TISA (Time-Space Averaging) Update

D. Doelling
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TISA Team:
R. Bhatt, B. Lock, D. Morstad, C. Nguyen, M. Nordeen, R. Raju, M. Sun, H. Syed
SSAI

15th CERES-II Science Team Meeting
Newport News, VA, April 26-28, 2011
Outline

• GEO calibration update
• CERES prototype ordering tool improvements
• ISCCP-D2like and Flux-by-cloud-type products
• Surface flux validation
• GEO 1-hourly SW regional normalization
• Summary
GEO calibration update

• Recalibrate all GEOs to Aqua-MODIS between 2000-2011 over their respective life times to retrieve Edition4 GEO cloud properties
  – Currently (Edition2) piece wise (3-year increments) calibration coefficients are delivered
  – Radiometrically scale Terra 0.65μm radiance to Aqua-MODIS
  – Use Aqua as a reference and use Terra, desert and DCC to monitor stability of GEO’s
  – Take into account spectral response differences using SCIAMACHY

D. Doelling, P. Minnis, NASA LaRC
R. Bhatt, D. Morstad, B. Scarino, A. Gopalan, SSAI
J. Xiong, A. Wu, NASA GSFC
MODIS retrieved cloud properties

• Jack Xiong indicated 2 Terra MODIS instrument anomalies occurred on July 2003 and April 2009
• There is a downward trend in the IWP and optical depth derived from Terra, but not from Aqua
Terra and Aqua MODIS DCC trends

- Methodology: perform monthly PDFs of the Band 1 (0.65\(\mu\)m) radiances from pixels with 30°S<Lat<30°N, SZA<40°, VZA<40°, T(11\(\mu\)m)<205°K, \(\sigma\)T(11\(\mu\)m) <1°K, \(\sigma\) (0.65\(\mu\)m)<3%
- Apply CERES DCC bidirectional model to convert radiance to overhead sun
- Use either the means or mode to track DCC radiances over time

- Aqua_MODIS seems to be less noisy and more stable over time
Deep convective clouds (DCC) are stable invariant targets.

- Terra DCC indicate a 2.7%/10 years drop, and Aqua a 0.1%/10 years drop.
- Aqua band 1 is 3% brighter than Terra based on DCC.
Invariant deserts and snow targets indicate a 1.6 to 2.9%/10 years drop for Terra and 0.0 to 1.8% drop for Aqua.
Terra/Aqua SNO Collection 5

July 2002
~72°N
intersects

MAX  309.03  307.44
MIN  8.45   8.59
RNG  300.58  298.85

- Terra and Aqua simultaneous nadir radiance measurements (SNO)

- Use Aqua as a reference and tie Terra to Aqua for GEO calibration
- Factors to put on Terra-MODIS on the same radiometric scale as Aqua
GOES-12 gain trend

Before TA adjustment

After TA adjustment

- DCC and deserts normalized to Terra ray-matching
Met-9 gain trend

Before TA adjustment

After TA adjustment

- Note that DCC and deserts have a different trend than Terra ray-matching
- Note the consistency between Terra, DCC and deserts
Scan angle dependencies
correction factor to convert Collection 5 to 6

Terra

Aqua

- The difference in correction factor across can be as great as 2%, typical 0.5%
Terra/Aqua SNO Collection 6

Band1 (0.65\(\mu\)m)

7.804e-6*DSL+1.008
2.8%/decade

- Collection 6 will also Terra and Aqua relative calibration differences
CERES Prototype Ordering Tool

“Please excuse the fact that it's not really anything like the interface I just used of yours to get the CERES data!”
(User comment, April 12, 2011)

I do have one suggestion, which is that to be able to order data for one particular day, it would be nice to have the time range include the day of the month. As it is, I will have to download all the days in a month just to get on particular day (User comment, Jan 7, 2011)

D. Doelling
NASA LaRC

C. Chu, E. Kizer, C. Mitrescu, E. Heckert
SSAI
CERES Tiger Team

- CERES key concept or product web pages would be explained in a few bullets with expandable pages and hyper-links for more information, instead of the DQS approach which overwhelmed the user
- Every page designed to help the user quickly decide the product for their application, user realizes there are multiple spatial, temporal and algorithm differences for a given parameter

D. Doelling
NASA LaRC

J. Corbett*, Z. Eitzen*, E. Kizer*, J. Norris,
D. Rutan*, P. Taylor*, T. Wong*
*SSAI, NASA LaRC

• Always looking for new volunteers, ideas and critique of pages
Order tool statistics (May2010-Apr2011)

- Number of unique users (email) 136 that ordered
- Number of unique users (IP addresses) 272 that browsed or ordered

<table>
<thead>
<tr>
<th></th>
<th>Orders</th>
<th>Files</th>
<th>Months</th>
<th>Subset (GB)</th>
<th>HDF* (TB)</th>
<th>Subset/ HDF</th>
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<tbody>
<tr>
<td>EBAF</td>
<td>138</td>
<td>138</td>
<td>10.5K</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSFlite</td>
<td>229</td>
<td>302</td>
<td>18K</td>
<td>145</td>
<td>4.4-13.2</td>
<td>1-3%</td>
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<tr>
<td>SYNlite</td>
<td>227</td>
<td>313</td>
<td>16K</td>
<td>144</td>
<td>3.9-11.7</td>
<td>1-3%</td>
</tr>
</tbody>
</table>

* Depends on whether monthly, daily or TOA, or cloud properties were ordered

- Users only grab the parameters they want
CERES subset, browse and order the latest Edition Products PAGE

http://ceres.larc.nasa.gov

Pages should be Compatible with Safari, Firefox, IE, Chrome

CERES archived HDF Data Products, all Editions, products, instruments, etc, PAGE

CERES Data Products

To subset, visually browse, and download CERES data products in multiple file formats, click "Browse & Order". For more information on a specific product, click on the "Data Product" name. Or as a quick reference, click on the icon.

Access to the complete CERES archived HDF data products,

• DQS as PDF, easy for product lead to update, and user to browse

User feedback

• Soon to come, ISCCP-D2like and SSF (level 2) Products
### CERES Archived HDF Data Products

To subset, visually browse, and download data in netCDF format, [Browse & Order](#).

#### Data Products

**Level 3: Spatial and temporally (daily, monthly, etc) averaged fluxes and cloud properties.**

<table>
<thead>
<tr>
<th>Data Product</th>
<th>Description</th>
<th>Parameter</th>
<th>Resolution</th>
<th>Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYN/AVG/ZAVG</td>
<td>3-hourly (SYN), monthly mean (AVG/ZAVG) computed surface and in-atmospheric fluxes consistent with the CERES observed fluxes and clouds.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
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<tr>
<td>SFC</td>
<td>Instantaneous footprint gridded means of flux and cloud parameters from the SSF product.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>FSW</td>
<td>Instantaneous footprint gridded means of computed flux and observed cloud parameters from the CRS product.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>ISCCP-D21ke</td>
<td>Monthly 3-hourly (GMT based) and monthly mean cloud properties stratified by ISCCP cloud types and in the similar D2 format.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>FLASH_TISA</td>
<td>Near real-time observed TOA fluxes and clouds with parameterized surface fluxes, not officially calibrated for publication.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>ES4/ES9</td>
<td>Instantaneous gridded (ES4) and monthly (ES9) mean TOA fluxes using algorithms identical to those used by ERBE.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
</tbody>
</table>

#### Level 2: CERES instantaneous footprint level fluxes and cloud properties.

<table>
<thead>
<tr>
<th>Data Product</th>
<th>Description</th>
<th>Parameter</th>
<th>Resolution</th>
<th>Availability</th>
<th>Order Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSF</td>
<td>CERES observed TOA flux, MODIS clouds and aerosols and parameterized surface fluxes</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>CRS</td>
<td>Computed flux profiles from MODIS clouds and aerosols</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>FLASH_SSF</td>
<td>Near real-time SSF product, not officially calibrated for publication.</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>CERES-MISR</td>
<td>Nadir view CERES-SSF/MODIS/MISR collocated parameters</td>
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<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>CCCM</td>
<td>Nadir view CERES-SSF/MODIS/CALIPSO/CloudSat collocated parameters</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
<tr>
<td>ESR</td>
<td>CERES observed TOA fluxes using original ERBE algorithms</td>
<td></td>
<td></td>
<td></td>
<td>Order via ASDC</td>
</tr>
</tbody>
</table>
Shopping cart pages

- New tab available when orders are in the shopping cart
- Data volume of shopping cart shown
- Select tab to view the shopping cart

To prepare sub-setter for large volume dataset, such as SYN/AVG/ZAVG

- A shortcut for data orders less than 2GB is still available

If the 2GB limit is exceeded, then the options are:
- add the order to the Shopping Cart or
- return to the Data Selection Page to modify the order

Upon selecting “Add to Cart”, the volume of data added is show below
Shopping cart pages

- “Submit Order” initiates the processing

- Shopping cart requires password and email
- You can remember your password, or have it mailed to you
Monitor the processing after order has been submitted.
### SSF (level 2) sub-setting (to be released shortly)

Parameter selection, not all parameters offered

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Selected Fields: None</th>
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<tbody>
<tr>
<td>Time/Location/Angles</td>
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</tr>
<tr>
<td>CERES Observed</td>
<td></td>
</tr>
<tr>
<td>TOA Fluxes and Radiances</td>
<td></td>
</tr>
<tr>
<td>CERES TOA Shortwave</td>
<td>□</td>
</tr>
<tr>
<td>CERES TOA Longwave</td>
<td>□</td>
</tr>
<tr>
<td>CERES TOA Window</td>
<td>□</td>
</tr>
<tr>
<td>Surface Fluxes</td>
<td></td>
</tr>
<tr>
<td>Surface Parameters</td>
<td></td>
</tr>
<tr>
<td>GEOS-5</td>
<td></td>
</tr>
<tr>
<td>Atmosphere Parameters</td>
<td></td>
</tr>
<tr>
<td>Cloudy Footprint Area</td>
<td></td>
</tr>
<tr>
<td>MODIS Land Aerosols</td>
<td></td>
</tr>
<tr>
<td>MODIS Ocean Aerosols</td>
<td></td>
</tr>
</tbody>
</table>

SSF (level 2) sub-setting

• The HDF sub-setted parameters and location will be written out in netCDF

• Option to retain hourly SSF filenames in the netCDF files or to merge them into 2GB files ordered in time
SSF (level 2) site ordering

- Parameter Selection: SW, LW and WN flux
- Spatial Selection: Cairo lat and lon with a 30km radius
- Temporal Selection: all of 2008
- Result: One NetCDF file (0.4MB) of 730 footprints
- Time to order file: 25 minutes
- Traditional Way: ~0.5TB of 8760 HDF files (1250x more data)

Courtesy of Walt Baskins (ASDC)
SSF level 2 plotting package

- To give the user an idea of what the data and CERES swath looks like
- Map up to a day’s worth of orbits of a single SSF parameter
- Work with DAAC to quickly transfer from DPO to browse package
CERES Ordering Tool Highlights

- Aug 2009 – Initial web pages designed and framework developed on MAC laptops
- Apr 2010 – Live demonstration of tool at CERES science team meeting
- Jun 2010 – 1 CPU machine installed @ building 1250 with Tool Version 1.0 serving SSF/SYN1deg-lite-beta data products in time for AMS radiation conference in Portland Oregon
- Aug 2010 – Newly redesigned CERES web pages go live, giving users access to tool and providing user oriented information
- Sept 2010 – 2 CPU machines and 40TB hardware being installed @ building 1268 and incorporating Edition 2.5 SSF/SYN1deg-lite and EBAF data products including daily parameters
- Oct 2010 – Tool Version 1.1 released for the A-train users workshop. The tool was highlighted to introduce new users to CERES data.
- Apr 2011 – ISCCP-D2like, SSF (level 2) sub-setting soon to be added, integration of traditional HDF ordering pages, SYN/AVG/ZAVG next
ISCCP-D2like and Flux_by_cldtype Products

- Soon to put 10-years of ISCCP-D2like day, GEO, and Terra/Aqua/GEO product on sub-setter
  - Minor optical depth bug fixed, data has been reprocessed
- Flux by ISCCP cloud type beta product soon to be tested by Jason Cole
  - Instantaneous gridded fluxes by cloud type

D. Doelling, N. Loeb, NASA LaRC

M. Sun, R. Raju, H. Syed, SSAI
### Parameters

<table>
<thead>
<tr>
<th>Parameter selection</th>
<th>Liquid</th>
<th>Ice</th>
</tr>
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<tbody>
<tr>
<td>Cloud Fraction</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Cloud Effective Pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloud Effective Temperature</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Cloud Optical Depth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Path</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Particle Radius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared Emissivity</td>
<td></td>
<td></td>
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</table>

### Cloud Types

<table>
<thead>
<tr>
<th>Cloud Types</th>
<th>Thin (0.02-3.55)</th>
<th>Mid-Thick (3.55-22.63)</th>
<th>Thick (22.63-378.65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (10-440)mb</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Mid (440-580)mb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (680-1000)mb</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CERES ISCCP-D2like subset and ordering page

Spatial Resolution
- Regional (1° x 1° global grid)

Satellite

Order MODIS, GEO and Terra/Aqua/GEO daytime cloud properties

Time Range
From: 03 - 2000 (MM-YYYY) To: 02 - 2010 (MM-YYYY)

Email Address
david.r.doelling@nasa.gov

Browse Data
Get Data
Add to Cart
(for orders less than 2 GB) (registration required)
CERES ISCCP-D2like browse page (Terra-MODIS June 2009)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Stratus</th>
<th>Amount (%)</th>
<th>DCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Cloud Fraction - Daytime (K)</td>
<td>Stratus Low Thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Cloud Effective Temperature - Daytime (K)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Cloud Water Particle Radius - Daytime (µm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T(K)°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particle Size (µm)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ISCCP-D2like Terra MODIS-day product, 10-years

Total Cloud Fraction (%)

Cloud Fraction by cloud type (%)
Flux Algorithm

SSF Footprints

NB2BB: clear/cld1/cld2

BB2Flx: clear/cld1/cld2

Sort cloud/flux into D2like cloud types

Grid SSF into 1x1

Monthly Average

Monthly NB2BB coefficients
- 0.65, 0.86, 2.1 μm MODIS to BB CERES
- Use clear and overcast footprints

ADM
- Use clear/overcast models

NetCDF file for modeler

QC observational mean
Validation: SW NBtoBB-observed flux, Dec 2002

- Derived NB to BB flux = clear-sky + cloud layers based on clear or overcast NB to BB monthly coefficients

Sample: 10,258,348 partly cloudy footprints

- Production normalizes the footprint derived fluxes to the observed

**SW**
- Bias: 4.72
- Std: 14.33
- Cor: 0.994

**LW**
- Bias: 4.31
- Std: 6.65
- Cor: 0.984
Validation: SW NBtoBB-observed flux, Dec 2002

- The NB to BB algorithm is free from SZA, VZA, cloud fraction, & optical dependencies
Flux-by-cloud-type Monthly QC

• Derive the SW daily flux from the instantaneous flux assuming constant meteorology using CERES directional model
• Assume no diurnal variation in the LW, use constant flux for the day
• Take all regionally gridded observational daily SW and LW fluxes and compute monthly means
• Bin in appropriate optical depth and pressure layers
Cloud Fraction by type, Terra Day, Dec 2002
Flux by cloud-type, Terra Day, Dec 2002

Preliminary Results

Clear-sky global SW flux = 53.8
Clear-sky global LW flux = 263.7
FLUX BY CLOUD-TYPE, TERRA DAY, DEC 2002

Net CRF

SW CRF

LW CRF

Preliminary Results
Surface Flux Validation

• Compare Terra constant meteorology, Terra+GEO (SYN Terra), Aqua+GEO (SYN Aqua), Terra+Aqua +GEO (SYN Ed3) Fu-Liou radiative transfer computed surface fluxes to ground site observations over several diurnal 3-hour time increments over the day
• Is GEO adding value?
• Is the Terra/Aqua SYN an improvement over single satellite SYN?

D. Doelling, NASA LaRC

D. Rutan, SSAI
### SW Surface Flux Down (％)

<table>
<thead>
<tr>
<th>Group</th>
<th>Process/Time</th>
<th>6-9AM</th>
<th>9-12PM</th>
<th>12-3PM</th>
<th>3-6PM</th>
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<tbody>
<tr>
<td>SGP Site</td>
<td>MODIS Only</td>
<td>7(33)</td>
<td>4(21)</td>
<td>1(16)</td>
<td>-3(25)</td>
</tr>
<tr>
<td></td>
<td>SYN Aqua</td>
<td>3(22)</td>
<td>1(16)</td>
<td>1(14)</td>
<td>-2(18)</td>
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<tr>
<td></td>
<td>SYN Terra</td>
<td>3(22)</td>
<td>1(15)</td>
<td>1(15)</td>
<td>-2(18)</td>
</tr>
<tr>
<td></td>
<td>Terra &amp; Aqua</td>
<td>1(22)</td>
<td>0(15)</td>
<td>-0(14)</td>
<td>-3(19)</td>
</tr>
<tr>
<td>DESERT</td>
<td>MODIS Only</td>
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<td>0(9)</td>
<td>0(10)</td>
<td>-2(14)</td>
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<tr>
<td></td>
<td>SYN Aqua</td>
<td>-3(15)</td>
<td>1(9)</td>
<td>1(9)</td>
<td>-2(12)</td>
</tr>
<tr>
<td></td>
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<td>-3(15)</td>
<td>1(9)</td>
<td>1(9)</td>
<td>-1(12)</td>
</tr>
<tr>
<td></td>
<td>Terra &amp; Aqua</td>
<td>-5(16)</td>
<td>-0(9)</td>
<td>-0(9)</td>
<td>-3(13)</td>
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<td>BSRN Continental</td>
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<td>1(26)</td>
<td>2(23)</td>
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<tr>
<td></td>
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<td>1(20)</td>
<td>2(22)</td>
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<td></td>
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<td>2(19)</td>
<td>3(22)</td>
<td>-1(28)</td>
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<tr>
<td></td>
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<td>0(19)</td>
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<td>-2(28)</td>
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<td>7(26)</td>
<td>8(25)</td>
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<td></td>
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<td>6(22)</td>
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<td>10(24)</td>
<td>8(30)</td>
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<td></td>
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<td>6(30)</td>
<td>4(20)</td>
<td>9(23)</td>
<td>7(30)</td>
</tr>
</tbody>
</table>

- Adding GEO improves the RMS error in morning and evening
- Terra/Aqua slightly improves the bias over single satellite
LW Surface Flux Down (%)

<table>
<thead>
<tr>
<th>Group</th>
<th>Process/Time</th>
<th>6-9AM</th>
<th>9-12PM</th>
<th>12-3PM</th>
<th>3-6PM</th>
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<tbody>
<tr>
<td>MODIS Only</td>
<td>MODIS Only</td>
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<td>-2(4)</td>
<td>-3(4)</td>
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<tr>
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<td>SYN Aqua</td>
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<td>-3(4)</td>
<td>-3(4)</td>
<td>-2(4)</td>
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<tr>
<td>SYN Terra</td>
<td>SYN Terra</td>
<td>-2(4)</td>
<td>-3(4)</td>
<td>-3(4)</td>
<td>-2(4)</td>
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<td>Terra &amp; Aqua</td>
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</table>

• LW surface flux down is insensitive to cloud input
GEO Narrowband to Broadband

- GEO visible and IR radiances are calibrated against MODIS
- GEO Cloud properties
  - Uses subset of CERES MODIS cloud algorithm based on VIS and IR radiances, need to convert radiances into fluxes
- GEO Narrowband to Broadband radiance conversion
  - First adjust GEO radiance to MODIS using models
  - MODIS equivalent to broadband radiance using model based on coincident MODIS and CERES measurements
- CERES ADMs are used to convert GEO broadband radiances into fluxes
- GEO derived instantaneous SW fluxes are regressed monthly against coincident CERES observed fluxes over a 5°x5° domain
- Normalization of GEO SW flux data stream with CERES mitigated regional biases and functionality with SZA, VZA and cloud amount
- Improve SW regional normalization using 1-hourly GEO
GEO SW regional flux normalization with CERES

- Expect large nonGEO Aqua-Terra difference based on overpass times
- If GEO derived BB fluxes were perfect there would be no Aqua-Terra difference
- Note the 45° longitude banding, due to GEO SW regional normalization artifact
SW regional normalization, Jan 2010

3-hourly GEO ΔGMT

1-hourly GEO ΔGMT

R²

R²
SW regional normalization, Jan 2010

**Aqua-Terra 3-hourly GEO**

- SYN Global: 104.33
- SSF Global: 104.85
- BIAS Global: -0.52

**Aqua-Terra 1-hourly GEO**

- SYN Global: 104.73
- SSF Global: 105.34
- BIAS Global: -0.62
TISA near term goals

• Deliveries since last April 2010
  – TSI Ed3, ISCCP-D2like merge Ed2

• Projected deliveries
  – GEO coefficients valid to Dec 2010
  – SYN and SSF lite Edition2.5b products until Dec 2010
  – EBAF Ed2.5b from Mar00 to Dec 2010, with the SW nonGEO-GEO trend removed
  – Flux_by_cloudtype beta to be tested by Jason Cole and any other volunteers

• Edition4 improvements
  – Finalize GEO coefficients with desert, DCC, spectral corrections, consistency with Terra and Aqua MODIS
  – Quantify 1-hourly GEO over 3-hour GEO derived flux improvements
    • Release in next version of SYN lite product
  – LW angular NB to BB and regional normalization, similar to SW
    • Currently global NB to BB coefficients and instantaneous normalization
  – GEO based land clear-sky maps for improved GEO cloud retrievals
    • Test 5-channel GEO cloud code

• Finish writing CERES TISA paper
  – Finalize GERB results