AWIPS II Client-side RGB Product Generation in the GOES-R Era

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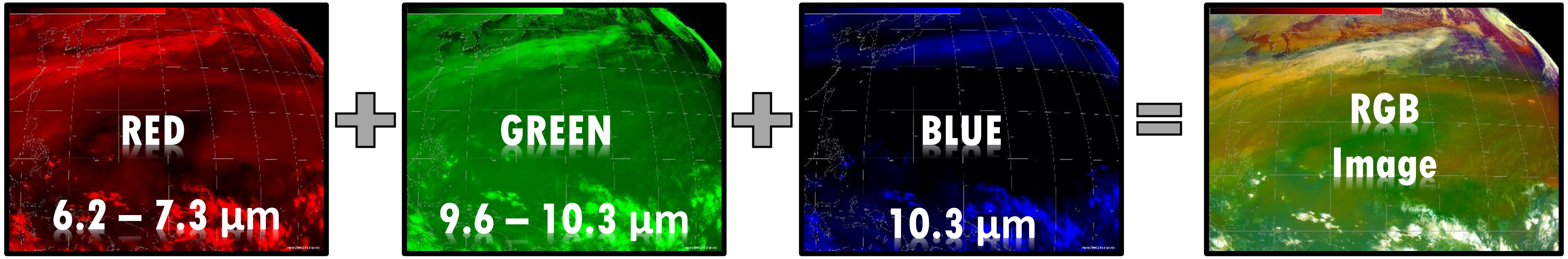
Goals and Motivation

- Develop framework for generating on-demand multispectral 24-bit Red-Green-Blue (RGB) products within the Advanced Weather Interactive Processing System II (AWIPS II) D2D Perspective
- Utilize GOES-16 Advanced Baseline Imager (ABI) channels already received and ingested at NWS forecast offices from NOAAPORT/Satellite Broadcast Network
- Greatly reduce processing latency and amount of disseminated data compared to pre-generating these products locally at NASA SPoRT
- Allow easy modification to existing product recipes or define new recipes
- Avoid modifying baseline AWIPS II code
- Products are only pre-generated as-needed for the AWIPS II National Centers Perspective

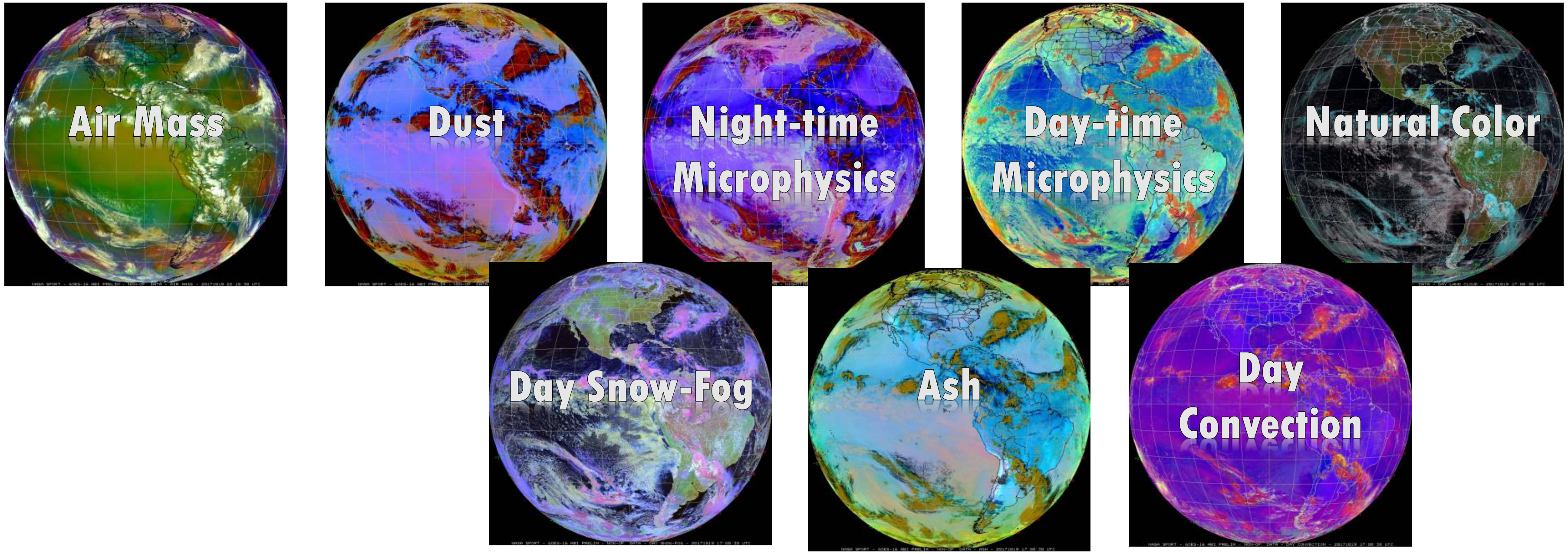
What is an RGB Composite?



- Multispectral or Red-Green-Blue (i.e., RGB) Composites are qualitative images designed to enhance a specific feature
  - Low clouds and fog
  - Dust
  - Convection
  - Air Mass characteristics
  - Fire Hot Spots
  - Snow/Ice
  - Cloud Phase
  - Volcanic Ash
- The 24-bit image is created by combining band or band differences into each of the Red, Green, and Blue components with a defined recipe
- The advantage of RGB products is the ability to look at a single image to identify a feature instead of analyzing multiple single channels

How are RGBs Created?

- In the early 2000s, EUMETSAT developed a set of RGB recipes or best practices following the launch of Meteosat Second Generation with the SEVIRI instrument onboard.



- This equation is used for the byte value conversion to store color intensity for each component over 8 bits (values of 0-255)

$$(R,G,B) = 255 * \left[\frac{(TB,\Delta TB,R,\Delta R) - MIN}{MAX - MIN}\right]^{\left(\frac{1}{\gamma R,G,B}\right)}$$

TB = Brightness Temperature
ΔTB = Brightness Temperature Difference
R = Reflectance
ΔR – Reflectance Difference
γ = Gamma Enhancement

AWIPS II to the Rescue

- Much easier to integrate experimental data products
- Plugin architecture lends to functionality expansion
- Derived Parameter framework offers ability to run Python functions
- TrueColor Viz plugin allows display of 24-bit imagery

Experimental Product Development Team

- The EPDT was a multi-organization group led by NASA SPoRT and CIRA to extend the capabilities of AWIPS II and facilitate the integration of experimental data products
- RGB team was comprised of representatives from SPoRT, NESDIS, and NOAA
- Wrote Python software to generate 24-bit RGBs based upon recipes defined within XML files (no modification to base code)
- Originally developed using MODIS and VIIRS data and expanded to incorporate AHI and ABI
  - Unable to request calibrated MODIS/VIIRS data from EDEX, requiring Python code to convert raw byte values into brightness temperature and reflectance

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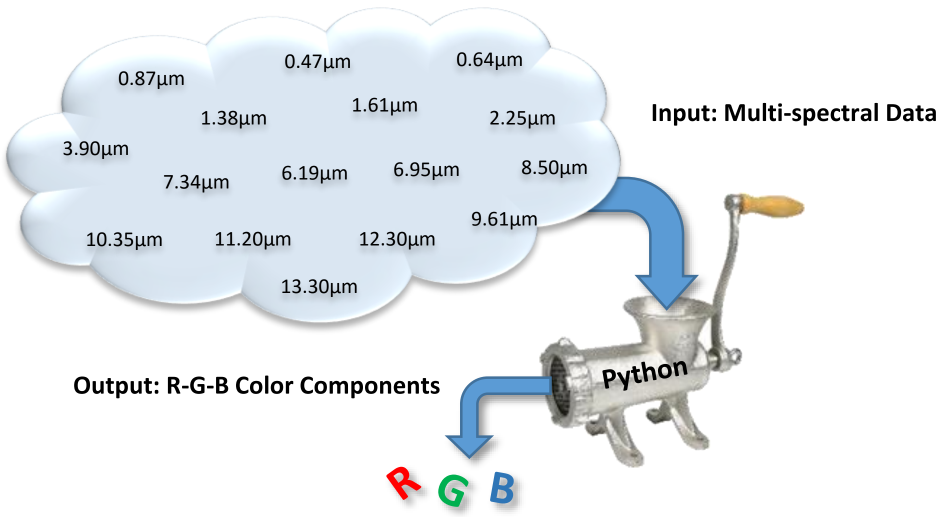
Configurations

- Derived Parameters:
  - Functions (Python):
    - Single Channel Recipe
    - Channel Difference Recipe
    - Calibration
  - Definitions:
    - Red, Green, Blue XML file for each product
- Menus (XML)
- Bundles (XML)



- Implements RGB Recipe:

$$Byte = 255 \times \left[\frac{Value - Min}{Max - Min}\right]^{1/Gamma}$$

- Computes 8-bit value for each R-G-B color

Example: Air Mass

Process flow: Menu -> Bundle (XML) -> Color-Specific DP Definitions (XML) -> DP Functions (Python)

Band/Difference	Gamma	Minimum	Maximum	Inverted?
6.19 - 7.34 µm	1	-26.2 K	0.6 K	No
9.61 - 10.35 µm	1	-43.2 K	6.7 K	No
6.19 µm	1	208.5 K	243.9 K	Yes

Derived Parameter Definitions

```
<DerivedParameter name="GOES-R ABI Air Mass - Red Component"
abbreviation="goesrAirMassRed" xmlns:ns2="group">
   <Method name="satRgbRecipeDiff">
      <Field abbreviation="ABI-CH-08-6.19um-Alias"/>
      <Field abbreviation="ABI-CH-10-7.34um-Alias"/>
      <ConstantField value="0"/>
      <ConstantField value="-26.2"/>
      <ConstantField value="0.6"/>
      <ConstantField value="1.0"/>
      <ConstantField value="0"/>
   </Method>
</DerivedParameter>
```

Air Mass - Red

```
<DerivedParameter name="GOES-R ABI Air Mass - Blue Component"
abbreviation="goesrAirMassBlue" xmlns:ns2="group">
            <Method name="satRgbRecipeSingleChannel">
                        <Field abbreviation="ABI-CH-08-6.19um-Alias"/>
                        <ConstantField value="0"/>
                        <ConstantField value="0."/>
                        <ConstantField value="208.5"/>
                        <ConstantField value="243.9"/>
                        <ConstantField value="1.0"/>
                        <ConstantField value="1"/>
            </Method>
</DerivedParameter>
```

Air Mass - Blue

satRgbRecipeDiff.py

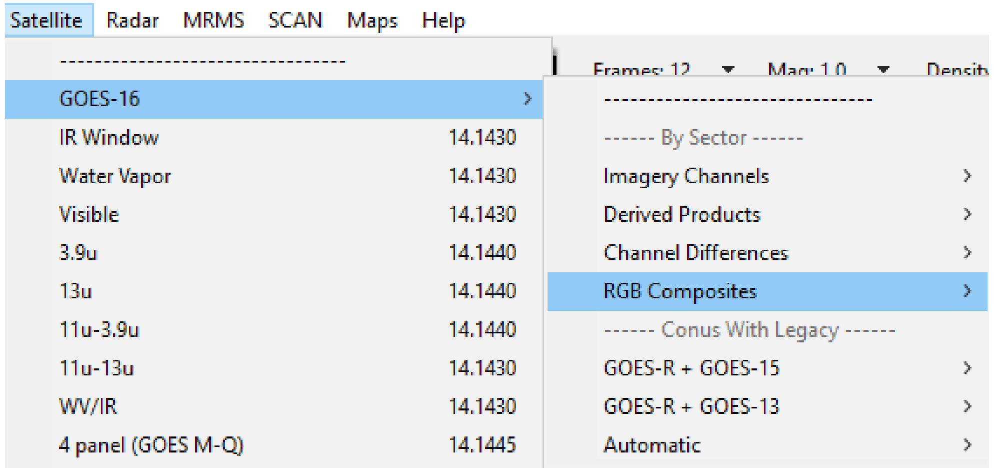
```
diff_calibrated         = a1_calibrated - a2_calibrated
diff_calibrated_clipped = np.clip(diff_calibrated, minCalibratedValue, maxCalibratedValue)
dispValue_float         = 255.*(np.power( (diff_calibrated_clipped -
                          minCalibratedValue)/(maxCalibratedValue - minCalibratedValue), (1./gamma)))

if (invert):
   dispValue_float = 255. - dispValue_float

dispValue_byte          = np.array(dispValue_float, dtype=np.int8)
```

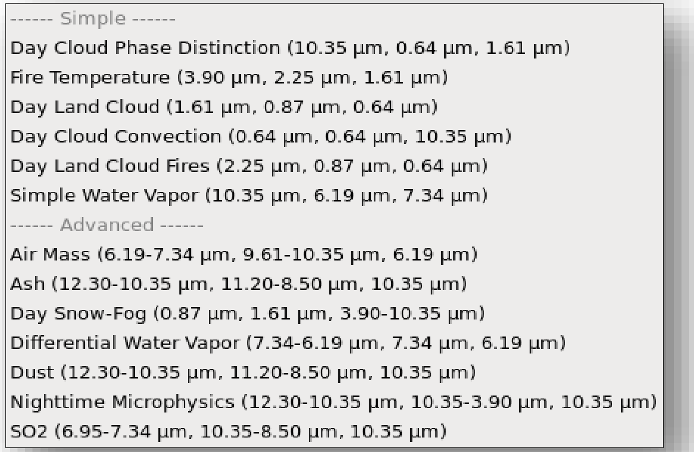
Testing by the Operations Proving Ground

- Client-side RGB capabilities were first tested at the NWS OPG using AHI data and at the NWS HUN WFO with MODIS and VIIRS data
- A number of AWIPS II performance issues were identified, reported to the AWIPS program office, and have been resolved
- Incorporated into Science Operations Officer/Development and Operations Hydrologist course

Deployment via TOWR-S

- The NWS Total Operational Weather Readiness - Satellites (TOWR-S) community supports the validation and implementation of new satellite products for NWS operations
- Presently providing AWIPS II RGB capabilities via RPM to forecast offices
- Utilizes data ingested by the GOES-R EDEX plugin (AHI and ABI)
- Capabilities will be baselined in AWIPS II version 18.2+ with deployment in late 2018





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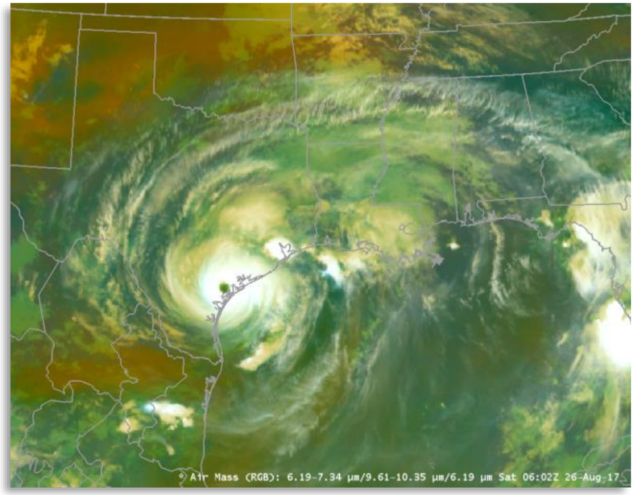
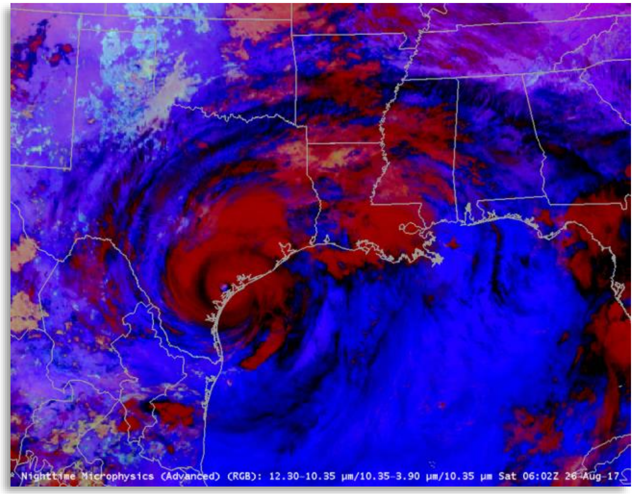
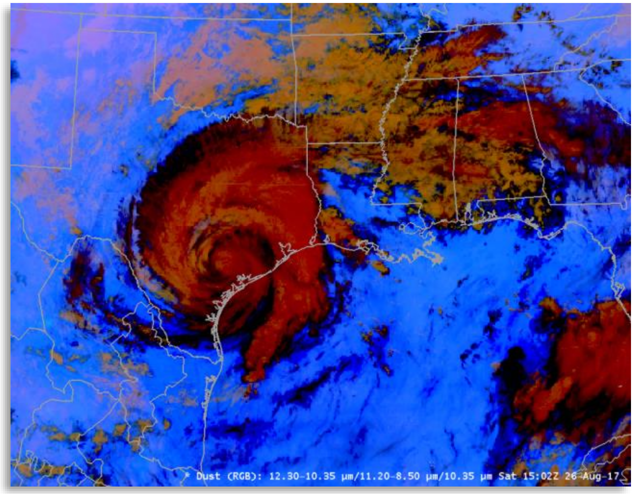
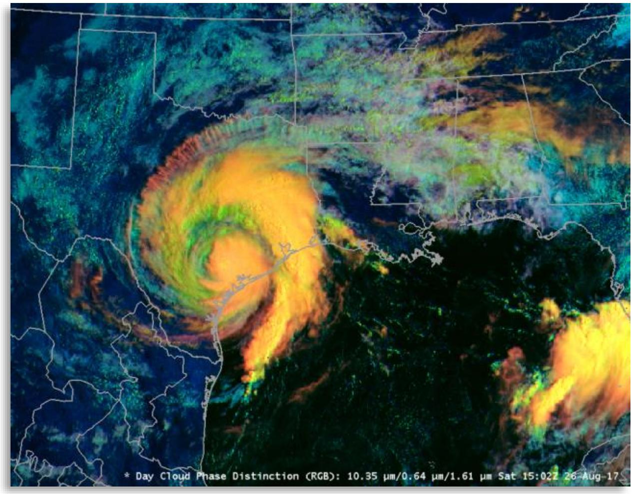
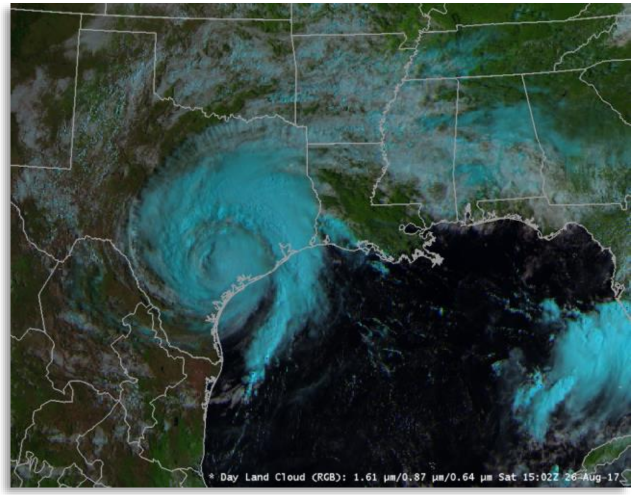
Examples

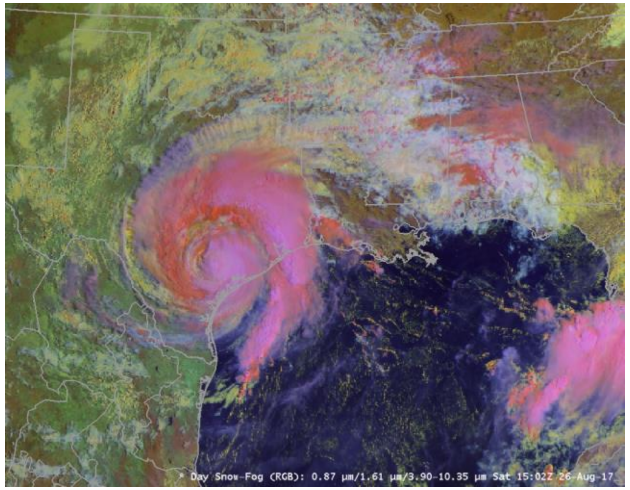

* Air Mass (RGB): 6.19-7.34 µm/9.61-10.35 µm/6.19 µm Sat 06:02Z 26-Aug-17

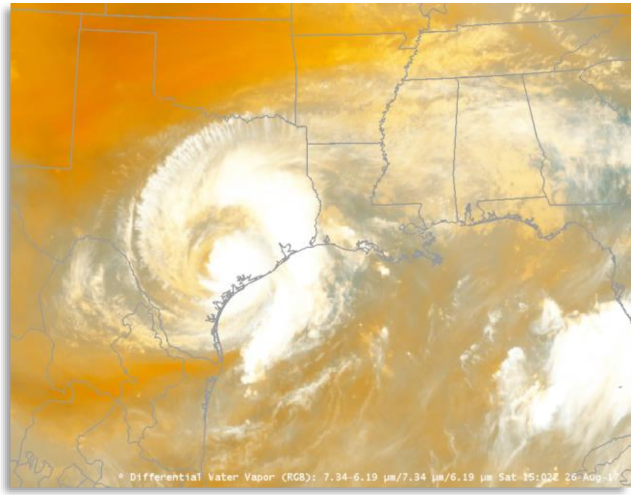

* Nighttime Microphysics (Advanced) (RGB): 12.30-10.35 µm/10.35-3.90 µm/10.35 µm Sat 06:02Z 26-Aug-17

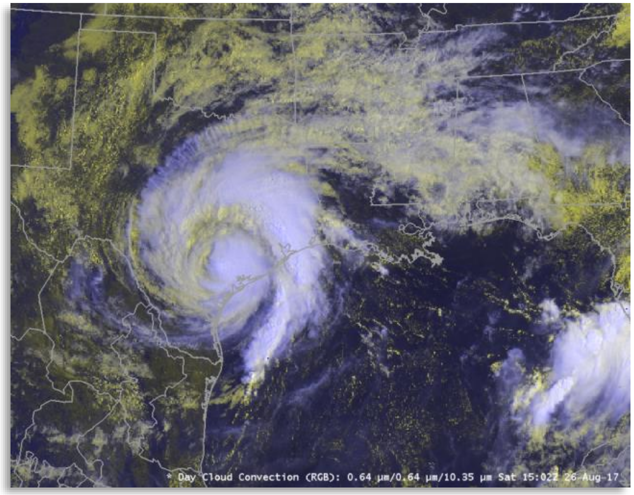

* Dust (RGB): 12.30-10.35 µm/11.20-8.50 µm/10.35 µm Sat 15:02Z 26-Aug-17


* Day Cloud Phase Distinction (RGB): 10.35 µm/0.64 µm/1.61 µm Sat 15:02Z 26-Aug-17


* Day Land Cloud (RGB): 1.61 µm/0.87 µm/0.64 µm Sat 15:02Z 26-Aug-17


* Day Snow-Fog (RGB): 0.87 µm/1.61 µm/3.90-10.35 µm Sat 15:02Z 26-Aug-17


* Differential Water Vapor (RGB): 7.34-6.19 µm/7.34 µm/6.19 µm Sat 15:02Z 26-Aug-17


* Day Cloud Convection (RGB): 0.64 µm/0.64 µm/10.35 µm Sat 15:02Z 26-Aug-17

Alternate Method: OpenGL Shading Language

- OpenGL Shading Language (GLSL) is a high-level shading language outsources rendering calculations to the graphics card
- Utilized by the trueColor visualization plugin
- Could eliminate dependency upon custom Python code
- Successfully tested on RGB recipes with Gamm = 1. CIMSS working to fix issues with other recipes and refine sampling information.

Future

- Support National Centers Perspective
  - 24-bit visualization
  - Derived Parameters
- Resolve EPDT vs. GLSL methodology
- Baseline

Contact Information

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https://weather.msfc.nasa.gov/sport/