



**N
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Potential Applications of GPM at NOAA/NWS/NCEP

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Presentation Outline



- **The NCEP Mission**

- **Potential use of GPM data at NCEP Centers**
 - **National Hurricane Center**
 - **Hydrometeorological Prediction Center**
 - **Aviation Weather Center**
 - **Storm Prediction Center**
 - **Climate Prediction Center**

- **Importance of satellite data to NWP**

- **Global Forecast & Data Assimilation System**
 - **Attributes**
 - **Operational Requirements**
 - **Data Assimilated**
 - **Performance evolution since 1998**

- **Improvements in Global NWP Skill**

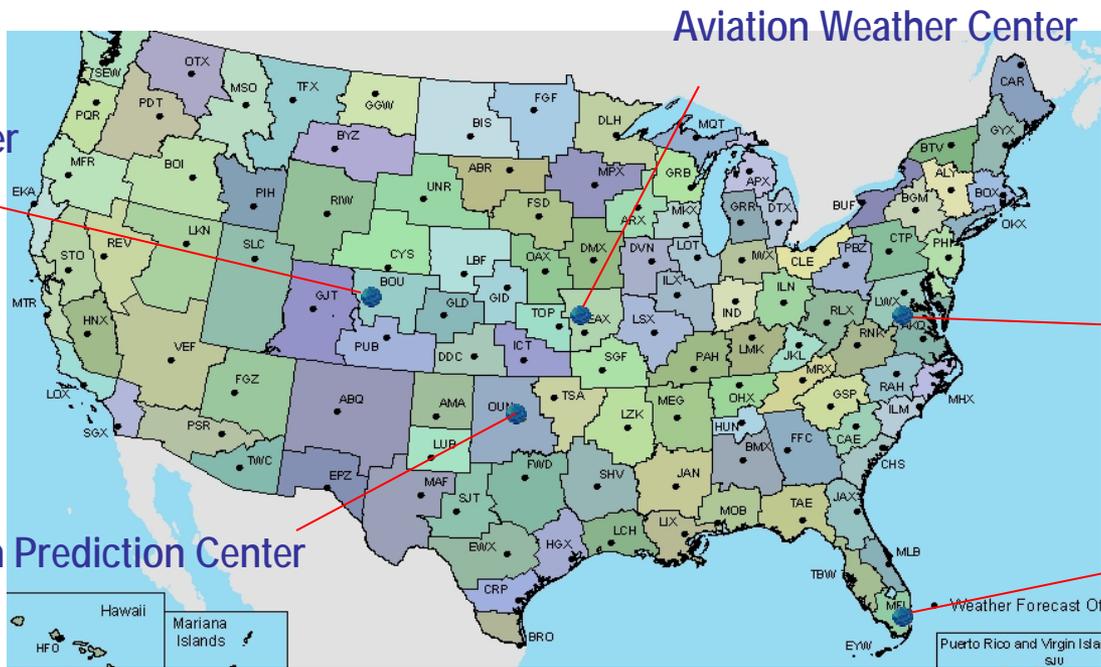


NCEP Supports the NOAA Seamless Suite of Climate, Weather, and Ocean Products



Organization: Central component of NOAA National Weather Service

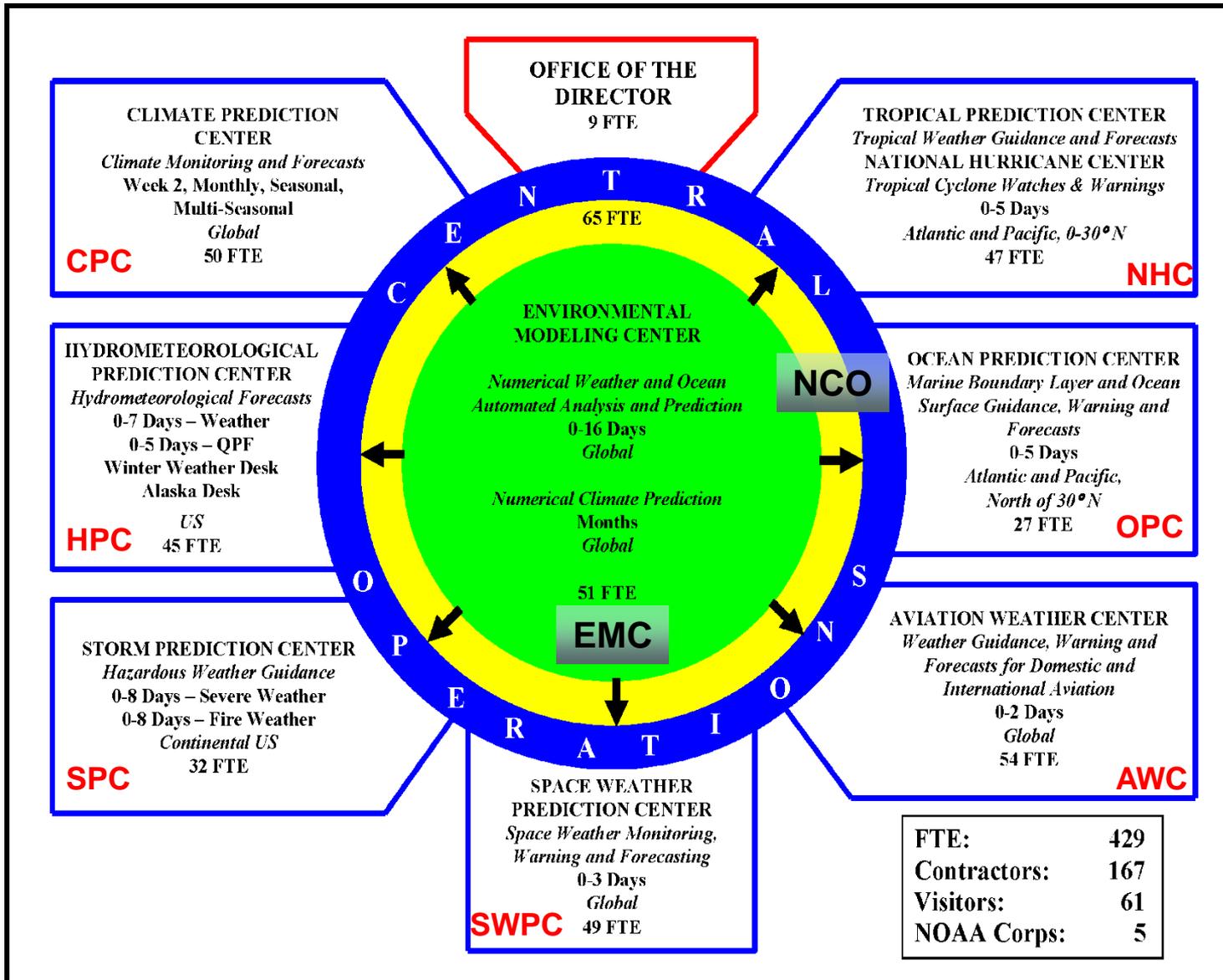
Mission: NCEP delivers science-based environmental predictions to the nation and the global community. We collaborate with partners and customers to produce **reliable, timely, and accurate** analyses, guidance, forecasts, and warnings for the protection of life and property and the enhancement of the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



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



NCEP Organizational Structure



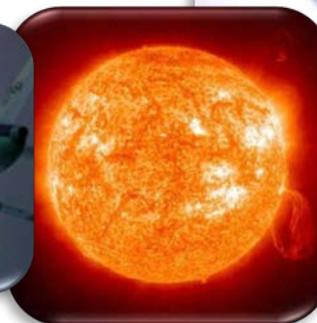
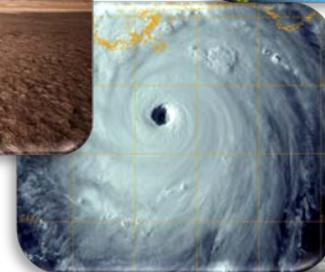
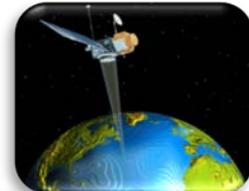


Test Beds



Service – Science Linkage with the Outside Community: Accelerating the R2O Transition Process

- **EMC** **Developmental Test Center**
Joint Center for Satellite Data Assimilation
- **CPC** **Climate Test Bed**
- **NHC** **Joint Hurricane Test Bed**
- **HPC** **Hydrometeorological Test Bed**
- **SPC** **Hazardous Weather Test Bed with NSSL**
- **SWPC** **Space Weather Prediction Test Bed with AFWA**
- **AWC** **Aviation Weather Test Bed**
- **OPC** **IOOS Supported Test Bed (in discussion with
NOS/IOOS)**



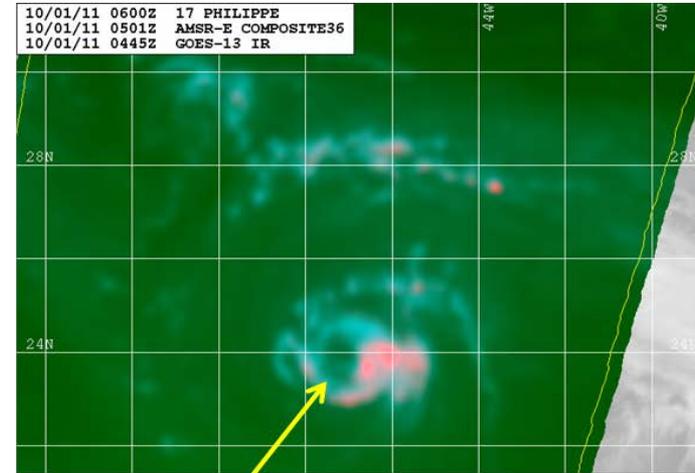


National Hurricane Center: *Tropical Cyclone Analysis (1)*

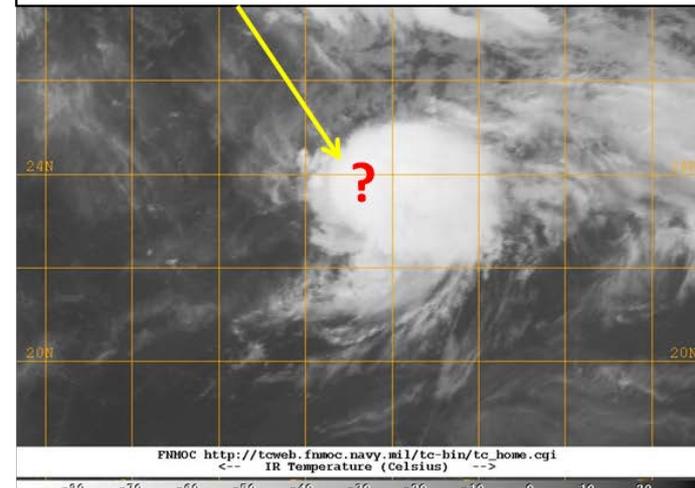


- The GPM Microwave Imager (GMI) will help improve NHC's analysis of tropical cyclones (TCs) in several ways:
 - Determining if a formative system has a **well-defined center** (a requirement to initiate advisories)
 - **Locating** the center of a TC when it is not apparent in geostationary imagery, especially for weaker systems (a critical step in establishing the initial position and motion for model guidance)
 - **Assessing trends** in TC structure and intensity, such as eyewall formation and replacement cycles

Benefits from GPM Working Group
Recommendations: 2 and 4

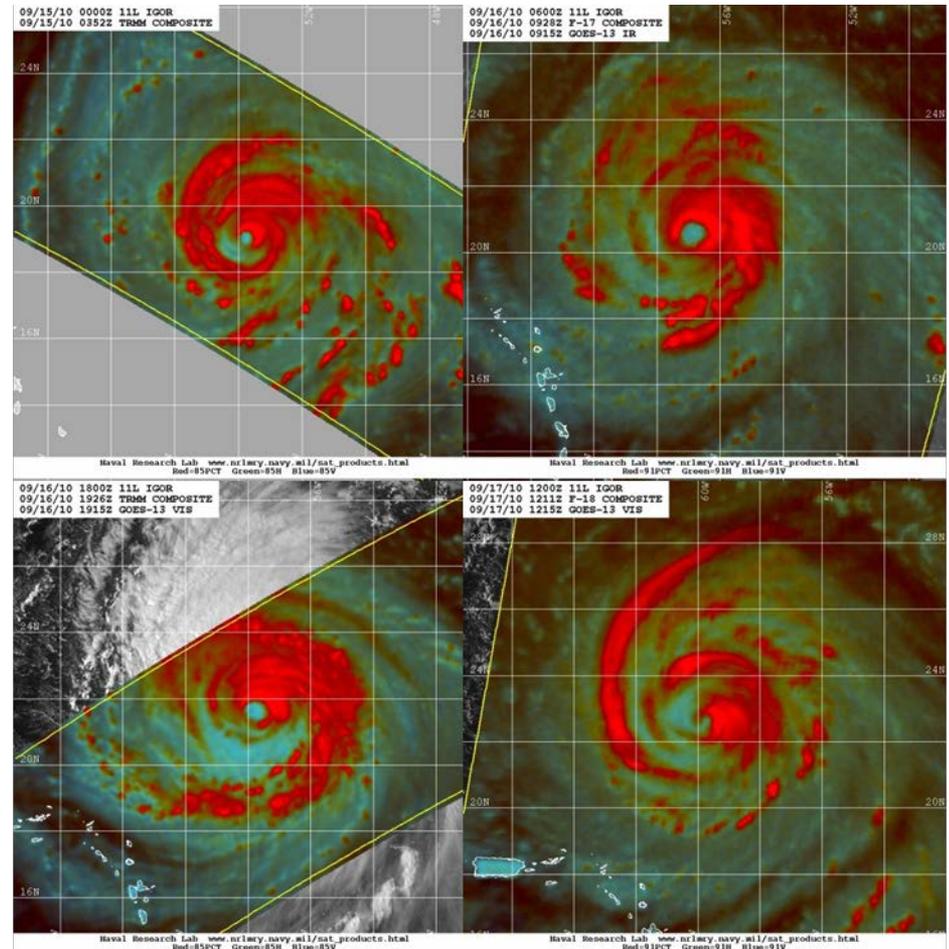


AMSR-E 36-GHz color composite image clearly shows the center of TS Philippe at 0501 UTC 1 October 2011, while center is not apparent in geostationary infrared imagery



- **GPM will provide a new important tool in the microwave imagery toolbox for NHC forecasters**
 - High spatial resolution of GMI will allow NHC forecasters to analyze **small-scale features** that cannot be seen with current microwave imagers
 - GMI will provide additional chances to **sample** TCs due to the sporadic nature of LEO satellite passes, improving the temporal continuity of imagery

Benefits from GPM Working Group Recommendations: 2 and 4



Eyewall replacement cycles in Hurricane Igor from multiple satellites 13-18 Sep 2010



Hydrometeorological Prediction Center



- **Model diagnostics and feature identification**
 - **precipitable water anomalies**
 - **atmospheric rivers**
 - **potential predecessor rainfall events (PREs)**

- **Use to help with the prediction of extreme rainfall and flash flooding – especially over western U.S. where radar coverage is poor**

- **Enhance short term prediction of extreme rainfall**
 - **statistical-dynamical approach with**
 - **Rapid Refresh model data**
 - **GOES-R Rainfall Rate,**
 - **Total Precipitable Water**
 - **lighting data sets**

- **Verification of model and forecaster QPF --particularly over regions with poor Stage 4 data coverage**

- **Identification of:**
 - **moisture flux anomalies**
 - **measurement of wind and water vapor**
 - **potential vorticity anomalies to better forecast frontogenesis and Rossby Wave breaks**

- **Surface analysts may use GPM data to locate surface features**

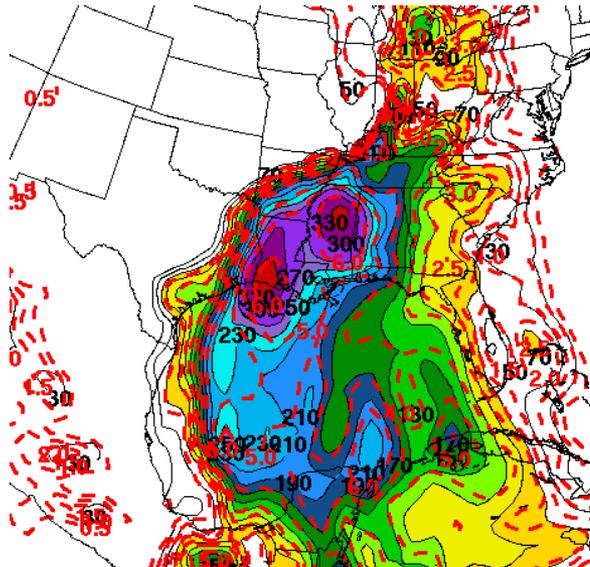


Hydrometeorological Prediction Center

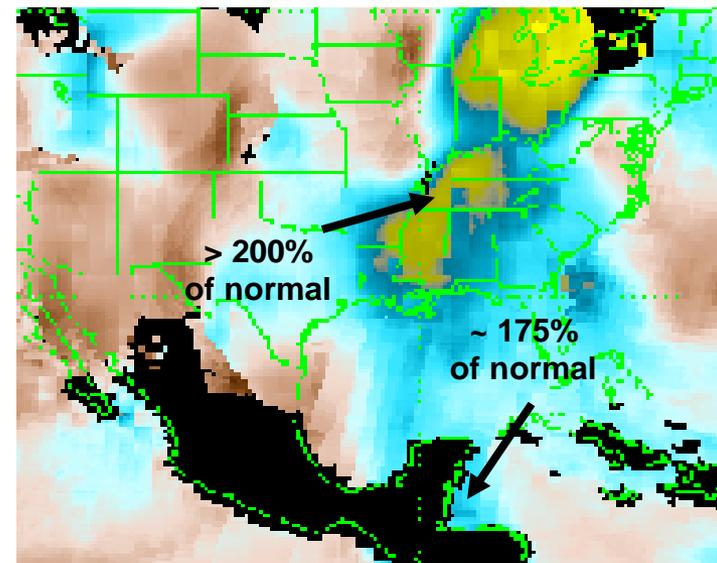


- HPC has the capability to view precipitable water (PW) and tropical precipitable water (TPW)
- However anomalous moisture transport where scalar wind speed is combined with water vapor to generate a moisture flux
- Water vapor transported by meridional flow would be a great addition

GFS 850mb Moisture Flux Anomalies (12UTC 1 May 2010)



Blended TPW Percent of Normal 1215 UTC May 1, 2010





Aviation Weather Center



- **GPM would increase situational awareness for the International Operations Branch at AWC**

- **GPM data could be combined with global lightning and model analyses for a Global Convective Weather Diagnostic (GCWD)**

- **GPM and a GCWD could be used to verify:**
 - **AWC Significant Weather High CB Forecasts**
 - **Operational global model guidance (e.g., GFS; NAEFS)**



Storm Prediction Center



- Improved mapping of hemispheric water vapor and atmospheric rivers that subsequently impact thunderstorm development over the CONUS
 - Source regions over the Pacific, Atlantic, and Caribbean/Gulf of Mexico
 - Important during the cool season—moisture return from GoM can play a key role in severe storm development over the southeast US
 - Onset of offshore flow and cold frontal passage into the Gulf and beyond

- Improved precipitation mapping over the western US will permit better documentation of dry thunderstorms occurrence and frequency
 - High resolution and accurate QPE is important input for the SPC Fire Weather program
 - Impacts soil dryness and dry fuel potential
 - high-based thunderstorms that produce little precipitation at the ground are a leading cause of lightning-based fire starts
 - Radar coverage is more limited over complex terrain from the Rockies westward
 - QPE accuracy is noticeably lower compared to areas east of the Rockies
 - Can play a key role in research efforts to improve prediction of dry thunderstorms

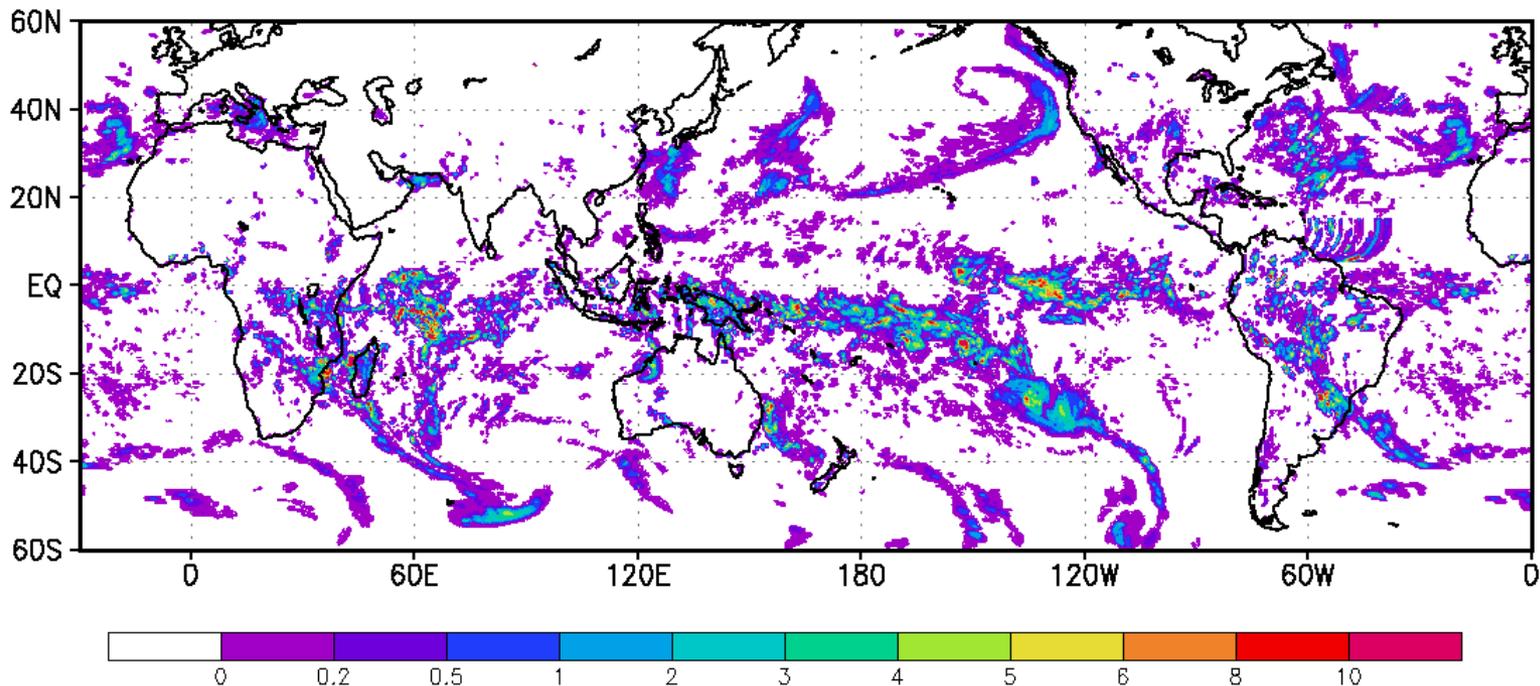


Climate Prediction Center



- **CPC integrates information derived from TRMM / GPM and other satellites to construct high-resolution precipitation estimates on a very high space and time resolution (8km / 30-min) from 1998 to the present (CMORPH)**
- **CMORPH precipitation estimates used for climate monitoring, model evaluation, and climate assessments;**
- **PMW observations from GPM will enable the production of a long-term high-resolution global precipitation data set**

CMORPH 3hourly Precip for 1998. 2. 1. 0Z





Satellite Data is Required to Help Meet Key NOAA Performance Metrics



- Numerical Weather Prediction
 - Global Anomaly Correlation Score – “Internal” metric
 - Related to ability to meet service-based metrics (below)

- National Weather Service GPRA* Metrics
 - (* Government Performance & Results Act)
 - Hurricane Track and Intensity Forecast Accuracy
 - Winter Storm Warning Lead Time and Accuracy
 - Precipitation Threat Accuracy
 - Flood Warning Lead Time and Accuracy
 - Marine Windspeed and Wave Height Forecast Accuracy

- NAM and GFS are primary tools used by the NWS to meet the above goals



Global Data Assimilation System (GDAS)



- **Grid-point Statistical Interpolation (GSI)**
- **3D-variational approach**
- **Unified system for all NCEP atmospheric applications**
 - Global (GDAS/GFS)
 - Regional (NDAS/NAM) & HWRF
 - Real Time Mesoscale Analysis (RTMA)
 - Rapid Refresh (RR)
- **Developed for operational application**
 - Forecasts must be completed within schedule
 - Trade-offs
 - **More accurate formulation – higher resolution**
 - **Improved model – improved analysis**
 - **Enhanced physics – higher resolution**
 - Must work everywhere – all the time
 - Manual intervention should be minimal
 - Both operational and research data used in systems



Assimilated Satellite Radiance Data



Global: (All thinned to 145km)

GOES-11 Sounder

Channels 1-15
Individual fields of view
4 Detectors treated separately
Over ocean only

AMSU-A

NOAA-15 Channels 1-10, 12-13, 15
NOAA-18 Channels 1-8, 10-13, 15
NOAA-19 Channels 1-7, 9-13, 15
METOP Channels 1-6, 8-13, 1
AQUA Channels 6, 8-13

AMSU-B/MHS

NOAA-15 Channels 1-3, 5
NOAA-18 Channels 1-5
METOP Channels 1-5

HIRS

NOAA-17 Channels 2-15
NOAA-19 Channels 2-15
METOP Channels 2-15

AIRS

AQUA 148 Channels

IASI

METOP 165 Channels

Regional

GOES-11 Sounder: Thinned to 120km

Channels 1-15
Individual fields of view
4 Detectors treated separately
Over ocean only

AMSU-A: Thinned to 60km

NOAA-15 Channels 1-10, 12-13, 15
NOAA-18 Channels 1-8, 10-13, 15
METOP Channels 1-6, 8-13, 15

AMSU-B/MHS: Thinned to 60km

NOAA-15 Channels 1-3, 5
NOAA-18 Channels 1-5
METOP Channels 1-5

HIRS: Thinned to 120km

NOAA-17 Channels 2-15
METOP Channels 2-15

AIRS: Thinned to 120km

AQUA 148 Channels



Assimilated Conventional Data and Satellite Products



Conventional

- Radiosondes
- Pibal winds
- Synthetic tropical cyclone winds and pressures(when needed)
- Wind profilers
- Conventional aircraft reports
- ASDAR aircraft reports
- MDCARS aircraft reports
- Dropsondes
- Surface land observations
- Surface ship and buoy observation
- Doppler radial velocities (regional)
- VAD (NEXRAD) Winds
- TAMDAR aircraft data
- Mesonet data

Satellite Products

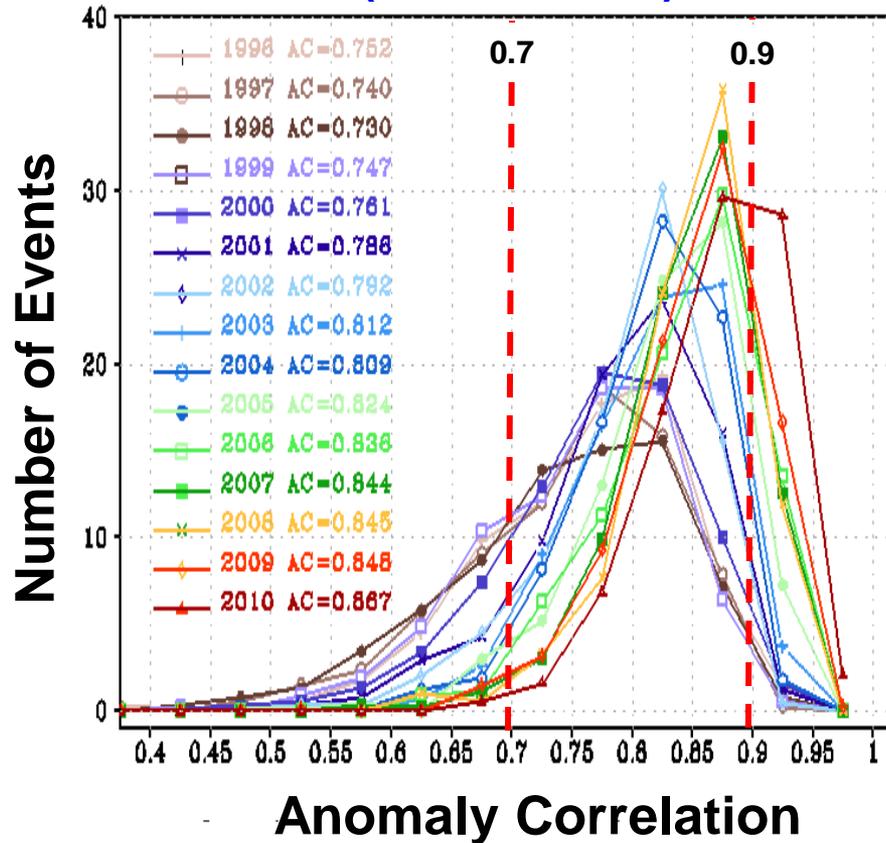
- MODIS IR and water vapor winds
- GMS, METEOSAT and GOES cloud drift IR and visible winds
- GOES water vapor cloud top winds
- TRMM TMI precipitation estimates
- GPS precipitable water estimates
- GPS Radio occultation refractivity profiles
- SBUV ozone profiles (other ozone data under test)
- OMI total ozone



500-hPa Height AC Frequency Distribution GFS 00Z Cycle Day-5 Forecast



Northern Hemisphere (1996 to 2010)

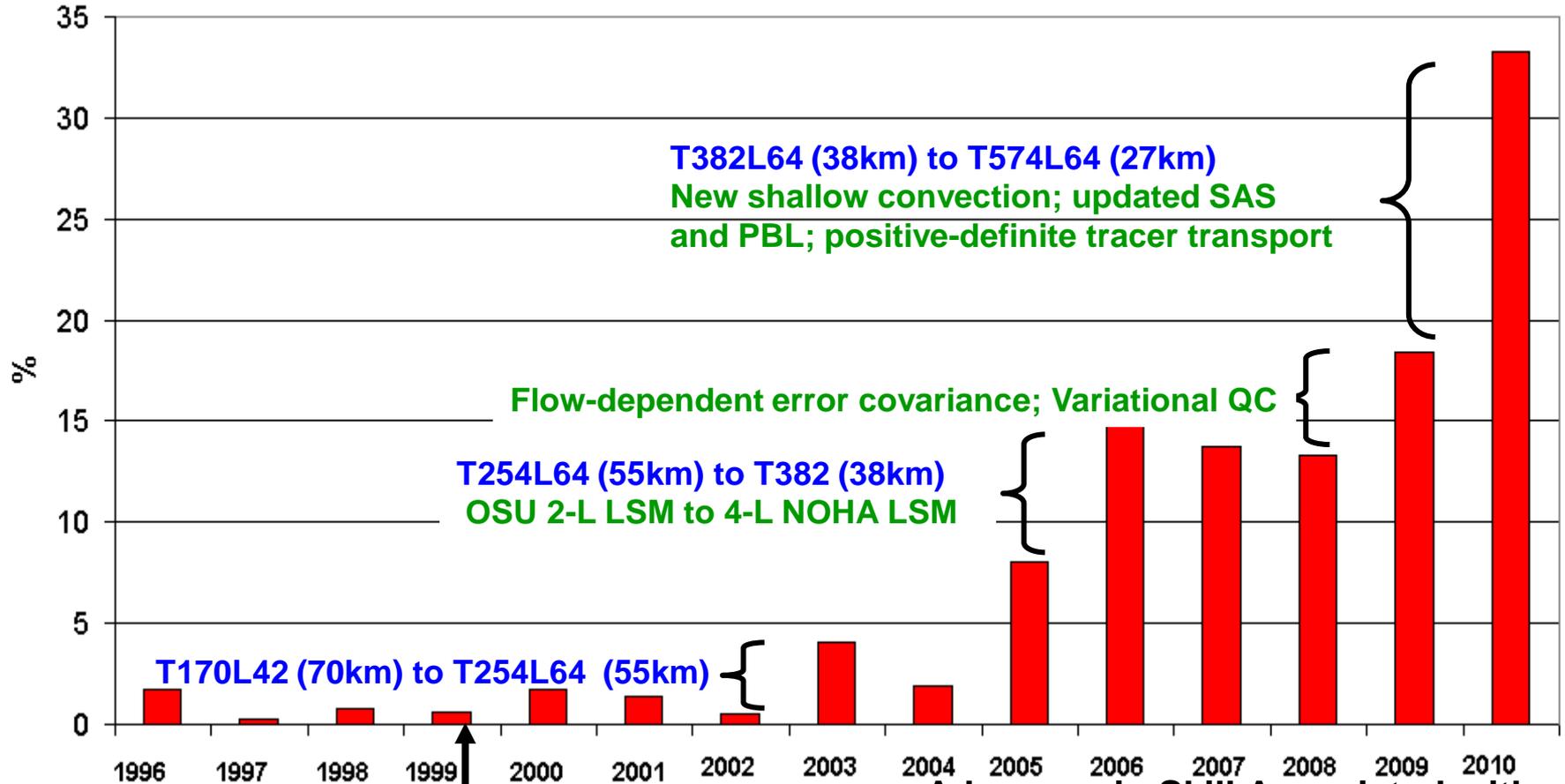


Frequency of:

- Poor forecasts (AC < 0.7) decrease
- Good forecasts (AC > 0.9) increase



Percentage of Good Forecasts 5-Day 500mb AC < 0.9 v.s. Model Upgrades



AMSU-A & HIRS-3 data

Advances in Skill Associated with

- Model Physics & Resolution (HPC)
- Data and QC
- Assimilation Methodology

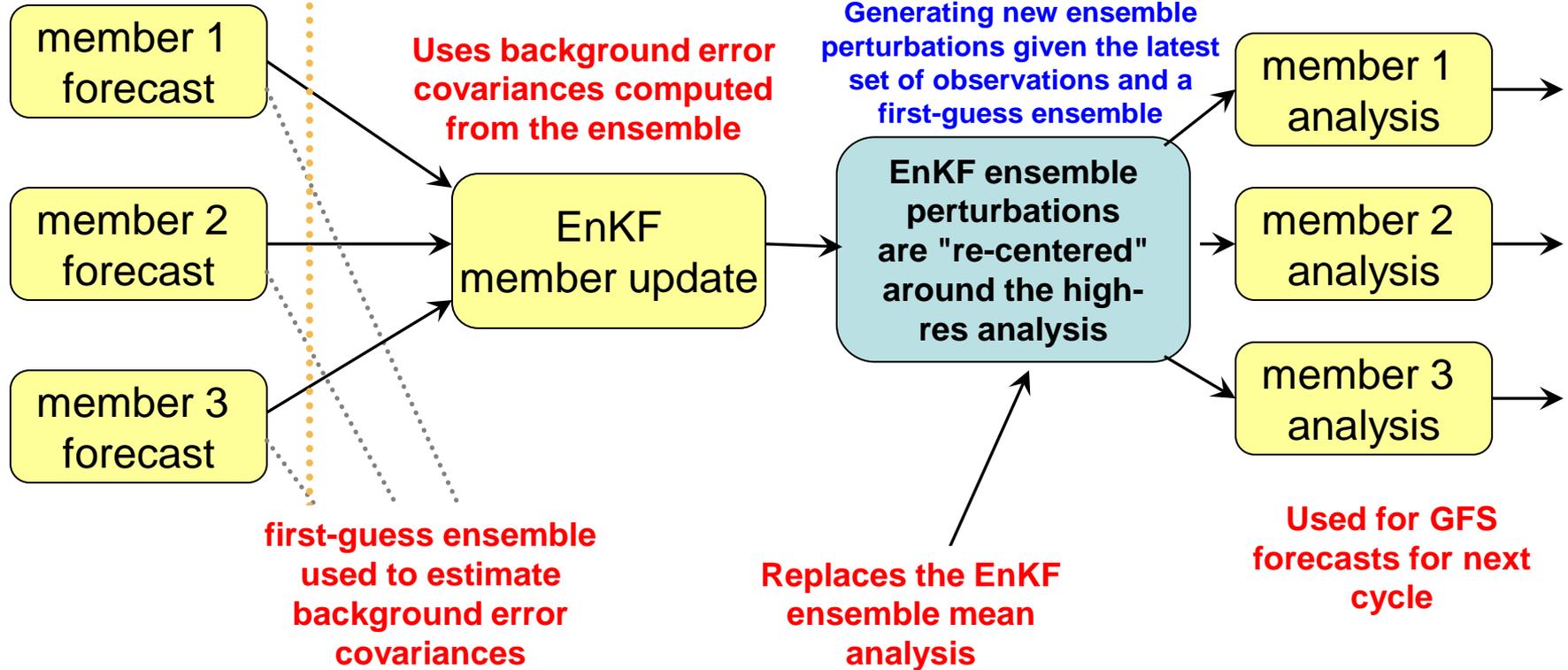


Dual-Resolution Coupled Hybrid 3D-VAR/EnKF

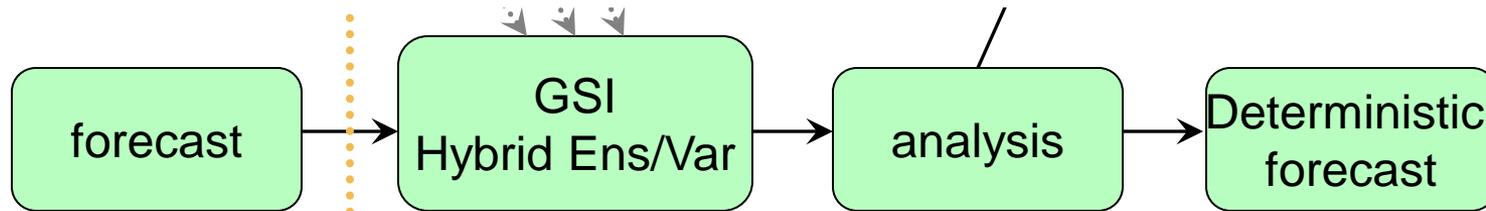
(Target: Operational April 2012)



T254L64



T574L64



Previous Cycle

Current Update Cycle



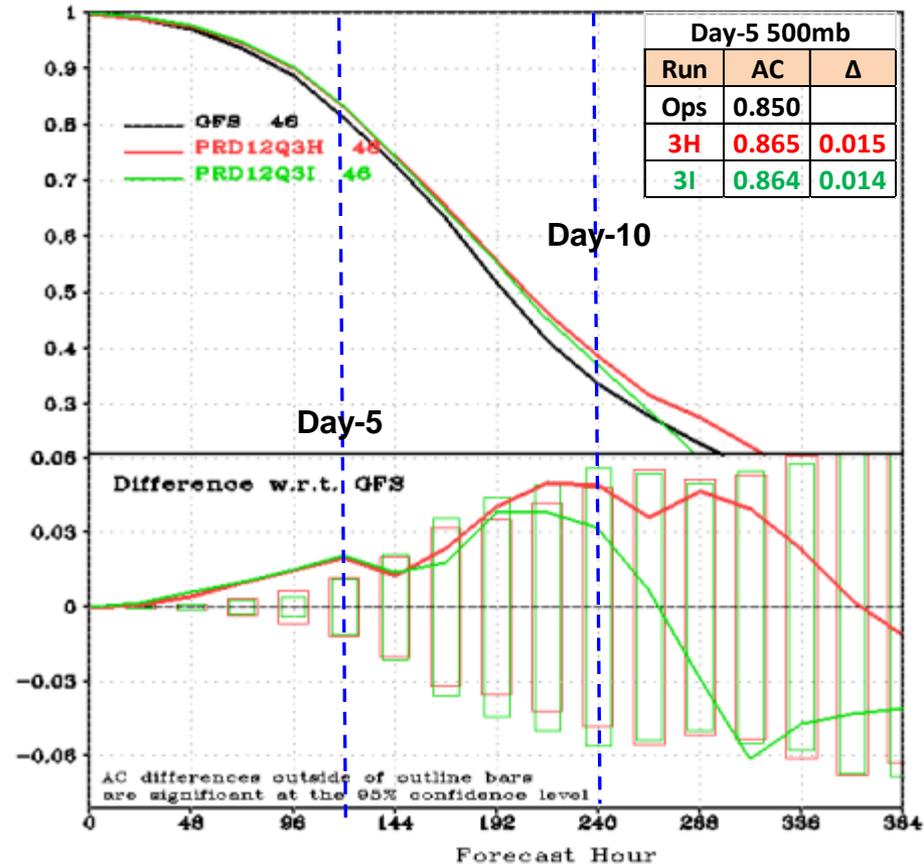
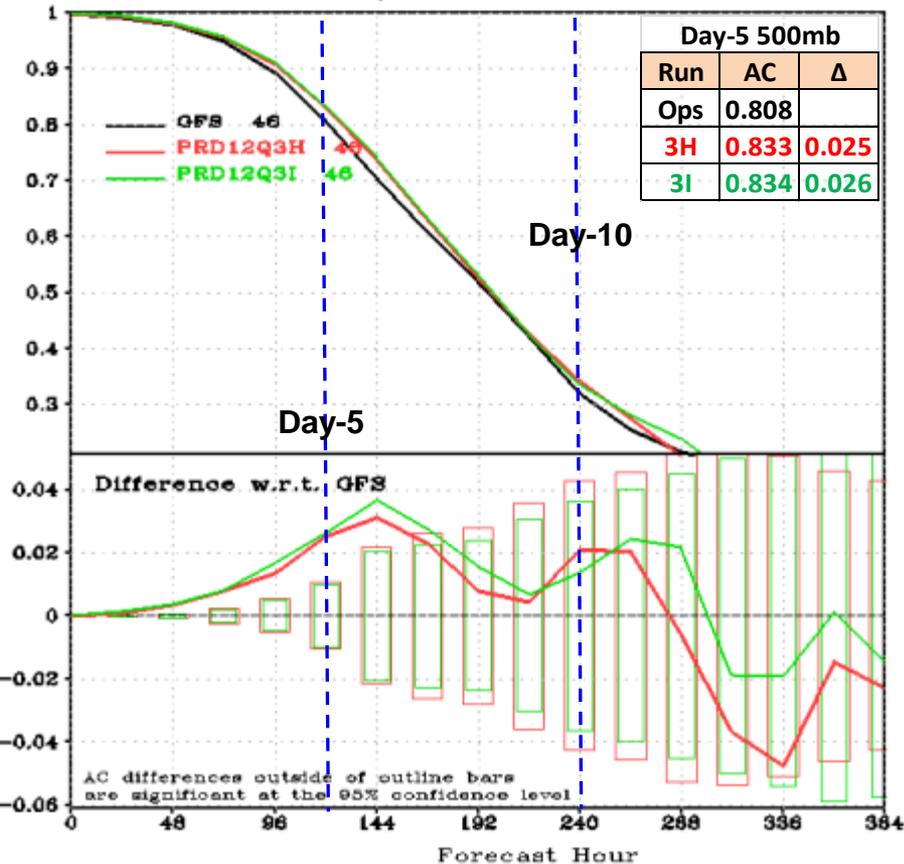
Performance of Hybrid Parallels



**500mb AC for 00Z Cycles
16 June to 08 August 2011**

Northern Hemisphere

Southern Hemisphere





Importance of Precipitation and MW Radiances to EMC



➤ Data Assimilation:

- Microwave radiances very important
- Satellite estimates of precip assimilated but less important
- Precipitation to force land surface model

➤ Model Verification/Assessment:

- Precipitation
- Precipitable water
- Clouds

➤ Model physics:

- Precipitation
- Precipitable water
- Vertical distribution of latent heating
- Moisture
- Cloud liquid water



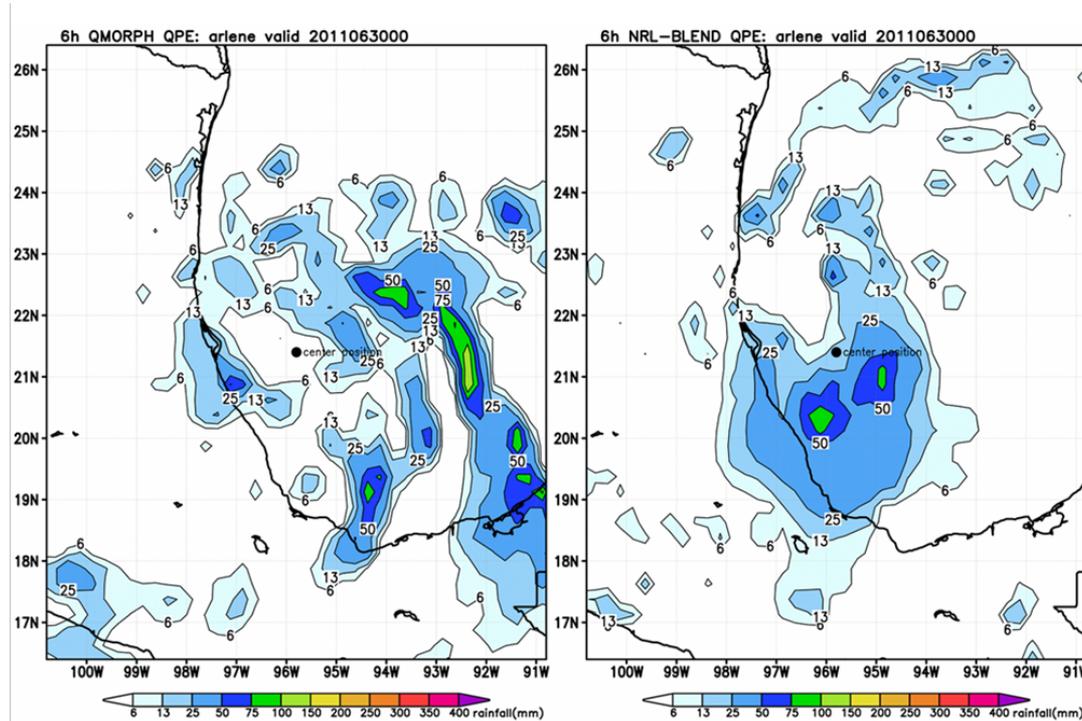
Questions Welcome



National Hurricane Center: *Satellite Precipitation Estimate Products*



<http://www.nhc.noaa.gov/experimental/rainfall/>



If GPM products are included in QMORPH and/or NRL-Blend,
NHC storm-specific satellite rainfall estimates will benefit from the increase in the
amount, quantity, and/or quality of rainfall rate data.
These rainfall products are hosted by NHC and updated four times a day.

Benefits from GPM Working Group Recommendations: 2, 3, 4



Feedback from EMC to GPM



- **Usually NWP centers see problems with instruments before notification by providers**
- **Tests compatibility of observations with other observations and with atmosphere as represented by GFS**
- **NWP products extensively examined by large community of users**
- **Parallel assimilation tests of changes can explore impact of new data**



The GPM Concept

Unify and advance precipitation measurements from space to provide next-generation global precipitation products within a consistent framework

Low Inclination Observatory (40°)

GMI (10-183 GHz)
(NASA & Partner, 2014)

- Enhanced capability for near realtime monitoring of hurricanes & midlatitude storms
- Improved estimation of rainfall accumulation

Partner Satellites:

GCOM-W1
 DMSP F-18, F-19
 Megha-Tropiques
 MetOp, NOAA-19
 NPP, JPSS (over land)

GPM Core Observatory (65°)

DPR (Ku-Ka band)
GMI (10-183 GHz)
(NASA-JAXA, LRD 2013)

- Precipitation physics observatory
- Transfer standard for inter-satellite calibration of constellation sensors

Key Advancement

Using an advanced radar/radiometer measurement system to improve constellation sensor retrievals



Coverage & Sampling

- 1-2 hr revisit time over land
- < 3 hr mean revisit time over 90% of globe