Overview of the Next Global Forecast System GFSv17

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System Overview

● Goals/Scope
● Expected Benefits from GFSv17
● Potential Component Updates
Overview of GFS

- Global deterministic model
- Run 4 times a day out to 16 days
  - Hourly output for first 120 hours
  - 3 hourly for days 6-16
- Global Data Assimilation System (GDAS)
- Provides initial and/or boundary conditions for multiple downstream forecast systems
Goals/Scope of GFSv17

- Coupled forecast model (atm, land, ocn, ice, wav)
- Improved DA with JEDI for non-atm components
- Towards consolidation of NCEP production suite
- Improve on known issues in GFSv16
System Overview

- **Coupled system resolutions**
  - Atmosphere/land:
    - Forecast: C768 or C1152, L127
    - Analysis/DA Ensemble: C384 L127
  - Ocean
    - ¼° tripolar
    - 75 layers (41 or 75 in Analysis/DA Ensemble)
  - Sea ice
    - ¼° tripolar
  - Waves
    - Unstructured grid
    - Undecided if will be included in DA ensemble
  - Aerosol
    - Included in GDAS deterministic forecast
    - No aerosol-radiation interaction

- **GFS and GEFS will be separate systems**
  - Infrastructure will be as unified as possible
  - Code deliveries are separate
  - Implementation day planned to be the same day
Expected Benefits of GFSv17

- **Atmosphere**
  - Removal of the negative tracer values that occurred from the PBL and convection schemes
  - Improvement of forecasts of low-level inversions
  - Enhancement of the underestimated surface-based convective available potential energy (CAPE)
  - Improvement of hurricane forecasts
  - Reduction of the nighttime cold 2m temperature biases over CONUS forested regions
  - Reduction of the CONUS 10m wind speed biases
  - Improvement of radiation and cloud coupling
  - Improvement of air-sea coupling and atmospheric dominant modes
  - Improvement of MRW forecasts of large-scale flow pattern and precipitation events
  - If 9km: Providing higher resolution lateral and boundary conditions for running downstream applications.

- **Wave**
  - Address low bias in high amplitude wave events
  - Improved swell forecasts in the Pacific
  - Possibly increase the global resolution or add high resolution coastal nests (unstructured grids)
Expected Benefits of GFSv17

- **Coupling**
  - New ocean and ice components, providing a consistent atmosphere-ocean-ice-wave deterministic forecast
  - Based on ECMWF, UKMet and ECCC, *possible* impact of coupling:
    - Improve general skill in the middle and upper troposphere
    - Largest impacts to be in relation to tropical cyclones:
      - Track, central pressure, intensity, and false alarms
      - Note, there is no guarantee we will see this in GFSv17

Weakly Coupled DA Overview

- **Atmosphere**
  - GSI-based hybrid 4D-EnVar deterministic analysis
  - GSI-based 4D-LETKF ensemble analysis
  - Additional early cycle ensemble analysis for GEFS initialization (if resources allow)

- **Marine**
  - Sea-ice Ocean and Coupled Analysis (SOCA): ocean and sea ice are strongly coupled
  - JEDI-based hybrid 3D-EnVar for deterministic analysis
  - JEDI-based 3D-LETKF for ensemble analysis

- **Land**
  - JEDI-based 2D OI for snow
  - Possible LETKF (GSI or JEDI) for soil moisture and soil temperature

- **Aerosol**
  - JEDI-based 3DVar
  - Initializes central analysis only (no ensemble perturbations)
  - Inclusion of aerosols is undecided for deterministic GFS forecast
Atmospheric DA (GSI)

- Early Cycle EnKF
- Accommodations for Thompson Microphysics
  - Modify GSI interface to ingest new number concentration variables
  - Additional optimizations (e.g. error model, cloud optical table)
- Other Radiance/All Sky Assimilation Upgrades
  - Upgrade to CRTM 3.0
- Scale-Dependent Localization
  - Leveraging work recently merged to GSI repo by Sho Yokota and OU-MaP for RRFS.
- New Observations
Atm Physics

- **Description of ATM physics potential upgrades**
  - **Cumulus Convection**: positive definite mass flux; stochastic convective organization; prognostic closure; optimization; improved CAPE forecast; improved hurricane forecasts
  - **Planetary Boundary Layer (PBL)**: positive definite mass flux; optimization; improved surface inversion forecast; improved CAPE forecast; improved hurricane forecasts
  - **Surface Layer**: sea spray parameterization; optimization
  - **Microphysics (MP)**: replacing GFDL MP scheme with Thompson MP scheme - improving computational instability and forecast accuracy of cloud hydrometers and radiative fluxes in the tropics
  - **Gravity wave drag (GWD)**: small-scale gravity wave drag; turbulent orographic form drag; updates of orographic GWD, mountain blocking, and non-stationary GWD
  - **Radiation**: improving radiation and cloud interactions
  - **Aerosol**: OPAC data replaced by MERRA2 aerosol climatology
  - **Albedo and Emissivity over Fractional Grid**
Land Component

- NOAH-MP Land Surface Model (LSM)
  - Replacing Noah LSM with Noah-MP LSM
  - Noah-MP uses multiple options for key land-atmosphere interactions; (a) a tiled approach to separate vegetation and bare soil, (b) a dynamic vegetation scheme, (c) a multi-component, separate vegetation canopy, (d) canopy radiative transfer with shading geometry, (e) a multi-layer snow pack, (f) canopy heat storage; increase number of soil layers and depth of soil column
  - Update vegetation type from MODIS to VIIRS
  - Update land-sea mask using VIIRS dataset
Marine Components

- **MOM6 Ocean Model**
  - OM4 Physics [Adcroft, 2019]
  - Provides SST to atm model which calculates a near-sea-surface temperature (NSST)

- **CICE6 Ice Model**
  - 5 thickness categories
  - Using Mushy thermodynamics

- **WAVEWATCH III (WW3) Wave Model**
  - Updated current and ice input from coupled model
  - Feedback to atm and ocean models
    - Additional experiments are underway to examine the impact and potentially improve the feedback from the wave model to the atm model
  - Improve on known issues with low bias in high seas and low-swell in Pacific
Summary

- **Goals/scope of GFSv17**
  - Coupled forecast model (atm, land, ocn, ice, wav)
  - Improved DA with JEDI for non-atm components
  - Towards consolidation of NCEP production suite
  - Improve on known issues in GFSv16

- **Additional details:**
  - **UIFCW talk:** *Evaluation of High Resolution Prototypes for the Next Global Forecast System GFSv17*, Lydia Stefanova
  - **UIFCW talk:** *Demystifying NCEP’s Global Workflow [GFS]*, Rahul Mahajan
  - **UIFCW talk:** *Model Infrastructure Development in UFS Weather Model*, Arun Chawla
Thank you!
Back-up Slides
Current Operations: GFSv16
**GFS DET**

- GSI
- SOCA-Hyb
- Land DA
- Aero DA

**Coupled Forecast**
ATM/Noah-MP
MOM6
CICE6
WAVEWATCHIII

**GDAS DET**

- GSI
- SOCA-Hyb
- Land DA
- Aero DA

**Coupled Forecast**
ATM/Noah-MP
MOM6
CICE6
WAVEWATCHIII

**Proposed GFSv17**

**GFS ENS**

- LETKF
- SOCA-Ens
- Land DA

**Coupled Forecast**
ATM/Noah-MP
MOM6
CICE6
WAVEWATCHIII

**GDAS ENS**

- LETKF
- SOCA-Ens
- Land DA

**Coupled Forecast**
ATM/Noah-MP
MOM6
CICE6
WAVEWATCHIII

**GEFS**

- LETKF
- SOCA-Ens
- Land DA

**Coupled Forecast**
ATM/Noah-MP
MOM6
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WAVEWATCHIII

**GOCART**