Engaging the Community in the Development of Physics for NWP Models

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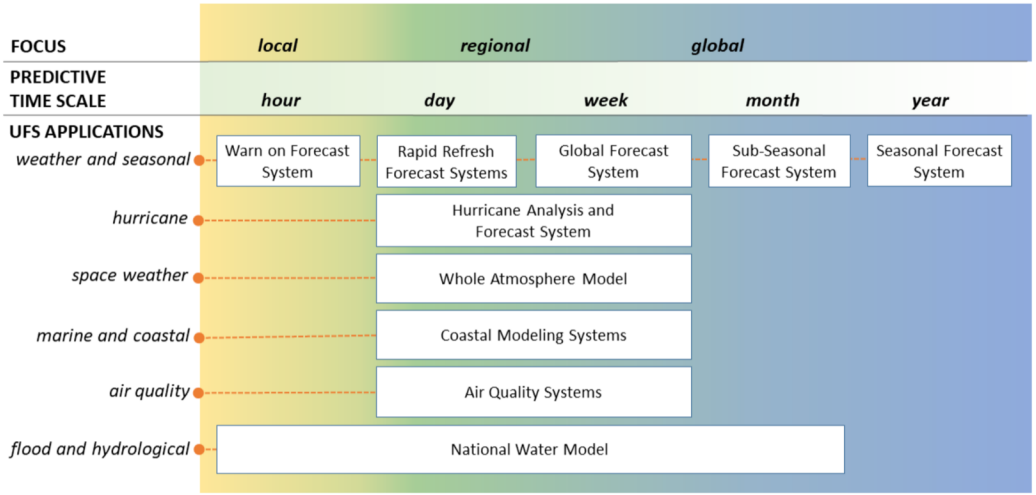
Outline

- The Unified Forecast System
- The need to facilitate Transition of Research to Operations (R2O) in Numerical Weather Prediction
- Developmental Testbed Center efforts in the area of physics R2O
- Wrap-up

Unified Forecast System

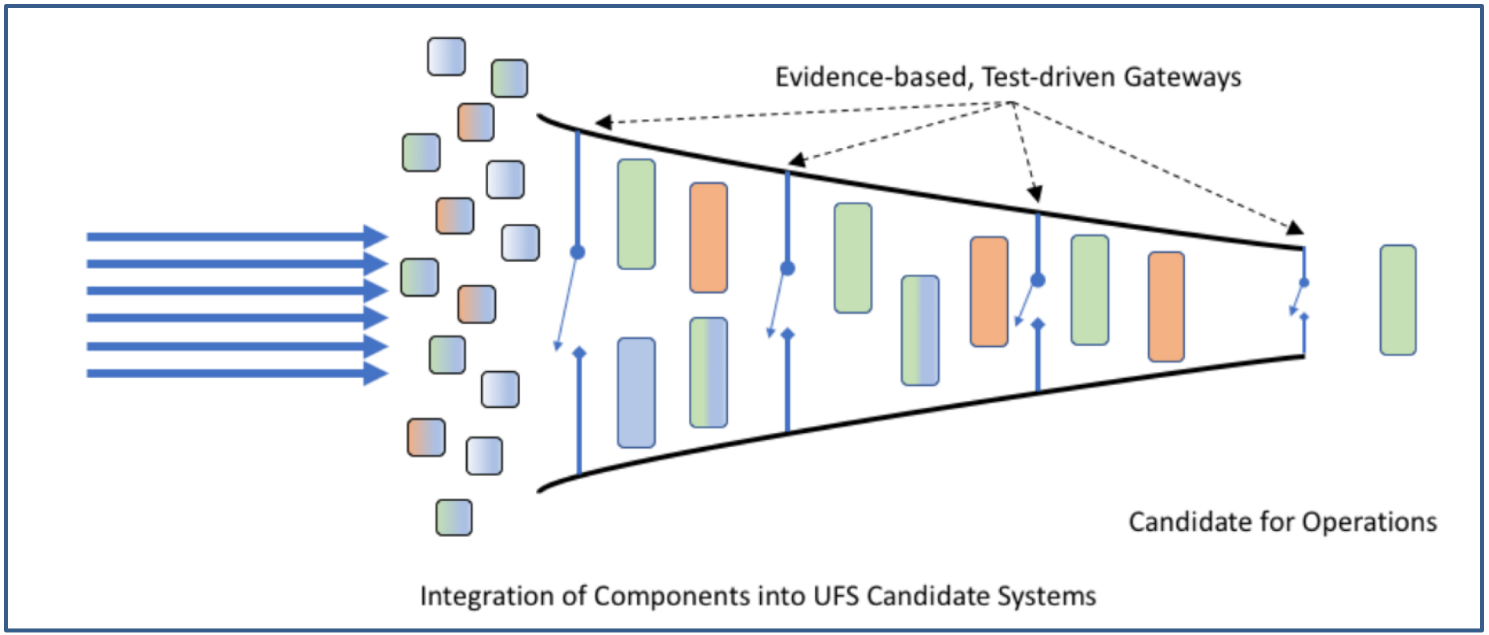
- **A community-based**, coupled, comprehensive Earth modeling system targeted towards improvements in **NWS operational modeling suites**
- UFS can be configured into **multiple global and regional applications** (medium-range weather, short-range weather, hurricane, etc.)



From ufscommunity.org

Transition of research to operations

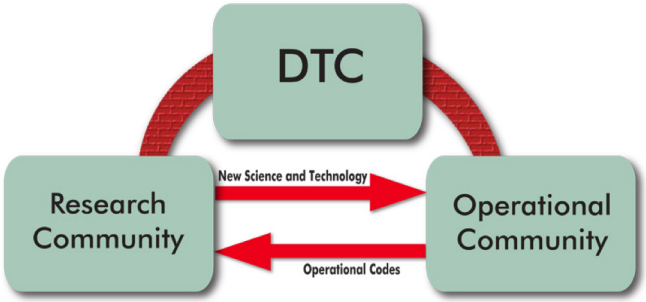
In order to improve UFS forecasts, it is necessary to facilitate the transition of innovations to operations



From ufscommunity.org

Developmental Testbed Center (DTC)

DTC's role is to stimulate exchange between the research and operational NWP communities



From dtcenter.org

Selected efforts related to facilitating physics improvements

- Public releases of the UFS
- Common Community Physics Package
- Hierarchical System Development
  - Case Studies
  - Single-Column Model

UFS Medium-Range Weather Application

- The first public release of the UFS was the Medium Range Weather Application 1.0, which provides global atmospheric forecasts
- The aim of the release was to introduce the UFS to the broader scientific community
- It can be used on a number of computational platforms, has a friendly workflow, and is documented and supported

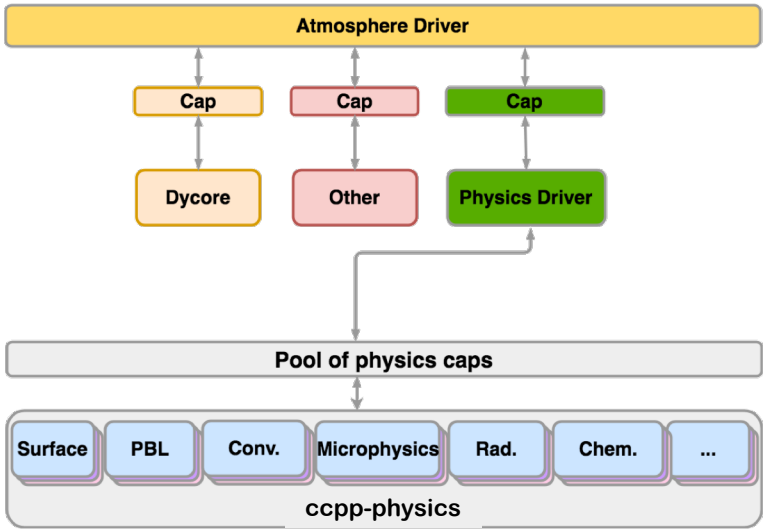
Release was a multi-institution effort under the leadership of
L. Nance (DTC), A. Chawla (EMC), and M. Vertenstein (NCAR)

Release Content and Access

- Libraries, Pre- and Post-processing utilities, Workflow
- Global configuration of the UFS weather model
  - Finite-Volume Cubed-Sphere Dynamical Core (FV3)
  - Stochastic physics package
  - Common Community Physics Package (CCPP)
    - GFSv15p2: Configuration from current operational GFSv15
    - GFSv16beta: Beta testing version under development for GFSv16 implementation

To get code and information, please see the UFS Medium-Range Weather App v1.0.0 User's Guide at https://ufs-mrweather-app.readthedocs.io/en/ufs-v1.0.0/

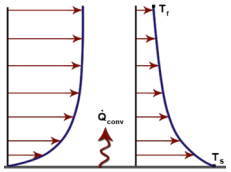
Common Community Physics Package



CCPP

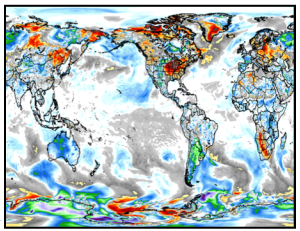
- Library of physical parameterizations
- Framework to connect parameterizations to host models
- Used in the UFS and other hosts
- Clear software interfaces that lower the barrier for contributing new schemes, modifying schemes, and understand data flow
- Supported and documented
- CCPP v4 released March 2020 (dtcenter.org/ccpp)
- See Heinzeller et al. in this AGU meeting

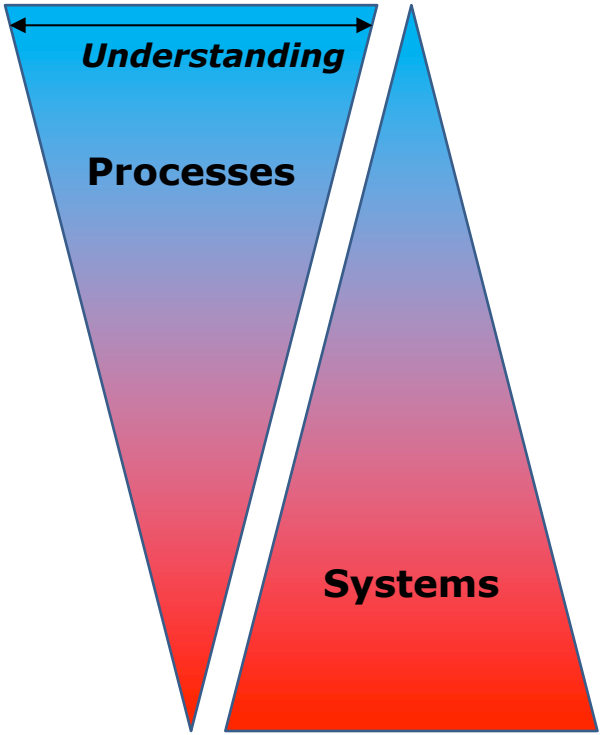
Hierarchical Systems Development



"Simple" Processes

Complex Systems



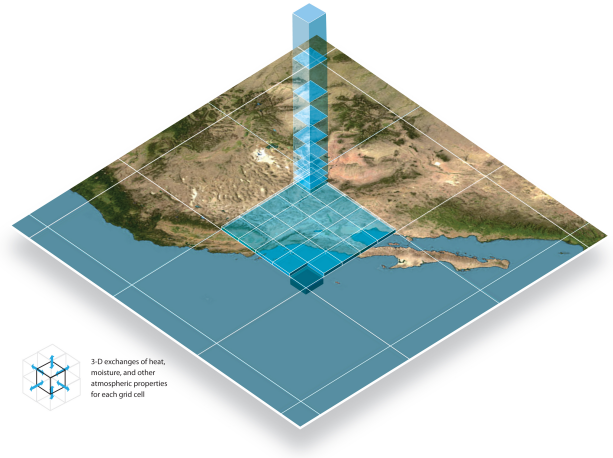


HSD Testing "Harness"

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

CCPP Single Column Model

- Initial state from pre-existing combined observational Large-Eddy Simulation efforts (soon also from UFS)
- Forcing applied to mimic changes in column state from surrounding environment
- CCPP Physics responds to these changes and further modifies the column state



Pros

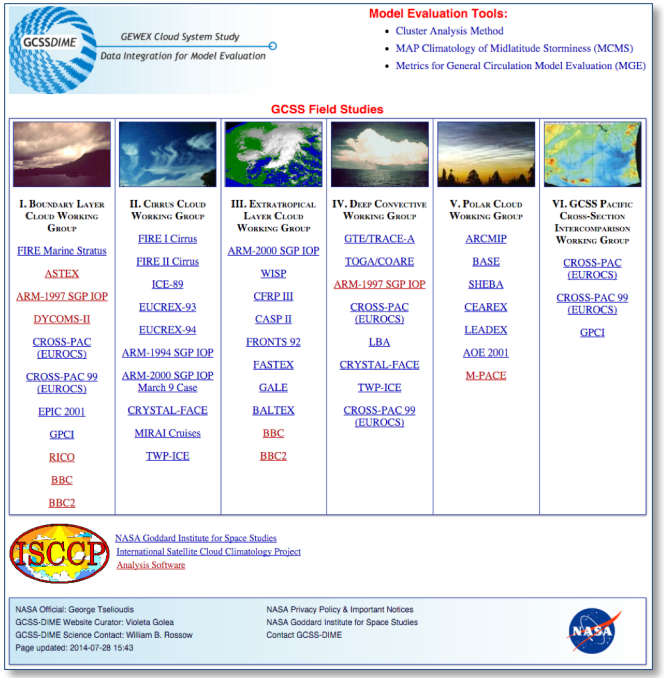
- Simple and cheap
- Interpretability
- Approachable

Cons

- Necessary, but not sufficient
- Forcing sensitivity

To get code and information, please see the CCPP Single-Column Model User's Guide
https://dtcenter.org/GMTB/v4.0/scm-ccpp-guide-v4.0.pdf

Using Observations to Drive SCM



Available in SCM v4

- GASS/TWP-ICE (maritime convection)
- ARM Great Plains (continental convective)
- EUCLIPSE/ASTEX (stratocumulus)
- LASSO (continental shallow cumulus)
- BOMEX (maritime shallow cu)

Planned

- Expand the variety of meteorological regimes

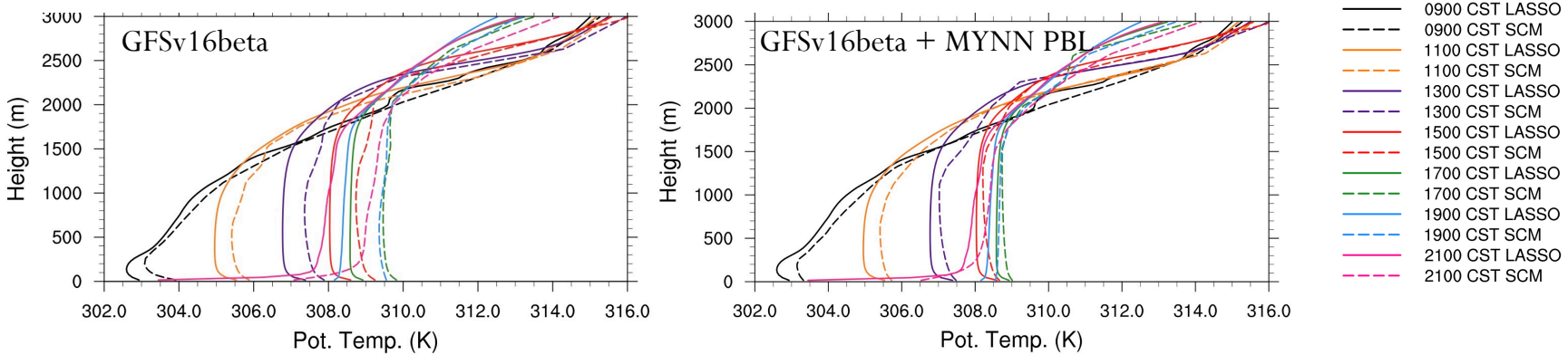
The SCM User's Guide explains how community users can add their own cases/data.

Sample results from CCPP Single-Column Model

Potential temperature profiles for CCPP SCM vs LASSO LES ("truth")

Case: 06/11/2016 (shallow continental convection over central US)

Physics: GFSv16beta (uses TKE-based EDMF PBL) and GFSv16beta + MYNN PBL



CCPP SCM

Can reproduce the θ evolution (daytime convective PBL, nighttime stable PBL)

Has a warm bias with slightly overestimated PBL height (alleviated with MYNN PBL)

Courtesy Dan D'Amico, Weiwei Li, and Lulin Xie (NCAR DTC)

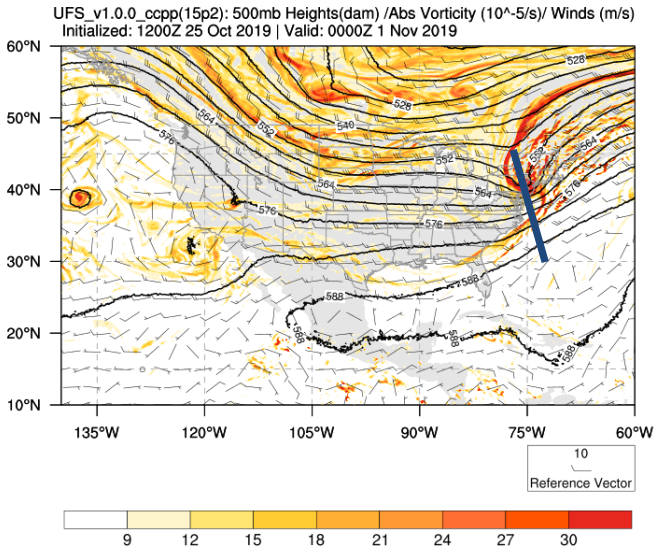
Case Studies: Another Tier in the Hierarchy

- The UFS Application Teams are starting to publish their "forecast challenges"
  - Synoptic patterns are too progressive
  - Positive bias in 2-m T (occasional, warm season, US Southern plains and corn belt etc.)
  - Negative bias in 2-m T (cold season)
  - Etc.
- Case studies can illustrate specific problems and provide a testbed for sensitivity tests and experiments

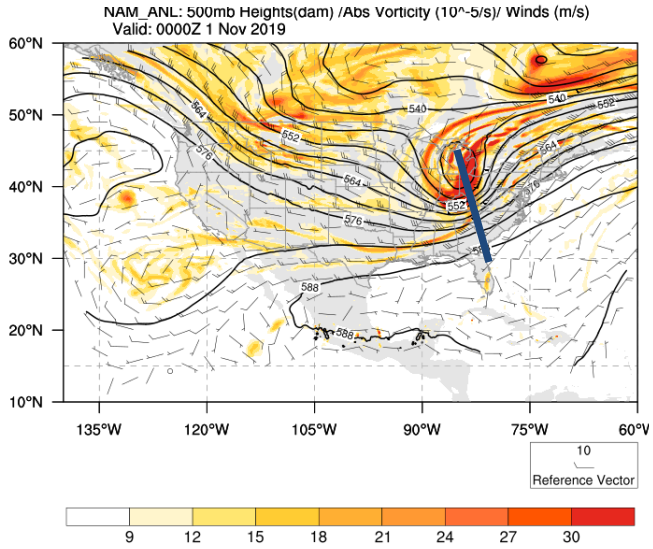
Progressive pattern: 2019 Halloween storm

Example of a case that will be distributed to enable experimentation to address a known systematic bias

UFS MRW App with oper GFS physics



NAM analysis



Wrap up

- Further development and improvement of physical parameterizations is a key element in improvement of operational NWP prediction
- Community engagement is a key aspect of the UFS
- The Developmental Testbed Center is contributing to community involvement through public releases of the UFS, development of the CCPP and its SCM, and publication of forecast challenges and case studies to illustrate them
- Resources
  - dtcenter.org
  - dtcenter.org/ccpp
  - dtcenter.org/visitor-program (currently accepting proposals! Come work with us)