

Response to Reviewer Comments

Aerodynamic evaluation of wind speed sensor placement on UAVs for meteorological applications

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Atmospheric Measurement Techniques: EGUSPHERE-2026-977

The authors of the submitted manuscript titled ‘*Aerodynamic evaluation of wind speed sensor placement on UAVs for meteorological applications*’ would like to extend our sincere gratitude to the reviewer from the ‘*Atmospheric Measurement Techniques*’ journal for taking time to consider our submission, assess our work and provide detailed, invaluable comments/ reviews/ suggestions. We have carried out additional in-depth numerical and experimental analyses to address each query of the reviewer, and compiled the findings and responses in this document. We would like to note that:

1. Throughout this document, the questions/comments from the reviewer are provided in blue colour, and the authors’ responses are provided in black colour.
2. Figures, tables, and discussions are presented for each of the points raised by the reviewer, as applicable.
3. The revised manuscript would be provided as per EGU sphere guidelines, post the closure of the online forum including the discussion on this response document.

Reviewer #2

Recommendation: Major Revisions

This manuscript (egusphere-2026-977), titled *Aerodynamic evaluation of wind speed sensor placement on UAVs for meteorological applications*, investigates how rotor-induced flow affects the placement of UAV-mounted wind-speed sensors for meteorological applications. The authors employ an in-house free-vortex wake model (FVM) to simulate an APC 12 x 6E propeller in isolated single-rotor, quadrotor, and hexa-rotor configurations. The single-rotor analysis covers hover, axial descent, and forward descent, whereas the multi-rotor analysis is restricted to hover. Two disk-loading conditions, 100 and 300 N m⁻², are considered. Regions in which the time-averaged induced-velocity magnitude is no greater than 1% of the rotor-tip speed are identified as quiet zones for sensor placement. The FVM is compared with TriSonica Mini measurements along the axis of a single rotor in hover at a disk loading of 200 N m⁻², together with previously reported thrust and power comparisons. The authors conclude that the available quiet zones depend strongly on flight condition and that locations near the geometric centre or between rotor axes may provide candidate mounting positions for multi-rotor UAVs.

The topic is relevant to Atmospheric Measurement Techniques, and an efficient mid-fidelity framework for screening rotor-induced disturbances could be useful for UAV-based atmospheric measurements. The manuscript is generally structured clearly and contains potentially valuable flow-field results. However, the current definition of a quiet zone is not tied to a meteorological measurement-error requirement, the model validation is not sufficient to establish the reported placement boundaries, and the numerical convergence and cross-scale generalisation remain unresolved. These issues affect the central conclusions rather than presentation alone. Therefore, I recommend major revisions before the manuscript can be considered for publication in AMT.

General Comments

1. The quiet-zone criterion needs stronger measurement-based justification. For the radius and angular-speed range in Table 1, $0.01V_{\text{tip}}$ equals approximately 0.79–1.37 m s⁻¹, which may be substantial for low-wind, vertical-wind, and turbulence measurements. Moreover, the classification is based on a time-averaged induced-velocity magnitude. Although Figs. 8 and 10 and Fig. A1 show 1-sigma bands for selected axial profiles, these do not characterise the individual velocity components or candidate multi-rotor locations, where cancellation may produce a small mean but large fluctuations. Please relate the threshold to the intended measurand, sensor uncertainty, acceptable component and direction errors, and atmospheric wind range; report component-wise mean bias, RMS or standard deviation, relevant percentiles, and spectra at candidate locations; and clarify whether the metric is $|\langle V_{\text{ind}} \rangle|$ or $\langle |V_{\text{ind}}| \rangle$.

Quiet-Zone Boundaries: We appreciate the reviewer’s rigorous focus on the definition of quiet zones, and the need to tighten the justification based on meteorological considerations. The end goal is to define a boundary beyond which placement of a wind-speed sensor would not pick up the rotor induced velocity — which decreases further away from the rotor along the axial direction. For the parameters chosen in the current study, V_{tip} ranges from 79 – 137 m/s. As the reviewer points out, the chosen quiet-zone definition of $0.01V_{\text{tip}}$ may be insufficient for capturing low-speed winds as signal-to-noise ratio would be poor. However, there is also the issue of sensor accuracy at these lower wind speeds. For the TriSonica Mini weather sensor [LI-COR Environmental \(2025\)](#) utilised in the present study, the uncertainty in measurement is ± 0.2 m/s in the low wind-speed range of 0 – 10 m/s. This uncertainty also places an additional constraint in resolv-

ing the boundaries of quiet zones, and is in turn dependent on the sensor employed for UAV-based meteorological measurements. Details of the TriSonica Mini weather sensor, and other widely employed wind-speed sensors are provided in Table 1, to highlight the inherent uncertainty in measuring different wind speeds.

Considering the aforementioned sensor accuracy limitation, and the possible insufficiency in a 1% tip-speed threshold for defining quiet zones at low wind speeds, Figure 1 shows three different quiet-zone boundaries for the APC $12 \times 6E$ single rotor in hover (disk loading, $DL = 100 \text{ N/m}^2$) with emphasis on regions above the rotor disk. The red boundary is the one shown in the original manuscript with a threshold of $0.01V_{\text{tip}}$, i.e., 1% tip speed. Also included are $0.001V_{\text{tip}}$ as the green boundary and 0.2 m/s as the sensor boundary. These plots (such as Fig. 1) can dictate the choice of the sensor placement based on the accuracy of the wind velocity required; furthermore, based on our response to Reviewer Question #4, DL can also be used additionally as a reasonable metric to determine quiet zones. Regardless, for measurements with the TriSonica Mini weather sensor, the 0.2 m/s sensor boundary can be treated as the maximum height for the sensor placement where the induced velocity cannot be resolved any further, and the vehicle structural and stability requirements are also satisfied. While dynamic positioning of the sensor within the

Table 1: Properties of various wind-speed sensors utilised for UAV-based measurements.

Sensor Property	TriSonica Mini LI550 LI-COR Environmental (2025)	FT Technologies FT742 FT Technologies (2026)	Gill WindMaster Gill Instruments (2026)	LCJ Capteurs CV7-V LCJ Capteurs (2026)
Range	0 – 50 m/s	0 – 75 m/s	0 – 50 m/s	0.13 – 41.16 m/s
Resolution	0.01 m/s	0.1 m/s	0.01 m/s	0.05 m/s
Accuracy (Low)	$\pm 0.2 \text{ m/s}$ (0 – 10 m/s)	$\pm 0.3 \text{ m/s}$ (0 – 16 m/s)	$\pm 1.5\% \text{ RMS}$ (0 – 50 m/s)	$\pm 0.13 \text{ m/s}$ (Full dynamic range)
Accuracy (Mid)	$\pm 2\%$ or $\pm(0.2 - 0.6) \text{ m/s}$	$\pm 2\%$ (16 – 40 m/s)	—	—
Accuracy (High)	$\pm 2\%$ or $\pm(1.24 - 2) \text{ m/s}$	$\pm 4\%$ (40 – 75 m/s)	—	—

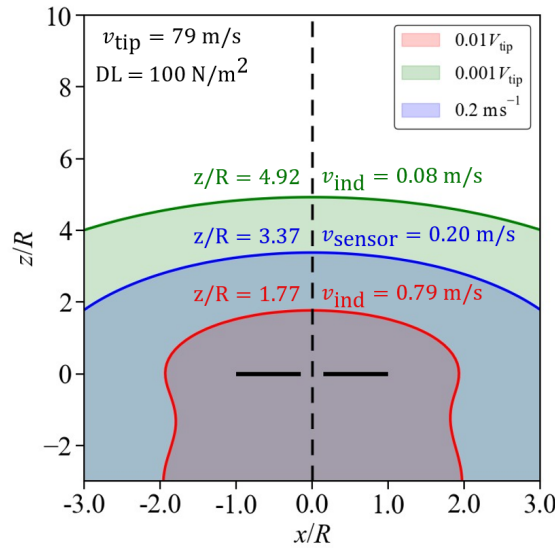


Figure 1: Quiet zone boundary definition based on tip-speed and the sensor accuracy.

0.01 V_{tip} and the sensor boundary may not be possible and advisable due to operational challenges and additional data contamination issues, an optimal height for sensor placement that is devoid of rotor-wake influences to the practically permissible limits, can be obtained through careful consideration of Fig. 1.

FVM Velocity Statistics (In response to Figs. 8 and 10 and Fig. A1 in the original manuscript): We have looked at the velocity statistics for the APC single rotor along the axis of rotation above the rotor, and for the APC quadrotor along a line passing through the geometric centre between the four rotors (same as in the original manuscript) – both at a disk loading of 100 N/m² – with the data presented in Table 2. Shown are the mean velocities in each direction (u, v, w), along with the corresponding standard deviation, minimum and maximum values. Only the centreline velocity data is presented for the quadrotor configuration as that would be the most natural design choice to place the wind-speed sensor owing to aircraft stability concerns. The mean velocity V_{mag} is the magnitude of the time-average of the individual velocity components, i.e., $|\langle V_{\text{ind}} \rangle|$. Table 2 shows that fluctuations in the computed induced velocities are indeed small (by observing the min/max values) at each z/R location, and so are the standard deviation values, indicating that large-amplitude velocity fluctuations are not being cancelled out. Consequently, the mean and standard deviation serve as the necessary and perhaps sufficient quantities to characterise the induced velocity field in the numerical model. Therefore, the narrow distribution of the minimum and maximum values of the velocity components, and the stable mean and standard deviation distribution justify the use of $|\langle V_{\text{ind}} \rangle|$. As the FVM does not contain any turbulence modelling, higher-order metrics such as percentiles and spectral distribution are not presented, and they are also beyond the scope of the present work for quiet-zone identification within the numerical FVM framework.

Potential addition to the manuscript: We will include the sensor accuracy boundary (0.2 m/s) to all the quiet zone plots in the original manuscript, to help better guide the choice of sensor location based on the different thresholds and the sensor accuracy consideration. Clarification on the mean velocity and the associated fluctuations based

Table 2: Statistics of the FVM velocity components at different axial locations (heights) for the APC single rotor and quadrotor configurations.

z/R	Mean(V_{mag}) (m/s)	$\boldsymbol{u}$ (m/s)				$\boldsymbol{v}$ (m/s)				$\boldsymbol{w}$ (m/s)			
		Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.
<i>Single rotor along rotational axis</i>													
1.0	2.092	-0.004	-0.022	0.021	0.010	-0.001	-0.018	0.012	0.007	-2.092	-2.115	-2.068	0.010
1.5	1.075	-0.003	-0.016	0.016	0.007	-0.001	-0.014	0.008	0.005	-1.074	-1.091	-1.061	0.006
2.0	0.617	-0.002	-0.012	0.013	0.005	-0.001	-0.011	0.006	0.004	-0.616	-0.629	-0.608	0.004
2.5	0.386	-0.002	-0.010	0.010	0.004	0.000	-0.009	0.005	0.003	-0.386	-0.396	-0.380	0.003
3.0	0.259	-0.001	-0.008	0.009	0.004	0.000	-0.007	0.004	0.002	-0.259	-0.266	-0.254	0.003
3.5	0.182	-0.001	-0.007	0.007	0.003	0.000	-0.006	0.003	0.002	-0.182	-0.188	-0.179	0.002
4.0	0.133	-0.001	-0.006	0.006	0.003	0.000	-0.005	0.003	0.002	-0.133	-0.138	-0.130	0.002
4.5	0.101	-0.001	-0.005	0.005	0.002	0.000	-0.005	0.002	0.001	-0.101	-0.104	-0.098	0.001
5.0	0.078	-0.001	-0.004	0.005	0.002	0.000	-0.004	0.002	0.001	-0.078	-0.081	-0.076	0.001
<i>Quadrotor Centreline (Geometric Centre)</i>													
1.0	3.581	-0.045	-0.200	0.182	0.070	-0.080	-0.336	0.292	0.173	-3.575	-3.902	-3.287	0.127
1.5	2.631	-0.042	-0.170	0.112	0.051	-0.054	-0.247	0.185	0.102	-2.628	-2.809	-2.464	0.065
2.0	1.873	-0.036	-0.139	0.073	0.039	-0.035	-0.177	0.112	0.059	-1.871	-1.968	-1.774	0.035
2.5	1.344	-0.031	-0.113	0.050	0.031	-0.023	-0.128	0.069	0.037	-1.343	-1.398	-1.280	0.022
3.0	0.983	-0.027	-0.093	0.036	0.025	-0.016	-0.094	0.044	0.025	-0.982	-1.018	-0.939	0.015
3.5	0.734	-0.023	-0.077	0.027	0.021	-0.011	-0.072	0.029	0.019	-0.733	-0.759	-0.702	0.011
4.0	0.560	-0.020	-0.065	0.024	0.018	-0.008	-0.056	0.028	0.016	-0.559	-0.578	-0.536	0.009
4.5	0.435	-0.017	-0.055	0.021	0.016	-0.006	-0.045	0.027	0.013	-0.435	-0.450	-0.417	0.007
5.0	0.345	-0.015	-0.047	0.018	0.014	-0.004	-0.037	0.025	0.012	-0.344	-0.356	-0.329	0.006

Note: The w component is positive upward; hence, negative values indicate downward velocity.

on Table 2 (without including the table for the sake of brevity) will also be presented.

2. The validation is insufficient for quantitative placement boundaries. The new experiment covers one isolated rotor, one hover operating point, and axial locations only; it does not validate the two-dimensional contour, descent or oblique inflow, or multi-rotor interaction. The reported upstream difference of about $0.005 V_{\text{tip}}$ is already roughly half of the $0.01 V_{\text{tip}}$ threshold. Please provide validation statistics and an uncertainty budget covering sensor accuracy, position, RPM and thrust variation, repeatability, averaging duration, blockage, laboratory background flow, and confidence intervals, and add spatial or multi-rotor validation. Otherwise, present the results explicitly as qualitative screening.

We understand that the presented experimental-FVM validation (Fig. 8 in the original manuscript) maybe insufficient to claim that the FVM model fully resolves the spatial characteristics of the rotor induced velocity, and that multi-rotor validation is also necessary to strengthen the credibility of the numerical model. Existing literature on wind-speed measurement from UAV-mounted sensors (Thielicke et al. (2021); Wilson et al. (2022); Jin et al. (2024); Ghirardelli et al. (2023, 2025)) revealed the lack of a consistent set of experimental results that we can use to either verify spatial induced velocity distribution on single rotors, or perform multi-rotor validation. Therefore, we have conducted additional experiments to capture the 2-D quiet-zone boundary over a single rotor in hover, and compared our FVM model with these experimental results. For multi-rotor FVM validation, we have compared our numerical results against the work of Wilson et al. (2022). We have presented the findings of both the investigations in the following sections. Other studies under climb, descent, or oblique flow scenarios on single rotors, and multi-rotors investigations are beyond the scope of our current experimental capability.

Additional experimental validation: We have conducted additional experiments across a 2-D spatial matrix of measurement locations covering different rotor upstream and downstream distances, for the APC $12 \times 6E$ single rotor in hover (disk loading $DL = 100 \text{ N/m}^2$). Details of the measurement locations are presented in Fig. 2.

Experiments were conducted in a laboratory measuring $10 \times 5 \times 3 \text{ m}$, on a test rig whose cast iron base measures $1.2 \times 1 \text{ m}$. The motor-propeller assembly is mounted on this test rig base at a height of $\approx 1 \text{ m}$ from the ground. The support structure is an open cubical frame constructed using $40 \times 40 \text{ Aluminium}$ extrusion profiles. Rotor induced velocity is measured using the TriSonica Mini weather sensor (accuracy of $\pm 0.2 \text{ m/s}$) mounted

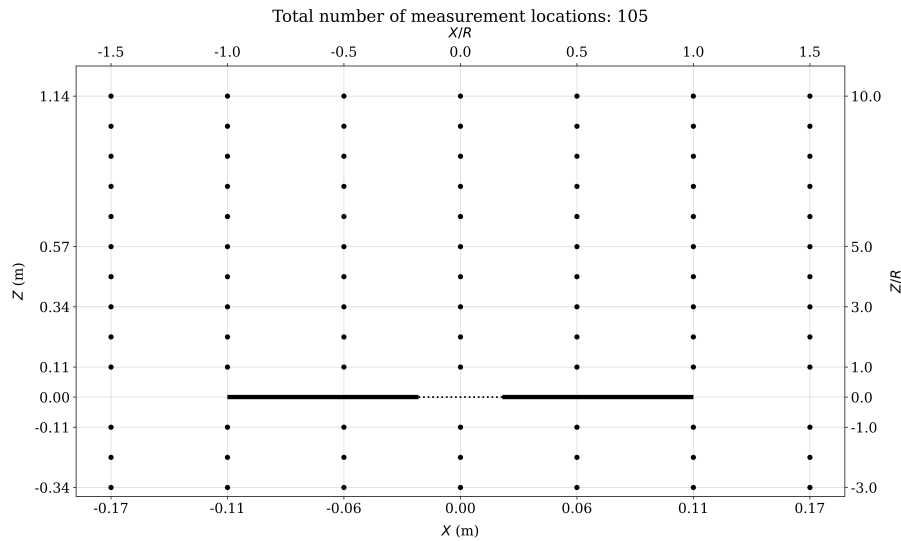


Figure 2: Measurement locations for the 2-D spatial contour validation of induced velocity.

on a movable Aluminium extrusion profile of identical cross-section. The accuracy of positioning the sensor at a given location is $\approx \pm 0.005$ m. Particular care is taken to ensure that no external intrusions block the measurement domain. Experiments were repeated for three 30s trials at each measurement location, and 15s of this data was considered for further analyses, ensuring elimination of transients in achieving the desired operating condition (wherein variations in the operating angular speed are maintained at ± 50 RPM). Ambient flow velocities were also measured during each trial for 10s to assess the nature of background flow conditions.

Validation statistics: The mean and standard deviation of the velocity data were computed for each trial to ascertain the repeatability of the experiments. A representative axial induced velocity profile obtained from the experiments along the centreline (rotational axis of the rotor) is presented in Fig. 3 with FVM results as well. For each trial (differentiated by shades of grey), the corresponding mean ambient velocities (background flow) are subtracted before plotting. All three trials demonstrate excellent repeatability across locations, with their 1σ standard deviation considerably narrow in the upstream of the rotor (region of interest for sensor placement). Fig. 3 also shows the ensemble mean and standard deviation in solid black colour, computed with data from all the three trials. The ensemble quantities reduce statistical uncertainty by increasing the number of samples, ensuring that the experimental results are mathematically robust for validation with the FVM model. The metrics obtained here are $|\langle v_{\text{ind}} \rangle|$, similar to the earlier quiet-zone boundary results — the associated trial-wise mean, minimum, maximum, and standard deviation for a few representative measurement locations are provided in Table 3. As with the quiet-zone results, the underlying fluctuations are tightly bound, indicating that large-amplitude cancellations do not occur, and that the experimental results are stable across various trials and locations. This property of the obtained signal eliminates the need for a formal confidence interval calculation, as the tightly bound fluctuations inherently ascertain high statistical confidence in the dataset.

The ensemble mean velocities and the standard deviation of each of the velocity components are presented in Table 4 for all the upstream measurement locations. These values were obtained after subtracting the ambient flow conditions, the statistics of which are also presented in Table 5 and Table 6. The background flow is quite stable, exhibiting minor fluctuations (indicated by the low values of standard deviation, minimum and maximum velocities) and is quantified to lie around the order of ≈ 0.5 m/s. Notably, the sensor uncertainty is $\pm(0.2 - 0.4)$ m/s across the measurement range, which is of the same order of magnitude as the ambient flow, indicating that experimentally obtained quiet-zones cannot be clearly resolved below the ambient flow.

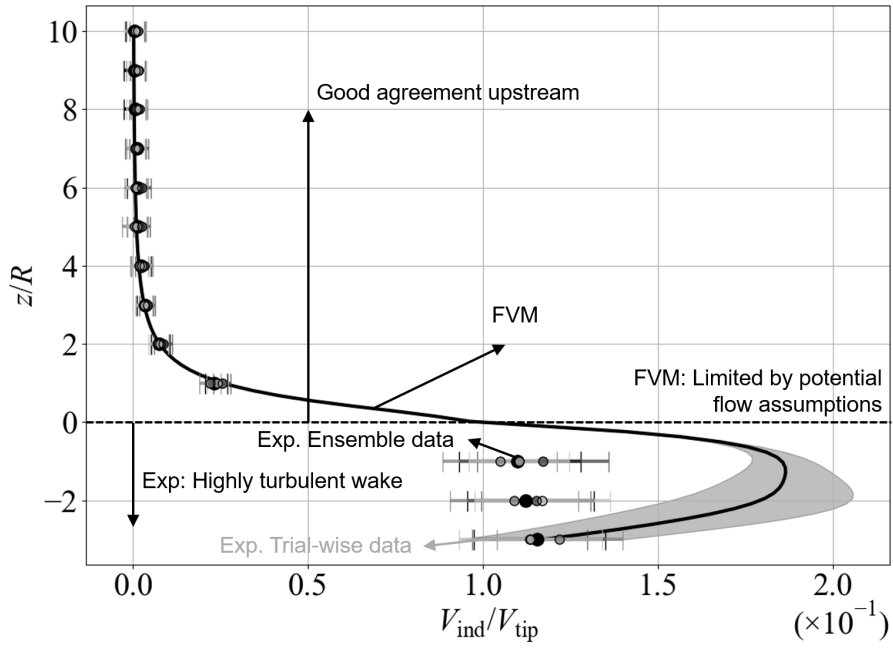


Figure 3: Representative variation of the induced velocity profile obtained for the APC single rotor in hover operating at $DL = 100 \text{ N/m}^2$. Solid line denotes the FVM data with a shaded 1σ standard deviation band. Circular grey markers with error bars depict the multiple trials, along with the ensemble data represented with black circles.

Table 3: Trial-wise statistics of the experimental induced-velocity components at representative axial locations (z/R) and radial positions (x/R) for the APC single rotor.

x/R	z/R	V_{ind} (m/s)	u (m/s)				v (m/s)				w (m/s)			
			Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.
Trial-1														
-1.0	2.0	0.599	-0.520	-1.005	-0.091	0.163	-0.291	-0.852	0.442	0.264	-0.056	-0.521	0.183	0.097
	4.0	0.106	-0.085	-0.512	0.258	0.141	-0.047	-0.586	0.601	0.213	-0.041	-0.824	0.240	0.105
	6.0	0.089	-0.040	-0.411	0.358	0.127	-0.075	-0.506	0.452	0.212	-0.027	-0.460	0.166	0.082
	8.0	0.057	-0.001	-0.309	0.343	0.123	-0.056	-0.558	0.375	0.195	-0.010	-0.564	0.216	0.077
	10.0	0.061	-0.018	-0.398	0.294	0.121	-0.052	-0.421	0.397	0.164	-0.025	-0.810	0.191	0.092
0.0	2.0	0.639	-0.633	-1.177	-0.261	0.166	-0.079	-0.592	0.451	0.250	-0.021	-0.573	0.171	0.081
	4.0	0.238	-0.211	-0.695	0.122	0.138	-0.105	-0.629	0.344	0.218	-0.032	-0.612	0.226	0.094
	6.0	0.195	-0.105	-0.504	0.330	0.148	-0.162	-0.700	0.378	0.204	-0.025	-0.373	0.232	0.098
	8.0	0.104	-0.055	-0.521	0.200	0.124	-0.085	-0.507	0.367	0.179	-0.020	-0.525	0.226	0.090
	10.0	0.050	0.034	-0.432	0.447	0.135	-0.024	-0.431	0.383	0.166	-0.028	-0.444	0.203	0.086
1.0	2.0	0.416	-0.387	-0.731	-0.120	0.112	0.150	-0.389	0.647	0.203	-0.022	-0.418	0.173	0.065
	4.0	0.118	-0.117	-0.562	0.181	0.120	-0.005	-0.395	0.510	0.196	-0.009	-0.576	0.240	0.082
	6.0	0.182	-0.132	-0.558	0.180	0.138	-0.122	-0.650	0.390	0.209	-0.031	-0.429	0.219	0.085
	8.0	0.061	-0.019	-0.383	0.340	0.146	-0.053	-0.613	0.461	0.200	-0.023	-0.379	0.188	0.080
	10.0	0.190	-0.134	-0.658	0.242	0.136	-0.134	-0.616	0.283	0.174	-0.009	-0.434	0.267	0.087
Trial-2														
-1.0	2.0	0.502	-0.502	-1.110	-0.060	0.177	-0.010	-0.635	0.597	0.250	-0.009	-0.507	0.226	0.073
	4.0	0.193	-0.131	-0.611	0.199	0.138	-0.137	-0.735	0.389	0.209	-0.033	-0.473	0.261	0.090
	6.0	0.089	-0.083	-0.457	0.240	0.118	-0.030	-0.544	0.445	0.206	-0.010	-0.408	0.255	0.078
	8.0	0.040	0.028	-0.302	0.316	0.127	-0.028	-0.503	0.445	0.196	-0.008	-0.285	0.257	0.070
	10.0	0.117	0.117	-0.309	0.455	0.138	0.007	-0.405	0.490	0.172	-0.009	-0.498	0.235	0.079
0.0	2.0	0.580	-0.579	-1.059	-0.234	0.166	-0.013	-0.503	0.486	0.233	0.012	-0.764	0.238	0.087
	4.0	0.128	-0.121	-0.571	0.184	0.141	0.040	-0.424	0.661	0.209	-0.011	-0.916	0.231	0.103
	6.0	0.044	-0.037	-0.451	0.305	0.122	0.021	-0.476	0.540	0.213	-0.012	-0.419	0.314	0.081
	8.0	0.130	0.108	-0.434	0.622	0.136	0.072	-0.410	0.528	0.192	-0.006	-0.489	0.229	0.088
	10.0	0.098	0.066	-0.287	0.547	0.155	0.072	-0.396	0.575	0.176	0.000	-0.343	0.217	0.080
1.0	2.0	0.326	-0.320	-0.948	0.014	0.150	0.053	-0.476	0.771	0.239	-0.027	-0.659	0.236	0.091
	4.0	0.090	0.077	-0.221	0.348	0.110	0.045	-0.371	0.501	0.176	-0.009	-0.365	0.201	0.080
	6.0	0.138	0.115	-0.310	0.402	0.128	0.075	-0.438	0.604	0.217	0.011	-0.434	0.258	0.092
	8.0	0.119	0.114	-0.244	0.454	0.123	0.034	-0.347	0.445	0.168	-0.010	-0.562	0.240	0.084
	10.0	0.067	0.065	-0.361	0.337	0.115	-0.003	-0.423	0.494	0.173	0.015	-0.371	0.221	0.072
Trial-3														
-1.0	2.0	0.603	-0.516	-0.955	-0.152	0.171	-0.309	-0.914	0.314	0.247	-0.049	-0.653	0.229	0.106
	4.0	0.124	-0.092	-0.538	0.293	0.165	-0.082	-0.691	0.463	0.220	-0.013	-0.412	0.227	0.093
	6.0	0.046	-0.038	-0.411	0.327	0.123	-0.023	-0.530	0.567	0.201	-0.012	-0.679	0.245	0.092
	8.0	0.147	-0.126	-0.454	0.217	0.124	-0.074	-0.518	0.337	0.185	-0.011	-0.355	0.171	0.067
	10.0	0.018	-0.005	-0.317	0.301	0.101	-0.009	-0.432	0.448	0.172	0.015	-0.253	0.196	0.067
0.0	2.0	0.537	-0.520	-1.146	-0.100	0.172	-0.130	-0.785	0.558	0.247	-0.041	-0.720	0.293	0.105
	4.0	0.184	-0.139	-0.614	0.227	0.171	-0.117	-0.610	0.469	0.232	-0.028	-0.585	0.258	0.126
	6.0	0.082	-0.078	-0.589	0.248	0.143	-0.021	-0.641	0.504	0.237	-0.015	-0.451	0.194	0.095
	8.0	0.059	0.015	-0.596	0.311	0.145	-0.054	-0.469	0.423	0.190	-0.017	-0.603	0.210	0.097
	10.0	0.037	0.034	-0.486	0.476	0.153	0.012	-0.416	0.529	0.183	0.005	-0.507	0.221	0.090
1.0	2.0	0.437	-0.436	-0.959	-0.130	0.159	-0.002	-0.554	0.618	0.249	-0.038	-0.825	0.226	0.090
	4.0	0.083	-0.077	-0.563	0.243	0.129	-0.030	-0.551	0.381	0.194	-0.011	-0.804	0.279	0.100
	6.0	0.195	-0.169	-0.609	0.186	0.150	-0.097	-0.632	0.619	0.223	-0.003	-0.539	0.246	0.084
	8.0	0.092	-0.062	-0.373	0.238	0.123	-0.065	-0.542	0.426	0.189	-0.019	-0.363	0.189	0.085
	10.0	0.039	0.025	-0.440	0.410	0.125	-0.026	-0.467	0.436	0.179	-0.014	-0.723	0.230	0.085

Note: Only selected locations are presented here for brevity. Negative z/R locations are omitted since the present study focuses on sensor placement above the rotor-disk plane. V_{ind} is the magnitude of time-average of the components for each trial, consistent with the formulation used in the previous investigations, and followed for the subsequent computations.

Table 4: Ensemble statistics of the experimental induced-velocity components at different axial locations (z/R) and radial positions (x/R) for the APC single rotor.

x/R	z/R	V_{ind} (m/s)	u (m/s)				v (m/s)				w (m/s)			
			Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.
-1.5	1.0	0.018	-0.701	-1.334	0.253	0.220	-0.644	-1.496	0.047	0.264	-0.025	-0.811	0.406	0.151
	2.0	0.482	-0.402	-1.018	0.400	0.227	-0.264	-1.028	0.475	0.294	-0.027	-0.628	0.344	0.122
	3.0	0.268	-0.256	-0.849	0.267	0.172	-0.076	-0.830	0.631	0.274	-0.023	-1.365	0.295	0.120
	4.0	0.163	-0.147	-0.714	0.319	0.171	-0.068	-0.771	0.576	0.255	-0.017	-0.619	0.297	0.105
	5.0	0.104	-0.089	-0.628	0.324	0.147	-0.046	-0.655	0.570	0.233	-0.027	-1.055	0.260	0.106
	6.0	0.066	-0.043	-0.556	0.459	0.133	-0.039	-0.545	0.576	0.212	-0.031	-0.626	0.253	0.101
	8.0	0.045	-0.031	-0.399	0.300	0.121	-0.032	-0.488	0.474	0.176	-0.011	-0.709	0.271	0.089
-1.0	10.0	0.018	-0.009	-0.512	0.332	0.133	0.015	-0.519	0.458	0.176	-0.006	-0.704	0.244	0.084
	1.0	1.298	-1.051	-1.632	-0.364	0.204	-0.762	-1.379	0.093	0.242	-0.018	-0.585	0.359	0.114
	2.0	0.519	-0.486	-1.172	0.009	0.180	-0.178	-0.842	0.538	0.265	-0.035	-0.641	0.241	0.094
	3.0	0.278	-0.238	-0.721	0.112	0.159	-0.141	-0.738	0.481	0.227	-0.032	-0.725	0.261	0.099
	4.0	0.139	-0.107	-0.622	0.275	0.152	-0.085	-0.718	0.579	0.214	-0.027	-0.821	0.270	0.096
	5.0	0.105	-0.098	-0.559	0.268	0.140	-0.033	-0.524	0.540	0.213	-0.015	-0.813	0.299	0.086
	6.0	0.060	-0.045	-0.464	0.392	0.128	-0.037	-0.543	0.573	0.207	-0.016	-0.679	0.255	0.084
-0.5	8.0	0.052	-0.021	-0.429	0.387	0.138	-0.047	-0.556	0.432	0.192	-0.008	-0.567	0.264	0.071
	10.0	0.033	0.027	-0.416	0.392	0.128	-0.019	-0.447	0.498	0.175	-0.007	-0.802	0.224	0.081
	1.0	1.627	-1.509	-2.142	-0.412	0.219	-0.608	-1.557	0.502	0.360	0.002	-0.455	0.861	0.101
	2.0	0.602	-0.530	-1.175	0.163	0.184	-0.283	-1.091	0.930	0.278	-0.031	-1.255	0.579	0.129
	3.0	0.233	-0.231	-0.683	0.134	0.129	-0.027	-0.925	0.708	0.267	-0.019	-0.495	0.333	0.093
	4.0	0.158	-0.131	-0.612	0.281	0.126	-0.085	-0.694	0.521	0.229	-0.017	-0.536	0.322	0.090
	5.0	0.097	-0.077	-0.560	0.283	0.135	-0.052	-0.663	0.572	0.236	-0.026	-0.725	0.305	0.093
0.0	6.0	0.046	-0.036	-0.449	0.313	0.134	-0.025	-0.591	0.694	0.226	-0.014	-0.653	0.345	0.088
	8.0	0.077	-0.048	-0.497	0.320	0.136	-0.058	-0.557	0.508	0.209	-0.017	-0.461	0.203	0.085
	10.0	0.072	-0.013	-0.449	0.423	0.145	-0.068	-0.611	0.422	0.186	-0.021	-0.884	0.247	0.091
	1.0	1.739	-1.738	-2.322	-1.102	0.205	-0.048	-1.005	0.775	0.242	0.036	-0.659	0.432	0.127
	2.0	0.565	-0.560	-1.145	-0.099	0.172	-0.068	-0.745	0.598	0.244	-0.015	-0.783	0.307	0.092
	3.0	0.258	-0.256	-0.748	0.159	0.143	-0.027	-0.719	0.513	0.224	-0.016	-0.952	0.321	0.094
	4.0	0.168	-0.156	-0.629	0.212	0.152	-0.060	-0.607	0.610	0.224	-0.022	-0.920	0.248	0.109
0.5	5.0	0.095	-0.084	-0.632	0.604	0.140	-0.039	-0.572	0.539	0.212	-0.022	-0.660	0.291	0.102
	6.0	0.094	-0.066	-0.618	0.409	0.142	-0.063	-0.677	0.488	0.220	-0.021	-0.461	0.308	0.092
	8.0	0.042	0.041	-0.592	0.598	0.138	-0.003	-0.453	0.497	0.190	-0.009	-0.600	0.239	0.092
	10.0	0.032	0.028	-0.493	0.501	0.148	0.013	-0.434	0.549	0.178	-0.006	-0.517	0.223	0.085
	1.0	1.372	-1.350	-2.078	-0.906	0.187	0.244	-0.882	1.185	0.375	-0.005	-1.138	0.361	0.136
	2.0	0.526	-0.525	-1.126	-0.071	0.163	-0.020	-0.679	0.857	0.285	-0.028	-1.351	0.207	0.101
	3.0	0.285	-0.255	-0.779	0.230	0.158	-0.118	-0.776	0.625	0.243	-0.046	-1.171	0.278	0.107
1.0	4.0	0.161	-0.151	-0.646	0.327	0.127	-0.052	-0.641	0.522	0.200	-0.020	-0.674	0.216	0.083
	5.0	0.098	-0.079	-0.516	0.430	0.142	-0.054	-0.737	0.502	0.203	-0.020	-0.641	0.259	0.090
	6.0	0.046	-0.013	-0.460	0.379	0.134	-0.043	-0.600	0.512	0.196	-0.011	-0.724	0.233	0.088
	8.0	0.034	-0.023	-0.468	0.300	0.117	-0.023	-0.501	0.479	0.177	-0.010	-0.557	0.236	0.077
	10.0	0.032	0.020	-0.344	0.409	0.120	-0.025	-0.431	0.423	0.157	-0.005	-0.488	0.242	0.070
	1.0	1.006	-0.860	-1.613	-0.066	0.164	0.521	-0.138	1.231	0.242	-0.023	-1.106	0.336	0.131
	2.0	0.389	-0.384	-0.997	-0.035	0.146	0.059	-0.532	0.745	0.236	-0.030	-0.822	0.229	0.083
1.5	3.0	0.203	-0.202	-0.712	0.291	0.132	0.007	-0.519	0.731	0.215	-0.021	-0.979	0.243	0.091
	4.0	0.053	-0.051	-0.542	0.264	0.122	-0.004	-0.541	0.521	0.189	-0.013	-0.811	0.272	0.088
	5.0	0.053	-0.043	-0.486	0.335	0.131	-0.028	-0.632	0.504	0.200	-0.015	-0.598	0.248	0.087
	6.0	0.079	-0.056	-0.511	0.321	0.140	-0.055	-0.623	0.680	0.218	-0.011	-0.548	0.240	0.087
	8.0	0.038	-0.005	-0.422	0.407	0.141	-0.035	-0.645	0.457	0.190	-0.014	-0.564	0.238	0.083
	10.0	0.036	-0.000	-0.634	0.462	0.149	-0.036	-0.620	0.507	0.190	0.004	-0.706	0.271	0.082
	1.0	0.677	-0.519	-0.917	-0.052	0.133	0.434	-0.287	1.000	0.223	-0.012	-0.862	0.313	0.119
1.5	2.0	0.334	-0.305	-0.893	0.279	0.145	0.132	-0.633	0.844	0.276	-0.037	-0.635	0.281	0.093
	3.0	0.170	-0.162	-0.557	0.352	0.129	0.046	-0.622	0.658	0.238	-0.021	-0.733	0.258	0.085
	4.0	0.080	-0.078	-0.890	0.504	0.153	-0.002	-0.563	1.068	0.219	-0.015	-1.271	0.418	0.100
	5.0	0.091	-0.063	-0.637	0.439	0.154	-0.063	-0.639	0.684	0.223	-0.019	-0.573	0.291	0.103
	6.0	0.050	-0.010	-0.437	0.574	0.153	-0.042	-0.601	0.633	0.221	-0.024	-0.536	0.381	0.097
	8.0	0.047	0.017	-0.455	0.655	0.140	-0.044	-0.592	0.461	0.188	-0.004	-0.417	0.211	0.078
	10.0	0.063	0.062	-0.383	0.424	0.133	0.000	-0.479	0.535	0.179	-0.003	-0.617	0.255	0.086

Note: Negative z/R locations are omitted for brevity.

Table 5: Trial-wise statistics of the ambient velocity components at representative axial locations (z/R) and radial positions (x/R) for the APC single rotor.

x/R	z/R	V_∞ (m/s)	u_∞ (m/s)				v_∞ (m/s)				w_∞ (m/s)			
			Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.
<i>Trial-1</i>														
-1.0	2.0	0.093	0.068	-0.106	0.305	0.082	0.061	-0.111	0.209	0.055	0.017	-0.125	0.139	0.041
	4.0	0.021	0.002	-0.151	0.281	0.063	-0.008	-0.181	0.158	0.065	0.019	-0.180	0.151	0.046
	6.0	0.056	0.034	-0.147	0.298	0.081	0.037	-0.151	0.218	0.062	0.024	-0.148	0.147	0.046
	8.0	0.065	0.051	-0.216	0.278	0.084	0.037	-0.129	0.171	0.055	0.016	-0.072	0.158	0.038
	10.0	0.037	-0.026	-0.292	0.251	0.089	0.001	-0.169	0.230	0.069	0.026	-0.069	0.205	0.045
0.0	2.0	0.015	-0.010	-0.163	0.242	0.077	-0.003	-0.181	0.173	0.069	0.010	-0.256	0.140	0.050
	4.0	0.109	0.073	-0.125	0.297	0.073	0.077	-0.116	0.269	0.077	0.023	-0.240	0.185	0.058
	6.0	0.124	0.082	-0.082	0.317	0.069	0.093	-0.099	0.236	0.062	0.013	-0.313	0.141	0.055
	8.0	0.053	0.024	-0.230	0.266	0.084	0.042	-0.132	0.262	0.077	0.020	-0.218	0.169	0.051
	10.0	0.075	-0.058	-0.296	0.225	0.088	-0.044	-0.241	0.205	0.082	0.019	-0.142	0.270	0.051
1.0	2.0	0.022	-0.011	-0.218	0.218	0.067	0.001	-0.185	0.175	0.063	0.019	-0.117	0.160	0.041
	4.0	0.031	-0.022	-0.190	0.261	0.084	-0.006	-0.226	0.189	0.068	0.021	-0.100	0.168	0.042
	6.0	0.088	0.053	-0.140	0.336	0.075	0.064	-0.099	0.270	0.072	0.030	-0.208	0.170	0.056
	8.0	0.074	-0.059	-0.363	0.244	0.112	-0.040	-0.270	0.225	0.081	0.018	-0.091	0.190	0.040
	10.0	0.043	0.030	-0.191	0.330	0.082	0.030	-0.156	0.213	0.072	0.009	-0.359	0.177	0.053
<i>Trial-2</i>														
-1.0	2.0	0.113	-0.094	-0.725	0.245	0.136	-0.062	-0.481	0.151	0.097	0.006	-0.216	0.180	0.057
	4.0	0.085	-0.026	-0.352	0.204	0.089	0.077	-0.199	0.311	0.087	0.025	-0.175	0.150	0.044
	6.0	0.034	-0.007	-0.271	0.238	0.089	0.025	-0.170	0.362	0.078	0.022	-0.105	0.189	0.043
	8.0	0.041	-0.023	-0.250	0.250	0.081	0.022	-0.303	0.232	0.074	0.026	-0.125	0.178	0.049
	10.0	0.138	-0.134	-0.449	0.149	0.113	-0.031	-0.413	0.243	0.079	0.007	-0.240	0.175	0.041
0.0	2.0	0.130	-0.112	-0.859	0.196	0.170	-0.064	-0.418	0.393	0.115	-0.019	-0.576	0.142	0.076
	4.0	0.061	-0.057	-0.481	0.190	0.090	-0.023	-0.428	0.418	0.077	0.000	-0.403	0.150	0.054
	6.0	0.032	-0.026	-0.260	0.217	0.085	-0.019	-0.266	0.188	0.074	0.002	-0.267	0.152	0.051
	8.0	0.089	-0.077	-0.396	0.173	0.090	-0.043	-0.421	0.217	0.075	0.007	-0.198	0.216	0.041
	10.0	0.127	-0.108	-0.383	0.122	0.100	-0.067	-0.247	0.212	0.076	-0.005	-0.209	0.162	0.044
1.0	2.0	0.094	-0.093	-0.792	0.164	0.165	-0.005	-0.378	0.200	0.092	0.005	-0.350	0.154	0.051
	4.0	0.174	-0.163	-0.420	0.133	0.123	-0.061	-0.256	0.136	0.073	0.007	-0.073	0.163	0.030
	6.0	0.174	-0.157	-0.444	0.108	0.090	-0.074	-0.276	0.291	0.083	-0.003	-0.272	0.230	0.050
	8.0	0.073	-0.067	-0.398	0.253	0.104	-0.027	-0.368	0.460	0.087	0.011	-0.177	0.178	0.046
	10.0	0.054	-0.026	-0.311	0.226	0.095	0.047	-0.238	0.290	0.089	0.005	-0.427	0.203	0.057
<i>Trial-3</i>														
-1.0	2.0	0.074	0.008	-0.823	0.239	0.168	0.069	-0.426	0.376	0.096	0.024	-0.213	0.212	0.063
	4.0	0.037	-0.033	-0.464	0.347	0.135	-0.013	-0.499	0.248	0.094	0.009	-0.146	0.207	0.052
	6.0	0.037	-0.002	-0.348	0.244	0.107	0.030	-0.276	0.274	0.089	0.022	-0.254	0.165	0.051
	8.0	0.073	0.032	-0.179	0.242	0.082	0.062	-0.200	0.315	0.084	0.022	-0.188	0.187	0.053
	10.0	0.090	0.064	-0.151	0.376	0.097	0.061	-0.285	0.407	0.088	0.016	-0.372	0.200	0.055
0.0	2.0	0.088	-0.085	-0.999	0.186	0.208	0.018	-0.446	0.393	0.114	0.014	-0.246	0.162	0.061
	4.0	0.035	-0.016	-0.546	0.190	0.106	0.031	-0.341	0.279	0.103	-0.006	-0.427	0.155	0.080
	6.0	0.026	-0.026	-0.303	0.223	0.102	-0.003	-0.222	0.318	0.088	-0.002	-0.280	0.144	0.051
	8.0	0.056	-0.049	-0.321	0.174	0.085	0.024	-0.260	0.374	0.084	0.010	-0.181	0.159	0.046
	10.0	0.078	-0.069	-0.556	0.253	0.164	-0.033	-0.344	0.218	0.108	-0.011	-0.327	0.178	0.058
1.0	2.0	0.058	-0.035	-0.638	0.198	0.131	0.043	-0.147	0.404	0.079	0.018	-0.513	0.164	0.062
	4.0	0.045	-0.044	-0.242	0.179	0.093	-0.007	-0.175	0.272	0.081	0.008	-0.217	0.193	0.049
	6.0	0.172	0.141	-0.363	0.419	0.124	0.098	-0.283	0.491	0.091	0.006	-0.192	0.183	0.043
	8.0	0.035	0.018	-0.340	0.306	0.098	0.023	-0.288	0.322	0.089	0.020	-0.240	0.154	0.054
	10.0	0.101	0.058	-0.205	0.265	0.086	0.080	-0.151	0.340	0.085	0.022	-0.222	0.157	0.055

Table 6: Ensemble statistics of the experimental ambient velocity components at different axial locations (z/R) and radial positions (x/R) for the APC single rotor.

x/R	z/R	V_∞ (m/s)	u_∞ (m/s)				v_∞ (m/s)				w_∞ (m/s)			
			Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.	Mean	Min	Max	Std.-dev.
-1.5	1.0	0.069	-0.065	-1.072	0.311	0.225	-0.037	-1.083	0.362	0.180	0.021	-0.387	0.289	0.059
	2.0	0.051	-0.047	-0.818	0.325	0.156	-0.011	-0.894	0.476	0.116	0.015	-0.290	0.237	0.055
	3.0	0.023	-0.015	-0.709	0.330	0.135	0.010	-0.723	0.379	0.106	0.015	-0.338	0.225	0.050
	4.0	0.035	-0.016	-0.624	0.301	0.111	0.014	-0.435	0.345	0.090	0.022	-0.167	0.351	0.052
	5.0	0.034	-0.017	-0.525	0.323	0.108	0.019	-0.478	0.349	0.089	0.023	-0.253	0.188	0.049
	6.0	0.034	-0.027	-0.452	0.288	0.111	0.004	-0.479	0.358	0.090	0.021	-0.358	0.271	0.051
	8.0	0.030	-0.005	-0.306	0.292	0.098	0.028	-0.305	0.418	0.079	0.009	-0.595	0.189	0.049
	10.0	0.019	-0.005	-0.356	0.602	0.112	0.002	-0.478	0.267	0.088	0.019	-0.225	0.228	0.050
-1.0	1.0	0.130	-0.123	-1.391	0.324	0.292	-0.037	-1.219	0.346	0.190	0.024	-0.185	0.328	0.052
	2.0	0.035	-0.032	-0.823	0.305	0.158	-0.003	-0.676	0.376	0.116	0.012	-0.246	0.212	0.054
	3.0	0.019	-0.008	-0.724	0.289	0.111	0.010	-0.562	0.259	0.096	0.014	-0.281	0.293	0.048
	4.0	0.026	-0.015	-0.464	0.347	0.106	0.014	-0.499	0.558	0.100	0.016	-0.246	0.207	0.052
	5.0	0.036	0.013	-0.419	0.320	0.092	0.029	-0.431	0.340	0.081	0.017	-0.242	0.183	0.051
	6.0	0.032	-0.000	-0.348	0.298	0.092	0.024	-0.369	0.362	0.076	0.022	-0.254	0.189	0.048
	8.0	0.041	0.007	-0.309	0.329	0.091	0.035	-0.303	0.315	0.075	0.019	-0.362	0.187	0.048
	10.0	0.035	-0.027	-0.449	0.376	0.122	0.011	-0.413	0.423	0.086	0.018	-0.372	0.205	0.049
-0.5	1.0	0.184	-0.181	-2.034	0.290	0.407	0.044	-1.079	0.305	0.175	-0.003	-0.397	0.277	0.054
	2.0	0.029	-0.025	-0.903	0.452	0.191	0.012	-0.419	0.555	0.123	-0.009	-0.595	0.216	0.067
	3.0	0.024	-0.008	-0.516	0.359	0.128	0.023	-0.436	0.417	0.112	-0.001	-0.398	0.153	0.053
	4.0	0.018	0.007	-0.322	0.340	0.119	0.014	-0.605	0.283	0.094	0.008	-0.308	0.195	0.047
	5.0	0.048	0.004	-0.512	0.307	0.104	0.044	-0.664	0.404	0.090	0.018	-0.238	0.226	0.052
	6.0	0.029	-0.016	-0.390	0.375	0.096	0.020	-0.458	0.318	0.086	0.013	-0.220	0.220	0.048
	8.0	0.031	-0.000	-0.346	0.304	0.112	0.025	-0.403	0.270	0.082	0.017	-0.183	0.223	0.045
	10.0	0.034	-0.024	-0.393	0.378	0.114	0.021	-0.329	0.259	0.086	0.012	-0.344	0.245	0.051
0.0	1.0	0.170	-0.164	-2.272	0.333	0.418	0.142	-0.771	0.437	0.109	0.013	-0.436	0.406	0.071
	2.0	0.089	-0.086	-0.999	0.242	0.169	0.077	-0.446	0.722	0.104	-0.000	-0.576	0.162	0.061
	3.0	0.046	-0.046	-0.545	0.300	0.122	0.087	-0.448	0.582	0.087	0.003	-0.366	0.213	0.052
	4.0	0.028	-0.001	-0.546	0.297	0.108	0.073	-0.428	0.455	0.100	0.004	-0.427	0.185	0.066
	5.0	0.020	-0.018	-0.573	0.355	0.103	0.025	-0.491	0.379	0.095	0.008	-0.346	0.194	0.059
	6.0	0.034	0.003	-0.404	0.317	0.100	0.041	-0.358	0.318	0.095	0.008	-0.313	0.170	0.054
	8.0	0.054	-0.053	-0.396	0.266	0.099	0.034	-0.421	0.374	0.088	0.007	-0.218	0.216	0.046
	10.0	0.074	-0.062	-0.556	0.413	0.128	0.020	-0.344	0.259	0.092	-0.001	-0.345	0.270	0.053
0.5	1.0	0.171	-0.091	-1.786	0.271	0.345	0.098	-0.303	1.256	0.206	0.028	-0.286	0.384	0.069
	2.0	0.081	-0.017	-0.869	0.365	0.174	0.021	-0.453	0.722	0.106	0.022	-0.279	0.211	0.056
	3.0	0.092	0.016	-0.622	0.399	0.119	0.087	-0.289	0.582	0.093	0.024	-0.329	0.196	0.050
	4.0	0.082	0.029	-0.449	0.345	0.100	-0.017	-0.377	0.272	0.086	0.023	-0.217	0.193	0.053
	5.0	0.031	-0.001	-0.406	0.443	0.100	-0.006	-0.417	0.383	0.079	0.018	-0.348	0.199	0.055
	6.0	0.045	0.012	-0.443	0.335	0.103	0.037	-0.335	0.491	0.081	0.016	-0.272	0.180	0.048
	8.0	0.042	0.015	-0.337	0.413	0.091	-0.008	-0.435	0.460	0.075	0.020	-0.268	0.168	0.047
	10.0	0.031	-0.018	-0.456	0.426	0.123	0.034	-0.354	0.318	0.090	0.015	-0.351	0.180	0.052
1.0	1.0	0.125	-0.073	-1.200	0.263	0.244	0.098	-0.165	0.909	0.139	0.024	-0.407	0.210	0.055
	2.0	0.051	-0.044	-0.792	0.274	0.128	0.021	-0.378	0.404	0.082	0.015	-0.513	0.205	0.052
	3.0	0.054	0.011	-0.414	0.325	0.112	0.050	-0.400	0.403	0.091	0.017	-0.467	0.209	0.052
	4.0	0.069	-0.065	-0.464	0.261	0.116	-0.017	-0.269	0.272	0.079	0.015	-0.217	0.202	0.044
	5.0	0.053	-0.050	-0.619	0.255	0.106	-0.006	-0.464	0.383	0.084	0.017	-0.348	0.214	0.046
	6.0	0.040	0.006	-0.444	0.419	0.145	0.037	-0.353	0.491	0.105	0.015	-0.272	0.230	0.053
	8.0	0.026	-0.020	-0.398	0.506	0.130	-0.008	-0.368	0.460	0.095	0.013	-0.240	0.190	0.047
	10.0	0.035	0.006	-0.311	0.330	0.106	0.034	-0.390	0.340	0.100	0.005	-0.510	0.212	0.064
1.5	1.0	0.094	-0.014	-0.781	0.462	0.138	0.091	-0.368	1.025	0.156	0.021	-0.601	0.285	0.065
	2.0	0.045	-0.001	-0.529	0.325	0.150	0.044	-0.227	0.523	0.101	0.010	-0.444	0.192	0.053
	3.0	0.026	-0.015	-0.580	0.324	0.131	0.017	-0.370	0.369	0.094	0.012	-0.350	0.170	0.041
	4.0	0.022	-0.013	-0.395	0.303	0.112	0.013	-0.502	0.381	0.088	0.013	-0.166	0.270	0.045
	5.0	0.056	0.024	-0.429	0.361	0.105	0.049	-0.336	0.482	0.080	0.014	-0.444	0.153	0.048
	6.0	0.021	0.011	-0.421	0.378	0.102	0.010	-0.531	0.330	0.090	0.015	-0.235	0.188	0.048
	8.0	0.048	0.018	-0.263	0.345	0.101	0.043	-0.258	0.366	0.095	0.014	-0.307	0.186	0.055
	10.0	0.045	-0.043	-0.469	0.350	0.148	-0.014	-0.454	0.241	0.120	0.003	-0.345	0.204	0.057

Spatial validation: The quiet-zone threshold was imposed on the results obtained from the additional 2-D spatial experiments and the FVM model for the APC single rotor under the flow conditions mentioned in the previous section. Fig. 4 shows the $0.01 V_{\text{tip}}$ threshold obtained from both the experimental measurements and the FVM model, along with the sensor boundary set at 0.2 m/s . Note that experimental data is not available in the region $(-R, +R)$ due to mechanical and blockage considerations in placing the velocity in close proximity to the propeller; subsequently, the values of the induced velocity in $(-R, +R)$ are obtained by linearly interpolation of the velocities across the 105 discrete measurement locations. Moreover, experimental values are ambient-corrected, with an inherent uncertainty of $\pm 0.2 \text{ m/s}$.

From Fig. 4, it can be observed that both experiment and FVM predict the 1% tip-speed threshold accurately (resulting in a $z/R \approx 1.8$ at the rotor hub). Successively, the sensor boundaries also agree reasonably between the experiment and FVM. Overall, it is observed that the single rotor experimental and FVM results demonstrate close agreement between each other, with the experimental velocity statistics exhibiting a stable behaviour across all measurement points Tables 3 to 6, while the numerical velocities performing similar to the results presented in Table 2. This result strengthens the credibility of both the FVM model and the in-house experimental setup in resolving the spatial distribution of the induced velocity flow field of a single rotor.

Multi-rotor validation: As per the reviewer comments, an attempt at the validation of induced velocity characteristics predicted by the FVM model against the experimental investigation of Wilson et al. (2022) was conducted.

The rotor system considered for validation is a quad-X configuration from the reference paper (3rd row, Fig. 2). The rotors are 3-bladed, and measure 0.0762 m (3 inches) in diameter. No explicit definition of the twist and chord geometry (either in the reference or from the manufacturer) exists, to model the rotor geometry in FVM; consequently, the chord distribution was measured manually from a digital image using basic scaling formulae, and replicated for the FVM study. Similarly, the rotor was assumed to be “ideally twisted” rotor (which is a hyperbolic span-wise twist distribution). The measured chord and twist distributions, and other geometric details of the quad-X configuration utilised for the FVM validation are presented in Fig. 5.

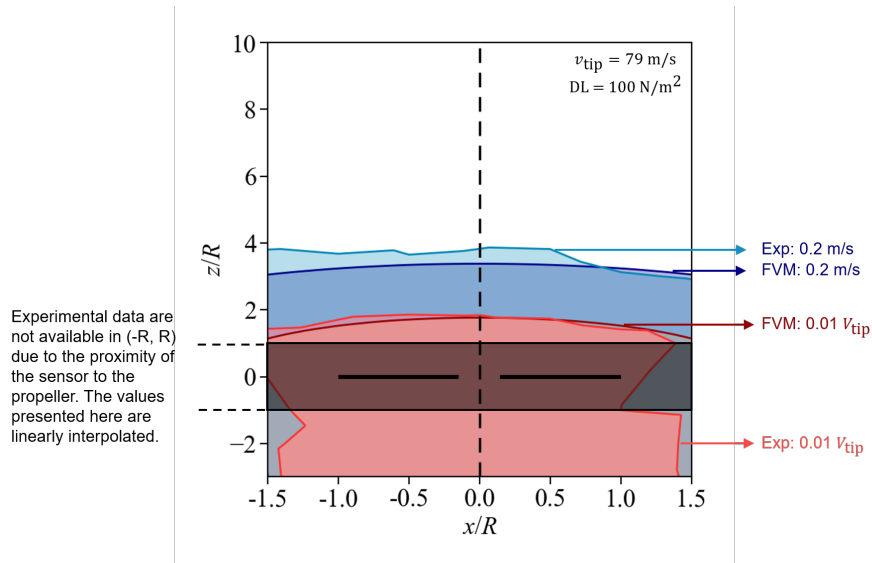


Figure 4: Comparison of quiet-zone threshold contours between 2-D spatial velocity experiments and FVM model for the APC single rotor in hover at $DL = 100 \text{ N/m}^2$.

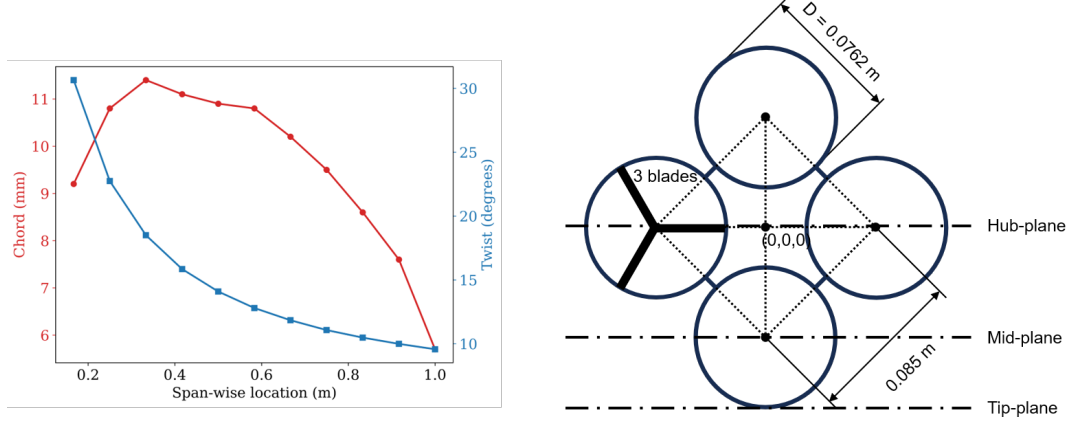


Figure 5: Rotor geometry details for the quad-X configuration presented in [Wilson et al. \(2022\)](#)

The original experiments in the paper were conducted in a water tunnel, whereas the FVM validation utilises the equivalent flow conditions in air, obtained by maintaining the same Reynolds Number ($Re = 38,100$) and advance ratio ($\mu = 0.1393$). Accordingly, the rotor angular speed was set to $\Omega = 1413.7167 \text{ rad/s}$ (225 Hz), and the freestream velocity at 7.5 m/s. For the aforementioned geometry and flow parameters, the streamwise variation of the vertical velocity component presented in the reference paper for $Y/D \approx 0.35$ from the rotor disk plane (Fig. 4 in the reference paper) was compared with the results obtained from the FVM model for the hub, mid, and the tip planes (see Fig. 5).

The obtained velocity profiles are presented in Fig. ??, where the solid curves correspond to FVM, and dashed curves represent the results from the reference paper and the Masters thesis upon which it is based [Brenner \(2021\)](#). The induced velocity (y -axis) is normalised with the freestream velocity, and the streamwise direction (x -axis) is normalised with the rotor diameter (D). Additionally, the dimension values of the original experiments are presented in the secondary y -axis. It can be observed from Fig. ?? that the peak velocity

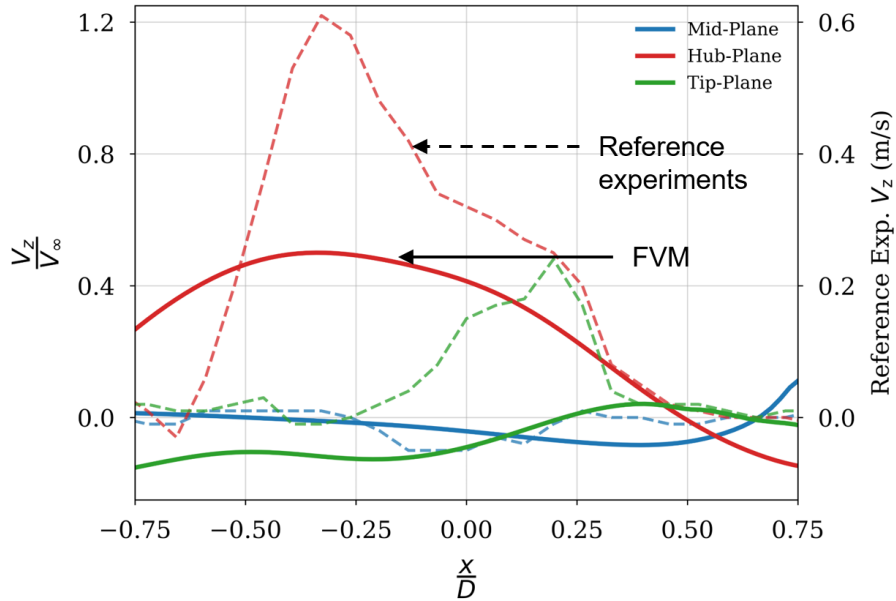


Figure 6: Validation of the FVM model for velocity field predictions of the quad-X configuration from the reference paper.

at the hub-plane is under-predicted by FVM ($0.5 V_\infty$ against $1.25 V_\infty$ from the reference results), and so is the peak at the tip-plane. Nevertheless, the location of the minima and maxima are predicted with reasonable accuracy at the various stream-wise locations for each of the measurement planes. While the normalised induced velocity trends and order of magnitude are captured by FVM in Fig. ??, lending some confidence in the predictions, visible disagreement in the prediction of exact values exists.

This disagreement between FVM and experiment could be attributed to either the assumptions of FVM, or the lack of clarity in the presentation of the experimental data. For instance, FVM simulates only isolated rotors, and do not model fuselage and other structural members (out of scope of the present study), whereas complete quad-rotor system is investigated in the reference experiment. The values presented in FVM are time-averaged over 10-rotor revolutions after the initial transients have settled. However, details of averaging techniques used to obtain the induced velocity, particle image velocimetry (PIV) measurement uncertainty and accuracy, physical limitations in resolving the locations of the measurement planes, the associated blockage effects, influence of ambient conditions, and rotor blade geometry (such as airfoil sections, span-wise chord, and twist distributions) are unclear in the reference paper. These quantities influence the induced velocity distribution significantly, and remain essential for effective modelling into FVM. Especially, since the reference velocities are not more than 0.6 m/s, without clarity on background flow and the associated measurement uncertainties, it becomes considerably hard to replicate the results and quantify disagreements in prediction with FVM. To obtain test cases with more complete information, we also performed a detailed analysis of the literature on wind-speed measurements using UAV-mounted sensors (Thielicke et al. (2021); Wilson et al. (2022); Jin et al. (2024); Ghirardelli et al. (2023, 2025)); however, we observed a similar lack of clarity on the governing parameters such as those listed above.

We note that a comprehensive, reproducible set of reference data is still not easily extractable from the literature, and hence, we are unable to perform a stringent comparison between numerics and experiments for multi-rotor systems. Regardless, we were able to model the rotor system provided in (Wilson et al. (2022)), for which the induced velocity results are presented in Fig. 6. Due to the discussed limitations in the literature and the FVM model, we acknowledge the observed disagreements in the comparison, and we will present the validation results in the revised manuscript as “potential” or “likely”, rather than those obtained after strong verification.

Operating conditions: Fig. 8 in the original manuscript was presented for $DL = 200 \text{ N/m}^2$, whereas results presented in this document correspond to $DL = 100 \text{ N/m}^2$, i.e., experiments were performed across two different operating hover conditions. Both cases provide excellent agreement in induced velocity above the plane of the rotor (Fig. 8 in the original manuscript, and Fig. 3 in this document), indicating model validity across RPM/Thrust conditions.

Potential addition to the manuscript: We will replace Fig. 8 in the original manuscript with the 2-D spatial variation presented in Fig. 4, and add the multi-rotor induced velocity comparison (Fig. Figures 5 and 6) along with the supporting text. Tables 3 to 6 and (Fig. 3) will not be included for brevity. Nevertheless, relevant explanation will be provided in text for completeness.

3. The numerical setup may control the reported descent boundaries. Only six wake turns are retained, and lines 305–308 state that the apparent decay above $z/R = 4.35$ is partly caused by truncation. The grid is stated to end at $z/R = 6$, whereas Figs. 10 and 11 report results up to approximately $z/R = 10$ and 7.5. Please reconcile the domains and demonstrate convergence with wake age, grid, time step, blade discretisation, vortex-segment length, and vortex-core treatment; numerical uncertainty should be well below the 1%

classification threshold.

Descent boundaries: The value of $z/R = 4.35$ as a boundary (Fig. 10c in the original manuscript) during axial-descent was attributed to the wake truncation. It is expected that if the number of wake-turns are altered, this boundary would be different (in line with the reviewer statement). However, any data obtained during axial descent in a practical scenario would be considered invalid as the sensor would be in the wake of the rotor and the fuselage. Such flows are highly turbulent in nature, and well beyond the capability of the FVM model used in this study (limited both by the formulation and the presence of isolated rotors). The axial study was shown in the original manuscript to hint at why measurements during this flight condition have a very low signal to noise ratio.

Sensitivity studies: The reviewer’s focus on performing a parametric study to quantify the influence of various FVM parameters on the computed induced velocity is noted. Towards the same, sensitivity analysis across a wide range of parameters have been carried out to assess the predicted induced velocity above the plane of the rotor — which is the region of primary interest in this study. This parametric study was performed by varying one numerical parameter at a time while keeping the remaining parameters at their baseline values used in the present study. The induced velocity was evaluated along the rotor axis over the same axial region considered in Fig. 8 of the original manuscript, from $z/R = -3$ to 10. Table 7 shows range of values for different parameters that was used for all the simulations, with the highlighted yellow entry in each row being the baseline condition. Note that in the current model implementation, the wake-age and vortex-segment length discretisation are the same, i.e., $\Delta\Psi = \Delta\zeta$. Additionally, the time step is tied to the wake-age discretisation via $\Delta t = \Delta\Psi/\Omega$.

The baseline configuration used six wake turns, a wake discretisation of $d\psi = 10^\circ$, 40 vortex segments, a core-growth constant of 0.01, and a 100×100 Cartesian post-processing grid. The mean induced velocity and the corresponding 1σ variation are computed for each case over 10 revolutions of the converged solution. Although small variations in disk loading (not more than $\pm 10\%$) occur when the numerical parameters are changed (which arises from numerical shifts in the wake-induced effects that affect local angle of attack and subsequently, the blade loading), the resulting induced-velocity profiles remain broadly similar. The results for the individual parameters are discussed below.

- (a) Figure 7a shows the effect of varying the number of retained wake turns from 4 to 10, with six wake turns corresponding to the baseline case.
- (b) Figure 7b shows the effect of varying the wake discretisation from 2.5° to 15° , with $d\psi = 10^\circ$ used as the baseline value.

Table 7: Parameter values considered in the study. Highlighted values denote the baseline configuration that are used for FVM simulations in the manuscript.

Parameter	Values considered			
Wake turns, N_{turns}	4	6	8	10
Wake-age, $\Delta\psi$	2.5	5	10	15
Core-radius / blade chord	0.005	0.01	0.015	0.020
Blade segments	10	20	30	40
Grid dimensions	50 x 50	100 x 100		

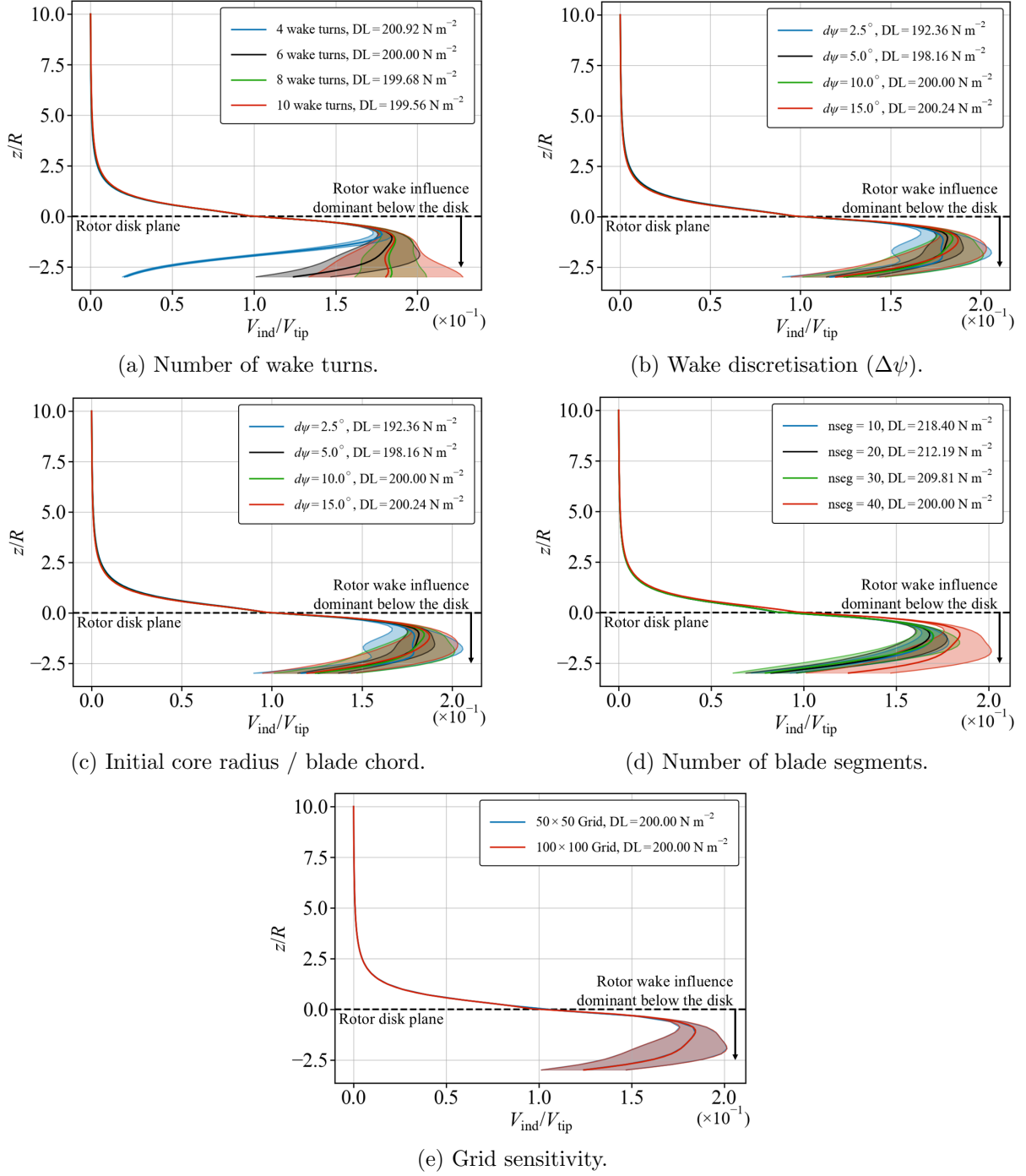


Figure 7: Sensitivity of numerical parameters to the induced velocity field predictions for the APC single rotor in hover, operating at $DL = 200 \text{ N/m}^2$. Shown in each colour are the mean values and the 1σ variation.

- (c) Figure 7c presents the induced-velocity profiles obtained by varying the core-growth constant from 0.005 to 0.020, with 0.010 used as the baseline value.
- (d) Figure 7d shows the effect of varying the number of vortex segments from 10 to 40, with 40 segments used as the baseline case.
- (e) Figure 7e compares the results obtained using 50×50 and 100×100 Cartesian post-processing grids, with the latter used as the baseline case.

The five parametric studies show that the predicted induced velocity above the rotor plane

is only weakly sensitive to the numerical parameters considered. Although differences are observed below the rotor plane, the overall trends remain similar for all the cases, across all parameters. The small changes in disk loading associated with the different numerical settings also do not result in a significant change in the induced-velocity profiles. The maximum excursion of the instantaneous induced velocity from its mean value, evaluated at $z/R = 1-10$ over the 360 instantaneous time steps (10 revolutions), was 6.237% across all the cases considered. These results support the numerical settings adopted in the present study and indicate that the induced-velocity predictions used for the sensor-placement analysis are not strongly dependent on the selected numerical parameters.

Potential Addition to the Manuscript: We will add a section on grid sensitivity studies to the appendix.

4. The cross-scale generalisation based on disk loading in Appendix A is not established. For a fixed-pitch rotor under aerodynamic similarity, the thrust coefficient is approximately independent of rotational speed apart from Reynolds-number, Mach-number, and other non-similar effects. Equal disk loading alone does not ensure similarity when blade loading, solidity, blade number, geometry, Reynolds number, Mach number, advance ratio, and rotor spacing differ. Figure A1 compares only one axial hover profile. Please revise the theoretical argument and restrict generalisation to the tested APC geometry unless a fuller similarity analysis is provided.

Disk loading was chosen as the parameter for normalisation based on the theoretical result from momentum theory for Helicopter (or equivalently propeller theory for propellers), which states that the induced velocity at the plane of the rotor is a function of $\sqrt{DL}$. However, we do concede that there may be other parameters that may influence the induced velocity distribution. As per the reviewer comments, a parametric study was taken up, and the results are presented in this section.

Solidity Effects on Normalised Induced Velocity Across Rotor Configurations:

We thank the reviewer for highlighting the need to examine the role of rotor geometry and solidity in the disk-loading-based comparison. To further assess this aspect, we performed an additional sensitivity study using the three baseline rotor geometries considered in Appendix A of the original manuscript, namely the Harrington single rotor (HSR), Advanced Precision Composites (APC) 12 × 6E rotor, and Hobbywing 2480 (HW) rotor. The respective rotor radii were retained for each baseline configuration, thereby preserving their original scale. For each rotor, the blade chord distribution was varied by $\pm 10\%$ from its baseline value, resulting in corresponding $\pm 10\%$ variations in rotor solidity, σ . The blade number and the remaining characteristics of each baseline rotor were retained, with the change in blade chord providing the prescribed change in solidity.

Figure 8 shows all nine cases that were evaluated in hover at a fixed disk loading of $DL = 100 \text{ N/m}^2$. For each modified-solidity case, the rotational speed Ω was newly trimmed for the UAV-scale rotors, while a collective trim was implemented for the HSR, so that the required thrust corresponding to the prescribed disk loading was achieved. Thus, the comparison was performed at the same disk loading while allowing the rotor operating speed or collective angle to adjust consistently with the modified solidity. In addition, the sectional lift coefficient used in the aerodynamic calculation was modified to include the compressibility correction as,

$$C_{l,\text{compressible}} = \frac{C_{l,\text{incompressible}}}{\sqrt{1 - M^2}} \quad (1)$$

where M is the local Mach number. The resulting time-averaged induced-velocity profiles were then normalised by the corresponding rotor-tip speed, $V_{\text{tip}} = \Omega R$, and plotted against

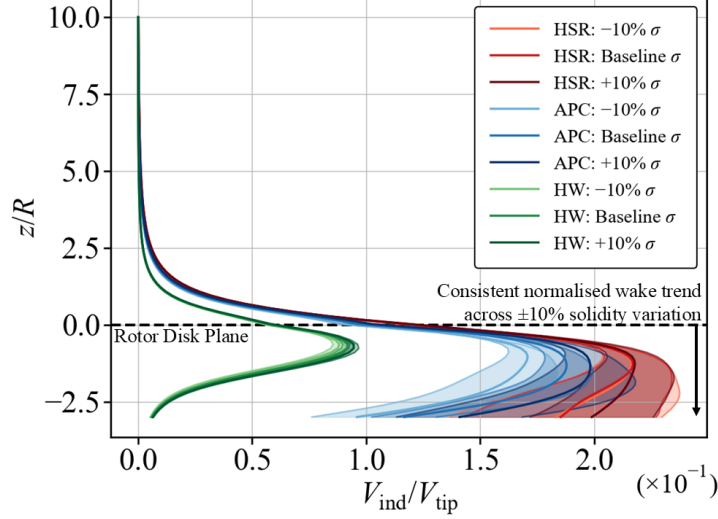


Figure 8: Comparison of time-averaged induced velocity normalised by rotor-tip speed ($V_{\text{ind}}/V_{\text{tip}}$), along the normalised rotor axis (z/R), for HSR, APC, and HW rotors in hover ($DL = 100 \text{ N/m}^2$), with $\pm 10\%$ blade-solidity variation.

the normalised axial location, z/R , as shown in Fig 8. For each of the three rotors, the $\pm 10\%$ solidity cases exhibit a systematic ordering of the normalised induced velocity, with

$$\left(\frac{V_{\text{ind}}}{V_{\text{tip}}}\right)_{+10\%\sigma} > \left(\frac{V_{\text{ind}}}{V_{\text{tip}}}\right)_{\text{Baseline } \sigma} > \left(\frac{V_{\text{ind}}}{V_{\text{tip}}}\right)_{-10\%\sigma} \quad (2)$$

While the magnitude of the induced velocity changes with solidity, the normalised axial trend and wake-development behaviour remain consistent within each rotor family across the solidity variation, especially in the rotor upstream (of interest for the present study).

Effects of blade number: The full-scale, variable pitch Harrington single rotor (HSR) was considered for this study. In addition to varying the blade chord to achieve variation in the rotor solidity, the blade number was now varied from the baseline ($N_b = 2$), to $N_b = 3, 4$, while retaining the original chord distributions and the rotor angular speed. A rotor collective trim is implemented to achieve $DL = 100 \text{ N/m}^2$. The effect of varying blade number was observed to be similar to that produced by the variation in chord (see Fig. 9a); the solidity of the rotor system effectively changes by varying the blade number, and the rotor upstream produces comparable normalised induced velocities for the different blade numbers when the operating condition was maintained at $DL = 100 \text{ N/m}^2$. Furthermore, the observed wake effects below the rotor system are also similar, albeit with minor variations as observed in Fig. 8.

This weak sensitivity of the induced velocity distribution to rotor solidity, which encompasses blade geometry and blade number, strengthens the use of disk loading as a flow similarity parameter for cross-scale generalisation. While rotational speed and collective trim can be implemented numerically on any rotor system, it is to be noted that fixed-pitch UAV-scale rotor systems and fixed-RPM full-scale rotor systems utilise only one of the methods for controlling their operating condition. Nevertheless, the rotor systems across scales demonstrate similar normalised induced velocity trends irrespective of the means of achieving the desired thrust condition.

Effects of Mach Number: Since the present study utilises potential flow formulations, viscosity and hence, effects of Reynolds number cannot be fully analysed. The formulation is also incompressible in nature. Regardless, some compressibility corrections were

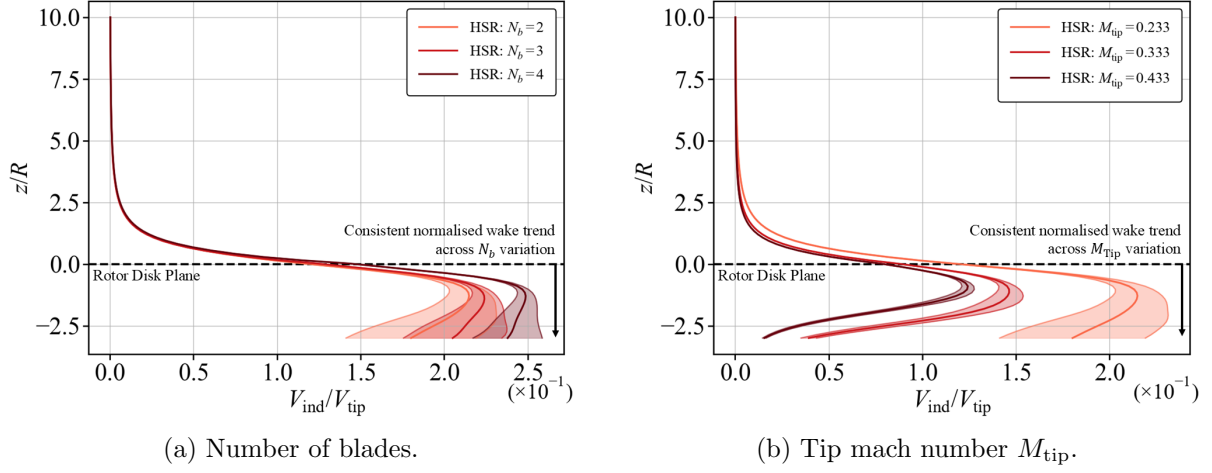


Figure 9: Comparison of time-averaged induced velocity normalised by rotor-tip speed (V_{ind}/V_{tip}), along the normalised rotor axis (z/R), for the HSR in hover ($DL = 100 \text{ N/m}^2$), with variations to the blade number and tip mach number.

introduced in the calculation of airfoil lift coefficient (see Eq. 1) to study its influence on the induced velocity distribution.

By holding the rotor geometry parameters constant and varying the operational speed, the effect of tip mach number on the induced velocity was evaluated by implementing rotor collective trim procedure to achieve the desired disk loading. The Harrington single rotor (HSR) was considered at two different tip mach numbers (M_{tip}) – +0.1 and +0.2 from the baseline $M_{tip} = 0.233$ presented in Fig. 8. It can be observed from Fig. 9b that while the mach number is different across the cases, the normalised induced velocity trends still remain significantly comparable, especially in the rotor upstream which is of primary interest in the present work for sensor placement. This result is particularly encouraging, indicative of the use of disk loading as a governing parameter for flow similarity analyses across rotors of various weight scales.

Table 8 shows the variations in different parameters simulated to establish disk loading as a common quantity for generalisation. Baseline values are highlighted in yellow. The effects of blade number and mach number are studied for the HSR, while the solidity effects are investigated for all the rotor systems. Show alongside these values are the aerodynamic minimum quiet zone values for the single rotor systems along the axis of rotation. Overall, the cross-scale generalisation investigation reveals that the tip-speed normalised induced velocity trends of different rotor geometries operating under flow conditions, converge to similar non-dimensional flow characteristics when operating the same disk loading. This convergence occurs despite the change in the magnitude of the dimensional induced velocity distribution changes with alterations to the rotor solidity (via modifications to the blade geometry parameters) or the tip Mach number. Furthermore, the normalised z/R values for sensor placement are comparable across different cases. This result is paramount in establishing disk loading as a strong similarity parameter for cross-scale generalisation.

Potential addition to the manuscript: We will include the results from the additional simulations discussed in this section to the “cross-scale generalisation” appendix and add supporting in text to suggest that disk loading is a strong similarity parameter in defining the quiet zone, but there could be other secondary influences.

5. The multi-rotor conclusions are based on idealised zero-freestream hover and omit the airframe. A UAV holding position in non-zero wind experiences oblique inflow, tilt, and

Table 8: Summary of rotor parameters and minimum axial locations $(z/R)_{\min}$ at the rotor hub (threshold $V_{\text{ind}}/V_{\text{tip}} = 0.01$) for HSR, APC, and HW rotors with compressibility effects at a constant $DL = 100 \text{ N/m}^2$.

Parameter	Rotor Type					
	HSR		APC		HW	
	Value	$(z/R)_{\min}$	Value	$(z/R)_{\min}$	Value	$(z/R)_{\min}$
Rotor radius, R (m)	3.81	–	0.15	–	0.31	–
Solidity, σ	0.069	1.929	0.079	1.684	0.063	1.181
	0.076	1.924	0.088	1.737	0.070	1.197
	0.084	1.926	0.097	1.803	0.077	1.215
Number of blades, N_b	2	1.912	–	–	–	–
	3	1.879	–	–	–	–
	4	1.949	–	–	–	–
Tip Mach number, M_{tip}	0.233	1.912	–	–	–	–
	0.333	1.492	–	–	–	–
	0.433	1.343	–	–	–	–

unequal rotor loading, while the omitted structures can distort the proposed mounting locations. Please analyse representative winds and directions, attitudes, rotor-speed imbalance, spacing, rotation, phase sensitivity, and preferably a full-platform sensor configuration. Otherwise, consistently describe the results as candidate regions of low rotor-induced mean velocity rather than validated optimal sensor locations.

Multi-rotor hover: As established in the original manuscript, hover and axial climb are the most favourable scenarios for wind measurements because effects of rotor-wake interactions are lower compared to oblique flow conditions; consequently, we concentrate on the zero-freestream hover to establish a conservative, aerodynamically safest baseline for sensor placement for the multi-rotor configurations.

Structural considerations: We recognise that the presence of the vehicle structure contribute significantly to the determination of an optimal quiet-zone. However, full-platform structural geometries and asymmetric rotor-trim mechanics are outside the scope of the current study. Therefore, in-line with the reviewer comments, we will consistently re-frame all arguments explicitly as “candidate regions of low rotor-induced velocity” or simply “potential quiet-zones”, rather than implying fully optimal sensor locations.

Potential addition to the manuscript: We will revise all “optimal quiet-zones” to “candidate locations of low induced velocity” or “potential aerodynamic quiet zones”.

- Several central statements are internally inconsistent. The single-rotor hover boundary is reported as about 1.86R in Sect. 3.2 and Fig. 10 but as 1.75R in the conclusions. The quadrotor geometric-centre values are about 2.10R and 3.30R, and the high-loading hexa-rotor value is about 3.36R, whereas the conclusions summarise the range as 1.75R–3R. The abstract favours the geometric centre over locations above individual rotor hubs, while Sects. 3.3.1 and 3.3.2 report lower minimum heights on the hub-intersecting planes. The statement that weak axial descent requires the greatest separation conflicts with Fig. 11, and hover is called the limiting condition although axial descent is more restrictive. Please reconcile all numbers and revise the abstract and conclusions to match the actual simulations.

Inconsistencies: We thank the reviewer for pointing out the inconsistencies. We understand that the numbers need to be reconciled and we will explicitly represent the values of the proposed “potential aerodynamic quiet-zones” based on the disk loading and flight condition, and ensure consistency in the claims throughout the manuscript, including abstract and conclusions.

The issue of geometric centre: We had noted in the results section for the multi-rotor (particularly the hexa-rotor configuration) that despite the non-geometric-centre planes providing a lower minimum z/R for sensor placement, the actual positioning of the sensor on these planes may introduce undesired asymmetry leading to vehicle stability concerns. Investigations of such asymmetric flow conditions on full-platform configurations are out of scope of the present study. However, considering such practical aspects, we stated that geometric centre would be the safest design choice.

Limiting conditions: We would like to clarify that hover and axial climb flight conditions are the most suitable for sensor placement. Among the two, hover is the limiting condition based on which we build the definitions of quiet-zones. We understand the lack of clarity is utilising “limiting condition” for hover, while axial descent demonstrates more restrictive for sensor placement. We will clarify and rephrase the statements. The inconsistency on weak axial descent and Fig. 11 is noted, and will be rectified accordingly.

Potential addition to the manuscript: We will revise the manuscript based on all the above corrections and ensure consistency throughout.

Technical Comments

1. Pages 8 and 11–12: clarify whether the rotor disk or rotor axis is parallel to the ground, how upstream and downstream measurements were obtained, and which TriSonica components were used to calculate V_{ind} , particularly because the vertical component was excluded. Provide the sampling duration, repeated runs, filtering or detrending, room dimensions, wall and ground clearances, environmental conditions, sensor-position accuracy, and independent disk-loading measurement. At approximately 7143 RPM, the two-bladed blade-passing frequency is about 238 Hz, far above the 40 Hz sampling rate; discuss aliasing and state that rotor-frequency fluctuations cannot be validated.

Experimental setup: The rotational axis of the rotor is parallel to the ground (refer Fig. 5 of the original manuscript). The TriSonica Mini weather sensor is positioned such that its heading (North) faces the propeller. Positive ‘ u ’ component of the flow velocity corresponds to wind from Trisonica’s North (therefore, the flow from the propeller). Similarly, wind from the East is the positive ‘ v ’ component, and vertically upward wind is the positive ‘ w ’ component. The range of measurement of the ‘ w ’ component is limited as per the manufacturer, and due to the sensor’s own blockage effects, corresponding measurements are less accurate; Hence, only the ‘ u ’ and ‘ v ’ components are utilised in the present study to calculate the induced velocity. Details of the experiments including room dimensions, sensor positioning accuracy, sampling duration, and repeatability, are explained in the ‘*Additional experimental validation*’ section of this document (first response to comment #2 of the reviewer).

Disk Loading: Routine experimental validation of rotor thrust and power vs angular speed (performance characteristics) were carried out before induced velocity experiments. The results were compared with the manufacturer datasheet. Accordingly, the rotor was maintained at an angular speed (within an accuracy of $\approx \pm 50$ RPM.) that achieves thrust corresponding to the desired disk loading.

Aliasing: We acknowledge that the blade passage frequency and higher rotor harmonics

will not be captured with the TriSonica Mini weather sensor. For the angular speeds corresponding to disk loading 100 and 200 N/m², the blade passage frequencies are in the range 150-250 Hz, respectively. These blade-passage harmonics are significantly higher than the maximum sampling frequency of the sensor (40 Hz, and a corresponding Nyquist limit of 20 Hz), and would therefore be aliased into the lower spectrum, as noted by the reviewer. Consequently, the higher “/rev” components cannot be resolved with the current experimental apparatus. Nonetheless, this limitation does not affect the validity of the quiet-zone measurements; moreover, the numerical model demonstrates that the high-frequency fluctuations are localised to the wake of the rotor system and the rotor upstream (where candidate sensor placement locations are present) is primarily characterised by stable velocity magnitudes with significantly less fluctuations compared to the rotor wake. Therefore, in the context of the present study, aliasing of the high-frequency rotor harmonics while mathematically present in the sensor measurements, has negligible effect on the computation of time-averaged induced velocity components required to identify the aerodynamic quiet-zones.

2. Pages 12–18: convert μ_x and μ_z into dimensional velocities for the tested rotor and discuss whether values up to 0.20 are representative of meteorological UAV operations.

The maximum value of tip-speed normalised axial or forward velocity ($\mu_{x,z} = 0.2$) corresponds to ≈ 16 m/s for the APC 12 $\times$ 6E rotor operating at a disk loading of DL = 100 N/m² (the rotor tip-speed here is $V_{\text{tip}} \approx 80$ m/s). Hence, $\mu_{x,z} \leq 0.2$ represent real-world flight velocity ranges for UAVs of similar geometrical scale, and are representative of typical operations for meteorological applications.

3. For the quad- and hexa-rotor cases, define whether disk loading is total thrust divided by total disk area or per-rotor thrust divided by one-rotor disk area and explain how it is imposed numerically. Also report the initial azimuth and relative phase of all rotors and whether phases remain locked.

All multi-rotor numerical simulations are carried out with an identical initial azimuth of 0° (Southward if viewed from top) for each rotor. Since the numerical framework prescribes a constant rotational speed (Ω), the relative phase angle between the blades of the rotors remain perfectly locked throughout the simulation.

The multi-rotor systems considered in the present study feature non-overlapping rotor disks. Therefore, the total disk loading $N_r \times T/N_r \times A$ (where N_r is the number of rotors, T is the thrust produced by each rotor, and A is the corresponding disk area) is equal to the disk loading of the individual rotors. The rotational speed of the rotors are fixed (according to the experimental validation of performance curves with the manufacturer) to produce the desired thrust, and therefore, each rotor and the consequently, the entire system operate at the same disk loading.

4. The 100 $\times$ 100 grids span approximately 7R laterally and 9R axially, yet quiet-zone locations are reported to two decimal places. Please state the contour-interpolation procedure and avoid precision unsupported by the grid and convergence uncertainty.

The induced velocity was obtained from the FVM model on a discrete set of equi-spaced grid points in the plane of interest. These values were linearly interpolated before plotting to provide a smooth representation of the induced velocity field. We understand the precision limitation imposed by the grid resolution, and to avoid over-reporting precision, we will revise all quiet-zone measurements to one-decimal place in the revised manuscript.

5. Figure 6: provide the source and calculation method for every UAV and helicopter data point. Also clarify whether all listed values use consistent definitions of maximum take-off weight, rotor area, and disk loading.

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The data points were plotted by considering the values reported by the manufacturers and official databases. The sources for the vehicles plotted in Fig. 6 of the original manuscript are listed in Table 9. The references will be included in the updated manuscript. We would like to note that consistency in the definitions of maximum take-off weight (maximum allowable gross mass of the aircraft in N), rotor area (area swept by all rotors in a vehicle), and disk loading (ratio of the thrust produced by a rotor system to the swept area of all the lifting rotors), and the conversions to SI units (where applicable) have been confirmed for all vehicles in Table 9.

Table 9: Sources of the rotorcraft data used in Fig. 6 (Manuscript).

S. No.	Rotorcraft	Reference
<i>UAVs</i>		
1	Dragonfly C-3XL	Draganfly (2025a)
2	Dragonfly H-L	Draganfly (2025b)
3	HZH JY30	Hongfei Aviation Technology Co., Ltd. (2026a)
4	HZH Y150	Hongfei Aviation Technology Co., Ltd. (2026b)
5	JOUAV CW-20	sUAS News (2016)
6	JOUAV CW-25H	JOUAV (2021)
7	JOUAV CW-25E	JOUAV (2026a)
8	JOUAV CW-30E	JOUAV (2026b)
9	JOUAV CW-80E	JOUAV (2026c)
10	Meteodrone MM670	Meteomatics (2026)
11	MotioNew H100	MotioNew (2026)
12	UAVOS	UAVOS (2026)
<i>Helicopters</i>		
13	AS 332 Puma	Leishman, J. G. (2006)
14	SA 365 Dolphin	
15	AS 350B Squirrel	
16	Augusta A109	
17	Bell 206	
18	Bell 412	
19	Bell AH-1 Cobra	
20	Bell 222B	
21	Boeing CH-46*	
22	Boeing CH-47C*	
23	MBB BO 105	
24	MBB BK 117	
25	Hughes 500E	
26	AH-64 Apache	
27	Robinson R22	
28	Schweizer 300	
29	Sikorsky UH-60	
30	Sikorsky S-76A	

6. Table 1 gives a collective pitch of 5.6168 degrees, whereas Appendix B describes the APC rotor using 5 degrees. Please reconcile these values and state whether the actual APC airfoil geometry or the surrogate NACA 0012 model is used in each calculation.

We thank the reviewer for pointing to the inconsistency. For all the APC simulations, the rotors are held at a constant collective of 5.6168° (obtained based on the blade pitch specified in the APC datasheet), and the rotational speed is trimmed to match the desired disk loading.

The HSR consists of NACA 0012 section by design, and rotor geometry details are available. Similarly, for all the APC rotor simulations, chord and twist distributions are obtained from the APC datasheet. However, sectional aerodynamic calculations utilise the surrogate NACA 0012 model detailed in the original manuscript.

We will clarify the above points explicitly in the revised manuscript.

7. Please proofread and improve presentation. Examples include “meterological”, “aysm-metric”, “cancelation”, “from from”, “with a significantly well”, “wake axial descent” (apparently “weak axial descent”), “analyzes” where “analyses” is intended, and the “1-XX” reference placeholder. Figures 9, 13, and 15 need clearer legends, color-blind-safe colormaps, more distinguishable binary shading or patterns, and explicit contour coordinates; cite the sources and permissions for Fig. 2 product images.

We fully appreciate the reviewer’s attention to these minor details. We will fix all typographical and grammatical errors based on a consistent dictionary, and ensure the use of colour-blind-safe colour maps.

The sources of all commercial wind-sensing devices shown in Fig 2 of the original manuscript are given in Table 10. We will update the citations in the revised manuscript.

We thank the reviewer once again for the detailed comments and suggestions.

Table 10: Commercial wind-sensing devices shown in Fig. 2 (Manuscript) and their corresponding manufacturers and product references.

Sensor image	Sensor	Manufacturer	Reference
	Pitotstatic tube	NW Blue	NW Blue (2026)
	Mechanical cup anemometer	PCE Instruments	PCE Instruments (2026)
	Thermal (hot-film) anemometer	Modern Device	Modern Device (2026)
	3D ultrasonic anemometer	LI-COR Environmental	LI-COR Environmental (2025)

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