Near-surface wind speed trends: uncertainty assessment of reanalysis products

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1 Introduction

Observational studies have identified wind speed trends in the last decades, but their causes are not fully understood. They have been attributed to several factors such as changes in the land use, aerosol emissions or atmospheric circulation [1,2]. For the wind energy sector the understanding of these wind speed trends can help to : risk estimation of wind energy resources, guide policy developments and avoid poor investment decisions.

However, in spite of the potential impact of this long-term variability in wind energy activities, this type of variability has not been fully characterized yet.

The three main objectives of this work are:

1. Characterization of the seasonal variability of the wind speed trends and their causes.
2. Assessment of the long-term variability of the high and low wind speed values.
3. Inter-comparison of the wind speed trends in different datasets.

2 Data description

Wind energy users have recently incorporated reanalysis products for the evaluation of the long-term wind speed variability. For some of these users it is still difficult to identify the most suitable dataset for their specific needs, because a comparison of the quality of the wind speed data from different reanalyses at global scale is not readily available.

The present study investigates the wind speed long-term trends at global scale in the last decades (1980-2015) using three state-of-the-art reanalyses: ERA-Interim [3], the Japanese 55-year Reanalysis (JRA-55) [4] and Modern Era Retrospective-Analysis for Research and Applications (MERRA-2) [5]. The most important specifications of these datasets have been summarized in Table 1.

	Institution	Horizontal resolution	Time resolution	Period
ERA-Interim	ECMWF	0.75º x 0.75º	6h	1979-present
JRA-55	JMA	0.56º x 0.56º	6h	1958-present
MERRA-2	NASA	0.625 º x 0.5º	1h	1980-present

Table 1*. Summary of the main characteristics of the three reanalysis datasets used in the present study.*

3 Seasonal variations of wind speed trends

Strong seasonal and regional variability of the ERA-Interim wind speed trendsFigure 1 (left) have been identified. In the boreal winter an increase of the wind speed over the oceans, particularly in the tropical regions, and a decline in some continental areas such as Europe or India are shown. The agreement among the trends at 10-m and at the level of 850 hPa (Figure 1, right) illustrates the link between the trends in both near-surface and the atmospheric circulation, which seems to be one of the main drivers of the near-surface wind speed trends.

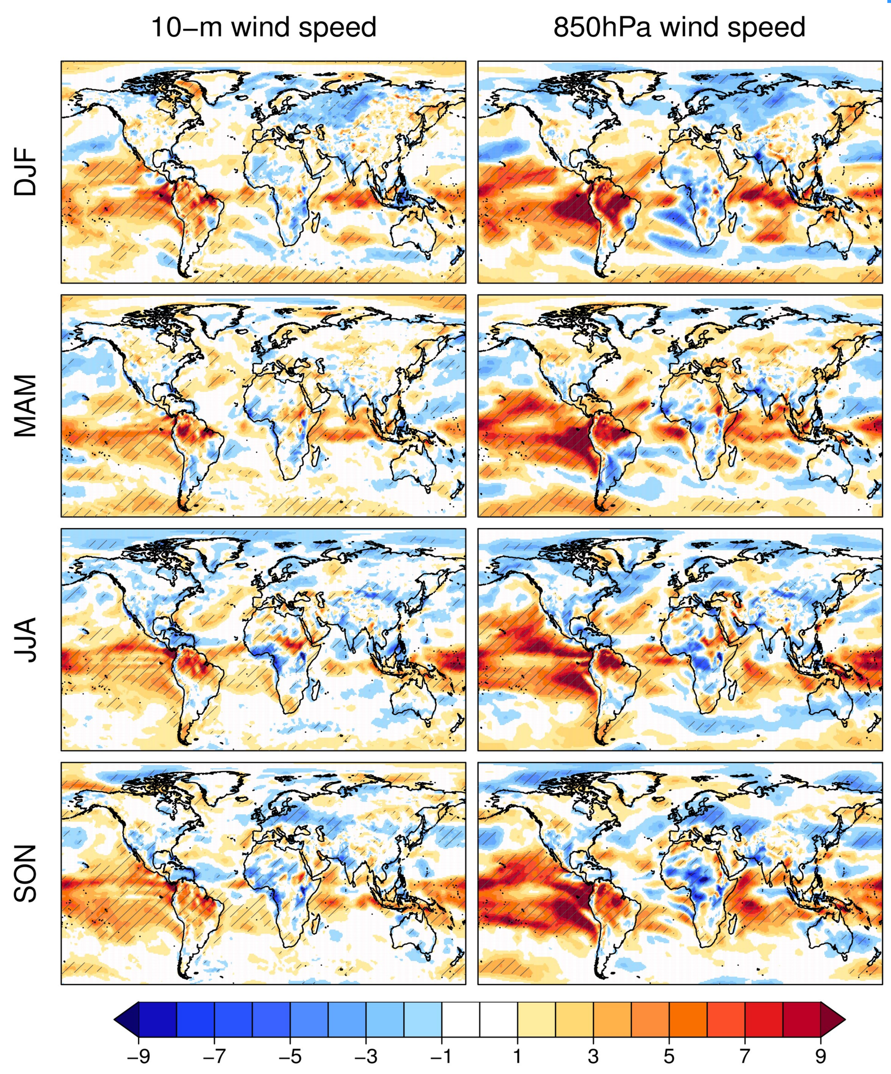

Figure 1*. Normalized linear trend (% per decade) calculated as the linear trend of ERA-Interim divided by the seasonal climatology of 10-m wind speed (left) and 850 hPa wind speed (right) in the period 1980-2015 in December-January-February (1st row), March-April-May (2nd row), June-July-August (3rd row) and September-October-November (4th row). Hatched regions indicate where the trends are significant at the 95 % confidence level.*

4 Trends of the 10th and 90th wind speed percentiles

The characterization of the near-surface extreme wind speeds can provide extra information about the long-term changes in the frequency of unusual events in a particular season. The analysis of the extreme events is based on two seasonal indices, the 10^{th} and 90^{th} percentiles of the 6-hourly near-surface wind speed.

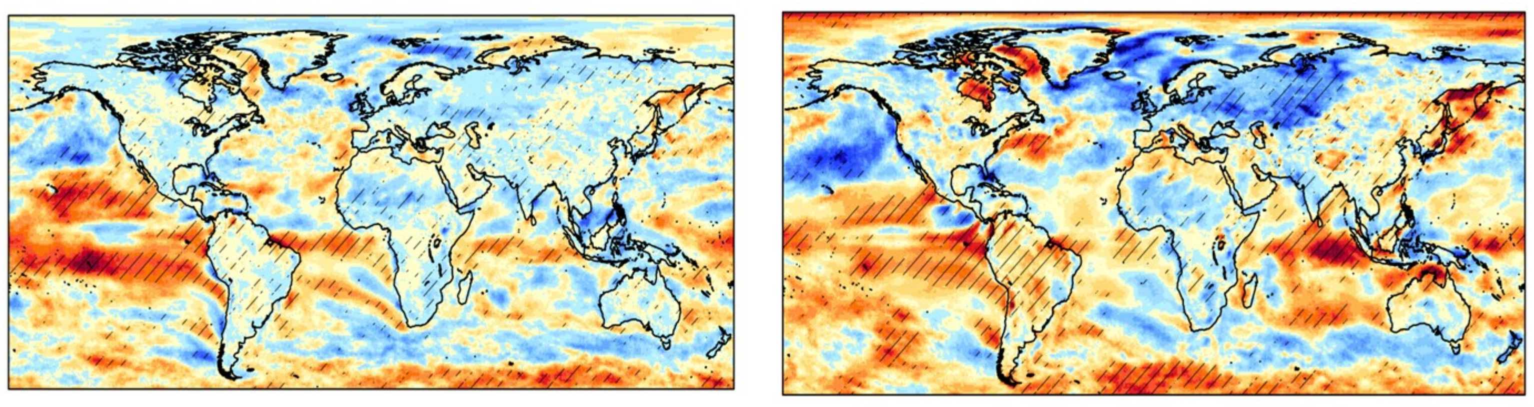

Figure 2*. Linear trend (m/s per decade) calculated as the linear trend of ERA-Interim 10th percentile (left) and 90th percentile (right) of the 10-m wind over 1980-2015 in December-January-February. Hatched regions indicate whre the trends are significant at the 95 % confidence level.*

Results for the DJF season (Figure 2) illustrates that the trends of the 90^{th} percentile (Figure 2, right) of the wind speed are more intense than the 10^{th} percentile (Figure 2, left). This indicates that the decline of the higher wind speeds is faster than the reduction in the lower values of wind speed.

5 Reanalyses inter-comparison

The discrepancies and similarities of the wind speed trends from each reanalysis in DJF are summarized in Figure 3. The three reanalyses show an increase of the wind speed values in Tropical areas and a wind speed decline is found in Eurasia that indicates that these trends are robust and they should be caused by changes in the atmospheric circulation since other possible factors, such as the time changes in land use or aerosols, are considered differently in these reanalyses.

Important differences have also been identified such as for the JRA-55 reanalysis that overestimates the negative trends over land (not shown). This problem is caused by a negative bias that is not fully corrected in the JRA-55 data assimilation process.

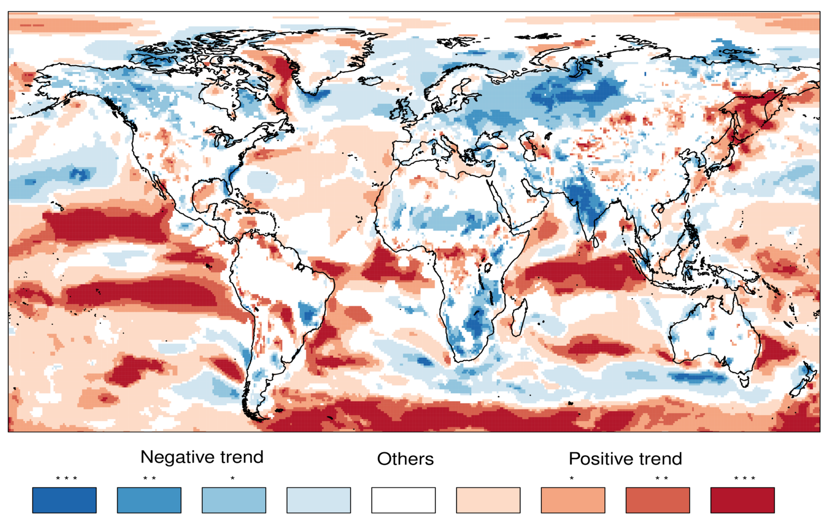

Figure 3*. Comparison of the 10-m wind speed trends from ERA-Interim, JRA-55 and MERRA-2. Blues (reds) indicate agreement between the three reanalyses about the negative (positive) trends of 10-m wind speed for December-January-February in the period 1980-2015. Astersisk indicates taht the trends are significant at the 95% confidence level: no asterisk indicates that the trends are not significant, (*) indicate that only one of the renalysis has significant trends, (**) informs that two reanalyses have significant trends, and (***) that the three reanalyses have significant trends.*

6 Conclusions

1. The near-surface wind speed trends show a strong seasonal variability that is in agreement with the obtained results for the winds at 850 hPa level. This connection between the wind speed at both levels indicates that the changes in the large scale circulation can be one of the most important driver of these trends.
2. The analysis of seasonal extremes of the near-surface wind speed reveals that the higher (90^{th} percentile) wind speeds are changing faster than the lower (10^{th} percentile) values.
3. There are many regions where the three reanalysis show similar near-surface wind speed, which indicates that the results of these trends are robust. However, some discrepancies have also be found, such as the intense negative trends for the JRA-55 data, that should be taken into account in those analyses where this dataset is used for the characterization of the long term wind speed variability.

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