CCPP Training
College Park, MD, March 12-13, 2019

Common Community Physics Package (CCPP) Introduction

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- Please raise your hand if…
  - You have run the FV3-based global system before
  - You work on the coupled S2S/climate system
  - You have run the FV3-based regional system before
  - You work with NAM, RAP, or HRRR
  - You work with HWRF or HMON
  - You have used git
  - You have used GitHub
  - You are a physics developer

Agenda for Training – Tuesday

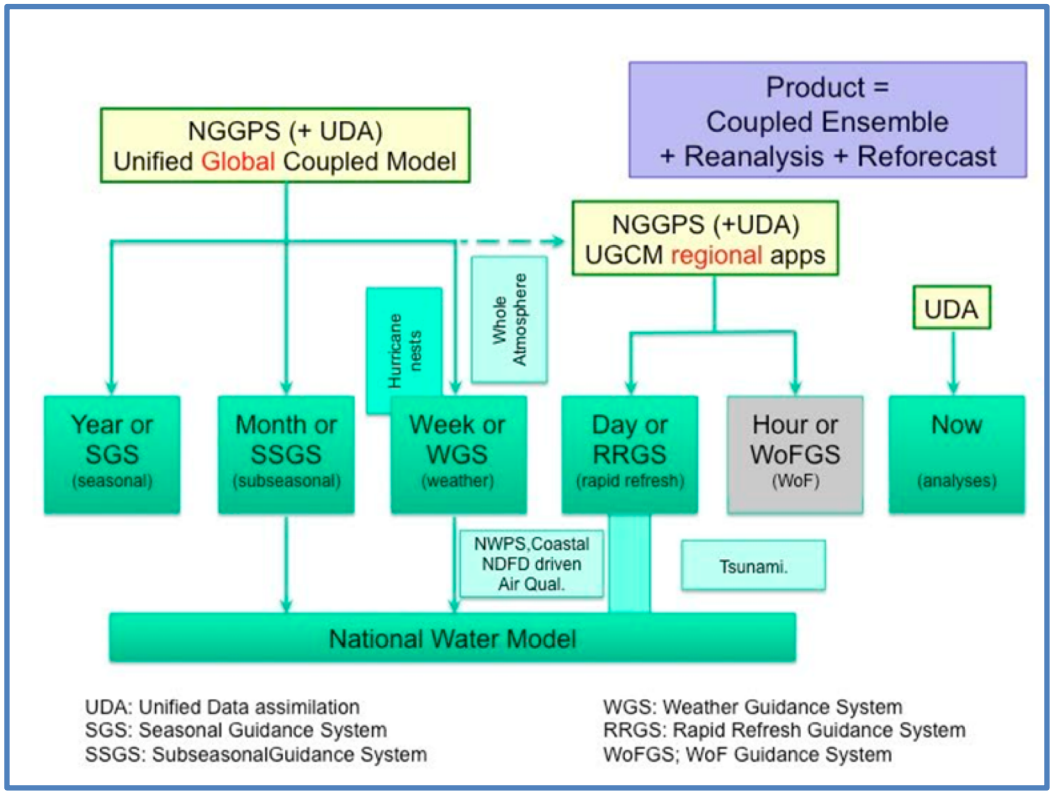
Time	Topic
8:30	Introduction
9:00	Physics schemes and interstitials
9:30	Suite Definition File
9:45	GitHub instructional
10:15	Break
10:45	Building NEMSfv3gfs with CCPP
11:15	Running NEMSfv3gfs with CCPP
11:30	The way forward, discussion
12:00	Lunch
2:00-4:00	Practical session on build and run

Agenda for Training – Wednesday

Time	Topic
8:30	CCPP-compliant parameterizations
9:00	Scientific documentation
9:30	CCPP prebuild
10:00	Break
10:30	Adding a new scheme/suite
10:45	Host-side coding
11:05	Code management
11:35	Governance
11:50	Wrap-up, discussion
12:15	Lunch
1:30 – 4:30	Practical session on development

NOAA's Unified Forecast System (UFS)

A modeling system that can be used for various scales and applications

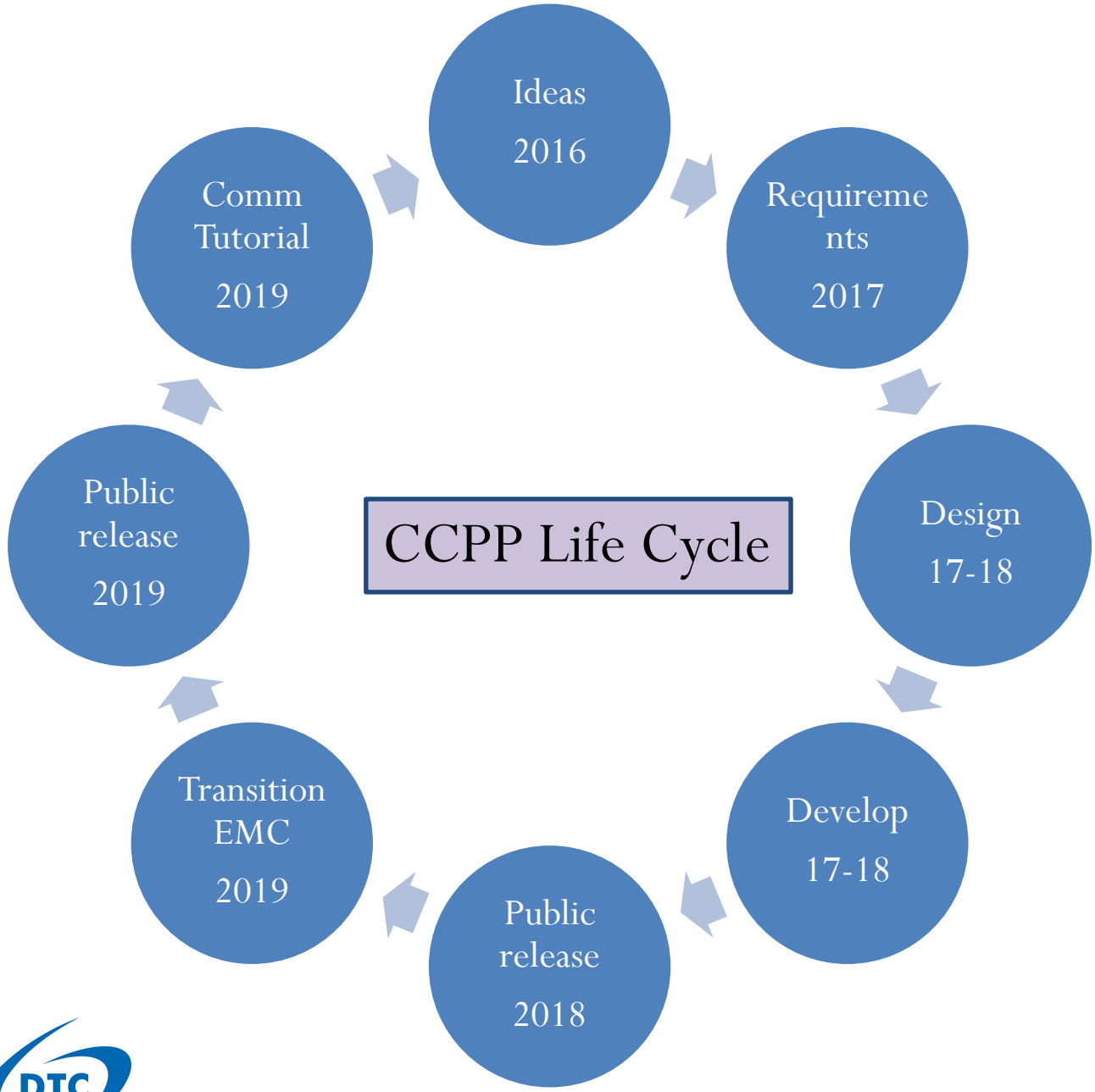


Source: https://www.weather.gov/sti/stimodeling_nggps

Goals for the UFS Physics

- **Consolidated**: Single library of operational and developmental parameterizations and suites for all applications
- **Supported:** Well-supported community code
- **Open:** Have accessible development practices (GitHub)
- **Clear interfaces:** Well-documented and defined interfaces to facilitate using/enhancing existing parameterizations and adding new parameterizations
- **Interoperable:** usable with other dycores/hosts to increase scientific exchange
  - Single-Column Model
  - Etc.

Common Community Physics Package (CCPP)

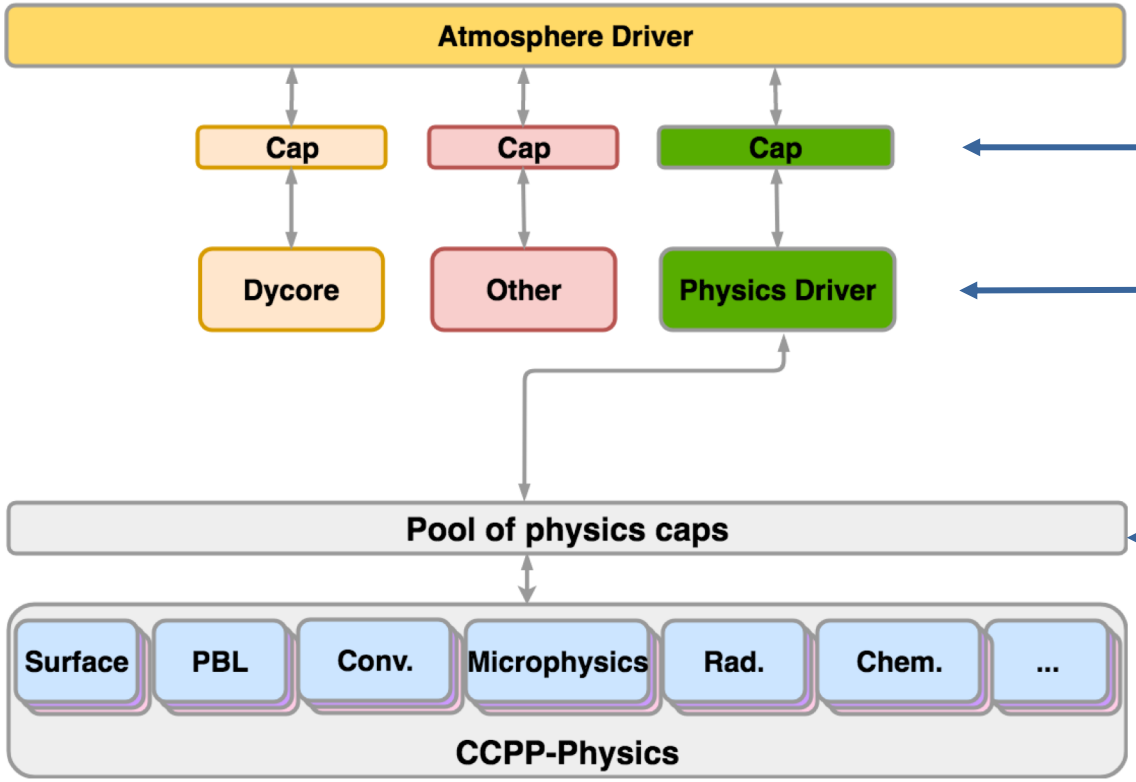


- CCPP has been developed by GMTB with NGGPS funding
- Critical partnership with EMC in planning process
- Planned transition to operations with GFS v16 in 2021

Your input is valuable

- Consider this training to be an initial delivery
- Several aspects of the CCPP are not set in stone and will continue evolving
- EMC staff are welcome to provide feedback to make the system better!
- Examples include code organization, physics *metadata*, training materials etc.

Physics-Dynamics Architecture



Host application cap with auto-generated code from host metadata

CCPP-Framework used before/at compile time and during run

Physics caps (auto-generated)

Parameterizations

Key Features of the CCPP

- **Configuration**
  - Run time (for flexibility of using any supported parameterizations/suite)
  - Compile time (for performance)
- **Subcycling**
  - Schemes can be called at higher frequency than others or than dynamics
- **Grouping**
  - Schemes can be called in groups with other computations in between (e.g. dycore, coupling)
- **Ordering**
  - User-defined order of execution of scheme
  - But note that this must be done very carefully. Just because you can re-order, it does not mean it will make scientific sense and be computationally stable!

Parameterizations, Interstitials & SDF

- **Parameterizations:** main physics schemes (PBL, cu etc.)
- **Interstitials:** secondary schemes
  - Data preparation and postprocessing for main schemes
  - "Glue" that allows schemes to function as suite
- **Suite Definition File (SDF)**
  - Lists the parametrizations and interstitials for a run

Communication: Physics and Host

- **Physics**
  - Main schemes and interstitials have a well-described interface
  - Input and output variables have *metadata* (standard names, units etc.)
- **Host model**
  - Has a list of variables that can be provided to the physics
- **Communications**
  - The CCPP build system and runtime API are responsible for using the *metadata to communicate* variables between physics and host

Scientific Documentation

- Parameterizations in CCPP have scientific documentation
- Inline documentation in code are parsed with Doxygen
- Figures, math formulas, call graph, references can be added
- Results can be displayed in html format

GMTB Common Community Physics Package(CCPP) Documentation

Version 0

Introduction

The following two equations can be used to calculate the precipitation rates of rain and snow at each model level:

$$P_r(\eta) = \frac{p_s - p_t}{g\eta_s} \int_{\eta_t}^{\eta_s} (P_{lsaut} + P_{lsacw} + P_{lsacr} + P_{im1} + P_{im2} - E_{lrc}) d\eta$$

[82] Q. Zhao and F.H. Carr. A prognostic cloud scheme for operational nwp models. *Monthly Weather Review*, 125:1931–1953, 1997.

Argument Table

local var name	longname	description	units	rank	type	kind	intent	optional
im	horizontal_loop_extent	horizontal loop extent	count	0	integer		in	F
ix	horizontal_dimension	horizontal dimension	count	0	integer		in	F
km	vertical_dimension	vertical layer dimension	count	0	integer		in	F
dt	time_step_for_physics	physics time step	s	0	real	kind_phys	in	F

CCPP-Physics: Current Parameterizations

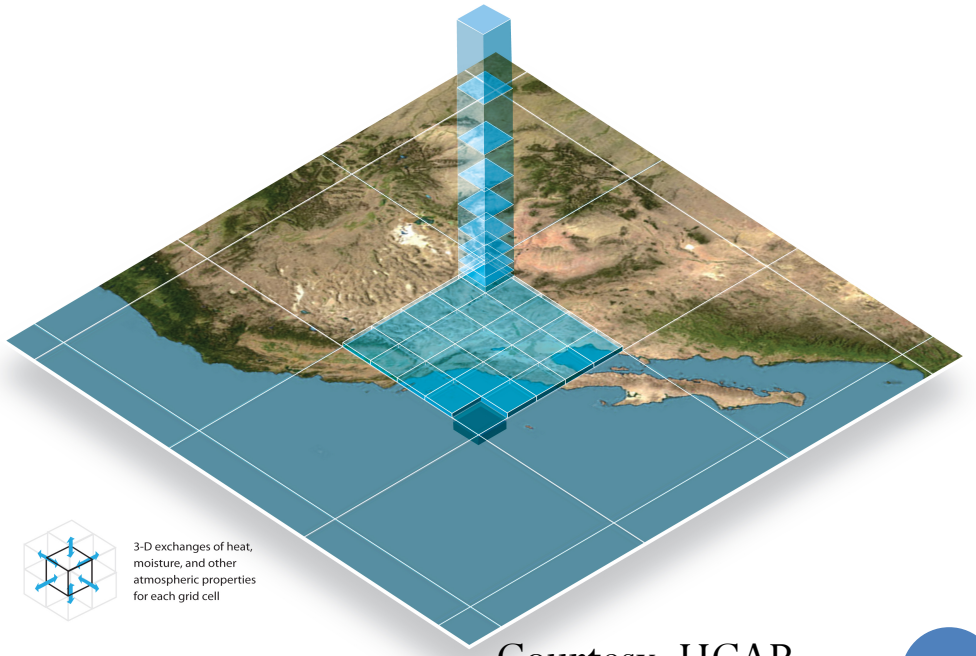
Schemes/Suites	CCPP v2	FV3GFSv1.1	EMC/CPT	GSD	Others
	Released	In master			
Microphysics	GFDL, Zhao-Carr	GFDL	M-G3	Thompson	
Boundary Layer	GFS/EDMF	TKE EDMF	GFS/EDMF	MYNN	SHOC, YSU, saYSU
Surface Layer	GFS	GFS	GFS	GFS	MYNN
Deep convection	saSAS	saSAS	Chikira-Sugiyama	Grell-Freitas	Tiedtke
Shallow Convection	saSAS	saSAS	saSAS	MYNN	SHOC, Tiedtke
Radiation	RRTMG	RRTMG	RRTMG	RRTMG	
Gravity Wave Drag	GFS	GFS	GFS	GFS	
Land	Noah	Noah	Noah	RUC	
Ozone	NRL 2006	NRL 2015	NRL 2015	NRL 2015	
H2O		NRL	NRL	NRL	

Host Models Currently Using CCPP

- **GMTB Single-Column Model**
- **UFS: NEMSfv3gfs**
  - Global weather configuration (FV3GFS) is being used in the Advanced Physics Test
  - Regional configuration (FV3-SAR) is being set up by HWT
- **MusicBox**
  - MusicBox is a toy chemistry model
  - NCAR has created a library of CCPP-compliant chemistry parameterizations for use with its various models (Model-Independent Chemistry Module; MICM)

GMTB Single-Column Model

- Simple host model for calling physics through CCPP
- Distributed with a variety of case studies that enable physics experiments in a controlled setting
- An important tier of a hierarchical testing framework



Courtesy: UCAR

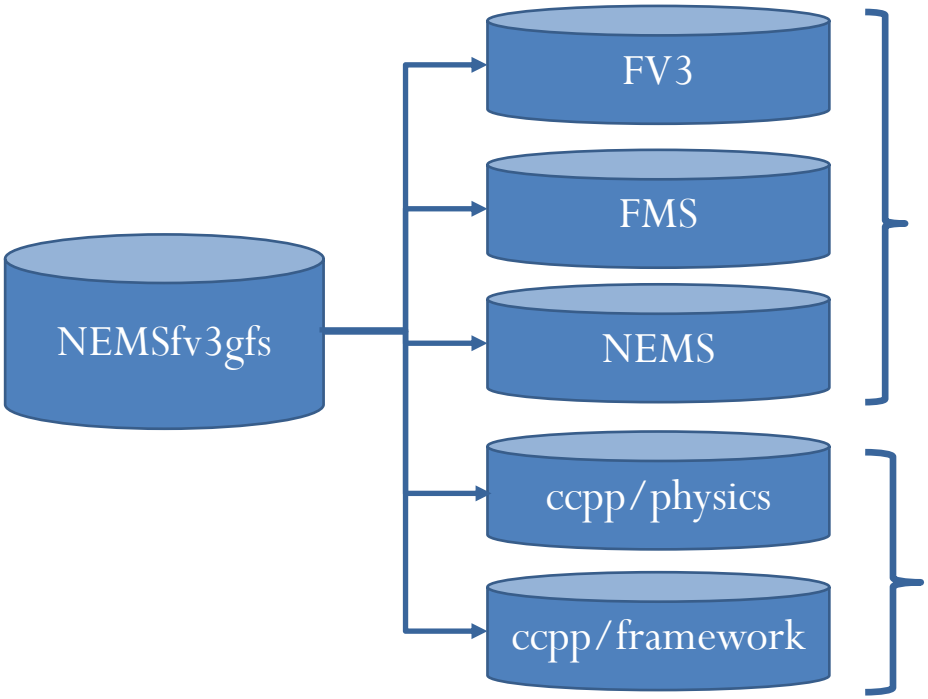
CCPP Releases

V	Date	Physics	Host
v1	2018 April	FY17 GFS operational	Single Column Model (SCM)
v2	2018 August	FY17 GFS operational updated GFDL microphysics Stochastic Physics	SCM FV3 for developers

CCPP v2: https://dtcenter.org/gmtb/users/ccpp/

- Physics and Framework
- Access: GitHub (release code and access to development)
- Portability: Theia, Cheyenne, Mac and beyond
- Docs: Scientific Doc, Users Guide, Developer's Guide, FAQ, Known Issues
- Technical overview, requirements, design
- Helpdesk: gmtb-help@ucar.edu

CCPP Code Within NEMSfv3gfs



Three repositories with added portability and modified code for using with CCPP

Two authoritative code repositories

- This training will use code in repository (not public release)
- Limited training in git and GitHub will be provided

Building NEMSfv3gfs with CCPP

- **Prebuild**
  - Utilizes a set of Python scripts distributed with the CCPP
  - Establishes links between variables provided by the host model and variables required by the parameterizations
  - Creates auto-generated code that is used to build the model
- **Build**
  - Library of physics is compiled and linked with host model

These two steps are executed automatically using the compile scripts for NEMSfv3gfs

What will not be covered in this training

- FV3GFS-specific training
  - Please refer to the EMC-led tutorial at https://vlab.ncep.noaa.gov/group/fv3gfs/

What to Expect from this Training

- Overall understanding of the CCPP
- Status of CCPP development/use and future plans
- How to get the CCPP code and build/run with NEMSfv3gfs
  - How to switch suites
- How to do development with the CCPP
  - Change existing schemes
  - Add new schemes
  - Contribute code back
- Availability of documentation, resources, and help

At the end of training, please fill our survey so we can provide any additional information needed and improve future training