Evaluation of Tropical Cyclone Activity in CMCC SPS Seasonal Forecast

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1 Background

Tropical Cyclones (TCs) are one of the most significant weather hazards in tropical regions; with strong wind, storm surge, and extreme precipitation, TCs cause a huge number of deaths and millions of losses of property after landfalling.

Hurricane Florence on the US southeast coast.

Tropical cyclone Idai made landfall.

2 Data and Methods

Data:

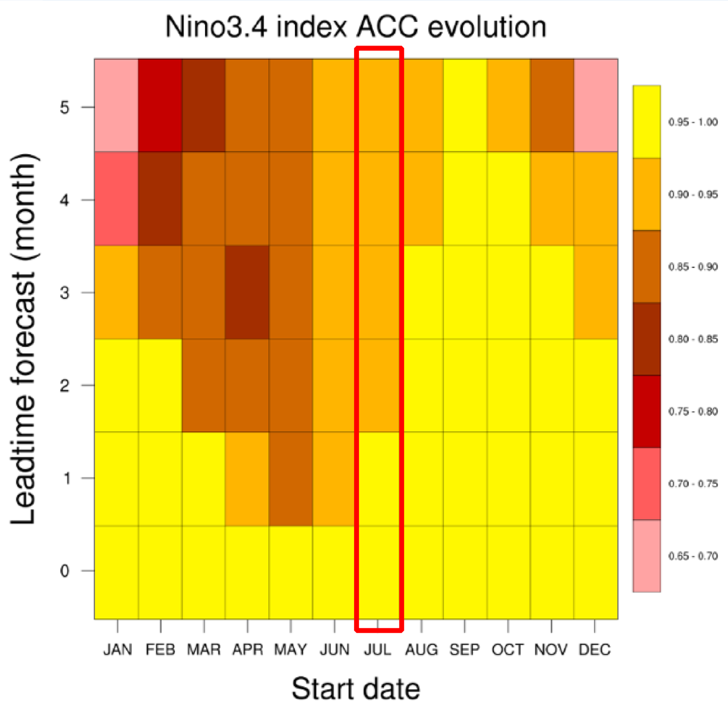
1) Observations and global climate models (GCMs)

Observations and CMCC		
International Best Track Archive for Climate Stewardship (IBTrACS)	1998-2016	3hourly
Euro-Mediterranean Center on Climate Change (CMCC) Seasonal Prediction System (SPS3.5)	1998-2016	Resolution: 0.5 degree, large ensemble members 6hourly

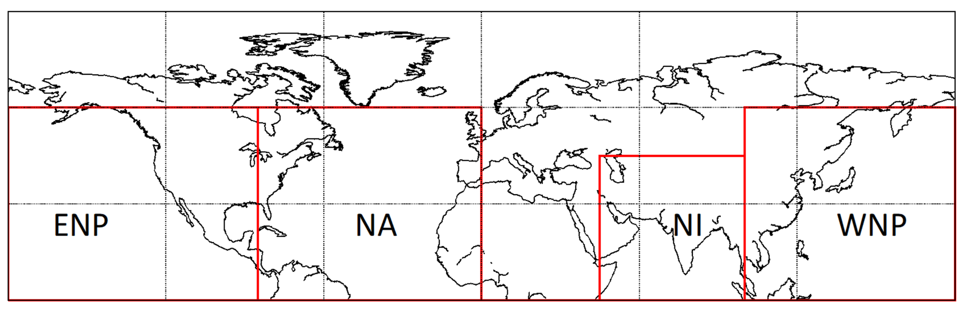
- Start month=7
- Time period: 1998-2016

  July August September

Nino3.4 index ACC evolution



Methods:



Operational set-up

- **Ten (10) atmospheric I.C.s** are prepared starting from 5-day back in time atmospheric states provided by the 10 ERA5 analyses, 12hour lagged each, interpolated to the CAM grid, then integrated in time in the SPS3.5 system up to the actual forecast start-date (1rst of the month, h: 00:00).
- **Three (3) land state I.C.s** are obtained from the land analyses performed with CLM forced with atmospheric fields from different analyses (ECMWF, NCEP, linear interpolation of the 2)
- **Perturbed ocean I.C.s are created by generating nine (9) reanalyses** through perturbation of the ocean observations (in the analysis step), perturbation of atmospheric forcing and introduction of stochastic physics, in the forecast step.

10 atmospheric ICs (12h back lagged in time each + SPS3.5 forecast)

3 CLM4.5 forced with ECMWF and NCEP atmospheric forcing to Land Surface

9 OCEAN ANALYSIS resulting from data assimilation

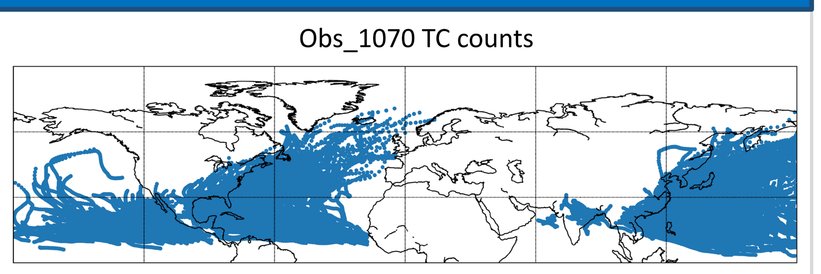
270 ICs → **40 forecast members each lasting 6 months**

Geophysical Fluid Dynamics Laboratory (GFDL) Tropical Cyclone tracking algorithm

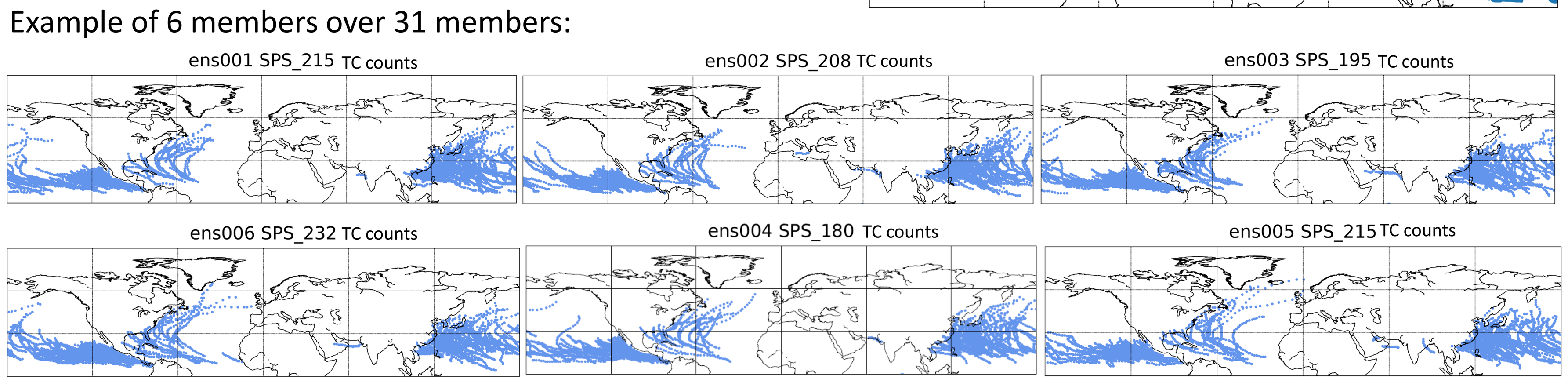
1. Check relative vorticity at 850 hPa>$1.6x10^{-4}s^{-1}$
2. Local sea level pressure minimum < distance of 2° latitude or longitude from the vorticity maximum, the point is considered as the center of the storm.
3. Warm-core temperature greater than 1°C with respect to the surrounding mean temperature.
4. For each potential storm condition, the algorithm verifies the presence of storms during the following 6-h time period within a distance of 400 km

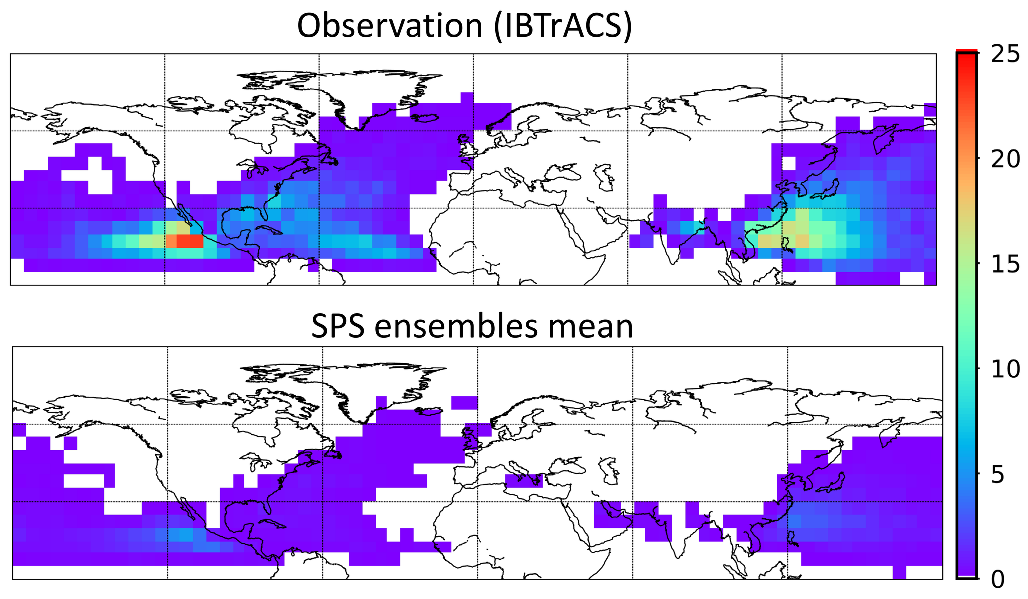
3 The new CMCC SPS3.5 model can well capture TC spatial distributions

1) The model can well capture TC spatial distributions over the Pacific and the western Atlantic Ocean while underestimating TC counts.



Example of 6 members over 31 members:

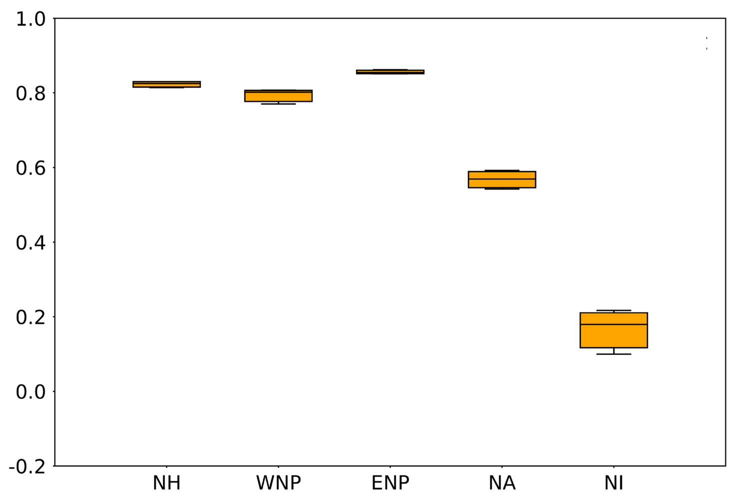




2) The new CMCC SPS3.5 model can well capture the TC spatial distribution pattern of 6h conditions while underestimating its absolute values.

(Number of TC/year conditions 6-hourly in 5x5 box)

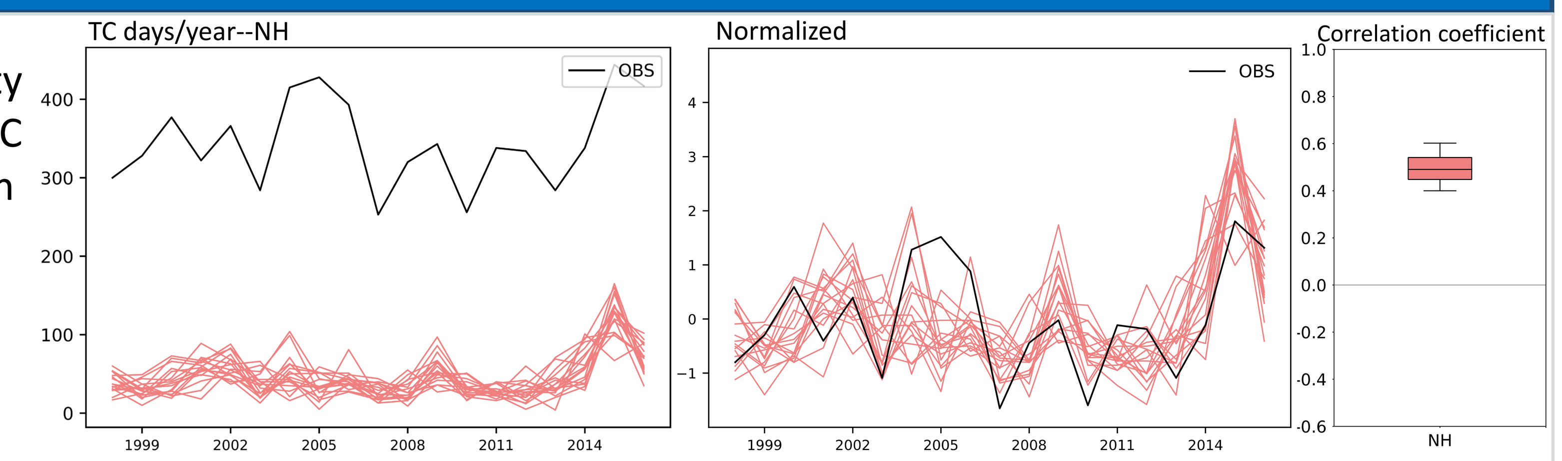
3) CMCC model captures TC best over the Pacific, while lower capability over the Atlantic and North Indian Ocean.



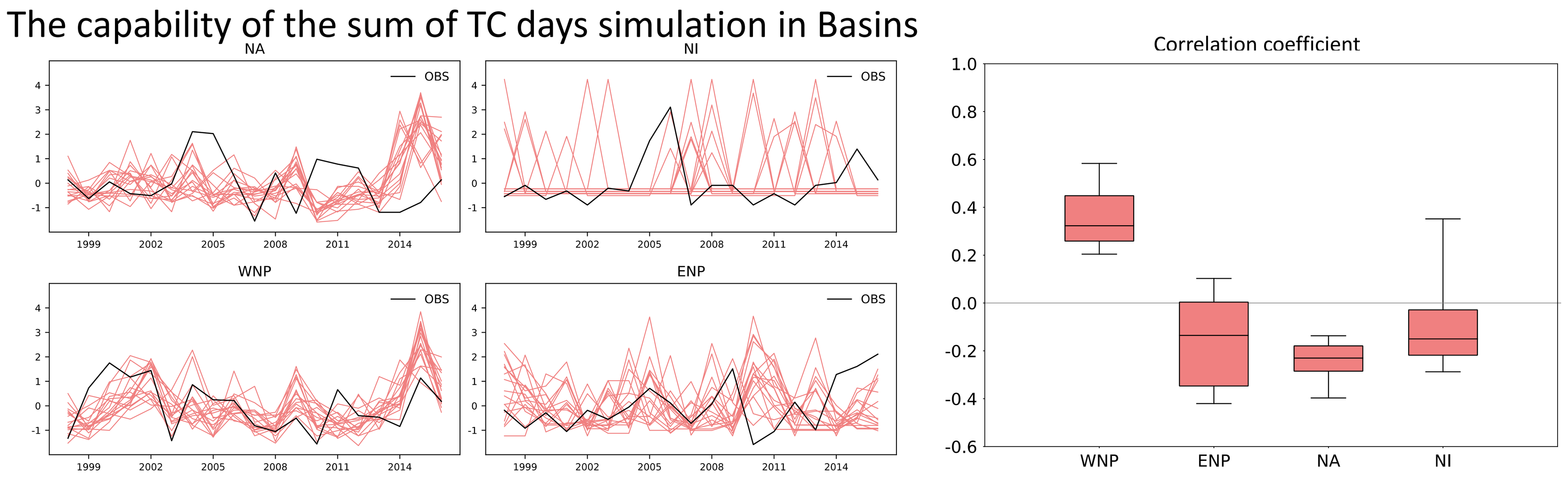
Spatial correlation coefficient (only ocean)

4 WNP is better in representing TC interannual variability

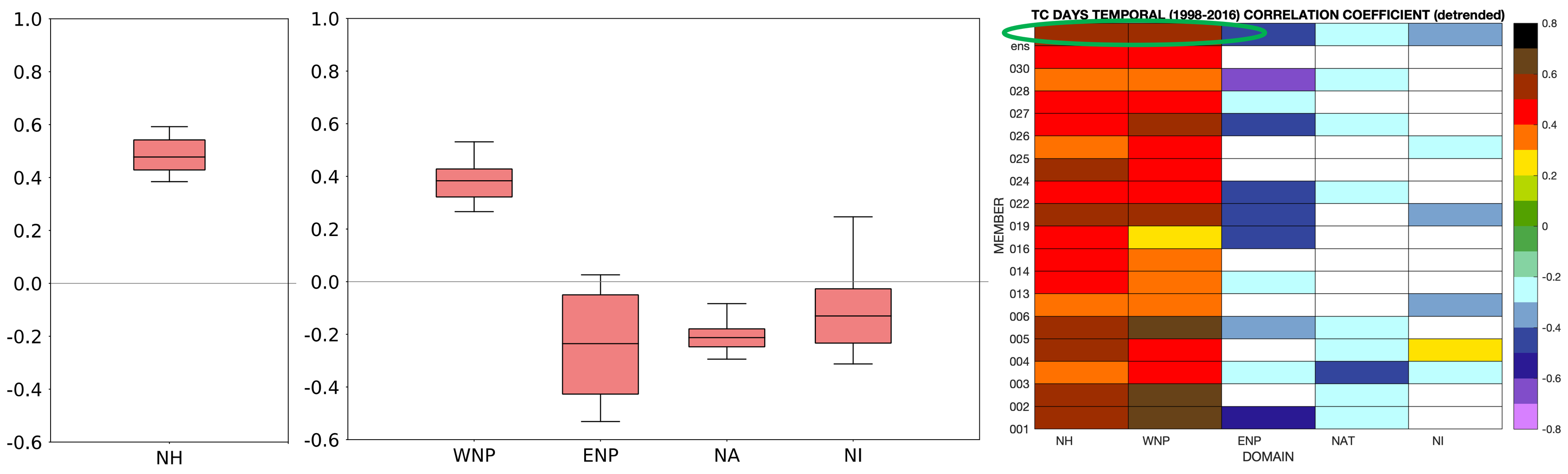
1) The capability of the sum of TC days simulation in the North Hemisphere



2) The capability of the sum of TC days simulation in Basins



3) Correlation coefficients of detrended observed TC days and CMCC members' TC days



4) Number of TC days larger than average during 1998-2016 (detrend)

NH			
Above average Number of TC days		Observed	
		Yes	No
Predicted	Yes	4 Hits	3 False alarm
	No	3 Misses	9 Correct rejections
Hit Rate:		57%	
False alarm Rate:		25%	
Hit +Correct rejections /Total:		68%	
False alarm +Misses /Total:		32%	

5 Conclusions

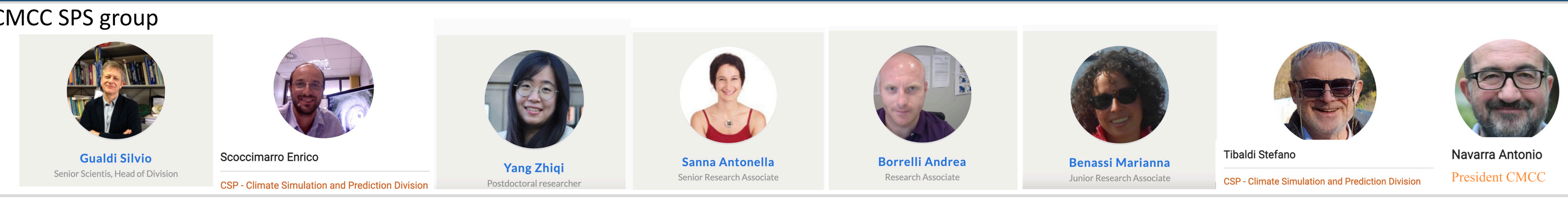
1) CMCC SPS3.5 system captures well the spatial distributions of TCs in the North Hemisphere, although with some underestimation of its absolute values.
2) It captures TC spatial distributions best over the Pacific, while lower capability is shown over the North Atlantic Ocean and North Indian Ocean.
3) In terms of the simulated TC days and their variability in time, we found the model performs well in Western North Pacific only.

Future research: Evaluating 40 members instead of 17 members; Investigating the large-scale parameters (CAPE, wind share, relative humidity, etc) associated to different cases; Evaluating 6 forecast months; Evaluating different start months in SPS3.5; Higher resolution data: next generation

	SPS3.5 (2020–2024)	**SPS4** (2024–)
Ocean	NEMO3.6 1/4° x 1/4° – 50 levs	NEMO4 1/4° x 1/4° – **70 vertical levs**
Atmosph.	CAM5.3 0.5° x 0.5° – 46 levs ~ 60km	CAM6 0.5° x 0.5° – **83 vertical levs ~80km** improved stratosphere dyn.
Land	CLM4.5 + River routing scheme	CLM5 + River routing scheme
Sea-ice	CICE4 (1 ice cat)	CICE6 (3 ice cat)
Initial Conditions	Ocean Analysis (CMCC) Atmosphere Analysis (ECMWF) Land Surface Analysis(CMCC)	Ocean **and Sea–Ice** Analysis (CMCC) Atmosphere Analysis (ECMWF) Land Surface Analysis (CMCC)

Acknowledgement

CMCC SPS group



- Yang, Z.*, E. Scoccimarro, M. Benassi, A. Borrelli, A. Sanna, S. Tibaldi , A. Navarra , and S. Gualdi, Evaluation of Tropical Cyclone Activity in CMCC SPS Seasonal Forecast (in preparation).