Reply to comments by Reviewer 1

Pascal Weihing

10. Januar 2024

The authors would like to thank Dr. Mockett for his efforts and valuable comments. They are very much appreciated and incorporated into the revised paper. In the present document the comments given by Dr. Mockett are addressed consecutively. The following formatting is chosen:

- The reviewer comments are marked in blue and italic.
- The reply by the author is in black color
- A marked-up manuscript is added. Changed sections with regard to the comments by reviewer 1 are marked in yellow. Changed sections with regard to comments by both reviewers are marked in green. Highlighting in gray denotes passages that have been changed by the author in order to improve the clarity or the argumentation but which are not related to specific reviewer comments.

Specific comments

1. "*Lines 220-225: The localised Bernoulli equation in the BDES is not Galilean invariant. Please add a few lines explaining how this is overcome for the moving geometry.*"

Thank you for pointing out this aspect which is particularly relevant for the rotary wing setup. An explanation was added at **R1:1.1** (page 9, line 224).

2. "*Lines 315-318: I haven't understood the boundary conditions on the front and rear part of the nacelle. Is this just a rotating wall velocity BC, or something else? Please adjust for clarity.*"

We were not quite sure whether you are referring to the small patch which was introduced to avoid the singular line, or the brown faces that shall be treated as non-rotating walls. Regarding the first one we used a simple slip-wall condition. It rotates as the grid is moving, but does not impose any velocities at te boundary. Concerning the second point we tried to make the description a bit clearer. Please see **R1:2.1** (page 12, line 322)

3. "*In the sections comparing simulation and PIV, key information is buried too late in the text. Please place explanations of the following more prominently: Are the results instantaneous or phase-averaged in the CFD and PIV? How do the locations in degrees relate to the position of the blade (e.g. are the snapshots always taken when the blade is at "top dead centre"?). Information on whether data is instantaneous or phase-averaged should be added to the relevant figure captions.*"

Further general information on the PIV sheets was added in the section describing the test case (see **R1:3.1** (page 6, line 171)). The information on the PIV phase angles relative the the blade, the locations of the PIV sheets and whether data are based on instantaneous or averaged fields were described in the beginning of each section discussing the PIV and CFD results:

- Comparison of the flow structures downstream of the blade: **R1:3.2** (page 22, line 519)
- Comparison of the radial traverses: **R1:3.3** (page 28, line 619) and **R1:3.4** (page 28, line 627)
- Comparison of the axial traverses: **R1:3.5** (page 31, line 695)
- Comparison of the tip vortices: **R1:3.6** (page 35, line 764)

The captions of Fig. 11-18 were adapted including the information on whether instantaneous or phase-averaged data were used.

Additionally, small sketches were included in the Figs. 11-16, in order to visualize the relative position of the blade of interest w.r.t. to the PIV plane.

4. "*Figure 17 and discussion: Please explain whether the radial position of the profiles is adjusted to the actual vortex location in each snapshot, or at a fixed location. This is important, as you observe later, since the vortex location wanders from cycle to cycle.*"

An explanation on the radial extraction position was added at **R1:4.1** (page 35, line 768). It was indeed at the position of maximum vorticity for each of the cases, respectively. Please note that the focus of this evaluation was on the change of the velocity amplitude. Therefore, instantaneous data was used rather than the phase-averaged fields. Vortex jittering effects were neglected, however, they may lead to slight changes in the x-position of the vortex core. A statement on this effect is added at **R1:4.2** (page 35, line 774). Concerning the vortex jittering, a more detailed analysis will be shown in part II of the study.

5. "*Lines 848-849: Please expand slightly. What aspect of BDES causes "almost implicit LES behaviour in flows of solid rotation"? The sigma-model form of the SGS mode?*"

As you have pointed out, it is the σ-velocity gradient operator utilized in the DES model that does not introduce eddy viscosity in flows with pure rotation. A statement on that was added in the revised manuscript at **R1:5.1** (page 39, line 867).

Technical corrections

We would also like to thank you very much for the editorial corrections. We have corrected them all according to your suggestions. We have also proofread the entire manuscript for orthography.

1. "*The word "though" is often used incorrectly. "However" or "nonetheless" are suggested instead, e.g. Lines 369, 596, 678, 877*" -> Corrected

2. "*Line 508: origin -> originate*" -> Corrected

3. "*Line 608: "pretend" isn't the right word, suggest "occur"*"" -> Corrected

4. "*Line 630: on behalf of -> for*" -> Corrected

5. "*Line 682: matter -> consequence*" -> Corrected

6. "*Line 707: but -> except*" -> Corrected

7. "*Lines 726-727: "which results that" is unclear, please revisit this sentence*"

The sentence was reformulated to: The induction factor is only $a_{ax} = 0.13$ at $r/R = 0.8$. This means that the average velocity is still about 75 % of the inflow velocity **R1:7.1** (page 34, line 738).