### 3.2.2. SOLAR RADIATION CALIBRATION FACILITY

***Solar Radiation Monitoring Support***

***CMDL baseline observatories.*** Support for monitoring surface radiation budget components at the four CMDL baseline observatories (BRW, MLO, SMO and SPO) was maintained during 1998 and 1999. Routine instrument exchanges and recalibrations were completed as required, and modifications and enhancements were incorporated as necessary.

***CMDL BSRN monitoring sites.*** At the three CMDL BSRN sites located at Bermuda, BAO, and Kwajalein, measurements continued and operational additions and improvements were completed. The Bermuda site was relocated during 1998, and a new instrument platform was designed, purchased, and deployed. Additional measurements were also added to the relocated Bermuda BSRN site with the installation of meteorological sensors. Wind speed, direction, pressure, temperature, and relative humidity are now being monitored at all three sites. The Bermuda meteorology sensors were installed in late 1998, and Kwajalein meteorology sensors were installed in late 1999.

***Collaborative activities.*** Post mission performance checks of sensors used during the Study of the Heat Budget in the Arctic (SHEBA) project were completed and provided to the institutions involved (NOAA Air Resources Laboratory, National Center for Atmospheric Research (NCAR), United States Navy/Post Graduate School, and University of Washington). Other checks were performed on sensors used by the NOAA Environmental Technology Laboratory, Indian Ocean Experiment (INDOEX), NOAA aircraft facility, University of Utah, and NCAR.

***SRF Reference Radiometers***

All CMDL solar radiation measurements are referenced to the World Radiometric Reference (WRR) as defined using the absolute scale. Comparison of the Boulder, Colorado, Solar Radiation Facility (SRF) reference radiometers to peer radiometers is the accepted method of ensuring long-term stability of their performance. The SRF has been comparing its reference radiometers annually with radiometers at the National Renewable Energy Laboratory (NREL) located in Golden, Colorado. At these comparisons, NPCs (NREL pyrheliometer comparisons), a WRR is constructed by forming an average irradiance with a group of radiometers that participated in the latest International Pyrheliometer Comparisons (IPC) in Davos. Typically this group consists of at least five radiometers.

Additionally, the SRF reference radiometers are compared every 5 years with the World Standard Group of radiometers maintained at the World Radiation Center in Davos. These comparisons are referred to as IPC. Regular checks of reference radiometer performance are also performed using groups of SRF sensors and checking their performance against each other.

Table 3.9 illustrates the results of comparisons of SRF references and their variability with respect to the WRR over time periods on the order of years.

TABLE 3.9. Comparisons of SRF References

| Pyrheliometer Comparison | AHF 28553 WRR Factor | TMI 67502 WRR Factor |
|---|---|---|
| IPC VIII (1995) | 0.99756 | 0.99869 |
| NPC 1998 | 0.99783 | |
| NPC 1999 | 0.99741 | |

***SRF Windowed Reference Radiometer Development***

The reference radiometers used by the SRF have cavity-type receivers that are open to the environment, which makes them unsuitable for continuous deployment at a monitoring site in an unmanned mode since dust, dirt, rain, insects, and other debris can enter the cavity receiver. Typically, reference cavity radiometer measurements are limited to fair weather, clear days, and manned operation. Testing of unmanned, all-weather cavity radiometers equipped with windows was begun by the SRF during 1998. Initial results using a cavity equipped with a quartz window material were compromised by the spectral limitations of the quartz window. The longwave cutoff of the quartz window material blocked solar radiation in the region above 4 microns. During atmospheric conditions when water vapor concentration is low, there is solar energy present beyond 4 microns. These conditions can occur in Colorado. Calcium fluoride window material with a longwave cutoff beyond 4 microns was selected as a possible replacement for the quartz. Comparisons between windowed and unwindowed cavity radiometers were conducted during 1999 using quartz and calcium fluoride windows as presented in Figure 3.14.

The data in Figure 3.14 illustrate the differences that are potentially present between windowed and unwindowed cavity radiometers under various atmospheric conditions. One cannot assign a unique window transmission factor, because each day generates a different factor depending upon the transmission of the atmosphere with the apparent dominant factor being the water vapor concentration. This presence of the water vapor effect is also suggested by results obtained using conventional pyrheliometers. Special calcium fluoride windows were fabricated to replace the usual quartz windows on SRF pyrheliometers. The pyrheliometers were calibrated with an unwindowed reference cavity and then operated side by side at the SRF, and the data show an apparent water vapor effect when pyrheliometers with calcium fluoride windows were compared with pyrheliometers with quartz windows. Some results of these comparisons are presented in Figure 3.15.

Cavity radiometers and conventional pyrheliometers equipped with calcium fluoride windows were deployed at the SRF roof facility in early 1999, and the long-term feasibility of using calcium fluoride windows is being investigated. Deployment of the first all-weather cavity radiometer will be to the BAO BSRN

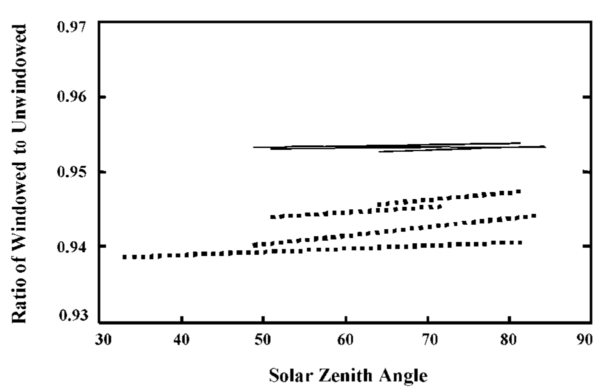


Fig. 3.14. Examples of clear-sky window transmissions for windowed cavity radiometers used for measurements at the CMDL facility in Boulder, Colorado. The calcium fluoride (solid line) window results in less day-to-day variability compared with the Suprasil 300 (dotted line) that is a type of quartz.

site in late 2000. Results of the SRF all-weather windowed cavity work were presented at the 1998 BSRN meeting, the CMDL annual meeting in 1999, and the American Meteorological Society Tenth Conference on Radiation in June 1999.

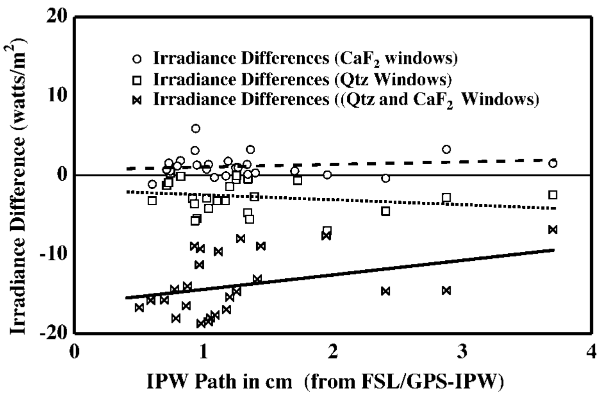


Fig. 3.15. Examples of measured irradiance differences between two pyrheliometers equipped with quartz windows, two pyrheliometers equipped with $CAF_2$ winds, or two pyrheliometers equipped with the quartz and $CAF_2$ windows. Measurements were made on clear sky days at the DSRC in Boulder.

***SRF Relocation***

During March 1999 the SRF was relocated to the new David Skaggs Research Center (DSRC) on the National Institute of Standard Technology (NIST) campus at 325 South Broadway in Boulder from its prior site at 3100 Marine Street site where it operated for 24 years. Measurements were begun at the new location during April 1999, and the facility was fully operational by mid-summer 1999.

***SRF International Activities***

***Global Atmosphere Watch (GAW).*** Visitors from GAW baseline stations at Ushuaia, Tierra del Fuego, Argentina; West Sumatra, Indonesia; Tamanrasset, Indonesia; and the Chinese station at Waliguan sent personnel to Boulder for training and site upgrade activity in 1998 and 1999. Contacts were also maintained with the Brazil GAW station at Arembepe. Collaboration with NREL personnel regarding data archiving procedures was begun, with NREL also hosting personnel from GAW stations and conducting site visits to Arembepe and Ushuaia for the purpose of installing data processing software and training site personnel in data editing, analysis, and archiving procedures.

***Baseline Surface Radiation Network (BSRN) activities.*** The SRF coordinated the process of upgrading the Algerian GAW site to BSRN status. This involved purchase of a dual tracking disk shading system, pyrgeometer, pyranometer, new data logger, and desktop computer as well as training of the Algerian site personnel in the installation and use of the new items.