A Comparison of Satellite-Based Multilayered Cloud Detection Methods

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Goal

- To provide more accurate satellite-derived cloud products for ARM

Impediments

- Frequent occurrence of multilayered (ML) clouds
- Single-layer plane-parallel cloud retrieval algorithms applied to multilayered clouds

Solution

- Utilize new multilayered cloud detection techniques to identify & analyze clouds

Methodology

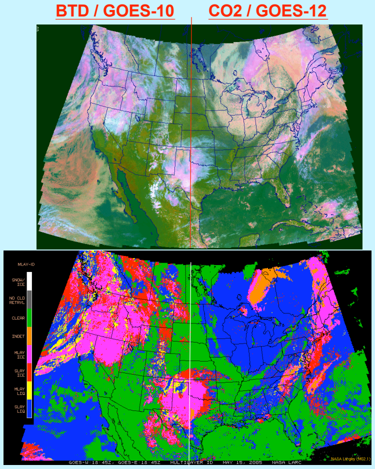
- Collect temporally and spatially matched GOES-10 & 12 data over the central United States
- Analyze GOES-11 with BTD (brightness temperature difference) method (*Pavolonis & Heidinger*, 2004)
- Analyze GOES-12 data with 2-channel version of CO2-slicing technique (*Chang & Li*, 2005)

Validation

- Intercompare techniques for consistency
- Comparison with ARM ARSCL data

GOES-10/12 ML Example, CONUS

BTD / GOES-10   CO2 / GOES-12



RGB

ML detection results

Figure 1. ML detection results over CONUS using BTD & CO2 methods, 1845 UTC, 15 May 2005. Line denotes image stitching at 99°W.

ARM Domain ML Example

BTD / GOES-10   CO2 / GOES-12

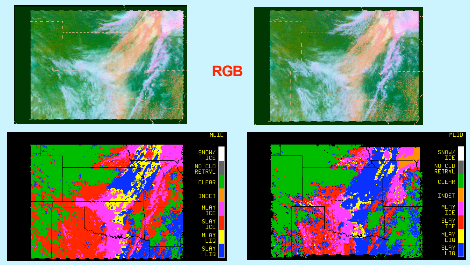


Figure 2. Comparison of BTD & CO2-slicing methods applied to 1845 UTC GOES-10/12 images over ARM SP domain, 18 May 2005.

Method Intercomparison

Pixel-to-pixel comparison not possible because of mis-registration & parallax. ML frequency is computed for each 1° region & frequencies compared for cloud amounts > 90%.

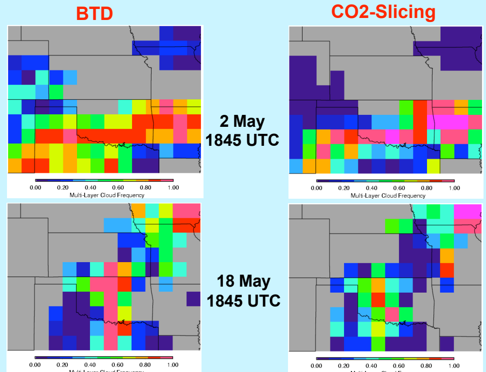


Figure 3. Examples of 1° ML detection frequencies

BTD \ CO2-Slicing	0 - 20%	20-50%	50-80%	80-100%
0 - 20%	15	2	0	0
20 - 50%	10	6	3	3
50 - 80%	5	8	8	8
80 -100%	3	5	8	17

Table 1. Comparison of BTD and CO2 ML frequencies (%), May 2005. N = 7998.

Total Frequency: BTD = 57.3%, CO2 = 48%

RMS Difference: 30.9% 1-bin agreement = 46%

Summary

Both techniques show skill in detecting multilayered clouds, but they disagree more than 50% of the time. BTD method tends to detect more ML clouds than CO2 method and has slightly higher detection accuracy. CO2 method might be better for minimizing false positives, but further study is needed.

Neither method as been optimized for GOES data. BTD technique developed on AVHRR, better BTD signals & resolution. CO2 developed on MODIS, better resolution & 4 CO2 channels.

Many additional comparisons with ARSCL data will be used to optimize both techniques. A combined technique will be examined using MODIS & Meteosat-8 data. After optimization, the techniques will be implemented in the ARM operational satellite cloud processing.

Comparison with ARSCL Data

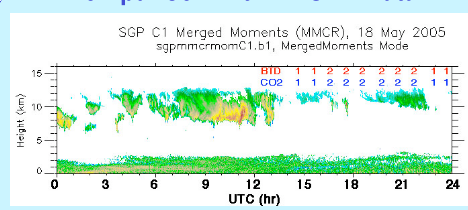


Figure 4. Comparison of ML detection & MMCR returns, 18 May 2005. Numerals denote number of detected layers for each method. In this case, CO2 and BTD are in good agreement. Thinnest cirrus missed by both at 145 - 1545 UTC.

Quantitative Comparisons

ML cloud detection verified using ARSCL data over SGP site. 10, 20, & 30-min avgs indicating # layers w/ separation > 2 km. 20-km radius circle used to determine frequency of ML clouds for each time slot. *GOES ML if 75% pixels are ML. ARSCL ML if 90% are ML. Likewise, SL. Indeterminate if neither ML nor SL. Indeterminate data excluded.*

20-min avg

BTD \ ARSCL	YES	NO
YES	31	5
NO	21	13

pody=yy/(yy+ny) = 60
podn=nn/(yn+nn) = 72
Ntot= 70

CO2 \ ARSCL	YES	NO
YES	18	5
NO	13	7

pody=yy/(yy+ny) = 58
podn=nn/(yn+nn) =58
Ntot= 43

Both techniques show skill for detecting both SL & ML clouds, BTD slightly better. For 30-min avg, CO2 podn increases to 82%.

References

Pavolonis, M. J. and A. K. Heidinger, Daytime cloud overlap detection using AVHRR and VIRS. *J. Appl. Meteorol.*, 43, 762-778, 2004.
Chang, F.-L. and Z. Li (2005), A new method for detection of cirrus overlapping water clouds and determination of their optical properties, *J. Atmos. Sci.*, 62, 3993-4009.

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