



Engaging the Community in the Development of Physics for NWP Models

Ligia Bernardet^{1,3}, Grant Firl^{2,3}, Dom Heinzeller^{1,3,5},
Laurie Carson^{2,3}, Xia Sun^{1,3,5}, Man Zhang^{1,3,5}, Linlin Pan^{1,3,5}

¹ NOAA Global Systems Laboratory

² NCAR Research Applications Laboratory

³ Developmental Testbed Center

⁵ University of Colorado Cooperative Institute for Research in Environmental Sciences

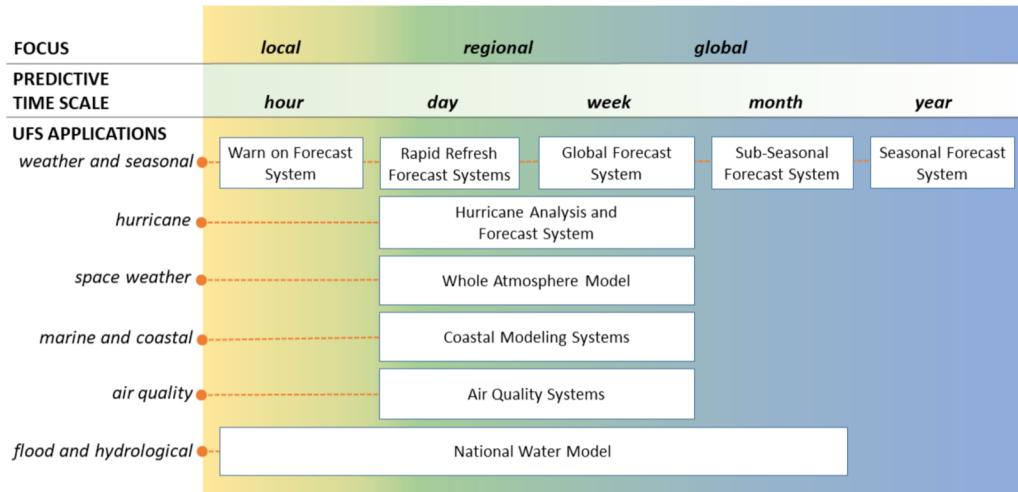


Outline

- 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

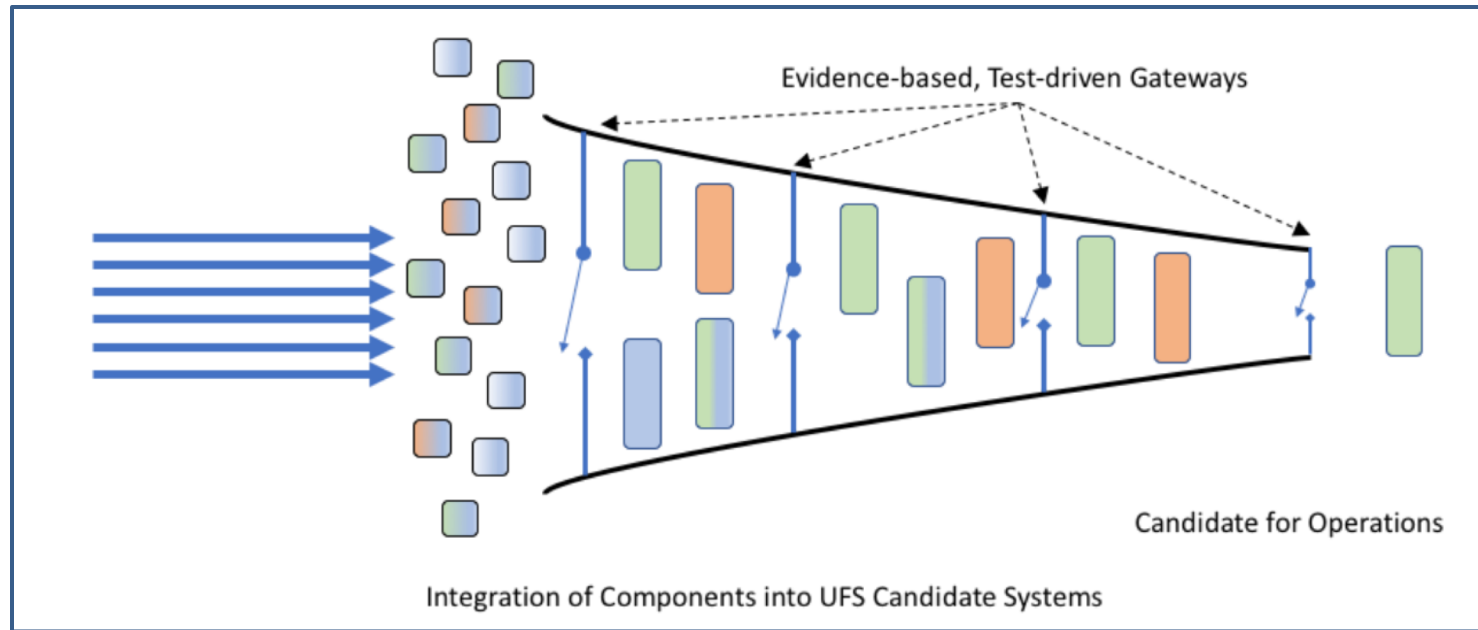
Unified Forecast System

- 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.)



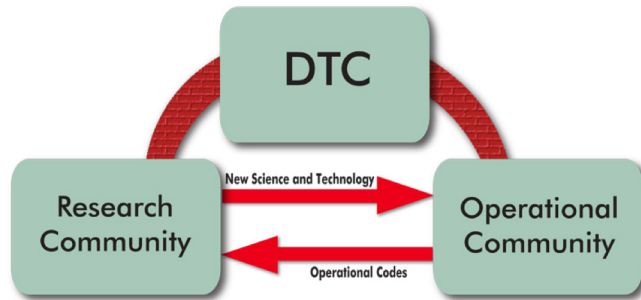
Transition of research to operations

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



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

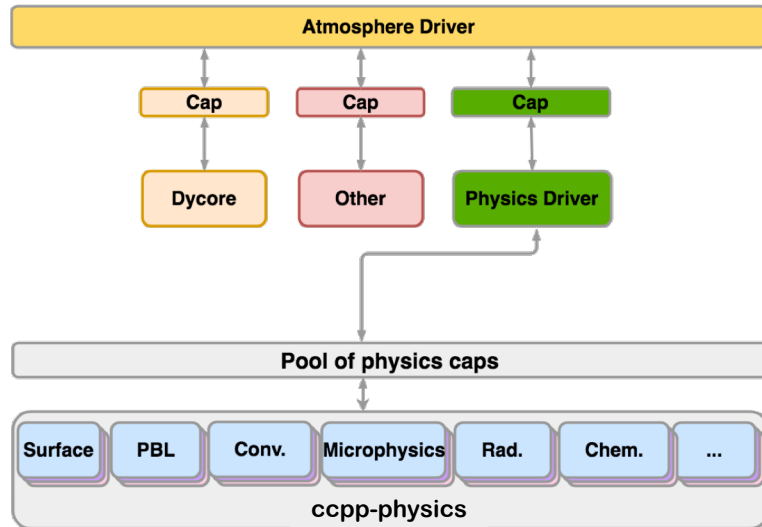
Release was a multi-institution effort under the leadership of L. Nance (DTC), A. Chawla (EMC), and M. Vertenstein (NCAR)

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

HSD Testing "Harness"

Parameterization Simulator

Single Column Model 

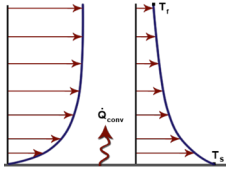
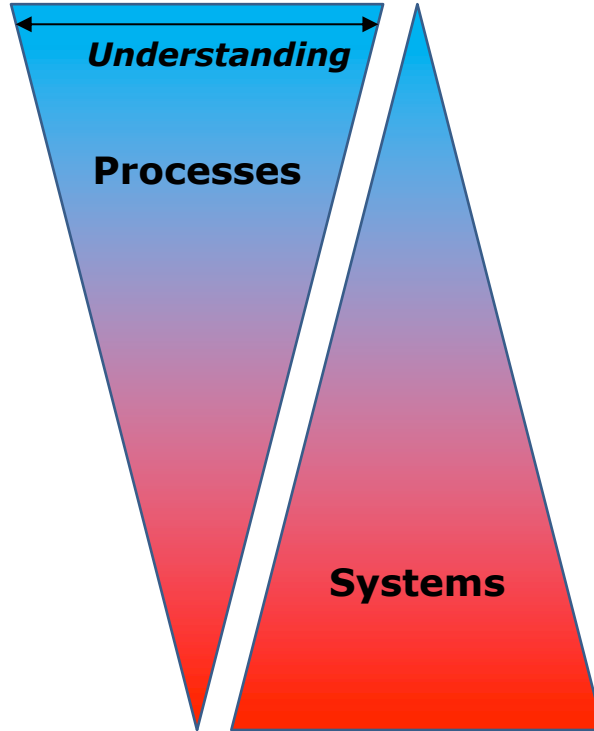
2-D Model

Limited-Area Domain

Regional Model

Global Model

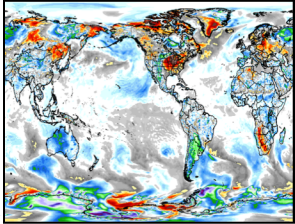
Fully-Coupled Model



"Simple" Processes

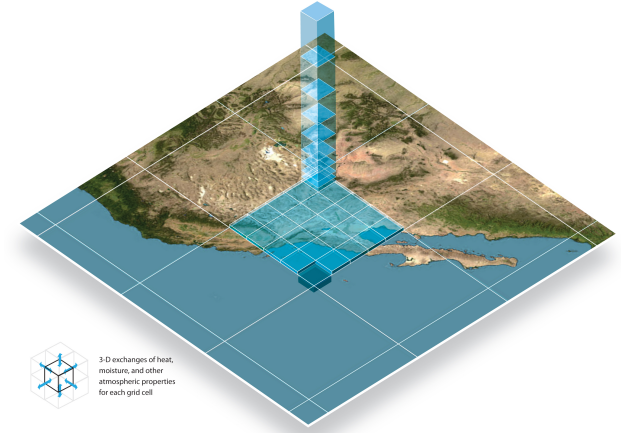


Complex Systems



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

GCSS-DIME GEWEX Cloud System Study
Data Integration for Model Evaluation

Model Evaluation Tools:

- Cluster Analysis Method
- MAP Climatology of Midlatitude Storminess (MCMS)
- Metrics for General Circulation Model Evaluation (MGE)

GCSS Field Studies

I. BOUNDARY LAYER CLOUD WORKING GROUP	II. CIRRUS CLOUD WORKING GROUP	III. EXTRATROPICAL LAYER CLOUD WORKING GROUP	IV. DEEP CONVECTIVE LAYER CLOUD WORKING GROUP	V. POLAR CLOUD WORKING GROUP	VI. GCSS PACIFIC CROSS-SECTION INTERCOMPARISON WORKING GROUP
FIRE Marine Stratus	FIRE I Cirrus	ARM-2000 SGP IOP	GTE/TRACE-A	ARCMIP	CROSS-PAC (EUROCS)
ASTEX	FIRE II Cirrus	WISP	TOGA-COARE	BASE	CROSS-PAC (EUROCS)
ARM-1997 SGP IOP	ICE-89	CFRP III	ARM-1997 SGP IOP	SHEBA	CROSS-PAC 99 (EUROCS)
DYCOMS-II	EUCREX-93	CASP II	CROSS-PAC (EUROCS)	CEAREX	GPCI
CROSS-PAC (EUROCS)	EUCREX-94	FRONTS 92	LBA	LEADEX	
CROSS-PAC 99 (EUROCS)	ARM-1994 SGP IOP	EASTEX	CRYSTAL-FACE	AOE 2001	
EPIC 2001	ARM-2000 SGP IOP March 9 Case	GALE	TWP-ICE	M-PACE	
GPCI	CRYSTAL-FACE	BALTEX	CROSS-PAC 99 (EUROCS)		
RICO	MIRAI Cruises	BBC			
BBC	TWP-ICE	BBC2			
BBC2					

ISCCP NASA Goddard Institute for Space Studies
International Satellite Cloud Climatology Project
Analysis Software

NASA Official: George Tselioudis
GCSS-DIME Website Curator: Violeta Golea
GCSS-DIME Science Contact: William B. Rossow
Page updated: 2014-07-28 15:43

NASA Privacy Policy & Important Notices
NASA Goddard Institute for Space Studies
Contact GCSS-DIME

NASA

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

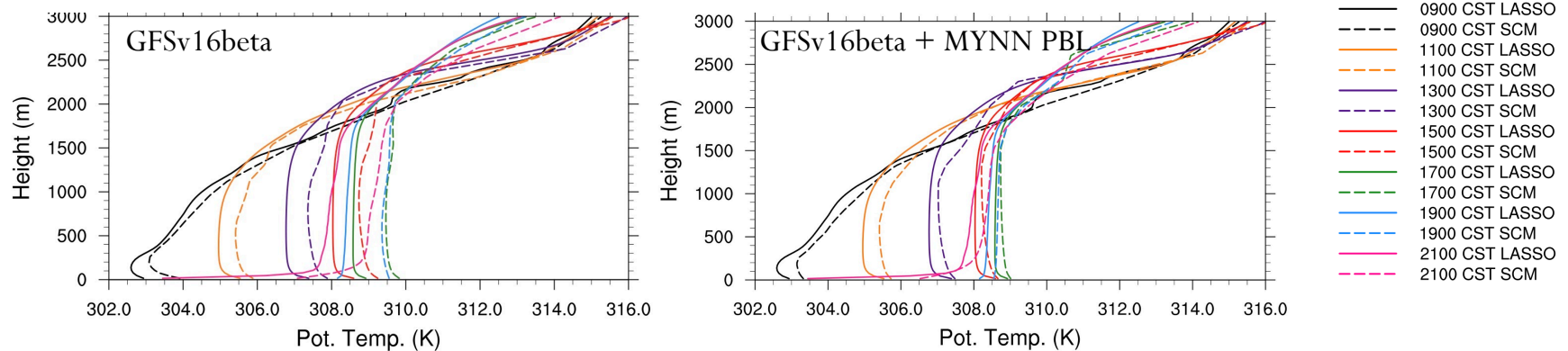
The [SCM User's Guide](#) explains how community users can add their own cases/data.

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)

Case Studies: Another Tier in the Hierarchy

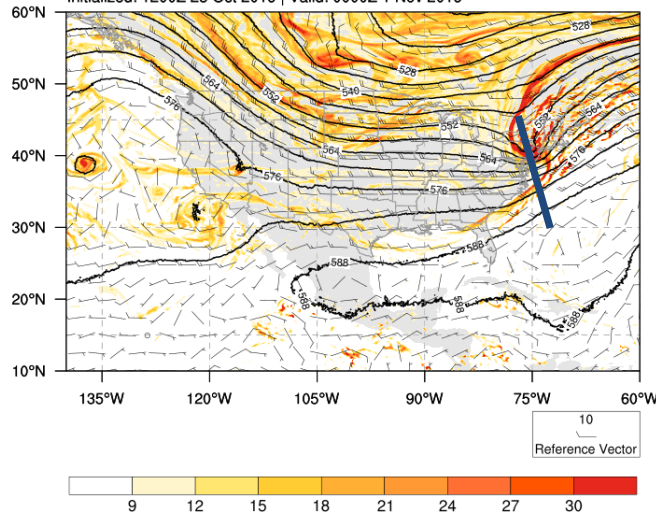
- The UFS Application Teams are starting to publish their “forecast challenges”
 - Synoptic patterns are too progressive
 - Positive bias in 2-m T (occasional, warm season, US Southern plains and corn belt etc.)
 - Negative bias in 2-m T (cold season)
 - Etc.
- Case studies can illustrate specific problems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

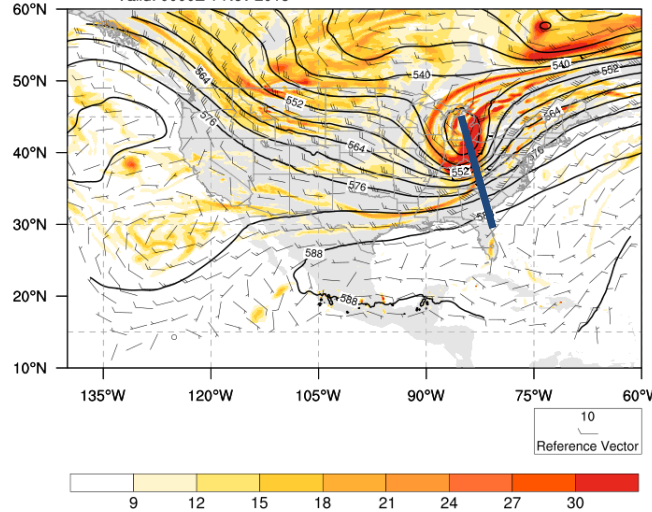
UFS MRW App with oper GFS physics

UFS_v1.0.0_ccpp(15p2): 500mb Heights(dam) /Abs Vorticity ($10^{-5}/s$) / Winds (m/s)
Initialized: 1200Z 25 Oct 2019 | Valid: 0000Z 1 Nov 2019



NAM analysis

NAM_ANL: 500mb Heights(dam) /Abs Vorticity ($10^{-5}/s$) / Winds (m/s)
Valid: 0000Z 1 Nov 2019



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)