



AMS Town Hall: Jan 14 2021



NOAA Unified Forecast System (UFS) Research to Operation (R2O) Project

Dorothy Koch, Yan Xue, Maoyi Huang, Youngsun Jung
NOAA/NWS/OSTI-Modeling

Russell Schneider, Chandra Kondragunta
NOAA/OAR/WPO



EMC, PSL, GSL,
CSL, NSSL, ARL,
GFDL, AOML,
NESDIS





Agenda



- Introduction to the UFS-R20 Project - **PO**
- Overview of the UFS-R20 Project - **Project/Team Leads**
 - Medium-Range Weather/S2S Application Team
 - Short-Range Weather(SRW) Application Team
 - Cross-cutting Infrastructure (CCI) Team
- How to Engage with the UFS-R20 Teams? - **PO**
- Q & A Session



The UFS-R2O Project



- **Unified Forecast System (UFS)** is a community-based, coupled Earth modeling system, to support the Weather Enterprise and to serve as the source for NOAA's operational applications.
- **UFS Research to Operations (R2O)** aims to develop next-generation global and regional forecast systems for NOAA's operations
- **UFS-R2O Project** is NOAA's largest investment in the UFS, \$13M/yr for 2 years, supported and managed by NWS and OAR jointly, to support operational applications by FY24
- Community project team with over **100 scientists** from NOAA operational centers, NOAA research laboratories, NCAR, JCSDA, DTC, Universities

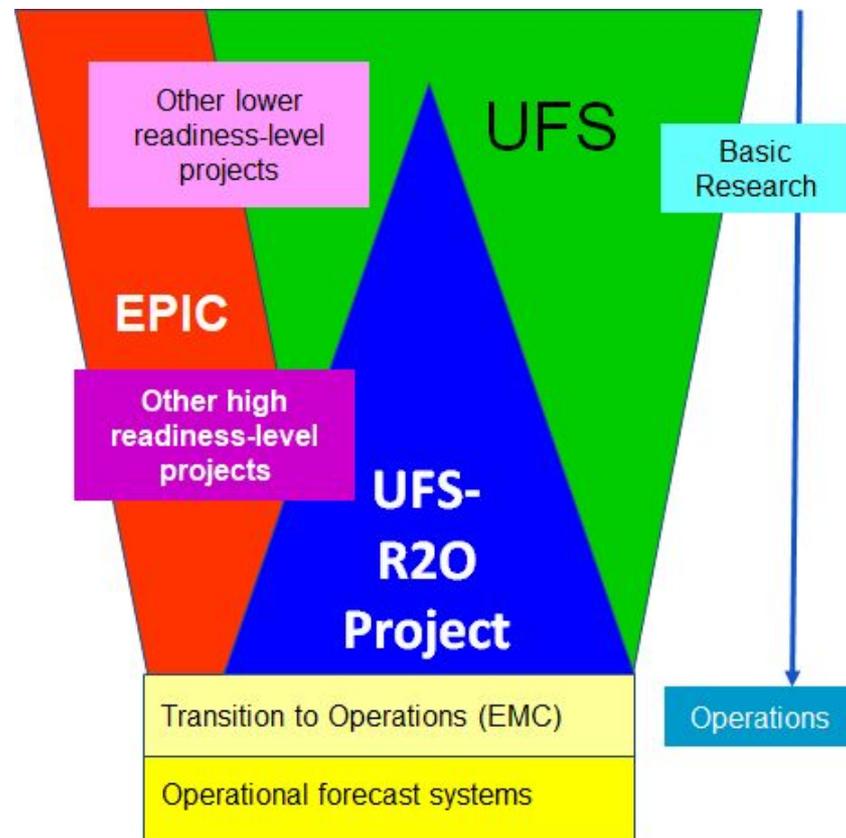


The Wider UFS Context



The **UFS-R20 Project** is a subset of the **UFS** supported by NOAA that focuses on the transfer of innovations into operations (**lower part of the R20 "funnel"**).

“Earth Prediction Innovation Center” (EPIC) is a new NOAA initiative that will be providing infrastructure and user support.





UFS R20 Project

<https://vlab.ncep.noaa.gov/web/ufs-r20>

Jim Kinter, Vijay Tallapragada, Jeff Whitaker
14 January 2021





UFS-R20 Project Inspiration



- From UCAR Modeling Advisory Committee (2018 [report](#)):
 - **NOAA must be “all-in” in developing and deploying a unified community model, with a unified strategy to collectively manage modeling and DA R&D and optimize collaboration**
- Establishment of Unified Forecast System (UFS) w/NGGPS FV3 dycore
- EPIC Mission and Vision:
 - **Accelerate scientific research and modeling contributions through continuous and sustained community engagement** to produce the **most accurate and reliable operational modeling system in the world.**



A New Way of Doing Business!

- **Project = Experiment**: carry out R&D **collaboratively within constraints imposed by operational imperatives and public release timelines**
- **Engagement**: within NOAA (NWS-OAR-NESDIS-NOS) and wider UFS community; coordinated funding from **NWS & OAR**
- **Participation**: Interested/engaged/willing scientists from inside and outside NOAA under a single management framework
 - 219 participants in July 2020 kickoff meeting
- **Timeline**: 5-year vision, with deliverables for first 2 years



Scientific Priorities



Motivated by forecast priorities collected from stakeholders/testbeds

- **Reduce coupled model biases.**
- Improve representation of **key modes of variability** (e.g. MJO).
- Optimally combine Earth system observations and model forecasts using an **advanced data assimilation system to initialize coupled ensembles** (land-ocean-sea ice-atmosphere-aerosols).
- Develop a **convection-allowing ensemble forecast capability** for short-range prediction of severe weather and hurricanes.
- Improve **quantification of model uncertainty in ensembles**, especially near model component interfaces.



Guiding Principles



- **Shared infrastructure and algorithms** for modelling and data assimilation (coordinated development across Earth prediction enterprise)
 - Data assimilation: *JEDI*
 - Coupling model components: *ESMF, NUOPC, CMEPS*
 - Interoperable atmospheric sub-grid physical parameterizations: *CCPP*
 - Uniform code management policies: Git-based repositories with *Gitflow* model
 - Forecast verification framework: *METplus*
- **Scientific rigor** - research publications in high-impact peer-reviewed journals
- **Streamline and accelerate R2O** - coordination of UFS community and NCEP/EMC
- **Documentation and user support** - coordination with UFS Communications & Outreach
- **Supporting datasets for model calibration and validation**
- **Accountability** to funding organizations and responsiveness to community

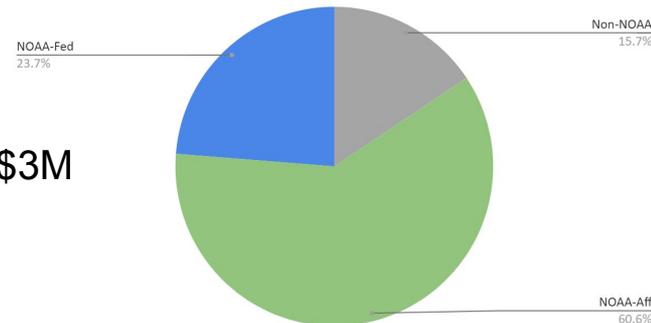


UFS-R20 Project History



- **Summer 2019:**
 - EPIC community meeting, need to better organize the UFS community to prepare
- **Fall 2019:**
 - NWS and OAR program managers agree to coordinate and commit resources
 - Program office invited 3-pager ideas from UFS community (approx 60 submitted, \$50M/y)
- **Winter 2019-2020:**
 - Proposal invited (2-year project)
 - Project team and [proposal](#) assembled
- **March 12-13, 2020:** Face-to-face peer-review
- **April-May 2020:** Funding finalized
 - \$13M/yr: NWS-OSTI \$10M and OAR-EPIC & JTTI \$3M
- **July 2020:** Project launch, Kick-off meeting (July 9-10)
- **October 1 2020:** First Quarterly Program Review

Participation to the UFS-R20 Kick-off meeting
Total number: 219





Project Outcomes – Years 1-2



- **First 2 major operational systems, global and regional, to be developed jointly between NOAA and the community!**
 - Initially targeting GFSv17/GEFSv13/HREFv3/RRFSv1/HAFSv1
- **Fully coupled (L-O-SI-A-Ae) global ensemble prediction system, including coupled DA**
 - Ready for pre-operational testing and suitable for community research use
 - Addressing science priorities and leading to operational forecast improvements in priority areas
 - Reanalysis/reforecast capability for calibration/bias correction (production in years 3-4)
 - Public releases of coupled Medium-Range weather/S2S application
 - Public releases of JEDI data assimilation framework
- **Regional rapid refresh ensemble forecast system for convection-allowing scales**
 - Ready for pre-operational testing (1-hour cadence) and suitable for community research use
 - Public release of Short-Range weather application
- **Sunset existing global and mesoscale prediction systems**
 - Forecast system unification – simplification of operational product suite



Operational Models Consolidation

NPS Modeling System	Current Version	Q1 FY 20	Q2 FY 20	Q3 FY 20	Q4 FY 20	Q1 FY 21	Q2 FY 21	Q3 FY 21 - Q2 FY 22 MORATORIUM	Q3 FY 22	Q4 FY 22	Q1 FY 23	Q2 FY 23	Q3 FY 23	Q4 FY 23	Q1 FY 24	Q2 FY 24	Q3 FY 24	Q4 FY 24	UFS Application	
Global Weather & Global Analysis	GFS/ GDASv15							MORATORIUM											UFS Medium Range & Sub-Seasonal	
Global Waves	GWMv3																			
Global Weather Ensembles	GEFSv11																			
Global Wave Ensembles	GWESv3																			
Global Aerosols	NGAC v2																			
Short-Range Regional Ensembles	SREFv7																			
Global Ocean & Sea-Ice	RTOFSv1.2																			
Global Ocean Analysis	GODASv2																			
Seasonal Climate	CDAS/ CFSv2																			
Regional Hurricane 1	HWRfV12																			
Regional Hurricane 2	HMONv2																			
Regional High Resolution CAM 1	HiRes Window v7																			
Regional High Resolution CAM 2	NAM nests/ Fire Wxv4																			
Regional High Resolution CAM 3	RAPv4/ HRRRv3																			
Regional HiRes CAM Ensemble	HREFv2																			
Regional Mesoscale Weather	NAMv4																			
Regional Air Quality	CMAQv5																			
Regional Surface Weather Analysis	RTMA/ URMA v2.7																			
Atmospheric Transport & Dispersion	HySPLITv7																			
Coastal & Regional Waves	NWPSv1.2																			
Great Lakes	GLWUv3.4																			
Regional Hydrology	NWMv2																			
Space Weather 1	WAM/IPEv1																			
Space Weather 2	ENLILv1																			



5 Year Vision (highlights)



- Advanced **coupled DA** capabilities
 - Allow observations of any component (e.g. atmosphere) to update all components.
 - Advanced ensemble, hybrid & 4D-Var algorithms
 - Enhanced use of satellite radiances using JEDI for all forecast systems.
- **Next-gen moist physics** suite for the atmosphere, **unified: CAM to global**
- **CAM-resolution inline air quality prediction** and direct aerosol feedback
- **Warn on Forecast** system for severe weather outbreaks & flash flooding events
- **Hurricane Analysis & Forecast System** (HAFS) with **multiple moving nests**
- New UFS-based applications
 - **Coastal inundation, storm surge**
 - **Surface hydrology**
 - **Space-weather prediction**
- **Broader partnerships** inside and outside NOAA



UFS-R20
Whitaker, Tallapragada, Kinter

NWS/OSTI OAR/WPO
Koch, Melendez,
Kondragunta

Project Engineer
Adimi, Flampouris, Kumar

MRW/S2S
Stan, Yang,
Whitaker, Kinter

SRW/CAM
Alexander, Carley,
Tallapragada, Whitaker

Cross-cutting Infrastructure
Dunlap, Jensen,
Kinter, Tallapragada

DA and R&R
Kleist,
Tremolet,
Penny, Frolov

Physics
Bao, Bengtsson

3DRTMA
Carley, Alexander

Hurricane
Mehra, **Zhang**

**Coupled Model
Development**
Mehra, Yang,
Jablonowski

**Atmospheric
Composition**
Stajner, **Frost**

RRFS
Carley, **Alexander**

**Warn on
Forecast**
Wicker, Clark

Modeling
Dunlap, Chawla

**Verification &
Post Processing**
Hamill, **Levit**



Path Forward



- **Integrate with EPIC**
 - Proposal included sections anticipating EPIC engagement
- **Community support (enhanced by EPIC)**
 - Support multiple compute-platforms and community collaborators
- **Organization**
 - Coordinate across multiple institutions using contemporary communication tools and project engineers; integrate other funded NOAA projects
- **Secure computing resources**
- **Make model output available to the community**
 - NOAA Data Lake & NOAA Big Data Program



Medium-Range Weather/S2S Application

- **Coupled Model Development (2 minutes)**
Avichal Mehra, NWS/EMC
- **Data Assimilation and Reanalysis/Reforecast (2 minutes)**
Daryl Kleist, NWS/EMC
- **Atmospheric Physics Development (2 minutes)**
Jian-Wen Bao, OAR/PSL
- **Atmospheric Composition Development (2 minutes)**
Greg Frost, OAR/CSL



MRW/S2S: Coupled Model Development Overview



Team:

Leads: A. Mehra (EMC), F. Yang (EMC), C. Jablonowski (U. Mich.).

Investigators: Christiana Stan (GMU); Jeff Whitaker (OAR-PSL)

Scope and Benefits:

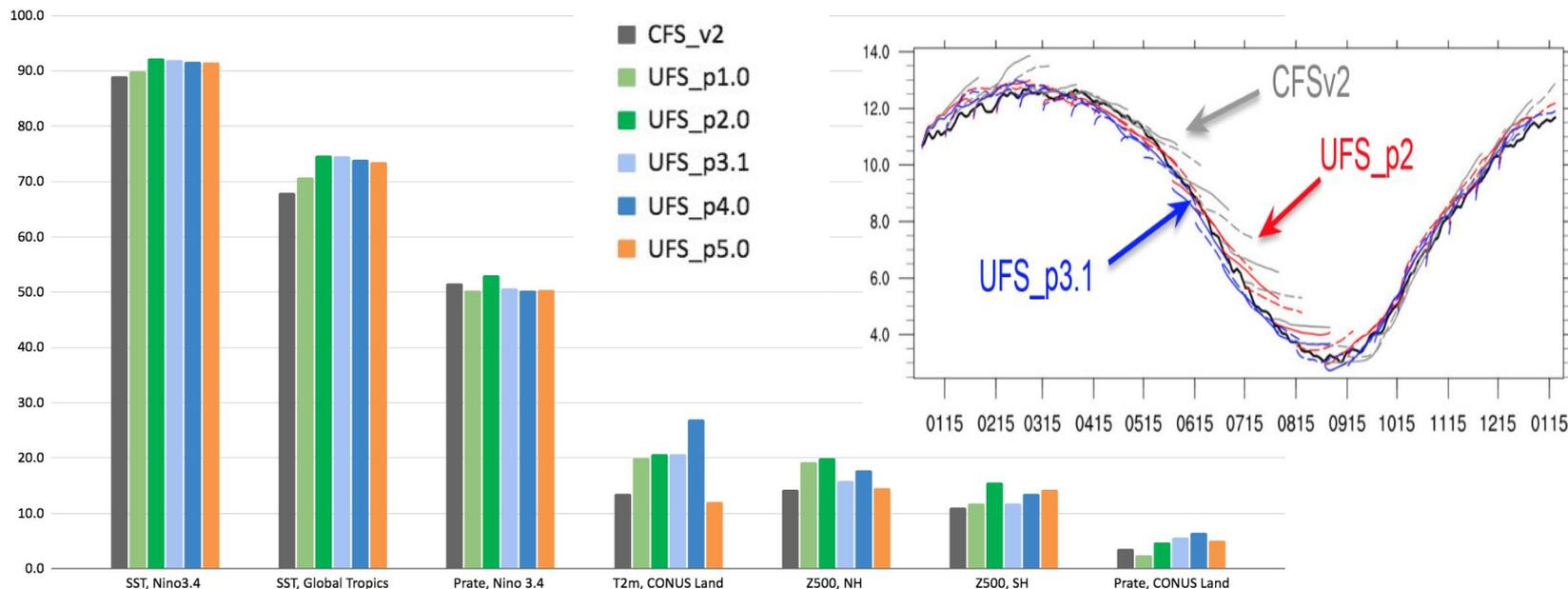
- Build six way coupled Earth system model
(**GFS-MOM6-CICE6-WW3-Noah-MP-GOCART**)
- Support weather (**GFSv17**) & sub-seasonal ensemble forecast system (**GEFSv13**) implementation in **FY24**, and seasonal forecast system (SFSv1) in FY25

Deliverables:

- Coupling to WW3, CICE6, upgrade to CMEPS coupler; update GFS.v16 physics & transition to CCPP; conduct coupled **S2S prototype runs**.
- Develop, evaluate and implement **stochastic perturbation schemes** for land, atmosphere, ocean, and ocean-atmosphere coupled system.
- Embed model diagnostics into FV3/ATM and assess **physics-dynamics coupling** paradigms.
- Implement and test **Noah-MP LSM** physics upgrades.
- Develop and apply diagnostic metrics to land and land-atm coupled system.
- Develop **low-resolution versions** of the coupled model



MRW/S2S: Coupled Model Development Early Results and Community Engagement



- **Entire model development is on GitHub.** The code repository is available at [ufs-weather-model](https://github.com/ufs-weather-model).
- Community infrastructure developments (ESMF, NEMS, NUOPC, CCM3, CMEPS, CDEPS, JEDI).
- Reforecast data from [Prototype 5](#) are available on [AWS cloud storage](#) platform for the community.



Team: Leads: **Daryl Kleist** (EMC), **Yannick Tremolet** (JCSDA), **Stephen Penny** (PSL, CIRES), & **Sergey Frolov** (PSL, CIRES)

Investigators: Rahul Mahajan (EMC), Jeff Whitaker (PSL), Clara Draper (PSL, CIRES), Henry Winterbottom (PSL, CIRES), Kevin Dougherty (EMC, IMSG), Kristen Bathmann (EMC, IMSG), Iliana Genkova (EMC, IMSG), Xiujuan Su (EMC, IMSG), Dagmar Merkova (EMC, IMSG), Jong Kim (EMC, IMSG), Shastri Paturi (EMC, IMSG), Xu Li (EMC, IMSG), Azadeh Gholoubi (EMC, IMSG), Stephen Herbener (JCSDA), Mark Miesch (JCSDA)

Scope and Benefits:

- Agile development and transition of next generation data assimilation infrastructure (JEDI) for all UFS components (Atm, Ocean, Sea Ice, Land) targeting **GFS v17**, **GEFS v13**, **GODAS**, and **SFSv1**.
- Advance state-of-the-science data assimilation of observations, algorithms, new components (land, ocean) and coupled system.

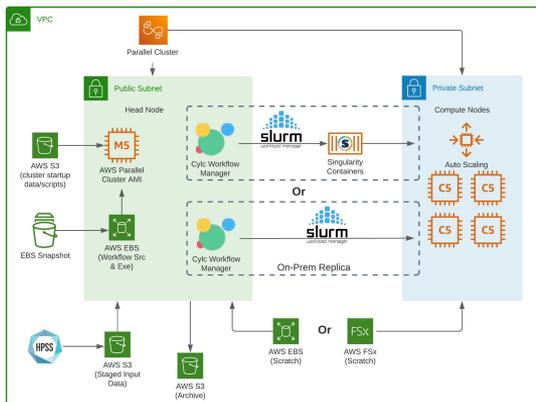
Deliverables:

- Assimilation infrastructure for UFS Applications (**JEDI**)
- Exploration of new algorithms including 4DVar
- **Improved use of observations** (correlated observation errors, **Unified Forward Operator** acceptance, improved pre-processing & QC)
- New marine assimilation capabilities and **30+ year marine reanalysis** based on UFS + JEDI
- JEDI-based land assimilation capabilities
- **“Weakly coupled”** assimilation capabilities for UFS
- Foundational capabilities for next-generation coupled reanalysis (GEFS v13)
- Prototype exploration of “strongly coupled assimilation”



MRW/S2S: Data Assimilation, Reanalysis & Reforecast

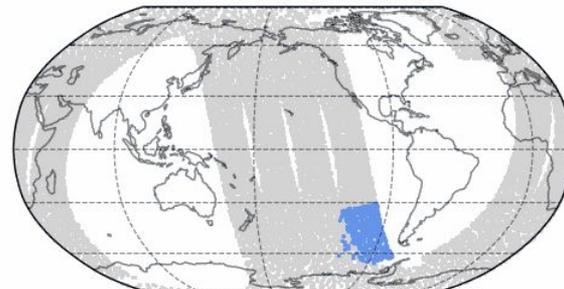
Early Results and Community Engagement



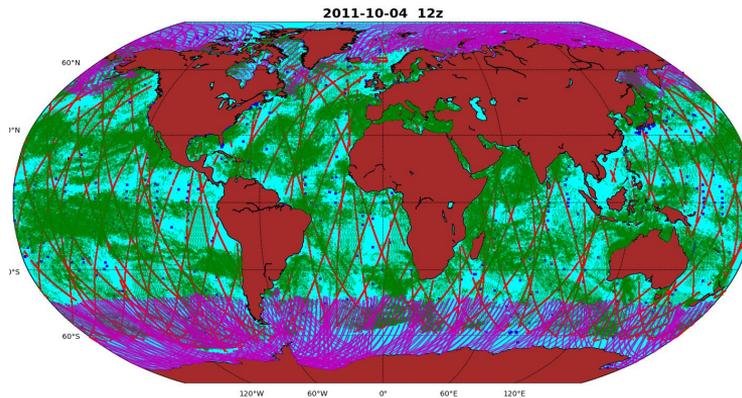
Workflow prototyping with cloud infrastructure (above)

First public release of JEDI (including JEDI-GFS and JEDI-GEOS) on Oct 29th, available at <https://www.jcsda.org/jedi-fv3-release>

Example from NRT (Right)



2020-10-12 21:00:00 ±10min



JEDI-Based Marine Data Assimilation (MOM6+ CICE)

One year worth of data available for assimilation (left), including SST, Absolute Dynamic Topography, ice concentration, and in-situ temperatures



MRW/S2S: Atmosphere Physics Development Overview



Team:

Leads: J.-W. Bao (PSL), L. Bengtsson (PSL)

Investigators: F. Yang (EMC); G. Grell (GSL), J. Olson (GSL), V. Yudin (CIRES); J. Doyle (NRL); L. Bernardet (DTC) and W. Li (DTC)

Scope and Benefits:

- Developing atmospheric physics parameterizations in the coupled UFS with advanced ideas and state-of-the-art techniques
- Alleviating GFS deficiencies and assisting EMC to achieve NOAA's operational objectives

Deliverables:

- Short-term: 1) Diagnose major deficiencies in the GFSv16 physics suite, and 2) an incremental upgrade of the physics suite with more advanced ideas and techniques to target the GFSv17 implementation
- Long-term: overhaul physics to deliver an advanced physics suite for coupled system, to be implemented in the UFS-GFS after GFSv17



MRW/S2S: Atmos. Phy. Development

Early Results and Community Engagement



Testing timetable for GFSv17/GEFSv13

	FY20			FY21														
	Q4			Q1			Q2			Q3			Q4					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			
Physics sub-project test plan (atmosphere only)	Write test plan																	
				Control														
	Develop/optimize RRTMGP			RRTMGP test														
	Develop/optimize uGWP			uGWP test														
				RRTMGP + uGWP test														
	Develop/optimize microphysics						Microphysics + RRTMGP + uGWP test											
	Upgrade/integrate/development/optimize Cloud, PBL, convection												Combined Physics Test #1					
Coupled Prototypes	P5			P6 (GFSv16 physics)			P7			P8 (physics tuning) and Phigh-res								
FY22																		
Q1			Q2			Q3												
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun										
Tune/Optimize																		
									Combined Physics Test #2									
									PN									

- Replace the microphysics parameterization in GFS v15 with a **multi-moment microphysics** scheme
- Unified gravity wave physics (**uGWP version 1**) parameterization that has physics-based representation of gravity wave sources and scale-aware gravity wave effects.
- Replace the RRTMG radiation scheme with **RRTMGP**
- Replace Noah LSM with **Noah-MP LSM**
- Changes for GEFSv13 in **atmospheric composition** and **stochastic physics**



MRW/S2S: Atmospheric Composition Overview



Team: Leads: **I Stajner (EMC)**, **G Frost (CSL)**. **Investigators:** G Grell, S Sun (GSL); L Zhang, R Montuoro, M Pagowski (GSL, CIRES); R Saylor (ARL); B Baker (ARL, UMBC); P Campbell, D Tong (ARL, GMU); S McKeen, R Schwantes, J He, S Wang, M Bela (CSL, CIRES); S Kondragunta (STAR); X Zhang (STAR, SDSU); E Hughes (STAR, IMSG); J McQueen (EMC); A Tangborn, P Bhattacharjee, L Pan (EMC, IMSG); C Martin (EMC, Redline)

Scope and Benefits:

- Develop an improved representation of atmospheric aerosols in the MRW/S2S system targeted for global subseasonal prediction in **GEFSv13**
- Integrate predicted aerosols with atmospheric physics by incorporating **aerosol-radiation feedbacks**
- Test the **aerosol data assimilation** to constrain aerosol
- Advance the long-term UFS goal of an integrated atmospheric composition capability for air quality, weather, S2S, and climate predictions.

Deliverables:

- Build NASA/NOAA repository for next-generation UFS aerosol forecasting
- Develop NASA/NOAA 2nd-generation **GOCART** model that connects NASA GOCART & GEFS-Aerosol
- Include aerosol-radiation interactions in GEFS-Aerosol
- Develop **global emissions** processing system
- Provide **biomass burning** and **dust emissions** out to S2S timescales
- Develop quality control and bias correction procedures for **AOD observations** used in data assimilation

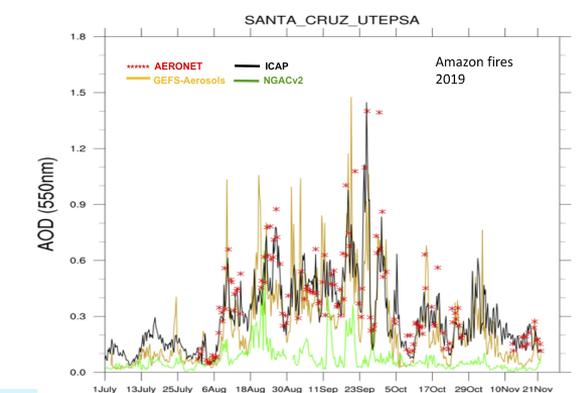
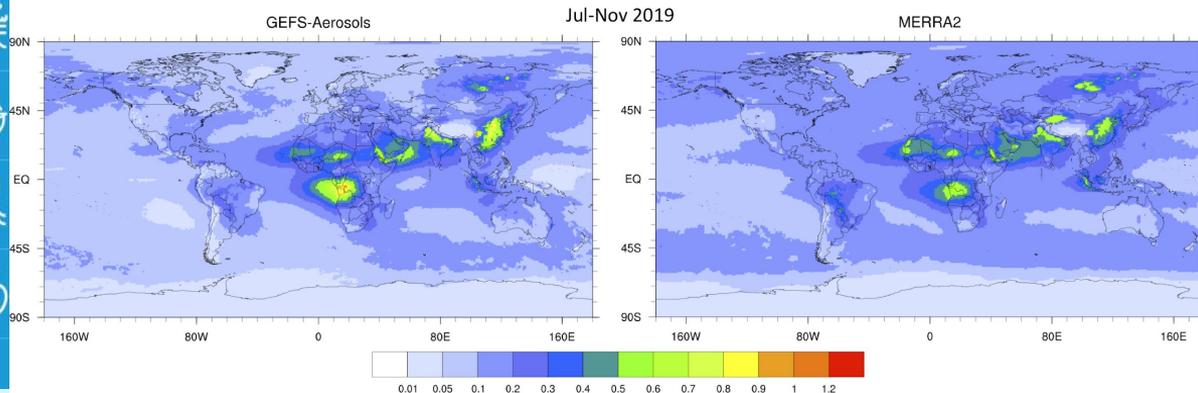


MRW/S2S: Atmospheric Composition

Early Results and Community Engagement



- NASA/NOAA joint repository with common GOCART codes
- Testing NASA/NOAA 2nd-generation GOCART model
- Testing CCPP FV3GFS-Aerosol
- Evaluating impact of aerosol-radiation interactions on S2S scales
- Emissions processing system in development, evaluating model responses to different anthropogenic inputs
- Evaluating biomass burning and dust emissions in S2S simulations
- Comparing VIIRS aerosol optical depth retrievals vs. AERONET observations to establish biases & observation errors for DA
- Evaluating modeled vertical distribution and chemical speciation predictions vs. aircraft observations
- Engaging UFS community through biweekly meetings, conference presentations, training session
- **Kate Zhang will present GEFS-Aerosol at UFS Webinar on Jan 28:** <https://ufsccommunity.org/ufs-webinar-series/>





Short-Range Weather/CAM Applications

- **Rapid Refresh Forecast System and Legacy Model Retirement (4 minutes)**
Curtis Alexander, OAR/GSL
- **3D-RTMA/URMA (2 minutes)**
Jacob Carley, NWS/EMC
- **Hurricane Analysis and Forecast System (HAFS) (2 minutes)**
Xuejin Zhang, OAR/AOML



SRW/CAM: RRFs and Legacy Model Retirement

Overview



Team:

Leads: **Curtis Alexander** (GSL), **Jacob Carley** (EMC)

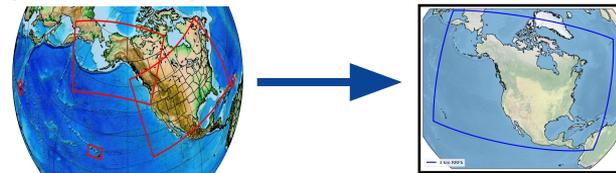
Investigators: Jamie Wolff (DTC/NCAR), Jeff Beck (DTC/GSL), Kimberly Hoogewind (NSSL), Xuguang Wang (OU-MAP), Ming Xue (OU-CAPS)

Scope and Benefits:

- Develop a new unified deterministic and ensemble storm-scale system called the **Rapid Refresh Forecast System (RRFS)**
- Evaluate RRFS to replace **NAMnests, HRRR, HiResWindows, HREF, NAM, RAP**
- Calibrate and evaluate GFS/GEFS for **NAM/RAP/SREF retirement**
- Advance data assimilation from GSI to JEDI
- Consolidate regional model suite resources for large North American storm-scale domain

Deliverables:

- HREFv3 operational implementation
- FV3 Limited Area Model (LAM) dynamics/physics baseline configuration
- Stochastic and mixed-physics ensemble design
- Unified workflow for development and operations
- JEDI transition
- GOES-16 all-sky radiance assimilation
- Machine learning approach for GEFS bias correction
- Optimization and evaluation of RRFS and CAM ensembles through day 3 using METplus scorecards
- Expanded comprehensive, consistent domain



- **RRFS implementation: ~FY23**



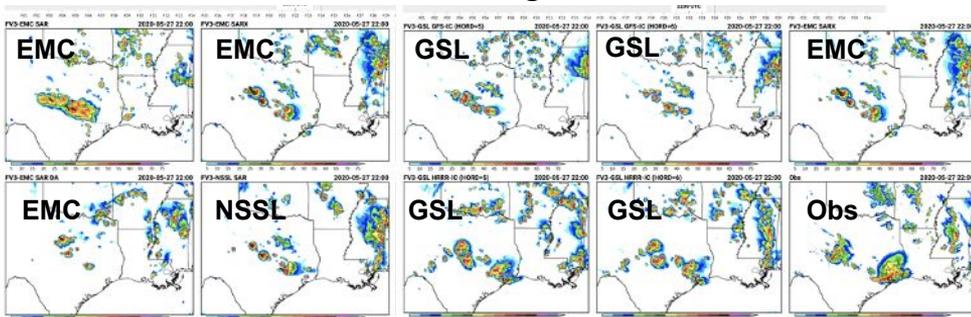
SRW/CAM: RRFs and Legacy Model Retirement

Early Results and Community Engagement



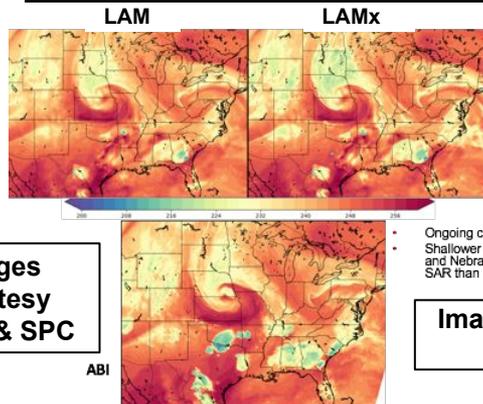
2020 Hazardous Weather Testbed Spring Experiment

FV3 LAM 3-km Configuration Evaluations



Images courtesy NSSL & SPC

FV3 LAM GOES ABI Comparison



On this case, deep convection has similar BT in SAR and SARx. Shallower clouds (e.g., South Dakota and Nebraska) again have cooler BT in SARx.

Ongoing convection not well initialized. Shallower clouds (e.g., South Dakota and Nebraska) have BT more similar to SAR than SARx.

Images courtesy OU-MAP

SRW/CAM Application Community Release (Mid-Feb '21)

Documentation

FV3-LAM/SRW App.
(FV3-Linked App Model) (Short Range Weather Application)

(Previously known as FV3SAR)

Changelog: June, 2021

Search: Preparation/Notes

Engineering and Deployment in Branch 003

NOAA/CI/CI/CI/CI/CI

August 19, 2020

User Support

UFS USERS' SUPPORT FORUMS

Forums

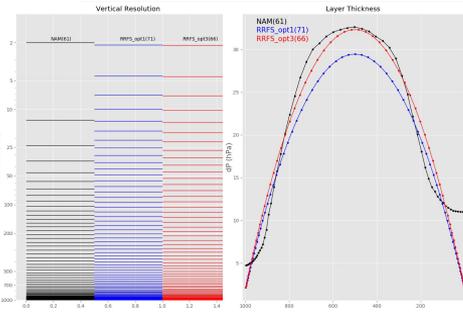
Labels Forum Topics

Platform Support

- Level 1: Preconfigured platforms**
 - Prerequisites and libraries installed
 - Workflow & model build/run out of the box
 - Comprehensive testing before release
 - NCAR Cheyenne (Intel & GNU)
 - NOAA Hera, Jet, WCOSS Cray and Dell (Intel)
 - NIST Orion (Intel)
- Level 2: Configurable platforms**
 - Prerequisites and libraries expected to install
 - Workflow and model expected to build/run
 - Comprehensive testing before release
 - Odin (Intel)
 - TACC Stampede (Intel)
- Level 3: Limited-test platforms**
 - Prerequisites and libraries expected to install
 - Workflow and model should build and run
 - Limited testing
 - macOS
 - Ubuntu
 - RedHat
- Level 4: Build-only platforms**
 - Prerequisites and libraries expected to install
 - Workflow and model should build
 - Very limited tests of running the model
 - All generic platforms with GNU
 - Pre-configured AMIs on AWS

Images courtesy EMC/DTC

RRFs Vertical Level Baseline



Images courtesy EMC

- 2 mb top
- ~8 m AGL bottom
- More than 65 levels

Enhanced vertical resolution compared to NAM/HRRR



SRW/CAM: RRFs and Legacy Model Retirement

Early Results and Community Engagement



Code Retirement

- NCEP has accumulated significant backlog of legacy modeling systems
- NWS is beginning the process of deliberate retirement of forecast models and downstream forecast products
- UFS R20 is funded to begin with regional systems, and develop a code retirement process that can be adapted for other systems.
- UFS R20 [website](#) will provide updates
- Coordination and communication with the field: planning, requirements, test cases, evaluation
- Finalized NCEP production suite simplification [plan](#)
 - Wave ensemble and NGAC merged with GFSv12, global wave merged with GFSv16
 - Plan to merge HiResW/NAM Nests/RAP/HRRR capabilities with RRFs (Q2FY23)
 - Plan to merge SREF and NAM capabilities with GFSv17/GEFSv13 (Q2FY24)

SRW/CAM Public Release

- Development system release, planned for February 2021 ([SRW Application 1.0 Public release](#))
- RRFs - ensemble-based CAM (~3km): FV3 Dynamic Core: CCPP based physics, JEDI based Data Assimilation



SRW/CAM: 3D-RTMA/URMA

Overview



Team:

Leads: **Jacob Carley** (EMC), **Manuel Pondeca** (IMSG and EMC), **Curtis Alexander** (GSL)

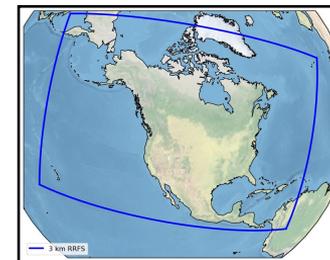
Scope and Benefits:

2D → 3D-RTMA/URMA

- Real time, rapid updated analysis of 3D atmospheric fields
 - **Severe and aviation weather parameters**
 - **Analysis of hydrometeor and cloud fields**
 - **Assimilation of radar observations**
 - **Heavy rainfall, etc.**
- 15 min updates
- Low latency

Deliverables:

- **3D RTMA/URMA that replaces 2D RTMA/URMA**
- **15 min updates with low latency**
- Highly efficient, multigrid background error
- Flow dependent analysis increments through use of RRFS ensemble
- More comprehensive, consistent coverage through expanded domain



- Improved observation quality control
- Improved analysis, especially in complex terrain
- **Implementation: ~FY23**



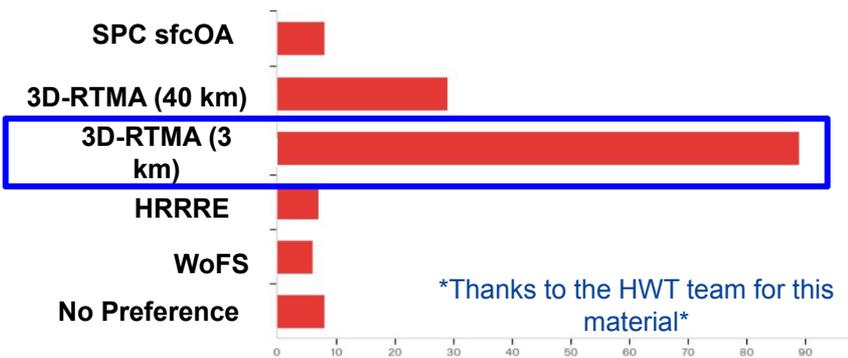
SRW/CAM: 3D-RTMA/URMA

Early Results and Community Engagement

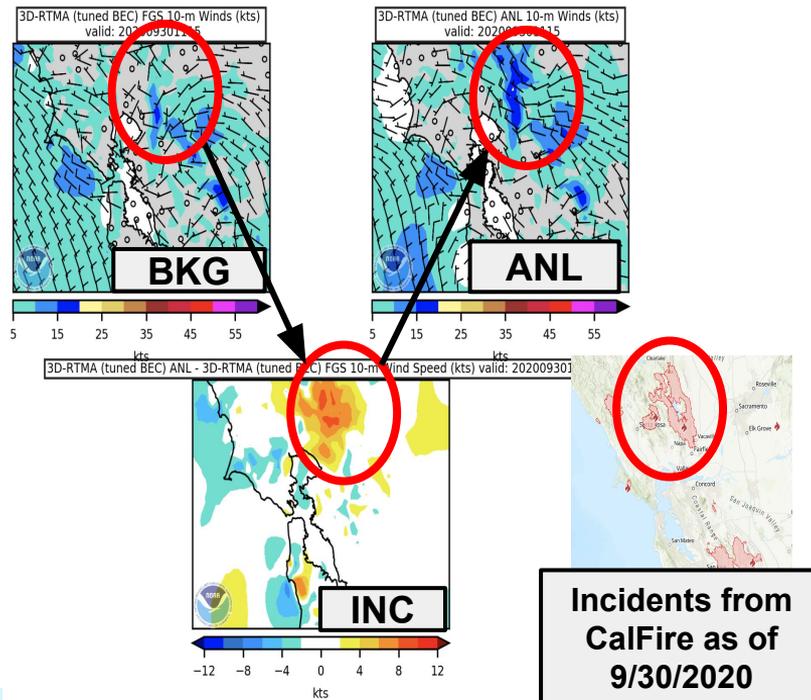


2019 Hazardous Weather Testbed

- High resolution 3D-RTMA was rated highest quality of all analyses during the Hazardous Weather Testbed (HWT) (~90 ratings)



Real Time Example: Fall 2020 CA Wildfires





CAM/Hurricane: HAFS Overview



Team:

Leads: Avichal Mehra (EMC), Xuejin Zhang (AOML)

Investigators: Frank Marks (AOML), S. Gopalakrishnan (AOML), Altug Aksoy (CIMAS), Jonathan Poterjoy (UMD), and Xuguang Wang (OU)

Scope and Benefits:

Upgrade and maintain the operational hurricane models (HWRF and HMON), and develop the **Hurricane Analysis and Forecast System (HAFS) data assimilation**, including TC initialization, atmosphere and ocean coupling, physics upgrades, telescopic moving nests.

- Reduce Tropical Cyclone (TC) forecast guidance errors, including during RI, by 50% from 2017
- Produce 7-day forecast guidance as good as the 2017 5-day
- Improve guidance on pre-formation disturbances, including genesis timing, and track and intensity forecasts, by 20% from 2017
- Improve hazard guidance and risk communication, based on social and behavioral science, for actionable lead-times for storm surge and all other threats

Deliverables:

Transition HWRF and HMON for operational implementation (10/09/2020)

Complete HFIP HAFS real-time demo (10/31/2021)

HAFS developments (with leveraging of Disaster Supplemental support):

- Workflow
- Coupling
- Preprocessing
- Physics developments
- HAFS initialization/DA
- FY22 initial implementation

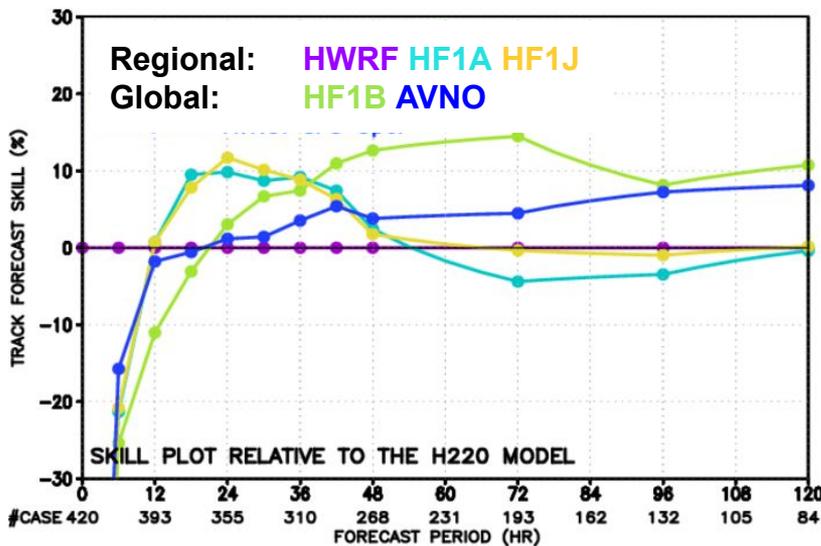


CAM/Hurricane: HAFS

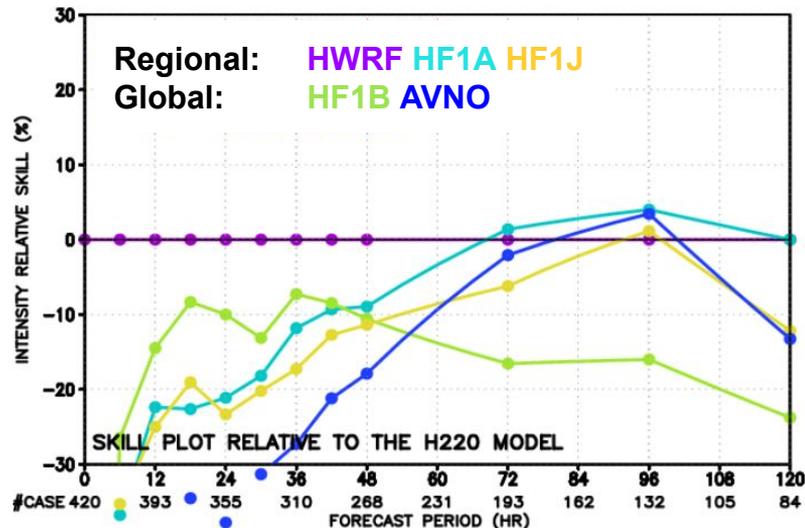
Early Results and Community Engagement



Track forecast skill



Intensity Forecast skill



Ongoing Development and Implementation

- Multiple scale data assimilation
- Telescopic, single and multiple moving nests
- Ocean coupling
- Physics improvement
- Workflow expansion

Community Engagement

- Shift to HAFS!
- Model development is on GitHub [ufs-hafs-model](https://github.com/ufs-hafs-model).
- Community infrastructure developments (FMS, NUOPC, CCM3, CMEPS, CDEPS, JEDI) are leveraged.



Cross-cutting Infrastructure (CCI) Team

- **Modeling Infrastructure (3 minutes)**
Rocky Dunlap, NCAR
- **Verification and Post-Processing (3 minutes)**
Tara Jensen, NCAR and DTC
- **UFS Support at DTC (2 minutes)**
Ligia Bernardet, OAR/GSL and DTC



CCI: Modeling Infrastructure Overview



Team:

Leads: Rocky Dunlap (NCAR), Arun Chawla (EMC)

Investigators: Mike Ek (NCAR/DTC), Louisa Nance (NCAR/DTC), Ligia Bernardet (NOAA/GSL/DTC)

Scope and Benefits:

Develop modeling infrastructure capabilities that provide core functionality across UFS applications.

- Flexible coupling infrastructure based on ESMF/NUOPC for assembling UFS applications from component models
- Support physics innovation and evaluation through the Common Community Physics Package (CCPP) and the Single Column Model (SCM)
- Unified component model/data assimilation interface
- Coupled model profiling and optimization
- Application support for the MRW and HAFS
- Coordination of UFS workflows

Use of community-based modeling infrastructure promotes broader participation of the research community in UFS modeling activities.

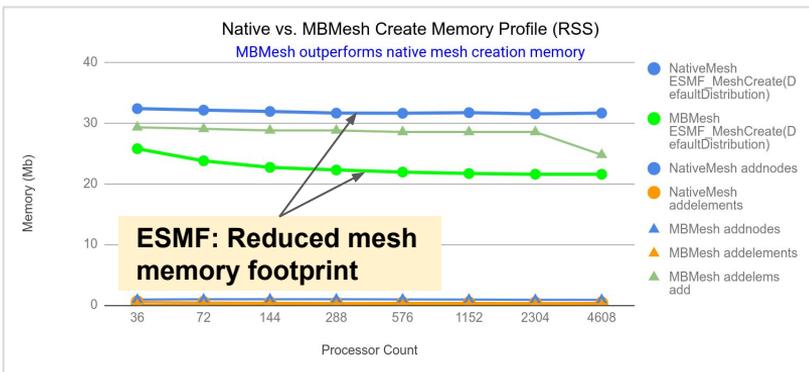
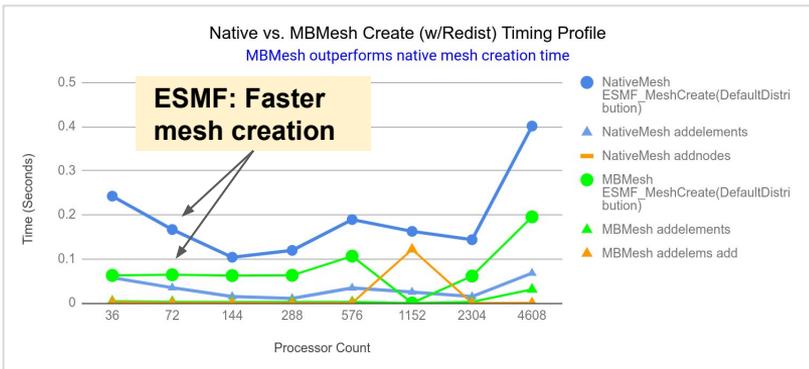
Deliverables:

- CCpp/SCM v4.1 and v5.0 releases (Q2FY21)
- ESMF v8.1 release (Q2FY21)
- Consistent JEDI/UFS build system (Q2FY21)
- Performance profiles collected for S2S (Q2FY21)
- JEDI-NUOPC generic interface implemented and documented (Q3FY21)
- Optimized S2S coupled model (Q3FY21)
- Transition MRW/S2S to CMEPS Mediator and retire NEMS Mediator (Q4FY21)
- HAFS code governance, regression testing, workflow (Q3FY21)
- MRW release support and User's Workshop



CCI: Modeling Infrastructure

Early Results and Community Engagement



Figures courtesy Ryan O'Kuinghtons/NCAR and Bob Oehmke/NCAR

Learn about and contribute to modeling infrastructure software supporting the UFS!

- CMEPS Mediator implemented in S2S prototype 5 and NEMS Mediator deprecated ([GitHub](#), [Docs](#))
- ESMF v8.1 Release Development & Support
 - Progress in integrating new internal mesh library (MOAB) with reduced mesh creation times and smaller memory footprint (see [all planned release items](#))
 - Visit [ESMF on GitHub](#) + [Tutorial Videos](#)
- Release of [Common Community Physics Package + Single Column Model \(v4.1\)](#)
- JEDI can now drive a UFS forecast through the top-level *unified* NUOPC Driver; one atmospheric export field exposed



CCI: Verification and Post-Processing Overview



Team:

Leads: **Jason Levit** (NOAA/EMC), **Tom Hamill** (NOAA/PSL)

Investigators: Tara Jensen (NCAR/RAL and DTC), Bonny Strong (NOAA/GSL and DTC), Jason Otkin (UW CIMSS)

Scope and Benefits:

Creation of community software for verification and evaluation of UFS modeling systems targeted for real-time operations

- Enhancement of METplus, a community verification and diagnostics framework, to evaluate the UFS
- Inclusion of more process-oriented diagnostics
- METplus used to evaluate upcoming NWS model implementations
- Tools for cloud-computing for analysis available to UFS community

Deliverables:

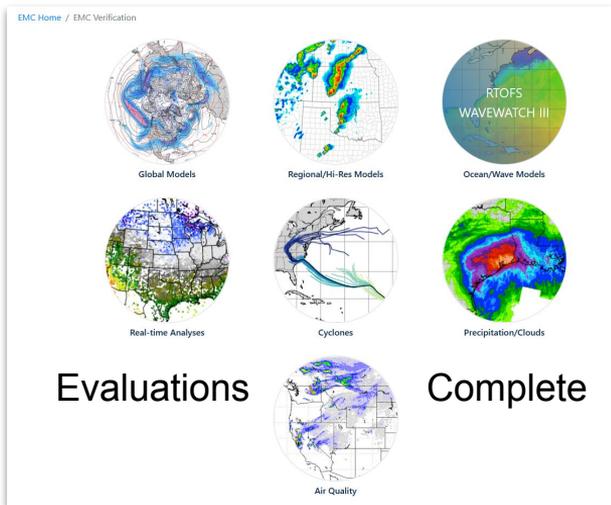
- Evaluate (a) HRWF v13/HMON v3, (b) GEFS v12, (c) RTOFS v2, (d) NWPS v1.3, (e) HREF v3, and (f) GFS v16
- Host a Metrics Workshop to define key metrics and priorities

METplus enhancements:

- Metrics to evaluate coupled systems, and each component (leveraging other projects)
- Include process-oriented diagnostics (leveraging several other projects)
- Support for drawing data from multiple databases on different platforms
- Include verification scorecard reduction and synthesis capability



CCI: Verification and Post-Processing Early Results and Community Engagement



In Progress

- Metrics: For Limited Area and Global Ensemble, Marine and Cryosphere, Tropical, and S2S applications
- Process-Oriented Diagnostics to evaluate: Temperature, SST, Cloud Cover and Precipitation, Teleconnections Processes (e.g. ENSO, MJO, etc.)
- Working to set up an Amazon Web Service (AWS) Machine Image (AMI) for community analysis and evaluation of UFS prototypes available on the NOAA Big Data Program

2021 DTC UFS EVALUATION METRICS WORKSHOP | REGISTRATION



FEB 22 - 24 2021

View Edit Test Results Outline Delete Revisions

The 2021 DTC UFS Metrics Workshop needs as much Community Input as possible to make sure we are all included in prioritizing the evaluation and diagnostics measures to be use for assessing the UFS. The workshop will be a 3-day event that includes a motivational Plenary Session on the first day and then significant time spent in Break-Out sessions to define the prioritized fields, sources of "truth", temporal and spatial attributes, and ultimately the metrics. Please register to join us for this very important process.

ABOUT

Registration
Pre-Workshop Survey 2
Pre-Workshop Survey 1
Sign-up For Updates

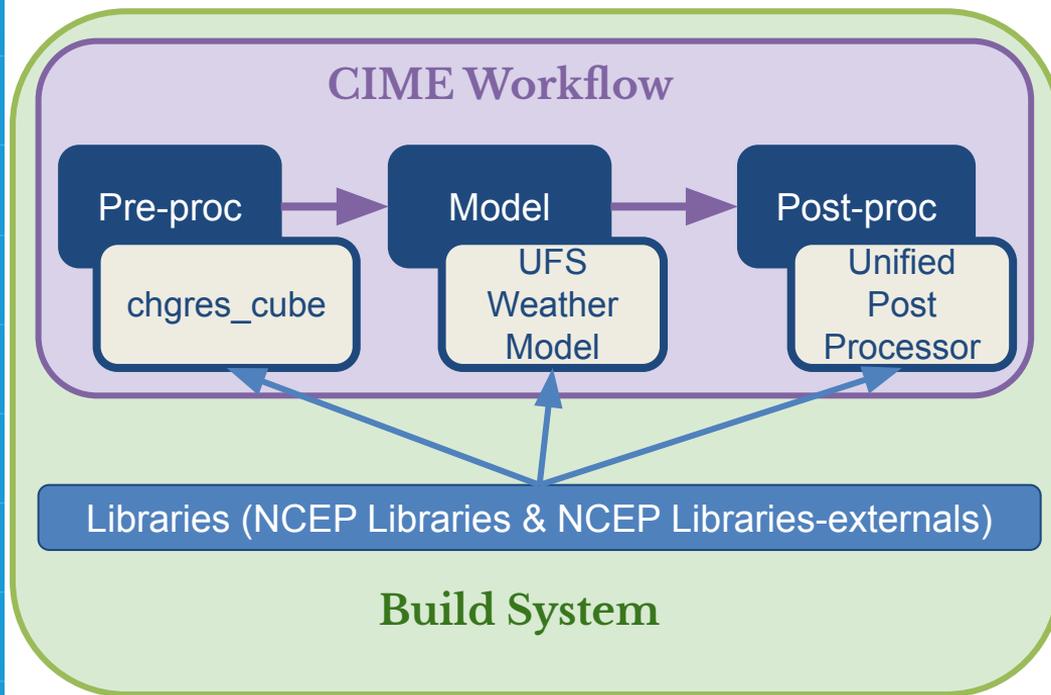
DTC 2021 UFS Metrics Workshop - Feb 22-24, 2021
Registration open - Pre-workshop Survey 2 of 3 open
[https://dtcenter.org/events/2021/
2021-dtc-ufs-evaluation-metrics-workshop](https://dtcenter.org/events/2021/2021-dtc-ufs-evaluation-metrics-workshop)



UFS Medium-Range Weather App Public Release (v1.0 in March 2020; v1.1 October 2020)



Developmental Testbed Center



- **Get the code**
 - <https://ufscommunity.org/science/code/>
- **User's Guide and documentation**
 - (<https://ufs-mrweather-app.readthedocs.io/en/ufs-v1.1.0/>)
- **Access the training (Nov 2020)**
 - <https://dtcenter.org/events/2020/unified-fore-cast-system-ufs-medium-range-weather-mr-w-application-users-training/agenda>
- **Visit the Forum**
 - <http://forums.ufscommunity.org>
- **Take the Graduate Student Test**
 - <https://ufscommunity.org/science/gst/>
- **Access case studies**
 - <https://ufs-case-studies.readthedocs.io/en/develop/>



Other Activities in UFS Support at DTC



UFS User's Workshop



- **1st Workshop July 2020**

- Nearly **500 attendees**. Over 46% of the participants were not affiliated with NOAA, with a strong showing from the academic community (approximately 25%) representing over **44 different academic institutions**. The **private sector** was the third largest contingent comprising almost 10% of the registrants.

- **2nd Workshop July 2021**

- See upcoming announcement at www.dtcenter.org

Upcoming UFS Public Release

- **UFS Short-Range App release planned for February 2021**





How to Engage with the UFS-R20 Teams?

UFS-R20 Web Site

<https://vlab.ncep.noaa.gov/web/ufs-r2o>

Dorothy Koch

NOAA/NWS/OSTI-Modeling





UFS-R20 Team: POCs



Project Leads: Jeff Whitaker (jeffrey.s.Whitaker@noaa.gov); Vijay Tallapragada (Vijay.Tallapragada@noaa.gov); Jim Kinter (ikinter@gmu.edu)

Model Infrastructure Leads

Rocky Dunlap (dunlap@ucar.edu)
Aun Chawla (Arun.Chawla@noaa.gov)

Verification & Post-processing Leads

Tara Jensen (jensen@ucar.edu)
Jason Levit (jason.levit@noaa.gov)

SRW/CAM Application Leads

RRFS: Curtis Alexander (curtis.alexander@noaa.gov)
3DRTMA: Jacob Carley (jacob.carley@noaa.gov)
HAFS: Xuejin Zhang (xuejin.zhang@noaa.gov)

MRW/S2S Application Leads

Cristiana Stan (cstan@gmu.edu)
Fanglin Yang (Fanglin.Yang@noaa.gov)

Coupled Model Lead

Avichal Mehra (Avichal.Mehra@noaa.gov)

DA, Reanalysis & Reforecast Lead

Daryl Kleist (daryl.kleist@noaa.gov)

Physics Lead

Jian-Wen Bao (jian-wen.bao@noaa.gov)

Atmospheric Composition Lead

Gregory Frost (gregory.j.frost@noaa.gov)



How to Engage with the UFS-R20 Teams

- Project website: <https://vlab.ncep.noaa.gov/web/ufs-r2o>
- For specific interests contact Project/Team Leads (previous slide)
- For sustained collaborations with the UFS R20 Project on the **developing** systems, partners are encouraged to:
 - Evaluate UFS-R20 Data on the Cloud (see **UFS R20 website**)
 - **UFS S2S prototype run on AWS**
 - GEFSv12 analysis and forecasts on AWS
 - GFSv16 Initial conditions on AWS
 - Contribute to UFS development code on Github
 - <https://github.com/ufs-community/ufs-weather-model>
- For **supported and tested** system, the publicly released MRW/S2S v1.1 system is best (https://ufscommunity.org/news/medrangeweatherapp_v1p1/)



Upcoming UFS Meetings & Events



- **Bi-Weekly UFS Webinar Series**

(<https://ufscommunity.org>, recordings and slides, Contact: Yan.Xue@noaa.gov)

- **AMS UFS special session (was Monday)**

- 11th Conference on Transition of Research to Operations - Advancing NOAA's Unified Forecasting System (UFS) as a Community-Based Modeling System for Research and Operations, Parts 1 & 2 (Jan 11)

- **UFS Evaluation Metrics Workshop (Feb 22-24, 2021; <https://dtcenter.org>)**

Contacts: Tara Jensen (jensen@ucar.edu), Geoff Manikin (geoffrey.manikin@noaa.gov)

- Survey 1 (community inputs on [fields](#), [indices](#))
- Survey 2 (community inputs on [levels](#), [accumulation intervals](#), [output frequency](#), [validation data sets](#))
- Survey 3 (community inputs on [statistics](#), [process-level diagnostics](#), [obs/analyses](#),)

- **Land modeling workshop (Spring 2021)**

- Strategy and partnerships for UFS and NOAA's next generation land modeling system
- Contact: Maoyi Huang (Maoyi.Huang@noaa.gov)



“Leveraged” NOAA Funded Projects

- **NWS University Grant Projects**
 - NGGPS, Weeks 3-4, HFIP
- **OAR University Grant and Lab Projects**
 - WPO/JTTI
 - WPO/S2S, WPO/CTB
 - GFDL, PSL, GSL, CSL, AMOL, PMEL
- **Disaster Supplemental Projects**
 - **FY18/IFAA:** Physics, Hurricane modeling, SAR & FV3-CAM, Infrastructure, DA/JEDI, and observation processing
 - **FY19/DSAP:** Hurricane modeling, RRFS on cloud, wildfire smoke, and satellite products for fire and smoke



Future Plans for UFS-R20 Project

- **Community and cloud, expand partnerships for:**
 - **Development & simulation**
 - **Model evaluation**
- **Strengthen forecaster engagement:**
 - **Model developments driven by forecaster needs**
 - **Partner on code retirement plans and process**
- **Phase 2 (2022-2025?):**
 - **Broaden NOAA engagement**
 - **Include new applications**
- **Strengthen interagency partnerships**



Questions?



For more information:

- **UFS-R20 Project:** <https://vlab.ncep.noaa.gov/web/ufs-r2o>
 - Dorothy Koch (NWS STI) dorothy.koch@noaa.gov
 - Vijay Tallapragada (NWS EMC) vijay.tallapragada@noaa.gov
- **UFS:** <https://ufscommunity.org/>
 - Hendrik Tolman (NWS STI) hendrik.tolman@noaa.gov
 - Ricky Rood (U-Michigan) rbrood@umich.edu