USING WIND DATA FROM METEOROLOGICAL STATIONS IN FRANCE FOR THE LONG-TERM ADJUSTMENT

WHY THE DECREASE OF THE WIND RESOURCE OBSERVED IN THE NORTHERN HALF OF FRANCE MIGHT NOT BE ATTRIBUTABLE TO CHANGES IN THE MEASUREMENT CONDITIONS (EVOLUTION OF VEGETATION COVER, SENSOR CHANGES…)?

AUTHORS

Hélène Willis, Eoltech, France, helene.willis@eoltech.fr

Marion Jude, Eoltech, France, marion.jude@eoltech.fr

NATIONAL PARTNER: AEE Spanish Wind Energy Associaton

REGIONAL PARTNERS: ENERGIAREN EUSKAL ERAKUNDEA ENTE VASCO DE LA ENERGÍA; EUSKO JAURLARITZA GOBIERNO VASCO

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SUMMARY

In the Northern half of France, recent studies have shown a significant decrease of the wind resource since the early 2000s. As these observations based on wind measurements from meteorological stations differ from the trends proposed by reanalyses data such as MERRA-2, the question remains: can changes in the measurement conditions (evolution of vegetation cover, sensor changes…) cause the downward trend registered by the ground meteorological stations?

For regions in France where at least 3 or 4 meteorological stations have shown similar decreasing trends, parameters that could cause such a trend like a change of sensors on a national scale or the evolution of the roughness surrounding the stations were examined.

Not only did these investigations show that sensor changes or roughness evolutions could not be the cause of this decreasing trend but other searches have shown that this evolution seems coherent with wind trends observed in regions close to the North Sea like in Belgium or Germany. Indeed, it appears that the decreasing trend diminishes gradually for North-Eastern regions.

These results tend to consider that the decreasing wind speed levels observed are limited to an effective decrease of the wind resource in these regions and should not be attributable to evolution in the measurement conditions such as the evolution of the surface roughness.

1. CONTEXT AND OBJECTIVES

Recent studies conducted by Eoltech have shown a significant decrease of the wind resource in the Northern half of France since the early 2000s. Throughout the years, two main hypotheses have been considered to try to explain this phenomenon: changes in the atmospheric circulation or changes in the measurement conditions.

As the observations based on wind measurements from meteorological stations differ from the trends proposed by reanalyses data such as MERRA-2 where the decreasing trend is diminished or inexistent, the question remains: can changes in the measurement conditions cause the downward trend registered by meteorological stations?

This study aims to answer the previous question by explaining why changes in the measurement conditions such as sensor changes or roughness evolutions could not be the only cause to the decreasing wind trends.

2. METHODOLOGY

The methodology used in this study first consisted in identifying meteorological stations providing consistent wind measurements on long-term periods (≈ 30 years).

For the chosen regions, the meteorological data from the measuring stations were then analysed. First, the maintenance history was reviewed for each meteorological station in order to determine if a sensor change on a national scale has occurred in the past 30 years and then, the environments of the stations were examined in order to answer the following questions:

- What are the meteorological stations surrounded by (water, cities, forests …)?
- Has there been an increase of the forested areas near the meteorological stations in the studied regions?
- Did the overall roughness around the meteorological stations significantly evolve these past years?

3. DATA COLLECTION

3.1. SELECTION CRITERIA

This study focuses on two regions in France: the North of France and Brittany (see Figure 1) as decreasing wind trends have previously been observed for these two regions [5]. It should be noted that both regions show similar trends as they can be associated to similar wind regimes (wind rose and energy distributions per sector on Figure 1).

Figure 1 Studied regions and associated wind rose and energy distribution per sector.

In each region, several meteorological stations with consistent wind data on long-term periods (≈ 30 years) were identified.

Once the meteorological stations were identified, annual wind indexes for each station were created based on the reference period January 1998 – December 2007. Note that the wind speed indexes were calculated on 12-months rolling periods on a monthly time step.

3.2. FINAL DATASETS

The location of the meteorological stations retained in this analysis as well as the corresponding annual wind speed indexes are shown below (the months on the graphs correspond to the beginning of the 12-months rolling periods).

Figure 2 Evolution of the annual wind speed indexes for the North of France.

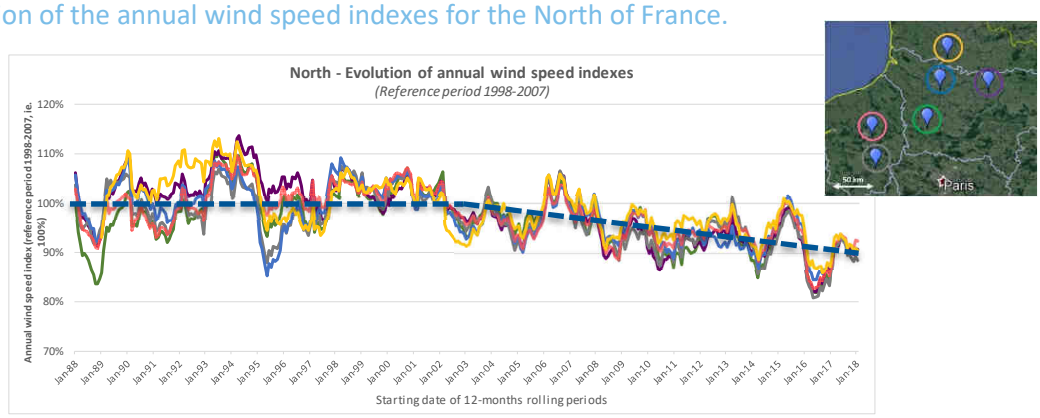
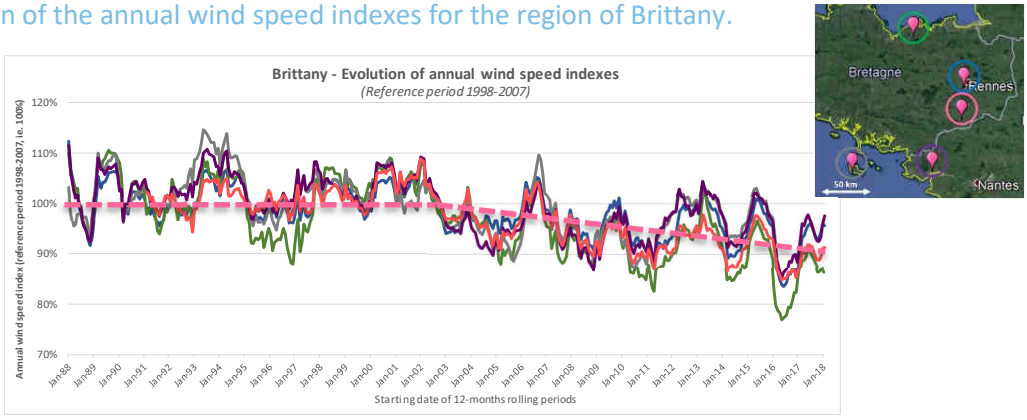


Figure 3 Evolution of the annual wind speed indexes for the region of Brittany.



It should be noted that even if some discrepancies between the stations can be observed punctually on the previous graphs, they are more likely related to local exposures rather than a consistency issue. **The global trend is the same for all stations within each region**.

4. REVIEW OF SENSOR CHANGES

In order to determine if a sensor change has occurred in the last 30 years on a national scale, the information related to the maintenance operations on the meteorological stations have been reviewed. Such information is freely available on the Météo-France Publithèque website. For this analysis, the sensor changes have first been listed and have then been indexed on a graph for a better visualization.

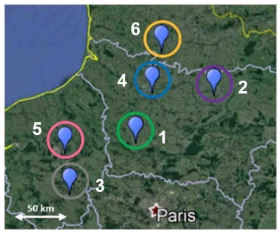
4.1. LIST OF SENSOR CHANGES

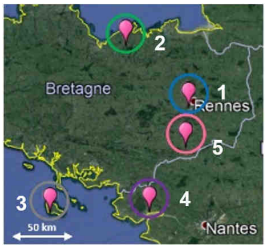
The table below lists all of the sensor changes that have occurred for the chosen meteorological stations between 1988 and 2018.

Table 1 List of sensor changes over the past 30 years.

Region	Station	Number of changes (*)	Date 1	Date 2	Date 3	Date 4
North	1	2	06/1993	12/2008	-	-
	2	2	04/1994	12/2000	-	-
	3	3	12/1989	06/2007	07/2008	-
	4	1	03/2005	-	-	-
	5	4	08/1992	10/1993	12/2001	07/2012
	6	1	10/2002	-	-	-
Brittany	1	2	05/1994	10/2001	-	-
	2	2	07/2002	08/2016	-	-
	3	3	10/1994	01/2002	02/2016	-
	4	3	06/1995	11/2008	01/2010	-
	5	3	03/1988	10/2003	09/2015	-

(*) *Changes of anemometers between 1988 and 2018*





4.2. VISUALIZATION OF THE SENSOR CHANGES

The graphs below represent the same annual wind indexes as presented previously but without the detail per station. Hence, the blue and pink lines correspond to the average annual indexes of all the meteorological stations and all of the annual indexes are comprised in the light blue and light pink ranges (minimum and maximum annual wind index).

On these graphs have been appended the sensor changes for a better visualization. Note that each colour refers to a specific meteorological station.

Figure 4 Visualization of the sensor changes in the North of France.

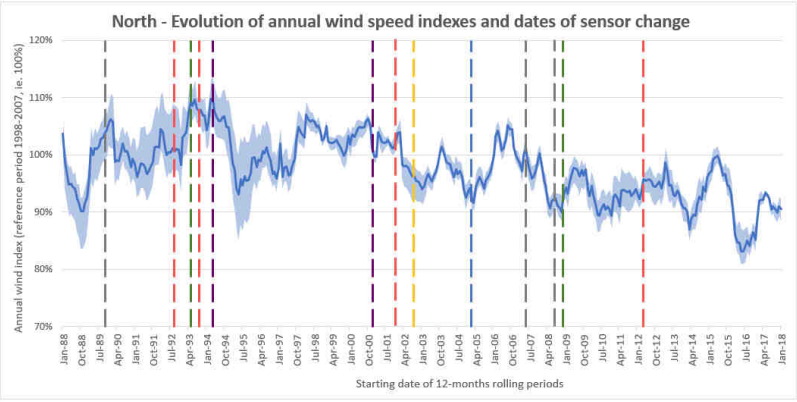
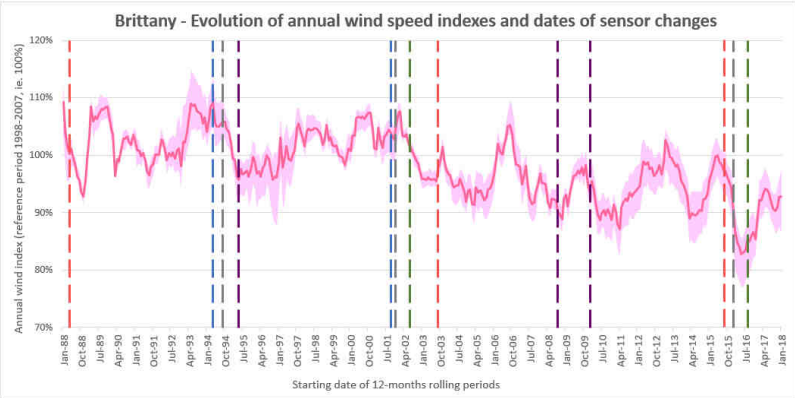


Figure 5 Visualization of the sensor changes in the region of Brittany.



As shown on the previous graphs, for both regions, no sensor changes have occurred at the same time for all of the meteorological stations.

Also, it should be noted that this hypothesis did not seem plausible to explain the entire decrease of the wind trend because **the decrease is gradual throughout the years and instrumental drifts would cause a sharp break.**

5. ENVIRONMENTS OF THE STATIONS

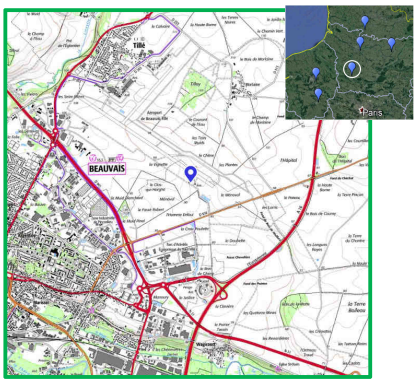
As previously mentioned, the surroundings of the meteorological stations were examined in order to answer the following questions:

- What are the meteorological stations surrounded by (water, cities, forests …)?
- Has there been an increase of the forested areas near the meteorological stations in the studied regions?
- Did the overall roughness around the meteorological stations significantly evolve these past years?

5.1. SURROUNDINGS OF THE STATION

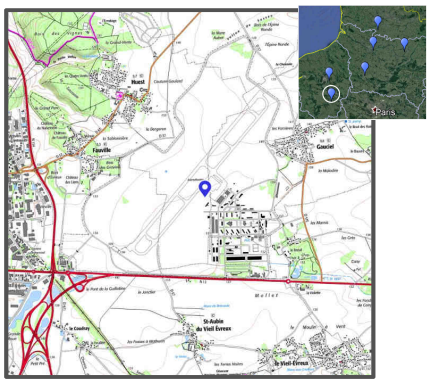
The images below show for both the North of France and Brittany, the location of each meteorological station and its surroundings.

Figure 6 Surroundings of the meteorological stations in the North of France.



Station 1

Station 2



Station 3

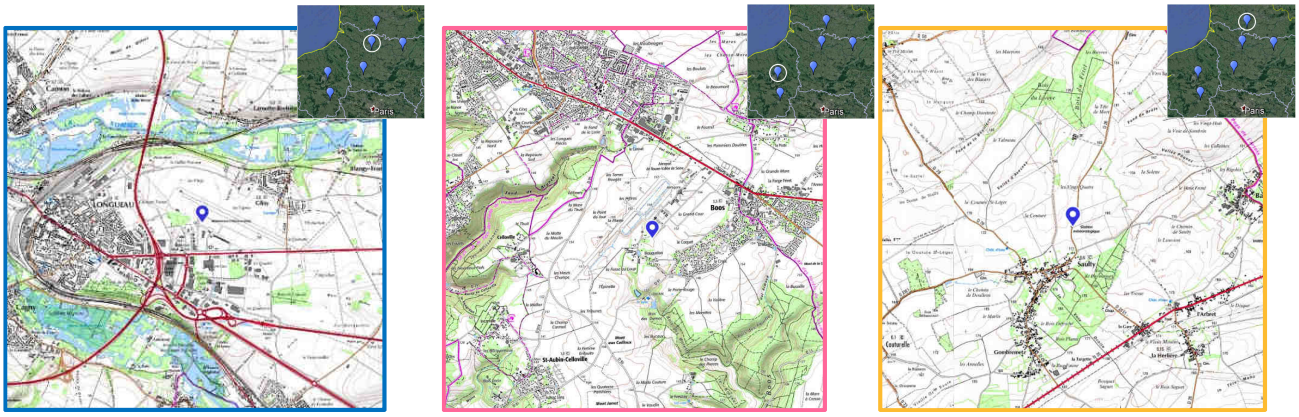


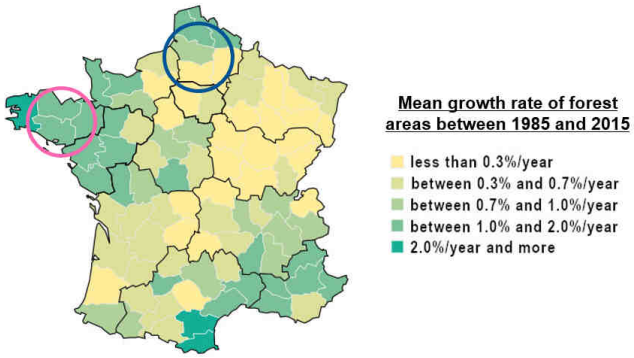
Figure 7 Surroundings of the meteorological stations in the region of Brittany.

Hence, as shown for both regions, the meteorological stations are located in both rural and urban areas and have rather different kinds of environments. On the prevailing wind sector South-West (see Figure 1), the meteorological stations are surrounded by water, cities, forests areas or have open environments. As the environments of each meteorological station are so different, they should have evolved in different ways.

5.2. EVOLUTION OF FOREST AREAS IN FRANCE

A forest inventory in France [1] was conducted by IGN (National Geographic Institute) to determine the evolution of forest areas in France between 1985 and 2015 (map below).

Figure 8 Evolution of forest areas in France between 1985 and 2015.



The figure above illustrates that forest areas have grown in France between 1985 and 2015. However, even if a growth of forest areas is observed these past 30 years, the growth rate is different for meteorological stations in a same region and is also different between regions providing similar long-term trends. The growth of forest areas could therefore not be the cause of the decreasing wind trend.

5.3. EVOLUTION OF ROUGHNESS

If it is quite complicated to determine precisely if the roughness around a meteorological station has evolved these past years, it is possible to establish that for some meteorological stations, there has been no change. To do so, the observation has to be based on stations with very open landscapes like the meteorological station of Belle-Ile-le-Talut (station 3 – Brittany). The images below show the aerial photographs of this meteorological station and thus the evolution of its environment from 1991 to 2016 using Google Earth satellite images.

Figure 9 Location of meteorological station Belle-Ile-le-Talut.

Figure 10 Evolution of the surroundings of meteorological station Belle-Ile-le-Talut.

As show on these images, no evolution of the roughness has occurred for this station, especially on the prevailing wind direction (ocean in the direction South-West). Nonetheless, this station still provides similar wind trend as the other stations in the inland region located in more complex environments (forests, bocages...).

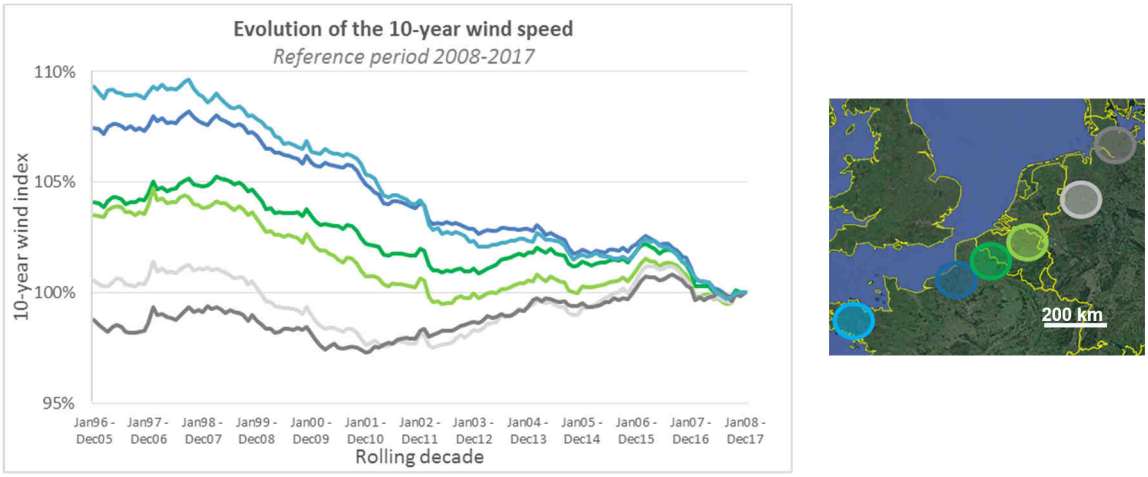
Hence, if the roughness could have evolved for other meteorological stations, it might not explain the global decreasing wind speeds observed in the area.

6. COMPARISON OF THE WIND TREND WITH NEIGHBOURING COUNTRIES

The elements presented in this paragraph are issued from a previous study carried out by Eoltech in September 2018 [5]. They show that the decreasing wind trend is not specific to France and is coherent with the wind trends observed in neighbouring countries.

The graph below illustrates the evolution of 10-year wind speeds compared to the wind speeds on the reference period 2008-2017 for 6 regions close to the North Sea.

Figure 11 Evolution of 10-year wind speeds in 6 regions close to the North Sea.



Hence, this graph shows that the decreasing trend diminishes gradually by moving to the North-East. There is thus a geographical coherence that, even if not explained today, allow to not question the trends provided by the meteorological stations in France.

7. CONCLUSIONS

This study performed on two regions in the Northern half of France shows that for stations with similar wind trends, no sensor changes have occurred at the same time and the environments of the meteorological stations have evolved in different ways.

These findings are coherent with studies conducted by Vautard *et al.,* 2010 [2], Bichet *et al.,* 2012 [3] and Jourdier, 2015 [4]. Through different methodologies using vegetation indexes or numerical studies, all papers come to the conclusion that instrumental drifts or roughness evolutions could not be the only cause of the decrease in winds.

Also, previous studies undertaken by Eoltech have shown that the global wind trend in the Northern half of France is coherent with wind trends in neighbouring countries (Belgium, Netherlands and Germany – progressive attenuation of the decrease going North-East) [5]. In addition, as analyses of pressure data allows to observe a slighter decrease in the winds than measured data [6], the question raises of a possible change in the atmospheric circulation and/or a change in vertical shear between surface and geostrophic winds.

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