IV. STATION CONFIGURATION AND SENSOR COMPARISONS

Comparison of solar radiation data gathered at different stations with diverse instrumentation requires an understanding of the accuracy and limitations of the instruments used to monitor the incident solar radiation. Five types of solar sensors and several different data loggers have been used to gather the solar radiation data presented in this data book. In this chapter, the instruments and data loggers used at different stations are discussed and compared.

The stations, instrument type, and data logger type are listed in Table 2. The types of instruments and their absolute uncertainty are listed in Table 3, and the data logger types are listed in Table 4.

Table 2. Station Configuration

Station Name	Station Type	Instruments	Data Logger
Aberdeen, Id.	AgriMet	LiCor	Sutron
Bend, Or.	PNRC RSP	Schenk RSP	Chart CR-10
Boise, Id.	RSP AgriMet	RSP LiCor	CR-10
Burns, Or.	First Class	PSP, NIP	UO DL CR-10
Christmas Valley, Or.	AgriMet	LiCor	Sutron
Coeur d'Alene, Id.	First Class	PSP, NIP	UO DL
Coos Bay, Or.	PNRC	Schenk PSP	Chart UO DL
Eugene, Or.	First Class	PSP, NIP LiCor	UO DL CR-10
Green River, Wy.	RSP	RSP	CR-10
Hermiston, Or.	First Class	PSP, NIP, RSP, LiCor	UO DL CR-10
Hood River, Or.	First Class	PSP, NIP	UO DL
Kimberly, Id.	First Class AgriMet	PSP, NIP LiCor	UO DL Sutron
La Grande, Or.	PNRC	Schenk	Chart
Madras, Or.	AgriMet	LiCor	Sutron
Moab, Ut.	RSP	RSP	CR-10
Parma, Id.	AgriMet	LiCor	Sutron
Picabo, Id.	AgriMet	LiCor	Sutron
Portland, Or.	First Class	PSP, NIP	UO DL
Whitehorse Ranch, Or.	PNRC First Class	Schenk PSP, NIP	Chart UO DL

First Class Stations

The first class stations are equipped with Eppley PSP pyranometers and Eppley NIP pyrheliometers. From 1978 through June of 1995, the first class stations used data logging systems (UO DL) developed by the UO Technical Services shop. In June of 1995, Campbell Scientific CR-10 data loggers were installed at the first class stations.

The Hermiston station is the main intercomparison station. Besides using first class instruments, AgriMet instruments and a RSP pyranometer are co-located at the station. Comparisons of the measurements at the Hermiston station are briefly discussed at the end of this section.

Data analysis for the first class stations is discussed in more detail in the chapters on Data Handling Procedures, Sensor Calibration, and Use of Chart Records in Data Analysis.

Table 3. Solar Instrumentation

Station Type	Solar Instrument	Data Measured	Absolute Accuracy
First Class	Eppley PSP	Global & Diffuse	3-4%
First Class	Eppley NIP	Beam	2-3%
PNRC	Schenk	Global	5%
AgriMet	LiCor	Global & Diffuse	5%
RSP	RSP	Global, Diffuse, & Beam	5-10%

Table 4. Data Logging System

Station Type	Data Logger Type	Uncertainty
First Class	UO DL	0.2%
First Class & RSP	CR-10	0.2%
AgriMet	Sutron	0.2%*
PNRC	Chart	2-3%

* *Precision with the older Sutron integrators is about 20 Wh/m^2 in a 15-minute interval.*

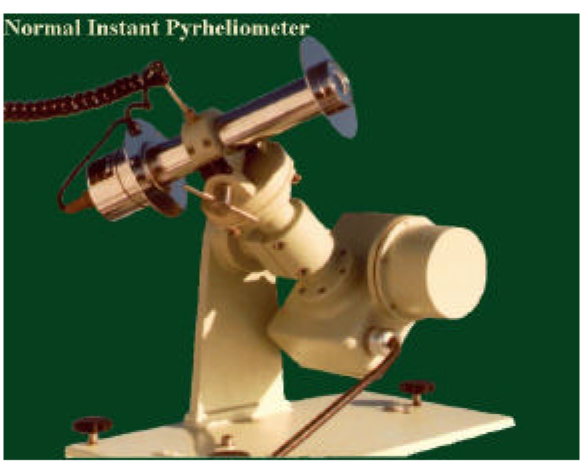
AgriMet Stations

The AgriMet network is operated by the US Bureau of Reclamation (USBR) to supply farmers with meteorological information to help schedule irrigation. Data from this network are uploaded every four hours to a satellite and downloaded to a USBR computer in Boise, Idaho. The data are then made available to the agricultural community.

AgriMet stations normally measure global radiation for input to transpiration calculations. The stations use a LiCor pyranometer. An additional LiCor pyranometer utilizing a LiCor designed shadow band was added to eight AgriMet stations to monitor diffuse radiation.

AgriMet stations use Sutron data loggers to record the global and diffuse radiation. The LiCor pyranometers are attached to integrators that are monitored by the data loggers. The original integrators had a precision of 10 to 40 Wh/m^2 per hour over a 15-minute period. In April 1996, new integrators were installed at Hermiston, Madras, and Christmas Valley. The new integrators have a precision better than 1 Wh/m^2 per hour over a 15-minute period. Considering that diffuse irradiance on a clear day is on the order of 50 to 100 Wh/m^2 per hour, the new integrators represent a significant improvement.

The older integrators produce a good estimate of the hourly and daily irradiance as the information lost due to low precision averages out over the longer hourly time period.



RSP Stations

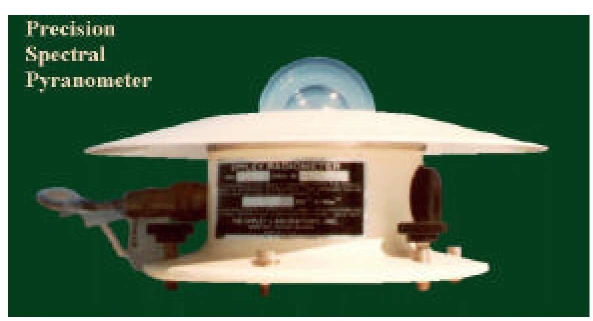
RSP stations use rotating shadow band pyranometers. RSPs measure global and diffuse radiation and calculate beam radiation from the global and diffuse measurements. A RSP employs a LiCor pyranometer that is obscured by a shadow band once a minute. Diffuse radiation is measured by recording the minimum of output of the pyranometer during the sweep of the shadow band. The beam radiation is calculated by subtracting the diffuse measurement from the global measurement to obtain the direct horizontal component. Then the direct horizontal component is divided by the cosine of the zenith angle to yield the direct normal beam value. The main advantage of an RSP is that no alignment is necessary to obtain the beam radiation.

The main advantage of an RSP is that no manual alignment is necessary to obtain the beam radiation.

The data acquisition system for the RSP is a Campbell Scientific CR-10 data logger. Data from the RSP stations are stored in 15-minute intervals and are downloaded to a UO Solar Monitoring Lab computer periodically via phone modem.

PNRC Stations

PNRC stations were part of the original solar monitoring network. Global irradiance was measured by Schenk pyranometers using strip chart recorders. The strip chart recorders



were equipped with integrators that recorded the sum of the solar radiation over the data. The integrator traces on the chart were used to obtain daily total irradiance. Beginning in 1980, a pit pad digitizer was used to give hourly values by tracing over the solar radiation plot.

Comparisons between the digitized charts and integrated values show that the digitizing introduces an uncertainty of about 2% to the daily totals.

Comparison of Instrumentation

Both the RSP and the AgriMet stations are based on LiCor pyranometers. The LiCor pyranometer is a solar cell covered with a diffusing cap. Since the LiCor pyranometer uses a silicon solar cell, the sensor is sensitive to only part of the solar spectrum. Because the beam and diffuse irradiance have different spectral weighting, systematic spectral errors are associated with use of LiCor pyranometers. When global measurements are made using LiCor pyranometers, these systematic errors tend to cancel and the daily global measurements agree closely with those using a thermopile instrument such as an Eppley PSP. However, the spectral nature of the LiCor pyranometer significantly affects the measurements for hourly values of beam and diffuse irradiance.

More information on the LiCor – PSP comparison is given in chapter VI on calibrations.

Hermiston as a Reference Station

The Hermiston station is equipped with a NIP, PSP, RSP, LiCor, and LiCor with a shadow band. By comparing the irradiance from the different instruments, an estimate of the relative accuracy of the different monitoring equipment can be obtained.

In a recent report [1], we made a preliminary comparison of the beam, global, and diffuse values obtain from the RSP with those obtained from the Eppley instruments.

Table 5. Monthly Average Differences 1997

Month/Irradiance	Global	Beam	Diffuse
January	5.7%	8.8%	-5.4%
February	5.2%	7.3%	-6.3%
March	3.6%	7.1%	-5.6%
April	1.5%	6.7%	-10.3%
May	0.8%	4.0%	-11.0%
June	-1.4%	2.9%	-13.8%
July	-0.7%	1.8%	-16.9%
August	0.9%	3.4%	-14.7%
September	2.5%	4.7%	-8.6%
October	4.1%	5.9%	-5.9%
November	4.0%	7.8%	-6.3%
December	3.5%	8.4%	-4.5%

Table 5 lists the monthly average difference between the values obtained from the Eppley instruments and the RSP for 1997. Of particular concern is the consistent difference between the beam values obtained from the RSP and the Eppley NIP. Other reports also show that the RSP overestimates the beam radiation and underestimates the diffuse radiation. However, our preliminary studies show that this overestimation is about twice as large as found in other studies. There is a significant difference between the response of the LiCor during clear and cloudy periods.

At least some of the difference between the measurements can be attributed to the spectral characteristics of the LiCor pyranometer used by the RSP. Models exist that compensate for the spectral response of the LiCor and the RSP data, but these models have not been used to correct the RSP data presented in this data book.

Remember that the beam values from the RSP stations are systematically high!

References

1. F. Vignola, Jimm Domingo, and D. K. McDaniels, Comparisons with a Rotating Shadowband Pyranometer. **Proceedings of the 1996 American Solar Energy Society Annual Conference**, Asheville, North Carolina, pg. 229-236, (1996).