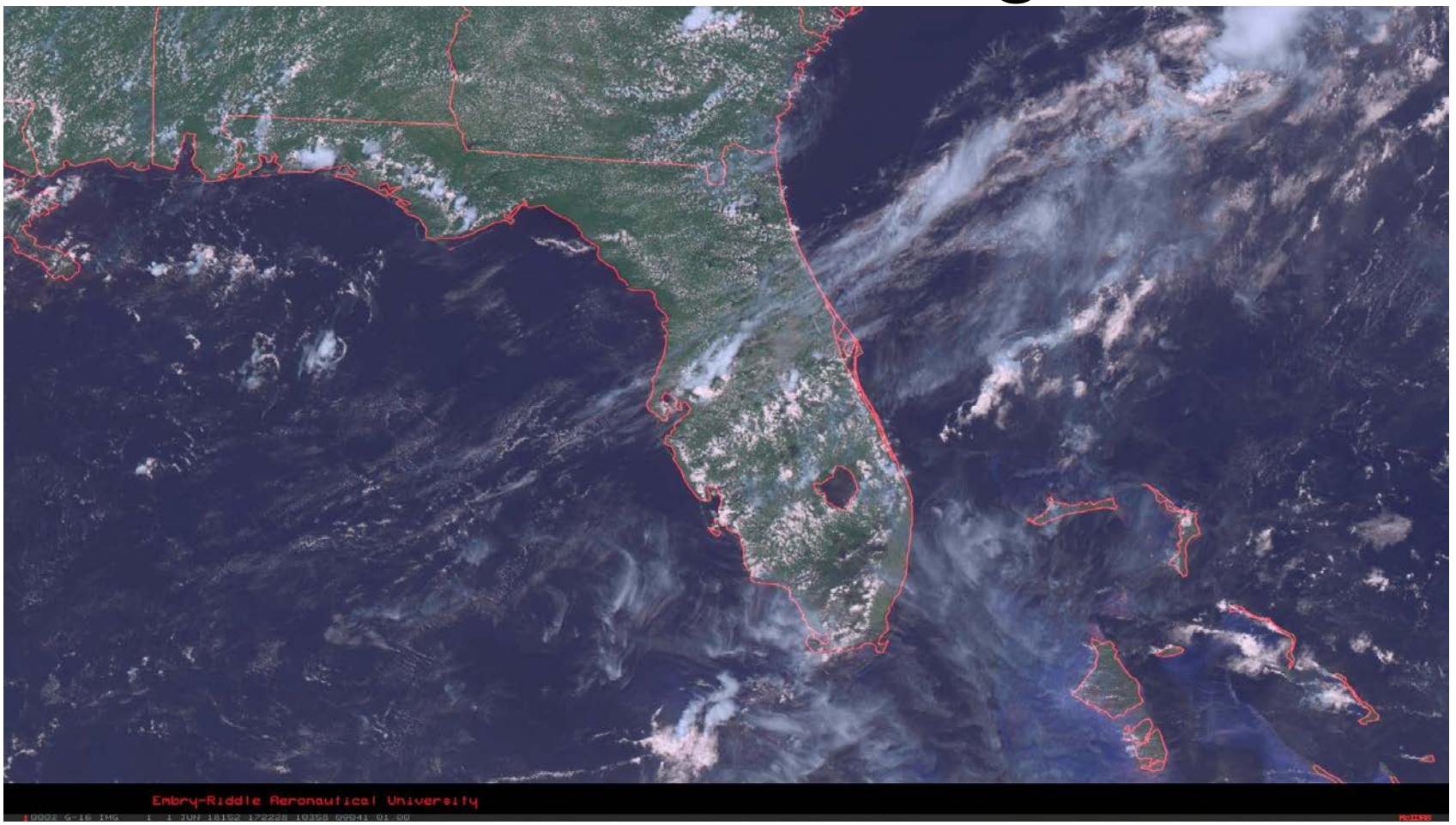
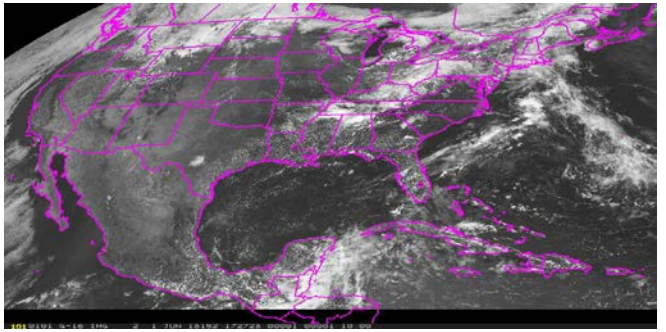
Introduction to the new GOES Era Satellites and Accessing the Data



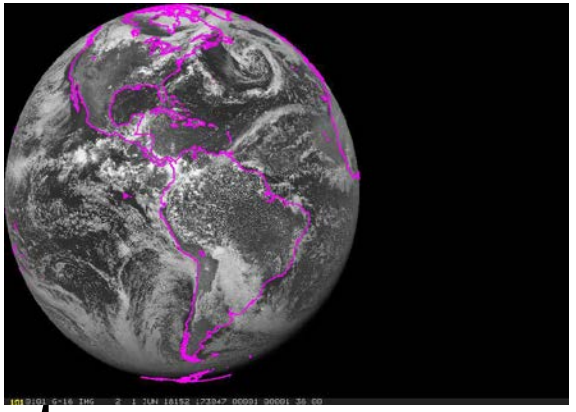
Dr. Frederick Mosher
Professor Emeritus
Embry-Riddle Aeronautical University
Daytona Beach, FL

Scan Times (all 16 channels)

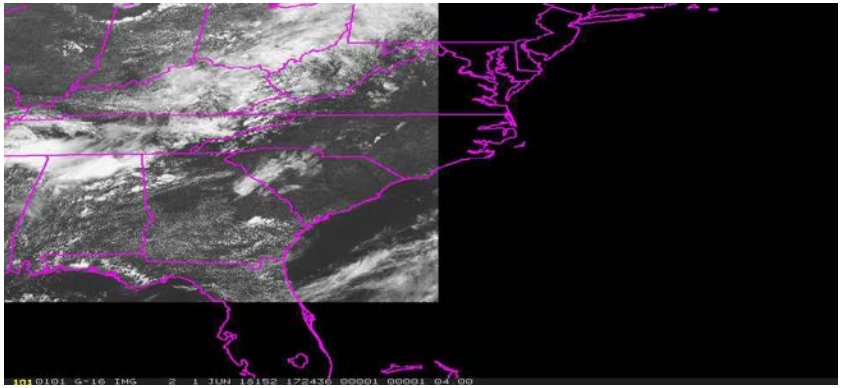
Conus every 5 minutes

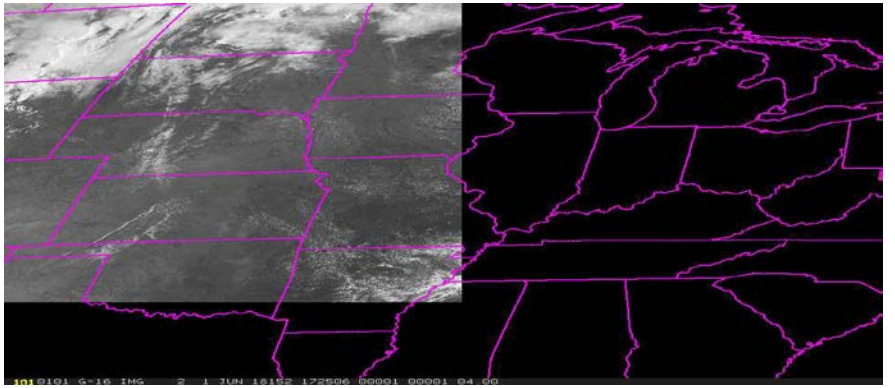


Full disk every 15 minutes

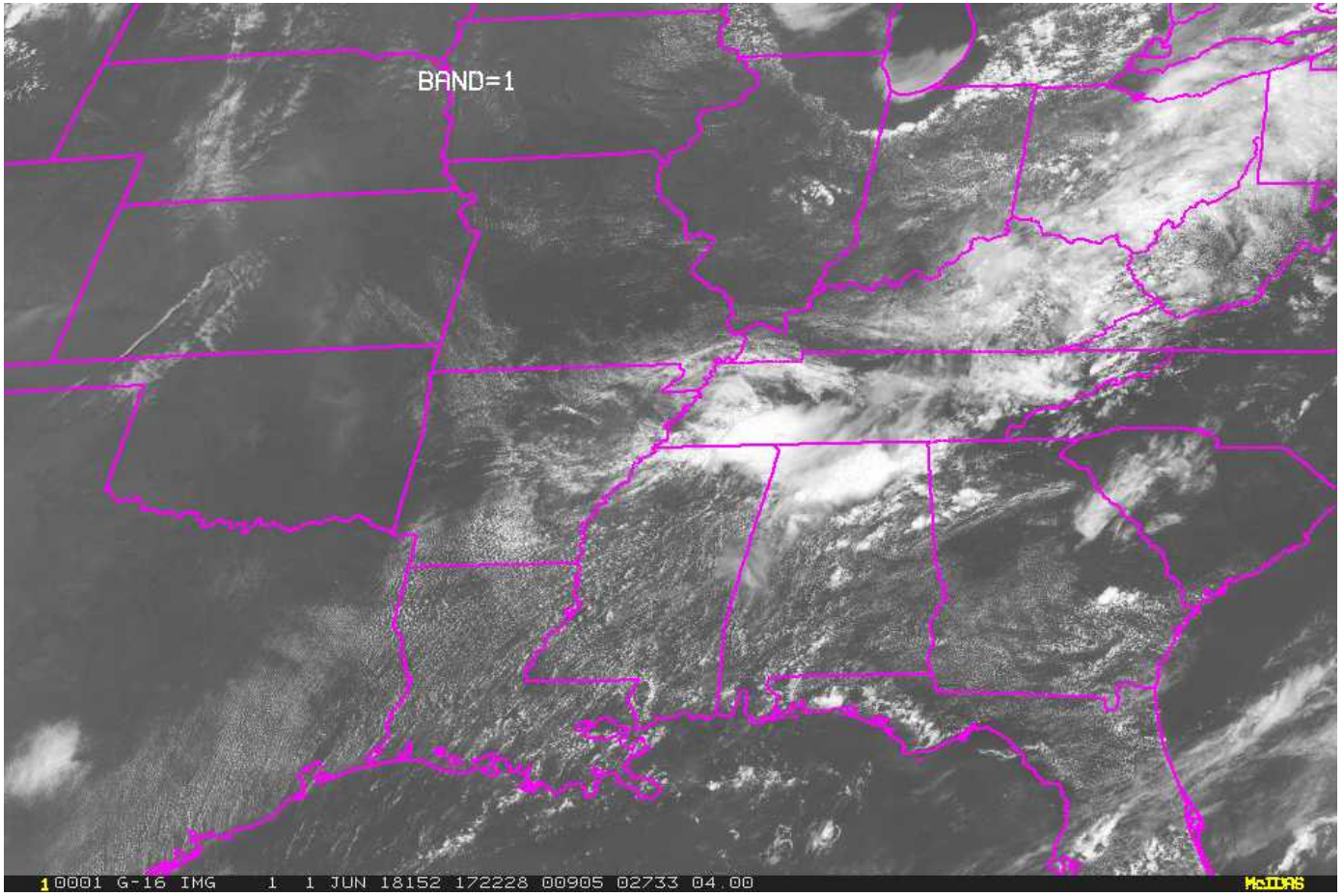


2 special scan areas every 1 minute

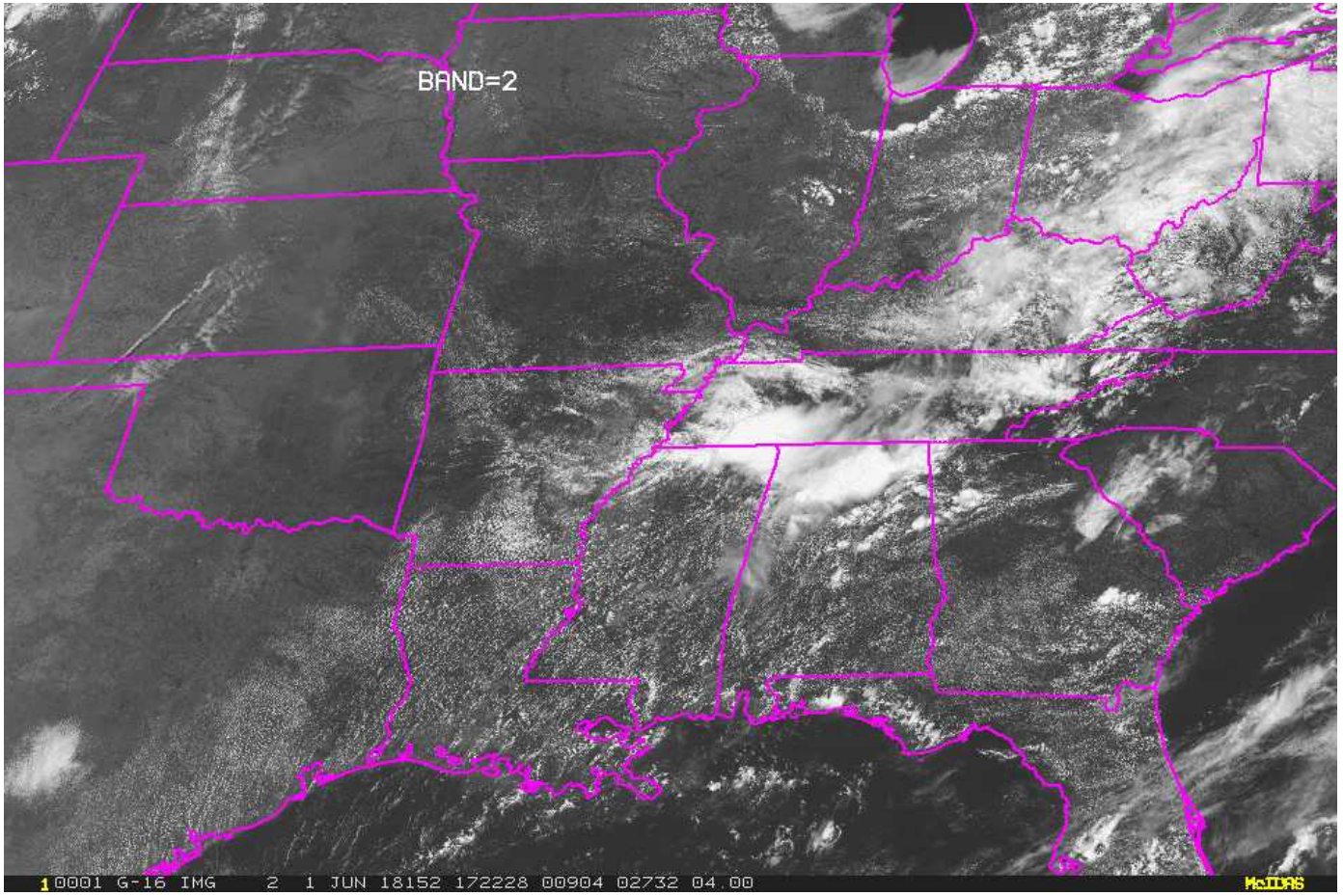




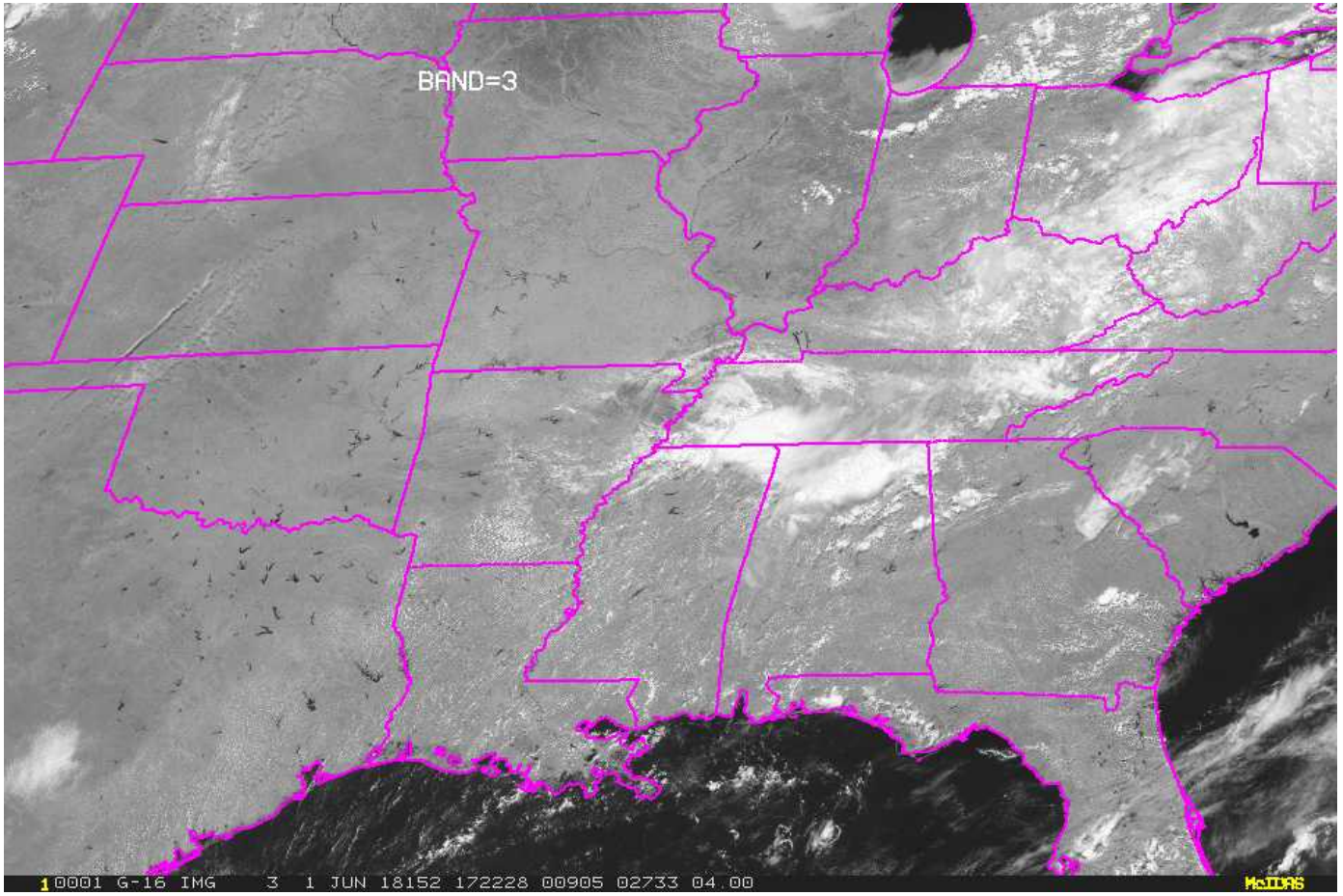
Band 1 (blue)
1 km resolution (shown as 2 km)
0.47 um VIS aerosol-over-land



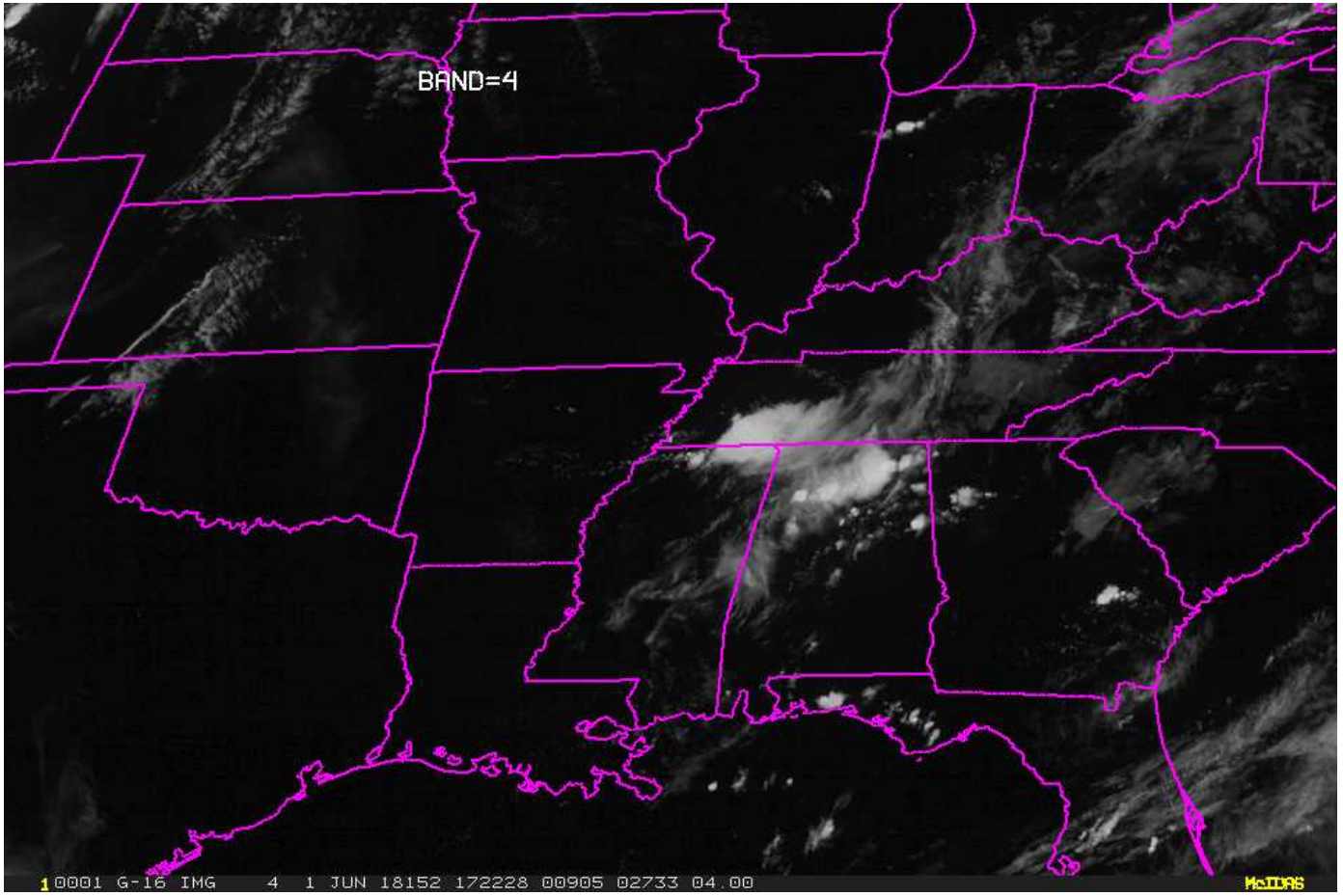
Band 2 (red) (traditional visible)
½ km resolution (shown as 2 km)
0.64 um VIS clouds fog/insol/winds



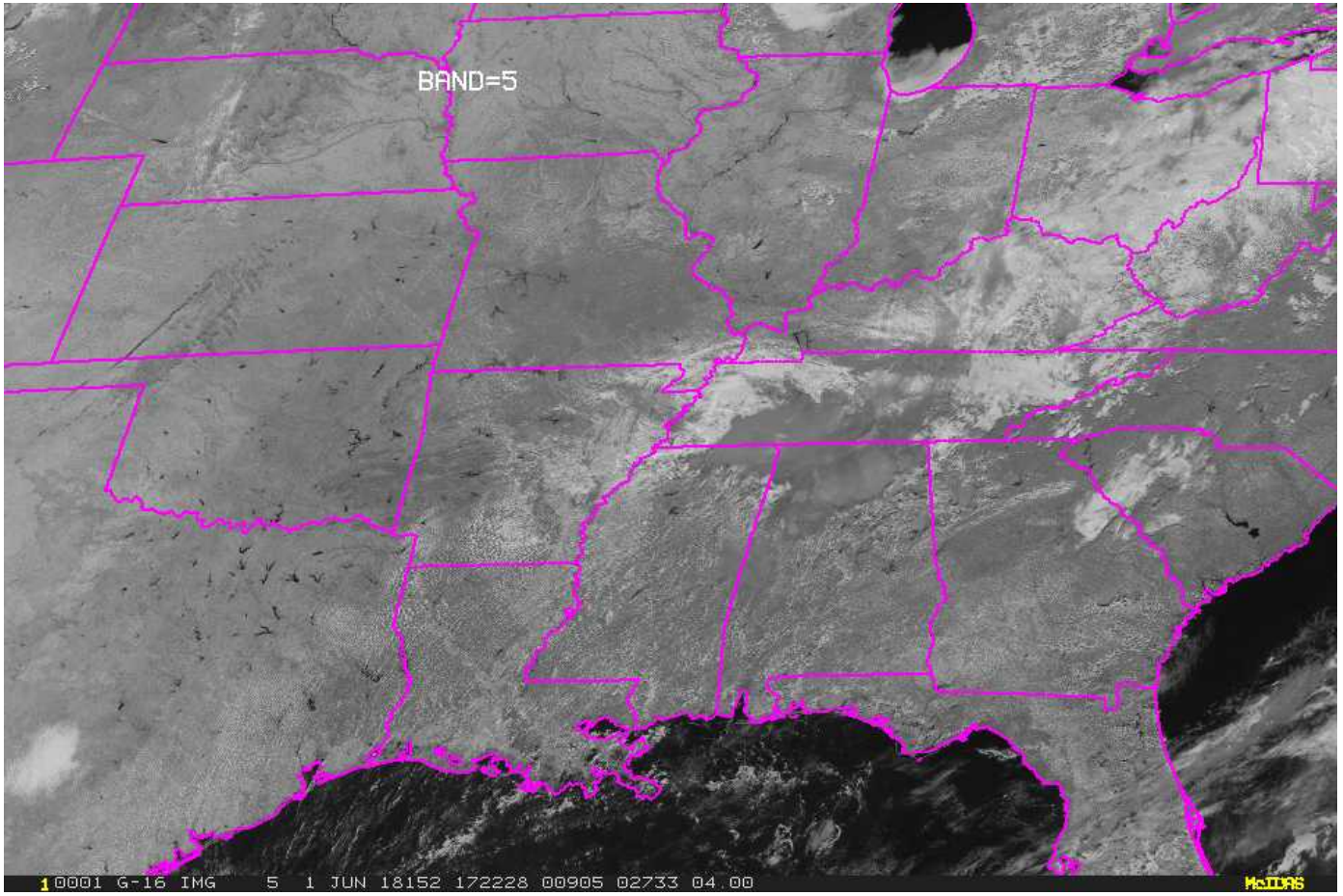
Band 3 (veggie “green”)
1 km resolution (shown as 2 km)
0.86 um Near IR veg/burn scar/aerosol



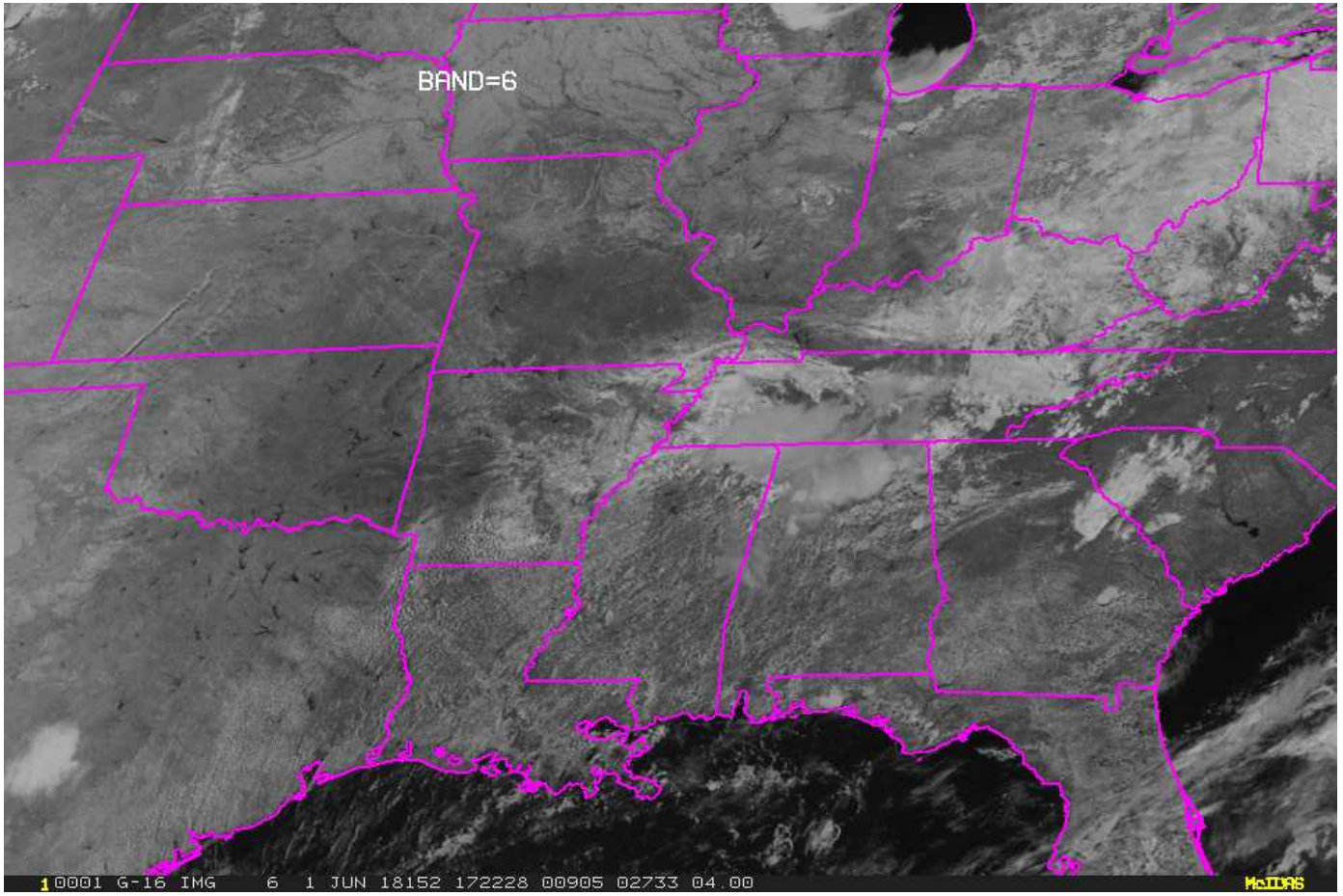
Band 4
2 km resolution
1.37 um Near IR cirrus cloud



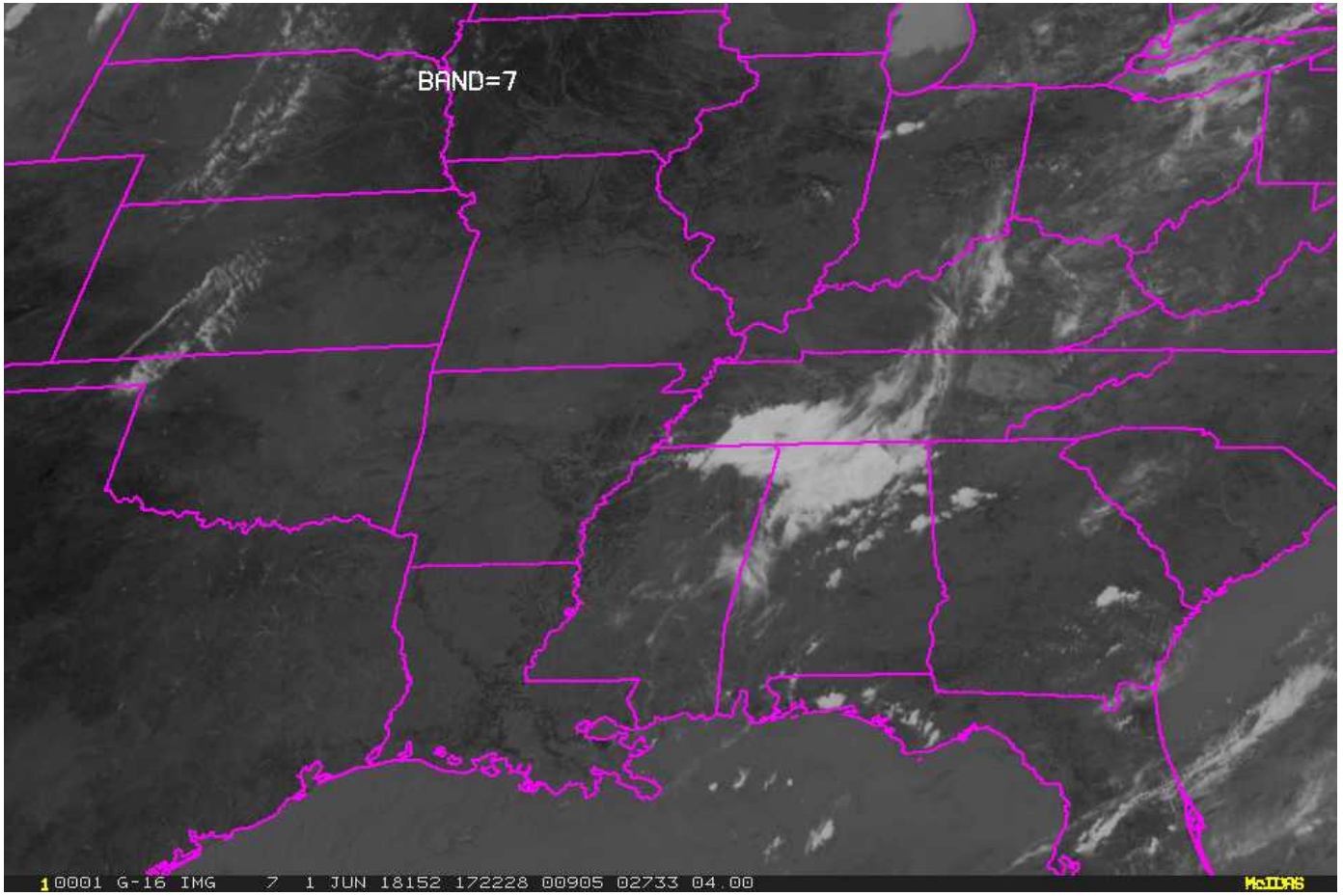
Band 5
1 km resolution (displayed as 2 km)
1.61 um Near IR cloud phase/snow



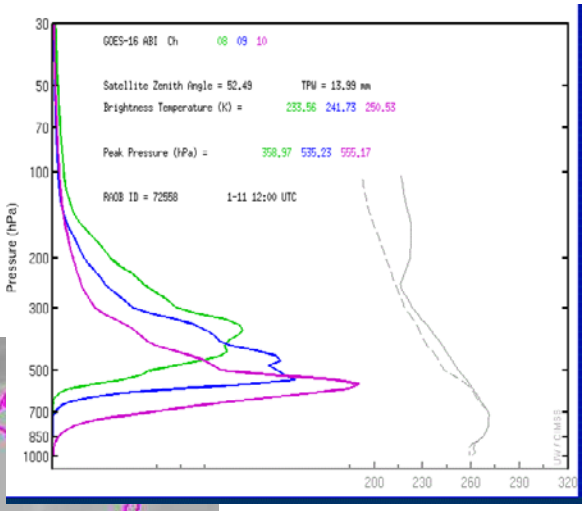
Band 6
2 km resolution
2.24 um Near IR land/cloud vege/snow

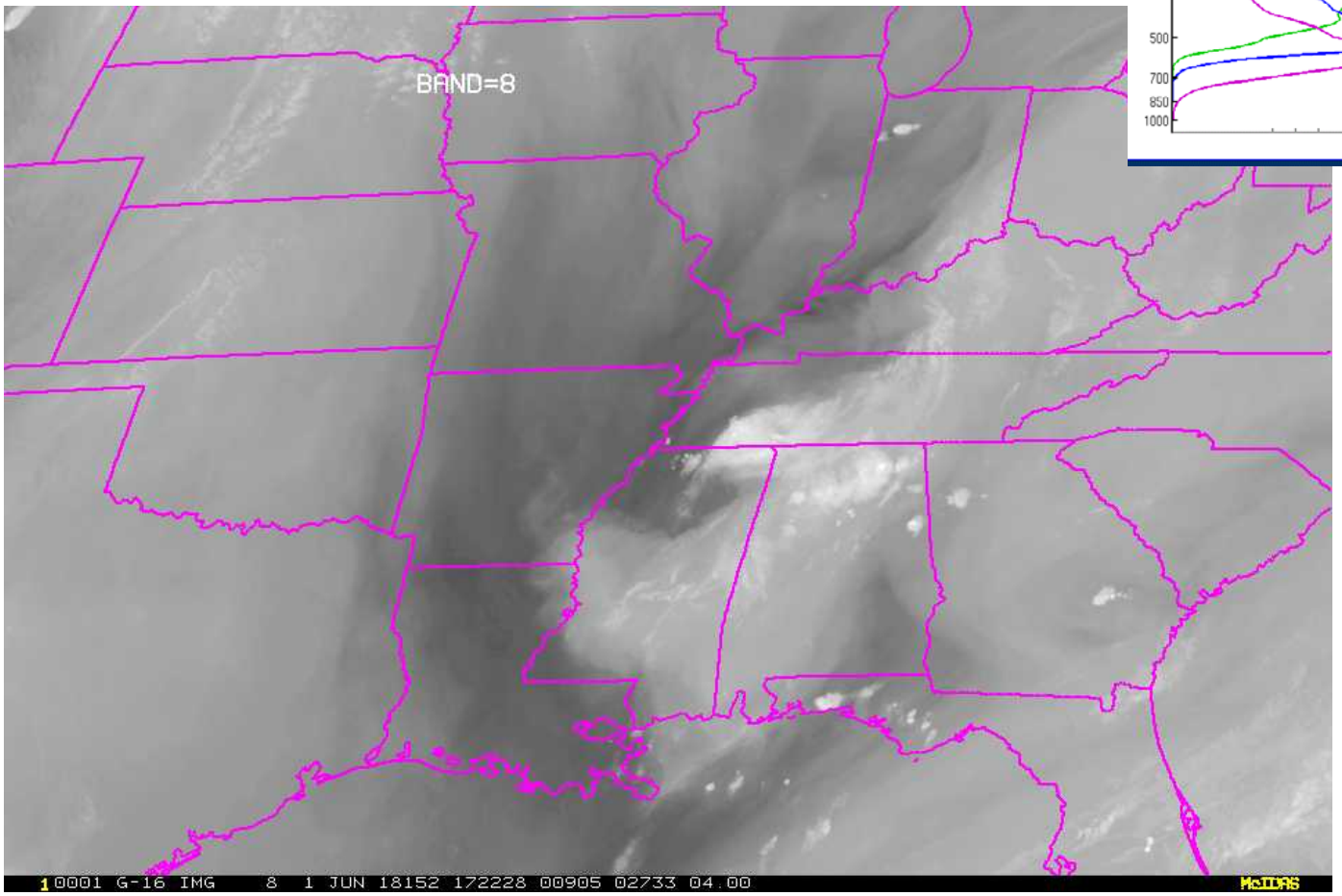


Band 7
2 km resolution
3.89 um IR Sfc/cloud/fog/fire/winds

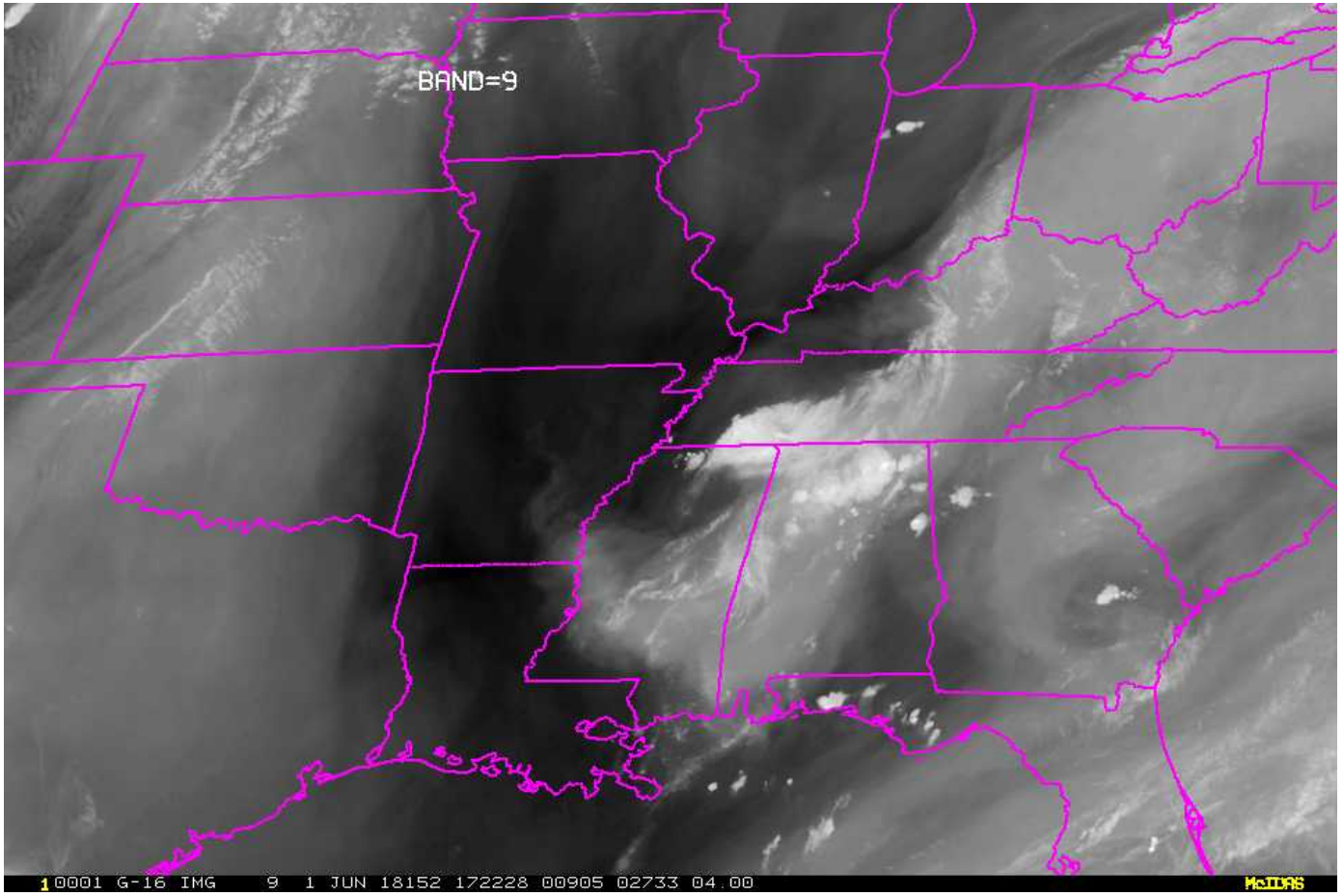


Band 8
2km resolution
6.17 um IR High-level WV/winds/rainfall

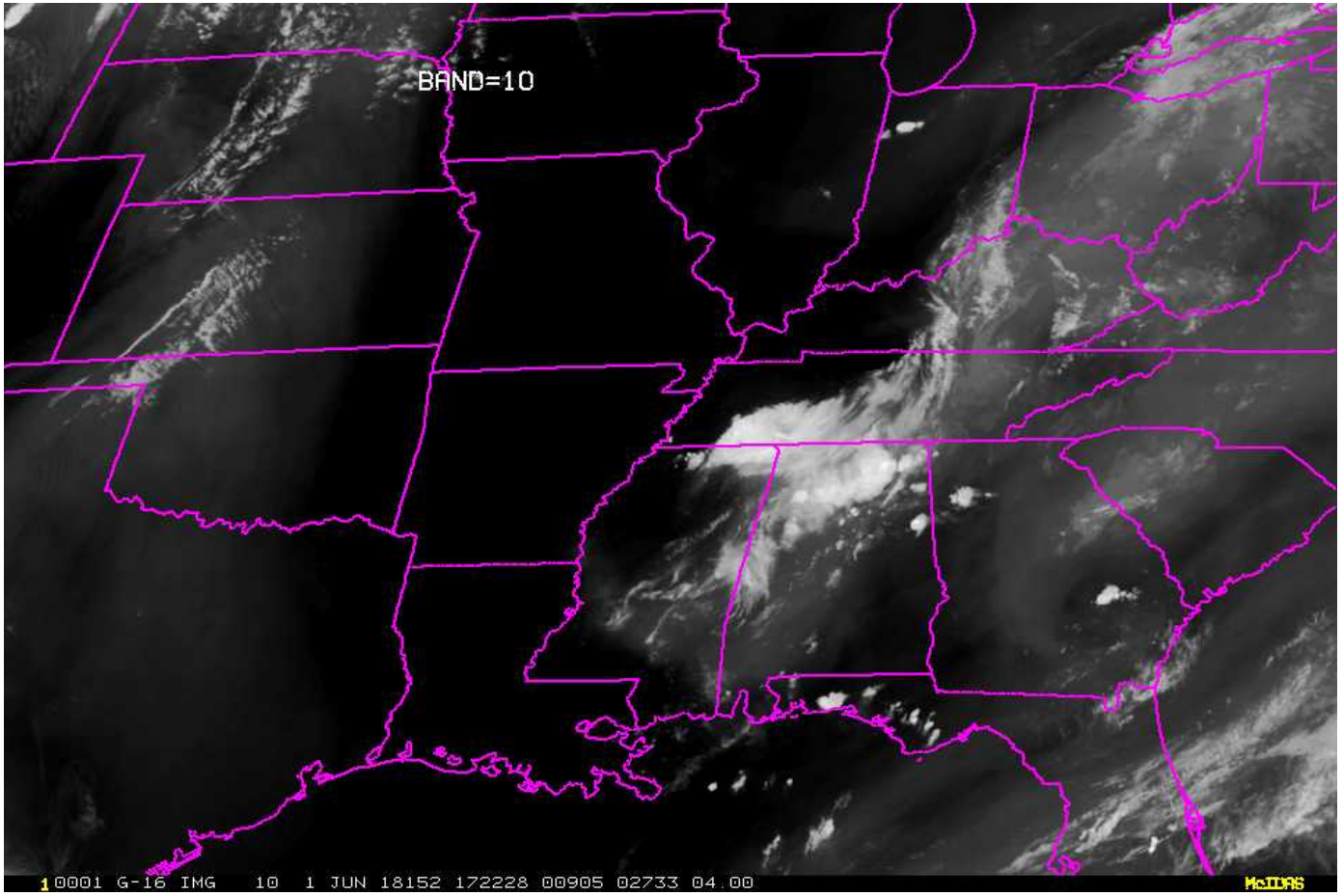




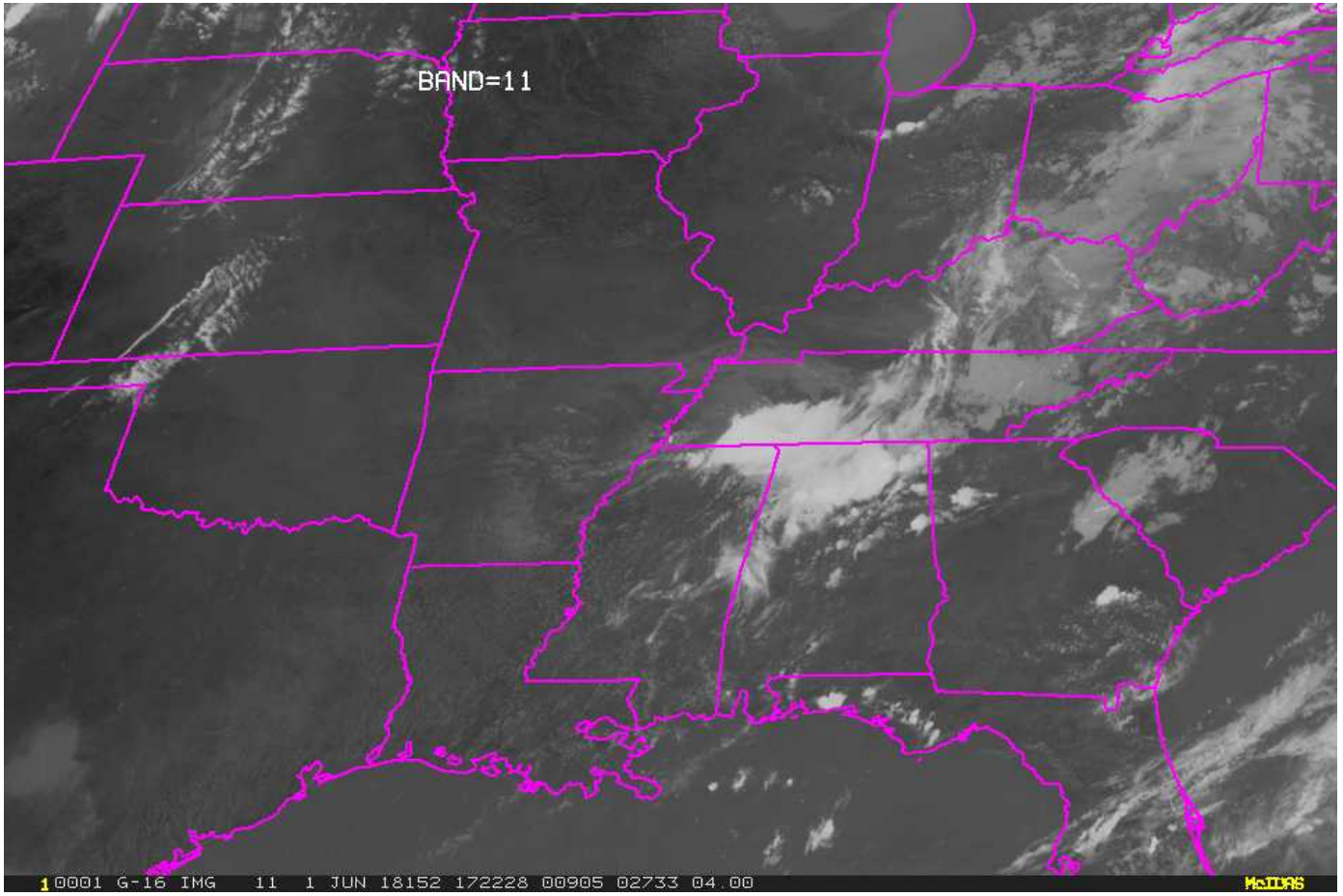
Band 9 (Water Vapor)
2 km resolution
6.93 um IR Mid-level WV/winds/rainfall



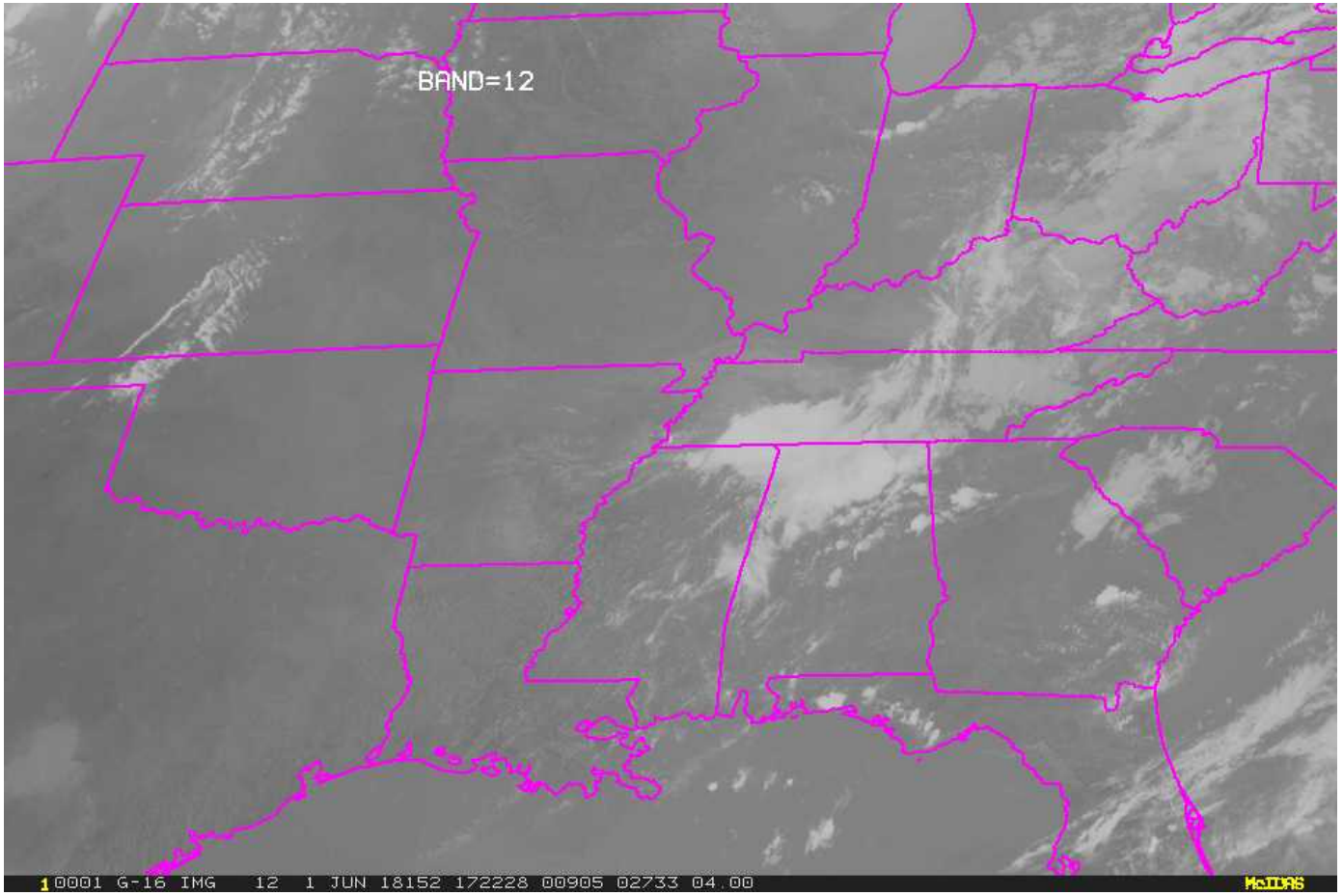
Band 10
2km resolution
7.34 um IR Lower-level WV/winds & SO^2



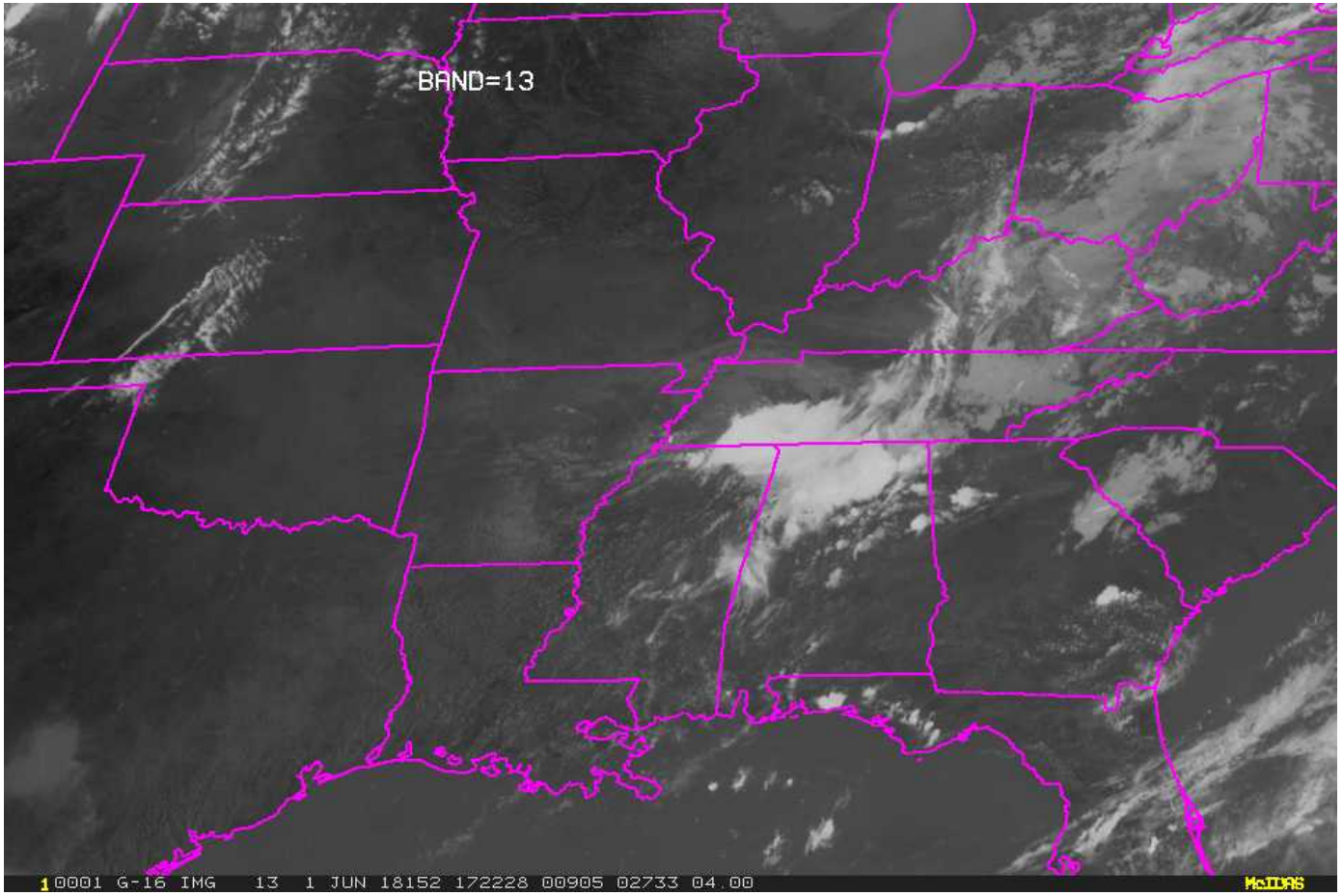
Band 11
2 km resolution
8.44 um IR Total WV cloud phase/dust



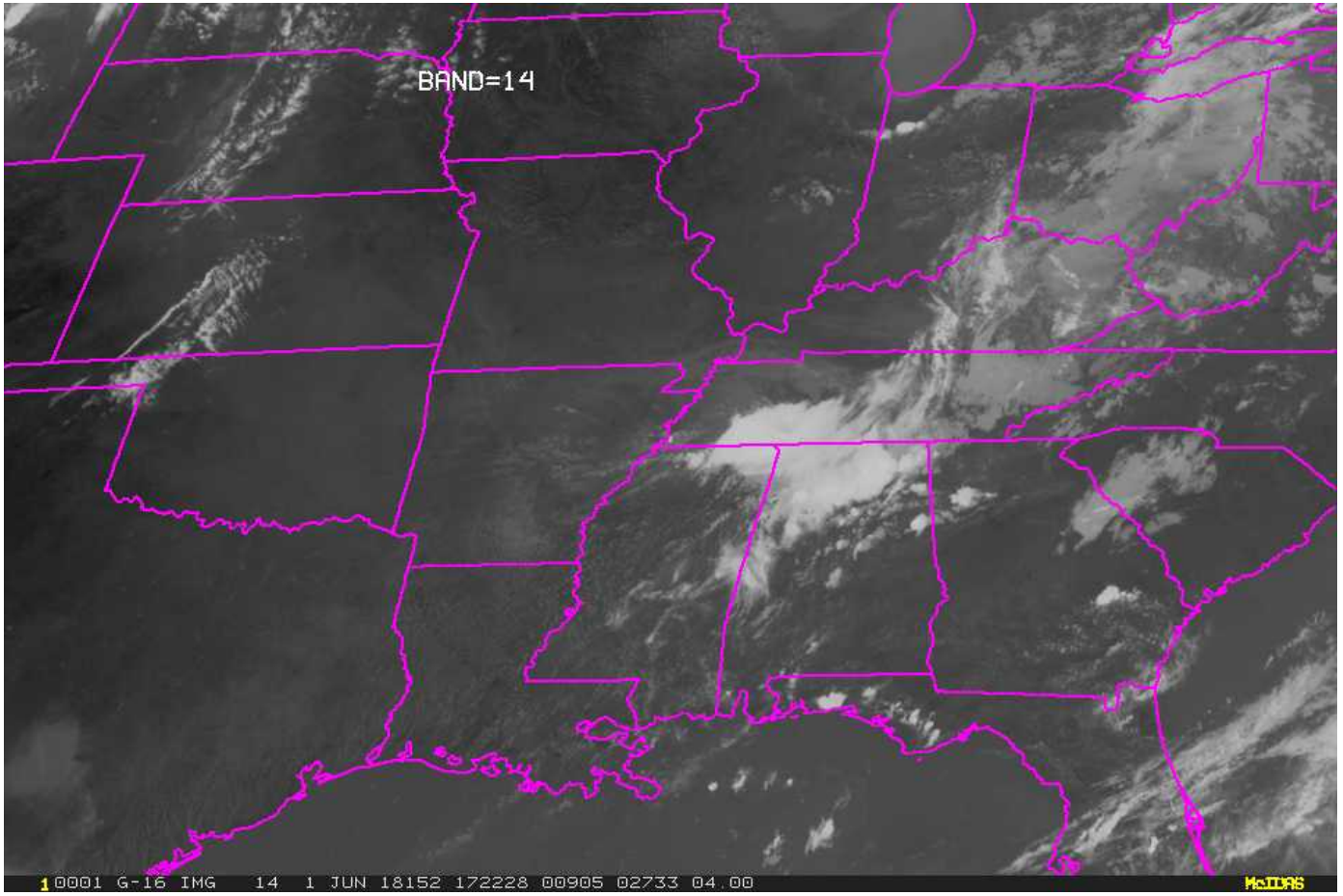
Band 12 (O^3)
2 km resolution
9.61 um IR Total ozone/turbulence/winds



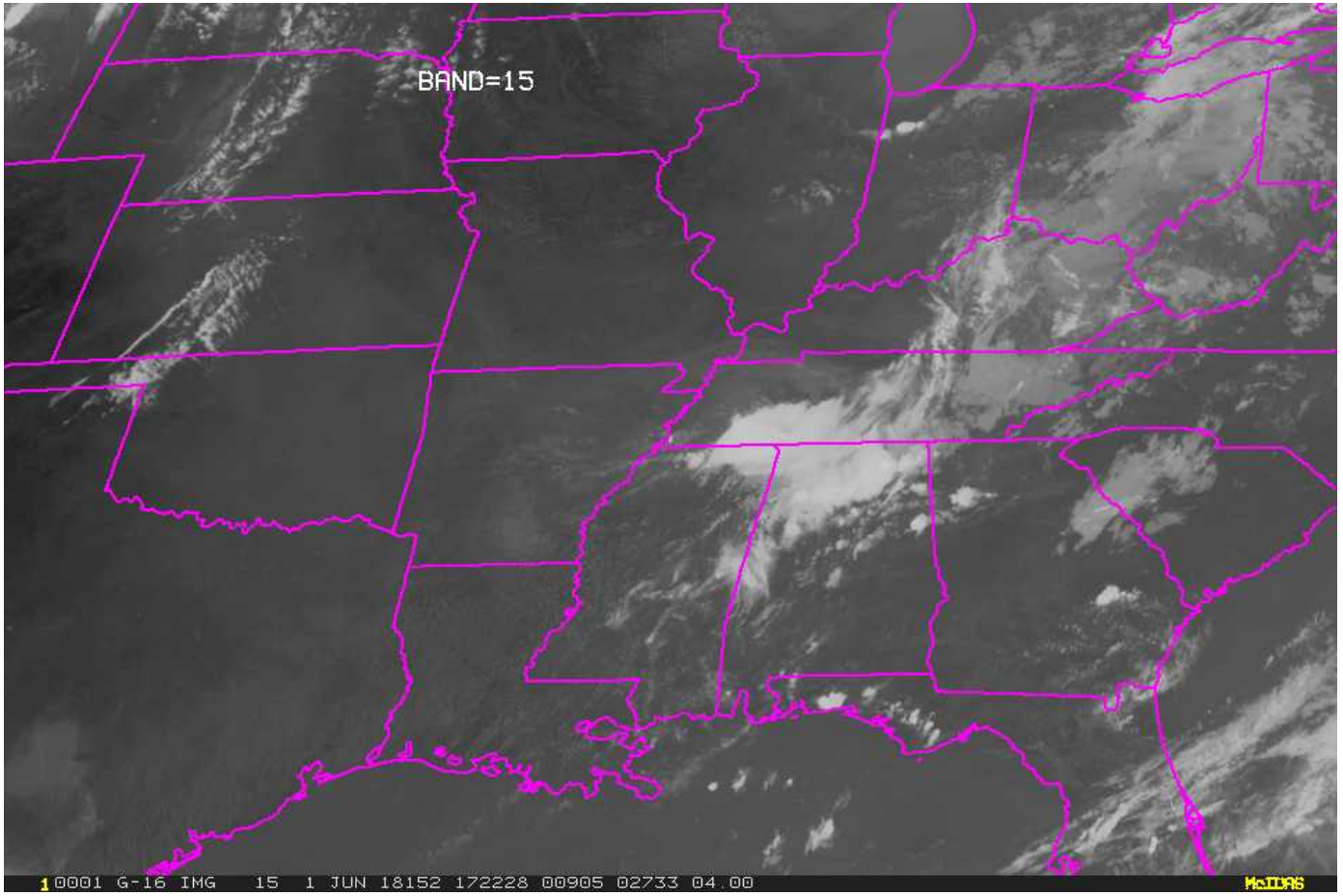
Band 13 (IR)
2 km resolution
10.3 um IR Surface & cloud



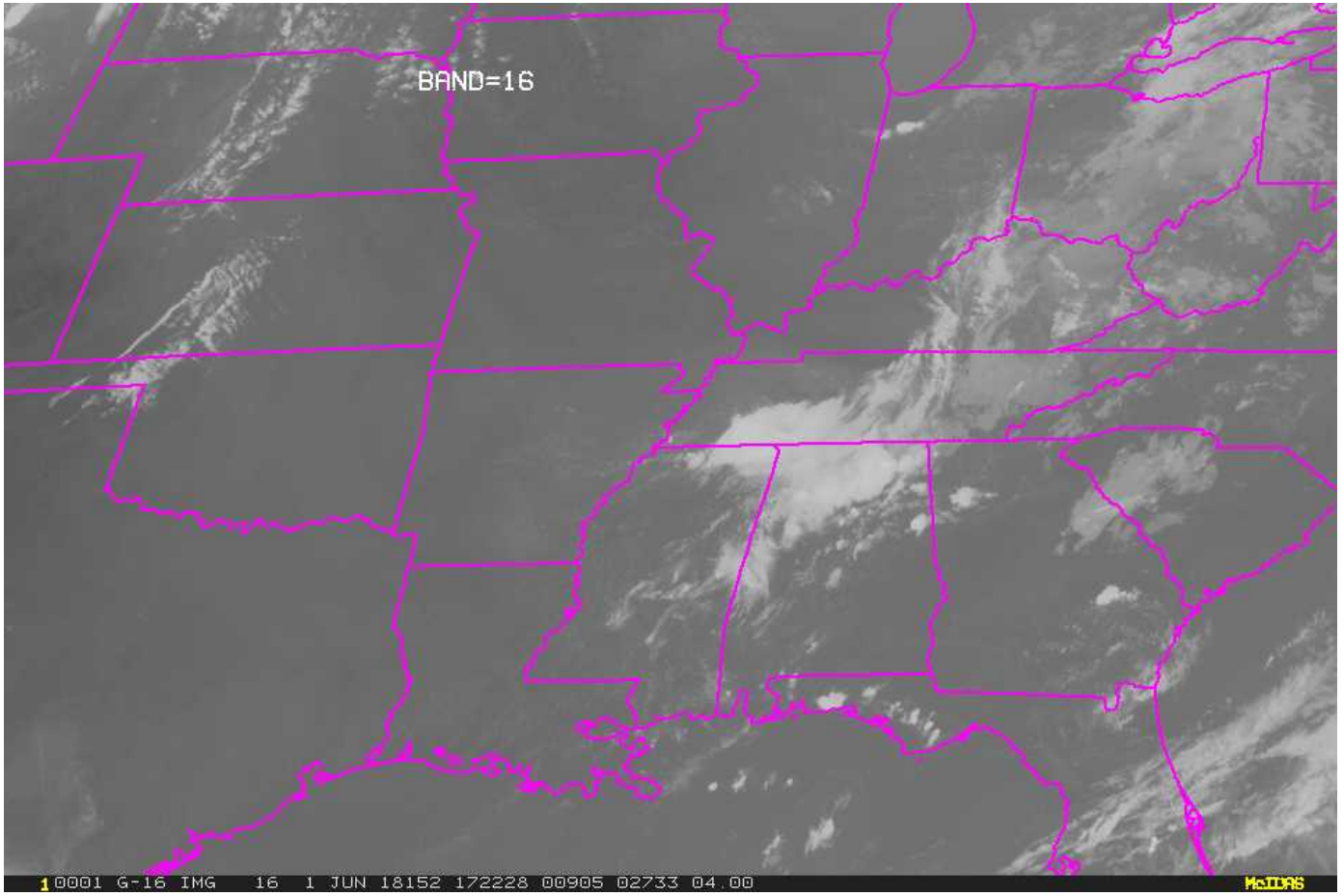
Band 14
2 km resolution
11.2 um IR Imagery/SST/clouds/rainfall



Band 15 (dirty window)
2 km resolution
12.3 um IR Total water/ash and SST



Band 16 (CO^2)
2 km resolution
13.3 um IR Air temp/cloud hgt and amt



They all look the same

- Three basic types of images:
-
- Reflected sunlight (bands 1-6, daylight band 7)
- Water vapor (bands 8-10)
- Infrared emission (bands 11-16, night band 7)

- Minor differences between bands of a given type which are difficult to see directly.
- Need to use digital techniques to obtain information contained within various bands.

Digital data access

- UCAR Unidata has GOES digital data servers available for universities and government.
- Raw digital GOES images and GOES Lightning Mapper available at ADDE server RTGOESR at lead.unidata.ucar.edu
- Remapped & processed digital GOES images transmitted via NOAAPort are available at ADDE server NPGOESR at lead.unidata.ucar.edu
- List of other servers at:

https://www.unidata.ucar.edu/software/mcidas/adde_servers.html

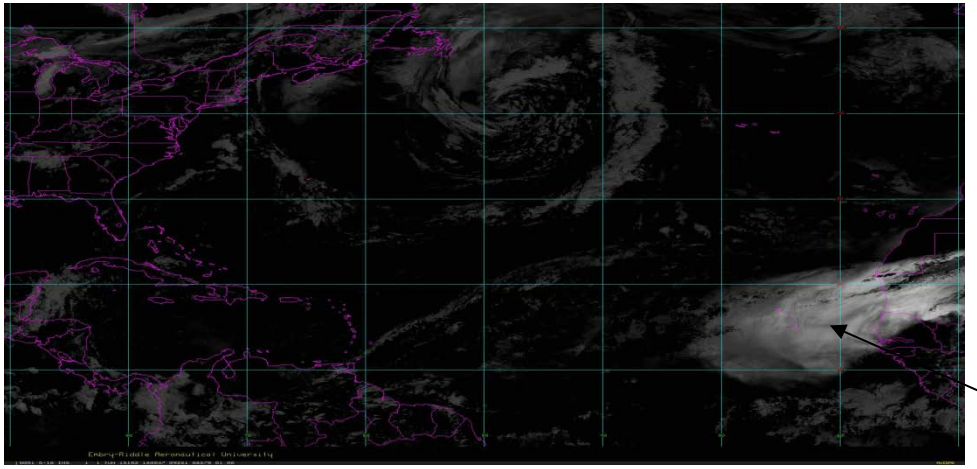
Digital Image Processing Software

- To generate derived image products, one needs digital image processing software.
- The following examples were generated using Mcidas-X (available from Unidata for universities and from UW SSEC for others)
- Mcidas-V, IDV, GEMPAK, Python software also can access and process digital satellite data.

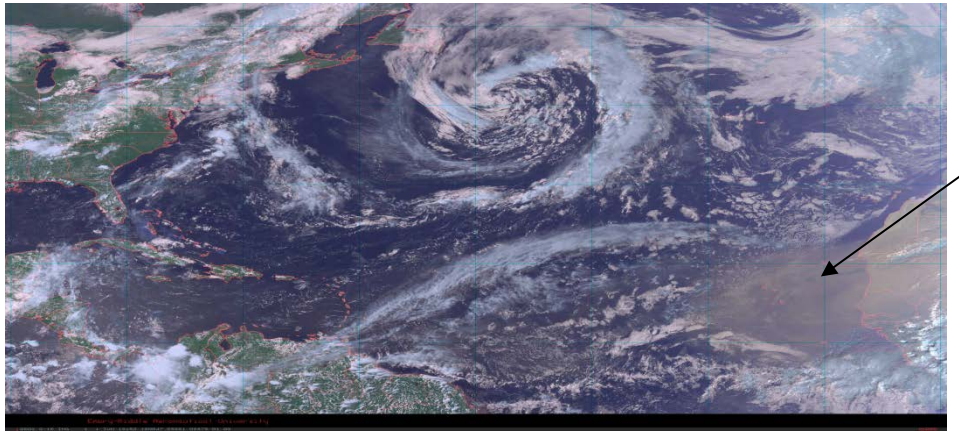
Enhancing differences between bands

Two ways:

Math differences between bands



Three channel color display



dust

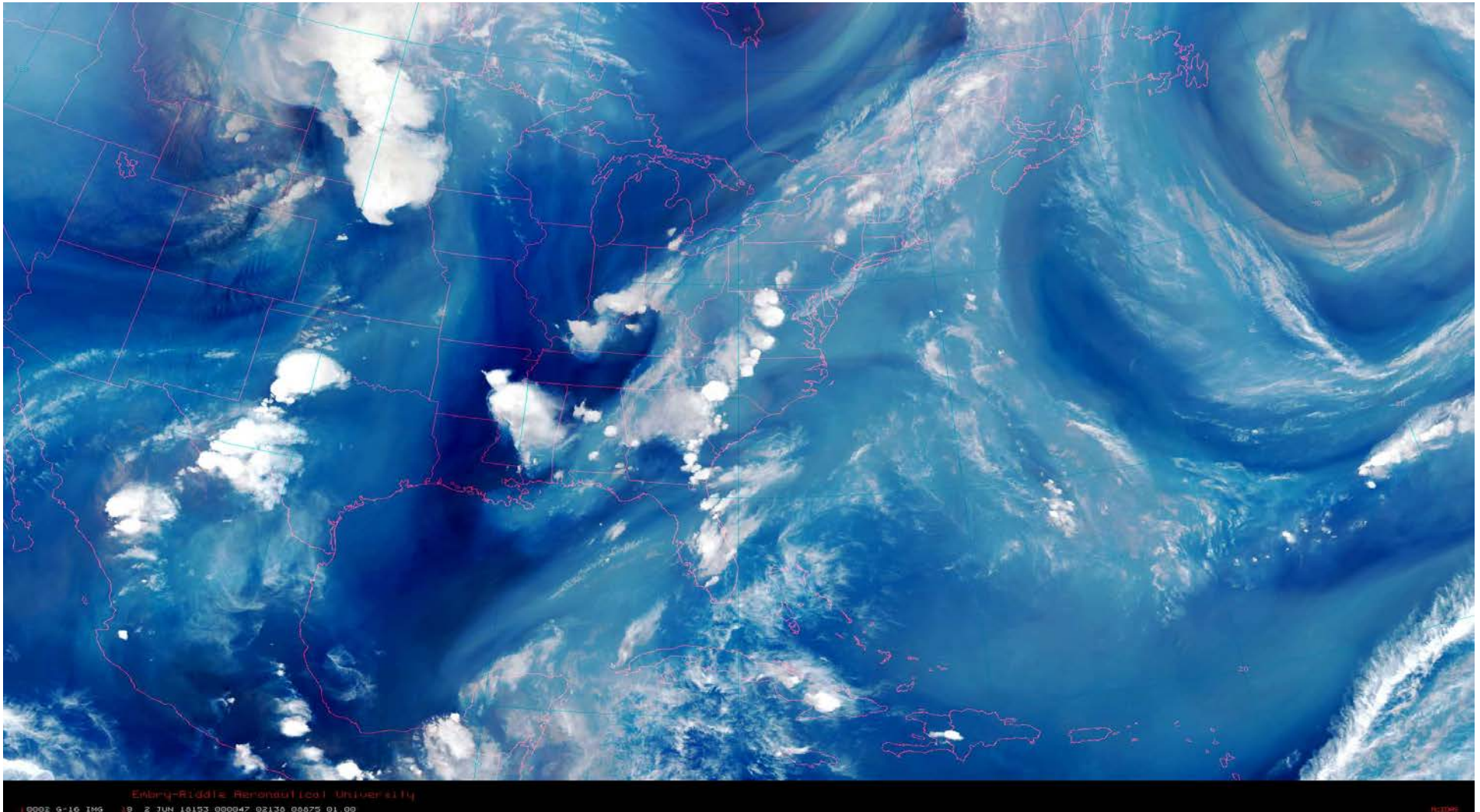
Color Monitors

- Human eye can see around 30+ shades of gray
- Human eye can see over 1 million shades of colors
- Color TVs and monitors have red, green, and blue dots at each pixel
- Each dot color can show up to 256 shades of the color
- Three different images can be sent to the three different color dots to form a color image.

Example of three water vapor bands as red/green/blue image

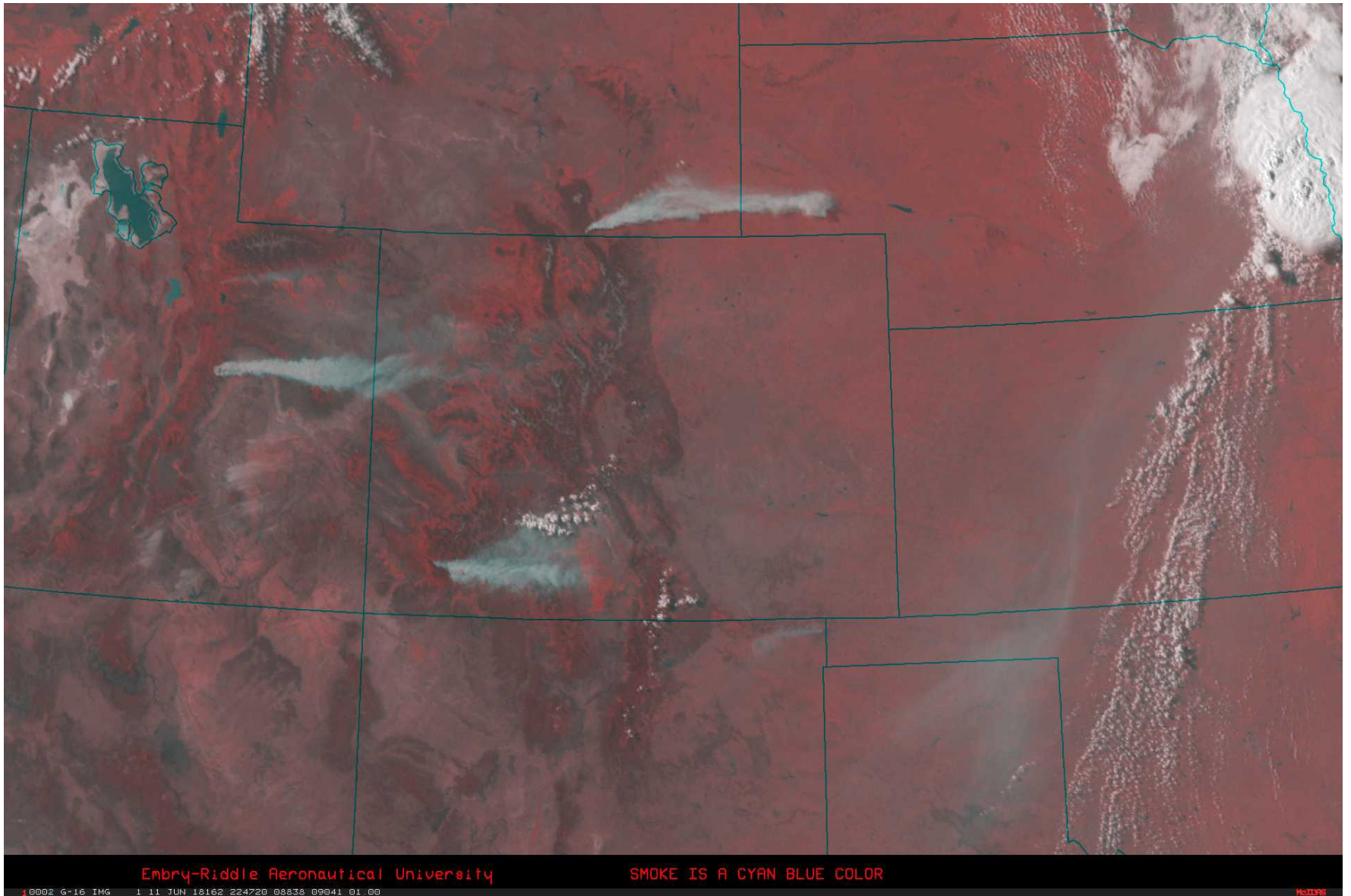
Available at http://wx.erau.edu/erau_sat/

- Band 8 to blue channel; band 9 to green channel; band 10 to red channel
- Dark blue=only high wv; cyan=deep wv;brown=lower wv &mid-level clouds



Smoke Images

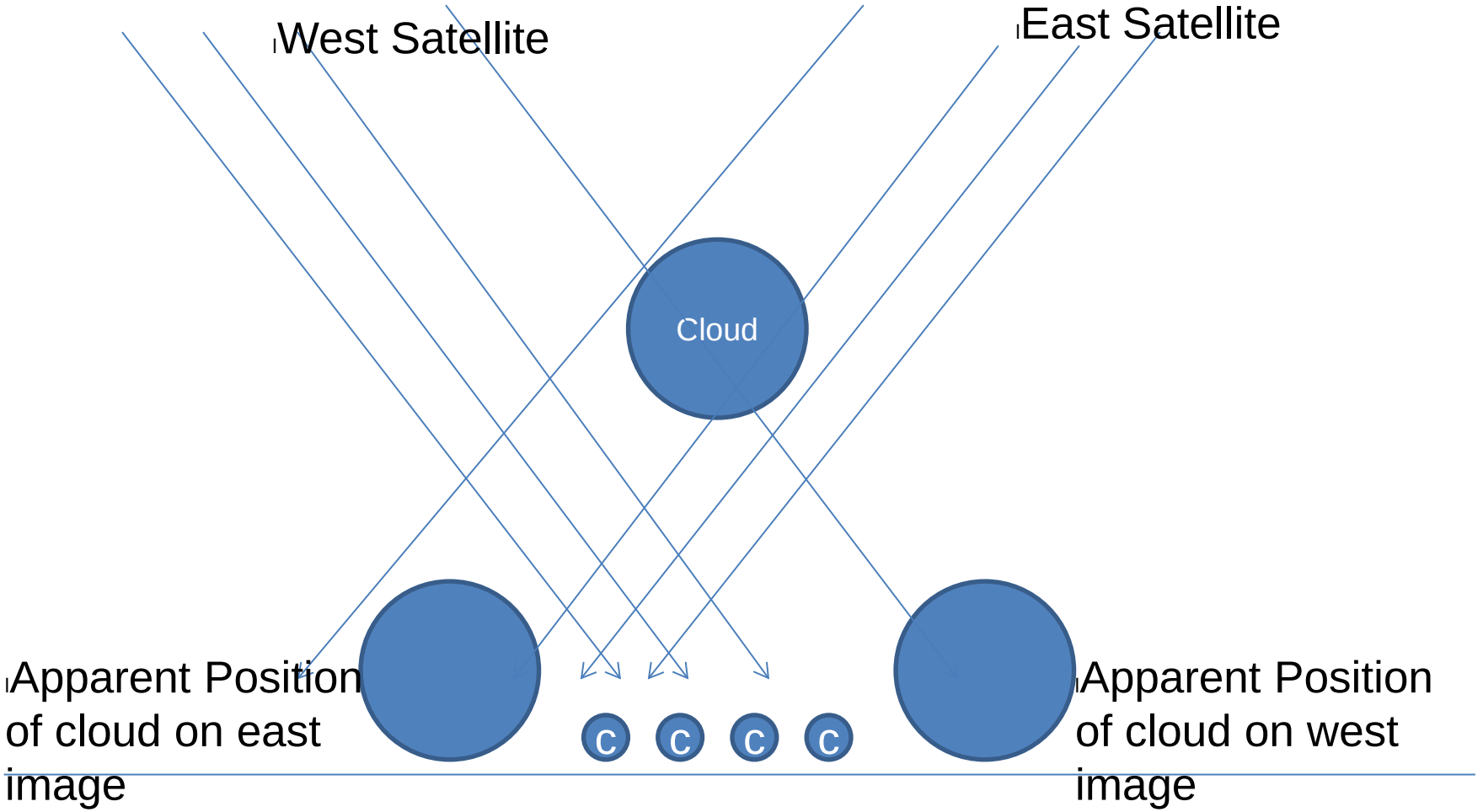
- Smoke reflects more in band 1 (blue) than band 3 (near ir)
- Band 3 displayed on red pixels; band 1 on blue and green pixels; smoke has cyan blue color.



3D Images

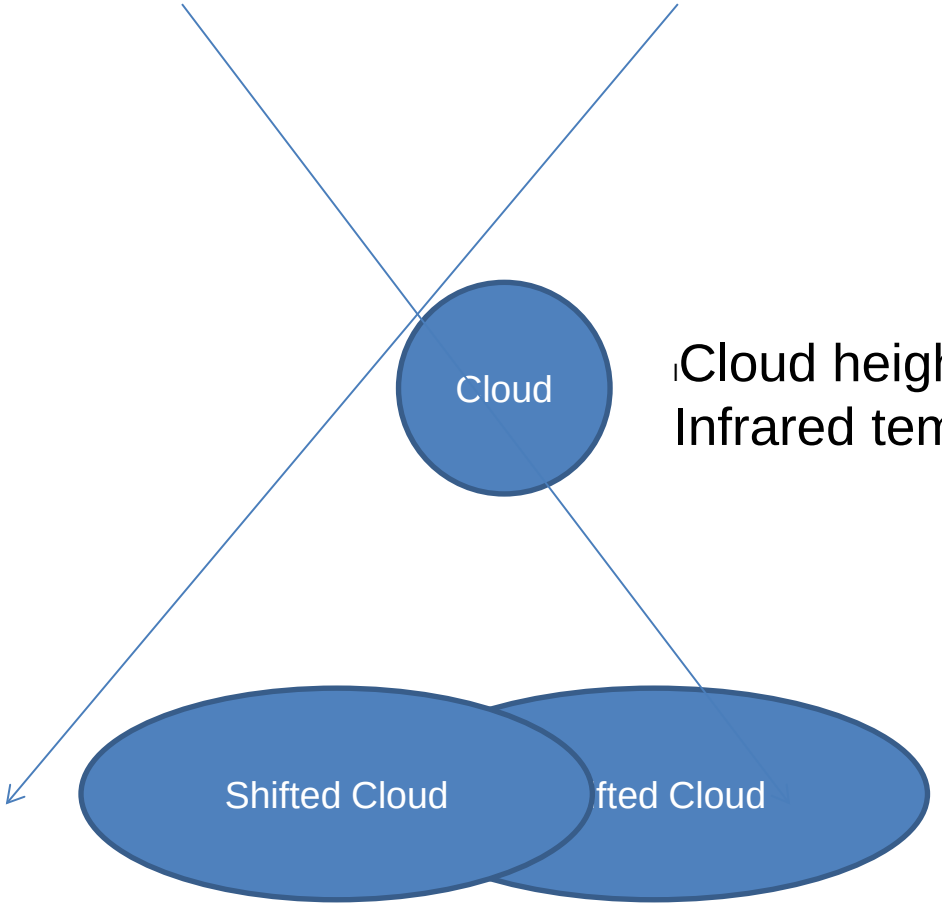
- Red/green/blue display channels can also be used to generate 3D images

True Stereo



Satellites can see small low clouds underneath the high cloud

Artificial Stereo

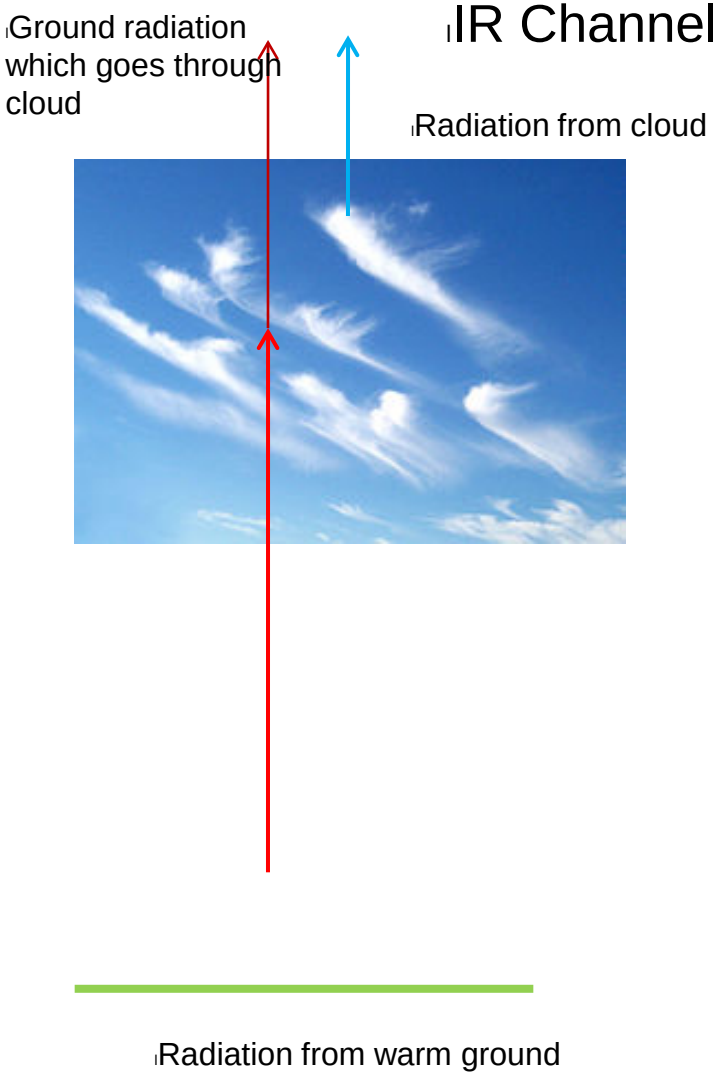


- Cloud height obtained from Infrared temperature.

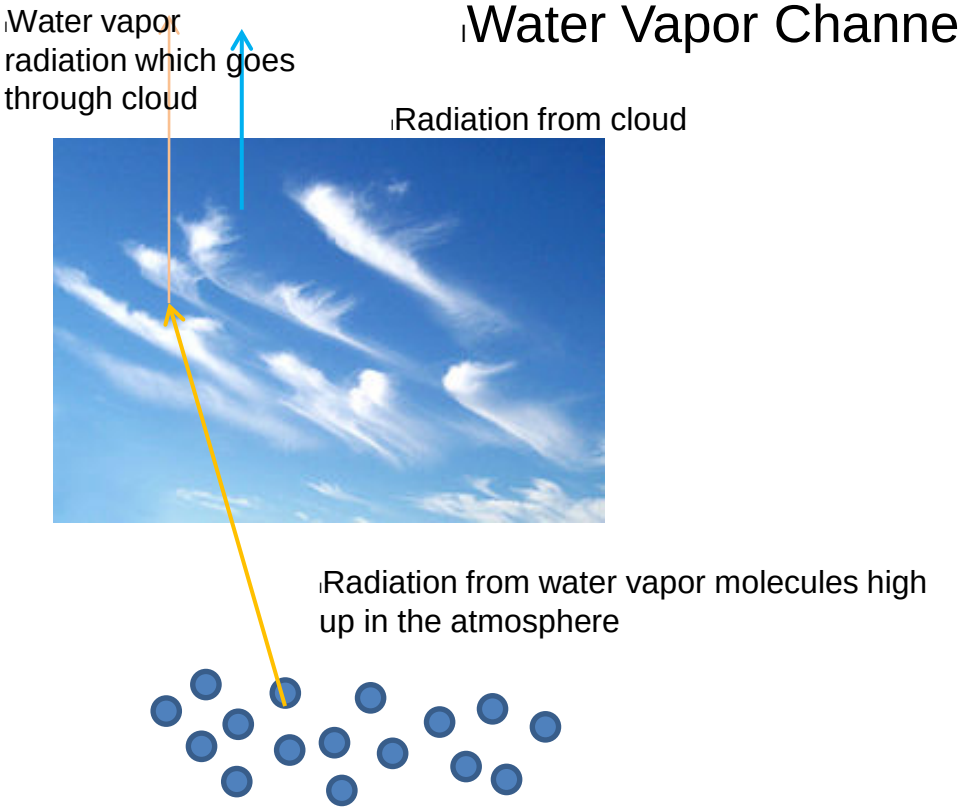
- Cloud is shifted left and right, but from one image, one does not know what lower clouds are below higher clouds, so leave original cloud pixels to right/left of shifted pixels. This limits the amount of the allowable shifts because of image distortion.

Cloud Height Problem

IR Channel



Water Vapor Channel

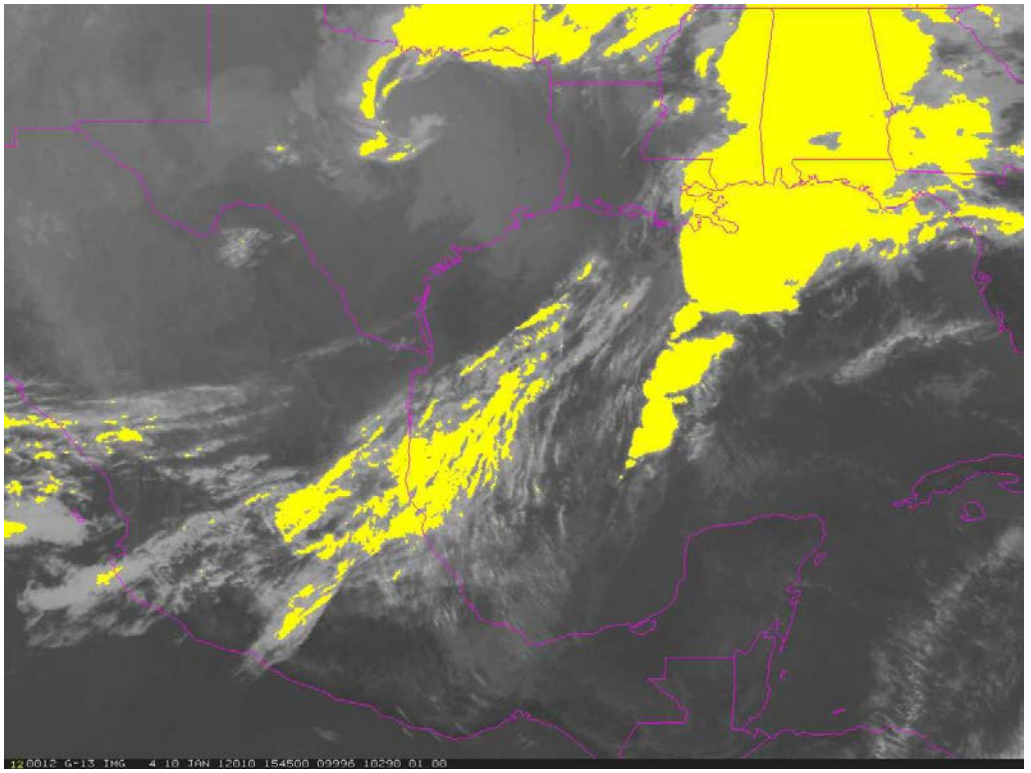


-Satellite sensed radiation is a mixture of radiation from the cloud and radiation from lower source going through the cloud.

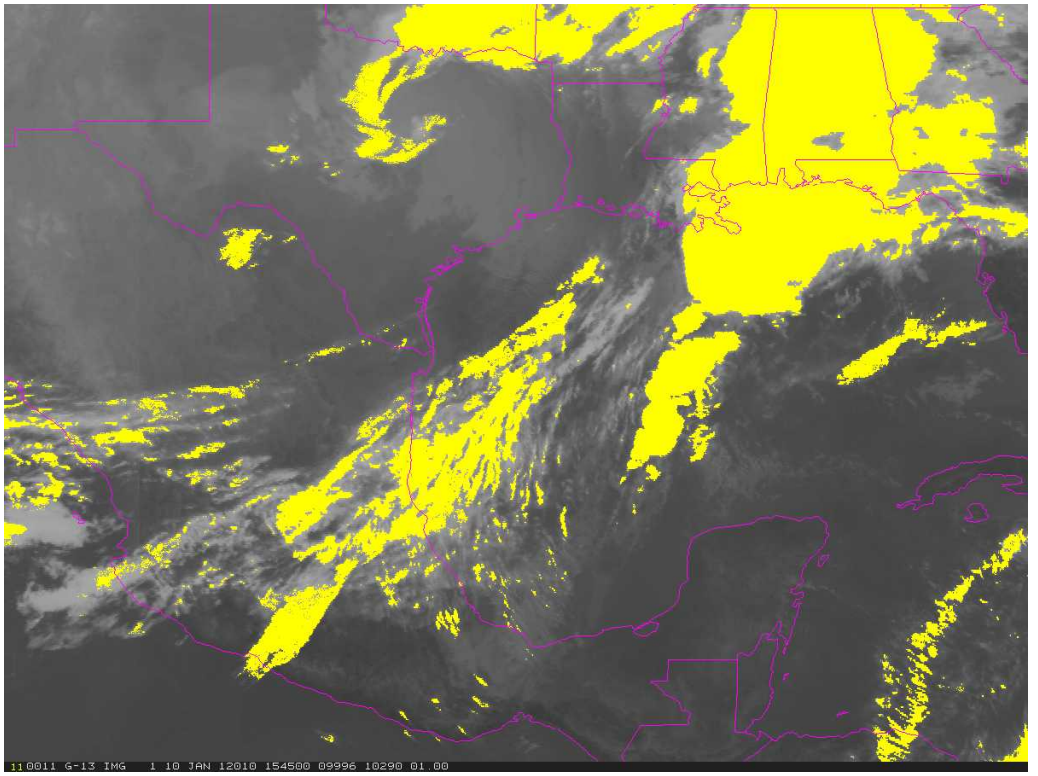
-Water vapor channel cloud height error is smaller than Infrared channel error.

Corrected IR

- IR values of cirrus clouds replaced with WV values



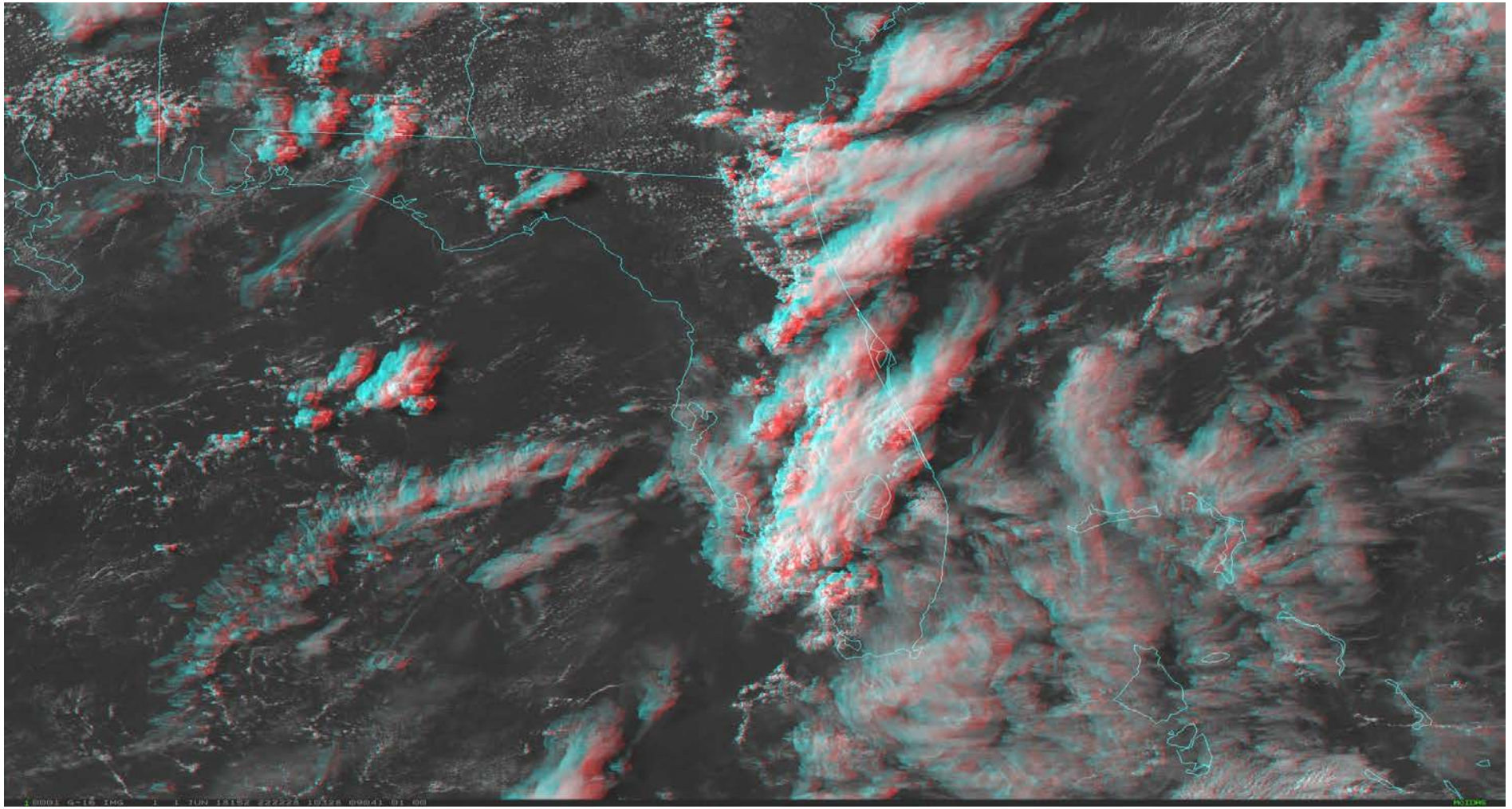
- Original IR (values colder than 245ºK shaded yellow)



- Corrected IR

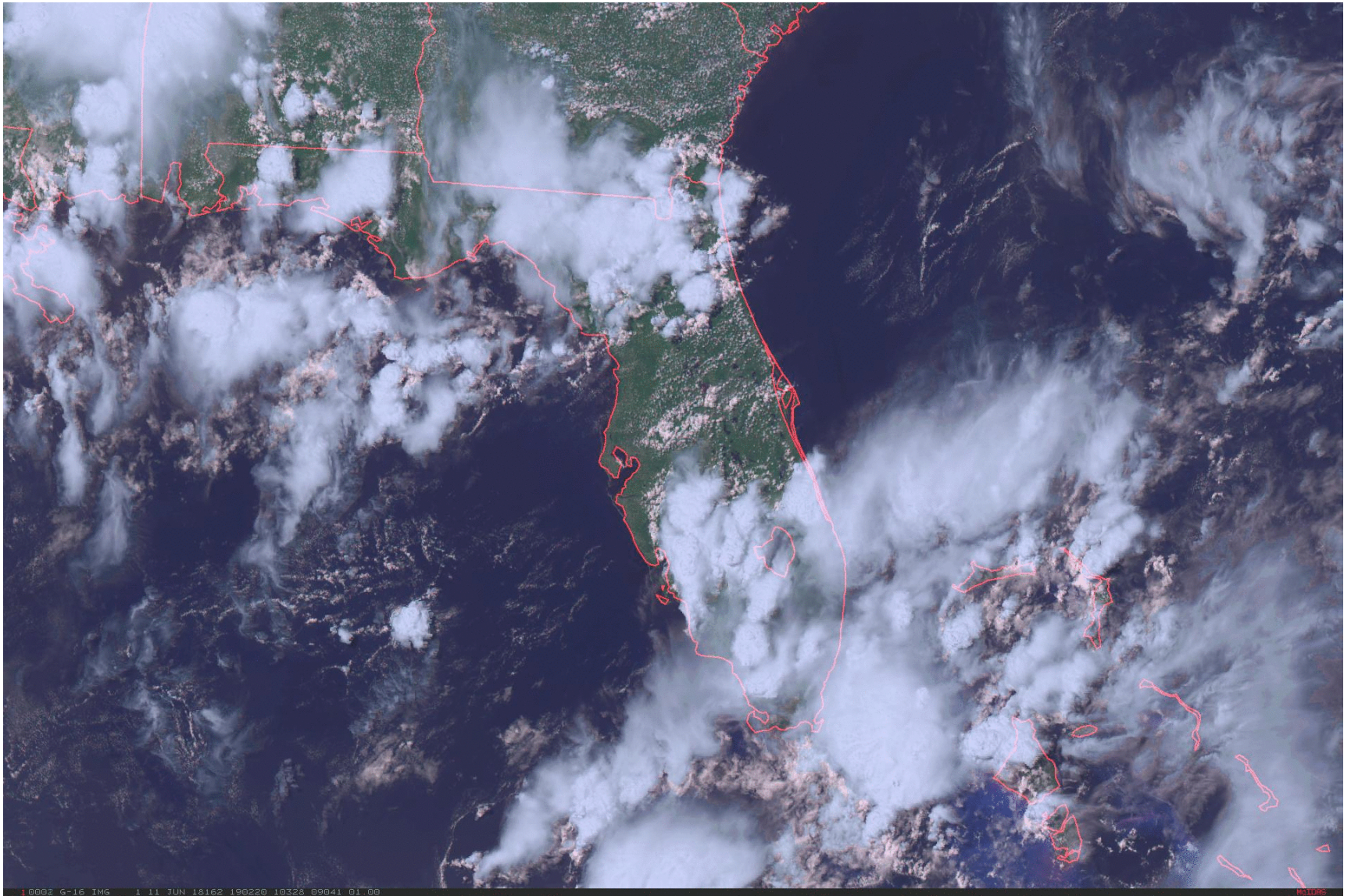
3D Satellite Data – Artificial Stereo

- WV corrected IR temperature used to compute cloud height.
- Images are shifted right (red channel) and left (green and blue channel) to minimize distortion. Holes are filled with original high cloud values.
- Real time 3D images available at http://wx.erau.edu/erau_sat



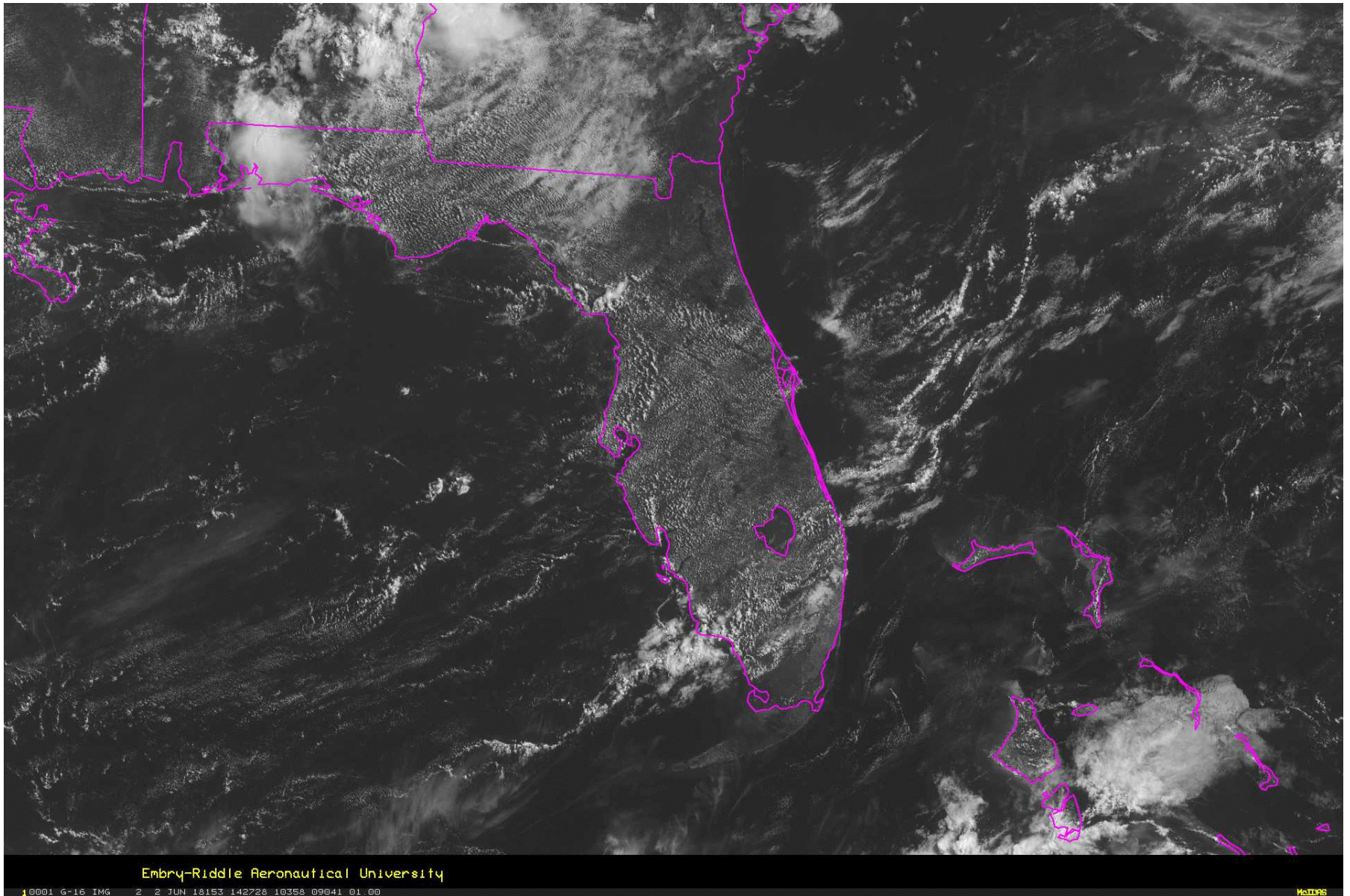
Wiggle 3D Also Available at http://wx.erau.edu/erau_sat/

- Left, center, and right shifted images put into a rapidly looping animated gif image. High clouds wiggle more than low.



Wizard of Oz Moment

- Color images were not part of the original GOES-16 specifications.
- Color image was first GOES-16 image released by NOAA Public Affairs.
- So far, geo-color images is the only derived product on NOAA web pages.



Natural Color Images

- GOES-16 has blue and red channels, but no green
- The band 3 (.8 micron) vegetation channel is centered on a chlorophyll absorption band.
- However the .8 micron albedo is much more than natural green albedo.
- Can make a “green” channel by mixing in some red and blue into the vege channel to wash out some of the green color.
- I use “green”=.29(red)+.29(blue)+.33(vege)
- Color images generated by blowing up blue and green channels to the same size as the red (or blowing down the red to the lower resolution) and then feeding the three channels to the red, green, blue display channels of monitor

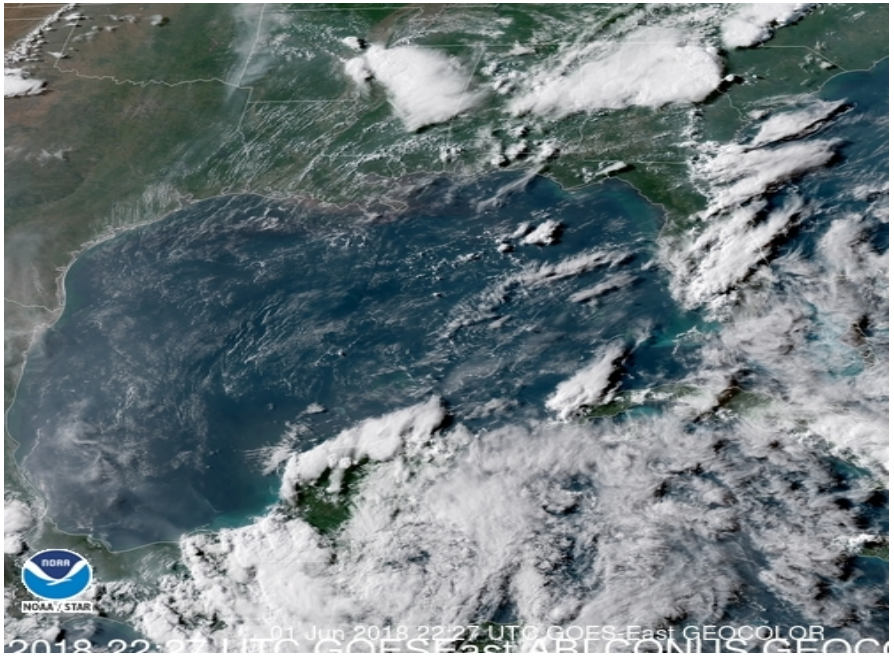
Three different sources of GOES-16 color images

- SSEC (http://www.ssec.wisc.edu/data/geo/#/animation)
- Select true color for channel. Only provides daytime images.
- NOAA (https://www.star.nesdis.noaa.gov/GOES/GOES16_CONUS.php)
- Select GeoColor. Derived multiband nighttime + static city lights

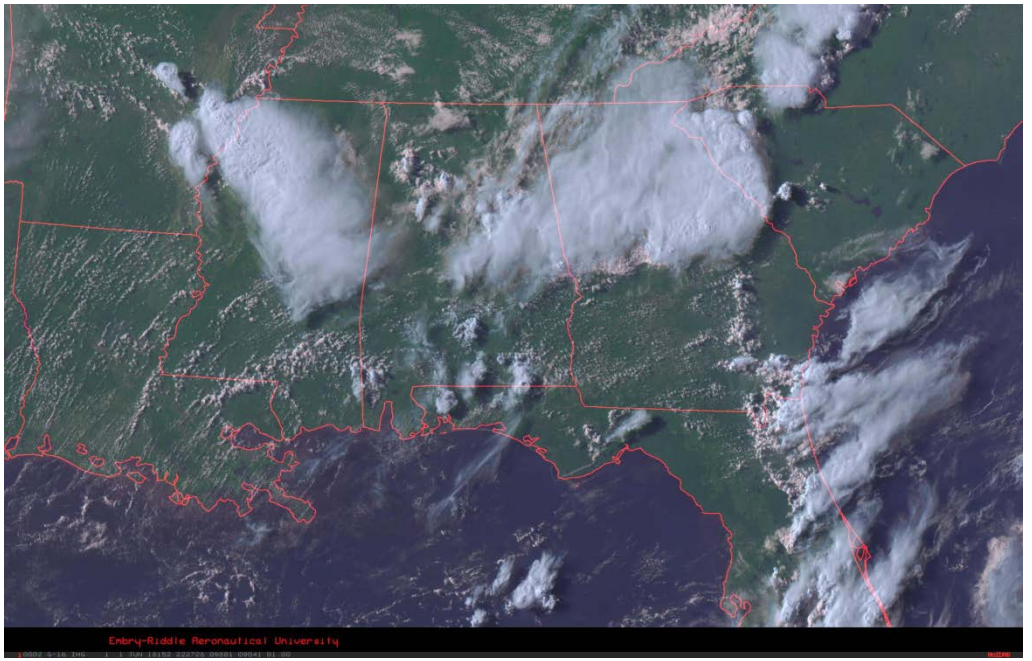
- ERAU (http://wx.erau.edu/erau_sat/) Select Day/Night Visible.
- Daytime brightness normalized correction; Rayleigh scattering correction of blue; clouds above 21,000 ft. tinted light blue
- Nighttime derived from multiple bands; low clouds generated by difference of bands 13-7; high clouds generated by difference of bands 13-12; “blue” nighttime channel generated by adding 30 counts to counts below 80 for pixels over water; “green” nighttime channel generated by adding 15 counts to counts below 80 for pixels over land; clouds above 21,000 feet tinted light blue; “red” channel is unchanged derived nighttime image.

Daytime Images

NOAA Geo-color

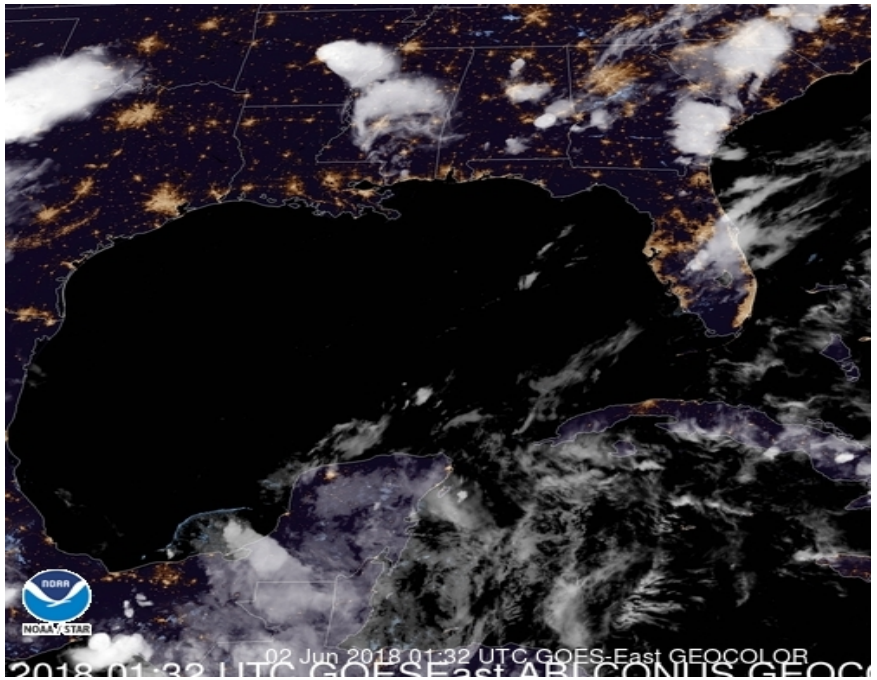


ERAU Day/Night Visible

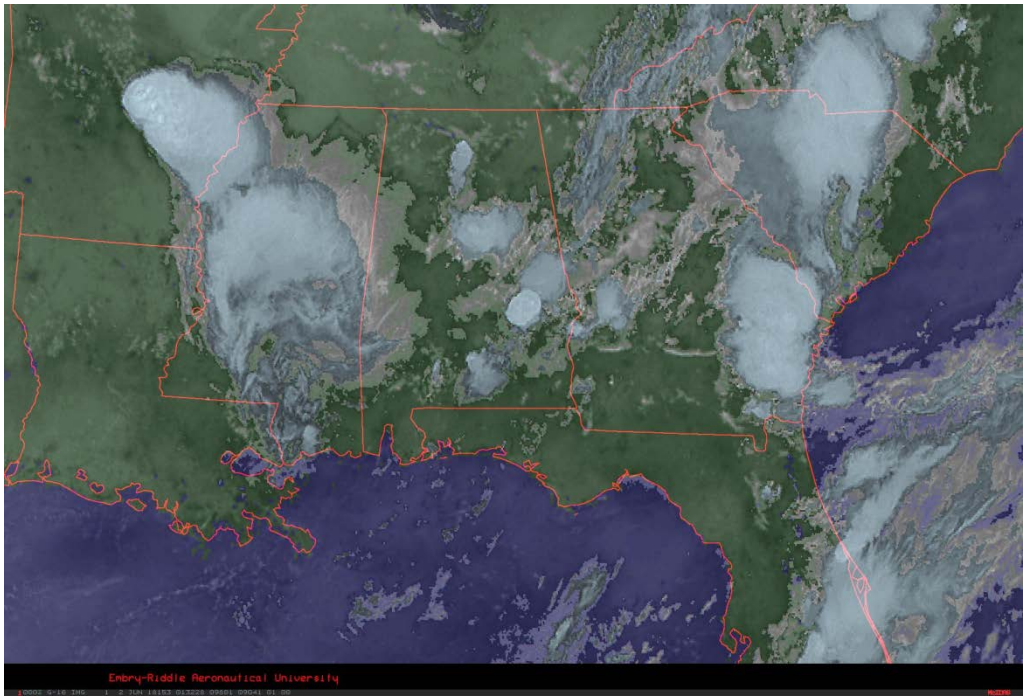


Nighttime Images

NOAA Geo-color

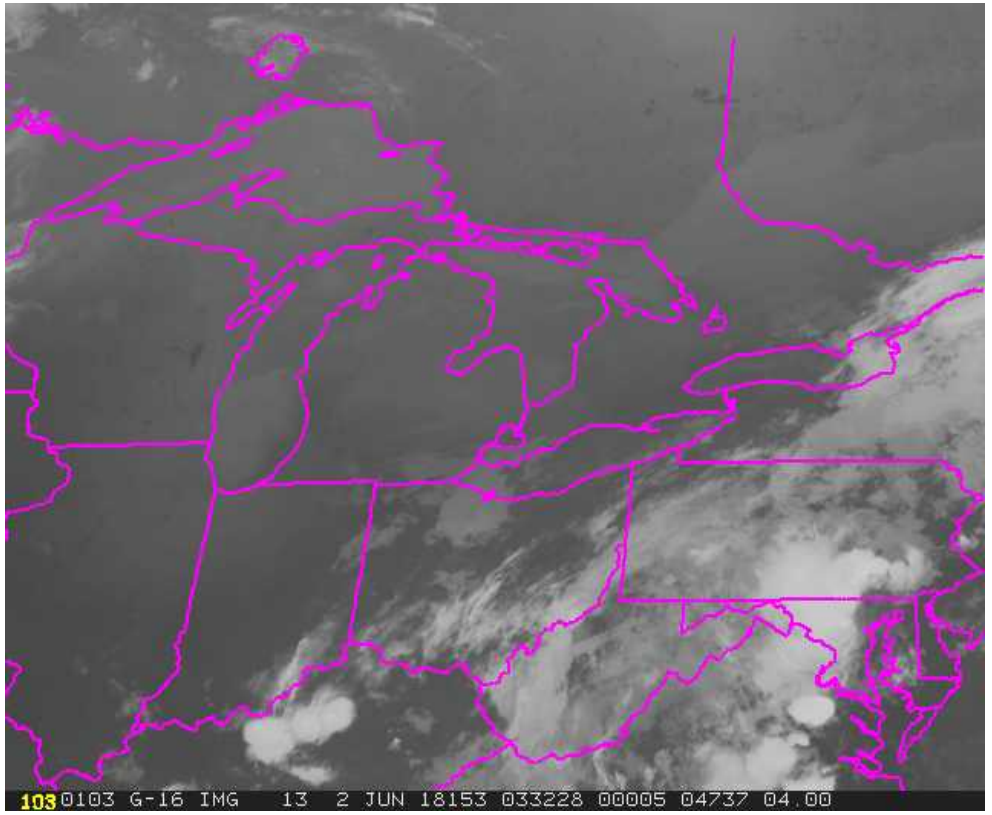


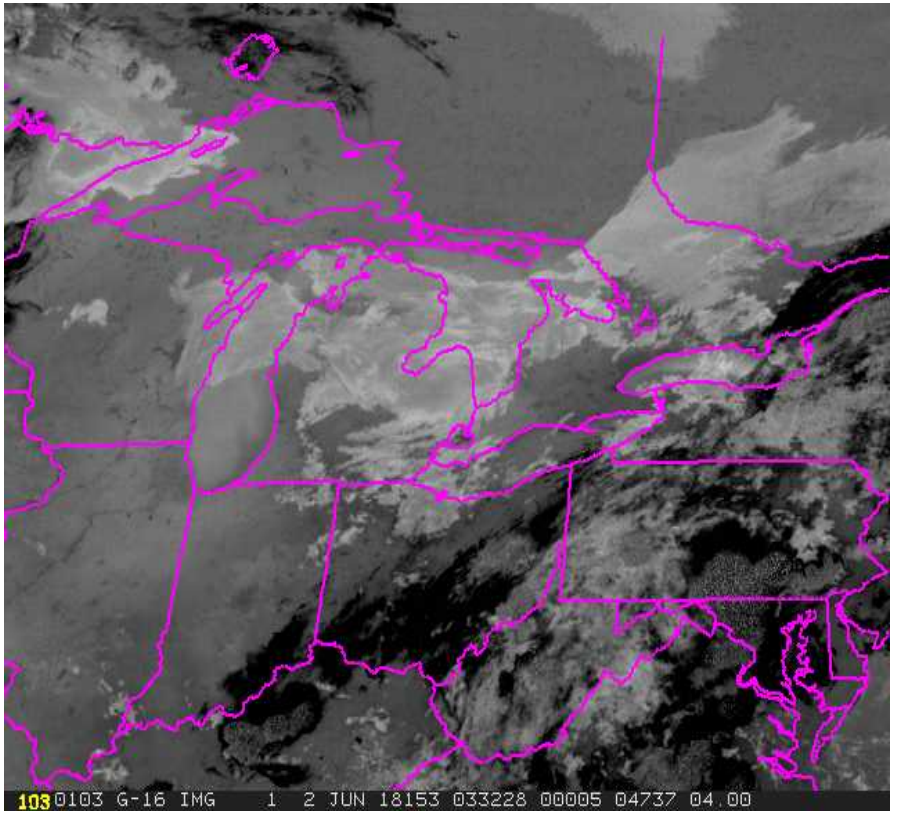
ERAU Day/Night Visible



Band Differences (bands 13 & 7)

- Subtract band 7 (3.9 micron) temperatures from band 13 (10.3 micron) temperatures at night to obtain low clouds and fog image at night. Stretch temperature difference of -4 to +10 degrees into brightness scale 30 to 255. Clouds with small droplets are white, large particles (ice crystals) are black.
- IR Fog difference



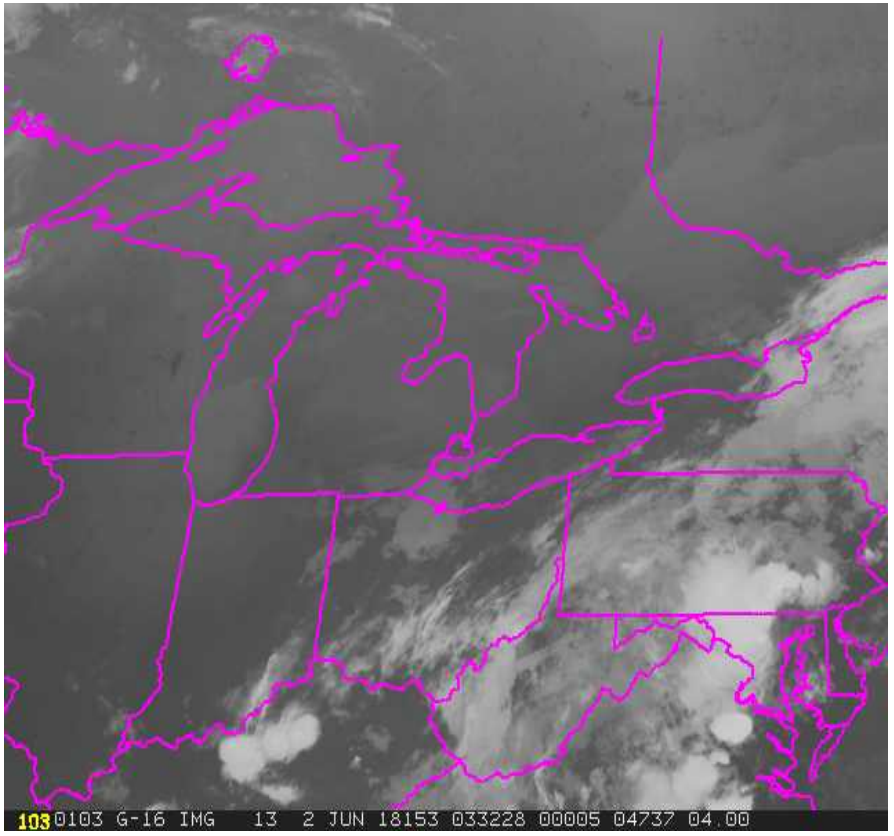


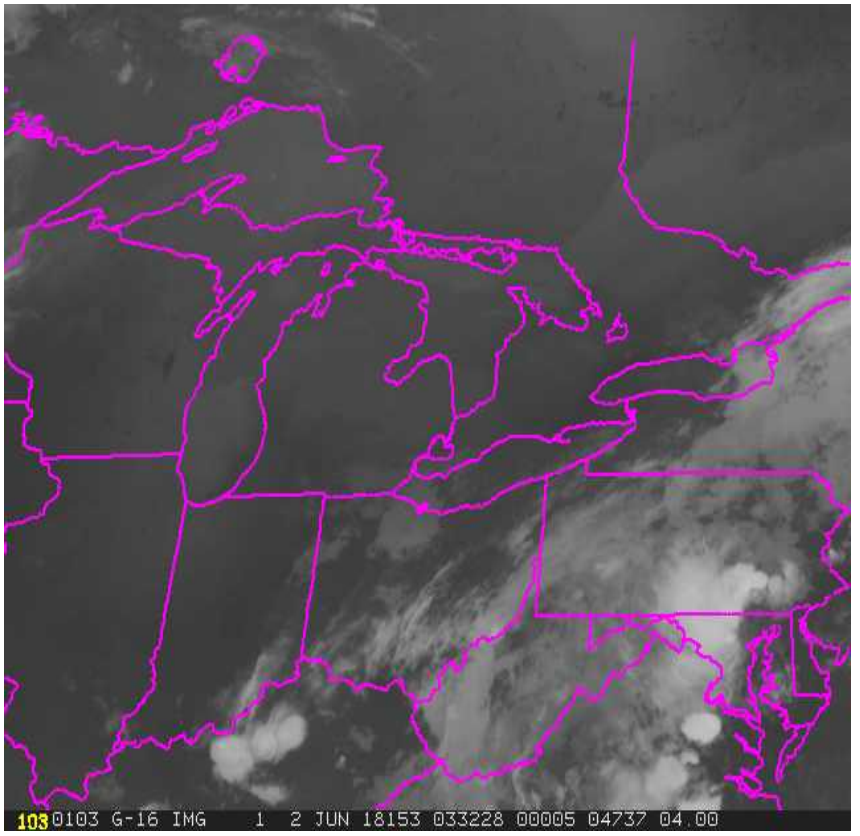
Band Differences (bands 13 & 12)

- Subtract band 13 (10.3 micron) temperature from band 12 (9.6 micron) temperature to obtain high cloud thickness at night. Thicker cirrus clouds are whiter.

- IR

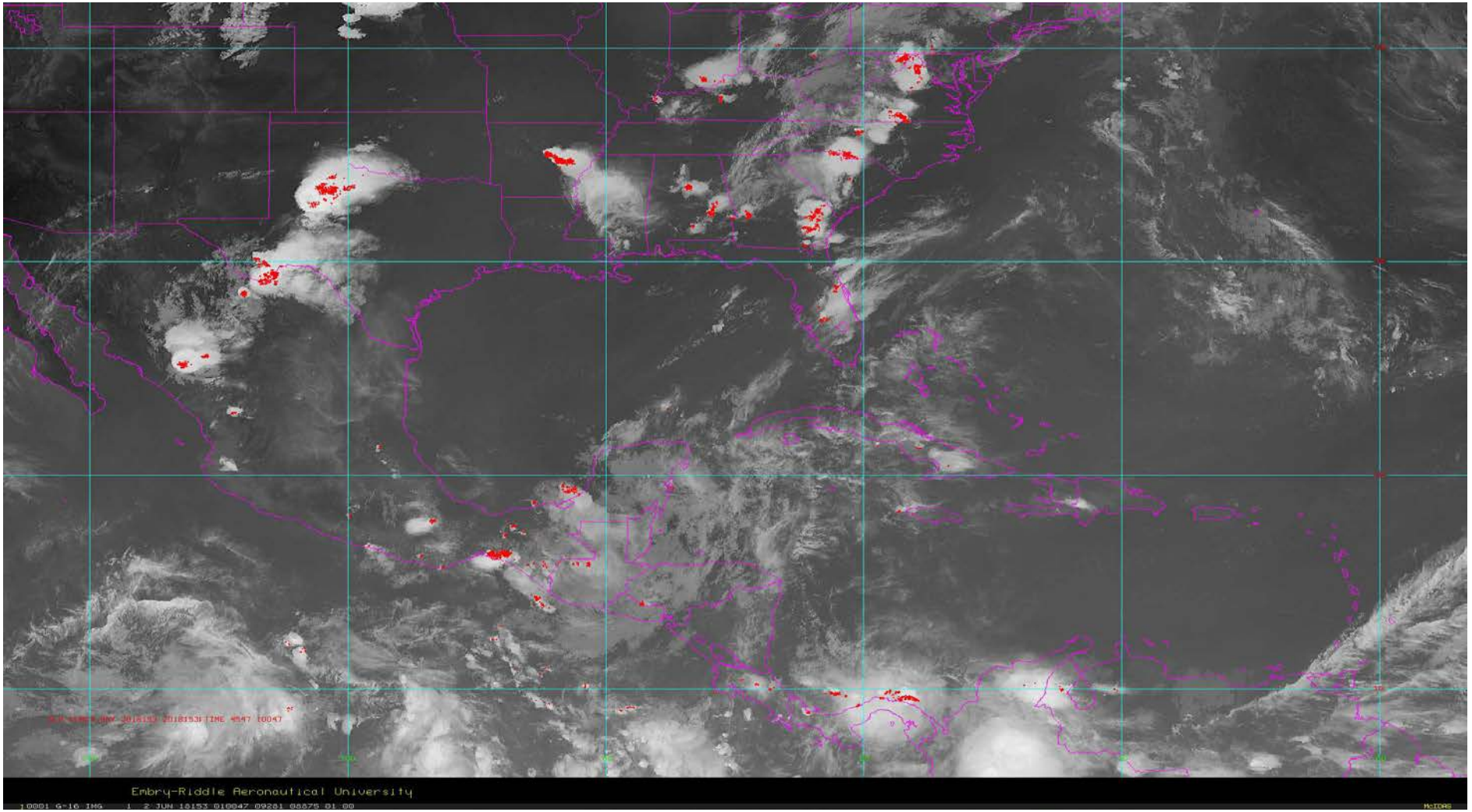
Thickness difference





Convective Clouds with GLM Overlay

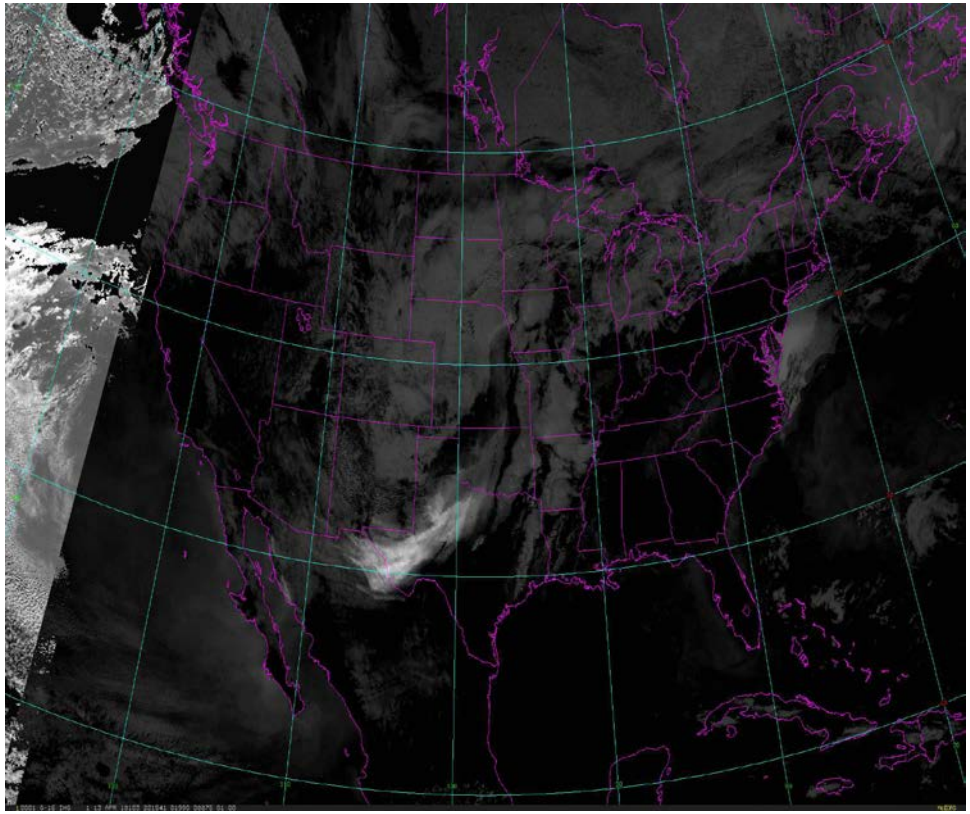
The band 12-13 difference image with overlay of GOES Lightning Mapper (GLM) data overlay. Available at http://wx.erau.edu/erau_sat/ hemispheric convective diagnostic product.



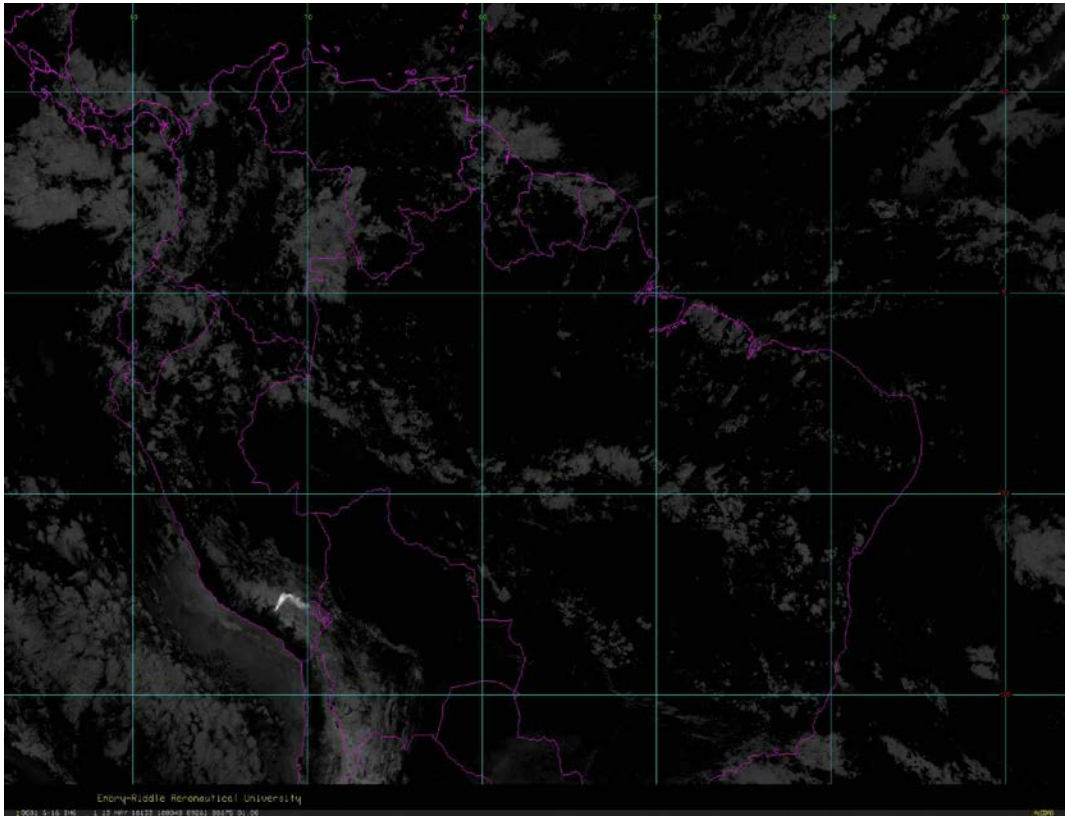
Dust/Volcanic Ash Difference

- Band 13 (IR window) – band 15 (dirty window) traditional method of obtaining volcanic ash. Addition of band 13 – band 11 difference further reduces water cloud images and enhances ash/dust signature. Available at http://wx.erau.edu/erau_sat/

- Dust



Volcanic Ash



Government Derived Product Suite

- The following are derived products implemented or planned by GOES project office:

Baseline Products

Aerosol Detection (Including Smoke and Dust)
Aerosol Optical Depth (AOD)
Clear Sky Masks
Cloud and Moisture Imagery
Cloud Optical Depth
Cloud Particle Size Distribution
Cloud Top Height
Cloud Top Phase
Cloud Top Pressure
Cloud Top Temperature
Derived Motion Winds
Derived Stability Indices
Downward Shortwave Radiation: Surface
Fire/Hot Spot Characterization
Hurricane Intensity Estimation
Land Surface Temperature (Skin)
Legacy Vertical Moisture Profile
Legacy Vertical Temperature Profile
Radiances
Rainfall Rate / QPE
Reflected Shortwave Radiation: TOA
Sea Surface Temperature (Skin)
Snow Cover
Total Precipitable Water
Volcanic Ash: Detection and Height

Future Products

Absorbed Shortwave Radiation: Surface
Aerosol Particle Size
Aircraft Icing Threat
Cloud Ice Water Path
Cloud Layers/Heights
Cloud Liquid Water
Cloud Type
Convective Initiation
Currents
Currents: Offshore
Downward Longwave Radiation: Surface
Enhanced "V" / Overshooting Top Detection
Flood/Standing Water
Ice Cover
Low Cloud and Fog
Ozone Total
Probability of Rainfall
Rainfall Potential
Sea and Lake Ice: Age
Sea and Lake Ice: Concentration
Sea and Lake Ice: Motion
Snow Depth (Over Plains)
SO2Detection
Surface Albedo
Surface Emissivity
Tropopause Folding Turbulence Prediction
Upward Longwave Radiation: Surface
Upward Longwave Radiation: TOA
Vegetation Fraction: Green
Vegetation Index
Visibility

- Some of these derived products are available at:

https://weather.msfc.nasa.gov/cgi-bin/sportPublishData.pl?dataset=goeseastabiconus&product=11p20um

http://weather.cod.edu/satrad/exper/?parms=fullconus-02-48-0