UFS R2O Project

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EMC, PSL, GSL, CSL, GFDL, NSSL, ARL, NESDIS AOML

Background

- **NOAA NGGPS to UFS Strategic Implementation Plan (FY19-21):**
  - UFS is a community-based, coupled comprehensive end-to-end Earth system prediction system, including data assimilation.
  - UFS applications span local to global domains and sub-hourly analyses to seasonal predictions.
  - UFS will support the Weather Enterprise and be the source system for NOAA's operational NWP applications.
  - UFS will serve both the R&D and Operational communities engaged in numerical prediction of the Earth System.

Inspiration

- **UCAR Modeling Advisory Committee (2018 report):**
  - To accelerate innovation into NOAA operations and provide the scientific community with a credible scientific tool for research to benefit the research to operations transition (R2O), **NOAA must be "all-in" in developing and deploying a unified community model**, with a **unified collaborative strategy** to develop the UFS, based on FV3, with no independent model developments
  - Modeling & DA in the NOAA labs (and Cooperative Institutes) needs to be **integrated and collectively managed** as much as possible

Guidance

- **UFS Steering Committee (R2O document):**
  - The UFS must accommodate far more complexity than previous NOAA forecast systems. **Existing R2O practices and capabilities are unlikely to meet the requirements** of a coupled, community-based system spanning all applications
  - The evolution of the UFS and the R2O process faces the challenges of **maintaining product generation in the short term, with longer-term evolution to a truly unified system**. Short-term activities must contribute to advancing long-term goals.

UFS R2O Project

- **A new way of doing business**
  - This project is an experiment to carry out R&D in a **collaborative project within constraints imposed by operational imperatives** and public release timelines
  - **Engagement by both NWS & OAR** with coordinated funding
  - **Interested/engaged/willing participants from inside and outside NOAA under a single management framework**
  - 2-year proposal with 3-5 year vision (not your standard AOP)
    - **Work on 3-5 year vision starts immediately** so the R2O pipeline is continuously fed

Forecast Priorities

- **Forecaster Priorities* - including but not limited to:**
  - Reducing quantitative precipitation forecast **(QPF) bias**
  - Improving **storm structure**
  - Resolving **pre-convective environment**
  - Enhancing **forecasts of clouds**, including ceiling & visibility (critical for aviation)
  - Improving **PBL inversion**
  - Reducing **winter cold bias** in the lower troposphere
  - Improving **track forecast of strong hurricanes** (initial wind > 33 m/s) in the Atlantic
- **Known Modeling Issues**
  - **Mid/upper tropospheric flow** (5-day Z500 AC)
  - **Near-surface temperature and precipitation**
  - **Convective initiation** (low-level moisture and inversion structure in PBL)
  - **Zonal flow bias** → poor **hurricane track forecasts beyond day 5**
  - **Weeks 3-4:**
    a. **MJO** intensity, propagation, and teleconnections
    b. **Land-atmosphere feedbacks**
    c. **Trop-strat interactions**

* obtained from testbed feedback and stakeholder interaction (e.g. STI SOO group)

Scientific Priorities

- Reduce coupled model biases
- Improve representation of key modes of variability
- Optimally combine Earth system observations and model forecasts using an advanced data assimilation system to initialize coupled ensembles (land-ocean-sea ice-atmosphere-aerosols).
- Develop a convection-allowing ensemble forecast capability for short-range prediction of severe weather and hurricanes.
- Improve initialization at all scales (convective to global), through improved use of observations and advances in data assimilation algorithms.
- Improve (ensemble) quantification of model uncertainty, especially near model component interfaces.

Technical Approaches

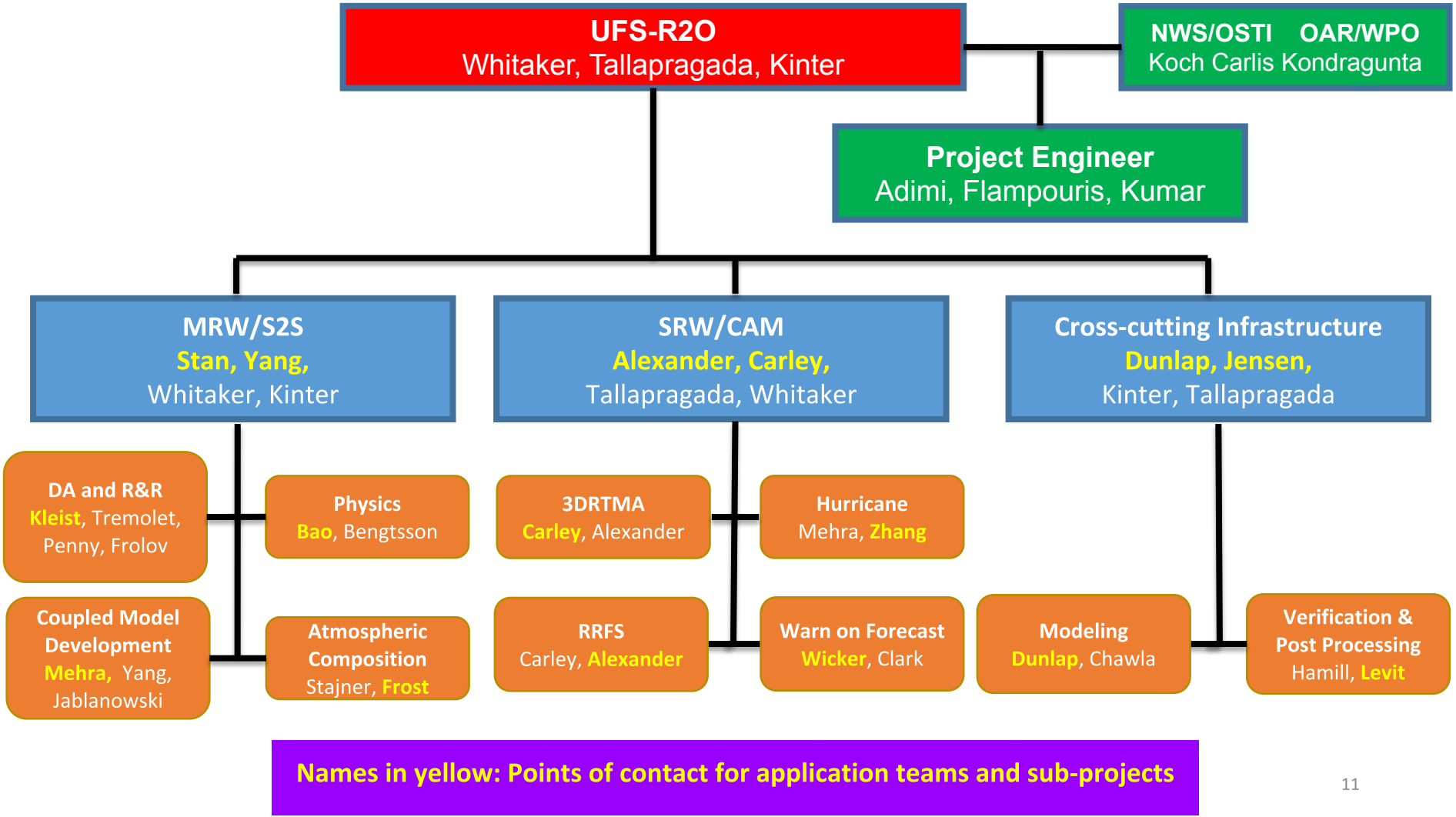
- **Coordinated development of shared modelling and data assimilation infrastructure and algorithms (across OAR, NWS and university partners)**
  - Data assimilation: JEDI
  - Coupling model components: ESMF, NUOPC, NEMS, CMEPS
  - Interoperable atmospheric sub-grid physical parameterizations: CCPP
  - Community data models: CDEPS
  - UFS community code management policies: Git-based repositories with Gitflow
  - Community workflow: CIME Case Control
  - Forecast verification: extension of MET+
- **Increased attention to documentation and user support (UFS Communications & Outreach)**
- **Development of supporting datasets, verification and validation framework**
- **Coordination with EMC operations to streamline/accelerate R2O (initially targeting GFS v17, GEFS v13, HREF v3**

Technical Approaches

- **Benchmarking strategy for MER/S2S:**
  - Coupled global model (and ensembles) reforecasts
  - Target: GFSv17/GEFSv13 are as good or better than GFSv16/GEFSv12 using community-determined metrics
  - Address known issues and forecast priorities
- **Benchmarking strategy for CAM:**
  - RRFS is benchmarked against existing, well-established CAMs for the rapid update component (i.e. HRRR)
  - Target: RRFS is as good or better than HREF as measured by community-determined metrics
  - Optimal spread-skill relationship while minimizing model biases (stochastic physics, etc.)

Project Structure

- **Application Teams -**
  - Global modeling for Medium Range Weather (MR Weather) and Subseasonal to Seasonal (S2S)
  - Convective-Allowing Model (CAM) for Short-Range forecast, hurricanes, etc. (SR Weather)
  - Cross-Cutting Infrastructure (CCI) Team to support both ATs
- **Sub-Projects - where work gets done on technical level to achieve AT goals**
- **Optimized coordination and collaboration across sub-projects, across teams**
- **Leverage EPIC, NOAA cloud computing and projects funded by NOAA NOFOs**
- **Maximize communication and mitigate risk**
  - Overlapping directorate and sub-project personnel
  - Frequent meetings, communication and documentation tools
  - Monitoring at sub-project, application team and project team levels
  - Coordination with Program Offices at NWS (OSTI) and OAR (WPO)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RRFS
Carley, Alexander
Warn on Forecast
Wicker, Clark
Modeling
Dunlap, Chawla
Verification & Post Processing
Hamill, Levit
Names in yellow: Points of contact for application teams and sub-projects

Project Goals

- Develop modeling innovations suitable for R2O transition
- Broaden access to, and usage of UFS by the research community
- Ensure that best available scientific understanding and evidence-based decision making is used to advance forecast models' capabilities
- Accelerate development of models so that deployment milestones are substantive and substantially improve forecast efficiency, skill, and utility
- Advance global modeling capability to address scientific and forecast priorities for predictions of MR Weather and S2S climate
- Advance convection-allowing modeling to address scientific and forecast priorities for SR Weather, rapid refresh, hurricanes and warn-on-forecast

CCI Support for Application Teams

- **Enable simplification of NCEP production suite and share common software across applications**
  - **Reusable solutions**
  - **Reduce duplication of effort**
- **Facilitate engagement of community partners via common infrastructure and community support**
  - **Documentation, tutorials, and workshops (complementary to C&O WG, ...)**
  - **Code and data repositories (within context of UFS System Architecture and Infrastructure WG)**
  - **Regression testing**
  - **User and developer/contributor support**

CCI Support for Application Teams

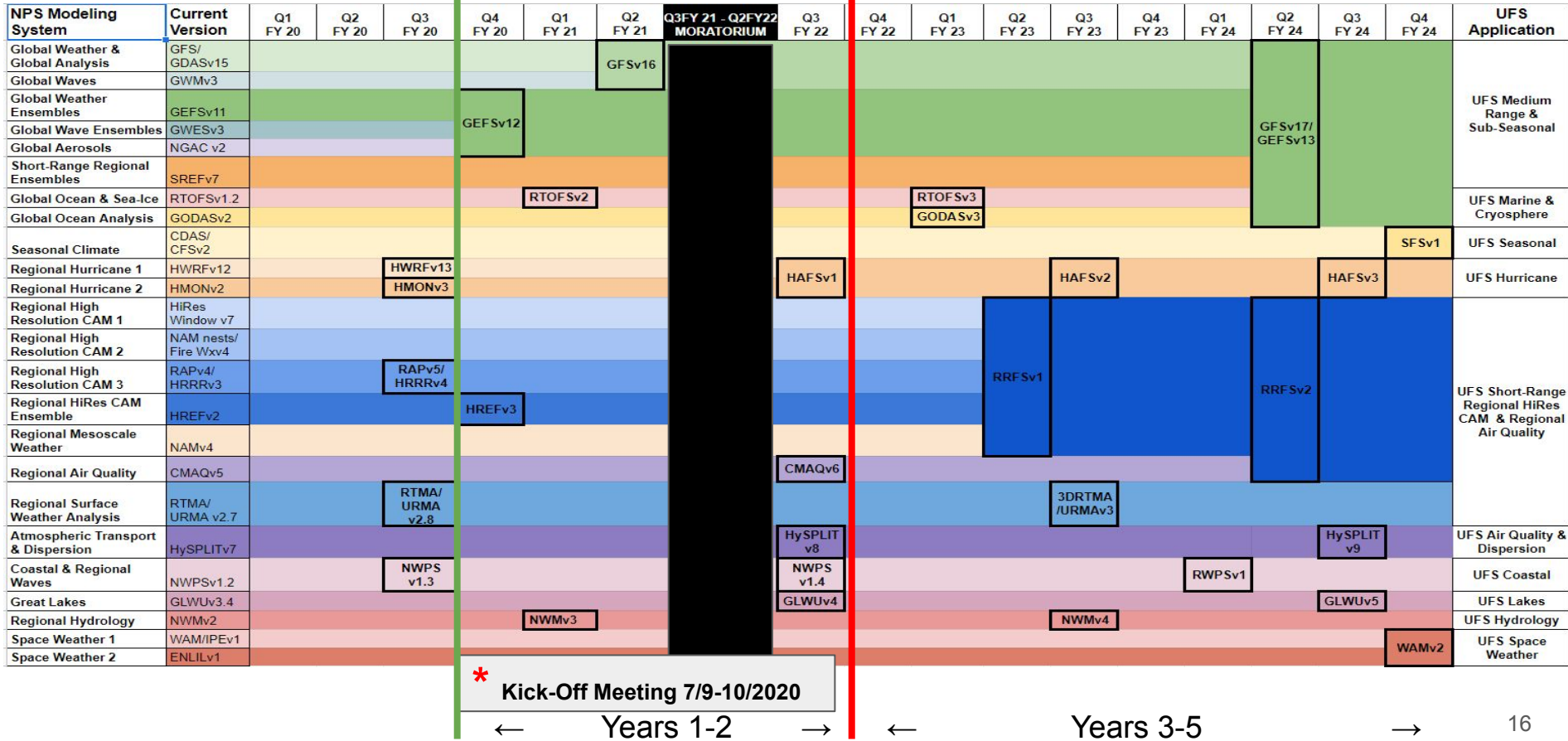
- **CCI development touches all parts of the R&D and Operational Workflows:**
  - Preprocessing
  - Data Assimilation
  - Model Components and Coupling
  - Ensemble Post Processing
  - Verification, Validation, and Diagnostics

Kickoff Meeting

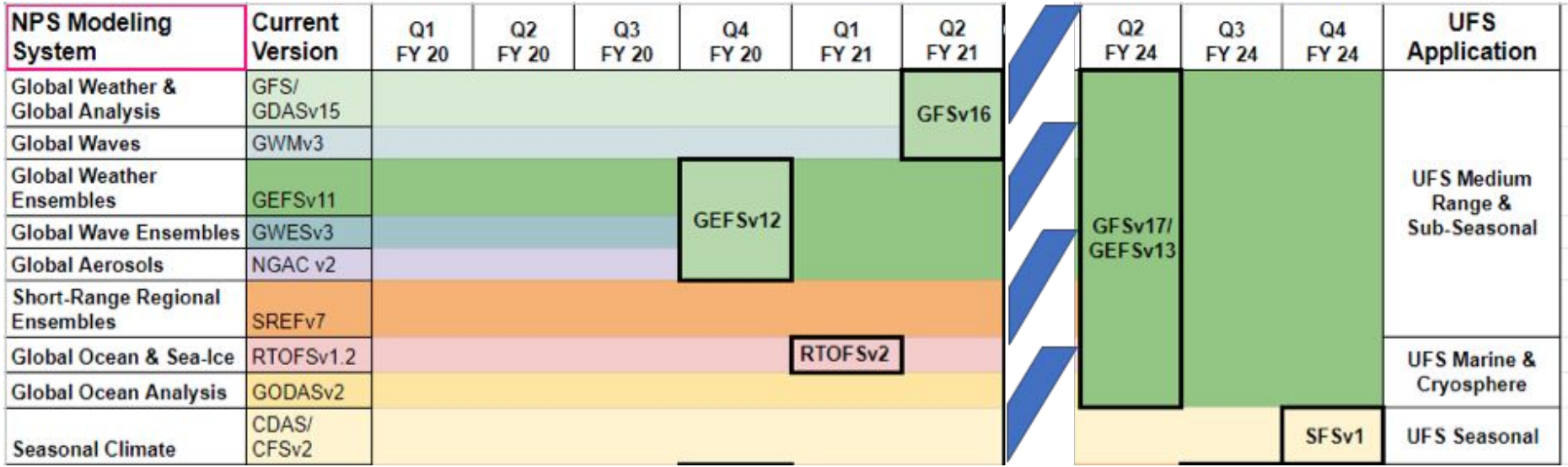
- 9-10 July 2020
- ~200 participants
- Successful launch with good discussions of goals, tasks, intra-project dependencies, planned experiments, and computing requirements

We're off and running!

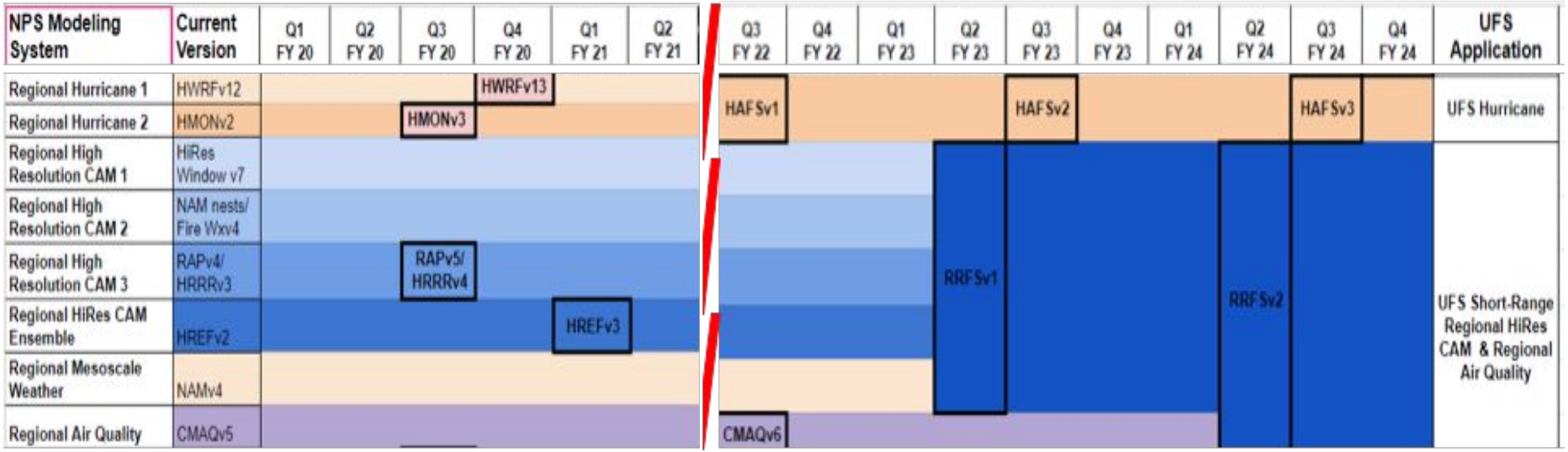
Operational Models Consolidation Timeline



Global Models Consolidation Timeline



Regional Models Consolidation Timeline



Project Outcomes - 1-2 Years

- **Fully coupled (L-O-SI-A-Ae) global ensemble prediction system, including coupled DA, ready for pre-operational testing and suitable for community research use**
  - Addressing science priorities and leading to improvements in forecast priority areas
  - Including reanalysis/reforecast capability for calibration/bias correction (production in year 3)
  - Public release of coupled MR Weather / S2S application
  - Public release of JEDI
- **Regional rapid refresh (1-hour cadence) ensemble forecast system for convection-allowing scales ready for pre-operational testing**
  - Public release of regional RRFS system
- **Start to sunset existing mesoscale prediction systems**

3-5 Year Vision (highlights)

- **Strongly-coupled DA capability for MR Weather / S2S**
- **JEDI for initialization of all forecast systems**
  - advanced ensemble and 4D-Var algorithms, enhanced use of all-sky radiances.
- **Next-gen moist physics suite for the atmosphere, unified for CAM to global**
- **CAM-resolution inline air quality prediction system for U.S. and aerosol feedback on MR Weather / S2S prediction.**
- **Warn on Forecast system running for SPC Hazardous Weather Testbed and for Weather Prediction Center prediction of significant flash flooding events.**
- **Hurricane Analysis & Forecast System (HAFS) with moving nests following multiple storms.**
- **Space-weather application.**
- **Research publications in high-impact peer-reviewed journals.**

Computing Requirements

Initial Estimate Year 1 (this is in the process of being updated)

	NOAA HPC		non-NOAA HPC		Cloud	
MER/S2S	270 M	1.3 PB	6 M	6 TB	7 M	2.1 PB
CAM	490 M	2.4 PB	3 M	360 TB	7 M	0.25 PB
Cross-Cutting	2 M	0.4 PB			0.04 M	0.05 PB
Total	762 M	4.1 PB	9 M	366 TB	14 M	2.4 PB

Notes:
NOAA HPC requirement ~ ⅓ of current NOAA R&D HPC resources
non-NOAA HPC requirement: Stampede2 allocation of ~20 M/year is possible
Could HPC: NOAA budgeting for cloud computing - UFS R2O project will have to compete

Thanks to the Whole Team!

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ANY QUESTIONS?

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