Société de Calcul Mathématique SA
Tools for decision help
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Cyclones

Available data and critical analysis

Extract of the white paper drawn up by the SCM
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First we looked at the quality of existing data on cyclones, which then enabled us to analyze the way in which the data are processed.

We answered the following questions:

- Where can one find data on cyclones?
- How have these data been obtained?
- For how long have data on cyclones been available?

I. Measurements

A. Sources of data

Various bodies are responsible for monitoring cyclones, depending on the cyclone basin concerned.

The National Hurricane Center (NHC) is one of the six services of the NOAA (National Oceanic and Atmospheric Administration).

The NHC covers the North Atlantic basin (including the Caribbean Sea and the Gulf of Mexico) and the North-East Pacific basin.

The NOAA website is very well documented, with plenty of data, and has a claim to scientific integrity [see Lubchenco].

We have looked at the NOAA data for the North Atlantic basin, working on the current HURCAT2 database. This is an updated version of HURCAT1, with new parameters having been added in 2004, and can be downloaded at [Cyclones_NOAA].

One difference between the HURCAT1 and HURCAT2 databases is that the former gives the categories of cyclones directly (using the Saffir-Simpson classification system). The Unisys website [see Cyclones_Unisys] presents HURCAT1 data as follows: for each year, it provides a chronological list of cyclones, giving their category, maximum wind speed and minimum pressure.

The other main difference between the two databases is that, since 2004, HURCAT2 has included six columns corresponding to new fields. These indicate how far from the center of the cyclone you need to be to record a certain wind speed.

B. Measurement technology

We have three technologies for monitoring hurricanes and predicting them as far as is possible.

1. Satellites

As we explained in Section I, ‘Temperatures’, there are two types of weather satellite.

The geostationary satellite monitoring the North Atlantic basin is **Goes-E**, an American NOAA satellite at longitude 75ºW.

The list of existing satellites is available on the extreme cyclone website, cyclonextreme.com [see Zucchi].

2. Doppler radars

In addition to the intensity and proximity of disturbances that are measured by basic weather radars, Doppler radars also measure the speed and direction of movement of these disturbances. The first Doppler radars were introduced in the 1950s.

The operational principle is as follows: Doppler radars emit microwaves that are reflected back by raindrops and ice crystals. Meteorologists can use the result received in numerical form to determine the quantity and speed of precipitations, cyclone patterns, and so on.

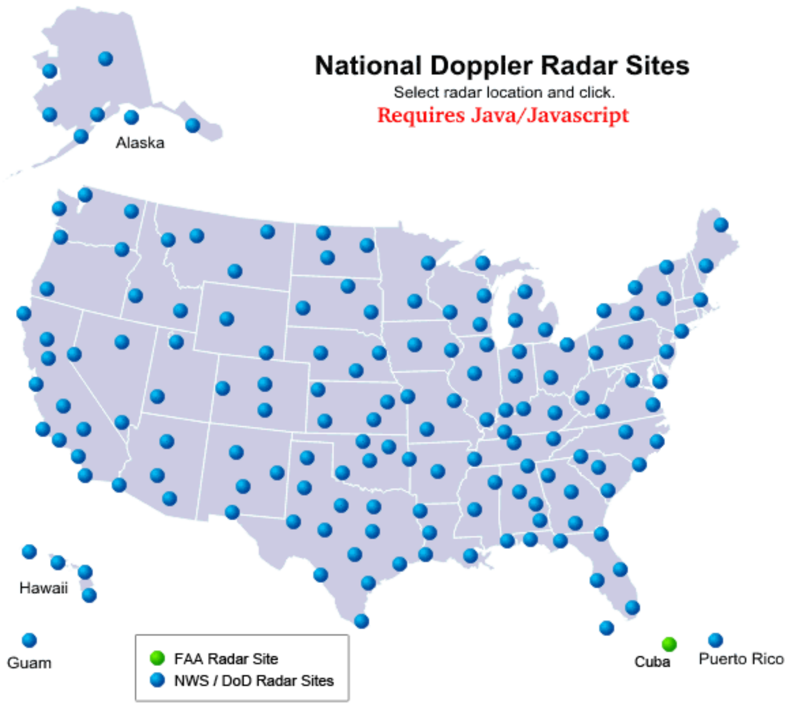


Figure 1. Distribution of radars in the US, according to the [NDRS]

A radar covers an area of 300 km, but cannot measure the speed of rotation of air masses at a distance of more than 100 km. Also, its resolution is of the order of one kilometer, when a tornado usually has a diameter of between one and 100 meters [see Radartutorial].

Radars are unevenly distributed in the rest of the world. In a country like France, where cyclones are rare, the purchase of radars is not financially justifiable.

3. Dropsondes

A dropsonde contains several weather instruments (barometer, thermometer, hygrometer and a GPS receiver making it possible to measure the direction and strength of the wind). Dropsondes are released from a weather reconnaissance aircraft and, as they fall, they collect various types of information on the cyclone.

Satellites are the best way of monitoring cyclones, which is why we think that the processing of data becomes pertinent as of the time they were put into effective, successful operation, which, according to Météo France, was in the 1970s.

In fact, global monitoring of the atmosphere has been conducted by the World Weather Watch global observation system since 1966.

II. Assessments based on the analysis of available data

A. Preliminary analysis and processing of NOAA data

We decided to work on the HURCAT2 database, which is an 'enhanced' and fuller version of the HURCAT1 database.

We have nonetheless checked whether the data contained in the two databases are the same. We did this using the Unisys website, which contains HURCAT1 data, and then HURCAT2 data from 2011 onwards.

The database covers the entire North Atlantic basin, and the cyclones listed have not necessarily reached the coast.

The Unisys website gives a chronological list of cyclones for each year from 1851 to 2014, providing the following information on each one: period of activity (from start date to end date), maximum sustained wind speed over a 10-minute period, minimum pressure, and the category of the cyclone.

According to the explanations provided, the category is determined according to the Saffir-Simpson scale, for which the criterion is maximum sustained wind speed over a 10-minute period.

We divided the differences we found into two groups:

- Differences in the number of cyclones, tropical storms and tropical depressions

In 2000, by comparison with the Unisys database, HURCAT2 includes an additional subtropical/extratropical storm, with a maximum wind speed of 55 knots.

In 2003, by comparison with the Unisys database, HURCAT2 includes an additional tropical storm (Peter), with a maximum wind speed of 60 knots.

In 2004, a tropical depression (Tropical Depression TWO), with a maximum wind speed of 30 knots, has been taken off the Unisys database and does not appear in HURCAT2.

In 2006, by comparison with the Unisys database, HURCAT2 includes an additional tropical storm (Unnamed 13), with a maximum wind speed of 45 knots.

In 2011, by comparison with the Unisys database, HURCAT2 includes an additional tropical storm (Unnamed 14), with a maximum wind speed of 40 knots.

In 2013, by comparison with the Unisys database, HURCAT2 includes an additional tropical storm (Unnamed 16), with a maximum wind speed of 55 knots. This last example shows that, in this case, the Unisys website decided (voluntarily or not) to withdraw the tropical storm.

Changes have been made only as regards tropical storms and tropical depressions. The number of cyclones does not vary. Also, since there are relatively few cyclones, we do not think that the updating of the HURCAT database is a 'camouflage' for including additional cyclones.

- Differences linked to wind speed

In 2008, Unisys incorrectly recorded the maximum sustained wind speed of cyclone OMAR, which it puts at 110 knots when it was actually 115 knots. This error does not appear in HURCAT1. It causes a Category 3 cyclone in 2008 to become Category 4 in HURCAT2.

The HURCAT2 database is presented in the form described below.

On the NOAA website, you can download a text file containing the following fields for each cyclone:

- Cyclone number for that year
- Name, if available, or else 'UNNAMED'
- Number of best track entries – rows – to follow
- Year
- Month
- Day
- Hours
- Minutes
- Record identifier:
    - L – Landfall (center of system crossing a coastline)
    - W – Maximum sustained wind speed
    - P – Minimum in central pressure
    - I – An intensity peak in terms of both pressure and wind
    - C – Closest approach to a coast, not followed by a landfall
    - S – Change of status of the system
    - G – Genesis
- Status of system, options are:
    - TD – Tropical cyclone of tropical depression intensity (< 34 knots)
    - TS – Tropical cyclone of tropical storm intensity (34-63 knots)
    - HU – Tropical cyclone of hurricane intensity (> 64 knots)
    - EX – Extratropical cyclone (of any intensity)

- SD – Subtropical cyclone of subtropical depression intensity (< 34 knots)
    - SS – Subtropical cyclone of subtropical storm intensity (> 34 knots)
    - LO – A low that is neither a tropical cyclone, a subtropical cyclone, nor an extratropical cyclone (of any intensity)
    - WV – Tropical Wave (of any intensity)
    - DB – Disturbance (of any intensity)
- Latitude
- Hemisphere
- Longitude
- Hemisphere
- Maximum sustained wind speed (in knots)
- Minimum pressure (in millibars)
- Additional detail on the track (position) of the cyclone

B. Processing of data

We found no outliers. There are missing and unchecked data, particularly as regards pressure.

We conducted a preliminary processing of the data to analyze trends in the number of cyclones over the years. We did not consider data preceding 1970 (as explained earlier). Among cyclones, we also included tropical depressions (which maximal wind speed is inferior to 34 knots) and tropical storms (which maximal wind speed is between 34 to 63 knots).

For each cyclone, we extracted the following information:

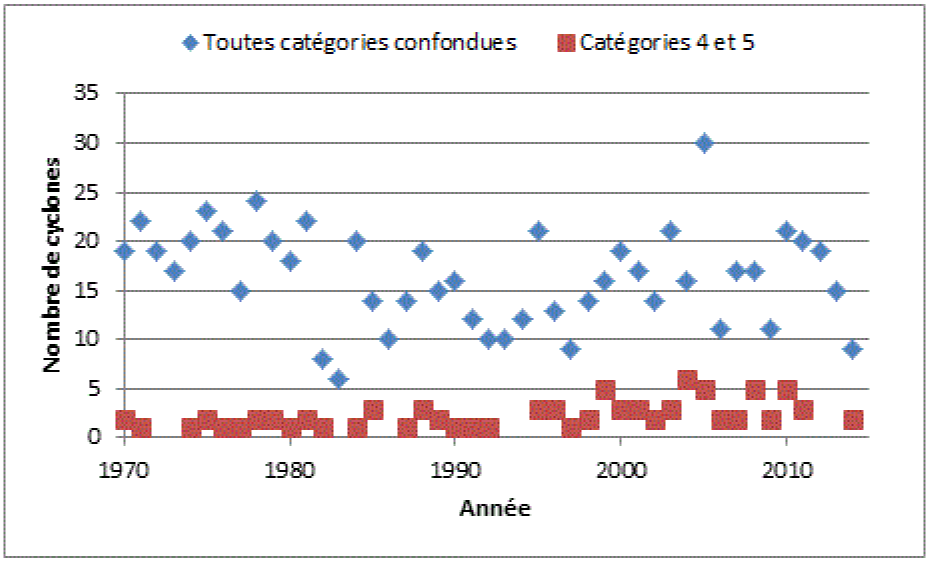
- Maximum recorded speed;
- Minimum recorded pressure;
- Duration (number of days).

We took account only of maximum recorded speed. We identified Category 4 and 5 cyclones. According to the Saffir-Simpson scale, these are cyclones whose maximum recorded speed is above 113 knots.

C. Results

To start with, we studied the trend in the number of cyclones in the North Atlantic basin since 1970, including data on cyclones that did not reach the American coast. The results show that there has been no increase in the number of cyclones since the 1970s.

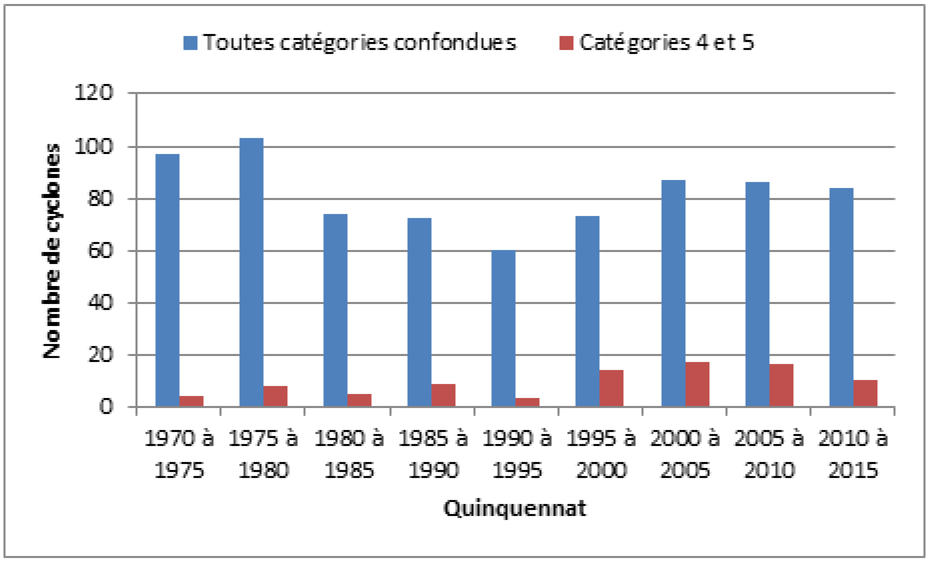
Next, we looked to see if there had been any increase in the number of Category 4 and 5 cyclones. The answer was yes:



Key

Top: All categories Categories 4 and 5
Vertical axis: Number of cyclones
Horizontal axis: Year

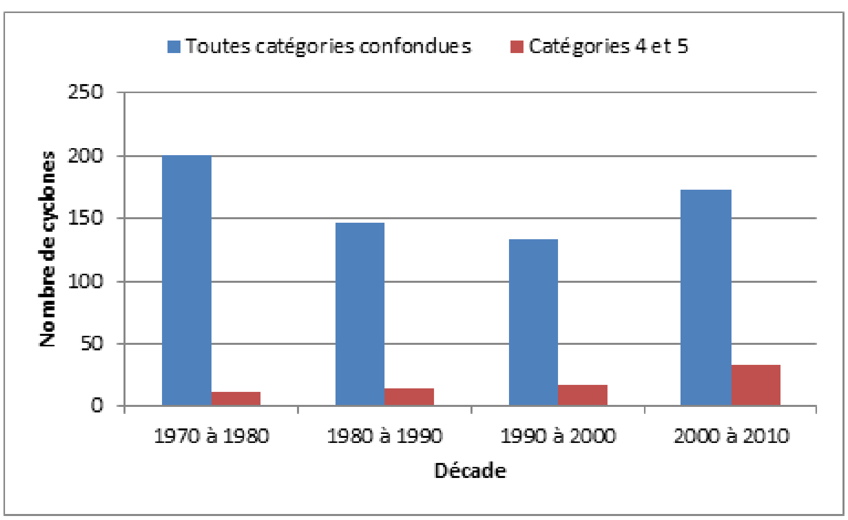
Figure 2. Trend in the number of tropical depressions (in blue) and Category 4 and 5 cyclones (in red) since 1970



Key

Top: All categories Categories 4 and 5
Vertical axis: Number of cyclones
Horizontal axis: Five-year period

Figure 3. Trend in the number of tropical depressions, tropical storms and cyclones (in blue)and Category 4 and 5 cyclones (in red) since 1970, in five-year periods



Key

Top: All categories Categories 4 and 5
Vertical axis: Number of cyclones
Horizontal axis: Decade

Figure 4. Trend in the number of tropical depressions, tropical storms and cyclones (in blue)and Category 4 and 5 cyclones (in red) since 1970, in decades

These data show a rise in the number of high-intensity cyclones and a fall in the number of low-intensity cyclones. However, as we shall see, this increase could simply be due to the improvement in measurement technologies.

III. Uniformity of data

A. Uniformity over time

We have testimonies dating back to 1500 that describe cyclones. But they do not enable us to assess their intensity with any precision. Also, they are obviously not exhaustive.

The NOAA databases date back to 1851 and were initially based on eye-witness accounts. Before 1944, observations of cyclones were made only by ship.

Since then, the introduction of reconnaissance aircraft, the establishment and constant improvement of the satellite system (Dvorak technique in 1970, and infrared in 1980), and the arrival of Doppler radars have made it possible to greatly improve measurements.

Infrared satellites in particular, which were developed in the 1980s, have enabled us to make real advances in the accuracy of wind speed measurements. This is a problem in terms of the classification of cyclones into different categories. In fact, the standard used is the Saffir-Simpson scale, which is based on maximum sustained wind speed during a 10-minute period.

Improvements in the satellite system, as explained by Christophe Landsea at the 22nd Annual Governor's Hurricane Conference, summarized in [Governor's Hurricane Conference], now enable us to identify Category 4 and 5 cyclones, which we could not do before. So the increase in the number of high-category cyclones might be due to these technical advances [see Landsea and Brown].

In a search for standardization, studies by J. P. Kossin et al [see Governor's Hurricane

Conference] were conducted by degrading the data obtained between 1983 and 2005 to bring it into line with the quality of old data. This had the effect of reducing the number of the most violent storms. However, it is incorrect to assess the trend on the basis measurements that have been corrected in this way, so we limited ourselves to studying these phenomena since 1970.

This is why, in our study, we give more weight to results concerning the trend in the number of cyclones since the 1970s than we do to those concerning the increase in their intensity.

The way in which data are analyzed varies, which also makes any standardization of the data difficult. We can cite the example of cyclone Andrew (1992), which was raised from Category 4 to Category 5 ten years later in the NOAA database.

In 2009, aware of the need for uniform data, the NHC launched the 'Atlantic Hurricane Database Re-analysis Project' [see NOAA_HRD], whose aim is to extend and review the HURCAT database. In order to do this, the analysts are going back to 1851, when records began, and are reviewing the data using up-to-date knowledge and techniques.

The NOAA is entirely transparent, as regards both the modifications to the database and the reasons for them, which are carefully explained on the website.

B. Uniformity over space

The quality of data varies significantly from one basin to another, and even for the same basin. Satellite coverage is far from uniform. The North Atlantic basin is well monitored and the recorded data are available.

C. Critical analysis

In this case, we have been able to obtain raw data and conduct our own analysis, which clearly demonstrates, contrary to what we are all reading all the time, that there has been no increase in the number of cyclones over the past 40 years. We have found a slight increase in the number of Category 4 and 5 cyclones (the strongest), but the numbers are very small each year, and the increase might simply be due to changes in 'accounting methods'.

A common deception is as follows: you begin by looking at cyclones that reach the US mainland (the ones that affect people and insurance companies) and you count them. Then you change the perimeter and include all cyclones in the North Atlantic, including ones that disperse at sea. Of course, the second group is bigger!

As we said earlier, the statistics presented here cover all cyclones in the North Atlantic.