UFS
UNIFIED FORECAST SYSTEM

UFS MRW Training, November 04, 2020

Overview of the UFS MRW App v1.1.0

Ligia Bernardet

Contributors to these slides: DaNa Carlis, Arun Chawla, Louisa, Nance, Mariana Vertenstein, Michael Ek, Dom Heinzeller, Laurie Carson, Jamie Wolff, Cecelia DeLuca, and release teams

Release Teams

- Leads: A. Chawla (NOAA EMC), M. Vertenstein (NCAR), M. Ek (NCAR DTC), L. Bernardet (NOAA GSL DTC)
- Participation: DTC, NOAA (GFDL, EMC, GSL, PSL, NSSL), NCAR, CU/CIRES, GMU, ESMF Team
- Focus teams
  - Model code (lead: Jun Wang)
  - Pre processing (lead: Larissa Reames)
  - Build system (lead: Dom Heinzeller)
  - Workflow (lead: Rocky Dunlap)
  - Testing (lead: Phil Pegion)
  - Documentation (lead: Ligia Bernardet)
  - Support Forum (lead: Jamie Wolff)
- Graduate Student Test: lead by the UFS Communications and Outreach Working Group

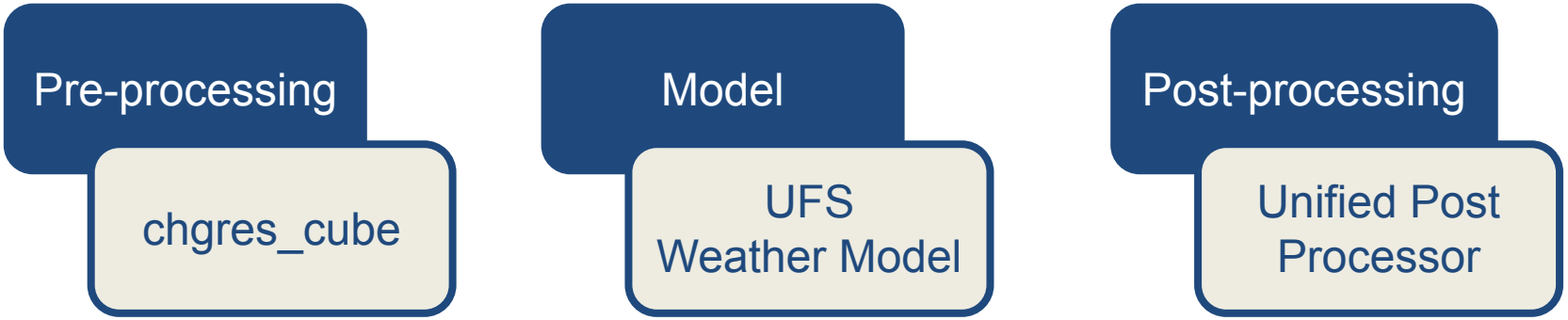
Release History and Goals

- The first public release of the UFS was the Medium Range Weather Application v1, which provides global forecasts for the atmosphere component only
- The aim of the release is to introduce the UFS to the broader scientific community with the following features
  - Ports easily to multiple platforms
  - Enables the users to run forecast-only experiments with a user-friendly workflow
  - Contains detailed documentation of the entire system
  - Provides support through forums

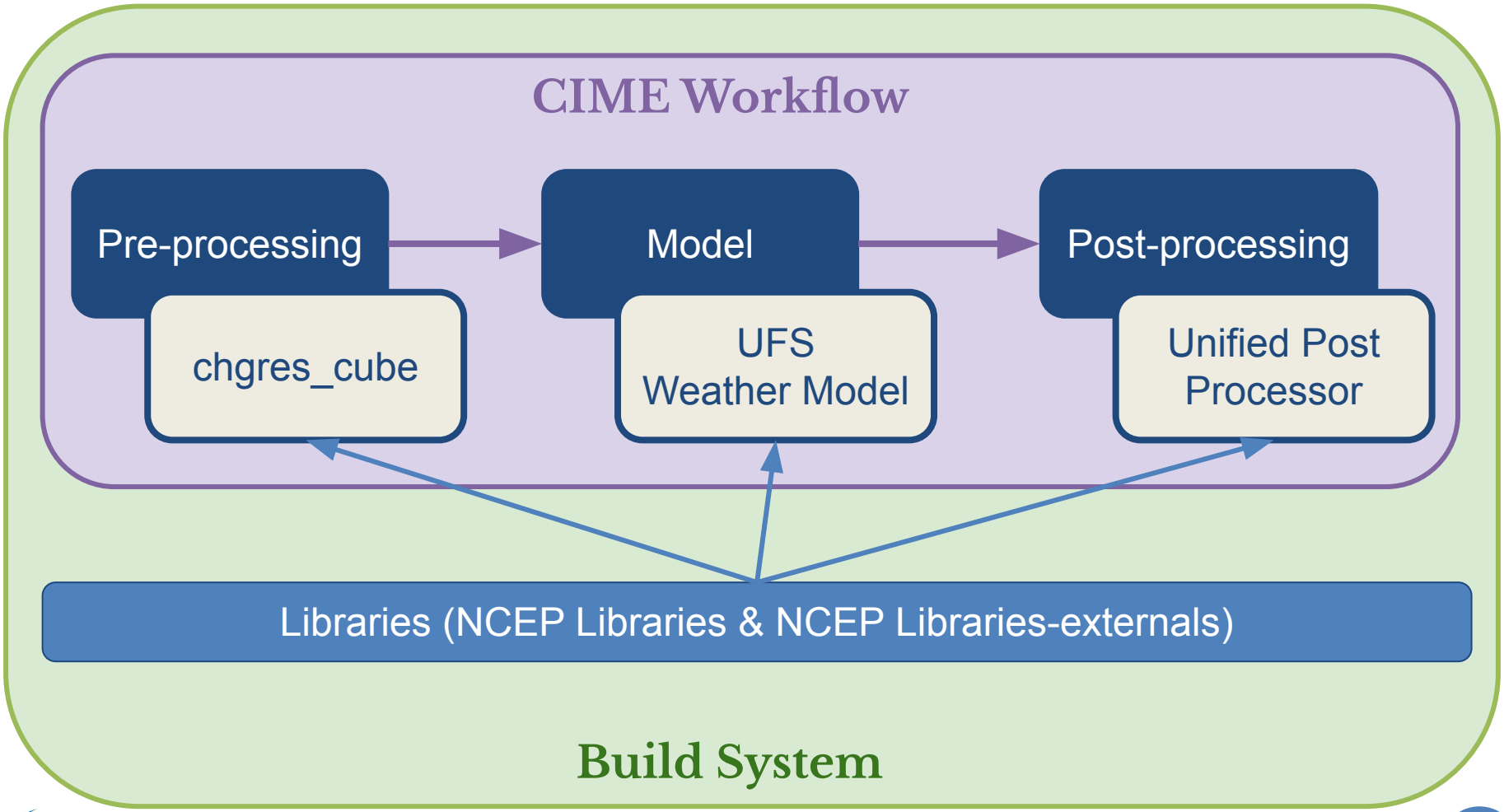
UFS MRW App Release History

Version	1.0.0	1.1.0
Release Date	March 2020	October 2020
Python version requirement	v2.x	v2.x or 3.x
Supported format of GFS for use as raw initial conditions	GRIB2 and NEMSIO	GRIB2, NEMSIO, and netCDF
Automatic download of raw initial conditions	Yes	No
Ability to customize the UPP output	No	Yes
Documentation	Complete	Updated

Prediction Steps included in App

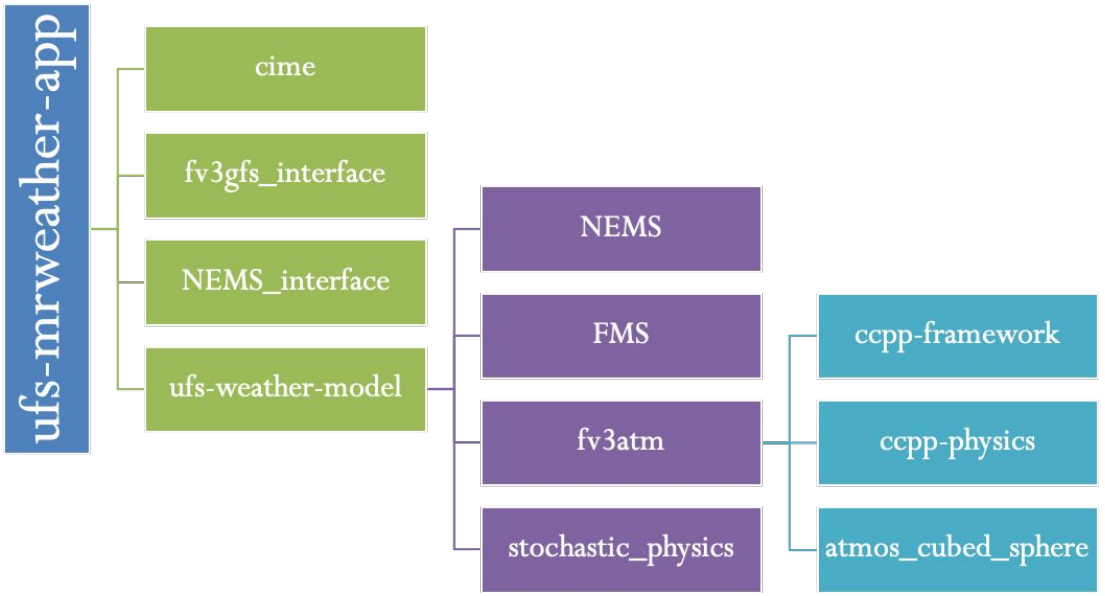


Additional App Components



App Code Repositories

- The App umbrella repository is https://github.com/ufs-community/ufs-mrweather-app
- Additional repositories are submodules and the entire system can be downloaded with a few commands
- The UFS modularity allows assembling the components for use in different Apps and in other models



Libraries

- **NCEP Libraries (NCEPLIBS)**
  - Libraries developed for use with the NCEP models
  - Contains: bacio, bufr, crtmg, g2, g2tmpl, gfsio, grib_util, ip, landsfcutil, nemsio, nemsiogfs, prod_util, sfcio, sigio, sp, w3emc, and w3nco
  - Pre-processor (chgres_cube) and Post-processor (UPP) have been bundled with the NCEPLIBS for use with the UFS MRW App
- **NCEPLIBS-external**
  - Third-party libraries developed externally to NCEP; general software packages also used by other models
  - Contains: netCDF, ESMF, hdf5, jasper, jpeg, png, wgrib2, and zlib

Preprocessor - chgres_cube

- Reads in raw initial conditions and creates initial conditions for the UFS Weather Model
- Only GFS analyses are supported as raw initial conditions
- The following formats of raw ICs are supported
  - GRIB2 (0.5 and 1.0 degree) - publicly available
  - NEMSIO (format used by GFS v15) - publicly available for the last 10 days
  - netCDF (format planned for GFS v16) - will be publicly available for the last 10 days after GFS v16 is implemented in operations in 2021

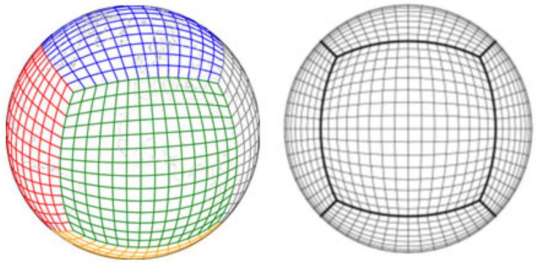
See the App User's Guide for more information about where to find data (https://ufs-mrweather-app.readthedocs.io/en/ufs-v1.0.0/inputs_outputs.html)

UFS Weather Model

- Uses the FV3 dynamical core
- Supports four grid resolutions -- C96 (~104km), C192 (~52km), C384 (~26km), and C768 (~13km) in 64 vertical levels
- Supports two physics suites
  - GFSv15p2 -- Physics used in the current operational GFS v15
  - GFSv16beta -- Physics used in the Oct 2019 beta version of the GFSv16 implementation (planned for 2021). Changes made in the physics for GFS v16 since Oct 2019 are not included in the App
- Runs with or without the Near Surface Sea Temperature (NSST) formulation that accounts for diurnal fluctuations
- Outputs history files in NetCDF format

FV3 Dynamical Core

- Finite-Volume Cubed-Sphere Dynamical Core (FV3)
- Developed at NOAA GFDL
- Is scalable, flexible, capable of simulations
  - Hydrostatic and non-hydrostatic
  - Global, stretched, limited-area, and nested domains



- Follows these development goals
  - Discretization should be guided by physical principles as much as possible
  - Computational efficiency is crucial
- Is a component of the operational in GFS v15 and GEFS v12

Common Community Physics Package: Suites Supported with this App

	GFS_v15p2	GFS_v16beta
Microphysics	GFDL	GFDL
PBL	K-EDMF	TKE EDMF
Surface Layer	GFS	GFS
Deep Convection	SAS	SAS
Shallow Convection	SAS	SAS
Radiation	RRTMG	RRTMG
Gravity Wave Drag	uGWP	uGWP
Land Surface	Noah	Noah
Ozone	NRL 2015	NRL 2015
H2O	NRL	NRL

These suites can also be used with the CCPP Single Column Model
http://dtcenter.org/ccpp

Sea Surface Temperature Representation

- The App is atmosphere-only (with an embedded land-surface model). There is no active ocean model
- The SST is initialized from analyses and forced toward climatology throughout the run
- The Near Sea Surface Temperature (NSST) is a scheme (in CCPP) for representing the diurnal cycle of SST
- NSST cannot be used with GRIB2 files due to lack of fields needed to initialize the parameterization
- The workflow will automatically include or exclude the NSST parameterization based on the format of raw initial conditions

Raw Initial Conditions	GRIB2	NEMSIO	netCDF
SST Representation	No NSST	NSST	NSST

Post-Processor - UPP

- Converts model output on the native model grid (in netCDF format) to standard isobaric coordinates (in GRIB2 format)
- Calculates additional diagnostic fields that are not part of model output
- Allows customization of the fields in the output files

Workflow Overview

- Workflow is based on the Common Infrastructure for Modeling the Earth (CIME).
- Python-based scripting infrastructure that provides a user-friendly, reproducible workflow
- Experiments can be created, configured, built and run by invoking only 4 commands
- Open community collaboration on public GitHub repository
- Multi-agency (NSF, DOE, NOAA) and multi-model (CESM, E3SM, NORESM and UFS)

Workflow Roles

- Create an experiment based on specifications
  - Choice of resolution, physics suite (GFSv15p2 or GFSv16beta), with/without UPP
- Allow user to customize the experiment, e.g.,
  - Date and format of raw initial conditions, forecast length
  - Pre-processor and model namelist options
  - Processor layout
- Build the model executable (not libraries, pre- or post-)
- Create namelists
- Auto-download and stage static (fixed) files
- Create job cards and dependencies
- Submit the jobs to the batch system

Build System

- Friendly build system that invokes CMake before building
- Linux and Mac operating systems are supported
- Intel and GNU compilers are supported
- **Prerequisite Libraries**
  - Straight-forward to build all software libraries required by the model, pre-processing and post-processing utilities
  - Libraries are already installed in preconfigured platforms
- **UFS MR Weather Application**
  - The CIME workflow builds the UFS Weather Model using a single command

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, Gaea, Jet (Intel)

Level 2: Configurable platforms
- Prerequisites and libraries expected to install
- Workflow and model expected to build/run
- Comprehensive testing before release

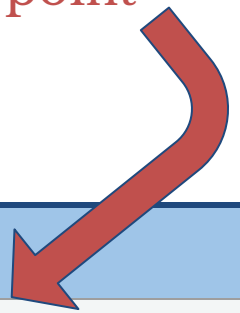
- MSU Orion (Intel)
- TACC Stampede (Intel)
- NOAA WCOSS (Intel)

Level 3: Limited-test platforms
- Prerequisites and libraries expected to install
- Workflow and model should build and run
- Limited testing

- macOS
- Ubuntu
- RedHat
- All generic platforms with GNU, pre-configured AMIs on AWS

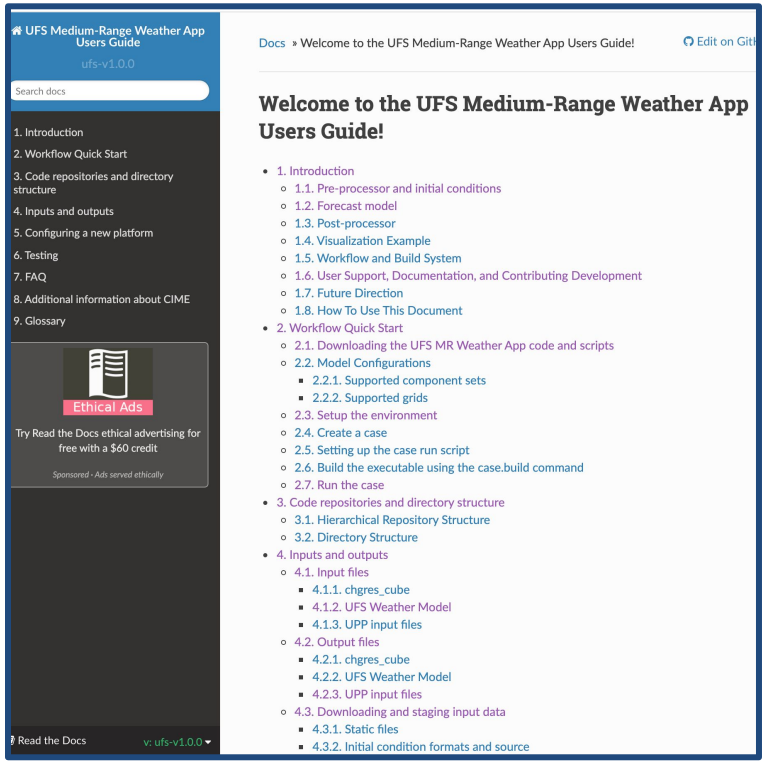
Documentation

App entrypoint



Type	Location
UFS MR Weather App v1.1 User's Guide	https://ufs-mrweather-app.readthedocs.io/en/ufs-v1.1.0
chgres_cube User's Guide	https://ufs-utils.readthedocs.io/en/ufs-v1.1.0
UFS Weather Model v1.1 User's Guide	https://ufs-weather-model.readthedocs.io/en/ufs-v1.1.0
FV3 Documentation	https://noaa-emc.github.io/FV3_Dycore_ufs-v1.1.0/html/index.html
CCPP Scientific Documentation	https://dtcenter.org/GMTB/v4.1.0/sci_doc
CCPP Technical Documentation	https://ccpp-techdoc.readthedocs.io/en/v4.1.0
Stochastic Physics User's Guide	https://stochastic-physics.readthedocs.io/en/ufs-v1.1.0
ESMF manual	http://www.earthsystemmodeling.org/esmf_releases/public/ESMF_8_0_0/ESMF_refdoc
Common Infrastructure for Modeling the Earth	http://esmci.github.io/cime/versions/ufs_release_v1.1/html/index.html
Unified Post Processor	https://upp.readthedocs.io/en/ufs-v1.1.0

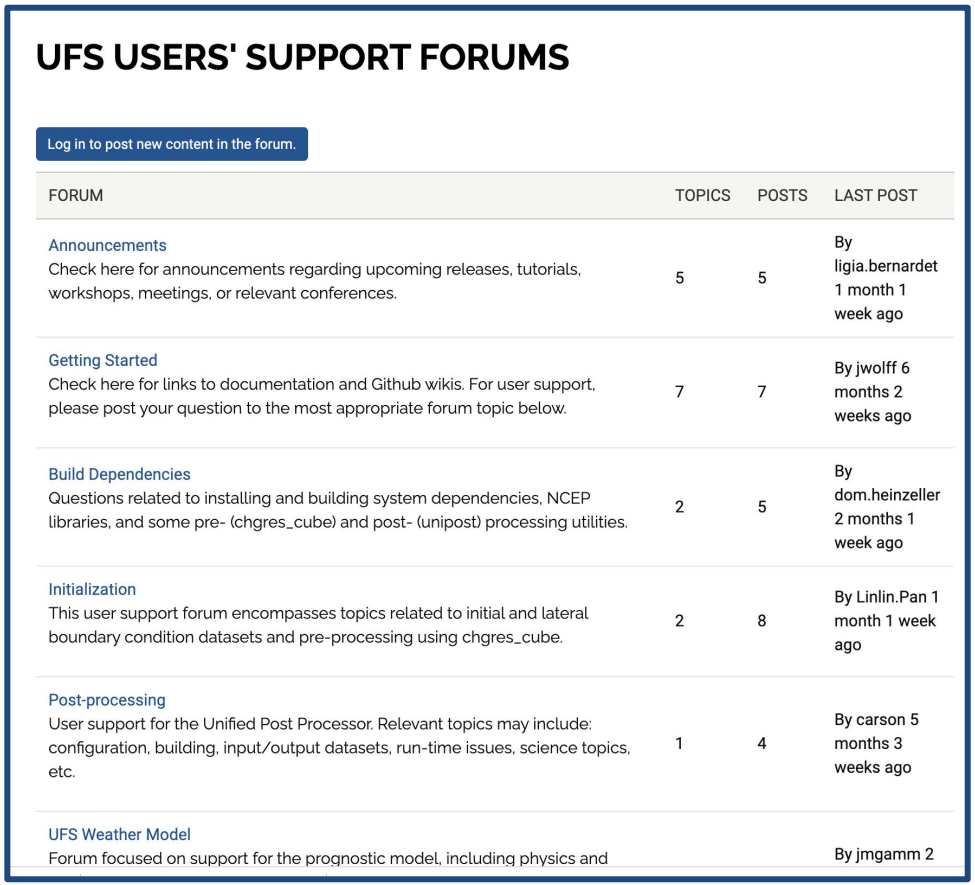
App User's Guide



- Overview
- How to use the workflow to configure a case, obtain code and run the App
- How to use the App on preconfigured, configurable, or limited-test platforms
- Links to component documentation, including how to contribute issues, bug reports, and development
- Link to UFS Users' Support Forums for asking/answering questions

App User's Guide
https://ufs-mrweather-app.readthedocs.io/en/ufs-v1.1.0/

Support Forums



UFS USERS' SUPPORT FORUMS

Log in to post new content in the forum.

FORUM	TOPICS	POSTS	LAST POST
Announcements Check here for announcements regarding upcoming releases, tutorials, workshops, meetings, or relevant conferences.	5	5	By ligia.bernardet 1 month 1 week ago
Getting Started Check here for links to documentation and Github wikis. For user support, please post your question to the most appropriate forum topic below.	7	7	By jwolff 6 months 2 weeks ago
Build Dependencies Questions related to installing and building system dependencies, NCEP libraries, and some pre- (chgres_cube) and post- (unipost) processing utilities.	2	5	By dom.heinzeller 2 months 1 week ago
Initialization This user support forum encompasses topics related to initial and lateral boundary condition datasets and pre-processing using chgres_cube.	2	8	By Linlin.Pan 1 month 1 week ago
Post-processing User support for the Unified Post Processor. Relevant topics may include: configuration, building, input/output datasets, run-time issues, science topics, etc.	1	4	By carson 5 months 3 weeks ago
UFS Weather Model Forum focused on support for the prognostic model, including physics and			By jmgamm 2

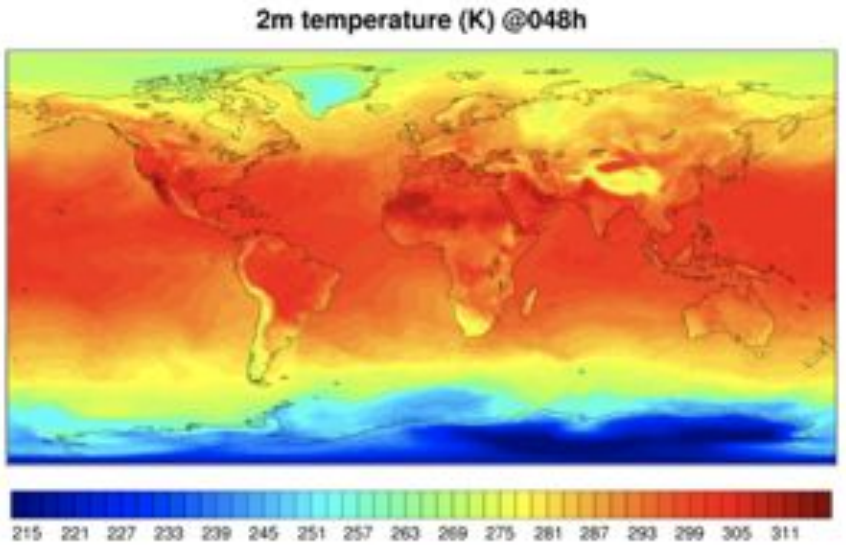
Support Forums
https://forums.ufscommunity.org/

- Publicly viewable support forum
- Registered users may post new topics and/or responses to existing topics
- Forums available
  - Build Dependencies
  - Initialization
  - Post-processing
  - UFS Weather Model
  - Medium-Range Weather Application
  - Short-Range Weather/Convection Allowing Application
  - General Discussion

Wiki and Getting Started

- The UFS MRW App GitHub wiki includes developer information (release notes, known bugs), policies, examples with images of outputs
- Examples allow for quick visual verification of correct operation

The wiki includes a Hurricane Dorian example (29 August 2019) with sample outputs and the scripts for generating them



MR Weather App wiki:
https://github.com/ufs-community/ufs-mrweather-app/wiki

Graduate Student Test (GST)

The GST is a measure of how successful the UFS project is in opening its code and development processes to the broader community. How easily, in under 6 h, can a student:

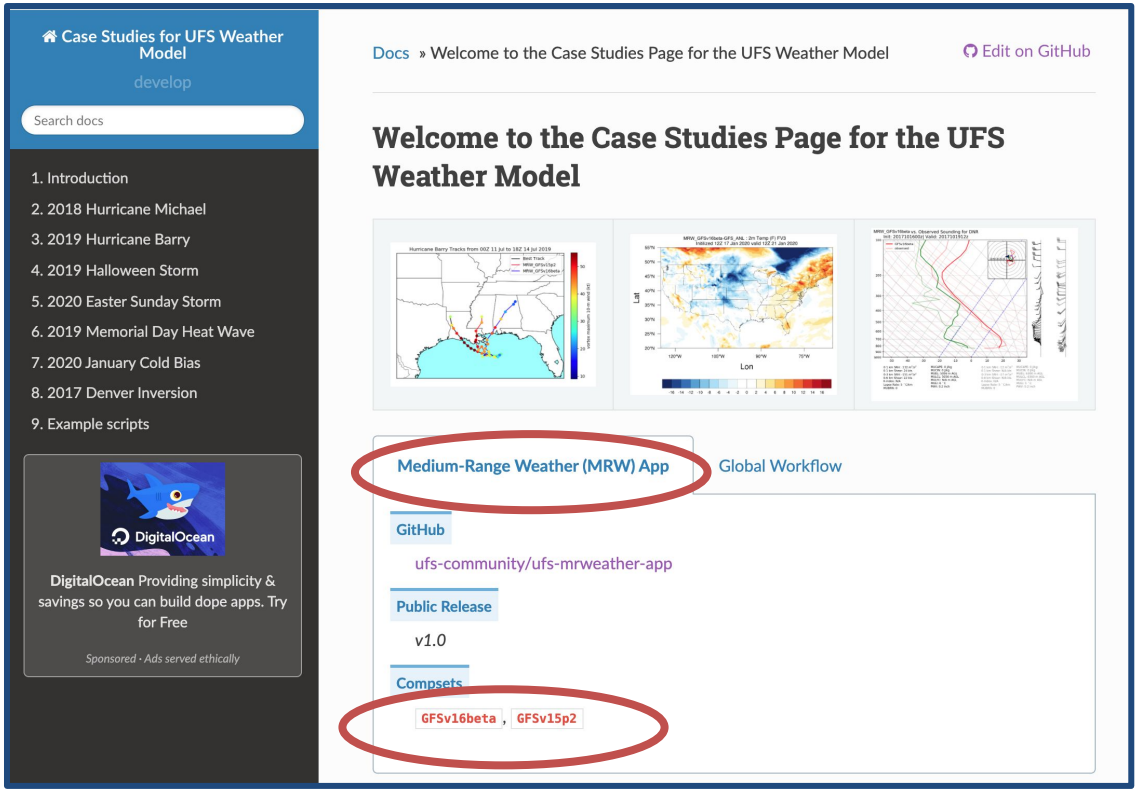
- Get, build, run, and change code, test code for correct operation
- Evaluate code with standard diagnostic packages
- Get documentation, user support, and training
- You don't have to be a graduate student to take the GST!

Medium-Range Weather App GST

- Dorian example - default + change the CNN concentration
- Visually compare the total cloud cover field
- Fill out a questionnaire about the experience
- Get involved! Register!

Graduate Student Test website
https://ufscommunity.org/science/gst

Benchmarks: UFS Case Studies



- Catalog of case studies that exemplify challenges for the UFS MRW App
- Initial conditions, instructions, verification datasets, and plotting scripts available
- An entry point for users and developers to test innovations to improve the UFS
- v1.0.0 cases still applicable for v1.1.0

UFS Case Studies Documentation
https://ufs-case-studies.readthedocs.io/en/develop/index.html

Join the UFS Community

- Conduct scientific research by running the code and analyzing output, resulting in feedback to the UFS community (via Forum etc.), presentations, or publications
- Report bugs - via Forum
- Ask and answer questions in the Forum
- Take the Graduate Student Test
- Participate in NOAA Notice of Funding Opportunities
- Participate in the DTC Visitor Program
- Read the UFS Newsletter and the DTC Newsletter
- Attend the annual UFS Users Workshop
- Develop code in one or more components

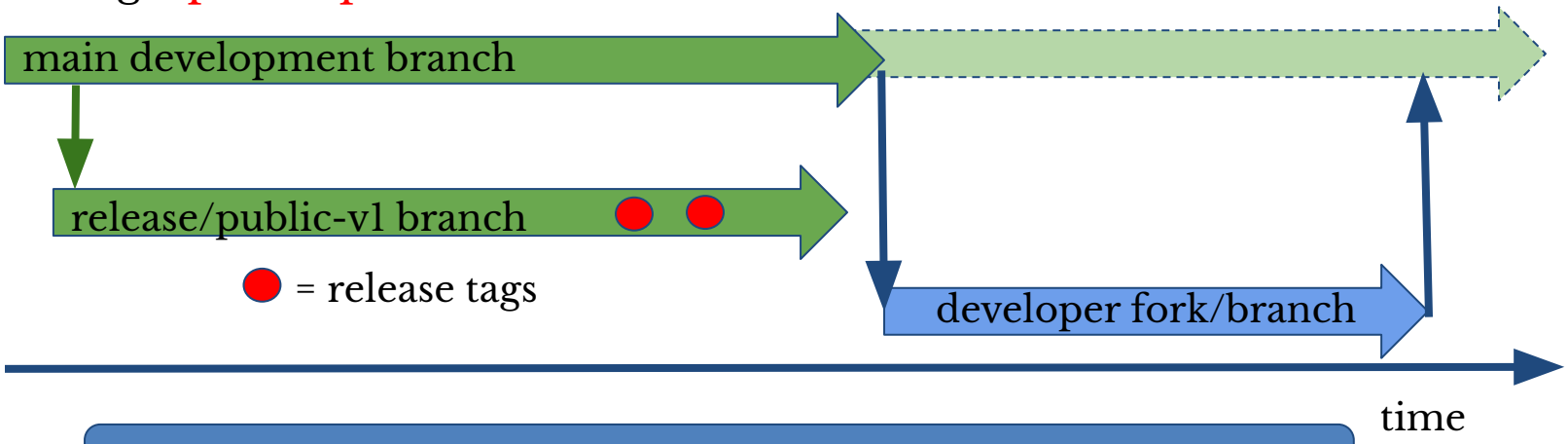
App Code Repositories

Repository Description	Authoritative repository URL
Umbrella for the UFS Weather App	https://github.com/ufs-community/ufs-mrweather-app
Umbrella for the UFS Weather Model	https://github.com/ufs-community/ufs-weather-model
CIME CSS	https://github.com/ESMCI/cime
Layer required for CIME to build ufs-weather-model	https://github.com/ESCOMP/fv3gfs_interface
Layer required for CIME to build NEMS driver	https://github.com/ESCOMP/NEMS_interface

All Components are public repositories on GitHub

Contributing Development

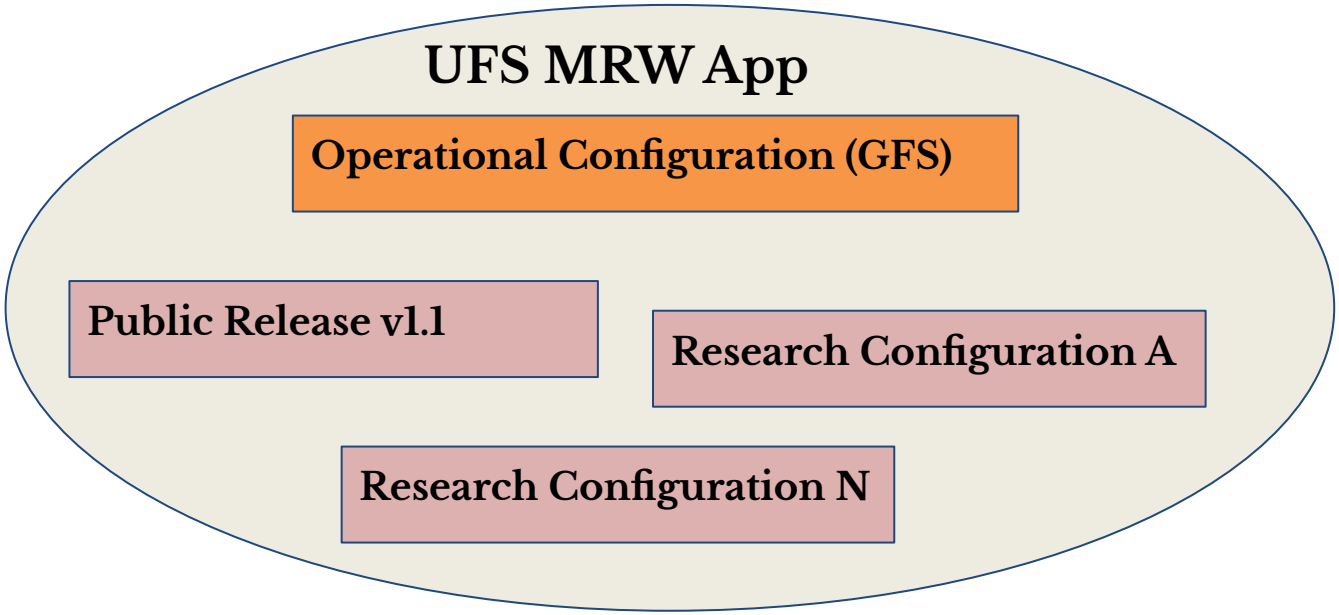
- The UFS MRW App repository, including the v1.1.0 release, uses *tags* of its components. *Tags* are frozen, static versions of the code.
- For doing development, it is necessary to use the **top of the main development branch** of each component
- Development involves following the code management rules of the relevant GitHub repository(ies), typically: creating an issue. forking/branching the repository, conducting regression tests, and issuing a pull request



Follow instructions for development provided on a 11/9 talks

App: operations and research

- The UFS MRW App includes both operational and research configurations.
- The public release is one of the research configurations
- The Global Forecast System (GFS) is the operational configuration



Public release vs GFS

	Public release v1.1	GFS v15
Goal	Portable, friendly	Continuously running, no failures
Workflow	CIME	*Global Workflow*
Initialization	Cold start from operational GFS analyses	Cycled data assimilation with observations inserted every 6h
Physics-dynamics Interface	CCPP	Interoperable Physics Driver
Forecast verification	Not included	Built-in

UFS - Looking Ahead

- Continued development of different UFS applications
- Future releases of applications as they reach mature levels of development. These include
  - Short Range Weather App (with limited area modeling capability) - Fall 2020
  - Hurricane App
  - Coupled modeling capability (ocean, sea ice, and waves)
  - Data assimilation capability