

# Uncertainty in near-surface wind speed trends at seasonal time scales

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**Keywords**— wind speed variability, trends, reanalyses, seasonal

## EXTENDED ABSTRACT

Observational studies have identified wind speed trends in the last decades [1,2] attributed to several factors such as changes in the land use, aerosol emissions or atmospheric circulation. 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. As a consequence such information is not currently incorporated in wind power decision-making processes related to planning and management.

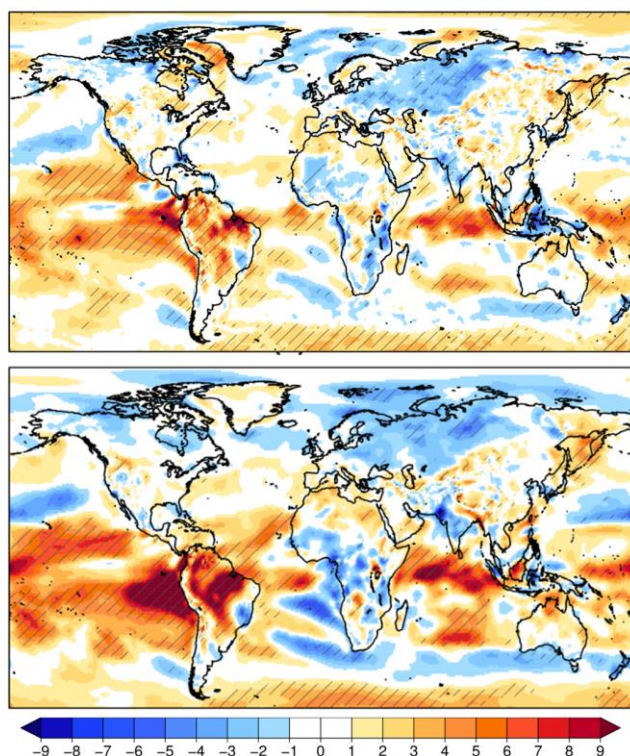


Fig. 1 Normalized linear trend (% per decade) calculated as the linear trend of ERA-I 10-m wind speed divided by the seasonal climatology of 10-m wind speed (top) and 850 hPa wind speed divided by the seasonal climatology of 850 hPa wind speed (bottom) over the period 1980-2015 in the December-January-February season. Hatched regions indicate where the trends are significant at the 95% confidence level.

The main limitation for the assessment of wind speed trends is the unavailability of long enough, homogeneous time series of historical data from observational measurements. These data products can be affected by discontinuities associated with changes in the measuring equipment or in the observing practices [3] which impacts on the data quality. To overcome these limitations, 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. For this reason, the present study investigates the wind speed long-term trends at global scale in the last decades (1981-2015) using three state-of-the-art reanalyses: ERA-Interim (ERA-I), the Japanese 55-year Reanalysis (JRA-55) and Modern Era Retrospective-Analysis for Research and Applications (MERRA-2).

Strong seasonal and regional variability of the wind speed trends have been identified. In the boreal winter (Fig. 1, top) 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. To investigate if these trends can be due to changes in the atmospheric circulation or to other forcings, the seasonal wind speed trends have been also computed at the level of 850 hPa (Fig. 1, bottom). The agreement among the trends at the two analysed levels 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.

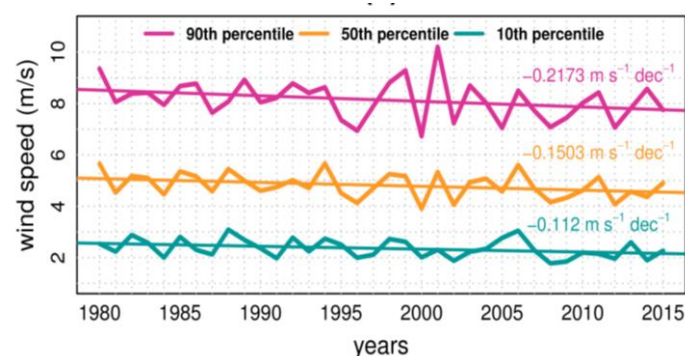


Fig. 2 Time series of the 90<sup>th</sup> (pink line), 50<sup>th</sup> (orange line) and 10<sup>th</sup> (green line) percentiles of the 10-m wind speed from ERA-I for December-January-February over the period 1980-2015 for a location in Poland [51.7° N and 18.9° E].

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 seasonal extreme events is based on two indices, the 10<sup>th</sup> and 90<sup>th</sup> percentiles. These indices are based on 6-hourly near-surface wind speed data. Results for the DJF season in a particular point in Poland [51.7°N- 18.9°E] (Fig. 2) illustrates that the trend of the 90<sup>th</sup> percentile (-0.2173 m/s per decade) of the wind speed is twice higher than the 10<sup>th</sup> percentile (-0.112 m/s per decade). This indicates that the decline of the higher wind speeds is faster than the reduction in the lower values of wind speed.

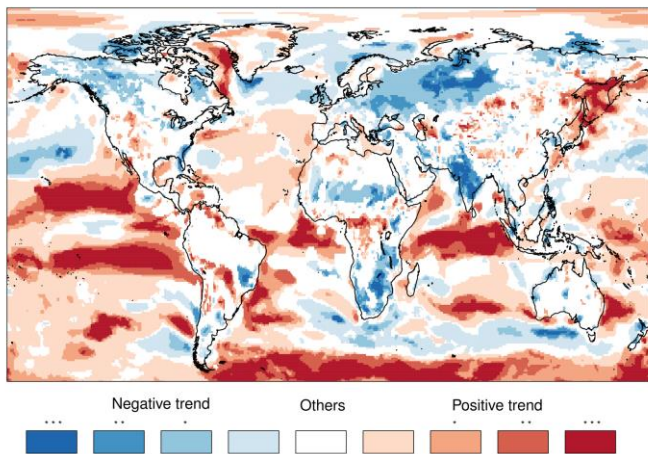


Fig. 3 Comparison of the 10-m wind speed trends obtained from ERA-I, JRA-55 and MERRA-2. Blue (reds) colours indicate agreement between the three reanalyses about the negative (positive) trends of the wind speeds for December-January-February in the period 1980-2015. Asterisks indicate that the trends in one (\*), two (\*\*), or the three (\*\*\*) reanalyses are significant at the 95% confidence level.

The discrepancies and similarities of the wind speed trends from each reanalysis in DJF are summarized in Fig. 3. The inter-comparison of the near-surface wind speed trends shows agreement in many regions. The three reanalyses show an increase of the wind speed values in Tropical areas and a wind speed decline is found in Eurasia. The agreement in the sign of the trends in those regions among the three datasets indicate 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.

Despite the existence of many regions where the trends are consistent in the three reanalyses, important differences have also been identified. The most important discrepancy has been found for the JRA-55 reanalysis that show intense negative wind speed trends over land. This problem is caused by a negative bias that appears in the interpolation of the near-surface wind speed from the atmospheric lowermost level. The impact of the discrepancies of the wind speed trends in different reanalyses can lead to inconsistencies in the evaluation of long-term wind power estimations that use reanalyses information for planning and management of wind farms. For this reason these results should be taken into account by users that employ these datasets in their decision-making processes.

Finally we have explored the near-surface wind speed trends in the European Centre for Medium-Range Weather operational seasonal prediction system, System 4, to investigate if this system is able to reproduce the trends that have been observed in the reanalyses. The seasonal predictions of the near-surface wind speed show weakened trends, and in some regions the sign of the trends is different to the wind speed trends in the reanalyses. This is an important aspect from the forecast verification point of view because different trends in the predictions and in the reference dataset could lead to an important skill reduction.

## References

- [1] Vautard, Robert, et al. "Northern Hemisphere atmospheric stilling partly attributed to an increase in surface roughness" *Nature Geoscience* 3.11 (2010): 756-761.
- [2] Bichet, A., et al. "Causes for decadal variations of wind speed over land: Sensitivity studies with a global climate model" *Geophysical Research Letters* 39.11 (2012).
- [3] Kaiser-Weiss, A. K., et al. "Comparison of regional and global reanalysis near-surface winds with station observations over Germany" *Advances in Science and Research* 12.1 (2015): 187-198.

## Author biography



**Verónica Torralba** studied her Degree in Physics and a Master in Meteorology and Geophysics at Complutense University of Madrid (UCM) in Spain, where she acquired a background in climate sciences. She joined the Climate Forecasting Unit (CFU) at the Catalan Institute of Climate (IC3) in October 2013 where

she worked in the adaptation of the existing tools in the CFU unit to create the necessary material for the development of climate services for the wind energy sector. She is currently working in the Earth Sciences Department at the BSC where she is a PhD student involved in different European Projects (EUPORIAS, SPECS, NEWA) and national initiatives (RESILIENCE). The overall aim of her PhD is the quality assessment of wind speed seasonal predictions and the application of different statistical post-processing methods. This information will be tailored to specific needs from the wind energy industry.