Satellite Observations and Products

Session Introduction: GOES Operational Continuity

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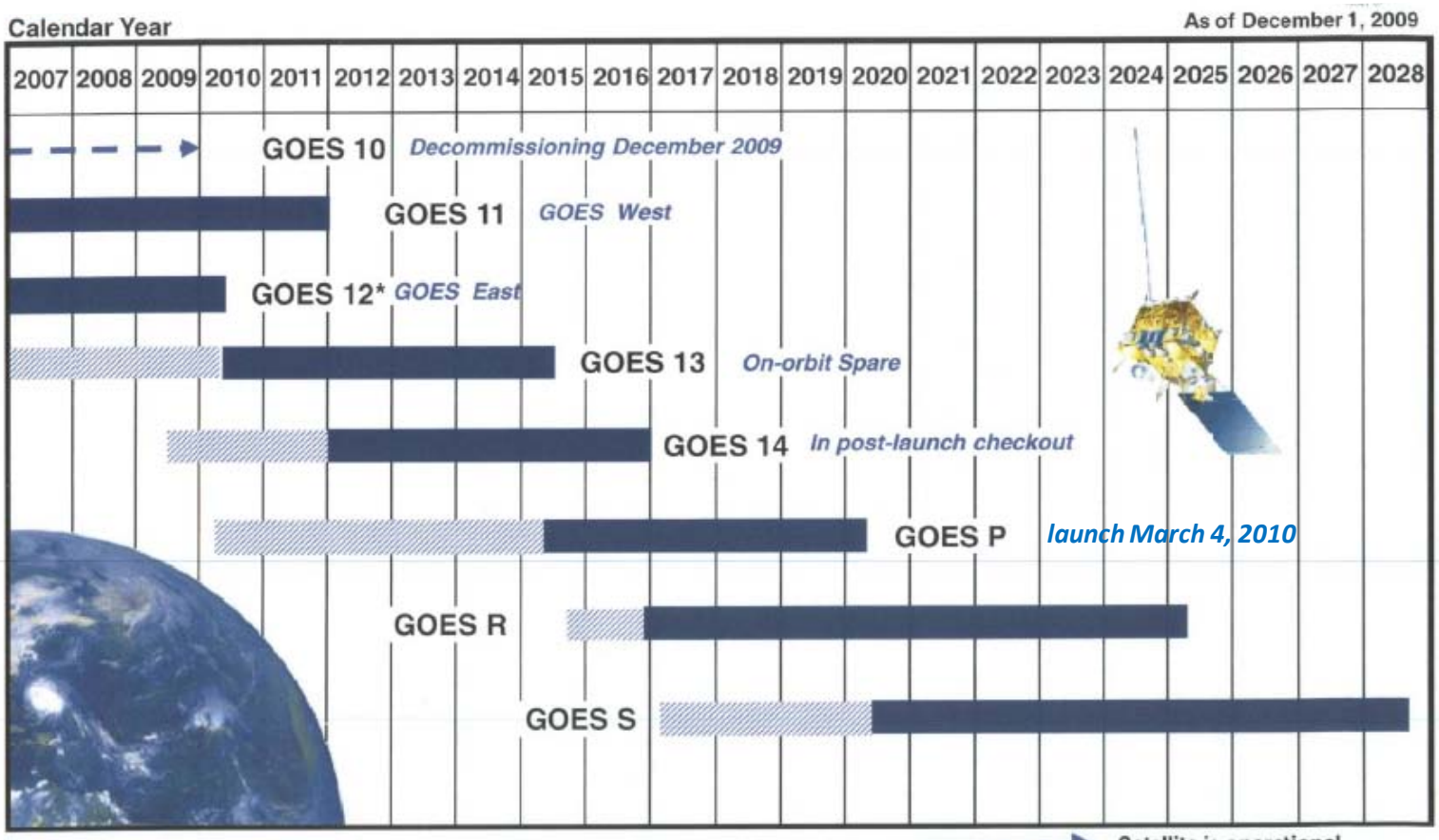
GOES Launch Schedule



Approved: Abigail Harper
Deputy Assistant Administrator for Systems

* Backup and South American Coverage beginning June 2010

Satellite is operational beyond design life
On-orbit GOES storage
Operational

Why GOES-R?

- Continuation of NOAA capability required to observe, protect and manage the earth's resources to promote environmental stewardship
- Enhance ability to predict and track storms; plan routes for airlines and ship traffic, identify demands for natural resources such as gas and water, and assess space weather impacts on sensitive electronics such as satellites and terrestrial communications
- Improve:
  - Hurricane track & intensity forecast
  - Thunderstorm & tornado warning lead time ← Advanced Baseline Imager (ABI) & Geostationary Lightning Mapper (GLM)
  - Aviation flight route planning
  - Solar flare warnings for communications and navigation ← Extreme Ultra Violet Sensor/X-Ray Sensor Irradiance Sensor (EXIS)
  - Power blackout forecasts due to solar flares ← Solar Ultra Violet Imager (SUVI)
  - Energetic particle forecasts ← Space Environmental In-Situ Suite (SEISS)

GOES-R Instruments:

GOES Product Heritage

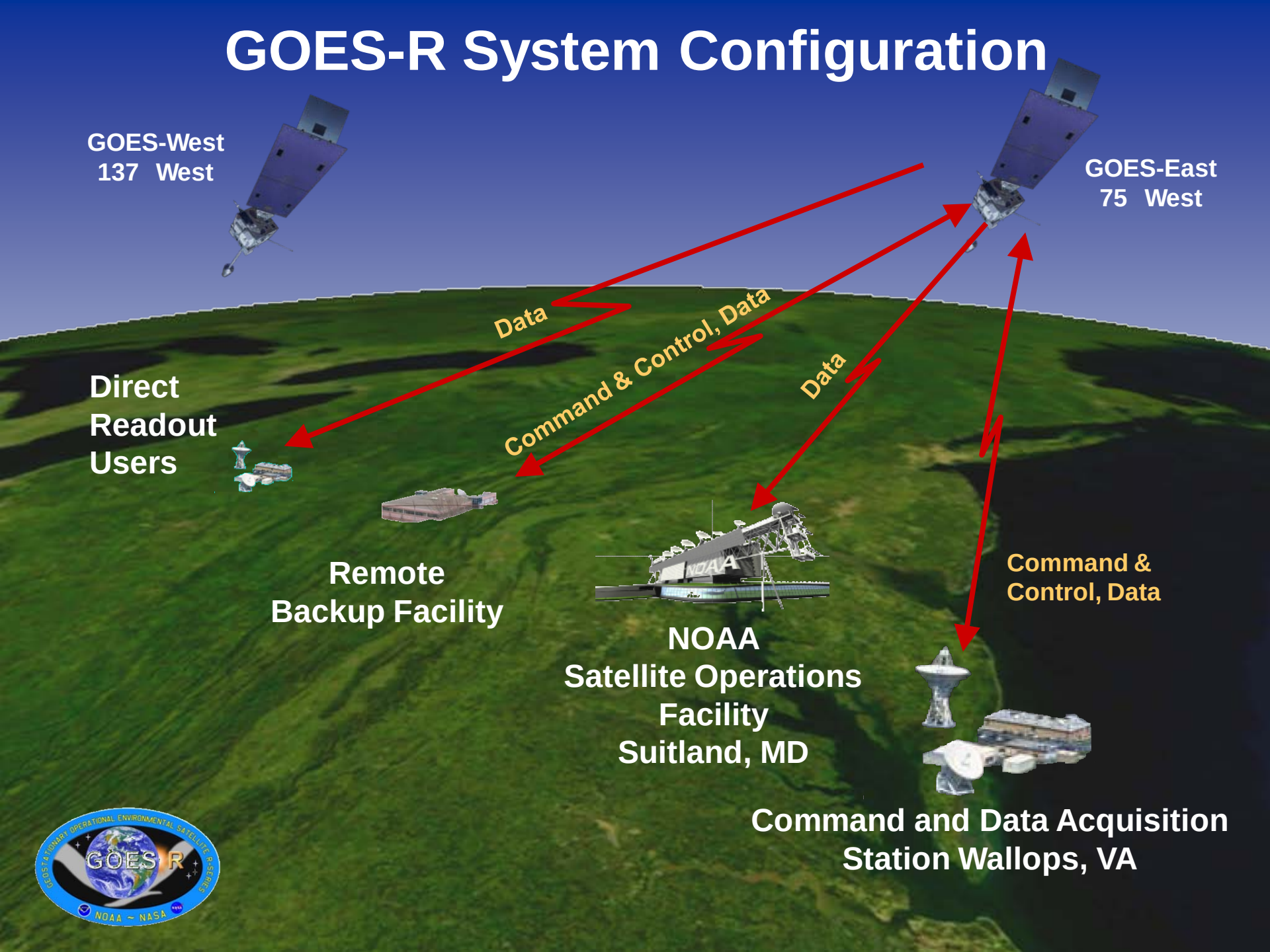
(Yellow = current GOES and GOES-R, Blue = GOES-R only)

1. Aerosol Detection (including Smoke and Dust)	
2. Aerosol Particle Size	+
3. Aerosol Optical Depth	
4. Volcanic Ash: Detection and Height	
5. Aircraft Icing Threat	+
6. Cloud Ice Water Path	+
7. Cloud Layers / Heights	+
8. Cloud Liquid Water	+
9. Cloud & Moisture Imagery	
10. Cloud Optical Depth	
11. Cloud Particle Size Distribution	
12. Cloud Top Phase	
13. Cloud Top Height	
14. Cloud Top Pressure	
15. Cloud Top Temperature	
16. Cloud Type	+
17. Convective Initiation	+
18. Enhanced "V" / Overshooting Top Detection	+
19. Hurricane Intensity	
20. Lightning Detection: 1) Events and 2) Flashes	
21. Low Cloud and Fog	+
22. Tropopause Folding Turbulence Prediction	+
23. Visibility	+
24. Probability of Rainfall	+
25. Rainfall Potential	+
26. Rainfall Rate/QPE	
27. Legacy Vertical Moisture Profile	
28. Legacy Vertical Temperature Profile	
29. Derived Stability Indices (5 indices: CAPE, Lifted Index, K-index, Showalter Index, Total Totals)	
30. Total Precipitable Water	
31. Clear Sky Masks	
32. Radiances	

33. Absorbed Shortwave Radiation: Surface	+
34. Downward Longwave Radiation: Surface	+
35. Downward Shortwave Radiation: Surface	
36. Reflected Shortwave Radiation: TOA	
37. Upward Longwave Radiation: Surface	+
38. Upward Longwave Radiation: TOA	+
39. Ozone Total	+
40. SO2 Detection	+
41. Derived Motion Winds	
42. Fire / Hot Spot Characterization:	
43. Flood/Standing Water:	+
44. Ice Cover: Hemispheric	+
45. Land Surface (Skin) Temperature	
46. Snow Cover	
47. Snow Depth	+
48. Surface Albedo	+
49. Surface Emissivity	+
50. Vegetation Fraction: Green	+
51. Vegetation Index	+
52. Currents	+
53. Currents: Offshore	+
54. Sea & Lake Ice: Age	+
55. Sea & Lake Ice: Concentration:	+
56. Sea & Lake Ice: Motion	+
57. Sea Surface Temperature (skin)	
58. Energetic Heavy Ions	
59. Magnetospheric Electrons and Protons: Low Energy	
60. Magnetospheric Electrons and Protons: Medium & High Energy	
61. Solar and Galactic Protons	
62. Geomagnetic Field	
63. Solar Flux: EUV (GOES-O will produce)	
64. Solar Flux: X-Ray	
65. Solar Imagery: X-Ray	

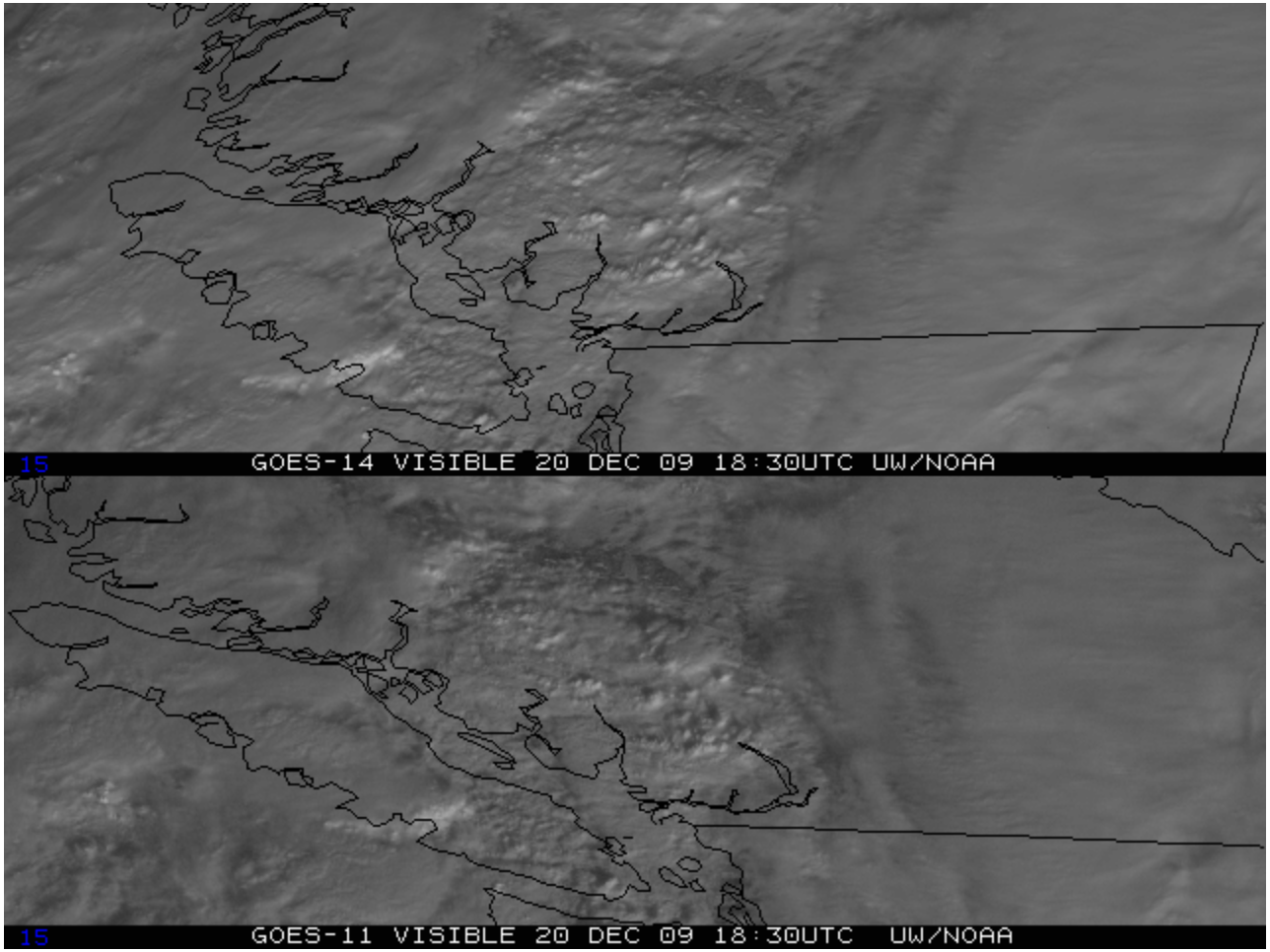
+ indicates Option 2 products (option 1 refers to reduced latency)

GOES-R System Configuration



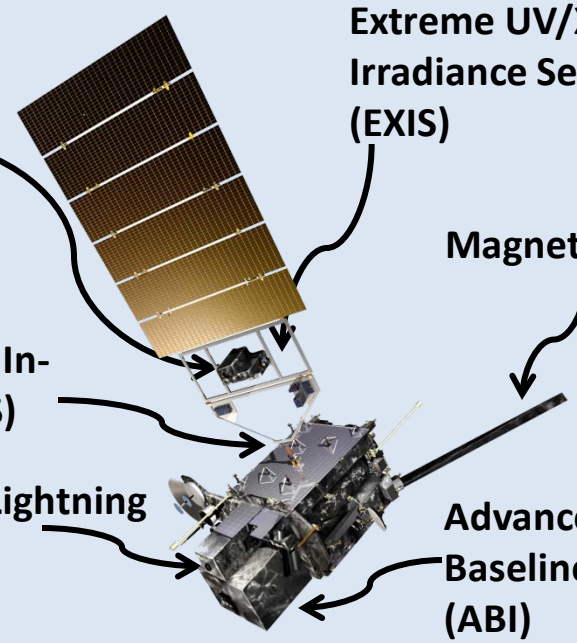
WMO WWRP SNOW V-10 Vancouver Olympics Research Demonstration Project

December 20, 2009 Snow/Rain Event: GOES 11 VIS SRSO vs 14 Comparison



GOES-R Spacecraft

- Lockheed-Martin Space Systems Co (LMSSC) began work on July 22, 2009.
- Spacecraft kick-off meeting September, 2009; SRR March 2010
- Size: ~5.5 meters (from launch vehicle interface to top of ABI)
- Mass: Satellite (spacecraft and payloads) dry mass <2800kg
- Power Capacity: > 4000W at end-of-life (includes accounting for limited array degredation)



Unique Payload Services:

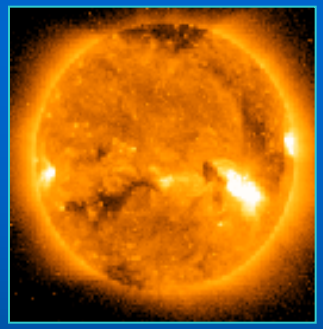
- High Rate Information Transmission/Emergency Managers Weather Information Network (HRIT/EMWIN)
- Data Collection System (DCS)
- Search and Rescue Satellite Aided Tracking (SARSAT) Repeater
- GOES-R Re-Broadcast (GRB)

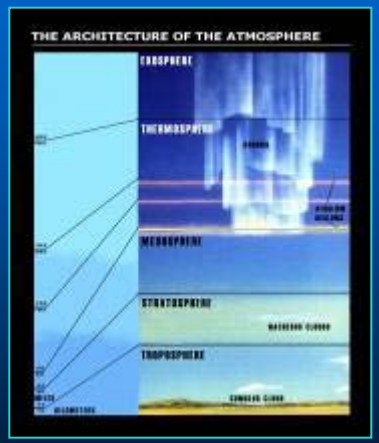
GOES-R Improvements vs Current GOES

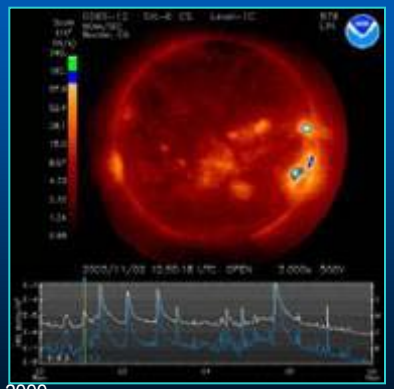
Performance Capability	GOES I-M	GOES N-P	GOES R
Imaging			
Visible Resolution	1 km	1 km	0.5 km (0.64 um)
IR Resolution	4-8 km	4-8 km N 4 km O/P	1-2 km
Full Disk Coverage Rate	30 min	30 min	5 min
Rapid Scan Imaging Mode	7.5 min	7.5 min	30 sec
# of Channels	5	5	16
Solar Monitoring	GOES-M only	Yes	Yes
Lightning Detection	No	No	Yes 8km <20 sec latency
Operate through Eclipse	No	Yes	Yes
Ground System Backup	Limited	Limited	Limited
Archive and Access	Limited	Limited	Yes
S/C Raw Data Volume	2.6 Mbps	2.6 Mbps	75 Mbps

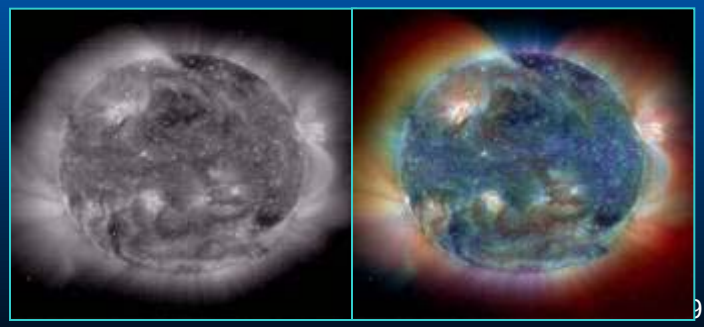
Space Weather Instruments

- Space Environment impacts Earth
  - Instruments provide early warning
  - Communications satellites / power grids
  - Voice and data blackouts over poles
    - Communications blackouts
    - Aviation routing
  - Astronaut safety
    - Solar storms can expose astronauts to equivalent of 8 chest X-rays



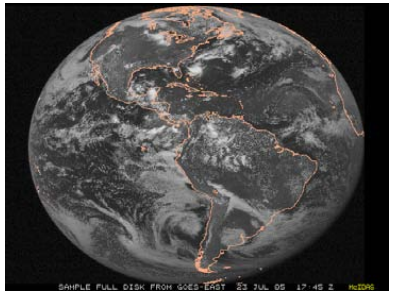




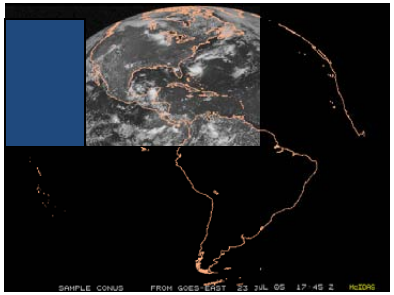


Imager Coverage in ~30 minutes

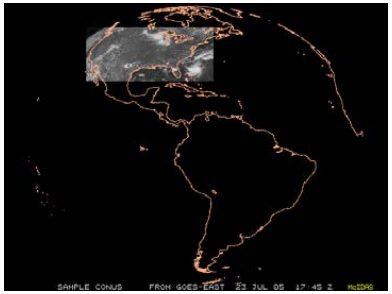
	Current Imager (Rapid Scan mode)	**Future Imager** ("Flex" mode)
Full Disk	0	2
Northern Hemi	1	-
CONUS	3	6
Mesoscale	0	60



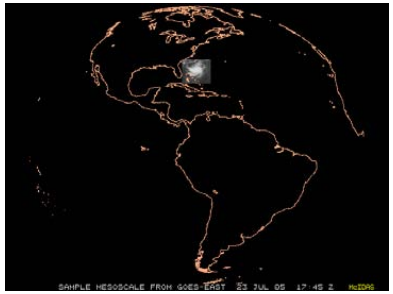
Full Disk



N. Hemisphere



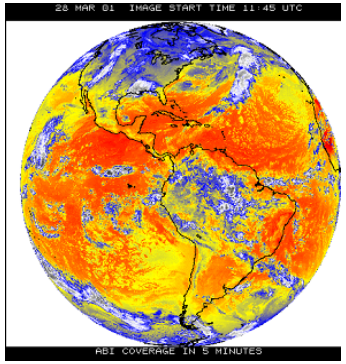
CONUS

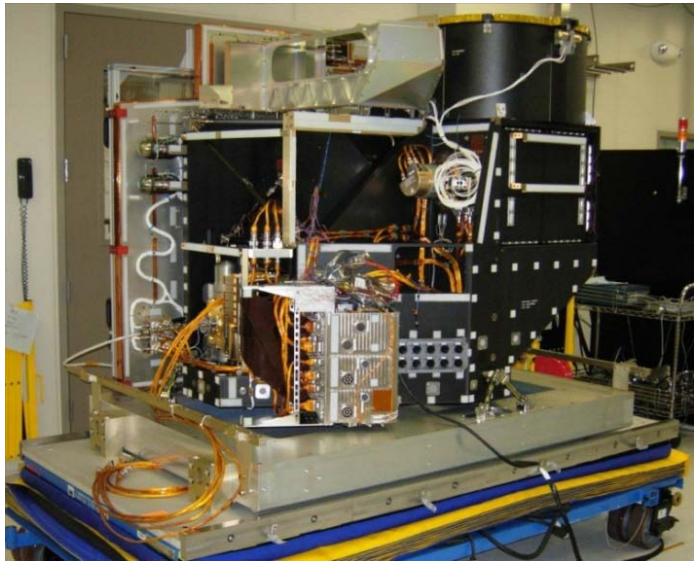


Mesoscale

Advanced Baseline Imager (ABI)

- 16 channel imager
- Improves upon current capabilities in spectral information (3X), spatial resolution (2X), and temporal resolution (5X)
- Continues current products and allows for new products for **severe weather forecasting, fire and smoke monitoring, volcanic ash advisories, and more**





Current Status

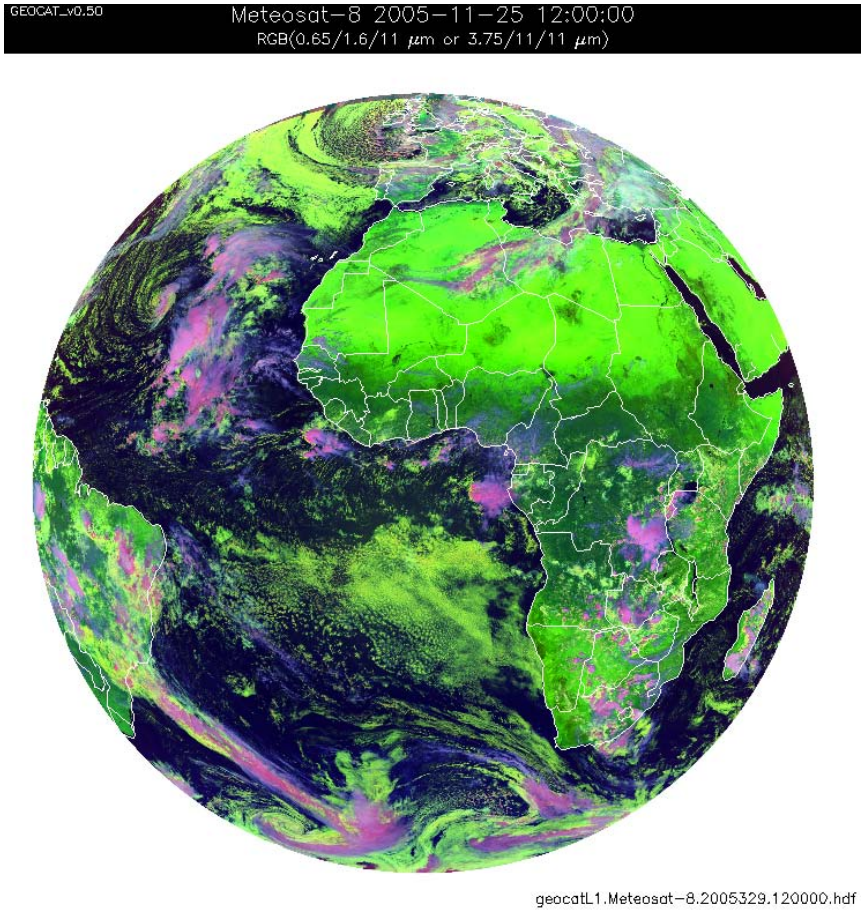
- Prototype Model (PTM) sensor unit complete
- PTM Instrument bench testing underway

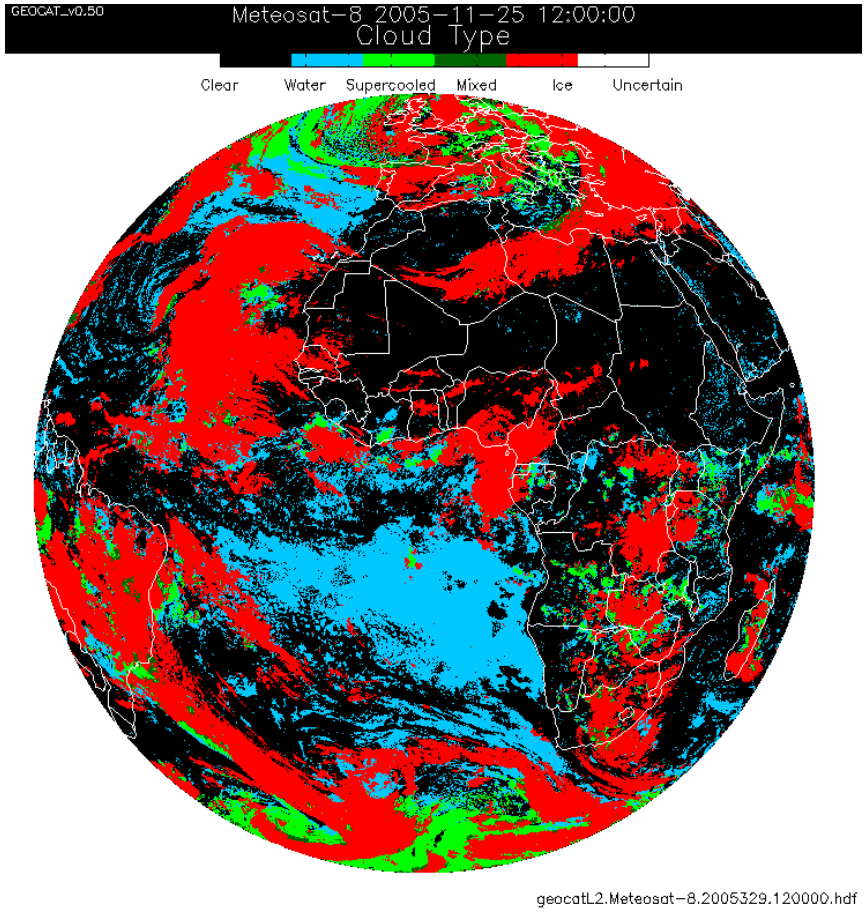
Coming Soon:

- PTM Environmental tests in Spring 2010
- Delta Critical Design Review (CDR) in late FY2010

Cloud Phase

Full disk cloud phase results (MSG SEVERI proxy data)

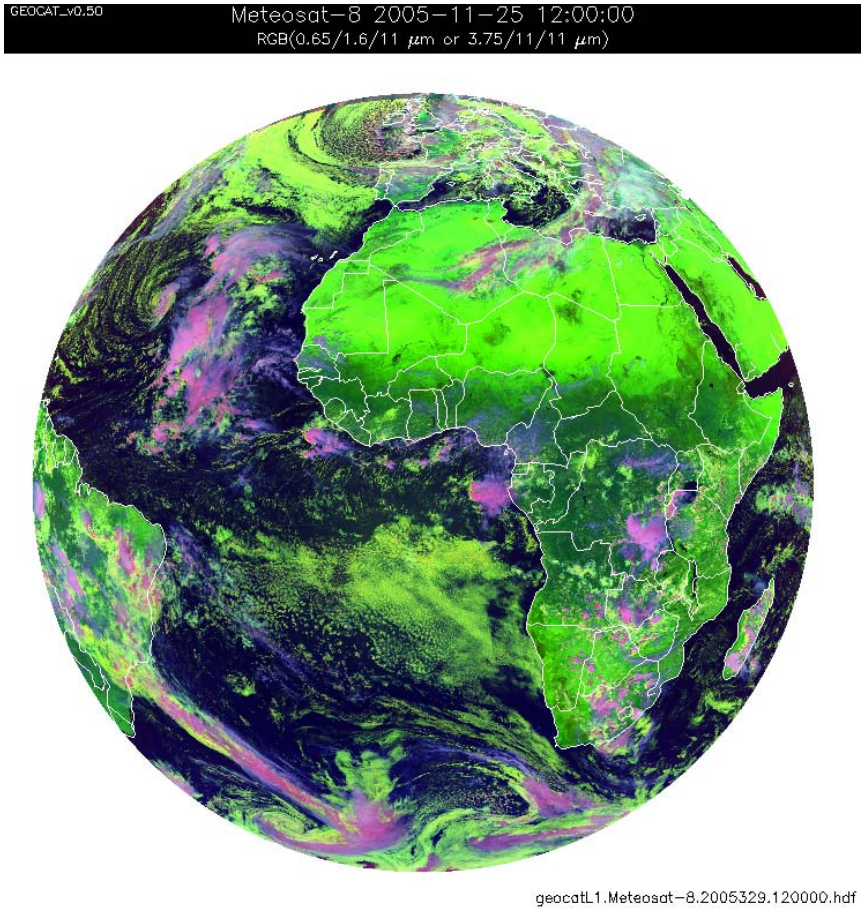


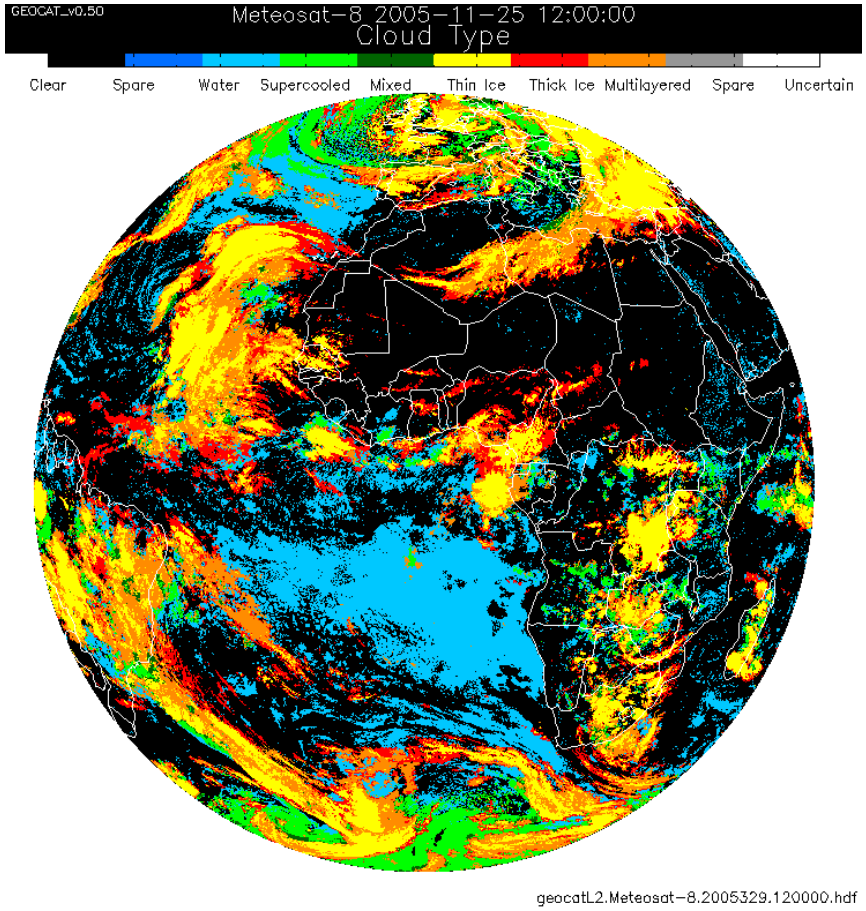


Water, Supercooled Water, Mixed Phase, Ice

Cloud Type

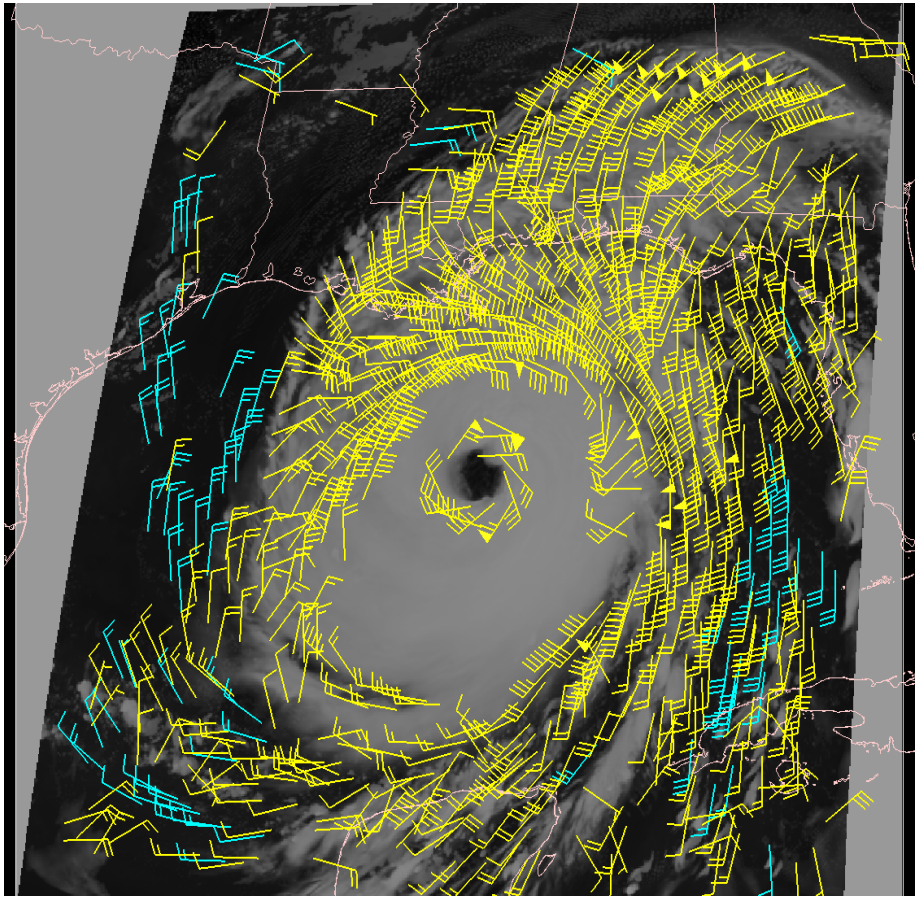
Full disk cloud type results (MSG SEVERI proxy data)



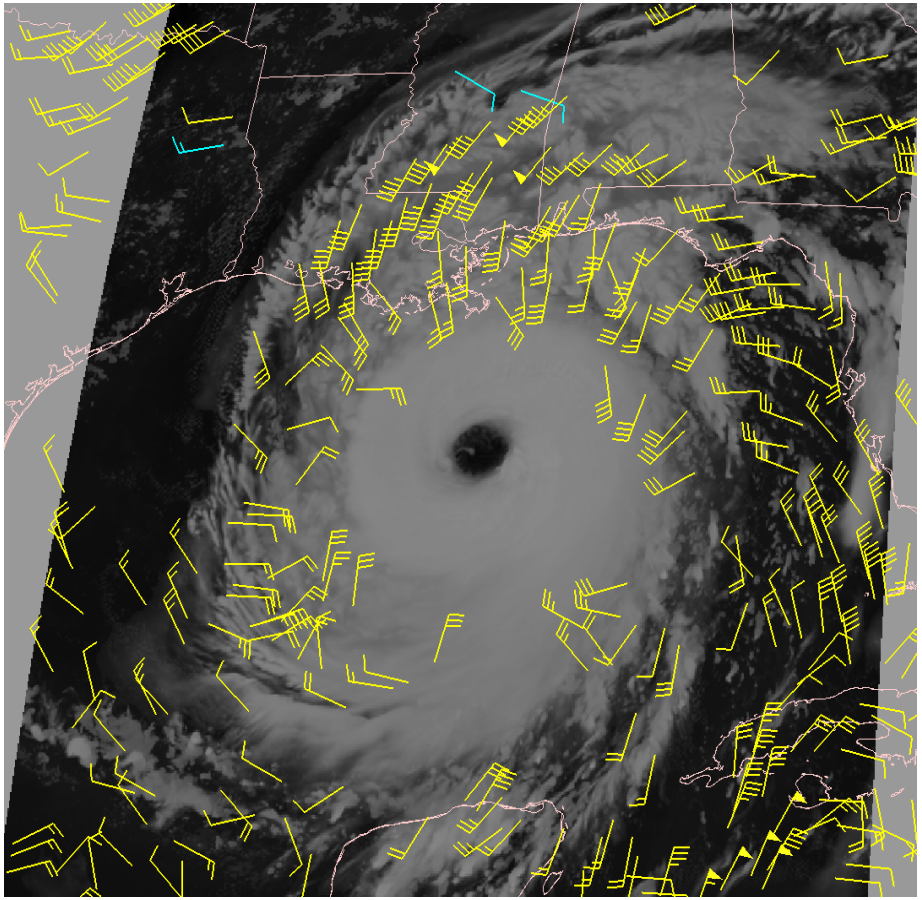


Water, Supercooled Water, Mixed Phase, Thick Ice, Thin Ice, Multilayered

GOES-R Atmospheric Motion Vectors Example: Hurricane Katrina



IR AMVs derived from WRF model images using simulated future GOES-R radiances 2 km resolution; 5-minute time step



IR AMVs derived from current GOES-12 4km resolution; 15-minute time step

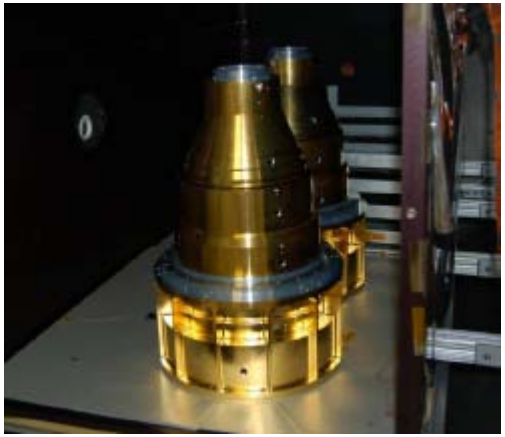
Low-mid level vectors- cyan Upper-level vectors - yellow

UWisc-CIMSS/NOAA-STAR

Geostationary Lightning Mapper (GLM)

- **Detects total lightning**: in cloud, cloud to cloud, and cloud to ground
  - Improves warning lead-time for severe storms and high impact weather
  - Improves aviation safety and efficiency due to avoidance of thunderstorms
- Near-uniform storm-scale coverage over oceans and land

Photo credit: Shane Lear, NOAA



EDU rear lens housing

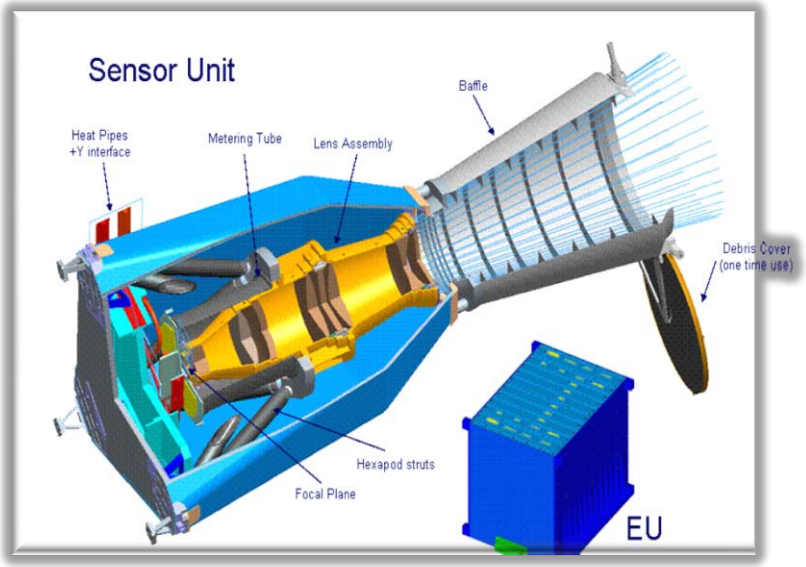
Current Status

- Successfully conducted Preliminary Design Review (PDR)
- Engineering Test Units and Engineering Demonstration Unit in fabrication

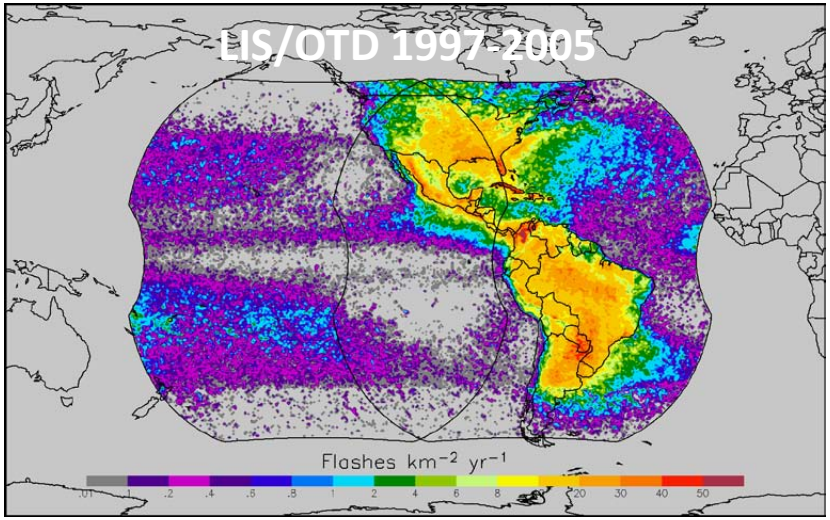
Coming Soon:

- CDR in summer 2010
- GPM CHUVA Proxy Data Campaign Sao Paulo

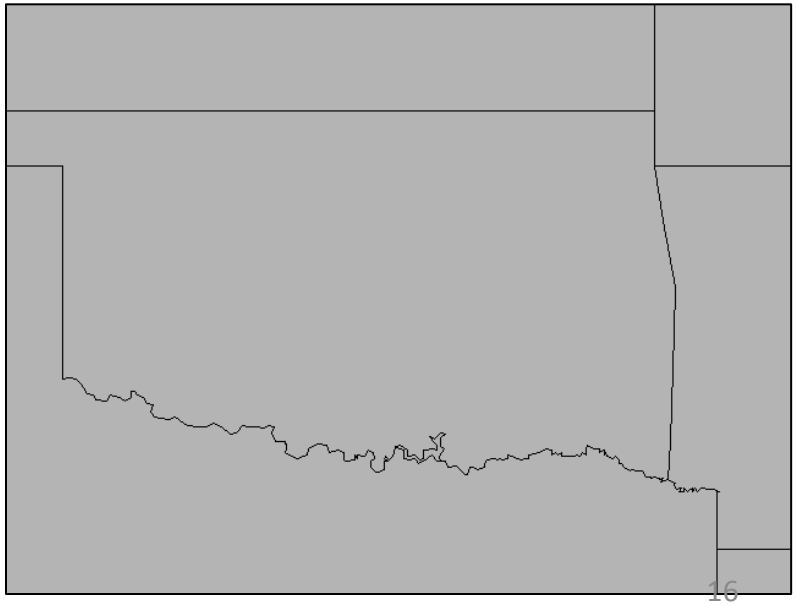
GOES-R Geostationary Lightning Mapper (GLM)



GLM Combined R/S Coverage



May 3 1999 Oklahoma Tornado Outbreak



1-minute of observations from TRMM/LIS

GLM Characteristics

- Staring CCD imager (1372x1300 pixels)
  - Single band 777.4 nm
  - 2 ms frame rate
  - 7.7 Mbps downlink data rate
- Near uniform spatial resolution/ coverage up to 52 deg lat
  - 8 km nadir to 14 km at edge
  - 70-90% flash detection
- < 20 sec product total latency

JCSDA 2010 Data Assimilation Initiative

Funding Opportunity Title: Research in Satellite Data Assimilation for Numerical Weather, Climate and Environmental Forecast Systems

The JCSDA's goal is to accelerate the abilities of NOAA, DOD, and NASA to ingest and effectively use large volumes of data from current and future satellite-based instruments (over the next 10 years). Maximizing the impact of these observations on numerical weather prediction and data assimilation systems is a high priority of the JCSDA.

New for 2010:
Advanced Instruments (e.g. IASI, ASCAT, SSMIS, Jason-2/3, SMOS, Aquarius, ADM, CrIS, ATMS, **ABI, GLM**, GPM, and other planned research missions) are or will become available over the course of the next decade.

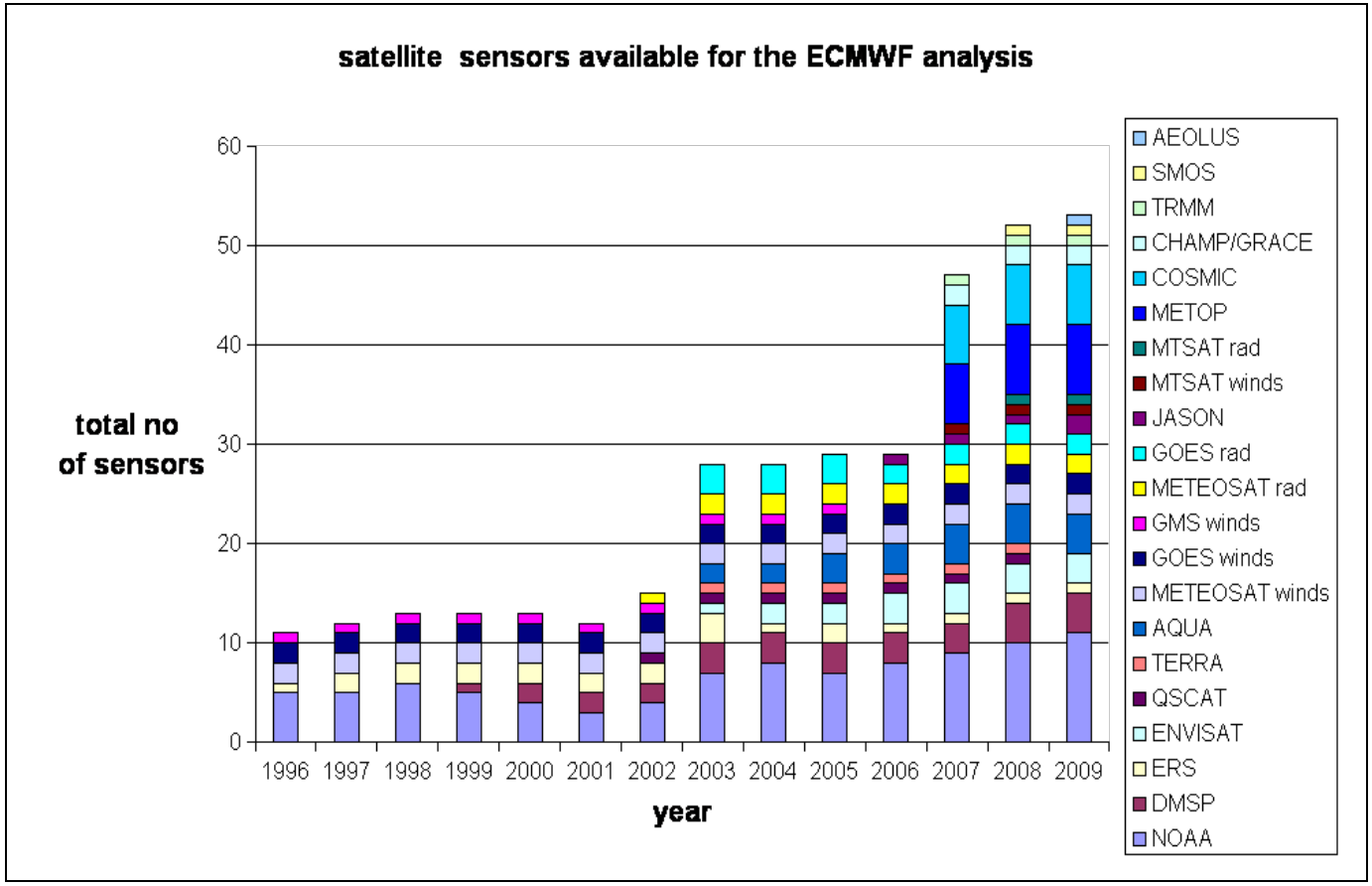
- Impact studies of assimilating future instruments data and products on the forecast of severe weather events (hurricanes, flash flooding, etc) at both global and regional scales.

Satellite Data used in NWP at NCEP

- HIRS sounder radiances
- AMSU-A sounder radiances
- AMSU-B sounder radiances
- GOES sounder radiances
- GOES, Meteosat, GMS winds
- GOES precipitation rate
- SSM/I precipitation rates
- TRMM precipitation rates
- SSM/I ocean surface wind speeds
- ERS-2 ocean surface wind vectors
- Quikscat ocean surface wind vectors
- AVHRR SST
- AVHRR vegetation fraction
- AVHRR surface type
- Multi-satellite snow cover
- Multi-satellite sea ice
- SBUV/2 ozone profile and total ozone
- Altimeter sea level observations (ocean data assimilation)
- AIRS
- MODIS Winds
- COSMIC

~33 instruments

Number of satellite sensors that are or will be soon assimilated in the ECMWF operational data assimilation



GOES-R Proving Ground

What is the GOES-R Proving Ground?

- Collaborative effort between the GOES-R Program Office, selected NOAA/ NASA Cooperative Institutes, NWS forecast offices, NCEP National Centers, and NOAA Testbeds.

- Where proxy and simulated GOES-R products are tested, evaluated and integrated into operations before the GOES-R launch

- A key element of GOES-R User Readiness (Risk Mitigation)

Proxy Data for GOES-R

No current GEO satellite has the spatial, spectral and temporal resolution of GOES-R

Use proxy and simulated data sets to develop, test and validate products, decision aids, data processing and distribution systems

- MODIS
- AIRS
- TRMM/LIS
- IASI
- SEVIRI
- NAST-I (airborne simulator)
- Unmanned Aircraft Systems-Global Hawk
- NPP/ VIIRS/ CrIS
- Ground-based Total Lightning Networks
- Computer Simulated Atmospheres- WRF radiances

GOES-R PG Warning Product Set

The following list is of products offers opportunity for near-real time Warning Related utility.

<u>Baseline Products:</u>
Volcanic Ash: detection & Height
Cloud and Moisture Imagery
Hurricane Intensity
Lightning Detection: Events, Groups & Flashes
Rainfall Rate / QPE
Total Precipitable Water
Fire/Hot Spot Characterization

<u>Option 2 Products:</u>
Aircraft Icing Threat
Convective Initiation
Enhanced “V” / Overshooting Top Detection
Low Cloud and Fog
SO_2 Detection

GOES-R Proving Ground Partners

75 Total Partners Preparing

Current as of December 2009

OTX
TFX
GGW
BPA
PDT
FGF
DLH
MQT
BYZ
BTV
ABR
MPX
GRB
MFR
UNR
ARX
EKA
RIW
CIMSS
MKX
BGM
CTP
ERH
PBZ
REV
WRH
CYS
DMX
DVN
UMBC
LOT
CIRA
IWX
CICS
IND
LWX
BOU
MTR
AWC/CRH
EAX
EPA
VEF
JKL
RNK
AKQ
ICT
SGF
RAH
MRX
ABQ
TSA
OHX
GSP
AMA
SPC
OUN
SPoRT
HUN
CAE
CHS
FFC
SRH
FWD
BMX
EPZ
MAF
MOB
TAE
HGX
SMG
MLB
CRP
NHC
MFL
KEY

NOAA/NWS Headquarters (Silver Spring, MD); Center for Satellite Applications and Research; Office of Satellite Data Processing and Distribution.

GOES-R Program Office (Greenbelt, MD).

PRH
NWS Pacific Region HQ

AFG
AFC
AJK
ARH
NWS Alaska Region HQ

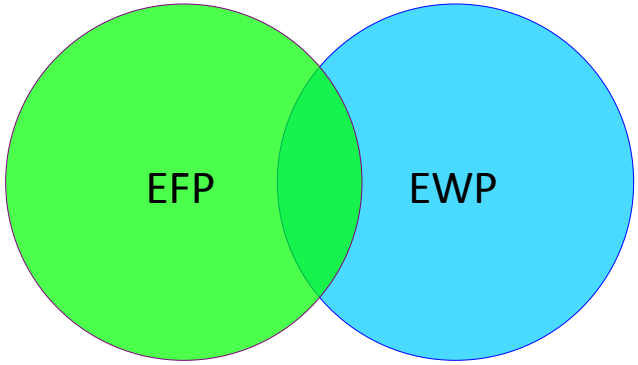
- ***3*** Weather Service Offices served by the Cooperative Institute for Research in the Atmosphere (CIRA)
- ***4*** Weather Service Offices served by the Cooperative Institute for Climate and Satellites (CICS) via SPoRT
- ***11*** National/Regional
- ***15*** Weather Service Offices served by the NASA Short-term Prediction Research and Transition Center (SPoRT)
- ***46*** Weather Service Offices served by the Cooperative Institute for Meteorological Satellite Studies (CIMSS)

NOAA Hazardous Weather Testbed

Collaboration with GOES-R Proving Ground

EWP 2010- 16 forecasters
EFP 2010 - 12 forecasters

Experimental
Forecast
Program



Experimental
Warning
Program

*Prediction of hazardous weather events from **a few hours to a week in advance***

*Detection and prediction of hazardous weather events **up to several hours in advance***

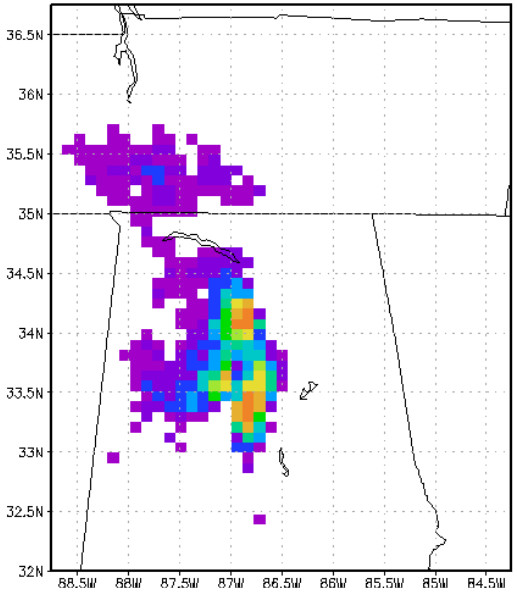
SPoRT Pseudo GLM Product

Provide forecaster exposure to GLM data, differences from LMA, applicability to severe weather forecasting – benefits transition of full AWG proxy when available

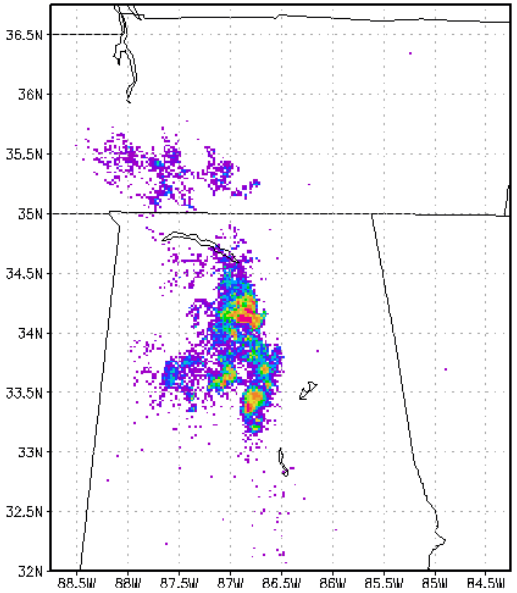
Flash Extent Density derived from LMA data at GLM resolution

- different from AWG proxy - no optical data
- forecaster demonstration and education
- applicable to other total lightning networks
- focus on AWIPS II development with user feedback

Pseudo GLM Flash Extent



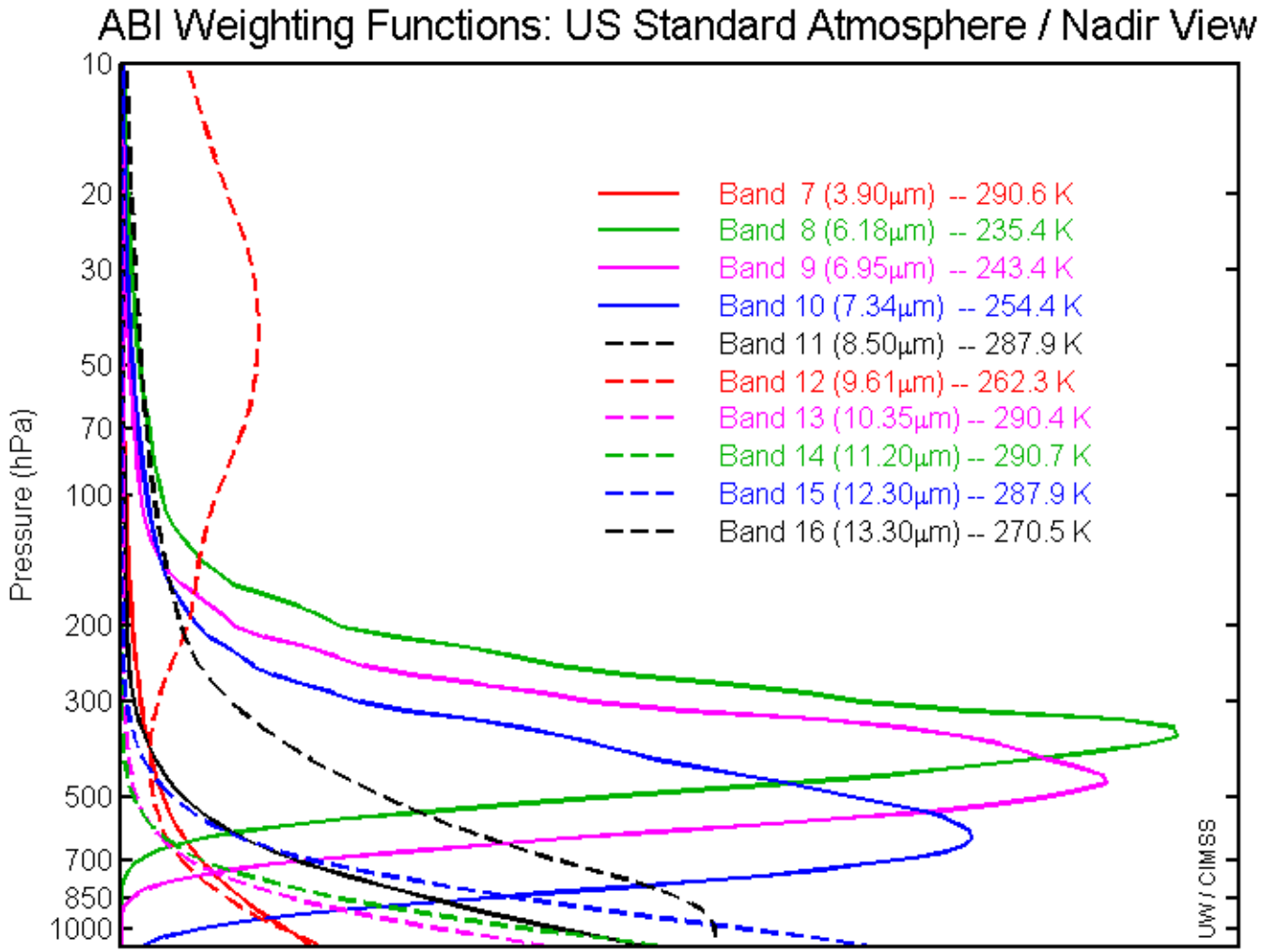
LMA Source Densities



Operational Products from the current GOES Sounder and how the ABI measurements, along with ancillary data, can produce legacy products.

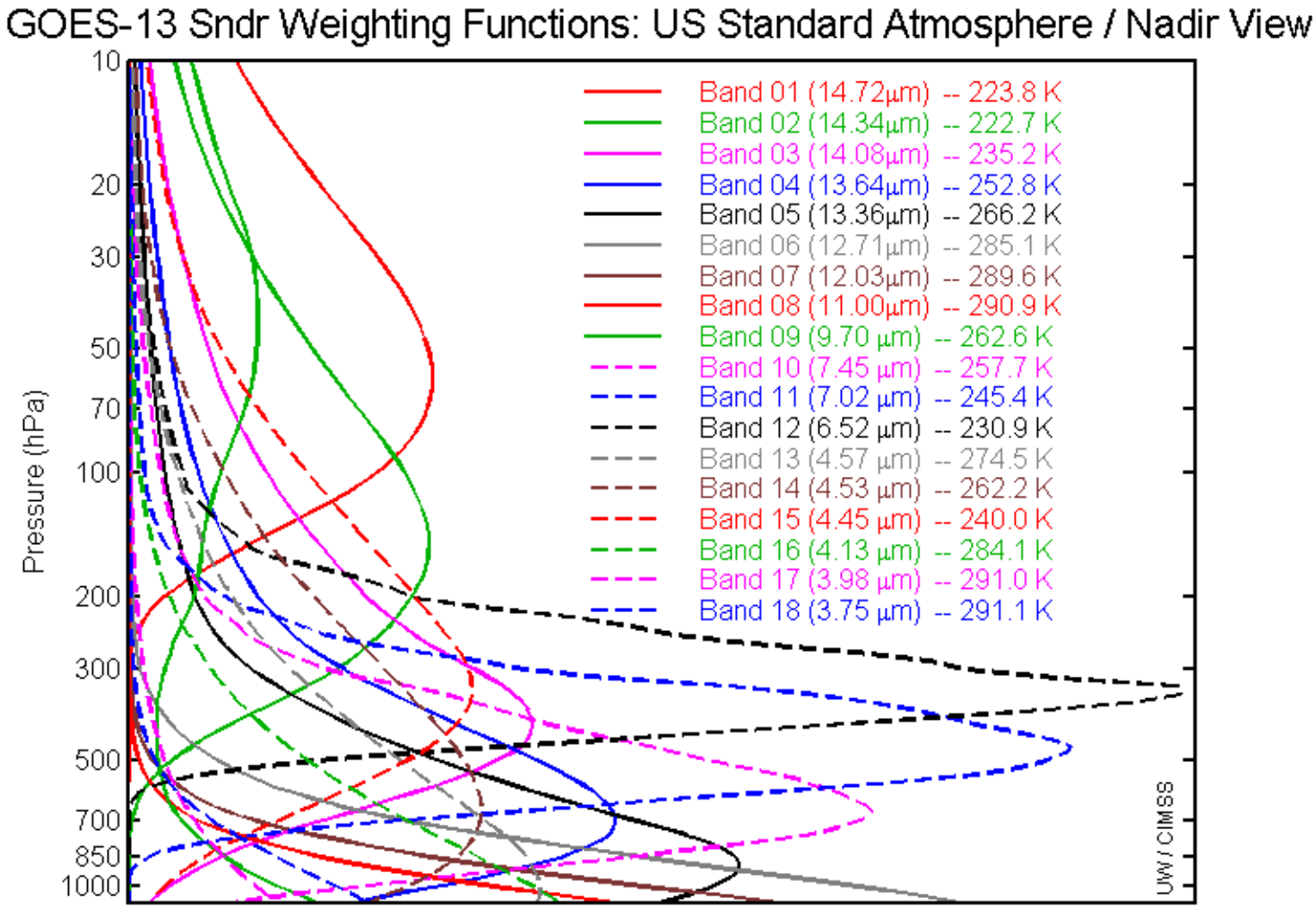
Product	Temporal/Latency	Spatial	Accuracy	Comments
Radiances	ABI ~ 20X faster	Comparable (when averaged)	Comparable for moisture information	Only 1 CO_2 band on ABI (5 bands on Sounder)
TPW	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	ABI product quality helped with model info
Lifted Index	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	ABI product quality helped with model info
Skin Temperature	ABI ~ 20X faster	Comparable (when averaged)	Comparable	ABI has extra window band
Profiles	ABI ~ 20X faster	Comparable (when averaged)	Sounder more precise	Worse upper-level T and lower-level moisture
Clouds	ABI ~ 20X faster	ABI Finer	Sounder more precise for cloud height	Current Sounder with more CO_2 bands gives a better height
Moisture winds	ABI ~ 20X faster	ABI Finer	Comparable	-

GOES-R ABI Weighting Functions



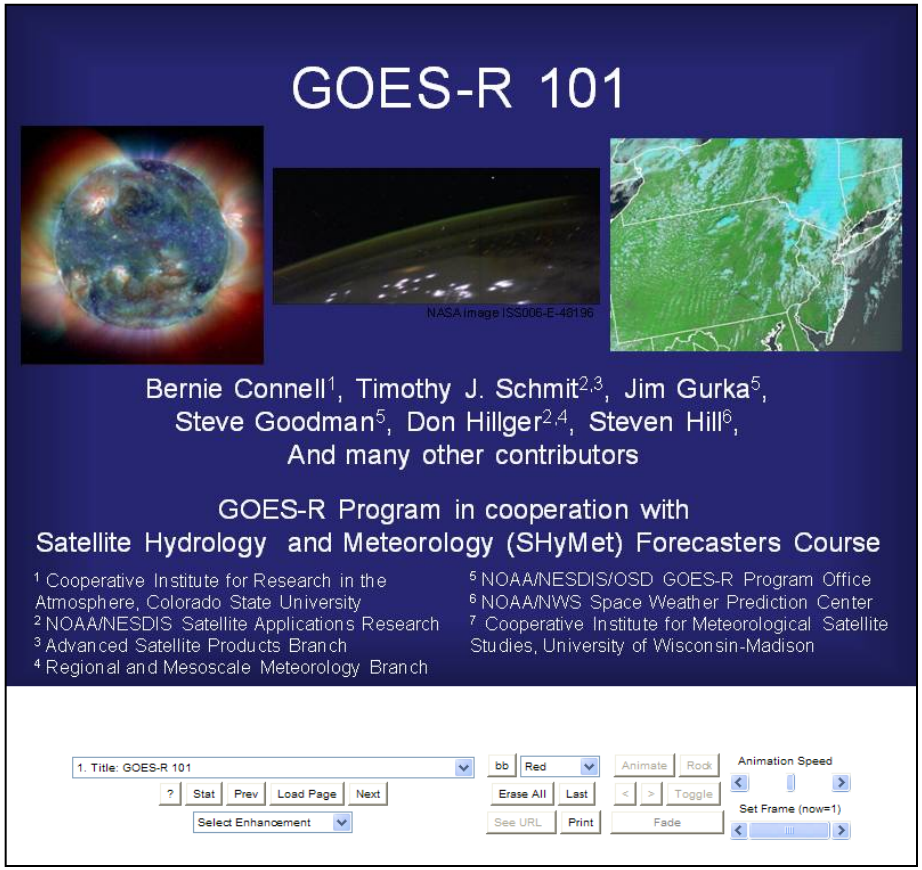
ABI has 1 CO_2 band, so upper-level temperature will be degraded compared to the current sounder

GOES-13 Sounder WFs



The GOES-N sounder has 5 CO_2 bands, more Shortwave bands than ABI

SHyMet for Forecasters: GOES-R 101

http://rammb.cira.colostate.edu/training/shymet/forecaster_GOESR101.asp

- Went live in January
- Available training options
  - A.) Web-based Video training session (90 min duration)
  - B.) Audio playback
  - C.) Web-based VISITview training session with notes
- Part of SHyMet Forecaster training series
- Announced to SOOs
- Planned link to GPO goes-r.gov web page
- Sponsored by GOES-R Risk Reduction