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

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Participating Organizations: DTC, NOAA (GFDL, EMC, GSL, NSSL, GLERL), NCAR, CIRA/CIRES/CIMMS

Focus teams:

- Build system (lead: Mike Kavulich)
- Model code (lead: Jeff Beck/Laurie Carson)
- Pre-processing (lead: Larissa Reames)
- Workflow (lead: Jeff Beck)
- Testing (lead: Dom Heinzeller)
- Documentation (lead: Jamie Wolff)
- Support Forum (lead: Jamie Wolff)

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 while also enabling research advancements within the broader weather enterprise

UFS Applications

	Atm	Land	Ocean	Sea Ice	Aerosol	Ionosphere	Storm Surge	Wave
Medium-Range Weather	●	●						●
S2S	●	●	●	●	●			
Hurricane	●	●	●					●
Short-Range Weather	●	●						
Space Weather	●	●				●		
Coastal							●	●
Air Quality	●	●			●			

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

  - 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 Application Release Goals

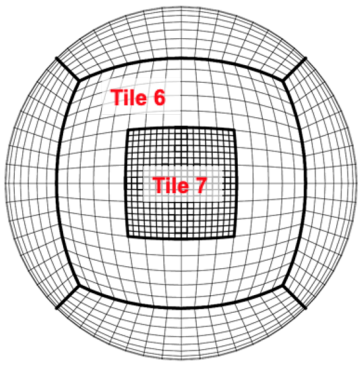
- The SRW Application is designed to be code that the research community can run, use for research, and commit any resulting innovation back to the relevant repositories
- The aim of the release is to introduce the atmospheric limited area version of the UFS to the broader scientific community, with the following features:
  - Allows users to run experiments with a user-friendly workflow
  - Ports easily to multiple platforms
  - Contains detailed documentation of the entire system
  - Provides support through forums

UFS Short-Range Weather (SRW) Application

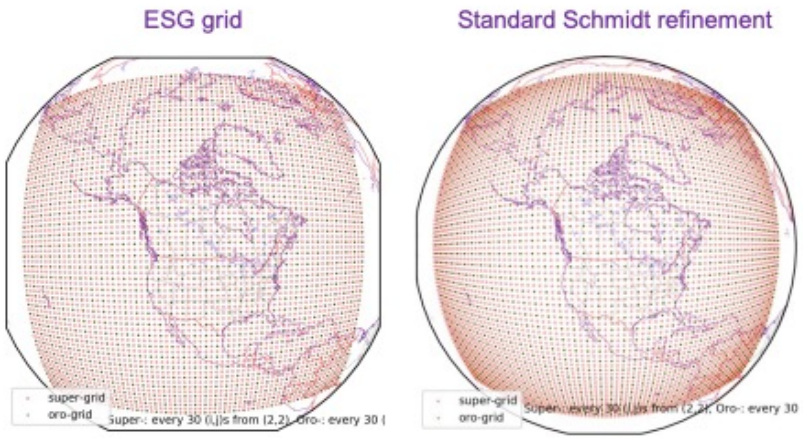
- Model
  - Finite-Volume Cubed-Sphere Dynamical Core (FV3)
    - Limited Area Model (LAM) capability
  - Common Community Physics Package (CCPP)
- End-to-end Application
  - User-friendly build system that invokes CMake
  - Experiment generation with support for the Rocoto workflow manager or stand-alone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

SRW Application Features

Limited Area Model Capability



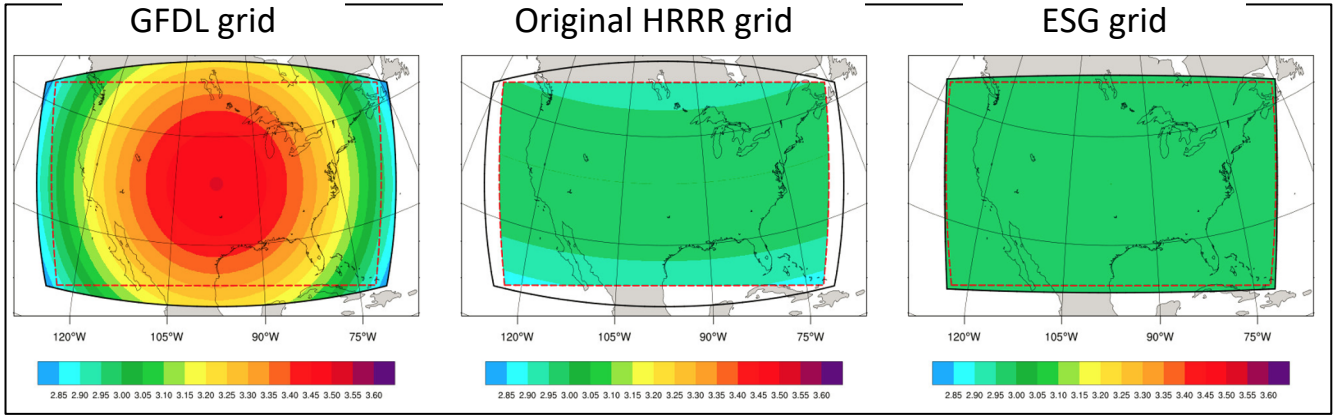
- FV3 Cubed-Sphere (Global Configuration)
  - Uses a gnomonic projection where great circles serve as model coordinates
  - Global coverage consists of six tiles
  - Offers grid uniformity (widest cell only √2 wider than narrowest), but only for standard six-tile global setup
  - Provides refinement through Schmidt transformation and nesting, but requires execution of a global domain
- Limited Area Model (LAM) capability
  - Motivated by convection-allowing modeling applications needs
  - SRW App supports two grid generation methods:
    - Standard Schmidt refinement (GFDLgrid)
    - Extended Schmidt Gnomonic (ESGgrid)
  - Most pre-defined grids in the SRW App use the ESGgrid approach due to the high uniformity in horizontal spacing across the grid



SRW Application Features

Grids and Boundary Conditions

- 3-km, 13-km and 25-km predefined Contiguous U.S. (CONUS) domain
  - Highly uniform Extended Schmidt Gnomonic (ESG) grid

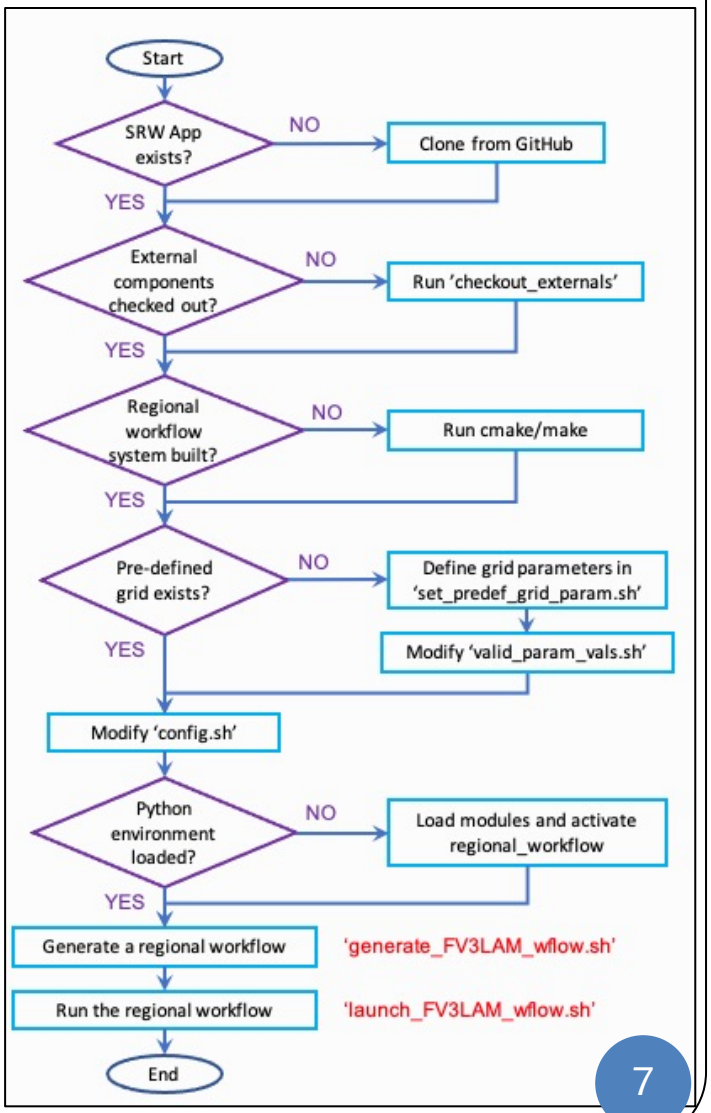


  - Tools for users to define their own domain also available
- HRRR, RAP, NAM, and GFS supported as external model data sources for initial/lateral boundary conditions (GRIB2 or NEMSIO format)

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

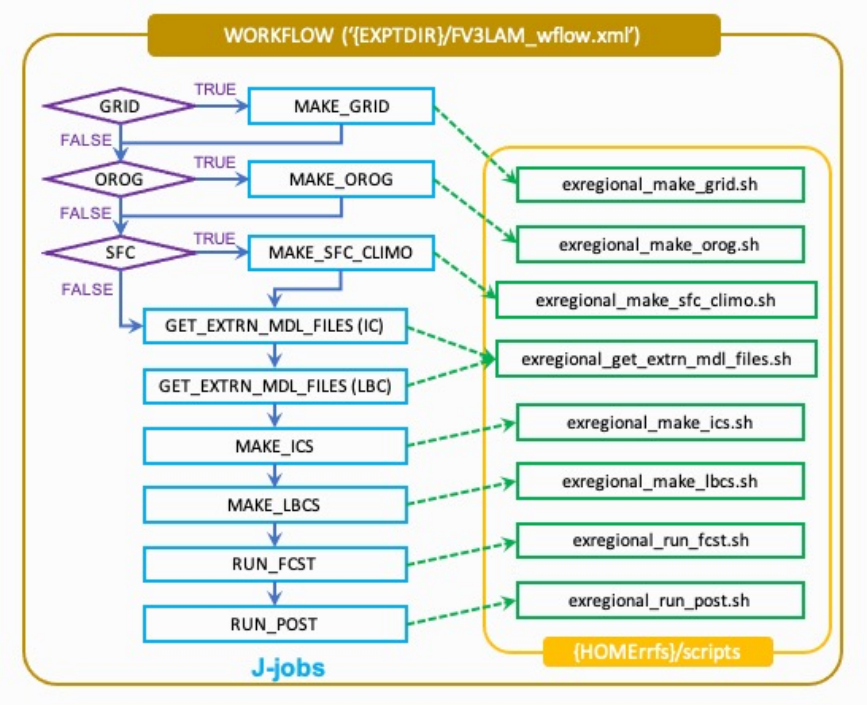
Workflow Tasks

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 extrenal 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 to generate grib2 files



SRW Application Features

Physics suites

- Two supported configurations through CCPP

	GFS_v15p2	RRFS_v1alpha
Microphysics	GFDL	Thompson-Eidhammer
PBL	K-EDMF	MYNN
Surface Layer	GFS	GFS
Deep Convection	SAS	-
Shallow Convection	SAS	-
Radiation	RRTMG	RRTMG
Gravity Wave Drag	GFS GWD	GFS GWD
Land Surface	Noah	Noah-MP
Ozone	NRL 2015	NRL 2015
H2O	NRL	NRL

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/NOAA-EMC/regional_workflow
Libraries	https://github.com/NOAA-EMC/NCEPLIBS https://github.com/NOAA-EMC/NCEPLIBS-external
UFS Utilities	https://github.com/NOAA-EMC/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, Gaea, WCOSS Cray and Dell (Intel)
- 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

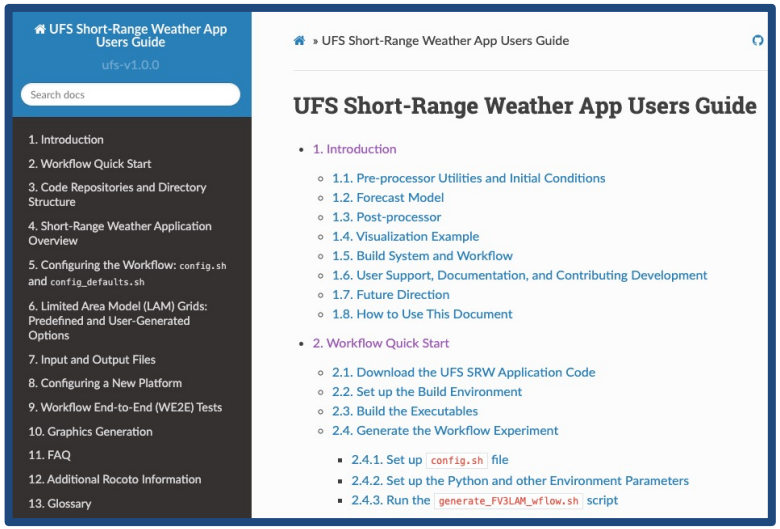
- Prerequisites and libraries expected to install
- Workflow and model should build
- Very limited tests of running the model

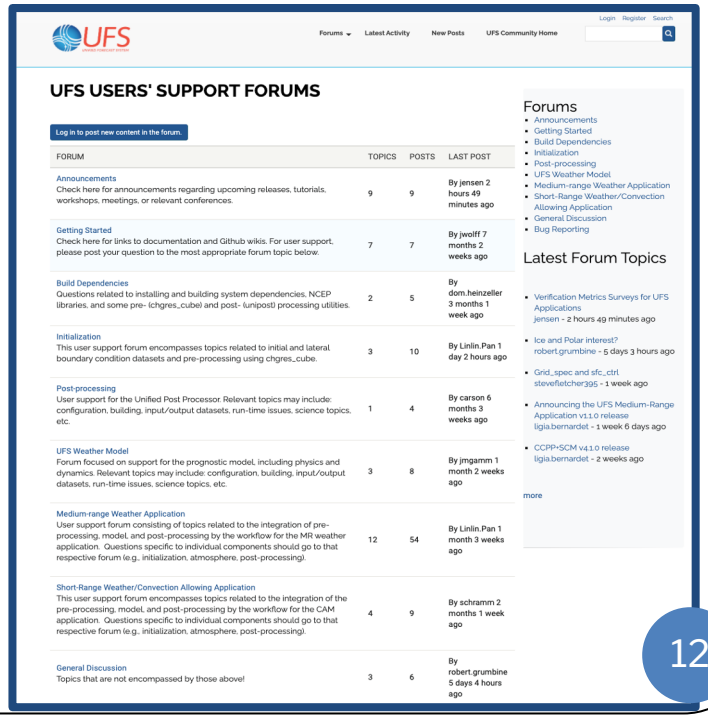
- All generic platforms with GNU
- Pre-configured AMIs on AWS

User Support

- Documentation
  - SRW App User's Guide (UG):

    https://ufs-srweather-app.readthedocs.io/en/ufs-v1.0.1/index.html
  - All components included:
    - UFS utilities, UFS weather model, FV3, CCPP, UPP, visualization, etc.
- Forums
  - https://forums.ufscommunity.org
  - Participation from Subject Matter Experts (SMEs)
  - Build knowledge within the community

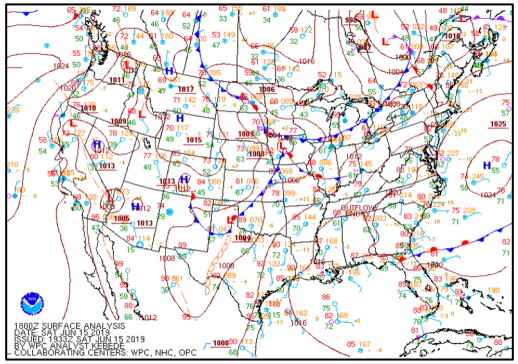




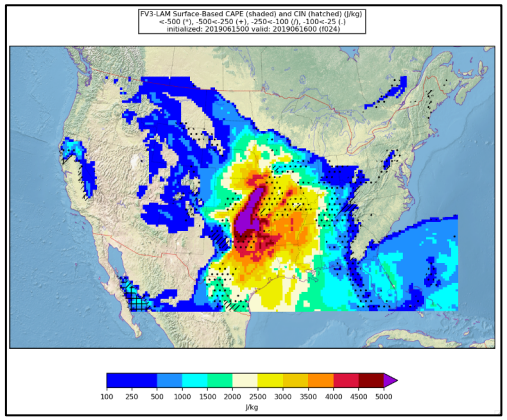
SRW Application

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
  - Fill out a questionnaire about the experience



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																

Join the UFS Community

- Conduct scientific research by running the code and analyzing output
- Share results through presentations and publications
- Develop code in one or more components (open issues/PRs)
- Report bugs - via the UFS Forum or GitHub issues
- Ask **and** answer questions in the UFS Forum
- Take the Graduate Student Test
- Participate in NOAA Notice of Funding Opportunities (NOFO)
- Participate in the DTC Visitor Program (https://dtcenter.org/visitor-program)
- Read the UFS Newsletter and the DTC Newsletter
- Attend the UFS Users Workshop

Questions?