https://dtcenter.org/community-code/common-community-physics-package-ccpp

The Common Community Physics Package (CCPP): a shared infrastructure for model physics for operations and research

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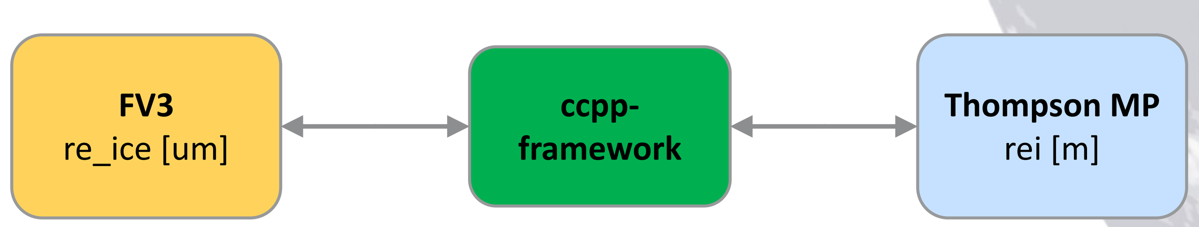
The Valley of Death

Improving numerical weather prediction systems depends critically on the ability to transition innovations from research to operations and to provide feedback from operations to research. This cycle, sometimes referred to as "crossing the valley of death", has long been identified as a major challenge for the U.S. weather enterprise.

As part of a broader effort to bridge this gap and advance U.S. weather prediction capabilities, the Developmental Testbed Center (DTC) has developed a shared infrastructure for model physics for operations and research, the Common Community Physics Package (CCPP), for application in NOAA's Unified Forecasting System (UFS). The CCPP consists of a library of physical parameterizations and a framework, which interfaces the physics with atmospheric models based on metadata information and standardized interfaces. The CCPP physics library contains parameterizations from the current operational U.S. global, mesoscale and high-resolution models, future implementation candidates, and other physics from NOAA and external organizations.

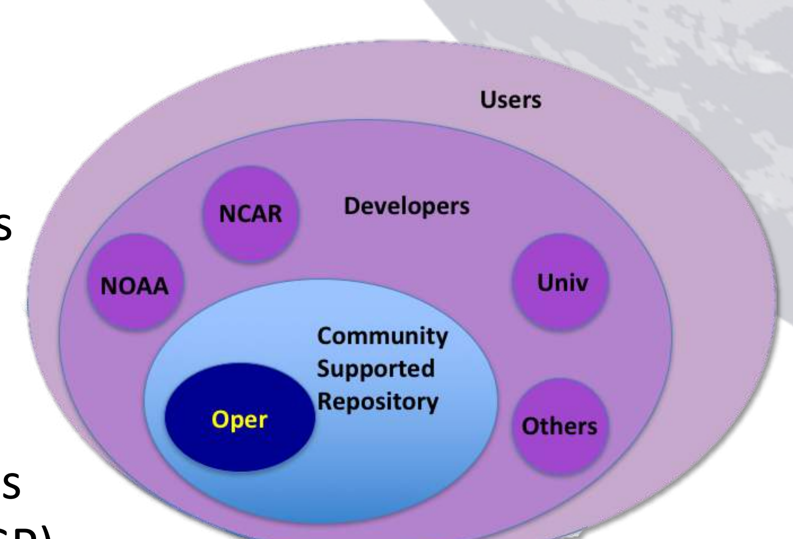
Key features

- Open source and accepting community contributions
- Dycore-agnostic to accelerate the transition of innovations
- Flexibility: compile-time configuration of physics suites (combinations of schemes into groups, support for sub-cycling)
- Performance: auto-generated Fortran API and suite/group caps
- Consistency check of host model variables and physics variables
- Automated unit conversions and handling of blocked model data



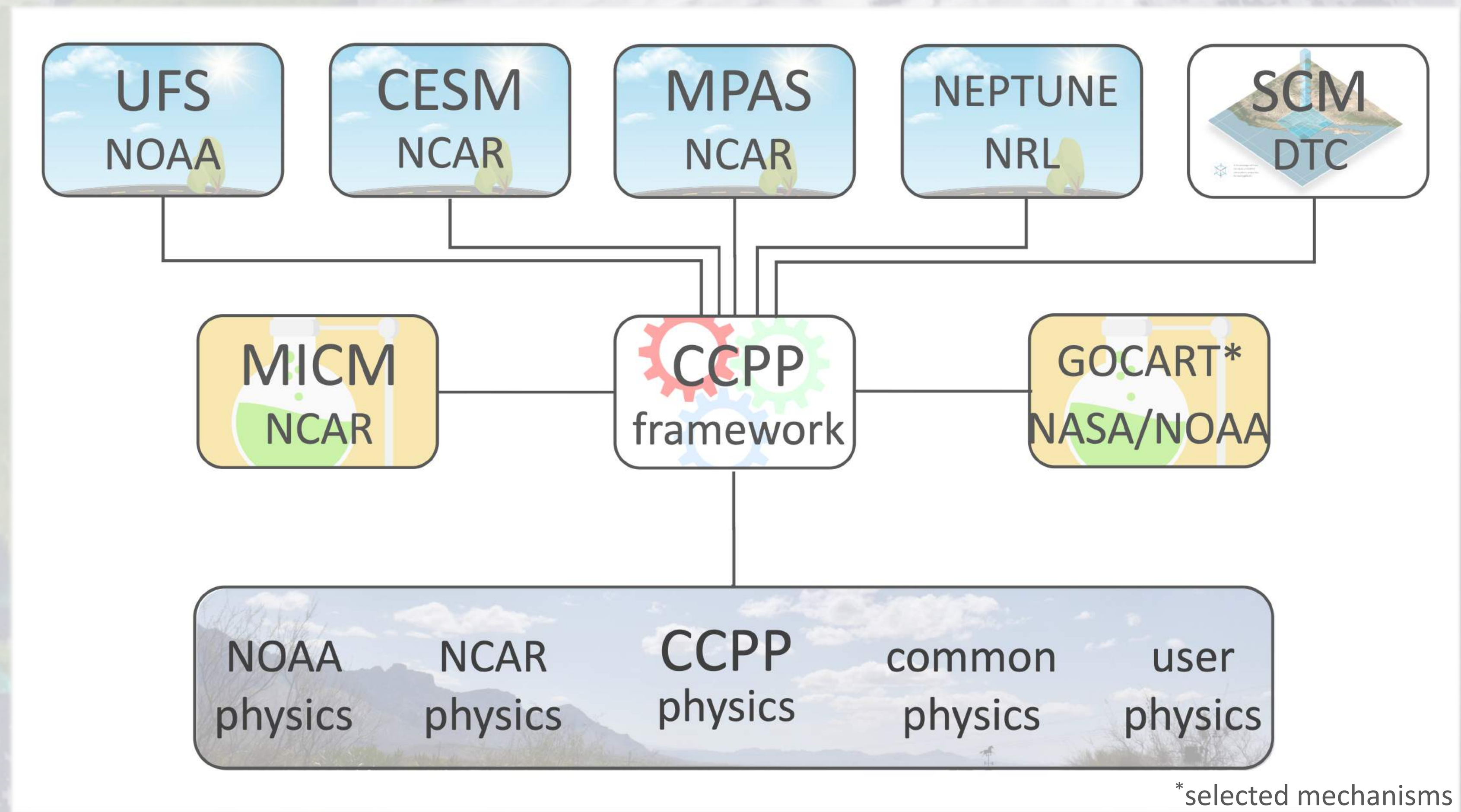
The CCPP ecosystem

- Multiple CCPP physics libraries can coexist and be used in one model
- The governance for these libraries lies with the sponsoring organizations to ensure quality and compliancy of the physics schemes
- CCPP physics libraries use submodules to point to external code (e.g. RRTMGP)



What makes a physics scheme CCPP compliant?

- Well-defined interfaces to the CCPP entry points are described by metadata tables (including variables in the argument list)
- Metadata contains variable standard names, units, dimensions
- Mandatory variables for error handling (host model has control)
- MPI communication only allowed for reading, computing and broadcasting lookup tables etc. (1-dim. column physics)
- More details can be found in the CCPP technical documentation https://ccpp-techdoc.readthedocs.io/en/latest/

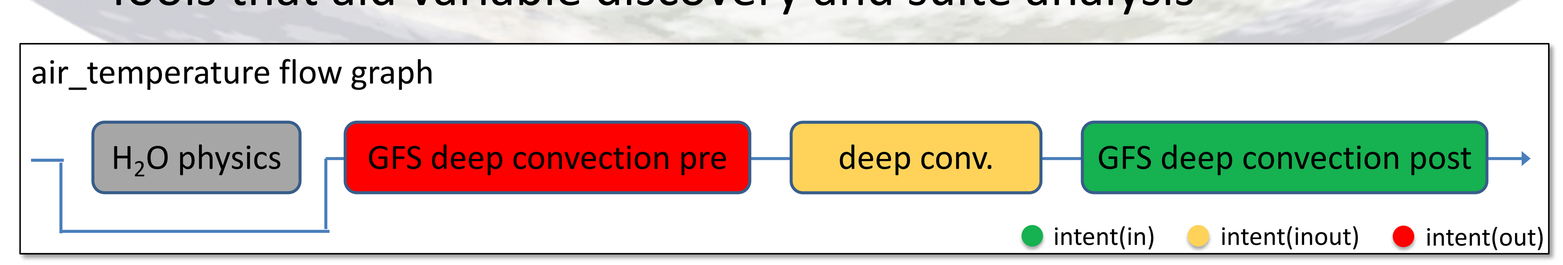


*selected mechanisms

Current and future developments

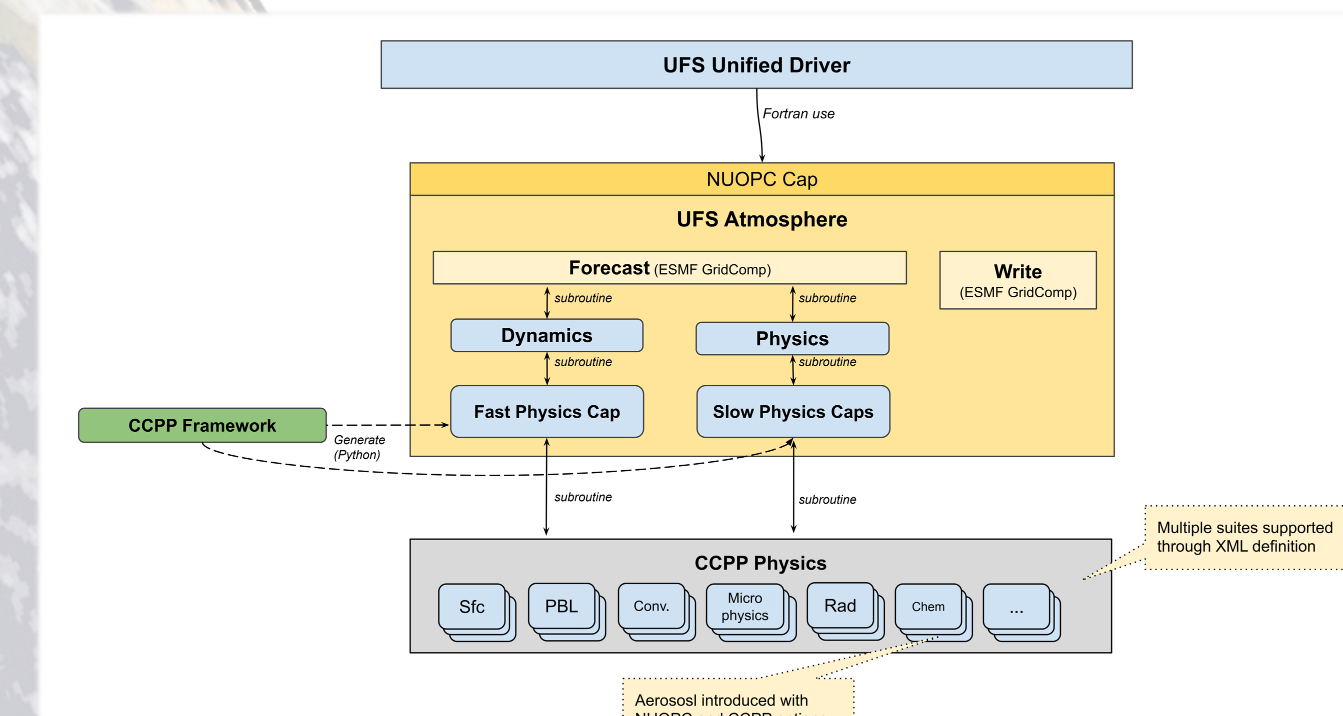
In 2020, NOAA and NCAR agreed to jointly develop CCPP as future infrastructure for connecting physics to atmospheric modeling systems. NOAA/UFS will transition to an updated ccpp-framework in 2021, which will open the door for the following improvements:

- Improved build system and code generator
- Automatic variable allocation for variables used by physics only
- Automated array transformations: (i,j,k) to (i,k) to (k,i) to …
- Automated calculation of derived variables: $\vartheta = f(T, Z_g)$ …
- Consistency checks of Fortran code versus variable metadata
- Dictionary of standard names and rules for composing names
- Tools that aid variable discovery and suite analysis



CCPP in the Unified Forecast System

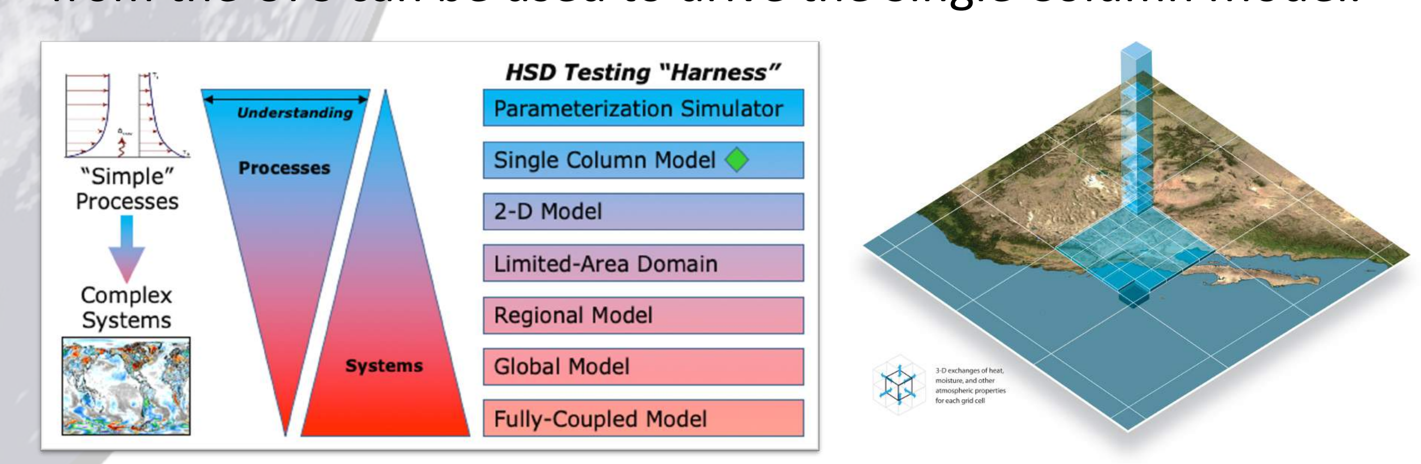
CCPP has been implemented in NOAA's Unified Forecast System (UFS) for future operational implementation in its various applications starting from 2022. CCPP handles calls to traditional ("slow") physics and "fast" physics processes that are tightly integrated into the GFDL FV3 dynamical core.



Courtesy: Rocky Dunlap

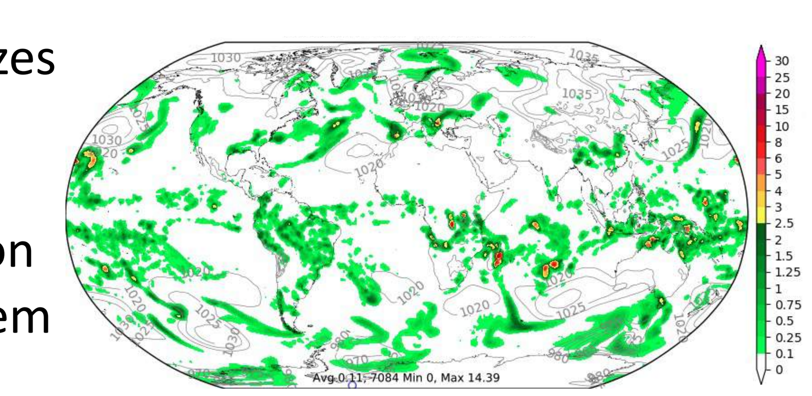
CCPP in the Hierarchical Testing Framework

CCPP plays an important role in the UFS Hierarchical Testing Framework. Using the CCPP Single Column Model developed by DTC, physics processes and their interplay can be studied outside of a full, 3-dimensional atmospheric model. Data from observational field campaigns and columns extracted from the UFS can be used to drive the Single Column Model.



CCPP in Navy's NEPTUNE model

The Naval Research Lab utilizes CCPP to call the GFS physics and other supported physics suites in their next-generation atmospheric prediction system system NEPTUNE.


Courtesy: Matus Martini

NEPTUNE-CCPP: 6-hour acc. precip and MSLP

Cooperative Institute for Research in Environmental Sciences
UNIVERSITY OF COLORADO BOULDER and NOAA

Glossary

UFS	Unified Forecast System (using FV3 dycore)
FV3	Finite-Volume Cubed-Sphere Dynamical Core
CESM	Community Earth System Model
MPAS	Model for Prediction Across Scales
SCM	Single Column Model
MICM	Model Independent Chemistry Module
GOCART	Goddard Chemistry Aerosol Radiation and Transport

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