Unified Forecast System Overview

About the UFS

Purpose The Unified Forecast System (UFS) is a comprehensive, community-developed Earth modeling system, designed as both a research tool and as the basis for NOAA's operational forecasts.

Governance Planning and evidence-based decision-making support improving research and operations transitions and community engagement.

Scope UFS is configurable into multiple applications that span local to global domains and predictive time scales from less than an hour to more than a year.

Design UFS is a *unified* system because the applications within it share science components and software infrastructure

Impact UFS is a **paradigm shift** that will enable NOAA to simplify the NCEP Production Suite, to accelerate use of leading research, and to produce more accurate forecasts for the U.S. and its partners.

UFS Applications

UFS is configurable into multiple applications, each of which will have:

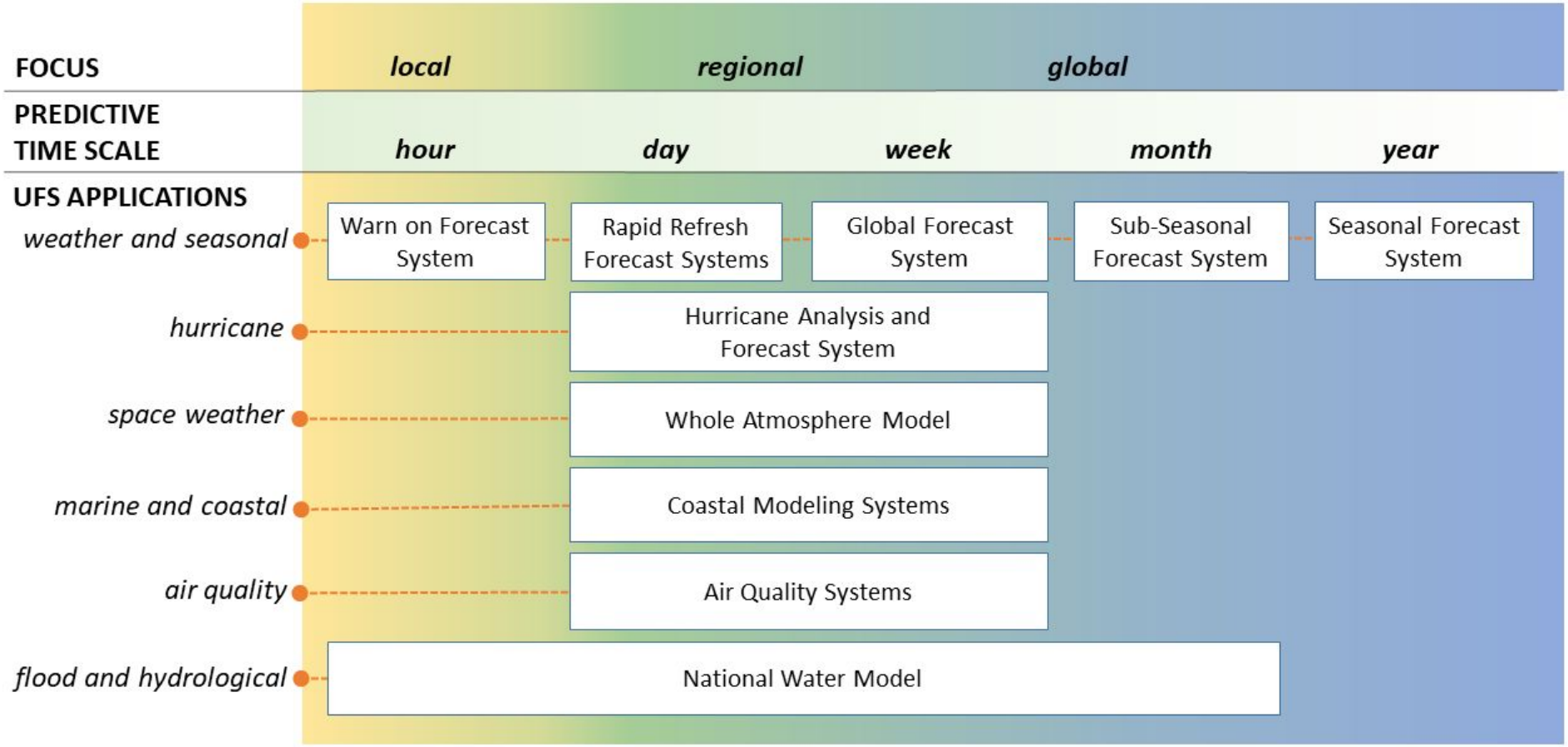
- A forecast target
- Its own “umbrella” repository with links to shared component and infrastructure code
- Lead(s), development plan, and test plan

UFS Applications

UFS applications include:

- Medium-Range Weather (Weather) - Atmospheric behavior out to about two weeks
- Subseasonal-to-Seasonal (S2S) - Atmospheric and ocean behavior from about two weeks to about one year
- Hurricane - Hurricane track, intensity, and related effects out to about one week
- Short-Range Weather/Convection Allowing - Atmospheric behavior from less than an hour to several days
- Space Weather - Upper atmosphere geophysical activity and solar behavior out to about one month
- Marine and Cryosphere - Ocean and ice behavior out to about ten days
- Coastal - Storm surge and other coastal phenomena out to about one week
- Air Quality - Aerosol and atmospheric composition out to several days

Scope of UFS



UFS applications span predictive timescales (less than an hour to more than a year) and focus on multiple spatial scales (local to global).

Why is UFS a paradigm shift?

SHIFT TO AN INTEGRATED EARTH SYSTEM APPROACH		
Atmospheric component is mostly run uncoupled	➔	Use of coupled components is routine for most predictive applications
Data assimilation architecture is *ad hoc*	➔	Move to more consistent, well-integrated, and strongly coupled approaches to data assimilation

Why is UFS a paradigm shift?

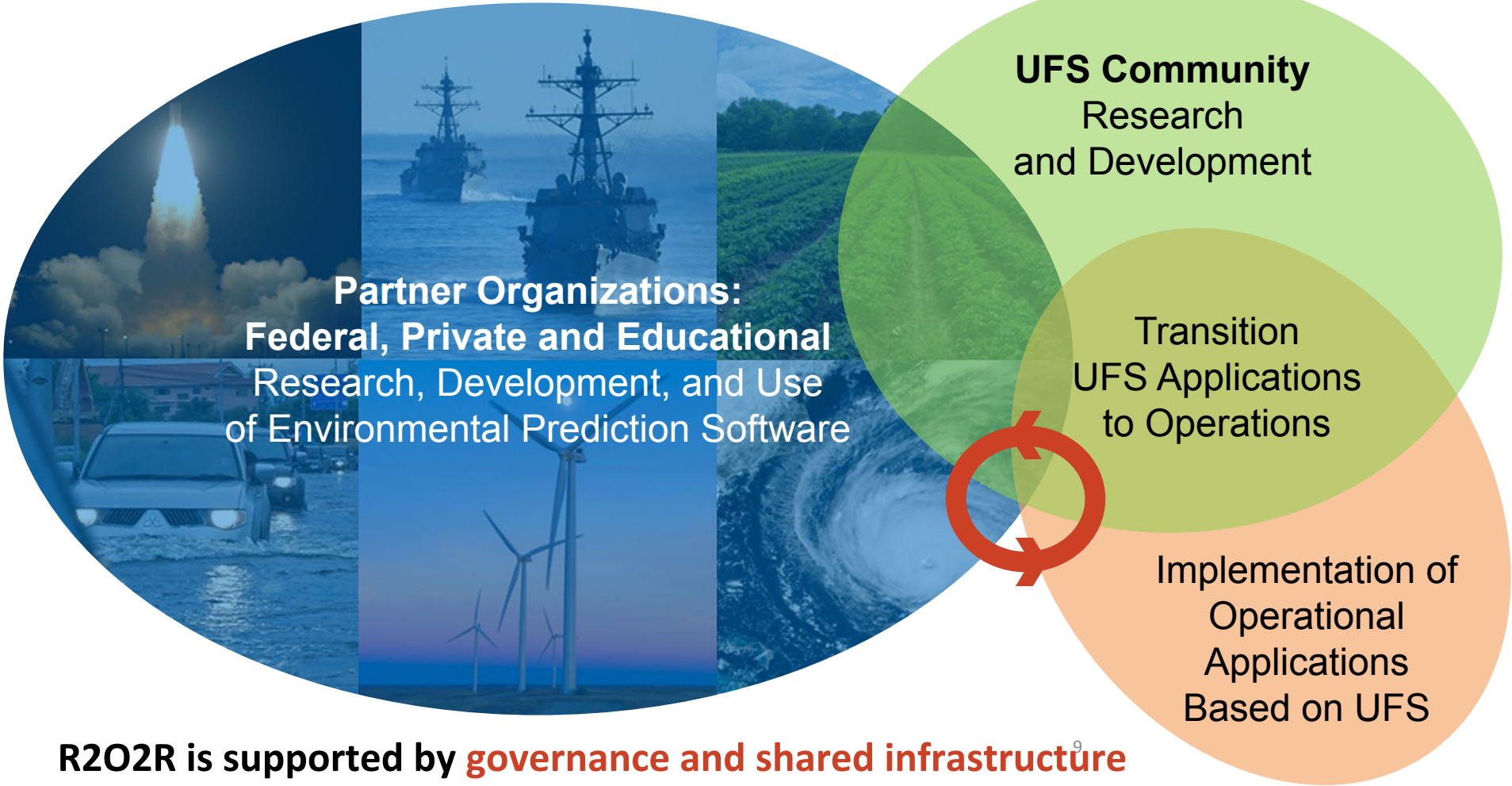
SHIFT TO A MORE CONSISTENT, SMALLER CODE BASE	
Research and operations use different codes	➔ Research and operations run the same codes
Different applications are based on different component models and infrastructures	➔ A unified system architecture, based on community-developed infrastructure and component models, results in less and more consistent code to develop, run, and test
Development happens independently at different laboratories	➔ Collaborative development is supported through a community repository strategy and clear development processes

Why is UFS a paradigm shift?

SHIFT TO COMMUNITY-BASED DEVELOPMENT		
Communication is *ad hoc*	➔	Working groups and regular meetings provide many more communication and coordination opportunities and there is an active Communication and Outreach team
Decision-making rationale is not always evident	➔	Governance approach emphasizes transparency and evidence-based decision making
Varying degrees of collaboration on community codes and limited cross-activity planning	➔	With the Strategic Implementation Plan and working groups, coordination spans multiple applications and efforts

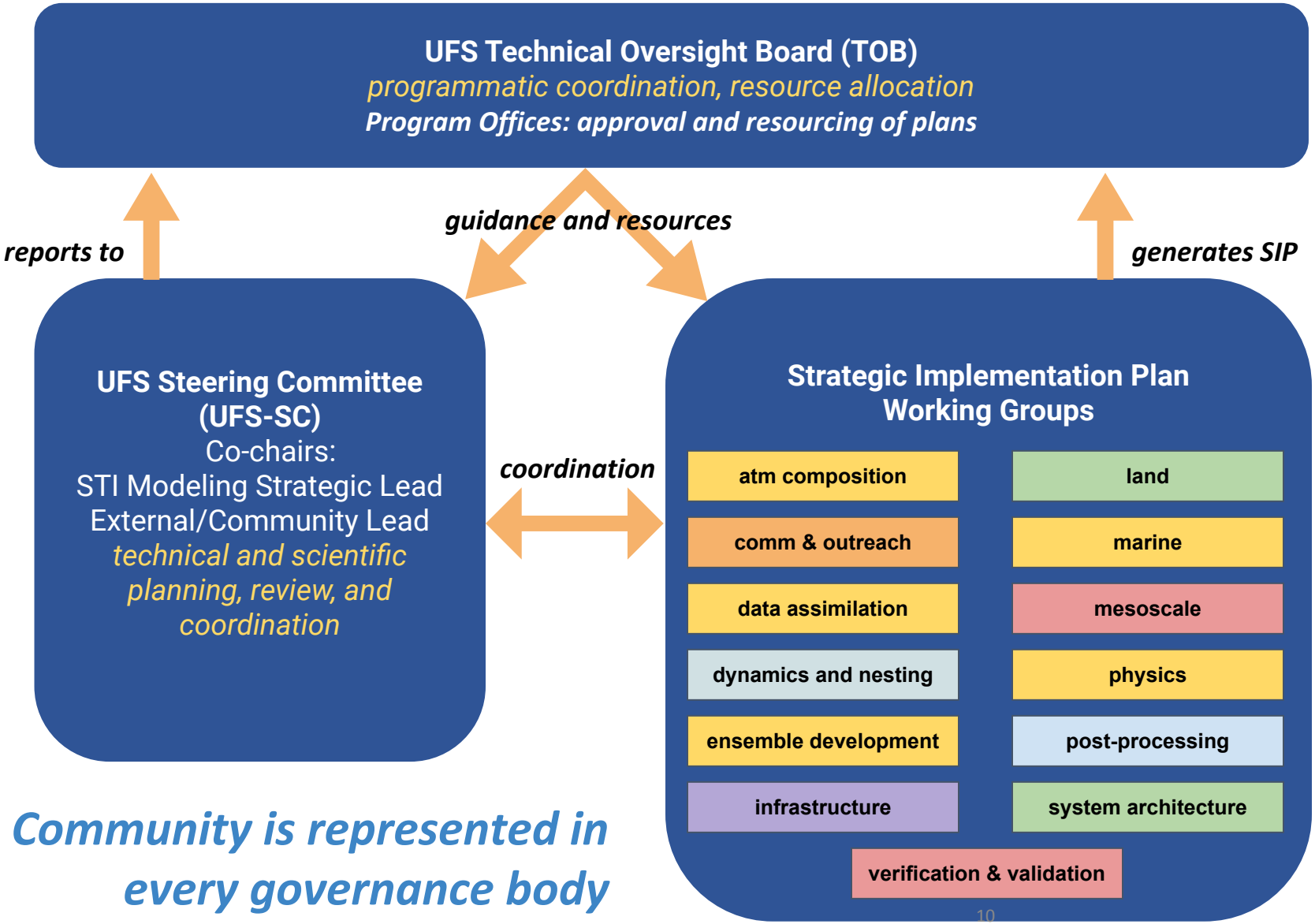
Community-Based Development

The Unified Forecast System (UFS) is a comprehensive, **community-based** Earth modeling system, designed as both a research tool and as the basis for NOAA's operational forecasts.



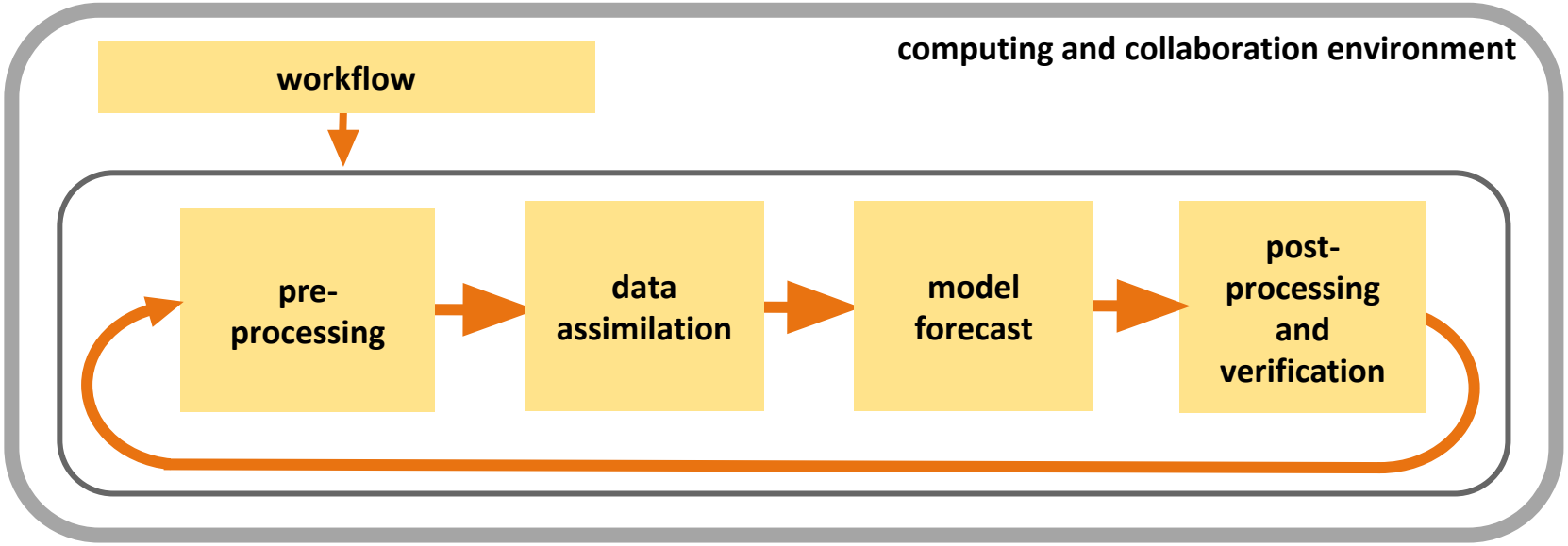
R2O2R is supported by governance and shared infrastructure

Governance



Community is represented in every governance body

Parts of a UFS Application



Pre-processing and data assimilation	•	Stages inputs, performs observation processing, and prepares an analysis
Model forecast	•	Integrates the model or ensemble of models forward
Post-processing and verification	•	Assesses skill and diagnoses deficiencies in the model by comparing to observations
Workflow	•	Executes a specified sequence of jobs
Computing and collaboration environment	•	May be different for research (experiment focus) and operations (forecast focus)
	•	Provides actual or virtualized hardware, databases, and support

Shared Community Infrastructure

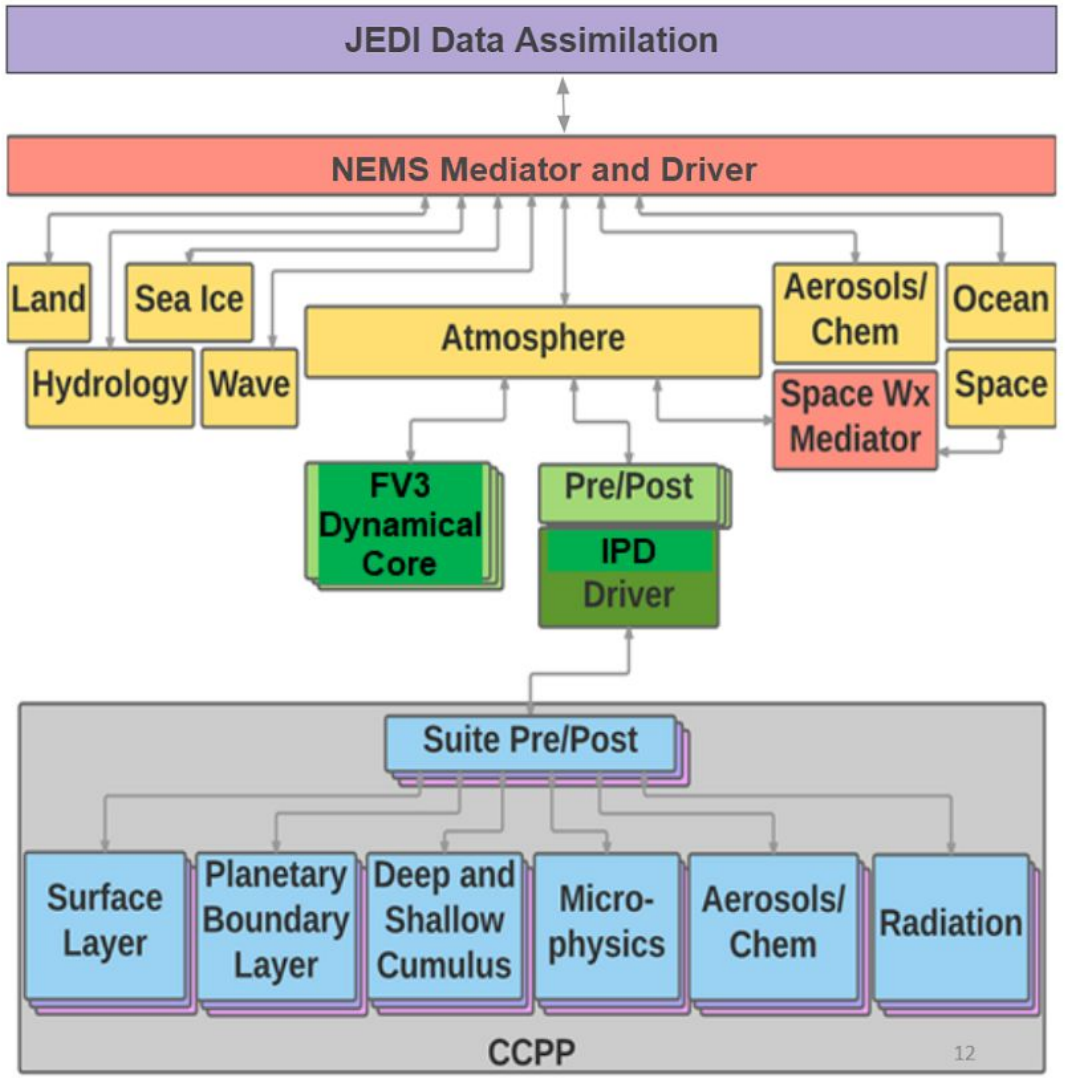
Infrastructure for data assimilation:
Joint Effort for Data assimilation Integration (**JEDI**)

Infrastructure for coupling models together:

- NOAA Environmental Modeling System (**NEMS**) coupler
- based on the Earth System Modeling Framework (**ESMF**)
- using National Unified Operational Prediction Capability (**NUOPC**) conventions

Infrastructure for interoperable physics:

- Common Community Physics Package (**CCPP**) framework



Shared Model Components

The UFS system currently includes the following components:

- NOAA's Environmental Modeling System (NEMS) coupling infrastructure
- FV3 Dynamical Core with Interoperable Physics Driver (IPD)
- MOM6 ocean model
- WAVEWATCH wave model
- CICE5 ice model
- GOCART aerosol model
- Noah MP land model

- Each component has its own community repository.
- NEMS infrastructure allows flexibility to connect codes from the repositories together to create a coupled modeling system.
- All developments involve creating branches in corresponding repositories, and connecting these together to build and test a coupled system.

NCAR-NOAA Infrastructure MOA

- NCAR, NWS, and OAR Memorandum of Agreement focuses on synergistic development and use of infrastructure
- Builds on existing multi-agency community-developed infrastructure (NASA, Navy, NOAA, NSF, DOE…)
- UFS Working Groups are already engaged in seven work areas specified by the MOA
- Finalized January, 2019 (link)

NCAR-NOAA Infrastructure MOA
Work Areas

1. Coupling components
New ESMF/NUOPC mediator (CMEPS/NEMS)

2. Interoperable atmospheric physics
CCPP & CPF frameworks

3. Community-friendly workflow
CIME - CROW unification, CIME Case Control System

4. Hierarchical model development capabilities
Extensions of CIME data models, unit, and system testing

5. Forecast Verification: Comparison to Observations
Extension of MET+

6. Software Repository Management
NCAR manage_externals tool

7. User / Developer Support
DTC and CESM Capabilities

Organizing Research to Operations Transitions
Released November, 30 2018

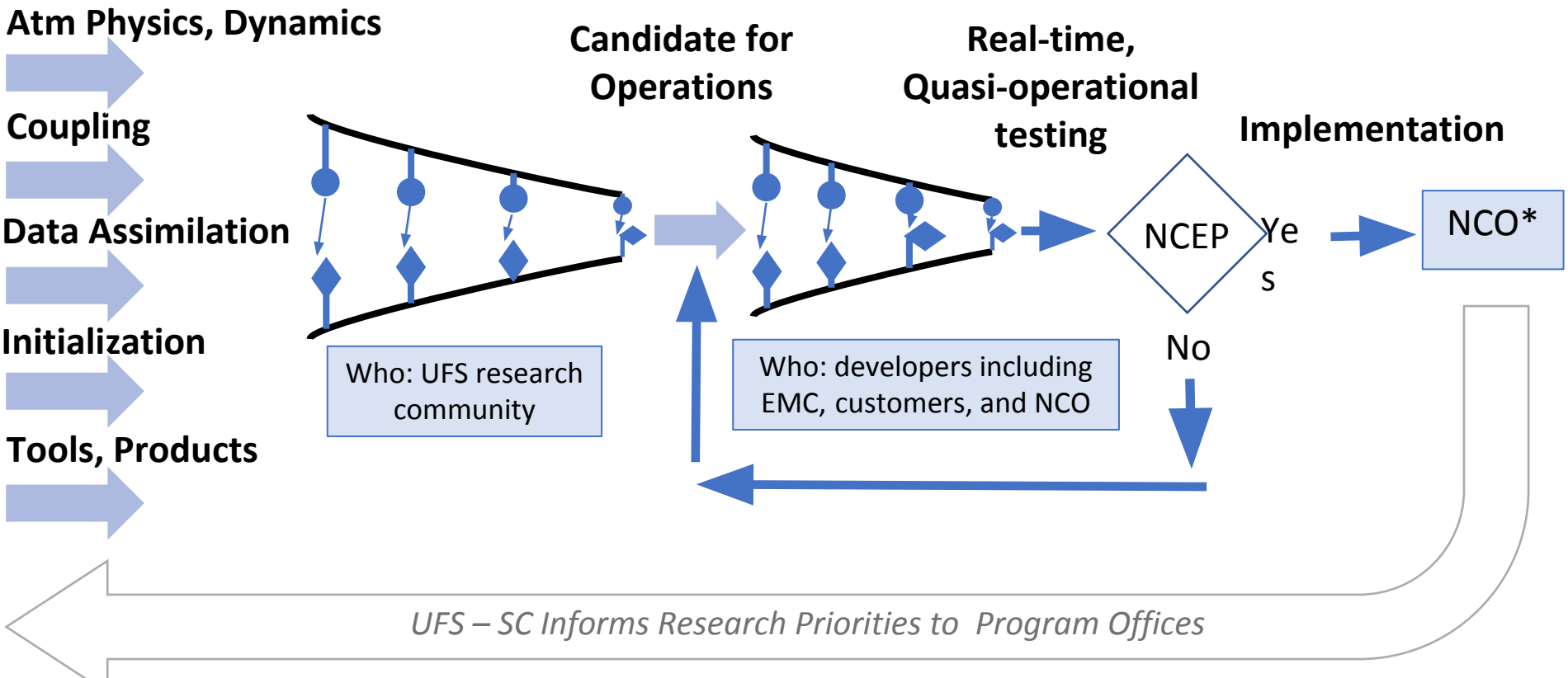
Purpose	The purpose of this document is to describe the transition of research to operations (R2O) in order to provide the foundation for improving the transition of R2O. With the definition of the R2O process, it will then be possible to organize, effectively, how operational applications can inform research activities (O2R).
Who	Writing led by the UFS-SC and the SIP Working Group Co-chairs. This includes representation from the federal and university communities.
How	Review of literature, analysis of past and current processes, discussion with community experts, and inclusion of NOAA policy and procedure.
Outcome	Description of the research to operations transition as a set of stages with evidence-based decision gates. Definition of functions in the end-to-end transition system. Identification of functional gaps. Plan to use graduate student test and upcoming transitions as use cases to improve R20 and then O2R.
Access	https://drive.google.com/file/d/14IDAKWA_-FVZaJrhqV625fwMePSJTBnc/

R202R: Functions and Analysis

Function	UFS-SC Analysis	Status Evaluation
Management and Decision Making	yes	some existing capacity
Workflow	yes	some existing capacity
Code Management	yes	some existing capacity
System Integration	no	major gap
Developer and User Support	no	major gap
Testing, Verification, and Validation	yes	some existing capacity
Computational Resources	no	some existing capacity

R202R: Improving by Doing

- Use FV3-GFS release to increase community engagement, advance UFS plans (e.g. graduate student test), develop linkages across applications
- Use the two planned cycles of physics development and ongoing coupled system development to define and improve the R2O process



* Plus any NOAA entity with responsibility for the implementation (e.g. GSD, MDL, NOS etc.)

What's in it for NOAA?

- Better forecasting capability through leveraging external expertise
- Shortening and systematizing the R2O transition
- Simplifying the process of improving the model - dependencies across applications are well known, well-documented and easier to manage
- UFS makes it possible to spread the labor of developing, testing and evaluating/validating the model(s) across a much wider pool of talent
- Bringing the community into the fold (it's "our" model now)

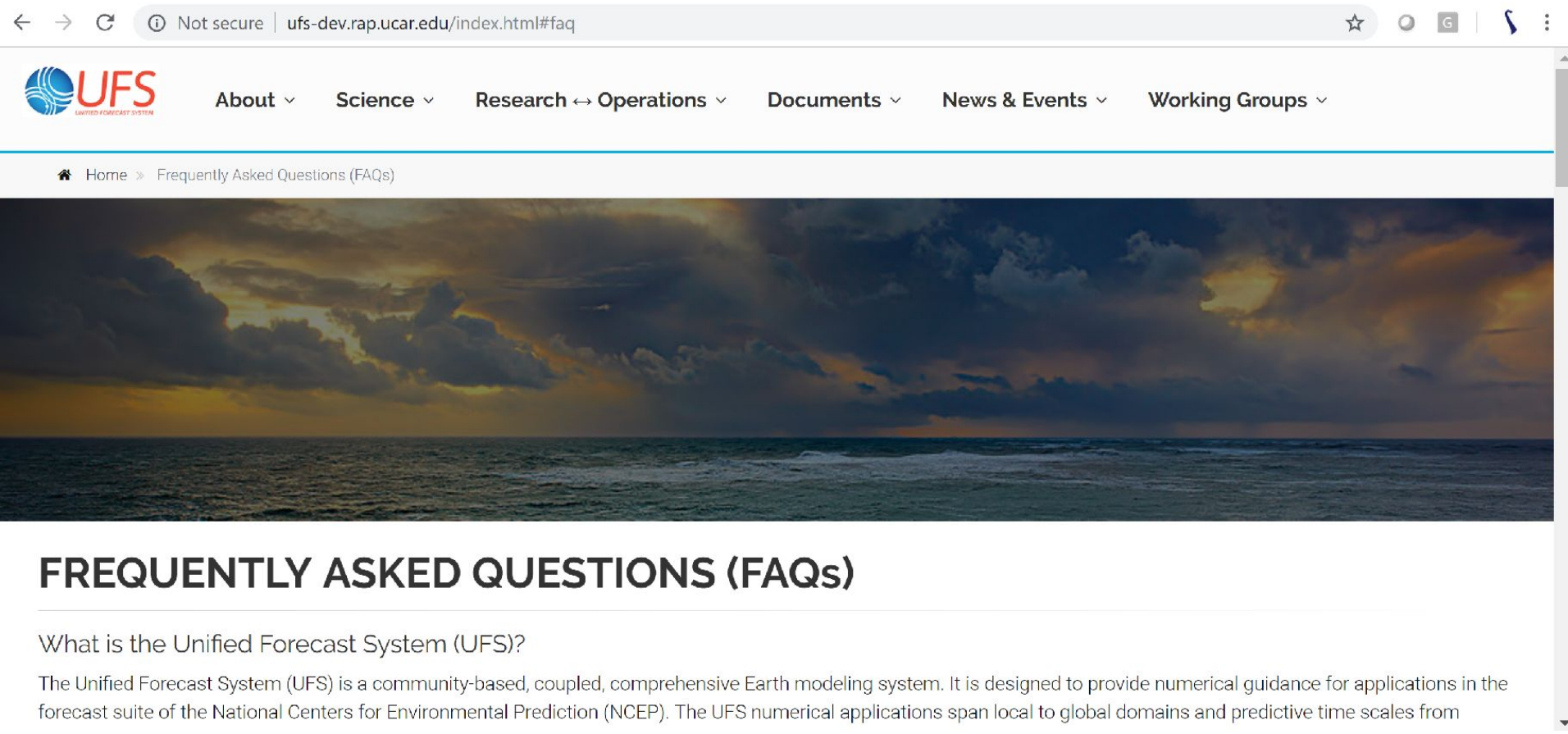
What's in it for Researchers?

- Researchers can contribute to operational outcomes and see their research have significant impacts
- Access to a first-class open source prediction model across timescales that is maintained through community processes
- A "community help desk" - all the other people in the community who can offer help when you hit a snag
- Computing resources to do NOAA-relevant research and a dedicated help desk (EPIC)
- Multiple entry points into the development process for different interest areas

Community Engagement

- UFS Focus Group established to provide feedback on a variety of UFS outputs
  - Diverse group of graduate students, scientists, developers, management, forecast officers, etc.
  - Promotes risk management rather than crisis management
- New UFS Portal under review by Focus Group members, launch anticipated in April 2019
- Annual meetings for the Strategic Implementation Plan
- Working Groups encouraging participation
- Repository plan emphasizes github open development repositories and gitflow-based processes

UFS Web Portal



Development site: http://ufs-dev.rap.ucar.edu

Planning

A concurrent, parallel planning approach

- **High-level/broad Strategic Plan**
  - High-level Strategic Plan
  - Detailed Roadmap document
- **Short-term (0 to ~2-3 years) Strategic Implementation Plan (SIP)** combines implementation activities with near-term strategic action
  - Led by NWS/NCEP/EMC with NOAA and external partners

Take Away and Discussion

- UFS focuses on the predictive ranges associated with the Weather Research and Forecasting Innovation Act of 2017

- Evolving set of activities on science, unification, community building, and capacity building.
  - Need: UFS to emerge as the focus of NOAA's predictive models for operations: Shared understanding, shared investment, strategic focus
- Governance is active and evolving
  - Need: Alignment of resources of tasks with the goals of simplification, community building, scientific excellence, and managed interfaces between research and operations
- Research and Operations Transitions
  - Need: Planning and implementation of end-to-end system. Balanced investment in functions that support the end-to-end system