Fostering Vibrant Development of Physical Parameterizations via the CCPP

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July 17, AMS 28th Conference on Numerical Weather Prediction

DTC Developmental Testbed Center

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Common Community Physics Package

CCPP Physics

- A library of physical parameterizations
- https://github.com/NCAR/ccpp-physics

CCPP Framework

- Software infrastructure that allows using the CCPP-Physics in a host model
- https://github.com/NCAR/ccpp-framework

CCPP Single Column Model

- A simple host model that employs the CCPP Physics and CCPP Framework
- https://github.com/NCAR/ccpp-scm

Motivations for the CCPP

COMMON COMMUNITY PHYSICS PACKAGE

Interoperability at the code level to foster collaborations

- A synergistic resource for research, development, transitions, and operations

Code Management

- Efficiency in physics development via centralization
- Process that facilitates research and transitions to operations

Hierarchical structure

- Promote process understanding and physics interactions
- Flexible for development; efficient for operations

Host Models Using CCPP

CCPP Single Column Model

- For hierarchical testing with CCPP

Unified Forecast System (UFS)

- For research and NOAA operations

US Navy Research Laboratory NEPTUNE model

- Using CCPP for pre-operational implementation tests

NCAR WRF, MPAS, CM1, CESM CAM-SIMA

- Experimental: Converting physics to CCPP-compliant

CCPP v6.0 Public Release – June 2022

- Released as standalone (with SCM)
- Central hub: https://dtcenter.org/ccpp
- 23 supported schemes and 6 suites
- Online tutorial and documentation updated
  - SciDoc, TechDoc, and User's Guide
- Support provided via GitHub discussions
- See Heinzeller et al., 2023, GMD

Parameterizations in Authoritative CCPP Repository

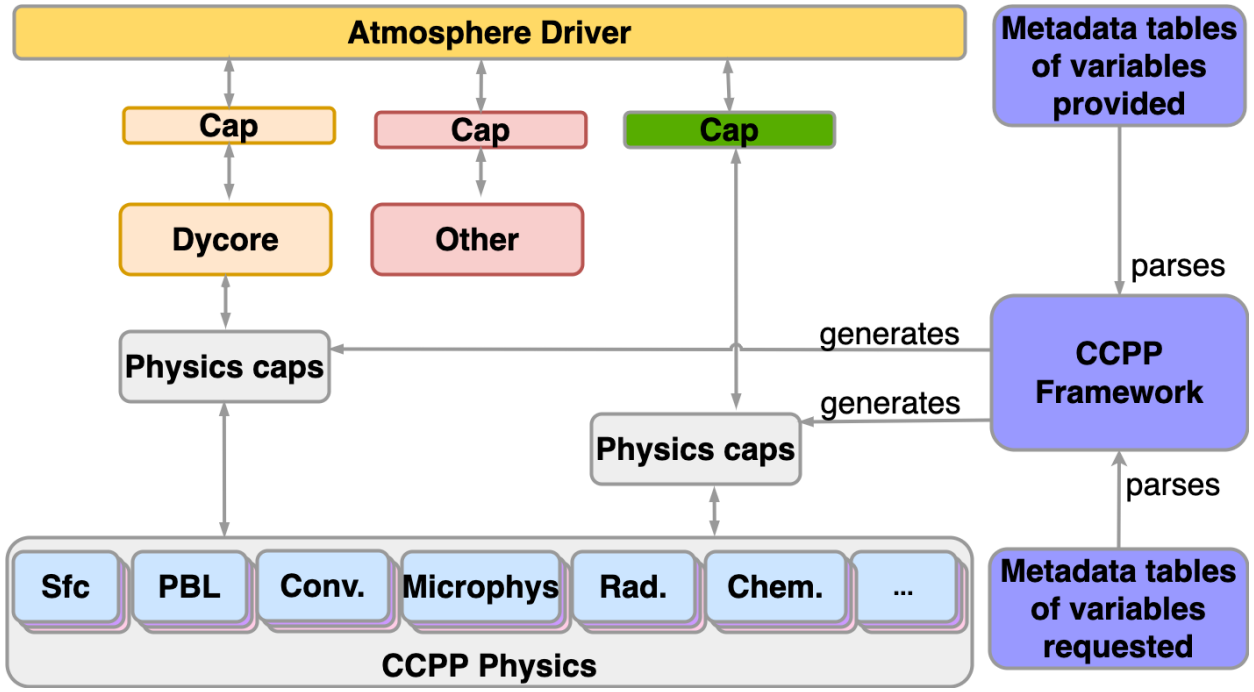
Microphysics	Zhao-Carr, GFDL, MG2-3, Thompson, F-A, NSSL
PBL	K-EDMF, old TKE-EDMF, TKE-EDMF, YSU, saYSU, MYJ
Surface Layer	GFS, MYNN, MYJ
Deep Convection	oldSAS, saSAS, RAS, Chikira-Sugiyama, GF, Tiedtke, C3
Shallow Convection	oldSAS, saSAS, RAS, GF, Tiedtke
Gravity Wave Drag	GFS orographic, GFS convective, GFS UGWP, uGWP v0, drag suite
PBL and Shal Convection	SHOC, MYNN
Radiation	RRTMG, RRTMGP
Surface (Land and Lake)	Noah, Noah-MP, RUC, CLM Lake, FLake
Ocean, Sea Ice	Near SST and Simple GFS ocean, Simple GFS sea ice
Ozone	2006 NRL, 2015 NRL
H_2O	NRL

Contributions
DTC
EMC
NSSL
PSL
GSL
OU
JCSDA

CCPP v6.0 Supported Parameterizations & Suites

Type	Operational	Developmental				
Suites	**GFS_v16**	**GFSv17_p8**	**RAP**	**RRFS_v1beta**	**WoFS**	**HRRR**
UFS regional	✅			✅	✅	✅
SCM	✅	✅	✅	✅	✅	✅
Microp	GFDL	Thomp	Thomp	Thomp	NSSL	Thomp
PBL	TKE EDMF	TKE EDMF	MYNN	MYNN	MYNN	MYNN
Sfc lay	GFS	GFS	MYNN	MYNN	MYNN	MYNN
Deep cu	saSAS	saSAS + CA	Grell-Freitas	N/A	N/A	N/A
Shal cu	saMF	saMF	Grell-Freitas	N/A	N/A	N/A
Radiation	RRTMG	RRTMG	RRTMG	RRTMG	RRTMG	RRTMG
GWP	cires_ugwp	unified_ugwp	drag_suite	cires_ugwp	cires_ugwp	drag_suite
LSM	Noah	NoahMP	RUC	NoahMP	Noah	RUC

CCPP Architecture with Framework



The **Framework** reads suites and outputs caps at compile time

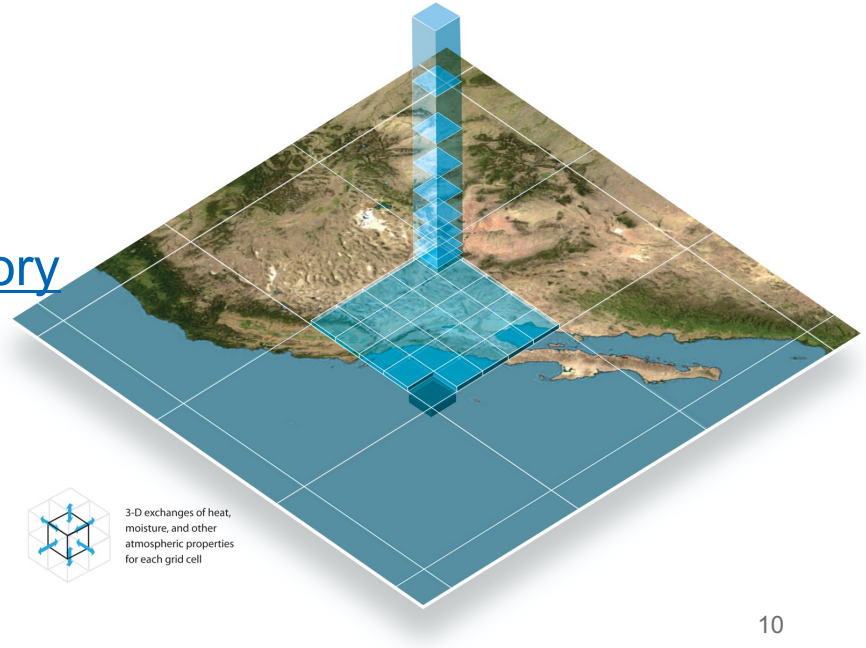
The **caps** communicate variables between host and physics at runtime

Capabilities Enabled by CCPP Framework include

- Altering order of schemes in suite
- Subcycling
- Unit conversions
- Fast and slow physics

CCPP Single Column Model Overview

- All CCPP schemes/suites are available to use with the SCM
- Decouples physics from dynamics for hierarchical studies
- Initialization from field program data
  - GASS/TWP-ICE (maritime convection; near Australia)
  - ARM Great Plains (continental convection)
  - EUCLIPSE/ASTEX (stratocumulus)
  - LASSO (shallow cumulus)
  - GABLS3 (mid-latitude continental)
  - Other cases offered through the DEPHY case repository

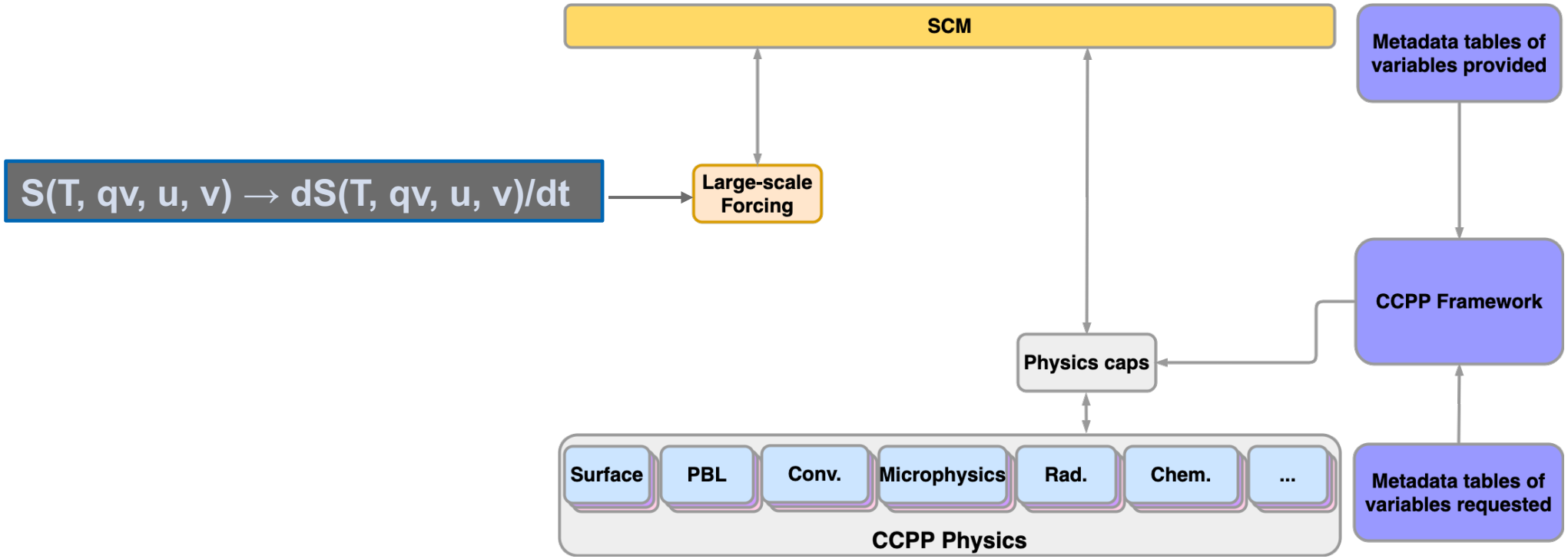


New and Updated Physics

- **New:** Community Convective Cloud (C3)
  - A merge of GF and saSAS convective schemes
  - A collaborative work-in-progress effort
- **New:** Community Land Model (CLM) Lake Model
  - 1-D lake model intended for small lakes
- **Updated:** Many!
  - Initial single-precision capability (thanks to NRL!)
  - GPU-compliancy: GF convection, Thompson mp, and MYNN sfc layer
  - Schemes for now-operational HAFS v1
  - Ongoing development for GFS v17, GEFS v13, RRFS v1
  - Readiness for experiments (HFIP, HWT, HMT, etc.)

Single Column Model: New Initialization and Capability

- **Parameterization simulator for SCM**
  - Ability to run a single parameterization, all others forced by data models
- **Initialization from UFS history files**
  - Enables more closely exploring the sources of UFS biases



Ongoing Work

- **Second-generation CCPP Framework – Lead: NCAR**
  - Lead development by NCAR CGD Lab
  - NCAR plans to adopt CCPP Framework in the System for Integrated Modeling of the Atmosphere (SIMA) and used it in CESM CAM-SIMA
  - DTC will integrate new development for use in UFS and CCPP SCM
- **Machine learning emulator for RRTM – Lead: NOAA `GSL non-DTC**
  - Starting point: Lagerquist et al., 2021 (JAOT)
  - Potential to substantially speed up radiation computations
- **GPU Compliancy - Lead: NOAA GSL non-DTC**
  - Several schemes now GPU compliant
  - Schemes tested with standalone drivers – substantial speedup
  - Currently integrating with Framework and host models

Opportunities for Engagement

- **CCPP hub at dtcenter.org/ccpp**
  - Code, documentation, tutorial, support
- **CCPP Visioning Workshop**
  - Registration is open at https://dtcenter.org/events/2023/ccpp-visioning-workshop
  - Virtual, week of August 14
  - Inform the community about capabilities
  - Discuss future direction
- **DTC Visitor Program (dtcenter.org/visitors)**
  - Propose a project to work with us!
    - PI – Up to 2 months salary, travel and per diem - can be multiple visits
    - Grad Student - Up to 1 year of temporary living per diem and travel expenses for graduate student, plus support for advisor visits

Summary

- Opportunities for collaborative physics development and testing
- Flexibility and configurability for research and development
- Performance for operations
- Ongoing development on multiple fronts
- Transitioned to NOAA operations (HAFS v1) in 2023
- Being integrated onto Navy and NCAR models
- Public releases and workshops offer opportunities for engagement

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2023 CCPP Visioning Workshop (virtual, week of August 14, 2023)

Who

- CCPP project leads and developers
- Physics and atmospheric composition/chemistry developers
- Scientists working on coupling for ESMs, especially physics-dynamics coupling
- NOAA, NCAR, NRL, NASA, academia, private sector, etc.

Committee: DTC, NCAR CGD and MMM, EMC, OU

Which models: UFS, SCM, NEPTUNE, SIMA etc.

Registration is open!
https://dtcenter.org/events/2023/ccpp-visioning-workshop

Goals

- Inform the community about capabilities
- Gather input from developers/SMEs
- Discuss best practices for interoperability and collaborative development
- Create a prioritized list of required advancements for CCPP

Desired outcome

- Common understanding of the state of CCPP and prioritized requirements and needs to meet scientific and technological frontiers in the next 5-10 years