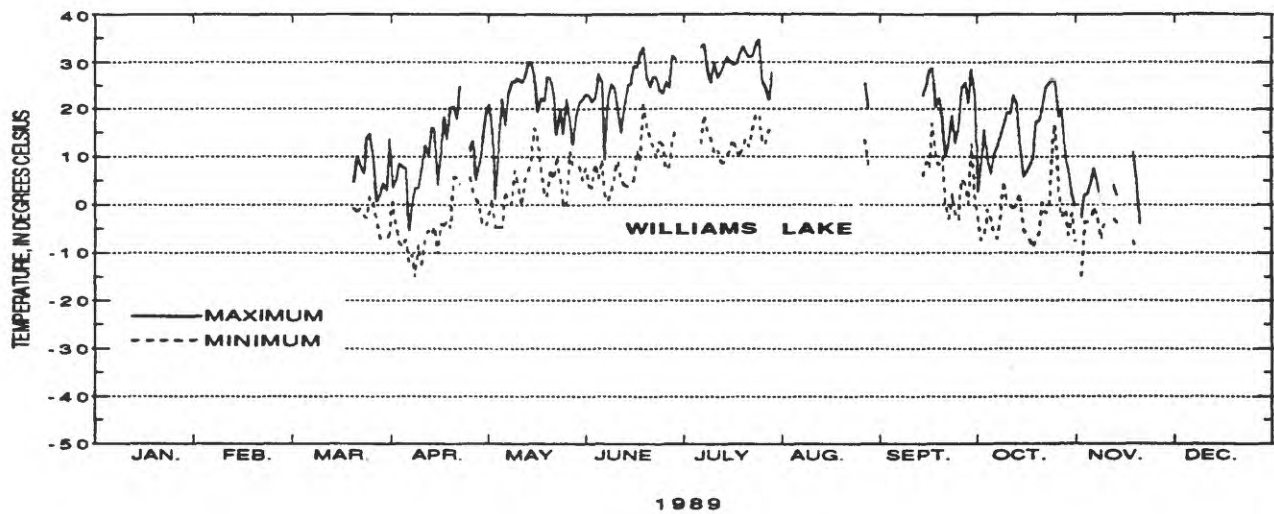


Figure 7.--Maximum and minimum daily air temperature at Shingobee Lake and Williams Lake land stations, 1989-91

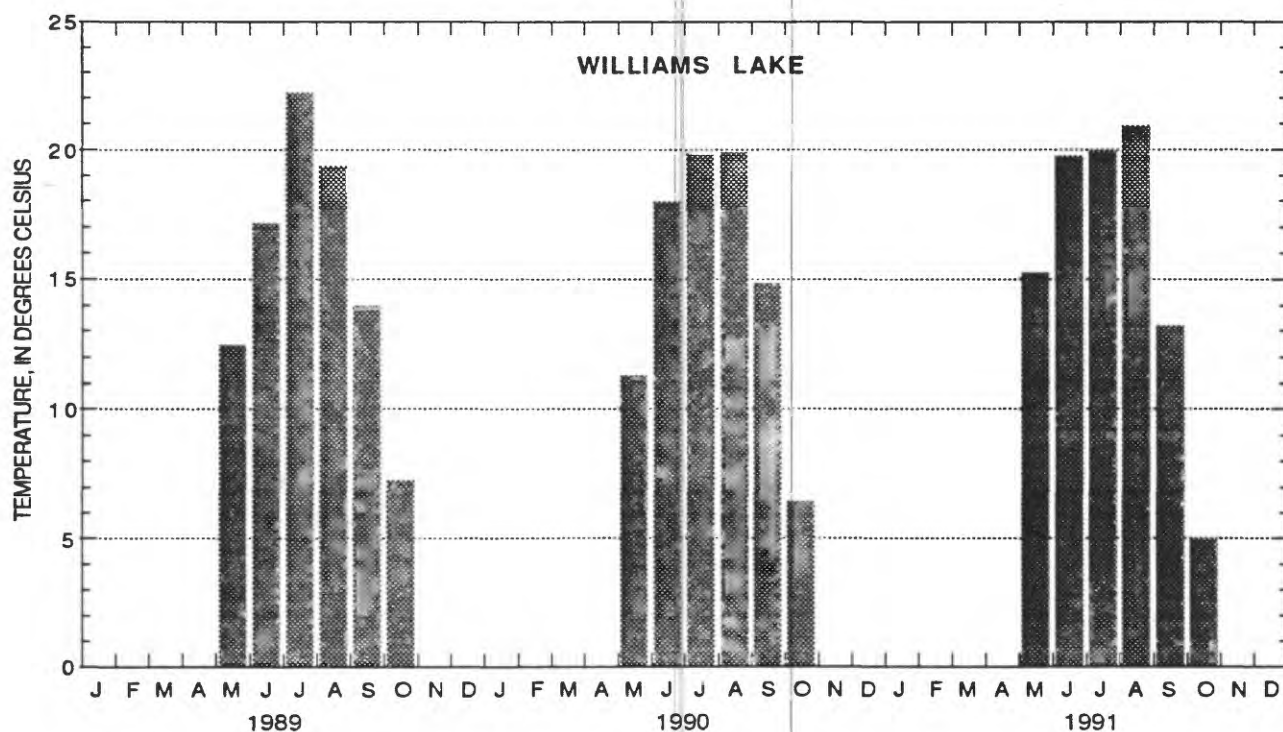
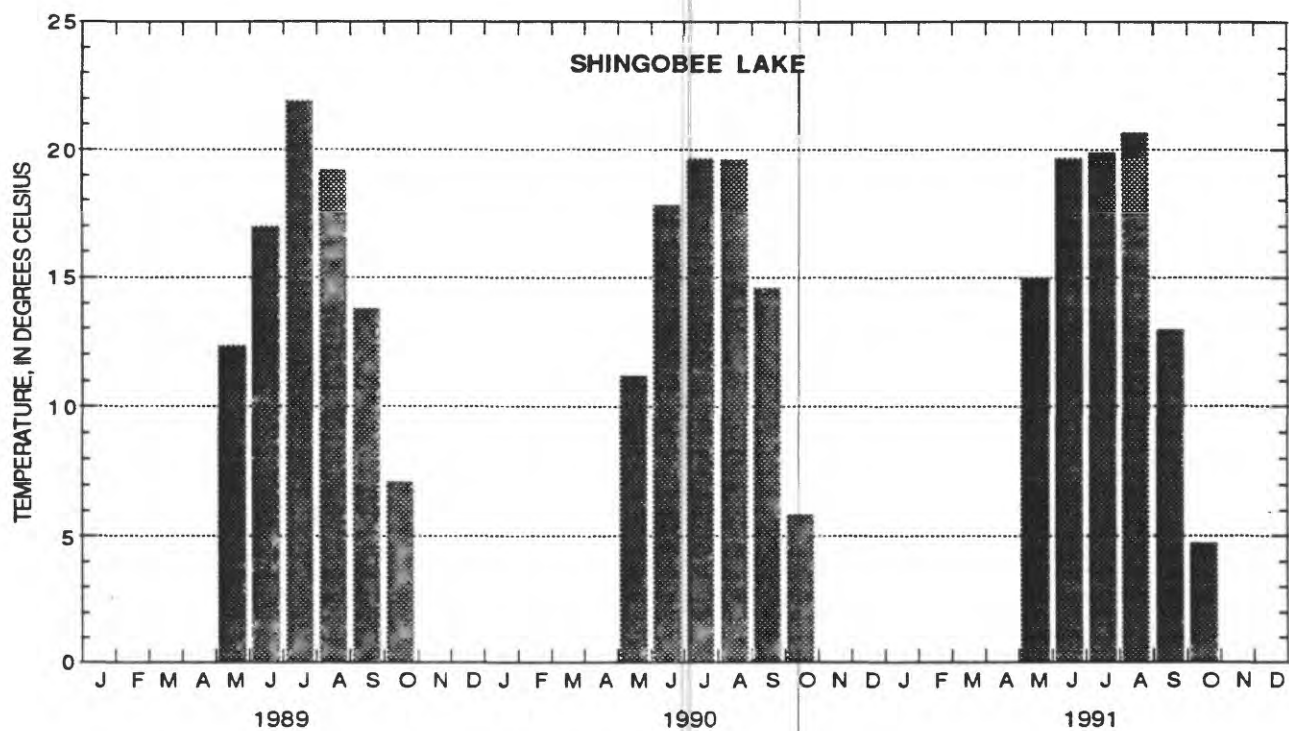


Figure 8.--Average monthly air temperature at Shingobee and Williams Lake raft stations, 1989-91

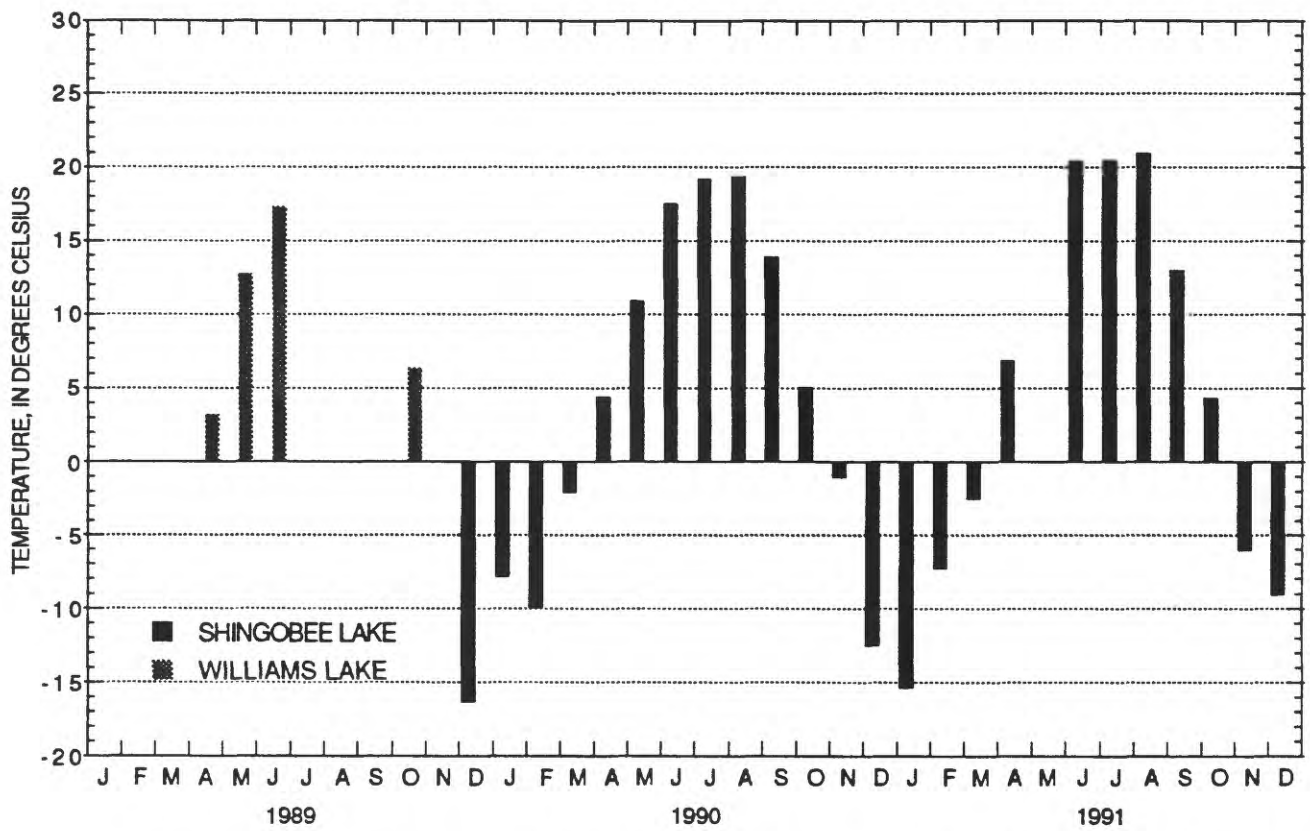


Figure 9.--Average monthly air temperature at Shingobee Lake and Williams Lake land stations, 1989-91

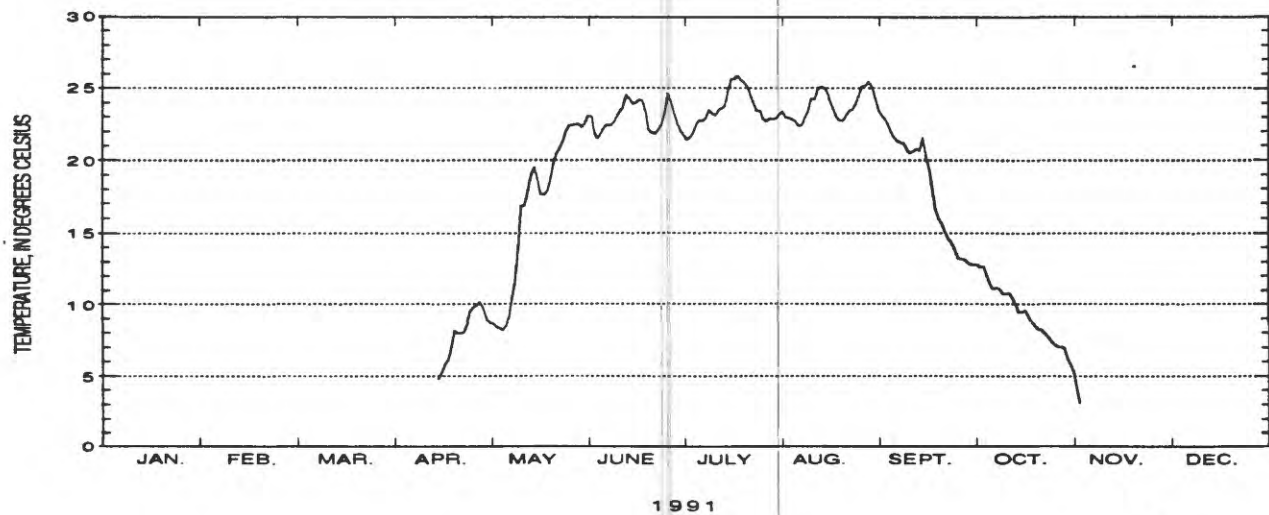
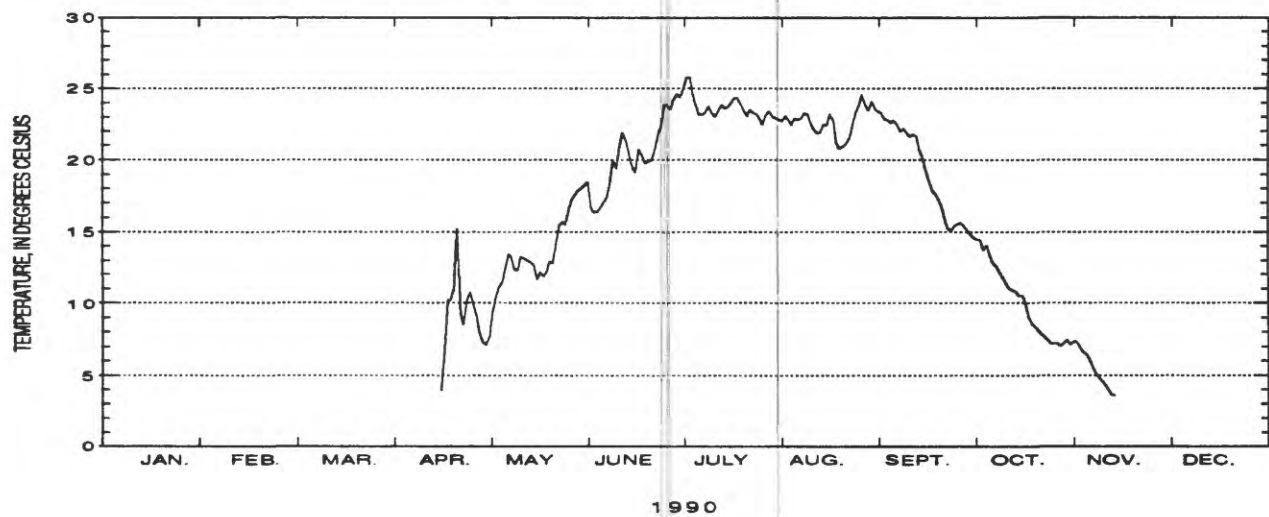
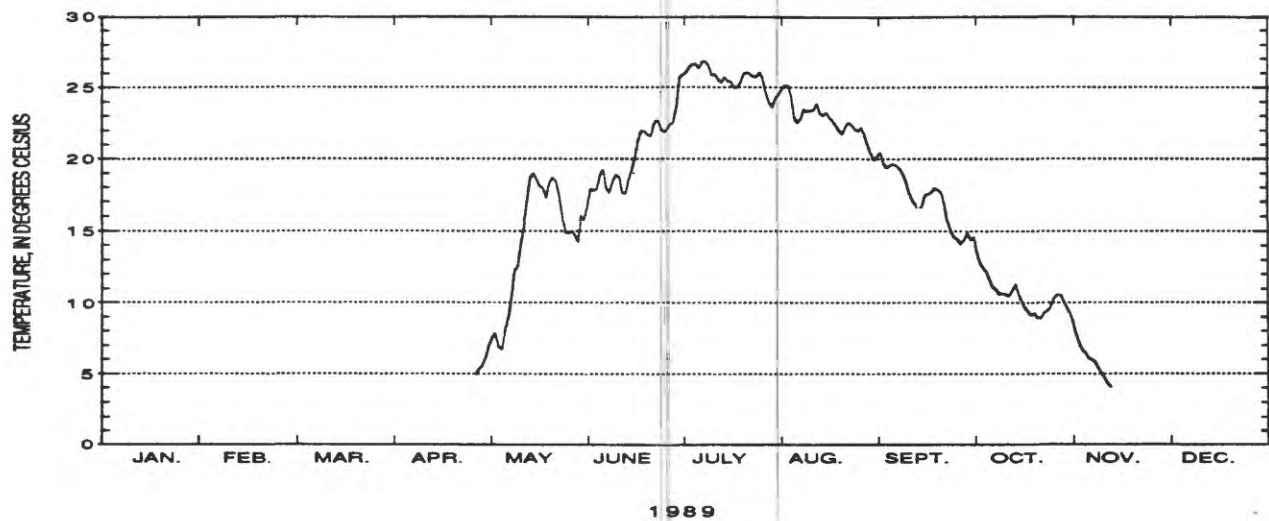


Figure 10.--Average daily water surface temperature at Shingobee Lake raft station, 1989-91

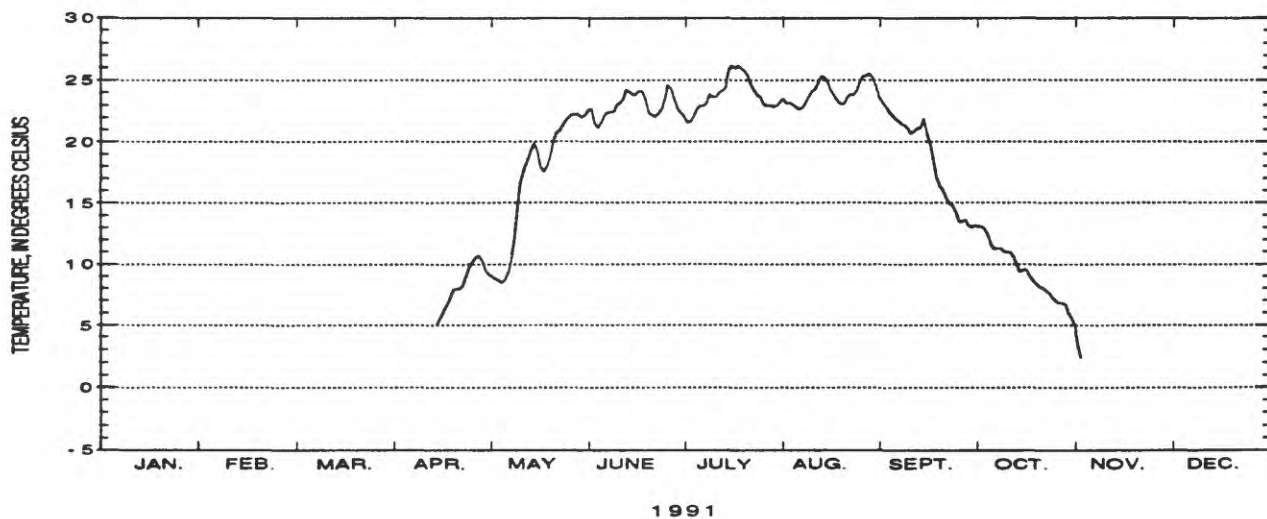
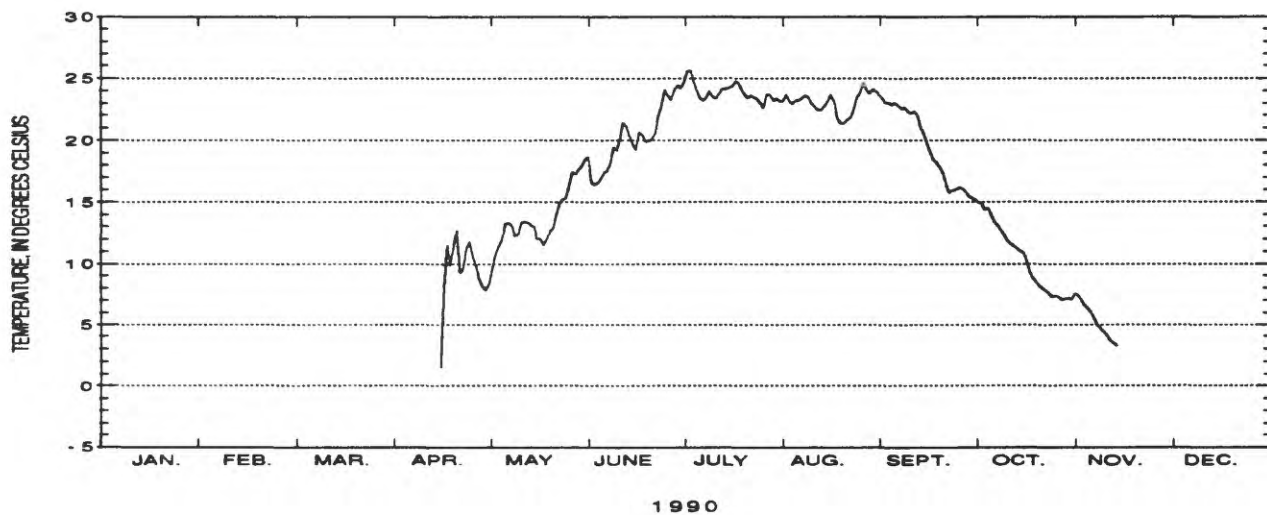
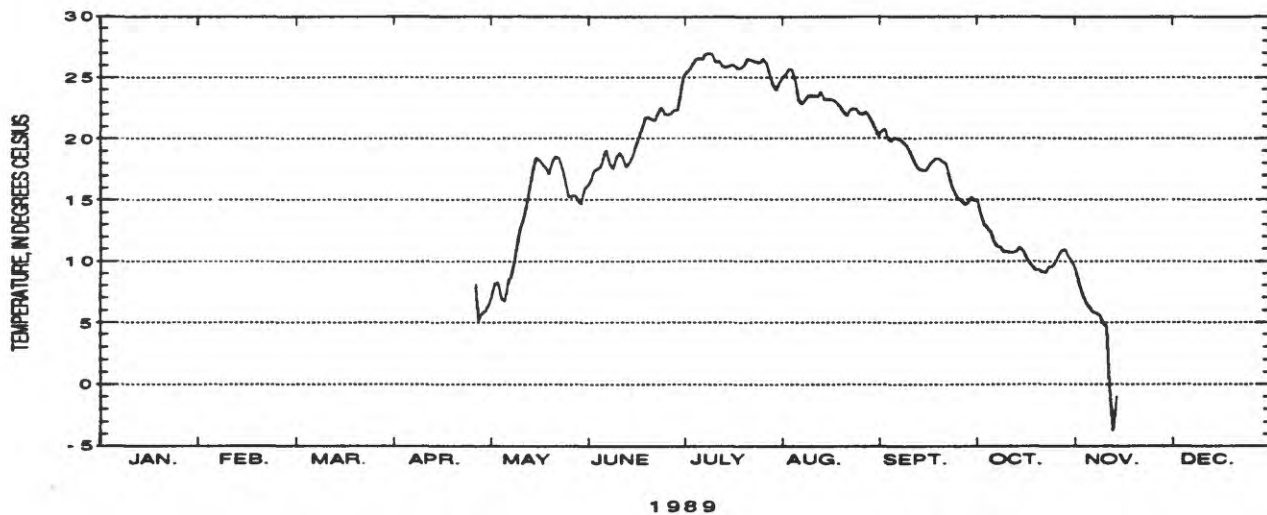


Figure 11.--Average daily water surface temperature at Williams Lake raft station, 1989-91

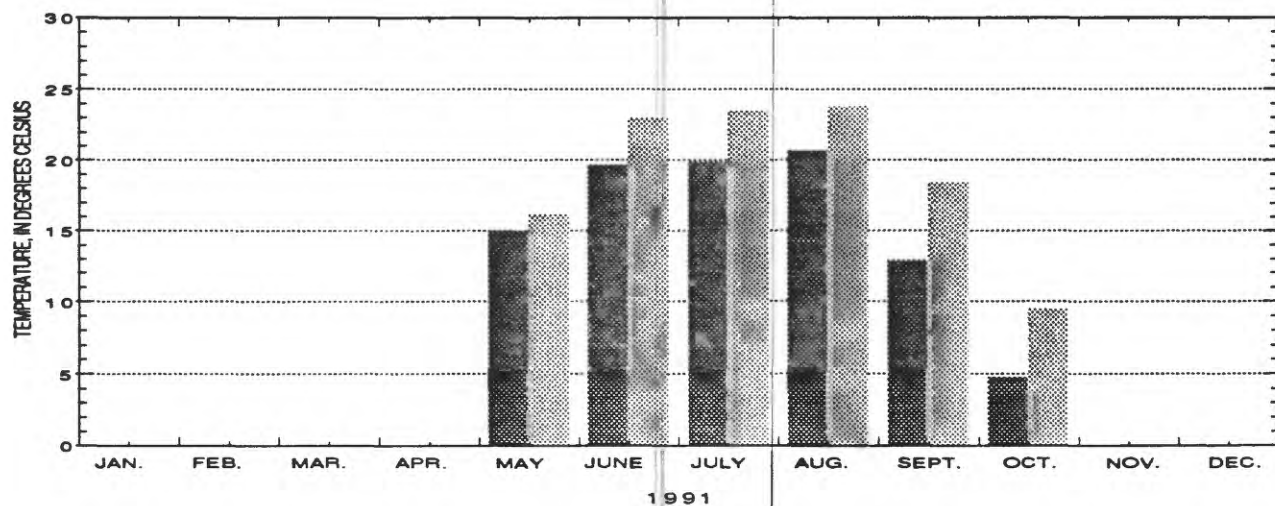
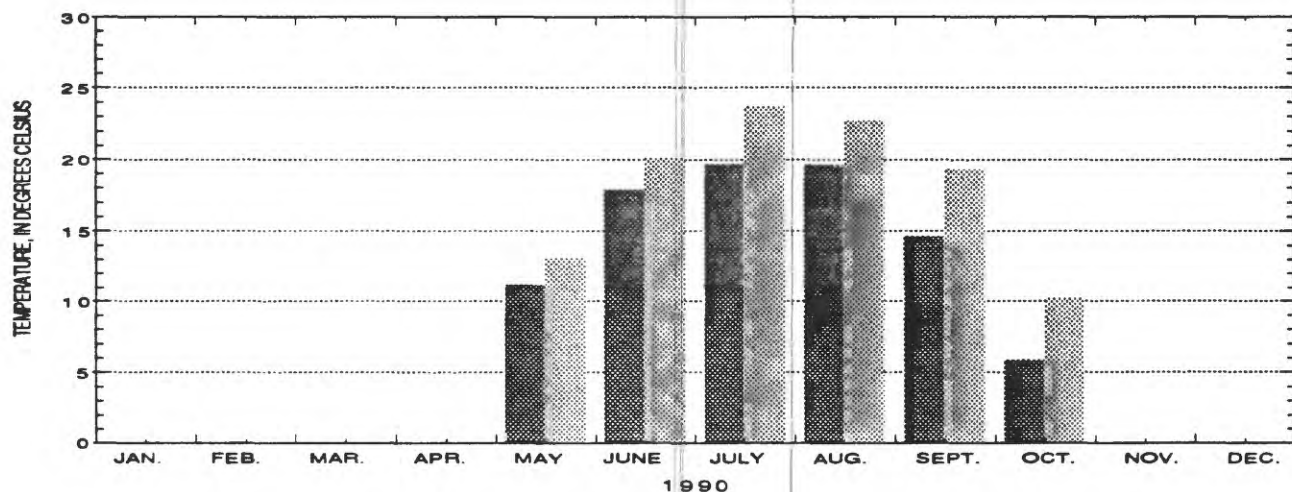
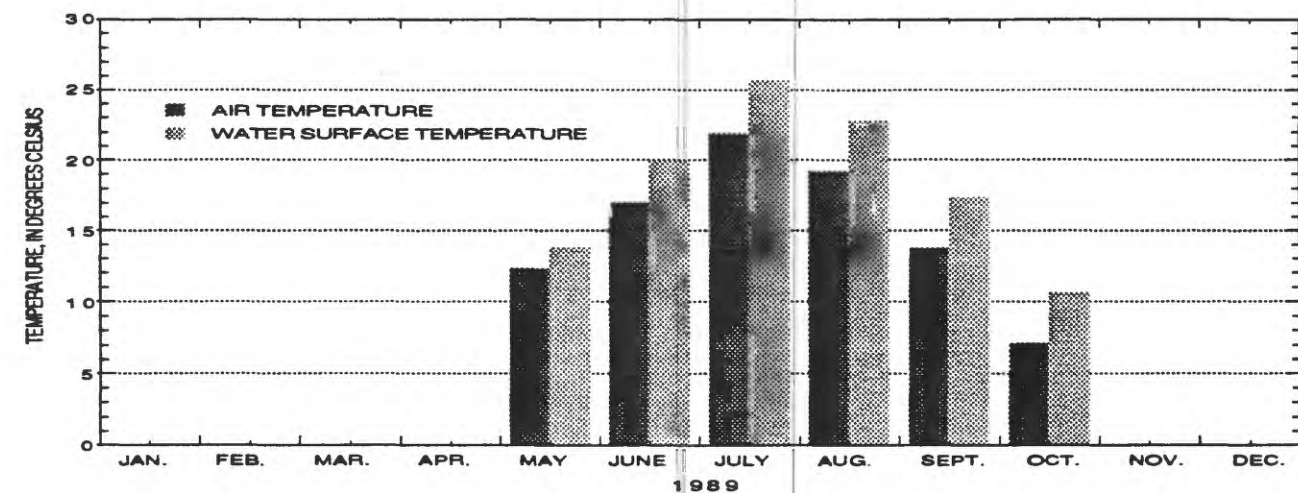


Figure 12.--Average monthly air and water surface temperature at Shingobee Lake raft station, 1989-91

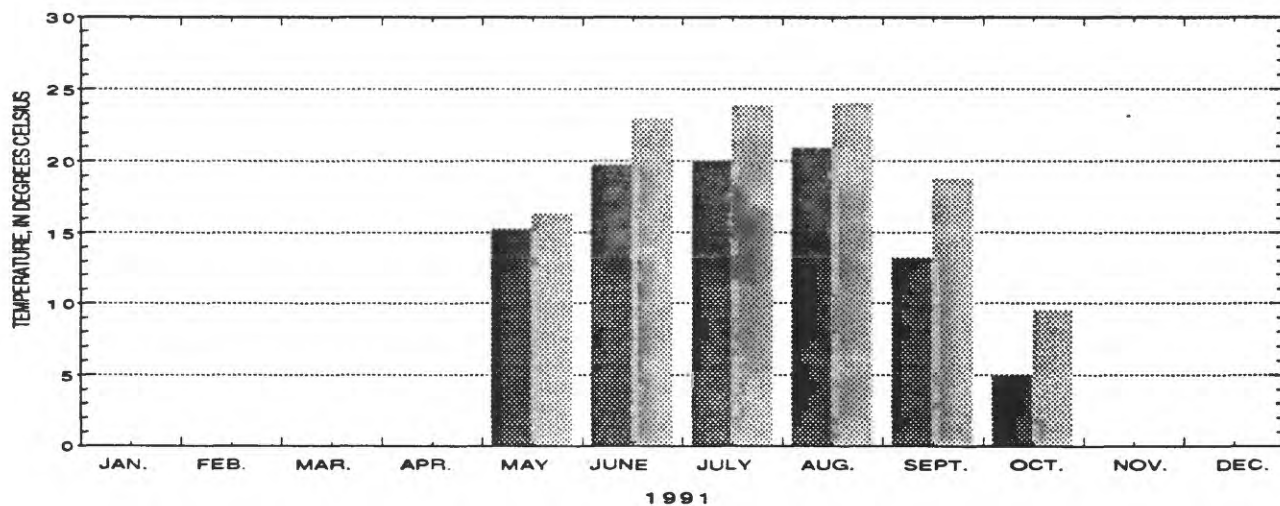
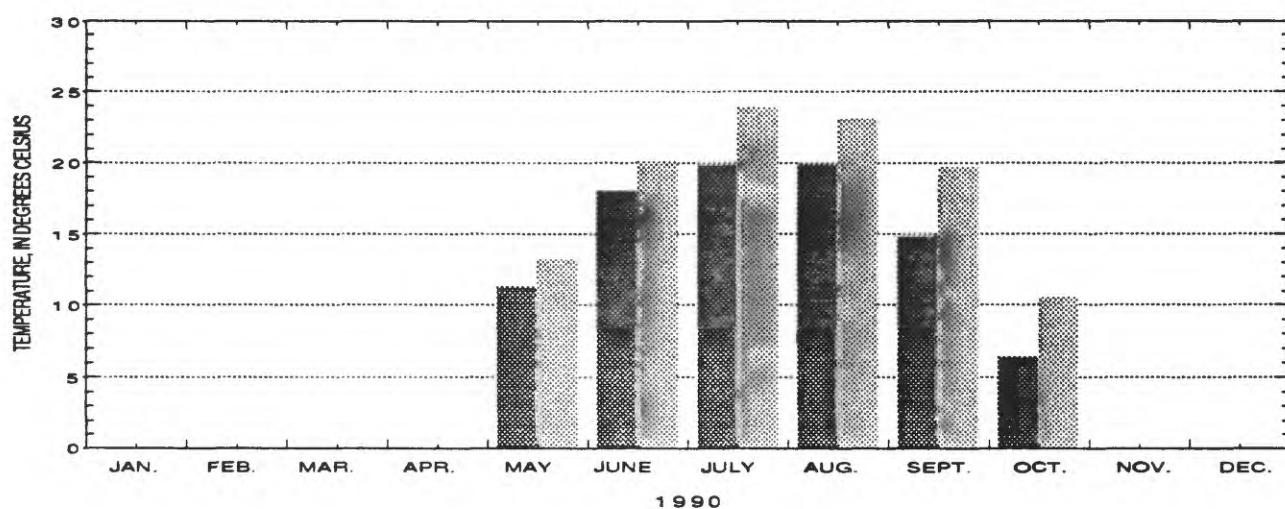
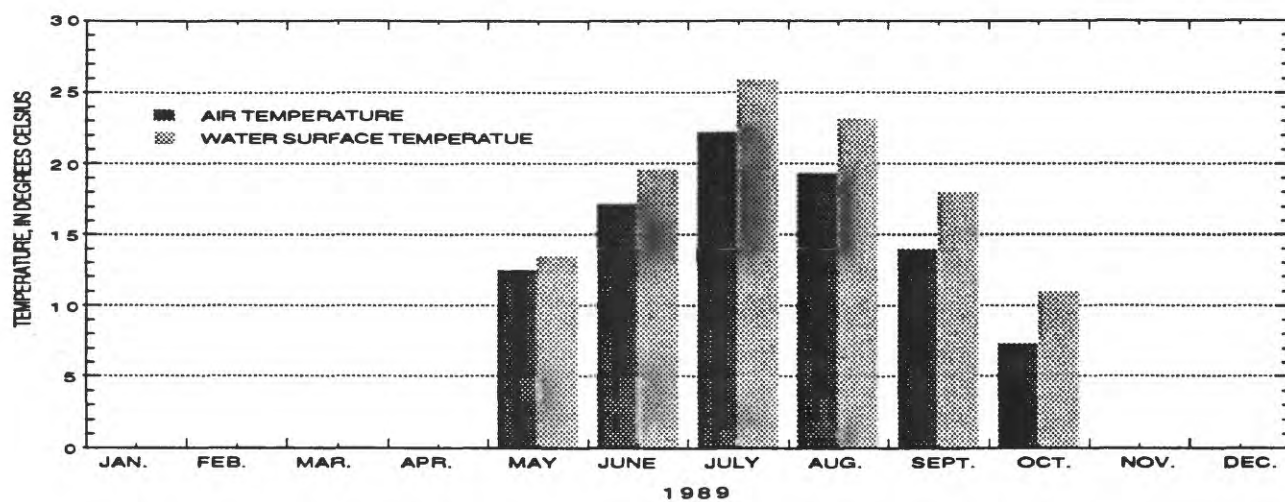


Figure13.--Average monthly air and water surface temperature at Williams Lake raft station, 1989-91

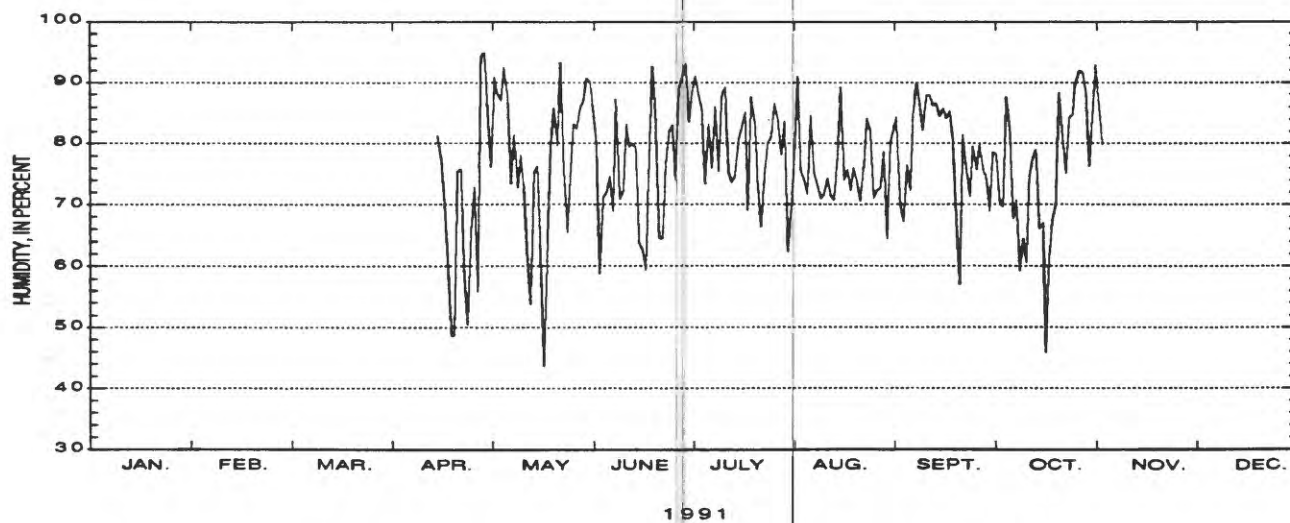
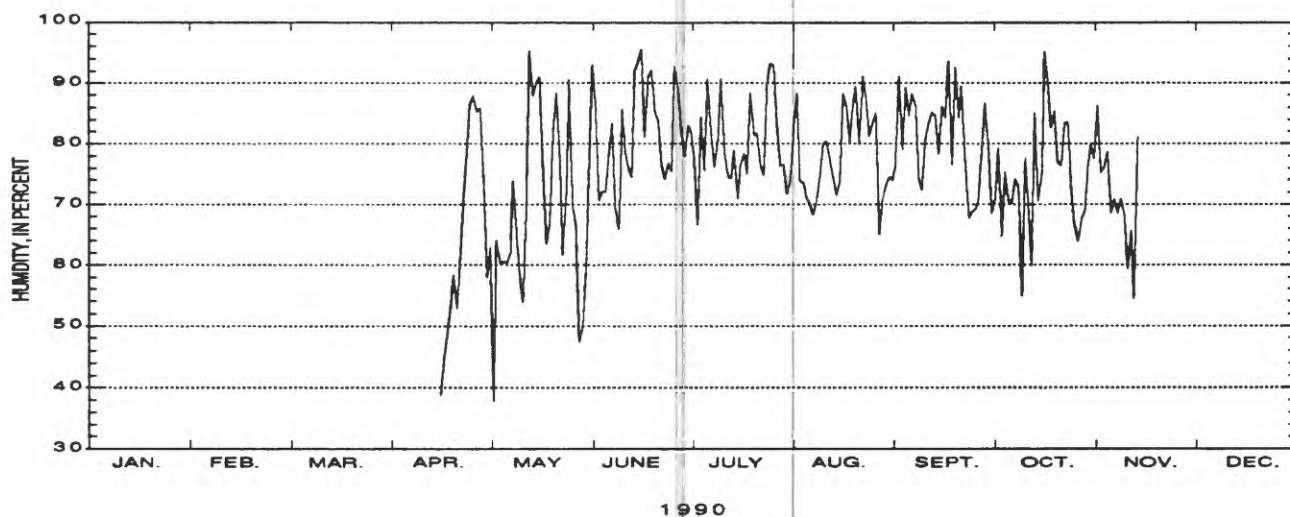
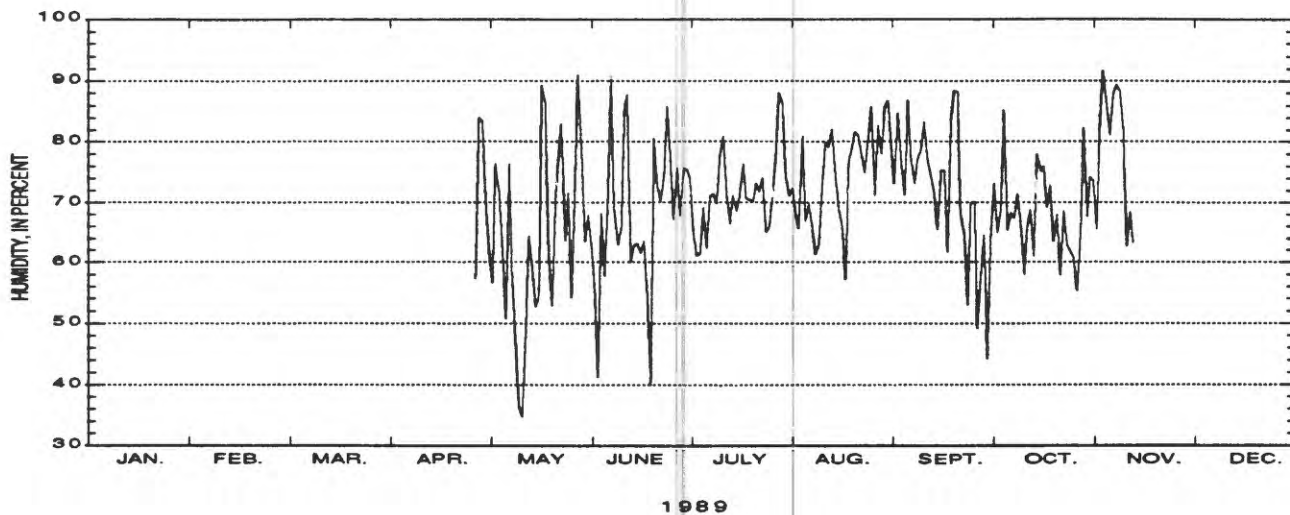


Figure 14.--Average daily humidity at Shingobee Lake raft station, 1989-91

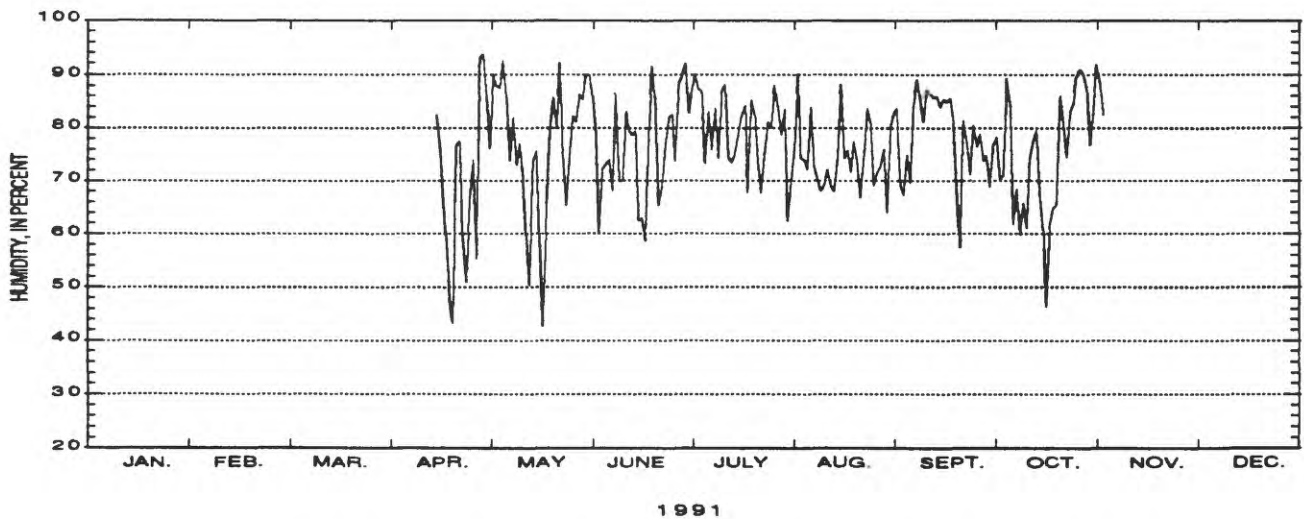
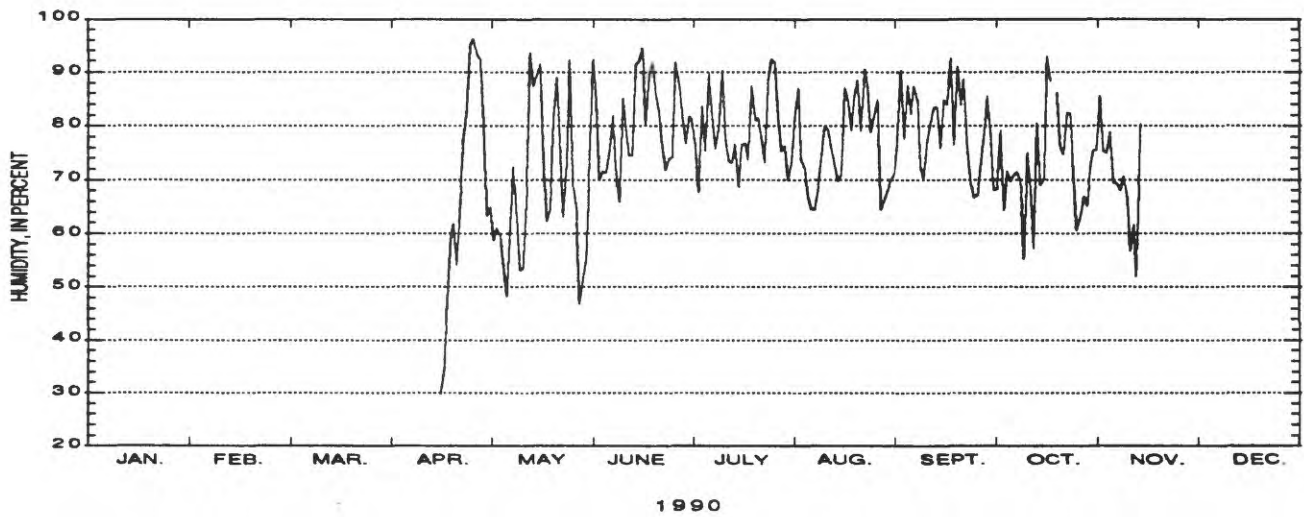
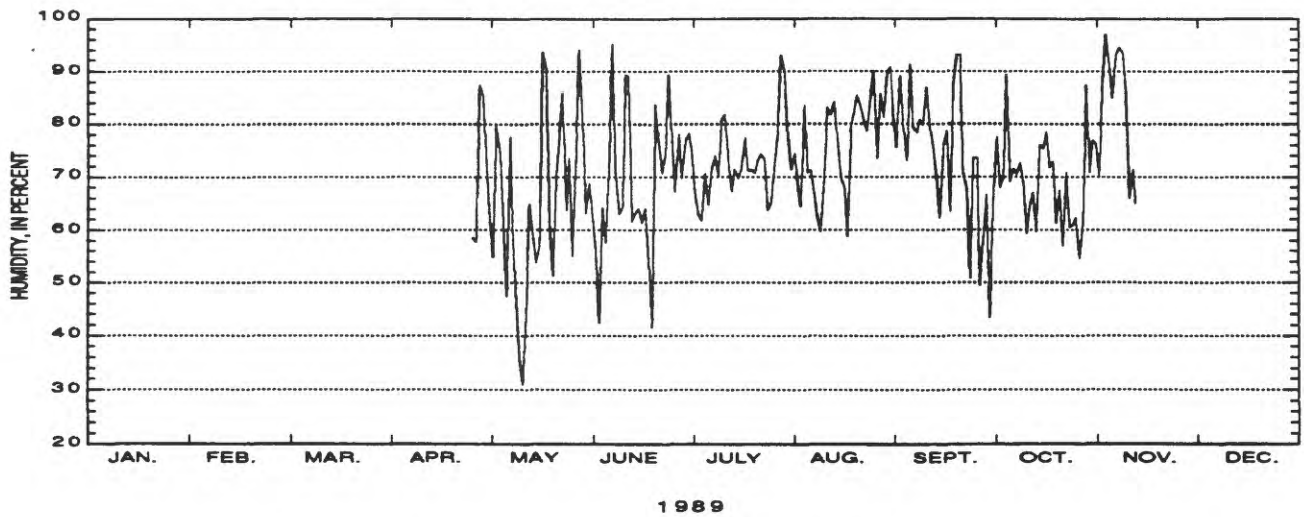


Figure 15.--Average daily humidity at Williams Lake raft station, 1989-91

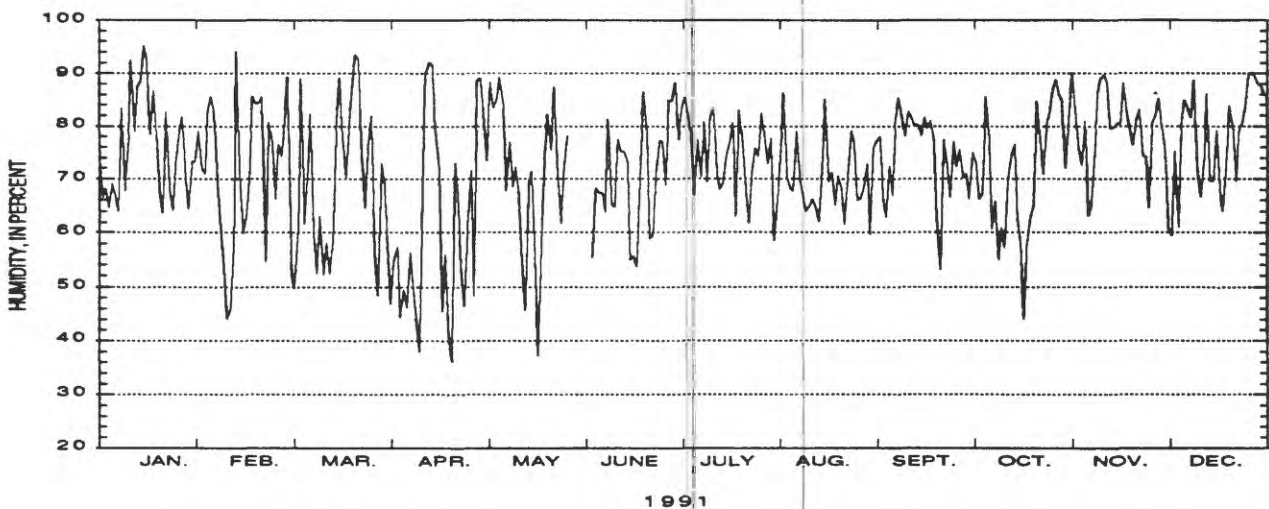
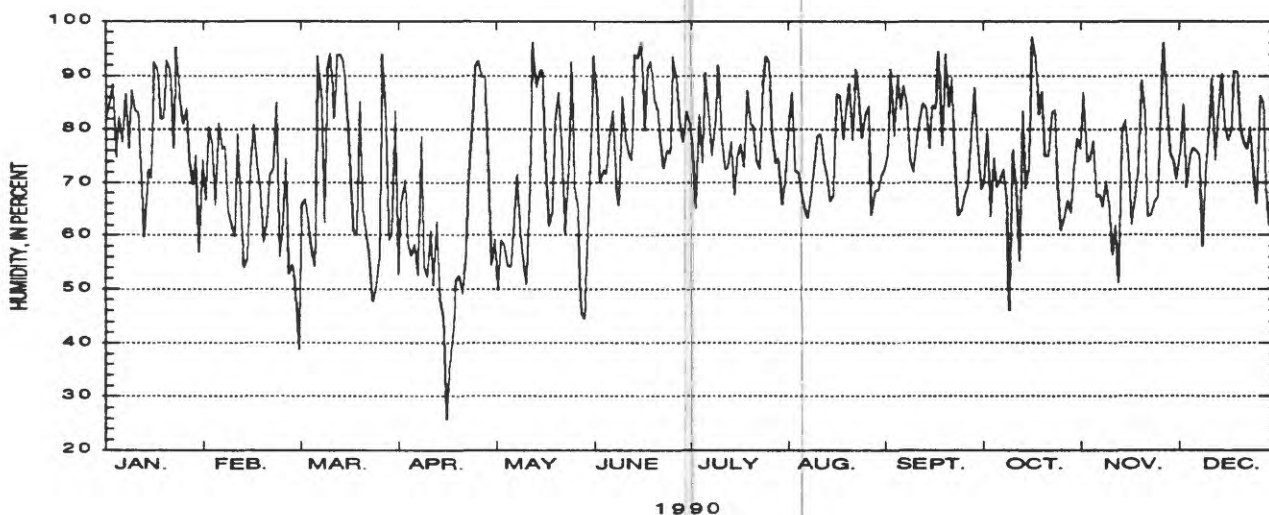
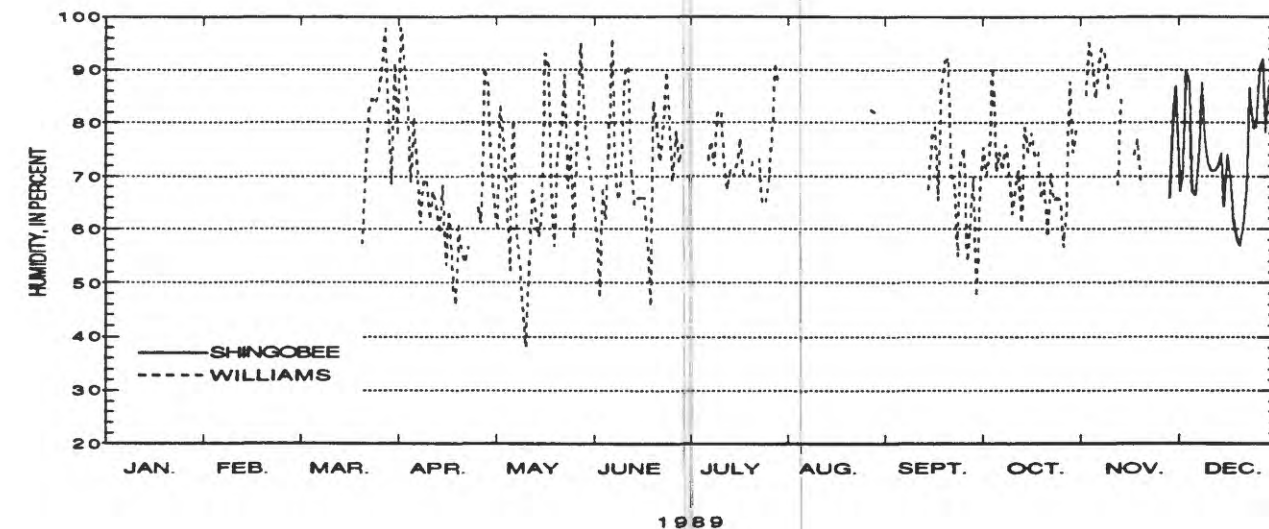


Figure 16.--Average daily humidity at Shingobee Lake and Williams Lake land stations, 1989-91

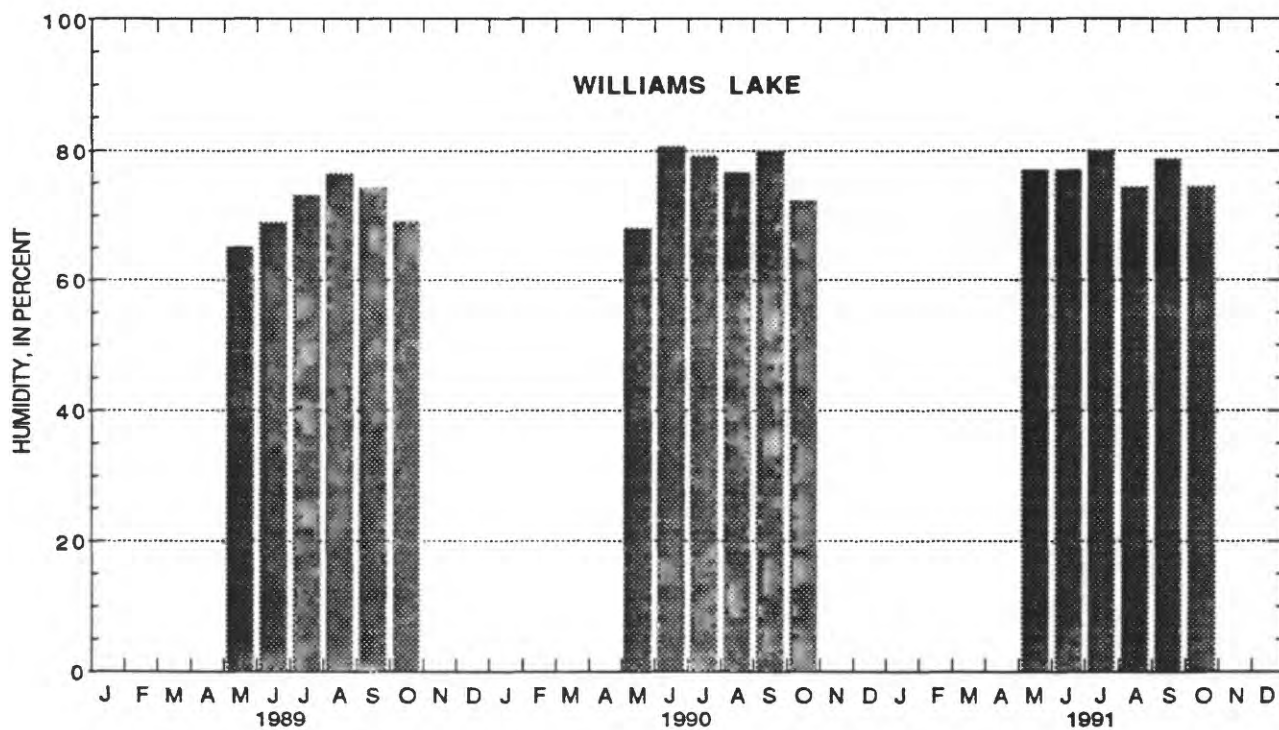
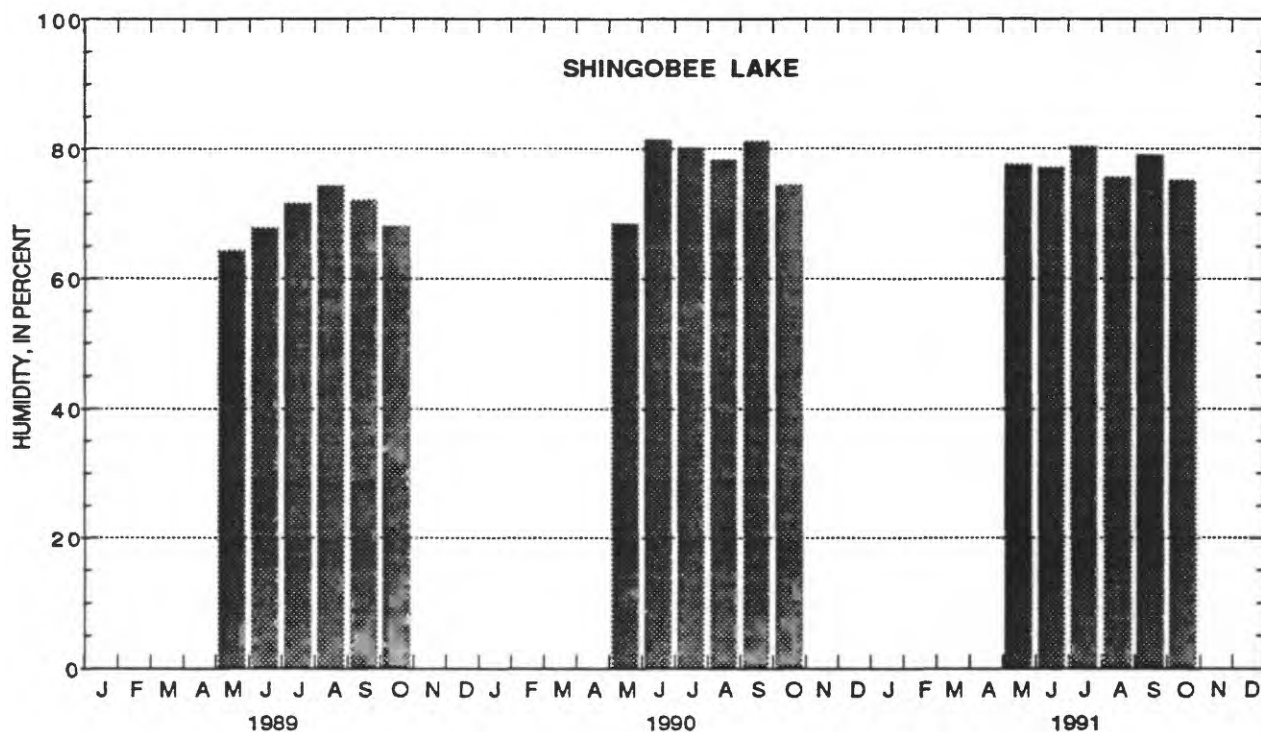


Figure 17.--Average monthly humidity at Shingobee Lake and Williams Lake raft stations, 1989-91

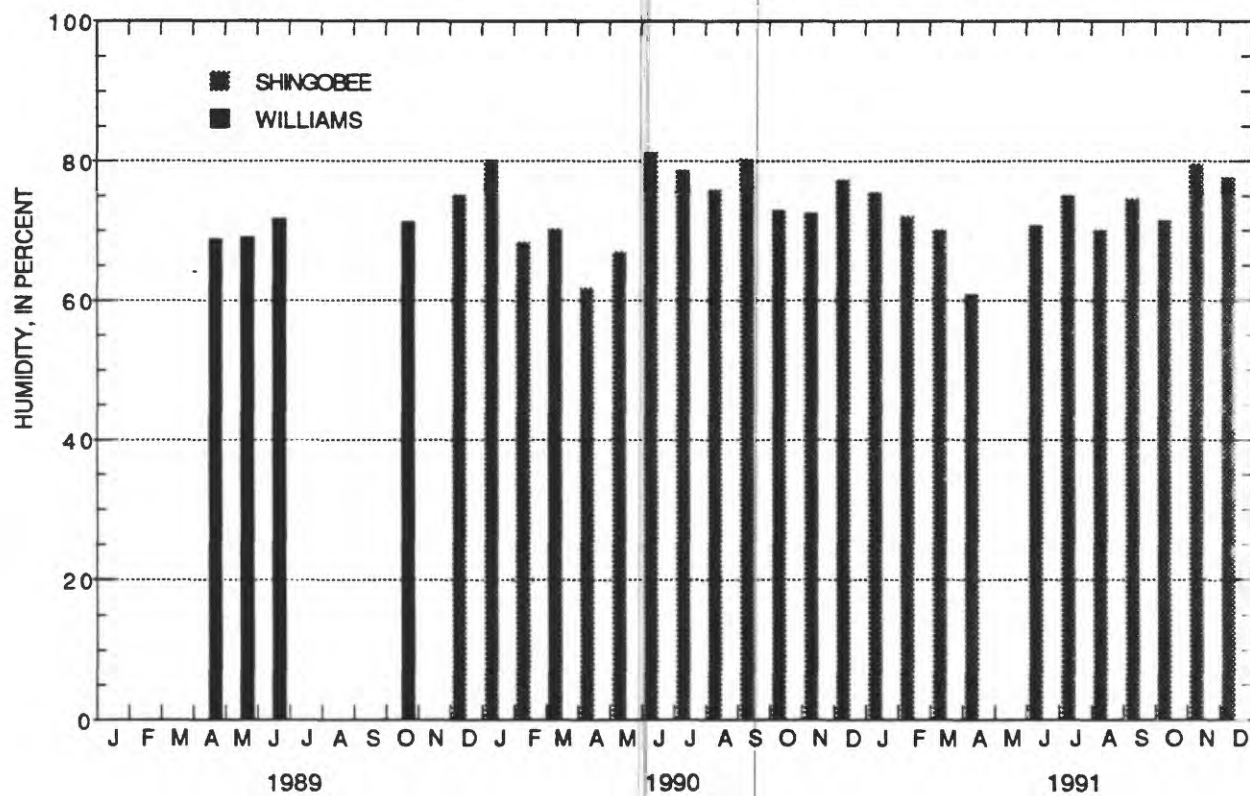


Figure 18.--Average monthly humidity at Shingobee Lake and Williams Lake land stations, 1989-91

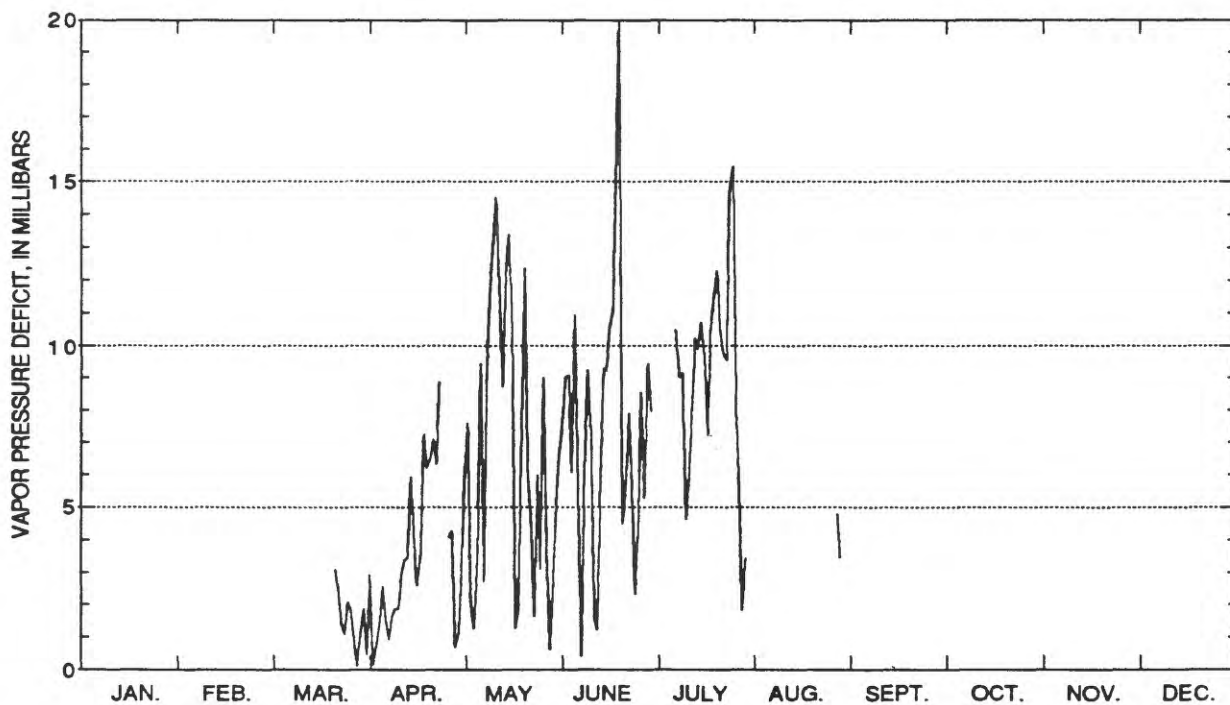
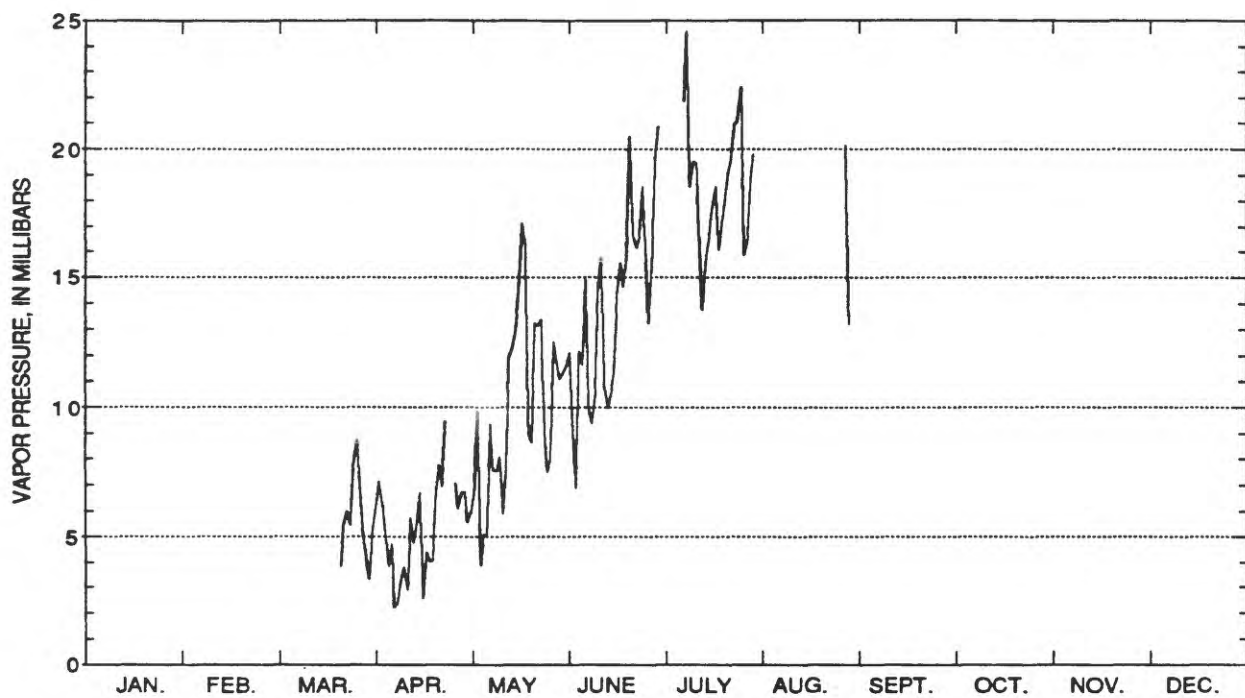


Figure 19.--Average daily vapor pressure and vapor pressure deficit at Williams Lake land station, 1989

[Vapor pressure deficit is the difference between the saturated vapor pressure and the actual vapor pressure]

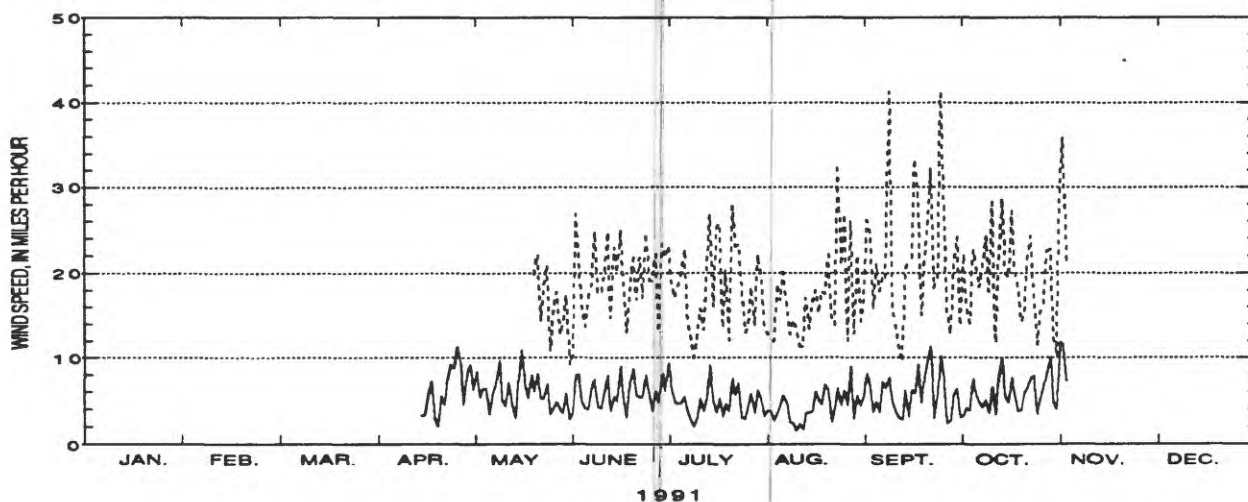
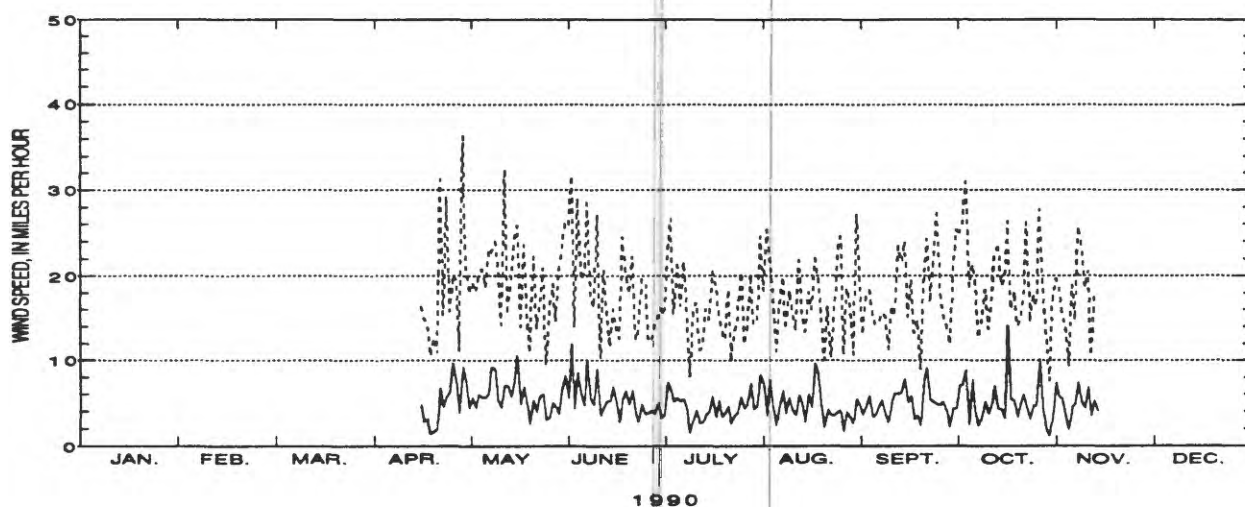
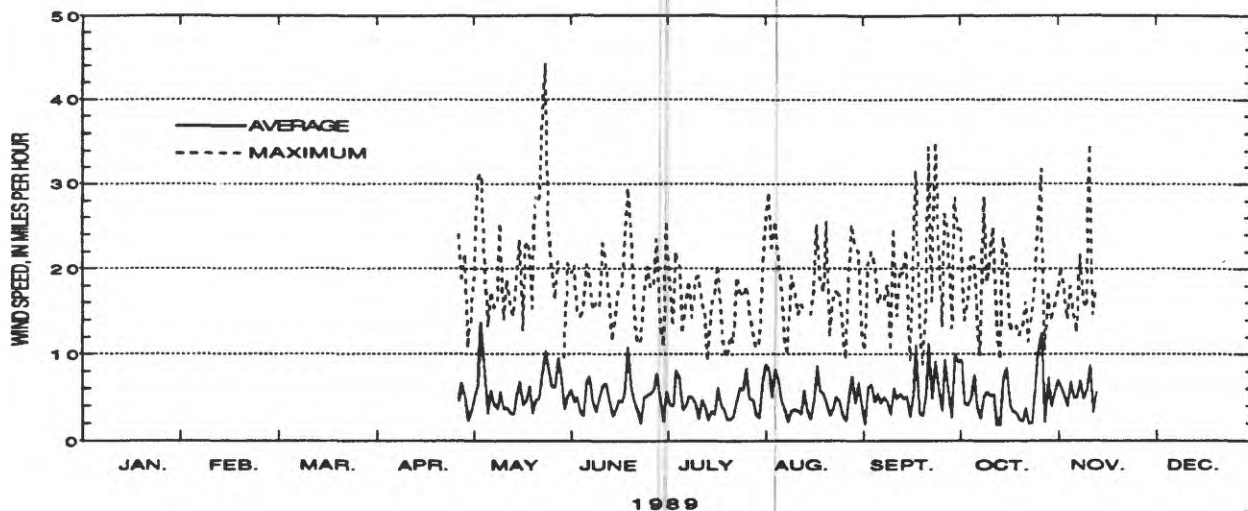


Figure 20.--Average and maximum daily wind speed at 2 meters above Shingobee Lake raft station, 1989-91

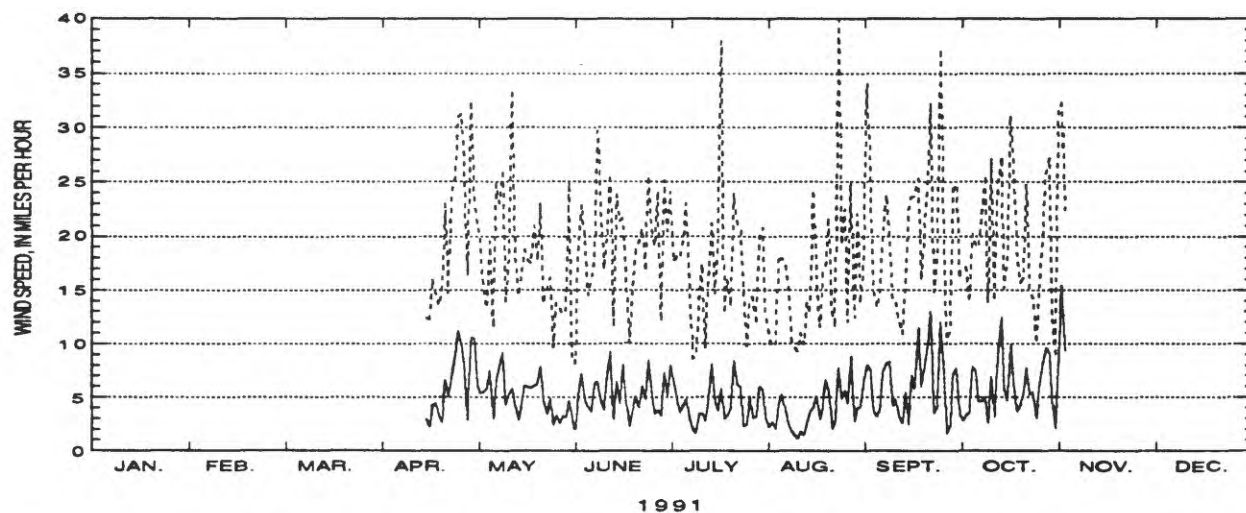
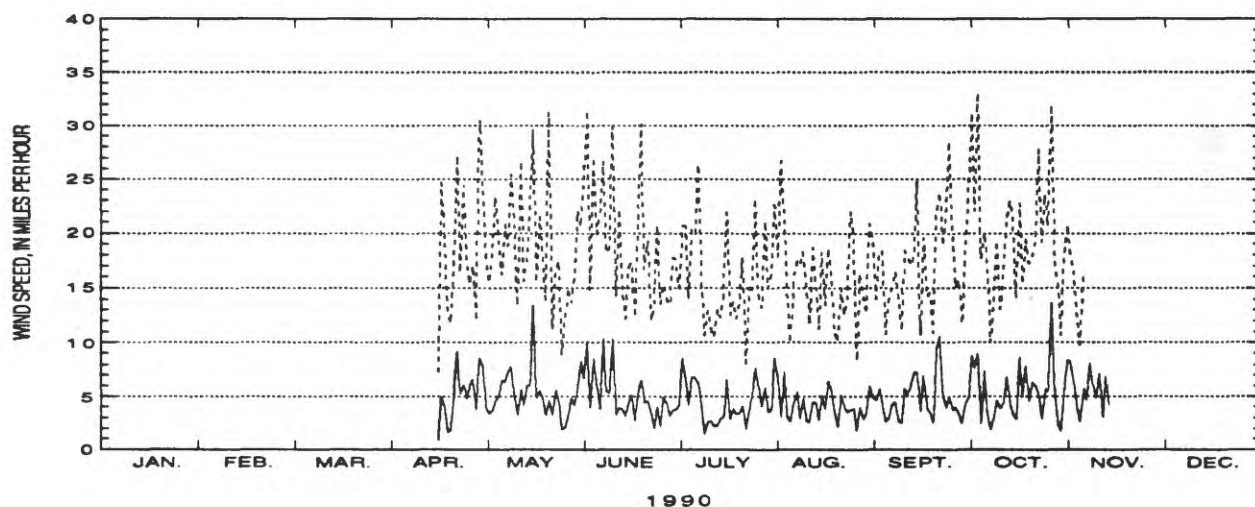
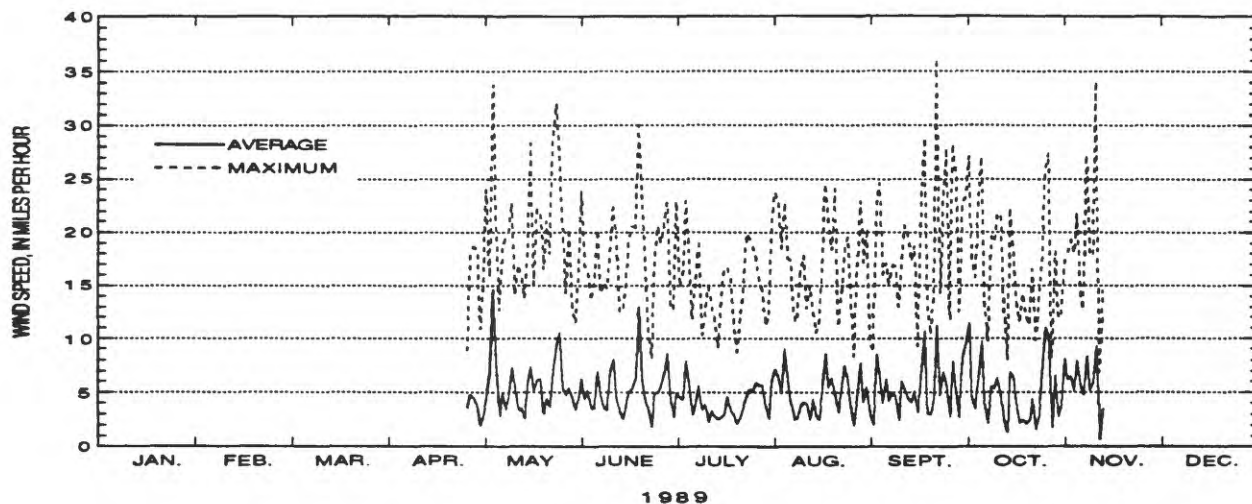


Figure 21.--Average and maximum daily wind speed at 2 meters above Williams Lake raft station, 1989-91

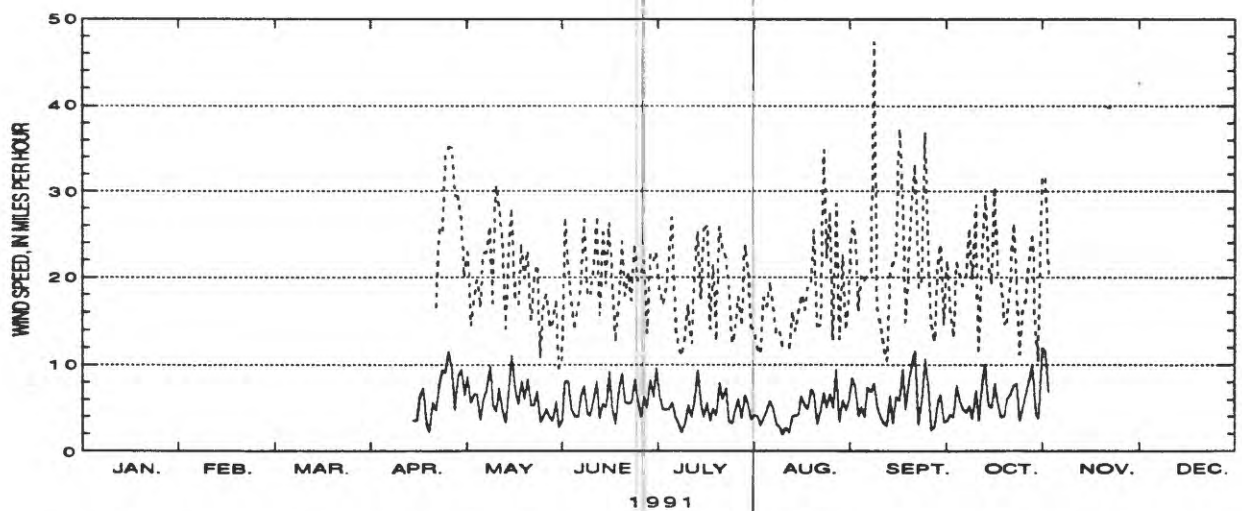
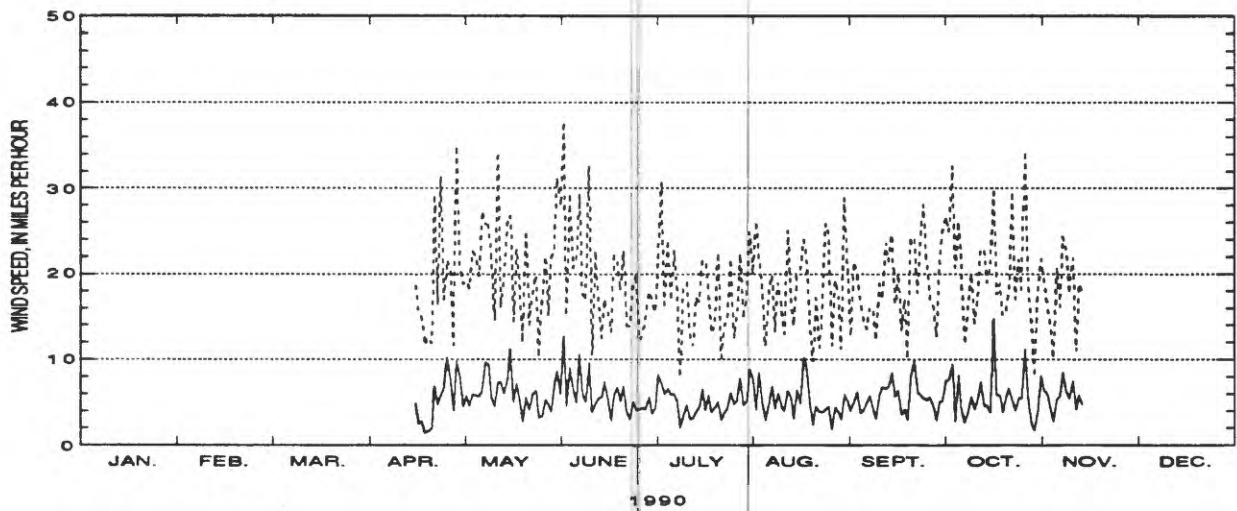
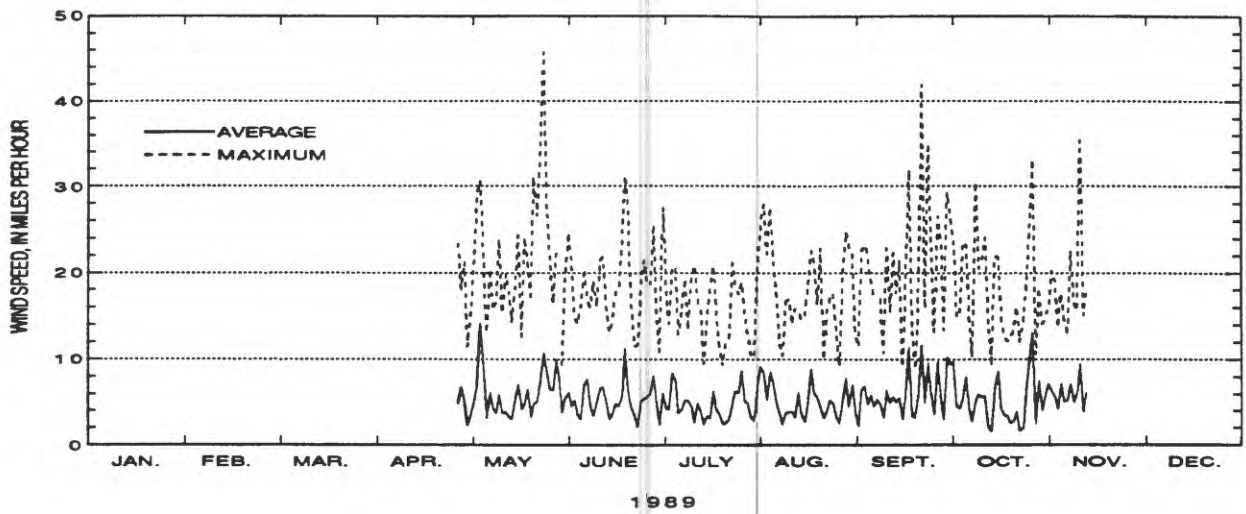


Figure 22.--Average daily and maximum wind speed at 3 meters above Shingobee Lake raft station, 1989-91.

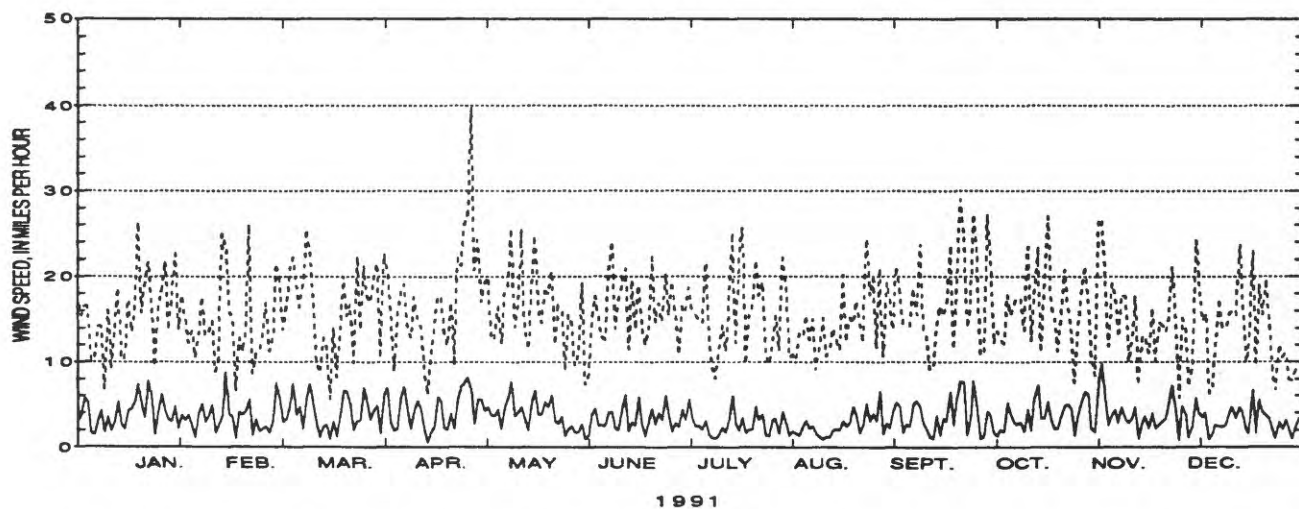
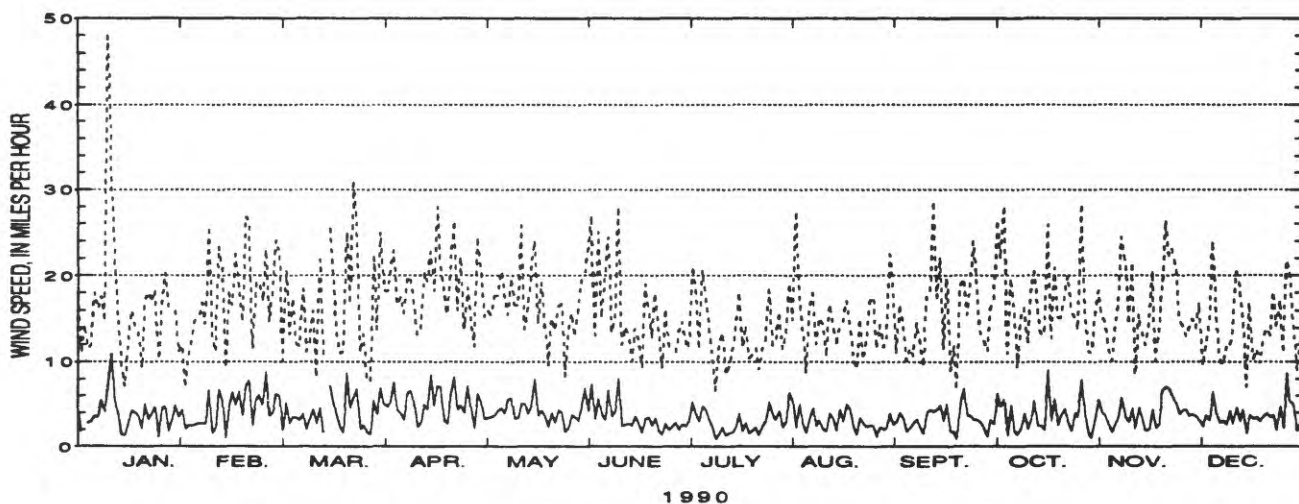
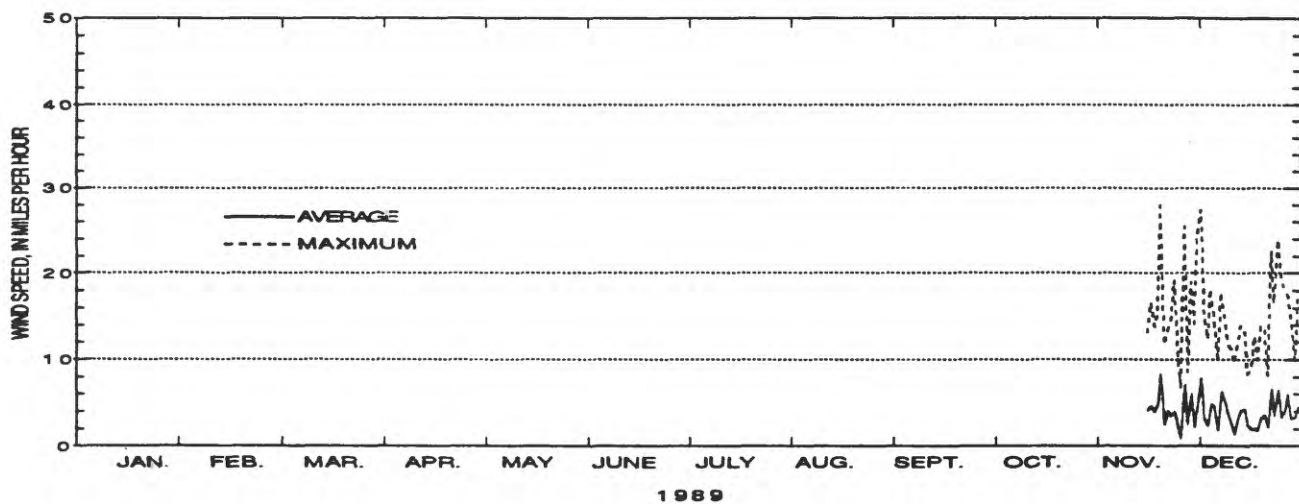


Figure 23.--Average and maximum daily wind speed at 2 meters above Shingobee Lake land station, 1989-91

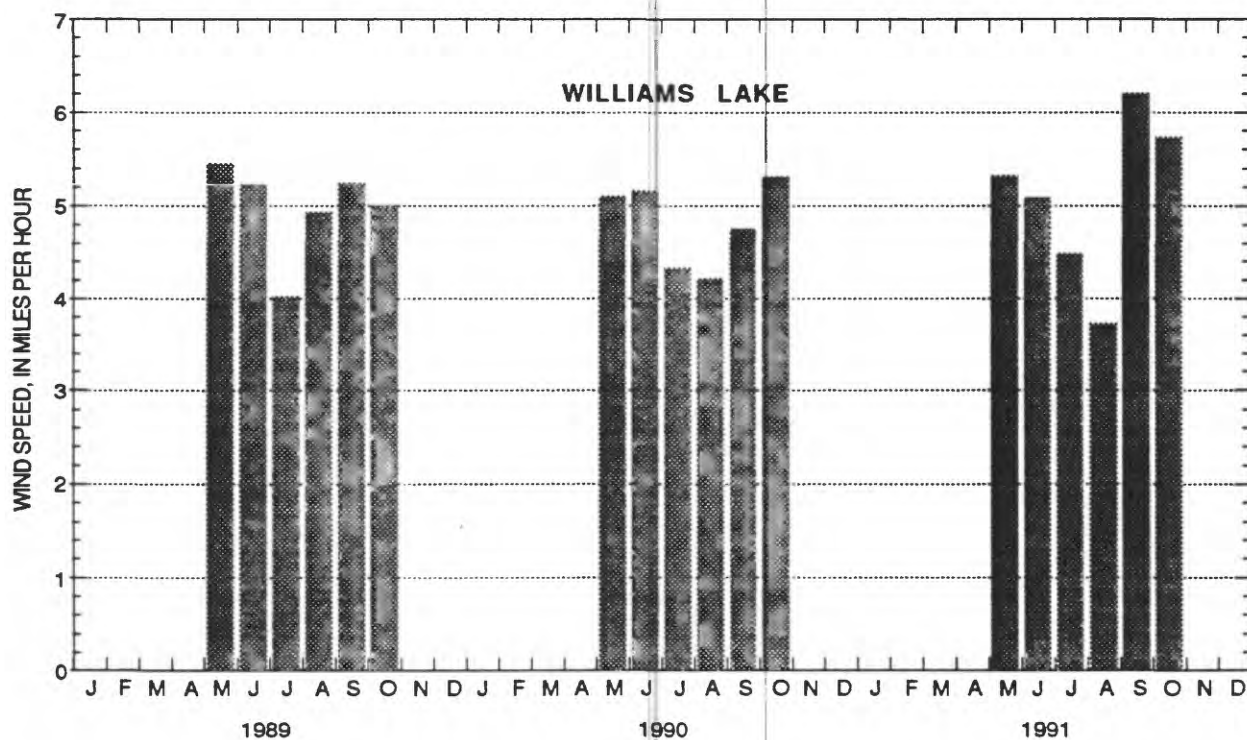
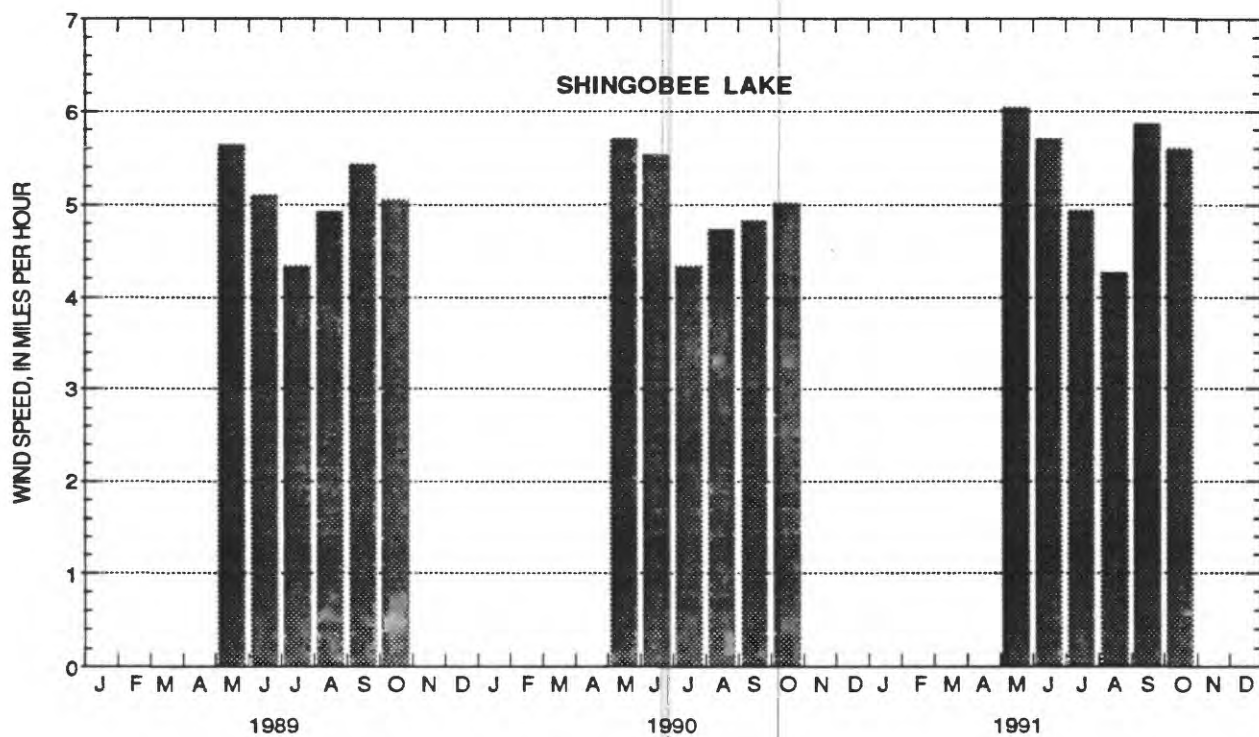


Figure 24.--Average monthly wind speed at 2 meters above Shingobee Lake and Williams Lake raft stations, 1989-1991

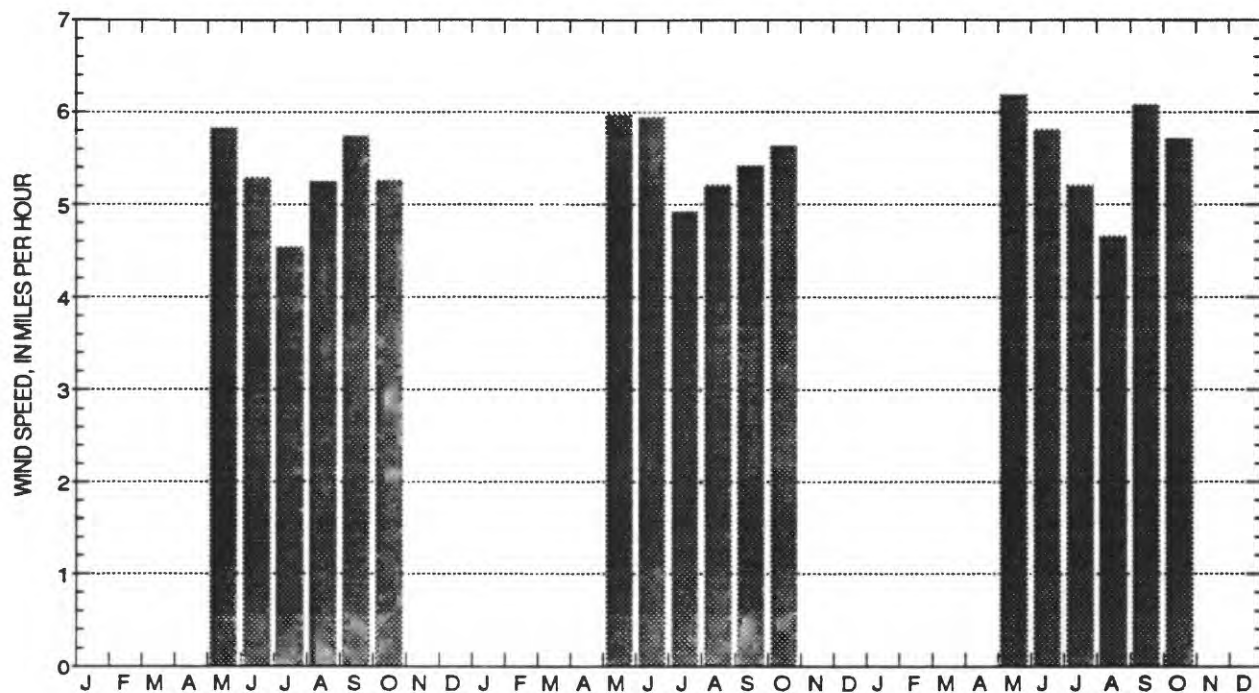


Figure 25.--Average monthly wind speed at 3 meters above Shingobee Lake raft station, 1989-91

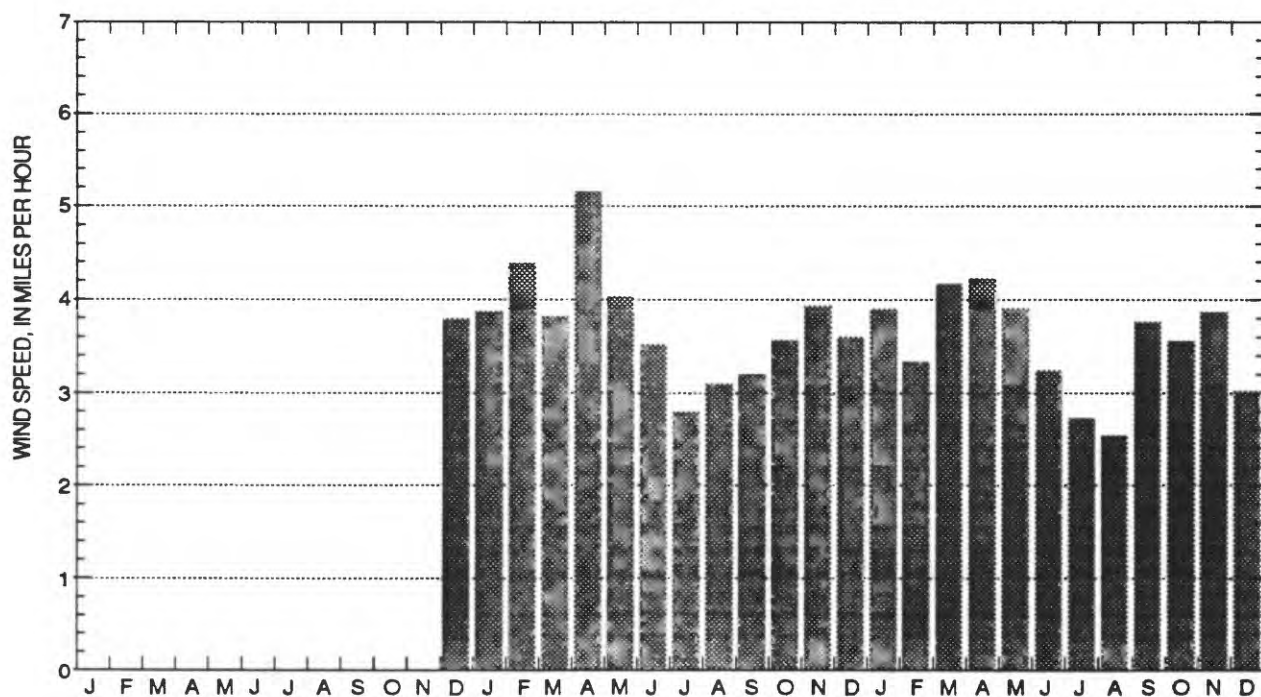


Figure 26.--Average monthly wind speed at 2 meters above Shingobee Lake land station, 1989-91

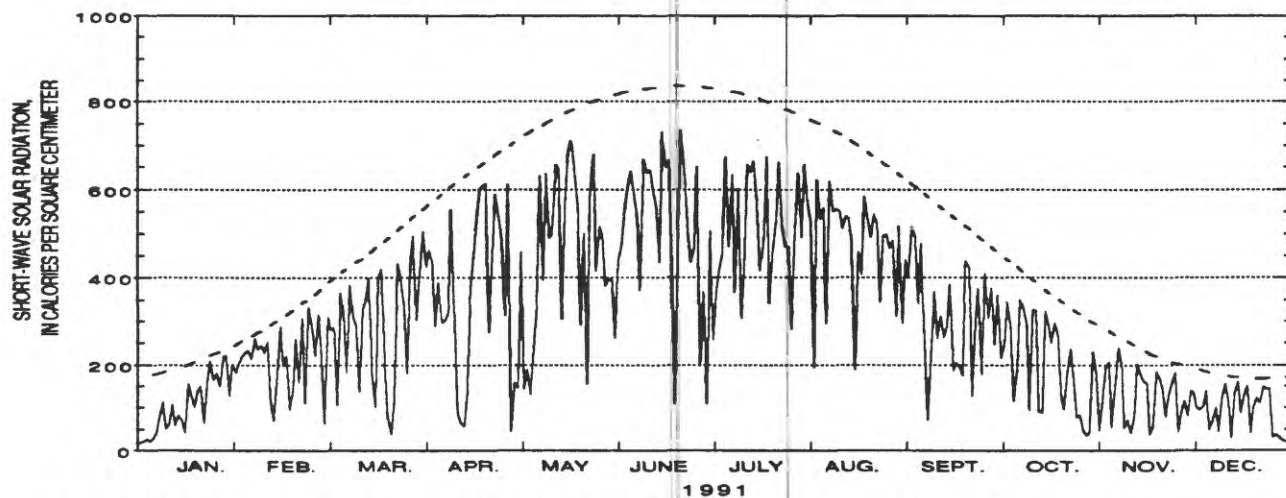
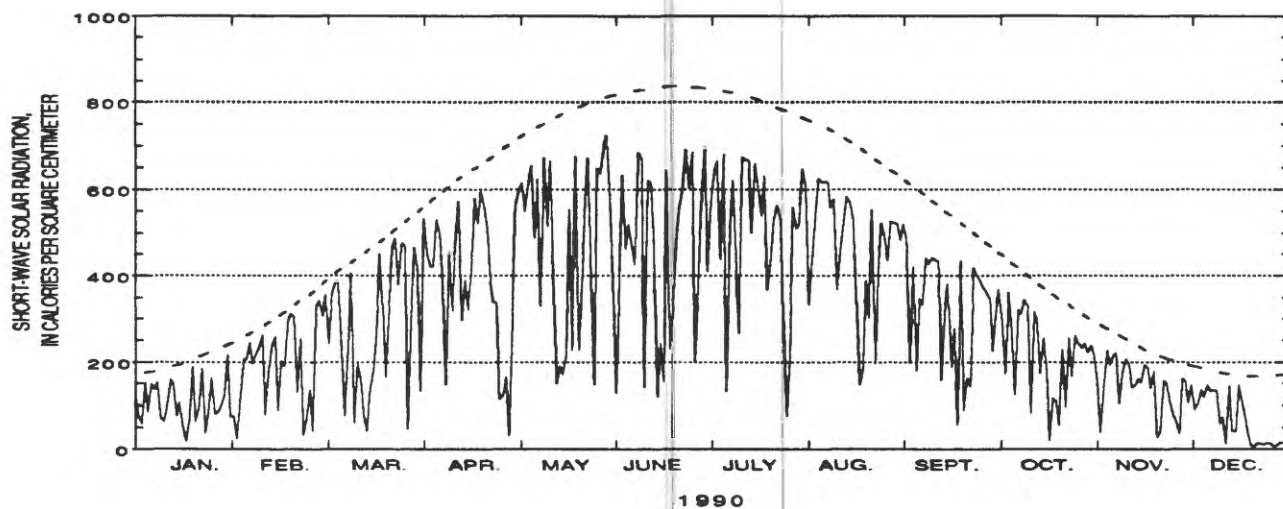
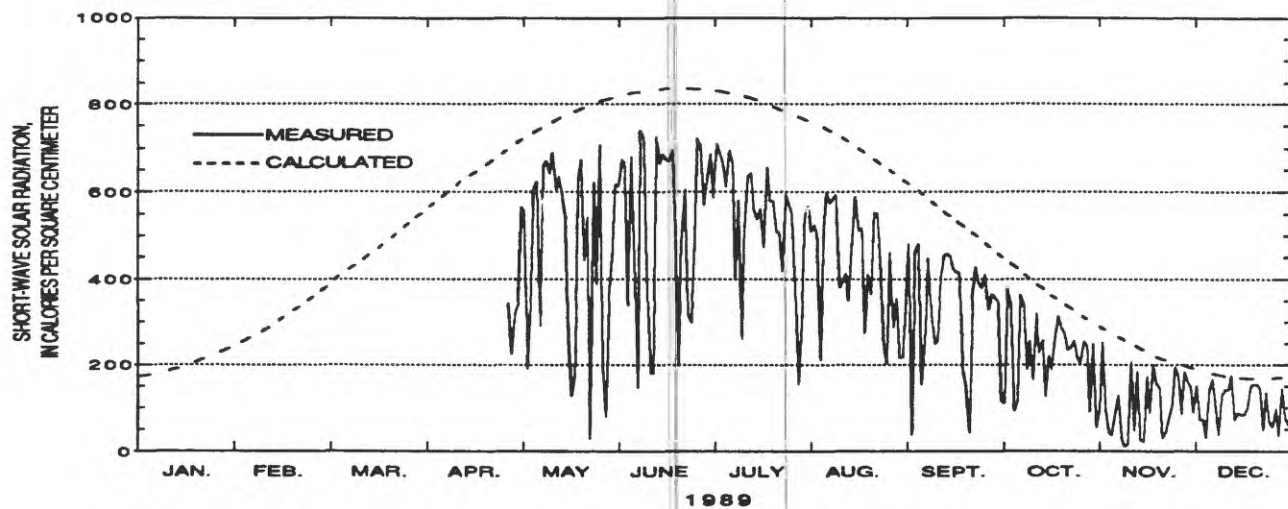


Figure 27.--Daily total short-wave solar radiation, measured and calculated, at Shingobee Lake land station 1989-91
 [Calculated, calculated from solar constant at 47° latitude]

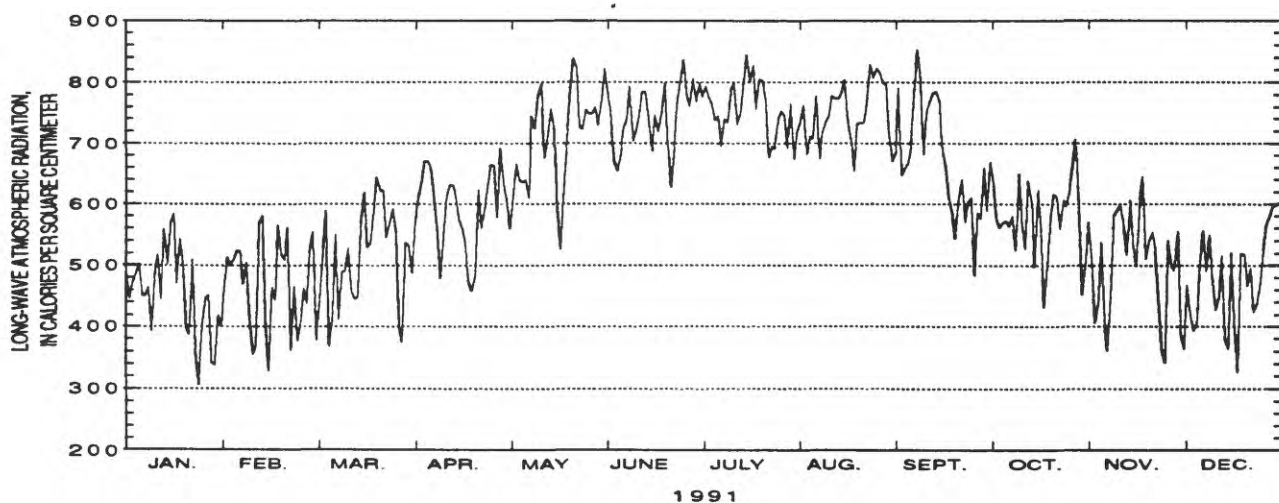
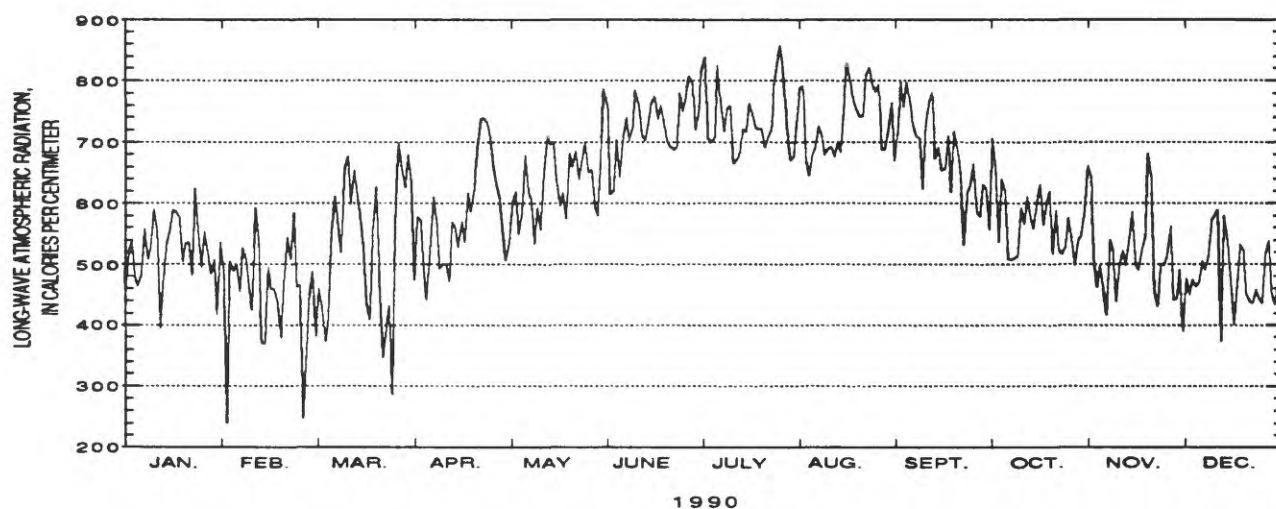
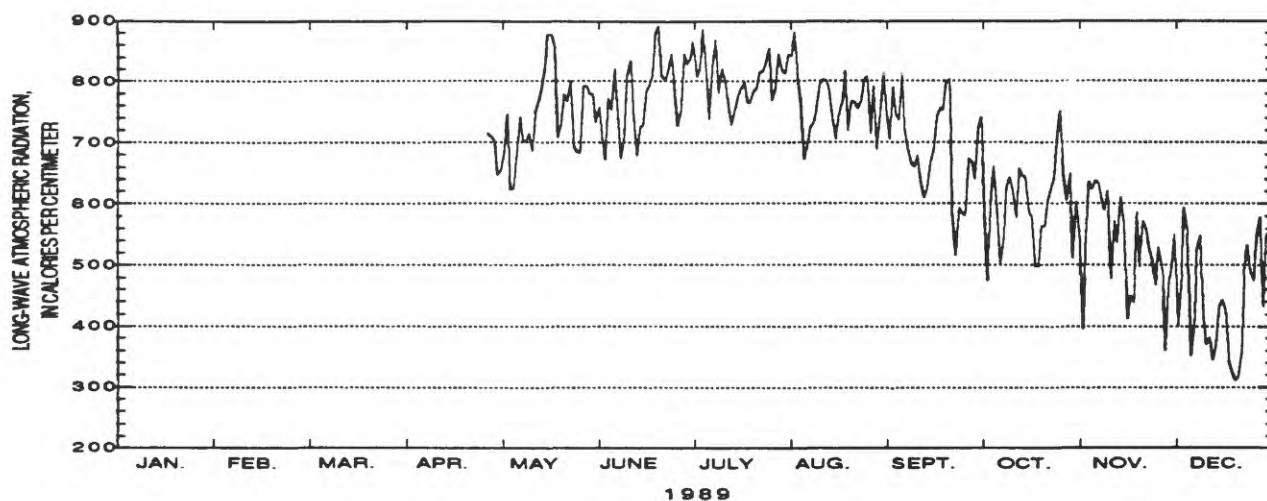


Figure 28.--Daily total long-wave atmospheric radiation at Shingobee Lake land station, 1989-91

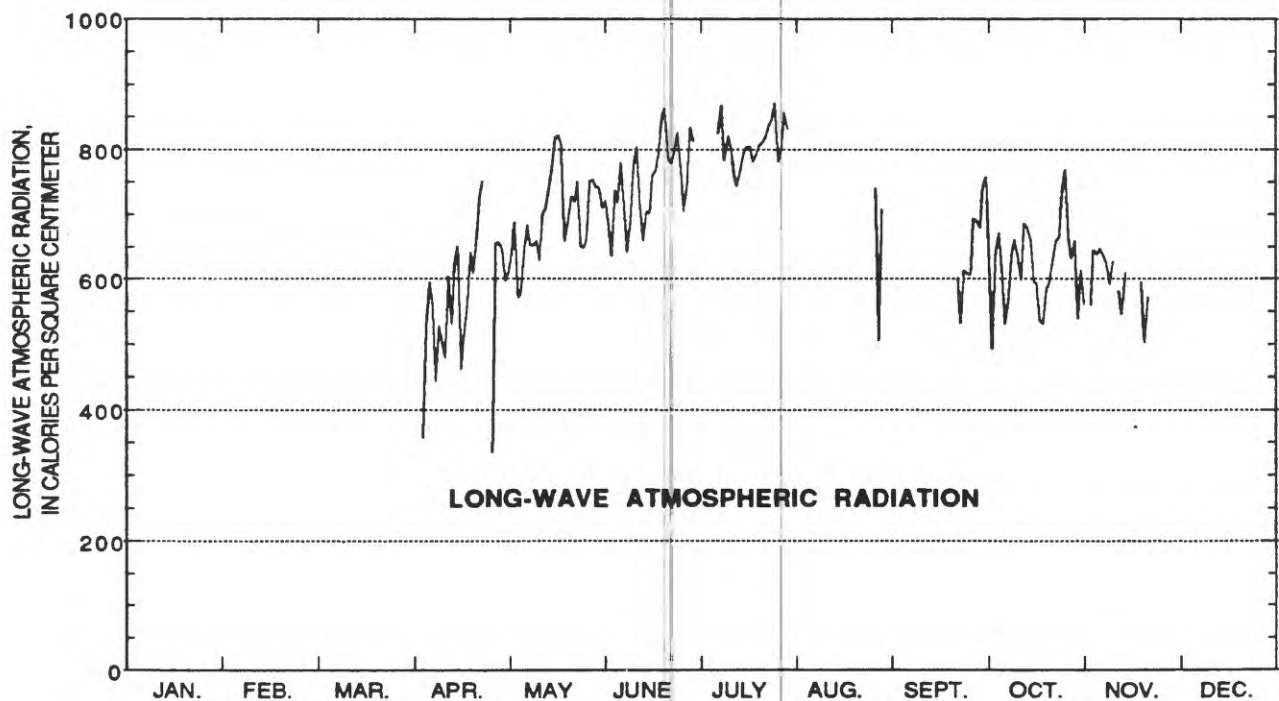
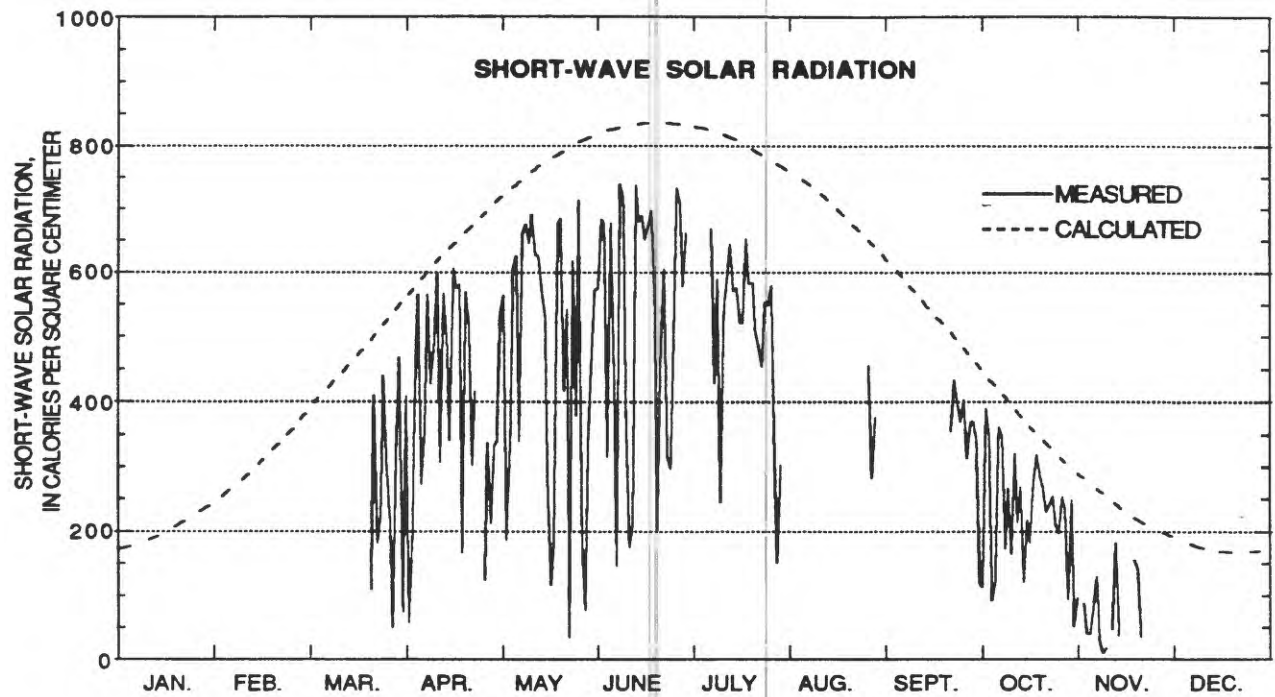


Figure 29.--Daily total short-wave solar radiation, measured and calculated, and long-wave atmospheric radiation at Williams Lake land station, 1989

[Calculated, calculated from solar constant at 47° latitude]

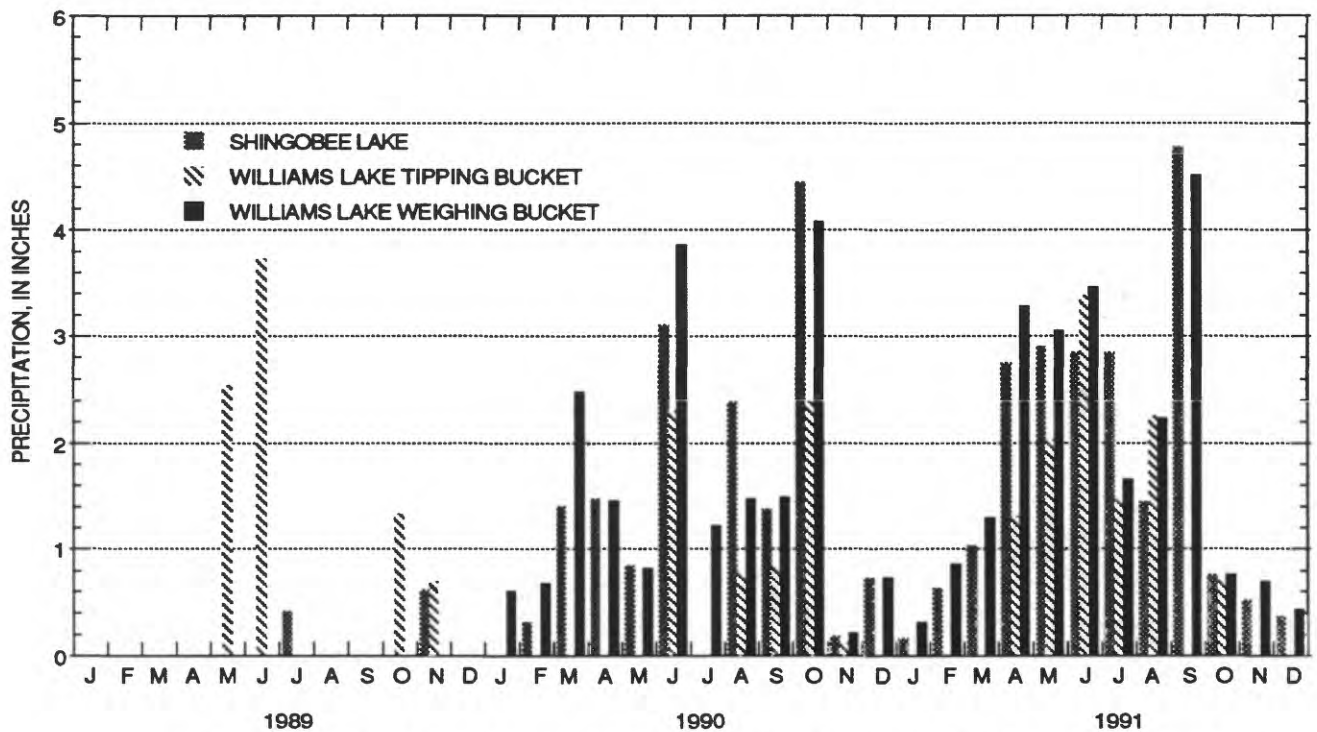


Figure 30.--Monthly total precipitation at Shingobee Lake and Williams Lake gages, 1989-91

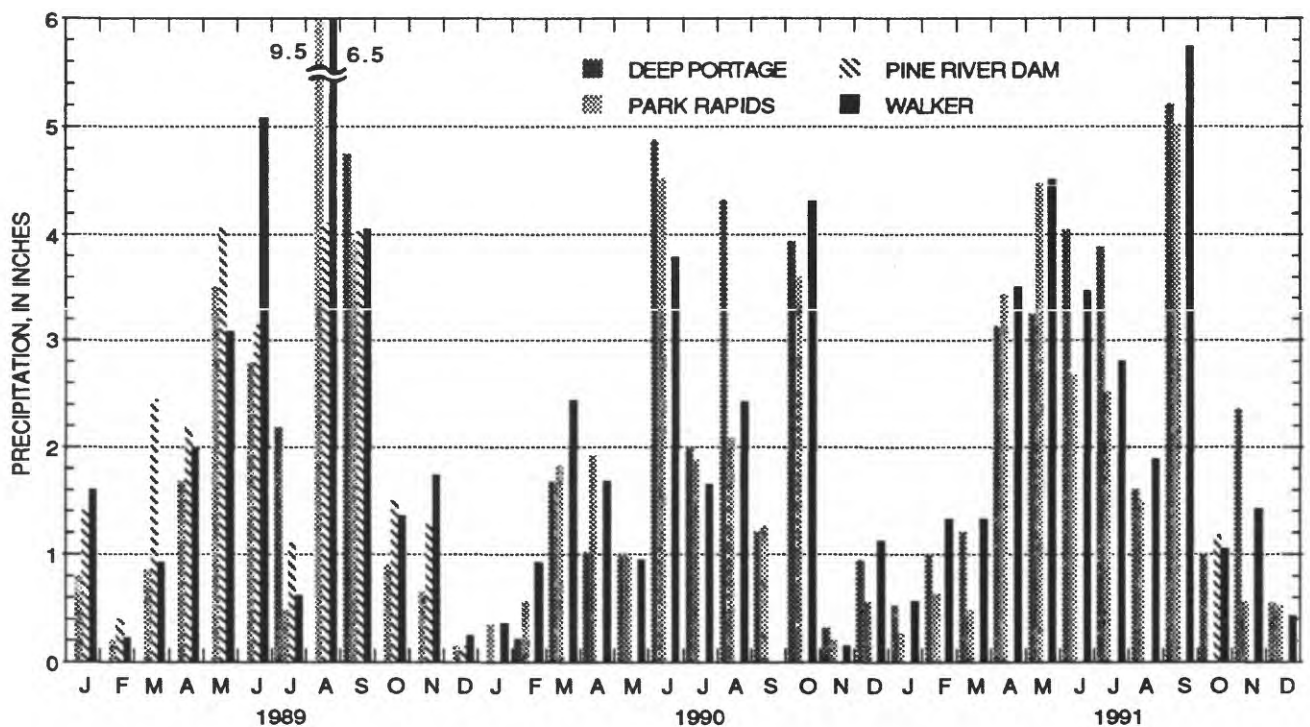


Figure 31.--Monthly total precipitation at National Weather Service gages