NATIONAL RENEWABLE ENERGY LABORATORY

Welcome!

NREL Pyrheliometer Comparisons 2019

NPC-2019

23 September – 4 October

NPC-2018 Participants

15013 Denver West Parkway
Golden, CO 80401
Phone 303-275-3000

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

Welcome to the 22nd NREL Pyrheliometer Comparisons NPC-2019

23 September – 4 October 2019
Solar Radiation Research Laboratory
Golden, Colorado

The purpose of this NPC is to provide participants with current World Radiometric Reference (WRR) reduction factors for their absolute cavity radiometers and other reference pyrheliometers based on results from the 12th International Pyrheliometer Comparisons (IPC-XII) conducted 28 September – 16 October 2015 at the Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC). Information about IPC-XII is available from : http://www.pmodwrc.ch/pmod.php?topic=ipcxii

C O N T E N T S

SRRL Staff

NREL Metrology Laboratory & Sensing and Predictive Analytics (SePA) group

Afshin Andreas	Computer Issues, NREL Cavity Operations
Pete Gotseff	Solar Trackers, Tools, Electronics and Hardware, NREL Cavity Operations
Aron Habte	General Assistance, Data collection and compilation
Mark Kutchenreiter	Electrical Power, Tools, Electronics and Hardware, NREL Cavity Operations
Martina Stoddard	Host (Security, Logistics, Food)
Ibrahim Reda	NPC Data Processing, General Cavity Assistance

SRRL Location

Solar Radiation Research Laboratory (SRRL)

Latitude:	39.742 N
Longitude:	105.18 W
Elevation:	1828.8 m AMSL
Mean Station Pressure:	820 mBar
Time Zone:	(GMT – 7.0)
Phone:	303-384-6326
Emergency Phone:	1234 (on-site)

Telephone Numbers:

EMERGENCY = 303-384-6811
Or
1 2 3 4 (From ***any*** NREL Desk Phone)

SRRL = 303-384-6326

Safety

Emergency Phone: **RED BOX** UNDER INSTRUMENT DECK
OR Press **1 2 3 4** from any NREL extension

Evacuation Assembly Area: Northeast Corner of Parking Area

Security

Phone: 303-384-6811 or Press 6811 from any NREL extension

NREL *Visitor Badges* issued on first day of NPC at the Visitor Center. Please wear your badge at all times at SRRL.

Communications

Local (Long Distance): **9** – (1) Area Code – Number

Internet Access:

NREL_Wireless was replaced with NREL-Guest. The new system does not require a user ID and password for access. Users, including visitors and partners, *will only need to accept the terms* of the acceptable use policy to gain access. The acceptable use policy will be presented each time your mobile device has been away from NREL for several days.

Food & Beverages

Lunch Menu will be circulated daily by 9:30 MDT (see Martina)

Non-alcoholic Beverages and snacks provided

Equipment Storage

Please use ***designated areas*** in SRRL staging areas.

Dinner on Tuesday (September 24th)

Please join us for the NPC Dinner!

Dinner will be at **Outback steakhouse**.

Boisterous Australian-themed chain serving steaks, seafood & other hearty steakhouse fare.

Located in: Denver West Village

Address: 14295 W Colfax Ave, Lakewood, CO 80401

Menu: places.singleplatform.com

We will meet for dinner around 6:30 PM.

NPC Schedule and Protocol Summary

1. Schedule

DAY # 1 September 23rd

a. Visitor check-in at NREL Site Entrance Building, 15013 Denver West Parkway, Golden, CO 80401.
Please plan to arrive at NREL between 07:00 and 08:00 MDT.
b. Drive to SRRL – Call 303-384-6326 and stay on the phone till the gate opens remotely.
c. 08:30 MDT - Equipment Installation & tests:
Dry Weather - See the **outdoor *seating diagram*** below for your workstation.
Wet Weather – Assemble and bench test your equipment inside SRRL.
Locate your equipment and review seating charts
d. Review of NPC Protocol
e. Review measurement protocol and procedures.
f. 10:00 to Sunset - Practice and/or NPC measurements (weather permitting)

DAYS #2-12: 24 September through 04 October (*Daily*, including the weekend):

a. Clear sky = Take Measurements!
-Arrive at SRRL by 08:00 MDT
-Equipment warm-up for at least 30-minutes
-First Cavity Calibration at 08:55 MDT
-Begin comparison "Runs" by 09:00 MDT (08:00 MST)
-Continue measurements until sundown or the clouds interfere.
b. Cloudy sky = No Measurements, but optionally...
-Review of previous day's data analyses
-Technical Briefings on Radiometry, Measurement Network Operations, etc.
-Equipment Test
-Office Time (wireless available)
c. We will determine the need for continued measurements at the end of each day.

2. Time Keeping

-Wim Zaaiman will again be our timekeeper (as long as his voice holds out!)
-***All time records will be Mountain Standard Time (MST)***
-Outdoor time display is available for guidance ***(Wim's time is the Reference Time!)***
-We need to keep all PC clocks in agreement to better than 1 sec.
-***Set your system clock at the daily start-up*** or as often as needed to keep 1-second accuracy. Check personal computer clocks during the day.

3. Minimum Data Set

Our goal for a minimum data set for these comparisons is to measure irradiance during three different days (all day or portion). Historically, we have acquired more 2,000 data values for each participating cavity radiometer. At least 300 data values are needed to provide a valid transfer of the WRR to the participating radiometers.

4. Measurements

- Do NOT apply any previous **WRR** correction factors to your measurements.
- Use only the **factory calibration factor** to adjust your data. As in the past, we will use the following terms:

"Calibrate" = Perform electrical calibration and wait for next measurement period to begin
"Read" = A measurement of direct irradiance within 1 sec of announcement at 30-sec intervals.
"Run" = Collection of 49 readings taken in sequence (also called a *Series*).

The *Timekeeper* will make the following announcements for each Run:

Next Run Begins at HH:MM (MST) [HH:MM (MDT)]
T minus 6 minutes. BEGIN CALIBRATION
T minus 3 minutes
T minus 2 minutes
T minus 1 minute
T minus 30 sec
T minus 10 sec
T minus 5 - 4 - 3 - 2 - 1 - READ!

Continued countdowns at 30 sec intervals until 49 readings have completed a "Run"

6. Data Transfer

The following *standard data format* will be used by each participant to improve our data processing efficiency. Please see the emailed example file format or see Reda or Aron if you have any questions about the data format.

After the last daily RUN, and ***before*** equipment tear-down, email your data file to aron.habte@nrel.gov and Peter.Gotseff@nrel.gov. Cavity calibration files are not needed.

7. Data Processing

- Described in each NPC published/distributed report.

8. Data Reporting

-Our goal is to provide each participant with next-day analyses.
-A final report will be published by NREL within two months of the comparisons.

9. Equipment Storage

-Each participant will be given space to store systems at SRRL.
-Please let us know if you wish to have any electronics connected to AC power while in storage.

10. Courtesies

-Please get permission before touching someone else's equipment (turning off power strips, adjusting trackers, etc.) to prevent inadvertent data loss.
-Please return borrowed tools to owner.

NREL Pyrheliometer Comparisons 2019
Seating Diagram

Tracker Info
Organizational Name
Participant Names

NREL-2AP #1	ARM-Brusag 3
Kipp & Zonen USA, Inc	PMOD/WRC
Victor Cassella	Wolfgang Finsterle
Joop Mes	

Bench # 1: Breaker # 9

NREL-2AP #2	Providing own tracker	NREL-2AP #2
SRML University of Oregon	Campbell Scientific Inc.	King Abdullah City for Atomic and Renewable Energy (KACARE)
Josh Peterson	Matt Perry	Mohammed Al Harbi
	Singh Ajay	Saad AlQahtani
		Sultan Bin Gasem

Bench # 2: Breaker # 7

ARM-Brusag 1	ARM-Brusag 2
DOE Atmospheric Radiation Measurement (ARM) Program	European Commission Directorate General JRC
Craig Webb	Wim Zaaiman
James Martin	

Bench # 3: Breaker # 6

Providing own tracker	Providing own tracker
NOAA/ESRL/GMD	EPPLEY LAB
Jim Wendell	Tom Kirk
Emiel Hall	

Bench # 4: Breaker # 11

NREL Brusag (Spare)	Providing own tracker	Providing own tracker
National Central University, Taiwan	AEMET	Science Systems & Applications, Inc.
Nai-Ju Hsueh	Irene Melero Asensio	Fred Denn
Kun-Wei Lin		

Bench # 5: Breaker # 3

Providing own tracker	Providing own tracker
EKO Instruments	Sandia National Laboratories (Photovoltaic Systems Evaluation Lab)
Imai Ayako	Bill Boyson
Will Beuttell	Charles Robinson
Shiobara Makoto	

Bench # 6: Breaker # 2

Table Top Breaker # 5

BORCAL STR32Gs
#N/A
Andreas Afshin
Ibrahim Reda

Breaker #1

ISO CAL supplied tracker	ISO CAL supplied tracker
Hukseflux Thermal Sensors	ISO-CAL North America, LLC
Thijs Nijveldt	Erik Naranen
Jörgen Konings	
SE Patio with EriK N	**SE Patio**

	NREL-STR32G Deck	
Masdar Institute of Khalifa University		
Peter Armstrong		

Attendees W/o Instruments	Attendees without Instruments
NOAA/ESRL/GMD	Solar Resource Solutions, LLC
Kathy Lantz	Tom Stoffel
Don Nelson	
Christian Herrera	
Diane Stanitski	
Laura Riihimaki	

Participant Contact Information

Full Name	Affiliation	E-mail
Irene Melero Asensio	AEMET	irene_melero@yahoo.es
Caitlin Hale	Atlas Material Testing Technology, LLC	caitlin.hale@ametek.com
Patrick Smith	Atlas Material Testing Technology, LLC	patrick.smith@ametek.com
Matt Perry	Campbell Scientific Inc.	mperry@campbellsci.com
Singh Ajay	Campbell Scientific Inc.	asingh@campbellsci.com
Kun-Wei Lin	Central Weather Bureau, Taiwan	adenins@gmail.com
Craig Webb	DOE Atmospheric Radiation Measurement (ARM) Program	craigw@ops.sgp.arm.gov
James Martin	DOE Atmospheric Radiation Measurement (ARM) Program	jmartin@ops.sgp.arm.gov
Ayako Imai	EKO Instruments	yano@eko.co.jp
Will Beuttell	EKO Instruments	beuttell@eko-usa.com
Makoto Shiobara	EKO Instruments	shiobara@eko.co.jp
Tom Kirk	EPPLEY LAB	tomkirk@eppleylab.com
Wim Zaaiman	European Commission Directorate General JRC	willem.zaaiman@ec.europa.eu
Thijs Nijveldt	Hukseflux Thermal Sensors	thijs@hukseflux.com
Jörgen Konings	Hukseflux Thermal Sensors	jorgen@hukseflux.com
Erik Naranen	ISO-CAL North America, LLC	enaranen@isocalnorthamerica.com
Mohammed Al Harbi	King Abdullah City for Atomic and Renewable Energy (KACARE)	mohammed.harbi@energy.gov.sa
Saad AlQahtani	King Abdullah City for Atomic and Renewable Energy (KACARE)	s.qahtani@energy.gov.sa
Sultan Bin Gasem	King Abdullah City for Atomic and Renewable Energy (KACARE)	s.gasem@energy.gov.sa
Victor Cassella	Kipp & Zonen USA, Inc	Victor.Cassella@kippzonen.com

Joop Mes	Kipp & Zonen USA, Inc	joop.mes@kippzonen.com
Nai-Ju Hsueh	National Central University, Taiwan	frankshiue@gmail.com
Ibrahim Reda	National Renewable Energy Laboratory (Metrology and SePA)	ibrahim.reda@nrel.gov
Afshin Andreas	National Renewable Energy Laboratory (Metrology, SePA, and Cell & Module Certification Group)	afshin.andreas@nrel.gov
Emiel Hall	NOAA/ESRL/GMD	emiel.hall@noaa.gov
Kathy Lantz	NOAA/ESRL/GMD	kathy.o.lantz@noaa.gov
Jim Wendell	NOAA/ESRL/GMD	jim.wendell@noaa.gov
Don Nelson	NOAA/ESRL/GMD	donaldnelson@mac.com
Christian Herrera	NOAA/ESRL/GMD	christian.herrera@noaa.gov
Diane Stanitski	NOAA/ESRL/GMD	diane.stanitski@noaa.gov
Laura Riihimaki	NOAA/ESRL/GMD	laura.riihimaki@noaa.gov
Wolfgang Finsterle	PMOD/WRC	wolfgang@pmodwrc.ch
Bill Boyson	Sandia National Laboratories (Photovoltaic Systems Evaluation Lab)	weboyso@sandia.gov
Charles Robinson	Sandia National Laboratories (Photovoltaic Systems Evaluation Lab)	cdrobin@sandia.gov
Fred Denn	Science Systems & Applications, Inc.	Frederick.M.Denn@nasa.gov
Tom Stoffel	Solar Resource Solutions, LLC	tstoffelsrs@gmail.com
Josh Peterson	SRML University of Oregon	jpeters4@uoregon.edu
Peter Armstrong	Masdar Institute of Khalifa University	peter.armstrong@ku.ac.ae