CERES TRMM VIRS & TERRA MODIS CLOUD PROPERTIES

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CERES Science Team Meeting
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CLOUD PROPERTIES

• USED TO RELATE CLOUDS TO THE RADIATION BUDGET
  - TIES HYDROLOGICAL CYCLE TO RADIATION
  - ENABLES IMPROVEMENT OF ADMs => BETTER FLUXES

• FUNDAMENTAL CLIMATOLOGICAL DATA

• CLOUD AMOUNT, HEIGHT, TEMPERATURE, PHASE,
  OPTICAL DEPTH, PARTICLE SIZE, LIQUID & ICE WATER PATH

• PRODUCTS AT PIXEL LEVEL*, CERES FOOTPRINT
• ALGORITHMS CURRENTLY BEING APPLIED TO VIRS, MODIS, GOES
STATUS OF VIRS CLOUDS

• CONTINUOUS ANALYSES COMPLETED FROM JAN 1998 - JULY 1999
  - ADDITIONAL MONTH, MARCH 2000
  - WORKING ON AUG 1999
  - RESULTS LOOK VERY CONSISTENT,
  - AMOUNTS COMPARE WELL WITH SFC CLIMATOLOGY
  - LWP EXCELLENT (TRMM TMI & SGP)
  - OD: FEW % LOW, re: 0.7 µm GREATER THAN SFC RADAR

• VALIDATION PAPER (Dong et al.) NEARLY READY FOR SUBMISSION

• CALIBRATION PAPERS ACCEPTED OR NEARLY COMPLETE

• WORKING ON DRAFTS FOR METHODOLOGY, RESULTS
MEAN CLOUD COVER, VIRS, JAN 1998

DAYTIME

NIGHT
MEAN EFFECTIVE CLOUD WATER DROPLET SIZE, VIRS, JAN 1998

DAYTIME

NIGHT

re, µm
MEAN EFFECTIVE CLOUD ICE PARTICLE SIZE, DAY, VIRS 1998

APRIL

JUNE
COMPARISON OF TOTAL CLOUD AMOUNTS


MAY TOTAL CLD AMT

CLOUD AMOUNT (%) vs. LATITUDE (°)

JAN TOTAL CLD AMT

CLOUD AMOUNT (%) vs. LATITUDE (°)

FEB TOTAL CLD AMT

CLOUD AMOUNT (%) vs. LATITUDE (°)

MARTOTAL CLD AMT

CLOUD AMOUNT (%) vs. LATITUDE (°)
Daytime thick clouds: 5 stratus cloud tops outside of bounds, $T(z)$ problem
Thin cloud daytime: 3 below cloud base, 1 above cloud top
Nighttime thick: 2 cirrus too high, 3 stratus too high [T(z) again]
Nighttime thin: 4 Ci too high, 1 too low; best agreement
Daytime VIRS and Surface Comparison at ARM SGP Site

- Effective radius (μm) vs. Number of Sample
- Optical depth vs. Number of Sample
- Liquid water path (LWP) vs. Number of Sample

Graphs showing comparisons between VIRS and surface measurements for effective radius, optical depth, and LWP, with RMS and correlation coefficients provided for each set of data.
Nighttime VIRS and Surface Comparison at ARM SGP Site

Effective radius (µm)

Optical depth

LWP (g/m²)

Number of Sample

RMS = 2.83
Corr = 0.00

RMS = 29.9
Corr = 0.01

RMS = 164
Corr = 0.03

Number of Sample

LWP (Surface)

RMS = 8.1
VIRS = 8.8

Surface = 31.7
VIRS = 10.8

Surface = 125
VIRS = 64
Multilayered clouds?
## ECMWF vs DAO SFC TEMPS FOR VIRS JULY 1998

- **Comparison of differences between model & observed clear-sky temperatures:** \( \text{DIF} = \text{TMOD} - \text{TOBS} \)

- **DAO GEOS 3.3 & ECMWF (CERES product)**

<table>
<thead>
<tr>
<th></th>
<th>ECMWF</th>
<th>( \sigma )</th>
<th>DAO</th>
<th>( \sigma )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DAY</strong></td>
<td>0.41 K</td>
<td>1.7 K</td>
<td>0.94 K</td>
<td>2.1 K</td>
</tr>
<tr>
<td><strong>DAY LAND</strong></td>
<td>-0.40</td>
<td>2.8 K</td>
<td>1.24 K</td>
<td>3.4 K</td>
</tr>
<tr>
<td><strong>NIGHT</strong></td>
<td>1.16 K</td>
<td>1.6 K</td>
<td>1.66 K</td>
<td>2.4 K</td>
</tr>
<tr>
<td><strong>NIGHT LAND</strong></td>
<td>1.62</td>
<td>2.3 K</td>
<td>3.13 K</td>
<td>3.8 K</td>
</tr>
</tbody>
</table>

- **DAO VERSION 4 IN THE PIPELINE, NOT YET ANALYZED**
STATUS OF CERES-MODIS CLOUD PROPERTIES

• CALIBRATION
  - Provisional MODIS comparisons show good agreement for most channels, except for
    - MODIS 0.65 reflectance ~3% > VIRS at large albedos
    - MODIS 3.7 temps 0.5K > VIRS (day)

• Betas in Archive
  - Beta1, March 2001
  - Beta2, April-May 2001
  - Beta1 & Beta2 used wrong 3.7-µm central wavelength
droplet sizes too small & night clouds too high
DAYTIME CLOUD OPTICAL DEPTH, APRIL 2001

Water

Ice
DAYTIME CLOUD EFFECTIVE PARTICLE SIZE, APRIL 2001

Water, \( (\mu m) \)

Ice, \( (\mu m) \)
DAYTIME CLOUD LWP & TEMPERATURE, APRIL 2001

LWP (g/m^2)

Temp (K)
APRIL TOTAL CLOUD AMOUNTS
CERES 2001; ISCCP D2 (84-91); SFC (71-95)

MODIS in twilight (SZA 78-90°) above 60°N; negates 3.7 µm impact on mask
THIN CLOUD HEIGHT VALIDATION CERES-MODIS, 11/00 - 5/01, BETA2

MODIS daytime optically thin clouds at the ARM SGP Site ($\tau<5$)

Cloud Heights (km)

Cloud Effective height (km)

Cloud Temperatures (°K)

Cloud Effective Temp (°K)

- Base Eff = -1.0, Std = 0.98
- Mean Eff = 0.24, Std = 0.84
- Base Eff = 4.2, Std = 6.7
- Mean Eff = -4.9, Std = 6.2
INITIAL CIRRUS PROPERTY VALIDATION
CERES-MODIS
11/00 - 5/01
BETA2
100 x 100 km box vs 30 min avg

• 3.7-µm calibration reduces re
• OD outliers due to strong gradient in box
COMPARISON OF MODIS & CERES CLOUD MASK, JULY 4 OVER ALASKA

0 - cld
1 - noret
2 - clr land
3 - clr snow
4 - clr ocn
COMPARISON OF MODIS & CERES CLOUD PHASE, JULY 4 OVER ALASKA

GREEN - CLEAR; BLUE - WATER; WHITE - ICE

PINK - noret; GOLD - no phase
COMPARISON OF MODIS & CERES CLOUD OD, JULY 4 OVER ALASKA
COMPARISON OF MODIS & CERES CLOUD re, JULY 4 OVER ALASKA
COMPARISON OF MODIS & CERES CLOUD MASK, JULY 8 OVER TWP
COMPARISON OF MODIS & CERES CLOUD MASK, JULY 8 OVER TWP

GREEN - CLEAR; BLUE - WATER; WHITE - ICE

PINK - noret; GOLD - no phase

2001070800

Cloud_Particle_Phase

MOD06_Cld_Phase

CERES Cloud Mask and MOD06 Retrievals: July 8, 2001
COMPARISON OF MODIS & CERES CLOUD OD, JULY 8 OVER TWP
COMPARISON OF MODIS & CERES CLOUD re, JULY 8 OVER TWP
COMPARISON OF MODIS & CERES CLOUD re, JULY 8 OVER TWP
COMPARISON OF MODIS & CERES CLOUD MASK, MAR 16 OVER SGP
COMPARISON OF MODIS & CERES CLOUD PHASE, MAR 16 OVER SGP

GREEN - CLEAR; BLUE - WATER; WHITE - ICE

PINK - noret; GOLD - no phase

Cloud Particle Phase
MOD06_Cld_Phase
CERES_Cloud_Mask
FAH_Classifier[CERES Regroup]
COMPARISON OF MODIS & CERES CLOUD OD, MAR 16 OVER SGP
COMPARISON OF MODIS & CERES CLOUD re, MAR 16 OVER SGP
COMPARISON OF MODIS & CERES CLOUD De, MAR 16 OVER SGP
COMPARISON OF MODIS & CERES CLOUD De, MAR 16 OVER SGP
### SUMMARY OF DIFFERENCES BETWEEN CERES & MODIS MASK

**GIVEN CERES CLASSIFICATION, IS MODIS THE SAME?**

<table>
<thead>
<tr>
<th></th>
<th>CLEAR: AGREE</th>
<th>DISAGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TWP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEAR:</td>
<td>34.8%</td>
<td>6.6%</td>
</tr>
<tr>
<td>CLOUD:</td>
<td>56.8%</td>
<td>2.4%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>35.0%</td>
<td>8.1%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>MODIS NONE 13.6%</td>
<td>CERES NORET 0.7%</td>
</tr>
<tr>
<td><strong>NSA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEAR:</td>
<td>19.2%</td>
<td>0.9%</td>
</tr>
<tr>
<td>CLOUD:</td>
<td>64.1%</td>
<td>13.0%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>22.9%</td>
<td>15.9%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>MODIS NONE 26.4%</td>
<td>CERES NORET 2.9%</td>
</tr>
<tr>
<td><strong>SGP</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLEAR:</td>
<td>26.4%</td>
<td>10.1%</td>
</tr>
<tr>
<td>CLOUD:</td>
<td>60.3%</td>
<td>1.2%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>42.3%</td>
<td>11.0%</td>
</tr>
<tr>
<td>PHASE:</td>
<td>MODIS NONE 7.4%</td>
<td>CERES NORET 1.4%</td>
</tr>
</tbody>
</table>
MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES
OVER NSA JULY 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 20 M-pixels)

(CERES- MODIS)

Particle size
3.7 Ret: $\text{re}_\text{Diff}_\text{Mean} = -0.67 \pm 1.33 \ \mu m$ (with empirical cal correction)
   $\text{De}_\text{Diff}_\text{Mean} = 5.88 \pm 26.0 \ \mu m$

1.6 Ret: $\text{re}_\text{Diff}_\text{Mean} = -4.77 \pm 6.29 \ \mu m$
   $\text{De}_\text{Diff}_\text{Mean} = 3.23 \pm 20.1 \ \mu m$

2.1 Ret: $\text{re}_\text{Diff}_\text{Mean} = -2.98 \pm 4.15 \ \mu m$
   $\text{De}_\text{Diff}_\text{Mean} = -0.46 \pm 18.6 \ \mu m$

Optical depth

$\text{re}_\text{OD}_\text{Diff}_\text{Mean} = 0.53 \pm 5.29$
$\text{De}_\text{OD}_\text{Diff}_\text{Mean} = 2.83 \pm 15.14$
MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES OVER TWP JULY 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 12 M-pixels)

(CERES- MODIS)

Particle size
3.7 Ret: re_Diff_Mean = -1.94 ± 3.39 µm (with empirical cal correction)
   De_Diff_Mean = -2.78 ± 20.7 µm

1.6 Ret: re_Diff_Mean = -9.81 ± 7.05 µm
   De_Diff_Mean = 9.83 + 18.71 µm

2.1 Ret: re_Diff_Mean = -9.20 ± 6.07 µm
   De_Diff_Mean = 5.42 + 21.9 µm

Optical depth
re_OD_Diff_Mean = 0.07 ± 2.06
De_OD_Diff_Mean = -0.87 ± 8.88
MEAN DIFFERENCES BETWEEN CERES & MODIS CLOUD PROPERTIES
OVER SGP MARCH 2001

BOTH CERES & MODIS MUST AGREE IN PHASE (SUBSET of 5 M-pixels)

(CERES- MODIS)

Particle size

3.7 Ret: \( \text{re\_Diff\_Mean} = -0.50 \pm 1.10 \mu m \) (with empirical cal correction)
\( \text{De\_Diff\_Mean} = 6.47 \pm 19.6 \mu m \)

1.6 Ret: \( \text{re\_Diff\_Mean} = -2.49 \pm 19.6 \mu m \)
\( \text{De\_Diff\_Mean} = 10.5 \pm 17.2 \mu m \)

2.1 Ret: \( \text{re\_Diff\_Mean} = -1.57 \pm 2.60 \mu m \)
\( \text{De\_Diff\_Mean} = 6.80 \pm 15.1 \mu m \)

Optical depth

\( \text{re\_OD\_Diff\_Mean} = 0.37 \pm 5.44 \)
\( \text{De\_OD\_Diff\_Mean} = 4.07 \pm 11.7 \)
CLOUD CODE IMPROVEMENTS FOR FINAL EDITION

- Calibration resolution

- 1.6-µm cloud retrieval test & validated, not implemented, reduce polar OD

  VINT: Visible Infrared Near-infrared Technique for polar region

- Improvement in twilight polar cloud mask

- Implementation of polar night mask

- Implement MODIS channel emittance models (improve cloud height at night)

- Update clear-sky reflectance maps for extratropical areas

  beta2 used estimates from VIRS (IGBP averages)
FINAL NOTE RELATIVE TO GERB

• CERES-LIKE ALGORITHMS BEING APPLIED TO GOES-8 DATA
  - AVAILABLE AT http://www-pm.larc.nasa.gov/
  - NEAR REAL TIME OVER ARM SGP SITE
    - 32°N - 42°N, 90°W - 114°W
    - VALIDATION PAPER ACCEPTED (Dong et al.)
  - CASE STUDIES OVER FLORIDA FOR CRYSTAL
  - 3-HOURLY OVER SE PACIFIC (OCTOBER 1999-?)

• PLAN TO APPLY SAME ALGORITHMS TO MSG SEVIRI
  - IF NASA $$