CERES Instrument Status
Flight Models 1-6 (FM1-FM6)

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CERES Instrument Working Group
CERES Spring Science Team Meeting
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CERES Instrument Operations

• Flight Models (FM) 1-4, FM6 are in nominal mode of operation- Crosstrack.
• FM5 is operating in ‘normal’ Biaxial mode since Mar 23, 2020.
• FM2 PAP scans of the MOSAiC Expedition:
  ▪ Conducted PAP scan test on Apr 23, 2020; Successfully targeted the location of the Polarstern.
  ▪ Plan is to conduct PAP scans of the location of the ship starting May 1, 2020.
• Planned Inter-comparison Operations during summer 2020
  ▪ Terra/FM1 – S-NPP/FM5: May 1 – Jul 31, 2020
  ▪ Terra/FM1 – NOAA-20/FM6: May 1 – Jul 31, 2020
  ▪ Terra/FM1 – Aqua/FM3: Jun 1 – 30, 2020
  ▪ Terra/FM2 – GERB: Jun 1 – 30, 2020
Instrument Product-line definitions

• NOAA-20
  ▪ *Edition 1*: Incorporates the most up-to-date calibration corrections, radiometric scaling to Aqua.

• S-NPP:
  ▪ *Edition 2*: Incorporates the most up-to-date calibration corrections, radiometric scaling to Aqua, and time varying SRF adjustments to TOT channel.

• Terra/Aqua:
  ▪ *Edition 4*: Incorporates the most up-to-date calibration corrections, radiometric scaling and time varying SRF adjustments to SW and TOT channels.
NOAA-20/FM6 Instrument Status
FM6 Internal Calibration

- For SW and TOT channels, the responses to the on-board sources (SWICS lamp and Blackbodies) continue to be stable after the initial rise of ~1.5% (SW) and ~2% (TOT) since start of mission.
- LW Channel (calibrated using blackbody) continues to show very little variation.

![FM6 In-Flight Ed1-CV Internal Calibration Results](image)
FM6 Solar Calibration

- Response of the SW and TOT channels while viewing the MAM that is illuminated by the sun.
- After the initial rise of ~1.5% for SW, and ~2.5% for TOT, the response is very stable.
FM6 Calibration- Since May 2018

FM6 Internal and solar calibration results show consistently very little change (~0.1%) since May 2018.
• FM6 Edition-1 record starts from May 2018
  ▪ After the settling out of the large initial change in gain.

• Incorporated the gain change from start of mission to May 2018

• Performed radiometric scaling to Aqua/FM3 in May 2018
  ▪ Used SSF-1deg product to determine required scaling for SW, TOT and LW channels based on observed differences with FM3.
  ▪ Scaling was incorporated into the FM6 SRFs.
# FM6 Edition 1- Radiometric Scaling to Aqua

## Scaling applied to FM6 SRF (May 2018):

- **SW**: -0.40%
- **TOT**: -0.08%
- **LW**: -0.45%

### Pre- Radiometric scaling

<table>
<thead>
<tr>
<th>SSF- 1deg Global avg. All-sky Flux Difference</th>
<th>FM6-FM3%</th>
<th>May 2018</th>
<th>Jun 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SW</strong></td>
<td>-0.287</td>
<td>-0.431</td>
<td></td>
</tr>
<tr>
<td><strong>LW (TOT-SW)</strong></td>
<td>-0.005</td>
<td>0.062</td>
<td></td>
</tr>
<tr>
<td><strong>LW Channel</strong></td>
<td>-0.482</td>
<td>-0.418</td>
<td></td>
</tr>
</tbody>
</table>

### Post Radiometric scaling

<table>
<thead>
<tr>
<th>SSF- 1deg Global avg. All-sky Flux Difference</th>
<th>FM6-FM3%</th>
<th>May 2018</th>
<th>Jun 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SW</strong></td>
<td>0.087</td>
<td>-0.057</td>
<td></td>
</tr>
<tr>
<td><strong>LW (TOT-SW)</strong></td>
<td>-0.025</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td><strong>LW Channel</strong></td>
<td>-0.063</td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>
Validation – Tropical Mean

• Average of the ES-8 Nadir radiances over Tropical ocean (20°N-20°S) scenes under All-sky conditions.

• TM Day-Night Difference (DN) is calculated:
  - TOT and SW sensors
    \[ \text{DN} = \text{TM}_D(\text{TOT-SW}) - \text{TM}_N(\text{TOT}) \]
  - LW sensor
    \[ \text{DN} = \text{TM}_D(\text{LW}) - \text{TM}_N(\text{LW}) \]

• Difference in the two DN values point to an anomaly in the shortwave regions of the sensors.
Validation - FM6 Tropical mean
FM6 3-channel Consistency check - Global LW Day and Night

Uses ES-8 Nadir
May 2018 - Jan 2020

Day Global Edition 1
TOT- SW vs. LW sensor

Daytime
$LW_{TOT-SW} - LW_{LWC} = 0.36\%$

Night Global Edition 1
LW from TOT vs. LW sensor

Nighttime
$LW_{TOT} - LW_{LWC} = 0.04\%$
S-NPP/FM5 Instrument Status
FM5 Biaxial mode

• FM5 was operated in restricted biaxial mode between Oct 1, 2019 through Mar 22, 2020.

• FM5 was transitioned into a ‘normal’ biaxial mode starting Mar 23, 2020 (for the daytime orbit)
  ▪ Some saturations observed in the SW sensor outputs in certain azimuth angles (in the unused space look positions).
  ▪ Likely cause is glint from antenna on spacecraft.
  ▪ Does not impact the ADM data collects.
FM5- Biaxial operation

FM5 is now operating in ‘Normal’ Biaxial mode since 03/23/2020 (daytime orbit).
In response to the blackbodies, the FM5 TOT and WN sensors show a ~0.5% rise since start of mission.

SW channel’s response to the SWICS has settled at ~-0.2% since start of mission.
FM5 Solar Calibration

- FM5 Solar calibration results show the MAMs are very stable.
- TOT and SW responses show a slight upward trend in latter part of mission.
Validation: S-NPP (Ed2) – Aqua (Ed4) Flux difference

S-NPP/FM5 shows consistency with the Aqua/FM3 instrument (Ed4) at BOM as well as long term.

Uses SSF data products

CERES Instrument Working Group
 Validation: FM5 SW and LW day Anomalies

- Uses SSF data products
- S-NPP/FM5 shows consistency with the trends for Terra and Aqua instruments for the period 2012-2019.
Validation - FM5 Tropical Mean

Nadir Tropical Mean FM5 Edition2

\[ \text{(Day - Night) Watts/m}^2 \text{ str} \]

- TOT-SW
- LW_regr
- Difference

Comparison of the radiance values from the three sensors of the instrument while viewing Deep Convective Clouds (DCC).

Two sets of longwave (LW) radiances were obtained:
- TOT and SW sensors
- Trained WN sensor

The trend between the difference of the two LW radiances and the SW radiance is monitored over time.

Highlights inconsistencies in the relationship in the response functions of the SW sensor and the shortwave part of the TOT sensor.
DCC 3-Channel Intercomparison

**FM5 Edition 2 Nadir Three Channel Intercomparison**

- **X-axis**: Oct-11 to Oct-19
- **Y-axis**: slope (ΔJW vs. f(IISW))

Values range from approximately -0.01 to 0.04.
Orbital Overlaps every ~64 hours

Matching criteria:
- Lat. and Long. difference <= 0.05°
- SZA, VZA difference < 2.0°
- RAZ difference < 5°

Aqua-NPP Inter-comparisons

CERES FM3 on Aqua
Altitude: 704 km
Inclination: 98.2°
Equatorial Crossing: 1:36 PM

CERES FM5 on S-NPP
Altitude: 824 km
Inclination: 98.7°
Equatorial Crossing: 1:27 PM

Spatially and temporally matched observations
FM5/FM3 Inter-comparisons: 2012-2019

Difference of Reflectance:

\[ \text{Reflectance} = \frac{SW_{rad} \times \pi}{F \times \cos(SZA)} \]

\[ F = 1361 \text{ W/m}^2 \]

Uses SSF data

Difference of Radiance:

2014 data used for the radiometric scaling FM5 to FM3.
Terra & Aqua Instruments’ Status
CERES FM1-FM4
Terra- FM1 & FM2 Internal Calibration

- For FM1, TOT channel shows ~0.7% rise, SW channel shows ~0.1% drop, and WN channel shows ~0.5% rise after initial drop.
- For FM2, TOT channel shows ~1.2% rise, SW channel shows ~0.6% drop, while WN channel shows ~0% change since start of mission.
Aqua- FM3 and FM4 Internal Calibration

- For FM3, TOT channel shows ~0.8% rise, SW channel shows ~0.5% rise, and WN channel shows ~0.8% drop.
- For FM4, TOT channel shows ~1% rise, while WN channel shows ~0.25% rise.
Terra- FM1 & FM2 Solar Calibration
Terra- Solar Calibration, Raster Scan only

- Since the transition over to raster scan for solar calibration, SW channel data shows a drop of response of ~1% and TOT channel shows a drop of ~1.5% for both FM1 and FM2 instruments.
Aqua Solar Calibration, Raster Scan only

FM3 SW shows ~1% drop in response since start of raster scan. TOT channel from both FM3 and FM4 show a similar >2% drop in response.
Validation: Terra and Aqua Ed-4 SW Flux Anomalies

SW flux anomalies show similar trends for all three instruments.

Uses SSF data products.
Validation: Terra and Aqua Ed-4 LW Flux Anomalies

LW flux anomalies show similar trends for all three instruments

Uses SSF data products
Validation - Terra and Aqua Tropical Mean
Validation - DCC 3-Channel Intercomparison
SUMMARY

• All CERES instruments continue to perform nominally.
  ▪ FM6 instrument continues to show stable performance after the initial sensor response rise.
  ▪ FM5 is currently operating in biaxial mode, collecting ADM data.
  ▪ FM1-FM4 continue to perform normally.
  ▪ Validations show that all instruments are performing consistently.

• Data products
  ▪ NOAA-20/FM6 Edition 1 gains and SRFs have been finalized and delivered through Jan 2020.
  ▪ S-NPP/FM5 Edition 2 gains and SRFs have been delivered through Jan 2020.
  ▪ Terra and Aqua instruments’ Edition 4 gains and SRFs have been delivered through December 2019.

• We congratulate and look forward to working with the Libera team to continue the data record.