

Tropical cyclones

Data analysis of hurricanes and typhoons

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01

An aerial photograph of the NOAA research ship "GORDON GUNTER" sailing on a choppy blue ocean. The ship is white with "NOAA R 336" and the name "GORDON GUNTER" printed on its hull. It features a large deck crane, a helipad, and various scientific equipment. A large white circle containing the number "01" is positioned in the top right corner of the slide.

CONTEXT & GOAL





01 - CONTEXT

Terminology



Cyclone : Large air mass that rotates around a strong center of low atmospheric pressure



Typhoon : Cyclone occurring in the **North East of Pacific Ocean**

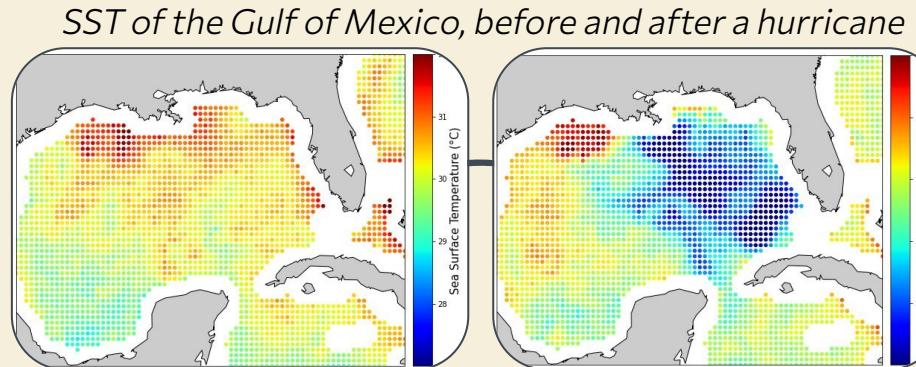


Hurricane : Cyclone occurring in the **Atlantic Ocean** or the **North East Pacific Ocean**

Relation to SST/SSH ? :

Sea Surface Temperature decreases after the passage of a cyclone

Sea Surface Height tends to increase around an occurring cyclone, since it is a low pressure zone (check data source !)



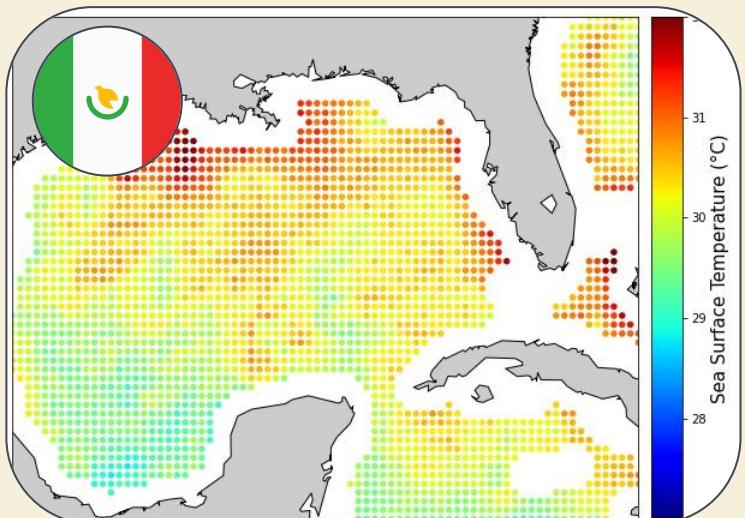


01 - CONTEXT

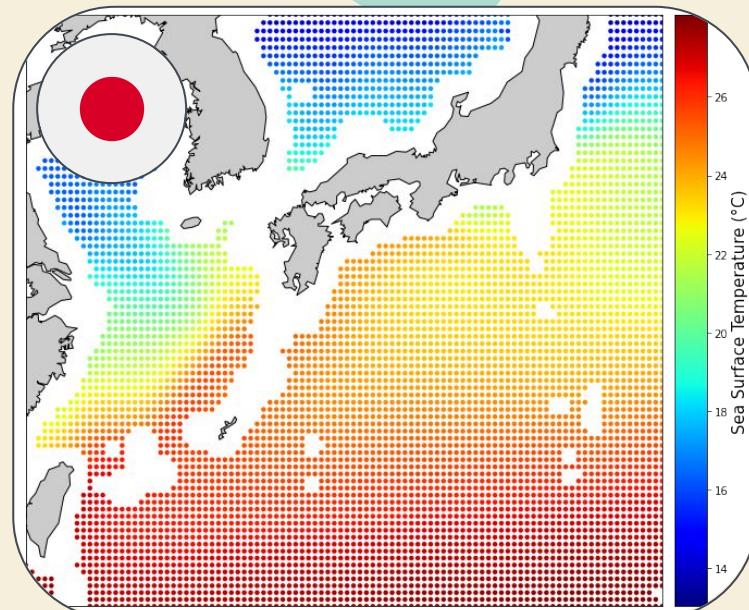
Case study

Using public data available in the course, providing SSH and SST around the globe from 1998 to 2015

2 different areas studied :



Gulf of Mexico
258 < lon < 280
18 < lat < 30



South of Japan
120 < lon < 145
20 < lat < 40



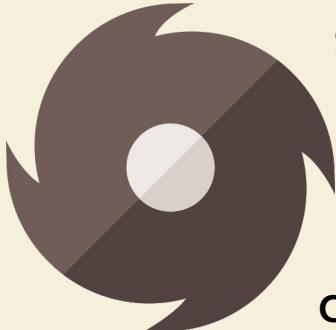
01 - CONTEXT

Cyclones history dataset

Using the International Best Track Archive for Climate Stewardship (**IBTrACS**), from the National Oceanic and Atmospheric Administration (**NOAA**), to retrieve the complete history of cyclones in the world, from 1998-2015

→ Will be used to compare with our results

Extracted data for our use case :



SID : Storm Identifier

LAT, LON : Coordinates of the cyclone

ISO_TIME : Time of the observation

USA_WIND : Maximum sustained wind speed

CATEGORY : Category of the cyclone

Category	1-minute maximum sustained winds			
	m/s	knots (kn)	mph	km/h
5	≥ 70 m/s	≥ 137 kn	≥ 157 mph	≥ 252 km/h
4	58–70 m/s	113–136 kn	130–156 mph	209–251 km/h
3	50–58 m/s	96–112 kn	111–129 mph	178–208 km/h
2	43–49 m/s	83–95 kn	96–110 mph	154–177 km/h
1	33–42 m/s	64–82 kn	74–95 mph	119–153 km/h
TS	18–32 m/s	34–63 kn	39–73 mph	63–118 km/h
TD	≤ 17 m/s	≤ 33 kn	≤ 38 mph	≤ 62 km/h

The Saffir–Simpson scale :
classification of cyclones by their intensity

02

Cyclone identification

- A. Method 1 : Time series method
- B. Method 2 : Variance method and trajectoires
- C. Results and comparison to real data



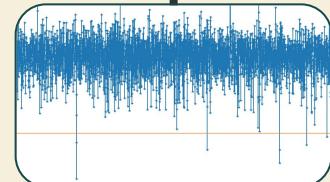


02 - Cyclone identification

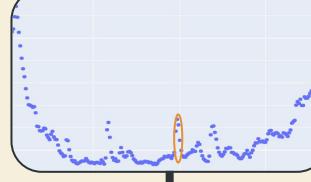
Principle



Goal : Cyclone identification using SST from 1998 to 2015



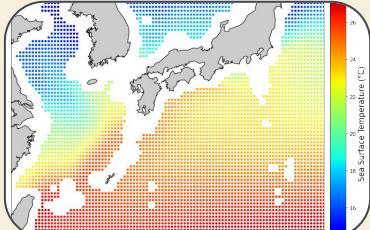
**Method 1 : SST
time variation**



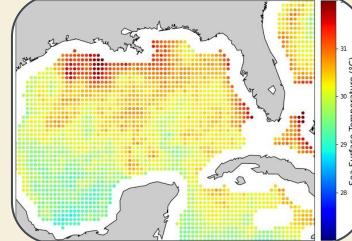
**Method 2 : SST
spatial variance**



South of
Japan



Gulf of
Mexico



Tested on both targeted areas



Results compared with IBTrACS dataset

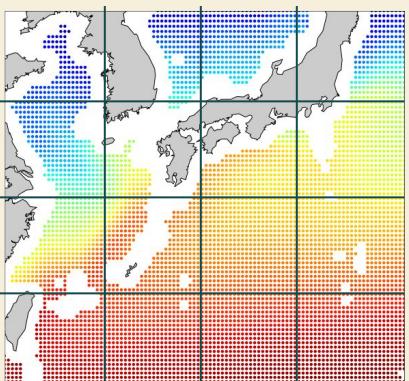


02 - Cyclone identification

A. Method 1: Variations of the SST in time

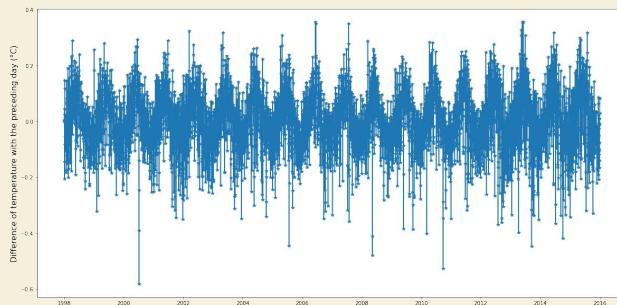
Data used

Grid of the mean SST in each region

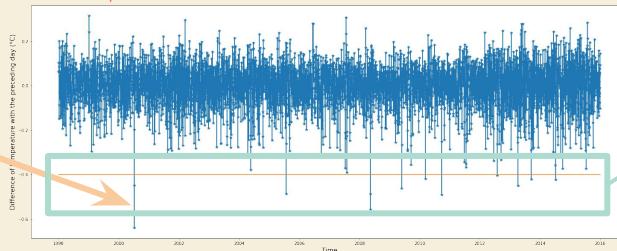


Derivative of the SST

Compute the derivative of the SST



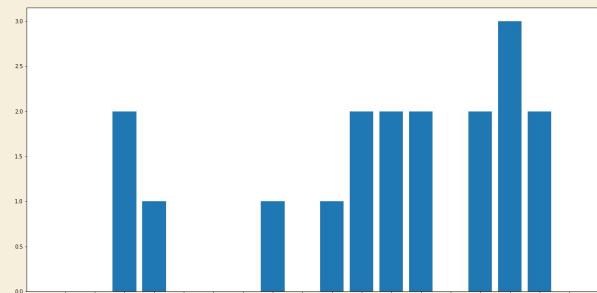
Remove the seasonal cycle



Negative anomaly

Count of negative anomalies

Count of negative anomalies by year





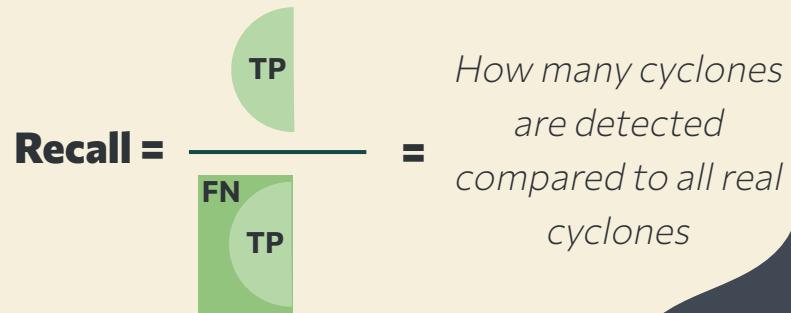
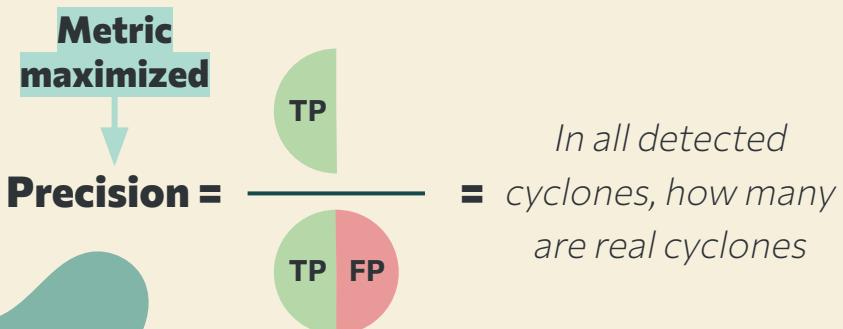
02 - Cyclone identification

A. Method 1: Variations of the SST in time

Fine tuning of the threshold, based on real data of Japan cyclones

Threshold(°C)	-0.15	-0.2	-0.25	-0.27	-0.28	-0.3	-0.33	-0.35	-0.37	-0.4
Precision	38%	52%	60%	69%	71%	69%	69%	69%	78%	88%
Recall	69%	40%	22%	17%	15%	12%	8%	13%	5%	2%

Doing the same for the Gulf of Mexico : threshold = -0.33°C; precision = 23%; recall = 6%



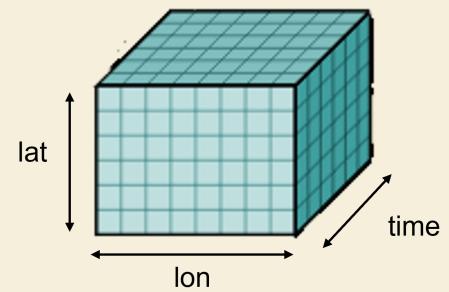


02 - Cyclone identification

B. Method 2 : Variance method and trajectories

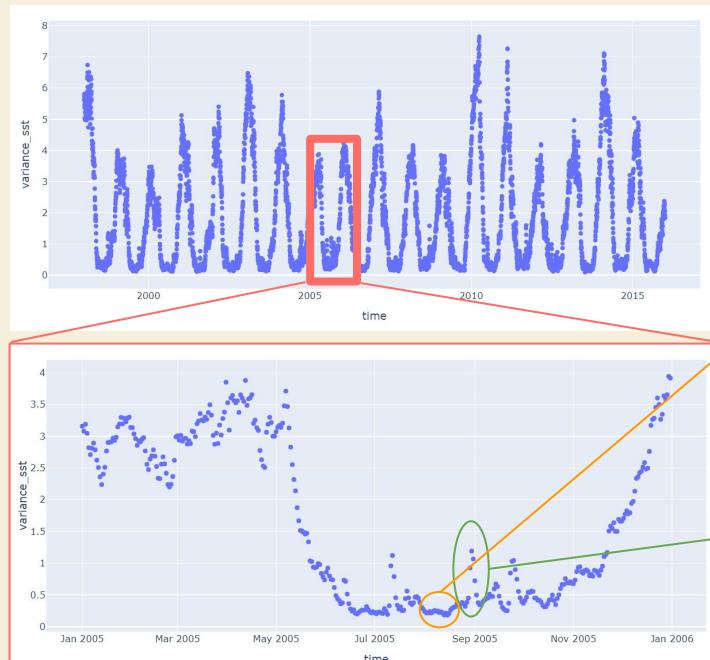
Data used

SST for each latitude and longitude at any time



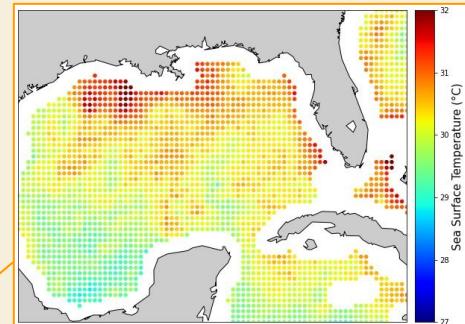
Variance

Compute the variance for every time

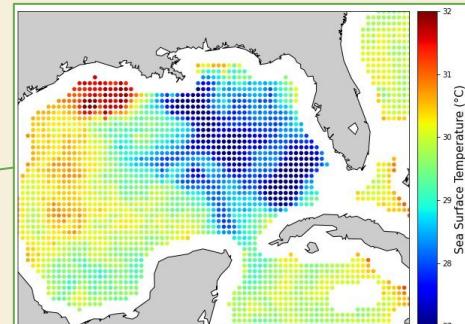


Peak detection

No cyclone : homogeneous SST = low variance



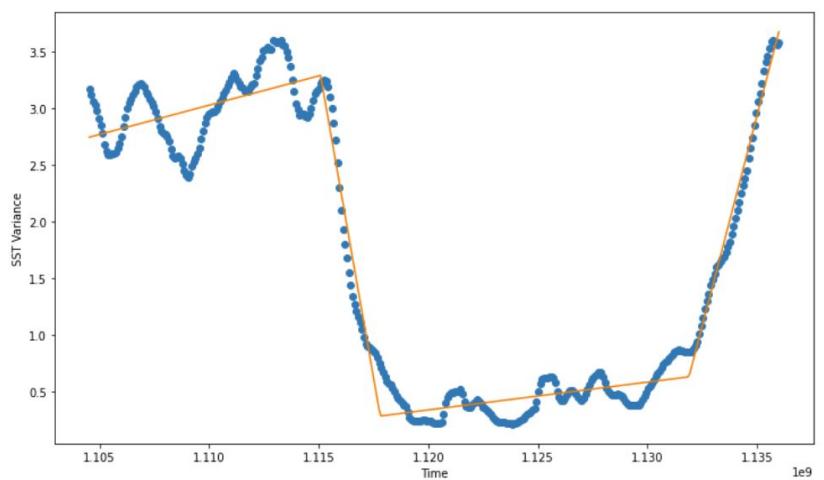
Cyclone : diminution of SST = peak





02 - Cyclone identification

B. Method 2 : Variance method and trajectories



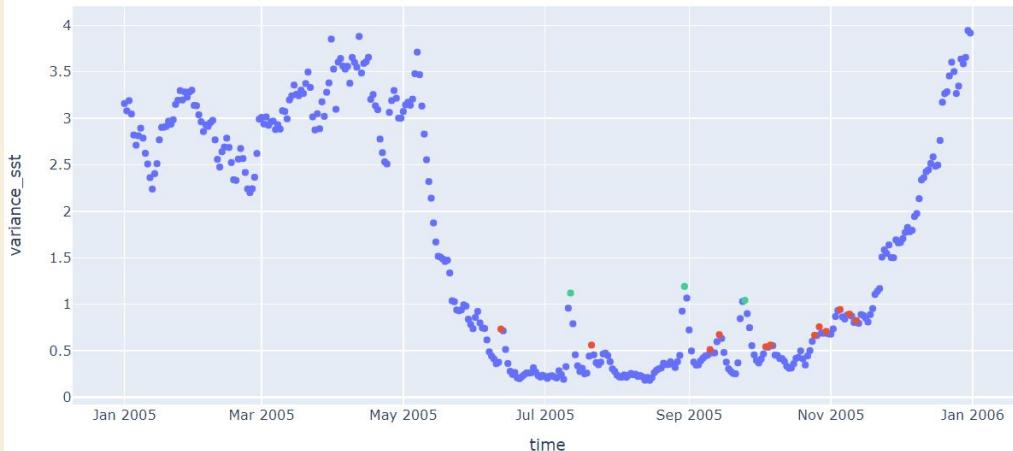
Linear regression

Linear regression by section to determine the portion corresponding to summer : the variance is globally low

We count the detected cyclones only in this portion

Peak detection

Detection of the peak of variance,
We classify cyclones on hurricanes or major hurricanes according to the height of the peak



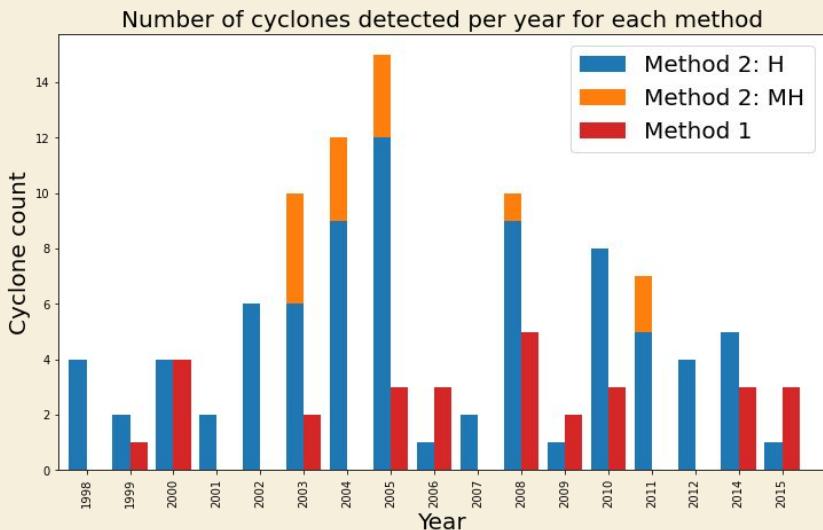
	Precision	Recall
Mexico	24 %	59 %
Japan	52%	87%



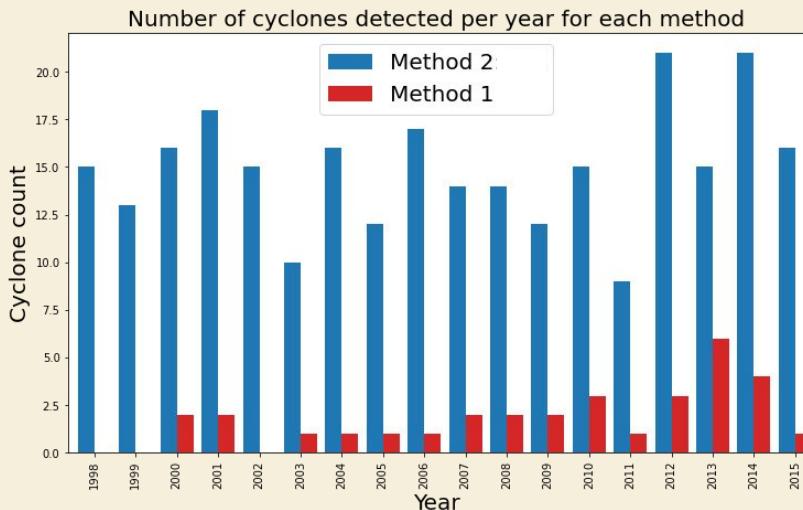
02 - Cyclone identification

C. Results and comparison to real data

Gulf of Mexico



Japan

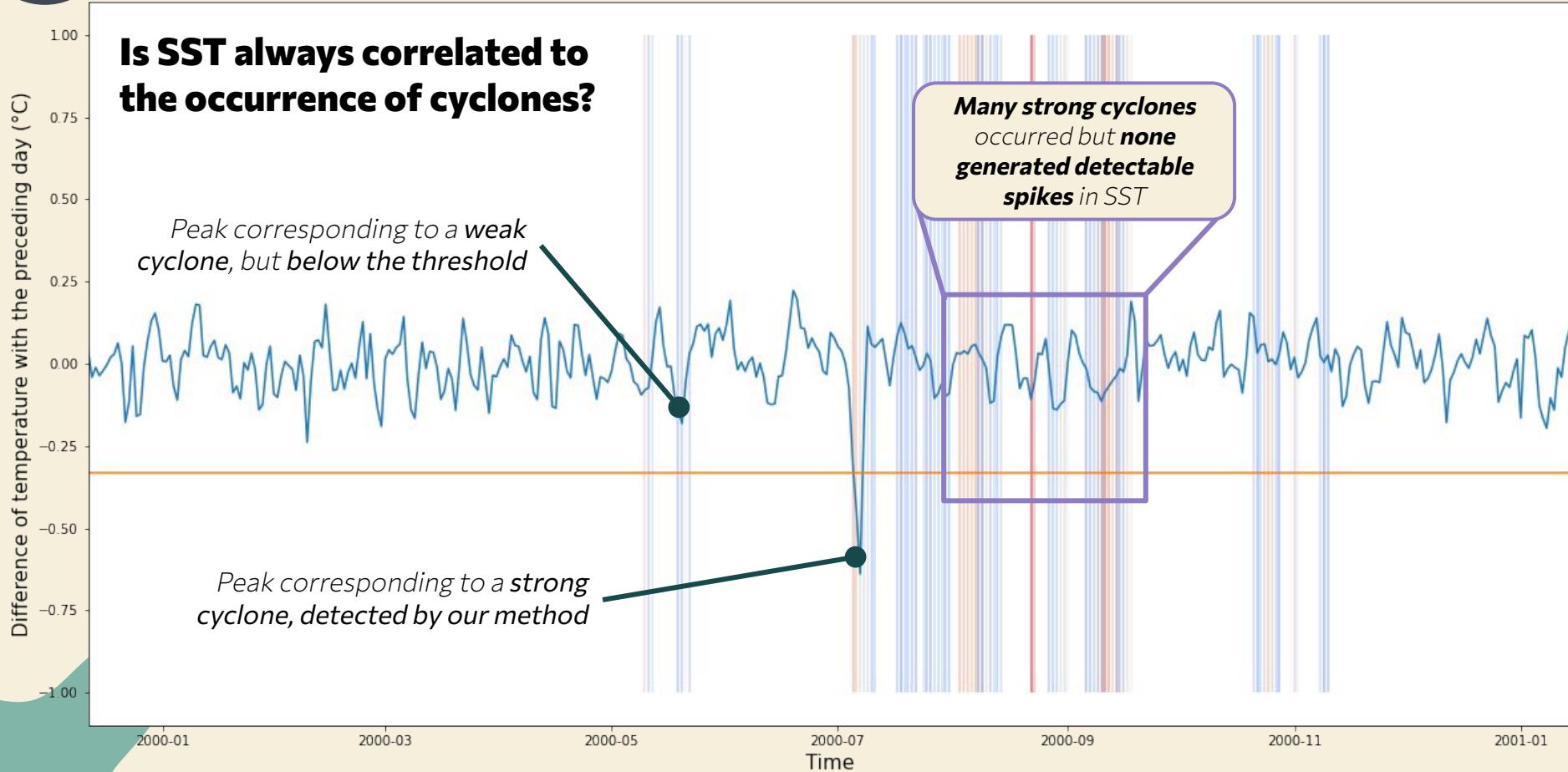


- Method 1 tends to detect less cyclones than the Method 2 in both areas, however Method 1 is more precise about its positive predictions
- **Trade-off between Precision/Recall**



02 - Cyclone identification

C. Results and comparison to real data



Descriptive statistics

- A. General and seasonal tendencies
- B. Trajectories derived from SST spatial variance

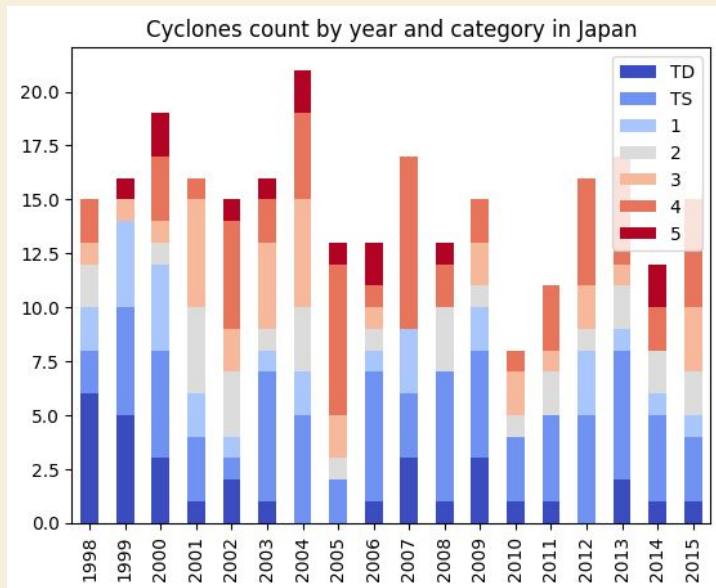


03

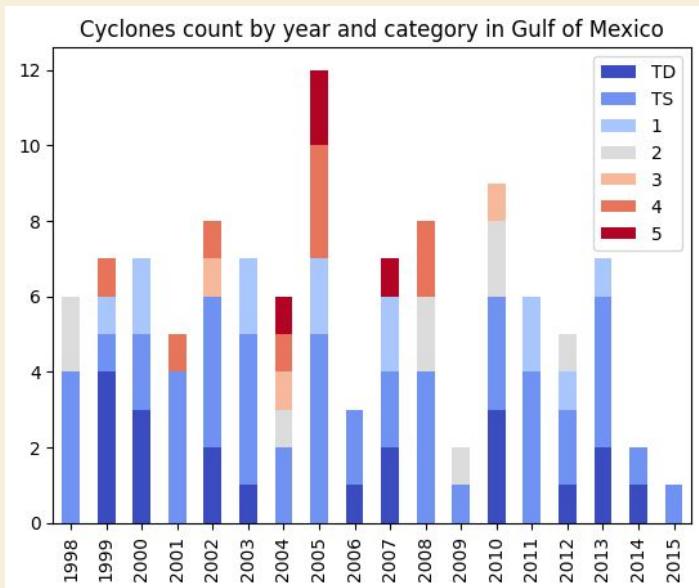
03 - Descriptive statistics

A. General and seasonal tendencies

Peak of intense cyclones occurring between 2003-2005



Small peak is in 2004 for Japan



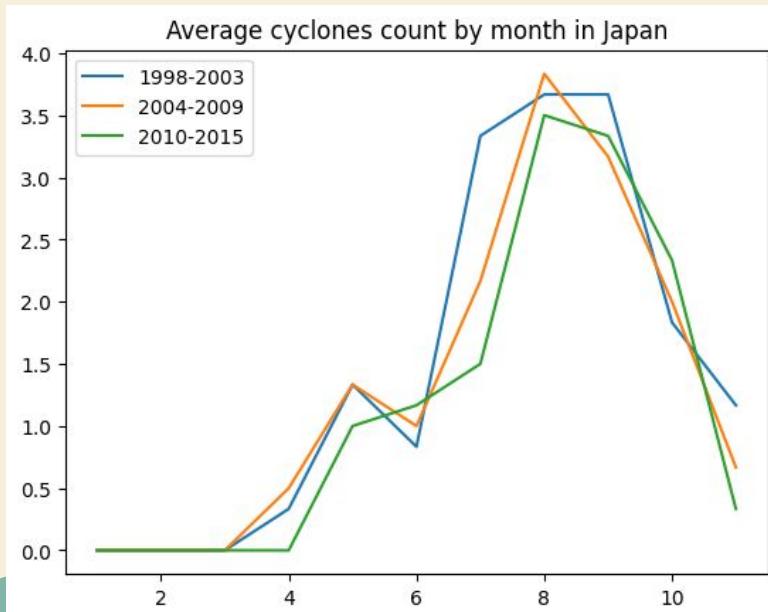
Clear peak in 2015

03 - Descriptive statistics

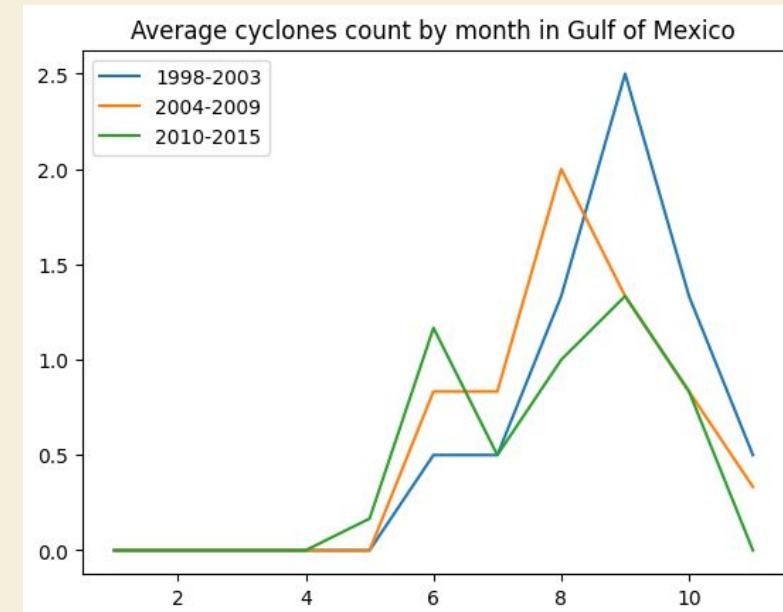
A. General and seasonal tendencies

→ **Cyclones always occur from early summer to autumn**

→ **Cyclones are occurring earlier each year (for the Gulf of Mexico only)**



Not the case for Japan



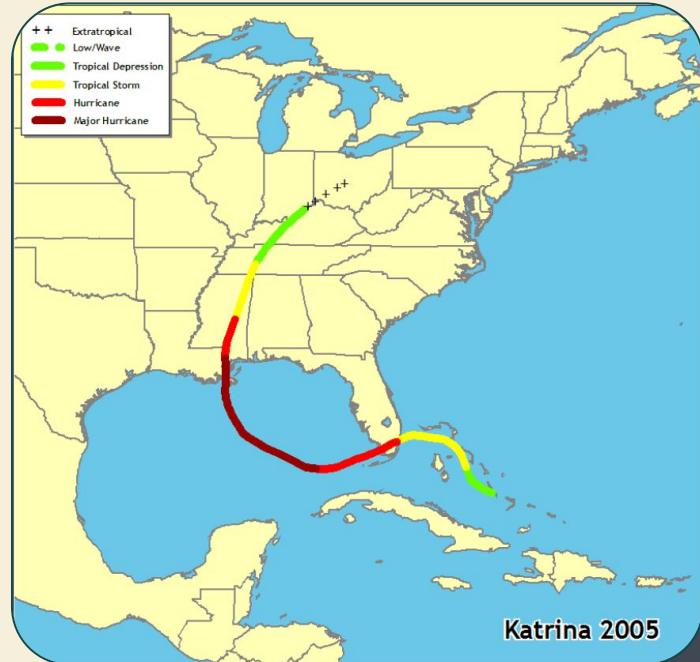
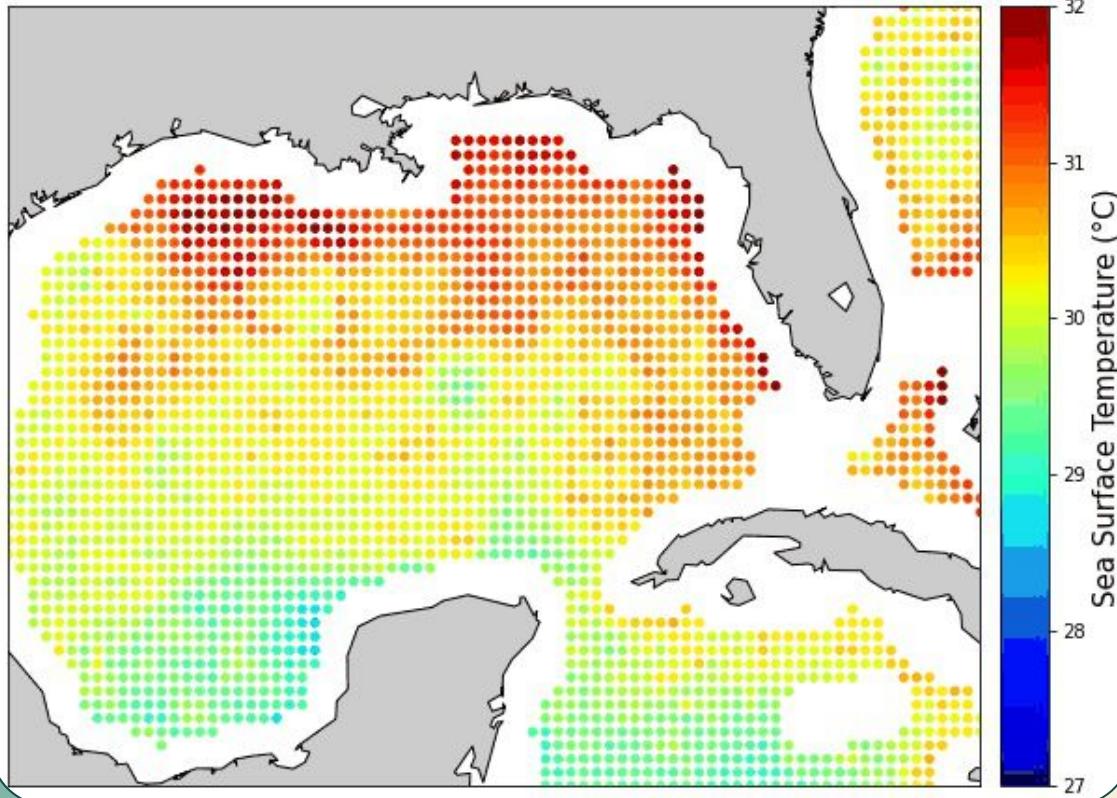
Clear spike in June for 2010-2015



03 - Descriptive statistics

B. Trajectories derived from SST spatial variance

2005-08-23



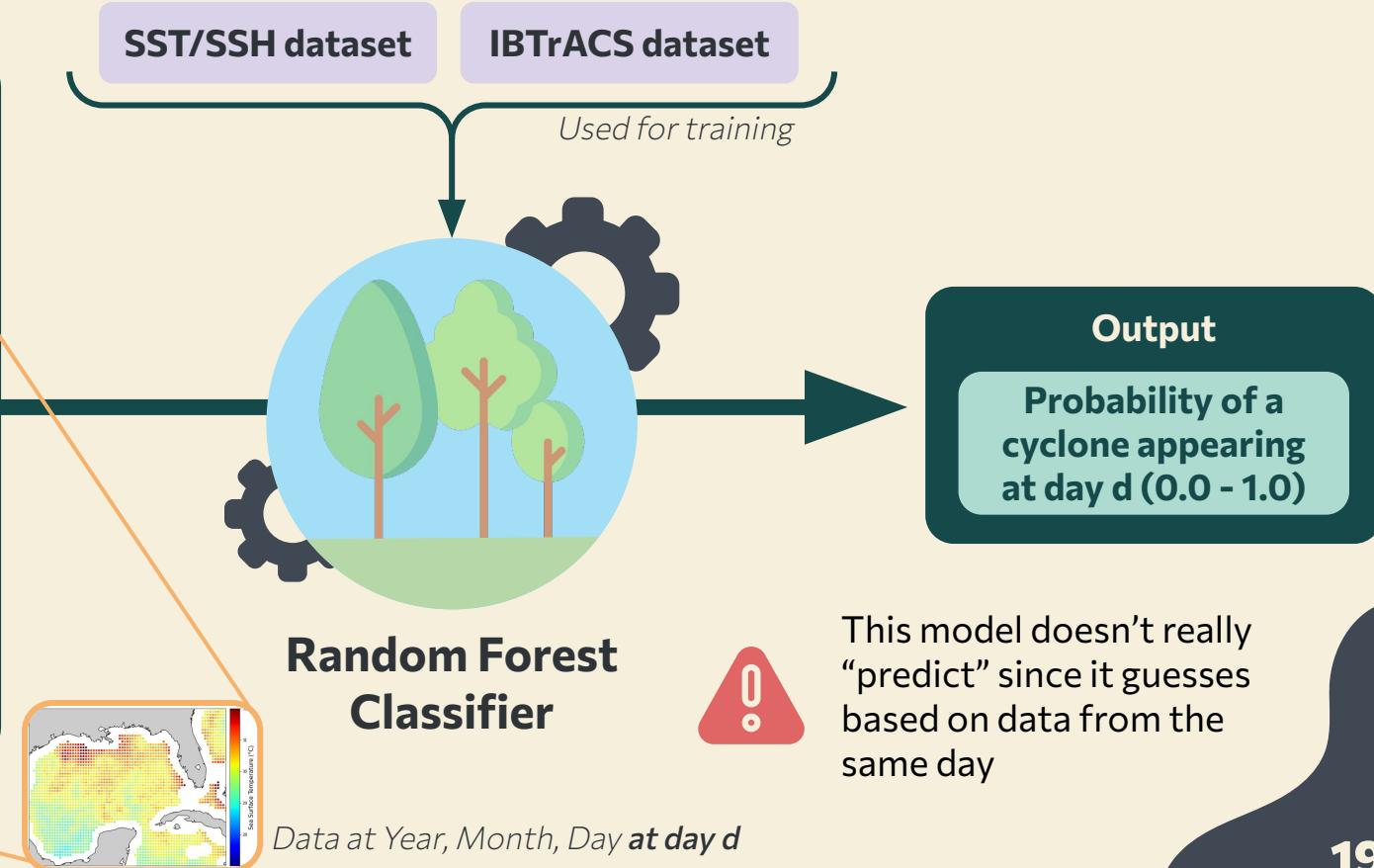
Source : <https://www.nhc.noaa.gov/>

Hurricane Katrina (category 5) in 2005 in Gulf of Mexico



04 - Cyclones apparition prediction

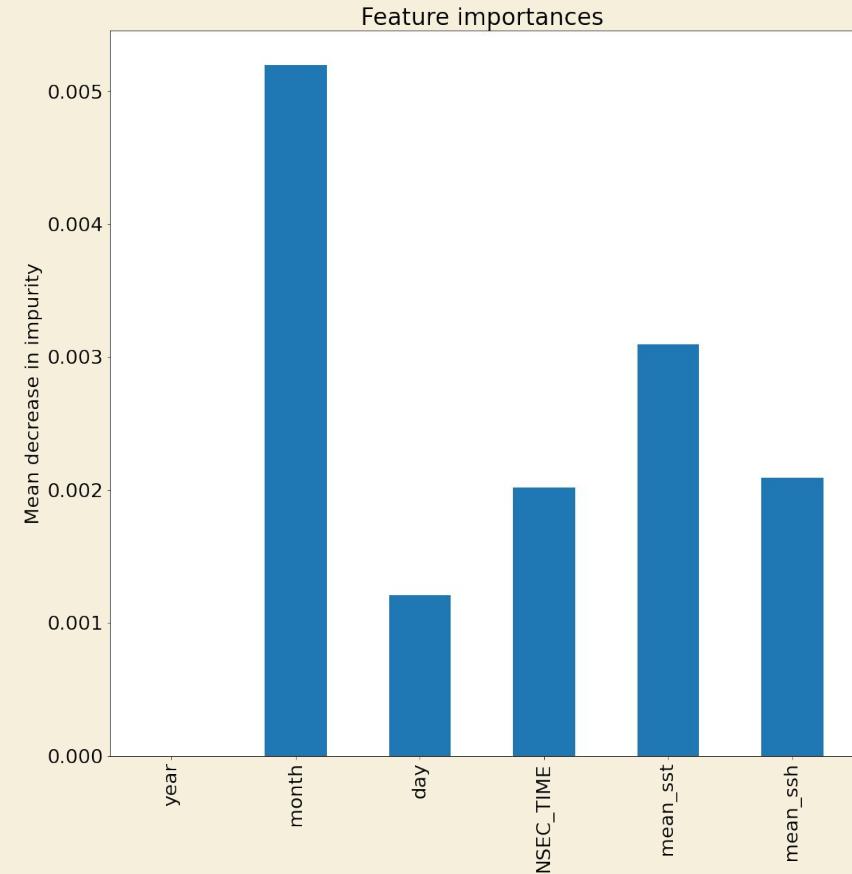
A. Method





04 - Cyclones apparition prediction

B. Results



After tuning the training dataset, the scores are :



Precision : 61.95%
Recall : 55.56%



Precision : 69.80%
Recall : 38.26%

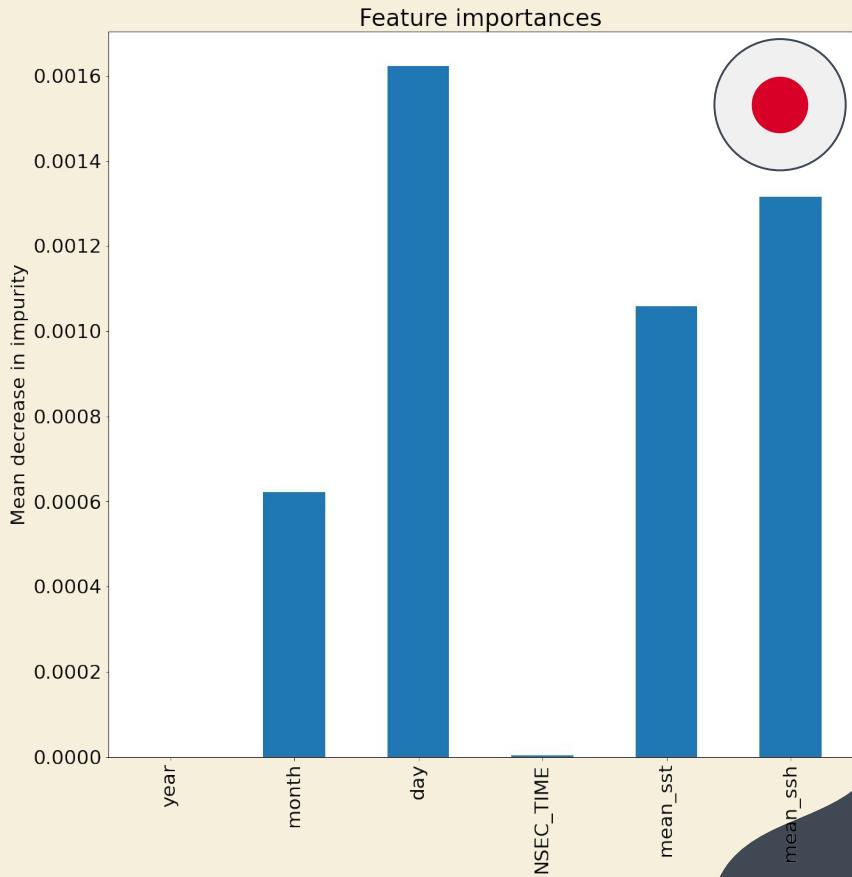
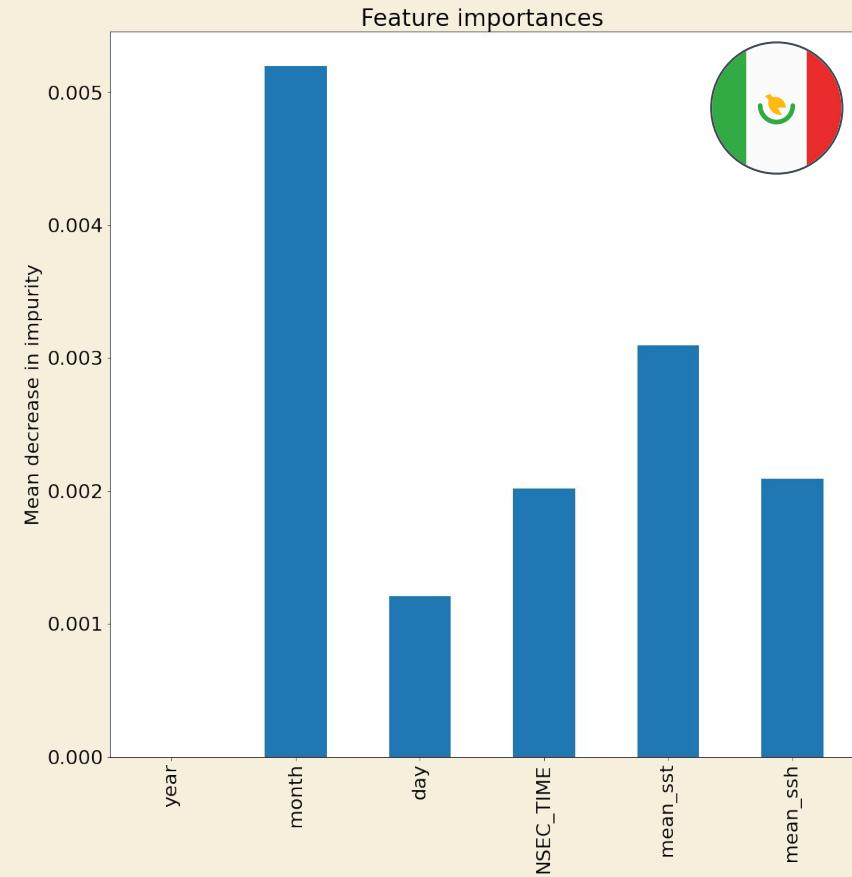
→ The model was tuned to **maximize Recall**, since we want to predict cyclones and prepare for them.

*Importance of each feature used by our RF to predict cyclone apparitions in the Gulf of Mexico :
Months > SST > time > SSH*



04 - Cyclones apparition prediction

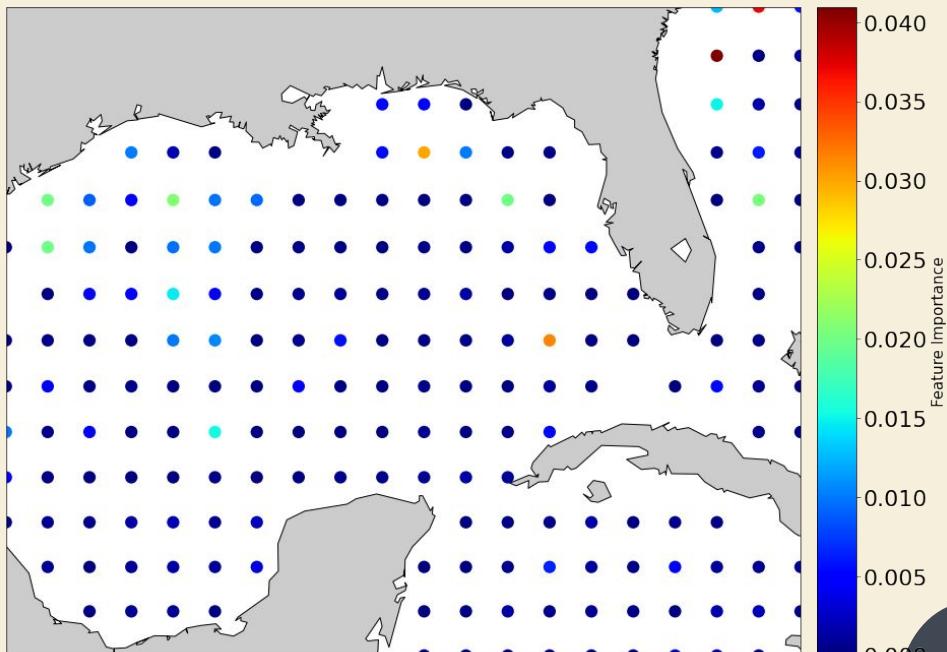
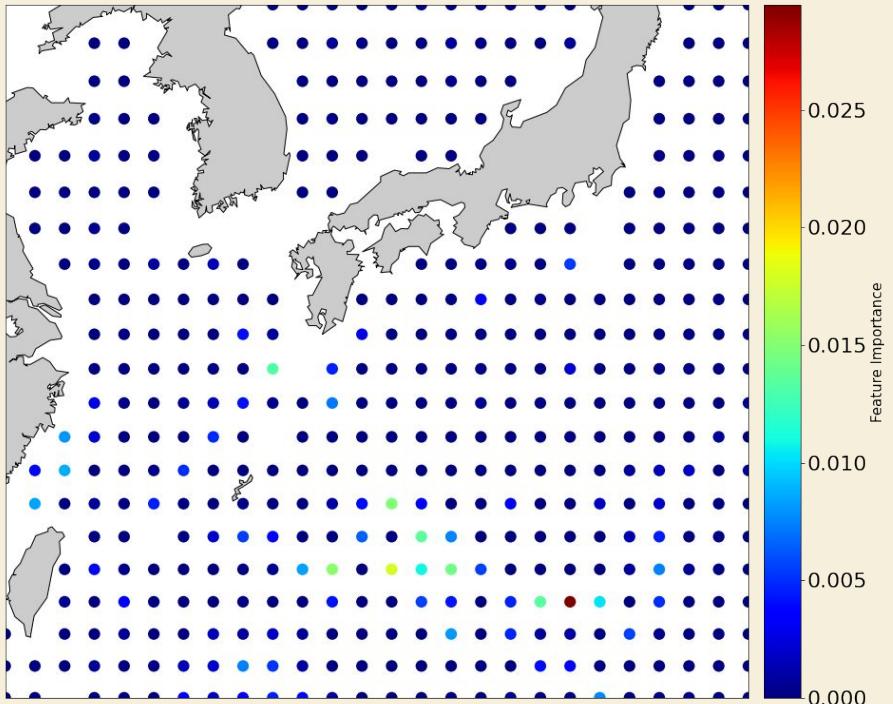
B. Results





04 - Cyclones apparition prediction

B. Results

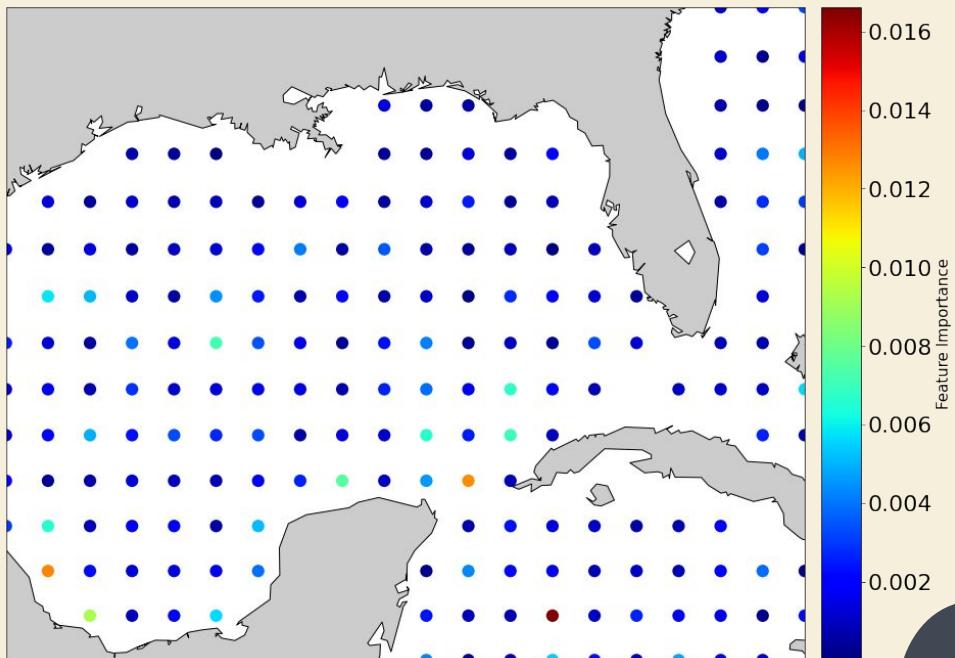
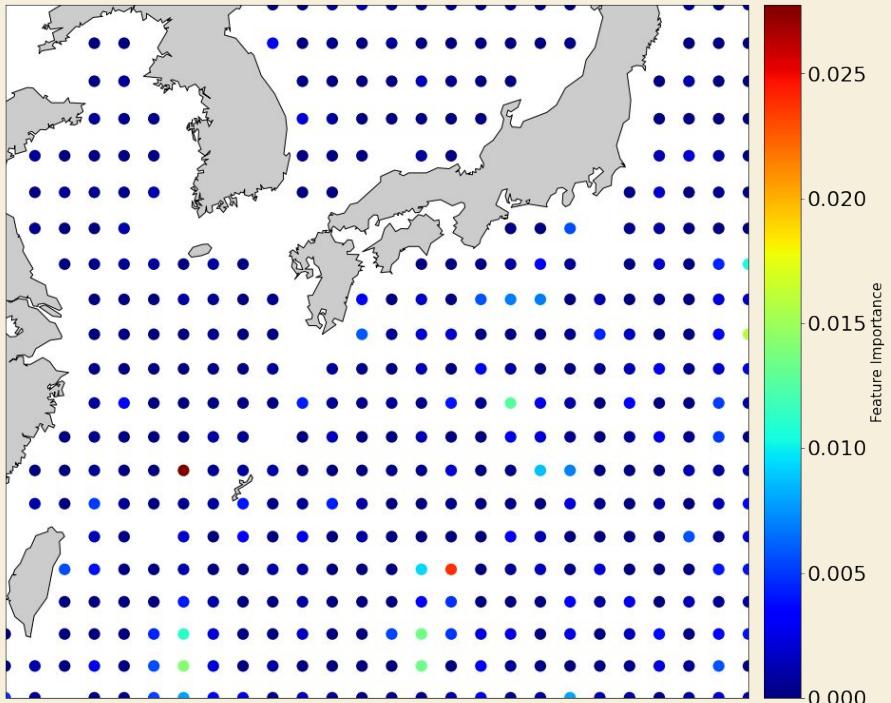


Importance of each **SST** point used by
our model to predict cyclone apparitions



04 - Cyclones apparition prediction

B. Results



Importance of each **SSH** point used by
our model to predict cyclone apparitions

Conclusion



Detection/Prediction methods might **need some refinement** (finer grid, decision models instead of a simple threshold)



Clear **connection** between **cyclones and SST** but **difficult to spot** cyclones only based on SST
Most research papers focus on the correlation between cyclone intensity/SST [1]



Cyclones are **related to many other climate aspects**
Cyclone prediction models are usually derived from actual **climate numerical models** [2]

[1] [Sea Surface Temperature Thresholds for Tropical Cyclone Formation](#). K. J. Tory and R. A. Dare

[Effect of remote sea surface temperature change on tropical cyclone potential intensity](#), Gabriel A. Vecchi

[Satellite microwave detected SST anomalies and hurricane intensification](#), Donglian S.

[2] [Recent Developments in : Tropical Cyclone Dynamics, Prediction, and Detection](#), Anthony Lupo

Thank you for your attention !

- Tropical cyclones -

Data analysis of hurricanes and typhoons

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