Deep-Dive Analysis of GOES-16/17 Atmospheric Motion Vectors Derived from the Advanced Baseline Imager (ABI)

(Virtual Poster)

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IWW15 Virtual Workshop Apr 12 - 16, 2021

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Both GOES-16 and GOES-17 Atmospheric Motion Vectors (AMVs) are now being produced operationally at NOAA/NESDIS. Efforts to validate and characterize the quality of these AMVs continue, particularly in light of the GOES-17 ABI cooling system anomaly. An enterprise version of the AWG Cloud Height Algorithm (ACHA) is also scheduled to be implemented into the GOES-R ground system in June, 2021. To support these efforts, a number of deep-dive analysis tools were developed and are used here to evaluate the quality of the AMVs on a case-by-case basis. Three of those cases are presented here.

CASES 1 and 2 evaluate the updated "enterprise" version of ACHA. Improvements to this algorithm include:

- More complex scheme where opaque parts of clouds are processed first and their values serve as the first guess for thinner cloud regions and edges which are typical AMV targets.
- Better estimation of a-priori cloud-top temperature values and uncertainties.
- Supports many IR channel combinations (Modes). For GOES-17, Mode selection is dynamic based on the best performing channels.

CASE 3 examines the impact of the GOES-17 Loop Heat Pipe (LHP) anomaly on current AMVs and strategies being applied to mitigate this impact.

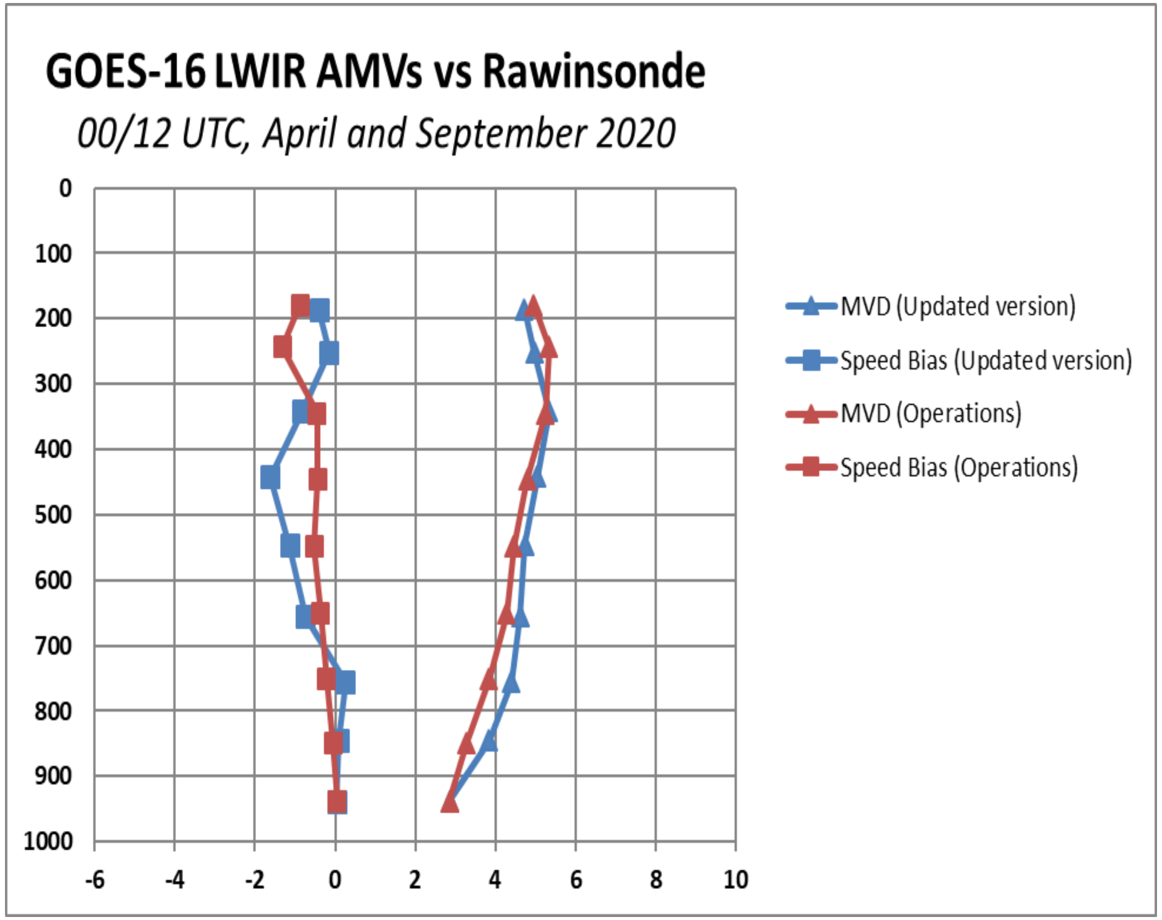
CASE 1: Mid-level Slow Bias

GOES-16 Ch14 (11 um) 4/15/2020 00Z

Enterprise version of the AWG Cloud Height Algorithm (ACHA) chosen as part of a GOES-R Program pilot project to be implemented into the GOES-R ground system June, 2021.

The use of cloud heights from this updated cloud height algorithm:

- Improves AMV performance (i.e., reduction of slow speed bias) at upper levels (*expected*)
- Degrades AMV performance (i.e., increase in slow speed bias) at mid levels (*unexpected*)
- Cloud team is addressing

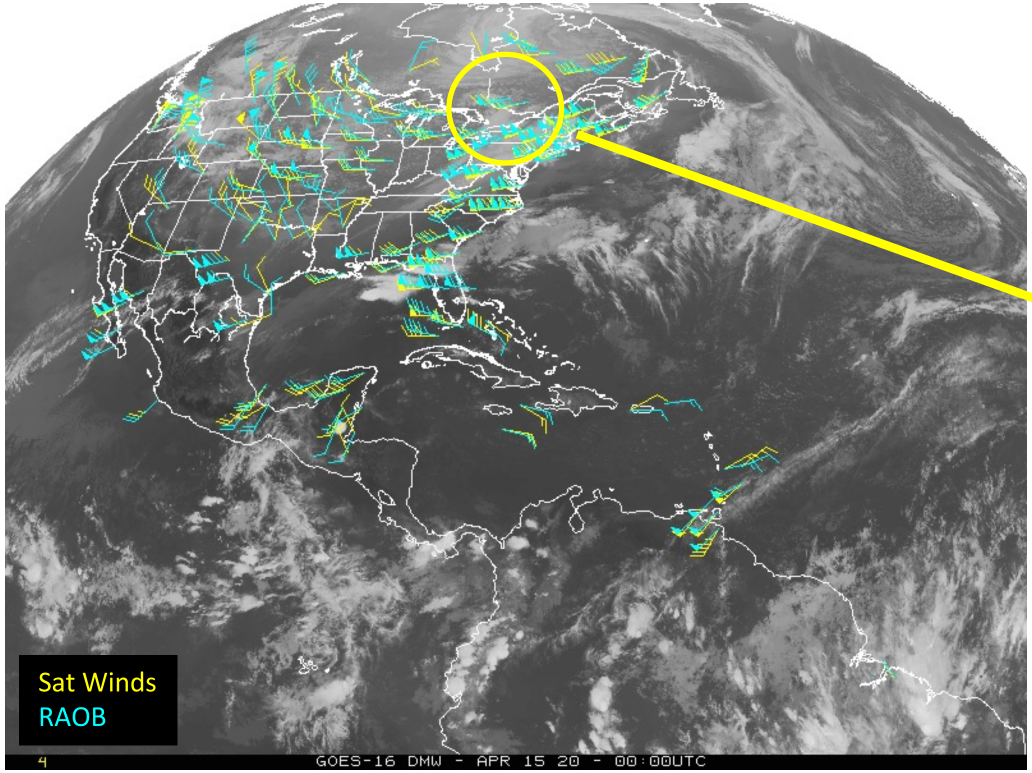


AMV – RAOB Speed (m/s)

CASE 1: Mid-level Slow Bias

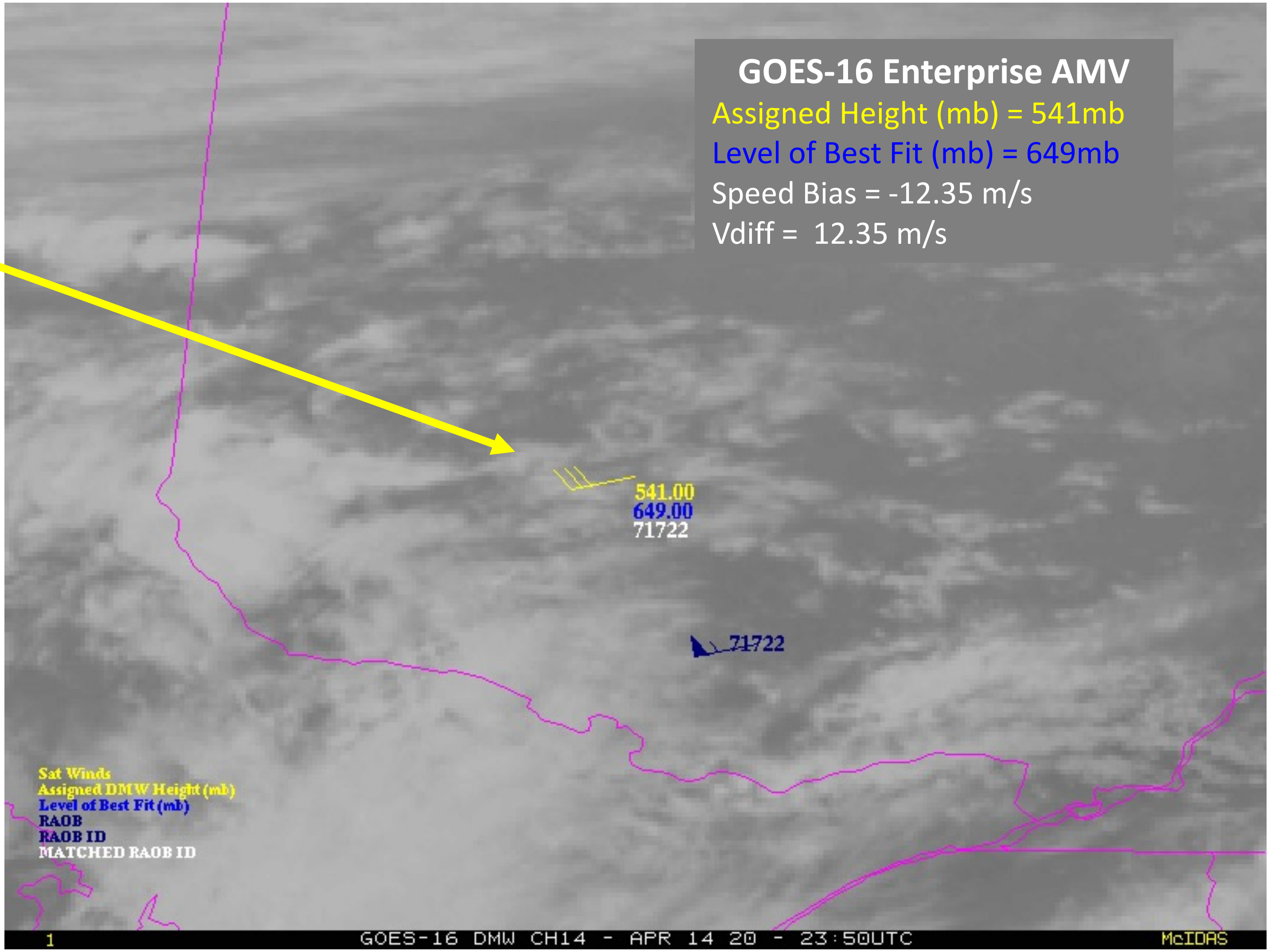
GOES-16 Ch14 (11 um)

4/15/2020 00Z



GOES-16 Ch14 AMVs vs. RAOB

- GOES-16 AMV matched to 00Z RAOB from Maniwaki, Quebec Canada
- Based on the Ground Truth (RAOB) the vector should have been assigned to a height lower in the atmosphere (higher P) by the Enterprise Cloud Algorithm.



CASE 1: Mid-level Slow Bias

GOES-16 Ch14

4/15/2020 00Z

GOES-16 Baseline AMV

Assigned Height (mb) = 678mb

Level of Best Fit (mb) = 664mb

Speed Bias = 1.85 m/s

Vdiff = 2.40 m/s

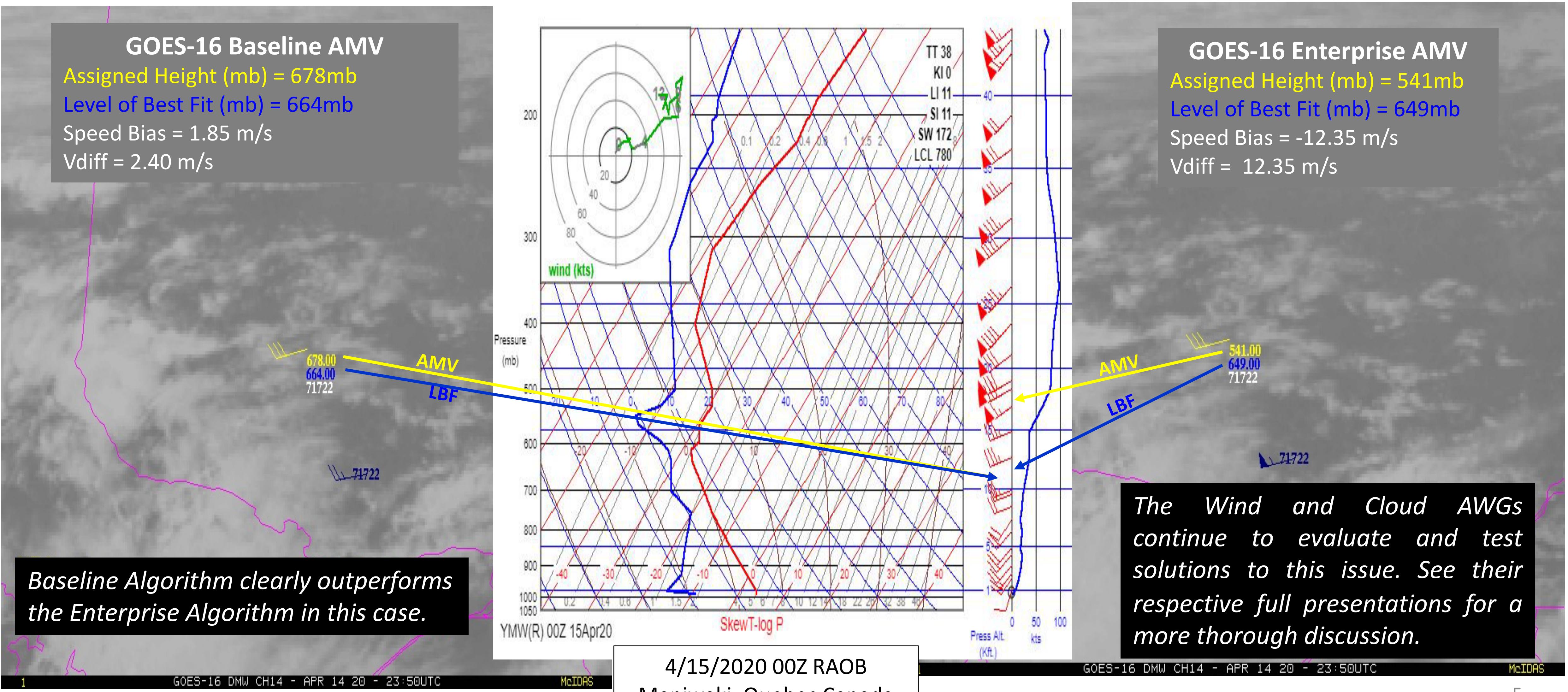
GOES-16 Enterprise AMV

Assigned Height (mb) = 541mb

Level of Best Fit (mb) = 649mb

Speed Bias = -12.35 m/s

Vdiff = 12.35 m/s



Baseline Algorithm clearly outperforms the Enterprise Algorithm in this case.

4/15/2020 00Z RAOB
Maniwaki, Quebec Canada

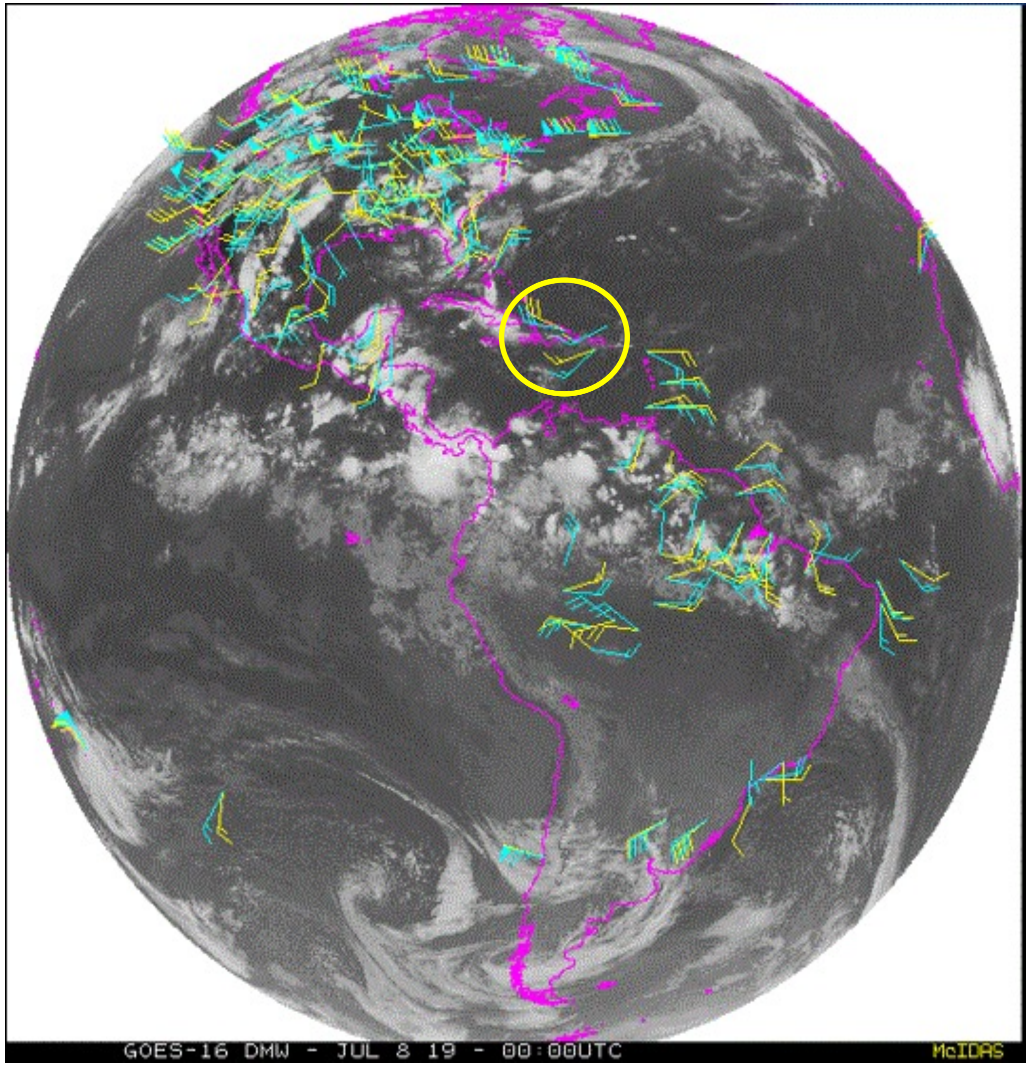
The Wind and Cloud AWGs continue to evaluate and test solutions to this issue. See their respective full presentations for a more thorough discussion.

CASE 2: Upper Level AMV

Enterprise vs Baseline Cloud Height Algorithm

GOES-16 Ch14 (11 um) 7/08/2019 00Z

- Upper level GOES-16 AMV collocated with Santo Domingo, DR Radiosonde (7/8/19 00UTC)
- Illustrates height assignment issue associated with baseline cloud height algorithm
- Illustrates better cloud heights with the updated (“Enterprise”) cloud height algorithm translating to a better AMV height and better agreement with the collocated radiosonde wind observation

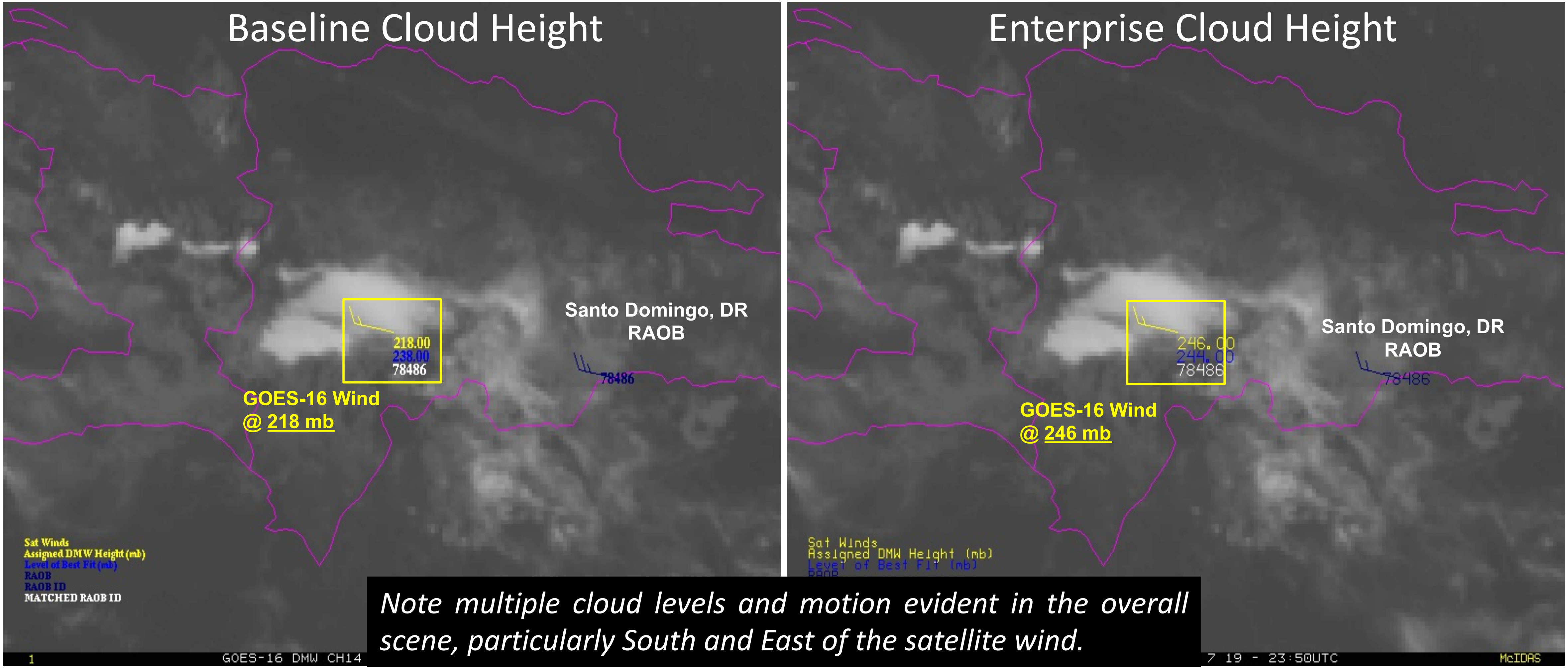


GOES-16 DMW vs. RAOB

CASE 2: Upper Level AMV

Enterprise vs Baseline Cloud Height Algorithm

GOES-16 Ch14 (11 um) 7/08/2019 00Z

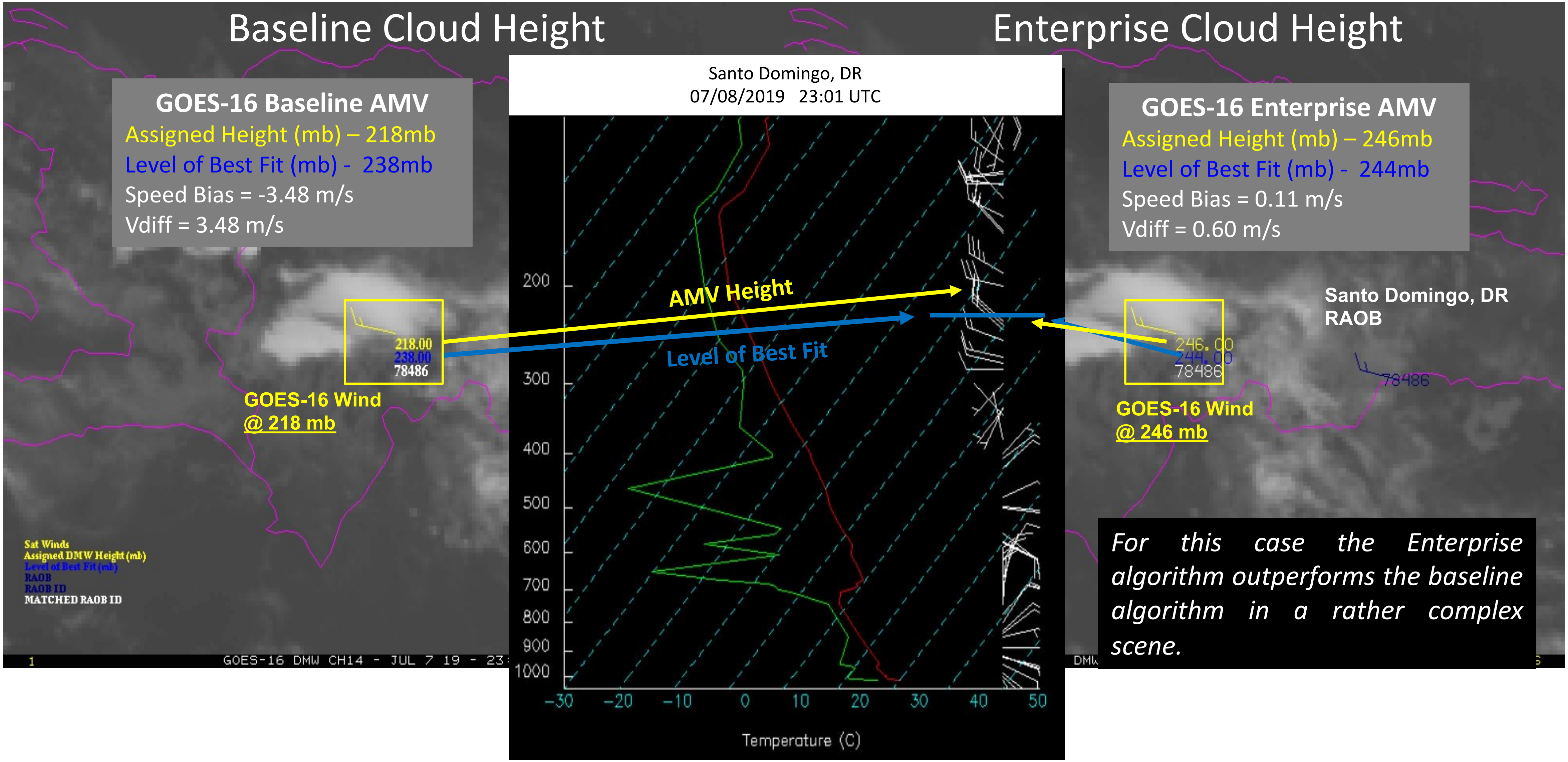


Note multiple cloud levels and motion evident in the overall scene, particularly South and East of the satellite wind.

CASE 2: Upper Level AMV

Enterprise vs Baseline Cloud Height Algorithm

GOES-16 Ch14 (11 um) 7/08/2019 00Z

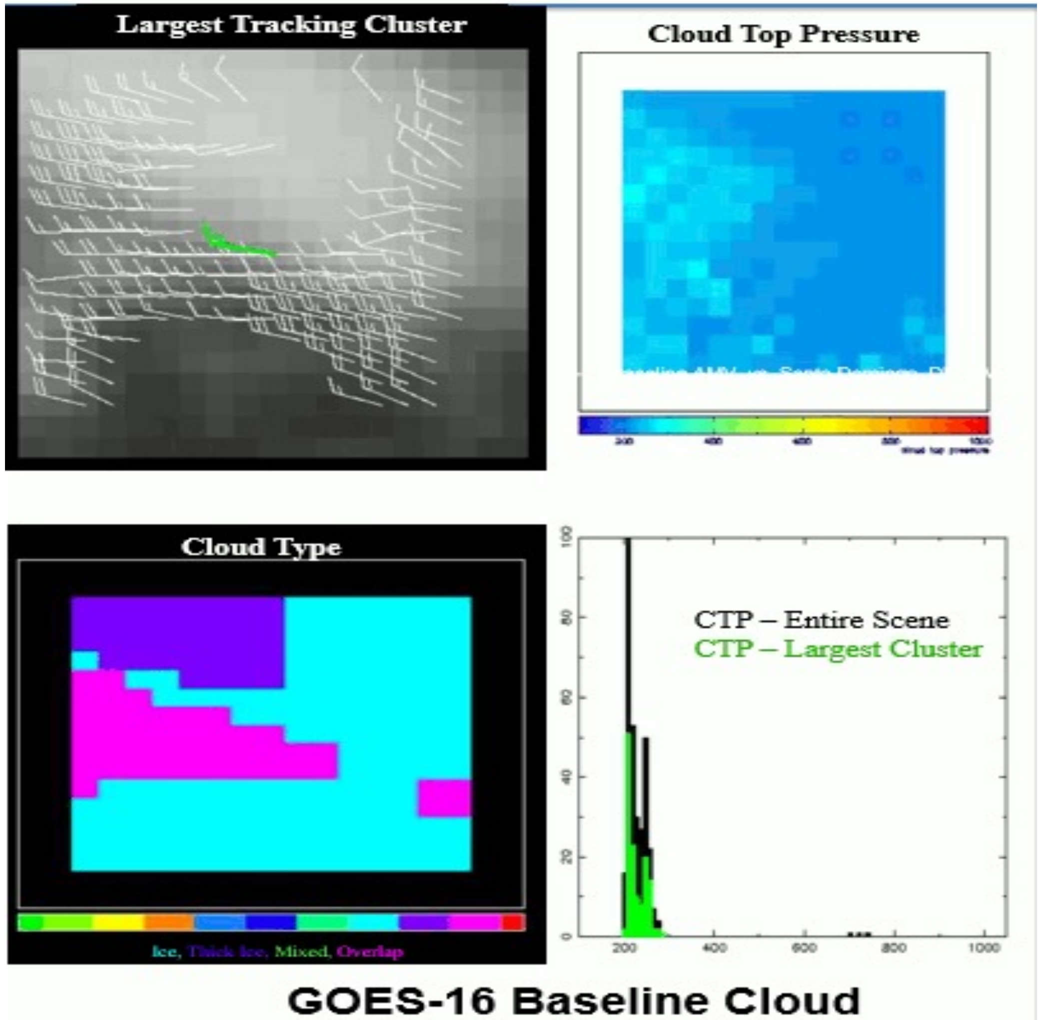


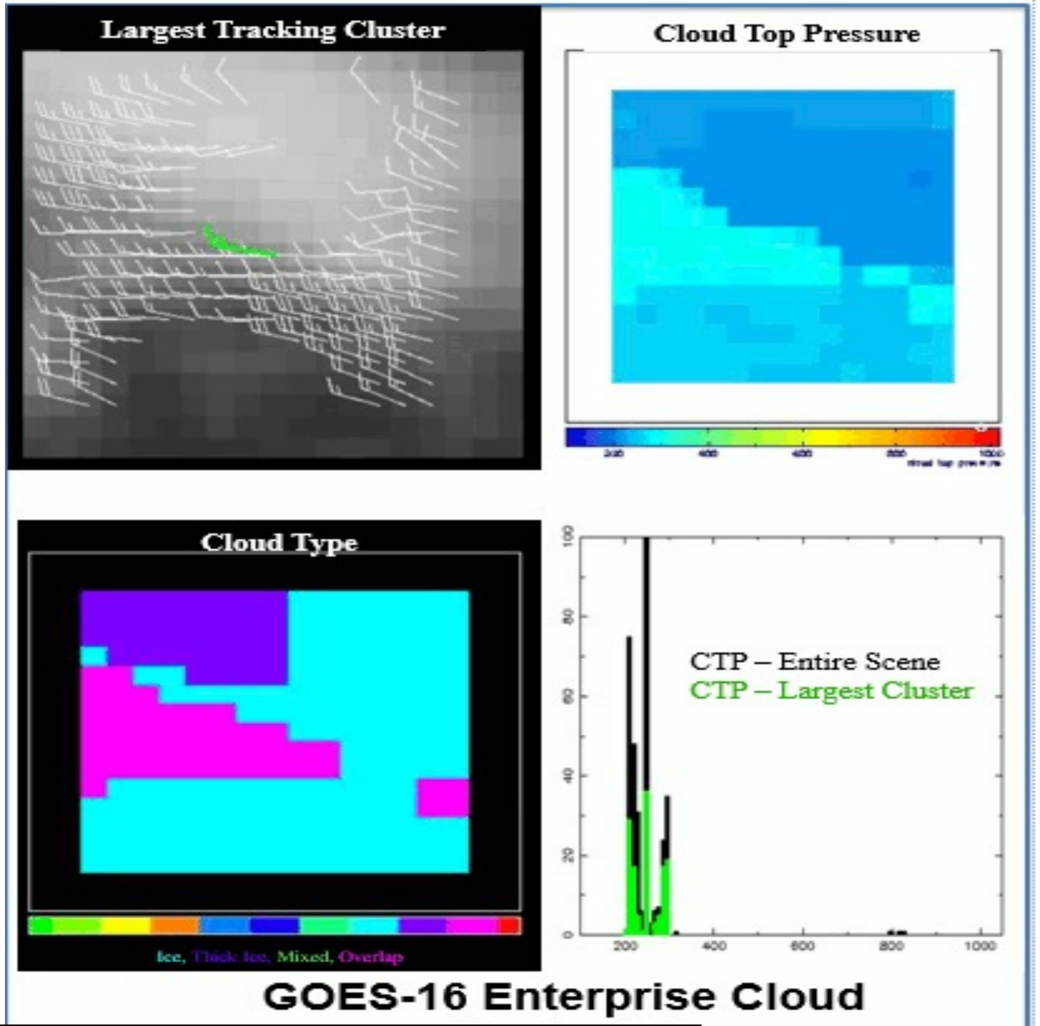
For this case the Enterprise algorithm outperforms the baseline algorithm in a rather complex scene.

CASE 2: Upper Level AMV

Enterprise vs Baseline Cloud Height Algorithm

GOES-16 Ch14 (11 um) 7/08/2019 00Z

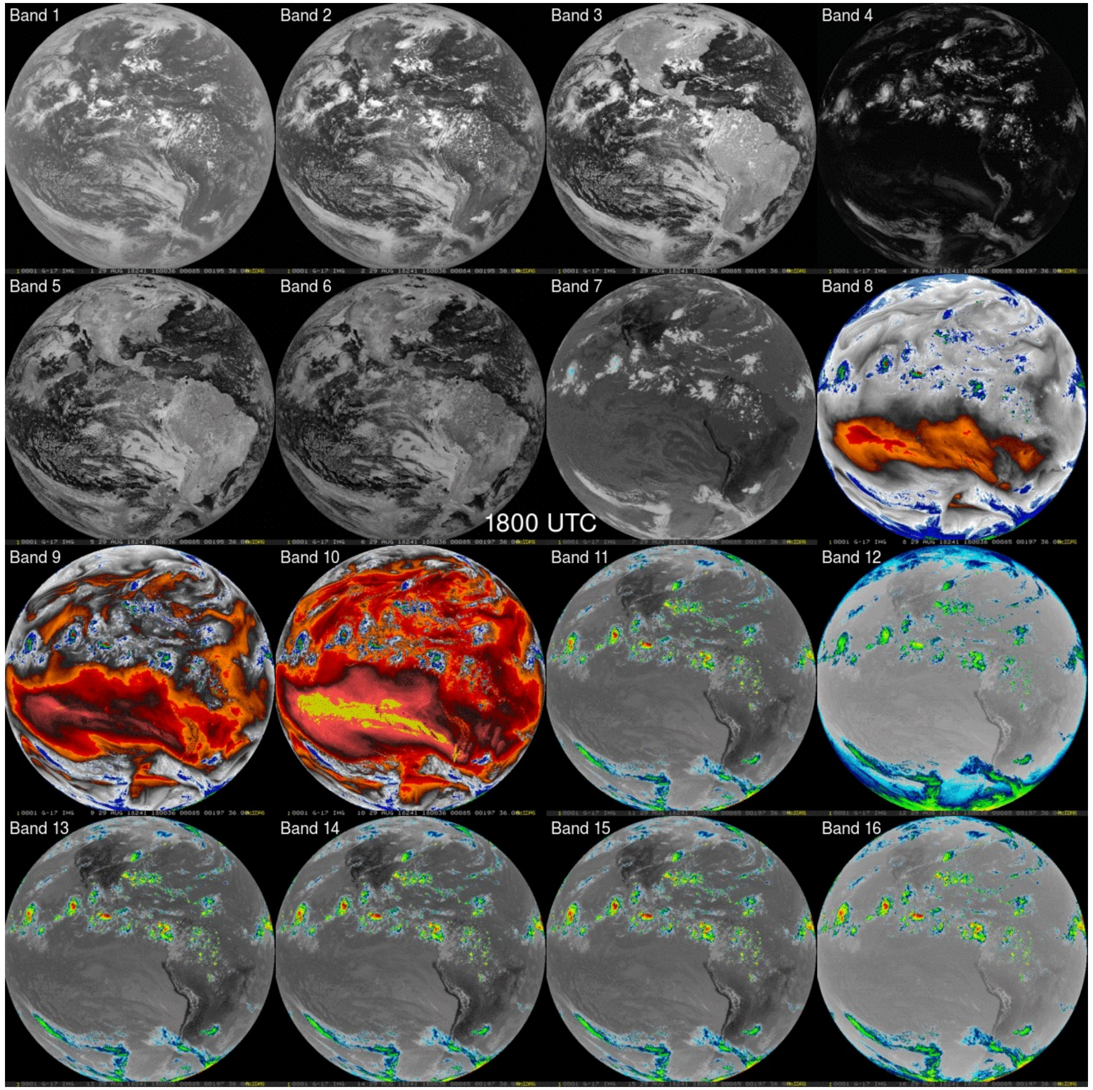




The Enterprise algorithm more accurately resolved the structure of the multilayer scene as shown here in the respective CTP histograms and CTP plots of the target scene.

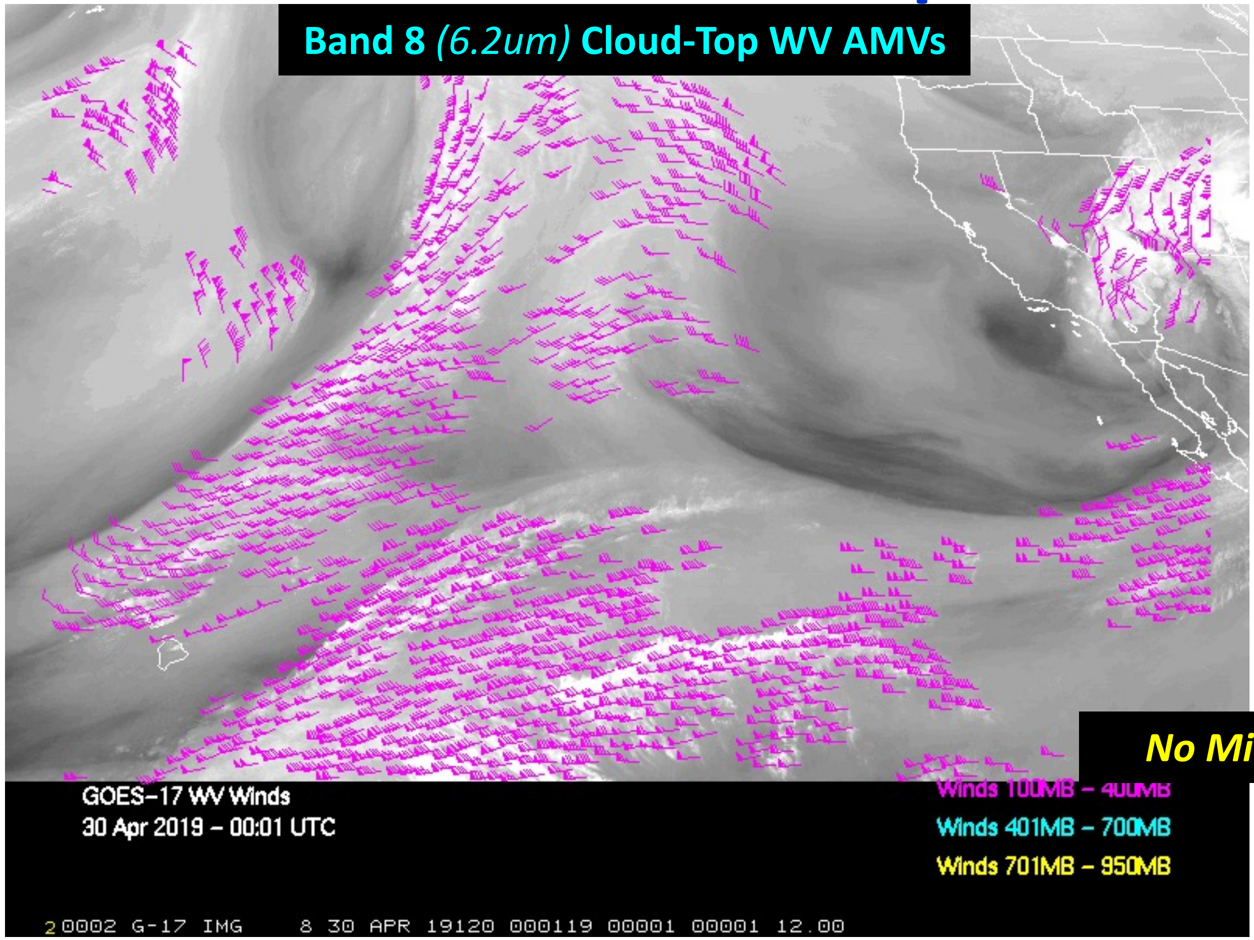
Case 3: GOES-17 ABI Loop Heat Pipe Issue Impact on GOES-17 AMVs

- GOES-17 Loop Heat Pipes for the ABI are not functioning at full capacity.
- During nighttime hours, the sun heats up the ABI detectors faster than they can be cooled.
- Eventually, local emission and noise overwhelm the signal from Earth.
- The longer wavelength IR channels are generally affected first and the shorter wavelengths (VIS and near-IR) not at all.
- Impact varies diurnally and seasonally.

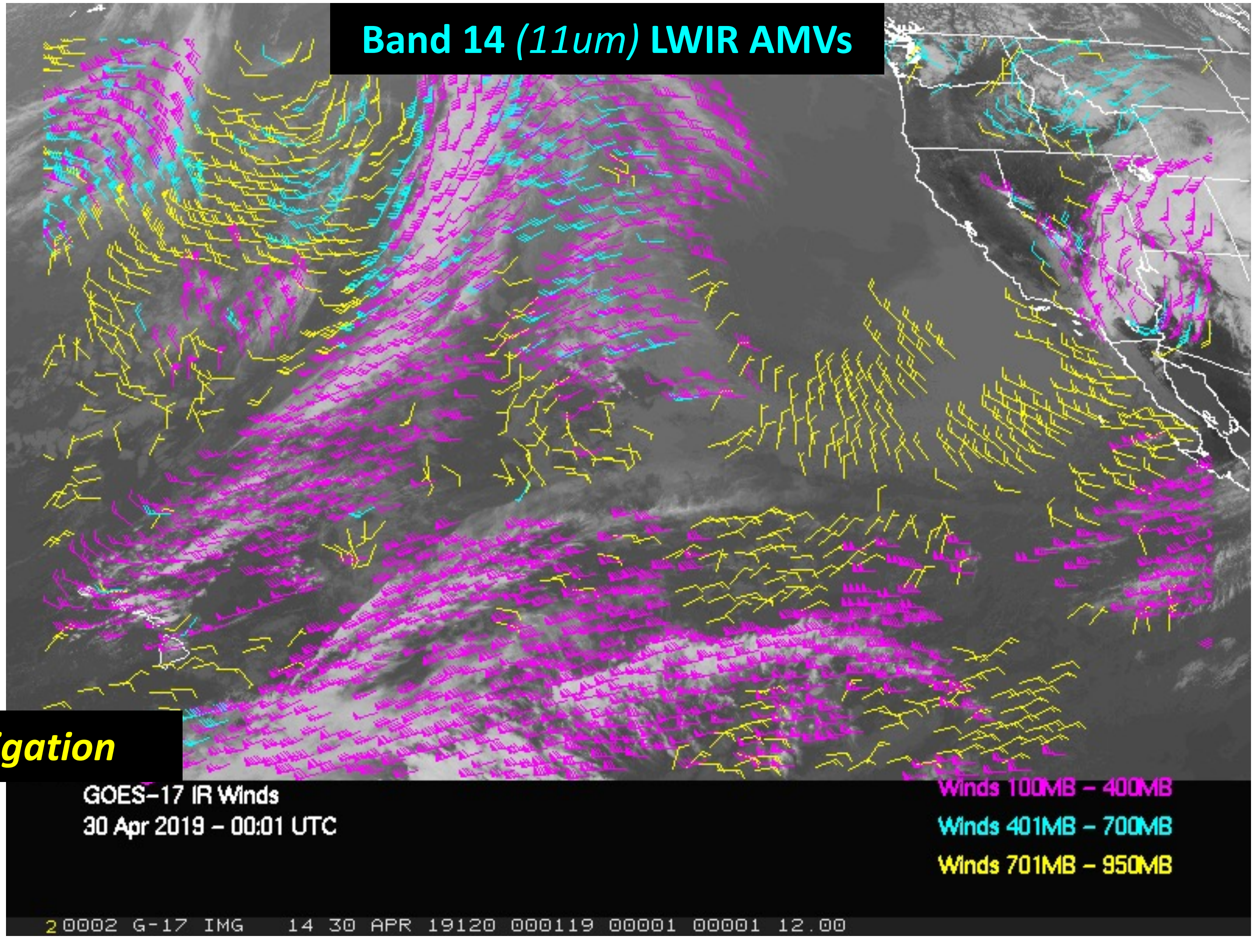


Case 3: GOES-17 ABI Loop Heat Pipe Issue
Impact on GOES-17 AMVs

Band 8 *(6.2um)* Cloud-Top WV AMVs



Band 14 *(11um)* LWIR AMVs

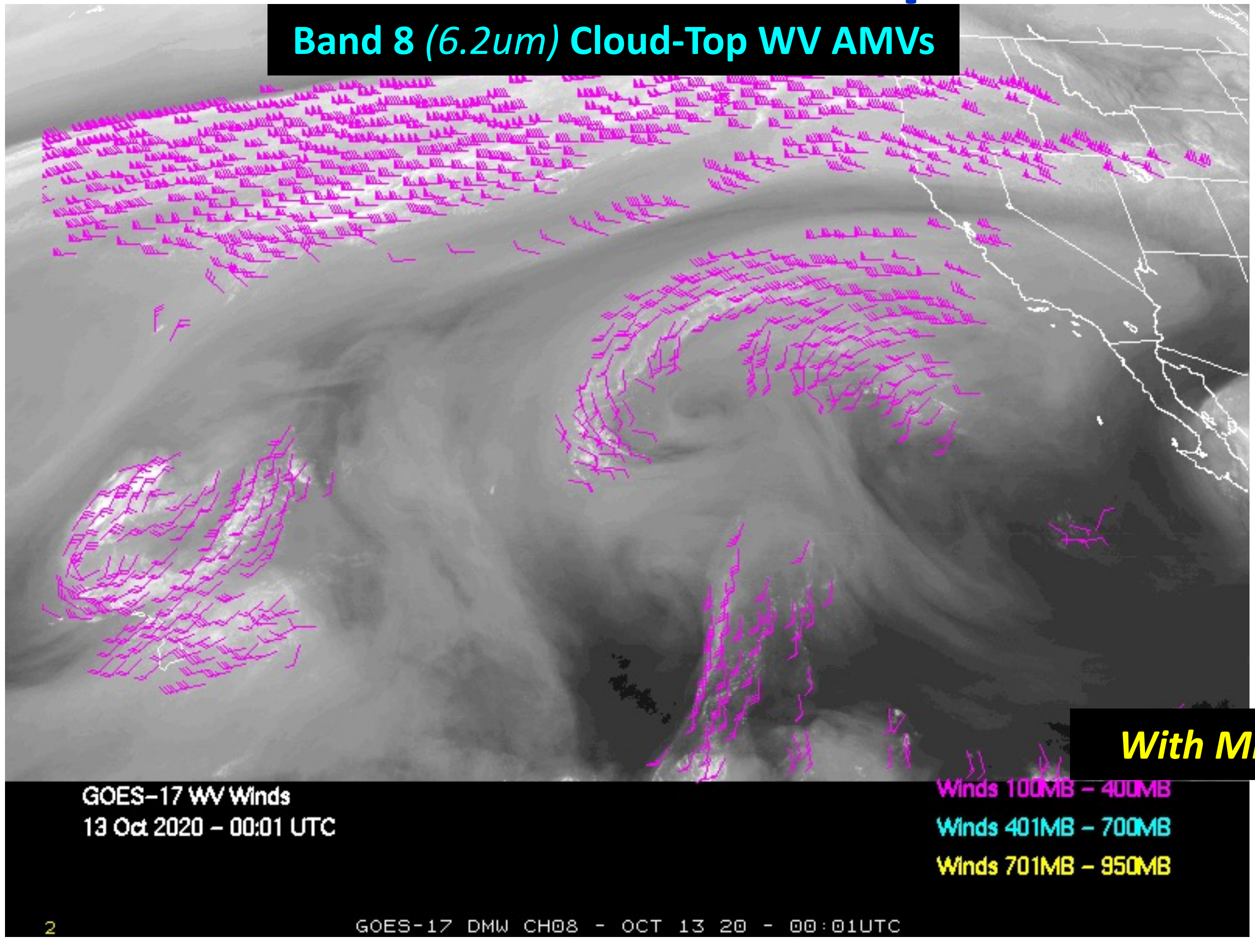


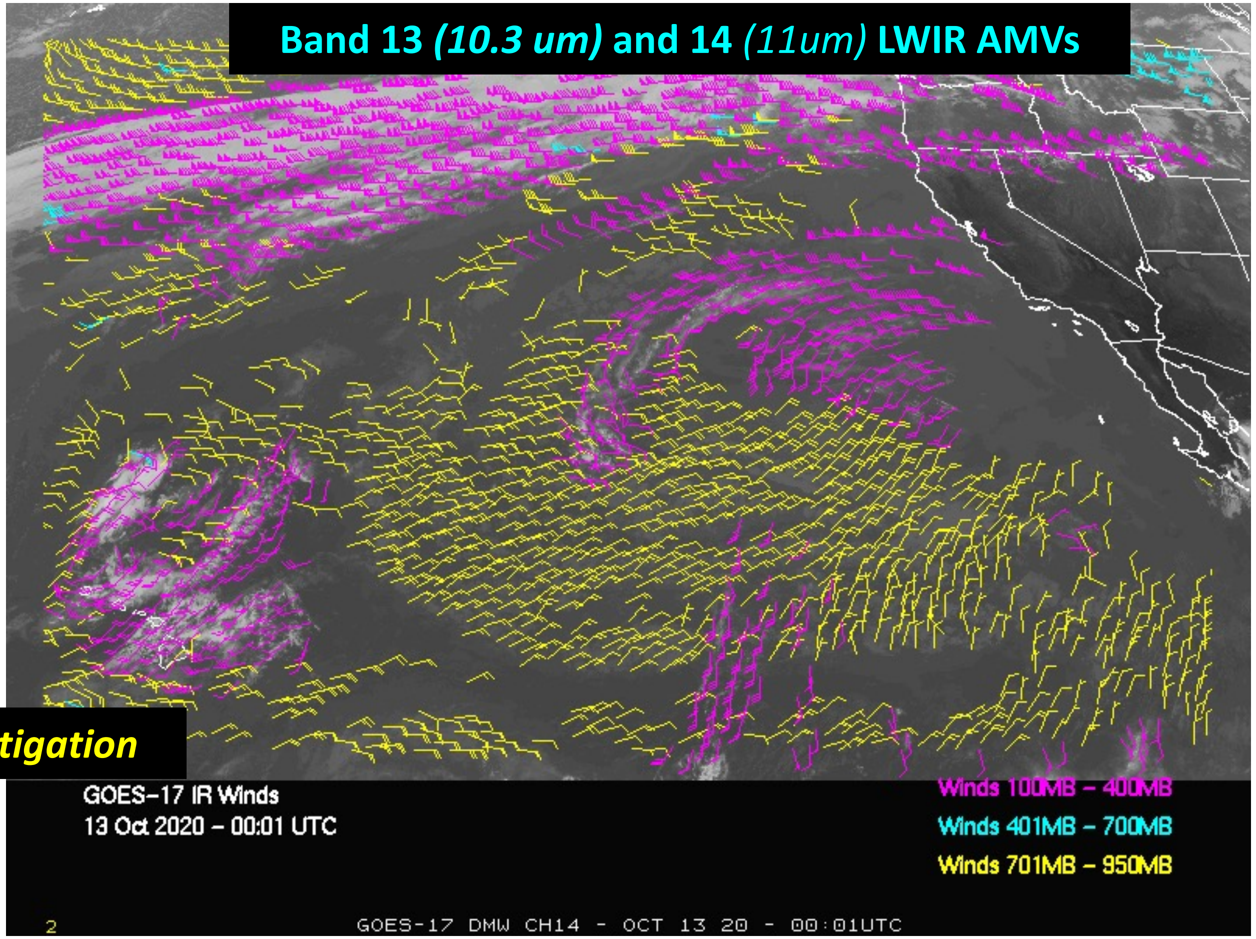
No Mitigation

Reductions in AMV counts and quality occur when the ABI Focal Plane Module (FPM) temperatures are too warm (approx. 10:00 – 15:00 UTC here).

High level winds, derived from tracking optically thin cirrus targets, suffer height assignment issues when the 12 and 13.3 um bands are degraded or saturated.

Case 3: GOES-17 ABI Loop Heat Pipe Issue Impact on GOES-17 AMVs





With Mitigation

Mitigated processing (described in next slide) during periods of high FPM temperatures minimizes the length of time AMVs are impacted. (Note: animations above are from a different, but comparable, FPM warm period than previous slide)

Comparing the animations above to the previous slide shows a shorter period of data loss across times of greatest heating (approx. 10:00 – 15:00 UTC here). See time series plot in next slide.

Case 3: GOES-17 ABI Loop Heat Pipe Issue Impact on GOES-17 AMVs

ABI L2 Algorithm Mitigation Strategies

Graceful degradation

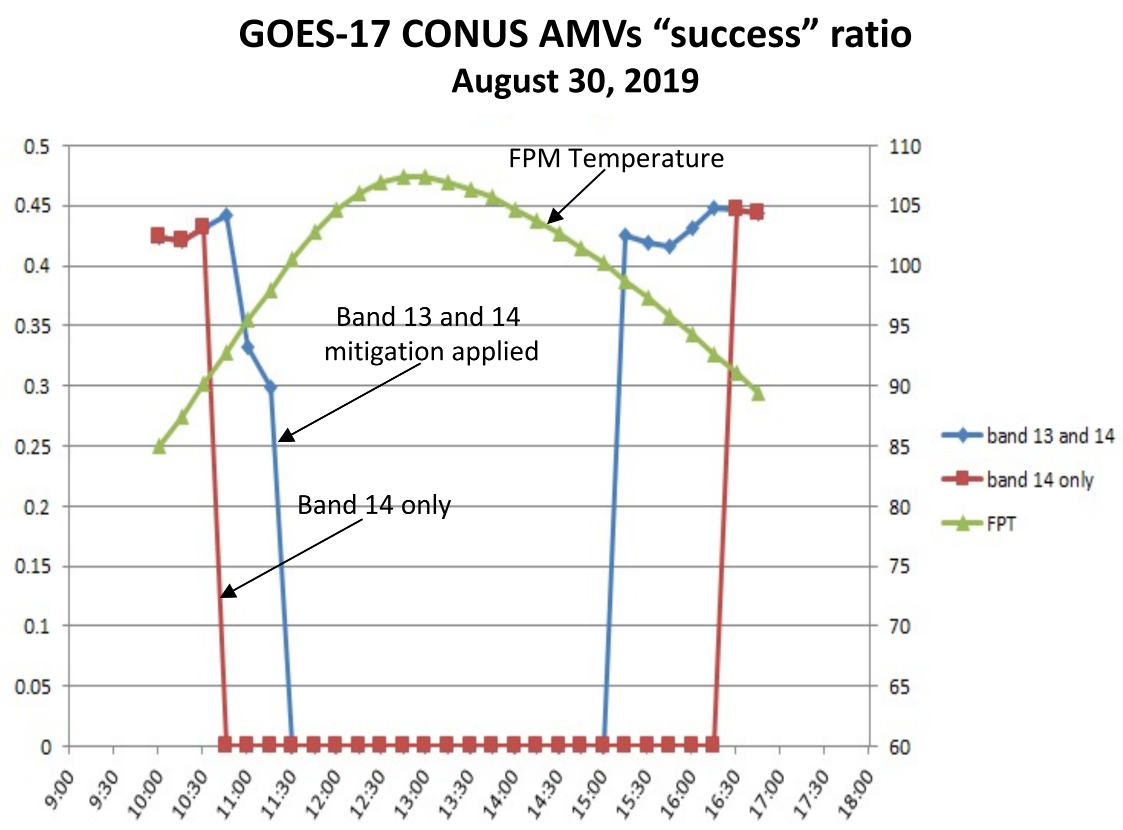
- Identify when channels degrade or saturate due to the LHP issue (L1b DQFs, etc.).
- Turn off tests or methodology that require those channels

Channel substitution and additional spectral bands

- Once disabling tests degrade the L2 product beyond a critical threshold, channel substitutions are applied.
- Utilize alternative channels in product retrieval.

Develop, deliver, and implement updated L2 product algorithms

- Incorporating L2 product algorithm LHP mitigations.
- Update L2 algorithms beyond the baseline algorithms (circa 2010) to the "Enterprise" algorithm versions.



Time series showing example of the impact of adding band 13 as a mitigation across a period of maximum FPM heating.