NOAA Solar Irradiance Requirements for Climate

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NOAA's Radiation Requirements for Climate Studies: Para 4.1.6.4 of IORD I

1. Albedo (Surface) (DOC/DoD)

a. Horizontal Cell Size
4 km
0.5 km
b. Mapping Uncertainty
4 km
1 km
c. Measurement Range
0 to 100%
0 to 100 %
d. Measurement Precision
2 % (albedo units)
1%
e. Measurement Accuracy
5 % (albedo units)
1.25%
f. Refresh
24 hrs
4 hrs
g. Long Term Stability
2 % (albedo units)
1%

2. Downward Longwave Radiation (Surface) (DOC)

a. Horizontal Cell Size
40 km at nadir
10 km
b. Mapping Uncertainty
10 km
c. Measurement Range
0 to 500 W/m²
0 to 500 W/m²
d. Measurement Precision
0.1 W/m²
0.1 W/m²
e. Measurement Accuracy
5 W/m²
1 W/m²
f. Refresh
14 hrs
6 hrs

3. Downward Shortwave Radiation (DOC)

a. Horizontal Cell Size
50 km
100 km
b. Mapping Uncertainty
5 km
10 km
c. Measurement Range
0 to 1400 W/m²
0 to 1400 W/m²
d. Measurement Precision
5 W/m²
0.1 W/m²
e. Measurement Accuracy
20 W/m²
1.0 W/m²
f. Refresh
24 hrs
24 hrs

4. Absorbed Solar Radiation (TOA) (DOC)

a. Horizontal Cell Size
100 km
20 km
b. Mapping Uncertainty
10 km
5 km
c. Measurement Range
0 to 900 W/m²
0 to 900 W/m²
d. Measurement Precision
3 W/m²
1.5 W/m²
e. Measurement Accuracy
5 W/m²
2.5 W/m²
f. Refresh
12 hrs
8 hrs

6. Outgoing Longwave Radiation (TOA) (DOC)

a.Horizontal Cell Size
100 km
20 km
b. Mapping Uncertainty
10 km
5 km
c. Measurement Range
0 to 500 W/m²
0 to 500 W/m²
d. Measurement Precision
3 W/m²
1.5 W/m²
e. Measurement Accuracy
5 W/m²
2.5 W/m²
f. Refresh
24 hrs (once/daytime, once/nighttime)
4 hrs

NPOESS: The Early Days (1996 – 2002)

- **SIM had only two spectral bands**

5. Solar Irradiance-Total & 2 Narrow Bands(DOC)	***Threshold***	***Objective***
a. Measurement Range		
1. Total	1320 to 1420 W/m²	1320 to 1420 W/m²
2. 200-300 nm band	0 to 10 W/m²	0 to 10 W/m²
3. 1500 nm band	0 to 10 W/m²	0 to 10 W/m²
b. Long Term Stability		
1. Total	0.002 % per year	0.0005% per year
2. 200-300 nm band	0.02% per year	0.01 % per year
3. 1500 nm band	0.01% per year	0.005% per year
c. Measurement Uncertainty		
1. Total	1.5 W/m^2	0.5 W/m^2
2. 200-300 nm band	2%	0.5%
3. 1500 nm band	2%	0.5%
d. Refresh	20 minute viewing sun each orbit, 1 satellite	20 minute viewing sun each orbit, 3 satellite

NPOESS: The Later Years (2002 - End)

From the IORDII_011402.pdf
4.1.6.4.5 Solar Irradiance (DOC). Incident radiation measurements (total and spectral at the top of the Atmosphere).

Systems Capabilities	Thresholds	Objectives
a. Measurement Range		
1. Total	1310 to 1420 W m-2	1310 to 1420 W m-2
2. Spectral (0.2-2mm)	0-10 W m-2 nm-1	0-10 W m-2 nm-1
b. Long Term Stability		
1. Total	0.002 % yr-1	0.0005 % yr-1
2. Spectral (0.2-2mm)		
a. l < 600 nm	0.02 % yr-1	0.01 % yr-1
b. l > 600 nm	0.01 % yr-1	0.01 % yr-1
c. Measurement Precision		
1. Total	0.002 % yr-1	0.0005 % yr-1
2. Spectral (0.2-2mm)	0.02 %yr-1	0.01 % yr-1
d. Measurement Accuracy		
1. Total	1.5 W m-2 (0.1 %)	0.15 W m-2 (0.01 %)
2. Spectral (0.2-2mm)	1 %	0.1 %
e. Refresh	20 min/orbit, 1 satellite	20 min/orbit, 3 satellites
f. Spectral Resolution		
1. l < 280 nm	1 nm	0.1 nm
2. 280 nm < l < 400 nm	5 nm	0.1 nm
3. l > 400 nm	35 nm	1.0 nm

JPSS: TSIS Level 1 Requirements Document: NASA Version

- **PERFORMANCE REQUIREMENTS**

The TSIS mission will be considered fully successful if it meets all of the following performance requirements.

5.1 TSIS shall collect TSI data, where TSI is defined as the radiant power (over the entire solar spectrum) per unit area incident on a plane surface at the top of the atmosphere that is normal to the direction from the Sun.

5.2 TSIS shall collect SSI data, where SSI is defined as the radiant power (over the solar spectrum from 200 nm to 2400 nm in wavelength) per unit area incident on a plane surface at the top of the atmosphere that is normal to the direction from the Sun per wavelength interval.

5.3 TSIS shall provide solar irradiance measurements (TSI and SSI) while operating at the orbit of the host spacecraft.

5.4 TSIS shall be designed to provide solar irradiance measurements (TSI and SSI) for five years and with a goal of seven years.

5.5 TSIS shall be compliant with the spacecraft to TSIS Instrument Interface Control Document (IICD).

5.6 TSIS shall measure TSI to an absolute accuracy of 100 parts per million (ppm) (1σ), with noise less than or equal to 10 ppm (1σ), where 1 ppm equals 0.0001%.

5.7 TSIS shall measure TSI with stability better than or equal to 10 ppm (1σ) per year.

5.8 The processing approach for the TSIS Total Solar Irradiance science data shall be consistent with the TSI measurements on the Glory and SORCE missions to maintain continuity of the long-term TSI data record.

5.9 TSIS shall measure SSI from 200 nm to 2400 nm with a spectral resolution (wavelength interval) of 1 nm at wavelengths less than or equal to 280 nm; 5 nm at wavelengths greater than 280 nm but less than or equal to 400 nm; and 35 nm at wavelengths above 400 nm.

5.10 TSIS shall measure SSI data from 200 nm to 2400 nm to an absolute accuracy of 0.2% with noise less than 100 ppm (1σ).

5.11 TSIS shall measure SSI from 200 nm to 2400 nm to stability of 0.05% (1σ) per year for wavelengths less than or equal to 400 nm; and 0.01% (1σ) per year for wavelengths greater than 400 nm.

5.12 The processing approach for the TSIS Spectral Solar Irradiance science data shall be consistent with the SSI measurements on the SORCE mission to maintain continuity of the SSI data record.

SYSTEM SUCCESS CRITERIA

The criteria for a minimally successful TSIS mission are:

9.1 TSIS shall measure TSI to an accuracy of 350 parts per million (ppm) (1σ) (0.35%), with a noise threshold less than or equal to 20 ppm (1σ), where 1 ppm equals 0.0001%.

9.2 TSIS shall measure TSI to stability better than or equal to 35 ppm (1σ) per year.

9.3 TSIS shall measure SSI from 200 nm to 2400 nm with a spectral resolution of 2 nm at wavelengths less than or equal to 280 nm; 5 nm at wavelengths greater than 280 nm but less than or equal to 400 nm; and 40 nm at wavelengths above 400 nm.

9.4 TSIS shall measure SSI Irradiance from 200 nm to 2400 nm to an absolute accuracy of 1.0% with noise less than 100 ppm (1σ).

9.4 TSIS shall measure SSI from 200 nm to 2400 nm to stability of 0.1% (1σ) per year for wavelengths less than or equal to 400 nm; and 0.01% (1σ) per year for wavelengths greater than 400 nm.

JPSS Requirements

From the IORDII_011402.pdf
4.1.6.4.5 Solar Irradiance (DOC). Incident radiation measurements (total and spectral at the top of the Atmosphere).

Systems Capabilities	Minimum Success	Requirements
a. Measurement Range		
1. Total	1310 to 1420 W m-2	1310 to 1420 W m-2
2. Spectral (200 to 2400 nm)	0-10 W m-2 nm-1	0-10 W m-2 nm-1
b. Long Term Stability		
1. Total	0.002 % yr-1	0.001 % yr-1
2. Spectral (0.2-2mm)		
a. l < 400 nm	0.1 % yr-1	0.05 % yr-1
b. l > 400 nm	0.01 % yr-1	0.01 % yr-1
c. Measurement Precision		
1. Total	0.002 % yr-1	0.0005 % yr-1
2. Spectral (0.2-2mm)	0.1 %yr-1	0.01 % yr-1
d. Measurement Accuracy		
1. Total	0.35 %	0.01 %
2. Spectral	1.0%	0.2%
f. Spectral Resolution		
1. l < 280 nm	2 nm	1 nm
2. 280 nm < l < 400 nm	5 nm	5 nm
3. l > 400 nm	40 nm	35 nm

JPSS Level 1 Requirements Document (2)

TSIS Requirements

Systems Capabilities	Thresholds	Objectives
1. Measurement Range		
a. Total Irradiance	1310 to 1420 Wm^2	1310 to 1420 Wm^2
b. Spectral Irradiance	0-10 Wm^2nm^{-1}	0-10 Wm^2nm^{-1}
2. Long Term Stability		
a. Total	0.001 % yr^{-1}	0.0005 % yr^{-1}
b. Spectral		
i. l < 400 nm	0.05%yr^{-1}	0.01% yr^{-1}
iii. l > 400 nm	0.01% yr^{-1}	0.01% yr^{-1}
3. Measurement Precision		
a. Total	0.002 %	0.0005 %
b. Spectral	0.01 %	0.005 %
4. Measurement Accuracy		
a. Total	0.15 Wm^2 (0.01 %)	0.08 Wm^2 (0.005 %)
b. Spectral	0.2%	0.1%
5. Signal to Noise		
1. Total	.001% (1 sigma)	0.0005% (1 sigma)
2. Spectral	.01% (1 sigma)	0.005% (1 sigma)
5. Spectral Information		
a. Range	200 to 2000 nm	200 – 2400 nm
b. Resolution		
i. l < 280 nm	1 nm	0.5 nm
ii. 280 nm < l < 400 nm	5 nm	0.5 nm
iii. l > 400 nm	45 nm	10.0 nm
6. Observations		
a. Observing time required	2 hrs every 6 hrs (33%)	Continuous
b. Refresh	4 per day	4 per day
c. Or for LEO Orbit	40 min per 90 min orbit	60 min per 90 min
7. Sensor Life		
On orbit Operations	5 Years	7 Years

TIM Requirements

- **Early requirements based on NOAA's Objective and Threshold**
- **First JPSS requirements based on NASA's Minimum Success Criteria and Requirements**
- **Final JPSS requirements are more ambitious and are based on the NOAA method**

Parameter	NPOESS (2000) Threshold	NPOESS (2000) Objective	NPOESS (2002) Threshold	NPOESS (2002) Objective	JPSS (2009) Min Success	JPSS (2009) Req.	JPSS (2010) Threshold	JPSS (2010) Objective
Accuracy	0.1%	0.03%	0.1%	0.01%	0.35%	0.01%	0.01%	0.005%
Precision			.002%	0.0005%	.002%	0.0005%	.002%	0.0005%
Stability	.002%/year	0.0005%/yr	.002%/year	0.0005%/yr	.002%/year	0.001%/yr	.001%/year	0.0005%/yr

SIM Requirements

- **Early requirements based on NOAA's Objective and Threshold**
- **First JPSS requirements based on NASA's Minimum Success Criteria and Requirements**
- **Final JPSS requirements are based on the NOAA method**

Parameter	NPOESS (2000) Threshold	NPOESS (2000) Objective	NPOESS (2002) Threshold	NPOESS (2002) Objective	JPSS (2009) Min Success	JPSS (2009) Req.	JPSS (2010) Threshold	JPSS (2010) Objective
Spectral Range (nm)	200-300 1500	200-300 1500	200 – 2000	200 – 2000	200 - 2400	200 - 2400	200 – 2000	200 – 2400
Spectral Resolution λ<280 280<λ<400 λ>400			 1.0 nm 5.0 nm 35 nm	 0 .1 nm 0 .1 nm 1.0 nm	 2 nm 5 nm 40 nm	 1 nm 5 nm 35 nm	 2 nm 5 nm 45 nm	 0 .1 nm 0 .1 nm 10 nm
Accuracy	2%	0.5%	1.0%	0.1%	1.0%	0.2%	0.25%	0.1%
Precision			0.02%	0.01%	0.1%	0.01%	0.01%	0.005%
Stability Short λ Long λ	 .02%/year 0.01%/yr	 0.01%/yr 0.005%/yr	 0.02%/yr 0.01%/yr Cutoff λ = 600 nm	 0.01%/yr 0.01%/yr	 0.1%/yr 0.01%/yr Cutoff λ = 400 nm	 0.05%/yr 0.01%/yr	 0.05%/yr 0.01%/yr Cutoff λ = 400 nm	 0.01%/yr 0.01%/yr

Observing Time and Latency

- **Early requirements assumed LEO orbit (NPOESS)**
- **Later requirements are more generic**

Parameter	NPOESS (2000) Threshold	NPOESS (2000) Objective	NPOESS (2002) Threshold	NPOESS (2002) Objective	JPSS (2009) Min Success	JPSS (2009) Req.	JPSS (2010) Threshold	JPSS (2010) Objective
Min Observing Time	20 minute viewing sun each orbit, 1 satellite	20 minute viewing sun each orbit, 3 satellite	20 minute viewing sun each orbit, 1 satellite	20 minute viewing sun each orbit, 3 satellite			2 Hours out of every 6 hours or 40 min per 90 min orbit	Continuous
Refresh							4 6-hour averages per day	Continuous
Latency							24 hours	90 minutes

Summary

- **TSIS Requirements have evolved**
  - **Early requirements were somewhat different (only two channels for SIM)**
  - **Overall requirements have become more challenging**
- **NASA and NOAA have different missions and motivations**
  - **NASA is success oriented.**
    - **Minimum success criteria were set low to guarantee success**
    - **Mission requirements were still ambitious**
  - **NOAA is mission oriented.**
    - **Threshold criteria are the lowest that will meet the climate mission requirements**
    - **Objective criteria are even more ambitious**