Verification and Evaluation in the Development of UFS Coupled Seasonal-to-Subseasonal Prototypes

NATIONAL WEATHER SERVICE

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Evaluation in UFS S2S Prototype Development

Targets of evaluation

- Checking/Monitoring for problems (e.g. non-physical values, unexpected systematic differences from previous prototype)
- Process validation (e.g. Diagnostic Toolkit developed by ESRL/PSL Polar Processes Team for evaluating coupled processes in the Arctic)
- Quantification of errors and skill (testing system performance under common framework) - focus of this talk.
- Also see @3:30 “Verification of the Ocean State in the UFS Coupled System” by Jiande Wang

Completed UFS-S2S Model Prototypes

	Initial Conditions			
	FV3 C384 (~25km) 64 levels	**MOM6** ¼ degree tripolar grid 75 hybrid levels	**CICE5** ¼ degree tripolar grid	**WW3** ½ degree lat/lon grid
Prototype 1	CFSR	CFSR	CFSR	n/a
Prototype 2	CFSR	3Dvar CPC	CFSR	n/a
Prototype 3	CFSR	3Dvar CPC	CPC ice analysis	n/a
Prototype 3.1	CFSR	3Dvar CPC	CPC ice analysis	n/a
Prototype 4.0	CFSR	3Dvar CPC	CPC ice analysis	generated with CFS forcing

Note that in addition to the main targeted feature change between prototypes, there are always model updates/upgrades. All prototypes use GFSv15.2 physics settings.

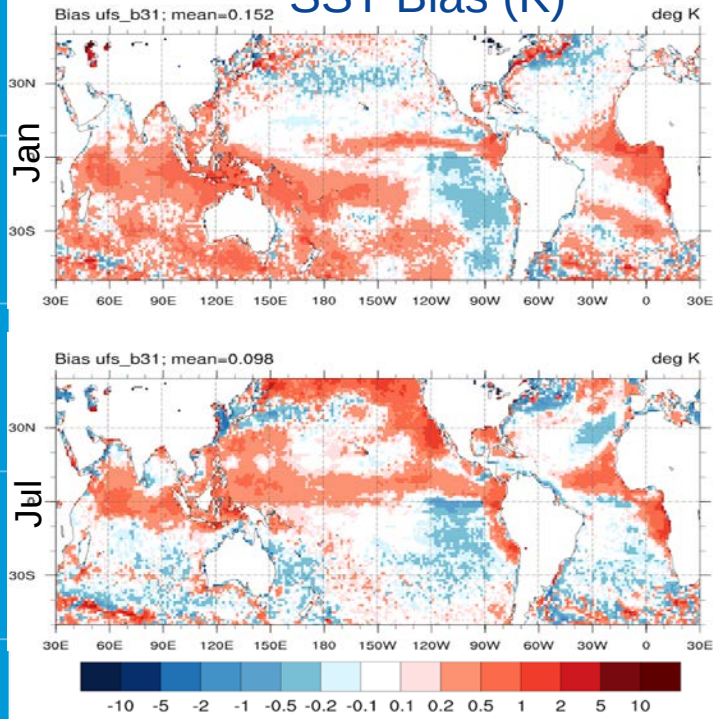
Benchmark Framework

The benchmark framework is designed to test system performance for each new UFS-S2S prototype with a consistent structure and fixed metrics. It consists of:

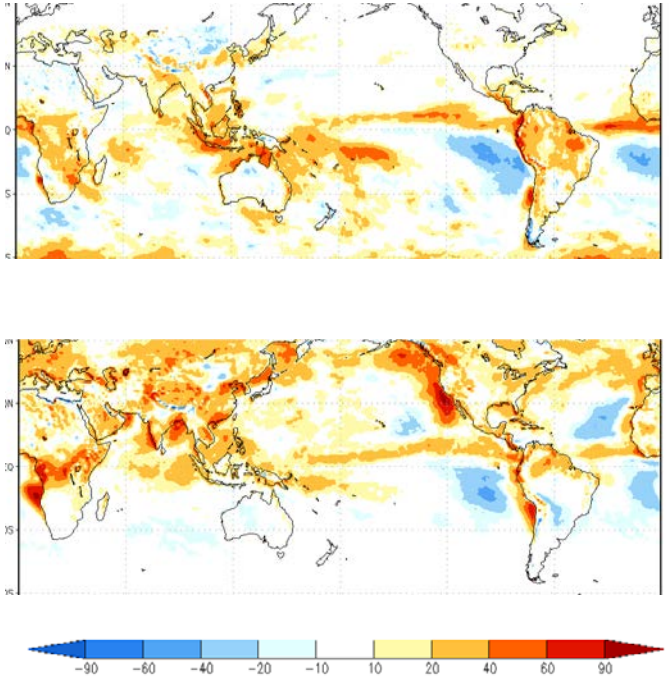
- 35-day free forecasts (deterministic)
- Spanning April 2011 to March 2018
  - Initialized from the 1st and 15th of each month
  - 7 years, 168 forecasts: balance between sufficient length for statistical analysis and use of computing resources
  - Includes both El Niño and La Niña years
  - Includes years with recent low (2017) and high (2013) Arctic ice extent

Seasonality of SST Bias in UFS S2S

SST Bias (K)



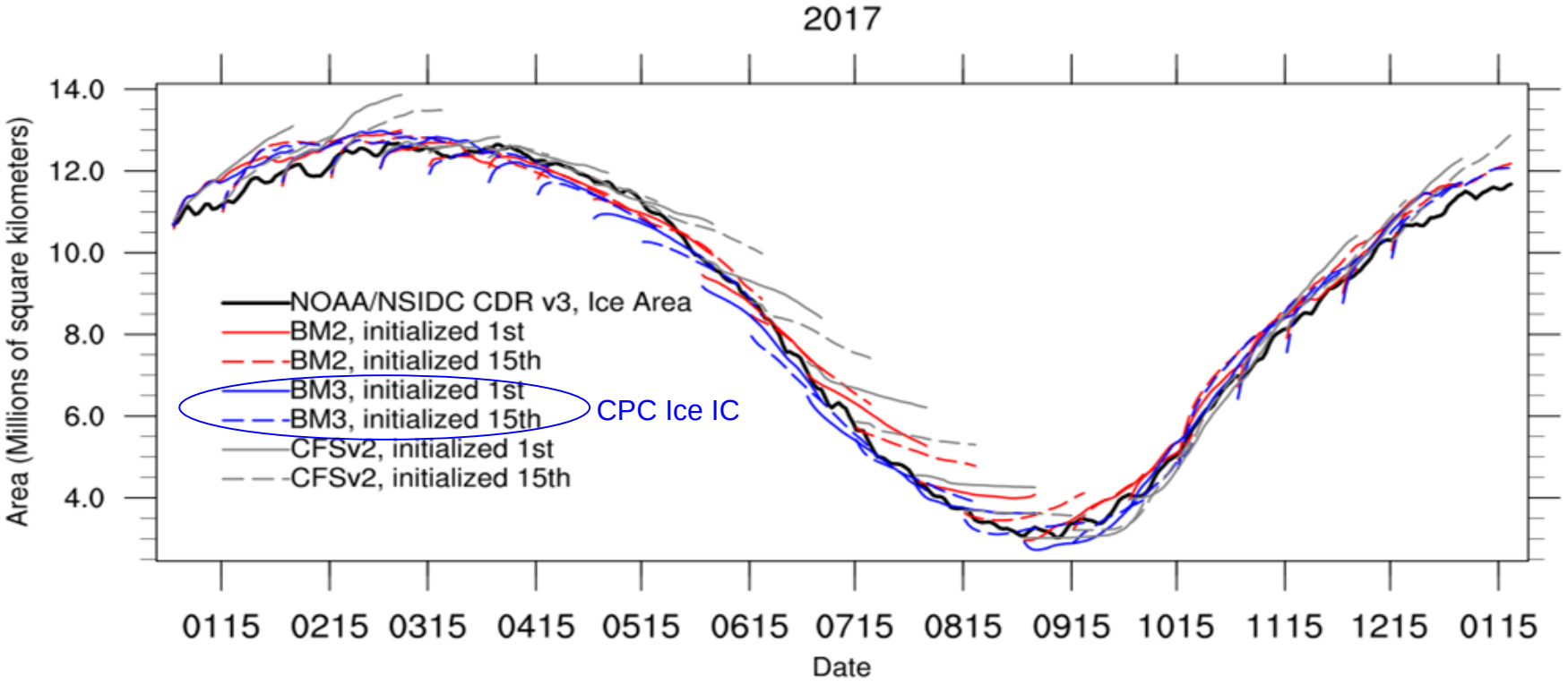
Net SW Bias (W/m^2)



The warm SST bias is more pronounced in the summer hemisphere; note cold bias in EPac

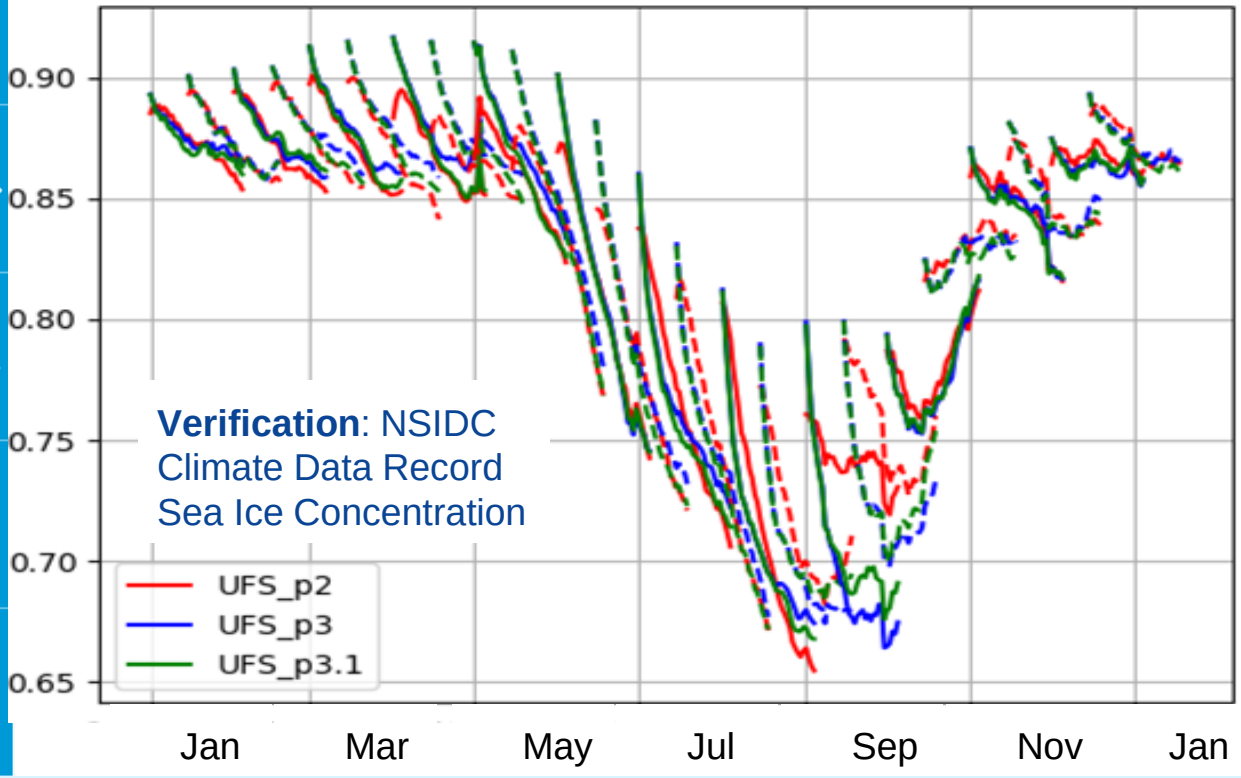
The spatial structure and seasonality of SST bias corresponds well to the bias in net shortwave radiation

Ice Area in UFS S2S



Ice Concentration in UFS S2S

Northern Hemisphere Threat Score (Ice Concentration > 15%)

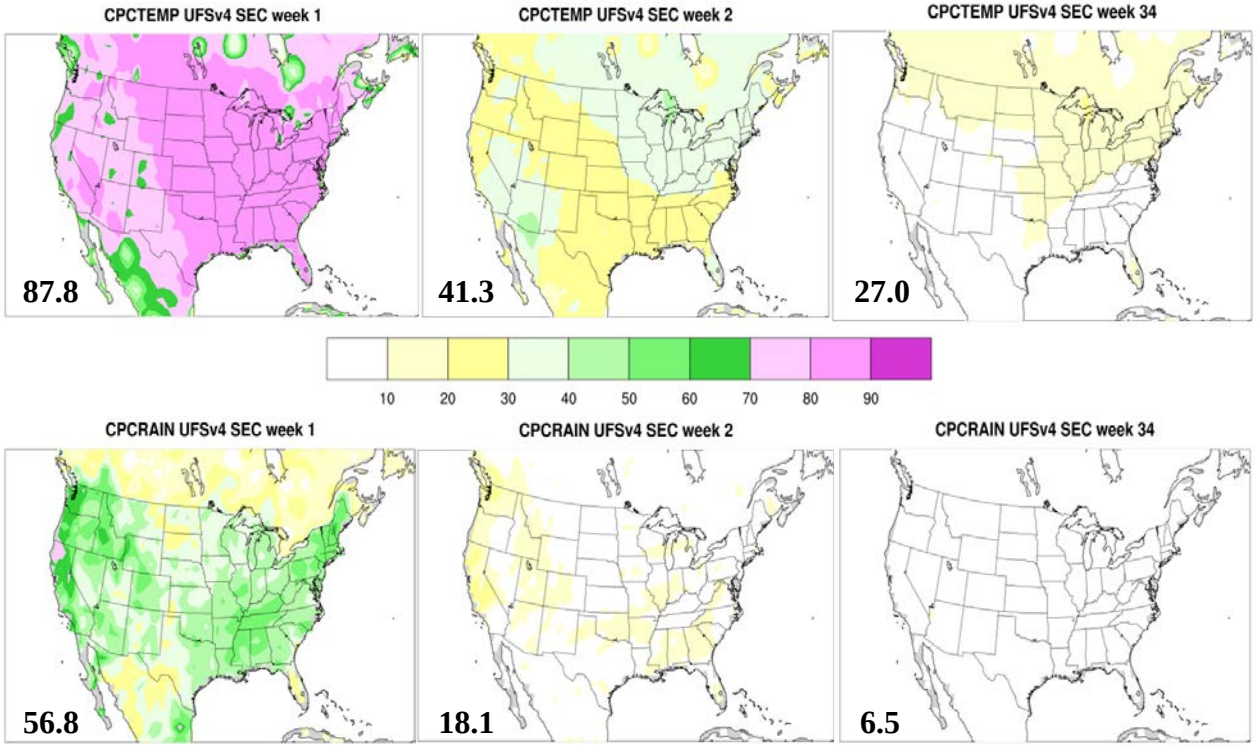


Threat score: [YY/(YN + NY + YY)] for Northern Hemisphere Ice concentration > 0.15

Highest score for forecasts initialized in March-April. Lowest score for forecasts initialized in August-September

Smallest drop-off in score for forecasts initialized October-December. Largest drop-off in score for forecasts initialized June-July

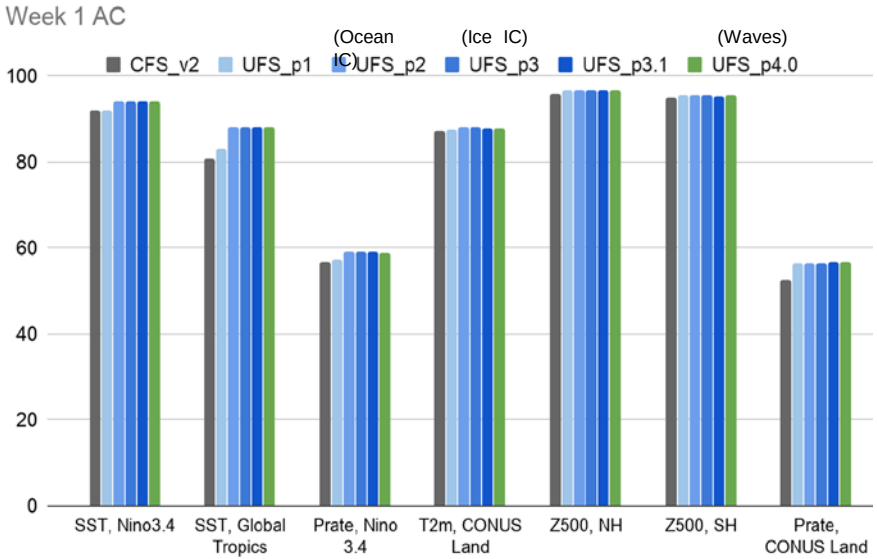
CONUS Anomaly Correlations in UFS-S2S

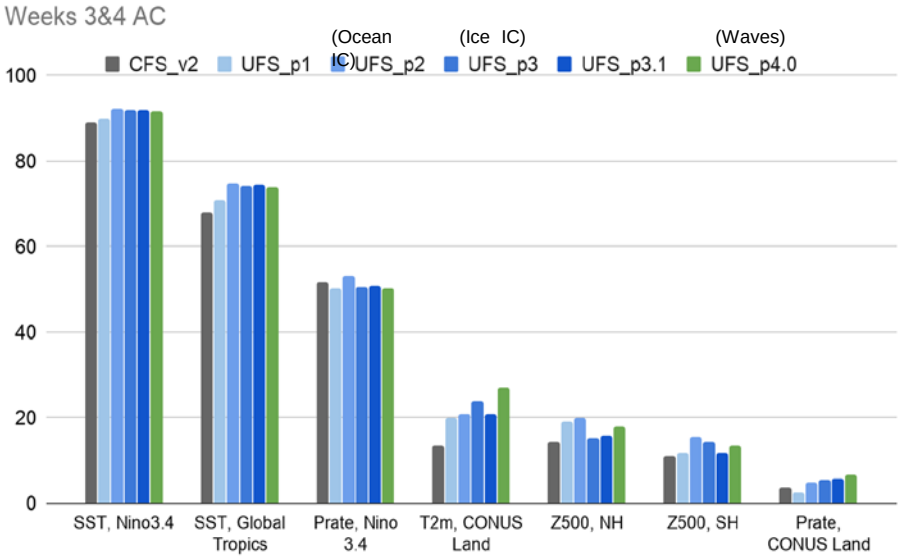


CONUS 2-m T AC starts off strong in week 1, drops below 0.5 by week 2, but still non-negligible in weeks 3&4

CONUS precipitation AC starts off slightly above 0.5 in week 1, drops below 0.2 in week 2, and is minimal in weeks 3&4

AC skill of UFS-S2S Prototypes





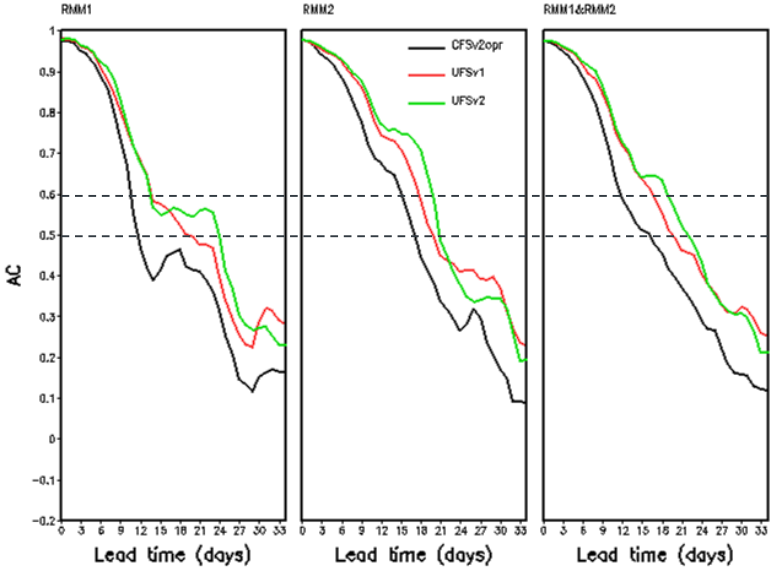
Week 1 AC skill is above 0.95 for Z500 and Nino 3.4 SST, and around 0.90 for Global Tropics SST and CONUS 2-m T

Compared to Week 1, Week 3&4 AC skill is only slightly lower for Nino 3.4 SST and Nino 3.4 precip, much lower for other quantities

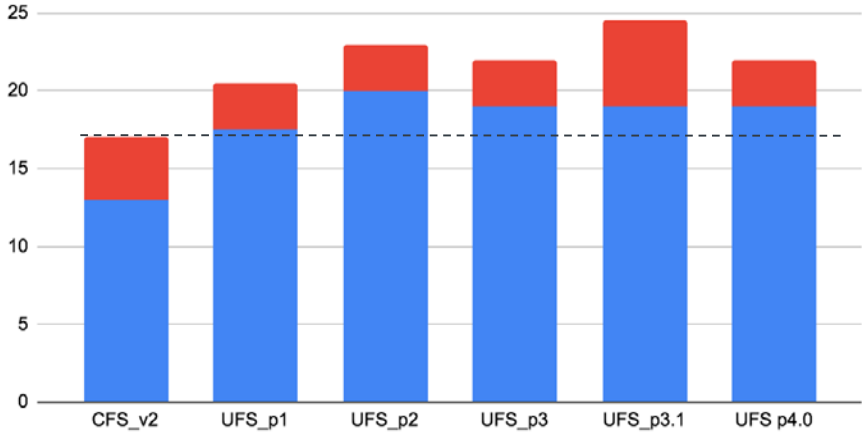
For most quantities, AC Prototypes > CFSv2

MJO Skill in UFS S2S Prototypes

AC for MJO index RMM1 and RMM2 and Bivariate Correlation for MJO index (RMM1 + RMM2)



Lead time for MJO AC to reach 0.6 (blue)/0.5 (red)



=> Lead time increased by 5-7 days over CFSv2

Summary and Conclusions

- All prototypes to date exhibit similar spatial/temporal structure of systematic errors.
- UFS S2S prototypes consistently outperform the operational CFSv2 for AC skill at weeks 3&4 for most metrics. Skill across prototypes is holding steady.
- Future performance gains are expected from planned component physics improvements and tuning and advances in intializations (e.g. via land DA).
- Near future prototypes: CMEPS, Fractional Masks, CICE6, GFSv16 physics