Horizontal reflection of a low-frequency sound signal from a moving nonlinear internal wave front

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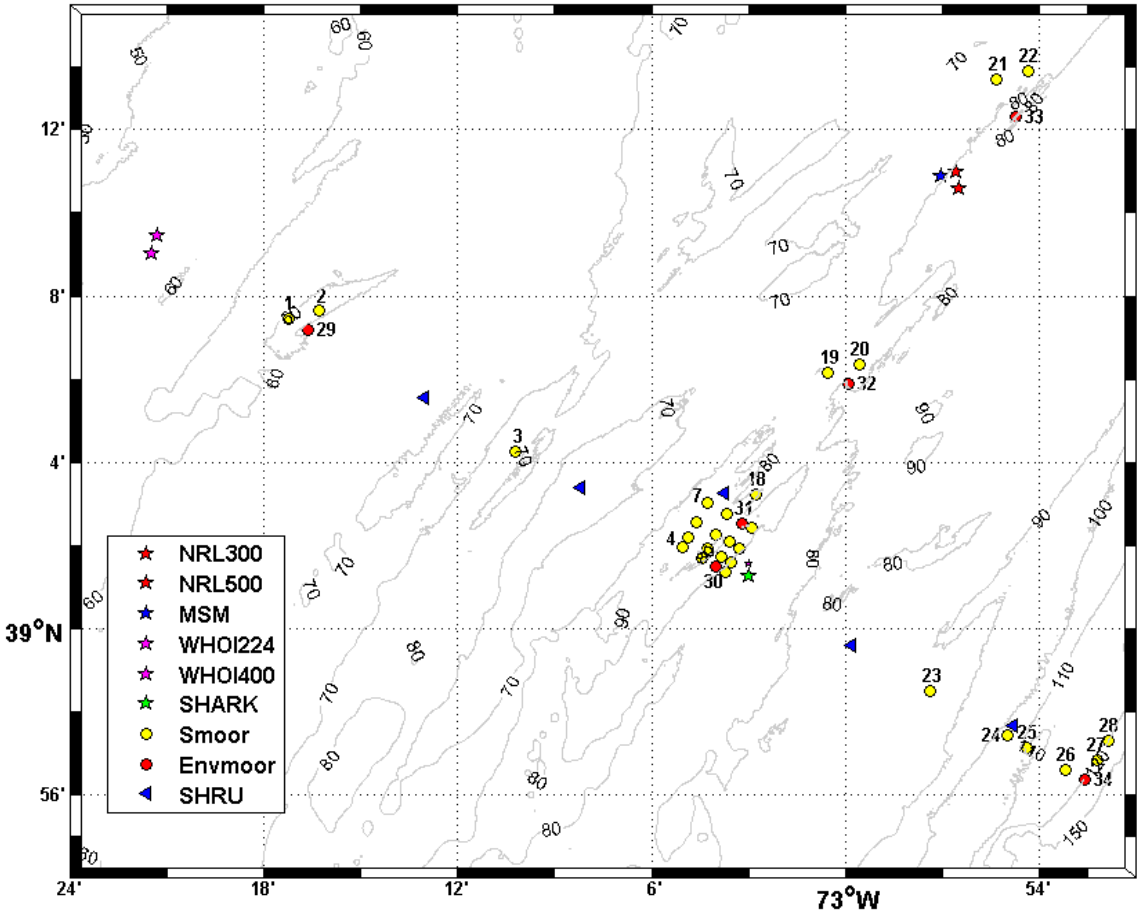
159 ASA meeting in Baltimore

April 22, 2010

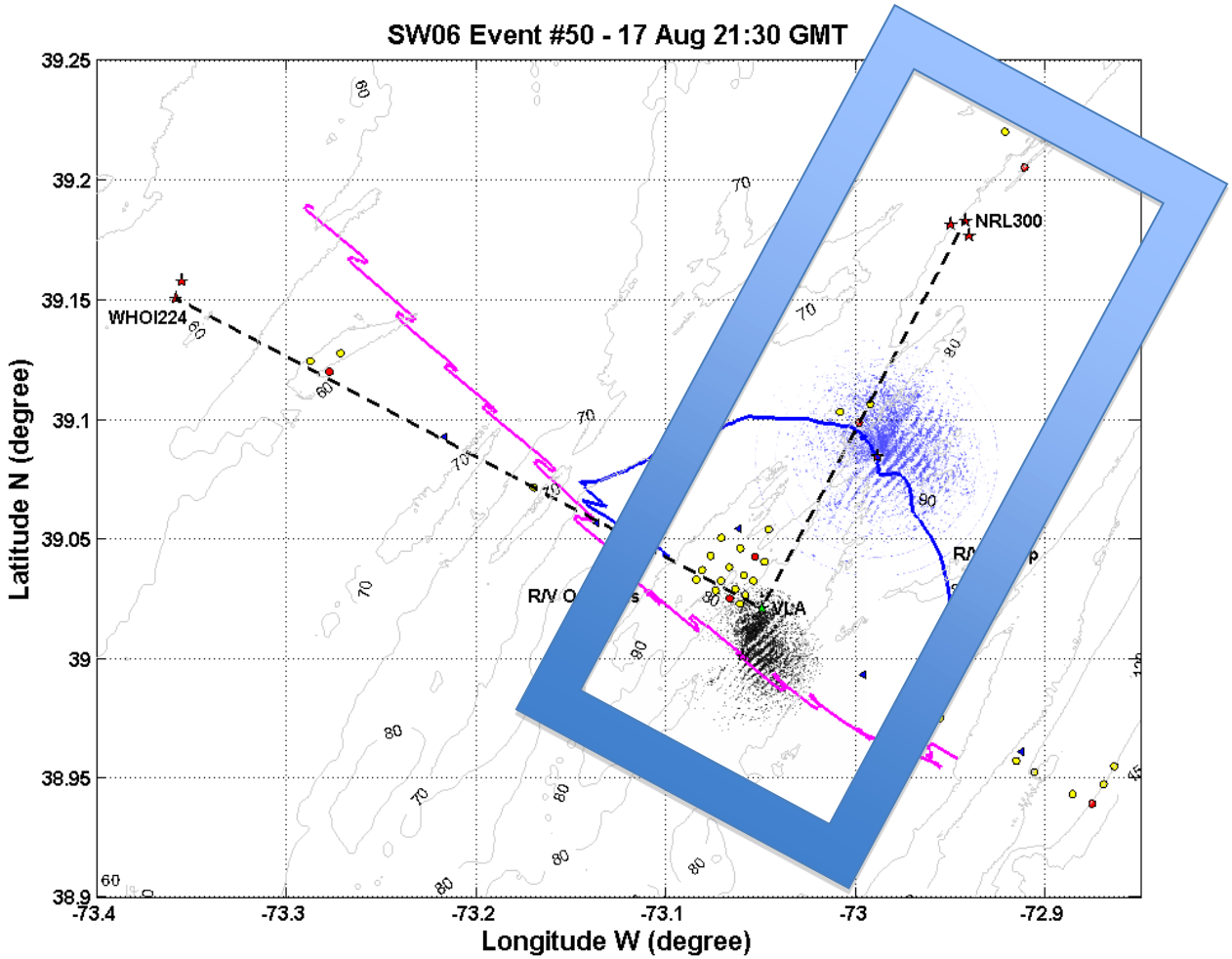
Outline

- Observation
- Modal picture
- Theory
- Discussion
- Summary

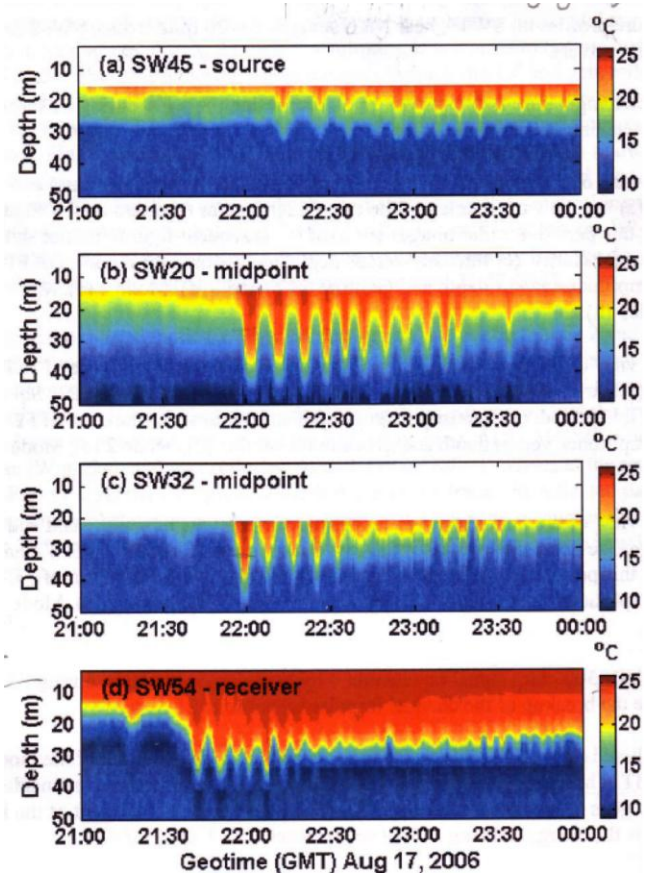
SW06 experiment, fixed source-receiver, IW Event 50

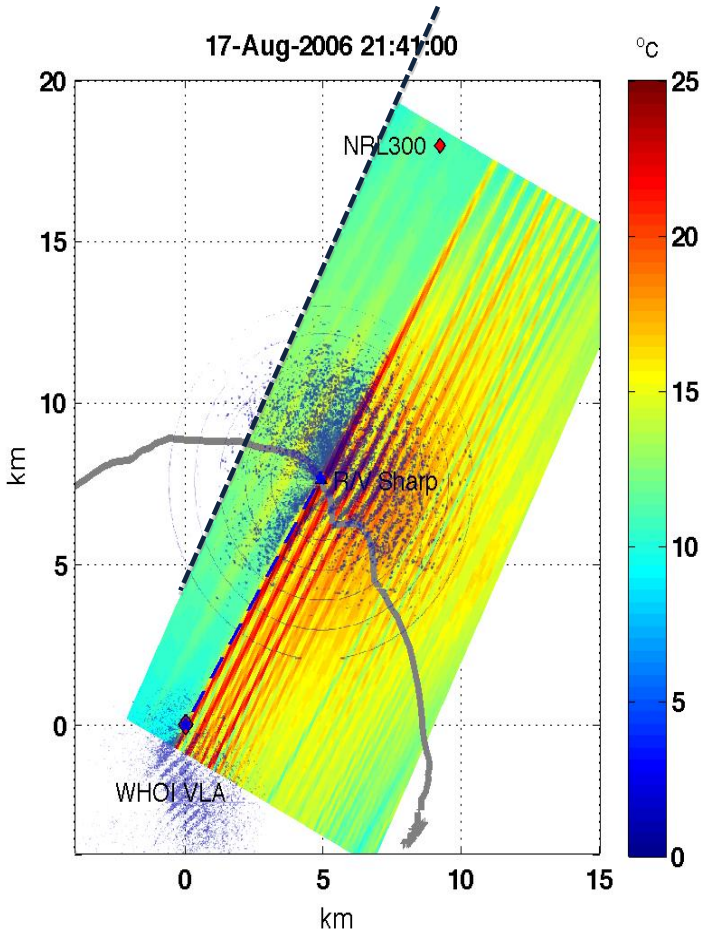


Source-receiver configuration



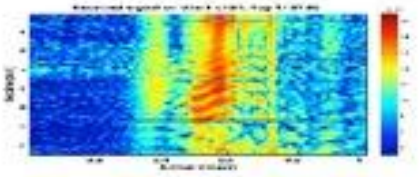
Environment re-construction



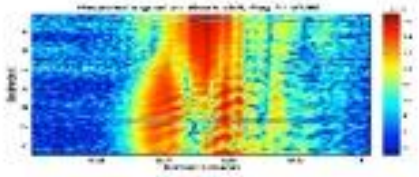


Hydrophones in depth

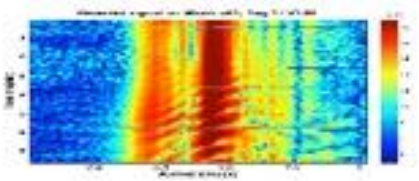
13.5 m



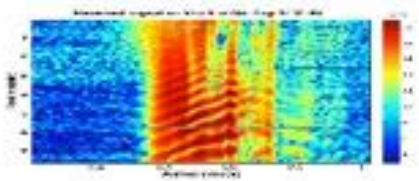
42.25 m



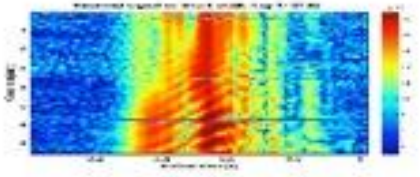
24.75 m



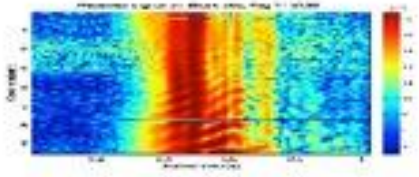
54.75 m



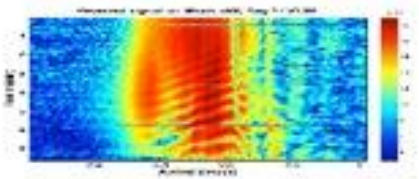
28.5 m



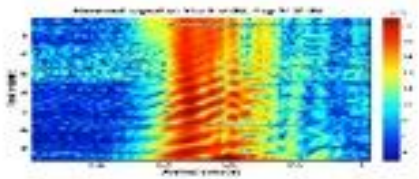
62.25 m



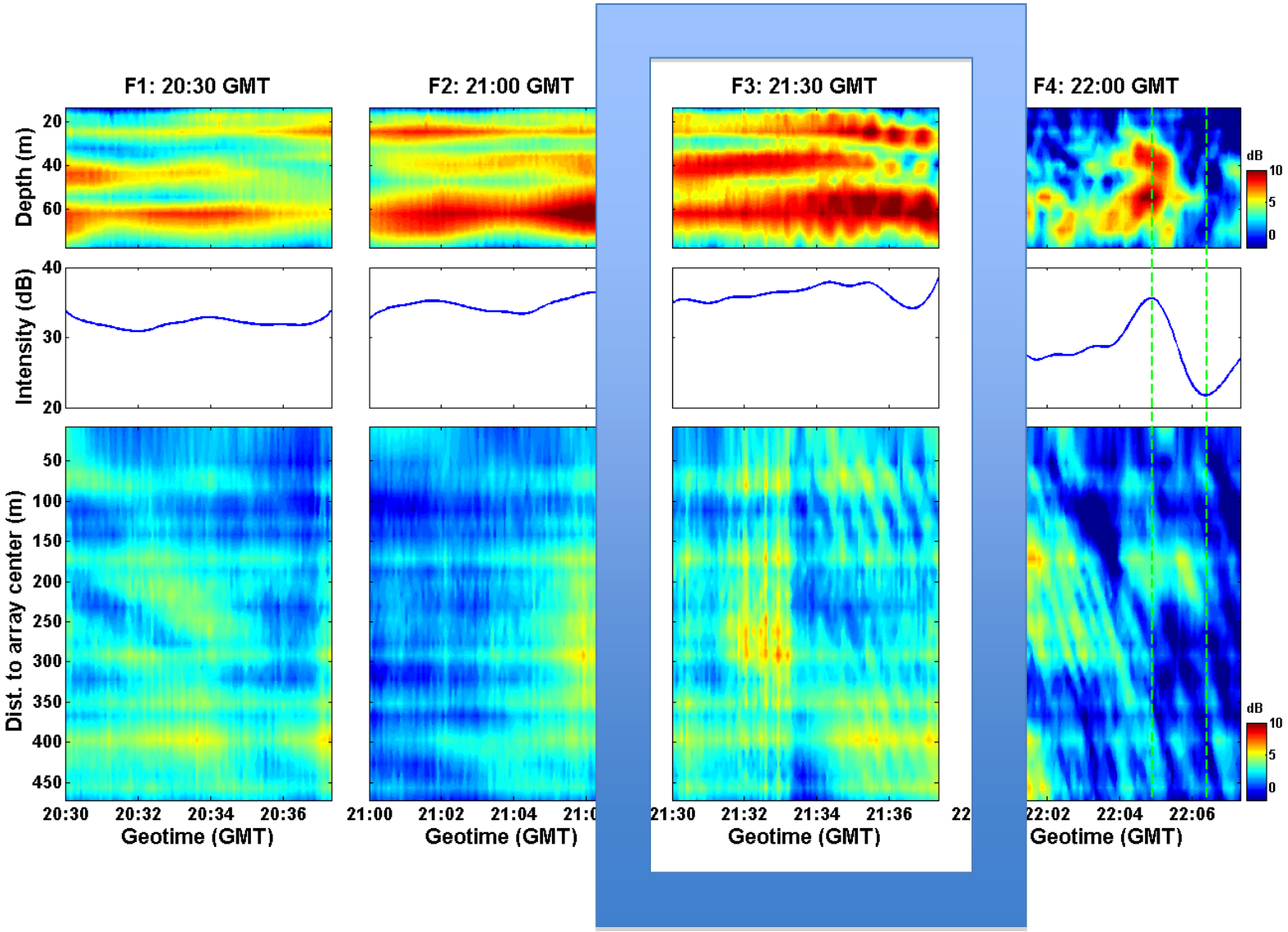
39.75 m



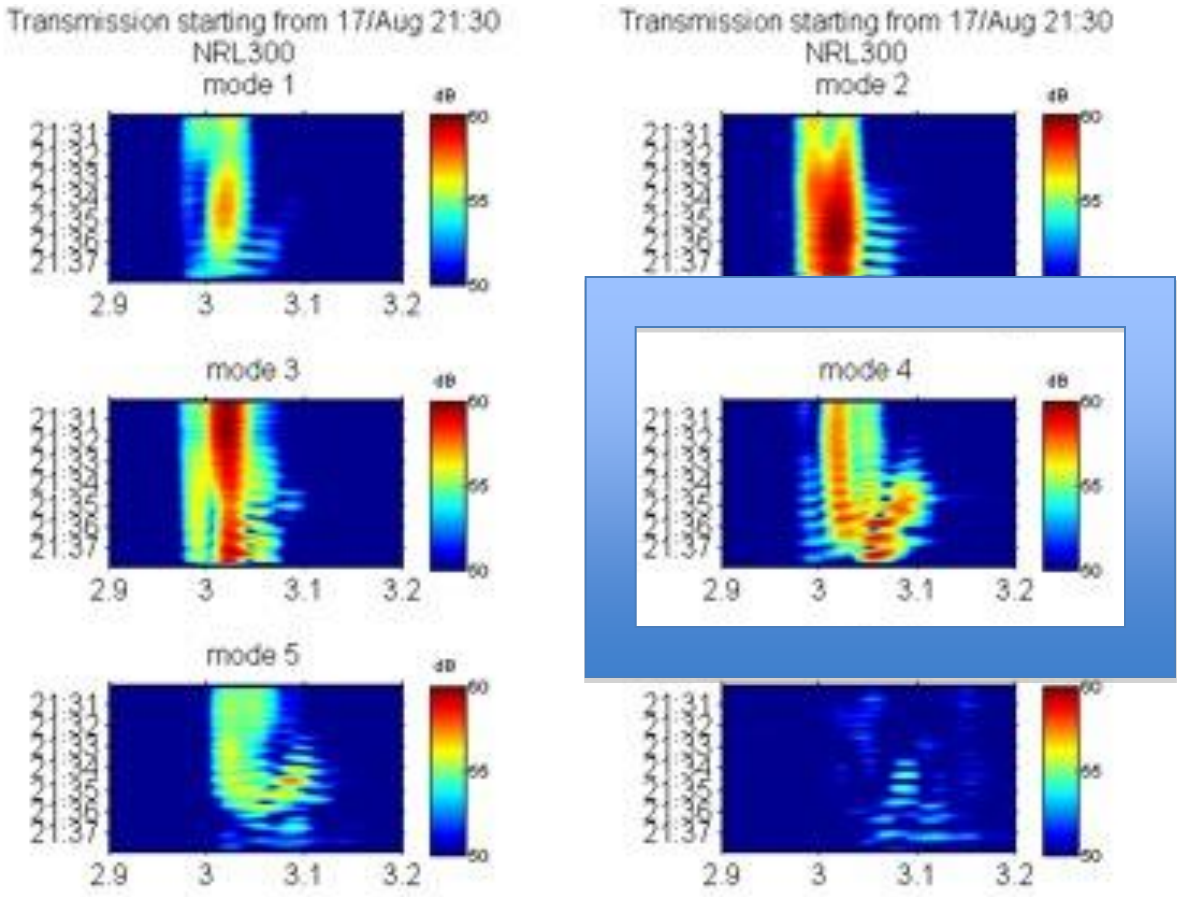
69.75 m



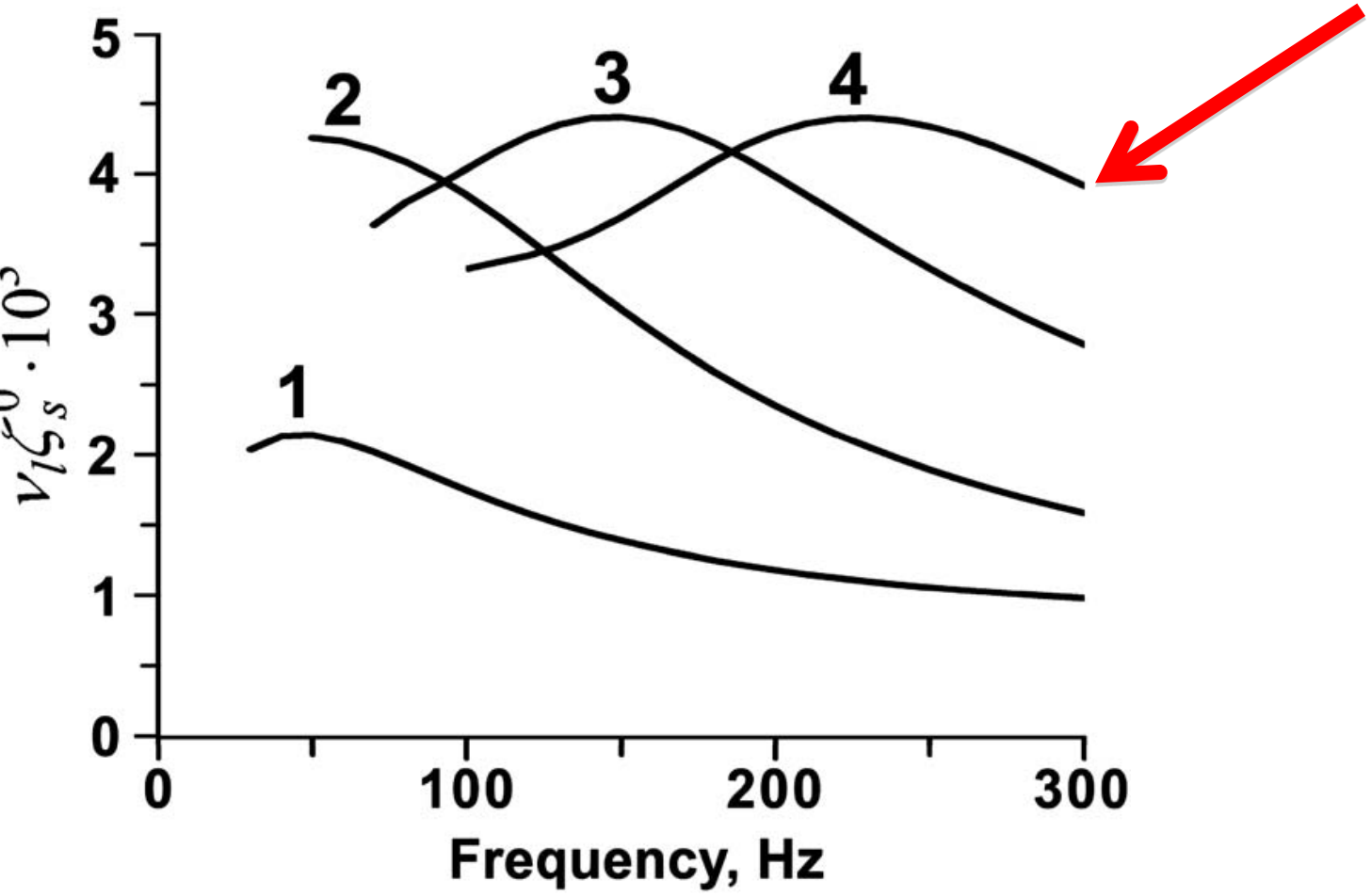
VLA & HLA for 4 Transmissions 7 mins each



Mode filtering

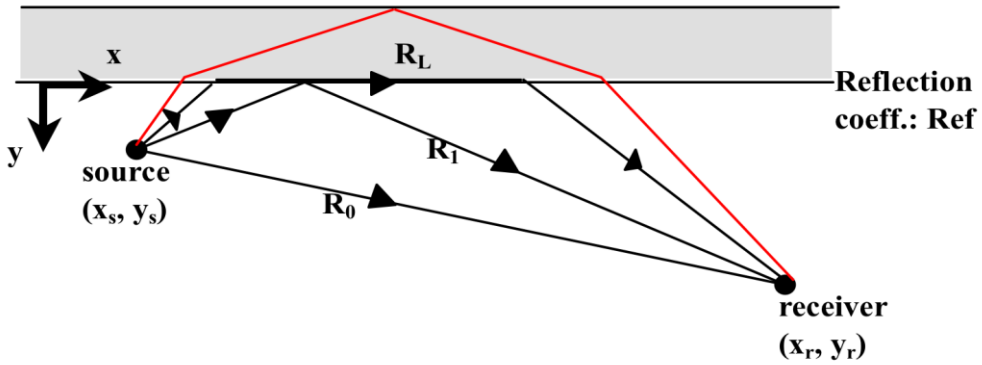


Frequency dependent index of refraction

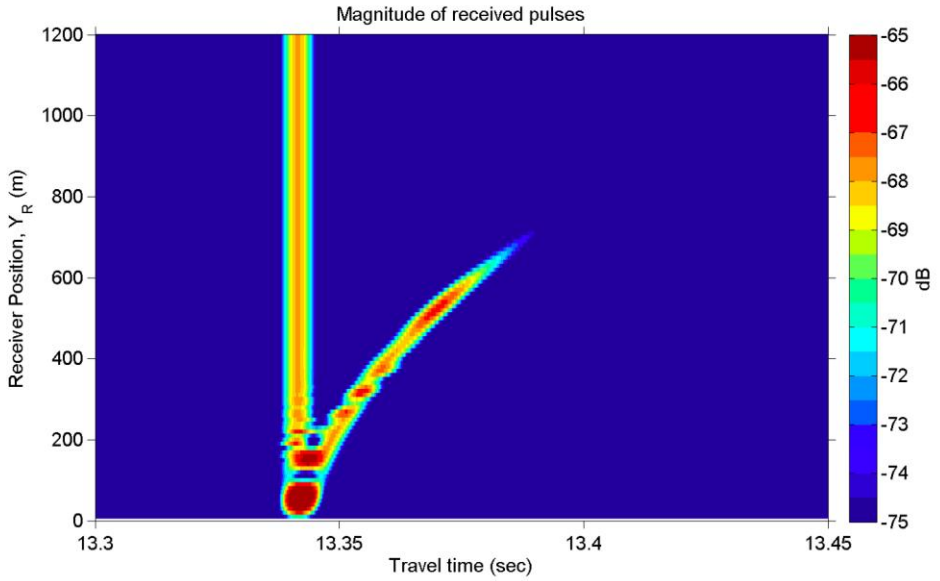


Badiey, Katsnelson, Lynch, Preselkov “Frequency dependence and intensity fluctuations due to shallow water internal waves” JASA 122(2), 2007

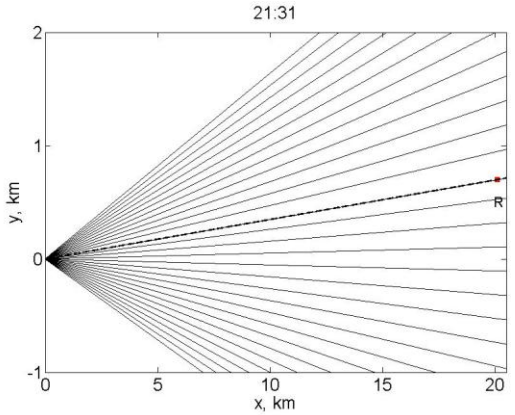
Simple theory



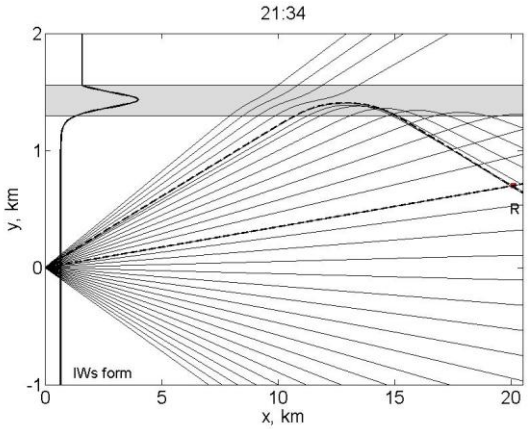
$$p = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{i}{2k_y}\left(e^{ik_y|y-y_s|} + \mathrm{Ref}\cdot e^{ik_y(y+y_s)}\right)e^{ik_x}\,dk_x$$



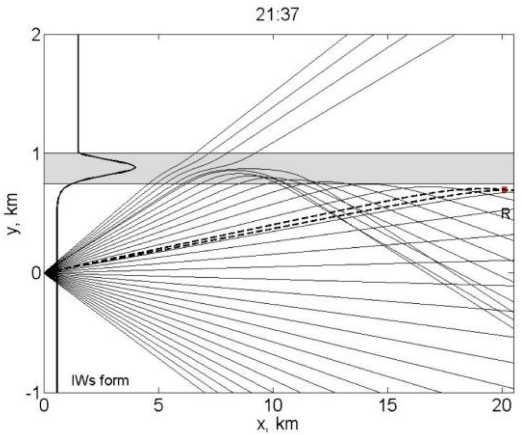
(a) No Internal Wave



(b) Internal Wave+ refraction



(c) After Internal Wave



$$\frac{d^2\psi_l(\vec{r},z,T)}{dz^2}+\left\{\frac{\omega^2}{\left[c_0(z)+\delta c(\vec{r},z,T)\right]^2}-\xi_l^2(\vec{r},T)\right\}\psi_l(\vec{r},z,T)=0$$

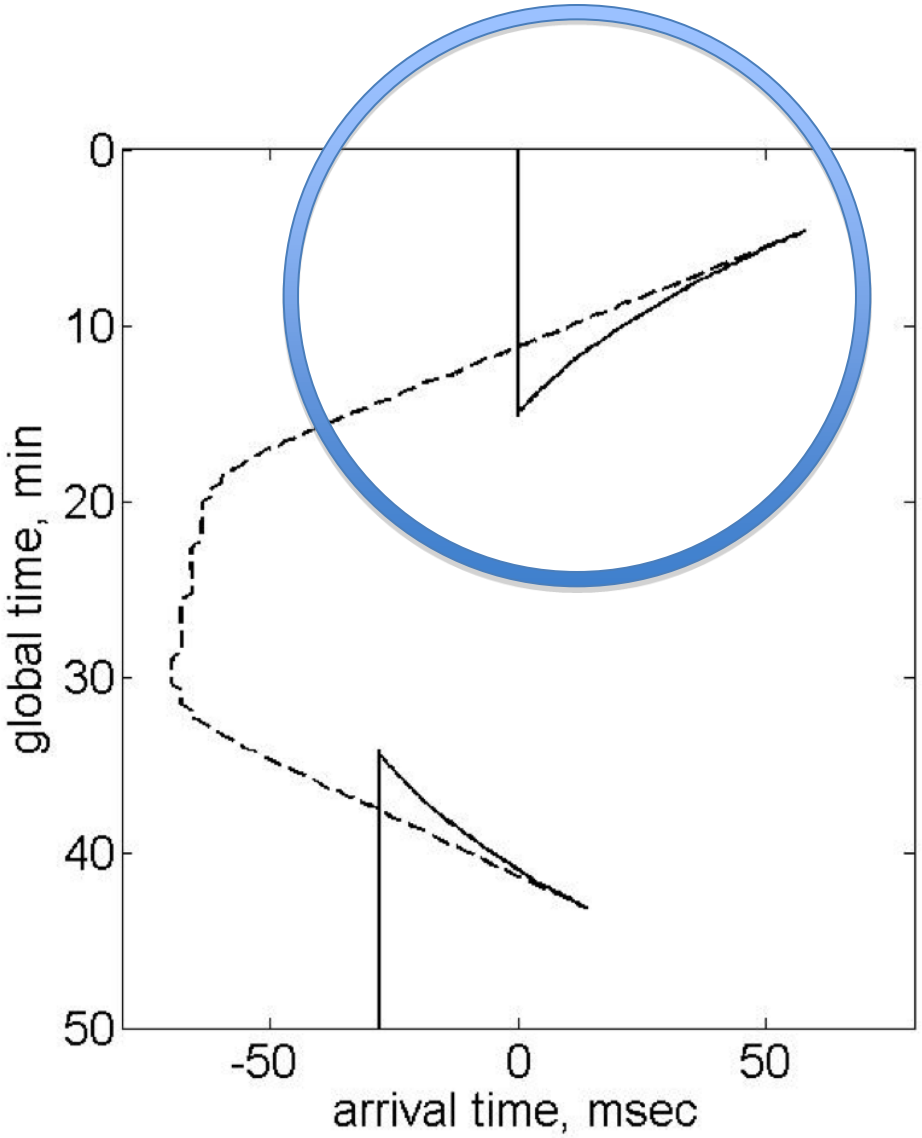
$$P(\vec{r},z,t)=2\int_0^{\infty}S(\omega)\sum_l P_l(\vec{r},\vec{r}_s)\psi_l(\vec{r},z)e^{-i\omega t}d\omega$$

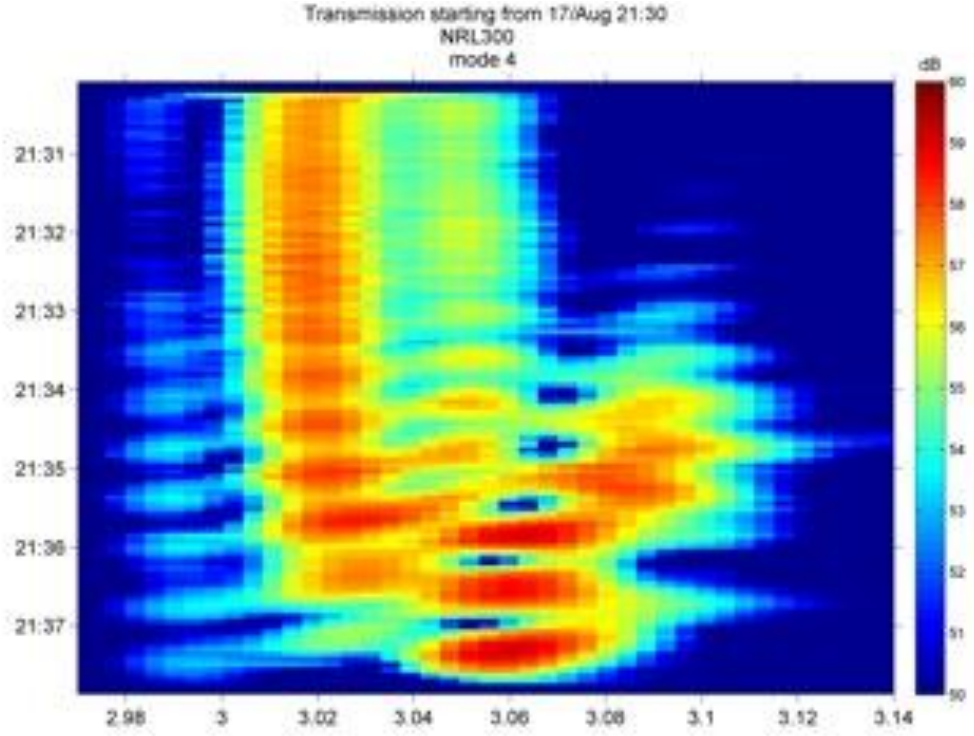
$$\mu_l=-\nu_l\zeta_s(\vec{r},T)$$

Where

$$\nu_l=\frac{2Qk^2}{(q_l^0)^2}\int_0^H\left[\psi_l^0(z)\right]^2N^2(z)\Phi(z)dz$$

Ray coupling & shadow zone




Transmission starting from 17/Aug 21:30
NRL300
mode 4
dB
60
59
58
57
56
55
54
53
52
51
50
21:31
21:32
21:33
21:34
21:35
21:36
21:37
2.98
3
3.02
3.04
3.06
3.08
3.1
3.12
3.14

Summary & conclusions

- Unique observation of reflection/refraction of signal in horizontal plane from an approaching internal wave in the water column
- Mechanism of horizontal refraction is confirmed (Modal and frequency dependence)
- Observation confirmed with our previous data collected in the same area in SWARM95