Leveraging Satellite Data at NOAA's National Centers for Environmental Prediction

NOAA Satellite Conference

College Park, MD
April 11, 2013

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NCEP and JCSDA

"Where America's Climate, Weather and Ocean Services Begin"

Overview

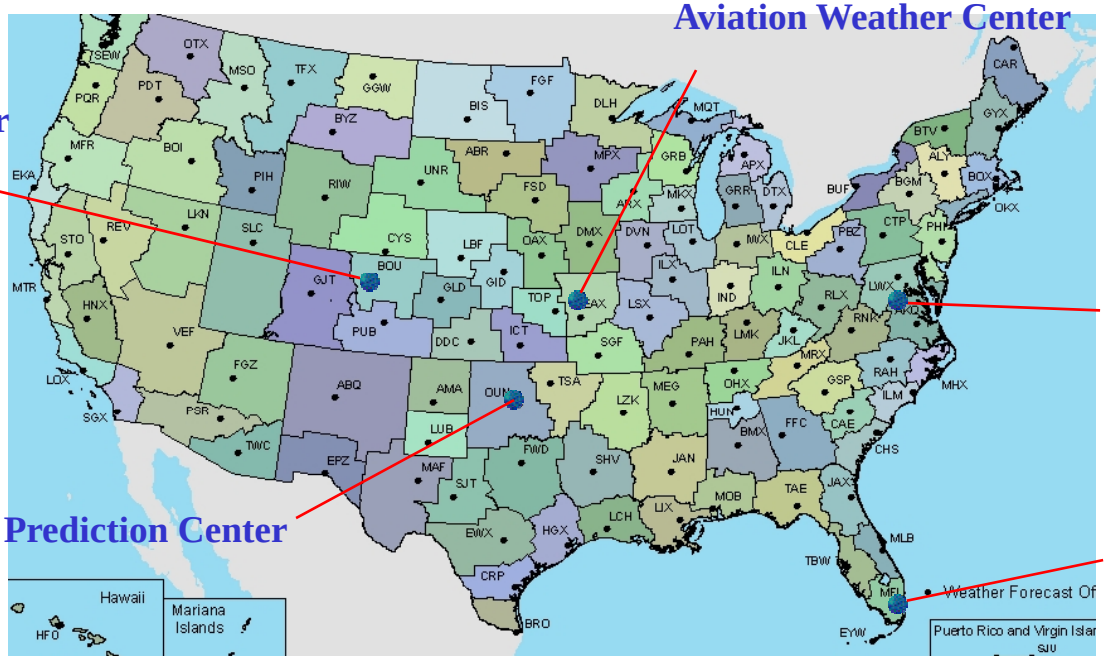
- Introduction to NCEP
- Using Satellite Data for Central Guidance
- Using Satellite Data at Service Centers
- Looking Forward
- Summary

Introduction to NCEP

NCEP Supports the NOAA Seamless Suite of Climate, Weather, and Ocean Products

Organization: Central component of NOAA National Weather Service

Mission: NCEP delivers science-based environmental predictions to the nation and the global community. We collaborate with partners and customers to produce reliable, timely, and accurate analyses, guidance, forecasts and warnings for the protection of life and property and the enhancement of the national economy.



Aviation Weather Center

Space Weather Prediction Center

NCEP Central Operations
Climate Prediction Center
Environmental Modeling Center
Weather Prediction Center
Ocean Prediction Center

Storm Prediction Center

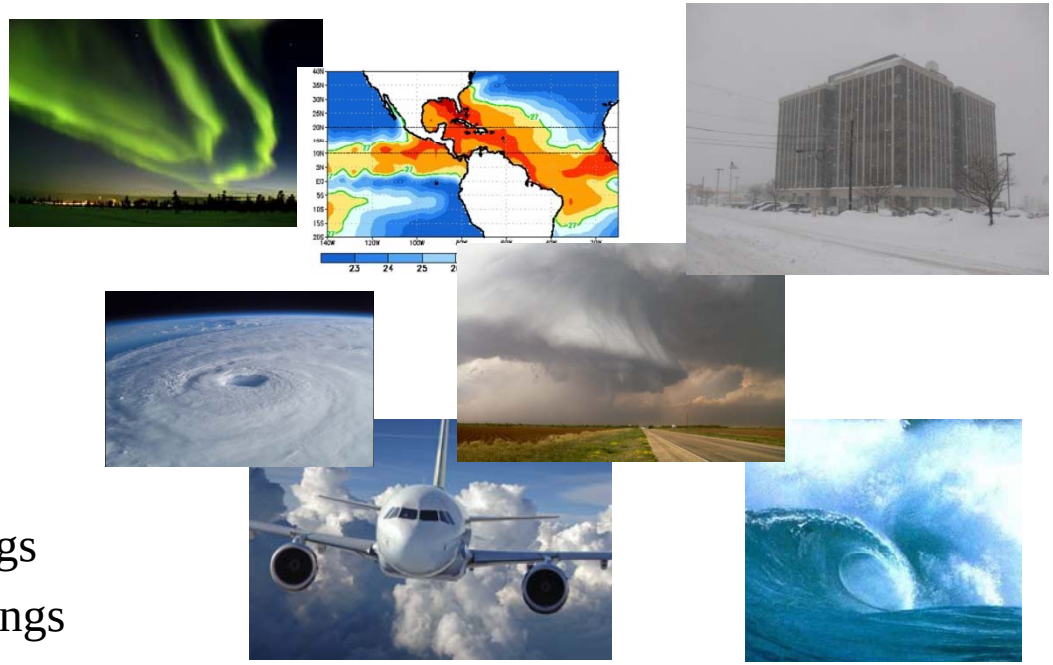
National Hurricane Center

Vision: The Nation's trusted source, first alert and preferred partner for environmental prediction services

What Does NCEP Do?

"From the Sun to the Sea"

- Solar Monitoring, Warnings and Forecasts
- Climate Seasonal Forecasts
- El Nino – La Nina Forecast
- Weather Forecasts to Day 7
- Extreme Events (Hurricanes, Severe Weather, Snowstorms, Fire Weather)
- Aviation Forecasts and Warnings
- High Seas Forecasts and Warnings

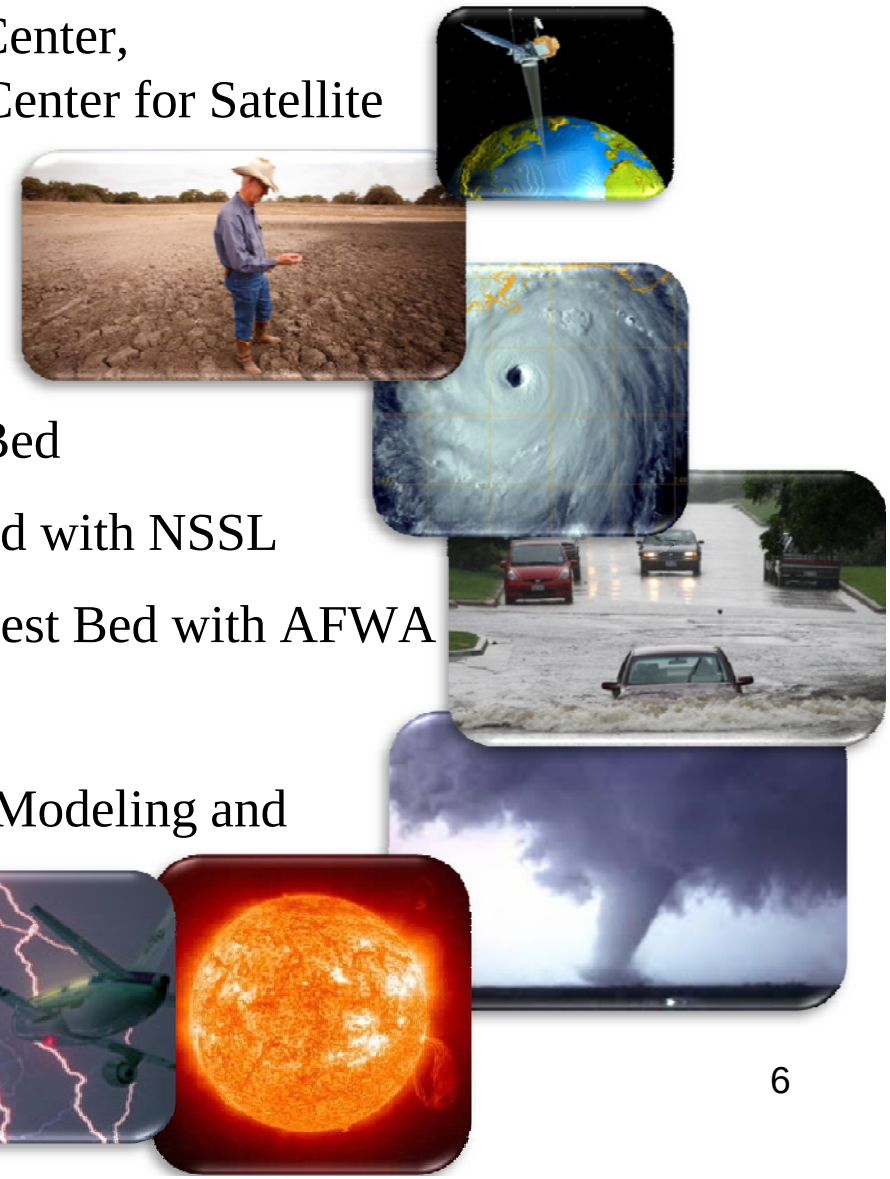


- Model Development, Implementation and Applications for Global and Regional Weather, Climate, Oceans and now Space Weather
- International Partnerships in Ensemble Forecasts
- Data Assimilation including the Joint Center for Satellite Data Assimilation
- Super Computer, Workstation and Network Operations

Research to Operations -TestBeds

Service – Science Linkage

- EMC — WRF Developmental Test Center, NASA/ NOAA/DoD Joint Center for Satellite Data Assimilation
- CPC — Climate Test Bed
- NHC — Joint Hurricane Test Bed
- WPC — Hydrometeorological Test Bed
- SPC — Hazardous Weather Test Bed with NSSL
- SWPC — Space Weather Prediction Test Bed with AFWA
- AWC — Aviation Weather Test Bed
- OPC — linked with EMC's Marine Modeling and Analysis Branch

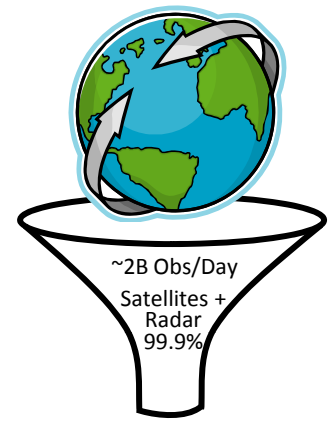


Using Satellite Data for Central Guidance

Three Components for NWP

- Observations
  - ~2 billion/day
  - 99.9% remotely sensed
- Modeling & Assimilation
  - Global & Regional Models
  - Hybrid 3DVAR EnKF DAS
- Computing

NOAA's Model Production Suite



Global Data Assimilation

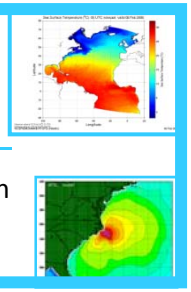
Global Forecast System

Climate Forecast System
GFS MOM4
NOAH Sea Ice

Hurricane
GFDL
HWRF

Coupled

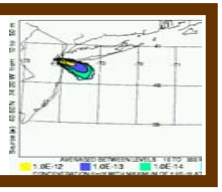
Oceans
HYCOM
WaveWatch III



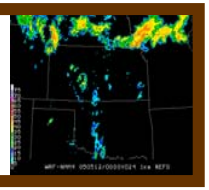
NOS – OFS
Great Lakes
Northern Gulf of Mexico
Bays
- Chesapeake
- Tampa
- Delaware

Regional DA
Regional NAM
WRF NMM

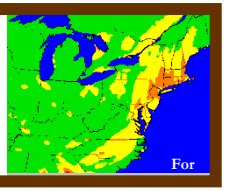
Dispersion
ARL/HYSPLIT



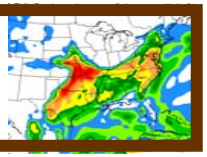
Severe Weather
WRF NMM/ARW
Workstation WRF



Air Quality
NAM/CMAQ



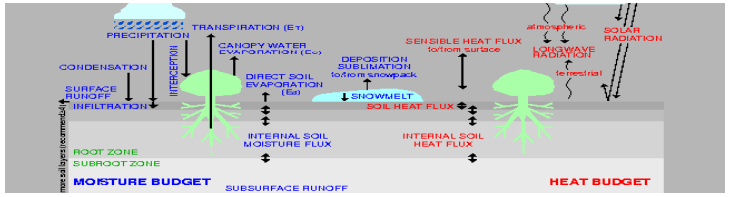
Rapid Refresh for Aviation



Space Weather
ENLIL

North American Ensemble Forecast System
GFS, Canadian Global Model

Regional DA
Short-Range Ensemble Forecast
WRF: ARW, NMM
ETA, RSM

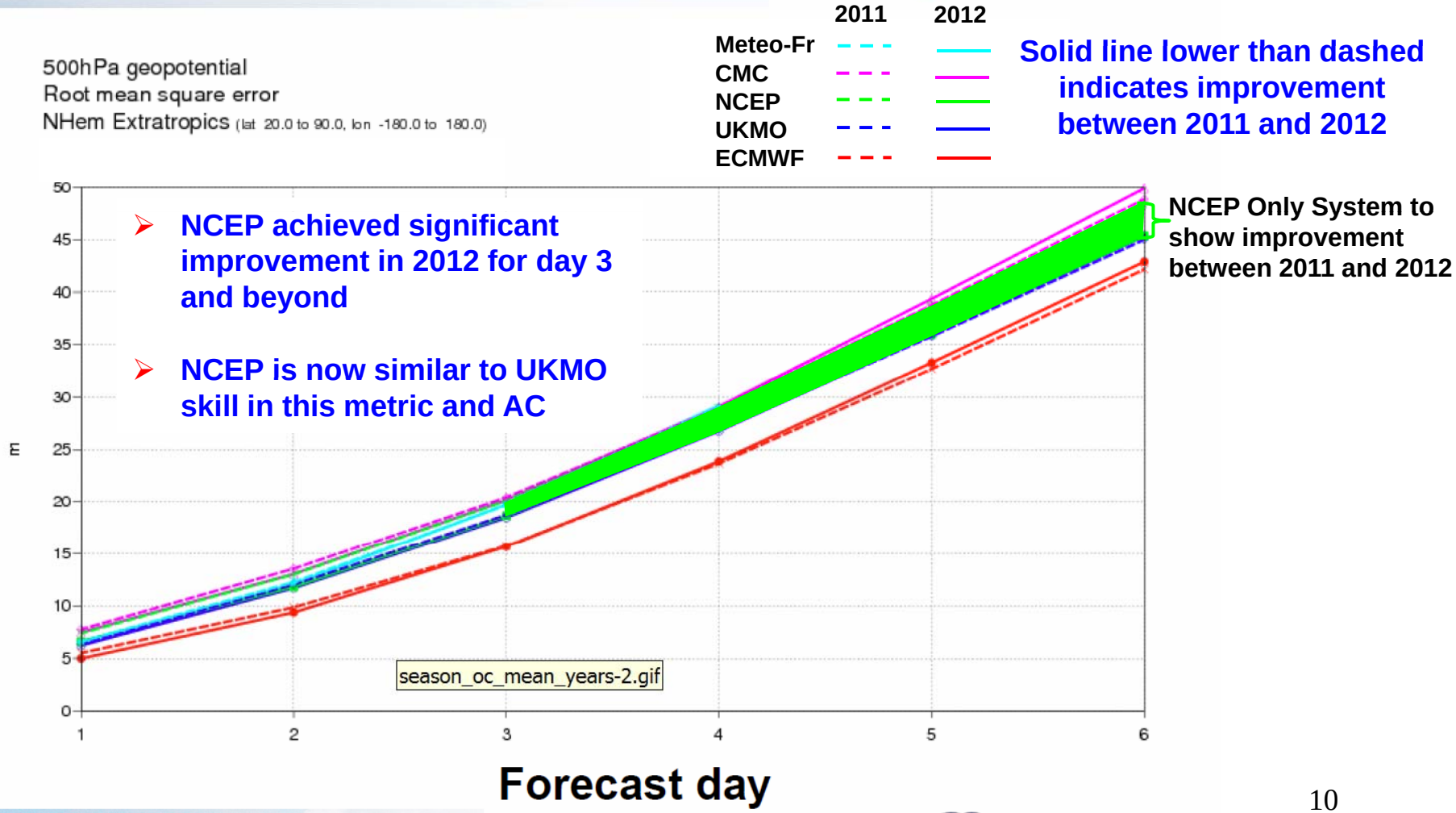


NOAH Land Surface Model

Impact of NCEP's Hybrid DAS

June, July, August 500hPa Geopotential RMSE

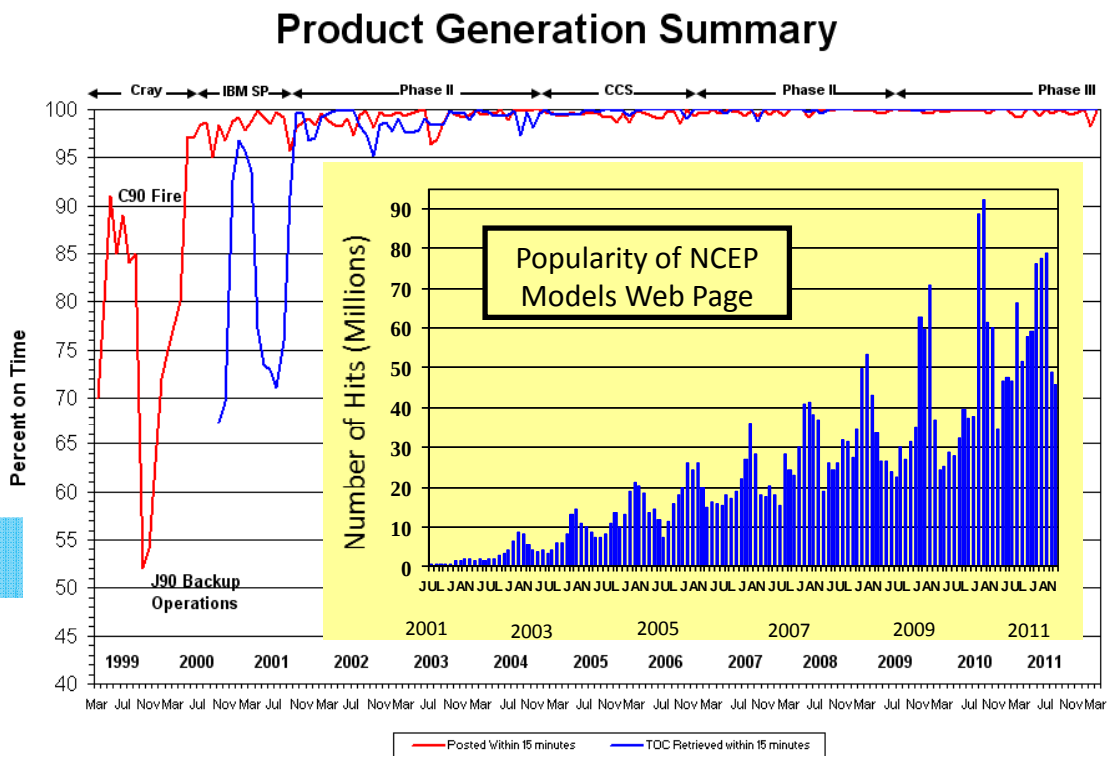
Comparison with other forecasting centres



Computing Capability

"Reliable, Timely and Accurate"

- Current computers
  - IBM Power6
  - 73.1 trillion calculations/sec
  - 27.8 million model fields/day
  - Primary: Gaithersburg, MD
  - Backup: Fairmont, WV
  - Guaranteed switchover in 15 minutes
- Next generation computer
  - IBM iDataPlex Intel/Linux
  - Primary: Reston, VA
  - Backup: Orlando, FL
  - 208 trillion calc/sec



Web access to models as they run on the CCS

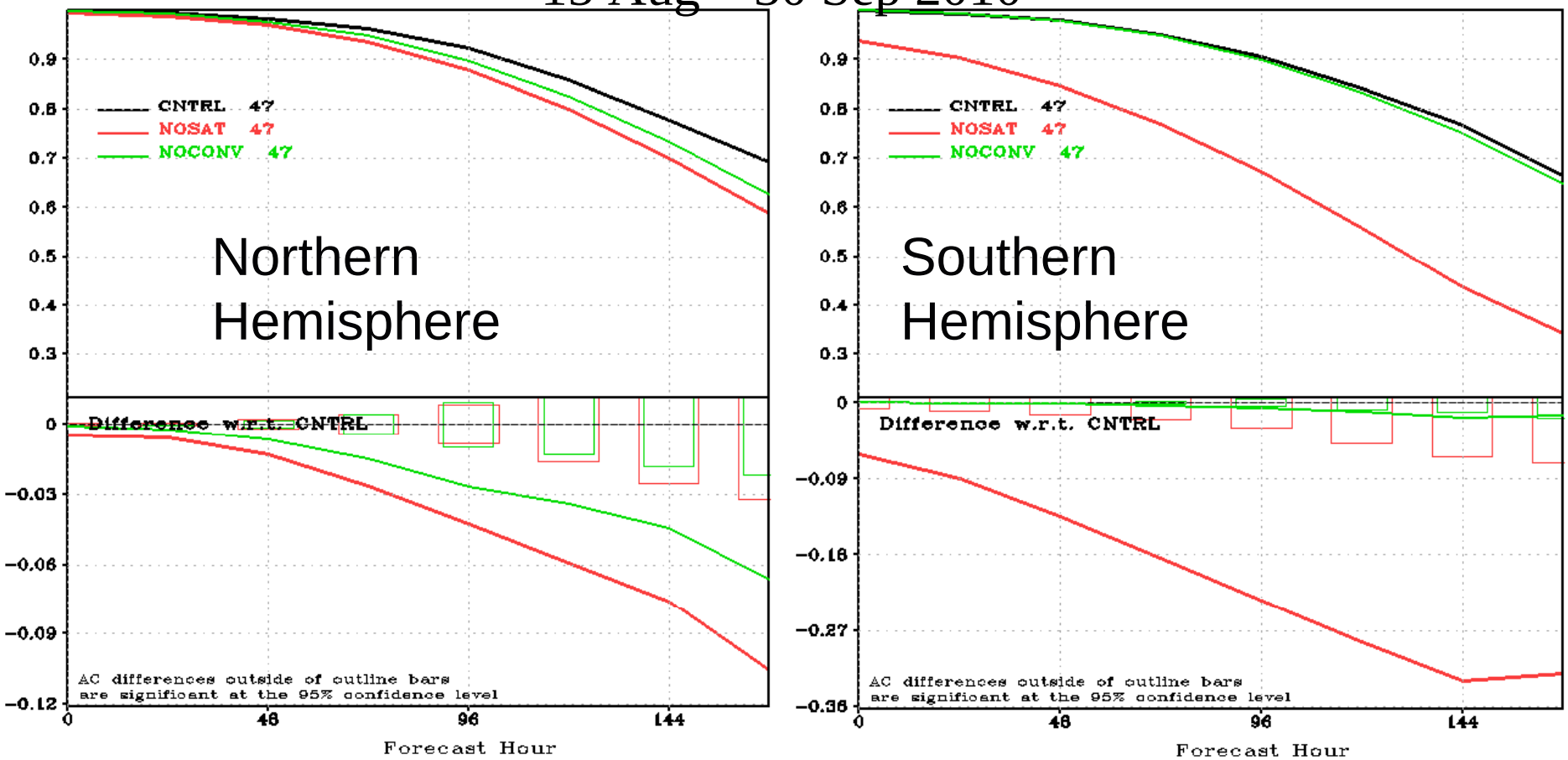
Satellite Data Used for NWP

- HIRS sounder radiances
- AMSU-A & B sounder radiances
- ATMS sounder radiances
- AIRS* sounder radiances
- IASI sounder radiances
- GOES sounder radiances
- GOES, Meteosat, GMS winds
- TRMM* precipitation rates
- SSM/I ocean surface wind speeds
- Quikscat* ocean surface wind vectors
- JASON ocean surface altimetry
- AVHRR SST
- AVHRR vegetation fraction
- AVHRR surface type

- Multi-satellite snow cover
- Multi-satellite sea ice
- SBUV/2 ozone profile & total ozone
- MODIS* polar winds
- GPS Radio Occultation
  - COSMIC, METOP/GRAS, CNOFS, GRACE,* SAC-C*, TerraSAR-X*
- SSMIS
- OMI*
- AMSR/E*
- MSG SEVIRI

* Indicates Research Satellite or Sensor

500 hPa Anomaly Correlations
15 Aug – 30 Sep 2010



Example of OSE diagnostics (J. Jung, 5th WMO Impact Workshop, Sedona 2012)

GDAS/GFS & GEFS Into 2015

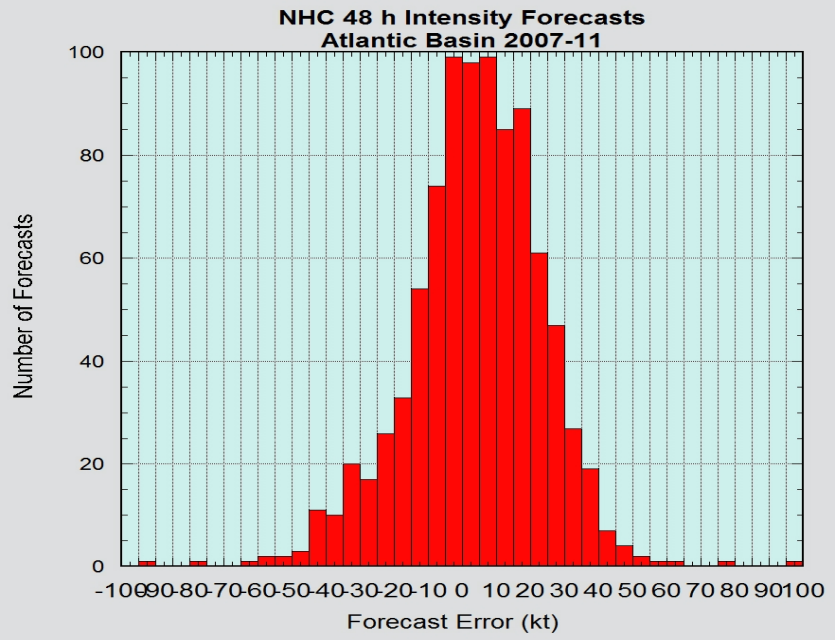
System	Current	Q2FY14	Q1FY15
GDAS	3D En-VAR Dual Res Hybrid	3D En-VAR Dual Res Hybrid	4D En-VAR Dual Res Hybrid
	80 Members @ T254 (55 km)	80 Members @ T574 SL (35 km)	80 Members @ T574 SL(35 km)
	Analysis @ T574 (27 km)	Analysis @ T1148 SL(16 km)	Analysis @ T1148 SL(16 km)
	64 Vertical Levels	64 Vertical Levels	128 Vertical Levels
		Additional Obs. and Hurricane relocation	Cloudy Radiances, Additional Obs., Improved QC and ob. errors
GFS	T574 (27 km) 0 to 7.5-d	T1500 SL (13 km) 0 to 10 d	T1500 SL (13 km) 0 to 10 d
	T254 (55 km) 7.5 to 16-d	T574 SL (35 km) 10 to 16-d	T574 SL (35 km) 10 to 16-d
	64 Vertical Levels	64 Vertical Levels	128 Vertical Levels
		Semi-Lagrangian – Enhanced physics	Higher top, non-hydrostatic, NEMS, Coupled Ocean
GEFS	T254 (55 km) 0 to 8-d	T574 SL (35 km) 0 to 16-d	T574 (35 km) 0 to 16-d
	T190 (70 km) 8 to 16-d		
	42 Vertical Levels	64 Vertical Levels	128 Vertical Levels
		Semi-Lagrangian Integrated with EnKF used in analysis	Full Stochastic physics

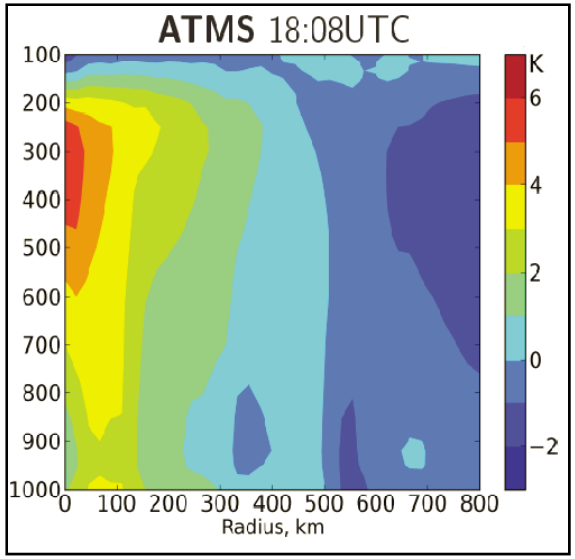
Using Satellite Data at NCEP Service Centers

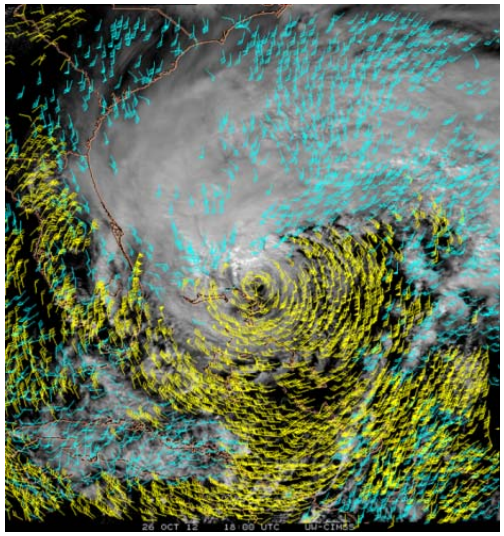
NHC Forecast and Analysis Challenges

- Biggest forecast challenge is rapid intensity change
- Limited skill at even **analyzing** TC structure
  - Critical to timing and placement of watches/warnings
- New GEO and LEO could help improve TC intensity forecast models

– Better satellite wind data and temperature data have potential to improve subjective estimates of TC structure and better data for assimilation into the models





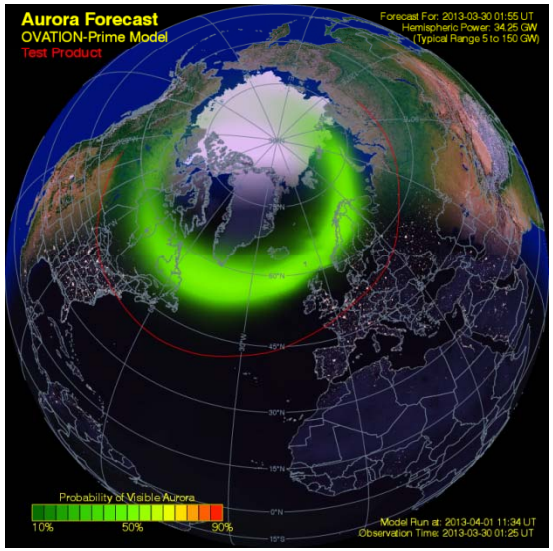


Climate Prediction Center: Pioneering Climate Applications of Satellite Data

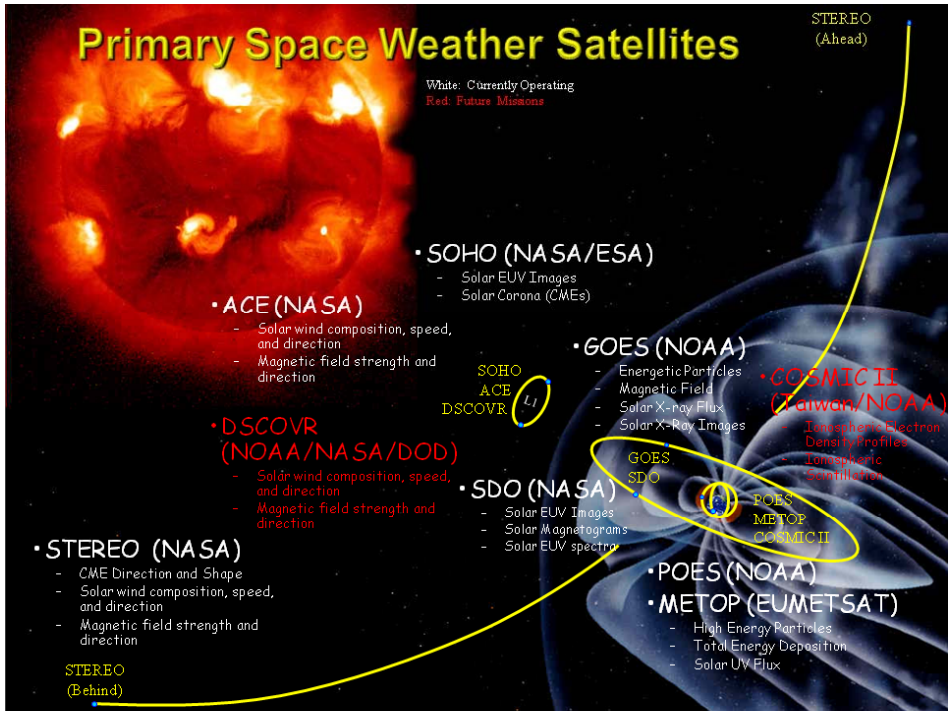
- Two types of satellite data applications
  - Direct use of satellite data
  - Integrated (e.g. combine data from individual platforms / sensors into climate analyses)
- Key contributions
  - 1983: GOES Precipitation Index
  - 1985: Outgoing Longwave Radiation
  - 1988: Sea Surface Temperature Analysis
  - 1994: Ultraviolet Index
  - 1996: Gauge-Satellite Merged Precipitation Analysis
  - 1999: Full-Res Global GEO IR Images
  - 2002: Hi-Res Global Satellite Precipitation Estimates

SWPC Reliance on Satellites

- **For Accurate Space Weather Forecasts, Observations must be made from Space**
  - **No ground-based alternatives for most observations**
- **Most Products Require Satellite Data**
  - **90% of products use satellite data**
  - **75% of products require satellite data**
- **Two of the Three Space Weather Scales are Derived solely from Satellite Observations**
- **Future Satellite Missions are Critical**
  - **DSCOVR: Continuity of L1 observations**
  - **GOES-R: Continuity of GEO observations**
  - **COSMIC II: Expand to real time**
  - **SunJammer: Solar wind measurements taken closer to the sun for longer forecast lead-times.**



Ovation – Forecasting the Location and Intensity of the Aurora: Driven by ACE solar wind data measured at the L1 point (1% of the distance between Earth and sun



Satellite Data at AWC

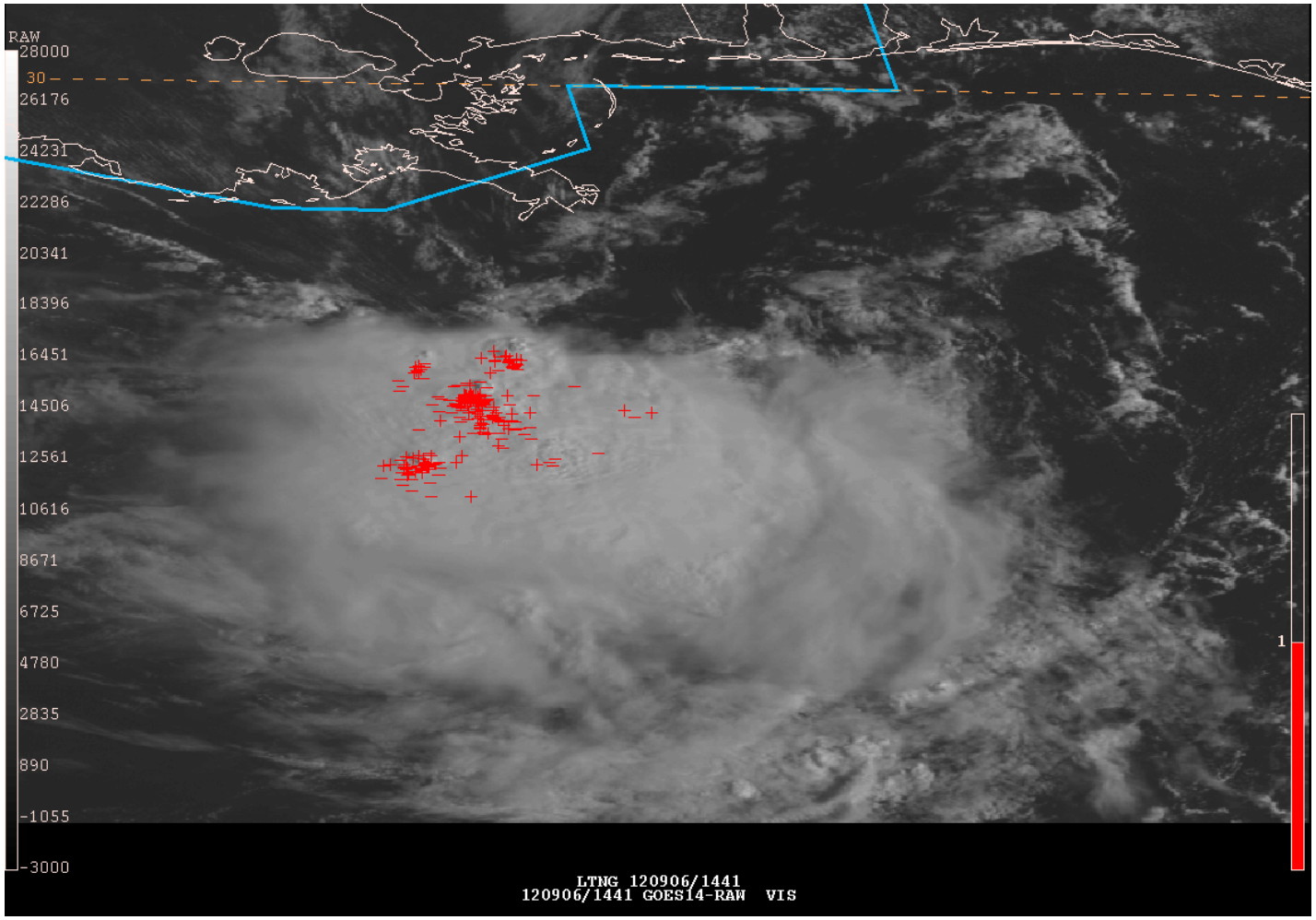
- AWC is a **global** forecast center
- Imagery vital to operations
- GOES-R and NPP data will improve current operations:
  - Mosaic and global imagery
    - VIIRs and GOES-R integration
  - Overlays with other aviation tools
    - ASDI (flight tracking) and EDR (turbulence reports)
- Research to support new applications
  - Collaborative projects involving both developers and forecasters, for example, turbulence detection

AWC Testbed Tools

1. Fog and Low Stratus
2. Simulated ABI
3. Flight Icing Threat
4. PGLM
5. CI toolbox
6. NearCasting Model
7. ACHA algorithms
8. VIIRS Imagery - CONUS

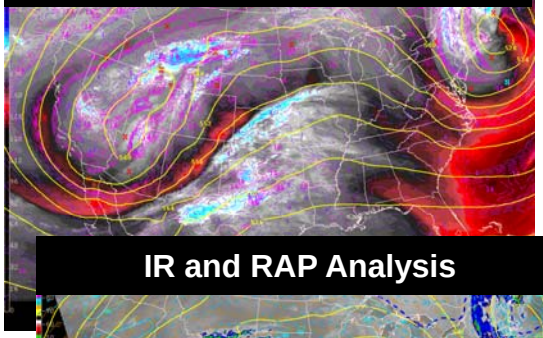
WPC/OPC Analysis of Hurricane Isaac

GOES-14 SRSO with GLD-360 1-min Lightning

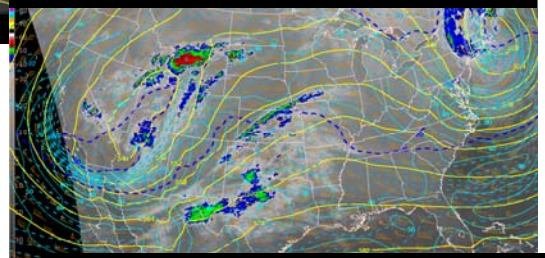


SPC Use of Satellite Data – Current and Futur

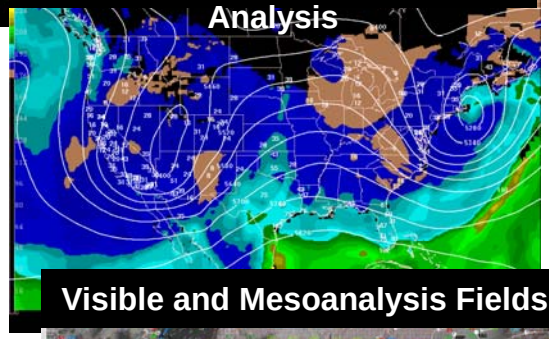
WV and RAP Analysis



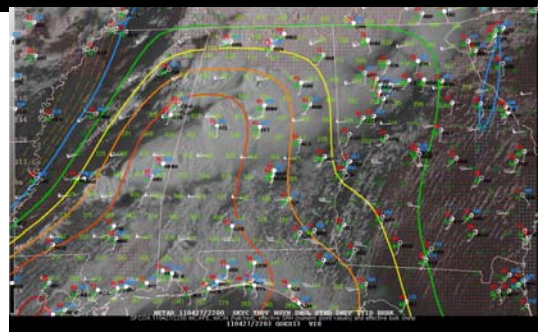
IR and RAP Analysis



Blended TPW , GPS, GFS Analysis



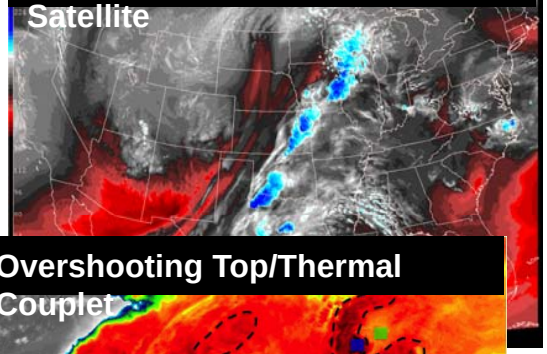
Visible and Mesoanalysis Fields



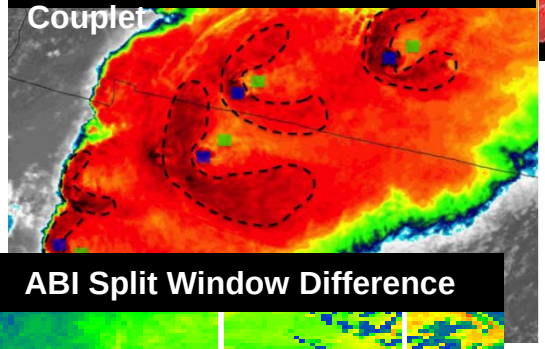
Current - Blending satellite imagery with NWP and environment data helps diagnose current environment

Future - New satellite products will improve ability to predict convective storms in advance, and to diagnose intensity and evolution of existing storms

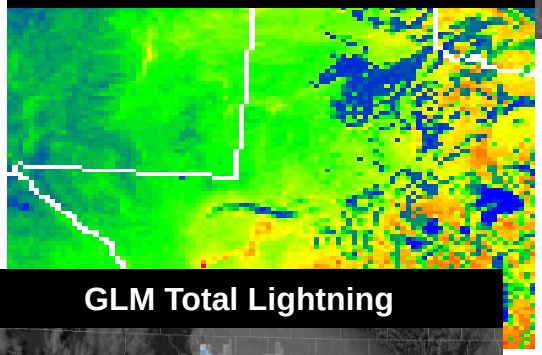
Stormscale NWP Simulated Satellite



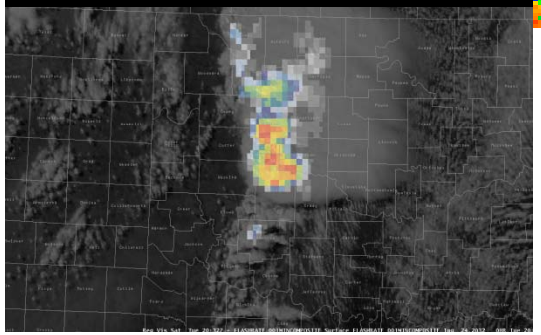
Overshooting Top/Thermal Couplet



ABI Split Window Difference



GLM Total Lightning



Looking Forward

Preparing for the Future

- New Operational satellites
  - JPSS (& more complete exploitation of S-NPP)
  - GOES-R
  - METOP-B
  - DMSP follow on
- New Research Satellites
  - ADM/Aeolus Doppler Wind Lidar
  - GPM, SMAP
- New International Satellites/Sensors
  - ASCAT, OSCAT, COSMIC-2, GCOM-W, Himawari, JASON-3, FY-3, Korean, etc.
- 4D Hybrid Data Assimilation
- Full Earth Systems Modeling:
  - Land, Ocean, and Ice as well as Atmosphere

Summary

- NCEP relies on satellite data to support all of its operational environmental predictions
  - This will continue and expand
- NCEP will exploit the advanced capabilities of future satellite sensors and data to help support a Weather Ready Nation
  - Using integrated approach
  - Emphasizing high-impact services
  - Leveraging Testbeds and Proving Grounds