Influence of the choice of long term sources in France
Modelled data vs measured data

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Abstract

The long term adjustment of wind measurements is one of the key issues in wind potential assessments. It can lead to significant deviations in terms of estimated production depending on the methodology, the length of the long-term period but also the choice of the sources considered as long term references. The influence of this latter criteria, particularly by comparing modelled data and measured data, is the main focus of this study.

To this end, two kinds of datasets were compared:

- Data from reanalysis (mainly MERRA-2)
- Data from a wind index based on the combination of consistent data from at least 4 ground meteorological stations in the same area.

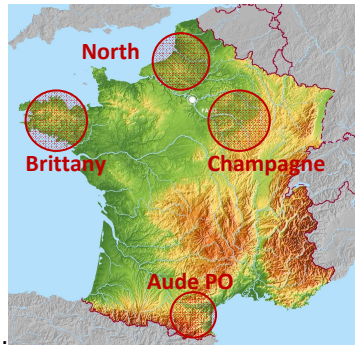
The latter, called multisource index, is considered as the referent one. Indeed, if the use of measured data requires a rigorous selection process and continuous control to check the consistency over time (sensitivity to the evolution of the environment), their combination ensures reliable results as the measurements are independent from each other.

In the end, the analysis carried out within the frame of this study have shown that while modelled data (as MERRA-2 reanalysis) are useful for numerous applications, their use for long term prediction can generate some biases in specific cases.

1 Background and objectives

The aim of this analysis is mainly to compare the long term adjustments of measurement campaigns on site using MERRA-2 data to the ones performed using a referent multisource index. The purpose is also to assess the magnitude of the deviations obtained depending on the considered source or the length of the long term period (from 10 to 17 years).

The focus of the study are 4 of the main areas of wind development in France (North, Champagne, Brittany and Aude-PO) representing more than half of the installed power in continental France.



Graph 1: Location of the considered main areas

Similar tests were also carried out using other sources of modelled data (ERA-I and CFSR) and over several other regions in Europe.

2 Methods

For each region taken into consideration – in which the wind resource is considered homogeneous (consistent regional wind regime) - two wind indexes have been established.

The referent one was based on data from meteorological ground stations at 10 m high, whose consistency has been ensured over the entire chosen history. This index, called multisource index, is considered as the reference as it is comprised of several sources coherent and independent from one another. The convergent conclusions that can be made from these sources over time ensure the reliability of this index. Indeed, each source taken separately would provide similar conclusions as the others in terms of representativeness of the wind resource.

The other index, called MERRA-2 index, corresponds to an average of 2 or 3 MERRA-2 datasets in the area (adjacent locations). Thus, it

cannot actually be considered as a multisource index in the sense that the MERRA-2 datasets at different locations might not be fully independent from one another.

First, long term trends of both indexes were compared (standardized wind speeds). Then the conclusions of long term prediction carried out with each index were compared.

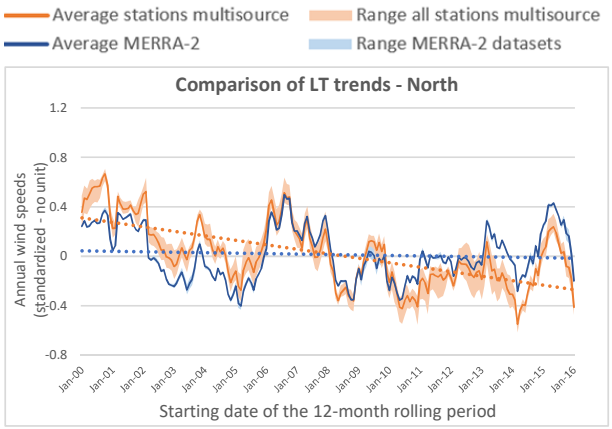
2 Results for MERRA-2 in France

2.1 Analysis of long term trends

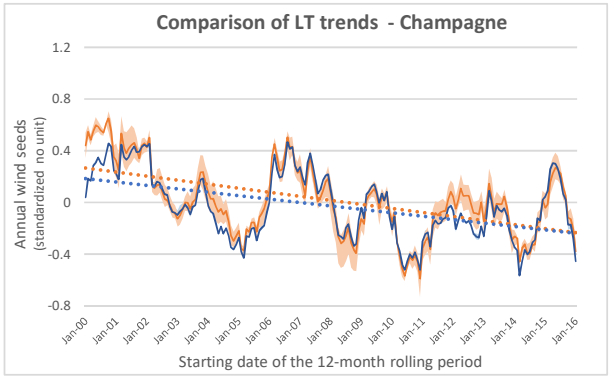
In order to check the long term consistency of MERRA-2 data, the trends of annual wind speeds have been compared since 2000 for all the ground stations comprising the referent index on the one hand and for the re-analysis data on the other hand.

The monthly mean wind speeds were standardized in order to make the evolution of annual wind speeds comparable (mean and standard deviation), using 2000-2016 as the referent period for standardization.

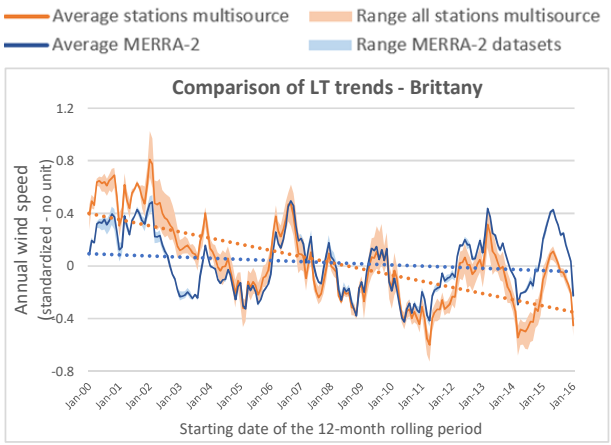
Thus, the graphs below present the annual standardized wind speed (rolling averages):



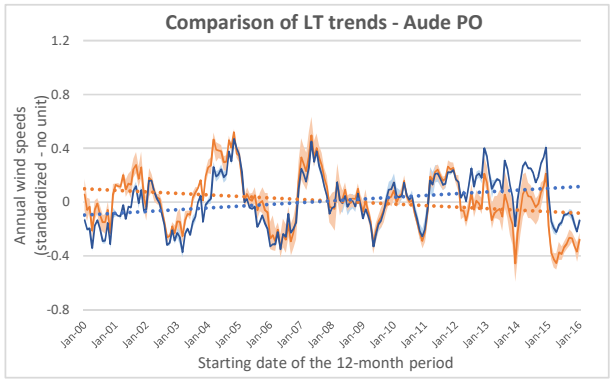
Graph 2 : Long term trends since 2000 (region North)



Graph 3 : Long term trends since 2000 (region Champagne)



Graph 4 : Long term trends since 2000 (region Brittany)



Graph 5 : Long term trends since 2000 (region Aude-PO)

It appears that, except for the region of Champagne, trends proposed by MERRA-2 data differ quite significantly from the referent trend based on multisource information.

For 3 of the 4 regions taken into account, the wind level proposed by MERRA-2 data seems to underestimate the decreasing trend observed in the wind resource since the beginning of the 2000s. These biases appear even more obvious when considering shorter referent periods for the standardization**.**

2.2 Consequences on long term prediction

2.2.1 Influence of the long term period duration on the predicted resource variations

The following table presents for each wind index (referent multisource and MERRA-2) the difference of wind resource obtained between the last decade (2007-2016) and longer periods.

Comparison of long term periods			
LT period / Last decade	2004-2016 (13yrs) / 2007-2016 (10yrs)	2002-2016 (15yrs) / 2007-2016 (10yrs)	2000-2016 (17yrs) / 2007-2016 (10yrs)
North			
Referent Multisource	100.8 %	101.5 %	102.2 %
MERRA-2	99.7 %	99.8 %	100.1 %
Champagne			
Referent Multisource	100.4 %	101.0 %	102.1 %
MERRA-2	100.1 %	100.7 %	101.1 %
Brittany			
Referent Multisource	100.8 %	102.4 %	103.3 %
MERRA-2	99.9 %	100.2 %	100.4 %
Aude PO			
Referent Multisource	100.6 %	100.4 %	100.6 %
MERRA-2	99.9 %	99.5 %	99.3 %

Table 1: Comparison of wind resource between long term periods – Referent multisource vs MERRA-2

Note that an error has occurred in the poster and that the real numbers are the ones in the table above.

The results above show that the choice of the long term period has a very low influence between 10 and 17 years when using MERRA-2 dataset as a single source (variation globally within the range ±1 % in terms of wind speeds).

However, the reference multisource index shows that on Northern France the impact of the choice of the long term period is more significant (wind speed variation within the range ±2.5 %).

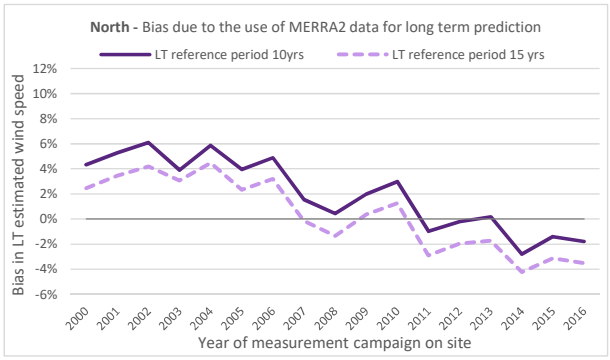
This observation is linked to the bias in long term trends observed on MERRA-2 data (almost no decrease considered on the long term wind resource in 3 of the 4 regions).

2.2.2 Biases on the estimation of long term wind speeds using MERRA-2 data

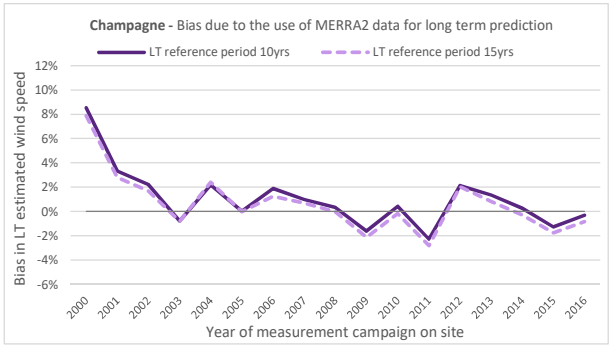
The correction to apply to a one-year wind speed measured on site has been compared either using the reference wind index (multisource) or the MERRA-2 index for each region. Two different long term (LT) periods were considered to observe the influence of the choice of the length of the LT period: 2007-2016 (10 years) and 2002-2016 (15 years).

The graphs below present the bias on the estimated long term wind speed due to the use of MERRA-2 datasets for the long term prediction, depending of the year of on-site measurement and the length of the LT period considered.

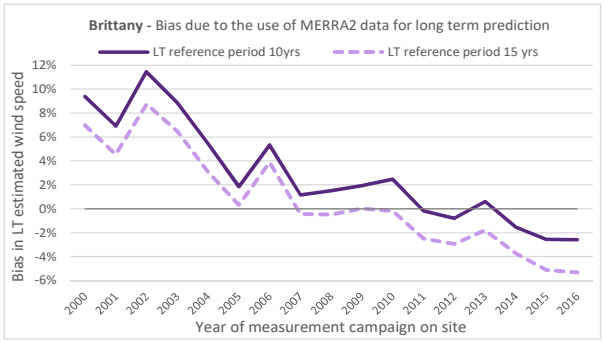
For the years when the curves are close to 0%, using the multisource index and MERRA-2 index will provide the same scaling factors for the estimation of long term correction. When the bias is positive, using MERRA-2 will tend to over-estimate the long term wind resource on site compared to the multisource index (and conversely when the bias is negative).



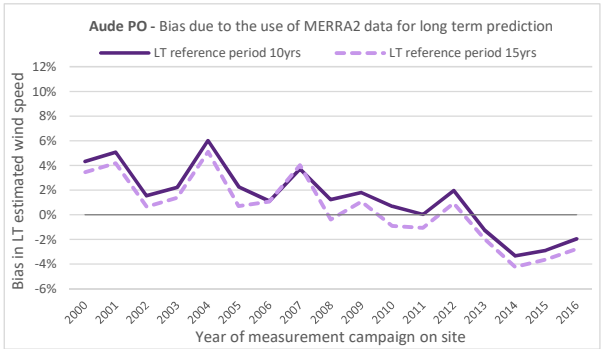
Graph 6 : Bias on the estimation of the long term wind speed using MERRA-2 data - North



Graph 7 : Bias on the estimation of the long term wind speed using MERRA-2 data - Champagne



Graph 8 : Bias on the estimation of the long term wind speed using MERRA-2 data – Brittany



Graph 9 : Bias on the estimation of the long term wind speed using MERRA-2 data – Aude PO

The following elements can be highlighted from this analysis:

- ✓ The behaviour of MERRA-2 data is rather satisfactory on the Champagne region, whatever the year of measurement after 2001 (bias within the range ±2% in terms of wind speed).
- ✓ On the other regions, the bias on the estimated long term wind speed can be significant.
- ✓ As current wind potential assessments are mainly based on quite recent periods of measurements on site, the conclusions for the early 2000s can be put into perspective. However, it appears that performing the long term prediction of recent years of measurement should be made with caution, as using MERRA-2 data can generate a bias in the LT wind speed up to -4 or -5 %, so up to -8 or -10 % in terms of LT production.
- ✓ For example, when using 10 years as long term period and MERRA-2 as the long term source, the bias on the long term predicted wind speed based on measuring campaigns in 2014 would be about -3 % in North and Aude PO, so about -5 to -6 % in terms of production.

3 Validation of the trends of the multisource index via a virtual regional wind farm

3.1 Principle

Beyond the fact that the measured wind data considered to establish the multisource energy index used as the reference were carefully selected (rigorous check of consistency over time), a third kind of data has been considered to validate the trend of the multisource index against the modelled data. Effective production data of active wind farms were gathered in two separate regions (Brittany and Aude PO), in order to create production data set of a virtual regional wind farm, less dependent of the specificity of each wind farm separately (exposure, uncertainty on losses due to availability issues…).

For each considered wind farm, monthly production data (from utility meter) and monthly availability rates were considered in order to get a monthly production equivalent to 100% availability for the wind farm.

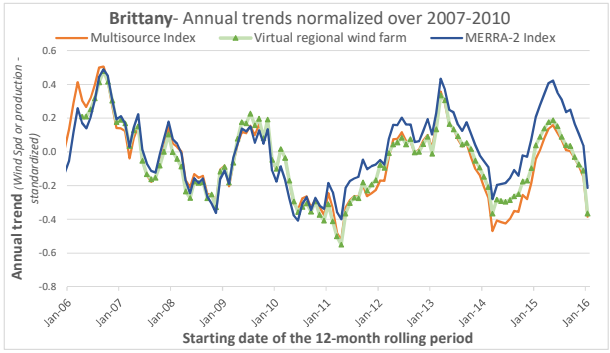
Monthly production equivalent to 100% availability of all the wind farms considered for each region were standardized in order to be comparable between themselves (mean and standard deviation), and several monthly values considered as too uncertain were filtered out (low availability rates or lack of consistency with other wind farms).

Finally, the standardized monthly production values were averaged to create the production data set of the virtual regional wind farm. Thus, these series are based on effective production data and were generated independently from either of the two wind indexes (Referent multisource or MERRA-2).

The data set was considered valid as long as production data of at least 3 different wind farms were usable to generate it.

3.2 Example 1: region Brittany

On the graph below, all sources of data were standardized over the period 2007-2010. Between 3 and 12 wind farms were used to generate the virtual series, and at least 8 since 2009.

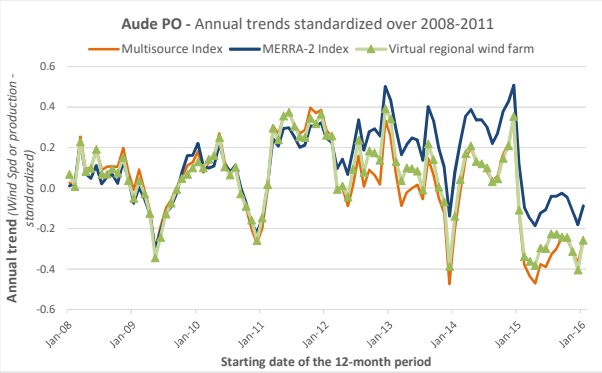


Graph 10 : Comparison of long term trends in Brittany – Multisource index, MERRA-2 Index and virtual wind farm

The graph 10 shows that after the period considered for the standardization of the data (2007-2010, i.e. 4 years of data), the trend observed for the virtual wind farm is more similar to the one proposed by the multisource index rather than the MERRA-2 one. Thus, effective production data recorded on active wind farms confirm that MERRA-2 data tends to overestimate the wind resource on most recent years compared to past years for this region.

3.3 Example 2: region Aude PO

On the graph below, all sources of data were standardized over the period 2008-2011. Between 3 and 5 wind farms were used to generate the virtual series.



Graph 11 : Comparison of long term trends in Aude PO – Multisource index, MERRA-2 Index and virtual wind farm

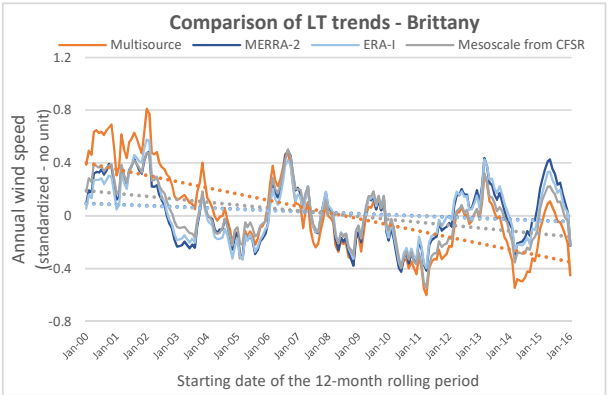
Once again, after the period considered for the standardization (overlapping trends), trends observed with the virtual regional wind farm tends to confirm the trend of the multisource index rather than the one from the MERRA-2 index, highlighting the drift in time assumed on this latter source.

3.4 Main outcomes

Effective production data recorded from different wind farms confirm the trends observed with the multisource index, and thus reinforce the assumption of bias on long term trends provided by MERRA-2 indexes.

4 Long term consistency of other re-analysis data sets in France

Some additional tests were carried out using data sets from ERA-I re-analysis as well as mesoscale data generated from CFSR re-analysis. Both have shown long term trends similar to the ones proposed by MERRA-2 data sets on the regions tested (example for Brittany see Graph 12).



Graph 12 : Comparison of long term trends in Brittany – Referent multisource vs various re-analysis data set

These observations tend to assume that the bias might be common to several re-analysis data sets. Further in-depth work on the methods of generation of these series would be interesting to understand this deviation.

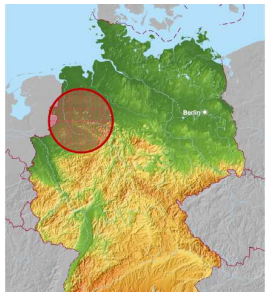
3 Long term consistency of MERRA-2 in other European countries

Even if the present analysis was mainly focused on France regions, similar analyses were carried out in other European countries in order to check if this long term bias was specific to French regions.

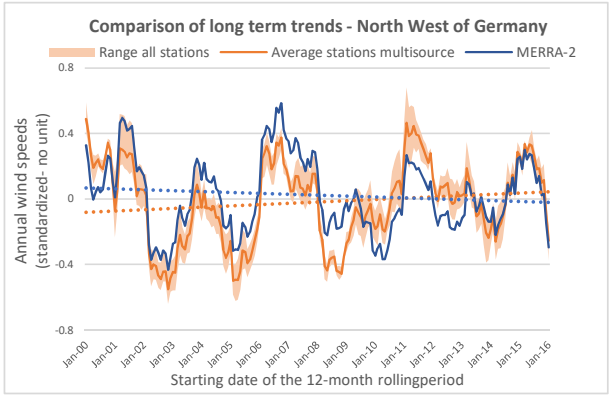
Multisource indexes and MERRA-2 indexes were compared on various regions of UK, Germany, Belgium and Netherlands.

It came out from these analyses that no similar long term bias in MERRA-2 data could be highlighted as observed in Brittany, North or Aude PO in France. Trends observed using MERRA-2 data on the one hand and multisource indexes generated from consistent ground stations in the area on the other hand have been similar since 2000.

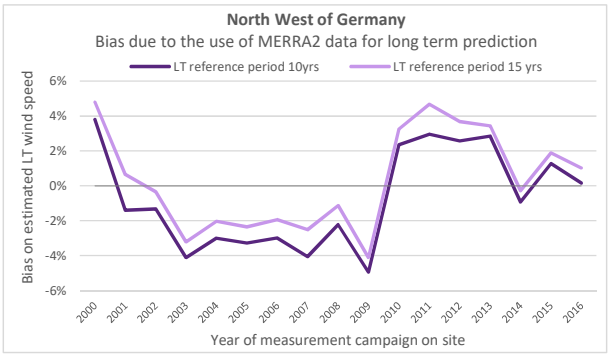
Punctual deviations have been observed for a few areas, as shown in the following graph for North West part of Germany but not attributable to a drift in a long term trends as the one observed in France.



Graph 14: North West part of Germany considered for analysis



Graph 15: Comparison of long term trends referent multisource index vs MERRA-2 index – North West of Germany



Graph 15: Bias on the estimation of the long term wind speed using MERRA-2 data – North West of Germany

Thus, in this specific area, some deviations are observed which could lead to biases in the estimated long term wind speeds using MERRA-2 as the main source for long term prediction (up to ± 4%). However, these deviations seem to appear randomly with no global drift becoming obvious.

As a reminder, cases like this were exceptional, and globally long term trends observed based on multisource indexes and MERRA-2 were similar in most tested areas across Germany, UK, Belgium, Netherlands and Denmark

4 Conclusions

In the end, in some areas in France the impact of the choice of the considered long term sources can be way more significant in terms of long term prediction than the choice of the length of the period itself. The choice of the sources can be considered as the key issue of the long term prediction process, which is for many projects in France the main source of output deviations between energy yield assessments.

This analysis has shown that in some major areas of wind development in France, using MERRA-2 data for the long term prediction can lead to biases in terms of long term production of 5 % or even more, due to a drift in the long term trends.

It should be noted that these trends to overestimate the wind resource in some areas in France in the recent years compared to past years are not specific to MERRA-2 data and can be observed with other modelled data (ERA-I for example). Similar tests were performed on other countries in Europe (Germany, UK…) and at this stage no similar biases were observed. However, if the global behaviour of reanalysis data seems quite satisfactory in these countries, punctual biases were pointed out in some regions.

To conclude, even if re-analysis data can be very useful information, we recommend when it is possible, to favour multisource wind indexes (at least for France) or to validate regularly modelled data with measured data in order to ensure the reliability of the long term prediction process.