ENSO prediction skill in Seasonal forecast models

Yanyun Liu[1,2] (Yanyun.Liu@noaa.gov), Wanqiu Wang[1], Johnna Infanti[1], Jieshun Zhu[1], Shan Sun[3], Philip Pegion[4], Xiao-Wei Quan[4,5], Arun Kumar[1]

[1]NOAA/NWS/NCEP Climate Prediction Center, [2]Earth Resources Technology Inc. [3]NOAA/OAR/GSL, [4]NOAA/OAR/PSL, [5]CIRES/University of Colorado Boulder

Introduction

The Seasonal Forecast System (SFS), based on the Unified Forecast System (UFS), is envisioned to replace the existing operational climate forecast system (CFSv2) as the dynamical component for NOAA's operational seasonal forecast products. The UFS model consists of FV3 atmospheric component, MOM6 oceanic component and CICE6 sea ice component. In this analysis, we will evaluate the ENSO prediction skill across three different sets of SFS hindcast experiments spanning the period from 1991 to 2021. The ENSO prediction skill and Sea Surface Temperature (SST) bias are compared with those of CFSv2, GFDL_SPEAR and North American Multi-Model Ensemble (NMME) models. Results indicate that skill differences may depend on both lead time and the initial start months. Additionally, ocean initial conditions may significantly impact on the ENSO prediction skill. These evaluations provide valuable insights for the further development of SFS to improve ENSO prediction.

Model output and observational datasets

SFS hindcasts

Experiments	Initial month	Ensemble size	Hindcast period	Lead (month)	Atm. IC	Ocn. IC	Sea ice IC	model	Atm reso Ocn/ice reso
SFSExp_Sun	May 21-25	5	1991-2022	0-10	CFSR	**ORAS5**	**ORAS5**	UFSp8 nowave, noaero	C96/L64 1deg
SFSExp_Zhu	May 21-25 Nov 21-25	5	1982-2021	0-8	CFSR	**GLORe**	**GLORe**	UFSp8, nowave, noaero	C96/L64 1deg
SFSExp_Pegion	Oct 1	10	1994-2023	0-8	Replay	Replay	Replay	UFSp8 with **stochastic physics** on	C96/L127 1deg

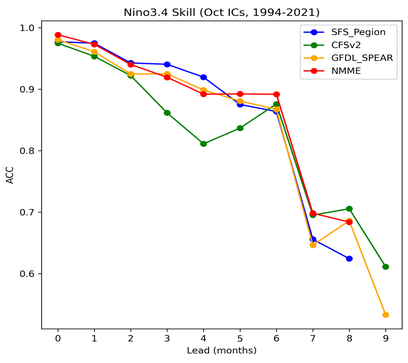
NMME models (ensemble size):

- CFSv2 (24), GFDL_SPEAR (15), NCAR_CCSM4 (10), GEM5_NEMO (10), CanCM4i (10), NASA_GEOS5v2 (4)

Observational dataset

- NOAA Optimal Interpolation Sea Surface Temperature Analysis, version 2.1 (OISSTv2.1)

Nino3.4 skill (Oct ICs)

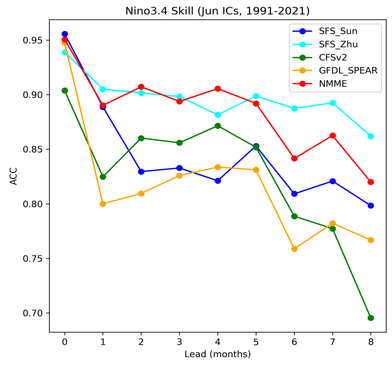


October ICs:

- CFSv2 shows lowest skill for first 6 months, highest skill afterwards.
- GFDL_SPEAR has better skill for months 4-6 than CFSv2.
- SFSExp_Pegion shows high skill for the first 5 months.

Fig. 1. Nino3.4 prediction skill for October initial conditions (ICs) from 1994-2021

Nino3.4 skill (Jun ICs)



Nino3.4 skill (Dec ICs)

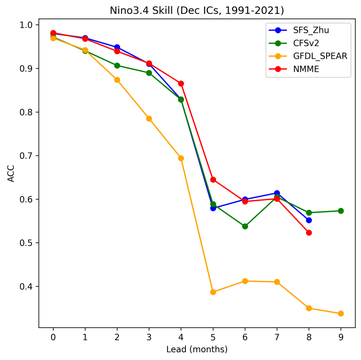


Fig. 2 Nino3.4 prediction skill for Jun (left) and Dec (right) ICs from 1991-2021

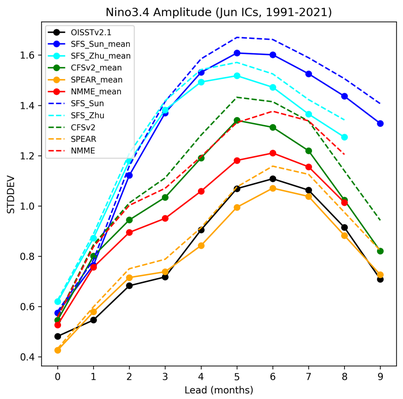
June ICs:

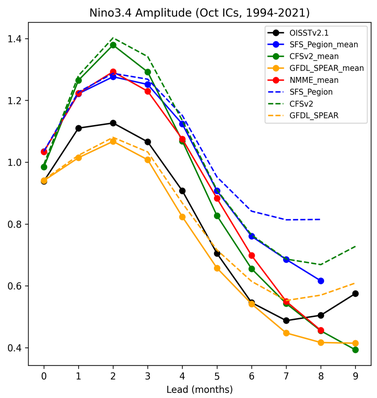
- NMME and SFSExp_Zhu have higher skill
- ORAS5 initialization (SFSExp_Sun) is better for the 1st month
- GLORe initialization shows better skill after the 1st month

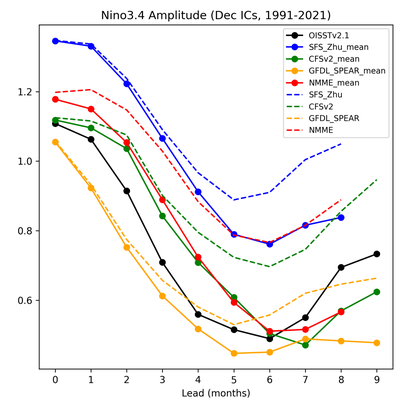
December ICs:

- NMME generally has better skill.
- SFSExp_Zhu has highest skill for individual models.
- GFDL_SPEAR has lowest skill

Nino3.4 amplitude







- Nino3.4 in SFS hindcasts shows a large amplitude.
- NMME mean has a large amplitude.

Fig. 3. Comparison of nino3.4 amplitude of SFS hindcasts, CFSv2, GFDL_SPEAR and NMME for June (upper left), October (upper right) and December (lower left) ICs. Solid lines represent ensemble mean of each model, while dashed lines show are Nino3.4 amplitude for individual members.

SST mean bias

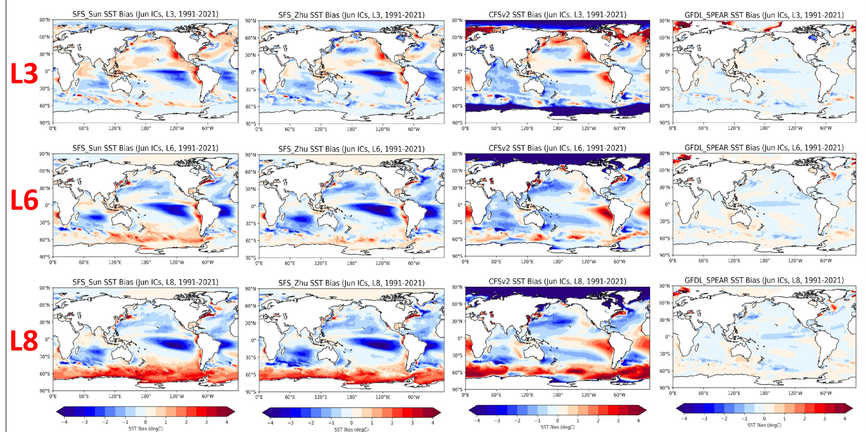


Fig. 4. SST mean biases for June ICs hindcasts at 3, 6 and 8-month leads.

- Warm bias in CFSv2 in tropical eastern Pacific and Atlantic
- SFS hindcasts show larger negative biases in tropical Pacific and tropical Atlantic.
- GFDL_SPEAR shows smallest mean bias due to ocean tendency adjustment.

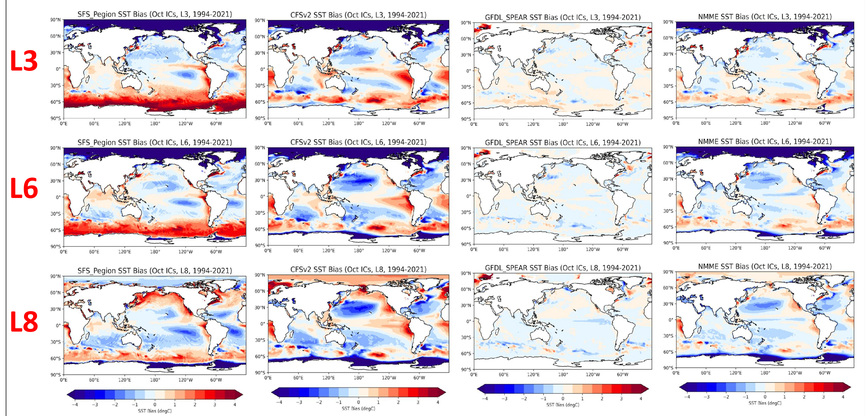


Fig. 5. SST mean biases for October ICs hindcasts at 3, 6, and 8-month leads.

- For Oct ICs, SFS hindcasts show smaller negative biases around tropical Pacific (seasonality of bias or impact of stochastic physics?)

Summary

- Skill differences may depend on lead time
  - ❑ CFSv2's skill for Oct ICs is lower than SPEAR for months 4-6, but becomes better after month 6
- Skill differences depend on initial months
  - ❑ GFDL_SPEAR is better for months 4-6 for Oct ICs, but not as good as CFSv2 for Jun and Dec ICs for most of target months
- Ocean initial conditions have impact on skill
  - ❑ For Jun ICs hindcasts, ORAS5 initialization (SFSExp_Sun) is better for the first month, GLORe initialization (SFSExp_Zhu) is better after the first month
- Tropical Pacific SST biases in UFS P8 are larger than that in CFSv2 in Jun and Dec ICs. But not in Oct ICs (seasonality of bias or impact of stochastic physics?)