Internal tides in the Luzon strait: a ROMS-laboratory comparison

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Introduction

The Luzon strait, situated between the Philippines and Taiwan, features a narrow ridge about 100 km wide that rises from a depth of about 3500 m to 500 m. The barotropic tides over this ridge generate strong (non-linear) internal waves. To better understand the internal wave generation mechanisms, ROMS and laboratory experiments are conducted. In the lab. experiment a Gaussian mount, representing Lan Yu ridge in the Luzon strait, is oscillated horizontally in a stratified water body. In this study, our aim is to mimic these experiments applying non-hydrostatic ROMS.

In the ROMS experiment real-world dimensions are used. To facilitate a better comparison, the non-dimensional parameters excursion length, slope parameter, and Froude numbers are equalized for both experiments **(I** and **II)**.

excursion length: $$\xi = \frac{u_0}{\omega L}$$

slope parameter: $$\epsilon = \frac{h}{L\alpha}, \text{ with } \alpha = \left(\frac{\omega^2 - f^2}{N^2 - \omega^2}\right)^{1/2}$$

$$\epsilon_s = \frac{1}{\alpha}\frac{\partial h}{\partial x}$$

Froude numbers: $$Fr_v = \frac{u}{Nh} \qquad Fr_h = \frac{u}{N2L}$$

the mount: $$h_m = -H + he^{-(x-x_0)^2/(2\sigma^2)}$$

I

	laboratory	Luzon
H [m]	0.127	3500
h [m]	0.10	3000
L [m]	0.50	50000
σ [m]	0.25	25000
ω [rad s^{-1}]	0.09	$1.41 \cdot 10^{-4}$
A [m]	0.006	608
u_0 [m s^{-1}]	0.00054	0.0857
u_{max} [m s^{-1}]	0.0025	0.60
N_{max} [rad s^{-1}]	1.06	0.0063
h/H	0.79	0.86
h/L	0.20	0.06
ξ	0.012	0.012
α_{max}	0.085	0.022
ϵ_{max}	2.35	2.69
$Fr_{v,max}$	0.0240	0.0316
$Fr_{h,max}$	0.0024	0.0009

ROMS model set up

- Non-hydrostatic ROMS (Kanarska et al., Ocean Modelling, 2007)
- free-slib at the bottom
- Western and eastern open boundaries with barotropic M2 tide
- bodyforce
- $nx \cdot nz$ = 3140·61
- 1200 km long domain, depth H=3500 m, Gaussian mount with height h=3000 m and width 2L=4σ=100 km
- linear equation of state
- realistic stratification **(III)**

Summary of preliminary results

A) The plots of the 2-D velocities (magnitude in color) for the laboratory and ROMS experiments reveal similar features. The low and high beams are present in both experiments and the phases of the velocities are also identical.

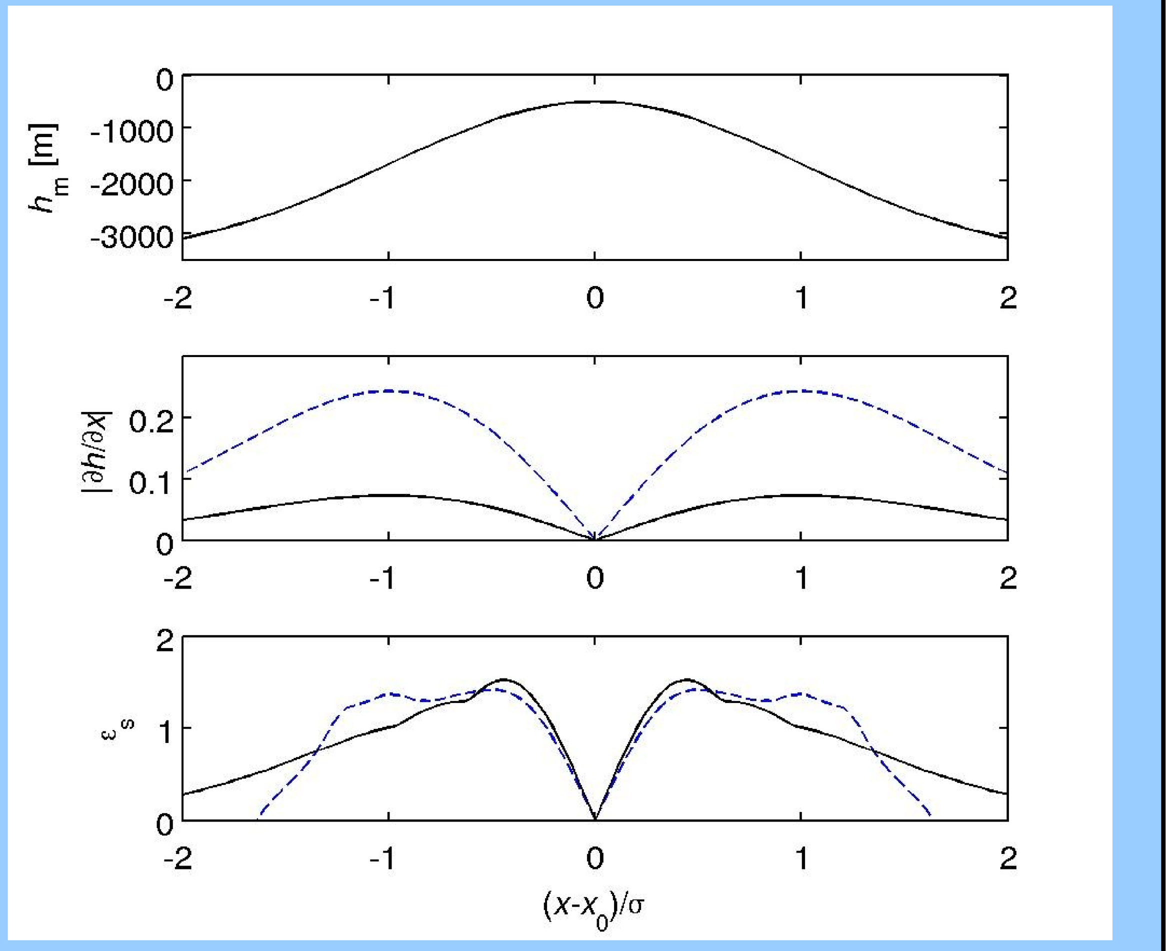
B) Snapshots of the east-west baroclinic velocity during one tidal cycle reveal interesting details near the top of the mount: upstream advection of features that may be hydraulic jumps; transient internal wave beams. The 10, 14, and 18°C contourlines are represented by the dashed, thick, and dashed lines, respectively.

C) The east-west baroclinic velocities for the non-hydrostatic run and the hydrostatic run. The solitons look different.

II

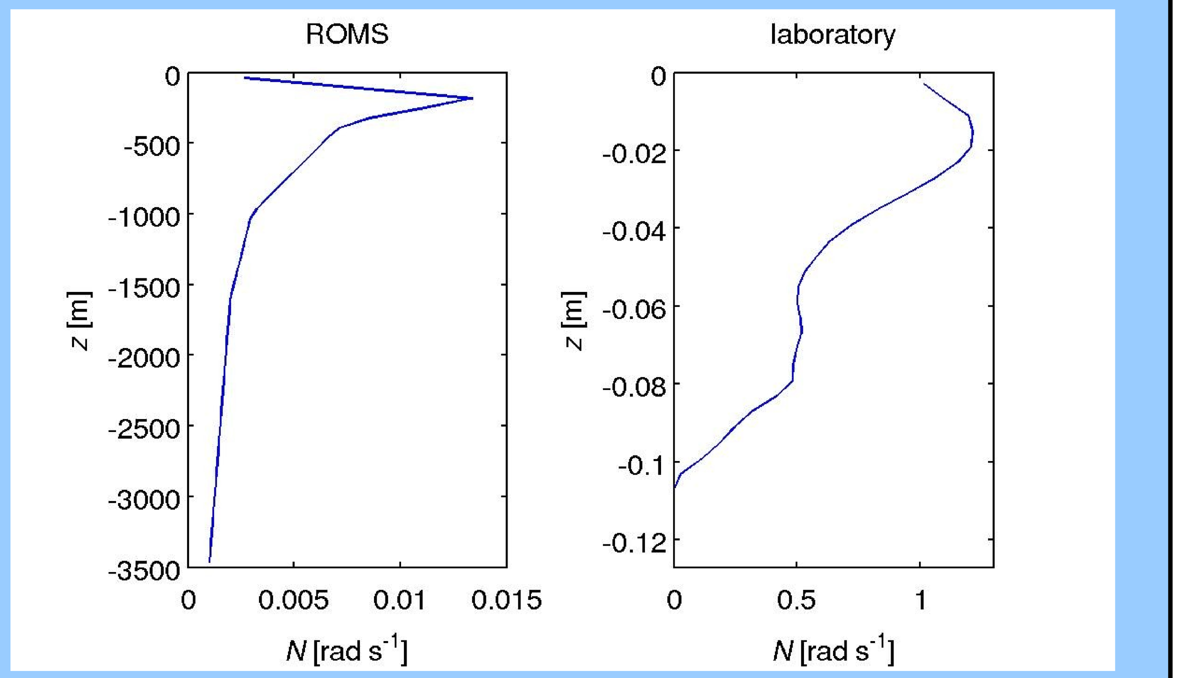
Gaussian mount

Elevation of the mount, the slope, and the slope parameter. Blue lines indicate the laboratory experiment. Near the top the slope parameter is equal for both experiments.



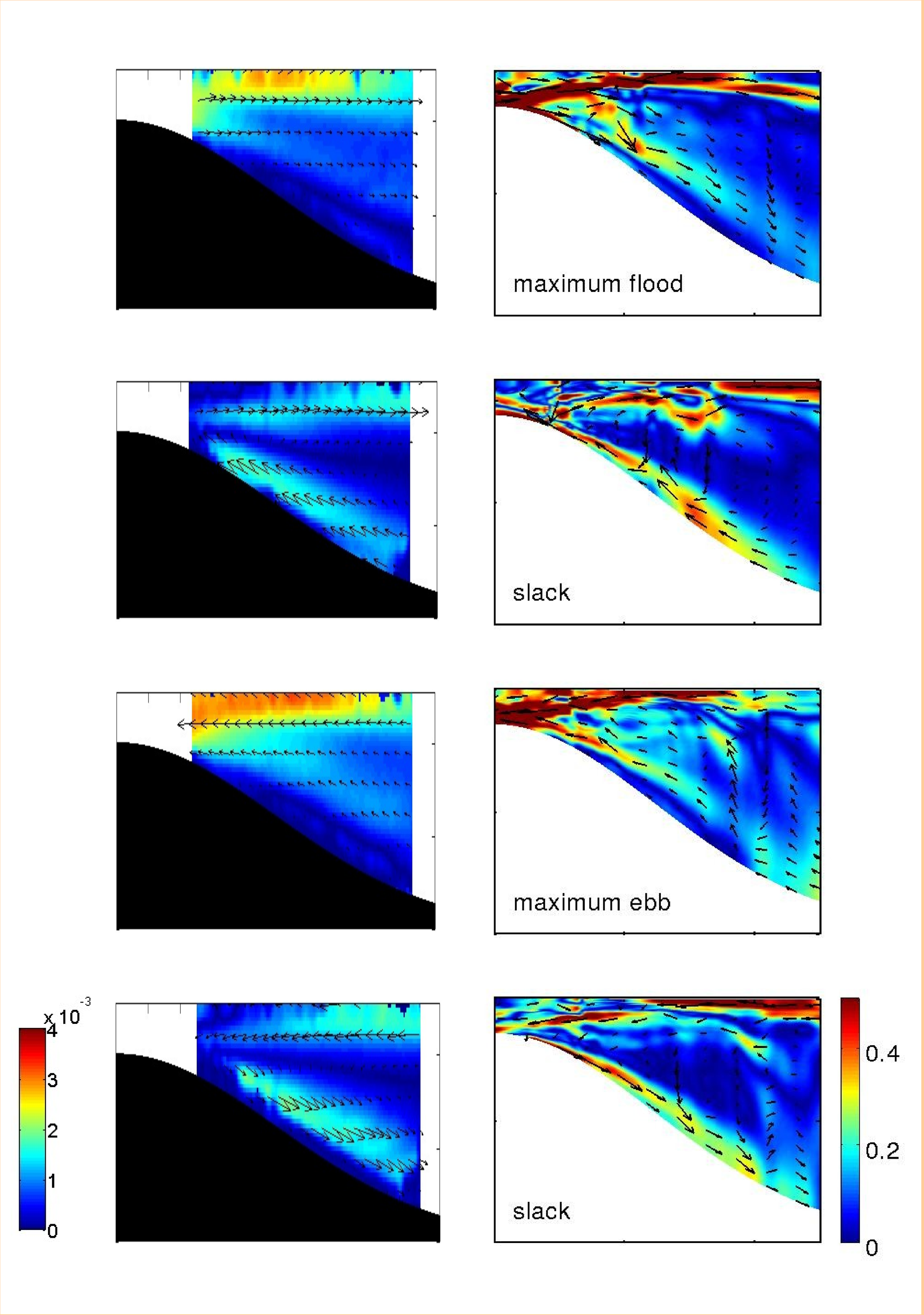
III

Stratification



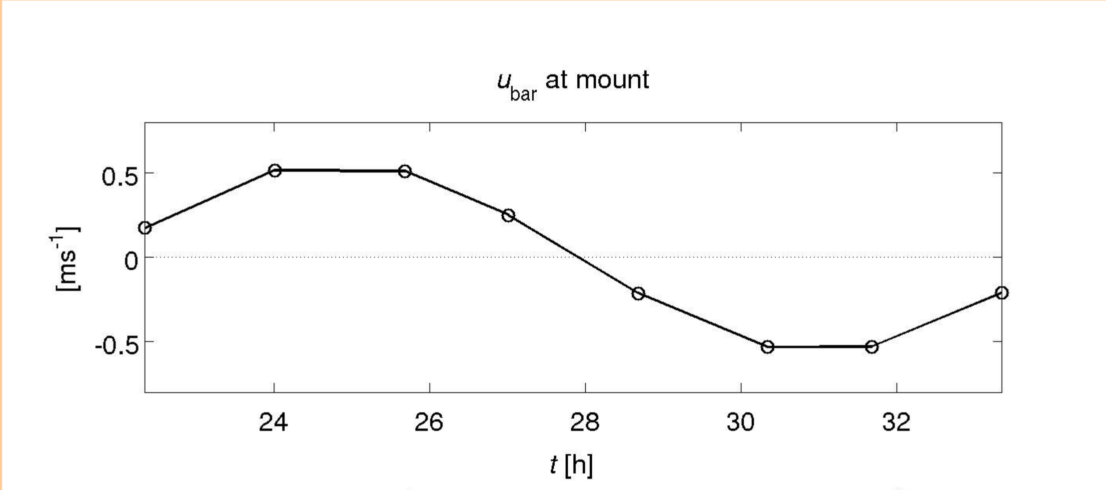
A

laboratory ROMS

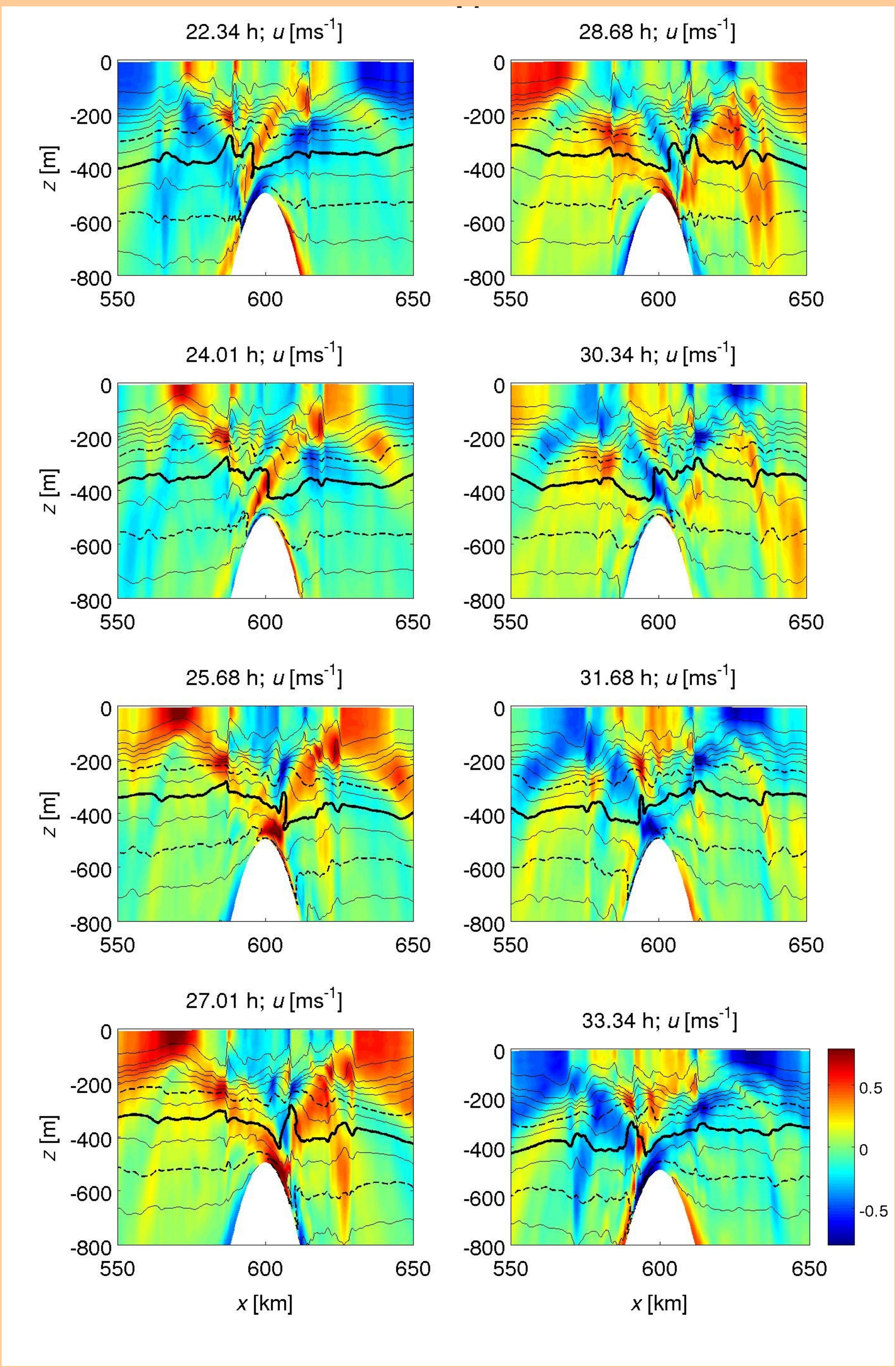


B

Baroclinic velocity during tidal cycle

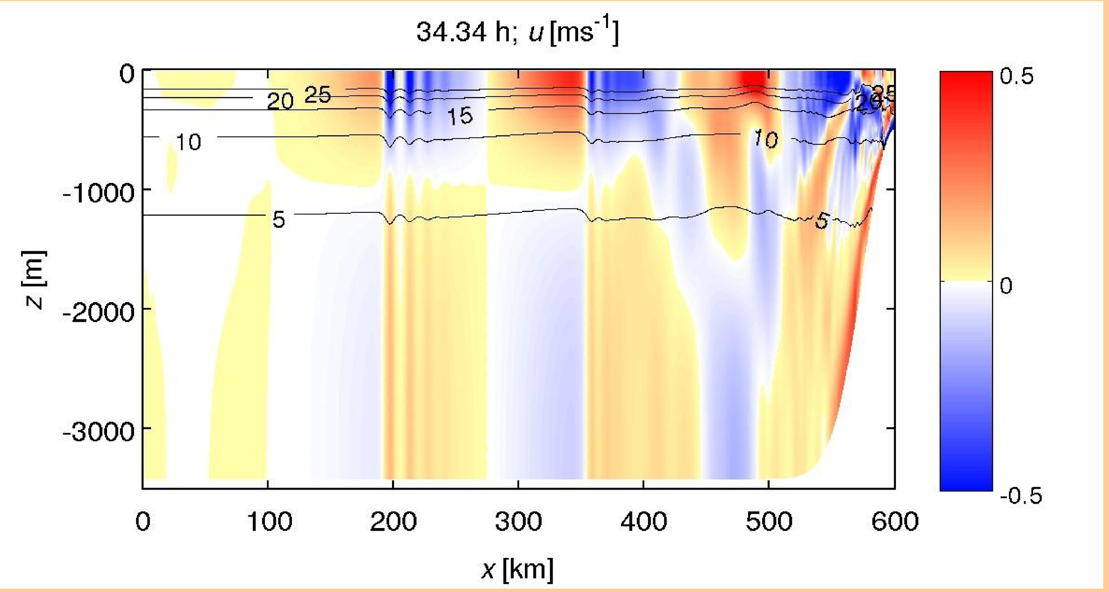


flood ebb

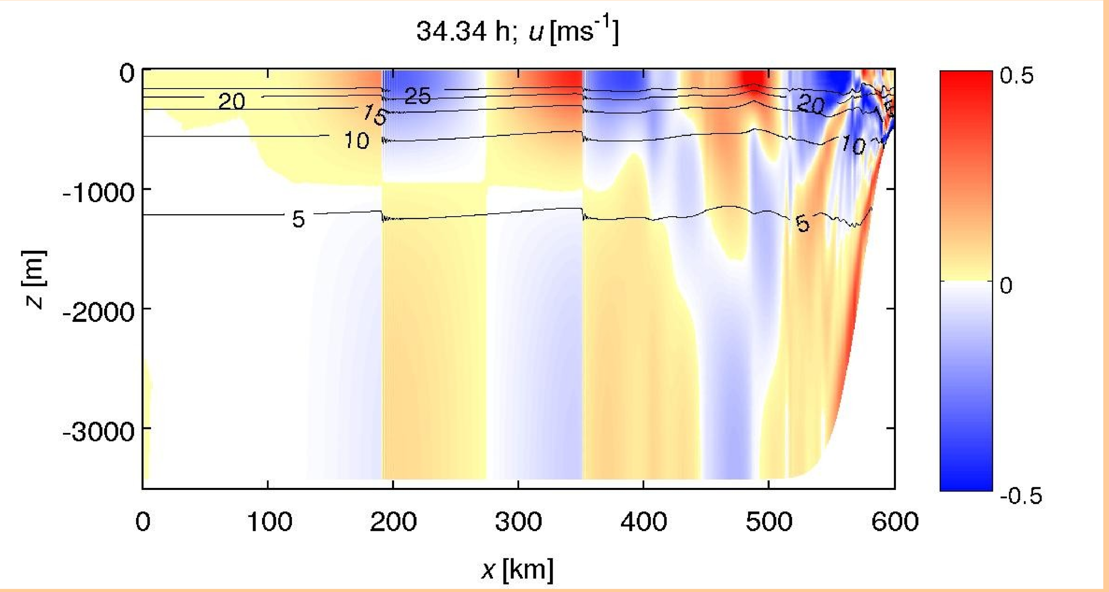


C

non-hydrostatic



vs. hydrostatic



Future work

- include more than 1 tidal component
- vary amplitudes
- study the effect for different N
- use varying bathymetries
- investigate (non-linear) internal wave beams near the top of the mount in the laboratory experiment
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