



Societal Benefits and Economic Value of the GOES-R Series Satellites

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95th AMS Annual Meeting
11th Annual Symposium on New Generation Operational
Environmental Satellite Systems

Phoenix, AZ

5 January 2015



GOES R

Geostationary Operational Environmental Satellite R-Series

Three times greater spectral information

Four times greater spatial resolution

Five times faster coverage of high impact weather phenomena

Real-time mapping of total lightning activity

Real-time monitoring of space weather

... Resulting in more timely, accurate, and actionable information leading to ...

Increased thunderstorm and tornado warning lead time

Improved hurricane track and intensity forecasts

More accurate detection of wildfires and volcanic eruptions

Improved monitoring of solar flares and coronal mass ejections

Improved geomagnetic storm forecasting

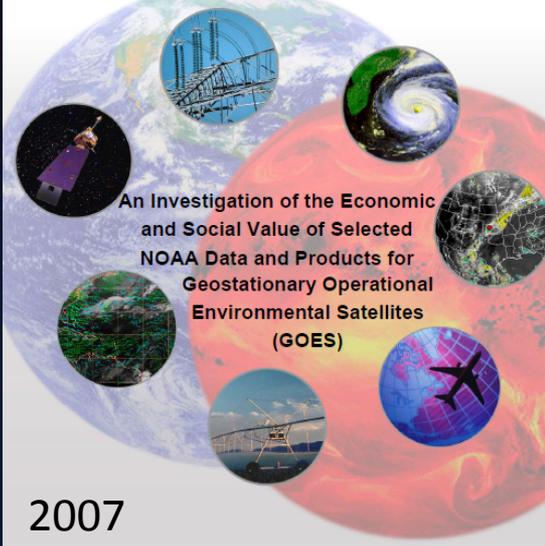
Investigating the Economic Value of Selected NESDIS Products



January 2003



2003



An Investigation of the Economic and Social Value of Selected NOAA Data and Products for Geostationary Operational Environmental Satellites (GOES)

2007

A Report to NOAA's National Climatic Data Center
 NOAA Satellite and Information Services
 National Environmental Satellite, Data, and Information Service

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An Agency within the National Oceanic and Atmospheric Administration



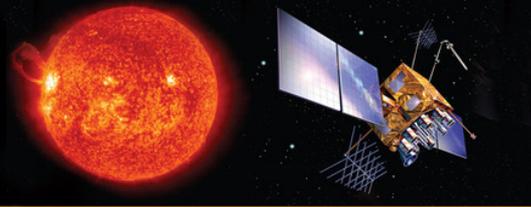
Grand Challenges for Disaster Reduction

National Science and Technology Council
 Committee on Environment and Natural Resources



A Report of the Subcommittee on Disaster Reduction

June 2005



SEVERE SPACE WEATHER EVENTS—

UNDERSTANDING SOCIETAL AND ECONOMIC IMPACTS



A WORKSHOP REPORT

2008

NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES

Unclassified

Project Report
 NOAA-18

An Assessment of the Operational Utility of a GOES Lightning Mapping Sensor

M.E. Weber
 E.R. Williams
 M.M. Wolfson
 S.J. Goodman

13 February 1998

Lincoln Laboratory
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY
 LEWINGTON, MASSACHUSETTS



Prepared for the National Oceanic and Atmospheric Administration under Air Force Contract F49620-95-C-0002.

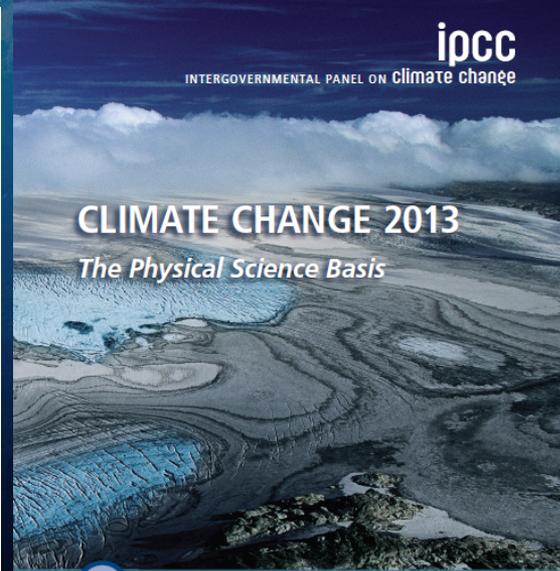
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1998

Unclassified

ipcc
 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

CLIMATE CHANGE 2013 The Physical Science Basis



WG I

WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE



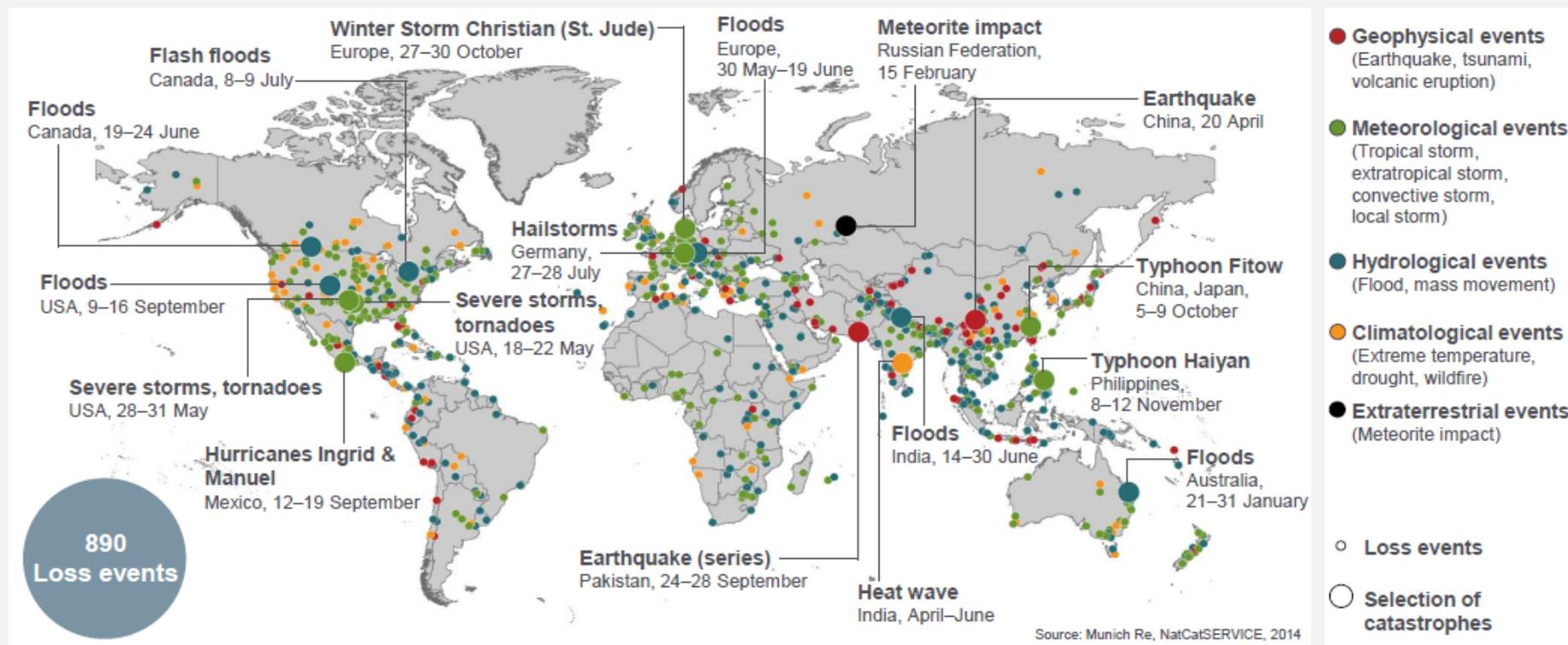
Losses Dominated by High Impact Weather and Climate Events



NatCatSERVICE

Loss events worldwide 2013

Geographical overview



Weather-related loss events worldwide 2013

Percentage distribution

790 Loss events



19,500 Fatalities*

*Number of fatalities without famine.



Overall losses US\$ 125bn



Insured losses US\$ 35bn

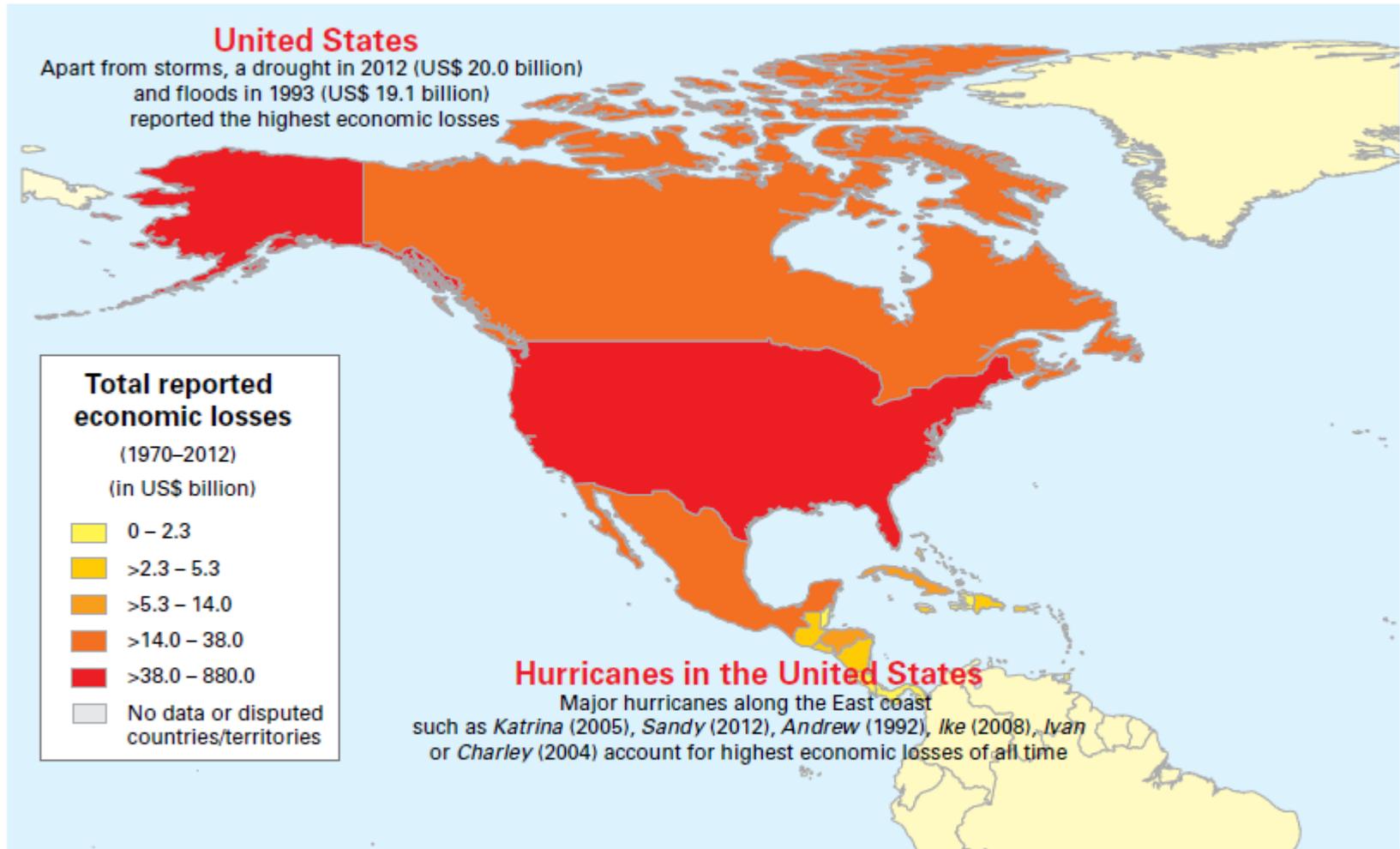


Meteorological events
(Tropical storm, extratropical storm, convective storm, local storm)

Hydrological events
(Flood, mass movement)

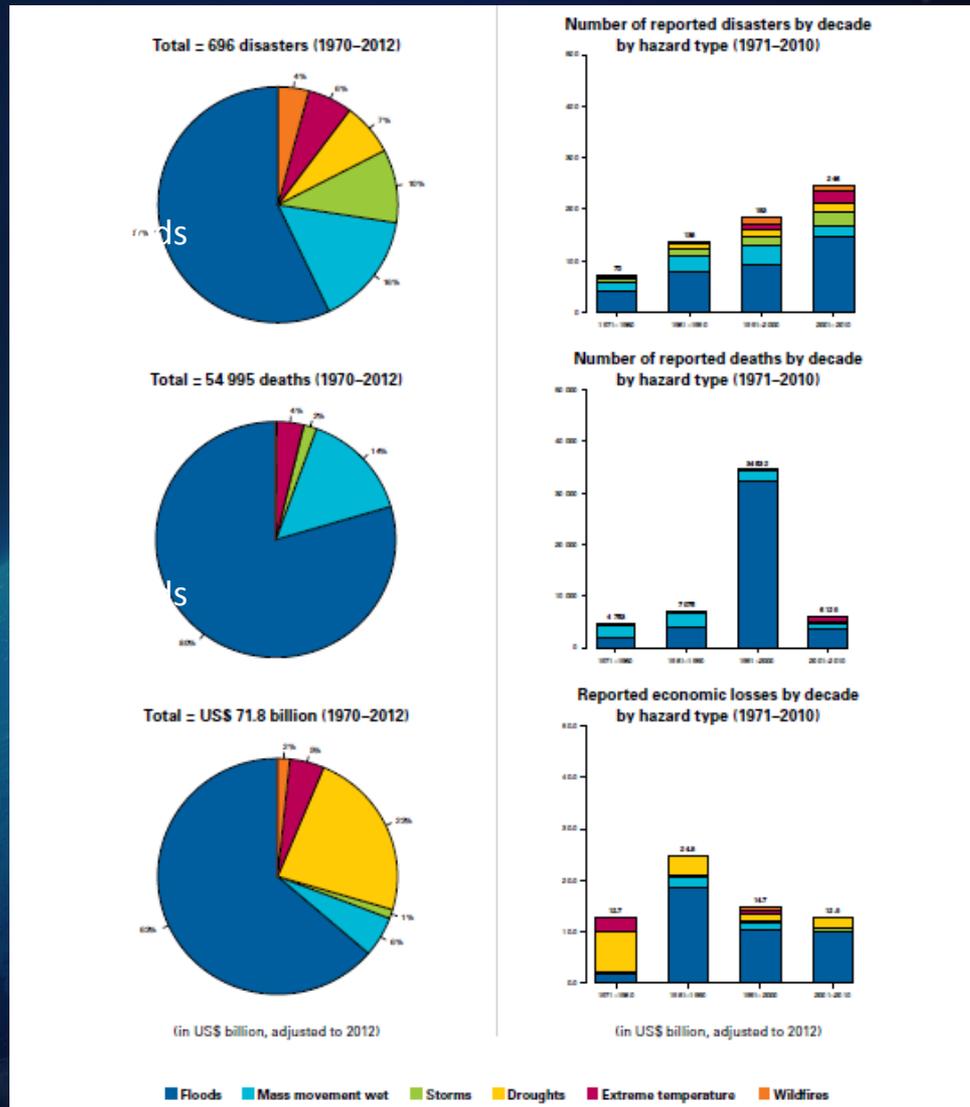
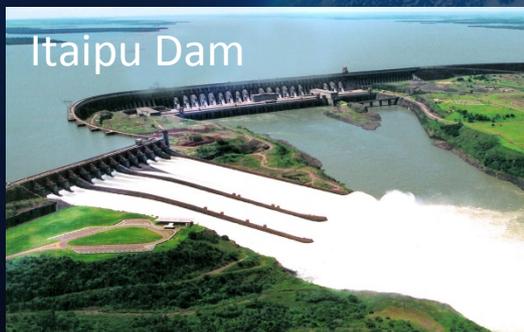
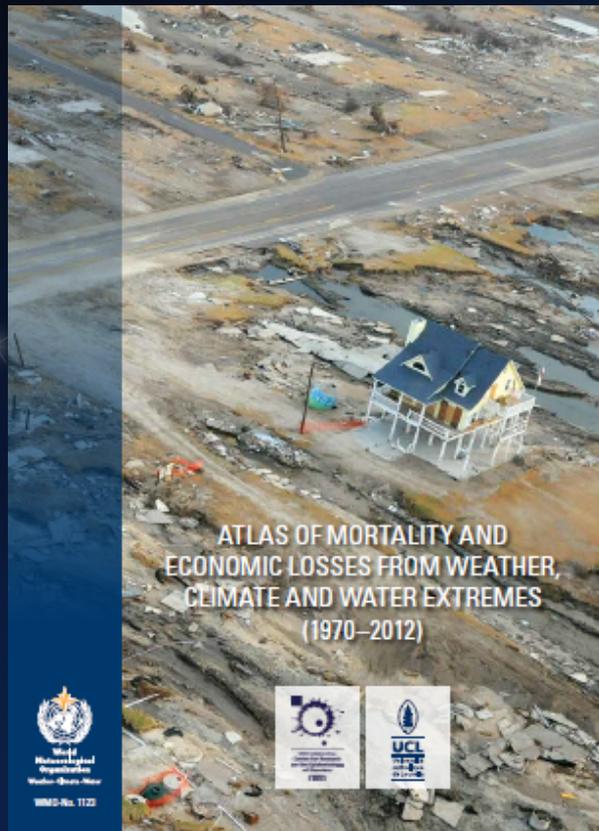
Climatological events
(Extreme temperature, drought, forest fire)

Map of reported disasters and their related economic losses (in US\$ billion, 1970–2012)



Water... Too Much or Not Enough

Losses by Hazard Type - South America



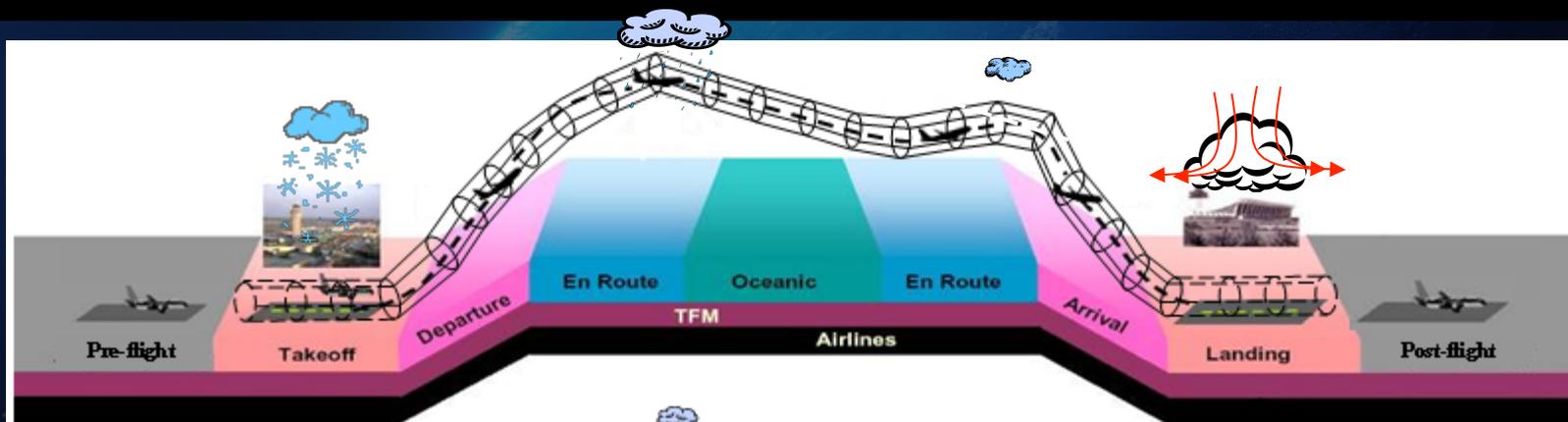
GOES-R: Helps provide advanced weather Information to enable collaborative planning and efficient utilization of airspace routes through entire trajectory

Nowcasting
Convective Initiation
NWP Forecasts
(radiances, winds, fires, profiles, clouds, etc.)

Cloud Classification
Lightning
Convective Initiation
Cloud & Moisture Imagery
Low Ceiling & Visibility
(Aerosols, clouds, dust)
Overshooting Top
Precipitation
Snow

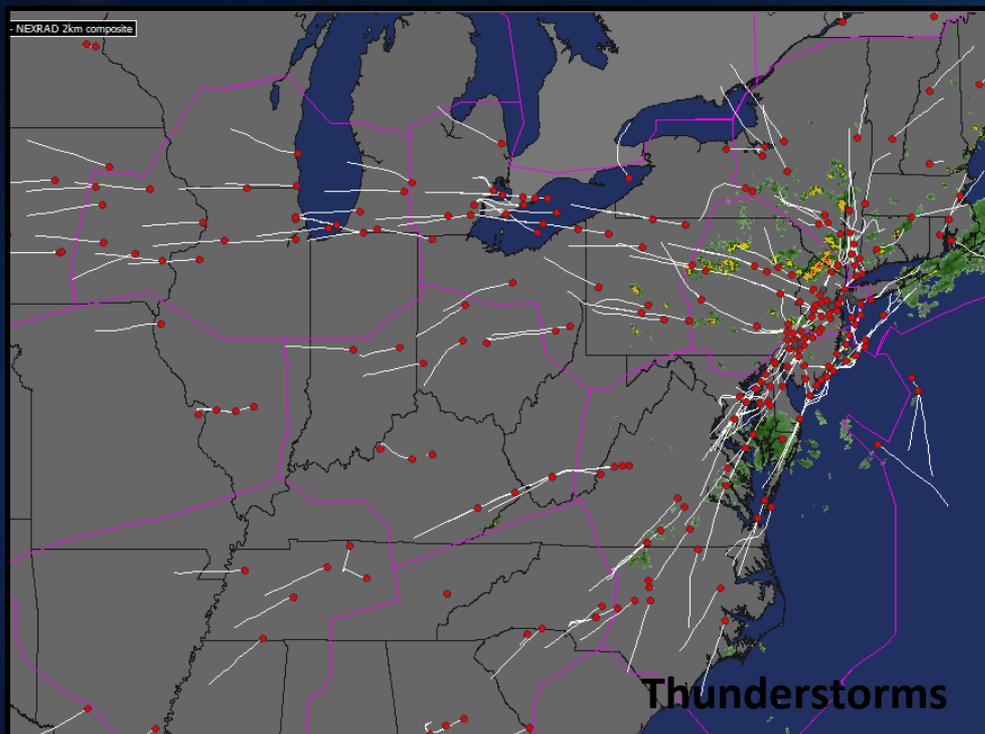
Cloud Classification, Jet Stream,
Volcanic Ash, Turbulence, Icing, Winds,
Convective Initiation
Mountain Waves
Cloud & Moisture Imagery
Cloud Top Information
SO2 Detection
Radiances

Cloud Classification
Lightning
Convective Initiation
Low Ceiling & Visibility
Overshooting Top
Icing
Precipitation
Snow



75%

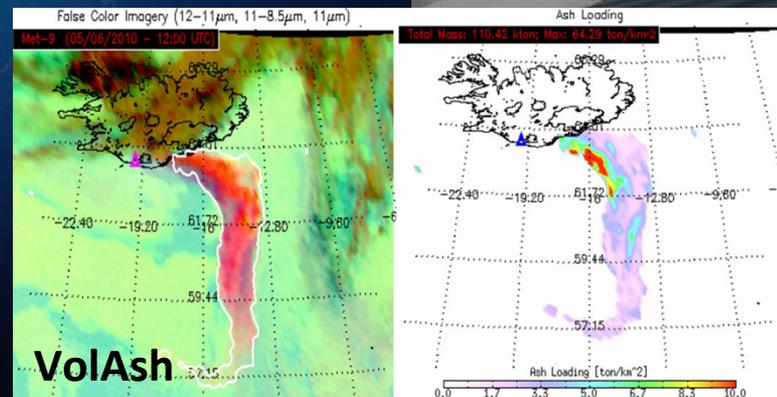
of aviation delays are due to weather



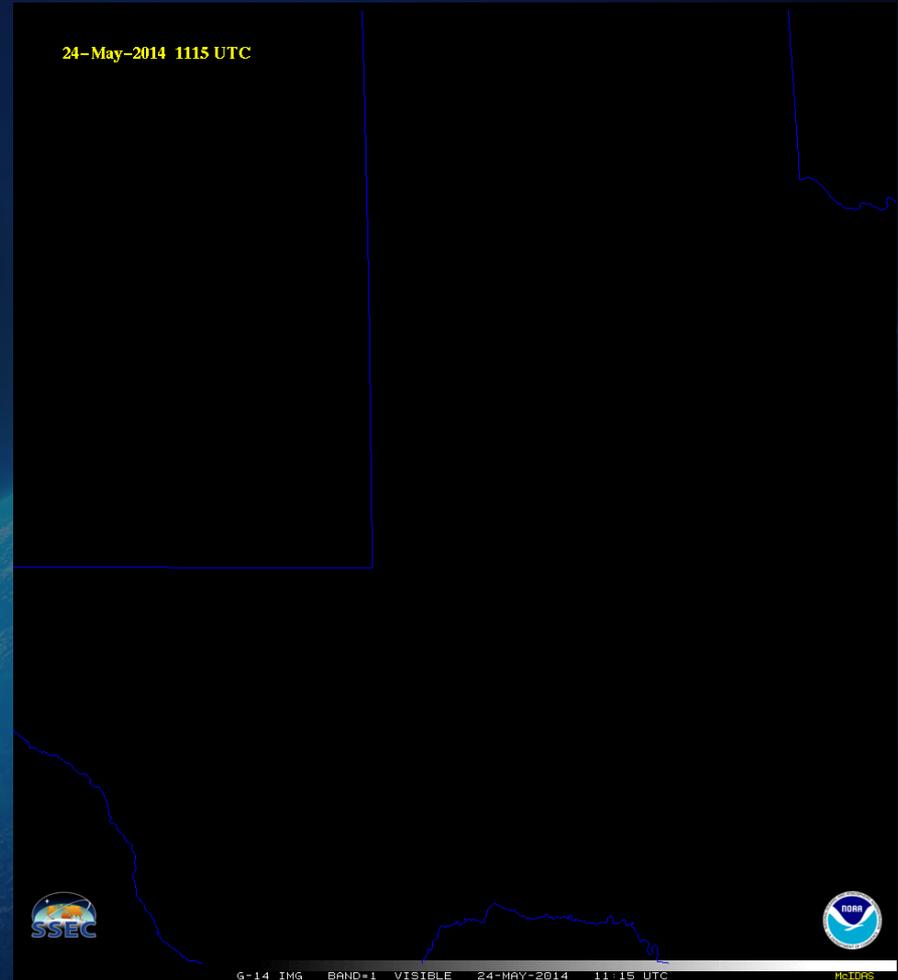
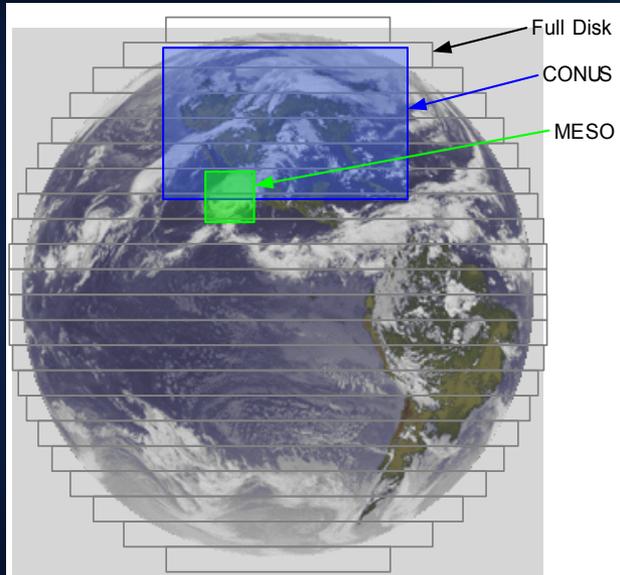
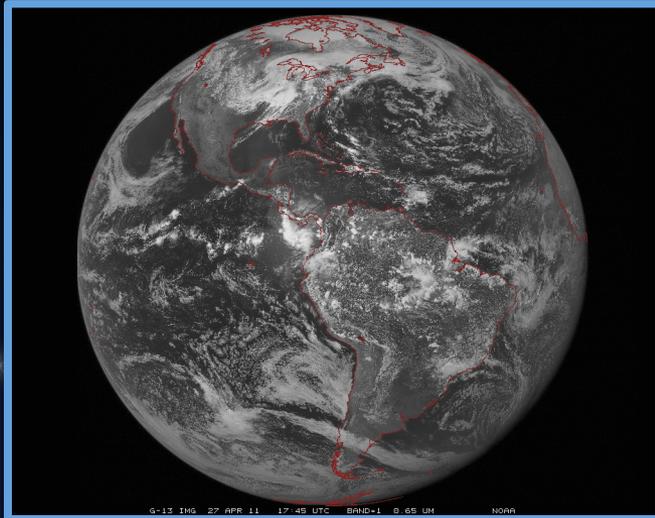
MIT Lincoln Lab



Ceiling and Visibility



Advanced Baseline Imager (ABI)



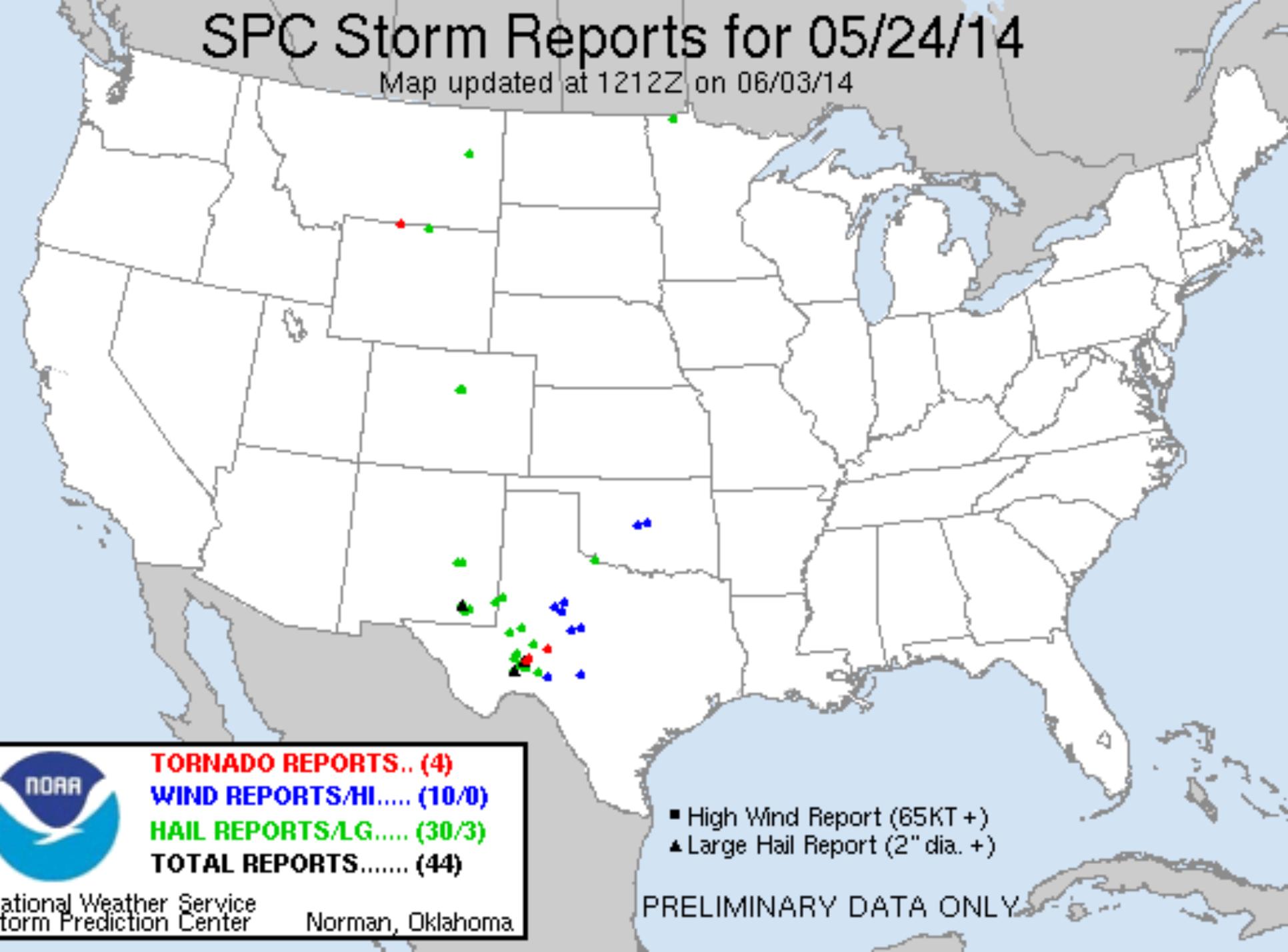
Forecasters can monitor the interactions between air masses, outflow boundaries and storms leading to increased situational awareness and confidence

Scan Mode 4- Full disk every 5 minutes

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

SPC Storm Reports for 05/24/14

Map updated at 1212Z on 06/03/14



TORNADO REPORTS.. (4)

WIND REPORTS/HI..... (10/0)

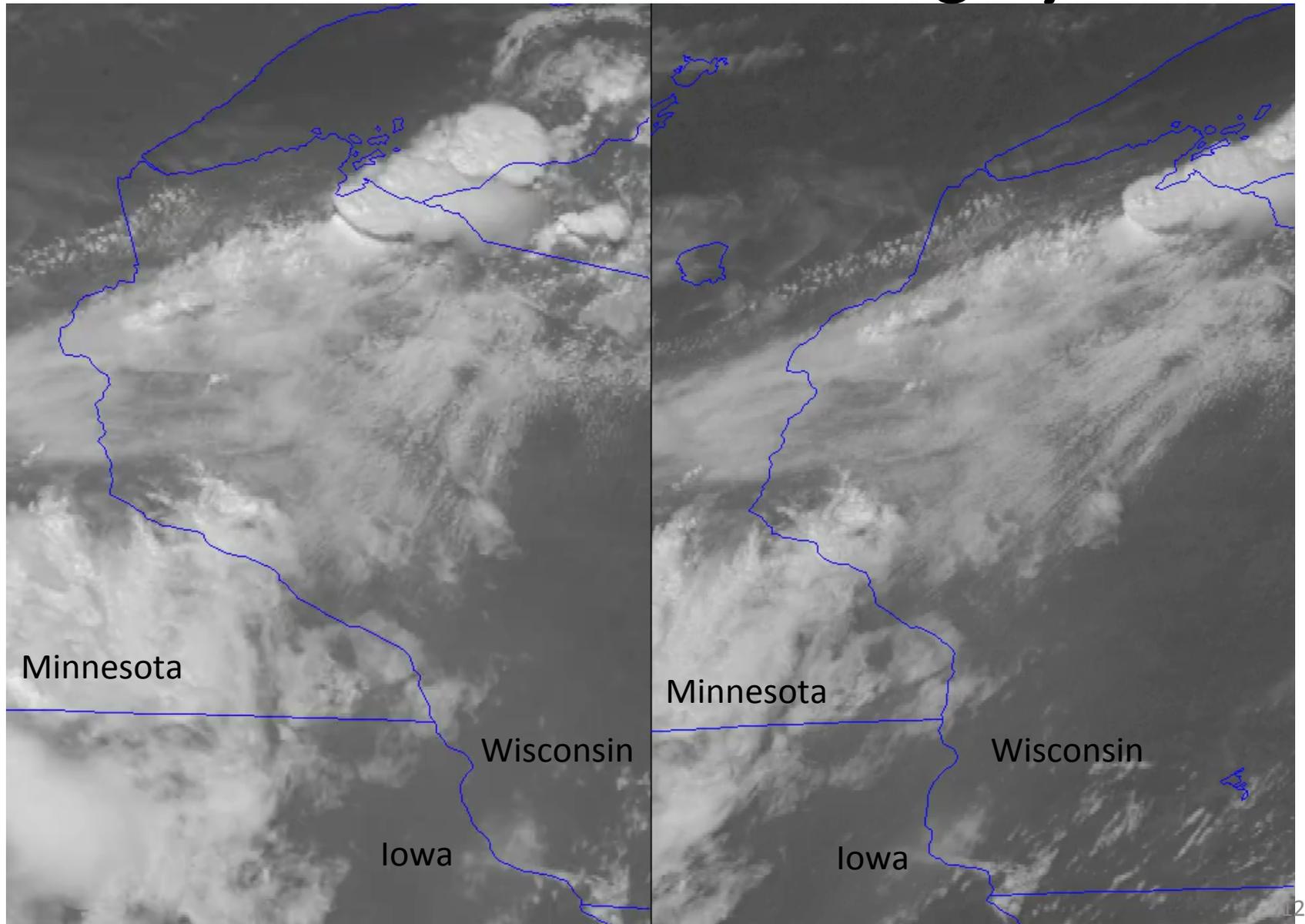
HAIL REPORTS/LG..... (30/3)

TOTAL REPORTS..... (44)

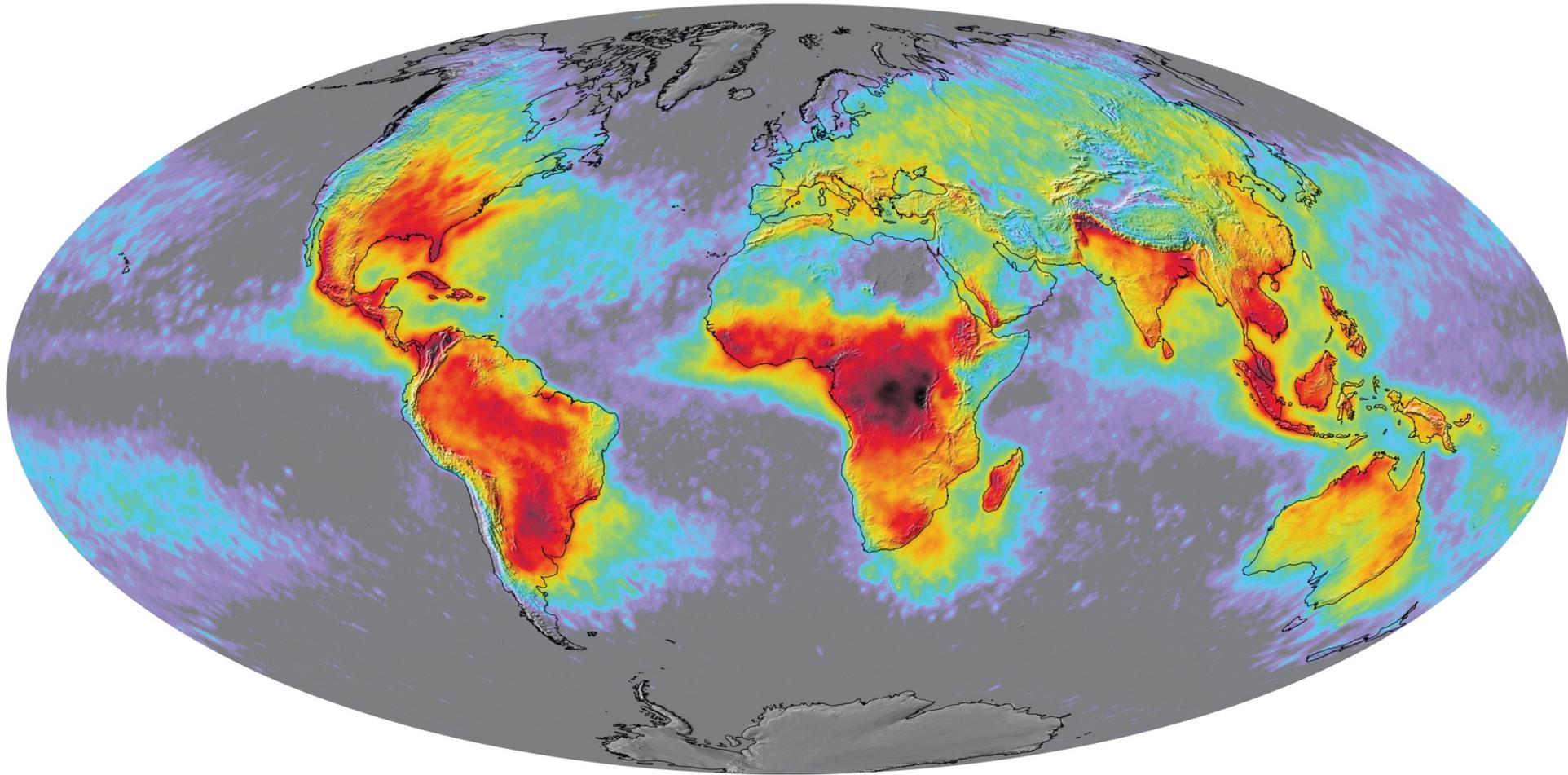
■ High Wind Report (65KT+)

▲ Large Hail Report (2" dia. +)

Future vs Current Imagery



Global Distribution of Lightning Activity



LIS Overpass
Australia

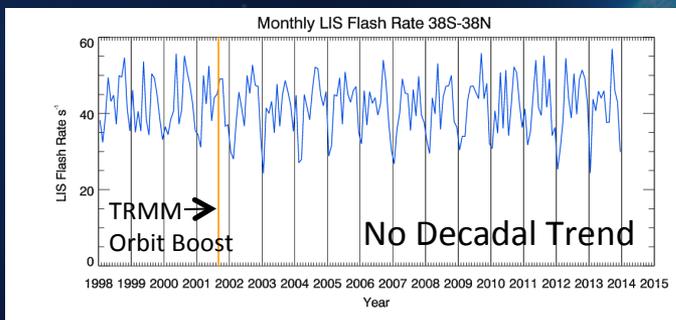
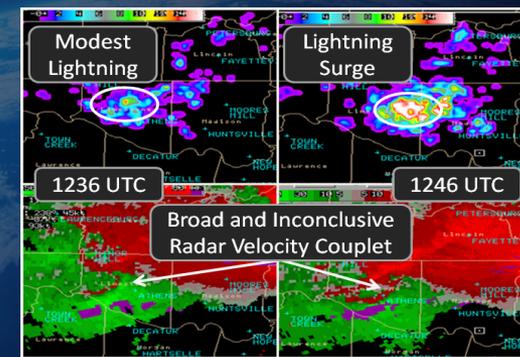
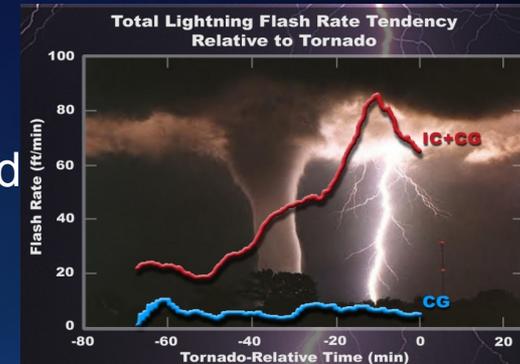


Goodman et al., 2007. Glimpses of a Changing Planet,
M. King, ed., Cambridge University Press

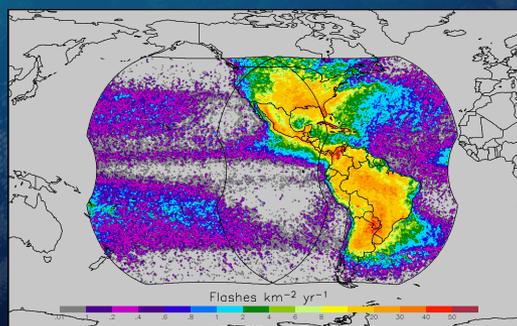
Mean annual global lightning flash rate (flashes km⁻² yr⁻¹) derived from a combined 8 years from April 1995 to February 2003. (Data from the NASA OTD instrument on the OrbView-1 satellite and the LIS instrument on the TRMM satellite.)

GLM Mission Benefits

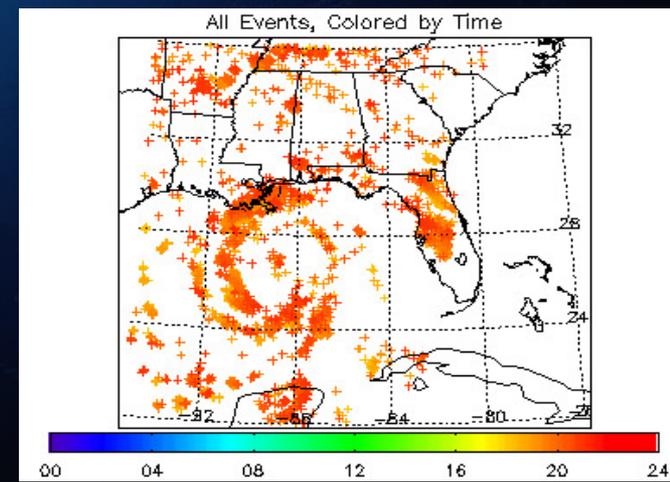
- Improved forecaster situational awareness and confidence resulting in more accurate severe storm warnings (improved lead time, reduced false alarms) to save lives and property
- Diagnosing convective storm structure and evolution
- Aviation and marine convective weather hazards
- Tropical cyclone intensity change
- Decadal changes of extreme weather – thunderstorms/lightning intensity and distribution
- GLM data latency only 20 sec



Global flash rate from LIS/OTD (1995-2014)



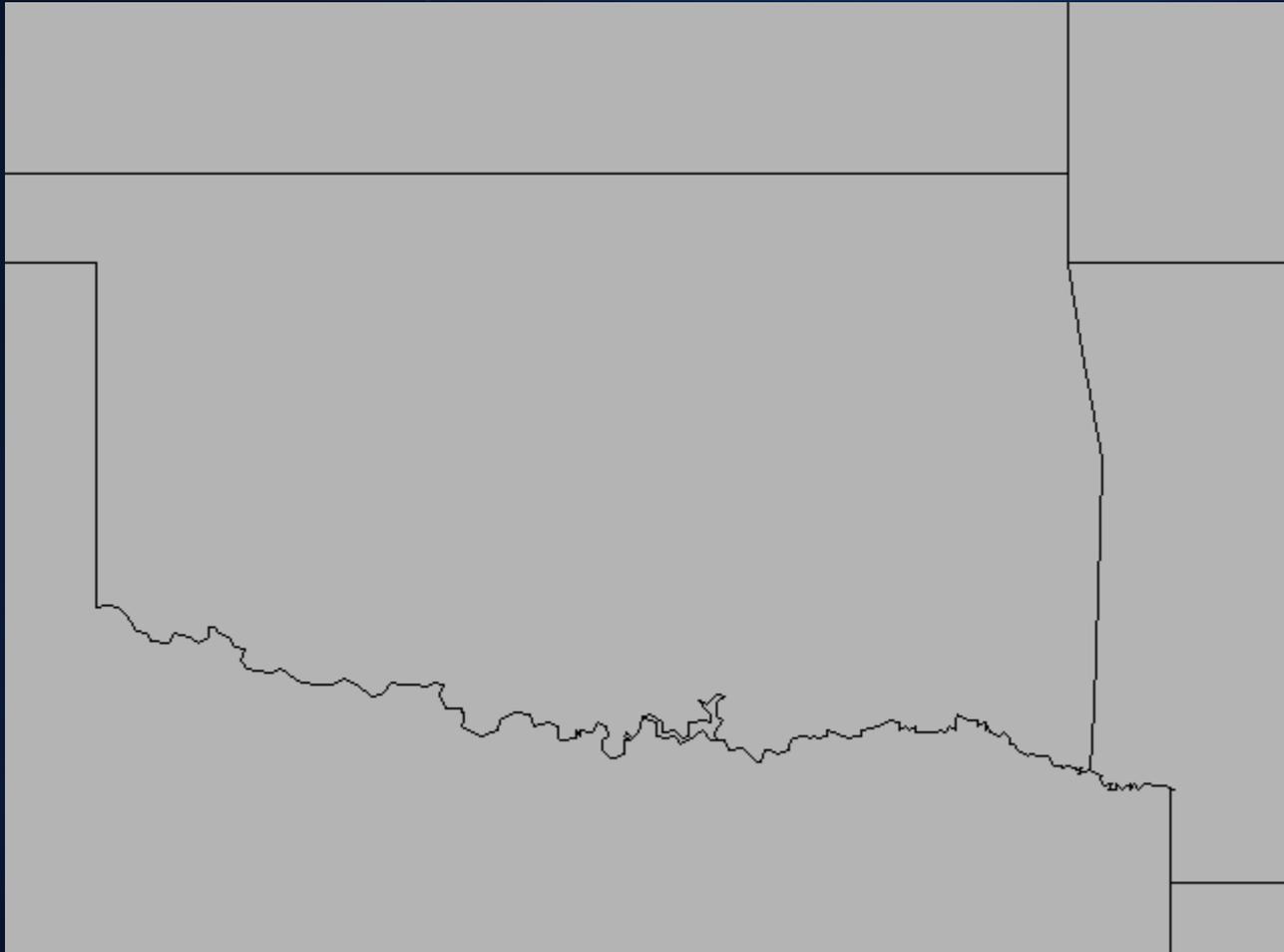
Lightning Climatology



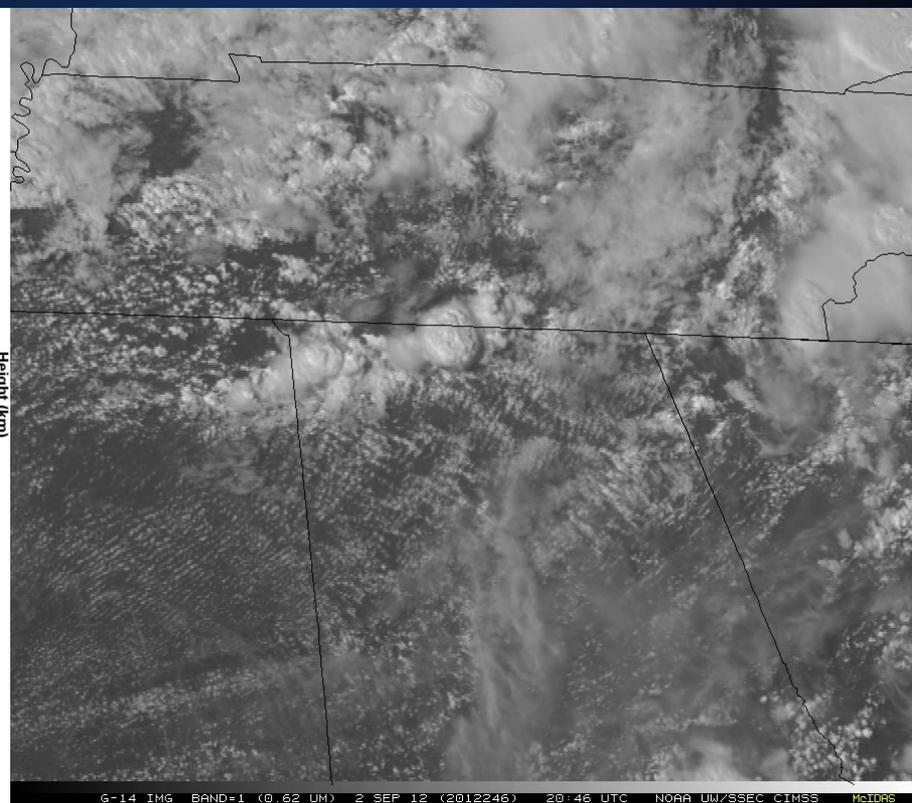
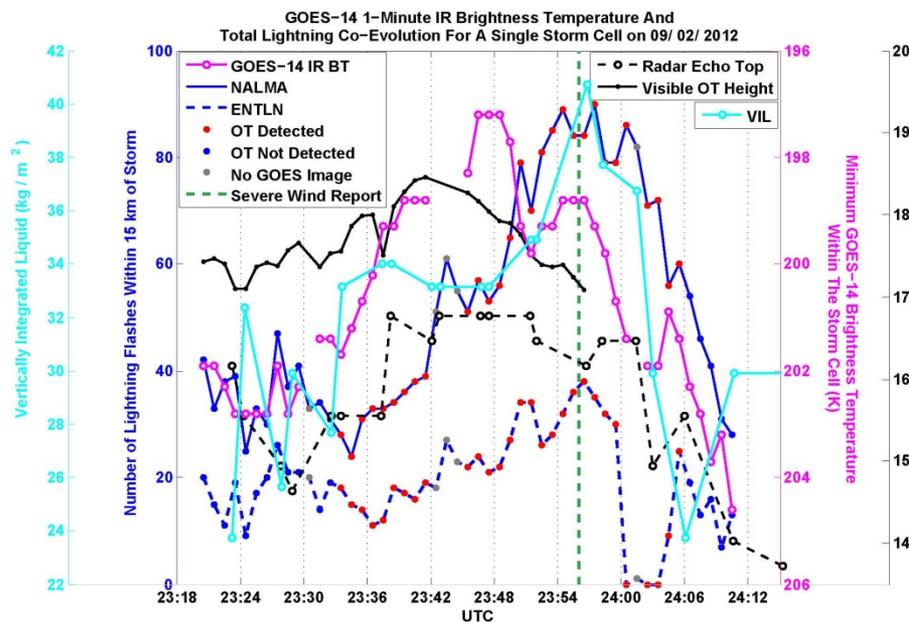
Hurricane Katrina

Total Lightning Detection

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



GOES-14 Super Rapid Scan 1-min Imagery to Prepare for GOES-R



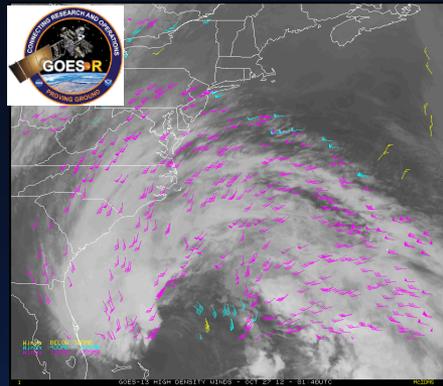
GOES-14 IR brightness temperature, GOES-R overshooting cloud top (OT) detection algorithm output, cloud-top height derived from the length of shadow produced by OT penetration above the surrounding anvil, WSR-88D derived vertically-integrated liquid (VIL) and precipitation echo top height, and total lightning from the Northern Alabama Lightning Mapping Array (NALMA) and Earth Networks Total Lightning Network (ENTLN).



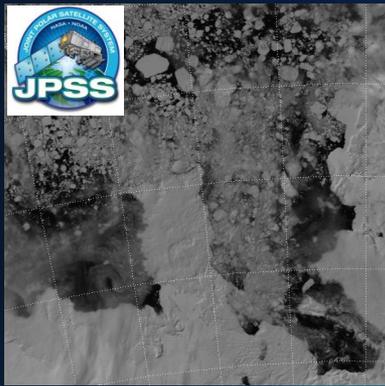
Satellite Proving Ground



Supporting demonstration and utilization of new capabilities by the end users
Facilitating the transition of GOES-R and JPSS to operations
Incorporating user feedback for product improvements

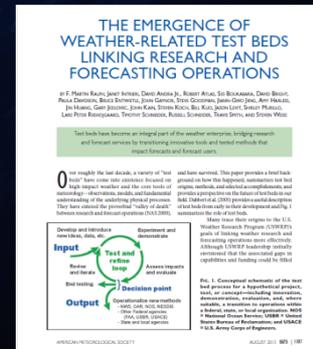
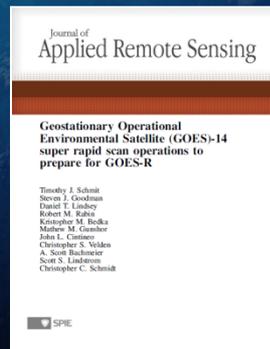
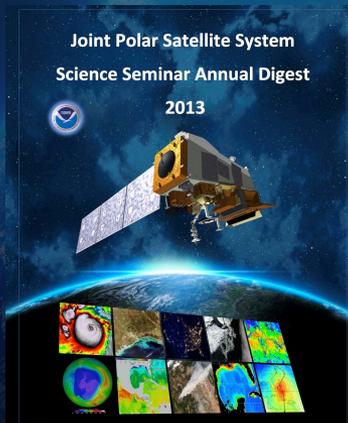
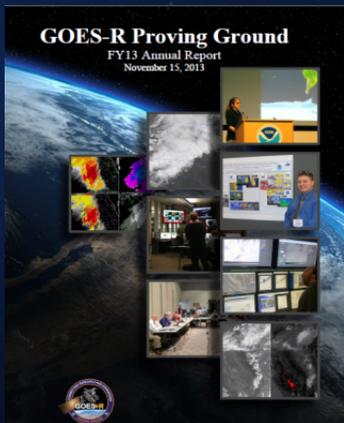


Hurricane Sandy-
GOES High Density
Atmospheric Motion Vectors



S-NPP Day/Night Band
Ice Detection

NOAA Hazardous Weather Testbed (HWT)



<http://www.goes-r.gov/users/proving-ground.html>

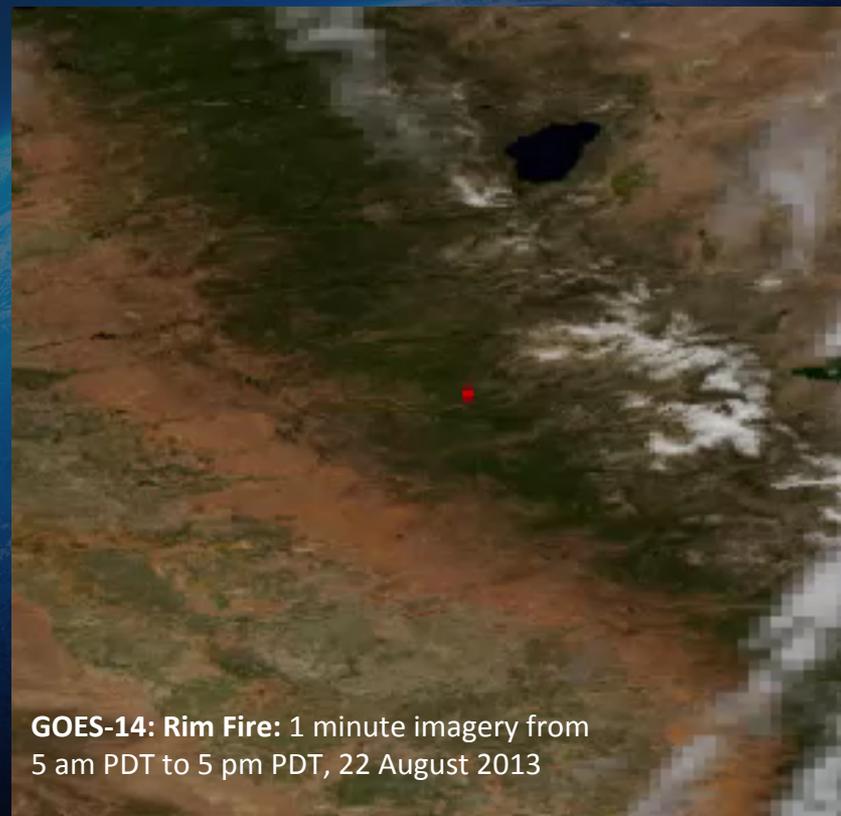


Forecaster Demonstration of 1-min Imagery

- Blog posts with SPC examples/comments on Satellite Liaison Blog:
<http://satelliteliaisonblog.wordpress.com/>
 - *“Post-storm initiation, the high-resolution data allowed for careful analysis of overshooting and collapsing tops, the character of the storm anvils (ie. health of the storm) and the identification of convectively generated outflows.”* - SPC forecaster
 - *Using cloud character and trends to diagnose boundary locations and motion, and nowcast their potential for either CI or influences on upshear storms to interact therewith.”* – SPC Forecaster
 - ***“Satellite imagery at 1-min temporal resolution needs to become the new standard for severe weather operations.”*** – SPC Forecaster
- Comments from HWT
 - All EWP survey respondents agreed that the 1-minute imagery provided additional value compared to 5- or 15- minute imagery.
 - *“It allowed you to see so much more structure/trends. You could easily see areas of subsidence as cu were squashed or boundaries where things were being enhanced.”* – Forecaster in EWP
 - *“Around great lakes looking at advection fog, I wish we had 1 minute updates so we could see how much fog is spreading inland.”* – Forecaster in EWP
 - *“Cumulus clouds growing into thunderstorms on the 1 minute imagery definitely provided lead time to when storms might develop, which is great for timing watch issuance's before the storms become severe. This is not easily observed with the 5 minute or longer visible imagery.”* - EFP

262,000

wildland fires since 2010 burned 26,000,000 acres



GOES-14: Rim Fire: 1 minute imagery from 5 am PDT to 5 pm PDT, 22 August 2013

Source: National Interagency Fire Center

2014 NHC Proving Ground Goals

- Maintain routine use of long-term RGB and image combination products
 - Air Mass, Dust, SAL, Pseudo Natural Color, Natural Color
- Provide exposure to new RGB and image products
 - VIIRS Day/Night Band, Convective Storms RGBs
- Continued quantitative evaluations of HIE and lightning-based Rapid Intensification Index
- Determine utility of 1-min data (e.g., center fixing at daylight)
- Use PG to help decide on NHC operational product suite
 - Compare lightning strike and lightning density products
 - Standard EUMETSAT Dust versus CIRA DEBRA product
- Informal introduction to new products if possible
 - ATMS storm environment soundings
 - Aerosol optical depth



NHC Tropical Cyclone Cristina

Discussion

June 10, 2014

CZC MIATCDEP3 ALL
TTAA00 KNHC DDHHMM

TROPICAL STORM CRISTINA DISCUSSION NUMBER 6
NWS NATIONAL HURRICANE CENTER MIAMI FL EP032014
800 PM PDT TUE JUN 10 2014

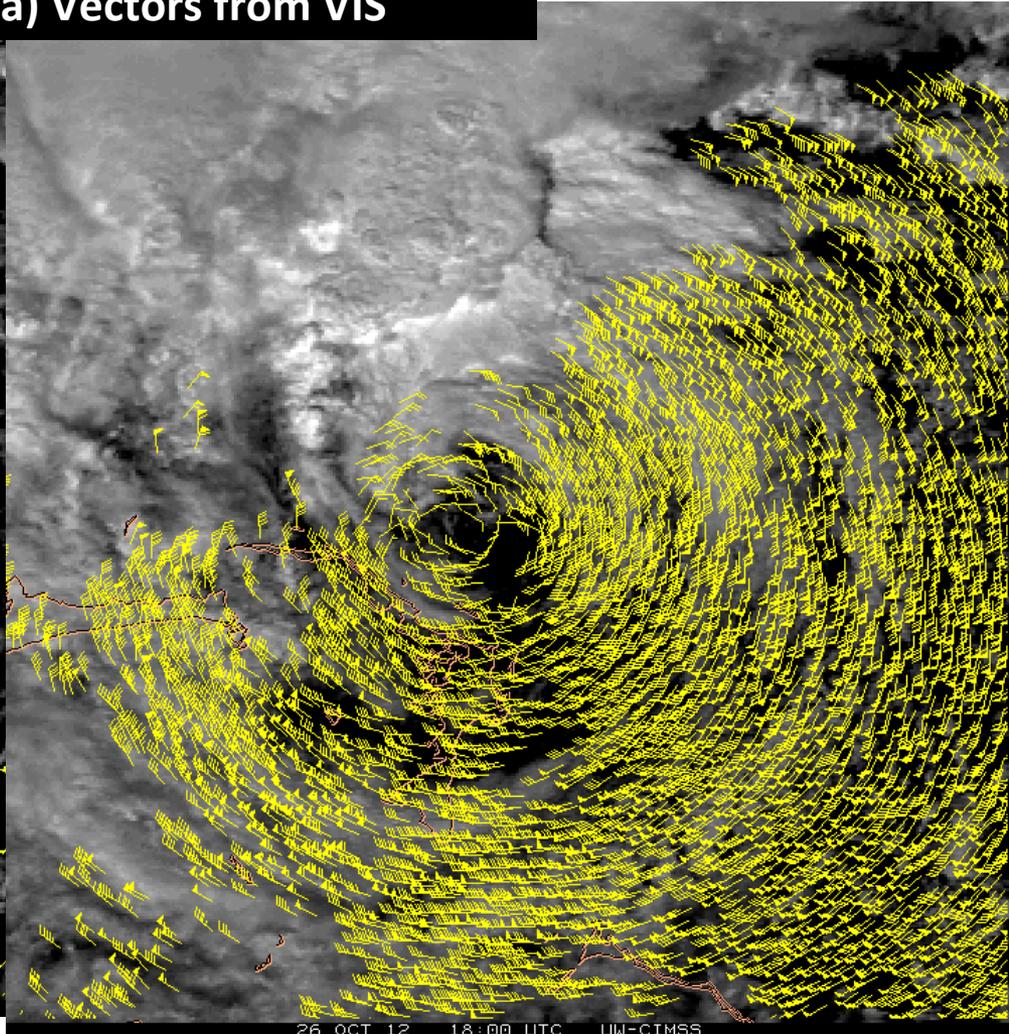
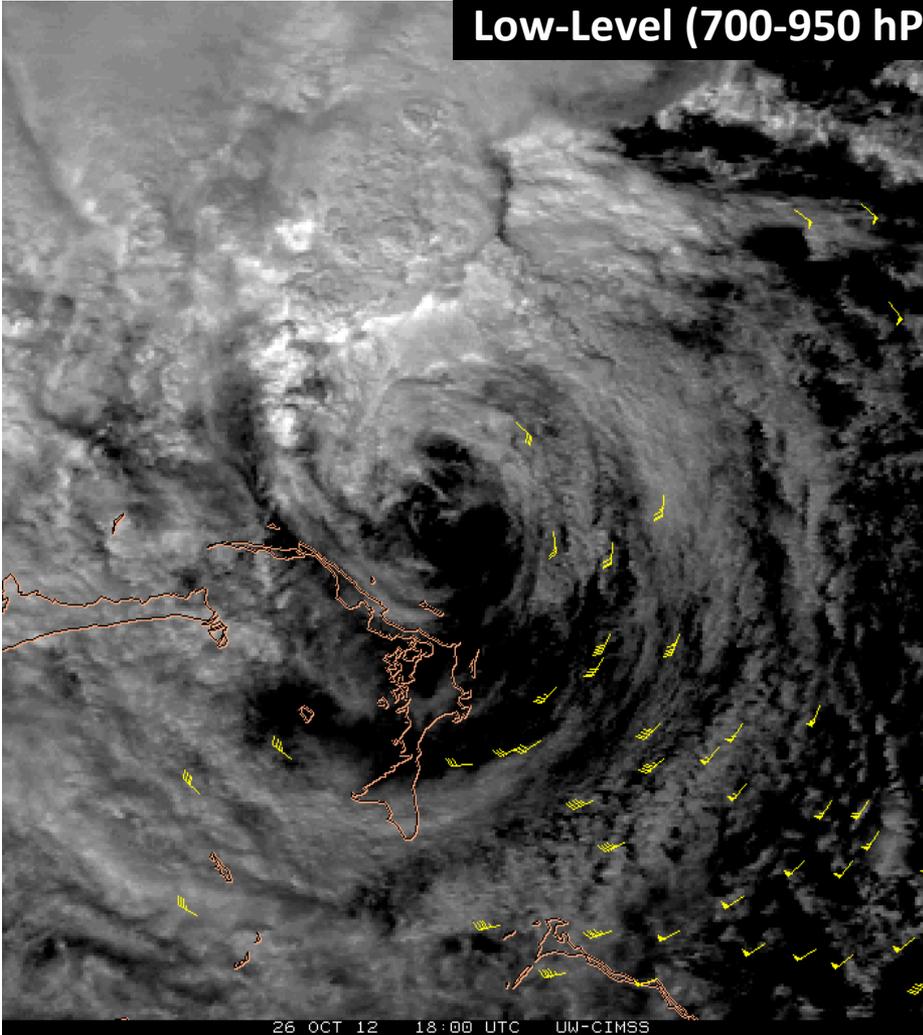
Cristina is intensifying this evening. The compact central dense overcast has become more circular, and hints of an eye have been apparent in geostationary satellite images. The initial intensity is increased to 55 kt, in agreement with unanimous Dvorak classifications of 3.5/55 kt from TAFB, SAB, and UW-CIMSS ADT.

Although the curved bands beyond the inner-core region remain fragmented, a considerable amount of lightning has been occurring in a rain band located about 120 n mi to the south-southwest of the center. Recent research has documented that lightning in the outer bands of the tropical cyclone circulation is often a precursor of significant intensification. The only apparent factor that could limit strengthening during the next couple of days is mid-level dry air, which has been an issue for Cristina during the past day or so. In about 3 days, Cristina is expected to move into an environment of stronger southwesterly shear and over cooler waters, which should end the strengthening trend and cause the cyclone to weaken. The NHC intensity forecast is slightly higher than the previous one, and

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)

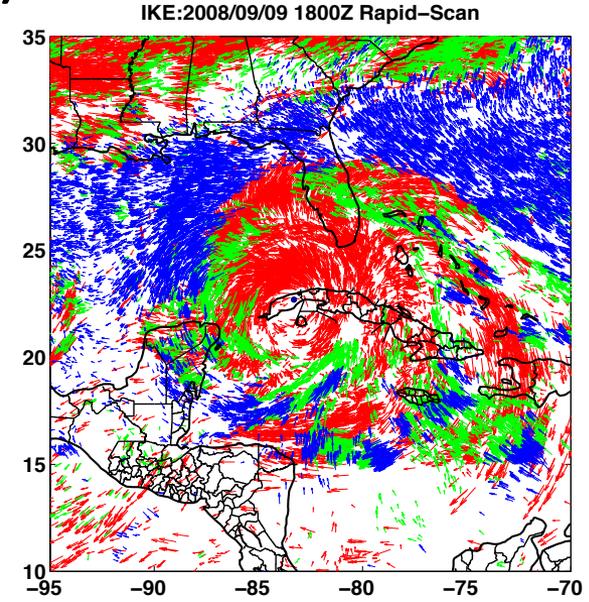
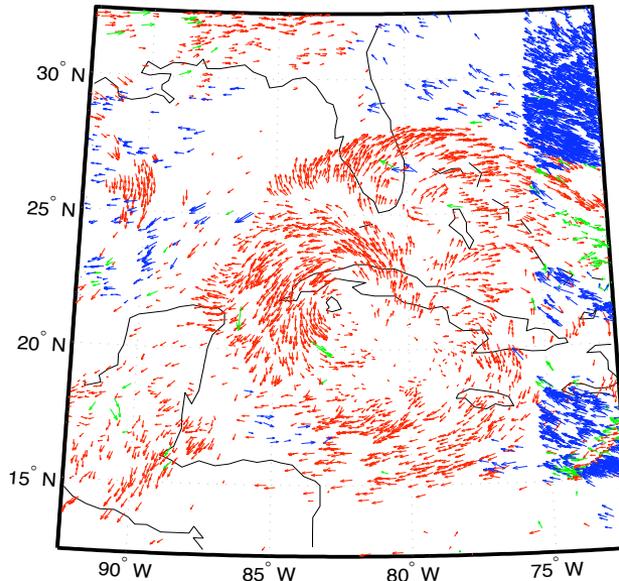
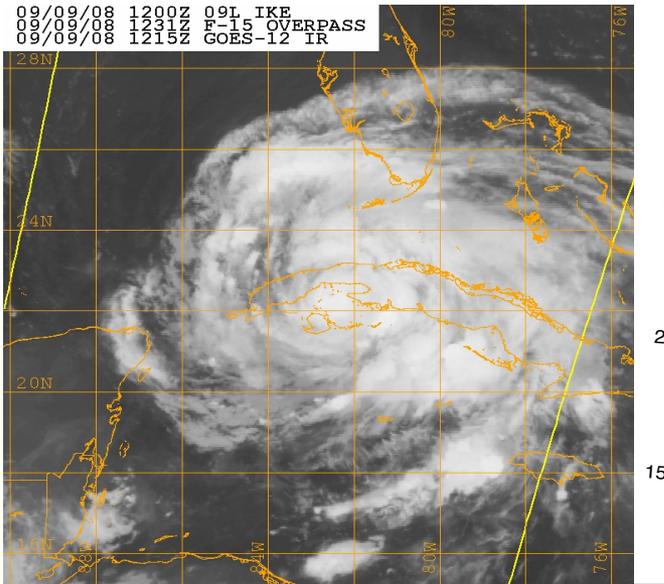
AMVs from **1-min images** (meso **GOES-R** sampling)

1800 UTC 26 Oct, 2012

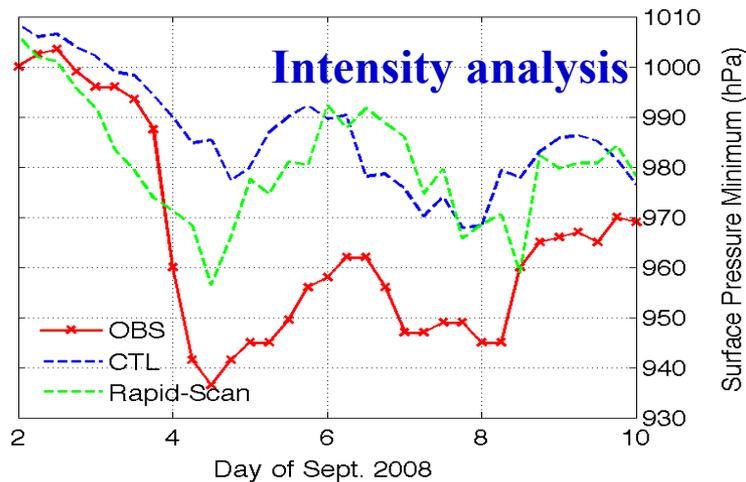
C. Velden (CIMSS)

Influence of Assimilating High-resolution Satellite-Derived Winds on Mesoscale Analyses and Forecasts of Tropical Cyclones

-- Example: Hurricane Ike (2008) --



$P \leq 350$ hPa $350 < P \leq 800$ hPa $P > 800$ hPa



Above: As a proxy for GOES-R 5-minute imagery, GOES-East rapid-scan imagery (7-min) is used to derive winds. The coverage vs. normally-available winds is substantially increased over Hurricane Ike.

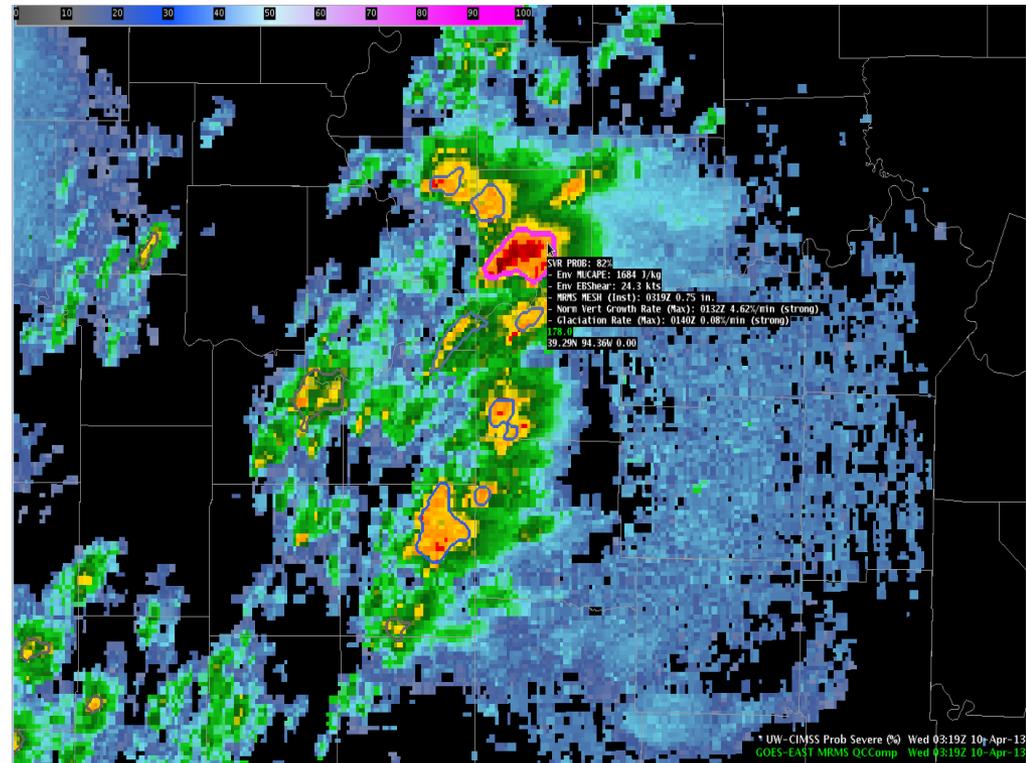
Left: Assimilation of the rapid-scan winds into the mesoscale DART/WRF system produces superior analyses of Hurricane Ike's intensity (OBS) over a Control (CTL) without the winds. *C. Velden, CIMSS*



Probabilistic Forecasting of Severe Convection through Data Fusion



- GOES-derived cloud growth rates, NEXRAD-derived products, and NWP-derived fields are used as input into a statistical model to compute the probability that a storm will first produce severe weather in the near-term
- Satellite and radar object-tracking are used to keep a history of storm development
- FY15-16 R3 project will investigate total lightning data and additional NWP sources, as well as advantages to be gained using super-rapid scan data
- The product display will complement NWS warning operations
- The product will be evaluated in testbeds and proving ground experiments

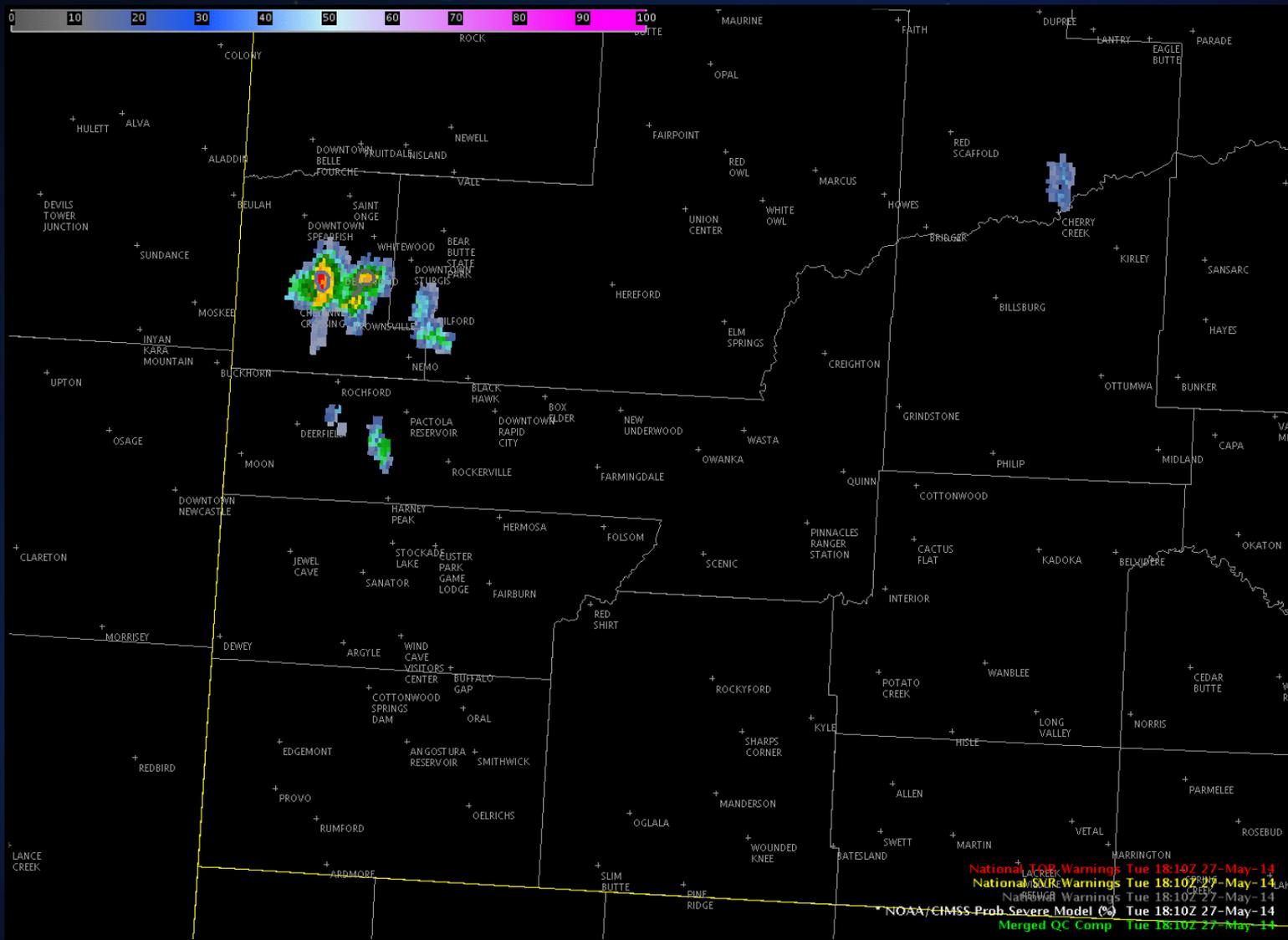


Merged radar reflectivity with model probability of severe contours. The highlighted storm had strong satellite growth rates, contributing to a high probability prior to severe hail occurrence. No warning was issued.

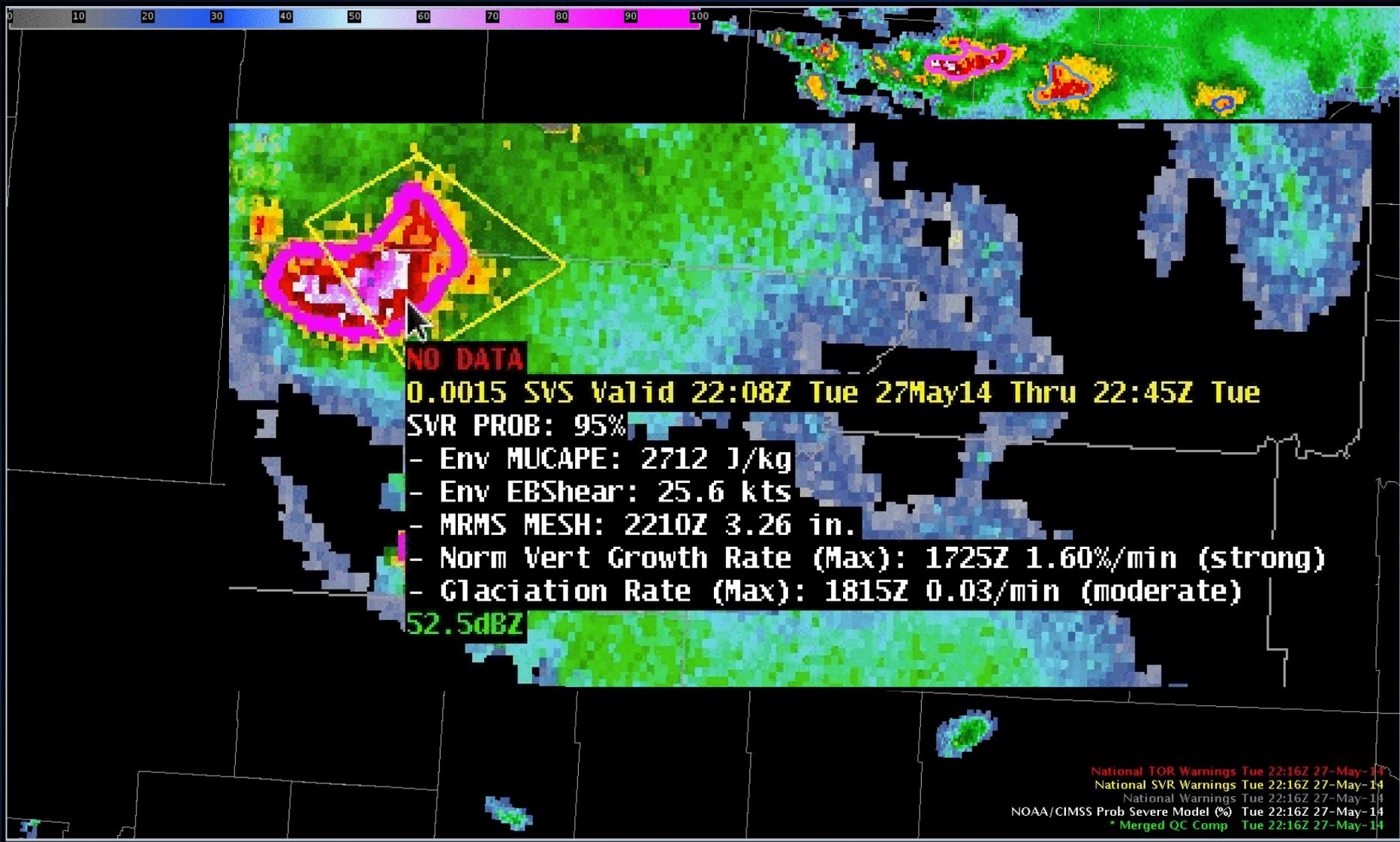
Help NWS forecasters skillfully increase warning lead time to severe hazards

M. Pavolonis (STAR/ASPB) and J. Cintineo (UW-CIMSS), J. Sieglaff (UW-CIMSS), D. Lindsey (STAR/RAMMB), D. Bikos (CSU-CIRA)

Probability of Severe Convection



Probability of Severe Convection





Summary

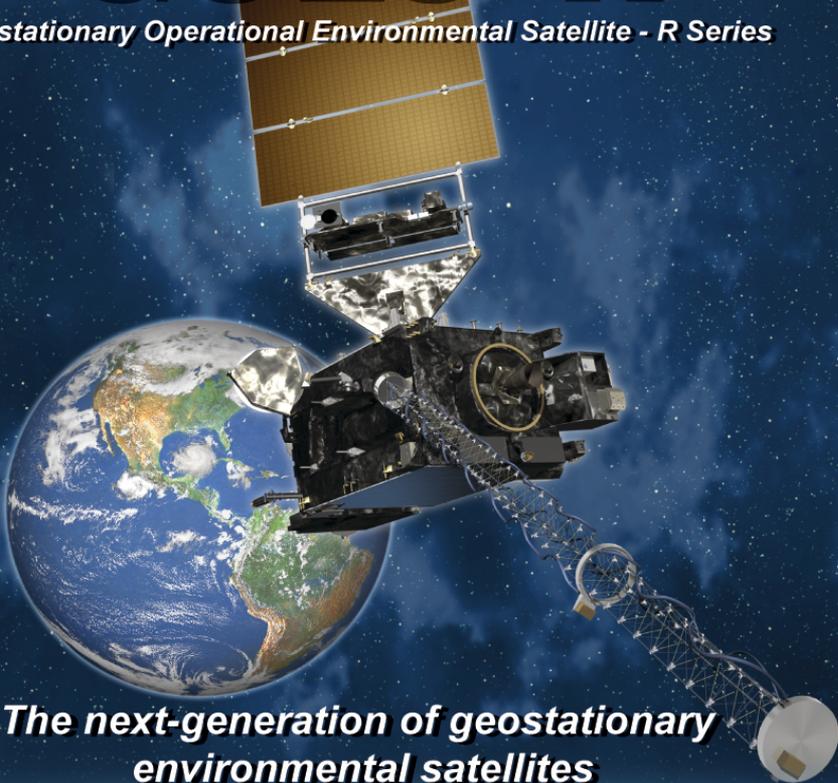


- GOES-R is coming - Launch early 2016
- New sensors, products, and services will help improve forecasts and increase lead times for warnings and decision makers
- Presents Challenges and Opportunities for model assimilation, data fusion and tools- hierarchical clustering, stochastic oscillators, ensemble NWP
- Product testing as soon as 2 months post-launch, also available to users for science assessment
- User preparation is essential to take advantage of the advanced capabilities to support a Weather Ready Nation - Hemisphere - World



GOES-R

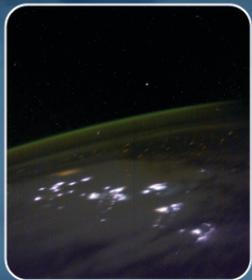
Geostationary Operational Environmental Satellite - R Series



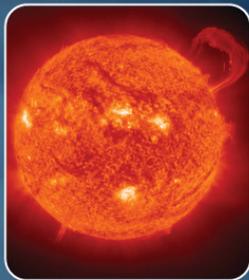
The next-generation of geostationary environmental satellites



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

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