Subseasonal Performance in UFS Simulations Using Two Different Physics Suites

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Ongoing work: UFS for subseasonal

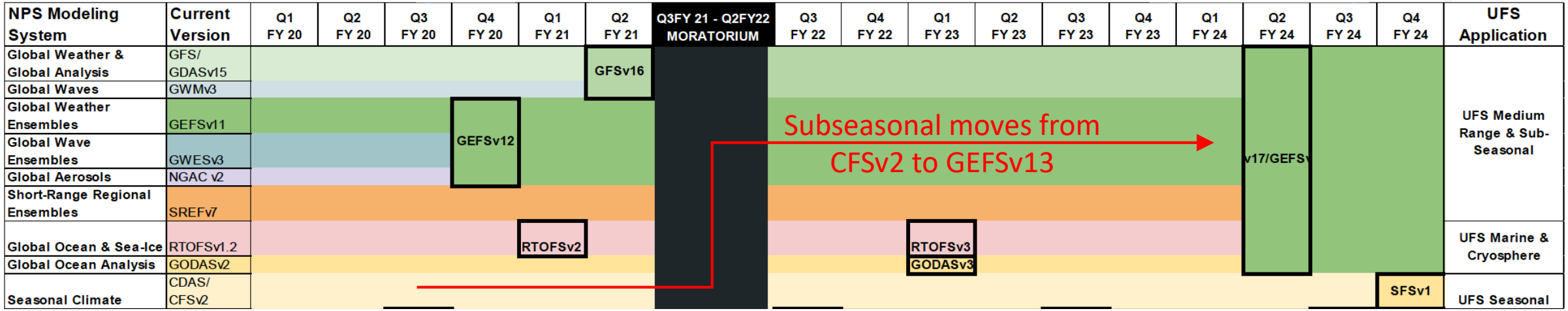
- **Many** talks at this workshop (12:30 ET session Wednesday; several others)

- Development of the **coupled** UFS for subseasonal (and seasonal) prediction is progressing rapidly, and involves:
  - Atmospheric model (FV3), including **CCPP** physics (CCPP added only 4 months ago)
  - Ocean model (MOM6)
  - Sea-ice model (CICE5, to be replaced by CICE6)
  - Wave model (WW3, added only ~2 months ago)
  - Mediator (NEMS, soon to be replaced by CMEPS) couples component models together

- Subseasonal UFS is a fast-moving target, so important disclaimer: **results presented here are not representative of current system!**

Background: Streamlining of NOAA operational models

- Current operations:
  - Runs out to 16 days done by **atmosphere-only GFS/GEFS**
  - Runs out to 45 days (and beyond) done by **fully-coupled CFSv2**
  - GFS/GEFS have very different physics schemes than CFSv2
- By 2024, all of NOAA's operational **global** Earth system prediction for lead times from **1 to ~45 days** will be consolidated into a **single UFS-based model** (GEFS)
  - New challenge: Ensure model has "reasonable" skill from daily to subseasonal time scales



Physics development in UFS: Opportunities and challenges

- Opportunities:
  - Under the CCPP framework, ability to swap parameterizations allows for robust A/B testing of individual schemes, as well as entire suites
  - "Cross-purpose" testing of schemes/suites: **how well does a physics suite developed/tuned for short-range regional mesoscale forecasting perform globally at subseasonal timescales?** → this talk
  - Development of schemes/suites that are intended to **work across spatiotemporal scales**

- Challenges:
  - Development of schemes/suites that are intended to **work across spatiotemporal scales**
  - Consolidation of operational model products widens the range of stakeholder needs: more compromise required

Mesoscale physics for subseasonal forecasts?

- NOAA's GSL (previously GSD) has been a leader in high-resolution, rapidly-updating, regional mesoscale modeling for decades (RUC/RAP/HRRR)
  - GSL has developed and fine-tuned a suite of physics parameterizations (goes by many names, including: "RAP/HRRR suite"; "GSD suite"; "RRFS suite")

- Components of this suite (not exhaustive):
  - Grell-Freitas scale-aware convection
  - MYNN-Olson planetary boundary layer
  - Thompson cloud microphysics
  - RUC land surface model

- Goal of this talk: Take a "first look" at how this suite performs in global UFS at subseasonal timescales

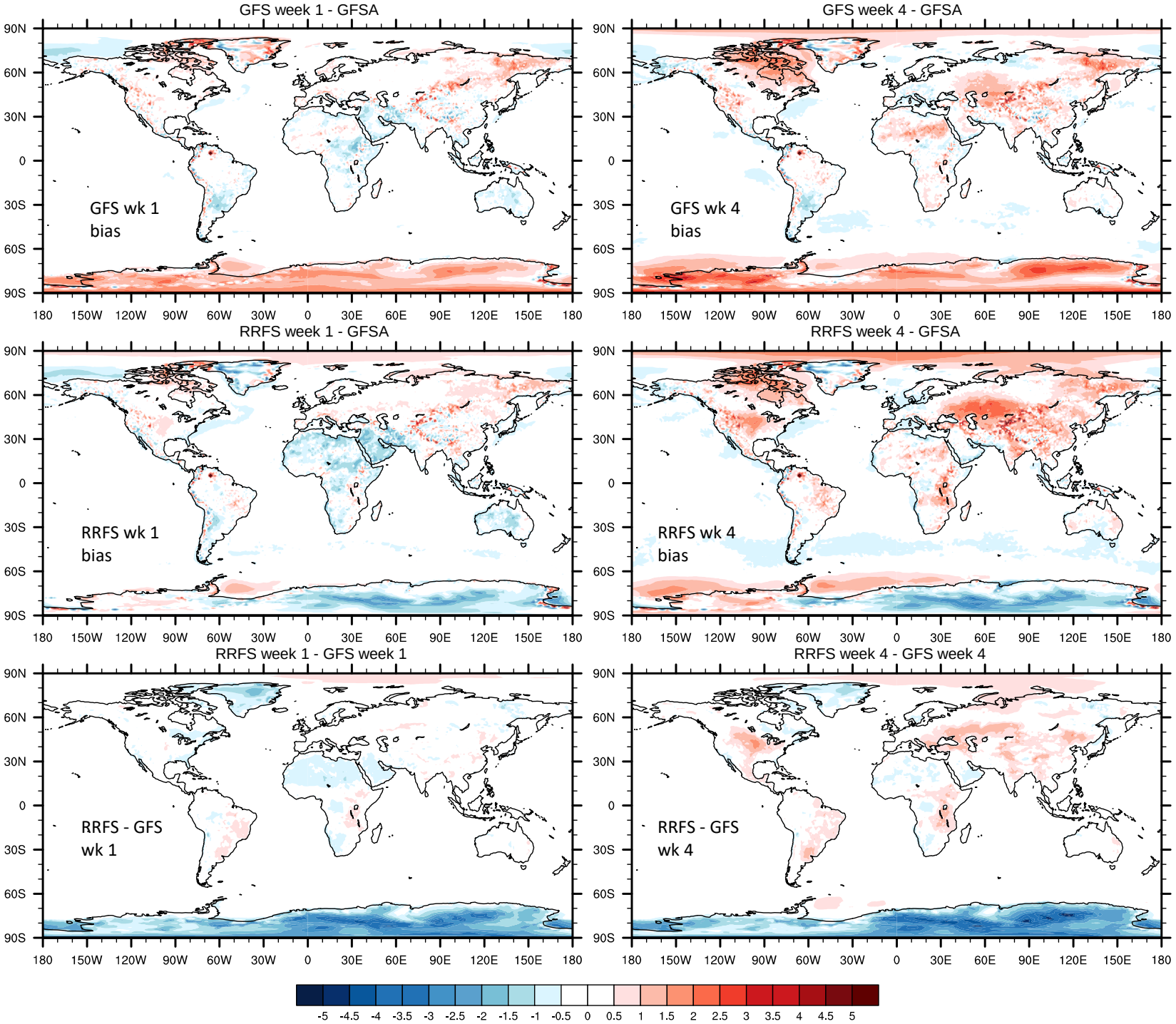
Experimental design

- Two physics suites, **both within CCPP framework**:
  - “GFS suite”: Operational GFS physics **from July 2019**
  - “RRFS suite”: Physics suite from GSL for RAP/HRRR **from July 2019**

- Perform **atmosphere-only** (uncoupled) runs in UFS out to 35 days lead
  - Why uncoupled? RRFS suite only available in UFS via CCPP, but **coupled** UFS only became capable of using CCPP a few months ago
  - **Ocean coupling is better for subseasonal**. The results shown here are the precursor for a systematic investigation into impacts of coupling on UFS at subseasonal scales

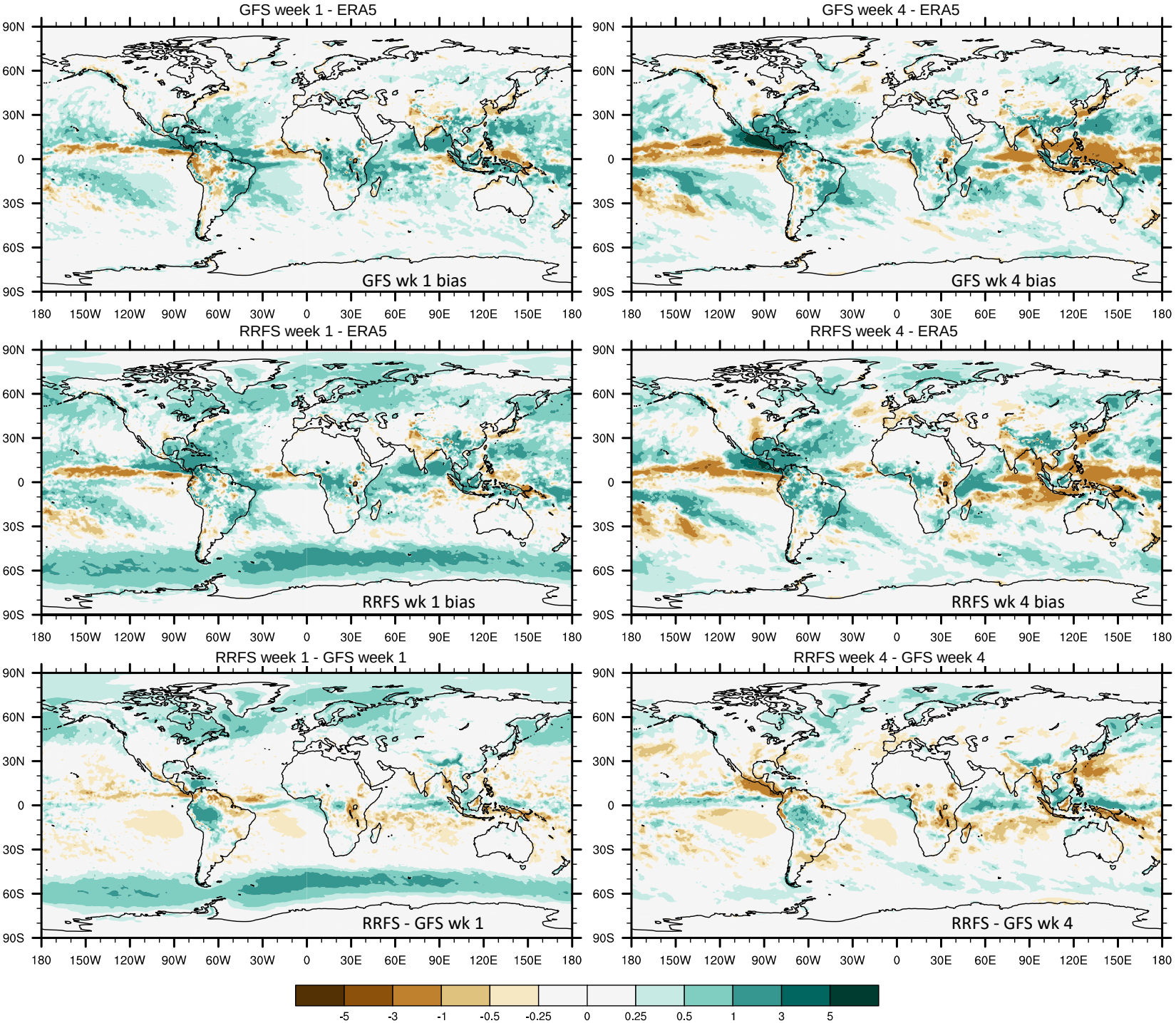
- Have 208 cases for each physics suite: Initializations at 0000 UTC every Wednesday from January 2015 through December 2018
  - C384 resolution, 65 levels, output daily at 1°x1°

Results: Biases in T2m



- Verify against oper. GFS analysis
- Table: Global avg. biases (**over land**)
- Week 1 (left):
  - Biggest differences between 2 suites over icy areas (Antarctica, Greenland)
  - GFS has warm bias; RRFS has cold bias
- Week 4 (right):
  - RRFS has **same mean bias over land** as GFS (see table)
  - Both suites have warm bias over land
  - RRFS has larger "model drift" (change from week 1 to week 4; bottom row)
  - Despite identical SST (uncoupled), still slight differences in T2m biases over ocean

Land (K)	GFS	RRFS
Week 1	0.057	-0.189
Week 2	0.262	0.182
Week 3	0.325	0.308
Week 4	0.353	0.352



Results: Biases in precip

- Verify against **ERA5** reanalysis
- Table: Global avg. biases (**land+sea**)
- Week 1 (left):
  - RRFS much wetter than GFS, due mainly to biases at high latitudes
  - GFS also has wet bias
- Week 4 (right):
  - RRFS has **smaller wet bias** than GFS
  - Both suites drift towards less precip, but more drift in RRFS
  - RRFS has larger “model drift” (change from week 1 to week 4; bottom row)
  - Suites differ over active MJO region and along Pacific coast of Central America

mm/dy	GFS	RRFS
Week 1	0.198	0.306
Week 2	0.161	0.137
Week 3	0.150	0.109
Week 4	0.133	0.110

Summary

- NOAA plans to streamline all global forecast model products for lead times of 0-45 days into a **single model based on UFS**

- This plan provides an impetus to evaluate the **subseasonal performance** of a physics suite (“RRFS”) developed and tuned for short-term, high-resolution mesoscale regional modeling

- First test of RRFS physics in an **uncoupled** framework found **comparable** results (can’t really say better or worse) to operational GFS physics

- Future work: update both RRFS and GFS physics to newer versions, and run 4 sets of experiments: GFS uncoupled, RRFS uncoupled, GFS **coupled**, RRFS **coupled**

Backup slides

NPS Modeling System	Current Version	Q1 FY 20	Q2 FY 20	Q3 FY 20	Q4 FY 20	Q1 FY 21	Q2 FY 21	Q3FY 21 - Q2FY22 MORATORIUM	Q3 FY 22	Q4 FY 22	Q1 FY 23	Q2 FY 23	Q3 FY 23	Q4 FY 23	Q1 FY 24	Q2 FY 24	Q3 FY 24	Q4 FY 24	UFS Application
Global Weather & Global Analysis	GFS/ GDASv15						GFSv16									v17/GEFSv			UFS Medium Range & Sub-Seasonal
Global Waves	GWMv3																		
Global Weather Ensembles	GEFSv11				GEFSv12														
Global Wave Ensembles	GWESv3																		
Global Aerosols	NGAC v2																		
Short-Range Regional Ensembles	SREFv7																		
Global Ocean & Sea-Ice	RTOFSv1.2					RTOFSv2					RTOFSv3								UFS Marine & Cryosphere
Global Ocean Analysis	GODASv2										GODASv3								
Seasonal Climate	CDAS/ CFSv2																	SFSv1	UFS Seasonal
Regional Hurricane 1	HWRFv12			HWRFv13					HAFSv1				HAFSv2				HAFSv3		UFS Hurricane
Regional Hurricane 2	HMONv2			HMONv3															
Regional High Resolution CAM 1	HiRes Window v7											RRFSv1				RRFSv2			UFS Short-Range Regional HiRes CAM & Regional Air Quality
Regional High Resolution CAM 2	NAM nests/ Fire Wxv4																		
Regional High Resolution CAM 3	RAPv4/ HRRRv3			RAPv5/ HRRRv4															
Regional HiRes CAM Ensemble	HREFv2				HREFv3														
Regional Mesoscale Weather	NAMv4																		
Regional Air Quality	CMAQv5								CMAQv6										
Regional Surface Weather Analysis	RTMA/ URMA v2.7			RTMA/ URMA v2.8									3DRTMA/ URMAv3						
Atmospheric Transport & Dispersion	HySPLITv7								HySPLIT v8								HySPLIT v9		UFS Air Quality & Dispersion
Coastal & Regional Waves	NWPSv1.2			NWPS v1.3					NWPS v1.4						RWPSv1				UFS Coastal
Great Lakes	GLWUv3.4								GLWUv4								GLWUv5		UFS Lakes
Regional Hydrology	NWMv2					NWMv3							NWMv4						UFS Hydrology
Space Weather 1	WAM/IPEv1																	WAMv2	UFS Space Weather
Space Weather 2	ENLILv1																		