EPIC Workshop

Running the Short-Range Weather App on the Cloud

UFS
UNIFIED FORECAST SYSTEM

Objective: I can use the Short-Range Weather Application to run, modify, and compare forecast outputs.

Jamiel Farhat - Technical Training Specialist - ?'s about EPIC

Dr. Neil Jacobs - Chief Science Advisor for the UFS - ?'s about UFS

Dr. Mark Potts - Lead Cloud Computing Engineer - ?'s about Accessing the Cloud

Dr. Jeff Beck and Dr. Gerard Ketefian - SRW App Developers - ?'s about the SRW App

UFS
UNIFIED FORECAST SYSTEM

How to use Slack

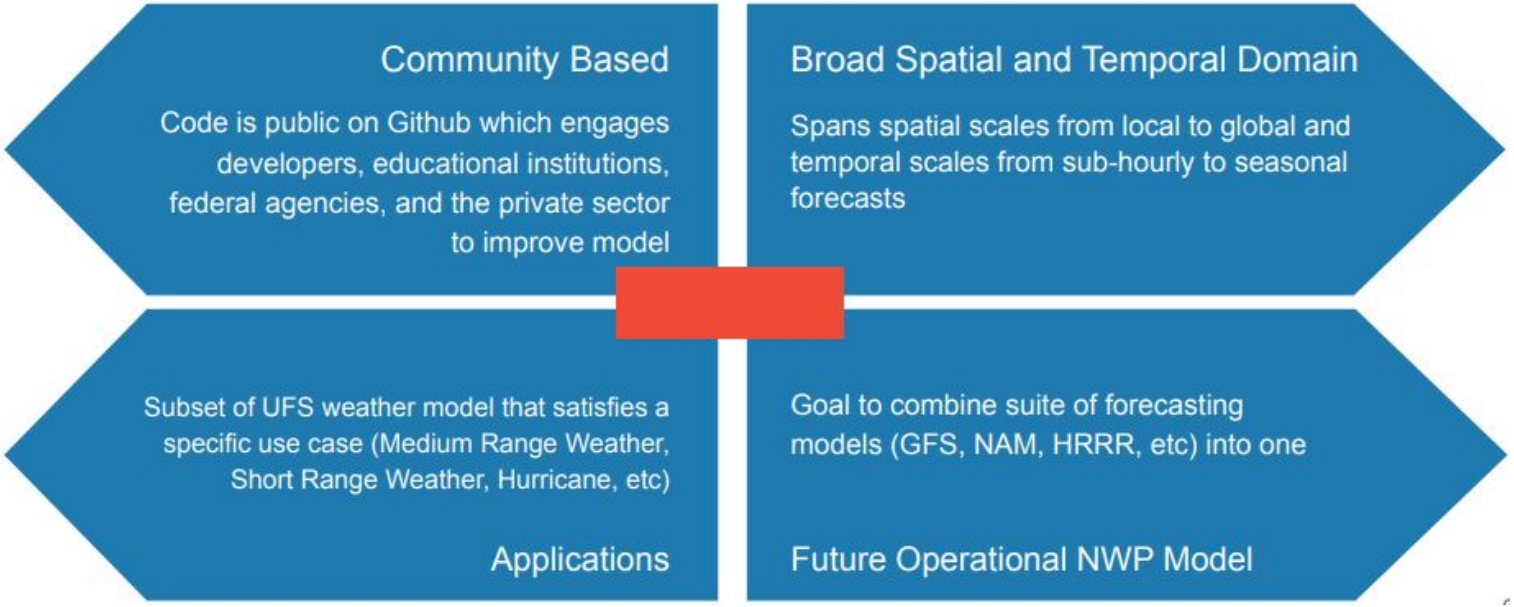
#ams-short-course-2022

If you have a question, pose it in this channel. Click “reply in thread” if answering a question.

If you have technical issues, the break out room is open for one-on-ones.

UFS
UNIFIED FORECAST SYSTEM

What is the Unified Forecast System (UFS)?



Overview of the Unified Forecast System Short-Range Weather (SRW) Application

Jeff Beck

Participating Organizations: EPIC, DTC, NOAA labs (GFDL, EMC, GSL, NSSL, GLERL), NCAR, CIRA, CIRES, CIWRO, others

Code Review Committee: EMC (Chan-Hoo Jeon, Ben Blake, Ratko Vasic), EPIC (Mark Potts, Jong Kim), GLERL/UM (David Wright), GSL (Jeff Beck, Gerard Ketefian, Linlin Pan, Christina Holt, Christopher Harrop, Daniel Abdi), NCAR (Mike Kavulich, Will Mayfield), NSSL (Yunheng Wang)

UFS Background

NOAA's numerical weather prediction (NWP) efforts have organized around a vision of a unified community-based modeling system, i.e. Unified Forecast System (UFS)

- Configurable for multiple applications across domains from global to regional to convection allowing (and ultimately cloud-resolving) forecasts
- Designed to be the source system for operational applications
- Applications are UFS configurations that support particular forecast requirements
- Each application can combine a numerical model, data assimilation, pre- and post-processing, a workflow, and other elements

SRW App:
Covers short-range weather & convection-allowing atmospheric phenomena from less than an hour to several days

UFS Short-Range Weather (SRW) Application

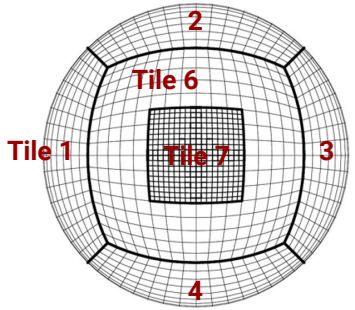
- Weather Model
  - Finite-Volume Cubed-Sphere Dynamical Core (FV3)
    - Limited Area Model (LAM) capability
  - Common Community Physics Package (CCPP)
- End-to-end Application
  - User-friendly build system that invokes CMake
  - Experiment generation with support for the Rocoto workflow manager
  - stand-alone scripts
  - Pre-processing, model execution, post-processing (official release), verification
  - Python scripts for basic graphics
- Comprehensive documentation
- User support forum: https://forums.ufscommunity.org/

SRW Application Features

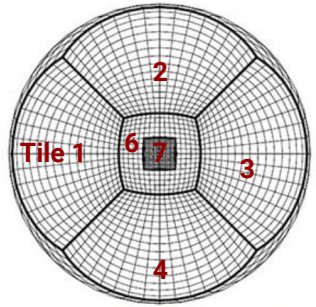
Background: global configuration

- FV3 = Finite Volume Cubed
- “Cubed” refers to the global cubed-sphere grid, where the sphere surface is projected onto the 6 faces (tiles) of a cube
- Uses a gnomonic projection, i.e. great circles serve as model coordinates
- Offers good grid uniformity: ratio of largest to smallest cell size is only √2 (if not using grid stretching/refinement)
- Allows for higher resolution (at a fixed horizontal location) via grid stretching (Schmidt transformation) and grid nesting (refinement), but must still run the forecast on a global domain

Uniform global grid



Stretched global grid



SRW Application Features

Regional (or LAM = Limited Area Model) Capability

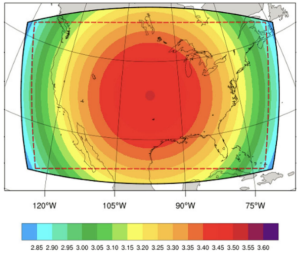
- Motivated by convection-allowing modeling applications needs
- Uses a single logically rectangular grid with lateral boundary conditions provided by an external model (e.g. FV3GFS, HRRR, RAP, NAM)
- Several predefined grids available in the SRW App. The following are supported in Version 2 of the App:
  - `RRFS_CONUS_25km`
  - `RRFS_CONUS_13km`
  - `RRFS_CONUS_3km`
- User may specify custom domains/grids

SRW Application Features

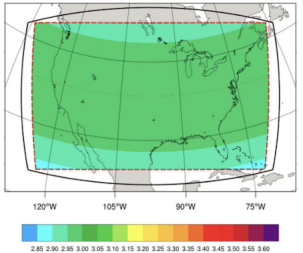
Regional (or LAM = Limited Area Model) Capability

- Two regional grid generation methods are available: "GFDLgrid" and "ESGgrid"
- "`GFDLgrid`":
  - Defines the regional grid with respect to a parent global cubed-sphere grid
  - Parent global grid covers the globe with 6 tiles
  - A 7th tile is created as a subregion of tile 6 and serves as regional grid; tiles 1 through 6 discarded before forecast is run
- "`ESGgrid`":
  - ESG = Extended Schmidt Gnomonic
  - More uniform regional grids than those generated via "GFDLgrid" method
  - Mathematical extension of Schmidt transformation to generate very uniform regional grids
- Most predefined grids in SRW App use the "ESGgrid" method

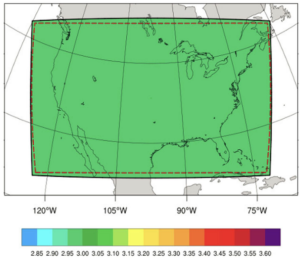
GFDL grid



HRRR grid
(Lambert Conf.)



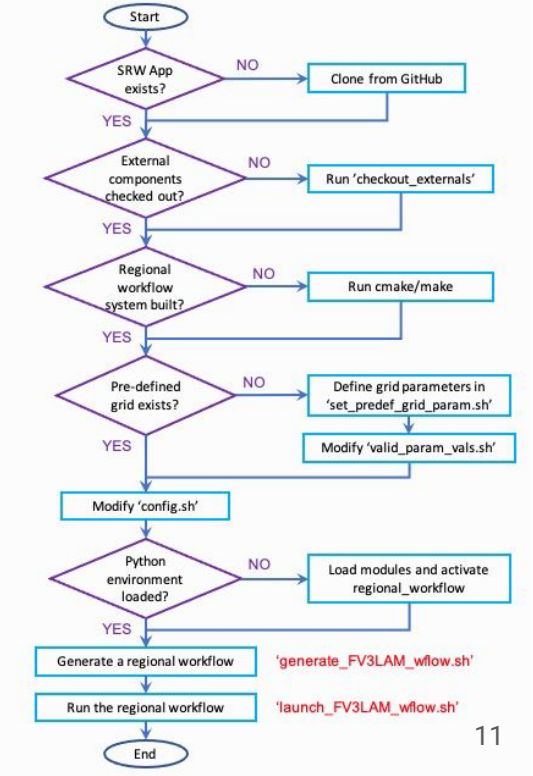
ESG grid



SRW Application Features

System Steps

- Build and compile
  - Umbrella CMake-based build system for all the code components to run the end-to-end SRW App workflow
- Create an experiment
  - Many customization options available
  - Script then builds configuration/namelists
- End-to-end execution with task management using Rocoto or stand-alone scripts
  - Pre-processing
  - Model execution
  - Post-processing using the Unified Post Processor
- Python scripts for basic graphics from UPP grib2 files



SRW Application Features

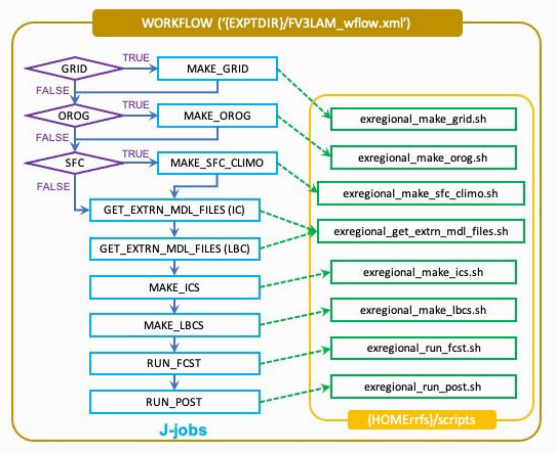
Workflow Tasks

Run once per expt (optional)

1. make_grid: Generates grid files
2. make_orog: Generates filtered orography files
3. make_sfc_climo: Generates surface climatology files (used if fields are not available in external model output)

Run once for each cycle

4. get_extrn_ics: Retrieves output files from the external model needed for generating ICs, surface fields, and the 0-th hour LBC
5. get_extrn_lbcs: Retrieves output files from the external model, needed for generating LBCs
6. make_ics: Creates ICs on the native FV3- LAM grid (including surface fields and the 0-th hour LBC)
7. make_lbcs: Creates LBCs for each boundary condition interval on the FV3-LAM grid
8. run_fcst: Runs a forecast (cycle) with the FV3-LAM
9. run_post: Processes write-component forecast output files through UPP generate grib2 files Run once per expt (optional) Run once for each cycle



SRW Application Features

Physics suites

- Four supported physics suites for SRW App v2 (available through CCPP)
- More available in develop branch

	GFS_v16	RRFS_v1beta	HRRR	WoFS_v0
Radiation (SW/LW)	RRTMG	RRTMG	RRTMG	RRTMG
Microphysics (MP)	GFDL	Thompson Aerosol Aware	Thompson Aerosol Aware	MP-2M (orig NSSL)
Boundary Layer (PBL)	TKE-EDMF	MYNN-EDMF	MYNN-EDMF	MYNN-EDMF
Surface Layer (SL)	GFS	MYNN	MYNN	MYNN
Gravity Wave Drag (GWD)	None	SSGWD/TOFD	SSGWD/TOFD	SSGWD/TOFD
Land Surface Model (LSM)	Noah	NoahMP	RUC	Noah
Deep Convection (DCU)	sa-SAS	None	None	None
Shallow Convection (SCU)	sa-MF	None	None	None
Lake Model (LM)	NSST	NSST	NSST	NSST

SRW Application Features - Code Repositories

Repository Description	Authoritative repository URL
Umbrella for the UFS SRW Weather App	https://github.com/ufs-community/ufs-srweather-app
Umbrella for the UFS Weather Model	https://github.com/ufs-community/ufs-weather-model
Regional Workflow	https://github.com/ufs-community/regional_workflow
Software Stack/Libraries	https://github.com/NOAA-EMC/hpc-stack
UFS Utilities	https://github.com/ufs-community/UFS_UTILS
Unified Post Processor	https://github.com/NOAA-EMC/EMC_post

All components are in public repositories on GitHub Posting of issues and submission of pull requests encouraged

Wiki pages on GitHub include helpful/getting started information

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, AWS and Google Cloud via Parallel Works
- MSU 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

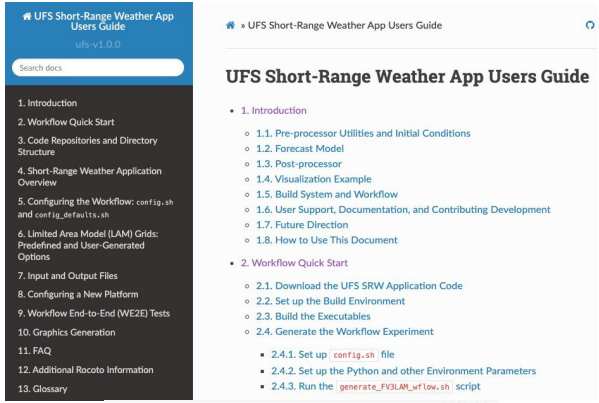
- macOS
- Ubuntu
- RedHat

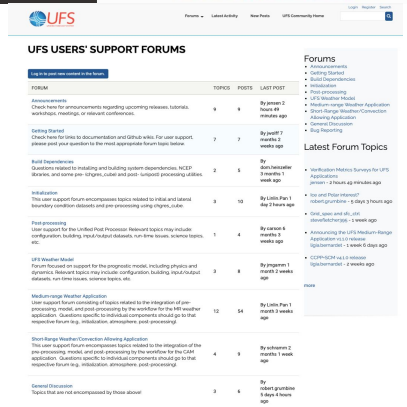
Level 4: Build-only platforms
- Prerequisites and libraries expected to install
- Workflow and model should build
- Very limited tests of running the model

- All generic platforms with GNU

User Support

- Documentation
  - SRW App User's Guide (UG): https://ufs-srweather-app.readthedocs.io/en/develop/
  - All components included:
    - UFS_UTILS, ufs-weather-model, FV3, CCPP, UPP, verification, visualization, etc.
- Forums
  - https://forums.ufscommunity.org
  - Participation from Subject Matter Experts (SMEs)
  - Build knowledge within the community

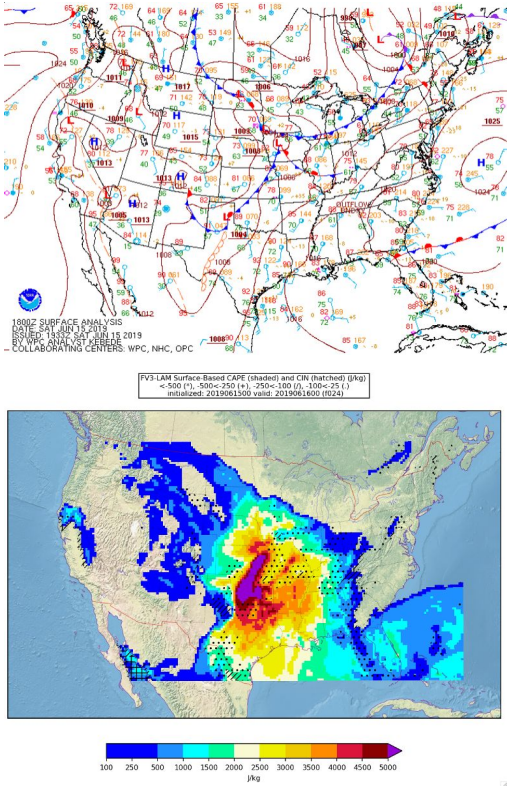




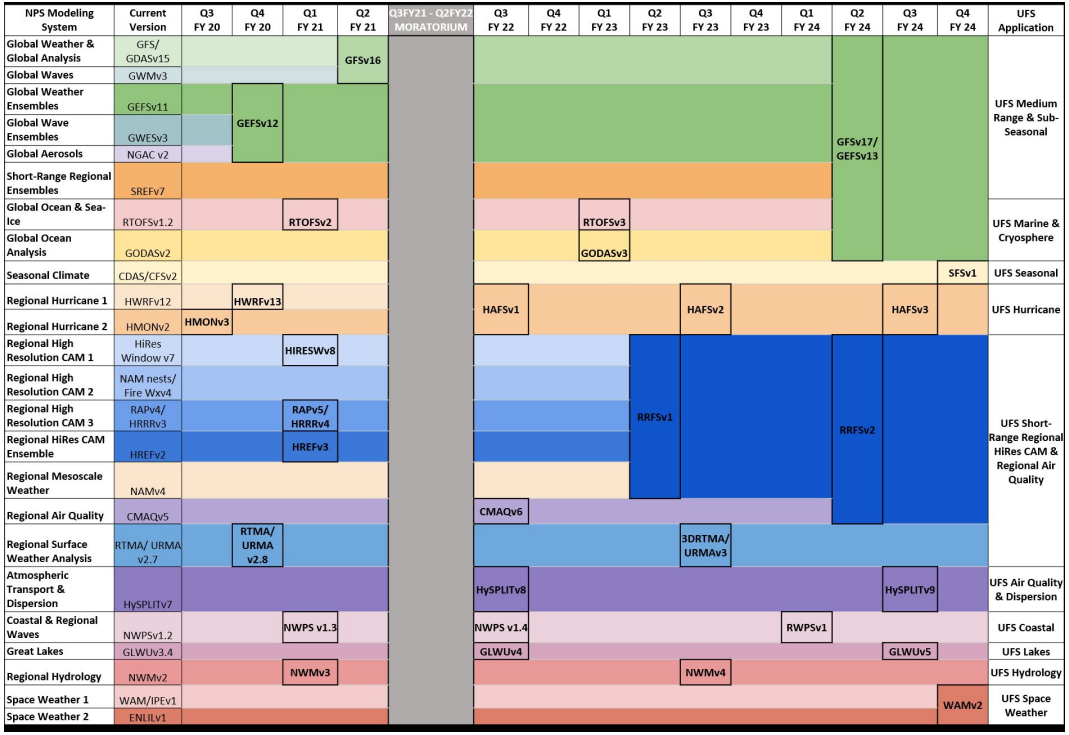
SRW Application

Graduate Student Test (GST)

- **Help measure success of the release related to code availability and development processes to the broader community**
- **Assesses whether a student can do the following (easily) in under six hours:**
  - Get, build, run, and change code, test code for correct operation
  - Evaluate code with standard diagnostic packages
  - Locate documentation, user support, and training
- **Short-Range Weather Application GST**
  - Includes a severe weather example case (15 June 2019) as a default, plus allows the user to change the physics suite and resolution in multiple iterations
  - Visually compare a number of output fields through use of Python scripts



Unified Forecast System - Operational Implementation Timelines



NPS Modeling System	Current Version	Q3 FY 20	Q4 FY 20	Q1 FY 21	Q2 FY 21	Q3FY21 - Q2FY22 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				GFSv16									GFSv17/ GEFSv13			UFS Medium Range & Sub-Seasonal
Global Waves	GWMv3																
Global Weather Ensembles	GEFSv11		GEFSv12														
Global Wave Ensembles	GWESv3																
Global Aerosols	NGAC v2																
Short-Range Regional Ensembles	SREFv7																
Global Ocean & Sea-Ice	RTOFSv1.2			RTOFSv2					RTOFSv3								UFS Marine & Cryosphere
Global Ocean Analysis	GODASv2								GODASv3								
Seasonal Climate	CDAS/CFSv2															SFSv1	UFS Seasonal
Regional Hurricane 1	HWRFv12		HWRFv13				HAFSv1				HAFSv2				HAFSv3		UFS Hurricane
Regional Hurricane 2	HMONv2	HMONv3															
Regional High Resolution CAM 1	HiRes Window v7			HIRESWv8						RRFSv1				RRFSv2			UFS Short-Range Regional HiRes CAM & Regional Air Quality
Regional High Resolution CAM 2	NAM nests/ Fire Wxv4																
Regional High Resolution CAM 3	RAPv4/ HRRRv3			RAPv5/ HRRRv4													
Regional HiRes CAM Ensemble	HREFv2			HREFv3													
Regional Mesoscale Weather	NAMv4																
Regional Air Quality	CMAQv5						CMAQv6										
Regional Surface Weather Analysis	RTMA/ URMA v2.7		RTMA/ URMA v2.8								3DRTMA/ URMAv3						
Atmospheric Transport & Dispersion	HySPLITv7						HySPLITv8								HySPLITv9		UFS Air Quality & Dispersion
Coastal & Regional Waves	NWPSv1.2			NWPS v1.3			NWPS v1.4						RWPSv1				UFS Coastal
Great Lakes	GLWUv3.4						GLWUv4								GLWUv5		UFS Lakes
Regional Hydrology	NWMv2			NWMv3							NWMv4						UFS Hydrology
Space Weather 1	WAM/IPEv1															WAMv2	UFS Space Weather
Space Weather 2	ENLILv1																