Cloud Mask and Water Vapor: Results and Validation

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Cloud Mask (MOD35)

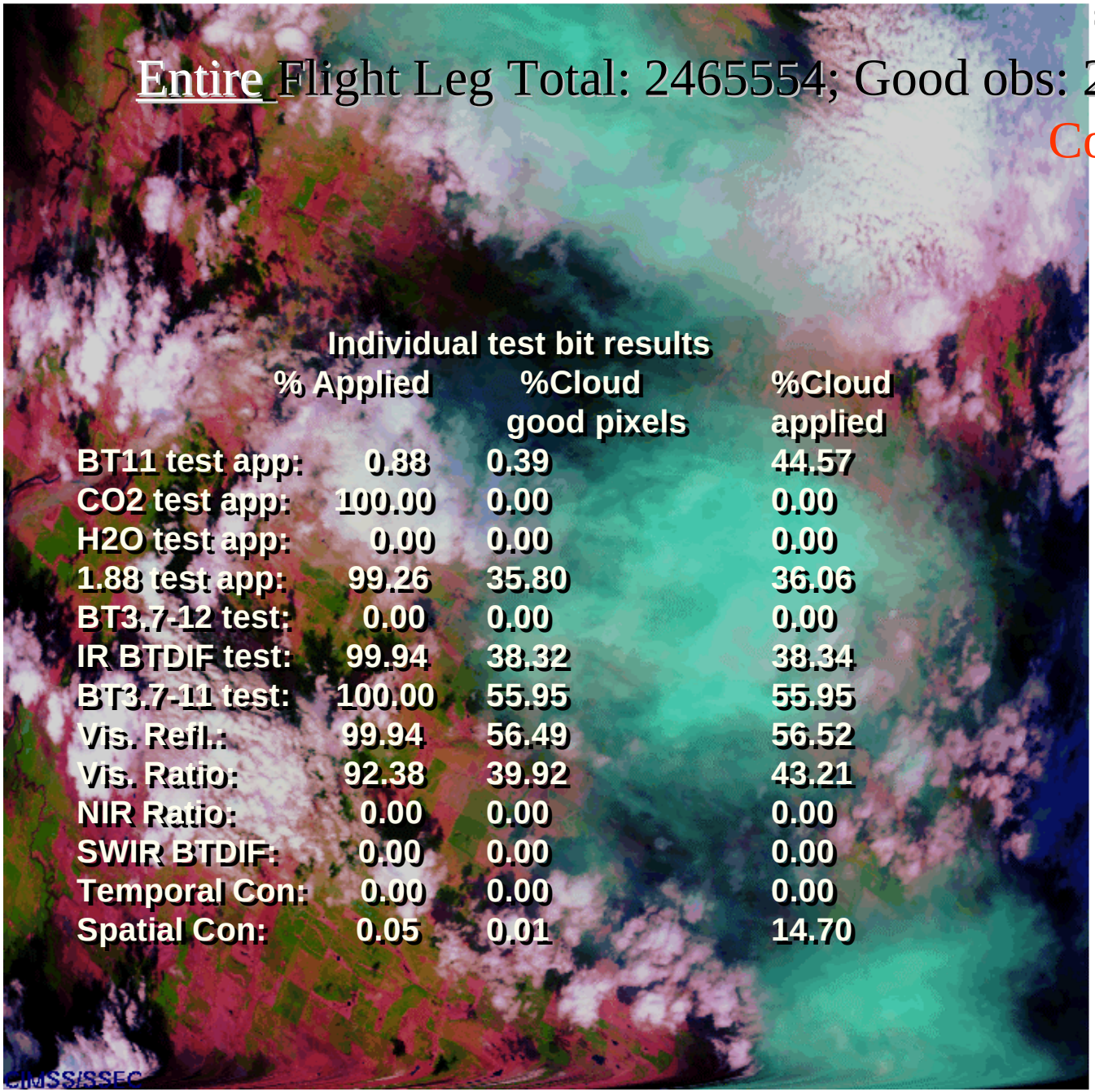
- Cloud Mask Studies with MAS data continue
  - Frequency bit studies with MAS
- Comparison of Cloud Masking with AVHRR data
- Cloud Masking and WILT
  - Issues
  - Lessons Learned
- Summary

Frequency Bit Mapping

- Compare cloud mask final result with individual test results
  - No one test dominating a particular condition
  - “Balance of tests” for different scenes
  - Can we eliminate tests?

MODIS Airborne Simulator 19960421 R:10,G:09,B:02

200033 UTC



195839 UTC

MAS Cloud Mask Release 2.0

Changes from the November 1997 version:

=Only Three Required Input Arguments: MAS hdf file name, output file name and ecosystem file. Will process entire flight line by default. Sub-segments may be processed by using optional arguments.

=MAS spectral configuration is now automatically determined using the date from the input HDF file.

=Code meets all F77 ANSI standards.

=More rigorous bad data checks are now included.

=Brightness temperatures are now calculated using standardized UW/CIMSS routines. This also means you **MUST** be using an archived **HDF** data set with **FINAL CALIBRATION**!

=APOLLO thin cirrus tests have been added to the night processing algorithms.

=Low cloud BT_{11}-BT_4 nighttime thresholds have been adjusted after testing with MAS WINCE data sets.

=There is an option to use the new global 1 km Olson ecosystem map distributed by the USGS.

This version 2 package has been tested on all 50 channel experiment data sets. The remainder of the MAS cloud mask effort will be a research effort focusing on the unused bits (i.e., 3.7-3.9BT, .936 bit, cloud shadow on cloud).

Comparison of Cloud Masks

- Berendes A (PAIR_HIST_MASK) Masking Technique
- Berendes B (MAXL_MASK) Masking Technique
- Berendes C (NNW_6CH_MASK) Masking Technique
- CASPR (Original) Masking Technique
- MISR Masking Technique
- MODIS Masking Technique

Dr. Eugene Clothiaux of MISR is leading this comparison effort. Steve Ackerman (Wisconsin-SSEC-MODIS; Richard Frey (Wisconsin-SSEC-MODIS); Larry Di Girolamo (Illinois-Atmos.Sci.-MISR) ; Eugene Clothiaux (Penn State-Meteorology-MISR); Todd Berendes (Alabama-Huntsville-Atmos.Sci.-CERES,ASTER); Jeff Key (BostonU); Charles Bachmann (NRL); Anne Nolin (NSIDC)

All Six Cloud Detection Algorithms

Table 1.

Cloud Mask Algorithm	No Retrieval	Cloud Pixels	Clear Pixels
ao11060692			
Berendes A	2.59155×10^7 (10.0)	1.44336×10^8 (55.4)	9.01334×10^7 (34.6)
Berendes B	2.60254×10^7 (10.0)	1.49700×10^8 (57.5)	8.46592×10^7 (32.5)
Berendes C	2.54198×10^7 (9.8)	1.40312×10^8 (53.9)	9.46532×10^7 (36.4)
CASPR	5.18697×10^6 (2.0)	1.51901×10^8 (58.3)	1.03297×10^8 (39.7)
MISR	4.54408×10^7 (17.5)	1.51278×10^8 (58.1)	6.36663×10^7 (24.5)
MODIS	4.11871×10^5 (0.2)	1.51377×10^8 (58.1)	1.08595×10^8 (41.7)
ao11010493			
Berendes A	7.78132×10^7 (27.7)	1.35013×10^8 (48.1)	6.78891×10^7 (24.2)
Berendes B	7.83642×10^7 (27.9)	1.30106×10^8 (46.3)	7.22454×10^7 (25.7)
Berendes C	7.72368×10^7 (27.5)	1.24827×10^8 (44.5)	7.86512×10^7 (28.0)
CASPR	3.74486×10^6 (1.3)	1.69299×10^8 (60.3)	1.07672×10^8 (38.4)
MISR	9.94302×10^7 (35.4)	1.28316×10^8 (45.7)	5.29693×10^7 (18.9)
MODIS	2.13268×10^6 (0.8)	1.67524×10^8 (59.7)	1.11059×10^8 (39.6)

number of pixels in ao11060692 and ao11010493: 2.60385×10^8 and 2.80715×10^8, respectively

MODIS-AVHRR Comparison with CLAVR

CLAVR/MODIS	>.99	>.95	>.66	≤.66	Totals
Clear	9.6	1.8	1.2	2.8	15.4
Mixed	6.9	3.4	4.4	40.3	55.0
Overcast	0.9	0.3	0.6	27.8	29.6
Totals	17.4	5.5	6.2	70.9	100.0

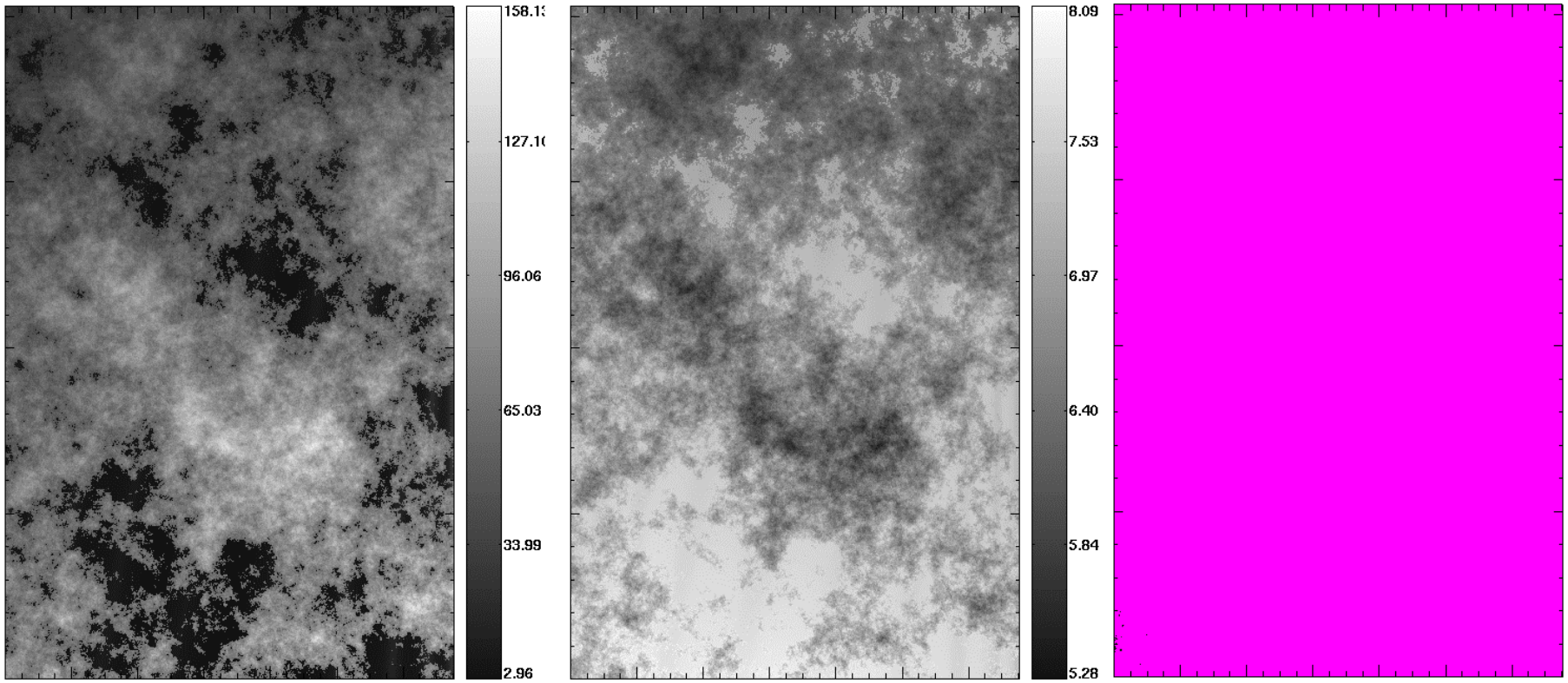
Total Comparisons for December 8, 1998
14 Orbits, +60 to -60 Latitude

Experiences with WILT

- Simulating MODIS scenes is not a simple problem.
- Cloud mask, though it appears to be incorrect, is behaving as expected.
- Interpretation of the results from three simulated scenes.
- What we've learned from this simulation.

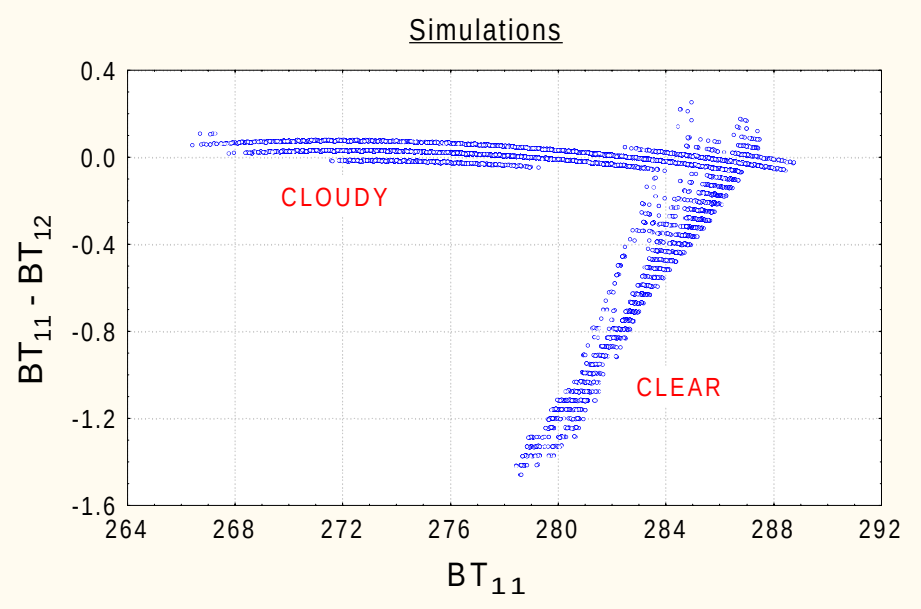
MODIS Model Simulation Water Scene Example

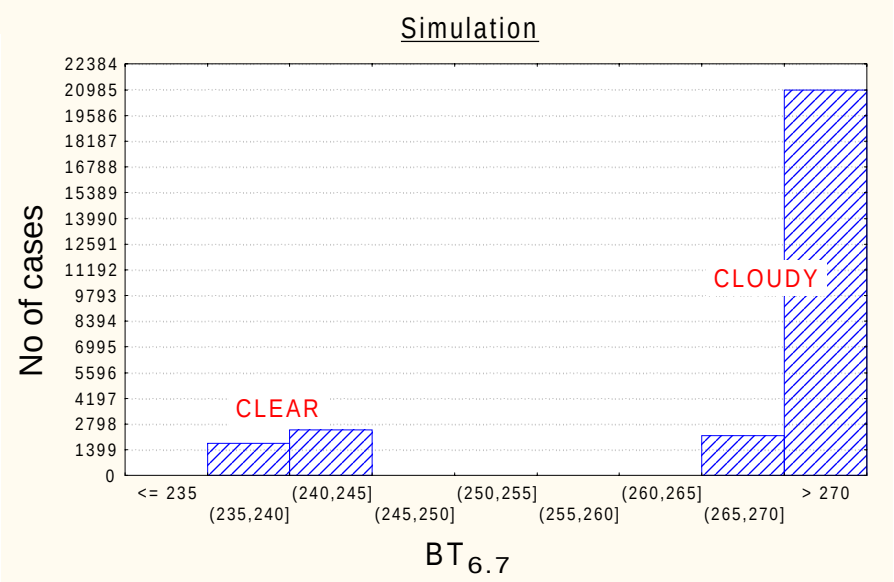
Granule MOD021KM.A1997212.0225.002.1998294215547.hdf



Cloud Mask indicates cloudy, even though 0.87 micron indicate clear regions

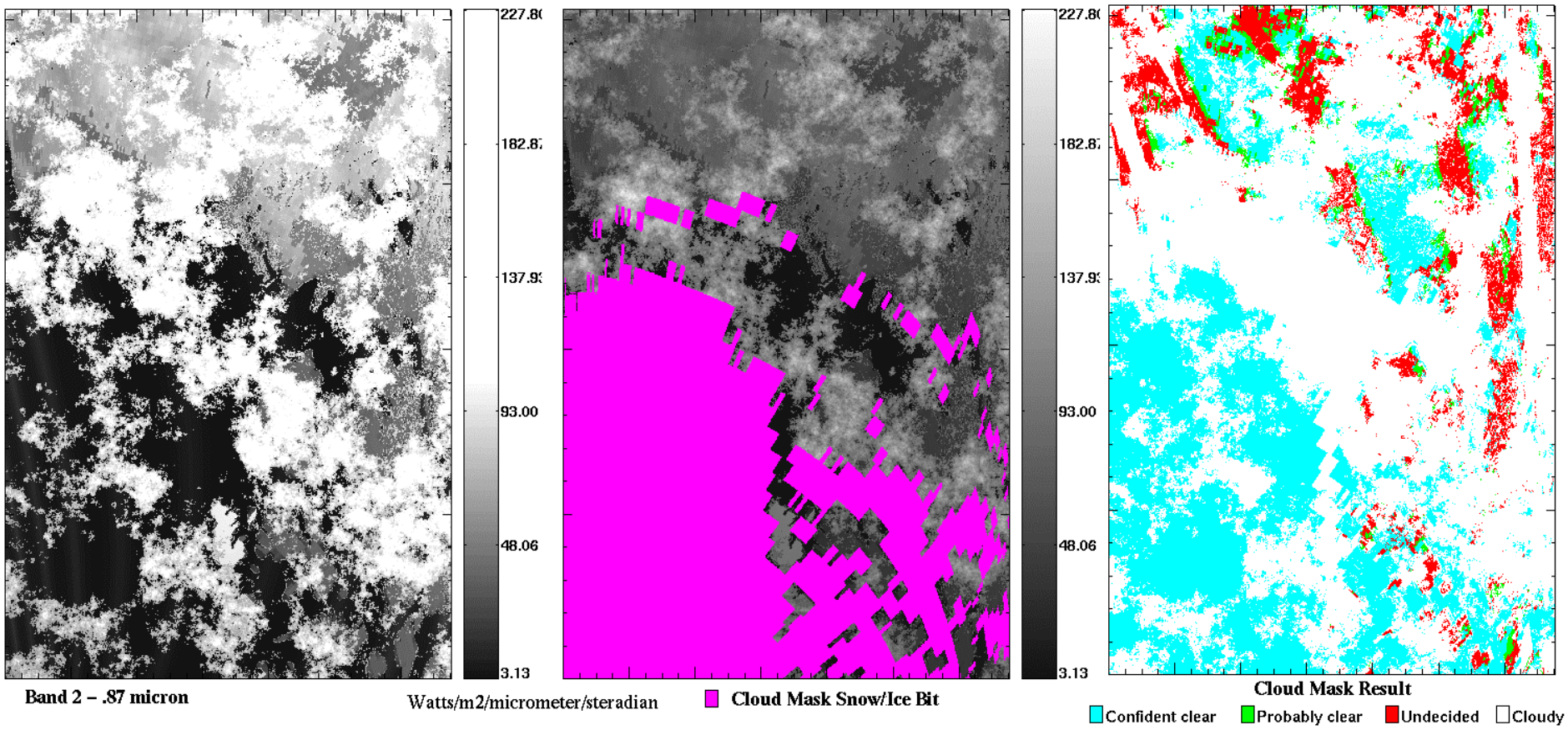
The Physical Explanation





MODIS Model Simulation Snow/Ice Scene Example

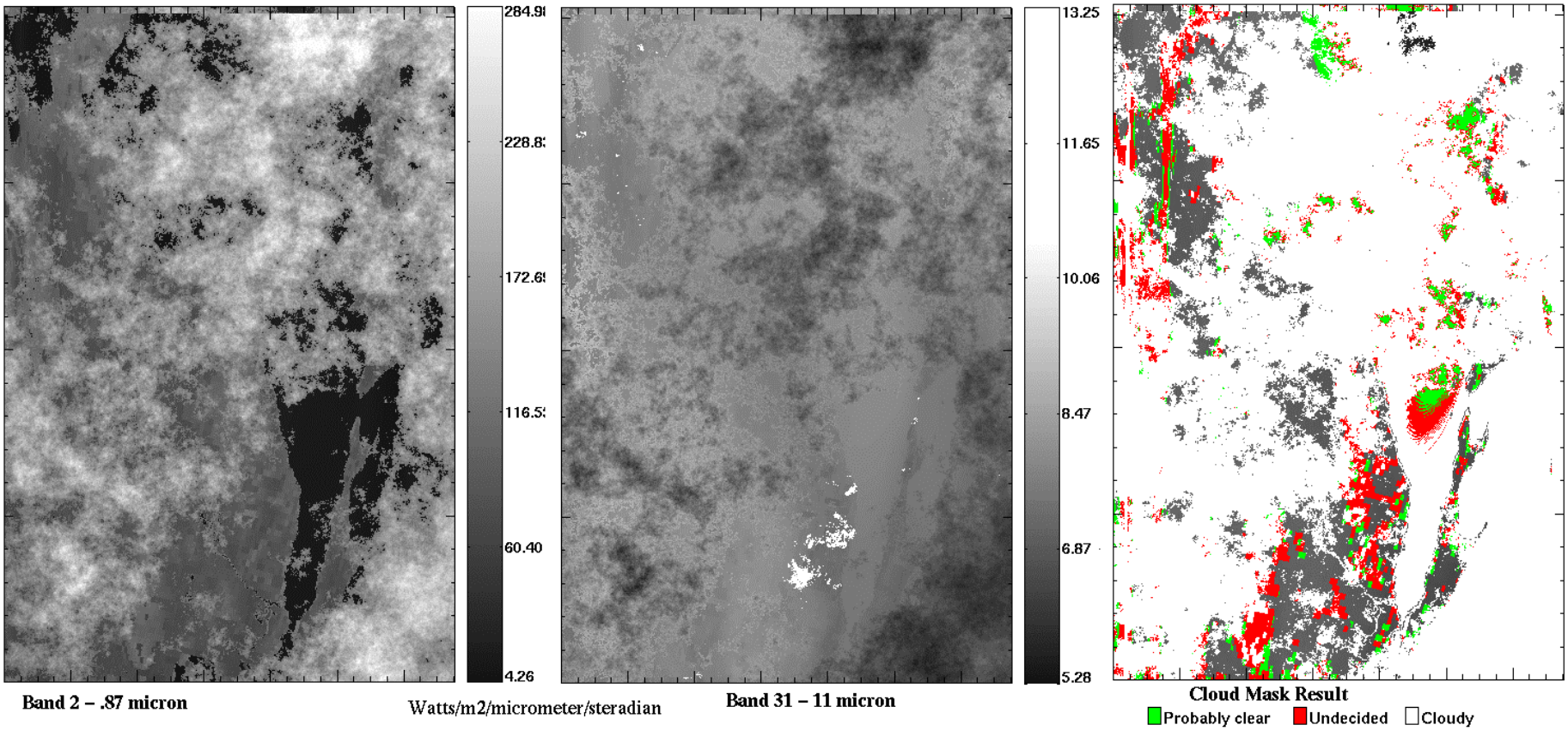
Granule MOD021KM.A1997211.2055.002.1998280060218.hdf



- Ancillary data indicates sea ice present, simulation shows no sea ice.
- Split Window is run in open water regions.
- Notice the cigar-shaped banded structure in cloud mask results, more on this later.

MODIS Model Simulation Land/Water Scene Example

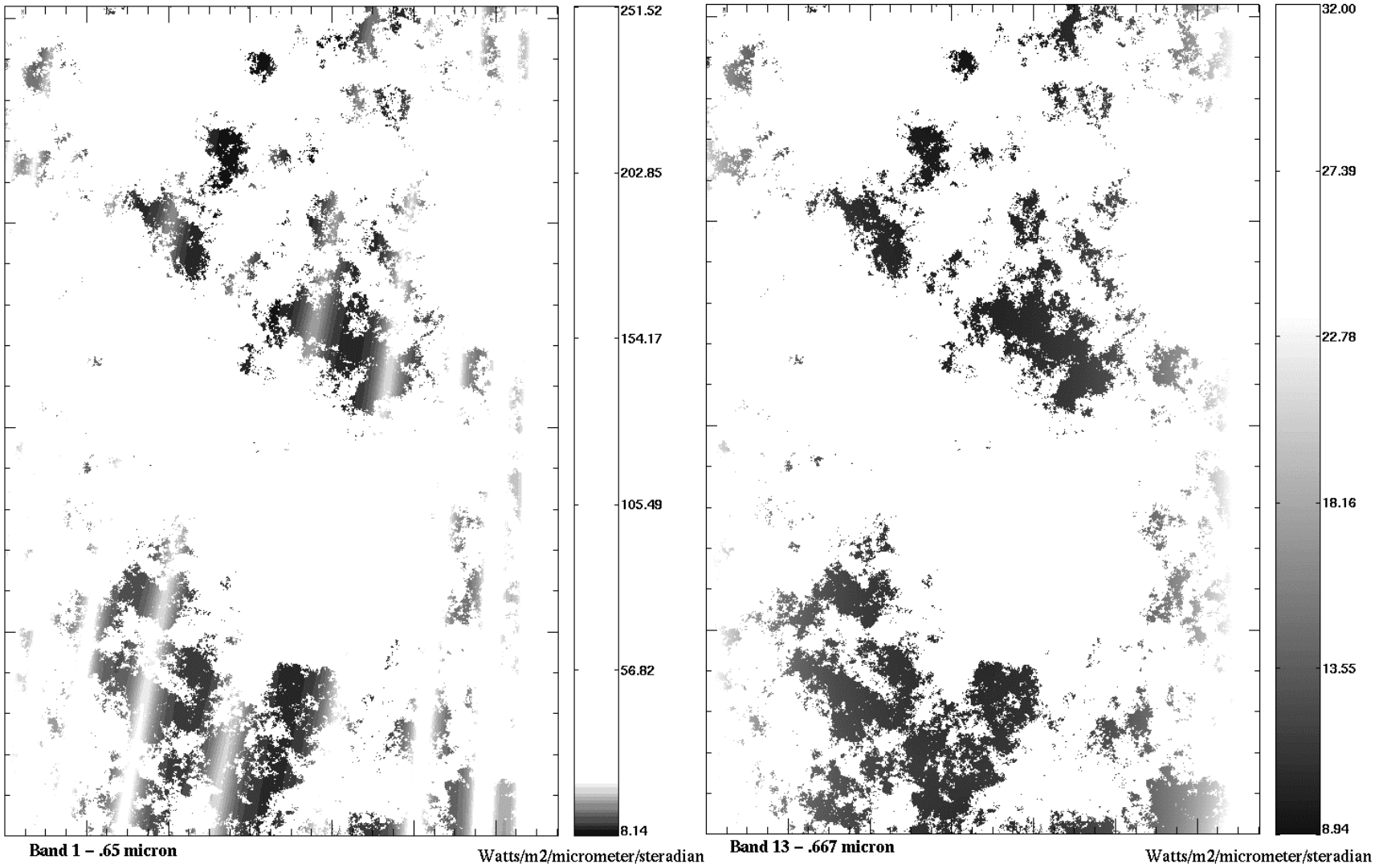
Granule MOD021KM.A1997212.0200.002.1998281122023.hdf



- Block structure due to ecosystem (navigation differences).
- Split Window is run in water regions only.
- Again the cigar-shaped banded structure in portions of cloud mask.

Model Simulation Radiance Comparison – Band 1 and Band 13 – 1 km File

Granule MOD021KM.A1997212.0225.002.1998294215547.hdf



- Band 13 is a 1km ocean channel so it saturates over clouds.
- Band 1, 250 m aggregated to 1 km is producing artifacts that impact cloud mask results.

What to do about *problems*?

- Generate simulated cloud mask (won't eliminate *problems*)
- Ignore split window test (beware multiple versions of code)
- Look at 1.38 (or other solar) test (beware multiple versions of code)

What we've learned

- Cloud mask is performing as expected.
- Communication/Cooperation/Changes
- Cloud Mask Users Guide - 10 pages maximum.
- Update cloud mask reader to input metafile information.
- Investigate/define needs for a MODIS cloud mask viewer for debugging purposes.
- Simulations can be used for certain purposes, not others.

Summary

- Previous validation studies focused on visualization and comparison with LIDAR and surface based observations - comparisons with other cloud algorithms indicate cloud mask is performing well.
- No individual test (or combined test) appears to be of extremely poor quality, according to MAS analysis.
- Lessons learned from the week in the life testing.

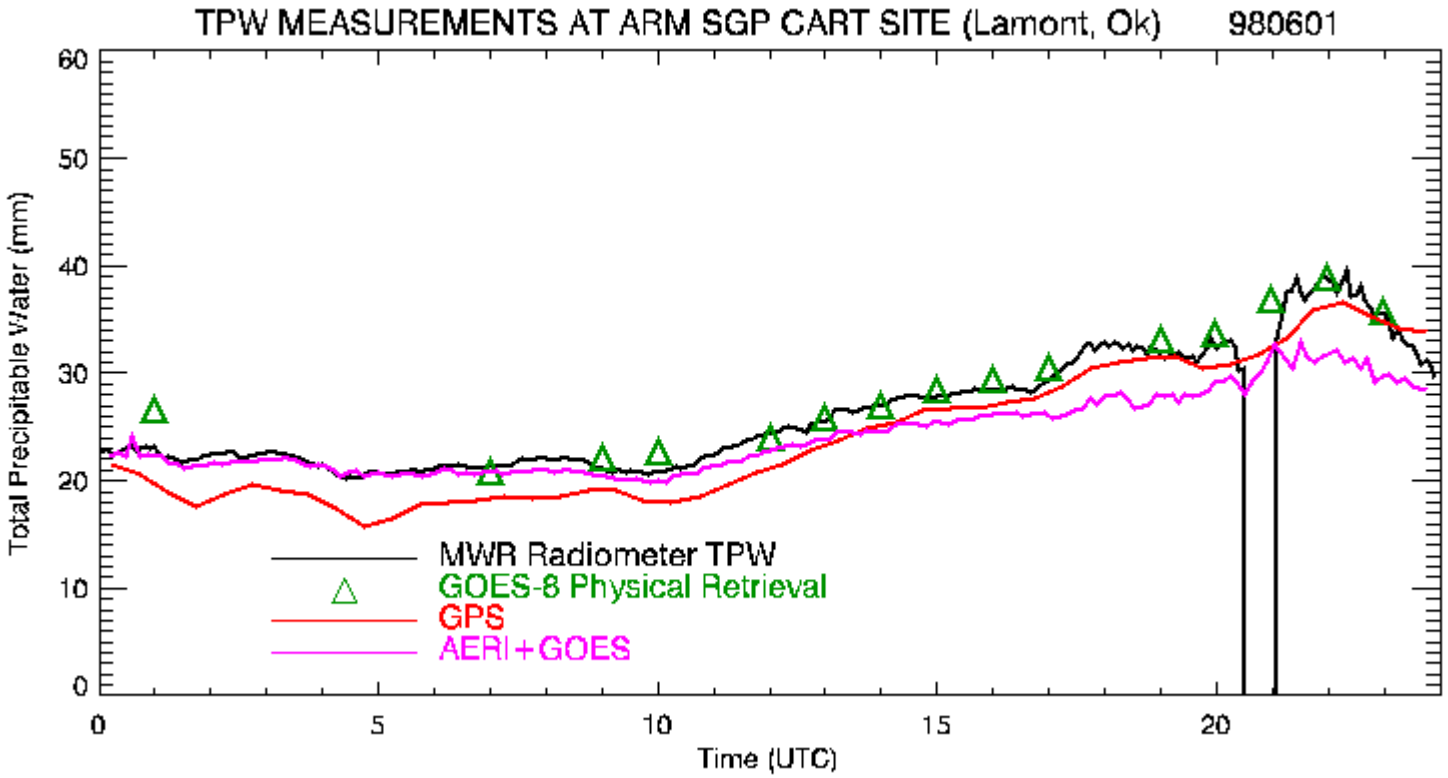
Total column precipitable water vapor (MOD05[MOD07])

- Determination of the total column precipitable water vapor is most directly done by integrating the moisture profile through the atmospheric column. **(MODIS ATMOSPHERIC PROFILE RETRIEVAL ALGORITHM THEORETICAL BASIS DOCUMENT)**
- Validation examples through comparison of instruments at the ARM SGP

Total Precipitable Water

- Microwave and AERI are ground-based column measurements with radiuses of 10-100 meters
- GOES and GPS are spaceborne footprint TPW. GOES is a 30 km by 30 km average while GPS has a footprint of 20 kilometers even though the receiver is located at the CART site.
- Therefore you may see differences between GOES and the ground based sensors when tight areal gradients of TPW occur across the CART site.

ARM Site Comparison



GOES approach similar to MODIS

More Comparisons