

## UFS-R2O Project Priorities for Year 3 (July 2022 - June 2023)

Description	Level/Plus Up	Continued vs. New
<b>MRW S2S</b>		
<b>Data Assimilation/Reanalysis Reforecasts:</b>		
Complete and evaluate low-resolution 3D-Var 'scout run' 30 year reanalysis (PSL)	Level	Continued
Generate C384 coupled initial conditions for 30-year reanalysis period by 'replaying' prototype 8 UFS model configuration to ERA5/ORAS5. Investigate strategies for generating ensemble perturbations to these initial conditions so that they may be used to initialize GEFSv13 reforecasts if reanalysis cannot be produced in time due to lack of resources (PSL, EMC) - this will require an extra 2 FTE	Plus Up Required	New
Define final configuration for higher resolution, ensemble-based coupled reanalysis, begin production in Q4 (PSL, JCSDA, EMC)	Level	Continued
Define final science configuration for GFSv17/GEFSv13 data assimilation system (PSL, EMC).	Level	Continued
JEDI-based prototype for all components in GDAS (atmosphere, sea-ice land and ocean). (PSL, JCSDA, EMC)	Plus up required	Continued
Begin comparing solver algorithms in JEDI (ensemble-variational, 4DVar etc). (EMC)	Level	Continued
Continue to integrate observation processing reengineering (FY18 DRAS component is ending soon, needs to be continued at EMC) -- this will require 2 additional FTEs	Plus Up Required	New to R2O (previously DRAS-funded)
Development efforts shift to improved use of observations (all-sky/all-surface radiances, commercial data), coupled observation operators, use of cross-component background-error covariances. (PSL for cross-component error covariances and coupled ob operators, EMC for the rest)	Level	Continued
Evaluate strategies to properly represent and initialize diurnal SST and near-surface SST in the coupled model and data assimilation system (PSL/EMC).	Level	Continued
<b>Coupled Model Development:</b>		
Define final configuration for GFSv17/GEFSv13 coupled model, deterministic (EMC, PSL)	level	continued
Define final configuration for GFSv17/GEFSv13 coupled model, stochastic (EMC, PSL)	level	continued
Investigate coupling strategy for high-res MRW application to maximize forecast skills (EMC)	Plus up	New
Begin development of initial prototypes for seasonal forecast system that will inform configuration of SFSv1. (EMC, PSL (for ensemble component), GMU)	Plus up	New
Evaluate performance of final GFSv17/GEFSv13, determine development priorities for next upgrade. (EMC, GMU)	level	continued
Improving the land model for all UFS applications across different spatiotemporal scales (EMC, GMU, GSL, NCAR)	Level (or Plus Up in s	continued
<b>Atmospheric Composition:</b>		
Test and evaluate composition coupling with radiation and microphysics.(GSL, EMC; in strong collaboration with physics subproject)	Plus up	Continued
Enhance accuracy and timeliness of aerosol and precursor emissions and distributions (ARL, GSL, STAR)	Level	Continued
Atmospheric composition model integration, testing and evaluation (EMC, CSL, ARL)	Plus up	Continued
AOD assimilation (EMC, JCSDA, GSL; in strong collaboration with DA subproject)	Plus up	New
RRFS-CMAQ development for RRFSv2 (EMC, ARL, GSL, CSL, PSL)	Plus up	New - Previously WF-1 DSUP funded
Prepare for constraints of aerosol and trace gas distributions from additional satellite data (e.g. TROPOMI, TEMPO, PACE)	Plus up	New - Some previous WF-1 DSUP funding
<b>Atmospheric Physics:</b>		
Finalize configurations for operations		
Finalize the configuration of the GFSv17/GEFSv13 deterministic physics suite, evaluate performance, identify development priorities for next upgrade. (EMC, PSL, GSL, NRL, DTC)	Level	Continued



Finalize the configuration of the RRFSv1 deterministic physics suite, evaluate performance, identify development priorities for implementation. (EMC, PSL, GSL, NRL, DTC)	Plus up	New
Continue development, test, and evaluation of microphysics, shallow convection, PBL, gravity wave, radiation processes for the next upgrade of all UFS applications. (EMC, PSL, GSL, DTC)	Level	Continued
Testing and evaluating physics coupled with DA systems	Plus up	New
<b>Scale-adaptive unified physics</b>		
a. Begin formal investigation/development of the use of convective parameterizations in RRFS, and develop convective parameterizations for global (GFS) grayzone resolutions (1-10km) (EMC, GSL,PSL).	Plus up	New
b. Develop, test, and evaluate unified physics for the UFS applications across different horizontal and vertical resolutions and forecast lengths, by: i) improving both spatial and temporal scale adaptations of physics parameterizations across all UFS applications. (EMC, PSL, GSL, NRL), ii) unifying processes (e.g avoid double counting of mass-flux computed in both shallow convection and turbulence schemes, processes leading to clouds) across parameterizations. (EMC, PSL, GSL), and iii) evaluating the unified physics in the UFS using hierarchical methods. (PSL, DTC)	Plus up	Continued
c. Continue development and testing of stochastic parameterizations (PSL,GSL).	Level	continued
<b>CAM/SRW</b>		
<b>3DRTMA:</b>		
Begin testing prototype 3DRTMA/3DURMA on the RRFS grid with scalable multigrid beta filter and automated QC package for surface and aircraft observations	Level	Continued
Connection to RRFS for background and ensemble fields	Level	New
Improve the background for 15, 30 and 45 minutes past the top of the hour	Level	New
Develop and integrate bias-correction algorithm for mesonet winds	Level	Continued
Encourage and respond to feedback from the NWS WFOs, Regional Centers, and Service Centers, perform additional DA tuning for fit to obs (obs QC, ob error, and bckg error tuning), seek smooth transition in analysis moving away from ob impact areas	Level	New
Add analysis of significant wave height, an RTMA operational parameter	Level	New
Incorporate the ability to estimate the analysis uncertainty in 3DRTMA/3DURMA		
Need to decrease run time and/or decide on acceptable latencies	Plus Up	Continued
Figure out how to get to NDFD 2.5km and 1.25 km grids for CONUS, AK, HI and PR	Level	Continued (downscaling)
Set up 3DRTMA/URMA for Guam	Level	New
<b>RRFS:</b>		
Continue JEDI transition work (RTMA+RRFS)	Level	Continued
Integration of RRFS smoke as follow-on on to DSUP-WF	Plus Up	New (previously WF1-3 DSUP funded)
Overlapping windows and spectral blending of global ensemble perturbations into ICs	Level	New
Tuning of the forecast ensemble including stochastic/mixed physics	Plus Up	Continued
Hybrid EnVar algorithm two-way re-centering testing and evaluation	Level	New
Establish end-to-end RRFS prototype in preparation for v1 implementation	Level	Continued
Continue RRFS forecast performance assessment as new development implemented	Level	Continues
Implement outcomes of metrics workshop ("tiers" of verification tasks) into SRW App to facilitate retirement efforts	Plus Up	New
Begin investigating and improving dynamics options in UFS at operational CAM resolutions. Specifically, seek solutions for marginally resolved convection, through improvement in dynamics-physics coupling and numerics/diffusion.	Plus Up	New
<b>Hurricane:</b>		



HFIP real-time experiments with multiple HAFS configurations for the 2022 season.	Level	Continue
IOC selection for HAFS v1 (with hybrid self-cycling DA for moving nests, finalized vortex initialization, calibrated HAFS physics for TC application, two way ocean-atm coupling, one-way wave coupling)	Level	New
Transition from NOAA to NOAA-MP, improve moving nest scalability and feedback scheme	Plus Up	New
HAFS evaluations (NHC, CPHC, JTWC basins), CONOPS	Level	Continue
Coupled Ocean-Wave-Atmosphere (Three-way); replace HYCOM with MOM6 in HAFS	Plus Up	New
Begin transition to mature JEDI modules for HAFS DA	Plus Up	New
Physics improvement and developments for Hurricanes (Explore GFDL-MP with AI technology; improvements in NOAA-MP LSM; improve convection schemes; uGWD parameterization tuning)	Plus Up	New
HAFS v1 transition to NCEP operations (Q3FY23)	Level	New
Transition some of Hurricane Supplemental supported development at AOML into operations (DRA 1A.4A, 3A.1, 3A.2, HU-2) (implementing DA methods, VI/VR, High-res physics, coupling techniques etc. into moving nest based HAFS for IOC)	Plus Up	New (previously funded by Hurricane Supplemental projects)
<b>CCI/Modeling, Verification&amp;Post-Processing, and Application Support:</b>		
<b>Tools to Support Efficient and Effective Modelling:</b>		
ESMF core infrastructure development, including releases, testing, porting, documentation, and user support.	Level	Continued
Address gaps in ESMF/NUOPC infrastructure to support operations needed for in-core coupled DA w/ JEDI: implement an in-memory "checkpointing" feature in ESMF/NUOPC that stores internal model state (physics and dynamics) and allows for resetting a model to a prior state at runtime, e.g., to reset forecast model state for 4dvar outer loop. Each coupled component needs to implement the checkpointing to allow for full coupled system "hot" (in-core) restart.	Level	Continued
Advance the CMEPS exchange grid to include additional surface flux computations beyond bulk atm-ocn fluxes	Level	Continued
Optimization and load balancing of MRW/S2S and HAFS at operational configurations and resolutions in preparation for implementations in FY23/24. Leverage detailed performance profiles collected under year 2 to determine sources of inefficiency.	Level	Continued
Implement a smoothing filter for combining ESMF Fields, such as blending forcing fields from file with a prognostic field in an active model. This is needed for HAFS coupling, but is also a general capability.	Plus Up	New
Advance UFS I/O infrastructure to support flexible model output, especially to reduce data volumes for upcoming UFS model evaluations:	Plus Up	New
Flexible output of atmosphere fields from the UFSATM write component on a per-field basis with different output frequencies, resolution, and domain subsetting (in the same run)	Plus Up	New
Make the UFSATM write component a separate NUOPC-compliant component to enable isolated testing (run standalone)	Plus Up	New
Larger project: unify I/O layers across all the coupled components, including a shared async I/O component	Plus Up	New
<b>Workflows</b>		
Develop a unified workflow infrastructure to support multiple applications for both research and operational environments	Plus Up	
At level funding, all code development will be reliant upon in-kind contributions from other sources	Level	
Maintain coordination efforts to inform and promote buy-in from application development teams	Level	Continue
Dedicated resources to develop generic toolsets, including project software engineer	Plus Up	New
Develop forecast-only prototypes for hurricane, regional, global configurations (applications currently sharing ufs-weather-model codebase, applications currently sharing the GSI code base, application currently evaluating JEDI components as replacements to the GSI)	Plus Up	New
Unit tests, documentation, CI/CD for different applications	Plus Up	New
Workflow testing on tier-1 [Cheyenne, RDHPCS, Orion, WCOSS], tier-2 [XSEDE], Cloud, linux workstations	Plus Up	New



Work with application teams to incorporate solutions into workflows	Plus Up	New
Interact and re-evaluate with NCO to integrate operational requirements into solutions and vice-versa	Plus Up	New
<b>CCPP</b>		
Code management and releases/community support for CCPP (Framework, Physics, and Single-Column Model, SCM)	Level	Continued
Requirements gathering and community visioning for future development of CCPP Framework	Level	New
Continuous synchronization and unification of the CCPP Framework between UFS and NCAR, as per the NOAA/NCAR MoA.	Level	Continued
Ability to compile the CCPP library in either single or double precision to explore improvements in computational performance.	Level	New
Increased number of CCPP physics schemes and suite(s) that can run on Graphical Processing Units (GPU).	Plus Up	New
Hardened CCPP Framework for use with GPUs.	Plus Up	New
Cap generator that enables a CCPP scheme/suite to run as a separate model component connected via the mediator or within the mediator itself, to facilitate flux computation on the exchange grid.	Plus Up	New
Extension of the CCPP Framework to simplify and reduce memory footprint of variables involved in the fractional landmask surface composites (that is, variables defined over land, water, and sea ice).	Plus Up	New
Continue to add/greatly expand the number of (CCPP) DEPHY-compliant (internationally-recognized format) SCM cases (e.g. now on the DTC website) available for Hierarchical System Development (HSD) testing.	Plus Up	New (previously funded by Hurricane Supplemental project ending mid-2022)
Further develop the Hierarchical System Development framework by hardening the CCPP SCM and UFS-LAM configurations to accept "Data Models" to replace "switched off" physics scheme(s).	Plus Up	New (previously funded by Hurricane Supplemental project ending mid-2022)
CCPP SCM verification: corresponding expanded METplus diagnostic capabilities to verify process-level SCM physics performance.	Plus Up	New
<b>Verification</b>		
NWS Field evaluation of HAFS v1 (Q1FY23)	Level	New
NWS Field evaluation of RRFS v1 (Q3FY23)	Level	New
NWS Field evaluation of 3D RTMA/URMA (Q1FY23)	Level	New
Integrate verification and evaluation methodologies into application workflows, utilizing components of the EMC Verification System (EVS)	Plus Up	New
Add remaining metrics to METplus as determined by 2021 Metrics Workshop and community priorities	Level	Continued
Optimize METviewer and METexpress database access to support more concurrent users	Level	Continued
Complete work for a federated database prototype, initially planned for year 2, but the federated database may potentially be replaced by implementation of full METplus suite in the AWS cloud during year 2.	Level	Continued
Work with EPIC to establish METplus on all 3 Cloud Service Providers if not done in year 2	Level	Continued
Establish strong connection with a UFS Observation Working Group or NOAA ICAMS observation service to drive requirements for additional verification sources	Plus Up	New
Integrate external packages like MDTF, MONET, etc... if not done in year 2	Plus Up	New
Analyze METplus performance on HPC and optimize algorithms if necessary	Plus Up	New
Test METplus on GPUs	Plus Up	New
Explore Jupyter Notebooks to reach the university community	Plus Up	New
Establish unified visualization capability	Plus Up	New
<b>Post-Processing: (all are plus-up over YR1/YR2 activities but need to be seriously considered)</b>		
Development of a Unified Ensemble Post Processing System (extension of the Unified Post Processor) to align ensemble post-processing methods and algorithms across all UFS applications	Plus Up	New
Development of a common statistical post processing/AI/ML software system to support calibration, bias correction, and other techniques to improve forecast skill.	Plus Up	New



Regular generation of supporting long time series of supporting data sets, reanalysis/reforecast.	Plus Up	New
Regular generation and updating of long time series of ground truth analyses for high impact variables, e.g., precipitation, surface temperature, surface wind. Used for calibration and validation.	Plus Up	New
Storage of reanalysis/reforecast/analysis data in convenient formats, e.g., netCDF, or cloud-preferred formats such as ZARR, ideally through NOAA's Big Data program.	Plus Up	New
<b>Application support</b>		
UFS user support and releases		
Provide UFS MRW App community support by answering questions on the forum [DTC]	Level	Continued
Provide UFS SRW App community support by answering questions on the forum [DTC]	Plus Up	New
Support EPIC and the larger community in preparing a UFS MRW App release [DTC]	Level	Continued
Support EPIC and the larger community in preparing a UFS SRW App release [DTC]	Plus Up	New
Annual UFS Users' Training		
Application(s) TBD [DTC]	Level (for one Applica Plus Up (for more tha	Continued
UFS Users' Workshop		
Host UFS Users' Workshop [DTC]	Plus Up	New
HAFS code management and user support		
Maintain HAFS scripts and workflow by conducting regression and consistency checks, as applicable [DTC]	Level	Continued
Provide HAFS community support by answering questions on the forum [DTC]	Level	Continued
Assist HAFS developers in creating and maintaining branches that contain their innovations in the HAFS code repository [DTC]	Level	Continued
Update/expanded documentation on using the HAFS workflow available to developers [DTC]	Level	Continued