Tracking des cyclones tropicaux dans ERA5 et perspectives d'utilisation des indices de cyclogénèse pour la prévision intra-saisonnière et saisonnière

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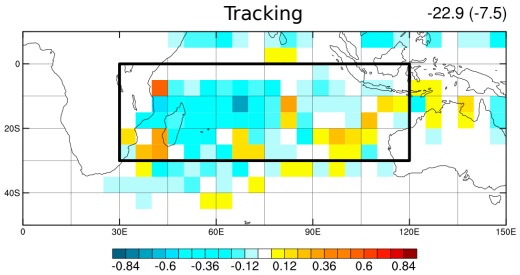
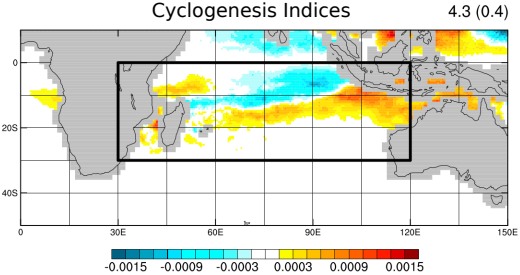
Problematic



Projected change in track density (points per year and per 5° x 5° grid box) from CNRM-CM6-HR forced by RCP 8.5 SST over the 2051-2094 time period relative to 1971-2014 (Cattiaux et al., 2020)



Projected change in the average of three cyclogenesis indices (TCs per year and per 0.5° x 0.5° grid box) from CNRM-CM6-HR forced by RCP 8.5 SST over the 2051 - 2094 time period relative to 1971-2014 (Cattiaux et al., 2020)

Projections diverge. **Why?**

Tracking scheme

(Chauvin et al., 2006)

Detection steps

1. Vorticity threshold (**VOR**)
2. Estimation of the system's size and its surroundings
   - 10 meter wind speed threshold (**RES**)
   - Temperature anomaly at (**TANOM**) (700, 500 and 300 hPa)
   - Temperature vertical profile gradient (**PT**) (300 hPa - 850 hPa)
   - Wind speed vertical profile (**PW**) (300 hPa - 850 hPa)
3. Criteria relaxation for forward and backward completion (**REL**)

Later addition

Latitudes of 200 hPa geopotential maximum gradient as poleward limit.

Data and Methods

Datasets: 1981 - 2019

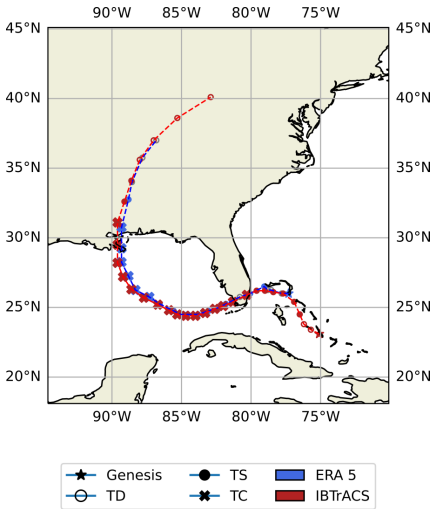
- CNRM Tracker over ERA5 at 0.25°
- IBTrACS v04 as reference

Method

Tool : Track pairing based on spatio-temporal overlapping:

1. Search for IBTrACS candidates based on temporal overlapping
2. Score based on the amount of points separated by less than 300 km
3. Selection of the pair with the highest score

$\rightarrow$ FAR $= \frac{N_{\text{ERA5}} - N_{\text{Hit}}}{N_{\text{ERA5}}}$, POD $= \frac{N_{\text{Hit}}}{N_{\text{IBTrACS}}}$



Hurricane Katrina, 2005, match result from the pairing algorithm

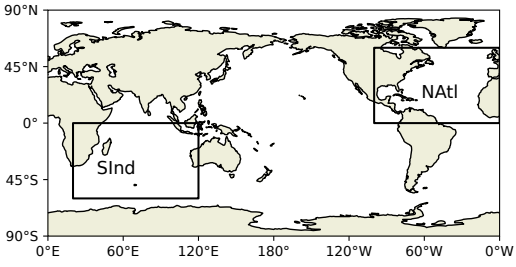
Protocol

Goal

Identify a set of thresholds (**VOR**, **RES**, **TANOM**, **PT**, **PW**) that both maximises the POD and minimizes the FAR

Limitation

No unique solution but a set of solution describing a **trade-off** between POD and FAR

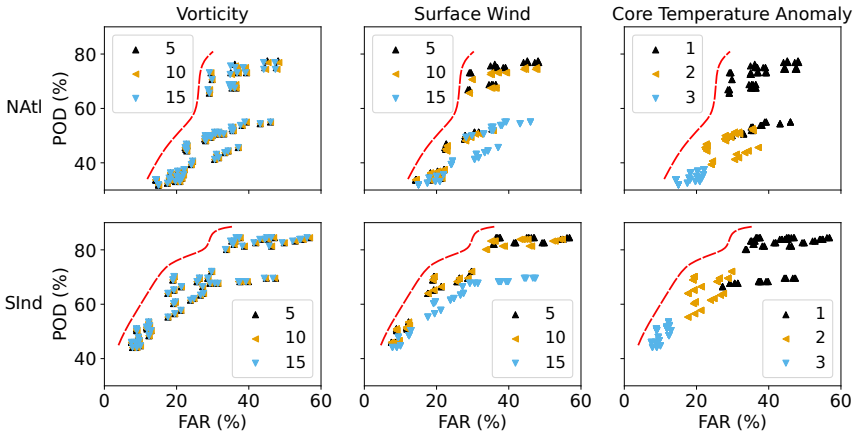


Method :

- 3 values per parameter, i.e 243 testing vectors
- 2 geographic regions (NAtl and SInd) between 2008 and 2018
- Tracking, pairing and FAR and POD calculation

Parameter	Value
VOR Vorticity threshold ($10^{-5} s^{-1}$)	5 ; 10 ; 15
RES 10m wind speed ($m.s^{-1}$)	5 ; 10 ; 15
TANOM Temperature anomaly (K)	1 ; 2 ; 3
PT Temperature vertical profile (K)	-1 ; -2 ; -3
PW Wind speed vertical profile ($m.s^{-1}$)	2 ; 5 ; 10

Tracking sensitivity in FAR / POD space



Trade off

We want to be as close as possible to the top left corner along the red line

Parameters

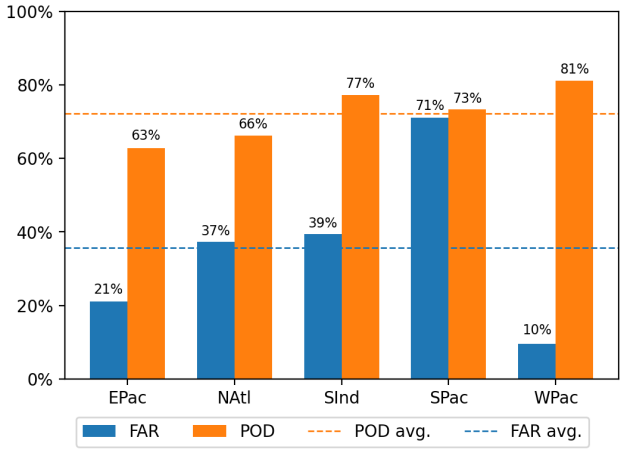
VOR : Tends to lower the FAR somewhat

RES : POD upper bound

TANOM : Stratifies vertically the FAR

FAR and POD per region

1981 - 2019



Detection thresholds

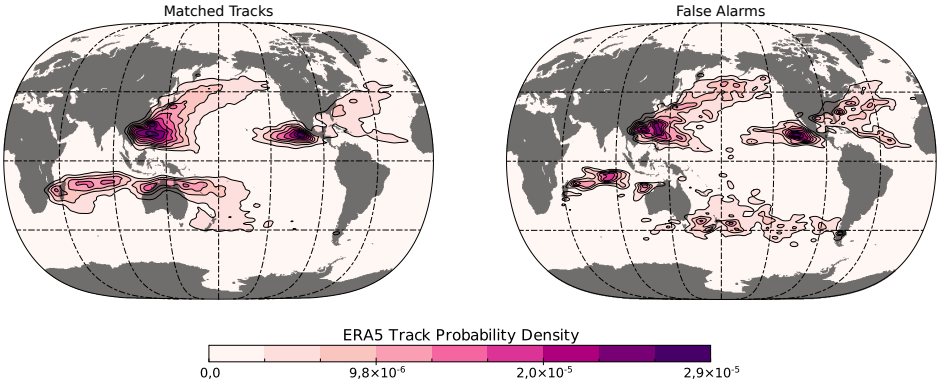
- **VOR** = 15 $\cdot 10^{-5} s^{-1}$
- **RES** = 5 $m.s^{-1}$
- **TANOM** = 1 K
- **PT** = -1 K
- **PW** = 5 $m.s^{-1}$
- **REL** = 25 $\cdot 10^{-5} s^{-1}$

Note

Includes the 200 hPa geopotential gradient filter

- POD: More consistent across regions with a 72.2% mean
- FAR: Global mean of 35.7% but largely due to SPac

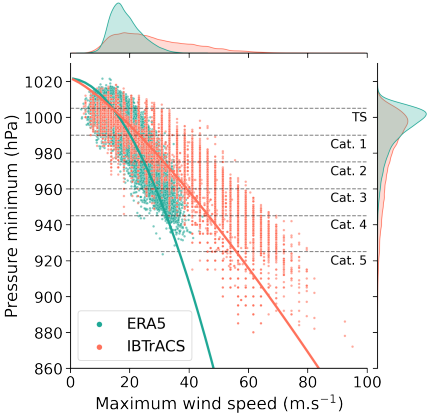
Density maps



Note

- "Good" false alarms : In the tropical belt
- "Bad" false alarms : Mid-latitudes systems, e.g South Pacific

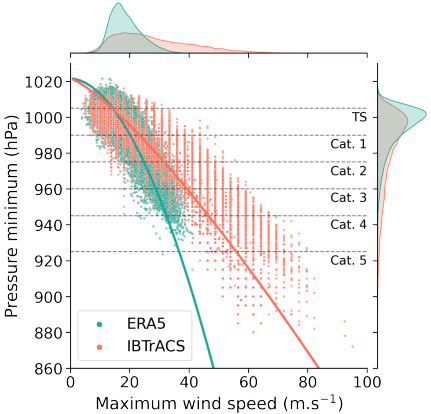
TC Intensity



Subset of matching points (59,613 points in each group)

- Wind speed largely underestimated
- Pressure distribution better represented

TC Intensity



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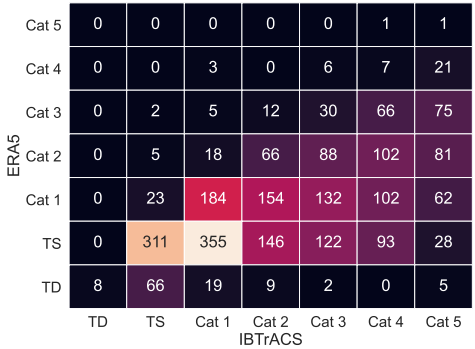
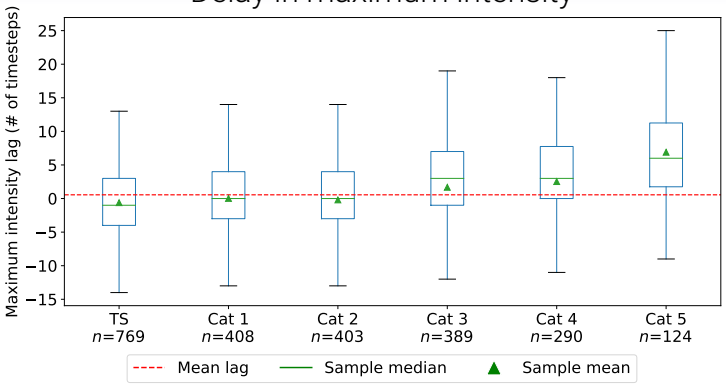


Pressure based SSHS categories crosstable

- Wind speed largely underestimated
- Pressure distribution better represented

- General agreement
- Large spread towards higher categories

Delay in maximum intensity



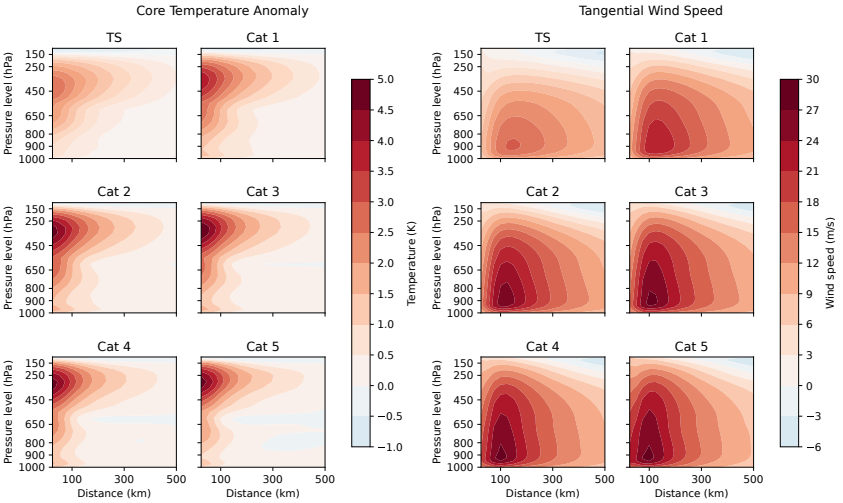
Note

Lag > 0 indicates ERA5 reaches max intensity **later** than IBTrACS

Commentary

The more intense the TC in IBTrACS, the larger the delay in ERA5.

Composites with respect to IBTrACS intensity classes



Method

Averaged composites from ERA5 at times where **IBTrACS is at said category**.

Commentary

Despite inconsistencies in intensity categories, the internal structure scales consistently with observations.

Definitions

- Mix of a thermic and dynamic potential to describe the **large scale** environment favorable to cyclogenesis *(Gray, 1968)*
- Relationships are fitted to match observed TC counts

$$N_{TC} = \iint_D \rho(y_1, y_2) dy_1 dy_2$$

- Designed to replicate spatial and temporal TC climatology

Definitions

Three indices:

- CYGP *(Royer et al., 1998)*
- GPI *(Emanuel and Nolan, 2004)*
- TCS / TIPP *(Tippet et al., 2011)*

Formulation

$$\log \text{TCS} = \log(\cos\phi) + b + \underbrace{b_\eta \eta + b_{V_{\text{shear}}} V_{\text{Shear}}}_{\text{Dynamic}} + \underbrace{b_H H + b_T T}_{\text{Thermic}}$$

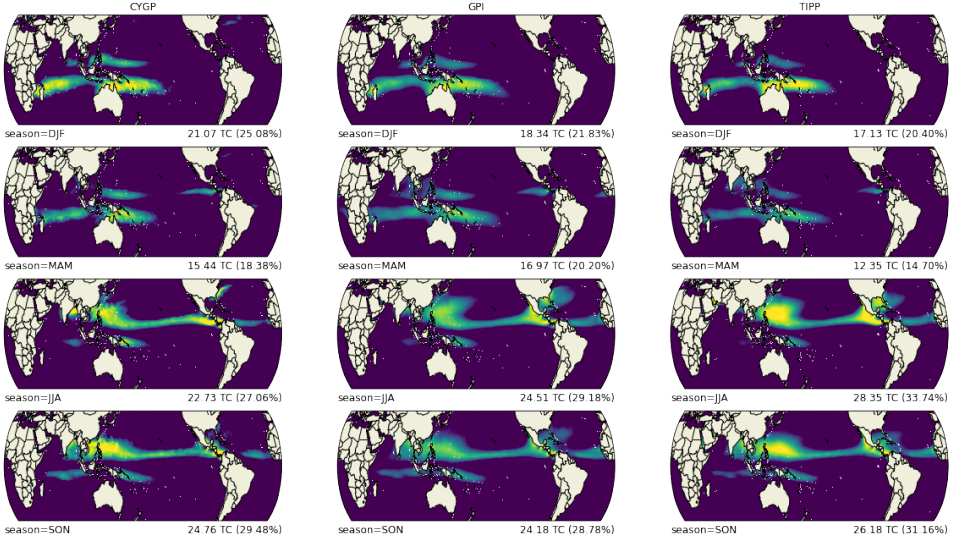
Where

- $T =$ SST anomaly w.r.t the tropical belt
- $\eta =$ Absolute vorticity
- $H =$ Relative humidity
- $V_{\text{shear}} =$ Vertical wind shear

Note

b coefficients from monthly climatologies
$\rightarrow$ No information about interannual variability

Seasonal mean of genesis indices over 1979-2020 in ERA 5



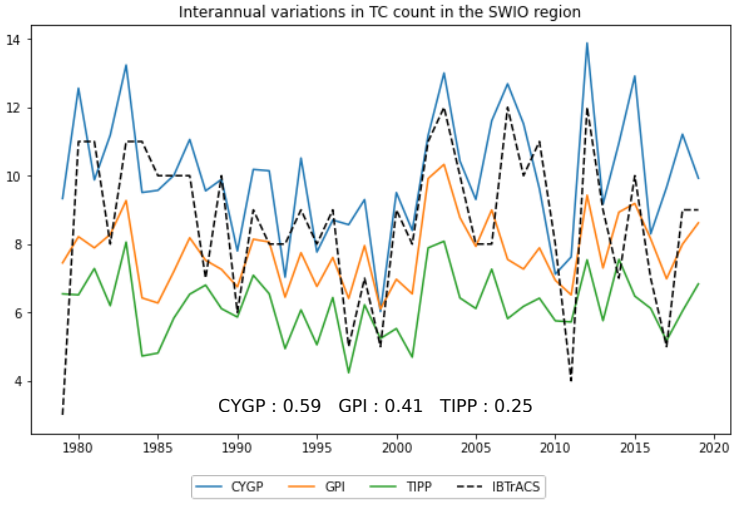
Problematic for climate change

Method

- TC count from integrated indices over the SWIO region
- IBTrACS count as reference

Notes

- GPI and TCS behave similarly but lack in amplitude
- CYGP is better correlated to IBTrACS. Good performance starting around 2000



Perspectives

Tracking in ERA5
Paper in preparation.

Genesis indices

- Improve representation of the interannual variability in genesis indices:
  1. By using different predictors (*Any ideas?*)
  2. By changing the regression's coefficients

  → Necessary condition for climate application

- Verify that improving interannual variability improves the consistency between tracking and genesis indices

- Apply both revisited indices and tuned tracking scheme to climate simulations (HighResMIP)...

- ... And to seasonal forecast simulations (CYPRESSA project)