Solar Energy Meteorological Research and Training Site - Region 5

U.S. DOE Grant EY-77-G-06-1059
Annual Report Prepared for
Division of Distributed Solar Technology
U.S. Department of Energy
30 September 1977—29 September 1978

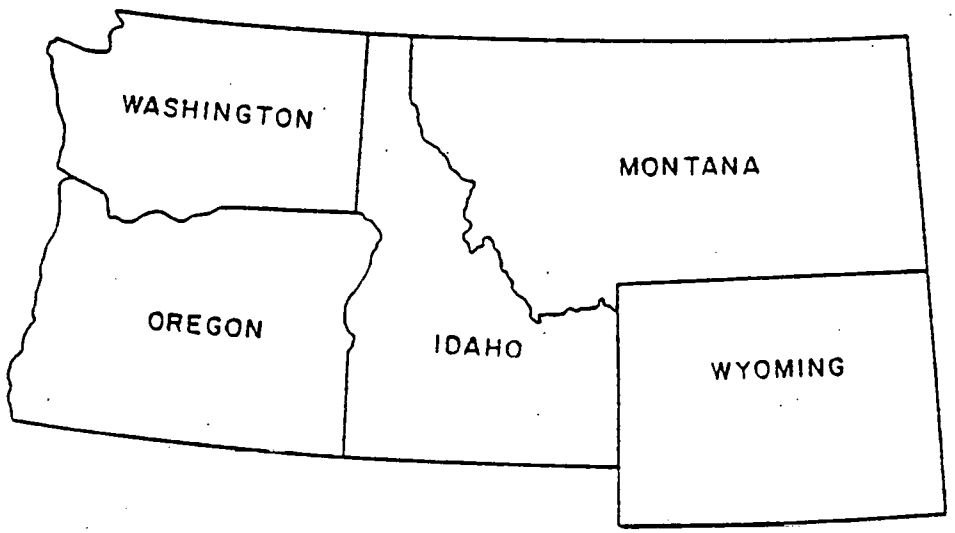
By
C. R. Nagaraja Rao and E. Wendell Hewson

DEPARTMENT OF ATMOSPHERIC SCIENCES
Oregon State University
Corvallis, Oregon

January 1979

DISCLAIMER

Solar Energy Meteorological Research and Training Site - Region 5



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Prefatory Note

We have given in this report a brief description of what has been accomplished during the first year of performance under the Solar Energy Meteorological Research and Training Site program for Region 5 (Idaho, Oregon, Montana, Washington and Wyoming). The primary facility which hopefully will evolve into a benchmark site for the acquisition of research quality solar radiation and solar energy related meteorological data has been set up in Corvallis and will be fully operational in the near future. The training program has been firmly established with the introduction of two, two-quarter courses on solar radiation and meteorological measurements and on atmospheric radiative processes. Also, as part of the training program, a week-long workshop on solar energy measurement and instrumentation was conducted during the summer of '78 and a series of seminars on solar energy related topics, catering to both professionals and non-professionals, was arranged during the 1977-78 academic year. A meeting of solar radiation scientists from the five states of the region was held in Corvallis (August '78) to explore the feasibility of setting up a regional network of stations to acquire research quality solar radiation and meteorological data. Very useful global irradiance measurements have been made at the five sites, making up the general quality network in Oregon, over the greater part of the year by Prof. McDaniels and his colleagues at the University of Oregon, Eugene, under a subcontract.

The administrative authorities at the University have been very generous in their support of the SEMRTS program. We are especially thankful to Prof. John V. Byrne, Dean of Research and to Prof. Robert W. Krauss, Dean of the College of Science, for their efforts in our behalf. We also wish to place on record at this time our sincere appreciation of the help and cooperation extended to us by Dr. Michael R. Riches, Division of Distributed Solar Technology (ERAB), U.S. Department of Energy, Washington, D.C.

C. R. Nagaraja Rao

C.R. Nagaraja Rao

E. Wendell Hewson

E. Wendell Hewson

1. Introduction

Oregon State University, Corvallis, was the recipient of a grant, effective 30 September 1977, from the U.S. Department of Energy to establish and execute, through its Department of Atmospheric Sciences, the Solar Energy Meteorological Research and Training Site program in the northwestern region of the contiguous United States (Idaho, Montana, Oregon, Washington and Wyoming) over a five-year period. The University of Oregon, Eugene would participate in this program as collaborator and subcontractor.

The main objectives of this five-year program, the primary responsibility for which would rest with Oregon State University, the grantee institution, are briefly mentioned below:

a. To establish a primary solar radiation and related meteorological measurements and research centre at Oregon State University, Corvallis;

b. To develope an academic year training program at Oregon State University on the theory and measurement of solar radiation and allied meteorological phenomena;

c. To conduct summer workshops and seminars on solar energy measurement and instrumentation techniques and other solar energy related topics for both professionals and nonprofessionals;

d. To initiate and maintain a regional effort directed towards solar radiation and meteorological monitoring by the expansion of existing observation networks, where practicable, and by the consolidation of ongoing activities in the region through the formation of a

viable working group of solar energy scientists; and

e. To make solar radiation and allied meteorological measurements at selected sites with a mobile laboratory to complement and supplement the work done under the regional effort.

The program, in essence, is thus directed towards upgrading the quality, availability and standardization of solar radiation and solar-related meteorological data in the region, and towards the development of quality educational and training programs to meet the present and future manpower needs in the region and, perhaps, in a larger part of the country.

Against this background, we shall describe in what follows the work performed during the reporting period to attain these project objectives under the headings of primary research centre, the training program, the regional effort and the planned research and general activities.

2. The Primary Research Centre

2.1 General

At the time the SEMRTS program was initiated, it had been recognized that successful utilization of solar energy would require a comprehensive solar radiation and solar related meteorological data base. This data base for any region would be made up of high density, general quality network data and low density, research quality data and would be assembled from the measurements made at various sites in the region and at the primary research and training centre, which would

preferably be located at a university with a well-established program of research and instruction in the atmospheric sciences.

The factors which render Corvallis an eminently suitable site for the location of the primary research centre and the facilities available at the Department of Atmospheric Sciences will now be briefly described. Corvallis is located centrally in the western portion of Region 5, and lies directly in the path of the winter cyclonic storms with their cloudy skies and the summer anticyclonic systems with their sunny skies which are so dominant in forming the solar climate of the region. Weather and climate patterns in Corvallis and in western Oregon in general, are influenced by systems originating over the Pacific Ocean and modified by orographic influences and are generally representative of what is encountered in much of region 5. Also, the industrialized cities of Albany (15 km), Eugene (40 km) and Portland (120 km) are easily reached and offer themselves as excellent sites for the study of the solar radiation regime in polluted atmospheres, if desired.

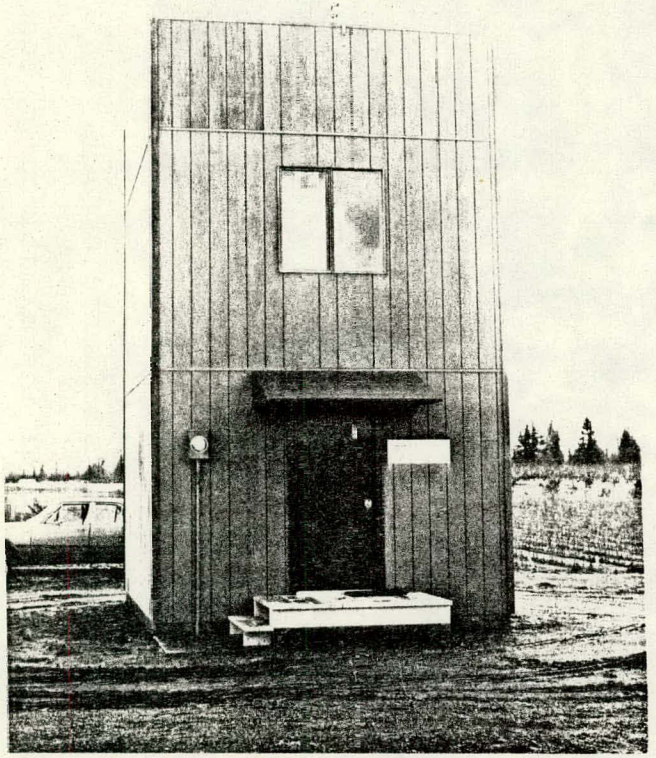
The Department of Atmospheric Sciences at Oregon State University, Oregon's only land-grant and sea-grant institution of higher learning, offers both undergraduate and graduate programs of study leading to the baccalaureate, master's and doctoral degrees. The areas of interest of the faculty are such that specialization at the post-baccalaureate level is possible in a wide variety of fields. These include, amongst others, atmospheric radiative transfer and solar energy, wind

power studies, air pollution, dynamical meteorology, atmospheric and ocean modelling, synoptic analysis, general circulation models, geophysical fluid dynamics, diagnostic and statistical studies and climate dynamics.

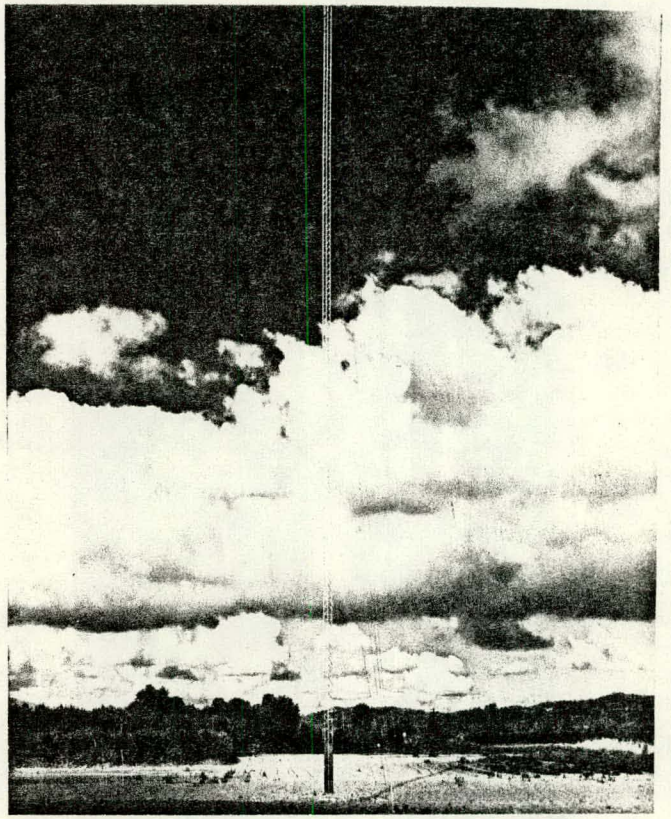
The recently commissioned SEMRTS field facility, the atmospheric radiation and optics laboratory, and the boundary layer laboratory make up the Department's resources for laboratory studies. Standard computing, weather teletype and facsimile and shop facilities are available. The department will soon have direct access to the CRAY-1 computer at the National Centre for Atmospheric research, Boulder, Colorado. The resources of the Climatic Research Institute, the Air Resources Centre, and the Schools of Agriculture, Engineering, Forestry and Oceanography are accessible on a cooperative basis.

2.2 The SEMRTS Field Facility

The SEMRTS field facility (44°35'N, 123°13'W, elevation 71.3 m) is located on a research farm of the Department of Botany and Plant Pathology, approximately 2 km east of campus. The university authorities have allowed the use of about 0.5 hectare of land to locate the field laboratory and the 48.8 m meteorological tower (Fig. 1). The two-story laboratory, measuring 3.96 m (W) x 4.88 m (L) x 6.50 m (H) provides adequate floor space for routine maintenance and service facilities on the first floor and for setting up the automated data acquisition system on the second. The radiation sensors are mounted on a rooftop platform (Fig. 2). The site provides optimum

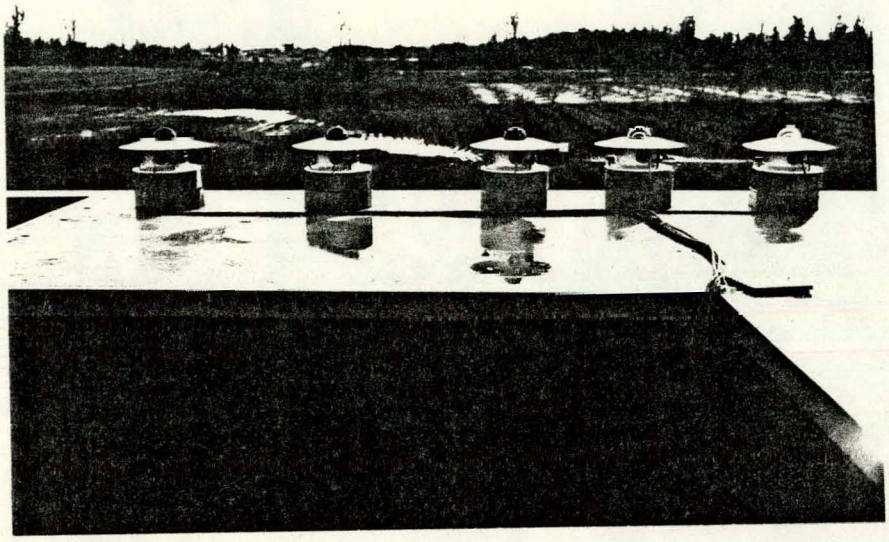


Field laboratory

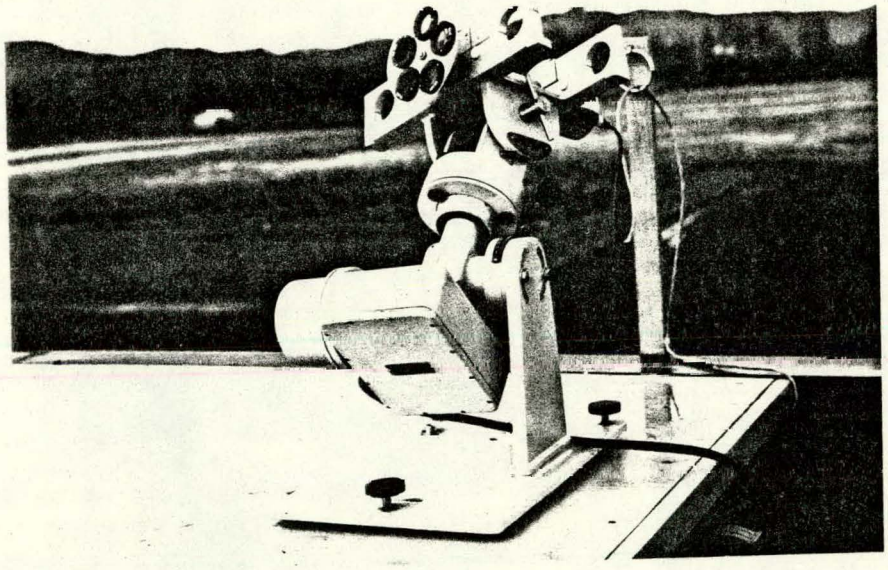


Meteorological tower

Figure 1. The SEMRTS field facility



Eppley precision spectral pyranometers

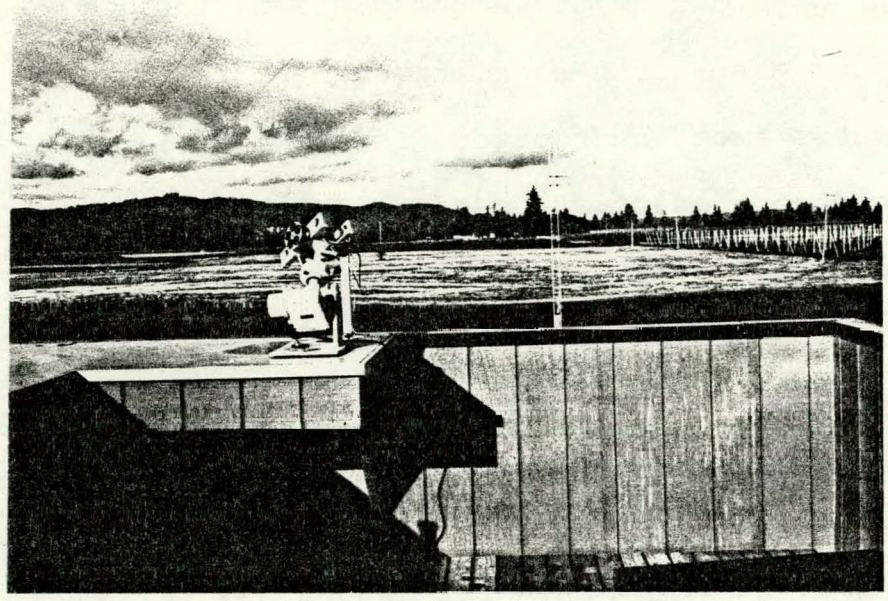


Eppley normal incidence pyrheliometer

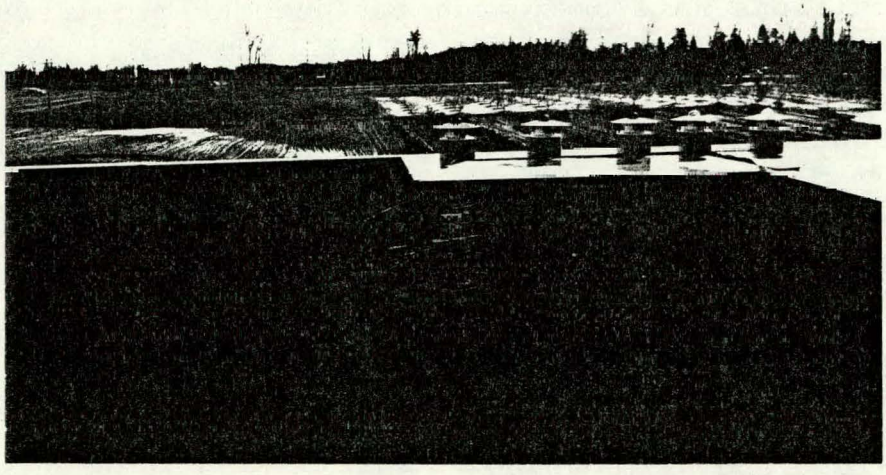
Figure 2. Provisional installations on the rooftop of the field laboratory

exposure to the radiation sensors with practically no obstructions extending beyond 3° above the plane of the sensor elements, especially from east-north-east, through south, to west-north-west. The views from the rooftop are shown in Figs. 3 and 4. The entire cost of construction of this laboratory, in the amount of $14,900, was underwritten by the University.

Figure 5 is a block diagram of the automated data acquisition system that will be installed on the second floor of the laboratory. The system is designed to accept up to 40 channels of sequentially sampled analog solar radiation and meteorological data and to process and record in appropriate SI units their average or integrated values, as desired and as often as necessary, on magnetic tape. Real time records of labeling information on the type and status of various sensors and of 'station-log' type data will also be made. Adequate provisions have been made for automatic calibration sequences, write-verify procedures and automatic restart after power interruptions. It is likely a dedicated telephone line will be installed between the field laboratory and the main campus so that relevant solar radiation and meteorological information can be displayed on a TV monitor in the department. Wind velocity, temperature and dewpoint will be measured at two levels--10 m and 48 m--on the tower. Total global radiation fluxes will also be measured at these levels; in addition, albedo measurements will be made at the 48 m level. Table 1 lists the various measurements to be made at this field facility.

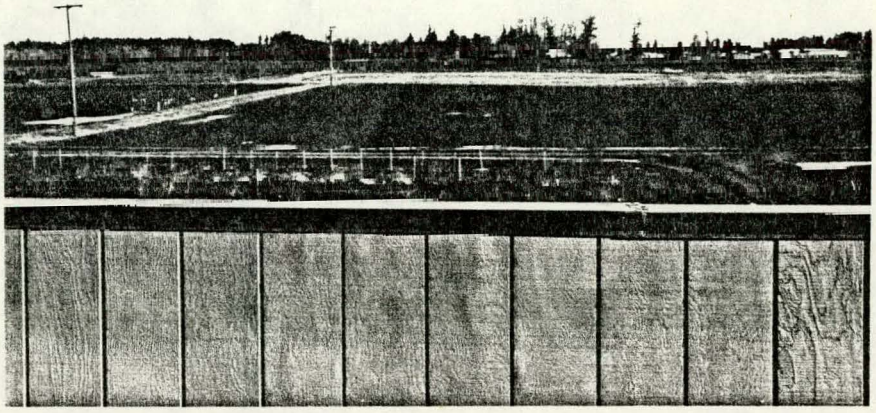


Northern

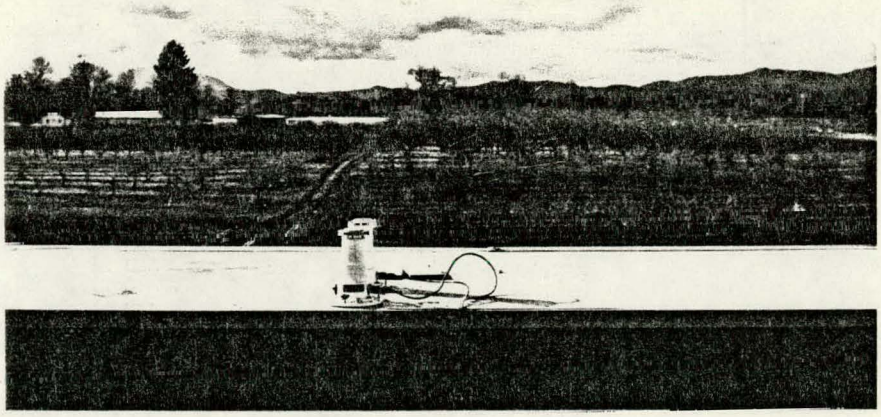


Southern

Figure 3. Views from the rooftop of the field laboratory



Eastern



Western

Figure 4. Views from the rooftop of the field laboratory

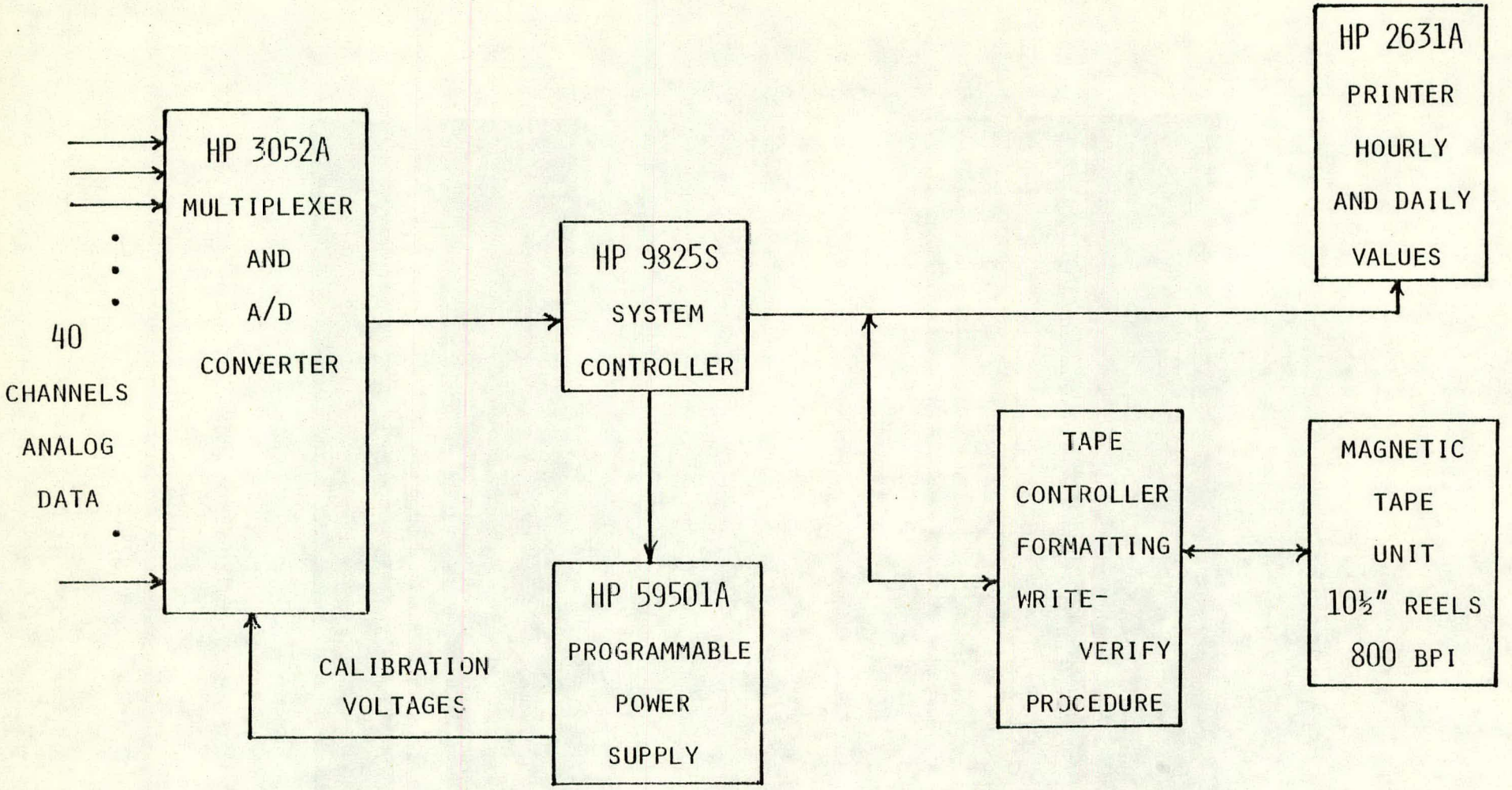


Figure 5. Block diagram of the automated data acquisition system (HP: Hewlett-Packard Product)

Table 1. Measurements to be made at the SEMRTS field facility

	Parameter	Instrument or Method	Location of Instrument
1.	Direct Irradiance	Eppley Normal Incidence Pyrheliometer; WG 295, OG 530, RG 630, RG 695 filters	Field Laboratory rooftop; 6.5 m
2.	Global Irradiance	Eppley Precision Spectral Pyranometers; WG 295, OG 530, RG 630, RG 695 domes	"
3.	Diffuse Irradiance	Eppley Precision Spectral Pyranometers with shadow-band and/or as differences between (2) and (1)(on a horizontal surface)	"
4.	Irradiance at surface, tilted at latitude, pointed south	Eppley Precision Pyranometer with WG 295 dome	"
5.	Global U.V. Irradiance	Eppley U.V. Photometer	"
6.	Sunshine Duration	Campbell-Stokes sunshine recorder	"
7.	Downward short and long wave radiations	C.S.I.R.O. Funk type radiometer	"
8.	Wind velocity	Cup and vane wind sensor	10 m and 48 m on tower
9.	Temperature and lapse rate	Matched thermistors	"
10.	Dewpoint	Lithium chloride element (to be supplemented with condensation-type hygrometers at a later date)	"

Table 1 (continued)

	Parameter	Instrument or Method	Location of Instrument
11.	Upward shortwave radiation	Inverted Eppley PSP or equivalent	48 m on tower
12.	Precipitation	Tipping bucket rain gauge	Field site
13.	Pressure	Anercid sensor	Field laboratory
14.	Atmospheric turbidity	Multispectral radiometers (Volz photometer and other instruments)	"

Note 1. There is space on the rooftop platform to mount additional radiation sensors and compare their performance with that of the calibrated Eppley PSP's as and when desired.

Note 2. Surface albedo and skylight polarization measurements will be made at the field site intermittently.

Note 3. Cloud cover will be estimated according to usual NWS practices and/or by analysis of all-sky photographs.

Note 4. Ozone (surface and columnar) measurements will be made from the third year onwards subject to the availability of funds.

Note 5. A more detailed description of the field facility will be found in the forthcoming publication 'The SEMRTS Field Facility Handbook.'

2.3 The Atmospheric Optics and Radiation Laboratory

The laboratory is presently housed in temporary quarters and the University is in the process of building a permanent structure at an estimated cost of $19,000. It is in the main equipped with electro-optical instrumentation developed under the direction of Prof. Rao while he was at the Department of Atmospheric Sciences, University of California, Los Angeles. The equipment includes a programmable reflectometer (Fig. 6) which can be adapted for the study of cosine and azimuth responses of pyranometers, a portable reflectometer for field use, electronic-servo governed, multicolour polarimeters, bread-board versions of multi-spectral radiometers, and auxiliary electronic and electro-optical test and calibration equipment. Part of the equipment is being used in the solar energy related laboratory course (AtS 420 Solar Radiation and Meteorological Measurements). The rest of the equipment will find greater use when research in the areas of atmospheric turbidity, skylight polarimetry and reflectivity and emissivity of natural formations is started.

3. The Training Program

The training program is made up of new academic year courses, summer workshops and seminars.

3.1 New Courses

Two new courses, one at the senior level but open to graduate students for both major and minor credit, and the other at the advanced graduate level, were developed and

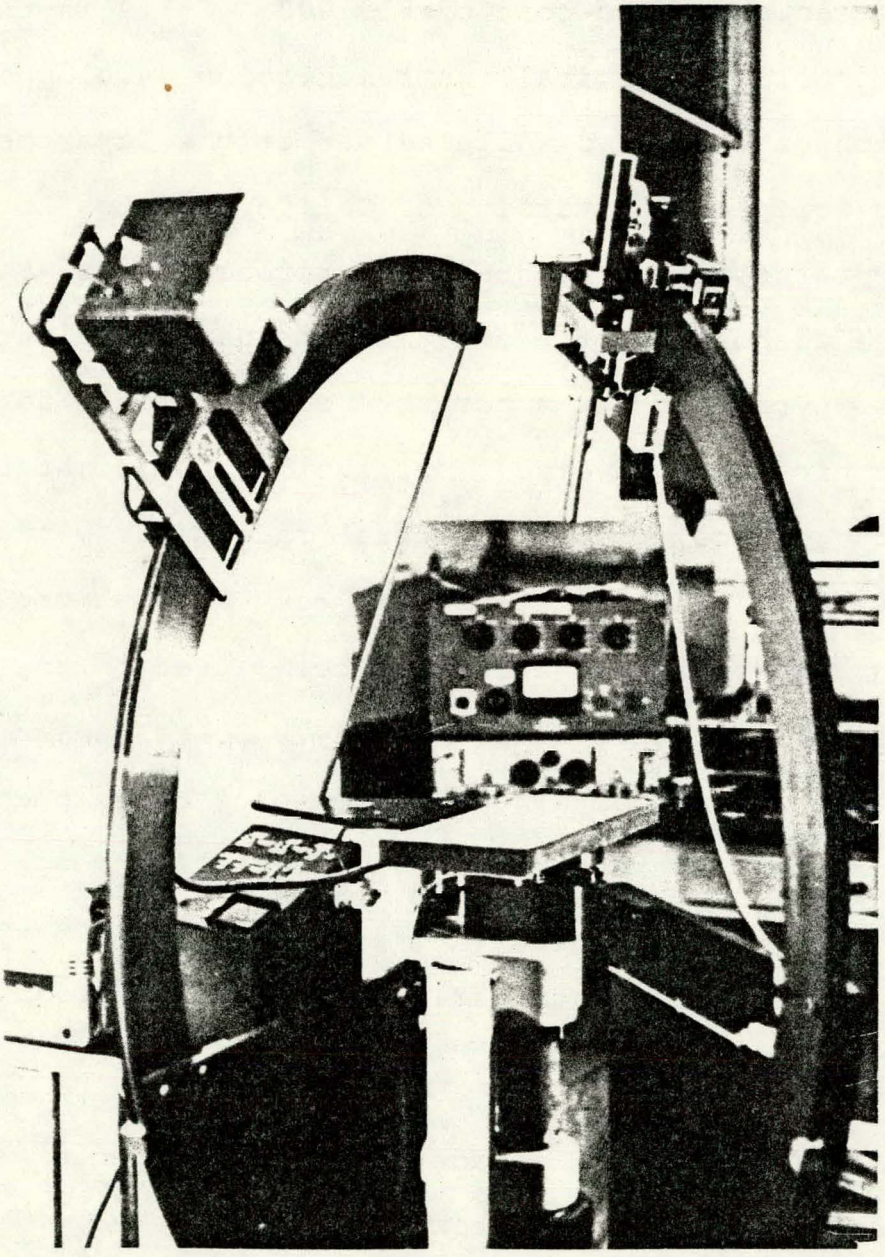


Figure 6. The programmable reflectometer

formally approved by the University authorities. They are being currently offered this 1978-1979 academic year. The syllabi of the two courses are given below:

> Atmospheric Sciences 420, 421 Solar Radiation and Meteorological measurements (G). Four hours, fall and winter (Rao, -)
>
> Spectral distribution of solar radiation; radiation and meteorological measurements and instruments; instrument siting, mounting and protection; instrument response characteristics, calibration and standardization; recorders and data logging systems; data processing techniques; precision radiometry; dispersive devices (filters, interferometers and spectrometers); atmospheric turbidity measurements; photopolarimetry and skylight; reflection properties of natural surfaces; laboratory experience with solar radiation and meteorological instruments at the OSU Solar Radiation Measurement Facility. Prerequisite: Physics 203 or 213 or consent of instructor.

Funds, in the amount of $3,000 have been spent by the department to purchase additional equipment for use in the laboratory for the course.

> Atmospheric Sciences 560, 561 Atmospheric Radiative Processes. Three hours winter and spring (Rao)
>
> Absorption, scattering and emission by atmospheric gases and particulates; thermodynamics of blackbody radiation; approximations and solutions in radiative transfer theory; computation of fluxes and heating rates; radiative and optical properties of clouds; radiation and climate; radiative transfer in planetary atmospheres. Prerequisite: AtS 413 or consent of instructor.

The objectives of the undergraduate courses (AtS 420, 421) are to educate the student in the physical principles of solar radiation and solar-related meteorological phenomena, to inform him/her of how the incoming solar radiation interacts with the atmosphere and surface and then to train him/her in the

measurement and interpretation of solar radiation and allied meteorological variables. The graduate level course is designed for those who are inclined towards solar energy research and application as a profession. It will equip them with the facts and knowledge of solar energy transfer in realistic atmospheres.

3.2 Summer Workshop

A summer workshop on 'Solar Energy Measurement and Instrumentation' was conducted at Oregon State University, Corvallis, Aug. 7-11, 1978. Prof. McDaniels and his group at the University of Oregon, Eugene, participated very effectively in the organization and conduct of the workshop from the very beginning as part of their activities under the subcontract. Because of practical considerations, the workshop took the form of tutorial and general lectures and a day-long tour of solar application sites in the southern Willamette Valley. Both OSU President MacVicar and Dean Krauss of the College of Science, dwelt upon the significance of the SEMRTS program in the general context of research at Oregon State University in their welcoming speeches.

Of necessity, the number of participants had to be restricted to forty, excluding the faculty numbering eight, and those who were present for a limited number of sessions. The distribution of participants by academic background was as follows: physicists - 13, chemists - 2, atmospheric scientists - 3, engineers - 10, architects - 2, biologists - 2, others - 8. The distribution by domicile was as follows: Idaho - 2,

Michigan - 1, Montana - 1, Oregon - 24, Washington - 8, Wyoming - 1, Florida - 1, Pennsylvania - 1, Texas - 1. The faculty for the workshop was drawn equally from Oregon State University, Corvallis, and the University of Oregon, Eugene.

The following topics were discussed:

Solar History
Physical Principles of Solar Radiation
Climatic Change: Past, Present and Future
Radiation on Tilted Surfaces
Diffuse Solar Radiation
Solar Radiation in the Pacific Northwest
Calibration and Data Processing
Meteorological Instrumentation
Solar Electric
Remote Sensing with Solar Radiation
Wind Energy
Survey of Northwest Buildings and Specific Examples

A certificate of completion (Fig. 7) was given to each of the participants at the end of the session. It is intended to make these workshops part of the continuing education program at Oregon State University in the coming years so that appropriate college credits can be given to those of the participants who may desire the same. It is also proposed to conduct discipline and interest oriented, short intensive courses on solar energy related matters in the future.

3.3 Seminars

It had been proposed that Oregon State University, through the SEMRTS program, and the University of Oregon, through the 'Solar Seminar' series conducted under the direction of Profs. McDaniels and Reynolds, would arrange a series of seminars to cater to both professionals and nonprofessionals. A partial list of those that were arranged during the reporting period is given in Table 2.

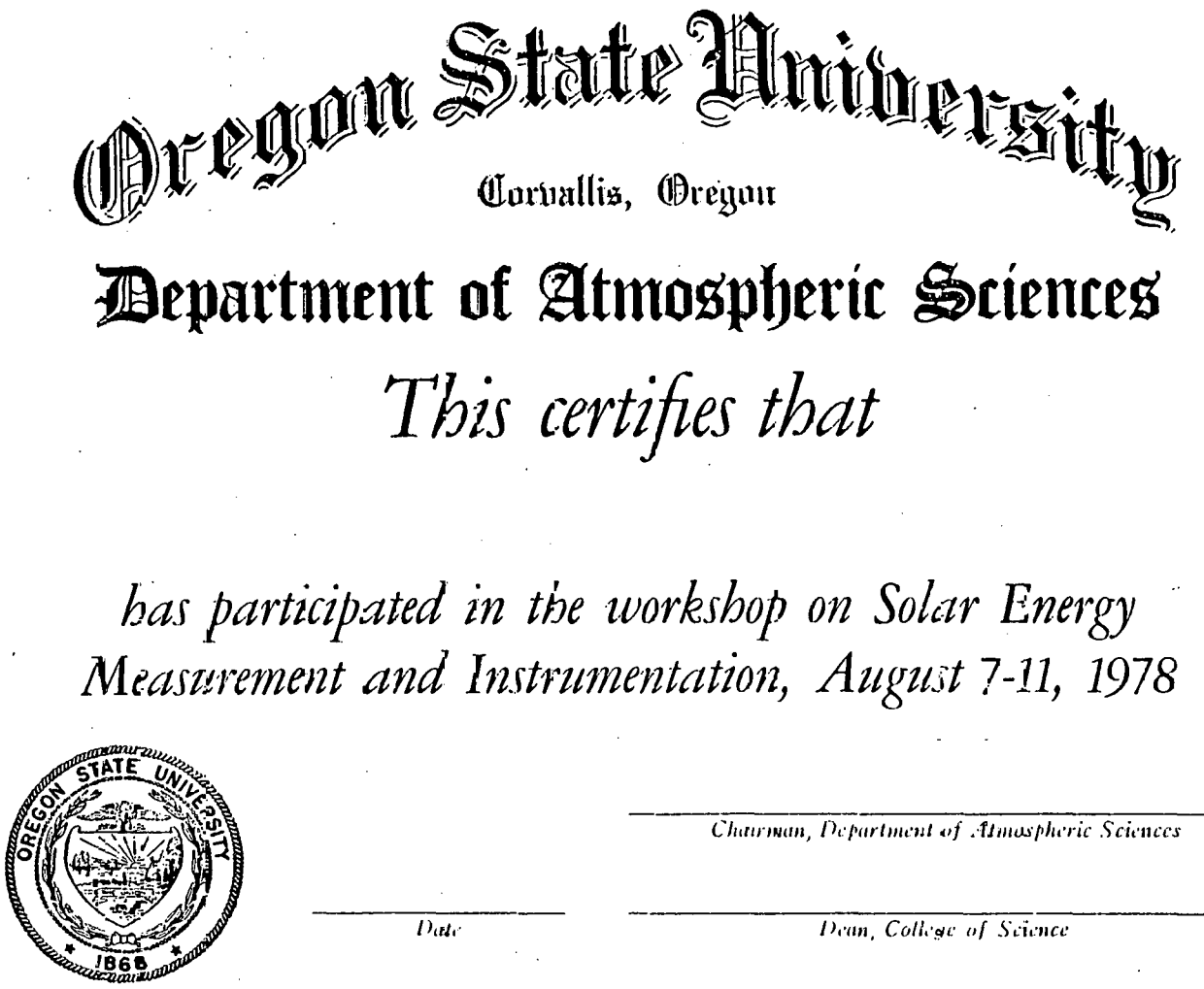


Figure 7. Facsimile of the certificate of completion (Summer workshop)

TABLE 2 - PARTIAL LIST OF SEMINARS

Date	Topic	Speaker(s)	Affiliation
Oct. 26, 1977	OSU's New Solar Energy Program[1]	Messrs. Hewson, Rao and Wolf	Oregon State University Corvallis
Nov. 2, 1977	Sun Rights: Legal Access to Solar Energy[2]	Mr. Gable and Ms. Ormsby	University of Oregon, Eugene
Dec. 8, 1977	Remote Sensing of Atmospheric Turbidity by Photopolarimetry[1]	Mr. Rao	Oregon State University Corvallis
Jan. 4, 1978	Northwest Solar Homes[2]	Mr. Lorenzen	University of Oregon Eugene
Feb. 22, 1978	Air Systems Using Eutectic Salts[2]	Mr. Bleige	Hitek Engineering, Sweet Home, Oregon
Apr. 12, 1978	Tracking the Sun[2]	Mr. Drumheller	Battelle Northwest, Richland, Washington
May 11, 1978	The Assessment of Wind Power Potential in the Pacific Northwest[1]	Messrs. Hewson, Baker and Wade	Oregon State University Corvallis
May 23, 1978	Solar Radiation in the Earth's Atmosphere[1, 3]	Mr. Rao	Oregon State University Corvallis

[1]OSU Department of Atmospheric Sciences Seminar in Corvallis
[2]University of Oregon 'Solar Seminar' in Eugene
[3]Organized jointly under 1 and 2 in Corvallis

4. Regional Effort

The regional effort consists of the establishment of high density, general quality and low density, research quality observational networks, consolidation of ongoing activities in the five states of the region through the formation of a working group of solar radiation scientists, and field measurements with a mobile laboratory at selected sites in the region.

4.1 Statewide Networks

4.1.1 Oregon

The five-station, statewide network (Fig. 8) which had been set up by the University of Oregon group under the direction of Profs. McDaniels and Reynolds at the time the award was made, has served as the nucleus of the regional effort. The network is presently being operated by the University of Oregon under the subcontract. A sixth station, located at Reed College, Portland, will shortly be added to the network.

These stations are located in distinct climatic zones in the state which in turn may be considered fairly typical of what is encountered in the region. Coos Bay, located on the Pacific Coast, experiences mild winters and cool summers because of the moderating influence of the Pacific Ocean. Eugene is located in the Willamette Valley and experiences relatively dry, hot summers and mild, wet winters. Bend, located on the western border of central Oregon's high plateau, has the dry, continental climate of the Great Basin. The winter days are cold and partly sunny; summers are hot, with low relative humidities. LaGrande is located in the northeastern highlands where the

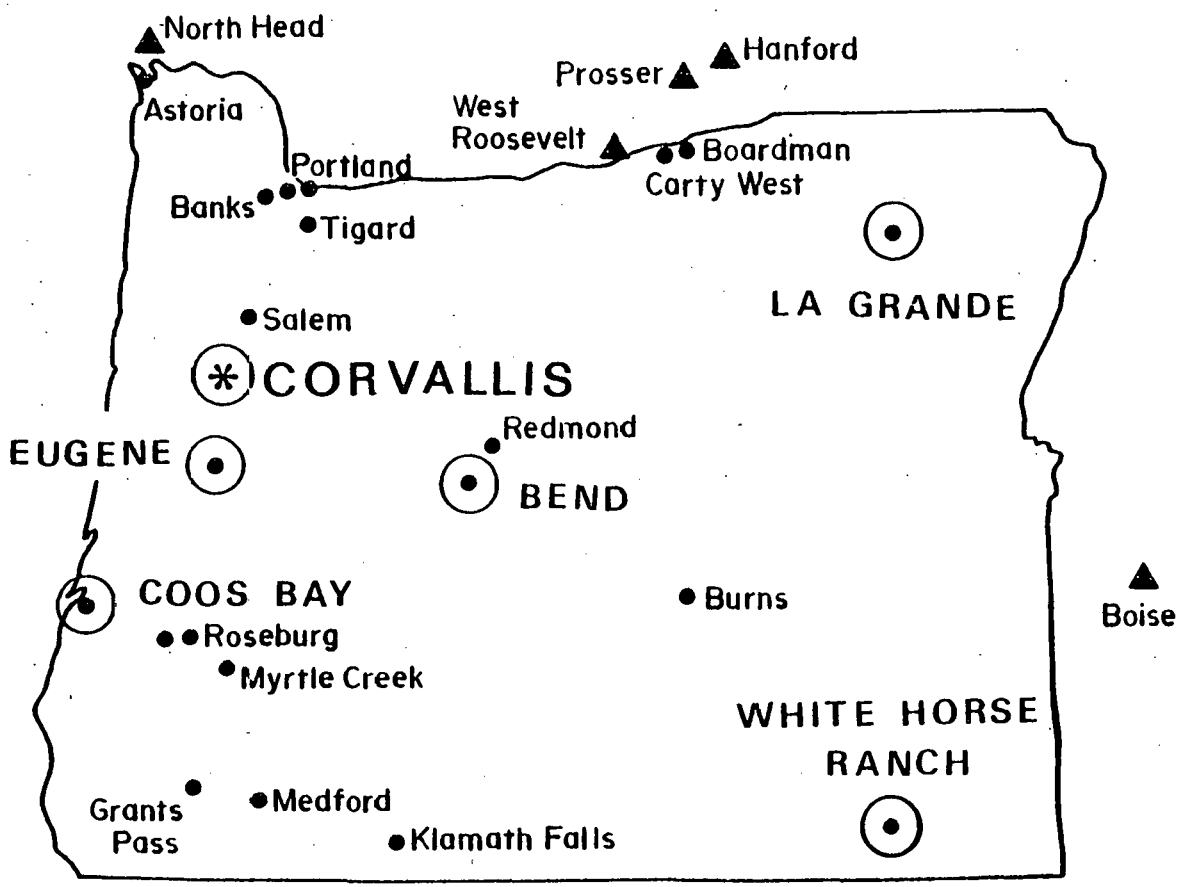


Figure 8. Solar radiation monitoring stations

(Oregon and vicinity)

◉ : U. of O. station; ● : Others in Oregon; ▲ : Others in the vicinity

⊛ : SEMRTS, Corvallis

variegated topography has a pronounced effect on local climate. White Horse Ranch, located in the Alvord Desert in the south-eastern part of the state has a semiarid climate and experiences cold winters and hot summers.

Daily totals of global radiation have been measured at each of these five stations using Class 2 Dirmhirn-Sauberer star pyranometers, manufactured by Philip Schenck Co., in Austria. These are periodically checked against Eppley precision spectral pyranometers, the performance of which, in turn, can be traced to national standards. In addition, both direct and global radiation fluxes are measured in Eugene with Eppley Class 1 instruments. Relevant meteorological information is obtained from either NWS offices or cooperative weather stations. Data for CY 1978 are presently being analysed. Funds are being sought from local and state agencies to upgrade the instrumentation and augment meteorological measurements at these sites.

4.1.2 Idaho, Montana, Washington and Wyoming

A preliminary survey of ongoing solar radiation monitoring activities has established that highly mission-oriented programs of differing durations are presently underway or have been completed in these four states of the region under the sponsorship of local, state, federal and private agencies. Instruments ranging from Class 1 to Class 3 (WMO classification) have been used mainly for the measurement of global radiation. Supporting meteorological data have been rather sparse.

4.2 Regional Working Group

As a first step towards consolidation of the solar energy monitoring activities in the various states of the region, a preliminary meeting of solar radiation scientists, attended by at least one knowledgeable investigator from each state, was convened by Profs. Hewson, Rao and McDaniels at Corvallis on 4 August 1978. Besides the senior scientists of the SEMRTS program, the one-day meeting was attended by Prof. Leo J. Fritschen, University of Washington, Seattle, Washington; Prof. James N. Peterson, University of Idaho, Moscow, Idaho; Dr. Charles Fowlkes, Fowlkes Engineering, Bozeman, Montana; and, Ms. Florence Barker, University of Wyoming, Laramie, Wyoming.

The following topics were discussed at the meeting:

i) Current and proposed solar radiation monitoring activities in the states of Region 5;

ii) Coordination of monitoring activities in the region through the formation of a viable working group;

iii) Climatology of the five states and the feasibility of acquiring solar energy related meteorological data at various locations;

iv) Possible locations for monitoring stations to make up a low density, research quality network;

v) Utilization of the OSU-SEMRTS mobile laboratory to make standardization measurements; and

vi) Sources of support.

The general feeling at the end of the meeting was that a research quality regional network, made up of one or two stations in each state, excluding those operated by NOAA at Boise (Idaho), Great Falls (Montana), Medford (Oregon),

Seattle-Tacoma (Washington) and Lander (Wyoming), can indeed be set up if sufficient funds are available. It was also felt these stations should be located on university campuses where competent, inexpensive technical assistance will be available. Some of the sites under consideration are shown in Figure 9. The main considerations governing the choice of the site will be the availability and willingness of an experienced investigator, availability of at least some Class 1 radiation instrumentation and ease of access to relevant meteorological data.

The next meeting will be held at the University of Washington, Seattle, in the summer of 1979. Prof. Leo J. Fritschen has agreed to act as host. It is intended to work out the details of the regional network at this meeting. State energy officials, utility representatives and others who may contribute to the formation of the regional network will be invited to attend this meeting.

4.3 Field Measurements with the Mobile Laboratory

It is hoped the mobile laboratory, housed in a conventional trailer, will be commissioned in the latter half of the second year. It will be equipped to perform routine radiation and meteorological measurements. Multispectral polarimetric and radiometric measurements will also be made at the same time.

When the regional network is finalized, the mobile laboratory will be used to make comparison measurements at selected sites in each of five states. Concepts underlying the design of optimum networks will be examined in the light of these

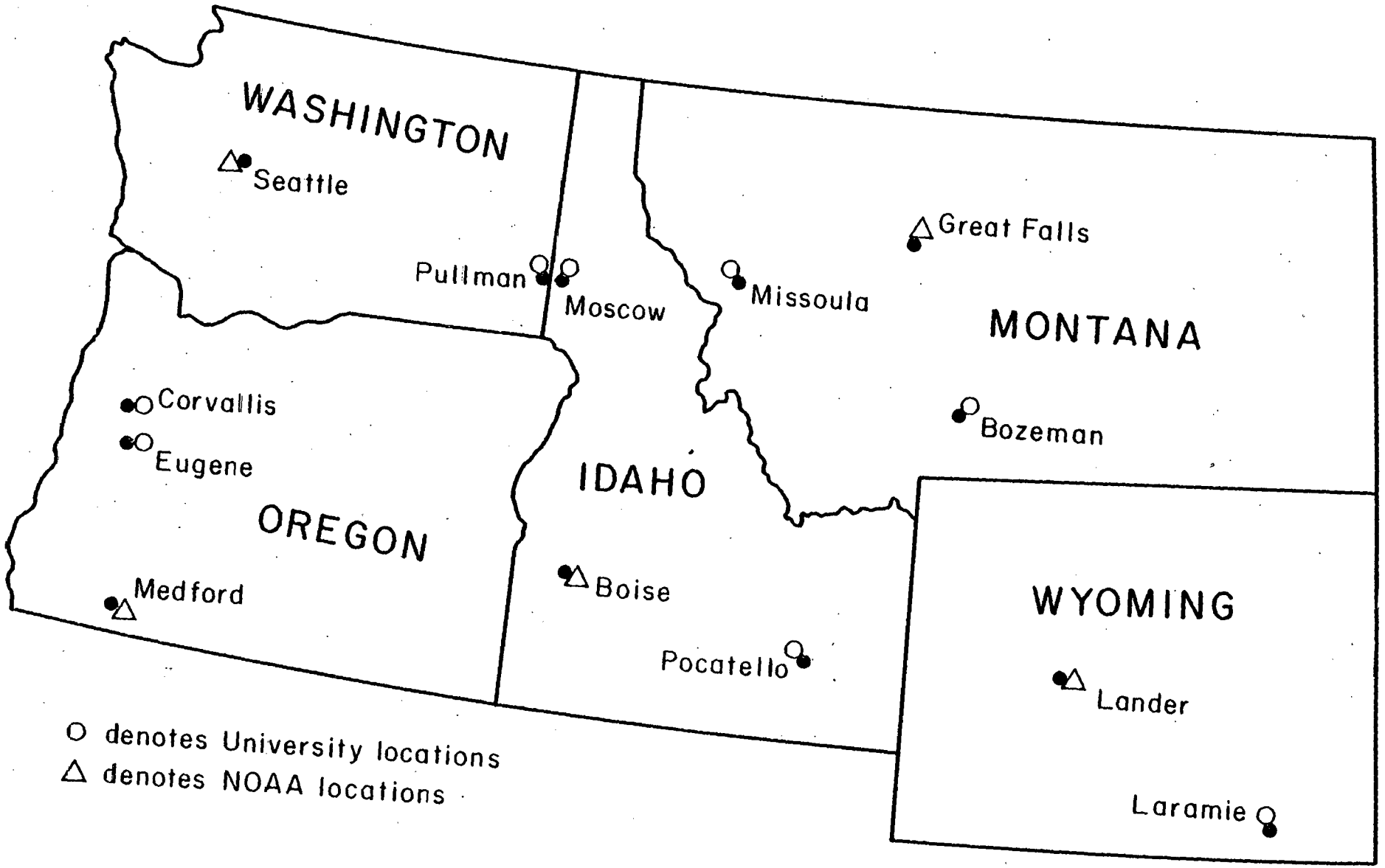


Figure 9. Possible locations for research quality stations

measurements. In addition, short term, mission-oriented tasks within the state of Oregon will also be undertaken.

5. Planned Research Program

The major part of the first year was utilized essentially in setting up the primary research centre, in developing the solar energy related courses, in conducting the summer workshop on Solar Energy Measurement and Instrumentation, and in doing the groundwork needed to carry out this challenging program of research and training in an optimum manner for the remainder of the five-year period. With this timescale in mind, some of the research activities we propose to undertake are briefly mentioned below:

- Radiation climatology of Region 5

  Radiative transfer in cloudy, turbid atmospheres
  Optical and radiative properties of clouds and fogs
  Multispectral radiometric and polarimetric investigations of atmospheric turbidity
  Optical and radiative properties of surfaces
  Insolation modeling from meteorological variables

- Topoclimatological influences on the radiation regime

  Information content of network data in mountainous terrain
  Interpolation techniques for such data

- Photometry of the daytime sky

In simple terms, the research program will be directed towards enhancing the utility of the solar radiation and solar related meteorological data that will be acquired through radiation climatological model development, model verification studies and appropriate parameterization that these studies may suggest.

It is recognized this is an ambitious program; however, we hope to accomplish a significant portion of this program by optimum use of the limited resources available to us.

6. General Activities

The community at large has been kept informed of the activities under the grant through meetings and media releases at appropriate intervals. The senior program scientists have appeared on several radio and television interviews from time to time and explained the significance of the SEMRTS program to a wider audience drawn from the five states of Region 5. Also, as a service to the public, inquiries in the area of solar energy applications addressed to the University are attended to by the program scientists.

Acknowledgments

Mr. Kenneth True, Project Technician, has helped in assembling some of the material used in this report. Mrs. Patricia Eckhout is responsible for the neat execution of the manuscript.

Appendix A: Project Personnel

Prof. E. Wendell Hewson	Principal Investigator
Prof. C. R. Nagaraja Rao	Project Coordinator
Prof. Marvin A. Wolf (Air Resources Centre)	
Mr. Peter Deneen	Engineering Aide
Miss Betsy Smith	Laboratory Assistant
Mr. Kenneth True	Project Technician
Mrs. Diane Waters	Secretary
Subcontract With University of Oregon, Eugene	
Prof. D. K. McDaniels	Principal Investigator
Prof. J. Reynolds	
Mr. S. Baker	
Dr. H. D. Kaehn	

Appendix B: Visitors

Name	Affiliation
Ms. Florence Barker	University of Wyoming, Laramine, WY.
Dr. Fowlkes	Fowlkes Engineering, Bozeman, MT.
Prof. Leo J. Fritschen	University of Washington, Seattle, WA.
Prof. Mylo A. Hellickson	South Dakota State University, Brookings, SD.
Mr. Alan Kiphut	Department of Energy, Salem, OR.
Dr. V. P. Meleshko	Main Geophysical Observatory, Leningrad, U.S.S.R.
Prof. James N. Peterson	University of Idaho, Moscow, ID.
Dr. David Philbrick	Department of Energy, Salem, OR.
Prof. Donald J. Portman	University of Michigan, Ann Arbor, MI.
Prof. Colin S. Ramage	University of Hawaii, Manoa, Honolulu, HI.
Dr. Ralph M. Rotty	Institute for Energy Analysis, Oakridge, TN.
Dr. John Rudzki	Trinity University, San Antonio, TX.
Prof. S. V. Venkateswaran	University of California, Los Angeles, CA.