

DEVELOPMENT OF AM 1.5 GLOBAL MEASUREMENT PROCEDURES AND INTERNATIONAL CELL MEASUREMENT ROUND ROBIN

JET PROPULSION LABORATORY

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Spectral Irradiance (JPL Unfiltered LAPSS)

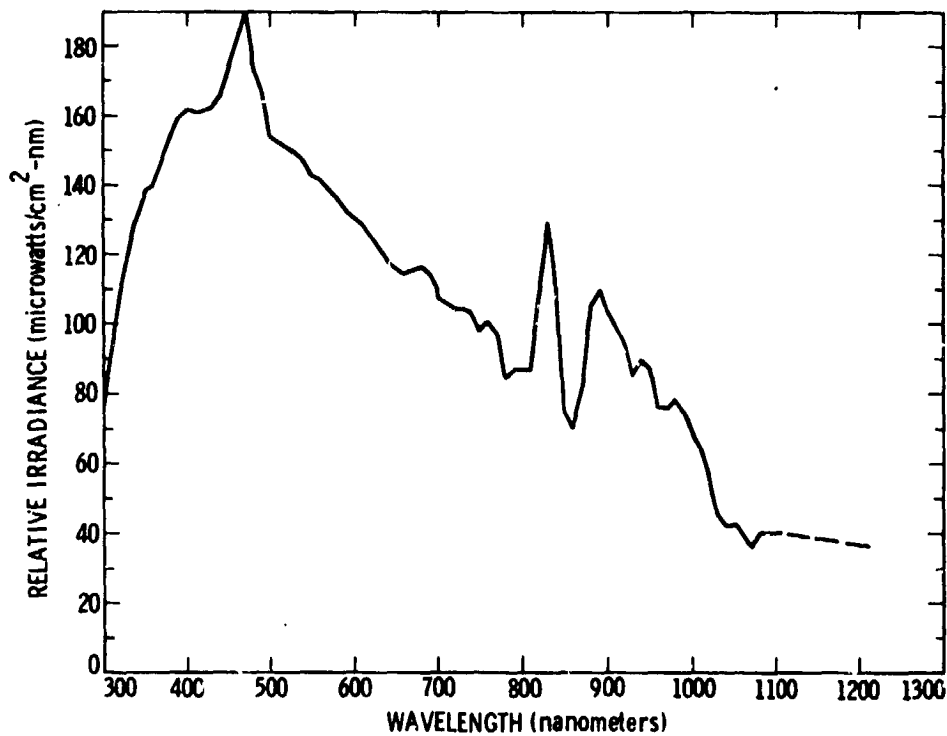


FIGURE 1

Spectral Irradiance (AM 1.5 Direct LAFSS Versus ASTM AM 1.5 Direct)

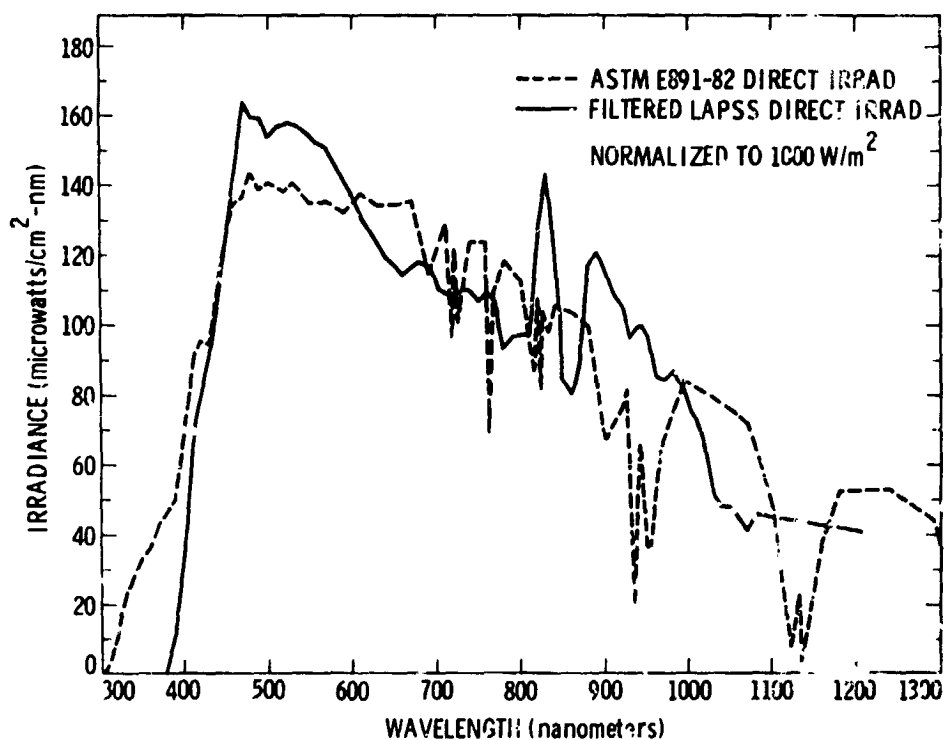


FIGURE 2

Spectral Distribution of Irradiance Performance
 JPL AM 1.5 Direct Filtered LAFSS (0.4 to 1.1 μm)

PERCENT OF TOTAL IRRADIANCE BETWEEN 0.4 μm AND 1.1 μm
 FOR NORMALIZED IRRADIANCE CURVES

WAVELENGTH INTERVAL, μm	(1) ASTM E 891-82 AM 1.5 DIRECT SPECTRUM	(2) JPL AM 1.5 DIRECT FILTERED LAFSS	RATIO (2) / (1)
0.4 to 0.5	13.0	15.8	0.989
0.5 to 0.6	18.6	20.2	1.085
0.6 to 0.7	18.0	16.1	0.893
0.7 to 0.8	15.5	14.0	0.905
0.8 to 0.9	13.3	14.4	1.085
0.9 to 1.1	18.6	19.5	1.046

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Airmass 1.5 Global Measurement Procedure

1. TYPE II (SECONDARY) CALIBRATION USING ASTM 130
2. LIGHT SOURCE IS THE JPL AM 1.5 GLOBAL FILTERED LAPSS
3. PRIMARY REFERENCE CELL CALIBRATED IN DIRECT NORMAL SUNLIGHT BY COMPARISON TO A NORMAL INCIDENCE PYRHELIOMETER USING ASTM 130
4. CALIBRATION VALUE OF PRIMARY REFERENCE CELL ADJUSTED MATHEMATICALLY TO THE ASTM E 892-82 GLOBAL SPECTRUM
5. TEMPERATURE OF PV DEVICE AND REFERENCE CELL ARE CONTROLLED

Adjustment of Primary Reference Cell (Direct Normal Calibration, DV_d , for a Global Calibration, DV_g)

$$CV_g = CV_d \frac{\int E_g(\lambda) R_r(\lambda) d\lambda \cdot \int E_d(\lambda) d\lambda}{\int E_d(\lambda) R_r(\lambda) d\lambda \cdot \int E_g(\lambda) d\lambda}$$

WHERE:

$E_d(\lambda)$ IS THE ABSOLUTE SPECTRAL IRRADIANCE FOR AM 1.5 DIRECT NORMAL, ASTM E 891-82

$E_g(\lambda)$ IS THE ABSOLUTE SPECTRAL IRRADIANCE FOR AM 1.5 GLOBAL, ASTM E 892-82

$R_r(\lambda)$ IS THE SPECTRAL RESPONSE OF THE PRIMARY REFERENCE CELL

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Why Use Secondary Calibration in JPL LAPSS?

1. PRIMARY CALIBRATION IN SUNLIGHT VERY TIME CONSUMING
2. ONLY A LIMITED SUNLIGHT CALIBRATION OF A PRIMARY REFERENCE CELL IS NECESSARY
3. THE JPL LAPSS IS FILTERED TO CLOSELY MATCH THE AM 1.5 GLOBAL SPECTRUM
4. TEMPORAL STABILITY OF THE FILTERED LAPSS IS EXCELLENT
5. PRIMARY REFERENCE CELL NOT REQUIRED TO BE SPECTRALLY MATCHED TO THE PV DEVICE BEING CALIBRATED
6. LOWER COST AND MORE TIMELY METHOD FOR PROVIDING REFERENCE CELLS

Spectral Irradiance (AM 1.5 Global LAPSS Versus ASTM AM 1.5 Global)

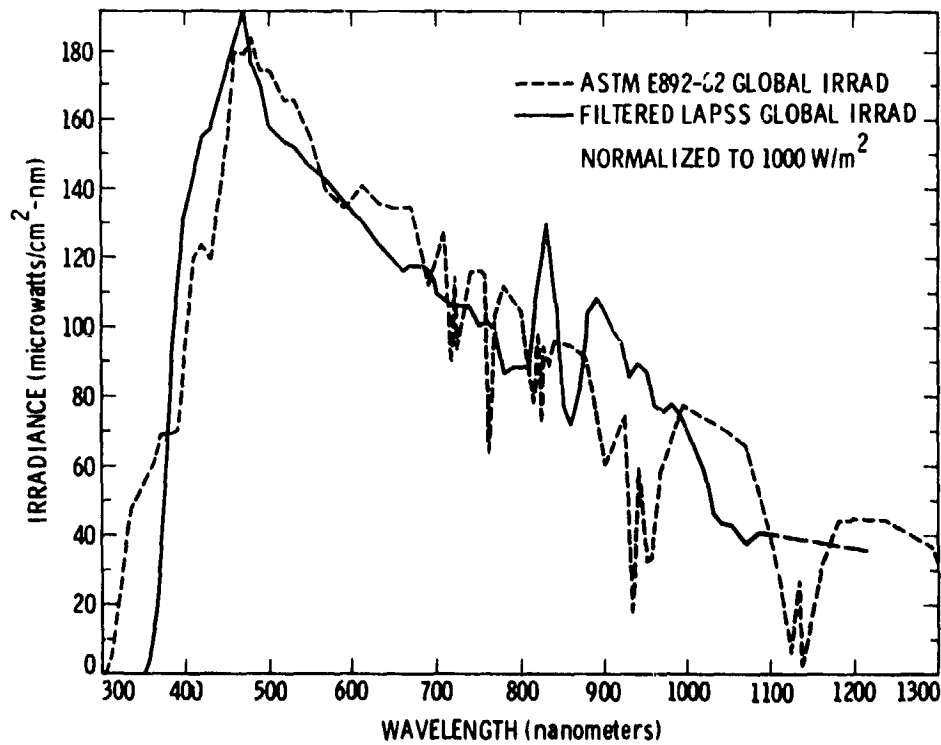


FIGURE 3

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Spectral Distribution of Irradiance Performance
 JPL AM 1.5 Global Filtered LAPSS (0.35 to 1.1 μm)

PERCENT OF TOTAL IRRADIANCE BETWEEN 0.4 μm AND 1.1 μm
 FOR NORMALIZED IRRADIANCE CURVES

WAVELENGTH INTERVAL, μm	(1) ASTM E 892-82 AM 1.5 GLOBAL SPECTRUM	(2) JPL AM 1.5 GLOBAL FILTERED LAPSS	RATIO (2) / (1)
0.4 to 0.5	20.0	21.8	1.090
0.5 to 0.6	20.4	19.3	0.946
0.6 to 0.7	17.5	16.0	0.914
0.7 to 0.8	14.3	13.2	0.923
0.8 to 0.9	11.8	12.9	1.093
0.9 to 1.1	16.0	16.8	1.050

Spectral Distribution of Irradiance Performance
 JPL AM 1.5 Global Filtered LAPSS (0.4 to 1.1 μm)

PERCENT OF TOTAL IRRADIANCE BETWEEN 0.35 μm AND 1.1 μm
 FOR NORMALIZED IRRADIANCE CURVES

WAVELENGTH INTERVAL, μm	(1) ASTM E 892-82 AM 1.5 GLOBAL SPECTRUM	(2) JPL AM 1.5 GLOBAL FILTERED LAPSS	RATIO (2) / (1)
0.35 to 0.4	4.3	3.8	0.884
0.4 to 0.5	19.1	21.0	1.099
0.5 to 0.6	19.5	18.5	0.949
0.6 to 0.7	16.8	15.4	0.917
0.7 to 0.8	13.7	12.7	0.927
0.8 to 0.9	11.3	12.4	1.097
0.9 to 1.1	15.3	16.2	1.059

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CEC Round Robin

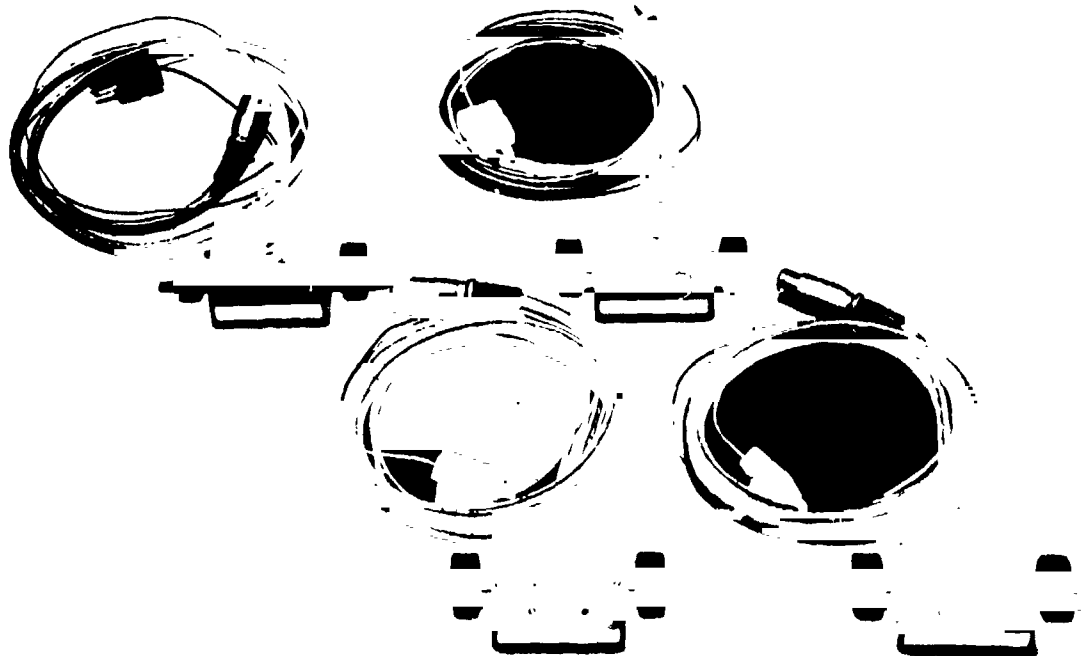
MANAGED BY: COMMISSION OF THE EUROPEAN COMMUNITIES
JOINT RESEARCH CENTRE
ISPRA ESTABLISHMENT
21020 ISPRA (VARESE) ITALY

OBJECT: TO RESOLVE DISAGREEMENT IN MEASUREMENTS

REFERENCE CELLS PROVIDED BY:

4 CELLS	AMORPHOUS SILICON	JMI (JAPAN MACHINERY & METALS INSPECTION INSTITUTE)
5 CELLS	MONO & POLYCRYSTALLINE	ENEA (NUCLEAR & ALTERNATIVE ENERGY AGENCY), ITALY
2 CELLS	POLYCRYSTALLINE SILICON	AEG (TELEFUNKEN) GERMANY
3 CELLS	MONOCRYSTALLINE SILICON	PW (PHOTOWATT ORGANIZATION), FRANCE
4 CELLS	MONO & POLYCRYSTALLINE	JPL (JET PROPULSION LABORATORY), USA

18 CELLS TOTAL



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MODULE DEVELOPMENT AND ENGINEERING SCIENCES

ORIGINAL DOCUMENTS
OF POOR QUALITY



CEC Round Robin Measurements Timetable

UNTIL AUG 7, 1984	JRC (JOINT RESEARCH CENTRE) ISPRA, ITALY
AUG 15 - SEPT 15, 1984	RAE (ROYAL AIRCRAFT ESTABLISHMENT), UNITED KINGDOM
SEPT 15 - OCT 15, 1984	CNES (NATIONAL CENTRE FOR SOLAR ENERGY), FRANCE
OCT 15 - NOV 15, 1984	ENEA (NUCLEAR AND ALTERNATIVE ENERGY AGENCY), ITALY
NOV 15 - DEC 15, 1984	DFVLR (RESEARCH & EXPERIMENT INSTITUTE FOR AIR & SPACE TRAVEL), GERMANY
JANUARY 1985	NRC (NATIONAL RESEARCH CENTRE), CANADA
FEBRUARY 1985	JPL (JET PROPULSION LABORATORY), USA
MARCH 1985	JMI (JAPAN MACHINERY & METALS INSPECTION INSTITUTE), JAPAN
APRIL 1985	JRC (JOINT RESEARCH CENTRE) ISPRA, ITALY

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Summary of the JPL Global I_{sc} Values for Summit Round Robin Cells (In mA @ 100 mW/cm² Irradiance)

CELL NUMBER		COLUMN NUMBER AND IRRADIANCE SPECTRUM (SEE COLUMN NOTES BELOW)				
RRC CELL*	JPL REF. CELL	(1) JPL LAPSS GLOBAL	(2) JPL LAPSS GLOBAL	(3) E892-82 (GLOBAL)	(4) E892-xx (GLOBAL)	(5) IEC (GLOBAL)
1	SS1439B	23.83	23.83	23.90	23.53	23.81
2	SS1439B	24.10	24.10	24.19	23.80	24.09
3	SS1439B	24.81	24.81	24.83	24.43	24.72
4	SS1439E	22.96	22.96	23.08	22.67	22.94
5	SS1440	105.7	105.0	106.2	106.8	108.1
6	SS1440	104.3	103.6	104.8	105.4	106.7
7	SS1440	99.9	99.9	100.6	101.4	102.6
8	SS1440	108.2	108.2	109.7	110.2	111.5
9	SS1440	99.0	97.6	98.4	98.9	100.1
10	SS1440	108.4	106.7	107.6	108.1	109.4
11	SS1440	114.3	114.2	115.5	115.9	117.3
12	SS1440	112.7	111.8	112.6	112.9	114.2
13	SS1440	110.9	110.2	111.0	111.4	112.7
14	SS1440	111.3	110.5	111.3	111.6	112.9
15	SS1440	135.3	135.4	135.5	135.4	137.1
16	SS1440	95.4	95.4	96.0	96.7	97.8
17	SS1440	131.7	131.8	131.8	132.0	133.5
18	SS1440	100.0	100.0	101.3	101.9	103.1

COLUMN NO.

I_{sc} EVALUATION METHOD

- (1) MEASUREMENT WITH FILTERED JPL LAPSS SIMULATING ASTM E892-82 SPECTRUM (GLOBAL)
 - (2) SAME AS (1) EXCEPT RRC CELL PREVIOUSLY EXPOSED TO SUNLIGHT FOR FIVE MINUTES
 - (3) COMPUTATION BY SPECTRAL MISMATCH CORRECTION OF VALUE IN COLUMN (2) TO THE ASTM E892-82 SPECTRUM (GLOBAL)
 - (4) COMPUTATION BY SPECTRAL MISMATCH CORRECTION OF VALUE IN COLUMN (2) TO A PROPOSED 1985 REVISION OF ASTM E892-82 SPECTRUM (GLOBAL)
 - (5) COMPUTATION BY SPECTRAL MISMATCH CORRECTION OF VALUE IN COLUMN (2) TO THE IEC SPECTRUM (GLOBAL)
- * CELLS 1 THROUGH 4 ARE AMORPHOUS SILICON. CELLS 5 THROUGH 18 ARE CRYSTALLINE SILICON.
 * THE VALUES IN COLUMN (5) ARE THE JPL CALIBRATION VALUES FOR THE SUMMIT ROUND ROBIN CONDITIONS.

Comparison of Relative Spectral Response

