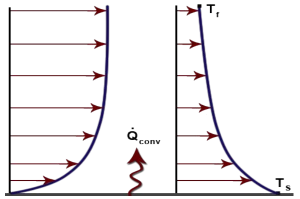
# CCPP SCM Overview

Grant Firl
Cooperative Institute for Research in the Atmosphere, NOAA Global Systems Laboratory, Developmental Testbed Center

Developmental Testbed Center

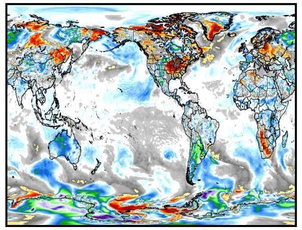
# Why a Single Column Model

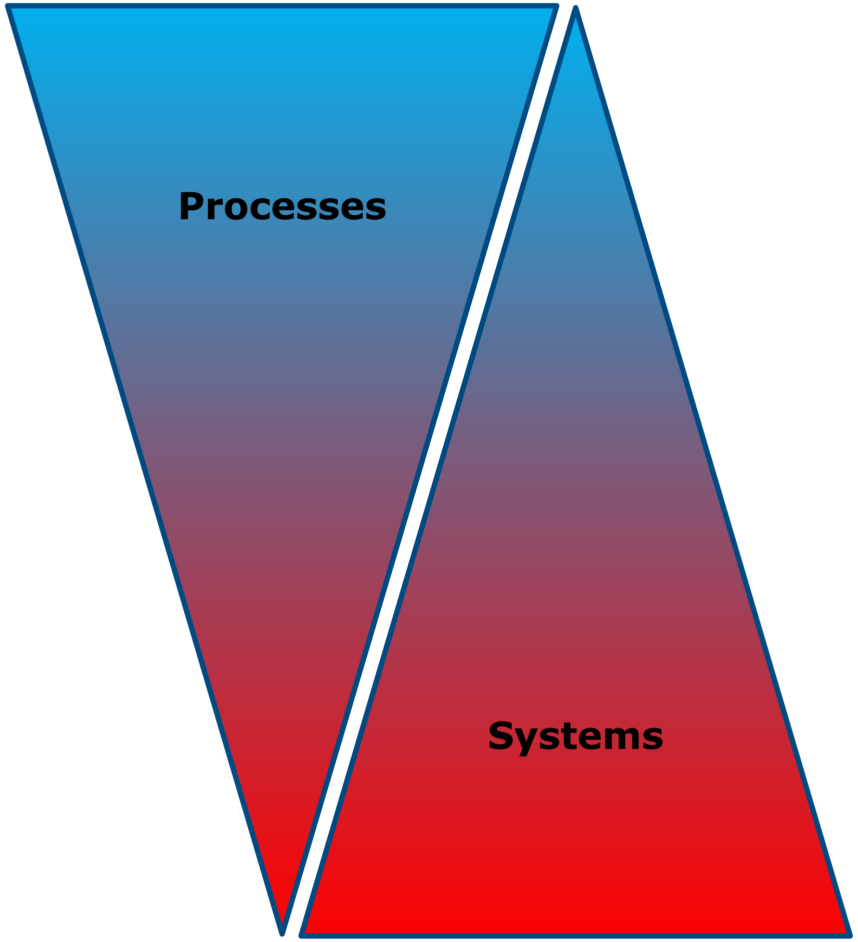
## Hierarchical Testing of Physics



"Simple" Processes

Complex Systems






### *HSD Testing "Harness"*

- Parameterization Simulator
- Single Column Model ◆
- 2-D Model
- Limited-Area Domain
- Regional Model
- Global Model
- Fully-Coupled Model

# Why a Single Column Model

## Usefulness for CCPP and UFS

- Developed by DTC in 2016 for several purposes
  - UFS was in need of a well-supported SCM
    - GFS SCM versions existed and used by Fanglin Yang, Shrinivas Moorthi, Laura Davies
    - Not actively maintained as GFS physics were updated
  - CCPP requires a host
    - SCM is simplest model to test entire physics suites
    - Simplicity is ideal for rapid prototyping and portability
    - Useful for software releases

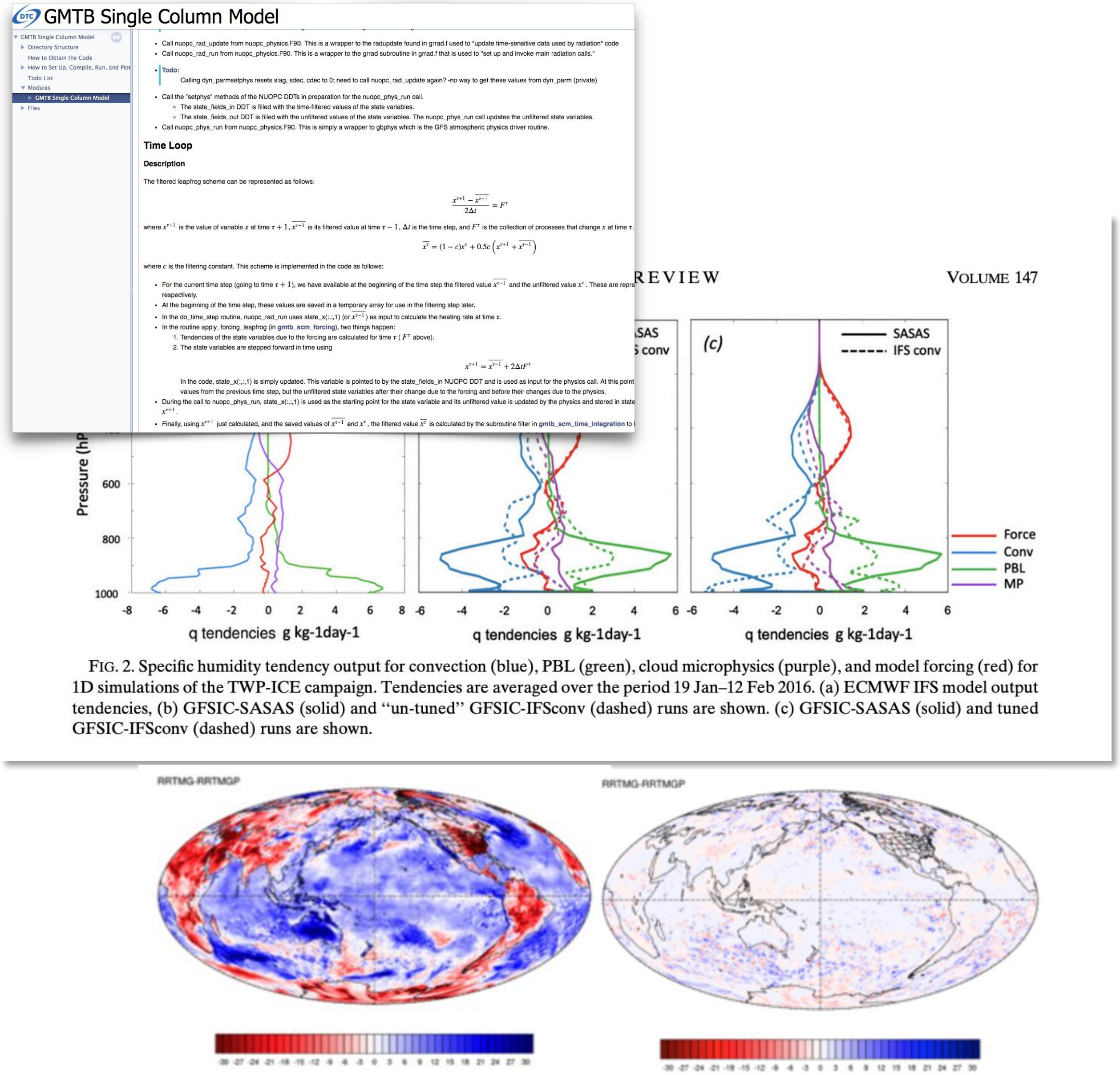



FIG. 2. Specific humidity tendency output for convection (blue), PBL (green), cloud microphysics (purple), and model forcing (red) for 1D simulations of the TWP-ICE campaign. Tendencies are averaged over the period 19 Jan–12 Feb 2016. (a) ECMWF IFS model output tendencies, (b) GFSIC-SASAS (solid) and "un-tuned" GFSIC-IFSconv (dashed) runs are shown. (c) GFSIC-SASAS (solid) and tuned GFSIC-IFSconv (dashed) runs are shown.

Courtesy: Robert Pincus and Dustin

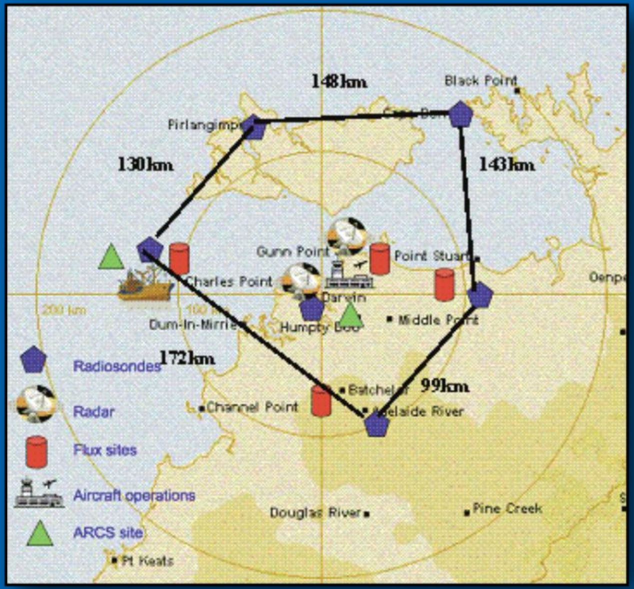
# Latest Release

## CCPP-SCM v6.0

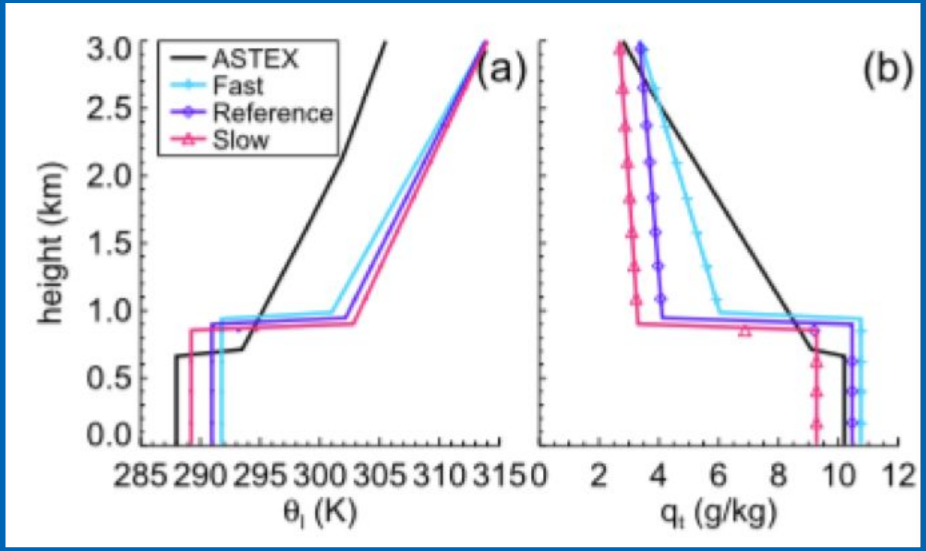
- Up-to-date with NOAA operational GFS v16 physics through the CCPP (and also works with developmental suites)
- Available to public on GitHub
- Bundled with CCPP v6
- Simple host model for calling physics through CCPP
    - Contains CCPP software framework and physics as Git submodules
    - Contains example of using CCPP framework to:
        - Reconcile model-provided data with that needed by all schemes in physics suite
        - Initialize a CCPP-compliant physics suite
        - Call physics suite (one-liner!)
- Run script to execute permutations of supported physics suites and cases
- Script to generate cases with UFS initial conditions (only!)
- Choice of prescribed surface fluxes, LSM, or simple ocean surface
- DEPHY international case data file format support

# Forcing the SCM

Observational Field Campaigns

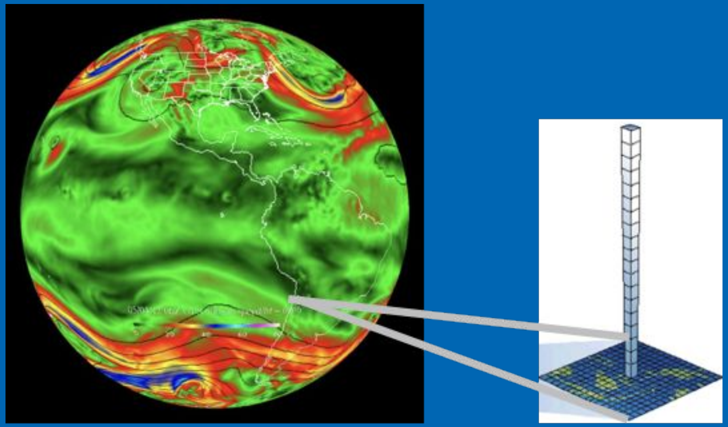



Idealized Cases




from de Roode et al. (2016, JAS)

3D Model Output



# Hierarchical System Development: SCM Cases

**Some cases using "DEPHY" format** (DEPHY: Développement et Evaluation des PHYsiques des modèles atmosphériques)**:**

- 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).

**A few cases added by ourselves:**

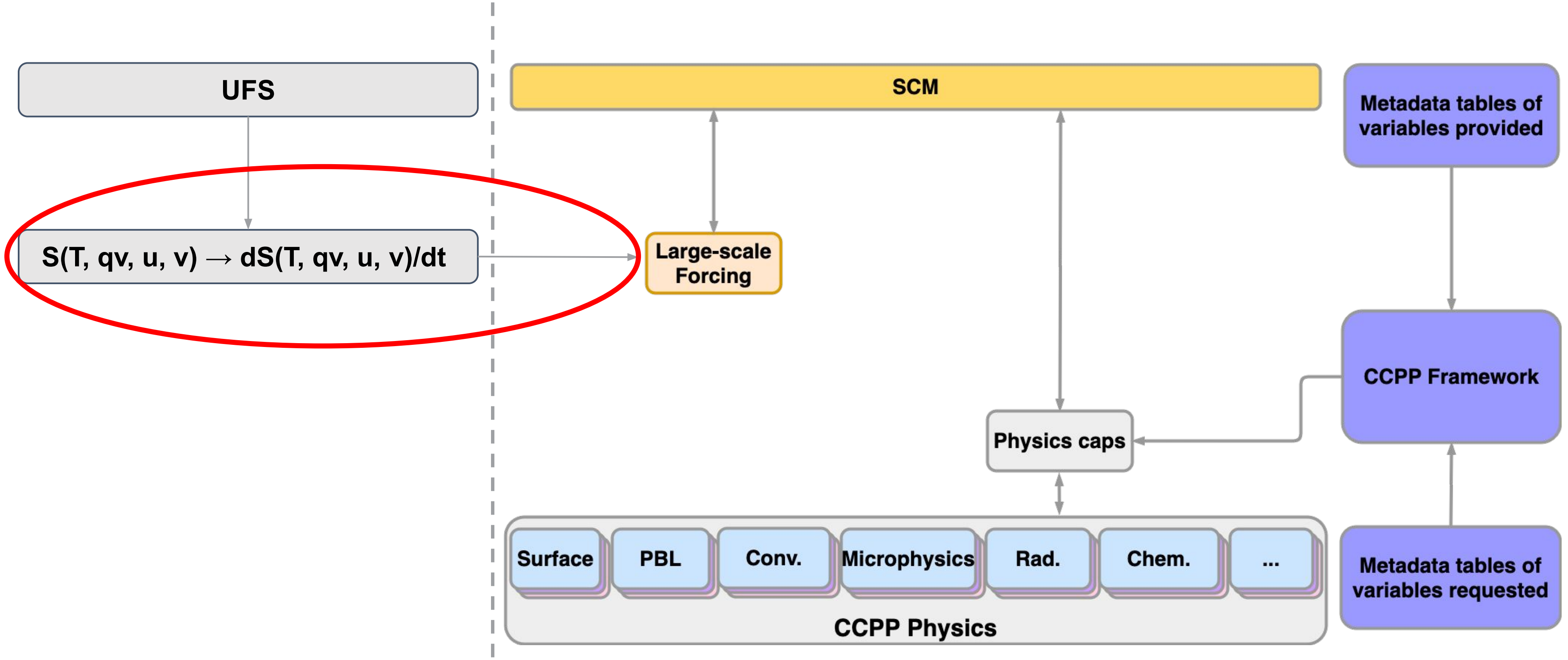
- Wangara Day 33: semi-arid dry convection over land. NWS, Australia.
- AWARE: ARM West Antarctic Radiation experiment.
- MAGIC Leg 15A. C. Bretherton's large-scale forcing (very similar to that in DEPHY).

**Collaboration with DTC on CCPP SCM:**

- There is a need for a community SCM case repository.
- Should we use the DEPHY repository (https://github.com/GdR-DEPHY/DEPHY-SCM)?
- What should the criteria be for accepting new cases?

# UFS replay

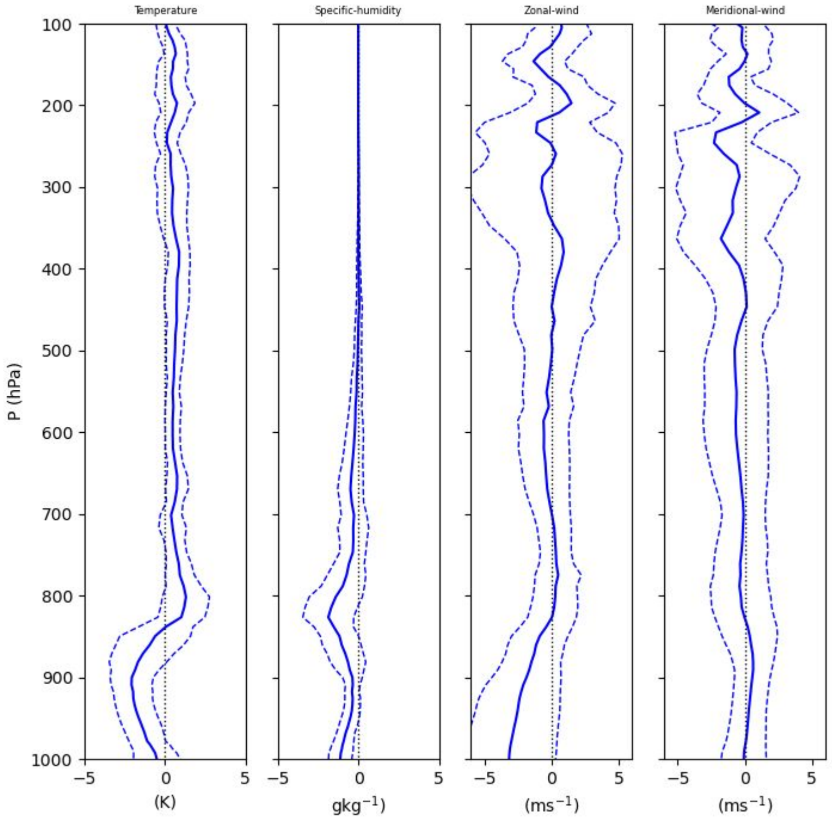
Using standard UFS output we can derive the large-scale forcing terms from the state variables to drive the CCPP-SCM.

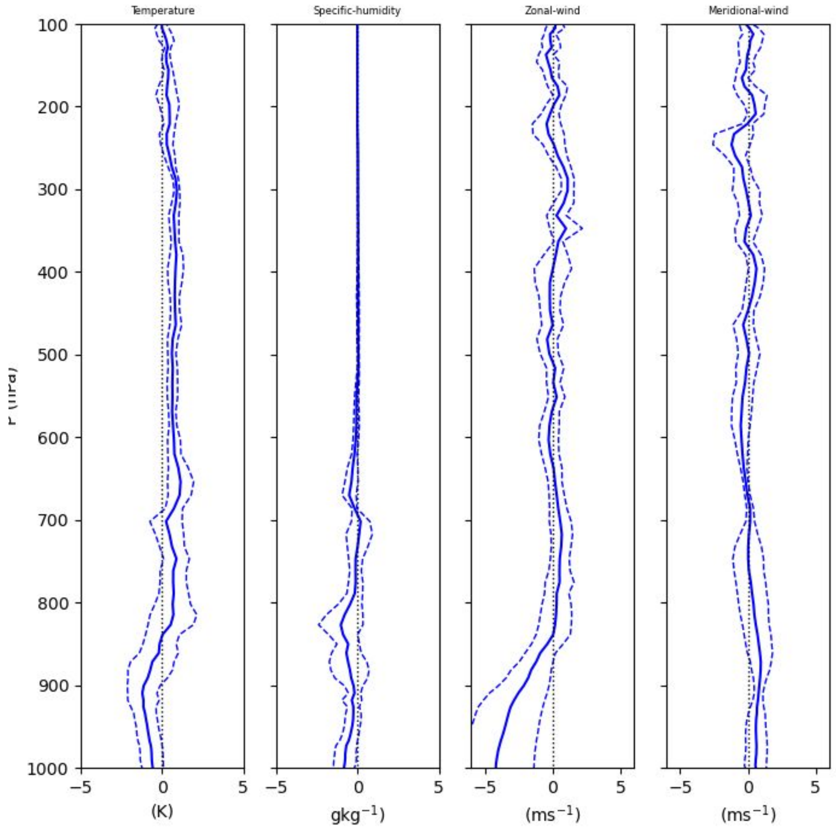



This gives us a sense of how physics innovations will behave with the same forcings as in the three-dimensional FV3, without the computational burden.

# UFS replay

How well does SCM with UFS-replay reproduce the state of the UFS?



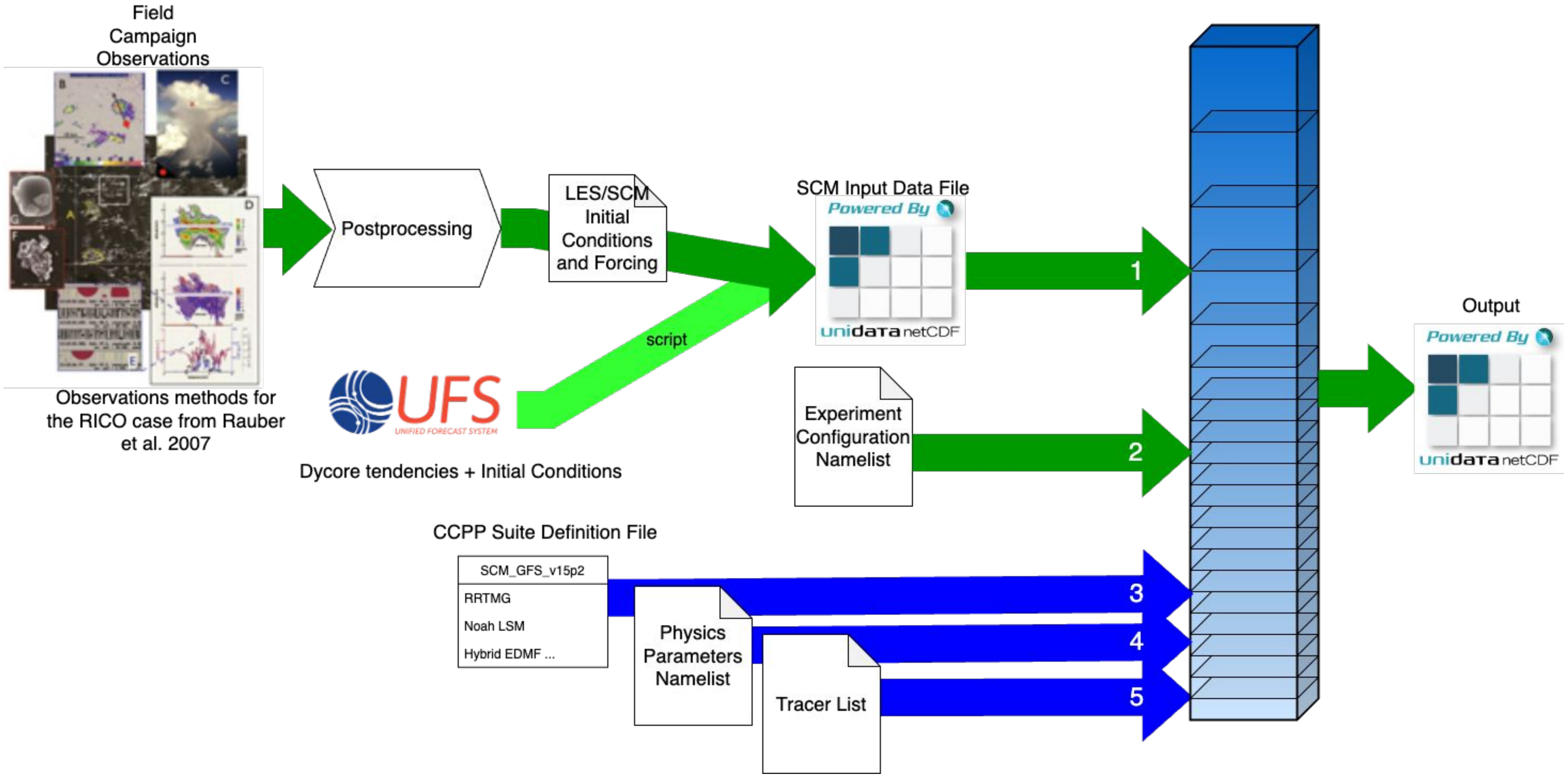




Mean differences (solid line) and variance (dashed lines) for an ***ensemble of SCM replay columns*** using 6-hourly UFS output (left) and using 1-hourly UFS output (right).

*Ensemble of SCM points [300$^o$ - 320$^o$ , 30$^o$ - 40$^o$]*

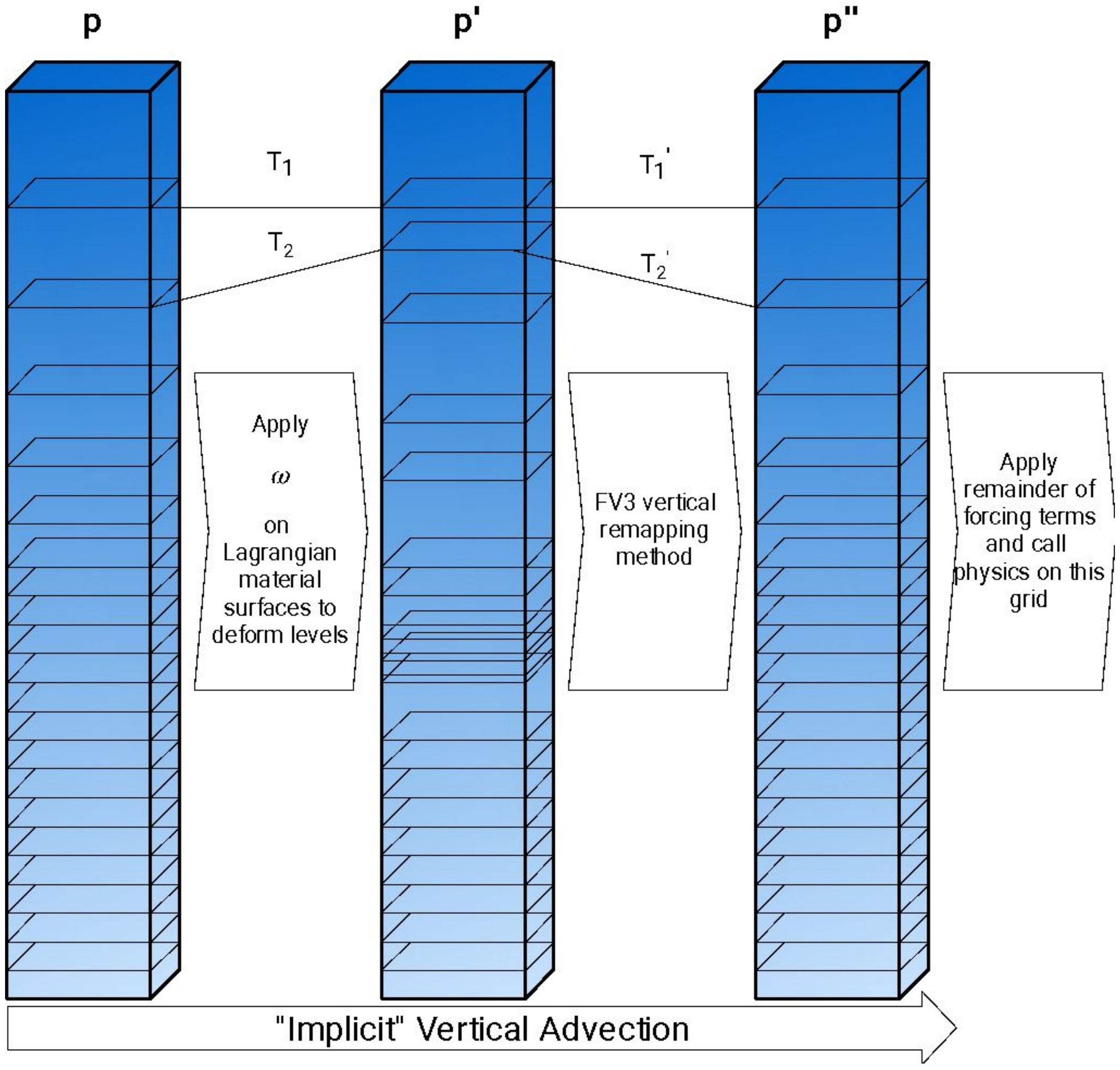
*UFS RT (c192) initialized @ 03/22/2021 dtp=dtf=360s*

# Inputs and Outputs



# Ties to the UFS

- Same vertical coordinate
  - $\sigma$-p hybrid
  - Today: Eulerian
  - Soon: semi-Lagrangian (allows for changing $p_s$)
- Physics namelist
- Physics data structure
  - GFS_typedefs.F90 with minor differences
- ICs/Forcing from configurable, selected columns
  - AKA “Column Replay”



# Walkthrough

- GitHub ccpp-physics
- GitHub ccpp-framework
- GitHub.com ccpp-scm
- Example scheme: mynnedmf_wrapper.F90
- Example meta: mynnedmf_wrapper.meta
- GitHub standard name dictionary
- Example SDF: suite_SCM_GFS_v17_p8.xml
- Host metadata: GFS_typedefs, CCPP_typedefs
- ccpp_prebuild_config.py
- ccpp_prebuild command: CMakeLists.txt
- Terminal: run cmake (ccpp_prebuild)
  - Script output: bin/ccpp_prebuild.er
  - Host vars: ccpp/physics/CCPP_VARIABLES_SCM.html
  - Autogenerated cmake info: bin/ccpp/physics/*.cmake
  - CCPP API: scm/src/ccpp_static_api.F90
  - Suite cap: bin/ccpp/physics/physics/suite_cap
  - Group cap: bin/ccpp/physics/physics/group_cap

Debug mode:
- Add –DCMAKE_BUILD_TYPE=Debug
- bin/ccpp_prebuild.err
- Group cap: bin/ccpp/physics/physics/group_cap

# Miscellanea

## Diagnostic Tendencies

One can request the host to enable diagnostic tendencies calculated in the CCPP:

- Has been tested with:
  - SCM: GFS_v16, GFS_v17_p8, RAP, RRFS_v1beta, WoFS, HRRR
  - UFS: GFS_v16, RRFS_v1beta, WoFS, HRRR

- Controlled via namelist settings:
  - `ldiag3d = T, qdiag3d = T, [dtend_select = list_of_strings]`
    - `dtend_select = 'dtend_temp_mp'` — Only one
    - `dtend_select = 'dtend_temp_*'` — All temperature tendencies
    - `dtend_select = 'dtend*mp'` — All microphysics tendencies

- See section 10.2.3 in the CCPP Technical Guide for more valid names.
- See section 10.2.5 for actually outputting the calculated tendencies in the UFS/SCM