Use of Deep-Dive Analysis Tools to Validate GOES-16/17 Atmospheric Motion Vectors

Andrew Bailey[1], Jaime Daniels[2], Wayne Bresky[1], Americo Allegrino[1], Steve Wanzong[3], Chris Velden[3]
I.M. Systems Group (IMSG), Inc.[1]
NOAA/NESDIS, Center for Satellite Applications and Research (STAR)[2]
University of Wisconsin, Cooperative Institute for Meteorological Satellite Studies (CIMSS)[3]

1. Introduction

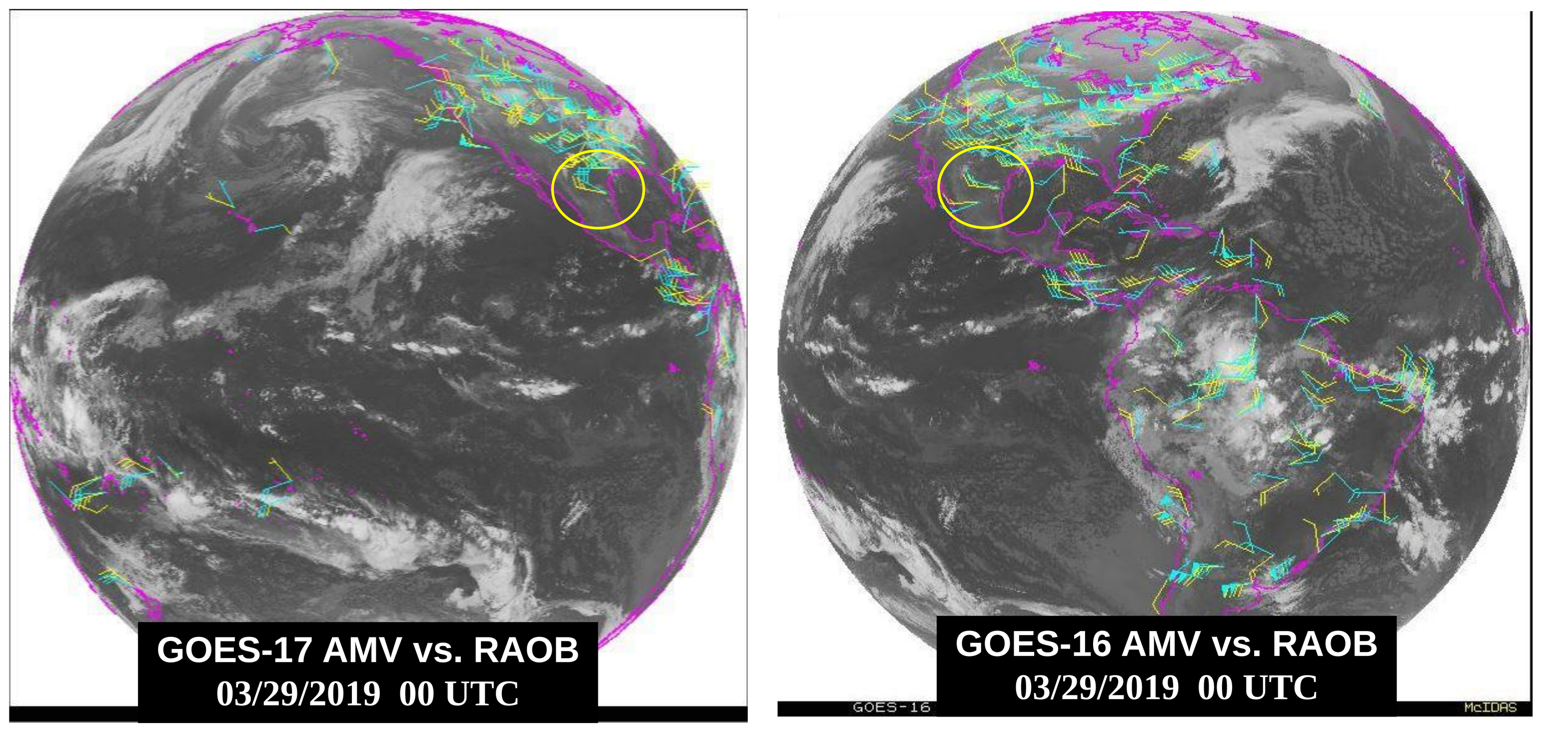
GOES-16 Atmospheric Motion Vectors (AMVs) were declared operational at NOAA/NESDIS on June 1, 2017. GOES-17 AMVs are currently being closely evaluated by the GOES-R Algorithm Working Group (AWG) winds product team in light of the GOES-17 ABI cooling system anomaly and in preparation for formal validation reviews.

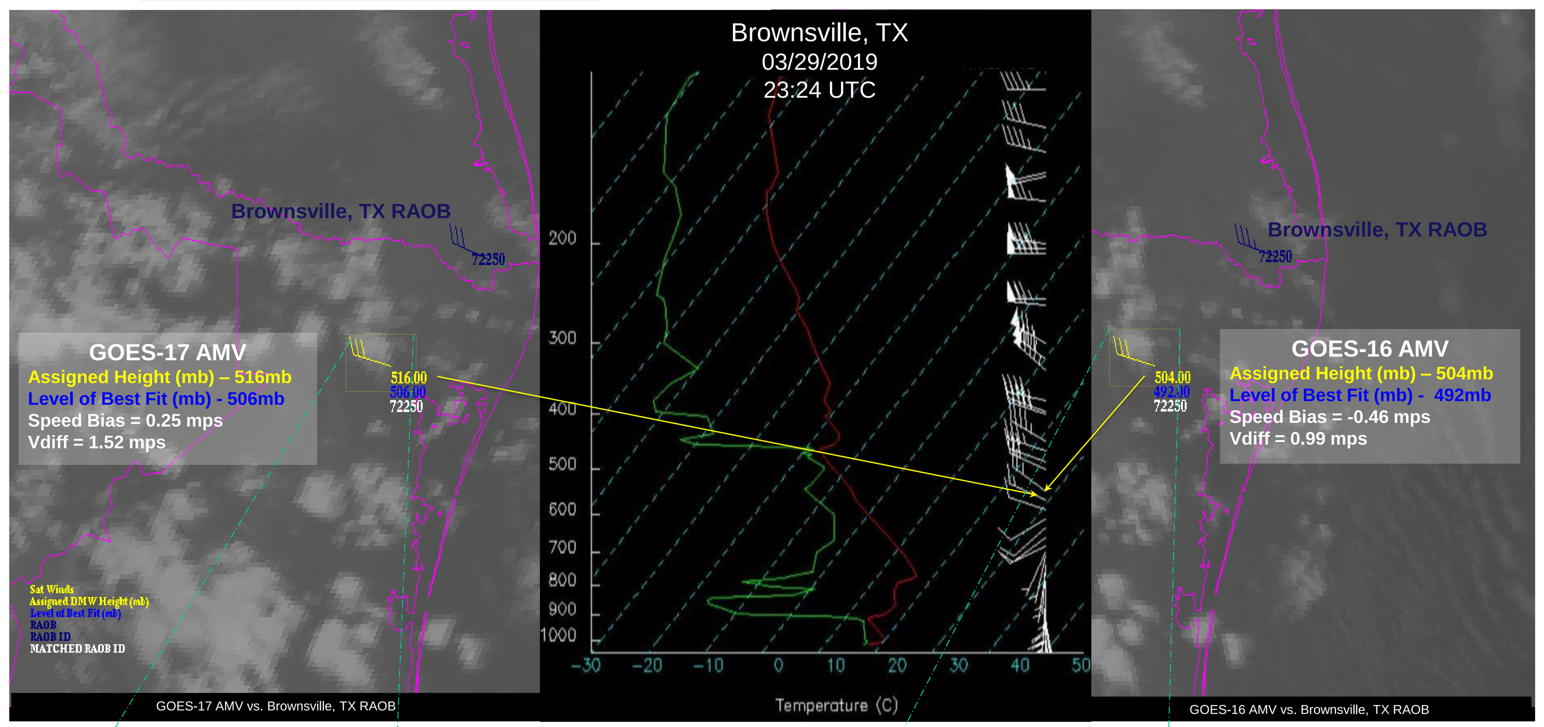
Efforts to validate and characterize the quality of AMVs from both GOES-16 and GOES-17 continue. A number of deep-dive analysis tools were developed to support this ongoing effort. More specifically, a stand-alone tool has been developed that permits the generation of AMVs for selected target scenes and deep-dive analysis of individual AMVs on a case by case basis. This tool, capable of displaying detailed output from the two major components of the wind derivation process (height assignment and tracking), allows for a more thorough examination of individual AMV target scenes. Another tool was developed that interrogates a database of collocated AMVs and rawinsondes to identify and isolate outlier AMVs for further study utilizing the stand-alone tool. The spatially and temporally collocated rawinsonde wind observations provide the necessary ground truth. The combination of these tools and others has been and continues to be critical to understanding and characterizing errors associated with the derived winds. This poster will present in depth GOES-16/17 case study results and findings from the use of all the validation and deep-dive tools noted above.

2. Deep-Dive Case Study Analysis

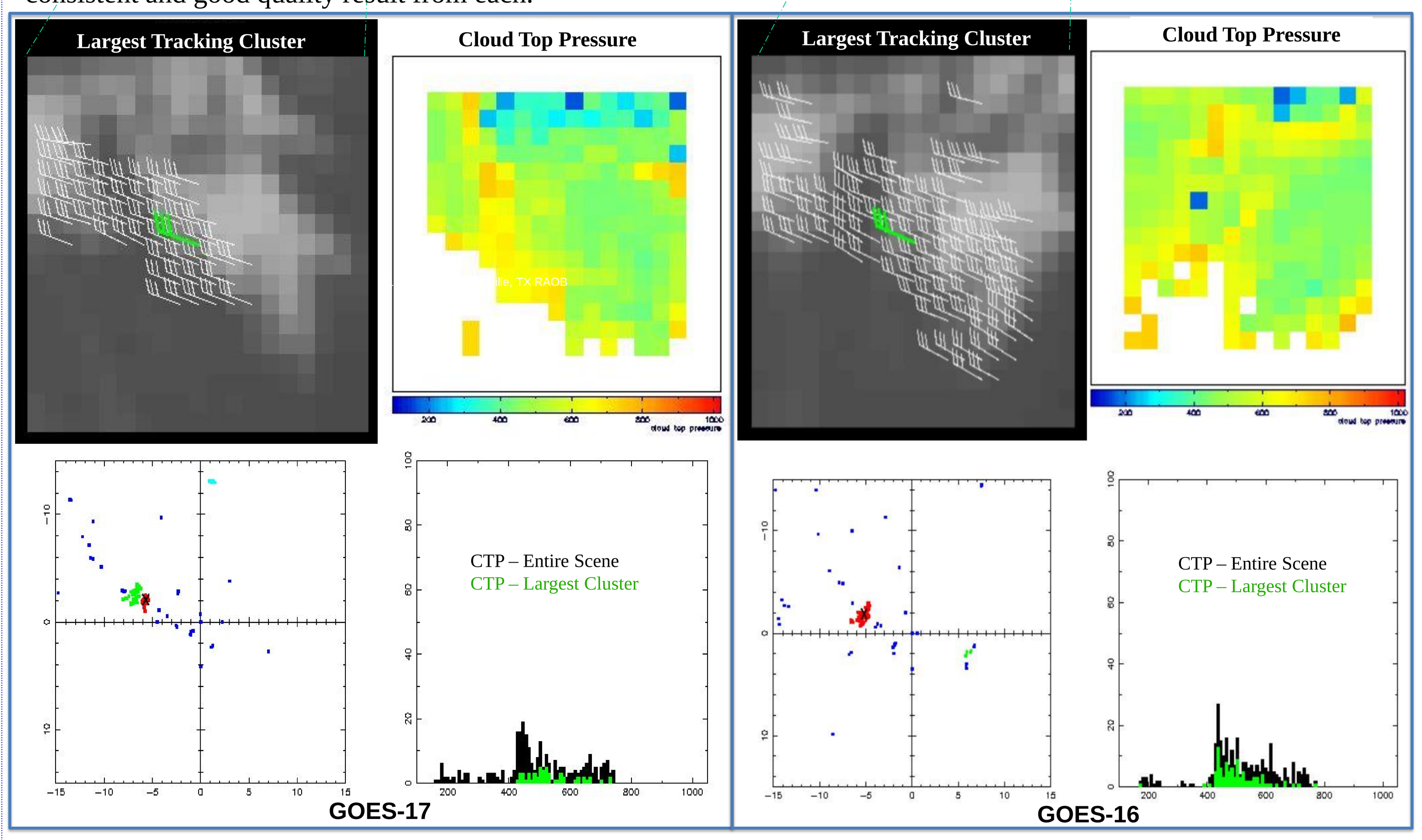
Deep-dive analysis tools, developed to both isolate outliers in the AMV vs. RAOB match verification database and evaluate detailed output from the two major components of the wind derivation process (height assignment and tracking), are utilized to better characterize AMV errors on a case by case basis. Coordination between the Winds and Cloud AWGs on these cases have led to a better understanding and improvement of overall AMV quality.

Case 1: GOES-16/17 Overlap Region Comparison – Band 14 AMV





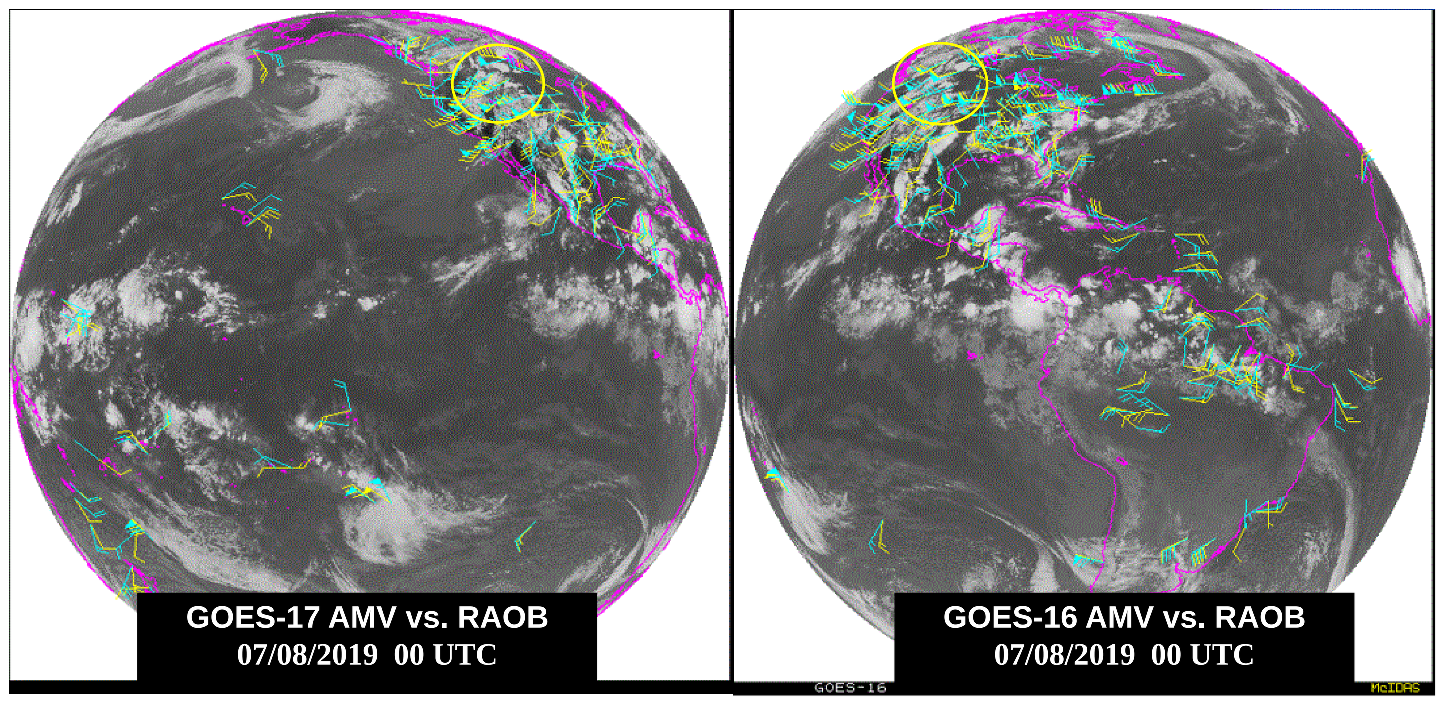
Full Disk images have been remapped to Mercator projection. The nominal image times are the same, but actual scan times of overlap region differ by a few minutes. The feature being tracked is the same from each satellite with consistent and good quality result from each.

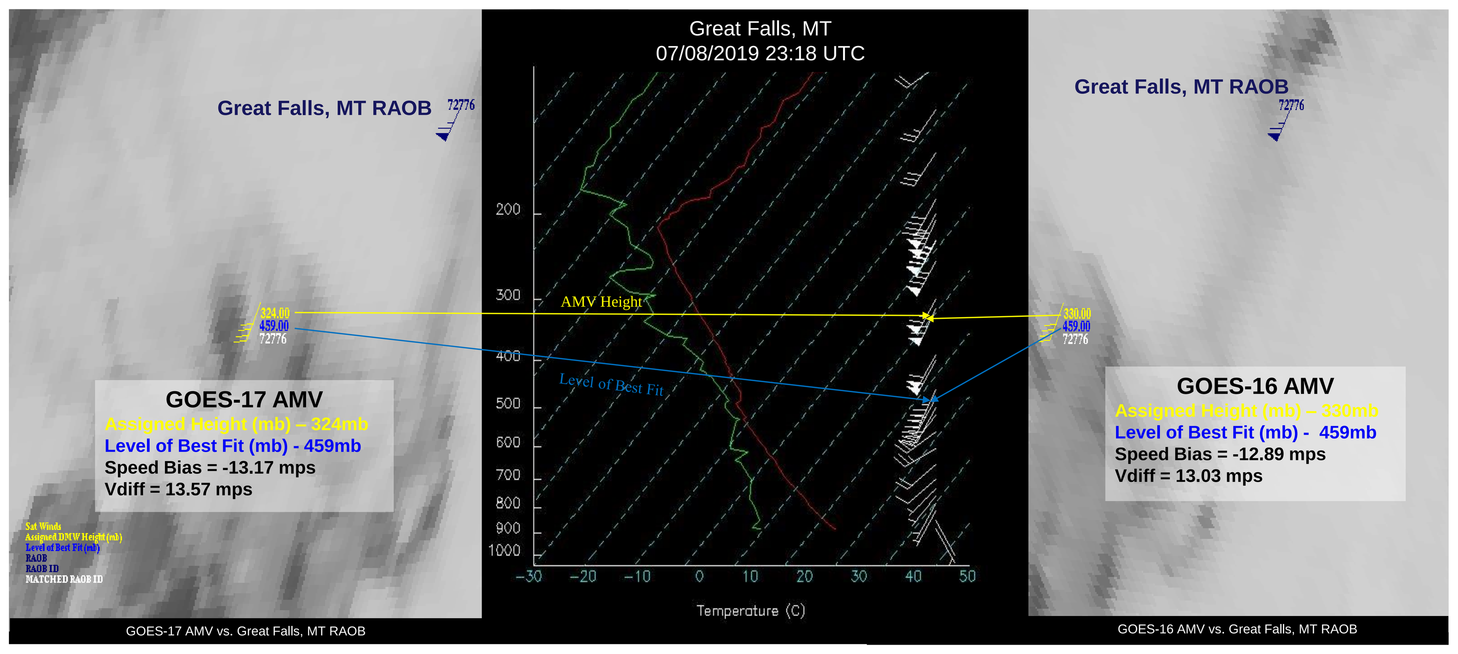


Selected output from the stand-alone processing tool showing largest tracking clusters, CTP field and histograms, and line/element scatter plot of motion (reverse timestep). For this case there was good agreement between the two retrieved vectors.

2. Deep-Dive Case Study Analysis (cont.)

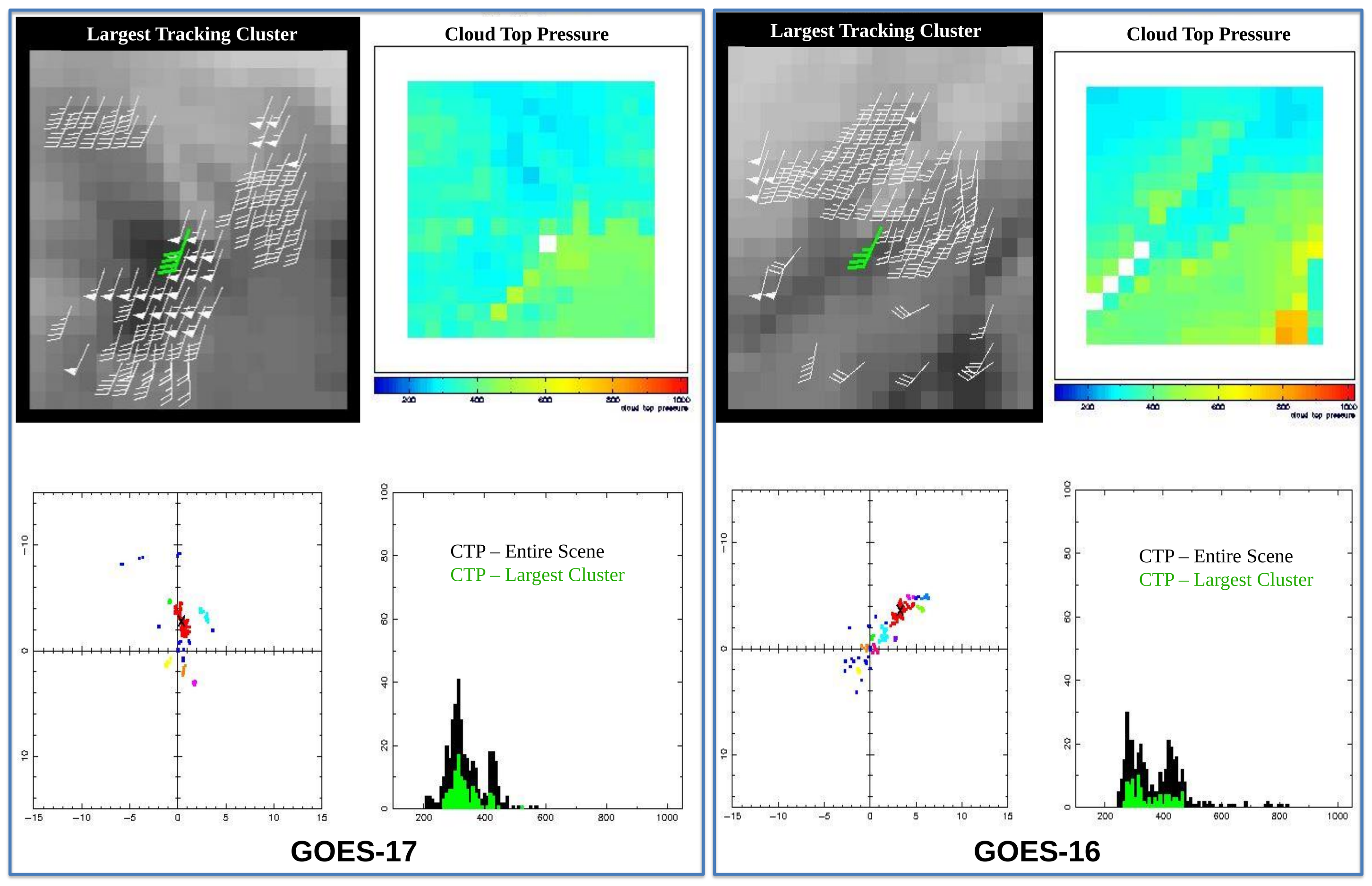
Case 2: GOES-16/17 Overlap Region Upper Level Slow Bias – Band 14 AMV



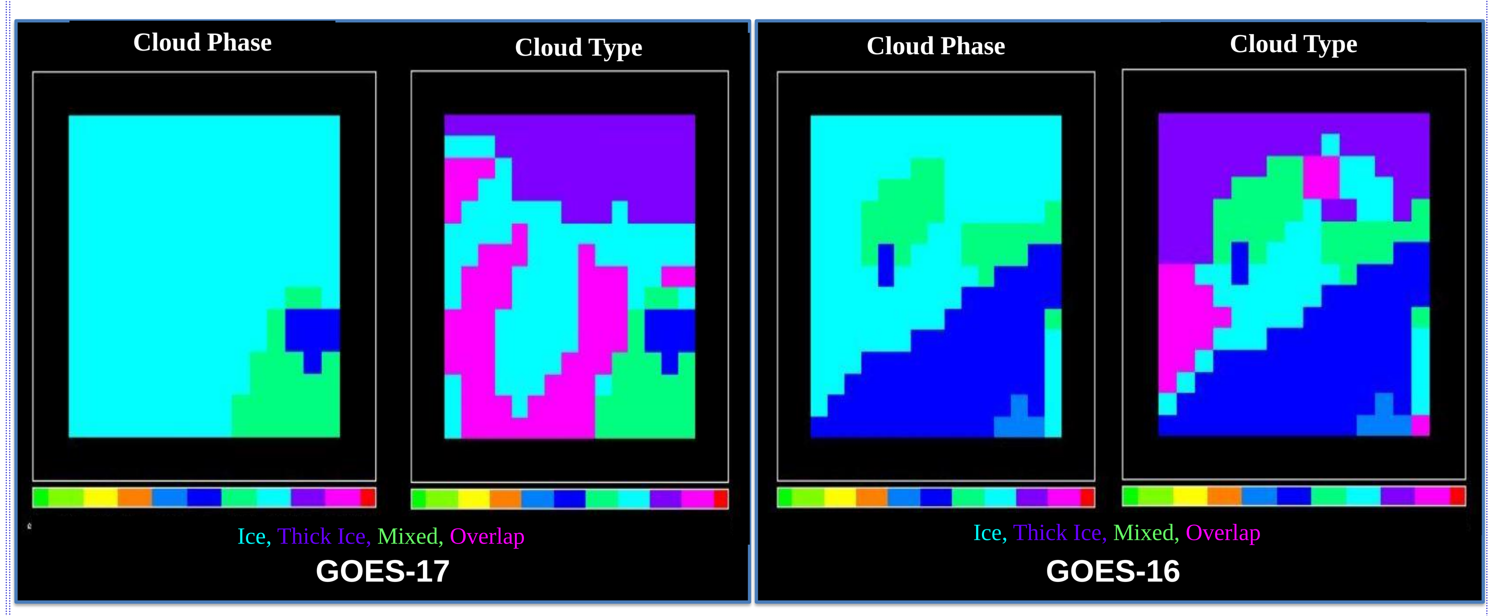


Full Disk images have been remapped to Mercator projection. The nominal image times are the same, but actual scan times of overlap region differ by a few minutes. The feature being tracked is the same from each satellite with consistent feature tracking results from each.

Ground Truth (Great Falls, MT RAOB) indicates Baseline algorithm height assignments for both retrievals were too high in the atmosphere (too low in P). The large height error combined with a strong gradient in vertical wind shear leads to large slow speed biases for both vectors.



Selected output from the AMV Stand-alone processing tool showing largest tracking clusters, CTP field and histograms, and line/element scatter plot of motion (forward timestep). For this case Histogram and CTP plots show large spread in heights, as well as two peaks in CTP values indicating a multi-level cloud scene.



The Dominant Cloud Type from the Baseline output for both vectors is "Thick Ice." However, that parameter is derived from the entire target scene. When evaluating the Largest Cluster from the stand-alone tool output, the scene is more accurately classified as "mixed." GOES-16 identified more pixels as super-cooled water with slightly higher CTP (lower Z) values assigned to those pixels.

For both vectors the tracking solution itself was robust, but height assignment errors of roughly 130 mb lead to large slow speed biases.

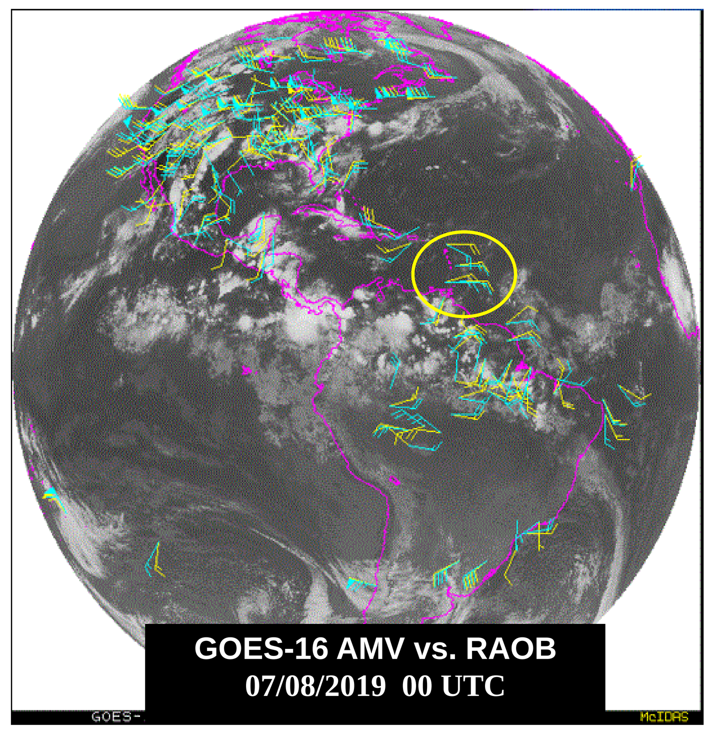
2. Deep-Dive Case Study Analysis (cont.)

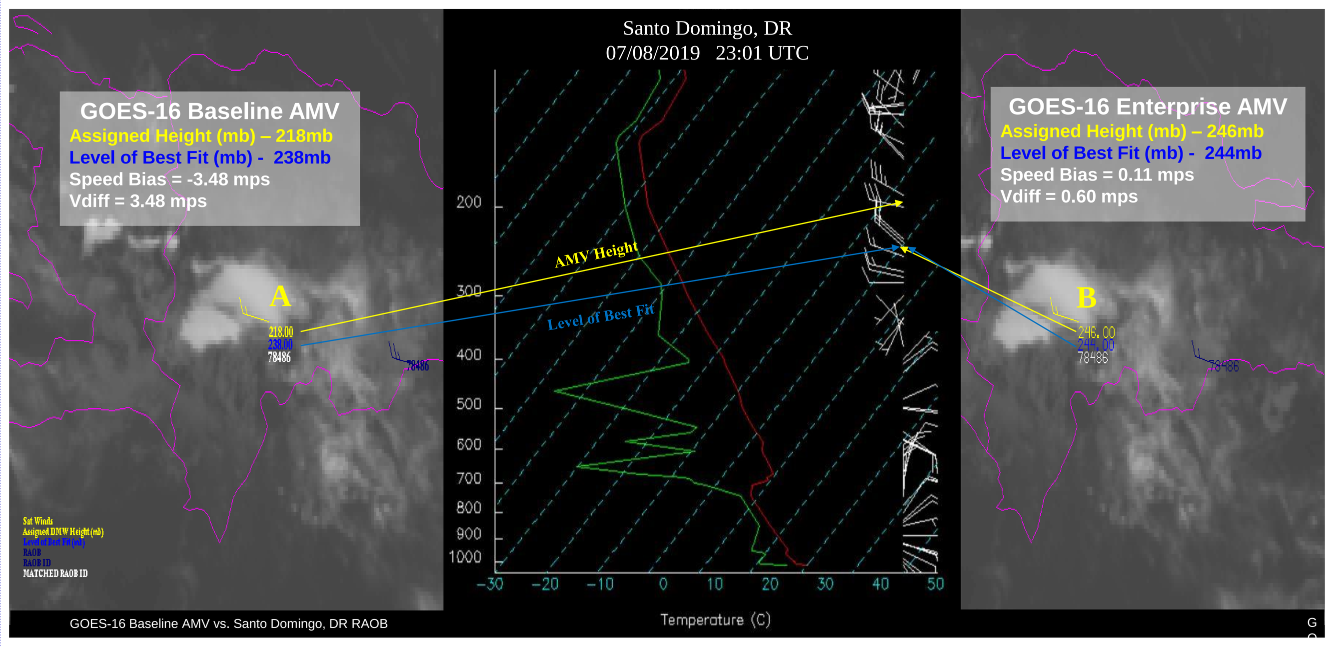
Case 3: GOES-16 Baseline vs. Enterprise Cloud – Band 14 AMV

This case highlights improvements made to the Baseline height assignment algorithm since its initial development.

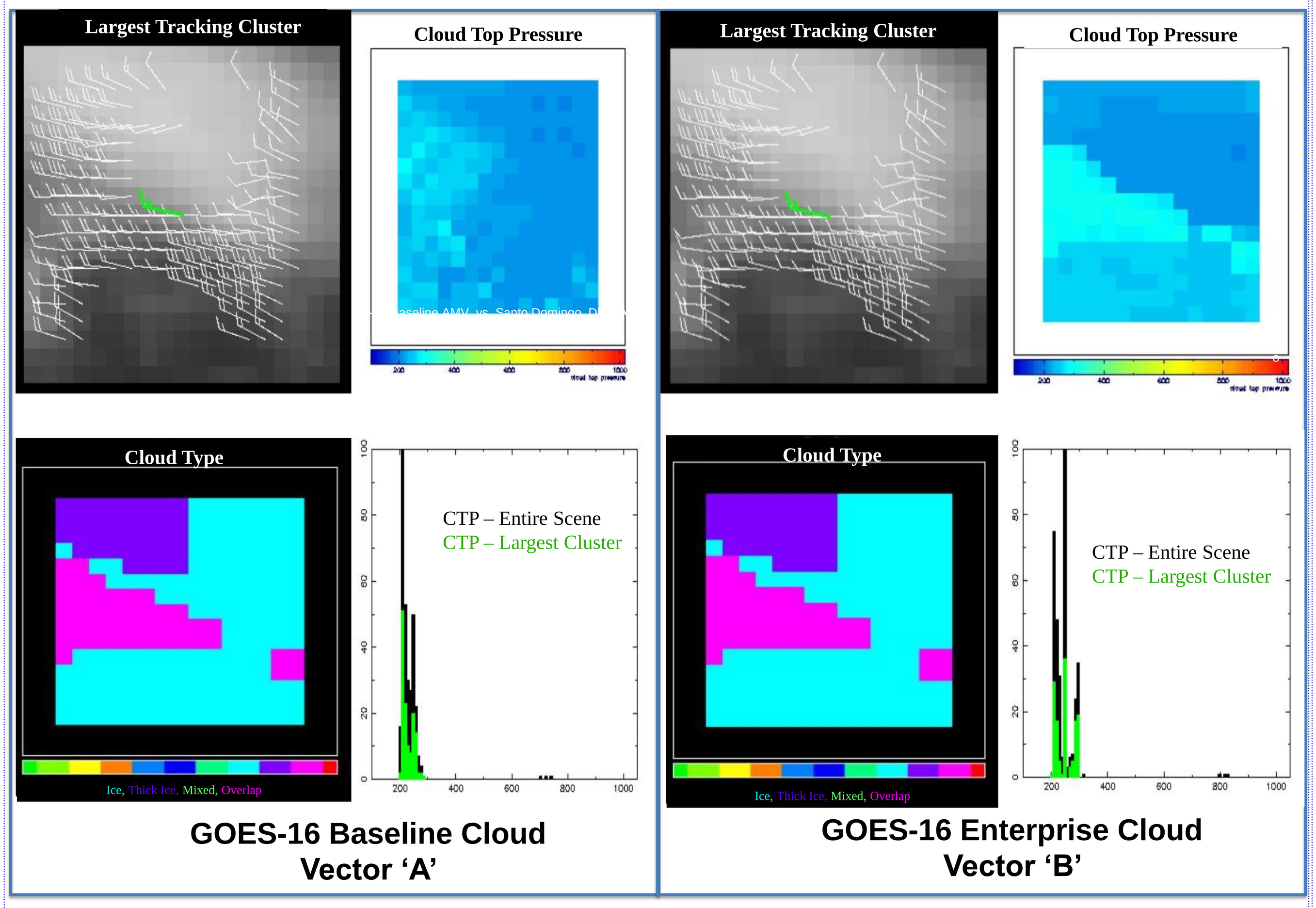
The AMV Stand-alone Tool is used here to process a Ch14 GOES-16 wind vector using the current Baseline Cloud Algorithm and comparing it to the same vector retrieved using the improved Enterprise Cloud Algorithm.

The region circled in the Caribbean will be the focus here.





Speed Bias and Vector Difference results from the RAOB match indicate the Enterprise Cloud algorithm (vector 'B') clearly performed better than the Baseline (Vector 'A') when assigning the height for this vector.



Selected output from the AMV Stand-alone processing tool showing largest tracking clusters, CTP field, CTP histogram, and Cloud Type field. Note the tracking and Cloud Type fields are identical as these components should be here. The differences between the cloud algorithms lie in the CTP. Also, note that the Enterprise CTP plots (vector 'B') show more indication of multi-level cloud in both the overall scene and largest cluster.

The dominant Cloud Type is ice with some overlap for both 'A' and 'B'. The Enterprise algorithm did a superior job identifying the lower heights (in atmosphere; higher P) in this scene, particularly for those pixels used in the tracking. The height assignment errors were enough to lead to a Baseline slow bias greater than 3m/s.

Why did the Baseline Cloud Height Retrieval perform poorly in this case?

- Target scene is on the edge of a dissipating cloud mass typed as ice.
- The current Cloud height algorithm is an Optimal Estimation (1D VAR) approach and the first guess cloud height is important for clouds like those shown in this target scene.
- Most cirrus are near the Tropopause and the cloud height algorithm's climatological first guess *overestimated* the cloud height (underestimated the cloud pressure).

Applying latest version of the Enterprise Cloud Height Algorithm to this case

- For this case the Enterprise version of the cloud height algorithm produces improved cloud top pressures, as well as better resolving the multi-level cloud structure present. These results are now consistent with and supported by the Santo Domingo radiosonde observation.
- The Enterprise Algorithm has progressed continuously since the development of the GOES-R Ground System Baseline Algorithm and now supports many sensors and IR channel combinations.
- It has implemented a more complex scheme where opaque parts of clouds are processed first and these values serve as the first guess for thinner cloud regions and edges (which often form AMV targets).
- The algorithm has also has benefitted from better Radiative Transfer and Microphysical methods implemented over the last decade.