Unified Global Modeling at NCEP:

Implementation Plans for FV3 GFS/GEFS Upgrades in NEMS

FV3 Technical Meeting

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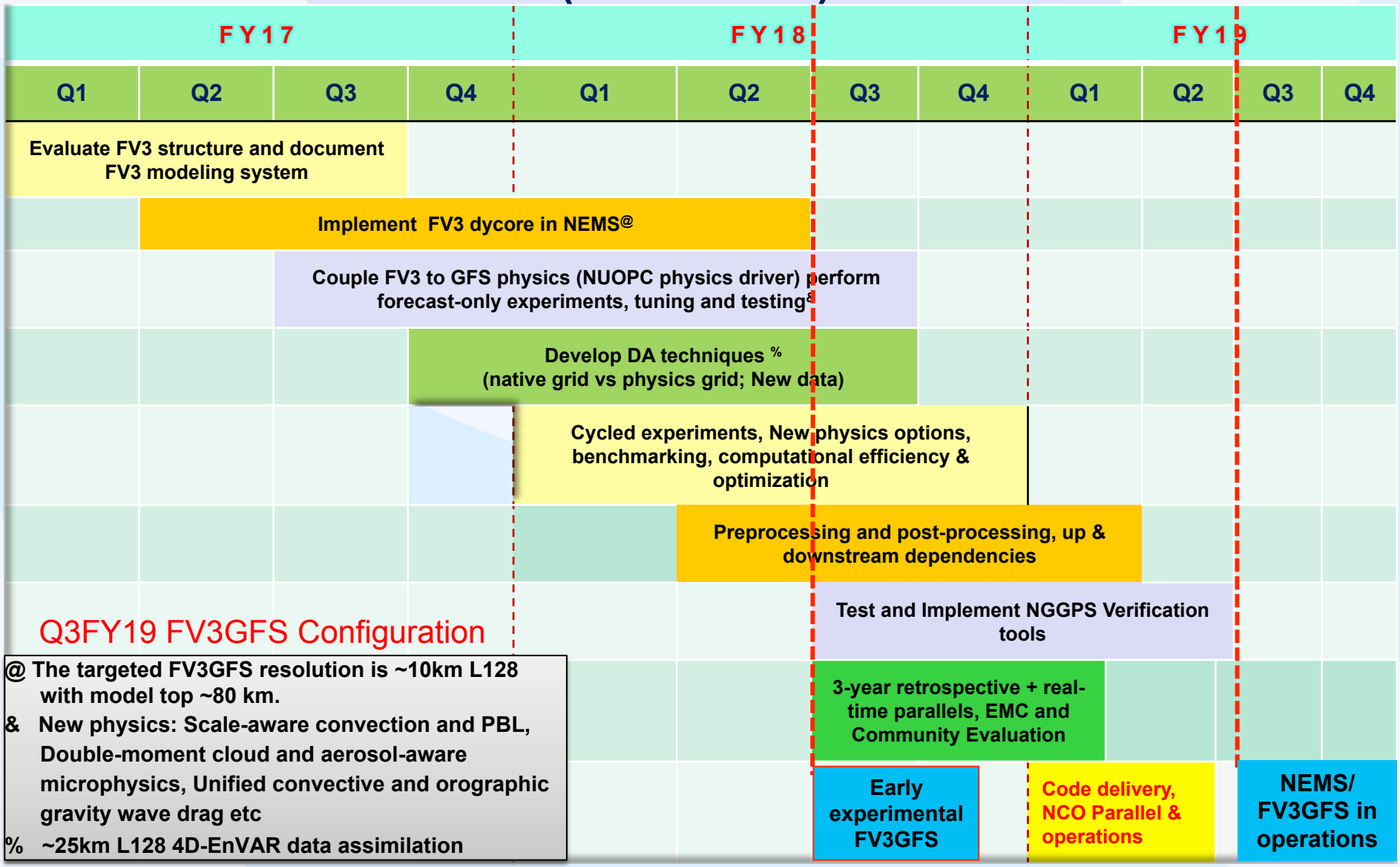
Scientific Changes Implemented/Planned (FY15-20)

(Blue represents significant upgrade)

GFS Implementation	Q3FY16 GFS V13.0	Q3FY17 GFS V14.0	FY18 GOES-R/ JPSS DA ONLY	Q3FY18 GFS V15x (beta)	Q3FY19 GFS V15.0	Q3FY20 GFS V16.0
Resolution	T1534 (13 km) L64	T1534 (13 km) L64	T1534 (13 km) L64	C768 (13 km) L64	C1152 (9 km) L128	C1152 (9 km) L128
Physics	Noah LSM Upgrades	NSST Noah LSM upgrades Scale-aware SAS & EDMF PBL		NUOPC Physics Driver	Advanced Physics TBD	Advanced Physics (TBD)
Dynamics	Semi-Lagrangian			FV3		
DA	- All-sky radiances - 4D Hybrid	JPSS, CrIS and GOES-R Ready SEVIRI IR; VIIRS GOES WV Winds GPSRO RARS & DBNET	- GOES-R & JPSS data assimilated	GSI for FV3	- JEDI/Unified forward operator - L128 mod	DA on FV3 grid
Products	- Hourly output - Five more levels	1/8 degree products		TBD	TBD	TBD
Significant Component	4D EnVAR LSM upgrades	NEMS/ESMF LSM upgrades	GOES-R/JPSS Data	GFS/FV3 (prototype experimental parallel)	Operational GFS/FV3	- Advanced Physics/ CCPP - DA on FV3 grid
	May 11, 2016 Done	**May 10, 2017 Planned**	**Planned**	**Planned**	**Planned**	**Planned**

Today

Implementation Plan of FV3GFS (FY17-FY19)



Q3FY19 FV3GFS Configuration

@ The targeted FV3GFS resolution is ~10km L128 with model top ~80 km.

& New physics: Scale-aware convection and PBL, Double-moment cloud and aerosol-aware microphysics, Unified convective and orographic gravity wave drag etc

% ~25km L128 4D-EnVAR data assimilation

FV3GFS Development/Implementation Plan

- After Q3FY17 NEMS/GSM implementation (last spectral model upgrade), all resources are diverted to FV3 implementation task
- Benchmark FV3GFS with fully cycled DA to match or exceed the skill of operational GFS
- Experimental early (parallel) implementation of FV3GFS in Q2FY18
- Simultaneous development and testing of advanced physics and higher resolution for FV3GFS
- First official implementation of FV3GFS in Q2FY19

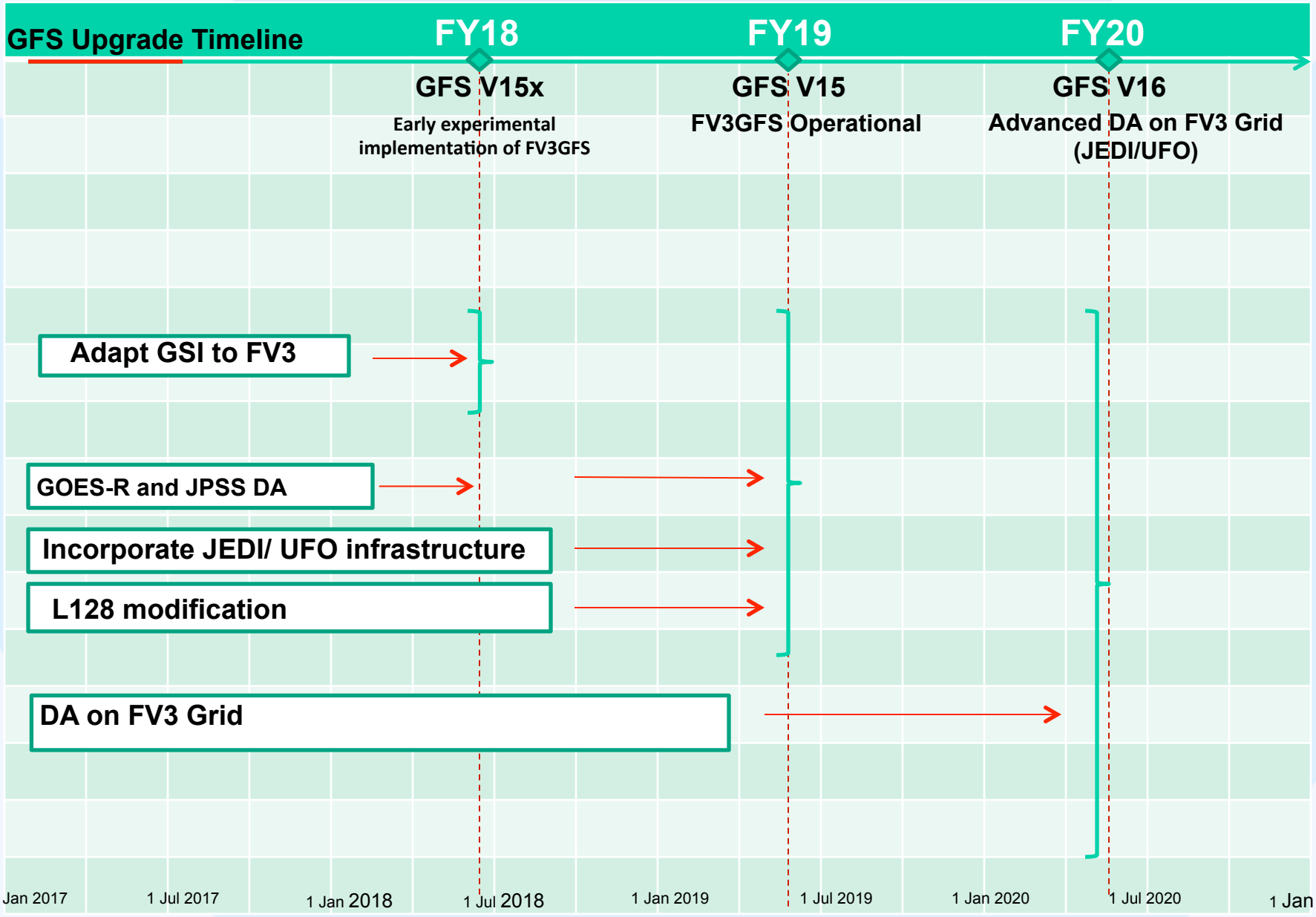
Physics: Two-Stream Strategy

NUOPC Physics Driver in NEMS using Community Common Physics Package

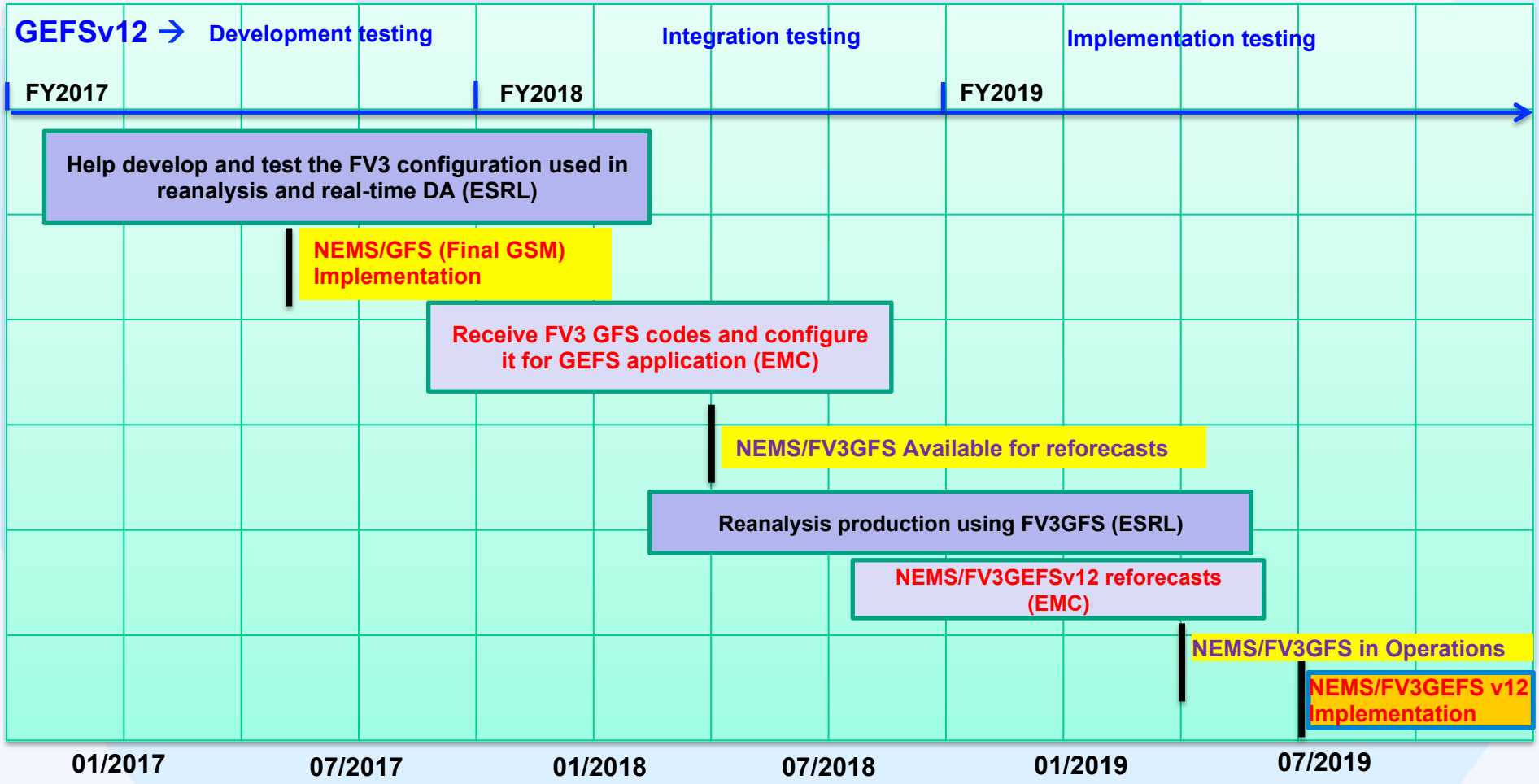
Physical Processes	Operational Physics	Advanced Physics* (CCPP – ongoing activities)
Radiation	RRTMG	RRTMGP (scale and aerosol aware, w/sub-grid scale clouds)
Penetrative convection and Shallow convection	SAS RAS	Scale-aware Chikira-Sugiyama & Arakawa-Wu; Grell-Freitas
Turbulent transport (PBL)	Hybrid EDMF	CS+SHOC (unified convection & turbulence)
Cloud microphysics	Zhao-Carr WSM-6	Double Moment scheme (Morrison, Thompson, Barahona)
Gravity wave drag	Orographic GWD Stationary convective GWD	Unified representation of GWD
Ozone physics	NRL simplified scheme	Modified NRL scheme
Land surface model (LSM)	Noah	Noah and LIS
SST	Reynolds/RTG SST	NSST

Includes aerosol chemistry (NGAC) module

FV3 GFS Data Assimilation Plan (30 Nov 2016)



FV3 based GEFS v12 plan (proposed) with reanalysis and reforecast



Proposed changes: 1) Start producing FV3-based reanalysis for GEFS v12 in ~Q1 FY18, using the configuration of FV3GFS. 2) Reforecasts will commence soon after starting the reanalysis, uncoupled*, with 2-tier SST approach, and will include extension to 35 days

FV3 GFS Development Tasks List

Project Area	Project	Lead/POC	Tasks	Dependencies	ESD	ECD
Development & Testing		Development & Testing				
Infrastructure	Code Build & Optimization	Mike Young	FV3GFS runs much slower than current NEMS GFS. Explore both code and running time optimizations GFDL uses mkmf to dynamically generate makefile. Need to rewrite makefile and compiling process to follow NCO/EMC style.			
	Code management & regression	Sam Trahan	NEMS/FV3 integration including external development (nesting)			
	Workflow and Superstructure	Fanglin Yang	include FV3GFS in the v15.0.0 implementation superstructure packages. Currently working on 1) moving all FV3GFS code and utilities to global_shared and gfs_workflow; 2) restructure and simplifiy para_config, create config files for each cycling step; 3) rewrite fcst.sh and create exgloba_fcst_fv3gfs; 4) work on post, vrfy and arch steps			
	Documentation	Rusty & Valbona	FV3 documentation (scientific, technical, and user guide)			
	Libraries	Mark Iredell	Develop and port libraries to WCOSS & RDHPCS (Jet, Theia, Gaea)			

FV3 GFS Development Tasks List

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Development & Testing		Development & Testing				
Dycore	Global Chgres	George Gayno	1. read in sigio and nemsio GFS IC, convert to FV3 6-tile IC; 2. Add NSST; 3. Optimization			
	FV3 CAP	Jun Wang	Add FV3 CAP to NEMS			
	FV3 write component	Jun Wang	Use NEMS write compnemnt for Fv3GFS output, inlcuding both fv3 restart files on model native grid in netCDF format and diagnostic/history files on global lat-lon or gaussian grid in nemsio format.			
	FV3 Chgres	Jim Purser	Change resolutions between FV3 grids			
	Selective hourly output and output at FH00	Rusty Benson & Jun Wang	hourly output up to 120 hours, then 3 hourly output; currently FV3GFS does not write out atmospheric fields after one-step time integration as GSM does. Need FH00 for operation.			
	Regridding	Cecelia Deluca	ESMF regridding vs GFDL regridding (within NEMS)			
Physics Driver	IPD FV3GFS coupling	Rusty Benson & Hang Lei	Couple IPD V3.0 to FV3GFS for benchmark test			

FV3 GFS Development Tasks List

Project Area	Project	Lead/POC	Tasks	Dependencies	ESD	ECD
Development & Testing		Development & Testing				
Physics	128 Layer	Moorthi	extend the model top to the mesopause and double vertical layers.			
	GWD	Jordan Alpert	non-orographic gravity-wave drag parameterization is required for the 128-L model			
	Microphysics	Ruiyu Sun	replace Zhao-Carr MP with a more advanced MP scheme			
	PBL & Convection	Jongil	finalize the schemes for FY18 & FY19			
	Radiation/ Aerosols	Yu-Tai Hou				
	stochastic physics/ ensembles	Dingchen Hou & Jeff Whitaker				
Land	NSST	Xu Li	Phase-II dycore comparison did not include NSST. Need to first include NSST in forecast			
	Land Surface	Helin Wei				

FV3 GFS Development Tasks List

Project Area	Project	Lead/POC	Tasks	Dependencies	ESD	ECD
Development & Testing		Development & Testing				
Data Assimilation	GSI Mod for FV3	Rahul	1. External regridding and change of variables to Gaussian/LatLon grid and reverse for increments 2. Stochastic physics into the FV3 model 3. Run GSI system with current 4DEnVar GSI			
		Russ	Transform from FV3 grid to Gaussian (or LatLon) grid and reverse for increments			
		Cathy	Generate new static background error covariances for initial FV3 system			
		Rahul	Retune free parameters (length scales, etc.) for initial FV3 forecast			
		Cathy	Ensure/Evaluate TLNMC appropriate for FV3			
		Whitaker & Rahul	Incorporate IAU capability in NEMS/FV3			
	DA workflow	Russ	Develop appropriate scripting and workflow for EMC parallel system			
	New Satellites	Collard	Incorporate GOES-R Data			
			Incorporate JPSS Data			
	GSI Hybrid	Kliest	Plan and execute DA for 128 levels			

FV3 GFS Development Tasks List

Project Area	Project	Lead/POC	Tasks	Dependencies	ESD	ECD
Integration & Testing		**Integration & Testing**				
Integration testing	FV3GFS Forecast-only experiment	Fanglin Yang	1. port FV3GFS to WCOSS Cray (completed); 2. create fix fields for different resolution (completed); 3. convert FV3 6-tile output to NEMSIO (completed); 4. Run NCEP POST (in progress); 5. verification etc; 6. run daily forecasts with operational IC; 7. set up web display of results			
Integration testing	Configuration Test	Kate Howard	GFDL only provided a configuration that only applies to the C768 dycore comparison project. The configuration needs to be generalized and tested for different resolution and with different physics and dynamics options. For instance, to test IAER, ICO2, IMES, ISOL options etc.			
Benchmarking		**Benchmarking**				
Cycled experiment		Gan				
Pre Processing		**Pre Processing**				
Pre Processing		Alpert	Orography and fixed fields			
		Qingfu Liu	TC Relocation			
		Stokes	Obsproc			
Post Processing		**Post Processing**				
	NCEP POST	Chuang				
	Downstream	Boi Vuong				

FV3 GFS Development Tasks List

Project Area	Project	Lead/POC	Tasks	Dependencies	ESD	ECD
Integration & Testing		Integration & Testing				
Pre-Implementation test		Pre-Implementation test				
	Real Time & retro parallels	Lin Gan				
V&V		V&V				
	Verification	Fanglin Yang	including trackers			
	Diagnostics	Glenn White	Implement Steve Lord's diagnostic package			
Transition to Operations		Transition to Operations				
		Gan	Implementation Manager			
		Fanglin	Verification/Evaluation Manager			
		NCO	Production			

Next Steps:

- Project Leads will developed plans for each task area
- Membership, milestones and deliverables identified for each task area
- Appropriate review process established
- O2R2O Process linked to dependencies (community modeling approach)
- Expand Project Areas to include GEFS and Coupled Systems
- Expand Project Areas to include Global-Meso Unification (Nesting)

FV3GFS Input and Output

Cold RESTART

gfs_ctrl.nc sfc_ctrl.nc
gfs_data.tile$n.nc
sfc_data.tile$n.nc
Where n=1,2,…6

Created by CHGRES using operational GFS IC as input

Warm RESTART

coupler.res fv_core.res.nc
fv_core.res.tile$.nc
fv_srf_wnd.res.tile$n.nc
fv_tracer.res.tile$n.nc
sfc_data.tile$n.nc

Written out at the end of forecast

Forecast HISTORY

$cdate.nggps2d.tile$n.nc
$cdate.nggps3d_4xdaily.tile$n

Written out at $fdiag interval

Forecast DIAG and misc

$cdate.atmos_4xdaily.tile$n.nc
atmos_static grid_spec

Written out at $fdiag interval

Data Assimilation Steps W/O ENKF

1. Use Cold RESTART (first time) or thereafter analyses in Warm-RESTART file style to run 9-hour forecast.
2. Convert hourly or 3-hourly **Forecast HISTORY** netCDF files to nemsio global Gaussian grid files (aka "first guess" ?)
3. Feed "first guess" into GSI for data assimilation. GSI writes out analyses in nemsio format on global Gaussian grid.
4. Gaussian grid analysis increments are read in by the model, interpolated to the cubed sphere mesh, and added to the hour-6 Warm RESTART fields from step 1) on the fly during the next cycle GDAS forecast step.

A **tool** is needed to change resolution of Warm RESTART files for

1) Running forecasts at a different resolution
2) Running multiple segments of GFS forecasts at different resolution for different forecast-leading time

Alternative approach: analyses in nemsio format on global Gaussian grid made from step 3) in the left box can be fed into CHGRES, converted to Cold RESTART initial conditions at any desired resolution to run forecasts.

Towards Global-Meso Unification (including Hurricane Models)