The CERES Terra & Aqua Edition 4.0 processing uses MODIS radiances and aerosols as key inputs.

CERES Edition 4.0 started with MODIS Collection 5. However, C5 processing at GSFC was terminated at data date February 2017 and superseded with MODIS Collection 6.

MODIS C6 has been superseded with MODIS Collection 6.1.

MODIS Collection 6.1 is a major calibration upgrade for select Terra (6.72 and 8.6 µm) and Aqua (visible) channels.

- Significantly improves the quality of the MODIS cloud mask, especially for Terra.
• CERES Team has reprocessed Level 2 SSF and all downstream Level 3 products with MODIS C6.1 starting in March 2016, when the MODIS Terra water vapor channel showed a large spurious loss of sensitivity.

• In addition, CERES SYN1deg and EBAF SFC fluxes were reprocessed for the entire CERES record because of a large discontinuity in aerosol optical depths between MODIS C5 and C6.1. AODs are assimilated in MATCH and used to compute surface fluxes.

• EBAF all-sky TOA fluxes remain unchanged between Ed4.0 and Ed4.1.

• Introducing new clear-sky fluxes in EBAF Ed4.1. Definition is more in line with that used in climate models.

• CERES data for 03/2000-02/2016 will not be reprocessed until Ed 5.
### Terra & Aqua Ed4.1 vs Ed4.0 Changes

**Parameter**                              | **ED4.0**                                                                 | **ED4.1**                                                                 |
---                                         |                                                                          |                                                                          |
MODIS-collection                            | Terra-MODIS 6.7, 8.6 μm striping, March 2016 to March 2018               | MODIS C6.1 resolved the Terra-MODIS 6.7, 8.6 μm striping                  |
MATCH-Edition                               | Large discontinuity between MODIS C5 & C6.1 AOD inputs                  | Uses MODIS C6.1 AODs as input for entire CERES record                    |
MODIS Clouds                                | Impacted Terra cloud properties                                         | Terra cloud properties corrected beginning in Feb 2016                  |
GEO Clouds                                  | Him-8, GOES-16,17, Met-8,11 cloud codes with bugs                       | Consistent cloud code using MATCH Ed4.1, begin July 2015                 |
Surface fluxes                              | The clear-sky SW down surface flux was impacted by MODIS C5 & C6.1 AOD discontinuity | SYN surface fluxes, computed using consistent GEO cloud code with MATCH Ed4.1 and tuned fluxes to correct GEO TOA flux |
Summary of Changes in EBAF Ed4.1

1) Introducing new clear-sky fluxes & associated CREs

2) Entire surface flux record reprocessed using consistent aerosols (C6.1) throughout

3) Reprocessed cloud properties from 03/2016 onwards (C6.1)

Note: No change to TOA fluxes
### “Clear-Sky” Definitions in Models & Observations

<table>
<thead>
<tr>
<th>Historical Name</th>
<th>Source</th>
<th>Description</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1</td>
<td>Observation</td>
<td>Observed clear-sky flux for cloud-free regions within gridbox</td>
<td>(F_\text{cs}^0)</td>
</tr>
<tr>
<td>(Potter et al., 1992)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 1b</td>
<td>Model</td>
<td>Model clear-sky flux over gridbox weighted by model clear-sky fraction</td>
<td>(F_\text{cs}^M(\text{ModWgt}))</td>
</tr>
<tr>
<td>(Potter et al., 1992)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 1c</td>
<td>Hybrid</td>
<td>Calculated clear-sky flux over gridbox weighted by observed clear-sky fraction</td>
<td>(F_\text{cs}^C(\text{ObsWgt}))</td>
</tr>
<tr>
<td>Method 2</td>
<td>Model</td>
<td>Model or calculated clear-sky flux over gridbox determined by ignoring clouds in the atmospheric column</td>
<td>(F_\text{cs}^M(\text{CldRem})), (F_\text{cs}^C(\text{CldRem}))</td>
</tr>
</tbody>
</table>

- Most model evaluation is between Method 2 (Model) & Method 1 (CERES)
“Clear-Sky” in Models & Observations

- Cloudy columns generally moister than clear columns => Impact on OLR comparisons
- AODs typically larger in cloudy columns => Impact on SW comparisons
New EBAF Ed4.1 Clear-Sky Flux

• We derive an adjustment ($\Delta^C$) to the EBAF observed monthly mean clear-sky flux that enables direct comparisons with model clear-sky fluxes determined by ignoring (“removing”) clouds:

$$F_{cs}^O(CldRem) = F_{cs}^o + \Delta^C$$

$$\Delta^C = F_{cs}^C(CldRem) - F_{cs}^C(ObsWgt)$$

$F_{cs}^O$ = Observed clear-sky flux for cloud-free regions within gridbox (original EBAF)

$F_{cs}^C(CldRem)$ = Computed clear-sky flux over entire gridbox determined by ignoring clouds in the atmospheric column (from CERES SYN1deg product)

$F_{cs}^C(ObsWgt)$ = Computed clear-sky flux over entire gridbox weighted by MODIS clear-sky fraction (analogous to $F_{cs}^o$).
The overall global mean LW $\Delta^C$ for the entire 07/2005-06/2015 period is $-2.2 \text{ Wm}^{-2}$
TOA SW Adjustment Factor ($\Delta^C$)
(Climatological Monthly Mean for 07/2005-06/2015; Units: Wm$^{-2}$)

- The overall global mean SW $\Delta^C$ for the entire 07/2005-06/2015 period is 0.5 Wm$^{-2}$
LW $\Delta^C$ is positive during winter at high latitudes because surface and boundary layer temps are warmer in cloudy conditions.

$$\Rightarrow F_{cs}^{C}(CldRem) > F_{cs}^{C}(ObsWgt)$$
SYN1deg LW $\Delta^C$ vs MERRA-2, ERA-Interim and ERA5 (January 2008; For same MODIS-observed clear-sky weights)

- Regional RMS difference < 1 Wm$^{-2}$. 
SYN1deg SW ΔC vs MERRA-2, ERA-Interim and ERA5
(January 2008; For same MODIS-observed clear-sky weights)

(a) ΔC(SYN1deg)  (Wm⁻²)
(b) ΔC(MERRA-2) - ΔC(SYN1deg) (Wm⁻²)
(c) ΔC(ERA-Interim) - ΔC(SYN1deg) (Wm⁻²)
(d) ΔC(ERA5) - ΔC(SYN1deg) (Wm⁻²)

- Regional RMS difference ~2 Wm⁻². (1 Wm⁻² for non-Polar Oceans).
- Largest discrepancies over sea-ice and in heavily polluted land regions (e.g., China).
Anomalies in Global Mean $\Delta^c$ and CRE (07/2002-09/2018)

Standard Dev (Wm$^{-2}$)

$\Delta^c$: 0.11
CRE: 0.28

$\Delta^c$: 0.069
CRE: 0.51
Standard Deviation in Regional Anomalies of $\Delta^C$ and CRE

RMS

(a) Standard Deviation in LW $\Delta^C$ Anomaly

RMS 1.74

(b) Standard Deviation in SW $\Delta^C$ Anomaly

RMS 1.96

(c) Standard Deviation in LW CRE Anomaly

RMS 6.64

(d) Standard Deviation in SW CRE Anomaly

RMS 11.3
TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models (2003-2014; Shading: ±1 Standard Deviation from the Multimodel Mean)

(a) LW

- EBAF (Without $\Delta^C$ Adjustment)
- EBAF (With $\Delta^C$ Adjustment)
- Multimodel Mean
TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models (2003-2014; Shading: ±1 Standard Deviation from the Multimodel Mean)

(b) SW

- Black: EBAF (Without Δ^C Adjustment)
- Red: EBAF (With Δ^C Adjustment)
- Blue: Multimodel Mean

(Wm^(-2))

(-90, -90)
LW TOA Cloud Radiative Effect: CERES EBAF vs Multimodel Mean of 7 CMIP6 Models (2003-2014; Shading: ±1 Standard Deviation from the Multimodel Mean)

(a) CERES EBAF LW CRE (with Δ° Adjustment)

(b) Multi-Model minus EBAF (with Δ° Adjustment)  
RMS: 4.5 Wm^{-2}

(c) Multi-Model minus EBAF (Without Δ° Adjustment)  
RMS: 6.1 Wm^{-2}
Uncertainty in $1^\circ \times 1^\circ$ Regional Monthly TOA Fluxes and CREs

<table>
<thead>
<tr>
<th></th>
<th>TOA (Wm$^{-2}$)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All-Sky</td>
<td>Clear-Sky</td>
<td>CRE</td>
</tr>
<tr>
<td>SW</td>
<td>2.5</td>
<td>5.4</td>
<td>5.9</td>
</tr>
<tr>
<td>LW</td>
<td>2.5</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>NET</td>
<td>3.5</td>
<td>7.1</td>
<td>7.4</td>
</tr>
</tbody>
</table>
# Changes to CERES EBAF Ordering Page

## CERES EBAF Ordering Page

### EBAF Browse and Subset Products

**Edition 4.1**

<table>
<thead>
<tr>
<th>EBAF Product</th>
<th>Parameters</th>
<th>Data Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOA Fluxes, Clouds</td>
<td>Observed TOA all-sky and clear-sky fluxes; CERES-MODIS cloud properties</td>
<td>03/2000 - 12/2018</td>
<td>[Browse &amp; Subset]</td>
</tr>
<tr>
<td></td>
<td>(<em>Clear-sky for cloud free areas of 1ºx1º region</em>)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOA &amp; Surface Fluxes, Clouds</td>
<td>Observed TOA and computed surface all-sky and clear-sky fluxes; CERES-MODIS cloud properties</td>
<td>03/2000 - 03/2018</td>
<td>[Browse &amp; Subset]</td>
</tr>
<tr>
<td></td>
<td>(<em>Clear-sky for total area of 1ºx1º region</em>)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Changes to CERES EBAF Ordering Page

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Clear Sky (for cloud-free areas of region)</th>
<th>Clear Sky (for total region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOA Fluxes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shortwave Flux</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longwave Flux</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Flux</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOA CRE Fluxes (clear-sky cloud removed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Flux</td>
<td></td>
<td></td>
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<tr>
<td>Cloud Parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Fluxes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface CRE Fluxes (clear-sky cloud removed)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Click to select individual parameters
Summary

- Ed4.1 changes include:
  - New clear-sky fluxes & associated CREs. Clear-sky definition is more consistent with that used in climate models.
  - Reprocessed surface fluxes using consistent aerosols throughout (No changes made to TOA fluxes).
  - Reprocessed cloud properties from 03/2016 onwards (C6.1)

- Clear-sky adjustment reduces global mean clear-sky LW flux by 2.2 Wm\(^{-2}\) and increases SW flux by 0.5 Wm\(^{-2}\). Larger regional changes.

- Global mean TOA CRE changes:

<table>
<thead>
<tr>
<th></th>
<th>EBAF Ed4.0</th>
<th>EBAF Ed4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW</td>
<td>27.9</td>
<td>25.7</td>
</tr>
<tr>
<td>SW</td>
<td>-45.8</td>
<td>-45.3</td>
</tr>
<tr>
<td>Net</td>
<td>-17.9</td>
<td>-19.6</td>
</tr>
</tbody>
</table>
Towards a Consistent Definition Between Satellite and Model Clear-Sky Radiative Fluxes


Journal of Climate
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Abstract | PDF

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