Including Sea Ice and Ocean Models in GEFSv13

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NATIONAL WEATHER SERVICE

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NCEP Global Ensemble Forecast System (Configuration)

Components		V12 (Oct. 2020)	V13 (Q2FY25)
Atmos	Dynamics	FV3 (Finite-Vol Cubed-Sphere) GFSv15	FV3 (Finite-Vol Cubed-Sphere) GFSv17
	Physics	saSAS, GFDL-MP, K-EDMF, oroGWD	saSAS, Thompson-MP, sa-TKE-EDMF, uGWD
	Initial perturbation	EnKF f06 (previous cycle)	EnKF f00 (early cycle)
	Model uncertainty	5-scale SPPT and SKEB	5-scale SPPT, SKEB, SPP, CA
	Boundary (ocean surface)	NSST + 2-tiered SST	NSST
	Resolutions	C384L64 (25km)	C384L127 (25km)
Land	Model	NOAH-LSM	NOAH-MP
	Initial perturbation	N/A	Soil moisture
Ocean	Model	N/A	MOM6 (0.25°L75)
	Initial perturbation	N/A	SOCA-Ens
	Model uncertainty	N/A	5-scale oSPPT and ePBL
Ice	Model	N/A	CICE6 (0.25°)
	Initial condition	N/A	SOCA-Ens
Wave	Model	WW3 (one way)	WW3 (2-way) (0.25° lat/lon grid)
Aerosol	Model	GOCART (one way)	GOCART (2-way)

NCEP Global Ensemble Forecast System (Configuration)

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Atmos			
Land			
Ocean	Model	N/A	MOM6 (0.25°L75)
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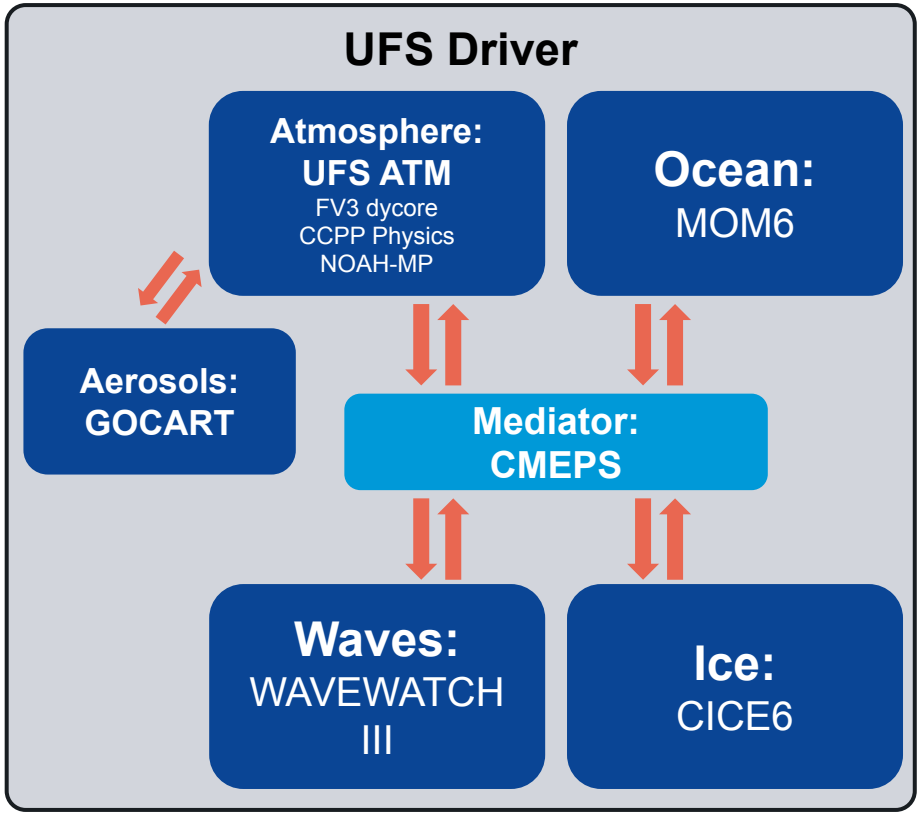
Ice	Model	N/A	CICE6 (0.25°)
	Initial condition	N/A	SOCA-Ens
Wave			
Aerosol			

CICE and MOM6 in GEFS/UFS



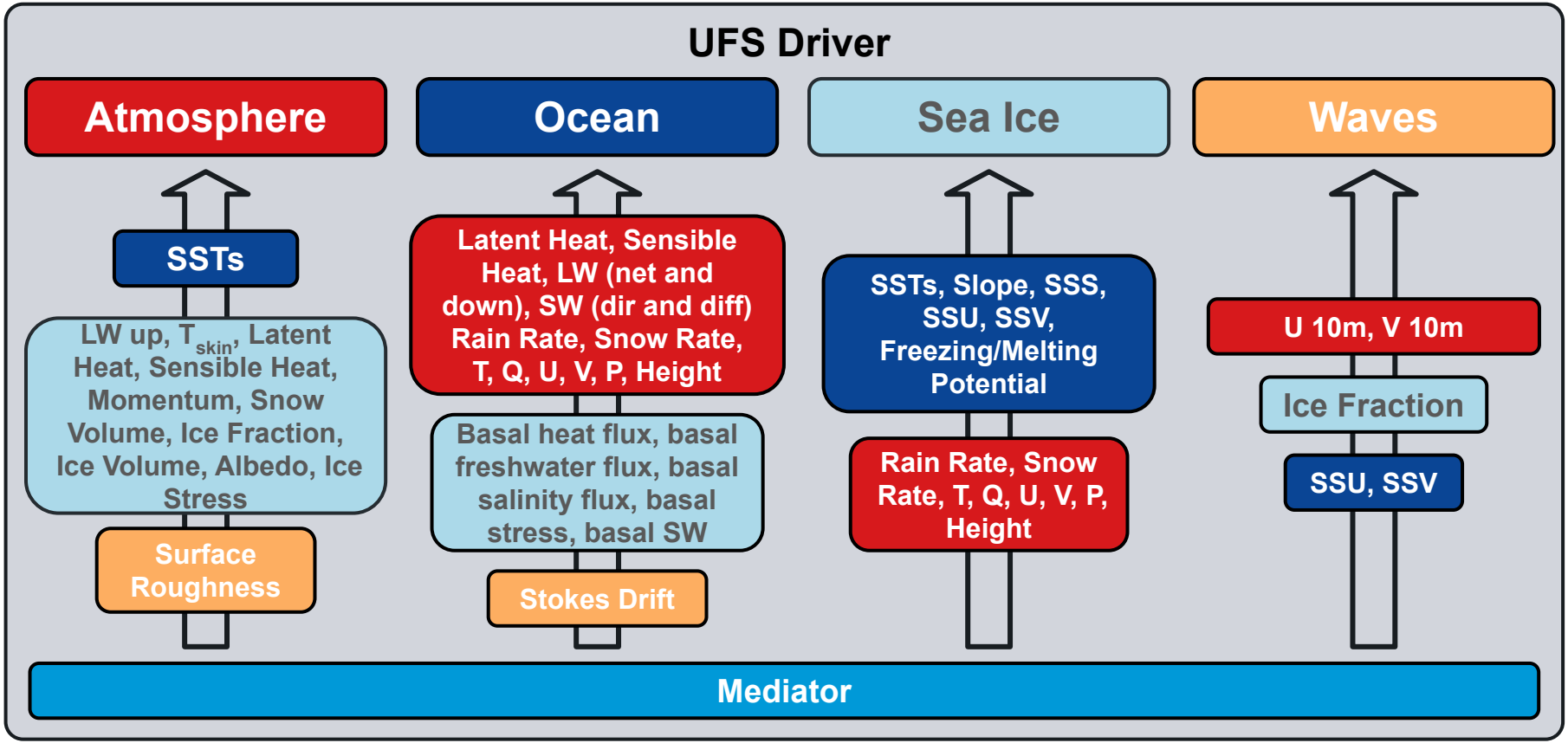
CICE6

- Department of Energy Based Model
  - Los Alamos National Laboratory (LANL)
- CICE consortium
  - DOE, NSF, US Naval Research Lab, NASA, NOAA, DMI, Environment Canada, iPAN
- ¼ degree tripolar grid (same as ocean)
- B-grid
- 5 thickness categories, 7 ice layers, 1 snow layer
- Mushy thermodynamics

MOM6

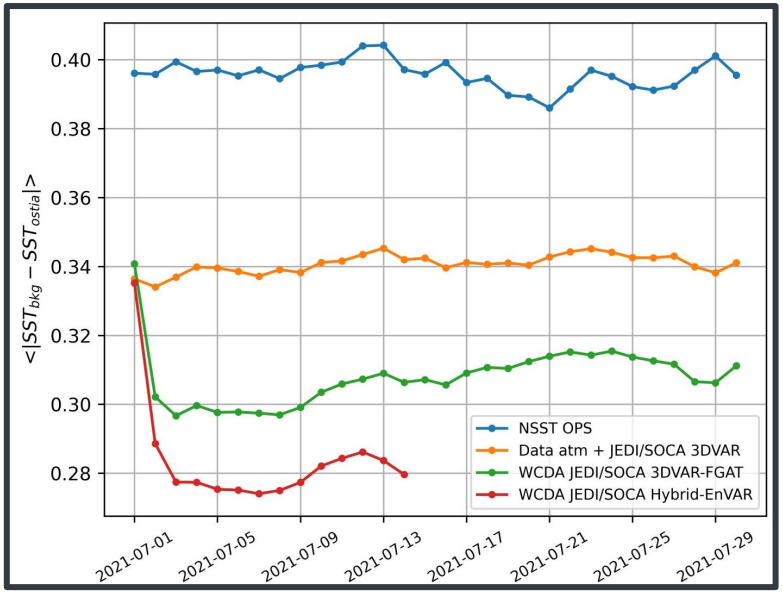
- Developed at the GFDL
- ¼ degree tripolar grid (same as sea ice)
- C-grid
- 75 hybrid levels
- Flexible Modeling System (FMS)

Coupling in GEFS/UFS



Planned Ocean/Sea Ice DA for GEFSv13

- Weakly coupled DA with atmosphere
- Strongly coupled DA between the Ocean and Sea Ice
- JEDI Sea-ice Ocean and Coupled Analysis (SOCA) implementation
- Sea Ice Control Variables:
  - concentration, thickness, snow depth
- Ocean Control Variables:
  - T, S, U, V, SSH
- IAU for MOM6 and direct insertion for CICE6
- Hybrid 3DEnVAR with LETKF perturbations
  - Initialization for GEFS members
  - Early cycle (GDAS)



POCs for Ocean Ice DA work: Guillaume Vernieres (EMC) and Catherine Thomas (EMC)

Planned Ocean/Sea Ice Forecast Perturbations for GEFSv13

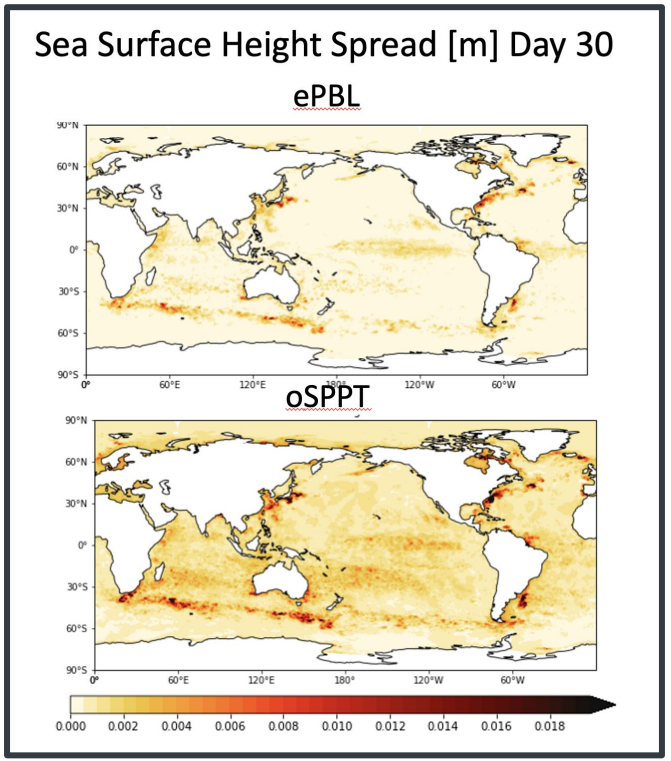
MOM6:

Following Juricke et al. 2017

- oSPPT: perturbed temperature, salinity and layer thickness tendencies from vertical parameterizations
- ePBL: perturbed KE generation and dissipation rates in energetic PBL parameterization.

CICE6:

- No perturbations



POCs for Ocean Ice DA work: Philip Pegion (PSL)

Preliminary Ocean Results

Ensemble Prototype 4:

- Oct. 2017 - Sept. 2019: 2 years
- Once per week: Wednesday 00UTC
- 11 members
- 35 days forecasts

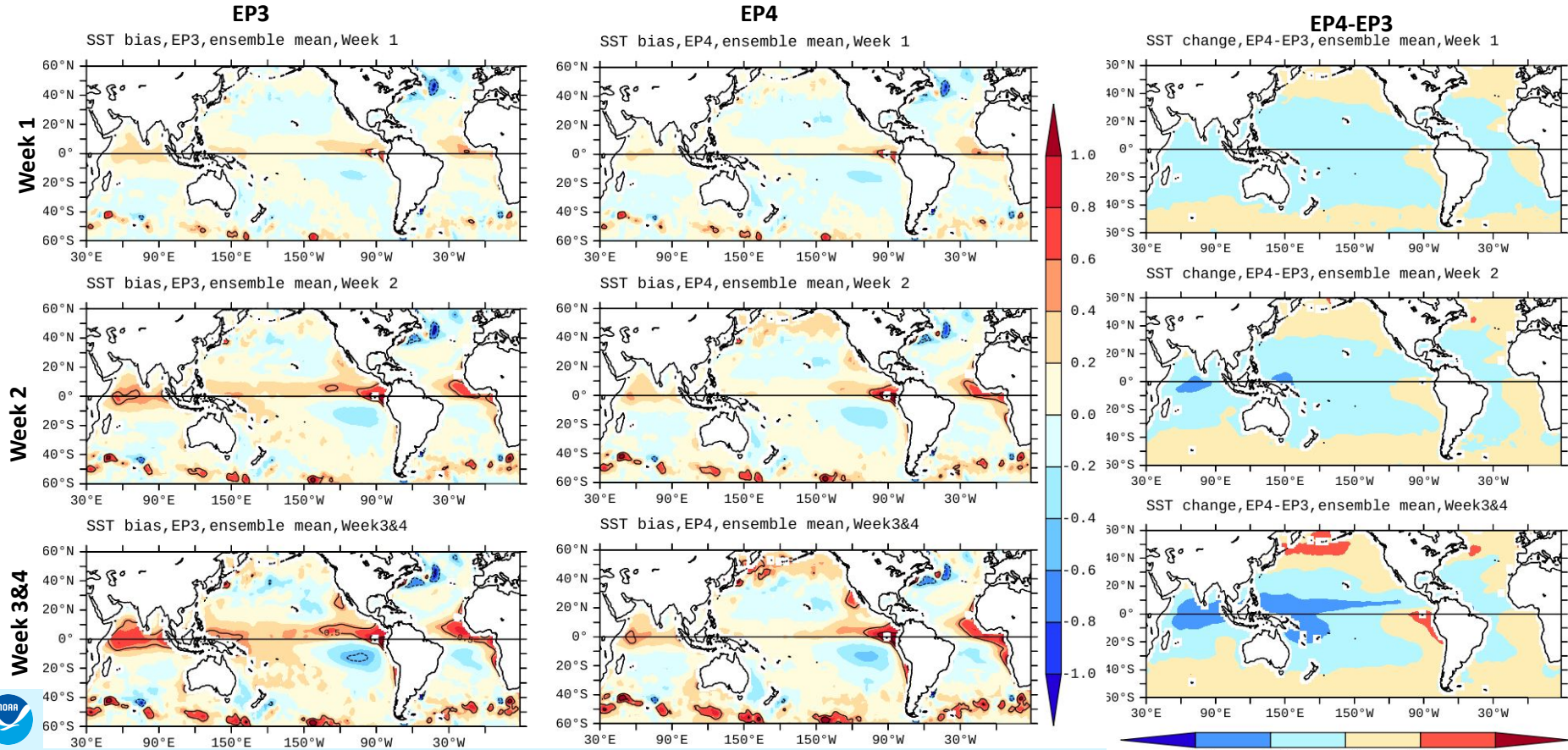
Initial Conditions:

- FV3: GEFS Reanalysis
- CICE: CPC analysis (CSIS) (Liu et al. 2019)
- MOM6: ORA5 analysis with perturbations

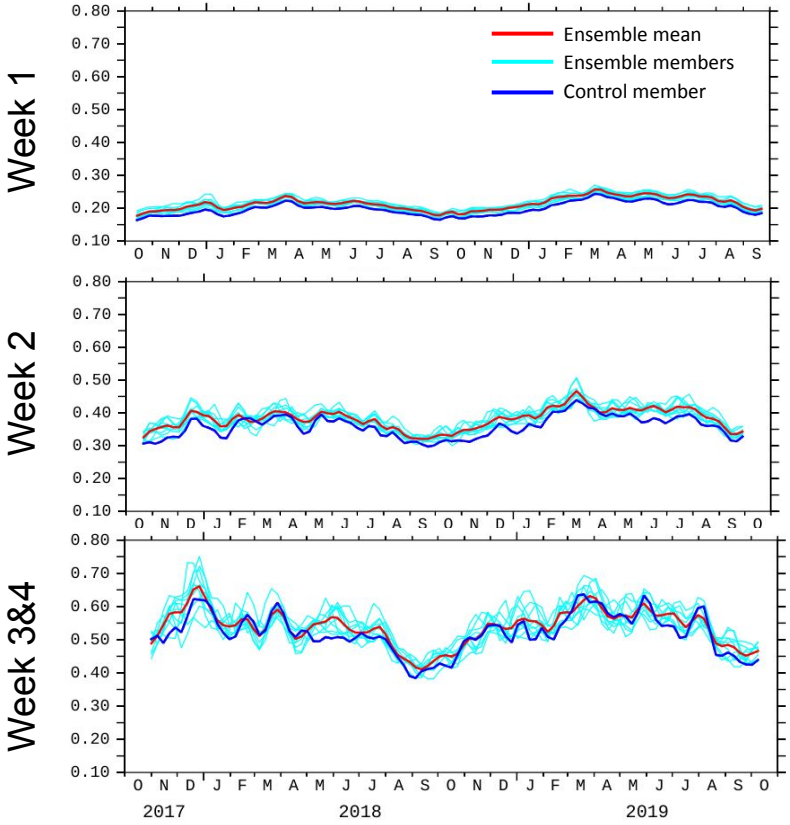
POCs for Ocean Diagnostics: Sulagna Ray (SAIC at EMC)

SST biases in Ensemble Mean

- EP4 has cooler tropics than EP3: reduced warm bias
- EP4 has a slightly warmer bias along the coasts compared to EP3: increased warm bias

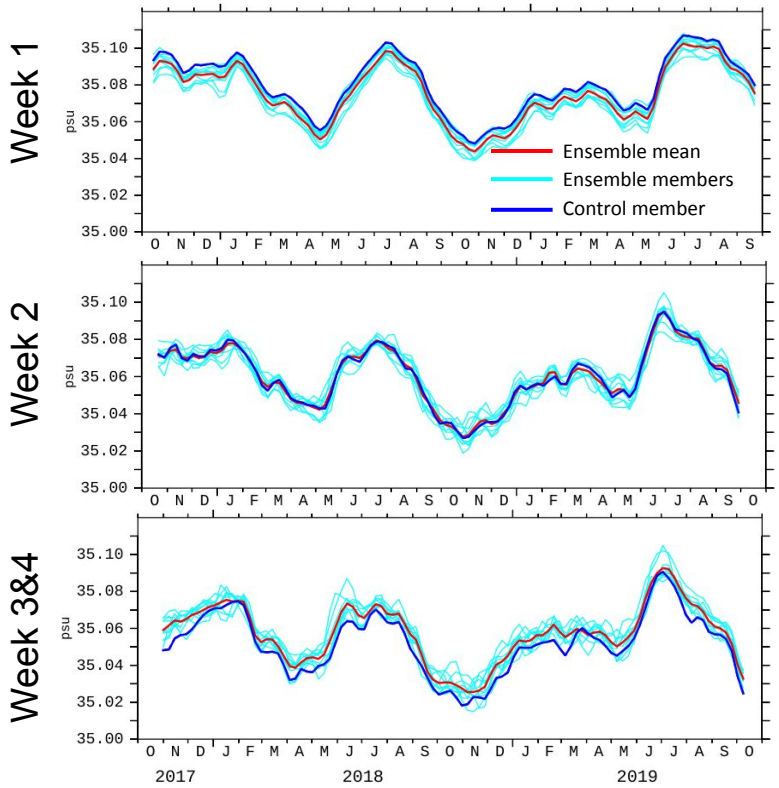


Mean Squared Error in SST (40°S to 40°N)



- Magnitude of forecast error increases from Week 1 to Week 3&4
- Control MSE is clearly lower in Week 1, and 2, and in general in Week 3&4 forecast compared to ensemble mean

Global Mean SSS



- Control member is saltier than ensemble mean in Week 1 transitioning to being more fresher than ensemble mean by Week 3&4
- In Week 1 and Week 3&4 the control tends to be an outlier

Preliminary Sea Ice Results

Prototype 8:

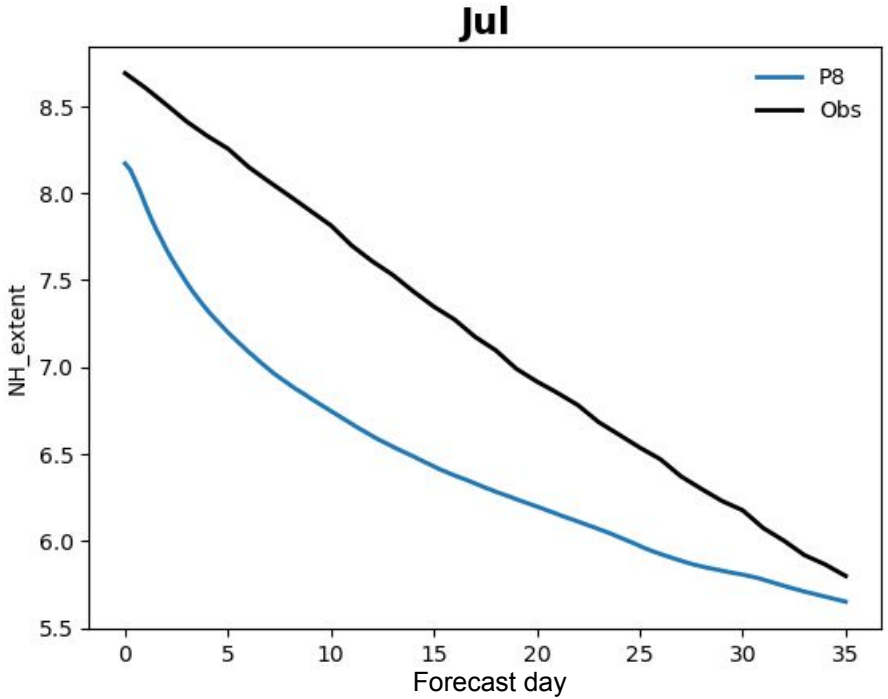
- April 2011 to March 2018
- Every 1st and 15th day
- 35 Day Forecasts

Initial Conditions:

- FV3: GEFS Reanalysis
- CICE: CPC analysis (CSIS) (Liu et al. 2019)
- MOM6: CPC 3DVAR

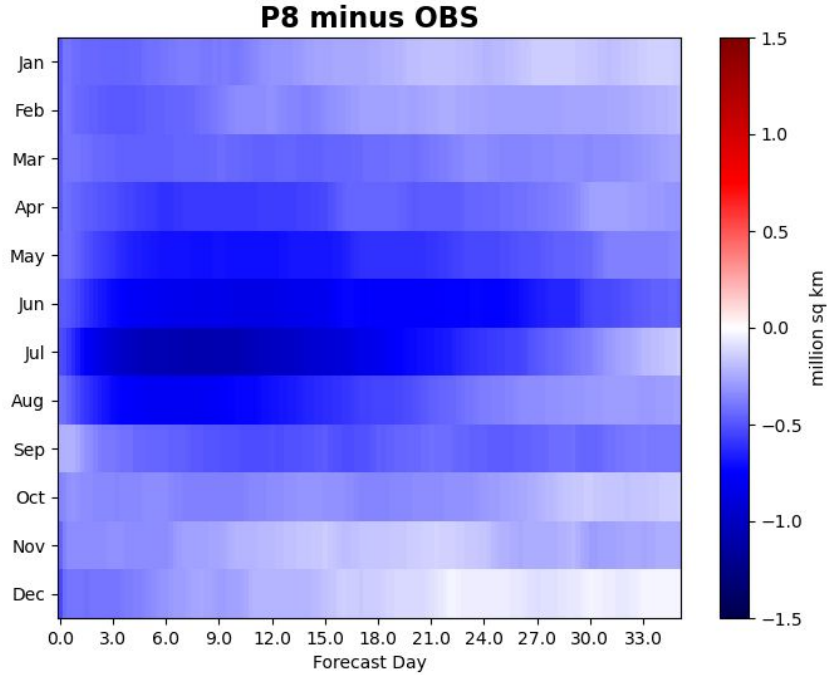
POCs for Ocean Diagnostics: Neil Barton (EMC)

NH Sea Ice Extent



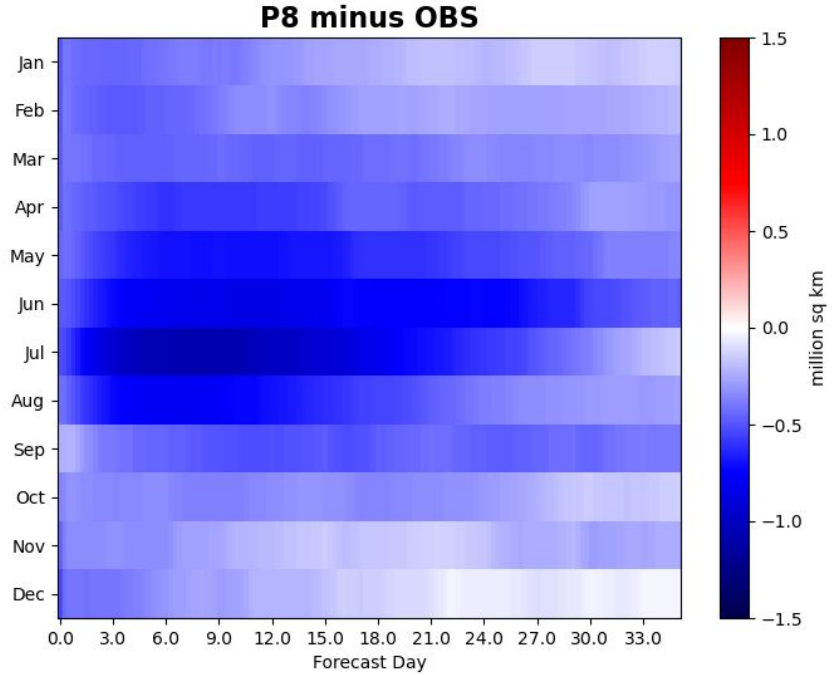
- Sea Ice Extent
  - Area with > 15% sea ice

NH Sea Ice Extent



- Negative bias in Sea Ice extent
- Negative bias in initial conditions
- Greater negative biases during summer melt months
  - More rapid melt

NH Sea Ice Extent



- Negative bias in Sea Ice extent
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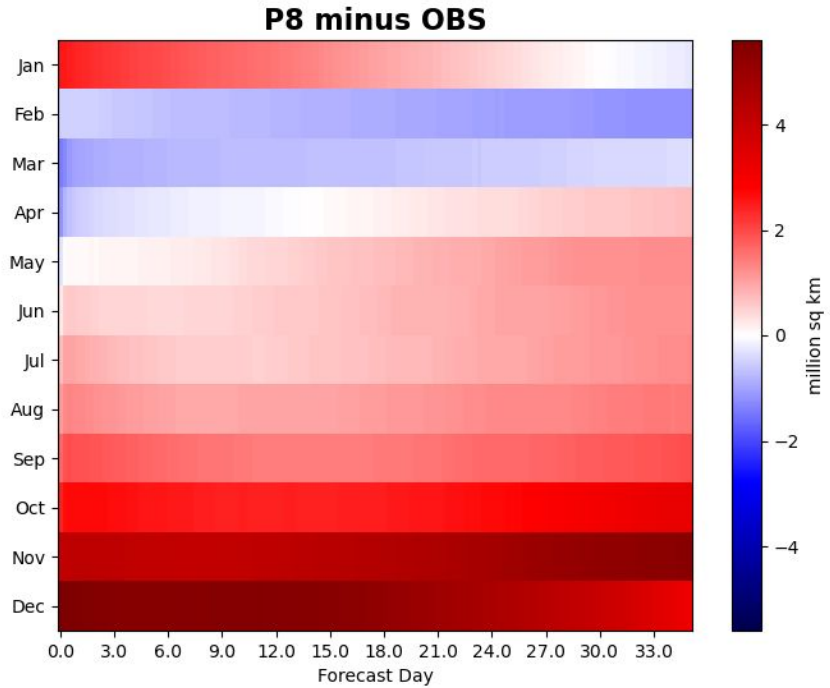
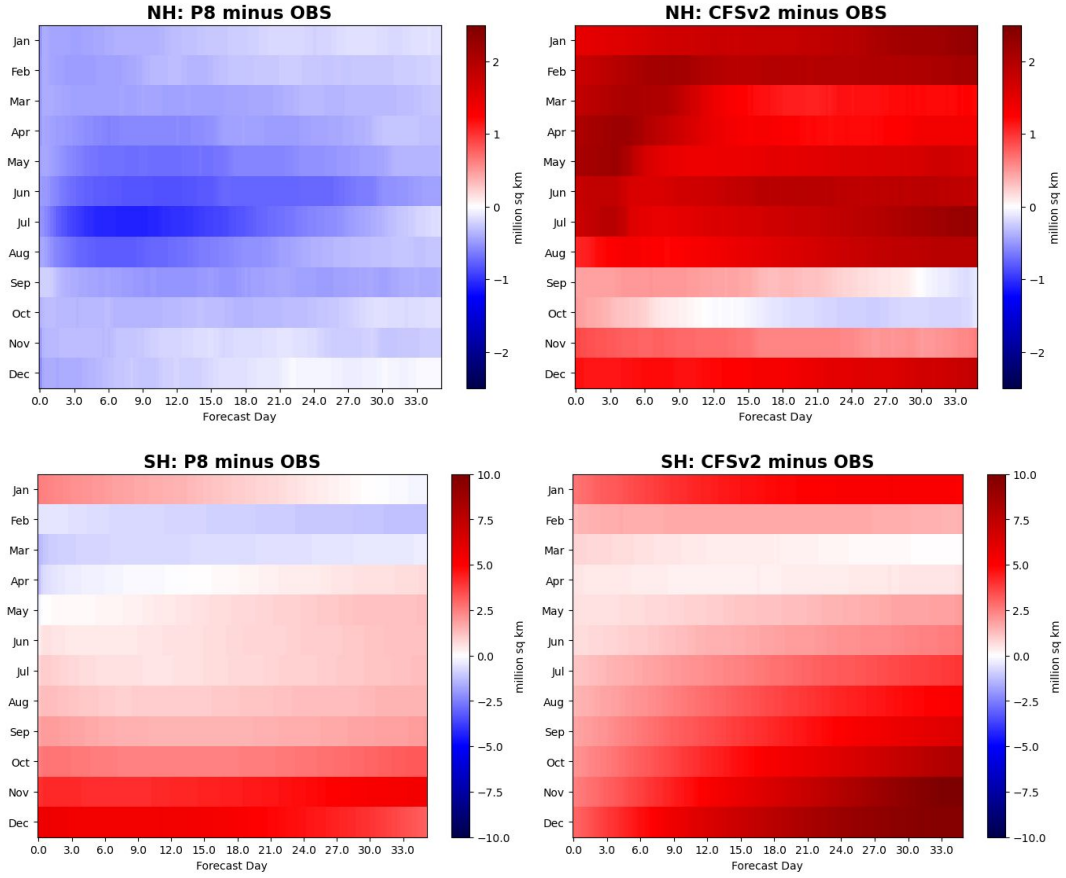
SH Sea Ice Extent



- SH sea ice extent biases are larger than NH biases.
- P8 SH sea ice extent is mostly greater than observations except during seasons melt period.
- Larger differences in initial sea ice compared to observations when comparing to NH

Comparison to CFSv2



- Raw, uncorrected model results
- P8 sea ice extent biases are much smaller than CFSv2 biases in Northern and Southern Hemisphere
- Recalibration needed for biases corrections for S2S UFS runs

Conclusions

- GEFSv13 will include MOM6 and CIC6 on a 0.25 degree tripole grid
- DA
  - Ocean and sea ice DA is weakly coupled with atmosphere
  - Strongly coupled between ocean and sea ice
  - 3DEnVAR with 3D LETKF from GDAS to initialize GEFS
- Forecast perturbations:
  - Ocean: oSPPT, ePBL
  - Sea Ice: none
- Initial examination of ocean and sea ice results is reasonable
  - Sea ice extent results have smaller biases than CFSv2
- Challenges:
  - Testing has all occurred with initial conditions outside of DA. Results will and have varied depending on ICs.
  - Ocean and sea ice diagnostics being developed
- Longer Term Updates/testing:
  - CICE6: C-grid and parameterization testing (Meltponds, landfast ice)
  - MOM6: use of OM5 settings when available

Thank You!

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