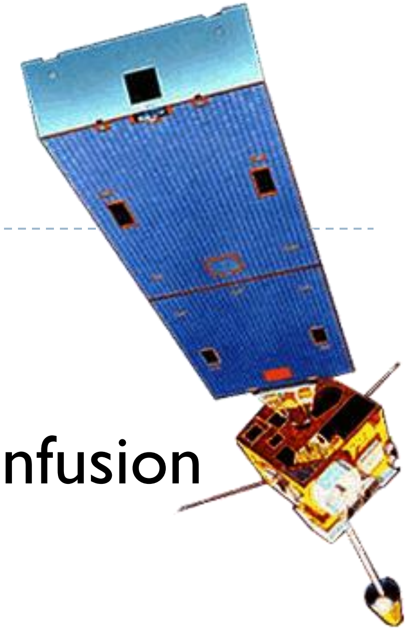
AWIPS II and GOES-R: When updated information processing systems and new satellites meet

Jordan Gerth, Research Assistant
Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin

Session XI – Wednesday, October 6, 2010
National Weather Association Annual Meeting, Tucson, Arizona

Presentation Outline



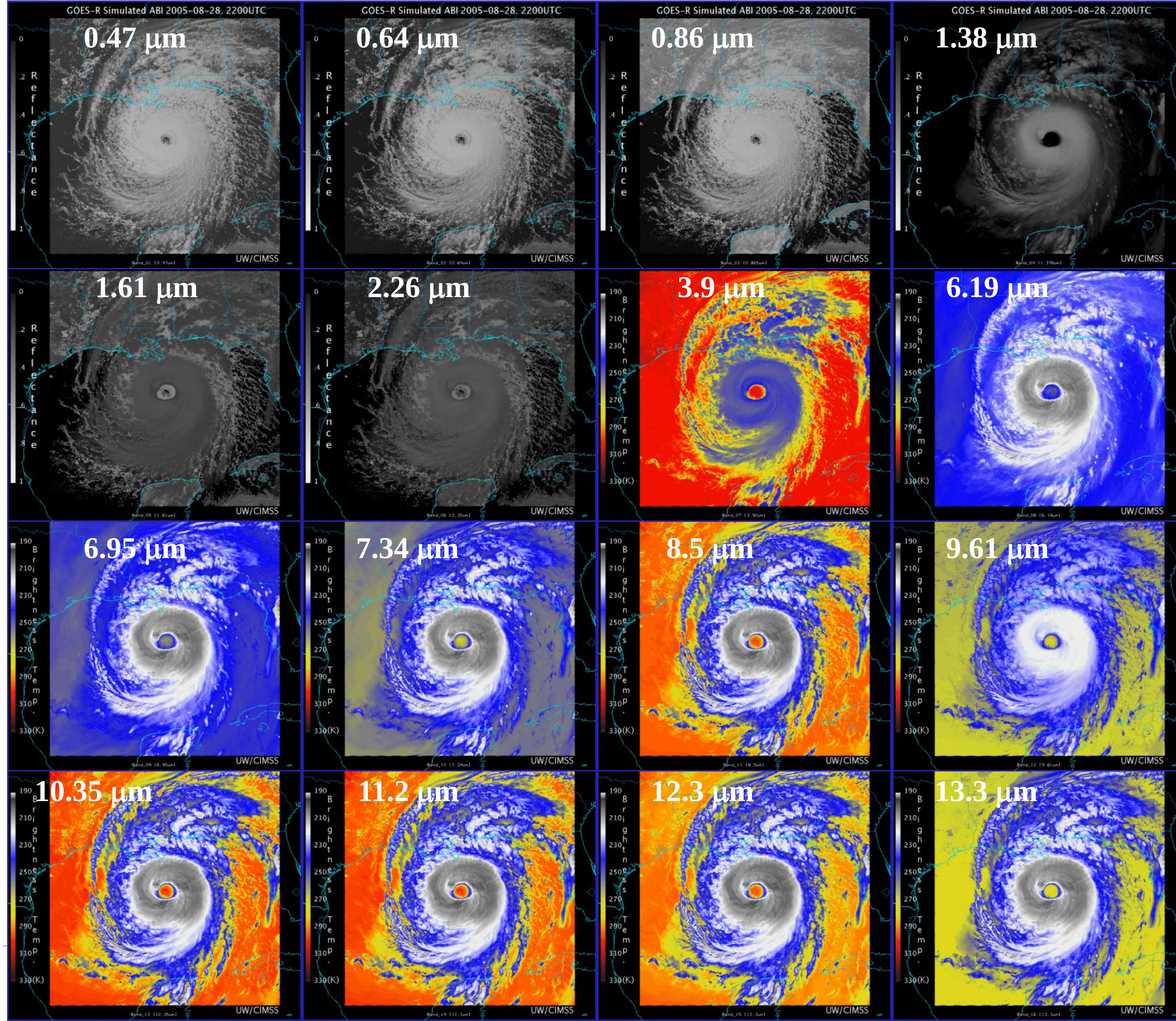
- Introduction to GOES-R/S Series
  - GOES-R Proving Ground and Partners
- Introduction to AWIPS II, AWIPS Technology Infusion
- Why AWIPS II must be the future
- Data Implications from GOES-R
  - Is the delivery of high spatial, spectral, and temporal resolution data from GOES-R necessary?
- RGB/RGBA Image Combinations
- Today's Primary Delivery Mechanisms
  - Case Study: POES Imagery
- Delivery Mechanisms of Tomorrow
- Conclusions and Future Directions

CIMSS

GOES-R/S Series

- Geostationary Operational Environmental Satellite
- Scheduled for launch in 2015, and expected for operational use as GOES-West starting in 2017, GOES-R will represent the first significant upgrade in capabilities to the United States' geostationary satellite series since 1994
- GOES-S (East) will launch in 2017 for operational use in 2020
- The Advanced Baseline Imager (ABI) will provide 5x faster spatial coverage, 4x improved resolution, and 3x more spectral channels than currently on GOES-13/14/15 (N/O/P)
- An optical sensor on the Geostationary Lightning Mapper (GLM) will provide continuous lightning flash rates
- No Sounder until at least GOES-U, scheduled for launch in 2027, expected operational in 2028

AWG Proxy ABI Simulations of Hurricane Katrina



NOAA/NESDIS STAR and GOES-R Imagery Team

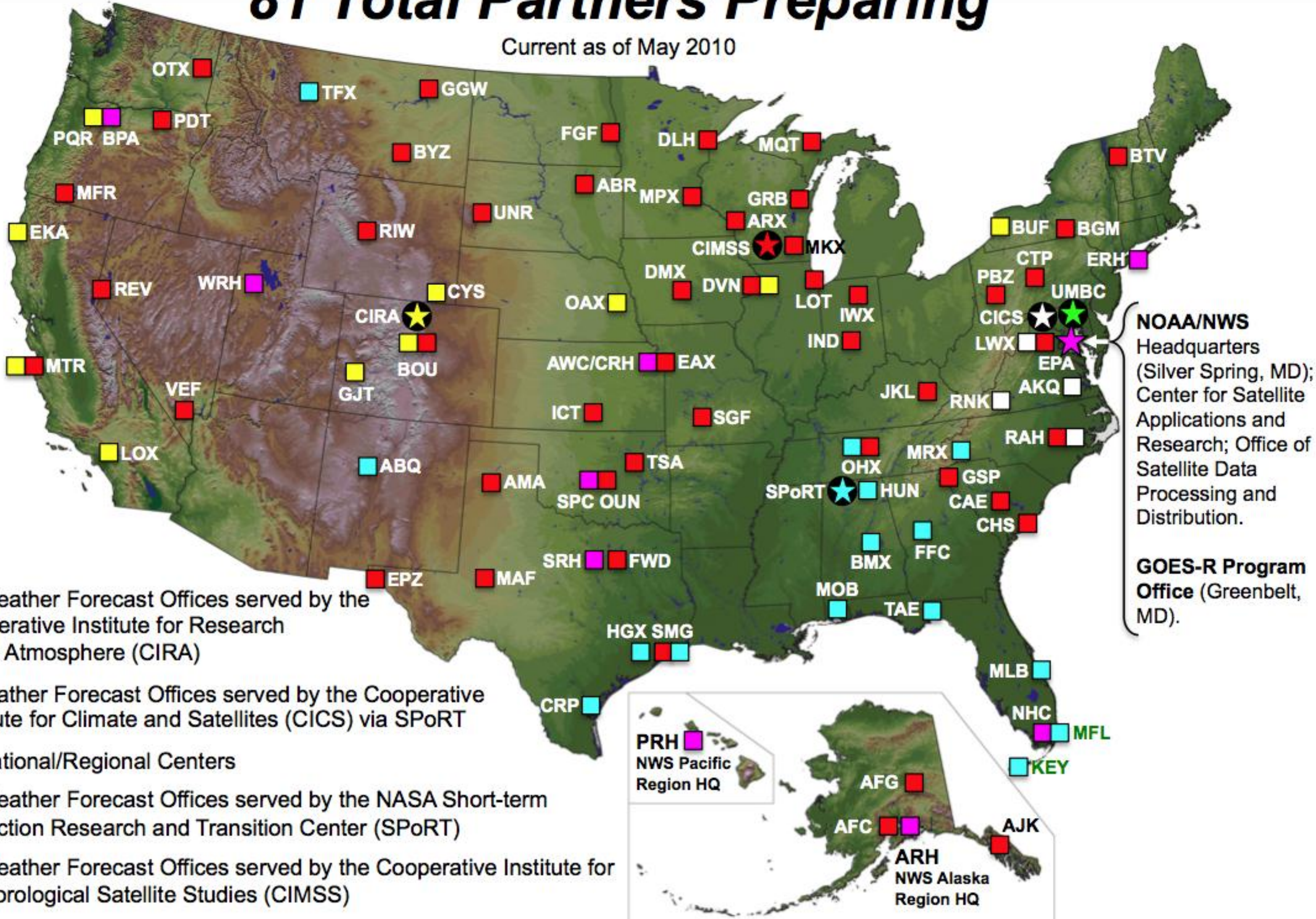
GOES-R Proving Ground

- A proving ground is designed to showcase future capabilities and identify possible gaps as a forward-thinking exercise to prepare the end user for upcoming science and technology.
- The GOES-R Proving Ground connects research and operations to assure widespread day-one readiness through:
  - Applying current earth observing systems and numerical weather prediction models to demonstrate GOES-R capabilities today
  - Transitioning new algorithms and techniques to the field early to assure forecaster familiarity with GOES-R products
  - Making operational meteorologists part of the discussion when it comes to designing and implementing effective GOES-R decision support products and visualization tools
- The GOES-R Proving Ground is a collective effort between many NOAA and NOAA-supported agencies and universities.

GOES-R Proving Ground Partners

81 Total Partners Preparing

Current as of May 2010



- ***10*** Weather Forecast Offices served by the Cooperative Institute for Research in the Atmosphere (CIRA)
- ***4*** Weather Forecast Offices served by the Cooperative Institute for Climate and Satellites (CICS) via SPoRT
- ***11*** National/Regional Centers
- ***15*** Weather Forecast Offices served by the NASA Short-term Prediction Research and Transition Center (SPoRT)
- ***48*** Weather Forecast Offices served by the Cooperative Institute for Meteorological Satellite Studies (CIMSS)

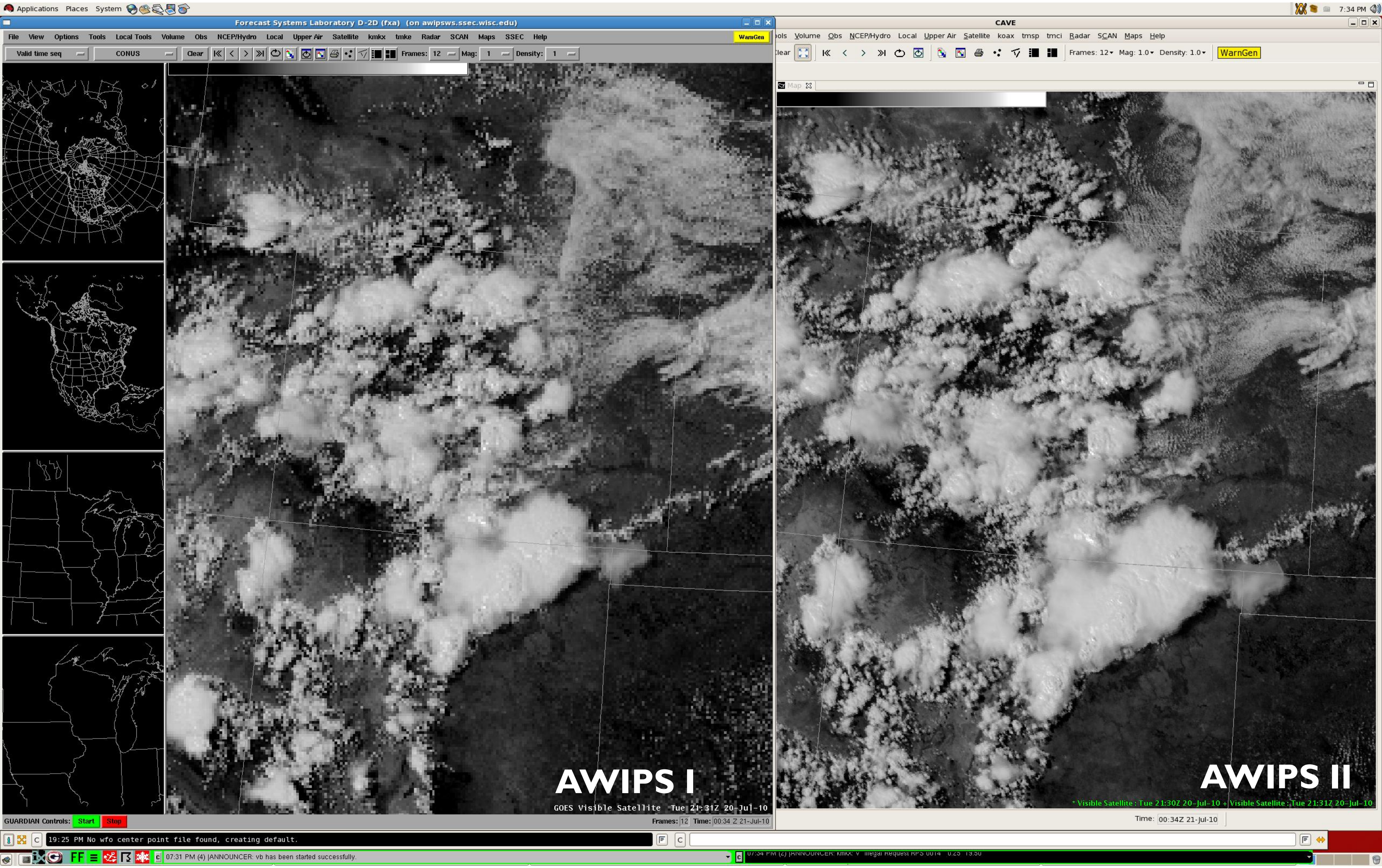
AWIPS "I"

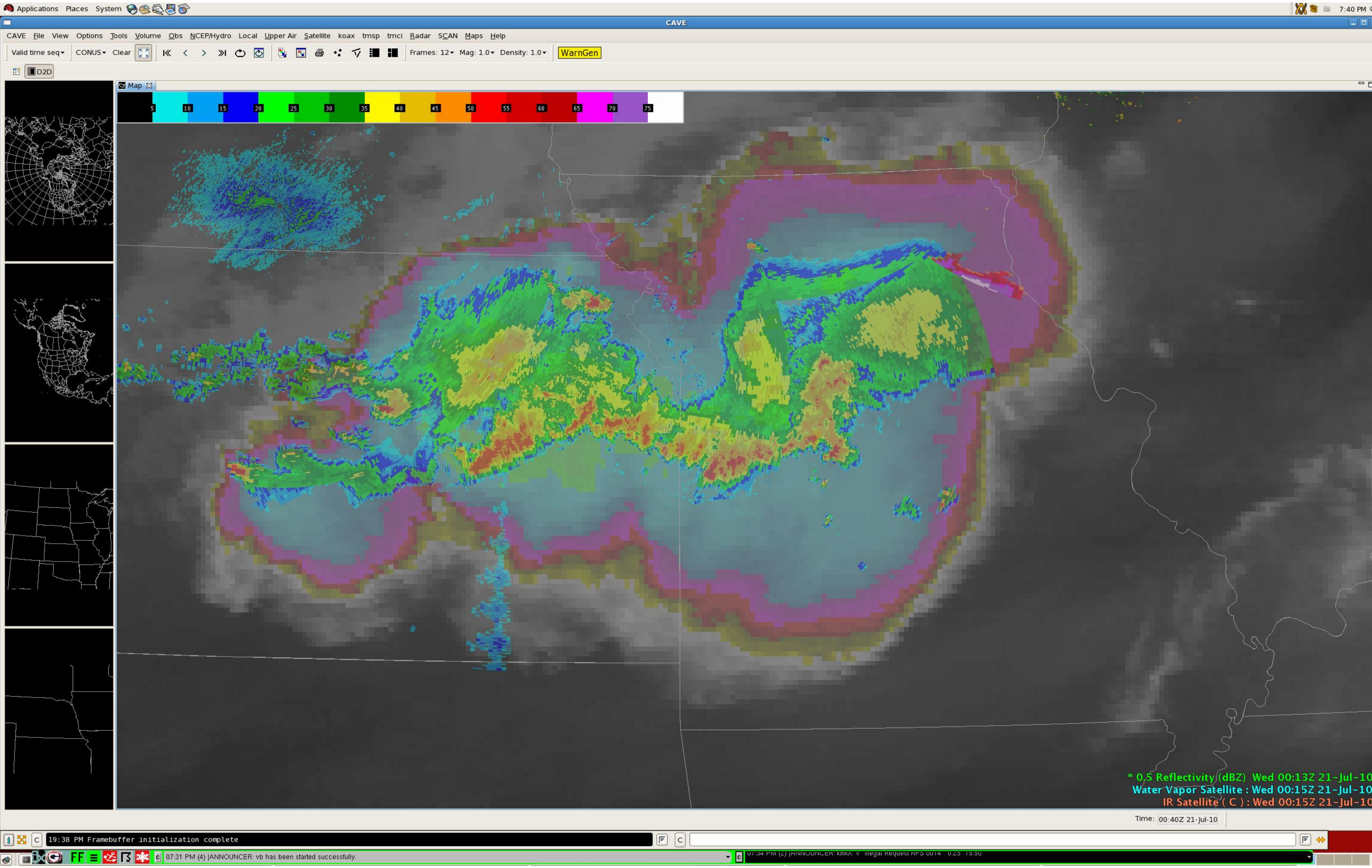
- Advanced Weather Interactive Processing System
- The primary tool used at National Weather Service offices across the country for weather data visualization and product issuance, fielded in 1998 after a lengthy development throughout the 1990s
- Display panes in Display Two-Dimensions
  - Six pre-defined scales
  - Centric to the geographic location of the NWS forecast office
  - Zooming and panning on a pane confined to the scale
  - Limited high-resolution data beyond localized area of responsibility
- Single-layer data displays restrict the compositing of multiple datasets to provide blended products
  - 8-bit (256) color
  - Only two images are allowed to overlay
  - Difficult to synthesize a large amount of information at a single time
- Certain datasets confined to specific scales based on spatial resolution
  - Expected that radar data would only be viewed on local area scales
  - Model data intended for viewing on regional and national scales

AWIPS "II"

- AWIPS II brings a new, integrated mapping interface which allows much more flexibility to meteorological analysis and data interrogation over large areas
- Gone are
  - the resolution restrictions to scales
  - the expectations that certain data is only useful on certain scales
- AWIPS II represents an end-to-end, design-level overhaul of the legacy AWIPS "I" to respond to changes in technology and data requirements over the previous decade
  - Maintains user interface nearly similar to AWIPS I
- AWIPS Technology Infusion will occur in two phases:
  - Migrating the current functionality over to a service-oriented architecture (SOA) based in Java and employing other open source software to accomplish tasks (Expected deployment in 2011)
  - Extending and evolving the functionality across all levels of the NWS enterprise to include the capabilities of the current National Center AWIPS (N-AWIPS) and Weather Event Simulator (WES)
- Central components of the migrated software will be available to academic institutions and others through Unidata, but not considered open source
- The migrated AWIPS software signals the end of the coupling of the AWIPS software to the data distribution network was has long inhibited the expansion of narrowly focused datasets and model output into the field

AWIPS II does not regionalize high-resolution geostationary satellite imagery like legacy AWIPS




Applications Places System
7:40 PM
CAVE
CAVE File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite koax tmsp tmci Radar SCAN Maps Help
Valid time seq CONUS Clear
Frames: 12 Mag: 1.0 Density: 1.0
WarnGen
D2D
Map
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
* 0.5 Reflectivity (dBZ) Wed 00:13Z 21-Jul-10
Water Vapor Satellite : Wed 00:15Z 21-Jul-10
IR Satellite (C) : Wed 00:15Z 21-Jul-10
Time: 00:40Z 21-Jul-10
19:38 PM Framebuffer initialization complete
07:31 PM (4) |ANNOUNCER: vb has been started successfully.

AWIPS II – The Near Term

- Necessary to meet the requirements of tomorrow's hydrometeorological datasets
  - Effectively and dynamically producing displays using the graphics card
    - Integrating multiple datasets "on the fly" to minimize forecaster use of multiple products for similar information
  - Modernizing and standardizing data storage repositories and the discovery database (for metadata)
    - Optimizing access attempts for quickest ingest and display
  - Development must continue to keep pace with existing technology
- Because of the complexities resulting from a service-oriented architecture, developers will need more training to effectively extend the software
- Local application development should not occur without adequate governance
  - Plug-ins are essentially required to run within AWIPS II, and it is unlikely most will be able to run independently as with legacy AWIPS

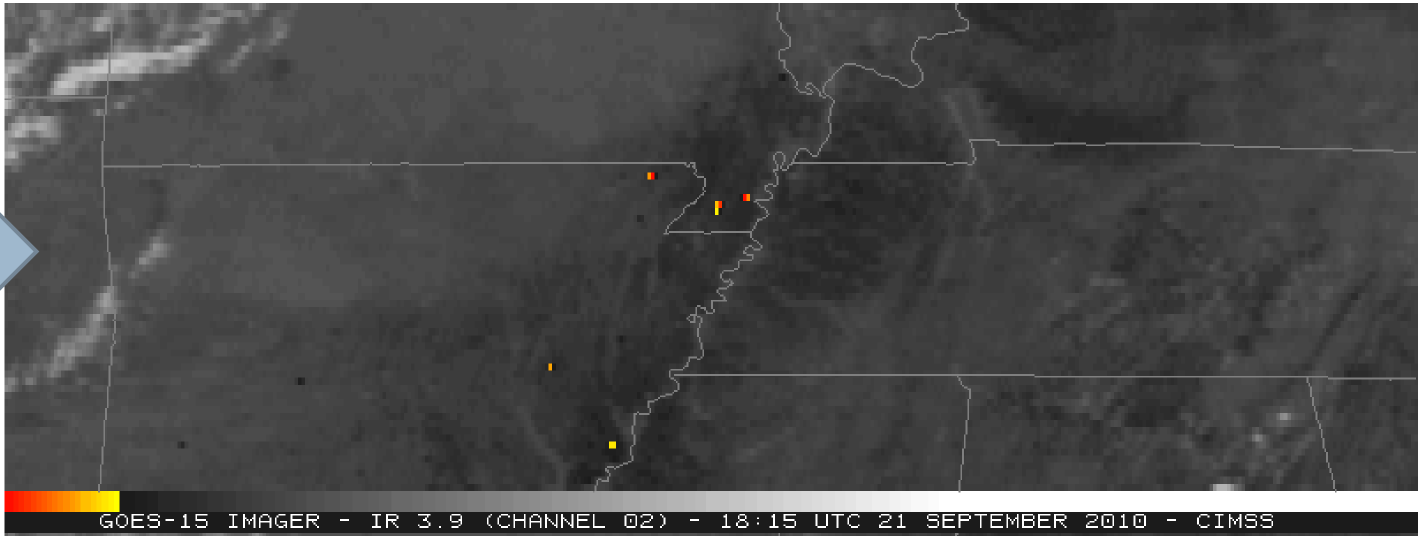
GOES-R/S Series – The Far Term

- The additional capabilities of the ABI will produce approximately 60 times (5x4x3) more data than the current GOES Imager
- If data is delivered at full bit depth (12 to 14 bits), approximately 50% more bandwidth will be required
- Delivering geostationary satellite data in 2020 using a similar methodology as today may require up to **90** times more bandwidth than currently, compression aside, not including products
- The questions we have to answer:
  - Are the visualization tools in place to allow for effective interrogation of this data?
  - How can we better devise blended products to deliver more information to the forecaster without requiring the review of multiple images (from different bands, satellites, times)?
  - Is *all* satellite imagery needed by *all* AWIPS sites *all* the time?
    - Is it time to rethink the delivery paradigm? Delivery data format?

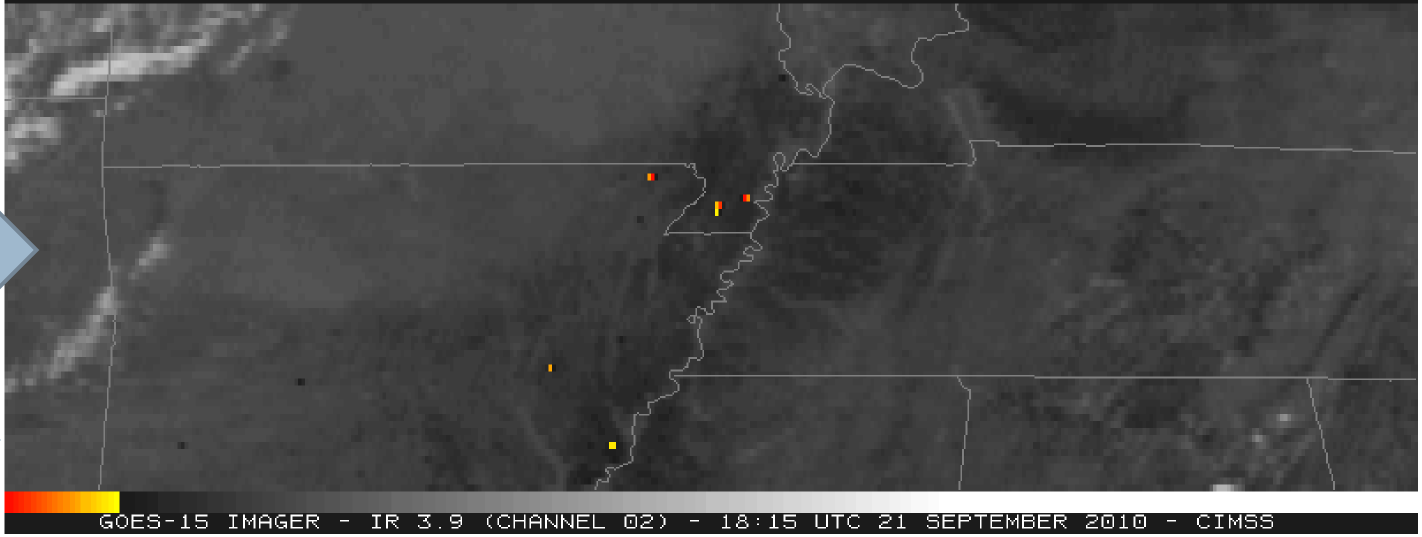
High Temporal Resolution (SRSO)

- Fire detection using shortwave infrared (3.9 µm) imagery

1-minute GOES-15 SRSO



15-minute GOES-15 scans

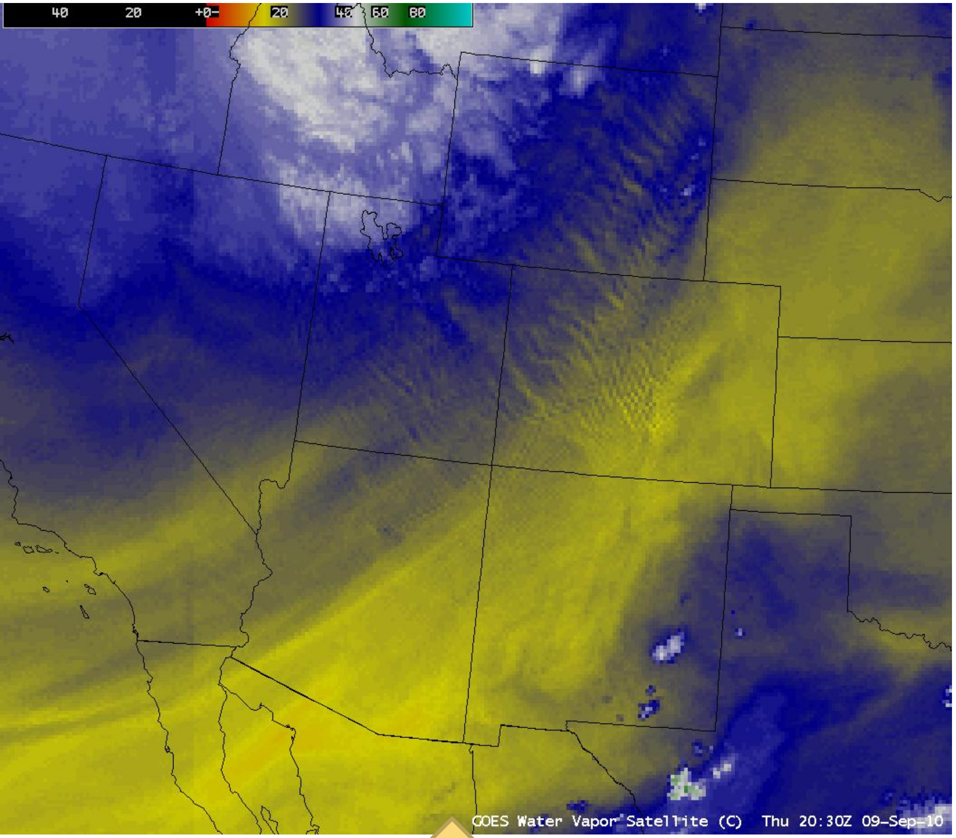


Example courtesy of Scott Bachmeier, CIMSS

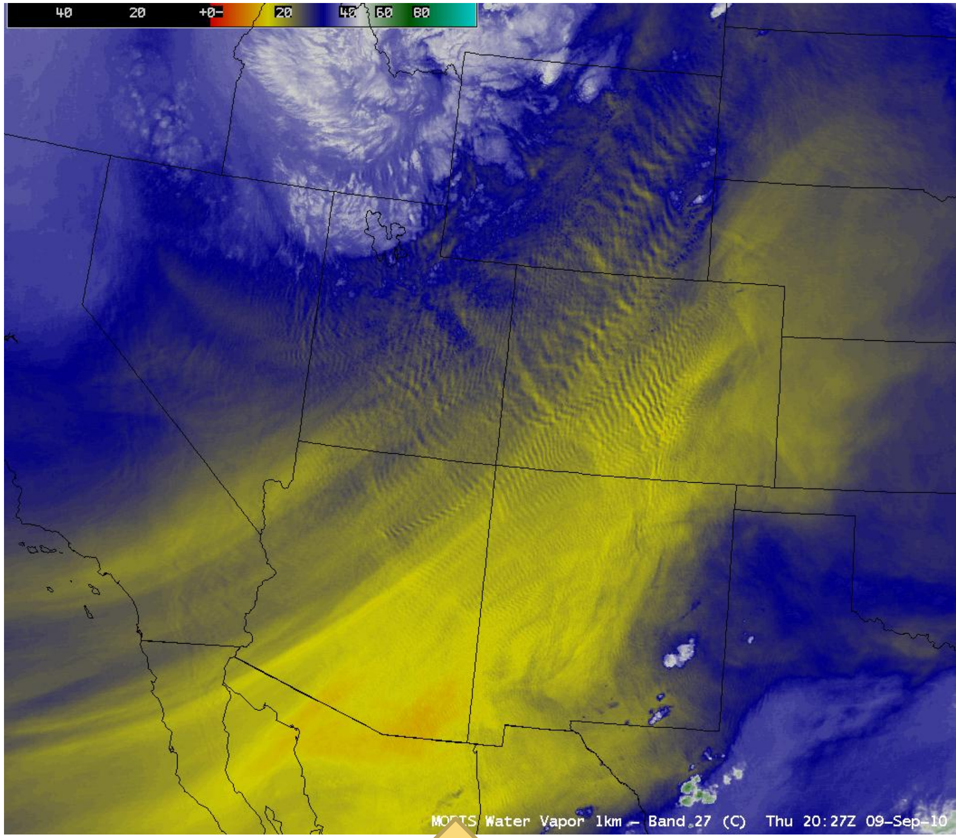
High Spatial Resolution

There will be three water vapor channels on GOES-R at nadir resolution of 2 km.

- Mountain wave detection using water vapor imagery



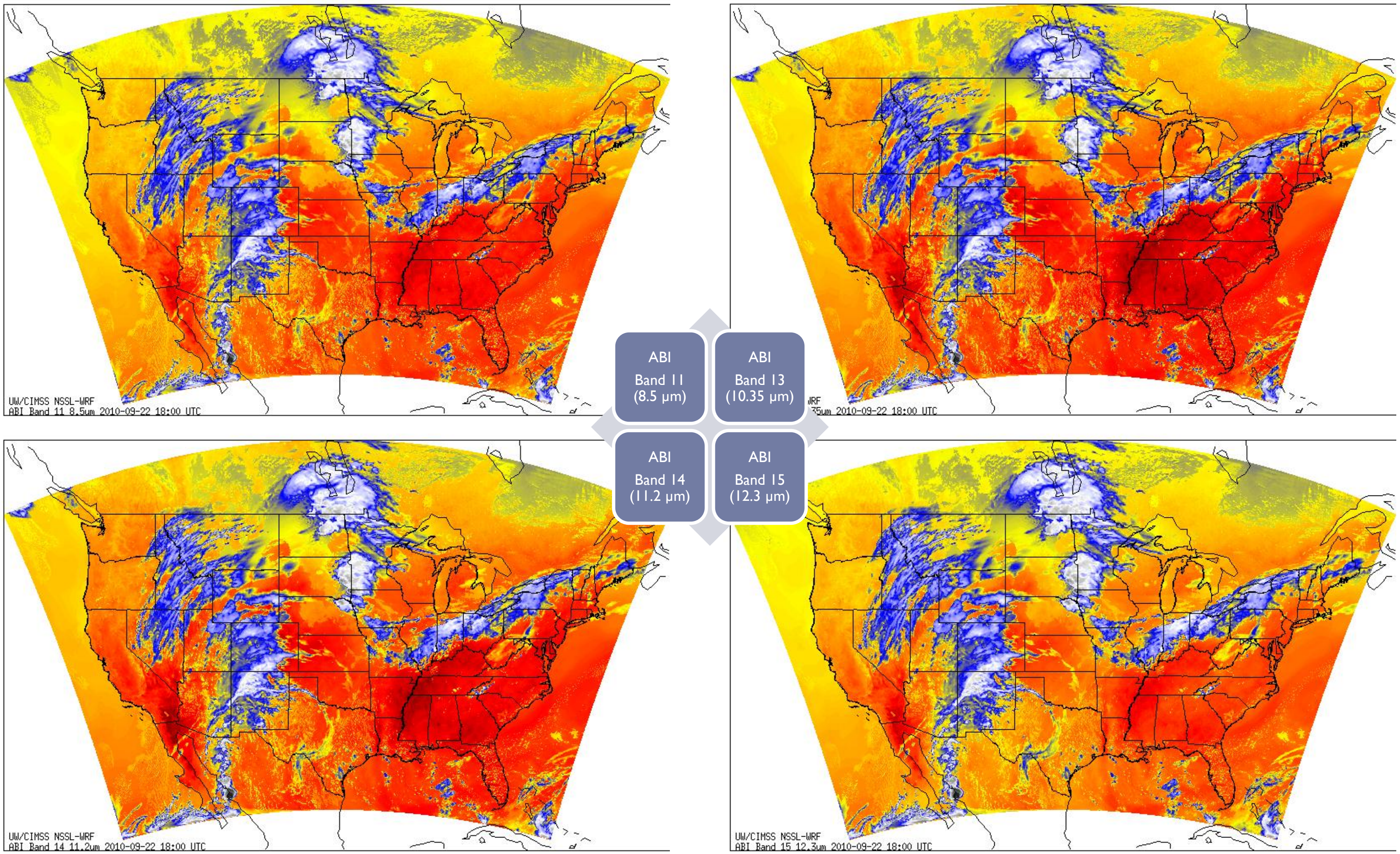
GOES 4km Resolution



MODIS 1km Resolution

Example courtesy of Scott Bachmeier, CIMSS

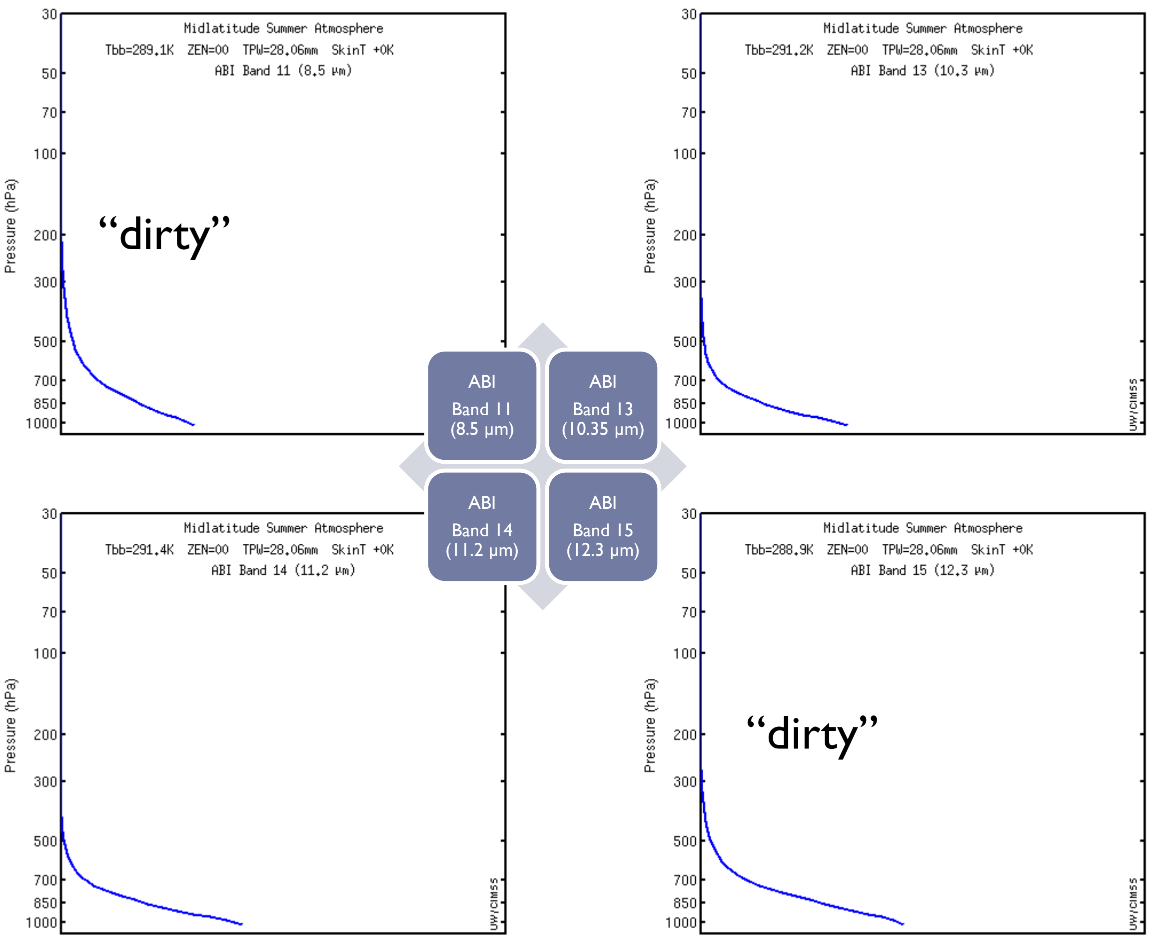
Different Spectral Channels

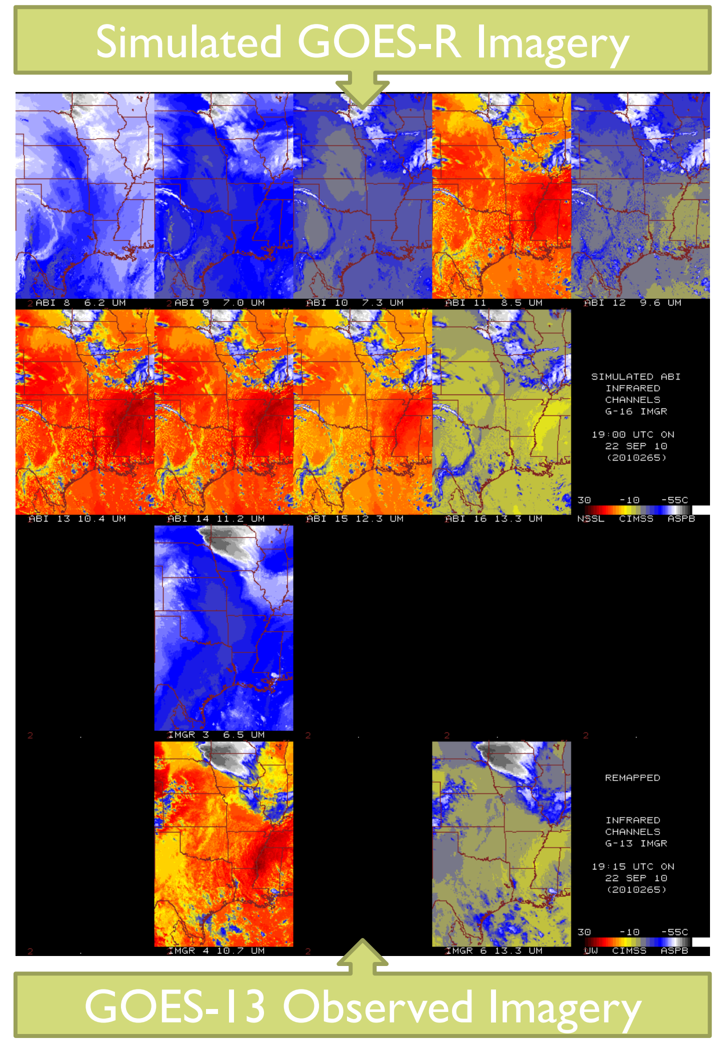


- Simulated ABI imagery from NSSL-WRF

Images courtesy of Justin Sieglaff, CIMSS

Useful for Operations?



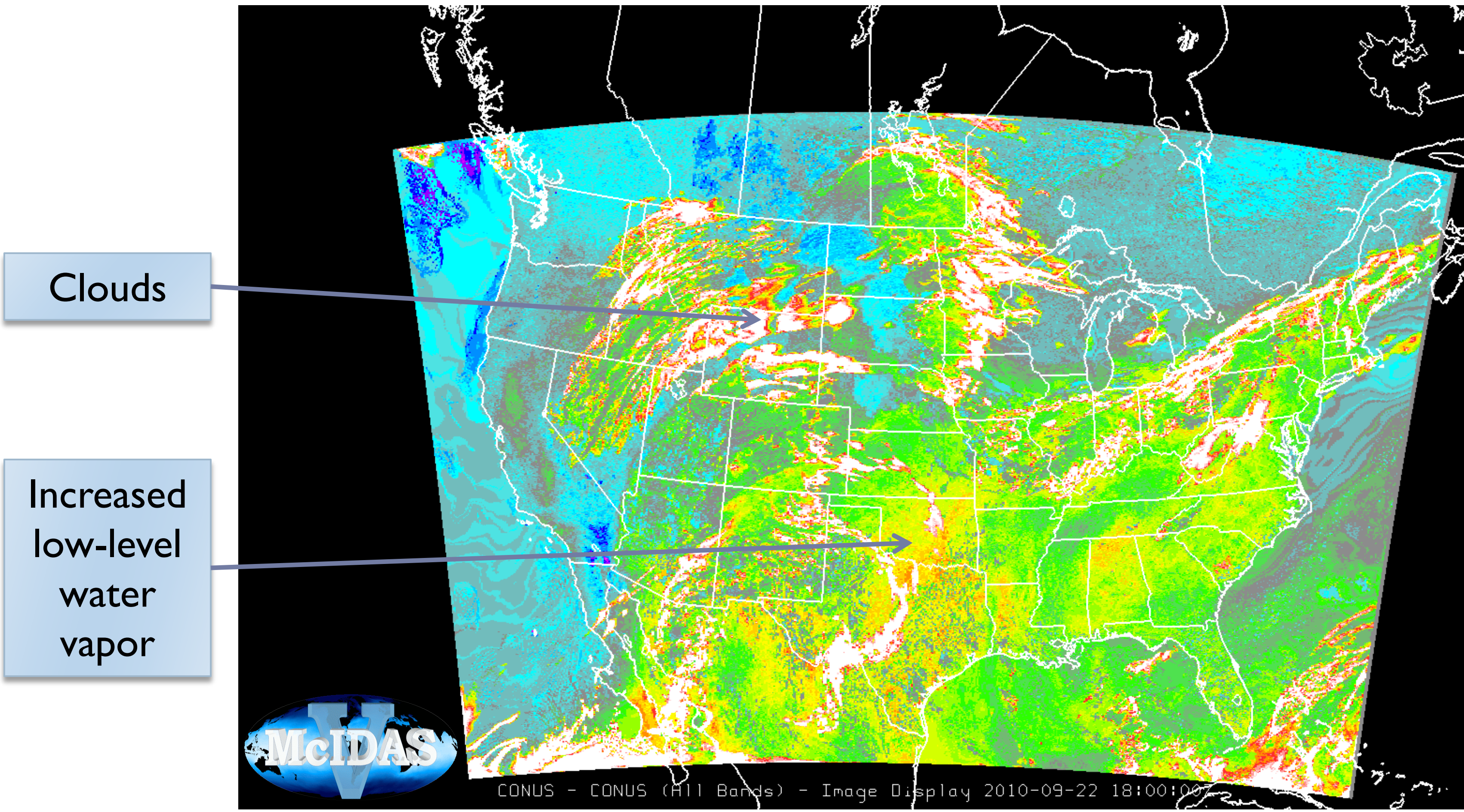


- Midlatitude summer weighting functions

Plots courtesy of Mat Gunshor, CIMSS

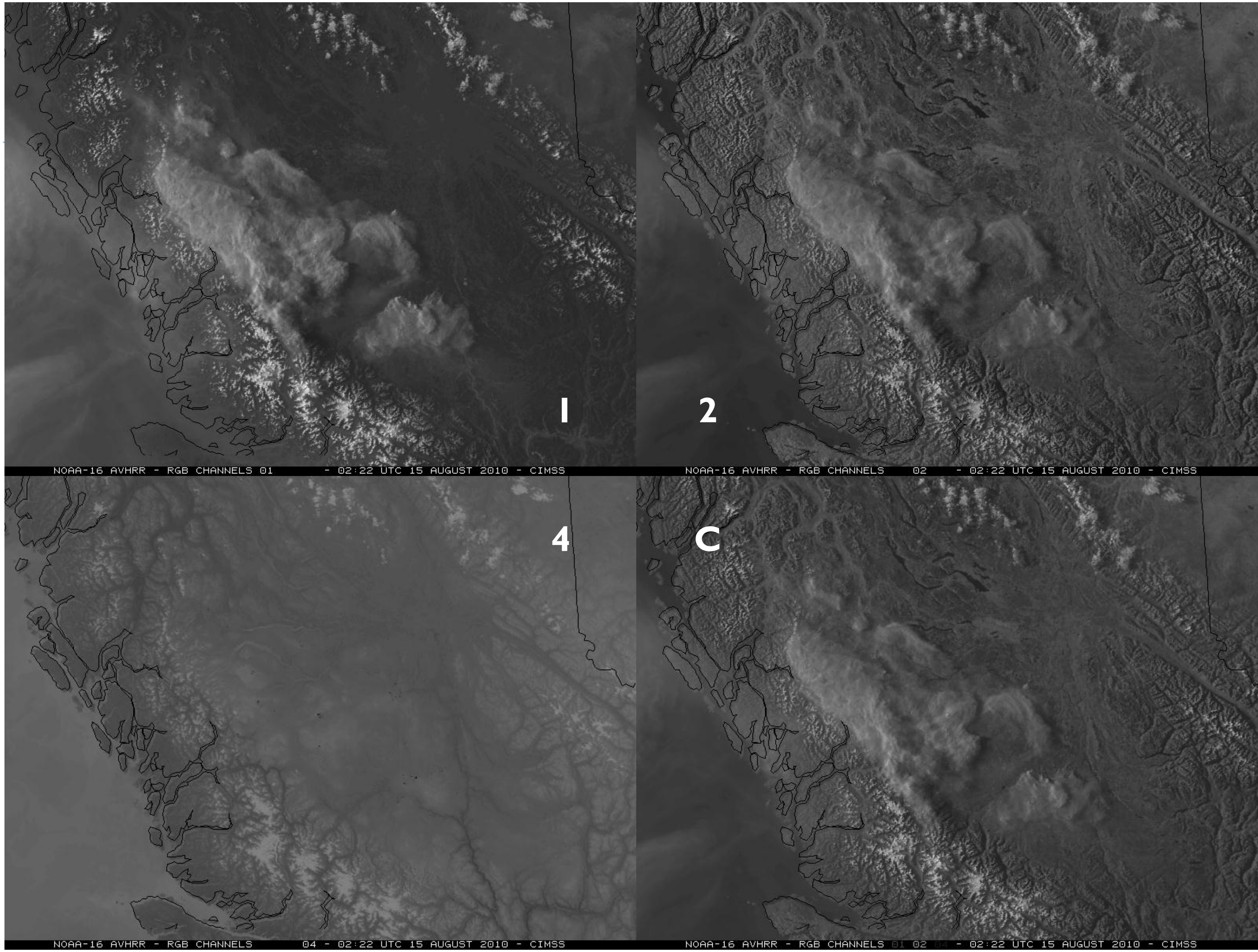
Useful for Operations?

- Linear simulated ABI band combination: (11+13)–(15+14)

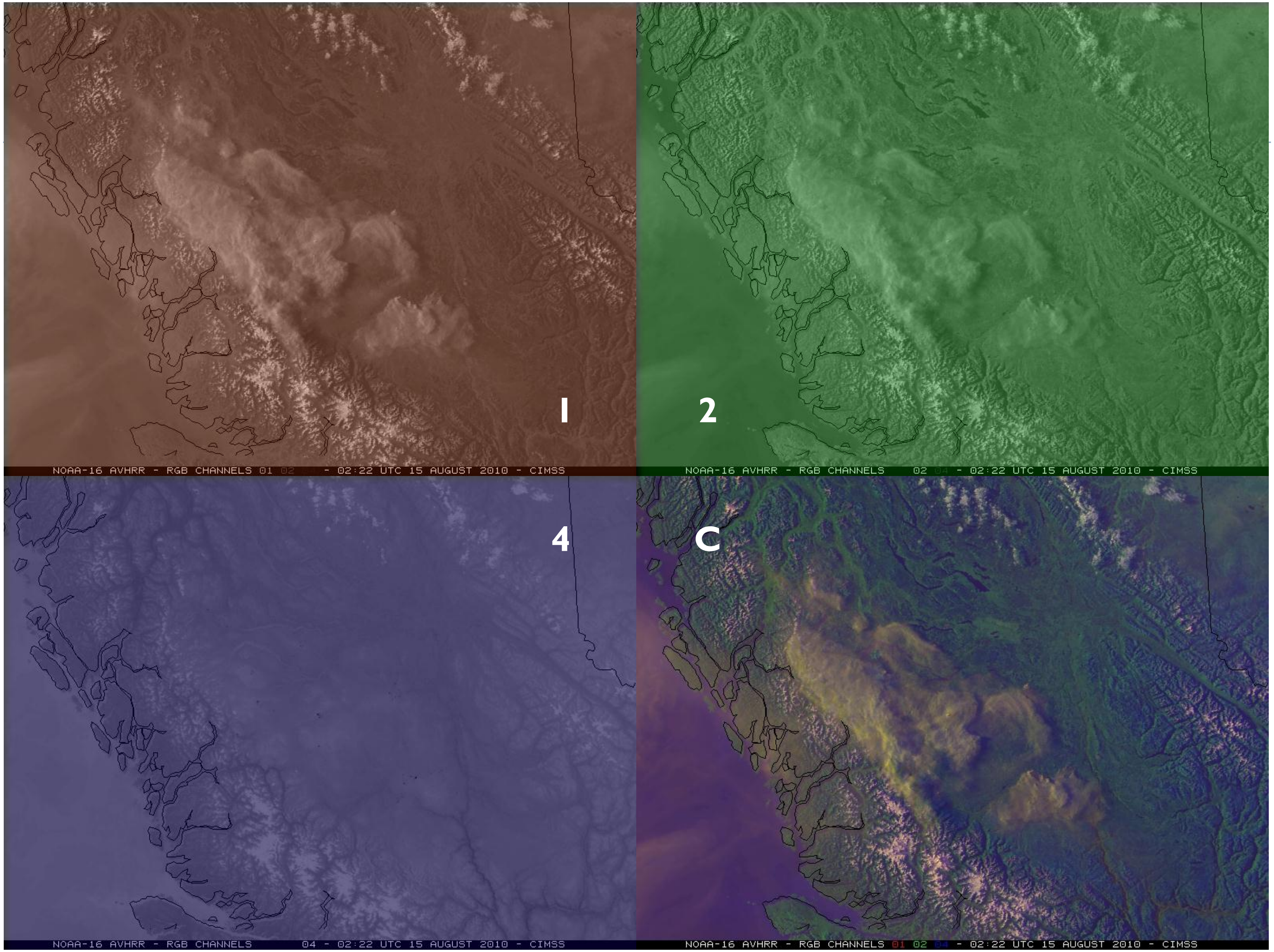


RGB/RGBA Image Compositing

- In order to maximize the use of current and future satellite imagery and products, as well as the software display, it is necessary to integrate and support a flexible bit depth data format and three-way or four-way (with an alpha channel) image blending functionality into the AWIPS II software.
- This would leverage a red-green-blue-alpha (RGBA) capability in pre-release versions of the migrated software.
- The implementation of a data format and display system allowing for bit depths greater than the current specification has numerous applications useful to operational weather analysis and forecasting beyond current capabilities and techniques, including but not limited to:
  - the discrimination of snow cover from supercooled water droplet clouds,
  - the discrimination of snow cover from areas with significant ice accrual,
  - determining the areal extent of river flooding,
  - assessing fire hot spots and burn scar coverage,
  - determining vegetation properties,
  - finding convincing damage swaths caused by tornadoes, hail, and wind,
  - improved tropical cyclone analysis, and
  - diagnosing swaths of wet ground following rain.



Example courtesy of Scott Bachmeier, CIMSS



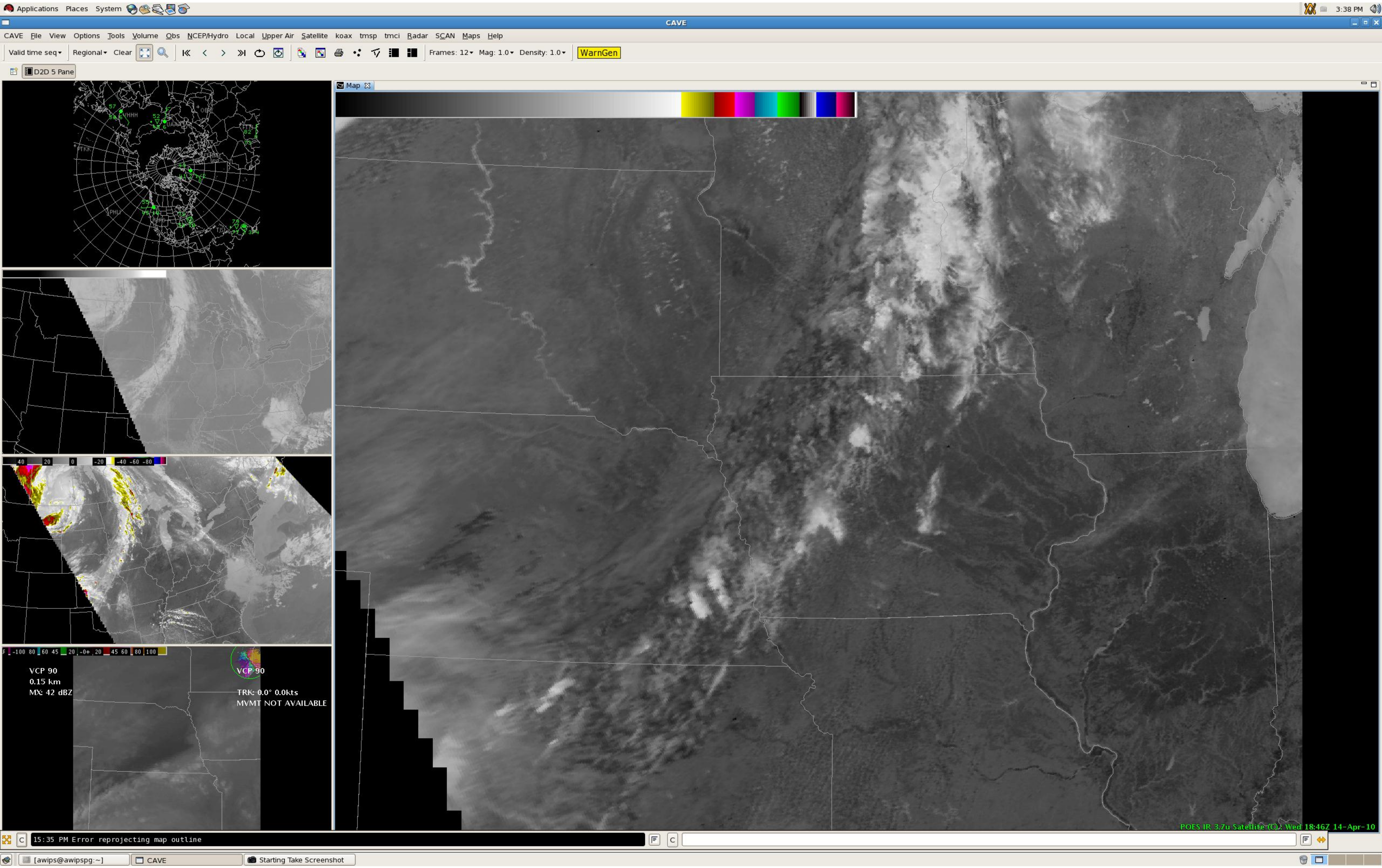
Example courtesy of Scott Bachmeier, CIMSS

Today's Primary Delivery Mechanisms

- NOAAPort: Satellite-based system used as the primary delivery mechanism for hydrometeorological data and model output to the field, as well as NOAA's partners
  - Strengths: Reliable and operationally supported, transmits broad range of data, bandwidth increase expected in 2011
  - Weaknesses: Approval process for transmission lengthy, not all data within geographic area important to the user
- Local Data Manager (LDM): Event-driven data sharing network that utilizes the Internet to mass move various data between NOAA agencies and universities
  - Strengths: Easy delivery method to NWS field offices, widespread use throughout NWS enterprise and universities, user configurable to only ingest certain products
  - Weaknesses: Not operational, strains bandwidth available to the field, limited connectivity to NOAA partners
- Web: Displaying text data or images on a web page
  - Widespread access, but outside of AWIPS, so data interrogation limited

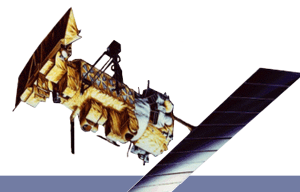
Case Study: POES Imagery

- In response to NWS AWIPS OB7 requirements, NESDIS planned to add NOAA polar-orbiter visible (0.63 µm), shortwave IR (3.7 µm), and longwave IR (10.8 µm) imagery to NOAAPort on June 7, 2006.
- After testing, it was determined that there was an insufficient amount of bandwidth between NESDIS and the Network Control Facility (NCF). Thus, this imagery could not be broadcast and delivered to the field.
- In 2009, CIMSS worked with NESDIS to obtain the code for adequately formatting the POES imagery into the standard distributable GINI format (AWIPS I/II decoder compliant), and adapting it to run in real-time at the University of Wisconsin.
- Field sites can now obtain this imagery from CIMSS via LDM.
  - Additional products also available.
- NESDIS may be able to proceed with operational distribution no sooner than April 2011 (likely late 2011).
- Eventually NPP/JPSS imagery should be available on NOAAPort.


Applications Places System
3:38 PM
CAVE
CAVE File View Options Tools Volume Obs NCEP/Hydro Local Upper Air Satellite koax tmsp tmci Radar SCAN Maps Help
Valid time seq Regional Clear
Frames: 12 Mag: 1.0 Density: 1.0
WarnGen
D2D 5 Pane
Map
VCP 90
0.15 km
MX: 42 dBZ
VCP 90
TRK: 0.0° 0.0kts
MVMT NOT AVAILABLE
POES IR 3.7u Satellite (C): Wed 18:46Z 14-Apr-10
15:35 PM Error reprojecting map outline
[awips@awipspg:~]
CAVE
Starting Take Screenshot

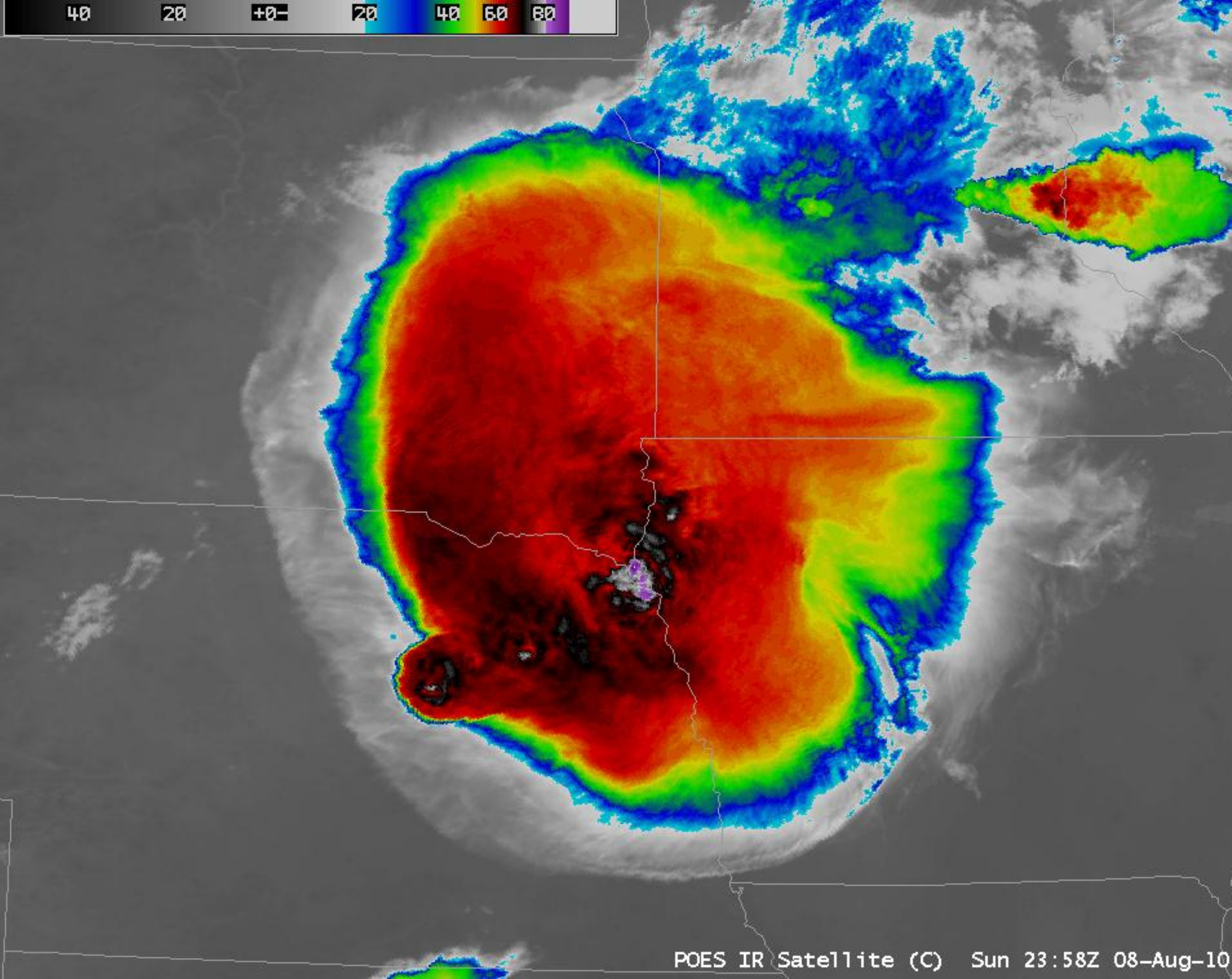
Case Study: POES Imagery

All NOAA Polar Operational Environmental Satellites (POES) are equipped with an Advanced Very High Resolution Radiometer (AVHRR) which has a resolution of 1.09 km at nadir.

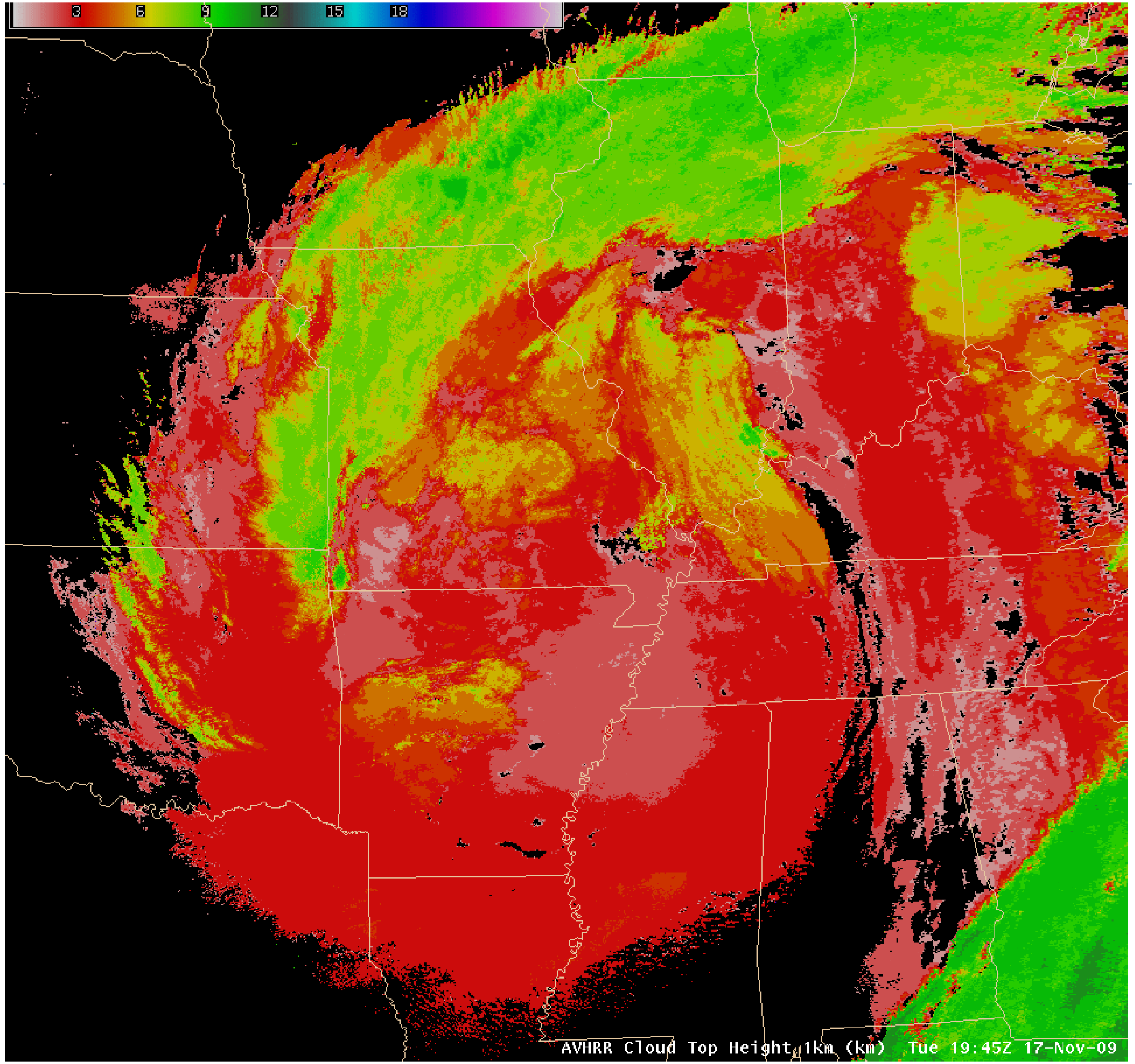


GINI Sector	Frequency
Alaska National	12 to 14 per day
East CONUS	10 per day
Hawai`i National	2 per day
Puerto Rico Nat'l	10 per day
West CONUS	4 to 6 per day

- Additional AVHRR imagery available includes:
  - Band 2 (0.86 μm), for distinguishing land and water
  - Band 5 (12.0 μm), for detecting volcanic ash
- Additional AVHRR products available include:
  - Sea Surface Temperature
  - Cloud Type
  - Cloud Top Temperature
  - Cloud Top Height
  - Cloud Optical Depth
  - Cloud Particle Effective Radius



Example courtesy of Scott Bachmeier, CIMSS

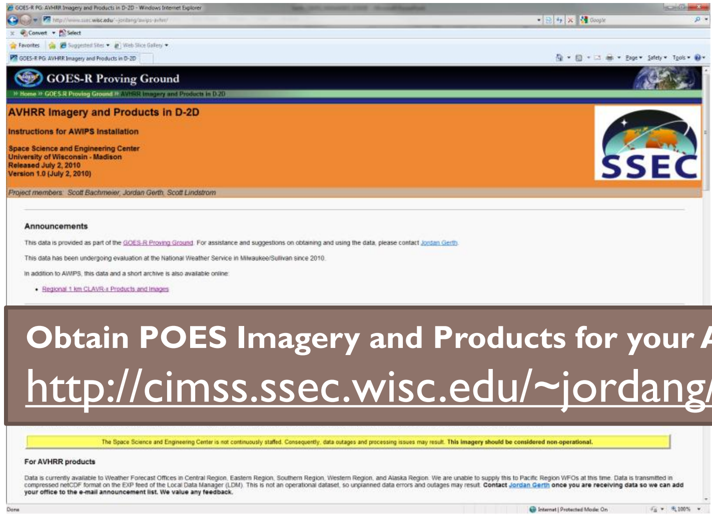


Example courtesy of Scott Bachmeier, CIMSS

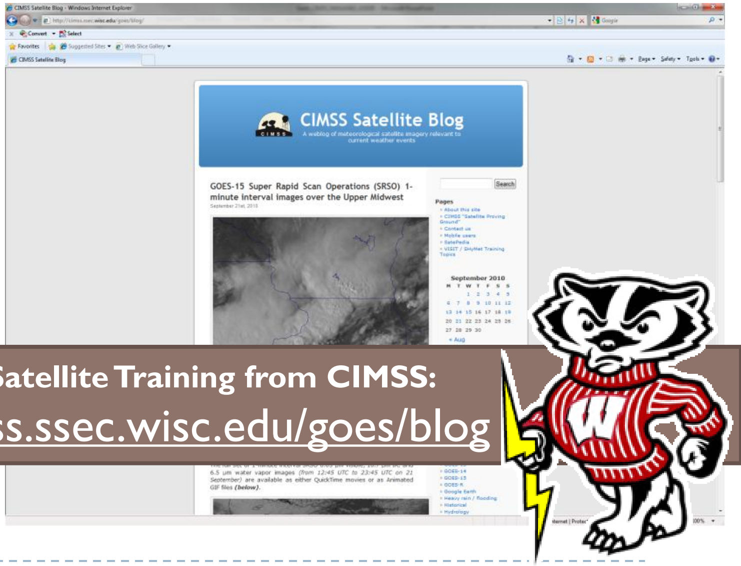
Case Study: POES Imagery

Value to the Forecaster

- Near-term (less than 12 hours) forecasts
  - Precipitation potential
    - Cloud optical depth product
    - Cloud particle effective radius product
  - Precipitation type: Snow or drizzle?
    - Cloud type product
- Short-term (12 to 36 hours) forecasts
  - Areas of fog formation (10.8–3.7 μm)
  - Air temperatures in nearshore areas based on water temperatures
- Post-event analysis
  - Flooding rivers and tributaries
  - Rain-cooled ground on IR Window
  - Cloud top temperature and cloud height products

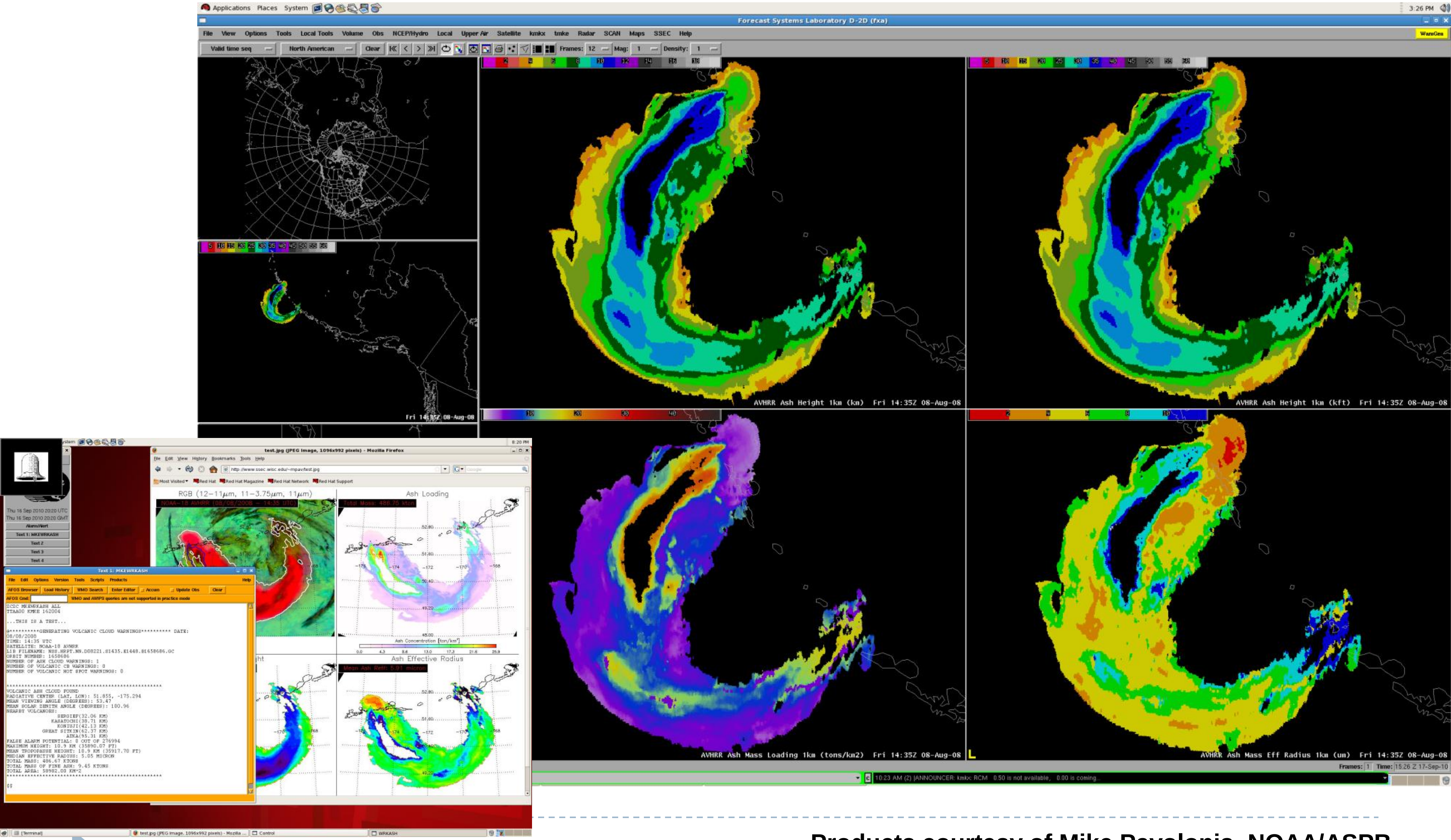


Obtain POES Imagery and Products for your AWIPS:
http://cimss.ssec.wisc.edu/~jordang/awips-avhrr



Just in Time Satellite Training from CIMSS:
http://cimss.ssec.wisc.edu/goes/blog

Kasatochi August 2008 Eruption



Products courtesy of Mike Pavolonis, NOAA/ASPB

Delivery Mechanisms of Tomorrow

- NOAAPort: In 2011, the delivery bandwidth will increase from 10 Mbps to 30 Mbps as part of upgrading the signal demodulators from DVB-S to DVB-S2. NOAAPort will remain the primary delivery mechanism through at least 2013. (Source: Brian Gockel, NWS OST SEC)
  - Increased bandwidth will accommodate transmission of dual-polarization radar data, bias-corrected SREF, other NCEP model output, and new satellite imagery/products (even prior to GOES-R) over the next two years.
  - Examine types of data compression as transmitted data continues to rise?
- LDM: The LDM will facilitate the raw data ingest from NOAAPort into AWIPS II (no longer confined to the LDAD), such that terrestrial data delivery could be a strong candidate without significant retooling if sufficient Internet bandwidth exists at field offices.
  - The well-established LDM network could be leveraged to support backup operations in the event of a downlink failure at one or more sites.
- Repository: "Push-pull" and "on-request" technology has been investigated as a way to deliver weather data to remote locations (FxNet and AWIPS II Thin Client), and could be expanded to alleviate bandwidth over NOAAPort for regional data and products.
  - Use regional headquarters as hubs? Web mapping services (WMS)?

Conclusions and Future Directions

- AWIPS II will play a significant role in promoting the capabilities of GOES-R and new polar-orbiting satellites because the expanded distribution and development group will lead to an implementation of additional features which maximize the utility of satellite imagery and products in concert with other in-situ observations and model output.
  - Blended and combined products
- It will also allow for the efficient transfer of new science and technology into NWS operations without delay.
  - To accomplish this, we will have to investigate and utilize delivery mechanisms outside of NOAAPort
- Our future AWIPS will not be confined to NWS offices, but extend to universities and become an integral part of the increasing research to operations activities.
  - Unique applications of the software will increase
- Now is the time to start investigating data overload, and developing methodology which optimizes the use of data, imagery, products, and tools which are situation and scenario relevant, and leads the decision support thought process.
  - Too focused situational awareness decreases overall situational awareness

Questions? Comments? Contact me: Jordan Gerth, Jordan.Gerth@noaa.gov