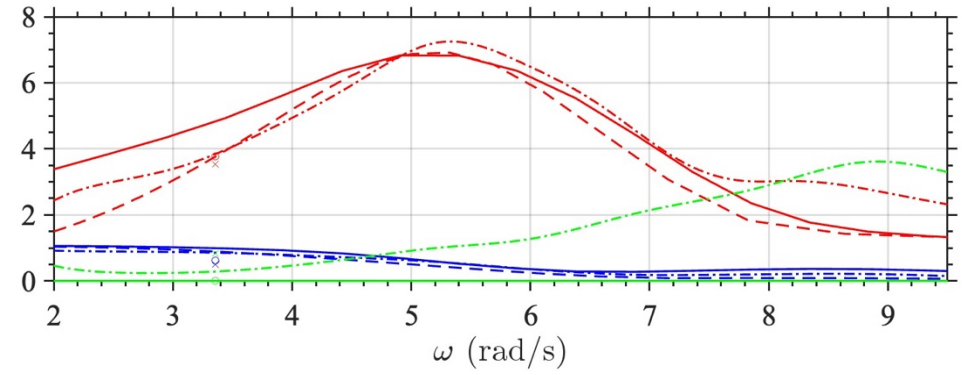
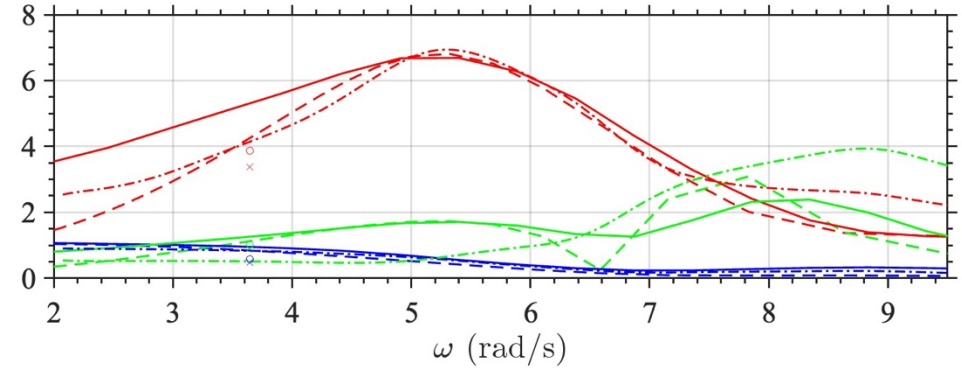
Supplementary material S1: model-experiments comparison at zero speed (20 cases)

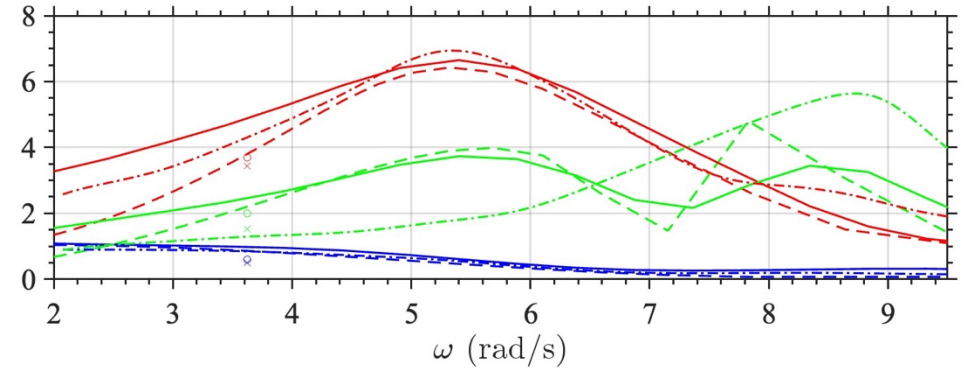
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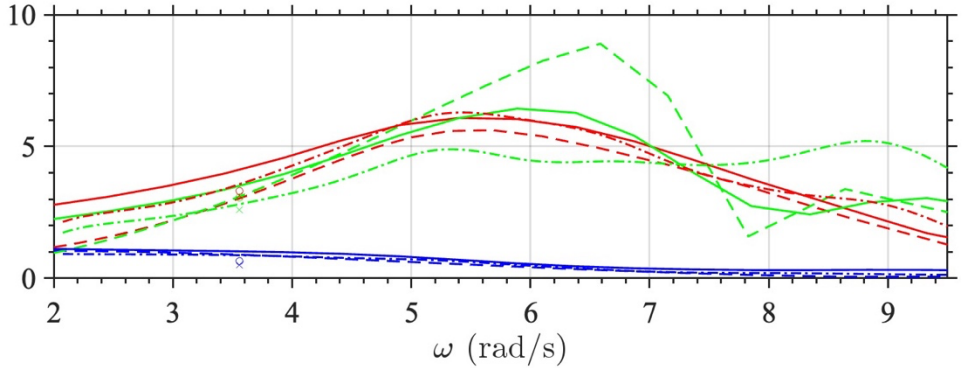
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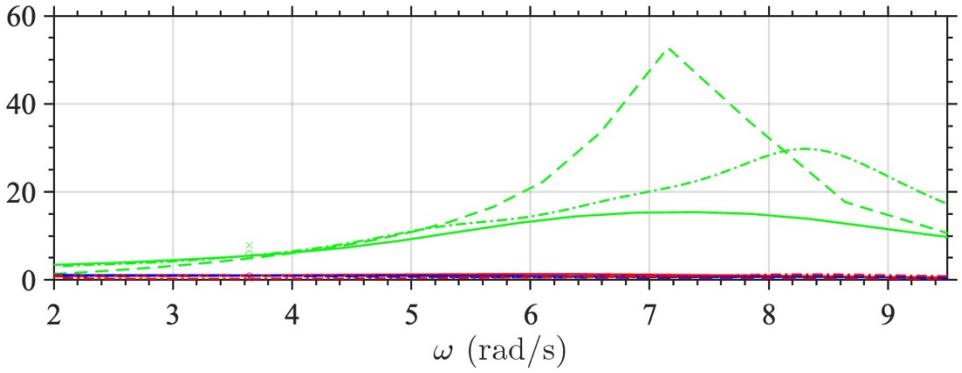
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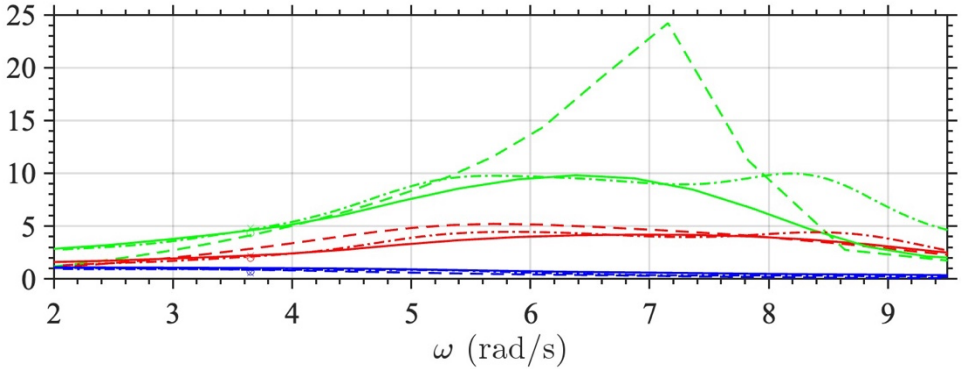
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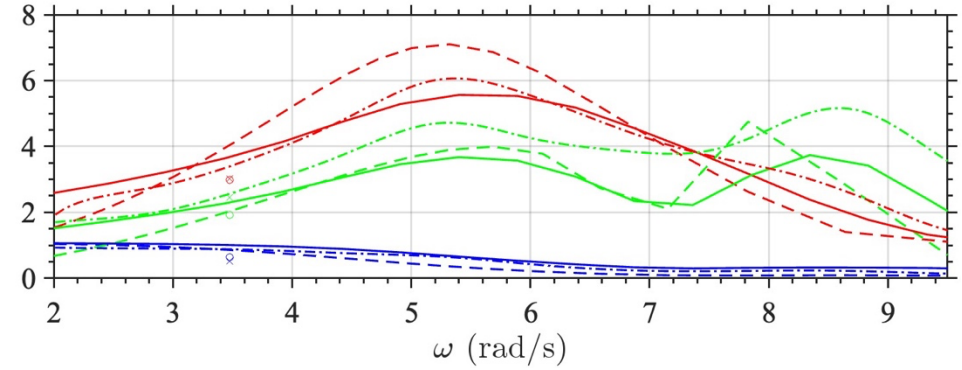
(e)


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ω (rad/s)

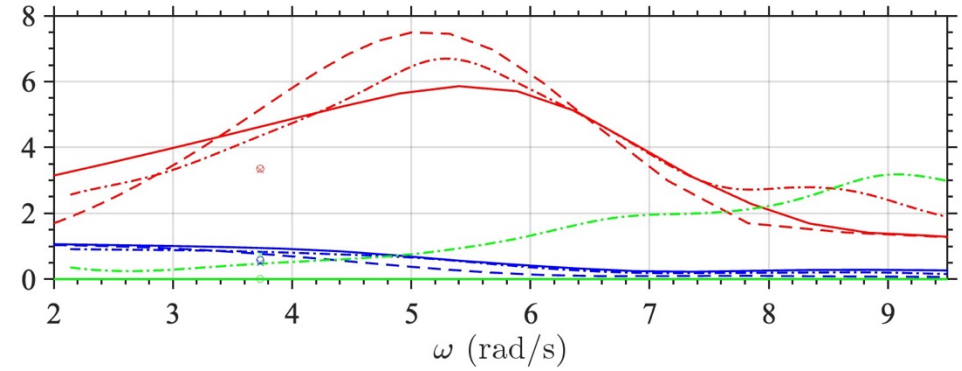
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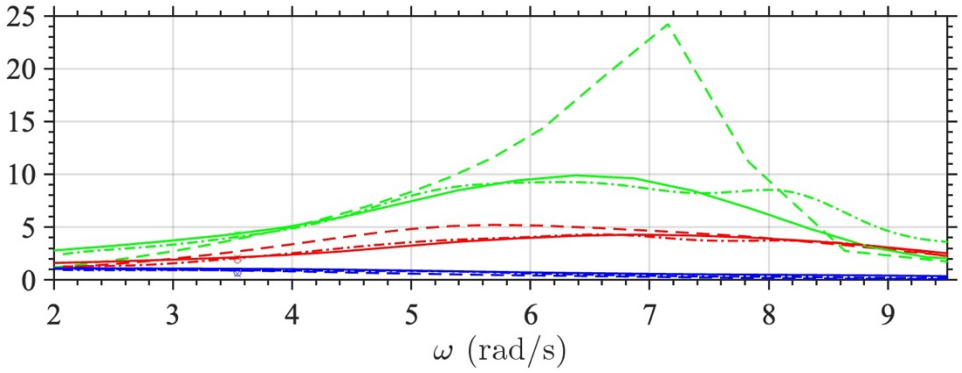
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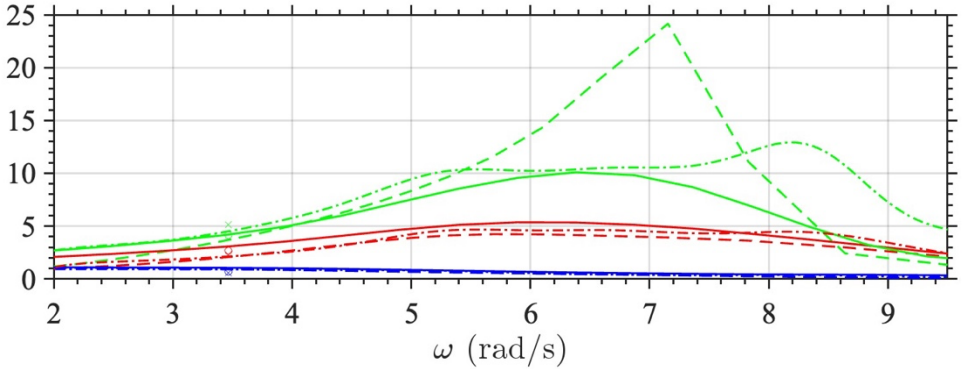
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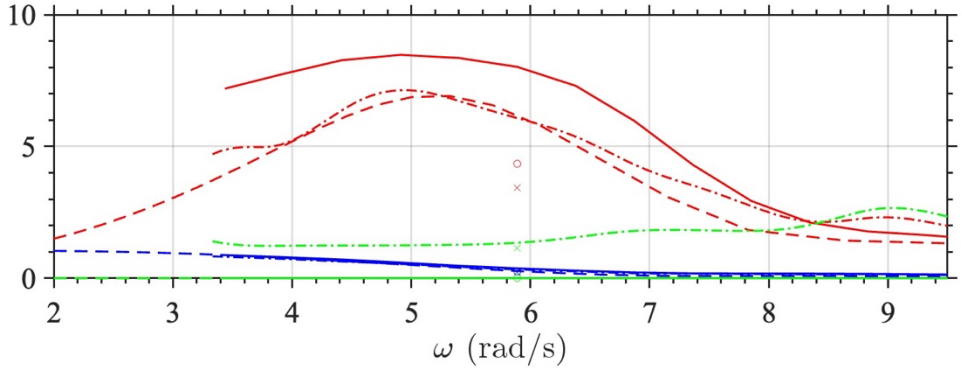
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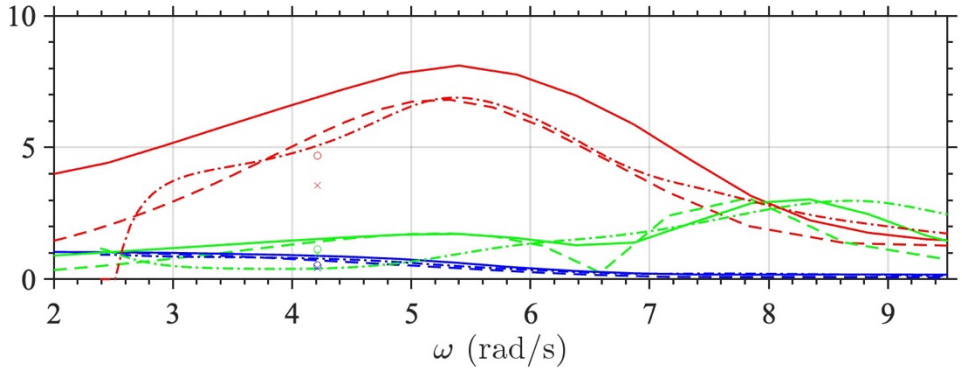
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ω (rad/s)

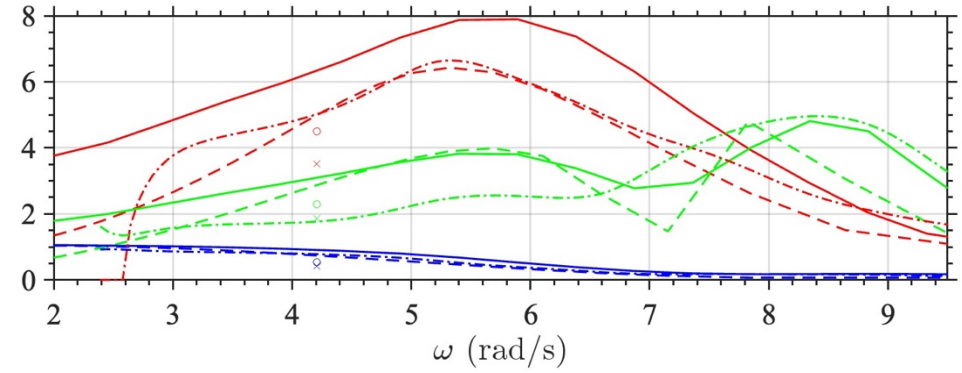
(k)


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ω (rad/s)

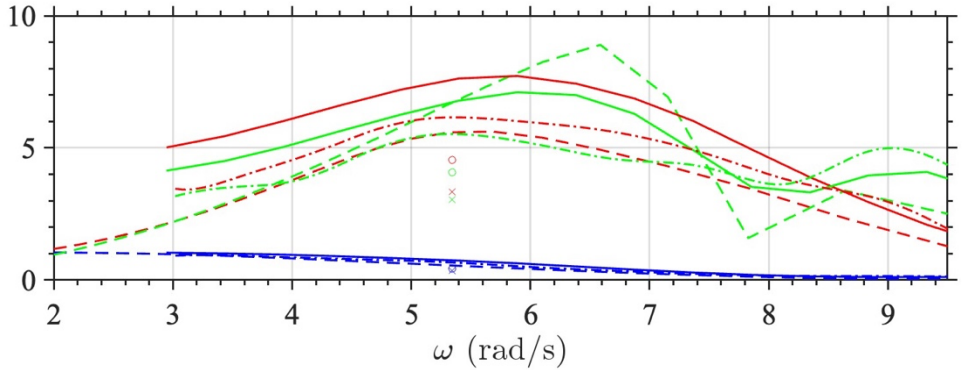
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ω (rad/s)

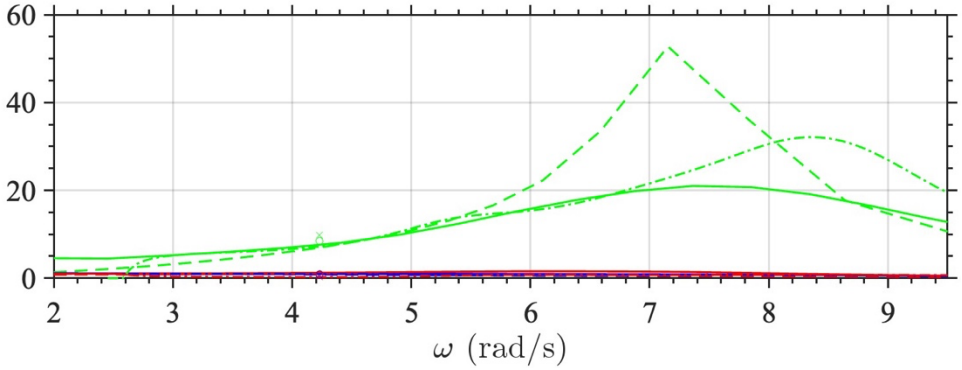
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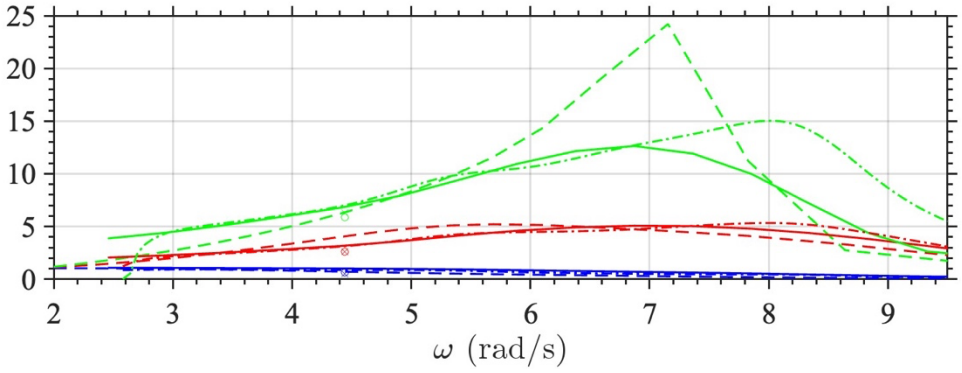
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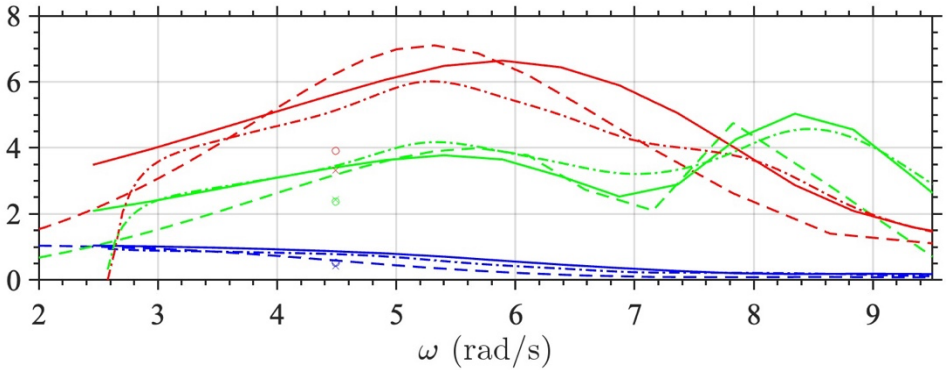
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ω (rad/s)

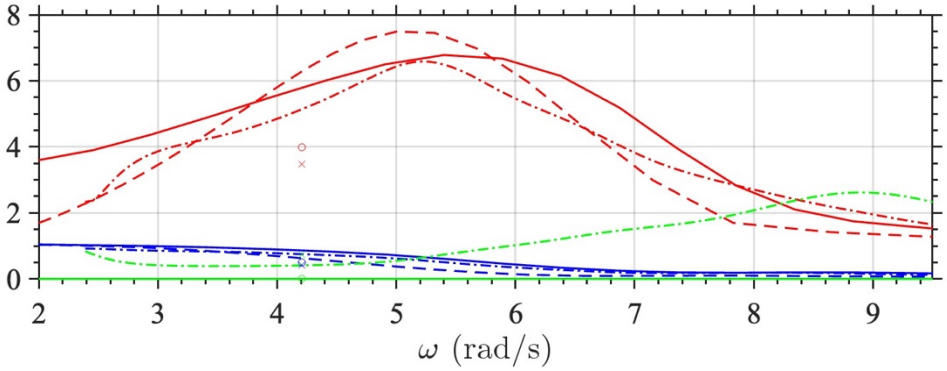
(p)


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ω (rad/s)

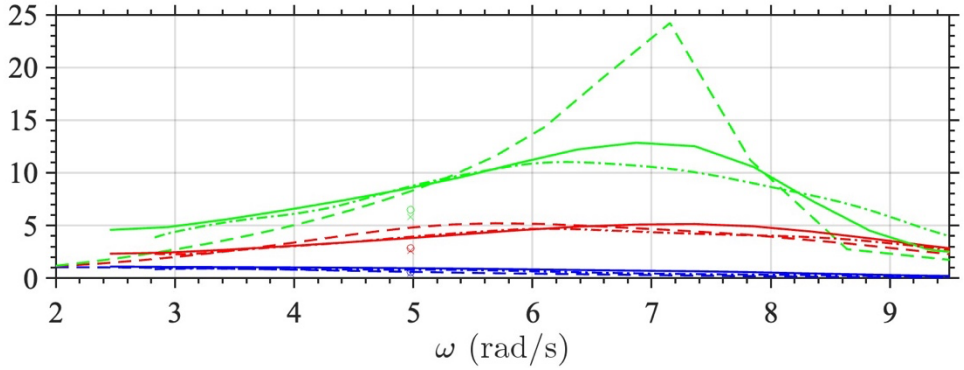
(q)


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ω (rad/s)

(r)


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ω (rad/s)

(s)


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ω (rad/s)

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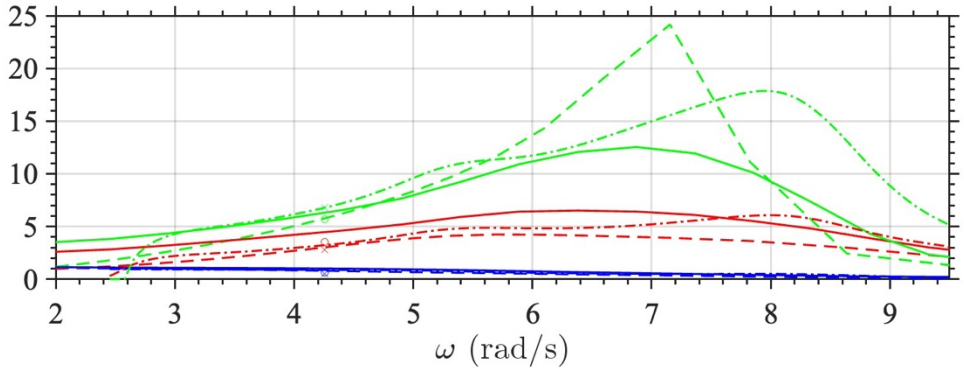

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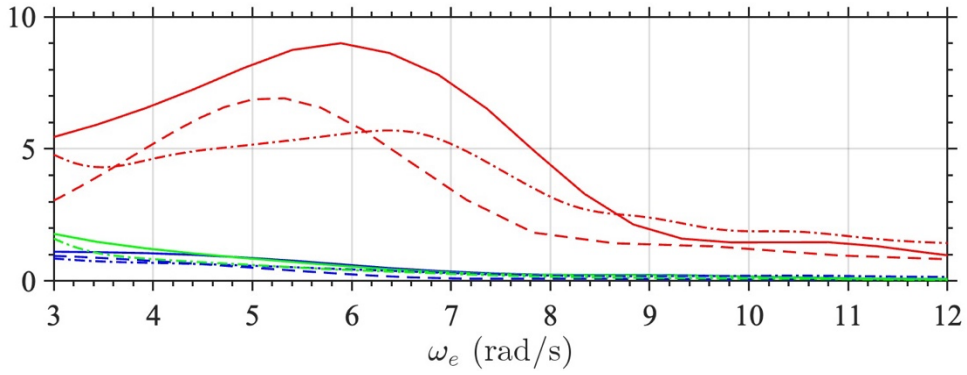
Figure S1: Additional cases similar to those shown in Figs. 11 (no forward speed; $U = 0$). Comparison of the tugboat RAOs, computed at laboratory scale with Eq. (A.1), based on results of the calibrated nonlinear model (—-) and on experimentally measured boat motions (– - –), in: heave (blue), roll (green) and pitch (red). The combination of 2D spectral parameters (H_s, T_p, $\omega_p = 2\pi/T_p$) for each case are given in Table S1, in which here θ_p denotes the angle of the boat model with respect to the 2D waves direction. The RAOs based on AQWA results (- - - -) for periodic waves are also plotted for comparison. The colored symbol plotted at $\omega = \omega_p$, denote the RAOs based on the Root-Mean-Square (RMS) motions of the model: (x) measure in experiments; (o) calculated from the nonlinear model results.

Table S1: 2D spectral parameters (H_s, T_p, $\omega_p = 2\pi/T_p$) and approximate sea-state (SS) at laboratory scale, and model orientation (angle) θ_p for each case shown in Fig. S1. Note, cases shown in Fig. 11a,b are c and j.

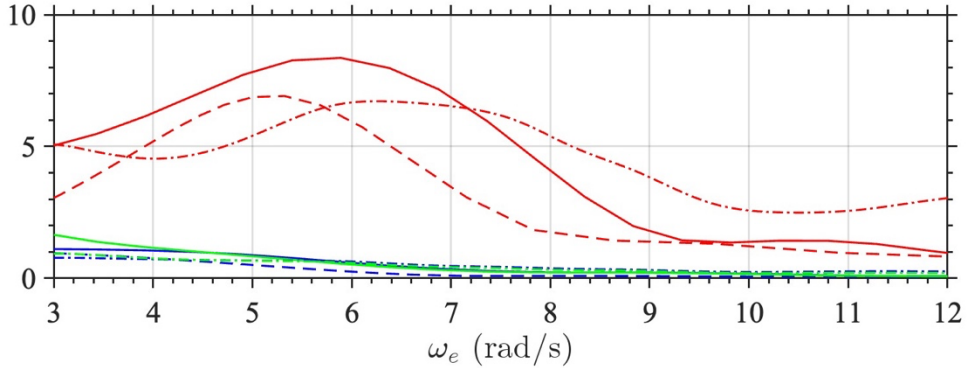
Case	SS	H_s (m)	T_p (s)	ω_p (rad/s)	θ_p (deg.)
a	4	0.1010	1.87	3.360	0
b	4	0.0993	1.72	3.651	15
c (11.a)	4	0.0980	1.73	3.630	30
d	4	0.0976	1.77	3.548	45
e	4	0.0806	1.73	3.630	90
f	4	0.0983	1.72	3.651	120
g	4	0.0983	1.81	3.470	150
h	4	0.1020	1.68	3.738	180
i	4	0.0972	1.77	3.548	240
j (11.b)	4	0.0976	1.81	3.470	300
k	2	0.0220	1.07	5.869	0
l	2.5	0.0296	1.49	4.215	15
m	2.5	0.0309	1.49	4.215	30
n	2	0.0229	1.18	5.322	45
o	2.5	0.0295	1.49	4.215	90
p	2.5	0.0294	1.41	4.454	120
q	2.5	0.0275	1.40	4.486	150
r	2.5	0.0331	1.49	4.215	180
s	2	0.0236	1.26	4.984	240
t	2.5	0.0304	1.48	4.243	300

Supplementary material S2: model-experiments comparison at advancing speed (18 cases)

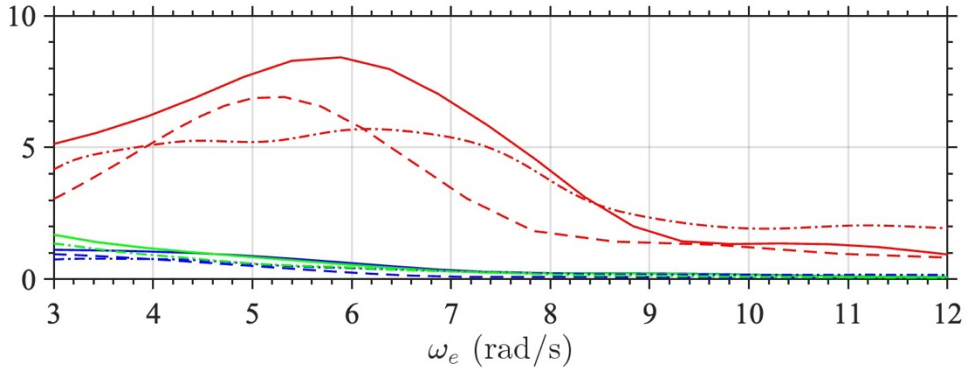
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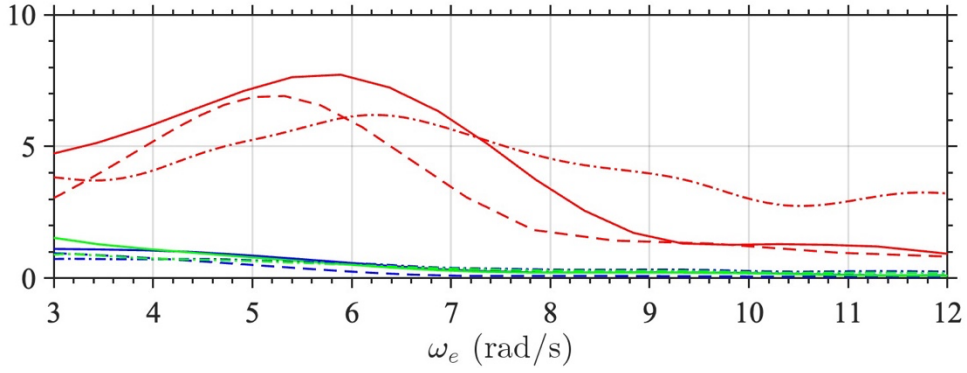
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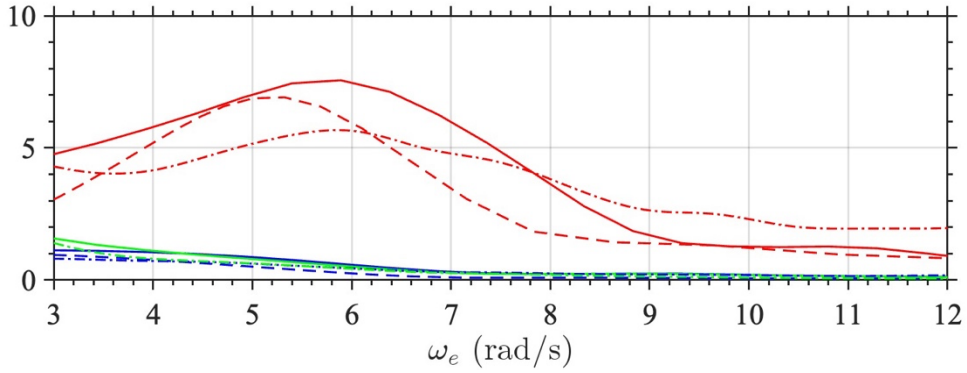
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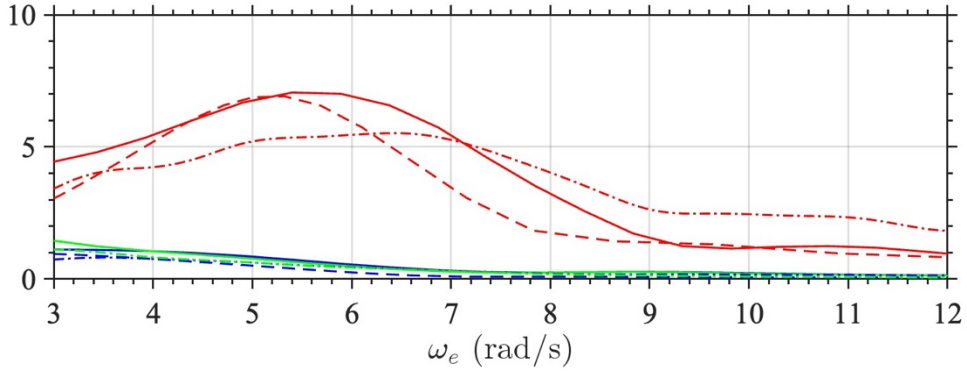
(d)



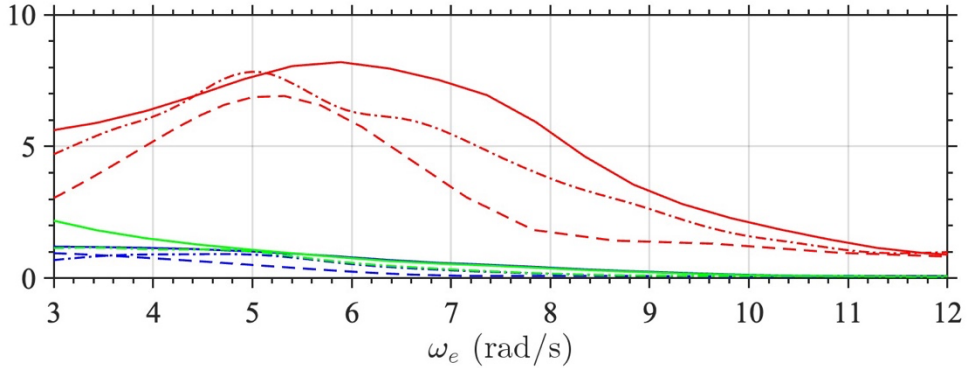
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ω_e (rad/s)

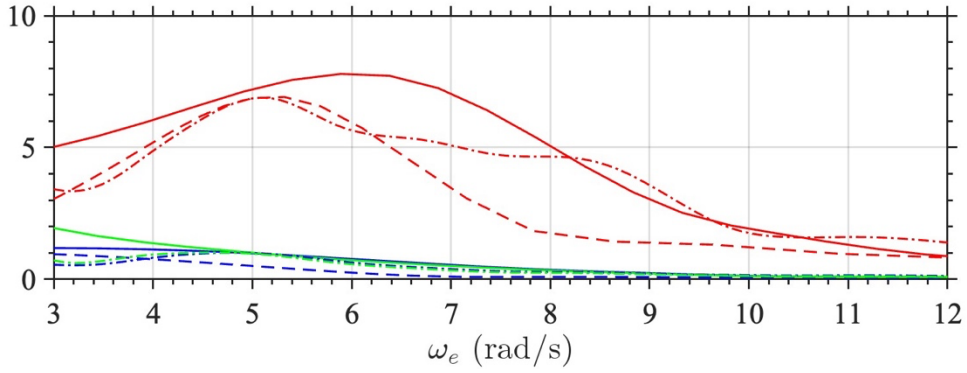
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ω_e (rad/s)

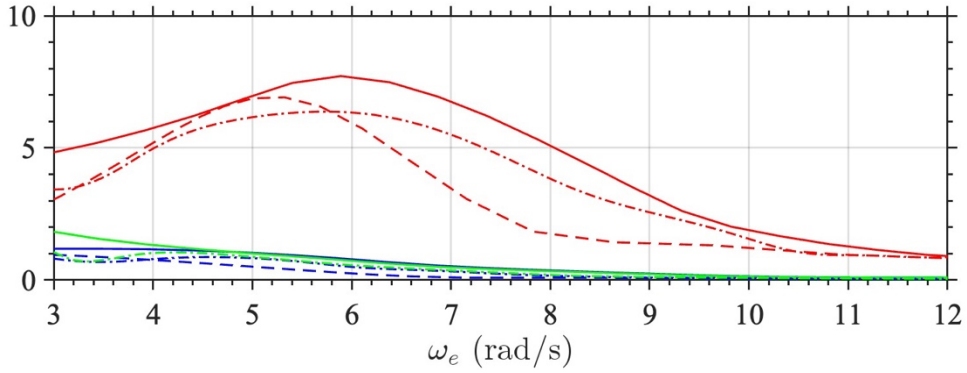
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ω_e (rad/s)

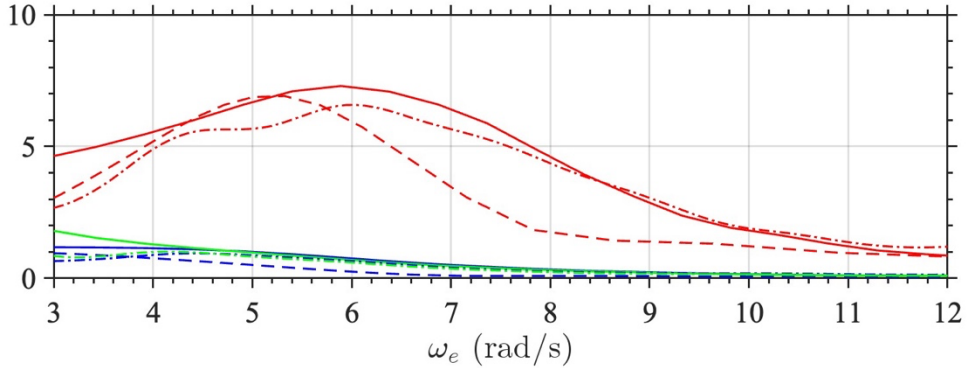
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ω_e (rad/s)

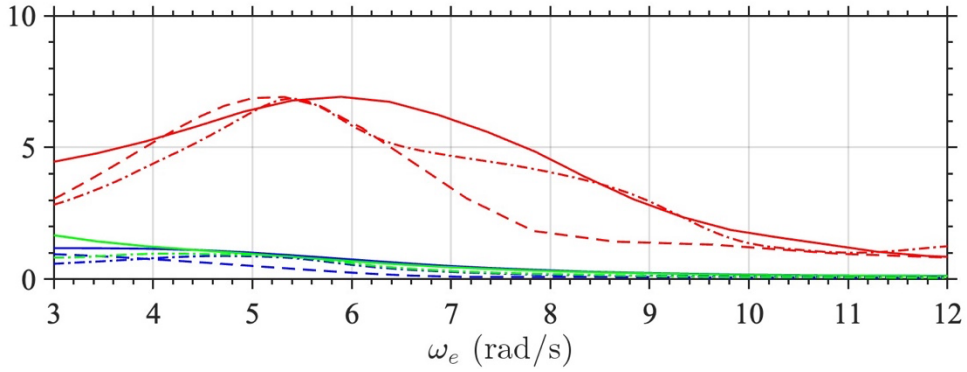
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ω_e (rad/s)

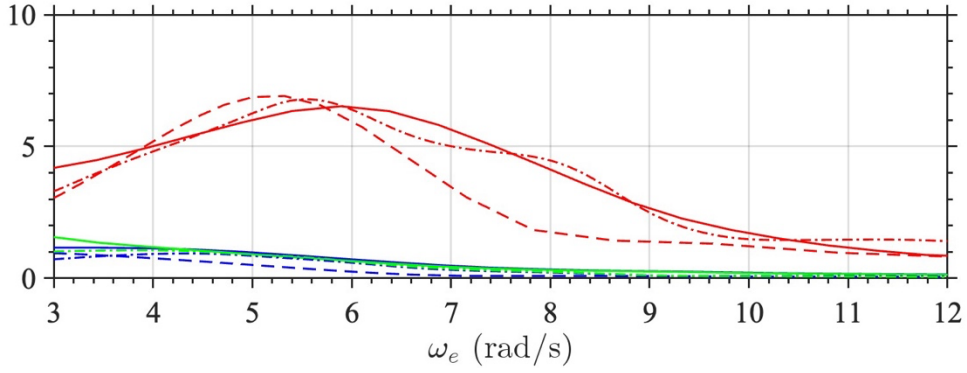
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ω_e (rad/s)

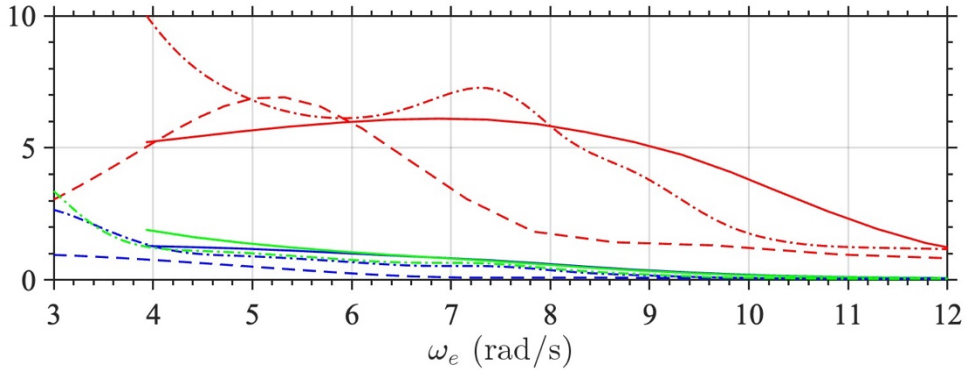
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ω_e (rad/s)

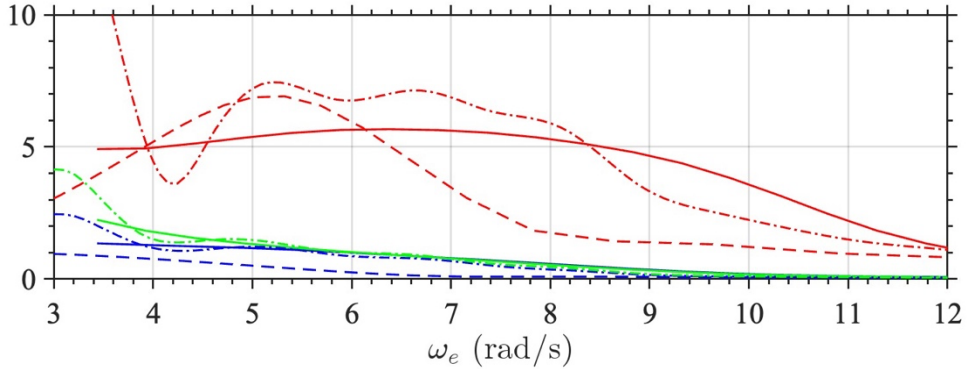
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ω_e (rad/s)

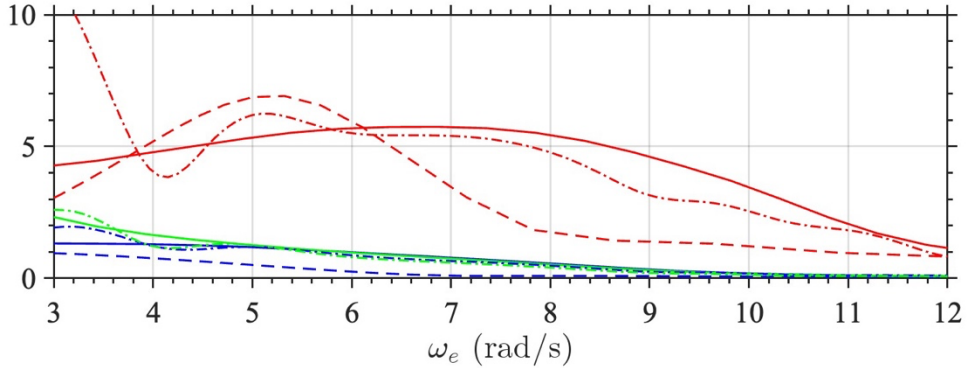
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ω_e (rad/s)

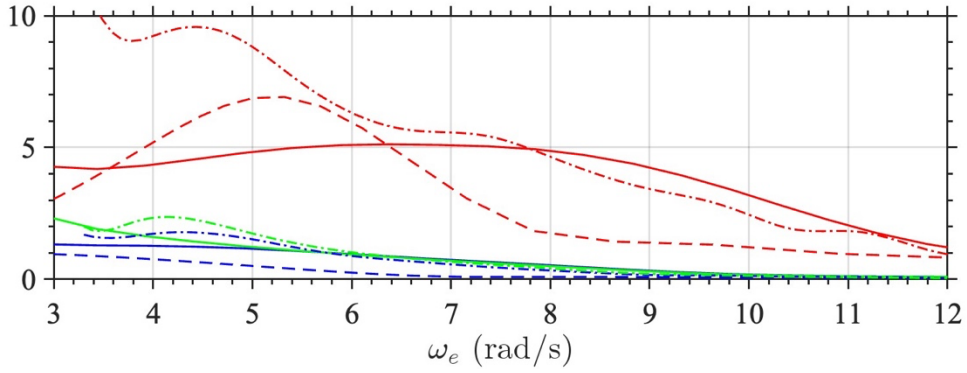
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ω_e (rad/s)

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ω_e (rad/s)

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ω_e (rad/s)

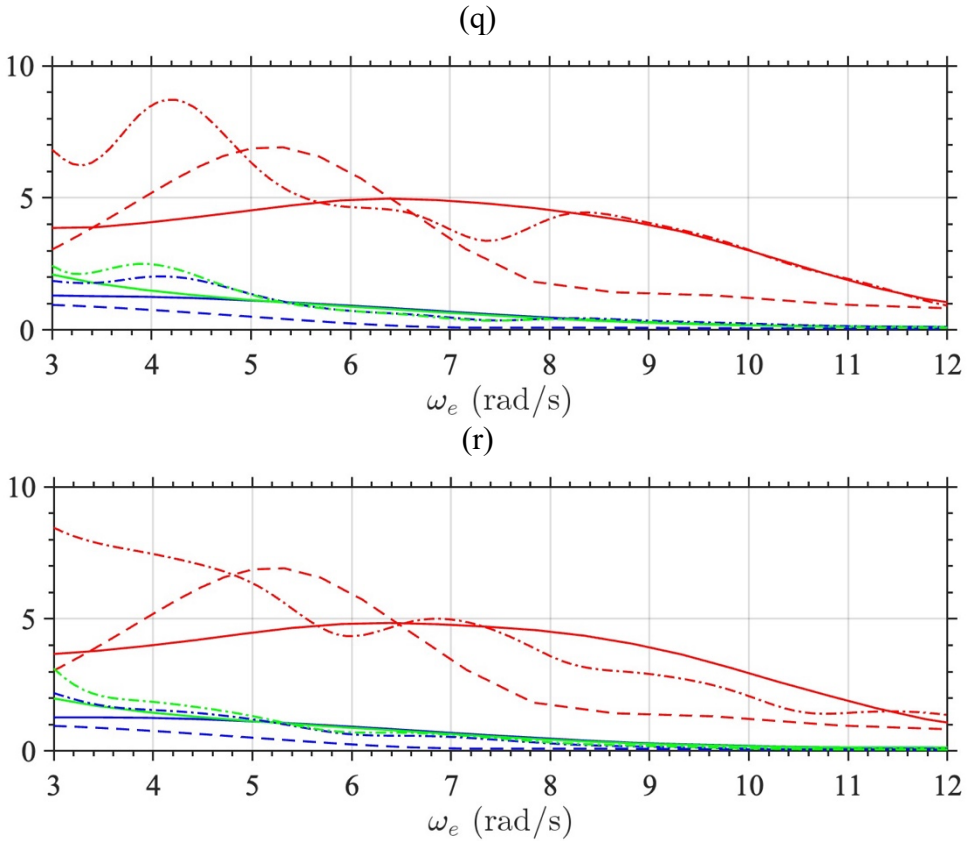


Figure S2: Additional cases similar to those shown in Figs. 12 (forward speed; $U > 0$). Comparison of the tug boat RAOs, computed at laboratory scale with Eq. (A.1), based on results of the calibrated nonlinear model (—-) and on experimentally measured boat motions (– - –), in: heave (blue), heave acceleration (green), and pitch (red) (no roll permitted with forward speed). The boat model was angled at $\theta_p = 0$ deg. (head seas). The combination of 2D spectral parameters (H_s, T_p, $\omega_p = 2\pi/T_p$) and advancing speed U for each case are given in Table S2. The RAOs based on AQWA results (- - - -) for periodic waves at zero forward speed ($U = 0$) are also plotted for comparison. Note, as explained in the main text, in order to have a sufficiently long data set to accurately compute the RAOs, each plot is based on combining results of 6 repeats of each experiments.

Table S2: 2D spectral parameters (H_s, T_p, $\omega_p = 2\pi/T_p$), approximate sea-state (SS), advancing peak frequency $\omega_{ep} = \omega_p(1+ U\,\omega_p/g)$, and mean advancing speed during measurement plateau U, at laboratory scale, for each case shown in Fig. S2. Note, cases shown in Fig. 12a,b,c are cases f, l and r.

Case	SS	H_s (m)	T_p (s)	ω_p (rad/s)	ω_{ep} (rad/s)	U (m/s)
a	2.0	0.0204	1.36	4.618	5.066	0.206
b	2.5	0.0304	1.49	4.215	4.590	0.207
c	2.5	0.0348	1.47	4.272	4.666	0.212
d	3.0	0.0542	1.63	3.853	4.148	0.195
e	3.5	0.0605	1.61	3.901	4.233	0.214
f (12.a)	4.0	0.0833	1.75	3.589	3.862	0.208
g	2.0	0.0198	1.27	4.945	6.147	0.482
h	2.5	0.0303	1.39	4.518	5.452	0.449
i	2.5	0.0344	1.53	4.105	4.911	0.469
j	3.0	0.0482	1.56	4.026	4.776	0.454
k	3.5	0.0578	1.70	3.694	4.349	0.471
l (12.b)	4.0	0.0797	1.79	3.508	4.099	0.471
m	2.0	0.0193	1.22	5.148	7.701	0.945
n	2.5	0.0330	1.28	4.906	7.239	0.951
o	2.5	0.0332	1.43	4.391	6.193	0.917
p	3.0	0.0546	1.45	4.331	6.167	0.960
q	3.5	0.0747	1.58	3.975	5.478	0.933
r (12.c)	4.0	0.0778	1.65	3.806	5.203	0.946