On the generation and evolution of internal solitary waves in the northwestern South China Sea

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Outline

- Motivation
- Model setup
- Results of reference experiment
  a) Generation process of ISWs
  b) Generation mechanism of the ISWs
  c) Scrutiny of the ISWs
- Sensitivity experiments
- Conclusions

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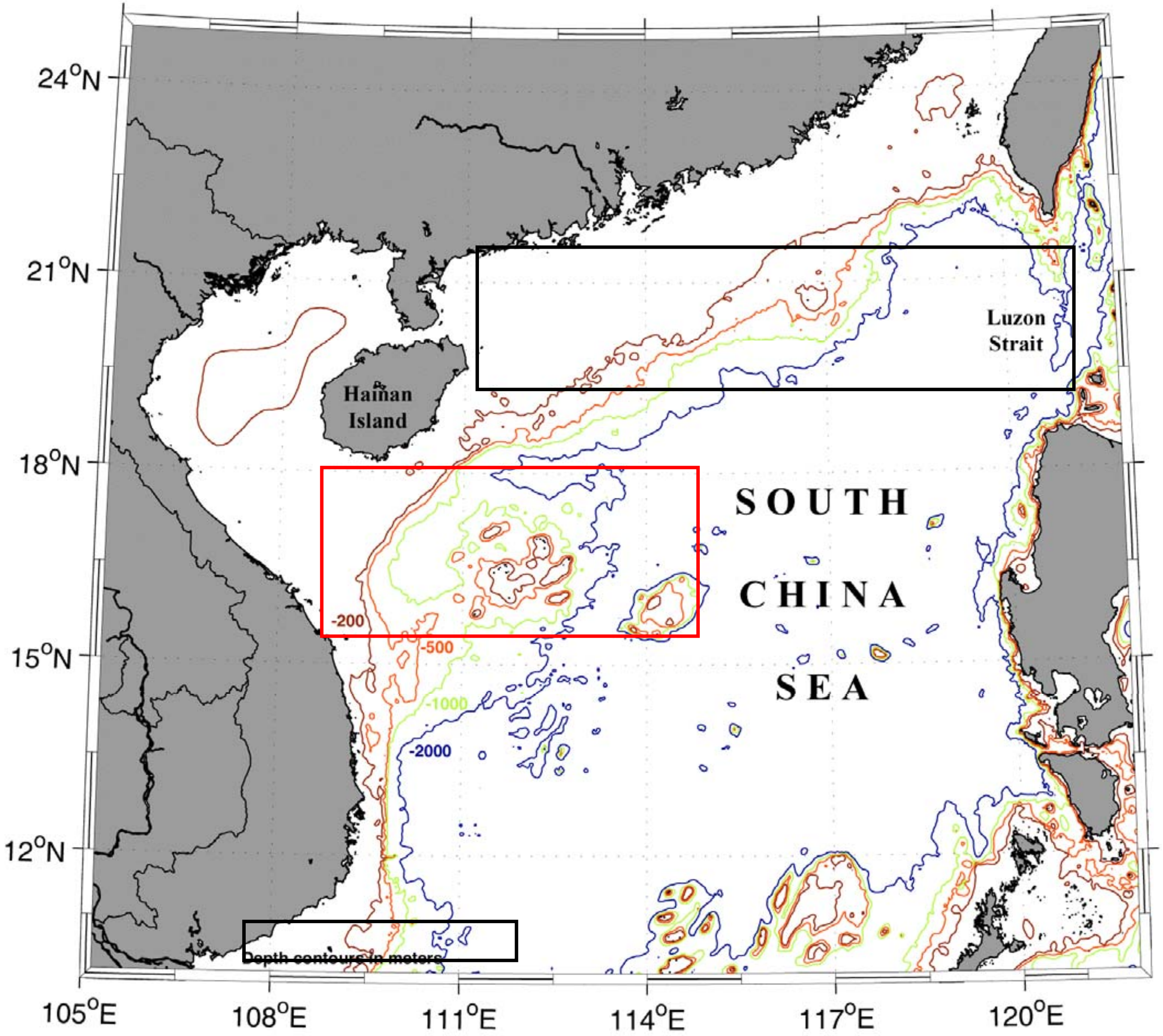
Bathymetry of the South China Sea([Smith and Sandwell, 1997])



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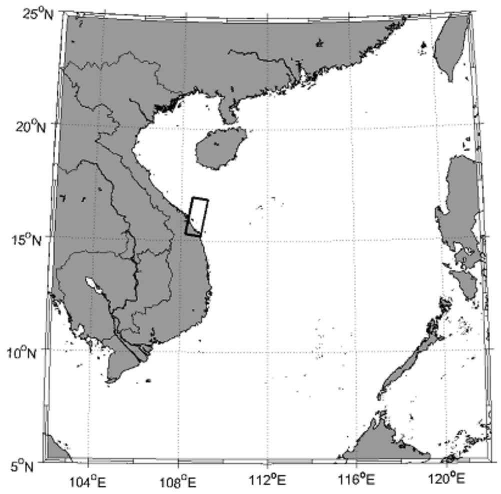
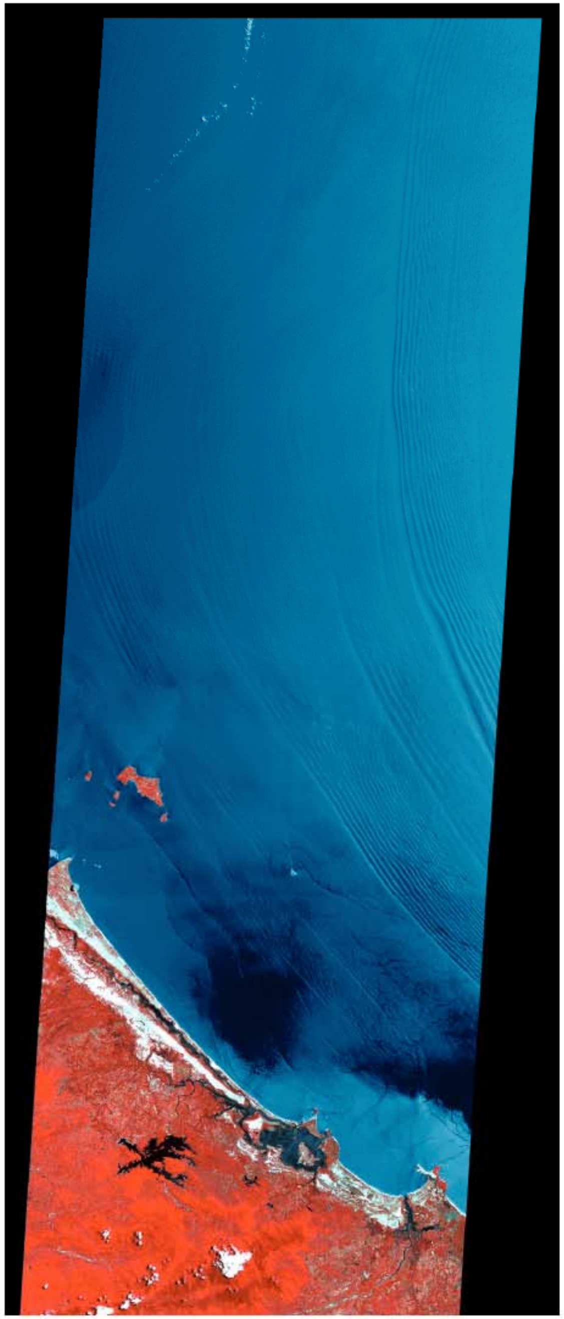
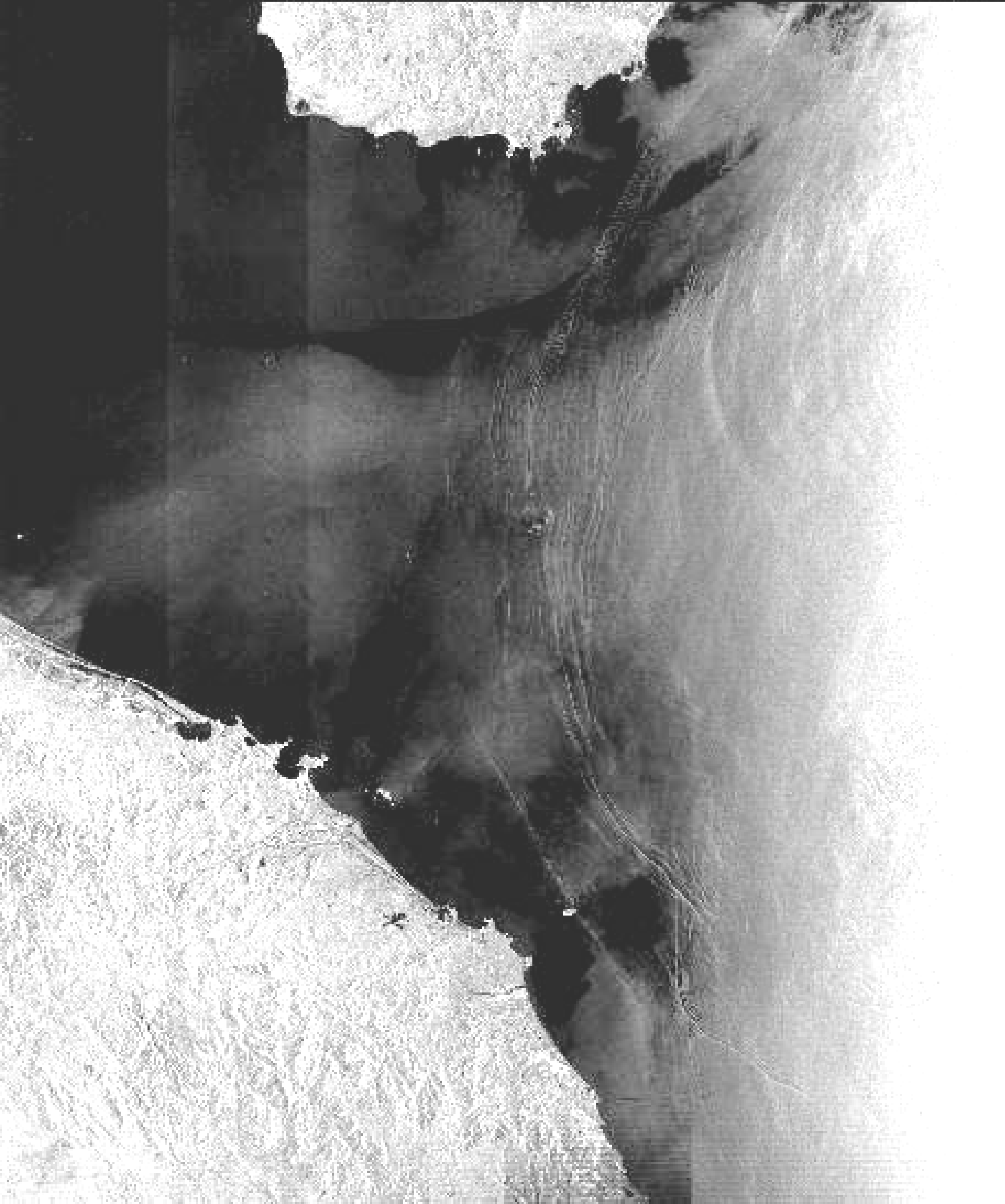
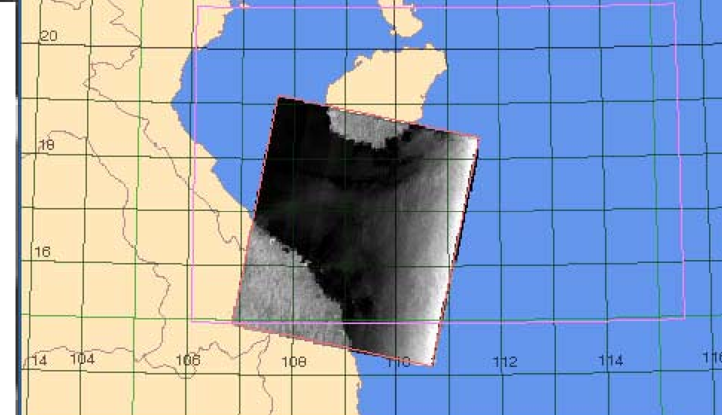




An ASTER false-color VNIR image taken on 29 July 2001





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ASAR wide swath

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Model setup

- MIT general circulation model (MITgcm);
- Primitive equations with fully nonlinear, non-hydrostatic terms;
- 2D modeling;
- High spatial resolution: 250 m and 10 m in the horizontal and vertical directions, respectively.

Parameterization Scheme:

The Richardson number-dependent parameterizations (Pacanowski and Philander, 1981) and the scheme by Leith (Leith, 1996) are used.

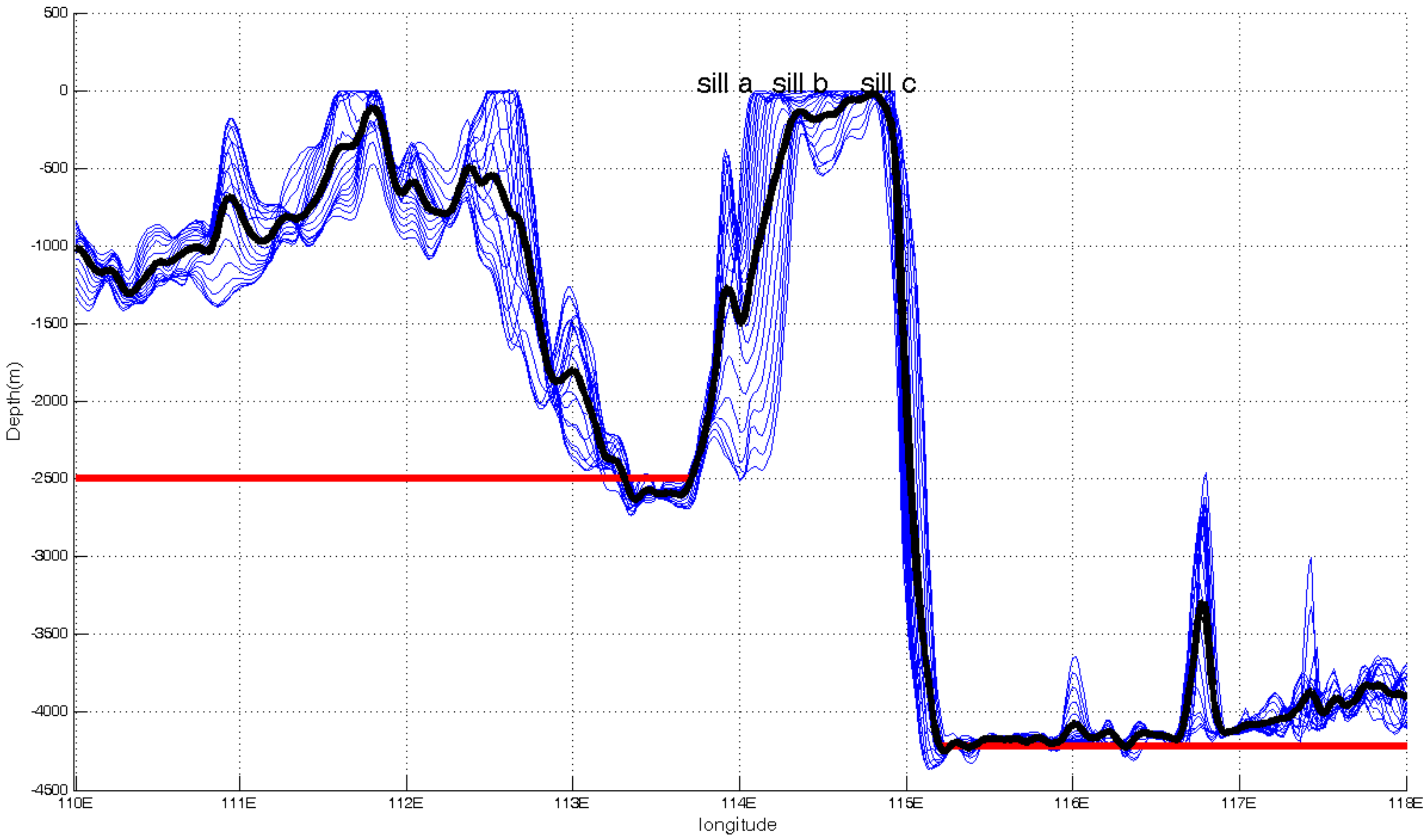
Model forcing:

zonal direction $\boldsymbol{F}_x = \boldsymbol{U}H_0 / H(x, y)\sigma\cos(\sigma t)$

meridional direction $\boldsymbol{F}_y = \boldsymbol{U}H_0 / H(x, y) f \sin(\sigma t)$

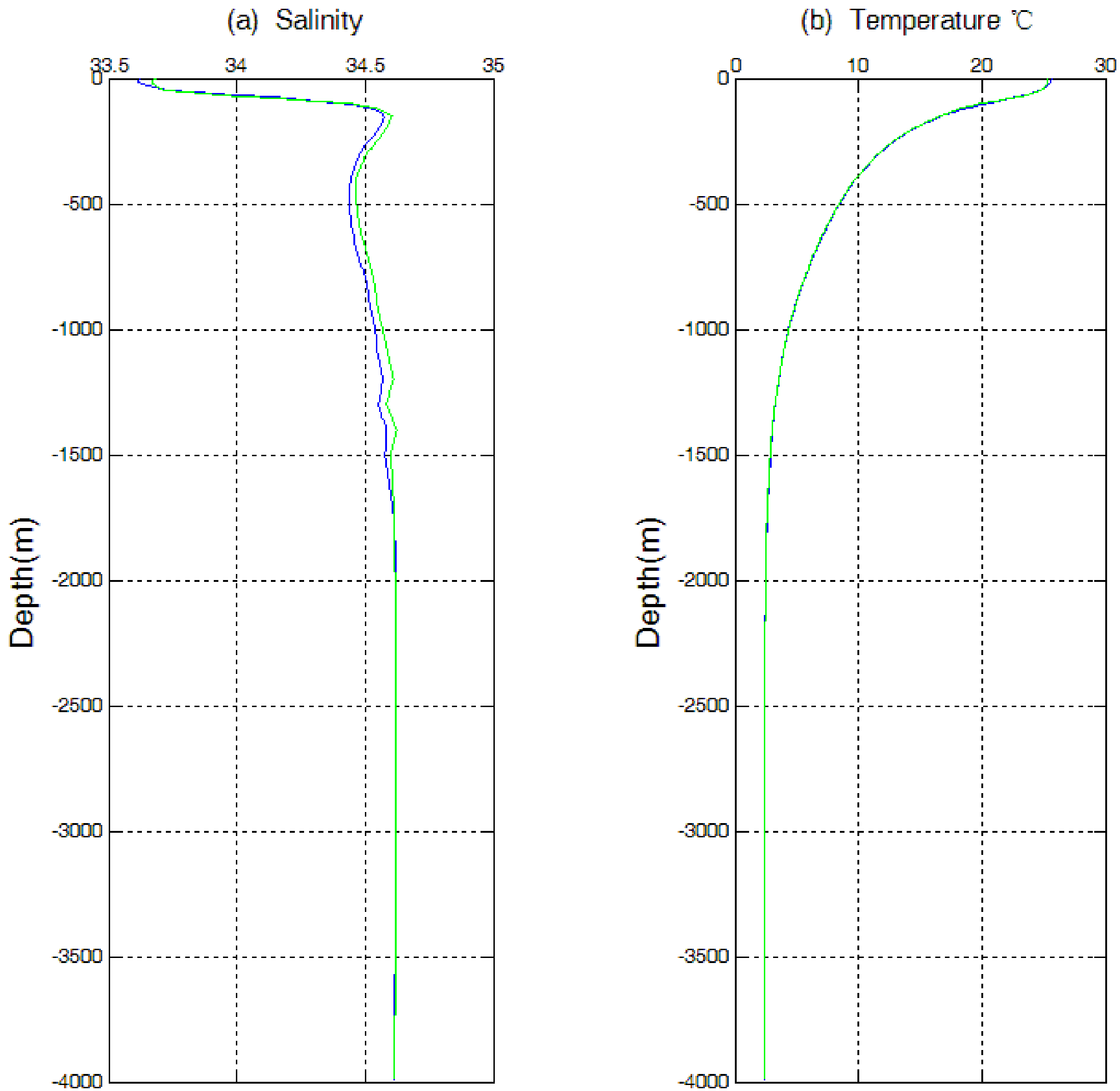
are added to the zonal and meridional momentum balance equations as the external forces.

Topography



Averaged west-eastward transect bathymetry between $16°N$ and $16.3°N$, with the initial topography data from ETOPO1. We set the ocean floor to depth of 2500 m and 4220 m west and east of the ridge.(Red line)

Stratification



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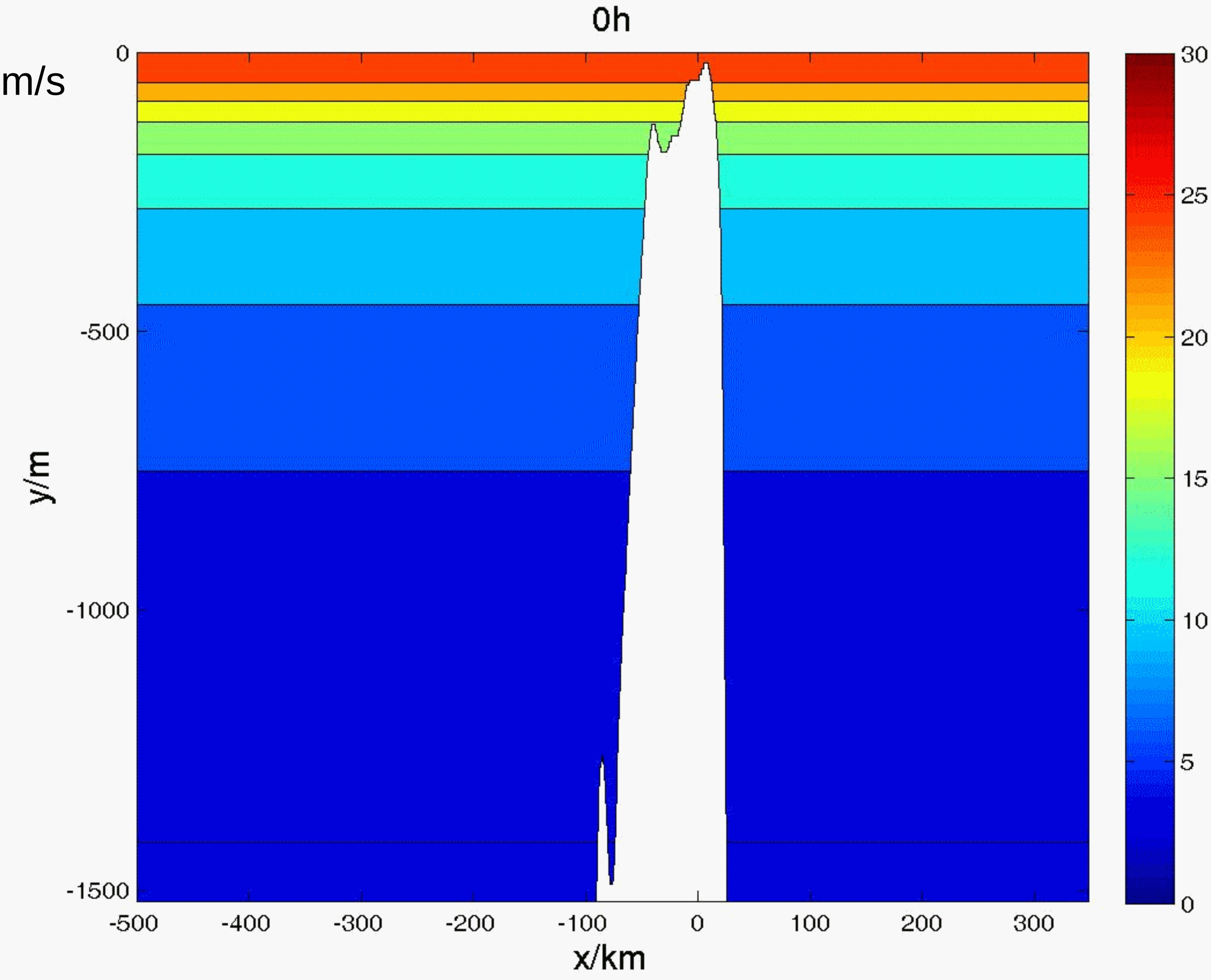
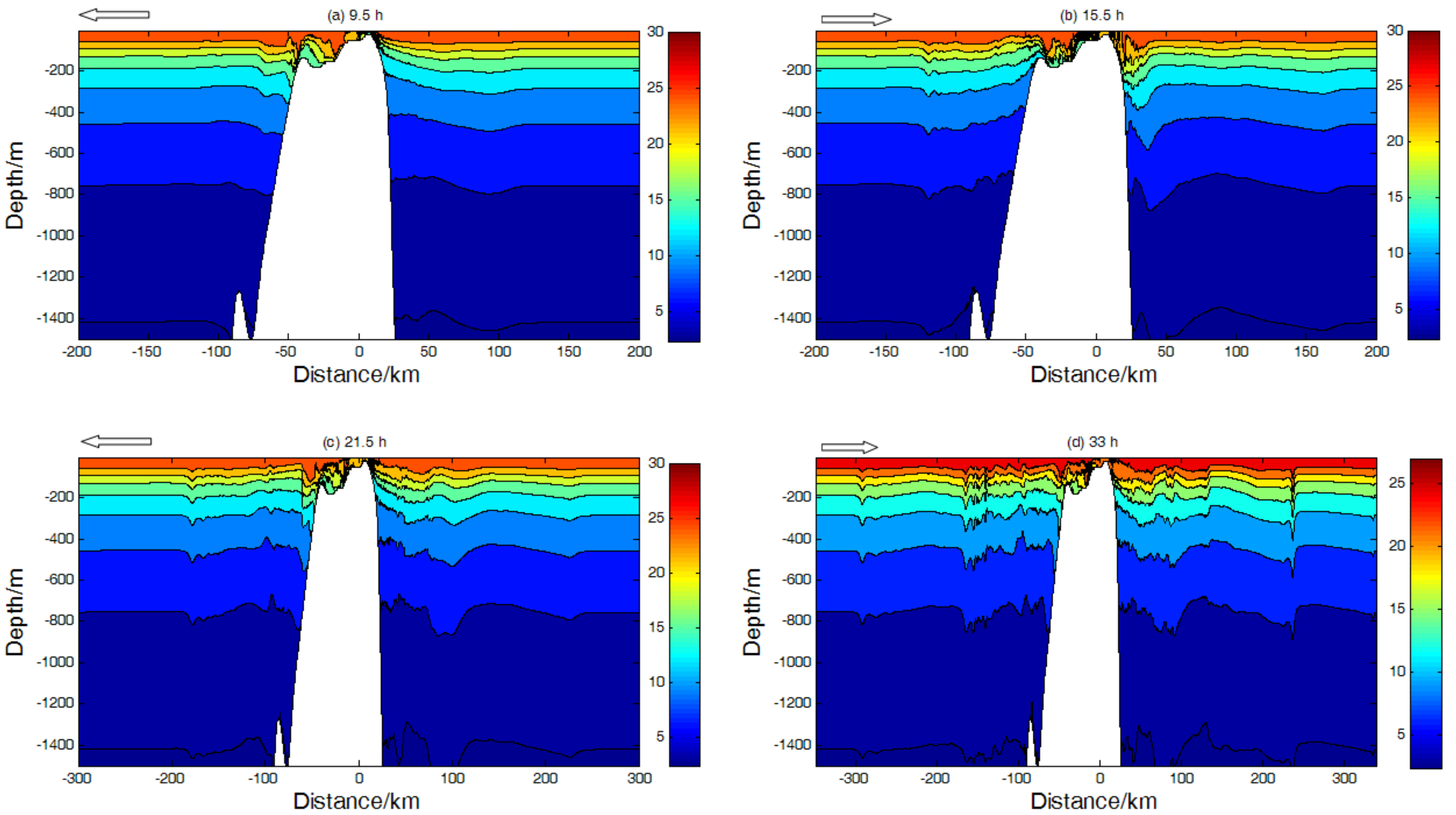
a) Generation process of ISWs

M_2
U=0.024m/s



Four snapshots at different time



b) Generation mechanism of the ISWs

- Two non-dimensional parameters that classify generated baroclinic tides over varying bottom topography by barotropic tidal should be considered : $Fr = \boldsymbol{kU_0} / \sigma$

(1) Froude number : $Fr \succ\succ 1$

a: $Fr \prec\prec 1$ unsteady lee waves

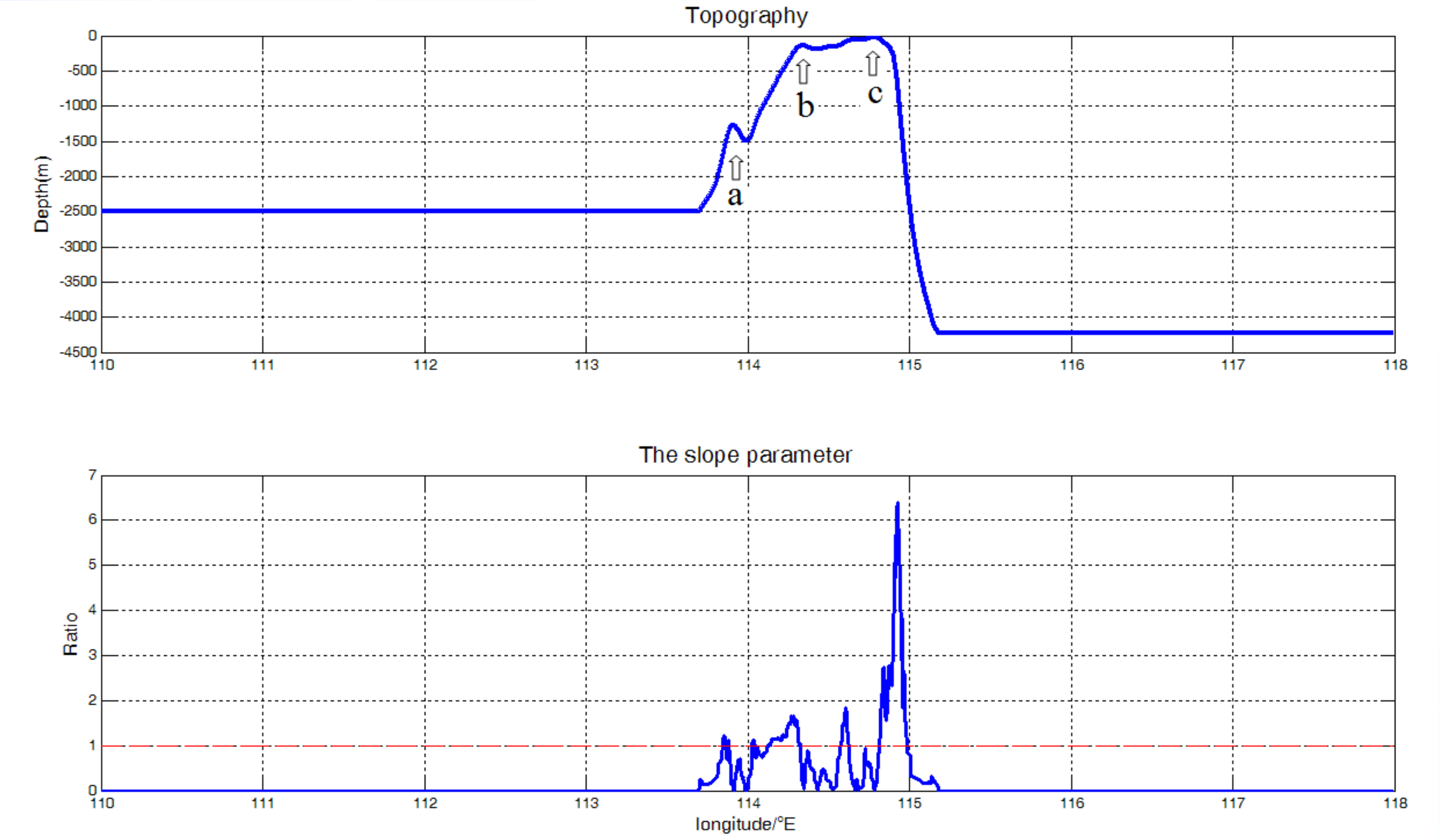
b: $Fr \approx 1$ baroclinic tides

c: mixed tidal-lee waves

In our modelling domain, it has the value in the order of unit around the sill b (≈0.6) and sill c (≈1.5)

(2) The slope parameter: $\gamma = \dfrac{dh/dx}{\sqrt{(\omega^2 - f^2)/(N^2 - \omega^2)}}$

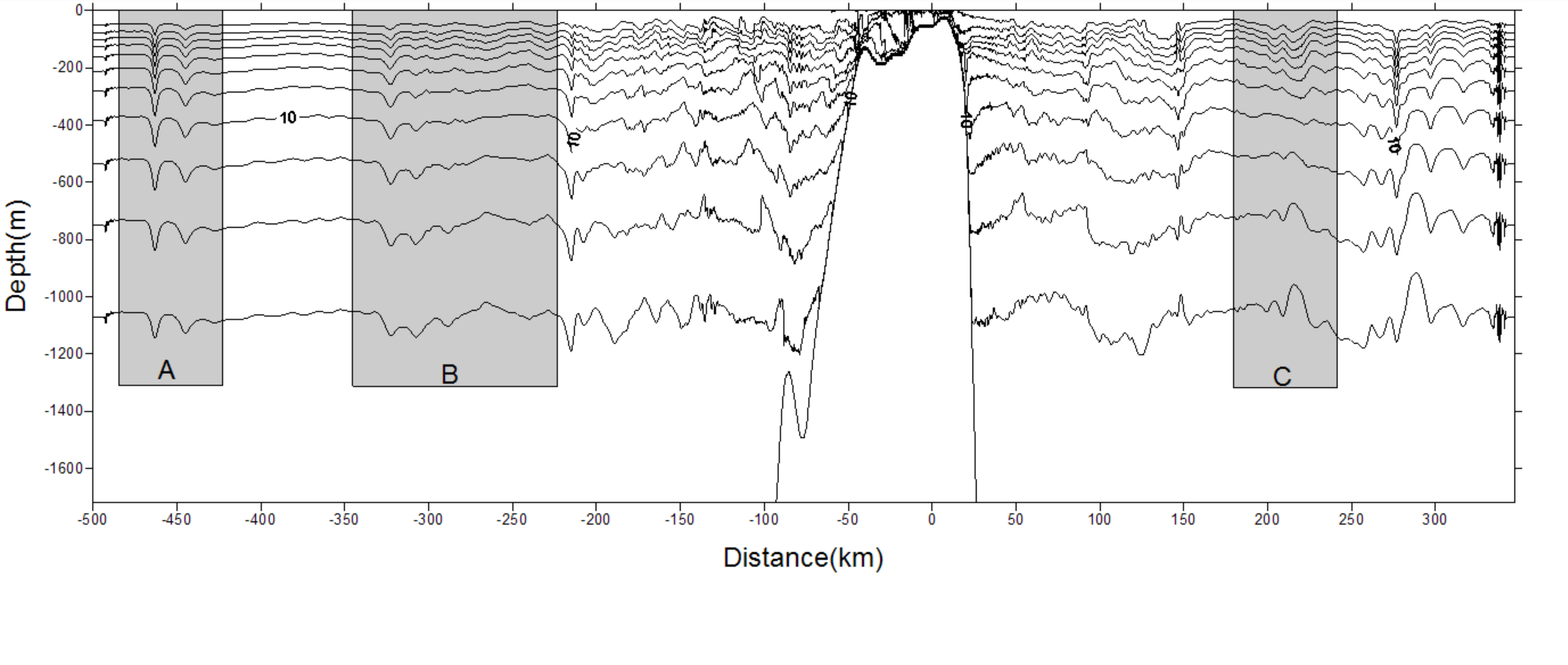
ISWs are not generated when the topography slope is less than critical value even when the Froude number is close to one (Shaw et al., 2009)



Critical and supercritical slopes mainly exist around the three sills.

It can be concluded that the generated waves are mixed lee waves

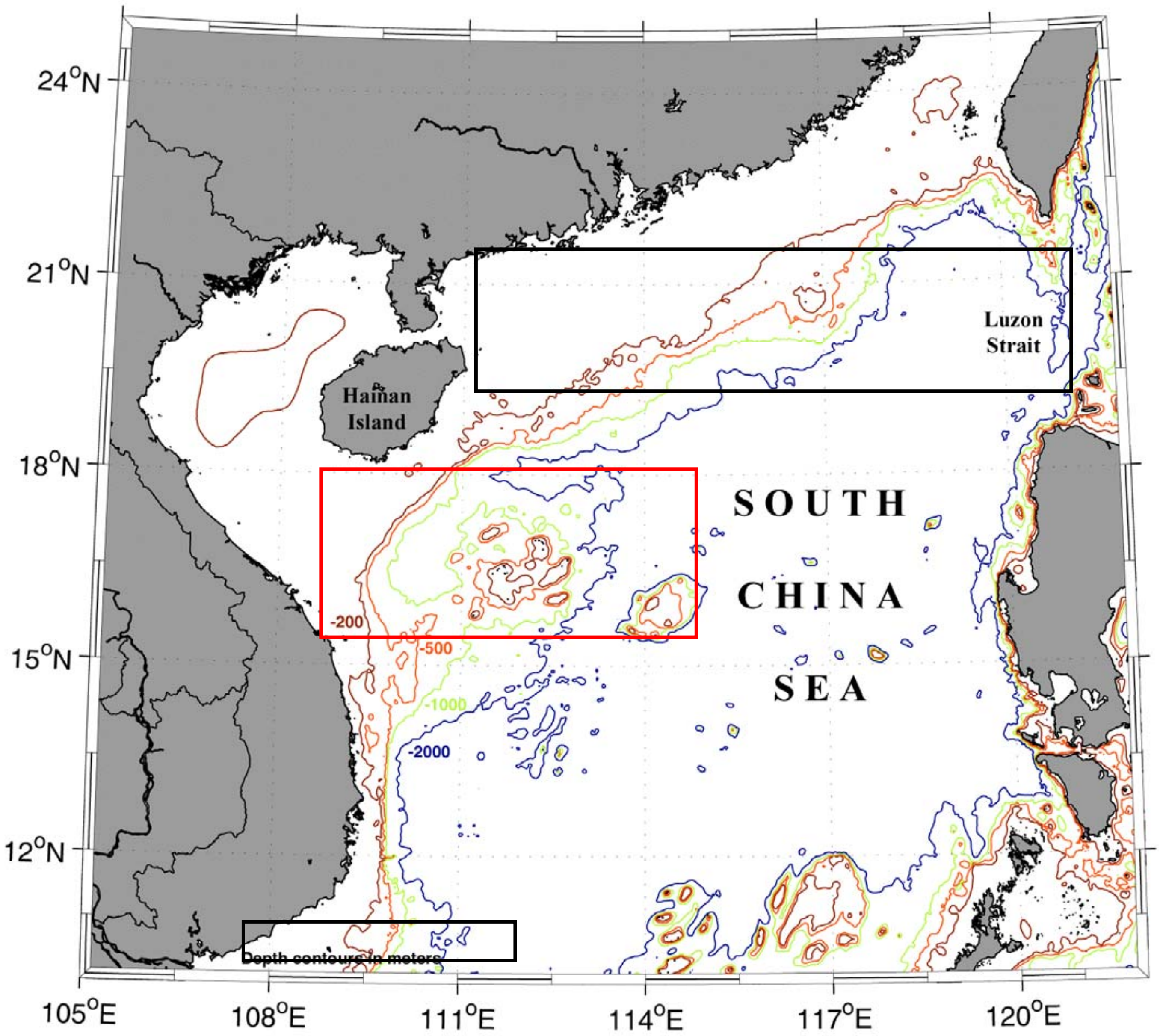
c) Scrutiny of the ISWs



Fragment A : a well-developed packet of solitary waves.
Fragment B : a developing packet of solitary waves of depression in the frontal side and second-mode-type internal waves at its trail edge.

Fragment C : well developed second-mode irregular waves.

Bathymetry of the South China Sea([Smith and Sandwell, 1997])



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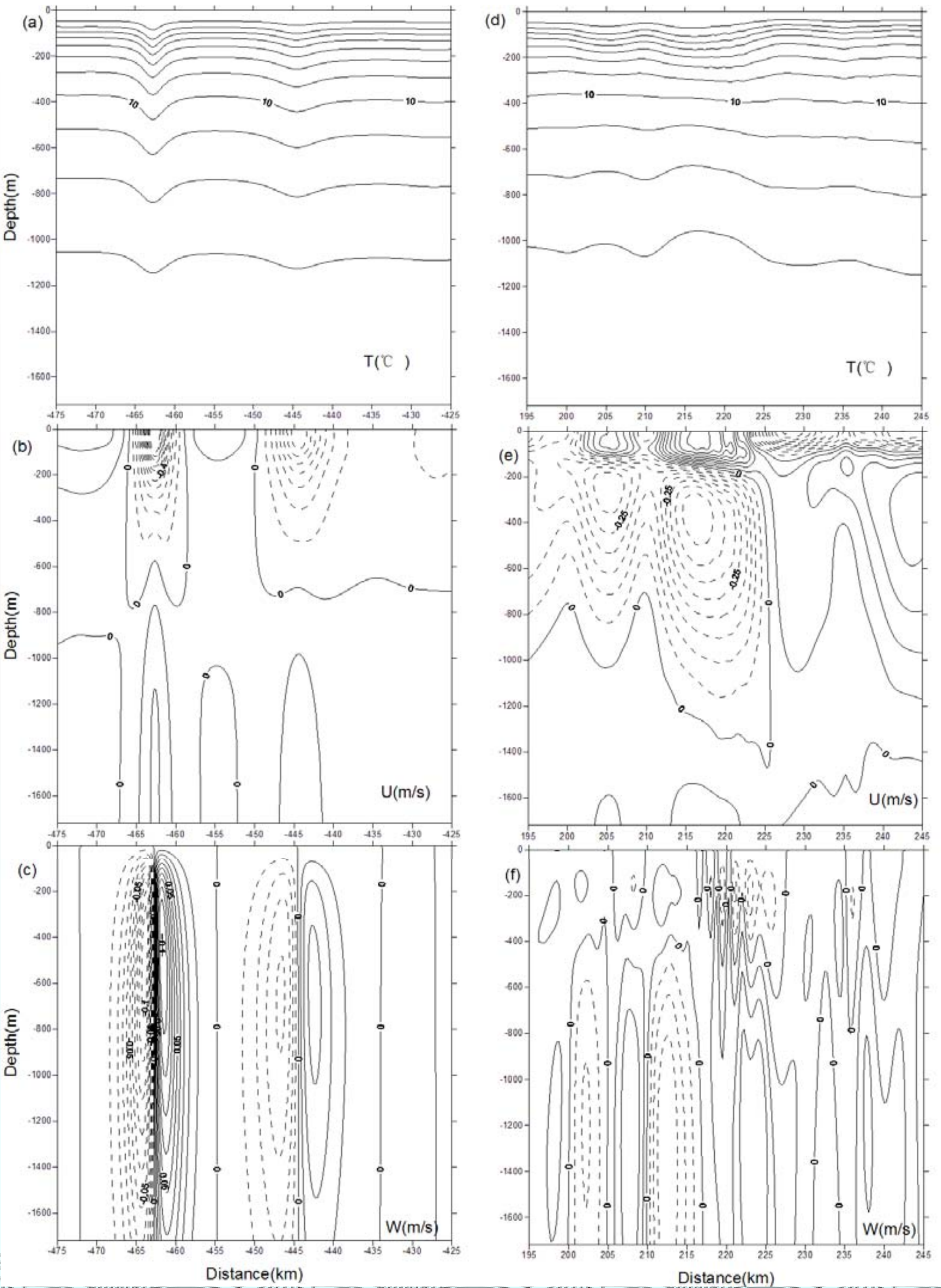

Figure (a) shows fragment A in greater detail, corresponding horizontal and vertical velocity are shown in Figure b and c, respectively.

The isotherm displacements along with horizontal and vertical velocity fields of fragment C are shown in figure d, e and f, separately.

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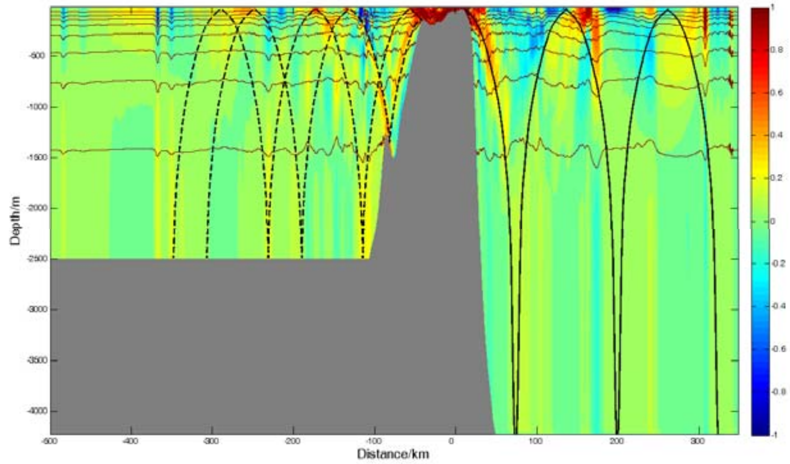
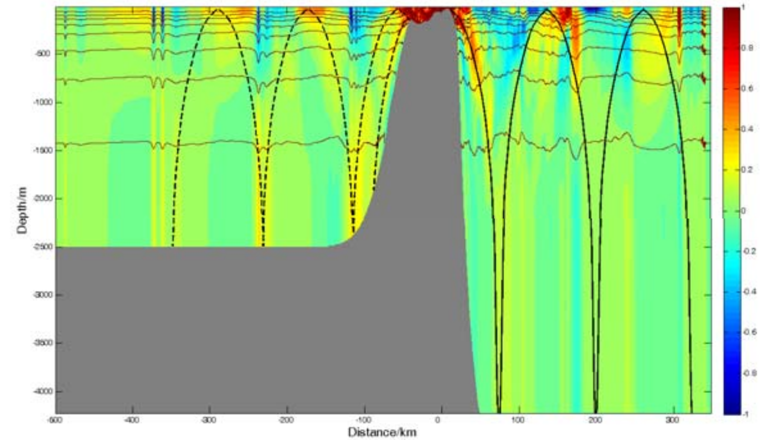
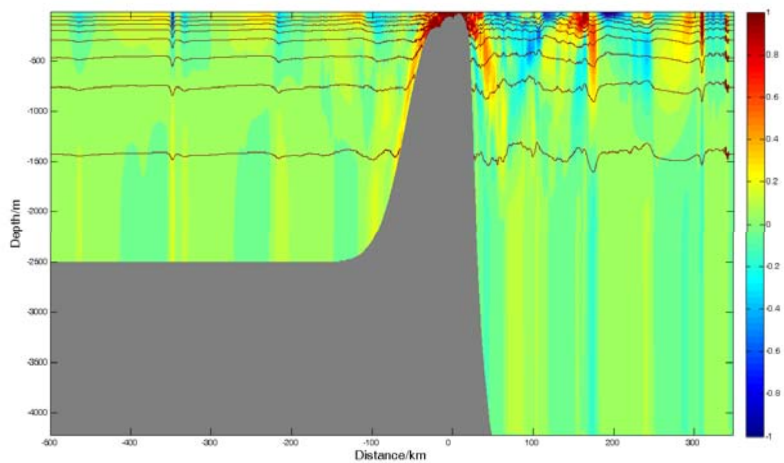
Change of topography



A



B



C

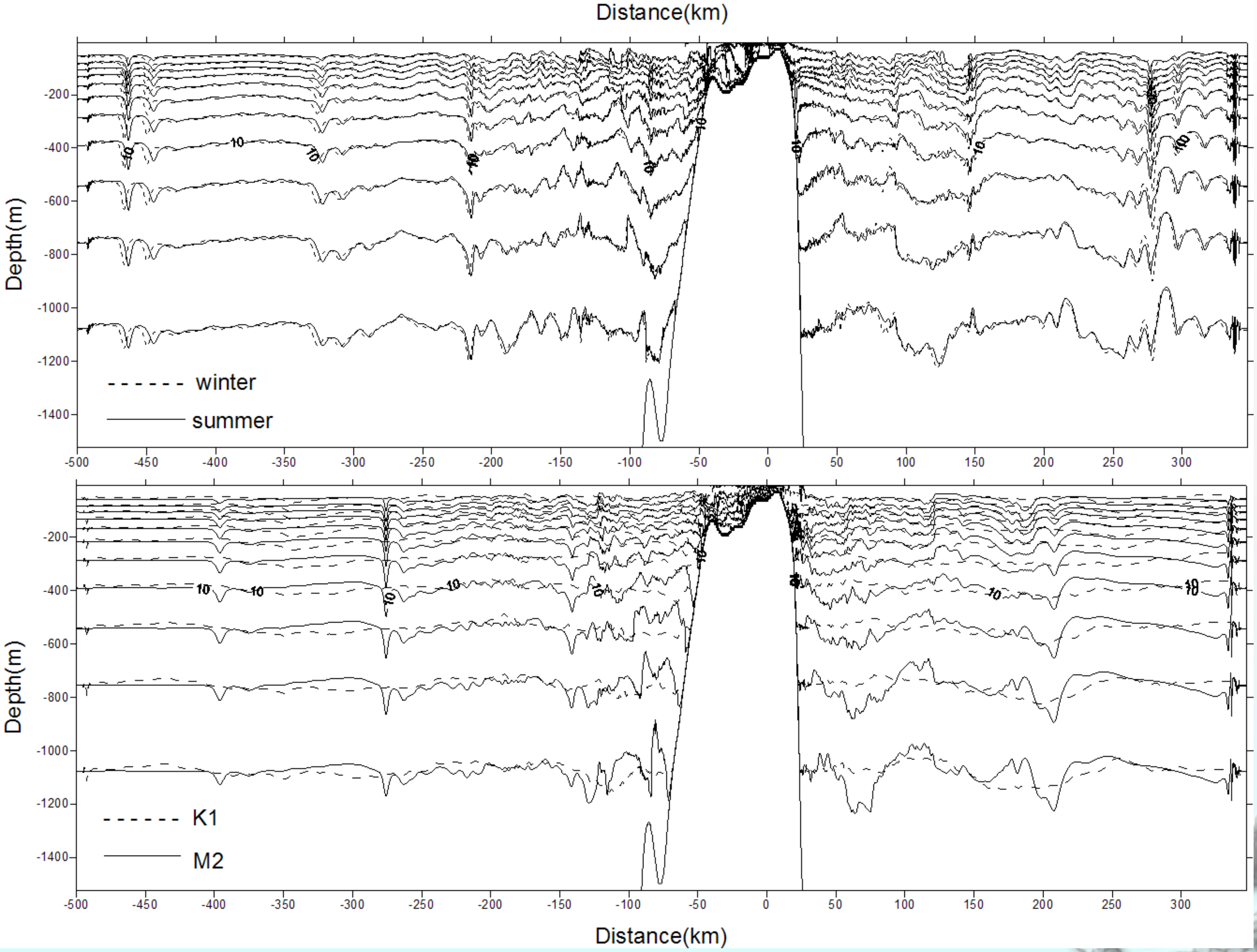
a) Beam paths are calculated from the initial stratification.

A: reference experiment

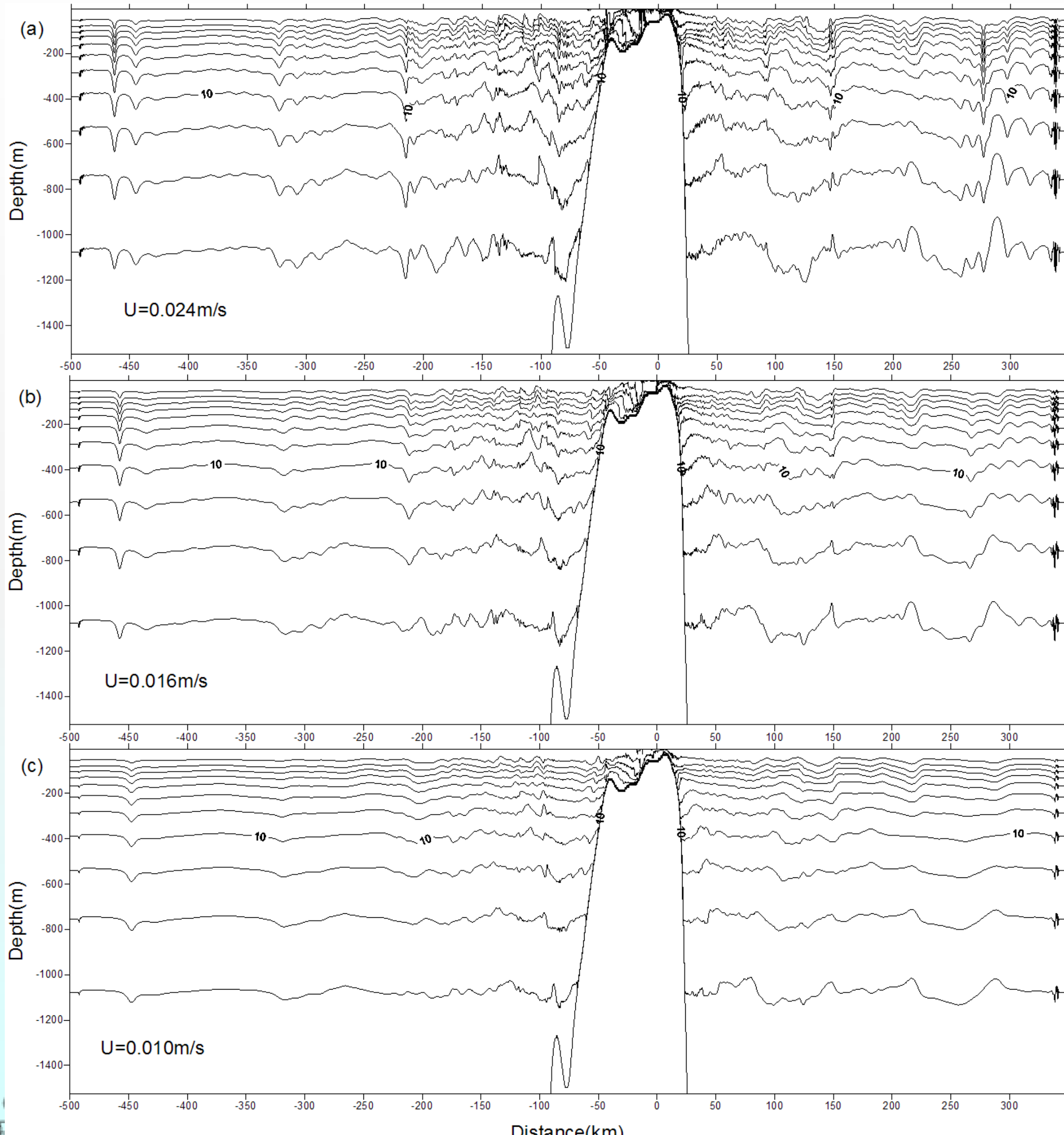
B: sill a removed

C: both sill a and sill b removed

Stratification and tidal component



The barotropical tidal forcing



The amplitudes of ISWs decrease with the reduction of the barotropical tidal forcing.

Conclusions

1. The generation of internal waves in this area is subject to mixed lee wave
2. The ISWs on the west side of these sills are generated from both sill b and sill c, while the sill a only acts as the role of intensifying nonlinearity of these internal waves and generating higher internal wave modes.
3. The ISWs on the east side of these sills can only be generated from sill c.
4. The stratification, tidal component and the strength of the barotropical tidal forcing has influences on the generation internal waves.

Thanks for your attention!