Development of RGB Composite Imagery for Operational Weather Forecasting Applications

[1]Andrew L. Molthan, [2]Kevin K. Fuell, [3]Hayden K. Oswald, and [4]John A. Knaff

[1]NASA Short-term Prediction Research and Transition (SPoRT) Center, NASA MSFC, Huntsville, Alabama, [2]University of Alabama Huntsville/SPoRT, Huntsville, Alabama
[3]University of Missouri/NASA Summer Intern Program, Columbia, Missouri, [4]NOAA/NESDIS Regional and Mesoscale Meteorology Branch, Fort Collins, Colorado

andrew.molthan@nasa.gov

What is an RGB Composite Image?

- Current and future satellite instruments provide remote sensing at a variety of wavelengths.
- RGB composite imagery assign individual wavelengths or channel differences to the intensities of the red, green, and blue components of a pixel color.
- Each red, green, and blue color intensity is related to physical properties within the final composite image.
- Final color assignments are therefore related to the characteristics of image pixels.
- Products may simplify the interpretation of data from multiple bands by displaying information in a single image.

Product Development

- Products shown here were generated based upon recipes developed by EUMETSAT.
- Each individual input channel or paired channel difference is assigned a series of thresholds for linear and gamma-factor image enhancement:

$$R,G,B = 255\left[\frac{\text{VALUE} - \text{MINIMUM}}{\text{MAXIMUM} - \text{MINIMUM}}\right]^{\frac{1}{\gamma}}$$

- Slight differences in temperature thresholds, brightness enhancements, and other characteristics are applied to account for differences in instruments.

Night Microphysics				
Color	Channels (μm)	MIN	MAX	GAMMA
R	12.0-10.8	-4 K	+2 K	1.0
G	10.8-3.9	0 K	+10 K	1.0
B	10.8	243 K	293 K	1.0

Table 1. Recipe for construction of the Night Microphysics product designed by EUMETSAT, based upon their Best Practices for Display of RGB Images documentation.

An Example of RGB Construction

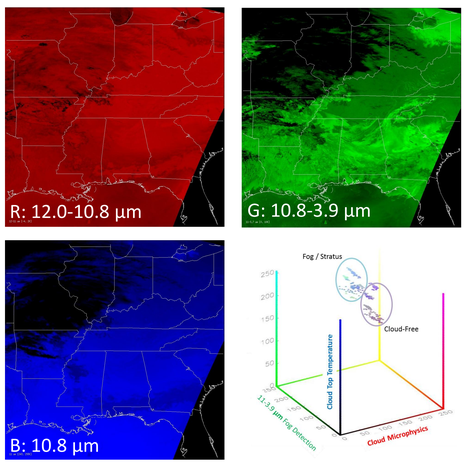

Figure 1. An example of the red, green, and blue color inputs to the Nighttime Microphysics product derived from MODIS based upon EUMETSAT guidelines and separation of features by color.

MODIS Night Microphysics Composite

- The EUMETSAT Night Microphysics product was originally designed for the SEVIRI instrument but can also be applied to similar bands available from MODIS.
- This product allows for color separation of fog and low stratus from other cloud types and bare land or open water features. Input components for this product and color separation characteristics are shown in Figure 1.
- The multispectral image combines four channels of data (Table 1) into vibrant colors that discriminate low clouds from other features.
- Low clouds and fog in characteristic blue shades correspond to reports of low visibility.

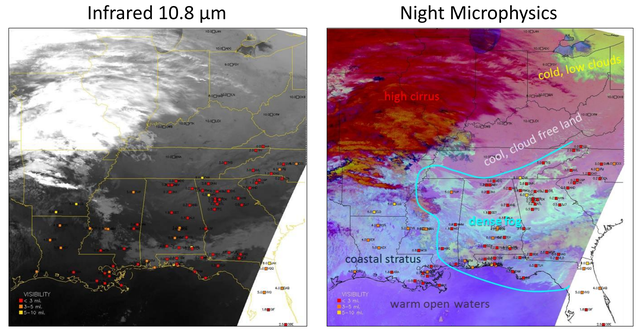

Figure 2. Comparison of single channel infrared data and RGB Night Microphysics imagery for a fog event at 0815 UTC on 24 November 2010. Data were acquired from Aqua MODIS processed according to EUMETSAT guidelines.

MODIS Air Mass Composite

- The EUMETSAT Air Mass product can also be generated from MODIS.
- Color separation helps to identify the temperature and moisture characteristics of various air masses which are in turn related to various synoptic-scale features.
- In the image below, a single channel water vapor image is compared to the air mass composite. Vibrant colors in the air mass product correspond to synoptic-scale features and air mass characteristics as the storm progressed eastward.
- Fields from available RUC analysis were used to confirm synoptic-scale features evident in the water vapor image and their relationship to the air mass imagery.
- The upper level vorticity maximum, jet streak, and thermal ridge are apparent.

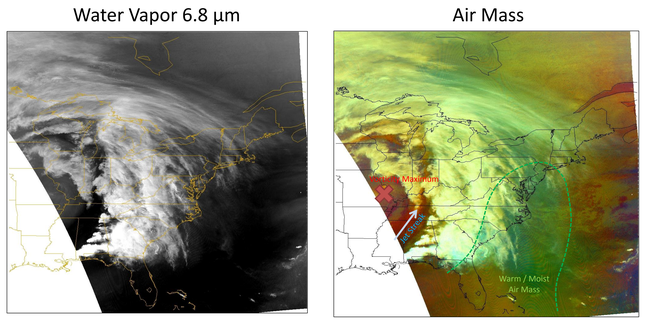

Figure 3. Comparison of single channel water vapor imagery and multispectral RGB air mass imagery for a severe weather event occurring across the southeastern United States at 0315 UTC on 16 April 2011. Data were acquired from the MODIS instrument aboard the Aqua satellite and processed according to EUMETSAT guidelines.

GOES Sounder Air Mass Composite

- Although the current GOES East and West imagers lack some of the spectral bands required to produce an air mass image, the GOES Sounder can be used to produce capabilities expected from the GOES-R Advanced Baseline Imager.
- CIRA has developed a technique to produce the air mass product from the GOES Sounder, with hourly updates of imagery across the United States.
- In the image below, the CIRA GOES Sounder RGB Air Mass product provides continuity to the MODIS imagery by relating color to synoptic-scale features.

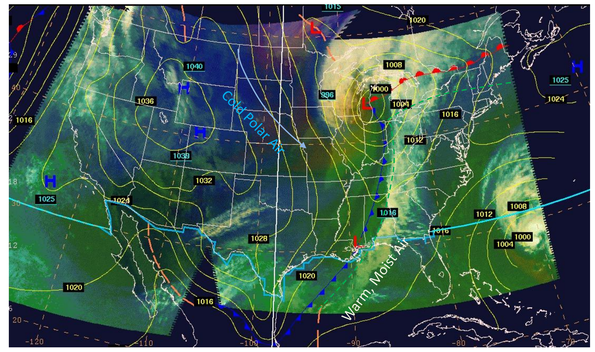

Figure 4. Air Mass multispectral RGB imagery developed by CIRA based upon channels available on the GOES Sounder. In this case, a midlatitude cyclone was moving through the Upper Midwest on November 9, 2011, with various shades depicting cloud cover, moisture, and cold air moving in behind the cold front. Synoptic features and isobars provided by the NOAA/NCEP Hydrometeorological Prediction Center.

SEVIRI Multispectral Composites

- EUMETSAT produces RGB composite imagery in real-time from the SEVIRI instrument aboard Meteosat-9. SPoRT produces equivalent imagery from NESDIS data.
- SEVIRI products can be used to monitor the Atlantic basin, with multiple products helping to confirm features based upon multispectral characteristics.
- Clear skies in the natural color image correspond to regions of subsidence and lofted dust, precluding the widespread development of convection.
- The multispectral composites in each product each provide a unique depiction of the ongoing weather and cloud features, useful in image interpretation.

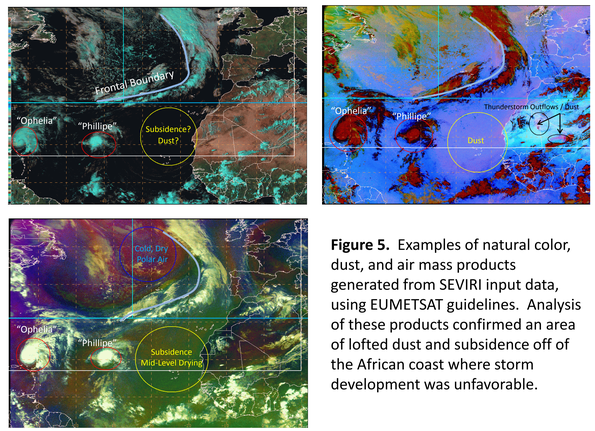

Figure 5. Examples of natural color, dust, and air mass products generated from SEVIRI input data, using EUMETSAT guidelines. Analysis of these products confirmed an area of lofted dust and subsidence off of the African coast where storm development was unfavorable.

Applications in the GOES-R Proving Ground

- Although RGB composite imagery are 24-bit, current AWIPS and NAWIPS systems do not support their display.
- SPoRT has developed a technique to display these images in AWIPS and NAWIPS by quantizing each to the number of colors displayable with each system: 254 for AWIPS, 95 for NAWIPS.
- Images are provided to NOAA/NWS WFOs and NOAA/NCEP National Centers participating in the GOES-R Proving Ground.
- These products are evaluated by duty forecasters with responses provided to algorithm developers at SPoRT and CIRA in order to improve the products prior to their possible availability in the GOES-R era.

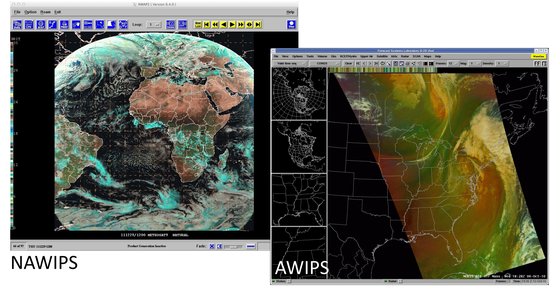

Figure 6. Examples of SEVIRI natural color product displayed in the current version of NAWIPS, and example of a MODIS air mass product displayed in AWIPS. These systems are used at NOAA/NWS Weather Forecast Offices and National Centers to integrate various data sets.

Summary and Future Work

- The launch of NPP provides additional observations from VIIRS, which is similar to MODIS and will provide additional composites:

Product	Instruments	Purpose
Air Mass	SEVIRI, MODIS, GOES Sounder	Air mass type discrimination
Dust	SEVIRI, MODIS, VIIRS	Blowing or suspended dust
Night Microphysics	SEVIRI, MODIS, VIIRS	Fog and low clouds
Day Microphysics	SEVIRI, MODIS, VIIRS	Fog and low clouds
Day Snow/Fog	SEVIRI, MODIS, VIIRS	Fog, low clouds, and snow
Daytime Storms	SEVIRI, MODIS, VIIRS	Identifies convective storms
Natural Color	SEVIRI, MODIS, VIIRS	Approximates a true color image
True Color	MODIS, VIIRS	True color, photograph image
False Color Snow	MODIS, VIIRS	Discriminate clouds from snow

Table 2. RGB composites expected from sensors currently in orbit.

- Interactions with forecasters, algorithm developers at CIRA, and discussions with EUMETSAT will continue to improve upon current products in advance of their potential availability from GOES-R.
- Additional forecaster feedback will be acquired to understand how to best apply these products to weather forecasting and analysis, with feedback implemented into future training materials.

Acknowledgements

This collaborative work is sponsored in part by the GOES-R Proving Ground Activity. The authors thank collaborators Michael Folmer (HPC) and Jack Beven (NHC) for providing examples of product usage at their respective NOAA Centers. Author Hayden Oswald was sponsored by the NASA Summer Intern Program at Marshall Space Flight Center in Huntsville, Alabama.