TERRA Validation:
Saudi Arabian Solar Radiation FluxGround Measurements

Network Instrumentation

The following table lists network instrumentation common to all sites.

TABLE 1. INSTRUMENTATION COMMON TO ALL NETWORK SITES.						
PARAMETER	**UNITS**	**SENSOR**	**MANF.**	**MODEL**	**UNCERTAINTY**	**COMMENTS**
Ambient Temperature	Deg C	1000 Ohm Plat. Resistance Thermometer	Vaisala	50 Y	+/- 0.5 Deg C	Combined Temp. and RH sensor
Relative Humidity	% RH	Capacitive	Vaisala	50Y	+/- 2.5%	0%-100% range
Global horizontal solar Irradiance	W/m^2	Type -T Thermopile	Eppley Laboratory	PSP	+/- 3.0% @ 1 kW/m^2	Using single calibration factor
Direct Beam Solar Irradiance	W/m^2	Type -T Thermopile	Eppley Laboratory	NIP	+/- 2.0% @ 1 kW/m^2	5.7° field of view
Diffuse Horizontal Solar Irradiance	W/m^2	Type -T Thermopile	Eppley Laboratory	PSP	+/- 3.0% @ 1 kW/m^2	Under tracking shading disk subtending 5.7°
Solar Tracker: Direct Beam	n/a	Synchronous motor drive	Eppley Laboratory	ST-1	+/- 3.0° per day	manual alignment daily
Solar Tracker: Shade Disk	n/a	Synchronous motor drive	Eppley Laboratory	RSD-2	+/- 3.0° per day	manual alignment daily

Data Logger	volts	Analog to digital sample and hold	Campbell Scientific, Inc.	CR-10	0.2% Full Scale	Full scale: 25 mV Resolution 3.33 mV Time +/- 4 ms noise<0.8 uV RMS

All but Solar Village instrumentation is mounted on 0.5 m tall instrumentation platform at station ground level. At sandy soil sites, platform mounted on concrete pads. Solar Village Installation on 0.5 m tall instrumentation platform at 10 m above ground on building rooftop. Site layout to be incorporated into metadata.

Sample rate: 10 seconds (0.1 Hz)
Data rate: 5 minute (0.0033 Hz)
Clock accuracy +/- 2.0 Sec/ Day (set nightly with respect to national time standards)

Additional Instrumentation

The Solar Village station is instrumented with addition sensors designed to operate in conformance with WMO/WCRP BSRN specifications. BSRN instrumentation deployed at the Solar Village is described in table 2.

TABLE 2. SOLAR VILLAGE BSRN RADIOMETRIC INSTRUMENTATION

PARAMETER	UNITS	SENSOR	MANF.	MODEL	UNCERTAINTY	COMMENTS
Direct Beam Absolute Cavity Pyrheliometer	W/m^2	Wire wound Type T Cu-Ct Thermopile solid silver inverted cone cavity	Eppley Laboratory	AHF Auto-matic Hickey-Frieden	+/- 0.45%	@ 1kW/m^2 Corning 7940 fused silica window correction factor additional 0.8% uncertainty. Tracking by BRUSAG tracker
Downwelling longwave (sky	W/m^2	Pyrgeometer Type T	Eppley Laboratory	PIR	+/- 10 W/m^2	Silicon dome with thin film interference

irradiance) under Shading Disk		Thermopil es				filter passing longwave (wavelength >8 micron) infrared Shade disk mounted on BRUSAG tracker
Upwelling Longwave (ground emission)	W/m^2	Pyrgeomet er Type T Thermopil es	Eppley Laboratory	PIR	+/- 10 W/m^2	As above, mounted at 100 ft (33 m) level at 3 ft (1 m) from 1 ft (0.3 m) diameter tower; body shaded from direct sun, downward looking
Upwelling shortwave radiation	W/m^2	Type T Thermopil es	Eppley Laboratory	PSP	+/- 3.0% @ 1 kW/m^2	100 ft (33 m) level at 3 ft (1 m) from 1 ft (0.3 m) diameter tower; body shaded from direct sun, downward looking
Solar Tracker: Cavity radiometer Direct Beam and downwelling longwave shade disk	n/a	Stepping motor drive	BRUSAG	INTRA	+/- 0.2° per day	autonomous, self correcting based on quad Silicon solar sensor input on clear days

Aerosol Optical Depth	n/a	filtered silicon cell sunphoto-meter(*)	CIMEL Electronique	CE-318	+/- 0.01 OD	Wavelengths at 340, 380,440,500,670,870, 1020 nm. Autonomous collection at 0.5 air mass intervals. Real time collection via METEOSAT at NASA Langley
Total Column Water Vapor	cm	as above	as above	as above	+/- 10%	Range 0.1-5 cm (1 mm to 50 mm)
Cloud Properties (height, layers)	km	Nd:YF diode laser source & EGG SPCM-AQ-121 avalanche diode detector	Science and Engineering Services, Inc.	MPL(**)	+/- 0.3 km	523 nm Wavelength, 18 bins up to 60 km 300 m resolution. Layer and boundary information from backscatter analysis

(*) Deployed by 24 Feb 1999 (**) deployment to be determined with respect to availability of instrumentation and logistics with Saudi participants.

BSRN radiometric fluxes recorded at 2 second (0.5 Hz) sample interval with 1 minute (0.0167 Hz) averages reported.

The Solar Village site serves as the Central Calibration Facility and Network Operations Center for the Saudi Arabian Solar Network. Calibration instrumentation deployed at the site is listed in the following table:

TABLE 3. SOLAR VILLAGE RADIOMETRIC CALIBRATION INSTRUMENTATION						
PARAMETER	**UNITS**	**SENSOR**	**MANF.**	**MODEL**	**UNCERTAINTY**	**COMMENTS**
WRR Direct Beam Calibration Reference	W/m^2	Wire wound Type T Cu-Ct Thermopile on solid silver inverted cone cavity	Eppley Laboratory	AHF (Auto-matic Hickey-Frieden)	+/- 0.45%	@ $1kW/m^2$ Corning 7940 fused silica window correction factor additional 0.8% uncertainty. Participated in WMO WRR IPC VIII 1995
TWO Shading Disk Diffuse Pyranometers	W/m^2	Type T Thermopiles	Eppley Laboratory	PSP	+/- 3.0% @ 1 kW/m^2	Average of two tracking shading diffuse readings used for diffuse reference
Atmospheric Stability Monitors	W/m^2	Silicon cell pyranometer	Li-Cor, Inc.	SB-200	n/a	Monitor global sky stability, flag all data where variation over last 3 data pts exceeds 1%
Solar Tracker: Cavity radiometer Direct Beam and downwelling longwave shade disk	n/a	Stepping motor drive	BRUSAG	INTRA-1	+/- 0.2° per day	autonomous, self correcting based on quad Silicon solar sensor input on

						clear days
Calibration Data Logger	volts	Analog to digital sample and hold	John Fluke Company	Helios	0.05% Full Scale	Full scale: 25 mV Resolution 100 nV noise<50 nV RMS

Data is recorded during Broadband Outdoor Calibration (BORCAL) events at 30 second intervals using the NREL Radiometer Calibration and Characterization (RCC) software. The software monitors atmospheric stability, total column water vapor, and broadband aerosol optical depth during the calibration event. Pyrheliometers are calibrated directly against the absolute cavity pyrheliometer. Pyranometers are calibrated against the reference irradiance derived from the absolute cavity pyrheliometer * cosine (zenith angle) + diffuse reference irradiance. Basic uncertainty "kernel" for each individual derived calibration factor (responsivity) is 1.3% (13 W/m^2) of full scale reading (1 kW/m^2) due to WRR uncertainty, temperature, data logger, solar geometry, and individual instrumental effects. Pyranometer calibration factors are binned according to 10 degree zenith angle increments for post-processing removal of cosine response effects for each individual radiometer. A "composite" cosine weighted average of the binned responsivities is used to derive the calibration factor used in recording the network 5 minute average data.