Aircraft Observation data impact on GFS Forecasting Skill of the North Atlantic Tropical Cyclone

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Outline

• Data Impact Experiment with GFSv16
• Results (Track, Intensity and Minimum Center Pressure)
• Summary
Data Impact Experiments with GFSv16

• **TC 2020: Jul 20 to Sep 23**
  - CTRL – assimilate dropsonde and HDOB data
  - DENY – deny dropsonde and HDOB data
  - DDSO - deny dropsonde only (Aug 15 to Sep 23)

• **TC 2021: Aug 9 to Sept 11**
  - CTRL – GFSv16 operation: Assimilate dropsonde and HDOB data
  - DENY – deny dropsonde and HDOB data

• **TC 2022: Sep 23 to Sept 30 (Ian)**
  - CTRL – GFSv16 operation: Assimilate dropsonde and HDOB data
  - DDSO – deny dropsonde only
GFSv16: Major Changes to the Forecast Model

Model resolution:
Increased vertical layers from 64 to 127 & raised model top from 54 km to 80 km

FV3 dynamical core and Physics updates:
- **PBL/turbulence:** Replaced K-EDMF with sa-TKE-EDMF (Revised background diffusivity as a stability dependent function).
- **GWD:** Added a parameterization for subgrid scale nonstationary gravity-wave drag.
- **Radiation:** Updated calculation of solar radiation absorption by water clouds; Updated cloud overlap assumptions.
- **Microphysics:** Updated GFDL microphysics scheme for computing ice cloud effective radius.
- **Noah LSM:** Revised ground heat flux calculation over snow covered surface; Introduced vegetation impact on surface energy budget over urban area.

Coupling to Wave Model:
One-way coupling of atmospheric model with Global Wave Model (WaveWatch III, Multi_1)
Major Upgrades to GDAS

- **Local Ensemble Kalman Filter (LETKF)** with model space localization and linearized observation operator to replace the Ensemble Square Root Filter (EnSRF)

- **4-Dimensional Incremental Analysis Update (4D-IAU)**
  - Turn on SKEB in EnKF forecasts
  - New variational QC
  - Apply Hilbert curve to aircraft data
  - **Correlated observation error** for CrIS over sea surfaces and IASI over sea and land
  - Update temperature aircraft bias correction with safeguard
  - Assimilate AMSU-A channel 14 and ATMS channel 15 w/o bias correction

- Assimilate CSR data from ABI_G16, AHI_Himawari8, and SEVIRI_M08; AVHRR from NOAA-19 and Metop-B for NSST

- Assimilate additional GPSRO (add Metop-C GRAS, More Cosmic-2)

- **Assimilate** high-density flight-level wind, temperature, and moisture observations (HDOBS) in tropical storm environment (first time in operations for GFS)

- Reduce the distance threshold for inner core dropsonde data to 55km (from 111km or 3*RMW (radius of maximum wind speed)) and add a wind threshold of 32 m/s to allow more dropsonde data being assimilated

- Use CRTM v2.3.0
Upgrades to GDAS for TC in GFSv16 (3/22/2021)

GFSv15
111 km
or
3*RMW
REJECT
sonde winds for all
tropical cyclones

GFSv16
55 km
REJECT
sonde winds
If VMAX
> 32 m/s
+
ADD
HDOB

Sippet et al. 2022 WAF
TC 2020 Track Skill & Error: All Storms (Jul 20 - Sep 23)

Negative impact (~5%) of TC Recon data on track forecast when all storms are considered
Positive impact (3-12%) of TC Recon data on track forecast
Neutral or mixed impact of TC Recon data on track forecast when all storms are considered.
TC 2020 and 2021 Track Skill: Strong Storms
Vmax > 50kts

Positive impact of TC Recon data on track forecast, mostly for 2020 and 0-108h for 2021
Positive impact of TC Recon data on track forecast 0-108h when 2020 and 2021 are combined
TC Recon data on the intensity forecast is mixed 0-72h, negative for the first day; the impact is positive for the long-lead forecast 84-168h
TC 2020 Track Skill: All & Strong Storms (Aug 15 - Sep 23)

**Negative impact of TC Recon data on track forecast when all storms are considered, but HDOBs data alone seem to have a positive impact for 24-120h forecast.**

**Positive impact of TC Recon data on track forecast mostly (0-36h and 60-168h). However, negative impact from HDOBs alone from 24-96h, but positive for long-lead 108-168h.**
Positive impact of TC Recon data on intensity forecast with long-lead 84-168h, the impact from HDOBs data alone is mixed, mostly negative 0-84h and positive 84-138h.
TC Recon dropsonde data on center pressure forecast is positive, the impact of HDOBs on center pressure forecast is mixed, negative 48-108h
TC 2022 Ian: Track & Intensity Skills

Positive impact of TC dropsonde data on track forecast for 24-168h

Mixed impact of TC dropsonde data on intensity forecast
Summary

• When all storms are considered for the cases selected, the impact of Recon data (dropsondes and HDOBs) seems to be different between 2020 and 2021. The overall impact is neutral, but positive for strong storms.

• The impact of TC Recon data on the intensity forecast is neutral to positive.

• The HDOBs data helps improve the track forecast from the 2020 experiment, but has a mixed impact on the minimum center pressure forecast.

• The impact of TC dropsonde data on minimum center pressure forecast is positive, also for the track for hurricane Ian.
Thanks for your attention

Questions?