

The 104th AMS Annual Meeting, 28 January to 1 February, 2024 in Baltimore, Maryland.

The Transition of RGB Imagery Applied to Fog and Low Clouds from NASA Capabilities within the GOES Proving Ground to the Present Era

Kevin Fuell¹, Douglas Schneider², David Hotz², Emily Berndt³

1. University of Alabama in Huntsville/NASA SPoRT, Huntsville, AL
 - 1.National Weather Service Morristown, TN
 - 2.NASA Marshall Space Flight Center, Huntsville, AL

Where do you sit?

Research
To
Operations

Why fog / low clouds have been an issue?

Capobianco 2001:
fatal weather accidents common factors

- Low ceiling (20%), Fog (14%)

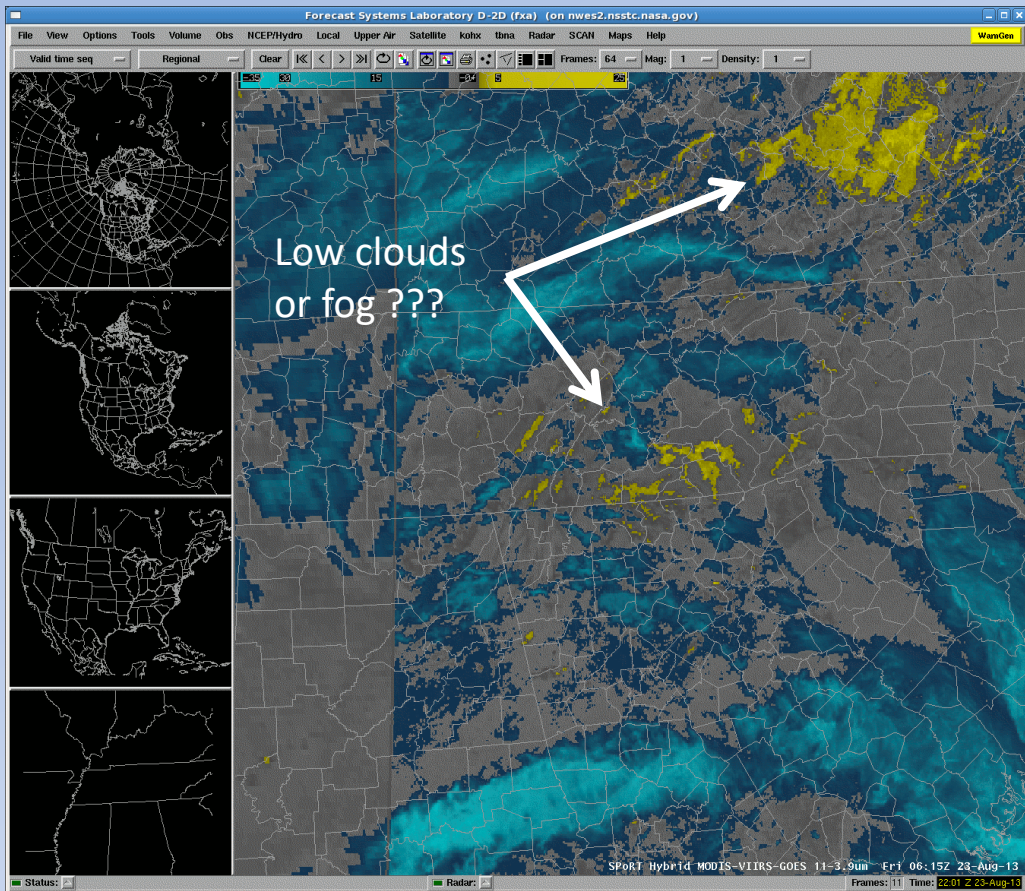
Tech Report 2011:
Airport Wx Conditions

- 40% of all accidents wx related
 - **2/3 of these are Low Ceiling and Fog**

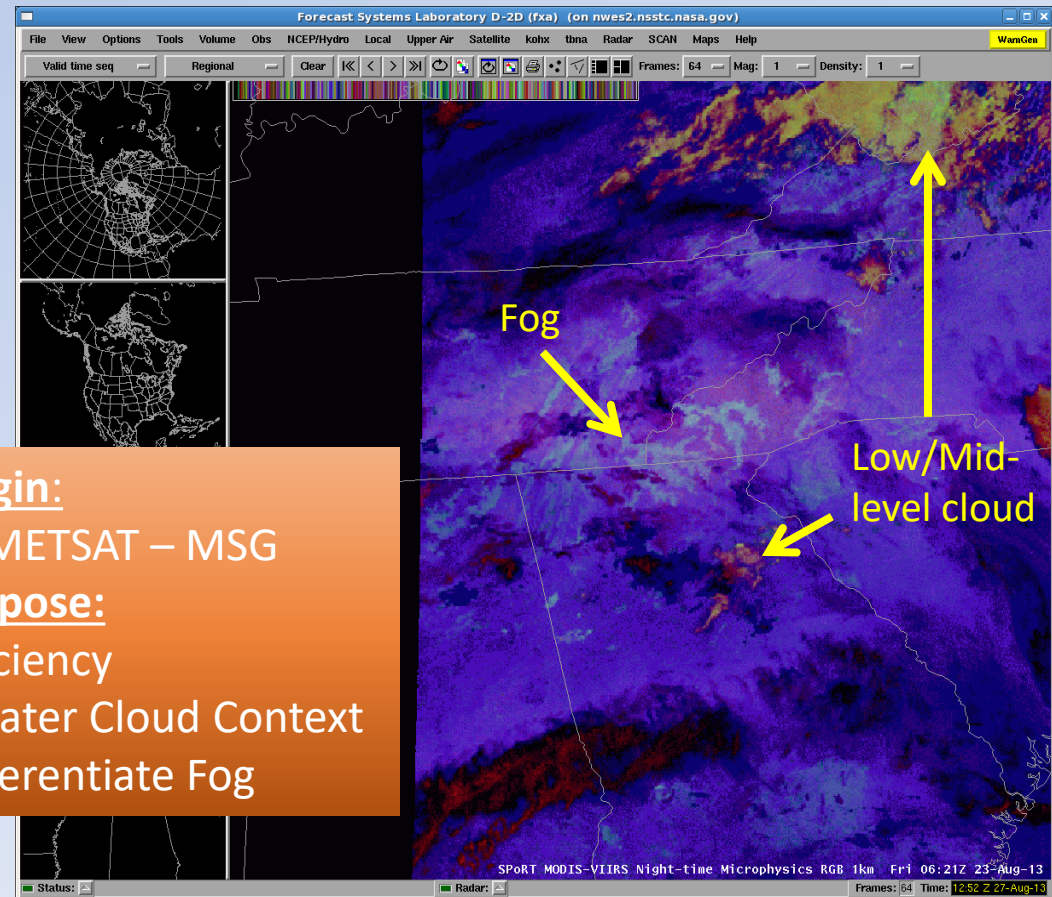


NtMicro RGB Origin and Purpose; NASA Proxy

Legacy Diff Product GOES



Nighttime Microphysics RGB (MODIS, VIIRS)



Origin:
 EUMETSAT – MSG
Purpose:
 Efficiency
 Greater Cloud Context
 Differentiate Fog

Transition Method & Experience

Insights *(your winning recipe):*

- Understandable Guidance
- Local Advocate
- Integrated Access

Doug: *“We like to look at products that we understand, that are easy to interpret, and are easy to access.”*

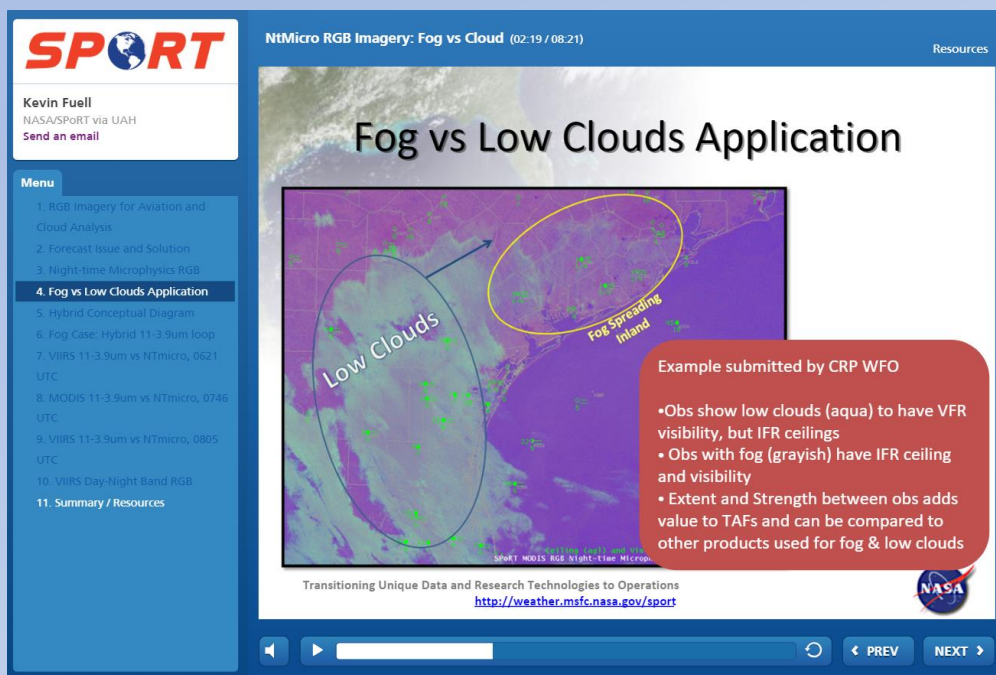
Use of NASA LEO capability to prepare for GOES ABI:

- *How does one know that the early prototype was beneficial vs just waiting for the GOES version of the product and eventual popularity?*

Training in Short Form, then QG

Microlesson
(<10 minutes, complement, details)

Quick Guide
(tool, reference)



SPoRT NtMicro RGB Imagery: Fog vs Cloud (02:19 / 08:21) Resources

Kevin Fuell
NASA/SPoRT via UAH
Send an email

Menu

1. RGB Imagery for Aviation and Cloud Analysis
2. Forecast Issue and Solution
3. Night-time Microphysics RGB
4. Fog vs Low Clouds Application
5. Hybrid Conceptual Diagram
6. Fog Case: Hybrid 11-3.9um loop
7. VIIRS 11-3.9um vs NtMicro, 0621 UTC
8. MODIS 11-3.9um vs NtMicro, 0746 UTC
9. VIIRS 11-3.9um vs NtMicro, 0805 UTC
10. VIIRS Day-Night Band RGB
11. Summary / Resources

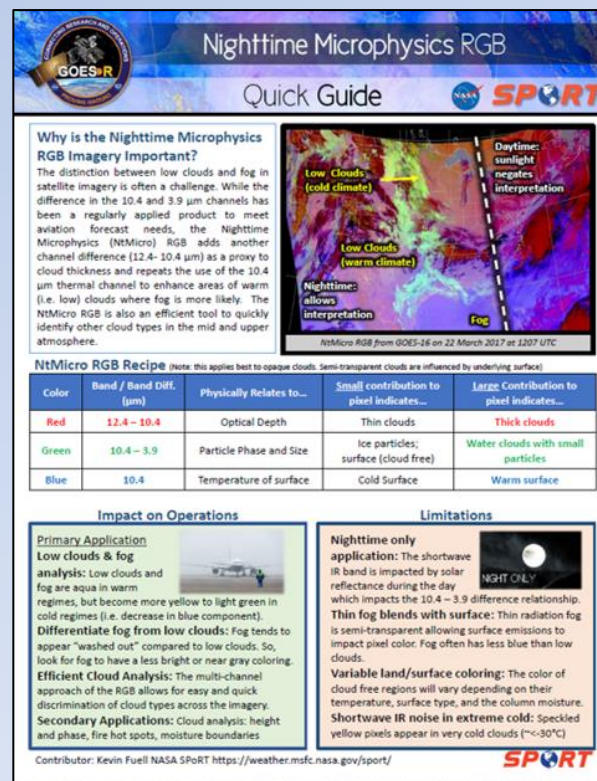
Fog vs Low Clouds Application

Example submitted by CRP WFO

- Obs show low clouds (aqua) to have VFR visibility, but IFR ceilings
- Obs with fog (grayish) have IFR ceiling and visibility
- Extent and Strength between obs adds value to TAFs and can be compared to other products used for fog & low clouds

Transiting Unique Data and Research Technologies to Operations
<http://weather.mfc.nasa.gov/spoort>

2013



Nighttime Microphysics RGB Quick Guide

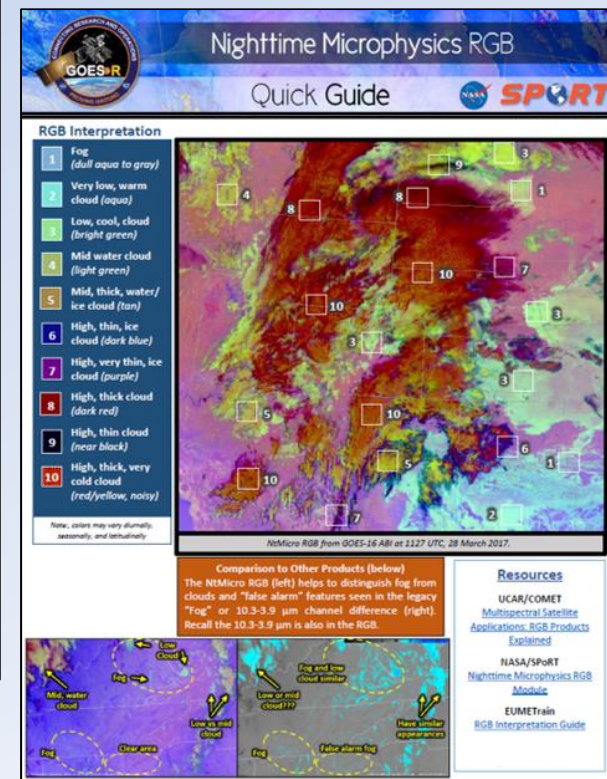
Why is the Nighttime Microphysics RGB Imagery Important?
The distinction between low clouds and fog in satellite imagery is often a challenge. While the difference in the 10.4 and 3.9 μm channels has been a regularly applied product to meet aviation forecast needs, the Nighttime Microphysics (NtMicro) RGB adds another channel difference (12.4 - 10.4 μm) as a proxy to cloud thickness and repeats the use of the 10.4 μm thermal channel to enhance areas of warm (i.e. low) clouds where fog is more likely. The NtMicro RGB is also an efficient tool to quickly identify other cloud types in the mid and upper atmosphere.

NtMicro RGB Recipe (Note: this applies best to opaque clouds. Semi-transparent clouds are influenced by underlying surface)

Color	Band / Band Diff. (μm)	Physically Relates to...	Small contribution to pixel indicates...	Large Contribution to pixel indicates...
Red	12.4 - 10.4	Optical Depth	Thin clouds	Thick clouds
Green	10.4 - 3.9	Particle Phase and Size	Ice particles; surface (cloud free)	Water clouds with small particles
Blue	10.4	Temperature of surface	Cold Surface	Warm surface

Impact on Operations
Primary Application
Low clouds & fog analysis: Low clouds and fog are aqua in warm regimes, but become more yellow to light green in cold regimes (i.e. decrease in blue component).
Differentiate fog from low clouds: Fog tends to appear "washed out" compared to low clouds. So, look for fog to have a less bright or near gray coloring.
Efficient Cloud Analysis: The multi-channel approach of the RGB allows for easy and quick discrimination of cloud types across the imagery.
Secondary Applications: Cloud analysis: height and phase, fire hot spots, moisture boundaries

Limitations
Nighttime only application: The shortwave IR band is impacted by solar reflectance during the day which impacts the 10.4 - 3.9 difference relationship.
Thin fog blends with surface: Thin radiation fog is semi-transparent allowing surface emissions to impact pixel color. Fog often has less blue than low clouds.
Variable land/surface coloring: The color of cloud free regions will vary depending on their temperature, surface type, and the column moisture.
Shortwave IR noise in extreme cold: Speckled yellow pixels appear in very cold clouds ($\sim -30^{\circ}\text{C}$)



Nighttime Microphysics RGB Quick Guide

RGB Interpretation

1. Fog (dull aqua to gray)
2. Very low, warm cloud (aqua)
3. Low, cool, cloud (bright green)
4. Mid water cloud (light green)
5. Mid, thick, water/ice cloud (tan)
6. High, thin, ice cloud (dark blue)
7. High, very thin, ice cloud (purple)
8. High, thick cloud (dark red)
9. High, thin cloud (near black)
10. High, thick, very cold cloud (red/yellow, noisy)

Note: colors may vary diurnally, seasonally, and latitudinally.

Comparison to Other Products (below)
The NtMicro RGB (left) helps to distinguish fog from clouds and "false alarm" features seen in the legacy "Fog" or 10.3-3.9 μm channel difference (right). Recall the 10.3-3.9 μm is also in the RGB.

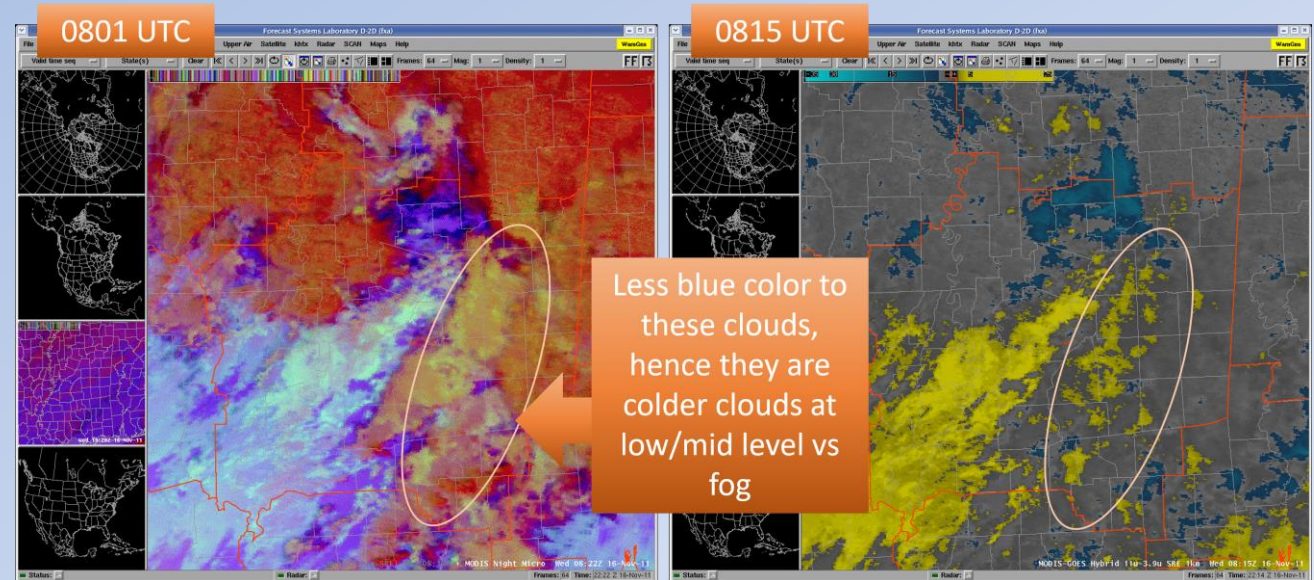
Resources
UCAR/COMET
Multispectral Satellite Applications: RGB Products Explained
NASA/SPoRT
Nighttime Microphysics RGB Module
EUMETrain
RGB Interpretation Guide

2011 – Initial AWIPS Integration for Testing

Integrate RGB into Display System

From Operations:

- ‘So much data available ... limited time’
- ‘For new products, hard to break through the habit ... and routine’



Umut Çolak, Public domain, via Wikimedia Commons

Advocate: Peer-to-Peer Sharing

- Demonstration of value
- Reminder of new product
- Trusted source
- Culture Change

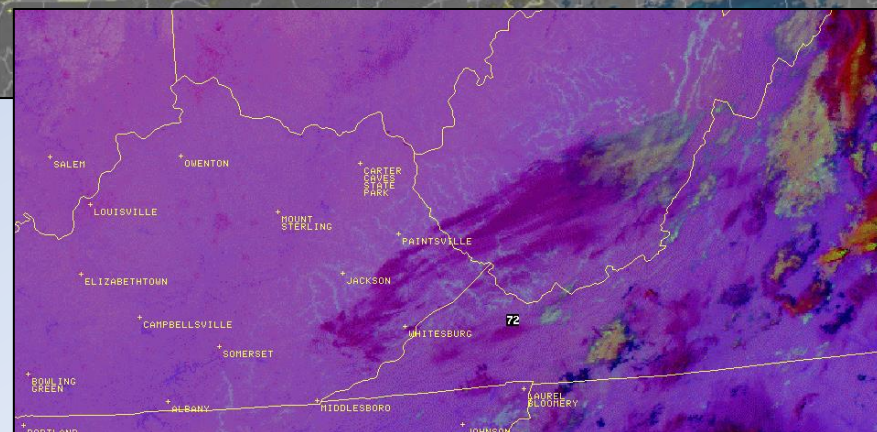
“For some forecasters, looking at NASA SPoRT products had become a regular part of their daily weather analysis routine, so the transition to new GOES-16 products was virtually seamless.”

MAY 16, 2012 BY WFOHUNKRIS

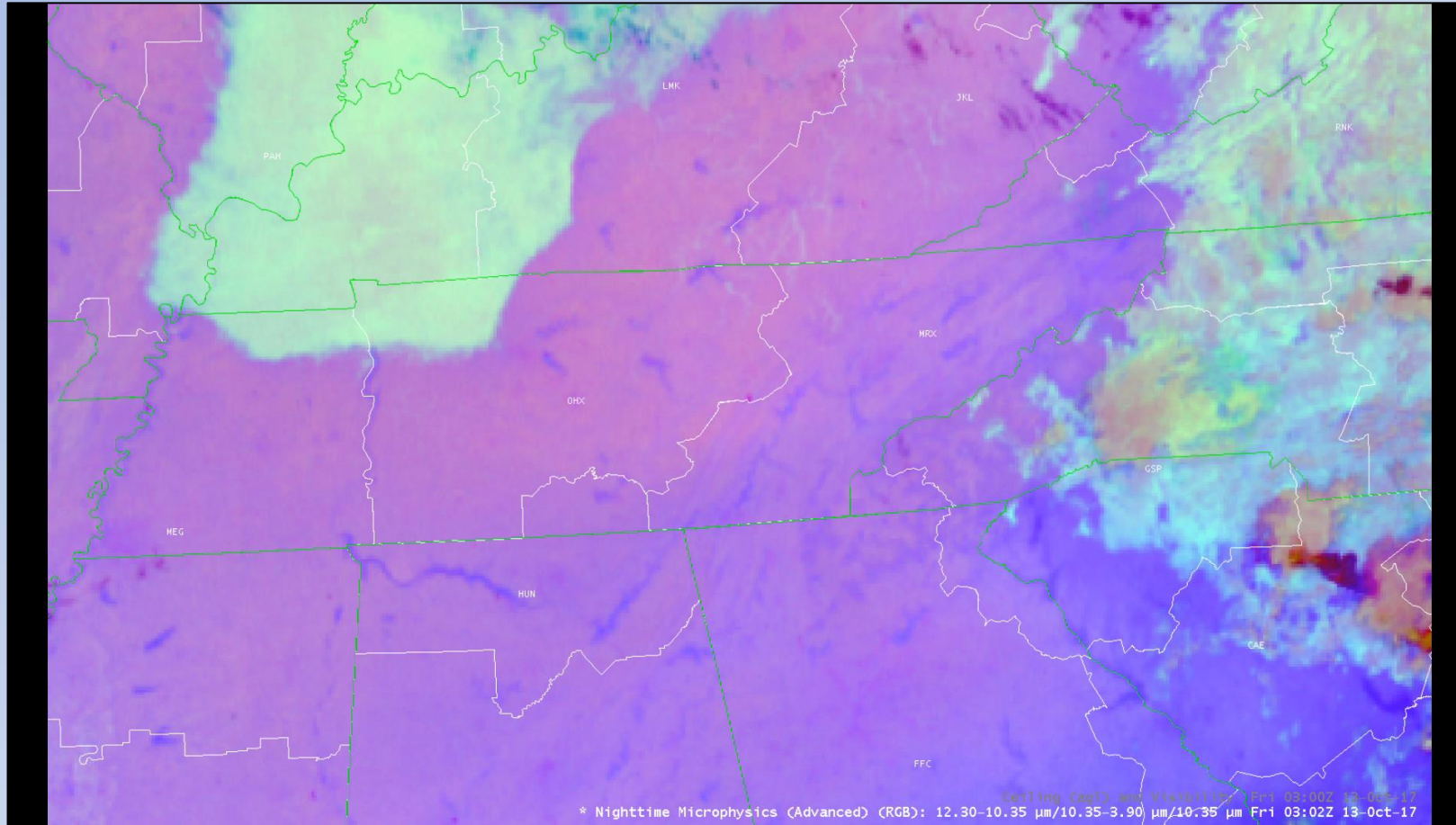
RGB Products Show Enhanced Utility for Fog Monitoring

It was a “typical” post-rain foggy morning for portions of the Appalachian region this morning. When looking at the suite of SPoRT satellite products this morning, I noticed the usual fog in the GOES and MODIS imagery, but what caught my attention was the early detection of fog by the Nighttime Microphysics RGB product. Image 1 below shows the GOES-MODIS 10.8-3.9 μm product currently created by SPoRT and available through the Southern Region LDM to collaborating offices.

2012 – SPoRT Blog:
Post by WFO HUN



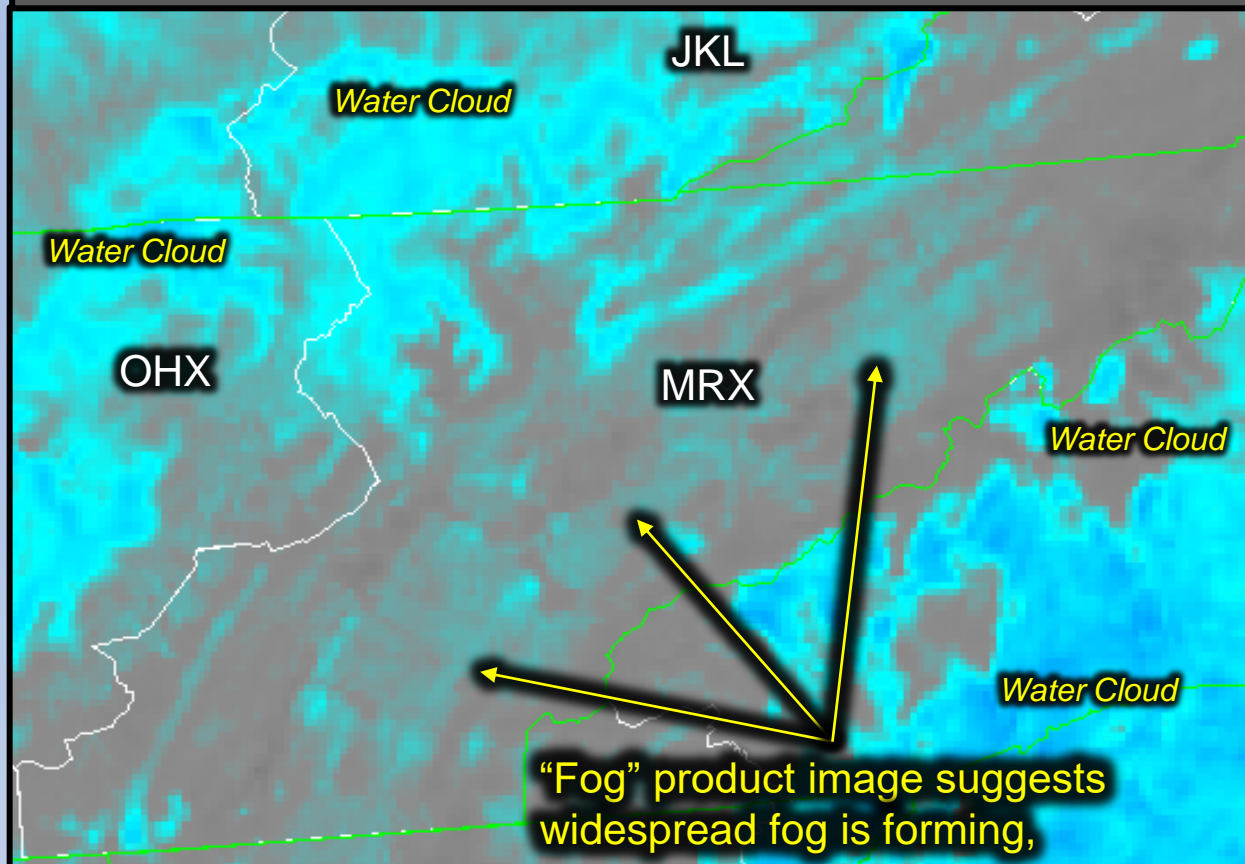
ABI Instrument Era: NtMicro RGB Events



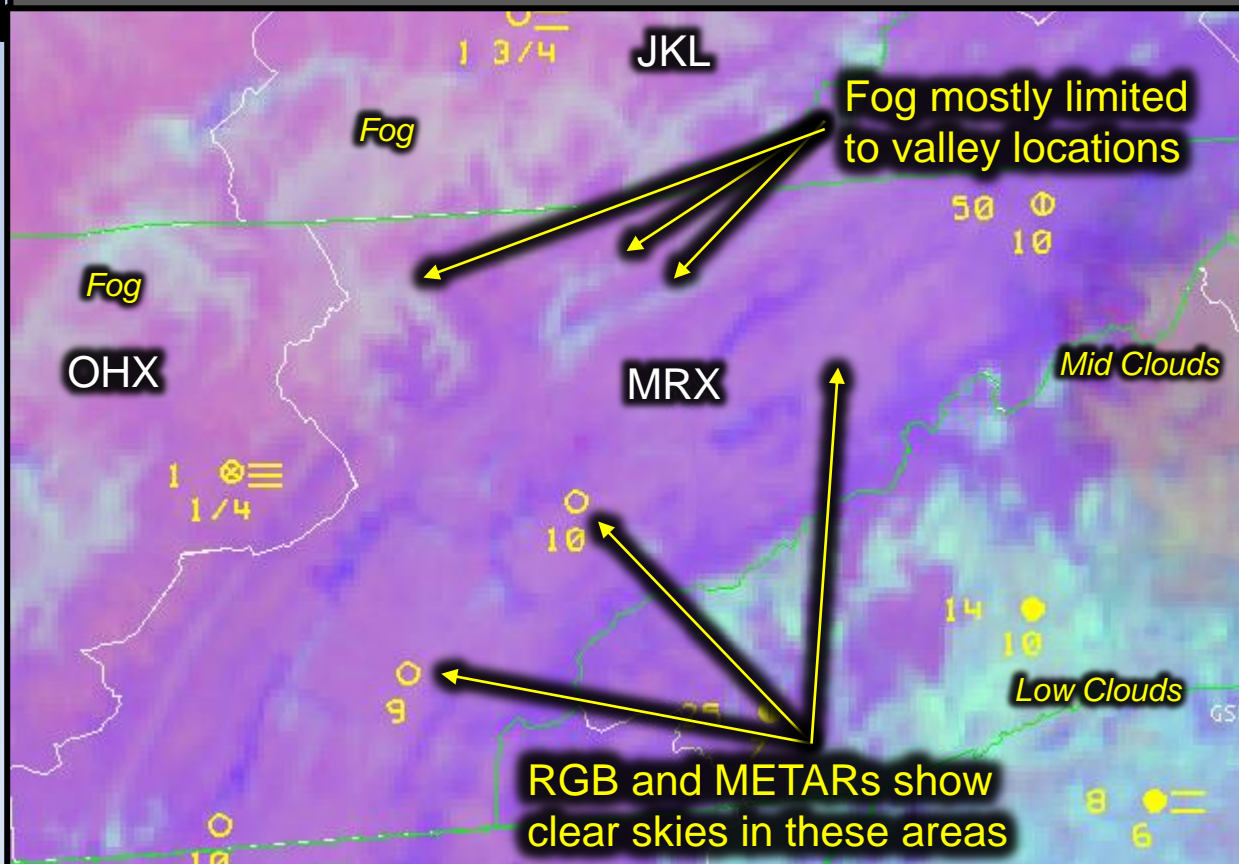
Example: Avoid 'False Alarm' Advisory at MRX

MRX Forecaster Feedback: "Using the NtMicro RGB actually helped me decide not to issue a dense fog advisory, due to the fog being isolated to water and valleys, while OHX and JKL did issue advisories."

10.3-3.9 μm Difference or "Fog" Product via GOES-R
at 0817 UTC, 13 October 2017



Nighttime Microphysics RGB via GOES-R, METAR Ceiling/Visibility
at 0817 UTC, 13 October 2017



State of NtMicro RGB today:

- Both NtMicro and Diff. products still used today
 - (Ever growing list of products)
- Given only one product allowed, ~70% choose the NtMicro RGB
- The other 30%: site 'ease', 'familiarity' with Diff. product
 - Missing out on false alarm value, context, and other applications



This image was acquired from [Pixabay](https://www.pixabay.com/). It was marked as Public Domain or CC0 and is free to use.

Future

Needs in NtMicro and other RGBs

- User Feedback: 'Blogs becoming outdated'
 - Would like 'video' or social media formats to showcase value
- Quick Guides = helpful,
 - Need better ways to keep these in front of users
- Products to complement
 - ML /AI

Research to Operations



Public Domain via Pexels

References

¹Capobianco G., Lee M.D. The Role of Weather in General Aviation Accidents: An Analysis of Causes, Contributing Factors and Issues. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* 2001;**45**:190–194.
doi: 10.1177/154193120104500241.

²*EUROCONTROL Algorithm to Describe Weather Conditions at European Airports.* Eurocontrol; Brussels, Belgium: 2011. Technical Report.