GOES-R Program GLM Update

Steve Goodman

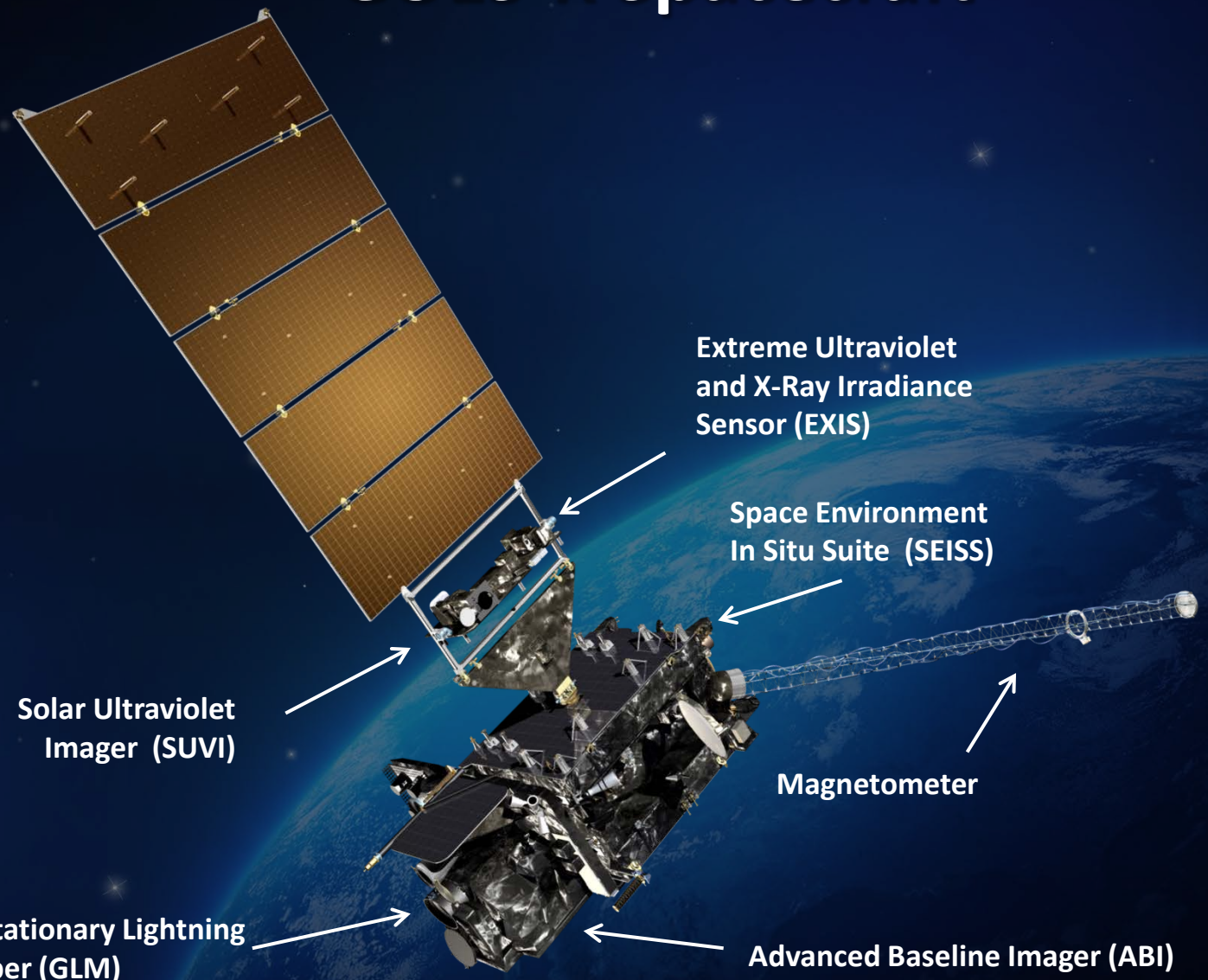
GOES-R Program Chief Scientist

GOES-R GLM Science Meeting and Annual Review
September 24-26, 2013

Outline

- Mission Status
- Cal/Val
- Research and Applications
- Proving Ground Demonstrations
- Training and User Education
- LOI and VSP Status
- Meetings
- Summary

GOES-R Spacecraft



GOES-R Milestones

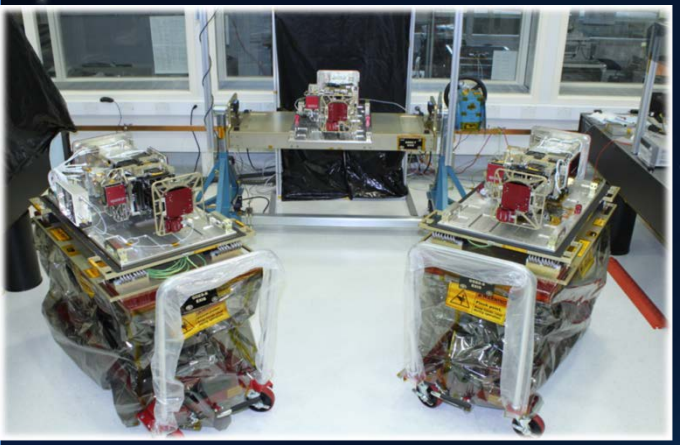
		2010	2011	2012	2013	2014	2015	2016
Program/ System		Mission System Design Review (SDR)	Mission Preliminary Design Review (PDR) Part I	Mission PDR Part II Mission Critical Design Review (CDR) Part I Mission CDR Part II				
Flight Segment	Spacecraft	S/C SDR complete	S/C PDR complete	S/C CDR	ABI Pre –Environmental Review (PER)	S/C Integration and Test (I&T) Begins ABI Delivery		
	Instruments	All instruments have passed CDR	ABI Delta CDR complete	EXIS PER	SEISS PER SUVI PER	EXIS Delivery GLM PER GLM Delivery SEISS Delivery SUVI Delivery		
Ground Segment		Core GS PDR completed Antenna System PDR completed 100 % delivery of baseline product algorithms	GS Project PDR complete	Core GS CDR Antenna System CDR Environmental Satellite Processing and Distribution System (ESPDS) CDR Comprehensive Large Array-data Stewardship System (CLASS) CDR GS Project CDR		Antenna Delivery (2 WCDAS, 1 NSOF) Antenna Delivery (2 RBU, 1 NSOF) R1 Ready – HW/SW at NSOF, WCDAS, RBU Antenna Delivery (1 WCDAS, 1 RBU, 2 NSOF) Launch Operational Baseline		

Launch Readiness 2QFY 2016

Development → Integration and Testing

Flight Project Progress

EXIS FM1 Pre-Shipment Review Complete
EXIS FM2 Pre-Environmental Review Complete
EXIS FM3 Preparing for Pre-Environment Calibrations



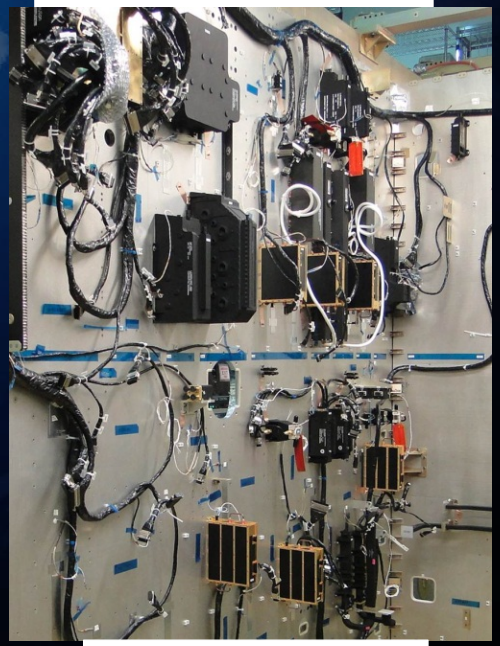
ABI Environmental Testing Complete

ABI Thermal Vacuum Testing

SEISS Environmental Testing Complete

SEISS Thermal Vacuum Chamber Entry

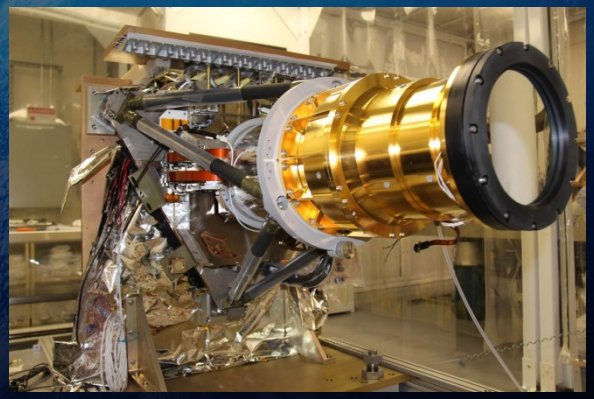
Spacecraft in Assembly



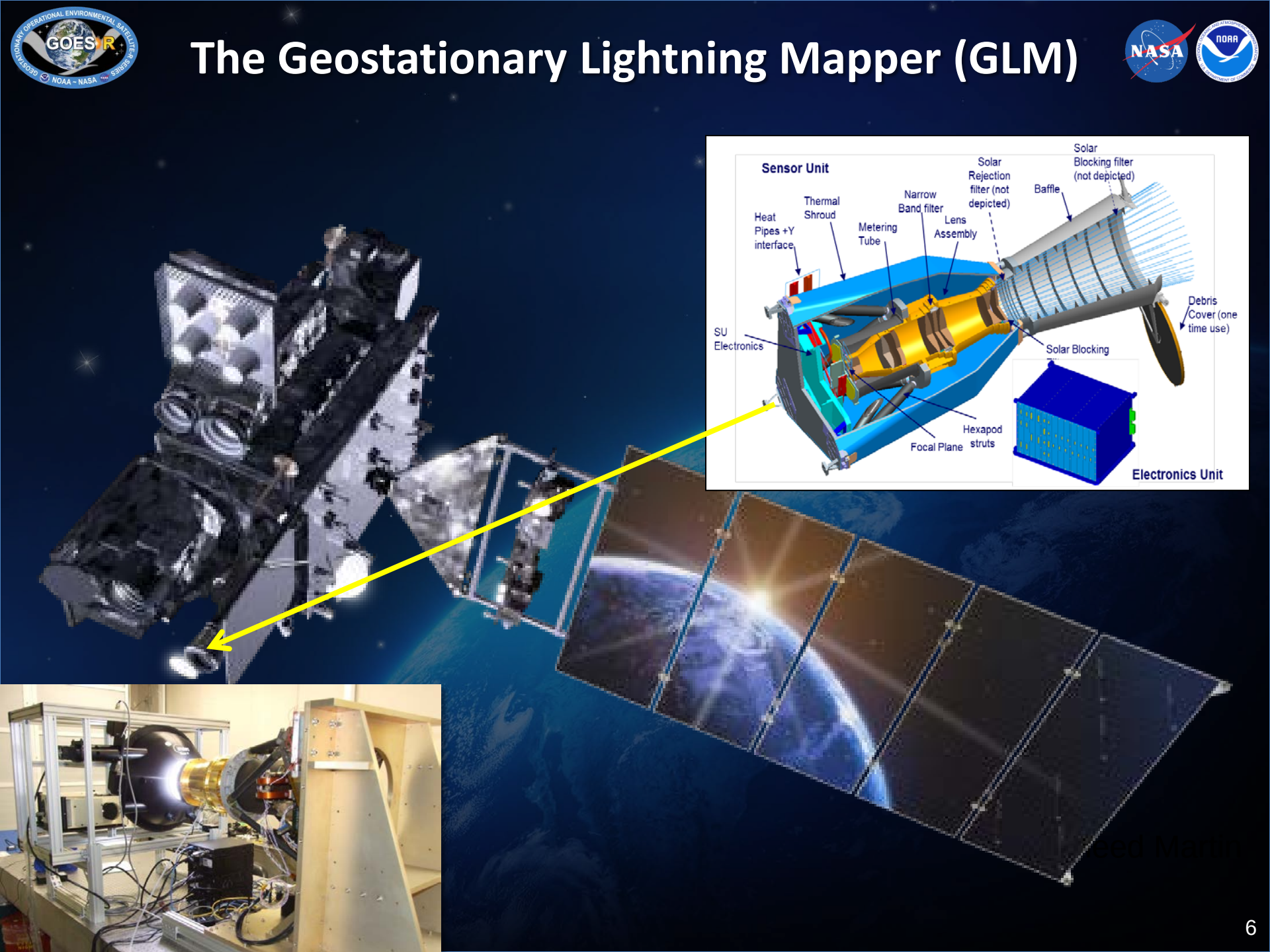
System Module

SUVI Environmental Testing Complete

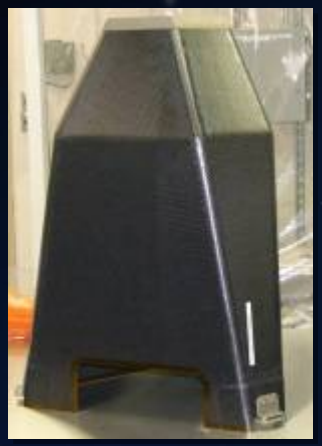
GLM FM1 Sensor Unit FPAA First Power Up

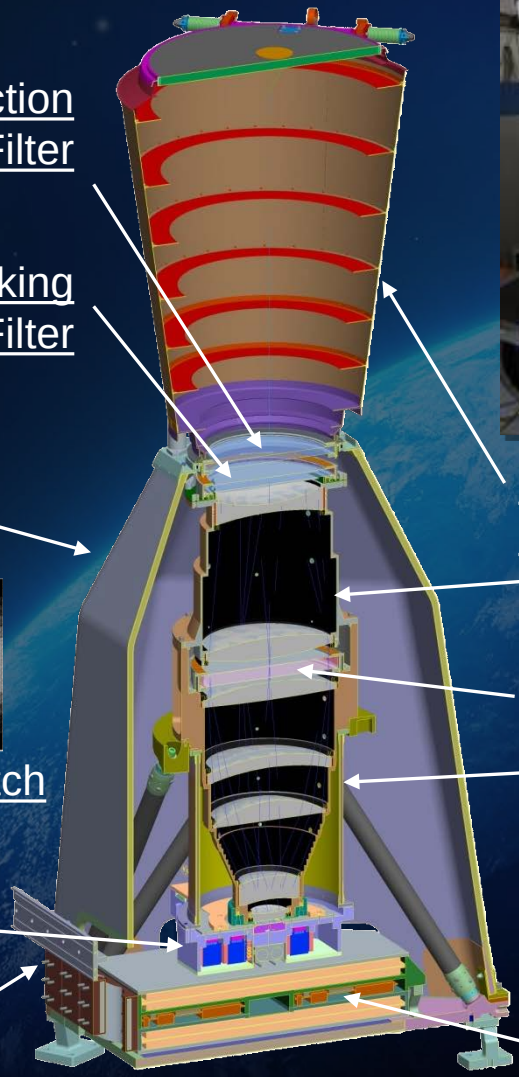


The Geostationary Lightning Mapper (GLM)



GLM Sensor Unit Overview





Solar Rejection Filter

Solar Blocking Filter

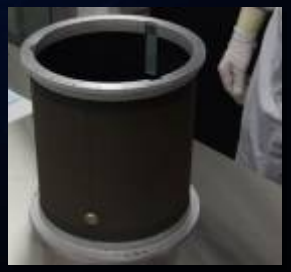
Baffle Support

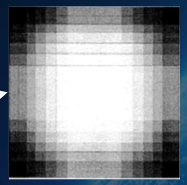
Baffle & Door

Lens Housing & Support Structure

Narrow Band Filter

Metering Tube





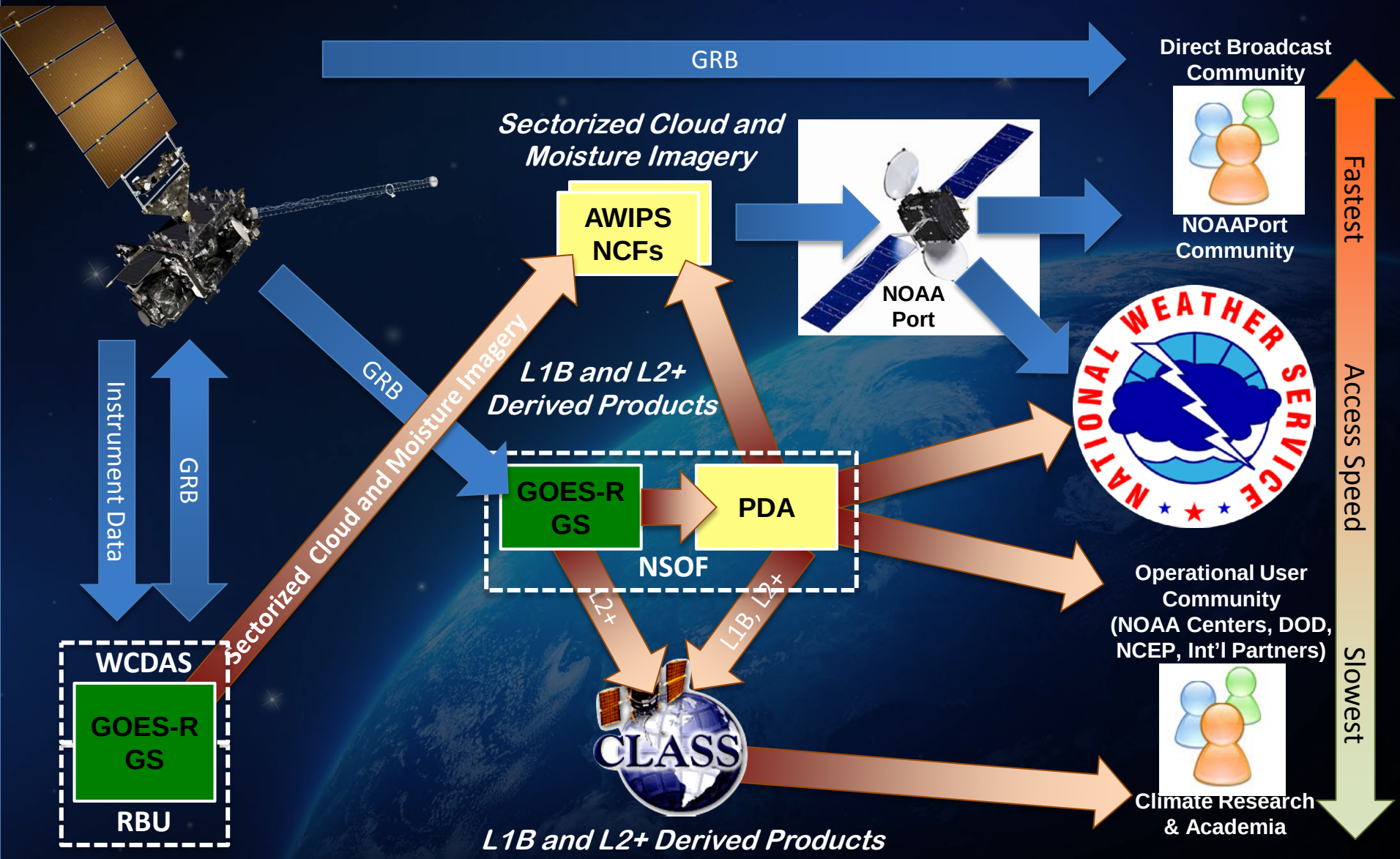
Variable Pitch CCD

Focal Plane Array Assembly (FPAA)

Loop Heat Pipes (FPAA) and Thermal Straps (SEB)

Sensor Unit Electronics Box (SEB)

GOES-R Data Distribution



Ground Segment Progress

WCDAS Antenna Sites

RBU Antenna Sites

GOES-R Antenna Structure Assembly at RBU Complete

WCDAS Site 5 Antenna Installation

MMP Installation at NSOF

Core GS Integrated Baseline Review Complete

NSOF PATRON Tool Now Operational

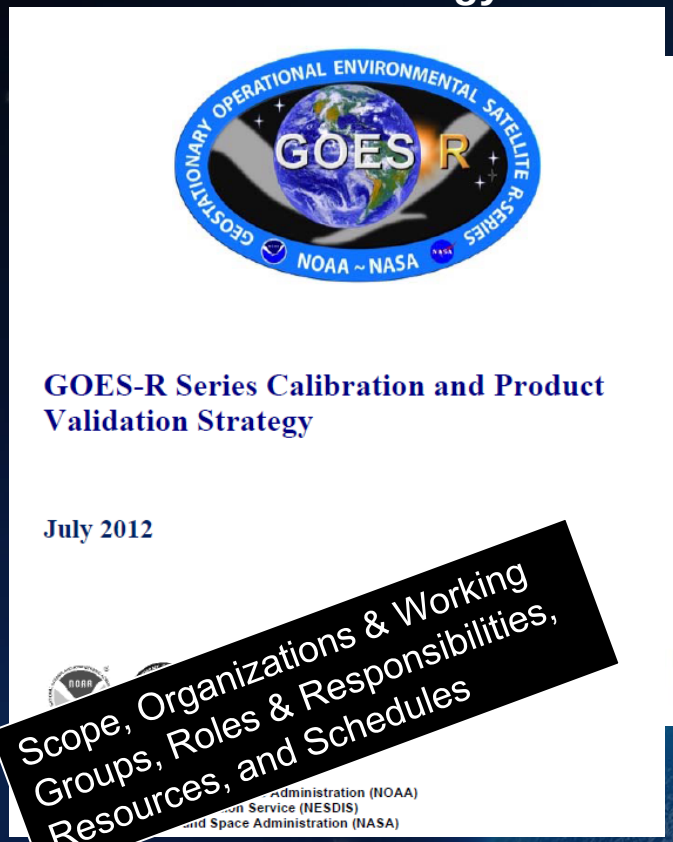
GOES-R Rebroadcast Simulators Shipped

Front

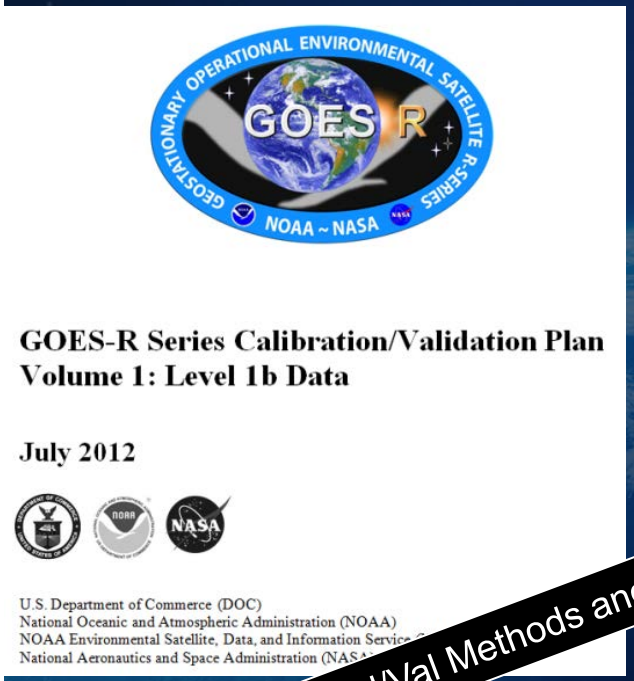
Rear

GOES-R Program Cal/Val Documents

Calibration and Product Validation Strategy



Cal/Val Plan Vol. 1: L1b Data



Cal/Val Plan Vol 2: L2+ Product Val

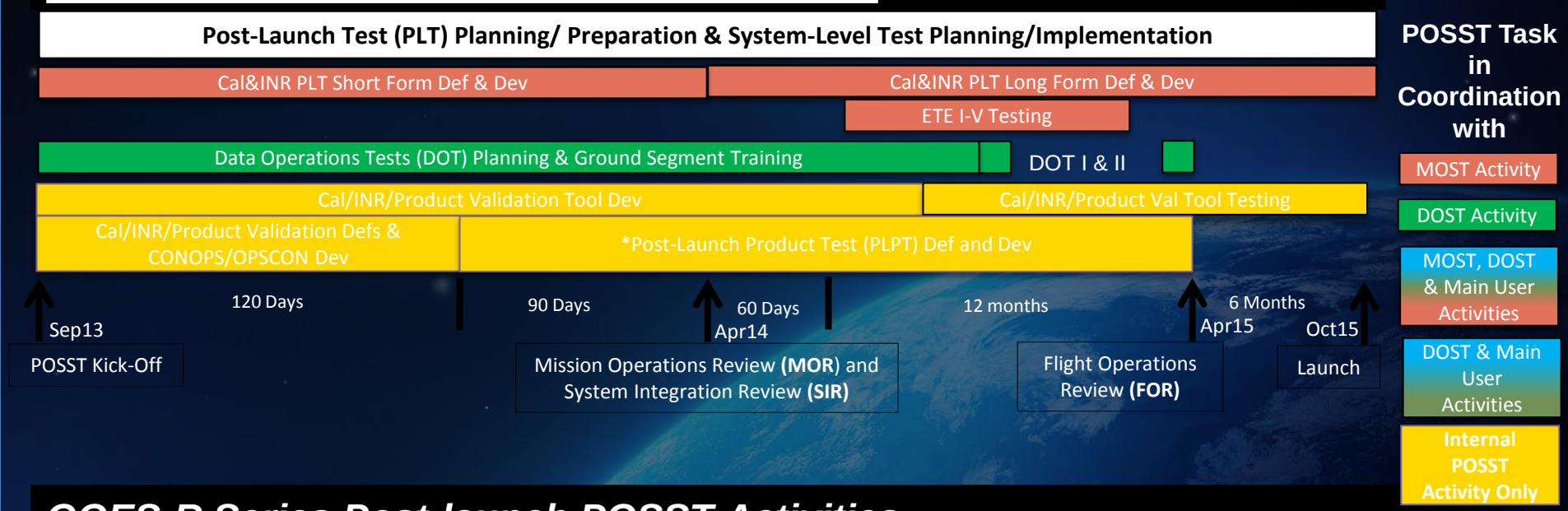
Scope, Organizations & Working Groups, Roles & Responsibilities, Resources, and Schedules

Cal/Val Methods and Processes

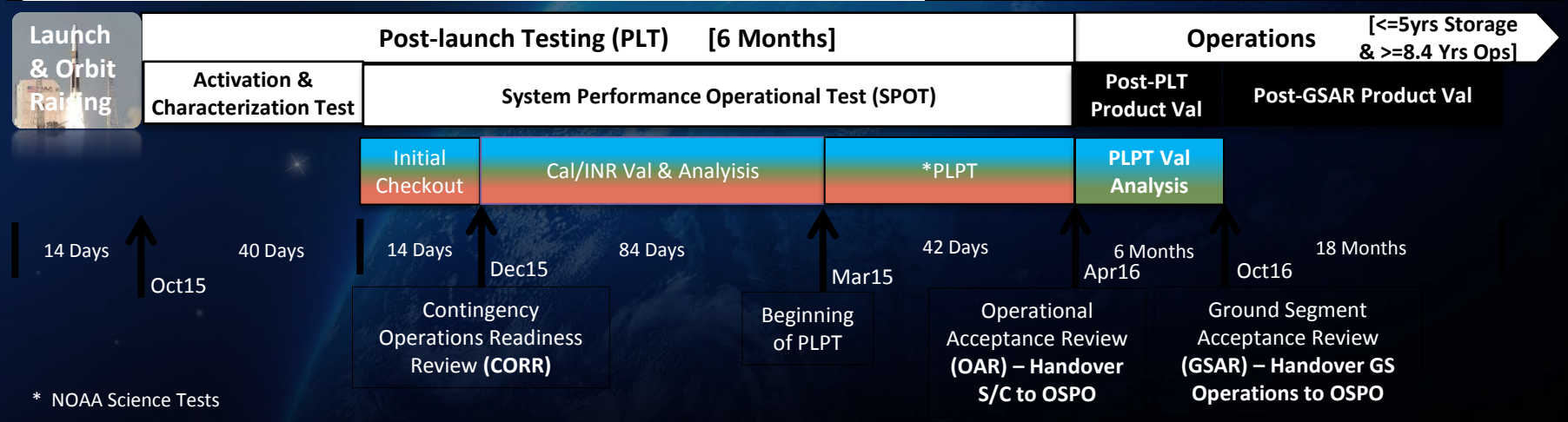
All documents at CDR-level - Scope defined, technical methods mature, organizational role and responsibilities and processes defined, resources allocated, and schedules defined.

GOES-R POSST Timeline

GOES-R Series Pre-launch POSST Activities

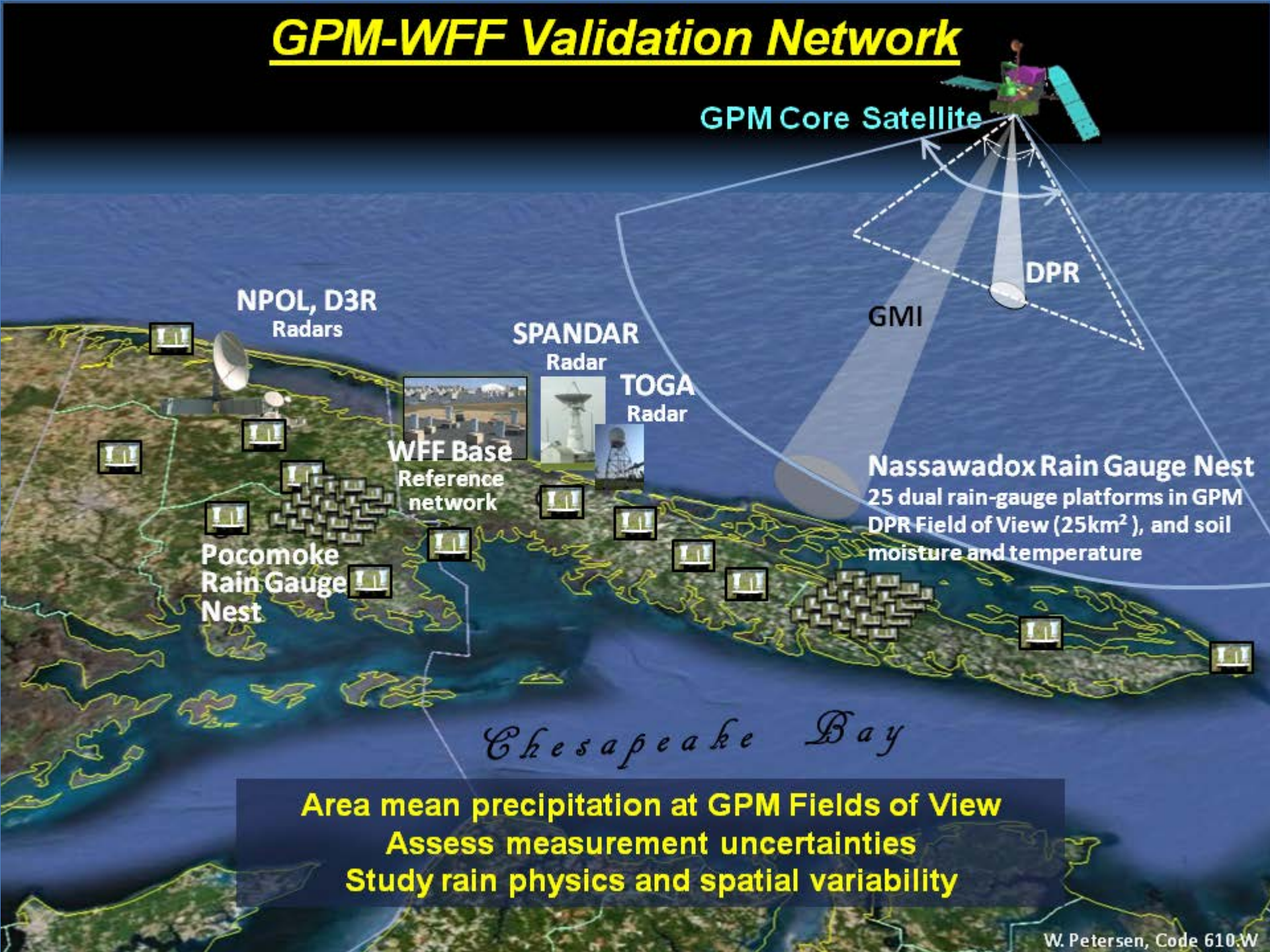


GOES-R Series Post-launch POSST Activities



* NOAA Science Tests

GPM-WFF Validation Network



Area mean precipitation at GPM Fields of View
Assess measurement uncertainties
Study rain physics and spatial variability

W. Petersen, Code 610.W

GPM –WFF Instrumentation Supersite

Radars: Domain 4-D precip structure, DSD, rates

NPOL Radar: S-band, dual-polarimetric scanning

D3R radar: Dual-frequency (KA-KU), dual-polarimetric, Doppler radar.

TOGA C-band Doppler radar

4 Metek Micro Rain Radars (K-band), vertically pointing

Disdrometers/Gauges: DSD, particle imager, rain rate and rain/snow water

6 2D Video Disdrometers

30 Parsivel-2 laser disdrometer

8 Joss Waldvogel

5 Precip Imaging Packages (PIP)

100+ Met One TB rain gauges

50 dual-gauge dense network + Pit

7 Hot plate sensors – Snow

9 OTT Pluvio$_2$ gauges – Snow

GLM and Proving Ground Overview

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The GOES-R Geostationary Lightning Mapper (GLM)

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ABSTRACT

The Geostationary Operational Environmental Satellite R-series (GOES-R) is the next block of four satellites to follow the existing GOES constellation currently operating over the Western Hemisphere. Advanced spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. Advancements over current GOES capabilities include a new capability for total lightning detection (cloud and cloud-to-ground flashes) from the Geostationary lightning Mapper (GLM), and improved cloud and moisture imagery with the 16-channel Advanced Baseline Imager (ABI). The GLM will map total lightning activity continuously day and night with near-uniform storm-scale spatial resolution of 8 km with a product refresh rate of less than 20 s over the Americas and adjacent oceanic regions in the western hemisphere. This will aid in forecasting severe storms and tornado activity, and convective weather impacts on aviation safety and efficiency. In parallel with the instrument development, an Algorithm Working Group (AWG) Lightning Detection Science and Applications Team developed the Level 2 (stroke and flash) algorithms from the Level 1 lightning event (pixel level) data. Proxy data sets used to develop the GLM operational algorithms as well as cal/val performance monitoring tools were derived from the NASA Lightning Imaging Sensor (LIS) and Optical Transient Detector (OTD) instruments in low Earth orbit, and from ground-based lightning networks and intensive prelaunch field campaigns. The GLM will produce the same or similar lightning flash attributes provided by the LIS and OTD, and thus extend their combined climatology over the western hemisphere into the coming decades. Science and application development along with preoperational product demonstrations and evaluations at NWS forecast offices and NOAA testbeds will prepare the forecasters to use GLM as soon as possible after the planned launch and checkout of GOES-R in late 2015. New applications will use GLM alone, in combination with the ABI, or integrated (fused) with other available tools (weather radar and ground strike networks, nowcasting systems, mesoscale analysis, and numerical weather prediction models) in the hands of the forecaster responsible for issuing more timely and accurate forecasts and warnings.

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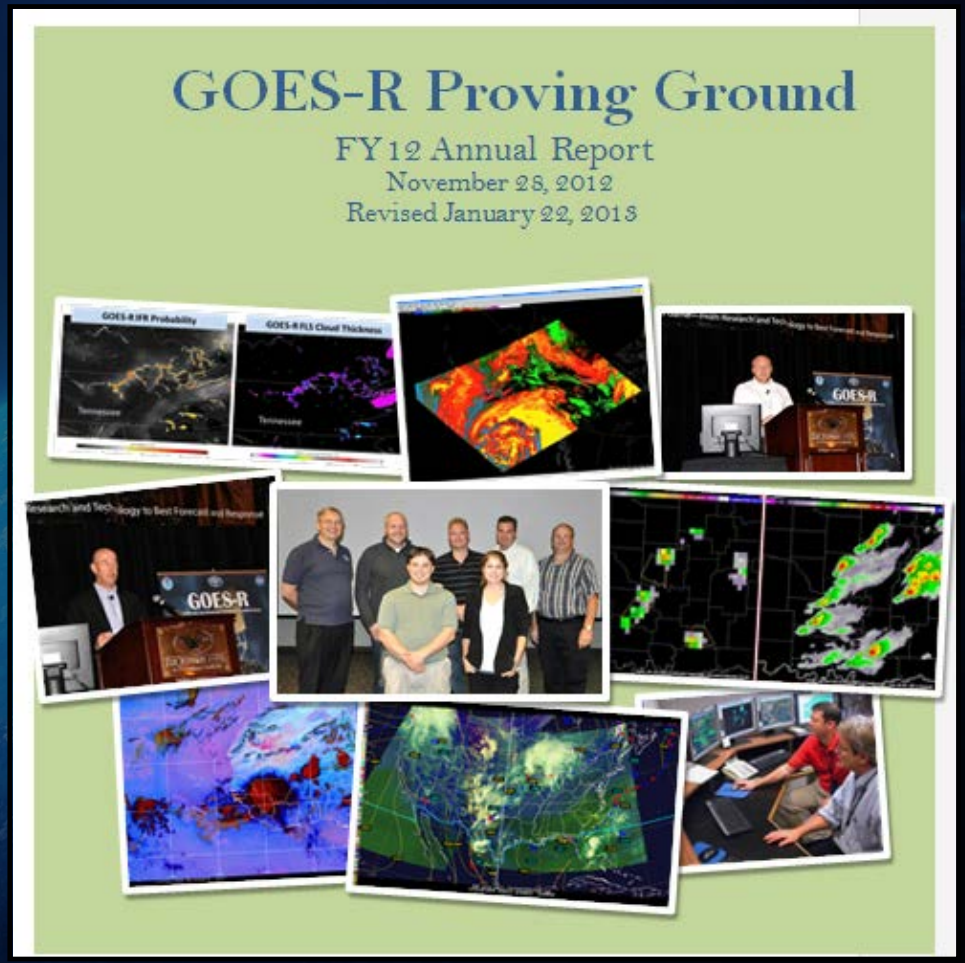


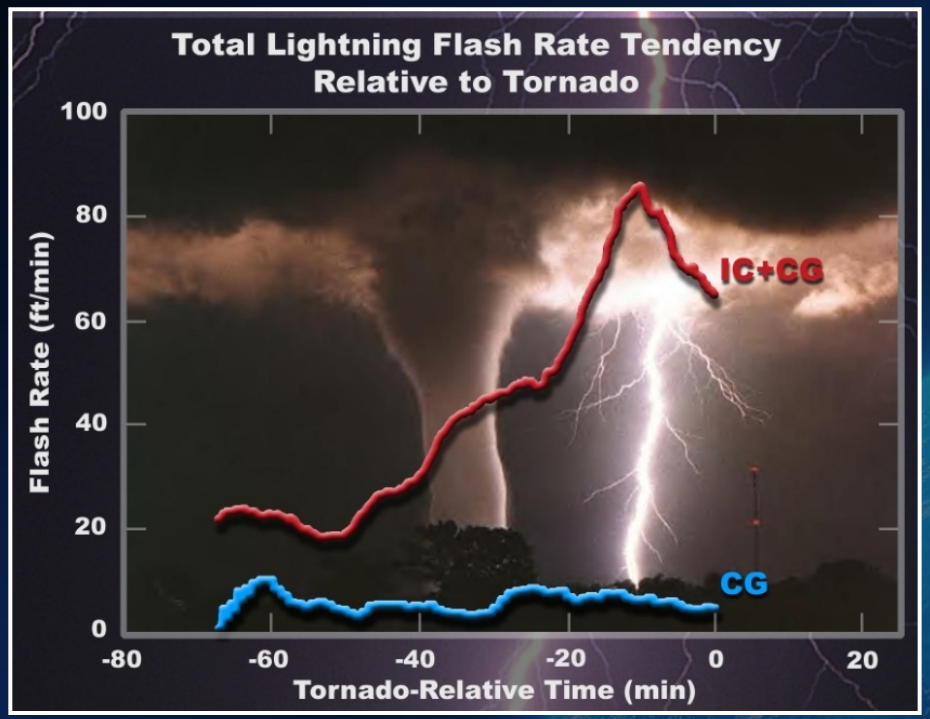
NWS Preparations for GLM Use

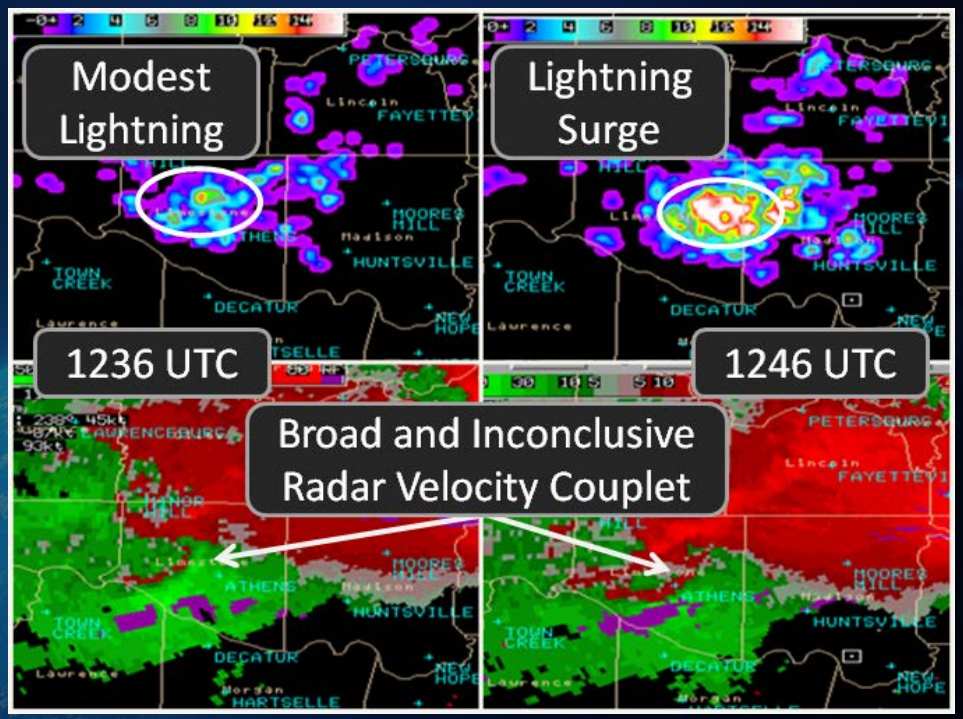
Most-Promising GLM Contributions

- GLM represents a new/unique capability
  - High efficiency Total Lightning (TL) detection eventually stretching from the Pacific to the Atlantic (+ EUMETSAT-MTG, CMA FY-4)
- Improved Convective Warnings (combine TL, radar, other)
  - Reduced FAR, Increased POD, Increased Lead Time for Tornado Warnings and other Severe Convective Warnings
  - Enhanced Situational Awareness for Aviation Services over broad geographic area (especially trans-oceanic flights)
  - Enhanced Situational Awareness for Convective Precipitation (Flash-Flood)
- Improved Forecasts of Rapid Intensification (RI) and Rapid Weakening (RW) in Tropical Storms
- Short-term numerical weather prediction improvement-assimilation of TL as proxy for strong convection

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

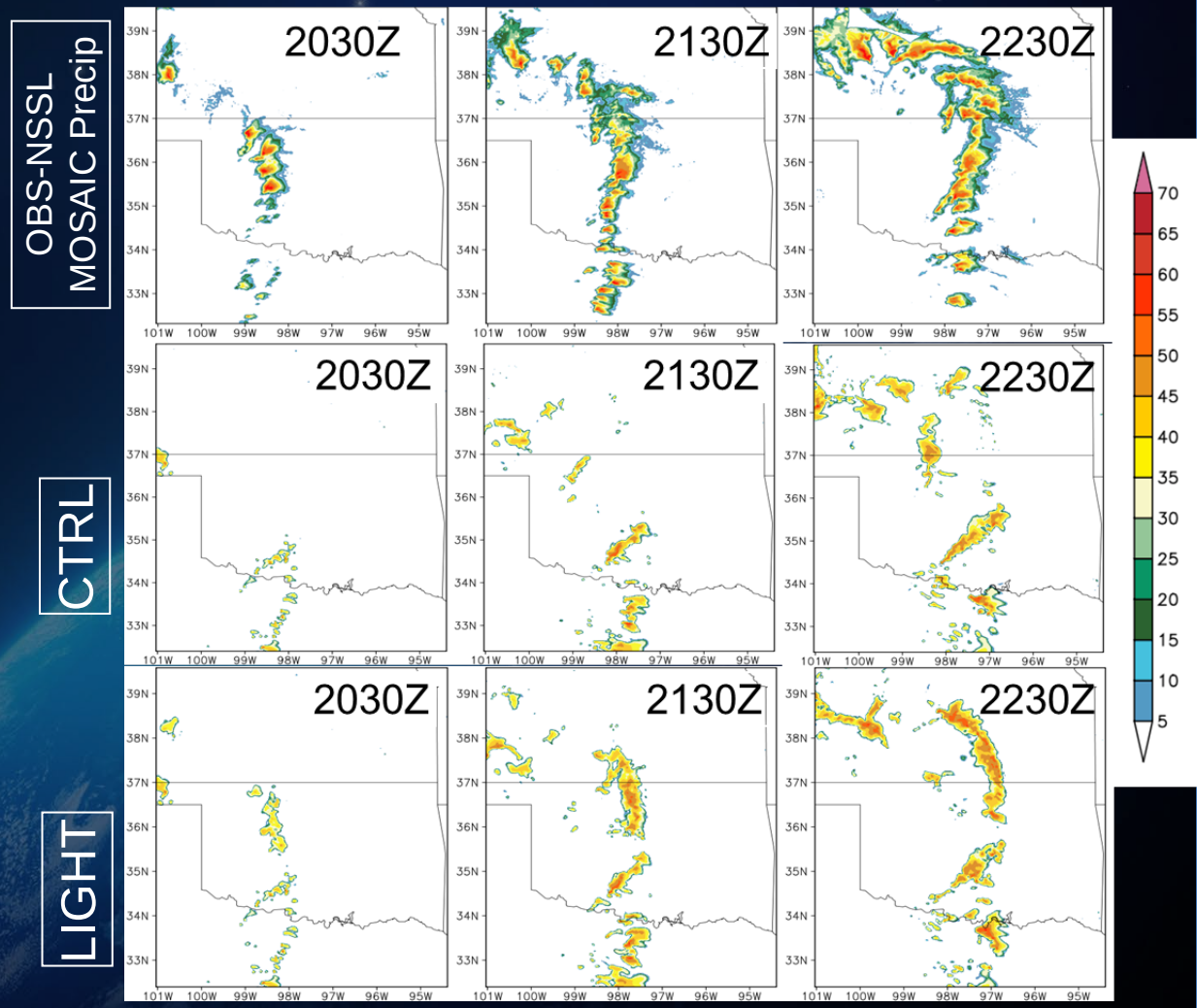
- Using lightning data alone, predicted severe weather with 20.65 min lead time
- 79% probability of detection (POD)
- 36% false alarm rate (FAR)

Rudlosky et al. 2013

- Severe = 1.44 jumps h^{-1}; Non-severe = 0.92 jumps h^{-1}
- *Adding a 10 mm Maximum Expected Size of Hail (MESH) threshold:*
- Severe = 1.25 jumps h^{-1}; Non-severe = 0.61 jumps h^{-1}

GLM Contributions to NWP: Total Lightning Provides Better Initial Conditions

- GLM Total lightning proxy data from the ENTLN were assimilated into the WRF-ARW model at cloud-resolving scales.
- Improved Initial Conditions will provide a better physical background at analysis time towards improving short term high impact weather forecasts (~3h). Lightning data also used to limit the presence of spurious convection (and cold pools). Key in radar data sparse areas.
- To alleviate the need to use proxies for lightning in the model (e.g. lightning threats), full charging/discharge physics are currently being implemented into WRF-ARW within the NSSL 2-moment microphysics.



Courtesy of A. Fierro, CIMSS/NOAA

The GOES-R Proving Ground

- Collaborative effort between the GOES-R Program Office, selected NOAA Cooperative Institutes, NWS forecast offices, NCEP National Centers, NASA SPoRT, JCSDA, and NOAA Testbeds
- Responsible for user readiness testing of GOES-R baseline products and future capabilities prior to launch
- Where proxy and simulated GOES-R products are tested, evaluated, and integrated into operations before the GOES-R launch
  - Satellite liaisons (subject matter experts) at NWS National Centers
  - Develop training for users
  - Prepare for display within AWIPS/AWIPS-II/N-AWIPS
  - Initial focus on High Impact Weather and warning related products requested by NWS
- A key element of GOES-R User Readiness (Risk Mitigation)
- Proving Ground activities are having an impact **NOW!**

GOES-R Proving Ground

THE GOES-R PROVING GROUND

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

BY STEVEN J. GOODMAN, JAMES GURKA, MARK DEMARIA, TIMOTHY J. 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.

The Geostationary Operational Environmental Satellite R series (GOES-R) Proving Ground (PG) is an initiative to accelerate user readiness for the next generation of U.S. geostationary environmental satellites. The GOES-R system is a joint development between the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA), with NASA responsible for the space segment (spacecraft and instruments) and NOAA responsible for the overall program and ground segment. The GOES-R PG is a collaborative effort between the GOES-R Program Office (GPO); NOAA Cooperative Institutes; NASA's Short-Term Prediction Research and Transition Center (SPoRT); National Weather Service (NWS) Weather Forecast Offices (WFOs); NWS National Centers for Environmental Prediction (NCEP); National Environmental Satellite, Data, and Information Service (NESDIS) Office of Satellite and Product Operations (OSPO) and the Center for Satellite Applications and Research (STAR); and NOAA test beds to conduct demonstration activities to gain early experience with GOES-R capabilities in an operational environment. Improved spacecraft and instrument technology will support expanded detection of environmental phenomena, resulting in more timely and accurate forecasts and warnings. The Advanced Baseline Imager (ABI), described by Schmit et al. (2005), is a 16-channel imager with 2 visible channels, 4 near-infrared channels, and 10

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The abstract for this article can be found in this issue, following the table of contents.
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THE EMERGENCE OF WEATHER-RELATED TEST BEDS LINKING RESEARCH AND FORECASTING OPERATIONS

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 RIISHOJGAARD, 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.

Over roughly the last decade, a variety of "test beds" have come into existence focused on high-impact weather and the core tools of meteorology—observations, models, and fundamental understanding of the underlying physical processes. They have entered the proverbial "valley of death" between research and forecast operations (NAS 2000), and have survived. This paper provides a brief background on how this happened; summarizes test bed origins, methods, and selected accomplishments; and provides a perspective on the future of test beds in our field. Dabbert et al. (2005) provides a useful description of test beds from early in their development and Fig. 1 summarizes the role of test beds.

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

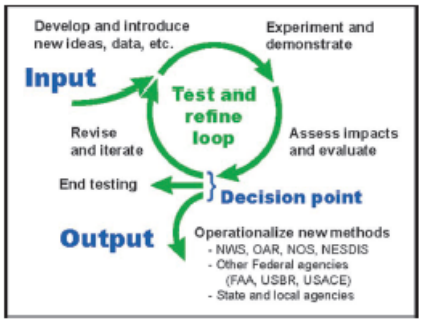
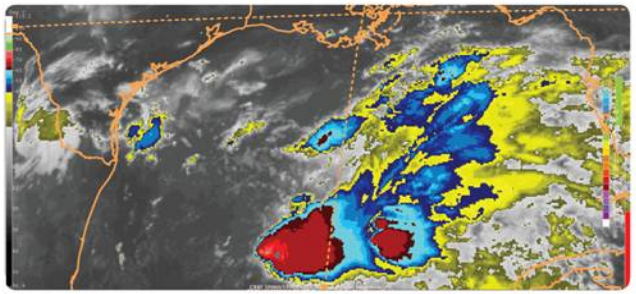
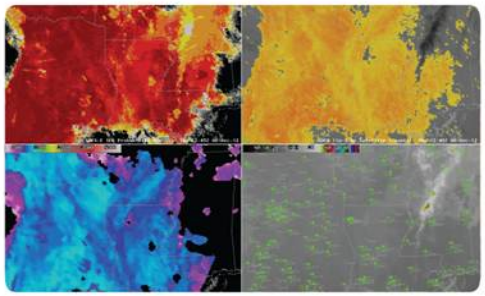


FIG. 1. Conceptual schematic of the test bed process for a hypothetical project, tool, or concept—including innovation, demonstration, evaluation, and, where suitable, a transition to operations within a federal, state, or local organization. NOS = National Ocean Service; USBR = United States Bureau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

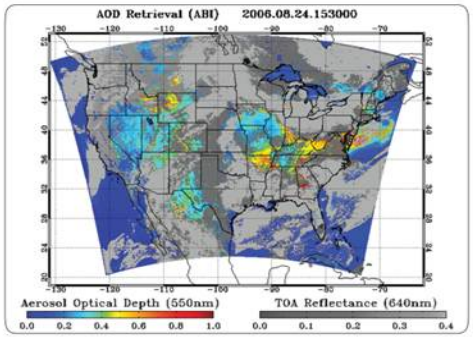
The GOES-R Proving Ground



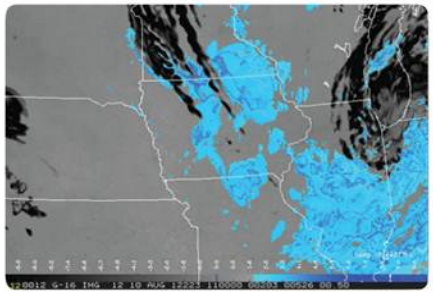
Aviation Weather Center (AWC) – Kansas City, MO
IR Imagery of Oceanic Storms



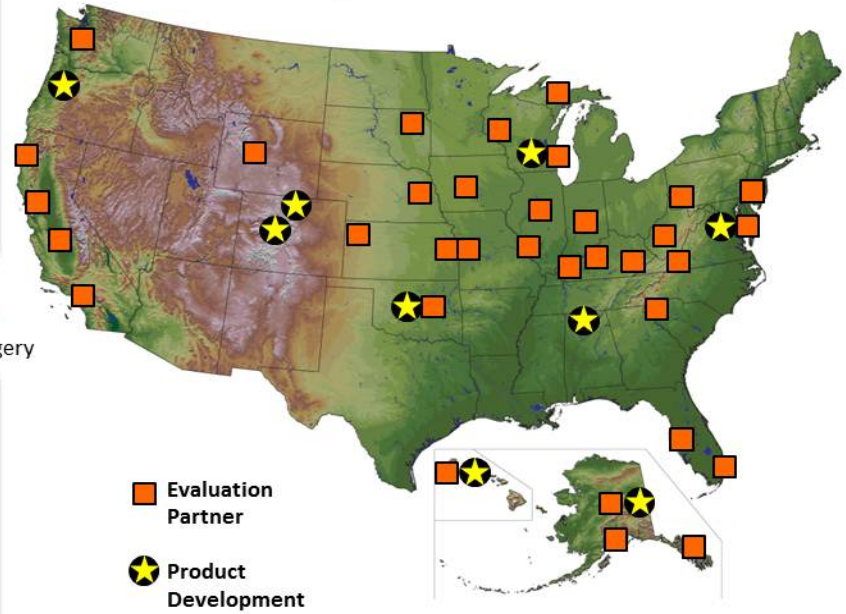
Cooperative Institute for Meteorological Satellite Studies (CIMSS)/Center for Satellite Applications and Research (STAR) – Madison, WI
Fog/Low Stratus Product



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

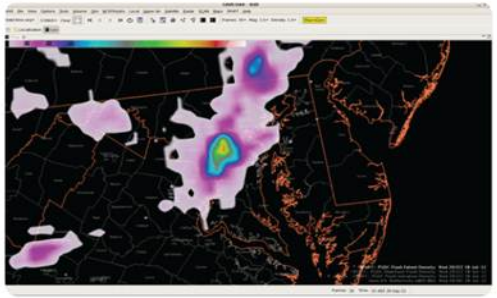


Cooperative Institute for Research in the Atmosphere (CIRA)/STAR – Ft. Collins, CO
ABI Synthetic Low Cloud Enhancement Imagery

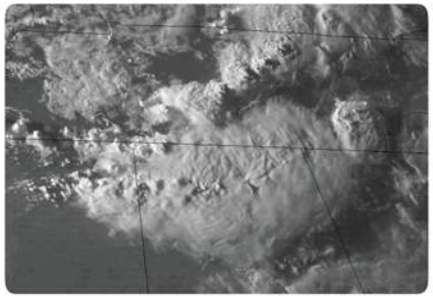


Evaluation Partner

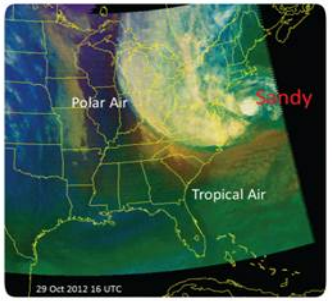
Product Development Partner



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

Satellite Proving Grounds

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

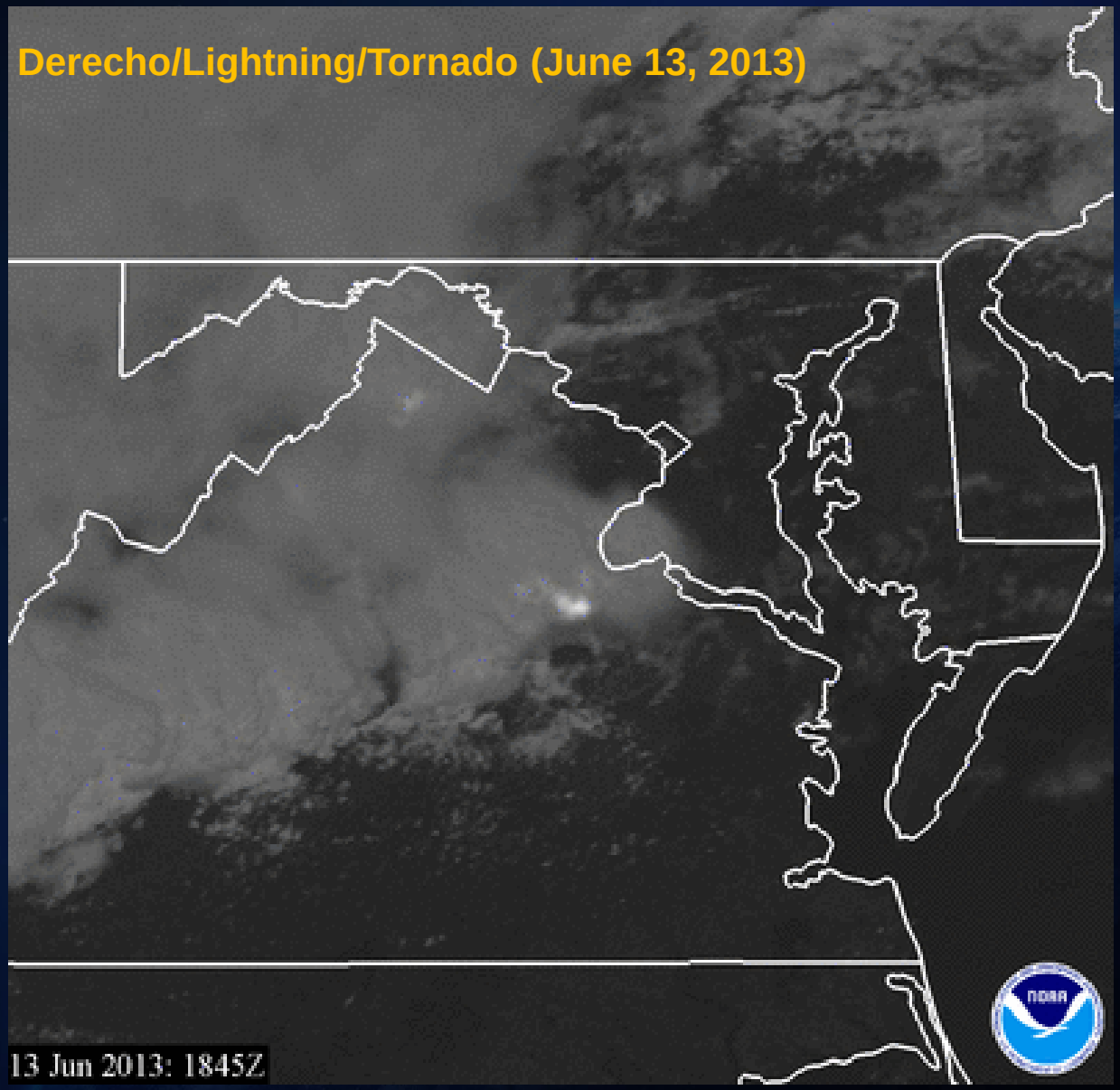
- Several GOES-R level 2 products are demonstrated in the GOES-R Proving Ground.
- Examples can be found on the PG blogs and through the website www.goes-r.gov.
- International Projects
- Visiting Scientist Program

NOAA HWT

CHUVA PROJECT

2012 ESSL Testbed

GOES 14 Out-of-Storage SRSOR



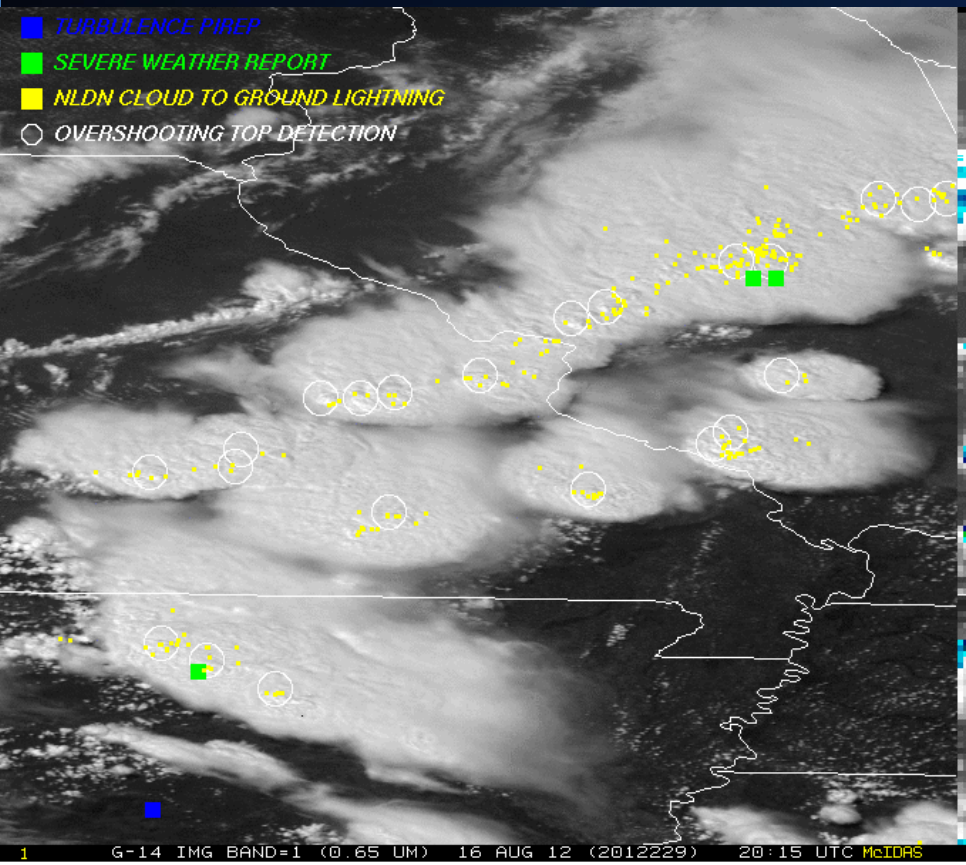
S. Rudlosky

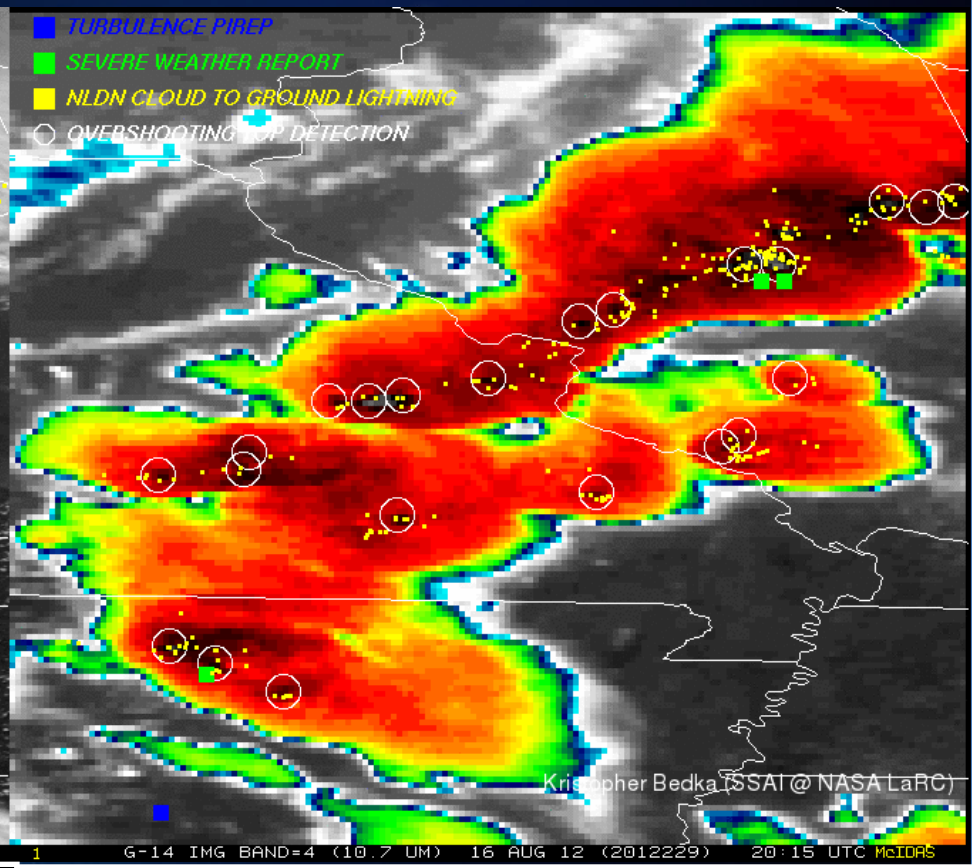
http://cimss.ssec.wisc.edu/goes/srsor2013/GOES-14_SRSOR.html

Photpo credit Buddy Denham- sailing between Long Island and Jersey shore

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)*

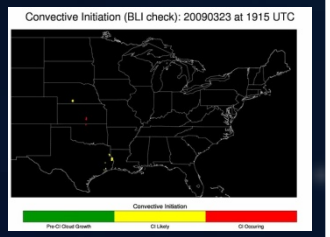
Why NWS needs this?

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

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

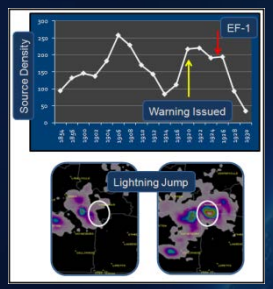
A Potential Operational Example: Convective Initiation/Severe Wx
How can we integrate the information in future tools?

CI

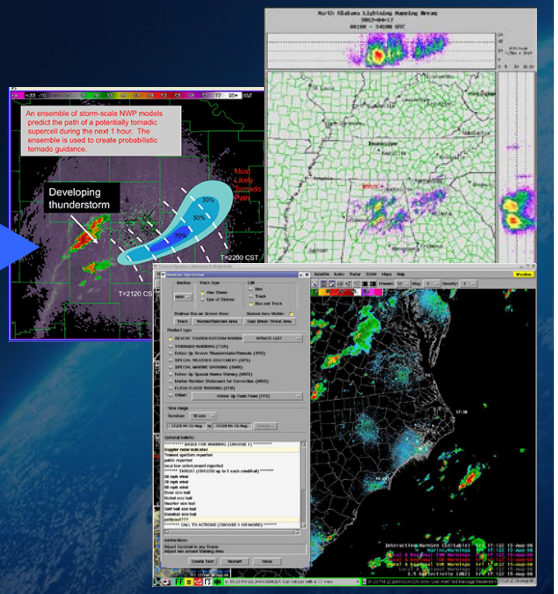


Over-shooting tops

Lightning Jumps



Next Generation Warning System



Why NWS needs this?

Situational Awareness
Warning confidence
Decision Support (venues)

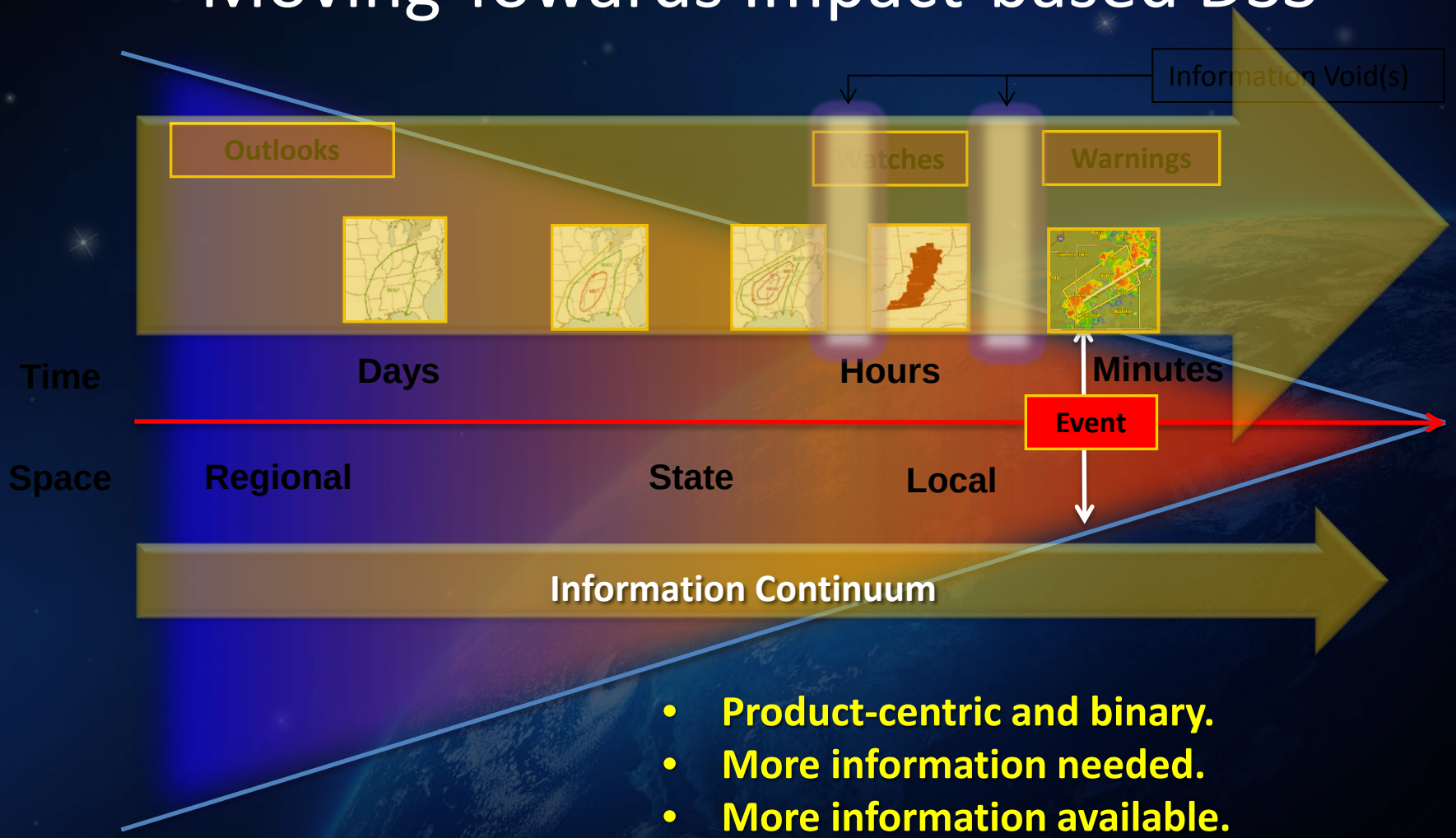
Situational Awareness:

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)

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

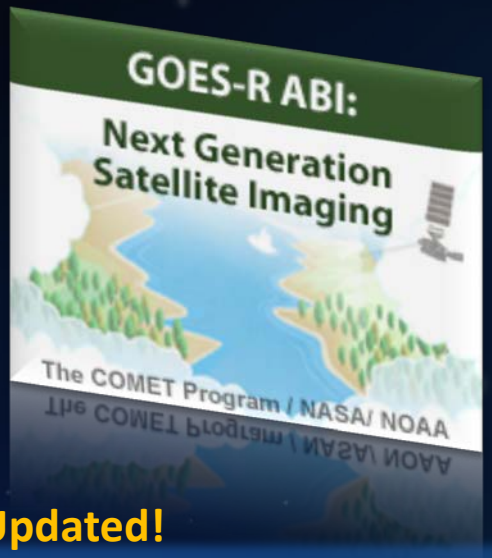


- **Product-centric and binary.**
- **More information needed.**
- **More information available.**

Adapted from Dr. Heather Lazrus (SSWIM)

Training and User Education Update

New!



Updated!

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

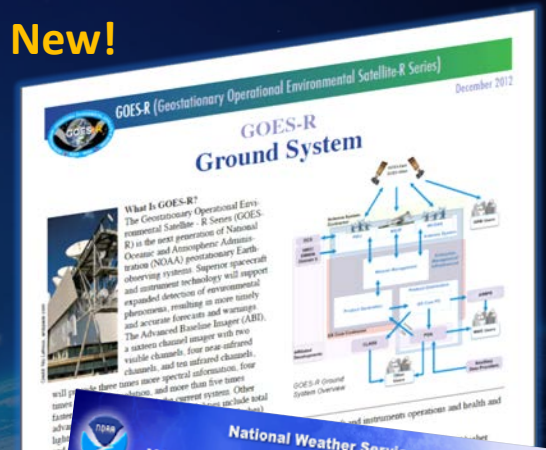
Printed Materials

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

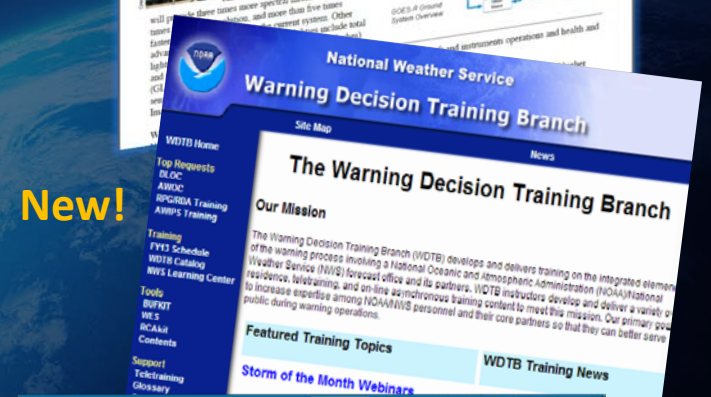
GRB Simulators

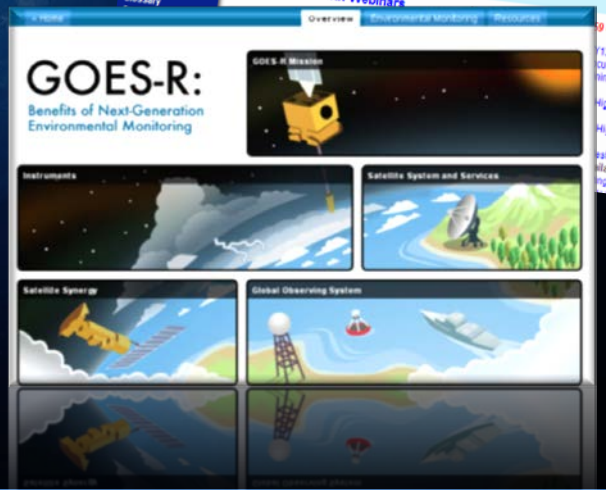
- Available late 2013 – Industry Day October 25, 2013

New!



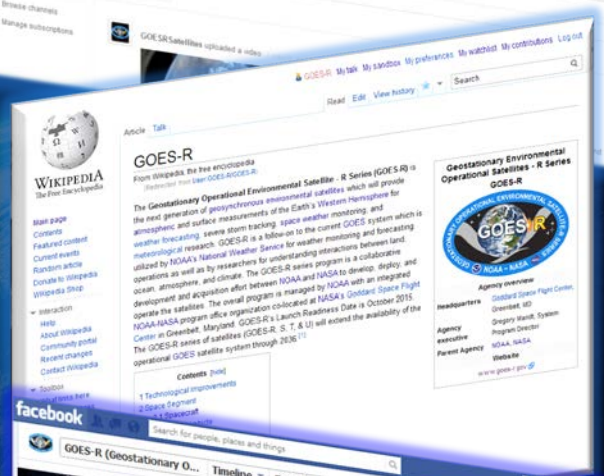
New!

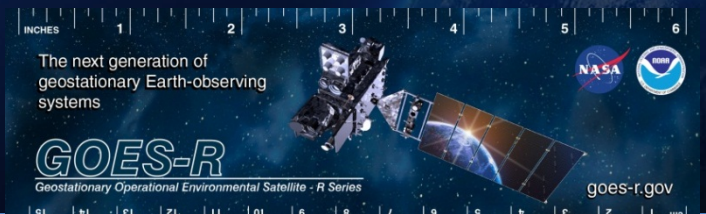




Education and Public Outreach Update

https://www.youtube.com/user/goesrsatellites





www.facebook.com/ GOESRsatellite

GOES-R Risk Reduction Request for Letters of Intent

The GOES-R Risk Reduction (R3) program provides support to develop applications to enhance the utilization of the GOES-R sensors, including the Advanced Baseline Imager (ABI), the Geostationary Lightning Mapper (GLM), and the space weather sensors. New proposals will be for two years, with an option for a third year for demonstrations of new capabilities.

Call for LOIs closed September 6, 75 LOIs received, Down-selection and request for full proposals late October-November (a little later than planned).

Emphasis will be given to projects that identify a clear path to operations. Real-time demonstrations through the Satellite and NWS Proving Grounds are encouraged. Projects that fuse information from multiple sources (multi-satellites, radar, in situ data including surface meso-networks, model data) will be given additional positive assessment, although the GOES-R data should be a central component.

The highest priority research topics fall into the areas of (A) Improving NWS Operational Numerical Weather Prediction (NWP) and (B) Situational Awareness Monitoring Applications with emphasis on AWIPS-2. About 10% of the funding will also be reserved for (C) Higher Risk Exploratory Research.

GOES-R Visiting Scientist Program

- Federal and non-federal scientists contributing to GOES-R3, Algorithm Working Group and Proving Ground efforts and international operational space agency partners (eg scientists associated with JMA Himawari algorithms and EUMETSAT Satellite Application Facilities (SAFs)) to exchange ideas and initiate/continue collaborations applicable to their current research with other scientists and users.

- Visits focused on future capabilities including the use of decision tools, integrated observations and NWP are encouraged.

- Visits to scientific partners developing and evaluating relevant algorithms and applications at National Weather Service (NWS) Weather Forecast Offices, NWS National and Regional Centers, federal laboratories, universities, and EUMETSAT SAFs are also encouraged. Ideas, algorithms, products, and applications can be explored in detail during these visits that may be from 1 to 4 weeks in duration.

- Letters of intent must be received by 5 PM eastern time on October 8, 2013.

Science Meetings

- NWA – October 12-17, Charleston, SC
- *AWG Cal/Val TIM - October 30-31, NCWCP, MD
- *6th GPM GV Workshop - November 5-7, CNR Rome, Italy
- AGU Fall Meeting – December 9-13, San Francisco, CA
- AMS – February 2-6, Atlanta, GA (R2O/Satellite Joint Session)
- *WoF-High Impact WX TIM, Feb. 17-19, Norman, OK
- *Satellite Science Week, R3 Virtual – March 10-14, Madison, WI
- Vaisala 23rd ILDC/ILMC – March 18-21, Tucson, AZ
- *Proving Ground Users TIM – May/June, Kansas City or Boulder
- ICAE 2014 – June 15-20, Norman, OK
- *GLM Science Team Meeting- week of September 9 or 16

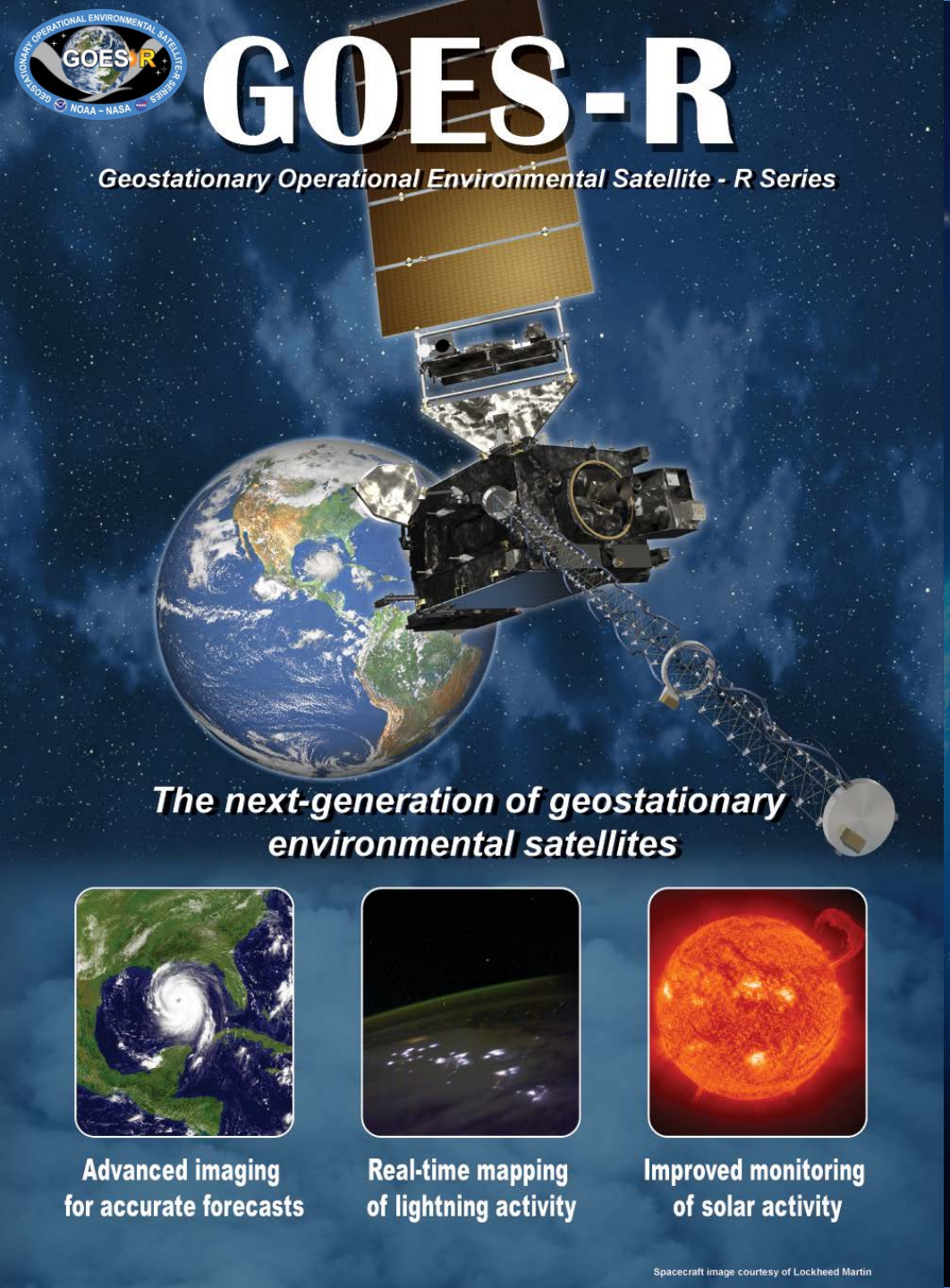
*By invitation only - program sponsored meetings

Summary

- New Launch Readiness Date- 2nd Quarter 2016
- ER2 on NASA Airborne Science manifest for PLT
- Program studying NWS request for GOES-R operations following PLT - decision later east vs west
- GLM in I&T, Pre-Ship Review planned for Spring 2014
- CWG conducting GLM IV&V studies
- AWG/CWG continued pre-launch assessments and cross-validation of ground-based network performance
- AWG development of deep dive L1B and L2 product monitoring tools
- No L0 Archive in CLASS- 2 yr rolling storage at WCDAS for CWG/AWG teams, CWG/AWG infrastructure refresh

Summary cont'd

- NOAA Total Lightning Working Group- TL in AWIPS-II
- Field Campaigns- analysis and future plans (CHUVA, HyMeX, IPHEX-HMT, Lake Vic, Relampago, ISS LIS, TARANIS, others)
- Candidate GV Supersites- North Alabama, NSSL, Fort Collins, KSC, Wallops
- Coordination with EUMETSAT Lightning Imager Science Team, Hydrology-SAF, Convection Working Group
- Risk Reduction Call for Proposals- selections in January
- JCSDA S4, JIBB Supercomputer (Sandy Supplement)
- Visiting Scientist Program- selections this Fall
- Planned TIMs and Meetings – still subject to NOAA and NASA fed travel approval



Thank you!

For more information visit www.goes-r.gov

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