

Accelerating User Readiness for the Next Generation of Geostationary Operational Satellites



**Steve Goodman** 

NOAA/ NESDIS/ GOES-R Program Office

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## Outline

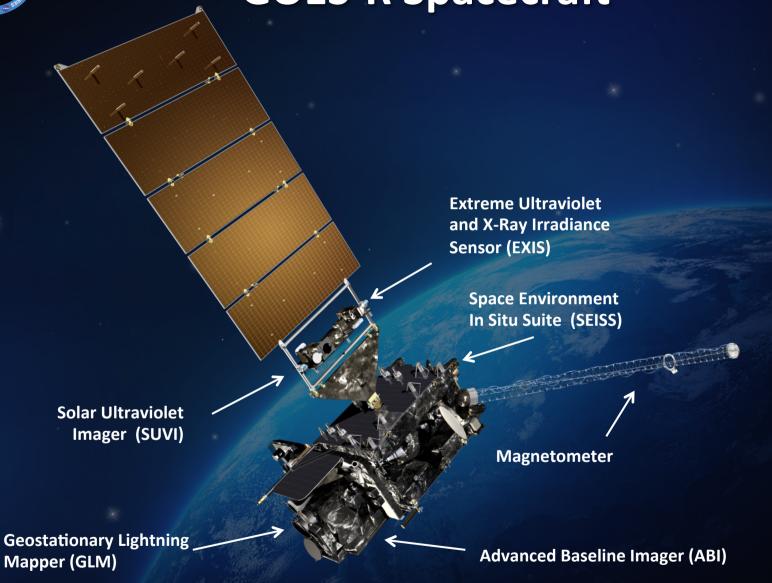
- GOES-R Mission and Products
- GOES-R Proving Ground Demonstrations
- Training
- Summary



## **GOES-R Spacecraft**









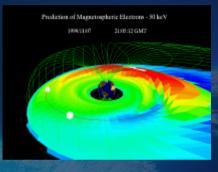
## **Mission Objectives - Why GOES-R?**



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



Floshes km<sup>-2</sup> yr<sup>-1</sup>





Visual & IR Imagery

**Lightning Mapping** 

Space Weather Monitoring

Solar Imaging

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

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



### **GOES-R ABI Products**



### **Baseline Products**

#### **Advanced Baseline Imager (ABI)**

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 Capabilities**

#### Advanced Baseline Imager (ABI)

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)

SO<sub>2</sub> Detection Surface Albedo Surface Emissivity

Tropopause Folding Turbulence Prediction Upward Longwave Radiation: Surface Upward Longwave Radiation: TOA

Vegetation Fraction: Green

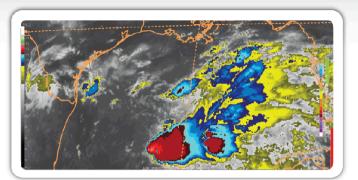
Vegetation Index

Visibility

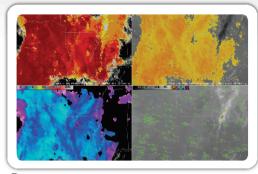


## **The GOES-R Proving Ground**

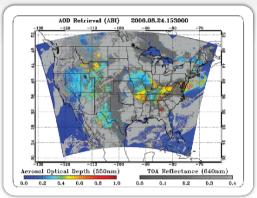




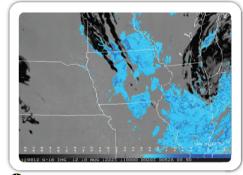
AWC - Kansas City, MO IR Imagery of Oceanic Storms



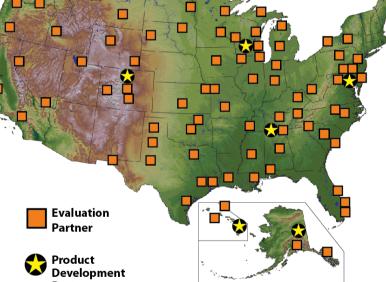
CIMSS/STAR – Madison, WI Fog/Low Cloud Product



STAR/UMBC - College Park, MD Aerosol Optical Depth

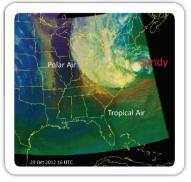


CIRA/STAR – Ft. Collins, CO ABI Synthetic Low Cloud Enhancement Imagery





SPORT/NASA – Huntsville, AL **GLM Lightning Density** 



NHC -Miami, FL **RGB Air Mass** for Hurricane Sandy



Severe Storms 1-Min Visible Imagery of Overshooting Tops



## **GOES-R Proving Ground**



#### THE GOES-R PROVING GROUND

Accelerating User Readiness for the Next-Generation Geostationary Environmental Satellite System

BY STEVEN I. GOODMAN, IAMES GURKA, MARK DEMARIA, TIMOTHY I. SCHMIT, ANTHONY MOSTEK, GARY JEDLOVEC, CHRIS SIEWERT, WAYNE FELTZ, JORDAN GERTH, RENATE BRUMMER, STEVEN MILLER, BONNIE REED, AND RICHARD R. REYNOLDS

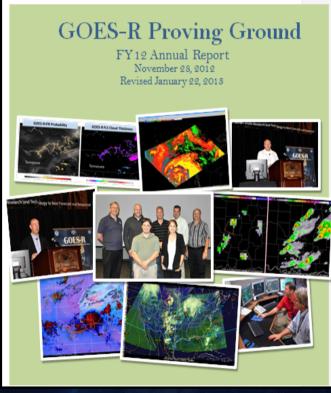
By demonstrating the advanced capabilities of the next generation of geostationary satellites, the proving ground addresses user readiness and the research-to-operations-to-research loop.

he Geostationary Operational Environmental Service (NWS) Weather Forecast Offices (WFOs); Satellite R series (GOES-R) Proving Ground NWS National Centers for Environmental Predic-

for the next go ronmental sate development b Space Admini Oceanic and Atr with NASA re (spacecraft and for the overall GOES-R PG i GOES-R Progr Institutes; NAS and Transition

AFFILIATIONS: Go Program Office, Green NESDIS/Center for Sal Collins, Colorado: Sci Applications and Rese National Weather Serv Short-Term Prediction Alahama: Sigwest-Co logical Studies, Norma BRUMMER AND MILLER-Atmosphere, Fort Coll

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College Park, MD

**Final Report** 

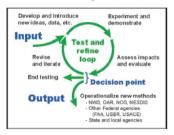
#### THE EMERGENCE OF WEATHER-RELATED TEST BEDS LINKING RESEARCH AND

BY F. MARTIN RALPH, JANET INTRIERI, DAVID ANDRA JR., ROBERT ATLAS, SID BOUKABARA, DAVID BRIGHT, PAULA DAVIDSON, BRUCE ENTWISTLE, JOHN GAYNOR, STEVE GOODMAN, JIANN-GWO JIING, AMY HARLESS, JIN HUANG, GARY JEDLOVEC, JOHN KAIN, STEVEN KOCH, BILL KUO, JASON LEVIT, SHIRLEY MURILLO, LARS PETER RIISHOIGAARD, TIMOTHY SCHNEIDER, RUSSELL SCHNEIDER, TRAVIS SMITH, AND STEVEN WEISS

Test beds have become an integral part of the weather enterprise, bridging research and forecast services by transitioning innovative tools and tested methods that impact forecasts and forecast users

meteorology-observations, models, and fundamental provides a perspective on the future of test beds in our They have entered the proverbial "valley of death" of test beds from early in their development and Fig. 1 between research and forecast operations (NAS 2000),

ver roughly the last decade, a variety of "test" and have survived. This paper provides a brief backbeds" have come into existence focused on ground on how this happened; summarizes test bed high-impact weather and the core tools of origins, methods, and selected accomplishments; and understanding of the underlying physical processes. field. Dabbert et al. (2005) provides a useful description



Many trace their origins to the U.S. Weather Research Program (USWRP)'s goals of linking weather research and forecasting operations more effectively. Although USWRP leadership initially envisioned that the associated gaps in capabilities and funding could be filled

FIG. 1. Conceptual schematic of the test bed process for a hypothetical project. tool, or concept-including innovation, demonstration, evaluation, and, where suitable, a transition to operations within a federal, state, or local organization. NOS = National Ocean Service; USBR = United States Bureau of Reclamation; and USACE U.S. Army Corps of Engineers.

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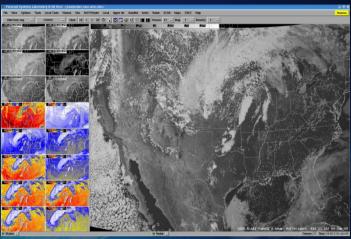
## Introducing NWS Forecasters to Prototype GOES-R Products



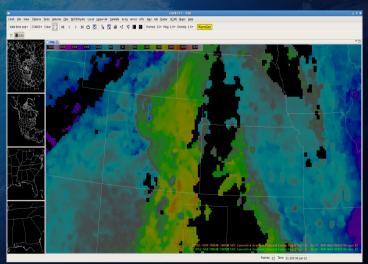
- Synthetic GOES-R Products representing ABI were demonstrated at the Hazardous Weather Testbed and other NOAA testbeds
- Synthetic GOES-R products can help increase forecaster utilization on day one

"Synthetic WRF imagery can enhance forecasts by providing model data in a familiar satellite format which makes model analysis, model comparison to obs and model forecast projections easier to visualize and understand"

Facilitates user training



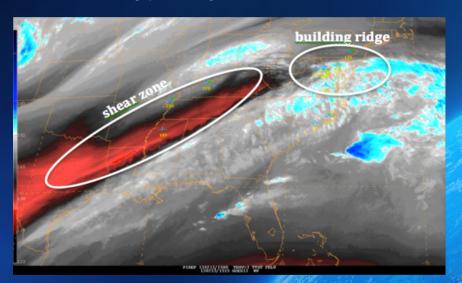
Simulated ABI bands in AWIPS



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

## Simulated Cloud and Moisture Imagery

The simulated imagery was praised for picking up not only the intense shear zone over the southern Mississippi Valley, but also the 'notches and bumpiness' in the building ridge over the Mid-Atlantic, both of which are features typically associated with moderate or great turbulence events.





**AWC Demo.** 20130213 1515 UTC. Strong jet with core winds > 150 kts, (left) GOES-13 water vapor and 1500 UTC MOG turbulence PIREPs, (right) 1500 UTC NSSL-WRF simulated water

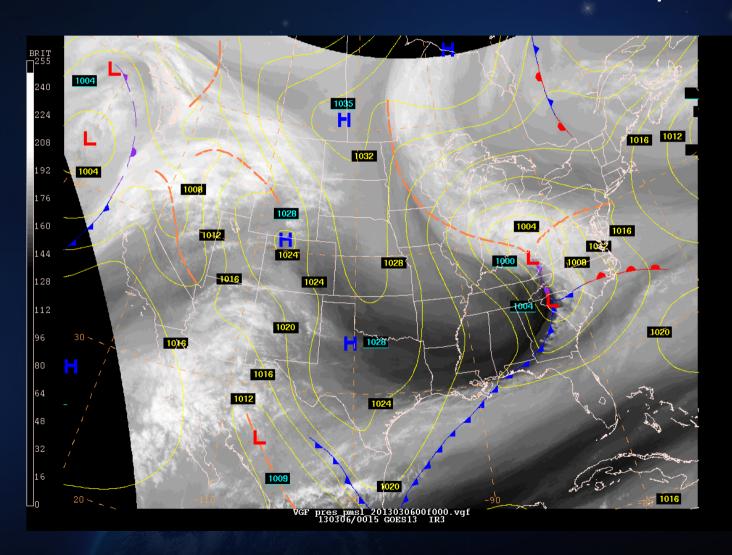
"It was very helpful in determining the signatures associated with moderate or greater turbulence events."





## March 6 & 7, 2013 Nor'easter

GOES-13 WV overlaid with WPC sfc analyses

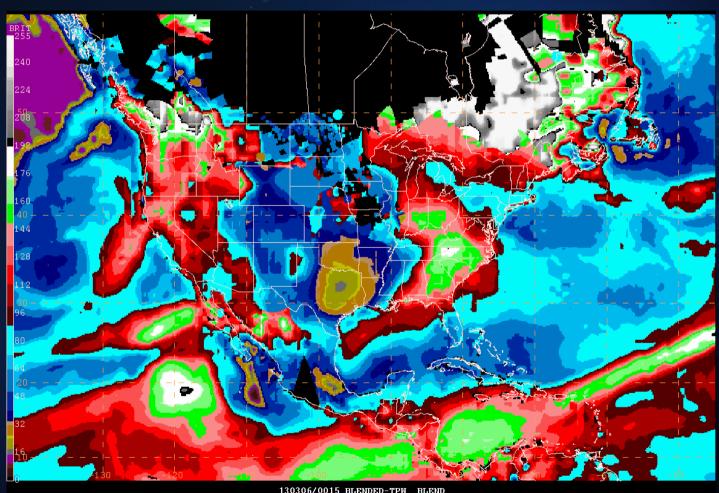






## March 6 & 7, 2013 Nor'easter

Blended Total Precipitable Water Percent of Normal

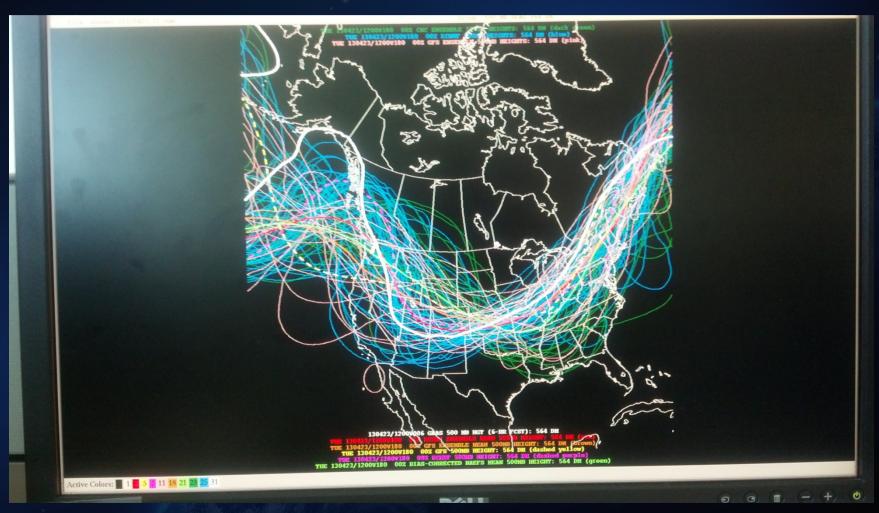






## **Medium Range Forecast Issues**

Spaghetti Plot of the 564 DM Height Line



Courtesy of Michael Schichtel (WPC)



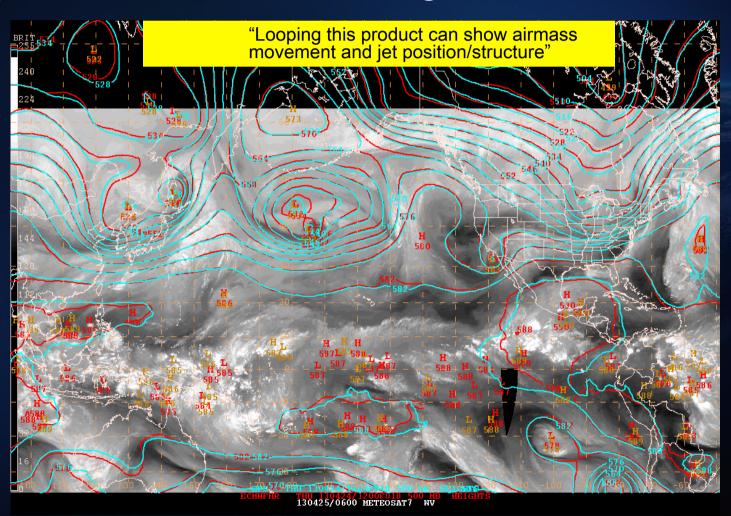
## Satellite Observations vs. Model 👺 🤡





## **Forecasts**

GFS and ECMWF 500 mb Heights overlaid on WV

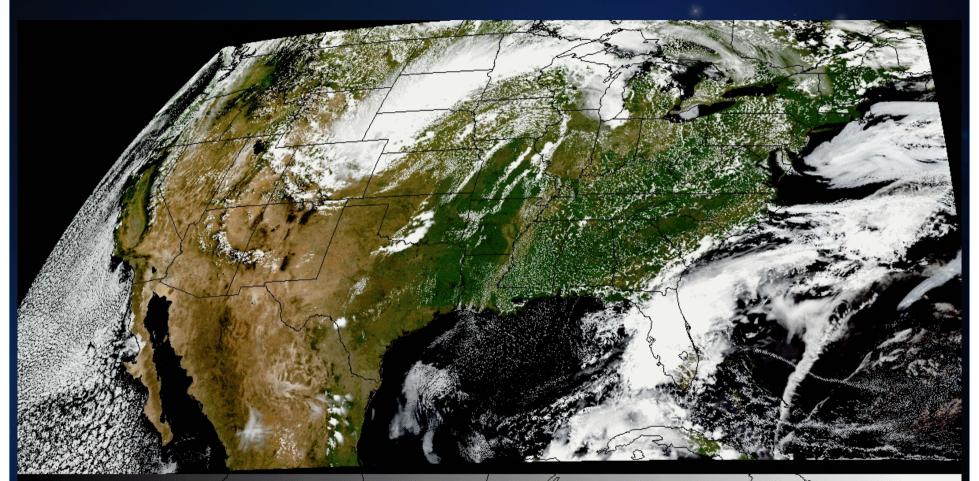




## **GOES-R Pseudo Natural Color** (R-IR-B bands)





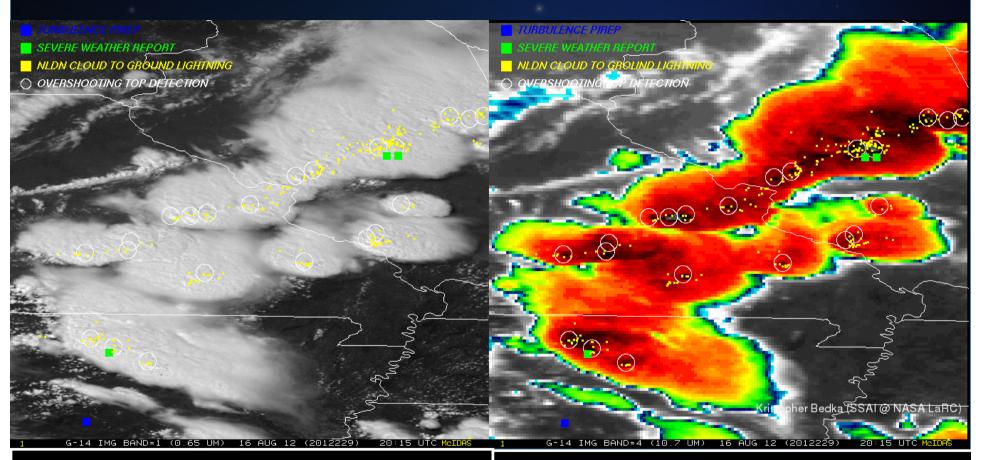




# GOES-R Super Rapid Scan Moving toward data fusion







#### 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?

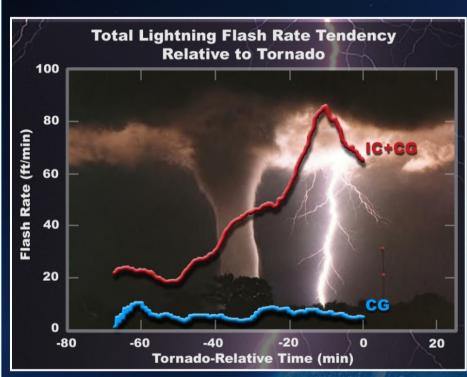
- Situational Awareness
- Warning confidence
- Decision Support (venues)

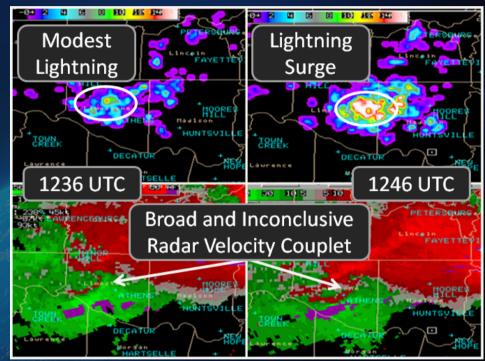


## **Lightning Jumps and Severe Storms**



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





#### Schultz et al. 2011

- Using lightning data alone, predicted severe weather with 20.65 min lead time
- 79% probability of detection (POD)
- 36% false alarm rate (FAR)

#### Rudlosky et al. 2013

- Severe = 1.44 jumps h<sup>-1</sup>; Non-severe = 0.92 jumps h<sup>-1</sup>
- Adding a 10 mm Maximum Expected Size of Hail (MESH) threshold:
- Severe = 1.25 jumps h<sup>-1</sup>; Non-severe = 0.61 jumps h<sup>-1</sup>

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## **Proving Ground Forecaster Feedback**

- "The total lightning data is an excellent tool for monitoring convection..."
- "I utilized it as a situational awareness product ...the data gave me more confidence in my warning."

"We saw several instances where the total lightning was picking up on storms before the AWIPS lightning [NLDN] program picked up on them. One could see the utility of this in the future, bringing with it a potential for lightning statements and potentially lightning based warnings."

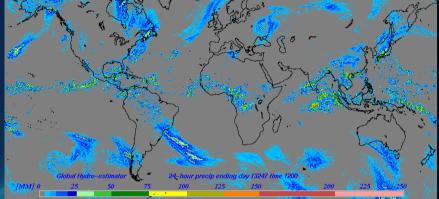
-Pat Spoden (SOO, NWSFO Paducah, KY)

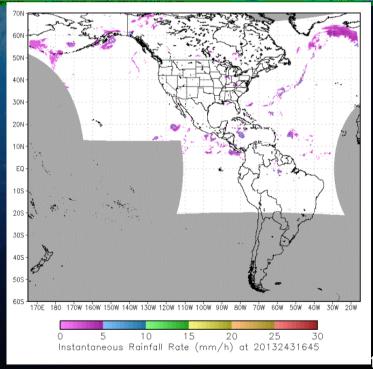


Rainfall Rate – Multi-Platform, Multi-Sensor Geo, Polar, GPM, Dual-pol radar

- Current Algorithm: Global Hydro-Estimator
  - Global coverage, 65 S 65 N at satellite scan schedule
  - Single-band (IR window)
     algorithm with fixed calibration
     using NWP model data to adjust
     for moisture, stability,
     topography
- Next-Generation Algorithm
  - Multi-band algorithm with adjustable calibration (vs. MW rain rates)
  - Current-GOES (2/5 bands) being run in real time and evaluated by several NWS forecast offices
  - Feedback leading to algorithm improvements

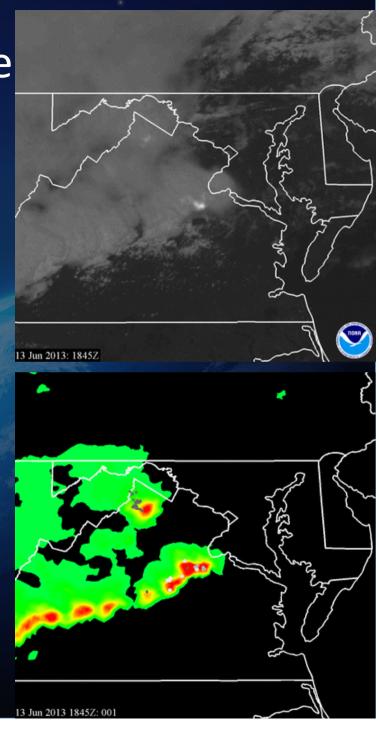
    R. Kuligowski





## Satellite QPE - The Future

- Fusion Science
  - JPSS and GOES-R Risk reduction programs
    - MW and IR
    - MW, IR and lightning
    - Orographic enhancements
    - Snowfall rates
    - Fusion (regional, short term)
  - NOAA PMM Team
    - Utilization on TRMM and GPM
    - Fusion (global, longer term)
- Fusion Systems
  - NESDIS Ground Systems Enterprise
    - Reduce "stove pipes"
    - We are pushing for the GPM-based PPS as a prototype (next slide)
  - NOAA wide precipitation products
    - Ambitious effort but would fold in all types of products if we can





PMW

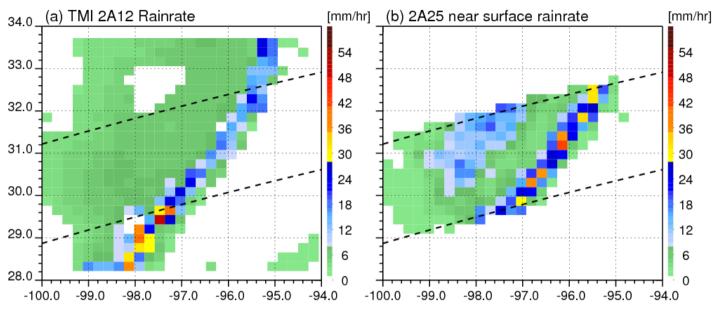
SCaMPR

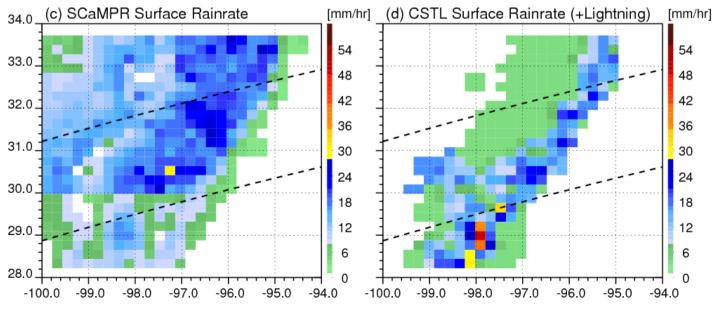
## **CSTL RR - SCaMPR Comparison**





20120320, 0854UTC, Orbit: 81709, Lat: 31.0, Lon: -97.0





Radar

(Final Product

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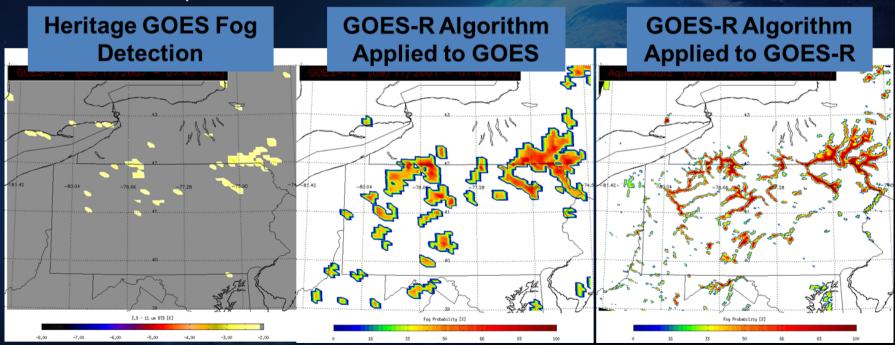




# Future Capability: Fog Detection

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





## Fused Fog/Low Cloud Detection Approach 🕬

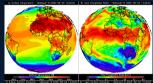


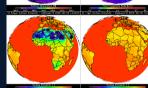






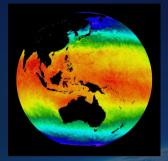
-Minimum channel requirement: 0.65, 3.9, 6.7/7.3 and 11/13.3 μm -Previous image for temporal continuity (GEO only) -Cloud Phase





- -DEM
- -Surface Type -Surface Emissivity

**Daily SST Data** 



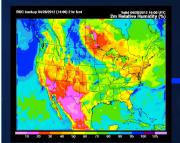
0.25 degree OISST

**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**

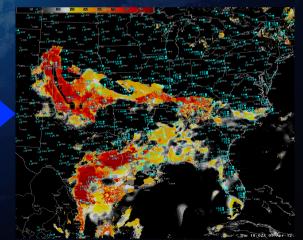


-RUC (2-3 hr forecast) or GFS (12 hr forecast)

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





## Observations from HWT-EFP

- Use of Satellite products...integral part of situational awareness: Used water vapor imagery to track basic flow, short wave troughs, and upper level drying.
  - On Monday.... Simulated water vapor close to reality... gave confidence in model forecasts
- Tuesday...used vis to evaluate clear areas for heating; IR window for presence of mid clouds (indicator of lift); used blended PW product (for possible derecho in E TX, LA, and Srn Arkansas); also used blended PW on Friday
- Throughout week used vis loops to track progress of convective development
- Need more training for team leaders to make use of more proxy GOES-R products such as simulated window channel for AM cloud cover fcst; RGB; Nearcast products.



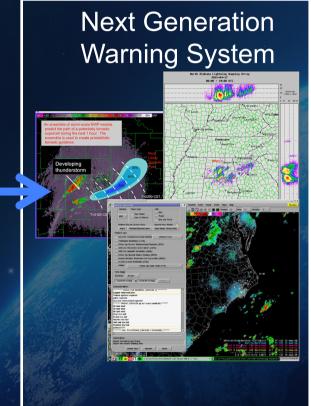
## NWS Vision to Integrate ABI and GLM Products with Other Data and Models





A <u>Potential</u> Operational Example: Convective Initiation/Severe Wx How can we integrate the information in future tools?





Why NWS needs this?

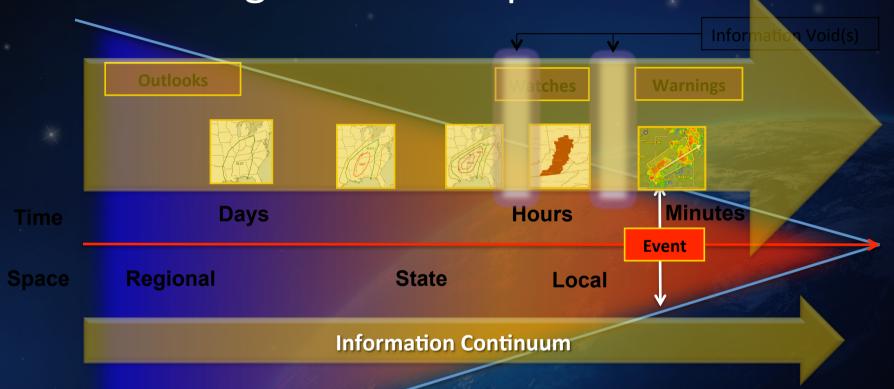
Situational Awareness
Warning confidence
Decision Support (venues)

#### **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)

# Current Warning System "Challenges" Moving Towards Impact-based DSS



- Product-centric and binary.
- More information needed.
- More information available.

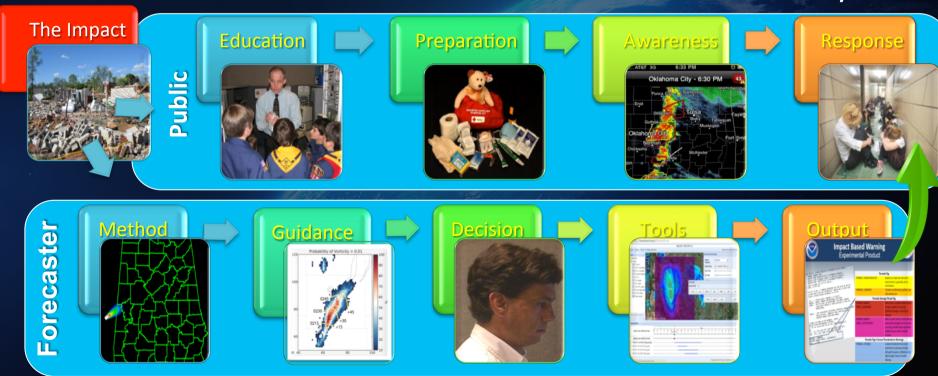
Adapted from Dr. Heather Lazrus (SSWIM)





## **Effective Response**

- Start at the end...
  - "Look at the desired response and work our way backwards from there." - Dr. Russ Schneider/SPC





## Training and User Education Update









#### **Updated!**



GOES-R data and products, methods for interpreting GOES-F data, new features, capabilities and algorithms, and a better tanding of atmospheric sciences and mesoscale ology in preparation for the future GOES-R Series

GOES-R training is developed and provided by a number of artners across the weather enterprise through the GOES-R ather event simulations, and special case studies.

atellite liaison" to prepare forecasters for the data that will be vailable with GOES-R and to ease the transition to ions. Satellite liaisons are stationed at most of the National Centers and the NWS Training Center. Satellite liaisons are tasked with running the various GOES-R ssentially research-to-operations liaisons, improving upor raining from the product developers to present to testbed rticipants, and providing participant feedback to the

For more information click on the GOES & Training Approach briefly

- ► Aviation
- ► Climate
- ► Clouds
- ► Crysnenhor
- ► Hydrology

### **Online Training Modules**

- GOES-R ABI: Next Generation Satellite Imaging (COMET)
- GOES-R: Benefits of Next-Generation **Environmental Monitoring (COMET)**
- **GOES-R 101**
- Satellite Hydrology and Meteorology for Forecasters (SHyMet)
- SPoRT product training modules
- **VISIT Training Resources**
- **Commerce Learning Center**

#### **Printed Materials**

- GOES-R Fact Sheets (18)
- GOES-R Tri-fold
- User Readiness Plan
- **GRB** Downlink Specifications and **Product Users Guide**

#### **GRB Simulators**

 Available late 2013 – Industry Day October 25, 2013





## **Education and Public Outreach Update**









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

Thank you!

For more information visit www.goes-r.gov

