

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

Ground support data for the aircraft multispectral reflectance  
and thermal scanner mission Nov./Dec. 1977,  
on the island of Hawaii.

by  
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Open-File Report 80-470

1980

This report is preliminary and has not been edited for  
conformity with U.S. Geological Survey standards.

## Introduction

Radiometric and meteorological data were acquired at three ground stations on the island of Hawaii from November 26 through December 10, 1977. These data were collected to support the aircraft multispectral reflectance and thermal scanner data acquired during this time period. The parameters measured are direct solar radiance, total solar radiance, sky radiance, air temperature, relative humidity, wind speed, and wind direction.

## Instrument Description

Direct solar radiance was measured with an Eppley<sup>1/</sup> normal incidence pyrheliometer (NIP) mounted on a solar tracker. The sensitive element of the pyrheliometer is a thermopile with a 1 mm quartz window, transparent to the total visible spectrum (0.3 to 3.0  $\mu\text{m}$ ). The solar tracker is electrically driven and geared to solar time. The direct solar radiance was measured to an accuracy of about 30  $\text{W}/\text{m}^2$ .

Total solar radiance is the short wavelength radiation flux ( $<3 \mu\text{m}$ ) from the sun and sky and was measured using an Eppley precision spectral pyranometer (PSP). The sensitive element is another thermopile with a clear glass hemisphere that is transparent from a wavelength of about 0.28 to 2.8  $\mu\text{m}$ . The accuracy of the measurements is  $\sim 25 \text{ W}/\text{m}^2$ .

Sky radiance is the long wavelength radiation flux ( $<74 \mu\text{m}$ ) of the sky and was measured using an Eppley precision infrared radiometer (pyrgeometer). The sensing element is a sensitive thermopile. A

<sup>1/</sup> The use of brand names in this paper are for descriptive purposes only and do not necessarily constitute endorsement by the U.S. Geological Survey.

hemispherical bulb with a vacuum-deposited interference filter on the inner surface has a composite transmission of about 4 to 50  $\mu\text{m}$  bandwidth. The accuracy of the measurements is about 20  $\text{W/m}^2$ .

Air temperature and relative humidity were measured with a Rustrak RH/TEMP sensor assembly. The single assembly contains the two sensing elements. The thermistor is a temperature-sensitive resistor; humidity is monitored through an electro-humidity sensor. The RH/TEMP sensor assembly was mounted at approximately one and one half meters above the ground. Temperature was measured to an accuracy of 1° C and relative humidity to an accuracy of 5 percent.

Wind speed and wind direction were measured with a Weathermeasure wind system. This system, consisting of a 3-cup anemometer for wind speed and an airfoil vane for wind direction, was mounted on a common vertical tower approximately one and one half meters above ground. Wind speed was measured to an accuracy of 1 m/sec and the wind direction to an accuracy of about 25°.

#### Data Summary

Three stations were established near the Kilauea caldera. Site number 1 was on the rim of Halemaumau, adjacent to the Hawaiian Volcano Observatory (Figure 1). Site number 2 was in the Kau Desert southwest of the Chain of Craters road. Site number 3 was about 15 km southwest of the caldera on the western edge of the Kau Desert. Table 1 summarizes the measurements collected at each site from November 26 through December 10, 1977 and Table 2 summarizes the weather conditions during that time period. All of the radiometric and meteorological

data were recorded continuously on chart recorders and digitized at half hour intervals. Figures 2 through 32 present these data adjusted to local solar time. For those measurement which were taken simultaneously at more than one site, the data are displayed on the same graph with a fixed displacement of the ordinate axis. The amount of displacement is noted in the figure caption. The data for site one are represented by squares, for site two by circles, and site three by triangles.

Table 1. - Summary of data coverage at each of the three stations from November 26 through December 10, 1977.

(P indicates partial coverage; X indicates total coverage; Leaders (--) indicate no data acquired.)

DATE	SKY RADIANCE			DIRECT SOLAR RADIANCE	SITE	TOTAL SOLAR RADIANCE			AIR TEMPERATURE	SITE	RELATIVE HUMIDITY		WIND SPEED	SITE	WIND DIRECTION		SITE
	1	2	3			1	2	3			1	2			1	2	
Nov. 26	P	P	X	--		--	P	X	X	P	X	P	X	P	X	P	
Nov. 27	X	--	X	P		--	X	--	X	X	X	X	X	X	X	X	
Nov. 28	X	P	P	X		P	P	P	P	X	P	X	X	X	X	X	
Nov. 29	X	P	--	X		X	--	--	--	X	--	X	X	X	X	X	
Nov. 30	X	--	P	X		X	P	P	P	X	P	X	X	X	X	X	
Dec. 1	P	P	X	P		P	P	X	X	X	X	X	X	X	X	X	
Dec. 2	P	P	--	--		--	--	X	X	X	X	X	X	X	X	X	
Dec. 3	X	P	P	P		P	P	X	X	X	X	X	X	X	X	X	
Dec. 4	X	--	--	X		X	--	--	X	X	X	X	X	X	X	X	
Dec. 5	X	P	P	X		X	X	X	X	X	X	X	X	X	X	X	
Dec. 6	X	X	P	X		X	X	--	X	X	X	X	X	X	X	X	
Dec. 7	X	X	P	P		P	--	P	X	X	X	X	P	X	X	X	
Dec. 8	X	X	X	P		P	P	X	X	X	X	X	P	X	X	X	
Dec. 9	X	X	X	--		P	--	X	X	X	X	X	X	X	P	X	
Dec. 10	P	P	P	P		P	--	--	P	P	P	P	P	P	--	P	

Table 2. - Summary of the weather conditions at each of the three stations from November 27 through December 10, 1977

DATE	SITE 1	SITE 2	SITE 3
Nov. 27	clear; cloudy over Kilauea rift to east	no data	no data
Nov. 28	clear; cloudy over Kilauea rift to east	windy and cloudy	no data
Nov. 29	cloudy	cloudy	cloudy
Nov. 30	cloudy from west to Mauna Loa	mostly cloudy	mostly cloudy
Dec. 1	no data	overcast by noon	very clear in a.m. and overcast in p.m.
Dec. 2	rain	rain	rain
Dec. 3	clear and windy in a.m.	partially overcast by about 10 a.m.	no data
Dec. 4	clear	clear	no data
Dec. 5	no data	mostly clear with low clouds to east in a.m.	no data
Dec. 6	clear	no data	no data
Dec. 8	partly cloudy in a.m.	light rain in p.m.	no data
Dec. 9	clear over Kilauea with cloud build-up on east horizon	no data	no data
Dec. 10	mostly clear	no data	no data

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Figure 32--Wind direction for December 8, 9, and 10 from station 2.

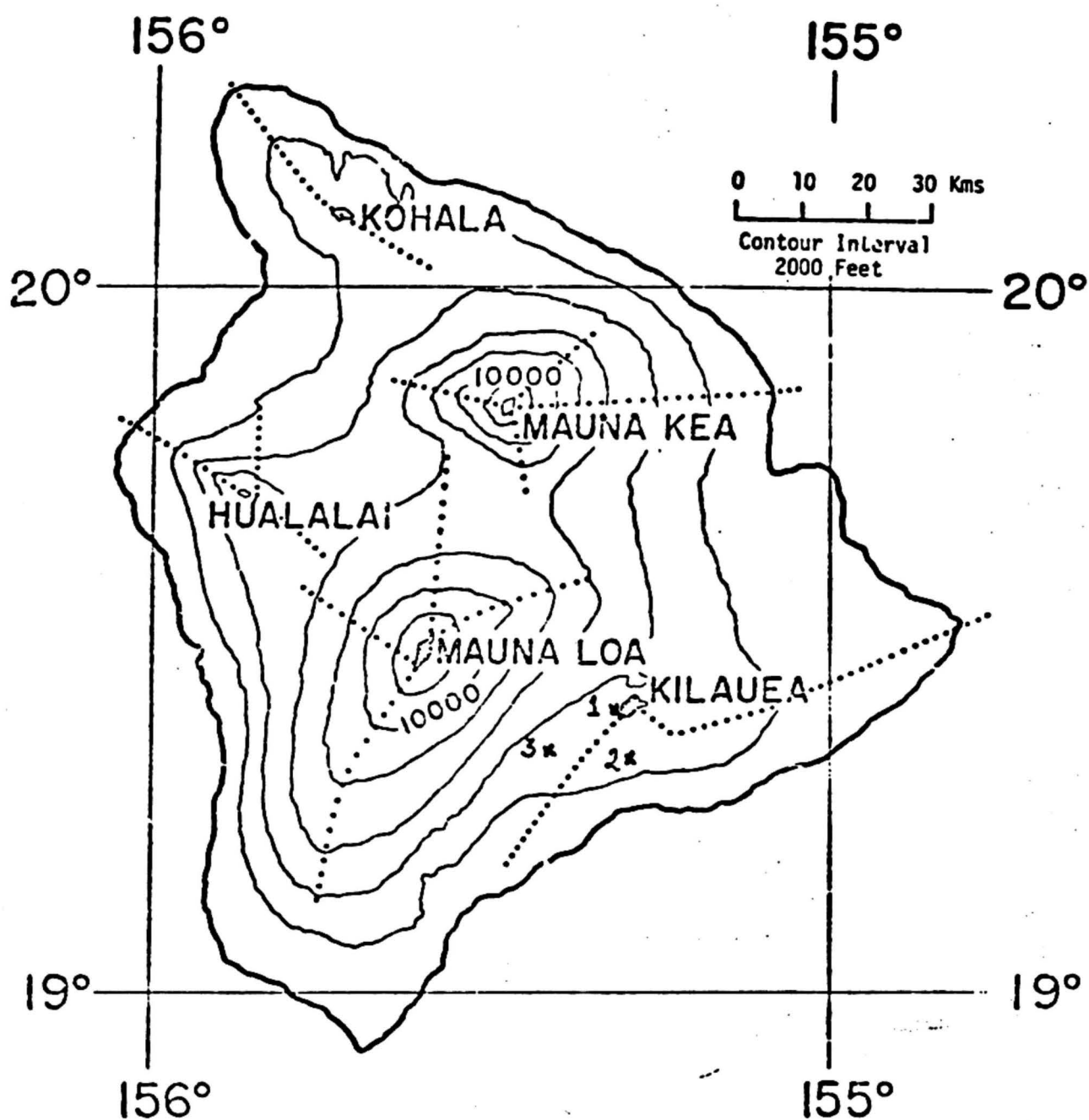


Figure 1.--Map of the island of Hawaii showing the location (x) of the three ground stations with respect to the volcanoes and rift zones (dotted lines).

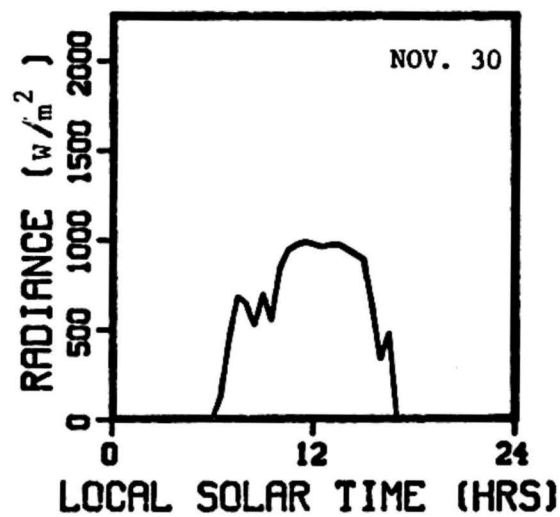
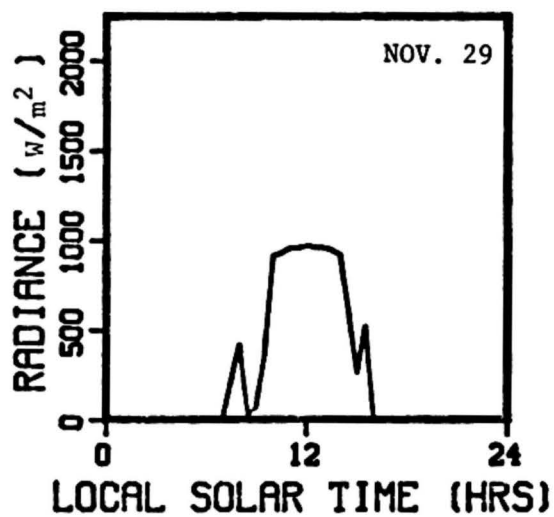
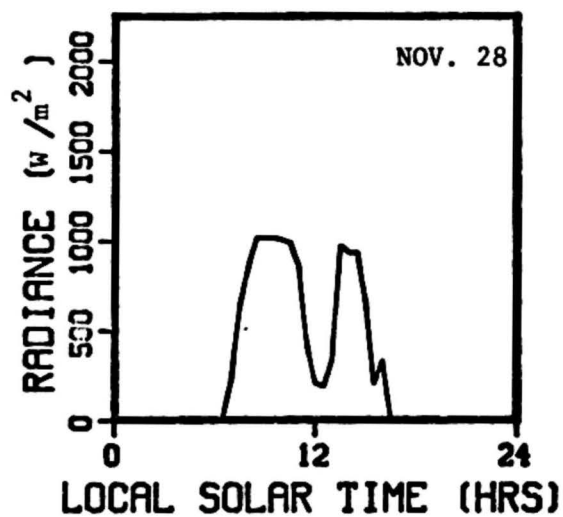
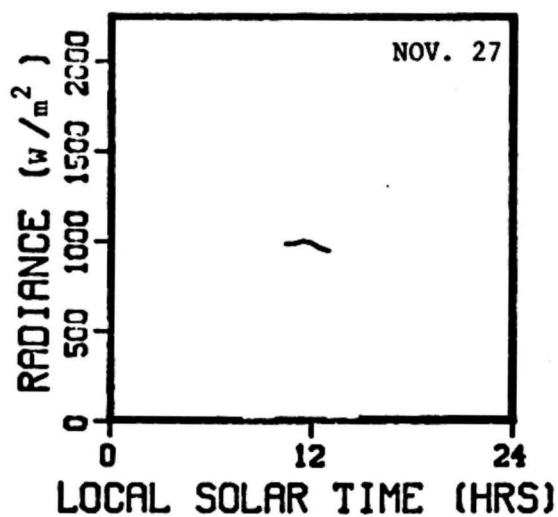


Figure 2.--Direct solar radiance for Nov. 27, 28, 29, and 30 from station 1.

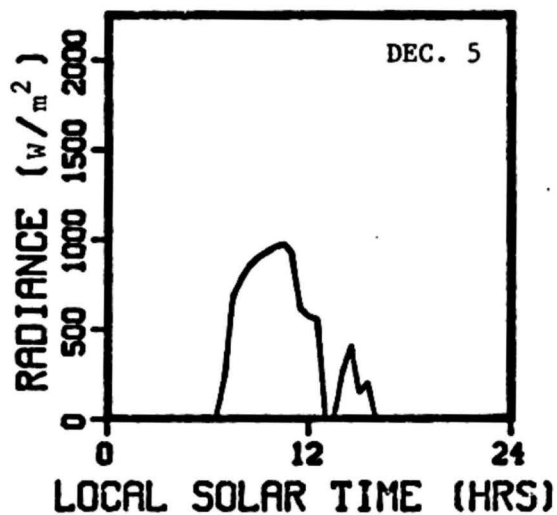
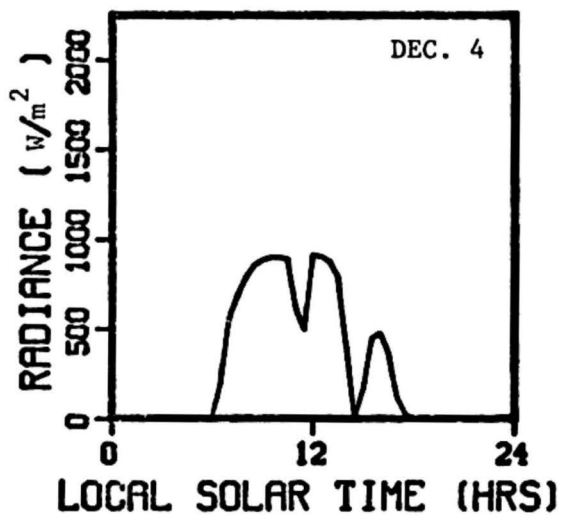
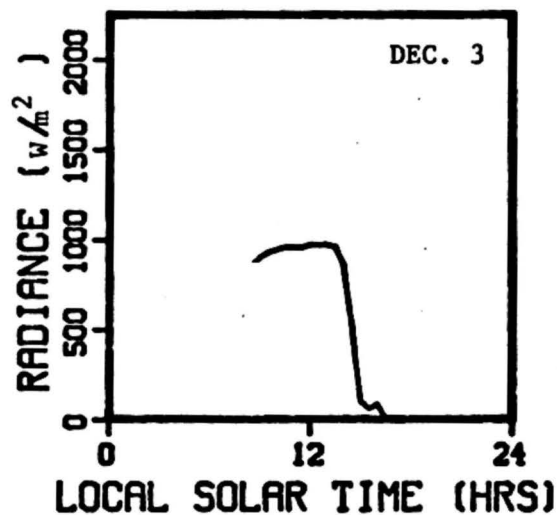
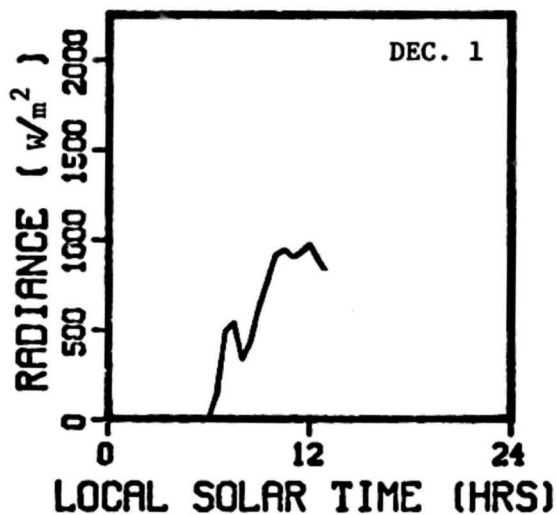


Figure 3.--Direct solar radiance for Dec. 1, 3, 4, and 5 from station 1.

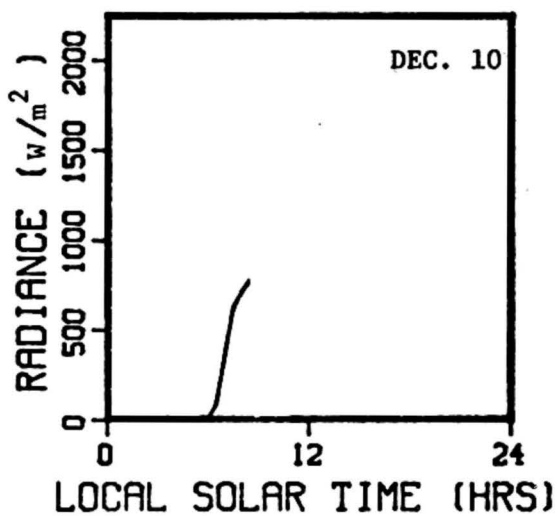
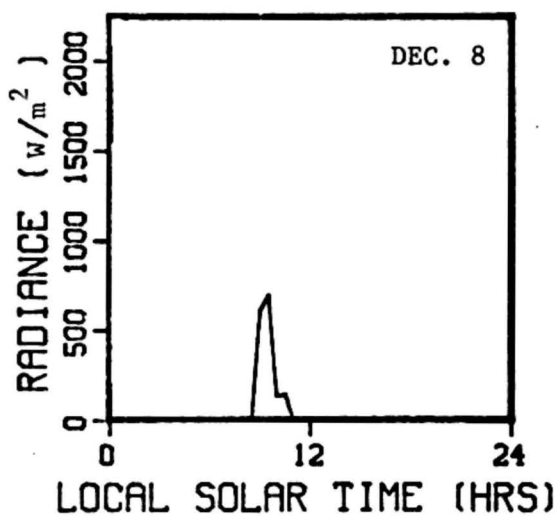
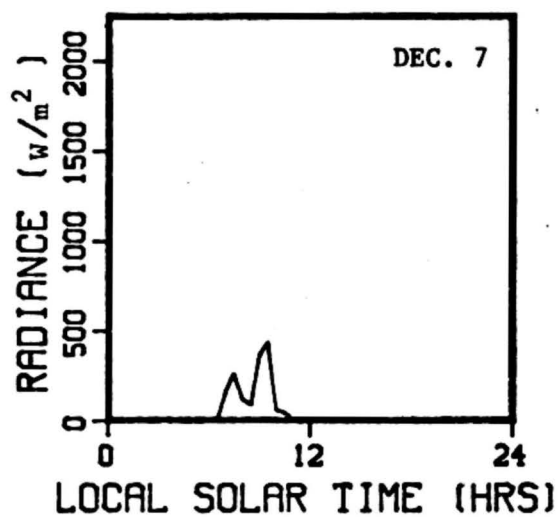
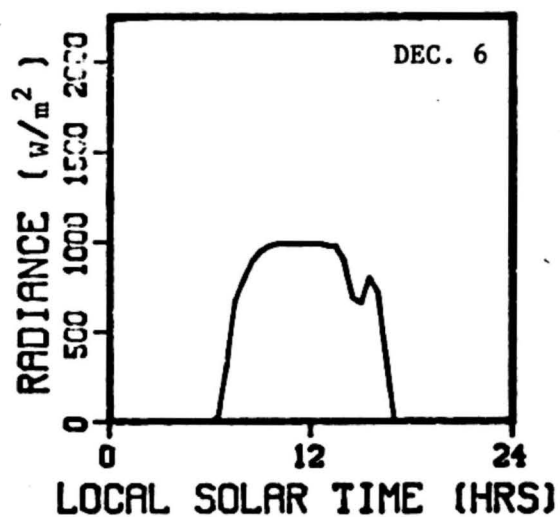


Figure 4.--Direct solar radiance for Dec. 6, 7, 8, and 10 from station 1.

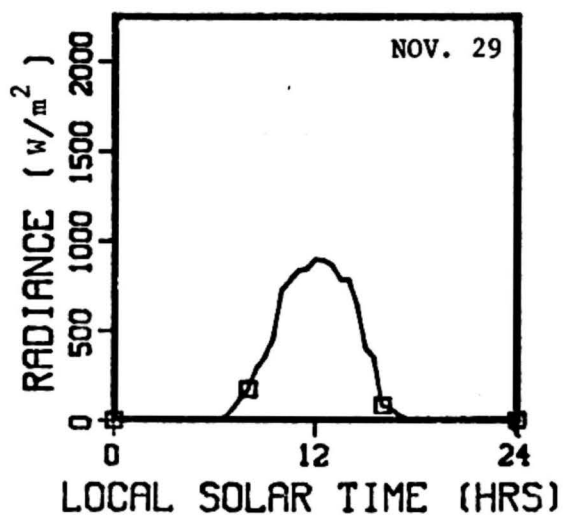
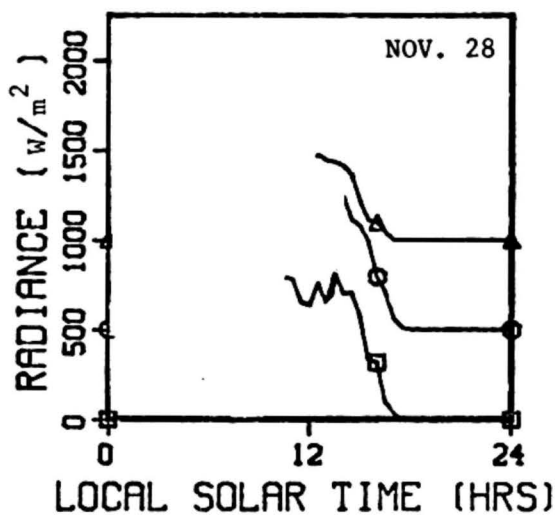
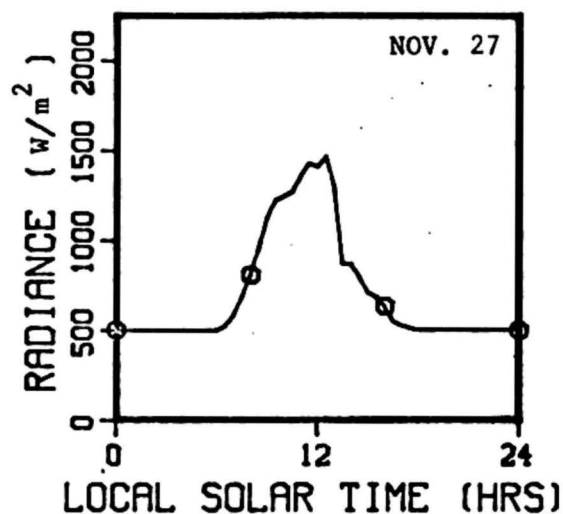
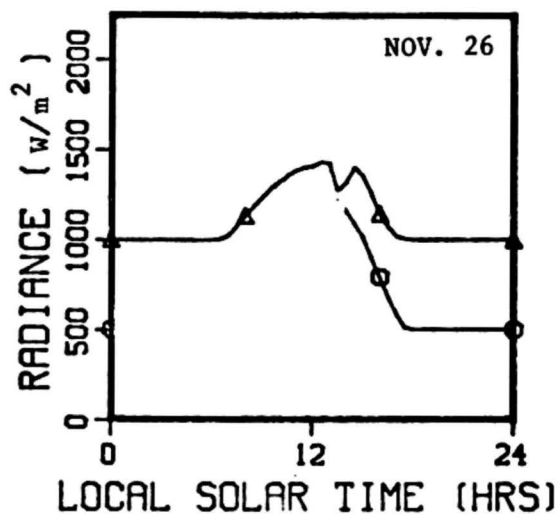


Figure 5.--Total solar radiance for Nov. 26, 27, 28, and 29 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W}/\text{m}^2$ ).

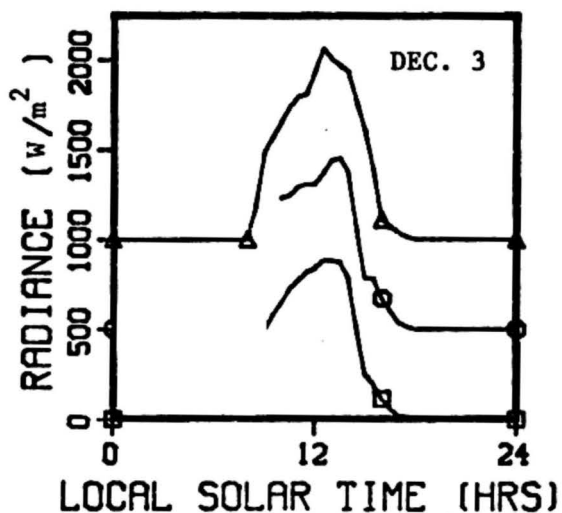
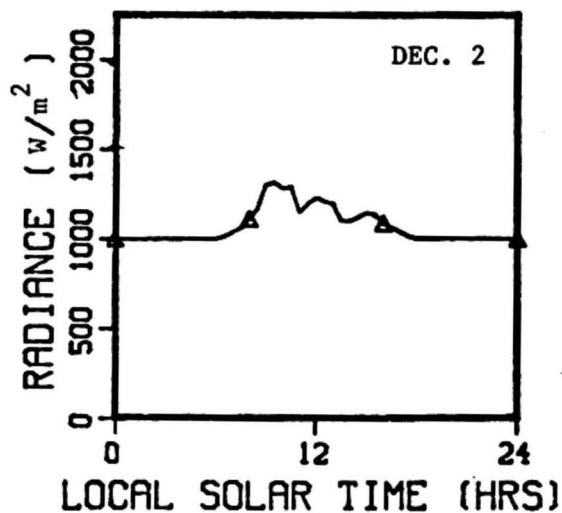
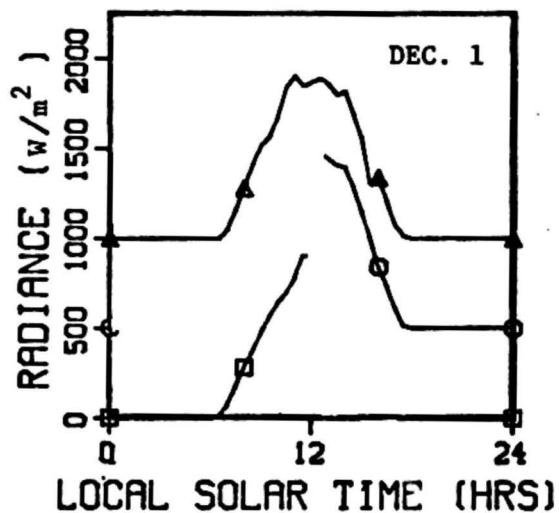
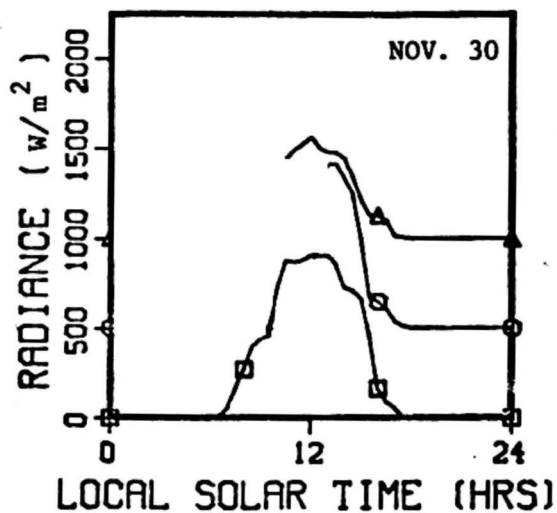


Figure 6.--Total solar radiance for Nov. 30, Dec. 1, 2, and 3 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W}/\text{m}^2$ ).

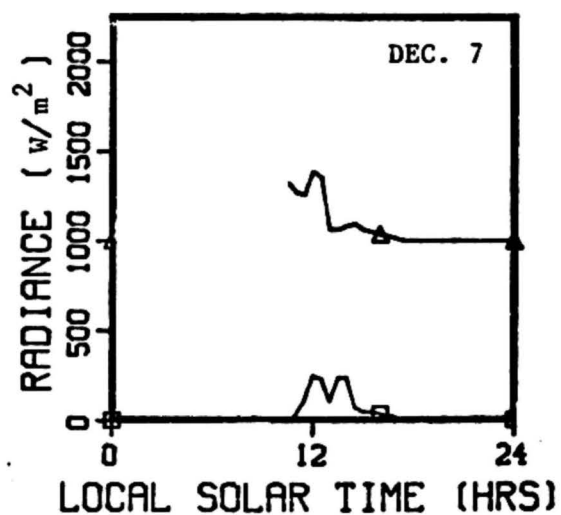
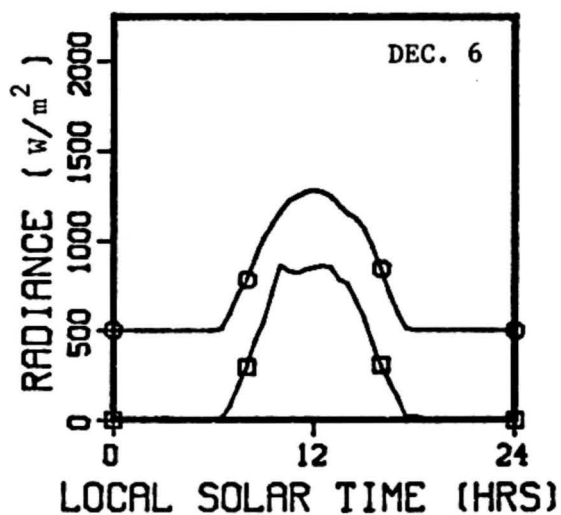
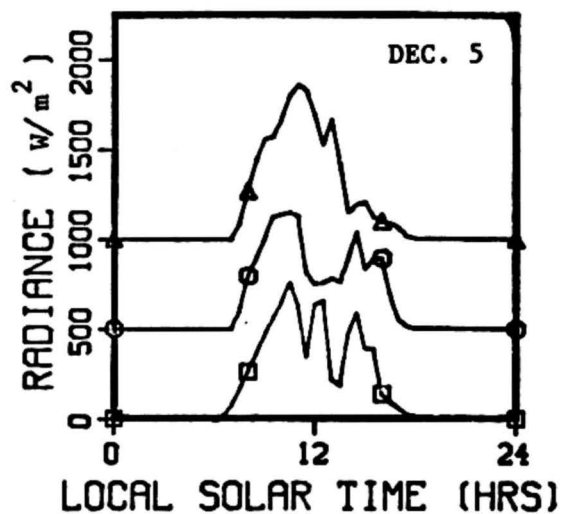
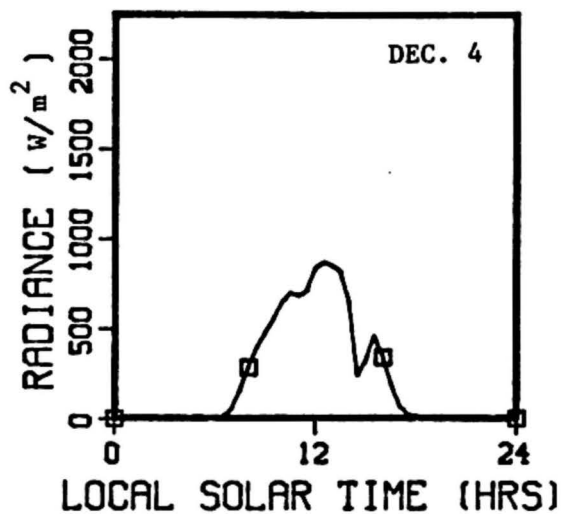


Figure 7.--Total solar radiance for Dec. 4, 5, 6, and 7 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W}/\text{m}^2$ ).



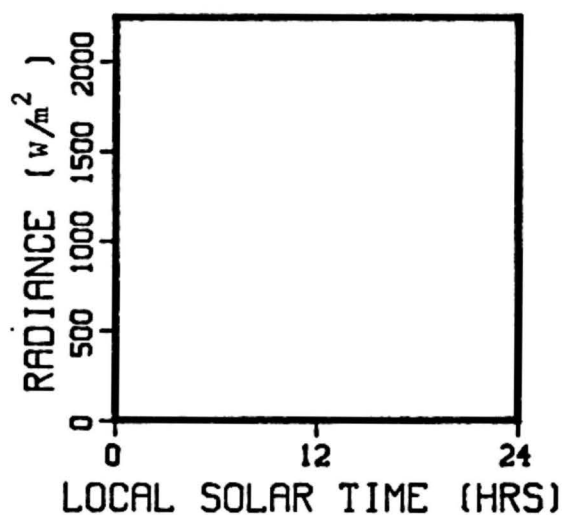
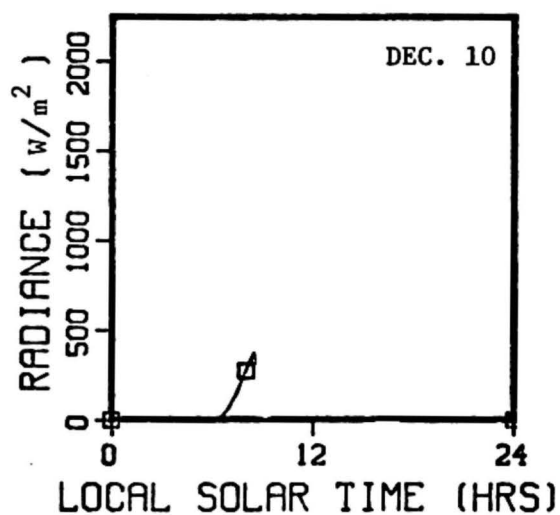
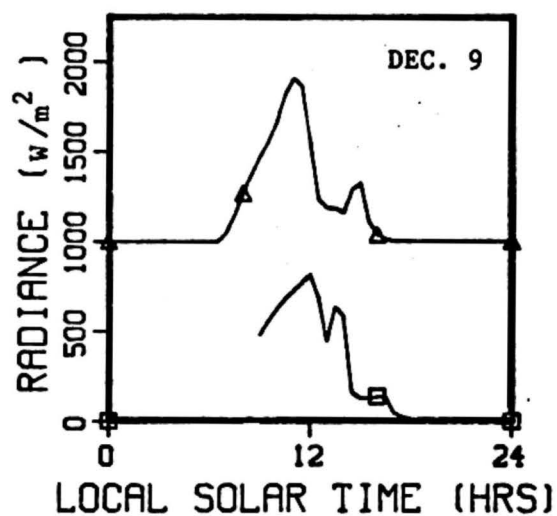
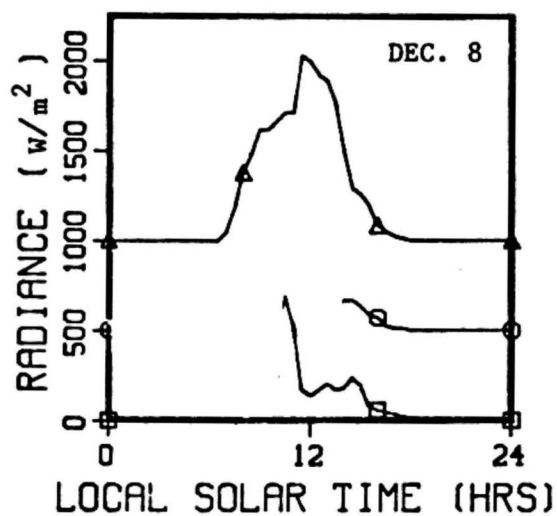


Figure 8.--Total solar radiance for Dec. 8, 9, and 10 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W}/\text{m}^2$ ).

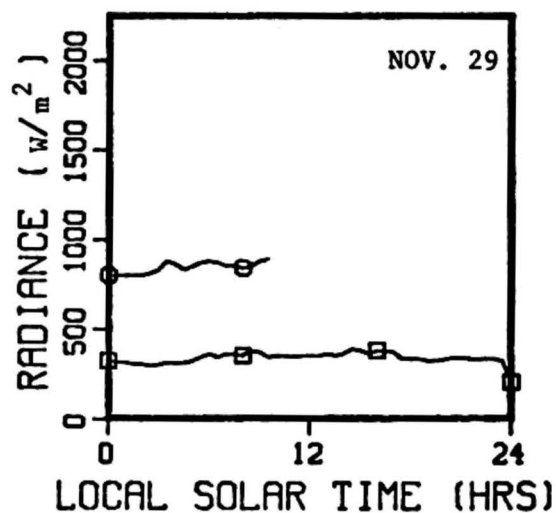
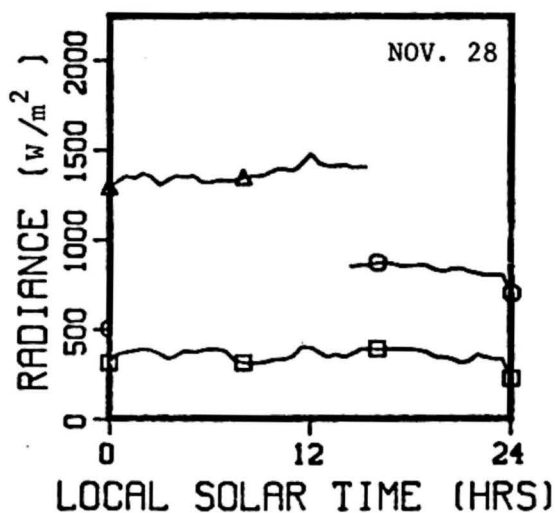
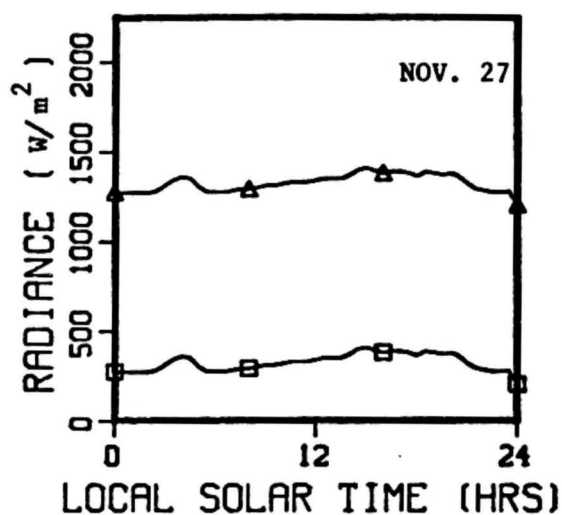
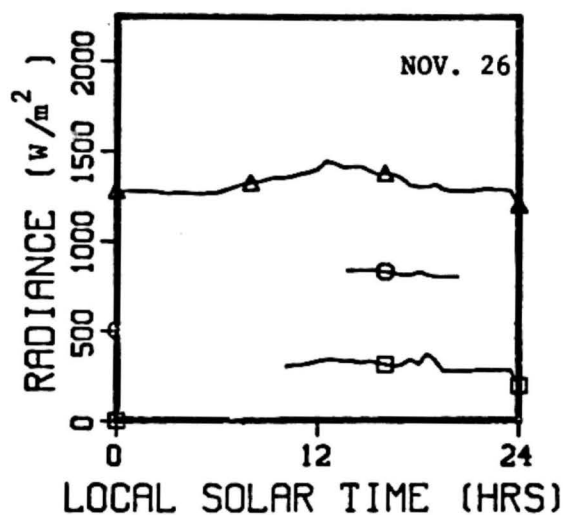


Figure 9.--Sky radiance for Nov. 26, 27, 28, and 29 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W/m}^2$ ).

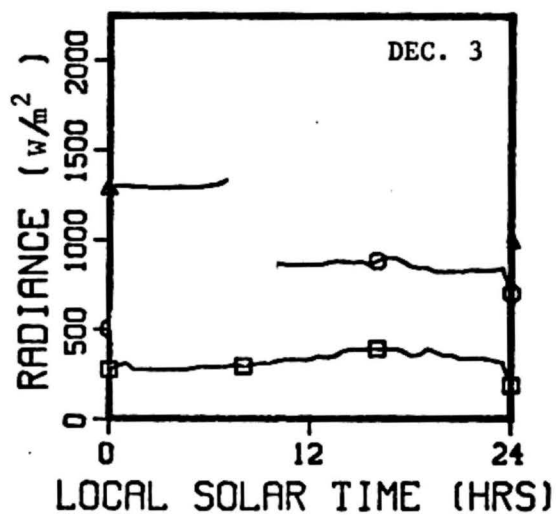
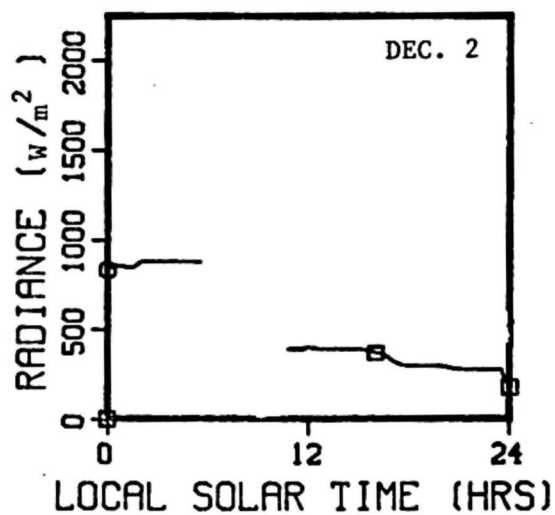
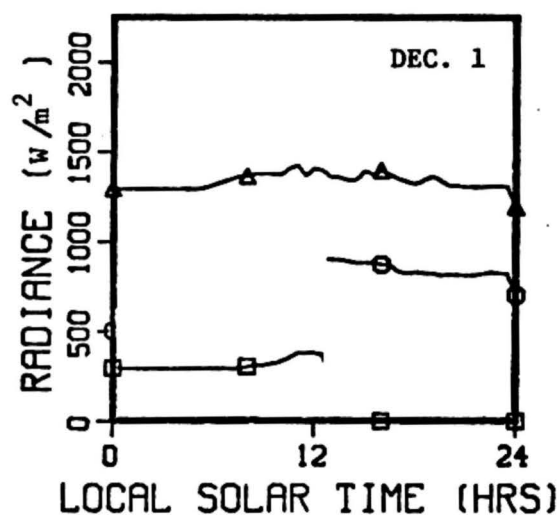
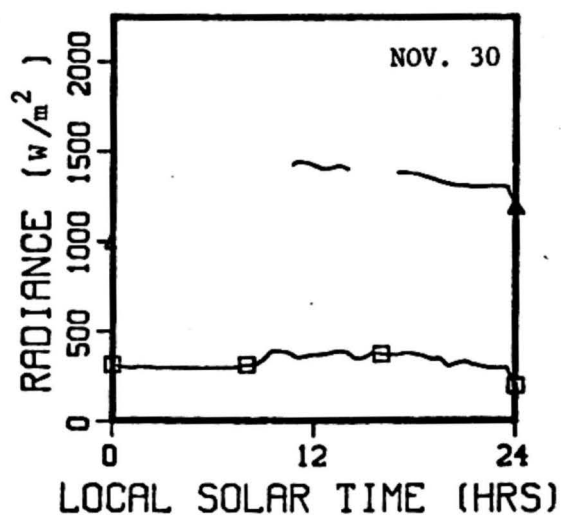


Figure 10.--Sky radiance for Nov. 30, Dec. 1, 2, and 3 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W}/\text{m}^2$ ).

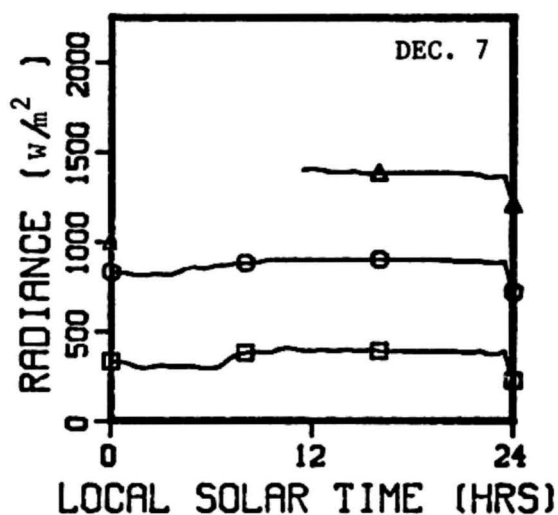
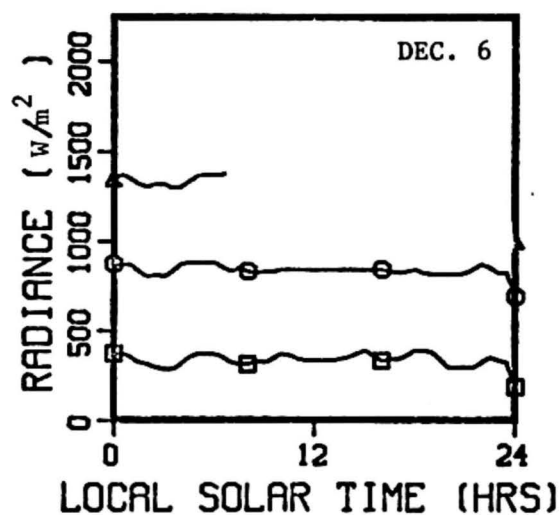
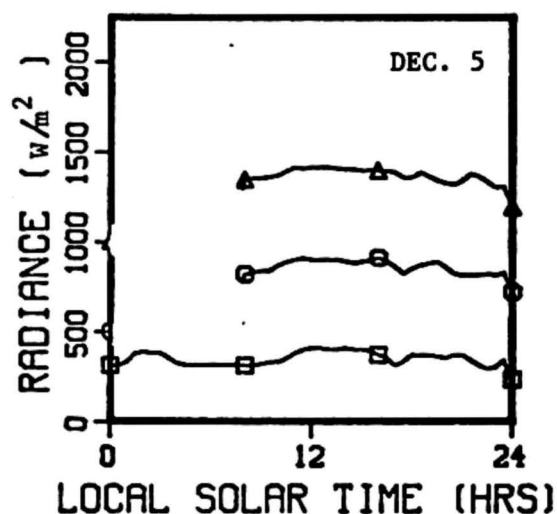
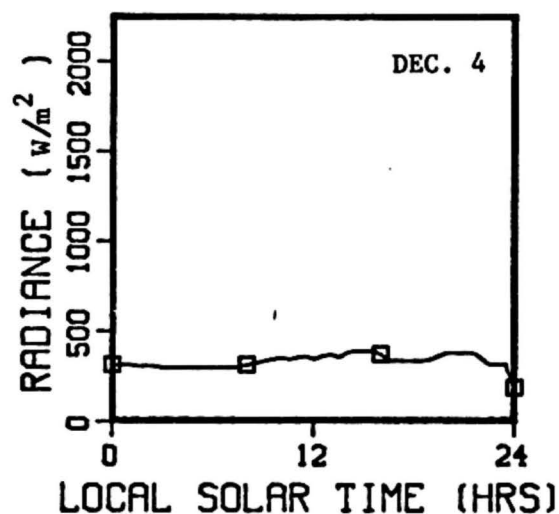


Figure 11.--Sky radiance for Dec. 4, 5, 6, and 7 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement 500  $\text{W/m}^2$ ).

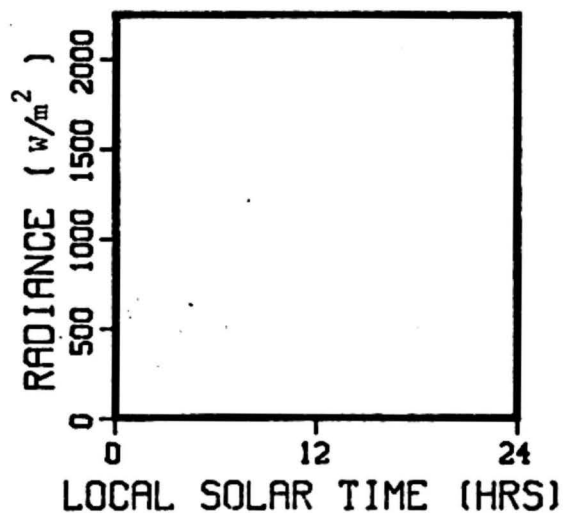
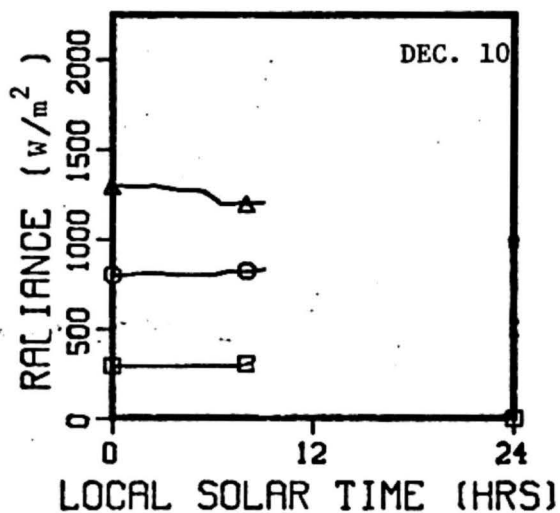
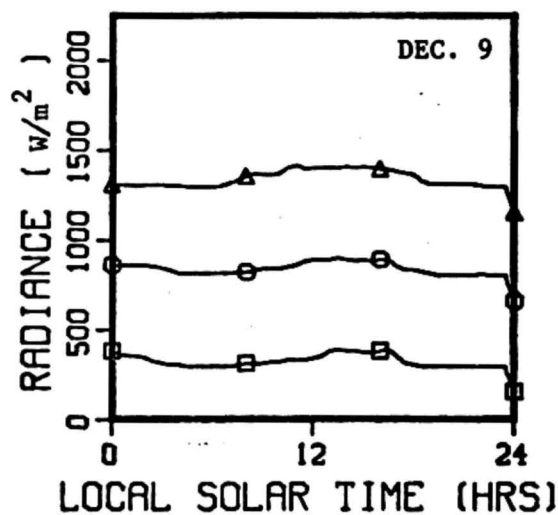
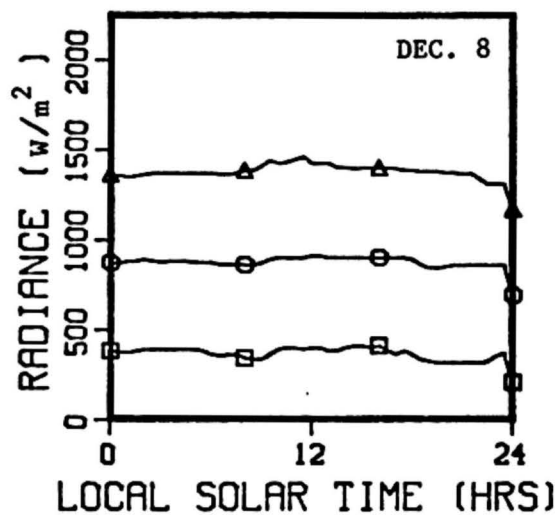


Figure 12.--Sky radiance for Dec. 8, 9, and 10 from station 1 ( $\square$ ), station 2 ( $\circ$ ), and station 3 ( $\Delta$ ) (displacement  $500 \text{ W/m}^2$ ).

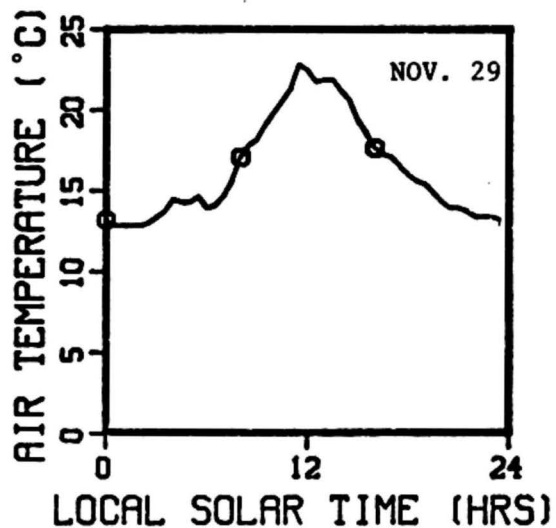
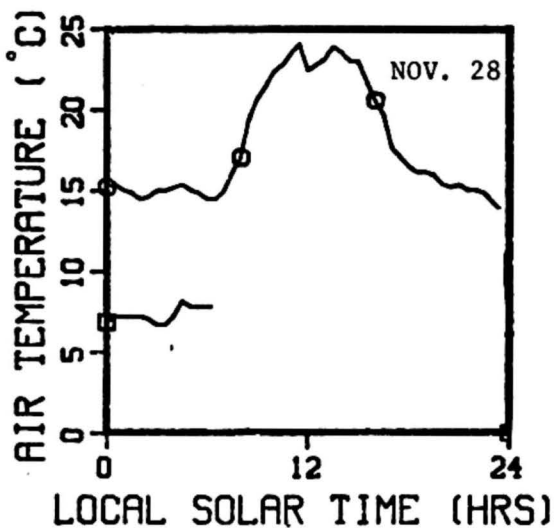
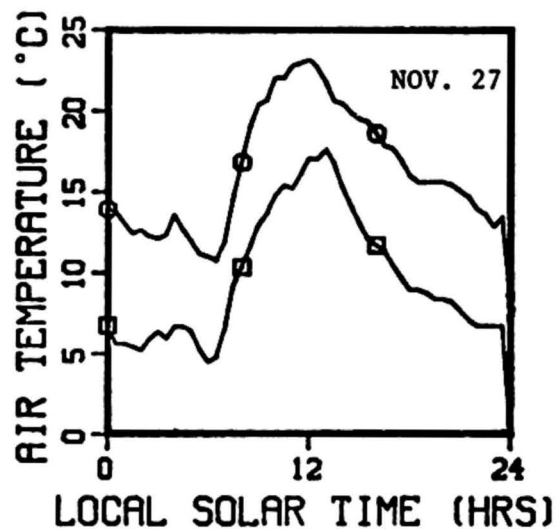
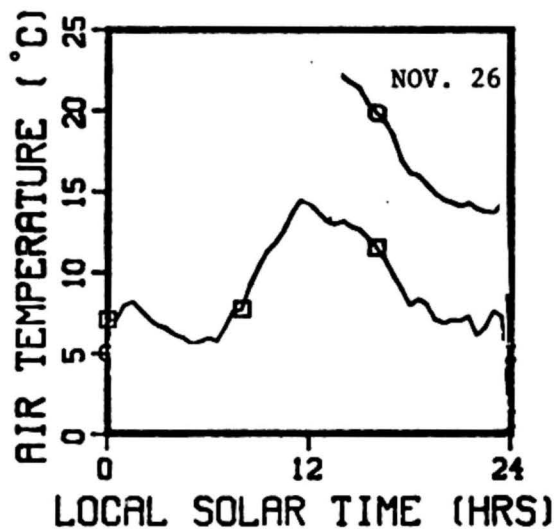


Figure 13.--Air temperature for Nov. 26, 27, 28, and 29 from station 1 (□) and station 2 (○) (displacement 5° C).

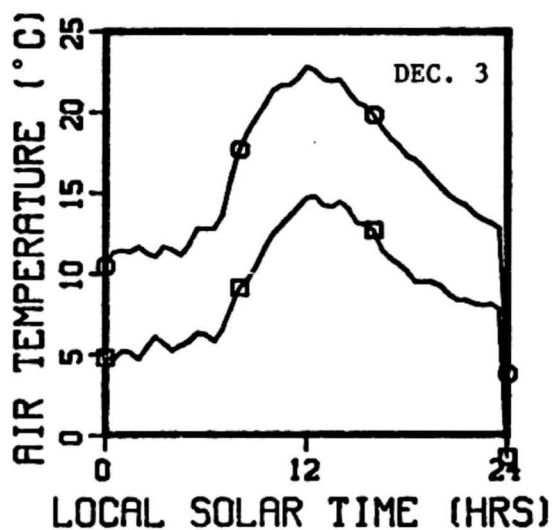
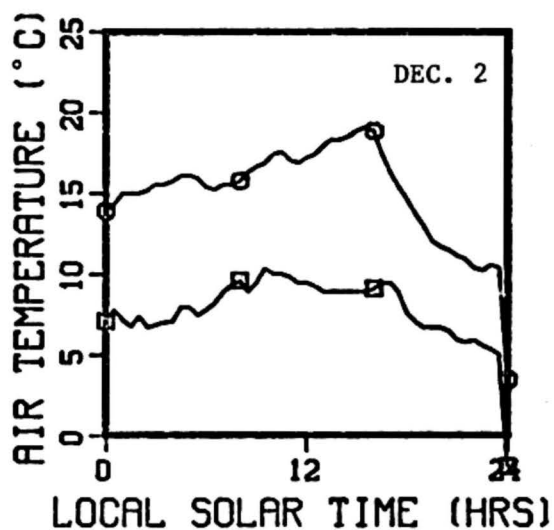
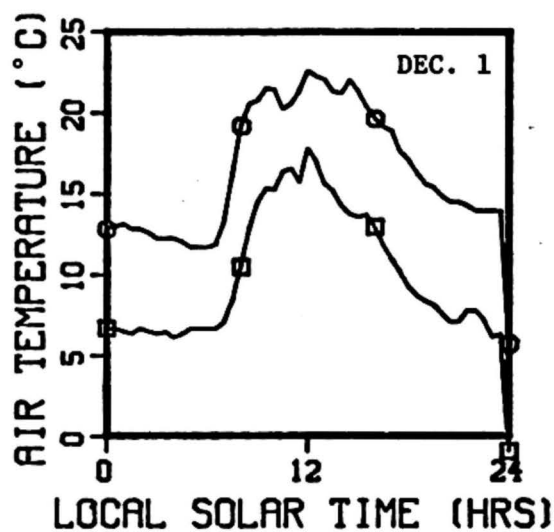
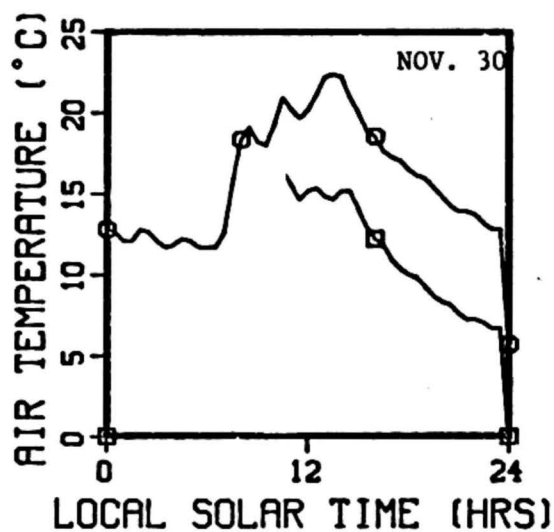


Figure 14.--Air temperature for Nov. 30, Dec. 1, 2, and 3 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement  $5^{\circ}\text{C}$ ).

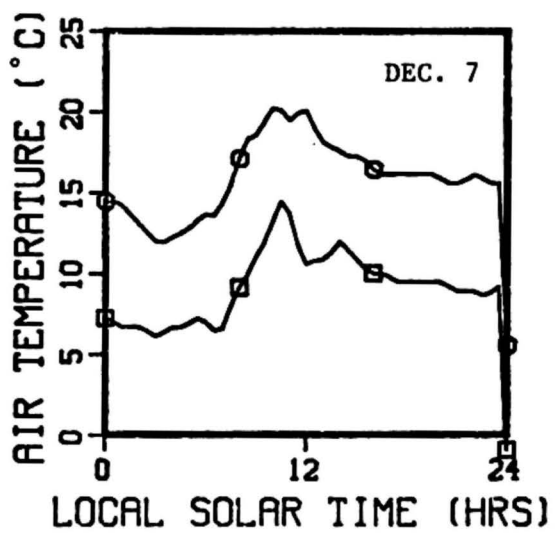
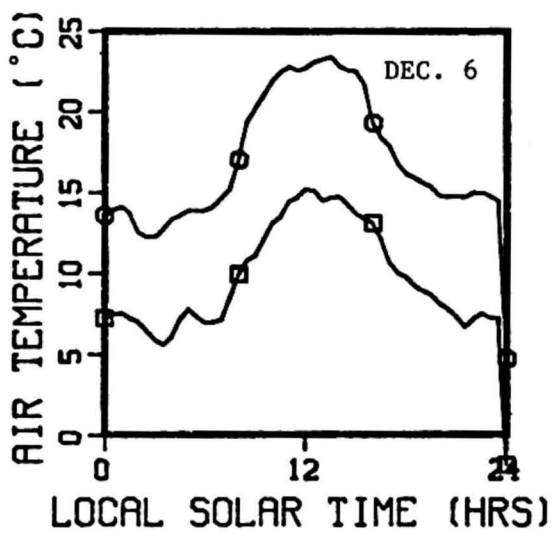
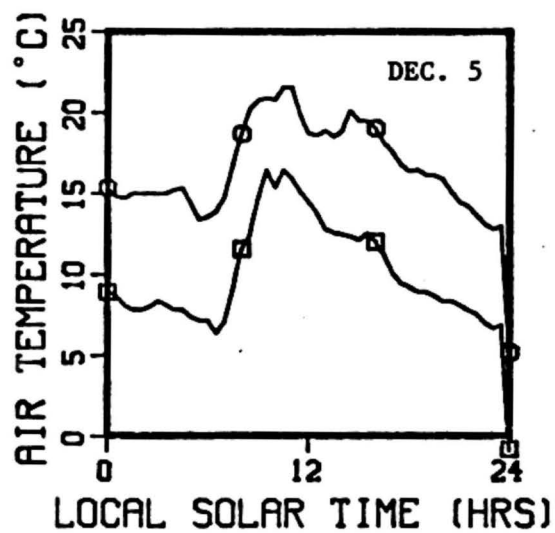
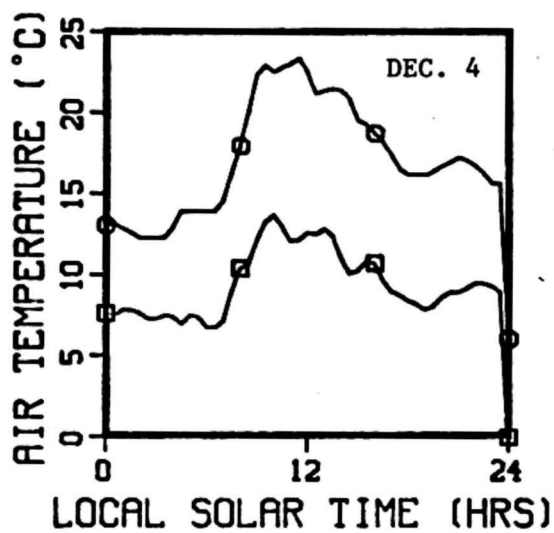


Figure 15.--Air temperature for Dec. 4, 5, 6, and 7 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement  $5^{\circ}\text{C}$ ).



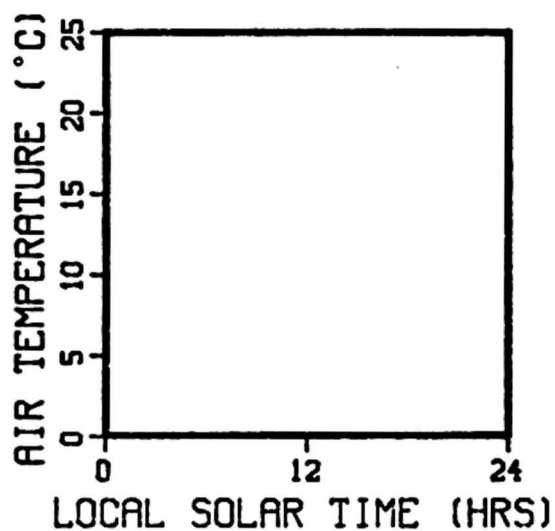
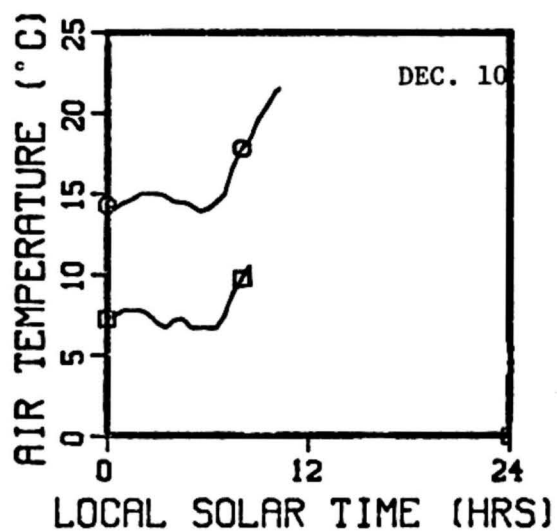
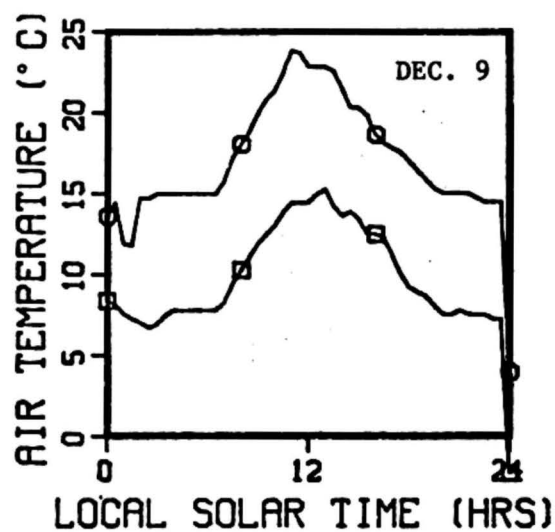
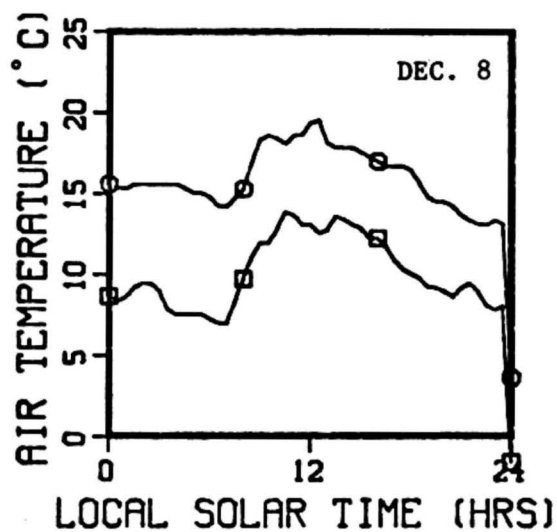


Figure 16.--Air temperature for Dec. 8, 9, and 10 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement  $5^{\circ}$  C).

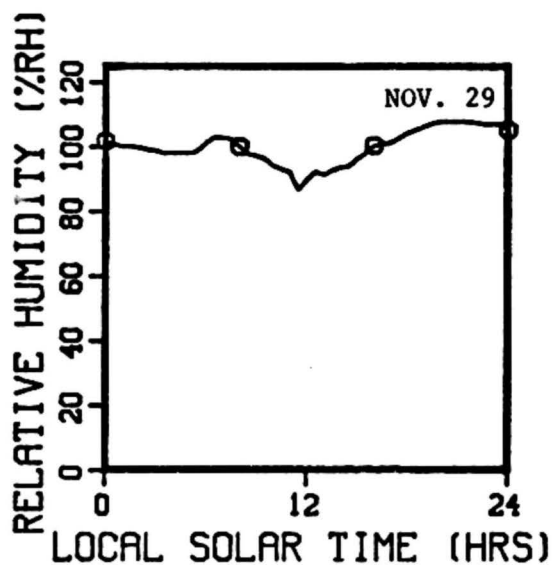
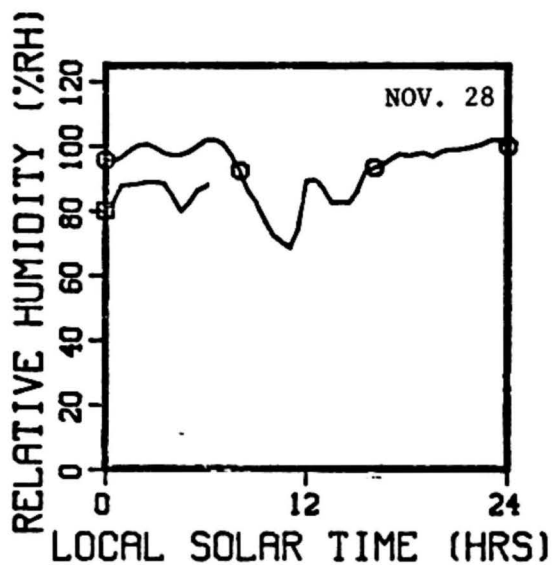
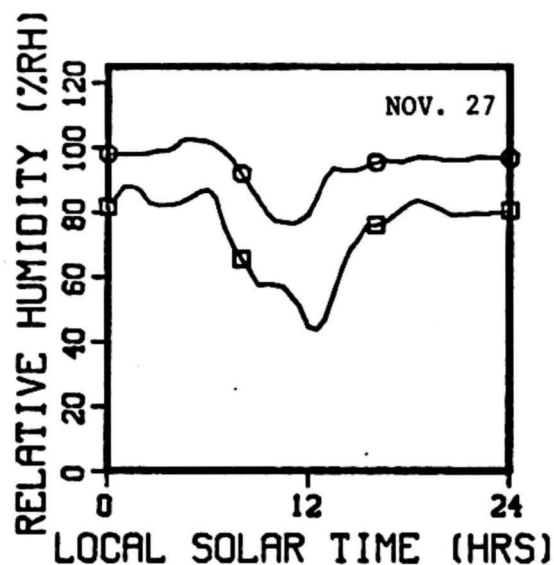
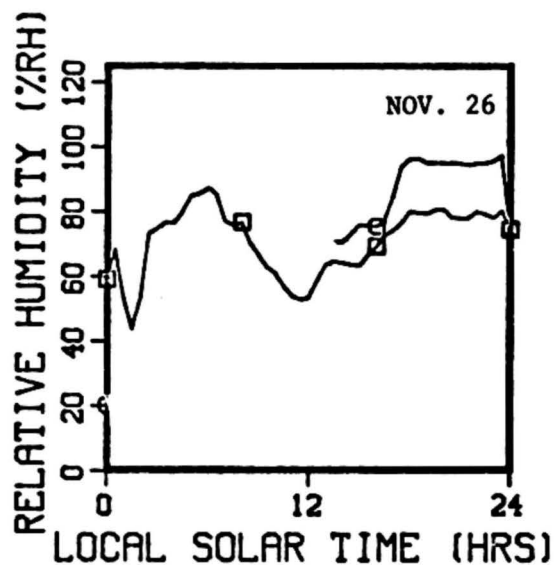


Figure 17.--Relative humidity for Nov. 26, 27, 28, and 29 from station 1 (□) and station 2 (○) (displacement 20% RH).

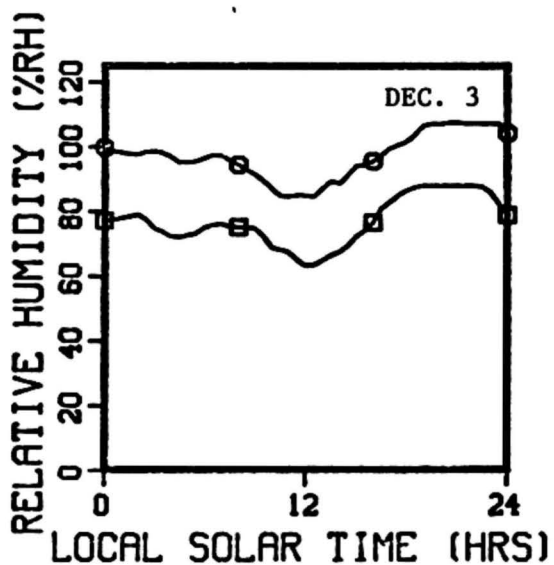
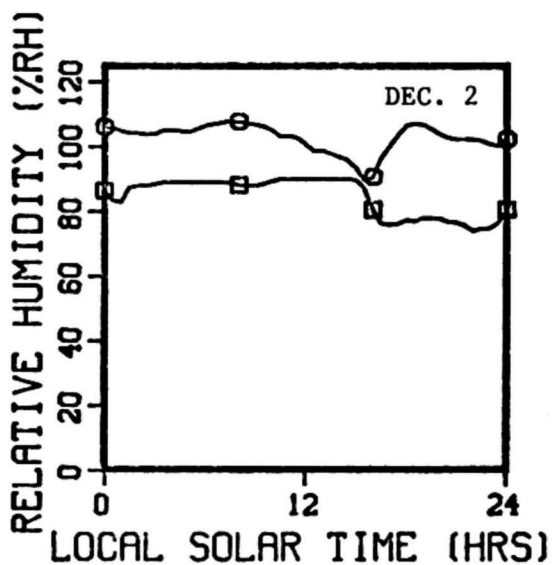
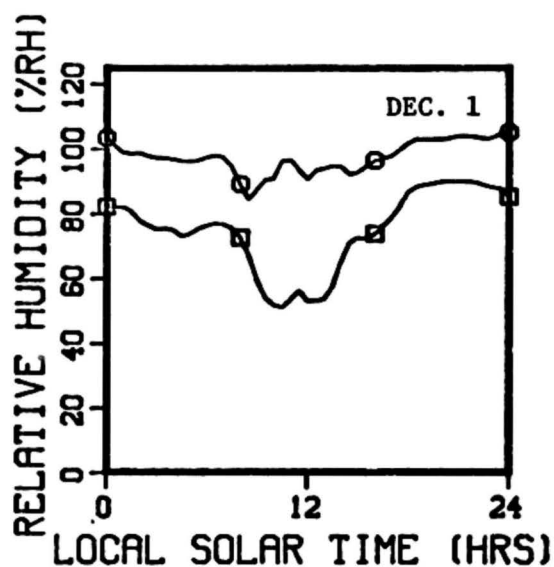
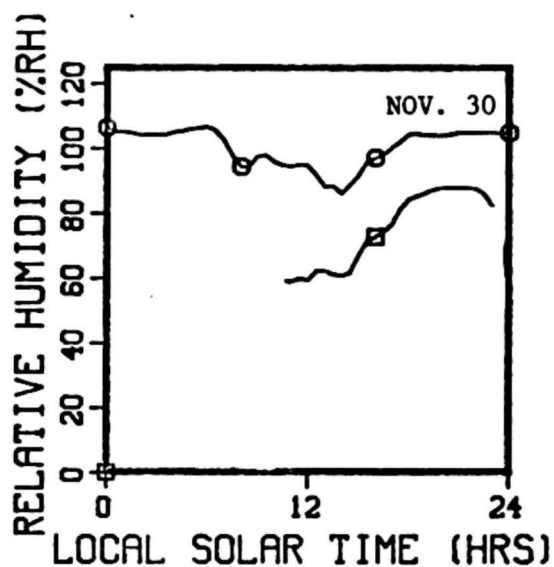


Figure 18.--Relative humidity for Nov. 30, Dec. 1, 2, and 3 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 20% RH).

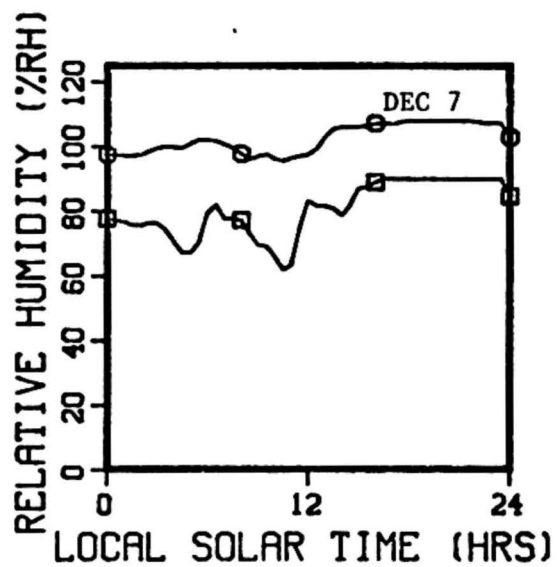
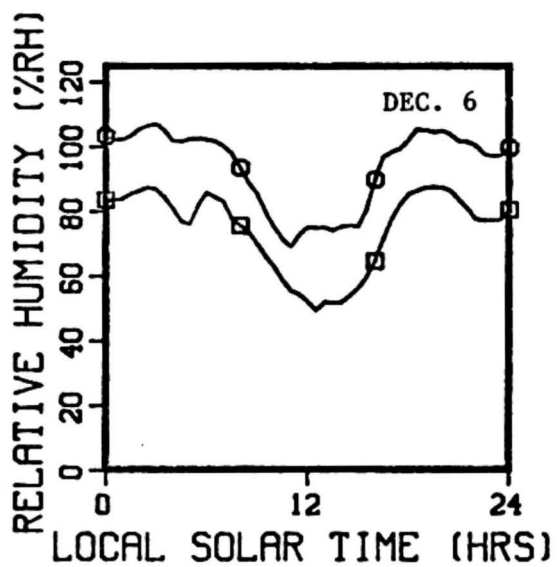
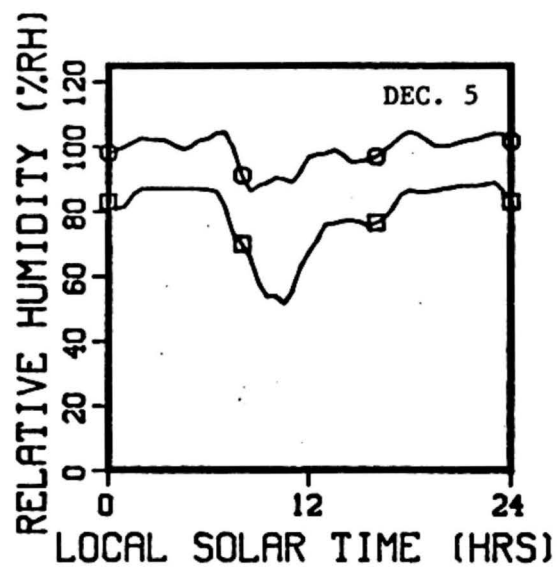
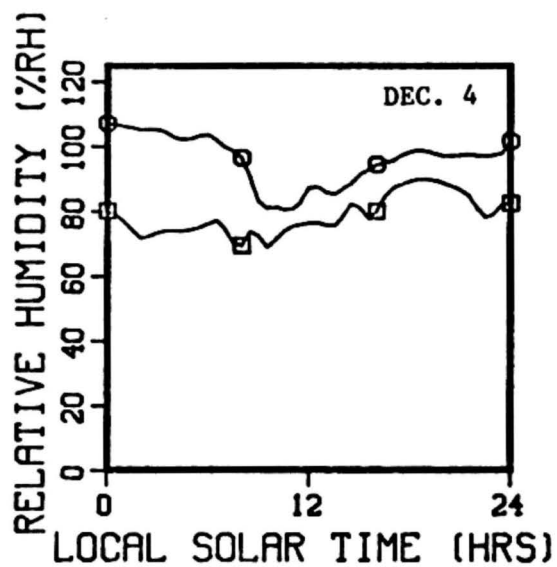


Figure 19.--Relative humidity for Dec. 4, 5, 6, and 7 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 20% RH).

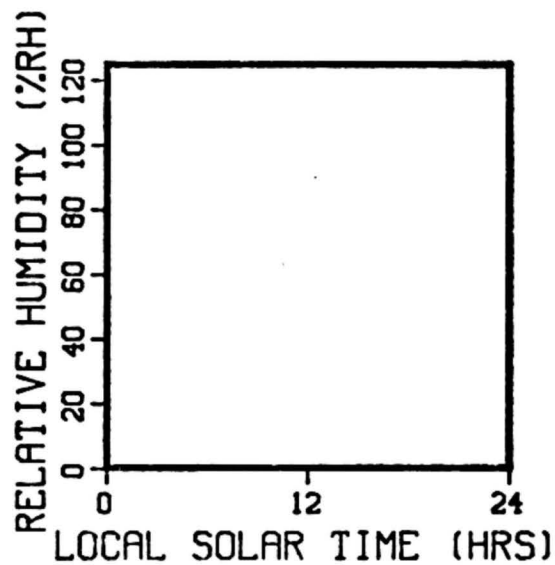
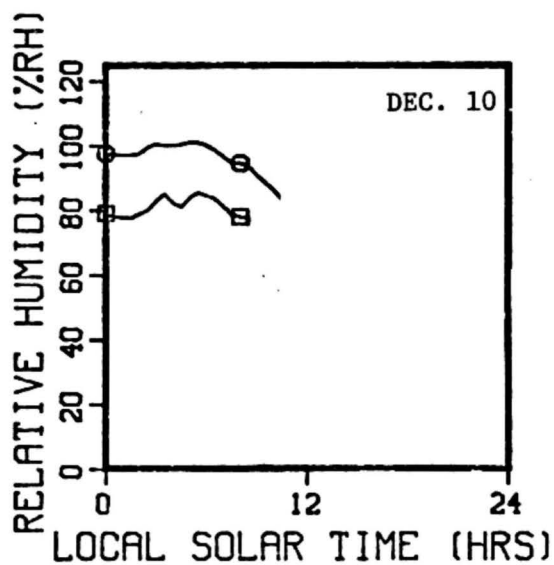
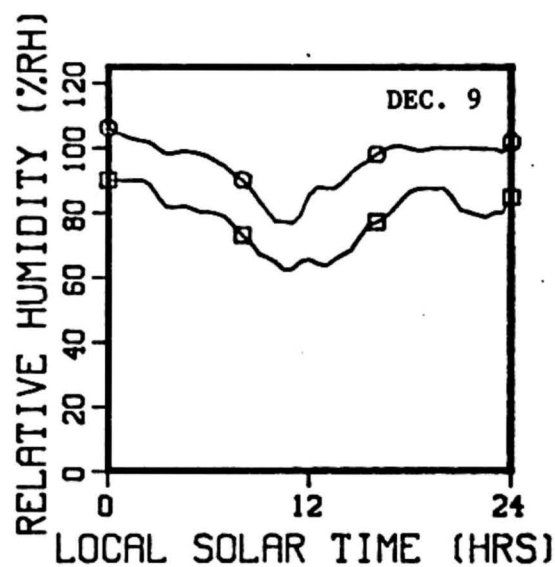
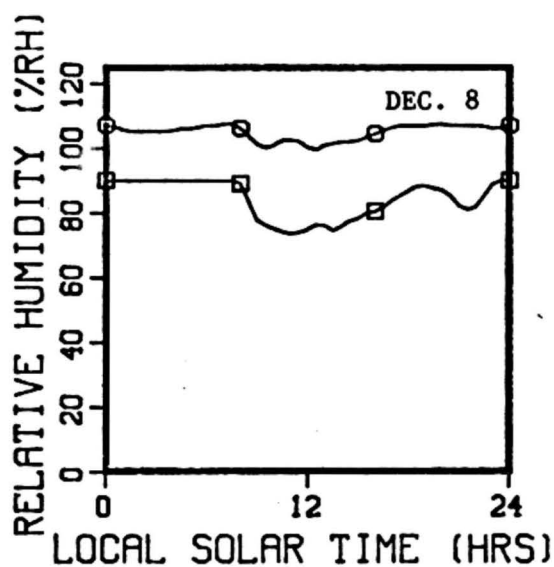


Figure 20.--Relative humidity for Dec. 8, 9, and 10 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 20% RH).

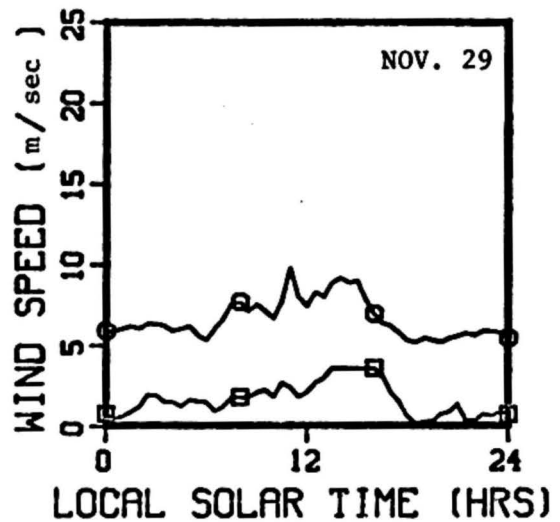
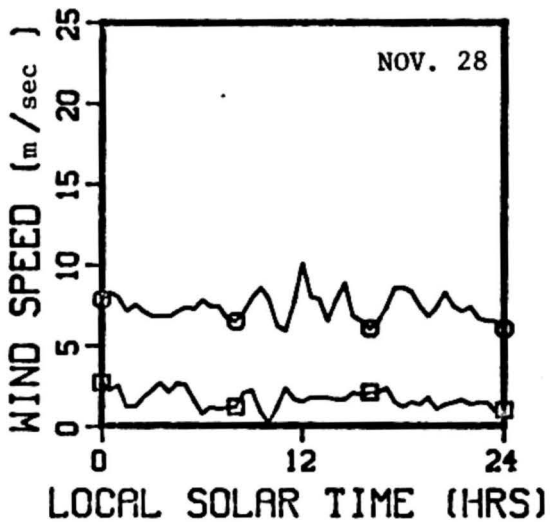
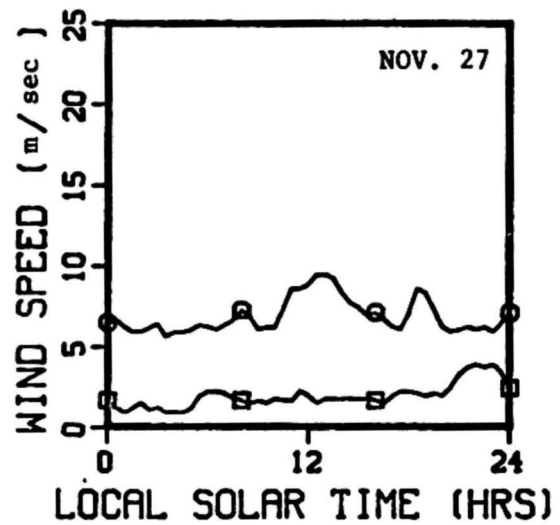
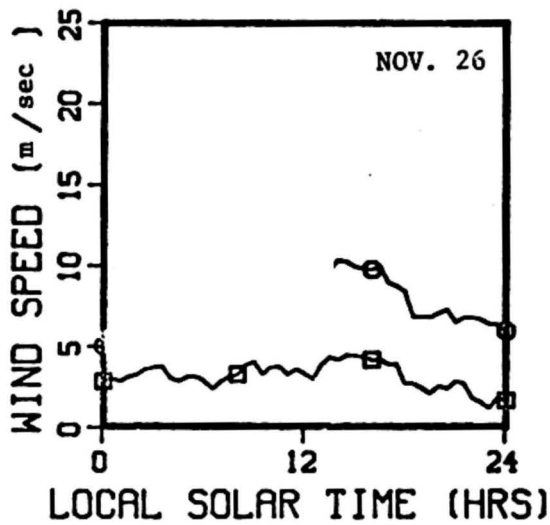


Figure 21.--Wind speed for Nov. 26, 27, 28, and 29 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 5 m/sec).

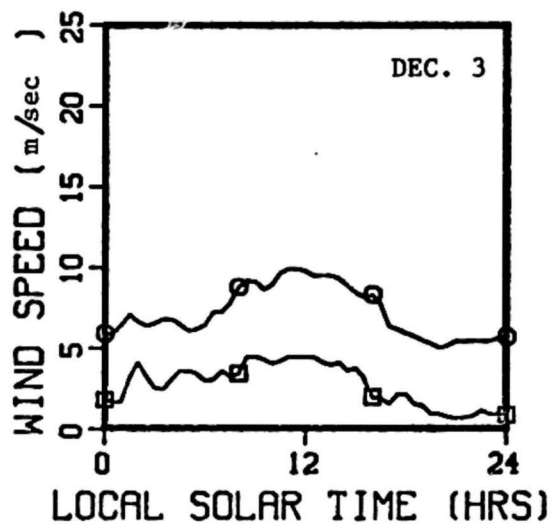
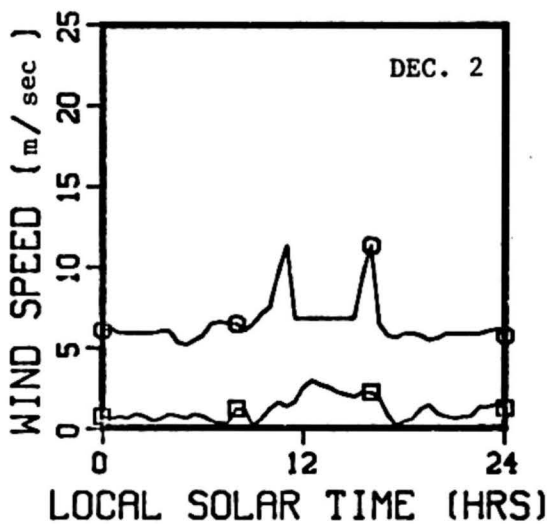
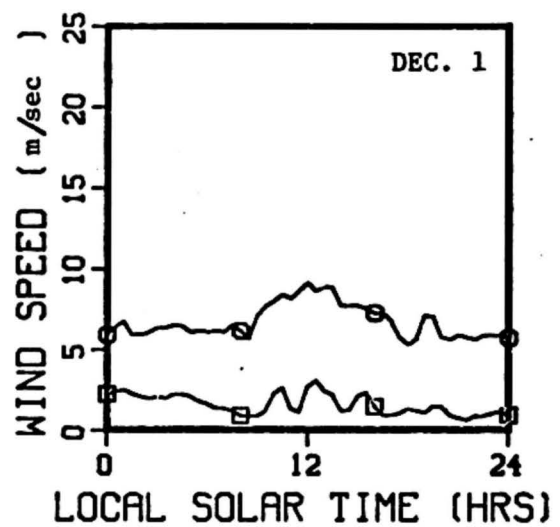
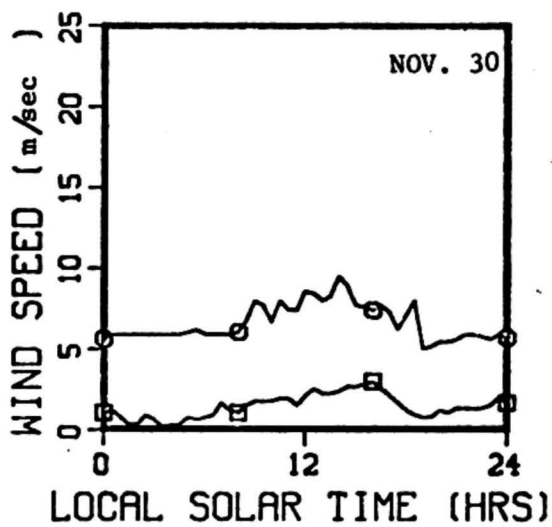


Figure 22.--Wind speed for Nov. 30, Dec. 1, 2, and 3 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 5 m/sec).

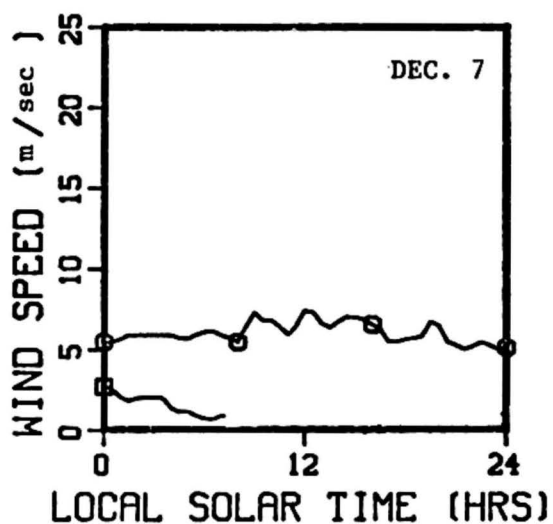
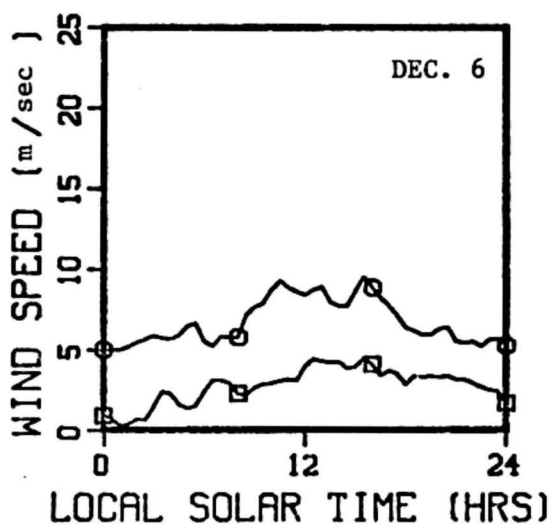
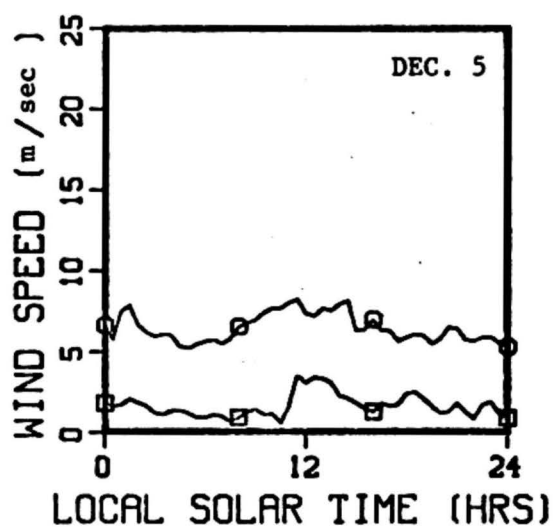
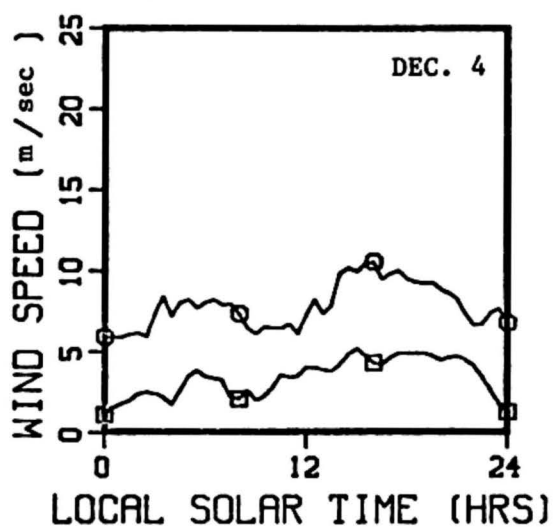


Figure 23.--Wind speed for Dec. 4, 5, 6, and 7 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 5 m/sec).



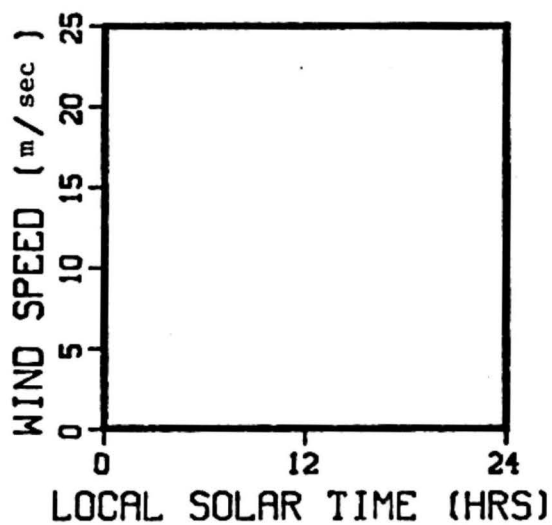
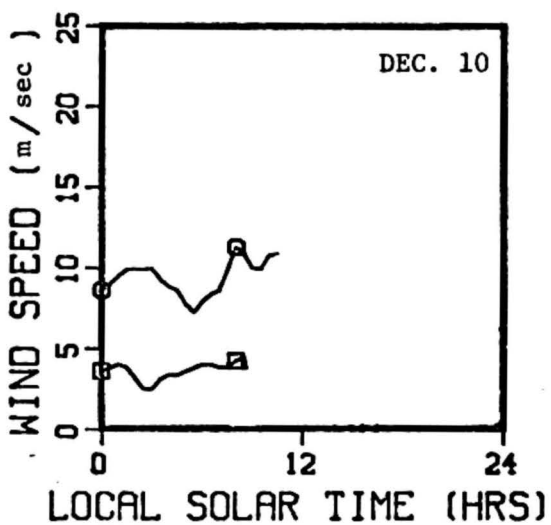
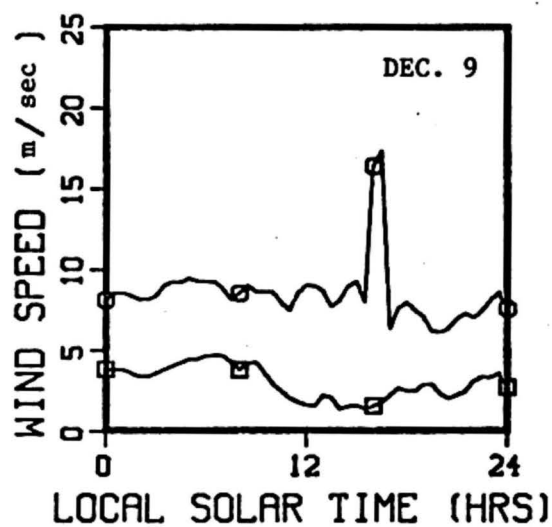
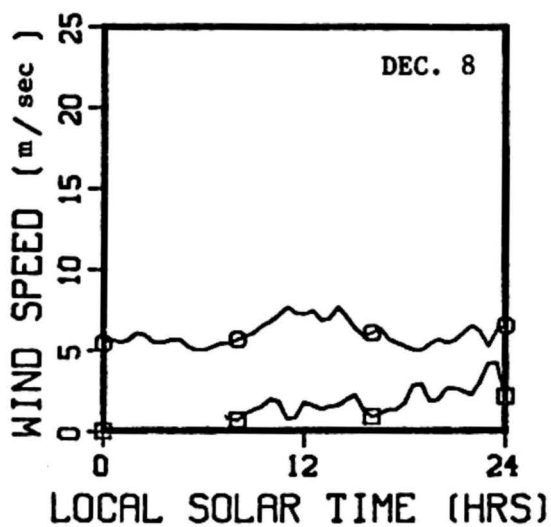


Figure 25.--Wind speed for Dec. 8, 9, and 10 from station 1 ( $\square$ ) and station 2 ( $\circ$ ) (displacement 5 m/sec).

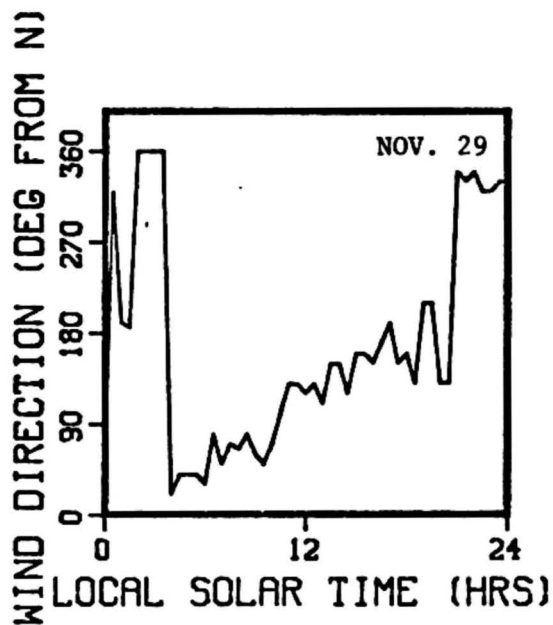
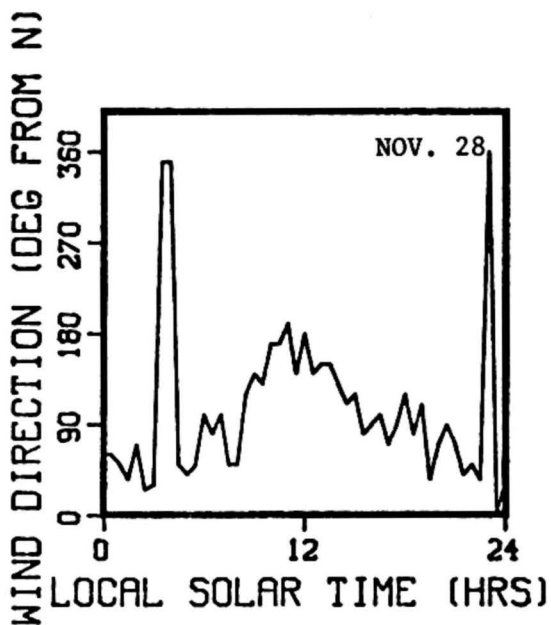
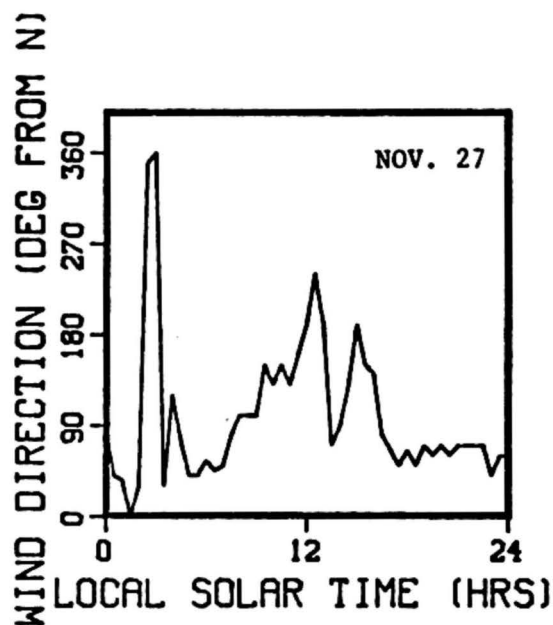
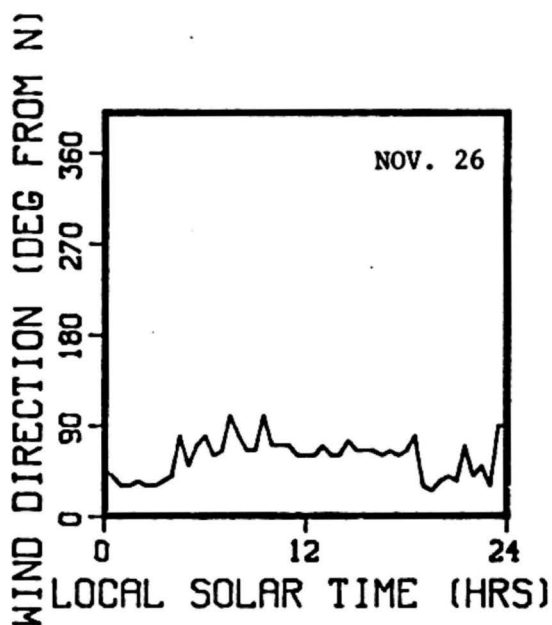


Figure 25.--Wind direction measured from true north for Nov. 26, 27, 28, and 29 from station 1.

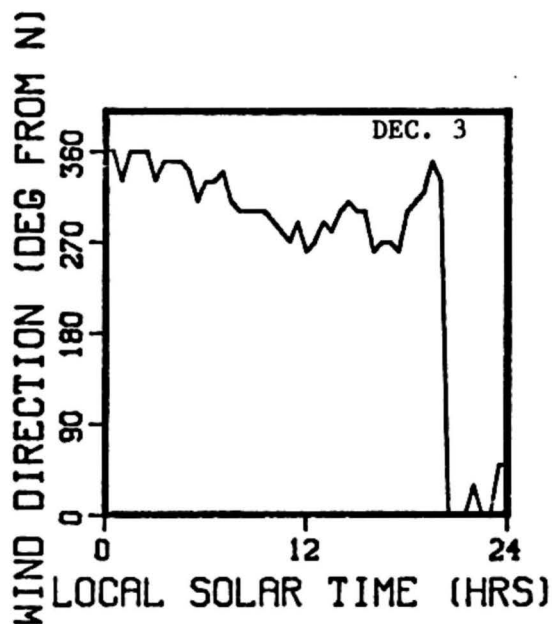
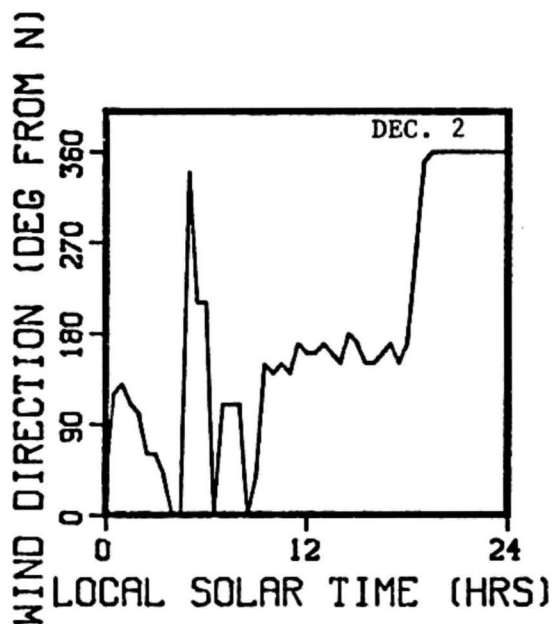
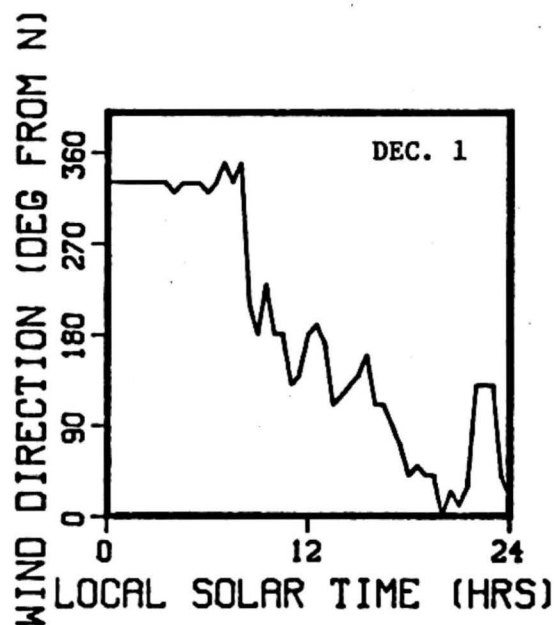
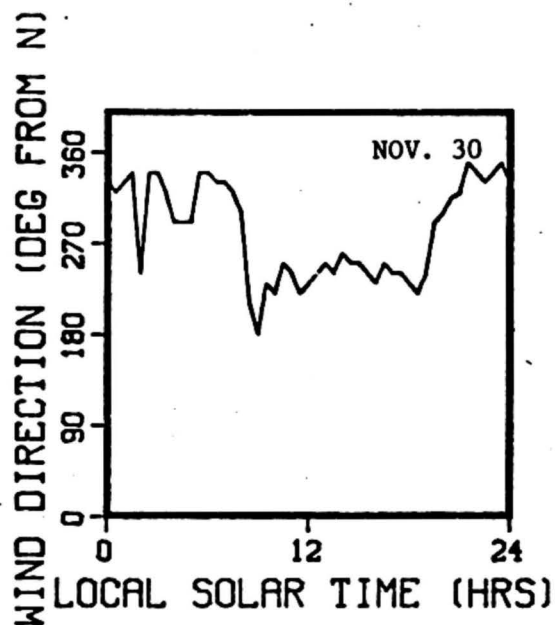


Figure 26.--Wind direction measured from true north for Nov. 30, Dec. 1, 2, and 3 from station 1.

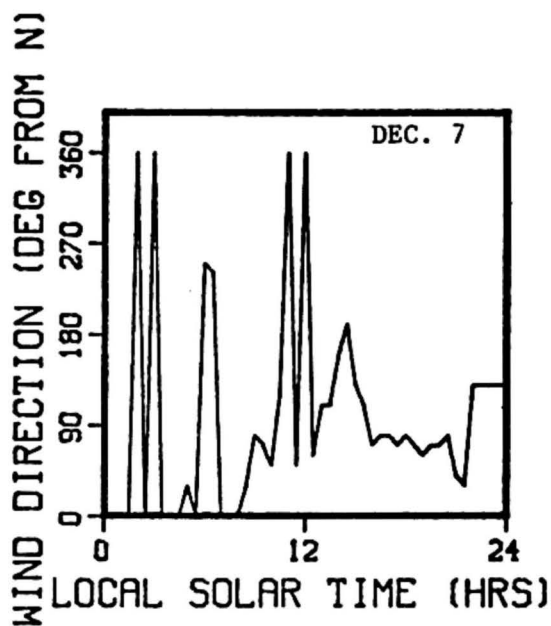
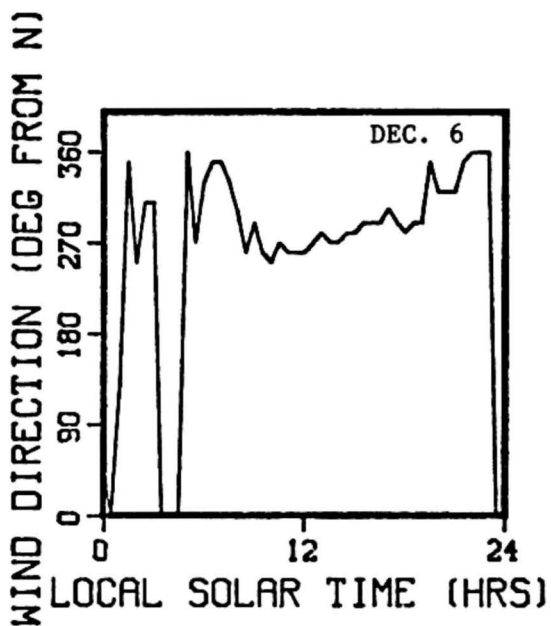
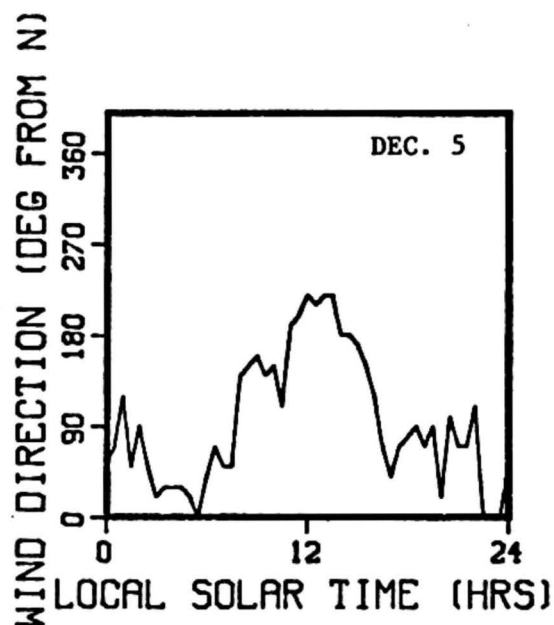
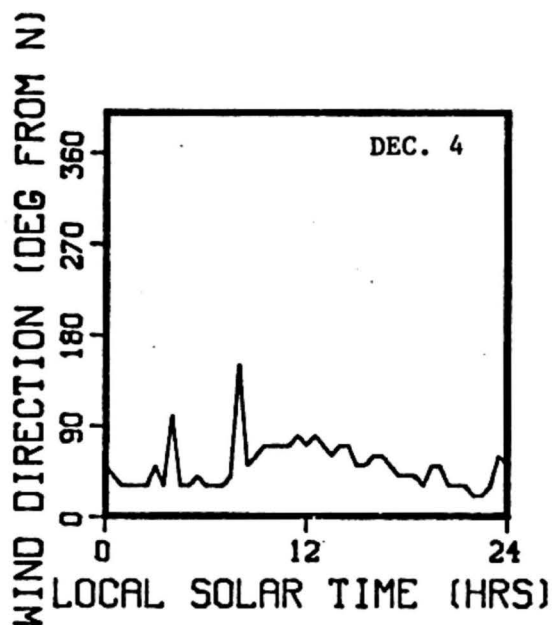


Figure 27.--Wind direction measured from true north for Dec. 4, 5, 6, and 7 from station 1.

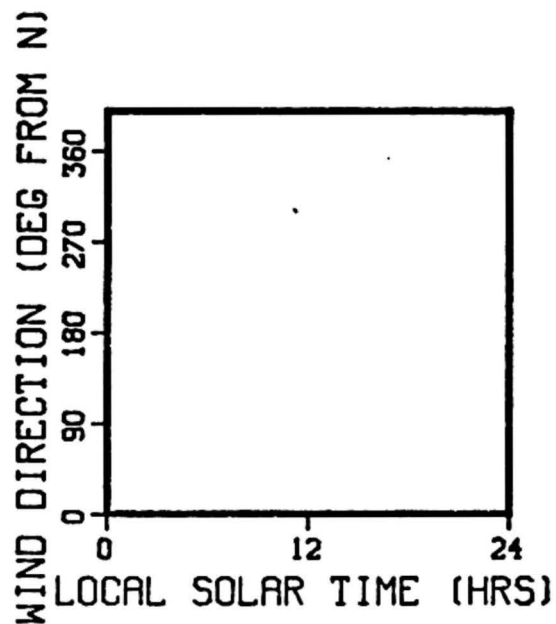
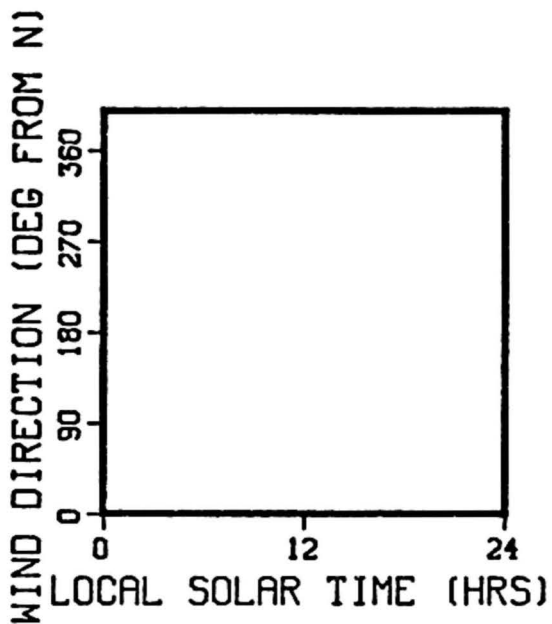
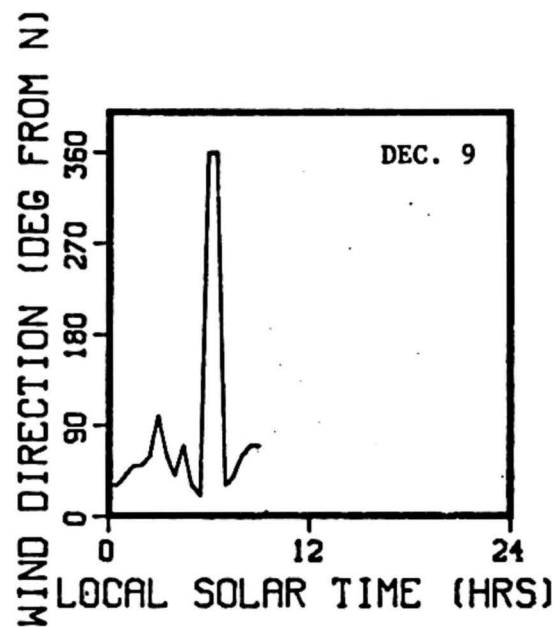
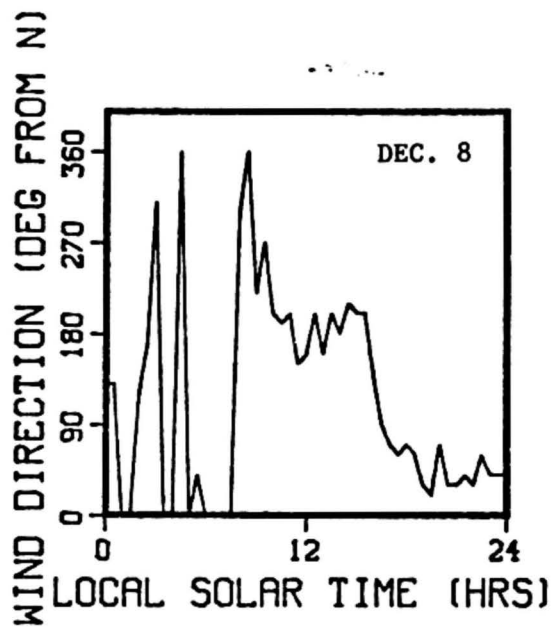


Figure 28.--Wind direction measured from true north for Dec. 8 and 9 from station 1.

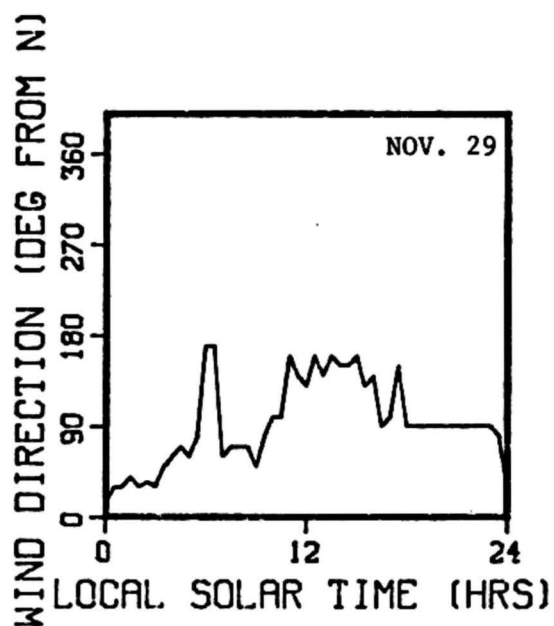
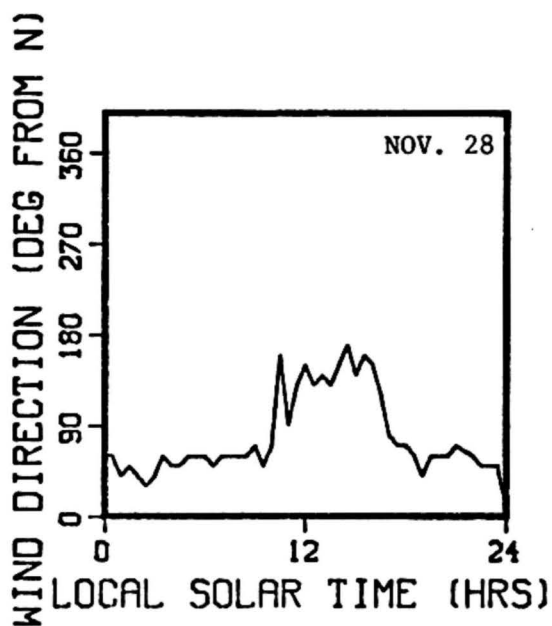
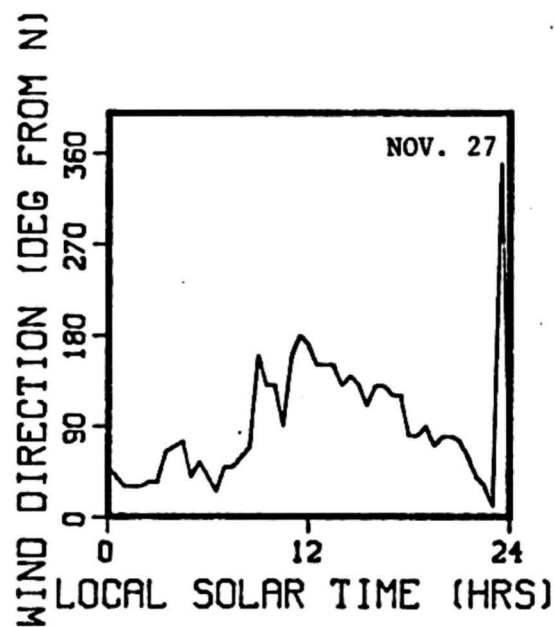
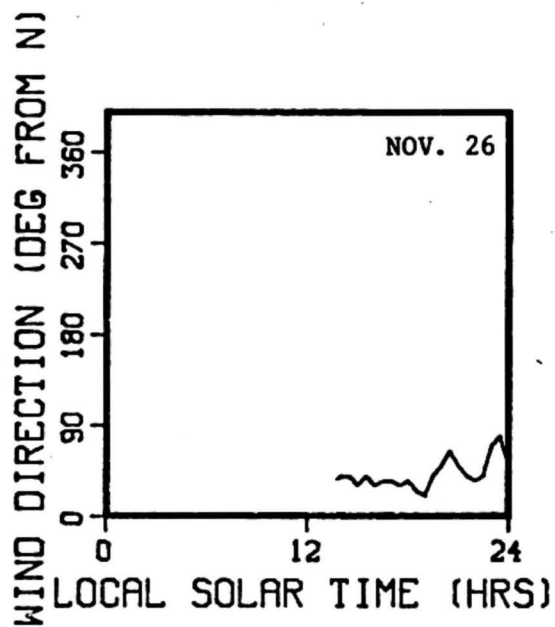


Figure 29.--Wind direction measured from true north for Nov. 26, 27, 28, and 29 from station 2.

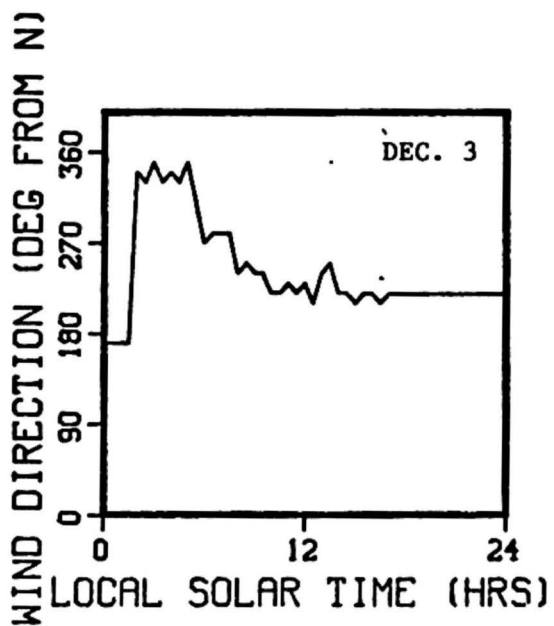
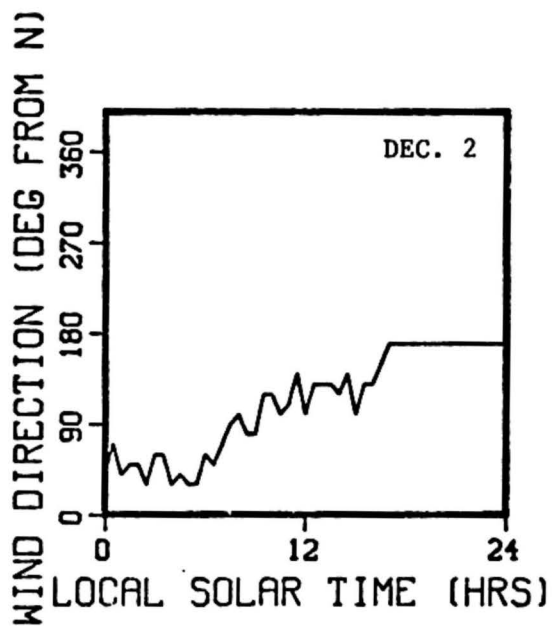
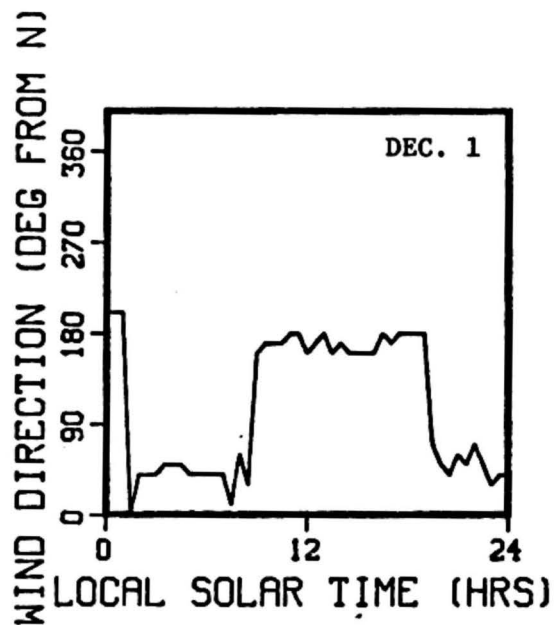
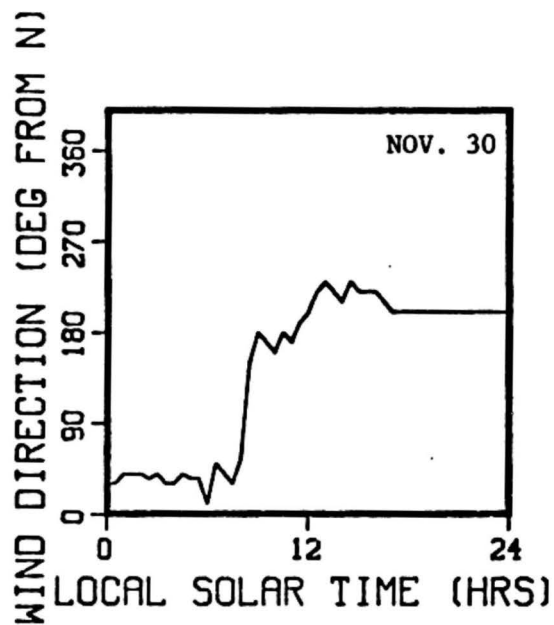


Figure 30.--Wind direction measured from true north for Nov. 30, Dec. 1, 2, and 3 from station 2.

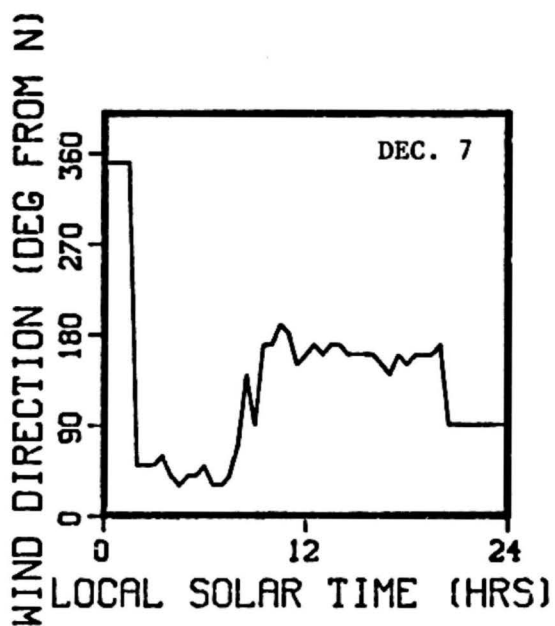
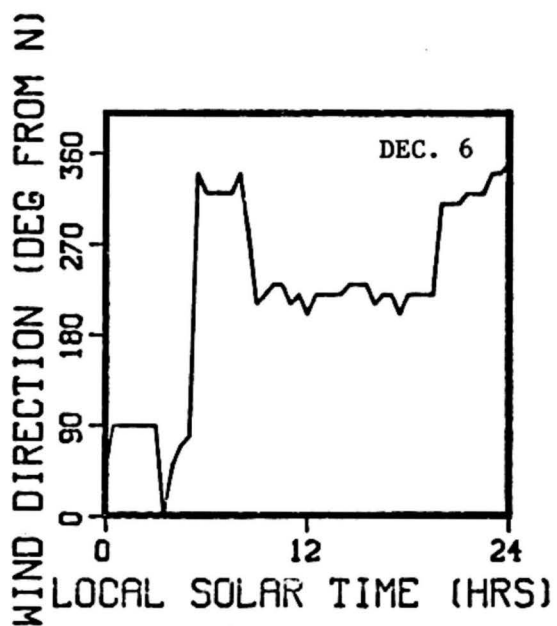
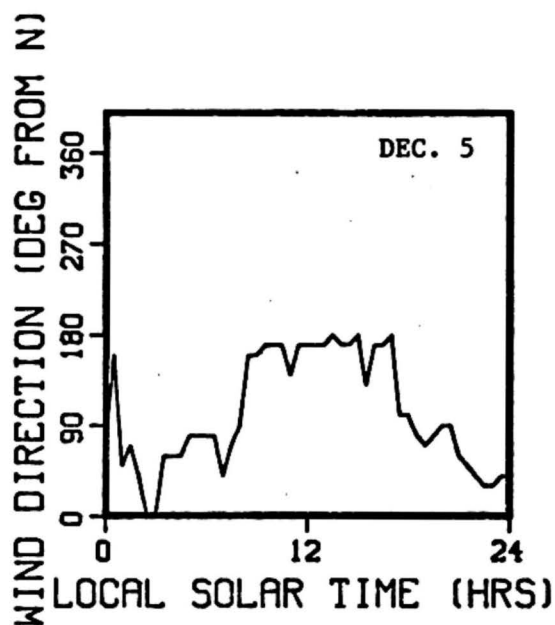
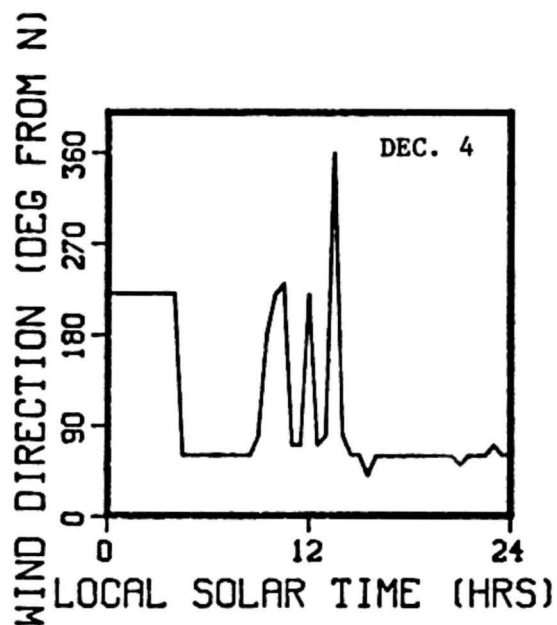


Figure 31.--Wind direction measured from true north for Dec. 4, 5, 6, and 7 from station 2.



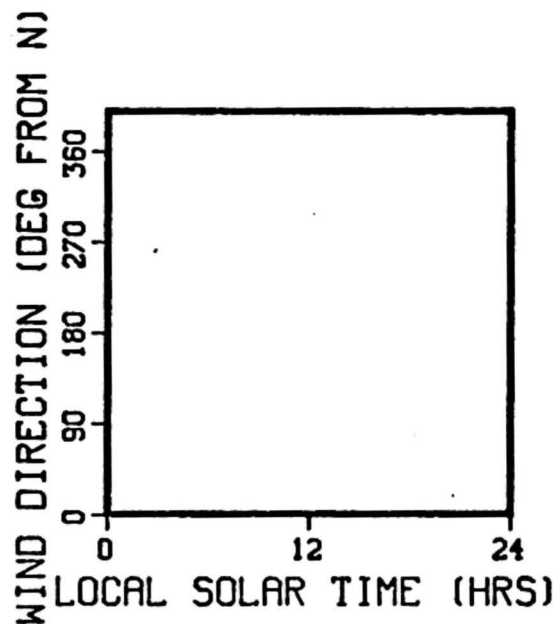
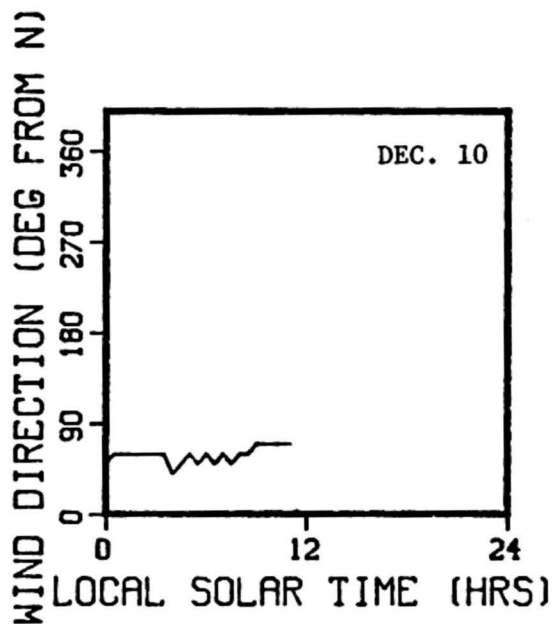
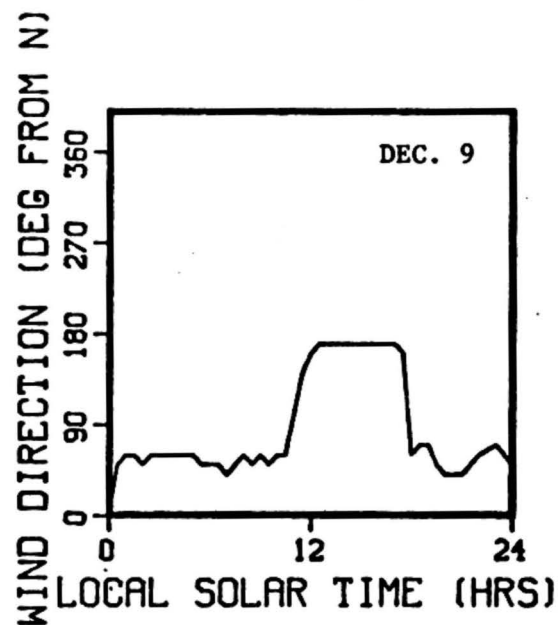
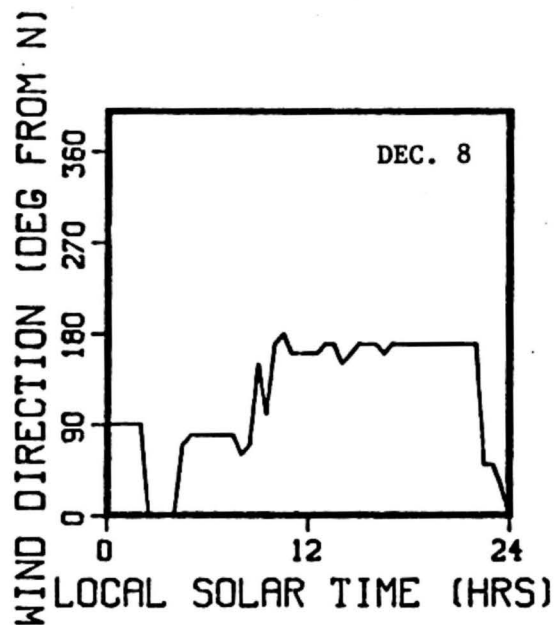


Figure 32.--Wind direction measured from true north for Dec. 8, 9, and 10 from station 2.