BETA4 TSI/SYNI Status

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8th CERES-II Science Team Meeting
8:30am Thursday 15th November
Fairmont Empress Hotel
Victoria, British Columbia, Canada
Nov 14-16 2007
Outline

• TSI Changes for Beta4
  – Ed3 like daytime TOA LW correction

• SYNI Changes for Beta4
  – Sfc Albedo History revised maps
  – Sea Ice Surface Albedo perturbation method
  – Snow Grain size retrieval

• Validation
  – PAR {SeaWifs Comparison}
  – UVA, UVB {USDA Sfc Obs}
  – SYNI @ CERES times compared to FSW
  – Model Vs Observed TOA Flux
    • Geo vs Ceres Times
SYNI Product *What is it?*

- Global 1x1 deg Grid Hourly
- Fu-Liou radiative transfer broadband SW and LW TOA, surface and atmosphere

**TSI Input product for SYNI**
- CERES & MODIS (~twice a day)
- 3 hourly Geostationary
  - Normalized to CERES for TOA Fluxes
  - Geostationary radiances calibrated to MODIS for Cloud Properties (τ, height, phase, particle size)

**Other major input products for SYNI**
- GEOS4 Temperature & Humidity
- SMOBA Ozone
- Modis and Match AOTs, Match constituents
- Microwave daily Snow & Ice
TSI Changes For BETA4

• Produce grid-hour **integrated** sun angle!
  ‒ 1 Hour in **Time**
    • Beta4 center on **bottom** of hour: Was centered @ Top of the hour in Beta3
  ‒ 1x1 degree Grid Box in **Space**.

• Rev1 SW correction applied

• Ed3*like Daytime Longwave Correction ( ~ +1%)

• No interpolation of MODIS Aerosol during cloudy non-retrieval periods. (SYNI reverts to MATCH AOTs)
  ‒ Reduce cloud contamination
  ‒ MODIS AOTs *as is*, **not** filtered by CERES FOV Cloud mask

• Fixed occasional cloud top > cloud base pressure problem

• Supply clear sky TOA albedo even when overcast
  ‒ If clear sky present at some time in month
Ed3-like Daytime Longwave Correction

- Monthly Parameterization to Ed2 (SW minus LW) Toa Flux
- Based on Loeb processing of daily data Edition 3 Beta7
Ed3-like Daytime Longwave Correction
FM1 Trends as function of SW minus LW value

Bright/Cold scenes correction decreases
Dark/Warm scenes correction increases

TIME (Year)
SYNI vs FSW CERES
OBSEVED LW

Ed3-like daytime OLR correction
SYNI vs FSW CERES
Observed SW Reflected Flux and TOA Insolation

- FSW average whatever FOVs fall into 1x1\text{deg} \times 1\text{hr} hourbox
- SYNI spatial temporal integration over hourbox
- Rev1 Correction applied to Obs TOA SW in TSI/SYNI

![SYNI-FSW 200207 TOA INSOLATION (@CERES day Times)](image)

- Differences follow Terra orbit equator crossing time
- Solar Declination computed hourly in TSI, only daily in FSW/CRS
SYNI uses Fu-Liou Code

- Gamma weighted 2-Stream (SW), 2/4 Stream (LW) pristine multi-stream correction to COART
  - Treats sub-computational scale Inhomogeneous clouds (S.Kato)
- Correlated k: 29 Bands: 15 SW, 14 LW, 3 of 14 LW in WN
  - Enhanced output of PAR and UVA, UVB (W.Su)
- Shortwave: (0.17 - 4.0 or \(\text{inf}\))\(\mu\) [2500-57000 cm-1]
  - HITRAN 2000 (\(H_2O\)) w/(\(O_2,CO_2,CH_4\))@Fixed concentration
  - JPL(1994) \(O_3\) uv, WMO(1985) \(O_3\) vis
- Longwave (0-2850 cm-1) (3.5\(\mu\) – Infinity)
  - \(H_2O,CO_2,O_3,N_2O,CH_4,CFCs,H_2O\) continuum
- Optical Properties: spectral (\(\beta, \omega, g\))
  - Water Cloud (Y.Hu)
  - Ice Cloud (Q.Fu 1996, Dge)
  - Aerosol Optical Properties (OPAC, Tegin&Lacis, d’Almedia)
- Major Revisions
  - 10 visible SW bands reworked for \(O_3\) and rayleigh in 1995
  - Near-Ir 0.7-1.3\(\mu\) subdivided into 4 bands in 2005
- Online Version http://www-cave.larc.nasa.gov/cave
Beta4 SYNI CHANGES

- Use Daily MATCH aerosol assimilation when no MODIS
  - Cloudy sky aerosol retrieval contamination issue
- Revise Monthly Surface Albedo History(SAH) maps to include Ocean Sea Ice domain and monthly average snow &/or sea ice fraction field.
- Simple Snow Grain size retrieval using CERESonly Broadband
  - Spectral surface albedo at non-ceres times assume constant snow grain size
- Separate Clear & Cloudy Sky Colorization of Spectral Sfc AlbedoLUT
- Zhuo Wang two coef. diurnal models for surface albedo(igbp 1-10&12)
- Add outputs field to SYNI
  - MATCH AOT
  - SAH surface albedo values (consistency check)
  - UVB Total Sky Upward Flux
  - Retrieved snow grain size
- Fix known bugs ::
  - Omission of high thin clouds T<235K & Tau < 0.2
  - Insure pristine sky toa correction is output on product
  - Cloudy Sky albedo not at diffuse angle for partly cloudy grid boxes
  - Allow model computation even if no SW Toa flux given in TSI
SYNI Surface Optics

- **Scene Id:**
  - IGBP
  - Daily Snow Ice maps (NSIDC microwave)
    - Where No microwave data
      - Threshold of Cloud WG Daily 0.63μ & 1.6μ overhead sun albedo

- **Emissivity**
  - Cloud WG seasonal maps (3 window bands)
  - SOFA (IGBP based for remaining LW bands)

- **Broadband Surface Albedo:**
  - Multiple methods :: apriori and retrievals
  - More explanation to follow…..
Surface Albedo History (SAH)
Global Monthly Weighted Mean Maps

- 10’ grid (2160x1080) ~18x18km
- Clear Sky Toa based Surface Albedo Retrieval
  - SfcAlb = f (ToaAlb, SZA, PW, O3, TauAer, SSAAer, Elevation, IGBP)
- Monthly Weighted Mean ::
  - SfcAlbedo@overheadsun, CosSZA, Cryosphere%
- Weight = u0 * v0 * f(Sa2-Sa1)
  - u0 : Cosine Solar Zenith Angle (0-1)  u0<0.3 allowed
    - Less atmosphere correction at high sun
  - v0: Cosine View Zenith Angle (0-1)
    - Spatial resolution better near nadir, 10’ map is filled
    - Oblique views fill multiple 10’ grids @ low weight
  - f(Sa2-Sa1): Aerosol Forcing to Retrieved Surface Albedo
    - Match Aerosol AOT and Constituents
Surface Albedo History
Composite Creation

• Monthly maps generated separately for FM1 & FM2
  – Rev1 correction applied before retrieval
• Individual instrument maps composited to fill spatial gaps (clouds)
• Remaining gaps filled according to hierarchy
  – 1) Canonical Season Month
  – 3) IGBP default.
Surface Albedo History
perturbation by daily sea ice data

• Can we use daily microwave Sea Ice variability to *perturb* monthly surface albedo?
  • YES! A Correlation to CERES Clear sky TOA albedo is present
    – One month of CERES and Microwave SeaIce
    – Cos Sol 0.75 – 0.60
Cloudy Sky Sea Ice  SAH perturbation method

Development Surface Albedo History VS SAH,v5.200107

Development Surface Albedo History VS SAH,v5.200107

Monthly mean SAH

Monthly mean SeaIce

DAILY SeaIce Frac

DAILY

0 1

0 1

Sea Ice Fraction 1

Day of Month 31

0 31
Spectral Albedo and Snow Grain Size
COART model example

• VIS albedo sensitive @ large grain sizes
• NIR albedo sensitivity @ small grain sizes
Snow Grain Retrieval Background

- NIR senses only top 1cm or less
- Visible penetrates snowpack

~From COART (Zonghi Jin)

- Small grain size near top
- Larger sizes with depth

~From Aoki 2000

**Figure 1.** Vertical profile of snow grain size in eastern Hokkaido, Japan from Aoki et al., [2000]. $r_1$ is one-half the length of the major axis of crystals or dendrites, and $r_2$ is one-half the branch width of dendrites or one-half the dimension of the narrower portion of broken crystals.
Snow Grain Size Retrieval

- Limited to >90% snow cover in grid box according to microwave snow map
- COART(Z.Jin) spectral surface albedo LUT for SNOW
  - $S_{fcalb}(\lambda) = f(CosSZA, Aot, soot, grain size, \lambda)$
- Fu Liou calculations using snow spectral albedo for multiple ($CosSZA, PW, Aot, O_3, GrainSize$) to generate $2^{nd}$ LUT of SW broadband TOA albedo as function of snow grain size
- PRIMARY PURPOSE: retrieval finds a depth and wavelength integrated effective snow grain size consistent with broadband CERES TOA albedo and other LUT inputs that has realistic surface albedo spectral shape for snow!
SYNI Effective Snow Grain Retrievals Beta4@SCF

Jan 2001 SH
Mean = 487 nm

July 2001 SH
Mean = 755 nm

Effective Broadband Snow Grainsize (µm)
## Surface Albedo Mode Summary Table

<table>
<thead>
<tr>
<th></th>
<th>Clear <em>high sun</em> u0 &gt; 0.3</th>
<th>Clear <em>low sun</em> u0 &lt; 0.3</th>
<th>Cloudy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ocean</strong></td>
<td>Z. Jin COART LUT</td>
<td>Z. Jin COART LUT</td>
<td>Z. Jin COART LUT</td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td>TOA Retrieval</td>
<td>Monthly SAH map moved to u0 by Wang(b1,b2)</td>
<td>Monthly SAH map moved to u0<em>diffuse</em> by Wang(b1,b2)</td>
</tr>
<tr>
<td><strong>SeaIce</strong></td>
<td>TOA Retrieval</td>
<td>Ice Perturbed Monthly SAH moved diurnally to u0 by Dickenson(d)</td>
<td>Ice Perturbed Monthly SAH moved to u0<em>diffuse</em> by Dickenson(d)</td>
</tr>
<tr>
<td><strong>Snow</strong></td>
<td>Snow Grain retrieval ONLY @CERES Times SAH as needed</td>
<td>Snow Spectral albedo using last SGR @u0 SAH as needed</td>
<td>Snow Spectral albedo using last SGR@u0<em>diffuse</em> SAH as needed</td>
</tr>
</tbody>
</table>
Selected Validation Efforts
Comparison of Beta4 SYNI and SEAWIFS Photo synthetically Active Radiation (PAR) products for July 2002
Comparison of SYNI and SeaWiFS PAR

- SeaWiFS noon orbit w/diurnal model
- SYNI (captures full diurnal cycle)
  - Terra CERES/MODIS (10:30)
  - 3-hourly Geostationary

SYNI minus SeaWiFS PAR

July 2002 SYNI Beta4G8

SYNI Vs SeaWifs PAR

SeaWifs PAR (Wm^-2)

SYNI PAR (Wm^-2)

Log10(Population)

N= 32812.

Mean (StdDev)

SeaWifs PAR (Wm^-2) 87.36 (39.92)
SYNI PAR (Wm^-2) 85.77 (39.39)
Y-X -1.59 (7.00)
RMS( 7.18).............

PAR Difference (Wm^-2)

Mean= -1.59

-10.0 -6.7 -3.3 0.0 3.3 6.7 10.0
SYNI Diurnal Cycle of PAR off coast of Angola July 2007
SGP UV Validation 2002

- Beta3 SYNI for entire year of 2002
- Validation analysis by Wenying Su

We are off by ½ hour
Beta3 at Top of Hour
USDA Bottom of hour
Bondville
UV Validation

**UVA 400-320nm**
- Sample: 3698
- Mean SYNI: 20.2
- Mean USDA: 20.3
- RMS: 7.3

**UVB 320-290nm**
- Sample: 3688
- Mean SYNI: 0.392
- Mean USDA: 0.382
- RMS: 0.190
SYNI vs FSW
Surface and TOA Model Albedo

SYNI-FSW 200207 SFC Albedo (@CERES day Times)

SYNI-FSW 200207 Tuned TOA Albedo (@CERES day Times)

Sfc Albedo Difference

TOA Albedo Difference
SYNI vs FSW Model OLR

- SYNI uses solely GEOS4 Skin Temperatures
- FSW used Clear sky MODIS Skin temperatures

SYNI-FSW 200207
Ut LW (@CERES all Times)
TOA SW Bias @CERES/MODIS Vs GEO Times
GEO minus MODIS
Cloud Amount & Cloud Tau

EXP [ ln(tau_geo) - ln(tau_modis) ]

-0.37/4.12 = -9%

GEO - MODIS Total Cloud Amount July 2002

GEO - MODIS Total Cloud Log Optical Depth July 2002

GEO
Global 64.39
60N-60S 63.36
30N-30S 57.34

BIAS
MODIS
Global 61.49
60N-60S 60.23
30N-30S 55.67

BIAS
TAU
Difference
GEO
Global 3.95
60N-60S 3.82
30N-30S 3.18

BIAS
MODIS
Global 4.31
60N-60S 4.20
30N-30S 3.36

Bias: -0.37
RMS: 1.10
Shortwave  Model Untuned-Observed  Longwave
January 2002
TOA FLUX  Beta4 SYN
April 2002
Mean= 0.13  Mean= -0.85
July 2002
Mean= 0.46  Mean= -0.94
Mean= 0.41  Mean= -0.97
Synoptic SARB Validation Grid Boxes

172 grid box hourly subset product SYNS

- CAVE sites (with surface flux)
- Ocean Sites
- CERES validation regions (no surface flux)
- AERONET (Limited MPL)
- AERONET Sites
- Polar Ice Sites
WEBSITES

• SYNI plots of output fields (including movies) from developmental SCF runs
  – http://snowdog.larc.nasa.gov/rose/syni/

• CERES ARM Validation Experiment(CAVE)
  – http://www-cave.larc.nasa.gov/cave/
Last Minute
Obs SW Clear Sky problem

- Pre TSI Clear Sky
  OBS SW Bug Fix

- Post Bug Fix
  (11-8-07)
BACKUP SLIDES
GEOSTATIONARY CLOUDS (20N 200207)
Aerosol Forcing to Surface Albedo Retrieval Weighting

- Retrieve Twice
  - Sa1) Pristine (no aerosol)
  - Sa2) Using MATCH (AOT, ω)
- Use Aerosol Forcing to Surface Albedo
  - \( f(Sa2-Sa1) = 1.0-(\exp(-0.005/\text{abs}(Sa2-Sa1))) \)
  - Maximum Weight = 1.0 when NO forcing
  - Weight = 1/e (~0.36) @ 1% absolute albedo forcing
  - Lowest weights when large aerosol forcing likely

![Graph showing Retrieval Weighting Factor vs. (Sa2-Sa1) Aerosol forcing to Sfc Alb](image)
Broadband Surface Albedo Mode

- **OCEAN**
  - COART *apriori* surface albedo via look up table
    - (τ, solar zenith angle, wind speed, chlorophyll)
- **Clear Land** (at least 10% of gridbox has clear data)
  - ‘*CERES*’ SW TOA with LaRC Fu-Liou atmosphere correction LUT
    - Clear sky CERES monthly mean diurnally modeled (NOT Geo)
- **Cloudy: Land+SeaIce + snow when no grain size retrieved**
  - Monthly Surface Albedo History 10' grid based on clear sky albedo retrieval from Ed2 SSF
  - **Perturbed** according to Daily microwave SeaIce or Snow(<90%)
  - Diurnal model to diffuse angle
- **Snow** (> 90% gridbox coverage)
  - Clear sky via CERES only snow grain size retrieval
  - Cloudy sky albedo uses grain size in snow spectral albedo LUT
  - Non-CERES times use last retrieved grain size in snow spectral albedo LUT