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
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)
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
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
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.
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)
Innovative 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
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
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, 1

**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

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Presented at 2'nd NOAA GPM Users Workshop Nov 2011
**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
**Northern Hemisphere**
*(1996 to 2010)*

![Graph](image)

**Number of Events vs. Anomaly Correlation**

- **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
- T170L42 (70km) to T254L64 (55km)
- T254L64 (55km) to T382 (38km)
- OSU 2-L LSM to 4-L NOHA LSM
- T382L64 (38km) to T574L64 (27km)
  - New shallow convection; updated SAS and PBL; positive-definite tracer transport

Flow-dependent error covariance; Variational QC

Advances in Skill Associated with
- Model Physics & Resolution (HPC)
- Data and QC
- Assimilation Methodology

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Dual-Resolution Coupled Hybrid 3D-VAR/EnKF
(Target: Operational April 2012)

Previous Cycle

T254L64

- member 1 forecast
- member 2 forecast
- member 3 forecast

Deterministic forecast

Uses background error covariances computed from the ensemble

EnKF member update

GSI Hybrid Ens/Var

Generating new ensemble perturbations given the latest set of observations and a first-guess ensemble

EnKF ensemble perturbations are "re-centered" around the high-res analysis

Replaces the EnKF ensemble mean analysis

Deterministic forecast

Current Update Cycle

T574L64

- forecast

- member 1 analysis
- member 2 analysis
- member 3 analysis

- member 1 forecast
- member 2 forecast
- member 3 forecast

first-guess ensemble used to estimate background error covariances

Generating new ensemble perturbations given the latest set of observations and a first-guess ensemble

Used for GFS forecasts for next cycle

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Performance of Hybrid Parallels

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

Northern Hemisphere

Day-5 500mb

Run | AC | Δ
---|----|---
Ops | 0.808 |   
3H  | 0.833 | 0.025
3I  | 0.834 | 0.026

Day-10

Southern Hemisphere

Day-5 500mb

Run | AC | Δ
---|----|---
Ops | 0.850 |   
3H  | 0.865 | 0.015
3I  | 0.864 | 0.014

Day-10
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 real-time monitoring of hurricanes & mid-latitude storms
- Improved estimation of rainfall accumulation

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

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

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

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