SATELLITE REMOTE SENSING WITH GOES-R

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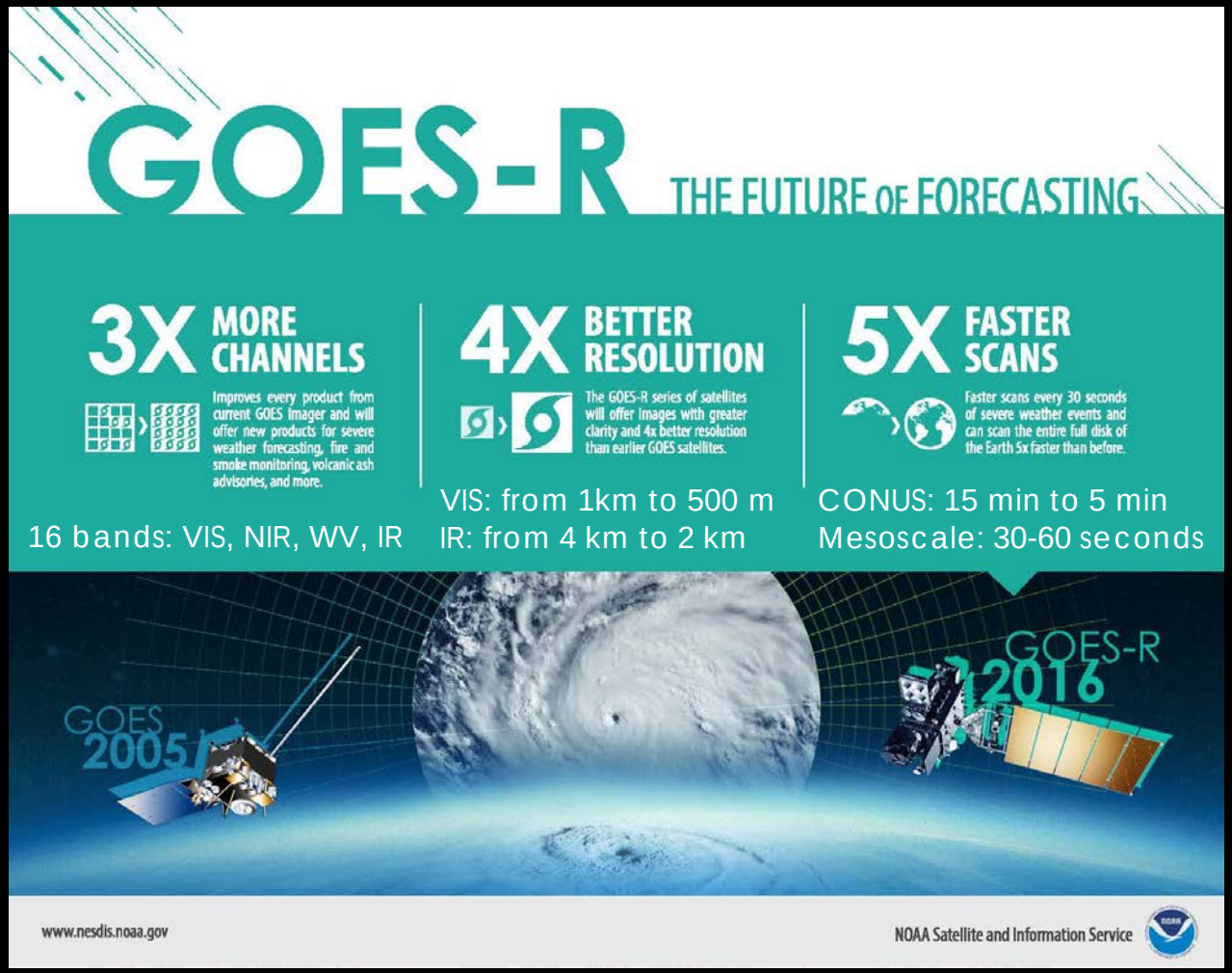
BACKGROUND

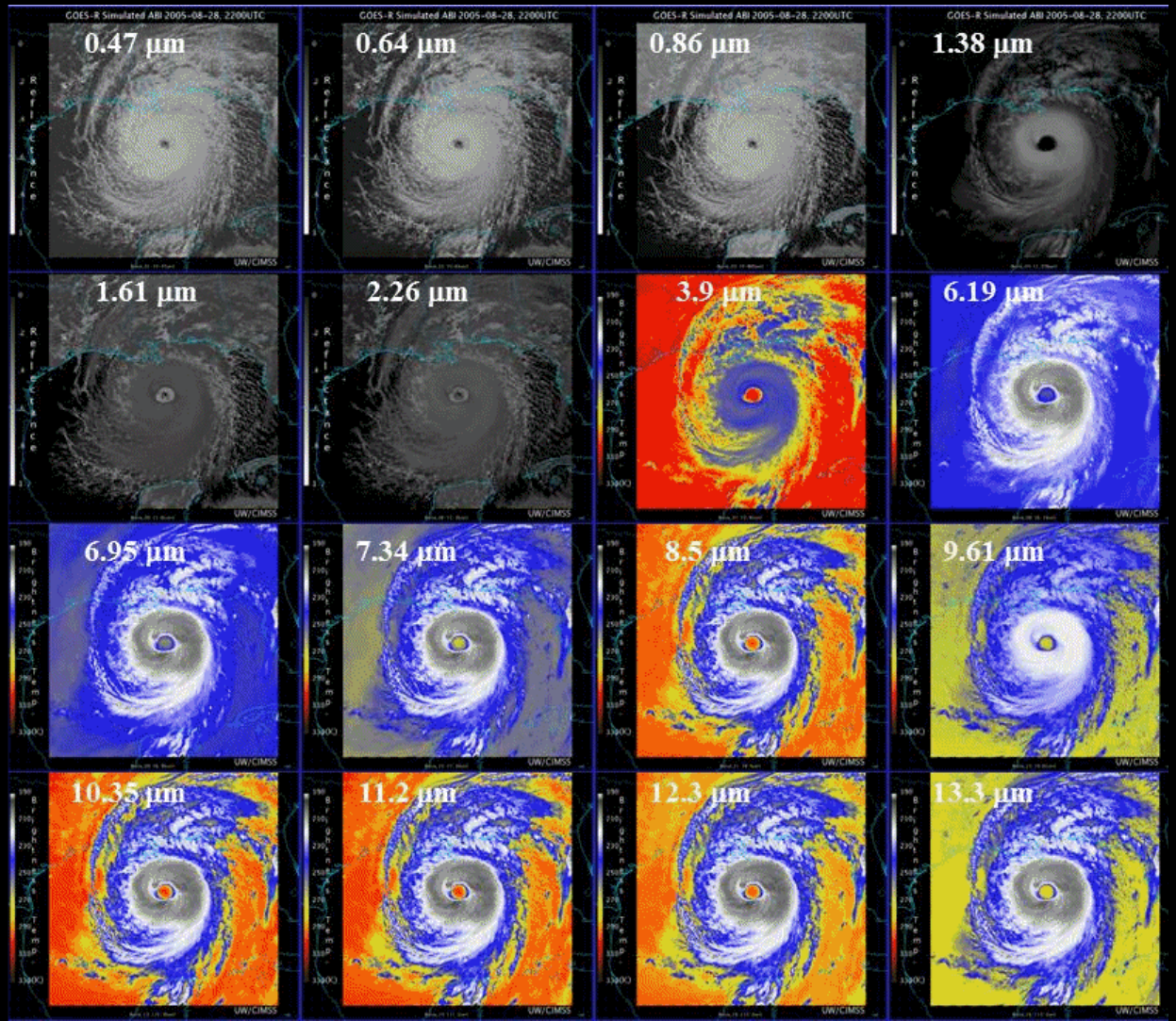
- On November 4, GOES-R is scheduled to launch, to be followed by several months of science check-out and then operational use in mid-2017.
- GOES-R will provide a substantial increase in:
  - Number of spectral bands of imagery
  - Spatial resolution
  - Temporal resolution
  - New lightning imaging
  - Innovative imagery and value-added products for weather forecasting

GOES-R CAPABILITIES



GOES-R VS. CURRENT GOES

Proxy ABI Simulations of Hurricane Katrina



UW/CIMSS

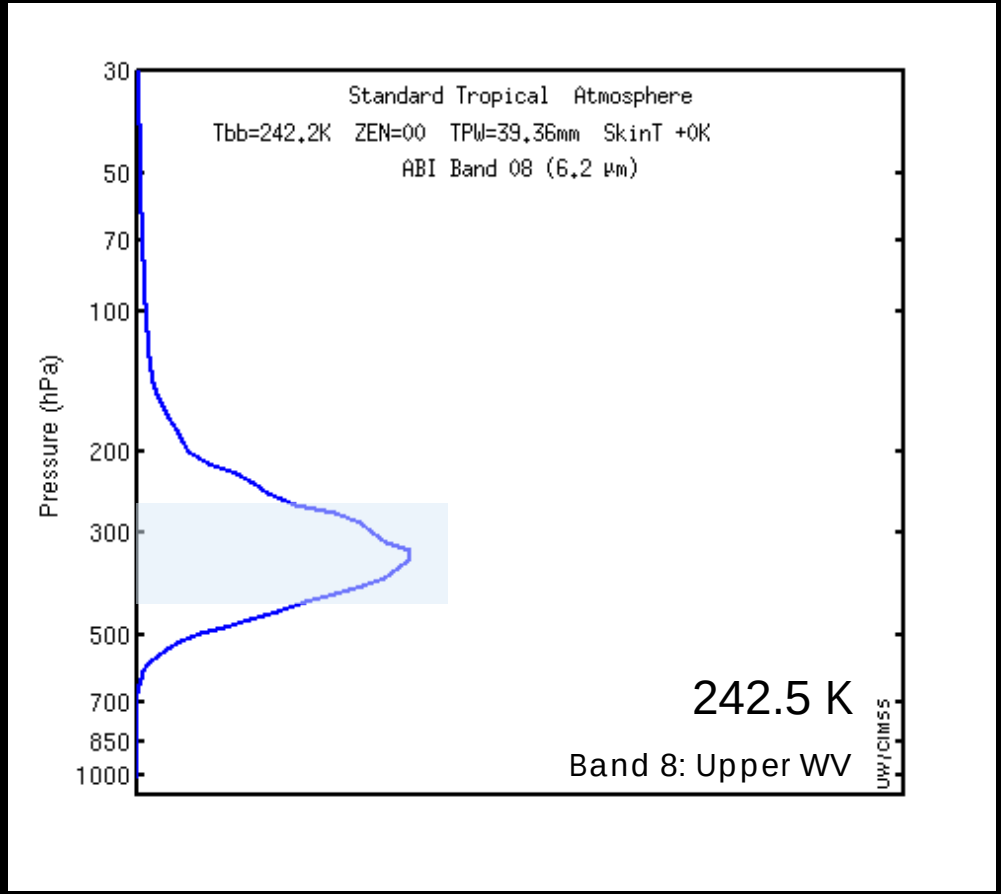
SPECTRAL BANDS

#	um	Name	Examples of Typical Applications
1	0.47	Blue	Haze, dust, smoke, and aerosols
2	0.64	Red	Cloud and land reflectance (“traditional vis”)
3	0.86	Veggie	Land surface/water discrimination
4	1.37	Cirrus	Improves thin ice / cirrus detection
5	1.60	Snow/Ice	Separates clouds/snow on ground
6	2.20	Cloud Particle Size	Cloud property retrievals, also fires and hot spots
7	3.90	Shortwave Window	Cloud-top particle size (daytime), liquid water/fog (nighttime)
8	6.20	Upper Level WV	Like the current WV, but sensitive to the upper atmosphere
9	6.90	Mid Level WV	Like the current WV, but sensitive to the middle atmosphere
10	7.30	Lower Level WV	Like the current WV, but for lowest-level water vapor
11	8.40	Cloud-Top Phase	Cloud properties, discriminating water from ice clouds
12	9.60	Ozone	Stratospheric intrusions, tropopause folds, mesoscale features
13	10.3	Clean IR	Traditional IR, better view of the surface/skin temperature
14	11.2	Longwave IR	Most like the current GOES IR band
15	12.3	Dirty IR	Compared against cleaner IR bands to help with dust and aerosol detection, volcanic ash, etc.
16	13.3	CO2	Compared against other bands for cloud properties, cloud top height

WEIGHTING FUNCTIONS

Weighting functions highlight the layer of atmosphere that is contributing radiance to the overall satellite measurement and calculated brightness temperature.

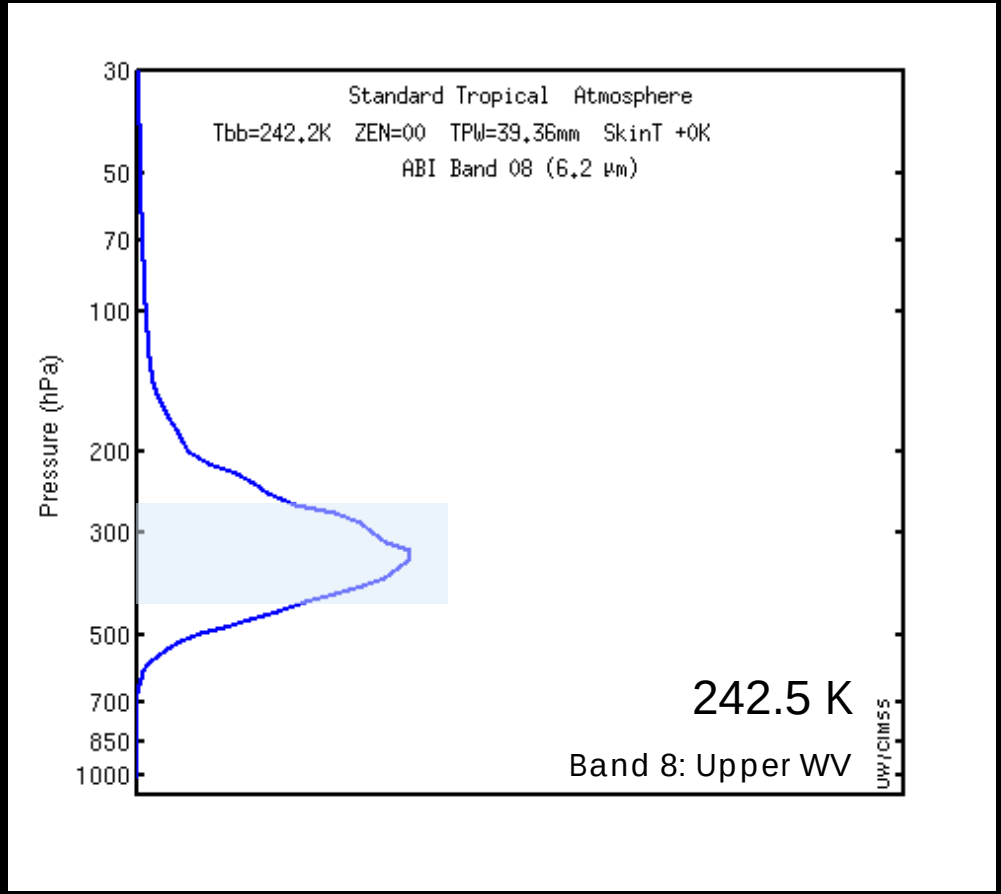
Sensitive to the amount of water vapor in the column, temperature, and other constituents.



WEIGHTING FUNCTIONS

Here, simulations are provided to show the weighting function for each WV band, assuming a “Standard Tropical Atmosphere” that has a high water vapor content.

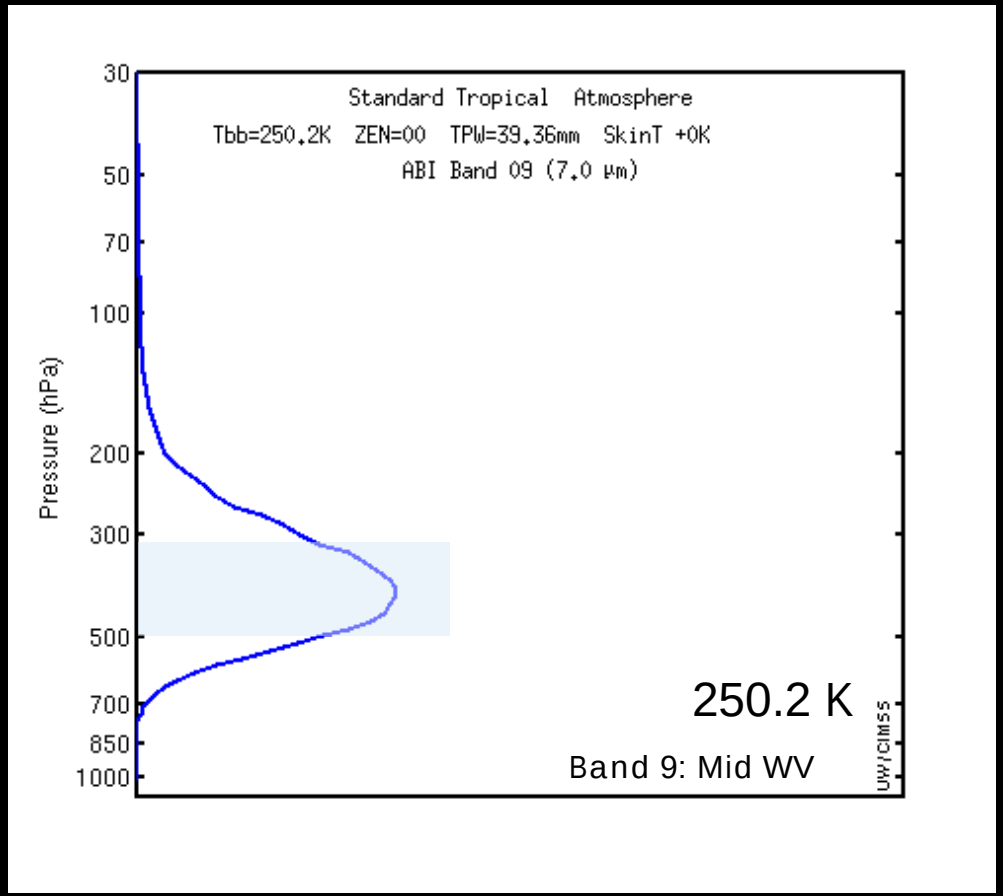
Peaks in the weighting function approximate “where” most of the emission is coming from and corresponding brightness temperature.



WEIGHTING FUNCTIONS

Each channel in the GOES-R set has a weighting function that "peaks" lower in the atmosphere, so that radiance is contributed from varying layers.

This allows for visual interpretation of WV features at varying levels, along with additional satellite retrievals for vapor and temperature.

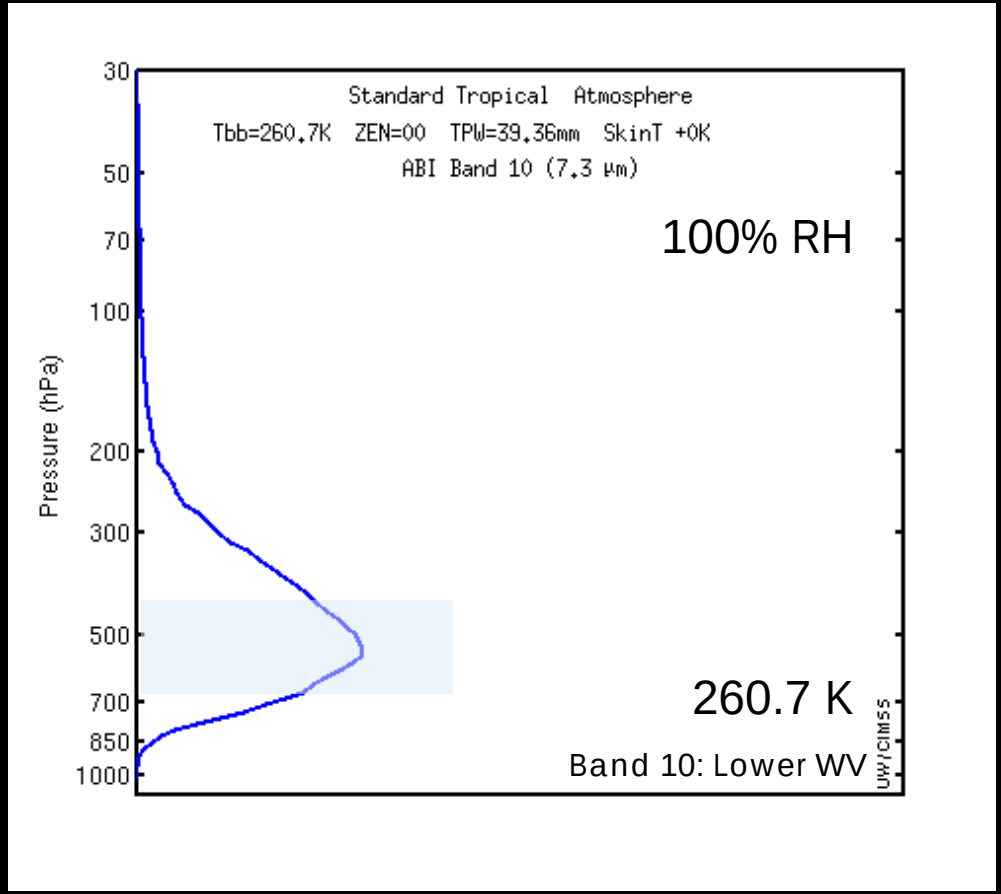


WEIGHTING FUNCTIONS

Weighting functions continue to peak downward.

Increasing the amount of water vapor will:

- Move the weighting function peak to higher altitude (lower pressure)
- Result in a cooler brightness temperature
- Visually, a lighter gray/white color in B/W imagery.
- Clouds: similar in all bands



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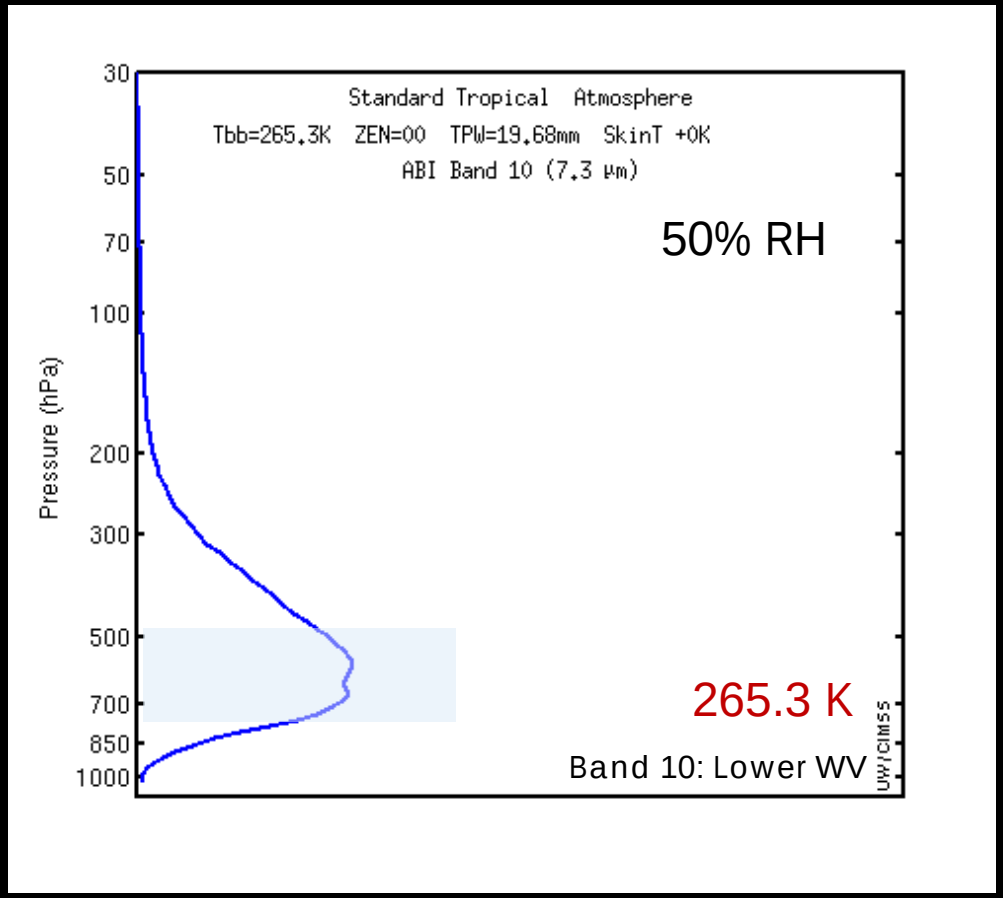
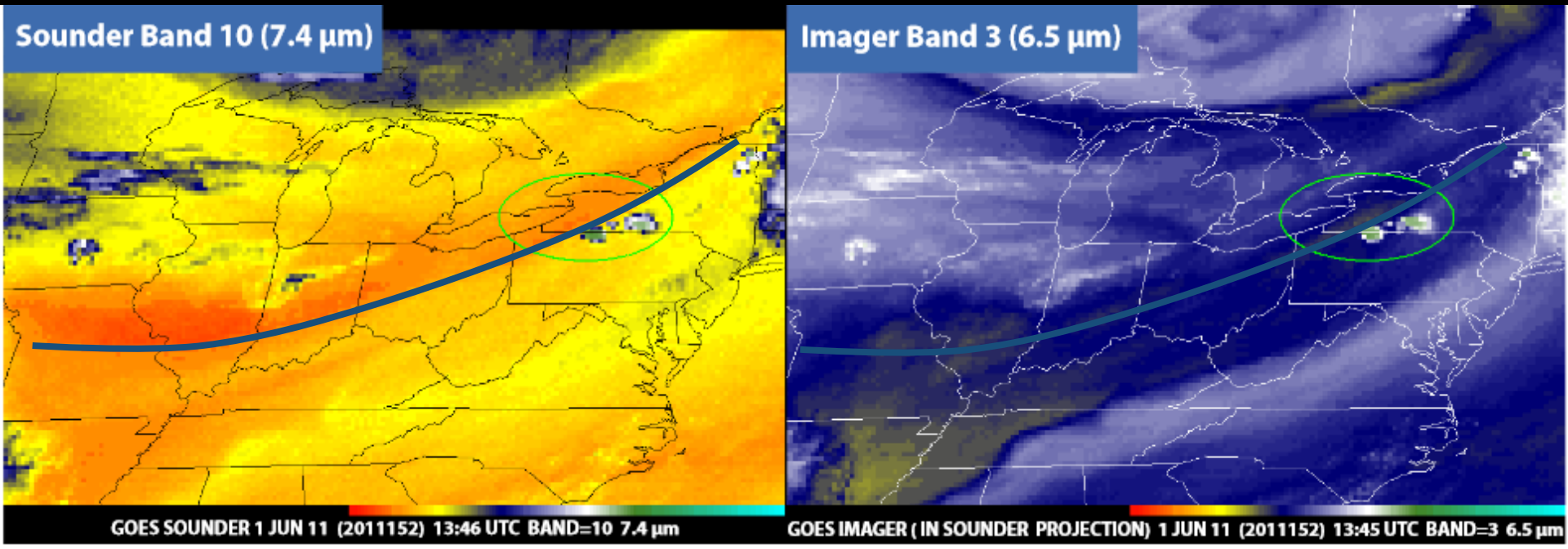


APPLICATION



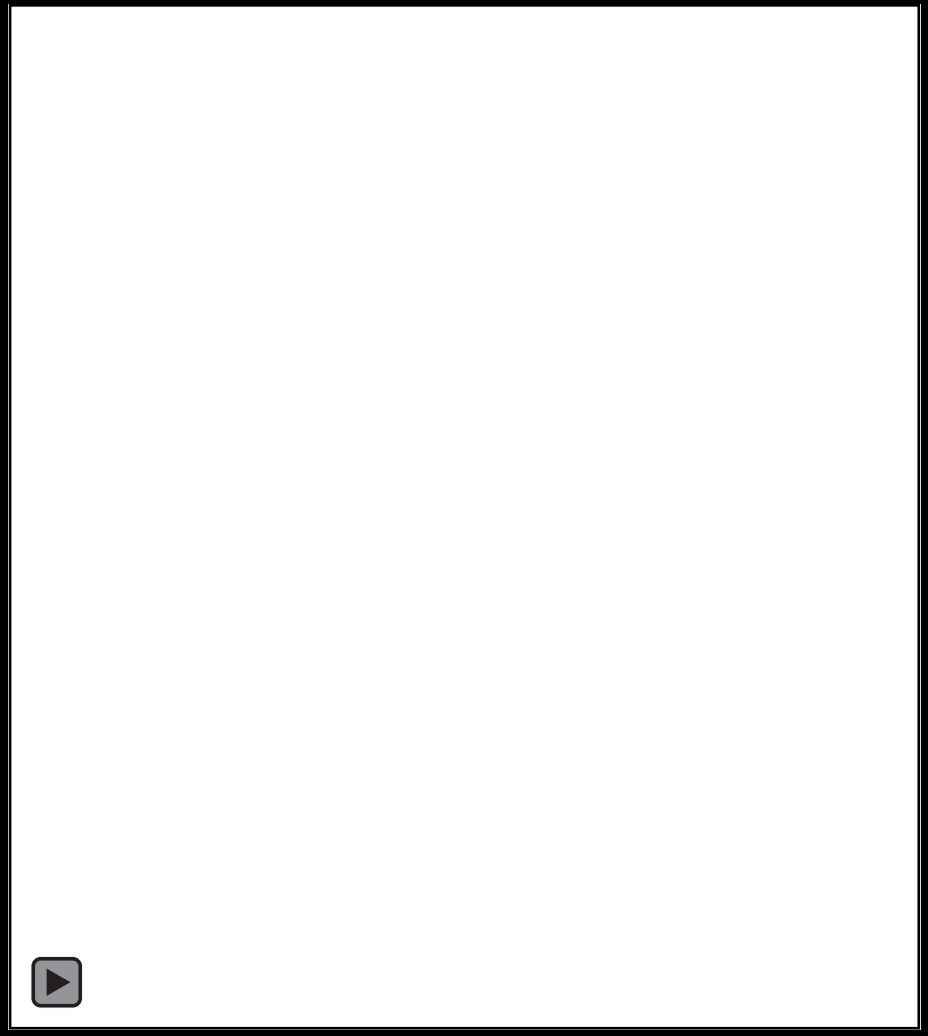
Left: Using a current mid/low-WV band from the GOES Sounder, you can see a mid-level frontal boundary initiating convection in southern New York.

Right: Current GOES WV imagery, where the feature is less pronounced.

Image from GOES-R Fact Sheet / C. Gitro NWS Pleasant Hill

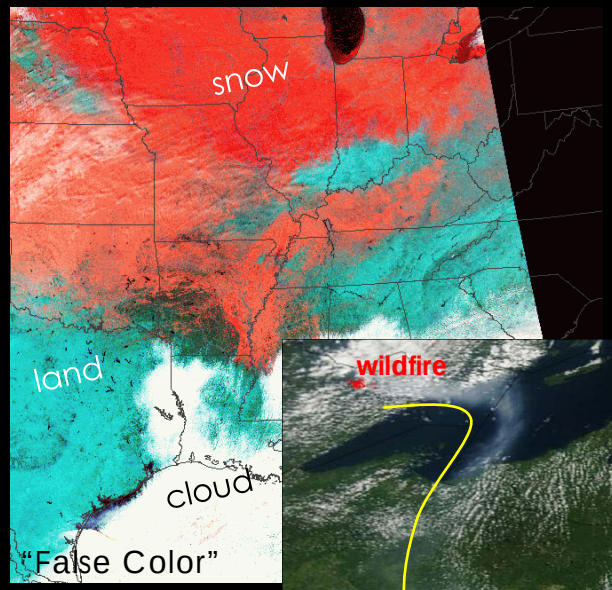
MESOSCALE IMAGERY

- Temporal resolution is dramatically increased with GOES-R for all scanning strategies
  - CONUS: now 5 min rather than 15
- GOES-R will also provide up to two mesoscale sectors with rapid imaging of all bands, allowing for visualization of numerous fine-scale features.
  - Super Rapid Scan Operation of current GOES emulates this, provided by UW/CIMSS

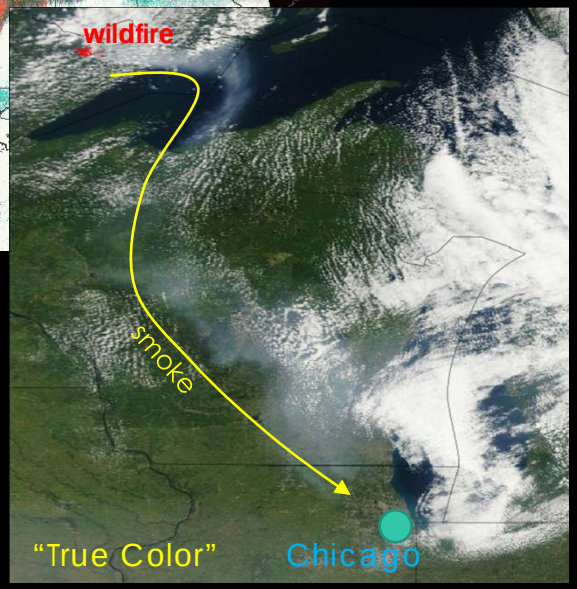


MULTISPECTRAL IMAGERY

- Composite satellite imagery provides data fusion of multiple bands into a single image.
  - Specific products for a specific purpose
  - Bands or differences are assigned to each pixel's red, green, and blue intensity.
  - Referred to as an "RGB" product.
- Examples:
  - True Color:
    - Puts the red visible in the red component, green in the green, and blue in the blue. Results in an image of "true color", the way that we would see with our eyes.
  - False Color:
    - Combinations of bands or band differences that create "wrong" colors but those that draw our attention to specific features.
    - Many "false color" products are given names specific to an application and referred to as an "RGB" product.



VIS, N-IR
3 inputs



VIS
3 inputs

AIR MASS RGB

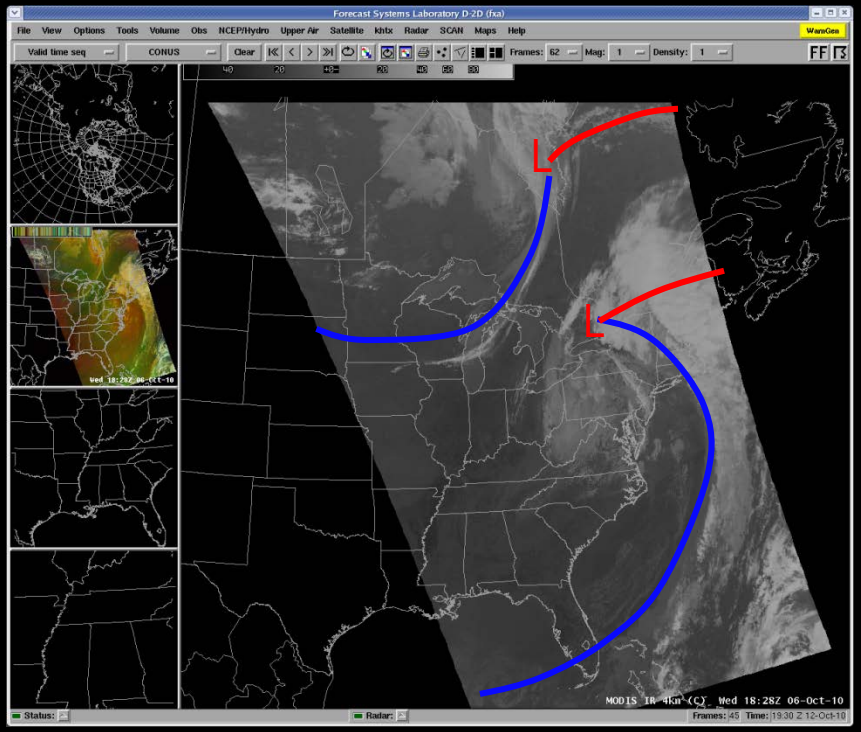
RGB Air Mass Product - What is used in the combine and what does each color represent?

Color	Band / Band Diff.	Physically Relates to….	Little contribution to composite indicates…..	Large contribution to composite indicates …..
Red	**6.7 – 7.3**	Vertical water vapor difference	Moist conditions high levels	Dry conditions at high levels
Green	**9.7- 10.7**	Estimate of tropopause height based on ozone. Polar (tropical) air has higher (lower) ozone concentrations	Tropopause height is low. Typically indicates a polar air mass, where 9.7 has very cold brightness temperature compared to 10.7	Tropopause height is high. Likely a tropical air mass where the two channels will have similar brightness temperature values
Blue	**6.7**	Water Vapor in layer from ~200 – 500 mb	Dry at upper levels Warm brightness temperatures have little blue	Moist at upper levels Cold brightness temperatures result in lots of blue

The Air Mass RGB was designed by EUMETSAT for their Meteosat/SEVIRI instrument to highlight synoptic-scale features, such as contrasts of warm/cold air associated with strong fronts, differences in moisture content, and other large-scale features.

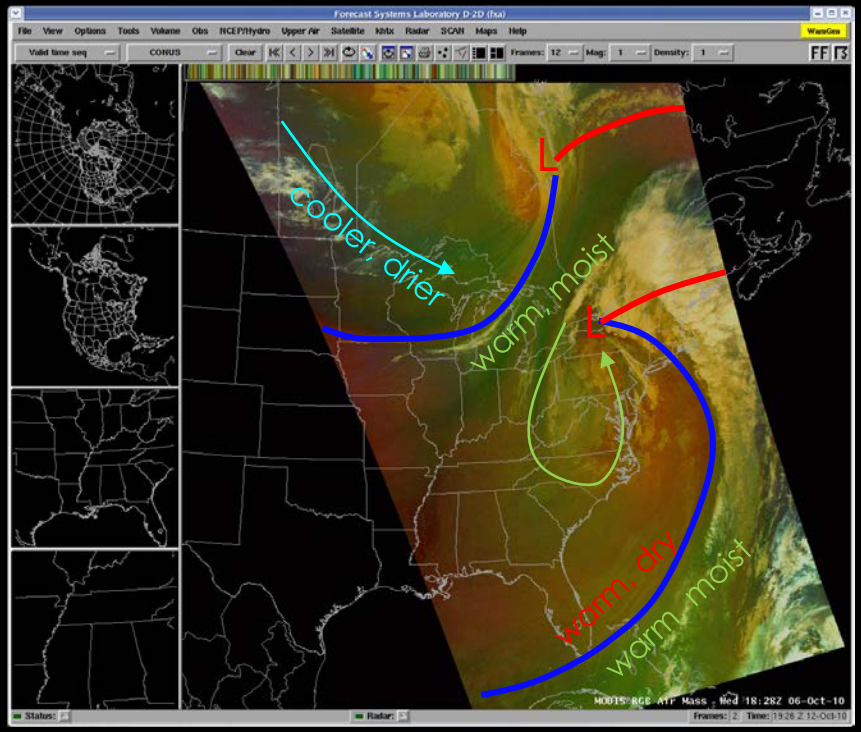
AIR MASS RGB

Single Channel Water Vapor – Features



Single Channel Water Vapor – Features

"Air Mass" – Feature Detection

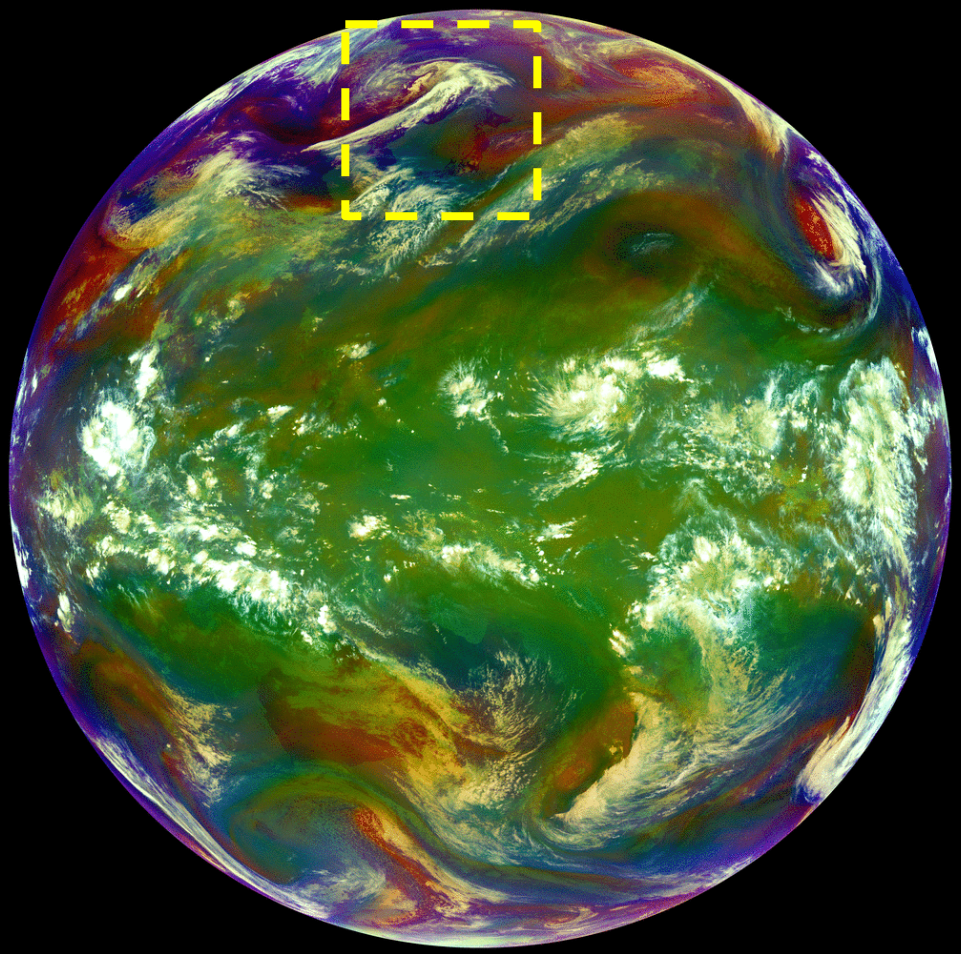


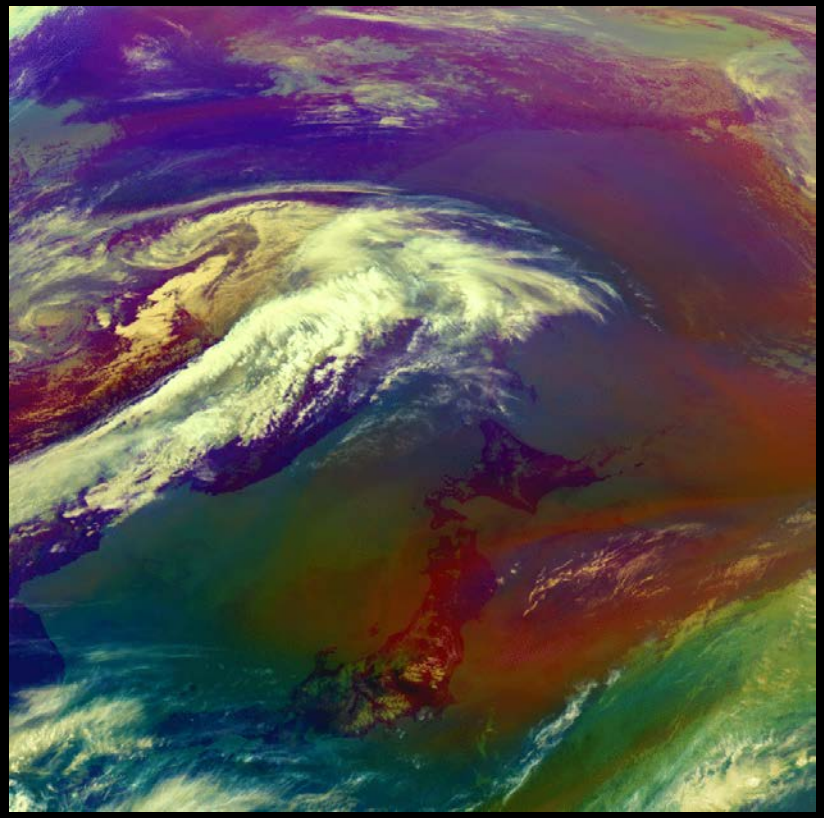
R: 6.2 µm-7.3 µm, G: 9.7 µm-10.8 µm, B: 6.2 µm

Combines 4 channels of information.

AIR MASS RGB

JAPAN'S HIMAWARI-8/AHI (PROXY FOR GOES-R)



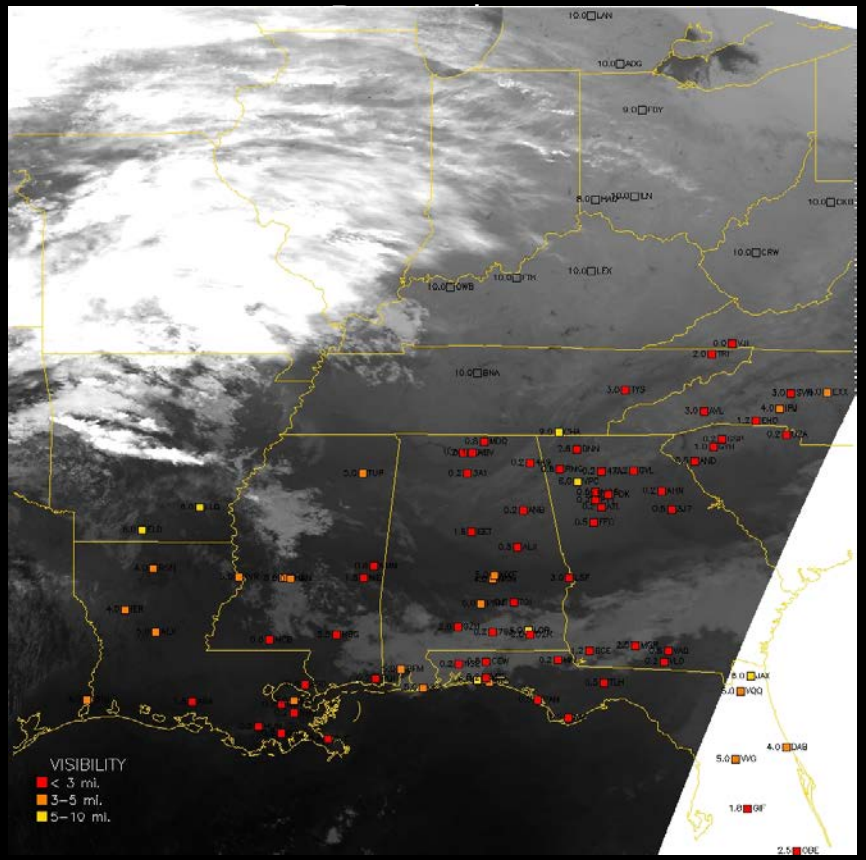


NIGHTTIME MICROPHYSICS

Description text

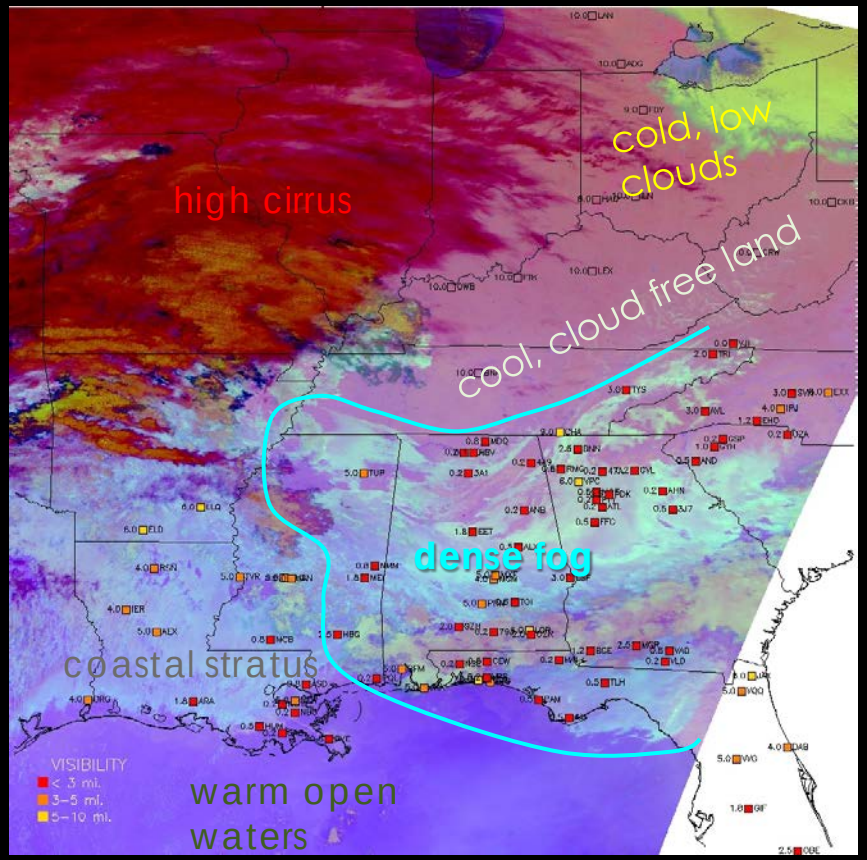
NIGHTTIME MICROPHYSICS

Single Channel Infrared – Fog



Color enhancement to single 11 µm (MODIS)

"Night Microphysics" – Fog Detection

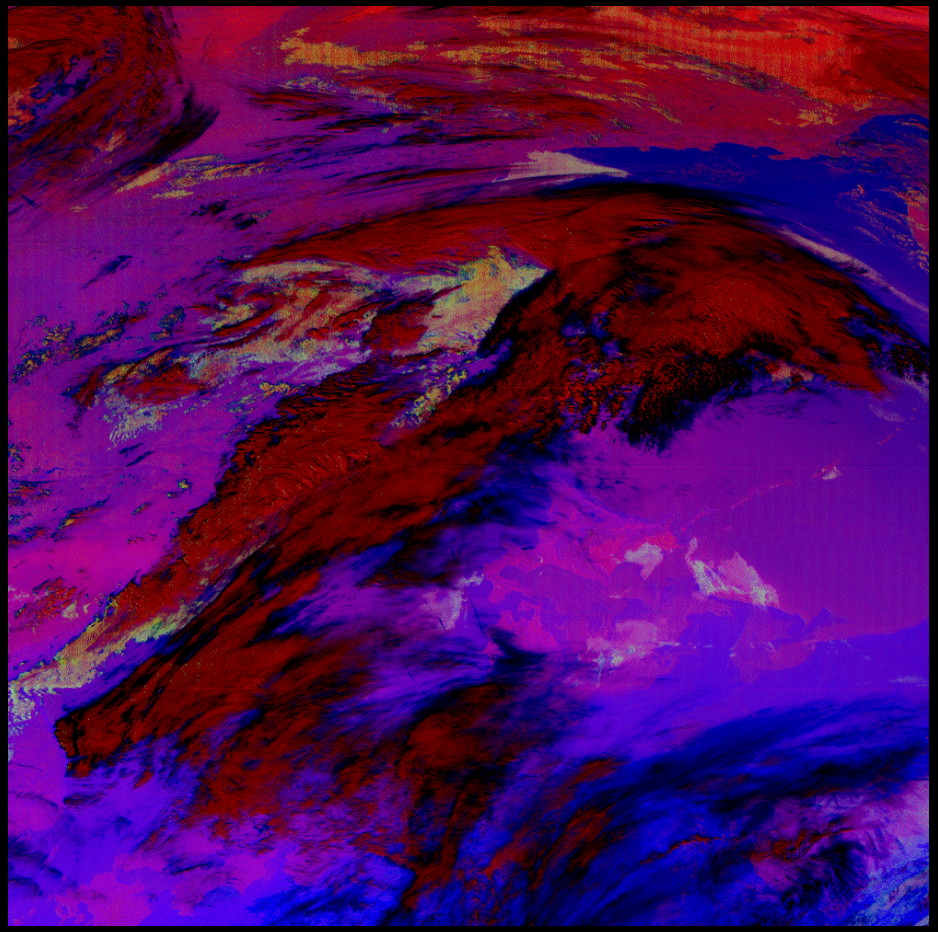


R: 12-11 µm, G: 11-3.9 µm, B: 11 µm

Combines 3 channels of information.

NIGHTTIME MICROPHYSICS

JAPAN'S HIMAWARI-8/AHI (PROXY FOR GOES-R)



Description text

24-H MICROPHYSICS

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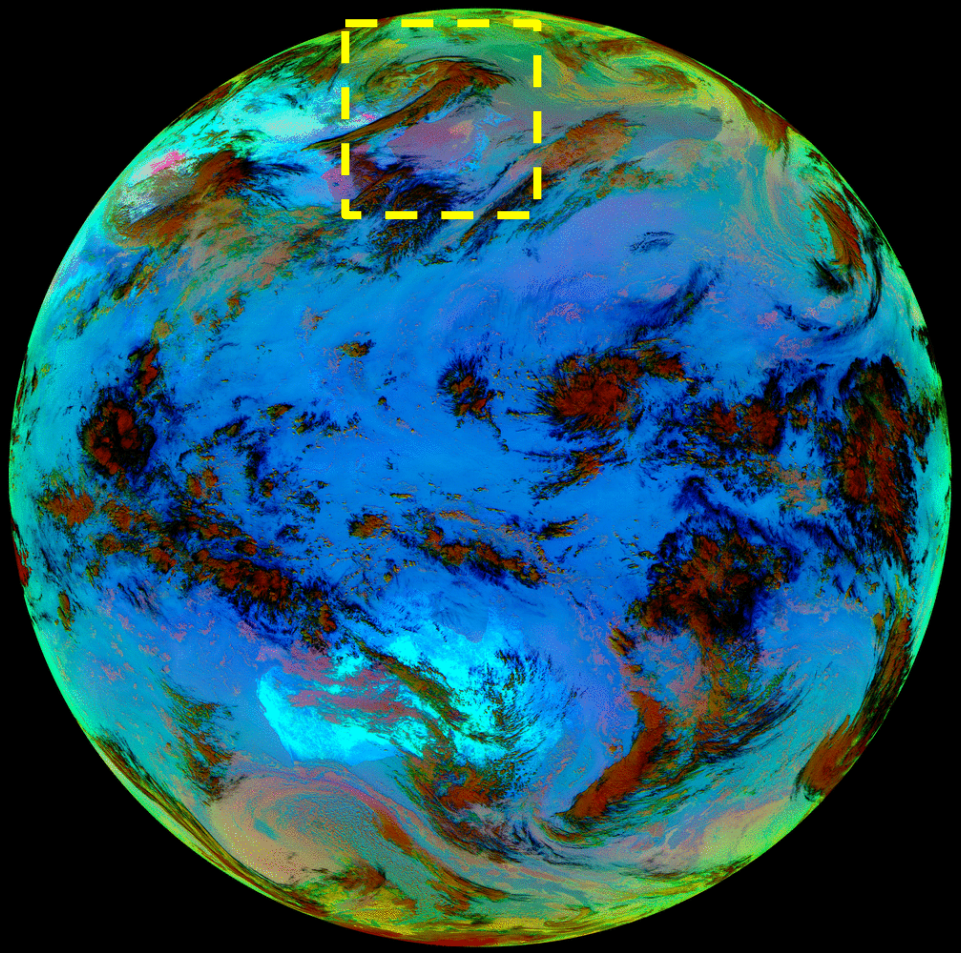
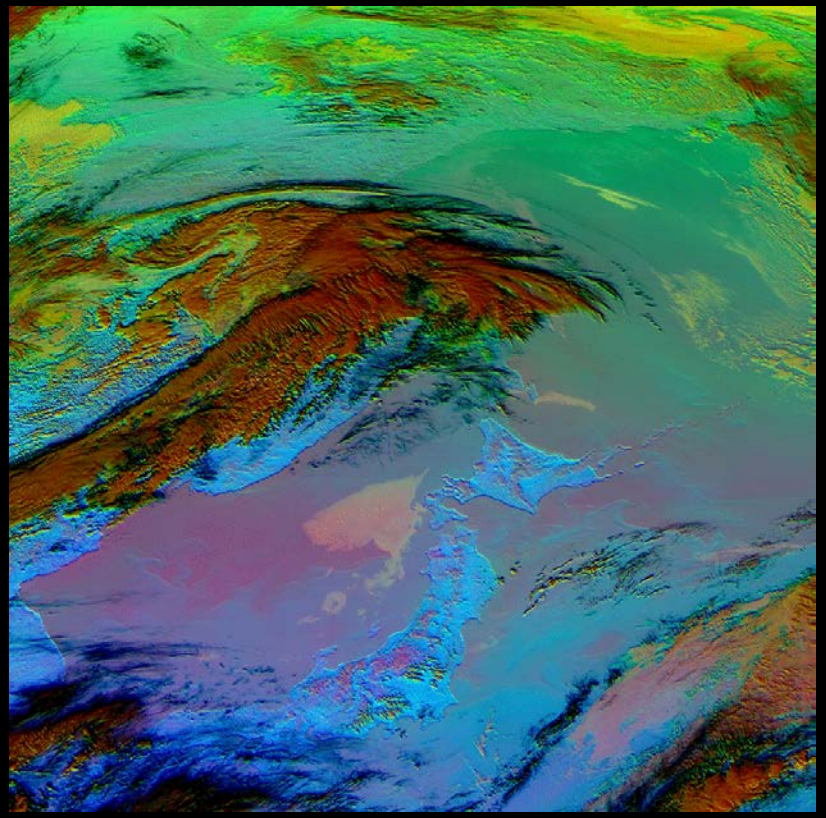
JAPAN'S HIMAWARI-8/AHI (PROXY FOR GOES-R)

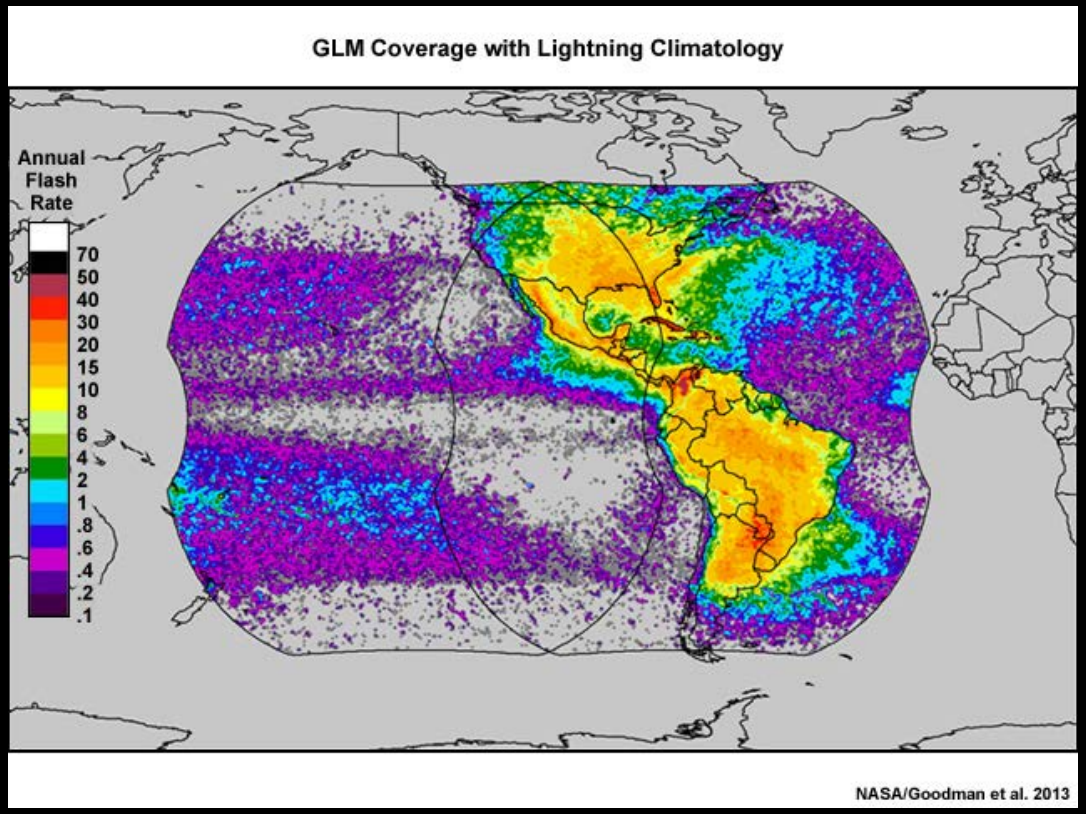




GEOSTATIONARY LIGHTNING MAPPER (GLM)

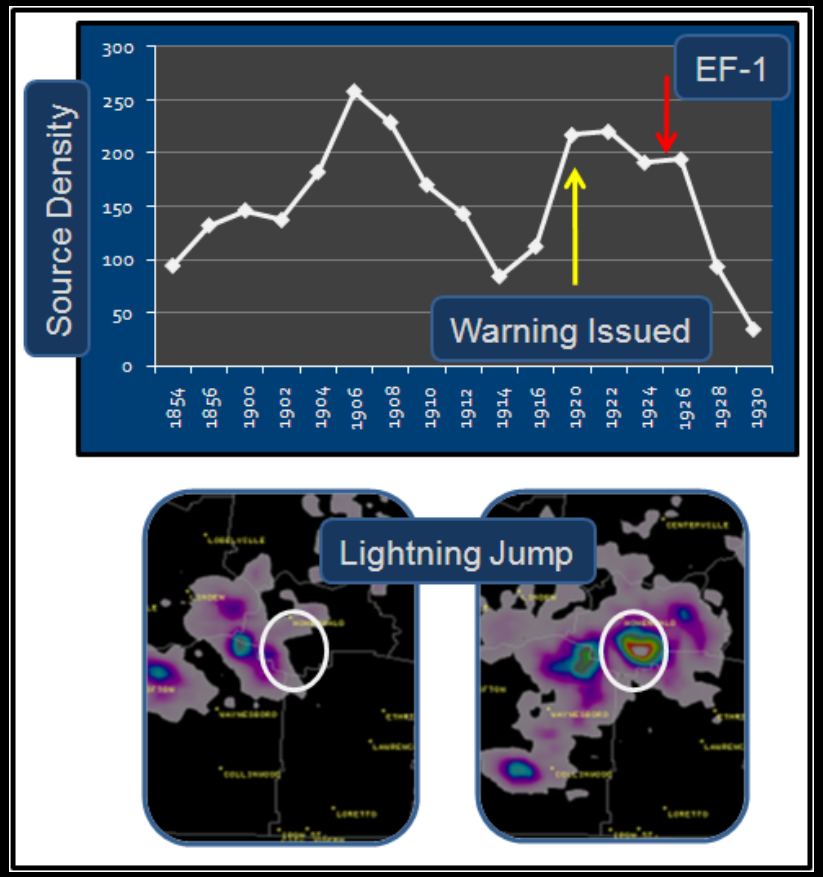
The Geostationary Lightning Mapper for GOES-R will provide lightning detection from geostationary orbit.

This provides more consistent mapping of lightning over land and data-void oceanic areas for severe weather warnings and situational awareness.



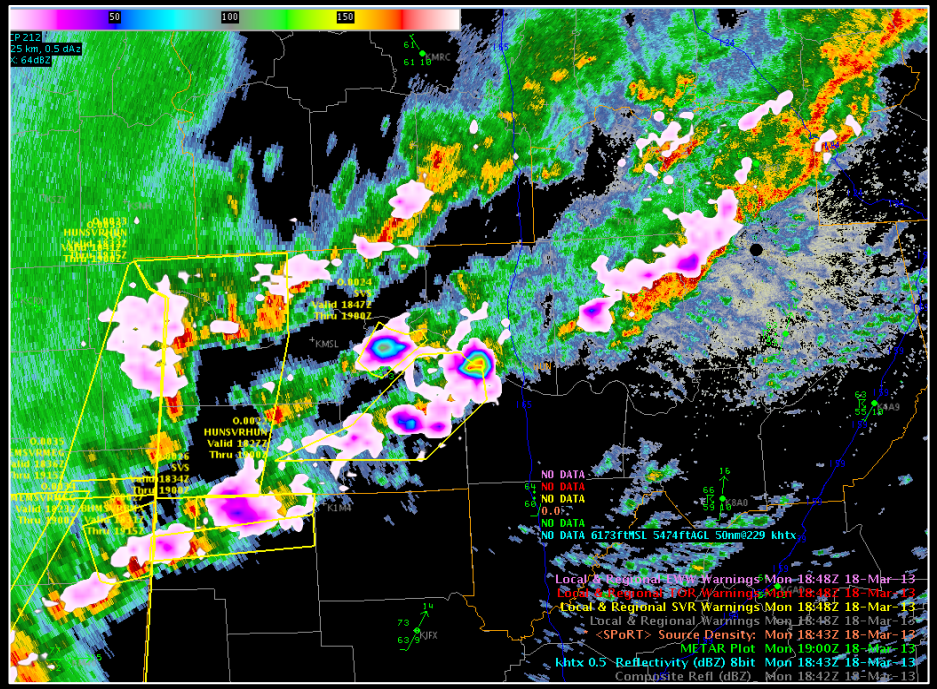
LIGHTNING AND SEVERE WEATHER

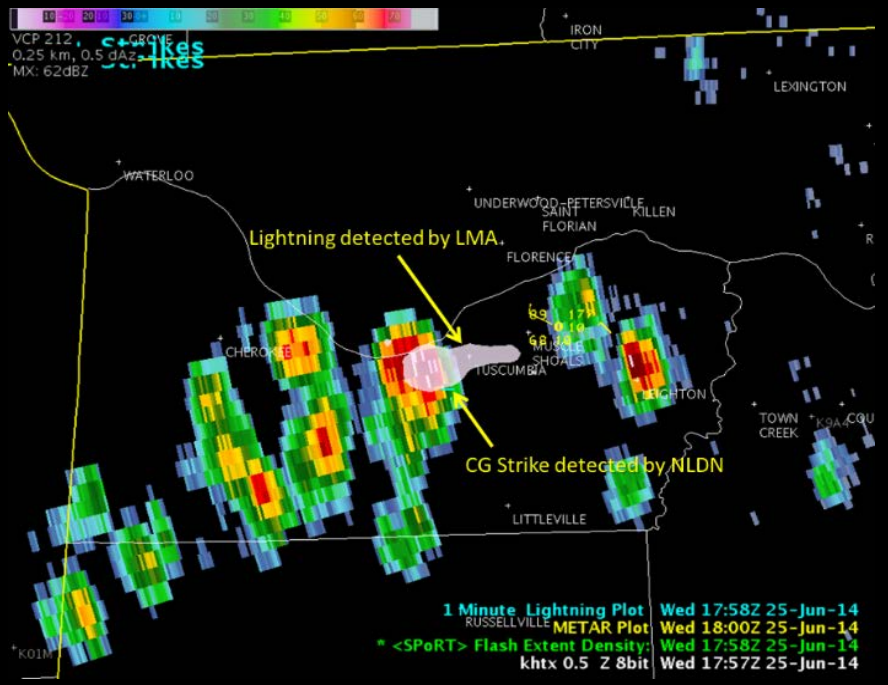
- Several studies have linked “total lightning”, or the combined in-cloud and cloud-to-ground lightning flash rate, with severe weather occurrence.
- These studies noted that a sudden increase in lightning flash rate signaled a strengthening updraft, which frequently led to hail, damaging winds, or tornadoes 15-30 minutes afterwards.



GOES-R GLM

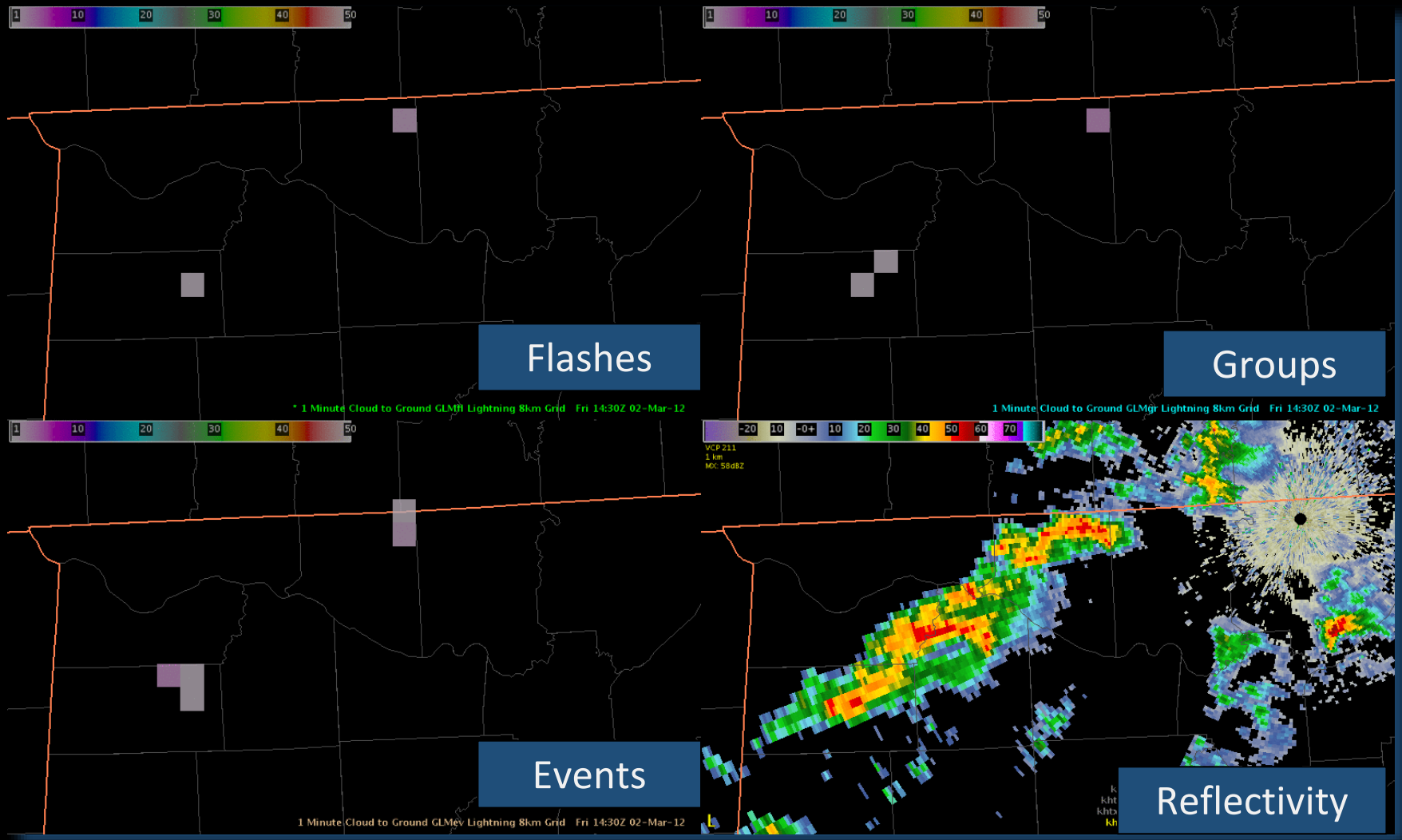
Ground-based lightning mapping arrays provide observations that can be used to simulate GOES-R types of capabilities for severe weather and public safety applications.





Lightning observations used to identify most severe and active cells (left), and for additional public safety by identifying lightning activity ahead of isolated storms (right).

GOES-R GLM


1 10 20 30 40 50
Flashes
* 1 Minute Cloud to Ground GLMfl Lightning 8km Grid Fri 14:30Z 02-Mar-12
1 10 20 30 40 50
Groups
1 Minute Cloud to Ground GLMgr Lightning 8km Grid Fri 14:30Z 02-Mar-12
1 10 20 30 40 50
Events
1 Minute Cloud to Ground GLMev Lightning 8km Grid Fri 14:30Z 02-Mar-12
-20 10 -0+ 10 20 30 40 50 60 70
VCP 211
1 km
MX: 58dBZ
Reflectivity

POST-LAUNCH

- With a scheduled launch of November 4, 2016, just a few weeks away, forecasters and the public can look forward to GOES-R products available mid-2017 following a short checkout period of the satellite's performance, and fine-tuning of derived products.
- A follow-on mission of GOES-S will provide continuity of coverage for new imaging and lightning capabilities in late 2018.
- GOES-T and GOES-U will follow, and the "GOES-R Series" of geostationary missions are expected to operate through the 2030s.
  - Now's the time to learn about this game-changing observational platform that will be available throughout your early and mid-career!

USER READINESS

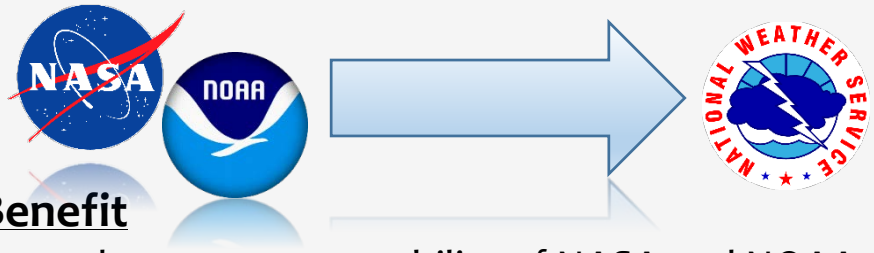
- Several groups have partnered with NOAA to prepare forecasters for the GOES-R era, participating in the GOES-R Proving Ground, which has spent the past few years using current GOES, along with NASA's MODIS and NASA/NOAA Suomi-NPP VIIRS data.
- Activities focus on creating GOES-R-like products from these platforms, verifying and validating their effectiveness, and working closely with NWS meteorologists to ensure forecasters find the products useful and are ready to fold them into their operations on day-one of operational data being available.

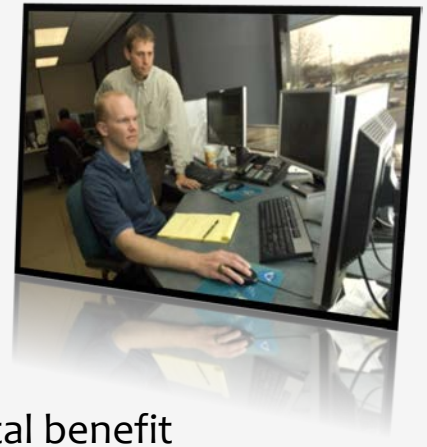
Short-term Prediction Research and Transition (SPoRT) Center

SPoRT is focused on transitioning unique NASA and NOAA observations and research capabilities to the operational weather community to improve short-term weather forecasts on a regional and local scale.

- close collaboration with numerous WFOs and National Centers across the country
- SPoRT activities began in 2002, first products to AWIPS in 2003
- co-funded by NOAA since 2009 through satellite "proving ground" activities

Proven paradigm for transition of research and experimental data to "operations"





Benefit

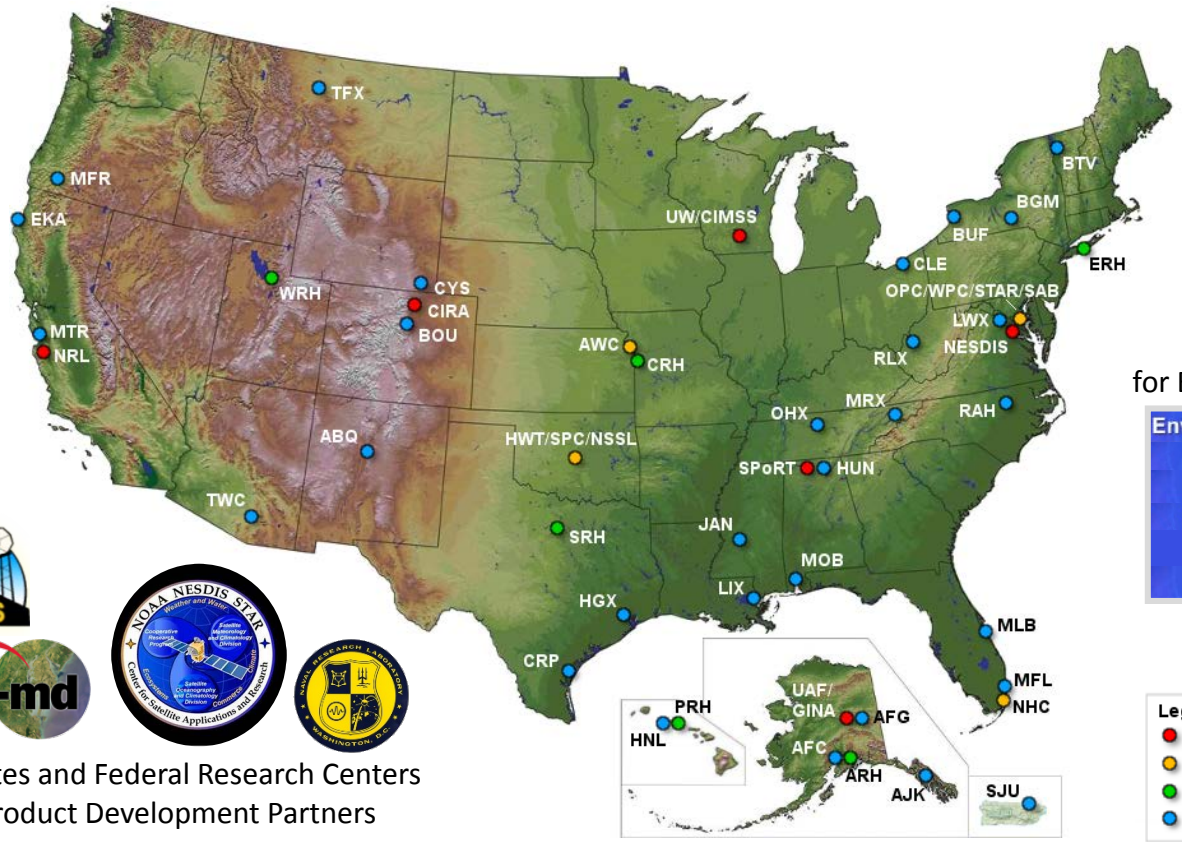
- demonstrate capability of NASA and NOAA experimental products to weather applications and societal benefit
- prepares forecasters for use of data from next generation of operational satellites (JPSS, GOES-R)

SPORT

NASA NOAA

Partnerships with NOAA

Over 30 NWS WFOs and All Regional Headquarters



National Centers for Environmental Prediction

- Environmental Modeling Center
- National Hurricane Center
- Weather Prediction Center
- Ocean Prediction Center
- Aviation Weather Center
- Storm Prediction Center

NOAA Cooperative Institutes and Federal Research Centers as Data Delivery and Product Development Partners

Legend
- Product Development Partner
- National Center Evaluation Partner
- NWS Regional Headquarters
- WFO Collaborative Partner

SPoRT collaborates with NOAA Cooperative Institutes to develop and distribute products to partnering NWS WFOs and National Centers, providing unique observation and modeling capabilities to support their daily forecasting operations.

Partnerships with NOAA

Hydrometeorology Testbed

- Using NOAA and NASA satellites and collaborative models to understand atmospheric rivers and flooding events

Joint Center for Satellite Data Assimilation

- Developing and further improving data assimilation techniques to improve regional weather forecasting

Developmental Testbed Center

- Collaborating on new tools that use NASA and NOAA satellite imagery for model validation

Aviation Weather Testbed

- Providing near real-time satellite imagery and lightning products to aid aviation forecasters

Operations Proving Ground

- Creating new decision support system (AWIPS II) capabilities for next-gen satellites and models

Hazardous Weather Testbed

- Exploring the use of lightning data from ground networks as precursors to GOES-R and ISS capabilities

SPoRT participates in NOAA's Testbeds and Proving Grounds, assisting the meteorological community in development of new applications.

SPORT

NASA

NOAA

Partnerships with NOAA

- NASA's MODIS imagers aboard Terra and Aqua are used to develop products that train forecasters for future GOES-R capabilities.
- Lightning data from ground networks prepare forecasters to use GOES-R data in severe weather warnings.

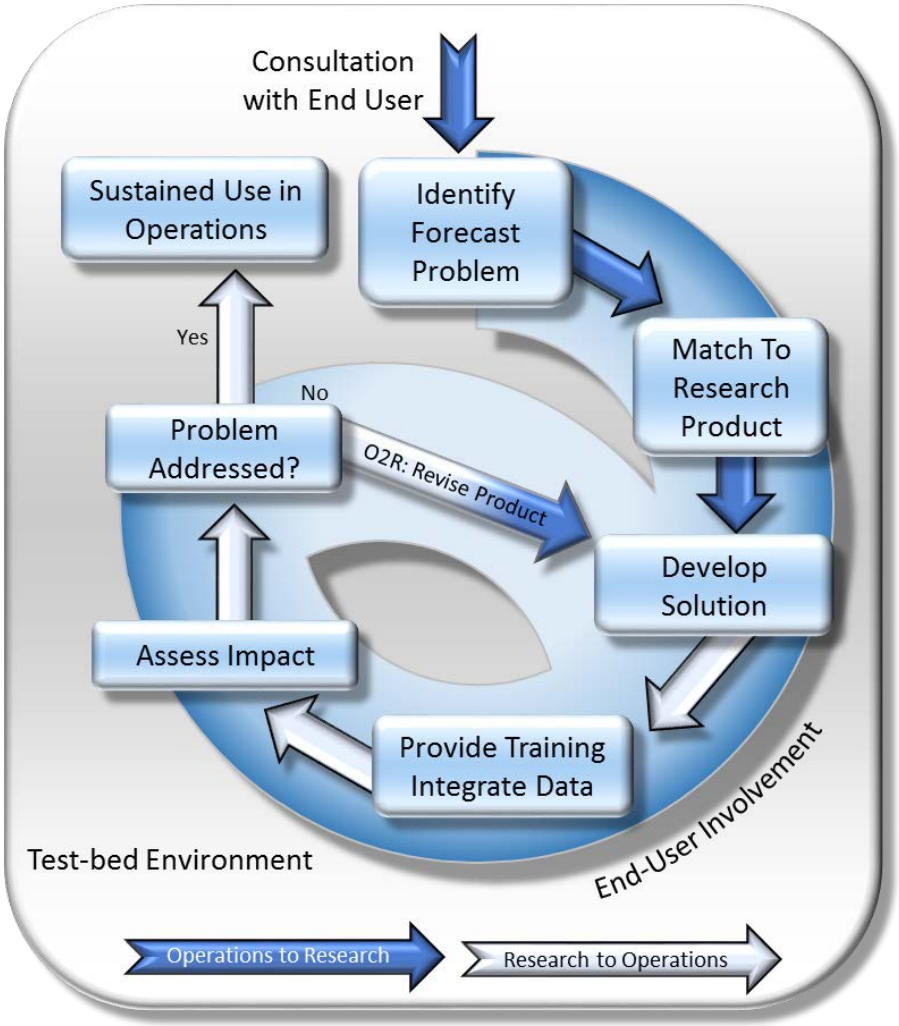
- The Suomi-NPP VIIRS imager extends MODIS capabilities and offer additional training perspectives.
- Atmospheric profiles aid forecasters in data-sparse regions.
- New capabilities from the day-night band are explored to prepare for operational JPSS missions.

SPoRT provides training and support to weather forecasters, using NASA capabilities to prepare them for the next generation of NOAA operational satellite missions.

SPORT

NASA NOAA

SPoRT Paradigm for R2O and O2R Success



Keys to success

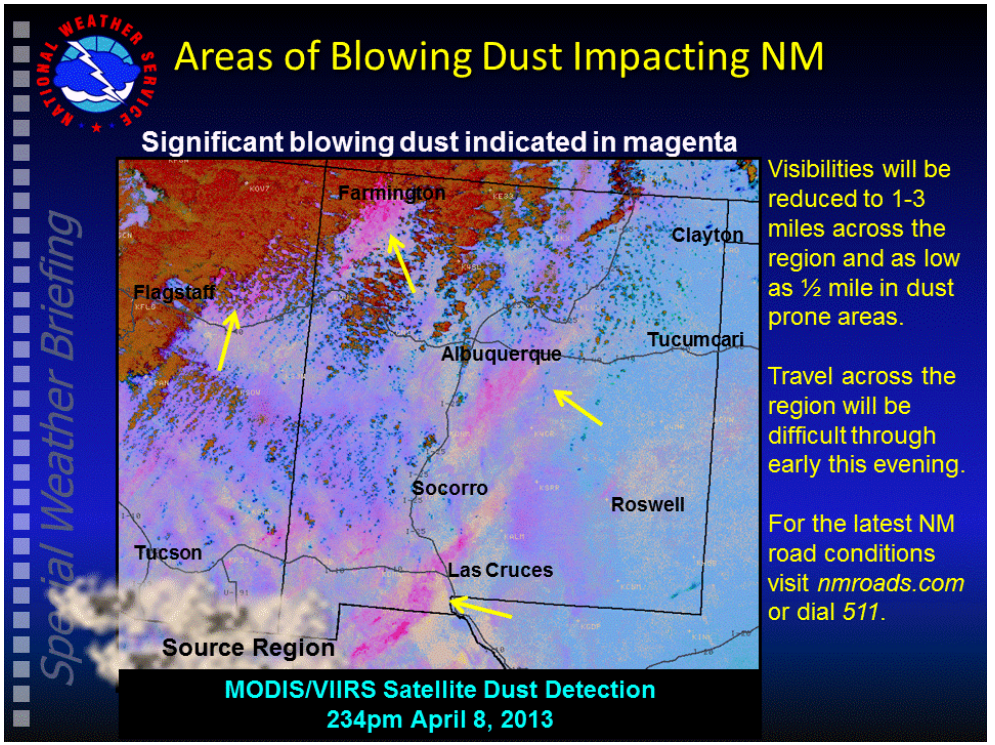
- Involve end user in entire process
- Develop end-user appropriate training
- Assess impact of solution on operations
- Incorporate feedback as part of the O2R process

A successful transition occurs when a new capability has a predominately positive impact on the forecast problem and is used "operationally" in the end users decision support system.

"Operational" use means regular or sustained use of data / products to make decisions

RGB Products Used in Operations

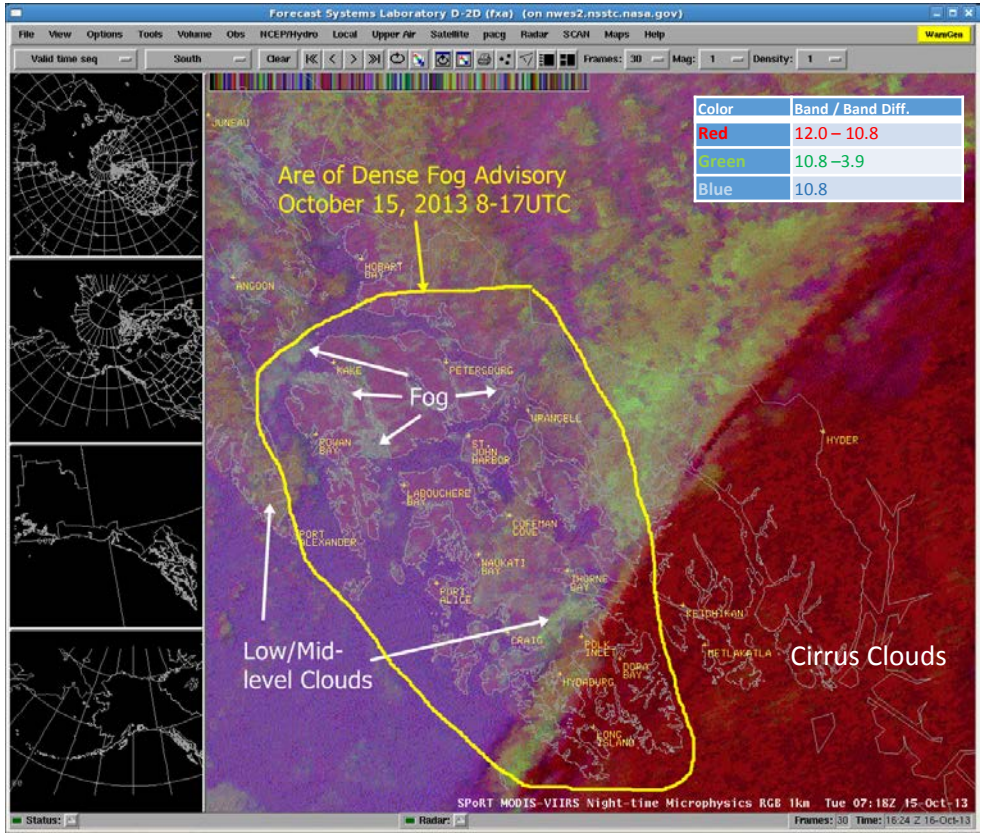
- Multispectral image composites (RGBs) fuse information from 3-6 channels to address specific forecast challenges.
- Here, SPoRT's partners in Albuquerque used MODIS and VIIRS imagery to improve the issuance of a "Dust Storm Warning" and to "Blowing Dust Advisory"
  - Publication completed in NWA J. of Operational Meteorology with Brian Guyer of WFO ABQ



RGB integrated into Graphicast (above) and other social media. ABQ reports that Power users are eager for this information" and that these products improve communication to the public.

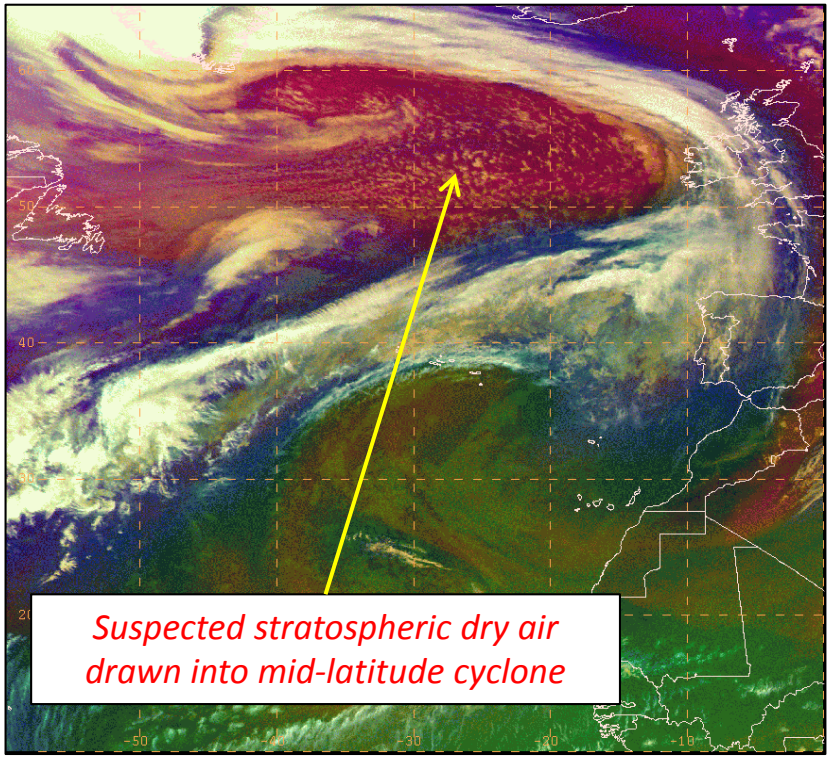
RGB Products Used in Operations

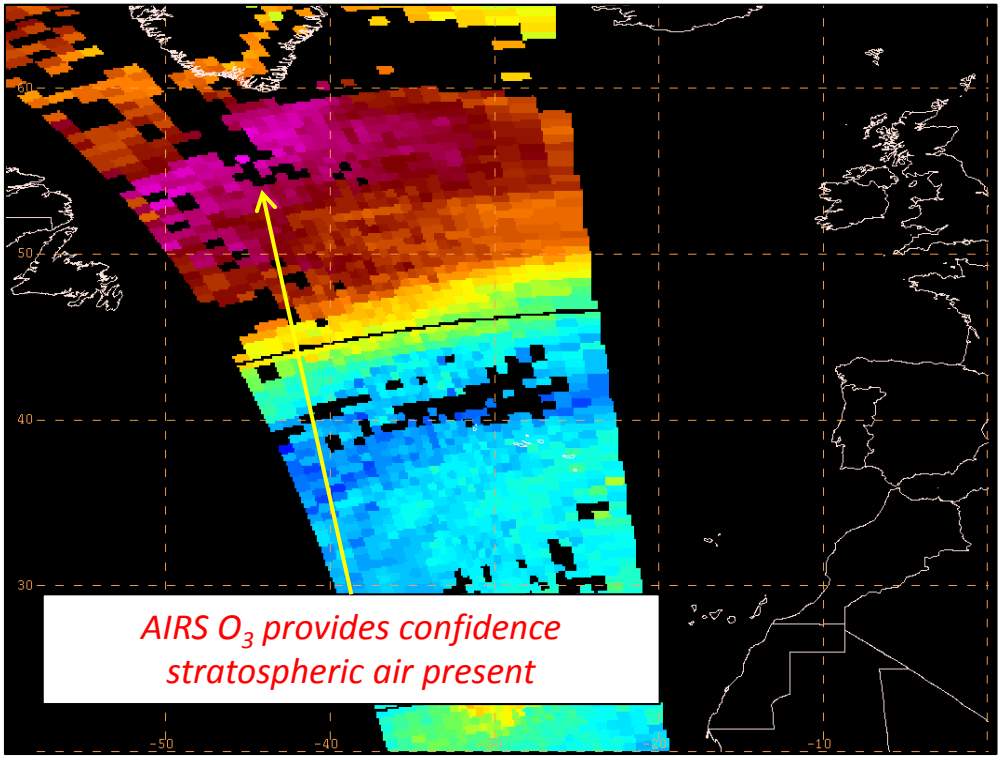
- Alaska WFOs benefit from increased temporal coverage of polar-orbiting satellites and sensors (VIIRS, MODIS)
- Higher resolution depiction of cloud features and RGB compositing allows for improved sensing of low clouds and fog.
- Here, partners in Juneau used RGB products to confirm fog within a Dense Fog Advisory for their area



Juneau, AK. 15 October 2013 the NtMicro RGB assists with analysis of fog in the area where Dense Fog Advisory was issued.

RGB Products Used in Operations

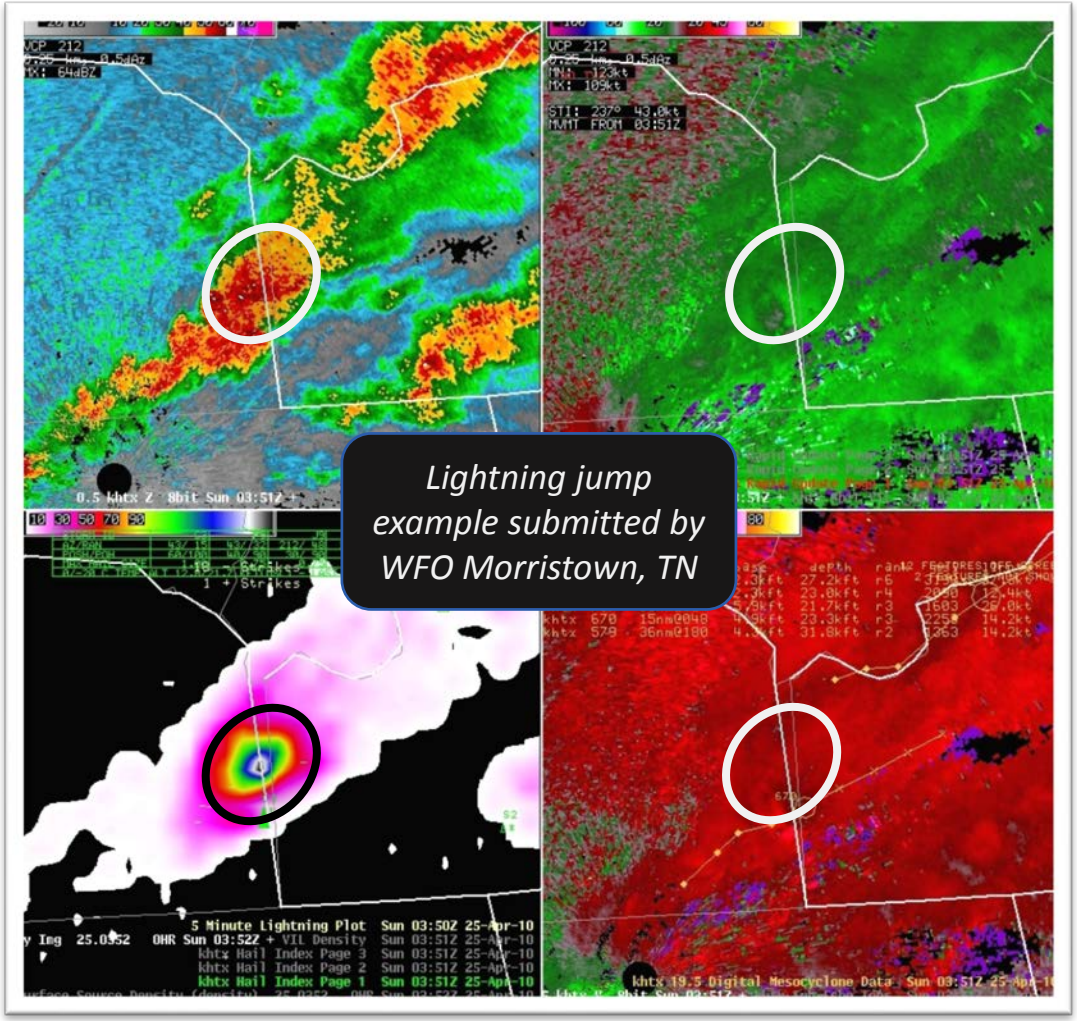




National Center partners such as WPC and OPC use multispectral products from MODIS, VIIRS, and SEVIRI, but also incorporate profile information from AIRS to understand the influence of stratospheric air (via ozone) on the development and intensification of midlatitude cyclones.

Operational Use of Total Lightning

- Early Success Story
  - Initial data to Huntsville WFO began in 2003, using NASA's North Alabama Lightning Mapping Array (NALMA)
  - Expanded to NASA's KSC and Washington D.C. networks, continues to expand to other ground-based networks
- Operational Impact
  - Allows users to be exposed to total lightning information prior to the launch of GOES-R
  - Forecasters with LMA access adopt "lightning jump" concept to assist with issuance of severe weather warnings
    - Sharp, sudden increase of lightning activity often occurs prior to severe weather



SUMMARY

- GOES-R will provide new capabilities to the National Weather Service and partners in the public/private sectors following launch in 2016, including:
  - More spectral bands to support analysis and applications
  - Better spatial resolution across all bands
  - Better temporal resolution, including very high temporal resolution mesoscale sectors focused on severe weather and other hazards
  - New lightning imaging capabilities to support severe weather and public safety
- Opportunities to leverage GOES-R types of data will be available for the next several years as follow-on missions are launched to continue geostationary observations.