CCPP Programmatic Overview

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NOAA GLOBAL SYSTEMS LABORATORY & DEVELOPMENTAL TESTBED CENTER

August 15, 2023 – CCPP Visioning Workshop

DTC Developmental Testbed Center

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

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

CCPP Standard Names

- Rules and dictionary
- https://github.com/ESCOMP/CCPPStandardNames

Brief History

- *Kalnay et al. (BAMS 1989) rules* spearheaded best practices in interoperability
  - Doyle et al. 2015: *Revisiting Kalnay's "Rules for Physics Interoperability" 25 Years Later* (AMS presentation)
- NOAA Next-Generation Global Prediction System (NGGPS) dycore test (2016)
  - Various hosts/dycores needed to run with the GFS physics suite
  - Interoperable Physics Driver was developed by EMC and later GFDL
- Physics Interoperability Team (NUOPC/ESPC/ICAMS): NCAR, NOAA, NRL
  - Specification of requirements for CCPP (2016/2017)
- CCPP gets started funded by NOAA

Common Community Physics Package (CCPP): Requirements for supported schemes/suites and driver layer

Developed by the Global Model Test Bed

Current 9/14/2017

Approval/Signature

Date 10/19/2017 — NWS EMC Director — MIKE FARRAR

Date 10/17/2017 — NGGPS Program Manager — FREDERICK TOEPFER

Hosts Using CCPP

CCPP Single Column Model

- For hierarchical testing with CCPP

Unified Forecast System (UFS)

- For research and NOAA operations

CMEPS Mediator (aka coupler) used in UFS and NCAR models

- Used CCPP on exchange grid to compute fluxes atmosphere-ocean fluxes

US Navy Research Laboratory NEPTUNE model

- Using CCPP for pre-operational implementation tests

NCAR

- **WRF, MPAS, CM1**
  - Converting physics to CCPP-compliant
- **CESM CAM-SIMA**
  - Converting physics to CCPP-compliant
  - Developing CCPP Framework

Other modeling systems have contacted us and are exploring CCPP

NCAR-NOAA Memorandum of Agreement (2019)

MEMORANDUM OF AGREEMENT

AMONG THE

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

ACTING ON BEHALF OF THE

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

AND THE

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

AND THE

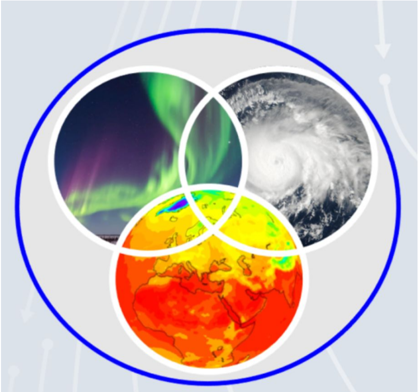
OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

FOR

CO-DEVELOPMENT OF COMMON MODELING INFRASTRUCTURE

concluded that the CCPP framework satisfies many NCAR requirements, paving the way

- Expressed an intention of collaborating in modeling infrastructure
- Limited resources available at NCAR until recently
- Now CCPP is an integrant of NCAR's System for Integrated Modeling the Atmosphere



CCPP in the UFS

- After a detailed testing and acceptance period, CCPP now a cornerstone of UFS infrastructure
- Integrated into the UFS Weather Model, used for all Apps
- Became operational in the Hurricane Analysis and Prediction System (HAFS) v1 in June 2023
- On target for operational implementation in the upcoming
  - Global configurations
    - Medium-range weather: GFS
    - Sub-seasonal: GEFS
    - Seasonal: SFS
  - Regional Configuration
    - Short-range weather: RRFS

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, C3
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 Governance

- CCPP Framework Developers Committee
  - Discusses upcoming directions for Framework development
  - Reviews proposed changes to Framework and Standard Names
- CCPP Physics Code Management Team
  - Representatives from all organizations actively contributing
  - Discusses collaboration and interoperability issues
- Points of Contact for Each Primary Scheme
  - Review proposed changes to CCPP Physics
  - Assist with documentation

CCPP v6.0 Public Release – June 2022

- Released as standalone (with SCM) and within UFS SRW App
- 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

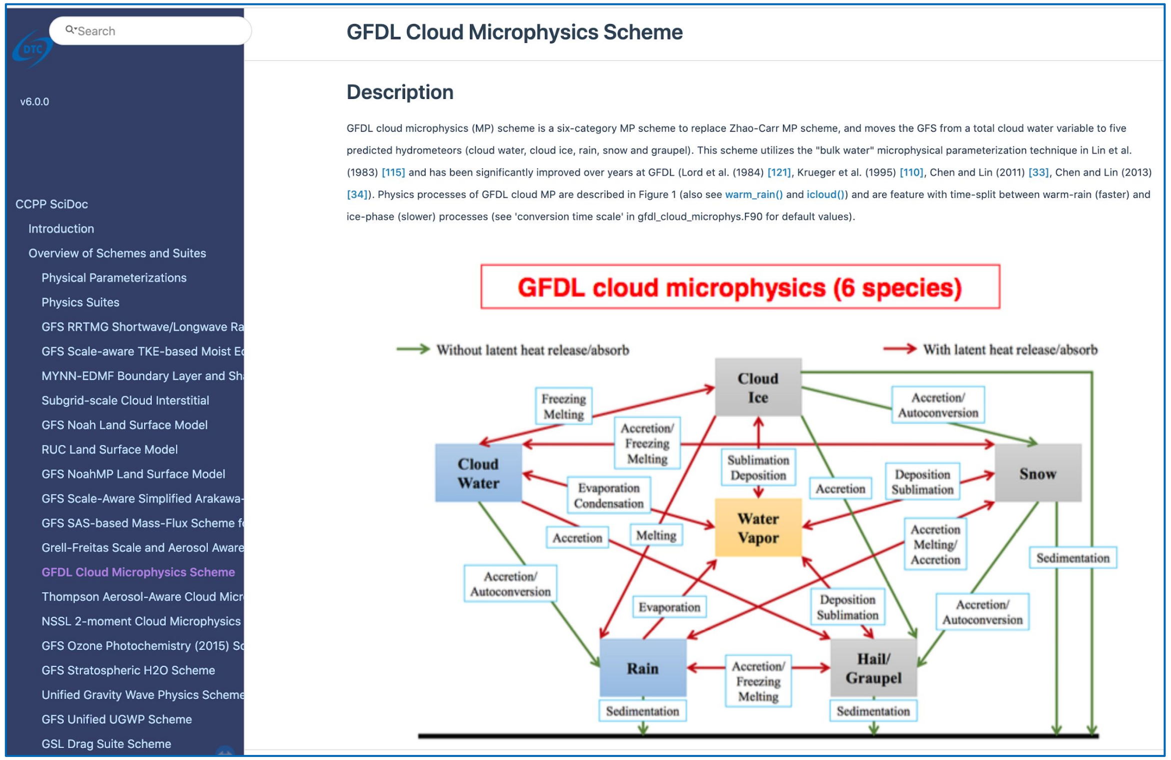
Also available: CCPP tags associated with with *major events* (e.g., UFS App releases)

CCPP v6.0 Supported Parameterizations & Suites

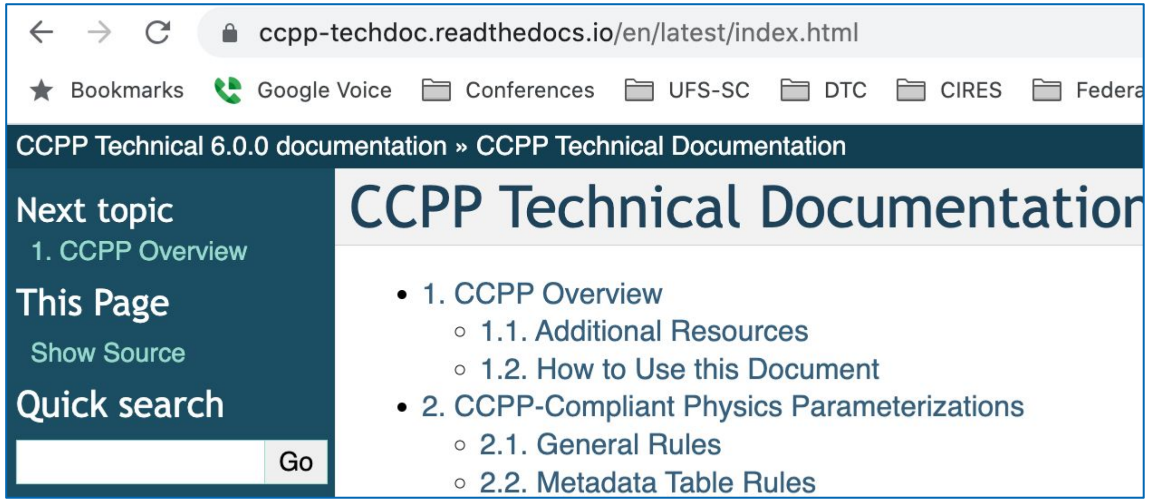
Type	Operational	Developmental				
Suites	GFS_v16	GFSv17_p8	RAP	RRFS_v1beta	WoFS	HRRR
UFS regional	✅			✅	✅	✅
SCM	✅	✅	✅	✅	✅	✅
Microp	GFDL	Thomp	Thomp	Thomp	NSSL	Thomp
PBL	TKE EDMF	TKE EDMF	MYNN	MYNN	MYNN	MYNN
Sfc lay	GFS	GFS	MYNN	MYNN	MYNN	MYNN
Deep cu	saSAS	saSAS + CA	Grell-Freitas	N/A	N/A	N/A
Shal cu	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 Documentation

Scientific Documentation



Technical Documentation

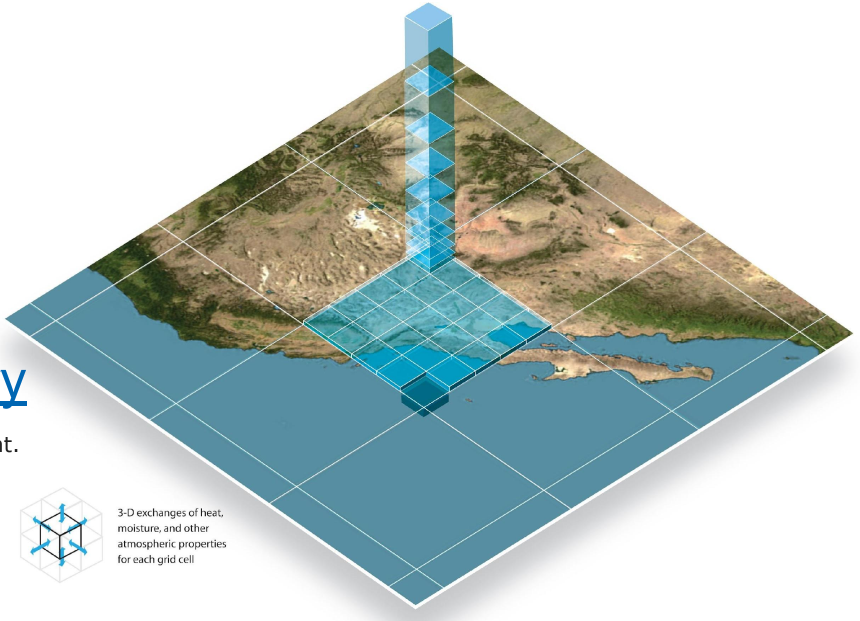


Also available

- CCPP SCM User's Guide
- Online tutorials
- Instructional videos
- FAQ

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 UFS (aka UFS replay)
- 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
    - BLLAST (BL afternoon transition; also https://bllast.aeris-data.fr/).
    - CASES-99 (GABLS2), Southern Great Plains, US, early autumn with a strong diurnal cycle with no clouds present.
    - AYOTTE cases (highly idealized cases; dry CBL).
    - DYNAMO: MJO initiation case.
    - MAGIC (all cruise legs): marine Sc cases.
    - GABLS4: Antarctic snow-covered SBL.
    - ISDAC: Arctic mixed-phase clouds (MP properties).
    - MPACE: ARM Mixed-Phase Arctic CloudExperiment.
    - RICO: trade-wind cumulus and rain process.
    - Sandu and Astex: Stratocumulus-to-Cumulus Transitions.
    - SCMS: Small Cumulus and Microphysics Study (1995 near Cocoa Beach, Florida US).

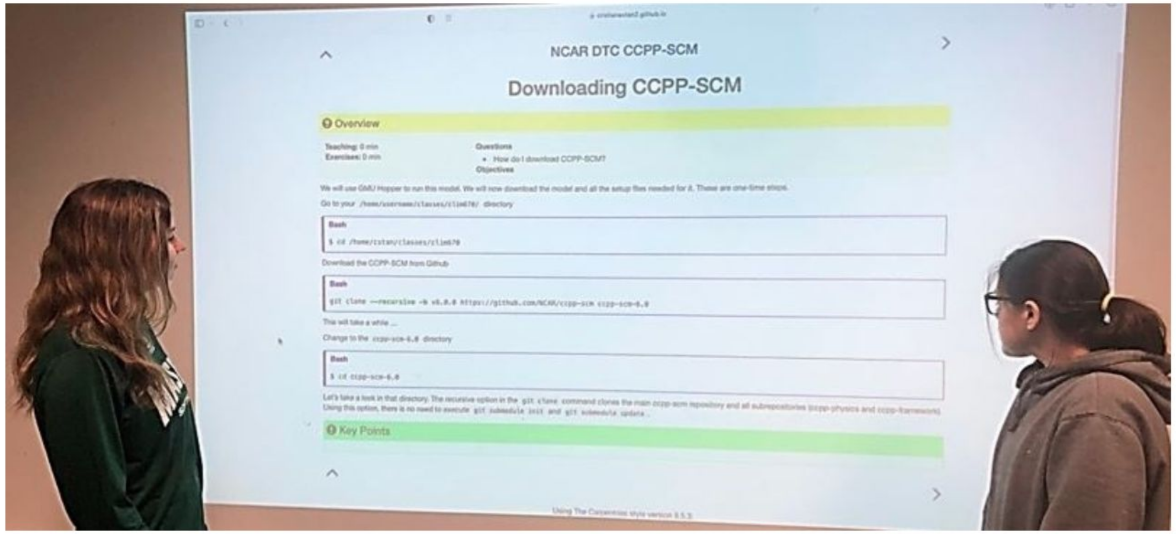


Recent: New and Updated Physics

- **New:** Community Convective Cloud (C3)
  - A forward looking scheme originating from GF and SAS
  - 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 testbed experiments (HFIP, HWT, HMT, etc.)

Frontiers: As More Groups/Models Adopt CCPP (I)

- Community Engagement
  - Documentation, training, support
    - Users
    - Developers
  - Classroom use Curriculum development
    - E.g., Cristiana Stan (GMU)



Students discussing an instructional slide

https://dtcenter.org/news/2023/01/using-ccpp-scm-teaching-tool

Frontiers: As More Groups/Models Adopt CCPP (II)

- Physics
  - Code management – keeping us all going forward together
    - Curation and governance
    - Coordinate multiple groups and repositories
    - Avoid duplications
  - Advance interoperability
    - Exercise schemes in multiple models to reach full interoperability
  - Prepare for future needs
    - 3D physics
    - Schemes entirely or partially based on AI
  - Interaction with chemistry modules

Frontiers: As More Groups/Models Adopt CCPP (III)

- Framework
  - Code Management - go forward together
  - Interoperability
    - Further development to meet the needs of all models
  - Additional capabilities
    - There is so much more we can automate to make our life simpler

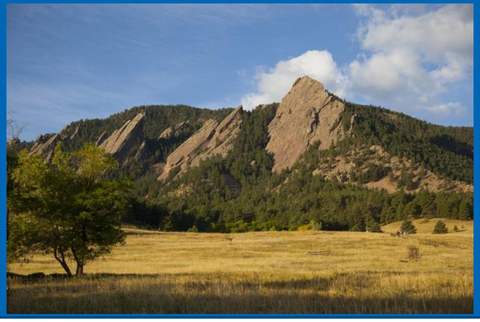
- Computational Architectures
  - Performance
  - New architectures, such as GPUs

Ongoing Work

- **Second-generation CCPP Framework – Lead: NCAR non-DTC**
  - 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
- **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
      - Plus support for advisor visits



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