

UFS Coupling:

How the UFS Is Being Expanded to Include Additional Environmental Modeling Components

Overview of UFS components, their coupling, and highlights of newly developed capabilities

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Background materials

- **Programmatic**

- [UFS Strategic Plan](#) 2021-2025
- [UFS Organization and Governance](#) 2021 (draft)

- **Technical**

- Dunlap et al. (UFS SAICCT), 2021. [UFS Architecture Diagrams](#)
- Wang, J. et al. , 2023. [Model infrastructure development in UFS weather model](#)
- Worthen, D. et al., 2024. [Coupling Infrastructure Capability in UFS Weather Model](#)

Thanks for fruitful discussions: Jun Wang, Dustin Swales, Becky Schwantes, Pedro Jimenez, Hendrik Tolman, Brian Dobbins, Ann Tsay, ESMF Team, and many UFS colleagues

UFS Weather Model Components

- **Mediator:** CMEPS
 - **Data Models:** CDEPS
 - **Sea ice:** CICE6
 - **Waves:** WW3
 - **Fire:** Community Fire Behavior Model
 - **Atmosphere:** FV3 and MPAS dycores, CCPP and Stochastics Physics, WAM
 - **Land:** LM4, Noah MP (but also RUC, Noah, and NoahMP as CCPP parameterizations)
 - **Ocean:** MOM6, ROMS (HYCOM being phased out)
 - **Coastal:** ADCIRC, SCHISM
 - **Lakes:** FVCOM (and CLM Lake as CCPP parameterization)
 - **Aerosols and Chemistry:** CMAQ, GOCART, CATChem (GFDL AM4.1)
- Note that some components are not part of the authoritative UFS WM but are used by UFS Apps

UFS Components Outside of Weather Model

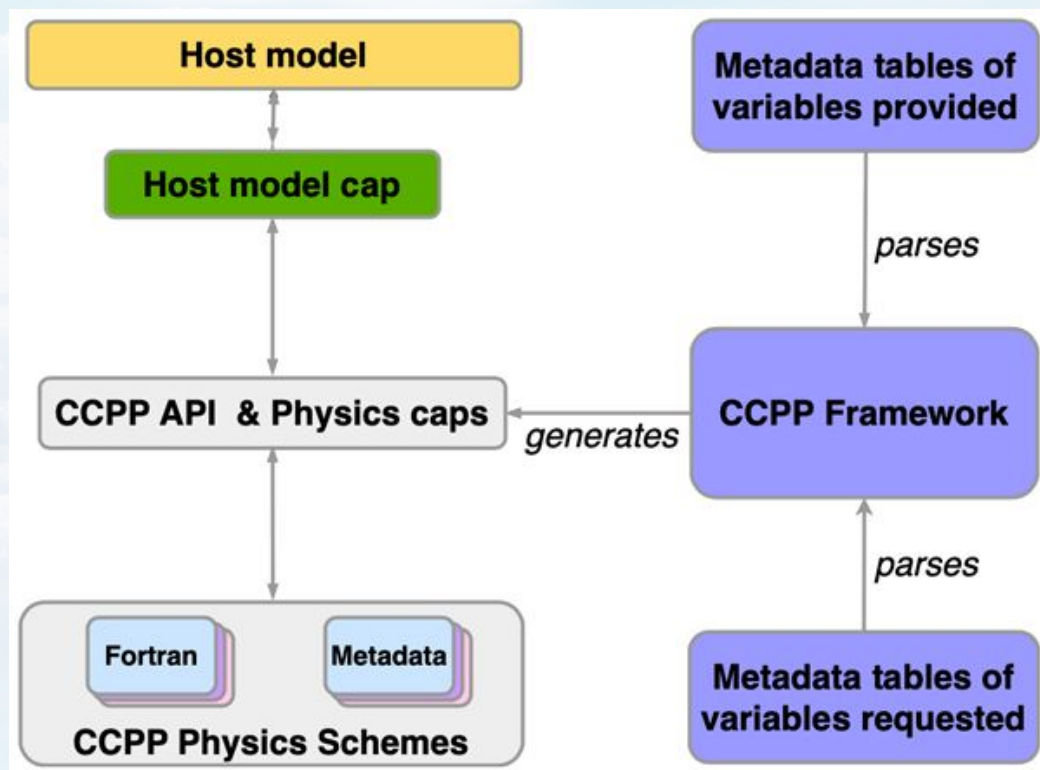
Coupling exchange via disk or in-core

- **Pre-processing:** UFS-UTILS
- **Data Assimilation:** JEDI
- **Post-processing:** UPP
- **Vortex tracker:** GFDL
- **Verification:** METplus
- **I/O:** ESMF Write Grid Component
- (...)
- **Workflow:** global workflow, RRFS workflow, HAFS workflow, SRW App workflow, Unified Workflow Tools, and others

Why Does the UFS have (sub) Components?

- Harness existing community efforts
- Enable hierarchy for scientific and software tests
- Provide flexibility of applications
 - **Short-Range Weather (RRFS):** atm
 - **Hurricane (HAFS):** atm and ocean
 - **Medium-Range Weather and S2S (GFS/GEFS/SFS):** atm, ocean, sea ice, waves
 - **Air Quality (AQM):** atm + CMAQ
 - **Coastal:** DATatm + SCHISM + WW3 and other configurations
 - Etc.

Coupling Strategies: Intra-component

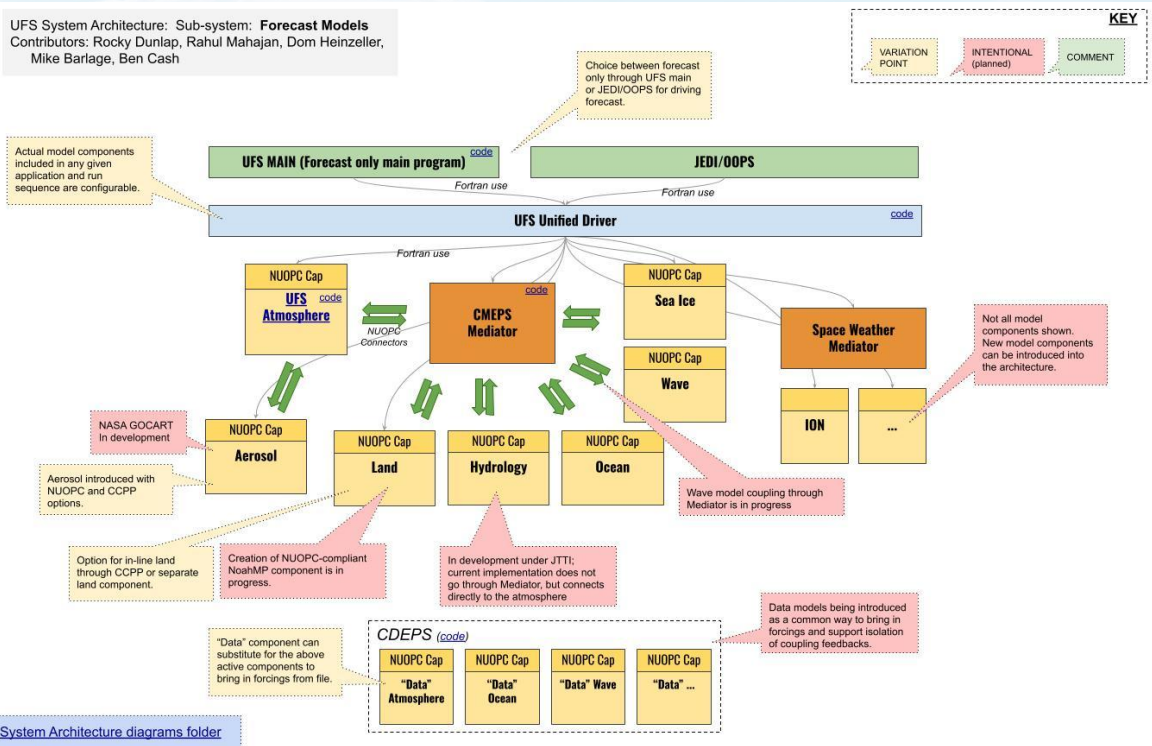


Multi-agency: DTC,
NOAA, NCAR
Navy

The CCPP Framework
is used to couple
physics to the host
model

Coupling Strategies: Inter-Component with ESMF

UFS System Architecture: Sub-system: **Forecast Models**
 Contributors: Rocky Dunlap, Rahul Mahajan, Dom Heinzeller,
 Mike Barlage, Ben Cash



Multi-agency: NOAA,
 NASA, NCAR, Navy

NUOPC Layer extends
 ESMF for more
 interoperability

CMEPS is a
 NUOPC-compliant
 mediator that
 standardizes coupling
 science

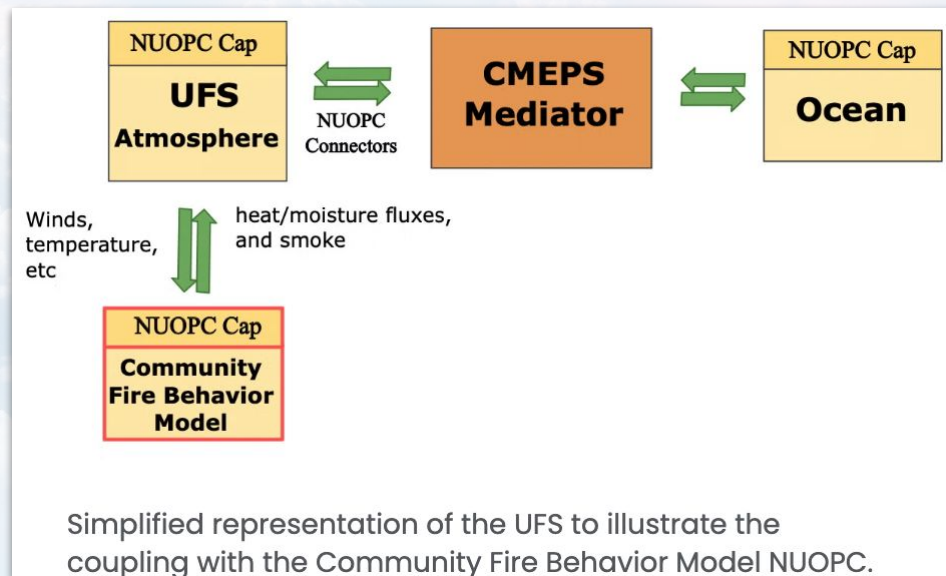


New (1) : Fire Behavior Model

Jimenez et al., 2025. <https://doi.org/10.5194/gmd-2024-124> (led by NCAR)



By Gemini

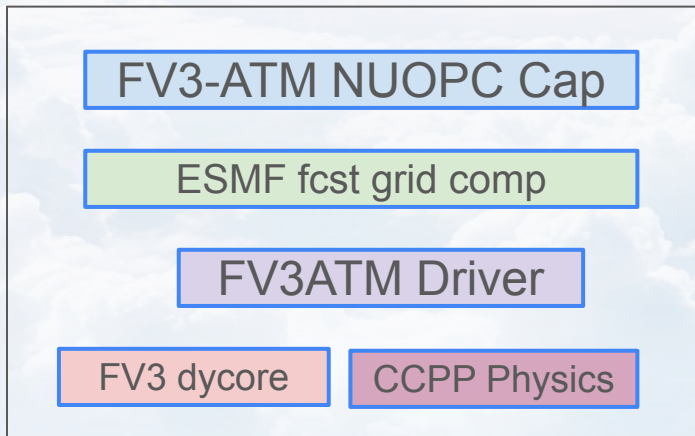


<https://ral.ucar.edu/model/community-fire-behavior-model#ufs3>

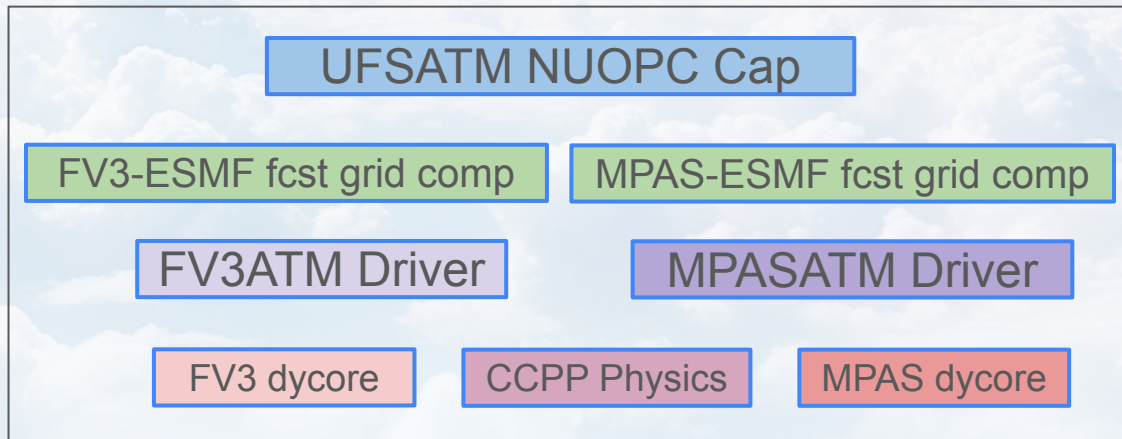
New (2): MPAS dycore (Led by DTC and GSL)

Under development: UFS Weather Model with MPAS dycore

BEFORE

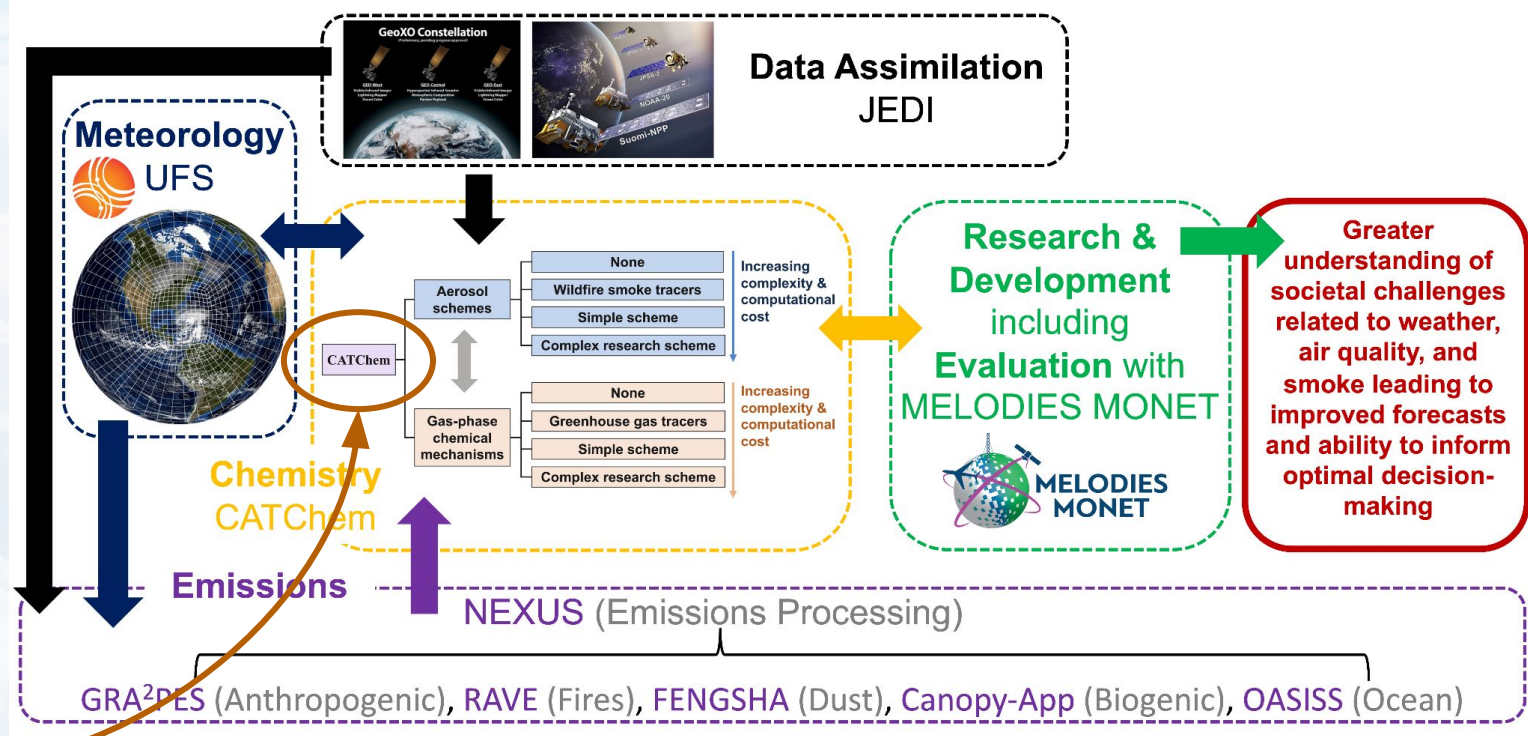


AFTER



New (3): CATChem - under development

Chemistry library and modeling component
All UFS chemistry-related code in one location



CATChem will be coupled to the UFS WM using CCPP and/or NUOPC

Led by NOAA Labs
[He et al., 2025](#)

What is Involved in Adding New Components

- **Projects via funding agency** (e.g., NOAA OSTI/WPO/CPO)
 - Application targets (need for research and/or operations)
 - Scientific innovation
- **Collaboration with ESMF coupling team**
- **Do no harm**
 - RTs (including on computational expenses and robustness/reliability)
 - Backwards compatibility
 - Concurrence for anything that hampers operations
- **Coding Standards** (purview of the component)
- **Ownership:** designated entity responsible for its maintenance

Final Remarks

- The UFS is under active development with new components recently added
- Keys to having an efficient and effective coupled system
 - Effective technical coupling
 - Effective governance
 - Complexity brings power
 - Complexity increases maintenance overhead

