NH31C-1893586

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

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1. Introduction

NOAA–GFDL provides real-time dynamical hurricane forecasts to NHC & CPC. SPEAR replaced FLOR in 2021 as the operational research prediction system.

Motivation

- Assessing the prediction skill of SPEAR compared to FLOR
- Why did prediction skill change across basins?
- What controls TC response to large-scale climate drivers?

2. Model and Retrospective Seasonal Forecasts

Models

New System (SPEAR Based)
- **SPEAR**
  - Higher-resolution atmosphere (50-km mesh) + improved AM4 physics
- **HiFLOR-S**
  - High-resolution version of FLOR (25-km mesh)
  - Forced with predicted SPEAR SSTs

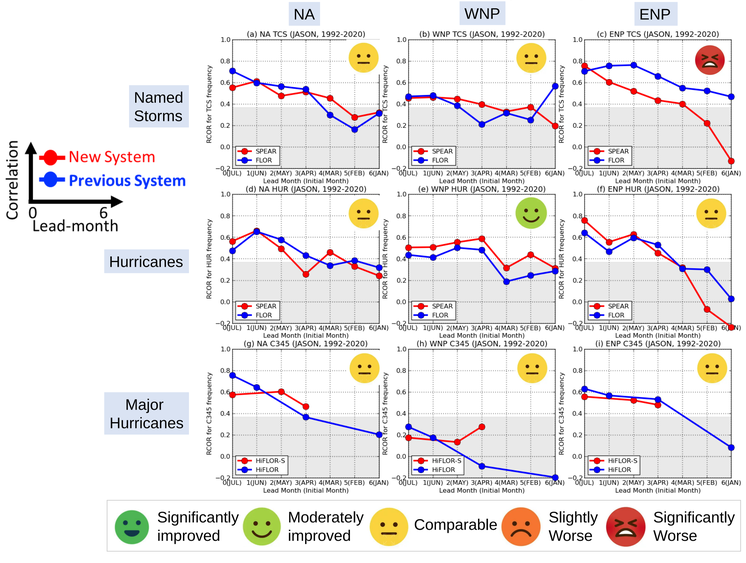
Old System (FLOR Based)
- **FLOR**
  - Higher-resolution atmosphere (50-km mesh) + AM2.5 physics
- **HiFLOR**
  - The same ocean initial conditions with FLOR

Retrospective Seasonal Forecasts

- Evaluation period & season: 1992–2020, July-November
- Evaluation TC Metrics: Named Storms, Hurricanes, Major Hurricanes, ACE, PDI, Landfalling storms
- Ocean Basins: North Atlantic (NA), Eastern North Pacific (ENP), Western North Pacific (WNP)

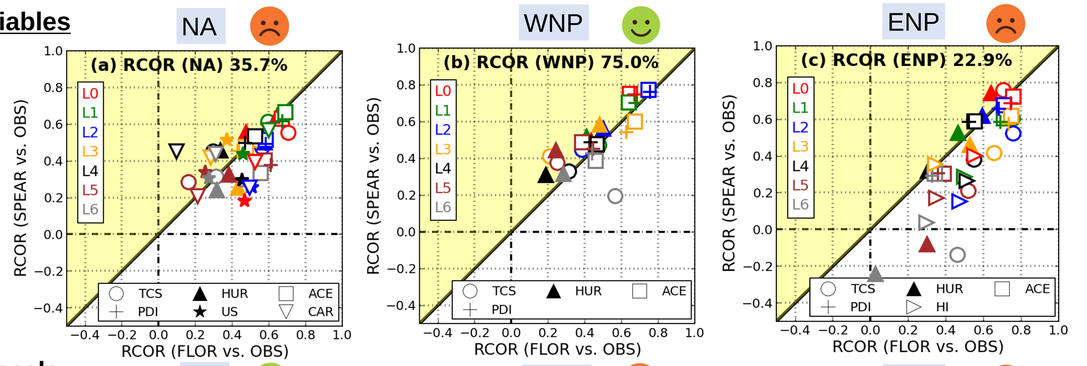
3. Skill Comparisons for Basin-Total TC Metrics

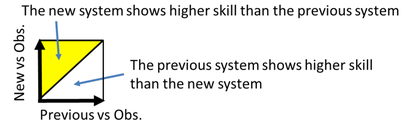
- SPEAR shows different skill relative to FLOR depending on the ocean basins



4. Improved TC prediction skill does not necessarily correspond to improved skill in large-scale environments

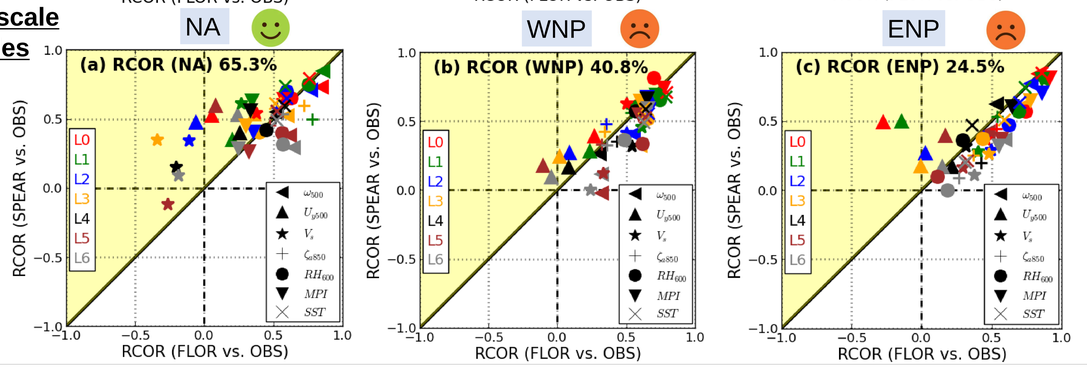
TC Variables





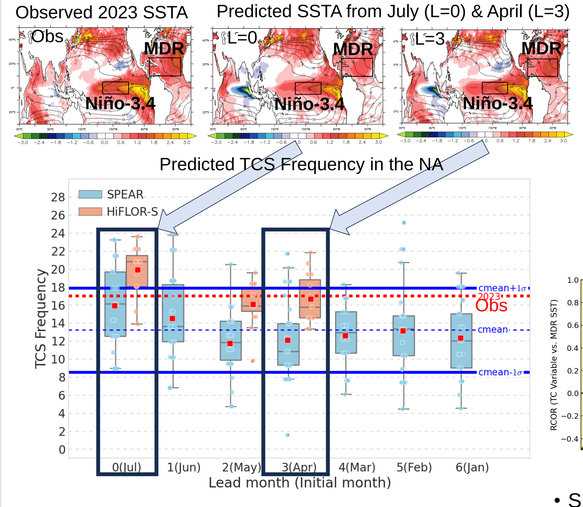
Various TC variables to evaluate:
- TCS: Named storms
- HUR: Hurricane
- ACE: Accumulated Cyclone Energy
- PDI: Power Dissipation Index
- US: US landfalling storms
- CAR: Caribbean landfalling storms
- HI: Hawaiian landfalling storms

Large-scale Variables

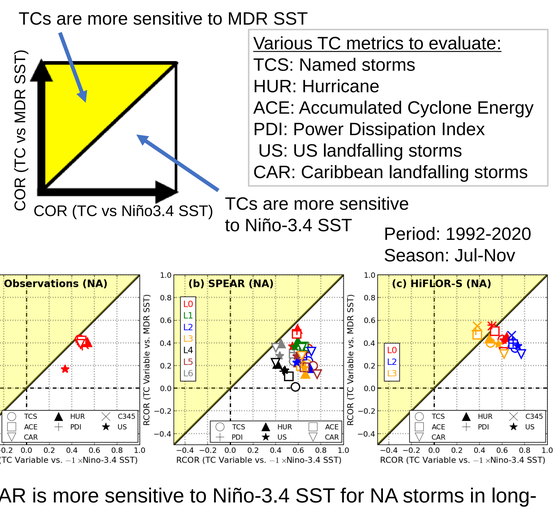


Various large-scale variables to evaluate:
- ω_{500}: Vertical motion at 500 hPa
- $U_{\psi 500}$: Shear vorticity of zonal winds at 500 hPa
- V_s: Vertical wind shear
- ζ_{a850}: Absolute vorticity at 850 hPa
- RH_{600}: Relative humidity at 600 hPa
- *MPI*: Potential Intensity
- *SST*: SST anomaly

5. NA TCs are more sensitive to Niño-3.4 SST than MDR SST in SPEAR



- Inconsistent 2023 NA TC prediction between SPEAR and HiFLOR-S given the same SSTA. Why?



- SPEAR is more sensitive to Niño-3.4 SST for NA storms in long-lead month predictions.
- HiFLOR is more sensitive to MDR SSTs as observations.

5. Key Takeaways

- SPEAR demonstrates improved skill in predicting TC activity for the WNP, while exhibiting comparable or slightly degraded skill for the ENP and NA
- Improved skill in local large-scale environments does not necessarily lead to improved skill in TC predictions
- Enhancing the model's TC–climate sensitivity—not just large-scale environmental skill—is essential for advancing seasonal TC prediction


1 MAY 2025 MURAKAMI ET AL.

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Published in the *Journal of Climate* in 2025