

Post-Processing of Laboratory Experimental Data on Island Wakes and Numerical Comparison with Laboratory Experimental Data

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LONG-TERM GOALS

The long-term goal of the project is to understand generation and evolution of vorticities generated in the island wakes and their impacts the marine environment.

OBJECTIVES

The objectives of the project are:

- 1) Continue the participation of the post-processing data collected in a series laboratory experiments. A laboratory experimental project “*Three Dimensional Vortex Street Instability at High Reynolds Number around Islands*” (*TIRIS*), funded by the 6th European Commission (EC) Framework Program Hydralab III, was conducted on the largest rotating tank in the world, the Coriolis Platform (13m diameter), located at Laboratoire des Ecoulements Géophysiques et Industriels (LEGI) in Grenoble, France, in November, 2008. The PI has participated in the project as co-PI.
- 2) Make use of the laboratory experimental data to evaluate the Regional Oceanic Model System (ROMS performance. A series of numerical simulations using the ROMS based on the laboratory experimental parameters will be generated. The evaluation will be directly applied to the improvement of the ROMS.
- 3) Analyze the laboratory experimental data and the numerical modeling solutions, which will lead to systematic understanding the eddy generation and evolution in the island wake.

APPROACH

The project is in collaboration with scientists from Europe: Prof. Alex Stegner from France and Dr. Rui Caldeira from Portugal. We are taking two approaches in the project

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- 1) Improve the PIV (Particle Image Velocimetry) method to extract more accurate velocity data from image data we collected in the Grenoble.
- 2) Using numerical model (ROMS) to reproduce the lab experiments.
- 3) Using numerical reproduced lab results which contain more information than lab experiments, we conduct extensive dynamics study of island wakes

WORK COMPLETED

In last seven months since the project was funded,

- 1) we have extracted more velocity data from lab experiments using improved PIC methods and made analysis of the data set.
- 2) we have conducted a series of numerical experiments to reproduce lab experiments, see Table 1.

Table 1. Island Wake Numerical Experiment Parameters by Dong

Ref	N/f	2h/D	Bu	Ro	Re	
T038	10	0.05	0.25	1	10 ⁴	
T039	100	0.02	4	1	10 ⁴	
T040	10	0.2	4	1	10 ⁴	
T041	10	0.08	0.64	1	10 ⁴	
T042	10	0.1	1	1	10 ⁴	
T043	10	0.1	1	0.25	10 ⁴	
T044	10	0.1	1	0.5	10 ⁴	
T045	10	0.1	1	0.75	10 ⁴	
T046	10	0.1	1	0.8	6400	
T047	10	0.1	1	0.8	6400	KPP for Vertical Viscosity
T048	10	0.1	1	0.8	256	KPP for Vertical Viscosity
T046-N	10	0.1	1	1.25	10 ⁴	
T047-N	10	0.1	1	1.25	10 ⁴	KPP for Vertical Viscosity
T048-N	10	0.1	1	1.25	400	KPP for Vertical Viscosity
T049	10	0.1	1	1.25	200	KPP for Vertical Viscosity

Physical parameters

Ref	N (s-1)	F (s-1)	U (cm/s)	v (m2/s)	h(m)	D(km)	δ (m)
T038	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	20	0.3	500	20	200
T039	$2 \cdot 10^{-3}$	$2 \cdot 10^{-5}$	20	0.4	200	20	200
T040	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	2	0.004	200	2	20
T041	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	5	0.025	200	5	50
T042	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	10	0.05	500	10	
T043	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	5	0.05	500	20	
T044	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	5	0.025	500	10	
T045	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	7.5	0.0375	500	10	
T046	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	8.0	0.0625	500	10	
T047	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	0.0625	500	10	
T048	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	1.5625	500	10	
T046-N	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	0.0625	500	10	
T047-N	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	0.0625	500	10	
T048-N	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	1.5625	500	10	
T049	$2 \cdot 10^{-4}$	$2 \cdot 10^{-5}$	12.5	3.125	500	10	

The project is under right track and right pace.

RESULTS

1. We have improved the PIV method to extract more accurate results of velocity field from the lab experiments. See Fig. 1
2. Based on the series of numerical experiments, which reproduce lab data, we are working the dynamics analysis. Fig. 2 show one analysis result.

IMPACT/APPLICATIONS

The implementation of the project will have impacts on:

- 1) understanding of influence of islands on marine environments
- 2) improving of the numerical experiments
- 3) better interpretation of laboratory experiments.

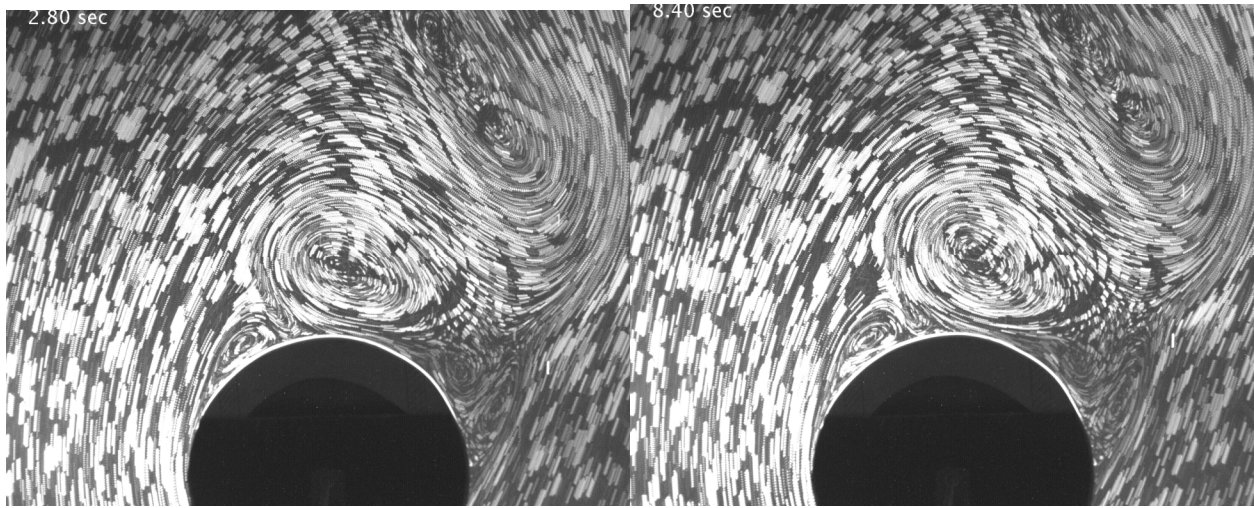


Fig.1 An example of time series of wake images taken in the lab experiments. The velocity fields can be extracted from the series of images using PIV. There are some uncertainty in existing PIV codes, and we have improved the method and get more accurate results.

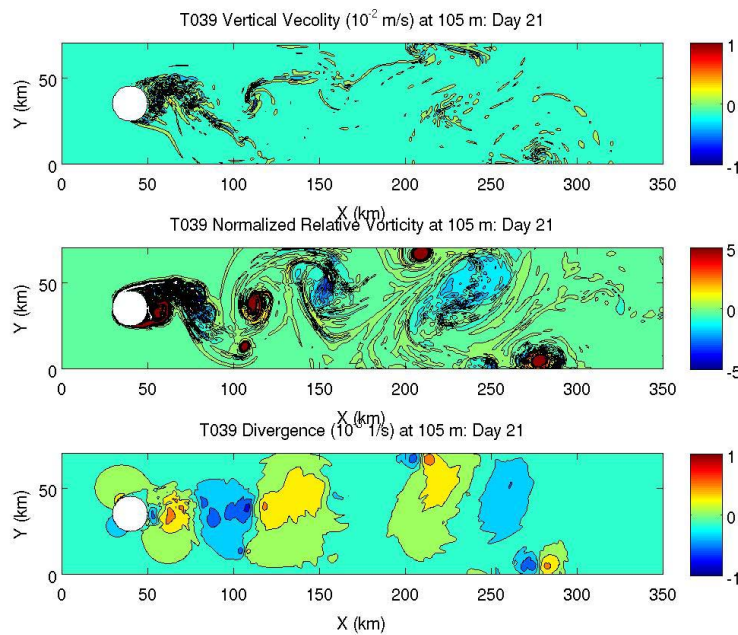


Fig. 2 A snapshot of a numerical experiment case T038: vertical velocity (top), vorticity (middle) and divergence (bottom).