



**NATIONAL
WEATHER
SERVICE**

The Development of UFS-based Coupled Global Ensemble Forecast System for weather and subseasonal forecast

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1.IMG at NOAA/NWS/NCEP/EMC

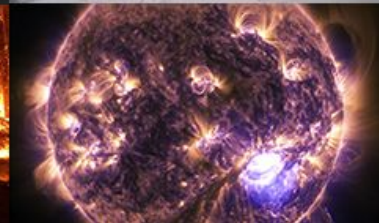
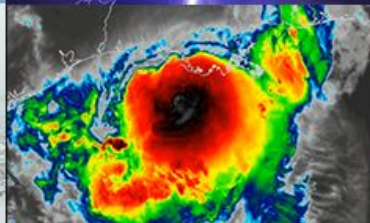
2.NOAA/NWS/NCEP/EMC

3.NOAA/ESRL/PSL

4.SRG at NOAA/NWS/NCEP/EMC

Unifying Innovations in Forecasting Capabilities workshop, College Park, July 18-22

Acknowledgements: EMC coupled model group





Outline



➤ Introduction



➤ UFS coupled model prototypes and ensemble prototypes



➤ Results from UFS coupled ensemble prototypes



➤ Summary





Introduction



- ❖ NOAA/NCEP is planning to implement a fully coupled UFS global forecast system (GFS) and GEFS in 2024. This is the first time for a fully coupled model to be implemented.
- ❖ Significant changes of model behavior are expected given the fact that model is upgraded from a ATM-only model to a fully coupled ATM-OCN-ICE-WAV-CHM model. There is a critical need to test and evaluate the fully coupled GEFS in preparation for the next model upgrade.

UFS coupled model prototypes

UFS prototypes	Model components	Initial conditions				Highlights of updates
		ATM	OCN	ICE	WAV	
P1	C384L64-MOM6-CICE5 NEMS mediator	CFSR	CFSR	CPC ice analysis	N/A	First prototype
P2	C384L64-MOM6-CICE5 NEMS mediator	CFSR	CPC-3Dvar	CPC ice analysis	N/A	New ocn ICs
P3	C384L64-MOM6-CICE5 NEMS mediator	CFSR	CPC-3Dvar	CPC ice analysis	N/A	
P4	C384L64-MOM6-CICE5-WW3 NEMS mediator	CFSR	CPC-3Dvar	CPC ice analysis	CFS forcings	CCPP, wave feedback to ocn
P5	C384L64-MOM6- CICE6 -WW3 CMEPS mediator	CFSR	CPC-3Dvar	CPC ice analysis	CFS forcings	GFSv15 physics, wav-atm coupling fix, CICE6
P6	C384 L127 -MOM6-CICE6-WW3 CMEPS mediator	CFSR	CPC-3Dvar	CPC ice analysis	CFS forcings	Fractional Grid, L127, sa-tke-EDMF
P7	C384L127-MOM6-CICE6-WW3 CMEPS mediator	GEFS-RR	CPC-3Dvar	CPC ice analysis	CEFS forcings	NOAH-MP, NSST, updated physics
P8	C384L127-MOM6-CICE6-WW3- GOCART CMEPS mediator	GEFS-RR	CPC-3Dvar	CPC ice analysis	GEFS forcings	Thompson MP, updated physics ...

Initial conditions in ensemble prototypes (EP)

	EP1(p5) (C384L64, OCN_L75)	EP2(p7) (C384L97,OCN_41)	EP3(p8) (C384L97,OCN_41)
ATM	GFSv15 EnKF&ANL (L64)	GFSv15 EnKF&ANL (L97) sfc spinup (NOAH-MP)	GFSv15 EnKF&ANL (L97) (new oro) sfc spinup (NOAH-MP) updated
OCN	CFSR Salinity and T	CFSR Salinity and T	ORAS5 anl + pert
ICE	CPC ice analysis	CPC ice analysis	CPC ice analysis
WAV	CFSv2 wind/ice forcing	GFSv15 wind/ice forcing	GFSv15 wind/ice forcing



Model physics in ensemble prototypes



	EP1(p5) (C384L64, OCN_L75)	EP2(p7) (C384L97,OCN_41)	EP3(p8) (C384L97,OCN_41)
phy	Hybrid-EDMF Sa-SAS GFDL-MP GWD (stationary oro) NOAH-LSM ...	Sa-TKE-EDMF Sa-SAS (updated) GFDL-MP GWD (stationary oro) NOAH-MP NSST ...	Sa-TKE-EDMF (updated) Sa-SAS (updated) Thompson-MP uGWDv0+GSL NOAH-MP (updated) NSST ...
stoch	SPPT (0.56,0.28,0.14,0.056,0.028) SKEB (0.7)	SPPT (0.56,0.28,0.14,0.056,0.028) SKEB (0.7) CA pert_mp, radtend ocnSPPT(0.8,0.4,0.2,0.08,0.04) ePBL (0.8,0.4,0.2,0.08,0.04)	SPPT (0.6,0.3,0.15,0.06,0.03) SKEB (0.8) CA pert_mp, radtend ocnSPPT(0.8,0.4,0.2,0.08,0.04) ePBL (0.8,0.4,0.2,0.08,0.04)



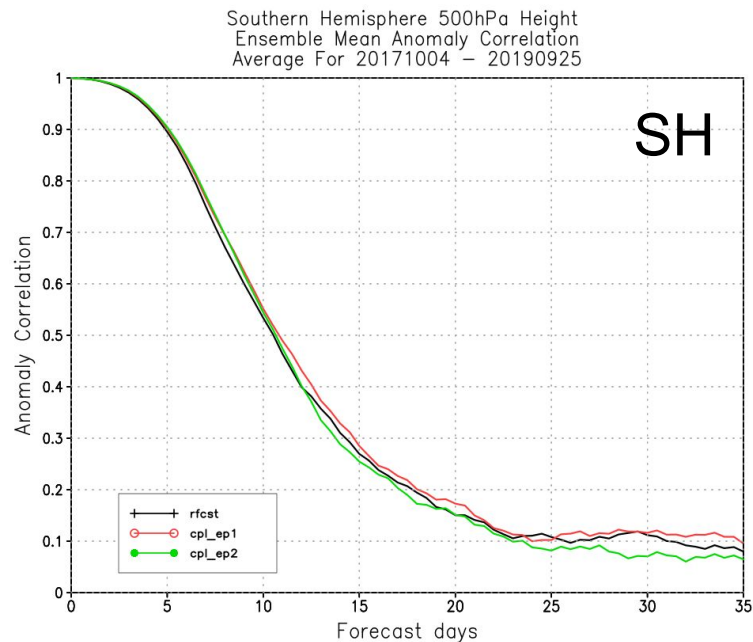
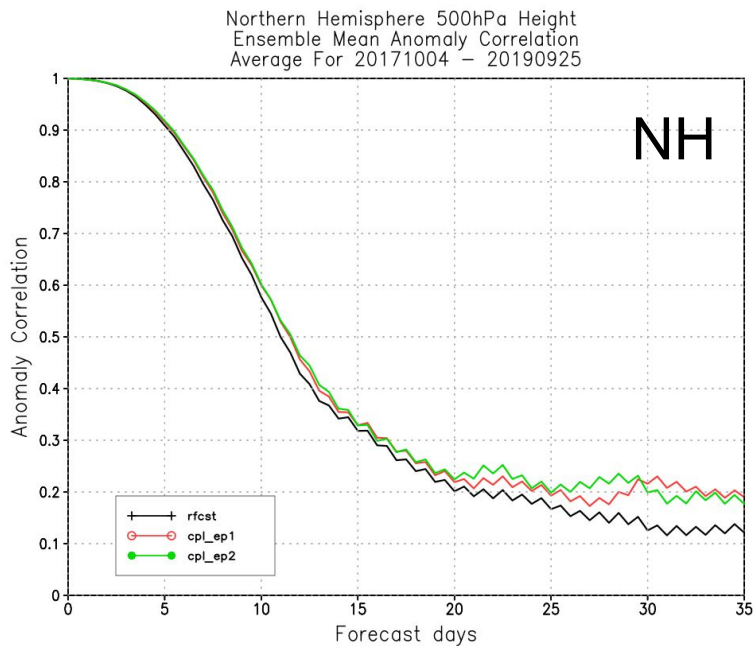
Description of the ensemble experiments



- ❖ Period:
 - Oct 2017 - Sep 2019, once (00Z) per week, 104 cases
- ❖ Ensemble members:
 - 10 perturbed members, 1 un-perturbed member
- ❖ Experiments:
 - GEFSv12 reforecast (control)
 - EP1
 - EP2
 - EP3: ongoing, preliminary results will be showed



Z500 PAC in the Northern and Southern hemisphere

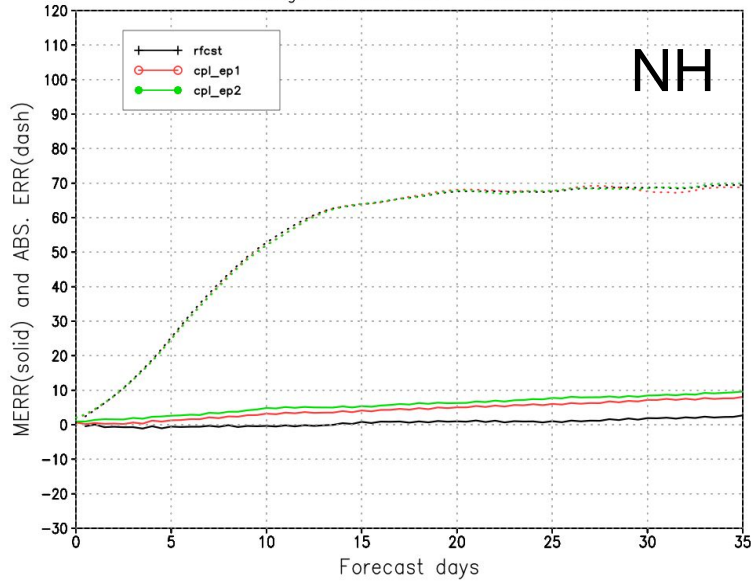




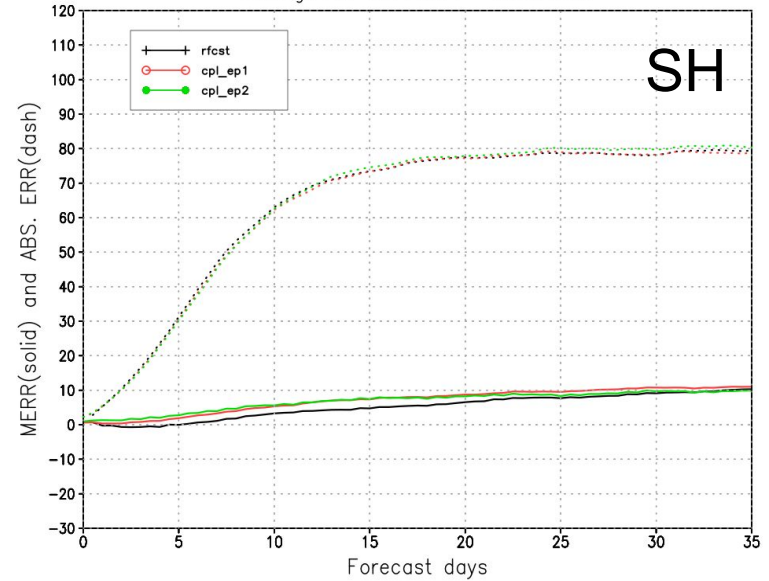
Z500 MERR (Bias) and Absolute Error



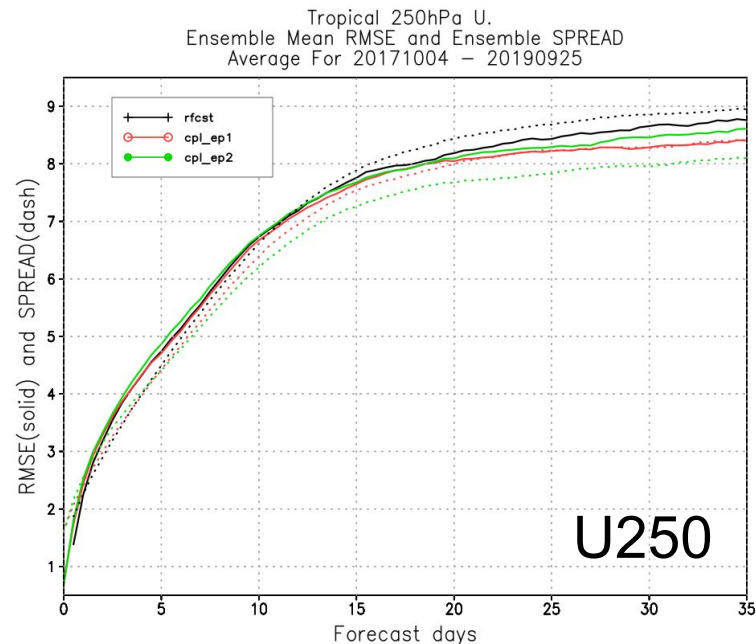
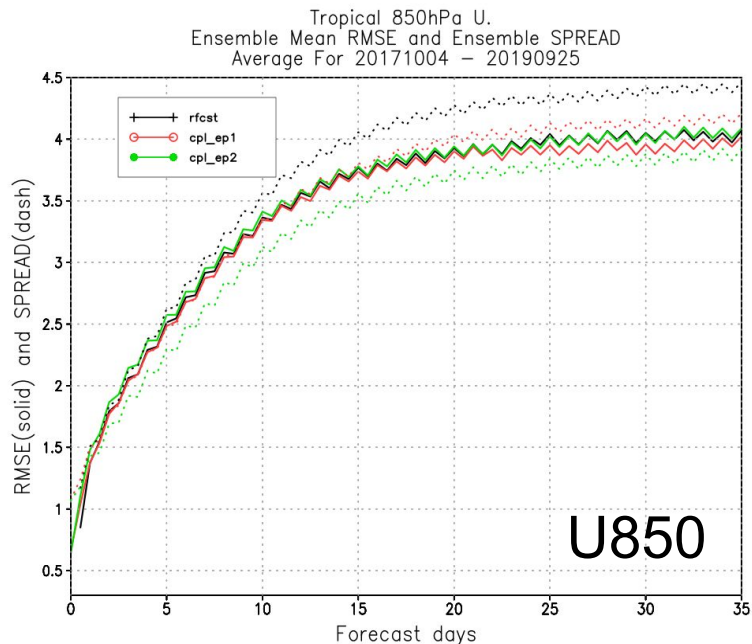
Northern Hemisphere 500hPa Height
Ensemble Mean Error and Ensemble Abs. Error
Average For 20171004 – 20190925



Southern Hemisphere 500hPa Height
Ensemble Mean Error and Ensemble Abs. Error
Average For 20171004 – 20190925

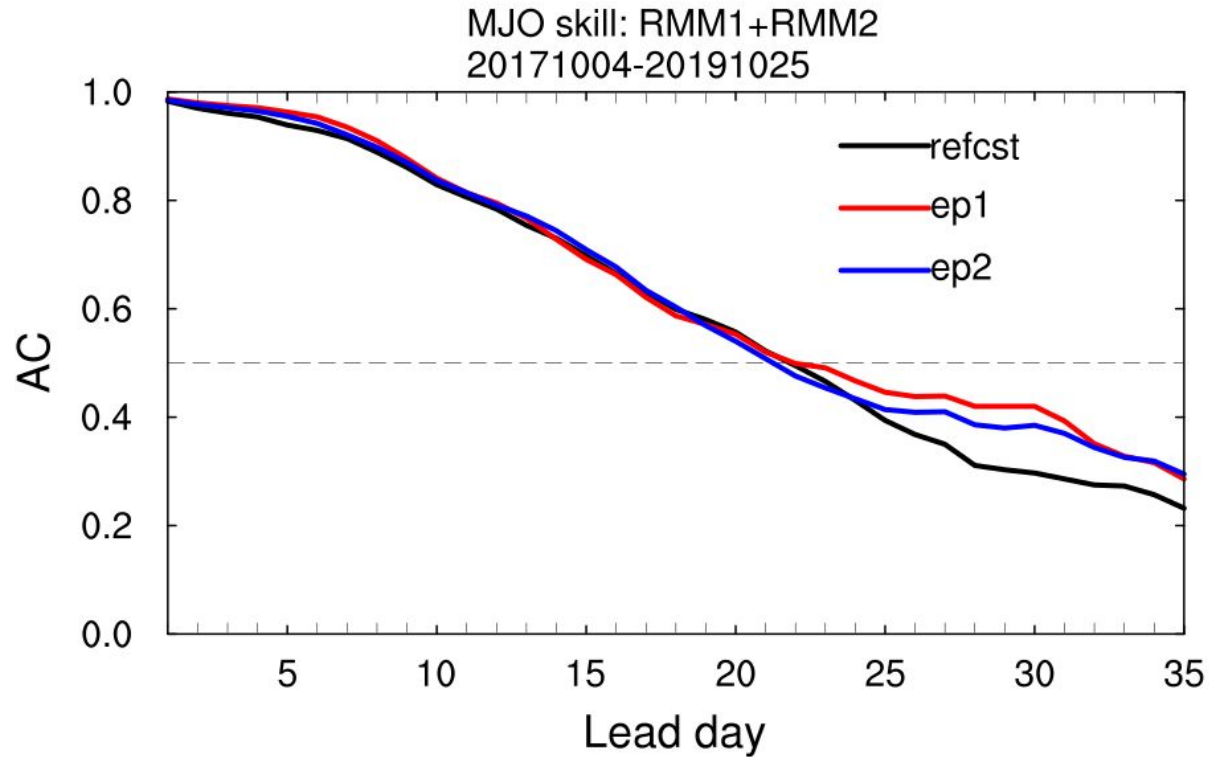


RMSE and SPRD of Tropical U850 (left) and U250 (right)



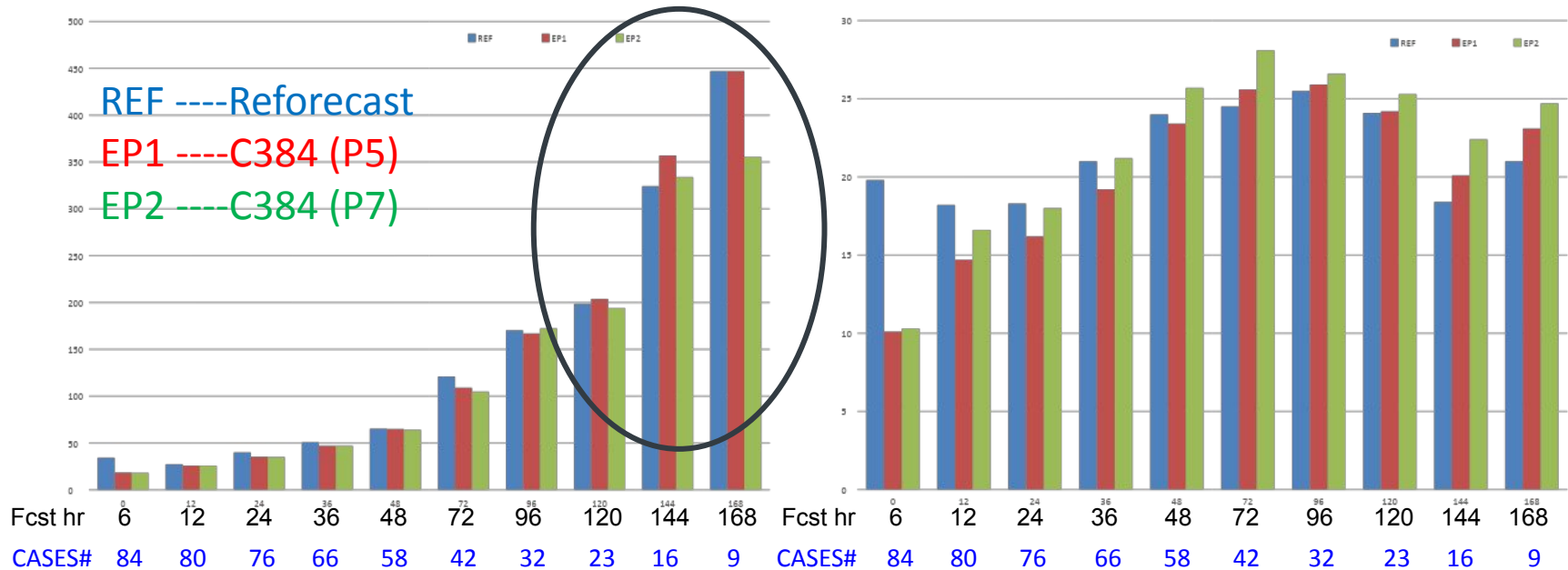


MJO prediction in EP1 and EP2



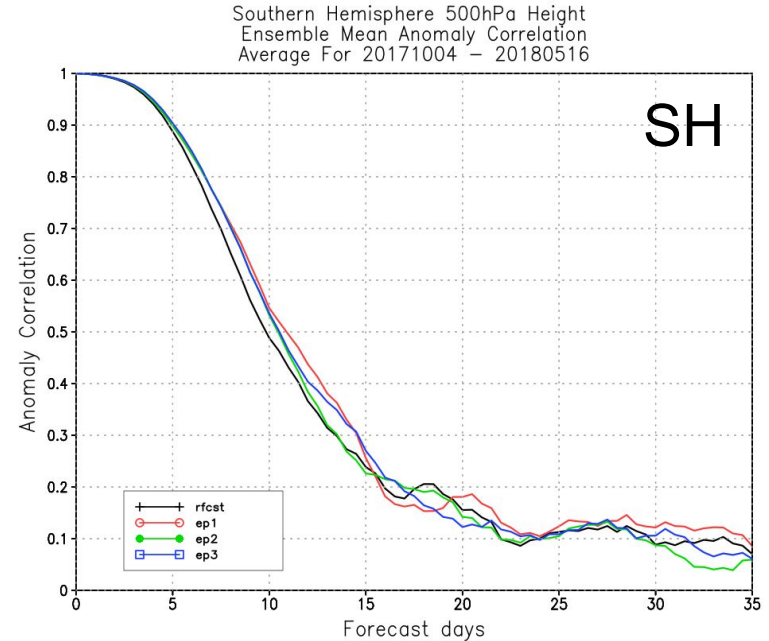
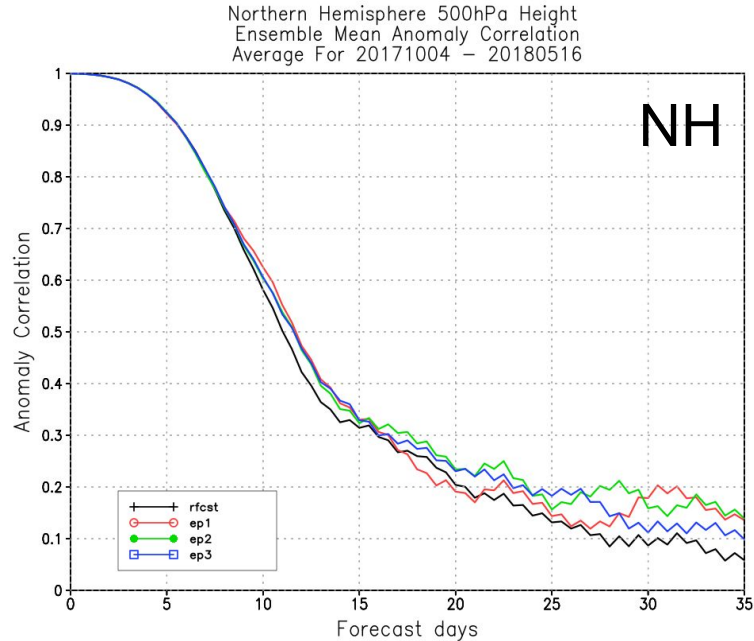


Hurricane forecast in EP1 and EP2



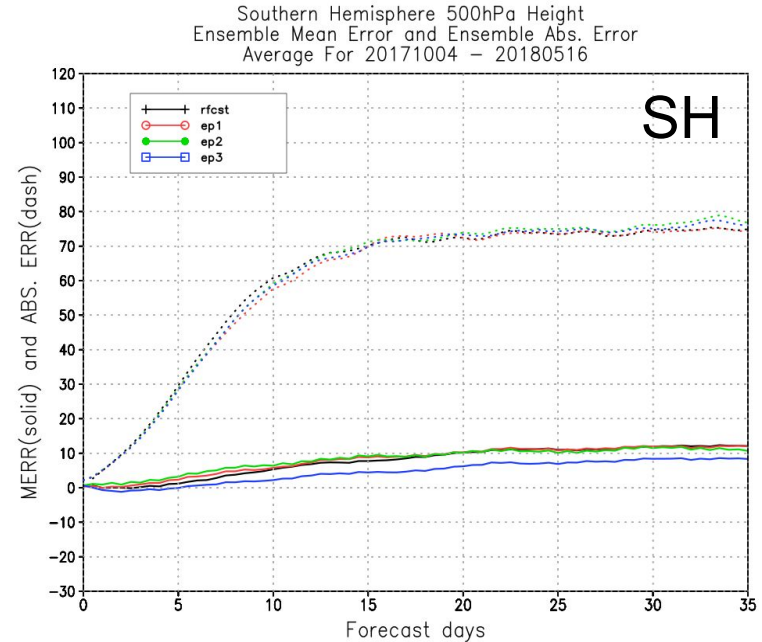
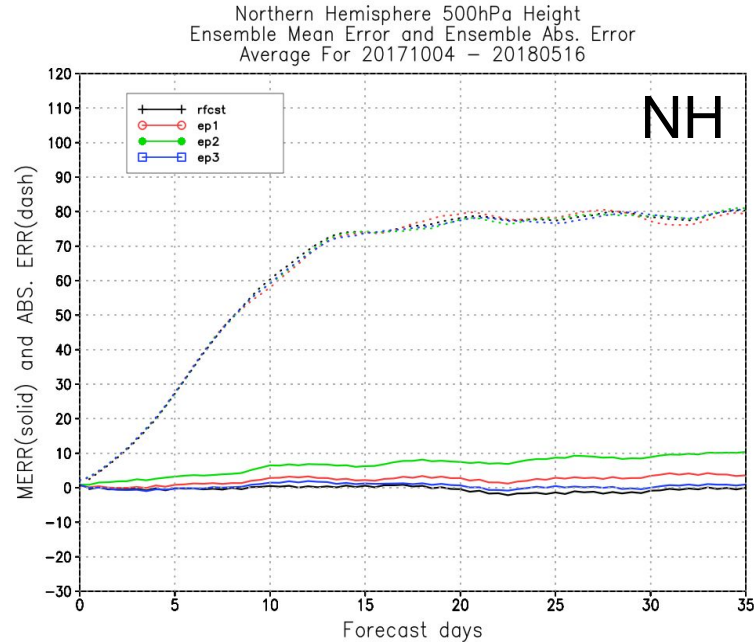
Preliminary EP3 results (33 cases)

PAC of Z500 in the Northern and Southern hemisphere



Preliminary EP3 results (33 cases)

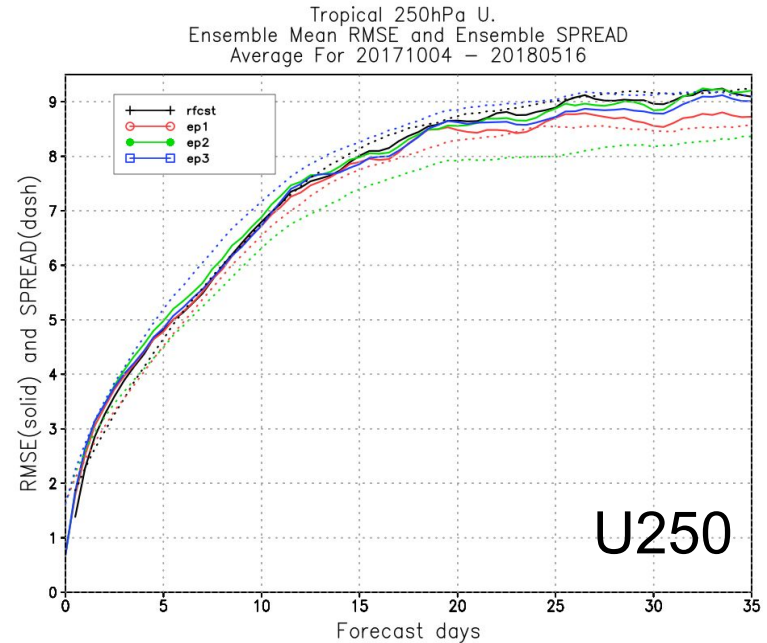
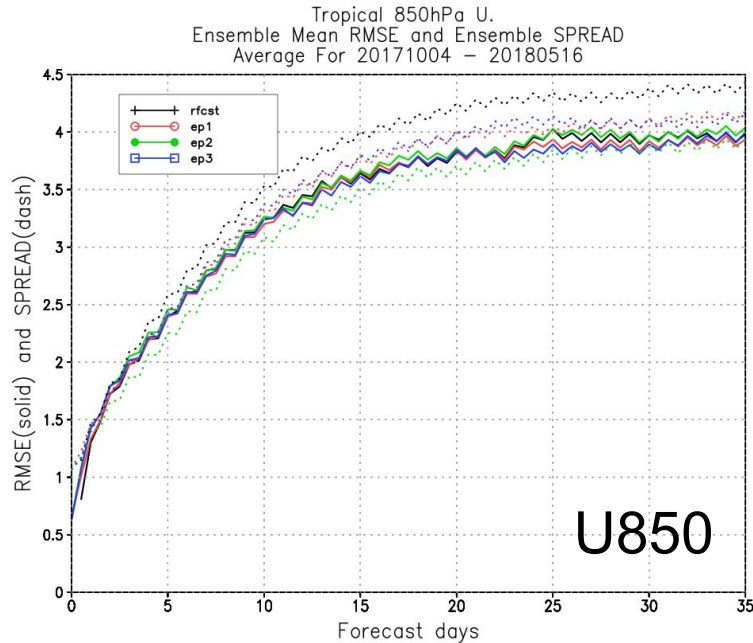
Z500 MERR (Bias) and Absolute Error





Preliminary EP3 results (33 cases)

RMSE and SPRD of Tropical U850 (left) and U250 (right)





Summary



- ❖ A series of UFS coupled ensemble prototypes have been developed in preparation for next GEFS implementation
- ❖ The first two ensemble prototypes (EP1, EP2) overall show some improvements compared with current operational GEFSv12
- ❖ Preliminary results in EP3 show improved bias than EP1 and EP2