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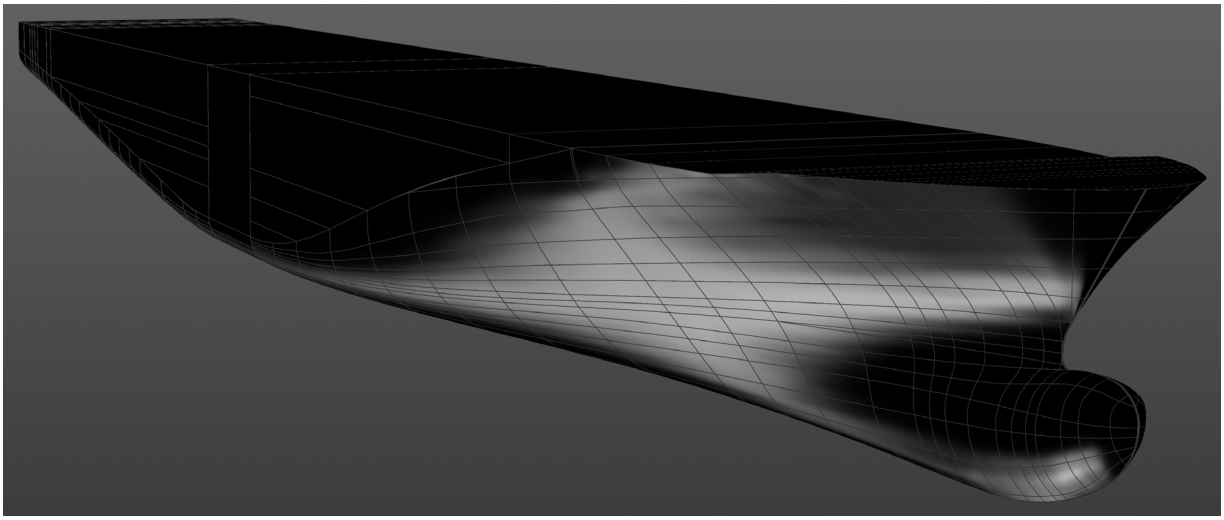
Comparison of PDStrip and WASIM with Model Test Results for Added Resistance in Waves of DTC Container Ship, S-VLCC Tanker and K-Supramax Bulk Carrier



DTC container ship

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SUMMARY

This report shows calculations of added resistance in waves for the DTC container ship, S-VLCC tanker and K-Supramax bulk carrier. Calculations are done using PDStrip and WASIM software, and compared with model test results.

PDStrip is a strip theory code, designed for slender hulls. WASIM is a panel code, applicable to a wider range of hull shapes.

For the most slender hull (DTC container ship), PDStrip and WASIM gave similar results, and both agreed quite well with model test results.

For the less-slender S-VLCC and K-Supramax hulls, PDStrip was found to greatly over-estimate the added resistance peak in head seas. WASIM was found to agree quite well with model test results for these ships.

NOMENCLATURE

a	Wave amplitude (m)
B	Ship beam (m)
DTC	Duisburg Test Case
g	Acceleration due to gravity (m/s^2)
L_{oa}	Ship length overall (m)
L_{pp}	Ship length between perpendiculars (m)
R_{AW}	Added resistance force due to waves (N)
$\bar{R}_{AW}$	Non-dimensional added resistance $= \frac{R_{AW}}{\rho g a^2 B^2 / L_{pp}}$
TUHH	Technical University Hamburg-Harburg
VLCC	Very large crude carrier
ρ	Water density (kg/m^3)
λ	Wavelength (m)
β	Wave angle to ship, 0° = following seas, 90° = starboard beam seas

1. Introduction

PDStrip is a strip theory code developed at TUHH by Söding et al. (Söding 2006). PDStrip calculations of ship wave-induced motions at forward speed have been shown to generally agree well with model test results (Gourlay et al. 2019, 2015). As a strip theory code, PDStrip is expected to be more accurate for slender hulls (Söding 2006, p28-29) and to lose accuracy for λ/L_{pp} < 0.4 (Söding 2006, p44).

WASIM is a time-domain Rankine-source panel code developed by DNV (DNV 2024). The "linear" version of WASIM was used, in which double-body flow is assumed for the calm-water flow about the ship, and the resulting added resistance is of second order in the wave amplitude.

2. Dimensions of ship test cases

Details of the ships modelled in this study are shown in Table 1.

Ship dimensions			
	Duisburg Test Case	*S-VLCC*	*K-Supramax*
Ship type	Container ship	Tanker	Bulk carrier
Reference	El Moctar et al. (2010)	Park et al. (2019), Lee et al. (2021)	Lee et al. (2020, 2021)
L_{oa}	373.0 m	331.1 m	200.0 m
L_{pp}	355.0 m	323.0 m	192.0 m
B	51.0 m	60.0 m	36.0 m
L_{pp}/B	6.96	5.38	5.33
Maximum draft	14.5 m	21.0 m	11.2 m
Block coefficient	0.660	0.811	0.840

Table 1: Dimensions of modelled ships

3. Results for DTC container ship

A hull file of the DTC for PDStrip and WASIM was developed as described in Gourlay et al. (2019).

Model tests to measure added resistance in waves for the Duisburg Test Case container ship in deep water were undertaken at MARINTEK with a 1:63.65 scale model. These tests formed part of the SHOPERA project. The model test results presented here are taken from Shigunov et al. (2018, Figs. 6,8) and Sprenger et al. (2016, Fig. 11).

Comparison between calculations and model test results are shown in Figure 1 to Figure 3.

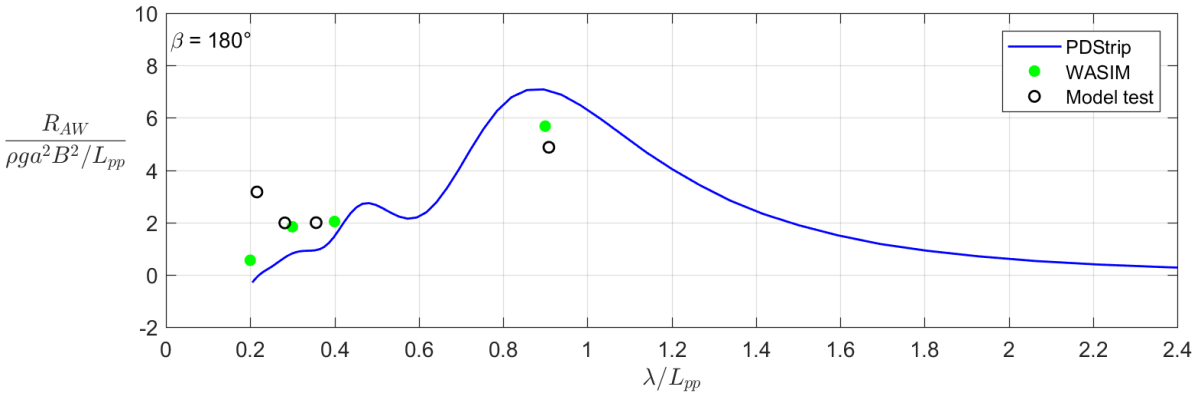

Figure 1: Added resistance of DTC container ship at 16.0 knots full-scale speed, β = 180°

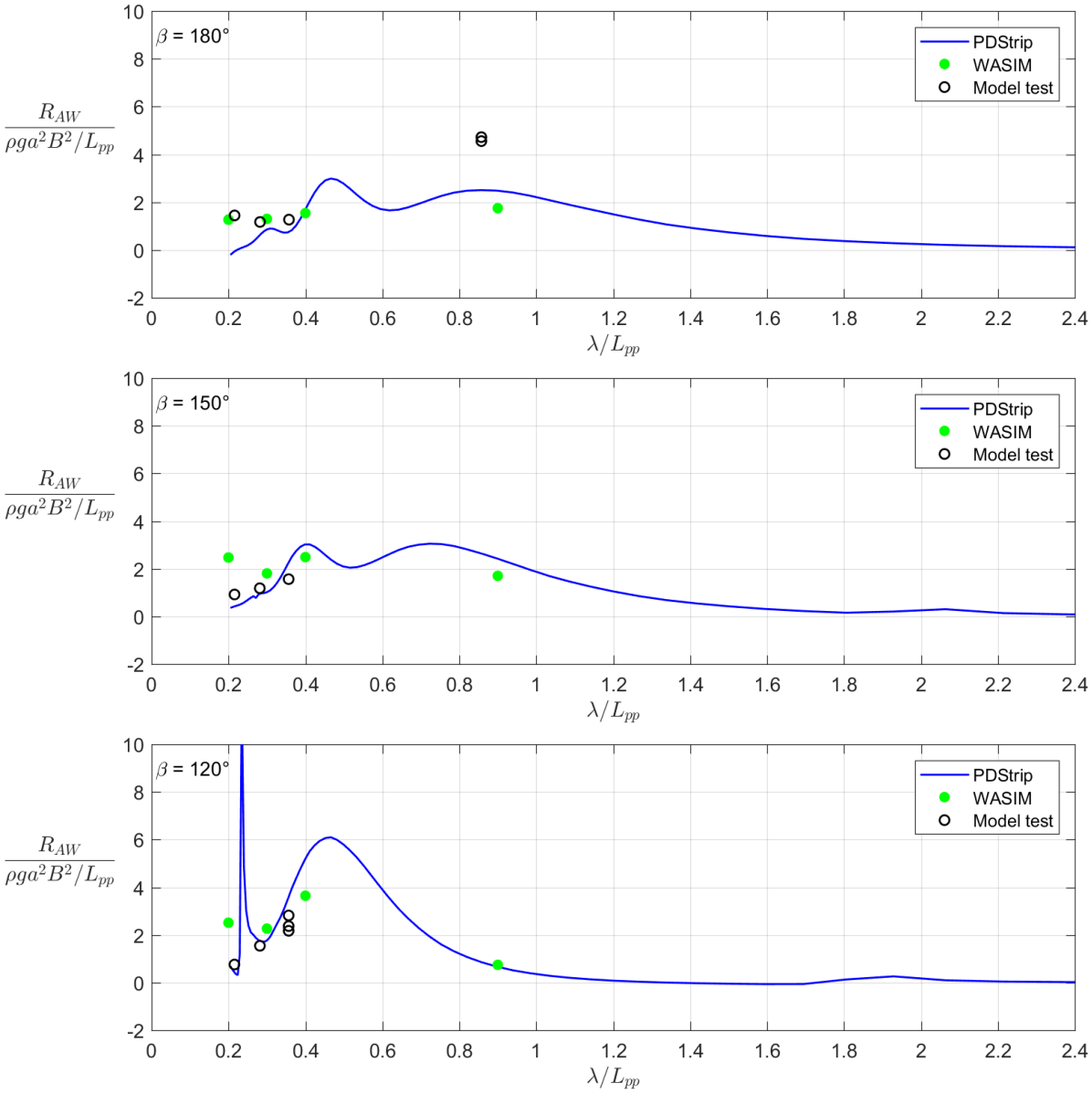

Figure 2: Added resistance of DTC container ship at 6.0 knots full-scale speed, β = 180°, 150°, 120°

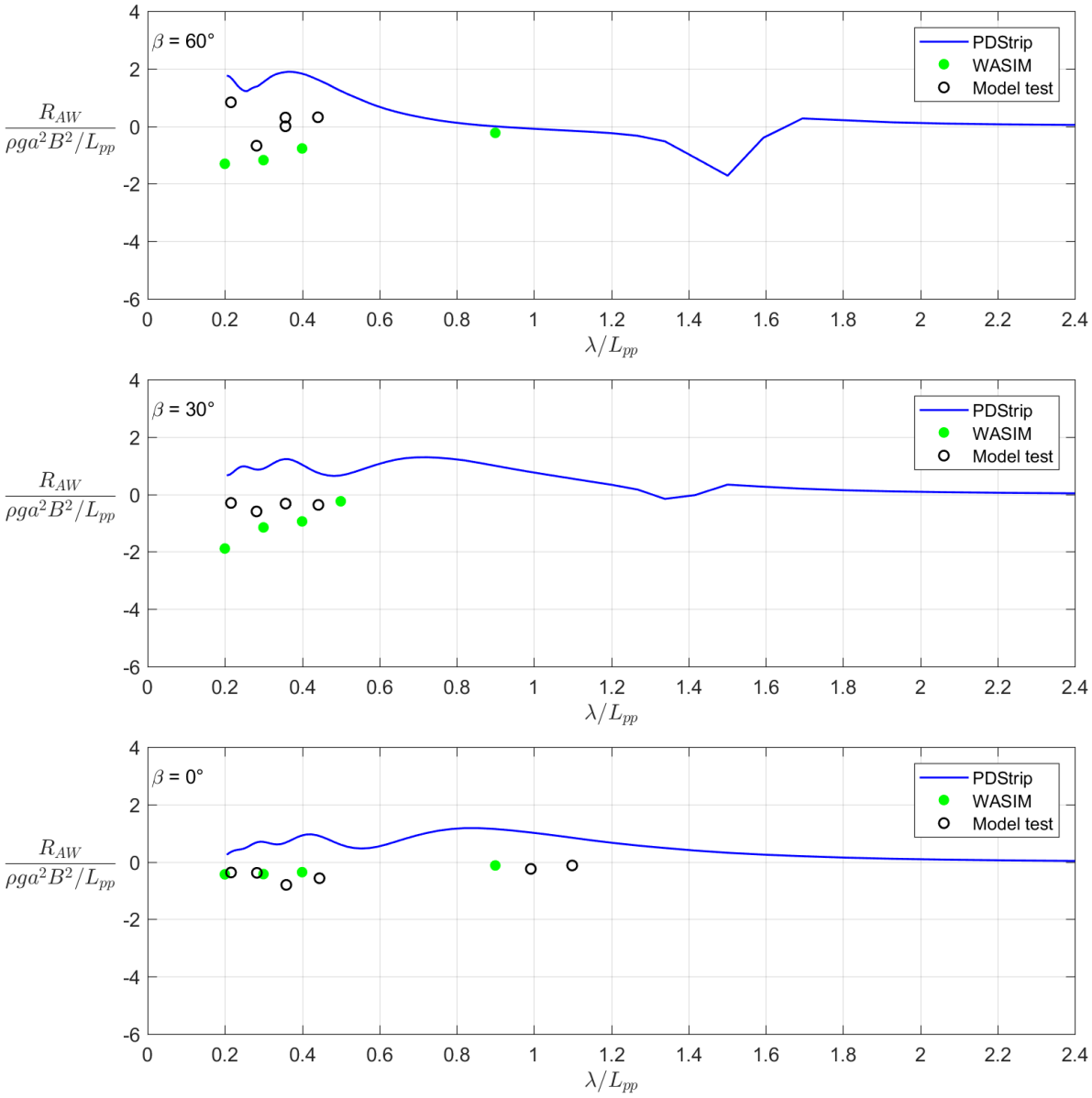

Figure 3: Added resistance of DTC container ship at 6.0 knots full-scale speed, β = 60°, 30°, 0°

4. Results for S-VLCC tanker

A hull file of the S-VLCC for PDStrip and WASIM was developed using the principal particulars and body plan shown in Lee et al. (2021, Table 1 and Fig. 3).

Model tests to measure added resistance in waves for the S-VLCC tanker in deep water were undertaken in the SSPA seakeeping basin with a 1:68 scale model. The model test results presented here are taken from Park et al. (2019, Figs. 10,11).

Comparison between calculations and model test results are shown in Figure 4 and Figure 5.

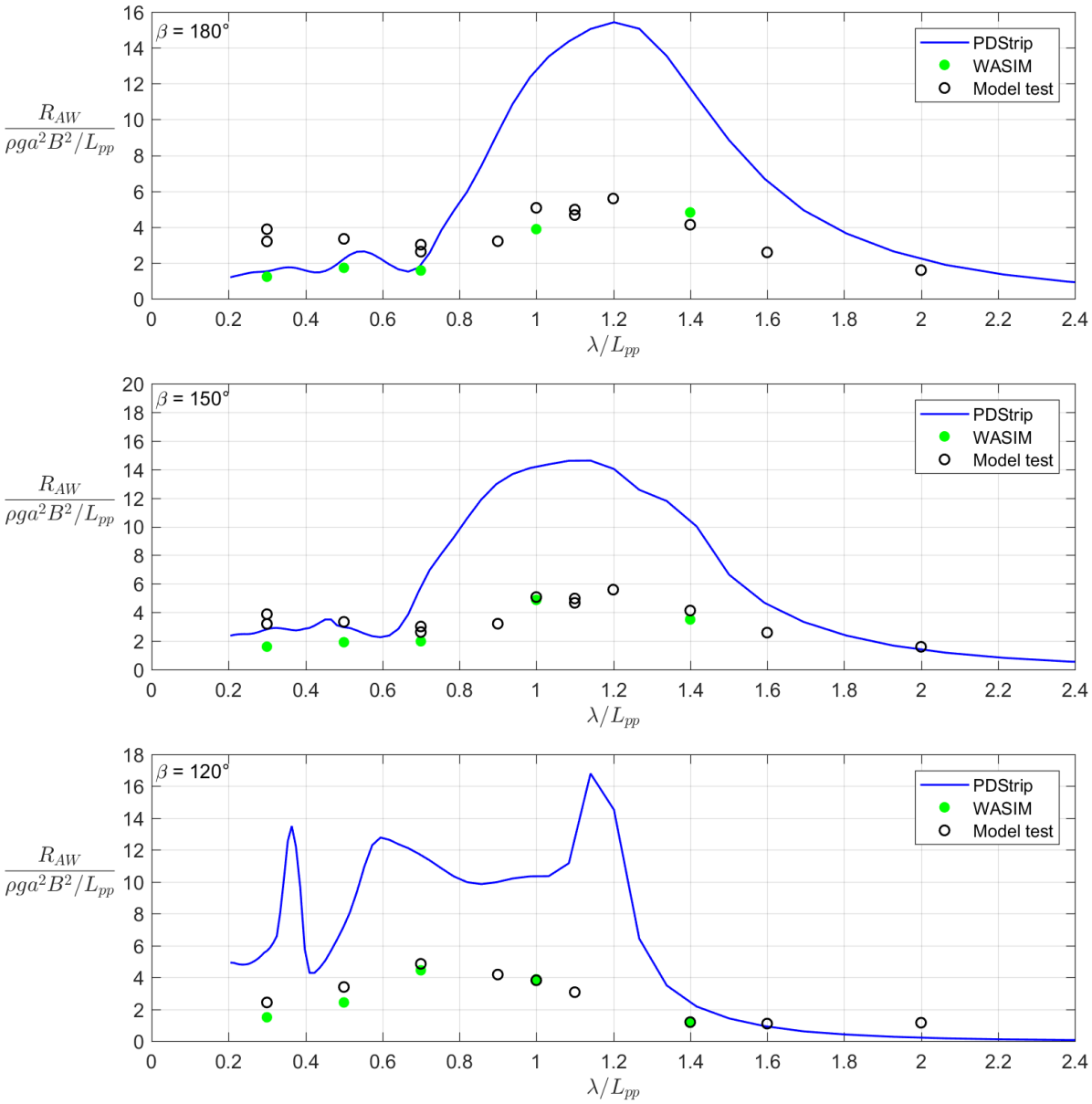

Figure 4: Added resistance of S-VLCC tanker at 15.0 knots full-scale speed, β = 180°, 150°, 120°

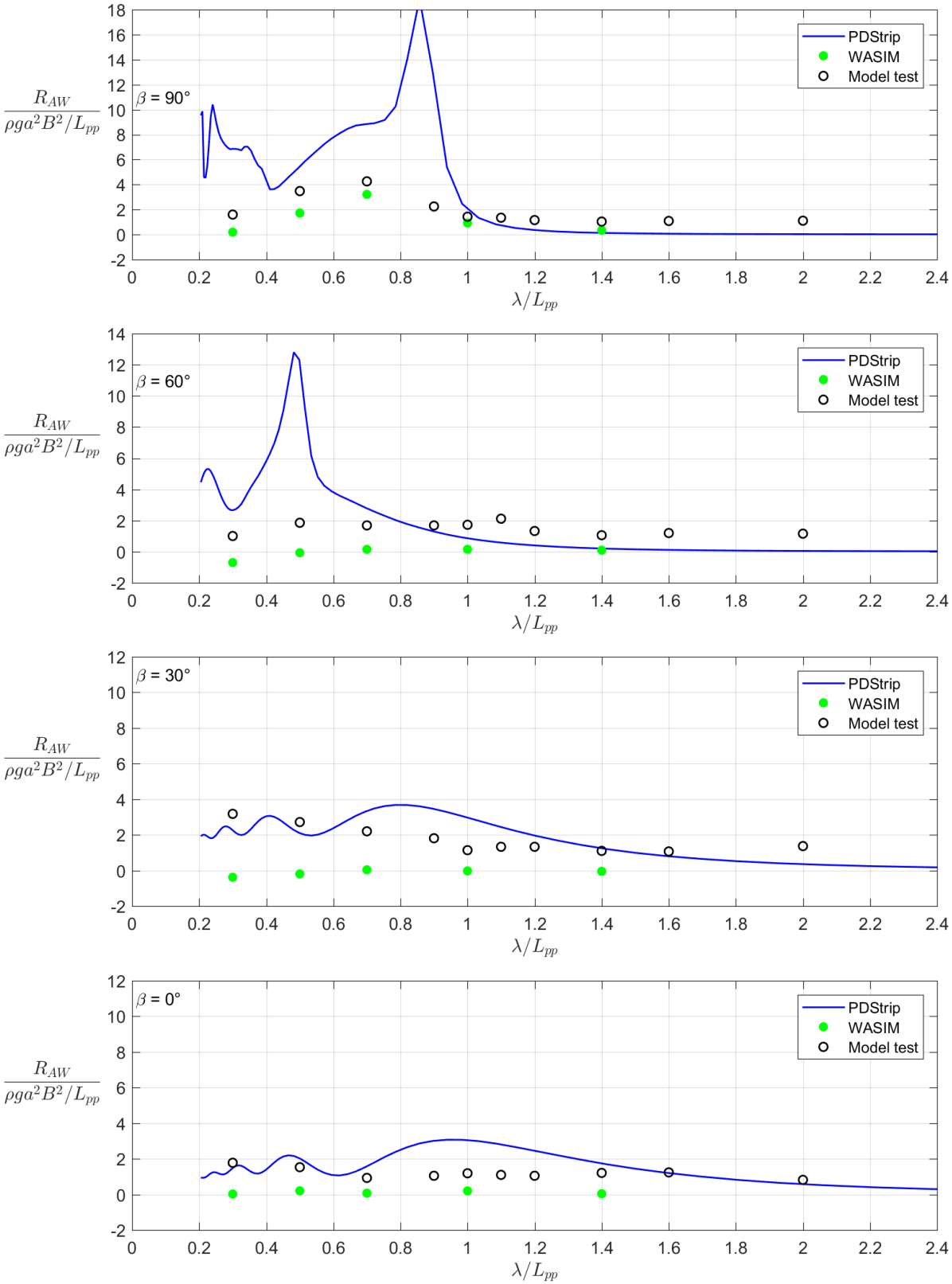

Figure 5: Added resistance of S-VLCC tanker at 15.0 knots full-scale speed, β = 90°, 60°, 30°, 0°

5. Results for K-Supramax bulk carrier

A hull file of the K-Supramax for PDStrip and WASIM was developed using the principal particulars and body plan shown in Lee et al. (2021, Table 1 and Fig. 3).

Model tests to measure added resistance in waves for the K-Supramax bulk carrier in deep water were undertaken in the SSPA seakeeping basin with a 1:40.42 scale model. The model test results presented here are taken from Lee et al. (2020, Figs. 2,7).

Comparison between calculations and model test results are shown in Figure 6.

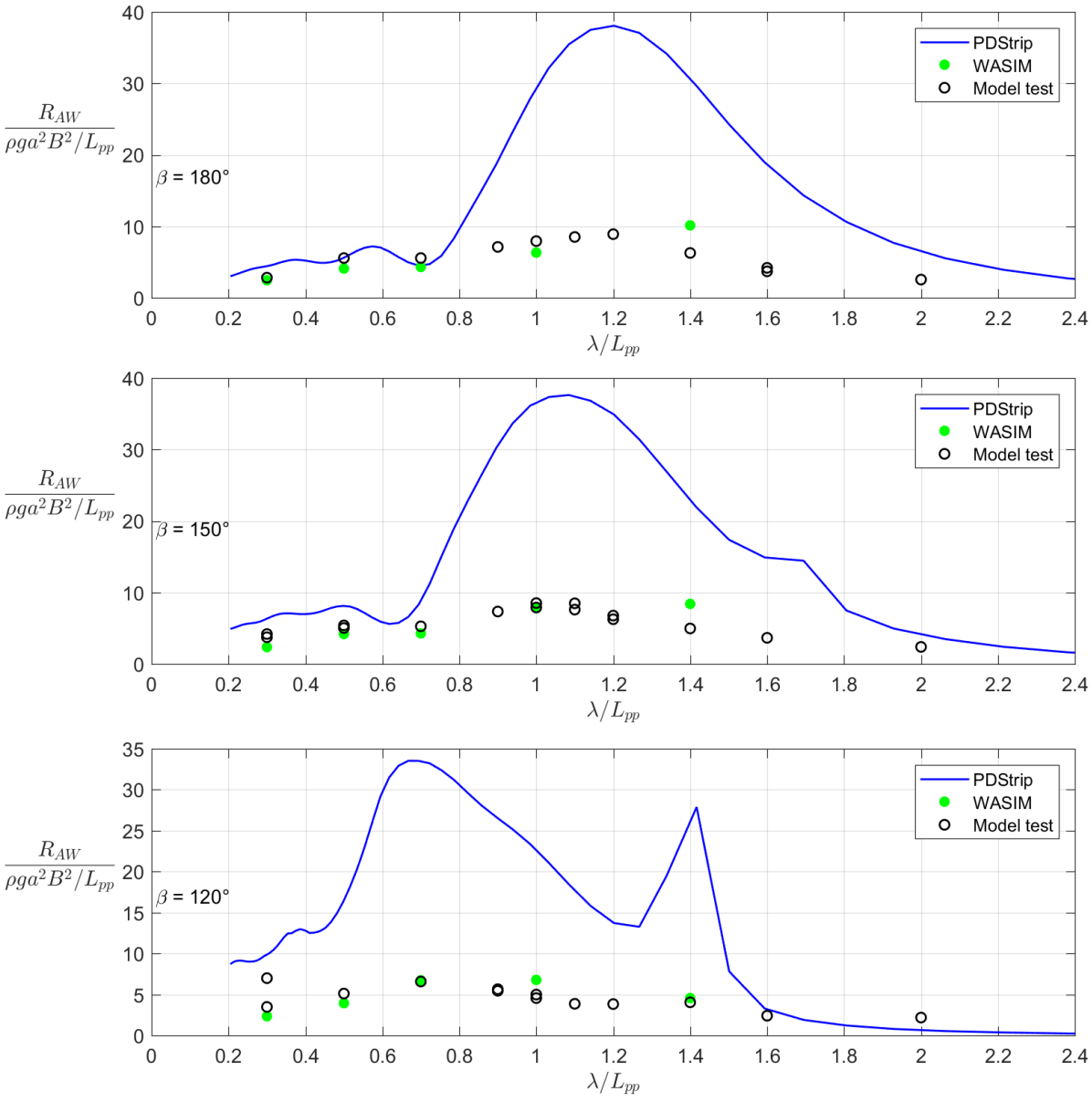

Figure 6: Added resistance of K-Supramax bulk carrier at 14.5 knots full-scale speed.

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Appendix A – PDStrip added resistance contour plots

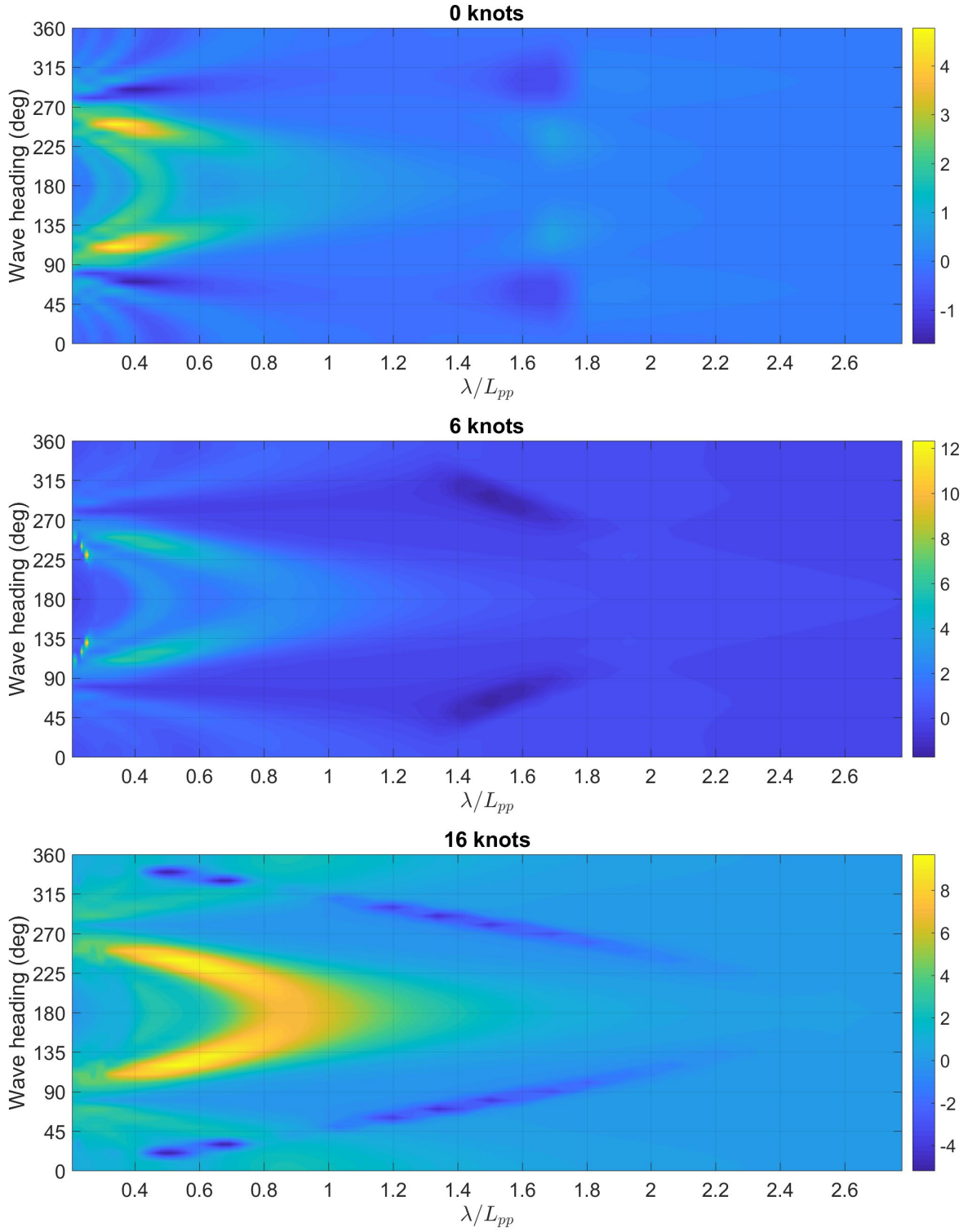

Figure 7: Non-dimensional added resistance $\overline{R}_{AW}$ of DTC container ship for 0, 6, 16 knots, as calculated with PDStrip

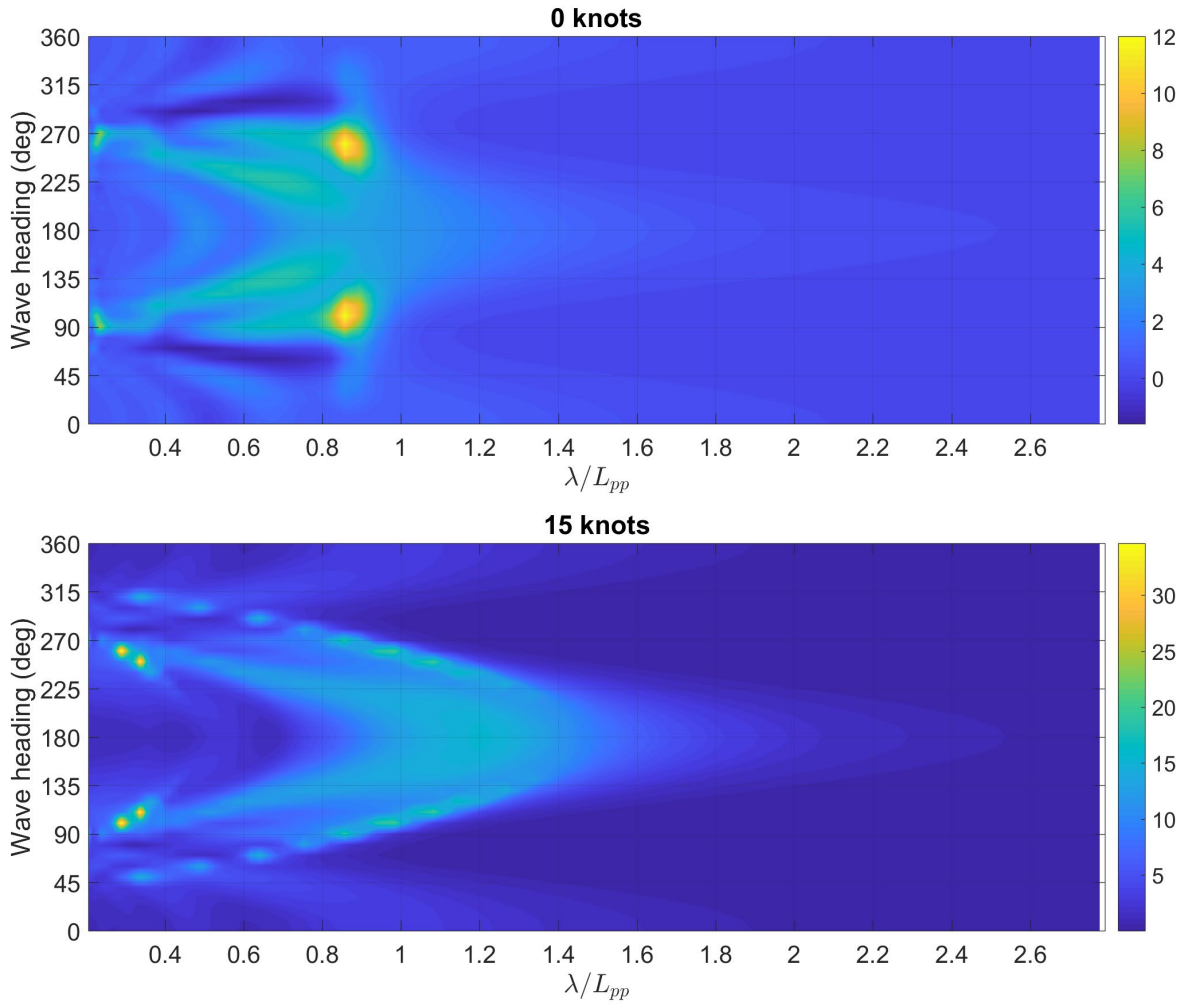

Figure 8: Non-dimensional added resistance $\overline{R}_{AW}$ of S-VLCC tanker at 0 knots and 15 knots, as calculated with PDStrip

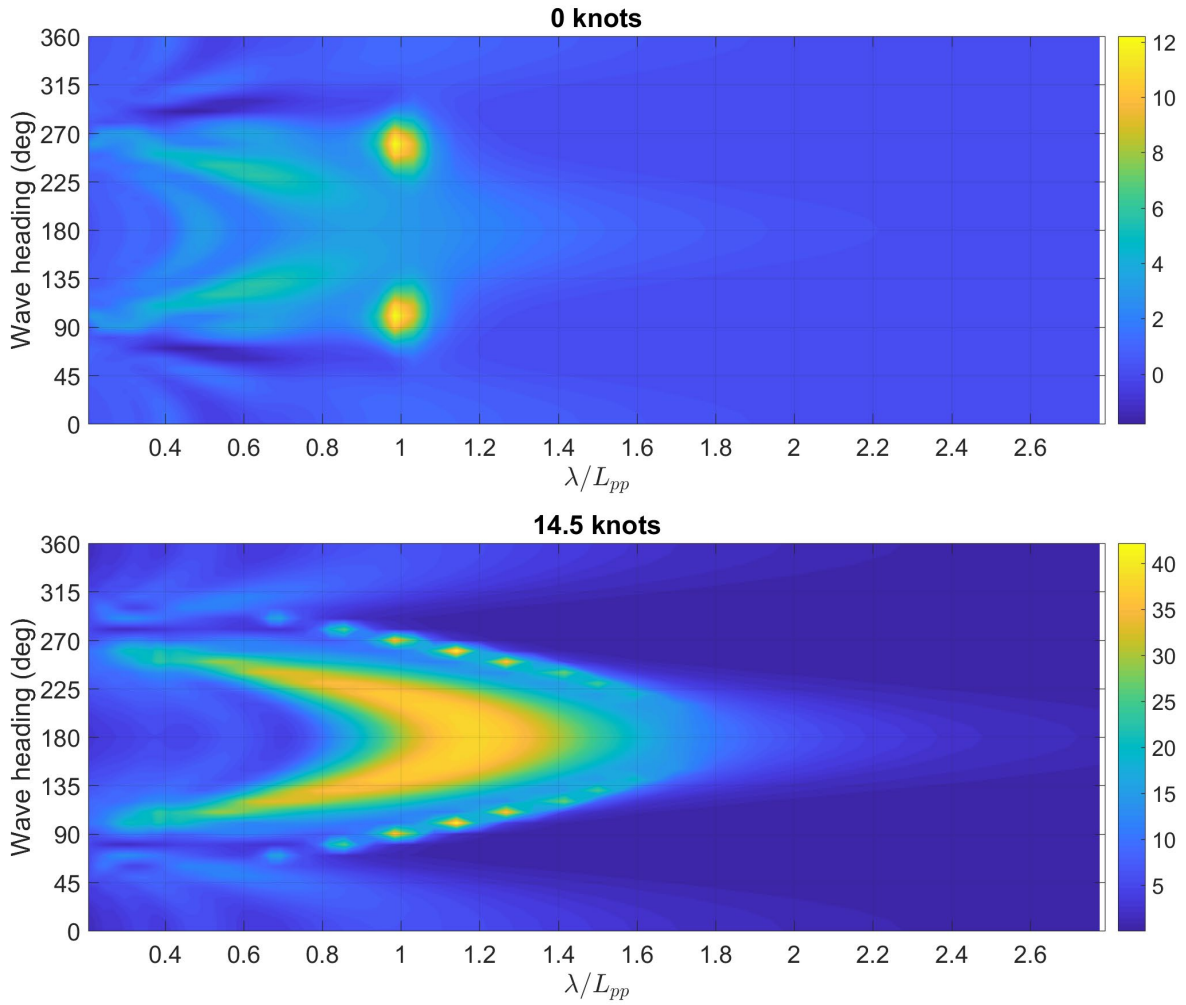

Figure 9: Non-dimensional added resistance $\overline{R}_{AW}$ of K-Supramax bulk carrier at 0 knots and 14.5 knots, as calculated with PDStrip