Comparing CERES Measurements using ScaRaB-3

by

Lou Smith, Z. Peter Szewczyk,
Kory J. Priestley and Remy Roca
FM-5 Gives us a Unique Opportunity to Determine whether the Internal Black Bodies and Shortwave Internal Calibration Sources have changed.

The Earth Radiation Budget Climate Data Record is based on the Assumption that the IBBs and SWICSs have not changed during their Decade of Operation in Space.
Internal Calibration Module and On-orbit Calibration

Internal Calibration Module

In-Orbit Calibration using Internal Calibration Module
The ScaRaB-3 can be used as a Transfer Radiometer between the CERES FM-1, -2, -3, -4 and -5 to Address these Vital Questions

This will also give a Comparison of CERES with ScaRaB-3
Comparisons between ScaRaB and CERES Instruments

ScaRaB will greatly enhance comparison opportunities

Figure 1: Comparisons between ScaRaB and CERES instruments. Numbers on lines for comparisons denote:
1. Both instruments on same spacecraft, 2. Special operations near 70° at solstice, 3. Comparisons during underpass, 4. Using ScaRaB as transfer radiometer.
Comparison of measurements from satellite radiation budget instruments

G. Louis Smith, Z. Peter Szewczyk, David A. Rutan, and Robert B. Lee III

Table 5. Shortwave Relative Flux Biases at TOA (Above Diagonal) and Standard Deviations (Below Diagonal), W m⁻²

<table>
<thead>
<tr>
<th></th>
<th>ERBS Sc</th>
<th>ERBS NS</th>
<th>ScaRaB 1</th>
<th>CERES/TRMM</th>
<th>ScaRaB 2</th>
<th>CERES FM 1</th>
<th>CERES FM 2</th>
<th>CERES FM 3</th>
<th>CERES FM 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERBS Sc</td>
<td>-</td>
<td>-0.5</td>
<td>-5.9</td>
<td>-3.1</td>
<td>-6.6</td>
<td>-3.3</td>
<td>-2.9</td>
<td>-2.2</td>
<td>-2.3</td>
</tr>
<tr>
<td>ERBS NS</td>
<td>0.3</td>
<td>0.4</td>
<td>0.9</td>
<td>2.8</td>
<td>0.7</td>
<td>2.6</td>
<td>3.0</td>
<td>3.7</td>
<td>3.6</td>
</tr>
<tr>
<td>ScaRaB 1</td>
<td>0.5</td>
<td>0.4</td>
<td>-</td>
<td>1.9</td>
<td>-1.6</td>
<td>1.7</td>
<td>2.1</td>
<td>2.8</td>
<td>2.7</td>
</tr>
<tr>
<td>CERES/TRMM</td>
<td>0.8</td>
<td>0.7</td>
<td>0.8</td>
<td>-3.5</td>
<td>-0.2</td>
<td>0.2</td>
<td>0.9</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>ScaRaB 2</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.4</td>
<td>-</td>
<td>3.3</td>
<td>3.7</td>
<td>4.4</td>
<td>4.3</td>
</tr>
<tr>
<td>CERES FM 1</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>-</td>
<td>0.4</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>CERES FM 2</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>0.8</td>
<td>1.6</td>
<td>-</td>
<td>0.7</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>CERES FM 3</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>0.2</td>
<td>0.6</td>
<td>-</td>
<td>-0.1</td>
</tr>
<tr>
<td>CERES FM 4</td>
<td>1.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>0.1</td>
<td>0.6</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

Table 8. Longwave at Night Relative Flux Biases at TOA (Above Diagonal) and Standard Deviations (Below Diagonal), W m⁻²

<table>
<thead>
<tr>
<th></th>
<th>ERBS Sc</th>
<th>ERBS NS</th>
<th>ScaRaB 1</th>
<th>CERES/TRMM</th>
<th>ScaRaB 2</th>
<th>CERES FM 1</th>
<th>CERES FM 2</th>
<th>CERES FM 3</th>
<th>CERES FM 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERBS Sc</td>
<td>-</td>
<td>1.5</td>
<td>2.2</td>
<td>-0.5</td>
<td>1.1</td>
<td>-1.9</td>
<td>-1.1</td>
<td>-1.7</td>
<td>-1.7</td>
</tr>
<tr>
<td>ERBS NS</td>
<td>0.1</td>
<td>0.7</td>
<td>-2.0</td>
<td>-0.4</td>
<td>-3.4</td>
<td>-2.6</td>
<td>-3.2</td>
<td>-3.2</td>
<td></td>
</tr>
<tr>
<td>ScaRaB 1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>-2.7</td>
<td>-1.1</td>
<td>-4.1</td>
<td>-3.3</td>
<td>-3.9</td>
<td>-3.9</td>
</tr>
<tr>
<td>CERES/TRMM</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>-</td>
<td>1.6</td>
<td>-1.4</td>
<td>-0.6</td>
<td>-1.2</td>
<td>-1.2</td>
</tr>
<tr>
<td>ScaRaB 2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>-</td>
<td>-3.0</td>
<td>-2.2</td>
<td>-2.8</td>
<td>-2.8</td>
</tr>
<tr>
<td>CERES FM 1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.2</td>
<td>-</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>CERES FM 2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
<td>-0.6</td>
<td>-0.6</td>
<td></td>
</tr>
<tr>
<td>CERES FM 3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.0</td>
<td>0.6</td>
<td>-</td>
<td>0.0</td>
</tr>
<tr>
<td>CERES FM 4</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.0</td>
<td>0.2</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

ScaRaB 1 agreed very well with ERBE
Opportunities to Compare Earth Radiation Measurements

- The Megha-Tropique Orbit crosses the Terra orbit near 10:30 (High Sun) and near 23:30 for a night measurement.
- The Megha-Tropique Orbit crosses the Aqua and NPP orbits near 13:30 (High Sun) and near 01:30 for a night measurement.
Special Operations of CERES Instruments to make Comparisons

• Near the Intersections of the Terra orbit with the Megha-Tropique orbit, FM-2 will be rotated in Azimuth so that its Scan Plane will be Coplanar with that of ScaRaB-3.

• FM-2 will operate in the Half-scan Mode so as to scan from Space view aft to Nadir and back, thus never looking in Ram Direction.

• FM-3 on Aqua and FM-5 on NPP will operate similarly.
View in Scan Plane

CERES Science Team Meeting, Newport News, Virginia
1-3 May 2012
Footprint growth with Distance from CERES nadir point

Arc distance from CERES nadir point, degrees

6° from CERES is limit due to footprint Growth
Increase of View Zenith Angle with Distance from CERES nadir Point

View Zenith Angle at Primary Scene, degrees

Arc distance from CERES nadir point, degrees

For 6° from CERES, VZA is 45°
Range of Distances from CERES Nadir matching Scene within 5° VZA

Data will cover one 1° region well.
Number of CERES Measurements with VZA within 5° of Primary Scene

CERES Science Team Meeting, Newport News, Virginia
1-3 May 2012
Latitudes of Orbit Crossings with Megha-Tropique

Terra

Aqua

Local Solar time of Ascending Node of Megha-Tropique

CERES Science Team Meeting, Newport News, Virginia
1-3 May 2012
Azimuth Rotation of CERES to Match ScaRaB Scan Plane

Terra

Azimuth rotation Of CERES to match ScaRaB Scan Plane

Local Solar time of Ascending Node of Megha-Tropique
Concluding Remarks

• The Geometry for Special Operations of CERES to compare with ScaRaB has been defined.
• Sampling Requirements must be defined.
• Special Operations of CERES began 17 April 2012