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Sensitivity of Tropical Cyclones to Resolution, Convection Scheme and Ocean Flux Parameterization over Eastern Tropical Pacific and Tropical North Atlantic Oceans in RegCM4 Model

Ramón Fuentes Franco, Filippo Giorgi, Erika Coppola,
Klaus Zimmermann

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Objectives

- To explore the sensitivity of TCs simulations to
  - model resolution,
  - cumulus convection and
  - ocean surface flux parameterization

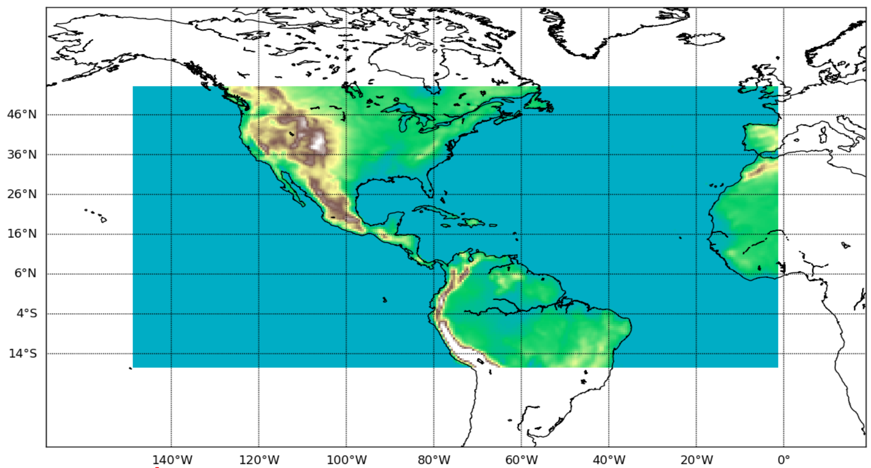
From the simulated Tropical Cyclones (TCs) we analyzed

- Duration
- Maximum wind speed reached
- Minimum surface pressure

Over the Tropical North Atlantic (TNA) and Eastern Tropical Pacific (ETP).

RegCM4 configuration

Central America CORDEX domain



- Resolution
  a. 50 km
  b. 25 km
- Convection schemes over Ocean
  a. Emanuel (1991)
  b. Kain-Fritsch (Kain-Fritsch 1990, Kain 2004)
- Ocean flux parameterization
  a. Zeng et al. (1998)
  b. Monin-Obukhov (BATS, Dickinson et al. 1993)

- 10 TC seasons (JJASON) 1989-1998
- ERA Interim 0.75 degrees ICBC
- Radiation: Kiehl et al. [1996],
- Planetary boundary layer: Holtslag et al. [1990],
- Resolvable scale precipitation: Pal et al. [2000],
- Community Land Model 4.5
- Grell convection scheme over the land points of the domain,

Ocean Flux Parameterization by Zeng

- In the Charnock approach used by Zeng, the ocean surface roughness is given by the formula:

$$z_u = \frac{\alpha u_*^{\,2}}{g} + \frac{0.11\nu}{u_*}$$

ν: molecular viscosity of air;
g: gravitational acceleration;
u_*: friction velocity;

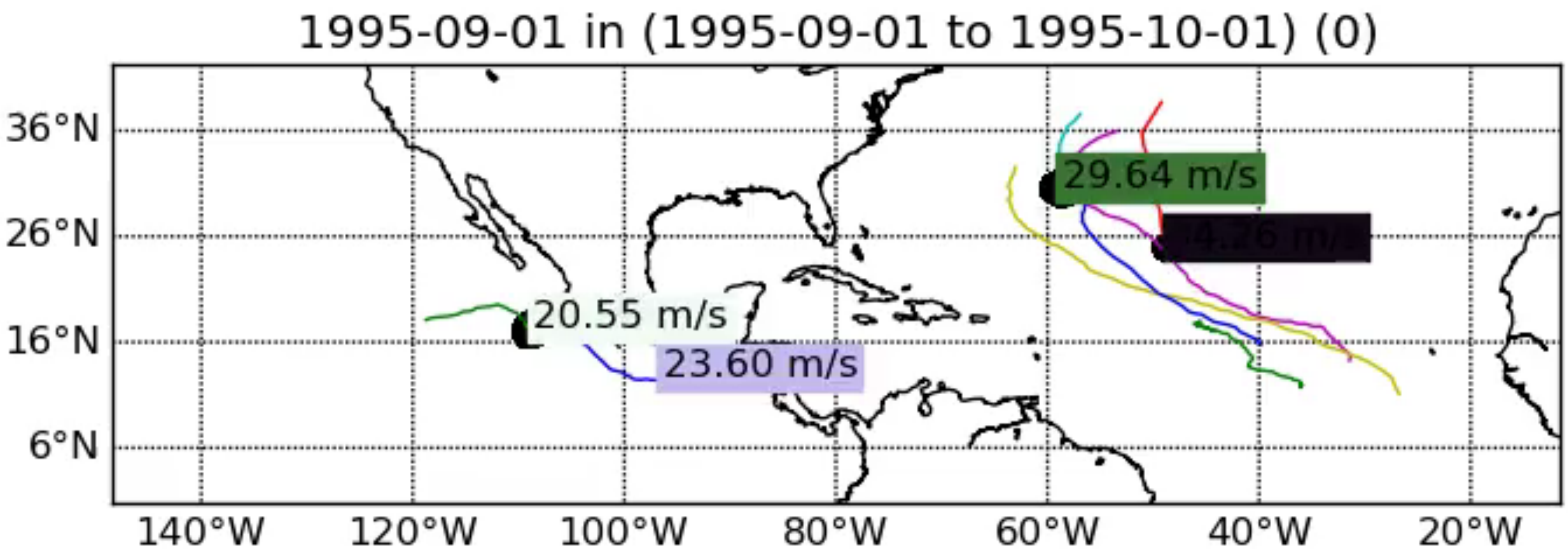
α: Charnock parameter, a constant with values in the range of 0.011-0.035.

We tested two values α_1=0.013 corresponding to 10 $ms^{-1} \leq U_{10} \leq$ 18 ms^{-1} and α_2=0.018, corresponding to 18 $ms^{-1} \leq U_{10} \leq$ 25 ms^{-1} [Fairall et al 2003, Zeng et al 2010].

Set of experiments

	Emanuel	Kain-Fritsch	Zeng		Monin-Obukhov	Resolution	
			α=0.013	α=0.018		50km	25km
Em50	X		X			X	
KF50		X	X			X	
Em25	X		X				X
KF25		X	X				X
KF25Z		X		X			X
KF25B		X			X		X

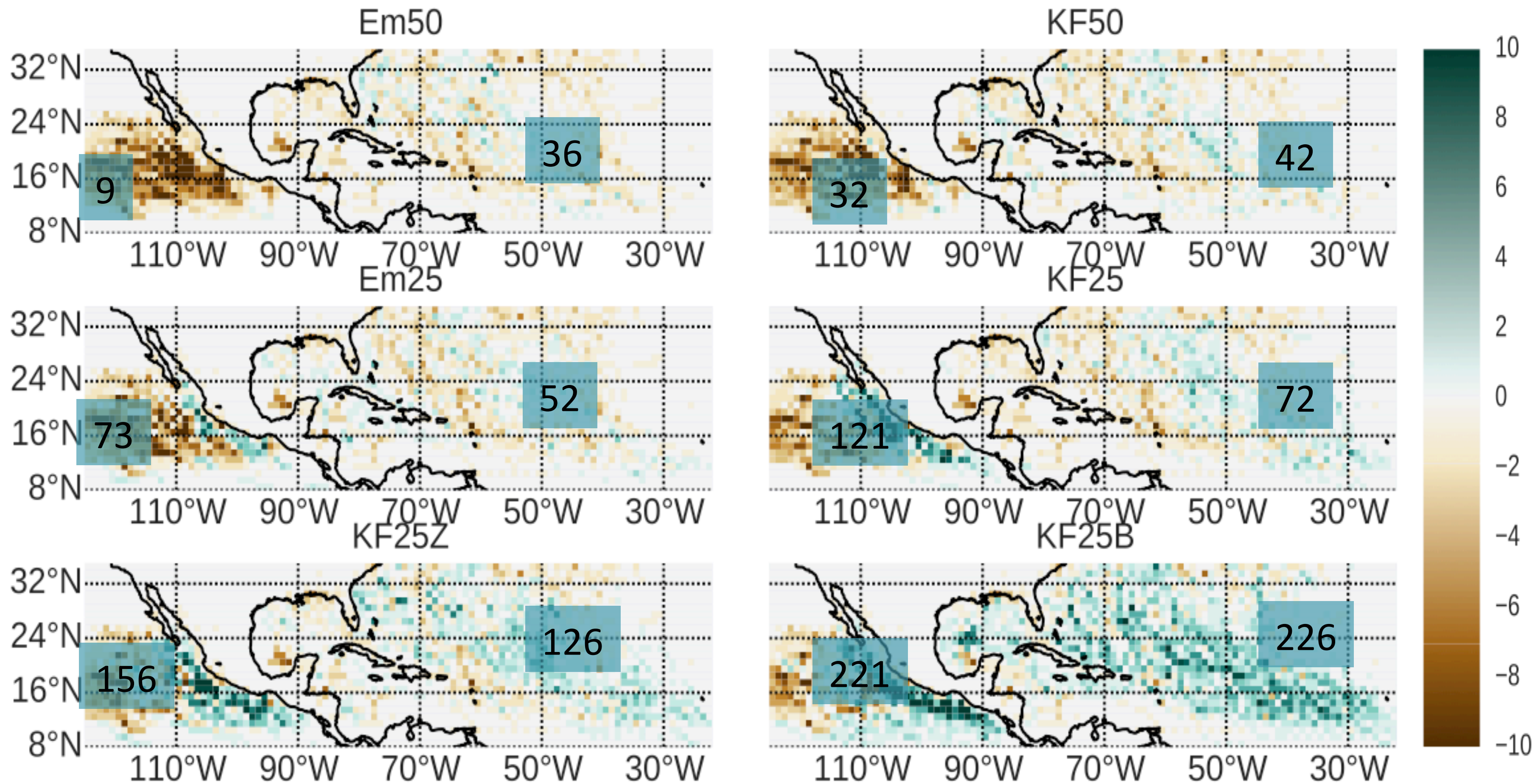
TCs detection and tracking



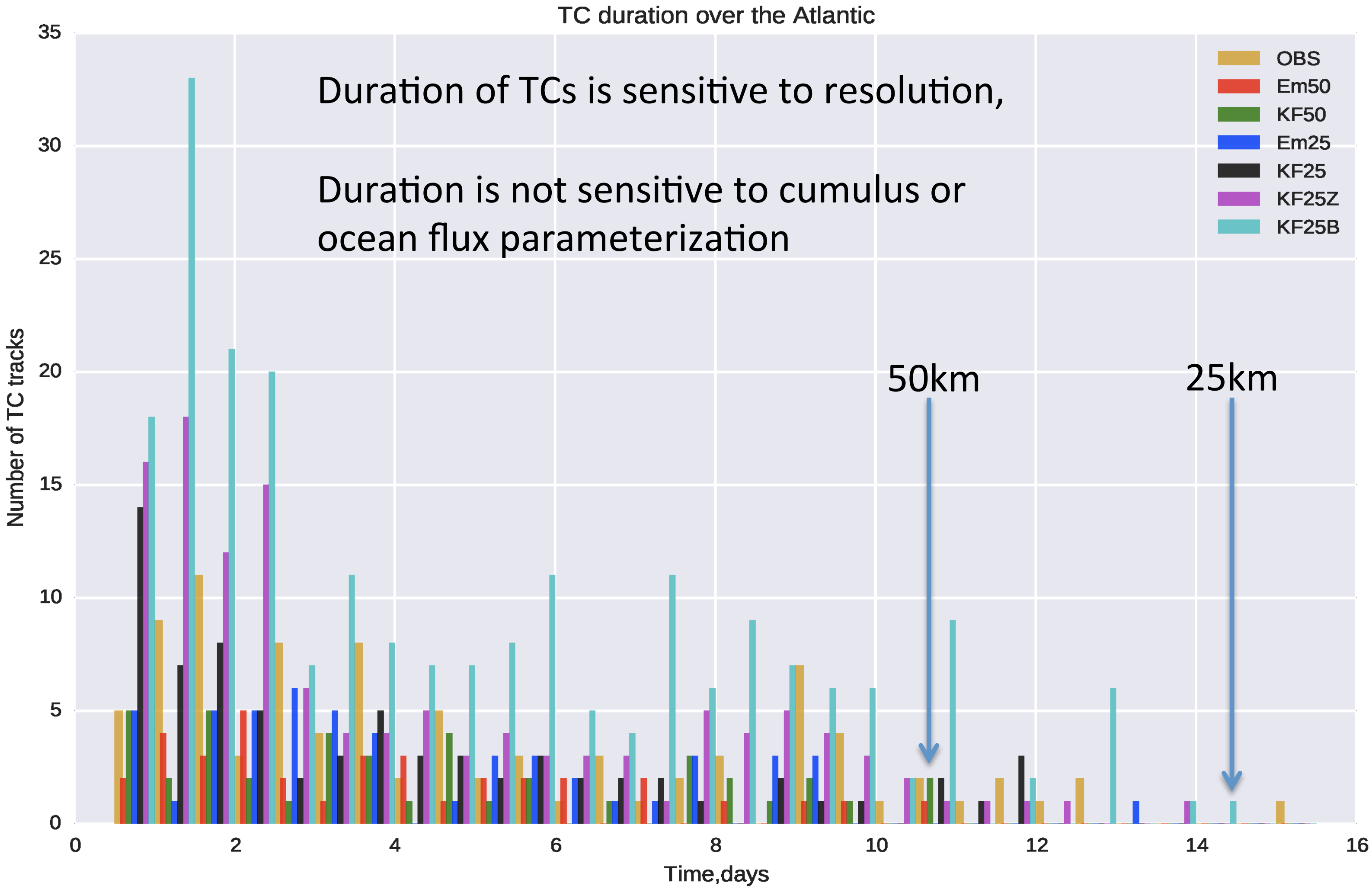
Cyclops: Cyclone's detector and tracker: https://github.com/fuentesfranco/cyclops

Detection thresholds: Wind speed >21 ms^{-1}, SLP<1005 hPa, SST >= 25 C
Tracking algorithm: a check is performed on each six hourly sample to find whether there are cyclones during the next 24 hour period within a radius of 6X6 longitude- latitude grid boxes.
Output: Time, latitude and longitude of centroid of the simulated TC. Maximum windspeed and minimum pressure at the same time step as the input files.

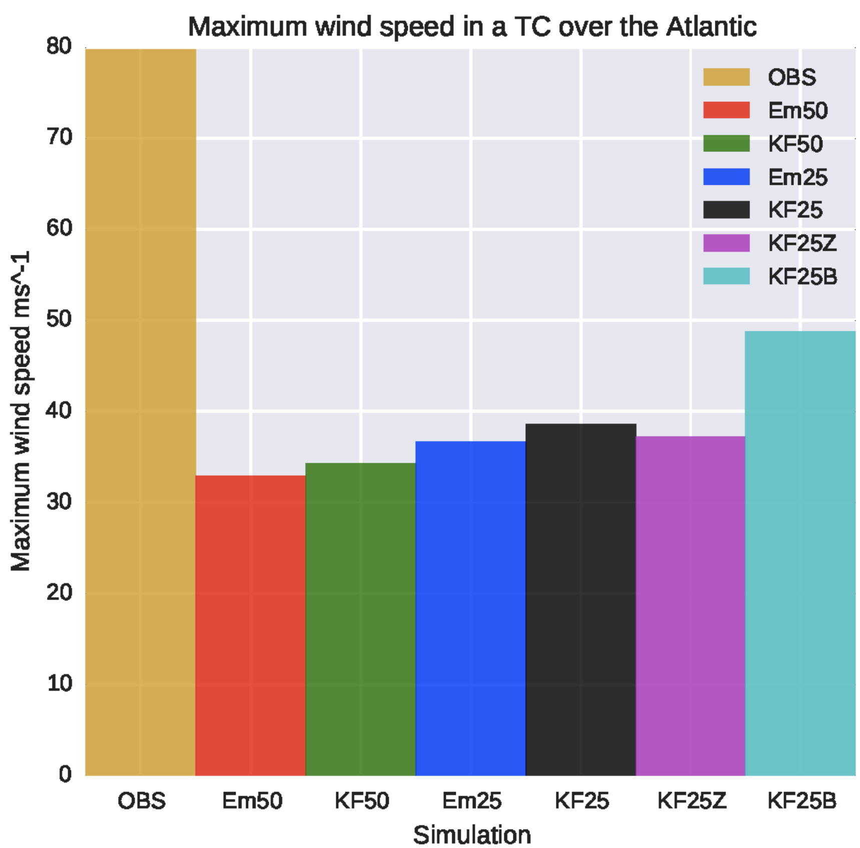
Spatial TC density bias: simulated Number of TC tracks minus observed TCs

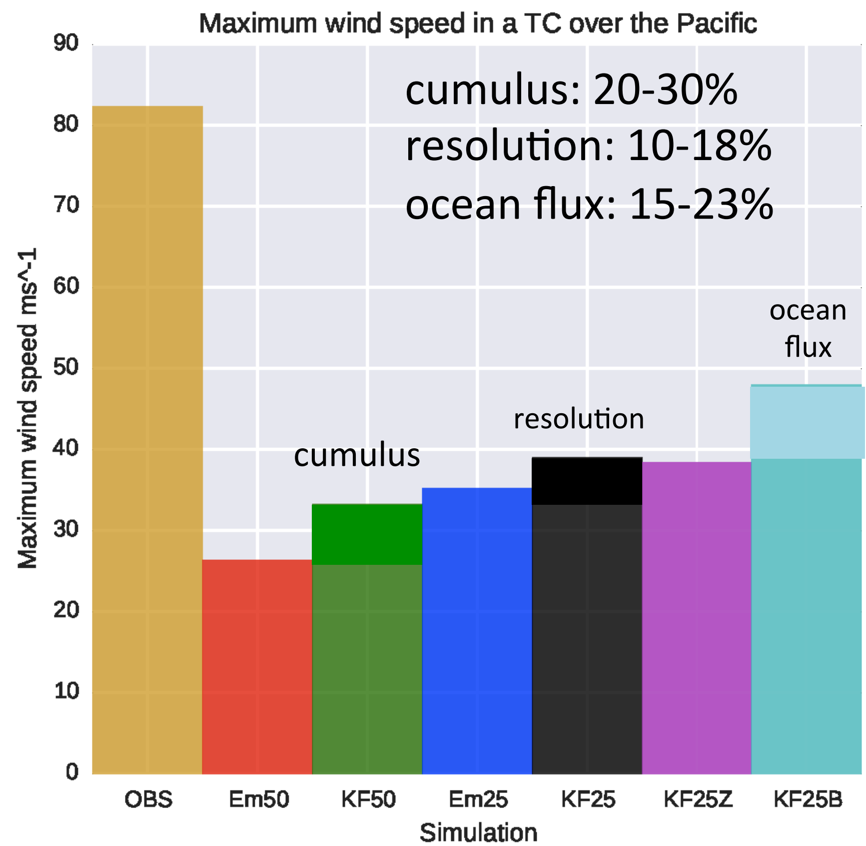


Duration of TCs

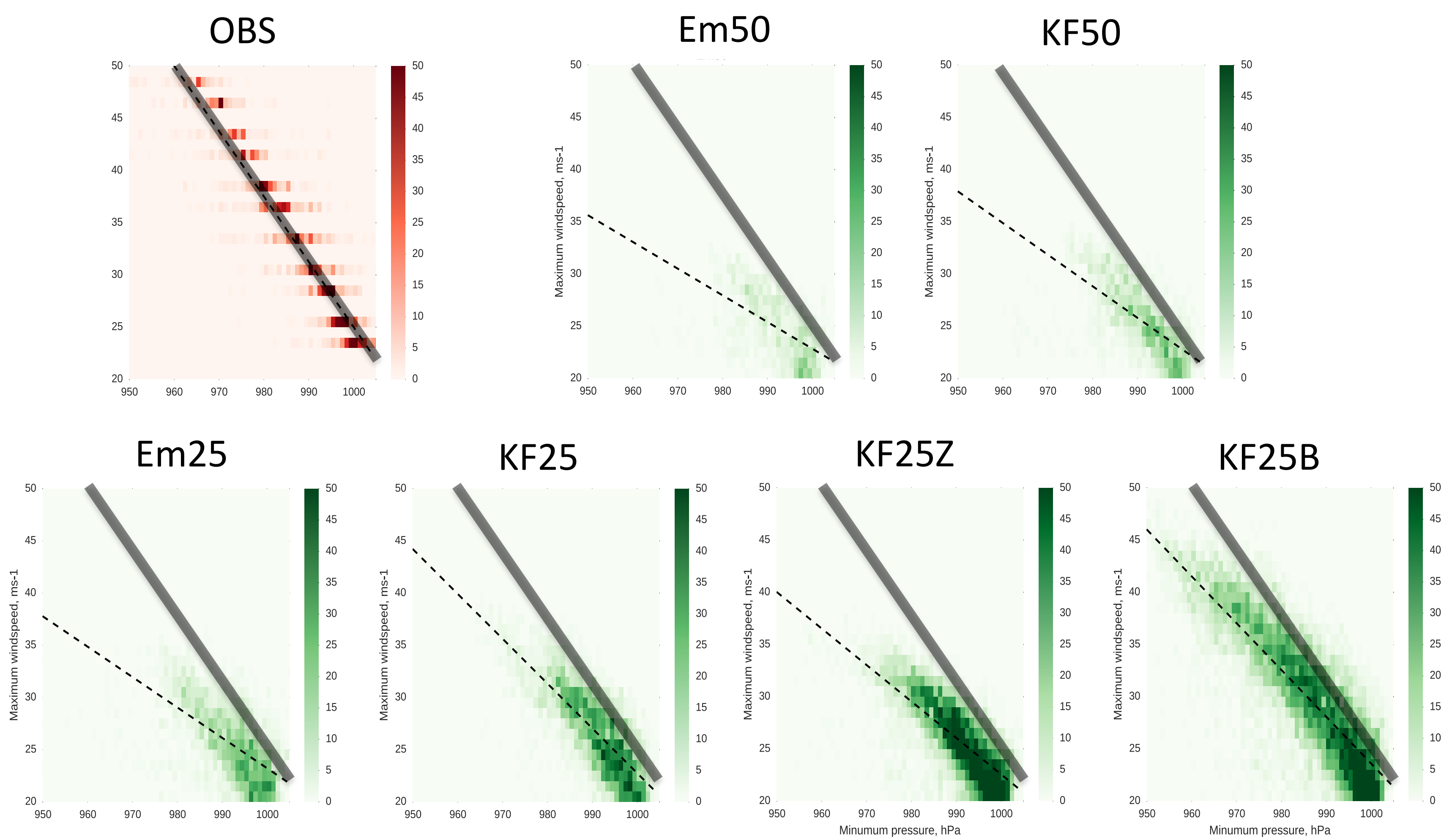


TC's maximum wind speed (mws)

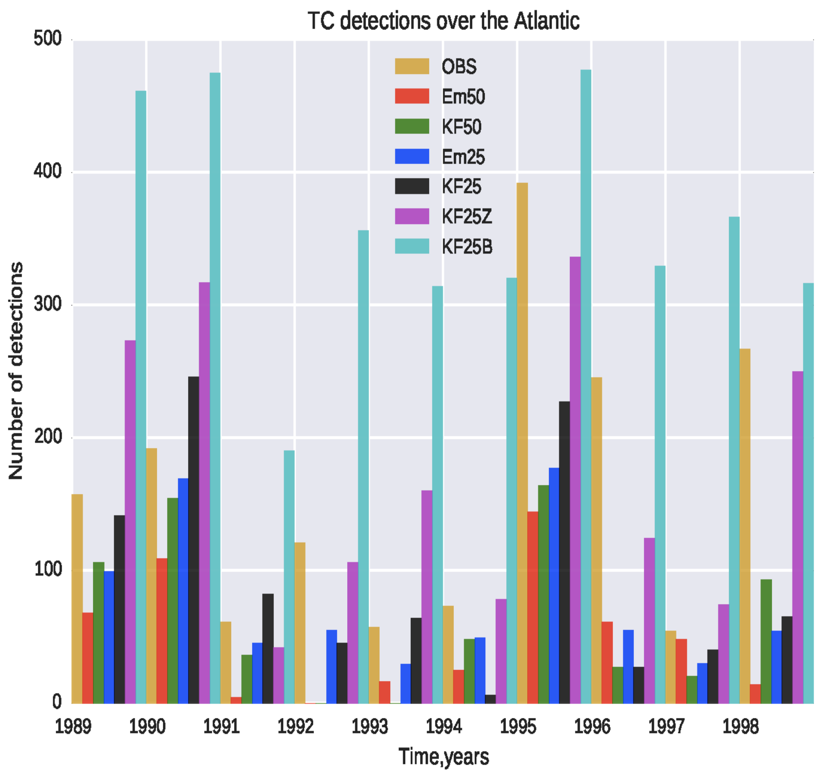




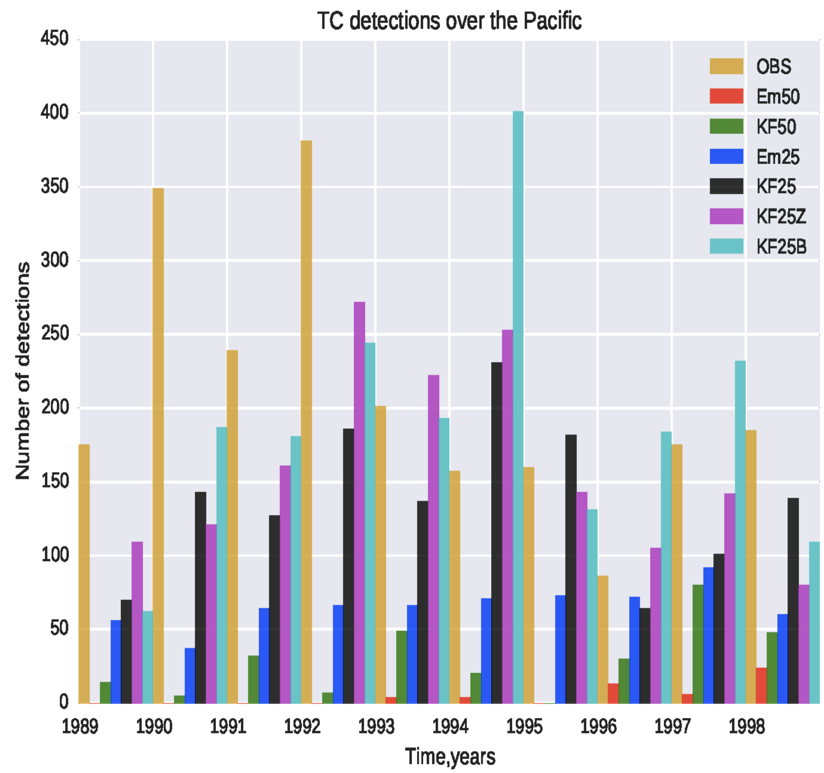
Minimum pressure vs maximum wind speed



Interannual variability of TCs



Em50	KF50	Em25	KF25	KF25Z	KF25B
0.69	0.71	0.69	0.55	0.74	0.52

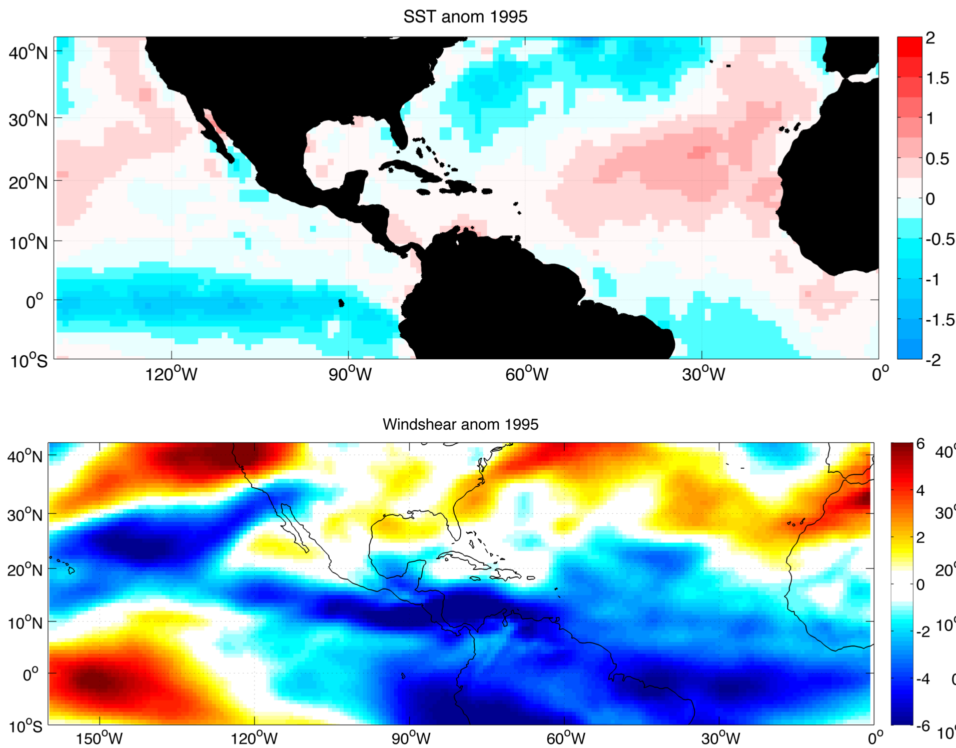


Em50	KF50	Em25	KF25	KF25Z	KF25B
-0.15	0.02	0.21	0.30	0.07	0.11

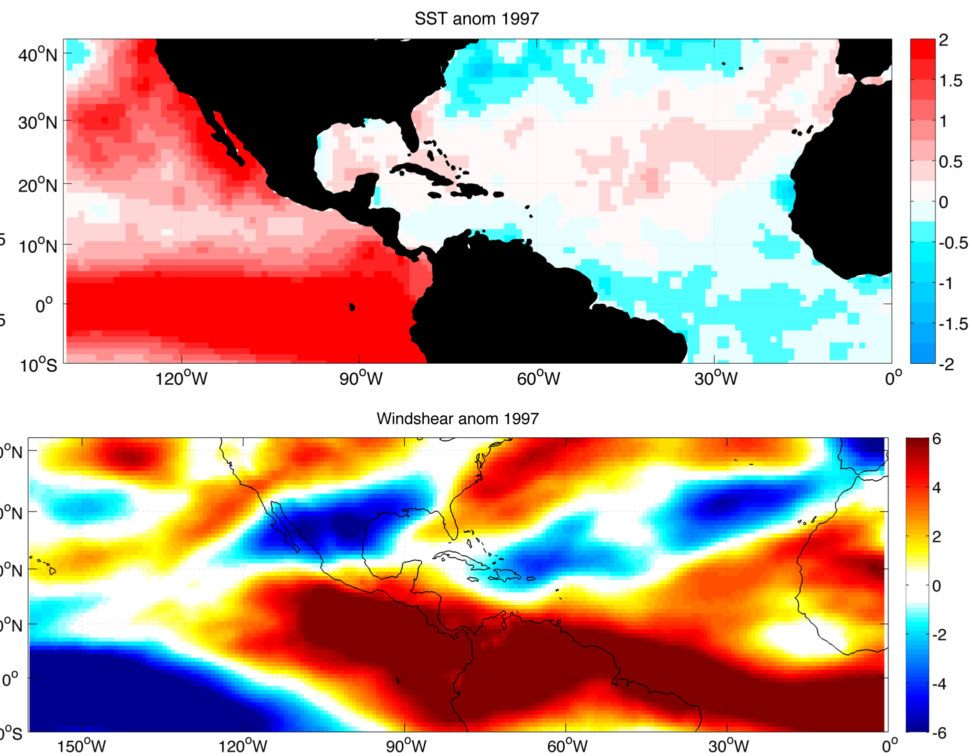
- Given the perfect boundary forcing from SST and lateral boundary conditions:
  - Are simulated cyclogenesis and TC tracks coincident to observed?
  - If the latter is true, up to which point are they coincident?

Observed SST and wind shear (EIN) anomalies

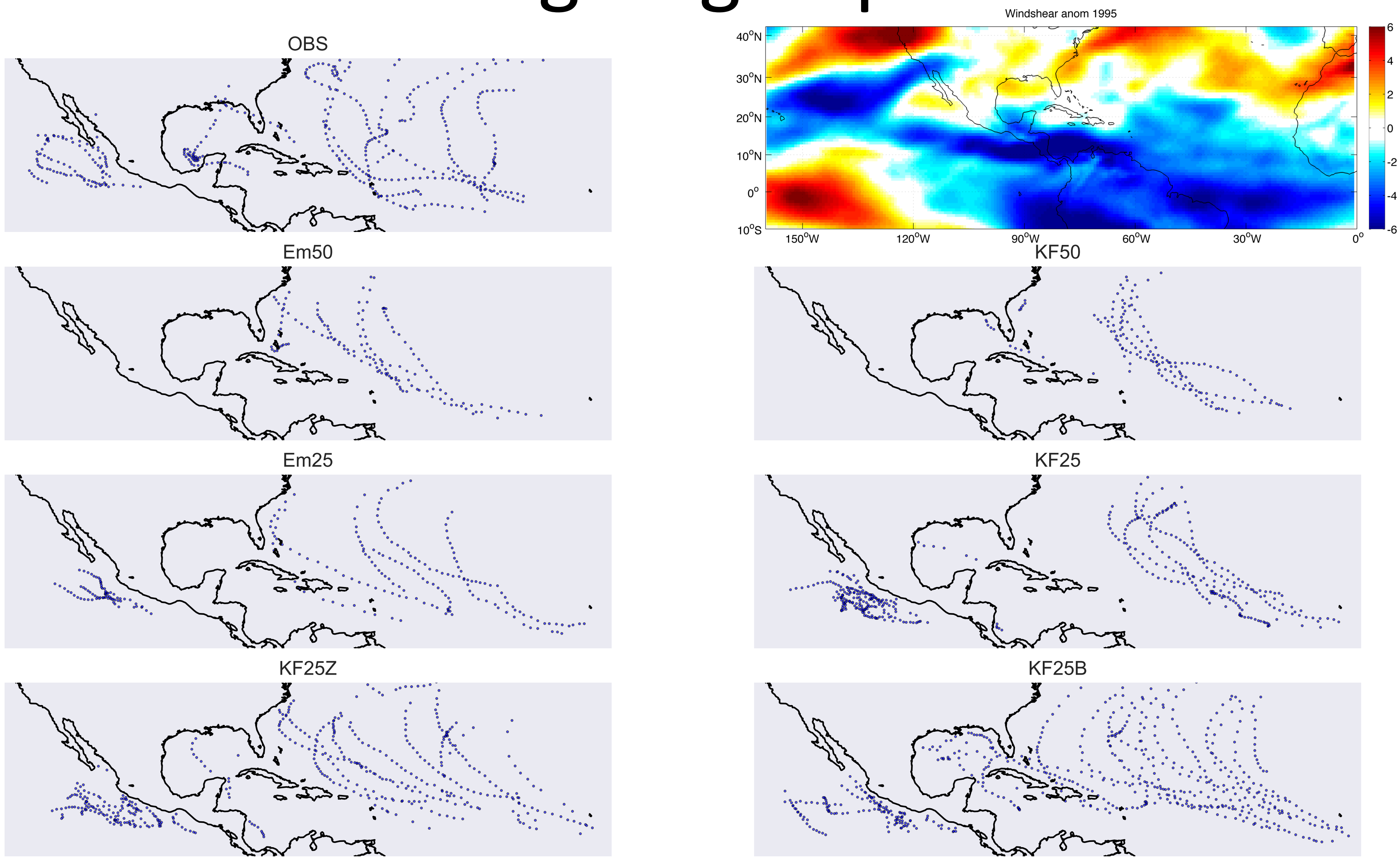
1995



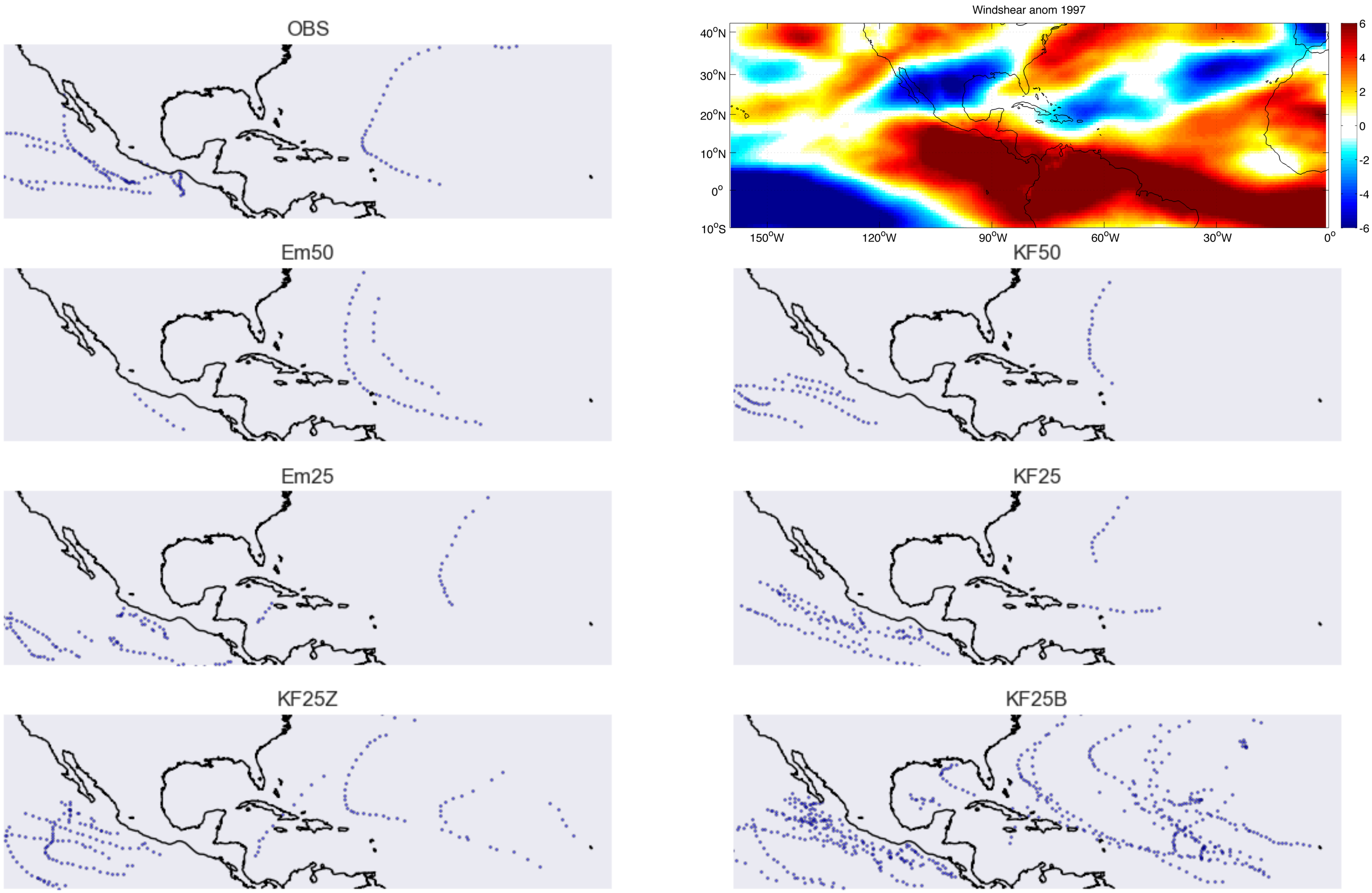
1997



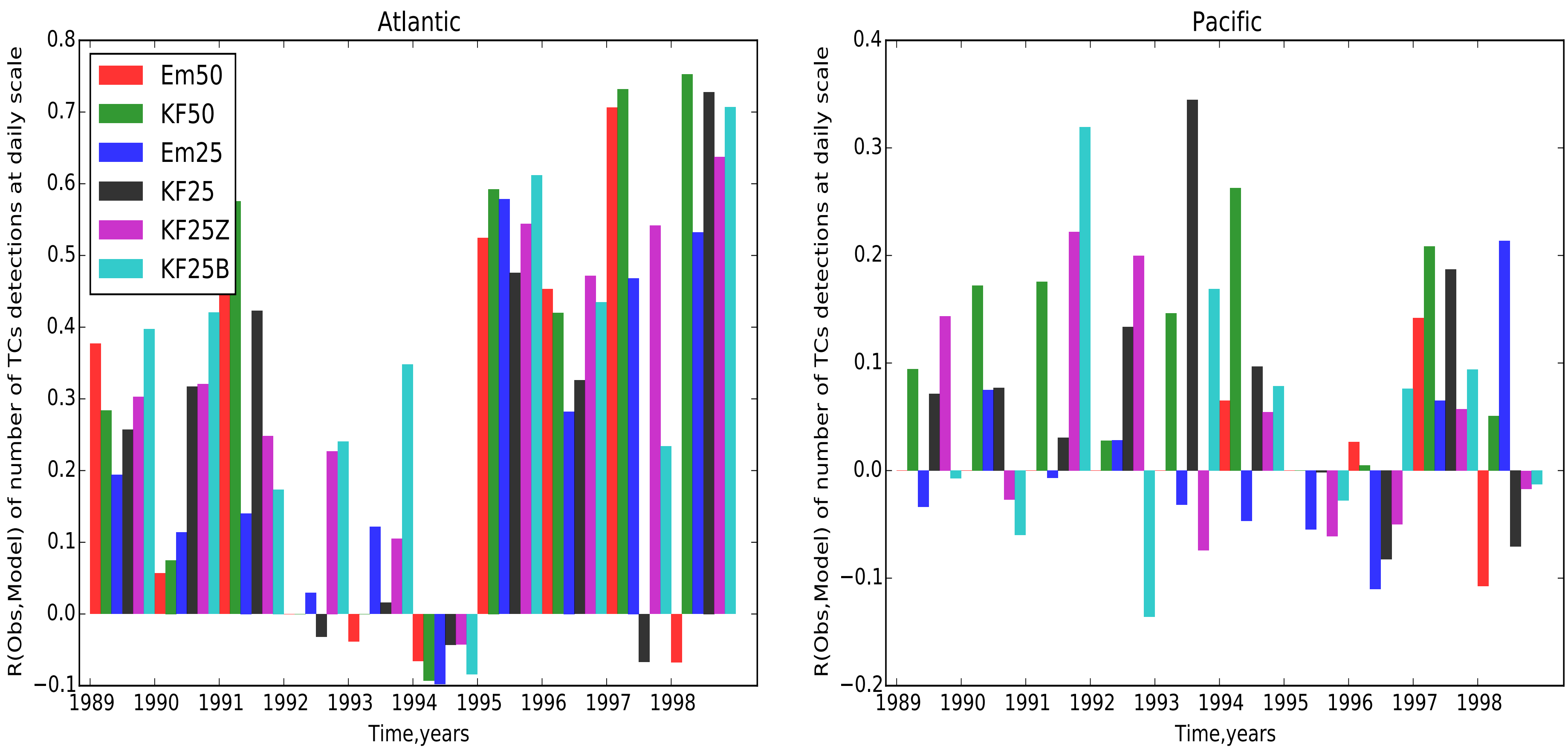
TCs during Aug-Sept 1995



TCs during Aug-Sept 1997

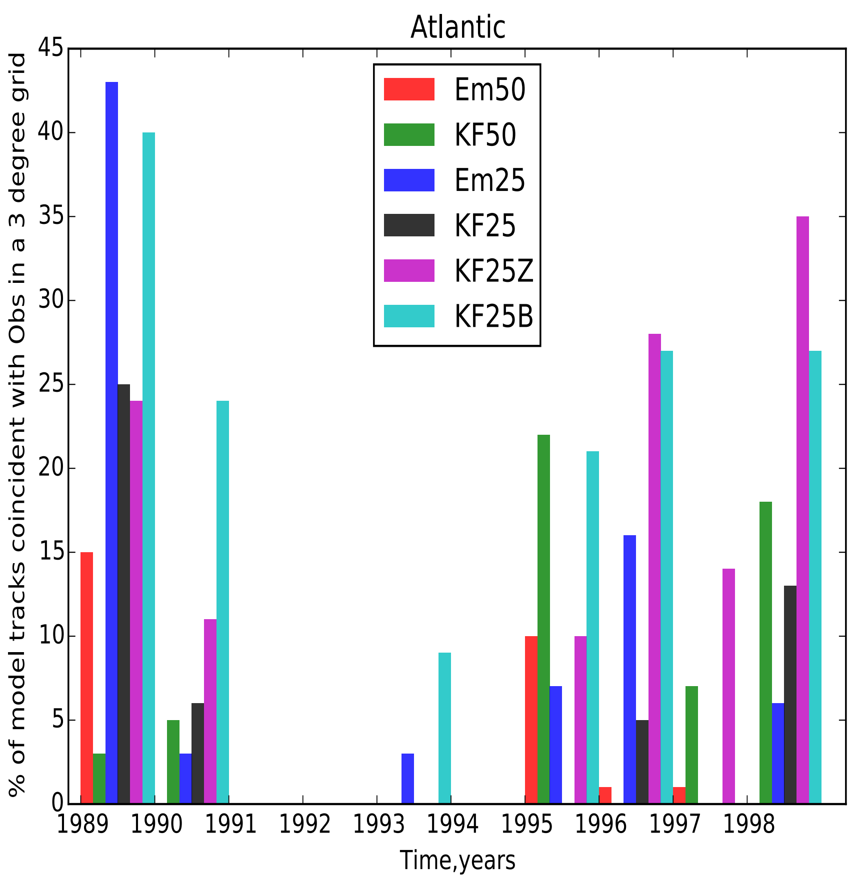


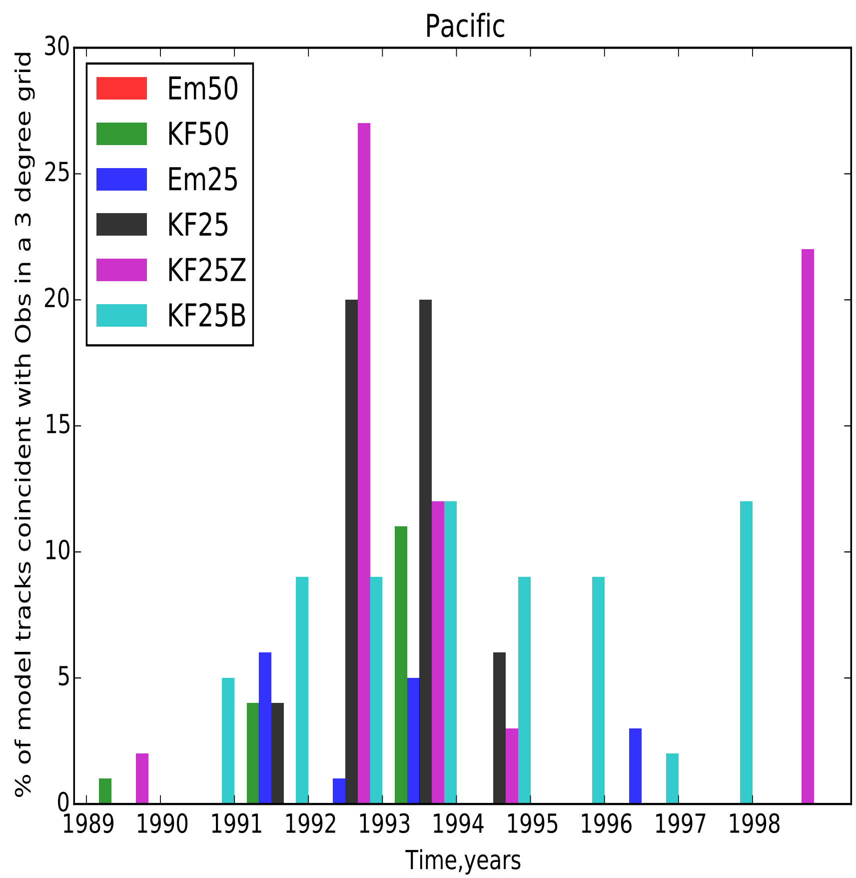
Correlation of observed and simulated number of TCs detected at the daily scale over the TNA (left) and ETP (right)



The correlation values are calculated annually using daily time series

Percentage of number of observed TC that had a simulated TC within a 3 degree radius





The percentage is calculated considering the total amount of observed TCs

Conclusions

The model exhibited a basin-dependent response.

- TNA: Greater sensitivity to physics schemes (particularly to ocean fluxes) than to resolution.
- ETP: Strong sensitivity to resolution, more than to the physics schemes.

Conclusions

The relationship between peak wind speed and central SLP, is underestimated, which can be attributed, at least partially, to the mis-representation of the wind-dependence of the surface roughness for the high wind speeds found in TCs.

The interannual variability of TC counts over the TNA basin was well simulated by all model configurations, suggesting that it did capture the large scale constraints on the TC genesis.

Conclusions

- Overall the best model performance was using:
  - 25 km resolution
  - Kain-Fritsch as convection scheme.
  - Zeng as ocean flux parameterization with α=0.013.

- Paper submitted to Climate Dynamics (2016)

Thank you!