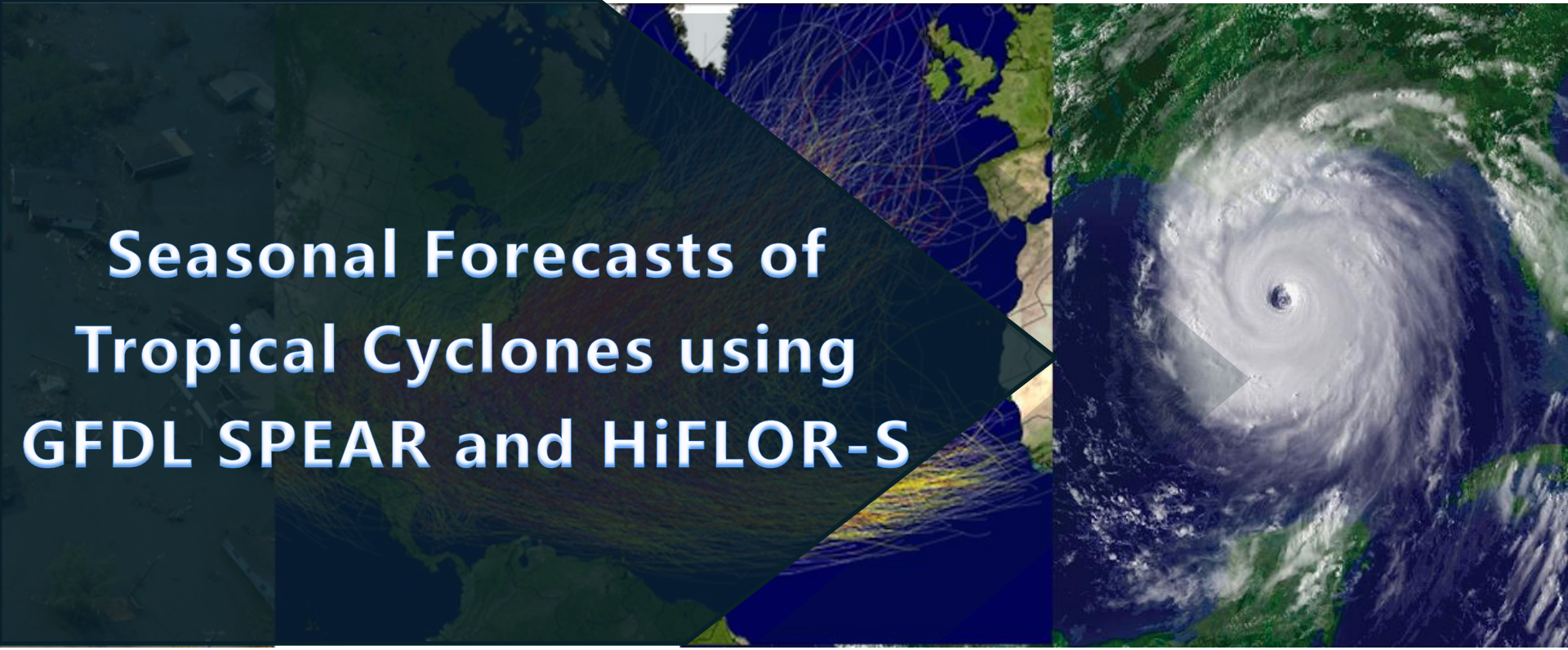


Seasonal Forecasts of Tropical Cyclones using GFDL SPEAR and HiFLOR-S

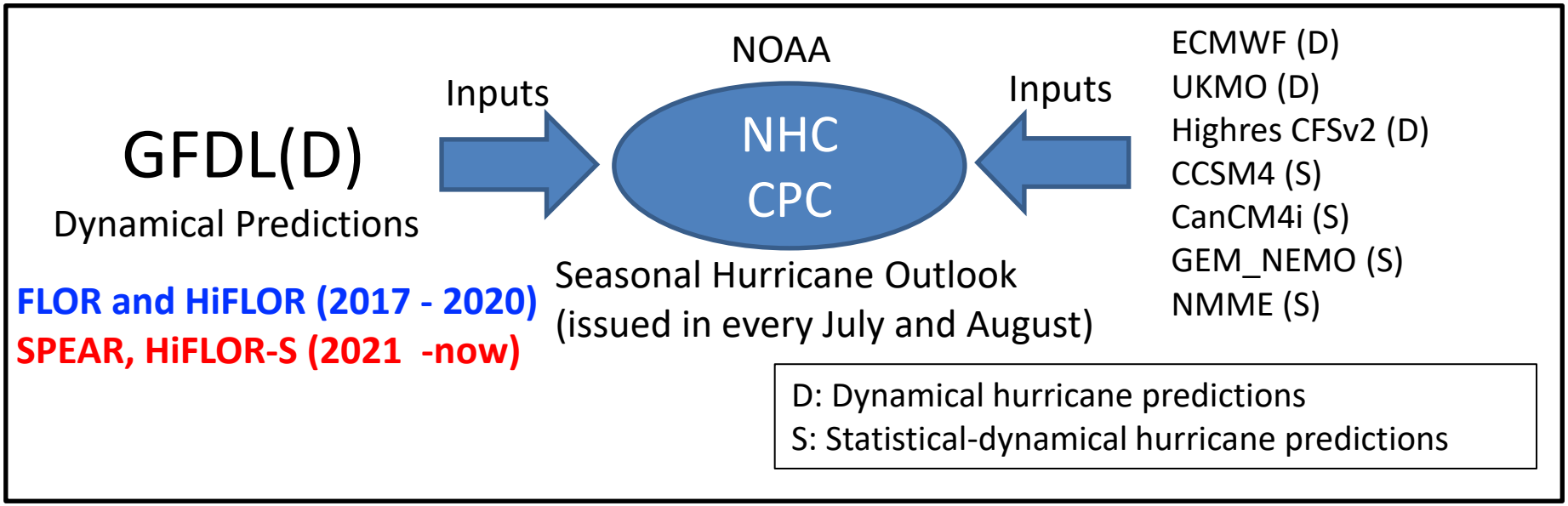
Hiro Murakami, T. Delworth, N. Johnson, F. Lu, C. McHugh, and L. Jia

Geophysical Fluid Dynamics Laboratory (GFDL), OAR, NOAA, USA
Hiroyuki.Murakami@noaa.gov

NOAA's Subseasonal and Seasonal Applications Workshop on Sep 5th, 2024

Experimental seasonal hurricane predictions at NOAA's GFDL

- NOAA-GFDL has been supporting experts at the National Hurricane Center and Climate Prediction Center since 2017 for the hurricane seasonal outlook.
- GFDL is one of the two U.S. institutions that provides **dynamical** seasonal hurricane forecasts



- In January 2021, GFDL updated its real-time experimental seasonal to decadal prediction system to **SPEAR** from **FLOR**.

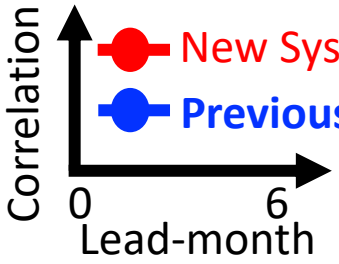
The S2D TC prediction system at GFDL

	Previous Prediction System (before 2021 January)		New Prediction System (since 2021 January)	
	FLOR	HiFLOR	SPEAR	HiFLOR-S
Atmos Resolution	50 km	25 km	50 km	25 km
Ocean Resolution	100 km		100km	
Ocean IC	ECDA (Zhang and Rosati, 2010)		SPEAR_ECDA (Lu et al. 2020)	N/A
Atmos. IC	AMIP-simulation forced with observed SST		SPEAR nudged to reanalysis	AMIP-simulation forced with observed SST

Motivation of this study

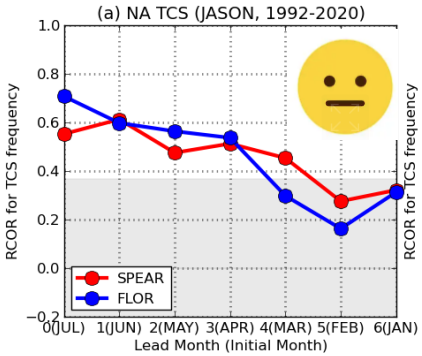
- We assess the prediction skill of TCs using the **new prediction system** and compare the skill with those of the **previous prediction system**.
- Our target for TC predictions is **July-November**

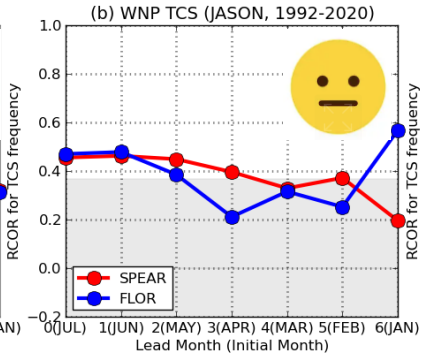
Skill comparisons for basin-total storm frequency

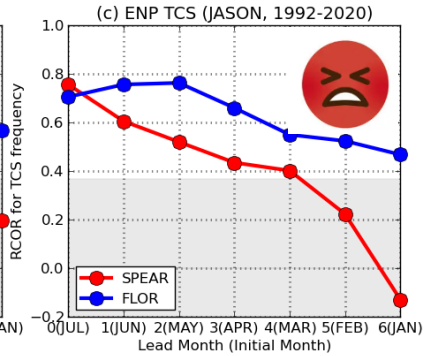


North Atlantic | Western North Pacific | Eastern North Pacific

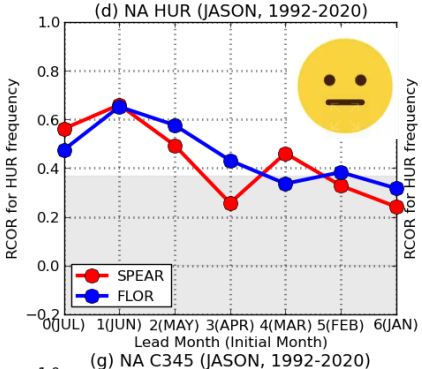
Named Storms

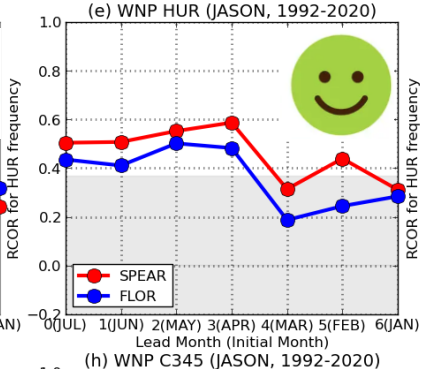


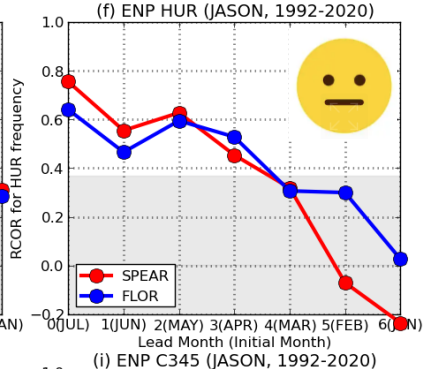




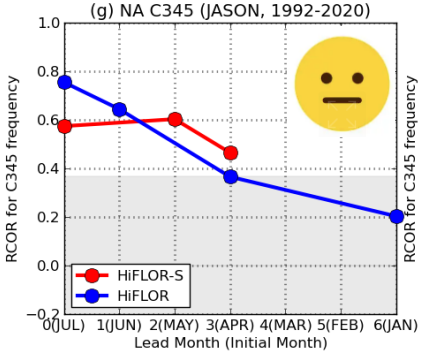
Hurricanes

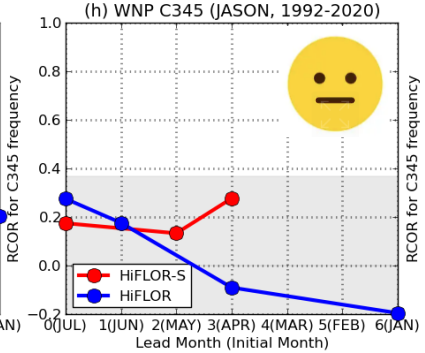


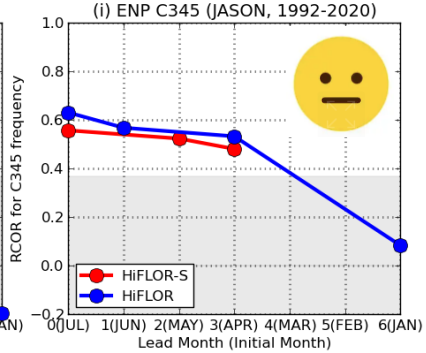




Major Hurricanes



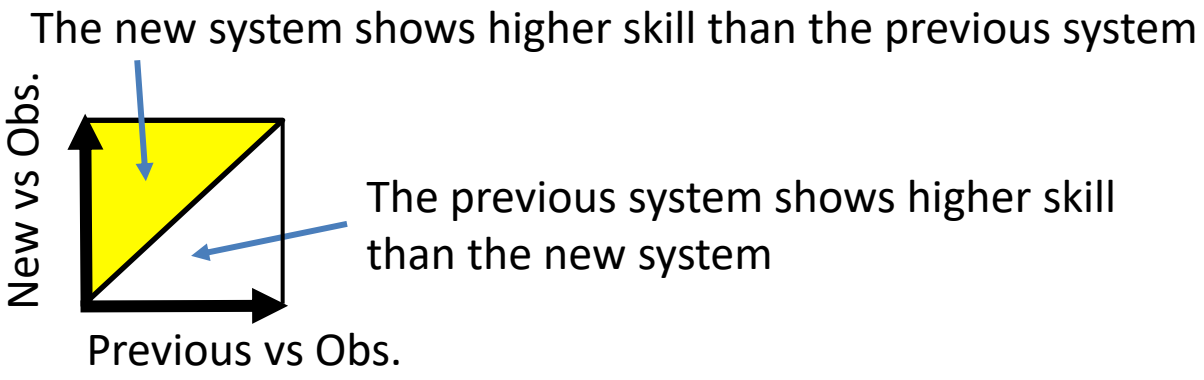




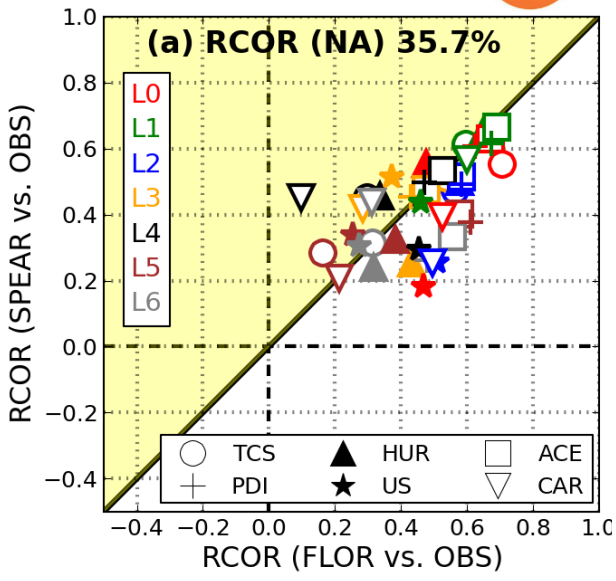
Significantly improved | Moderately improved | Comparable | Slightly Worse | Significantly Worse

Skill comparisons for other TC metrics

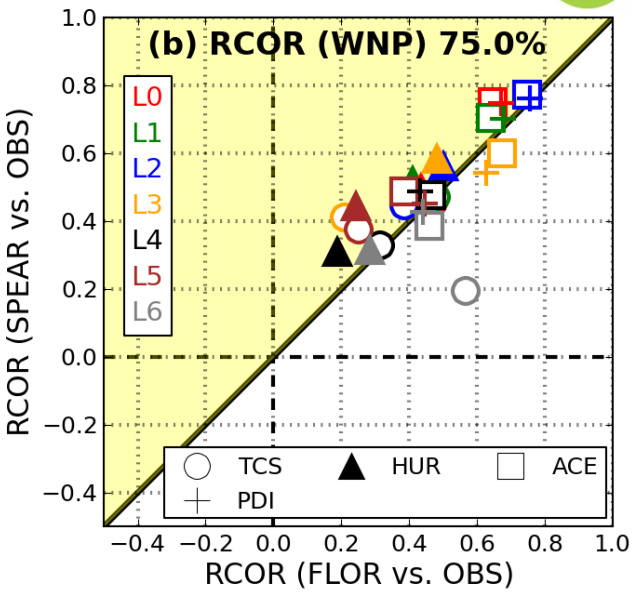
Various TC metrics to evaluate:
TCS: Named storms
HUR: Hurricane
ACE: Accumulated Cyclone Energy
PDI: Power Dissipation Index
US: US landfalling storms
CAR: Caribbean landfalling storms
HI: Hawaiian landfalling storms



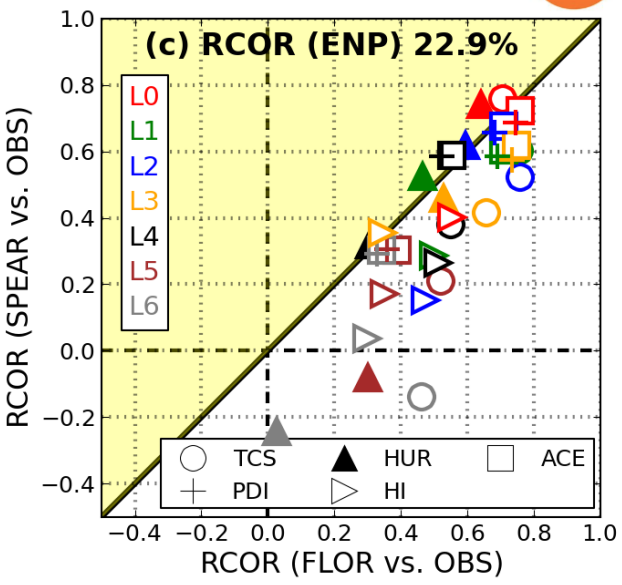
North Atlantic



Western North Pacific



Eastern North Pacific



Significantly improved
Moderately improved
Comparable
Slightly Worse
Significantly Worse

Skill comparisons for large-scale environments

Various large-scale parameters:

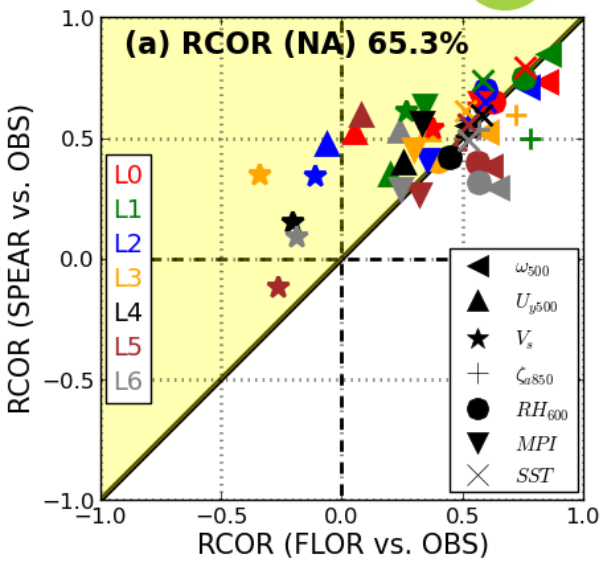
V_s: Vertical wind shear
RH_{600}: Relative humidity at 600 hPa
ζ_{a850}: Absolute vorticity at 850 hPa
MPI: Potential Intensity
SST: SST anomaly
U_{y500}: Shear vorticity of zonal winds at 500 hPa
ω_{500}: Vertical motion at 500 hPa

Improved skill in local large-scale environment

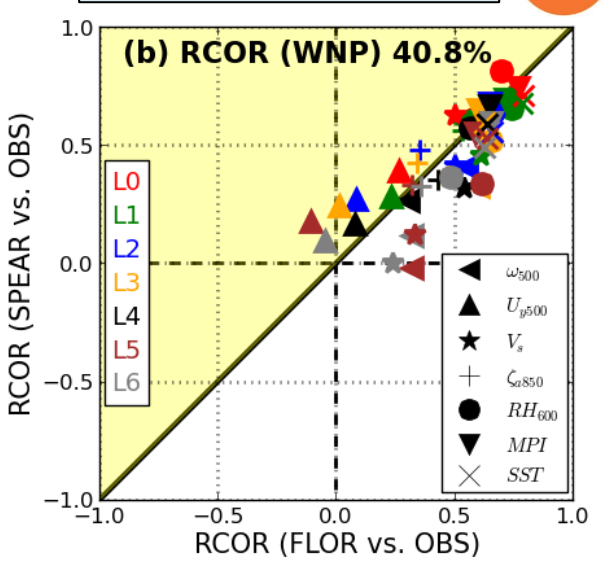
≠

Improved skill in TC predictions

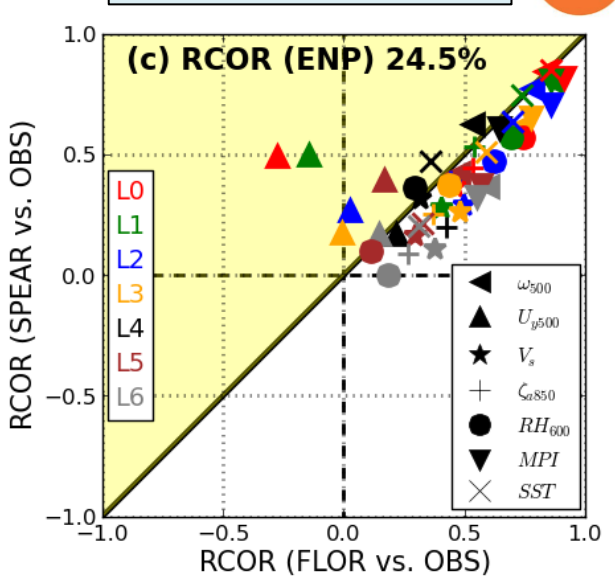
North Atlantic



Western North Pacific



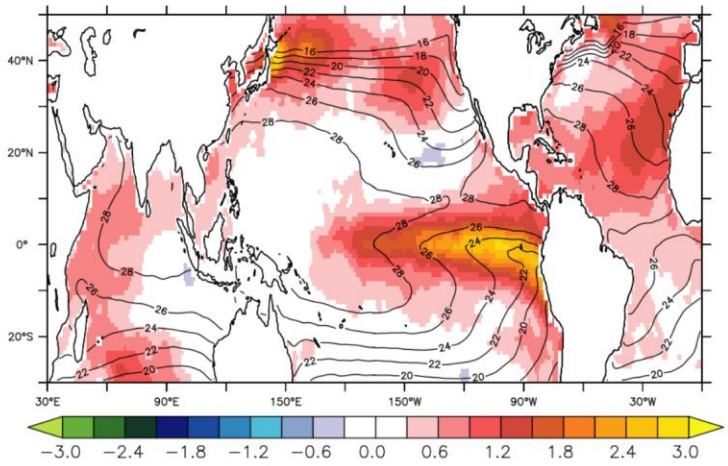
Eastern North Pacific



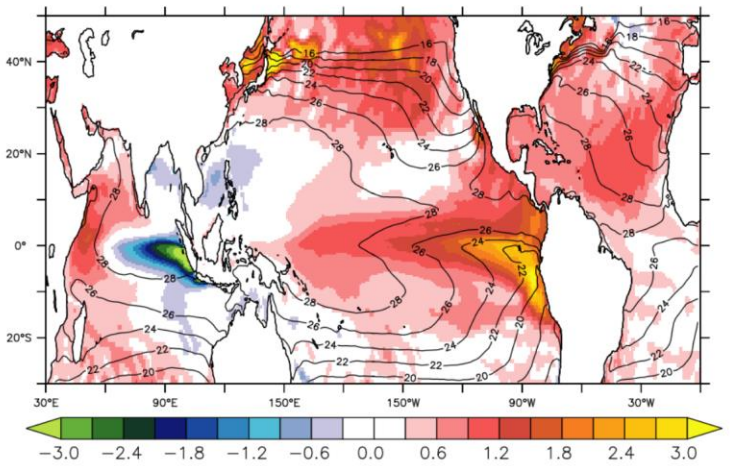
Significantly improved | Moderately improved | Comparable | Slightly Worse | Significantly Worse

Inconsistent 2023 NA TC prediction between SPEAR and HiFLOR-S

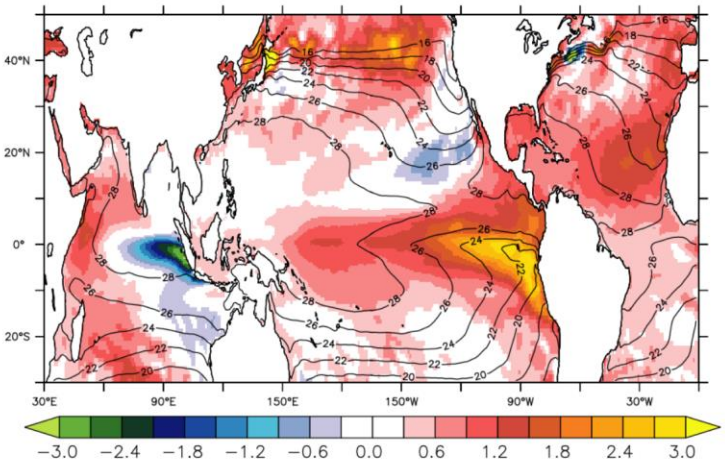
(a) Observed 2023 SSTA



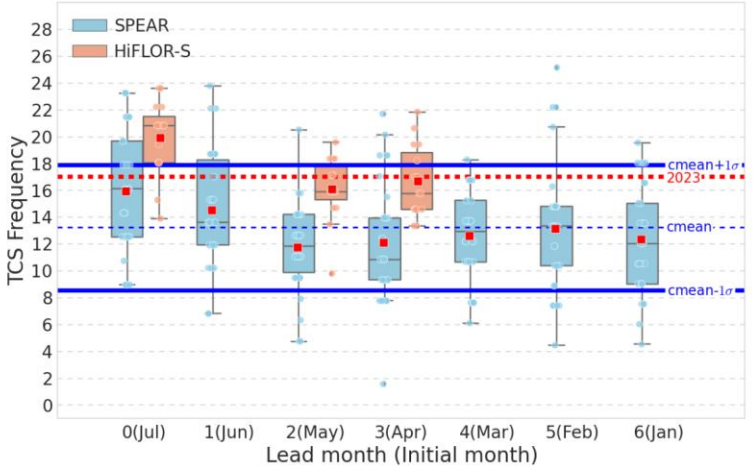
(b) Predicted 2023 SSTA from April (L=3)



(c) Predicted 2023 SSTA from July (L=0)

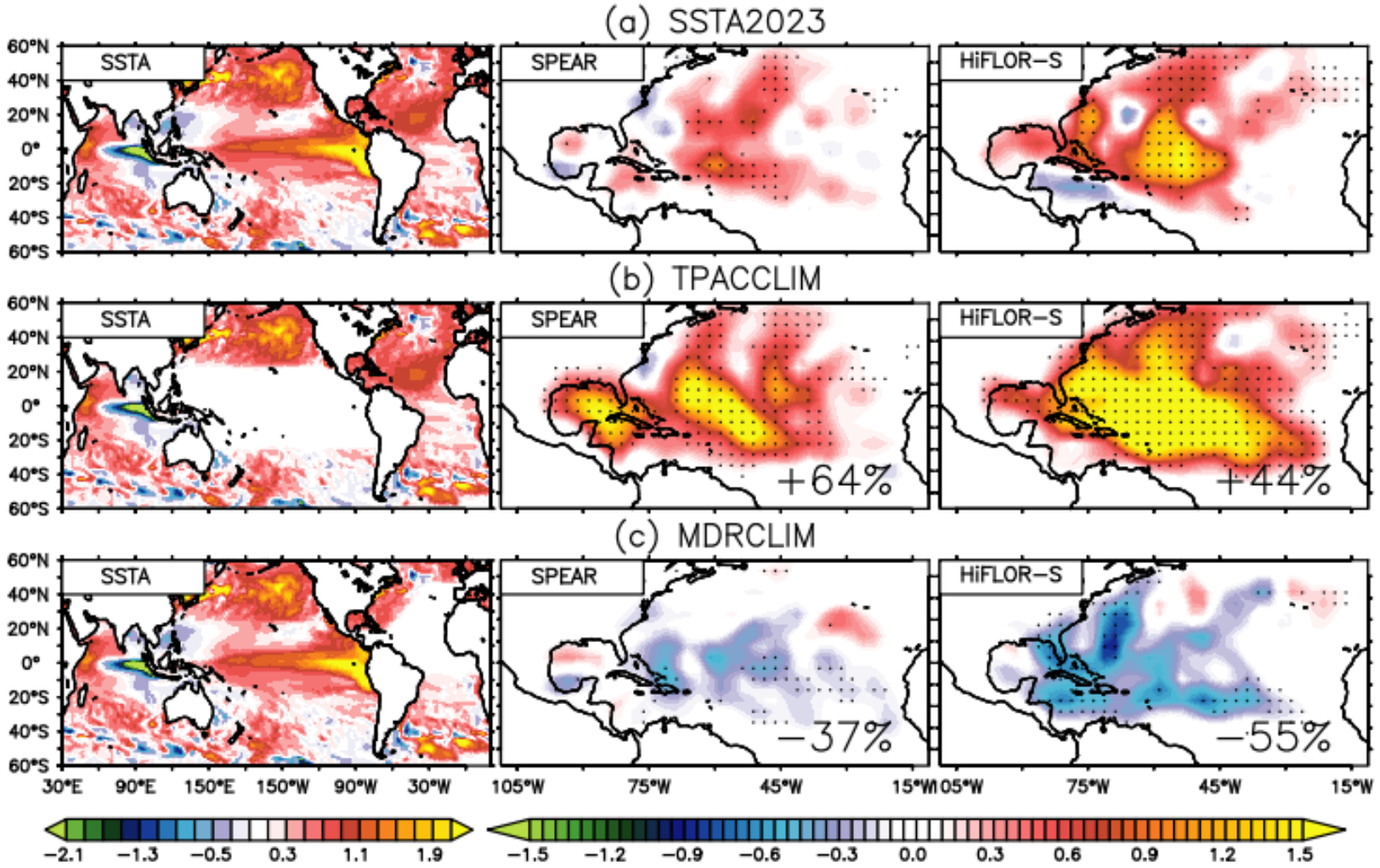


(d) Predicted TCS Freqeuncy in the NA



- SPEAR predicted a neutral 2023 Atlantic storm season, whereas HiFLOR-S predicted an active 2023 storm season.
- Why are they so different despite sharing the same SST in the lower boundary conditions?

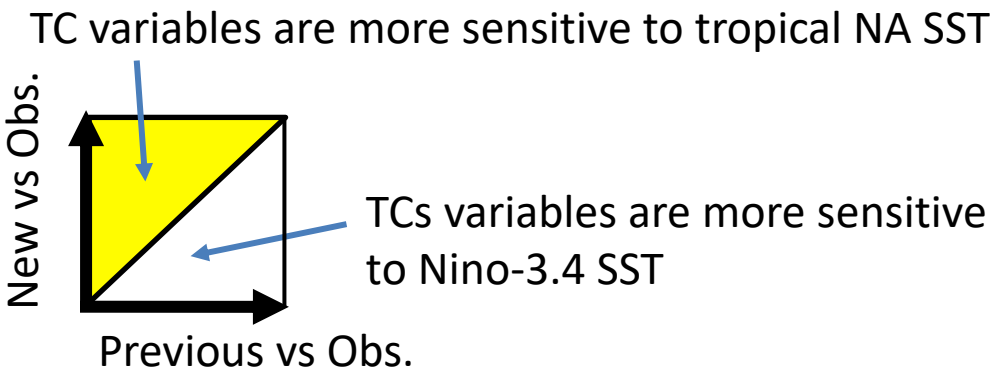
Idealized seasonal prediction for the Summer of 2023



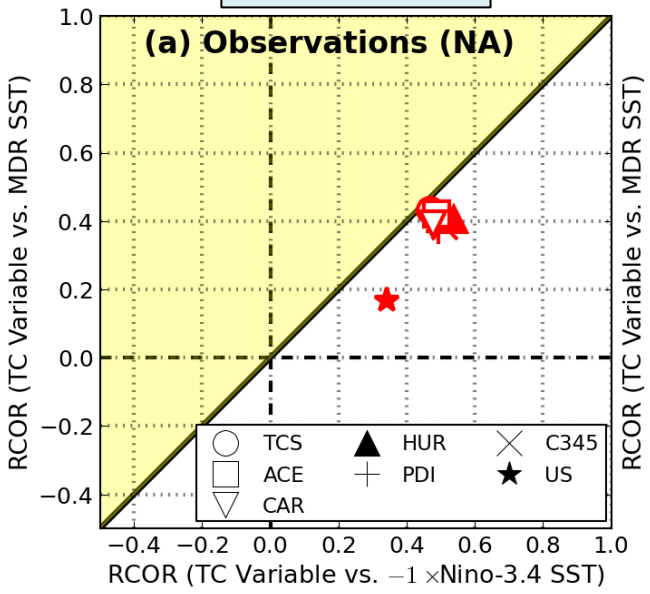
- SPEAR is more sensitive to El Niño condition for NA storms.
- HiFLOR is more sensitive to tropical Atlantic SSTs for NA storms.

Sensitivity of NA storms to Nino-3.4 or tropical NA

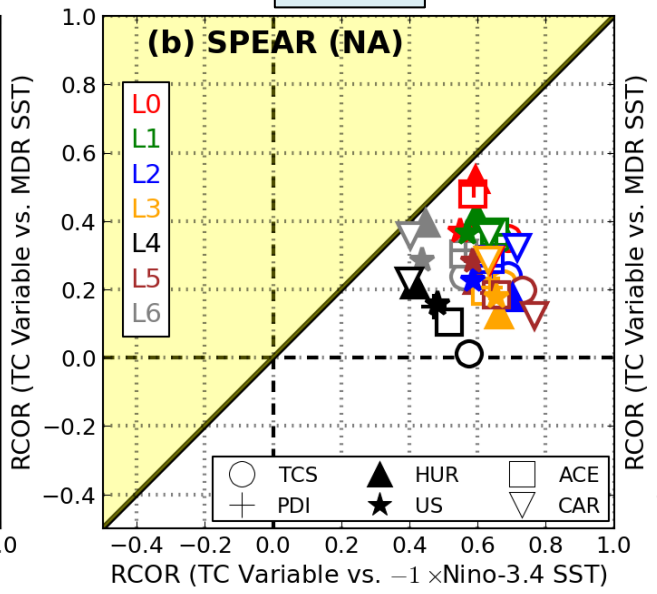
Various TC metrics to evaluate:
TCS: Named storms
HUR: Hurricane
ACE: Accumulated Cyclone Energy
PDI: Power Dissipation Index
US: US landfalling storms
CAR: Caribbean landfalling storms



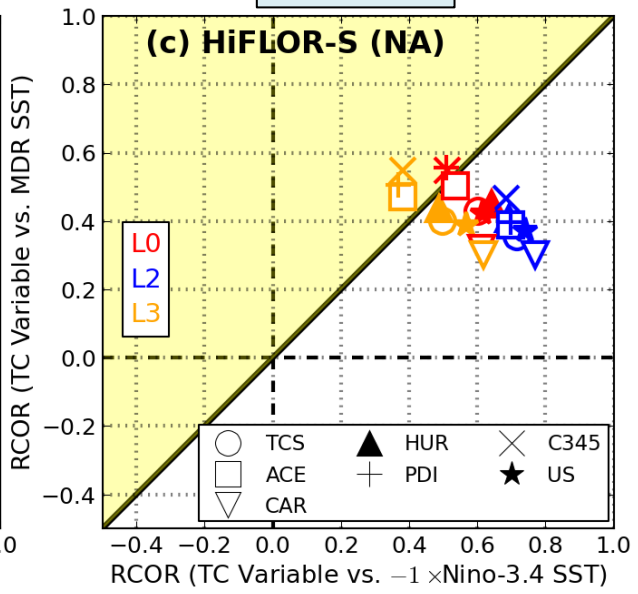
Observations



SPEAR



HiFLOR-S



- SPEAR is more sensitive to El Nino condition for NA storms in long-lead month predictions.
- HiFLOR is more sensitive to tropical Atlantic SSTs as observations.

Key takeaways

- New GFDL TC S2D prediction system demonstrates skillful predictions of TC activity across the three ocean basins.
- Relative to the previous GFDL prediction system, the new prediction system shows comparable TC prediction skill for the NA, improved skill for the WNP, but degraded skill in the ENP.
- Different skill in TC predictions are not relevant to the changing skill in large-scale environment.
- This study underscores the importance of not only improving the prediction skill of SSTs and large-scale environments themselves but also enhancing the model's response of TCs to such large-scale conditions like SSTs to achieve further improvement in TC prediction skill at a seasonal time scale.