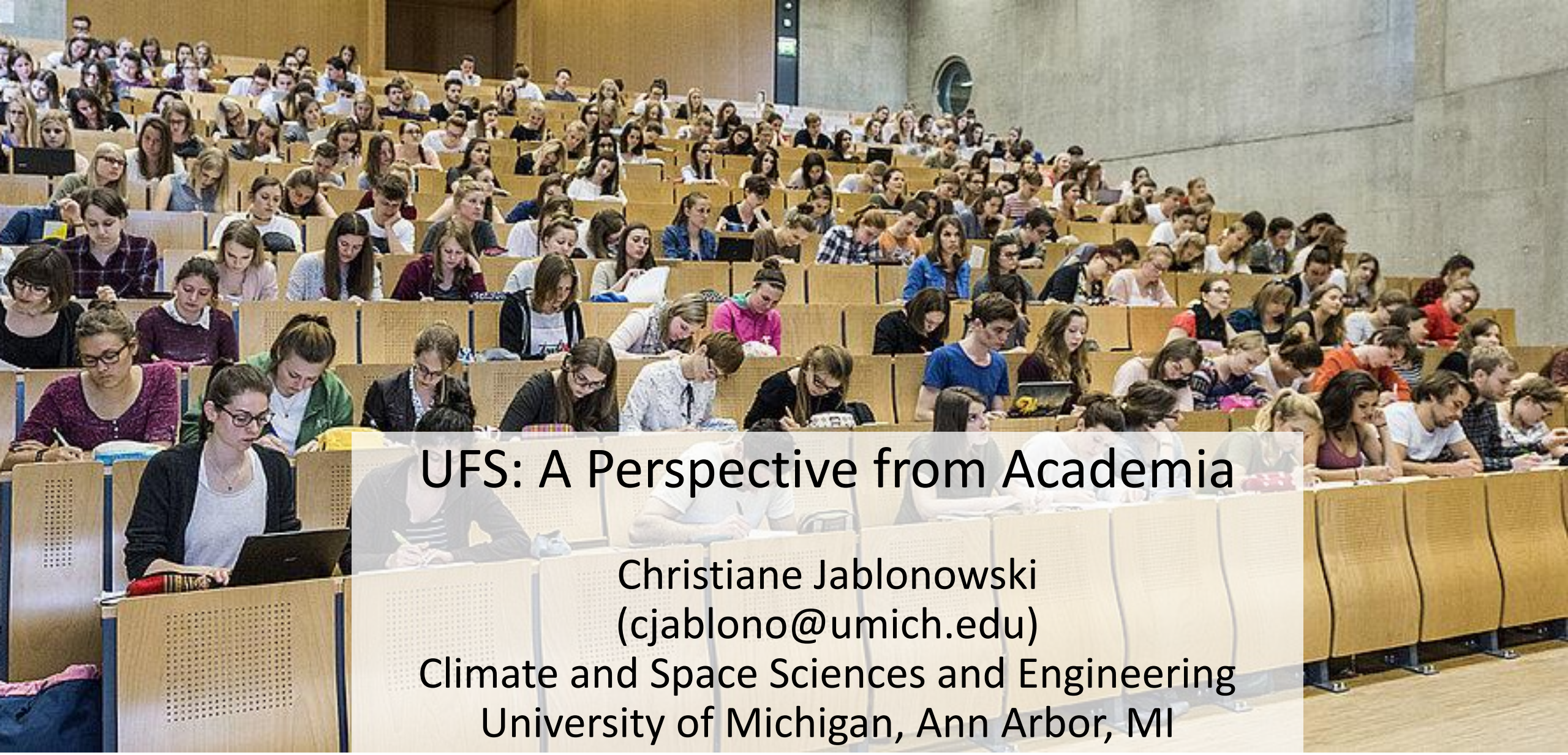


UFS: A Perspective from Academia

Christiane Jablonowski
(cjablono@umich.edu)
Climate and Space Sciences and Engineering
University of Michigan, Ann Arbor, MI

Academia and the UFS: Speakers

Christiane Jablonowski

Professor, Atmospheric dynamics and modeling expert, Department of Climate and Space Sciences and Engineering (CLASP), University of Michigan

Lou Wicker

NOAA Scientist and Affiliate Professor (School of Meteorology, University of Oklahoma), Convection-allowing modeling expert, NOAA's National Severe Storms Laboratory

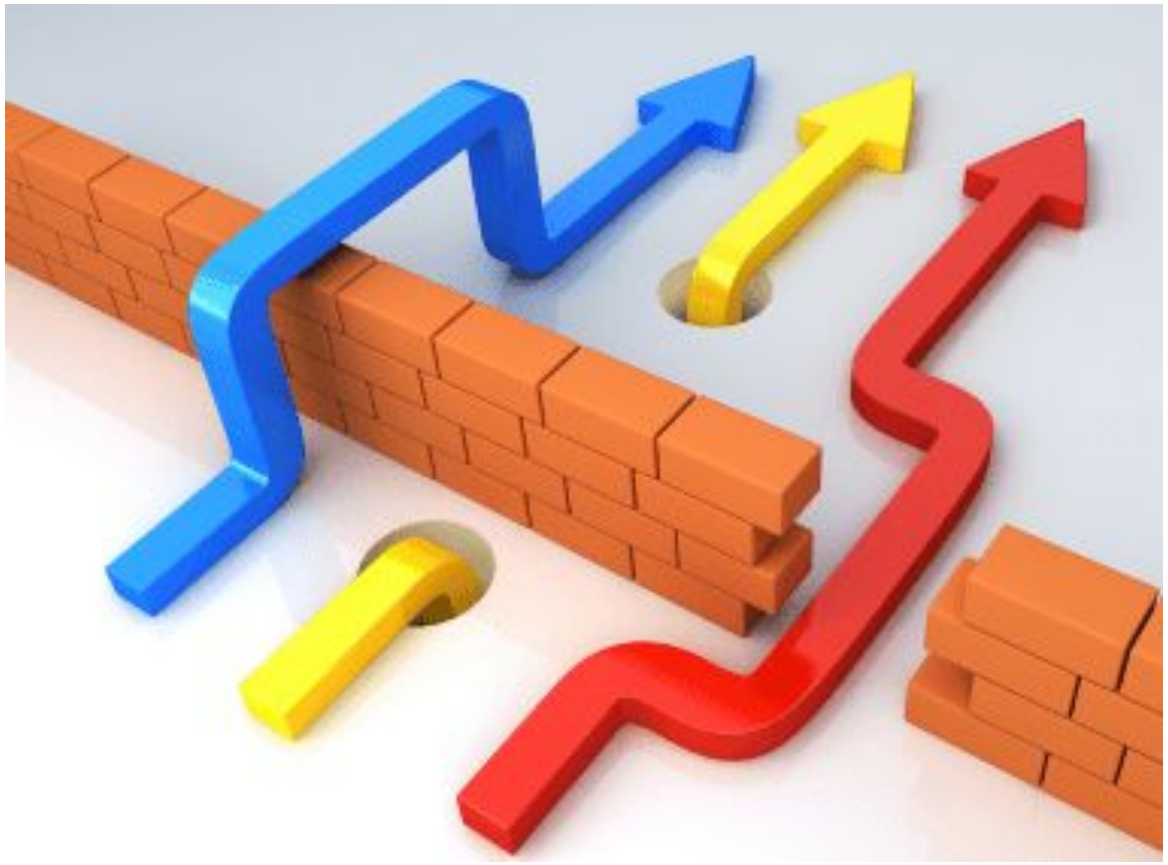
Eric Anderson

Associate Professor, Hydrology expert (with a focus on lake modeling), Department of Geophysics, Colorado School of Mines

Ayumi Fujisaki-Manome

Assistant Research Scientist, Ice expert (with focus on lake and ocean interactions), Cooperative Institute for Great Lakes Research (CIGLR) and CLASP, University of Michigan

A Perspective from Academia



Academia's wish list closely aligned with EPIC's mission (with one caveat):

To be the catalyst for community research and modeling system advances that continually inform and accelerate advances in our nation's operational forecast modeling systems.

Caveat: Model investigations and advances at universities might not all be targeted towards operations.

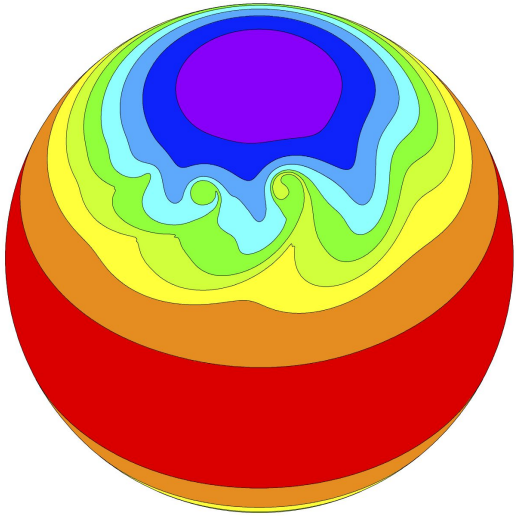
What Academia Needs:

Remove the barriers that prevent Academia from effectively participating in the NOAA Unified Forecast System (UFS) Endeavor

Composition of the Model-Oriented Academic Community

Model Development Community (10%)

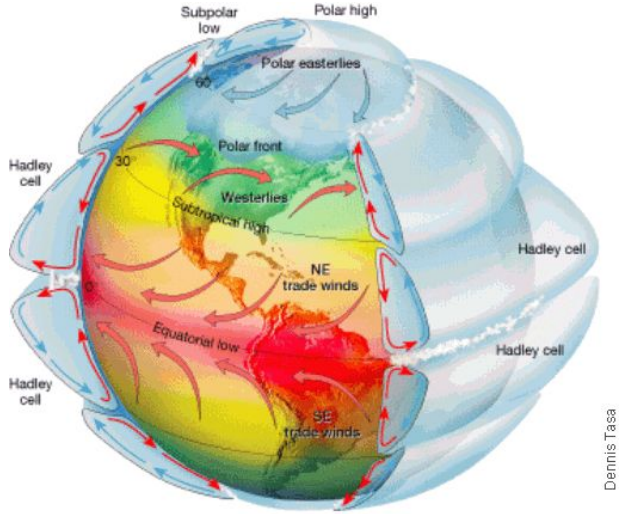
- Primarily interested in advancing the design aspects of weather and climate models



- Longer-term research (3-5 years and beyond)
- Close interaction with a modeling institution likely, often required for successful funding decisions (like DoE's E3SM)
- Fewer publication opportunities, fewer universities with training opportunities

User Community (90%)

- Primarily interested in understanding processes in weather and climate models



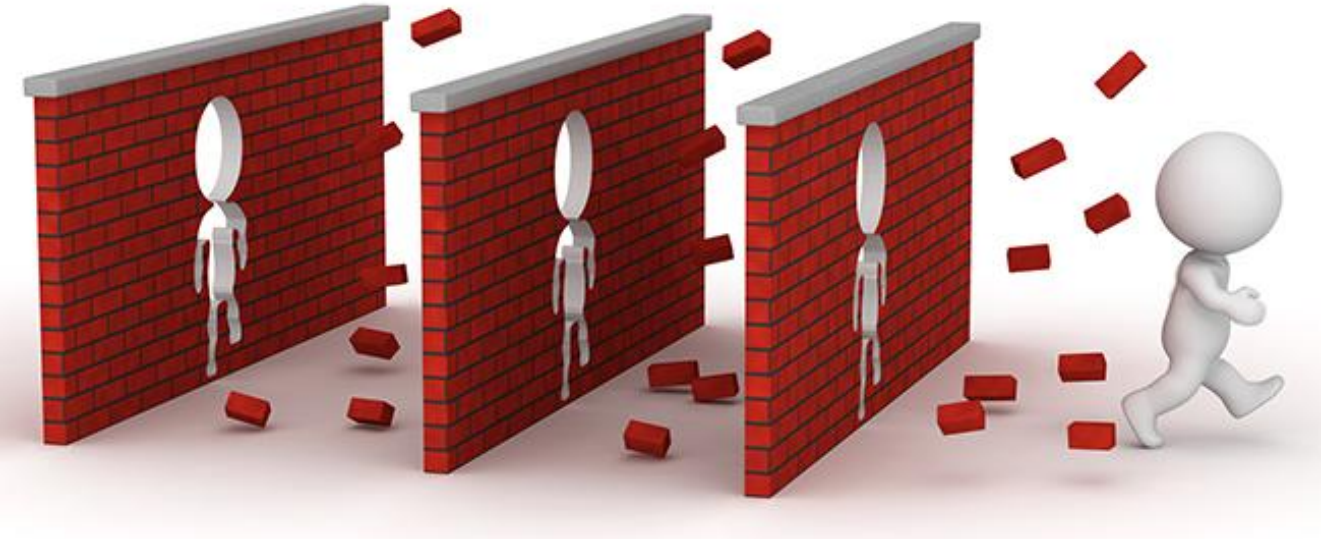
- No or very minor changes to the model design and parameters (if model is run)
- Interaction with modeling center is minimal
- Also common: A focus on the analysis of existing model data (e.g. from intercomparisons like CMIP6, or Large Ensemble data)

Characteristics of Successful Model Communities

Examples of functional communities: inspired by lessons-learned from CESM and WRF (NCAR)

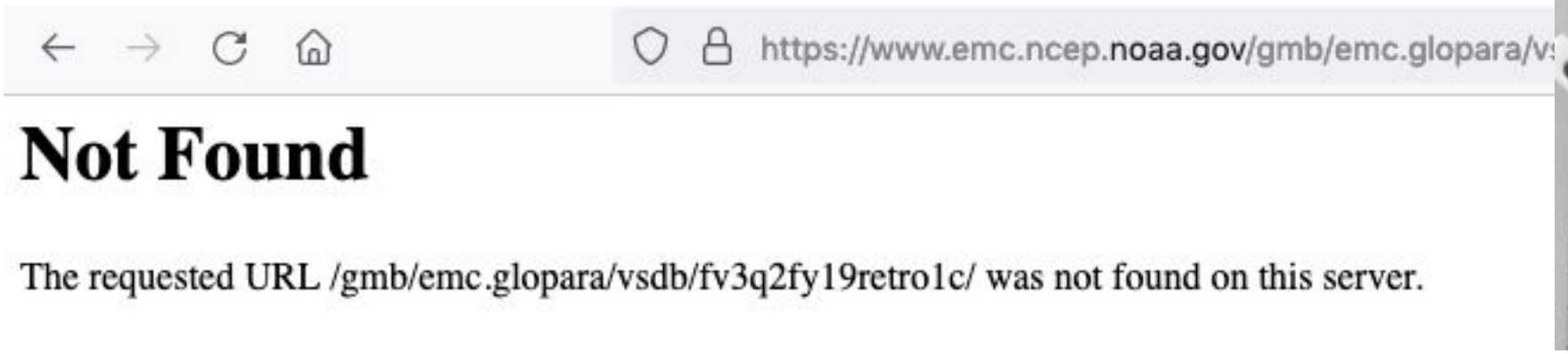
- Welcoming environment: Community is viewed as an asset and not a burden
- Institutional support: Scientific & Software Engineering support for the community (liaison, base-funded at the institution)
- Open-source code bases and flexible workflows, ease-of-use determines model decisions
- Portability of the code to a wide variety of computing architecture
- Regular scientifically-vetted releases with …
- … In-depth documentation: Scientific Description and User's Guide
- Community is involved in decision-making (scientific steering committee)
- User engagement via in-house workshops and working groups
- Training opportunities for new users (tutorials, recorded and in-person)
- Online Bulletin Boards and Help Desks
- Funding opportunities for hypothesis-driven research and experimentations (e.g. NSF)
- No expectation that research will advance the code base (although it might)

UFS: Develop A Shared Understanding how Academia Works

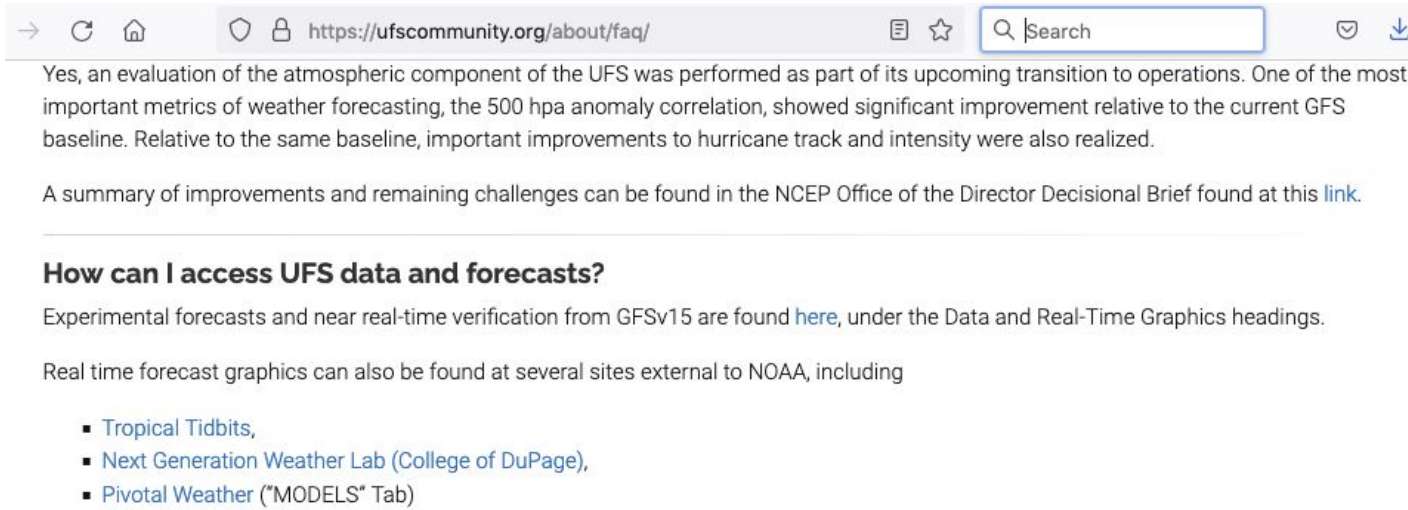


- Universities foster model innovations and provides diagnostic contribution
- University **research needs funding** to allow participation in the UFS
- Ph.D. students need 5 years, NOAA funding is 2-3 years
- University research might be at lower Readiness Levels (RL 1-3), which often prevents participation in NOAA funding calls like JTTI
- UFS funding mechanisms/decisions should allow for risk (ideas can fail)
- Internships (without nationality restrictions) are a great way to connect

Provide Seamless Access to Information about the UFS



- UFS-relevant model documentation is scattered, often inconsistent, not necessarily up-to-date, or occasionally not found
- Wish list: EPIC should become the **go-to destination / community gateway (portal)** that provides the **information**/documentation about all UFS applications, contact people, **help desks**/ forum, UFS training opportunities



Make the Access to UFS Data Easy

- Data formats: Research community works with the NetCDF data format, NOAA UFS data are largely in grib2 data that do not supply Metadata (data that describe the data): difficult to use
- UFS data are scattered (ftp servers, cloud, on NOAA HPC systems behind the firewall), disorganized
- Wish list: Provide a **NOAA UFS data hub / portal** for operational/experimental UFS data and all supporting files to allow new model experiments
- **Modernize the data access** to enable community involvement
- In case of cloud computing: how is it paid for?

ftp.ncep.noaa.gov

Index of /data/nccf/com/gfs/prod/gfs.20210908/00/atmos

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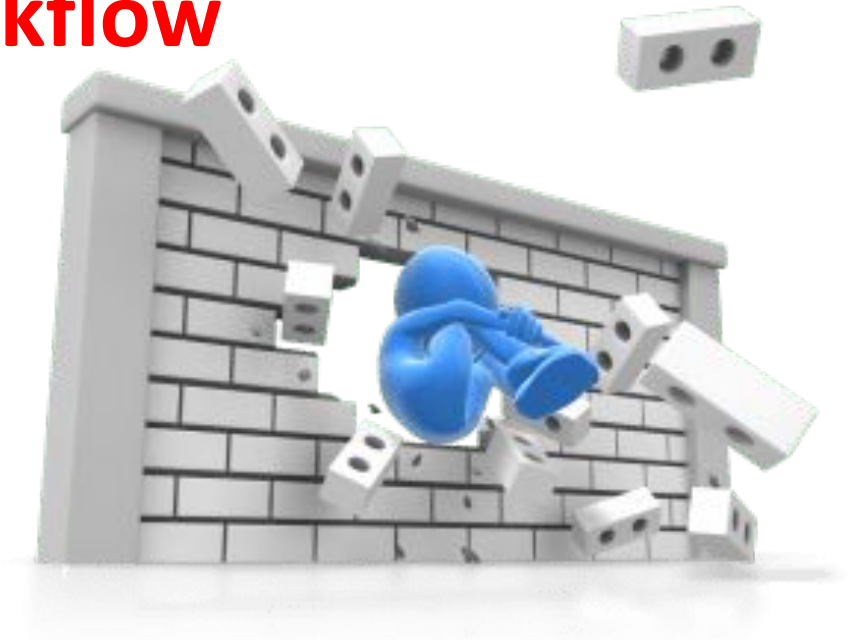
Enhance UFS's Portability & Flexible Workflow



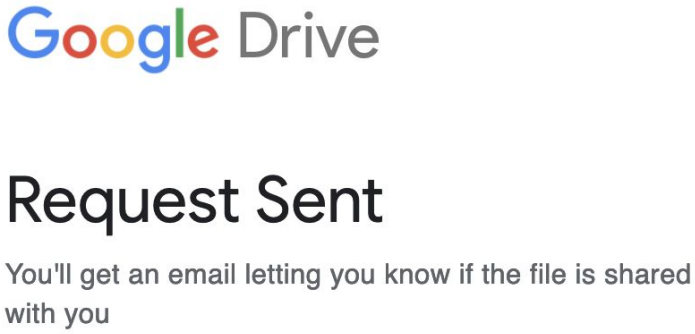
- University community typically does not have computing resources on NOAA's tier-1 HPC systems that support the UFS software stack
- Our own experience: UFS can even break on tier-1 machines, like RRFS prototypes on NCAR's Cheyenne system (libraries might fail)
- UFS is difficult to port to other HPC machines (like NSF's XSEDE)
- UFS workflow should allow for maximum flexibility (e.g. idealized setups)
- Even if the UFS model can be ported, the operational workflow might not be portable, is in flux (MRW), and is often not fully documented
- Wish list: enable community participation via a portable, documented UFS software stack and workflow **(advance usability)**

Community's Use of HPC Resources: Need UFS Portability

- Cloud computing requires funding that the community does not have
- Community has access to institutional clusters or HPC systems from funder
- Typical: funding source allows/provides free access to HPC resources
  - NSF: NCAR HPC Cheyenne (current) and Derecho (future)
  - DoE: NERSC machine
  - NASA: NASA HPC
  - NOAA: no clear mechanism, access to NOAA HPC might be granted through friendly NOAA collaborators on a specific project, getting access takes more than a year and might be impossible for foreign nationals
- Funding-independent HPC systems (need elaborate proposals, scaling info)
  - NSF's XSEDE infrastructure (diverse HPC systems)
  - DOE Incite and ALCC programs (large shuffle-ready compute needs, no development)

Governance & Decision Making & Communication

- Shared understanding is needed how
  - model development priorities are determined
  - the UFS makes decisions about community-led model innovations
  - UFS funding decisions are made
- Wish list:
  - support the **transparent governance** of the UFS, empower community
  - simplify the access to UFS information and **foster NOAA-community interactions**



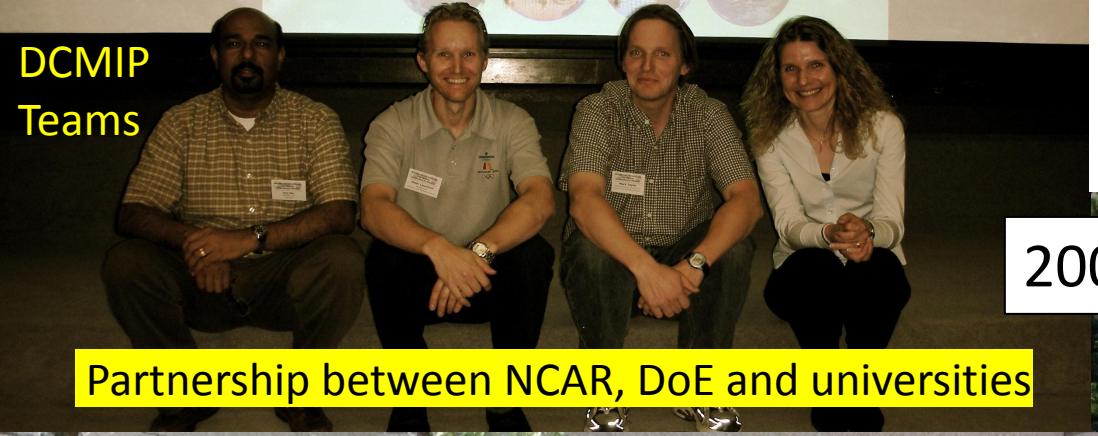
Academia and the UFS: Win-Win

- The academia community is a partner that
  - offers fresh perspectives how future models/versions should be built
  - is more risk-tolerant than operational centers
  - fosters model innovations
  - trains the future generation of model developers and users
- Concrete example from an educational viewpoint:
  - Dynamical Core Model Intercomparison Project (DCMIP)
  - Class at the University of Michigan: The Art of Climate Modeling

Academia and the UFS: Win-Win

- The academia community is a partner that
  - is more risk-tolerant than operational centers
  - offers fresh perspectives how future models/versions should be built
  - can enhance access to HPC for UFS investigations (e.g. XSEDE, joint UM-NOAA UFS award 2021-2022 was valued $2.8 million, impossible to raise such funding for cloud computing), need: portable UFS
  - fosters model innovations (see also Eric and Ayumi's talks)
  - trains the future generation of model developers and users
- Concrete example from an educational viewpoint:
  - Dynamical Core Model Intercomparison Project (DCMIP)
  - Class at the University of Michigan (UM): The Art of Climate Modeling

Summer Schools: Dynamical Core Model Intercomparison Project (DCMIP)



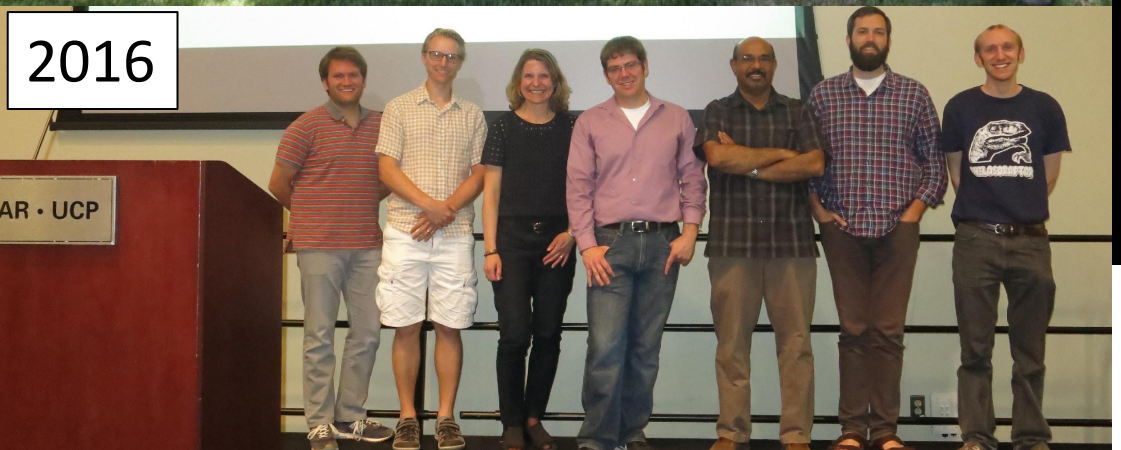
Partnership between NCAR, DoE and universities

2008

2012

Is NOAA (UFS, EPIC) interested in playing a future role?

2016



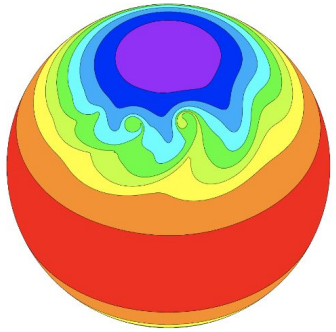
2008, 2012,
2016, 202X?

2016


DCMIP
Hands-on Learning
MPAS (2016)
FVM
CAM -FV
E3SM
CAM-SE
MCORE/Tempest
UZIM/CSU
ICON-MPI-DWD
FV3
IFS
MPAS (2012)
ICON-IAP
OLAM
GEM
DYNAMICO
ENDGame
FIM
NEPTUNE
NICAM
NIM

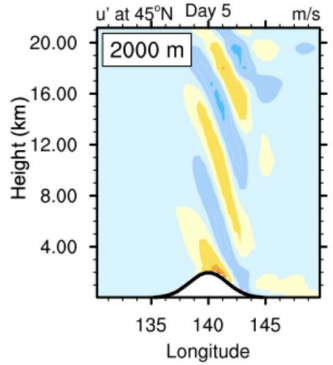
U. Michigan class: The Art of Climate Modeling

- Project-driven hands-on introduction to weather and climate modeling (CLIMATE 589)
- Covers the broad spectrum of model design aspects (dynamics and physics)
- Students experiment with idealized model configurations, students also picked E3SM & MPAS for their final project
- Tool: CESM model environment with its “simpler model” hierarchy
- Could UFS be used? Desirable!



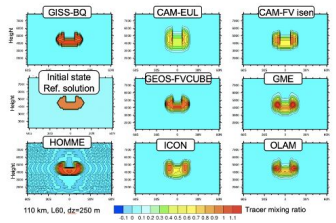
[Class Project 1](#)

Analyze baroclinic waves in a dry GCM.



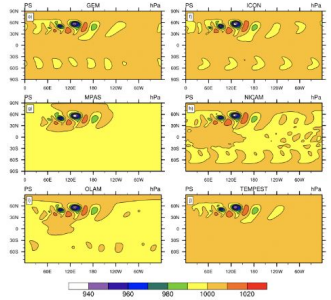
[Class Project 2](#)

Evaluate the impact of topography and a simple rain scheme on the circulation.



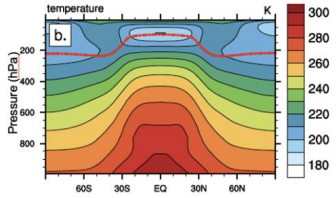
[Class Project 3](#)

Understand the advection process via passive, dynamically active and interacting tracers.



[Class Project 4](#)

Investigate the impact of dissipation mechanisms on the fluid flow.



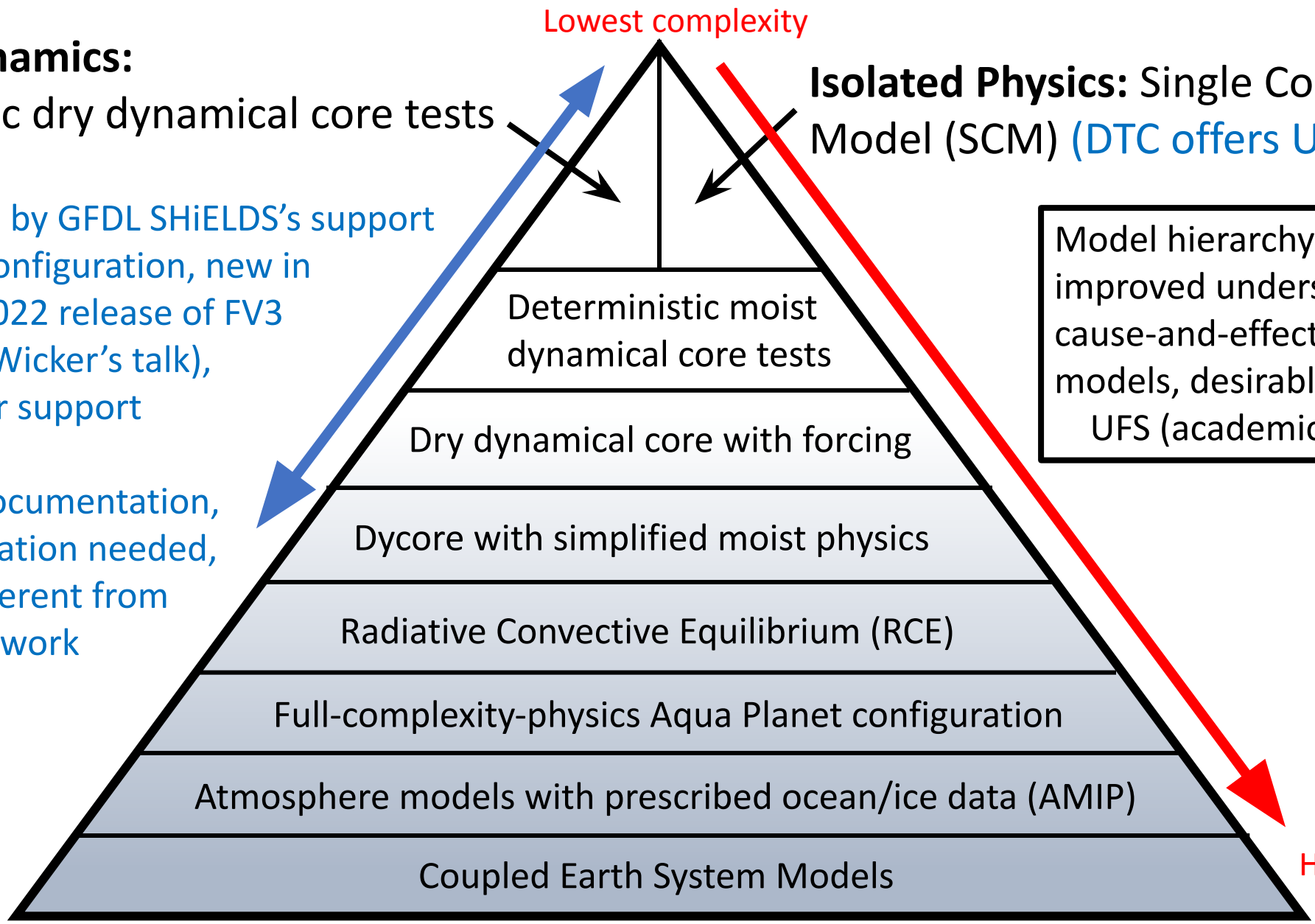
CAM5 Aqua-Planet simulation

[Class Project 5](#)

Assess climate simulations with intermediate-complexity model configurations.

CESM “simpler model” hierarchy:
https://www.cesm.ucar.edu/models/simpler-models/

CESM Model Hierarchy



Isolated Dynamics:
Deterministic dry dynamical core tests

Partly covered by GFDL SHiELDS's support of the 'Solo' configuration, new in GFDL's April 2022 release of FV3 (see also Lou Wicker's talk), also: container support

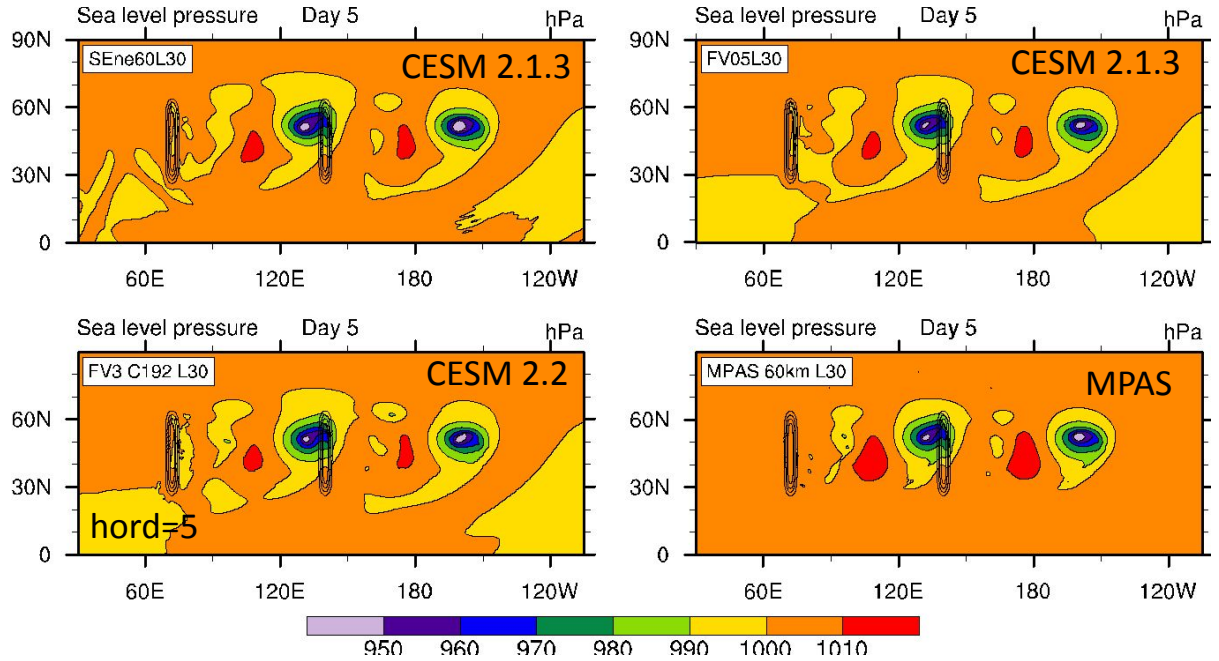
Caveats: no documentation, insider information needed, SHiELDS is different from the UFS framework

Isolated Physics: Single Column Model (SCM) (DTC offers UFS SCM)

Model hierarchy provides an improved understanding of the cause-and-effect relationships in models, desirable to have in the UFS (academic wish list)

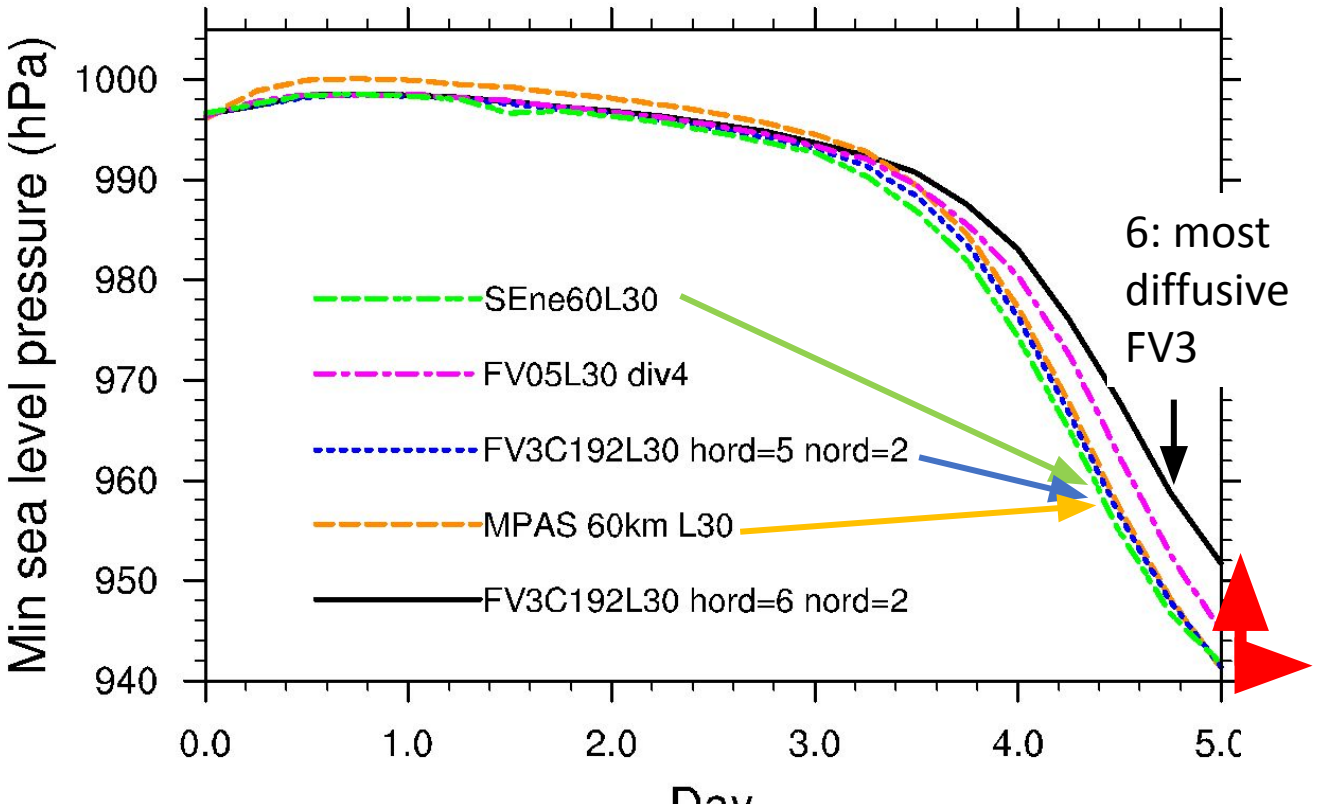
Final Thoughts: Science Example with FV3 via CESM framework

Comparison of SE, FV, FV3, MPA: Moist Baroclinic Wave



Resolutions: ≈ 50 km L30

Time series: Minimum sea level pressure



- SE, FV3 (hord=5) and MPAS closely track each other (SLP time series overlap)
- FV3 (hord=6) most diffusive (as an aside: FV3 is now part of CESM, easy access via CESM)
- Sea Level Pressure (SLP) minimum is highly sensitive to the FV3 diffusion settings
- **Example how idealized configurations shed light on the FV3 model design and options**