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WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Characterisation of Intra-hourly Wind Power Ramps at the Wind Farm Scale and Associated Processes" *by* Mathieu Pichault et al.

Ásta Hannesdóttir (Referee)

astah@dtu.dk

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First I would like to apologise for the delay of my review.

This paper deals with a very interesting topic, namely automatic characterisation of wind power ramps at a wind farm site. The analysis consists of many well-performed steps and ambitious tasks. The paper is well structured, the introduction is well written and formulated, and the methodology section is very clear.

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Discussion paper

There are however some assumptions in the paper that lead to some of the final conclusions being rather unreliable. I believe that the main issue is that the available measurements at the wind farm site are quite limited and cannot accurately represent the parameters that the ramp classification is based on.

Major issues:

1. Using TI as proxy for atmospheric stability. The papers that are referenced: Wharton and Lundquist (2012) and Hansen et al. (2012) investigate the influence of stability on TI. It can be seen in these studies that the spread of TI in each stability category is simply too high to give a reliable measure of stability on a 10-minute basis. As can be seen from table 1 in the current paper, a TI of 7% would represent convective conditions according to Hansen et al. but stable conditions according to Wharton and Lundquist! In a more recent paper, some of the same authors conclude: "Analysis indicates that while TI is generally lower in the stable class this assumption cannot be uniformly applied due to the wide range of TI in both stable and unstable classes " (Barthelmie et al., The role of atmospheric stability/turbulence on wakes at the Egmond aan Zee offshore wind farm, 2015) Further, there is no filtering of wake measurements. When the wind direction is in the range approx 100-190°, the mast is placed in the wind farm wake with high turbulence intensities. The wake flow is not representative of the general weather conditions. This will lead to falsely identified high turbulence conditions. Finally, there is a ramp effect. When the wind speed increases, e.g. during a frontal passage, the 10-minute TI will be relatively high, unless the wind speed measurements are detrended. Here there is no mention of detrending, so these conditions will also be falsely identified as high turbulence conditions.

2. The classification scheme, or ramp drivers, include categories that cannot cause

ramps on a wind farm scale. These are high turbulence and precipitation. While ramps can definitely be associated with both precipitation and high turbulence, these conditions are not the causality of wind farm ramp events.
Due to the non-linearity of the wind turbine power curve, high TI (disregarding shear and veer) will have the following effect: at high wind speeds (near rated wind speed) the wind turbine power curve is reduced. Conversely, at low wind speeds (near cut-in wind speed) the power curve will increase. So, high TI will have to be conditioned on wind speed and have a sudden change to result in a wind power ramp.
Also, due to the limited scale of turbulent fluctuations (microscale range) and their inherent stochastic nature, turbulent fluctuation cannot cause an increase in the power output of all the wind turbines in the farm simultaneously.
If the main purpose of the ramp classification is to improve ramp forecasts, then it is vital that the categories are real ramp drivers. It is e.g. not possible to forecast rain and then expect a ramp at the wind farm site.

Minor issues:

1. Using precipitation data 25 km away from the site can be problematic in the summertime, with frequent convective conditions and very local rain showers. This may lead to falsely detected rain events at the wind farm site.

2. The data (temperature, pressure, density and relative humidity) shown in Figures 12-15 has not been mentioned anywhere in the text. Are these measurements from the meteorological station 25 km away?

Based on the major issues I suggest the following changes of the analysis:
Because the data on the wind farm site is quite limited, the analysis could be simplified. Focus on the ramp identification algorithm and the frontal passage detection. Include only three or four characterisation groups. These could be: Frontal passage, post

frontal activity, mesoscale fluctuations near rated wind speed, and other. This would be a first step towards a more detailed ramp classification scheme, but would be very valuable all the same. In order to define a more detailed ramp classification scheme, a more extensive data set at the wind farm site is needed.

The current paper also opens up for other interesting research questions such as: How often does a frontal passage result in a wind power ramp at the wind farm? Will all frontal passages lead to wind power ramps?

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