Current Status of the ERBS Nonscanner SW Data
Record from 10/1999 to 08/2005

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CERES Science Team Meeting
Victoria, B.C., Canada
14-16 November 2007
The Problem

- Without overlapping data, we can’t tie these two SW climate segments together due to absolute calibration and time sampling differences between these two satellite missions.
The Solution

- Develop simple method to connect these two SW segments together

1) Direct method: Use ERBS SW data from 10/1999 to 8/2005
   - However, ERBS instrument anomaly on 10/5/1999 has not been corrected and data after 10/1999 is not currently useable for climate study. Works on correcting this instrument issue is on-going

2) Indirect method: Use other stable climate data source (i.e., SeaWiFS PAR data) to guide the transition from the ERBE/ERBS SW nonscanner record to the CERES/Terra SW scanner record (Loeb et al., J. Climate., Feb 2007)
   - Give promising results
Outlines

• Give an overview on the current status of the ERBS Nonscanner SW data record from 10/1999 to 8/2005

1) Provide a description of the ERBS instrument anomaly and how it affects the SW record

2) Highlight steps that we have taken over the last 8 months to recover the last five years of ERBS data
   - Establishing instrument calibration after instrument anomaly
   - Determination of the instrument tilt angle
   - Reworking the inversion algorithm to account for (a) the tilt of the instrument and (b) the additional decreases in satellite altitude

3) Show initial SW results based on the new algorithm for 10/99 to 7/02

4) Summarize future works that are needed to release this last ERBS SW record
Description of the ERBS Instrument Problem

- ERBS instrument anomaly occurred on 10/5/1999 at the end of its normal calibration event. It stopped at an angle away from nadir. Consequently, new science algorithm will have to be developed and tested to remove this instrument tilt anomaly artifact from the ERBS scientific data after 10/5/1999.
**Instrument Tilt Anomaly Artifact**

- The effect of the instrument tilt anomaly, if not corrected, will appear as a sharp drop in the reflected shortwave fluxes after 10/5/1999.
Instrument Calibration (Gain)

- ERBS nonscanner instrument calibration was re-established through special spacecraft pitch maneuver on 9/16/2003 by looking directly at the Sun
- Non-scanner SW sensor gain was essentially unchanged between 9/1999 and 9/2003

![Graph showing measured gains from October 25, 1984 to September 16, 2003 for SWFOV and TWFOV channels.](image-url)
Instrument Calibration (Offset)

- ERBS nonscanner instrument calibration was re-established through special spacecraft pitch maneuver on 9/16/2003 by looking directly at the Sun.
- Non-scanner SW sensor offset was essentially unchanged between 9/1999 and 9/2003.
Instrument Tilt Angle Determination

- The tilt angle is defined by the directions between the ERBS non-scanner optical axes and the spacecraft nadir. This angle is critical for removing instrument artifact in the TOA SW fluxes.

Total Solar Irradiance (Wm\(^{-2}\))

<table>
<thead>
<tr>
<th>Date</th>
<th>Total</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>~11/21/1984</td>
<td>1371.5</td>
<td>1353.1</td>
</tr>
<tr>
<td>*11/21/1984</td>
<td>1373.7</td>
<td>1354.0</td>
</tr>
<tr>
<td>~10/20/1985</td>
<td>1368.2</td>
<td>1330.5</td>
</tr>
<tr>
<td>*10/20/1985</td>
<td>1368.5</td>
<td>1330.9</td>
</tr>
<tr>
<td>~12/04/2002</td>
<td>1317.7</td>
<td>1194.3</td>
</tr>
<tr>
<td>*09/16/2003</td>
<td>1375.1</td>
<td>1247.0</td>
</tr>
</tbody>
</table>

Tilt Angle = \(\cos^{-1}\left(\frac{\text{TSI}_{2002}}{\text{TSI}_{2003}}\right)\)

<table>
<thead>
<tr>
<th>Tilt Angle (Degree)</th>
<th>Total</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16.6</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Consistent to within 0.1 degree

~ Azimuth setting of 0 degree
* Azimuth setting of 90 degrees
ERBS Nonscanner SW Inversion

- ERBS SW inversion algorithm inverts the SW measurement at satellite into SW flux at top of the atmosphere (TOA)
- SW$_{\text{toa}}$ is determined by SW$_{\text{sat}}$, instrument tilt angle (ta), satellite altitude (alt), solar zenith angle (sza), and satellite relative azimuth angle (raa)

$$\text{SW}_{\text{toa}} = \frac{\text{SW}_{\text{sat}}}{\text{Factor (ta, alt, sza, raa)}}$$

<table>
<thead>
<tr>
<th>Date</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/30/1999</td>
<td>0.86</td>
</tr>
<tr>
<td>10/6/1999</td>
<td>0.72</td>
</tr>
</tbody>
</table>

The lower value of the inversion “Factor” will increase the SW$_{\text{toa}}$
The new algorithm moves the ERBS post-anomaly time series back to the same radiometric level as the pre-anomaly data.

The recovered ERBS Nonscanner time series also matches well with the overlapping CERES/Terra scanner data.

\[
\begin{align*}
\text{ERBS}_{\text{pre}} &= 92.3 (3.7) \\
\text{ERBS}_{\text{nocor}} &= 76.2 (2.8) \\
\text{ERBS}_{\text{cor}} &= 92.8 (3.7) \\
\text{Terra} &= 91.1 (3.3)
\end{align*}
\]
Monthly Mean Comparison, September 2001

CERES/Terra ERBE-like

CERES minus ERBS

<table>
<thead>
<tr>
<th>Time</th>
<th>CERES</th>
<th>ERBS NS</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/2001</td>
<td>94.5 (21.1)</td>
<td>92.8 (19.2)</td>
<td>1.7 (7.9)</td>
</tr>
</tbody>
</table>

NASA Langley Research Center / Science Directorate
Monthly Mean Comparison, September 2001

CERES/Terra ERBE-like SW vs. ERBS SW

<table>
<thead>
<tr>
<th>Time</th>
<th>CERES</th>
<th>ERBS NS</th>
<th>R^2</th>
<th>Slope</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/2001</td>
<td>94.5 (21.1)</td>
<td>92.8 (19.2)</td>
<td>0.92</td>
<td>0.84</td>
<td>13.4</td>
</tr>
</tbody>
</table>
Summary and Future Works

- The recovery of the ERBS SW record from 10/1999 to 8/2005 is currently underway with some promising initial results.
- Additional works are needed to determine the uncertainty of the tilt angle and how this will affect the quality of the final SW time series.
- Further validation activities are required to map the CERES vs. ERBS SW differences as a function of both the instantaneous and the temporal sampling differences and to determine whether these are consistent with previous studies.
- ERBS nosncanner SW data from other months also need to be examined for data quality issues.
- Finally, future work will be needed for the recovery of the ERBS total channel data record, if funding permits.
- This work was funded by the ERBS end-of-mission funding.