



Overview of GFSv17

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Overview of the Operational Global Forecast System

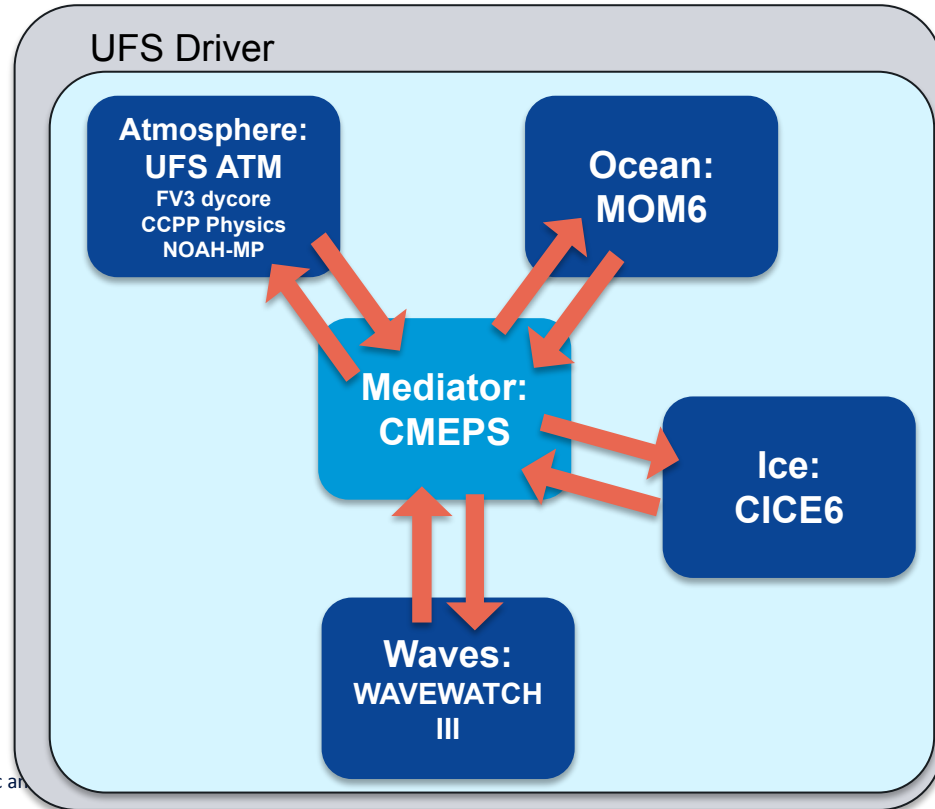
- Global deterministic model: GFSv16
 - C768 (~13 km), L127
 - One-way coupled with wave model
- Run 4 times a day out to 16 days
 - Hourly output for first 120 hours
 - 3 hourly for days 6-16
- Global Data Assimilation System (GDAS)
 - 80 ensemble members
 - C384 (~25 km), L127
- Provides initial and/or boundary conditions for multiple downstream forecast systems including the Global Ensemble Forecast System (GEFS)

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
- Increase ATM horizontal resolution to 9 km
- Upgrade ATM physics (Thompson, Noah-MP)

System Overview: Resolutions

- Atmosphere/land
 - Forecast model: C1152 L127
 - History file output: C768 L127
 - Analysis/DA Ensemble: C384 L127
- Ocean
 - $\frac{1}{4}^\circ$ tripolar
 - 75 layers
- Sea ice
 - $\frac{1}{4}^\circ$ tripolar
- Waves
 - Unstructured grid
- Aerosols
 - Moved to GCAFS



Joint Effort for Data assimilation Integration (JEDI)

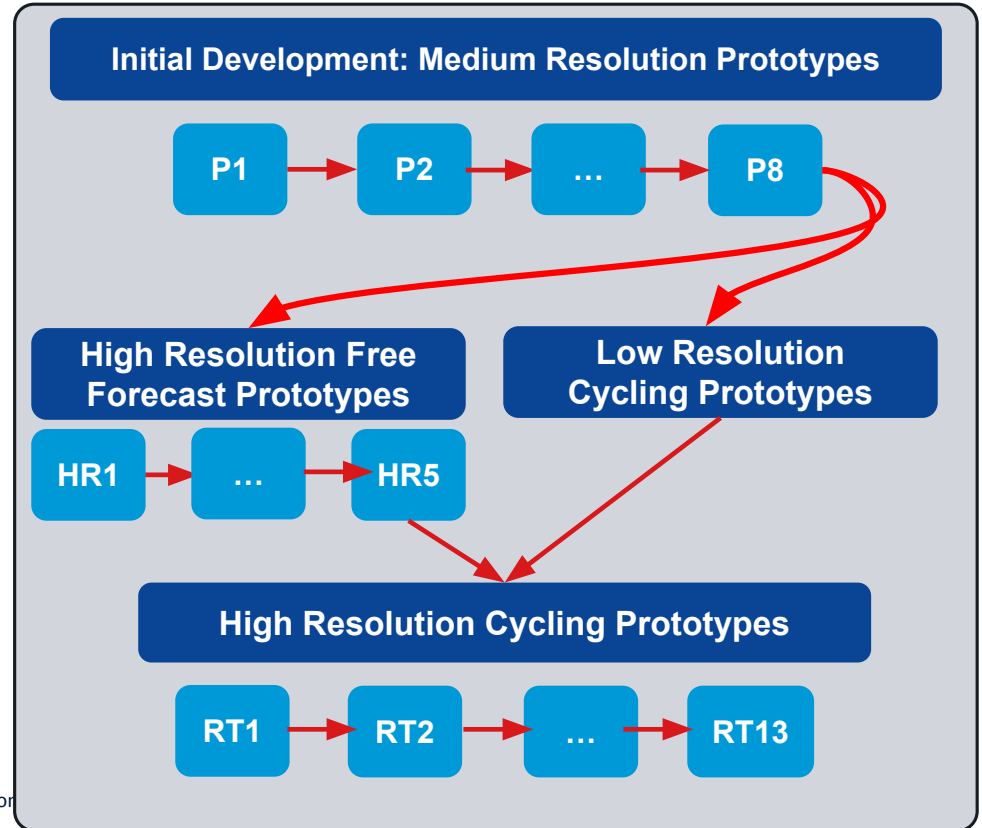
- JEDI is a project within the Joint Center for Satellite Data Assimilation (JCSDA)
- JEDI provides a software infrastructure for data assimilation that
 - is model agnostic
 - is generic and portable, from toy models running on laptops to operational Earth system coupled models running in the cloud.
 - enables DA on the model native grid
 - does not impose one specific DA methodology or algorithm
 - provides a framework for rapid uptake of new observations into operations with generic observation handling and modeling
 - encourages implementation of model-independent observation operators [Unified Forward Operator (UFO)]
 - provides a unified Interface for Observation Data Access (IODA)
 - is adaptable to exascale computing
- JEDI is for scientific exploration and operational forecasting.
- The keys to success are separation of concerns and interfaces.

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
- Marine
 - Sea-ice Ocean and Coupled Analysis (SOCA): ocean and sea ice are strongly coupled
 - JEDI-based 3DVar-FGAT for deterministic analysis
 - Ensemble forecast will be coupled and recentered about the deterministic analysis
- Land
 - JEDI-based 2DVar for snow
 - GSI-based 4D-LETKF for soil moisture and soil temperature (strongly coupled with atmosphere)
- Aerosol
 - Moved to GCAFS

Iterative Prototype Development

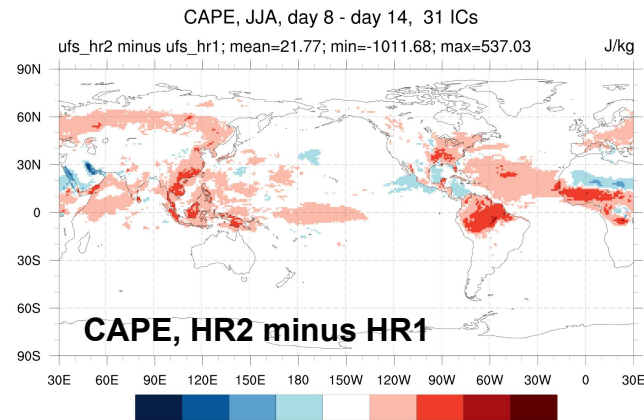
- Discrete system prototypes with gradually increasing complexity were defined and evaluated
- Findings were used to inform subsequent development



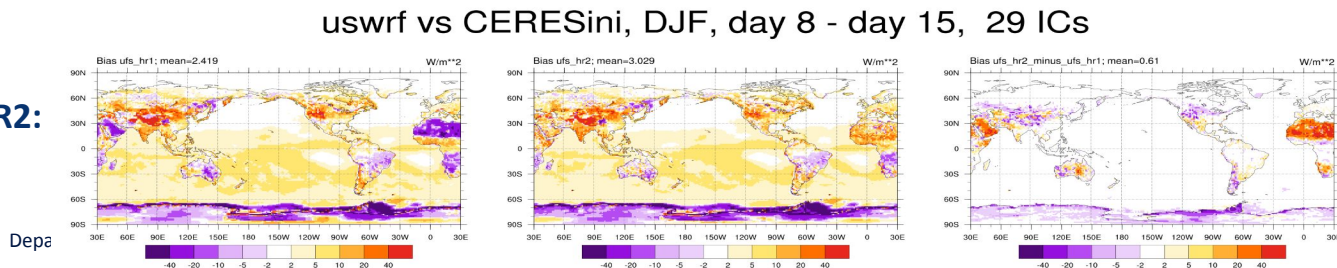
High Resolution (HR) Prototypes

- Coupled model (ATM, OCN, ICE, WAV)
- Free forecast (no DA)
- Atmosphere: C768 (HR1, HR2, HR3a), C1152 (HR3b+)
- Ocean/Ice: ¼ degree tripolar
- Waves: ¼ degree tripolar (HR1-2), Unstructured grid (HR3+)

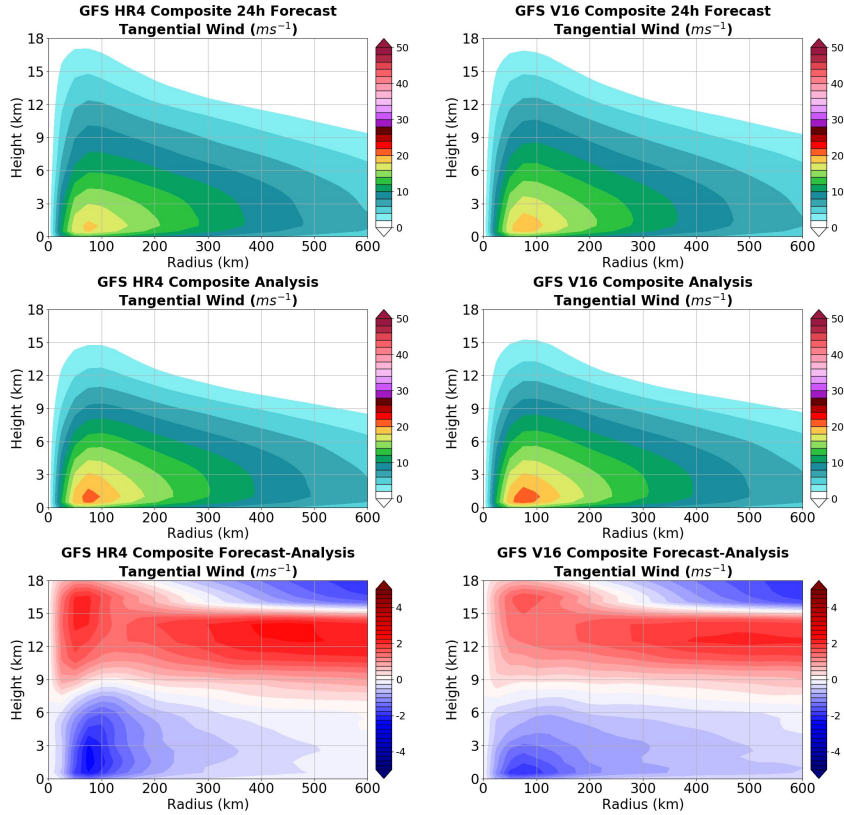
CONUS Summer CAPE enhancement GFSv16→HR1→HR2



Soil albedo changes HR1→HR2:
clear impact over deserts



HR Evaluation Highlights



TC Structure Evaluation of HR4
(Andy Hazelton)

▲	HR5 is better than HR4 at the 99.9% significance level	▼	HR5 is worse than HR4 at the 99.9% significance level
▲	HR5 is better than HR4 at the 99% significance level	▼	HR5 is worse than HR4 at the 99% significance level
▲	HR5 is better than HR4 at the 95% significance level	▼	HR5 is worse than HR4 at the 95% significance level
■	No statistically significant difference between HR5 and HR4	■	Not statistically relevant

		N. America						N. Hemisphere						S. Hemisphere						
		Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	
JJA	Heights	250hPa	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		500hPa	▲	▲	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■	■
		700hPa	▲	▲	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■	■
		1000hPa	■	▲	■	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■
	Vector Wind	250hPa	■	■	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■	■
		500hPa	■	■	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■	■
		850hPa	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Temp	250hPa	■	▲	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■	■
		500hPa	■	▲	■	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■
		850hPa	▲	▲	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MSLP	MSL	■	▲	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
			N. America						N. Hemisphere						S. Hemisphere					
		Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16	
DJF	Heights	250hPa	▲	▲	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■	
		500hPa	▲	▲	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■	
		700hPa	▲	▲	■	■	■	■	▼	■	■	■	■	■	■	■	■	■	■	■
		1000hPa	■	▲	■	■	■	■	■	▼	■	■	■	■	■	■	■	■	■	■
	Vector Wind	250hPa	■	▲	■	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■
		500hPa	■	▲	■	■	■	■	■	▲	▲	■	■	■	■	■	■	■	■	■
		850hPa	■	▲	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Temp	250hPa	■	▲	■	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■
		500hPa	■	▲	■	■	■	■	■	■	▲	■	■	■	■	■	■	■	■	■
		850hPa	▲	▲	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MSLP	MSL	▲	▲	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

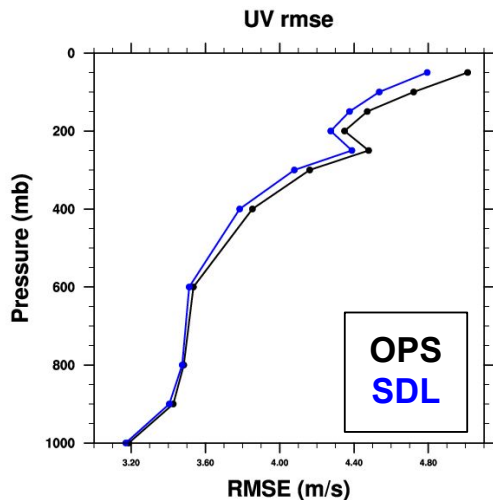
ACC Scorecard for HR5 vs. HR4
(Lydia Stefanova)

Cycling Prototypes

- Started with low resolution prototypes, isolating different combinations of components. For example:
 - ATM-OCN-ICE C384mx025 3DVar ATM DA + Marine DA
 - ATM-only C384/C192 ATM DA + Soil DA
 - ATM-only C384 ATM DA + Snow DA
- Moved to initial full resolution experiments with the target system to test the infrastructure.
- Currently running full resolution “retrotests” using the targeted retrospective time periods and initial conditions to evaluate the science.
- Goal: Cycle as much as possible to get as many samples/cases as we can to stress test the system.

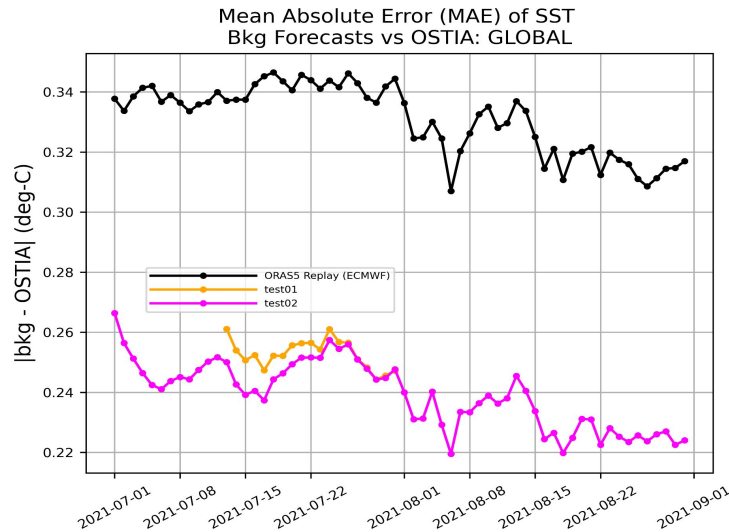
Low Resolution Cycling Prototypes: Atmos and Marine DA

Scale-dependent localization with 3 scales reduced the RMSE compared to radiosondes in the upper layers



Atmospheric DA

Scale Dependent Localization



The mean error of SST against OSTIA is reduced when including ocean/sea ice DA

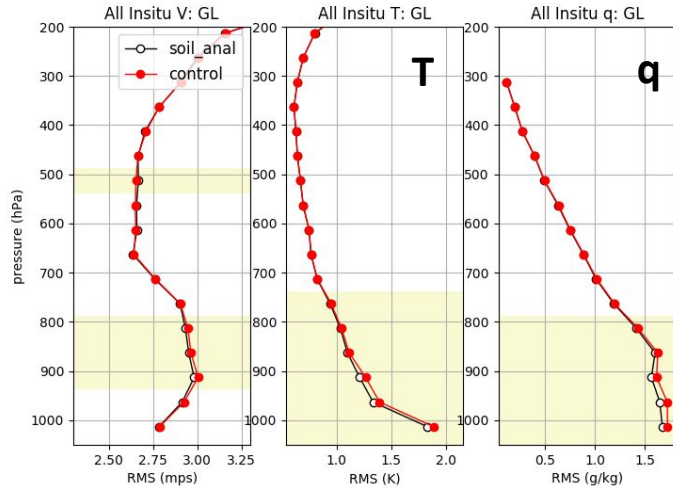
Marine DA

(Guillaume Vernieres)

Low Resolution Cycling Prototypes: Land DA

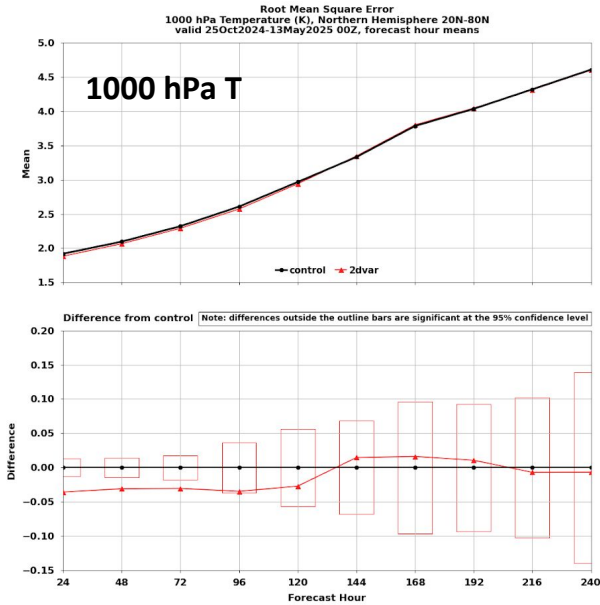
Significant reduction in fits to aircraft data in lower level T and q with soil DA included

20220501 - 20220523 RMS O-F



Soil DA

(Clara Draper/Tseganeh Gichamo)

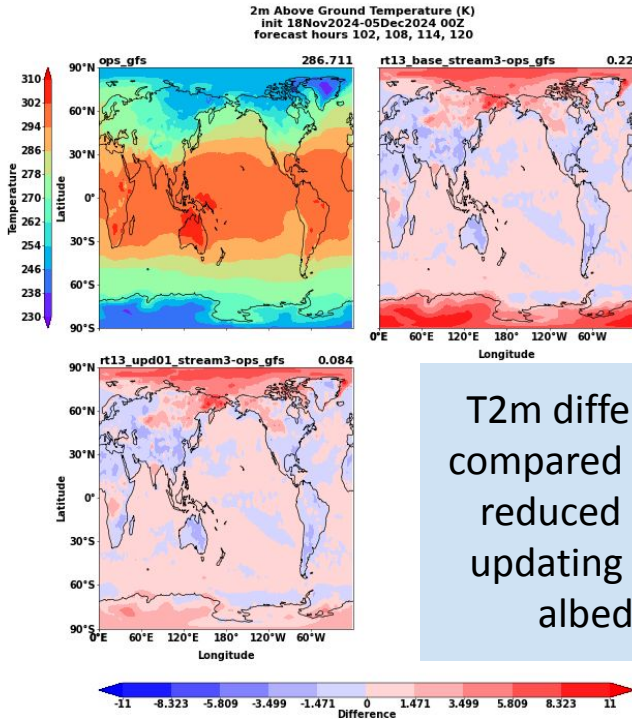


Significant reduction in RMSE for low level T with snow DA included

Snow DA

(Cory Martin/Jiarui Dong)

Latest Cycling Prototypes



T2m difference compared to Ops reduced after updating snow albedo

Evaluating adjustments to physics/land model
Candidate 1 vs. Candidate 2
(~3 weeks of cycling each season)

		N. America					N. Hemisphere					S. Hemisphere									
		Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10		
Winter Anomaly Correlation Coefficient	Heights	250hPa																			
		500hPa																			
		700hPa																			
		1000hPa																			
	Vector Wind	250hPa																			
		500hPa																			
		850hPa																			
	Temp	250hPa																			
		500hPa																			
		850hPa																			
	MSLP	MSL																			

Summary and Next Steps

- Goals of GFSv17
 - Coupled forecast model (atm, land, ocn, ice, wav)
 - Improved DA with JEDI for non-atm components
- Experiments
 - Full resolution cycling is ongoing over multiple time periods, including real time, while we continue to evaluate and tweak the system
 - Official retrospective parallels are scheduled to begin by the end of the calendar year
- Targeting FY2027 for implementation



Questions?

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