Supported in part by the UFS-R2O Project co-funded by NWS/STI and WPO
(https://vlab.noaa.gov/web/ufs-r2o)

The Common Community Physics Package and its role as an enabler of Hierarchical System Development

Ligia Bernardet and Michael Ek

DTC CCPP developer team

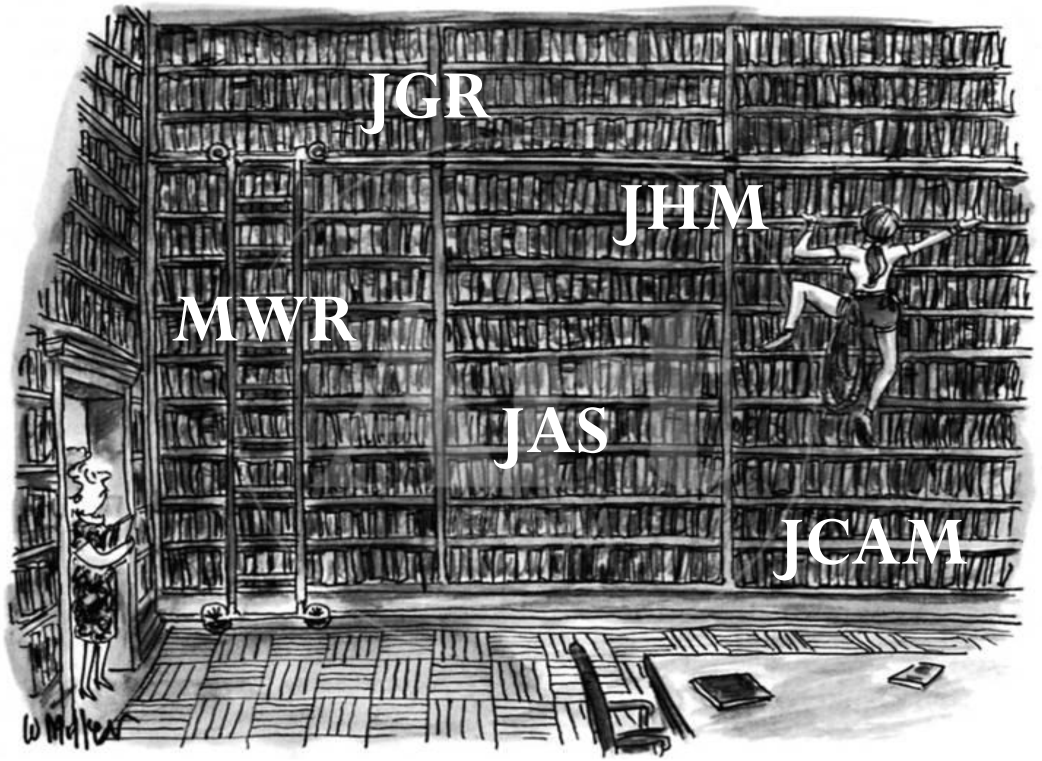
Dom Heinzeller, Grant Firl, Laurie Carson, Man Zhang, Julie Schramm, Xia Sun, Weiwei Li, Jimy Dudhia

Thanks also to Evan Kalina

UFS Webinar
14 October 2021

Research-to-Operations & Operations-to-Research

Previous Paradigm



A lot of great research!

…that needs to be identified/transitioned

"Toss it over the fence" ?!

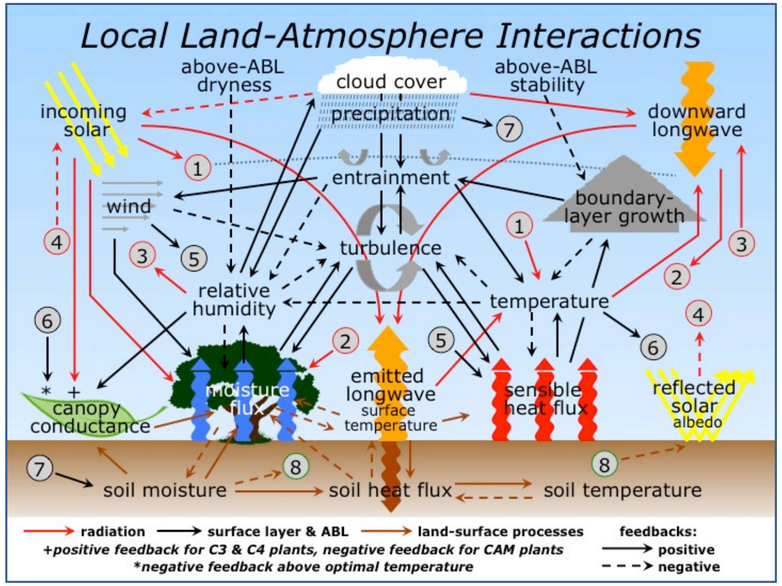
How can we help to improve this process?

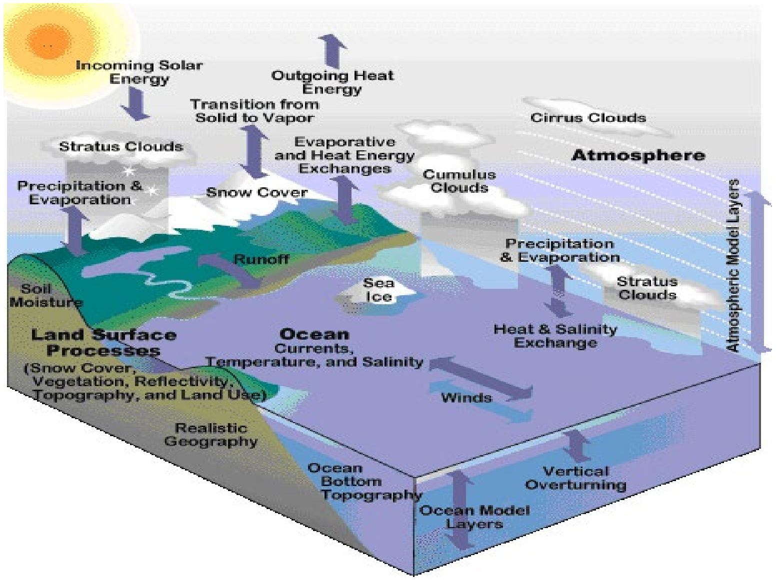
Hierarchical System Development. *What is it?*

- Hierarchy (from taxonomy): an arrangement or classification of things according to relative importance or inclusiveness.
- Hierarchical System Development (HSD): a systematic approach that tests small elements (e.g. physics schemes) of an Earth System Model (ESM) first in isolation, then progressively connects those elements with increased coupling between ESM components, all the way up to a fully-coupled global model.
- *System* in HSD is end-to-end in that it includes data ingest and quality control, data assimilation, modeling, post-processing, and verification.
- Necessary to have an efficient infrastructure to connect the HSD steps for an effective R2O2R process.

Hierarchical System Development. *Why do we need it?*

- To understand model biases, we often need to simplify the atmosphere down to a few key processes and interactions.
- To save compute resources by identifying/fixing bugs early in the testing process.
- There are **many** Earth System process to consider, from local to regional & global.





Hierarchical System Development: *Some Background*

- Climate workshop in 2016, where climate community uses hierarchical approach to test Earth system components first for better understanding and proper use of CPU/HPC resources, before fully-coupled ESM runs with long simulations.


WCRP
World Climate Research Programme
About WCRP | Core Projects | Unifying Themes | Grand Challenges | Lighthouse

Model Hierarchies Workshop

Princeton University, New Jersey, USA, 2-4 November 2016

The Modeling Hierarchies Workshop will be held on the campus of Princeton University, New Jersey, USA. The meeting will run from 13:00, 2 November 2016 to 17:00, 4 November 2016. This meeting is held in conjunction with WSCM-20, which runs from 1-2 November 2016.

Background

In "On Exactitude in Science", the Argentinian writer Borges tells the parable of a nation bankrupted by its cartographers, who endeavoured to create a map of the country on the scale of the country itself. It is sometimes argued that builders of Earth System models, which continue to grow in resolution and complexity, somewhat resemble Borges' mapmakers. Models so intricate that their behaviour is as rich and mysterious as the planet's itself, may

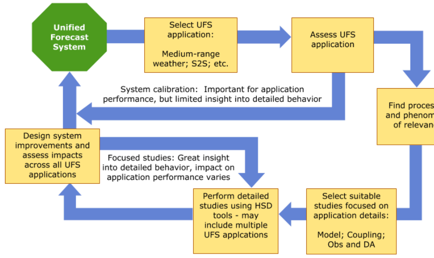
Venue

PRINCETON UNIVERSITY

Princetown University
McDonnell Hall

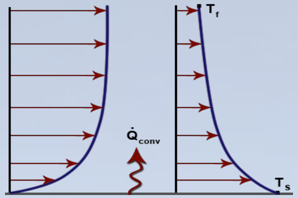
https://www.wcrp-climate.org/gc-model-hierarchies-home

- Tim Palmer (Univ. Oxford, UK MetOffice, ECMWF): "***Hierarchical thinking should be second nature for all weather/climate scientists (of course).***"
- Also, Julia Slingo's (UK Met Office) 2017 review of/report on WCRP. ***Findings: (1) increase focus on process-level understanding for model improvement, (2) connect Weather&Climate.***
- Christian Jakob (Monash U., Australia; AMS BAMS 2010): ***"To address long-standing systematic errors, community needs to improve the diagnosis of key processes contributing to these errors, and more model developers are needed."***
- See article that leverages Jakob (2010), which is HSD focused:
  www.ufscommunity.org/articles/hierarchical-system-development-for-the-ufs



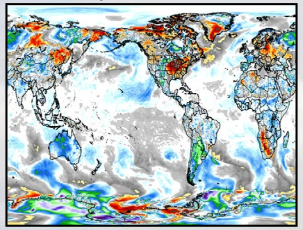
HSD in the UFS Development Process (Figure adapted from Christian Jakob, BAMS 2010)

Hierarchical System Development (HSD): *A simple-to-more-complex comprehensive approach to identify systematic biases and improve models*

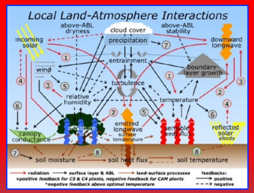


Single Processes

Complex Systems



Processes



e.g. land-PBL

Systems

Understanding

HSD Testing "Harness"

Process-level assessments

- **Physics Process Simulator**
- **Single Column Model** ◆
- **2-D Model**
- **Limited-Area Model**
- **Regional Model** ★
- **Global Model** ★
- **Fully-Coupled Model** ★

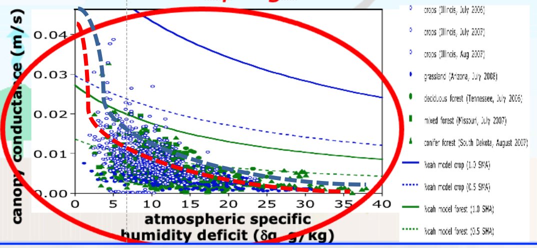
Drive and validate models using observational, model output and idealized data sets with "cumulative benchmarks"

◆ Simplest framework for intra-suite physics interaction

✈ May involve cold starts or cycled runs

Hierarchical System Development: *Examples*

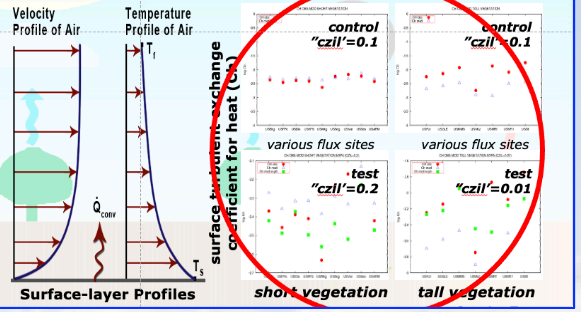
- **GOAL**: Improve canopy conductance (gc) (to calculate ET).
- **TOOL**: CCS code determines canopy conductance from land model (e.g. Noah) used in meso-NAM and medium-range GFS.
- **METHOD**: Use incoming solar, air temperature, specific humidity deficit & soil moisture (S↓, Tair, δq, Θ) observations to drive CCS, and compare with "observed" (inferred) gc from independent fluxnet obs of sensible & latent heat flux (H, LE).
- **FINDINGS**: Bias in gc for δq (dryness of air) a function of vegetation type: too small (large) for high (low) observed gc.
- ***ACTION**: Adjust coefficient term for δq in gc formulation.*
- **FOLLOW-ON**: Repeat for other gc factors, i.e. S↓, Tair, Θ, and additional factors such as CO_2 & soil temp., using other fluxnet data (add'l veg types).



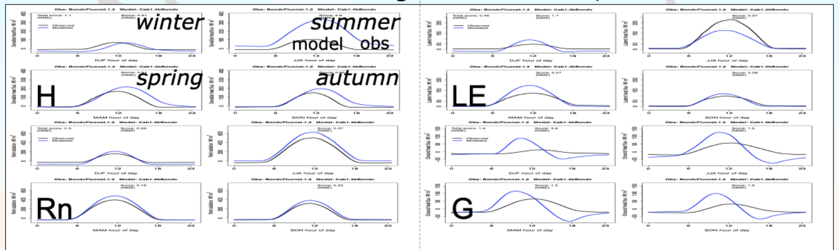
Canopy conductance: surface moisture flux sub-component.

Surface-layer exchange coefficient: surface heat flux sub-component.

- **GOAL**: Improve surface turbulent exchange coefficient for heat (Ch).
- **TOOL**: SLS code simulates surface-layer schemes, e.g. from meso-NAM and medium-range GFS.
- **METHOD**: Use fluxnet observations to drive SLS (10-m U, 2-m T & q, and surface skin temperature, Tsfc) and compare with inferred Ch from observed surface fluxes (H, LE, τ).
- **FINDINGS**: Bias in Ch dependent on vegetation height.
- ***ACTION**: Adjust Ch thermal parameter as a function of veg hgt.*
- **FOLLOW-ON**: Repeat procedure for surface drag coefficient (Cd).



- **GOAL**: Improve land-surface model fluxes.
- **TOOL**: Land model benchmarking, i.e. How good model needs to be? Then run model & ask: Does model reach required level?
- **METHOD**: Protocol for the Analysis of Land Surface models, GEWEX/GLASS project; compare with statistical approaches.
- **FINDINGS**: Systematic biases for different vegetation classes, seasons, diurnal cycle, in particular latent heat flux.
- ***ACTION**: Review land-model subcomponent algorithms.*
- **FOLLOW-ON**: Evaluate using add'l data sets; momentum flux.

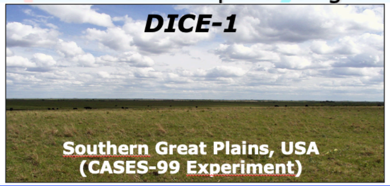


PALS example: CABLE (BOM/Aust.) land model, Bondville, IL, USA (cropland), 1997-2006, avg diurnal cycles.

Land model only study: focus on surface fluxes.

Single column model study: focus on land-atmosphere interaction.

GOAL: Improve land-atmosphere interaction.
TOOL: Assess impact of land-atmosphere feedbacks via the Diurnal land-atmosphere coupling experiment (DICE) approach (cooperative GEWEX/GLASS-GASS project).
METHOD: Stage 1: stand-alone land model, and stand-alone single column model (SCM). Stage 2: Coupled land-SCM. Stage 3: Sensitivity of LSMs and SCMs to variations in forcing. DICE-1 cases from CASES-99 field program (US southern Great Plains).
FINDINGS: Surface fluxes in land-atmosphere coupling are an important mechanism to represent more properly in our models.
***ACTION**: Review/refine land-model surface flux calculations.*
FOLLOW-ON: Repeat using other SCM data sets (e.g. Dome C).



But these were "one-off" studies.

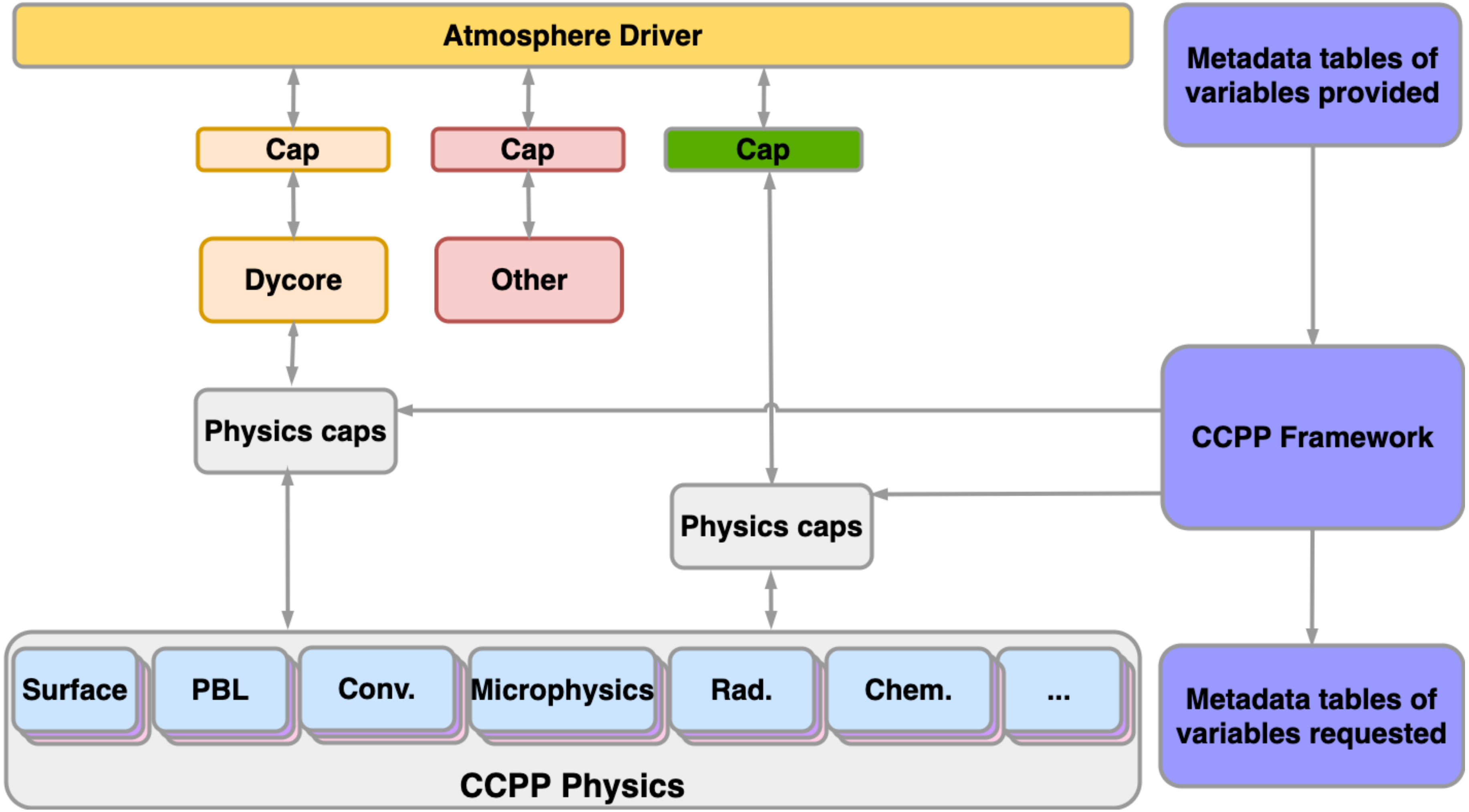
Hierarchical System Development. *How can we use it?*

- **How to make Hierarchical System Development work for R2O2R?**
- **One piece of this is the Common Community Physics Package!**
- **…where CCPP is an important enabler of the HSD.**

CCPP Elements

- **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 Architecture



DTC Developmental Testbed Center

CCPP Physics

CCPP-Physics: Primary Parameterizations

Microphysics	Zhao-Carr, GFDL, MG2-3, Thompson, Ferrier-Aligo
PBL	K-EDMF, TKE-EDMF, moist TKE-EDMF, YSU, saYSU, MYJ
Surface Layer	GFS, MYNN, MYJ, GFDL
Deep Convection	oldSAS, saSAS, RAS, Chikira-Sugiyama, GF, Tiedtke
Shallow Convection	oldSAS, saSAS, RAS, GF, Tiedtke
PBL and Shal Convection	SHOC, MYNN
Radiation	RRTMG, RRTMGP
Gravity Wave Drag	GFS orographic, GFS convective, uGWD, RAP/HRRR drag suite
Land Surface	Noah, Noah-MP, RUC
Ocean / Lake	Simple GFS ocean, NSST, FLake
Sea Ice	Simple GFS sea ice, RUC
Ozone	2006 NRL, 2015 NRL
H_2O	NRL

Implementation
- DTC
- NOAA GSL
- NOAA PSL
- OU
- NOAA EMC

There are also *interstitial* schemes in the CCPP : “glue” code between primary schemes

CCPP Physics: Upcoming contributions

- **New schemes on the horizon**
  - Community Land Model (CLM) lake model (GSL)
  - NSSL 2-moment microphysics (NSSL)
- **GPU-compliant schemes** (GSL)
- Transition of **Noah-MP** to refer to its authoritative repository (EMC)

Lots of opportunity for streamlining/modernizing existing code

What makes a parameterization CCPP compliant?

```
module myscheme
  implicit none
  contains

!> \section arg_table_myscheme_run Argument Table
!! \htmlinclude myscheme_run.html
!!
  subroutine myscheme_run(ni, psfc, errmsg, errflg)
    integer,            intent(in)    :: ni
    real,               intent(inout) :: psfc(:)
    character(len=*),   intent(out)   :: errmsg
    integer,            intent(out)   :: errflg
    ...
  end subroutine myscheme_run

end module myscheme
```

```
[ccpp-table-properties]
  name = myscheme
  type = scheme
  dependencies = ...
[ccpp-arg-table]
  name = myscheme_run
  type = scheme
[ni]
  standard_name = horizontal_loop_extent
  long_name = horizontal loop extent
  units = count
  dimensions = ()
  type = integer
  intent = in
  optional = F
[psfc]
  standard_name = surface_air_pressure
  long_name = air pressure at surface
  units = Pa
  dimensions = (horizontal_loop_extent)
  type = real
...
```

Five possible phases of a CCPP scheme

1. **init**

initializes physics (e.g. look-up tables)

2. **timestep_init**

time-dependent (but domain-decomposition independent) calculations

2. **run**

executes the bulk of the parameterization during integration

2. **timestep_finalize**

time-dependent (but domain-decomposition independent) calculations (e.g. global diagnostics)

3. **finalize**

cleans up allocated memory and any other final operations

invoked once per run (init)

invoked once per physics timestep (timestep_init, run, timestep_finalize)

invoked once per run (finalize)

More About CCPP-Compliant Schemes

- **Error handling.** Schemes cannot stop the model and must gracefully pass stop error flags and messages to the host model
- **Modern Fortran.** Schemes should not have common blocks, should explicitly declare all variables, and avoid *goto* statements
- **Compiler bounds check.** Schemes should use assumed-shape array dimensions to enable compiler bounds check
- **Hooks to scientific documentation**. Schemes should have markup comments used by Doxygen, the software employed to create the scientific documentation

```
!> \section arg_table_myscheme_run Argument Table
!! \htmlinclude myscheme_run.html
!!
  subroutine myscheme_run(ni, psfc, errmsg, errflg)
```

DTC Developmental Testbed Center

For complete description, see CCPP Tech Doc

Metadata: also used for Scientific Documentation

CCPP Scientific Documentation

v5.0.0

Search

GFDL Cloud Microphysics Module

This is cloud microphysics package for GFDL global cloud resolving model. The algorithms are originally derived from Lin et al. (1983) [107]. most of the key elements have been simplified/improved. This code at this stage bears little to no similarity to the original Lin MP in zetac. therefore, it is best to be called GFDL microphysics (GFDL MP) . More...

Detailed Description

Author

Shian-Jiann Lin, Linjiong Zhou

The module contains the GFDL cloud microphysics (Chen and Lin (2013) [31]). The module is paired with **GFDL In-Core Fast Saturation Adjustment Module**, which performs the "fast" processes.

The subroutine executes the full GFDL cloud microphysics.

Argument Table

local_name	standard_name	long_name	units	type	dimensions	kind	intent	optional
levs	vertical_dimension	number of vertical levels	count	integer	()		in	False
im	horizontal_loop_extent	horizontal loop extent	count	integer	()		in	False
con_g	gravitational_acceleration	gravitational acceleration	m s-2	real	()	kind_phys	in	False
con_fvirt	ratio_of_vapor_to_dry_air_gas_constants_minus_one	rv/rd - 1 (rv = ideal gas constant for water vapor)	none	real	()	kind_phys	in	False
con_rd	gas_constant_dry_air	ideal gas constant for dry air	J kg-1 K-1	real	()	kind_phys	in	False
frland	land_area_fraction_for_microphysics	land area fraction used in microphysics schemes	frac	real	(horizontal_dimension)	kind_phys	in	False
garea	cell_area	area of grid cell	m2	real	(horizontal_dimension)	kind_phys	in	False
islmsk	sea_land_ice_mask	sea/land/ice mask (=0/1/2)	flag	integer	(horizontal_dimension)		in	False
gq0	water_vapor_specific_humidity_updated_by_physics	water vapor specific humidity updated by physics	kg kg-1	real	(horizontal_dimension, vertical_dimension)	kind_phys	inout	False
gq0_ntcw	cloud_condensed_water_mixing_ratio_updated_by_physics	cloud condensed water mixing ratio updated by physics	kg kg-1	real	(horizontal_dimension, vertical_dimension)	kind_phys	inout	False
gq0_ntrw	rain_water_mixing_ratio_updated_by_physics	moist mixing ratio of rain updated by physics	kg kg-1	real	(horizontal_dimension, vertical_dimension)	kind_phys	inout	False
gq0_ntiw	ice_water_mixing_ratio_updated_by_physics	moist mixing ratio of cloud ice updated by physics	kg kg-1	real	(horizontal_dimension, vertical_dimension)	kind_phys	inout	False
gq0_ntsw	snow_water_mixing_ratio_updated_by_physics	moist mixing ratio of snow updated by physics	kg kg-1	real	(horizontal_dimension, vertical_dimension)	kind_phys	inout	False

Link to CCPP Scientific Documentation: https://dtcenter.ucar.edu/GMTB/v5.0.0/sci_doc/index.html

CCPP Scientific Documentation

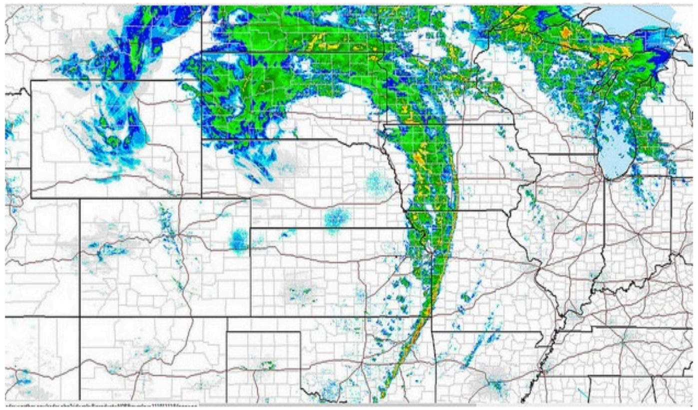
CCPP Scientific Documentation
v5.0.0

Search

- CCPP Scientific Documentation
  - Introduction
  - Parameterizations and Suites Overview
  - GFS_v15p2 Suite
  - GFS_v16beta Suite
  - GSD_v1 Suite
  - csawmg Suite
  - RRFS_v1alpha Suite
  - Namelist Options Description
  - Bibliography
  - CCPP-Physics Modules

Introduction

Welcome to the scientific documentation for the parameterizations available in the Common Community Physics Package (CCPP) v5.0.0 and the suites that can be configured using them.



The CCPP-Physics is envisioned to contain parameterizations used in NOAA's Unified Forecast System (UFS) applications for weather through seasonal prediction timescales, encompassing the current operational GFS schemes as well as developmental schemes under consideration for upcoming operational implementations. New in this release is suite RRFS_v1alpha, which is being tested in the UFS Short-Range Weather Application for future use in the convective-allowing Rapid Refresh Forecast System (RRFS), slated for operational implementation in 2023. Convection-allowing models allow us to begin to resolve the fine details within storm systems that are necessary for the accurate predition of high-impact events such as tornadoes, flash floods, and winter weather. Experience gained from the development of earlier operational and experimental convective-allowing models (CAMs), such as the High Resolution Rapid Refresh (HRRR) and HRRR Ensemble (HRRRE), the North American Mesoscale Forecast System (NAM) nests, the NSSL Experimental Warn-on-Forecast System for ensembles (NEWS-e), the NCAR experimental CAM ensemble, and GFDL's FV3-based CAM efforts, guide this process.

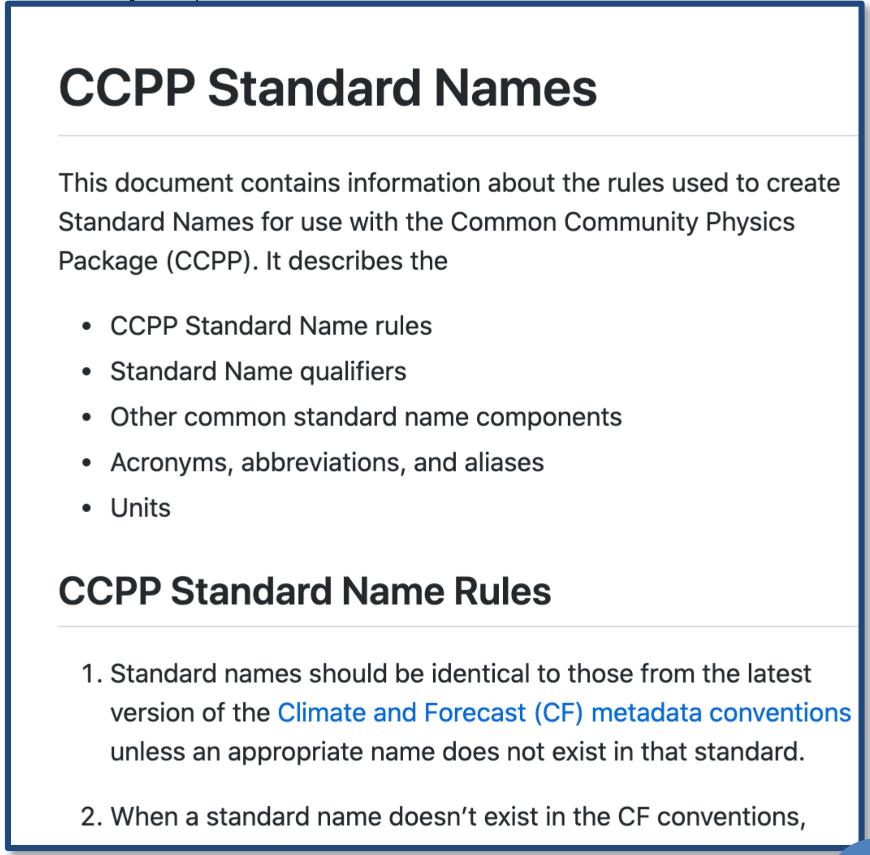
The CCPP parameterizations are aggregated in suites by the host models. The CCPP Single Column Model (SCM), developed by the Development Testbed Center, supports suites GFS_v15p2, GFS_v16beta, GSD_v1, csawmg, and RRFS_v1alpha, while the UFS Short-Range Weather Application supports suites GFS_v15p2 and RRFS_v1alpha. The UFS Medium-Range Weather Application is not intended for use with CCPP v5.0.0.

In this website you will find documentation on various aspects of each parameterization, including a high-level overview of its function, the input/output argument list, and a description of the algorithm. More details about this and other CCPP releases may be found on the CCPP website hosted by the Developmental Testbed Center (DTC).

Link to CCPP Scientific Documentation: https://dtcenter.ucar.edu/GMTB/v5.0.0/sci_doc/index.html

CCPP Standard Names: Rules and Dictionary

- Standard names are a **key aspect of the CCPP** since they are used to communicate variables between the host model and the physics
- Whenever possible, use **CF convention**
- If standard name not available in CF convention, invent new name
- **Problem:**
  - Lack of rules for creation of new names
  - Lack of mechanism to share existing names
- **Solution:** A new repository was created to house
  - Rules for creating standard names
  - Dictionary of standard names in use



CCPP Standard Names

This document contains information about the rules used to create Standard Names for use with the Common Community Physics Package (CCPP). It describes the

- CCPP Standard Name rules
- Standard Name qualifiers
- Other common standard name components
- Acronyms, abbreviations, and aliases
- Units

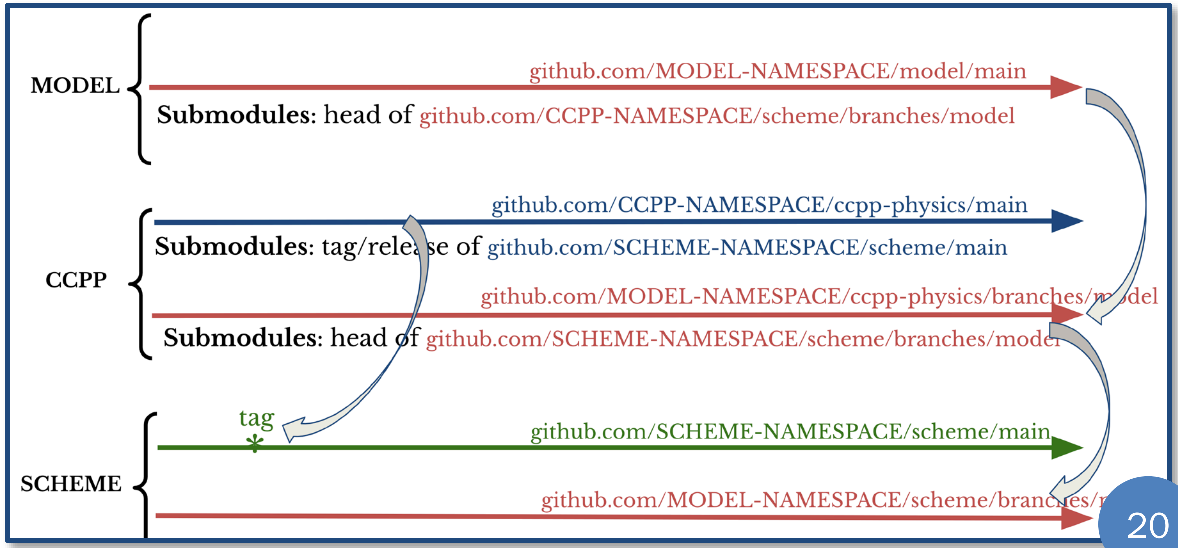
CCPP Standard Name Rules

1. Standard names should be identical to those from the latest version of the Climate and Forecast (CF) metadata conventions unless an appropriate name does not exist in that standard.
2. When a standard name doesn't exist in the CF conventions,

https://github.com/ESCOMP/CCPPStandardNames

CCPP Physics Code Management

- **Multi-institutional team:** DTC, NRL, NOAA, and NCAR
- **What do we want this collaborative effort to look like?**
- Various **common interests**, such as
  - Parameterizations for some processes
  - Collaborations with broader community
- **Topics addressed so far**
  - Code repository structure
  - Standardization of scheme names
  - Responsibilities for PR reviews
  - Best practices for interoperability
  - Dictionary of standard names



CCPP Framework

CCPP Suites

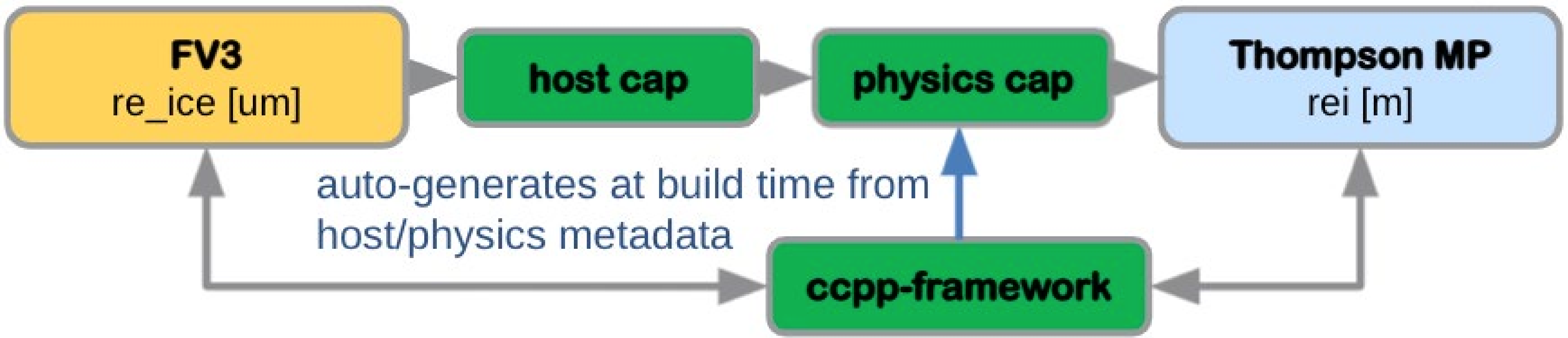
- The **Suite Definition File (SDF)** in XML format describes which schemes should be called at runtime

- The SDF enables various aspects of HSD
  - **Ordering**: user-defined order of execution of schemes (caution: proceed with carefully)
  - **Grouping**: schemes can be called in groups with other computations in between (e.g. dycore, coupling)
  - **Subcycling/iterations**: individual schemes can be called at higher frequency than others/dynamics

CCPP: Performance and Flexibility

CCPP must provide high performance for operations (fast execution and low memory footprint) and flexibility for research

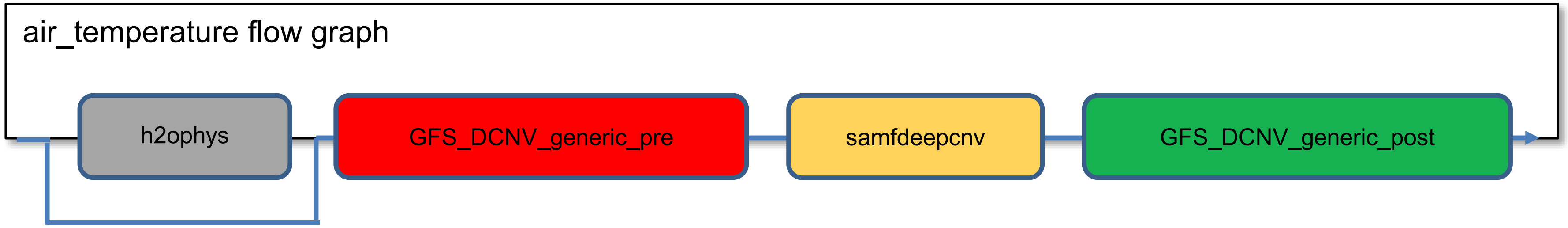
- When using CCPP, a physics driver is not employed, avoiding if/else statements. This makes for faster execution
- A multi-suite build is used, which retains the performance, while enabling researchers to use a variety of suites with a single executable
- Automatic unit conversions expedite development and transition



✓ Funded
⚠☐ Pending
➡☐Future

CCPP Framework – Outlook 1

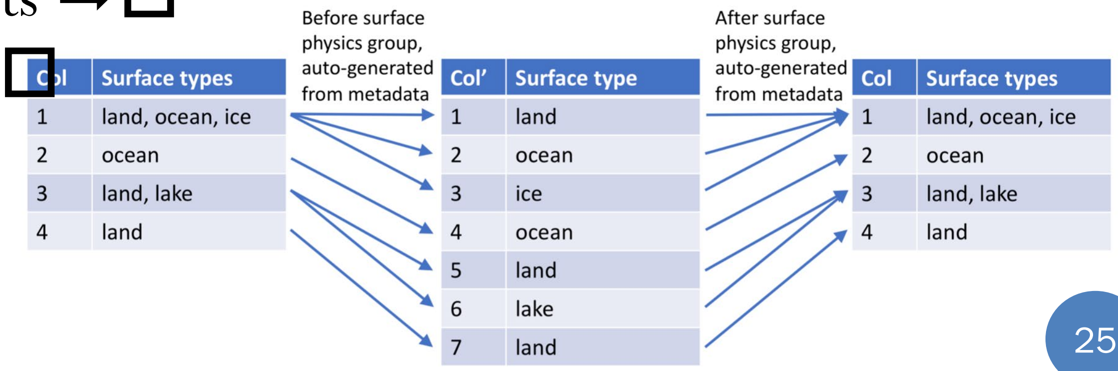
- **Facilitate addition of new schemes**
  - Automatic array transformations (i,k,j) to (i,k) to (k,i) ✓
  - Calculation of derived variables: e.g., pot. temp. from temp. and geopotential ✓
  - Vertical flipping ➡☐
- **Improve debugging and investigation**
  - Error handling including traceback information to replace existing error message/flag ✓
  - Extended diagnostic output capabilities from schemes (beyond tendencies) ➡☐
  - Visualization of how variables travel through a physics suite ✓



CCPP Framework – Outlook 2

✓ Funded
⚠☐ Pending
➡☐Future

- **Enable new capabilities in coupling**
  - Schemes to either update the model state or that return tendencies ➡☐
  - Suite definition file used to choose process- or time-split integration ➡☐
  - Ability to auto-generate a mediator cap for a CCPP scheme ➡☐
- **Increase performance**
  - Ability to use single vs double precision physics ⚠☐
  - Capability to dispatch physics to CPUs and GPUs⚠☐
- **Increase independence from hosts**
  - Automated saving of physics state for restarts ➡☐
  - Improved handling of constituent arrays ➡☐
  - Abstraction of surface composites ⚠☐



CCPP SCM

CCPP Single Column Model Overview

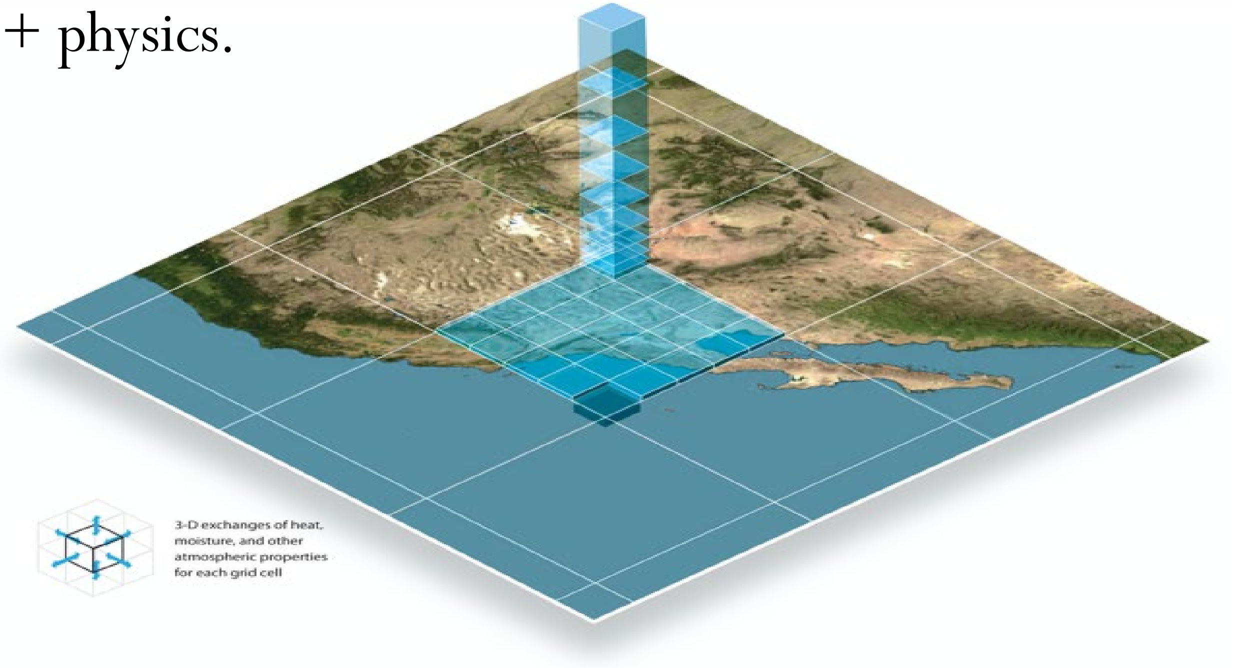
- Initial state (T, q, u, v) from observations, idealization, or model output.
- Forcing is applied to mimic changes in column state from surrounding environment (replaces dycore).
- Physics responds to changes in column state and in turn changes the column state.
- End state is a combination of forcing + physics.

Pros:

- Simple to develop.
- Easy to interpret.
- Computationally inexpensive.

Cons:

- Sensitive to forcings.
- Necessary but not sufficient.

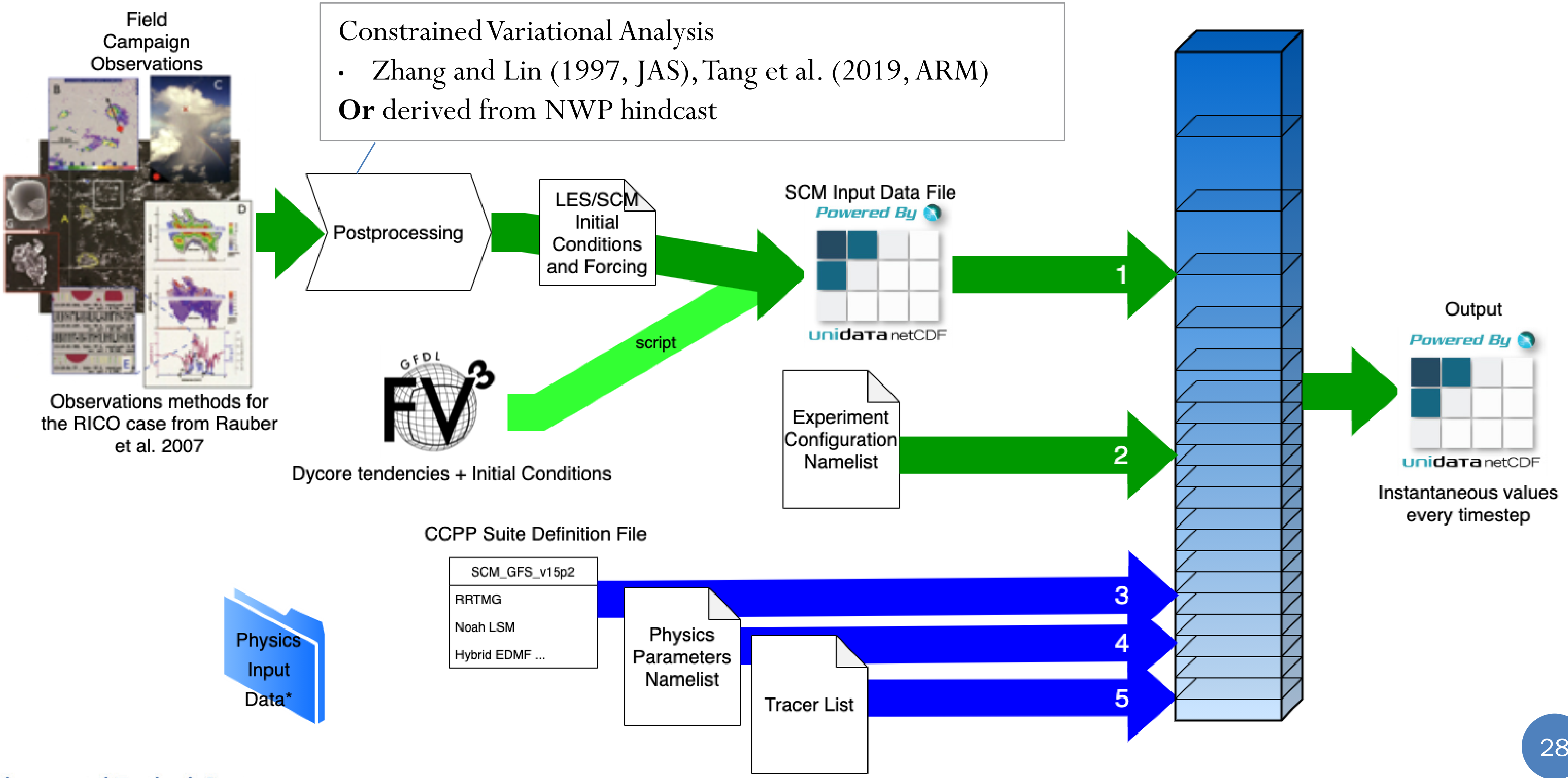


DTC's CCPP SCM - Inputs and Outputs

Constrained Variational Analysis

- Zhang and Lin (1997, JAS), Tang et al. (2019, ARM)

Or derived from NWP hindcast

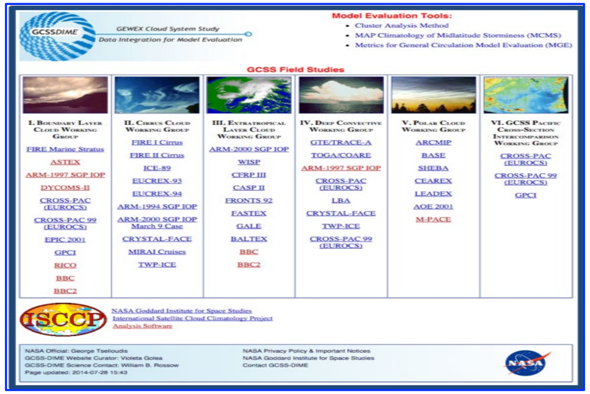


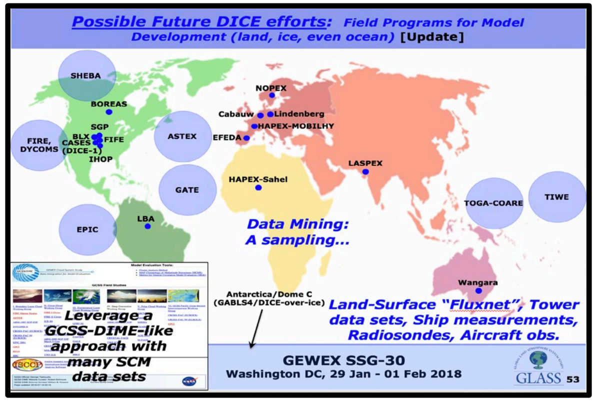
CCPP SCM Cases

Cases available:

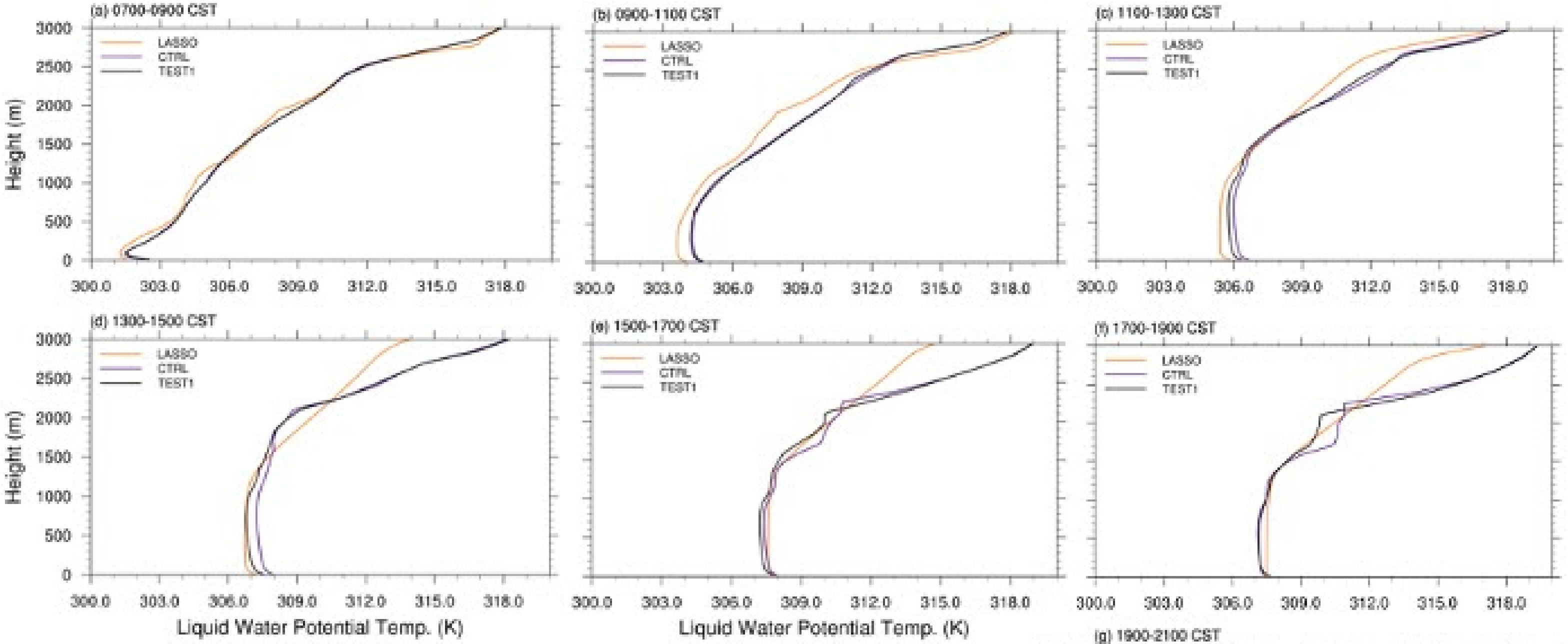
- GASS/TWP-ICE (maritime convection; near Australia).
- ARM Great Plains (continental convection).
- EUCLIPSE/ASTEX (stratocumulus).
- LASSO (shallow cumulus).
- GABLS3 (mid-latitude continental). Cabauw, Netherlands. Very useful for land, surface layer, and PBL scheme testing/development, and land-atmosphere interaction study.

GOAL: Generate MANY SCM cases for the model physics development community leveraging a number of measurement networks and field programs, including those from the international community where CCPP SCM has adopted the international SCM DEPHY data format.

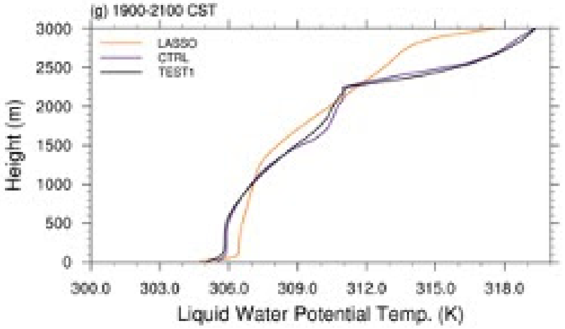




CCPP SCM useful for studying sensitivity of model results to heat fluxes



20190714



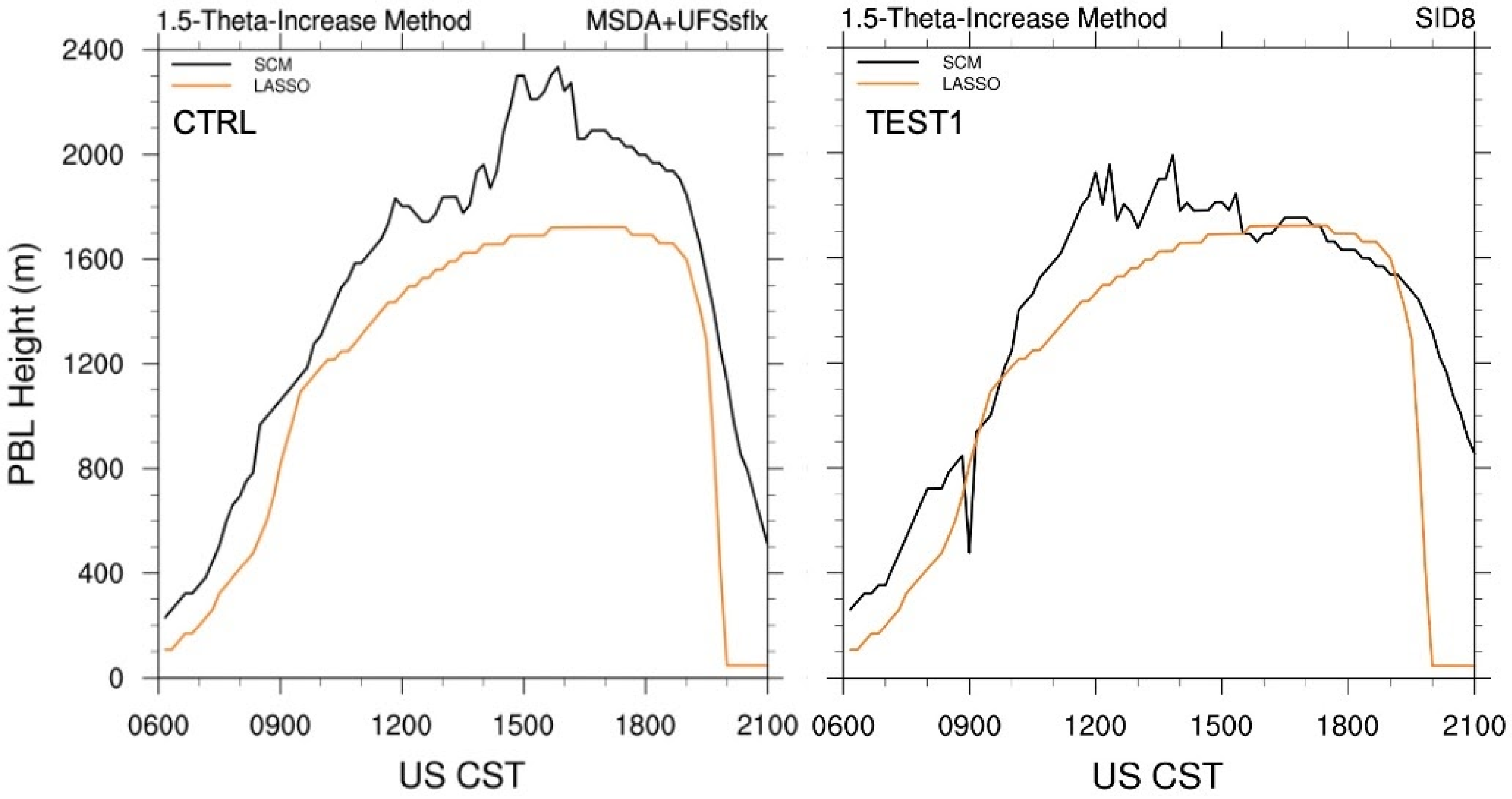
SCM vs LASSO

CTRL and TEST1 can reproduce evolution of θ throughout the day

- CTRL (prescribed with UFS sfc heat fluxes): too deep daytime PBL while too shallow nighttime PBL compared to LASSO
- TEST1 (prescribed with MSDA sfc heat fluxes): problem is mitigated slightly → UFS surface heat fluxes not realistic enough

Developmental Testbed Center

CCPP SCM reveals that PBL height is sensitive to surface heat fluxes



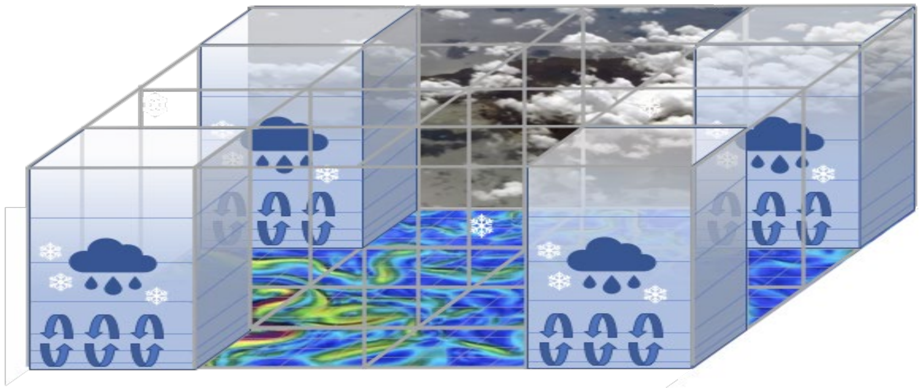
CTRL and TEST1: PBL is deeper than LASSO but TEST1 (with MSDA sfc fluxes) is better than CTRL

Developmental Testbed Center

CCPP SCM as part of MU-MIP

- The "***Model Uncertainty-Model Intercomparison Project***" (MU-MIP; ***mumip.web.ox.ac.uk***) is an international effort to better understand model-physics uncertainty, and how to represent it in stochastic physical parameterizations.
- MU-MIP participants will run an array of approximately **40,000** Single Column Model (SCM) simulations forced by coarse-grained high-resolution model output (figure below), initially from the DWD ICON (3-km) model, later high-res UFS.
- DTC is participating in MU-MIP using the CCPP SCM.

High-resolution model output (small boxes) is coarse-grained and mapped to grid (target: GEFS resolution) to provide column forcing to drive array of CCPP SCMs.



SCM Outlook

- **Additional cases**
  - **Wangara:** ideal for convective PBL studies.
  - **Green Ocean Amazon** (DoE): tropical rainforest case.
  - **Clouds, Aerosols and Precipitation in the MBL:** subtropical marine.
- **Column Replay Mode:** ability to force a run from UFS.
- **Arbitrary physics subsets**: replace active components with data models.

CCPP Dissemination

CCPP Public Releases

Ver.	Date	Physics	Host
1.0	2018 Apr	GFS v14 operational	SCM
2.0	2018 Aug	GFS v14 operational updated GFDL microphysics	SCM UFS WM for developers
3.0	2019 Jul	GFS v15 operational Developmental schemes/suites	SCM UFS WM for developers
4.0	2020 Mar	GFS v15 operational Developmental schemes/suites	SCM UFS WM / UFS MRW App v1.0
4.1	2020 Oct	GFS v15 operational Developmental schemes/suites	SCM UFS WM / UFS MRW App v1.1
5.0	2021 Mar	GFS v15.2 operational Developmental schemes/suites	SCM UFS WM / UFS SRW App v1.0

Supported Suites

Type	Operational	Developmental			
Suite Name	GFS_v15p2	GFS_v16beta	csawmg *	GSD_v1 *	RRFS_v1alpha
Host	MRW v1, SCM	MRW v1, SCM	SCM	SCM	SRW v1,SCM
Microphysics	GFDL	GFDL	**M-G3**	**Thompson**	**Thompson**
PBL	K-EDMF	**TKE EDMF**	K-EDMF	**saMYNN**	**saMYNN**
Surface Layer	GFS	GFS	GFS	GFS	MYNN
Deep Cu	SAS	saSAS	**Chikira-Sugiyama**	**Grell-Freitas**	N/A
Shallow Cu	SAS	saSAS	saSAS	**MYNN and GF**	**MYNN**
Radiation	RRTMG	RRTMG	RRTMG	RRTMG	RRTMG
Grav Wave Drag	uGWP	uGWP	uGWP	uGWP	uGWP
Land Surface	Noah	Noah	Noah	**RUC**	**Noah-MP**
Ozone	NRL 2015	NRL 2015	NRL 2015	NRL 2015	NRL 2015
H2O	NRL	NRL	NRL	NRL	NRL

CCPP User Support

- **Main hub for code and support:** https://dtcenter.org/ccpp
- **DTC CCPP Forum:** https://dtcenter.org/forum/ccpp-user-support
- **UFS Forum:** https://forums.ufscommunity.org
- **Scientific Documentation:** https://dtcenter.ucar.edu/GMTB/v5.0.0/sci_doc/index.html
- **Technical Documentation:** https://ccpp-techdoc.readthedocs.io/en/v5.0.0
- **User's Guide:** https://dtcenter.org/sites/default/files/paragraph/scm-ccpp-guide-v5.0.0.pdf
- **GitHub Discussions:** https://github.com/NCAR/ccpp-physics/discussions
- **CCPP and CCPP SCM Online Tutorials:** (includes video presentations and exercises)

  https://dtcenter.org/ccpp-scm-online-tutorial/video-presentations

CCPP Physics: Enabled capabilities

- **GFS v17 baseline:** a CCPP-compliant emulation of GFS v16 was assembled to serve as a baseline for GFS v17 development
- **GEFS v13 baselines:** GitHub branches established for collecting physics development for the coupled prototypes toward GEFS v13
- **RRFS:** All schemes needed for RRFS alpha suite
- **HAFS:** All schemes needed for initial HAFS testing

CCPP Transition to UFS Operations

- CCPP selected as the framework for atmospheric physics in the UFS
- Scheduled for all upcoming operational implementations

Without CCPP			With CCPP		
2019	2020	2021	2022	2023	2024
GFS v15		GFS v16			GFS v17
GEFS v12			WCOSS moratorium		GEFS v13
				HAFS v1	HAFS v2
				RRFS v1	RRFS v2

adapted from Tallapragada, Whitaker, and Kinter (2021)

Collaborations

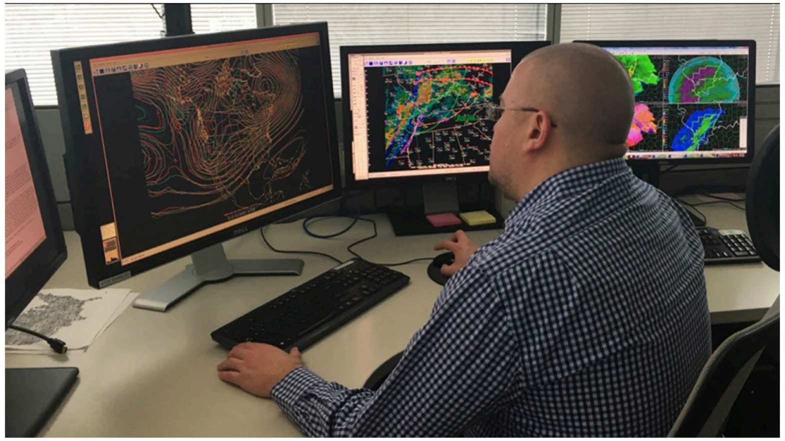
- CCPP is being used by NRL in NEPTUNE model
- CCPP Framework is being adopted and enhanced for NCAR models

NOAA and NCAR partner on new, state-of-the-art U.S. modeling framework

Agreement paves way for U.S. to accelerate use of weather, climate model improvements

Focus areas: Weather **Topics:** climate, forecasting, weather **Share:**

February 7, 2019



National Weather Service meteorologist Andrew Orrison uses weather model data to generate precipitation forecasts from NOAA's Weather Prediction Center in College Park, Maryland. (NOAA)

Summary – Challenges & Opportunities

- Earth System Models (ESMs) for weather & climate becoming increasingly complex, with many processes and interactions in ESMs. Need to to get the **right answers for the right reasons!**
- Hierarchical System Development (HSD) is a systematic approach that tests small elements (e.g. physics schemes) of an ESM first in isolation, then progressively connects those elements with increased coupling between ESM components, all the way up to a fully-coupled global model.
- The Common Community Physics Package (CCPP) is that efficient infrastructure and set of physics to connect the HSD steps, where CCPP is being increasingly adopted by the ESM community for use in making the R2O2R process of model physics improvements more effective.
- The CCPP is under active development, with new parameterizations and framework capabilities being added. Establishing multi-institutional governance for the CCPP Physics is one of our primary efforts to create a solid foundation for CCPP use by research and operations.

https://dtcenter.org/ccpp