

## ***Interactive comment on “A simple methodology to detect and quantify wind power ramps” by Bedassa R. Cheneka et al.***

**Bedassa R. Cheneka et al.**

b.r.cheneka@tudelft.nl

Received and published: 18 August 2020

[journal abbreviation, manuscript]copernicus

Thank you for your detailed comments. Following your comments and feedback we have added some additional results and explanation to improve the quality of the paper. The most important changes to the paper include:

- We have made an analysis of the seasonal and diurnal variation of the ramps for the offshore data.
- We have analysed an additional data-set (Swedish onshore wind farm data)

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which allows us to show how it can be used when the installed capacity of the fleet changes during the time series being analysed.

- We have compared our method with with the min-max ramp identification method of Bianco et al. 2016.

We have responded to the referee comments by including our answers below the original comments. Our answers are preceded with the following labels:

RC = referee's comments

AC = authors' comments

### **General comments**

RC: Ramp events are rapid changes of wind power production over short period of times and grid operators have to be prepared to switch between renewable and other forms of energy during these rapid changes in wind power availability. The definition of ramp events is not unique and this manuscript describes a methodology that uses a wavelet transform to discriminate ramp events above stochastic wind variations. The subject of the study is suitable to Wind Energy Science. Overall the manuscript reads well and the methodology is adequately described. Figures are OK, although some improvements have to be performed, as suggested in the specific comments below.

This Referee thinks that since other procedures, also referenced in the manuscript, have been introduced in other studies the authors could explain better what are the benefits of this methodology versus the others and maybe even compare the results of ramp identification when using other methodologies against this one. For instance, the Min-Max method introduced in Bianco et al. 2016 is easily reproducible and it could be employed with many different ramp definitions on the 10 days data-set used

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in this manuscript, marking positively all the times when any ramp is identified, and comparing with the output of the wavelet transform method introduced here.

AC : Thank you for this feedback. We have expanded the scope of the paper to show the advantages of the method (including the analysis of a data-set where installed capacity changes). We have compared the wavelet transform method with the min-max method and contrasted sensitivity to parameter choices.

RC: Also, the authors claim that the disadvantages of other methods are that they rely on specific thresholds, but it seems that this procedure also rely on some decision on thresholds (i.e. the authors decide to go with a 10% rejection level, instead of a 5%, 2% or 1%). This threshold could be dependent on the data-set, as I imagine that aggregating over more turbines would smooth out the wind power time series.

AC: We agree that the statistical discrimination level is a matter of choice, but we believe that this approach is more robust and less sensitive to approaches which rely on specific power level or time-scale changes, particularly where a data-set is non-stationary, e.g. where installed capacity increases. We have added some additional explanation and data analysis (the Swedish data and the comparison with the min-max method) to try and better explain the advantages of the method.

RC: Finally, since the data-set used in Section 6 is longer (2 years) than the one used in the previous sections to introduce the methodology (10 days), this section could be expanded to include more quantitative statistical results, maybe also looking at daily, or seasonal distribution of ramp events, for instance.

AC: We have expanded the analysis to look at diurnal and seasonal variation for the Belgian offshore wind farm cluster.

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### **Specific comments**

RC: Fig. 1: You need to stretch the x-axis of the bottom panel to match the length of the upper panel's one, as it is difficult now to see how the large values of  $W$  in the lower panel correspond to the up- or down-ramps visible in the upper panel.

AC: This figure has been changed.

RC: Page 3, lines 83-84 and page 4, lines 85-86: Referring to Fig. 2 you mention "top left plot" and "bottom right plot", which makes me think there are 4 panels in your figure, but I can only see a left and right panel.

AC: Figures have been revised and each sub-figure is now referred to as (a), (b), (c), etc.

RC: Fig. 2: Please introduce what  $P$  and  $P'$  are in the figure caption.

AC: We have made this explicit in the caption.

Rc: Fig. 3: Change label to explain that left panels are for 10% and 5% rejection levels, and right panels for 2% and 1%. Also, introduce what is  $R$  on the left-y-axis.

AC: We have changed the plots in this figure and added text in the paper to make things clearer.

RC: Fig. 4: "the colour scale is blue (ramp-up events), red (ramp-down events)". Isn't it the opposite of what you are saying?

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AC: This has been corrected.

RC: Fig. 5: Could you try to keep consistency with previous figures in colors identifying up and down-ramp events?

AC: We have changed this to make things more consistent.

RC: Page 9, Lines 146-147: "though the correlation is stronger for the ramp-up events than the ramp-down events". Can you provide statistical values for this statement?

AC: As we have expanded the resolution of this figure, this is no longer as obvious so we have removed the comment about the correlation being stronger for the ramp-up events.

RC: Section 6: I think in general this section could be expanded to include more quantitative statistical results as well as analysis of daily and seasonal distribution of up- and downramp events, for instance.

AC: We have expanded the analysis to look at seasonal and diurnal trends.

RC: Fig. 7: How are the durations binned?

AC: This is hourly. We have added this in the text.

#### **Technical corrections**

RC: Page 2, line 40: Replace "was used detect ramps" with "was used to detect ramps"

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AC: We have amended this sentence.

C6