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JPSS and GOES-R Multispectral Imagery Applications and Product Development at CIRA

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GOES-R/JPSS Poster Session I

Introduction

The **Visible Infrared Imaging Radiometer Suite (VIIRS)** is one of the five instruments on-board the **Joint Polar Satellite System (JPSS) Suomi National Polar-Orbiting Partnership (S-NPP)** satellite and will soon fly on the upcoming **JPSS** series of satellites.

VIIRS has

- **16 Moderate Resolution Channels** (M-Band; **750 m** resolution **at nadir**)
- **5 Imaging Resolution Channels** (I-Band; **375 m at nadir**) and
- **Day/Night Band** (DNB, **750 m across the scan**, nominal bandwidth from 500 to 900 nm), sensitive to the low levels of light that occur at night

covering the visible, near-IR, mid- and longwave IR portions of the electromagnetic spectrum (0.412 – 12.0 µm).

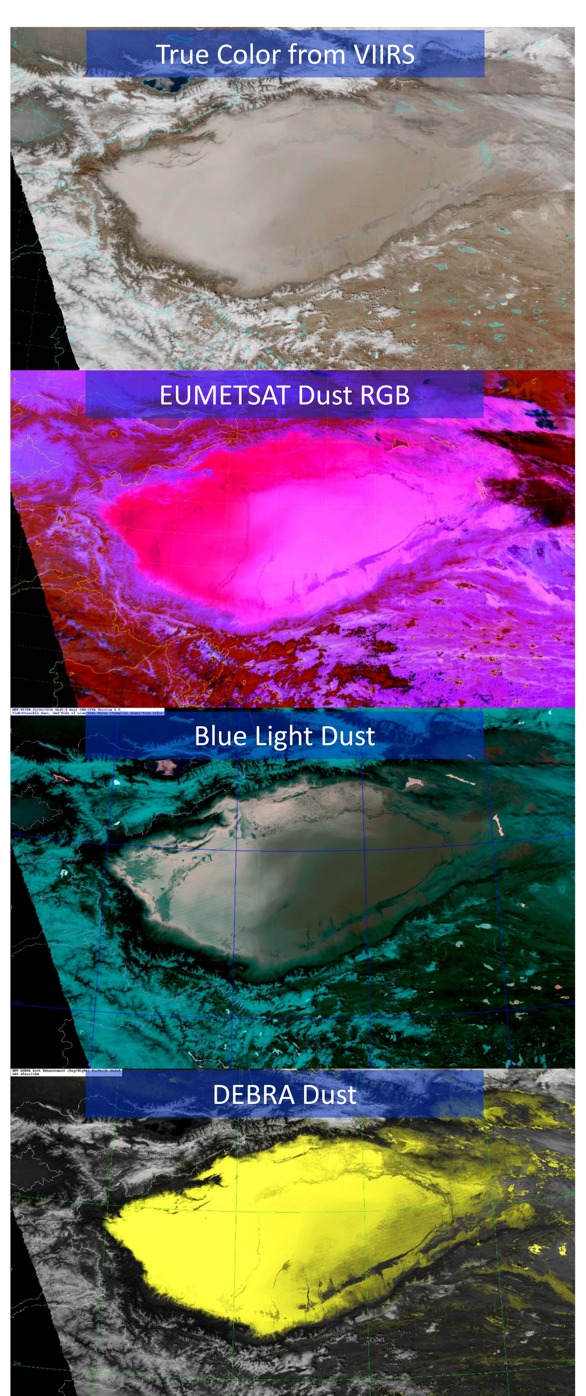
The **Advanced Baseline Imager (ABI)** is one of five instruments on-board the **GOES-R** series of satellites, which includes the recent successful launch of **GOES-16** and the upcoming **GOES-S**. Like the **Advanced Himawari Imager (AHI)** on-board the **Himawari-8/9** satellites, the **ABI** has 16 channels ranging from 0.46 µm to 13.3 µm, with spatial resolution from 500 m (red visible) to 2 km (mid- and longwave IR).

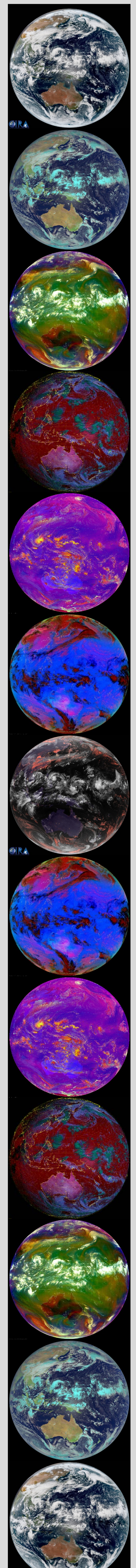
Spectrally speaking, **ABI** and **AHI** are similar to **VIIRS** with the addition of three water vapor bands and the longwave IR CO_2 band, although they lack the **Day/Night Band**. The multitude of spectral channels available to these instruments offer a wide variety of multi-spectral imagery applications and RGB composites useful for the detection of hazards (e.g. dust, volcanic ash, smog, fog, severe convection, fires and smoke) and rapid characterization of the environment (e.g. cloud phase, vegetation health, snow/ice coverage, flooding, fall foliage).

CIRA continues to develop new multi-spectral imagery products that make use of the vast amount of spectral information available on today's weather satellites. **VIIRS** and **AHI** have been used to demonstrate new capabilities of **GOES-R** and improve upon techniques for extracting valuable information from the latest generation of imagers.

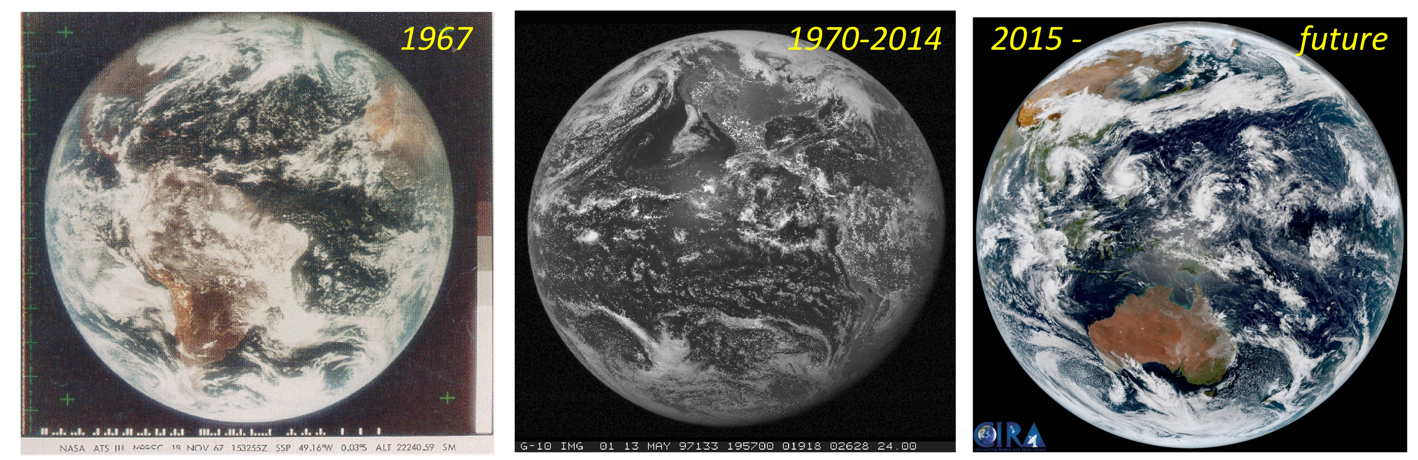
Dust Detection

- **True Color** is useful for detecting dust, although desert-like backgrounds pose a challenge due to a lack of contrast
- We have demonstrated EUMETSAT's **Dust** RGB on **VIIRS** and **AHI** and will do the same with **ABI**
  - Red: BTD (12.3 – 10.7 µm)
  - Green: BTD (10.3 – 8.6 µm)
  - Blue: BT 10.7 µm
- We have also developed two dust detection algorithms: **Blue Light Dust** and the **Dynamic Enhanced Background Reduction Algorithm (DEBRA) Dust**
- **Blue Light Dust** takes advantage of the fact that dust's scattering properties differ from clouds and dust layers are often cooler than the background surface
  - Uses 7 channels in the visible, near-IR and longwave IR
  - Output is an RGB using layer blending
- **DEBRA Dust** is *not* an RGB. This algorithm detects differences between the current scene and a clear-sky composite background to determine the likelihood that dust is present
  - The higher the confidence that dust is present, the more yellow the pixel
- The examples on the right show dust over the Takla Makan Desert in far western China as it appears in these imagery products applied to **VIIRS**
- **ABI** versions coming soon!



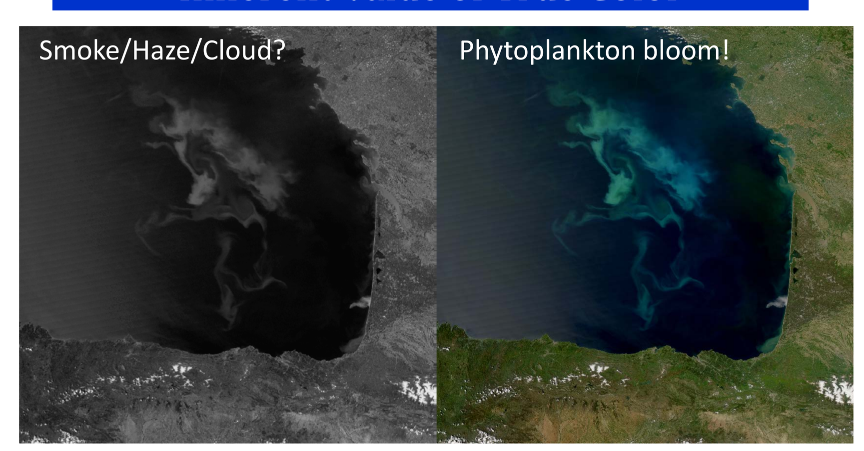


True Color: From Novelty to Operational Advantage

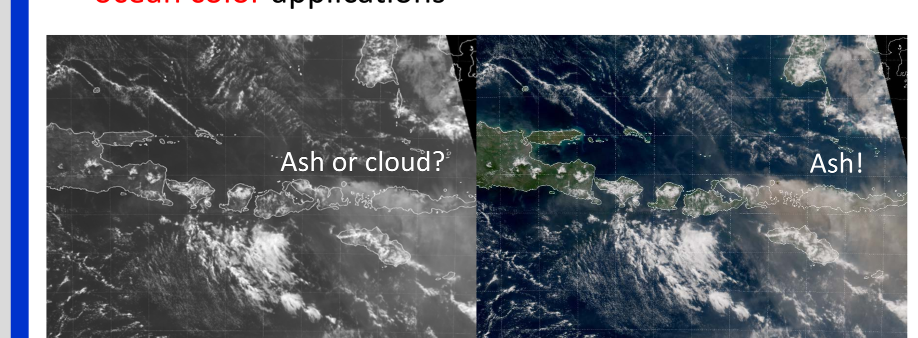


True Color capability (RGB composite of blue, green and red visible channels) first appeared on NASA's ATS-3 satellite in 1967. Seen as a novelty with no operational value, subsequent geostationary satellites only had a single (red) visible channel. The **AHI** on Himawari-8 has brought back **True Color** to the geostationary platform and demonstrated it's value. With the help of **VIIRS**, **CIRA** has developed improved **True Color** for **AHI (HAC)** and a synthetic version **(SHAC)** for **ABI**, which lacks a green-wavelength visible band.

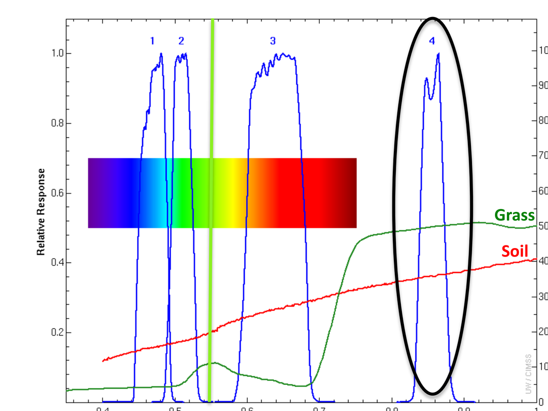
Inherent Value of True Color



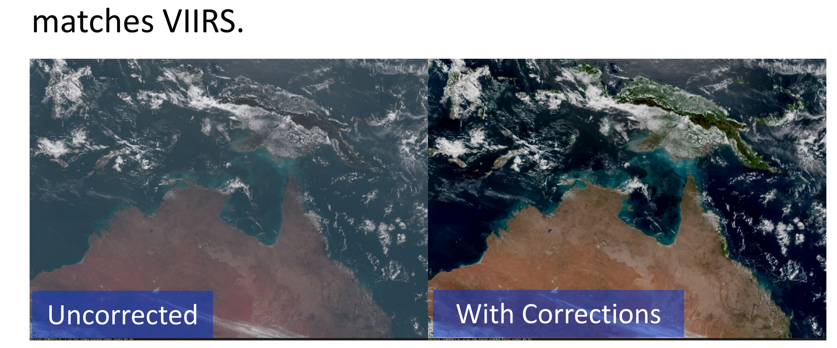
- **True Color** replicates the way the human eye responds to color
- It is the most intuitive of all RGB composites, with no training required
- Easy to distinguish dust, smoke, smog and volcanic ash from clouds and snow
- Can be used to monitor vegetation health and has ocean color applications



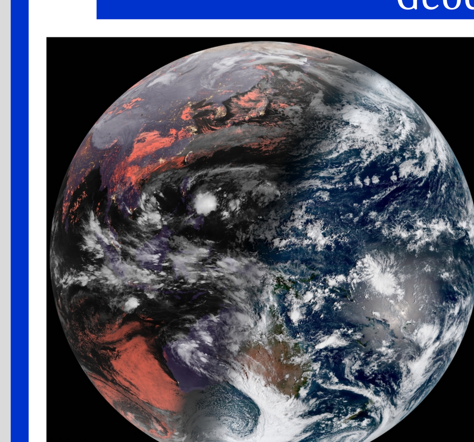
HAC True Color for AHI



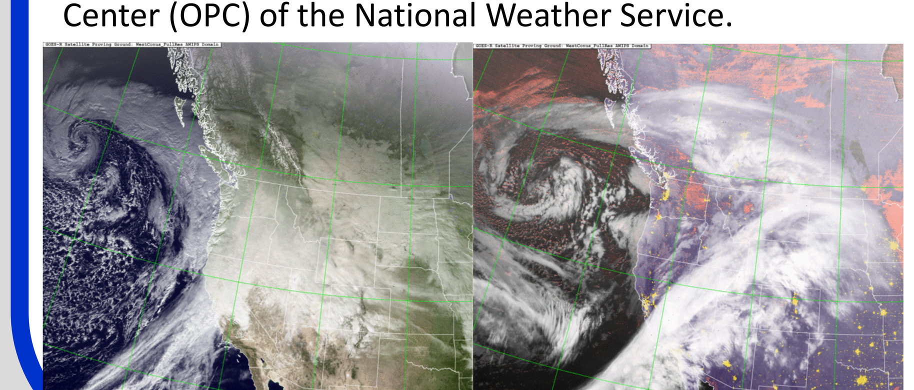
The green band (Ch. 2) on **AHI** is centered at 510 nm, which is offset from the peak chlorophyll reflectance at 555 nm as well as the green bands on **MODIS** (Ch. 4) and **VIIRS** (M-4). The offset also means that bare soil is less reflective in the **AHI** green. We combine the green band with the vegetation band (Ch. 4; 856 nm) into a "hybrid green" band and correct for Rayleigh scattering in all four bands to create **Hybrid, Atmospherically Corrected (HAC) True Color** that matches VIIRS.



Geocolor

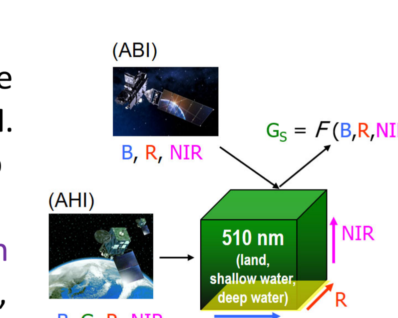


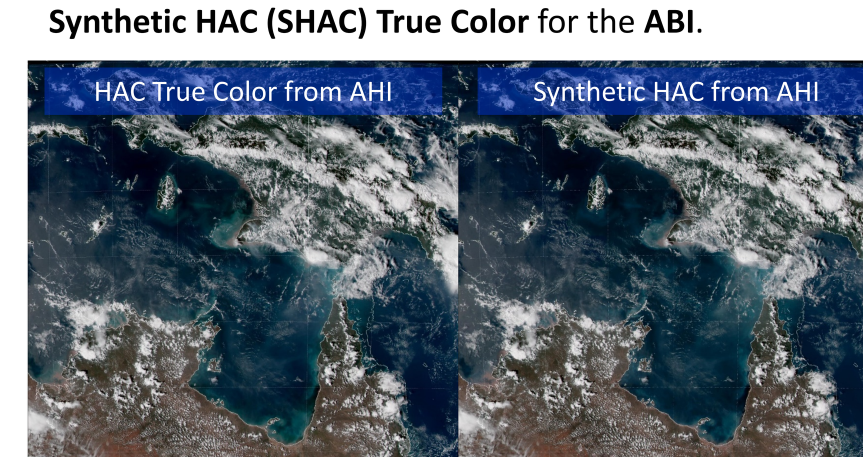
Geocolor blends True Color imagery during the day with a low cloud/fog detection product at night. Low clouds are highlighted in magenta at night. A city lights mask from the **VIIRS Day/Night Band** highlights population centers. This product has become very popular with forecasters at the Aviation Weather Center (AWC), Weather Prediction Center (WPC) and Ocean Prediction Center (OPC) of the National Weather Service.

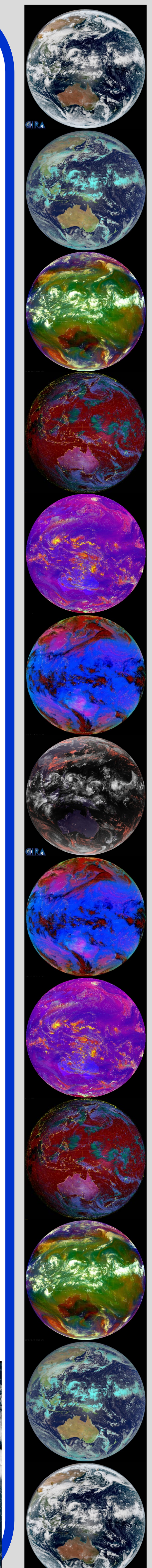


SHAC True Color for ABI

The **ABI** does not have a green visible band. But, we can synthesize it using **AHI**. By finding the relationship between the blue, green, red and near-IR vegetation bands for different scenes, we can predict what the green value should be given the observed values of blue, red and near-IR. Applying the same Rayleigh correction and using our "hybrid green" approach, we can create **Synthetic HAC (SHAC) True Color** for the **ABI**.



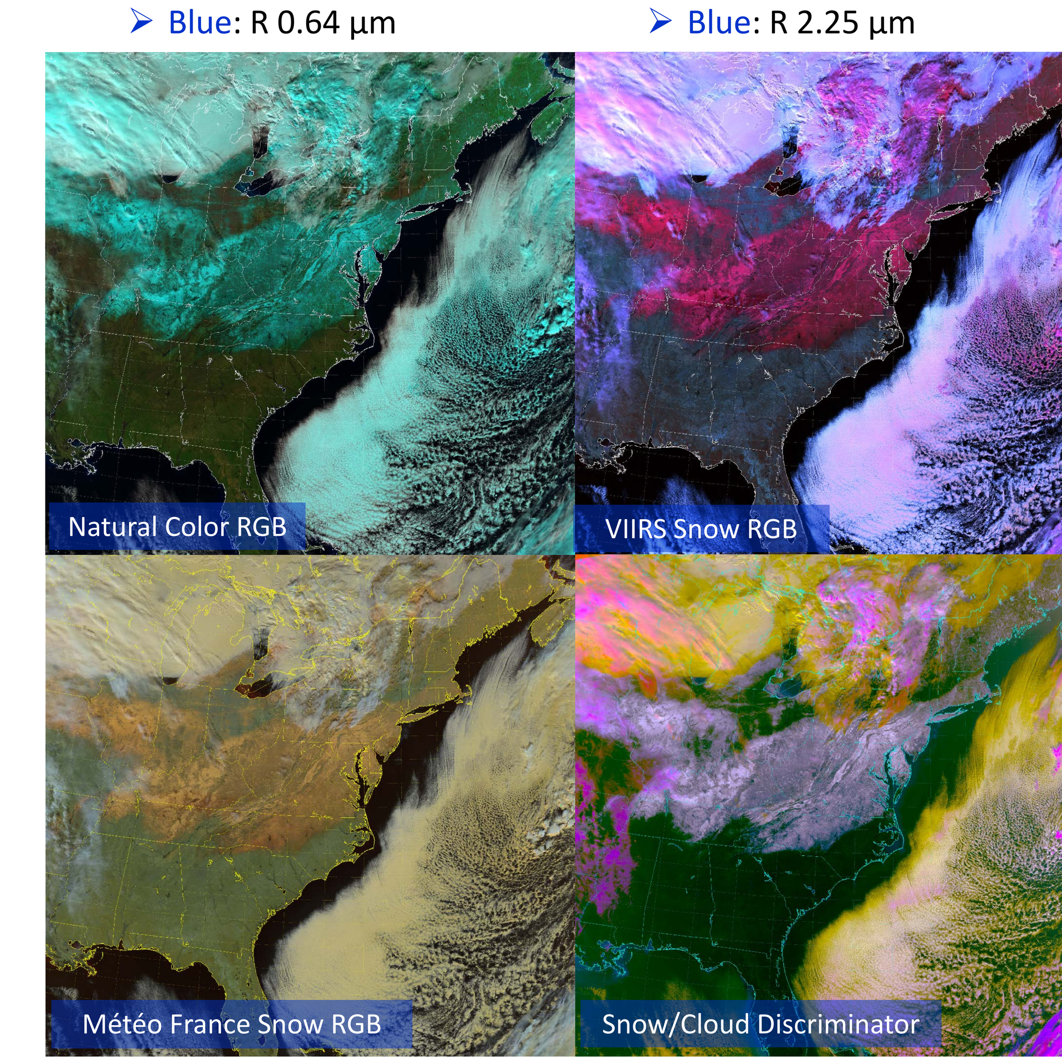




Discriminating Clouds, Snow and Ice

IR methods have difficulty detecting snow at night due to a lack of temperature contrast with the background and low clouds. Visible methods (True Color included) have difficulty since snow, clouds and ice all appear white. But, there are number of multi-spectral algorithms that may be used to discriminate clouds from snow and ice.

- The **Natural Color** RGB has long been used by EUMETSAT
  - Red: R 1.6 µm
  - Green: R 0.86 µm
  - Blue: R 0.64 µm
- We modified EUMETSAT's **Snow** RGB for **VIIRS**
  - Red: R 0.86 µm
  - Green: R 1.6 µm
  - Blue: R 2.25 µm



- Météo France modified EUMETSAT's **Snow** RGB for **VIIRS**
- Uses 5 bands (0.86 µm, 1.24 µm, 1.38 µm, 1.6 µm, 2.25 µm)
- Designed to improve upon the original RGB developed for **MSG SEVIRI**, which uses 0.86 µm, 1.6 µm and 3.9 µm

- We have developed a **Snow/Cloud Discriminator** that works day and night
- Uses 11 bands (7 day/4 night) including the **Day/Night Band**
- Snow is white, low clouds appear yellow, mid-level clouds appear orange and high clouds appear magenta

Fires and Hot Spots

VIIRS and the new generation GEO imagers (**AHI**, **ABI**, etc.) have additional bands in the near- and shortwave IR that can help with fire detection. Replacing the 1.6 µm band with the 2.25 µm band (or even 3.9 µm) makes the **Natural Color** RGB more sensitive to fires. As a result, we call it the **Natural Fire Color** RGB. The combination of 3.9 µm, 2.25 µm and 1.6 µm makes hot spots and fires appear red, orange, yellow or even white, depending on intensity and size. We call this the **Fire Temperature** RGB. Versions for **VIIRS** and **AHI** are available now with the **ABI** version coming soon!

On the Web

- Suomi NPP (National Polar-orbiting Partnership) **VIIRS** Imagery and Visualization Team Blog
  http://rammb.cira.colostate.edu/projects/npp/
- RAMSDIS Online Near-Realtime Imagery from **VIIRS**, **GOES**, **MODIS**, **MSG** and **Himawari**
  http://rammb.cira.colostate.edu/ramsdis/online/index.asp
- **Himawari** Loop of the Day Webpage
  http://rammb.cira.colostate.edu/ramsdis/online/loop_of_the_day/
- We also distribute products to **AWIPS-II**, and **N-AWIPS**!