An Overview of Updates for Global Ensemble Forecast System (GEFSv13) and Seasonal Forecasting System (SFSv1)

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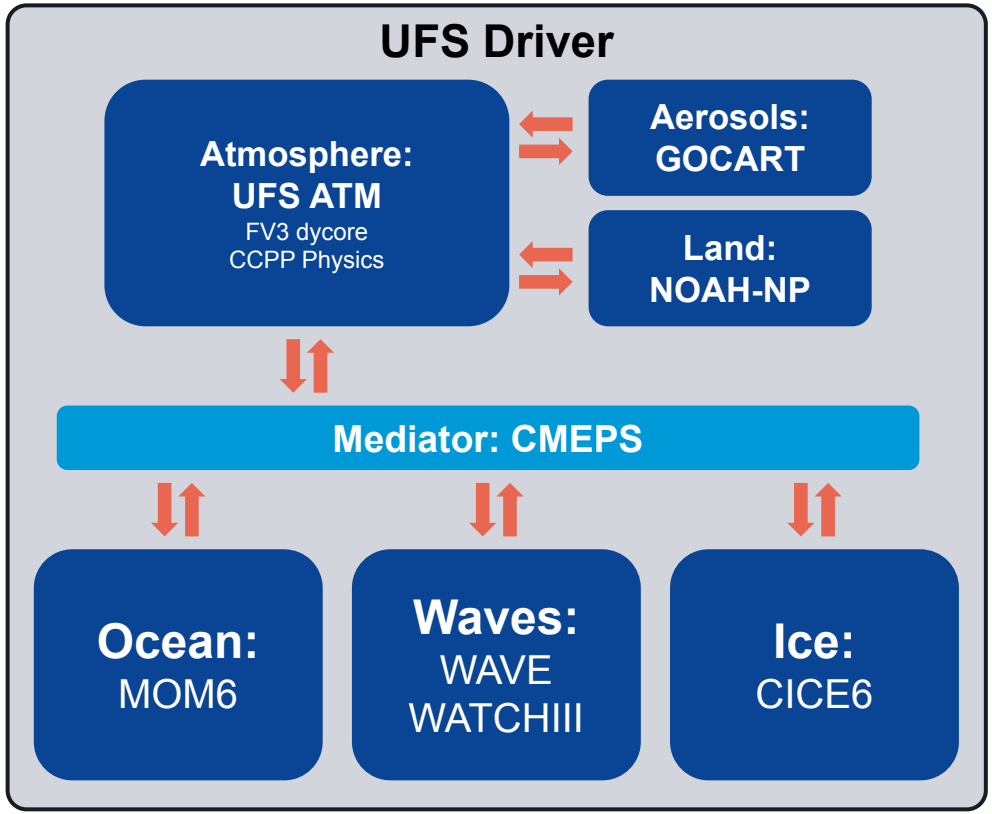
Unified Forecast System (UFS)



- Model infrastructure:
  - ESMF, NUOPC, CMEPS
- Atmosphere model:
  - FV3 dycore, CCPP Physics
- Ocean model:
  - MOM6
- Ice model:
  - CICE6
- Wave model:
  - WW3
- Aerosol model:
  - GOCART
- Land model:
  - Noah-MP

GEFSv13

	GEFSv12	GEFSv13
Atmosphere	C384L64 (~25km), FV3	**C384L127, FV3**
Land	NOAH-LSM	**NOAH-MP**
Aerosol	1-way coupling with GOCART, 1 member	**all-way coupling with GOCART, all members**
Waves	1-way coupling to WAVEWATCH III	**all-way coupling with WAVEWATCH III (0.25° regular lat/lon grid)**
Ocean	None	**all-way coupling with MOM6 (0.25° tripole grid, 75 layers)**
Sea Ice	None	**all-way coupling with CICE6 (0.25° tripole grid, 5 ice categories, 7 layers)**

Forecast Perturbations: Ocean/Sea Ice Forecast

FV3:

- SPPT: (stochastically perturbed physics tendencies – Palmer et al. 2009) - Designed to represent the structural uncertainty of parameterized physics.
- SKEB: (stochastic KE backscatter - Palmer et al. 2009)
- CA: (Cellular Automata) - Bengtsson, L et al. 2013

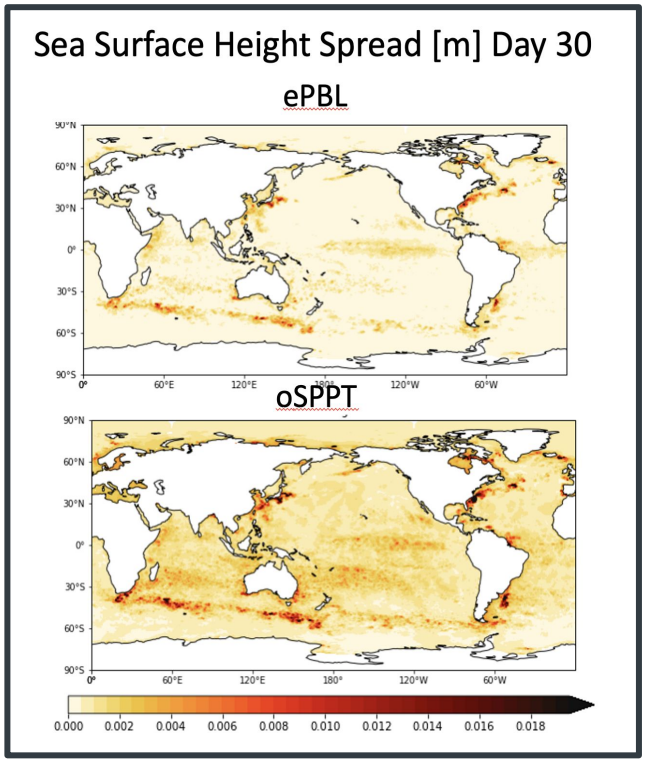
MOM6:

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.

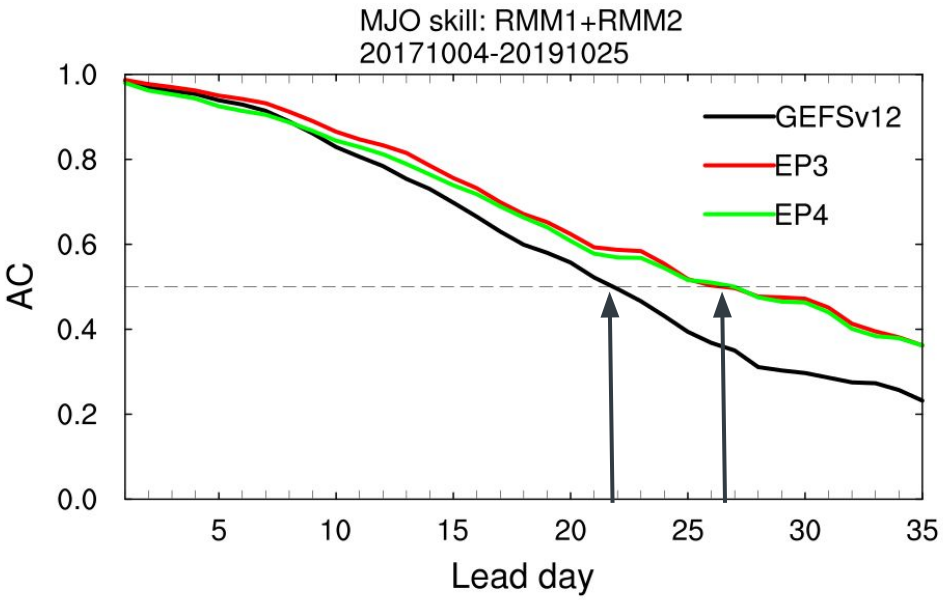
LAND, AEROSOLS CICE6, WAVEWATCH III:

- No perturbations
- Forced problem



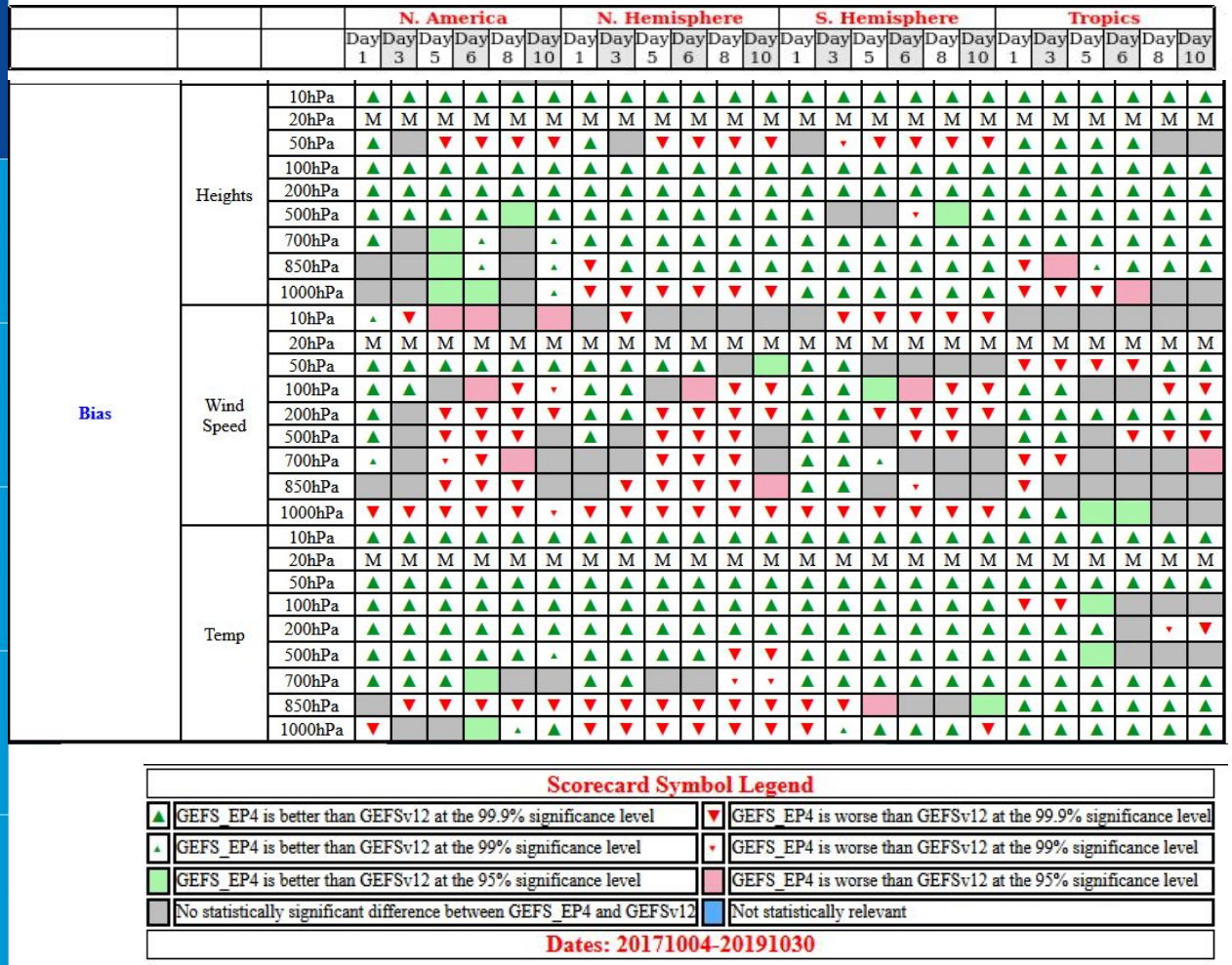
POCs for Ocean Perturbations work: Philip Pegion (PSL)

MJO Skill in GEFSv13



- **Ensemble Prototypes (EP) 3 and 4 both have higher MJO skill (RMM1+RMM2) than GEFSv12 for longer lead times (extend skill for 4-5 days).**

Courtesy: Eric Sinsky

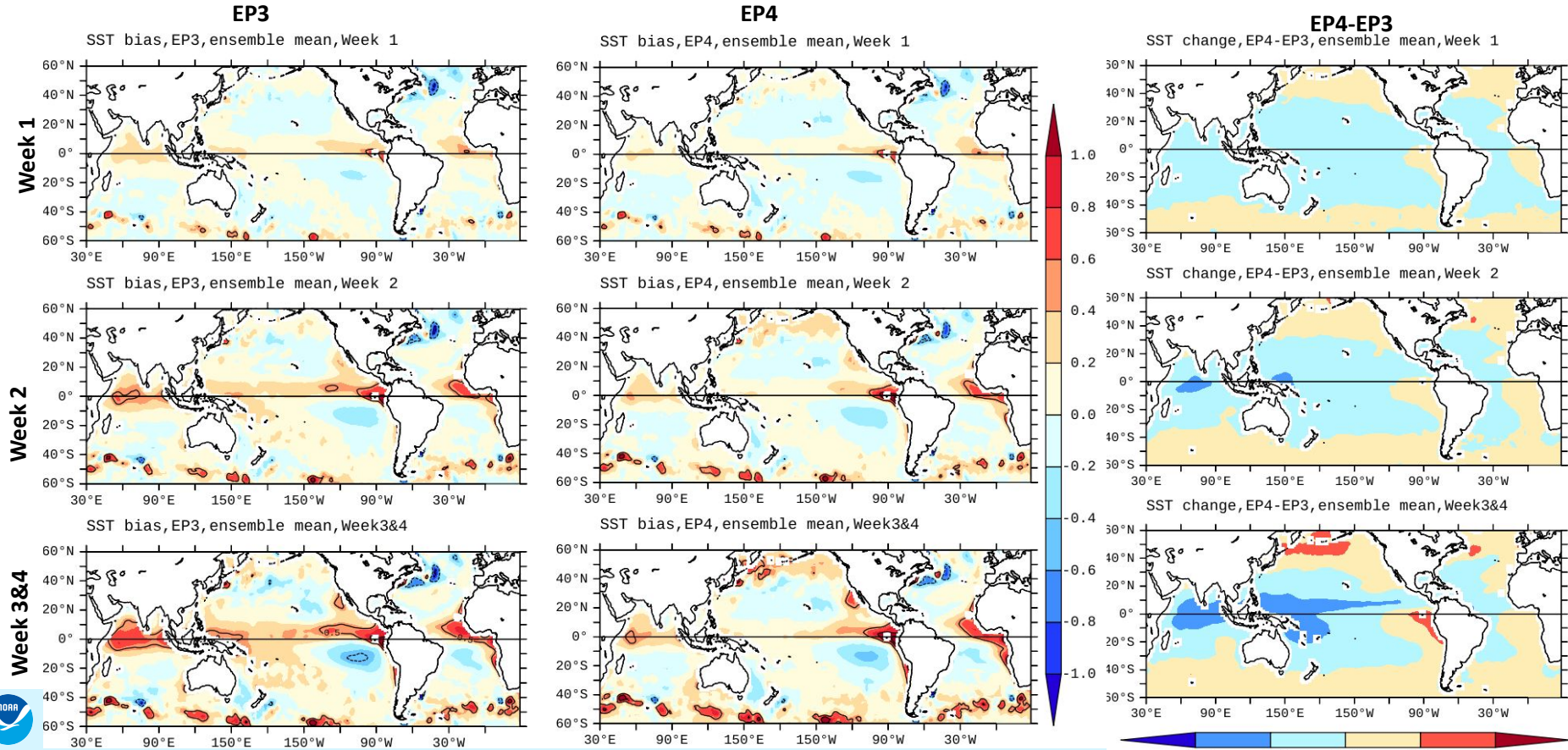


EP4 vs GEFSv12 Reforecast Scorecard: Bias (2017-2019)

- Mid-level temperature and heights are generally better in our latest ensemble prototype (EP4) experiments
- Low-level (1000 hPa) variables in EP4 show degradation compared to GEFSv12

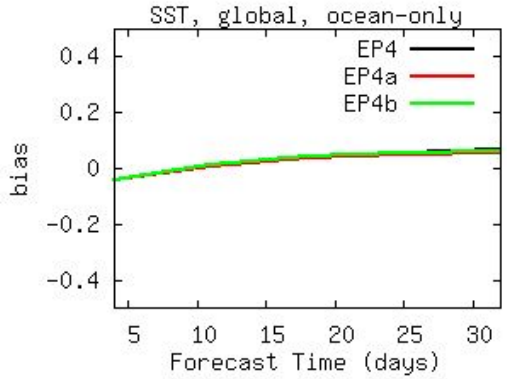
SST biases in Ensemble Mean

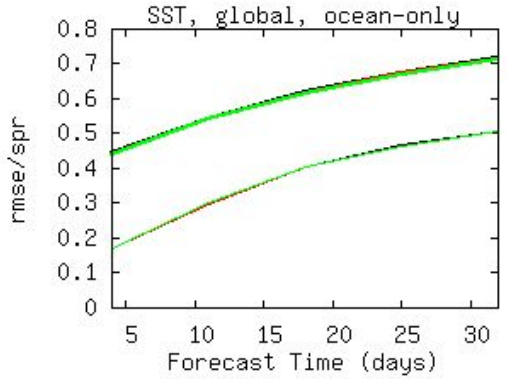
- EP4 has cooler tropics than EP3: reduced warm bias
- EP4 has a slightly warmer bias along the coasts compared to EP3: increased warm bias



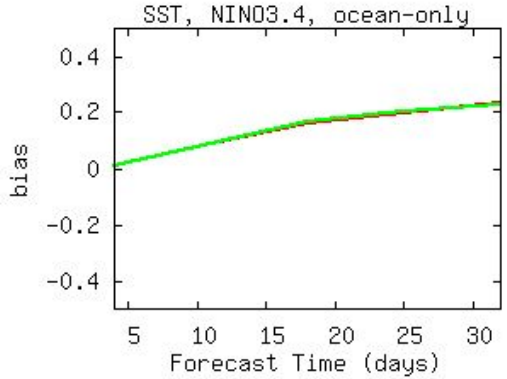
Comparison of SST's bias and RMSE/SPRD for different domains (2 years) (Ref. OSTIA)

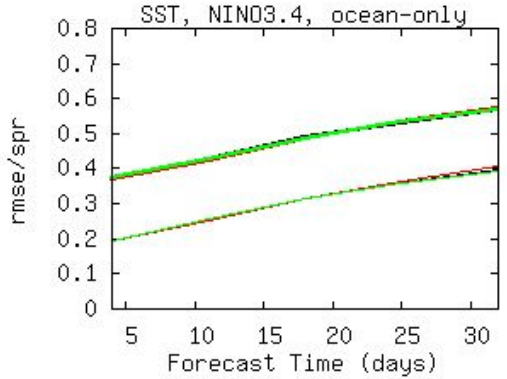
Global





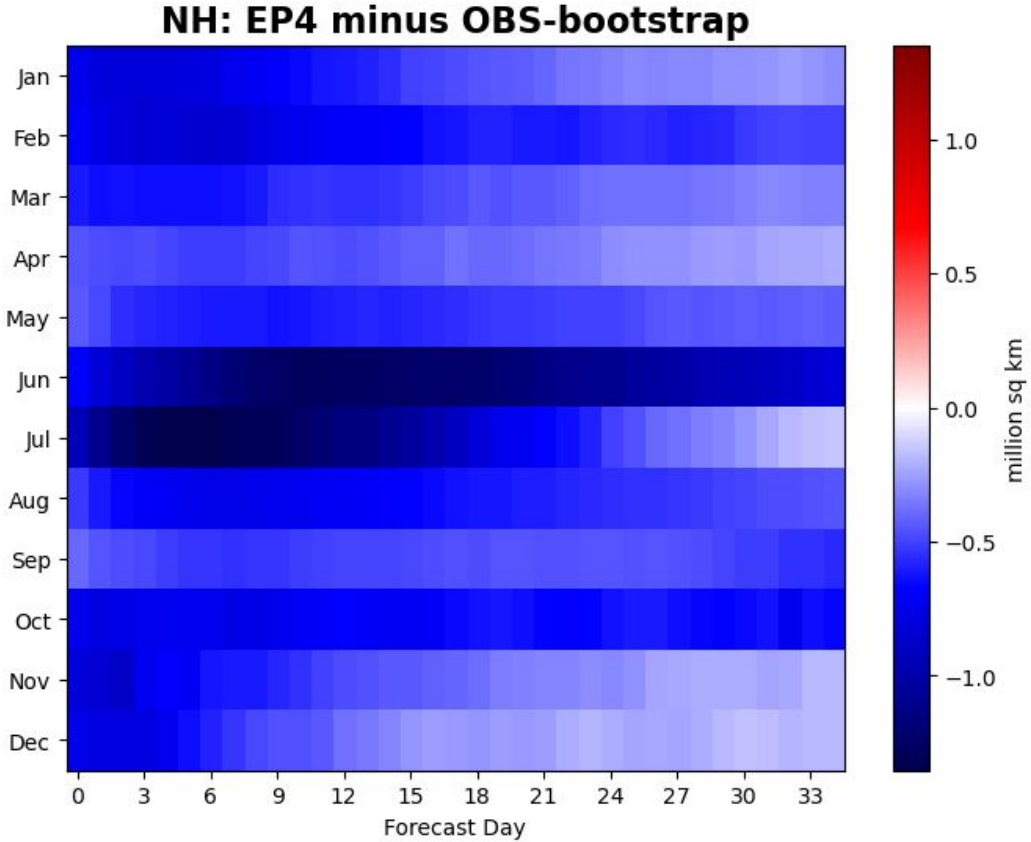
NINO3.4





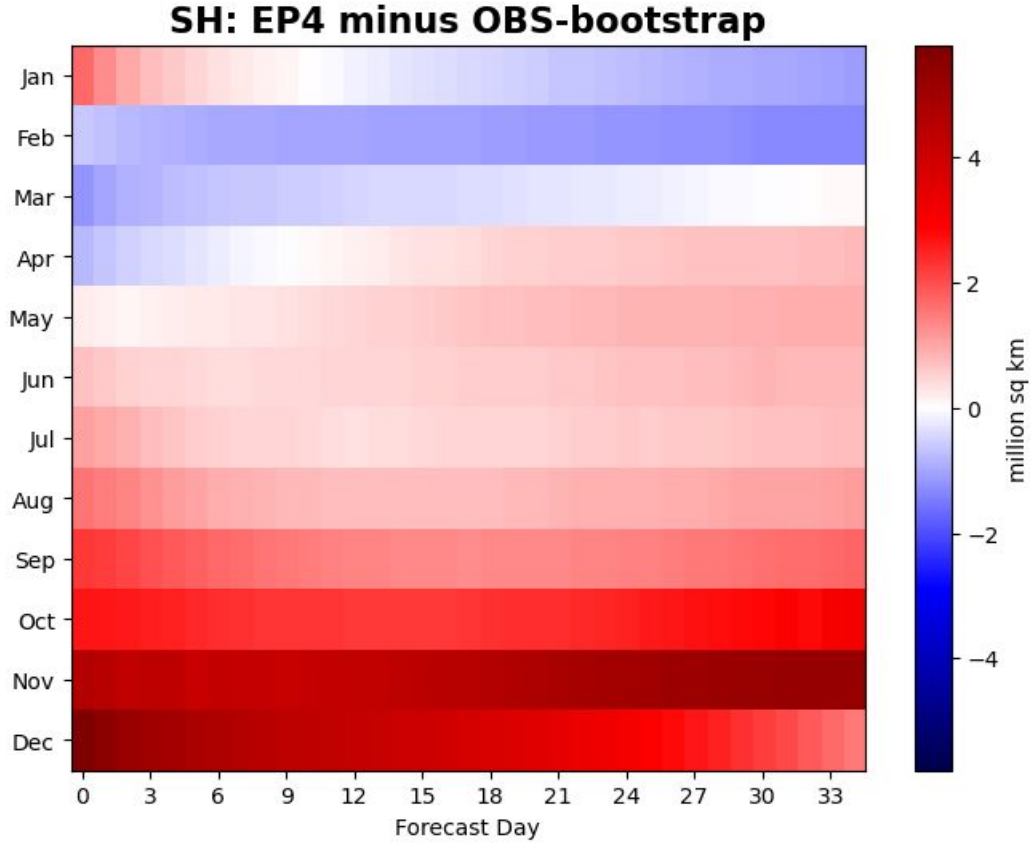
- For global domain, SST biases are small in EP testing. For NINO3.4, biases increase with lead days.
- SST is underspread

Sea Ice Extent Results: NH



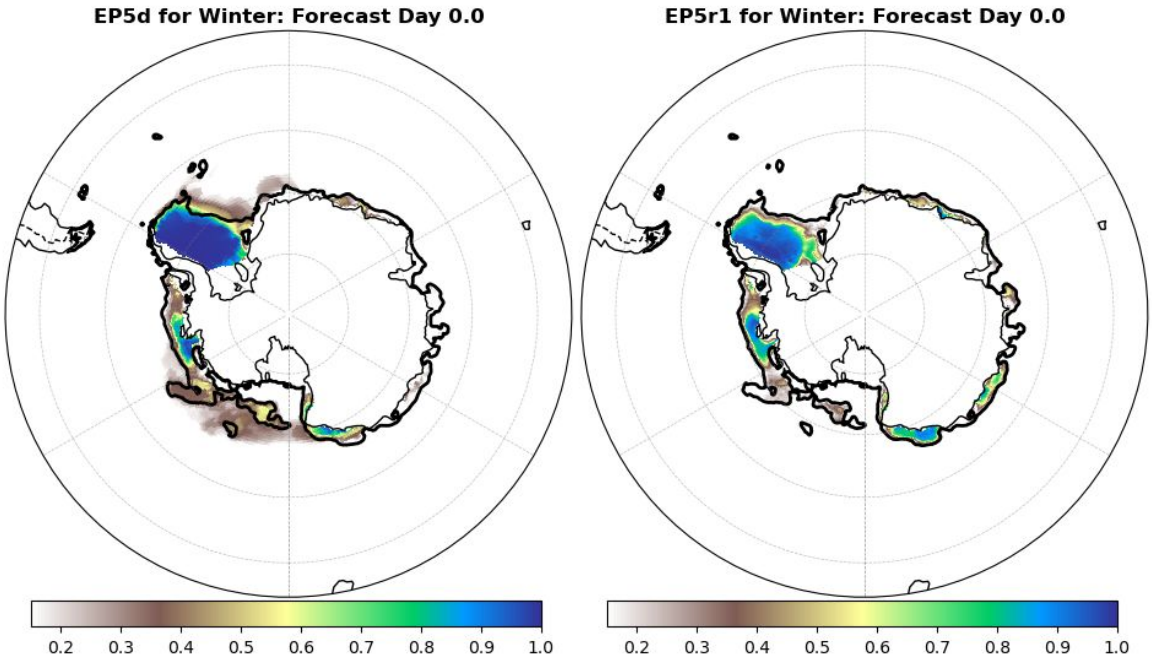
- Negative bias in Sea Ice extent
- Negative bias in initial conditions
- Greater negative biases during summer melt months
  - More rapid melt
- Results dependent on Initial conditions

Sea Ice Extent Results: SH



- SH sea ice extent biases are larger than NH biases.
- SH sea ice extent is mostly greater than observations except during melt season period
- Issues capturing the ice melt in SH Spring
- New sea ice initial conditions greatly aid in sea ice forecast in SH

Jan–Feb Ice concentration

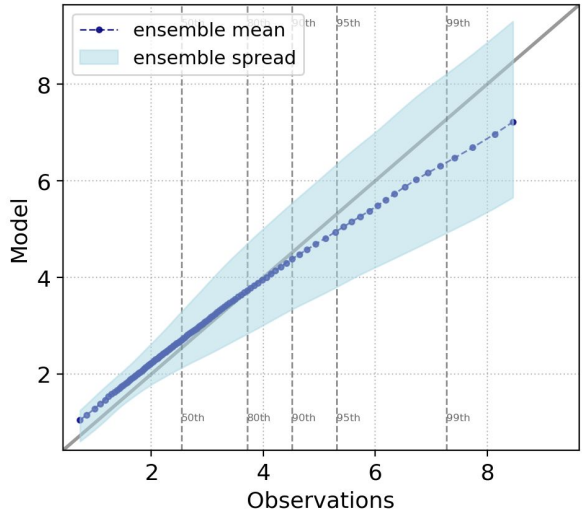


- Use of replay aid in better initialization for sea ice in southern hemisphere
- Experiment with new initial conditions currently running

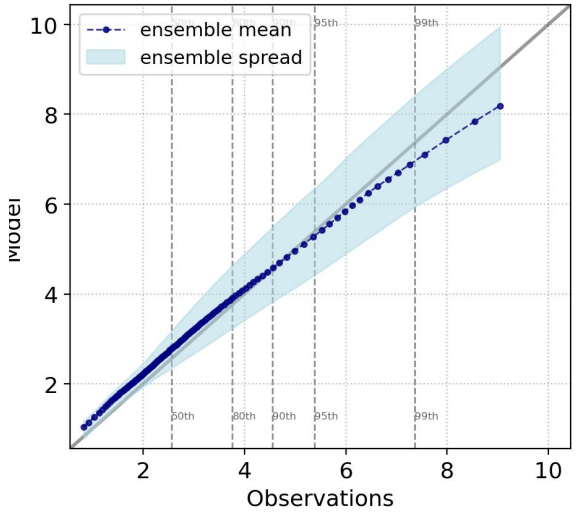
Wave Height: QQ plots, Hs(m) Ensemble Mean/ Ensemble Spread

Week 1 Forecast

GEFSv12



EP4



- Under prediction of waves in high events.
- EP4 has similar significant wave height forecasts in waves below the 90th percentile compared to GEFSv12.

Winter 2018

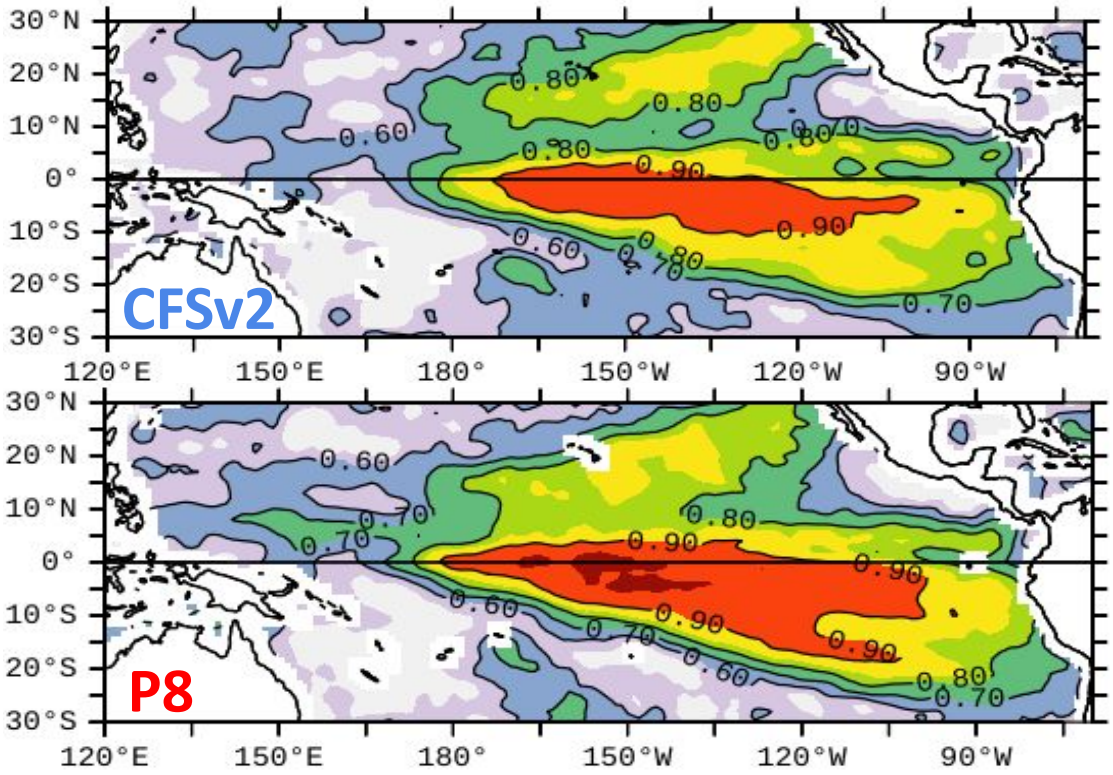
SFSv1

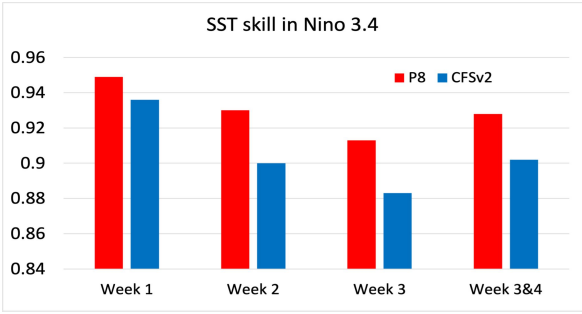
SFS Components

	CFSv2	SFS
Atmosphere	T126/L64, GSM	**C192L127 (~50m), FV3**
Land	Noah 4 level soil model	**NOAH-MP**
Aerosol	none	**all-way coupling with GOCART (TBD)**
Waves	none	**all-way coupling with WAVEWATCH III (TBD)**
Ocean	2-way coupling with MOM4 (0.25°-0.5°, tripole grid, 40 Levels)	**all-way coupling with MOM6 (0.25° tripole grid, 75 layers)**
Sea Ice	2-way coupling with SIS1 (0.5° tripole grid, 5 ice thickness categories)	**all-way coupling with CICE6 (0.25° tripole grid, 5 ice categories, 7 layers)**

Initial SST Skill Compared to CFSv2

SST anomaly correlation, Week 3&4 forecasts





- **SST skill in Week 3&4 forecasts improves in P8 in the equatorial Pacific, with prominent improvement in the Niño 3.4 region.**

POC: Sulanga Ray (EMC)

Ray et al., (Clim Dyn 2023)

Conclusions: GEFS development

- GEFSv13
  - Atmosphere vertical levels increase to 127, forecast out to 48-days (00Z only)
  - Wave Watch III will be two way coupled in all members
  - Ocean (MOM6) and Sea Ice (CICE6) coupling on a 0.25 degree tripole grid
  - Inclusion in Aerosols (GOCART) in all members
- Forecast perturbations:
  - Atmosphere: SPPT, SKEB and CA
  - Ocean: oSPPT, ePBL
  - Aerosols, Land, Sea Ice, and Waves: none
- Initial examination of waves, ocean, sea ice results is reasonable
- Challenges:
  - Not all atmosphere variables are improved in GEFSv13 compared to GEFSv12
  - Weakly coupled data assimilation in rapid development
  - Ocean and sea ice diagnostics and products are being developed
- SFSv1 development has recently begun

Thank You!

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