The GOES-R Series: The Nation's Next-Generation Geostationary Weather Satellites

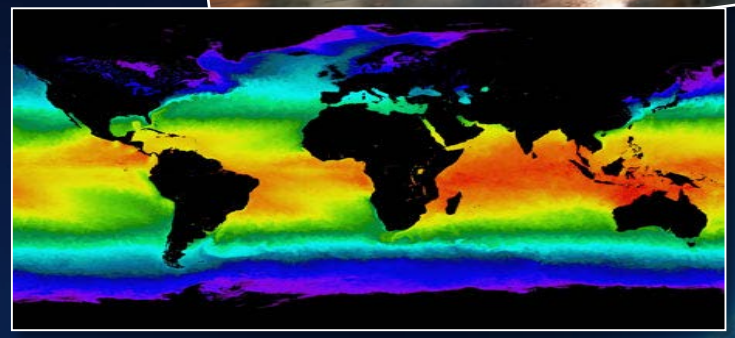
Greg Mandt

GOES-R System Program Director

28th Annual Glen Gerberg Weather and Climate Summit

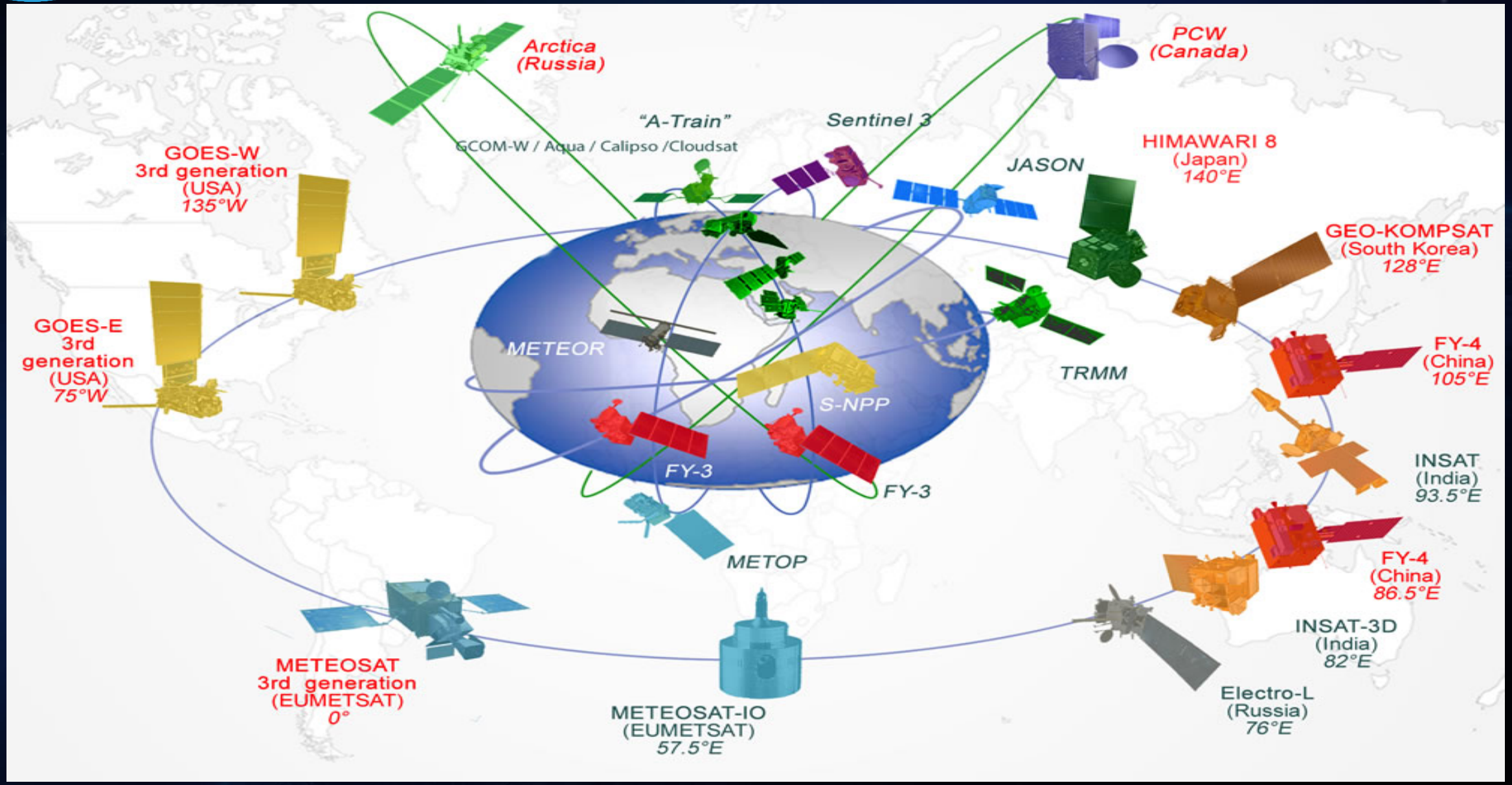
January 13, 2015

NOAA Satellite and Information Service (NESDIS)



Our mission is to provide timely access to global environmental data from satellites and other sources to promote, protect and enhance the Nation's economy, security, environment and quality of life.

The Global Satellite Observing System



A History of GOES Weather Satellites

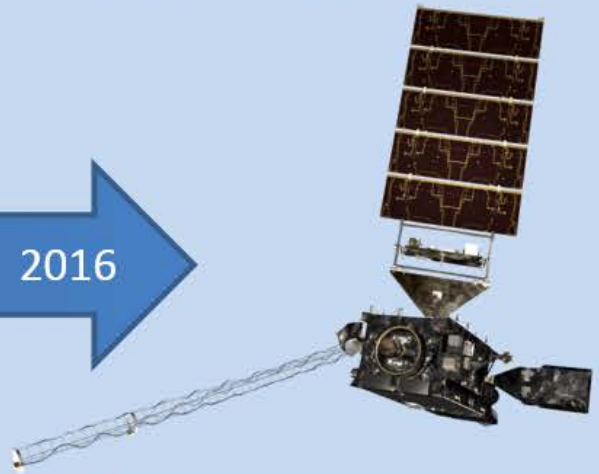
GOES 4-7
- Vertical profiling

GOES 13,14,15
- Simultaneous, independent imaging, sounding

1975 1980 1994 2006 2016

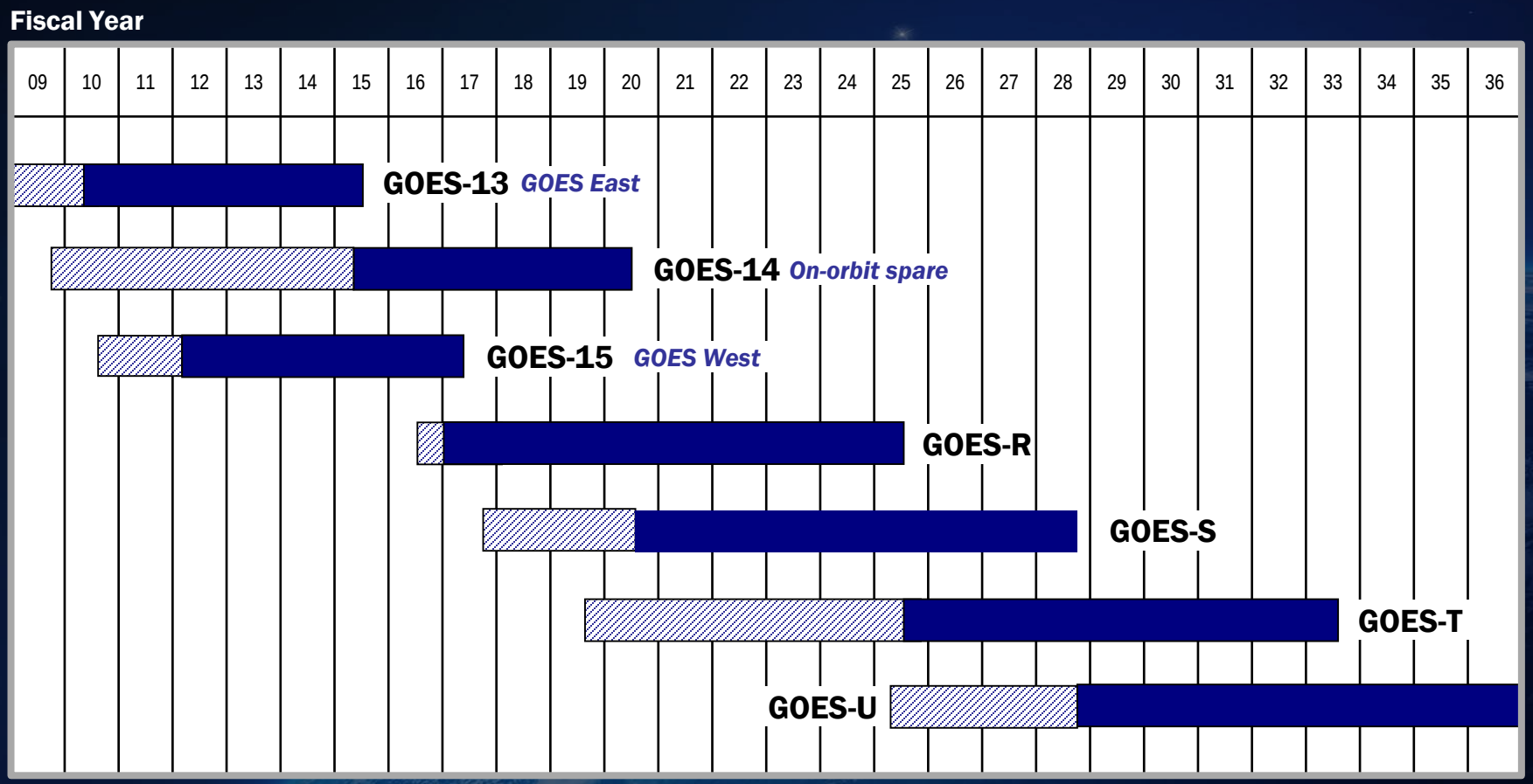
GOES 1-3
- NOAA's First GOES
- Spin-stabilized

GOES 8-12
- 3-axis stabilized
- Simultaneous imaging, sounding 100% of time



GOES-R Series
- Improved spectral, spatial and temporal resolution in imaging
- Lightning mapping
- Improved space weather monitoring

Continuity of GOES Operational Satellite Program



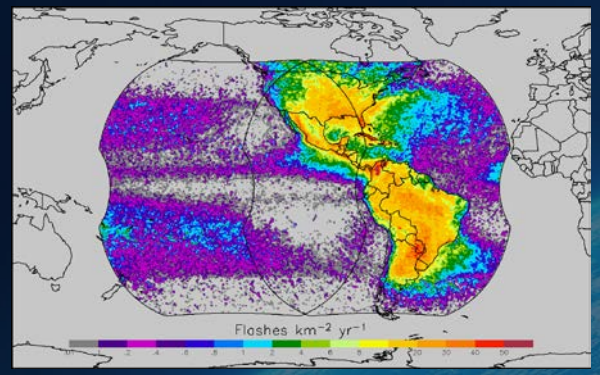

GOES-R
launches in
March
2016!

Why GOES-R ?

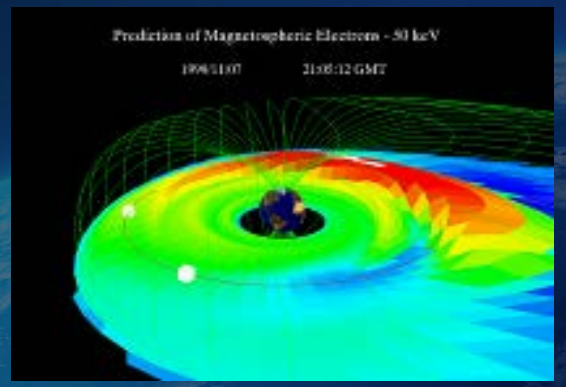
The GOES-R series will provide significant improvements in the detection and observations of meteorological phenomena that directly impact public safety, protection of property, and our Nation's economic health and prosperity.

Visual & IR Imagery

- ✓ Improves hurricane track & intensity forecasts
- ✓ Increases thunderstorm & tornado warning lead time
- ✓ Improves aviation flight route planning
- ✓ Data for long-term climate variability studies

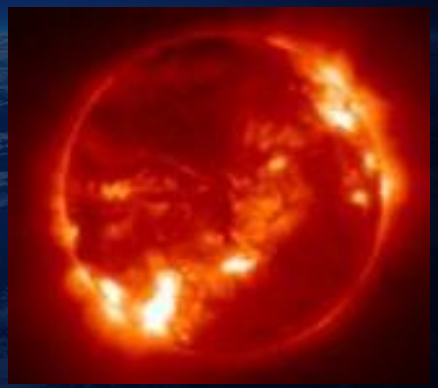


Lightning Mapping



Space Weather Monitoring

- ✓ Improves solar flare warnings for communications and navigation disruptions
- ✓ More accurate monitoring of energetic particles responsible for radiation hazards to humans and spacecraft
- ✓ Better monitoring of Coronal Mass Ejections to improve geomagnetic storm forecasting



Solar Imaging

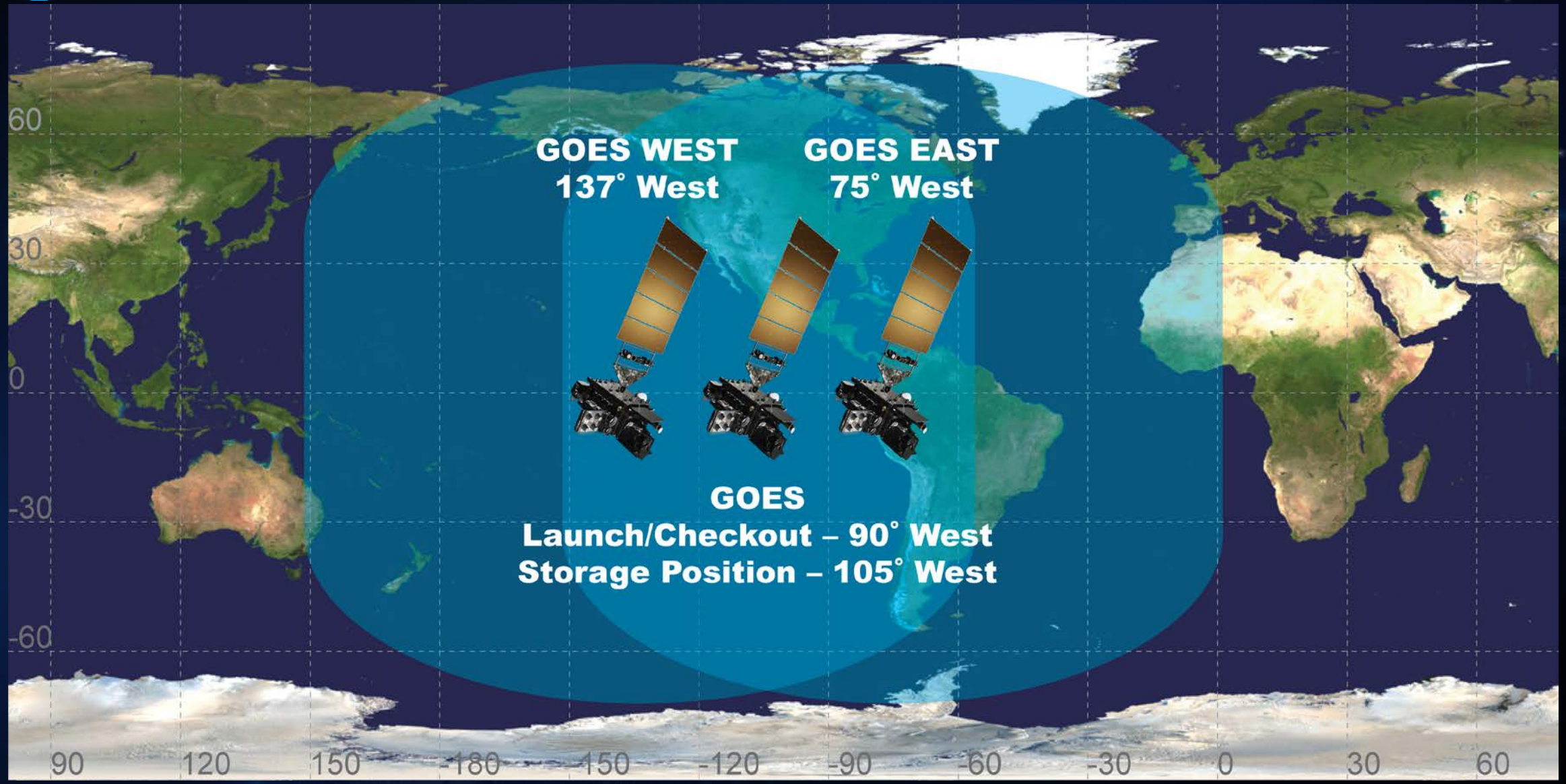
GOES-R Series Program Overview

Mission: Provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere and space weather monitoring.

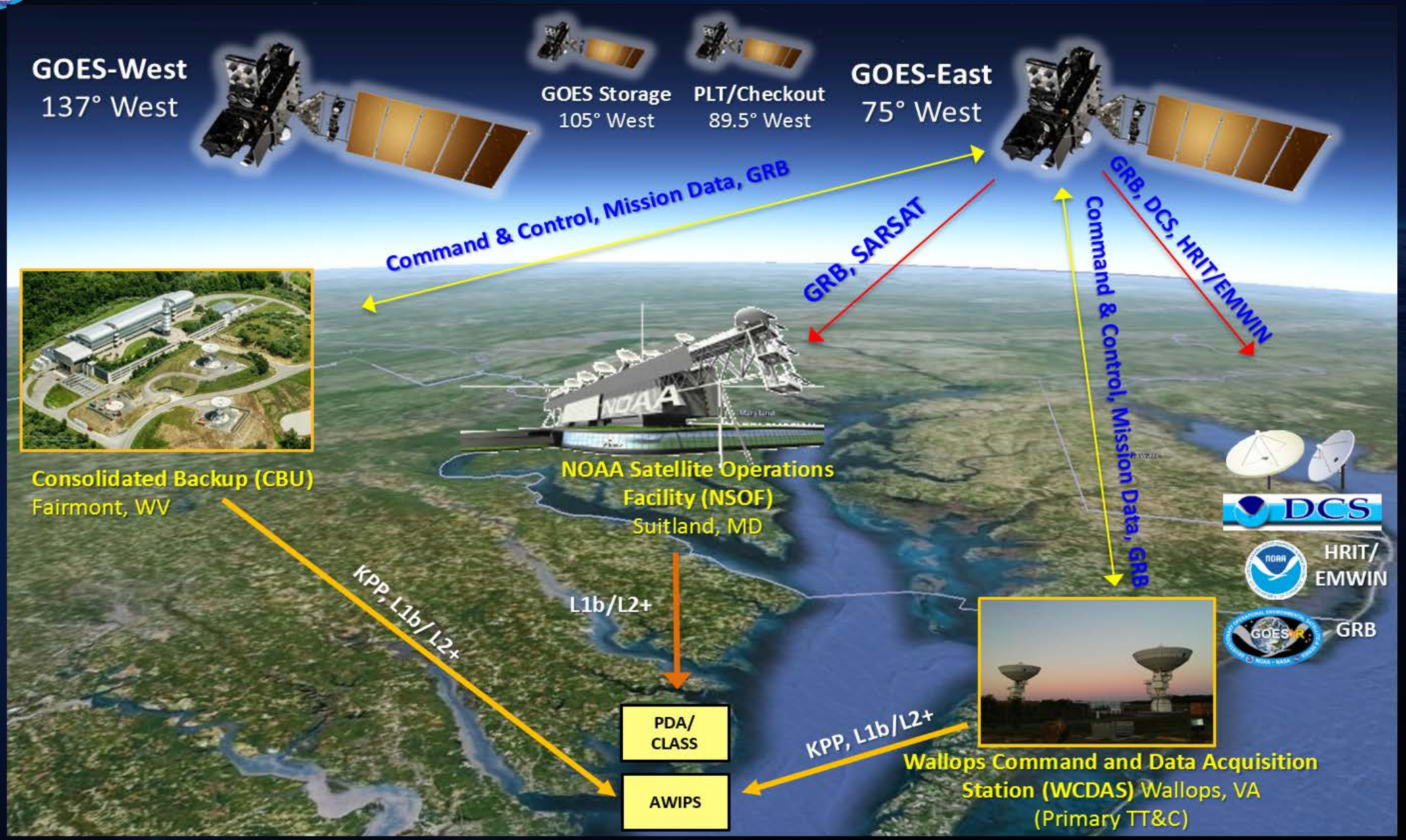
- **NOAA Responsibilities:**
  - Overall programmatic responsibility
  - Procurement of the Ground Segment
- **NASA Responsibilities:**
  - Procurement of the Space Segment
  - Systems Engineering lead
  - Safety and Mission Assurance lead
- **Joint mission between NASA and NOAA**
  - Builds upon successful GOES legacy program since the late 1970s

Host Center	**NASA Goddard Space Flight Center**
Program Architecture	**Four Satellites (GOES-R, S, T, U)**
Launch Readiness Dates	**GOES-R: March 2016** **GOES-S: 3Q FY 2017** **GOES-T: 3Q FY 2019** **GOES-U: 1Q FY 2025**
Program Operational Life	**FY 2017 – FY 2036**

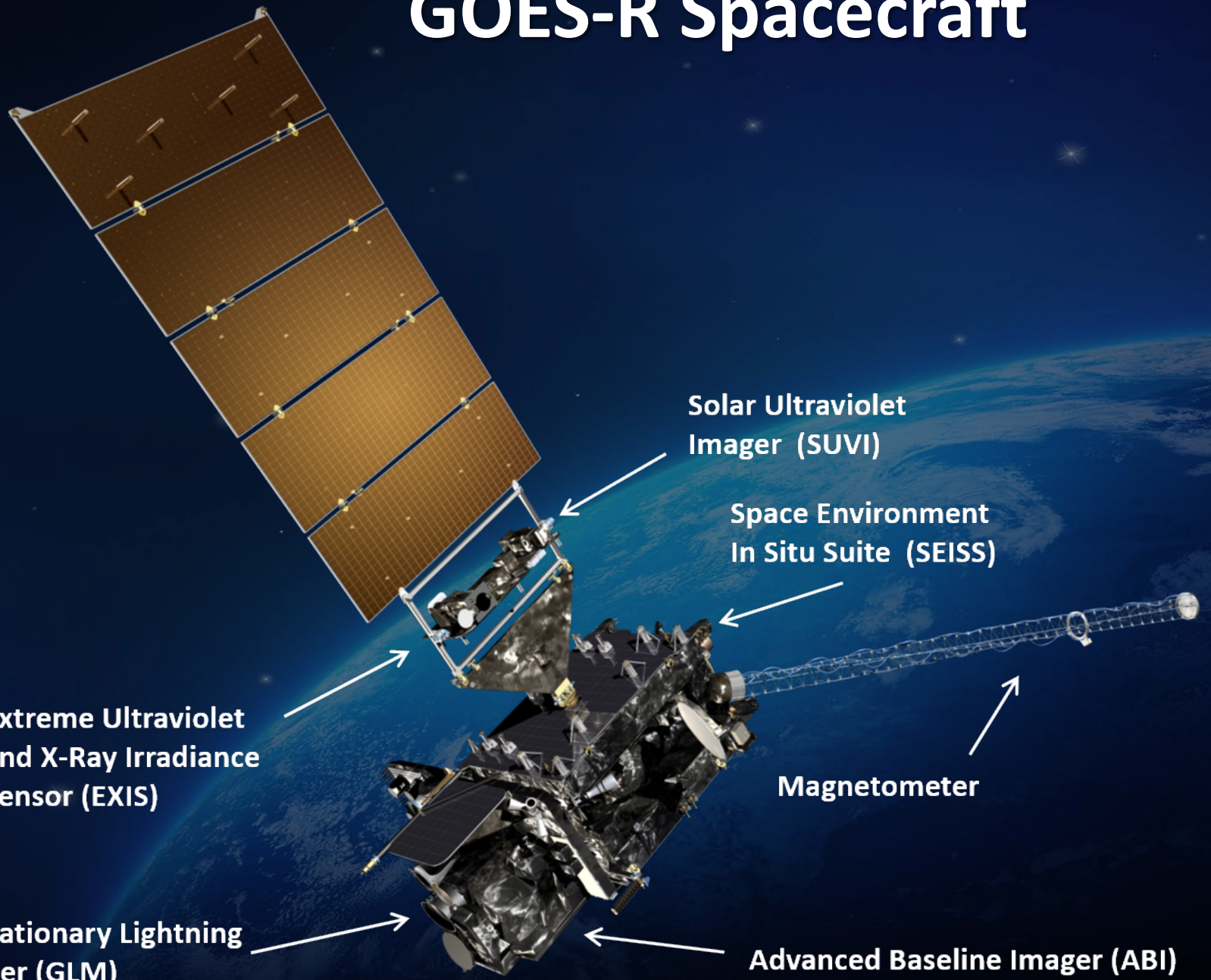
GOES Fleet Configuration



GOES-R System Architecture



GOES-R Spacecraft



GOES-R Instruments

Earth Pointing

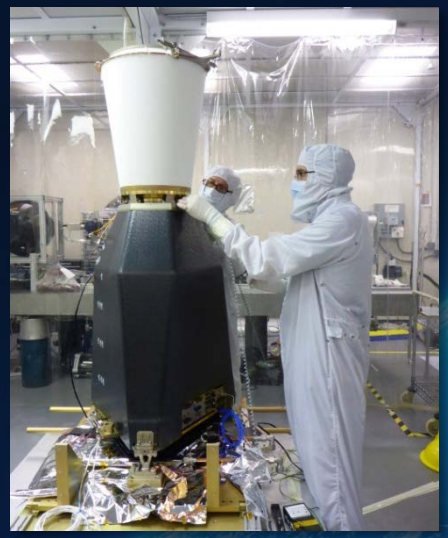
Visible & IR Imagery

Advanced Baseline Imager (ABI)

Exelis

Lightning Mapping

Geostationary Lightning Mapper (GLM)



Lockheed Martin Space Technology Advanced Research and Development Laboratories

In-Situ

Space Weather Monitoring

Space Environment in-Situ Sensor Suite (SEISS)

Assurance Technology Corp.

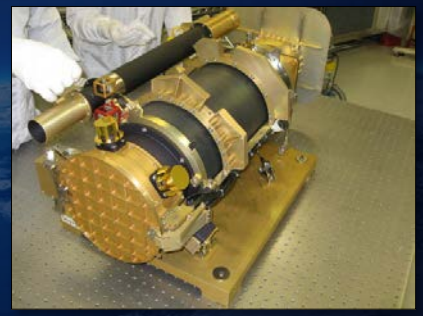
Magnetometer

Lockheed Martin with Macintyre Electronic Design Associates and ATK

Sun Pointing

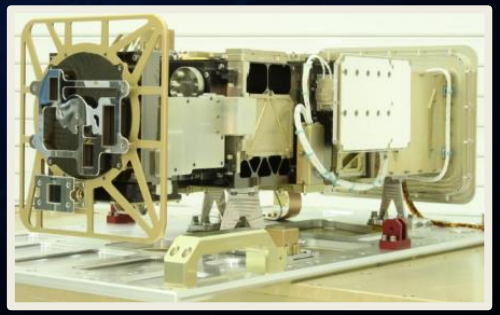
Solar Imaging

Solar Ultra-Violet Imager (SUVI)



Lockheed Martin Space Technology Advanced Research and Development Laboratories

Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS)

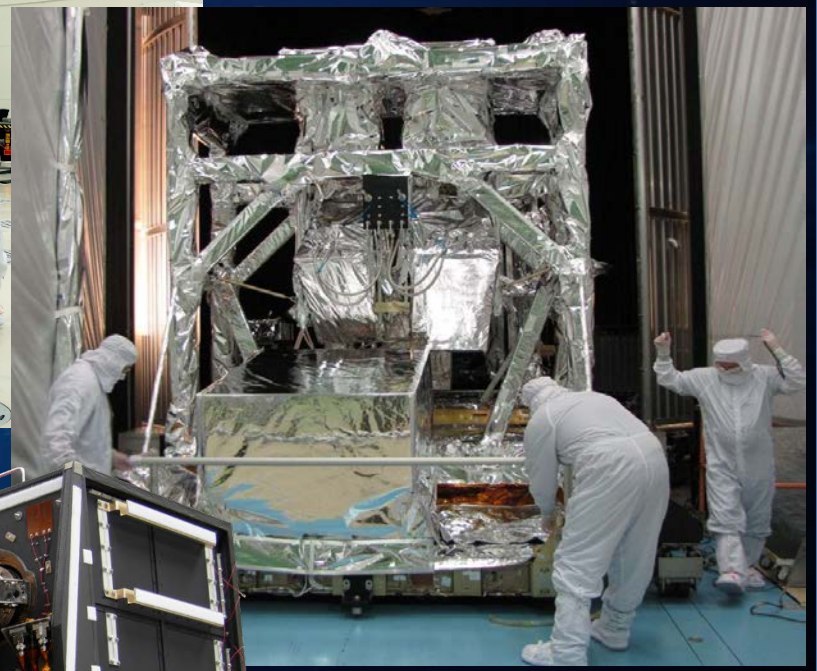


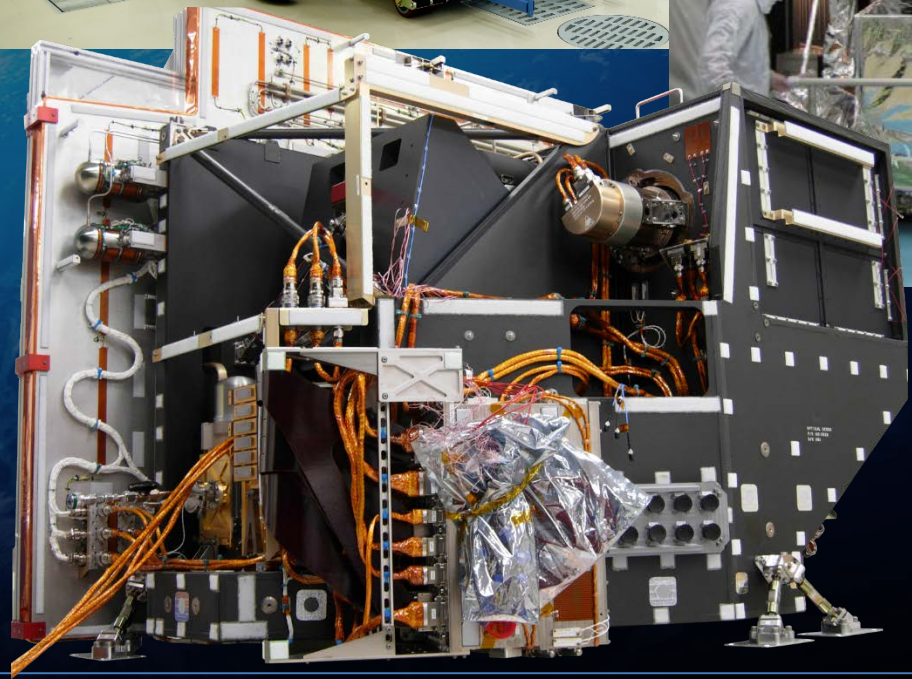
University of Colorado Laboratory for Atmospheric and Space Physics

Advanced Baseline Imager (ABI)

Specifications:

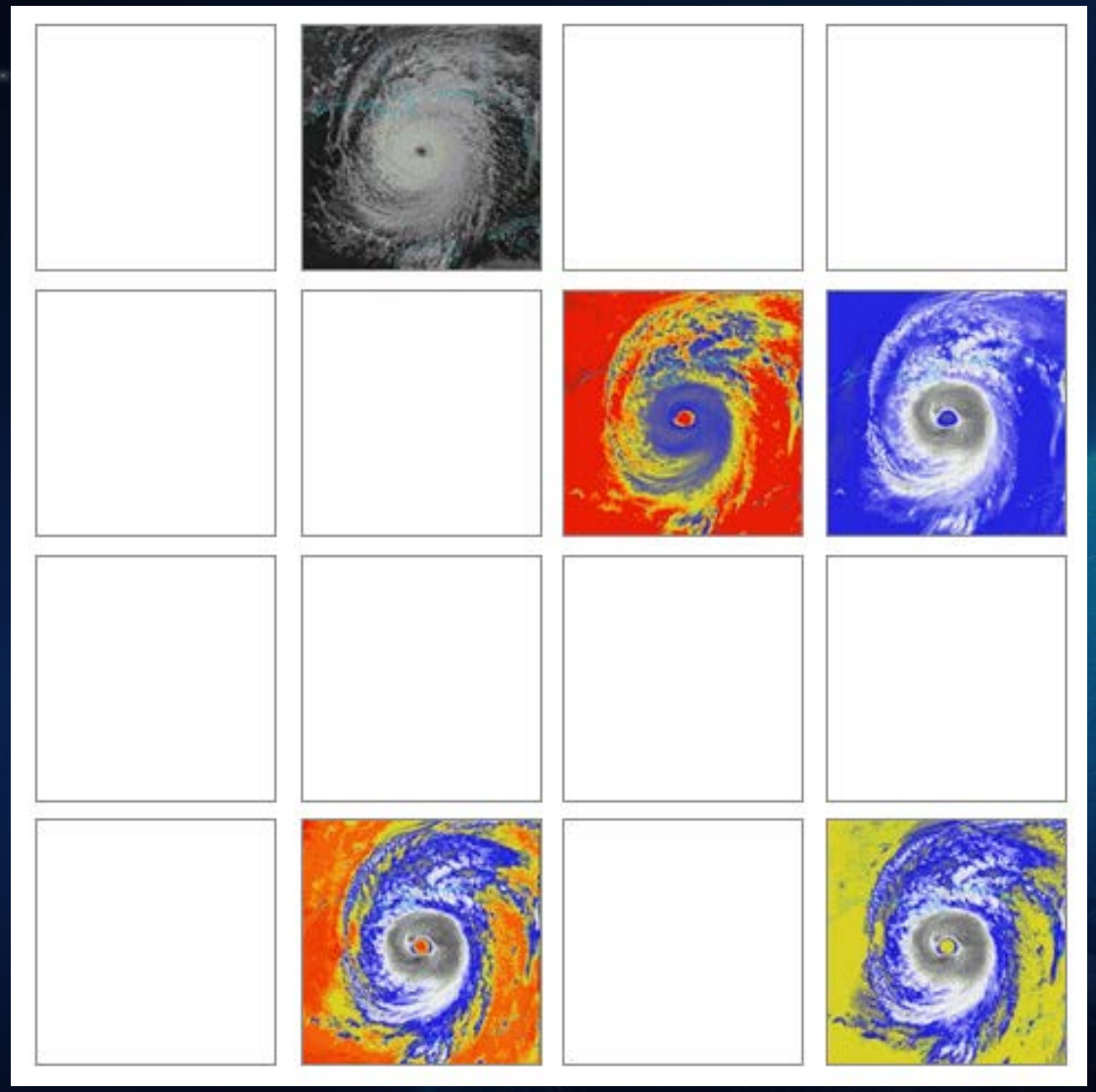
- Primary instrument in GOES-R series
- 16 channel imager
- Measures radiances in the visible and near-infrared wavelengths
- Improves every product from current GOES Imager and will offer new products for severe weather forecasting, fire and smoke monitoring, volcanic ash advisories, and more
- Improves upon current capabilities in spectral information (3X), spatial coverage (4X), and temporal resolution (5X)



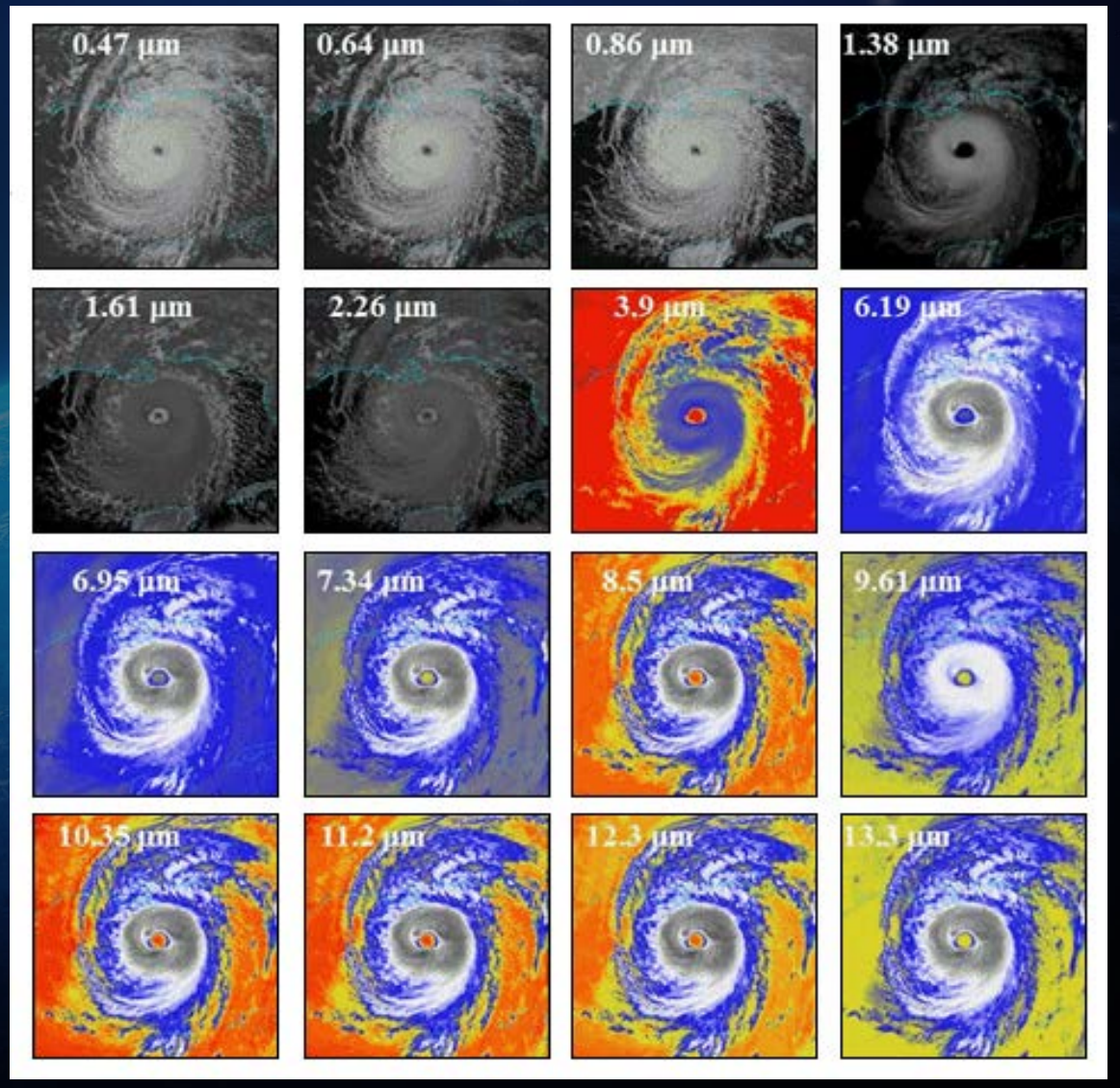


Three Times More Spectral Information

GOES-13/14/15 Spectral Bands



GOES-R Spectral Bands



ABI Visible/Near-Infrared Bands

Future GOES imager (ABI) band	Wavelength range (μm)	Central wavelength (μm)	Nominal subsatellite IGFOV (km)	Sample use
1	0.45–0.49	0.47	1	Daytime aerosol over land, coastal water mapping
2	0.59–0.69	0.64	0.5	Daytime clouds fog, inso-lation, winds
3	0.846–0.885	0.865	1	Daytime vegetation/burn scar and aerosol over water, winds
4	1.371–1.386	1.378	2	Daytime cirrus cloud
5	1.58–1.64	1.61	1	Daytime cloud-top phase and particle size, snow
6	2.225–2.275	2.25	2	Daytime land/cloud properties, particle size, vegetation, snow

Schmit et al, 2005

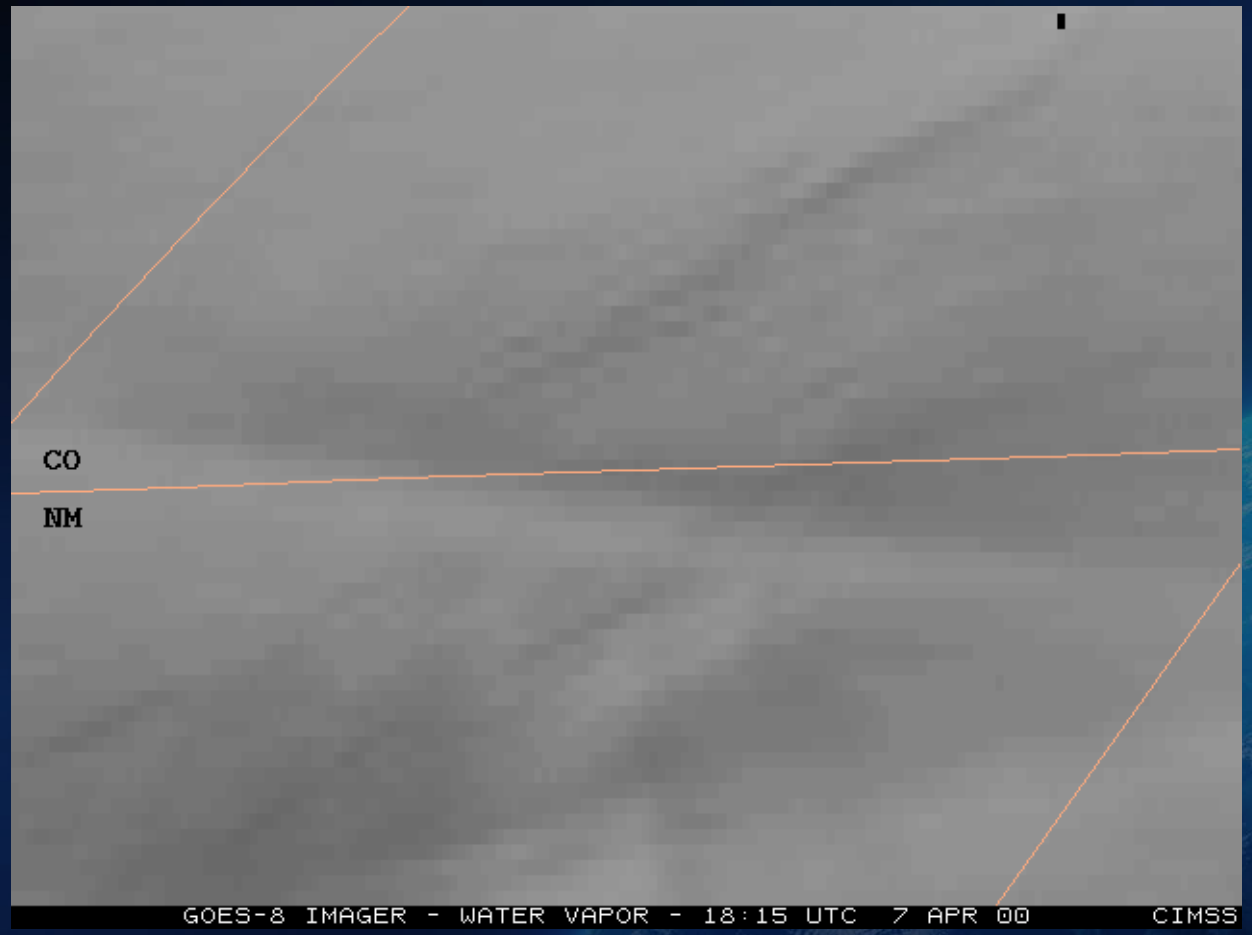
ABI Infrared Bands

7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO_2 rainfall
12	9.42–9.8	9.61	2	Total ozone, turbulence, and winds
13	10.1–10.6	10.35	2	Surface and cloud
14	10.8–11.6	11.2	2	Imagery, SST, clouds, rainfall
15	11.8–12.8	12.3	2	Total water, ash, and SST
16	13.0–13.6	13.3	2	Air temperature, cloud heights and amounts

Schmit et al, 2005

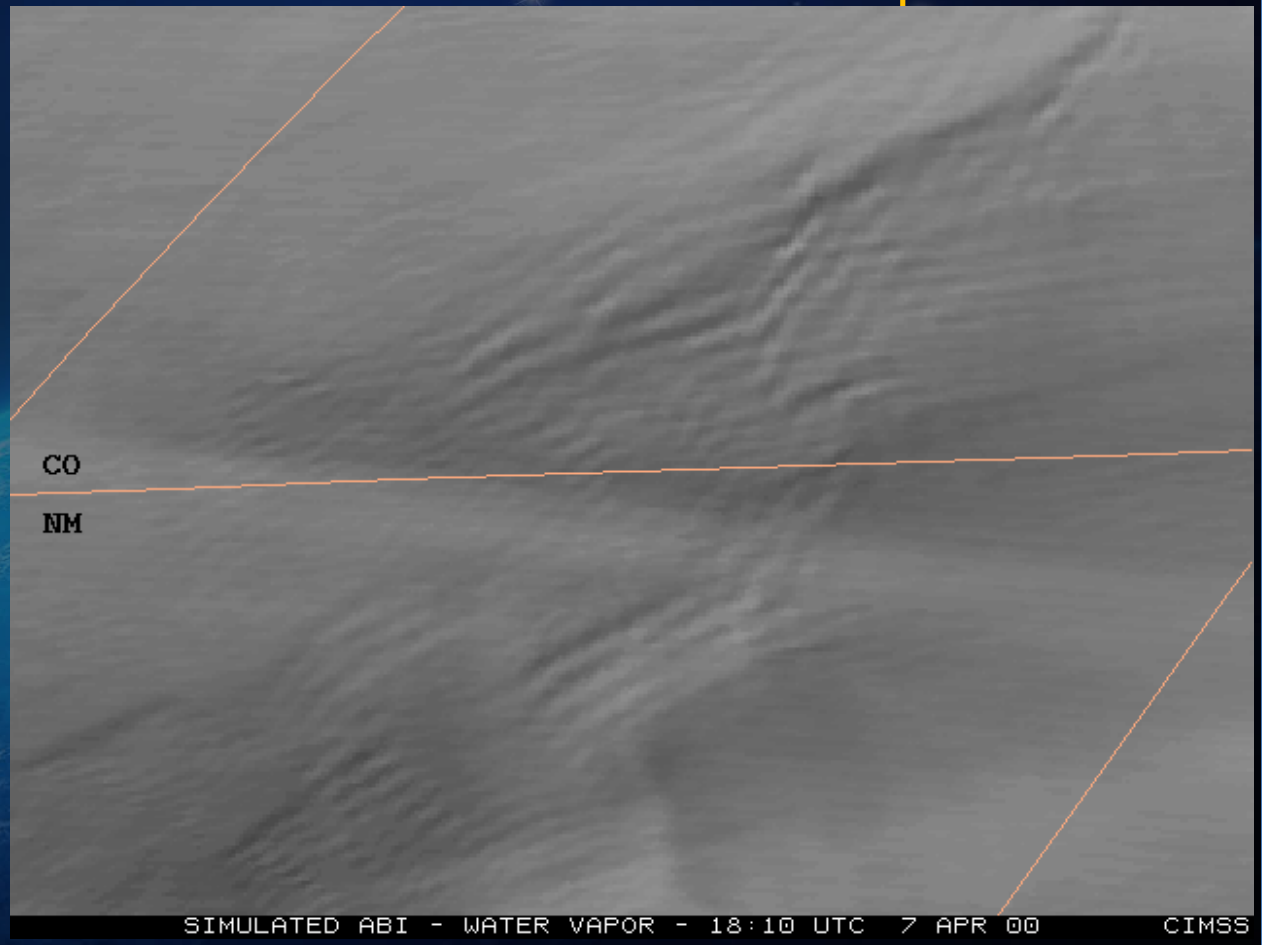
Four Times Greater Spatial Resolution

Actual GOES-8 Water Vapor



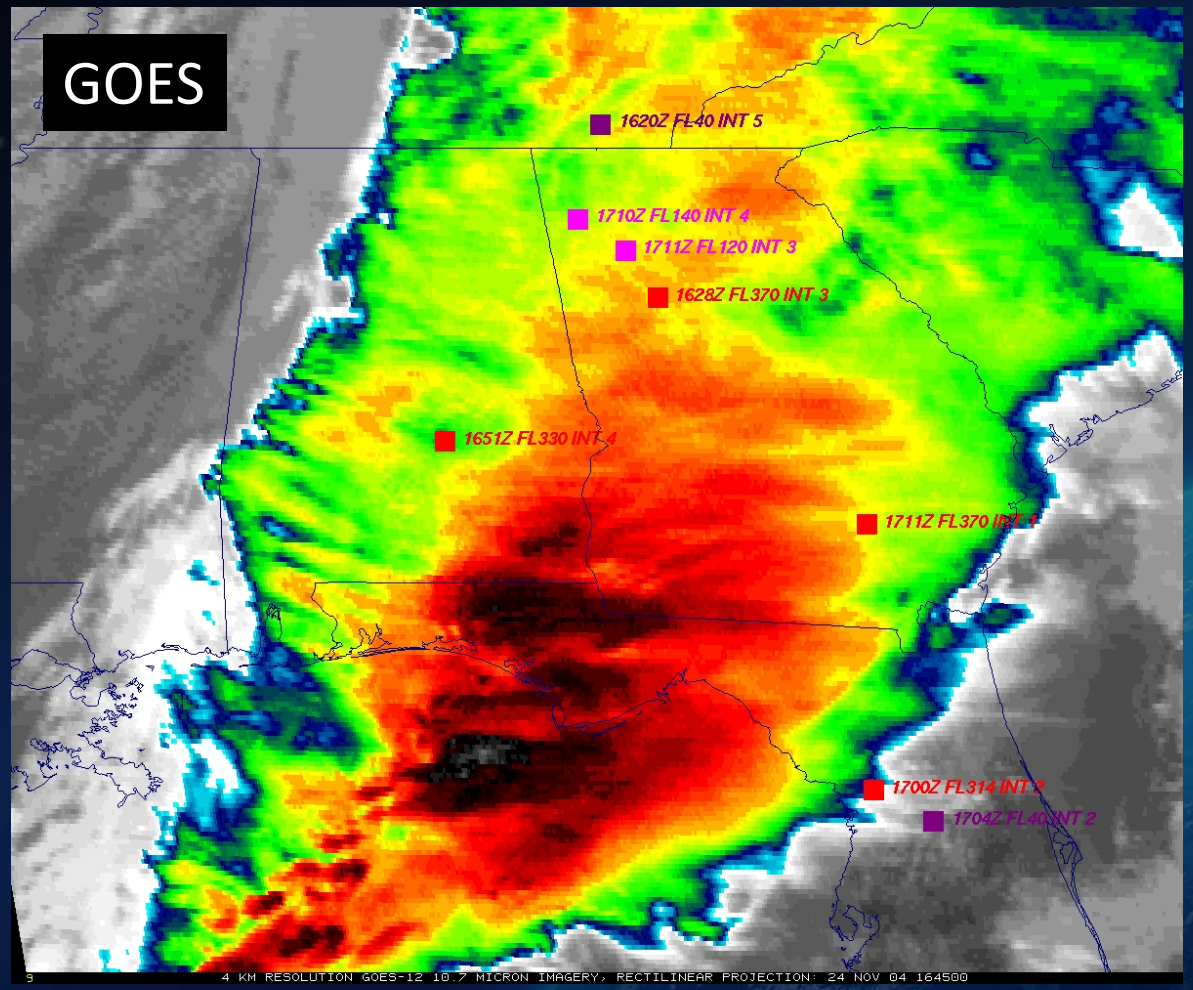
8 km IR

Simulated ABI Water Vapor

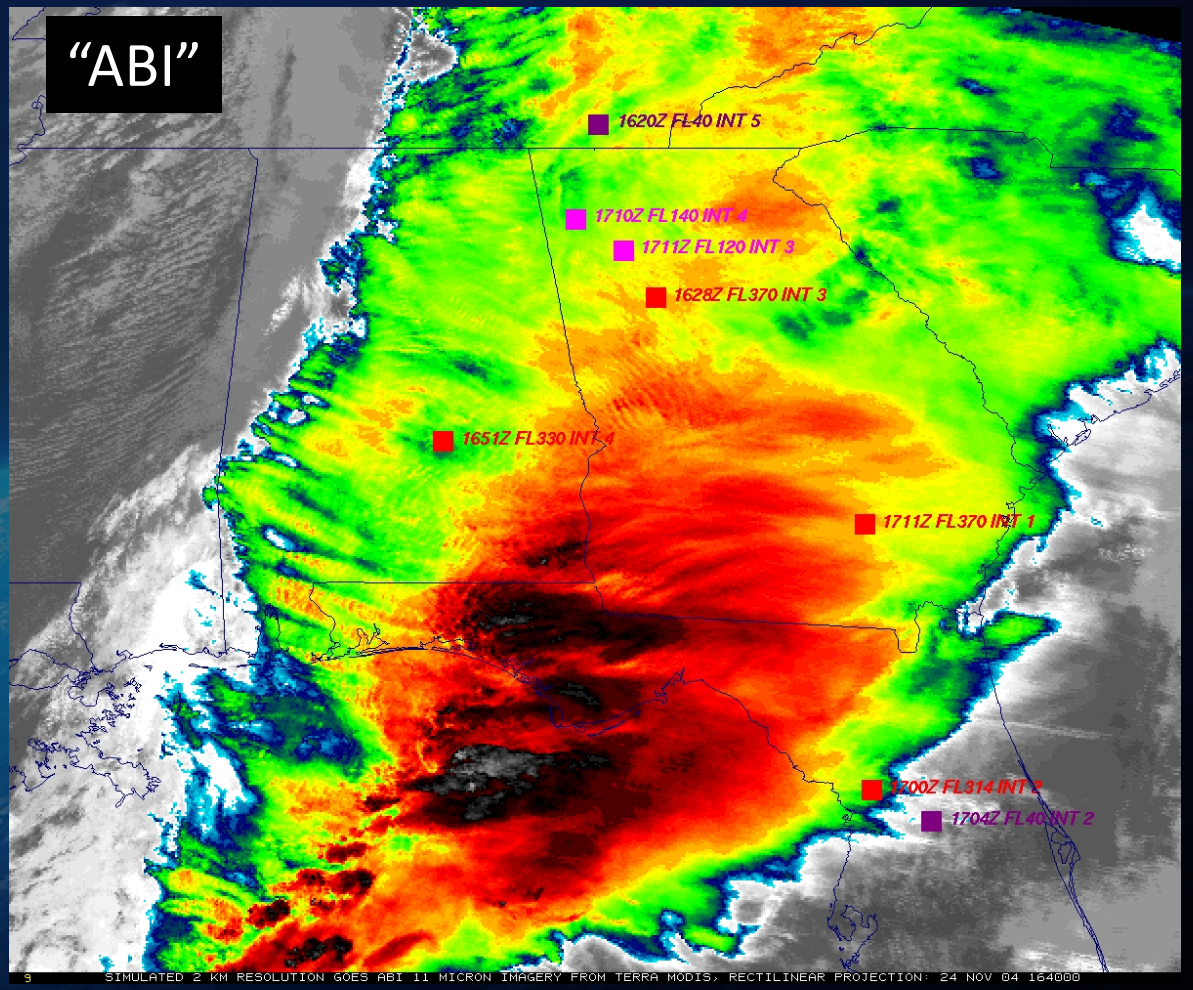


2 km IR

Four Times Greater Spatial Resolution



4 km IR



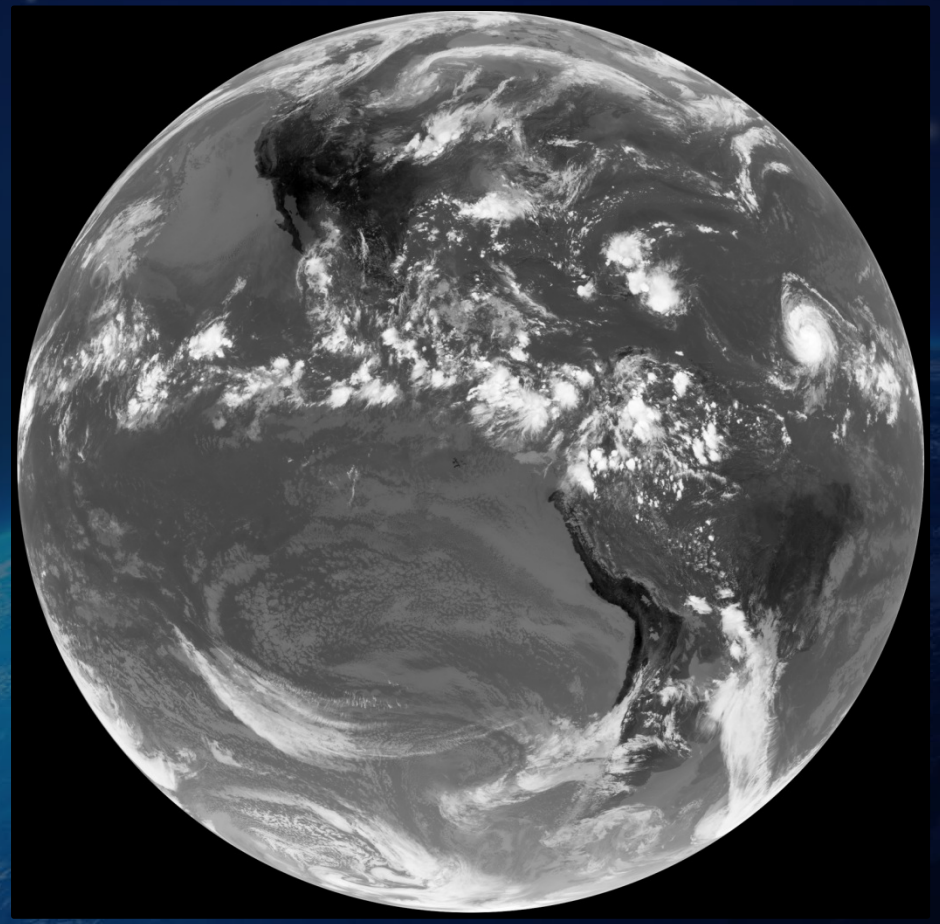
2 km IR

Figures courtesy of K. Bedka and W. Feltz

Five Times Faster Coverage

Current GOES

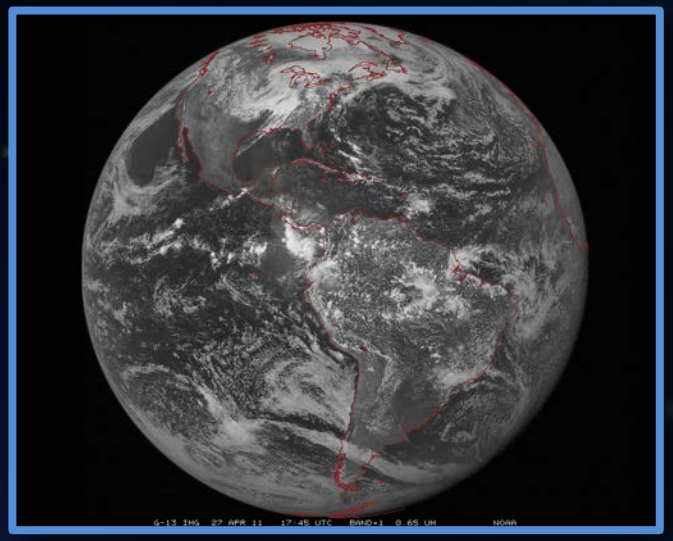
5 minute Capability

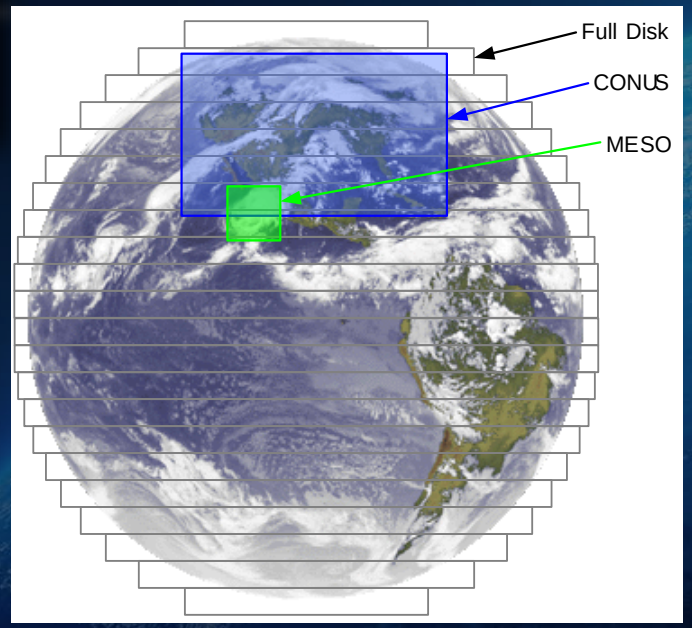


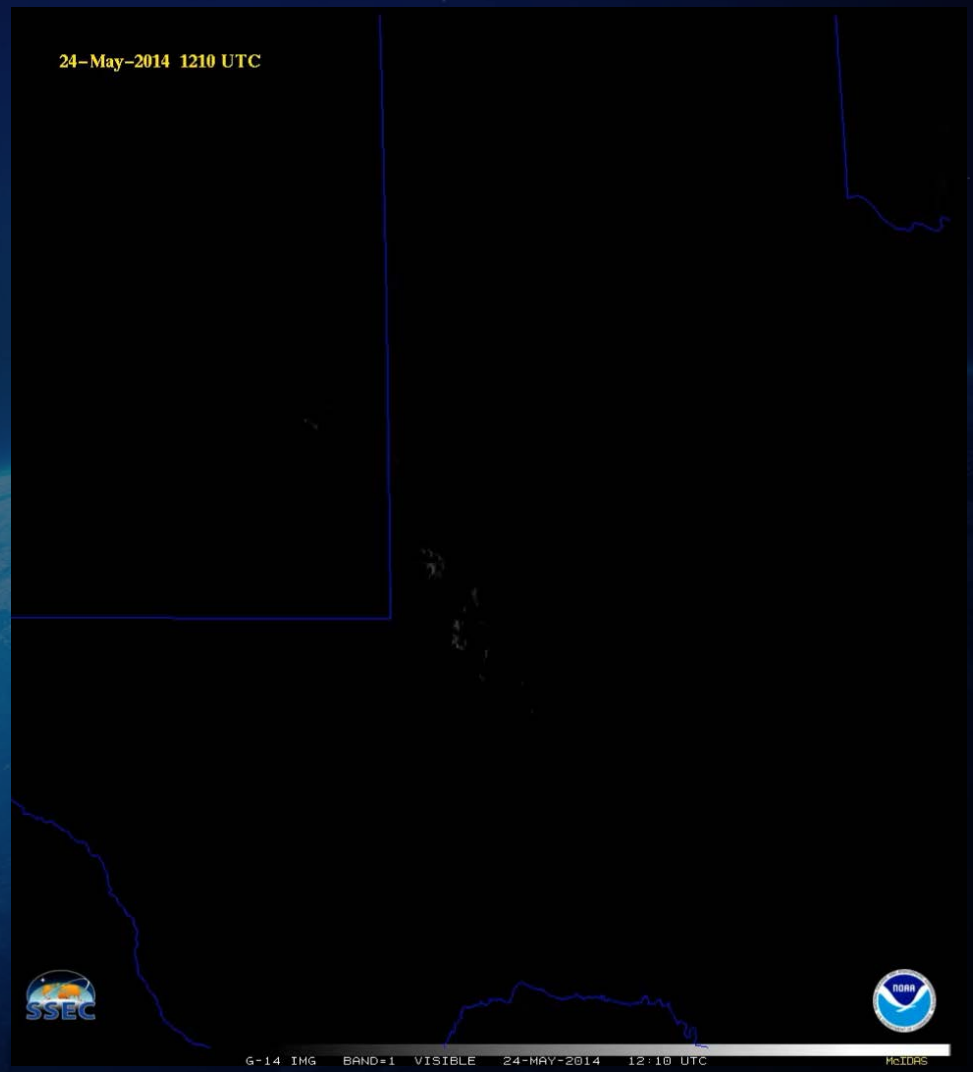
GOES-R

5 minute Capability

Five Times Faster Coverage







- Scan Mode 4- Full disk every 5 minutes
- Scan Mode 3- Full disk images every 15 minutes + 5 min CONUS images + 30 sec mesoscale.

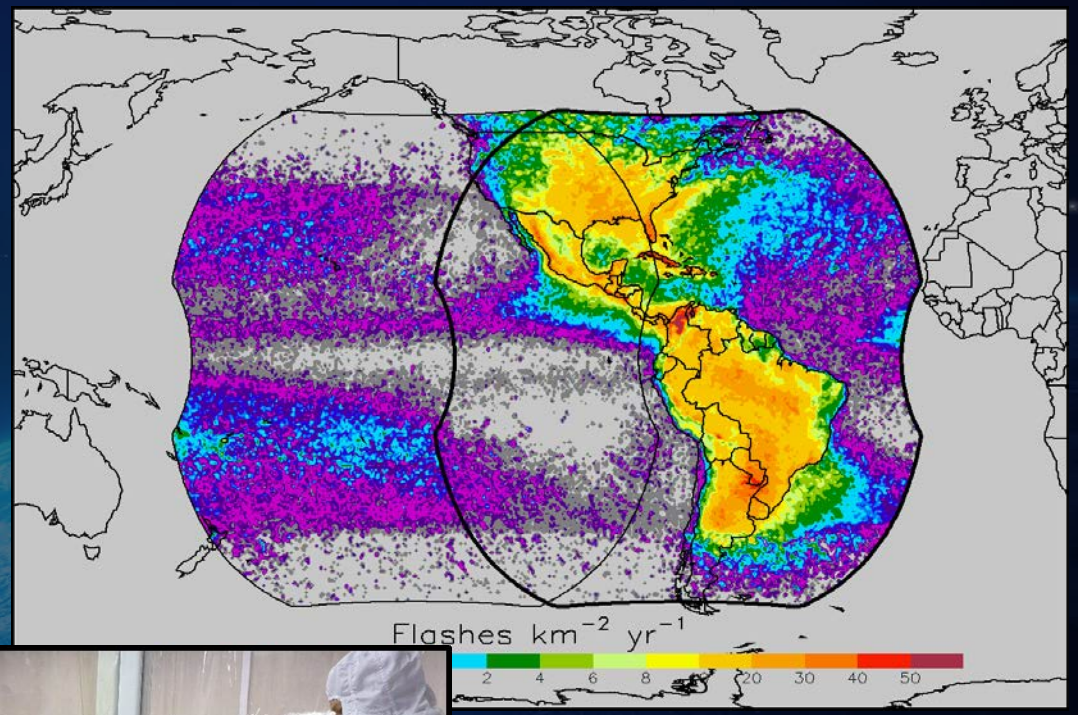
Forecasters can monitor the interactions between air masses, outflow boundaries and storms leading to increased situational awareness and confidence

Geostationary Lightning Mapper (GLM)

Specifications

- Detects <u>total lightning</u> activity across the Western Hemisphere: in cloud, cloud-to-cloud, and cloud-to-ground
  - — Provides coverage over oceans and land
  - – Currently no ocean coverage, and limited land coverage in dead zones
  - – Complements today's land based systems that only measures cloud to ground (~15% of the total lightning)

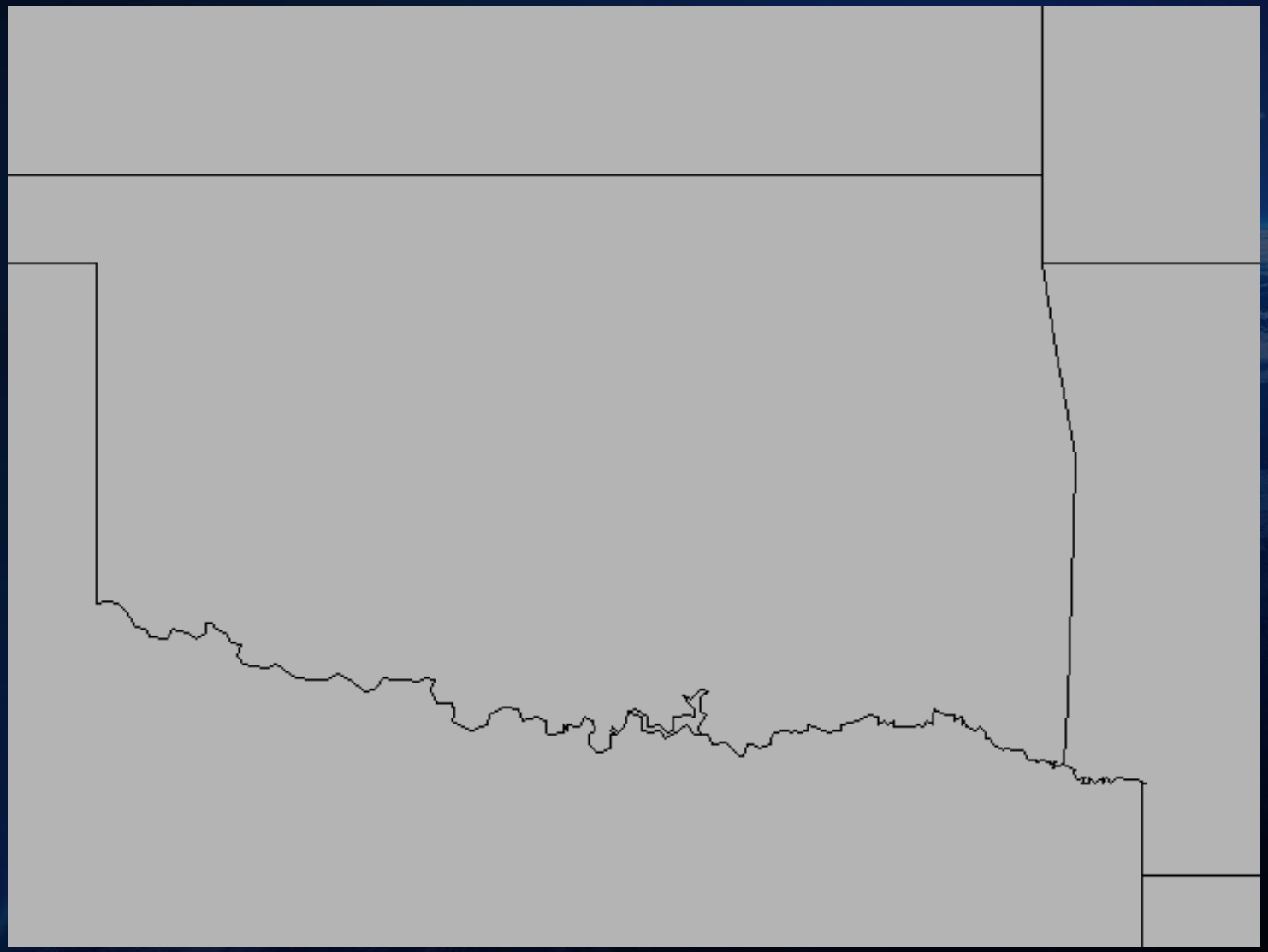
- Improved forecaster situational awareness and confidence resulting in more accurate severe storm warnings (improved lead time, reduced false alarms) to save lives and property



High Speed Digital Video
Lightning Flash 7500 fps

Total Lightning Detection

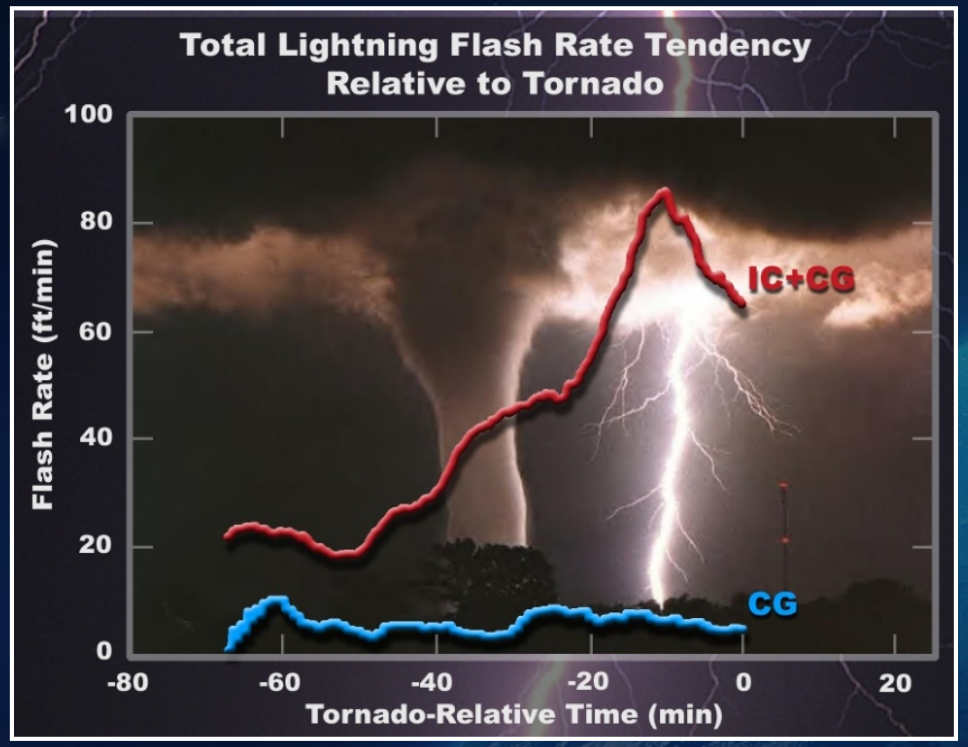
1-min TRMM/LIS overpass, May 3, 1999 tornado outbreak



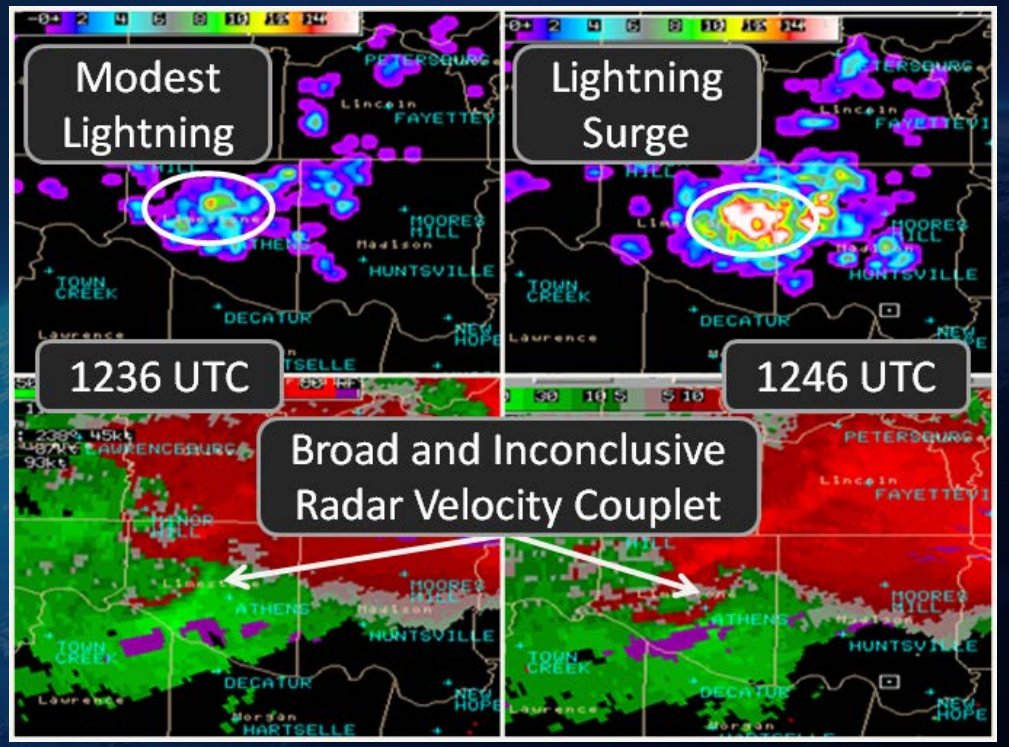
Lightning Jumps and Severe Storms

Improved forecaster situational awareness and confidence results in more accurate severe storm warnings (i.e., improved lead times and reduced false alarms)

Current national average for tornado warning lead-time is ~13 minutes

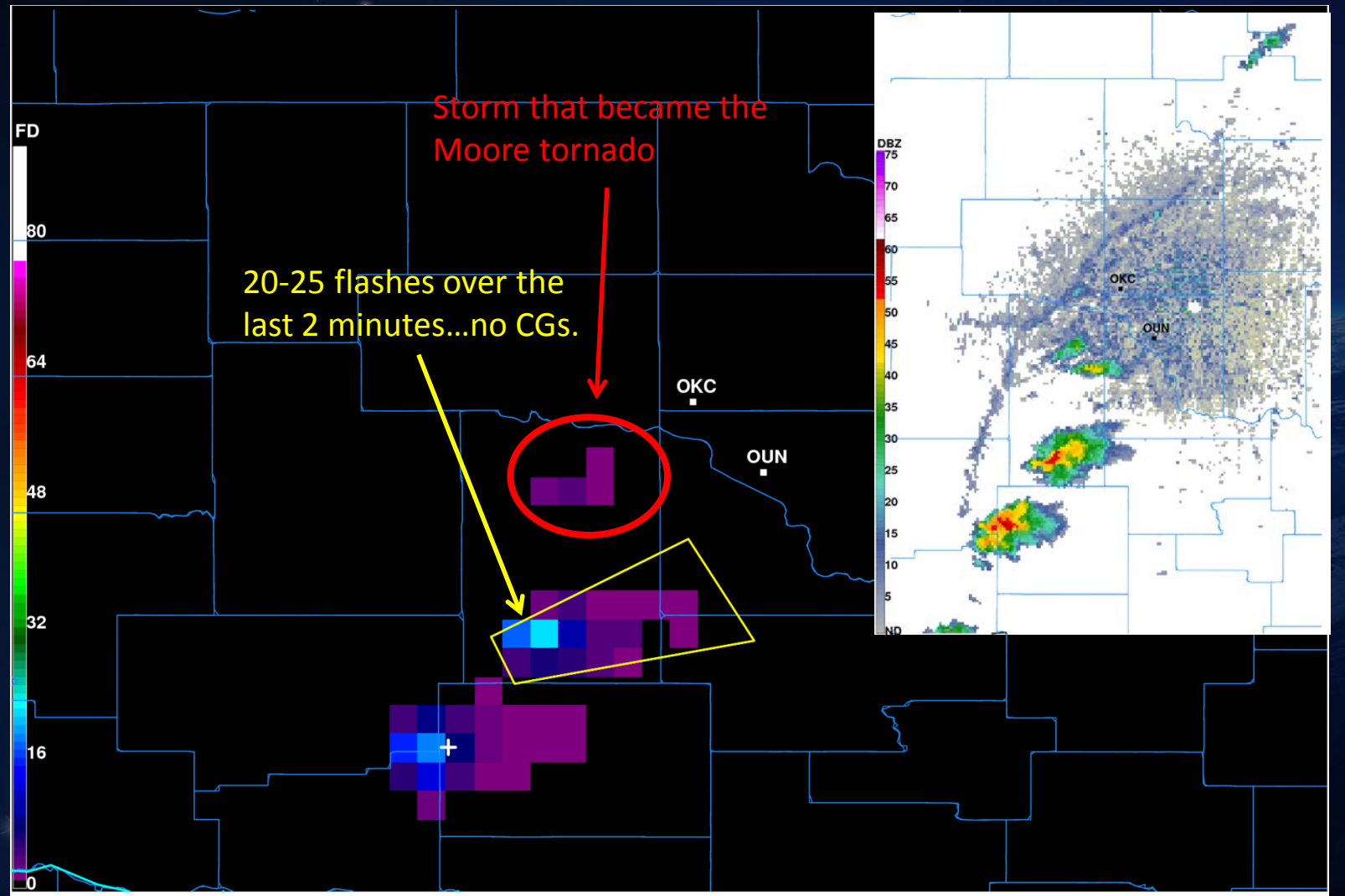


Lightning flash rate increase can be a predictor of tornado formation



Total lightning (Upper) from the North Alabama Lightning Mapping Array (LMA) coincident with NEXRAD radar-derived storm relative velocity (Lower) at 1236 (Left) and 1246 (Right) UTC on 6 May 2003. dar alone. Image courtesy of Geoffrey Stano and SPoRT.

Real-Time Mapping of Total Lightning Activity



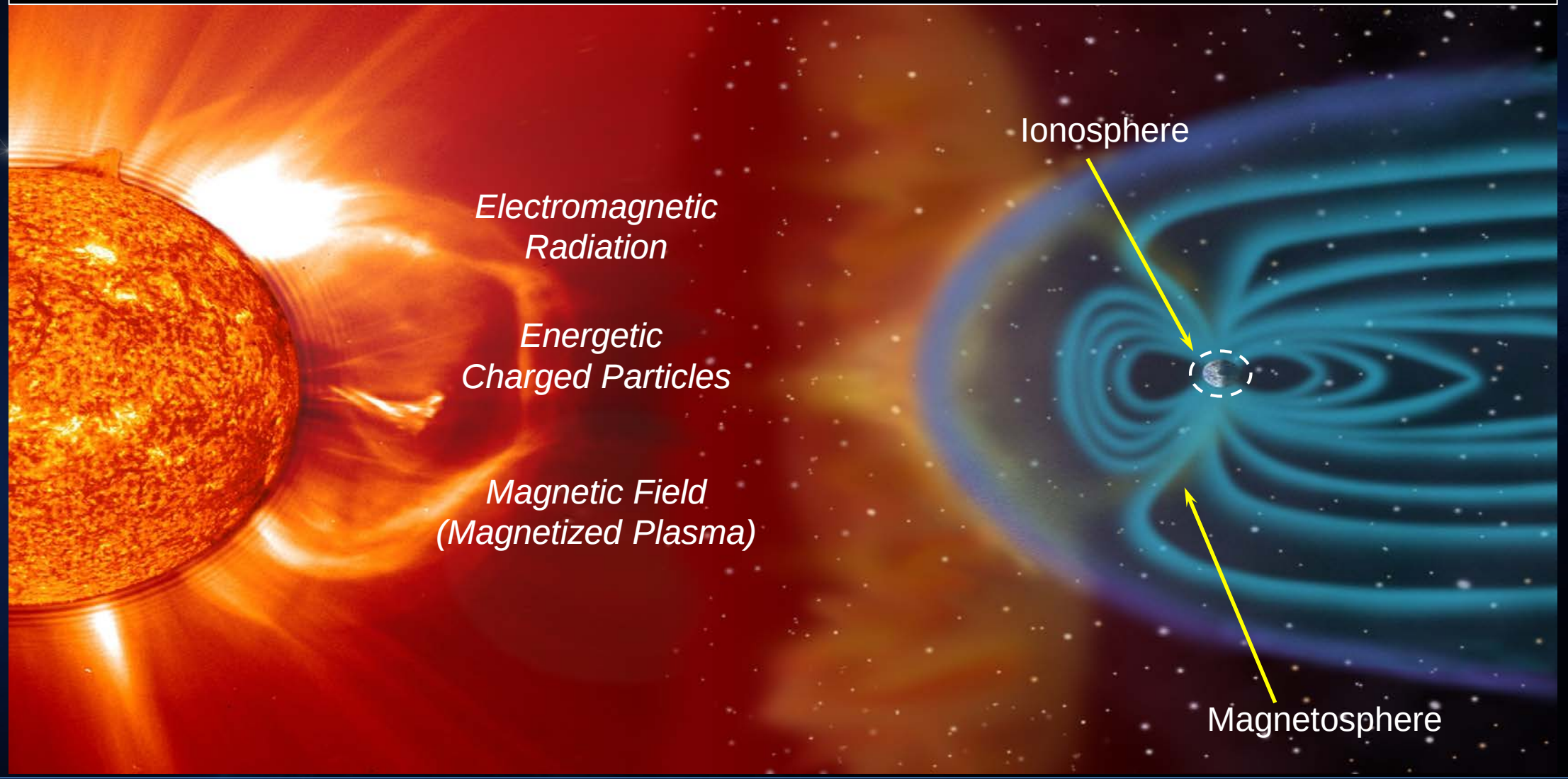
GOES-R Pseudo GLM Flash Extent Density and 2-min NLDN CG valid 20 May 2013 at 1900 UTC
TLX 1km Base Reflectivity valid 20 May 2013 at 1900 UTC

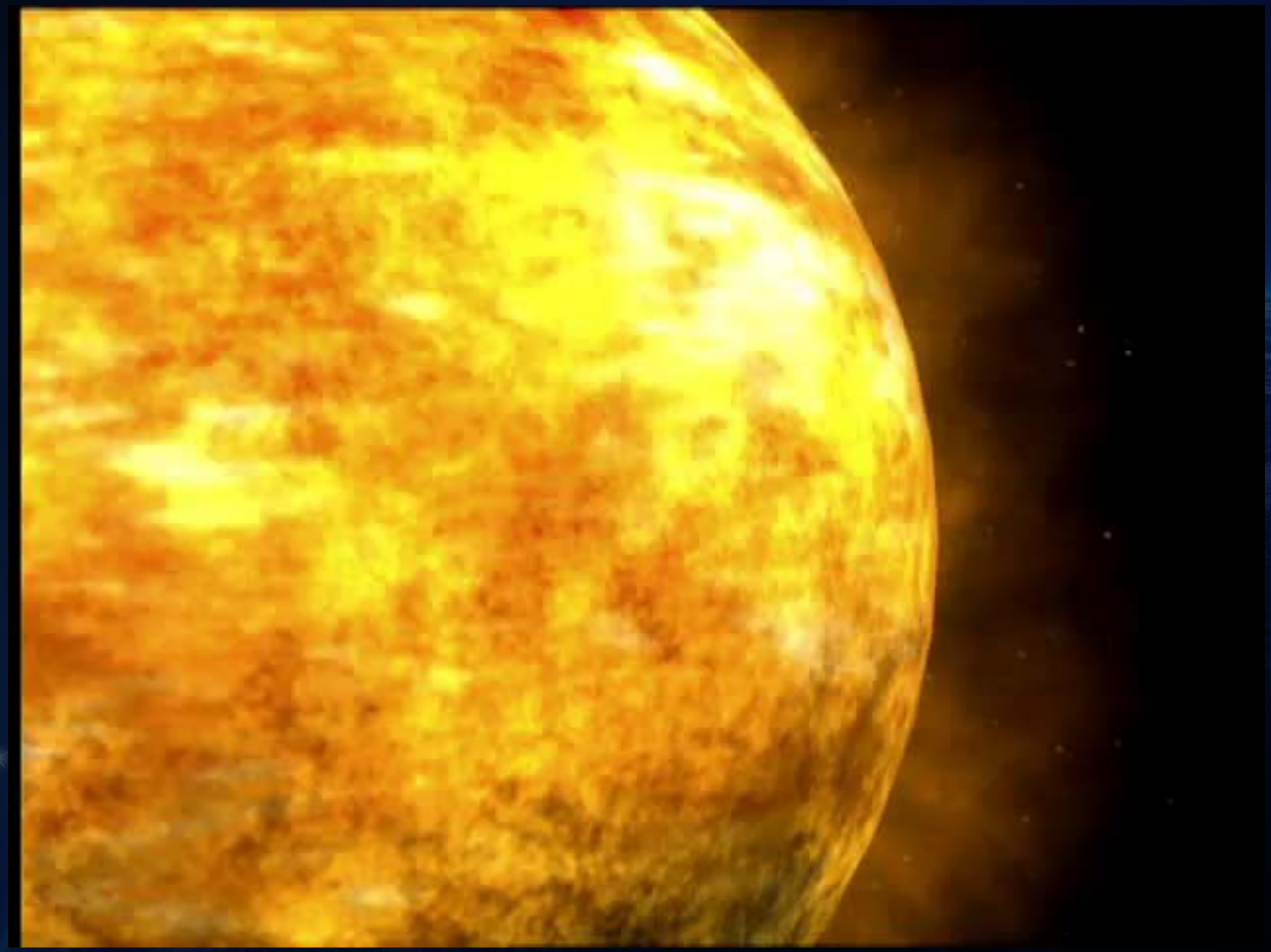
Moore, OK tornado
May 2013

Total lightning [Cloud-to-Ground (CG), Cloud-to-Air (CA), In-Cloud (IC), Cloud-to-Cloud (CC)] provides a better indication of the electrification of developing convection than CGs alone.

What is Space Weather?

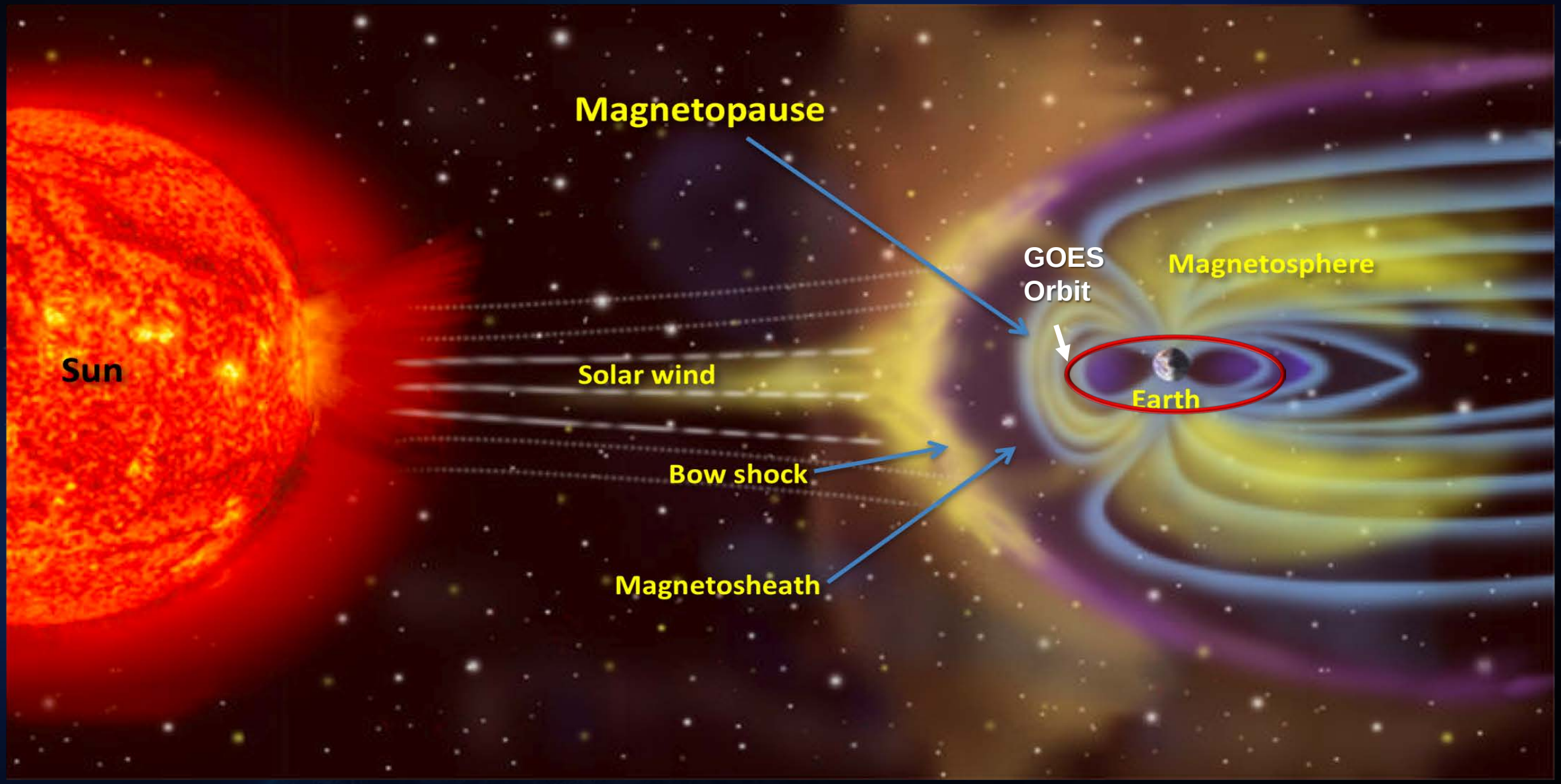
Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space and ground based technological systems, as well as endanger life or health.





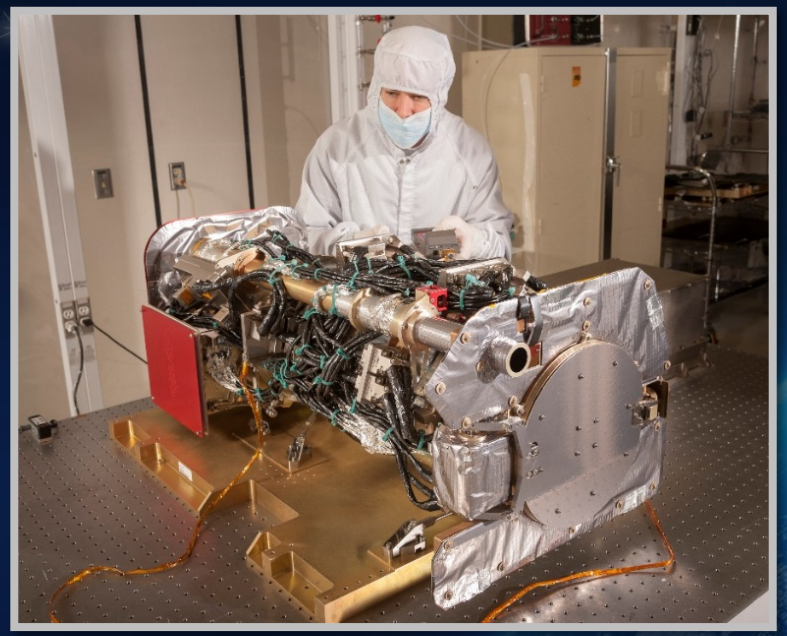
NASA Goddard Space Flight Center
Conceptual Image Lab

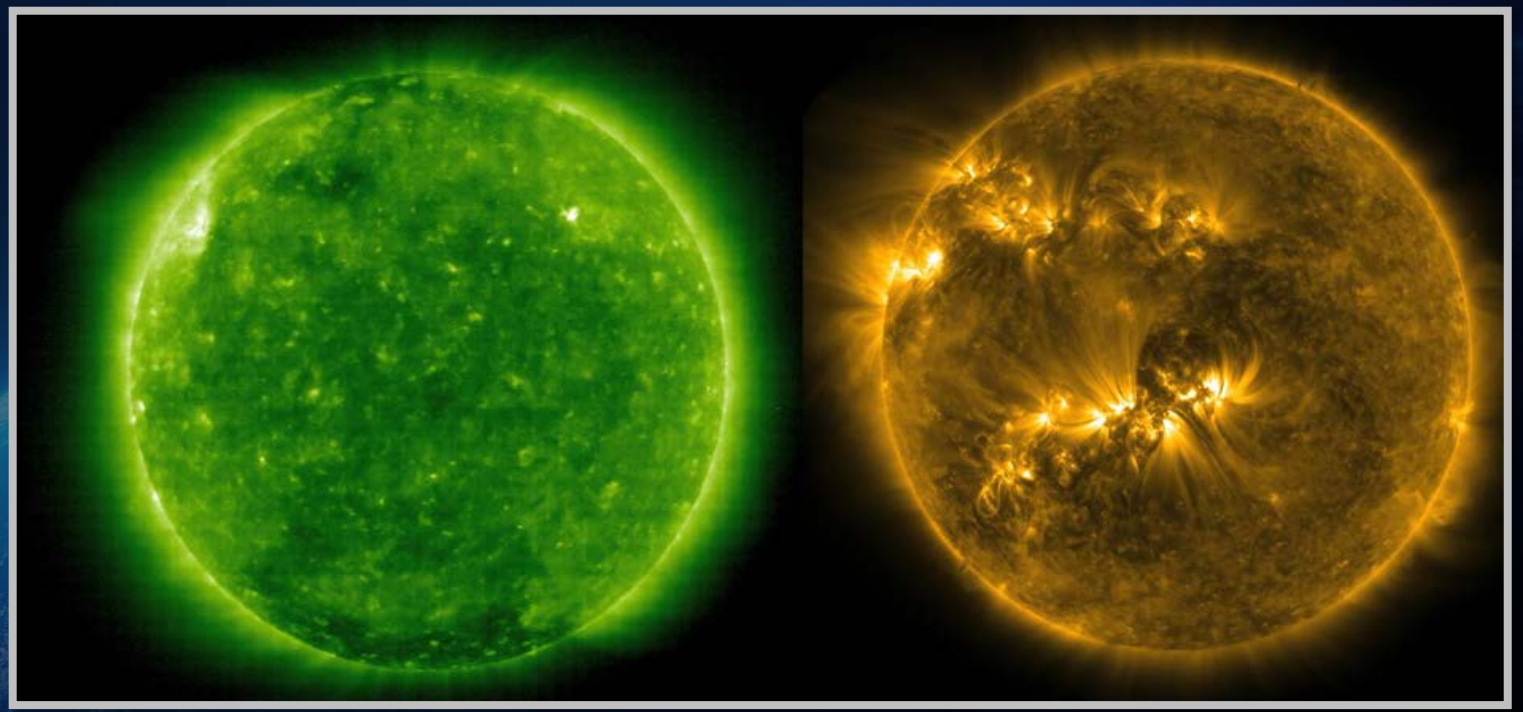
Living with a star can be dangerous!



Solar Ultra-Violet Imager (SUVI)

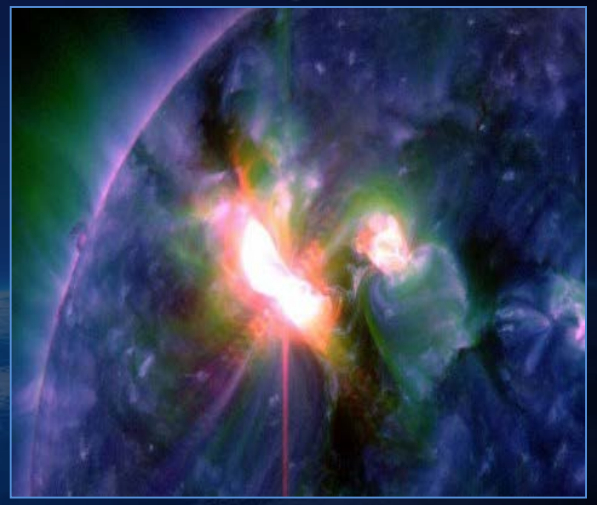
- Improved detection of coronal holes, flares and coronal mass ejection source regions
- Improved geomagnetic storm forecasting
- Increased dynamic range, resolution, and sensitivity in monitoring solar x-ray flux



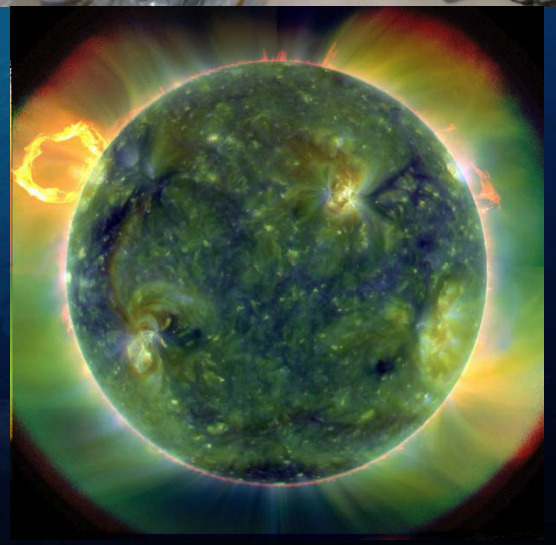


Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS)

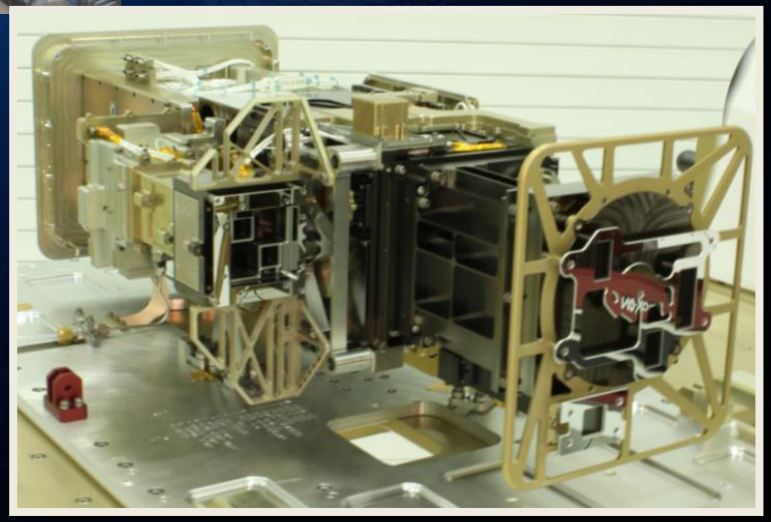
- EXIS has two sensors to measure solar radiation:
  - Extreme Ultraviolet Sensor (EUVS): monitors solar variations that affect satellite drag, and ionospheric changes impacting communication and navigation operations
  - X-Ray Sensor (XRS): detects the beginning, duration, and magnitude of solar X-ray flares
- EXIS provides improved solar flare warnings for communications and navigation disruption
- Provides input to models predicting severe impacts on satellites, astronauts, and airline passengers on polar routes, and provides input on possible impacts to power grid performance



Solar Flare

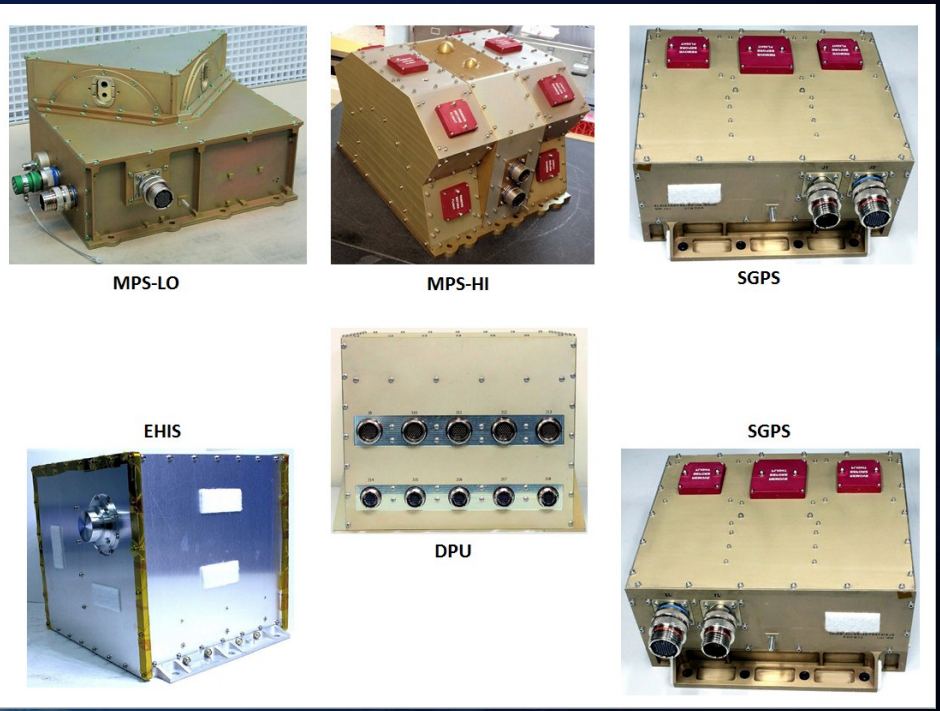


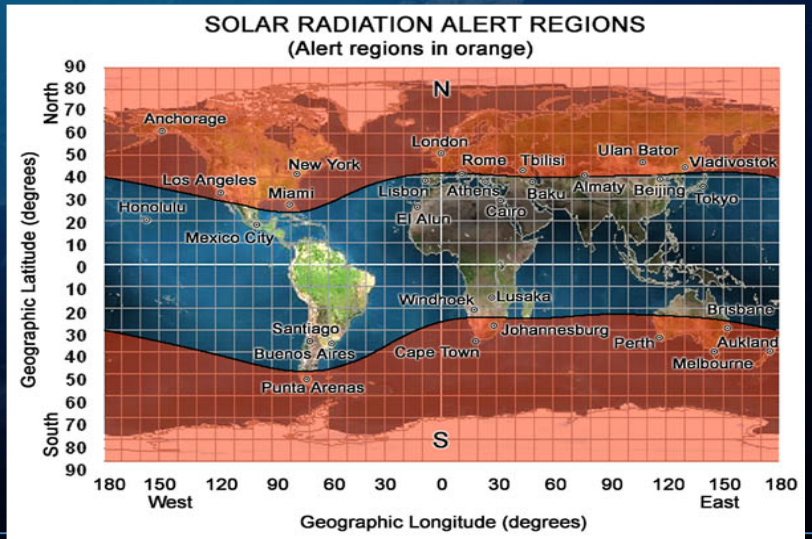
EUV Composite Solar Image



Space Environment in-Situ Sensor Suite (SEISS)

- SEISS consists of energetic particle sensors to monitor proton, electron and alpha particle fluxes to provide:
  - More accurate monitoring of energetic particles responsible for radiation hazards to humans and spacecraft
  - Better monitoring of low energy ionizing responsible for spacecraft charging
  - Improved warning of high flux events, mitigating damage to radio communication





Magnetometer

- The magnetometer measures the magnitude and direction of Earth's ambient magnetic field
- Will provide the only operational measure of the impact of geomagnetic storms at geosynchronous orbit (key for interpreting solar radiation storm measurements by SEISS)
- Provides automated Magnetopause Crossing Detection and automated Sudden Impulse Detection

Magnetometer Installation

Magnetometer Sensor

Magnetometer Boom

GOES-R Unique Payload Services

- **Search and Rescue Satellite Aided Tracking (SARSAT)**
  - All GOES-R satellites support the SARSAT system by relaying distress signals from 406 MHz emergency beacons
- **Information Network (HRIT/EMWIN)**
  - High Rate Information Transmission and Emergency Managers Weather Information Network services
  - Delivers selected imagery, charts, data products, and text messages (NWS Watches and Warnings) to users throughout western hemisphere.
- **Data Collection System (DCS)**
  - Relays data transmissions from over 20,000 in situ environmental data platforms from across the hemisphere
- **GOES-R Rebroadcast (GRB)**
  - Data from each of the GOES-R series instruments is processed on the ground, then bounced back through GOES-R satellites to users throughout the hemisphere.

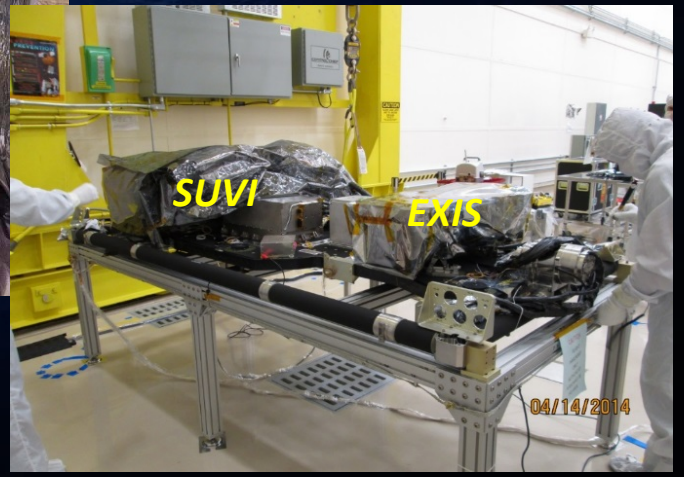
Emergency Beacons

Remote Automated Weather Stations transmitting to GOES

GOES- R Flight Segment Progress

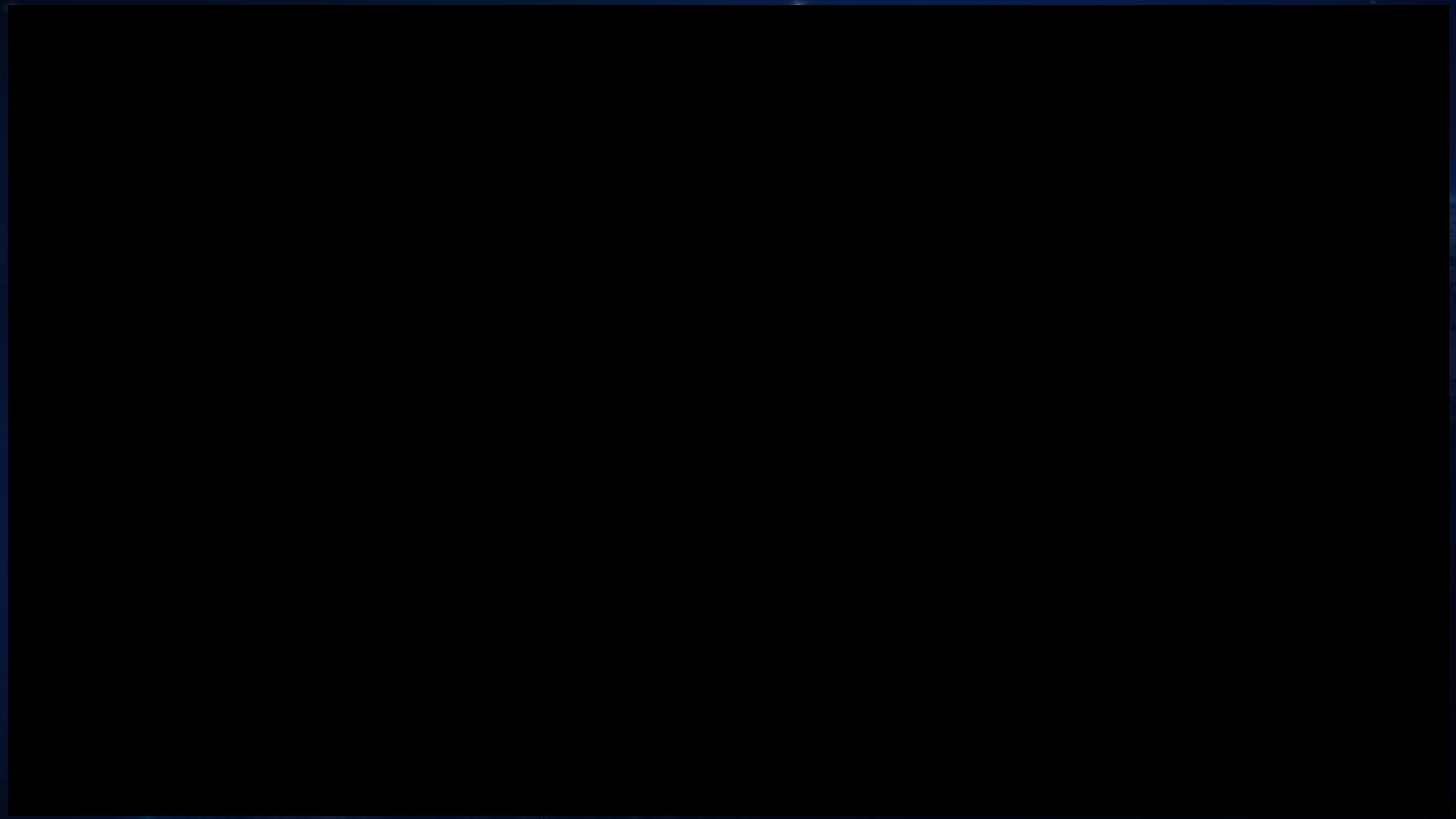
Completed “mate” of spacecraft system and core modules

All GOES-R instruments integrated with spacecraft



Solar Array delivered

GOES-R Spacecraft Mate Time-Lapse Video



Assembled GOES-R Spacecraft

GOES-R Facilities

NOAA Satellite Operations Facility (NSOF)
Suitland, Maryland

- Command and Control
- Archive
- Ancillary Data Relay System
- L2+ data processing

Wallops Command & Data Acquisition Station (WCDAS), Wallops, VA

- Telemetry, Tracking, and Command
- Command and Control
- GOES-R Rebroadcast (GRB) production and broadcast
- Select backup L2+ data processing

Consolidated Backup (CBU) Fairmont, WV

- Telemetry, Tracking, and Command
- Backup Command/Control
- GRB production and broadcast

GOES-R Ground Segment Progress

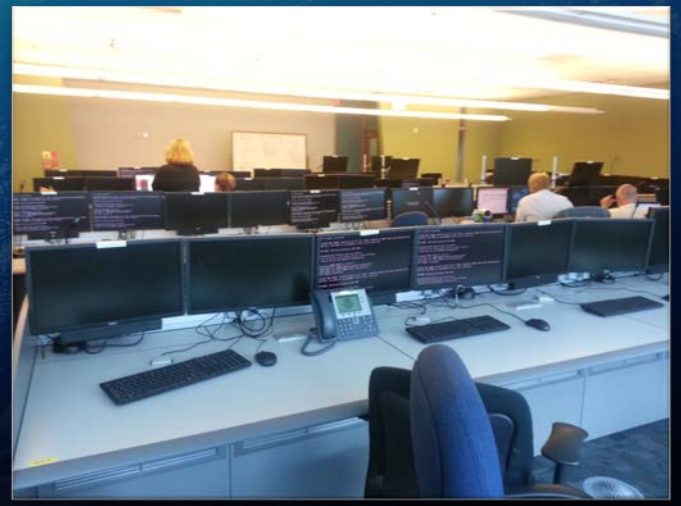
RMMU Installation at NSOF

W-1 antenna at WCDAS

EI Installation at CBU

N-1 antenna at NSOF

MMFR at CBU



CBU Antenna Stations

GOES-R Series Products

L1b Products →

L2+ Products are remainder outside of oval

Radiances*	Cloud and Moisture Imagery (KPP)
Solar Imagery: EUV*	Rainfall Rate / QPE
Energetic Heavy Ions*	Legacy Vertical Moisture Profile
Magnetospheric Electrons and Protons: Low Energy*	Legacy Vertical Temperature Profile
Magnetospheric Electrons and Protons: Medium and High Energy*	Derived Stability Indices
Solar and Galactic Protons*	Total Precipitable Water
Geomagnetic Field*	Clear Sky Masks
Solar Flux: EUV*	Downward Shortwave Rad.: Surface
Solar Flux: X-Ray*	Fire / Hot Spot Characterization
Lightning Det: Events, Groups, Flashes*	Land Surface (Skin) Temperature
Aerosol Detection (including Smoke & Dust)	Sea Surface Temperature (skin)
Aerosol Optical Depth	Reflected Shortwave Rad.: TOA
Volcanic Ash: Detection & Height	Snow Cover
Cloud Optical Depth	Derived Motion Winds
Cloud Particle Size Distribution	Hurricane Intensity
Cloud Top Phase	Cloud Top Pressure
Cloud Top Height	Cloud Top Temperature

← Key Performance Parameter (KPP)

ABI	GLM
SEISS	EXIS
SUVI	Magnetometer

*** Included in GRB**

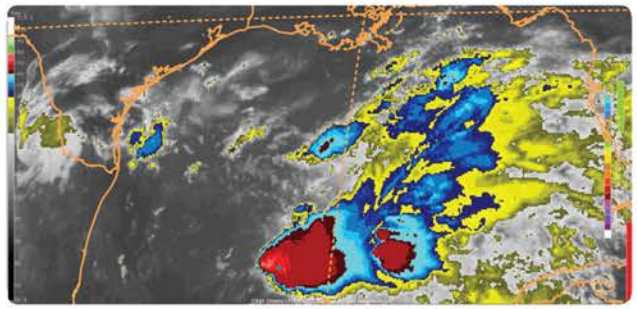
GOES-R Satellite Proving Ground

Making GOES-R test products available to forecasters, GOES-R level 2 products for research

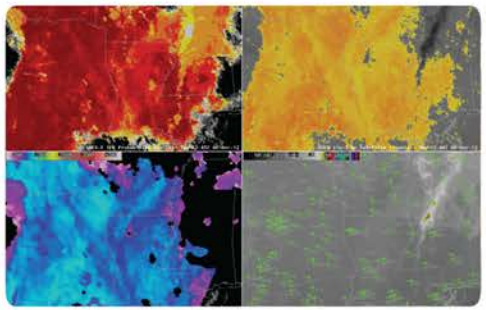
- Satellite liaisons (subject matter experts) at NWS National Centers
- Develop training for users
- Several GOES-R level 2 products are demonstrated in the GOES-R Proving Ground
- Examples can be found on the PG blogs and through the website www.goes-r.gov
- International projects
- Visiting Scientist Program

NOAA Hazardous Weather Testbed (HWT)

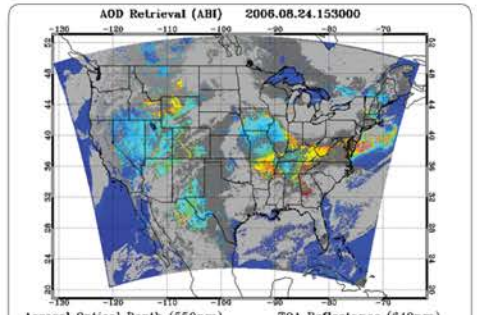
The GOES-R Proving Ground



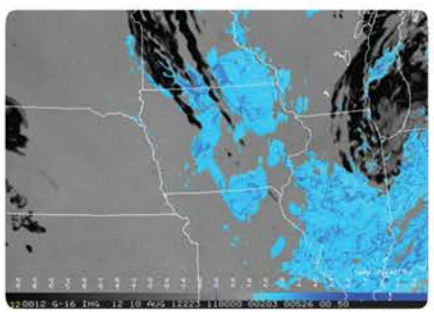
Aviation Weather Center (AWC) – Kansas City, MO
IR Imagery of Oceanic Storms



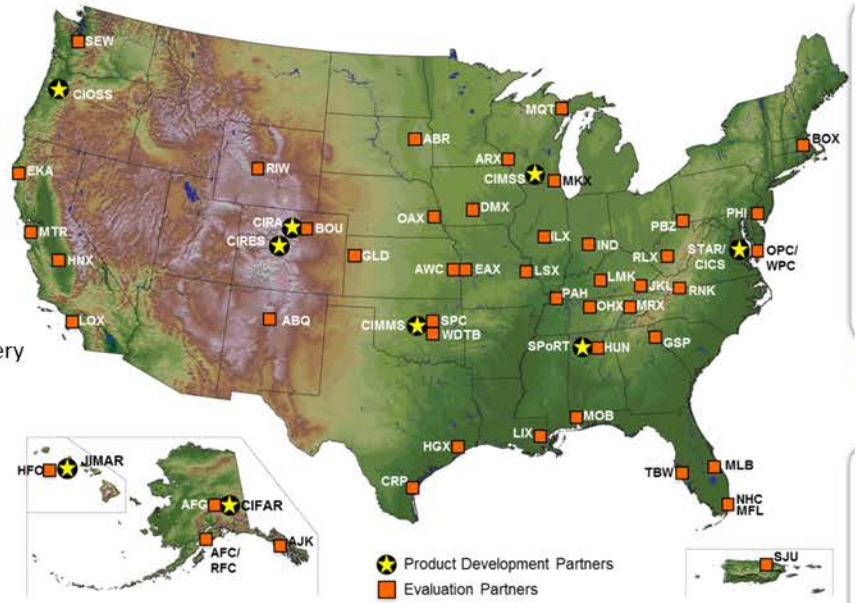
Cooperative Institute for Meteorological Satellite Studies (CIMSS)/Center for Satellite Applications and Research (STAR) – Madison, WI
Fog/Low Stratus Product

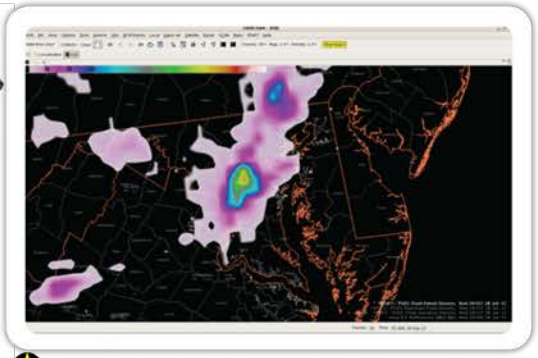


STAR/University of Maryland Baltimore County (UMBC)– College Park, MD
Aerosol Optical Depth

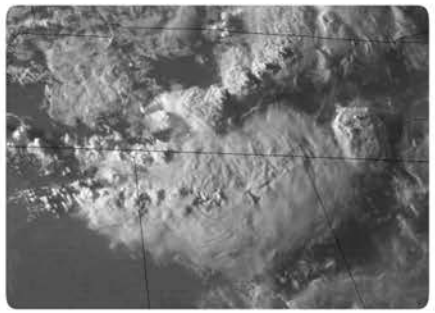


Cooperative Institute for Research in the Atmosphere (CIRA)/STAR – Ft. Collins, CO
ABI Synthetic Low Cloud Enhancement Imagery

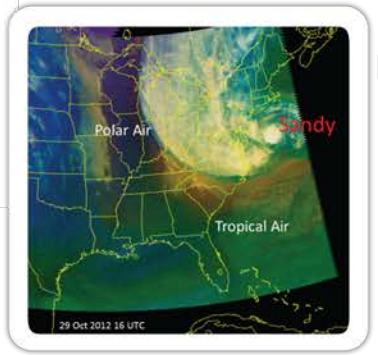




Short-term Prediction Research and Transition Center (SPoRT)/NASA – Huntsville, AL
GLM Lightning Density



Storm Prediction Center (SPC) – Norman, OK
Severe Storms 1-Min Visible Imagery of Overshooting Tops



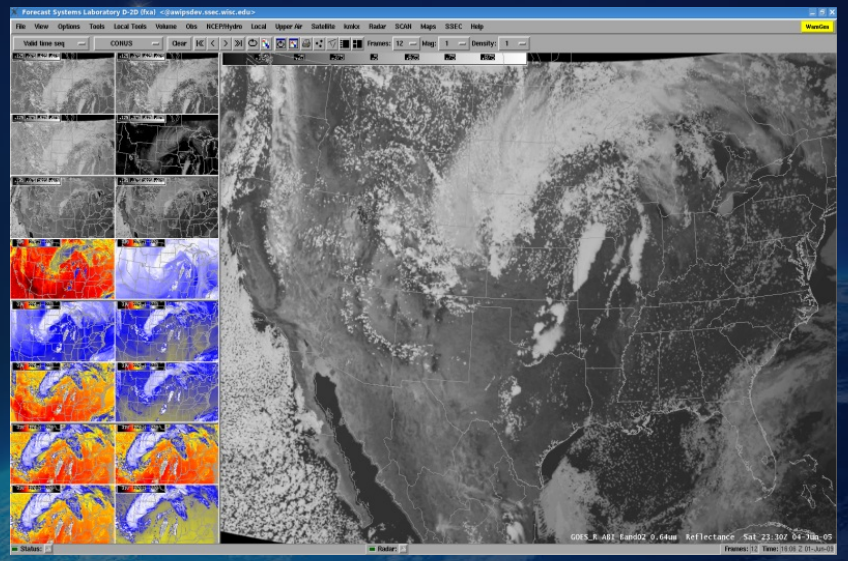
National Hurricane Center (NHC) – Miami, FL
RGB Air Mass for Hurricane Sandy

Introducing NWS Forecasters to Prototype GOES-R Products

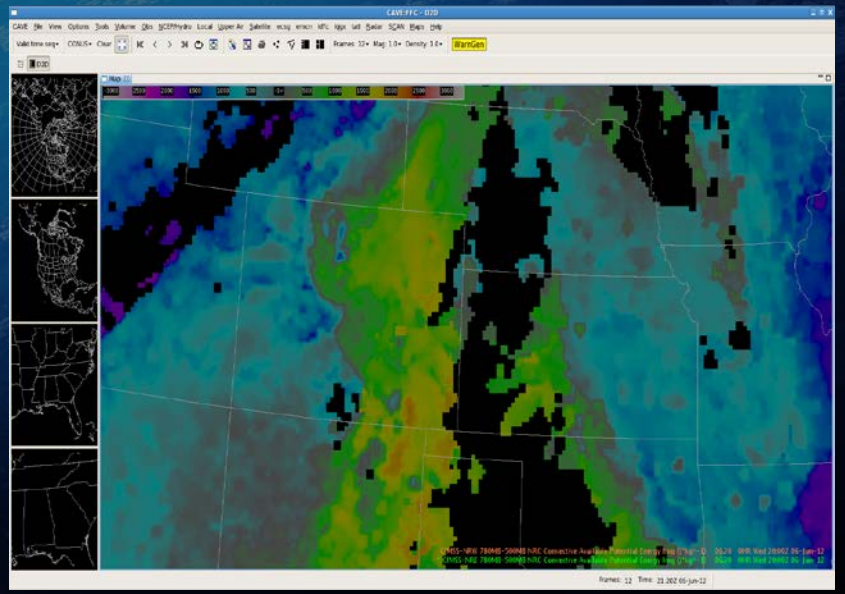
- Synthetic GOES-R products ABI products are being demonstrated at NOAA testbeds and GOES-R Proving Ground

- Synthetic GOES-R ABI products help forecaster readiness on day one

- Facilitates user training



Simulated ABI bands in AWIPS



CAPE- an example of Derived Stability Indices indicates a strong instability axis extending into the high plains east of the Rockies.

GOES-14 Super Rapid Scan Operations to Prepare for GOES-R (SRSOR)

SRSOR plans for 2015 : May 18-June 12, and August 10-22:

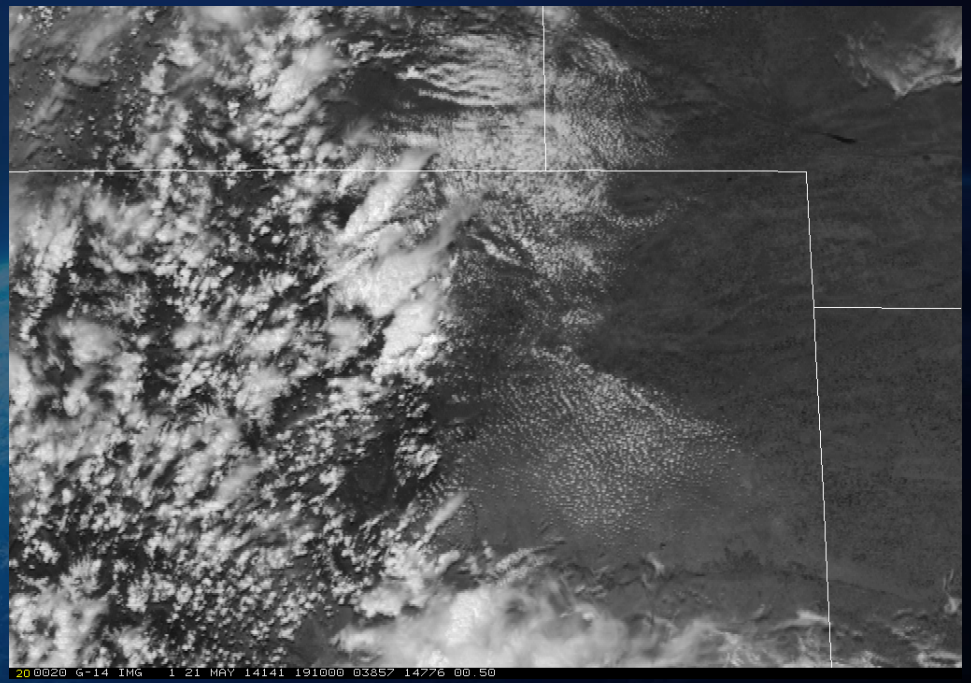
http://cimss.ssec.wisc.edu/goes/srsor2015/GOES-14_SRSOR.html

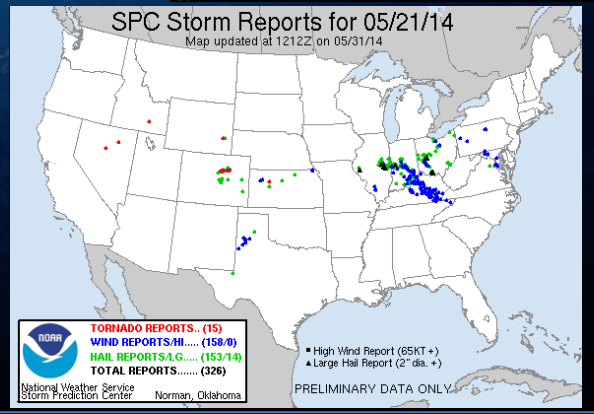
Data during parts of 2012 (Hurricane Sandy, convection), 2013 (CA Rim Fire, convection) and 2014 (Hurricane Marie, convection):

http://cimss.ssec.wisc.edu/goes/srsor/GOES-14_SRSOR.html
http://cimss.ssec.wisc.edu/goes/srsor2013/GOES-14_SRSOR.html
http://cimss.ssec.wisc.edu/goes/srsor2014/GOES-14_SRSOR.html

GOES-14 provided very unique data and offered a glimpse into the possibilities that will be provided by the ABI on GOES-R in one minute mesoscale imagery

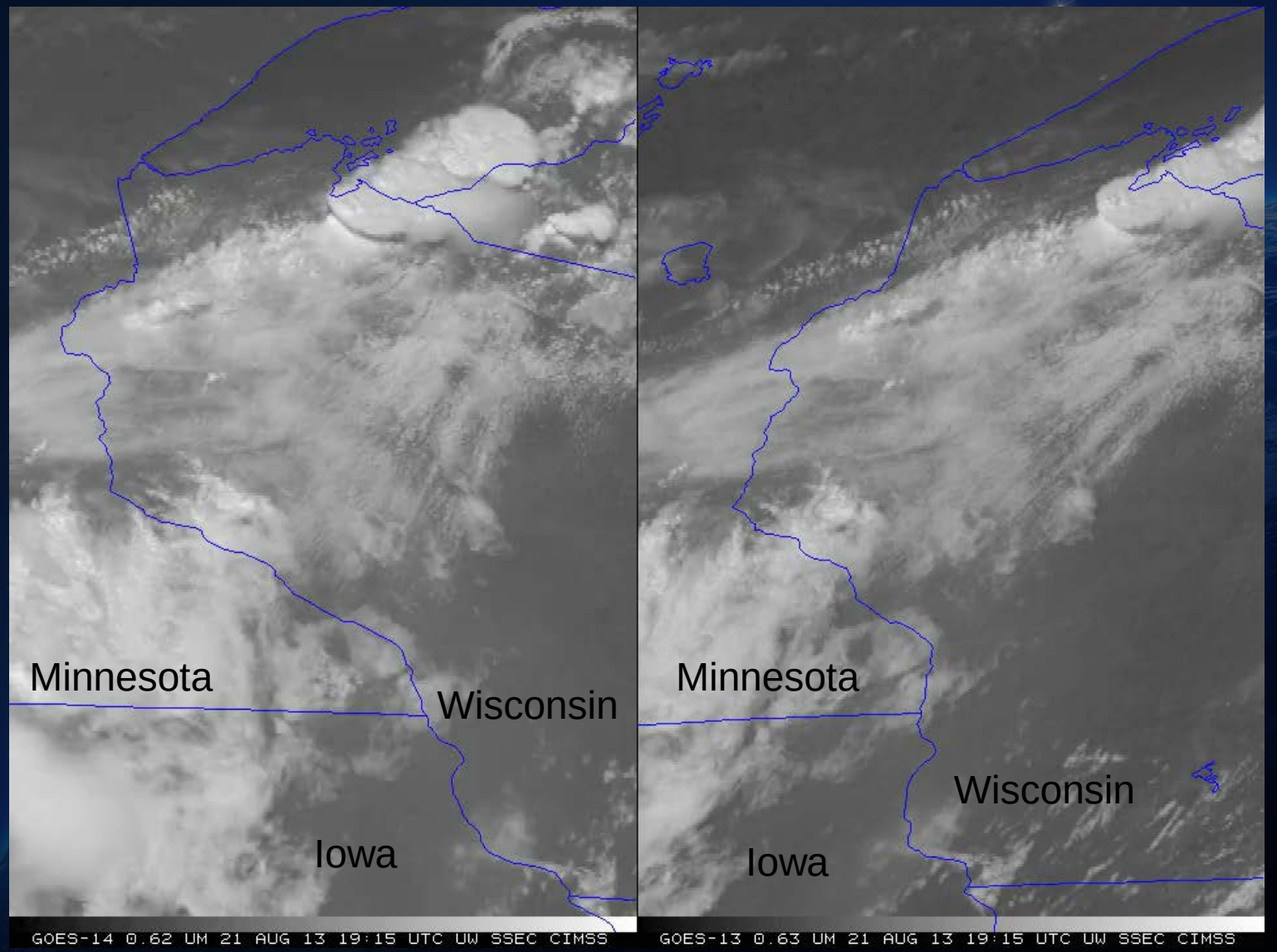
DIA Tornadic Storm



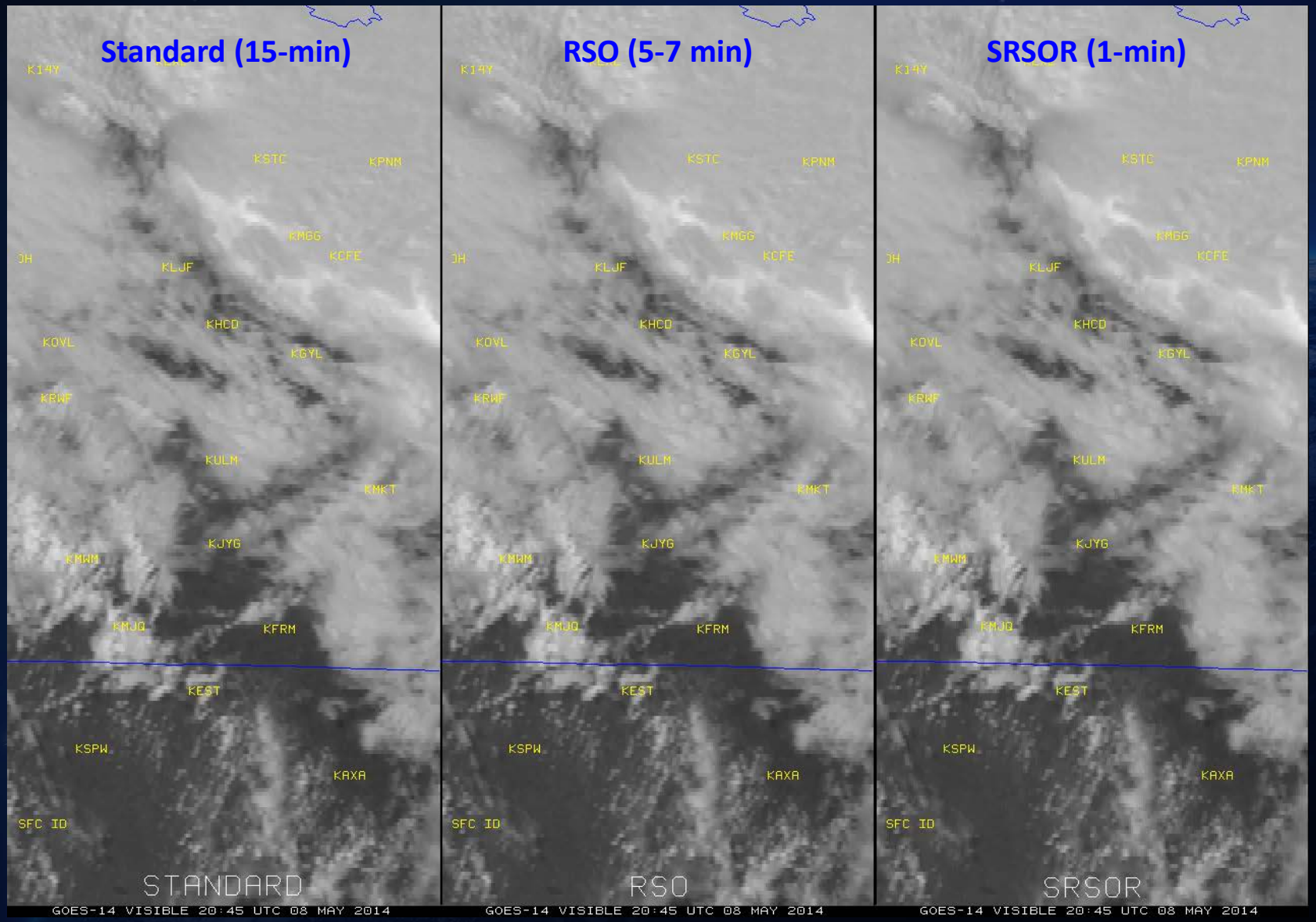


GOES-14 Rapid Scan 1-min Imagery

Future vs Current Imagery



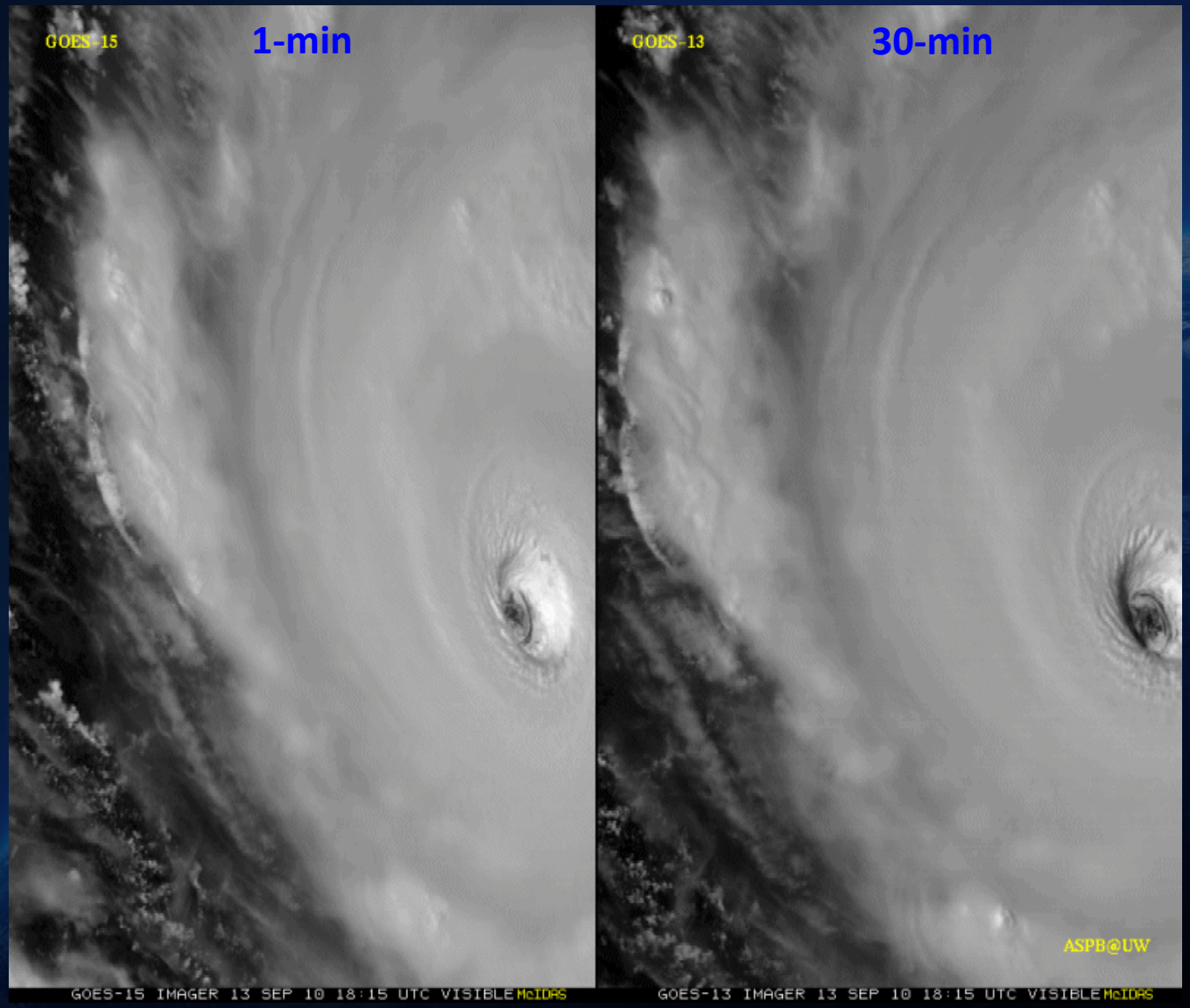
GOES-14 Rapid Scan 1-min Imagery



http://cimss.ssec.wisc.edu/goes/srsor2014/GOES-14_SRSOR.html

GOES-15 Rapid Scan 1-min Imagery

Hurricane Igor on September 13, 2010



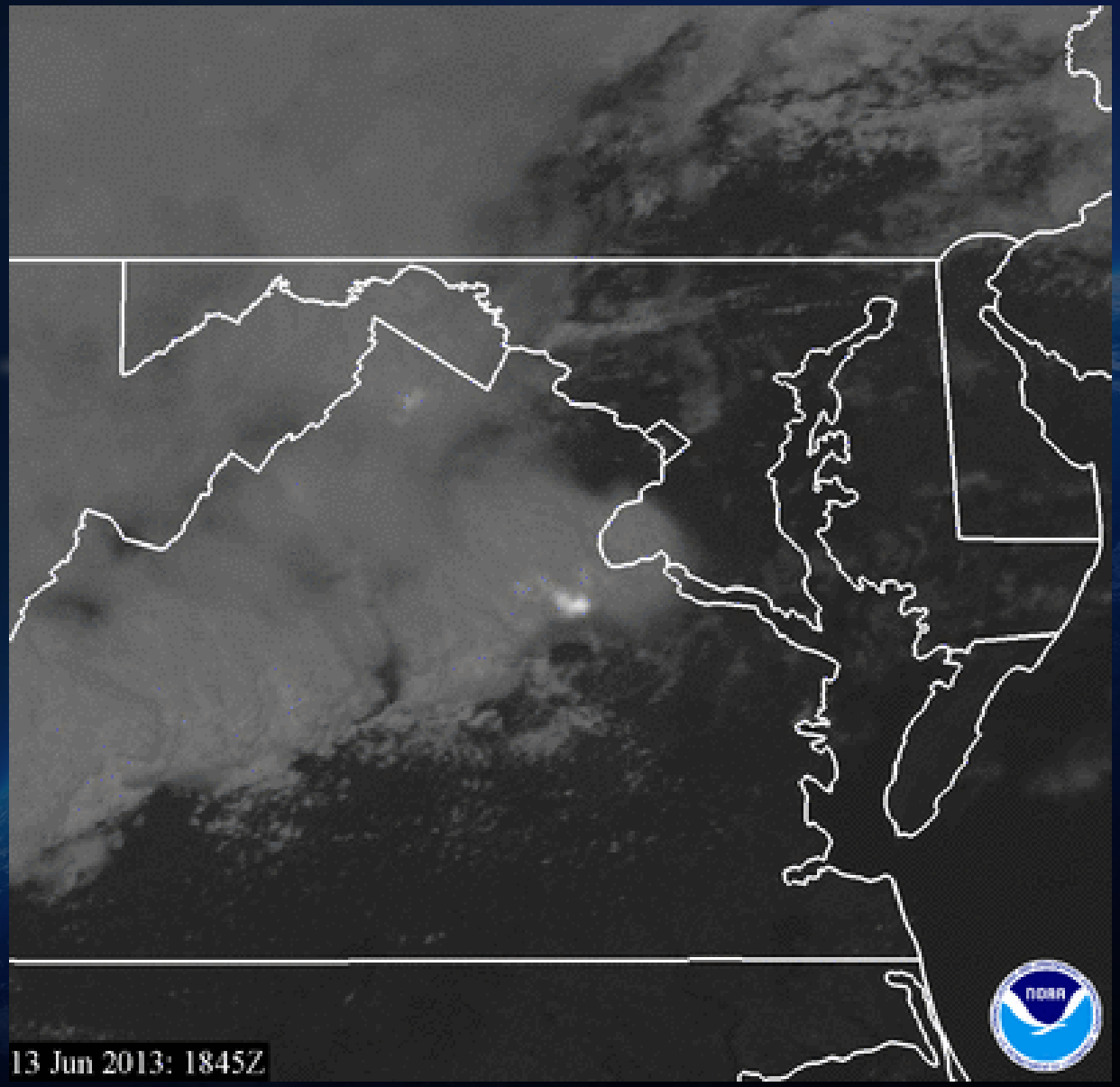
GOES-14 Rapid Scan 1-min Imagery

Hurricane Sandy over six days: October 25-31, 2012

Credit: Cooperative Institute for Meteorological Satellite Studies

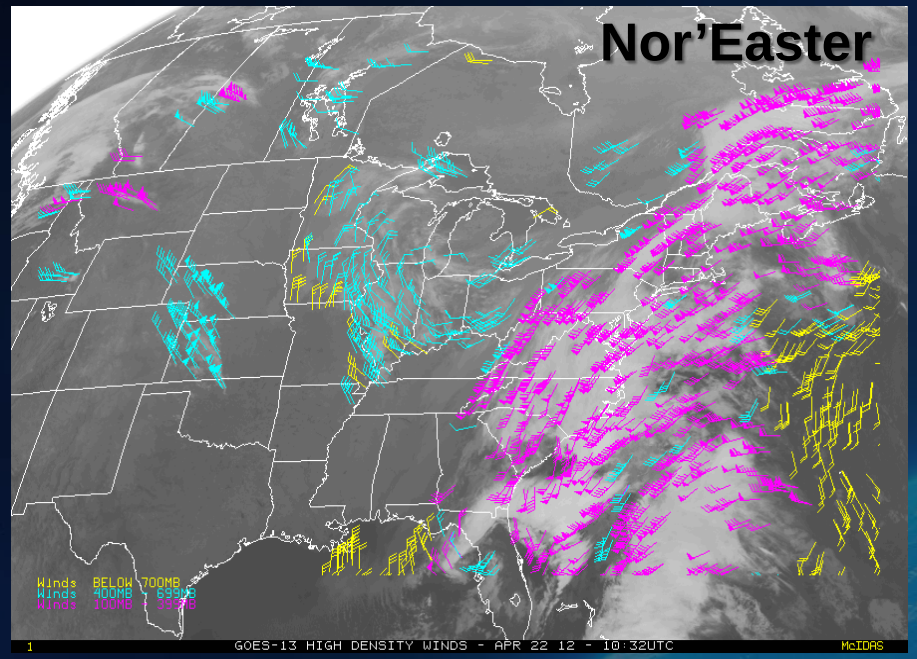
GOES-R Fusion of 1-min Imagery with Total Lightning

Derecho/Lightning/Tornado (June 13, 2013)



Courtesy of Scott Rudlosky, CICS-MD

GOES-13 Winds Using GOES-R Clear-Sky Mask, Cloud and Derived Motion Winds (DMW) Algorithms

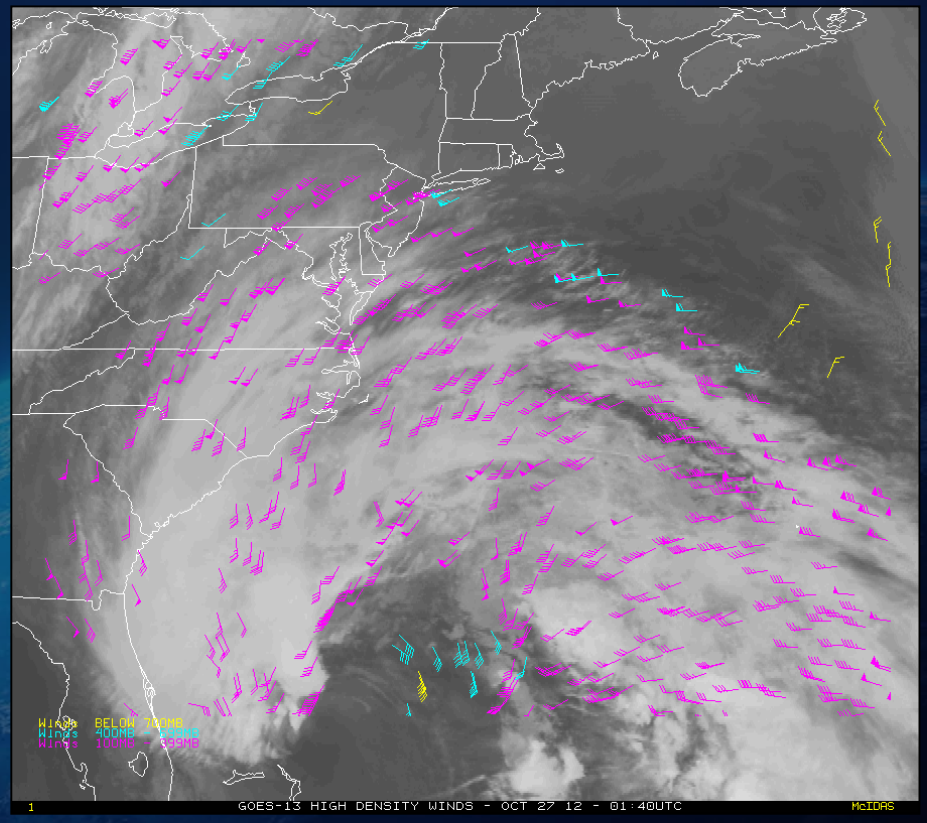


High-Level 100-400 mb Mid-Level 400-700 mb Low-Level >700 mb

Cloud-drift winds derived from 15-min GOES-13 11um imagery 1000 UTC 22 April 2012 – 0800 UTC 23 April 2012

Significance: Early demonstration of GOES-R algorithms using current operational GOES imagers. Plans and work in place to replace existing operational GOES cloud and DMW algorithms with GOES-R algorithms.

Hurricane Sandy



High-Level 100-400 mb Mid-Level 400-700 mb Low-Level >700 mb

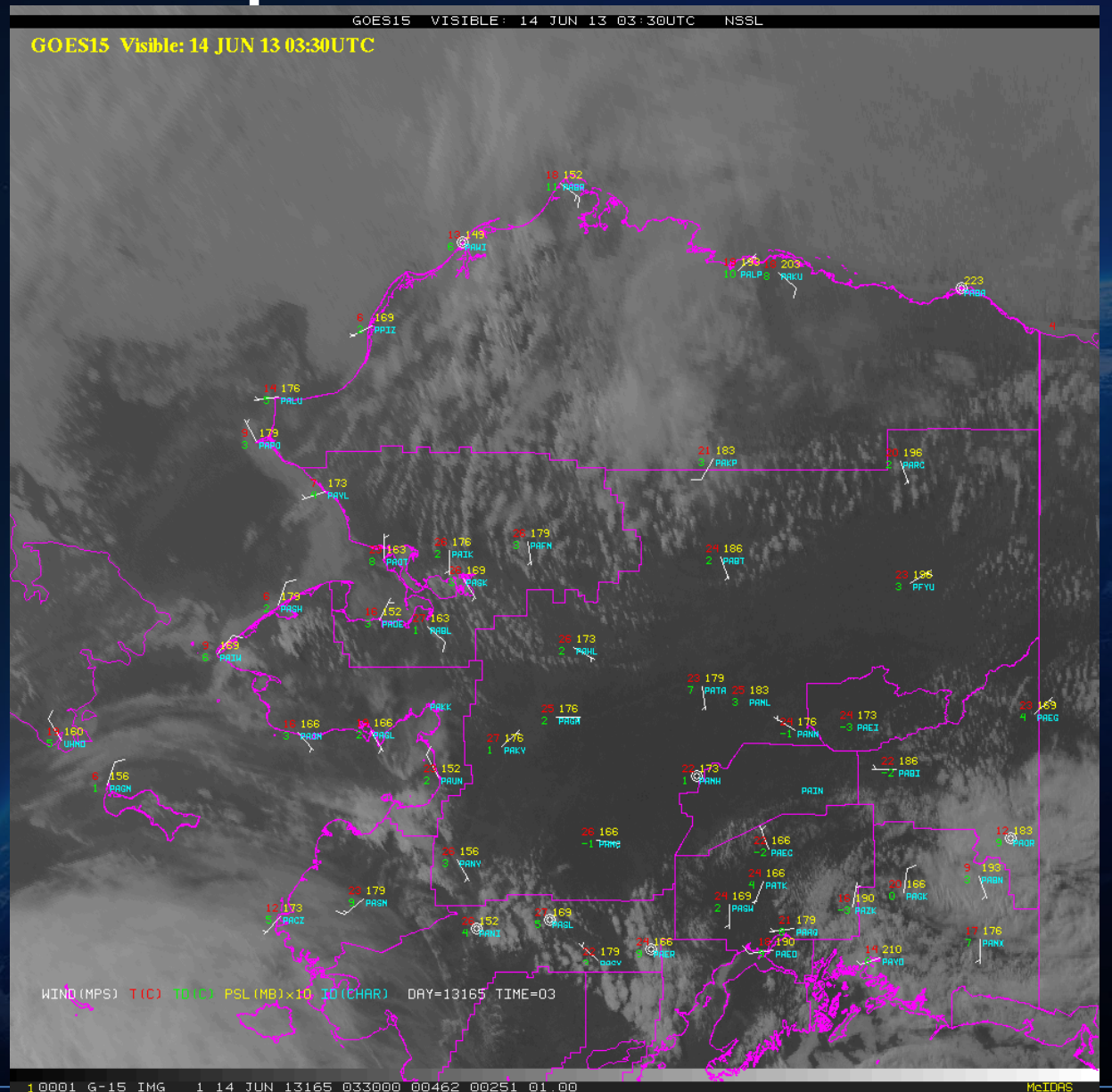
Cloud-drift winds derived from 15-minute GOES-13 LWIR (11um) imagery over Hurricane Sandy (4-day loop)

Courtesy of Chris Velden, CIMSS

Fire/Hot Spot Characterization

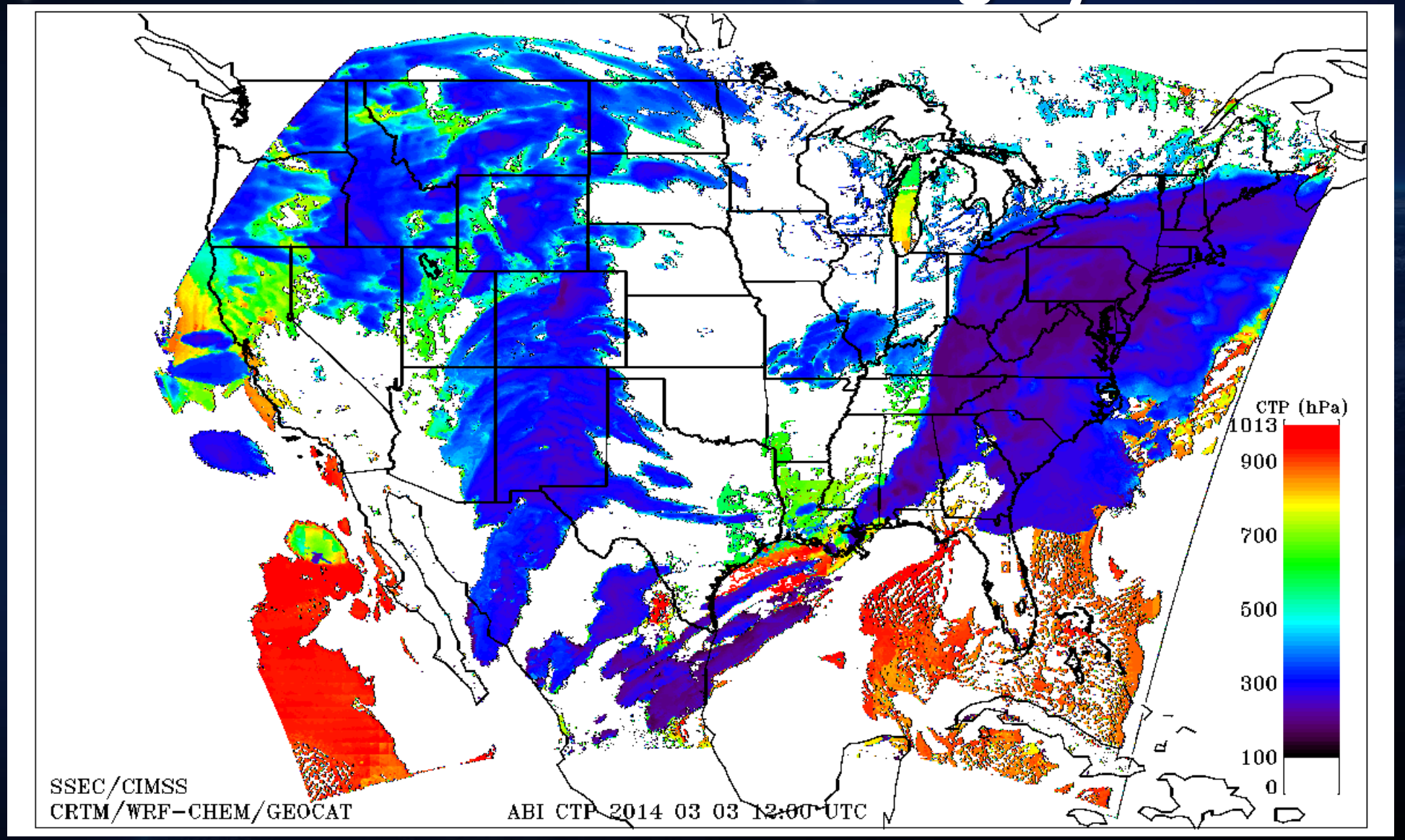
California Rim Fire, August 22, 2013

High Latitude Imagery:
North Slope of Alaska and Arctic Ocean

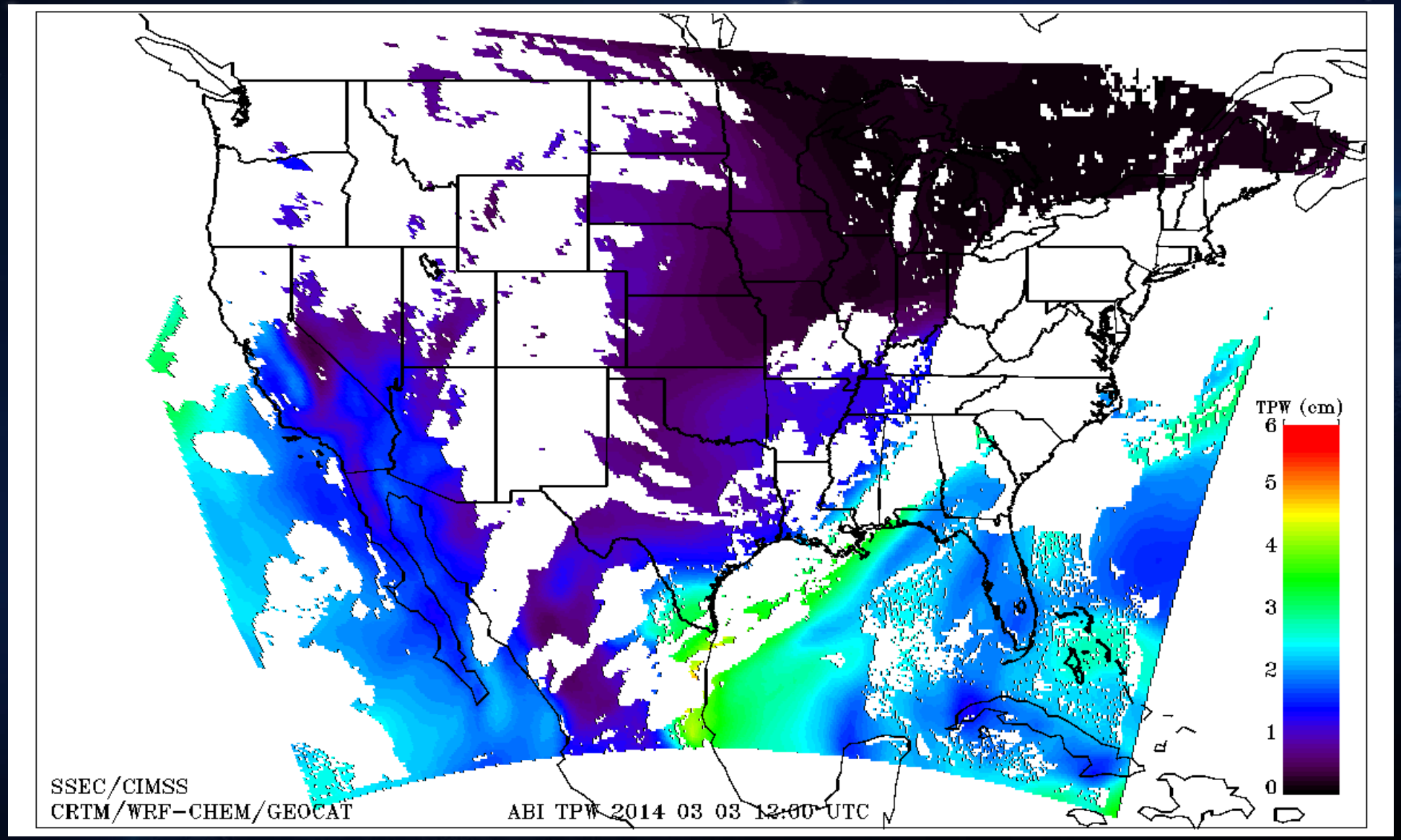


Courtesy of Robert Rabin
NOAA/NSSL

Cloud-Top Pressure Derived from Simulated ABI Imagery



Total Precipitable Water (TPW) Derived from Simulated ABI Imagery

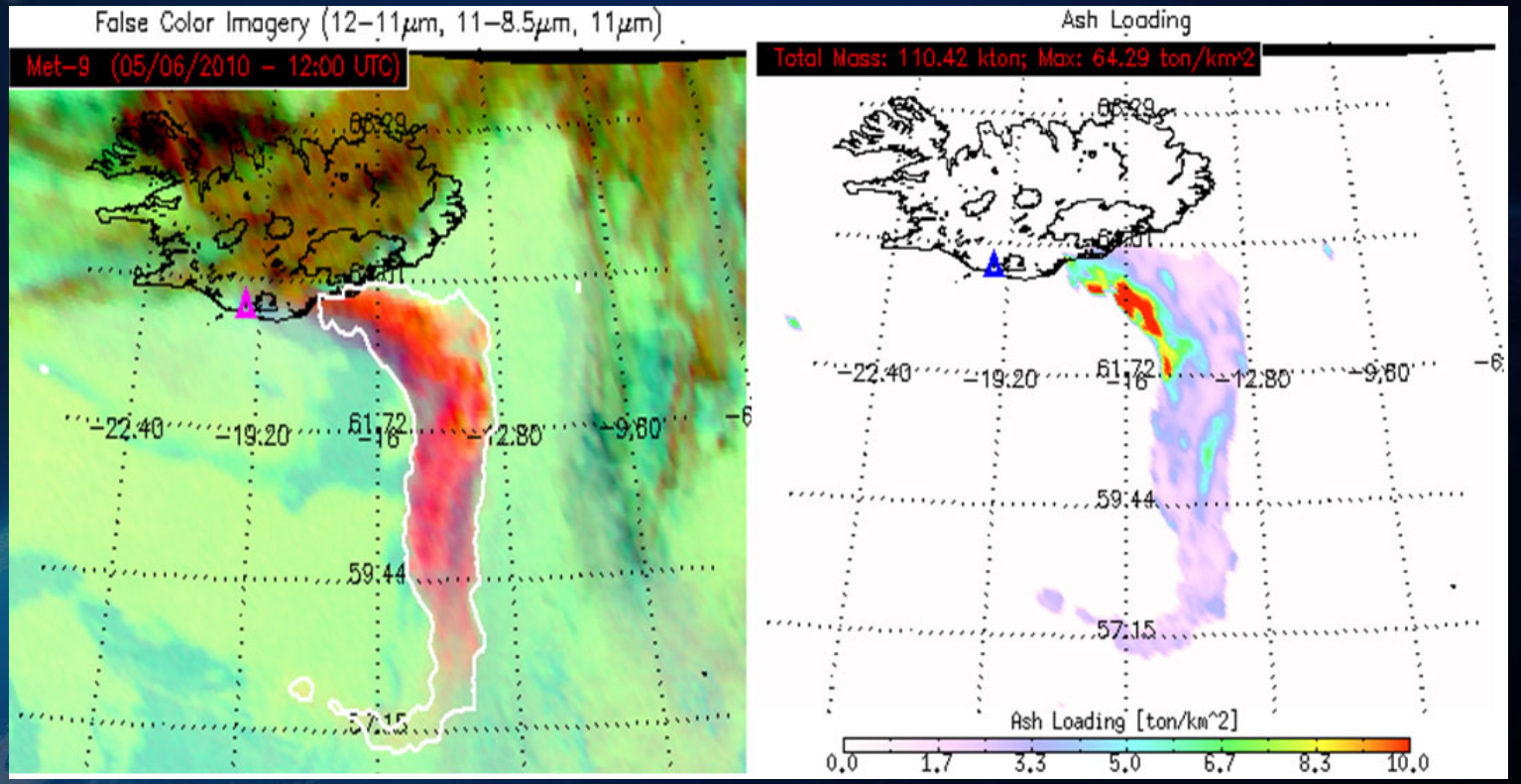


Volcanic Ash Prediction

2010 Eyjafjallajokull volcanic eruption

- The GOES-R Proving Ground provides near real-time volcanic ash retrieval products (using Meteosat SEVIRI data as a proxy for the GOES-R ABI) to identify a significant volcanic ash plume emerging over the Atlantic Ocean impacting aviation operations with many cancelled flights.

- GOES-R Volcanic Ash algorithm implemented at Japan Meteorological Agency (JMA) in 2013 in preparation for Himawari 8 (launched in October 2014)



Ash Detection product (left) and Ash Loading (right) using the GOES-R Volcanic Ash Algorithm applied to Meteosat-9/SEVIRI data

[1]**http:**//www.goes-r.gov/products/baseline-volcanic-ash.html

Courtesy of Mike Pavolonis, NESDIS/STAR, and Justin Sieglaff, CIMSS

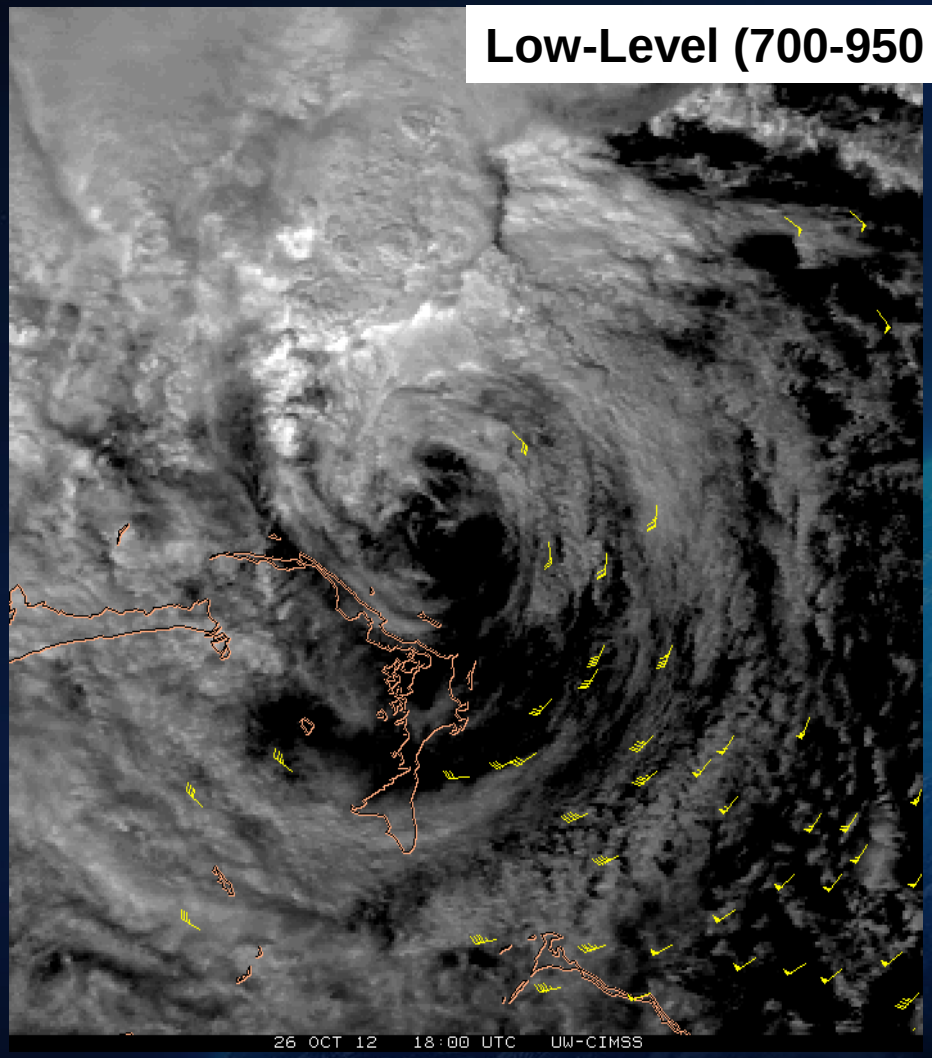
Future Capabilities

Atmospheric Motion Vectors from GOES-R

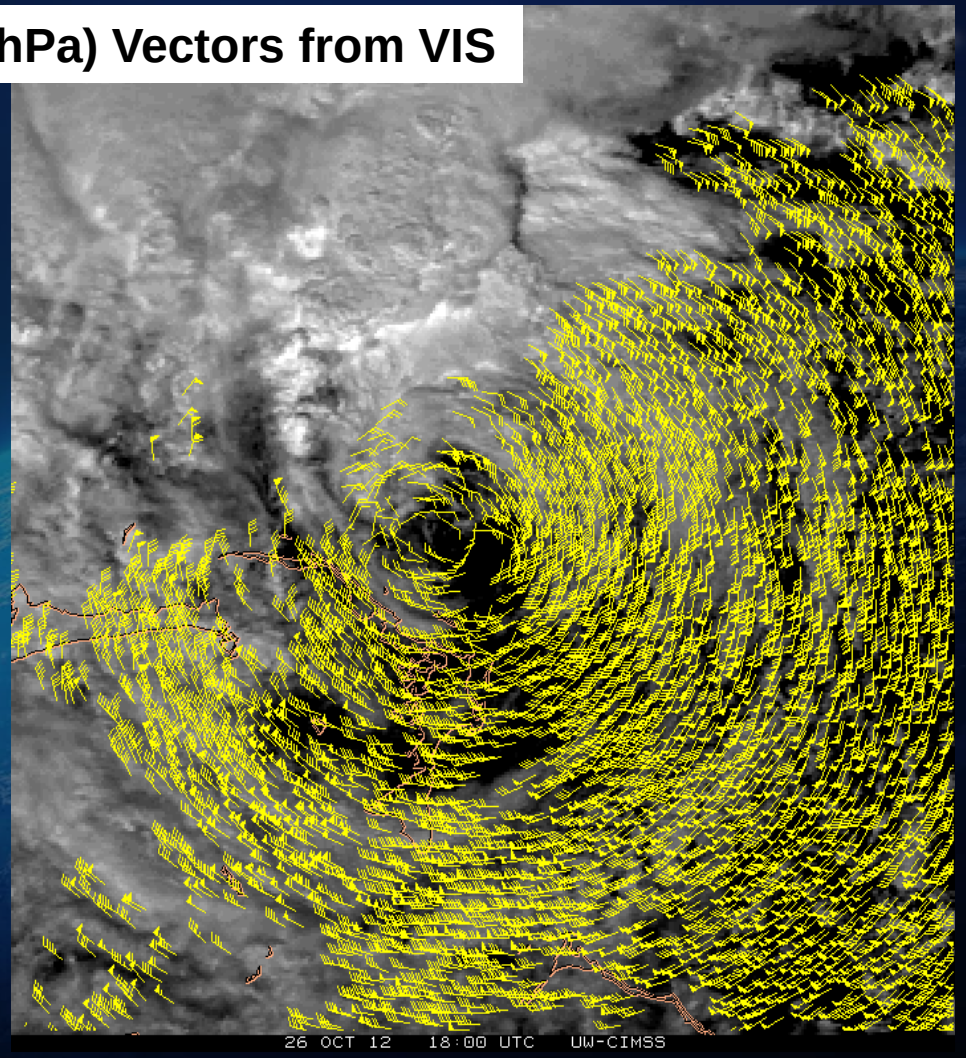
Proxy: AMVs from special GOES-14, 1-min super-rapid-scan operations

Hurricane Sandy

Low-Level (700-950 hPa) Vectors from VIS



AMVs from **15-min images** (routine **GOES** sampling)



AMVs from **1-min images** (meso **GOES-R** sampling)

1800 UTC 26 Oct, 2012

C. Velden (CIMSS)

GOES-R Fog/Low Stratus (FLS) Products

- **FLS = Fog/Low Stratus**
- **There is no widely accepted definition of fog/low stratus so the GOES-R definition of FLS is based on aviation flight rules**
- ***The primary goal of the GOES-R fog/low cloud detection algorithm is to determine the probability of IFR/LIFR conditions.***

- **VFR - Visual flight rules**
  ceiling > 3000 ft and vis > 5 mi
- **MVFR - Marginal visual flight rules**
  1000 ft < ceiling < 3000 ft or 3 mi < vis < 5 mi
- ***IFR - Instrument flight rules***
  ***500 ft < ceiling < 1000 ft* or 1 mi < vis < 3 mi**
- ***LIFR - Low instrument flight rules***
  ceiling < 500 ft or vis < 1 mi

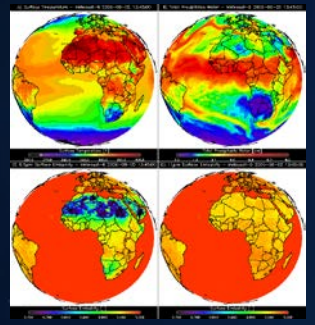
Fused Fog/Low Cloud Detection Approach

Satellite Data

-Minimum channel requirement: 0.65, 3.9, 6.7/7.3, 11, and 12/13.3 µm
-Previous image for temporal continuity (GEO only)
-Cloud Phase

+

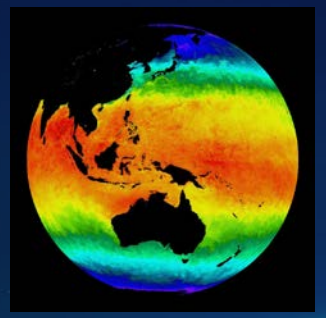
Static Ancillary Data



-DEM
-Surface Type
-Surface Emissivity

+

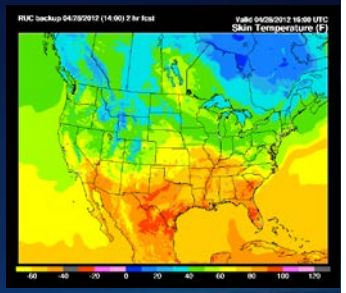
Daily SST Data



0.25 degree OISST

+

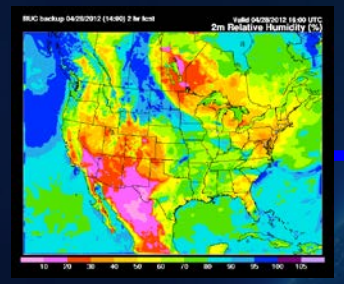
NWP



-Surface Temperature
-Profiles of T and q
-RUC/RAP (2-3 hr forecast) or GFS (12 hr forecast)

Clear Sky RTM

NWP RH Profiles

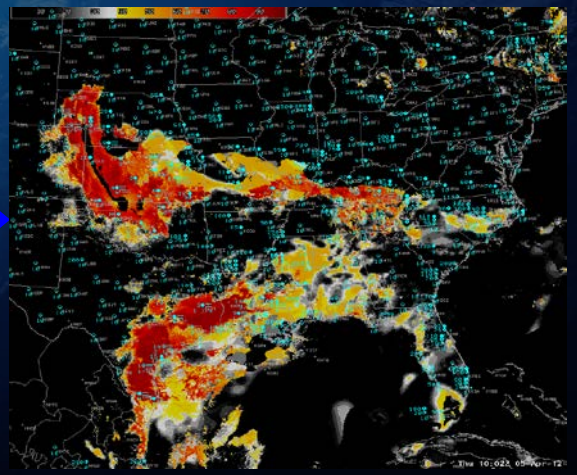


-RUC/RAP (2-3 hr forecast) or GFS (12 hr forecast)

Naïve Bayesian Model

Total run time: 2 - 3 minutes

IFR and LIFR Probability



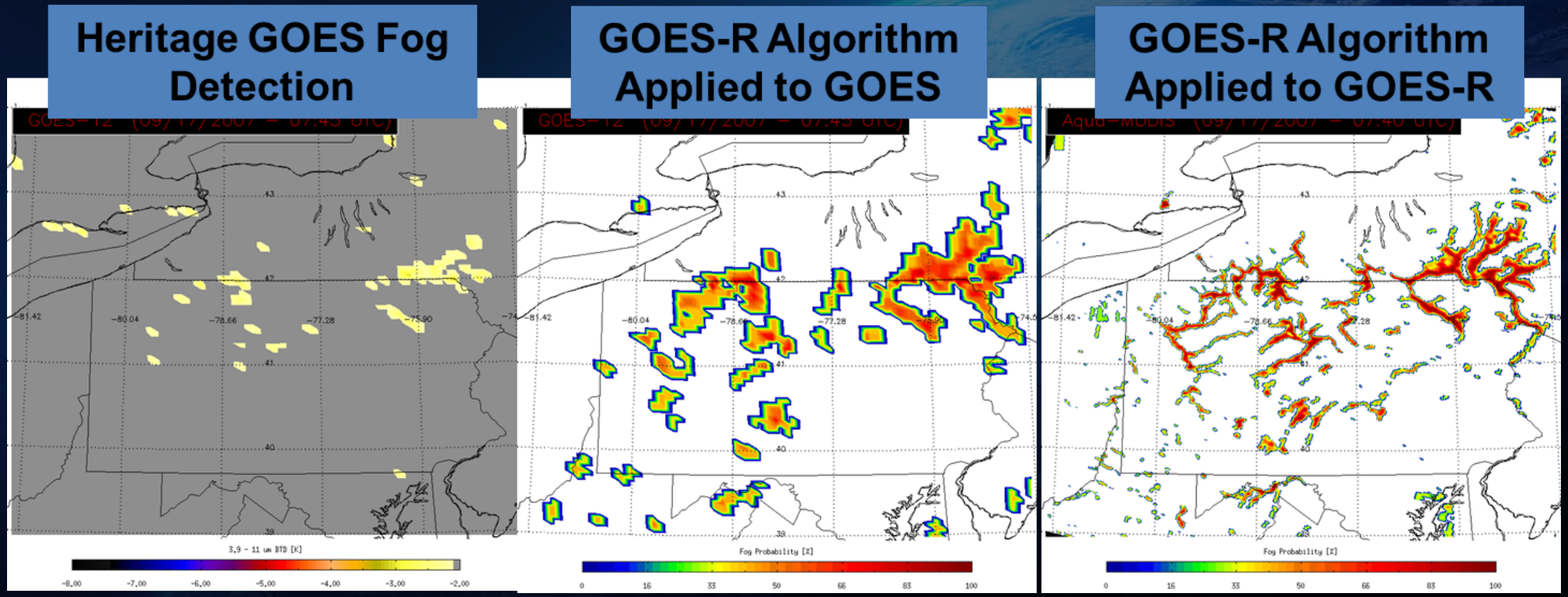
***IMPORTANT: Other sources of relevant data (e.g. sfc obs) influence results through the model fields

Fog Detection

The GOES-R fog detection product will significantly improve geostationary satellite fog monitoring capabilities because:

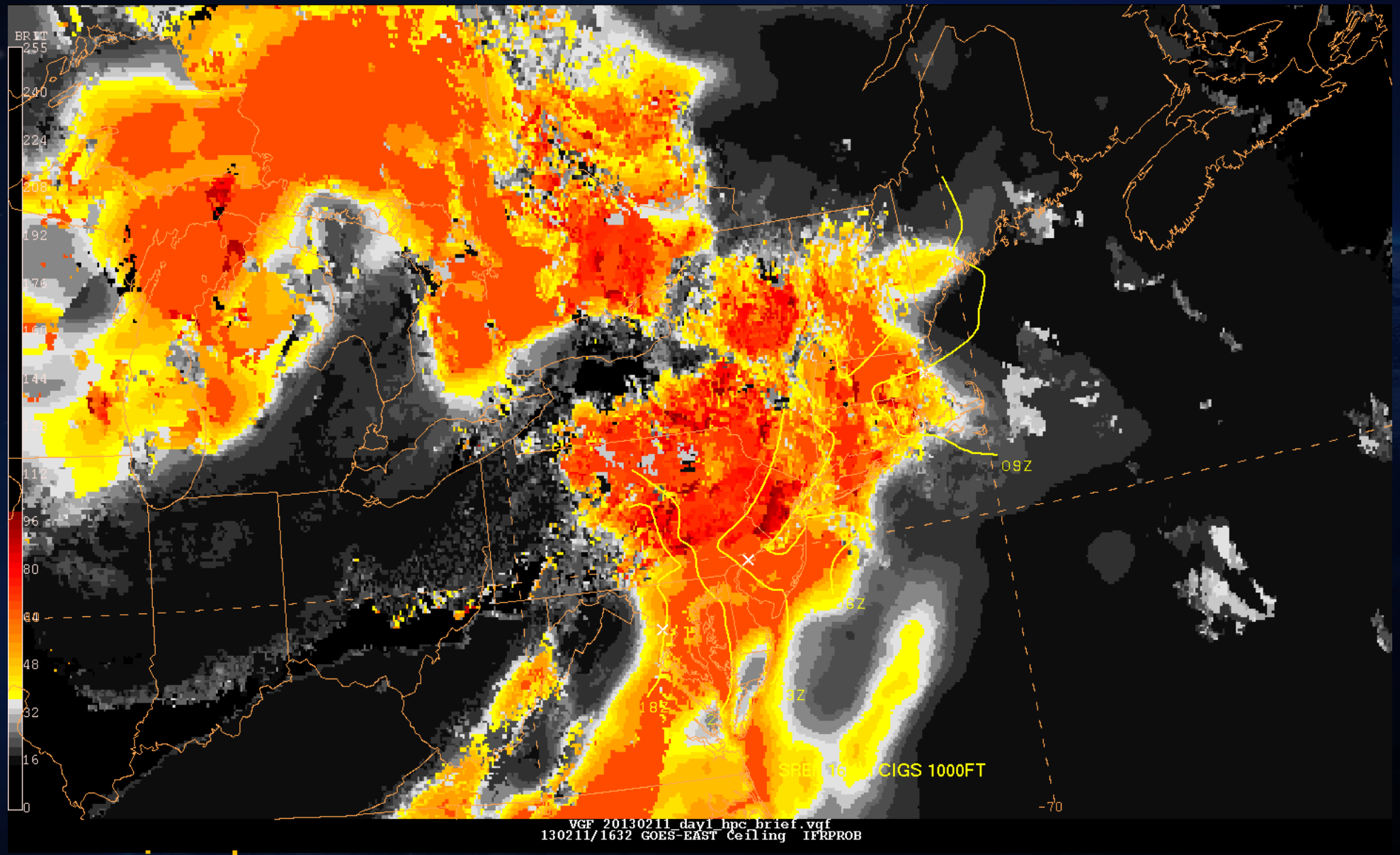
- ***Improved algorithm technology*** - the GOES-R algorithm provides quantitative information on fog probability, while heritage GOES fog detection products are more qualitative in nature

- ***Improved sensor technology*** - the ABI has greatly improved spectral information, spatial resolution, and temporal resolution



Courtesy: Mike Pavolonis/NESDIS STAR

Fog and Low Stratus Product



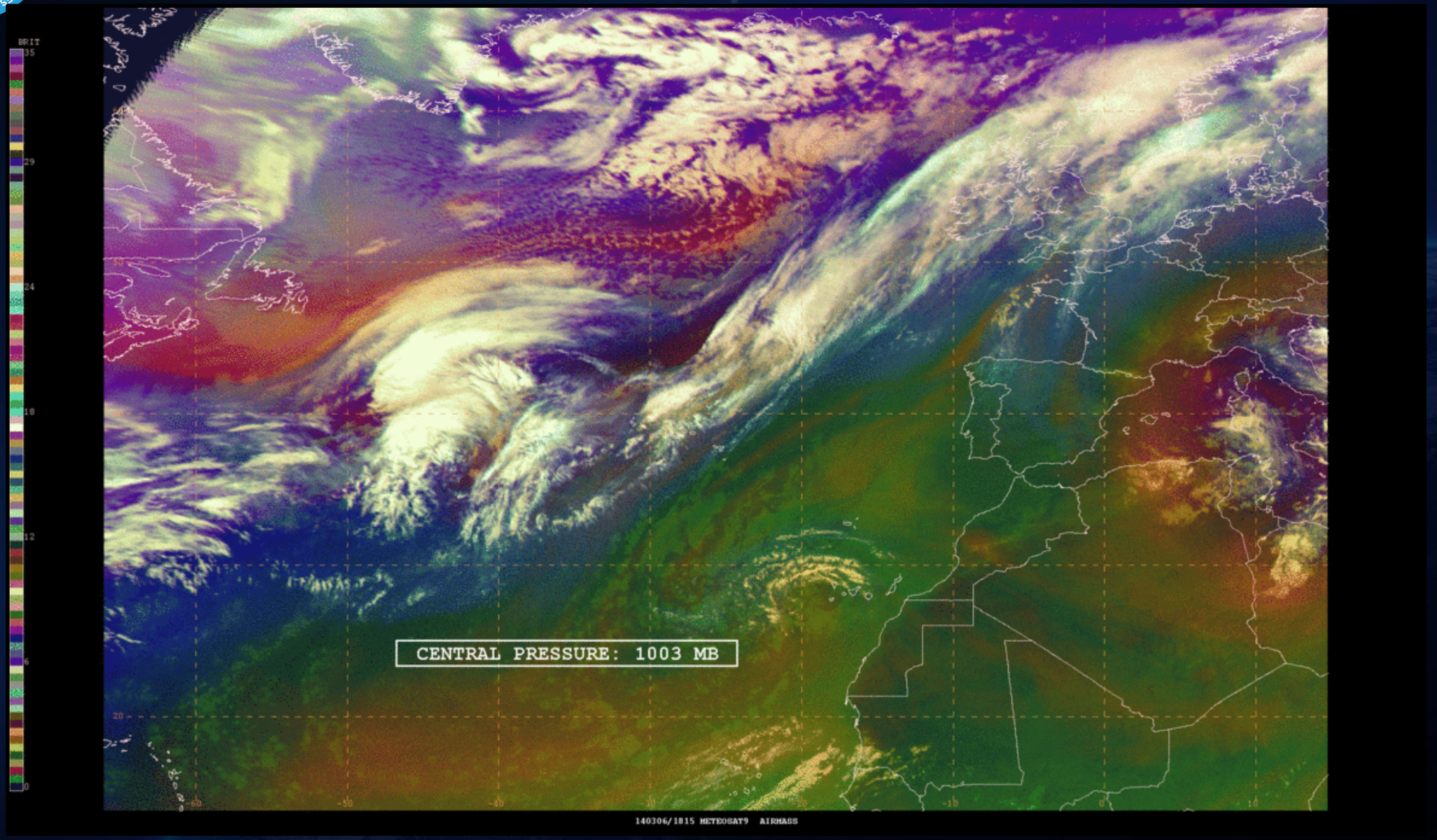
http://fusedfog.ssec.wisc.edu

Fog and Low Stratus – IFR probabilities

- Provides probabilities of Instrument Flight Rules (IFR)/Low Instrument Flight Rules (LIFR) conditions.
- Is currently used by the North American Mesoscale (NAM) models at the Command Center for terminal ceiling forecasts
- Can be used to estimated onset and dissipation of fog/low ceilings over terminals

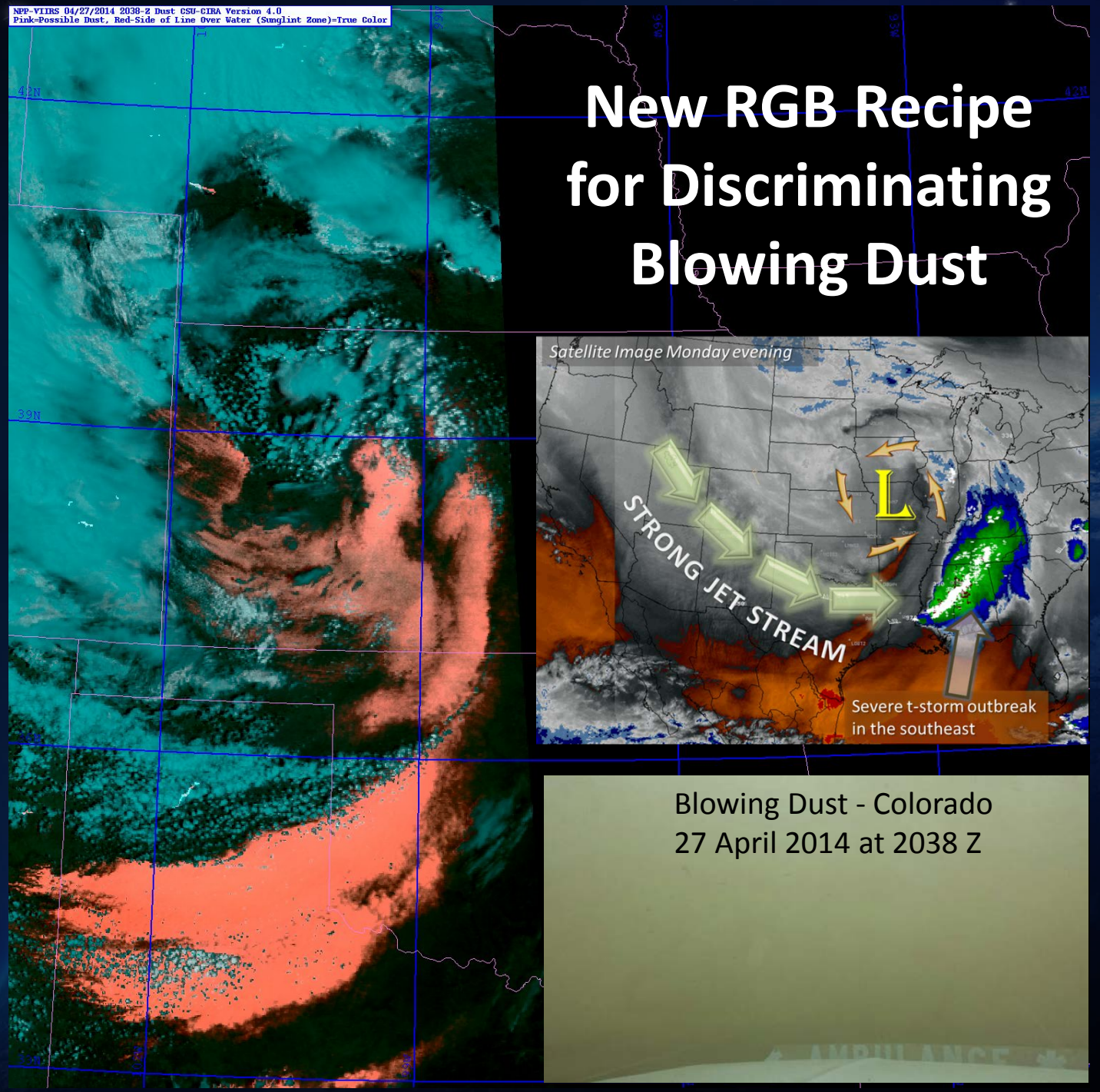
December 29th, 2013 – Eagle County Airport in Colorado… a significant decrease in GOES-R IFR probabilities resulted in the early cancellation of a Ground Stop, and subsequently saved time and $$

RGB Airmass Product



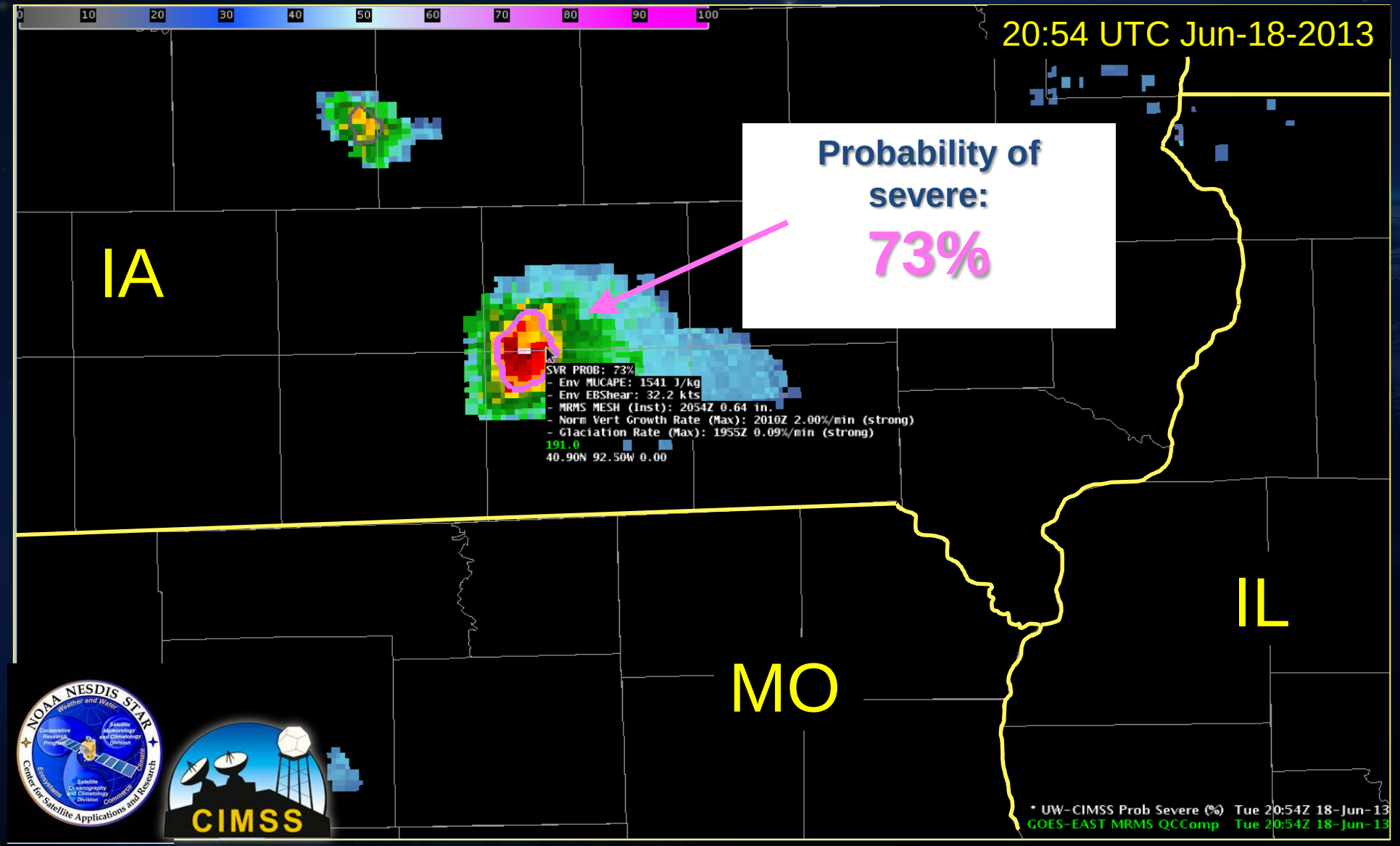
Courtesy of Michael Folmer and Tim Collins - Ocean Prediction Center

New RGB Recipe for Discriminating Blowing Dust

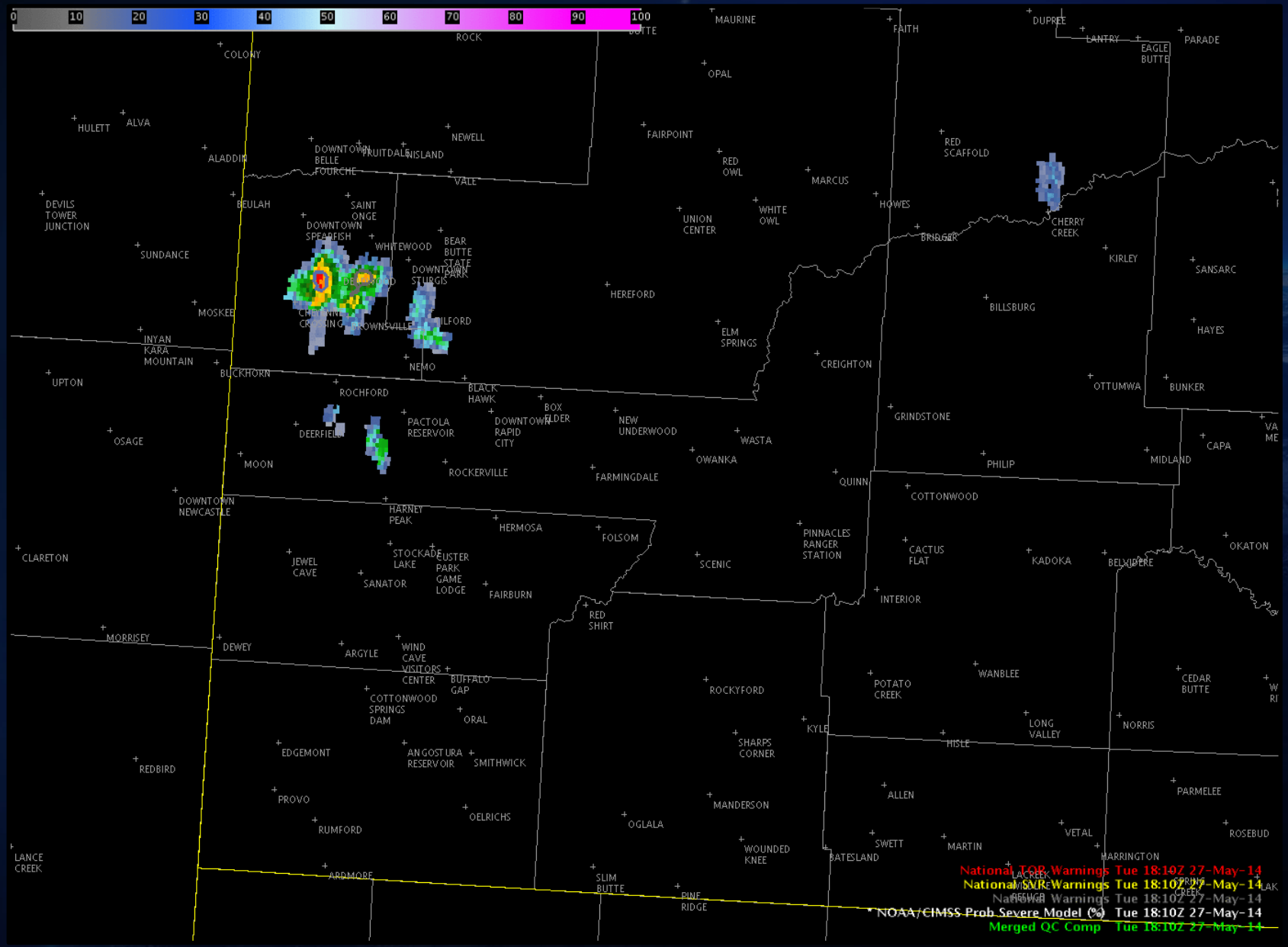


Blowing Dust courtesy of S. Miller

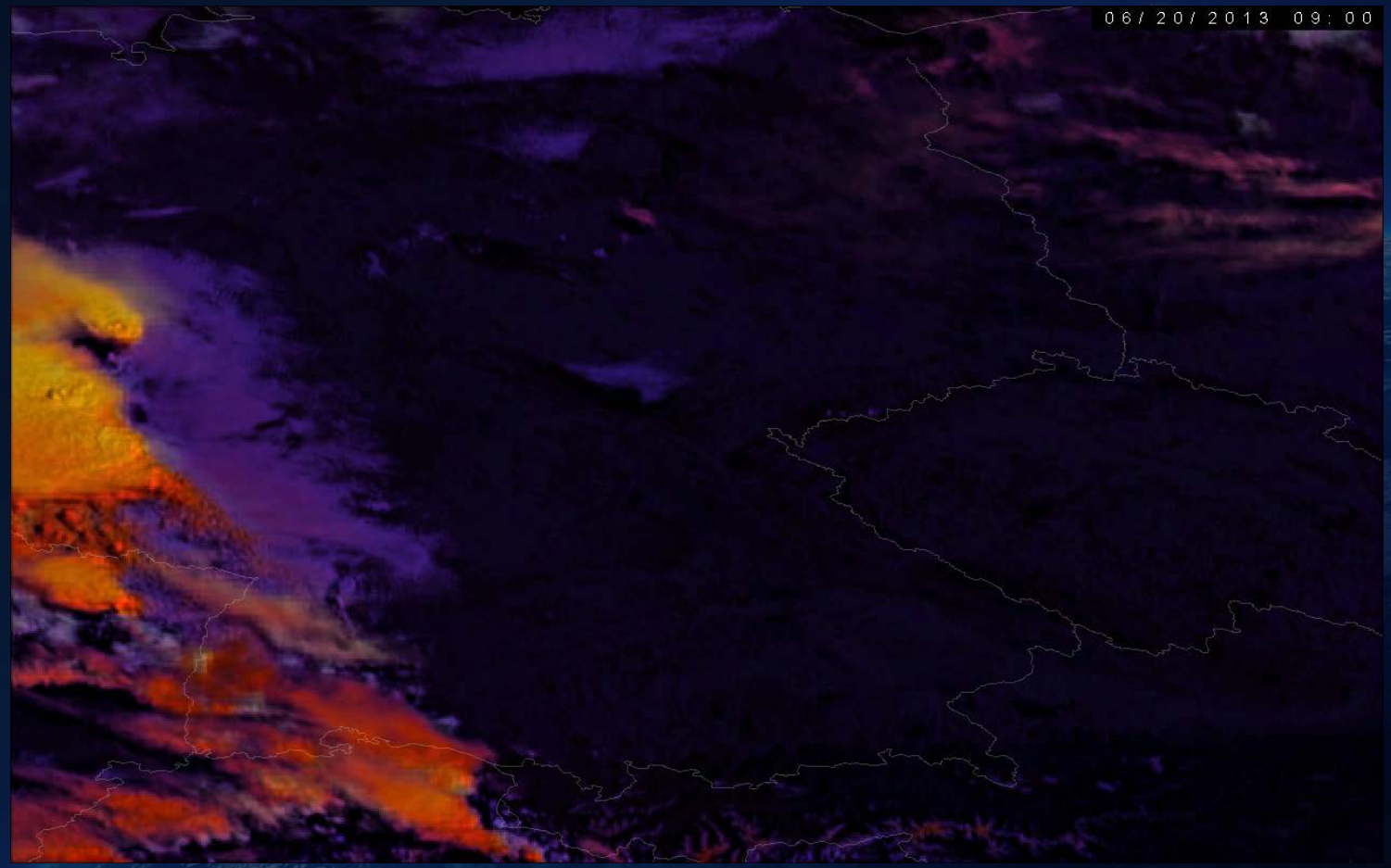
Probabilistic Forecast of Severe Storms through Data Fusion



Probability of Severe Convection



ABI Super Rapid Scan
Moving toward data fusion

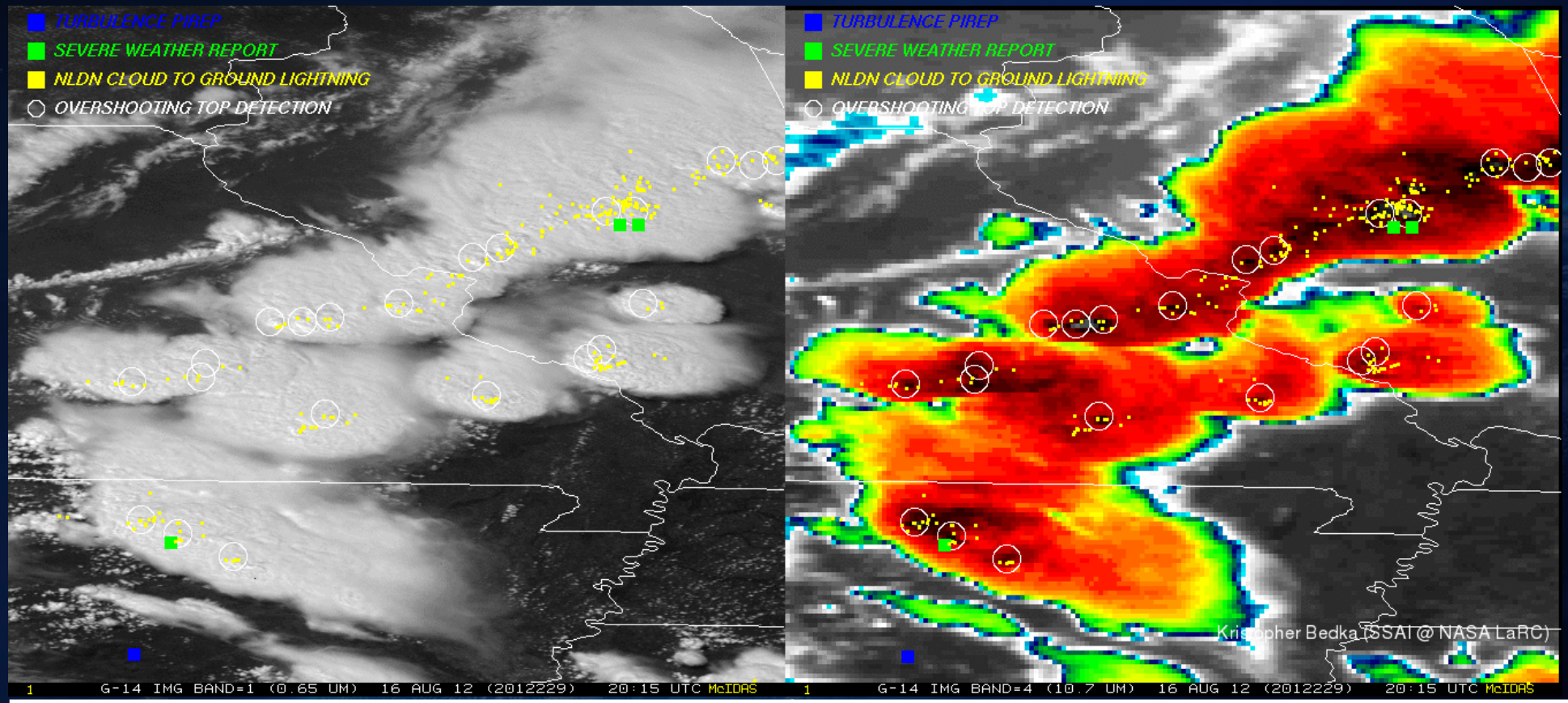


Why NWS needs this?

- Situational Awareness
- Warning confidence
- Decision Support (venues)

Courtesy of Martin Setvak, CHMI)

ABI Super Rapid Scan
Moving toward data fusion



Proving Ground Demonstration at AWC Testbed

User comment: 'Cloud Top Cooling product is an excellent source of enhancing the situational awareness for future convective initiation, particularly in rapid scan mode'. (*AWC Testbed forecaster, June 2012)*

Why NWS needs this?

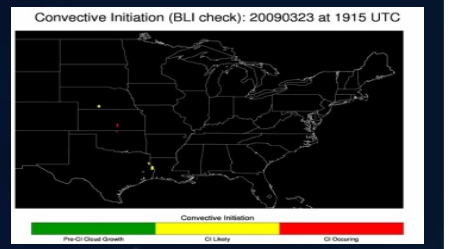
- Situational Awareness
- Warning confidence
- Decision Support (venues)

NWS Vision to Integrate ABI and GLM Products with Other Data and Models

A Potential Operational Example: Convective Initiation/Severe Wx

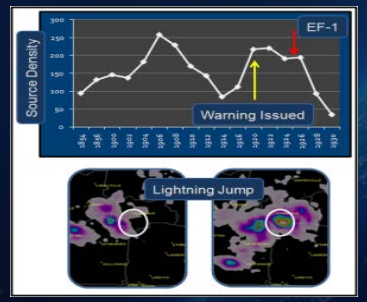
How can we integrate the information in future tools?

Convective Initiation

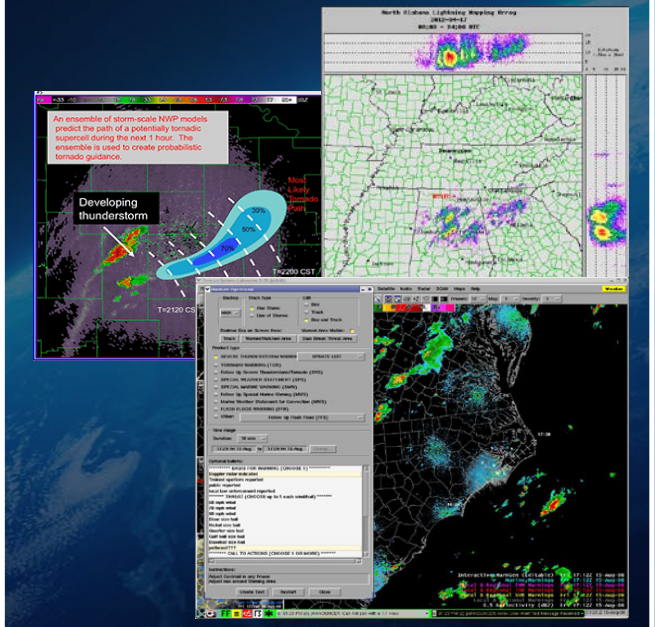


Over-shooting tops

Lightning Jumps



Next Generation Warning System



Why NWS needs this?

- Situational Awareness
- Warning confidence
- Decision Support (venues)

Situational Awareness:

User comment: 'Cloud Top Cooling product is an excellent source of enhancing the situational awareness for future convective initiation, particularly in rapid scan mode'.

AWC Testbed forecaster

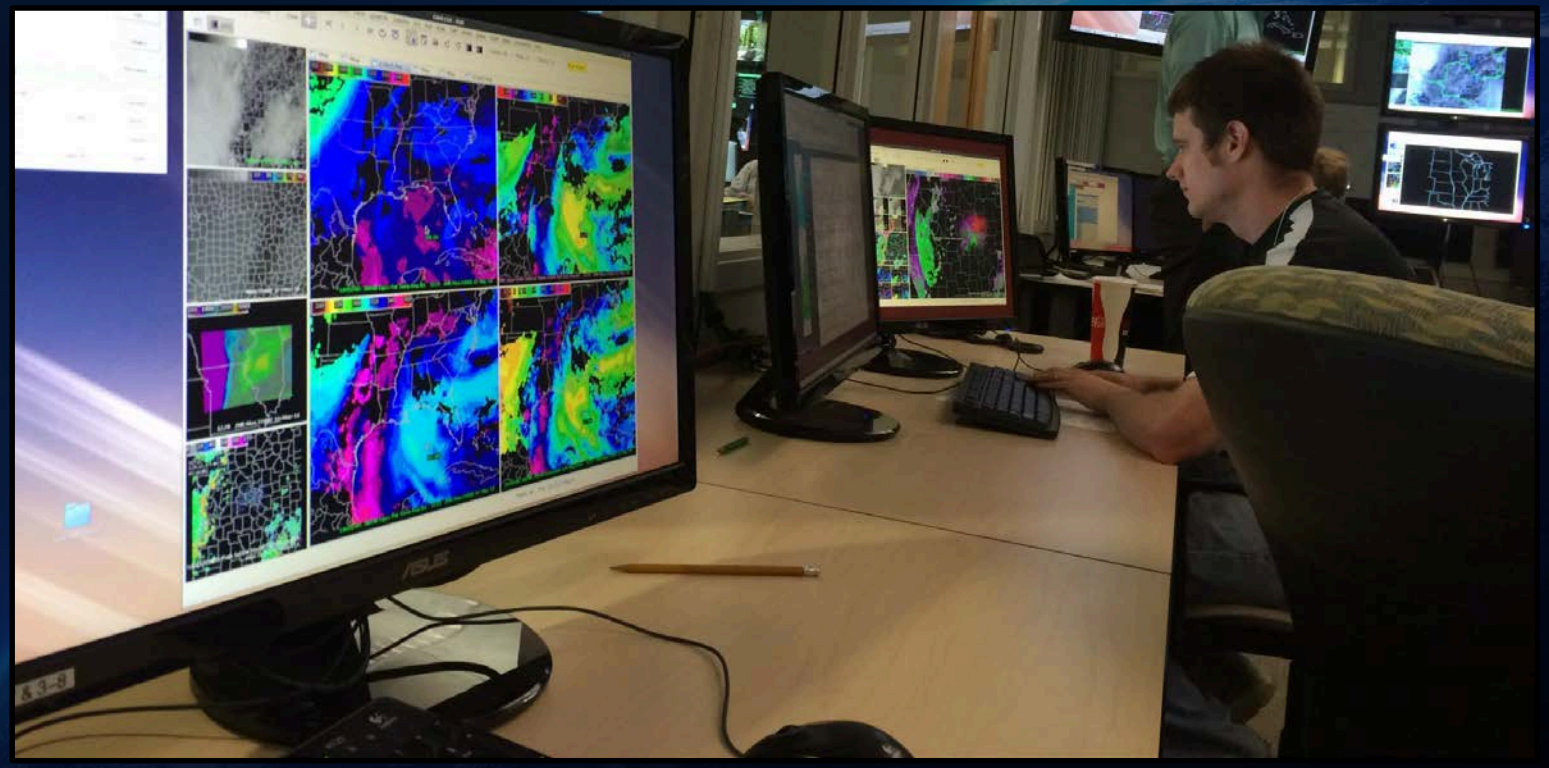
(June 2012)

Additional User Readiness Activities

GOES-R/Broadcast Meteorology Collaboration

Outreach efforts to introduce GOES-R products to forecasters and accelerate user readiness for the advanced capabilities of GOES-R.

GOES-R funded 4 broadcast meteorologists (with NWS forecasters) to attend the Hazardous Weather Testbed in Norman, OK this past May.



Courtesy of Erica Grow, WUSA9

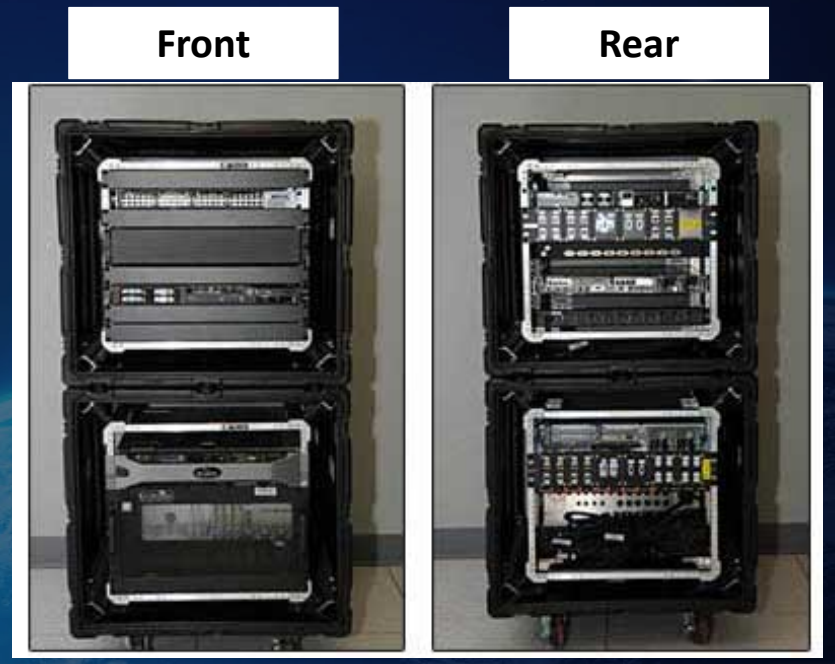
AMS Conference on Broadcast Meteorology

- Title: Capabilities of The Next-Generation Geostationary Environmental Satellite System for Operational Meteorology

- Proposal submitted to AMS Committee on Broadcast Meteorology with draft agenda for a “Short Course on GOES-R for broadcast meteorologists” at 2015 conference.

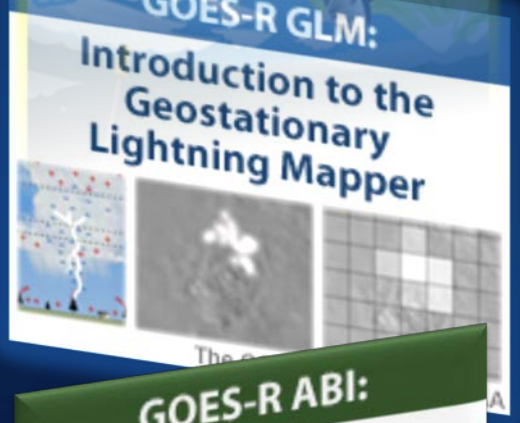
GRB Simulators

- On-site testing of user ingest and data handling systems
- Simulation of GRB downlink functionality by generating Consultative Committee for Space Data Systems (CCSDS) formatted GRB output data based on user-defined scenarios, test patterns, and proxy data files
- Four simulators designated for loan
  - Verification of GRB receive system compatibility with GRB transmission
  - **http://go.usa.gov/WvXY**



Industry Day: October 25, 2013
NOAA Science Center, Silver Spring, MD

Training and User Education Materials



Online Training Modules

- Cooperative Program for Operational Meteorology, Education, and Training (COMET): https://www.meted.ucar.edu/
- Satellite Hydrology and Meteorology for Forecasters (SHyMet): http://rammb.cira.colostate.edu/training/shymet/
- Short-term Prediction Research and Transition Center (SPoRT) product training modules: http://weather.msfc.nasa.gov/sport/training/
- Virtual Institute for Satellite Integration Training (VISIT) Training Resources: http://rammb.cira.colostate.edu/training/visit/

Printed Materials

- ABI Bands Quick Information Guides
- GOES-R Fact Sheets (18)
- User Readiness Plan
- GRB Downlink Specifications and Product Users' Guide
- Proving Ground Demonstration Final Reports and Annual Reports

2015 NOAA Satellite Conference

GOES-R

Geostationary Operational Environmental Satellite - R Series

The next-generation of geostationary environmental satellites

Advanced imaging for accurate forecasts

Real-time mapping of lightning activity

Improved monitoring of solar activity

Spacecraft image courtesy of Lockheed Martin

Thank you!

For more information visit www.goes-r.gov

CONNECT WITH US !

www.facebook.com/GOESRsatellite

www.youtube.com/user/NOAASatellites

twitter.com/NOAASatellites

www.flickr.com/photos/noaasatellites

BACKUP

GOES to GOES-R Comparison

	GOES I-M	GOES N-P	GOES R
Performance Capability			
Imaging			
Visible Resolution	1 km	1 km	0.5 km
IR Resolution	4-8 km	4-8 km N 4 km O/P	1-2 km
Full Disk Coverage Rate	30 min	30 min	5 min
# of Channels	5	5	16
Solar Monitoring	GOES-M only	Yes	Yes
Lightning Detection	No	No	Yes
Operate through Eclipse	No	Yes	Yes
Ground System Backup	Limited	Limited	Limited
Archive and Access	Limited	Limited	Yes
Raw Data Volume per spacecraft	2.6 Mbps	2.6 Mbps	75 Mbps

GOES-R vs. GOES N-P
Key Differences – Spacecraft

GOES N-P	GOES-R
10 year spacecraft / 5 year instrument life	**15 year spacecraft & instrument life**
>250 hours outage/yr due to stationkeeping / housekeeping	**No outages due to stationkeeping / housekeeping**
Stationkeeping via 5lb bi-prop thrusters	**Stationkeeping via low-thrust REAs and arc-jets**
Ground-based orbit determination	**On-board GPS navigation**
Ground-based clock synchronization	**On-board clock synchronization with GPS**
~24 hr storage/safe-hold to normal mode transition	**<4 hour storage/safe-hold to normal mode transition**
One command uplink frequency	**2 command uplink frequencies**
Raw data downlink via S-band	**Raw data downlink via X-band**

GOES-R vs. GOES N-P
Key Differences - Instruments

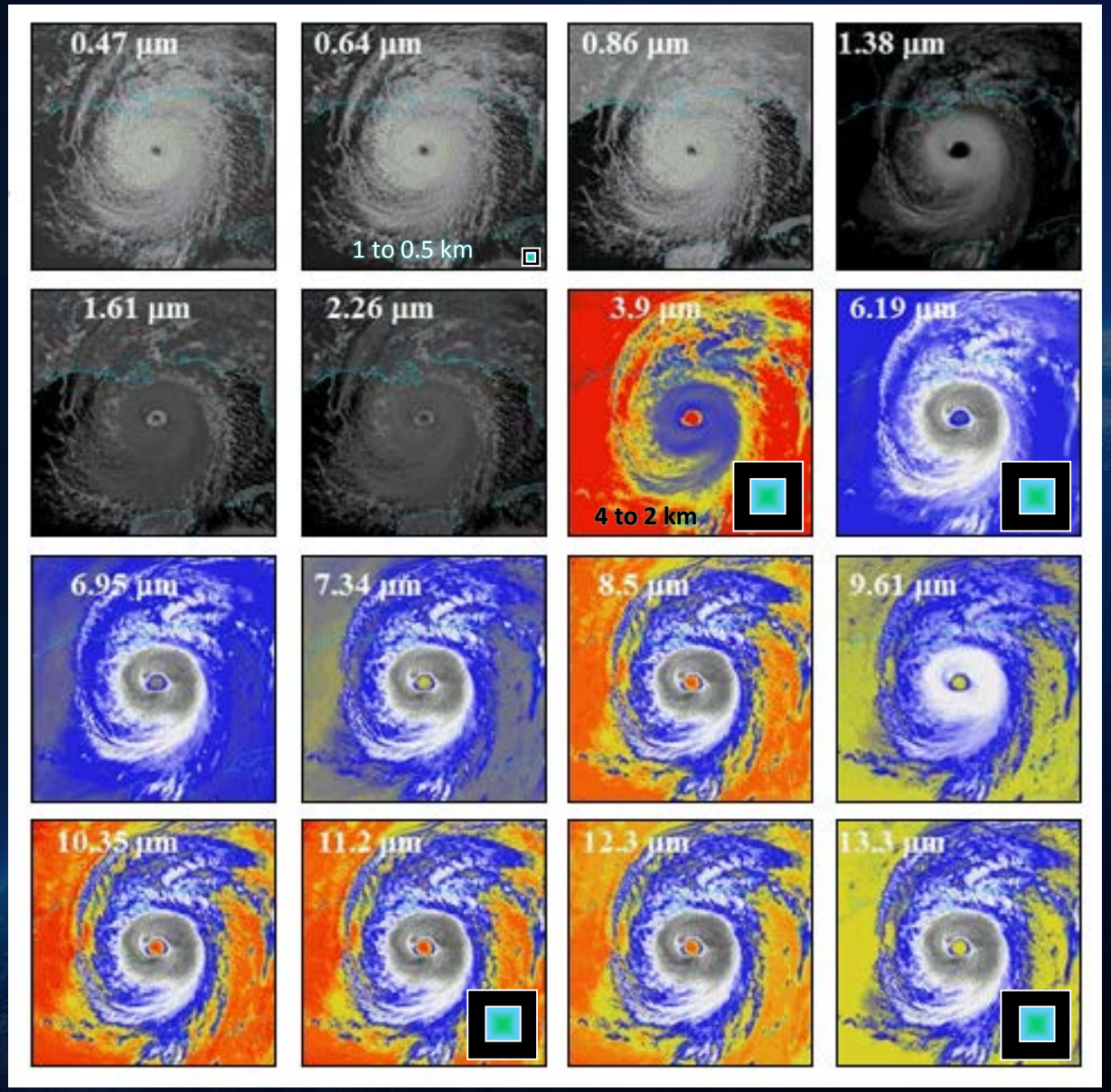
GOES N-P	GOES-R
Imager: 5 Channels 1.6 Mbs raw instrument data rate 1.0 km spatial resolution 26 min full disk Frame-by-frame commanding required via multiple daily schedules	**ABI** **16 Channels** **120Mbs raw instrument data rate** **0.5 km spatial resolution** **5 min full disk** **Autonomous sequences; no daily commanding**
INR: Accomplished by precise image acquisition (control) Requires multiple INR uploads daily	**INR: Accomplished by image post-processing (knowledge)** **Single ABI Target Star List uploaded daily**
Lightning Mapper: None	**GLM provides continuous full disk total lightning measurements**
SXI: X-ray/EUV CCD 512x512 pixels, 5 arcsec/pixel resolution	**SUVI: UV CCD 1280x2180 pixels, .28 arcsec/pixel resolution**
XRS: Ionization chamber design	**EXIS: Solid state detector design, higher dynamic range, adds flare location capability**

Generational improvement in instrument spatial, spectral and temporal resolution

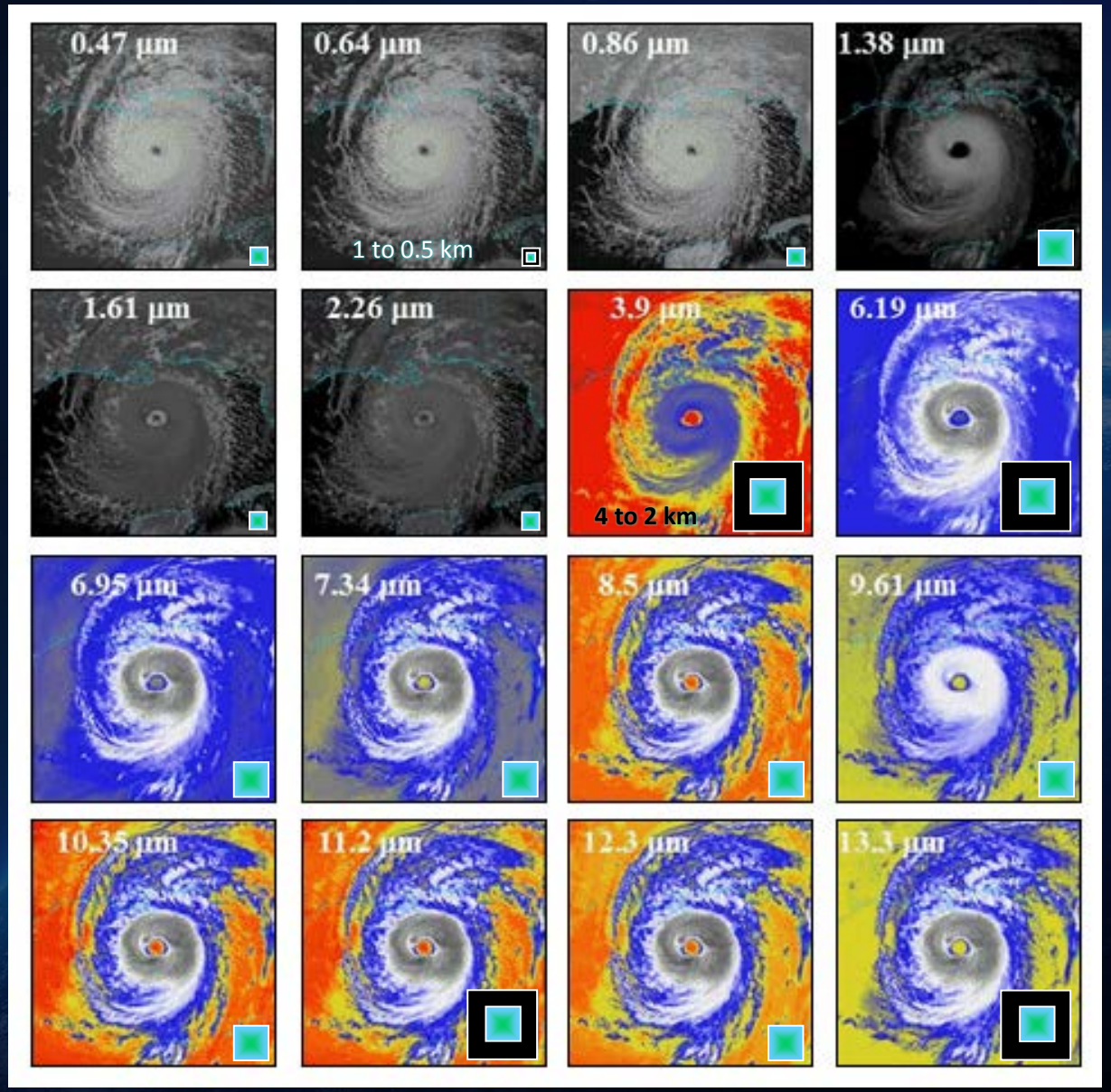
ABI Comparison to Current Imager

	ABI	Current
Spectral Coverage	**16 bands**	5 bands
Spatial resolution		
0.64 mm Visible	**0.5 km**	1 km
Other Visible/near-IR	**1.0 km**	n/a
Bands (>2 mm)	**2 km**	4 km
Spatial coverage		
Full disk	**4 per hour**	Scheduled (3 hrly)
CONUS	**12 per hour**	~4 per hour
Mesoscale	**30 sec (typical)**	n/a
Visible (reflective bands)		
On-orbit calibration	**Yes**	No

Four Times Greater Spatial Resolution



Four Times Greater Spatial Resolution

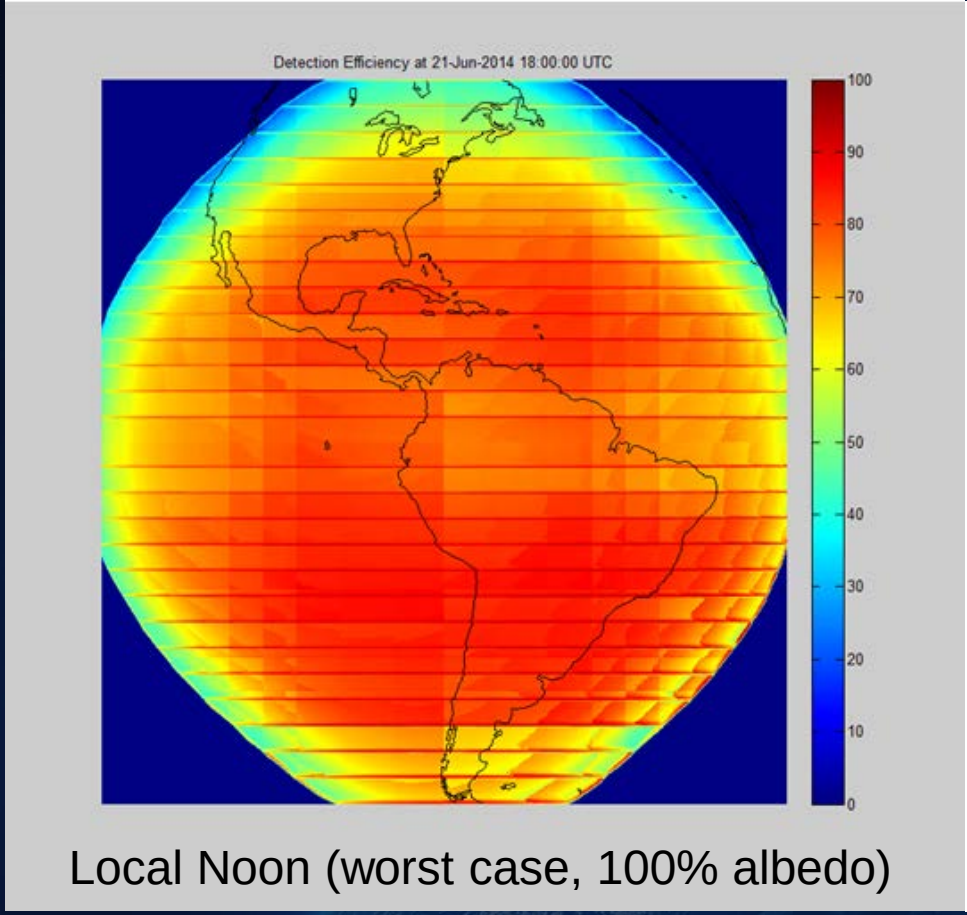


Positive Cloud-to-Ground Flashes

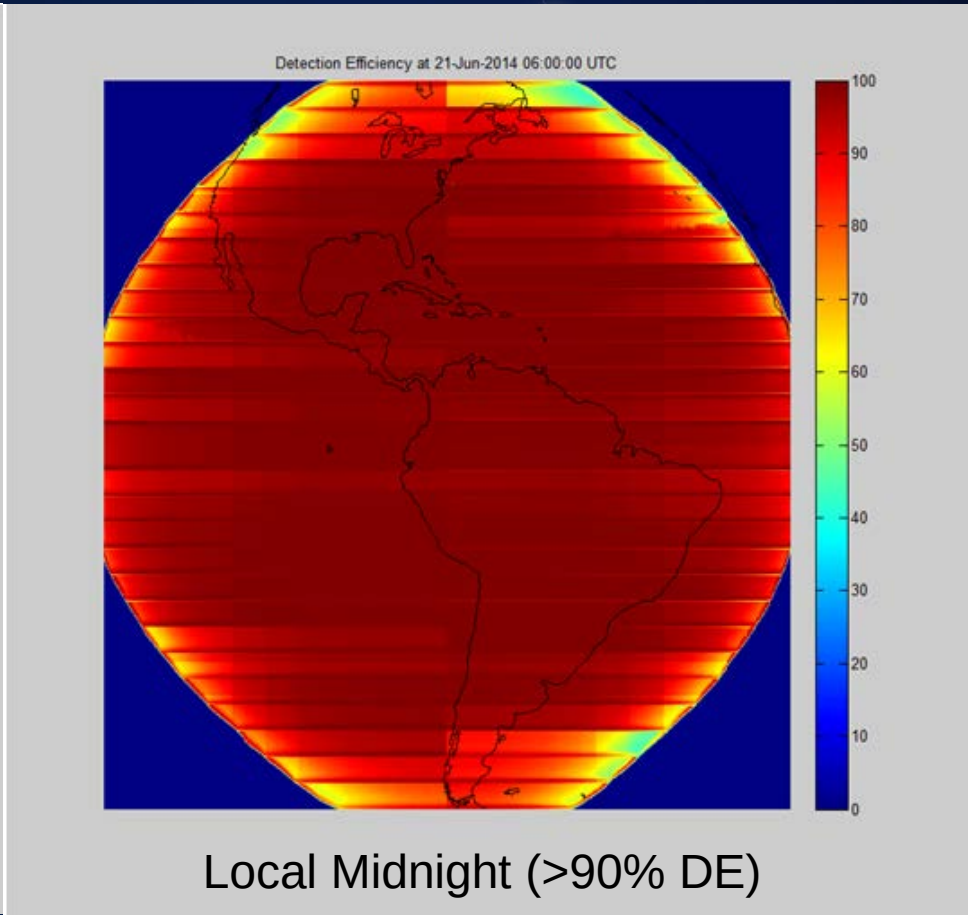
- 4-8% of all CG flashes
- Larger fraction in dissipating storms, winter storms, stratiform rainfall, and severe storms
- Almost all have continuing current and so more likely to start fires

Courtesy Don MacGorman

GLM Projected Detection Efficiency



Local Noon (worst case, 100% albedo)



Local Midnight (>90% DE)

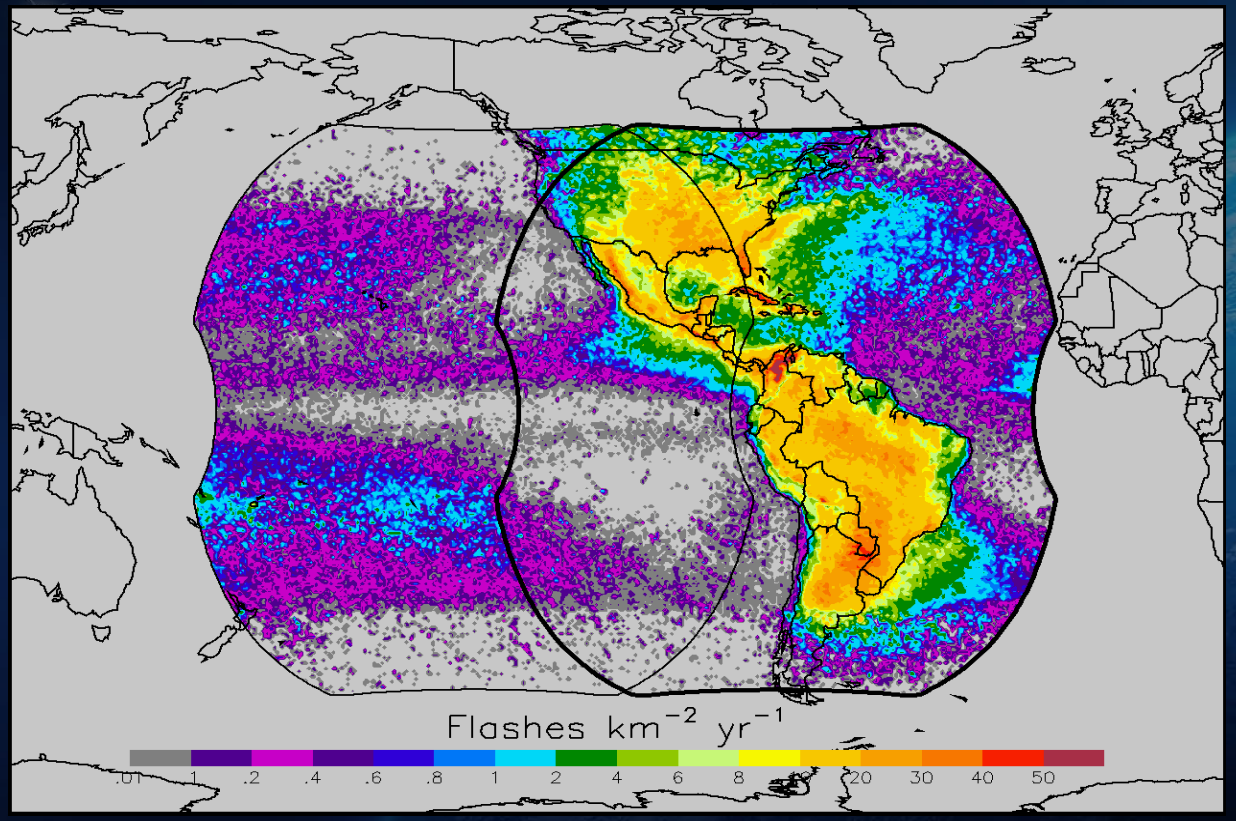
24 hour Avg	BOL DE	EOL DE	With GPA
Primary	83 %	81 %	75 %
Redundant	86 %	84 %	78 %

Lowering thresholds can increase FAR (estimate <1%, spec is 5%) and yet improve DE (spec is 70%) by having 2 or more events pass coherency filter.

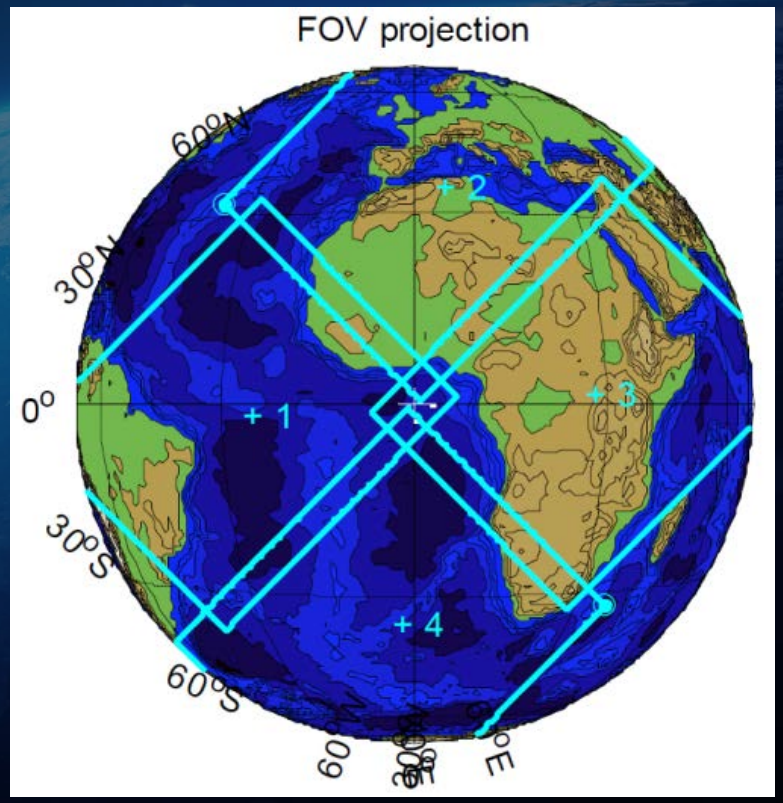
Coverage for the GOES-R GLM and MTG Lightning Imager

Goal: Globally Consistent Lightning Database

GOES-R GLM



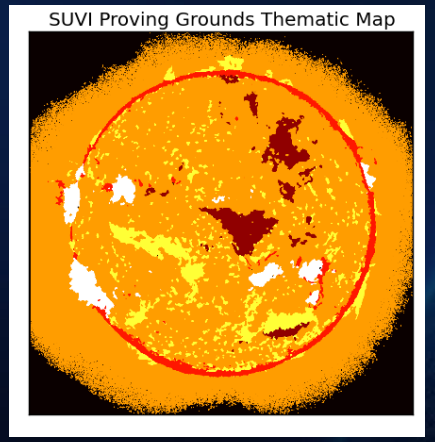
MTG-LI

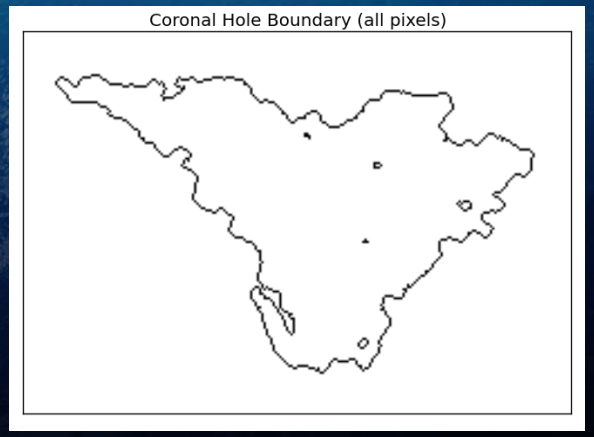


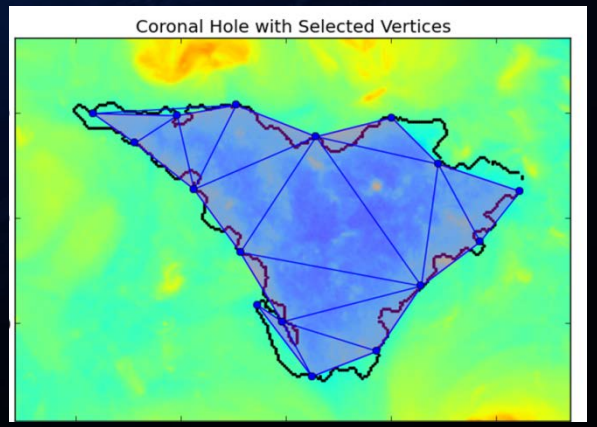
MTG-LI courtesy Jochen Grandell, EUMETSAT

Space Weather Prediction Testbed: GOES-R Proving Ground

- Focuses on readiness of new capabilities and integration with National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS) II Forecaster Workstation
- AWIPS II integration
- Thematic maps (multispectral pixel classifier) improvements
  - Assimilation of additional non-SUVI data (H-alpha images) in progress
  - Challenges with differing dynamic ranges and opacities (H-alpha vs. EUV)
- New product development based on Thematic Maps outputs
  - Bright regions – associated with solar active regions
  - Flare location – Solar eruptions seen as hottest & brightest of bright regions
  - Coronal Hole Boundaries – dark areas of strong, outflowing solar wind



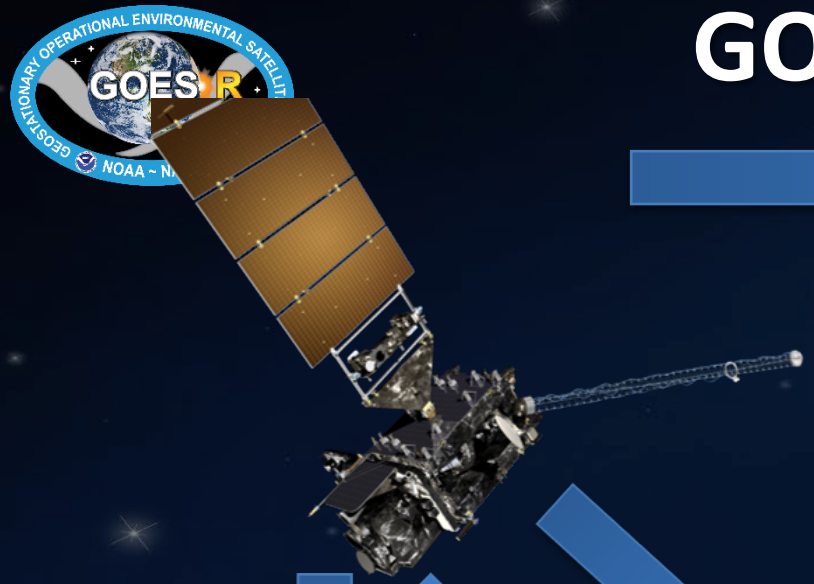




GOES-R vs. GOES N-P
Key Differences – Ground System

GOES N-P	GOES-R
Flight Operations system evolved from GOES I-M	**All new flight operations systems for command & control, flight dynamics / navigation, mission planning, trending & analysis**
Heritage data processing system: SPS	**All new data processing systems, including new algorithms (PG)**
Utilized existing NOAA antenna complement	**Upgraded and new antennas**
Limited WBU back-up facility	**Increased data volume**
	Incorporates a Consolidated Back-Up (CBU) facility New communication circuits
	Consolidated situational awareness and control of entire GOES-R Ground System
	Improved security

GOES-R Data Distribution



GOES-R Rebroadcast (GRB)

Direct Broadcast Community

NOAAPort Community

Sectorized Cloud and Moisture Imagery

Advanced Weather Interactive Processing System (AWIPS) Network Control Facilities

NOAA Port

Instrument Data

GRB

GRB

Sectorized Cloud and Moisture Imagery

L1B and L2+ Derived Products

NOAA Satellite Operations Facility

GOES-R Ground Segment

Product Distribution and Access (PDA)

NSOF

NATIONAL WEATHER SERVICE

Fastest

Access Speed

Slowest

Operational User Community (NOAA Centers, DOD, NCEP, Int'l Partners)

WCDAS

GOES-R Ground Segment

Consolidated Backup (CBU)

Wallops Command and Data Acquisition Station

L1B, L2+

CLASS

Comprehensive Large Array-data Stewardship System

Climate Research & Academia

L1B and L2+ Derived Products

Transition from GVAR to GRB

	GVAR	GOES Rebroadcast (GRB)
Full Disk Image	30 minutes	5 minutes (Mode 4)
		15 min (Mode 3)
Other modes	Rapid Scan, Super Rapid Scan	3000 km x 5000 km CONUS: 5 min
		1000 km x 1000 km Mesoscale: 30 sec
Polarization	None	Dual circular polarized
Receive Center Frequency	1685.7 MHz (L-band)	1686.6 MHz (L-band)
Data Rate	2.11 Mbps	~30 Mbps
Antenna Coverage	Earth coverage to 5°	Earth coverage to 5°
Data Sources	Imager and Sounder	ABI (16 bands), GLM, SEISS, EXIS, SUVI, MAG
Space Weather	None	~2 Mbps
Lightning Data	None	~0.5 Mbps