CERES GEO LW Narrowband to Broadband Radiance Algorithm and CERES simulator

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Outline

• Current GEO LW flux Status
• Ed4 2-channel NB-BB flux algorithm
• Ed4 NB-BB Radiance algorithm development
• Summary
• Future work
Current GEO NB-BB Flux
Matched GEO vs. Terra, January 2006

Global Mean RMS: 8.39
GEO LW and Terra LW Matched within 1.5 hours
Current GEO LW NB->BB Flux Algorithm

- WN => Nadir NB flux

\[ F_{NB} = 1.97\pi L_{WN}(\theta) / \gamma(\theta) \]

\[ \gamma(\theta) = \begin{cases} 1 & \theta \leq 11.7 \\ 1.000665 + 0.0324721\ln(\cos\theta) & \theta > 11.7 \end{cases} \]

WN Rad VZA

Limb darkening function

- NB flux => BB flux (OLR)

\[ OLR_{BB} = a_0 + a_1 F_{NB} + a_2 F_{NB}^2 + a_3 \ln(RH) \]

Column Relative Humidity

NB flux

\[ a_0, a_1, a_2, a_3 \] Coefficients for ocean and land separately
Current GEO NB->BB Flux Algorithm

- The algorithm is based on Minnis et al. 1991 and not updated since then.
- Doelling et al. (1998 and 2003) validate the algorithm over ocean and land area and investigate the effects of different channels and relative humidity on RMS.
- LW RMS (~3-5%).
Areas for Improvement

- Use Ed4 GEO multiple channels vs. Ed2/Ed3 WN only
- Use WV channel to replace GEOS Relative Humidity
- Use ADM-like scene types vs. global land/ocean formula
Ed4 NB->BB Radiance Development

- Data: SSF-Ed4 (MODIS radiance and CERES flux)
- Test multiple channels:
  - 3.79μm (Night only), 6.72μm, 11.03μm, 12.02μm
- Create scene types:
  - **Ocean/land (6)**: Ocean, Forests, Savannas, Grass-Crop, Dark and Bright Deserts.
  - **Day/Night (2)**
  - **Clear/cloud (2)**
  - **Precipitable Water (4)**: 0-1, 1-3, 3-5, 5-10 cm
  - **Viewing Zenith Angle (7)**: 0°-70°, every 10°
- Total: 672 scene types
Ed4 NB->BB Radiance Development

• For each scene type:

  Linear regress: CERES $LW_{BB}$ vs. MODIS ($Rad_{nb1}$, $Rad_{nb2}$, $Rad_{nb3}$)

  \[ LW_{est} = a_0 + a_1 Rad_{1.1\mu m} + a_2 Rad_{6.7\mu m} + a_3 Rad_{12\mu m} \]

• Evaluation of the algorithm:

  \[ RMS = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (LW_{i est}^{BB} - LW_i^{BB})^2} \]
Method

1. Calculate NB-BB flux directly using 11.03µm and 6.72µm for all scenes.

2. Calculate NB-BB flux using current 11.03µm global formula and then sort the data according to the same scene types as in 1.
NB Rad -> BB Flux
2-ch vs. WN-only (All scenes)

Based on SSF-Ed4 April, 2000
NB Rad -> BB Flux
Daytime

Based on SSF-Ed4 April, 2000
Based on SSF-Ed4 April, 2000
NB Rad - BB Flux
Land and Ocean

### Land Scenes

- **Old**
  - Scenes: 490
  - Mean: 10.26
  - 0-5: 8.0%

- **New**
  - Scenes: 490
  - Mean: 4.47
  - 0-5: 65.7%

### Ocean Scenes

- **Old**
  - Scenes: 110
  - Mean: 10.01
  - 0-5: 12.7%

- **New**
  - Scenes: 110
  - Mean: 4.56
  - 0-5: 69.1%
NB Rad -> BB Flux
Clear and Cloud

Clear Scenes

Cloud Scenes
### NB Rad -> BB Flux

#### Table

<table>
<thead>
<tr>
<th>Types</th>
<th>Total Scenes</th>
<th>Ed2/Ed3 WN-only</th>
<th>Ed4 WN + WV</th>
<th>Ed4 vs. Ed2/3 RMS diff (%)</th>
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<tr>
<td></td>
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<td>Mean RMS (%)</td>
<td>(%) RMS &lt; 5</td>
<td>Mean RMS (%)</td>
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<tr>
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<td>10.21</td>
<td>8.8</td>
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<td>10.26</td>
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<td>4.47</td>
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<td>10.01</td>
<td>12.7</td>
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NB -> BB Radiance
All Scenes

April, 2000
NB Rad -> BB Rad
Day and Night, April 2000

Day

Night
### NB Rad -> BB Rad Table

<table>
<thead>
<tr>
<th>Types</th>
<th>Total Scenes</th>
<th>Ed2/Ed3 WN-only</th>
<th>Ed4 WN + WV</th>
<th>Ed4 vs. Ed2/3 RMS diff (%)</th>
<th>Ed4 WN+WV+12μm</th>
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<td>Mean RMS</td>
<td>(%) RMS &lt; 1</td>
<td>Mean RMS</td>
<td>(%) RMS &lt; 1</td>
<td>Mean RMS</td>
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<tr>
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</table>
Summary

- ADM-like 2-channel (WN+WV) NB-BB flux algorithm reduce RMS by more than 55% compared with current WN only global land/ocean algorithm based on SSF Ed4 data.

- For NB-BB radiance conversion, 2-channel algorithm reduce RMS by about 40% compared with 1-channel algorithm averaged for all scenes.

- Adding other channels to the 2-channel algorithm improves RMS only slightly.
Future Work

- Adapt the 2-channel NB-BB radiance algorithm to the future ED4 GEO LW algorithm.
- Develop simulator for CERES ISCCP-like cloud
Simulator for CERES Cloud

Cloud Fraction by ISCCP-D1 types, Daytime, Terra, Dec 2002
Simulator for CERES Cloud

Flux by Cloud types, Daytime
Terra, Dec 2002
Simulator for CERES Cloud

- **ISCCP simulator**
  
  by Klein and Jakob, 1999; Webb et al, 2001

- **MODIS simulator**
  
  by Pincus et al. 2012
Simulator for CERES Cloud

A MODIS simulator for climate models (i)

Accepts sub-column inputs of \( r_{e(t,i)}(z) \), \( \tau_{(t,i)}(z) \) or \( q_{(t,i)}(z) \)

Provides subcolumn estimates of

\[
\tau = \int_{\text{TOA}}^{\text{sfc}} \sigma_c(z)dz
\]

(no errors, as ISCCP simulator)

\[
p_c = \frac{1}{2} \int_{\text{TOA}}^{\tau=2} p(z)\sigma_c(z)dz
\]

(when > 700 mb, use ISCCP IR)

\[
P = \int_{\text{TOA}}^{\tau=1} P(z)\sigma_c(z)dz
\]

(can be “undetermined”)

\[
r_e = F^{-1}(F(r_e(z)))
\]

(pseudo-retrieval based on near-IR fluxes)

**Pincus**

*Daytime only*
MODIS/ISCCP simulator modified for CERES

1. \( P_c > 700mb \), Klein/Webb ISCCP simulator
   
   *slightly different IR channels: 11.03\(\mu\)m vs. 10.5\(\mu\)m*

2. \( P_c \leq 700mb \), Pincus MODIS simulator
   
   \( r_e \) effective particle size

   CERES MODIS uses different lookup table to calculate
   
   \( \omega_o \) (single scattering albedo) and \( g \) (asymmetry factor)
   
   for \( R \) (Reflectance) for \( r_e \) pseudo retrieval
Simulator for CERES Cloud

CERES MODIS $\omega_0(R_e)$ and $g(R_e)$ calculation of Reflectance for pseudo retrieval

Minnis and Arduini
Thank You!
Backup

2-channel NB-BB flx
April, 2000