

Interactive comment on “Characterization of a new perturbation system for gust generation: The Chopper” by Ingrid Neunaber and Caroline Braud

Anonymous Referee #1

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General Comments:

In this work, the authors introduce and characterize a new method for generating large gust disturbances in a wind tunnel using a rotating blade. Two gust frequencies were tested, and hot-wire measurements showed large gust amplitudes in both cases. The gust signals were decomposed into mean, disturbance, and turbulence components, and each of these components was analyzed in detail. Overall, the study is well motivated, designed, and documented, and the capability of the “chopper” to generate significant, repeatable gust events is conveyed convincingly. I would prefer, however, that the aerodynamics of the device be considered in more detail. Since only two gust frequencies are studied, a more comprehensive explanation of the physical principles that govern the gust generator’s influence on the flow would greatly strengthen the

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characterization in this paper. Thus, while the gust-generation mechanism itself is novel and of interest to the wind-energy community, I believe a more detailed analysis of the results is required before this paper can be accepted for publication.

Specific Comments:

S1: [Section 1] The introduction motivates the problem well, and the review of relevant literature is concise and effective. I note, however, that the EOG profiles in Figure 1 are never compared with the gust profiles induced by the “chopper” mechanism. The authors could make the connection between these classes of gust profiles clearer. It should also be specified that the gusts of interest to this study are in the streamwise direction.

S2: [Section 2] More information about the closed-loop wind tunnel should be given. Since the test section of the wind tunnel is presumably discontinuous due to the construction of the gust generator, statistics regarding the baseline flow conditions in the measurement area would help isolate the influence of the gust generator from any background effects (especially in light of the turbulence intensities presented later in the work, e.g. Page 5, Line 94). The limitation of this gust-generation mechanism to wind tunnels with discontinuous test sections should also be stated, or modifications to the design for fully closed test sections should be proposed.

S3: [Section 2] The design of the “chopper” system should be further motivated by aerodynamical considerations. Is the primary purpose of the mechanism to produce large fluctuations in blockage, in order to create large oscillations in the free-stream velocity? If so, is there a qualitative difference in the method to closing and opening an active grid? Is the rotational motion of the blade intended to induce additional flow-normal velocity fluctuations due to the shearing action of the blade on the incoming flow? If, as the authors point out in Figures 6 through 9, the resulting flows are asymmetric in the test section, why was a rotating system used instead of a rising and falling guillotine-like blade? The authors should explain why this particular design was chosen in light of their goal of creating large-amplitude turbulent gusts.

S4: [Section 2, Page 4, Line 78] Why were 20 gust events chosen for these experiments? An analysis of statistical convergence would make the study more comprehensive.

S5: [Section 3.1] Why is it that the higher rotation frequency leads to stronger gusts (Page 5, Lines 97-98)? Why do the gust velocities in this case exceed twice the inflow velocity? I highlight these observations as examples: the authors are very comprehensive in explaining their findings, but a physically motivated discussion of the reported phenomena is generally lacking. I would prefer that these observations be explained (and further analyzed as necessary), so that the generalizability of these findings can be inferred.

S6: [Section 3.1, Page 5, Line 101] Please comment on why an isotropic-turbulence assumption applies to this flow. Given the character of the forcing, I would expect that the generated turbulence would be significantly anisotropic.

S7: [Section 3.1] The decomposition of the gust into three components is helpful for the analysis of the results. Please specify the method by which the gust shape and turbulent fluctuations were isolated from the mean flow, as the method by which these were obtained affects the spectral signatures of the gust and fluctuation profiles. In Section 4, Page 14, Line 14, the authors apply a second-order filter to obtain the corresponding spectra. If this was the method used to achieve the initial decomposition, how was the cutoff frequency selected? Why wasn't a filter with a sharper roll-off used? These details are needed to explain whether the fluctuations in the gust profiles shown in Figures 11 and 12 are part of the mean gust profile or turbulent fluctuations that passed through the filter due to the relatively gentle roll-off of the second-order filter.

S8: [Section 3.2] The authors do a good job characterizing the mean flow fields downstream of the gust generator. Could the authors comment on the extent to which the spanwise flow asymmetry shown in Figures 6 through 9 would affect wind-tunnel experiments (e.g. of nominally 2D wind-turbine blade sections)?

S9: [Section 3.3] Another instance of my request in S5, above. Please explain the

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qualitative trends described in the text. For example, why does the lower-frequency disturbance have a smaller increase in velocity at the beginning of the gust event than the higher-frequency disturbance (Page 9, Lines 149-150)?

S10: [Section 3.3] In Figure 11b, there is a strong spike in the gust profiles just before $t/T = 0$ that is not present in the corresponding profiles for the low-frequency case. Is this significant, or is it just an artifact of filtering (see S7, above)? If it is significant, what caused it? Its presence seems to suggest that different physics are involved in the high-frequency case. These dynamics should be discussed if the effects of the gust generator are to be inferred outside of the two frequencies tested in the experiments.

S11: [Section 3.3] In Figure 13a, the data points between $X/w_{CH} = 6$ and 9 appear to be offset uniformly downward from the trend of the rest of the data. Is this significant? Error bars for these data points would be helpful in answering this question, and in demonstrating the significance of the trends.

S12: [Section 4] The authors explain that the gusts have ‘outer’ and ‘inner’ scales, based respectively on the global gust disturbance and the integral length scale of the generated turbulence. It would be helpful to compare their relative magnitudes in physical space. Is there a frequency at which the outer scale would match the inner scale, and if so, would the character of the gusts qualitatively change at this frequency?

S13: [Section 4, Page 14, Line 208] Could the offset in the spectra be attributed in some way to the filtering method?

Technical Corrections:

T1: The use of the backslash to denote units in plots could be confusing. Parentheses or brackets would be preferable.

T2: Minor corrections to the references: 1) The two Wei et al. (2019) references on Page 2, Line 31 are reversed. 2) The active-grid reference on Page 2, Line 38 should use the surname Makita, rather than the given name Hideharu. 3) The Wester et al.

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(2018) and Petrovic et al. (2019) citations require conference information.

T3: The legend in Figure 5b may be clearer as “mean streamwise velocity”, since “gust velocity” carries the connotation of a disturbance rather than a mean quantity.

T4: The contours and labels in Figures 8b, 9b, and 15b are hard to read. Can they be shown in white instead?

T5: The caption to Figure 10 is written somewhat confusingly. It should read “The gust events are plotted in different colors, the smoothed average gust is marked in black, ...”. The color map of the gust events should also be specified, as it is in the caption to Figure 14.

T6: There are a number of minor typographical and grammatical errors in the manuscript. They do not impact the legibility of the work (on the whole, it is very well written and logically constructed), but they should be addressed at some point.

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