NATIONAL WEATHER SERVICE

Overview of the Next Global Forecast System GFSv17

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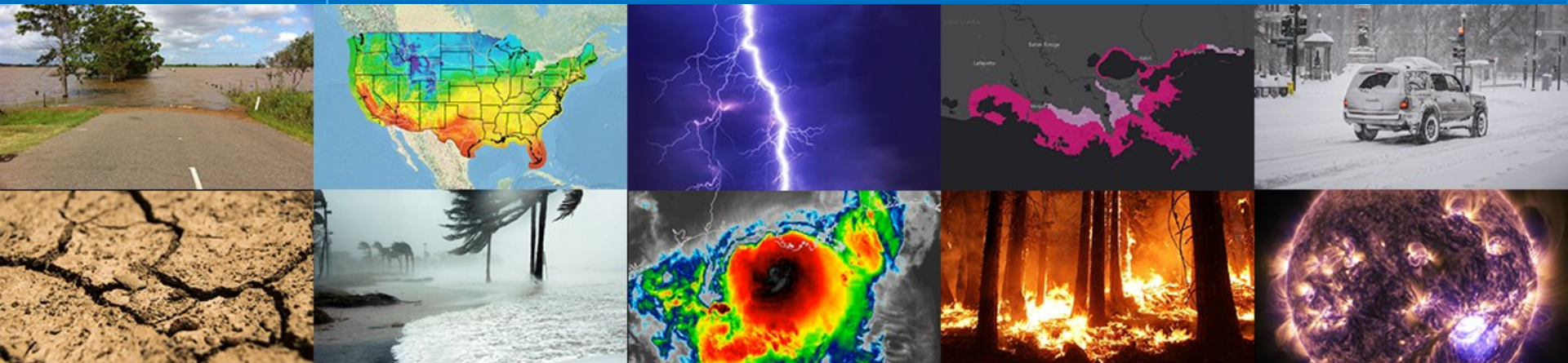

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NCEP/EMC: Catherine Thomas, Guillaume Vernieres, Daryl Kleist, Cory Martin, Andrew Collard, Jiarui Dong, Andy Eichmann, Travis Elless, Nick Esposito, Iliana Genkova, Azadeh Gholoubi, Brett Hoover, Xin Jin, Emily Liu, Haixia Liu, Hyun-Chul Lee, Xuanli Li, Ron McLaren, Dagmar Merkova, Sudhir Nadiga, Shastri Paturi, Ashley Stanfield, Steve Stegall, Andy Tangborn, Russ Treadon, Yaping Wang, Youlong Xia
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Coupled Model Component Development

NCEP/EMC: Jessica Meixner, Jiande Wang, Lydia Stefanova, Jun Wang, Yuejian Zhu, Neil Barton, Saeideh Banihashemi, Arun Chawla, Bing Fu, George Gayno, Robert Grumbine, Walter Kolczynski, Matthew Masarik, Avichal Mehra, Ali Salimi-Tarazouj, Denise Worthen
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Atmospheric Composition

Infrastructure

Coupled Model Evaluation

System Overview

- Goals/Scope
- Expected Benefits from GFSv17
- Potential Component Updates

Overview of GFS

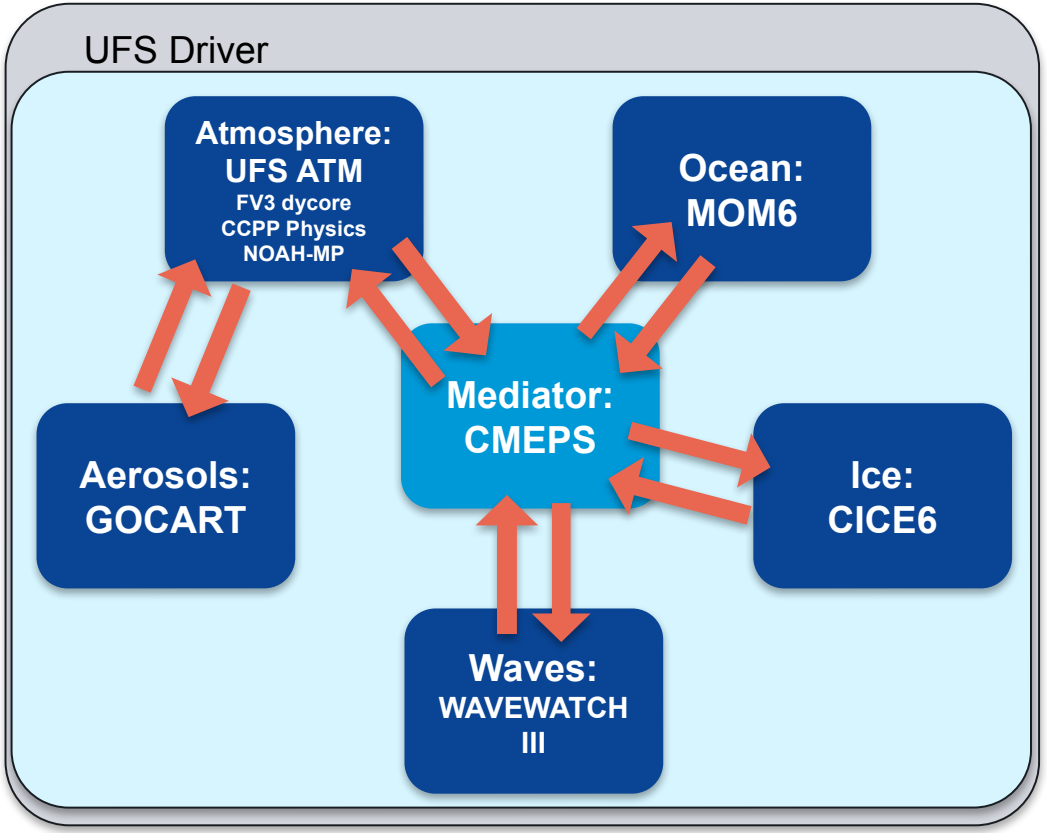
- Global deterministic model
- Run 4 times a day out to 16 days
  - Hourly output for first 120 hours
  - 3 hourly for days 6-16
- Global Data Assimilation System (GDAS)
- Provides initial and/or boundary conditions for multiple downstream forecast systems

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

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Mogensen, K., L. Magnusson, J.-R. Bidlot & F. Prates. Ocean coupling in tropical cyclone forecasts. *ECMWF Newsletter* No. 154 (2018).
Vellinga, M., et al. (2020). Evaluating Benefits of Two-Way Ocean–Atmosphere Coupling for Global NWP Forecasts, *Weather and Forecasting*, *35*(5), 2127-2144. Retrieved Nov 3, 2022, from https://journals.ametsoc.org/view/journals/wefo/35/5/wafD200035.xml
Smith, G. C., et al. (2018). Impact of Coupling with an Ice–Ocean Model on Global Medium-Range NWP Forecast Skill, *Monthly Weather Review*, *146*(4), 1157-1180. Retrieved Nov 3, 2022, from https://journals.ametsoc.org/view/journals/mwre/146/4/mwr-d-17-0157.1.xml

Weakly Coupled DA Overview

- **Atmosphere**
  - GSI-based hybrid 4DEnVar 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 3DEnVar 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

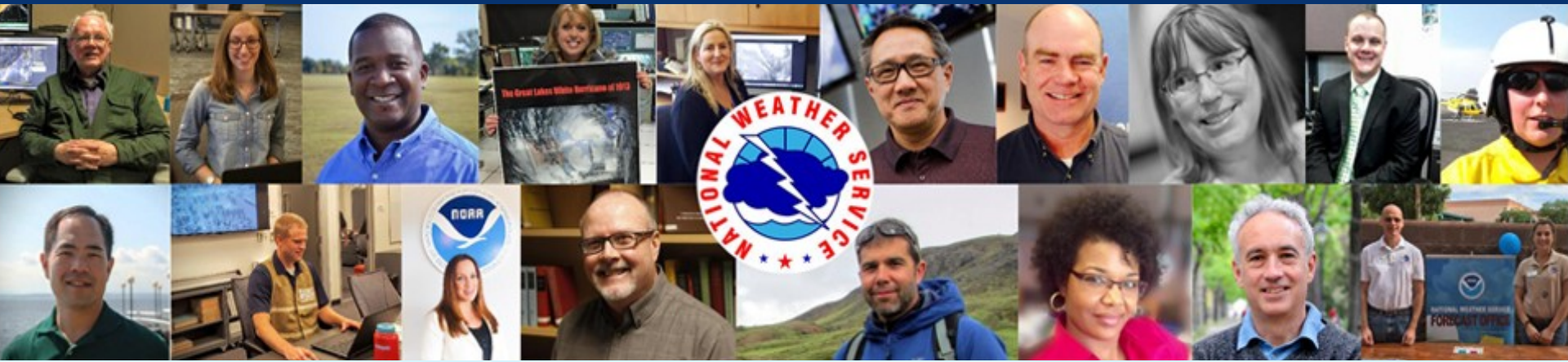
- **MOM6 Ocean Model**
  - OM4 Physics [Adcroft, 2019]
  - Provides SST to atm model which calculates a near-sea-surface temperature (NSST)
- **CICE6 Ice Model**
  - 5 thickness categories
  - Using Mushy thermodynamics
- **WAVEWATCH III (WW3) Wave Model**
  - Updated current and ice input from coupled 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

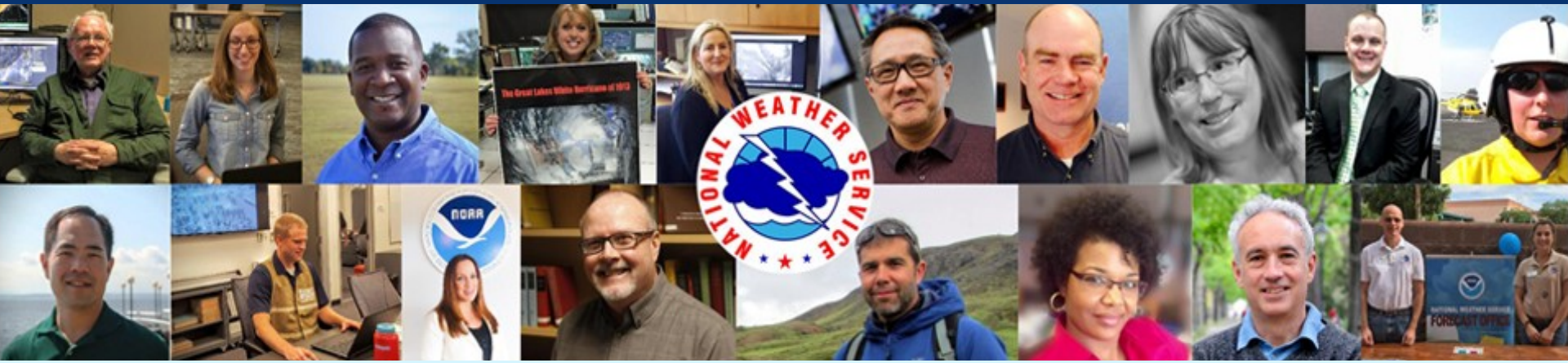
- **Goals/scope of GFSv17**
  - Coupled forecast model (atm, land, ocn, ice, wav)
  - Improved DA with JEDI for non-atm components
  - Towards consolidation of NCEP production suite
  - Improve on known issues in GFSv16
- **Additional details:**
  - **UIFCW talk:** *Evaluation of High Resolution Prototypes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

Questions

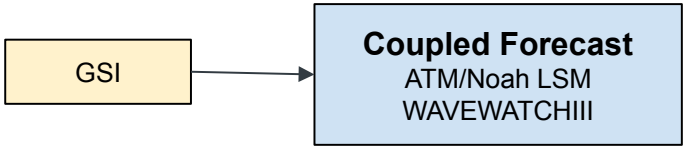
Thank you!



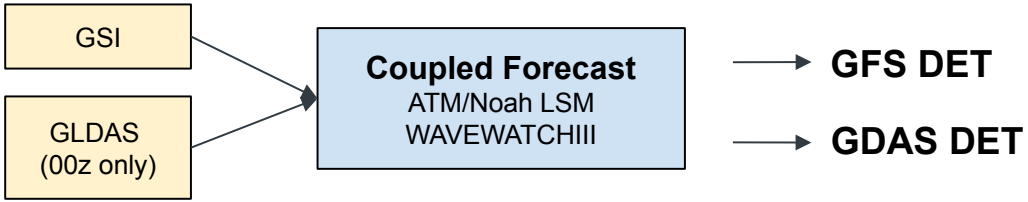
Back-up Slides



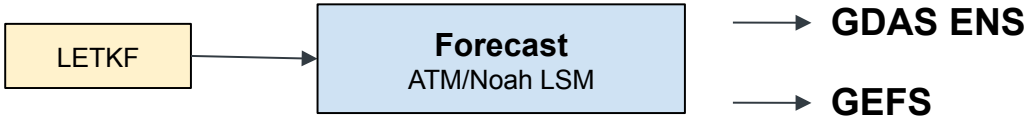
GFS DET



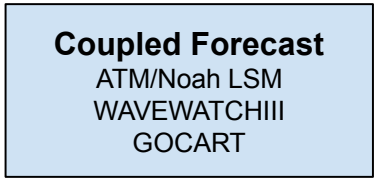
GDAS DET



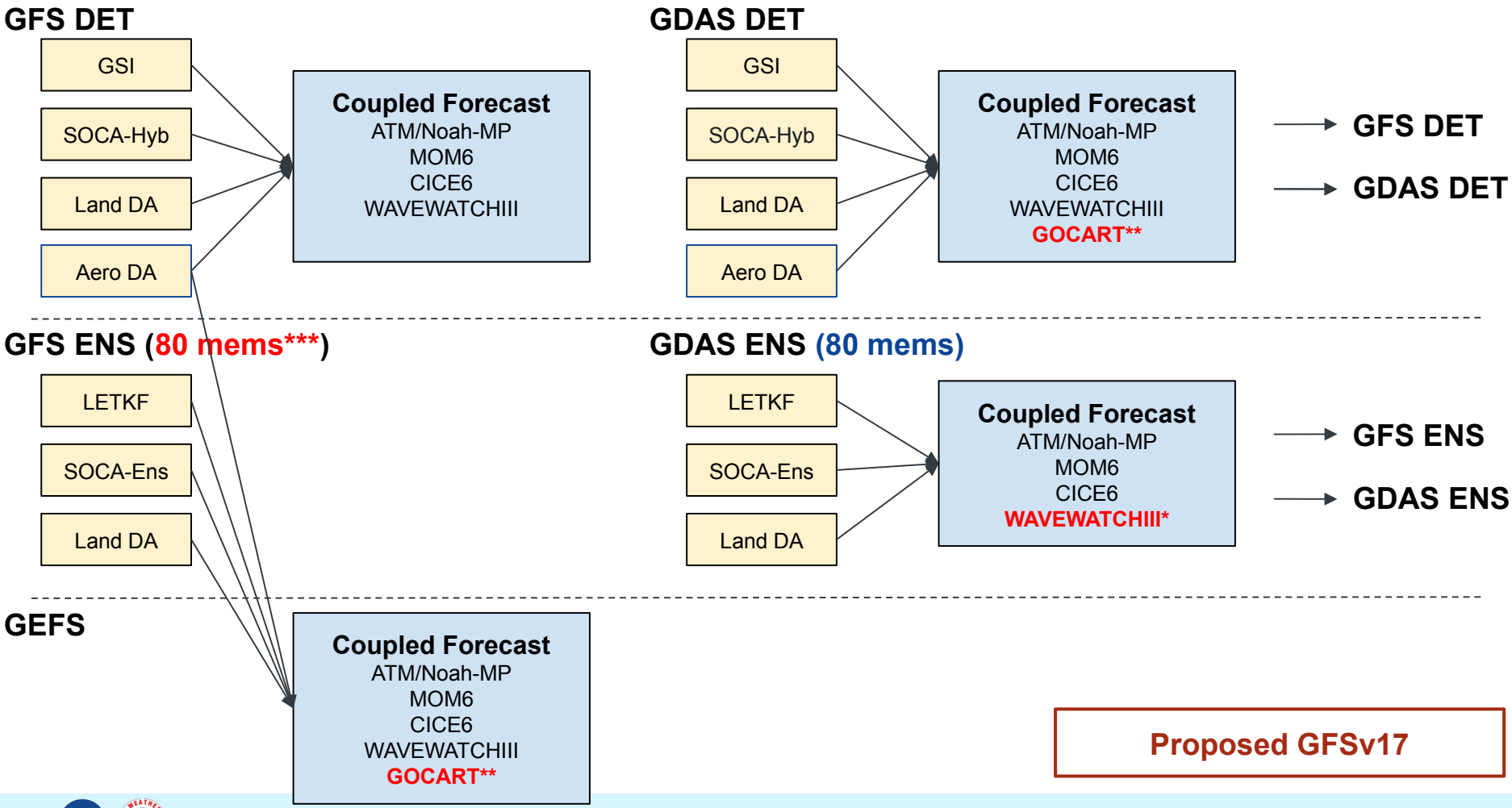
GDAS ENS (80 mems)



GEFS



Current Operations: GFSv16


GFS DET
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SOCA-Hyb
Land DA
Aero DA
Coupled Forecast
ATM/Noah-MP
MOM6
CICE6
WAVEWATCHIII
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CICE6
WAVEWATCHIII
GOCART**
GFS DET
GDAS DET
GFS ENS (80 mems***)
LETKF
SOCA-Ens
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Proposed GFSv17