CERES Ed4 Cloud Properties

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CERES Science Team Meeting, Newport News, VA, April 26-28, 2011
Update of CERES Cloud-related Papers, etc.

Edition-2 related


Update of CERES Cloud-related Papers, etc.

Edition-2 related


Update of CERES Cloud-related Papers, etc.

Edition-4 related


CERES-Developed MODIS Calibration Corrections

in current Ed 4

not in current Ed 4

not in current Ed 4

Cal differences affect optical depth, Re/re, cloud fraction
Ed4 Clouds

All results shown here use the code delivered in February but run offline while the code conversion and testing at ASDC continue
CERES Cloud Mask Changes Since Last STM

In framework that impacts final mask

- Terra $T_{3.75}$ new calibration, towards Aqua $T_{3.75}$
- Terra Ref $0.65$ correction, towards Aqua Ref $0.65$
- CO2 slicing cloudy overwrite mask clear and ratio 1.24/0.65 tests overwrite mask cloudy

Daytime non-polar, improved

- clear Sun glint detection after all B cloudy
- clouds in Sun glint detection after all B clear
- clouds, aerosol, and glint detection in 6 C tests
- dust / low cloud discrimination (added ratio 1.24/0.65)
- thin Ci detection over ocean and land
- coastal clouds detection

Nighttime non-polar

- Improved thin Ci and low clouds detection
- Increased clouds detection over ocean
- Increased desert cloud detection. Dropped 3.75-11 CS STD from 2 to 1.5K
CERES Cloud Mask Changes Since Last STM - 2

Daytime Polar

- Improved ice clouds, snow surface, clear land, thin Ci detection, (added ref1.38)
- Added clear_snow overwrite clear_good and clear_weak using snow, ice, IGBP maps and spectral tests

Nighttime Polar

- Improved normal clouds and inversion clouds detection
- Changed the cloud tests over super cold plateau (Antarctica and Greenland)
- Improved the classification of TBD pixels
- Added clear sky restoral tests
Comparison of Cloud Fraction between Ed4 and CALIPSO V3 VFM

2008 Fall SON Day

2008 FALL SON Night

Aqua Ed4

TerraE d4

CALIPO V3
Filtered out horizontal averaging 80 km required for detection
Aqua Ed4 and CALIPSO V3 VFM, 2008 Summer JJA

Filtered out 20 & 80 km horizontal averaging required for detection

Filtered out horizontal averaging 80 km for detection

Aqua Ed4

CALIPSO V3

Day

Night

NASA CERES
Aqua Ed4 and CALIPSO V3 VFM, 2008 Winter JFD

Filtered out 20 & 80 km horizontal averaging required for detection

Filtered out horizontal averaging 80 km for detection

Day

Aqua Ed4

CALIPSO V3

Night

CERES Ed4 is closer to CALIPSO filter out 20 & 80 km

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Zonal Cloud Fraction between Aqua Ed4 and CALIPSO V3 with different filters

- **Latitudes**
  - **Cloud Fraction**
  - **Day**
    - 2008 Summer
    - 2008 Winter
  - **Night**
    - 2008 Summer
    - 2008 Winter

Graphs showing cloud fraction variability with latitudes for different seasons and years, comparing Aqua Ed4 and CALIPSO V3 with different filters.
Seasonal Zonal Cloud Fraction between Aqua Ed4 and CALIPSO V3

2008 Spring

2008 Summer

2008 Fall

2008 Winter

dash lines: CAL_filtered 80km
solid lines: CERES_Aqua Ed4
Cloud Fraction, Aqua 2008, Night Time, Land
Cloud Fraction, Aqua 2008, Night Time, Ocean

Spring

Summer

Fall

Winter

Latitude

Latitude
**Ed4-Ed2 Differences**

**Cloud Fraction, 2008**

**Daytime**

Averages shown are for 60N-60S

- Liquid cloud increase
  - greatest over land & polar
- decrease in ice clouds
  - larger for Aqua
  - 1.2/vis ratio check?
  - worse for land
### Seasonal Global Cloud Fraction Comparison 2008

<table>
<thead>
<tr>
<th></th>
<th>Day</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Terra Ed4</td>
<td>Aqua Ed4</td>
</tr>
<tr>
<td>Spring</td>
<td>0.62</td>
<td>0.63</td>
</tr>
<tr>
<td>Summer</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>Fall</td>
<td>0.63</td>
<td>0.64</td>
</tr>
<tr>
<td>Winter</td>
<td>0.63</td>
<td>0.63</td>
</tr>
<tr>
<td>Total</td>
<td>0.63</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### Global Cloud Fraction Comparison 2008

<table>
<thead>
<tr>
<th></th>
<th>Terra Ed2B</th>
<th>Aqua Ed1C</th>
<th>Terra Ed4</th>
<th>Aqua Ed4</th>
<th>CAL_80km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>0.60</td>
<td>0.61</td>
<td>0.63</td>
<td>0.63</td>
<td>0.69</td>
</tr>
<tr>
<td>Night</td>
<td>0.59</td>
<td>0.59</td>
<td>0.66</td>
<td>0.67</td>
<td>0.73</td>
</tr>
</tbody>
</table>
Cloud Mask Summary

• Daytime
  - picking up more low clouds over land and ocean
    - *cloud type most missed by Ed2*
    - *overall increase of 0.027 relative to Ed2*
    - *closer to CALIPSO results than Ed2*
  - Aqua picking up 0.03 fewer ice clouds over land
    - *reason not clear, switch from liquid to ice?, ratio overwrite?*
    - *0.000 change overall in Terra data*

• Nighttime
  - picking up more clouds over land and ocean
    - *mostly low, water, type most missed by Ed2*
    - *overall increase of 0.098 relative to Ed2, 0.026 loss in ice clouds*
    - *greatest increases in Arctic & Tropics, decrease over Antarctica*

• Total
  - 0.06 less than CALIPSO leaving out 80-km clouds
    - *difference is 0.06 less than Ed2*
Cloud Property Retrievals

- new Terra calibration for 0.65 & 3.8 µm
- rough ice crystal reflectance models
- ozone attenuation correction
- increased tau limit from 128 to 150
- new thickness and physical top parameterizations
- new parameters for Ed4
Cloud Heights

- New lapse rate introduced for boundary-layer clouds
  - seasonally, regionally variable
  - increased layer top to 780 hPa over ocean, interpolation to 680 hPa
    750 hPa over land, interpolation to 650 hPa
    765 hPa over coast, interpolation to 665 hPa

- CO2 heights used when VISST too low

- rough models in VISST ice cloud retrieval yield different optical depths

- Cloud top physical height added and improved
Cloud Top Height km, Aqua 2008, Night Time, Land

Spring

Summer

Fall

Winter

Legend:
- CERES Ed4
- CALIPSO
- ISCCP
Cloud Top Height km, Aqua 2008, Day Time, Ocean

Spring

Summer

Fall

Winter

Latitude

CERES Ed4
CALIPSO
ISCCP
Cloud Height Changes from Ed2, Aqua

- Effective height changes all positive on average
- Terra same for ice clouds, near zero for water clouds
- 0.2 km Ed2 Terra – Aqua difference in water height gone in Ed4
Daytime Optical Depth Difference, Aqua Ed4 – Ed2

- Ice tau decreases in many ocean areas between 55°N and 45°S
  - water tau decreases in areas between 20°N and 20°S
  - Terra has similar ice tau decreases in that zone
- Large increases in polar cloud taus, Terra also
Daytime Optical Depth Differences, Ed4 – Ed2

- Minimal change in non-polar regions
- Significant increase in polar regions: 1.24-µm replaced 1.6/2.1 µm
Ed4 Optical Depth Difference, Terra – Aqua, 2008

- Minimal difference over non-polar ocean, mostly positive
  - stratus thinning?

- Significant negative difference over non-polar land
  - convective development in afternoon

- Significant positive difference over polar regions
  - none expected
  - likely due to 1.24-µm calibration
    - Terra brighter than Aqua
    - affects clear brightness maps
2008 Terra Cloud Droplet Effective Radius Difference (µm)

• 0.5 µm increase over ocean, expected
• > 1 µm increase over drier lands
  - more thin low clouds
  - background influence?
• decrease in some polar regions
  - increased tau => smaller $r_e$
• Aqua has net 0.0 change over water, 1 µm over land
  - decrease over Antarctica only
• $r_e$ decreases during day over many ocean & desert areas
  - thinning of stratus and altostratus?
• $r_e$ increases over land & marine deep convection areas
  - ice cloud contamination? Thickening?
2008 Zonal Average Ice Cloud Particle Size Differences, Ed-4 – Ed2

- Increase in $R_e$ for extratropical marine areas
- Increase over all land & snow, except for some desert

- Increase nearly universal for Terra due to $r_e$ increase
  - drop in avg over small Cu areas
- Except for marine Cu areas, increase everywhere for Aqua also

**Terra**

- **Non-polar**
  - 9.7 gm$^{-2}$
  - 10.2 gm$^{-2}$

- **Polar**
  - 13.8 gm$^{-2}$
  - 55.9 gm$^{-2}$

**Aqua**

- **Non-polar**
  - 6.9 gm$^{-2}$
  - 14.7 gm$^{-2}$

- **Polar**
  - 28.5 gm$^{-2}$
  - 56.4 gm$^{-2}$
2008 Day Cloud Ice Water Path Difference, Ed4 – Ed2

- Increase universal for both satellites due τ limit increase
- Greatest increase in polar areas: 1.24 μm increased τ, higher R_e

Non-polar
- Terra: 19 gm⁻², 53 gm⁻²
- Aqua: 26 gm⁻², 75 gm⁻²

Polar
- Terra: 81 gm⁻², 191 gm⁻²
- Aqua: 123 gm⁻², 171 gm⁻²
New Parameters for Ed4

• Cloud top height:
  - *avg height* 0.8 km above eff cloud height for ice clouds
  - *avg height* 0.03 km above eff height for water clouds

• $r_e / R_e$ at 1.2 and 2.1 µm
  - *only good for non-snow, tau > 2 or so*

• multilayer cloud detection / retrieval
Droplet Effective Radius, Aqua, 30 July 2008

RGB

3.7 µm

2.1 µm

1.24 µm
• Avg ratio only for $\tau > 2$
• Ratio $< 1$ over many polluted areas?
- Avg ratio only for $\tau > 2$
- Ratio < 1 over most of northern ocean
- Why is $r_e(1.2)$ larger than Aqua $r_e(1.2)$?
Droplet Effective Radius Ratios 3.7/X.X, Spring 2008

- Ratios mostly increase over ocean from morn to PM
- Ratio decrease over some land areas
- More drizzling over ocean in the morning?
Ice Crystal Effective Radius, Aqua, Spring 2008, $\tau > 2$

- 3.8 $\mu$m
- 2.1 $\mu$m
- 1.2 $\mu$m
- Ratio 3.7/1.2

- 2.1 $\mu$m Re almost always > Re(3.7), usually < Re(1.24)
  - Need to remove pegged values
- Terra-Aqua differences have some calibration errors
• Ratios mostly decrease over ocean from morn to PM for 1.24, not 2.1 µm
• 1.2 µm ratios exceed 1 over some land areas, even for Aqua
• Terra-Aqua differences have some calibration errors
Daytime Overlapped Clouds Using MCAT, Aqua, 2008

- Most detected overlap over water
  - Storm tracks and convergence areas
- 7.5 – 9.0% coverage, greatest in winter
• Terra & Aqua yield comparable results with MCAT
• BTD methods detect more overlap
  - Pavolonis method yields most over land & ocean
• ML low clouds have optical depths comparable to SL water clouds
• ML upper ice cloud optical depths too high – coding error
Clear-sky 10.8-µm Temperature Differences, Summer 2008

\[ T(GEOS-5) - T(\text{obs}) \]

- Good agreement over many ocean areas, a little overestimate
  - *large bias in cloud-heavy areas*

- Large negative differences over dry lands
  - *larger in afternoon*
  - *emissivity differences?*

- Reasonable agreement over vegetated land
Summary of Ed4 Clouds

• Delivered in February, not yet being processed

• Overall results look very good, but problems remain that need fixing
  - fast fixes

• Calibration
  - 1.24 and 2.1 µm have variations up to 5% between Aqua and Terra
  - affects cloud mask
  - affects snow albedos/ optical depth over snow
  - affects new particle size information

• Multilayered clouds
  - Upper cloud optical depths incorrectly calculated
    - easy fix

• Pegged 1.24/2.1 Re/re
  - prevents reliable statistical calculation

• Ice cloud decreases over land: not sure of problem, 2 weeks?