NPP Atmosphere PEATE
Critical Design Review

Part 3: Science Evaluation of NPP EDRs

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Grant Number # NNG05GN47A

Presented by the Atmosphere PEATE Team
Space Science and Engineering Center
University of Wisconsin-Madison
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Outline of the Science Evaluation of NPP EDRs

Part 1: Evaluation plan for the Cloud/Aerosol SDR's and EDR's
- Atmospheric PEATE EDRs
- EDR sources of uncertainty
- The PEATE evaluation methodology
- Evaluation measurements
- Evaluation tools
- Match system and match files
- Gridding and visualization
- EDR specific evaluation plan

Part 2: Demonstrations using MODIS
- VIIRS SDR (MODIS Radiance Evaluation) Tobin
- VIIRS CTP (MODIS Cloud Top Pressure) Menzel
- VIIRS COP (MODIS Effective Radius/Multi-layer) Platnick

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Evaluation Requirements

To meet the goals of the Atmosphere PEATE the system will need to:

- Have high quality evaluation measurements (ground, aircraft, and satellite)
- Produce evaluation products that can be compared directly to VIIRS
- Collocate (in space and time) the evaluation products with VIIRS
- Produce comparison results for the VIIRS science team
  - Collocated data products (match files)
  - Granule level and gridded visualization

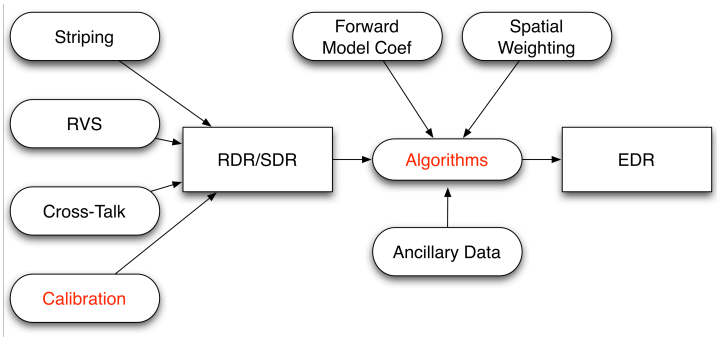
Atmospheric PEATE EDR Responsibilities

NGST global cloud and aerosol products:

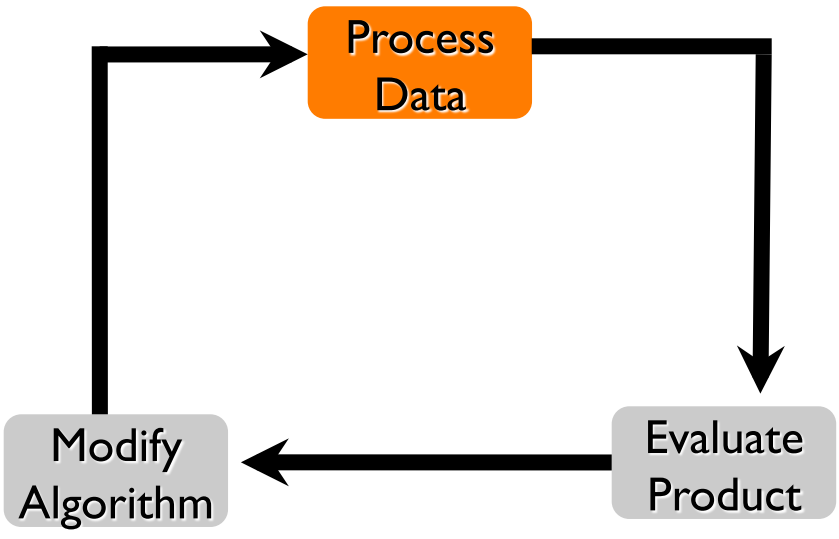
- Suspended Matter
- Cloud Cover/Layers
- Cloud Effective Particle Size
- Cloud Top Height
- Cloud Top Pressure
- Cloud Top Temperature
- Cloud Base Height
- Cloud Optical Thickness
- Cloud Mask/Phase/Type (IP)
- Aerosol Optical Thickness
- Aerosol Particle Size

EDR Sources of Uncertainty

- Raw measurements (RDR)
- Calibration (SDR)
- Retrieval (EDR)



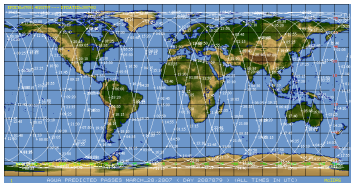
The PEATE Evaluation Methodology



Evaluation Measurements

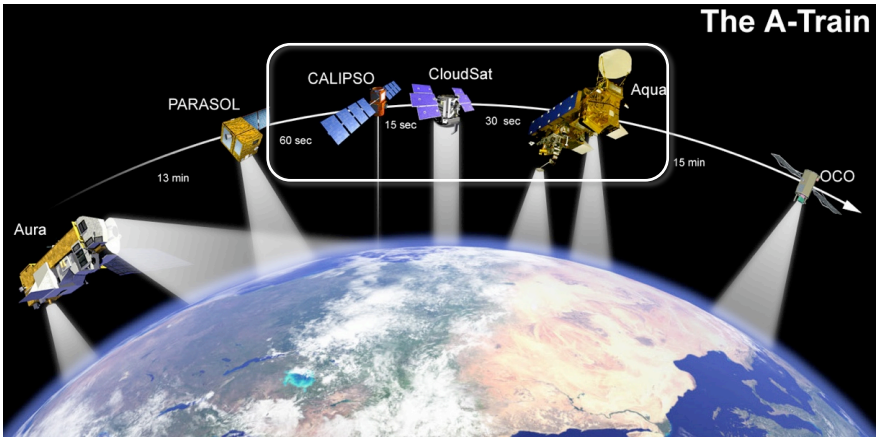
Process / Modify / Evaluate

- Ground
  - ARM (Atmospheric Radiation Measurements)
  - NOAA SEARCH
  - SSEC
  - AERONET
  - MPL Net
- Satellite
  - CALIPSO (Space Lidar)
  - CloudSat (Space Radar)
  - METOP
  - EarthCare
- Aircraft
  - SHIS, CPL, MAS/MASTER, ….



Evaluation Resource: Satellite Measurements

Process / Modify / Evaluate



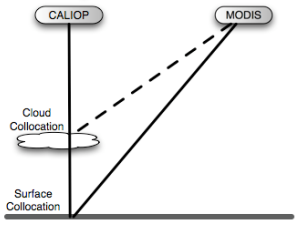
Evaluation Tools: Collocation

Process / Modify / Evaluate

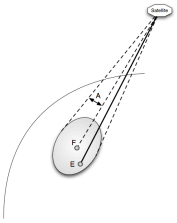
Types of Collocation
- Simultaneous Nadir Overpass (SNO)
- Satellite/Ground
- Sounder/Imager
- Imager/Lidar
- Imager/CloudSat
- Lidar/Radar

Software package developed at SSEC by Fred Nagle

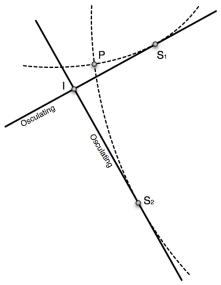
Imager/CALIOP



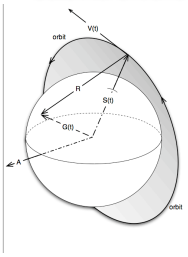
Sounder/Imager



SNO



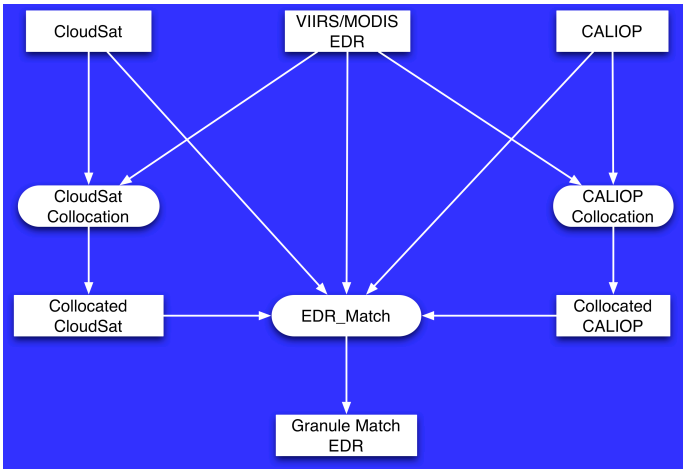
Satellite/Ground



Evaluation Example: Single Satellite or Formation

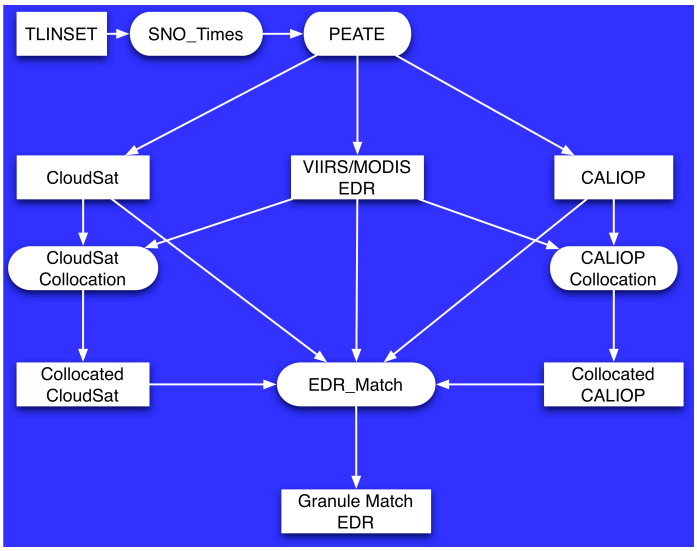
Process / Modify / Evaluate

Comparing A-Train CALIOP/CloudSat to MODIS



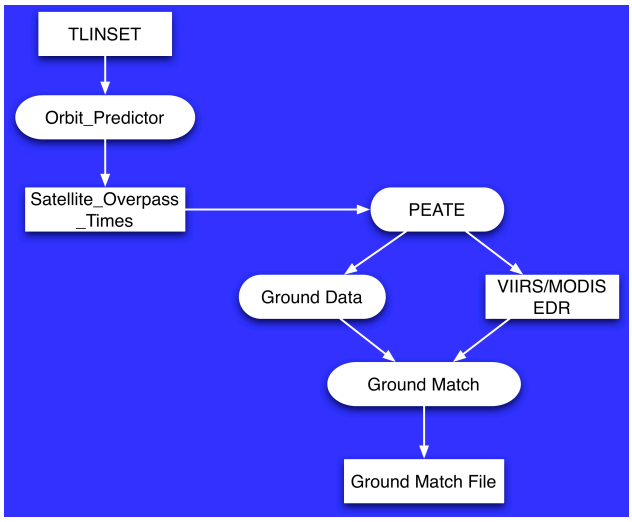
Evaluation Example: Satellite-->Satellite Two Orbits

Process
Modify
Evaluate



Evaluation Example: Satellite->Ground

Process
Modify
Evaluate



What is a Match file?

Process / Modify / Evaluate

- One match file is created for each EDR granule and saved in the hdf format
- This file contains evaluation and EDR measurements collocated and averaged to the same spatial resolution
- This allows direct comparisons between the EDRs and evaluation measurements
- Post-processing concatenation provides dynamic creation of day, month, or year match files with selected evaluation product

Match File Example

Process / Modify / Evaluate

Match File Variables Saved as HDF:

CTH Evaluation Match File

double MODIS_Cloud_Top_Pressure_5km(fakeDim0, fakeDim1) ;
MODIS_Cloud_Top_Pressure_5km:DataDiscription = "MODIS Cloud Top Pressure (mb)" ;

double MODIS_Cloud_Height_Method_5km(fakeDim2, fakeDim3) ;
MODIS_Cloud_Height_Method_5km:DataDiscription = "MODIS Cloud Top Pressure method" ;

double MODIS_Cloud_Fraction_5km(fakeDim6, fakeDim7) ;
MODIS_Cloud_Fraction_5km:DataDiscription = "The MODIS cloud fraction derived from the 5X5 1km array" ;

double MODIS_Cloud_Top_Height_5km(fakeDim10, fakeDim11) ;
MODIS_Cloud_Top_Height_5km:DataDiscription = "The MODIS cloud top height converted from pressure using the CALIPSO atmospheric profiles" ;

double CALIPSO_Layer_Top_Altitude_5km(fakeDim18, fakeDim19) ;
CALIPSO_Layer_Top_Altitude_5km:DataDiscription = "CALIPSO Cloud Top Altitude of the first layer" ;

double CALIPSO_Fraction_Cloudy(fakeDim24, fakeDim25) ;
CALIPSO_Fraction_Cloudy:DataDiscription = "Fraction of CALIPSO FOV found cloudy in the MODIS 5km FOV" ;

double CALIPSO_Max_Layers_5km(fakeDim64, fakeDim65) ;
CALIPSO_Max_Layers_5km:DataDiscription = "CALIOP 5 km averaged layer products maximum number of layers sensed" ;

Gridded Product Generation

Process / Modify / Evaluate

Why: NPP Science team members want to visualize global gridded statistics to investigate algorithm induced changes in regional and global trends

Method:

- Each granule is processed on a single CPU. When processing is complete, products are gridded and stored in a relational database for later use
- For each variable of interest, the number of points, sum of values, and sum of squares are stored, allowing dynamic computation of the mean and standard deviation over multiple grids and time periods.
- Each variable will include searchable properties such as surface type, cloud phase, multi-layer, confidence flag, …

Gridded Product Generation

Process / Modify / Evaluate

Using a database approach provides flexibility to adapt to specific needs.

Main advantages

- Producing gridded products at the granule level reduces the overhead of collecting and storing large amounts of input EDRs.
- The database provides the capability to create products on demand. For example Cloud Optical Thickness can be created dynamically and filtered for cases with single layer ice clouds during the first week in January.

The gridded results can be visualized graphically or packaged in an HDF file for download.

Visualization

Process / Modify / Evaluate

Why: Provide methods to inspect results without having to download large data sets.

Method:

- Create images from products for each granule
- Create global gridded images once all necessary records are in the database
- Create standard sets of images showing comparisons between sensors (e.g. CALIOP vs MODIS cloud height)
- On demand image generation for products not included in default set of images.

These images will be stored such that a user can browse through the global gridded products and select areas of interest. Granule level images and data files for the selected region will then be accessible.

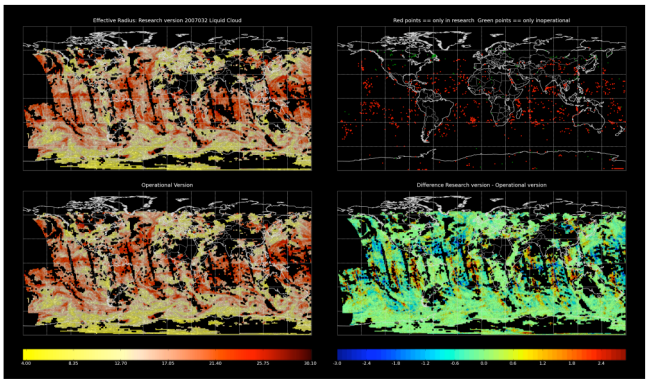
Example of Interactive Visualization

Process / Modify / Evaluate

You are currently viewing MYD06OD effective_radius 2007032 liquid_cloud

Top Next Day

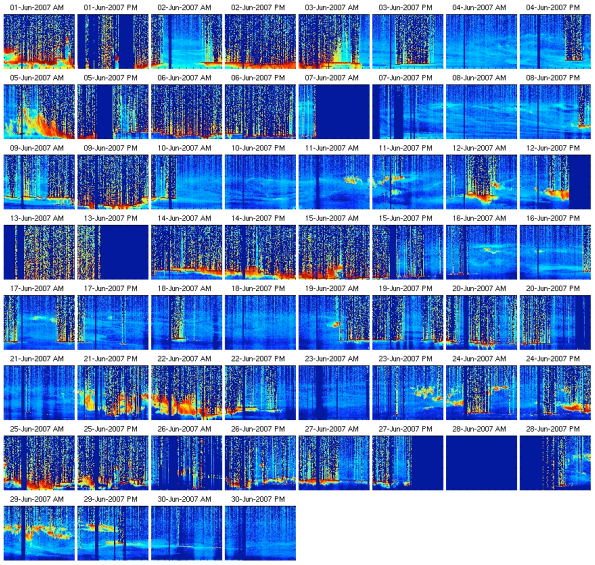
optical_thickness_liquid_cloud optical_thickness_ice_cloud optical_thickness_1621_liquid_cloud optical_thickness_1621_ice_cloud
effective_radius_liquid_cloud effective_radius_ice_cloud effective_radius_1621_liquid_cloud effective_radius_1621_ice_cloud



View full size image

Example of Ground/Satellite Visualization

Process
Modify
Evaluate



EDR Specific Evaluation Plans

Process
Modify
Evaluate

Each Atmospheric PEATE EDR has a custom evaluation plan which uses the three evaluation systems ie single satellite, multiple satellites, and ground evaluation measurements. The EDR's evaluated are:

- Suspended Matter
- Cloud Cover/Layers
- Cloud Effective Particle Size
- Cloud Top Height
- Cloud Top Pressure
- Cloud Top Temperature
- Cloud Base Height
- Cloud Optical Thickness
- Cloud Mask/Type/Phase (IP)
- Aerosol Optical Thickness
- Aerosol Particle Size

EDR Evaluation: Cloud Cover/Layers/Mask

Process / Modify / Evaluate

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software:

- **Retrieval**
  - HSRL Layer OD (Matlab)
  - mixra AERI OD/Effr (C)
- **Collocation**
  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - overspot (fortran 77)
  - snotimes (fortran 77)
  - Match files (Matlab)

Evaluation Measurements:

- **Satellite**
  - CALIOP
    - Cloud Layer Products
    - Aerosol Layer Products
- **Ground**
  - ARM
    - Raman
      - Raw data
      - UW Extinction Retrieval
    - MPL
      - Layer Retrievals
      - Raw Profile
  - SEARCH/SSEC
    - AHSRL (Extinction / ABSC)

EDR Evaluation: Cloud Top Height/Pressure/Temp

Process / Modify / Evaluate

Evaluation Measurements:

- **Satellite**
  - CALIOP
    - Cloud Layer Products
    - Aerosol Layer Products
  - CloudSat
    - Combined Lidar/Radar
  - CrIS/IASI
  - GOES
- **Ground**
  - ARM
    - Raman
      - Raw data
      - UW Extinction Retrieval
    - MPL
      - Layer Retrievals
      - Raw Profile
  - SEARCH/SSEC
    - AHSRL (Extinction / ABSC)

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software:

- **Retrieval**
  - HSRL Layer OD (Matlab)
  - mixra AERI OD/Effr (C)
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  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - snotimes (fortran 77)
  - overspot (fortran 77)
  - Evaluation Products
  - Match files (Matlab)

EDR Evaluation: Cloud Effective Radius

Process: Modify, Evaluate

Evaluation Measurements:

- **Satellite**
  - CALIOP
    - Cloud Layer Products
    - Aerosol Layer Products
  - CloudSat
  - Combined Lidar/Radar
- **Ground**
  - ARM
    - MMCR (Cloud Radar)
    - Raman
      - Raw data
      - UW Extinction Retrieval
    - MPL
      - Layer Retrievals
      - Raw Profile
  - SEARCH/SSEC
  - AHSRL (Extinction / ABSC)

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software:

- **Retrieval**
  - HSRL Layer OD (Matlab)
  - mixra AERI OD/Effr (C)
- **Collocation**
  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - snotimes (fortran 77)
  - overspot (fortran 77)
- **Evaluation Products**
  - Match files (Matlab)

EDR Evaluation: Cloud Optical Depth

Process: Modify, Evaluate

Evaluation Measurements:

- **Satellite**
  - CALIOP
    - Cloud Layer Products
    - Extinction Profiles
  - CloudSat
  - Combined Lidar/Radar
- **Ground**
  - ARM
    - Raman
    - Raw data
    - UW Extinction Retrieval
  - SEARCH/SSEC
    - AHSRL (Extinction / ABSC)

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software:

- **Retrieval**
  - HSRL Layer OD (Matlab)
  - mixra AERI OD/Effr (C)
- **Collocation**
  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - snotimes (fortran 77)
  - overspot (fortran 77)
  - Evaluation Products
  - Match files (Matlab)

EDR Evaluation: Suspended Matter

Process / Modify / Evaluate

Evaluation Measurements:

- **Satellite**
  - CALIPSO
    - Cloud Layer
    - Aerosol Layer
  - AIRS (Volcanic Ash)
  - MODIS
    - MYD07
  - CrIS
  - IASI
- **Ground**
  - ARM
    - Raman
    - Raw data
    - UW Extinction Retrieval
  - SEARCH/SSEC
    - AHSRL (Extinction / ABSC)
  - AERONET

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software

- **Collocation**
  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - snotimes (fortran 77)
  - overspot (fortran 77)
  - Evaluation Products
  - Match files (Matlab)

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EDR Evaluation: Aerosol OD/Effective Radius

Process / Modify / Evaluate

Evaluation Measurements:

- **Satellite**
  - CALIPSO
    - Cloud Layer Products
    - Aerosol Layer Products
  - MODIS
    - MYD07
- **Ground**
  - AERONET
    - L2 AOD.txt
  - Raman
    - Raw Data
    - UW Ext Retrievals
  - MPL
    - Layer Retrievals
    - Raw Profile
  - AERI
    - Aerosol OD/Effective Radius (Turner)
    - NOAA SEARCH:
  - AHSRL
    - Extinction Retrieval

Evaluation Systems

- Single Satellite
- Satellite->Satellite
- Satellite->Ground

Evaluation Software:

- **Retrieval**
  - HSRL Layer OD (Matlab)
  - mixra AERI OD/Effr (C)
- **Collocation**
  - calmodishdf (fortran 77)
  - airscalhdf (fortran 77)
  - snotimes (fortran 77)
  - overspot (fortran 77)
  - Evaluation Products
  - Match files (Matlab)

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Outline of the Science Evaluation of NPP EDRs

Part 1: Evaluation plan for the Cloud/Aerosol SDR's and EDR's
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Part 2: Demonstrations using MODIS
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- VIIRS CTP (MODIS Cloud Top Pressure) Menzel
- VIIRS COP (MODIS Effective Radius/Multi-layer) Platnick

Part 2: Evaluation Demonstrations Using MODIS

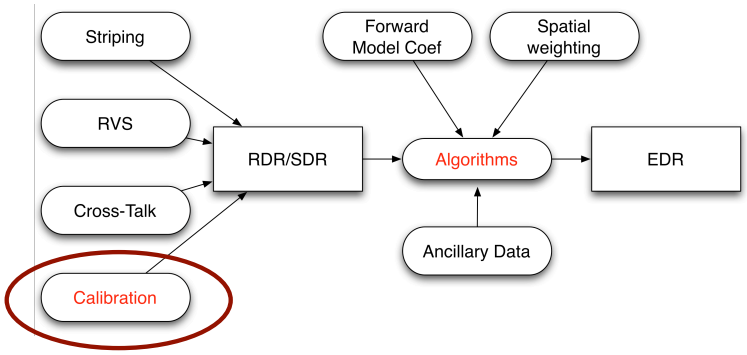
We have demonstrated the components of the PEATE that will be necessary to assess the VIIRS atmosphere algorithms and products.

The evaluation demonstrations allows for prototyping and testing of the evaluation measurements and products.

EDR Sources of Uncertainty

Process
Modify
Evaluate

- Raw measurements (RDR)
- Calibration (SDR)
- Retrieval (EDR)



Use of AIRS (CrIS) high spectral resolution spectra to assess the calibration of MODIS (VIIRS) on EOS Aqua (NPP)

David Tobin, Henry Revercomb, Chris Moeller, Robert Holz, Steven Dutcher

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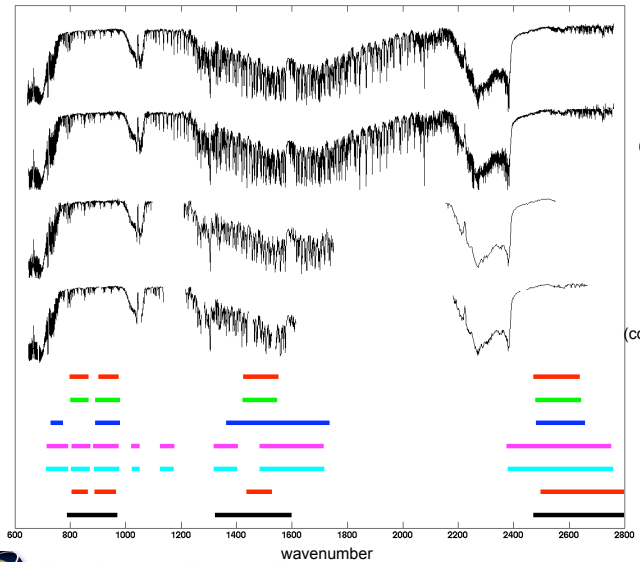
Outline

- Radiance Calibration Traceability
- Approach and case study results
- Example results from five years of global AIRS/ MODIS radiance comparisons
- Implications for PEATE activities

High Spectral Resolution IR for Intercal



IASI L1C

SHIS
(deapodized, truncated to 1cm MOPD)

CrIS
(truncated to 0.8, 0.4, and 0.2 cm MOPD)

AIRS
(convolved with AIRS SRFs)

GOES-10
GOES-11
GOES-12
MET-8
MET-9
MTSAT
FY2C

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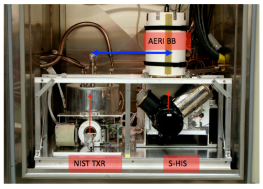
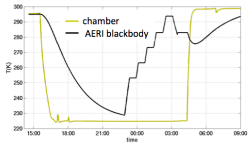
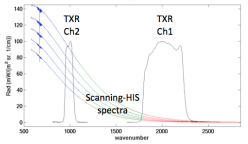
Radiance Calibration Traceability (1)

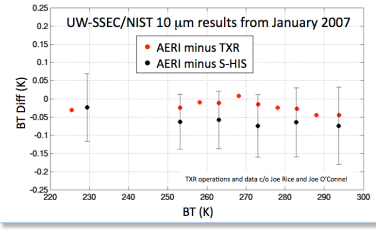
NIST TXR tests of Scanning-HIS Radiance Calibration & Blackbody Radiance Knowledge

Plan: perform **periodic end-to-end laboratory radiance evaluations** under flight-like conditions with NIST transfer sensors such that satellite validation analyses are traceable to the NIST radiance scale.





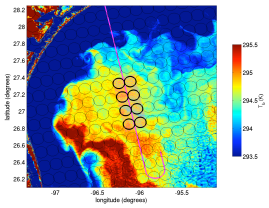


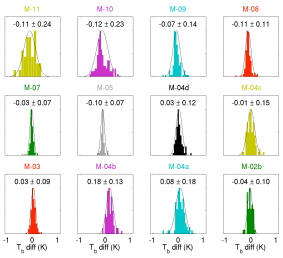


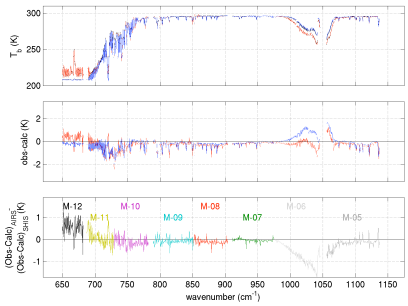
- mean agreement between TXR and S-HIS of ~30 mK, well less than conservative estimates of the S-HIS propagated 3-sigma absolute radiance uncertainties
- TXR uncertainty is ~0.2 K
- larger mean diffs (~0.15K) in Ch1 (5µm) under investigation

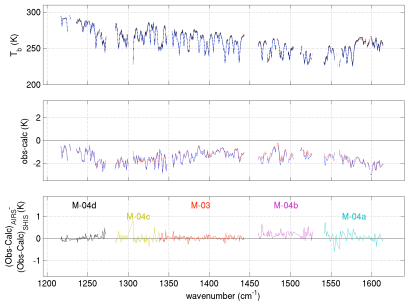
Radiance Calibration Traceability (2)

AIRS nadir underflight by S-HIS on ER-2 on 21 November 2002 over Gulf of Mexico



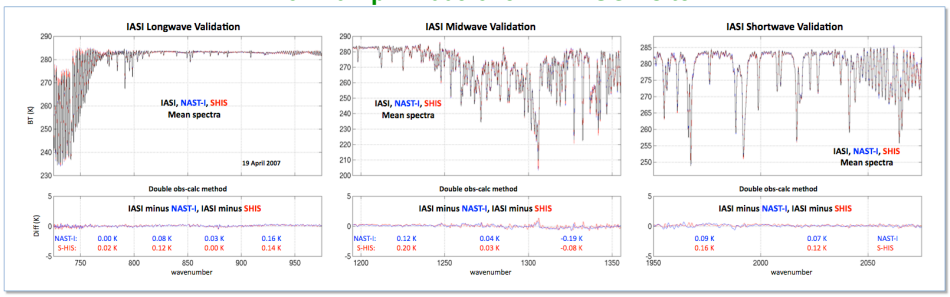




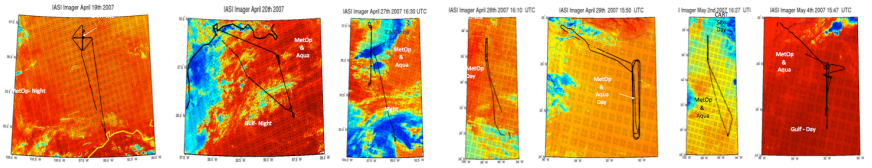


Radiance Calibration Traceability (3)

IASI nadir underflight by S-HIS/NASTI on WB-57 on 19 April 2008 over ARM SGP site



Other JAIVEx Cal/Val Flights: Four SGP CART-site (2 day & 2 night); Three Gulf of Mexico (2 day & 1 night); Five joint MetOp & Aqua (3 day & 2 night)



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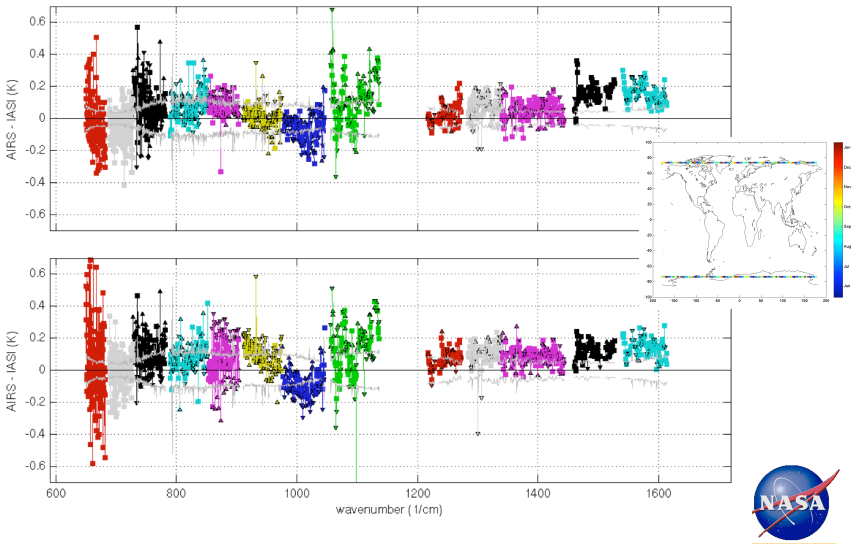
Radiance Calibration Traceability (4)

Direct Comparisons of AIRS and IASI spectral Radiances via Simultaneous Nadir Overpasses (SNOs)



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Approach and case study results

- Comparisons of Atmospheric InfraRed Sounder (AIRS) and MODerate resolution Imaging Spectroradiometer (MODIS) radiance observations
  - Spatially uniform scenes collected on 6 Sept 2002 and 18 Feb 2004
  - Differences characterized as functions of scene temperature, scan angle, and solar zenith angle.
- Important for:
  - Diagnosing calibration issues of the sensors
  - MODIS product generation and characterization
  - Climate studies utilizing data from one or both sensors
  - Understanding differences between AIRS products and MODIS products
  - Development of applications utilizing data from both sensors (e.g. AIRS cloud -clearing using MODIS data, synergistic use of AIRS and MODIS for cloud property retrievals)

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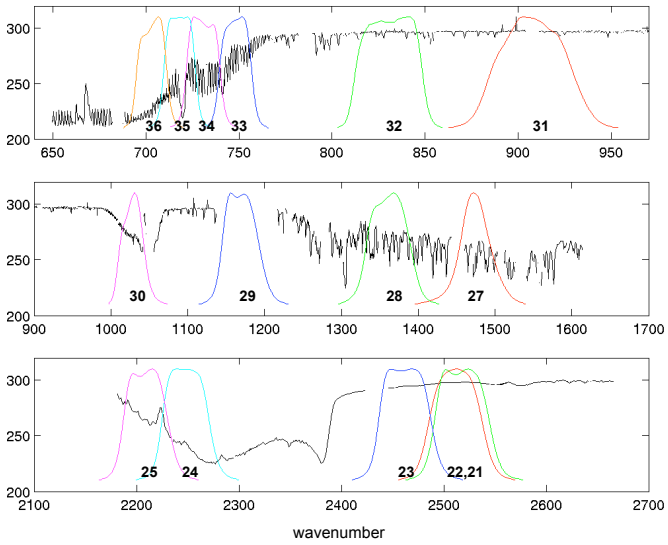
A sample AIRS brightness temperature spectrum overlaid with the Aqua MODIS Spectral Response Functions



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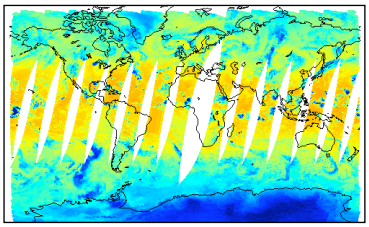
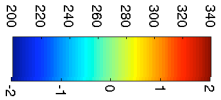
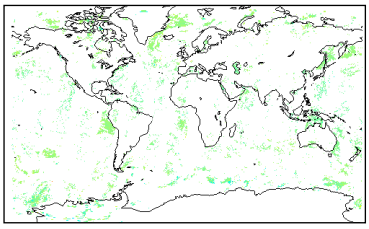
Example comparisons for band 22 (4.0 μm) on 6 Sept 2002

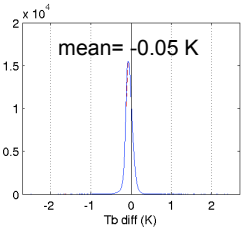


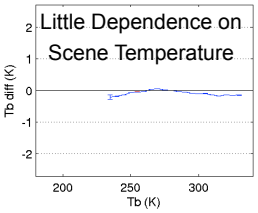
AIRS BT (K)

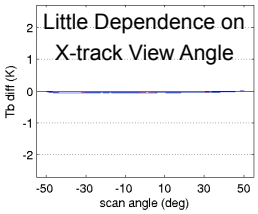


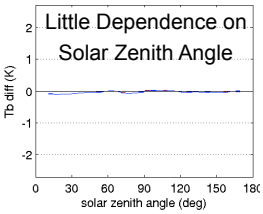
AIRS minus MODIS (K)











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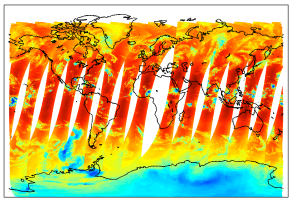
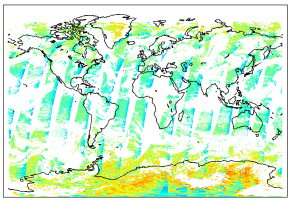
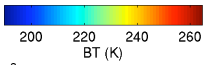
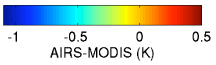
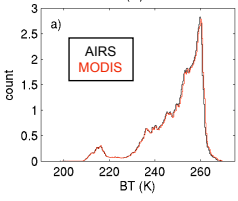
Example comparisons for band 34 (13.7 μm) on 6 Sept 2002.

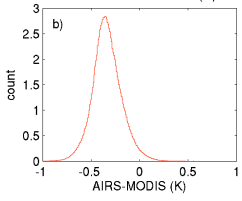


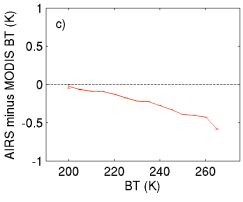


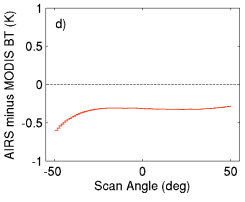












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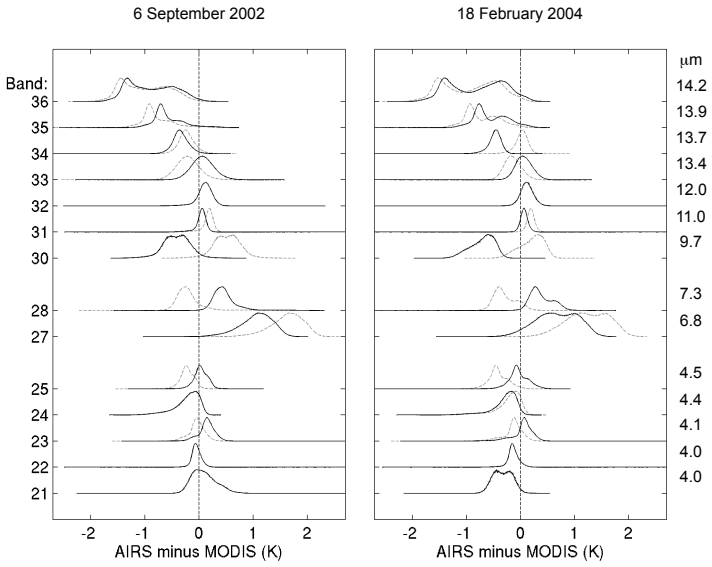
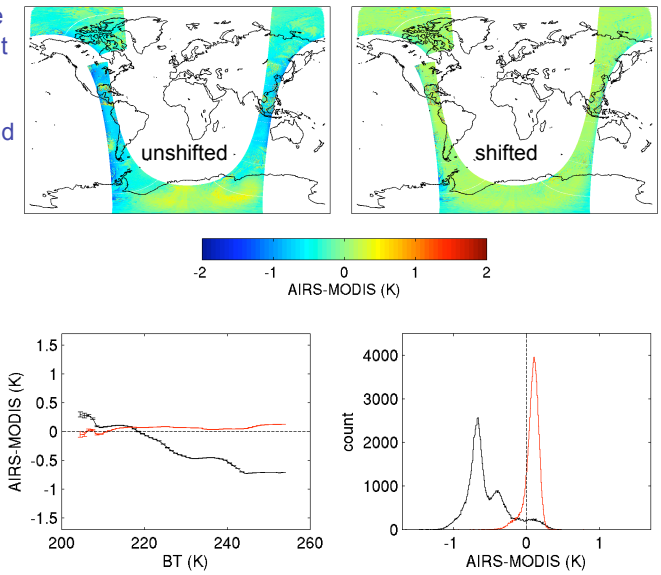
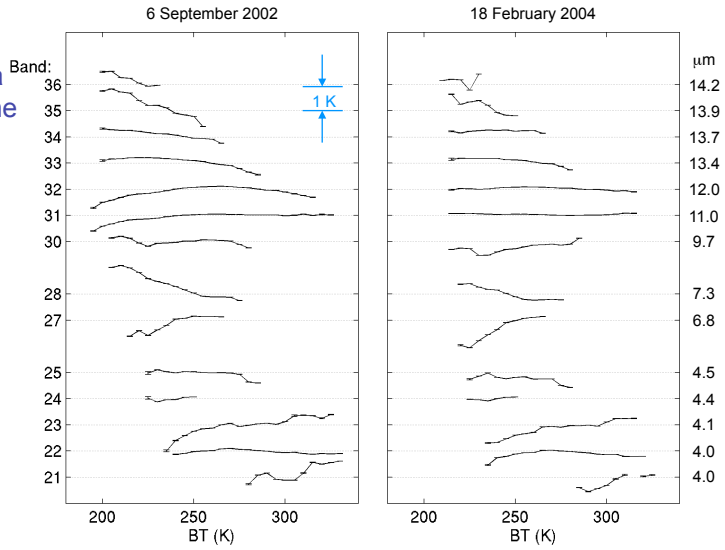
Histograms of brightness temperature differences.



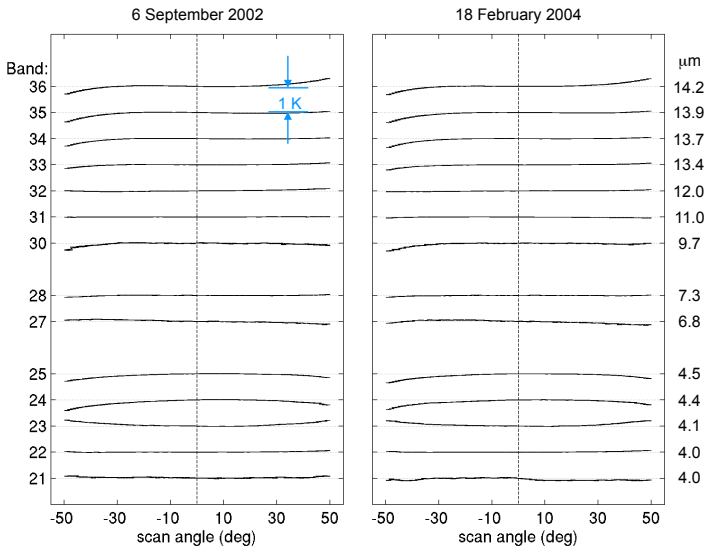
Band 35 (13.9 μm) brightness temperature differences for one orbit of data on 6 Sept 2002 using the nominal MODIS SRF (black) and using the MODIS SRF shifted by +0.8 cm^{-1} (red).



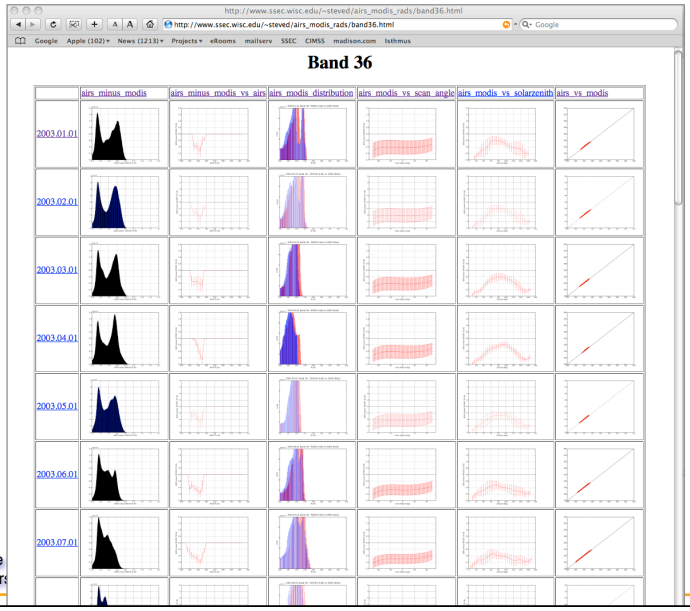
Brightness temperature differences as a function of scene temperature.



Brightness temperature differences as a function of scan angle.



PEATE processing of the first day of every month from Jan 2003 to present



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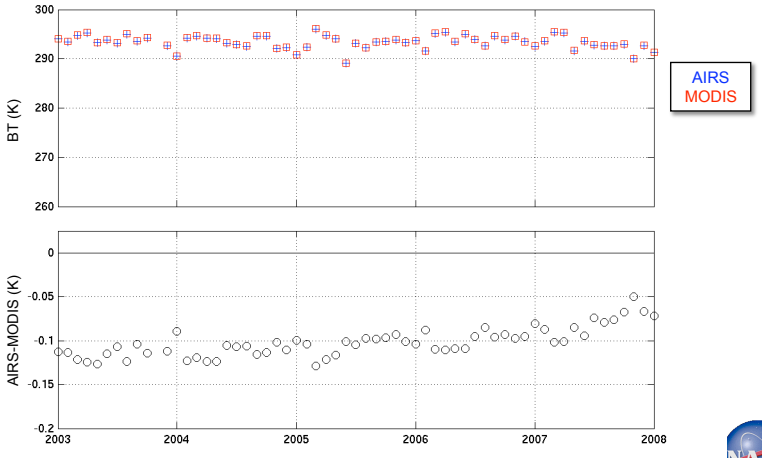
Example results from five years of global AIRS/MODIS radiance comparisons



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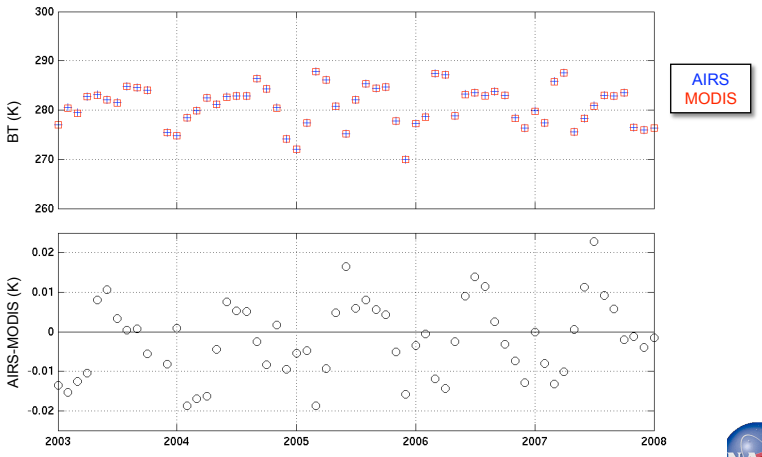
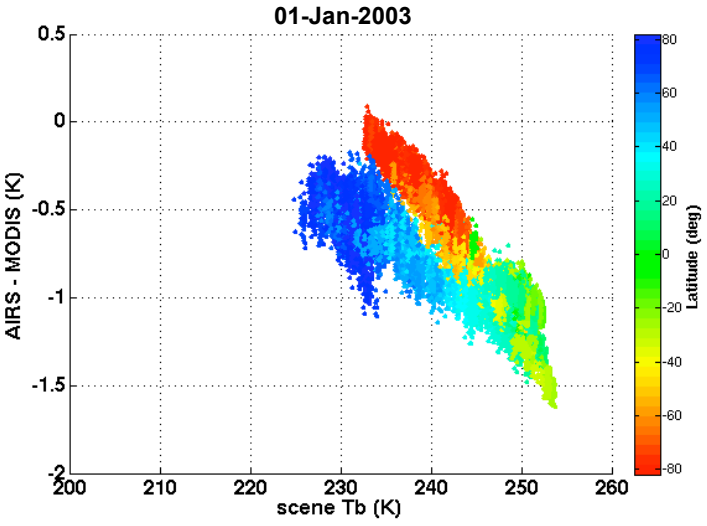
Example results from five years of global AIRS/MODIS radiance comparisons

MODIS Band 32 (12 μm)



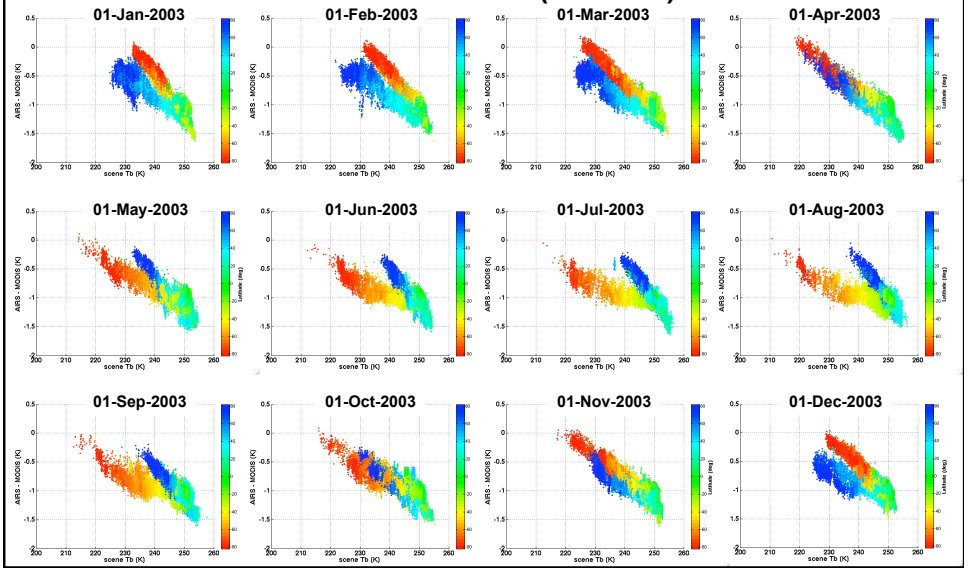
Example results from five years of global AIRS/MODIS radiance comparisons

MODIS Band 35 (13.9 μm)



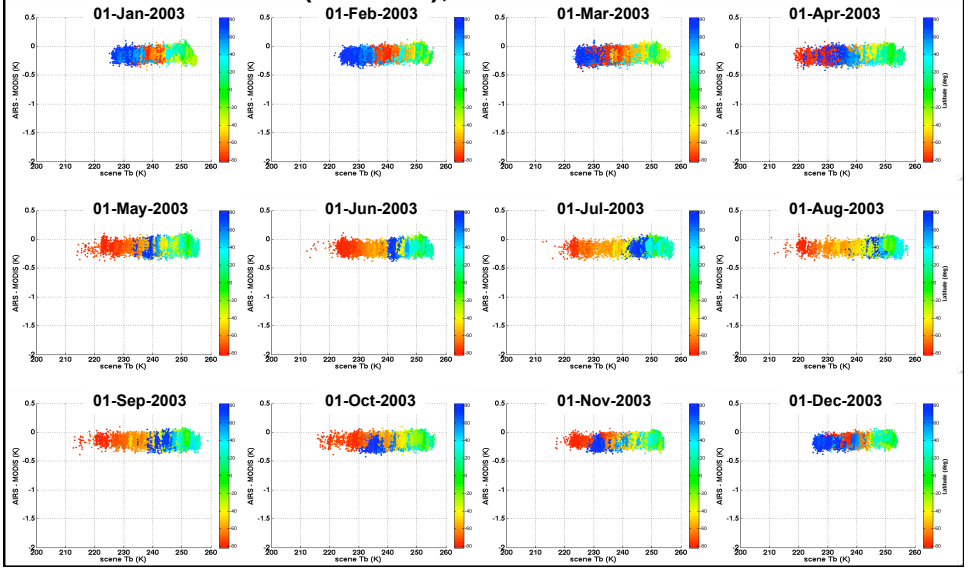
Example results from five years of global AIRS/MODIS radiance comparisons

MODIS Band 35 (13.9 μm)



Example results from five years of global AIRS/MODIS radiance comparisons

MODIS Band 35 (13.9 μm), with 0.8 cm^{-1} MODIS SRF shift



Implications for PEATE activities

EDR assessments and improvements should begin with SDR assessments and improvements.

Specific recommendations for VIIRS are:

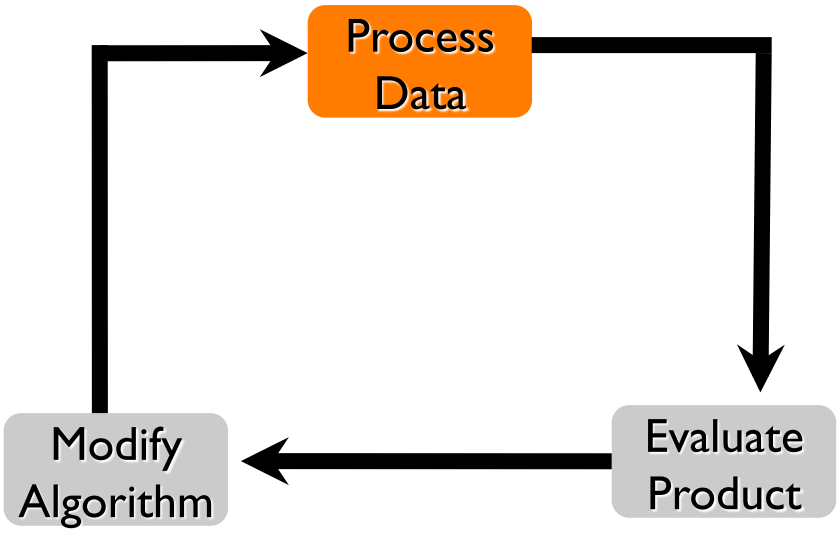
- Begin evaluation of VIIRS SDRs via SNO comparisons with IASI (and possibly AIRS as well) as soon as VIIRS data is available.
- Implement global evaluations of VIIRS SDRS with CrIS as soon as both datasets are available.

Demonstration #2: Cloud Top Height/Pressure

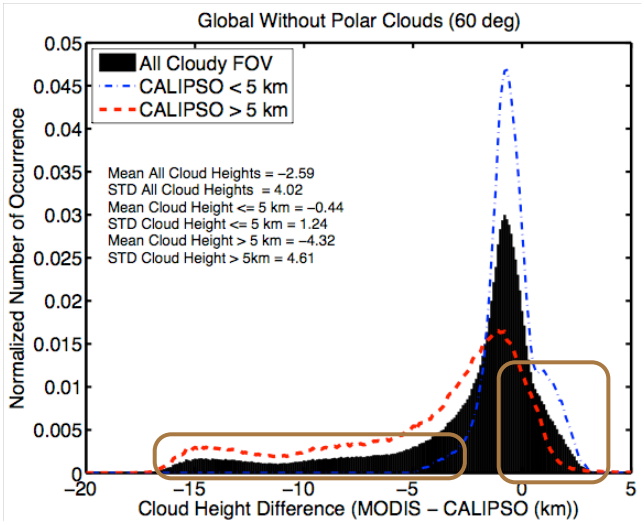
In collaboration with NPP science team methodologies for evaluating MODIS Cloud Top Height (CTH) retrievals are being developed

- Investigated the MODIS MYD06 CTH Retrievals using the evaluation match files
- Modified the MODIS CTH algorithms
- Changes resulting from the algorithm modifications are quantified using the evaluation system
- The PEATE global grids,satellite->satellite evaluation system, collocation, and match files are used

The PEATE Evaluation Methodology

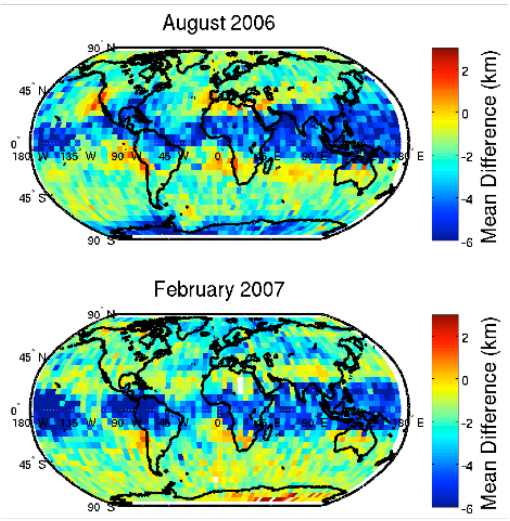


Cloud Top Height Differences August 2006



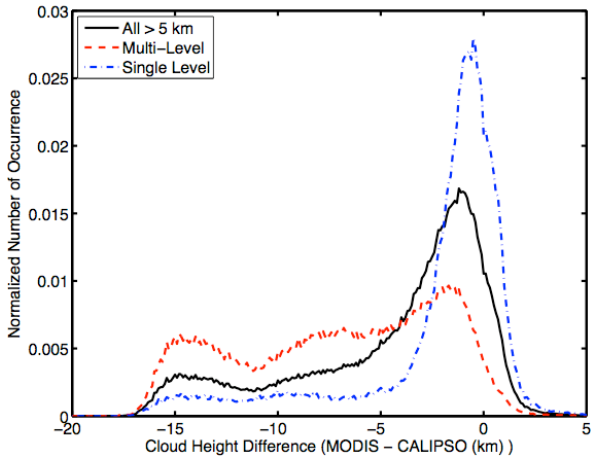
Global Grid:Cloud Height Differences

Process / Modify / Evaluate



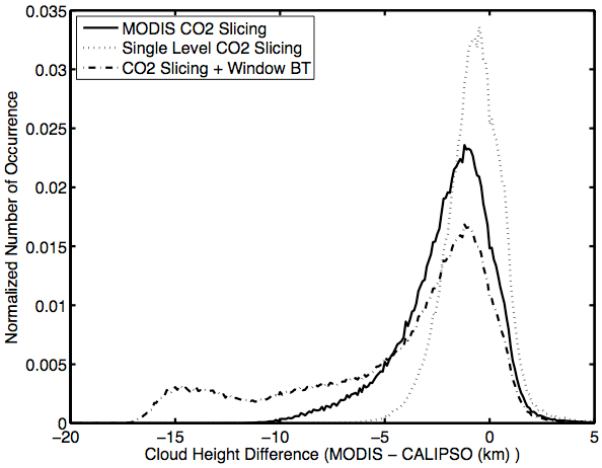
Multilevel Cloud Impact?

Process / Modify / Evaluate



CO2 Slicing Investigated

Process / Modify / Evaluate



Menzel's suggested modifications

Process / Modify / Evaluate

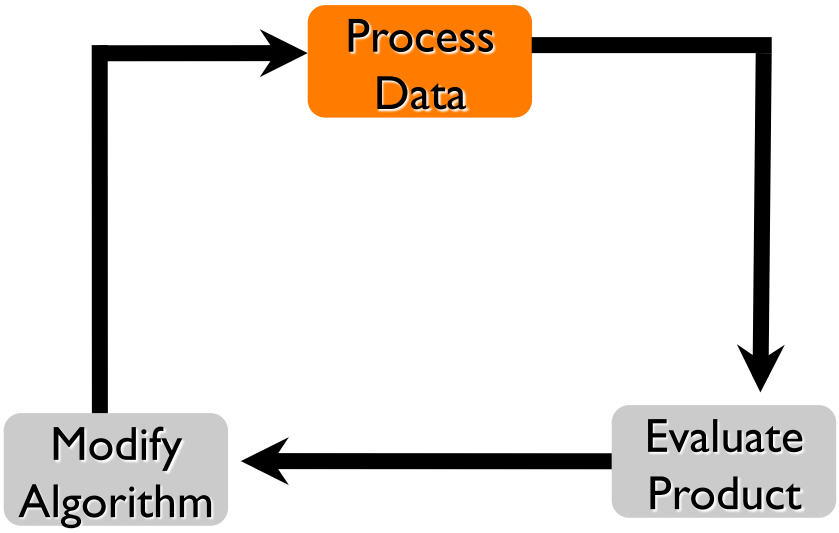
Test 1: Allow tropopause level to be the cloud height solution when no intersection is found between LHS and RHS of CO2-slicing equation; lower and upper bounds are window channel solution and tropopause, respectively.

Test 2: Perform selection of final result by "top-down" method; 36/35, 35/34, 34/33 in that order.

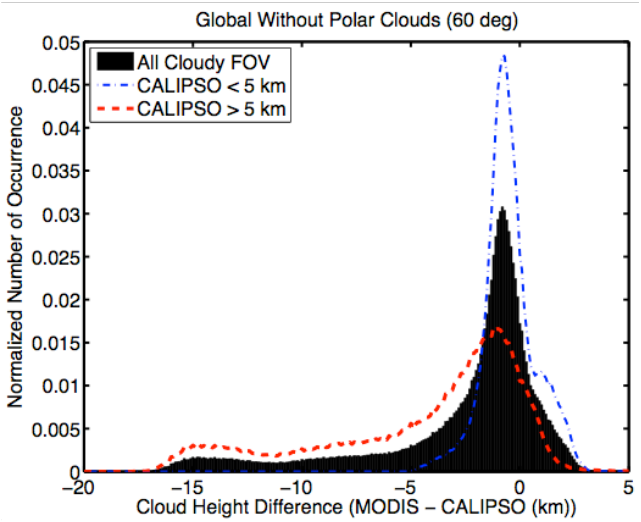
Test 3: Lower "noise" limits; clear vs. cloudy radiances required to be < a limit set for each of bands 33-36; do not use a band if the clear vs. cloudy difference is less than the limit. This has large impact on the number of 5x5s processed by the CO2-slicing algorithm as opposed to simple IR window channel technique.

Test 4: Adjust input climatological ozone profile between 10 and 100 hPa according to values in the GDAS data set.

The PEATE Evaluation Methodology

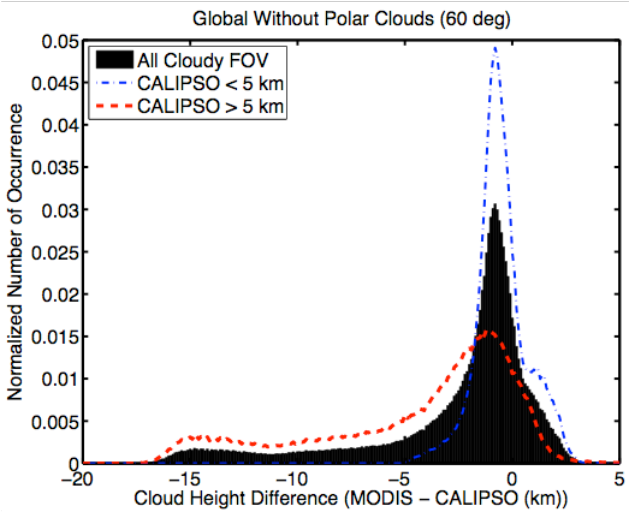


LAADS V5 CTH Compared to CALIOP



Test 1: Allow tropopause level to be the cloud height solution when no intersection is found between LHS and RHS of CO2-slicing equation

Process Modify Evaluate



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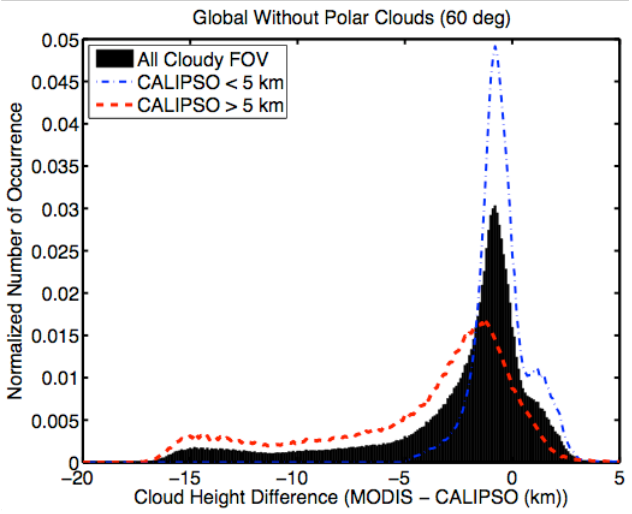
Test 2: Perform selection of final result by "top-down" method; 36/35, 35/34, 34/33 in that order.

Process Modify Evaluate



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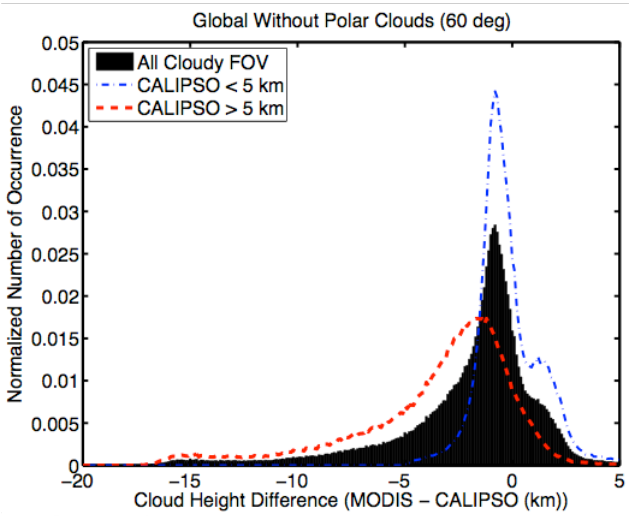
Test 3: Lower "noise" limits; clear vs. cloudy radiances required to be < a limit set for each of bands 33-36; do not use a band if the clear vs. cloudy difference is less than the limit.

Process
Modify
Evaluate



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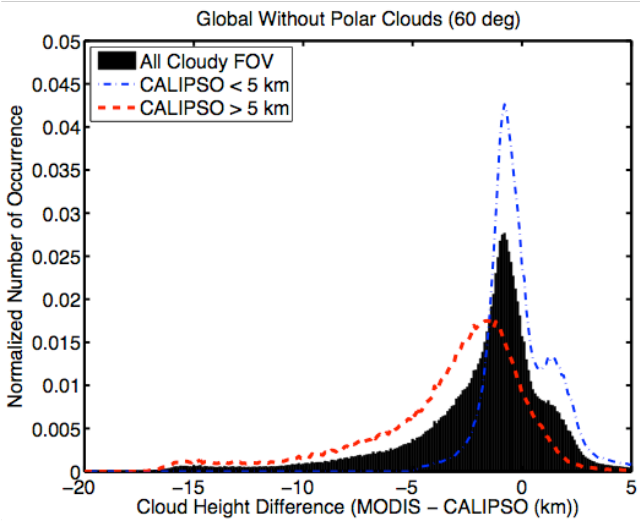
Test 4: Adjust input climatological ozone profile between 10 and 100 hPa according to values in the GDAS data set.

Process
Modify
Evaluate



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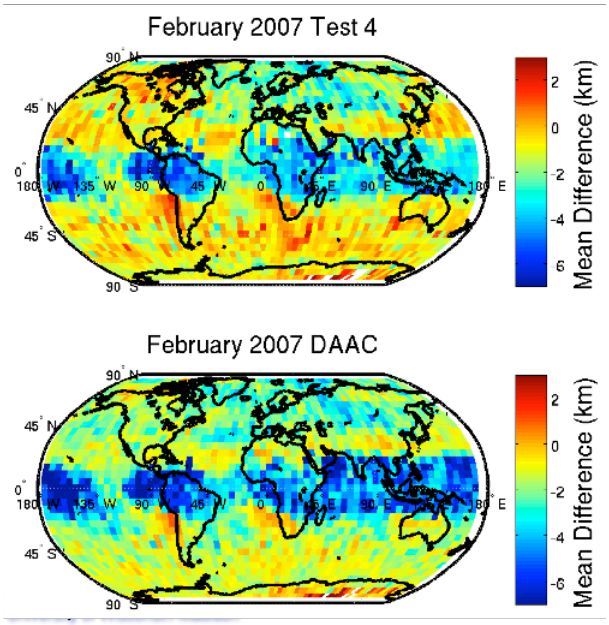
Re-Evaluate:Global CTH Differences

Process / Modify / Evaluate



SSEC

NASA

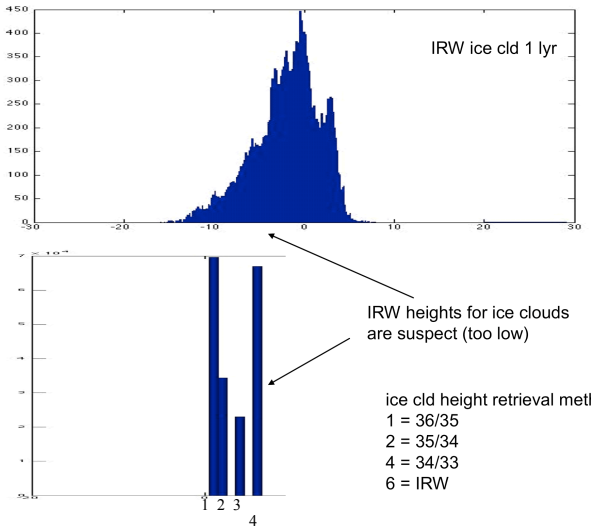
Other Pending CTH Tests

Process / Modify / Evaluate

- Avoid CO2 slicing solutions for water clouds
- Avoid IRW solutions for ice or mixed phase clouds
- Restrict CO2 channel pair solutions to appropriate portion of troposphere (determined by weighting functions)
- Implement spectral shifts to b35 & b36 indicated by Tobin AIRS–MODIS intercomparisons

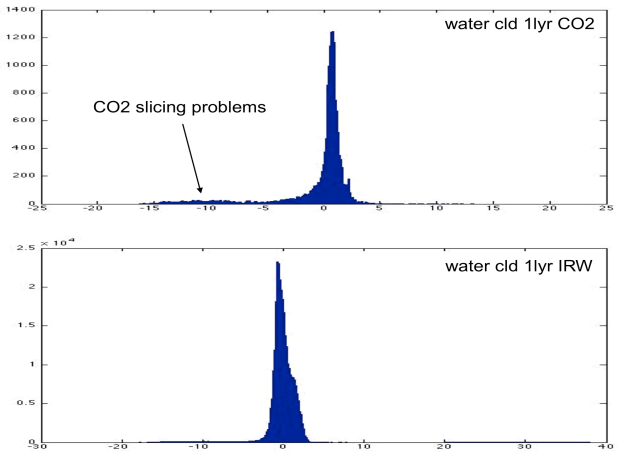
Avoid IRW solutions for ice or mixed phase clouds

Process
Modify
Evaluate



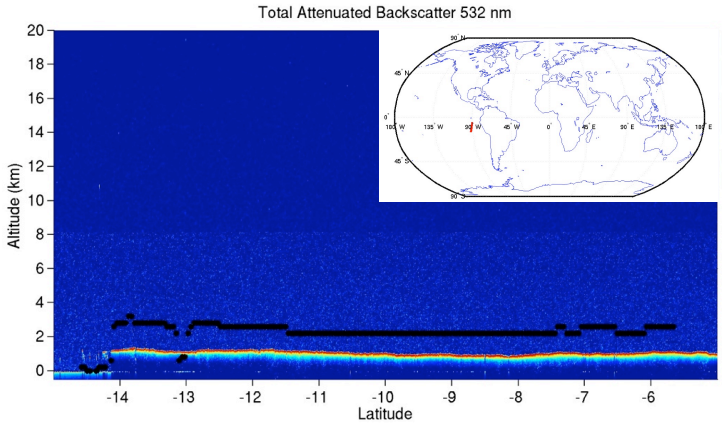
Avoid CO2 slicing solutions for water clouds

Process
Modify
Evaluate



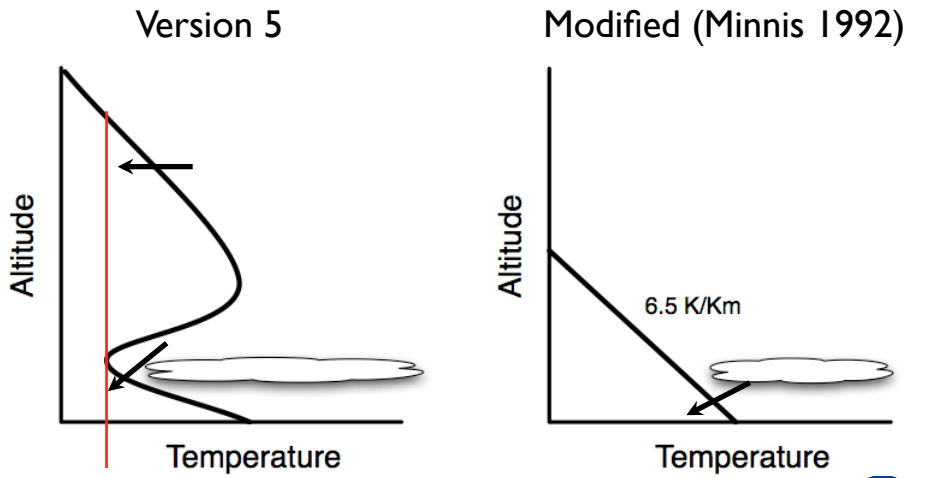
Marine Stratus Over-Estimated

Process | Modify | Evaluate



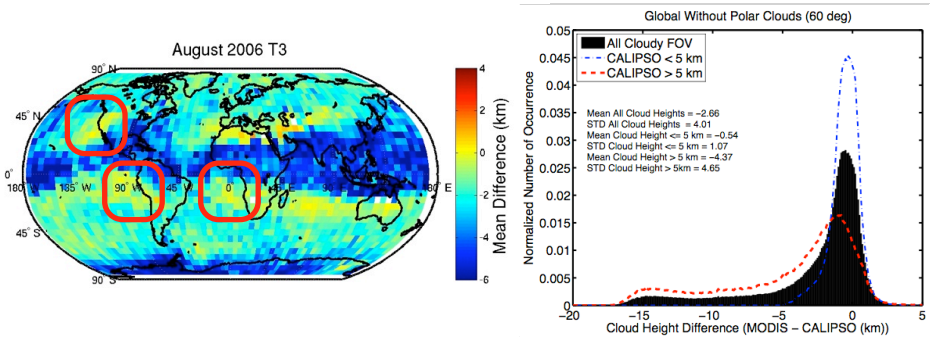
Marine Stratus Correction

Process | Modify | Evaluate



Marine Stratus Over-Estimation Fixed

Process
Modify
Evaluate



Conclusions: Cloud Top Height

- The largest cloud height differences results from not using CO2 slicing (>15 km)
- A high bias in marine stratus was identified in the MODIS retrievals
- The MODIS V5 cloud height algorithm was modified and re-evaluated. The Marine Height bias was mitigated for August 2006

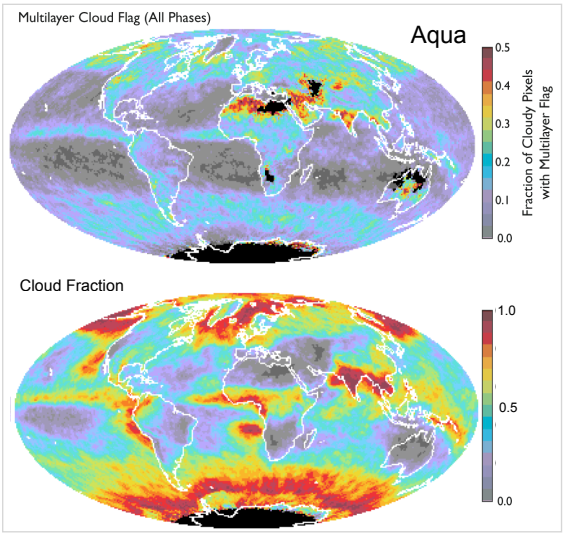
Demonstration #3: Effective Radius/Multi-Layer (ML)

- In collaboration with Steve Platnick methodologies for evaluating MODIS/VIIRS Effective Radius/Multi-Layer retrievals are being developed
- Investigated the MODIS MYD06 ML Retrievals using the A-PEATE evaluation match files
- Investigated the impact of the ML clouds on the MODIS effective Radius
- The PEATE L3 global grids, satellite->satellite evaluation system, collocation, and match files are used

MODIS Level-3 C5 Multilayer Cloud Flag, August 2006

Process / Modify / Evaluate

Fraction of cloud pixels (all phases) where the flag is set

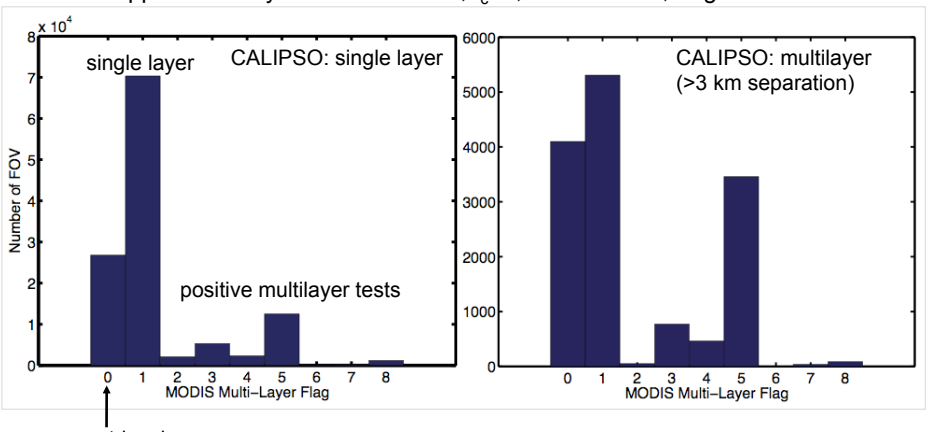


MYD06 Multilayer Flag vs. CALIOP: CALIOP as control

Process: Modify → Evaluate

Ocean Co-locations

CALIPSO single and multilayer layer co-locations
Upper cloud layer >1km & <-20C, f_c=1, ±70° latitude, August 2006



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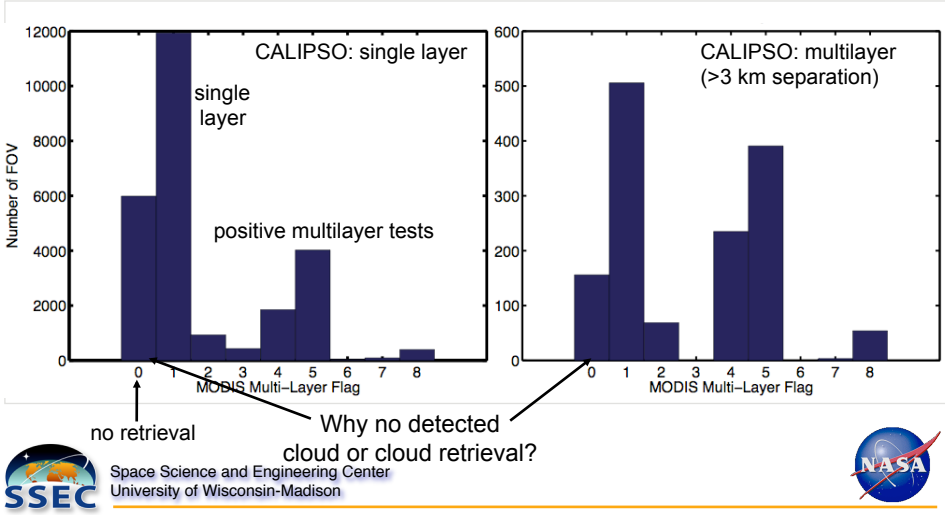
MYD06 Multilayer Flag : CALIOP as control

Process: Modify → Evaluate

Land (non-desert) Co-locations

CALIPSO single and multilayer layer co-locations
Upper cloud layer >1km & <-20C, f_c=1, ±70° latitude, August 2006



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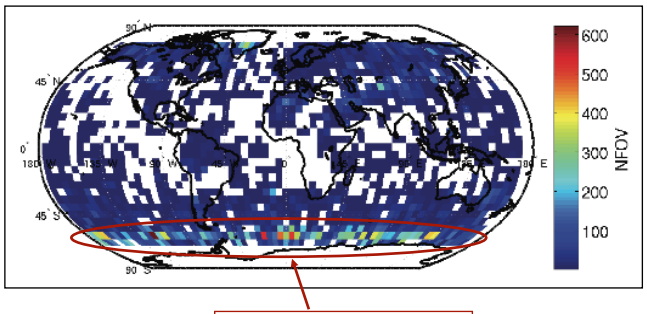
MYD06 Multilayer Flag: CALIPSO: CALIOP as control

Process / Modify / Evaluate

Gridded frequency of CALIOP single layer &. MYD06 ML flag=0

Upper cloud layer >1km & <-20C, f_c=1, ±70° latitude, August 2006



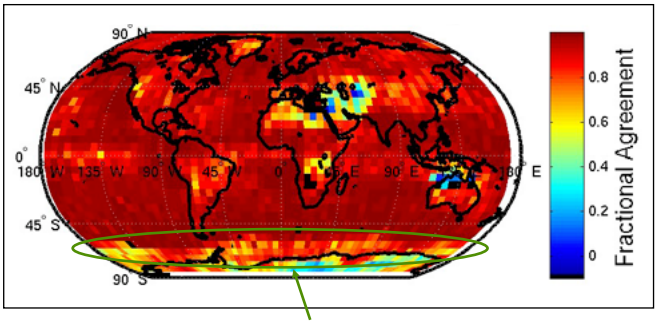
Most disagreement in far southern oceans

MYD06 Multilayer: CALIPSO: CALIOP as control

Process / Modify / Evaluate

Gridded frequency of CALIOP cloudy &. MODIS cloud mask clear

±70° latitude, August 2006



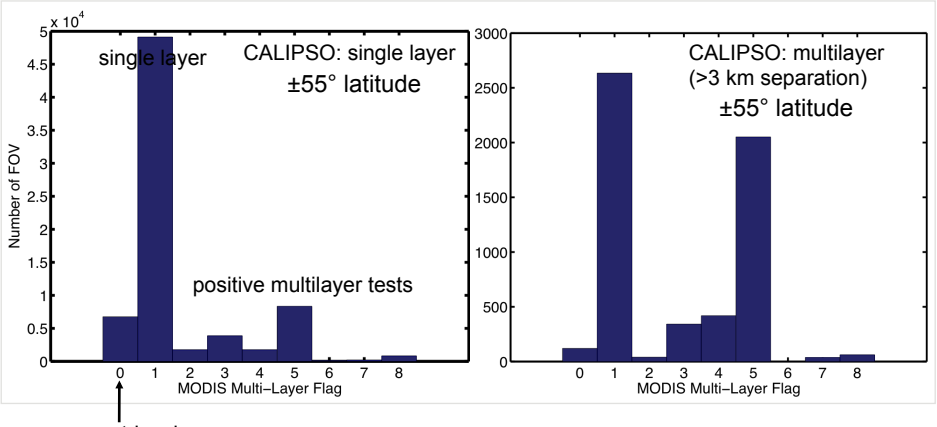
Most ocean disagreement in far southern oceans

MYD06 Multilayer Flag: CALIPSO: CALIOP as control

Process / Modify / Evaluate

Ocean Co-locations

CALIOP single and multilayer layer co-locations
Upper cloud layer >1km & <-20C, f_c=1, ±55° latitude, August 2006



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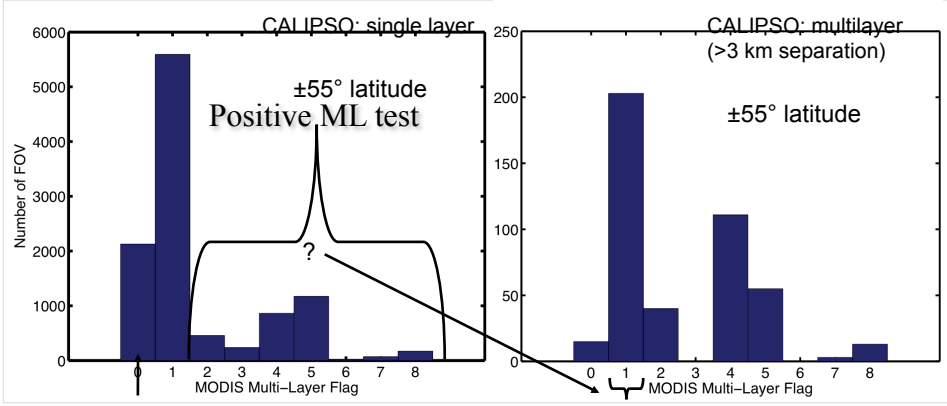
MYD06 Multilayer Flag:CALIPSO: CALIOP as control

Process / Modify / Evaluate

Land (non-desert) Co-locations

CALIOP single and multilayer layer co-locations
Upper cloud layer >1km & <-20C, f_c=1, ±70° latitude, August 2006



CALIOP SL includes opaque upper layer (need CloudSat)

CALIOP ML includes thin/subvis cirrus; broken Cu

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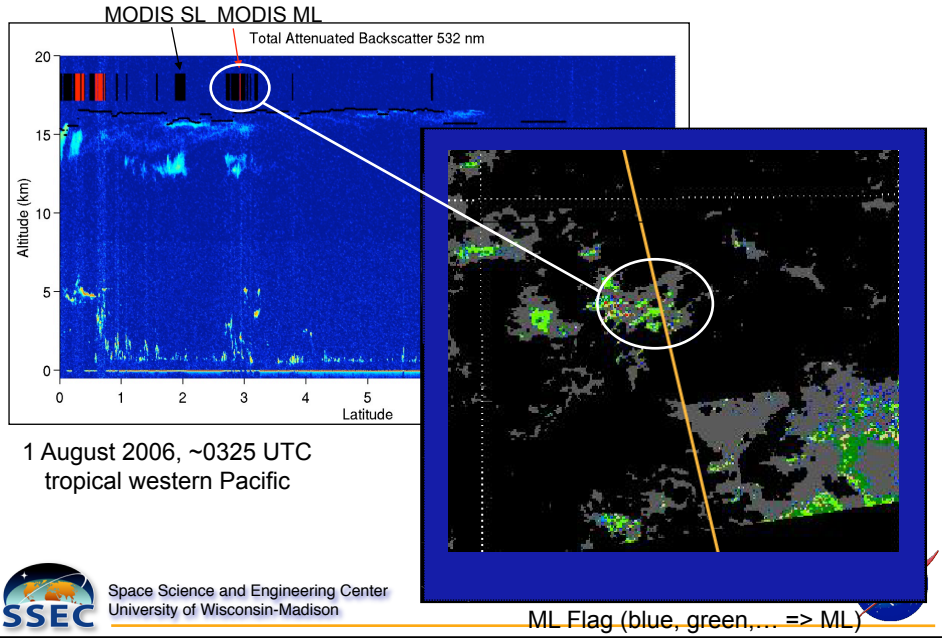
MYD06 Multilayer Flag: CALIPSO: granule-level

Process / Modify / Evaluate



1 August 2006, ~0325 UTC
tropical western Pacific

ML Flag (blue, green,… => ML)

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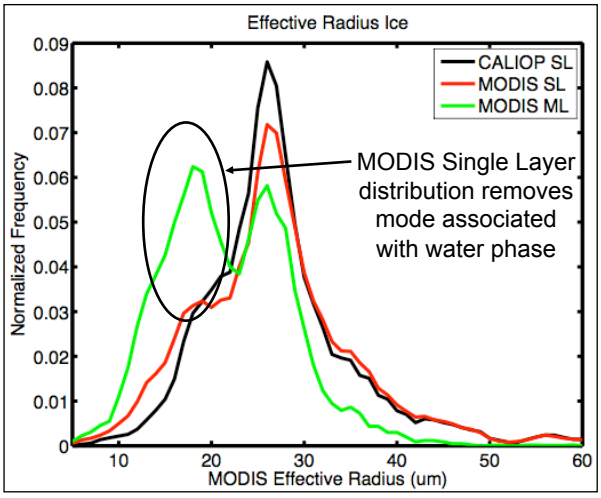
Impact on MODIS Ice Cloud Effective Radius Retrievals

Process / Modify / Evaluate

±55° latitude, land + ocean, 4 days in Aug 2006



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Conclusions Multi-Layer

- CALIOP-MODIS comparisons sensitive to:
  - MODIS thin cirrus detection limit
  - Layer separation distances
  - Lower cloud fraction/spatial structure, e.g., lidar aggregation (5 km vs. 1 km), low cloud reflectance from broken Cu, …
- Future work
  - Add CALIOP optical depth to analysis
  - investigate MODIS retrieved OD sensitivities

Science Evaluation Conclusions

- The NPP Atmosphere PEATE will be a powerful diagnostic tool for the NPP Science Team
- The model of Processing, Evaluating, and Modifying (PEM) has proven to be very effective at assessing EDR and SDR performance
- The PEATE structure enables rapid iteration of the PEM cycle and thus maximizes the capability of the Science Team to evaluate the algorithms
- Demonstrations with SDR, CM(IP), CTH, and COP illuminate the importance of an integrated system capable of rapid processing to support the NPP Science Team