

Instruments and Observing Methods
Report No. 130

Fourth WMO Regional
Pyrheliometer Comparison of RA II,
Jointly held with RA V
(23 Jan - 3 Feb, Tsukuba, Japan)

M. Omori (Japan), M. Milner (Australia), T. Aoyagi (Japan), O. Ijima
(Japan) and Y. Tsutsumi (Japan)



WORLD
METEOROLOGICAL
ORGANIZATION

This publication is available in pdf format, from the WMO Library website:

<https://library.wmo.int/opac/>

© World Meteorological Organization, 2018

The right of publication in print, electronic and any other form and in any language is reserved by WMO. Short extracts from WMO publications may be reproduced without authorization, provided that the complete source is clearly indicated. Editorial correspondence and requests to publish, reproduce or translate this publication in part or in whole should be addressed to:

Chairperson, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 8403
Fax: +41 (0) 22 730 8040
E-mail: Publications@wmo.int

NOTE

The designations employed in WMO publications and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of WMO concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or products does not imply that they are endorsed or recommended by WMO in preference to others of a similar nature which are not mentioned or advertised.

The findings, interpretations and conclusions expressed in WMO publications with named authors are those of the authors alone and do not necessarily reflect those of WMO or its Members.

This publication has been issued without formal editing.

FOREWORD

Every five years, the secondary standard pyrhelimeters from each WMO region assemble in Davos, Switzerland, to be directly intercompared with the World Standard Group of instruments during the International Pyrhelimeter Comparison (IPC), to establish the continuing traceability of these secondary instruments to the World Radiation Reference.

The onus is then on the keepers of the secondary standard(s) in each WMO region to ensure that they, in turn, are made available to be intercompared with national standards from each country in their region, to enable traceability to the world primary standard to be extended down the hierarchy to these national standards. With the last IPC having been held in Davos in 2015, the Japan Meteorological Agency organized a regional intercomparison of pyrhelimeters at its Regional Radiation Centre (RRC) in Tsukuba from 23 January to 3 February 2017 to accomplish this aim.

The difference between this, the fourth Regional Pyrhelimeter Comparison (RPC-IV) of WMO in Regional Association II (RA II, Asia), and previous RA II intercomparisons was that it included the participation of the Regional Association V (RA V, South-West Pacific) standard from the Bureau of Meteorology's RRC in Melbourne, Australia, to enable cross-comparison of the two standards approximately halfway through the IPC cycle and to comprise also a regional intercomparison for RA V. Other participating instruments included the national standards from China, Republic of Korea, Hong Kong (China) and New Zealand, and a new absolute pyrhelimeter under commercial development. Two additional experts attended: one from the World Radiation Centre in Switzerland, and one from the Solomon Islands.

The intercomparison was a resounding success. This report describes the intercomparison in detail: the instruments, the participants, the experimental setup, method and procedure, the data analysis technique used and the results. It is clear from the results that all of the participating instruments have been well maintained and remained stable since the previous intercomparison, which augers well for all radiation measurements within RA II and RA V. All participants were able to return home with newly derived WRR reduction factors for their instruments.

I wish to express my sincere gratitude, particularly to the Japan Meteorological Agency and the staff of its Regional Radiation Centre in Tsukuba, but also to the participants from Australia, WRC, China, Hong Kong (China), the Republic of Korea, New Zealand and the Solomon Islands, for the success of this latest intercomparison. I also thank all of those in RA II who have worked to make these regional intercomparisons a regular occurrence in recent years and I wish them every success with their continuation in the years to come.

(Prof. B. Calpini)



President

Commission for Instruments
and Methods of Observation

TABLE OF CONTENTS

Part I FOURTH WMO REGIONAL PYRHELIOMETER COMPARISON OF RA II, JOINTLY HELD WITH RA V

1. INTRODUCTION	1
2. LOCATION OF COMPARISON SITE	1
3. PARTICIPANTS	2
4. INSTRUMENTS	3
5. OUTLINE OF COMPARISON	4
5.1. Equipment and Facilities	4
5.2. Data Acquisition Method	4
5.3. Measurement Procedures	5
5.4. Daily Comparison Schedule	7
6. IRRADIANCE CALCULATION	7
7. DATA EVALUATION PROCEDURES	8
8. COMPARISON RESULTS	10
9. CONCLUSIONS	12
REFERENCES	12

Appendix

A: List of Participants	13
B: Measurement Values for Each Instrument	15
C: Plot Figures of Measurement Values	24
D: Meteorological Data	28
E: Group Photo of Participants	31
F: Activities of the Regional Radiation Centre, Tokyo	32

Part II CALIBRATION OF REFERENCE PYRANOMETERS

1. INTRODUCTION	33
2. METHOD OF CALIBRATION AND DATA ACQUISITION	33

3. PYRANOMETER CALIBRATION FACTOR DEFINITION	33
4. DATA EVALUATION PROCEDURE	33
5. CALIBRATION RESULTS	34
Appendix	
G: Measurement Values for Each Instrument	35
H: Plot of Measurement Values	37

Part I

FOURTH WMO REGIONAL PYRHELIOMETER COMPARISON OF RA II, JOINTLY HELD WITH RA V

(Tsukuba, Japan, 23 January – 3 February, 2017)

1. INTRODUCTION

The fourth Regional Pyrheliometer Comparison (RPC-IV) of the World Meteorological Organization (WMO) Regional Association (RA) II was conducted together with the RPC of RA V in Tsukuba, Japan, from 23 January to 3 February 2017. Attendees included experts from three National Radiation Centres in RA II and one in RA V, and the World Radiation Centre (WRC) in Davos, Switzerland.

The Japan Meteorological Agency (JMA) and the Australian Bureau of Meteorology serve as WMO Regional Radiation Centres (RRCs) in RA II and RA V in their roles as RRC Tokyo and RRC Melbourne, maintaining regional standard pyrheliometers to ensure the traceability of solar radiation measurements against the World Radiometric Reference (WRR). At the 12th International Pyrheliometer Comparison (IPC-XII) conducted at WRC from 28 September to 16 October 2015, the RA II and RA V regional standard pyrheliometers were found to have been maintained satisfactorily, and new WRR factors were determined for these instruments (WMO, 2016).

At RRC Tokyo and RRC Melbourne, the regional standard pyrheliometers are compared every year to check the stability of individual instruments in line with a recommendation made by the Commission for Instruments and Methods of Observation (CI MO). In January 2017, RRC Tokyo and RRC Melbourne expanded comparison work referred to as RPC-IV to ensure correspondence between the national standard pyrheliometers of RA II/RA V and regional standard pyrheliometers. Experts from China, Hong Kong and the Republic of Korea in RA II and from the Solomon Islands in RA V participated in the comparison, and WRC sent an expert to support related activities. In addition, a national standard pyrheliometer from New Zealand and a new absolute pyrheliometer under commercial development were also participated in the RPC.

The session was successful, producing positive results thanks to the close collaboration and hard work of the participants. This report presents the results of intercomparisons conducted over a period of four days with good weather conditions.

2. LOCATION OF COMPARISON SITE

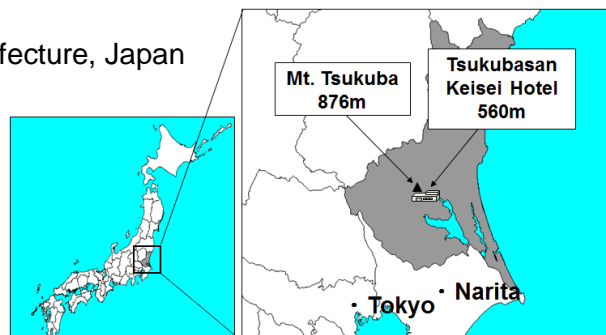
RPC activities took place at the Tsukubasan Keisei Hotel located halfway up the southeast side of Mt. Tsukuba in Japan's Ibaraki Prefecture. This is an isolated 877-meter-high mountain about 70 km northeast of Tokyo. The site was selected as the venue for the first RPC of RA II/V (RPC-I) in 1989 (WMO, 1989) after consideration of the conditions necessary for pyrheliometer intercomparison by WMO experts.

Address: 1 Tsukuba, Tsukuba City, Ibaraki Prefecture, Japan

Longitude: 140° 7.5' E

Latitude: 36° 12.9' N

Altitude: 560 m above sea level



3. PARTICIPANTS

Experts from three RA II members (China, Hong Kong and the Republic of Korea) and two RA V members (Australia and the Solomon Islands), an expert from WRC and JMA staff participated in the comparison.

Participants

Ms. Yang Yun	(China)
Ms. Ding Lei	(China)
Mr. Chong Wei	(China)
Mr. Tony Hak Ming Chau	(Hong Kong)
Mr. Soo-Ho Ryu	(Republic of Korea)
Mr. Yong-june Park	(Republic of Korea)
Mr. Bu-Yo Kim	(Republic of Korea)
Mr. Hyun-Seok Jung	(Republic of Korea)
Mr. Jin-Soo Park	(Republic of Korea)
Mr. Michael Milner	(Regional Radiation Center in RA V / Australia)
Mr. Barnabas Tahunipue	(Solomon Islands)
Dr. Wolfgang Finsterle	(World Radiation Center / Switzerland)
Dr. Yukitomo Tsutsumi	(Director, Regional Radiation Center in RA II / JMA Headquarters / Japan)
Dr. Toshinori Aoyagi	(JMA Headquarters / Japan)
Mr. Masao Omori	(JMA Headquarters / Japan)
Mr. Nozomu Ohkawara	(JMA Headquarters / Japan)
Mr. Hiroki Yuasa	(JMA Headquarters / Japan)
Mr. Akinori Ogi	(JMA Headquarters / Japan)
Mr. Osamu Ijima	(Aerological Observatory / Japan)
Mr. Matsumi Takano	(Aerological Observatory / Japan)
Mr. Yukihiko Nomura	(Meteorological Instruments Center / Japan)
Mr. Satoru Hagiya	(Meteorological Instruments Center / Japan)
Mr. Toshihiro Oka	(Meteorological Instruments Center / Japan)
Mr. Koji Haijima	(Meteorological Instruments Center / Japan)

A list of main participants and contact addresses is shown in **Appendix A**.

4. INSTRUMENTS

Following absolute pyrheliometers were compared.

Instrument

PMO6-CC	No. 0401	(WRC)
PMO6-CC	No. 0803	(WRC)
AHF	No. 32455	(WRC)
PMO6-CC	No. 0403	(Japan)
AHF	No. 37815	(Japan)
HF	No. 27160	(Australia)
TMI	No. 69137	(Australia)
AHF	No. 36012	(China)
PMO6-CC	No. 0806	(China)
PMO6-CC	No. 0102	(Hong Kong)
PMO6-CC	No. 0809	(Hong Kong)
PMO6	No. 951202	(Republic of Korea)
AHF	No. 36014	(Republic of Korea)
CHP1	No. 160360	(Republic of Korea)
CHP1	No. 110775	(New Zealand)
AHF	No. 32446	(Japan)
PMO6-CC	No. 1107	(Japan)
ACR	No. 01	(Middleton Solar, Australia)

During the comparison, ancillary data (air temperature, relative humidity, atmospheric pressure and wind speed/direction) were obtained from an automatic weather station (AWS). A precision filter radiometer (PFR) was operated to determine aerosol optical depth (AOD) at four wavelengths (368 nm, 412 nm, 500 nm and 862 nm). These data were used for screening in data evaluation procedures. The auxiliary instruments are listed below.

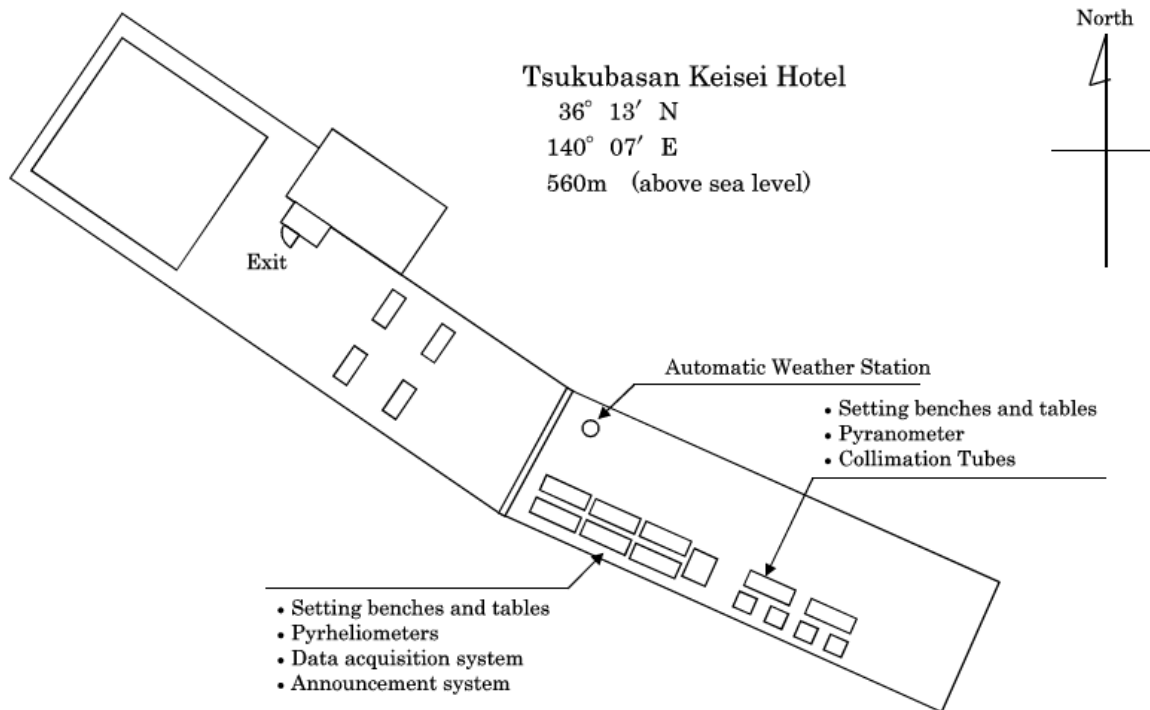
Auxiliary instruments

MetPak II	1723-PK-100	Automatic weather station
PFR	No. 47	Sunphotometer

5. OUTLINE OF COMPARISON

5.1. Equipment and Facilities

Flat benches, automatic active sun trackers, a data acquisition system, a voice-announcement and buzzer system (to indicate the start and end of measurements), an AWS (consisting of a thermometer, a hygrometer, a barometer and an ultrasonic anemometer) and some power supplies (100/220 V, 50 Hz) were set up on the rooftop of the venue. The pyrheliometer and sunphotometer sensors were mounted on seven sun trackers.



Layout of the Equipment and Facilities (Rooftop of the Tsukubasan Keisei Hotel)

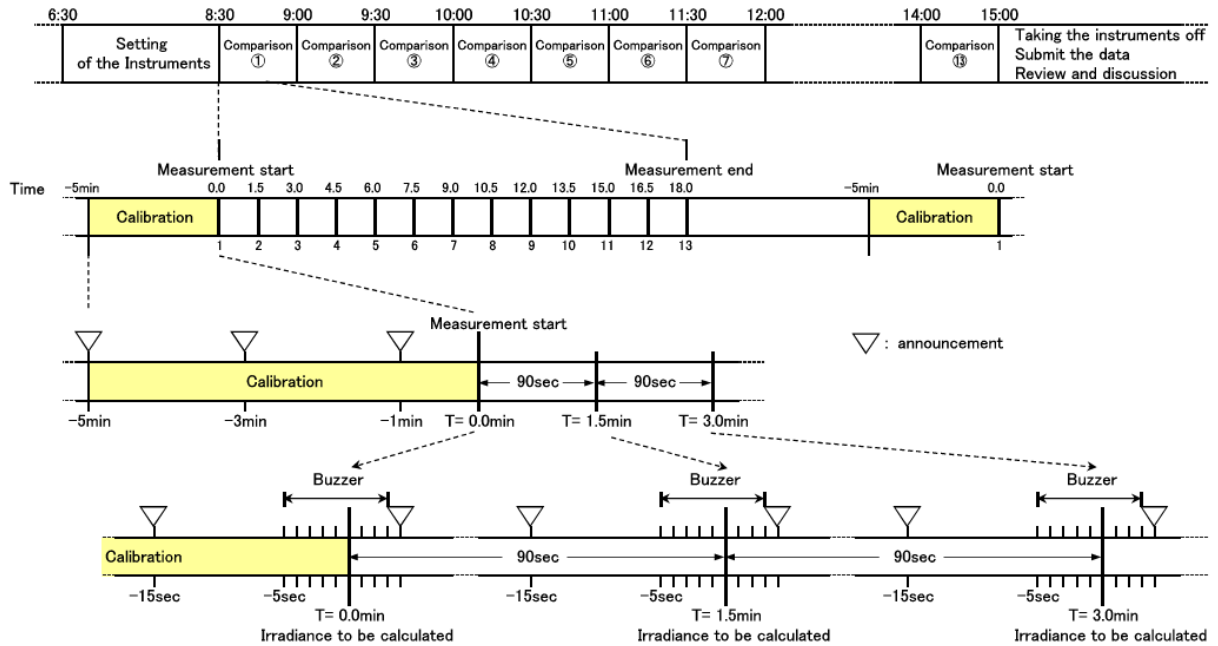
5.2. Data Acquisition Method

Digital data from the radiometer controllers were acquired by all members via a dedicated personal computer. Each member converted the data into the set format after daily observations and stored them on USB flash memory.

Analog signals from the controller of one PMO6 were acquired and stored immediately on a dedicated personal computer with a multi-channel analog data logger by JMA staff.

5.3. Measurement Procedures

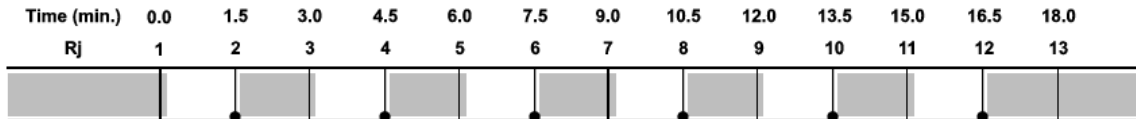
The sequence of measurements of a sample day is shown as below.



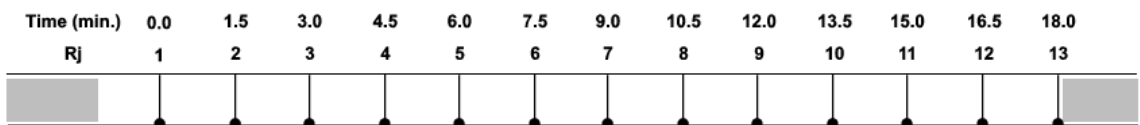
Measurement Sequence

Each set of measurements, referred to as a series, was composed of 13 data readings taken at 90-second intervals. Accordingly, the collection of one series took 18 minutes. The data sampling cycle for each instrument is shown as below.

PMO6



AHF, TMI & ACR



Rj : Running number of reading

: Read, then open

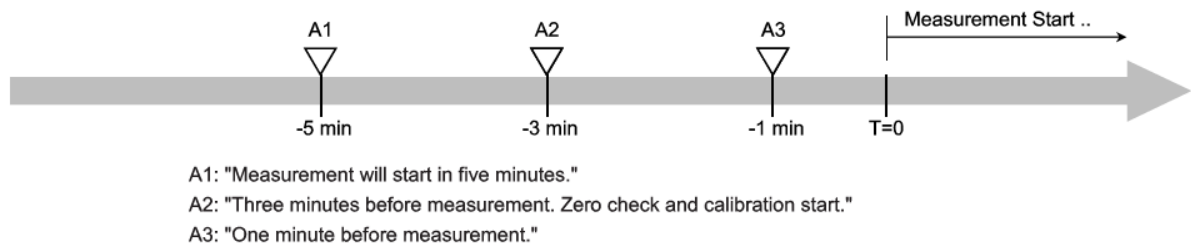
● : Irradiance to be calculated

: Read, then close

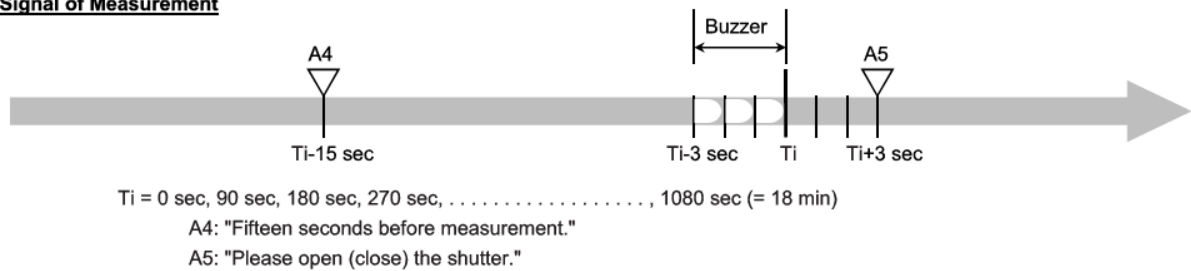
Data Sampling Cycle

The synchronization of measurements was performed by voice announcements and buzzers from a computer as shown as below.

Signal of Start



Signal of Measurement



Synchronization Diagram for Data Acquisition

The instruments were controlled and operated independently by the participants as described below.

(a) PMO-type absolute pyrheliometers (PMO6, PMO6-CC)

Each series started when the shutter closed, and PMO-type absolute pyrheliometer measurement was then carried out by opening and closing the shutter every 90 seconds. The PMO6 was operated using a controller to open and close the shutter automatically in synchronization with announcements and buzzers. PMO6-CCs were synchronized at the beginning of data series measurement and operated automatically from that point onward.

Irradiance data were acquired from measurements taken at both ends of the open phase and the end of the closed phase. Six sets of data taken at intervals of three minutes were therefore acquired in one series.

(b) HF-, TMI- and ACR-type absolute pyrheliometers

Zero adjustment and self-calibration were carried out before each series. A zero-point reading was taken with the shutter closed and heater off. The heater was turned on with the shutter closed when self-calibration was made. The heater voltage was selected manually or automatically beforehand to match the expected level of solar irradiance. After a while, the heater voltage, heater current and thermopile output were measured in order to estimate the sensitivity for the following measurement series. After the calibration, the heater was turned off and the shutter was opened for measurement. The thermopile output was read every 90 seconds, and 13 sets of irradiance data were acquired in each series.

These operations were performed automatically via program control. However, failure of the prototype shutter system resulted in mostly manual operation as for ACR.

5.4. Daily Comparison Schedule

Generally, the daily schedule was as follows:

- 06:30 – 08:20 The instruments were taken from the storage room to the rooftop, set up and connected. After inspection of the automatic active sun trackers, pyrheliometer alignment and the connection of the observation instruments to the data logger and computers etc., the instruments were allowed to warm up for at least 30 minutes.
- 08:30 – 15:30 Depending on suitable weather conditions, measurements were taken (see Section 5.3.). Pyrheliometer alignment was checked on an ongoing basis and fine adjustments were made using screws or similar where necessary.
- 15:30 – Measurement was ended and the instruments were returned to the storage room. The participants submitted measurement data, and the RRC distributed the preliminary results of measurement to the participants. The results were monitored every day to check the status of the instruments and the measurement procedures.

On cloudy days, country reports, technical visits to JMA's Meteorological Instrument Center and Aerological Observatory and training in radiation measurement were scheduled.

6. IRRADIANCE CALCULATION

The procedure used to calculate the irradiance of each instrument type is described below. The notations are as follows:

Symbols

S	direct solar irradiance [W m^{-2}]
V_{th}	output of thermopile [V]
U_H or U_I	voltage across the heater (H) or across the shunt resistor (I) [V]
R_N	precision shunt resistor to measure electric current [Ω]
R_C	correction resistance for heater leads [Ω]
C_1	calibration factor
P	electrical power in the active cavities [W]
F	tentative mean irradiance ratio
K	sensitivity

Subscripts

irrad	value during irradiance measurement phase
cal	value during calibration phase
zero	value during zero adjustment in calibration phase
open	value during shutter-open phase
closed	value during shutter-closed phase

(a) PMO-type absolute pyrheliometers (PMO6, PMO6-CC)

PMO-type absolute pyrheliometers have a primary black body cavity for measurement under conditions of exposure to the sun and a secondary black body cavity for compensation. These cavities are thermally interconnected via a heat sink, and the difference in temperature between them is kept constant by an electrical heater attached to the cavity for measurement regardless of open or closed shutter status.

When the shutter is opened for exposure to the sun, the electrical power needed to maintain the temperature difference decreases because of irradiance heating. The irradiance is in proportion to the difference between the open and closed shutters, and is calculated using the following formula:

$$S = C_1 (P_{\text{closed}} - P_{\text{open}})$$

P_{closed} is averaged from the closed values recorded before and after the shutter is opened. Power calculation was performed using the following formulas:

$$P = U_H U_I / R_N$$

(b) HF-, TMI- and ACR-type absolute pyrheliometer

HF-, TMI- and ACR-type absolute pyrheliometers have a black body cavity for measurement under conditions of exposure to the sun, as well as a thermopile and an electric heater.

Before each series, the shutter is closed, the heater current is turned on, and the voltage $U_{H(\text{cal})}$ across the heater system, the voltage $U_{I(\text{cal})}$ across the precision shunt resistor R_N and the thermopile output $V_{th(\text{cal})}$ are then measured. The zero value of $V_{th(\text{zero})}$ is also determined with the detector shaded and the heater switched off. After these procedures (namely self-calibration and zero adjustment) that is applied to obtain the proportional relationship between the quantity of heat added by the electrical heater and the thermopile output, the irradiance is retrieved continuously based on the thermopile output V_{th} according to the following formula:

$$S = C_1 \frac{V_{th(\text{irrad})} - V_{th(\text{zero})}}{V_{th(\text{cal})} - V_{th(\text{zero})}} \frac{U_{I(\text{cal})}}{R_N} \left(U_{H(\text{cal})} - \frac{U_{I(\text{cal})}}{R_N} R_C \right)$$

(c) CHP1 thermoelectric pyrheliometer

Irradiance is directly calculated from thermopile output using:

$$S = K V_{th(\text{irrad})}$$

7. DATA EVALUATION PROCEDURES

The data evaluation procedures were essentially the same as those used at the previous RPC of RA II (WMO, 2012), the details of which can be found in WMO technical documents (WMO, 1985). Below is a summary of the comparison procedures.

Step 1: The reference irradiances used to calibrate the national standard pyrheliometers were calculated from the three WRC instruments (PMO6-CC: No. 0401, No. 0803; AHF: No. 32455) and the four regional standard instruments (RA-II: PMO6-CC: No. 0403; AHF: No. 37815, RA-V: HF: No. 27160; TMI: No. 69137) which participated in IPC-XII.

Step 1-1: Data selection for the reference instruments

In each comparison series, six potential reference irradiances obtained at even running numbers of readings (i.e., $j = 2, 4, 6, 8, 10$ and 12) when irradiances could be measured by both reference instrument types were used for reference irradiance calculation. All of the irradiance values obtained were inspected carefully, and those deemed suspect due to instability or other influences relating to unpredictability were removed.

The following criteria were additionally applied to the selected data to get the final results in RPC-IV:

- (1) No cloud or haze in or around the direction of the sun
- (2) A solar elevation angle equal to or greater than 25 degrees
- (3) A wind speed equal to or less than 2.0 m/s
- (4) An AOD value at 500 nm equal to or less than 0.12

For wind speed, the criterion adopted at IPC-XII was applied to ensure sufficient selected data and appropriately low irradiance variability for reliable comparison results. For AOD, the criterion adopted at the previous RPC in RA-II was applied.

Step 1-2: Data selection for individual instruments in each series

If effective irradiances were obtained from more than two reference instruments in each series, all data were averaged into tentative reference irradiances for every measurement time. Data were selected only if those from each instrument were within 2% of the tentative reference irradiance values for each measurement time.

Step 1-3: Series selection to obtain reference irradiances

All effective data were averaged again into tentative reference irradiances for every reading time. Data evaluation was conducted for each reference instrument, and the data measured using the reference instrument in a series were selected only if all such measurement data in the series were within 0.2% of the tentative reference irradiance values for each measurement time.

Step 1-4: Calculation of reference irradiances

The individual reference irradiance of the selected series for each measurement time was the unweighted arithmetic mean of the effective reference instruments.

Step 2: The instruments used were calibrated according to the reference irradiances.

Step 2-1: Calculation of tentative mean irradiance ratios for the instruments used

Firstly, those irradiance data judged as doubtful by the participants were rejected. The individual irradiances to the reference value were then calculated for all instruments. Using these ratios, tentative mean ratios were calculated as follows:

$$S_R(1), S_R(2), S_R(3), \dots S_R(n) \quad \text{selected data group of reference irradiances}$$

$$S_a(1), S_a(2), S_a(3), \dots S_a(n) \quad \text{selected data group of irradiances for instrument a}$$

$$F_a = \frac{1}{n} \sum_{i=1}^n S_a(i) / S_R(i) \quad \text{tentative mean irradiance ratio } F_a \text{ for instrument a}$$

The number of measurements (n) depended on the instrument.

Step 2-2: Data selection for the instruments used

Individual data that differed by more than 0.2% from the tentative mean were rejected. It was considered that data deviations greater than 0.2% were excessive and that the instrument was not stable enough in the series for comparison.

Step 3: Calculation of new WRR reduction factors for the instruments used

The final mean irradiance ratio was calculated from a selected data group for each instrument used. The new WRR reduction factor $WRRf_{NEW}(a)$ should be equivalent to the inverse of the final irradiance ratio.

WRR reduction factors were calculated from the following formula:

$$WRRf_{NEW}(a) = WRR/S_a$$

where

WRR : World Radiometric Reference

S_a : irradiance measured using instrument a

8. COMPARISON RESULTS

By applying the data selection criteria defined in Section 7 (Step 1) for reference values, 167 irradiances (28 series) representing the WRR were finally used. The comparison results are shown in **Appendix B**, which lists observation times, irradiances by reference pyrhelimeter group, reference irradiances (i.e., averages for each observation time), irradiance values and ratios to the reference irradiances for each national and regional standard pyrhelimeter.

Plot figures for the comparison results are shown in **Appendix C**. The scatter plots show the ratios to the reference irradiances, and the histograms show the distribution of these ratios for each national and regional standard pyrhelimeter. The number of data along with the average and standard deviations of the ratios are also shown.

Auxiliary data for each series of measurements are given in **Appendix D**.

Results of pyrheliometer comparison (summary)

Instrument	Current WRR Reduction Factor	Ratio	Standard Deviation	Number of Data	New WRR Reduction Factor	Change Ratio of WRR Reduction Factor
PMO6-CC No. 0401 WRC	1.020799 C ₁ :50000m ⁻² (IPC-XII, 2015)	0.999703	0.000350	181	-	-
PMO6-CC No. 0803 WRC	1.000335 C ₁ :51221m ⁻² (IPC-XII, 2015)	1.000314	0.000365	175	-	-
AHF No. 32455 WRC	1.001380 C ₁ :20009.2m ⁻² (IPC-XII, 2015)	1.000084	0.000412	175	-	-
PMO6-CC No. 0403 Japan	0.999753 C ₁ :50489.5m ⁻² (IPC-XII, 2015)	0.999954	0.000465	181	-	-
AHF No. 37815 Japan	0.998679 C ₁ :20011m ⁻² C ₂ :0.066Ω (IPC-XII, 2015)	0.999976	0.000461	181	-	-
HF No. 27160 Australia	0.997425 C ₁ :20030m ⁻² (IPC-XII, 2015)	0.999986	0.000352	158	-	-
TMI No. 69137 Australia	1.002150 C ₁ :10020m ⁻² (IPC-XII, 2015)	0.999994	0.000558	153	-	-
AHF No. 36012 China	-	1.001084	0.000509	172	0.998918	-
PMO6-CC No. 0806 China	- C ₁ :51279.2m ⁻²	1.000414	0.000520	165	0.999586	-
PMO6-CC No. 0102 Hong Kong	0.997006 C ₁ :51213.4m ⁻² (RPC-RAII 3 rd , 2012)	1.002939	0.000695	175	0.997070	+0.01%
PMO6-CC No. 0809 Hong Kong	0.998459 C ₁ :50752.0m ⁻² (RPC-RAII 3 rd , 2012)	1.001370	0.000610	177	0.998632	+0.02%
PMO6 No. 951202 Korea	0.996809 C ₁ :51669.5m ⁻² (RPC-RAII 3 rd , 2012)	1.003353	0.000533	172	0.996658	-0.02%
AHF No. 36014 Korea	1.001494 C ₁ :1.99452m ⁻² (IPC-XII, 2015)	1.000869	0.000646	174	0.999132	-0.24%
CHP1 No. 160360 Korea	- 8.05x10 ⁻⁶ V/Wm ⁻² (Kipp&Zonen)	1.015539	0.000912	169	0.984699	-
CHP1 No. 110775 New Zealand	- 8.00x10 ⁻⁶ V/Wm ⁻² (Kipp&Zonen)	1.010617	0.000681	158	0.989495	-
PMO6-CC No. 1107 Japan	1.024318 C ₁ :51248.4m ⁻² (IPC-XII, 2015)	0.976438	0.000841	159	1.024131	-0.02%
AHF No. 32446 Japan	0.999941 C ₁ :19986.9m ⁻² C ₂ :0.066Ω (JMA, 2016)	1.000008	0.000526	181	0.999992	+0.01%

Instrument	Current WRR Reduction Factor	Ratio	Standard Deviation	Number of Data	New WRR Reduction Factor	Change Ratio of WRR Reduction Factor
ACR No. 01 MSolar	-	0.990180	0.000863	119	1.009918	-

9. CONCLUSIONS

The results of the regional pyrheliometer comparison can be summarized as follows:

- (1) Within a given period, four days worth of measurement data were acquired in favorable weather conditions, which led to the successful determination of reduction factors.
- (2) It was confirmed that the pyrheliometers involved in the comparison were appropriately maintained and showed high accuracy.
- (3) New WRR reduction factors for national standard instruments were determined as necessary to ensure the traceability of solar radiation measurements in each member country/region.
- (4) During the comparison, participants exchanged and shared scientific and technological information on radiation measurement through country reports, technical visits and training courses.

REFERENCES

- WMO (2016); International Pyrheliometer Comparison IPC-XII Final Report, *IOM report No. 124*, WMO.
- WMO (2012); Third WMO Regional Pyrheliometer Comparison of RA II, *Instruments and Observing Methods report No. 113*, WMO.
- WMO (1985); Keynote Papers presented at the Third WMO Technical Conference on Instruments and Methods of Observation (TECIMO-III), *Instruments and Observing Methods report No. 23*, WMO TD-No. 51, 65 – 84.

List of Participants

- Ms. Yang Yun
 Meteorological Observation Center
 China Meteorological Administration
 46, Zhongguancun Nandajie, Haidian district,
 Beijing, China
 Phone: +8610-68406936
 Fax: +8610-68409323
 E-mail: yyaoc@cma.gov.cn
- Ms. Ding Lei
 Meteorological Observation Center
 China Meteorological Administration
 46, Zhongguancun Nandajie, Haidian district,
 Beijing, China
 Phone: +8610-68406936
 Fax: +8610-68409323
 E-mail: dlaoc@cma.gov.cn
- Mr. Chong Wei
 Meteorological Observation Center
 China Meteorological Administration
 46, Zhongguancun Nandajie, Haidian district,
 Beijing, China
 Phone: +8610-68406936
 Fax: +8610-68409323
 E-mail: chongwei@cma.gov.cn
- Mr. Tony Hak Ming Chau
 Hong Kong Observatory
 134A Nathan Road, Tsim Sha Tsui,
 Kowloon, Hong Kong
 Phone: +852-2926-8115
 Fax: +852-2311-9448
 E-mail: hmchau@hko.gov.hk
- Mr. Soo-Ho Ryu
 Korea Meteorological Administration
 45 Gisnagchoing-gil, Dongjak-gu,
 Seoul, Republic of Korea
 Phone: +82-2-2181-0713
 Fax: +82-2-841-7045
 E-mail: rysuho@kma.go.kr
- Mr. Yong-june Park
 Korea Meteorological Administration
 45 Gisnagchoing-gil, Dongjak-gu,
 Seoul, Republic of Korea
 Phone: +82-2-2181-0719
 Fax: +82-2-841-7045
 E-mail: juni8207@kma.go.kr
- Mr. Jinsoo Park
 Korea Meteorological Industry Promotion Agency
 5 Yeouidaebang-ro, 9ga-gil,
 Yeongdeungpo-gu
 Seoul, Republic of Korea
 Phone: +82-10-9548-0365
 Fax: +82-2-836-0360
 E-mail: wonderjs@kmipa.or.kr
- Mr. Bu-Yo Kim
 Gangneung-Wonju National University
 Jukheon-gil, Gangneung-si, Ganwon-do,
 Republic of Korea
 Phone: +82-10-7633-1024
 Fax: +82-33-640-2324
 E-mail: kimbuyo@gwnu.ac.kr
- Mr. Hyun-Seok Jung
 Gangneung-Wonju National University
 Jukheon-gil, Gangneung-si, Ganwon-do,
 Republic of Korea
 Phone: +82-10-6602-6526
 Fax: +82-33-640-2324
 E-mail: kn_horizon@naver.com
- Mr. Michael Milner
 Bureau of Meteorology
 700 Collin St, Docklands, Victoria, 3008
 Australia
 Phone: +61-3-9669-4122
 Fax: +61-3-9669-4736
 E-mail: m.milner@bomgov.au
- Mr. Barnabas Tahunipue
 Solomon Islands Meteorological Service
 PO Box 21, Honiara, Solomon Islands
 Phone:
 Fax:
 E-mail: barneytahoo@gmail.com
- Dr. Wolfgang Finsterle
 Physikalisch-Meteorologisches
 Observatorium Davos
 World Radiation Center
 Dorfstrasse 33, CH-7260 Davos Dorf,
 Switzerland
 Phone: +41-81-417-5153
 Fax: +41-81-417-5100
 E-mail: wolfgang@pmodwrc.ch

Dr. Yukitomo Tsutsumi
Director,
Atmospheric Environment Division
Global Environment and Marine
Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku, Tokyo, 100-
8122
Japan
Phone: +81-3-3287-3439
Fax: +81-3-3211-4640
E-mail: y-tsutsumi@met.kishou.go.jp

Dr. Toshinori Aoyagi
Atmospheric Environment Division
Global Environment and Marine
Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku, Tokyo, 100-
8122
Japan
Phone: +81-3-3287-3439
Fax: +81-3-3211-4640
E-mail: aoyagi.toshinori@met.kishou.go.jp

Mr. Masao Omori
Atmospheric Environment Division
Global Environment and Marine
Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku, Tokyo, 100-
8122
Japan
Phone: +81-3-3287-3439
Fax: +81-3-3211-4640
E-mail: omori.masao@met.kishou.go.jp

Mr. Osamu Ijima
Ozone and Radiation Division
Aerological Observatory
Japan Meteorological Agency
1-2 Nagamine, Tsukuba-shi, Ibaraki, 305-
0052,
Japan
Phone: +81-298-51-4127
Fax: +81-298-51-5765
E-mail: ijima@met.kishou.go.jp

		PMO6 0401	PMO6 0803	AHF 32445	PMO6 0403	AHF 37815	HF 27160	TMI 69137	reference irr
Date	Time	WRC	WRC	WRC	JPN	JPN	AUS	AUS	
yyyy/mm/dd	hh:mm:ss	IRR(W)	IRR(W)	IRR(W)	IRR(W)	IRR(W)	IRR(W)	IRR(W)	
2017/1/25	10:01:30	981.99	982.73		982.32	981.09			982.03
2017/1/25	10:04:30	983.20	983.61		983.37	982.98			983.29
2017/1/25	10:07:30	981.95	982.93		982.17	981.76	981.08	981.95	981.97
2017/1/25	10:10:30	982.48	983.46		981.98	982.24			982.54
2017/1/25	10:13:30	981.66	982.45		982.43	981.91			982.11
2017/1/25	10:16:30	981.50	981.56		981.54	980.98			981.39
2017/1/25	11:31:30	994.64	995.21	994.95	994.77	995.31	994.14	994.26	994.75
2017/1/25	11:34:30	994.19	994.25	993.72	994.70	994.27	993.48	994.39	994.14
2017/1/25	11:37:30	999.21	999.97	1000.07	1001.23	1001.01	999.69	999.64	1000.12
2017/1/25	11:40:30	1000.43	1000.96	1000.77	1000.97	1001.09	1000.24	1000.70	1000.74
2017/1/25	11:43:30	1003.65	1003.94	1003.99	1003.65	1003.17	1003.46	1004.66	1003.79
2017/1/25	11:46:30	992.07	992.47	990.59	991.88	991.38	991.78	992.55	991.82
2017/1/25	12:01:30	989.93	989.78	989.38	989.09	989.07	989.05	989.55	989.41
2017/1/25	12:04:30	988.17	988.84	988.91	989.00	989.14	989.18	988.35	988.80
2017/1/25	12:07:30	985.46	985.93	985.90	985.41	985.23	985.32	986.24	985.64
2017/1/25	12:10:30	983.92	984.17	984.40	983.94	983.74	984.48	984.05	984.10
2017/1/25	12:13:30	995.61	996.22	996.40	996.63	996.31	996.68	996.31	996.31
2017/1/25	12:16:30	985.39	985.83	985.97	985.12	985.60	985.58	985.64	985.59
2017/1/25	13:01:30	973.17	974.21	973.41	972.98	973.15	972.97	973.39	973.33
2017/1/25	13:04:30	965.19	964.77	964.65	964.27	964.52	965.26	966.61	965.04
2017/1/25	13:07:30	961.04	959.81	960.36	959.68	960.10	960.84	962.02	960.55
2017/1/25	13:10:30	952.59	952.36	953.68	954.46	954.85	953.82	953.01	953.54
2017/1/25	13:13:30								
2017/1/25	13:16:30	955.09	955.21	955.06	955.04	954.70	955.14	955.61	955.12
2017/1/25	14:01:30								
2017/1/25	14:04:30								
2017/1/25	14:07:30								
2017/1/25	14:10:30								
2017/1/25	14:13:30	903.84	905.14	904.48	906.00	905.36	904.99	903.64	904.78
2017/1/25	14:16:30	899.08	900.59	901.24	902.11	901.60	901.03	900.34	900.85
2017/1/26	10:31:30	987.30	987.84	987.96	986.74	986.89	987.13	988.23	987.44
2017/1/26	10:34:30	990.48	990.07	990.44	990.21	990.60	990.54	990.94	990.47
2017/1/26	10:37:30	989.17	989.94	989.37	989.50	988.94	989.70	990.49	989.59
2017/1/26	10:40:30	994.40	995.33	994.66	994.67	994.21	995.21	995.40	994.84
2017/1/26	10:43:30	992.62	993.65	993.59	992.50	991.81	992.55	993.14	992.84
2017/1/26	10:46:30	992.52	993.33	992.59	993.89	992.54	992.60	992.98	992.92
2017/1/26	11:31:30	994.96	995.91	995.35	996.30	995.62	994.95	995.26	995.48
2017/1/26	11:34:30	1003.11	1003.41	1003.68	1003.64	1003.65	1002.67	1002.56	1003.25
2017/1/26	11:37:30	1010.32	1011.12	1010.69	1010.15	1010.68	1010.61	1010.65	1010.60
2017/1/26	11:40:30	1015.11	1015.62	1016.13	1015.21	1015.93	1015.43	1015.33	1015.54
2017/1/26	11:43:30	1012.30	1012.72	1013.17	1012.10	1012.76	1012.66	1012.09	1012.54
2017/1/26	11:46:30	1001.80	1002.28	1003.03	1002.72	1003.11	1002.33	1001.52	1002.40
2017/1/26	12:01:30	1008.84	1009.31	1009.65	1009.53	1010.14	1010.30		1009.63
2017/1/26	12:04:30	993.62	994.85	994.94	993.84	994.45	994.35		994.34
2017/1/26	12:07:30	989.28	989.67	989.70	989.65	989.38	989.97		989.61
2017/1/26	12:10:30	995.35	995.97	996.13	995.59	995.78	996.62		995.91
2017/1/26	12:13:30	1002.38	1002.94	1003.60	1001.99	1002.59	1003.45	1002.30	1002.75
2017/1/26	12:16:30	1002.20	1002.90	1002.96	1003.40	1002.75	1002.51	1001.80	1002.65
2017/1/26	12:31:30	1004.17	1004.78	1004.20	1004.80	1005.12	1004.19	1004.73	1004.57
2017/1/26	12:34:30	1005.64	1006.50	1006.42	1006.66	1006.25	1006.16	1007.70	1006.47
2017/1/26	12:37:30	1000.28	1001.16	1001.05	999.89	1000.44	1000.47	1000.50	1000.54
2017/1/26	12:40:30	998.78	999.38	999.48	998.39	998.54	999.21	999.58	999.05
2017/1/26	12:43:30	996.76	997.99	997.73	998.32	997.82	997.15	997.81	997.66
2017/1/26	12:46:30	989.31	990.71	990.47	990.34	990.44	989.65	989.97	990.13
2017/1/26	13:01:30	978.84	979.34	979.36	979.57	979.39	979.78	979.57	979.41
2017/1/26	13:04:30	968.21	968.94	968.43	969.37	969.85	968.65	968.46	968.85
2017/1/26	13:07:30	972.48	973.67	972.82	972.87	972.82	972.81	972.61	972.87
2017/1/26	13:10:30	971.18	971.48	971.00	971.34	971.38	972.34	972.24	971.57
2017/1/26	13:13:30	972.66	973.61	973.06	972.49	972.05	972.72	972.39	972.71
2017/1/26	13:16:30	967.46	968.12	966.41	966.65	966.26	967.45	967.45	967.11
2017/1/26	13:31:30	956.75	957.22	956.75	956.91	956.75	957.17		956.93
2017/1/26	13:34:30	950.31	950.79	950.46	950.97	950.43	950.25	949.72	950.42
2017/1/26	13:37:30	945.45	945.82	945.43	945.73	945.46	945.42	945.63	945.56
2017/1/26	13:40:30	945.42	945.54	945.13	945.10	944.82	945.31	944.93	945.18
2017/1/26	13:43:30	942.36	942.02	942.27	942.42	942.20	943.14	942.04	942.35
2017/1/26	13:46:30	939.58	939.72	939.37	938.96	939.02	939.50	938.74	939.27

Date	Time	PMO6 0401 WRC IRR(W)	PMO6 0803 WRC IRR(W)	AHF 32445 WRC IRR(W)	PMO6 0403 JPN IRR(W)	AHF 37815 JPN IRR(W)	HF 27160 AUS IRR(W)	TMI 69137 AUS IRR(W)	reference irr
yyyy/mm/dd	hh:mm:ss								
2017/1/26	14:01:30	935.45	936.19	935.34	935.90	935.77	936.40	936.13	935.88
2017/1/26	14:04:30	924.84	925.74	925.31	925.49	925.51	925.32	925.62	925.40
2017/1/26	14:07:30	923.19	923.47	922.76	923.65	923.19	922.71	923.08	923.15
2017/1/26	14:10:30	920.38	921.21	920.80	921.29	920.98	921.72	921.57	921.13
2017/1/26	14:13:30	920.89	921.56	921.28	920.68	920.19	921.54	921.46	921.08
2017/1/26	14:16:30	917.43	917.68	917.68	918.36	918.54	918.22	917.74	917.95
2017/1/28	9:31:30	943.21	943.97	943.37	944.14	944.38	943.98	943.75	943.83
2017/1/28	9:34:30	947.56	948.72	948.16	946.43	946.39	947.70	948.75	947.67
2017/1/28	9:37:30	935.14	936.80	936.90	935.37	936.01	935.88	936.09	936.03
2017/1/28	9:40:30	950.86	951.94	951.60	951.50	952.02	951.90	951.54	951.62
2017/1/28	9:43:30	954.09	954.89	955.62	956.08	956.56	955.70	955.35	955.47
2017/1/28	9:46:30	959.52	959.55	959.66	958.02	959.28	960.89	961.20	959.73
2017/1/28	10:31:30	989.26	990.17	990.34	989.73	989.49			989.80
2017/1/28	10:34:30	983.42	984.45	984.46	984.88	985.39			984.52
2017/1/28	10:37:30	991.98	992.25	991.88	991.37	992.00			991.90
2017/1/28	10:40:30	995.31	996.27	996.05	994.79	996.22			995.73
2017/1/28	10:43:30	995.45	996.08	996.24	995.87	996.61			996.05
2017/1/28	10:46:30	987.26	988.02	989.13	986.21	986.65			987.45
2017/1/28	11:01:30	990.64	991.75	992.07	992.25	991.66	991.53	991.65	991.65
2017/1/28	11:04:30	996.70	997.01	996.81	996.40	996.45	997.05	996.08	996.65
2017/1/28	11:07:30	1006.95	1007.49	1007.65	1007.32	1007.12	1006.61	1007.50	1007.23
2017/1/28	11:10:30	1003.74	1004.26	1004.42	1005.05	1004.08	1003.96	1004.29	1004.26
2017/1/28	11:13:30	1008.27	1009.33	1008.13	1008.29	1008.57	1008.29	1008.40	1008.47
2017/1/28	11:16:30	1006.88	1007.76	1008.15	1007.29	1007.13	1006.67	1006.81	1007.24
2017/1/28	11:31:30	997.19	998.02	998.19	998.76	998.50			998.13
2017/1/28	11:34:30	989.96	990.66	991.17	989.85	989.95			990.32
2017/1/28	11:37:30	997.41	997.59	997.72	997.48	997.35			997.51
2017/1/28	11:40:30	999.28	1000.38	1000.78	999.06	999.55			999.81
2017/1/28	11:43:30	999.75	1000.34	1000.45	999.28	999.32			999.83
2017/1/28	11:46:30	999.08	1000.19	1001.10	999.52	999.41			999.86
2017/1/28	12:01:30	1003.87	1004.63	1004.91	1004.23	1004.76	1004.74	1004.71	1004.55
2017/1/28	12:04:30	997.97	998.93	998.12	998.06	997.78	998.37	998.61	998.26
2017/1/28	12:07:30	996.57	996.94	996.83	996.66	996.46	996.47	996.74	996.67
2017/1/28	12:10:30	994.04	994.44	994.41	993.70	994.21	994.16	993.95	994.13
2017/1/28	12:13:30	993.83	994.11	994.51	994.44	995.22	994.40	993.47	994.28
2017/1/28	12:16:30	1005.78	1006.71	1005.94	1005.31	1006.22	1005.57	1004.24	1005.68
2017/1/28	12:31:30	988.91	989.79	989.73	989.86	989.84	989.11	989.14	989.48
2017/1/28	12:34:30	983.72	984.14	983.80	983.37	983.82	984.06	984.37	983.90
2017/1/28	12:37:30	979.85	980.63	980.31	979.66	979.83	980.42	980.74	980.21
2017/1/28	12:40:30	975.44	975.40	975.42	974.86	975.20	975.80	976.02	975.45
2017/1/28	12:43:30	979.71	980.23	979.91	980.08	979.76	980.28	979.62	979.94
2017/1/28	12:46:30	978.20	979.13	978.40	978.19	978.00	978.33	977.87	978.30
2017/1/28	13:01:30	964.54	965.87	965.40	965.35	965.64	965.02	965.43	965.32
2017/1/28	13:04:30	971.54	972.03	971.44	971.67	971.69	971.86	971.71	971.71
2017/1/28	13:07:30	966.39	967.08	967.54	966.65	966.92	966.65	966.68	966.84
2017/1/28	13:10:30	970.52	970.98	970.92	970.04	970.19	970.85	970.55	970.58
2017/1/28	13:13:30	970.47	971.22	971.35	971.37	971.04	970.76	970.90	971.02
2017/1/28	13:16:30	959.66	960.47	959.67	959.80	959.99	960.54	959.78	959.99
2017/1/28	13:31:30	946.51	946.60	946.31	946.17	946.10	946.96	947.24	946.55
2017/1/28	13:34:30	941.85	942.55	942.14	942.40	941.88	942.18	942.97	942.28
2017/1/28	13:37:30	937.99	938.35	937.89	938.56	938.17	938.31	938.60	938.27
2017/1/28	13:40:30	940.69	941.15	941.43	941.33	941.09	941.29	941.19	941.17
2017/1/28	13:43:30	935.21	935.65	935.32	934.97	934.99	935.05	935.32	935.21
2017/1/28	13:46:30	926.62	927.26	926.75	927.06	927.48	927.23	926.75	927.02
2017/1/28	14:01:30	917.41		917.54	917.42	917.76	917.35	917.96	917.57
2017/1/28	14:04:30	915.33		916.68	915.95	915.94	915.71	915.38	915.83
2017/1/28	14:07:30	906.32		906.56	905.76	905.99	906.36	906.34	906.22
2017/1/28	14:10:30	907.14		907.74	907.38	907.71	907.32	906.26	907.26
2017/1/28	14:13:30	912.53		913.68	912.51	913.71	913.65	912.28	913.06
2017/1/28	14:16:30	920.63		921.49	921.29	921.67	921.65	920.31	921.17
2017/1/31	9:31:30	926.68	927.23	926.43	926.62	926.52			926.70
2017/1/31	9:34:30	928.80	929.51	929.52	929.19	929.30			929.27
2017/1/31	9:37:30	928.11	928.61	928.28	928.48	928.63			928.42
2017/1/31	9:40:30	930.48	931.39	930.98	930.58	931.15			930.92
2017/1/31	9:43:30	931.76	931.97	931.93	931.23	931.76			931.73
2017/1/31	9:46:30	935.41	936.37	936.16	936.34	936.55			936.17

Date	Time	PMO6 0401 WRC IRR(W)	PMO6 0803 WRC IRR(W)	AHF 32445 WRC IRR(W)	PMO6 0403 JPN IRR(W)	AHF 37815 JPN IRR(W)	HF 27160 AUS IRR(W)	TMI 69137 AUS IRR(W)	reference irr
yyyy/mm/dd	hh:mm:ss								
2017/1/31	10:01:30	953.34	954.05	953.25	952.73	952.02	952.60	952.56	952.94
2017/1/31	10:04:30	959.65	959.98	959.35	959.30	959.16	959.20	959.15	959.40
2017/1/31	10:07:30	958.01	958.93	957.99	957.50	957.33	957.97	958.09	957.97
2017/1/31	10:10:30	956.39	957.07	956.42	956.60	955.97	956.20	955.99	956.38
2017/1/31	10:13:30	959.65	959.91	959.59	960.11	959.97	959.22	958.30	959.54
2017/1/31	10:16:30	958.15	959.04	958.44	958.96	958.39	958.09	956.63	958.25
2017/1/31	10:31:30	958.98	959.35	959.20	958.81	959.77	959.15	959.43	959.24
2017/1/31	10:34:30	966.82	967.62	967.72	966.58	966.81	967.33	967.52	967.20
2017/1/31	10:37:30	972.58	973.03	972.77	972.40	972.88	972.51	973.14	972.76
2017/1/31	10:40:30	977.69	978.12	978.35	978.61	978.55	977.69	978.07	978.15
2017/1/31	10:43:30	979.14	979.18	979.61	979.06	979.17	979.02	979.75	979.27
2017/1/31	10:46:30	982.88	983.43	983.66	983.48	983.60	983.16	983.70	983.41
2017/1/31	11:01:30	969.10	969.67	969.00	969.39	969.65	968.60	969.18	969.23
2017/1/31	11:04:30	971.47	972.07	971.53	972.01	971.87	971.60	972.16	971.82
2017/1/31	11:07:30	975.86	976.23	975.70	976.36	976.59	976.05	976.50	976.18
2017/1/31	11:10:30	967.67	968.13	967.94	968.99	968.52	968.30	968.67	968.32
2017/1/31	11:13:30	974.35	975.03	974.30	974.47	974.03	974.61	974.36	974.45
2017/1/31	11:16:30	980.39	980.77	979.96	979.90	980.18	980.13	980.14	980.21
2017/1/31	11:31:30	987.90	988.53	988.54	988.32	988.43	987.85	987.90	988.21
2017/1/31	11:34:30	988.56	989.35	989.92	988.83	988.86	989.45	989.28	989.18
2017/1/31	11:37:30	991.33	992.16	991.36	992.03	991.50	991.09	990.70	991.45
2017/1/31	11:40:30	992.37	993.07	993.30	992.41	992.64	992.56	992.01	992.62
2017/1/31	11:43:30	990.18	990.86	990.77	990.41	990.48	990.67	990.08	990.49
2017/1/31	11:46:30	987.51	988.45	988.31	987.72	988.41	987.89	987.19	987.93
2017/1/31	12:01:30	984.17	984.59	984.41	984.41	984.14	984.09	984.01	984.26
2017/1/31	12:04:30	979.31	979.52	979.39	979.36	978.57	979.19	980.11	979.35
2017/1/31	12:07:30	980.57	980.83	980.44	980.43	979.93	980.32	981.31	980.55
2017/1/31	12:10:30	978.93	979.65	978.95	979.35	978.51	978.41	978.79	978.94
2017/1/31	12:13:30	977.58	978.51	977.37	977.56	976.93	977.50	977.88	977.62
2017/1/31	12:16:30	979.20	980.68	979.00	979.02	978.43	979.20	978.53	979.15
2017/1/31	12:31:30	964.47	964.50	964.67	964.69	964.56	963.82	963.84	964.37
2017/1/31	12:34:30	967.67	967.83	967.12	967.82	968.03	967.42	967.74	967.66
2017/1/31	12:37:30	969.36	970.02	969.20	970.11	970.01	969.70	969.69	969.73
2017/1/31	12:40:30	971.19	971.09	970.92	971.52	971.48	971.32	971.44	971.28
2017/1/31	12:43:30	957.74	958.34	957.74	956.98	957.10	957.30	958.07	957.61
2017/1/31	12:46:30	950.15	950.82	949.78	949.98	950.13	950.94	950.87	950.38
2017/1/31	13:01:30	950.19	950.64	950.57	950.48	950.80	950.67	950.77	950.59
2017/1/31	13:04:30	955.46	955.85	956.23	955.87	955.93	956.16	956.31	955.97
2017/1/31	13:07:30	951.43	951.90	951.34	951.54	951.51	952.15	953.01	951.84
2017/1/31	13:10:30	952.05	952.72	952.68	952.59	952.24	952.36	952.35	952.43
2017/1/31	13:13:30	946.83	947.58	946.44	946.64	946.45	946.57	946.47	946.71
2017/1/31	13:16:30	946.11	947.18	946.37	946.83	946.86	946.62	945.84	946.54
2017/1/31	13:31:30	930.83	931.42	930.77	931.37	931.73	930.48	931.46	931.15
2017/1/31	13:34:30	931.51	932.13	930.87	931.51	931.33	930.83	931.14	931.33
2017/1/31	13:37:30	939.12	939.67	939.57	938.97	938.84	939.13	939.88	939.31
2017/1/31	13:40:30	936.59	936.59	936.94	936.22	936.25	936.62	937.41	936.66
2017/1/31	13:43:30	931.22	931.67	931.19	931.45	932.50	931.80	931.59	931.63
2017/1/31	13:46:30	919.27	919.72	918.81	918.32	919.59	919.18	919.02	919.13
2017/1/31	14:01:30	892.35	892.33	892.70	892.46	892.27	891.87	892.12	892.30
2017/1/31	14:04:30	897.91	898.47	898.46	898.34	897.81	897.81	898.26	898.15
2017/1/31	14:07:30	888.96	889.21	888.62	889.10	889.14	889.14	888.89	889.01
2017/1/31	14:10:30	884.67	885.07	885.48	884.50	884.54	884.85	883.96	884.72
2017/1/31	14:13:30	878.61	879.55	878.76	879.45	878.97	879.21	878.16	878.96
2017/1/31	14:16:30	872.27	873.10	871.63	872.14	873.87	872.94	872.43	872.63

Date	Time	reference irr	AHF		PMO6		PMO6		PMO6		PMO6		AHF	
			36012		0806		0102		0809		951202		36014	
			CHINA		CHINA		HONG KONG		HONG KONG		KOREA		KOREA	
yyyy/mm/dd	hh:mm:ss	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	
2017/1/25	10:01:30	982.03	980.39	0.9983			985.06	1.0031	983.33	1.0013	985.21	1.0032	983.25	1.0012
2017/1/25	10:04:30	983.29	983.69	1.0004			986.13	1.0029	984.73	1.0015	987.05	1.0038	984.03	1.0008
2017/1/25	10:07:30	981.97	981.95	1.0000			985.25	1.0033	983.21	1.0013	985.57	1.0037	982.93	1.0010
2017/1/25	10:10:30	982.54	982.62	1.0001			986.32	1.0038	984.46	1.0020	986.37	1.0039	984.33	1.0018
2017/1/25	10:13:30	982.11	981.76	0.9996			985.15	1.0031	983.47	1.0014	985.91	1.0039	984.03	1.0020
2017/1/25	10:16:30	981.39	981.16	0.9998			984.89	1.0036	983.34	1.0020	985.58	1.0043	983.41	1.0021
2017/1/25	11:31:30	994.75	995.81	1.0011			996.86	1.0021	995.53	1.0008	998.40	1.0037	999.10	1.0044
2017/1/25	11:34:30	994.14	995.06	1.0009			997.97	1.0038	995.90	1.0018	997.08	1.0030	998.07	1.0040
2017/1/25	11:37:30	1000.12	1001.50	1.0014			1001.98	1.0019	1000.43	1.0003	1002.75	1.0026	1005.43	1.0053
2017/1/25	11:40:30	1000.74	1001.69	1.0010			1003.53	1.0028	1001.95	1.0012	1004.15	1.0034	1005.53	1.0048
2017/1/25	11:43:30	1003.79	1003.71	0.9999			1007.66	1.0039	1005.93	1.0021	1007.78	1.0040	1007.66	1.0039
2017/1/25	11:46:30	991.82	992.40	1.0006			995.93	1.0041	993.87	1.0021	997.99	1.0062	995.81	1.0040
2017/1/25	12:01:30	989.41			1001.30	1.0120	993.61	1.0042	992.27	1.0029	993.41	1.0040	989.47	1.0001
2017/1/25	12:04:30	988.80			989.92	1.0011	990.68	1.0019	989.54	1.0008	992.28	1.0035	990.64	1.0019
2017/1/25	12:07:30	985.64			984.86	0.9992	989.84	1.0043	987.79	1.0022	988.52	1.0029	985.84	1.0002
2017/1/25	12:10:30	984.10			983.78	0.9997	987.70	1.0037	985.76	1.0017	987.62	1.0036	984.97	1.0009
2017/1/25	12:13:30	996.31			996.80	1.0005	999.00	1.0027	997.47	1.0012	999.41	1.0031	997.56	1.0013
2017/1/25	12:16:30	985.59			985.10	0.9995	989.56	1.0040	987.79	1.0022	989.75	1.0042	986.68	1.0011
2017/1/25	13:01:30	973.33	973.98	1.0007	973.24	0.9999	976.00	1.0027	974.46	1.0012	976.50	1.0033	973.80	1.0005
2017/1/25	13:04:30	965.04	964.97	0.9999	964.62	0.9996	970.53	1.0057	968.56	1.0036	969.04	1.0042	965.11	1.0001
2017/1/25	13:07:30	960.55	961.28	1.0008	959.95	0.9994	965.61	1.0053	964.23	1.0038	963.94	1.0035	961.00	1.0005
2017/1/25	13:10:30	953.54	955.98	1.0026	954.82	1.0013	955.53	1.0021	953.52	1.0000	954.13	1.0006	955.65	1.0022
2017/1/25	13:13:30													
2017/1/25	13:16:30	955.12	956.02	1.0009	955.63	1.0005	959.81	1.0049	958.14	1.0032	960.58	1.0057	955.77	1.0007
2017/1/25	14:01:30													
2017/1/25	14:04:30													
2017/1/25	14:07:30													
2017/1/25	14:10:30													
2017/1/25	14:13:30	904.78			906.23	1.0016	906.26	1.0016	905.51	1.0008	907.15	1.0026	904.03	0.9992
2017/1/25	14:16:30	900.85			901.45	1.0007	905.03	1.0046	902.97	1.0023	904.50	1.0040	900.56	0.9997
2017/1/26	10:31:30	987.44	988.16	1.0007	987.56	1.0001	991.07	1.0037	989.78	1.0024	991.17	1.0038	988.16	1.0007
2017/1/26	10:34:30	990.47	991.53	1.0011	991.97	1.0015	993.56	1.0031	992.28	1.0018	994.51	1.0041	991.88	1.0014
2017/1/26	10:37:30	989.59	990.12	1.0005	990.41	1.0008	992.89	1.0033	991.37	1.0018	993.26	1.0037	991.06	1.0015
2017/1/26	10:40:30	984.84	985.76	1.0009	985.34	1.0005	997.99	1.0032	996.29	1.0015	998.46	1.0036	996.57	1.0017
2017/1/26	10:43:30	992.84	993.91	1.0011	993.02	1.0002	995.54	1.0027	993.98	1.0012	996.02	1.0032	993.75	1.0009
2017/1/26	10:46:30	992.92	993.63	1.0007	994.25	1.0013	995.30	1.0024	993.65	1.0007	996.89	1.0040	995.07	1.0022
2017/1/26	11:31:30	995.48	996.48	1.0010	995.97	1.0005	998.22	1.0028	996.15	1.0007	999.02	1.0036		
2017/1/26	11:34:30	1003.25	1004.66	1.0014	1004.00	1.0008	1005.45	1.0022	1004.10	1.0009	1006.77	1.0035	1004.56	1.0013
2017/1/26	11:37:30	1010.60	1011.24	1.0006	1010.70	1.0001	1013.40	1.0028	1011.75	1.0011	1013.79	1.0032	1011.02	1.0004
2017/1/26	11:40:30	1015.54	1017.39	1.0018	1015.50	1.0000	1019.21	1.0036	1017.36	1.0018	1018.89	1.0033	1016.84	1.0013
2017/1/26	11:43:30	1012.54	1013.55	1.0010	1012.80	1.0003	1016.32	1.0037	1014.73	1.0022	1015.94	1.0034	1013.35	1.0008
2017/1/26	11:46:30	1002.40	1003.71	1.0013	1002.80	1.0004	1004.54	1.0021	1003.01	1.0006	1005.15	1.0027	1003.85	1.0012
2017/1/26	12:01:30	1009.63	1010.54	1.0009	1009.70	1.0001	1012.32	1.0027	1011.04	1.0014	1012.72	1.0031	1010.39	1.0008
2017/1/26	12:04:30	994.34	995.44	1.0011	993.94	0.9996	997.51	1.0032	995.43	1.0011	996.62	1.0023	995.05	1.0007
2017/1/26	12:07:30	989.61	991.11	1.0015	990.03	1.0004	991.36	1.0018	990.55	1.0010	992.54	1.0030	990.60	1.0010
2017/1/26	12:10:30	995.91	997.22	1.0013	996.42	1.0005	998.60	1.0027	997.20	1.0013	998.99	1.0031	996.74	1.0008
2017/1/26	12:13:30	1002.75	1003.69	1.0009	1002.80	1.0000	1005.75	1.0030	1004.19	1.0014	1005.22	1.0025	1003.23	1.0005
2017/1/26	12:16:30	1002.65	1003.76	1.0011	1003.30	1.0007	1005.02	1.0024	1003.60	1.0010	1005.56	1.0029	1003.45	1.0008
2017/1/26	12:31:30	1004.57	1005.84	1.0013	1005.30	1.0007	1007.79	1.0032	1006.11	1.0015	1008.04	1.0035	1005.55	1.0010
2017/1/26	12:34:30	1006.47	1007.49	1.0010	1007.60	1.0011	1010.52	1.0040	1008.50	1.0020	1009.63	1.0031	1007.68	1.0012
2017/1/26	12:37:30	1000.54	1001.63	1.0011	1001.00	1.0005	1003.03	1.0025	1000.96	1.0004	1002.80	1.0023	1001.71	1.0012
2017/1/26	12:40:30	999.05	1000.45	1.0014	999.15	1.0001	1001.42	1.0024	999.60	1.0006	1001.27	1.0022	999.46	1.0004
2017/1/26	12:43:30	997.66	998.58	1.0009	998.59	1.0009	1000.52	1.0029	998.42	1.0008	1000.70	1.0030	998.66	1.0010
2017/1/26	12:46:30	990.13	991.96	1.0019	990.86	1.0007	993.52	1.0034	991.85	1.0017	993.37	1.0033	992.13	1.0020
2017/1/26	13:01:30	979.41	980.44	1.0011	979.76	1.0004	981.81	1.0025	980.47	1.0011	981.95	1.0026	979.59	1.0002
2017/1/26	13:04:30	968.85	970.70	1.0019	968.49	0.9996	970.47	1.0017	968.75	0.9999	971.02	1.0022	970.28	1.0015
2017/1/26	13:07:30	972.87	973.30	1.0004	973.19	1.0003	974.70	1.0019	973.29	1.0004	975.32	1.0025	973.11	1.0003
2017/1/26	13:10:30	971.57	972.50	1.0010	972.41	1.0009	974.78	1.0033	973.40	1.0019	974.60	1.0031	972.23	1.0007
2017/1/26	13:13:30	972.71	973.47	1.0008	971.82	0.9991	975.56	1.0029	973.16	1.0005	974.24	1.0016	973.47	1.0008
2017/1/26	13:16:30	967.11	967.11	1.0000	967.93	1.0008	971.05	1.0041	968.65	1.0016	970.15	1.0031	968.03	1.0009
2017/1/26	13:31:30	956.93	958.02	1.0011	956.30	0.9993	960.46	1.0037	958.72	1.0019	959.65	1.0028	957.02	1.0001
2017/1/26	13:34:30	950.42	951.79	1.0014	951.03	1.0006	953.20	1.0029	951.54	1.0012	953.25	1.0030	950.35	0.9999
2017/1/26	13:37:30	945.56	946.99	1.0015	946.04	1.0005	948.58	1.0032	946.93	1.0014	948.71	1.0033	946.24	1.0007
2017/1/26	13:40:30	945.18	946.04	1.0009	946.05	1.0009	948.25	1.0032	946.31	1.0012	947.94	1.0029	945.69	1.0005
2017/1/26	13:43:30	942.35	943.00	1.0007	943.43	1.0011	945.35	1.0032	944.03	1.0018	945.46	1.0033	942.97	1.0007
2017/1/26	13:46:30	939.27	941.02	1.0019	939.83	1.0006	942.36	1.0033	941.11	1.0020	942.06	1.0030	939.99	1.0008

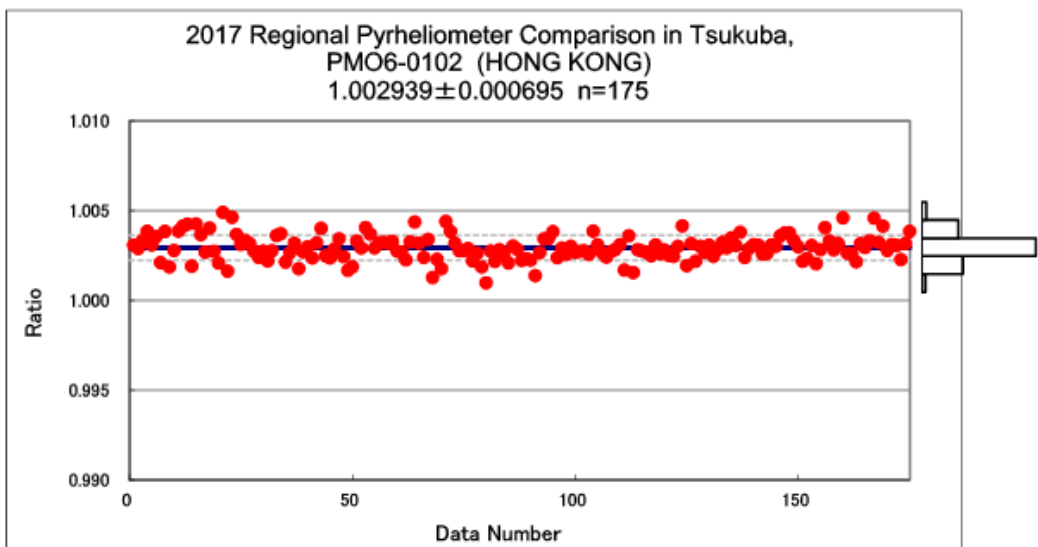
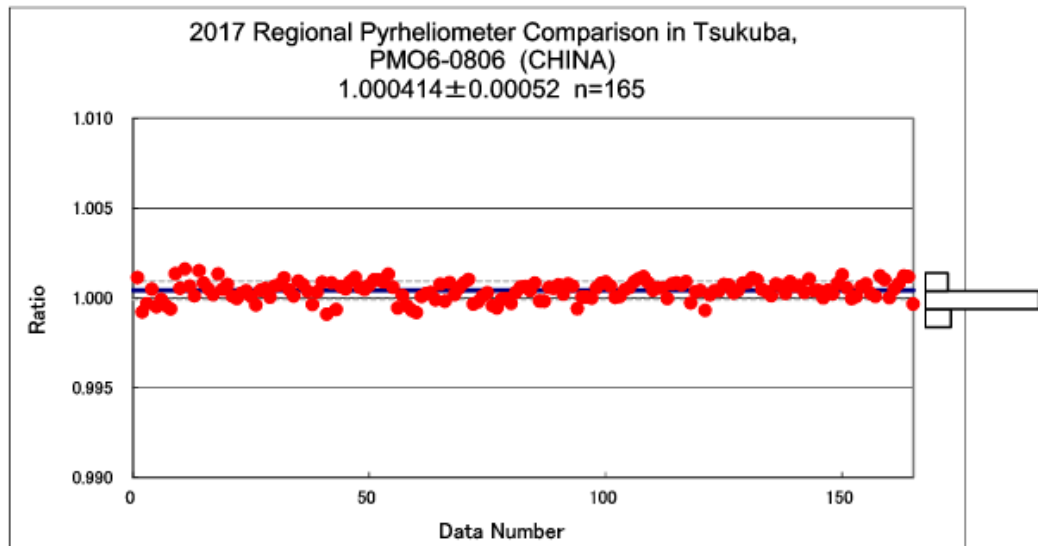
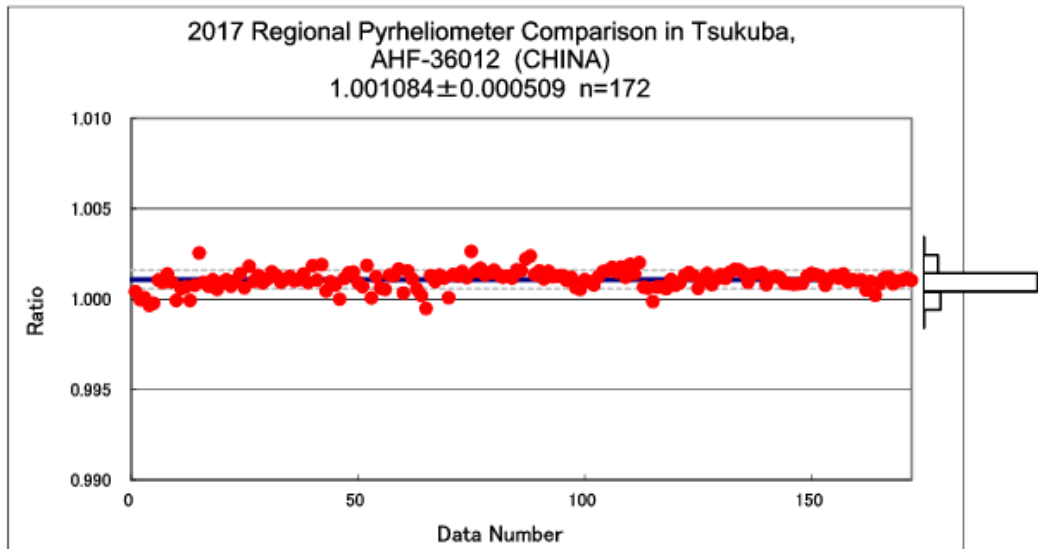
Date	Time	reference irr	AHF		PMO6		PMO6		PMO6		PMO6		AHF	
			36012		0806		0102		0809		951202		36014	
			CHINA		CHINA		HONG KONG		HONG KONG		KOREA		KOREA	
yyyy/mm/dd	hh:mm:ss	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	
2017/1/26	14:01:30	935.88	935.94	1.0001	936.32	1.0005	938.46	1.0028	936.81	1.0010	938.84	1.0032	936.63	1.0008
2017/1/26	14:04:30	925.40	926.55	1.0012	926.06	1.0007	927.90	1.0027	926.95	1.0017	928.12	1.0029	925.37	1.0000
2017/1/26	14:07:30	923.15	923.71	1.0006	924.08	1.0010	925.24	1.0023	924.14	1.0011	926.17	1.0033	923.45	1.0003
2017/1/26	14:10:30	921.13	921.63	1.0005	922.06	1.0010	924.14	1.0033	923.12	1.0022	923.84	1.0029	920.87	0.9997
2017/1/26	14:13:30	921.08	922.31	1.0013	921.90	1.0009	925.11	1.0044	923.27	1.0024	924.28	1.0035	921.22	1.0001
2017/1/26	14:16:30	917.95	919.15	1.0013	919.16	1.0013	920.87	1.0032	919.41	1.0016	921.44	1.0038	918.72	1.0008
2017/1/28	9:31:30	943.83	945.40	1.0017	944.39	1.0006	946.10	1.0024	945.13	1.0014	947.10	1.0035	945.66	1.0019
2017/1/28	9:34:30	947.67	947.99	1.0003	947.15	0.9994	950.89	1.0034	949.12	1.0015	950.03	1.0025	947.22	0.9995
2017/1/28	9:37:30	936.03	937.49	1.0016	936.16	1.0001	937.23	1.0013	935.63	0.9996	938.12	1.0022	937.44	1.0015
2017/1/28	9:40:30	951.62	952.68	1.0011	951.19	0.9995	953.80	1.0023	952.80	1.0012	954.55	1.0031	952.80	1.0012
2017/1/28	9:43:30	955.47	956.00	1.0005	954.80	0.9993	957.17	1.0018	955.49	1.0000	958.12	1.0028	958.19	1.0028
2017/1/28	9:46:30	959.73	959.92	1.0002	958.95	0.9992	963.96	1.0044	962.04	1.0024	962.64	1.0030	960.57	1.0009
2017/1/28	10:31:30	989.80	989.29	0.9995	989.87	1.0001	993.60	1.0038	991.59	1.0018	992.70	1.0029	989.95	1.0002
2017/1/28	10:34:30	984.52	985.79	1.0013	984.76	1.0002	985.01	1.0005	983.89	0.9994	986.70	1.0022	986.02	1.0015
2017/1/28	10:37:30	991.90	992.88	1.0010	992.19	1.0003	995.06	1.0032	993.80	1.0019	995.45	1.0036	992.90	1.0010
2017/1/28	10:40:30	995.73	997.05	1.0013	995.62	0.9999	1001.36	1.0057	998.86	1.0031	999.14	1.0034	997.13	1.0014
2017/1/28	10:43:30	996.05	997.20	1.0012	996.82	1.0008	998.81	1.0028	997.26	1.0012	999.31	1.0033	996.85	1.0008
2017/1/28	10:46:30	987.45	987.53	1.0001	987.27	0.9998	992.82	1.0054	990.93	1.0035	990.57	1.0032	987.48	1.0000
2017/1/28	11:01:30	991.65	993.00	1.0014	992.50	1.0009	994.40	1.0028	992.39	1.0007	994.55	1.0029	992.56	1.0009
2017/1/28	11:04:30	996.65	997.93	1.0013	996.82	1.0002	997.59	1.0009	996.60	1.0000	1000.31	1.0037	997.50	1.0009
2017/1/28	11:07:30	1007.23	1008.77	1.0015	1007.80	1.0006	1010.15	1.0029	1008.77	1.0015	1010.69	1.0034	1008.65	1.0014
2017/1/28	11:10:30	1004.26	1005.46	1.0012	1005.10	1.0008	1006.46	1.0022	1005.26	1.0010	1008.65	1.0044	1005.82	1.0016
2017/1/28	11:13:30	1008.47	1011.13	1.0026	1009.50	1.0010	1011.12	1.0026	1009.39	1.0009	1012.24	1.0037	1010.73	1.0022
2017/1/28	11:16:30	1007.24	1008.80	1.0016	1006.90	0.9997	1009.12	1.0019	1007.42	1.0002	1009.95	1.0027	1007.75	1.0005
2017/1/28	11:31:30	998.13	999.84	1.0017	997.92	0.9998	999.12	1.0010	998.13	1.0000	1001.42	1.0033	1000.01	1.0019
2017/1/28	11:34:30	990.32	991.64	1.0013	990.42	1.0001	993.05	1.0028	991.53	1.0012	993.16	1.0029	990.91	1.0006
2017/1/28	11:37:30	997.51	998.96	1.0015	997.80	1.0003	999.68	1.0022	998.38	1.0009	1001.01	1.0035	999.18	1.0017
2017/1/28	11:40:30	999.81	1001.41	1.0016	999.38	0.9996	1002.64	1.0028	1001.01	1.0012	1003.05	1.0032	1000.92	1.0011
2017/1/28	11:43:30	999.83	1001.17	1.0013	999.27	0.9994	1002.44	1.0026	1000.91	1.0011	1003.02	1.0032	1000.71	1.0009
2017/1/28	11:46:30	999.86	1001.07	1.0012	999.80	0.9999	1001.95	1.0021	1001.07	1.0012	1002.91	1.0030	1000.36	1.0005
2017/1/28	12:01:30	1004.55	1005.82	1.0013	1004.50	0.9999	1007.59	1.0030	1005.95	1.0014	1008.00	1.0034	1005.56	1.0010
2017/1/28	12:04:30	998.26	999.43	1.0012	997.95	0.9997	1001.11	1.0029	999.42	1.0012	1001.05	1.0028	998.71	1.0004
2017/1/28	12:07:30	996.67	998.28	1.0016	996.97	1.0003	998.90	1.0022	997.26	1.0006	999.90	1.0032	997.66	1.0010
2017/1/28	12:10:30	994.13	995.68	1.0016	994.72	1.0006	996.44	1.0023	995.22	1.0011	997.72	1.0036	995.18	1.0011
2017/1/28	12:13:30	994.28	996.49	1.0022	994.92	1.0006	996.52	1.0022	995.31	1.0010	997.60	1.0033	994.89	1.0006
2017/1/28	12:16:30	1005.68	1008.08	1.0024	1006.10	1.0004	1007.08	1.0014	1006.45	1.0008	1009.26	1.0036	1006.54	1.0009
2017/1/28	12:31:30	989.48	990.83	1.0014			992.12	1.0027	990.53	1.0011	992.73	1.0033	990.23	1.0008
2017/1/28	12:34:30	983.90	985.43	1.0016			987.28	1.0034	985.63	1.0018	987.46	1.0036	985.32	1.0014
2017/1/28	12:37:30	980.21	981.31	1.0011	994.10	1.0142	983.58	1.0034	981.63	1.0015	983.14	1.0030	981.12	1.0009
2017/1/28	12:40:30	975.45	976.95	1.0015	976.26	1.0008	979.18	1.0038	977.70	1.0023	978.84	1.0035	976.51	1.0011
2017/1/28	12:43:30	979.94	981.16	1.0012	979.78	0.9998	982.28	1.0024	981.16	1.0012	983.56	1.0037	980.76	1.0008
2017/1/28	12:46:30	978.30	979.56	1.0013	978.12	0.9998	981.16	1.0029	979.71	1.0014	980.93	1.0027	979.20	1.0009
2017/1/28	13:01:30	965.32	966.60	1.0013	965.88	1.0006	967.80	1.0026	966.32	1.0010	968.15	1.0029	966.26	1.0010
2017/1/28	13:04:30	971.71	972.72	1.0010	972.22	1.0005	974.64	1.0030	973.04	1.0014	974.76	1.0031	972.59	1.0009
2017/1/28	13:07:30	966.84	968.01	1.0012	967.56	1.0007	969.44	1.0027	967.73	1.0009	970.15	1.0034	967.70	1.0009
2017/1/28	13:10:30	970.58	971.20	1.0006	970.79	1.0002	973.24	1.0027	971.73	1.0012	973.82	1.0033	970.88	1.0003
2017/1/28	13:13:30	971.02	971.54	1.0005	971.71	1.0008	973.71	1.0028	972.22	1.0012	974.57	1.0037	972.00	1.0010
2017/1/28	13:16:30	959.99	961.01	1.0011	960.62	1.0007	962.46	1.0026	960.70	1.0007	962.92	1.0031	960.72	1.0008
2017/1/28	13:31:30	946.55	947.46	1.0010	945.99	0.9994	950.21	1.0039	948.36	1.0019			947.17	1.0007
2017/1/28	13:34:30	942.28	943.02	1.0008	942.32	1.0000	945.19	1.0031	943.39	1.0012			942.71	1.0005
2017/1/28	13:37:30	938.27	939.44	1.0012	938.31	1.0000	940.77	1.0027	939.67	1.0015			939.68	1.0015
2017/1/28	13:40:30	941.17	942.61	1.0015	941.15	1.0000	943.44	1.0024	941.82	1.0007			942.64	1.0016
2017/1/28	13:43:30	935.21	936.67	1.0016	935.73	1.0006	937.76	1.0027	936.22	1.0011			936.07	1.0009
2017/1/28	13:46:30	927.02	928.65	1.0018	927.78	1.0008	929.65	1.0028	928.27	1.0013			928.38	1.0015
2017/1/28	14:01:30	917.57	918.95	1.0015	918.39	1.0009	920.43	1.0031	919.13	1.0017	920.96	1.0037	918.03	1.0005
2017/1/28	14:04:30	915.83	917.46	1.0018	916.43	1.0007	917.39	1.0017	916.20	1.0004	917.98	1.0023	915.85	1.0000
2017/1/28	14:07:30	906.22	907.31	1.0012	906.25	1.0000	909.49	1.0036	908.35	1.0024	909.40	1.0035	905.41	0.9991
2017/1/28	14:10:30	907.26	909.01	1.0019	907.32	1.0001	908.67	1.0016	908.39	1.0012	911.22	1.0044	907.32	1.0001
2017/1/28	14:13:30	913.06	914.33	1.0014	913.48	1.0005	915.65	1.0028	914.41	1.0015	915.15	1.0023	912.50	0.9994
2017/1/28	14:16:30	921.17	923.03	1.0020	921.71	1.0006	923.71	1.0028	922.21	1.0011	923.62	1.0027	920.65	0.9994
2017/1/31	9:31:30	926.70	927.31	1.0007	927.53	1.0009	929.19	1.0027	928.12	1.0015	929.97	1.0035	928.06	1.0015
2017/1/31	9:34:30	929.27	929.84	1.0006	930.26	1.0011	931.59	1.0025	930.24	1.0010	932.52	1.0035	929.97	1.0008
2017/1/31	9:37:30	928.42	928.30	0.9999	929.51	1.0012	931.29	1.0031	929.90	1.0016	931.33	1.0031	928.79	1.0004
2017/1/31	9:40:30	930.92	931.54	1.0007	931.70	1.0008	933.34	1.0026	932.09	1.0013	934.37	1.0037	931.70	1.0008
2017/1/31	9:43:30	931.73	932.36	1.0007	932.12	1.0004	934.35	1.0028	933.22	1.0016	934.58	1.0031	932.37	1.0007
2017/1/31	9:46:30	936.17	936.72	1.0006	936.69	1.0006	938.52	1.0025	937.23	1.0011	939.43	1.0035	937.14	1.0010

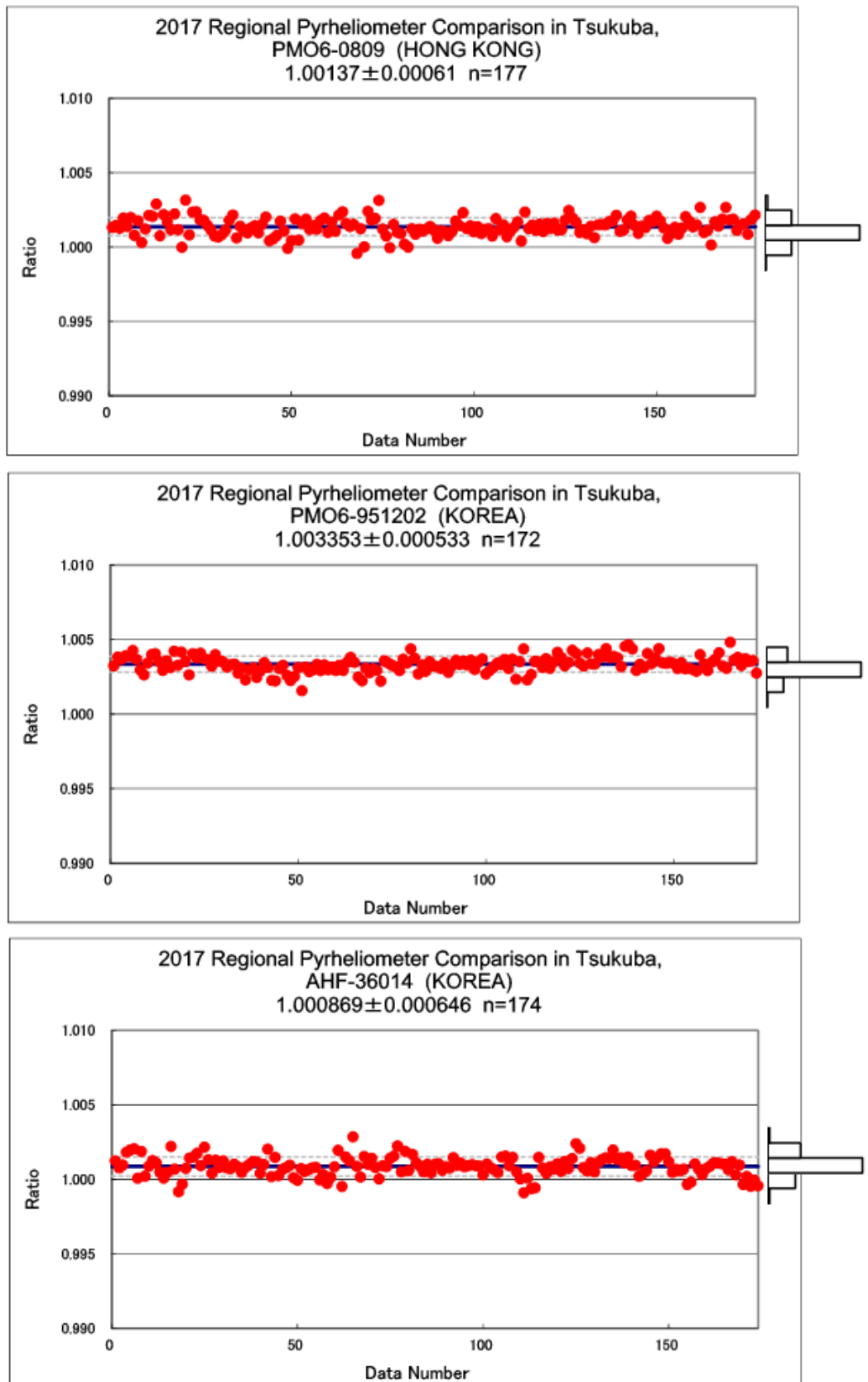
Date	Time	reference irr	AHF		PMO6		PMO6		PMO6		PMO6		AHF	
			36012		0806		0102		0809		951202		36014	
			CHINA		CHINA		HONG KONG		HONG KONG		KOREA		KOREA	
yyyy/mm/dd	hh:mm:ss		IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/31	10:01:30	952.94	953.97	1.0011	953.46	1.0005	955.29	1.0025	954.06	1.0012	956.88	1.0041	953.44	1.0005
2017/1/31	10:04:30	959.40	960.14	1.0008	959.37	1.0000	962.29	1.0030	961.14	1.0018	963.05	1.0038	960.54	1.0012
2017/1/31	10:07:30	957.97	958.84	1.0009	958.72	1.0008	961.95	1.0041	960.33	1.0025	961.08	1.0032	958.68	1.0007
2017/1/31	10:10:30	956.38	957.63	1.0013	957.18	1.0008	958.23	1.0019	958.23	1.0019	959.69	1.0035	957.71	1.0014
2017/1/31	10:13:30	959.54	960.94	1.0015	960.22	1.0007	962.58	1.0032	961.13	1.0017	963.64	1.0043	961.84	1.0024
2017/1/31	10:16:30	958.25	959.49	1.0013	959.11	1.0009	960.34	1.0022	959.19	1.0010	962.14	1.0041	960.24	1.0021
2017/1/31	10:31:30	959.24	959.81	1.0006	958.98	0.9997	962.14	1.0030	960.37	1.0012	962.52	1.0034	959.98	1.0008
2017/1/31	10:34:30	967.20	968.21	1.0010	967.54	1.0004	969.80	1.0027	968.07	1.0009	970.32	1.0032	967.74	1.0006
2017/1/31	10:37:30	972.76	974.15	1.0014	973.15	1.0004	975.75	1.0031	974.12	1.0014	976.74	1.0041	973.84	1.0011
2017/1/31	10:40:30	978.15	978.93	1.0008	977.48	0.9993	980.56	1.0025	978.77	1.0006	981.46	1.0034	978.65	1.0005
2017/1/31	10:43:30	979.27	980.37	1.0011	979.43	1.0002	982.06	1.0028	980.73	1.0015	982.57	1.0034	980.38	1.0011
2017/1/31	10:46:30	983.41	984.74	1.0013	983.80	1.0004	986.60	1.0032	984.90	1.0015	987.34	1.0040	984.72	1.0013
2017/1/31	11:01:30	969.23	970.34	1.0011	969.61	1.0004	972.06	1.0029	970.68	1.0015	972.95	1.0038	970.62	1.0014
2017/1/31	11:04:30	971.82	973.26	1.0015	972.54	1.0007	975.21	1.0035	973.48	1.0017	976.08	1.0044	973.17	1.0014
2017/1/31	11:07:30	976.18	977.78	1.0016	976.88	1.0007	979.17	1.0031	977.88	1.0017	979.88	1.0038	978.10	1.0020
2017/1/31	11:10:30	968.32	969.89	1.0016	968.58	1.0003	972.00	1.0038	970.39	1.0021	972.06	1.0039	969.62	1.0013
2017/1/31	11:13:30	974.45	975.86	1.0014	974.87	1.0004	976.79	1.0024	975.48	1.0011	978.12	1.0038	975.85	1.0014
2017/1/31	11:16:30	980.21	981.12	1.0009	981.01	1.0008	983.04	1.0029	981.33	1.0011	983.33	1.0032	981.29	1.0011
2017/1/31	11:31:30	988.21	989.55	1.0014	989.06	1.0009	991.29	1.0031	990.00	1.0018	992.69	1.0045	989.69	1.0015
2017/1/31	11:34:30	989.18	990.57	1.0014	990.28	1.0011	992.23	1.0031	991.24	1.0021	993.77	1.0046	990.11	1.0009
2017/1/31	11:37:30	991.45	992.89	1.0014	992.46	1.0010	994.02	1.0026	992.89	1.0014	995.79	1.0044	992.39	1.0009
2017/1/31	11:40:30	992.62	993.41	1.0008	993.10	1.0005	995.23	1.0026	993.54	1.0009	995.54	1.0029	992.83	1.0002
2017/1/31	11:43:30	990.49	991.65	1.0012	990.84	1.0004	993.56	1.0031	991.89	1.0014	993.80	1.0033	990.86	1.0004
2017/1/31	11:46:30	987.93	989.16	1.0013	988.05	1.0001	990.90	1.0030	989.24	1.0013	991.01	1.0031	988.50	1.0006
2017/1/31	12:01:30	984.26	985.44	1.0012	985.03	1.0008	987.80	1.0036	986.03	1.0018	988.25	1.0041	985.86	1.0016
2017/1/31	12:04:30	979.35	980.22	1.0009	980.00	1.0007	983.04	1.0038	981.02	1.0017	982.65	1.0034	980.50	1.0012
2017/1/31	12:07:30	980.55	981.39	1.0009	980.80	1.0003	984.25	1.0038	982.59	1.0021	984.24	1.0038	981.99	1.0015
2017/1/31	12:10:30	978.94	979.75	1.0008	979.83	1.0009	982.21	1.0033	980.67	1.0018	983.23	1.0044	980.63	1.0017
2017/1/31	12:13:30	977.62	978.45	1.0008	978.26	1.0007	980.54	1.0030	978.87	1.0013	980.97	1.0034	979.29	1.0017
2017/1/31	12:16:30	979.15	980.00	1.0009	979.82	1.0007	981.29	1.0022	979.73	1.0006	982.48	1.0034	980.31	1.0012
2017/1/31	12:31:30	964.37	965.60	1.0013	964.66	1.0003	966.62	1.0023	965.25	1.0009	967.73	1.0035	964.82	1.0005
2017/1/31	12:34:30	967.66	969.04	1.0014	968.69	1.0011	970.63	1.0031	968.95	1.0013	970.95	1.0034	968.31	1.0007
2017/1/31	12:37:30	969.73	971.04	1.0013	970.12	1.0004	971.71	1.0020	970.57	1.0009	972.69	1.0031	970.28	1.0006
2017/1/31	12:40:30	971.28	972.51	1.0013	971.68	1.0004	974.03	1.0028	972.52	1.0013	974.63	1.0034	971.95	1.0007
2017/1/31	12:43:30	957.61	958.35	1.0008	957.61	1.0000	961.50	1.0041	959.58	1.0021	960.53	1.0030	957.28	0.9997
2017/1/31	12:46:30	950.38	951.46	1.0011	950.78	1.0004	953.54	1.0033	952.03	1.0017	953.30	1.0031	950.20	0.9998
2017/1/31	13:01:30	950.59	951.84	1.0013	950.80	1.0002	953.27	1.0028	951.88	1.0014	953.43	1.0030	951.58	1.0010
2017/1/31	13:04:30	955.97	957.09	1.0012	956.75	1.0008	959.01	1.0032	957.40	1.0015	958.71	1.0029	956.62	1.0007
2017/1/31	13:07:30	951.84	953.17	1.0014	953.07	1.0013	956.22	1.0046	954.37	1.0027	955.63	1.0040	952.15	1.0003
2017/1/31	13:10:30	952.43	953.34	1.0010	952.95	1.0005	954.94	1.0026	953.36	1.0010	955.62	1.0034	953.09	1.0007
2017/1/31	13:13:30	946.71	947.72	1.0011	946.66	0.9999	949.18	1.0026	947.78	1.0011	949.47	1.0029	947.54	1.0009
2017/1/31	13:16:30	946.54	947.51	1.0010	946.63	1.0001	948.58	1.0022	946.68	1.0001	949.82	1.0035	947.56	1.0011
2017/1/31	13:31:30	931.15	932.14	1.0011	931.74	1.0006	934.10	1.0032	932.73	1.0017	934.56	1.0037	932.17	1.0011
2017/1/31	13:34:30	931.33	931.80	1.0005	932.05	1.0008	934.08	1.0030	932.63	1.0014	935.16	1.0041	932.31	1.0010
2017/1/31	13:37:30	939.31	940.23	1.0010	939.54	1.0002	942.43	1.0033	941.07	1.0019	942.33	1.0032	940.27	1.0010
2017/1/31	13:40:30	936.66	936.87	1.0002	936.74	1.0001	940.95	1.0046	939.15	1.0027	939.53	1.0031	937.28	1.0007
2017/1/31	13:43:30	931.63	932.41	1.0008	932.77	1.0012	934.64	1.0032	933.33	1.0018	936.12	1.0048	932.73	1.0012
2017/1/31	13:46:30	919.13	920.20	1.0012	920.06	1.0010	922.94	1.0041	920.86	1.0019	922.47	1.0036	919.40	1.0003
2017/1/31	14:01:30	892.30	893.39	1.0012	892.31	1.0000	894.79	1.0028	893.31	1.0011	895.70	1.0038	893.16	1.0010
2017/1/31	14:04:30	898.15	898.90	1.0008	898.59	1.0005	900.96	1.0031	899.48	1.0015	901.08	1.0033	897.85	0.9997
2017/1/31	14:07:30	889.01	889.92	1.0010	889.73	1.0008	891.73	1.0031	890.41	1.0016	892.30	1.0037	889.19	1.0002
2017/1/31	14:10:30	884.72	885.64	1.0010	885.80	1.0012	886.74	1.0023	885.49	1.0009	887.86	1.0035	884.31	0.9995
2017/1/31	14:13:30	878.96	879.98	1.0012	879.99	1.0012	881.75	1.0032	880.60	1.0019	882.12	1.0036	878.92	1.0000
2017/1/31	14:16:30	872.63	873.54	1.0010	872.33	0.9997	875.98	1.0038	874.51	1.0022	875.03	1.0028	872.25	0.9996

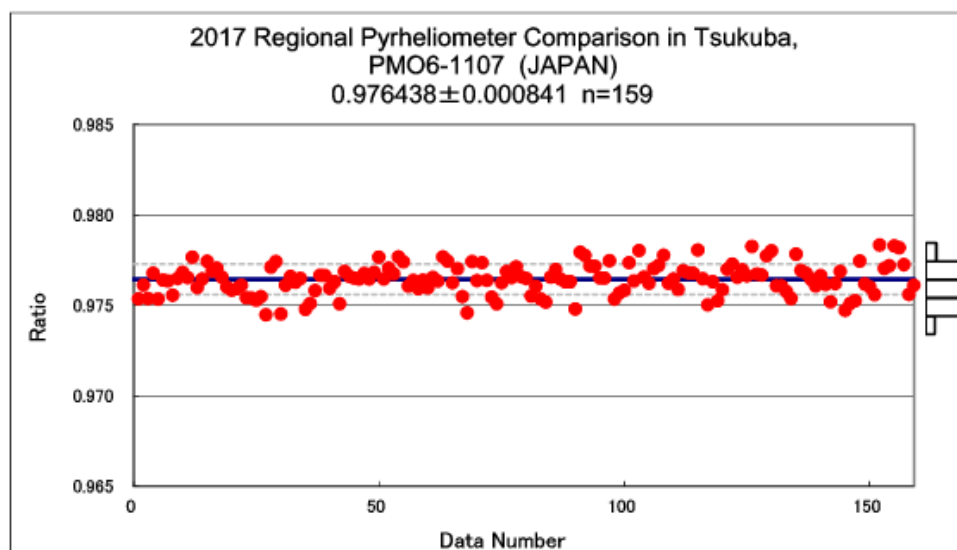
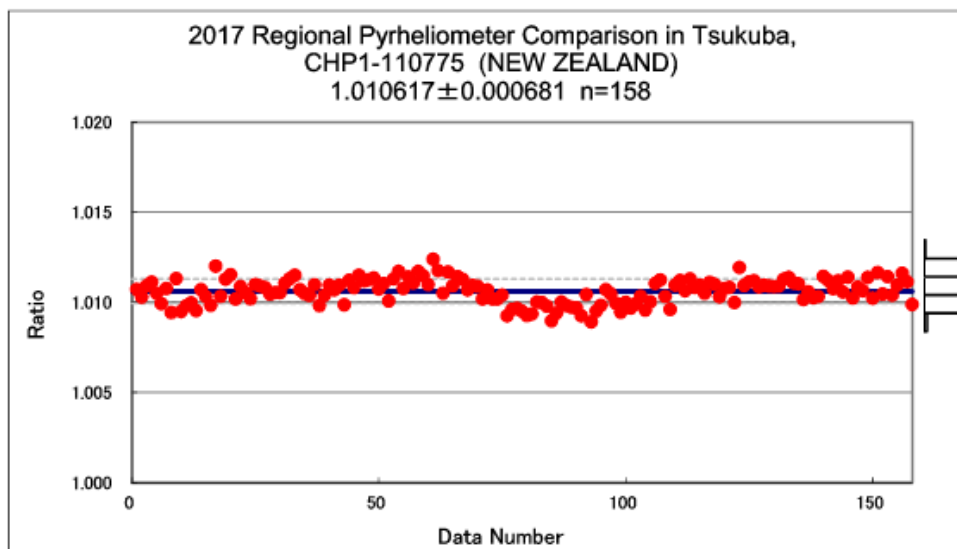
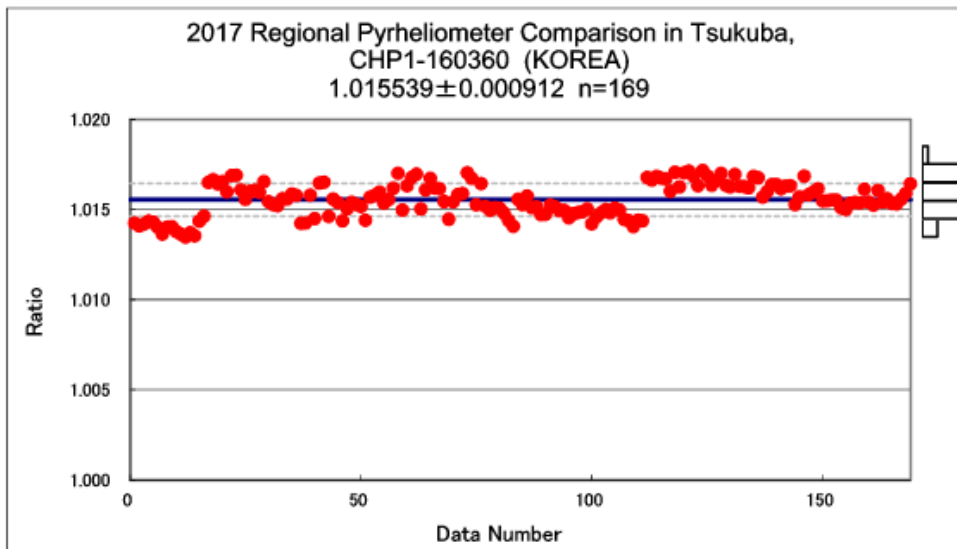
		reference irr	CHP1 160360		CHP1 110775		PMO6 1107		AHF 32446		ACR 01	
Date	Time		KOREA		NEW ZEALAND		JAPAN		JAPAN		Middleton Solar	
yyyy/mm/dd	hh:mm:ss		IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/25	10:01:30	982.03	996.02	1.0142			957.84	0.9754	981.23	0.9992		
2017/1/25	10:04:30	983.29	997.14	1.0141			959.81	0.9761	983.70	1.0004		
2017/1/25	10:07:30	981.97	995.90	1.0142	992.50	1.0107	957.79	0.9754	982.07	1.0001		
2017/1/25	10:10:30	982.54	996.65	1.0144			959.73	0.9768	983.30	1.0008		
2017/1/25	10:13:30	982.11	996.15	1.0143			957.90	0.9753	982.77	1.0007		
2017/1/25	10:16:30	981.39	995.16	1.0140			951.28	0.9693	982.28	1.0009		
2017/1/25	11:31:30	994.75	1008.32	1.0136	1005.00	1.0103	971.28	0.9764	995.26	1.0005		
2017/1/25	11:34:30	994.14	1008.07	1.0140	1005.00	1.0109	970.64	0.9764	994.82	1.0007		
2017/1/25	11:37:30	1000.12	1014.16	1.0140	1011.25	1.0111	975.68	0.9756	1001.21	1.0011		
2017/1/25	11:40:30	1000.74	1014.53	1.0138	1011.25	1.0105	977.21	0.9765	1001.70	1.0010		
2017/1/25	11:43:30	1003.79	1017.14	1.0133	1013.75	1.0099	980.53	0.9768	1003.61	0.9998		
2017/1/25	11:46:30	991.82	1005.34	1.0136	1002.50	1.0108	968.54	0.9765	992.10	1.0003		
2017/1/25	12:01:30	989.41	1002.73	1.0135	998.75	1.0094	967.31	0.9777	988.36	0.9989		
2017/1/25	12:04:30	988.80	1002.36	1.0137	1000.00	1.0113	965.06	0.9760	988.77	1.0000		
2017/1/25	12:07:30	985.64	998.63	1.0132	995.00	1.0095	960.05	0.9740	984.68	0.9990		
2017/1/25	12:10:30	984.10	997.02	1.0131	993.75	1.0098	960.94	0.9765	983.49	0.9994		
2017/1/25	12:13:30	996.31	1009.44	1.0132	1006.25	1.0100	973.82	0.9774	996.27	1.0000		
2017/1/25	12:16:30	985.59	998.39	1.0130	995.00	1.0095	965.34	0.9795	984.92	0.9993		
2017/1/25	13:01:30	973.33	985.84	1.0129	983.75	1.0107	950.85	0.9769	973.39	1.0001		
2017/1/25	13:04:30	965.04	977.14	1.0125	975.00	1.0103	938.80	0.9728	964.46	0.9994		
2017/1/25	13:07:30	960.55	973.04	1.0130	970.00	1.0098	941.12	0.9798	960.38	0.9998		
2017/1/25	13:10:30	953.54	966.46	1.0136	965.00	1.0120	926.01	0.9711	954.99	1.0015		
2017/1/25	13:13:30											
2017/1/25	13:16:30	955.12	967.20	1.0127	965.00	1.0103	936.52	0.9805	954.94	0.9998		
2017/1/25	14:01:30											
2017/1/25	14:04:30											
2017/1/25	14:07:30											
2017/1/25	14:10:30											
2017/1/25	14:13:30	904.78	917.76	1.0144	915.00	1.0113	881.10	0.9738	905.18	1.0004		
2017/1/25	14:16:30	900.85	914.04	1.0146	911.25	1.0115	874.33	0.9706	901.45	1.0007		
2017/1/26	10:31:30	987.44	1003.73	1.0165	997.50	1.0102	964.78	0.9771	986.85	0.9994	977.41	0.9898
2017/1/26	10:34:30	990.47	1006.96	1.0166	1001.25	1.0109	967.26	0.9766	991.09	1.0006	979.87	0.9893
2017/1/26	10:37:30	989.59	1005.84	1.0164	1000.00	1.0105	965.86	0.9760	990.15	1.0006	978.24	0.9885
2017/1/26	10:40:30	994.84	1011.30	1.0165	1005.00	1.0102	970.80	0.9758	995.24	1.0004	984.22	0.9893
2017/1/26	10:43:30	992.84	1008.70	1.0160	1003.75	1.0110	968.94	0.9759	993.16	1.0003	981.74	0.9888
2017/1/26	10:46:30	992.92	1009.69	1.0169	1003.75	1.0109	969.20	0.9761	993.53	1.0006	981.37	0.9884
2017/1/26	11:31:30	995.48	1012.30	1.0169	1006.25	1.0108	971.02	0.9754	995.43	0.9999	984.56	0.9890
2017/1/26	11:34:30	1003.25	1019.38	1.0161	1013.75	1.0105	978.58	0.9754	1003.24	1.0000	993.35	0.9901
2017/1/26	11:37:30	1010.60	1026.34	1.0156	1021.25	1.0105	984.66	0.9743	1010.18	0.9996	1000.71	0.9902
2017/1/26	11:40:30	1015.54	1031.80	1.0160	1026.25	1.0105	990.44	0.9753	1015.75	1.0002	1004.79	0.9894
2017/1/26	11:43:30	1012.54	1028.82	1.0161	1023.75	1.0111	987.72	0.9755	1011.73	0.9992	1002.78	0.9904
2017/1/26	11:46:30	1002.40	1018.39	1.0159	1013.75	1.0113	974.86	0.9725	1002.04	0.9996	992.32	0.9899
2017/1/26	12:01:30	1009.63	1026.34	1.0165	1021.25	1.0115	983.86	0.9745	1008.91	0.9993		
2017/1/26	12:04:30	994.34	1009.69	1.0154	1005.00	1.0107	971.59	0.9771	994.24	0.9999		
2017/1/26	12:07:30	989.61	1004.72	1.0153	1000.00	1.0105	967.26	0.9774	989.67	1.0001		
2017/1/26	12:10:30	995.91	1011.06	1.0152	1006.25	1.0104	970.53	0.9745	995.63	0.9997		
2017/1/26	12:13:30	1002.75	1018.39	1.0156	1013.75	1.0110	978.79	0.9761	1002.49	0.9997		
2017/1/26	12:16:30	1002.65	1018.26	1.0156	1012.50	1.0098	979.18	0.9766	1002.53	0.9999		
2017/1/26	12:31:30	1004.57	1020.50	1.0159	1015.00	1.0104	980.73	0.9763	1004.79	1.0002		
2017/1/26	12:34:30	1006.47	1022.36	1.0158	1017.50	1.0110	982.81	0.9765	1006.71	1.0002	994.17	0.9878
2017/1/26	12:37:30	1000.54	1014.78	1.0142	1011.25	1.0107	975.31	0.9748	1000.25	0.9997	989.32	0.9888
2017/1/26	12:40:30	999.05	1013.29	1.0143	1010.00	1.0110	974.18	0.9751	998.63	0.9996	988.40	0.9893
2017/1/26	12:43:30	997.66	1013.42	1.0158	1007.50	1.0099	973.53	0.9758	997.89	1.0002	987.34	0.9897
2017/1/26	12:46:30	990.13	1004.47	1.0145	1001.25	1.0112	967.01	0.9767	990.69	1.0006	980.92	0.9907
2017/1/26	13:01:30	979.41	995.53	1.0165	990.00	1.0108	956.53	0.9766	979.65	1.0002	969.87	0.9903
2017/1/26	13:04:30	968.85	984.84	1.0165	980.00	1.0115	939.73	0.9699	969.26	1.0004	958.51	0.9893
2017/1/26	13:07:30	972.87	987.08	1.0146	983.75	1.0112	949.46	0.9759	973.28	1.0004	964.20	0.9911
2017/1/26	13:10:30	971.57	986.71	1.0156	982.50	1.0113	948.54	0.9763	972.38	1.0008	963.10	0.9913
2017/1/26	13:13:30	972.71	985.71	1.0134	983.75	1.0113	948.48	0.9751	972.54	0.9998	964.04	0.9911
2017/1/26	13:16:30	967.11	981.99	1.0154	977.50	1.0107	944.75	0.9769	967.28	1.0002	958.96	0.9916
2017/1/26	13:31:30	956.93	970.68	1.0144	967.50	1.0110	934.53	0.9766	956.98	1.0001		
2017/1/26	13:34:30	950.42	964.72	1.0150	960.00	1.0101	928.09	0.9765	950.74	1.0003		
2017/1/26	13:37:30	945.56	960.12	1.0154	956.25	1.0113	923.30	0.9765	946.06	1.0005		
2017/1/26	13:40:30	945.18	959.63	1.0153	956.25	1.0117	923.22	0.9768	945.68	1.0005		
2017/1/26	13:43:30	942.35	956.65	1.0152	952.50	1.0108	920.16	0.9765	942.97	1.0007		
2017/1/26	13:46:30	939.27	952.80	1.0144	950.00	1.0114	917.51	0.9768	939.38	1.0001		

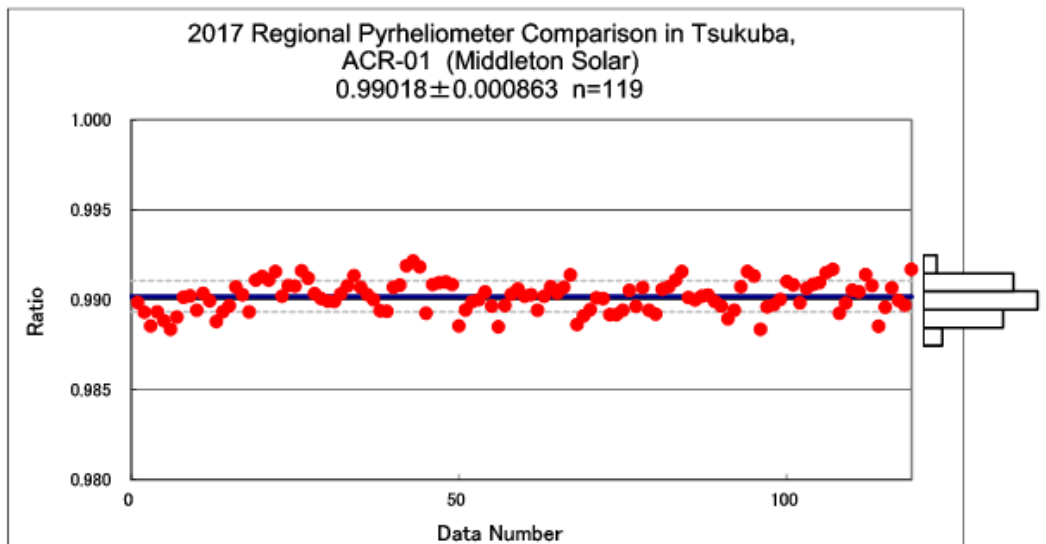
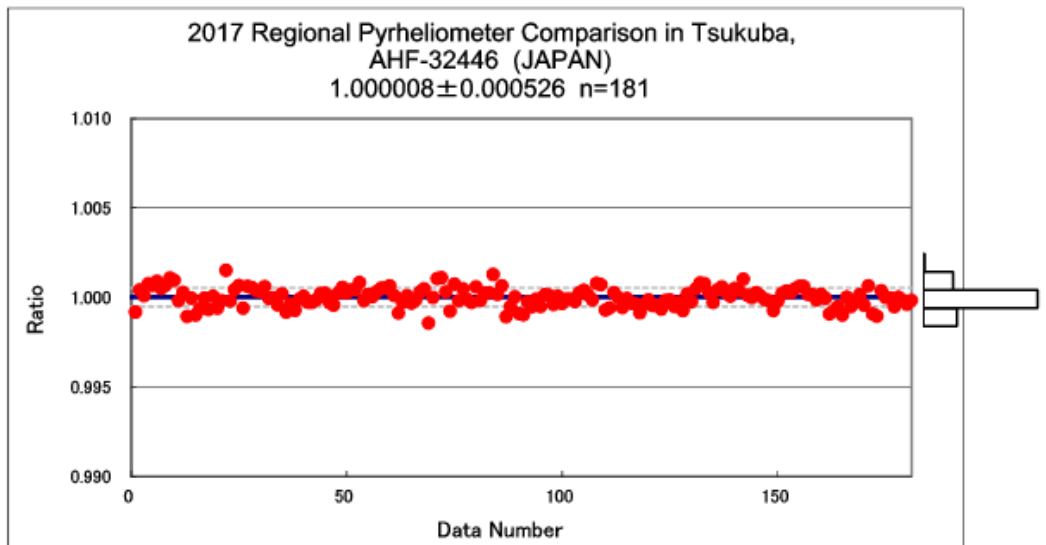
Date	Time	reference irr	CHP1 160380		CHP1 110775		PMO6 1107		AHF 32446		ACR 01	
			KOREA		NEW ZEALAND		JAPAN		JAPAN		Middleton Solar	
			IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/26	14:01:30	935.88	950.56	1.0157	946.25	1.0111	914.98	0.9777	935.07	0.9991	926.71	0.9902
2017/1/26	14:04:30	925.40	940.00	1.0158	936.25	1.0117	903.62	0.9765	925.15	0.9997	916.87	0.9908
2017/1/26	14:07:30	923.15	937.89	1.0160	933.75	1.0115	901.97	0.9771	923.24	1.0001	914.62	0.9908
2017/1/26	14:10:30	921.13	935.28	1.0154	931.25	1.0110	899.70	0.9767	920.84	0.9997	913.40	0.9916
2017/1/26	14:13:30	921.08	935.40	1.0155	932.50	1.0124	900.53	0.9777	920.95	0.9999	912.98	0.9912
2017/1/26	14:16:30	917.95	932.80	1.0162	928.75	1.0118	897.21	0.9774	918.22	1.0003	909.08	0.9903
2017/1/28	9:31:30	943.83	959.88	1.0170	953.75	1.0105	921.23	0.9761	944.28	1.0005	934.45	0.9901
2017/1/28	9:34:30	947.67	961.86	1.0150	958.75	1.0117	925.29	0.9764	946.31	0.9986	938.11	0.9899
2017/1/28	9:37:30	936.03	951.30	1.0163	946.25	1.0109	913.50	0.9759	936.03	1.0000	926.58	0.9899
2017/1/28	9:40:30	951.62	967.58	1.0168	962.50	1.0114	929.16	0.9764	952.62	1.0011	942.40	0.9903
2017/1/28	9:43:30	955.47	971.68	1.0170	966.25	1.0113	932.51	0.9760	956.53	1.0011	946.65	0.9908
2017/1/28	9:46:30	959.73	974.16	1.0150	970.00	1.0107	937.22	0.9765	960.04	1.0003	951.41	0.9913
2017/1/28	10:31:30	989.80	1005.71	1.0161			966.38	0.9763	989.04	0.9992		
2017/1/28	10:34:30	984.52	1000.99	1.0167			959.23	0.9743	985.25	1.0007	972.78	0.9881
2017/1/28	10:37:30	991.90	1007.95	1.0162			969.76	0.9777	991.73	0.9998	982.65	0.9907
2017/1/28	10:40:30	995.73	1011.80	1.0161			973.28	0.9775	996.22	1.0005	986.06	0.9903
2017/1/28	10:43:30	996.05	1011.43	1.0154			972.39	0.9762	995.94	0.9999	986.09	0.9900
2017/1/28	10:46:30	987.45	1001.74	1.0145			964.77	0.9770	987.19	0.9997	976.97	0.9894
2017/1/28	11:01:30	991.65	1006.96	1.0154	1002.50	1.0109	967.34	0.9755	992.24	1.0006	981.09	0.9894
2017/1/28	11:04:30	996.65	1012.42	1.0158	1007.50	1.0109	971.31	0.9746	996.49	0.9998	987.37	0.9907
2017/1/28	11:07:30	1007.23	1023.23	1.0159	1017.50	1.0102	984.49	0.9774	1007.47	1.0002	997.97	0.9908
2017/1/28	11:10:30	1004.26	1021.37	1.0170	1015.00	1.0107	980.52	0.9764	1004.53	1.0003	996.11	0.9919
2017/1/28	11:13:30	1008.47	1025.34	1.0167	1018.75	1.0102	985.64	0.9774	1009.77	1.0013	1000.55	0.9922
2017/1/28	11:16:30	1007.24	1022.61	1.0153	1017.50	1.0102	983.46	0.9764	1007.41	1.0002	999.00	0.9918
2017/1/28	11:31:30	998.13	1014.53	1.0164			973.63	0.9754	998.78	1.0006		
2017/1/28	11:34:30	990.32	1005.34	1.0152			965.65	0.9751	989.26	0.9989	979.67	0.9892
2017/1/28	11:37:30	997.51	1012.42	1.0149			973.82	0.9762	997.00	0.9995	988.38	0.9908
2017/1/28	11:40:30	999.81	1014.91	1.0151			976.68	0.9769	999.84	1.0000	990.76	0.9909
2017/1/28	11:43:30	999.83	1014.91	1.0151			976.36	0.9765	998.93	0.9991	990.81	0.9910
2017/1/28	11:46:30	999.86	1014.66	1.0148			976.99	0.9771	998.90	0.9990	990.70	0.9908
2017/1/28	12:01:30	1004.55	1019.01	1.0144	1015.00	1.0104	981.03	0.9766	1004.30	0.9998	993.04	0.9885
2017/1/28	12:04:30	998.26	1012.30	1.0141	1007.50	1.0093	974.80	0.9765	997.74	0.9995	987.71	0.9894
2017/1/28	12:07:30	996.67	1012.17	1.0156	1006.25	1.0096	972.27	0.9755	996.58	0.9999	986.59	0.9899
2017/1/28	12:10:30	994.13	1009.32	1.0153	1003.75	1.0097	970.32	0.9760	993.63	0.9995	984.19	0.9900
2017/1/28	12:13:30	994.28	1009.94	1.0157	1003.75	1.0095	969.77	0.9753	994.44	1.0002	984.76	0.9904
2017/1/28	12:16:30	1005.68	1020.87	1.0151	1015.00	1.0093	980.72	0.9752	1005.80	1.0001	995.26	0.9896
2017/1/28	12:31:30	989.48	1004.47	1.0151	998.75	1.0094	966.29	0.9766	989.09	0.9996	978.09	0.9885
2017/1/28	12:34:30	983.90	998.39	1.0147	993.75	1.0100	961.25	0.9770	983.96	1.0001	973.74	0.9897
2017/1/28	12:37:30	980.21	994.66	1.0147	990.00	1.0100	957.13	0.9765	979.87	0.9997	970.70	0.9903
2017/1/28	12:40:30	975.45	990.31	1.0152	985.00	1.0098	952.33	0.9763	975.36	0.9999	966.28	0.9906
2017/1/28	12:43:30	979.94	994.78	1.0151	988.75	1.0090	956.72	0.9763	979.86	0.9999	970.33	0.9902
2017/1/28	12:46:30	978.30	992.92	1.0149	987.50	1.0094	953.65	0.9748	978.08	0.9998	968.78	0.9903
2017/1/28	13:01:30	965.32	979.75	1.0149	975.00	1.0100	944.02	0.9779	965.57	1.0003	955.10	0.9894
2017/1/28	13:04:30	971.71	985.84	1.0145	981.25	1.0098	950.09	0.9778	972.10	1.0004	962.18	0.9902
2017/1/28	13:07:30	966.84	981.12	1.0148	976.25	1.0097	944.78	0.9772	966.99	1.0001	957.87	0.9907
2017/1/28	13:10:30	970.58	984.97	1.0148	980.00	1.0097	948.41	0.9772	970.46	0.9999	961.23	0.9904
2017/1/28	13:13:30	971.02	985.47	1.0149	980.00	1.0093	951.10	0.9795	971.79	1.0008	961.97	0.9907
2017/1/28	13:16:30	959.99	974.41	1.0150	970.00	1.0104	937.44	0.9765	960.68	1.0007	951.71	0.9914
2017/1/28	13:31:30	946.55	960.00	1.0142	955.00	1.0089	924.32	0.9765	945.89	0.9993	935.78	0.9886
2017/1/28	13:34:30	942.28	956.02	1.0146	951.25	1.0095	917.86	0.9741	941.73	0.9994	932.01	0.9891
2017/1/28	13:37:30	938.27	952.17	1.0148	947.50	1.0098	917.13	0.9775	938.52	1.0003	928.37	0.9894
2017/1/28	13:40:30	941.17	955.28	1.0150	951.25	1.0107	917.96	0.9753	941.15	1.0000	931.85	0.9901
2017/1/28	13:43:30	935.21	949.07	1.0148	945.00	1.0105	912.47	0.9757	934.68	0.9994	925.92	0.9901
2017/1/28	13:46:30	927.02	940.99	1.0151	936.25	1.0100	904.62	0.9758	926.97	0.9999	916.98	0.9892
2017/1/28	14:01:30	917.57	931.30	1.0150	926.25	1.0095	896.80	0.9774	917.28	0.9997	907.64	0.9892
2017/1/28	14:04:30	915.83	929.07	1.0145	925.00	1.0100	894.17	0.9763	915.51	0.9997	906.14	0.9894
2017/1/28	14:07:30	906.22	919.25	1.0144	915.00	1.0097	887.64	0.9795	905.45	0.9991	897.63	0.9905
2017/1/28	14:10:30	907.26	920.00	1.0140	916.25	1.0099	887.33	0.9780	906.88	0.9996	897.84	0.9896
2017/1/28	14:13:30	913.06	926.21	1.0144	922.50	1.0103	891.67	0.9766	912.94	0.9999	904.54	0.9907
2017/1/28	14:16:30	921.17	934.41	1.0144	930.00	1.0096	899.26	0.9762	920.75	0.9995	911.42	0.9894
2017/1/31	9:31:30	926.70	942.24	1.0168			905.40	0.9770	926.27	0.9995		
2017/1/31	9:34:30	929.27	944.72	1.0166			908.09	0.9772	928.67	0.9994		
2017/1/31	9:37:30	928.42	944.72	1.0176			907.78	0.9778	928.27	0.9998		
2017/1/31	9:40:30	930.92	946.58	1.0168			908.78	0.9762	930.79	0.9999		
2017/1/31	9:43:30	931.73	947.33	1.0167			909.79	0.9765	931.26	0.9995		
2017/1/31	9:46:30	936.17	951.80	1.0167			913.59	0.9759	935.91	0.9997		

Date yyyy/mm/dd	Time hh:mm:ss	reference irr	CHP1 160380		CHP1 110775		PMO6 1107		AHF 32446		ACR 01	
			KOREA		NEW ZEALAND		JAPAN		JAPAN		Middleton Solar	
			IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/31	10:01:30	952.94	968.20	1.0160	962.50	1.0100	930.94	0.9769	952.23	0.9993		
2017/1/31	10:04:30	959.40	975.78	1.0171	970.00	1.0110	937.14	0.9768	959.59	1.0002		
2017/1/31	10:07:30	957.97	973.54	1.0162	968.75	1.0112	935.73	0.9768	957.75	0.9998		
2017/1/31	10:10:30	956.38	972.67	1.0170	966.25	1.0103	935.40	0.9781	956.85	1.0005		
2017/1/31	10:13:30	959.54	976.52	1.0177	968.75	1.0096	936.97	0.9765	960.31	1.0008		
2017/1/31	10:16:30	958.25	974.66	1.0171	968.75	1.0110	934.32	0.9750	958.99	1.0008		
2017/1/31	10:31:30	959.24	975.40	1.0168	970.00	1.0112	936.52	0.9763	959.49	1.0003		
2017/1/31	10:34:30	967.20	982.98	1.0163	977.50	1.0106	942.29	0.9742	966.94	0.9997		
2017/1/31	10:37:30	972.76	989.44	1.0172	983.75	1.0113	948.68	0.9752	973.17	1.0004		
2017/1/31	10:40:30	978.15	994.66	1.0169	988.75	1.0108	954.54	0.9759	978.74	1.0006		
2017/1/31	10:43:30	979.27	995.28	1.0163	990.00	1.0110	956.74	0.9770	979.57	1.0003		
2017/1/31	10:46:30	983.41	999.75	1.0166	993.75	1.0105	961.08	0.9773	983.48	1.0001		
2017/1/31	11:01:30	969.23	985.71	1.0170	980.00	1.0111	946.50	0.9766	969.71	1.0005	958.76	0.9892
2017/1/31	11:04:30	971.82	987.70	1.0163	982.50	1.0110	949.43	0.9770	972.19	1.0004	962.66	0.9906
2017/1/31	11:07:30	976.18	992.05	1.0163	986.25	1.0103	953.36	0.9766	977.18	1.0010	967.12	0.9907
2017/1/31	11:10:30	968.32	984.72	1.0169	978.75	1.0108	947.26	0.9783	968.45	1.0001	959.69	0.9911
2017/1/31	11:13:30	974.45	990.31	1.0163	985.00	1.0108	951.77	0.9767	974.44	1.0000	967.00	0.9924
2017/1/31	11:16:30	980.21	996.15	1.0163	990.00	1.0100	957.35	0.9767	980.47	1.0003	971.94	0.9916
2017/1/31	11:31:30	988.21	1004.22	1.0162	1000.00	1.0119	966.21	0.9777	988.29	1.0001	978.44	0.9901
2017/1/31	11:34:30	989.18	1005.84	1.0168	1000.00	1.0109	969.61	0.9802	989.07	0.9999	979.26	0.9900
2017/1/31	11:37:30	991.45	1008.07	1.0168	1002.50	1.0111	969.66	0.9780	991.28	0.9998	981.74	0.9902
2017/1/31	11:40:30	992.62	1008.20	1.0157	1003.75	1.0112	968.88	0.9761	991.90	0.9993	982.95	0.9903
2017/1/31	11:43:30	990.49	1006.34	1.0160	1001.25	1.0109	966.79	0.9761	990.28	0.9998	980.49	0.9899
2017/1/31	11:46:30	987.93	1004.10	1.0164	998.75	1.0110	963.98	0.9758	988.15	1.0002	977.69	0.9896
2017/1/31	12:01:30	984.26	1000.37	1.0164	995.00	1.0109	960.03	0.9754	984.62	1.0004	973.37	0.9889
2017/1/31	12:04:30	979.35	995.16	1.0161	990.00	1.0109	957.64	0.9778	979.61	1.0003	968.99	0.9894
2017/1/31	12:07:30	980.55	996.52	1.0163	991.25	1.0109	957.93	0.9769	981.02	1.0005	971.44	0.9907
2017/1/31	12:10:30	978.94	994.91	1.0163	990.00	1.0113	956.21	0.9768	979.55	1.0006	970.68	0.9916
2017/1/31	12:13:30	977.62	992.55	1.0153	988.75	1.0114	954.59	0.9764	978.22	1.0006	969.12	0.9913
2017/1/31	12:16:30	979.15	994.53	1.0157	990.00	1.0111	955.73	0.9761	979.32	1.0002	971.51	0.9922
2017/1/31	12:31:30	964.37	980.62	1.0169	975.00	1.0110	941.84	0.9766	964.52	1.0002	953.13	0.9883
2017/1/31	12:34:30	967.66	982.98	1.0158	977.50	1.0102	944.59	0.9762	967.53	0.9999	957.59	0.9896
2017/1/31	12:37:30	969.73	985.22	1.0160	980.00	1.0106	945.67	0.9752	969.89	1.0002	959.76	0.9897
2017/1/31	12:40:30	971.28	986.96	1.0161	981.25	1.0103	948.17	0.9762	971.23	1.0000	961.58	0.9900
2017/1/31	12:43:30	957.61	972.42	1.0155	967.50	1.0103	935.47	0.9769	956.74	0.9991	949.00	0.9910
2017/1/31	12:46:30	950.38	965.09	1.0155	961.25	1.0114	926.36	0.9747	949.69	0.9993	941.66	0.9908
2017/1/31	13:01:30	950.59	965.34	1.0155	961.25	1.0112	926.92	0.9751	950.11	0.9995	940.92	0.9898
2017/1/31	13:04:30	955.97	970.81	1.0155	966.25	1.0108	932.32	0.9753	955.03	0.9990	947.02	0.9906
2017/1/31	13:07:30	951.84	966.21	1.0151	962.50	1.0112	930.37	0.9774	951.86	1.0000	943.14	0.9909
2017/1/31	13:10:30	952.43	966.71	1.0150	962.50	1.0106	929.74	0.9762	951.95	0.9995	943.80	0.9909
2017/1/31	13:13:30	946.71	961.24	1.0154	957.50	1.0114	924.01	0.9760	946.54	0.9998	938.66	0.9915
2017/1/31	13:16:30	946.54	961.12	1.0154	956.25	1.0103	923.44	0.9756	946.69	1.0002	938.67	0.9917
2017/1/31	13:31:30	931.15	945.47	1.0154	941.25	1.0108	910.98	0.9783	930.76	0.9996	921.14	0.9893
2017/1/31	13:34:30	931.33	946.34	1.0161	941.25	1.0107	909.95	0.9770	931.94	1.0007	921.84	0.9898
2017/1/31	13:37:30	939.31	953.79	1.0154	950.00	1.0114	917.88	0.9772	938.45	0.9991	930.42	0.9905
2017/1/31	13:40:30	936.66	950.93	1.0152	946.25	1.0102	916.33	0.9783	935.68	0.9989	927.70	0.9904
2017/1/31	13:43:30	931.63	946.58	1.0160	942.50	1.0117	913.29	0.9803	931.98	1.0004	923.61	0.9914
2017/1/31	13:46:30	919.13	933.29	1.0154	928.75	1.0105	900.43	0.9797	919.13	1.0000	910.65	0.9908
2017/1/31	14:01:30	892.30	906.21	1.0156	902.50	1.0114	872.83	0.9782	892.28	1.0000	882.05	0.9885
2017/1/31	14:04:30	898.15	911.93	1.0153	907.50	1.0104	879.02	0.9787	897.68	0.9995	888.79	0.9896
2017/1/31	14:07:30	889.01	902.61	1.0153	898.75	1.0110	870.39	0.9791	889.03	1.0000	880.70	0.9907
2017/1/31	14:10:30	884.72	898.51	1.0156	895.00	1.0116	864.59	0.9772	884.57	0.9998	875.84	0.9900
2017/1/31	14:13:30	878.96	892.92	1.0159	888.75	1.0111	857.52	0.9756	878.63	0.9996	869.89	0.9897
2017/1/31	14:16:30	872.63	886.96	1.0164	881.25	1.0099	851.78	0.9761	872.48	0.9998	865.37	0.9917









Meteorological Data

The table in this appendix shows meteorological data obtained during irradiance measurements.

1. Temperature (T), Relative Humidity (RH), Station Pressure (SP), Wind Direction (WD) and Wind Speed (WS)

Temperature, relative humidity, station pressure and wind direction/speed (instantaneous values) measured initially via an automatic weather station (AWS)

2. Irradiance (S) and Standard Deviation (σ)

Mean values calculated from seven reference irradiances for each measurement series and the related standard deviation

3. Elevation Angle (θ), Optical Air Mass (m)

Mean values for each measurement series

4. Aerosol Optical Depth (AOD)

Mean values calculated from the aerosol optical depth at 500 nm in each measurement series based on data from a precision filter radiometer (PFR)

Date	Time		T	RH	SP	WS	WD	S ± σ		θ	m	AOD
	(start)	(end)	(°C)	(%)	(hPa)	(m/s)	(degree)	(W/m ²)		(degree)		
24 Jan 2017	9:00	– 9:18	–2.1	44.9	954.4	3.3	202.9	934.1	± 8.6	22.6	2.44	0.03
	9:30	– 9:48	–1.5	42.8	954.5	4.1	209.5	967.2	± 7.3	26.3	2.11	0.03
	10:00	– 10:18	–1.0	40.2	954.7	3.8	204.4	991.5	± 5.9	29.5	1.91	0.04
	10:30	– 10:48	–0.5	36.7	954.7	3.5	211.2	1002.7	± 2.8	32.0	1.77	0.04
	11:00	– 11:18	0.0	31.1	954.7	3.6	217.9	995.6	± 17.0	33.7	1.69	0.06
	11:30	– 11:48	0.3	27.7	954.4	3.2	216.9	981.5	± 21.3	34.5	1.66	0.07
	12:00	– 12:18	0.5	27.0	953.9	3.9	218.3	915.2	± 108.8	34.5	1.66	0.09
	12:30	– 12:48	0.6	31.5	953.6	3.2	212.2	856.0	± 147.9	33.5	1.70	0.20
	13:00	– 13:18	0.2	30.8	953.4	3.0	221.6	667.4	± 106.0	31.7	1.79	0.94
	13:30	– 13:48	1.1	28.9	953.3	3.3	218.2	921.8	± 15.3	29.1	1.93	0.19
	14:00	– 14:18	0.8	28.5	953.4	3.9	224.7	942.7	± 5.9	25.8	2.15	0.05
14:30	– 14:48	1.0	29.9	953.8	3.4	209.4	899.9	± 7.9	21.9	2.50	0.05	
25 Jan 2017	9:00	– 9:18	–0.6	45.6	961.5	3.2	244.3	932.2	± 7.6	22.7	2.44	0.03
	9:30	– 9:48	0.0	43.4	961.6	3.3	231.4	967.7	± 5.1	26.5	2.12	0.03
	10:00	– 10:18	0.5	42.3	961.7	2.5	230.2	982.2	± 0.6	29.7	1.91	0.04
	10:30	– 10:48	0.4	43.6	961.8	3.3	243.5	990.6	± 1.8	32.2	1.77	0.05
	11:00	– 11:18	1.6	40.5	961.5	3.1	233.0	1001.6	± 2.8	33.9	1.70	0.04
	11:30	– 11:48	2.4	39.2	961.2	2.1	217.1	997.6	± 4.6	34.8	1.66	0.05
	12:00	– 12:18	2.8	38.8	961.0	1.8	205.1	988.3	± 4.4	34.7	1.66	0.06
	12:30	– 12:48	3.3	36.5	960.7	1.6	199.0	966.2	± 14.0	33.7	1.70	0.09
	13:00	– 13:18	3.4	34.1	960.6	1.5	194.6	961.5	± 8.0	31.9	1.79	0.25
	13:30	– 13:48	2.3	38.3	960.6	1.8	225.6	–	± –	29.3	1.93	1.70
	14:00	– 14:18	3.0	33.4	960.6	2.1	205.9	902.3	± 2.2	26.0	2.15	0.41
14:30	– 14:48	3.9	31.0	960.7	2.6	203.5	869.8	± 10.6	22.2	2.49	0.06	
26 Jan 2017	9:00	– 9:18	–	–	–	–	–	930.7	± 7.8	22.9	–	0.04
	9:30	– 9:48	–	–	–	–	–	961.1	± 5.8	26.7	–	0.04
	10:00	– 10:18	–	–	–	–	–	975.8	± 3.7	29.9	–	0.05
	10:30	– 10:48	4.0	42.8	964.1	1.2	146.2	991.3	± 2.7	32.4	1.77	0.05
	11:00	– 11:18	3.8	40.8	963.7	2.0	125.8	999.5	± 4.5	34.2	1.69	0.05
	11:30	– 11:48	4.1	38.7	963.2	1.7	134.0	1006.6	± 7.5	35.0	1.65	0.05
	12:00	– 12:18	4.1	41.6	962.9	1.8	138.5	999.1	± 7.2	35.0	1.65	0.06
	12:30	– 12:48	4.5	39.9	962.7	1.5	150.1	999.7	± 5.8	34.0	1.69	0.05
	13:00	– 13:18	4.7	36.3	962.6	1.1	140.6	972.1	± 4.2	32.2	1.78	0.06
	13:30	– 13:48	5.0	34.3	962.5	1.0	144.4	946.6	± 6.3	29.6	1.92	0.07
	14:00	– 14:18	5.2	34.6	962.5	1.0	152.5	924.1	± 6.3	26.3	2.14	0.07
14:30	– 14:48	4.8	33.6	962.6	1.1	124.0	881.0	± 9.8	22.4	2.48	0.07	

Date	Time		T (°C)	RH (%)	SP (hPa)	WS (m/s)	WD (degree)	S ± σ		θ (degree)	m	AOD
	(start)	(end)						(W/m ²)	(W/m ²)			
28 Jan 2017	9:00	– 9:18	4.4	44.3	961.4	0.8	157.1	924.6	± 6.2	23.3	2.39	0.04
	9:30	– 9:48	4.9	45.9	961.5	0.9	190.0	949.1	± 8.5	27.1	2.07	0.04
	10:00	– 10:18	5.7	43.9	961.4	1.0	182.3	970.1	± 6.2	30.4	1.87	0.05
	10:30	– 10:48	6.1	43.1	961.4	1.0	192.1	990.9	± 4.6	32.9	1.74	0.04
	11:00	– 11:18	6.6	40.2	961.0	1.1	172.4	1002.6	± 6.9	34.6	1.66	0.05
	11:30	– 11:48	7.5	37.2	960.8	1.0	187.9	997.6	± 3.7	35.5	1.63	0.05
	12:00	– 12:18	8.0	35.5	960.4	1.2	186.3	998.9	± 5.0	35.5	1.63	0.05
	12:30	– 12:48	8.5	32.5	960.2	1.4	214.2	981.2	± 4.9	34.5	1.67	0.06
	13:00	– 13:18	8.7	30.6	960.1	1.3	192.7	967.6	± 4.5	32.7	1.75	0.06
	13:30	– 13:48	8.9	30.4	960.4	1.0	177.1	938.4	± 6.8	30.1	1.88	0.07
	14:00	– 14:18	9.0	34.0	960.2	1.6	206.4	913.5	± 5.9	26.8	2.09	0.07
	14:30	– 14:48	8.7	34.1	960.4	1.2	176.4	873.5	± 12.2	22.9	2.42	0.07
	31 Jan 2017	9:00	– 9:18	1.5	38.7	955.9	0.8	177.2	916.0	± 4.4	23.9	2.32
9:30		– 9:48	1.7	40.1	956.3	1.2	160.2	930.5	± 3.3	27.8	2.02	0.06
10:00		– 10:18	2.3	38.6	956.6	1.4	176.4	957.4	± 2.5	31.1	1.82	0.06
10:30		– 10:48	2.8	35.7	956.8	1.3	182.1	973.3	± 8.9	33.6	1.70	0.06
11:00		– 11:18	3.6	34.5	956.6	1.3	184.8	973.4	± 4.5	35.4	1.62	0.07
11:30		– 11:48	3.5	33.1	956.6	1.5	167.1	990.0	± 1.9	36.3	1.59	0.06
12:00		– 12:18	3.8	31.0	956.7	1.2	172.7	980.0	± 2.3	36.3	1.59	0.07
12:30		– 12:48	4.0	31.2	956.3	1.4	200.5	963.5	± 8.1	35.3	1.63	0.07
13:00		– 13:18	4.3	29.4	956.1	1.2	175.6	950.7	± 3.6	33.5	1.70	0.07
13:30		– 13:48	5.1	28.2	956.0	1.2	171.2	931.5	± 6.9	30.9	1.83	0.07
14:00		– 14:18	4.9	27.8	956.3	1.2	176.4	886.0	± 9.2	27.5	2.03	0.08
14:30		– 14:48	4.9	27.8	956.5	1.0	159.3	843.9	± 13.6	23.6	2.34	0.08

Attendee group Photo



Participants in the fourth WMO Regional Pyrheliometer Comparison of RA II
(Tsukuba, Japan)

(Back row left to right)

J. S. Park, K. Haijima, T. H. M. Chau, S. H. Ryu, Y. J. Park, H. S. Jung, B. Y. Kim

(Middle row left to right)

K. Mori, W. Finsterle, Y. Tsutsumi, H. Uchida, D. Lei, Y. Yun, B. Tahunipue

(Front row left to right)

T. Aoyagi, O. Ijima, M. Milner, M. Omori, C. Wei, H. Yuasa

Activities of the Regional Radiation Centre, Tokyo

- 1964 Pyrheliometer Intercomparison : India - Japan (Pune, India)
- 1965 Regional Radiation Centre Established** (RA II Res.20, CIMO IV Rec.1,3,9)
- 1968 Pyrheliometer Intercomparison : Thailand - Japan (Tsukuba, Japan)
- 1970 Attendance at IPC-III (WRC/Davos, Switzerland)
- 1975 Attendance at IPC-IV (WRC/Davos, Switzerland)
- Pyrheliometer Intercomparison : China - Japan (Tsukuba, Japan)
- 1980 Attendance at IPC-V (WRC/Davos, Switzerland)
- 1983 Pyrheliometer Intercomparison : Hong Kong - Japan (Tsukuba, Japan)
- 1985 Attendance at IPC-VI (WRC/Davos, Switzerland)
- 1989 **RPC-I** : Regional Pyrheliometer Comparison: RA II & RA V (Tsukuba, Japan)
- 1990 Join in IPC-VII (WRC/Davos, Switzerland)
- 1994 Reference Pyranometer Calibration : Thailand (Tsukuba, Japan)
- 1995 Pyrheliometer Intercomparison : China - Japan (Tsukuba, Japan)
- Reference Pyranometer Calibration : Korea (Tsukuba, Japan)
- Attendance at IPC-VIII (WRC/Davos, Switzerland)
- 1996 Pyrheliometer calibration training : Korea (Tsukuba, Japan)
- 1997 Pyrheliometer Intercomparison : Hong Kong & Korea - Japan (Tsukuba, Japan)
- Reference Pyranometer Calibration training : Philippines (Tsukuba, Japan)
- 2000 Attendance at IPC-IX (WRC/Davos, Switzerland)
- 2002 Pyrheliometer Intercomparison : Hong Kong, China & Korea - Japan (Tsukuba, Japan)
- 2005 Attendance at IPC-X (WRC/Davos, Switzerland)
- 2007 **RPC-II** : Regional Pyrheliometer Comparison: RA II (Tsukuba, Japan)
- 2010 Attendance at IPC-XI (WRC/Davos, Switzerland)
- 2012 **RPC-III** : Regional Pyrheliometer Comparison: RA II (Tsukuba, Japan)
- 2015 Attendance at IPC-XII (WRC/Davos, Switzerland)
- 2017 **RPC-IV** : Regional Pyrheliometer Comparison: RA II and RA V (Tsukuba, Japan)

Part II

CALIBRATION OF REFERENCE PYRANOMETERS

1. INTRODUCTION

Calibration of Hong Kong's pyranometer (CMP6, No. 070713) and Korea's pyranometers (CMP22, No. 090081 and CMP22, No. 160428) was jointly carried out during the period of the Regional Pyrheliometer Comparison of RA II and RA V (27 January – 2 February, 2017).

2. METHOD OF CALIBRATION AND DATA ACQUISITION

Calibration was performed using the collimation tube method, in which the target pyranometer is attached to the bottom end of a collimation tube (i.e., a long tube with diaphragms) mounted on an automatic sun tracker (see Photo 1). As the optical geometry of the combined system involving the pyranometer and the collimation tube are adjusted to match that of an absolute cavity radiometer (a half opening angle of 2.5 degrees), both instruments can be compared directly using a common radiation source. Voltages from the pyranometer were measured every second. Values measured with the same timing as the reference irradiance were taken as output data for sensitivity calculation. In each series, six sets of output data were acquired with these time intervals.

3. PYRANOMETER CALIBRATION FACTOR DEFINITION

In this study, the pyranometer calibration factor was defined as the irradiance sensitivity based on the following formula:

$$S = V_{th}/K$$

where:

S irradiance [$W\ m^{-2}$]

V_{th} output of pyranometer [mV]

4. DATA EVALUATION PROCEDURE

The WRR reduction factor for the pyranometer was determined by applying the same evaluation procedures for pyrheliometers described in Section 7, Part I.

5. CALIBRATION RESULTS

Instrument	Current WRR Reduction Factor	Ratio	Standard Deviation	Number of Data	New Sensitivity	Change Ratio of Sensitivity
CMP6 No. 070713 Hong Kong	0.9822 K:0.01654mVW ⁻¹ m ² (Lijiang,China, 2009)	0.994177	0.001092	84	0.001644 mVW ⁻¹ m ²	-0.61%
CMP22 No. 090081 Korea	0.981253 K:0.00981mVW ⁻¹ m ² (RPC-RAII 3 rd , 2012)	1.000343	0.001018	112	0.00981 mVW ⁻¹ m ²	±0.00%
CMP22 No. 160428 Korea	- K:0.00868mVW ⁻¹ m ² (Kipp&Zonen, 2016)	1.029341	0.000547	113	0.00893 mVW ⁻¹ m ²	+2.80%

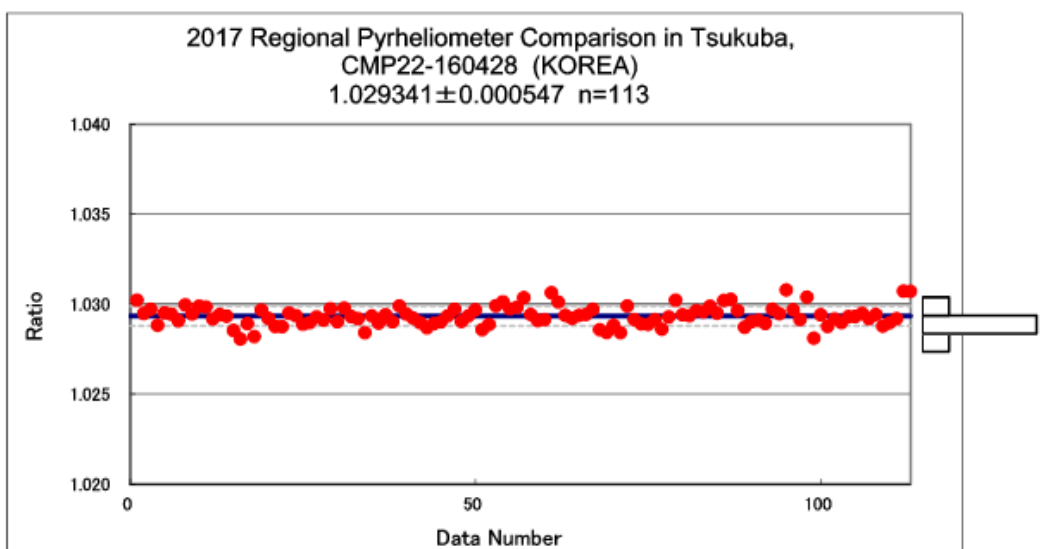
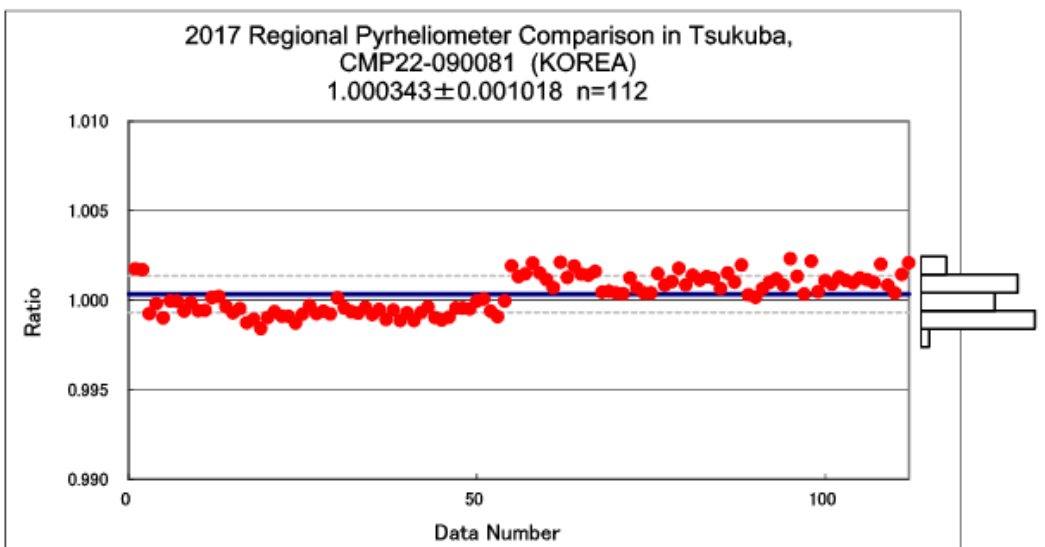
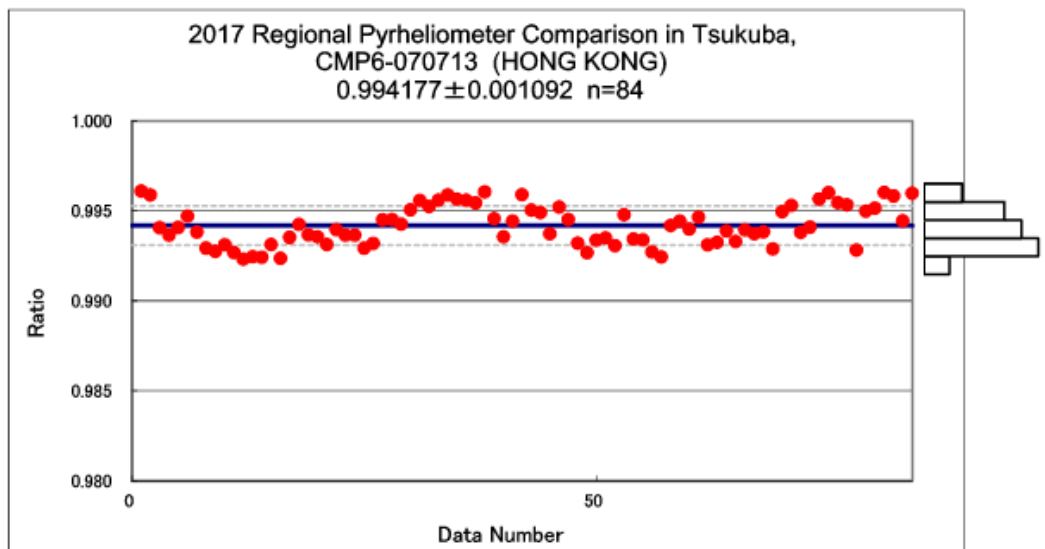
The measurement values for each instrument are listed in **Appendix G**. A plot of the calibration results is shown in **Appendix H**. The scatter plots show the sensitivities to the reference irradiances, and the histograms show the distribution of these sensitivities for each pyranometer. The number of data along with the average and standard deviations of the sensitivities are also shown.



Photo 1 The collimation tube/pyranometer combination. A pyranometer was attached to the bottom end of the tube.

		reference irr	CMP6		CMP22		CMP22	
			070713		090081		160428	
Date	Time		HONG KONG		KOREA		KOREA	
yyyy/mm/dd	hh:mm:ss		IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/28	9:31:30	943.83	940.15	0.9961	945.48	1.0018	973.57	1.0315
2017/1/28	9:34:30	947.67	943.77	0.9959	949.29	1.0017	976.32	1.0302
2017/1/28	9:37:30	936.03	930.47	0.9941	935.33	0.9992	963.62	1.0295
2017/1/28	9:40:30	951.62	945.59	0.9937	951.44	0.9998	979.90	1.0297
2017/1/28	9:43:30	955.47	949.82	0.9941	954.54	0.9990	983.01	1.0288
2017/1/28	9:46:30	959.73	954.66	0.9947	959.69	1.0000	988.06	1.0295
2017/1/28	10:31:30	989.80	983.68	0.9938	989.74	0.9999	1018.93	1.0294
2017/1/28	10:34:30	984.52	975.82	0.9912	983.92	0.9994	1013.13	1.0291
2017/1/28	10:37:30	991.90	984.89	0.9929	991.76	0.9999	1021.61	1.0300
2017/1/28	10:40:30	995.73	988.51	0.9928	995.16	0.9994	1025.06	1.0295
2017/1/28	10:43:30	996.05	987.91	0.9918	995.49	0.9994	1025.83	1.0299
2017/1/28	10:46:30	987.45	980.65	0.9931	987.60	1.0002	1016.91	1.0298
2017/1/28	11:01:30	991.65	983.07	0.9913	991.86	1.0002	1020.59	1.0292
2017/1/28	11:04:30	996.65	986.09	0.9894	996.28	0.9996	1025.97	1.0294
2017/1/28	11:07:30	1007.23	998.19	0.9910	1006.53	0.9993	1036.78	1.0293
2017/1/28	11:10:30	1004.26	994.56	0.9903	1003.79	0.9995	1032.91	1.0285
2017/1/28	11:13:30	1008.47	998.19	0.9898	1007.19	0.9987	1036.76	1.0281
2017/1/28	11:16:30	1007.24	996.98	0.9898	1006.16	0.9989	1036.37	1.0289
2017/1/28	11:31:30	998.13	987.91	0.9898	996.55	0.9984	1026.28	1.0282
2017/1/28	11:34:30	990.32	983.07	0.9927	989.36	0.9990	1019.70	1.0297
2017/1/28	11:37:30	997.51	989.12	0.9916	996.87	0.9994	1026.65	1.0292
2017/1/28	11:40:30	999.81	991.54	0.9917	998.92	0.9991	1028.57	1.0288
2017/1/28	11:43:30	999.83	992.14	0.9923	998.92	0.9991	1028.58	1.0288
2017/1/28	11:46:30	999.86	991.54	0.9917	998.59	0.9987	1029.36	1.0295
2017/1/28	12:01:30	1004.55	996.98	0.9925	1003.76	0.9992	1034.05	1.0294
2017/1/28	12:04:30	998.26	990.33	0.9920	997.96	0.9997	1027.10	1.0289
2017/1/28	12:07:30	996.67	989.12	0.9924	995.91	0.9992	1025.56	1.0290
2017/1/28	12:10:30	994.13	987.30	0.9931	993.52	0.9994	1023.24	1.0293
2017/1/28	12:13:30	994.28	986.70	0.9924	993.52	0.9992	1023.24	1.0291
2017/1/28	12:16:30	1005.68	997.58	0.9919	1005.82	1.0001	1035.59	1.0297
2017/1/28	12:31:30	989.48	983.07	0.9935	989.07	0.9996	1018.21	1.0290
2017/1/28	12:34:30	983.90	978.23	0.9942	983.26	0.9994	1013.19	1.0298
2017/1/28	12:37:30	980.21	974.00	0.9937	979.51	0.9993	1008.95	1.0293
2017/1/28	12:40:30	975.45	969.17	0.9936	975.06	0.9996	1003.92	1.0292
2017/1/28	12:43:30	979.94	972.19	0.9921	979.16	0.9992	1007.78	1.0284
2017/1/28	12:46:30	978.30	971.58	0.9931	977.80	0.9995	1007.01	1.0293
2017/1/28	13:01:30	965.32	959.49	0.9940	964.28	0.9989	993.27	1.0289
2017/1/28	13:04:30	971.71	965.54	0.9937	971.18	0.9995	1000.28	1.0294
2017/1/28	13:07:30	966.84	960.70	0.9936	965.75	0.9989	994.91	1.0290
2017/1/28	13:10:30	970.58	963.72	0.9929	969.89	0.9993	999.59	1.0299
2017/1/28	13:13:30	971.02	963.12	0.9919	969.91	0.9989	999.61	1.0295
2017/1/28	13:16:30	959.99	953.45	0.9932	959.32	0.9993	988.04	1.0292
2017/1/28	13:31:30	946.55	941.35	0.9945	946.19	0.9996	973.98	1.0290
2017/1/28	13:34:30	942.28	937.12	0.9945	941.38	0.9990	969.31	1.0287
2017/1/28	13:37:30	938.27	932.89	0.9943	937.24	0.9989	965.41	1.0289
2017/1/28	13:40:30	941.17	936.52	0.9951	940.28	0.9991	968.47	1.0290
2017/1/28	13:43:30	935.21	931.08	0.9956	934.80	0.9996	962.66	1.0294
2017/1/28	13:46:30	927.02	922.61	0.9952	926.61	0.9996	954.57	1.0297
2017/1/28	14:01:30	917.57	915.36	0.9976	917.13	0.9995	944.22	1.0290
2017/1/28	14:04:30	915.83	913.54	0.9975	915.79	1.0000	942.71	1.0293
2017/1/28	14:07:30	906.22	903.87	0.9974	906.28	1.0001	933.12	1.0297
2017/1/28	14:10:30	907.26	903.26	0.9956	906.70	0.9994	933.19	1.0286
2017/1/28	14:13:30	913.06	909.31	0.9959	912.22	0.9991	939.43	1.0289
2017/1/28	14:16:30	921.17	917.17	0.9957	921.14	1.0000	948.73	1.0299

		reference irr	CMP6		CMP22		CMP22	
			070713		090081		160428	
Date	Time		HONG KONG		KOREA		KOREA	
yyyy/mm/dd	hh:mm:ss		IRR(W)	RATIO	IRR(W)	RATIO	IRR(W)	RATIO
2017/1/31	9:31:30	926.70	922.61	0.9956	928.48	1.0019	954.62	1.0301
2017/1/31	9:34:30	929.27	925.03	0.9954	930.50	1.0013	956.91	1.0297
2017/1/31	9:37:30	928.42	925.03	0.9963	929.79	1.0015	956.11	1.0298
2017/1/31	9:40:30	930.92	927.45	0.9963	932.84	1.0021	959.18	1.0304
2017/1/31	9:43:30	931.73	928.05	0.9961	933.16	1.0015	959.15	1.0294
2017/1/31	9:46:30	936.17	931.08	0.9946	937.25	1.0012	963.39	1.0291
2017/1/31	10:01:30	952.94	946.80	0.9936	953.60	1.0007	980.72	1.0292
2017/1/31	10:04:30	959.40	954.05	0.9944	961.43	1.0021	988.80	1.0306
2017/1/31	10:07:30	957.97	954.05	0.9959	960.36	1.0025	986.82	1.0301
2017/1/31	10:10:30	956.38	951.63	0.9950	957.60	1.0013	984.47	1.0294
2017/1/31	10:13:30	959.54	954.66	0.9949	961.36	1.0019	987.57	1.0292
2017/1/31	10:16:30	958.25	952.24	0.9937	959.65	1.0015	986.40	1.0294
2017/1/31	10:31:30	959.24	954.66	0.9952	960.57	1.0014	987.46	1.0294
2017/1/31	10:34:30	967.20	961.91	0.9945	968.76	1.0016	995.94	1.0297
2017/1/31	10:37:30	972.76	966.14	0.9932	973.19	1.0004	1000.56	1.0286
2017/1/31	10:40:30	978.15	970.98	0.9927	978.65	1.0005	1005.96	1.0284
2017/1/31	10:43:30	979.27	972.79	0.9934	979.67	1.0004	1007.50	1.0288
2017/1/31	10:46:30	983.41	977.03	0.9935	983.77	1.0004	1011.36	1.0284
2017/1/31	11:01:30	969.23	962.52	0.9931	970.43	1.0012	998.21	1.0299
2017/1/31	11:04:30	971.82	966.75	0.9948	972.48	1.0007	1000.15	1.0292
2017/1/31	11:07:30	976.18	969.77	0.9934	976.58	1.0004	1004.40	1.0289
2017/1/31	11:10:30	968.32	961.91	0.9934	968.72	1.0004	996.28	1.0289
2017/1/31	11:13:30	974.45	967.35	0.9927	975.90	1.0015	1002.85	1.0291
2017/1/31	11:16:30	980.21	972.79	0.9924	981.03	1.0008	1008.26	1.0286
2017/1/31	11:31:30	988.21	982.47	0.9942	989.23	1.0010	1017.15	1.0293
2017/1/31	11:34:30	989.18	983.68	0.9944	990.94	1.0018	1019.08	1.0302
2017/1/31	11:37:30	991.45	985.49	0.9940	992.30	1.0009	1020.62	1.0294
2017/1/31	11:40:30	992.62	987.30	0.9946	994.01	1.0014	1021.77	1.0294
2017/1/31	11:43:30	990.49	983.68	0.9931	991.61	1.0011	1019.84	1.0296
2017/1/31	11:46:30	987.93	981.26	0.9933	989.22	1.0013	1017.14	1.0296
2017/1/31	12:01:30	984.26	978.23	0.9939	985.47	1.0012	1013.67	1.0299
2017/1/31	12:04:30	979.35	972.79	0.9933	979.98	1.0006	1008.24	1.0295
2017/1/31	12:07:30	980.55	974.61	0.9939	982.03	1.0015	1010.17	1.0302
2017/1/31	12:10:30	978.94	972.79	0.9937	979.93	1.0010	1008.58	1.0303
2017/1/31	12:13:30	977.62	971.58	0.9938	979.53	1.0020	1006.59	1.0296
2017/1/31	12:16:30	979.15	972.19	0.9929	979.44	1.0003	1007.27	1.0287
2017/1/31	12:31:30	964.37	959.49	0.9949	964.52	1.0002	992.36	1.0290
2017/1/31	12:34:30	967.66	963.12	0.9953	968.28	1.0006	995.83	1.0291
2017/1/31	12:37:30	969.73	963.72	0.9938	970.69	1.0010	997.78	1.0289
2017/1/31	12:40:30	971.28	965.54	0.9941	972.44	1.0012	1000.14	1.0297
2017/1/31	12:43:30	957.61	953.45	0.9956	958.41	1.0008	985.83	1.0295
2017/1/31	12:46:30	950.38	947.40	0.9969	952.58	1.0023	979.64	1.0308
2017/1/31	13:01:30	950.59	946.80	0.9960	951.85	1.0013	978.81	1.0297
2017/1/31	13:04:30	955.97	951.63	0.9955	956.30	1.0003	983.84	1.0291
2017/1/31	13:07:30	951.84	947.40	0.9953	953.92	1.0022	980.76	1.0304
2017/1/31	13:10:30	952.43	945.59	0.9928	952.88	1.0005	979.20	1.0281
2017/1/31	13:13:30	946.71	941.96	0.9950	947.74	1.0011	974.56	1.0294
2017/1/31	13:16:30	946.54	941.96	0.9952	947.39	1.0009	973.78	1.0288
2017/1/31	13:31:30	931.15	927.45	0.9960	932.36	1.0013	958.33	1.0292
2017/1/31	13:34:30	931.33	927.45	0.9958	932.36	1.0011	958.33	1.0290
2017/1/31	13:37:30	939.31	934.10	0.9945	940.22	1.0010	966.83	1.0293
2017/1/31	13:40:30	936.66	932.89	0.9960	937.83	1.0012	964.13	1.0293
2017/1/31	13:43:30	931.63	928.05	0.9962	932.70	1.0011	959.10	1.0295
2017/1/31	13:46:30	919.13	916.57	0.9972	920.05	1.0010	945.96	1.0292
2017/1/31	14:01:30	892.30	889.96	0.9974	894.10	1.0020	918.56	1.0294
2017/1/31	14:04:30	898.15	896.01	0.9976	898.91	1.0008	924.00	1.0288
2017/1/31	14:07:30	889.01	887.55	0.9984	889.37	1.0004	914.76	1.0290
2017/1/31	14:10:30	884.72	883.31	0.9984	885.99	1.0014	910.55	1.0292
2017/1/31	14:13:30	878.96	877.27	0.9981	881.26	1.0026	905.97	1.0307
2017/1/31	14:16:30	872.63	871.83	0.9991	874.45	1.0021	899.43	1.0307



For more information, please contact:

World Meteorological Organization

7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

Communication and Public Affairs Office

Tel.: +41 (0) 22 730 83 14/15 – Fax: +41 (0) 22 730 81 71

E-mail: cpa@wmo.int

public.wmo.int