GLOBAL SYSTEMS LABORATORY

DTC Developmental Testbed Center

Progress in Expanding the Unified Forecast System to Multiple Dynamical Cores

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NSF | NCAR Operated by UCAR

Forecast systems that deliver solutions

Contributions from DTC Developmental Testbed Center

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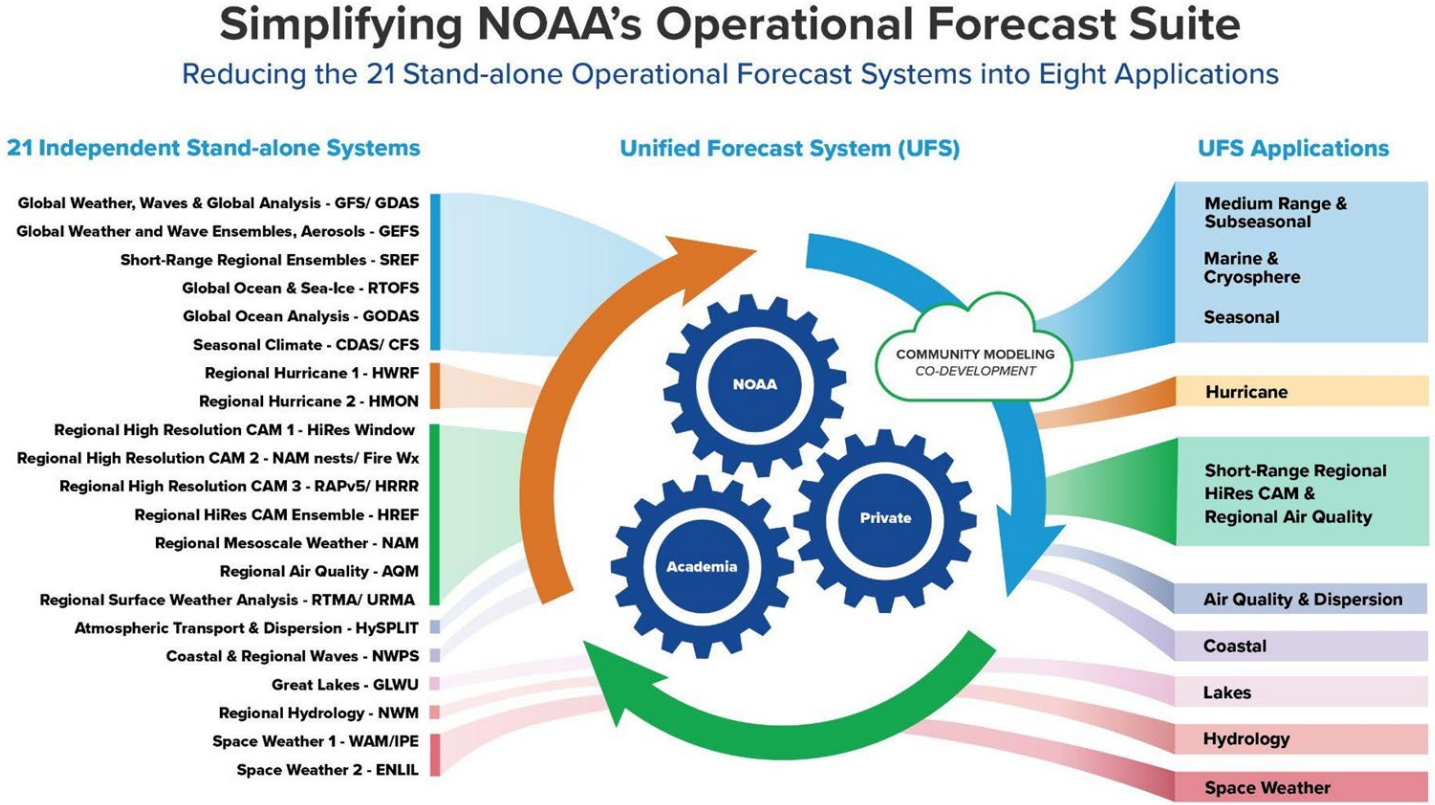
Several NOAA GSL contributors

UFS: For research and NOAA Operations

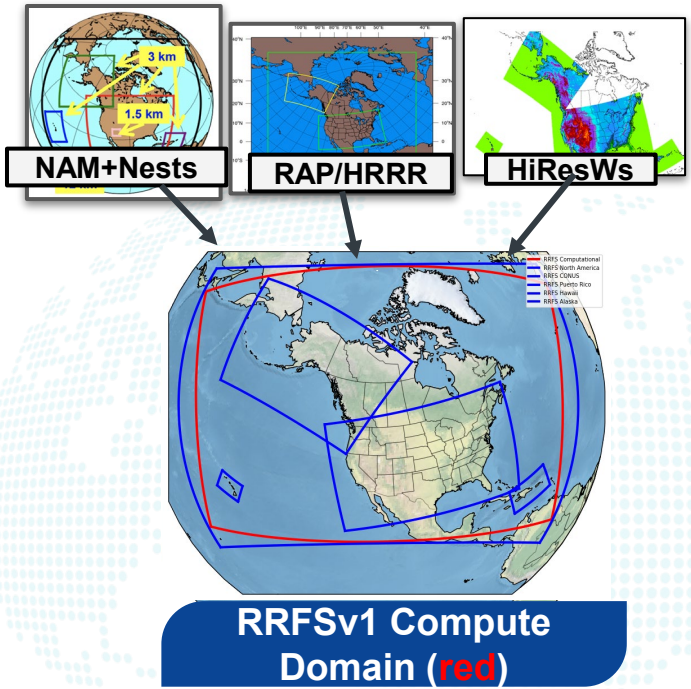


From Uccellini et al. (2022)

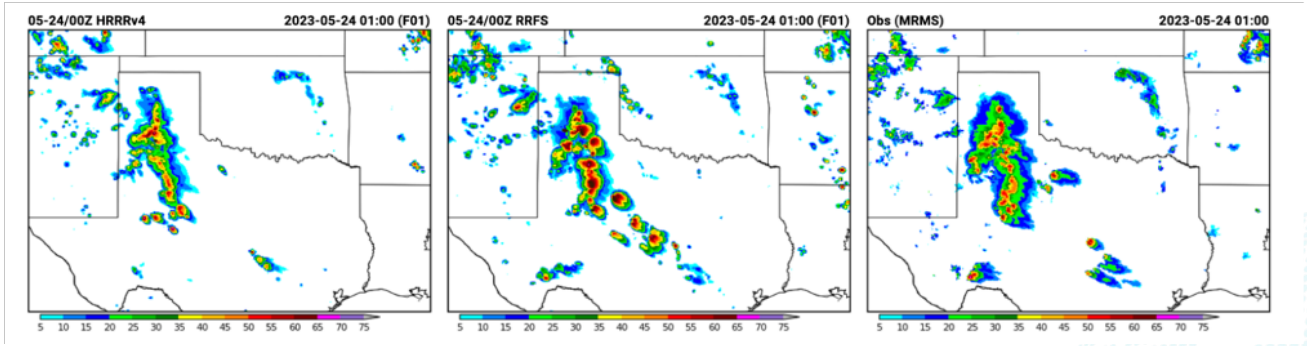
Slide adapted from Jacob Carley, UFS R2O meeting, Feb 6, 2024

Rapid Refresh Forecast System (RRFS) v1

- FV3 dynamical core (limited area model)
- Hourly updated
- 3-km grid spacing over North America
- 65 vertical layers
- Hybrid 3DEnVar data assimilation
- Includes smoke and dust



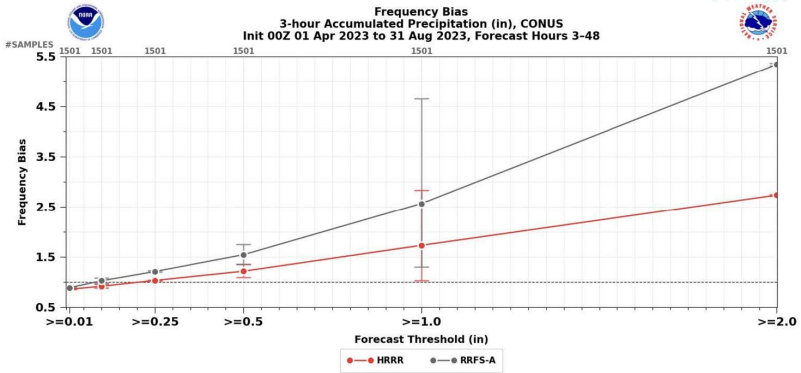
RRFS Springtime Challenges



Difficulty with springtime convective storms (too big, too much precipitation)

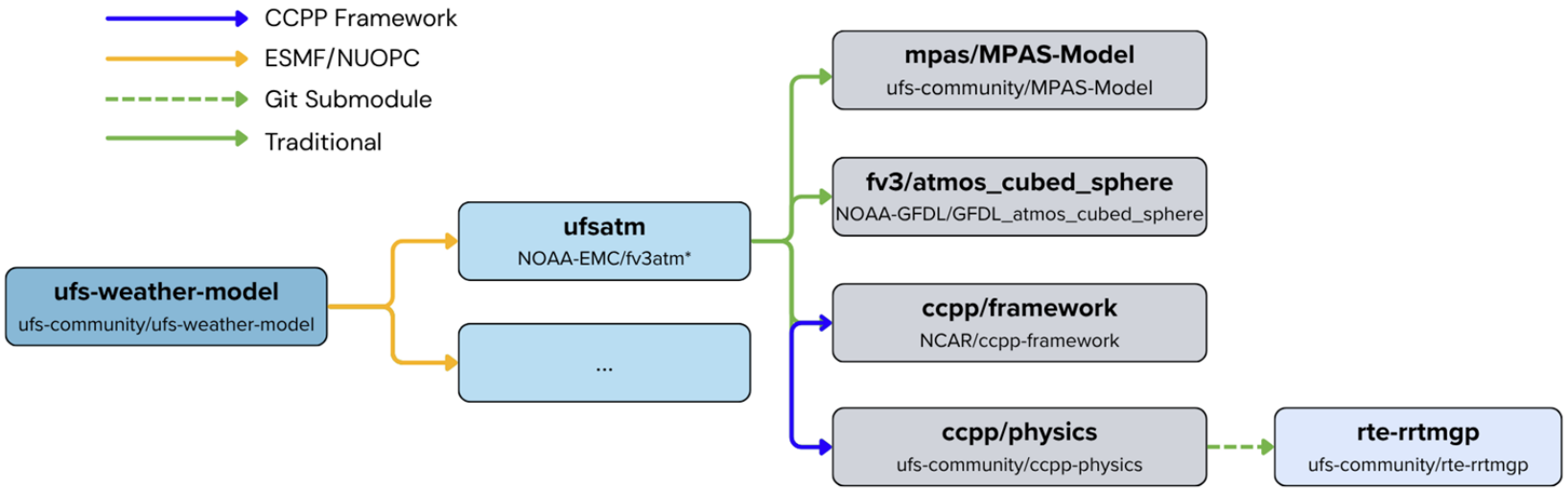
Recommendation to use MPAS dycore for RRFS v2

Wang, J. et al. (2023). Integration of MPAS dycore into UFS.



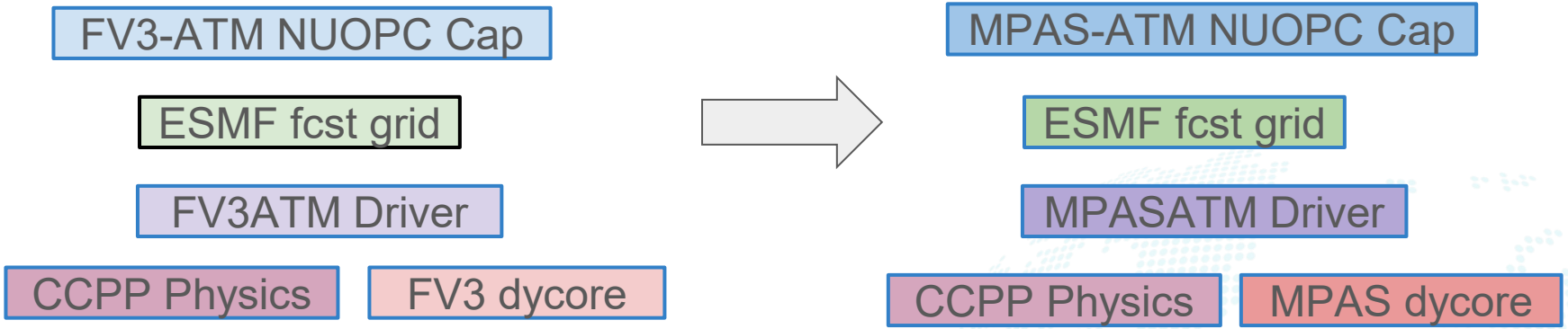
Carley, Jacob et al. (2023). Mitigation Efforts to Address Rapid Refresh Forecast System (RRFS) v1 Dynamical Core Performance Issues and Recommendations for RRFS v2. https://doi.org/10.25923/ccgj-7140

UFS Weather Model Architecture with two dycores



Step 1: Generalized FV3ATM -> UFSATM
Step 2: Included MPAS dycore (submodule)

Stub ESMF Infrastructure in Place for MPAS

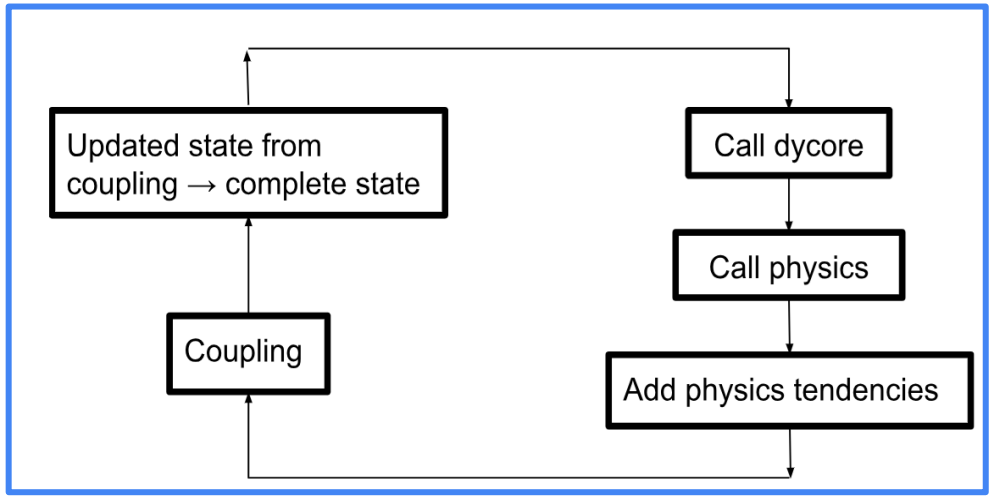


New capabilities:

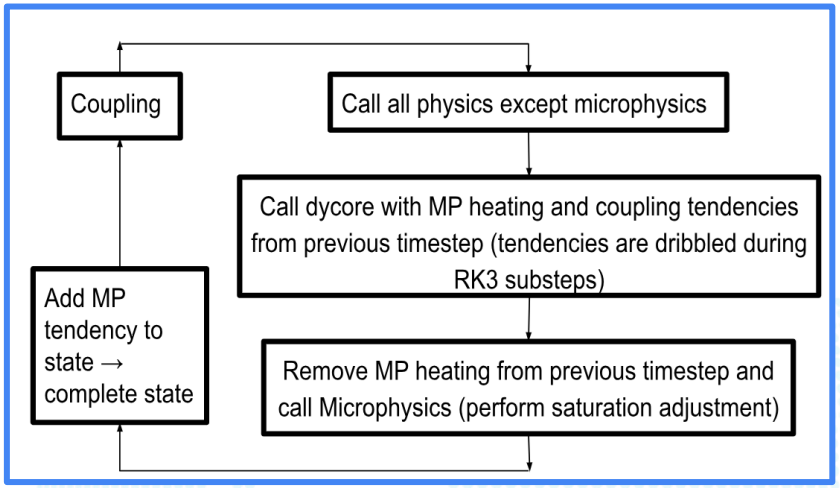
- Initialize and advance dycore
- Initialize and advance a “hello world” CCPP Physics scheme

Revised PhysicsDynamics Coupling (P2D) Needed

FV3



MPAS

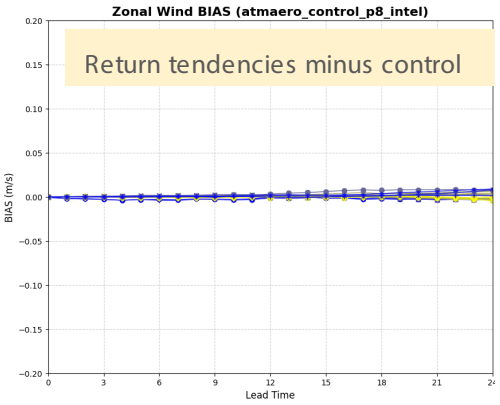


MPAS-UFS atmospheric driver has to be built to call the physics, dynamics, and coupling in specific order (which differs from FV3-UFS)

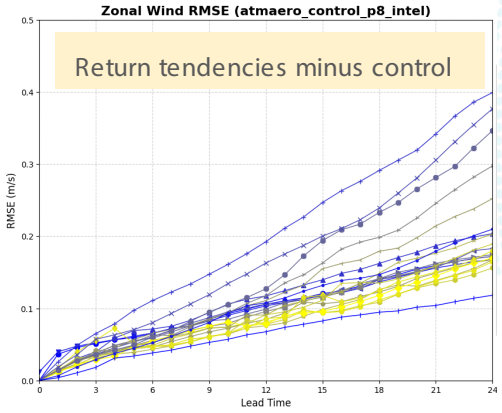
MPAS P2D Requires Parameterizations to Return Tendencies

- FV3-UFS uses a mix of process- and time-split
- All CCPP parameterizations can now return tendencies. Time split is done by host model controlling state updates.
  - Results are slightly different (tested one suite, one 24-h forecast)

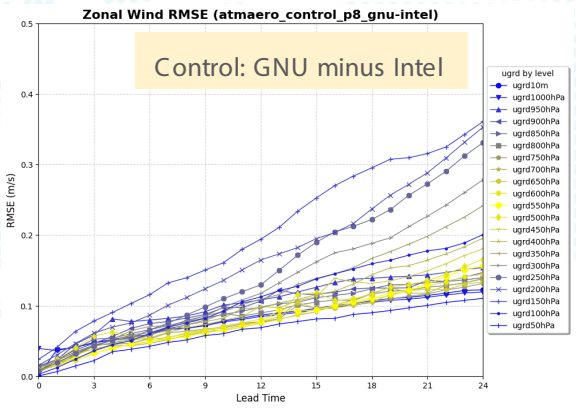
U bias is ~zero



U RMSE is small



U RMSE ~differences introduced by compilers



Additional Physics-to-Dynamics Coupling Work

	MPAS dycore	CCPP
Array layout	k,i	i,k
Vertical coordinate	height	pressure
Vertical ordering	bottom-up	top-down
Thermodynamics	dry, constant volume	moist, constant pressure

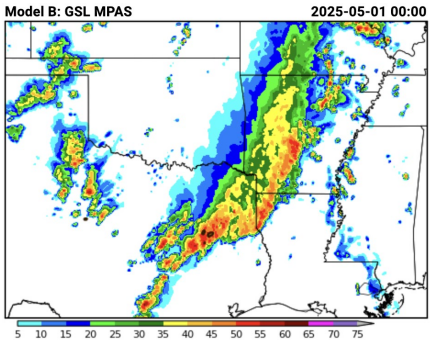
I/O: Hopefully Upcoming Work on (by NOAA/EMC and ESMF)

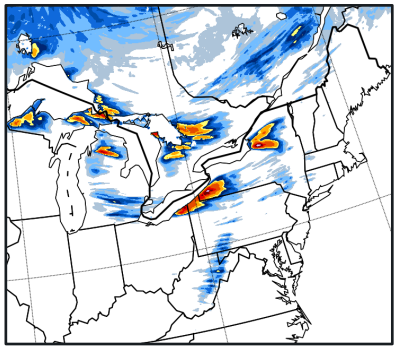
- **Background**
  - MPAS has PIO but not asynchronous I/O
- **Needs**
  - Speed up I/O
  - Output on necessary grids
- **Solutions**
  - Create MPAS-compatible ESMF write grid component
  - Extend NUOPC cap to call the forecast and write grid components

Coupling: Hopefully Upcoming Work on (NCAR/CGD/ESMF)

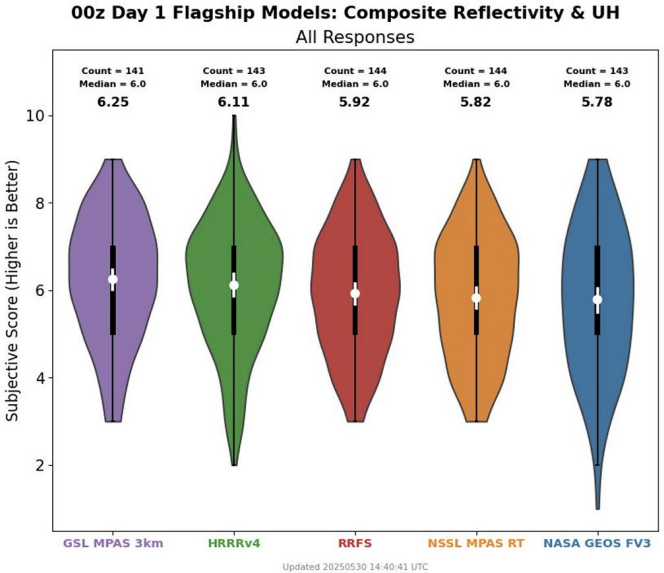
- **Background**
  - GSL/DTC auspices targeted at atmosphere-only forecasts
- **Needs**
  - Expand coupling capabilities to ocean, chemistry, etc.
- **Solutions**
  - Generalize coupling

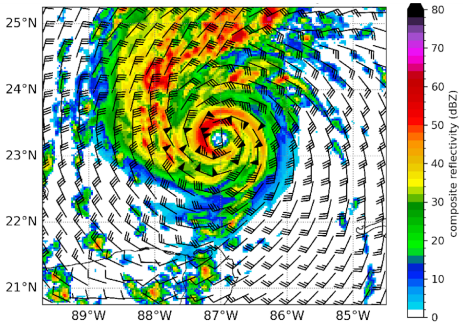
Meanwhile… NOAA GSL engaging with MPAS

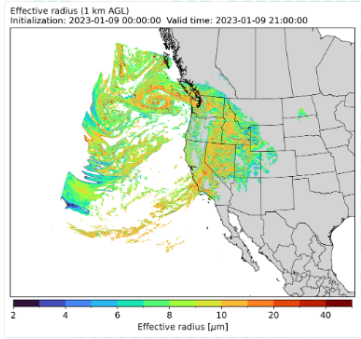




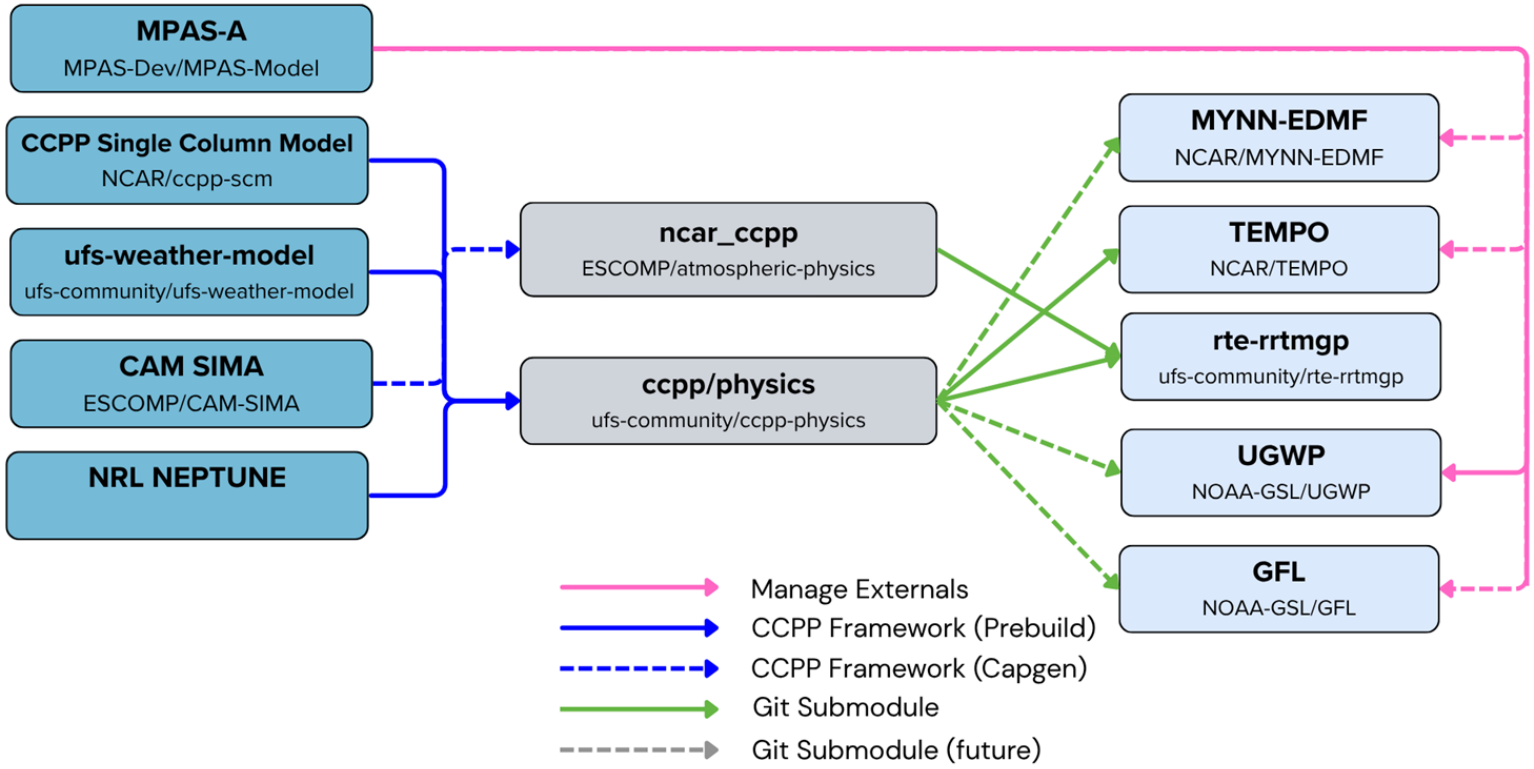
- Updated physics
- Realtime research
- Testbed engagements







Managing GSL-led Physics for MPAS-A and CCPP



Take-Away Messages

- Much progress has been made
  - Stub capability in place
- Plans and (partial) funding secured to continue
- Upcoming work will focus on P2D, I/O, and coupling to other components
- Meanwhile…science marches forward with MPAS-A
  - Strategies needed for the efforts of to be synergistic and avoid divergence