Modeled Acoustic Propagation Through Measured Large Depression Internal Waves In Northern South China Sea

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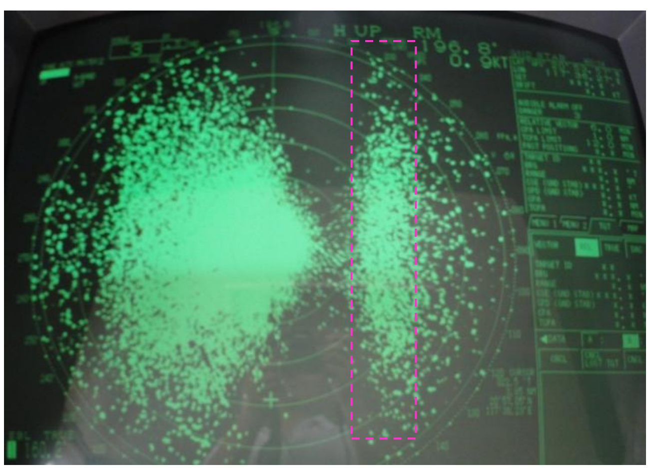
Brief Outline

- In-situ measurements of trains of nonlinear internal waves in northern South China Sea (SCS) were done in the SCS.
- An acoustic propagation model based on ray theory was applied to the calculation of transmission loss (TL) associated with a large depression measured internal waves.
- The TL was computed using the model considering:

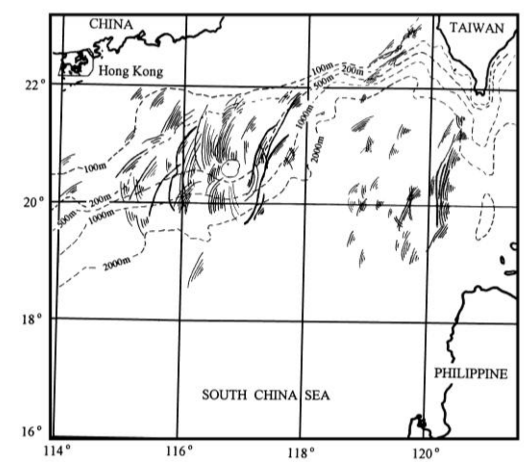
  (1) range-dependent and range-independent environmental scenario;

  (2) for different sources and receiver depth configurations.
- Preliminary results are presented from analysis of the modeled mid-frequency sound propagation through the measured large-amplitude nonlinear internal solitary waves.
- This presentation includes several interesting aspects of influence of internal waves on acoustic propagation, such as refraction, reflection, "shadow zones” and transmission loss.

(The breaking zone from breeze to calm sea was photographed on board the anchored *R/V Dongfanghong 2*)

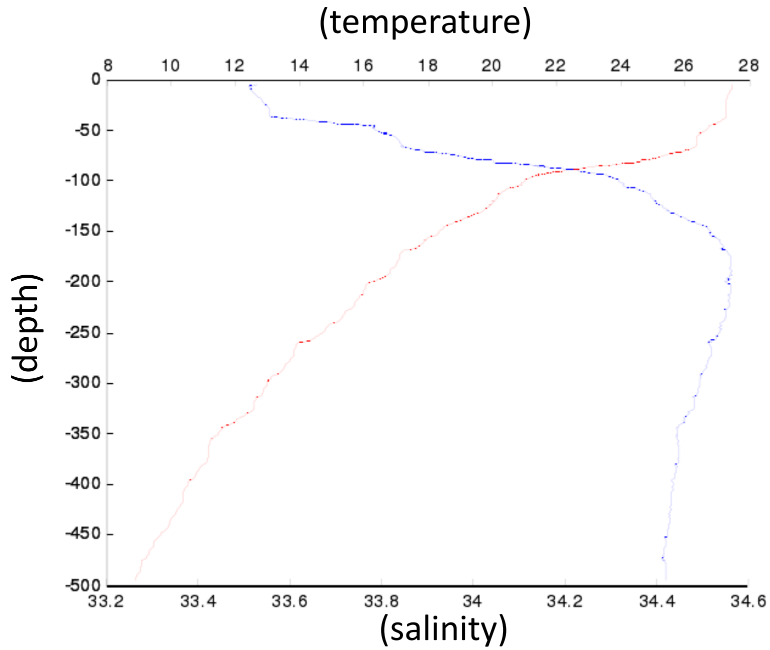


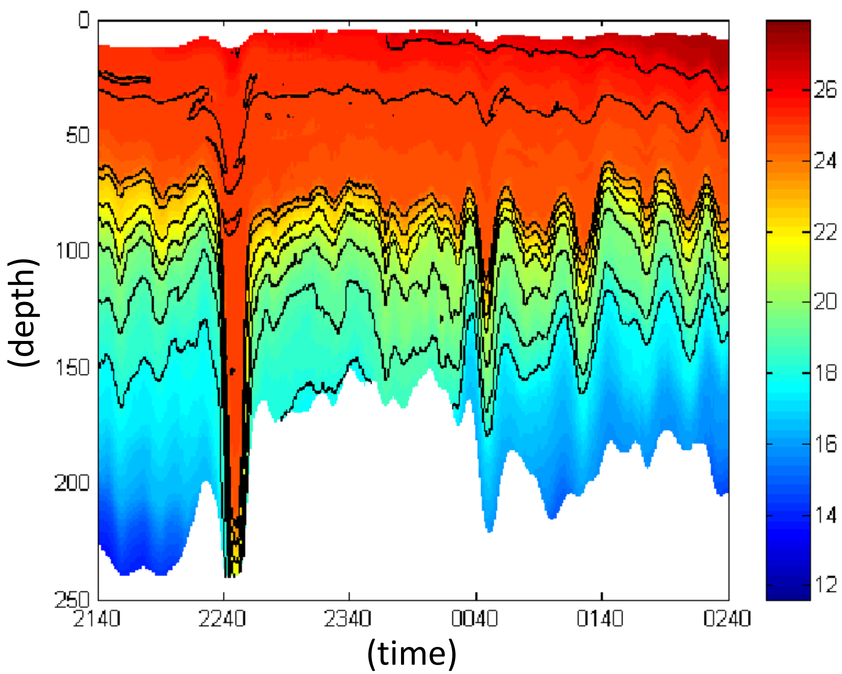
(The ship’s radar scanned the sea)

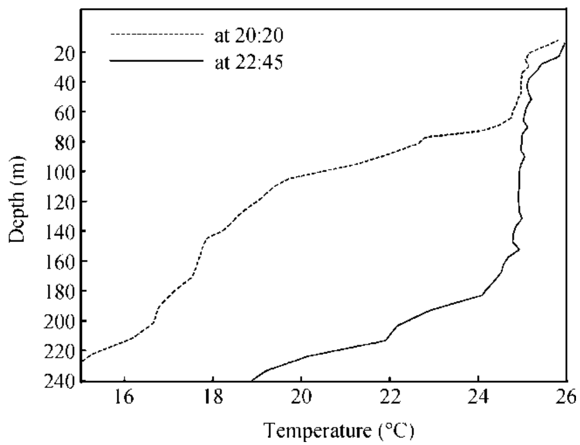


(from Hsu et al., 2000)

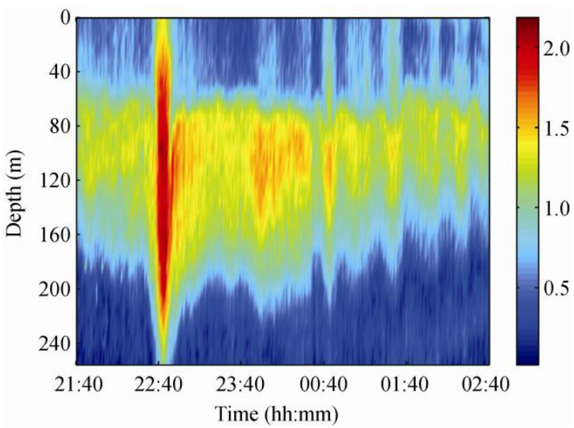
Thermistor chain measurements of the nonlinear internal waves from the anchored R/V ship

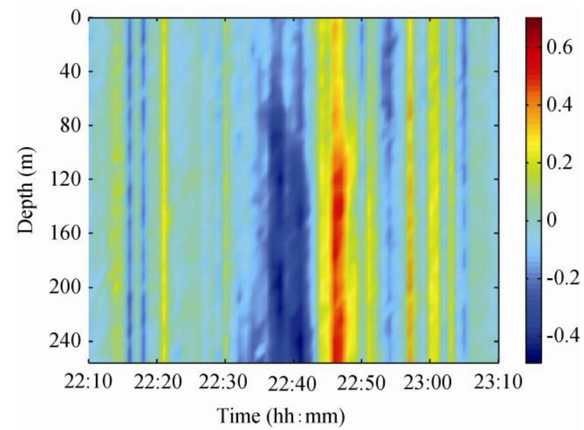






Temperature profiles with (at 22:45) and without (at 22:20) the soliton in place





Magnitude of the horizontal (left) and vertical (right) velocities of the nonlinear internal waves

Acoustic Model Based on Ray Theory

$$\frac{d}{ds}\left[\frac{1}{c(r,z)}\frac{dr}{ds}\right] = -\frac{1}{c^2(r,z)}\nabla c(r,z)$$

$$\xi = \frac{\cos\theta}{c} \qquad \zeta = \frac{\sin\theta}{c}$$

$$\frac{dr}{ds} = c\xi(s) \qquad \frac{d\xi}{ds} = -\frac{1}{c^2}\frac{dc}{dr}$$

$$\frac{dz}{ds} = c\zeta(s) \qquad \frac{d\zeta}{ds} = -\frac{1}{c^2}\frac{dc}{dz}$$

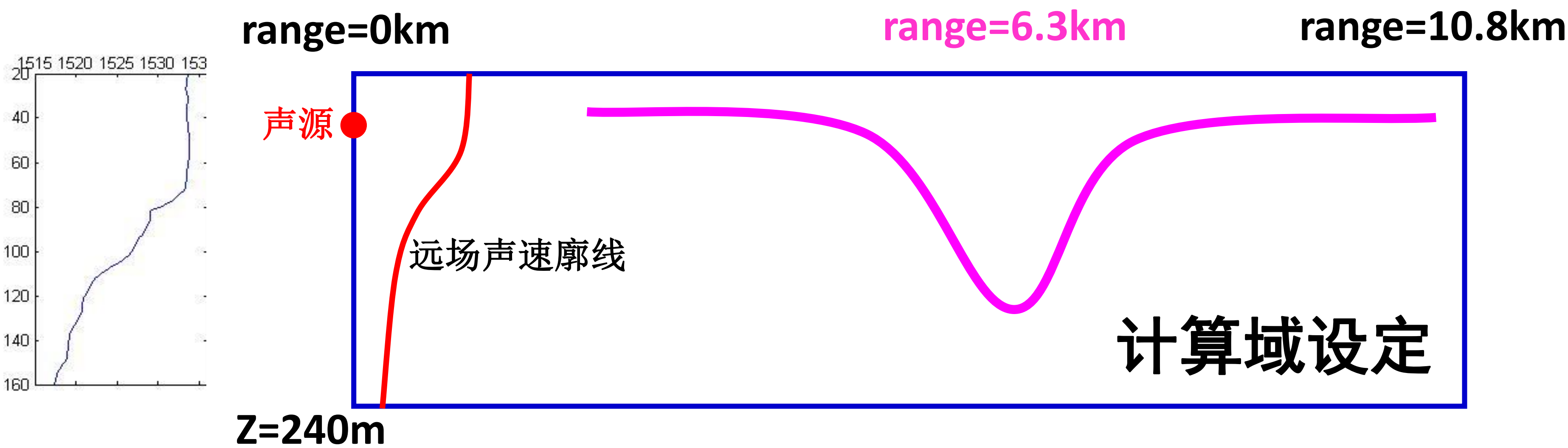
$$\frac{d\tau}{ds} = \frac{1}{c(s)}$$

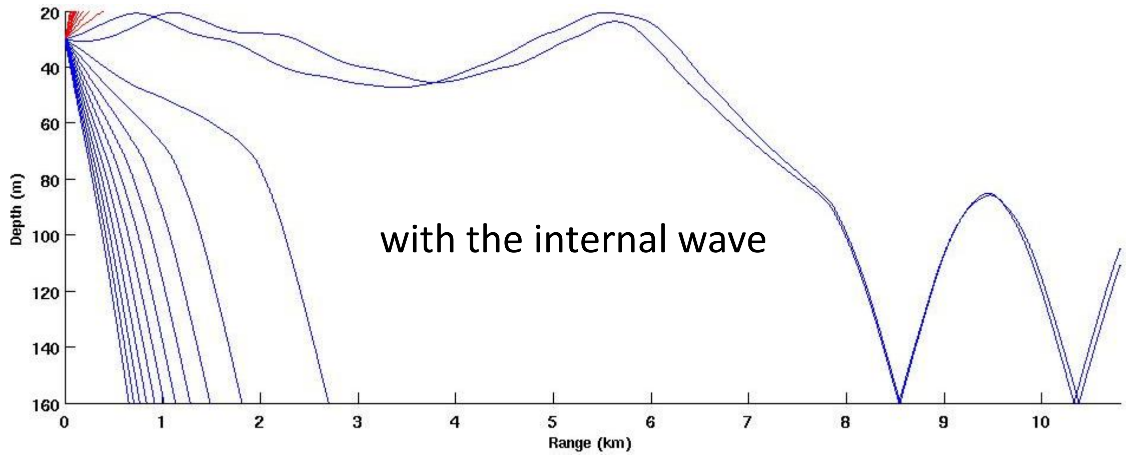
$$\tau(s) = \tau(0) + \int_0^s \frac{1}{c(s')}ds'$$

$$p_c(r,z) = \sum_{j=1}^{N} p_j(r,z)$$

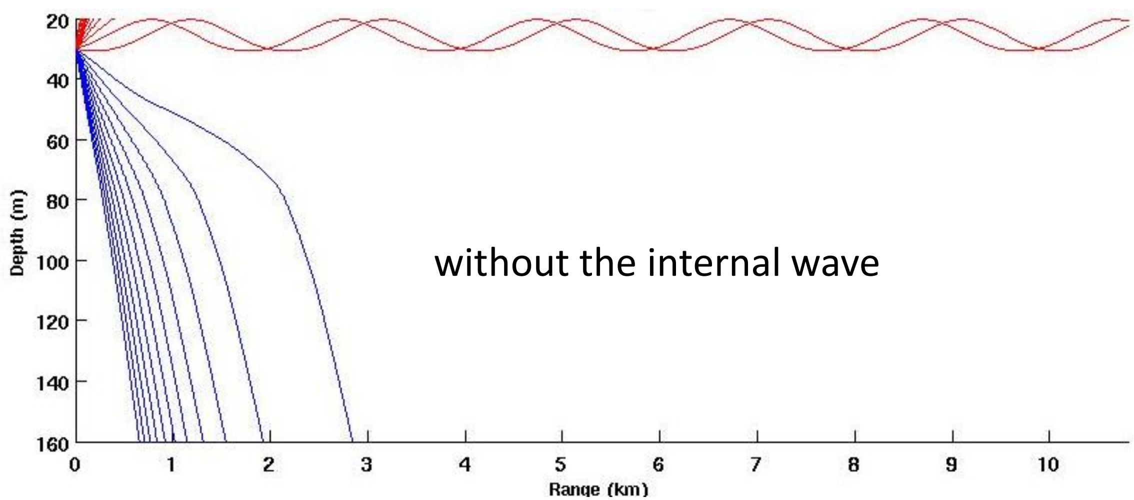
$$TL = 20\log\left|\frac{p_c(r,z)}{p_c(r,z)_{r=1}}\right|$$

The Configuration





20
40
60
80
100
120
140
160
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Range (km)
with the internal wave



20
40
60
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Depth (m)
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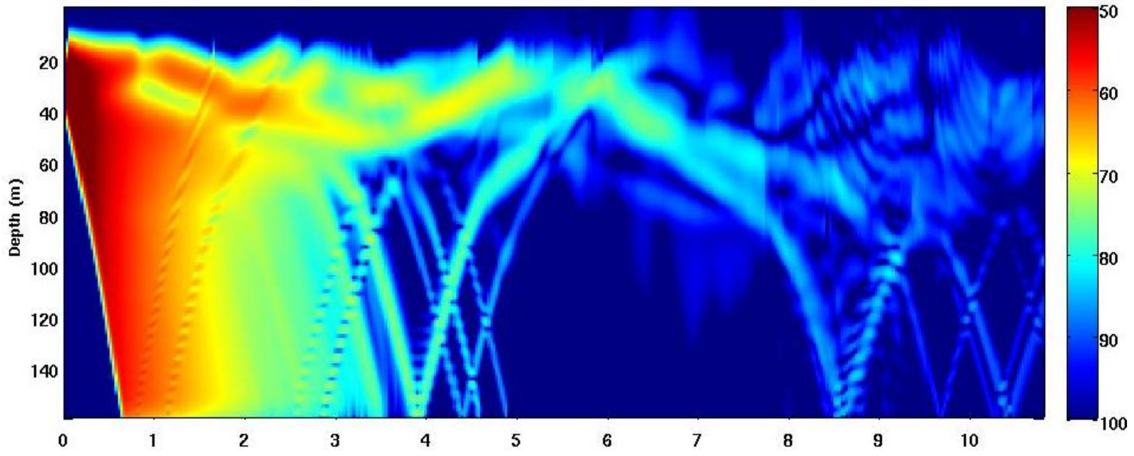
10
Range (km)
without the internal wave



Corresponding propagation loss predictions, both with and without the IW present are given. The downward refraction of ray paths and the multi-reflection of the seabed and the ranges correspond to the "shadow zones" are seen.

The purpose of this study is to investigate the fundamental effects of the IW on propagation

IWs are present in deep ocean as well as in marginal coastal areas. As the IWs oscillate underwater, they are potentially dangerous for submarines, off-shore platforms and ships.

Thank you