AMTD-2014-93

Interactive comment on "Re-construction of global solar radiation time series from 1933 to 2013 at the Izaña Atmospheric Observatory" by R. D. García et al.

This useful and well-presented study analyzes the changing uncertainties in a long term series of global radiation measurements made at Izaña since 1933. The results are of wide interest in view of the growing recognition of the importance of changes and trends in this parameter for climatic change. I recommend its publication after the authors have considered the following suggestions to enhance its practical relevance to those engaged in such studies.

Authors: We appreciate the positive and constructive comments, and in the following we discuss and respond to Dr. Stanhill's comments.

1. **To avoid unnecessary multiplicity the World Meteorological Organizations (WMO) recommended term and symbol Global radiation ($Eg_{\downarrow}$) should replace Global short-wave downward radiation (SDR).**

   Authors: Thank very much for your comment. However, the authors have followed a previous suggestion of Reviewer#1 how recommended to use global solar radiation (global SR) in the manuscript, which is the most common term in the bibliography. Nevertheless, we will also add a reference to the $Eg_{\downarrow}$ symbol at the beginning of the manuscript.

   Page 4193 Line 4-6: "…*Recently, the focus is on evaluating the long-term trends of solar radiation reaching the Earth's surface (global SR, or $Eg_{\downarrow}$) as well as on identifying the variability…*"

2. **It would be helpful to give values for the changing accuracy attainable for $Eg_{\downarrow}$ measurements, in particular to cite the values given in the analyses of the IGY results and in the eight editions of the WMO Guide to Meteorological Instruments and Methods of Observations.**

   Authors: Please, see comment# 5.

3. **The analyses of the uncertainties in daily values of $Eg_{\downarrow}$ should be repeated for longer periods such as means of weekly, monthly, seasonal and annual values.**

Authors: Following your recommendation, we have included weekly, monthly and annual mean values in the analyses of the uncertainties in daily global solar radiation values (see following Table).

	CS: 1997-1999				CSD: 2006-2008			
	Median	**RMSE**	**R**	**%days**	**Median**	**RMSE**	**R**	**%days**
Daily	-0.27	2.15(6.8%)	0.96	-	0.02	1.33(2.6%)	0.99	-
Weekly	-0.44	1.31(5.6%)	0.97	-	0.05	0.81(3.4%)	0.99	-
Monthly	-0.48	0.98(4.1%)	0.98	-	-0.05	0.59(2.5%)	0.99	-
Annual	-0.45	0.46(1.9%)	0.99	-	0.02	0.18(1.7%)	0.99	-
DJF	0.43	2.06(6.4%)	0.91	23	-0.26	1.52(4.6%)	0.95	24
MAM	-0.14	2.71(5.3%)	0.91	26	-0.34	1.41(2.5%)	0.97	25
JJA	0.27	1.87(3.1%)	0.85	27	0.20	0.92(1.5%)	0.96	25
SON	0.61	1.84(4.6%)	0.85	25	0.49	1.38(3.6%)	0.98	26
FCS(%)	**Median**	**RMSE**	**R**	**%days**	**Median**	**RMSE**	**R**	**%days**
≤ 20	1.09	4.19(12.1%)	0.51	8	-0.41	2.63(6.8%)	0.59	5
20-40	0.84	3.33(4.9%)	0.69	4	-0.34	1.92(3.5%)	0.78	5
40-60	0.96	2.54(3.6%)	0.83	6	0.06	1.74(2.8%)	0.89	7
60-80	0.35	1.81(4.2%)	0.92	23	-0.18	1.84(3.1%)	0.93	12
≥ 80	0.17	1.65(4.5%)	0.96	59	0.04	0.93(2.9%)	0.99	71
Total	0.27	2.16(9.2%)	0.96	-	0.02	1.33(5.5%)	0.99	-

Table 4 .- Statistics of the differences between simulations and measurements at IZ0 (in MJm^{-2}) between 1997 and 1999 (Campbell–Stokes Recorder, CS) and between 2006 and 2008 (Sunshine Duration Sensor, CSD) according to seasons and the fraction of clear sky (FCS). (RMSE: Root Mean Square Error; R: correlation coefficient. The statistics for the relative bias are in brackets (%)).

4. **The accuracy of sunshine duration measured with the Campbell-Stokes recorder should be determined by reference to the time that direct solar beam irradiance, as measured by a calibrated pyrheliometer, exceeds 120 Wm^2, rather than by comparison with another model of sunshine duration recorder.**

Authors: We fully agree. Unfortunately, direct solar radiation measurements were not available during the CS time series (See page 4199, lines 22-24).

In order to quantify the uncertainty of our direct solar radiation simulations, we have recently computed the relative difference ((simulation-measurement)/measurement, in %) between simulations with *LibRadtran* model and measurements with absolute cavity radiometer system (PMO-6) (see Figure 1), the maximum relative difference is 0.15 % (RMSE 0.49%) and 0.38% (RMSE 0.28%) for 6 and 10 June 2014, respectively. These simulations were performed in the framework of calibration routines for pyrhelimeters installed at Izaña Observatory. These results are similar to those obtained in Garcia et al., (2014)([1]).

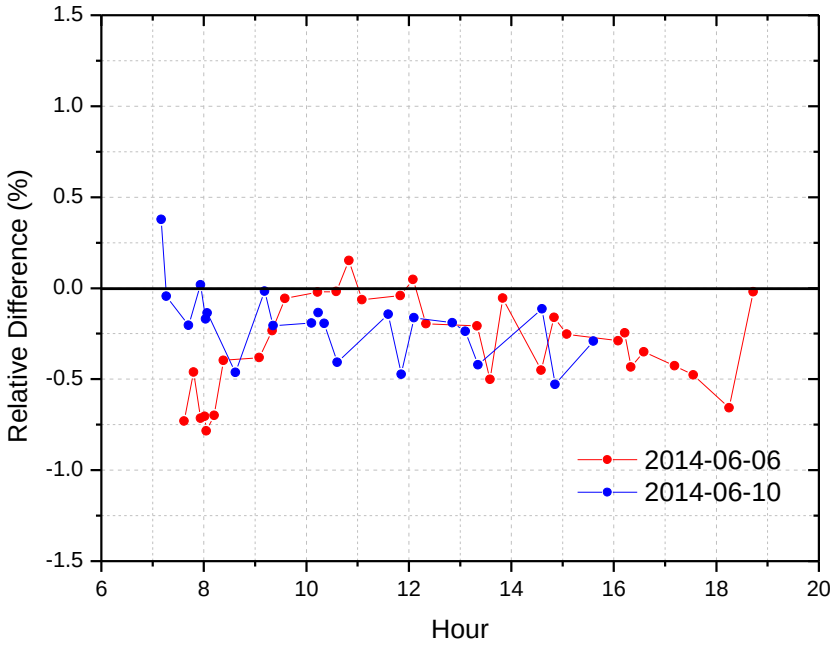

Figure 1.- Relative differences between direct solar radiation measurements with PMO-6 radiometer and simulations with LibRadtran model at Izaña Observatory on 6 (red line) and 10 (blue line) June 2014.

([1]) García, R.D., O.E. García, E. Cuevas, V.E. Cachorro, P.M. Romero-Campos, R. Ramos and A.M. de Frutos. Solar irradiance measurements compared to simulations at the BSRN Izaña station. Mineal dust radiatve forcing and efficiency study. J. Geophys. Res.,119, 179-194, doi:10.1002/2013JD020301.

5. Line 2 p 4194 A thermoelectric pyranometer capable of continuous accurate measurement of $Eg_{\downarrow}$, the Callendar sunshine receiver, was commercially available and in use in the first decade of the last century.

Authors: We appreciate this comment. It will be included the following text in the *Introduction* of the final manuscript:

"…Reliable solar radiation studies need of high-quality, long-term and worldwide distributed SDR measurements. *Although the first global SR instruments were designed in the first decade of the last century (Moll, 1913; Chaldecott, 1954; De Bruin et al., 1995; Stanhill, 1998)* regular and coordinated SDR observations were not well established until the 1950s within the framework of the International Geophysical Year (IGY) (Nicolet, 1982). *The accuracies reached in global SR measurements, measured by pyranometers, ranged from the 5% for daily totals reported in the results of the International Geophysical Year (IGY, 1957), to the 5% and 2% for high and good quality measurements respectively in daily totals reported in 2008 by the WMO Guide to Meteorological Instruments and Methods of Observation (WMO, 2008)..."*

References

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Stanhill, G.: Long-term trends in, and spatial variation of solar irradiance in Ireland, Int. J. Climatol, 18, 1015-1030, 1998.

World Meteorological Organization (WMO): Guide to Meteorological Instruments and Methods of Observation, WMO-No. 8, 7. Edn., Geneva, Switzerland, 2008.

6.Line 23 p 4198 begin should read below?

Authors: Thank very much for your comment. The SD definition has been changed as follows:

"… SD is the length of time that the ground surface is irradiated by direct solar radiation (i.e., sunlight reaching the earth's surface directly from the sun). In 1982, WMO defined it as the period during which direct solar irradiance exceeds a threshold value of 120 Wm^{-2} (WMO, 1982) …"