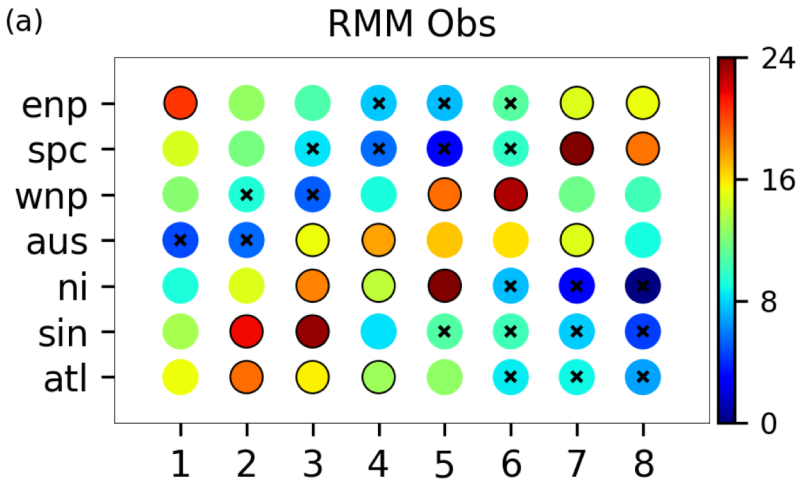
Tropical Cyclone Activity Prediction on Subseasonal time-scales

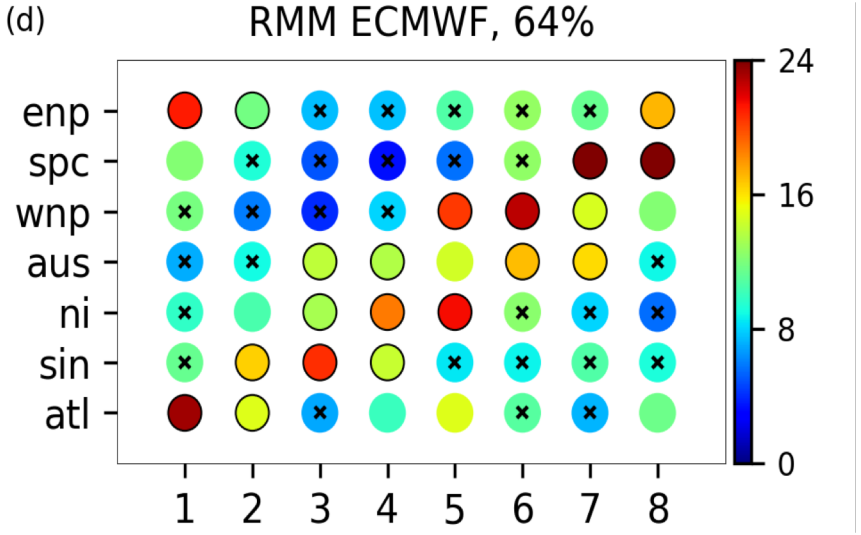
Suzana J. Camargo, Chia-Ying Lee, Fréderic Vitart, Adam H. Sobel, Michael K. Tippett, Shuguang Wang, Joanne Camp and Qidong Yang

Previous work – S2S dataset

Lee et al., WAF 2018: TC formation

- Most models have skill for week 1 (initialization important)
- Best performance – ECMWF:
  - Total TC genesis
  - TC genesis anomaly
- Model skill function of:
  - MJO prediction skill
  - Representation of TC climatology
  - Simulation of MJO-TC relationship



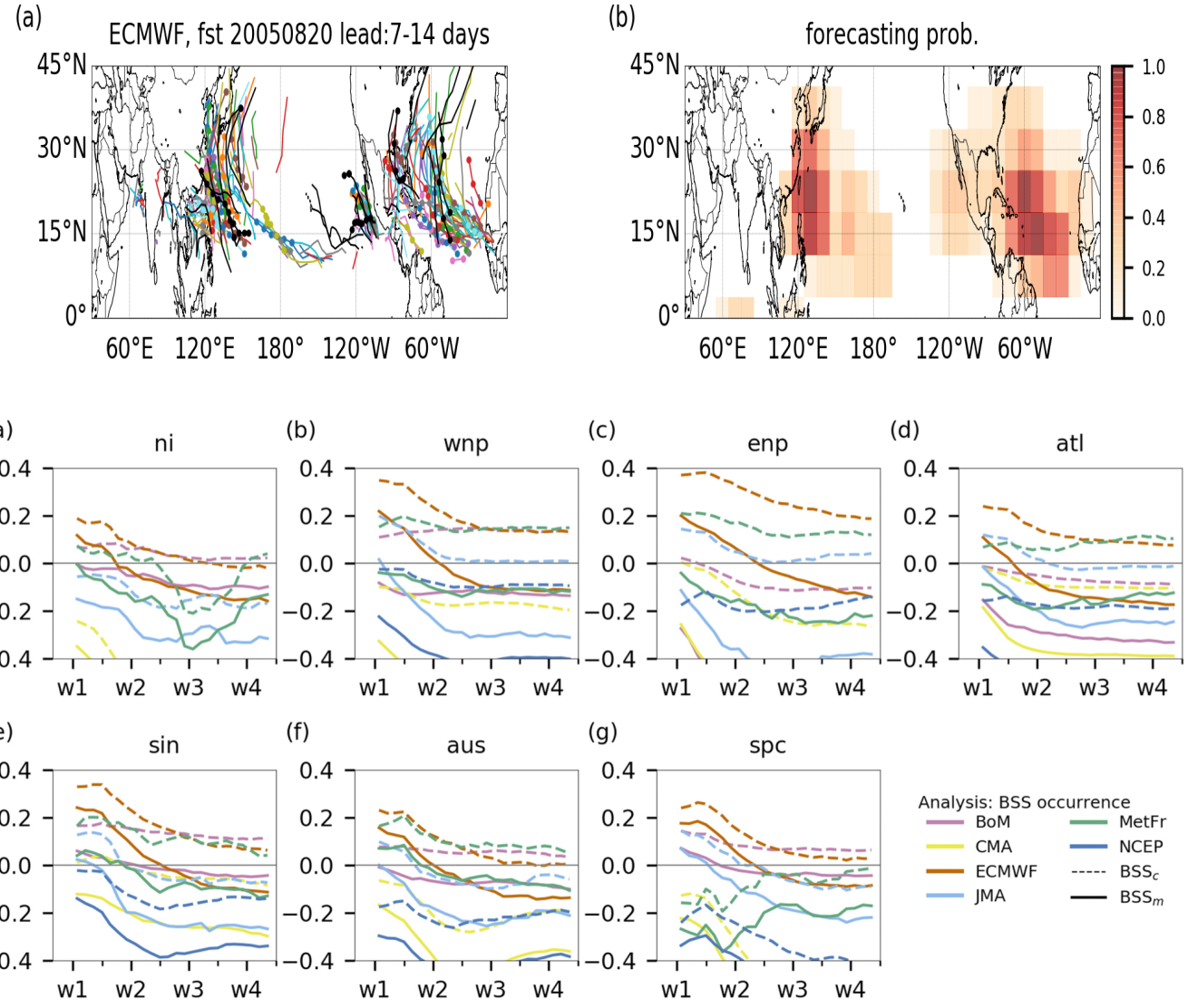


Lee et al., WAF 2018, doi: 10.1175/WAF-D-17-0165.1

S2S dataset

Lee et al., WAF 2020: TC occurrence

- ECMWF, BoM and Météo-France have skill in predicting **total** TC occurrence up to 4 weeks in advance.
- Only ECMWF is skillful in predicting TC occurrence **anomaly** beyond 1 week.

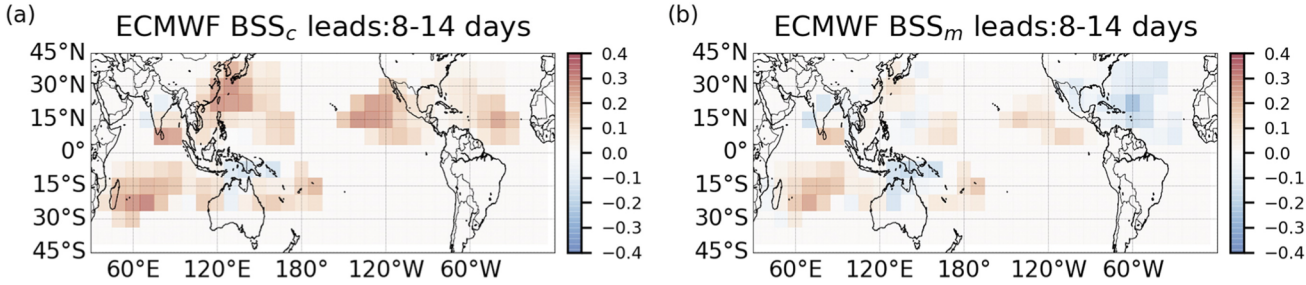


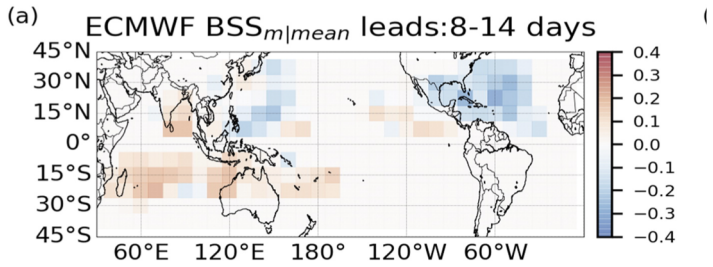
Lee et al., WAF 2020, doi: 10.1175/WAF-D-19-0217.1

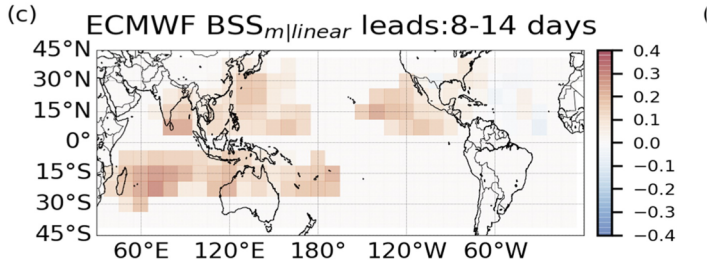
S2S dataset

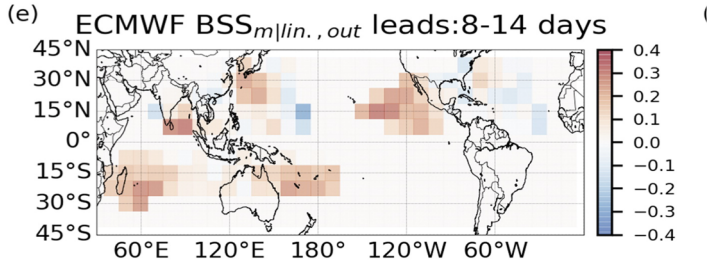
Lee et al., WAF 2020: TC occurrence

- Errors in genesis prediction limit models' skill in predicting TC occurrence.
- Removing the mean forecast bias does not always lead to a higher prediction skill (as measured by BSS).
- Three calibration methods were tested: a linear regression method has the best performance.









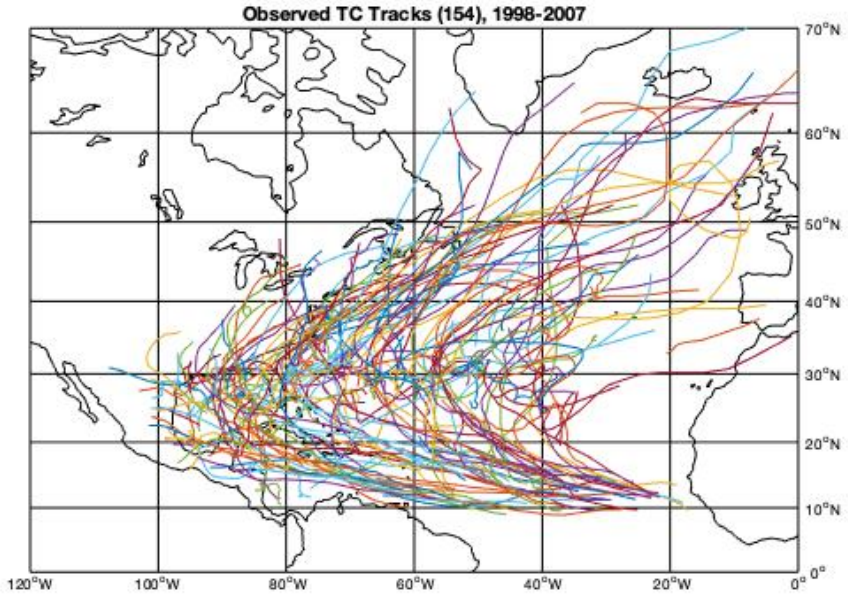
Lee et al., WAF 2020, doi: 10.1175/WAF-D-19-0217.1

Atlantic hurricanes ECMWF Monthly forecasts

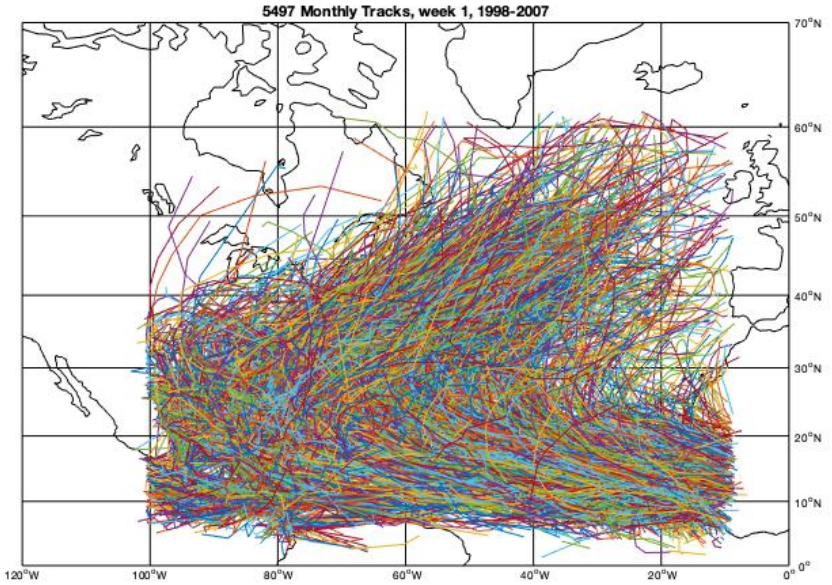
- TCs in the Monthly ECMWF forecasts (1998 – 2017)
  - Storms tracked in the original model resolution
    - 0.25° days 1 – 10
    - 0.50° days 11 – 46
  - Storms tracked twice a day
- 11 ensembles
- Forecasts: twice a week
- Length of each forecast: 46 days
- Full dataset (including TDs): 70,601 storms
- Excluding TDs using LMI threshold: 33,525 TCs
  - 35kt days 1– 10 (resolution 0.25 deg)
  - 25kt days 11 – 46 (resolution 0.50 deg)
- Observations (TSs and Hurricanes): 301 TCs

Camargo, Lee & Vitart, 2020, in preparation.

Tracks Atlantic TCs 1998-2007



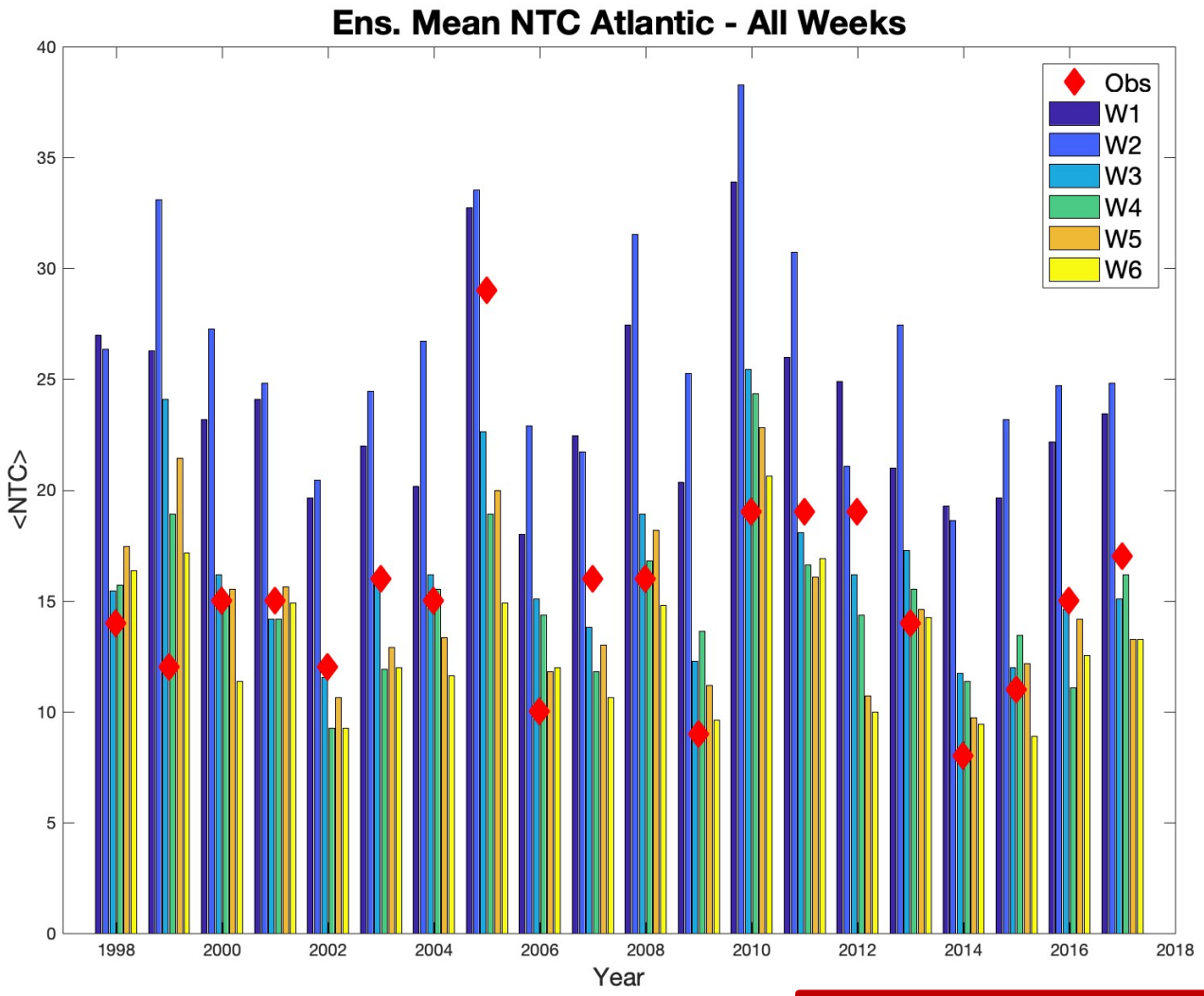
All TCs (154) - Observations



All TCs (5,497) week 1 – ECMWF

Camargo, Lee & Vitart, 2020, in preparation.

Number of TCs per year & lead

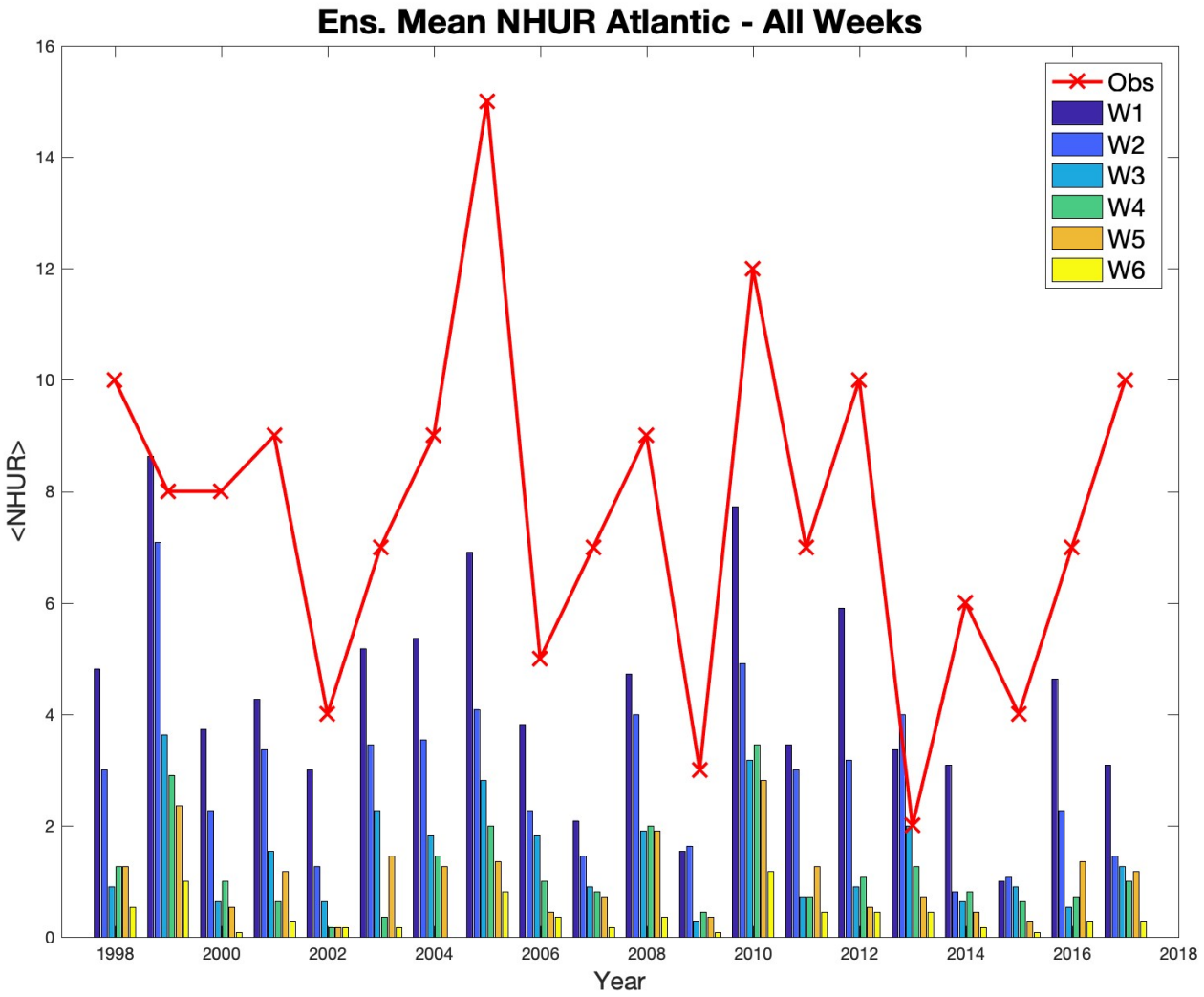


<NTC>	
ALL	18.2
W1	23.7
W2	26.3
W3	16.3
W4	14.9
W5	14.7
W6	13.0
OBS	15.0

Correlations	
ALL	**0.59**
W1	**0.77**
W2	**0.66**
W3	**0.44**
W4	**0.64**
W5	**0.53**
W6	**0.61**

Camargo, Lee & Vitart, 2020, in preparation.

Number of Hurricanes per year & lead



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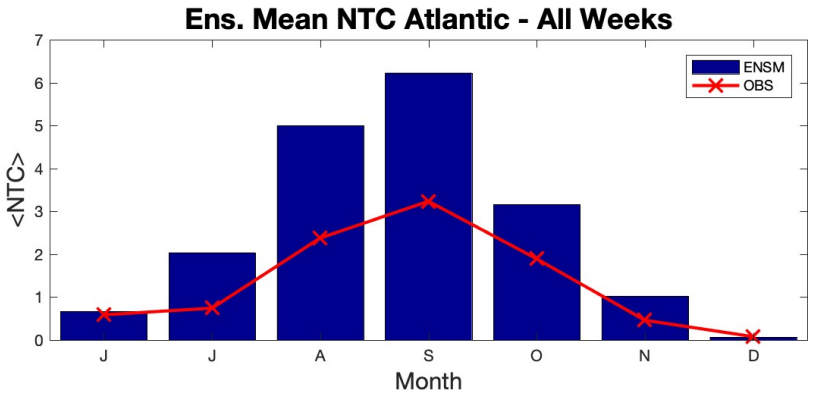
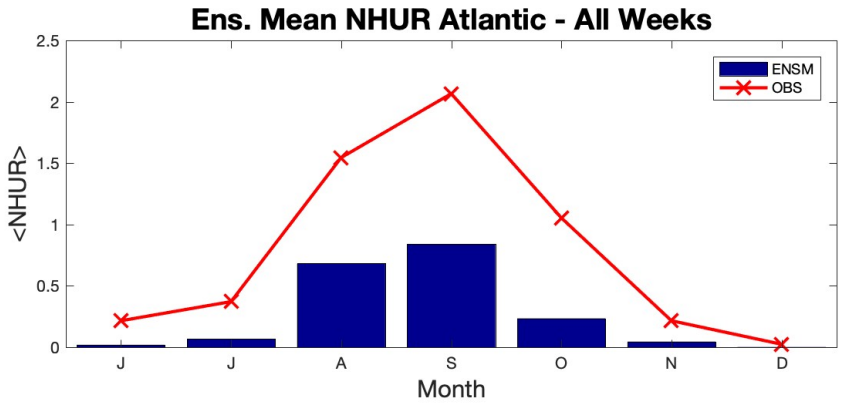
ALL	1.9
W1	4.3
W2	2.9
W3	1.5
W4	1.2
W5	1.1
W6	0.4
OBS	7.6

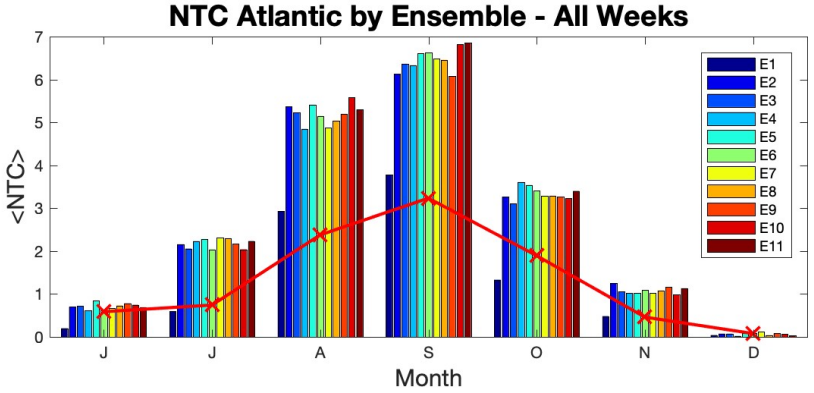
Correlations	
ALL	**0.59**
W1	**0.64**
W2	0.33
W3	**0.59**
W4	**0.49**
W5	**0.58**
W6	**0.48**

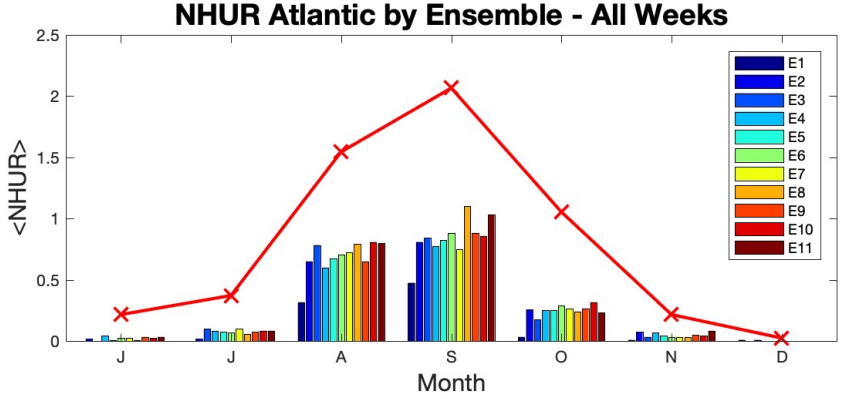
Camargo, Lee & Vitart, 2020, in preparation.

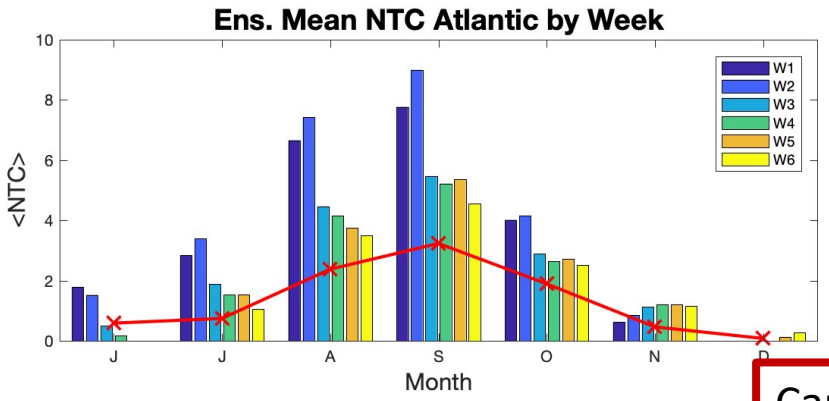
Seasonality

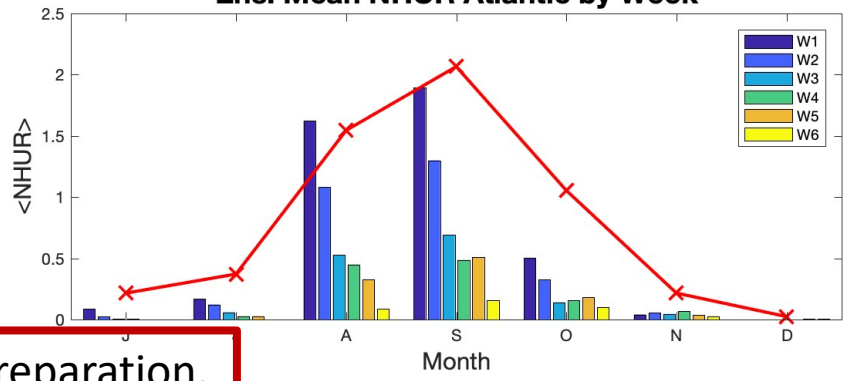










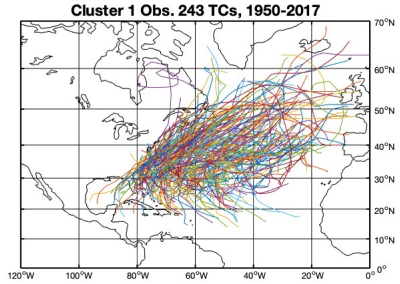


Camargo, Lee & Vitart, 2020, in preparation.

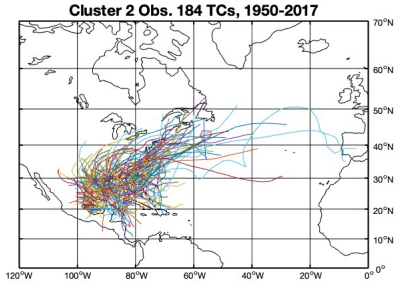
Cluster analysis

Observations (1998 – 2017)

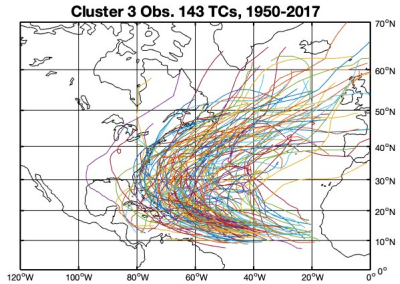
Subtropical



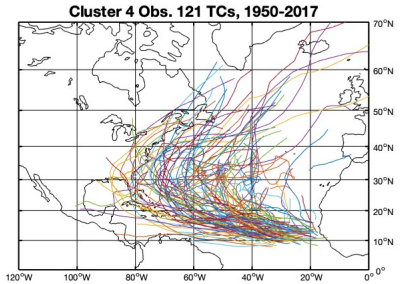
Gulf of Mexico



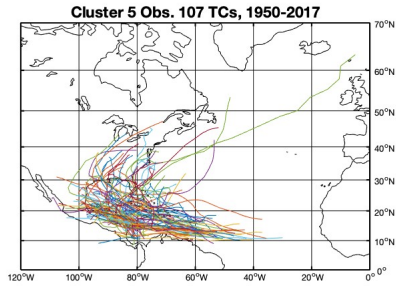
Tropical - E



Tropical - W

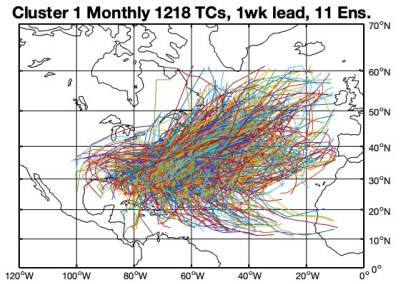


Caribbean

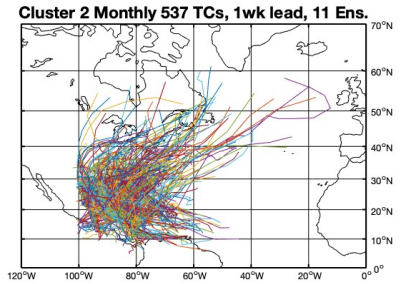


ECMWF Monthly Forecasts

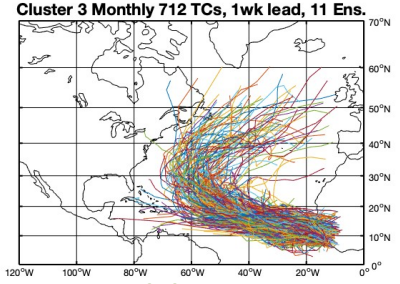
Subtropical



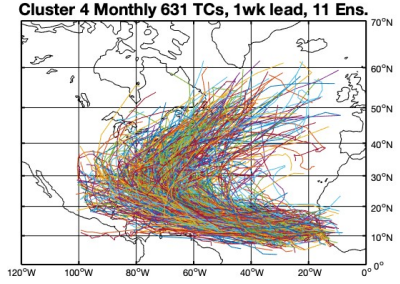
Gulf of Mexico



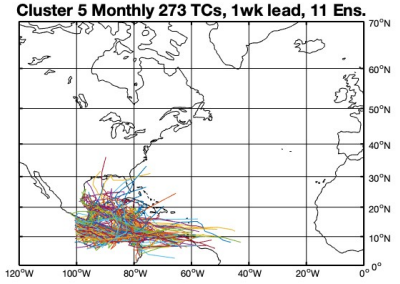
Tropical - E

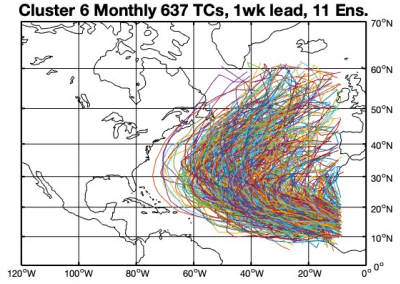


Tropical - W



Caribbean

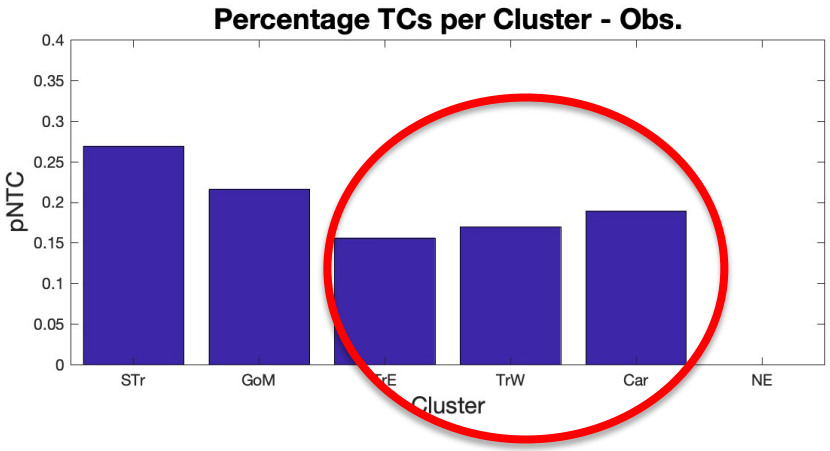


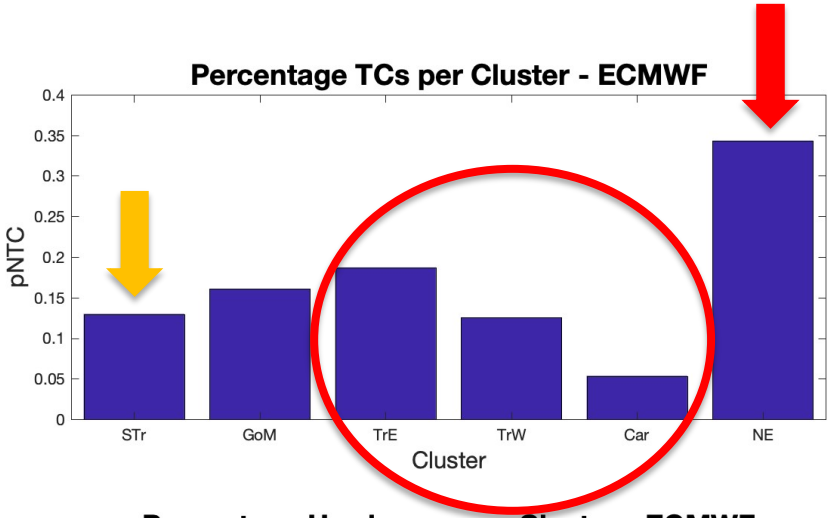


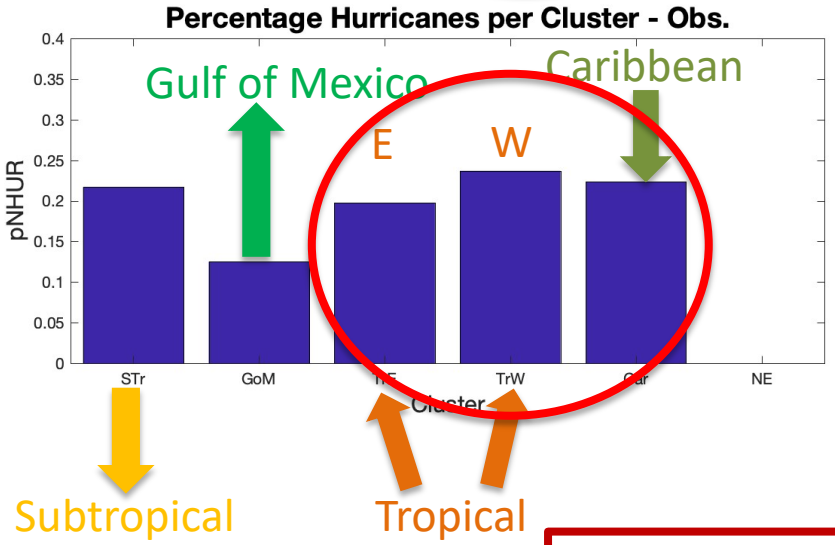
Similar to Kossin et al. J. Climate, 2010 (4 clusters): Tropical = Tropical E + Tropical W

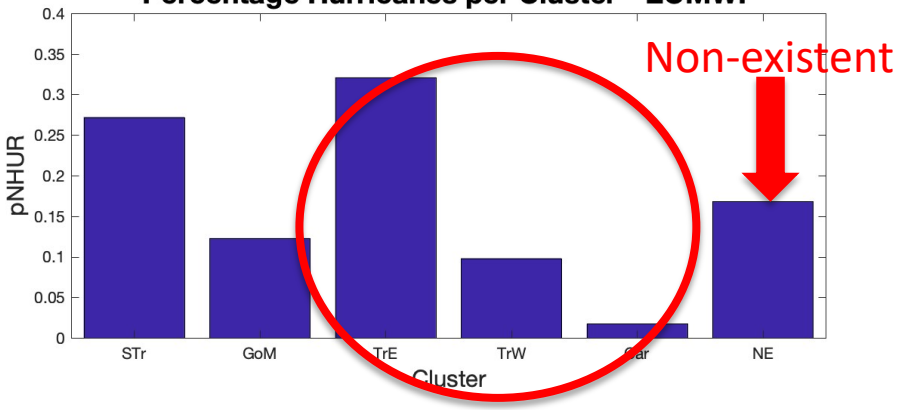
Camargo, et al. 2020, in preparation

Percentage of TCs per cluster









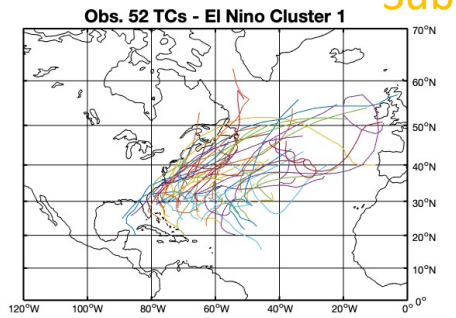
Camargo, Lee & Vitart, 2020, in preparation

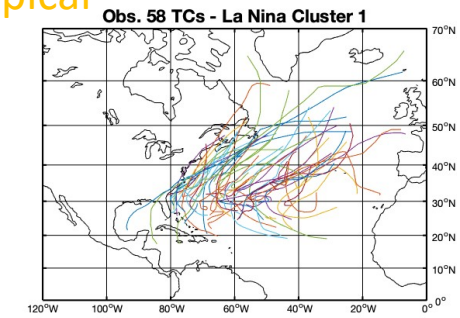
ENSO modulation – Observations (1950 – 2017)

El Niño

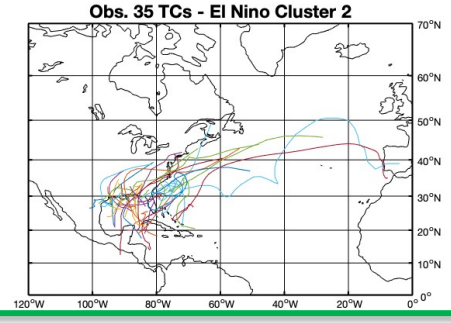
La Niña

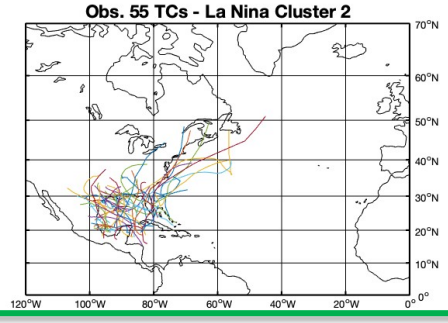
Subtropical



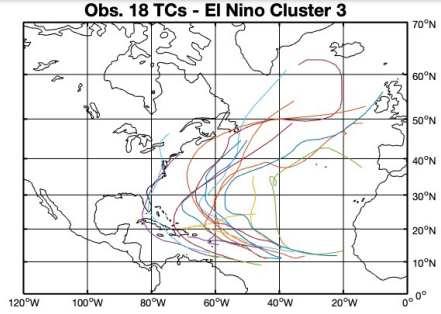


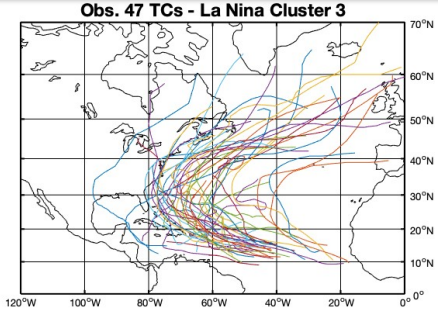
Gulf of Mexico





Tropical - E

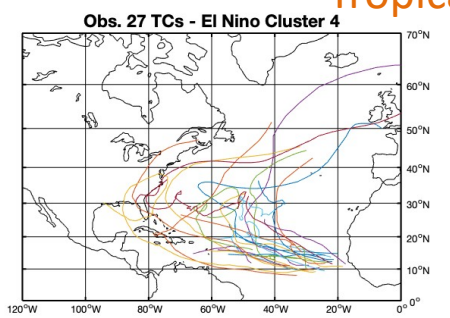


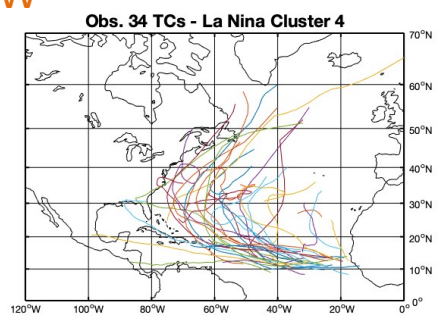


El Niño

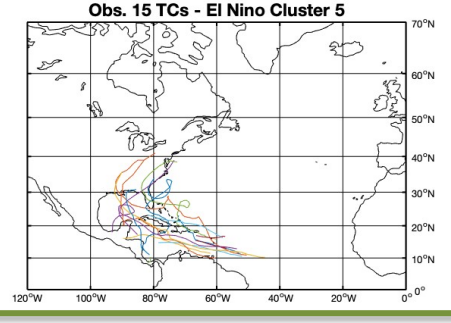
La Niña

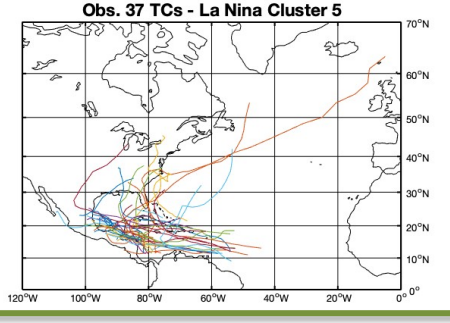
Tropical - W





Caribbean





Kossin et al. 2010 (data: 1950-2007):
4 Clusters:
Tropical = Tropical E + Tropical W
ENSO signal: Gulf of Mexico (weak), Tropical, Caribbean

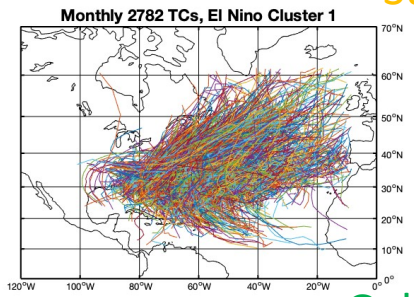
Camargo, Lee & Vitart, 2020, in preparation

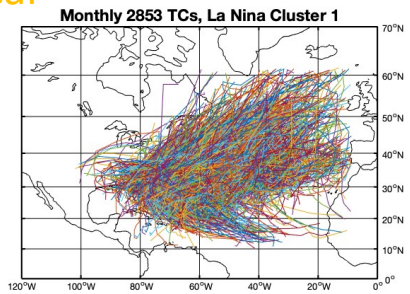
ENSO modulation - ECMWF

El Niño

La Niña

Subtropical

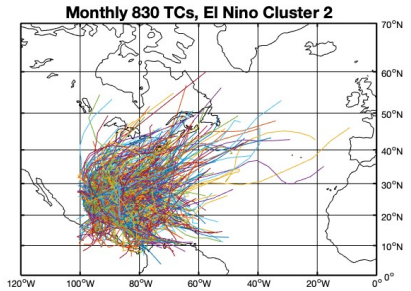


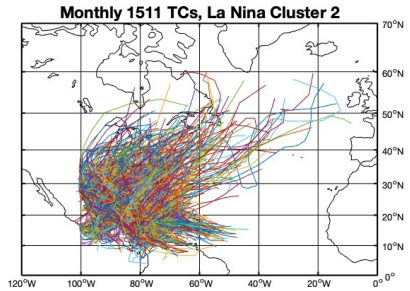


830 TCs

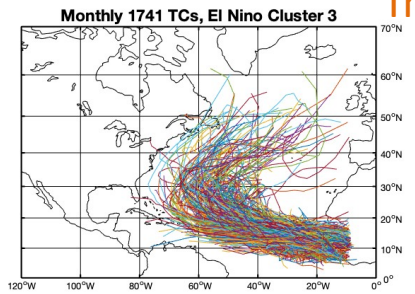
Gulf of Mexico

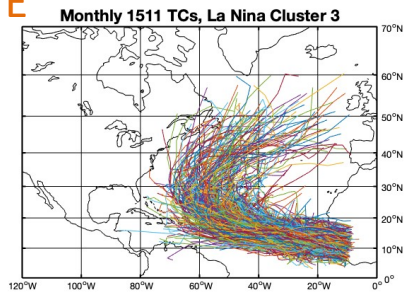
1511 TCs





Tropical - E





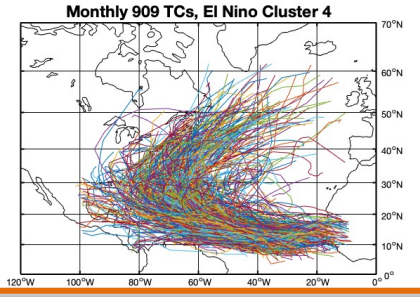
El Niño

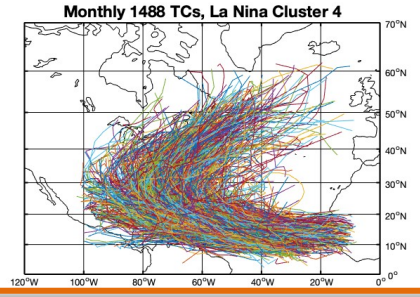
La Niña

909 TCs

Tropical - W

1488 TCs

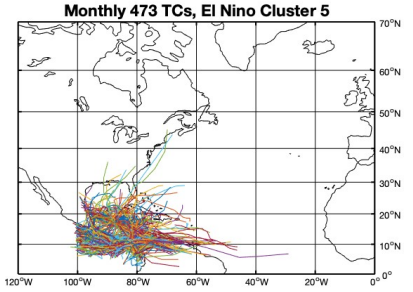


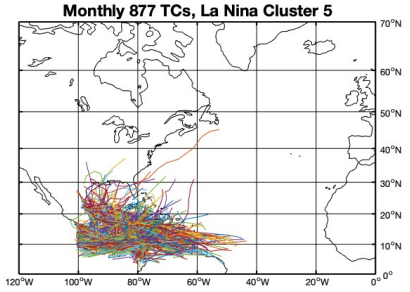


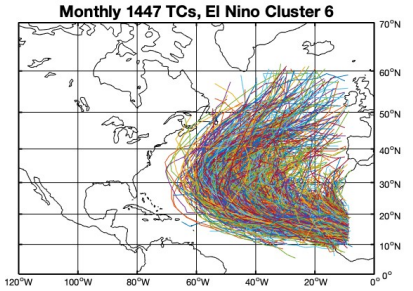
473 TCs

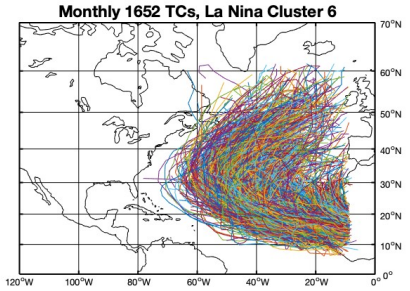
Caribbean

877 TCs





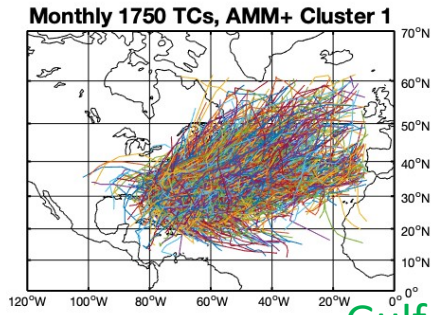


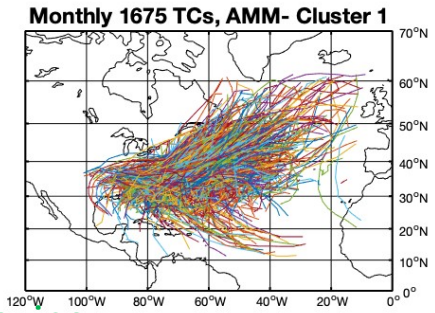


Camargo, Lee & Vitart, 2020, in preparation

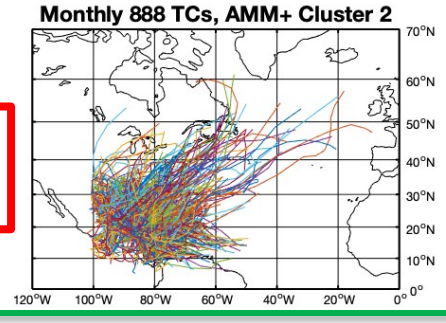
Atlantic Meridional Mode (AMM) Modulation

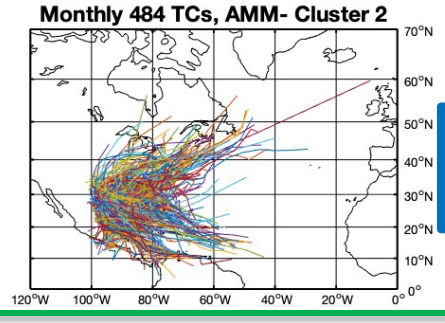
AMM+ | AMM-

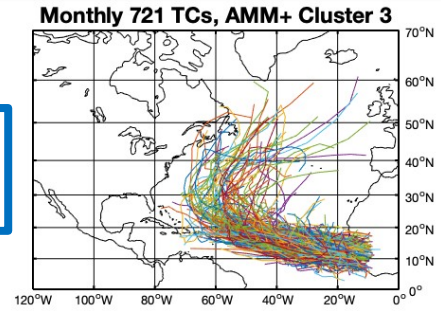


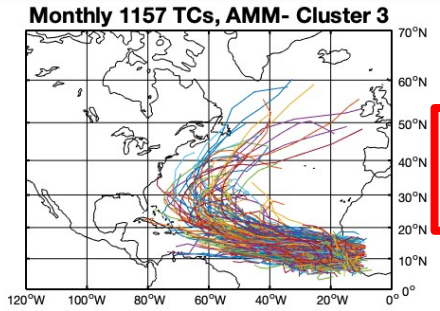


Gulf of Mexico





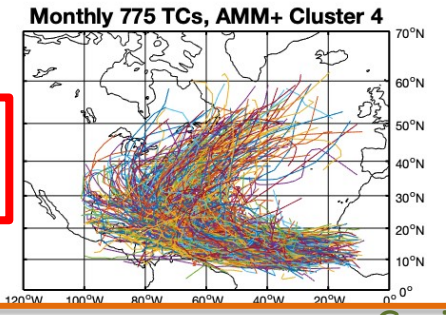


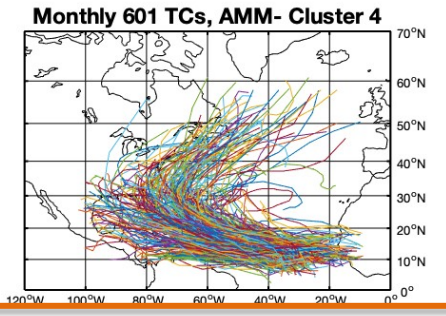


Tropical - E

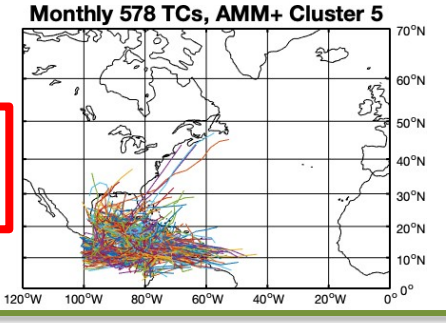
AMM+ | AMM-

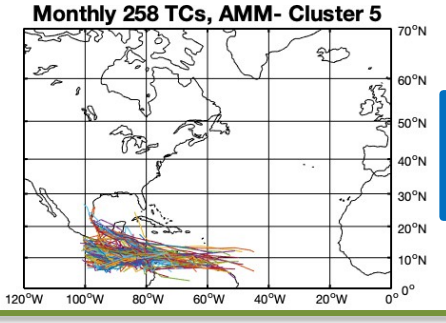
Tropical - W

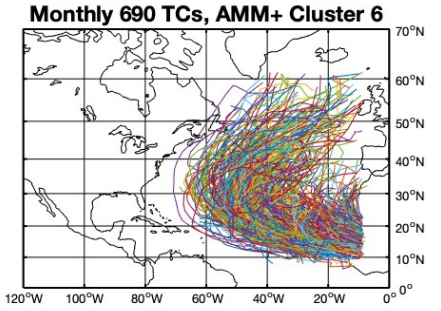


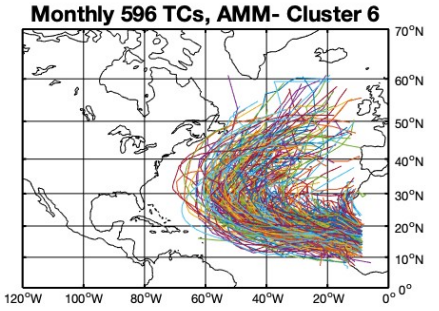


Caribbean



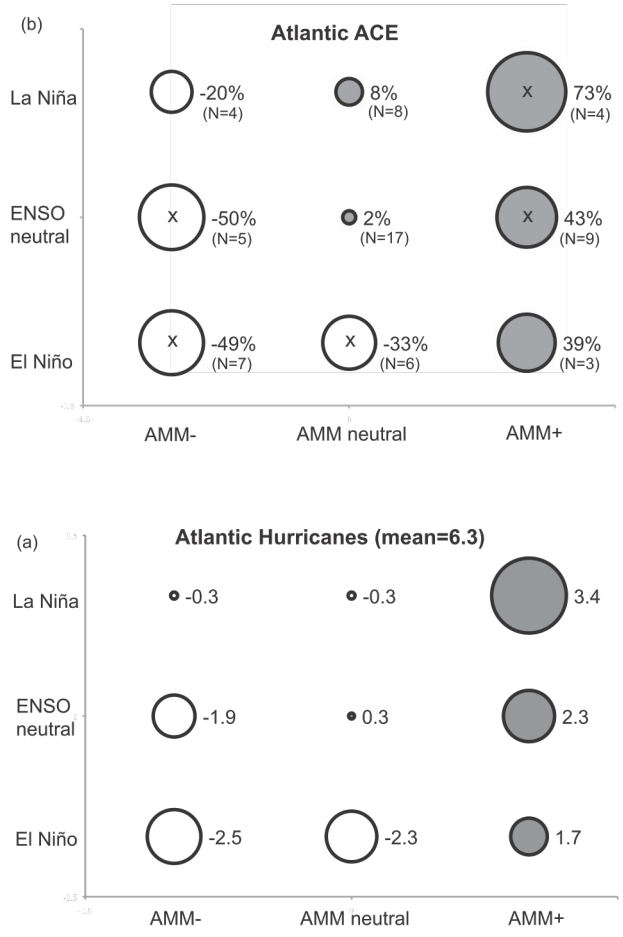






Camargo, Lee & Vitart, 2020, in preparation

Modulation of ENSO & AMM



Patricola et al. J. Climate 2014

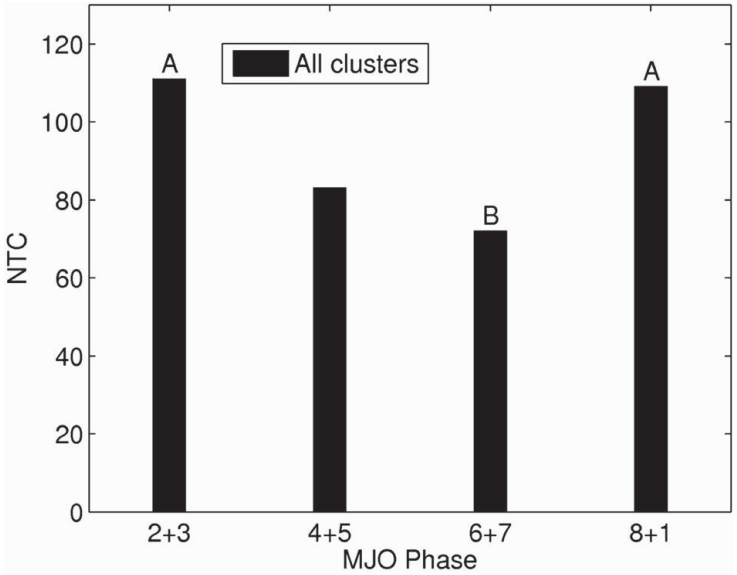
NTC

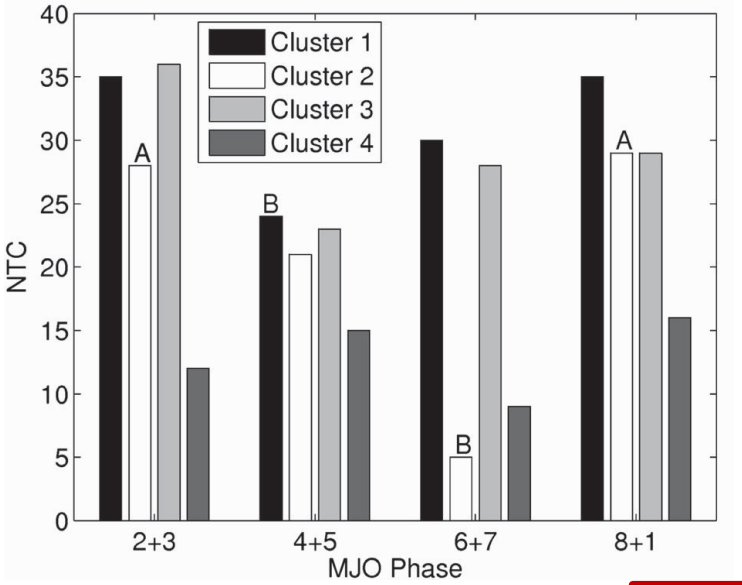
	AMM- El Niño	AMM- La Niña	AMM+ El Niño	AMM+ La Niña
ALL	23.3%	14.8%	12.6%	49.2%
Subtropical	26.9%	15.6%	19.2%	38.2%
Gulf of Mexico	14.8%	13.1%	15.1%	57.0%
Tropical-E	36.7%	17.9%	6.4%	38.9%
Tropical-W	16.1%	16.6%	5.3%	61.6%
Caribbean	9.7%	11.5%	22.4%	56.4%
Non-existent	24.5%	11.1%	1.6%	62.8%

OBS

MJO modulation

Observations





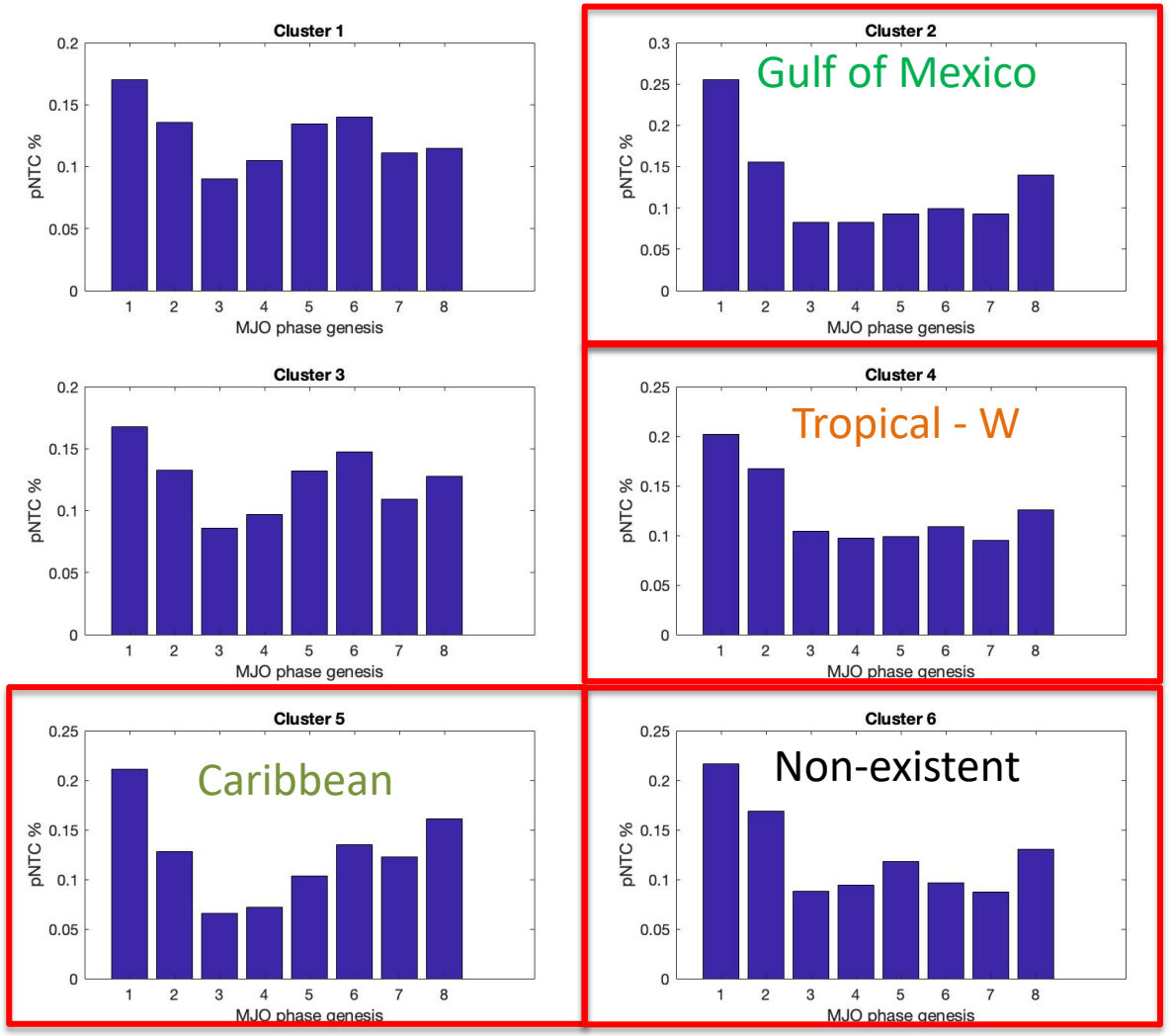
Kossin et al. 2010

Above-normal
Phases 8+1 & 2+3

Below-normal
Phases 6+7

Cluster Modulation:
Gulf of Mexico

ECMWF

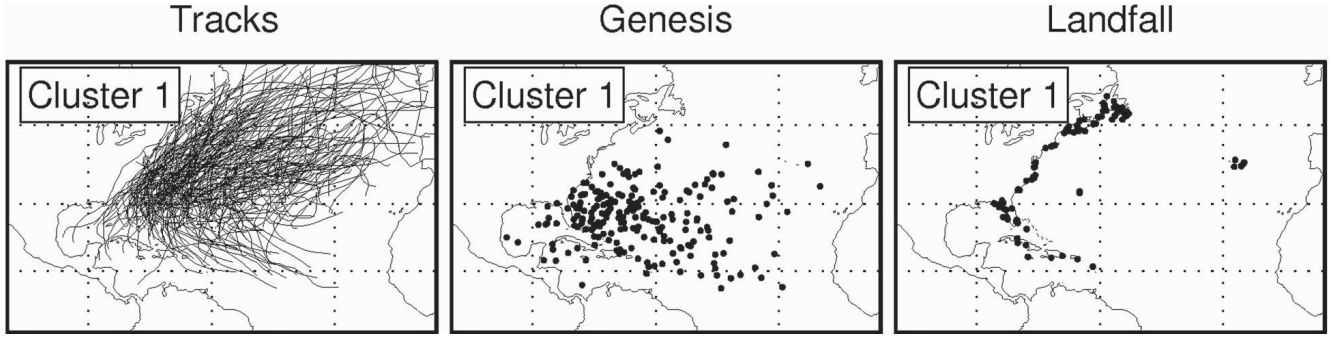


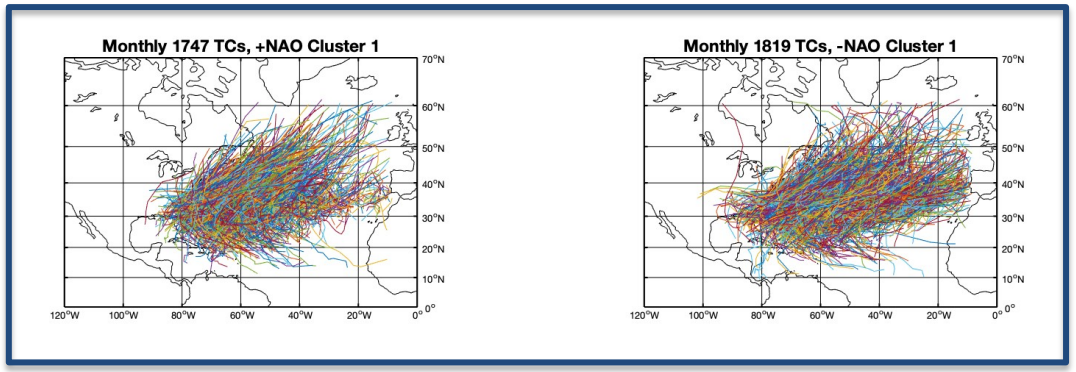
Camargo, Lee & Vitart, 2020, in preparation

Above normal: Phases 1+2

NAO modulation

Kossin et al. 2010:
NAO modulation of Subtropical Cluster





No significant modulation in ECMWF TCs
Why?
- Model NAO?
- NAO – TC relationship?

Camargo, Lee & Vitart, 2020, in preparation

US landfall predictions – preliminary results

Lead	Model	Clim.
w1	0.63	0.21
w2	0.40	0.21
w3	0.24	0.21
w4	0.17	0.21
w5	0.16	0.21
w6	0.13	0.21

Analysis by F. Vitart

- Week 1:
  - Very few false alarms
  - More cases of non-prediction, e.g. short lived systems
  - Associated with initialization errors
- Weeks 4 – 6:
  - Low skill
  - Probably due to seasonal cycle biases
- Smaller regions skill lower than whole U.S.

Camargo, Lee & Vitart, 2020, in preparation

Summary - ECMWF Monthly forecasts

- NTC overpredicted weeks 1 and 2.
- Number hurricanes typically underpredicted for all weeks.
- Atlantic tracks have similar characteristics to observed tracks, with exception of near Africa tracks.
- ENSO and MJO modulation clearly reproduced by ECMWF system.
- NAO modulation not significant in the ECMWF system.
- Preliminary results show promise in U.S. landfall forecasts.

Camargo, Lee & Vitart, 2020, in preparation