Current and Future Applications of Multispectral (RGB) Satellite Imagery for Weather Analysis and Forecasting

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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.

Current Products and Usage

- Collaborations between SPoRT, CIRA, and NRL have facilitated the use and evaluation of RGB products at a variety of NWS forecast offices and National Centers.
- **Table 1** provides a list of RGB products that have been developed by these groups and disseminated to end users for a variety of applications.

Product	Instruments	Purpose
Air Mass	SEVIRI, MODIS GOES Sounder	Discriminate between air mass types
Dust	SEVIRI, MODIS, VIIRS	Identify blowing or suspended dust
Fog and Low Clouds	SEVIRI, MODIS, VIIRS	Identify fog and low clouds
Natural Color	SEVIRI, MODIS, VIIRS	Smoke, burn scars, and fires
True Color	MODIS, VIIRS	True color, photograph image
False Color Snow	MODIS, VIIRS	Discriminates clouds from snow
Passive Microwave	DMSP via SSMI and SSMI/S TRMM	Tropical cyclone characteristics Midlatitude cyclones and precipitation
Day-Night Band	DMSP and VIIRS	Visible (moonlit) imagery provides cloud texture and city lights

Table 1. Brief list of RGB satellite products evaluated within the operational forecasting environment, the instruments currently used in their production, and likely applications.

- Forecasters provide feedback to product developers at SPoRT, CIRA, and NRL through a variety of interactions.
- SPoRT has established targeted evaluation periods with partnering forecast offices to acquire feedback that relates to product tuning or display characteristics within AWIPS.
- Other assessment activities have included GOES-R and JPSS Proving Ground interactions at NWS National Centers (**Figure 1**).
- Products are used within operations and occasionally cited within Area Forecast Discussions or other publically released products.

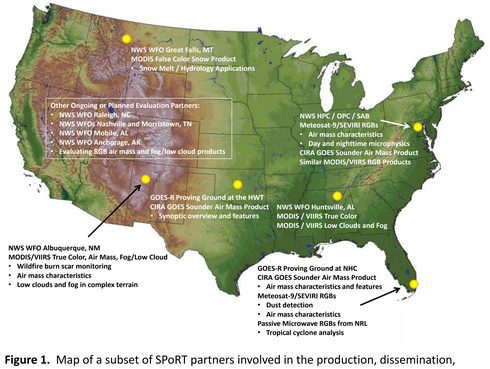

Figure 1. Map of a subset of SPoRT partners involved in the production, dissemination, and evaluation of multispectral satellite products in weather forecasting operations. Several other offices (not shown) participate in product evaluations with CIMSS and CIRA.

Product Examples and Usage

- Several products are being disseminated for test and evaluation by NOAA/NWS field offices and National Centers as part of NOAA's GOES-R and Joint Polar Satellite System (JPSS) Proving Grounds.
- SPoRT has partnered with the Naval Research Laboratory in Monterrey, CA to transition popular passive microwave composites to N-AWIPS for use at the National Hurricane Center and the Hydrometeorological Prediction Center.

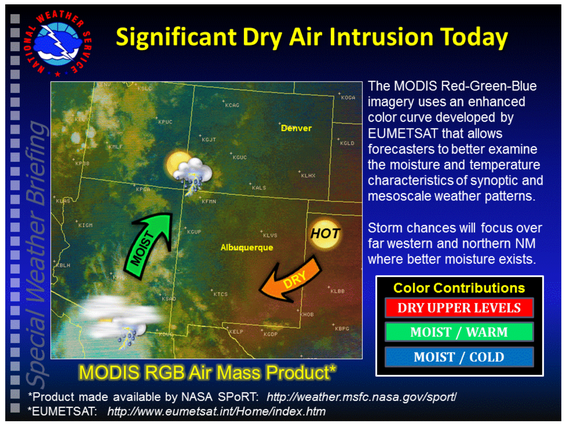

Figure 2. Example of the MODIS RGB Air Mass Product used to identify hot, dry air associated with a long-term heat wave over the Southern Plains, versus monsoon flow and moisture into Arizona and New Mexico. Example produced by the National Weather Service forecast office in Albuquerque, NM.

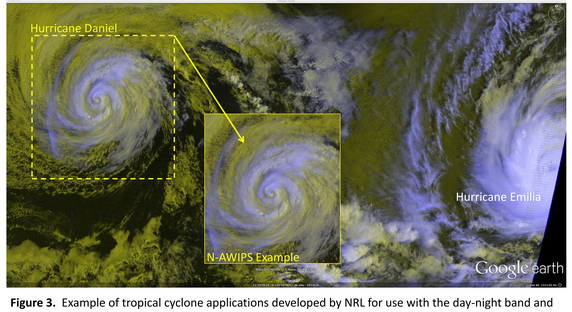

Figure 3. Example of tropical cyclone applications developed by NRL for use with the day-night band and infrared cloud top temperature band of VIIRS. Low level clouds stand out as yellow due to day-night band reflectance while high level clouds are shaded blue due to their cooler cloud-top temperature. The inset panel for Daniel provides an example of what the product would look like when colors are quantized for display within the N-AWIPS system used at the National Hurricane Center.

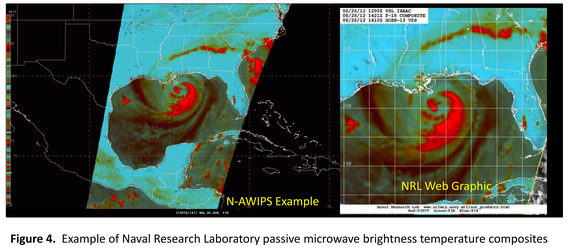

Figure 4. Example of Naval Research Laboratory passive microwave brightness temperature composites provided by NRL and SPoRT via N-AWIPS (left) versus current, popular web graphics (right) for Tropical Storm Isaac prior to landfall near New Orleans, LA. Image acquired at 1421 UTC on August 28, 2012.

- Training provided through SPoRT training modules, forecaster "quick guides", conference presentations , discussions with developers at CIRA, and materials developed by the satellite community.
- Feedback is provided through informal discussion or more formalized product surveys, in addition to operational use cases provided through GOES-R and SPoRT partner blog entries.

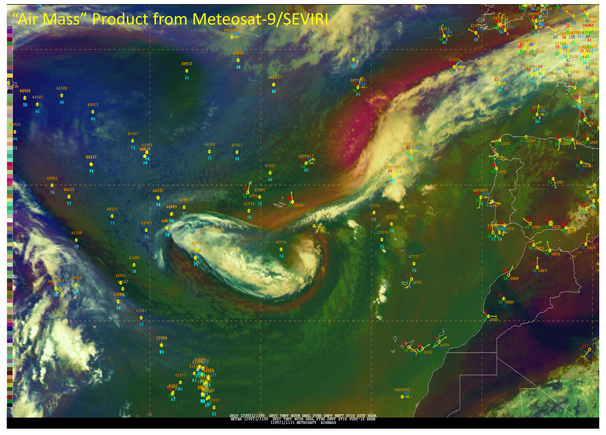

Figure 5. Example of the Meteosat-9/SEVIRI air mass product used to analyze the extratropical transition of Tropical Storm Nadine. Colors emphasize the possible intrusion of dry air and mid and upper levels (reds) near the cyclone in addition to interactions with a midlatitude cyclone to the northeast. Example and analysis provided by Michael Folmer (GOES-R/HPC) and Michael Brennan (NHC) via the GOES-R Proving Ground blog developed for HPC, OPC, and SAB. The Meteosat-9/SEVIRI Air Mass product was originally developed for Google Earth applications by CIRA and transitioned to use in N-AWIPS in collaboration with SPoRT.

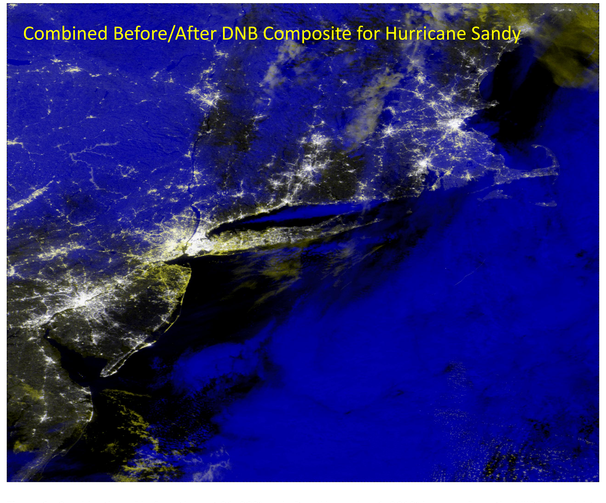

Figure 6. Combination of before (August 31, 202) and after (November 1, 2012) imagery from the VIIRS day-night band used to identify missing or reduced light emissions following the landfall of Hurricane (then Superstorm) Sandy. In this combination, the before-event imagery are placed in the red and green color intensities and the after-event imagery in the blue intensity. Reduced lights or cloud cover between August 31 and November 1 appear in shades of yellow whereas clouds from Sandy appear in blue. Lights in both images are white.

Future Challenges, Directions and Opportunities

- Examples demonstrate that multispectral (RGB) composite satellite imagery may offer some new applications using current satellite observations and those expected from future instruments such as GOES-R and JPSS.
- AWIPS and N-AWIPS cannot currently display 24-bit RGB imagery. New capabilities could be developed for AWIPS II and the National Centers perspective.
- These capabilities likely include:, but may not be limited to the following:

- Display of the 24-bit color resulting from the RGB triplet at each pixel.
- The ability to load pre-defined RGB composites as a "product baseline"
- Permitting minor adjustments or enhancements to product recipes.
- Enhancement techniques, such as histogram equalization or multiple segments of linear stretching.
- Expansion to 32-bit imagery via an alpha channel or transparency layer that includes the combination of satellite imagery and/or quantitative products.

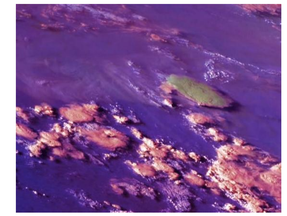

Figure 7. An example of a blend of a 24-bit RGB product (convective storms) and visible imagery for texture (32-bit), for fire-induced convection in Russia. Image courtesy of EUMETSAT, Zdenek Charvat and Daniel Lindsey of CIRA.

Data Dissemination Strategies

- As new satellites are launched and come online, they provide a tremendous increase in data volume distributed to operational centers in addition to continued increases in model output and availability of additional radar products.
- Some, but not all satellite platforms or channels are included as baseline products. Some RGB products may require the inclusion of an additional band , or several bands, that are outside of the baseline.
- In terms of efficient data distribution, there are several options that can be discussed and debated, ranging from dissemination of all required (missing) bands and production of the final product at the forecaster workstation to construction of products by a provider and shipment of a single file. Some options are outlined below.

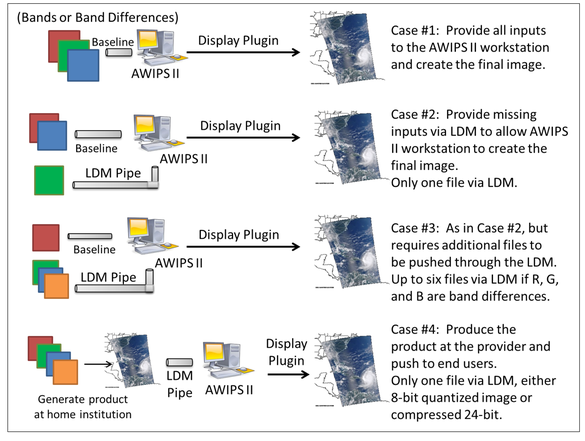

Figure 8. Possible options for disseminating the required inputs for final RGB composite products, ranging from the dissemination of all required bands via the baseline to dissemination of a single, final product generated by the data provider. Each dissemination option offers various strengths and weaknesses that will need to be discussed at a programmatic level among developers and users as these products gain more traction within the operational forecasting environment.