A comparative look of CERES OLR from Aqua and S-NPP

Xianglei Huang and Xiuhong Chen
the University of Michigan

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Acknowledgement: the CERES team
• With AIRS and CERES on Aqua, we have showed the synergy between hyperspectral sounder and broadband radiometer

  – At flux level
  • LW spectral flux derived from the AIRS footprint using collocated scene type info from CERES-SSF
  • Good agreement with CERES OLR over multiple years and multiple scene types

  – At radiance level
  • Assess the CERES radiance stability over multiple years

*Can we use the CrIS and CERES on S-NPP to show the same synergy, paving a road for future synergistic use of data from JPSS-1, JPSS-2?*
On spectral flux

CERES flux and radiance are never used. Only scene-type info in the CERES SSF datasets.

Output: spectral flux at 10cm\(^{-1}\) intervals through the entire longwave spectral range.

(Huang et al., 2008; 2010; 2014; Chen et al., 2013)
All collocated clear-sky observations in 2004 (80°S-80°N)

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Daytime ( \text{OLR}<em>{\text{AIRS_Huang}} - \text{OLR}</em>{\text{CERES}} ) (Wm(^{-2}))</th>
<th>Nighttime ( \text{OLR}<em>{\text{AIRS_Huang}} - \text{OLR}</em>{\text{CERES}} ) (Wm(^{-2}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>(0.58 \pm 1.43)</td>
<td>(-0.42 \pm 1.41)</td>
</tr>
<tr>
<td>Savannas</td>
<td>(-0.03 \pm 2.52)</td>
<td>(0.68 \pm 1.50)</td>
</tr>
<tr>
<td>Grasslands</td>
<td>(0.19 \pm 2.61)</td>
<td>(0.63 \pm 1.65)</td>
</tr>
<tr>
<td>Dark Desert</td>
<td>(-0.71 \pm 2.85)</td>
<td>(0.36 \pm 1.74)</td>
</tr>
<tr>
<td>Bright Desert</td>
<td>(1.67 \pm 2.62)</td>
<td>(1.42 \pm 2.28)</td>
</tr>
<tr>
<td>Ocean</td>
<td>(1.09 \pm 1.55)</td>
<td>(0.90 \pm 1.26)</td>
</tr>
</tbody>
</table>

Footprint statistics
AIRS
• Aboard Aqua with a 1:30 AM/PM equatorial crossing time
• A field of view 13.5 km (nadir)
• 2378 channels with a spectral resolving power ($\lambda /\Delta \lambda$) of 1200 from 650 to 2670 cm$^{-1}$ (non-continuous coverage)
• Data collection from Sep 2002 to present
• Stability: 0.002-0.003 K/yr in B.T. (Aumann et al., 2019, GRL)
• Radiometric Uncertainty: 0.05-0.2K in B.T.

CrIS
• Aboard Suomi-NPP with ~1:30 AM/PM equatorial crossing time
• 14-km nadir-view footprint
• 1305 channels over 3.92–4.64, 5.71–8.26, and 9.14–15.38 µm
• Data collection from Feb 2012 to present
• Stability: 0.003-0.016 K/yr in B.T. (Hepplewhite et al., 2019/2020)
• Radiometric Uncertainty: 0.03-0.2K in B.T.
CrIS NEdT vs AIRS and IASI at native instrument resolution (T=270K)

In thermal IR, CrIS has smaller noise levels than both AIRS and IASI

Zavyalov et al,
https://cimss.ssec.wisc.edu/itwg/itsc/itsc18/program/files/links/1.07_Zavyalov_po.pdf
Multi-year-mean spectral flux from Aug. 2012 to Jul. 2018
Spectra flux derived from CrIS

Cloudy-sky over nonfrozen surface $\text{OLR}_{\text{CRIS}} - \text{OLR}_{\text{CERES_NPP}}$ (Jan2016)
Multiple-year global comparisons: AIRS spectral OLR vs. CERES

(Huang et al., 2014, J Climate)

Footprint statistics

<table>
<thead>
<tr>
<th></th>
<th>Clear-sky</th>
<th>Cloudy-sky</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime</td>
<td>[-0.34, 0.42]</td>
<td>[2.20, 3.00]</td>
</tr>
<tr>
<td>Nighttime</td>
<td>[-0.67, -0.38]</td>
<td>[1.85, 2.12]</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>Daytime</td>
<td>[0.39, 1.07]</td>
<td>[1.48, 2.10]</td>
</tr>
<tr>
<td>Nighttime</td>
<td>[0.57, 0.89]</td>
<td>[1.69, 1.87]</td>
</tr>
</tbody>
</table>
WN-band Flux difference (CrIS – CERES)

- 2012 only includes Apr-Dec
- CERES FM5 Ed1

Clear-sky

- Daytime
- Nighttime

Cloud-sky

- Daytime
- Nighttime

Footprint statistics
OLR difference (CrIS – CERES)

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<tbody>
<tr>
<td>Daytime</td>
<td>[1.71, 2.43]</td>
<td>[1.42, 3.02]</td>
</tr>
<tr>
<td>Nighttime</td>
<td>[0.88, 1.03]</td>
<td>[1.45, 2.23]</td>
</tr>
</tbody>
</table>

2012 only includes Apr-Dec
CERES FM5 Ed1
2019 error bar is large due to missing CrIS data
AIRS-CERES Ed4 on Aqua vs. CrIS – CERES Ed 1 on S-NPP

**Clear-sky**

- **Daytime AIRS - CERES-Ed4**
- **Daytime CrIS - CERES-NPP**
- **Nighttime AIRS - CERES-Ed4**
- **Nighttime CrIS - CERES-NPP**

**Cloudy-sky**

- **Daytime AIRS - CERES-Ed4**
- **Daytime CrIS - CERES-NPP**
- **Nighttime AIRS - CERES-Ed4**
- **Nighttime CrIS - CERES-NPP**

Graphs showing the OLR difference in Wm$^{-2}$ from 2012 to 2019 for both clear-sky and cloudy-sky conditions.
On stability assessment

\[ r_{diff} = \frac{I_{LW-CERES(daytime)}}{I_{est(daytime)}} \]

- \( I_{LW-CERES(daytime)} \): CERES unfiltered LW radiances (W m\(^{-2}\) sr\(^{-1}\))
- \( I_{est(daytime)} \): AIRS integrated radiances (W m\(^{-2}\) sr\(^{-1}\))

Graphs showing changes in relative difference over time.
On stability assessment

Following Huang et al. (2012, JTECH)

1) Do regression using nighttime CrIS (or AIRS) and CERES WN and LW radiance
2) Estimate CERES LW **daytime** radiance using the regression coefficients from 1)
3) Estimate the relative difference for the daytime

\[
rdiff = \frac{I_{LW\_CERES}(daytime) - I_{est}(daytime)}{I_{est}(daytime)}
\]

Premise: if daytime vs. nighttime has changes with time, rdiff should be able to tell
The shift of mean $r_{\text{diff}}$ in Julies with respect to the mean $r_{\text{diff}}$ of July 2005.
For Julies, randomly select 20 subsets of data, which include 13~20 days, respectively. Then compute daytime shift for CERES FM3 Ed4.

Red line is obtained using all data
Black line: randomly chosen 50% data
Daytime shift for CERES FM5 Ed1 (Julies)

Red line is obtained using all data
Black line: bootstrap with randomly chosen 50% data
Why bother with the WN band?

It can provide additional infect for cloud feedback vs. cloud change

Conclusions and discussions

• Synergy exists between the CERES and hyperspectral observations
  – Agreements at both the radiances and flux are both reassuring the synergy
  – Collocated radiances can help assess CERES unfiltered radiance

• Window-band flux from CERES is under-utilized.
  – Channel performances stable over the year
  – Flux is consistent with the ones from AIRS/CrIS
References


Thank You!