

The MODIS cloud optical and
microphysical property product:
Overview of the Collection 6
algorithm and preliminary results

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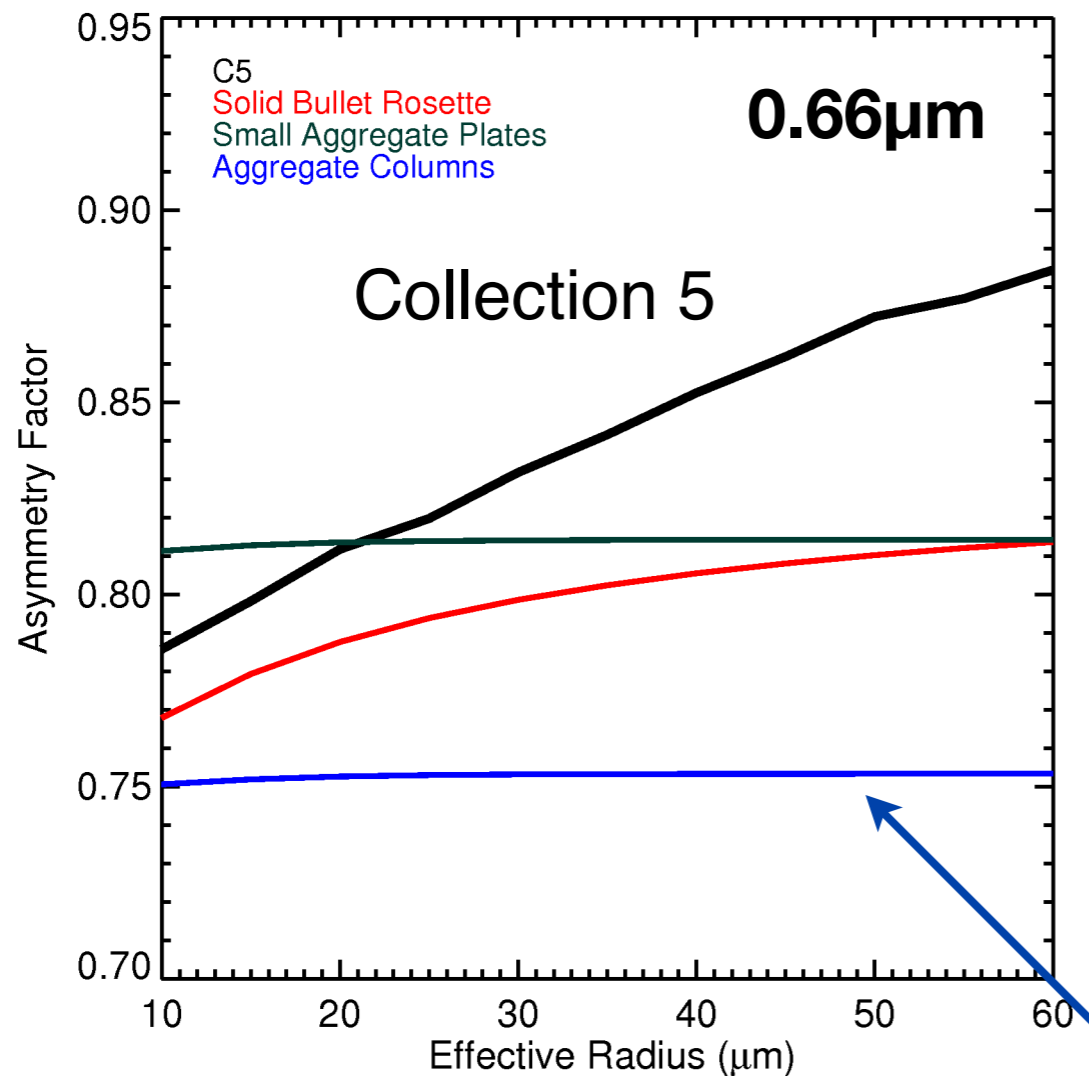
Jerome Riedi

Ping Yang

Changes for Collection 6 (C6)

Category	Collection 5	Collection 6	Notes
Radiative Transfer			
Cloud Model: all phases	Combined discrete ordinate LUT (small COT) + asymptotic theory parameters (large COT)	Full reflectance, flux, and emissivity LUTs across retrieval space/geometry. LUT entries provided for multiple scattering component only; phase function provide in file for direct calculation of single scattering component.	<ul style="list-style-type: none"> • Single approach (LUT) => easier retrieval code maintenance. • LUT grid designed to limit median linear interpolation error to << 1%. • Separation of single scattering component => fewer LUT grid points and interpolations during processing.
Ice Cloud Model	Variable habit (smooth) vs. size/ empirical distributions. Relatively large asymmetry parameter (g) and highly dependent on CER.	Single habit (severely roughened aggregated columns) w/analytic distribution (γ , ρ)	<ul style="list-style-type: none"> • Smaller g reduces COT & provides closure with non-opaque IR COT retrievals. • Constant g vs. CER. • SWIR/MWIR particle absorption decreases => larger retrieved CER.
Surface Ancillary Datasets	Team-designed nominal annual gap-filled spectral albedo dataset using Terra C5 product MOD43.	New dynamic gap-filled spectral albedo dataset derived from Aqua+Terra C5 MCD43B3. Emissivity dataset from MOD06 CT product for spectral consistency.	<ul style="list-style-type: none"> • C6 albedo dataset provided higher temporal resolution than C5 (8 day interval, 16 day average). • Sea-ice spectral albedo dataset same as for C5.
Ocean Surface BRDF	Lambertian (5%)	Cox-Munk BRDF for 3 wind speeds (3, 7, and 15)	<ul style="list-style-type: none"> • Independent ocean LUTs with Cox-Munk explicitly modeled.
Incorporation of Model Error Sources	N/A	LUT includes sensitivity datasets for and Cox-Munk wind vector.	No explicit model error sources used in C5 uncertainty calculations.

Bob Holz, Wednesday 12:00



↑ larger COT

Retrieved COT $\approx [1-g(r_e)]^{-1} 2R/(1-R)$

↓ smaller COT

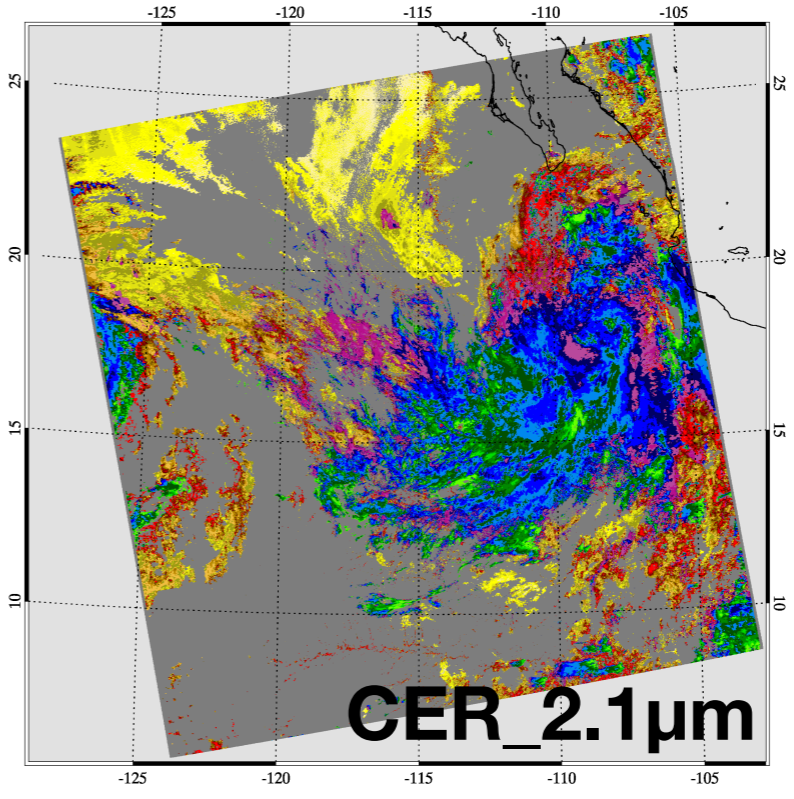
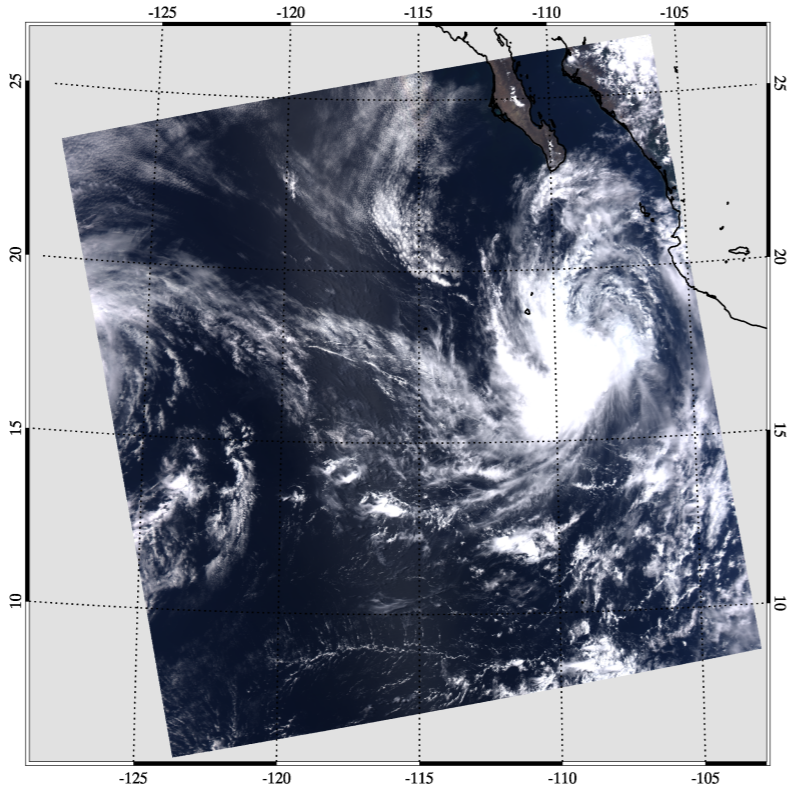
MODIS Collection 6:
severely roughened
aggregated column

Changes for Collection 6 (C6)

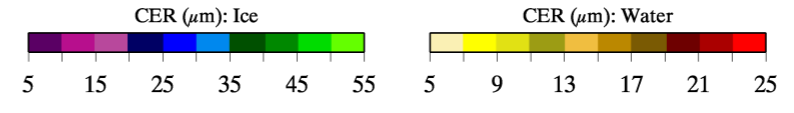
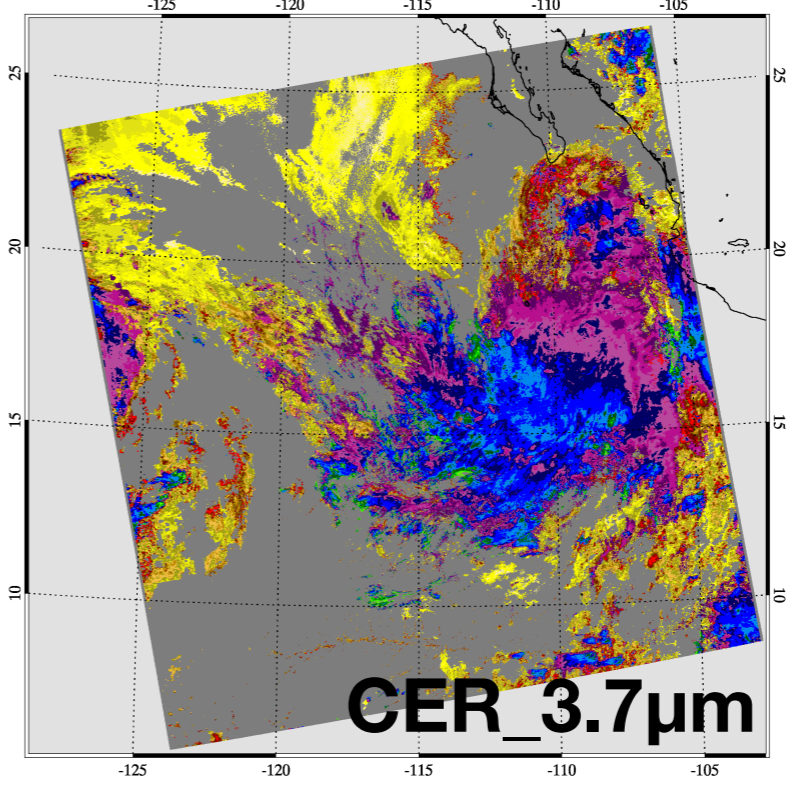
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Ice Cloud Model	Variable habit (smooth) vs. size/ empirical distributions. Relatively large asymmetry parameter (g) and highly dependent on CER.	Single habit (severely roughened aggregated columns) w/analytic distribution (γ , μ)	<ul style="list-style-type: none"> • Smaller g reduces COT & provides closure with non-opaque IR COT retrievals. • Constant g vs. CER. • SWIR/MWIR particle absorption decreases => larger retrieved CER.
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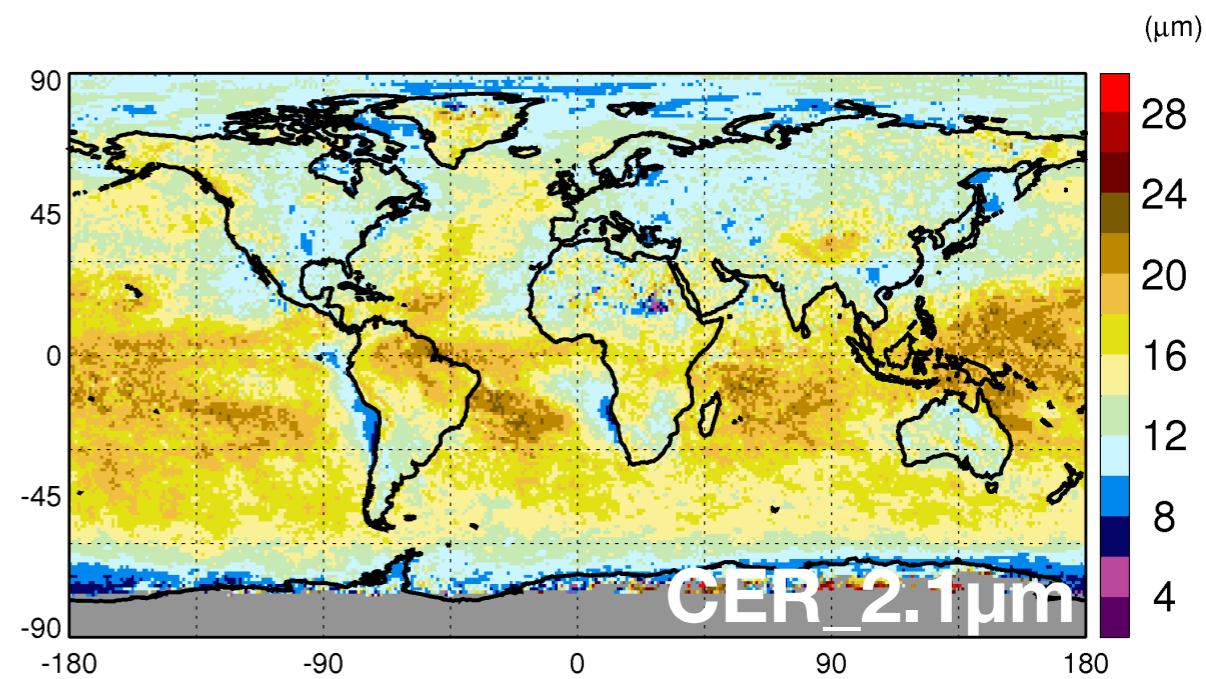
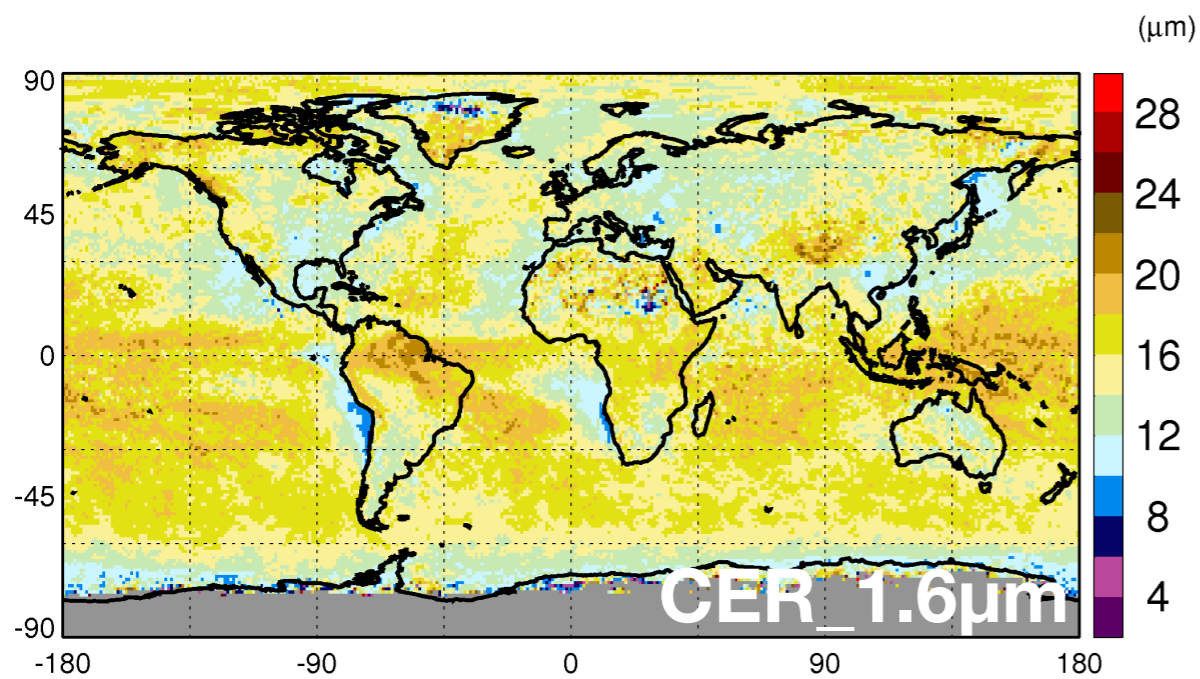
Changes for C6 (Continued)

Category	Collection 5	Collection 6	Notes
Level-1 Analysis/Corrections			
Band 1,2 trend detection/correction	N/A	COT monthly anomaly trend analysis	Used to justify MCST work with desert site response-vs-scan angle corrections.
Aqua Band 1,2 250m->1km aggregation	N/A	Used to improve known Aqua VNIR focal plane mis-registration w/SWIR, MWIR, and IR focal planes	Impacts Aqua COT and CER statistics in heterogeneous low cloud regions.
Algorithm - Retrieval Science			
Retrieval channel pairs	CER differences for VNIR-SWIR/MWIR channel pairs (relative to standard VNIR-2.1 μm).	Full retrievals reported separately for as many as 4 spectral channel pairs.	<ul style="list-style-type: none"> Doesn't filter alternate channel pair retrievals by success of standard retrieval. Allows for separate evaluation/aggregation of all channel pairs.
Cloud-Top (CT) Pressure/Temperature	Used 5 km MOD06 CT product.	Uses new 1km MOD06 CT product. Incorporates non-unity cloud emissivity from optical retrieval into low cloud CT retrievals that use IR window channel.	
Thermodynamic Phase	Used SWIR/VNIR ratio tests as a proxy for particle size that was then used to indicate phase.	SWIR/VNIR ratio tests replaced w/ separate ice and liquid retrievals. Uses new tri-spectral IR phase product. Eliminates use of individual cloud mask tests. Weights applied to various tests in lieu of strict logical approach.	<ul style="list-style-type: none"> Algorithm tests/weights validated against CALIOP, POLDER products. Significant skill improvement seen for most regions (e.g., land, ocean, snow/ice) though still limited by available spectral bands.
Misc.	N/A	Numerous science and code infrastructure performance improvements.	<ul style="list-style-type: none"> Improved processing efficiency. Easier code maintenance, porting to other sensors.

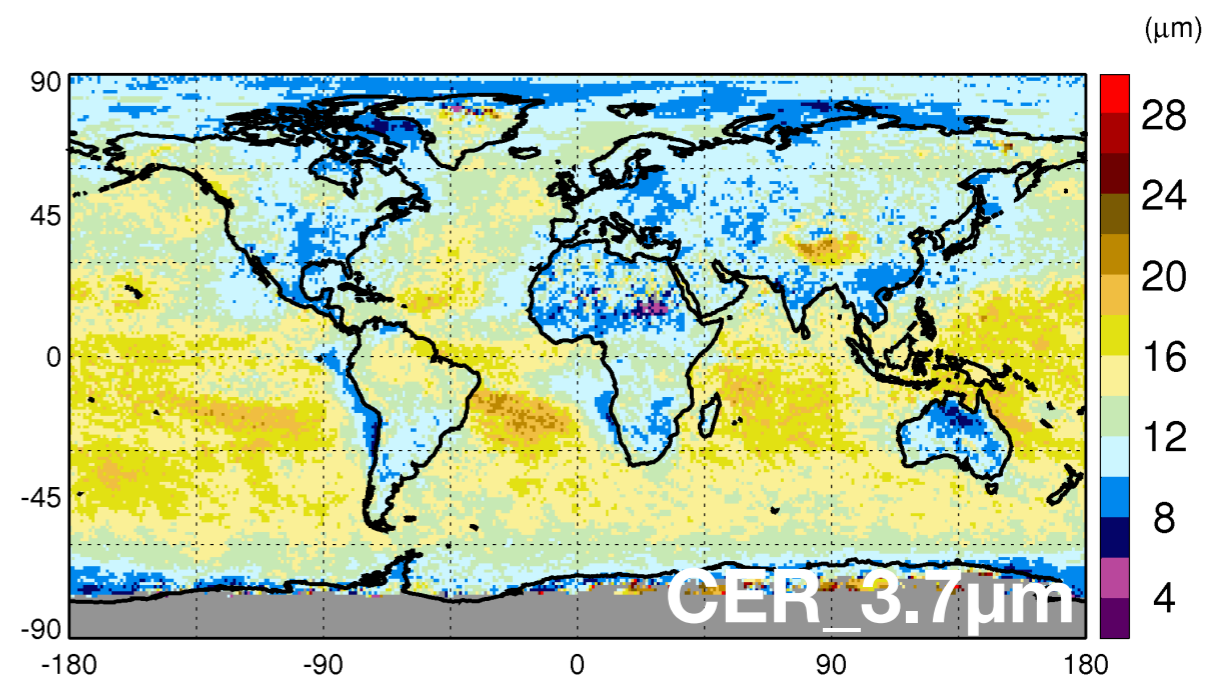


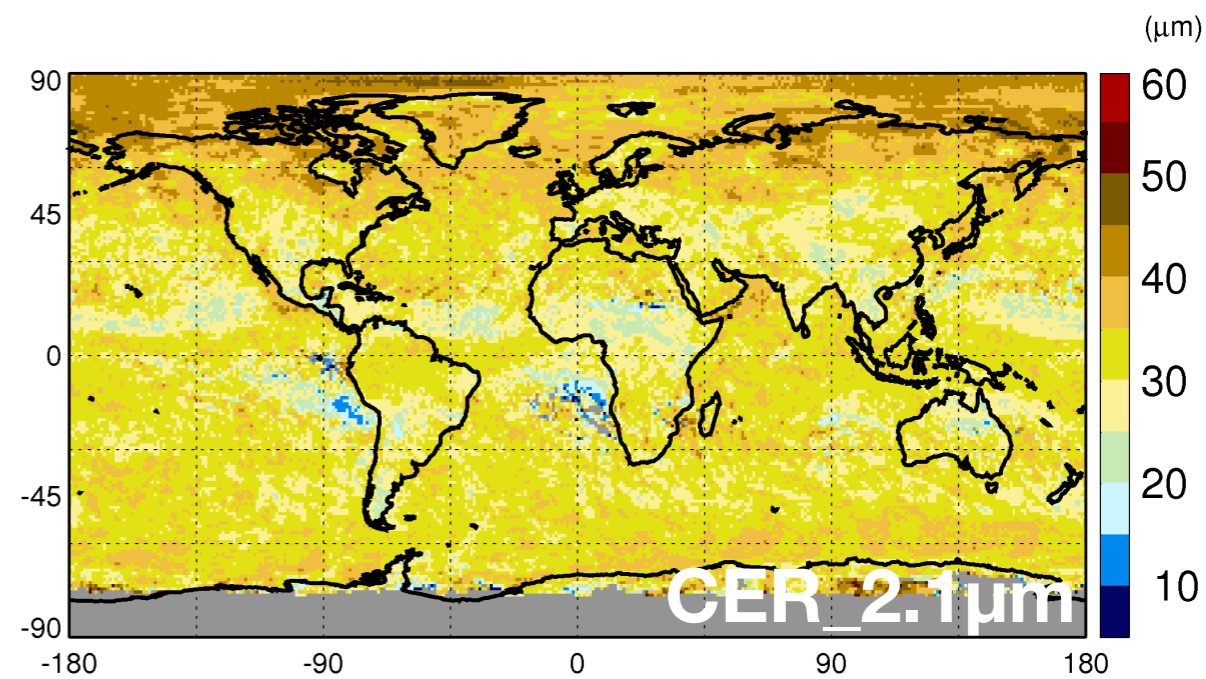
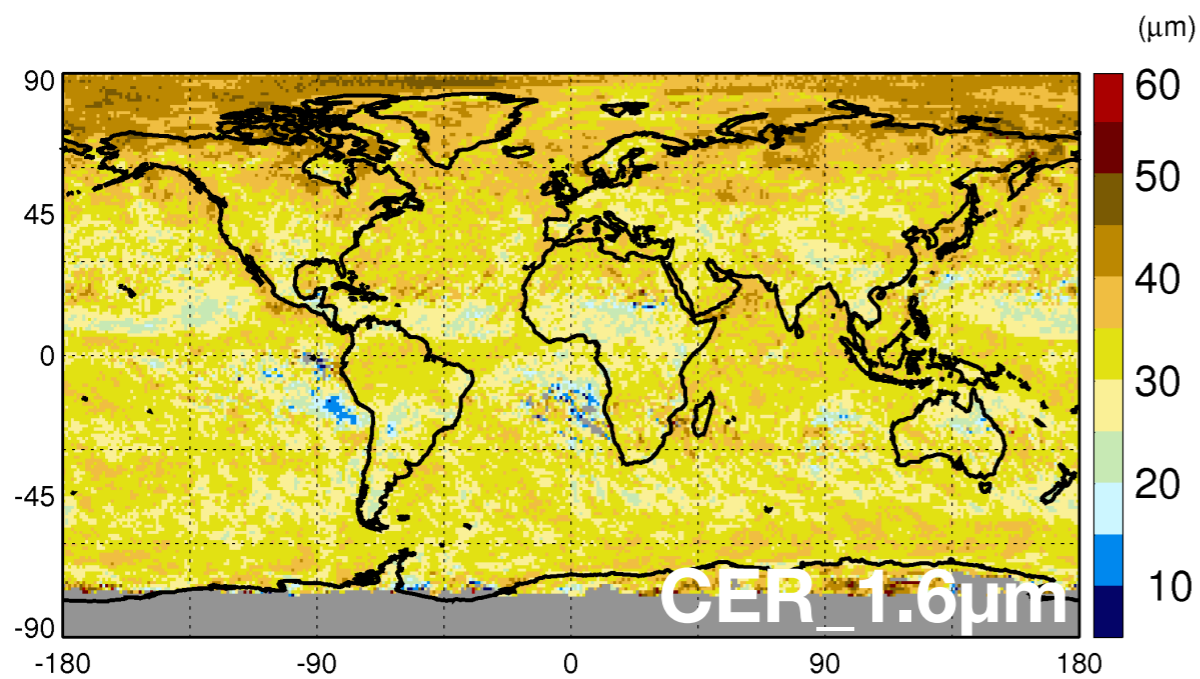
Aqua MODIS
2 July 2008 (2105 UTC)



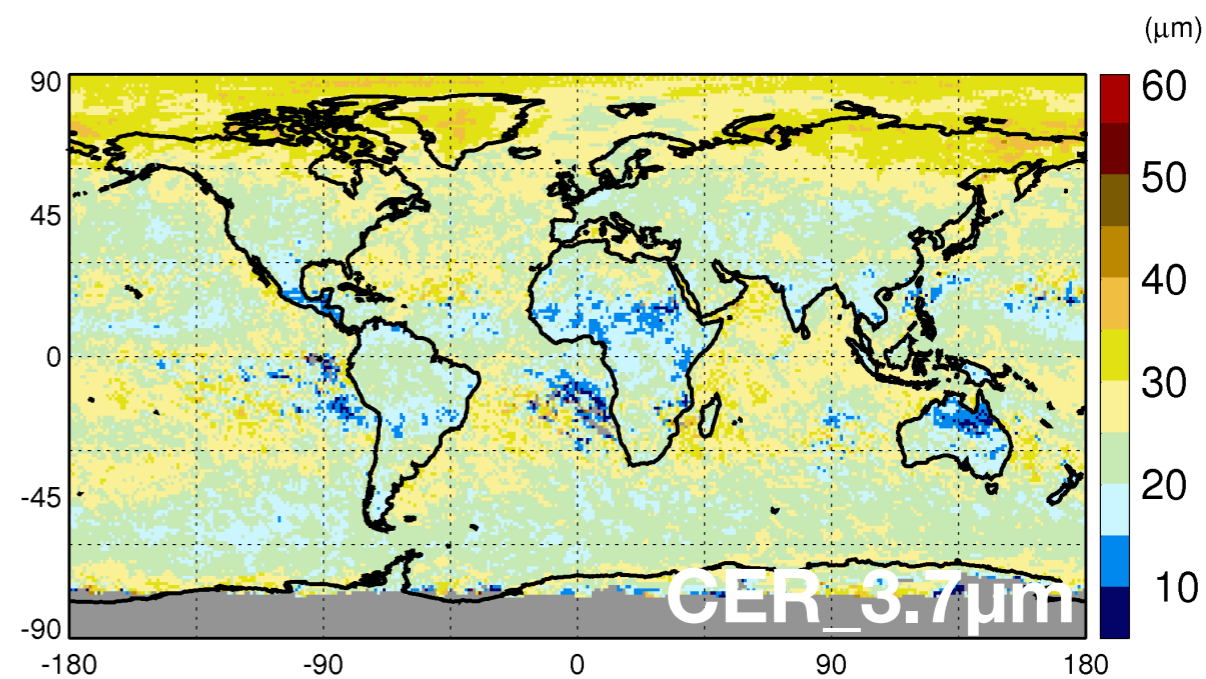


Aqua MODIS, April 2005
Overcast Liquid Phase Clouds





Aqua MODIS, April 2005
Overcast Ice Phase Clouds



Changes for C6 (Continued)

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Level-1 Analysis/Corrections			
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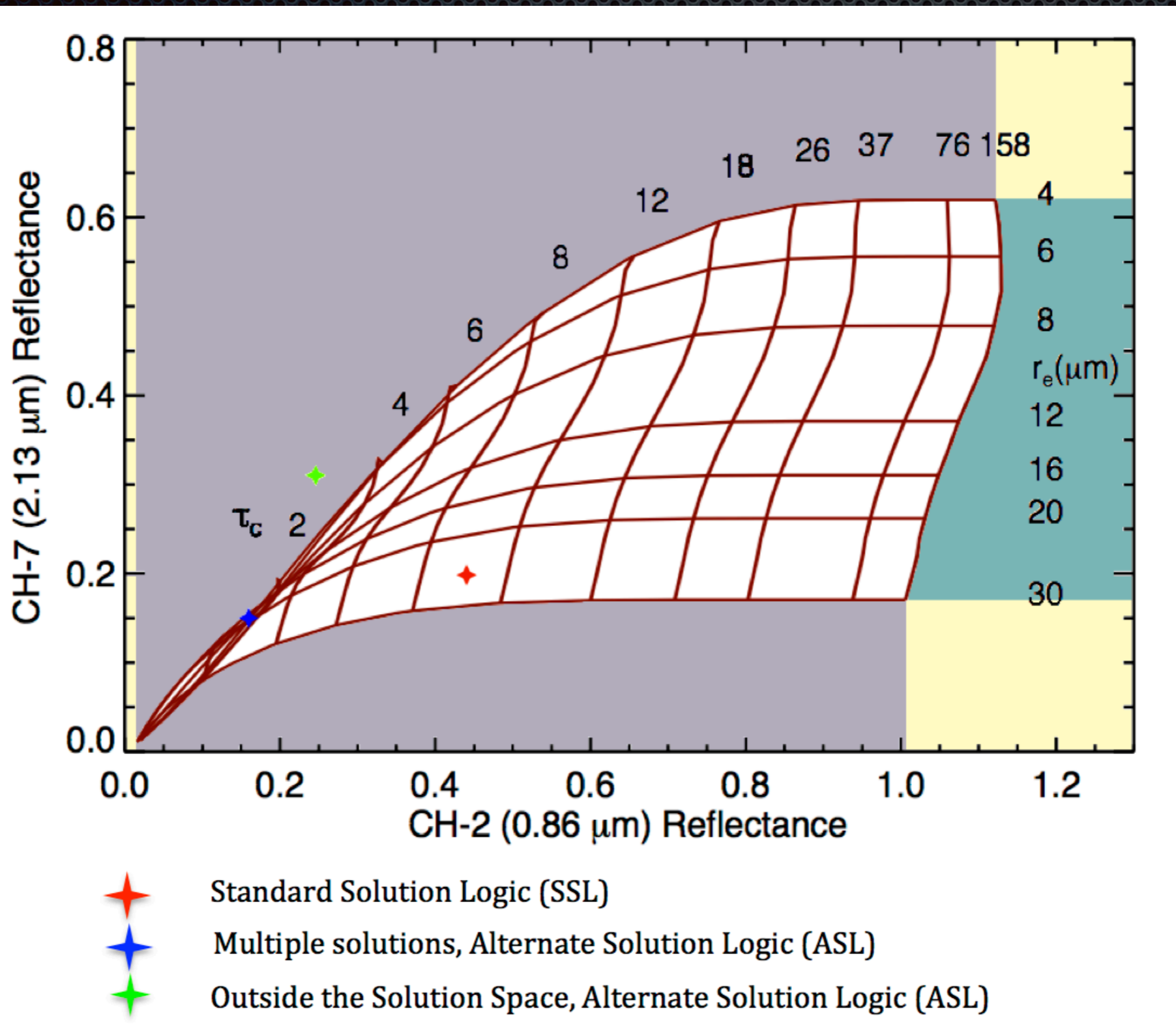
Ben Marchant, Today 11:30

Changes for C6 (Continued)

Kerry Meyer, Thursday 14:45

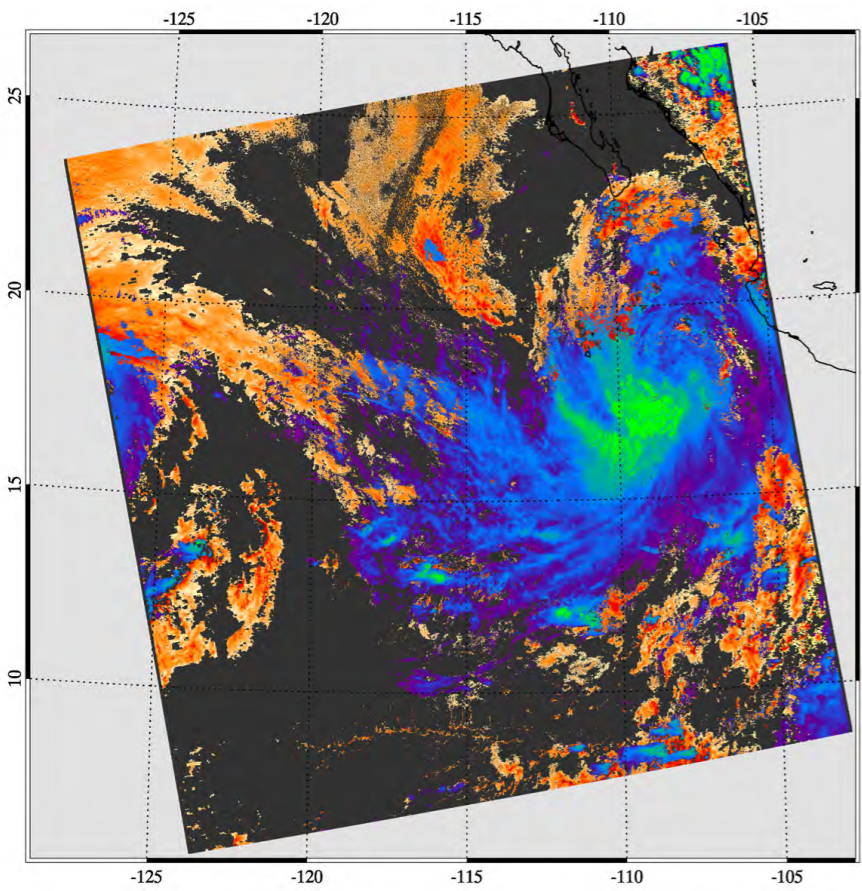
Algorithm - Pixel Quality Ass

Category	Collection 5		
Updated 'Clear Sky Restoral' (CSR) algorithm	N/A	Improve discrimination between heavy aerosol (smoke/dust) and glint from low uniform cloud population.	Added explicit aerosol model tests. Replaced 1.38 μm cloud height discrimination tests w/CT 'method' flags.
Pixels identified as not-overcast and/or cloudy FOV by CSR algorithm	Do not retrieve CSR-identified pixels	Attempt retrievals on CSR-identified pixels and, if successful, write results to separate dataset (SDS).	Separate SDS allows for analysis of CSR population w/out need to read/interpret QA assignments.
Failed Retrieval Metrics ('failure' defined as the simultaneous COT, CER solution being outside of LUT space)	No failure metrics reported	The following metrics are reported: nearest COT, nearest CER, relative distance from 2D measurement point to nearest LUT solution point.	Allow users to understand failure mode (e.g., large CER, small COT) for cloudy FOVs not meeting 1D fwd. model assumptions. Potentially useful for radiative studies, comparison with other observational datasets, and high resolution LES models.
Multilayer cloud detection	<i>Wind et al. (2010)</i>	Updated multilayer cloud detection using additional tests from <i>Pavolonis and Heidinger (2004)</i> .	
Retrieval Confidence QA	2-bit assignment	Not actively assigned. Superseded by pixel-level uncertainty SDS.	QA assignments confusing to users, lack of consistency across products. L3 users directed to "Uncertainty of Mean" SDS derived from pixel-level uncertainties.
Sub-pixel Heterogeneity	N/A	Bands 1 & 2 250 m reflectance heterogeneity included in MOD35 and MOD06 dataset.	Heterogeneity partial predictor for marine liquid water cloud spectral differences.

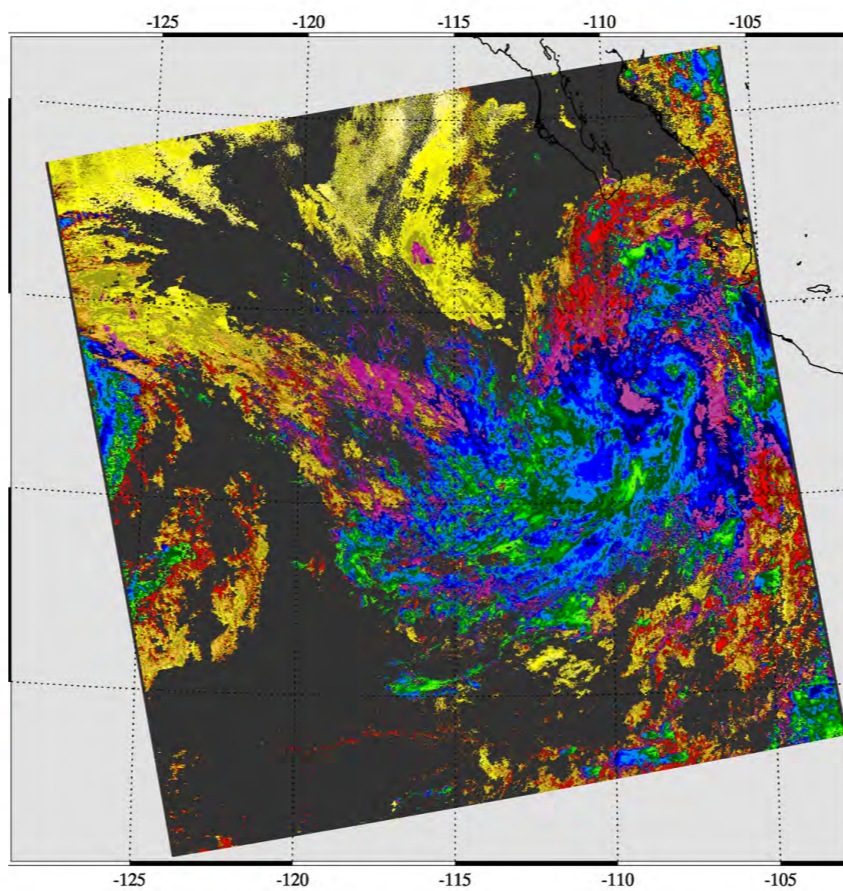
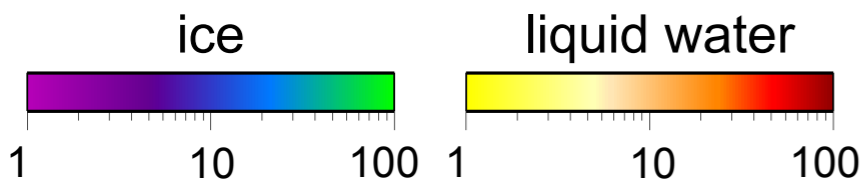


Changes for C6 (Continued)

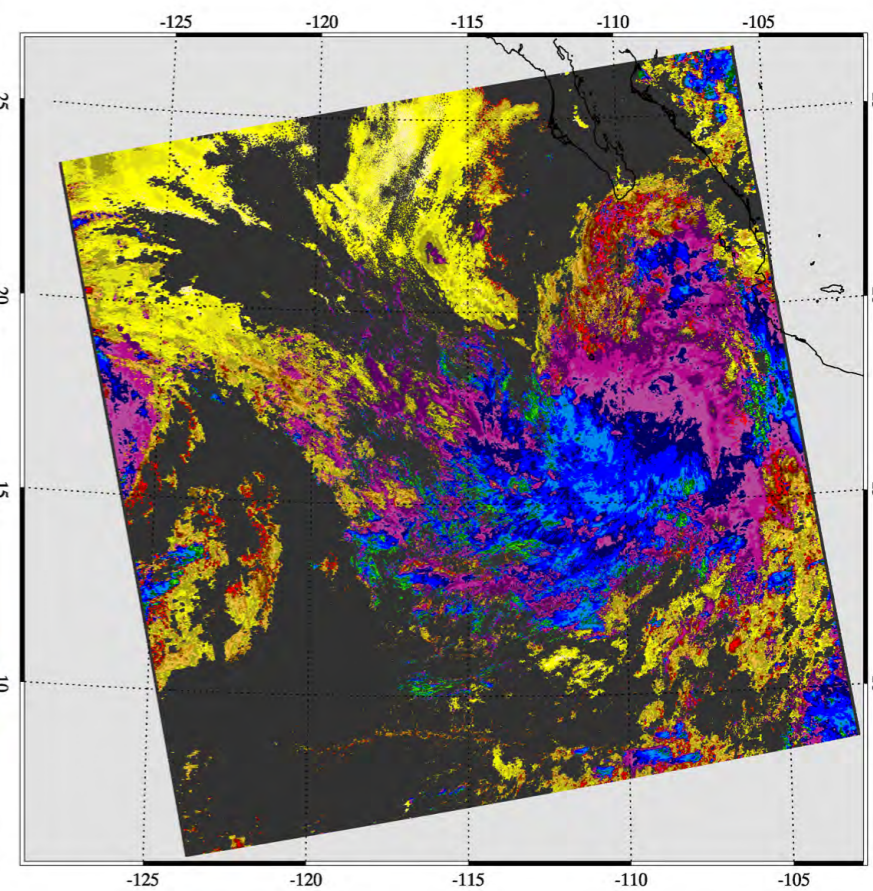
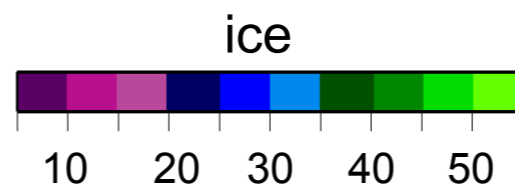
Category	Collection 5	Collection 6	Notes
Algorithm - Pixel Level Uncertainty			
Instrument Calibration	Combined with model error sources and fixed at 5% relative	Uses L1B scene-dependent pixel-level spectral uncertainty indices (improved for C6)	Reduces combined uncertainty in many cases.
Model Errors		See LUT above for details.	
3.7 μm Emission Error Sources	Not included	Accounts for effective cloud and surface emissivity including dependence on ancillary water vapor field.	More realistic (larger) 3.7 μm channel CER and water path uncertainties.



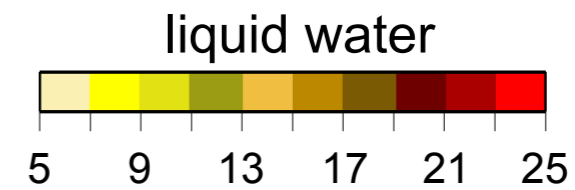
COT

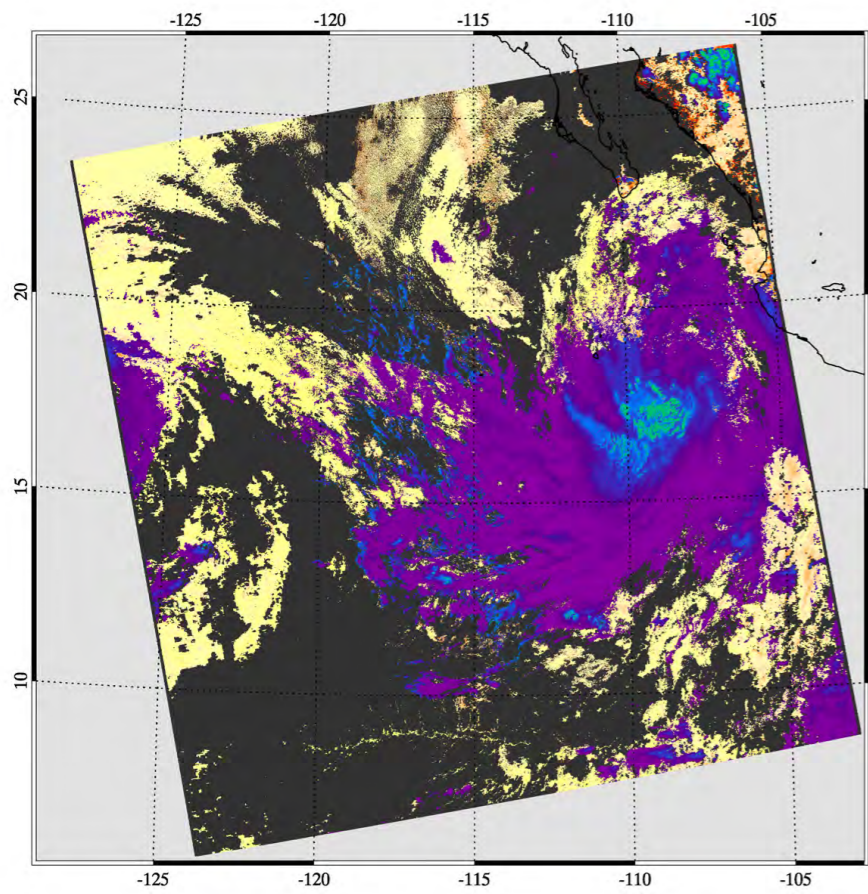


CER_2.1 (μm)

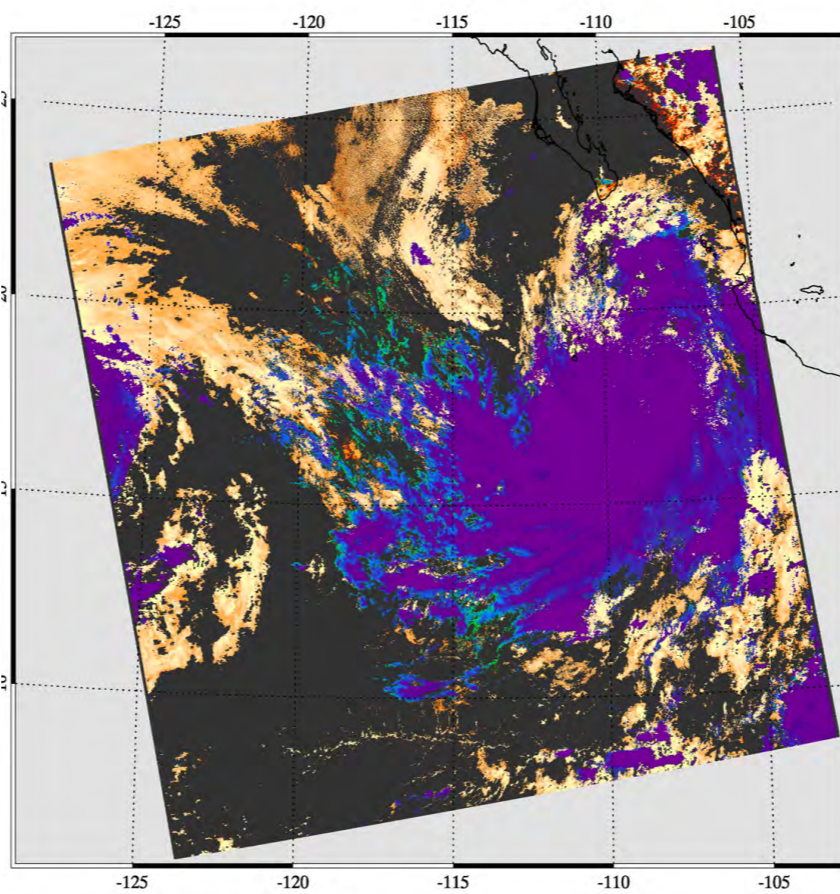


CER_3.7 (μm)

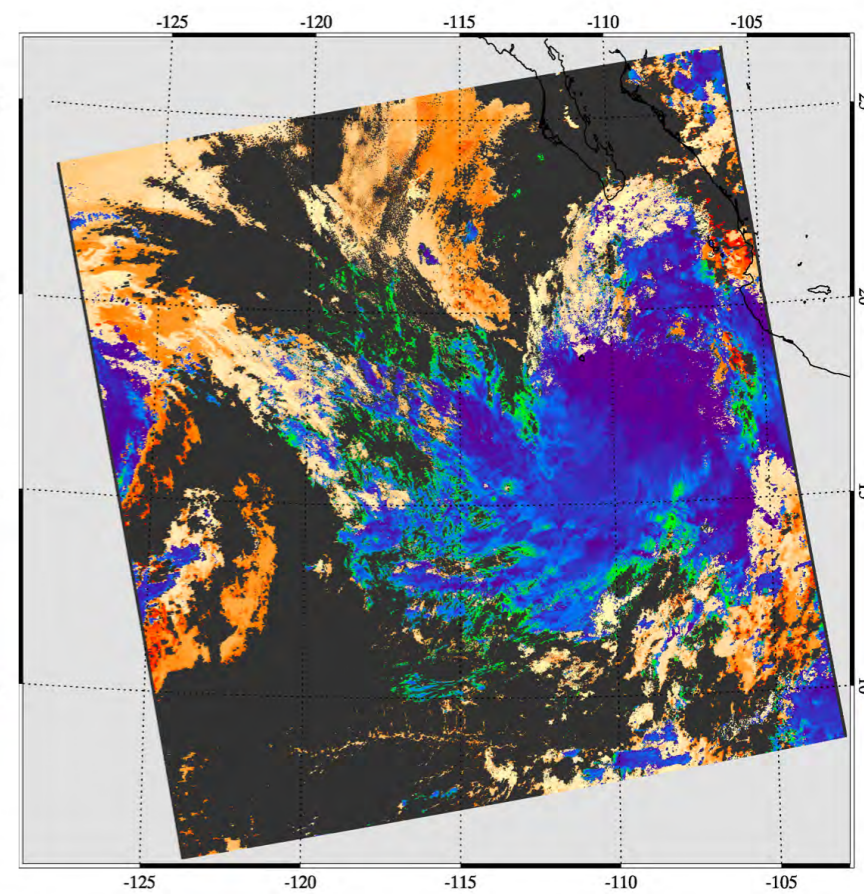




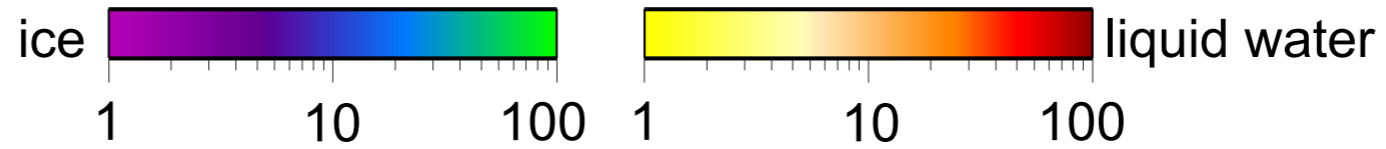
ΔCOT (%)



$\Delta\text{CER}_{2.1}$ (%)



$\Delta\text{CER}_{3.7}$ (%)



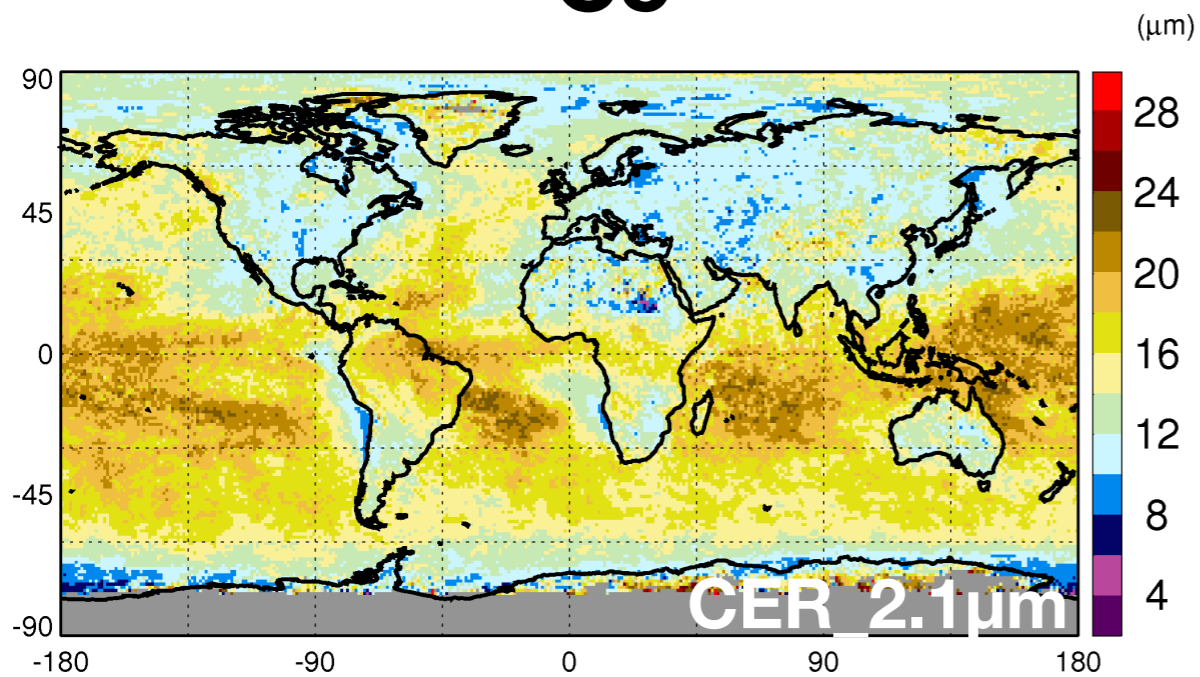
Changes for C6 (Continued)

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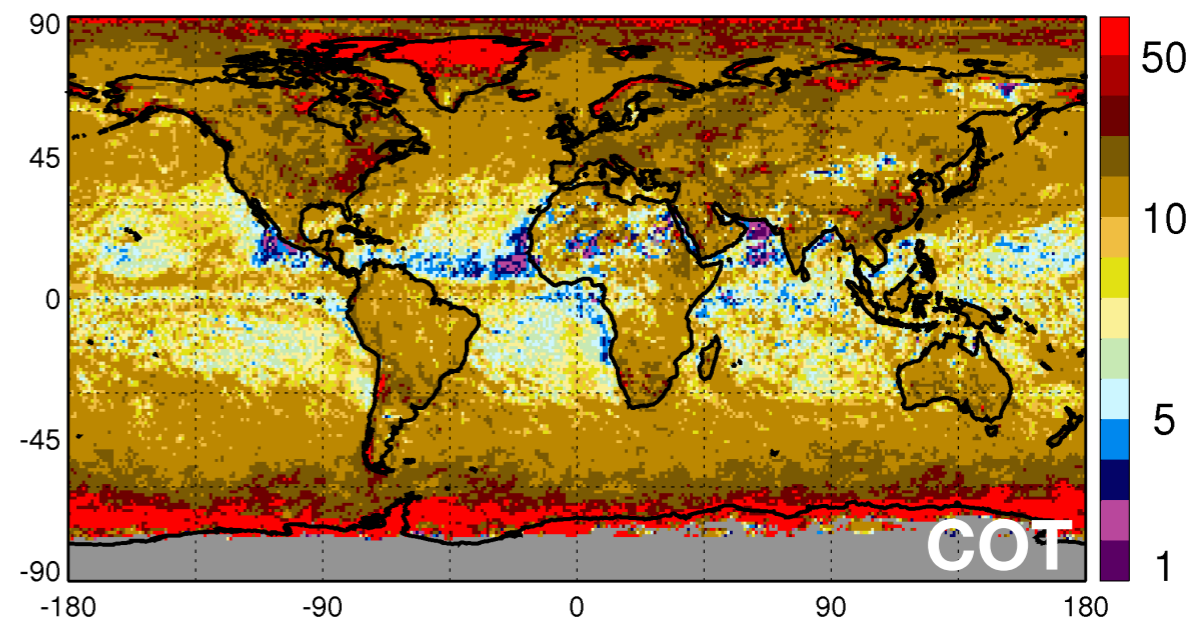
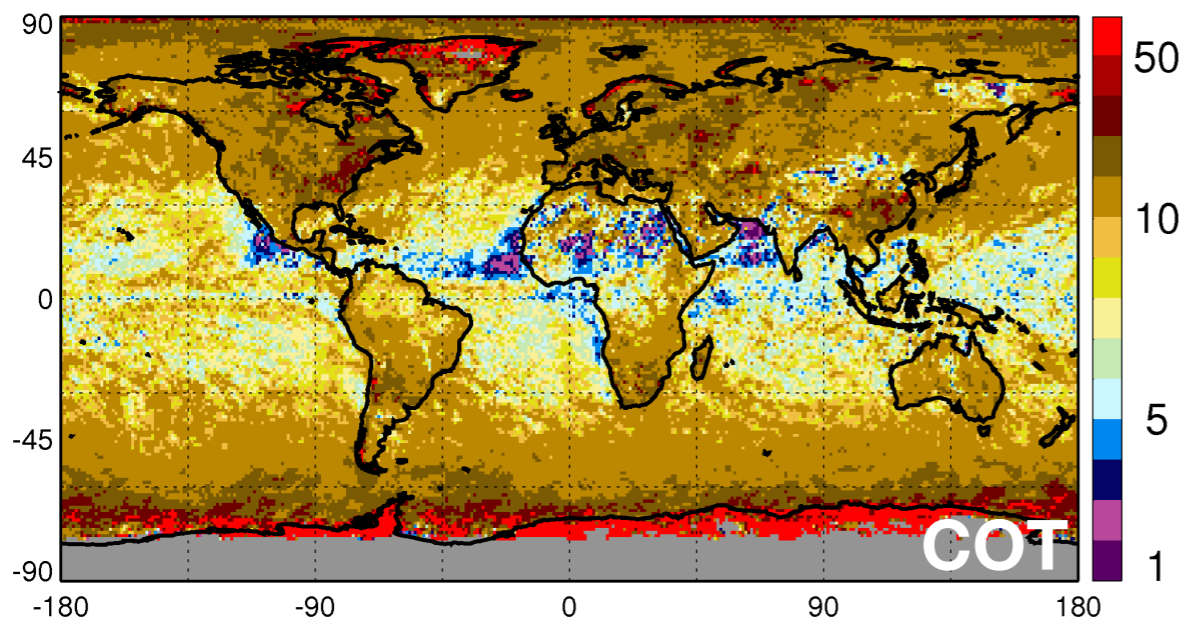
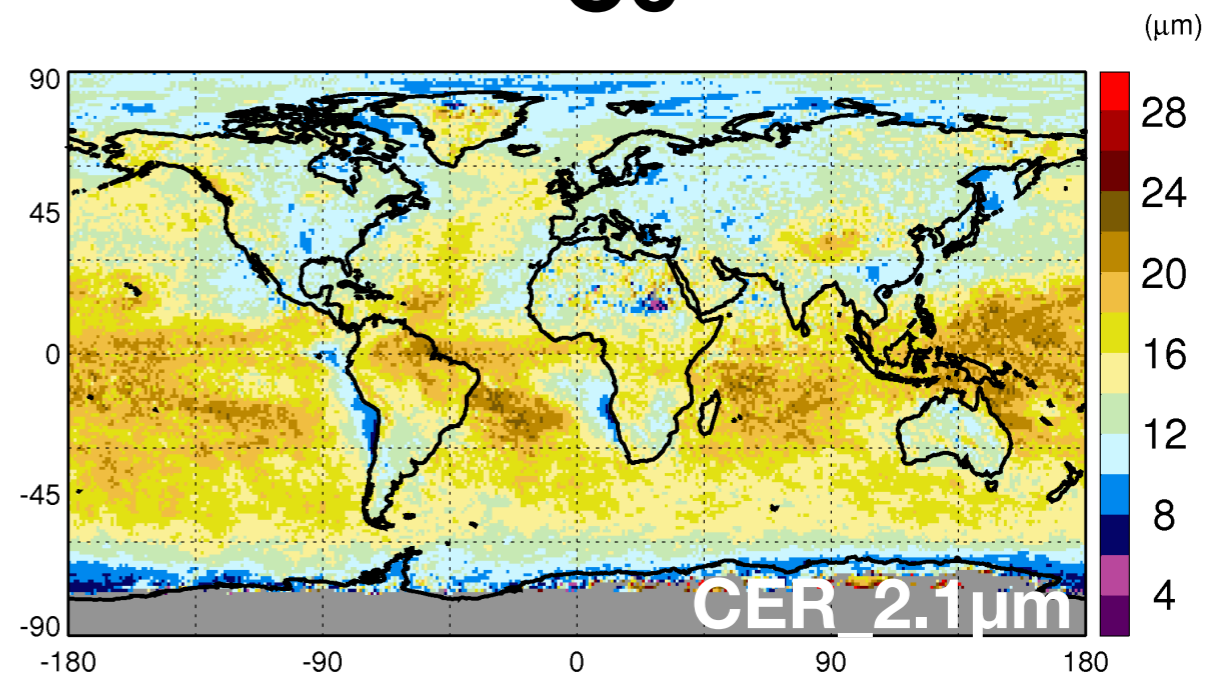
MOD06 uses a “shared-core” concept => can be applied to airborne (eMAS) and other satellite sensors (e.g. VIIRS, SEVIRI)

Gala Wind, Poster

C5



C6



Aqua MODIS April 2005, Liquid Phase

Summary

- Aqua Level-2 re-processing began late December 2013
 - Currently through 2008, to be finished sometime in May 2014.
 - Forward processing stream in parallel with C5 started January 2014.
- Terra re-processing TBD.
- Level-3 “beta” coming soon.
- Significant changes/enhancements in MOD06 C6.
 - User Guide in preparation.
- C6 MOD06 is portable!
 - MOD06 applied to SEVIRI [Gala Wind (poster)], VIIRS, airborne (eMAS, MASTER).