Unified Forecast System
SIP: Research and Operations

May 14, 2019

UFS-SC Co-chairs

- Recent Focus of UFS-SC (Brief)
- Research to Operations
- Relations to SIP Meeting

Unified Forecast System – Steering Committee

- Governance Strategy
  - Facilitates community model research, development, and applications (Includes policy, practice, tools, …)
  - Focuses on near-term projects that have long-term consequences
  - Improves scientific integrity at organizational level
  - Leads towards unified forecast suite with coupled predictive models (Simplification)
    - **Describe the end-to-end system**

- Meeting ~ weekly since March 2, 2018.
  - Presentations from invited working groups on priority items defined by SIP plan and Steering Committee members
  - Meet Friday at 11 Eastern
  - All presentation materials and minutes are posted at UFS - SC working site #COG (link)

UFS: Started from a set of important foundational decisions

- Dycore: Selection of the FV3 dynamical core for the GFS (Global Forecast System)
- Systems architecture for the coupled model
- Coupling infrastructure
- Strategic Implementation Plan (SIP)
- NCAR-NOAA Memorandum of Agreement

- EPIC Opportunity: Success of SIP and UFS is essential for EPIC.
  - SIP and UFS is part of the foundation for EPIC

What we have been doing

- Organizing Research to Operations Transition
- CAMDesign
- Communications
  - UFSCommunity Portal
  - UFS Overview Slide Deck

What we have been doing

- Repository Plan
- Graduate Student Test
- Focus Groups / Tiger Teams
  - Portability
  - Hierarchical Testing
  - Workflow
  - Data Assimilation Prototype:
    - NUOPC - JEDI Interoperability


UFS
UNIFIED FORECAST SYSTEM

Research and Operations

- Describe and analyze the R2O process in order to improve it
  - Transitions between research and operations are widely considered what we need to improve.
- We need to know what we are doing to be able to target resources for improvement.
  - Describe the end-to-end process
  - What are the key functions?
  - What are the barriers?
  - How does it all fit together?
- Improved O2R is interwoven with R2O

R2O: Description

The goal of the UFS R2O transition is to move complex scientific software from a loosely managed research community to rigorously defined production software. The production software provides science-evaluated environmental forecasts on a repeating schedule. The R2O transition process requires, therefore, evaluation of software quality, computational performance, and scientific quality.

Compared with our R2O experience the UFS

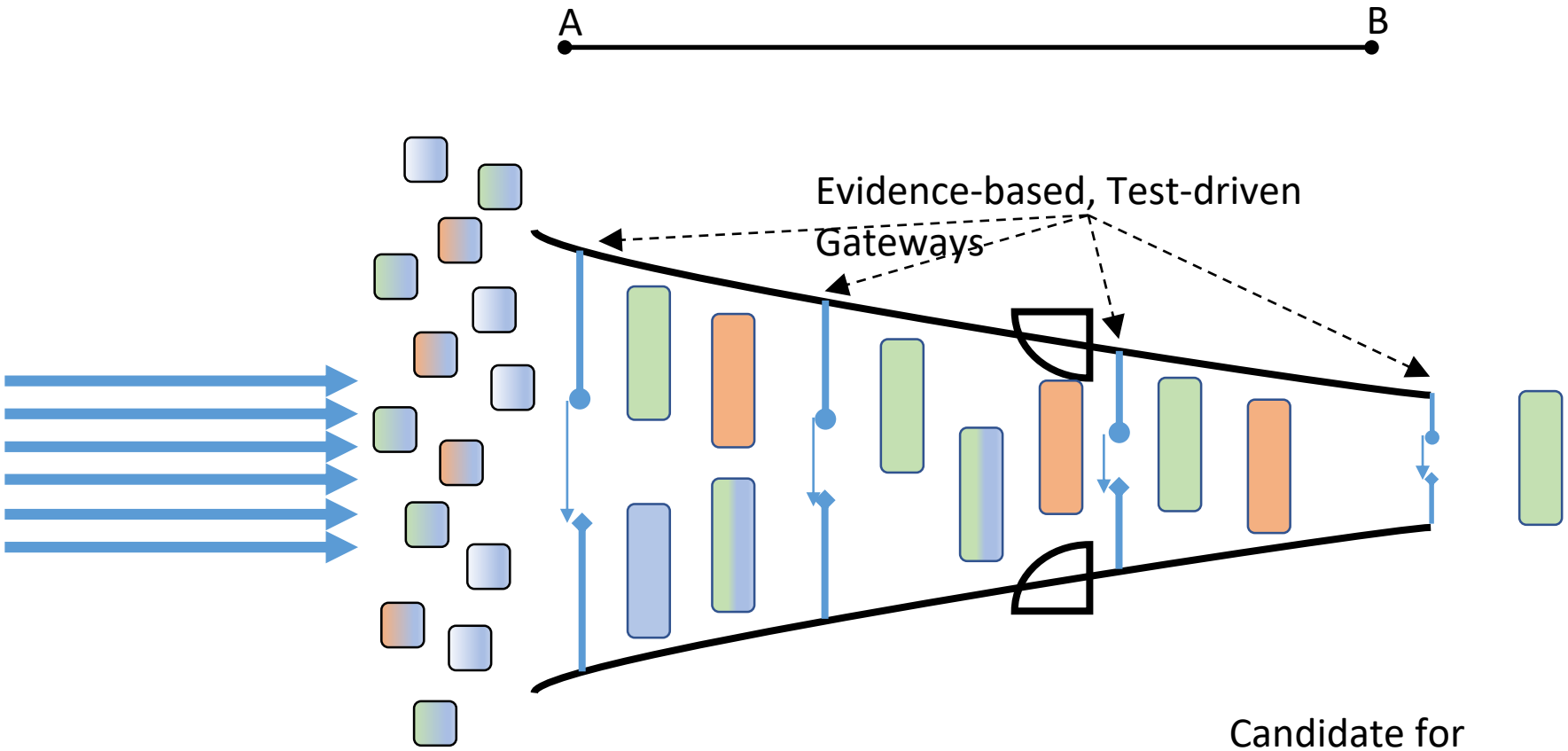
- Is far more complex software
- Has a strong relationship with communities
  - Developers
  - End-users
- Has distributed, heterogeneous computational and information systems

- Even if what we have been doing was optimal, it would have to evolve, adapt, and extend to the UFS.
  - EPIC is an opportunity to do this better.

R2O: Process (Our behavior)

- Building usable complex information systems and software requires:
  - Iterative design and testing
  - Iterations with developers, scientific experts, and application specialists (teaming and re-teaming)
    - Communications
    - Continuity
      - Definition (Developing common language)
      - Incremental Planning
      - Strategic goals
      - Integration into end-to-end systems to address application goals
      - Objective testing, verification, and validation at all steps

R2O: As a narrowing stage and gate process



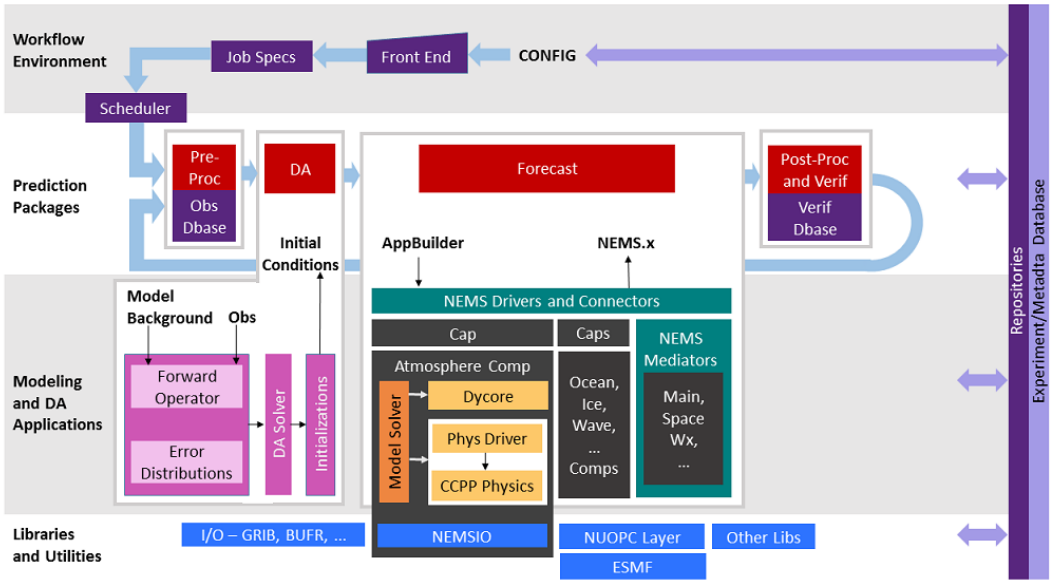
UFS System Architecture

Workflow

Prediction Packages

Modeling and DA Applications

Libraries and Utilities



Software engineering infrastructure: Repositories, Documentation

The Point: Complex system with differentiated functions. The functions are required to combine into end-to-end application systems. Requires data communication at the interfaces and communication among humans.

What we have been doing

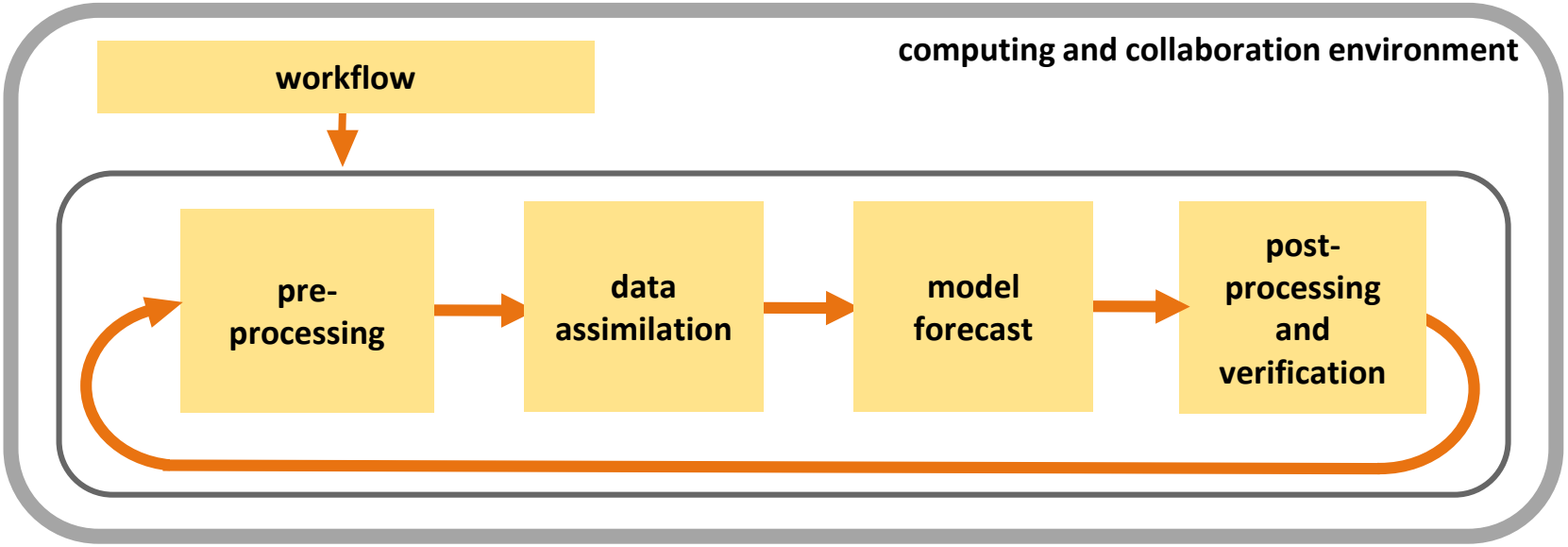
- What are the applications?
  - What are the forecast priorities?

UFS Applications

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

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

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

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

R2O: Major classes of functions

- Management and decision making
- Workflow
- Code Management
- Developer and User Support (Community Support)
- System Integration
- Testing, Verification, and Validation

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

R2O: Major classes of functions

- Management and decision making
- Workflow
- Code Management
- Developer and User Support (Community Support)
- System Integration
- Testing, Verification, and Validation

Agenda and R2O Functions

Wednesday afternoon:

Application Research and Development Goals, Priorities

- The forecast goals and science priorities define the **testing, verification, and validation**, and this anchors the **end-to-end system**.
- They also anchor the O2R priorities for the strategic research program.

Agenda and R2O Functions

Tuesday afternoon:

Model Evaluation Group evaluation is to inform the development of

- The forecast goals and science priorities of the Medium-range Weather application.

Agenda and R2O Functions

Thursday Morning:

- Developing test plan for end-to-end GFSv16 system and downstream applications
  - Testing, Verification and Validation: Hierarchical Testing and Design, Workflow, DA Prototype

- Using the GFSv15 release to advance community support capacity
  - Developer and User Support: Repository Plan, Graduate Student Test, Portability, Workflow

- Develop plans to replace current suite of limited area models with FV3-SAR solutions
  - CAMDesign: Leads towards unified forecast suite with coupled predictive models (simplification)

Backup & Informational Slides

R2O: Maturity and Readiness Level

UFS: Notional Categories of Maturity

- Step 1: Ideation
- Step 2: Preliminary Experimentation
- Step 3: Pre-operational Experimentation
- Step 4: Integration and Testing in Prediction Packages

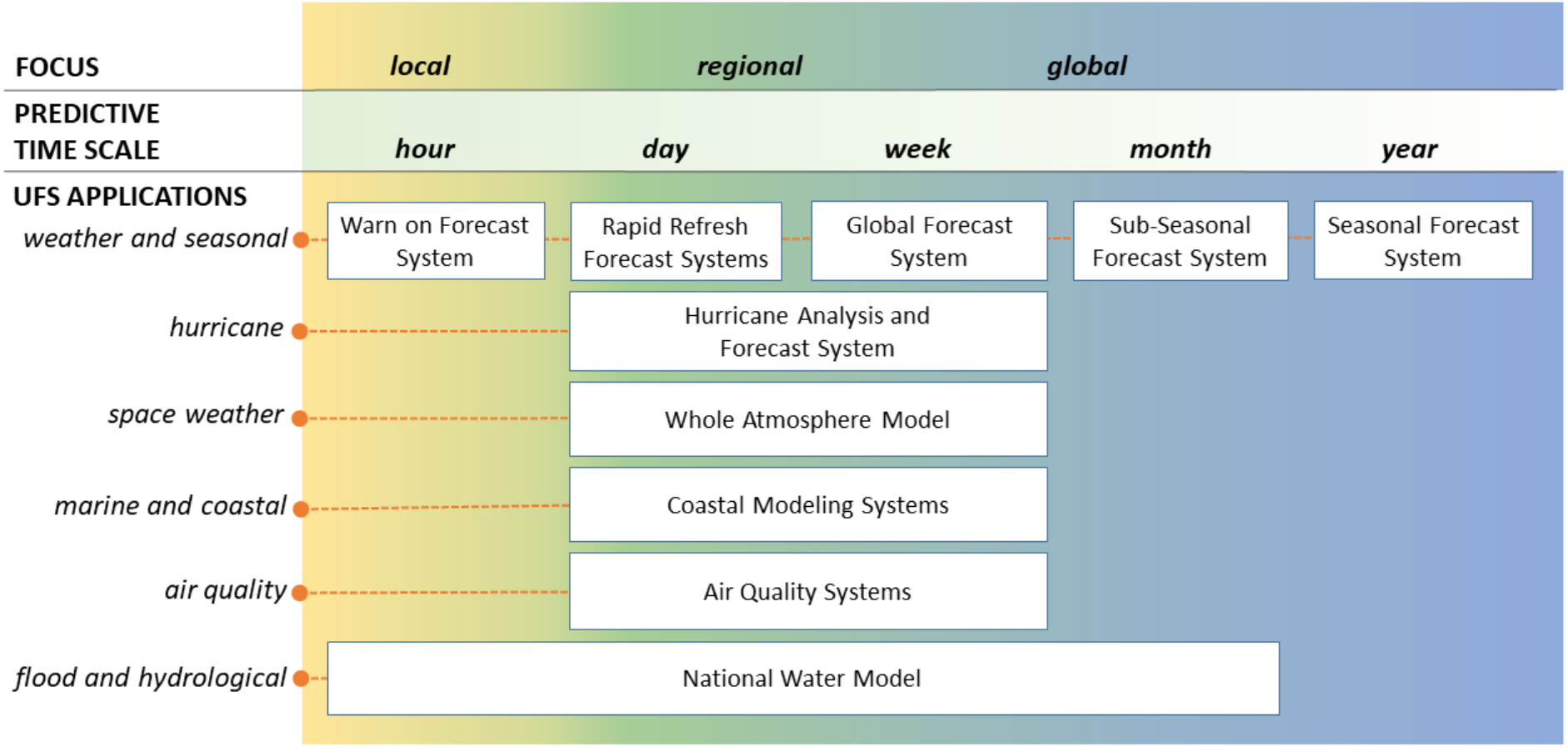
NOAA Readiness Level (RL)

- RL 1 and 2
- RL 3 and 4
- RL 5 – 9
- (Iterative processes)

Three types of R2O transitions:

- System Level Transition
  - Changing the dynamical core and physics of the GFS - GFSv15
- Application Level Transition
  - Physics upgrade for GFS – GFSv15 --> GFSv16
- Incremental Level Transition
  - Parameterization - level calibration (Improve cloud radiation interaction, super saturation in DA)

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).

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

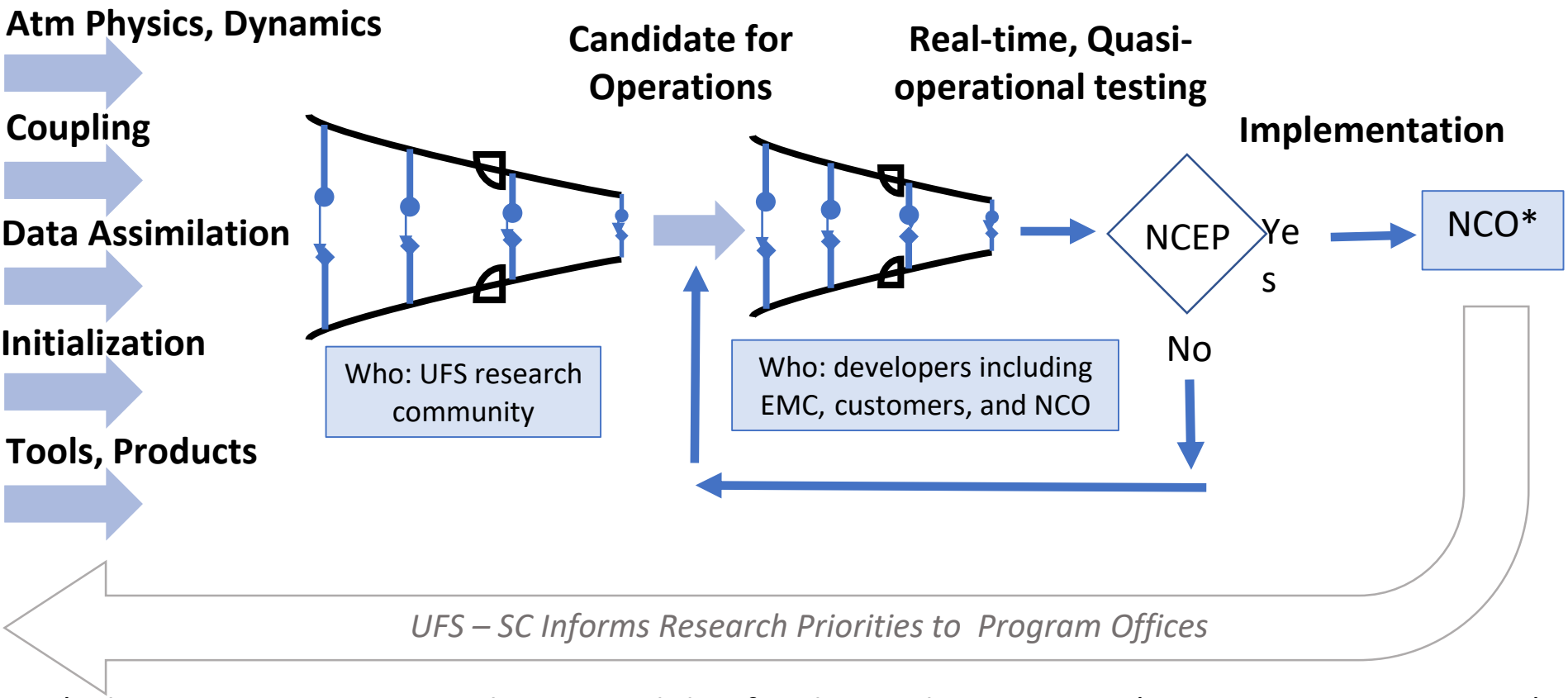
5. Forecast Verification: Comparison to Observations
Extension of MET+

6. Software Repository Management
NCAR manage_externals tool

7. User / Developer Support
DTC and CESM Capabilities

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.)

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