Cross-Coupling Between Device-Level CFD and Oceanographic Models Applied to Tisecs in Minas Passage and Petit Passage.

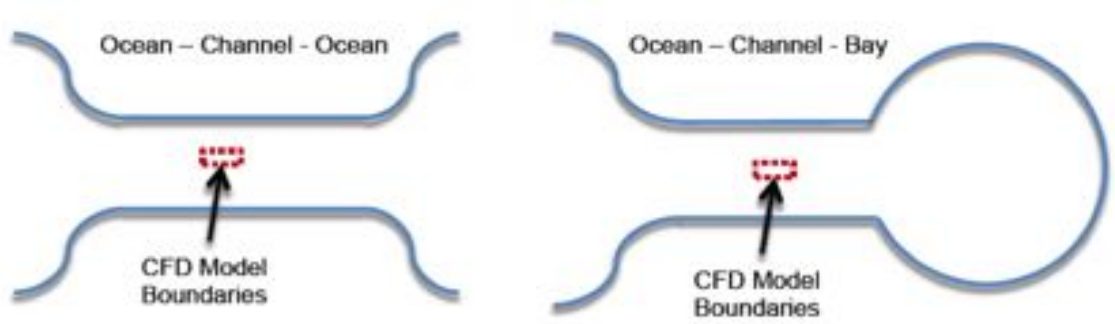
Voytek Klaptocz, Timothy Waung (Mavi Innovations Inc.)
Curran Crawford, Michael Shives (University of Victoria)
Clayton Hiles, Roy Walters (Cascadia Coast Research)

Richard Karsten (Acadia University)

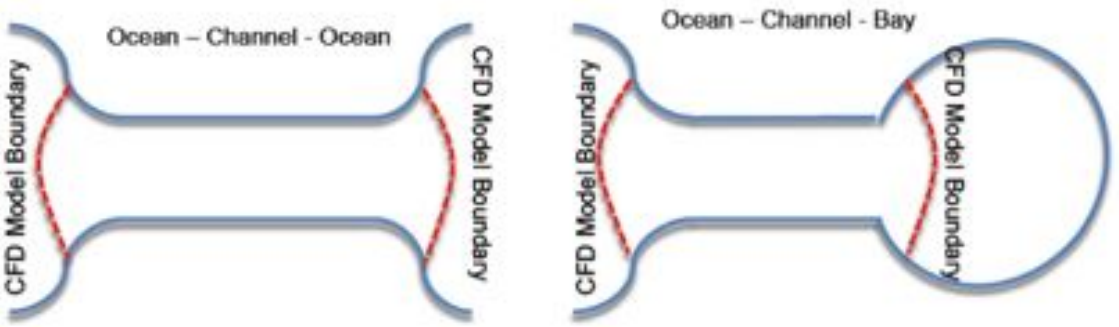
This work is dedicated to the memory of the late
Michael Tarbotton
of Triton Consultants who spearhead the initiative to take up this work. Through this project, he spawned a new generation of modelers, who, by following his example, will continue to push the boundaries of tidal models to ensure the successful, safe and environmentally benign build out of tidal power projects.

Project

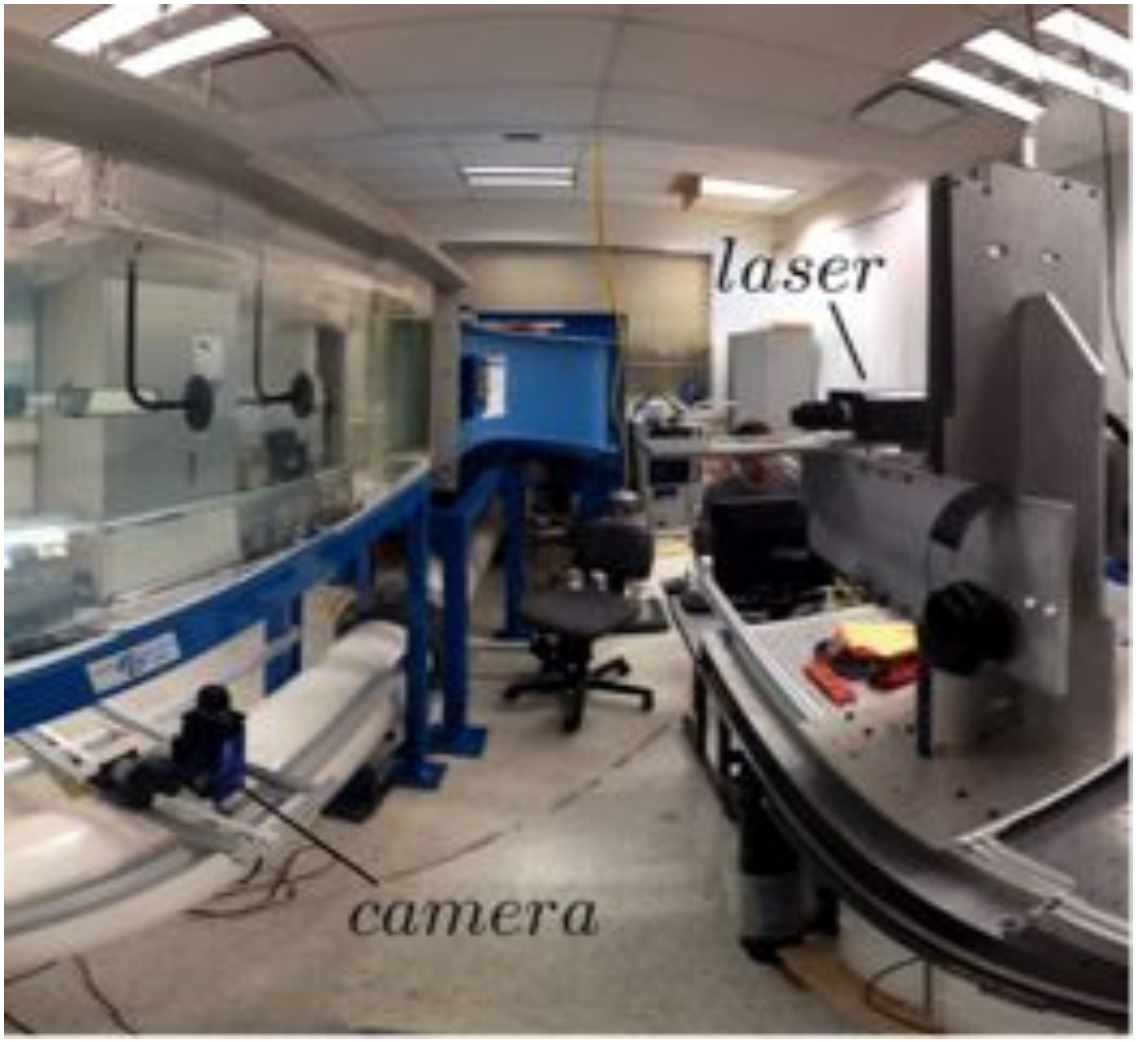
1. Single and multiple turbines in a straight channel
   - Flume Tank Experiments
   - CFD Modeling

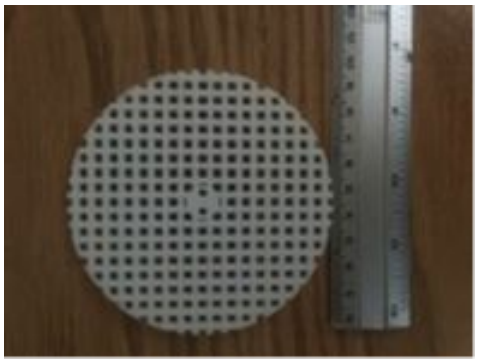


2. Case study modelling single and multiple turbines
   - Petit Passage
   - Minas Passage



Flume Tank Experiment: Setup





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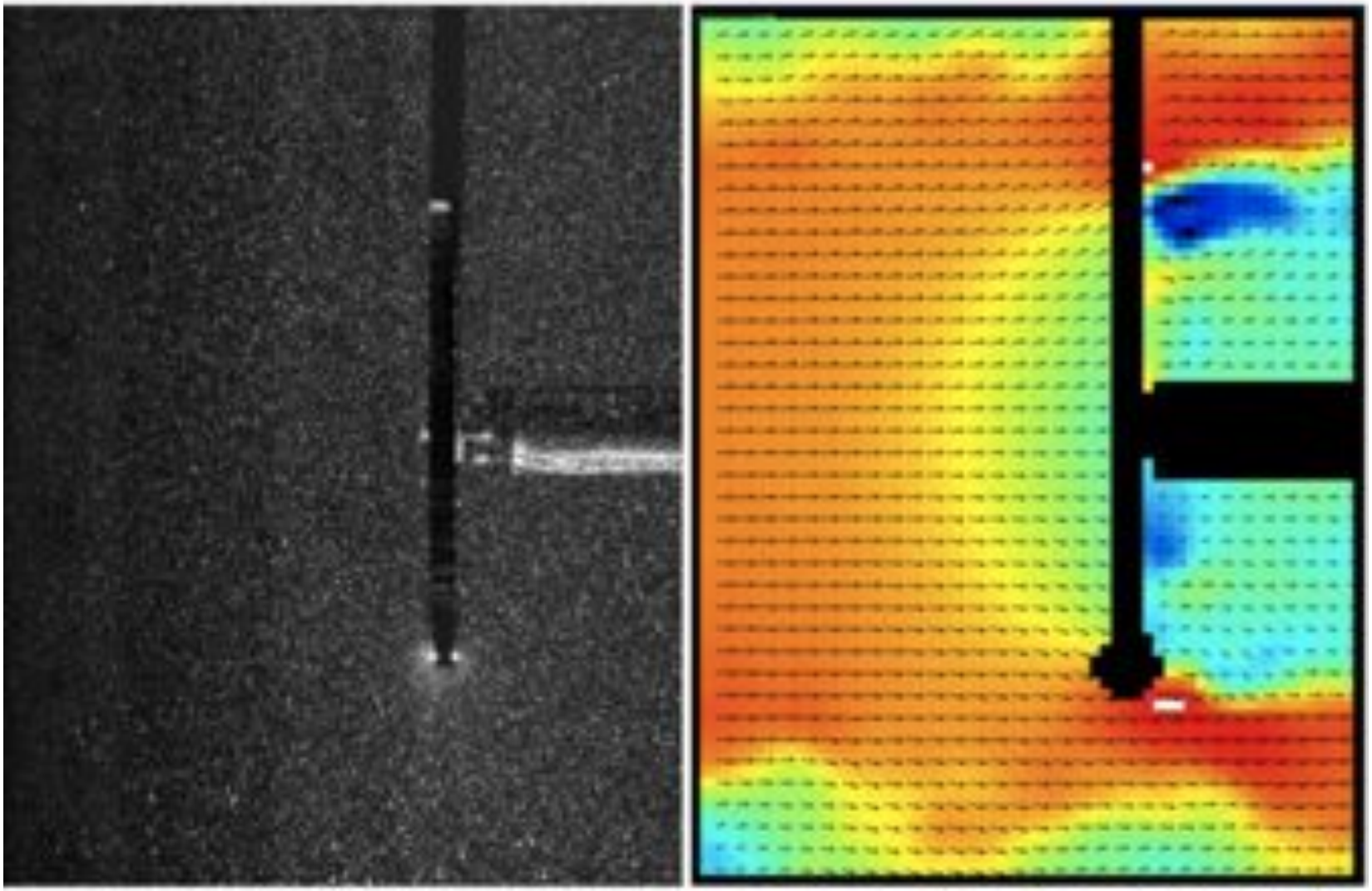
Flume Tank Experiment: Results



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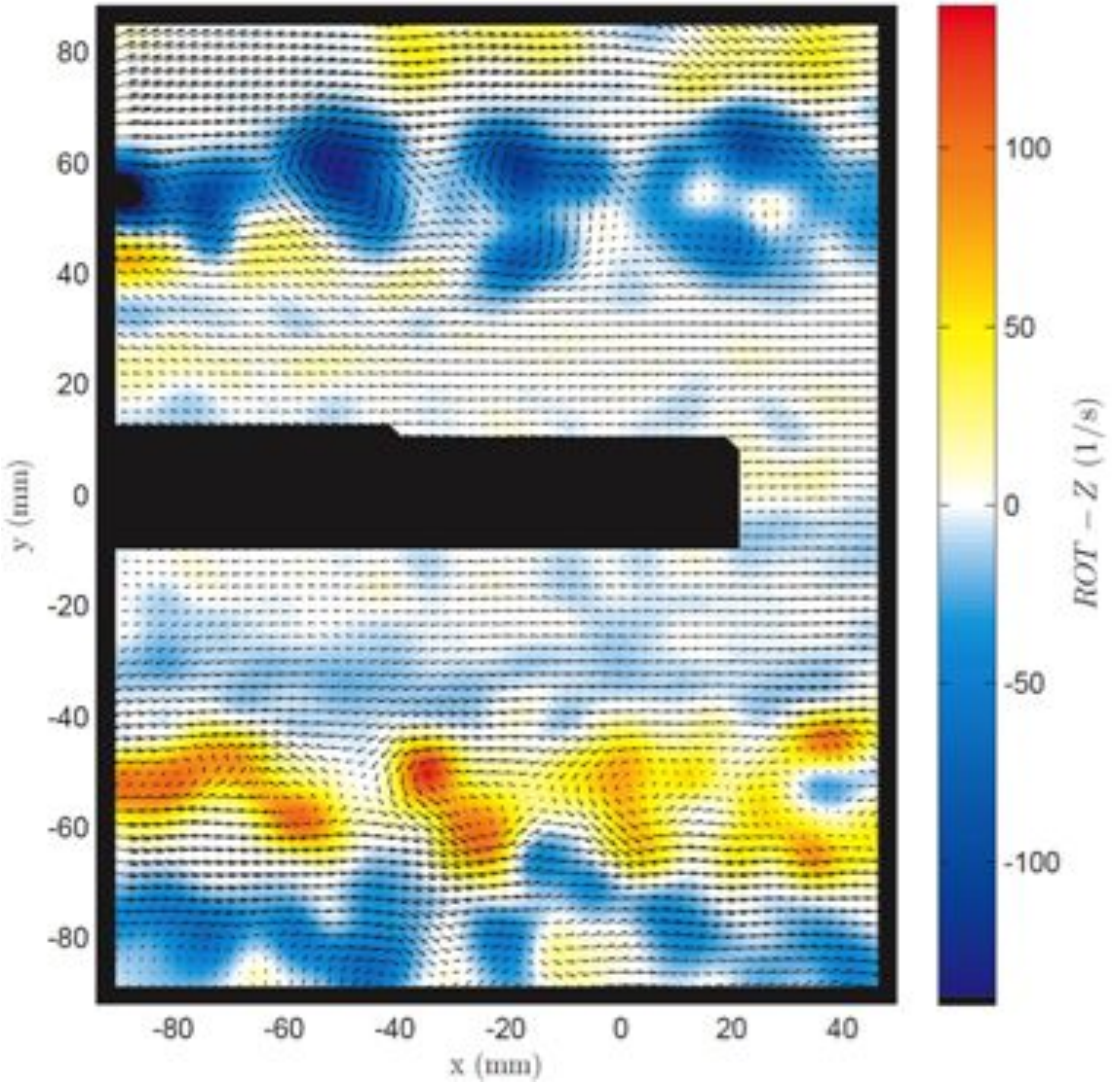
Flume Tank Experiment: Results



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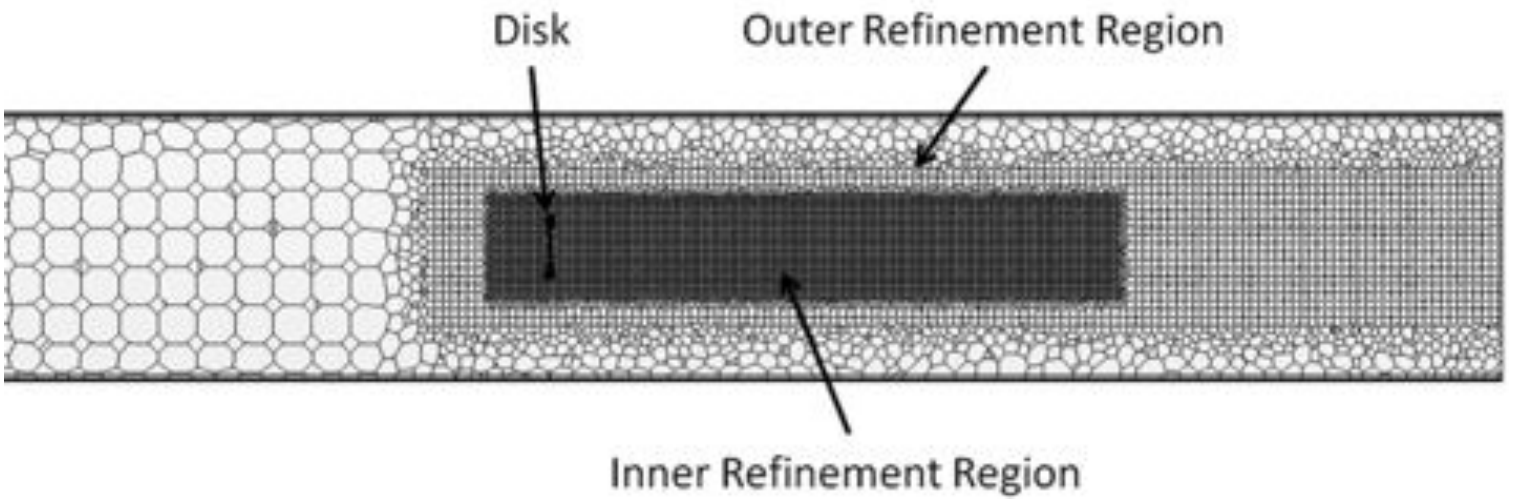
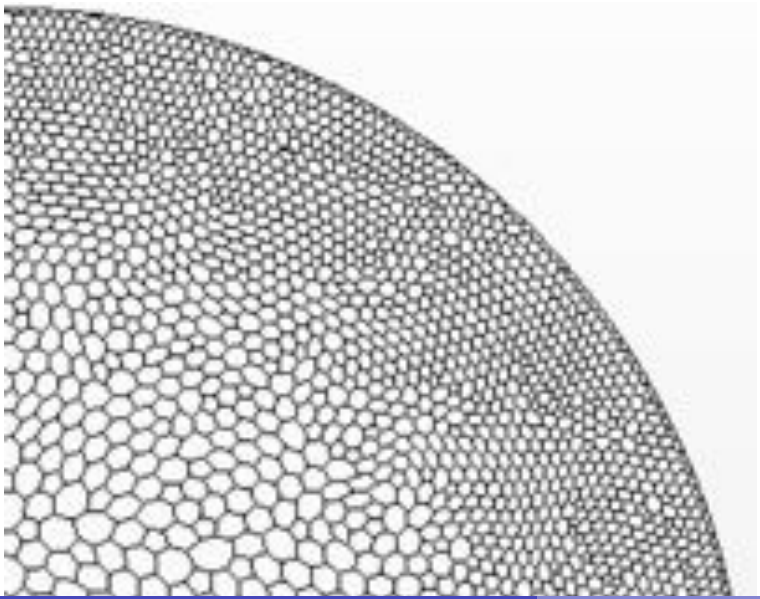
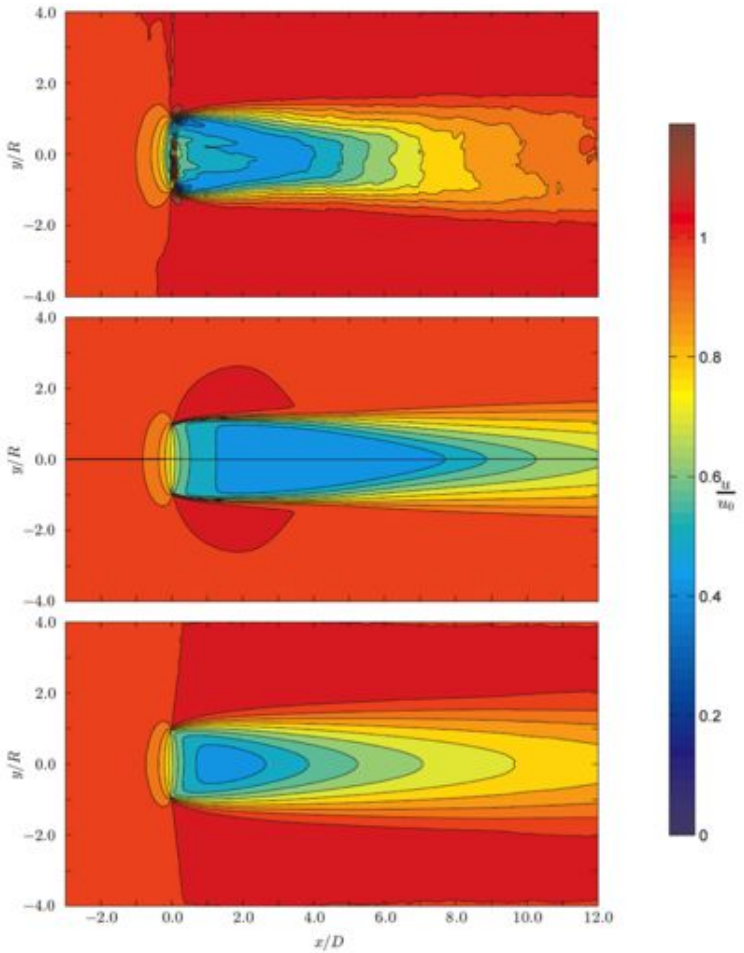
CFD Set up: Mavi and UVic



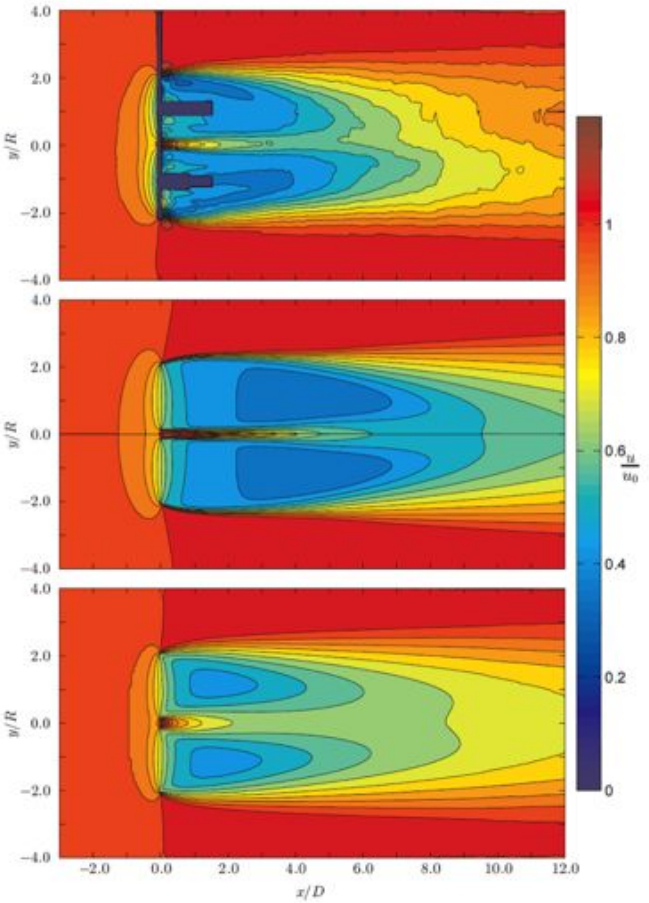


Region	Cell Size
Disk Face	1.8%
Disk Perimeter	0.9%
Inner Refinement	13.7%
Outer Refinement	64.0%

CFD-Experiment Comparison

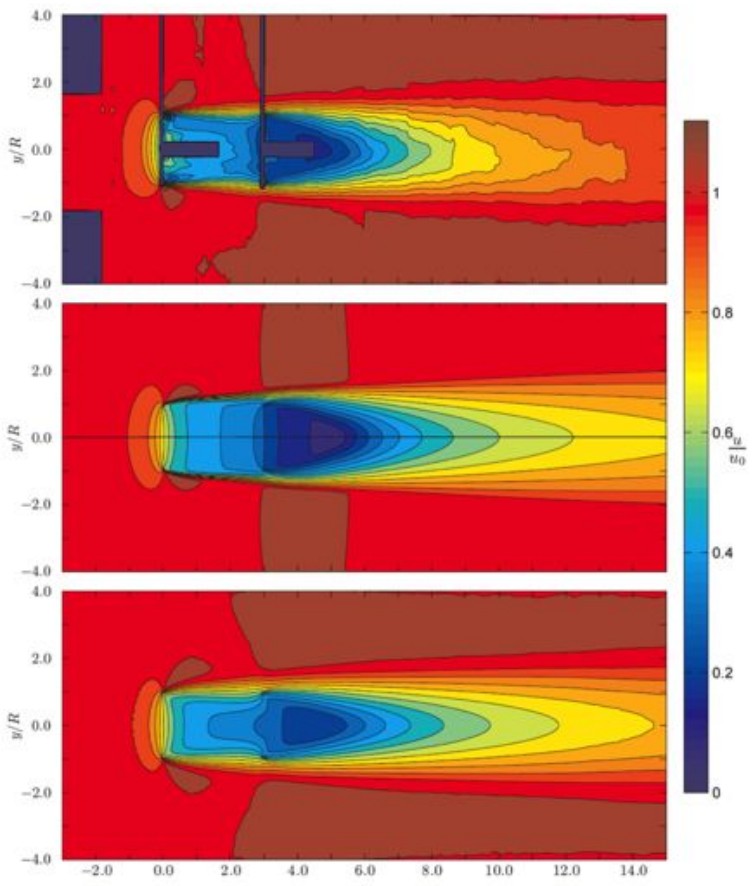


One Turbine

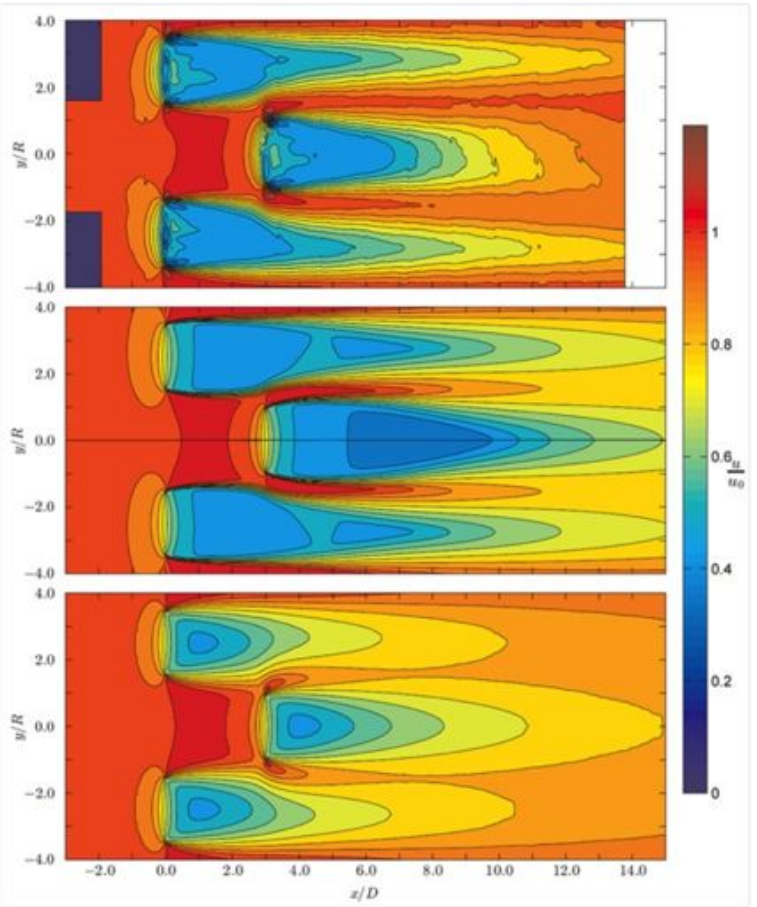


Two Turbine (adjacent)

CFD-Experiment Comparison

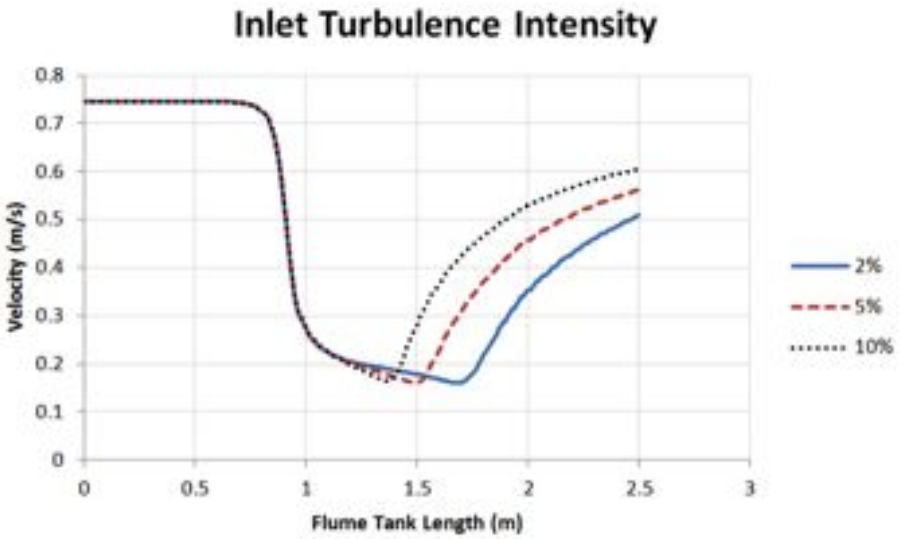


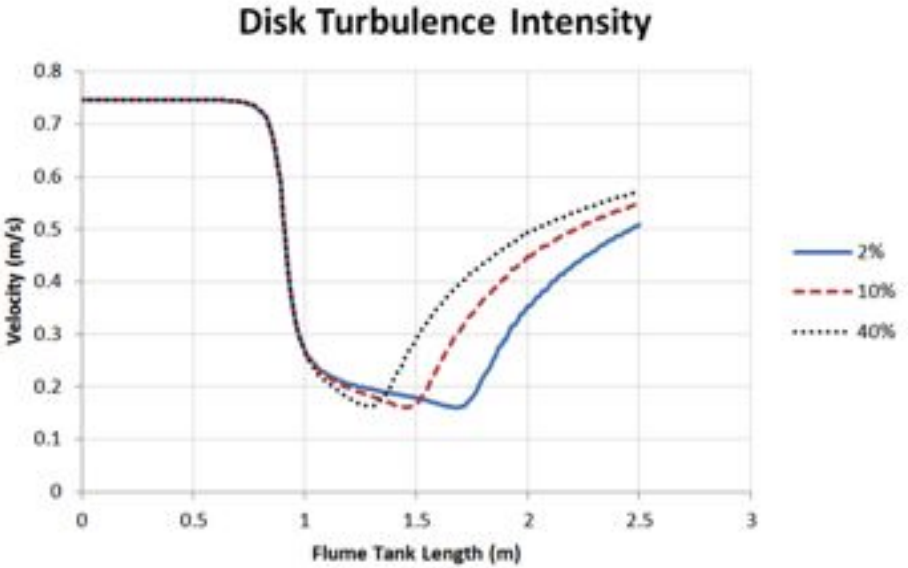
Two Turbines (in line)

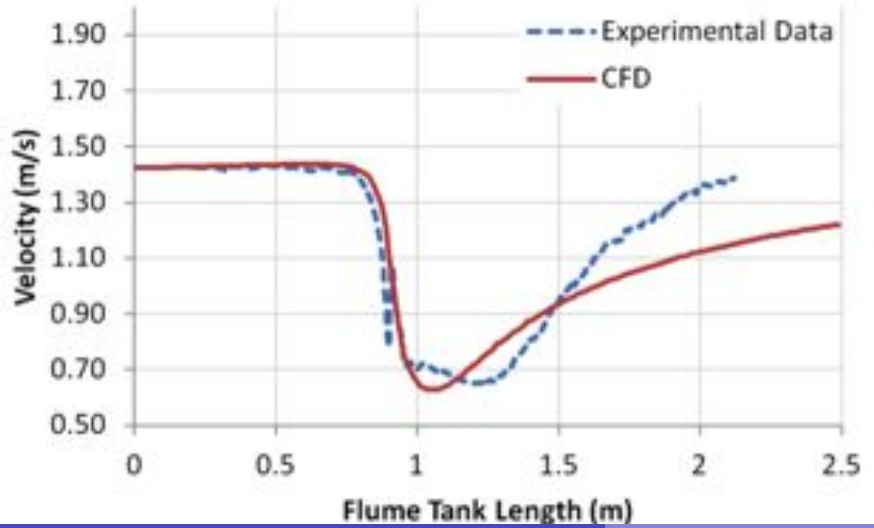


Three Turbines

Results

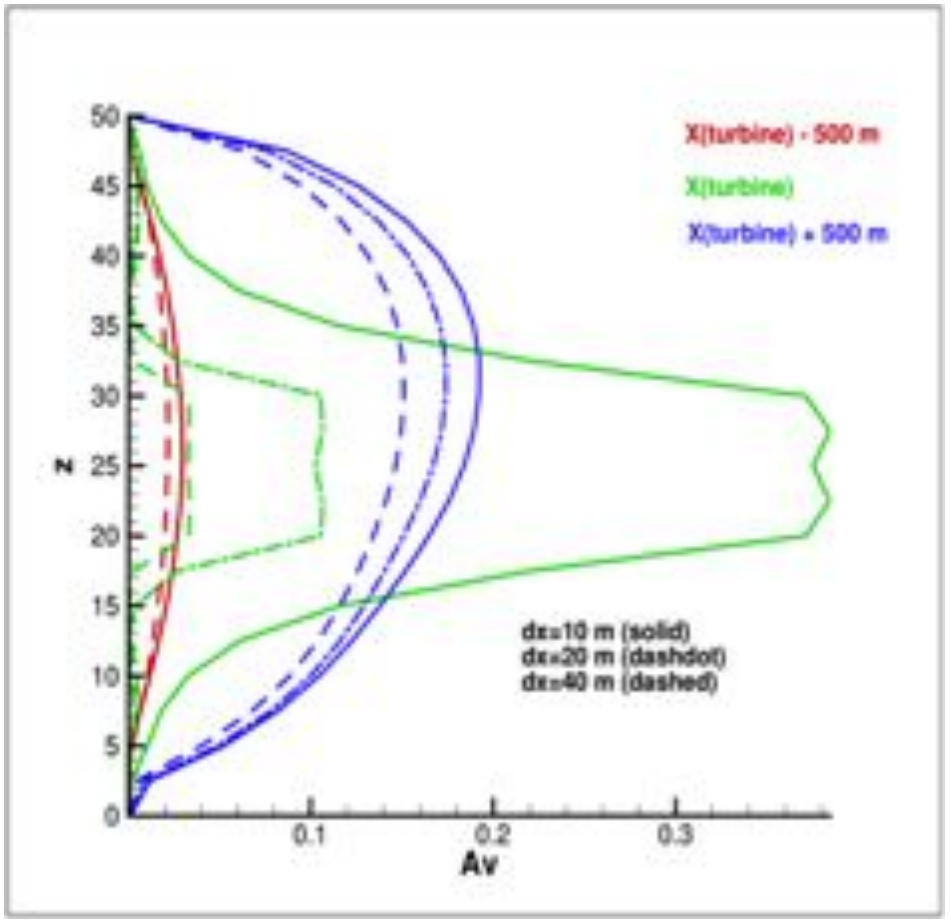






	% Difference in Thrust from Experimental	
Set 1c	Front Disk	
	-0.52%	
Set 3a	Front Disk	Rear Disk
	-5.30%	7.01%
Set 4a	Side Disks	
	-6.27%	
Set 7b	Side Disks	Centre Disk
	-6.41%	-7.69%

Parameterizing Turbines in Oceanographic Models



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Parameterizing Turbines in Oceanographic Models

$dx(m)$	U_0 (m/s)	$dz(m)$	A_v (m^2/s)	C_T^*	C_P^*	P_{CFD} (kW)	P_{ocn} (kW)	% Diff
50 m	3	10 m	k–ε	1.545	1.342	2018.1	2376.0	17.7%
50 m	3	20 m	k–ε	1.197	0.916	2018.1	2149.0	6.5%
50 m	3	10 m	0.1	1.545	1.342	2018.1	2307.0	14.3%
50 m	3	20 m	0.1	1.197	0.916	2018.1	2143.0	6.2%
60 m	3	10 m	k–ε	1.383	1.138	2018.1	2329.0	15.4%
60 m	3	20 m	k–ε	1.136	0.847	2018.1	2151.0	6.6%
60 m	3	10 m	0.1	1.383	1.138	2018.1	2309.0	14.4%
60 m	3	20 m	0.1	1.136	0.847	2018.1	2094.0	3.8%

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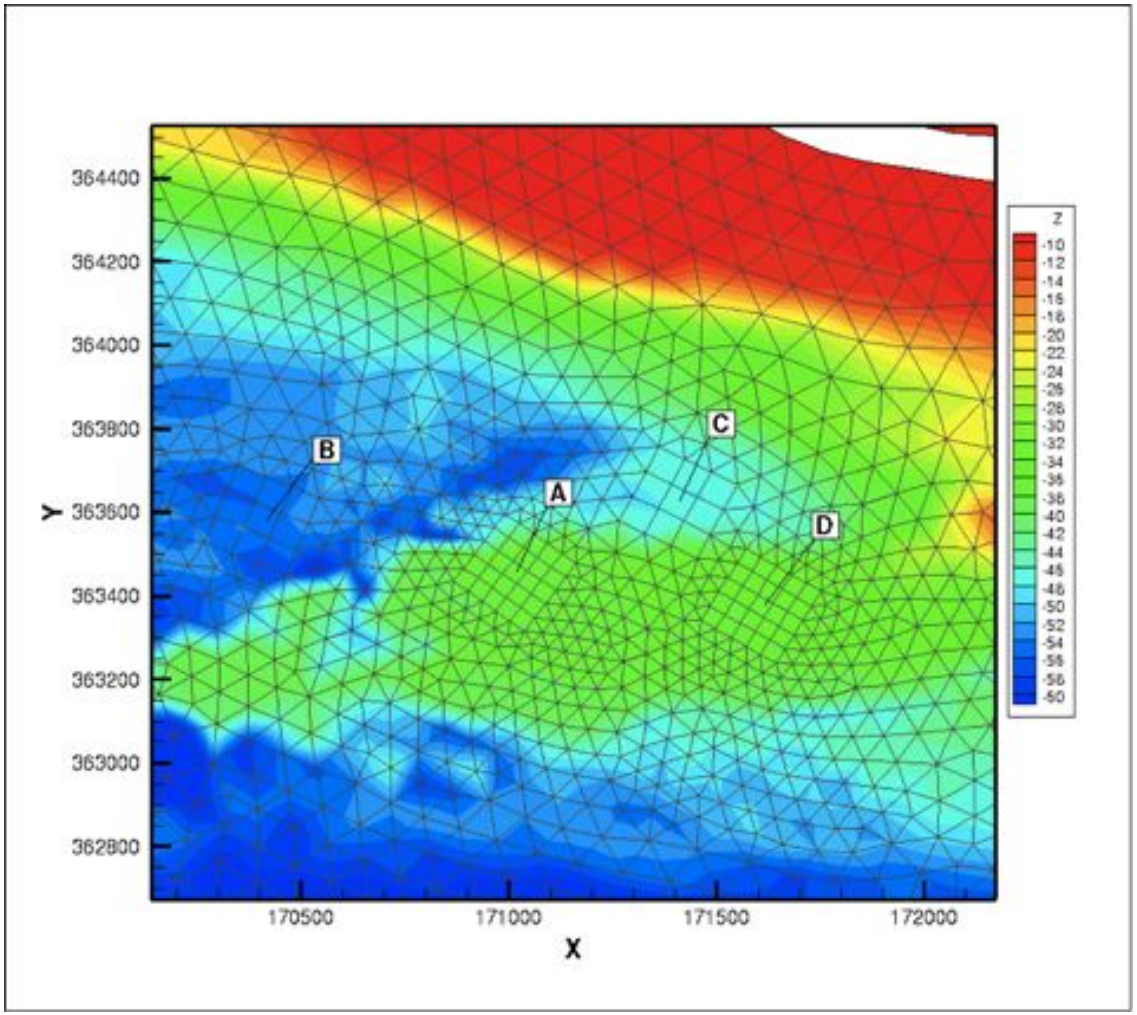
Parameterizing Turbines: Minas Passage



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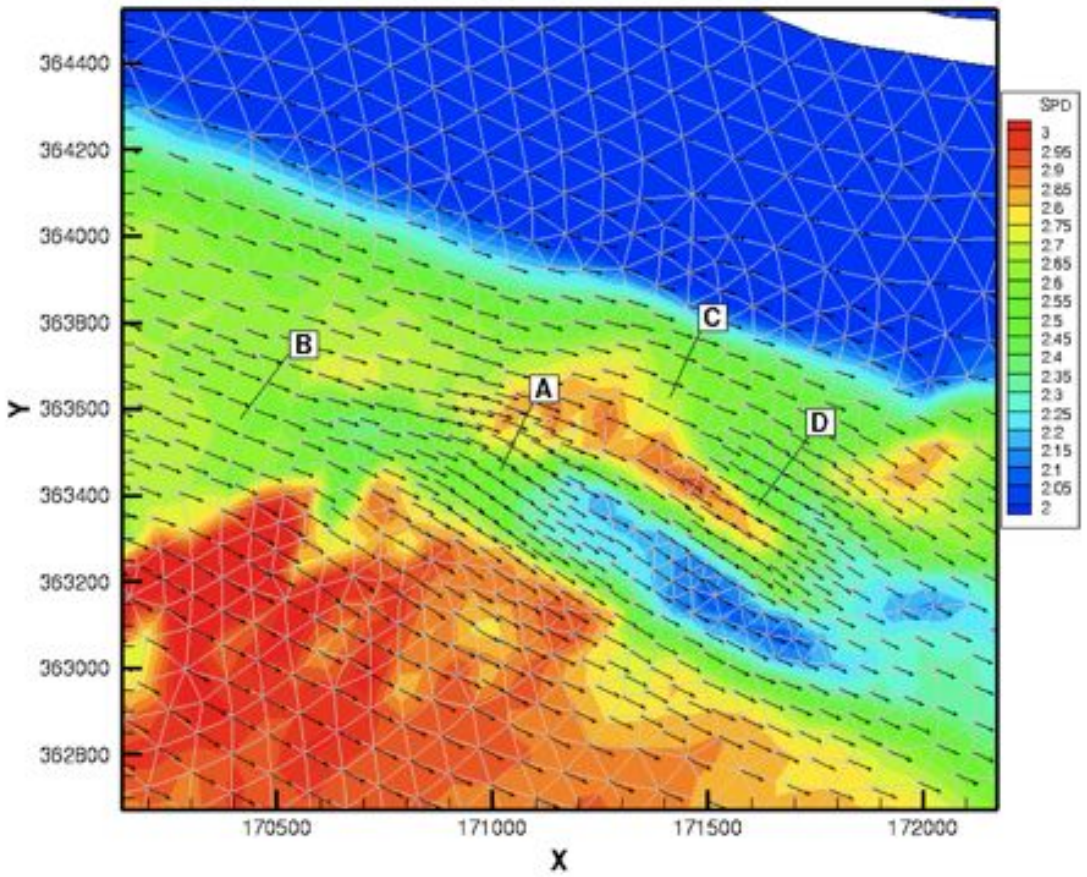
Parameterizing Turbines: Minas Passage



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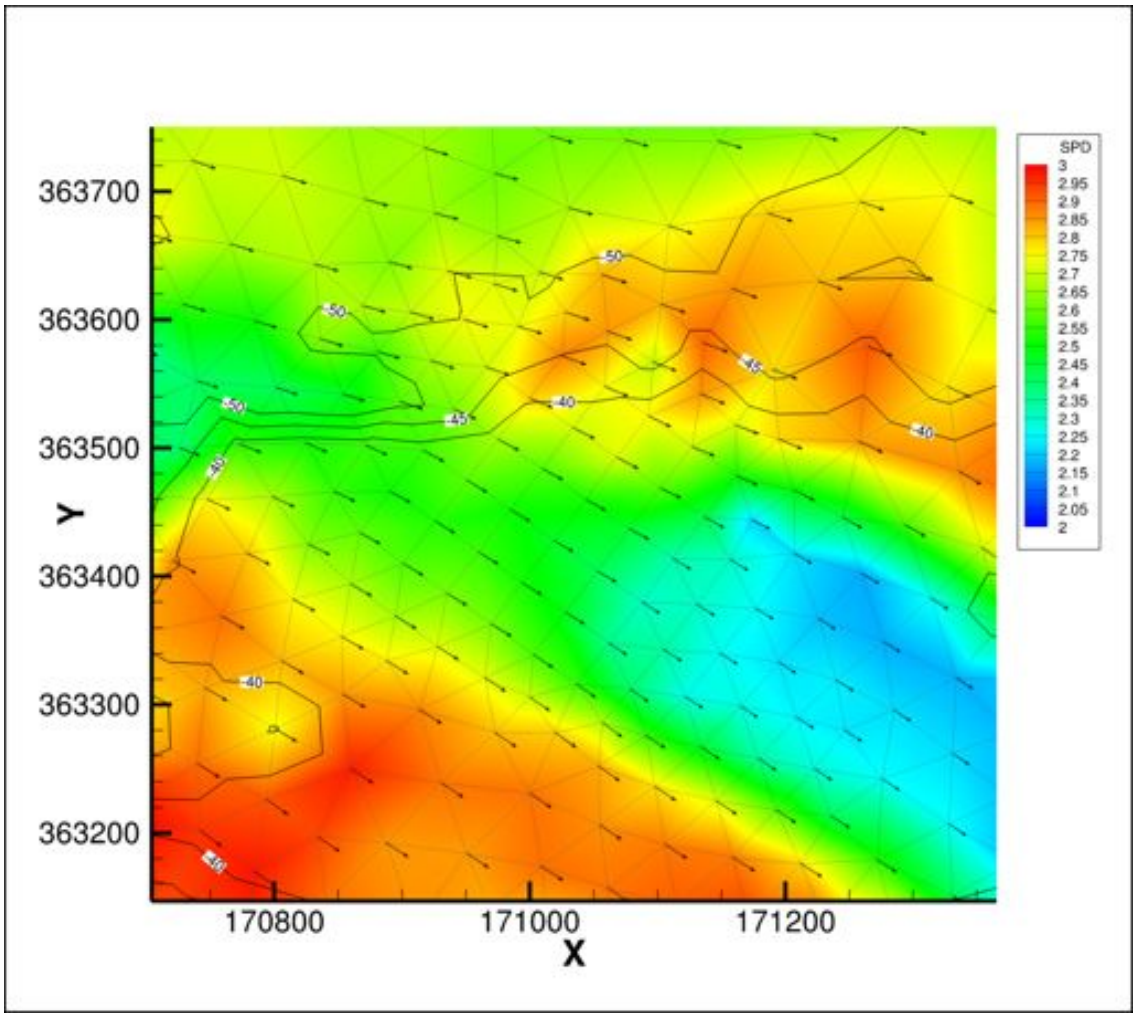
Parameterizing Turbines: Minas Passage



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Parameterizing Turbines: Minas Passage

Site	$dx(m)$	$dz(m)$	q	C_T^*	C_P^*	$P_{CFD}(kW)$	$P_{ocn}(kW)$	% Diff
A	40	H	126	1.031	0.767	989.7	1117	13%
B	66.67	H	113	0.988	0.727	1501.7	1266	-16%
C	66.67	H	117	1.002	0.739	1424.2	1284	-10%
D	40	H	121	1.020	0.761	1350.5	1397	3%
A	40	32	126	1.080	0.822	989.7	1249	26%
B	66.67	32	113	0.995	0.734	1501.7	1220	-19%
C	66.67	32	117	0.981	0.716	1424.2	1249	-12%
D	40	32	121	1.072	0.821	1350.5	1456	8%

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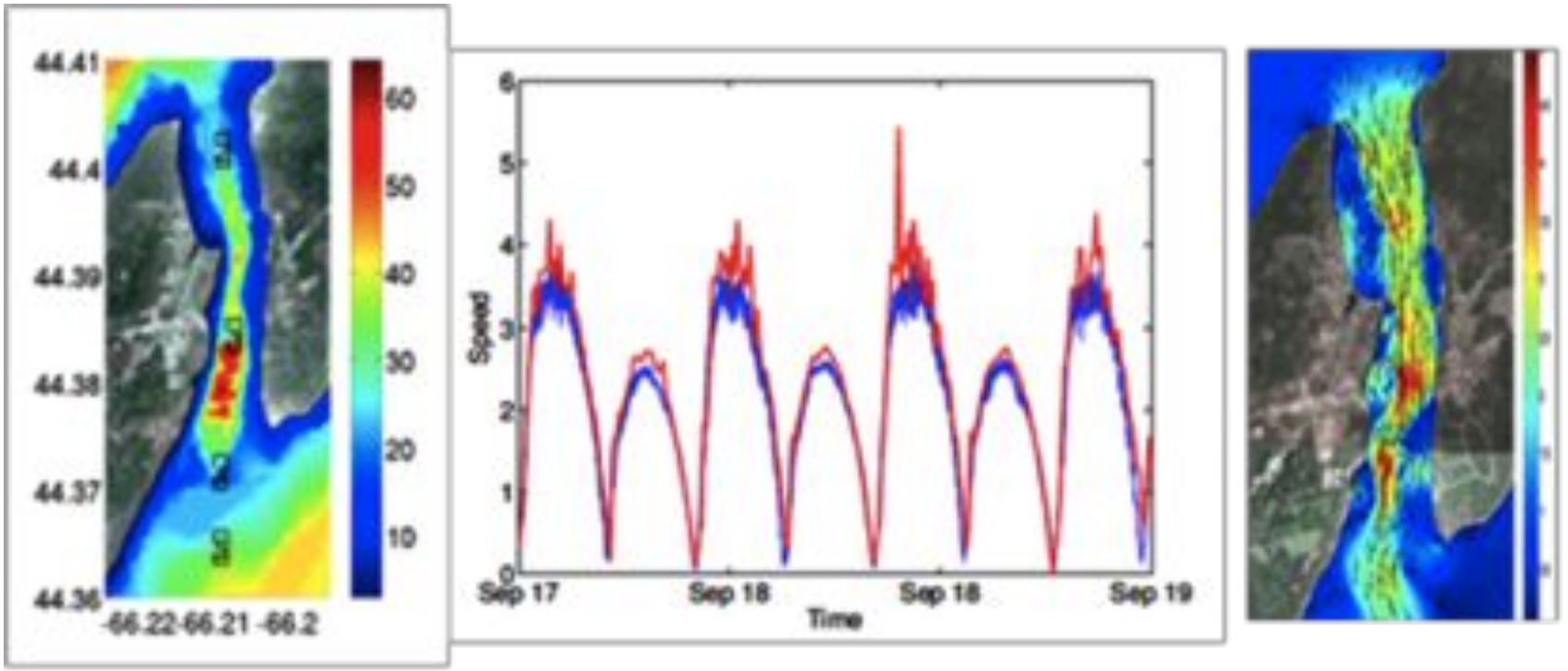
Modelling Turbines: Petit Passage



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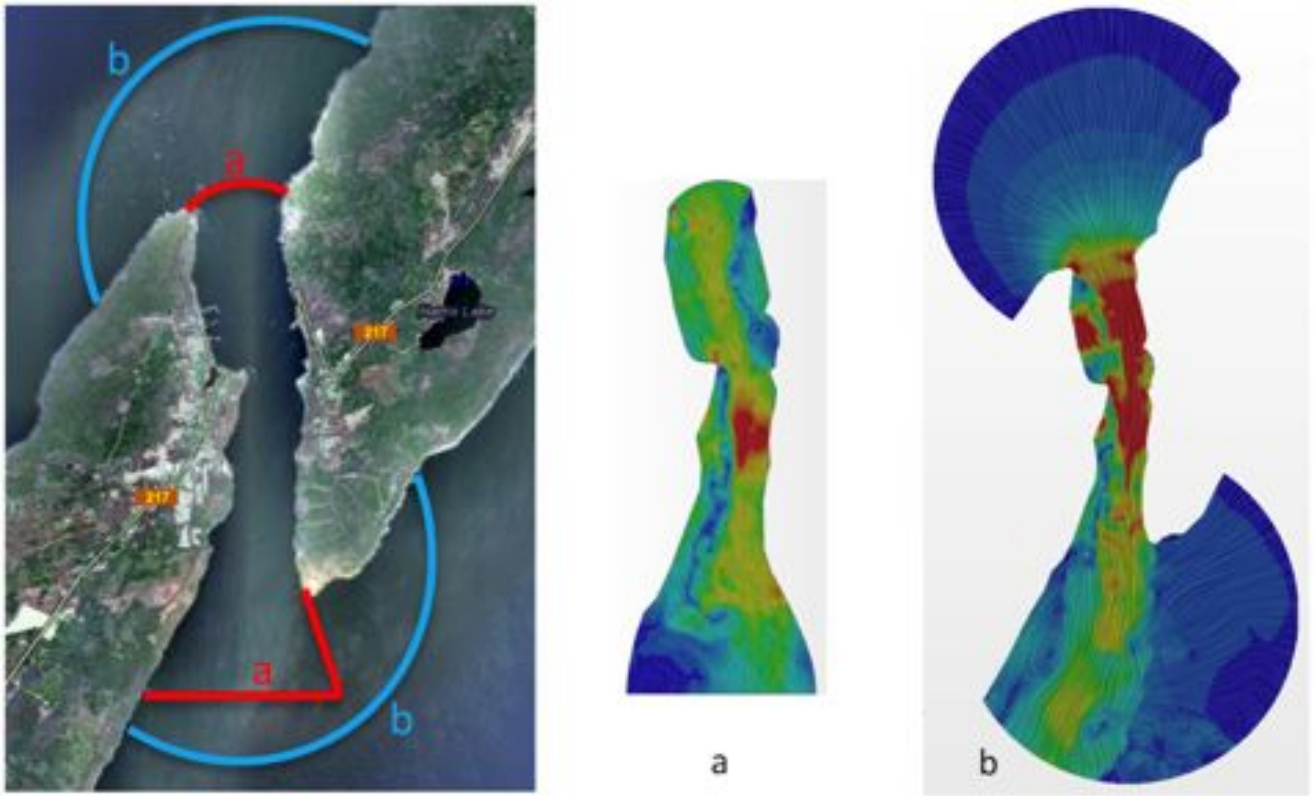
Modelling Turbines: Petit Passage



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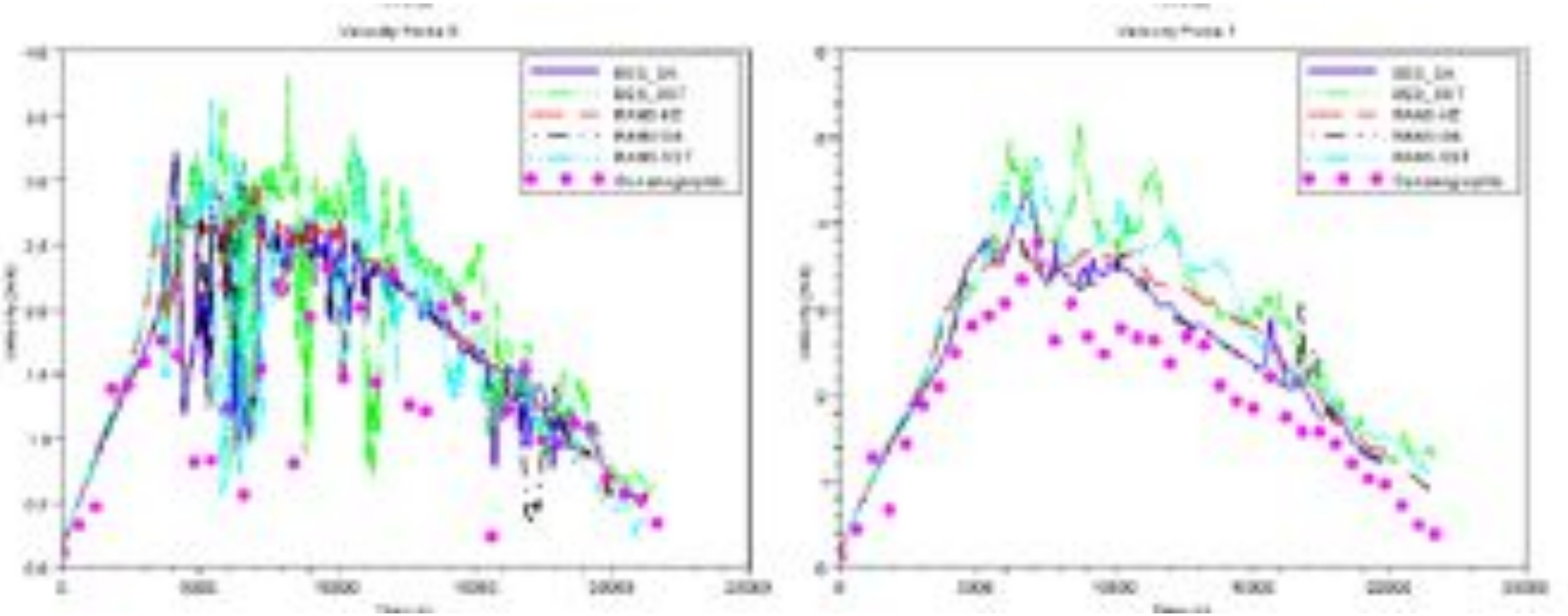
Modelling Turbines: Petit Passage



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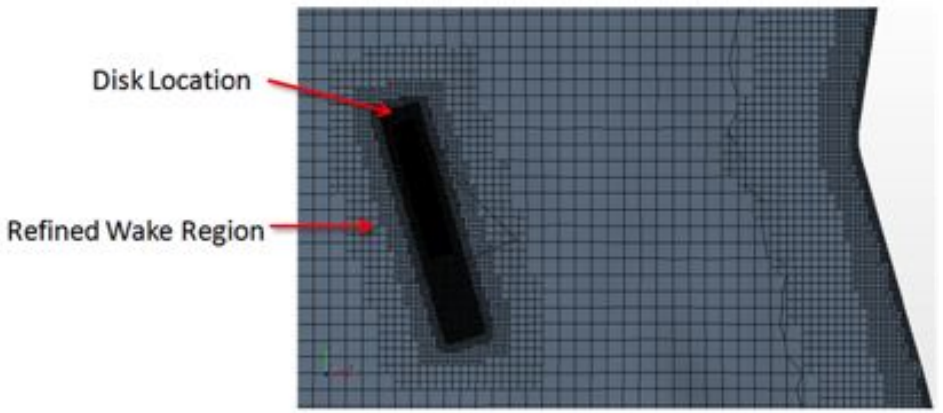

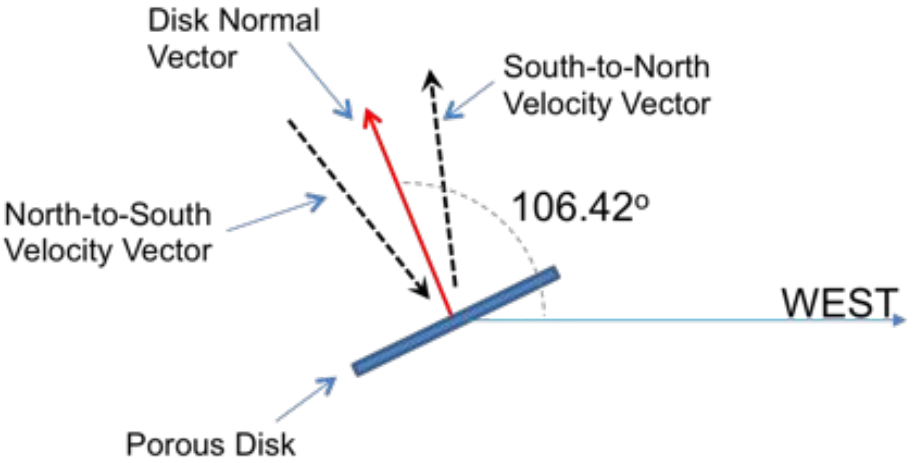

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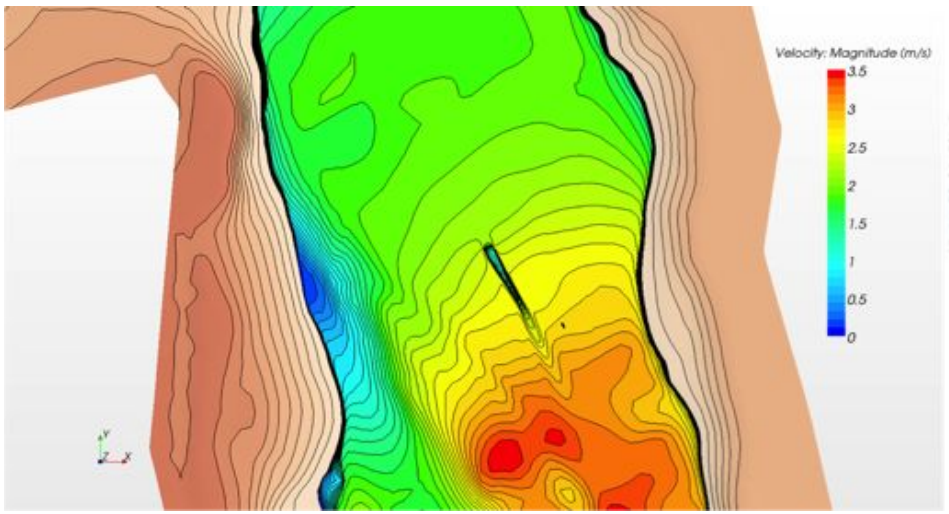

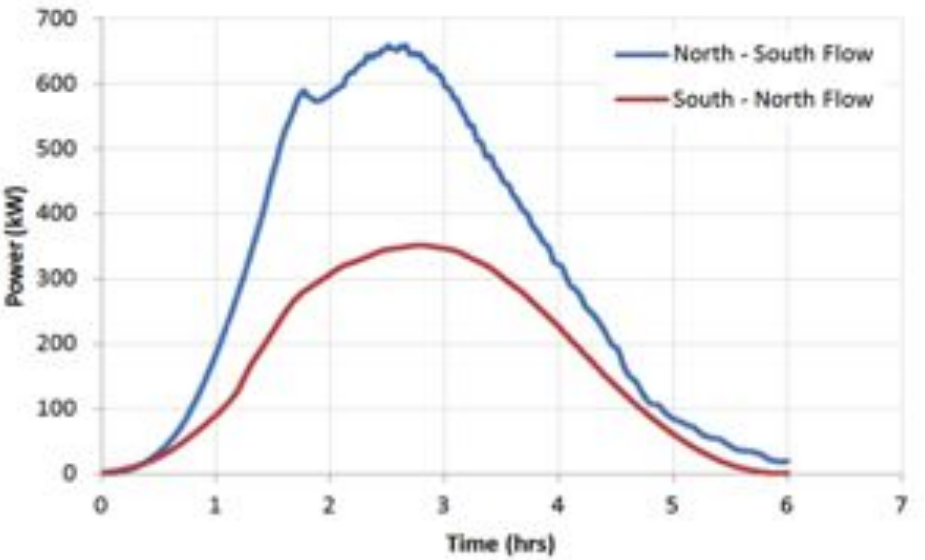

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Conclusions

- Success in matching CFD to Lab experiments for Actuator Disc
- Turbulent Intensity affects wake
- Near-field coupling method work shows great promise (identified appropriate averaging volume – twice the turbine diameter)
- Mid-field cross-coupling method was successfully implemented

- Thanks to

Offshore Energy and Research Association of Nova Scotia

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