GOES-R AWG Cloud Team: ABI Cloud MaskAlgorithm (ACM)
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The AWG Cloud Team Members

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- Cloud Mask
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- Cloud Type Phase
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- Cloud Height & Cloud Cover Layers
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  - Michael Pavolonis
- Daytime Optical/Microphysical Properties
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  - Pat Heck

Outline

- Executive Summary
- Algorithm Description
- ADEB and IV&V Response Summary
- Requirements Specification Evolution
- Validation Strategy
- Validation Results
- Summary

Executive Summary

- This ABI Cloud Mask Algorithm (ACM) generates the Option 1 product of a binary clear-sky mask.
- Version 5 was delivered in May. ATBD (100%) is on track for a July delivery
- The ACM is designed to maximize flexibility to allow it to be optimized for other applications.
- CALIPSO validation tools have been developed and applied to 10 weeks of SEVIRI data.
- CALIPSO and MODIS analyses indicate spec compliance for all products.

Algorithm Summary

- This ABI Cloud Mask Algorithm (ACM) generates the Option 1 products of a binary clear-sky mask.
- It also generates a 4-level cloud mask consistent with the cloud masks run by NOAA and NASA.
- It also provides the individual test decisions. Standard routines are available for unpacking these decisions, ignoring specific tests and defining a cloud mask that is optimal for any application.
- The cloud mask is therefore a “toolbox” of accepted spatial, spectral and temporal tests for the presence of cloud.
- As described next, our chosen channel set includes the 0.65, 1.38, 1.6, 3.9, 7.3, 8.5, 11, 12 and 13.3 micron channels.

Motivation for Cloud Mask Test Selection

• Given the advances in spectral and spatial information offered by the ABI, research was conducted to modify existing and develop new cloud mask tests.

•In general, the ACM makes heavy use of IR channels to strive for day/night consistency and makes heavy use of RTM calculations to make cloud detection be insensitive to viewing angles, surface temperatures and other issues.

•Several of the tests come from NESDIS GOES and POES imager experience.

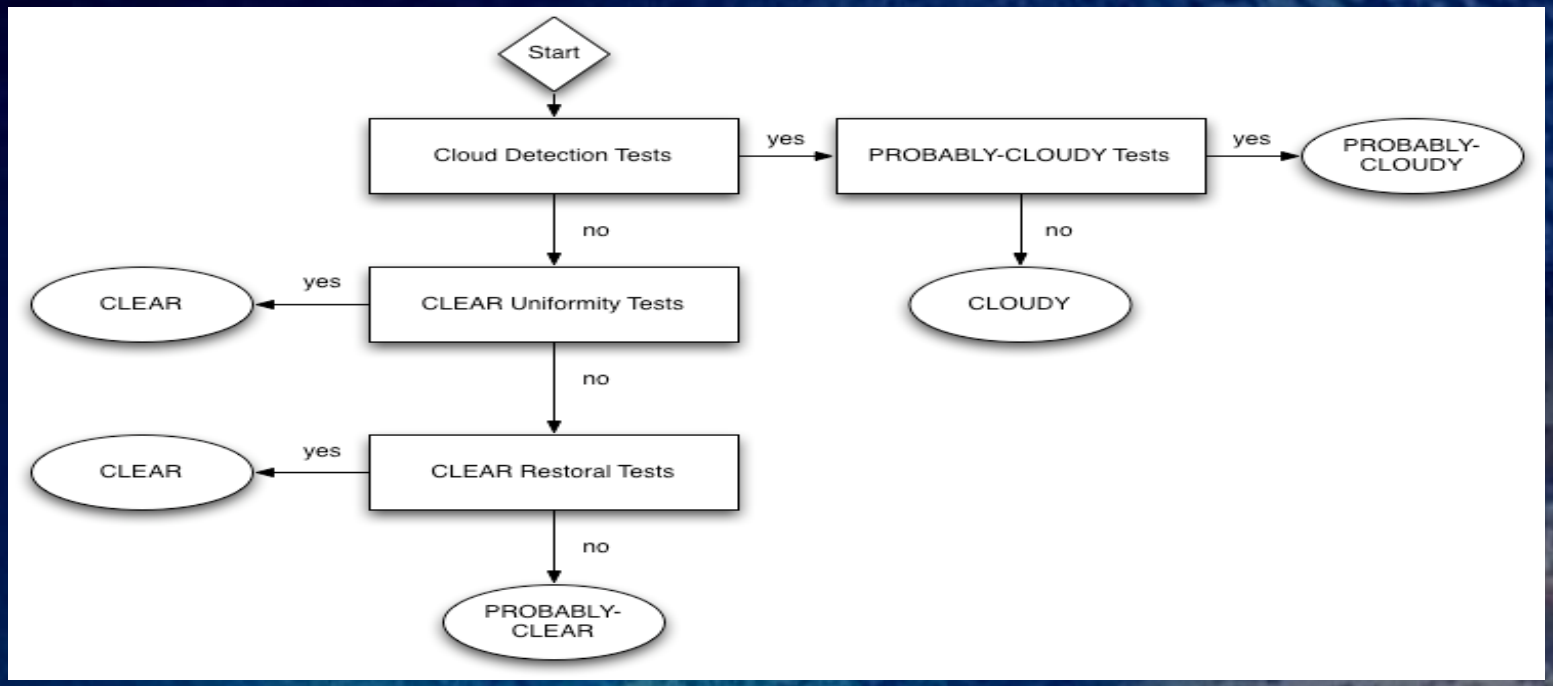
•Temporal tests where taken from EUMETSAT/SEVIRI and NESDIS/GOES experience.

•For bands not on SEVIRI, tests where taken from the MODIS cloud mask.

•The ACM's design allows for the addition of more tests as required by the AWG applications.

ACM Processing Schematic

The following diagram illustrates the logic within the ACM to generate the 4-level Mask (CLEAR, PROBABLY-CLEAR, PROBABLY-CLOUDY, CLOUDY)



- Currently, there are 12 Cloud Detection Tests and 2 Clear Uniformity Tests

- For the Binary Mask: Clear = Clear + Probably Clear
  Cloudy = Cloudy + Probably Cloudy

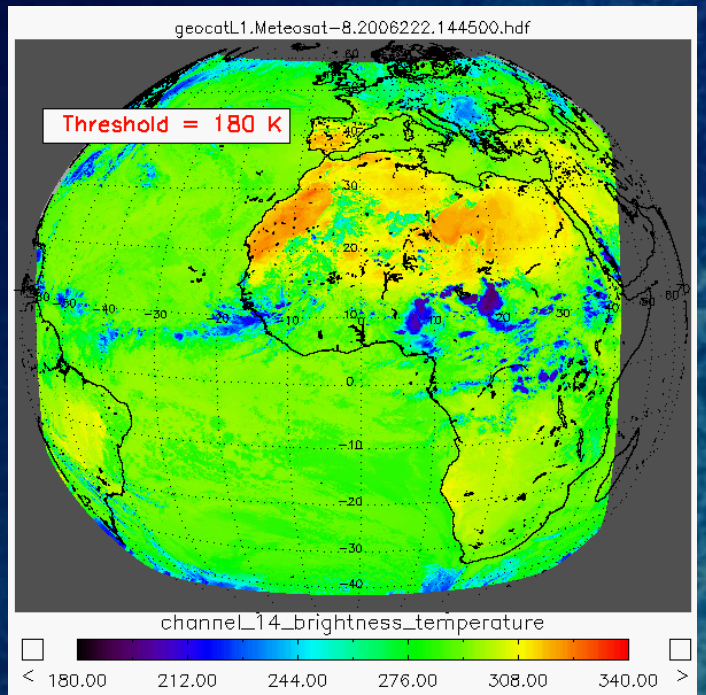
Threshold Determination

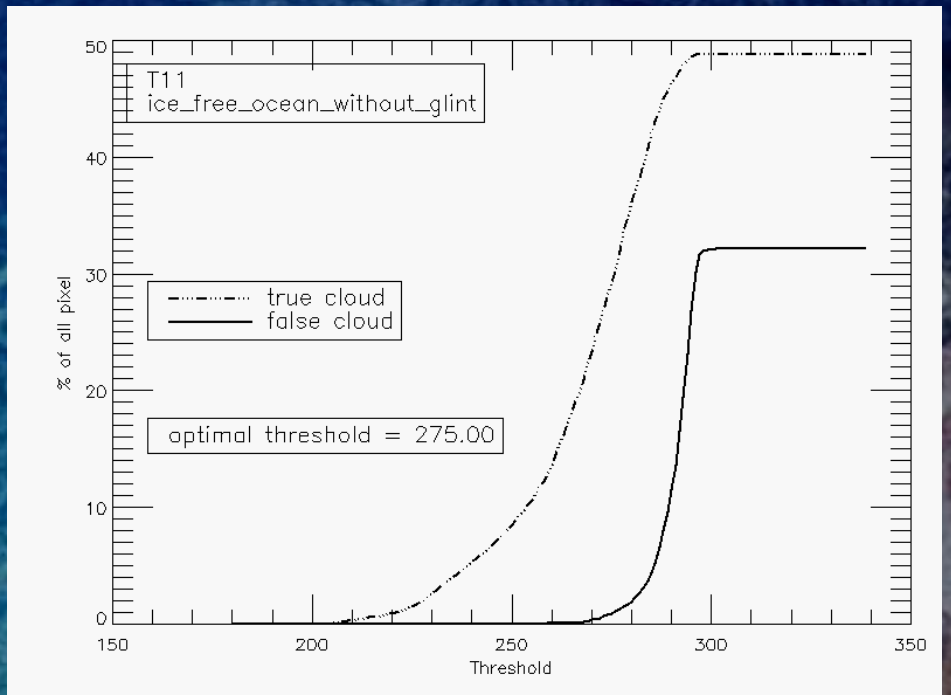
- The CALISPO 1 km Cloud Layer Product is used to separate pixels into clear or cloudy.

- The ACM threshold for a particular test is set ***to allow a 2% false cloud rate***.

- The 2% false cloud rate gave ***the maximum POD score.***

- ***The images below illustrate this process using the 11 μm BT***

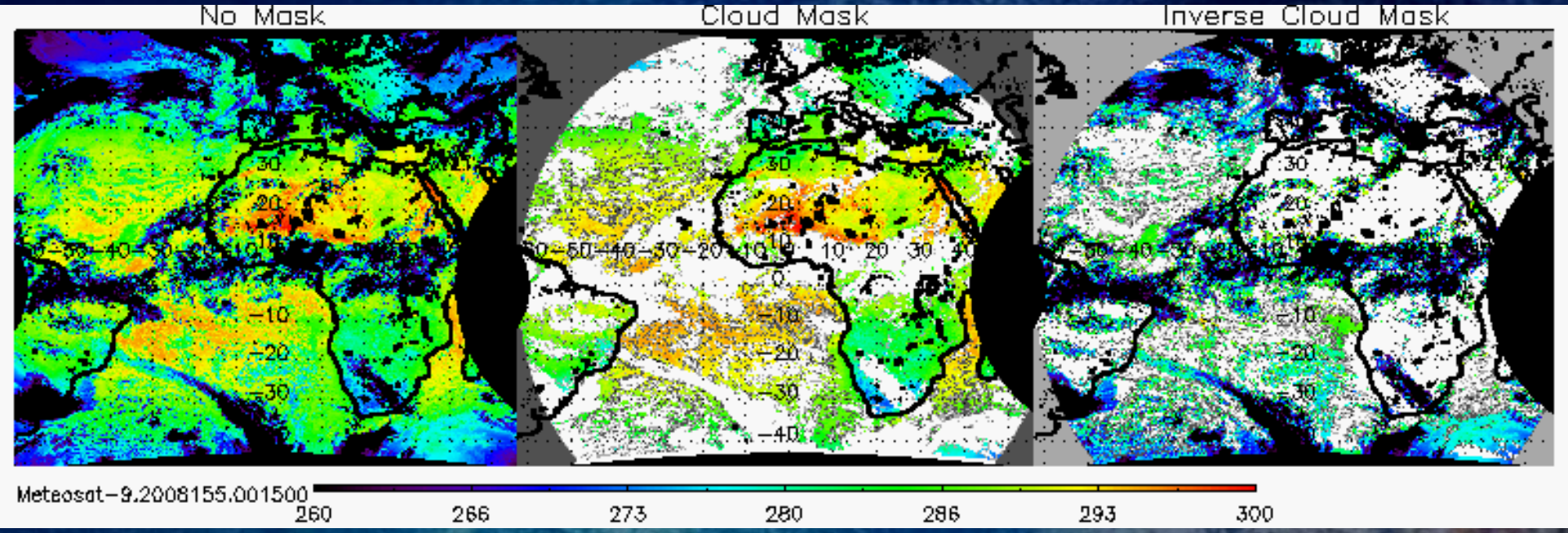




Example ACM Output

The images below show a daily animation of the ACM applied to SEVIRI.

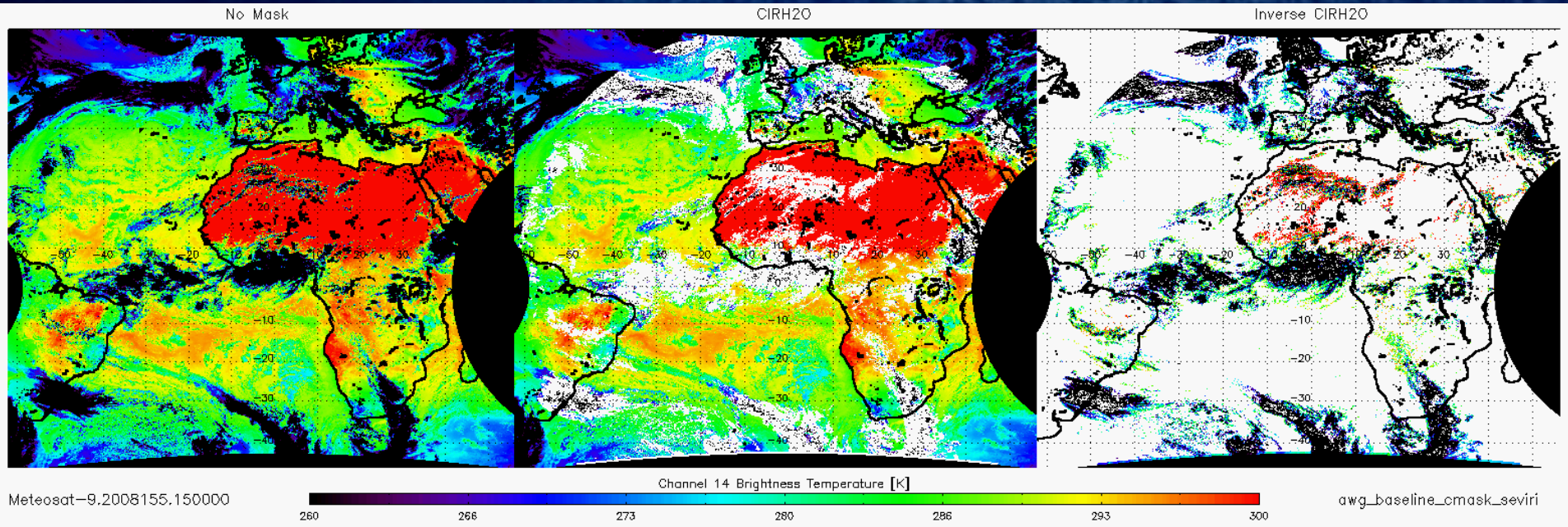
- image on left is the 11 μm brightness temperature (BT)
- center image is the cloud mask (white = cloudy) overlaid on the 11 μm BT
- right image is the inverse of the center image (white = clear).



Example ACM Output II

The images below show an animation of *all of the yes/no decisions in the ACM* applied to SEVIRI for one single dataset.

- image on left is the 11 μm brightness temperature (BT)
- center image is the bit mask (white = yes) overlaid on the 11 μm BT
- right image is the inverse of the center image (white = no).

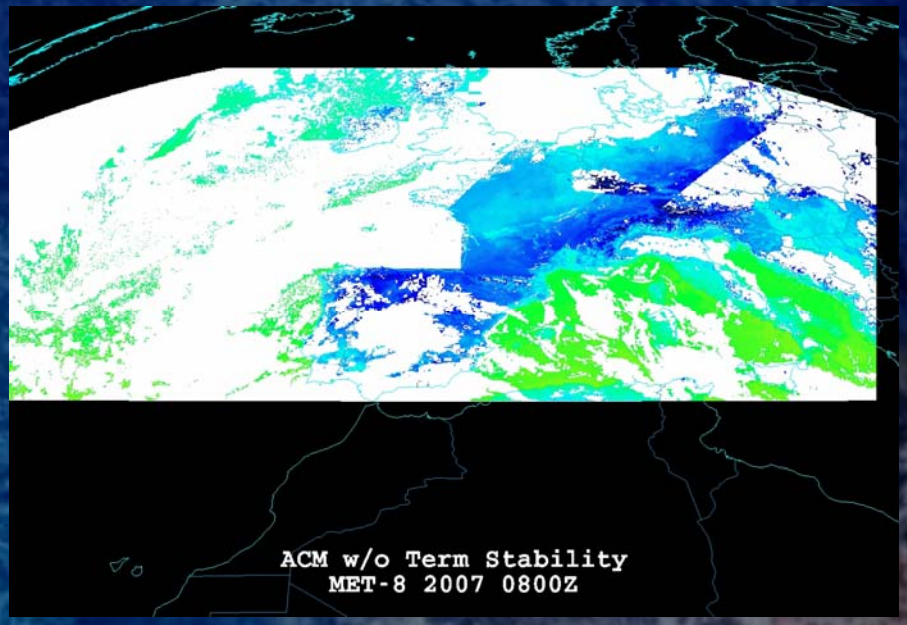


Algorithm Changes from 80% to 100%

- Added a water vapor test as suggested in the IV&V review.
- Added a test for temporal stability in terminator conditions taken from the MAIA mask developed by EUMETSAT for SEVIRI.
- Quality flags standardized.

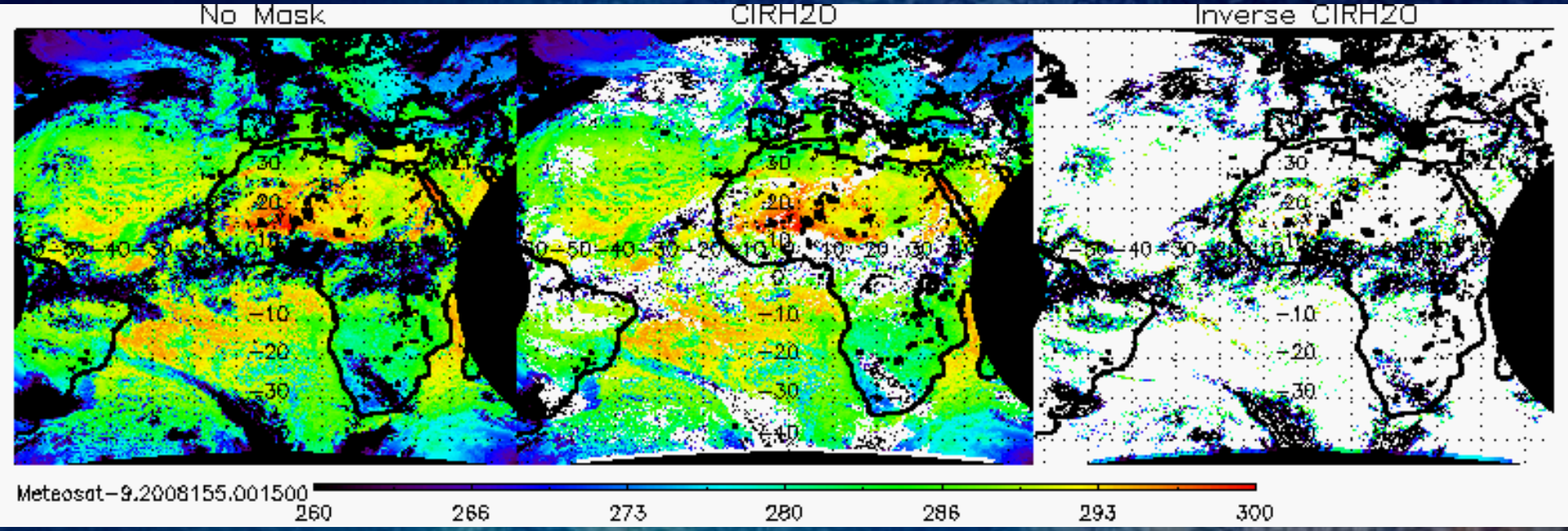
Example Change from 80% to 100%

- The terminator region (solar zenith angles of 87-93 degrees) is often a region where it is hard to detect clouds,
- Utilizing the EUMETSAT terminator stability test (Derrien and Le Gléau, 2010) to help fill in the gaps in the terminator region
- This is particularly useful in restoring low cloud missed in the terminator region, as can be seen in the example on the right.



ADEB and IV&V Response Summary

- All ATBD errors and clarification requests have been addressed.
- Water vapor test was added as suggested (see below)



Requirements

Product	*Accuracy*	*Precision*	*Latency (mesoscale)*	*horizontal resolution*
Clear-sky Mask	*88 % Prob of Correct Detection*	N/A	5 min	2 km

Qualifiers

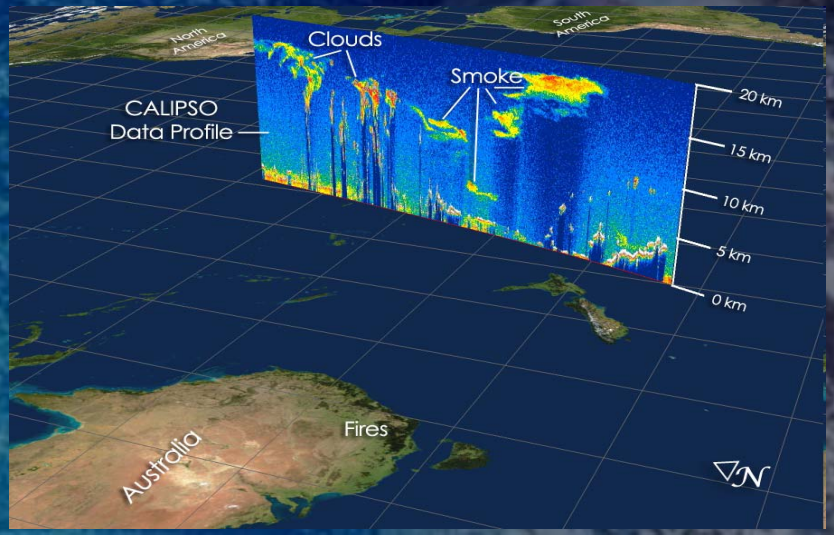
ACM is run are made with the following qualifiers.

- Sensor zenith angle < 70 degrees

Other AWG algorithms are tasked with the detection of dust, fog and volcanic ash. Therefore the ACM does not include these capabilities. ***Algorithms should read all masks for full description of scenes***.

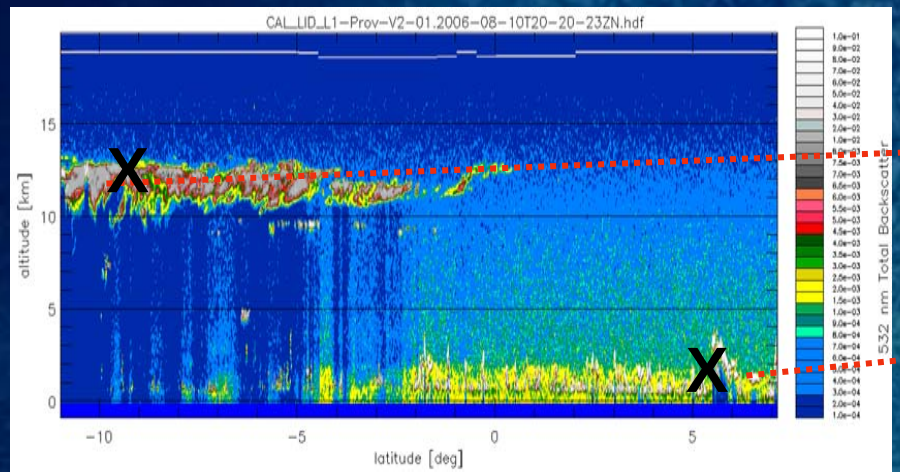
Validation Approach

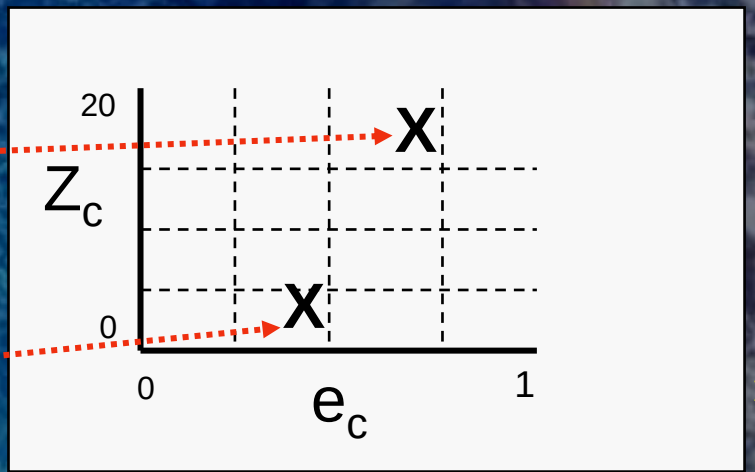
- With the launch of CALIPSO/CloudSat in 2006, NASA now provides information on the vertical profile of cloud and aerosol.
- With high sensitivity to the presence of cloud, the CALIPSO data have been used as our primary ACM validation tool.
- We have co-located CALIPSO with SEVIRI for the 10-week analysis period and this serves as our primary validation data-set. (*Using GEOCAT colocation tools*).
- Comparisons with MODIS, which offers a well-characterized cloud mask, are also valuable for algorithm validation.



Validation Approach

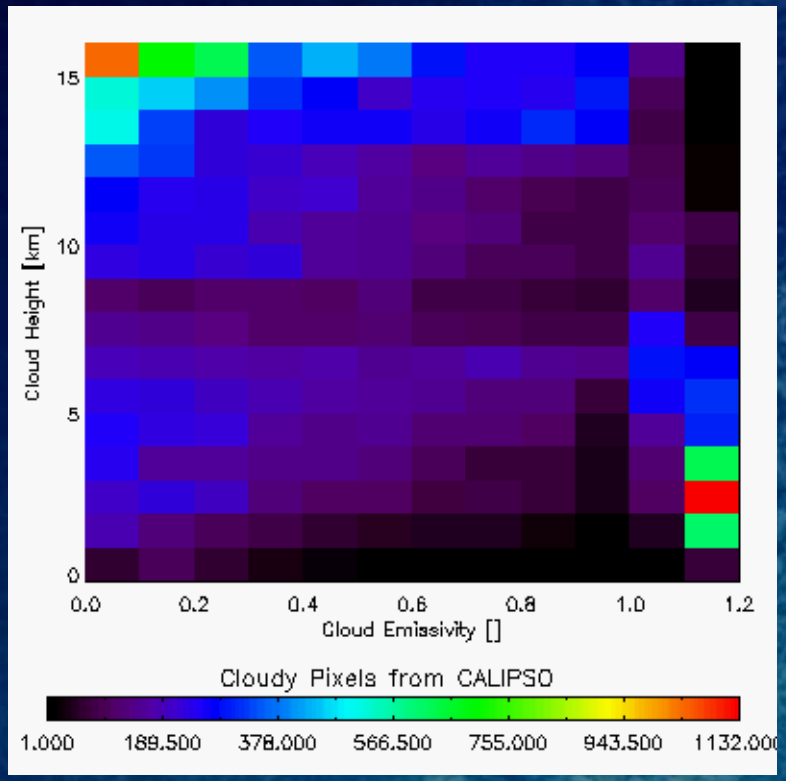
- For every cloudy CALIPSO pixel, the CALIPSO 1km Cloud Layer product provides information on the top and base of up to 10 cloud layers. The mean temperature of the layers are also provided.
- Using the knowledge of the clear-sky radiative transfer that we use for the algorithm and the observed 11 μm radiance, we can take the cloud heights from CALIPSO and estimate cloud emissivities.
- Therefore we can bin the ACM performance by both cloud height and cloud emissivity (*the two main drivers of performance*).
- This is illustrated below.

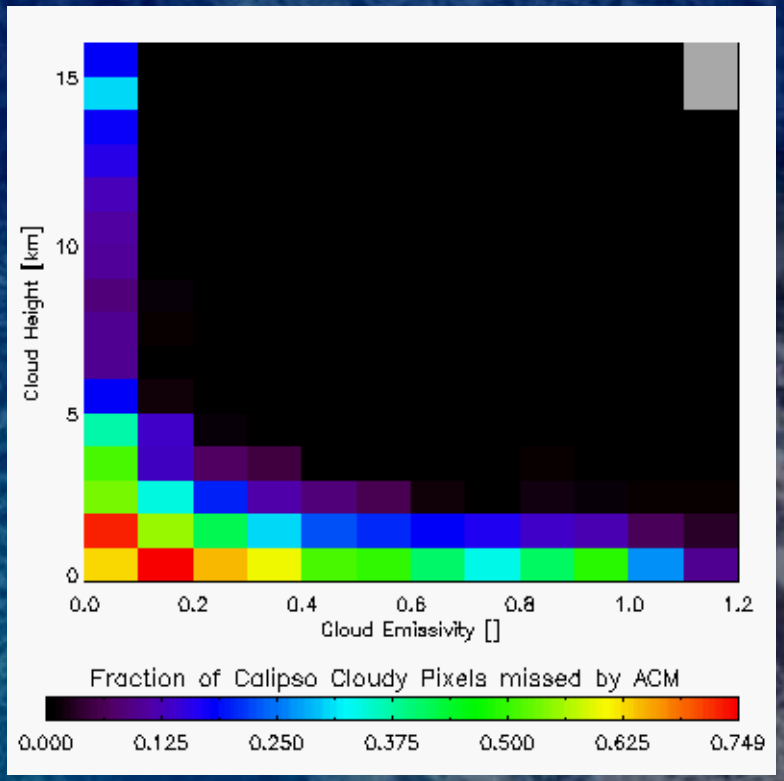




ACM CALIPSO-based Validation

The following images illustrate the height/emissivity distribution of the cloud distribution as determined by CALIPSO for the 10-week run on SEVIRI. The image on the left shows the distribution of all co-locations. The image on the right shows the distribution of missed cloud.



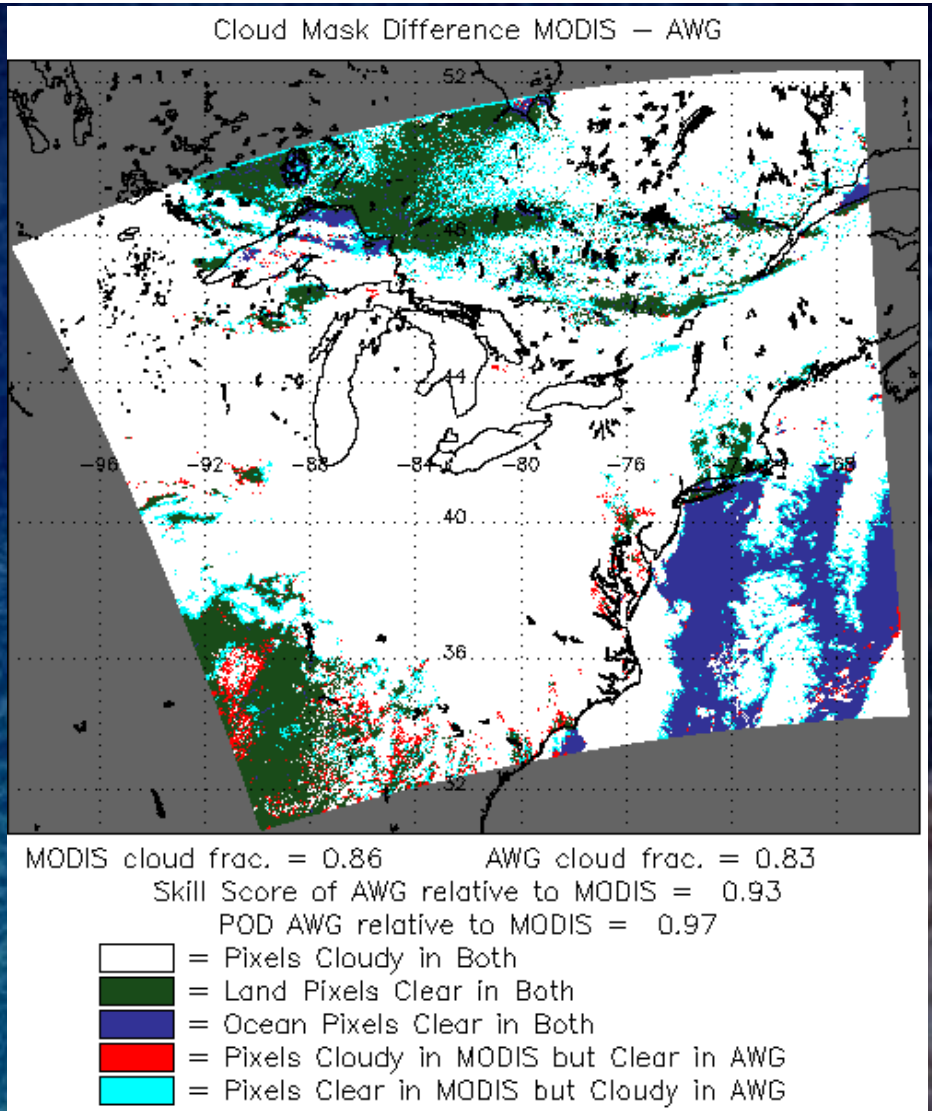


MODIS-based ACM Validation

- The MODIS cloud mask from NASA (developed at CIMSS) provides a well-characterized mask designed for an advanced imager.

- The image on the right shows a comparison of the ACM run on data from AQUA as compared to the MODIS cloud mask from that scene.

- Since these images are of the same time, we can convert both to a binary cloud mask, our POD values are 97% for this scene and 91% for all scenes analyzed.



Validation Results Summary

	Accuracy (spec)
Day Ocean (CALIPSO)	91% (88%)
Day Land (CALIPSO)	93% (88%)
Night Ocean (CALIPSO)	89.5% (88%)
Night Land (CALIPSO)	89.4% (88%)
All (CALIPSO)	91.2% (88%)
All (MODIS)*	91% (88%)

** - based on one day (288) granules of global AQUA/MODIS comparisons*

Future Development

- Future development will be aligned with the cloud detection needs of the AWG teams.

Summary

- The ABI Cloud Mask mixes new approaches with proven NASA, NOAA and EUMETSAT techniques to generate a Clear-sky mask that meets the GOES-R specification.
- The ACM's design is meant to maximize flexibility to allow for AWG applications to optimize the mask for their specific needs.
- Version 5 is delivered and the 100% ATBD is coming.