GOES-R AWG Aviation Team: Visibility

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Outline

- Executive Summary (1 slide)
- Algorithm Description (5 slides)
- Examples of Product Output (3 slides)
- Validation Approach (1 slides)
- Validation Results (3 slides)
- Summary (1 slides)

Executive Summary

- The ABI visibility algorithm generates one Option 2 product
- CDR scheduled for August 27, 2010*
- Delivery of research ATBD and codes to AIT scheduled for September 24, 2010*
- TRR scheduled for July 20, 2011*
- Algorithm uses ABI Aerosol Optical Depth, Cloud Optical Depth, Low Cloud/Fog Detection, Low Cloud/Fog depth, Low Cloud/Fog probability, and GFS Planetary Boundary Layer Depth to estimate surface visibility
- Validation Datasets: Extinction measurements from Automated Surface Observing Systems (ASOS), and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO)
- Validation of has focused on comparisons with 2007-2008 ASOS measurements

** Schedules have not been approved*

Algorithm Description

What Is Visibility?

Visibility is proportional to extinction^{-1} which is a measure of attenuation of the light passing through the atmosphere due to the scattering and absorption by aerosol particles.

For measurement of visibility in the daytime, Koschmieder's Law is used:

$$V = 3.9/\sigma$$

Where V is the visibility (in kilometers) and σ is the extinction coefficient.

The current reportable Automated Surface Observing Systems (ASOS), values of visibility in statute miles are: <1/4, 1/4, 1/2, 3/4, 1, 11/4, 11/2, 13/4, 2, 21/2, 3, 4, 5, 6, 7, 8, 9, 10+.

ABI visibility is reported in 4 categories:

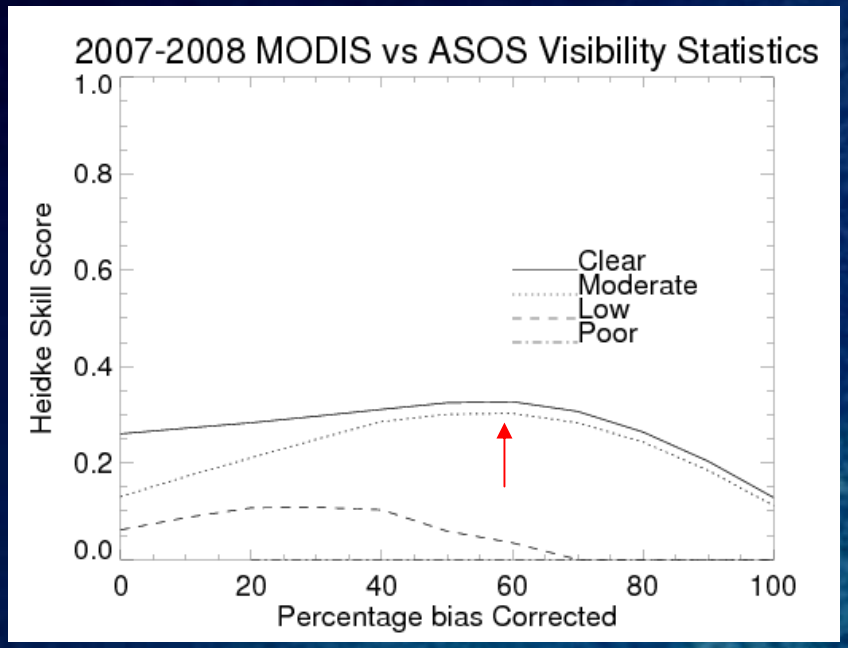
Clear V>30km
Moderate 10km<V<30km
Low 2km<V<10km
Poor V<2km

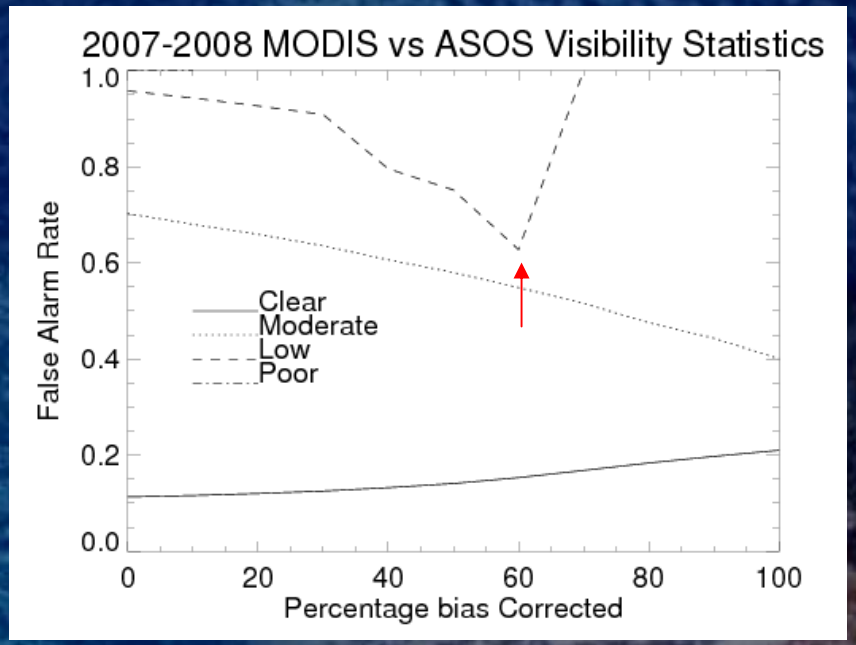
Algorithm Summary

- Input Datasets: ABI Aerosol Optical Depth (AOD), Cloud Optical Thickness (COT), Low Cloud/Fog Detection, probability and Thickness, GFS Planetary Boundary Layer Depth
- Conversion from AOD and Low Cloud/Fog COT to extinction requires knowledge of the depth of the aerosol/cloud layer, which is assumed to be determined by the depth of the planetary boundary layer (PBL) for aerosol visibility and the retrieved cloud depth for the Low Cloud/Fog visibility
- A LUT of Monthly and Categorical regression coefficients based on regressions between 2007-2008 ASOS, MODIS (AOD), and GOES (low cloud/fog COT) extinction measurements are used to construct bias corrected ABI visibility retrievals
- A “blended” visibility retrieval is constructed using a weighted combination of the non-bias corrected and bias corrected visibility estimates for both aerosol and low-cloud/Fog visibilities.
- Optimal weighting is determined based on assessment of required categorical accuracy (percent correct classification), required precision (standard deviation of categorical error), Heidke Skill Score (fractional improvement relative to chance), and false alarm rate.

Development of Bias correction LUT for Aerosol Visibility

Sensitivity studies have been conducted using 2007-2008 MODIS/ASOS coincidences to determine optimal weighting for blended MODIS aerosol visibility retrieval.

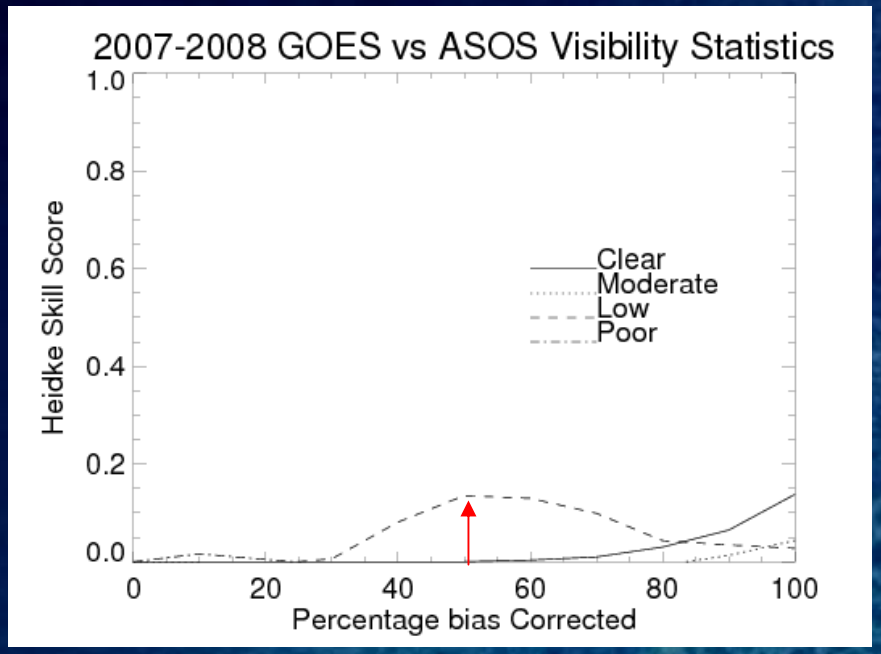


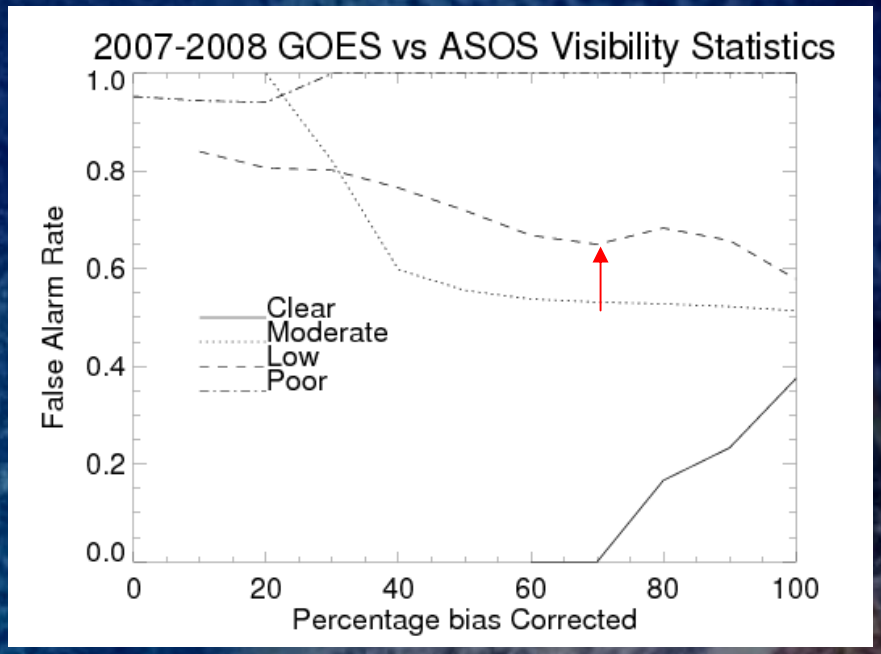


Results of Heidke Skill tests and False alarm rates showed that a 60% bias corrected weighting resulted in the largest improvement relative to chance for both Clear and Moderate aerosol visibility and minimizes false detections for Low aerosol visibility.

Development of Bias correction LUT for low cloud/Fog Visibility

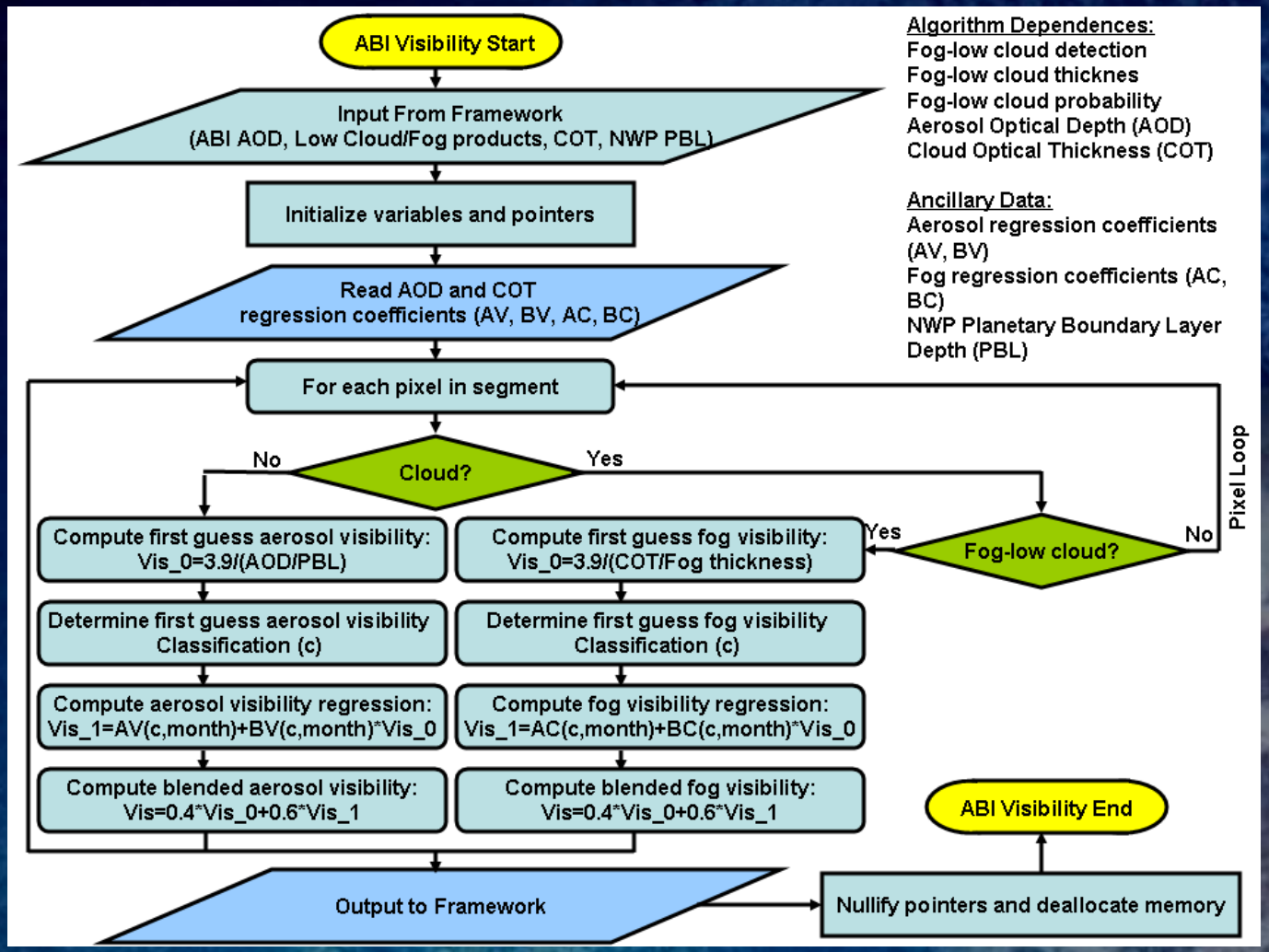
Sensitivity studies have been conducted using 2007-2008 GOES/ASOS coincidences to determine optimal weighting for blended GOES low cloud/fog visibility retrieval.





Results of Heidke Skill tests and False alarm rates showed that a 50% bias corrected weighting resulted in the largest improvement relative to chance for Low fog visibility and a 70% bias correction minimizes false detections for Low Fog visibility. A 60% weighting was chosen to maximize the Heidke Skill score and minimize false detections

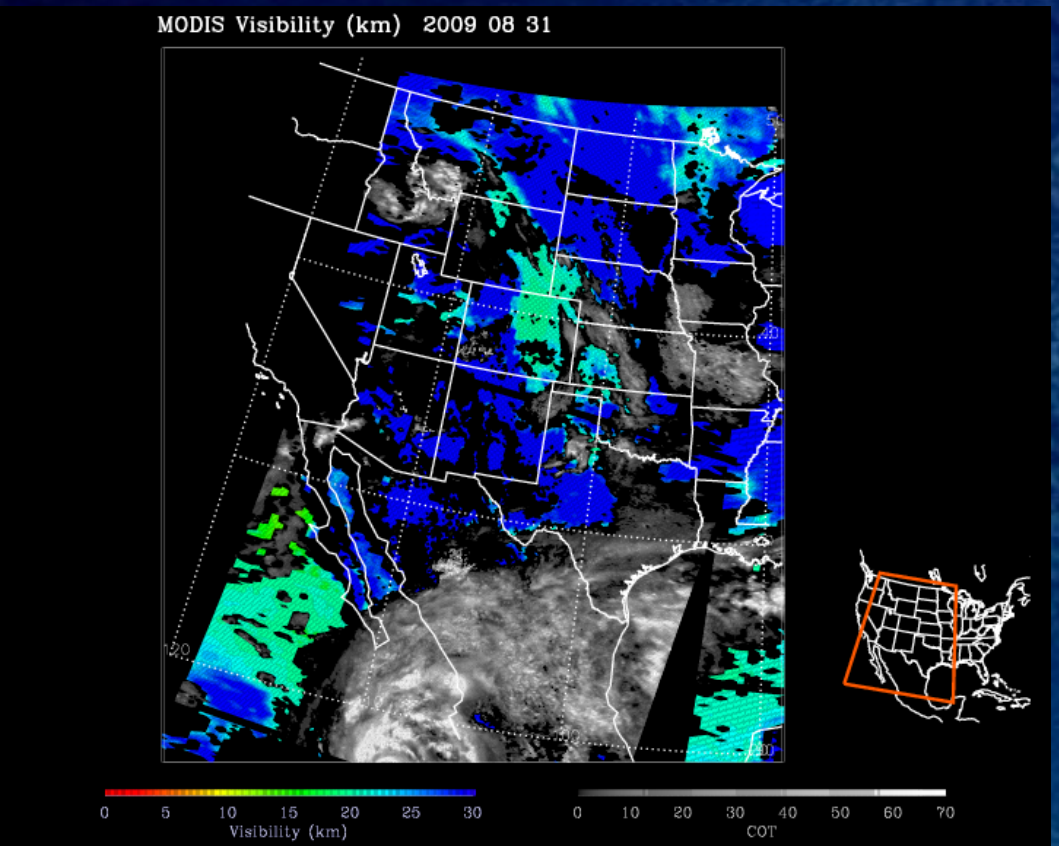
Visibility Processing Schematic



Examples of Product Output

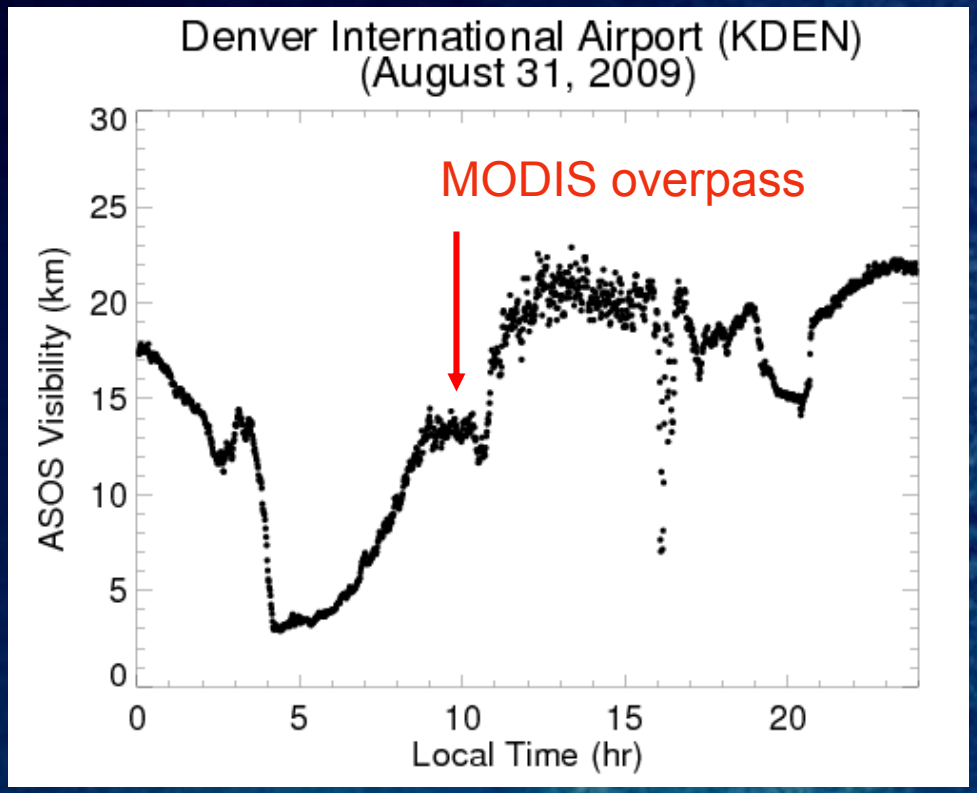
Reductions in visibility due to California Wildfires

In late August through mid October 2009, the Station Fire, near Los Angeles, CA burned a total of 160,577 acres and was the 10th largest fire in California since 1933. Smoke from the Station Fire was transported far down-wind affecting visibility over much of the western US.



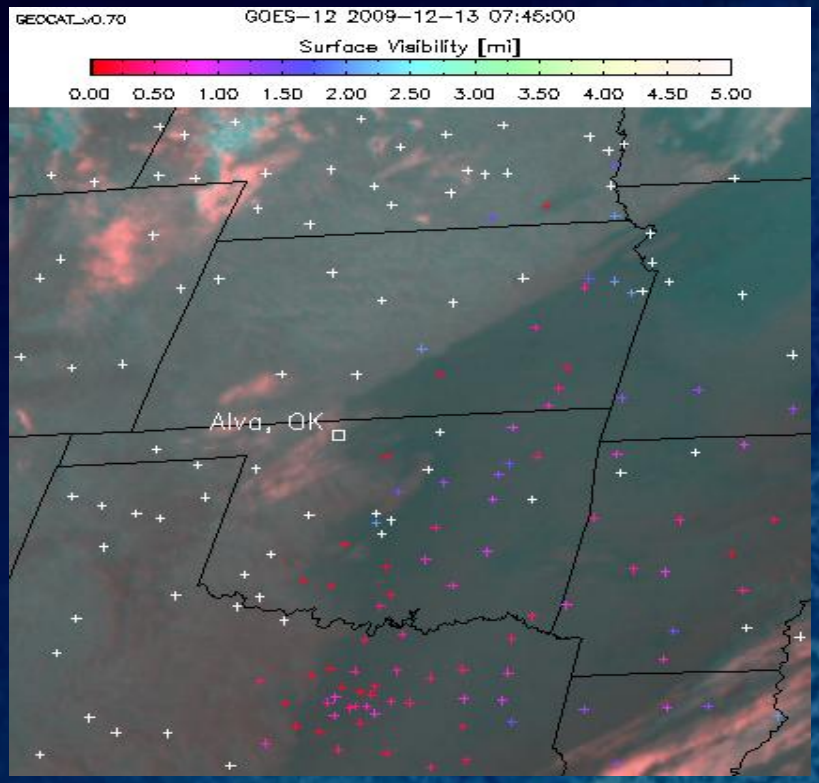
August 31st visibility retrievals based on MODIS AOD measurements (over Denver at 10:45am Mountain Standard Time) show a broad area of reduced visibility that extends throughout eastern Colorado, western Kansas and western Nebraska northward into eastern parts of Wyoming and central Montana.

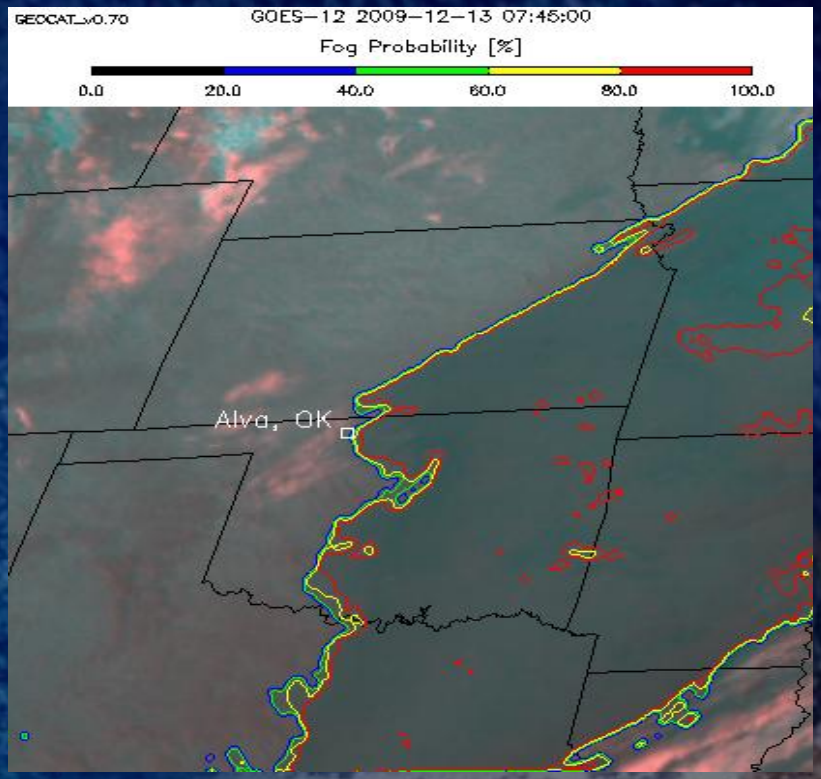
Reductions in visibility due to California Wildfires



Prior to the MODIS overpass, the Denver International Airport METAR reported scattered cloud cover and haze. ASOS measurements show that visibility at the Denver International Airport was abruptly reduced from near 12km to less than 3km (~2 miles) at 4:00am and remained below 5km until 7:00am due to smoke from the Station Fire.

Reductions in visibility due to Fog





- RGB image (R = 3.9 μm emissivity, G = 11 μm BT, B = 11 μm BT) of the US on December 13, 2009 at 7:45 UTC (1:45 am CST) with fog probability from the GOES-R fog algorithm contoured on top.

GEOCAT images from Mike Pavolonis

Validation Approach

Requirements and Product Qualifiers Visibility

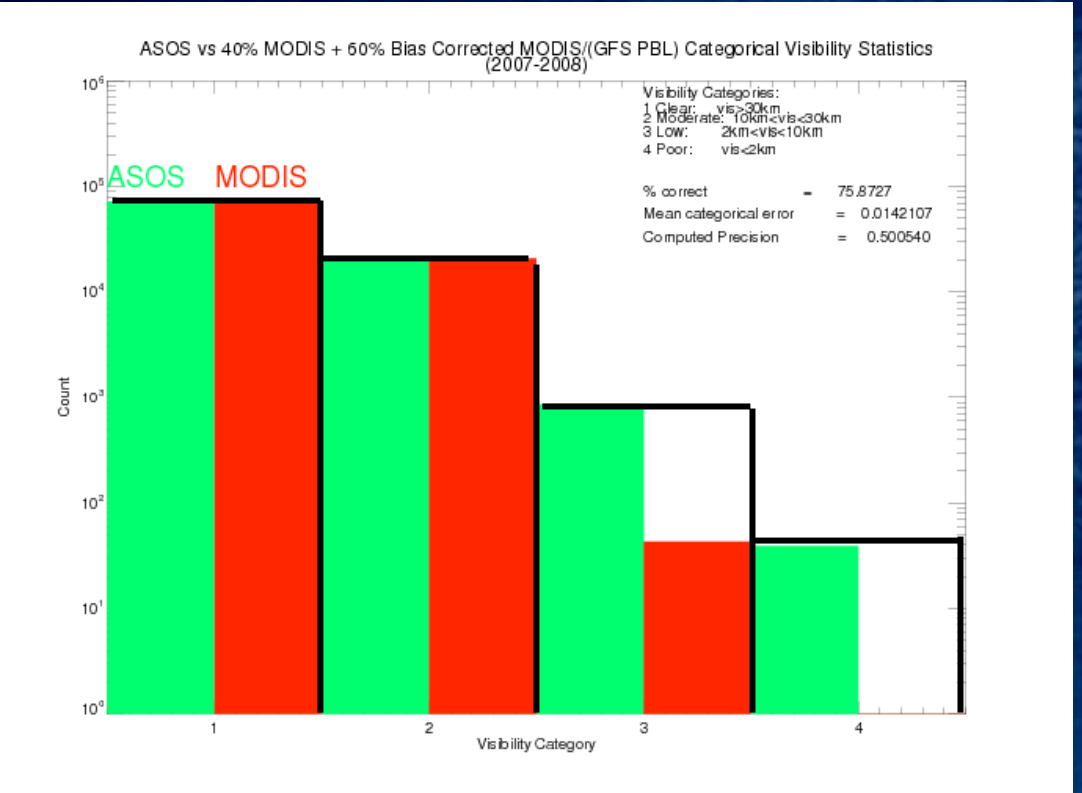
Name	User & Priority	Geographic Coverage (G, H, C, M)	Temporal Coverage Qualifiers	Product Extent Qualifier	Cloud Cover Conditions Qualifier	Product Statistics Qualifier
Visibility	GOES-R	Full Disk (Threshold) Global (Goal)	Daytime (Threshold) Day Night (Goal)	Quantitative out to at least 70 degrees LZA	Clear conditions (aerosol visibility) down to feature of interest (fog visibility)	Categorical

Name	User & Priority	Geographic Coverage (G, H, C, M)	Vertical Resolution	Horizontal Resolution	Mapping Accuracy	Measurement Range	Measurement Accuracy	Product Refresh Rate/Coverage Time (Mode 3)	Product Refresh Rate/Coverage Time (Mode 4)	Mission Product Data Latency	Product Measurement Precision
Visibility	GOES-R	Full Disk (Threshold) Global (Goal)	N/A	10 km	5 km	Clear (vis ≥ 30km) Moderate (10km ≤ Vis < 30 km) Low (2 km ≤ vis < 10 km) and Poor (vis < 2km)	80% correct classification	60 min	60 min	15 min	1.5 categories

Validation Results

Validation of aerosol visibility

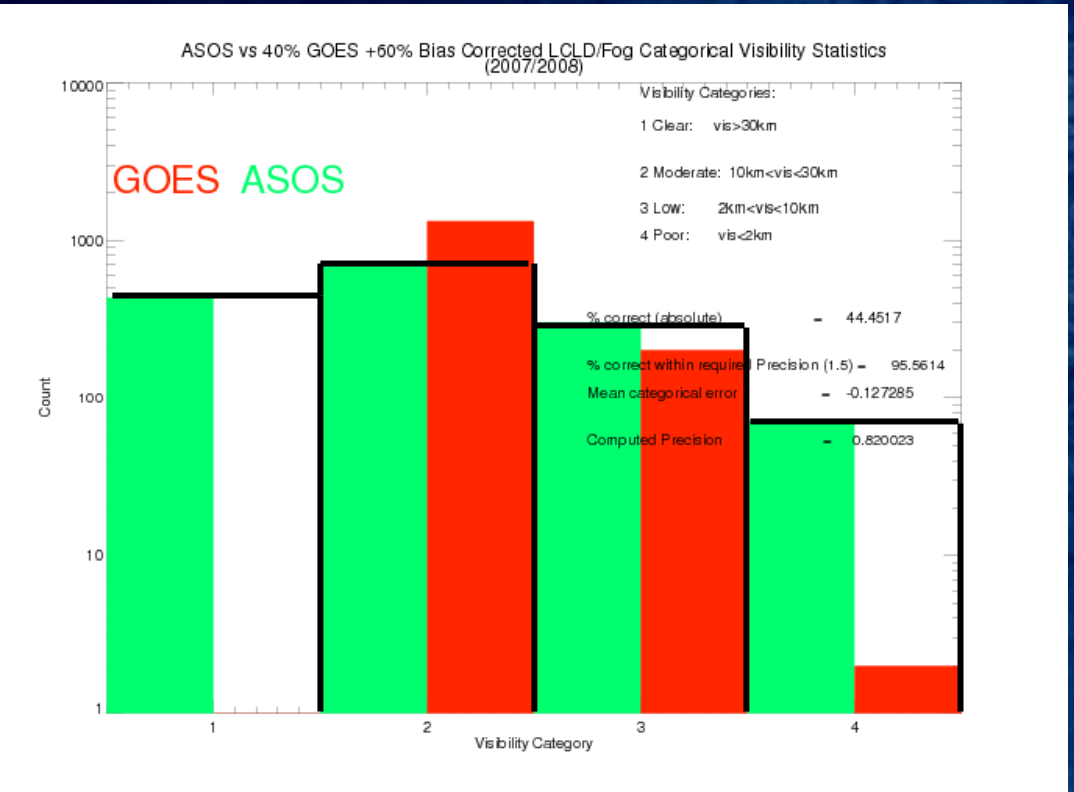
Histogram of ASOS & blended (40% non-bias corrected+ 60% bias corrected) categorical aerosol visibility classifications for 93873 coincident ASOS/MODIS measurement pairs during 2007-2008.



The blended aerosol visibility retrieval results in a 75.8% categorical success rate and an estimated precision of 0.50. It captures the frequency of clear and moderate visibility very well and improves the prediction of low visibility compared to the bias corrected MODIS visibility alone.

Validation of low-cloud/Fog visibility

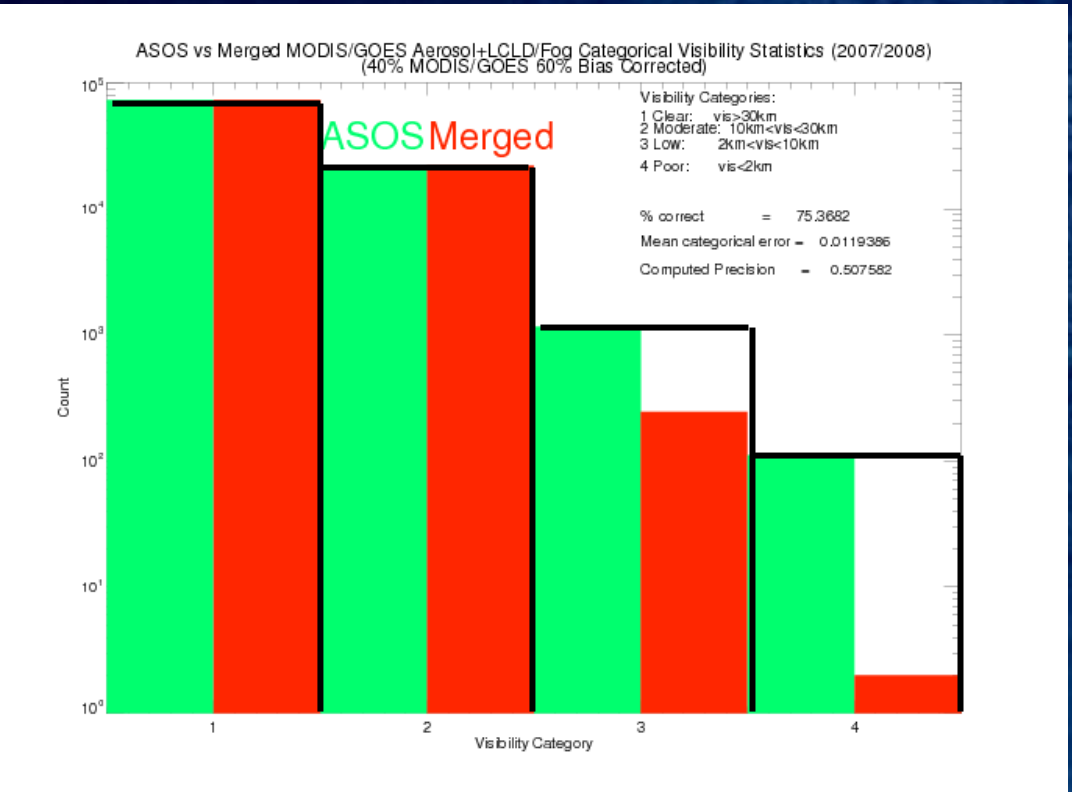
Histogram of ASOS & blended (40% non-bias corrected+ 60% bias corrected) categorical low-cloud/Fog visibility classifications for 1532 coincident ASOS/GOES measurement pairs during 2007-2008.



The blended low-cloud/Fog visibility retrieval results in a 44.5% categorical success rate and an estimated precision of 0.82. It does a fair job of capturing the frequency of moderate and low visibility but underestimates the frequency of clear and poor visibility categories.

Validation of Merged Aerosol/low-cloud/Fog visibility

Histogram of ASOS & blended (40% non-bias corrected+ 60% bias corrected) categorical aerosol visibility classifications for 93873 coincident ASOS/MODIS plus 1532 coincident ASOS/GOES measurement pairs during 2007-2008.



The merged aerosol+low-cloud/fog visibility retrieval results in a 75.4% categorical success rate and an estimated precision of 0.50. It captures the frequency of clear and moderate visibility very well but underestimates the frequency of low and poor visibility.

Summary

- The ABI Visibility Algorithm provides a new capability for estimating visibility from geostationary orbit and complements existing ASOS surface measurements
- The accuracy (75%) of the current visibility Algorithm does not meet the requirement (80%)
- The accuracy of the visibility algorithm is dependent on the accuracy of the AOD, COT, and low-cloud/Fog detection.
- Low-cloud/Fog detection requirement is 70% correct detection (yes/no)