



*Spatial Coherence of Signals
Forward Scattered from Sea Surface and Seabed
In the East China Sea*

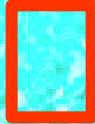
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Applied Physics Laboratory
University of Washington

EAST SEA

YELLOW SEA

Overall Goal of ASIAEX East China Sea:

*Understand the physics of sound
propagation and scattering in shallow
Asian seas, along with governing
geological and oceanographic processes*

EAST CHINA SEA 
MAY 29 – JUNE 9 2001
DEPTH 100 m

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Report Documentation Page

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RESEARCH OBJECTIVES

A. Understand behavior of vertical coherence in sea surface scattering, and its relation to:

- *sea surface bistatic cross section*
- *horizontal coherence*
- *wind speed, sea state, wave directionality*
- *frequency*
- *acquisition geometry*
- *sound speed profile*

B. Sea bed reflection (2-8 kHz)

- *what are bottom losses versus grazing angle, and are they consistent with inversions?*

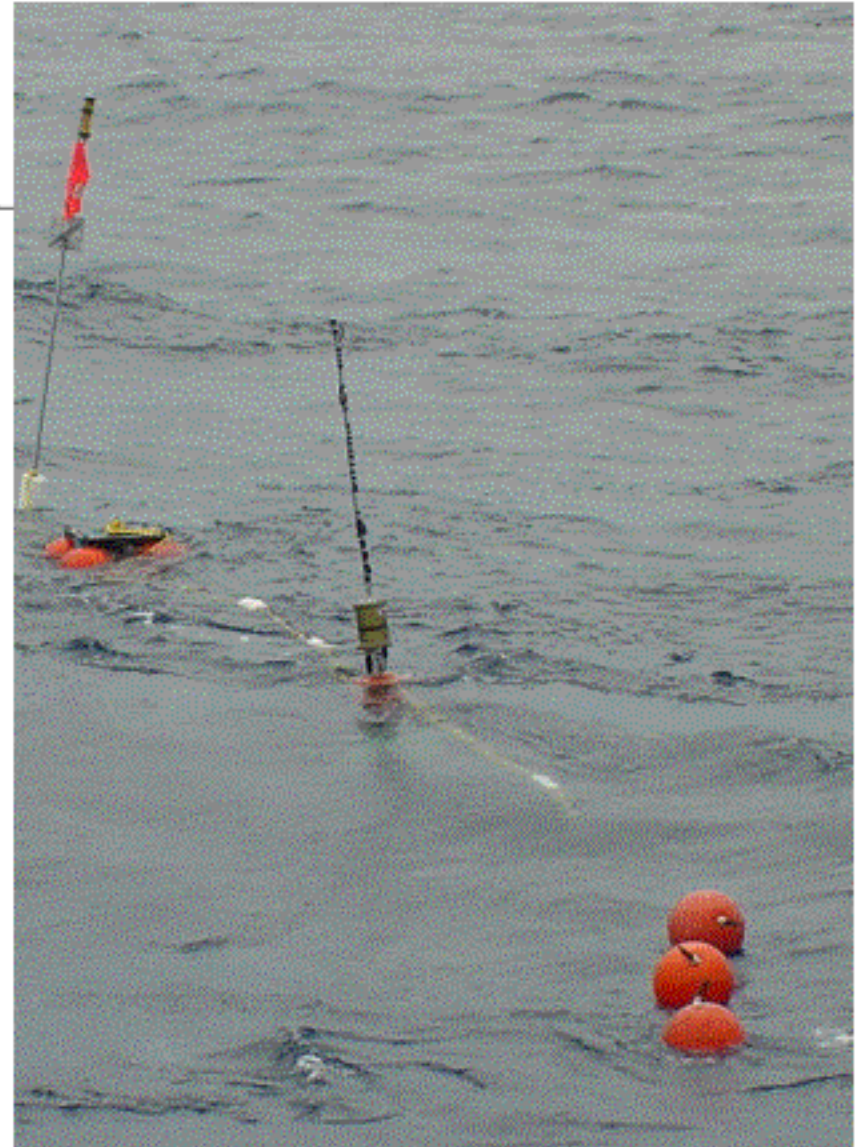
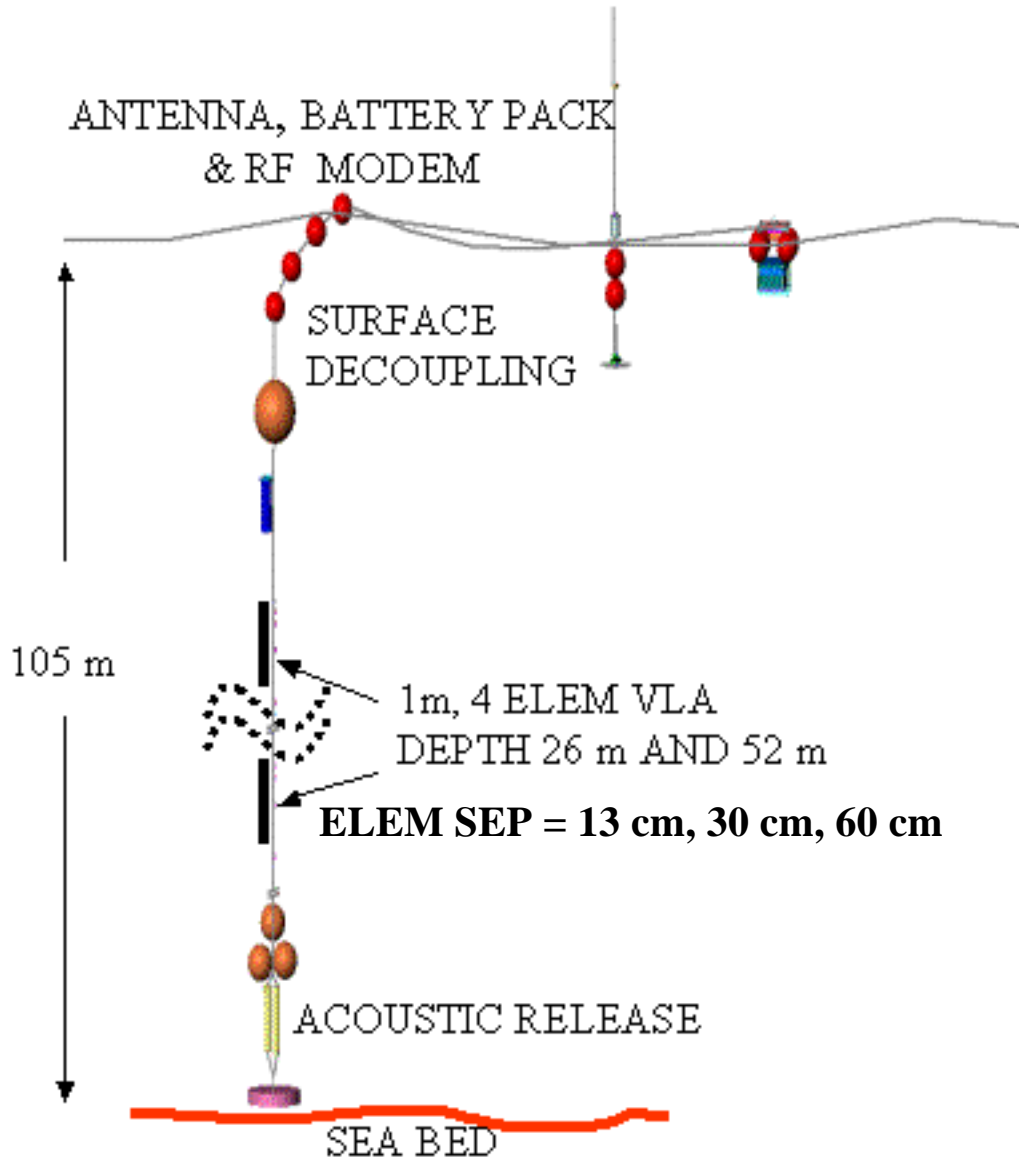






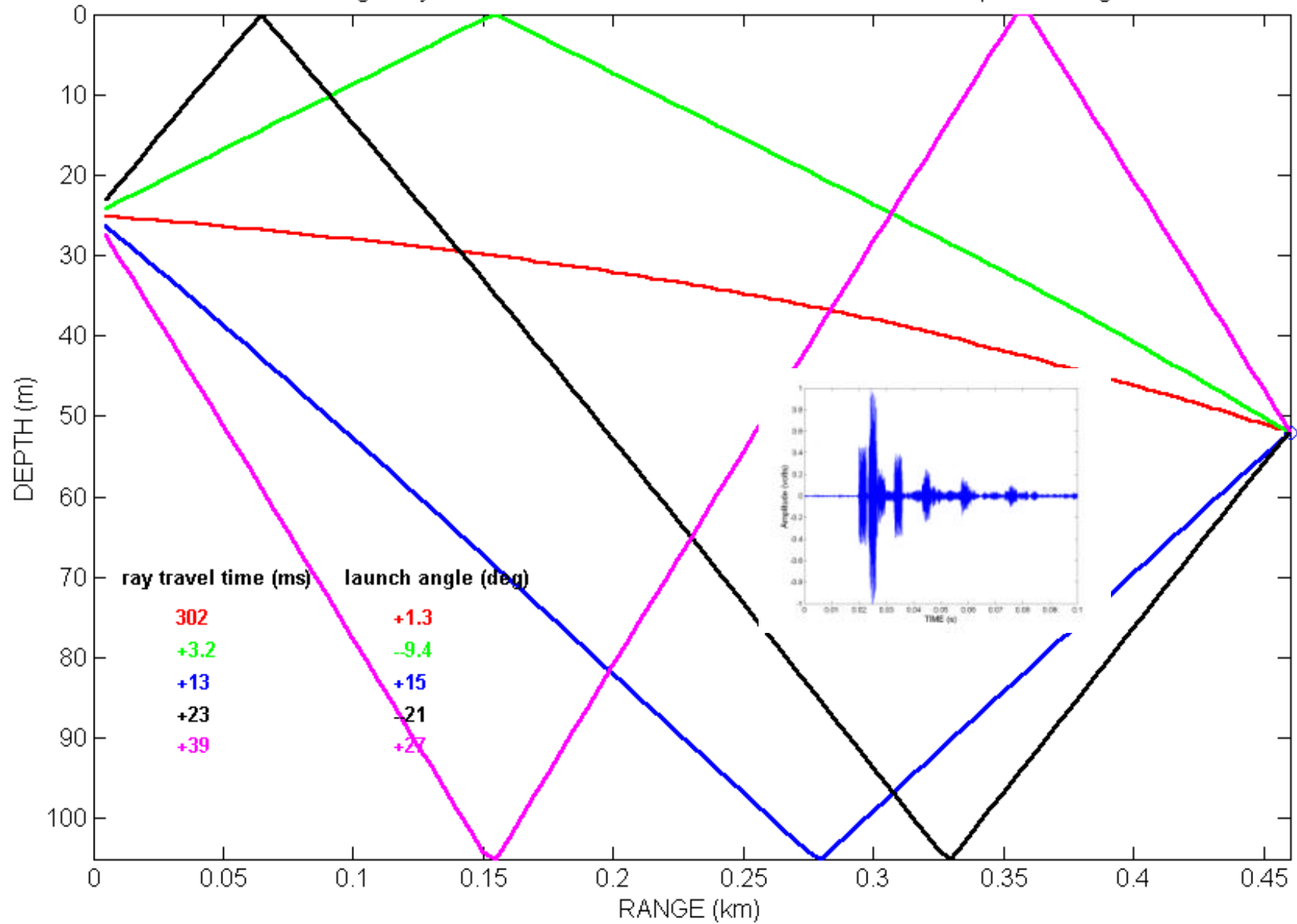


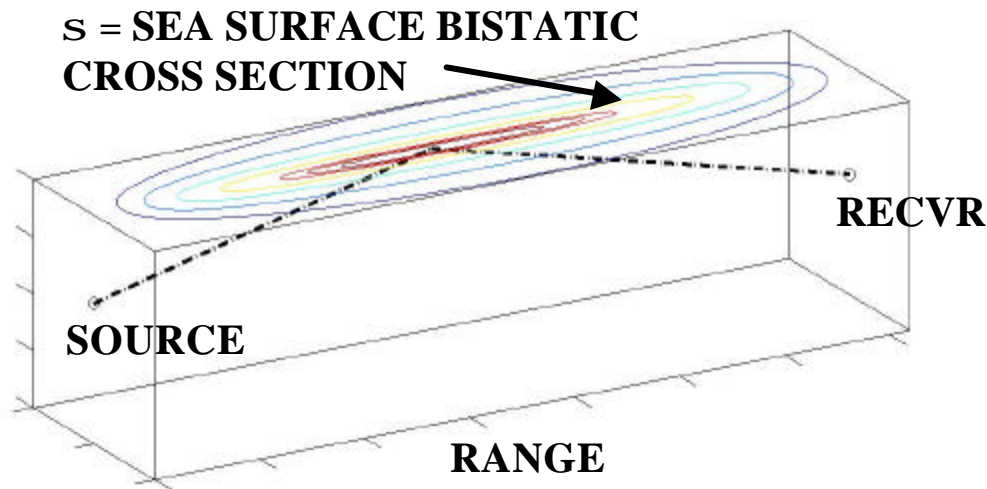
SOUND RECEIVER ARRAY





East China Sea Eigenrays SD = 25 m RD = 52 m RANGE = 0.46 km sound profile = avg of 6 casts





$$S \propto \iint e^{2ik(ax+bz)} e^{-\underbrace{?^2 [1-C(x,z)]}_{\text{ENVIRONMENTAL DEPENDENCE EMBODIED HERE}}} dx dz$$

$c = kH(\sin q_i + \sin q_s)$ **ROUGHNESS PARAMETER, FUNCTION OF kH INCIDENT AND SCATTERED ANGLES**

$C(x, z)$ **2D SEA SURFACE CORRELATION FUNCTION**

Sea surface bistatic cross section computed via the small slope approximation. Wave buoy data + wave model (Plant 2002) used for required sea surface correlation function



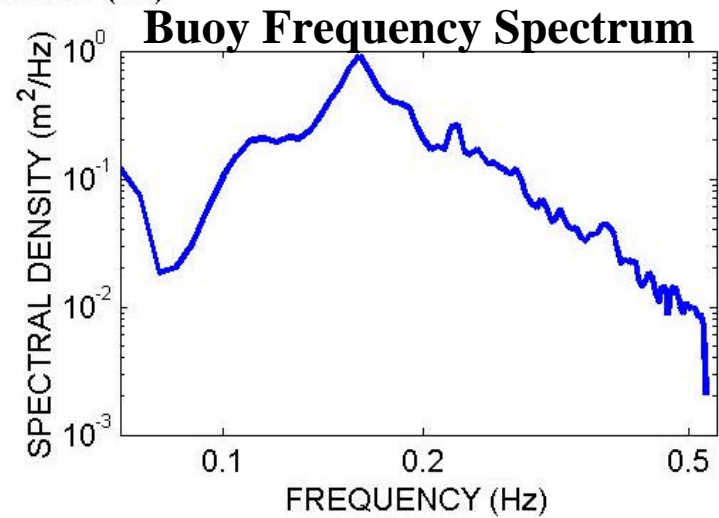
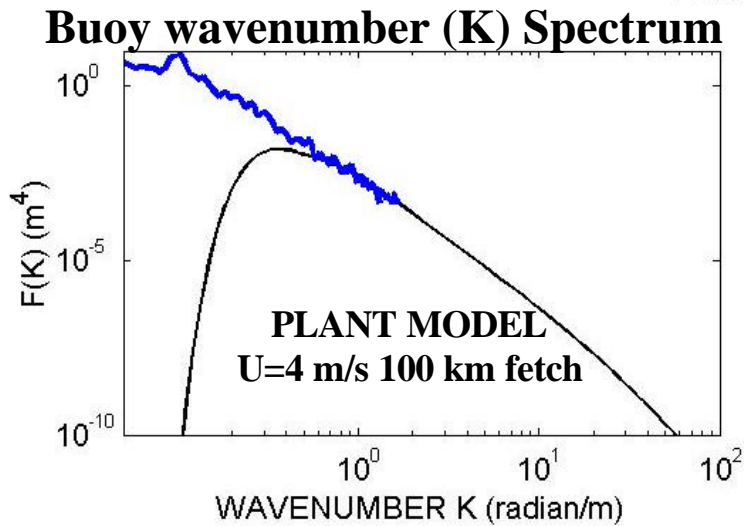
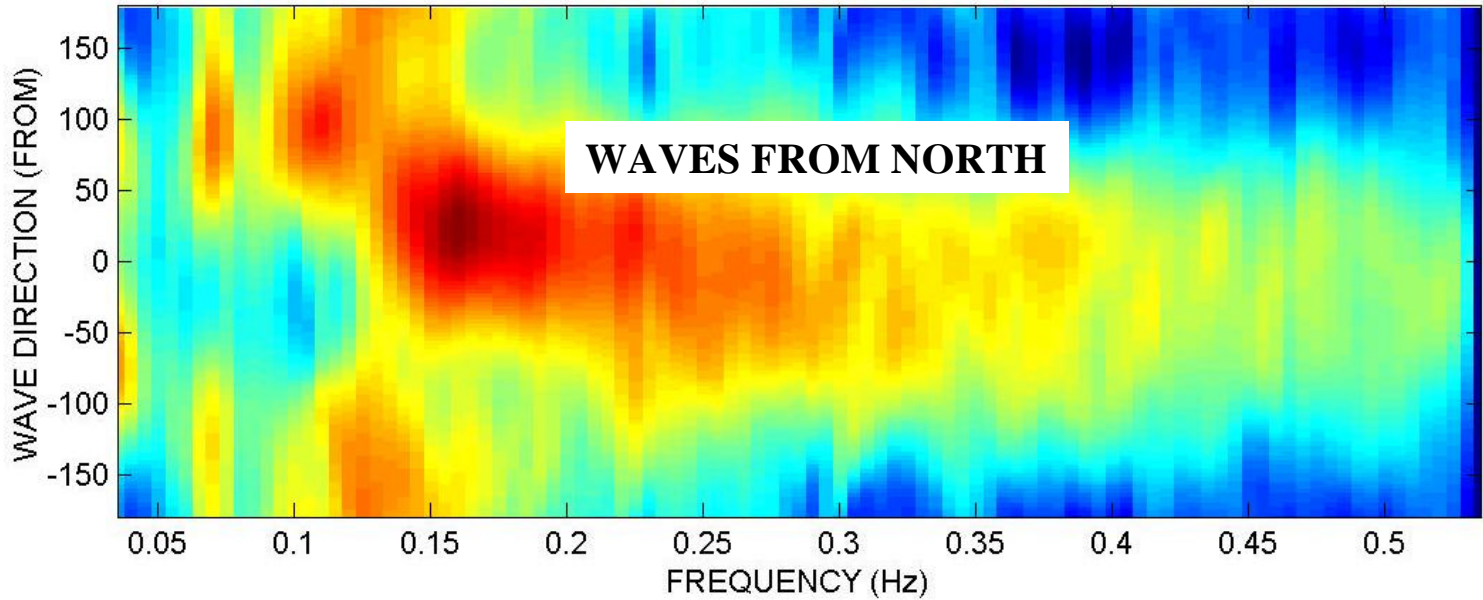
ENVIRONMENTAL ACOUSTIC MEASUREMENTS:
DIRECTIONAL WAVE BUOY

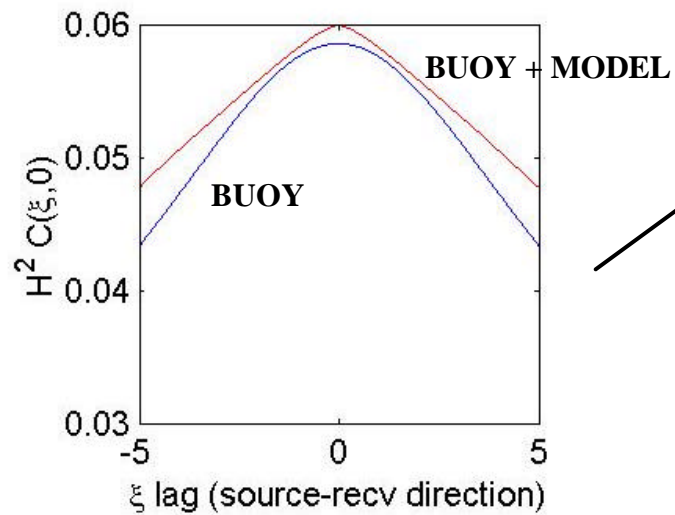
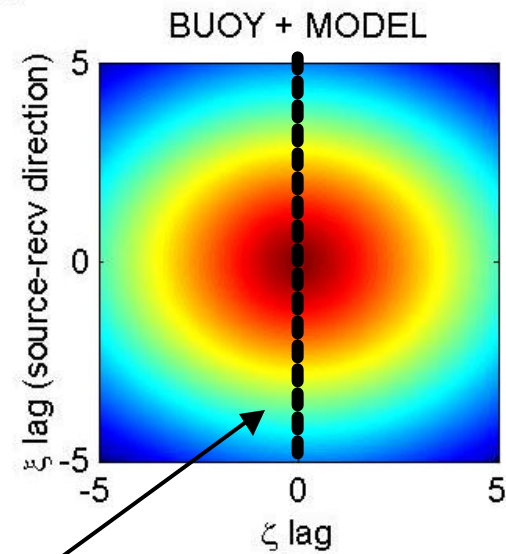
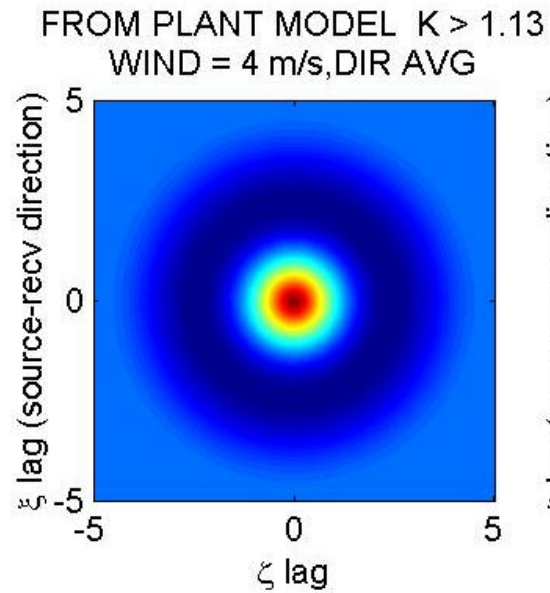
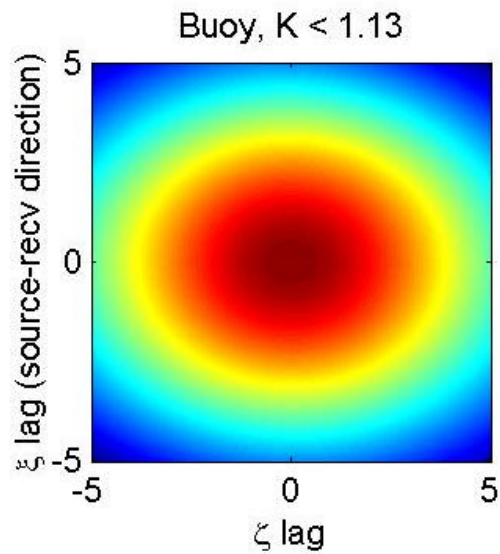
directional wave spectra every 0.5 h 28 May – 8 June

waveheight variance spectra
0.03 - 0.64 Hz, 0.005 Hz bins

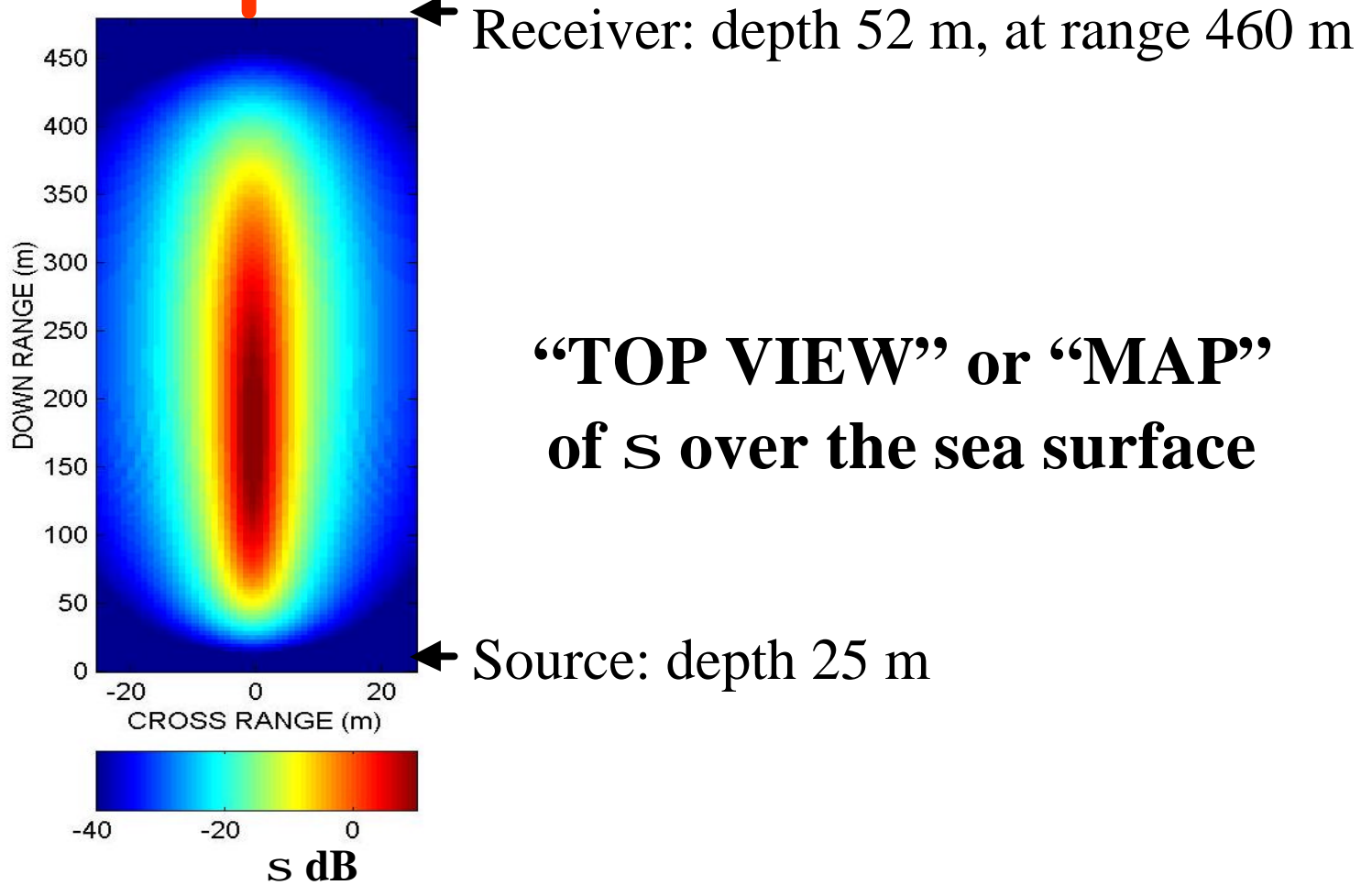
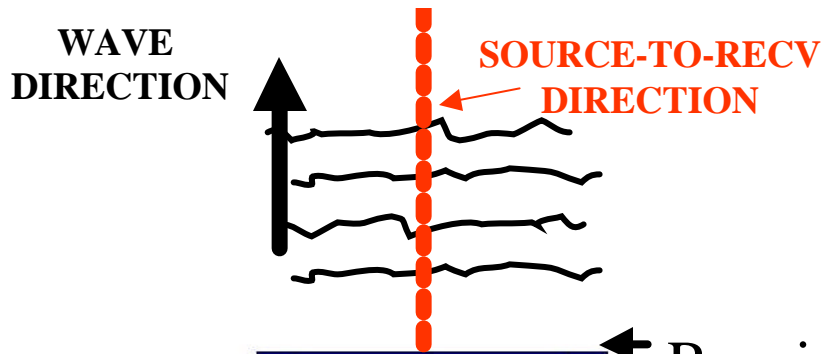
3-deg directional bins
20 min averaging period

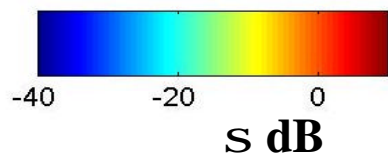
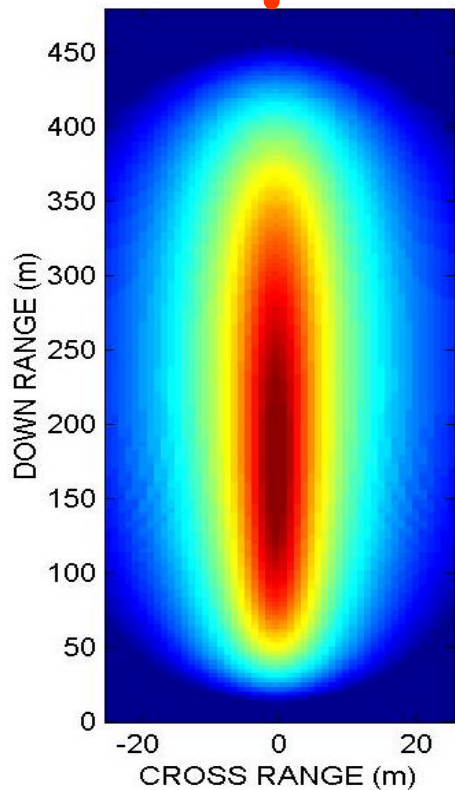
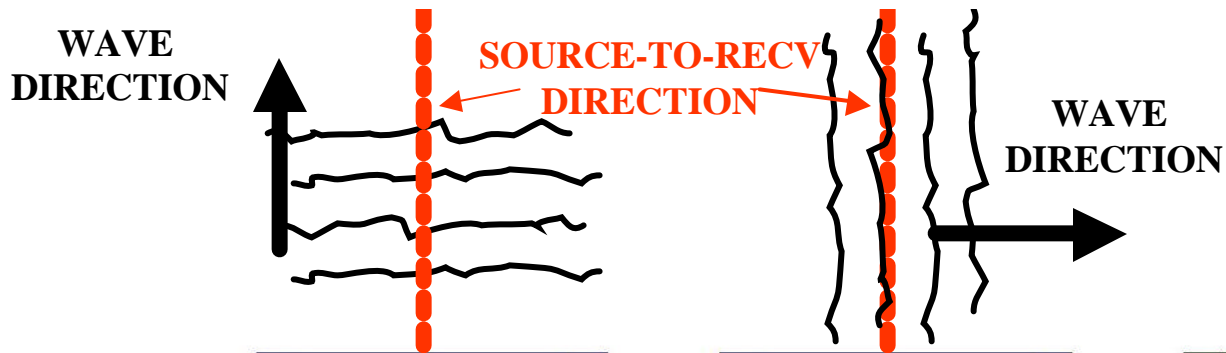
RAW DIRECTIONAL WAVE SPECTRUM FROM BUOY, RUN 22



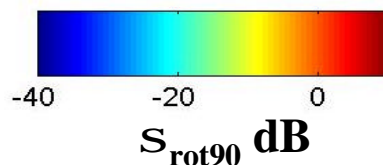
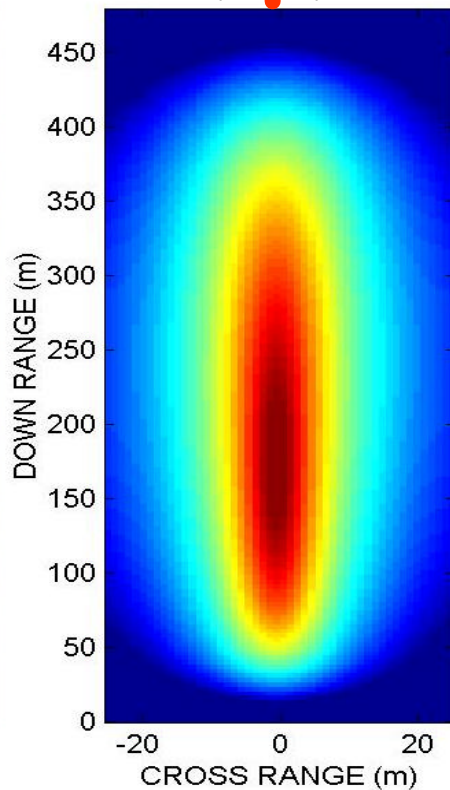


*A CUT DOWN THE IN-PLANE AXIS OR
SOURCE-RECEIVER DIRECTION*

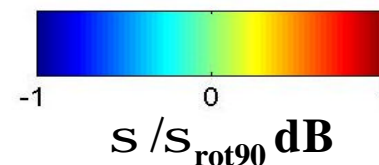
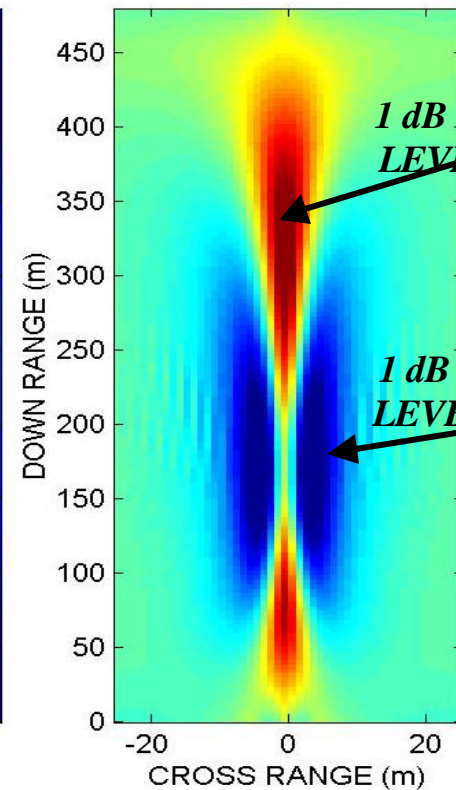




**CONDITION
FOR RUN 22**

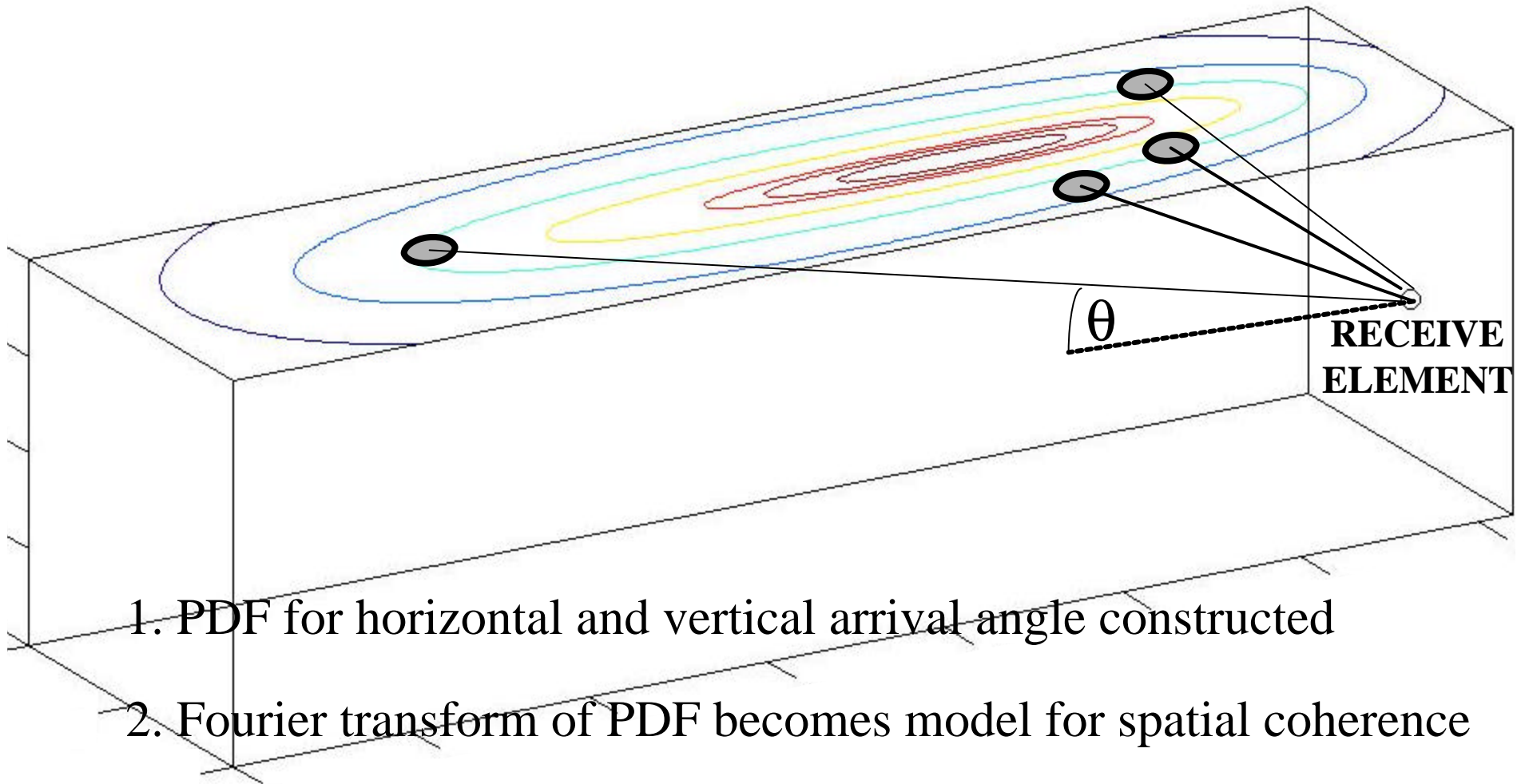


**HYPOTHETICAL
90 deg ROTATION**



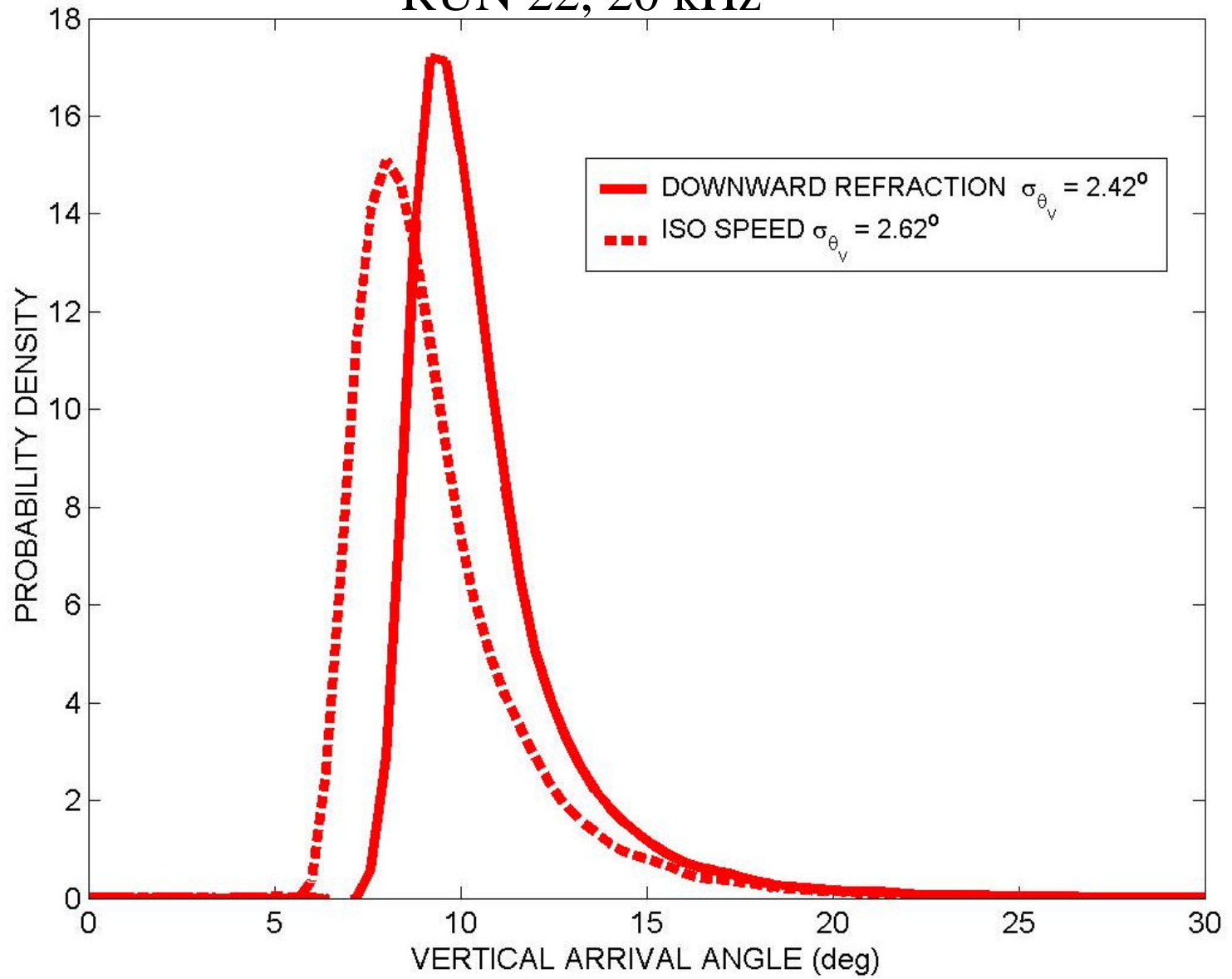
S/S_{rot90} dB

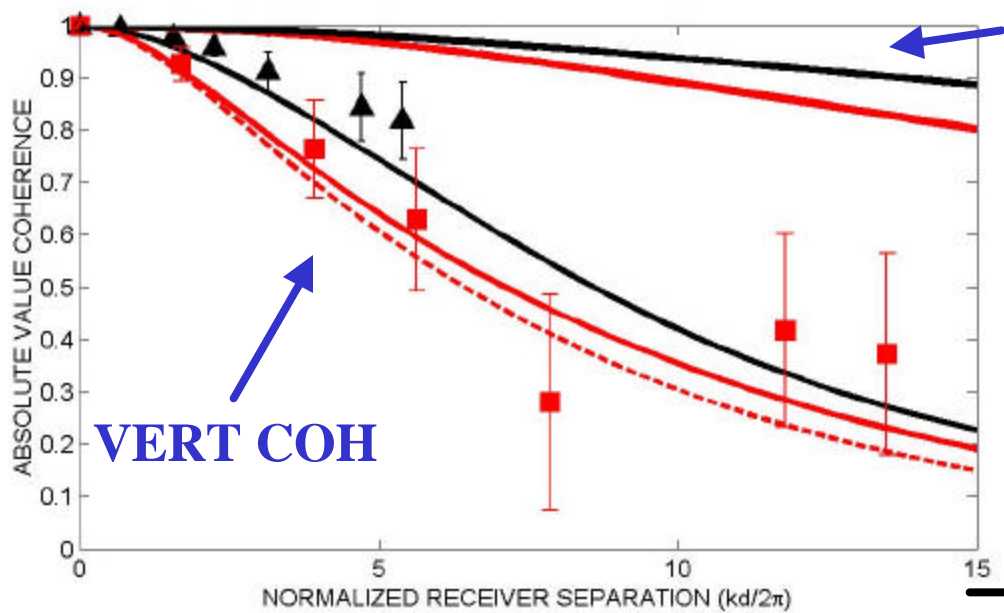
INTENSITY VS VERTICAL ARRIVAL ANGLE q



Dahl P. H., *J. Acoust. Soc. Am.*, 1996, 1999;
J. Oceanic Eng., 2001

RUN 22, 20 kHz





HORIZ COH

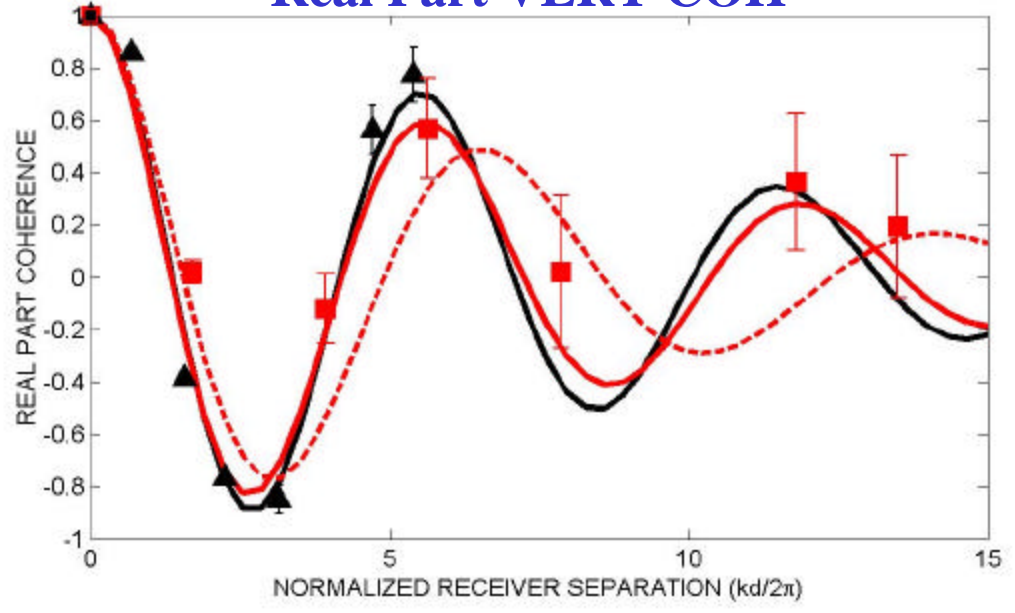
Run22: 5-31 2000 UTC

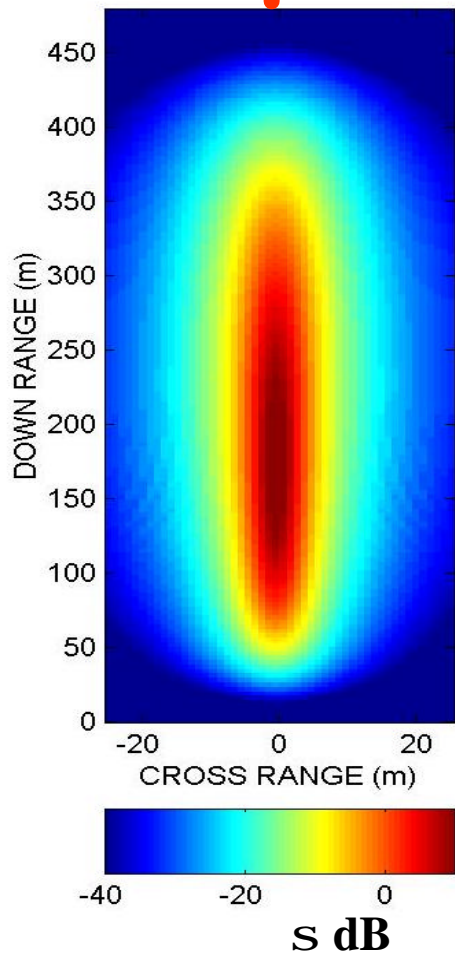
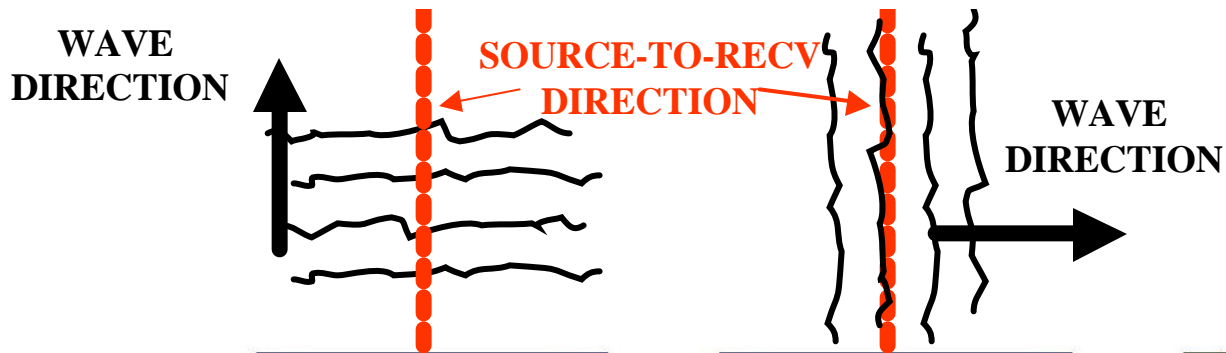
**SD 26 m, RD 52, Rg 481 m
U=4 m/s H=0.24 m**

VERT COH

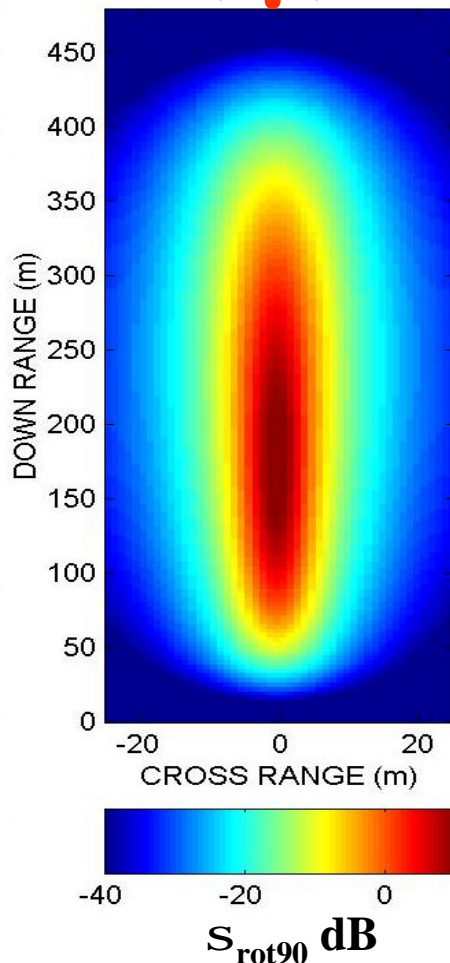
- ▲ 8 kHz MODEL, DATA**
- 20 kHz MODEL, DATA**
- 20 kHz ISO SPEED MODEL**

Real Part VERT COH

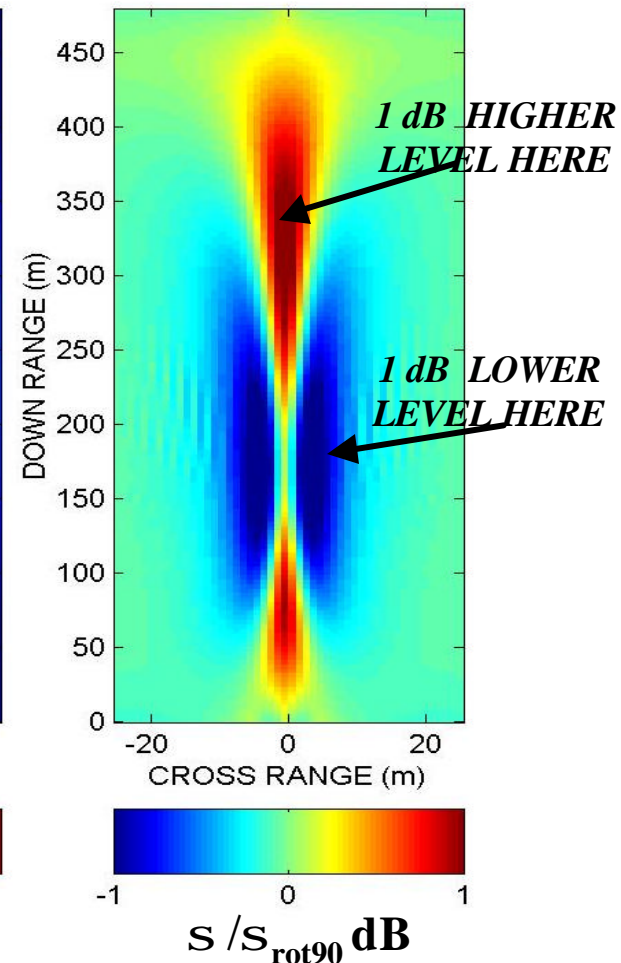




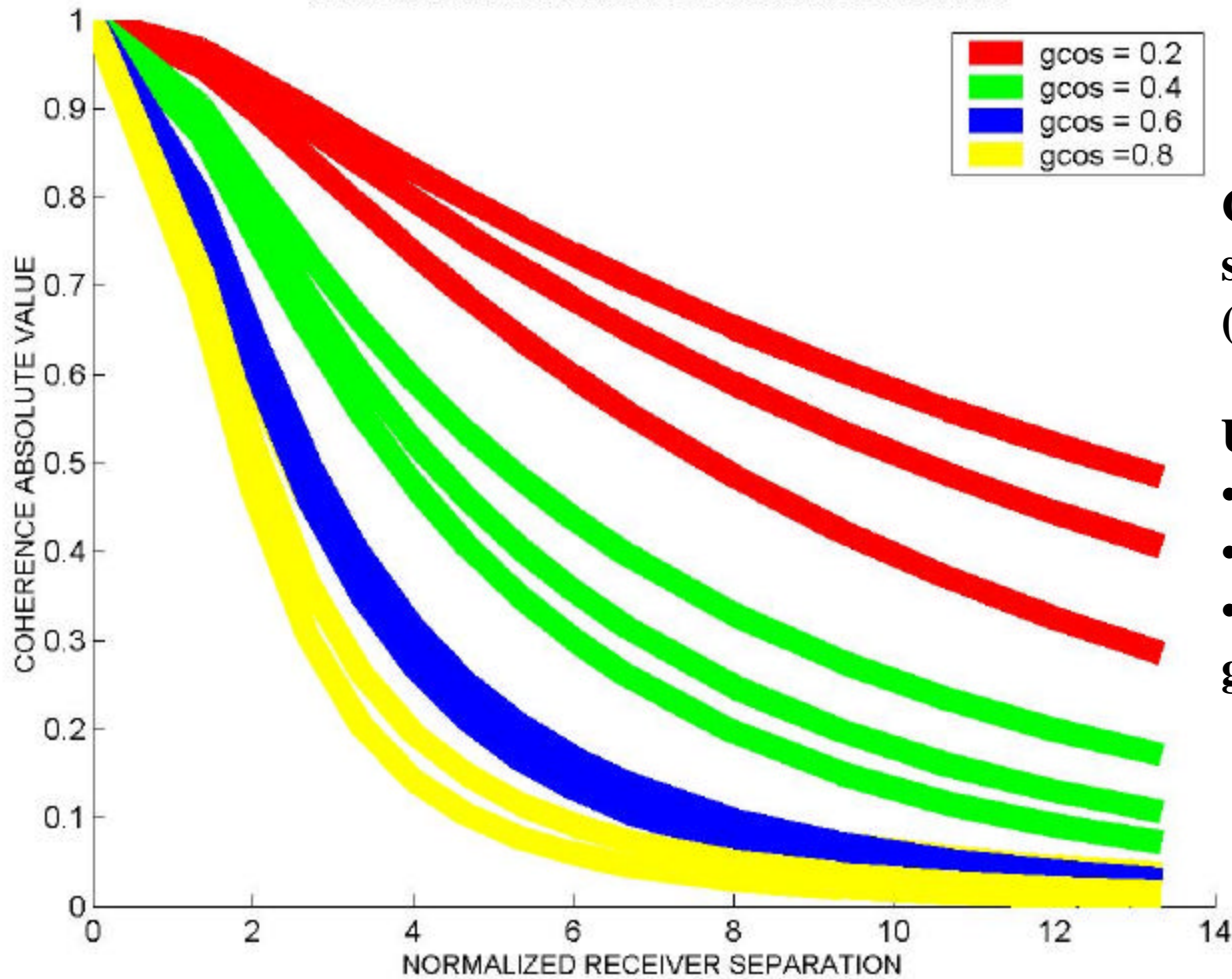
**CONDITION
FOR RUN 22**



**HYPOTHETICAL
90 deg ROTATION**



VERTICAL COHERENCE VS GEOMETRIC SCALE



Compute model at 20 kHz,
same environmental condition
(U = 7 m/s)

Use:

- ranges: 400-700 m
- src, rcvr depths: 10-100 m
- match the parameter

$$g_{\cos} = \frac{\cos q_g}{1 + RD / SD}$$



SUMMARY Part A: Sea Surface

1. Frequency dependence (8 & 20 kHz) observed in both data and modeling: \uparrow spatial coherence for \downarrow frequency

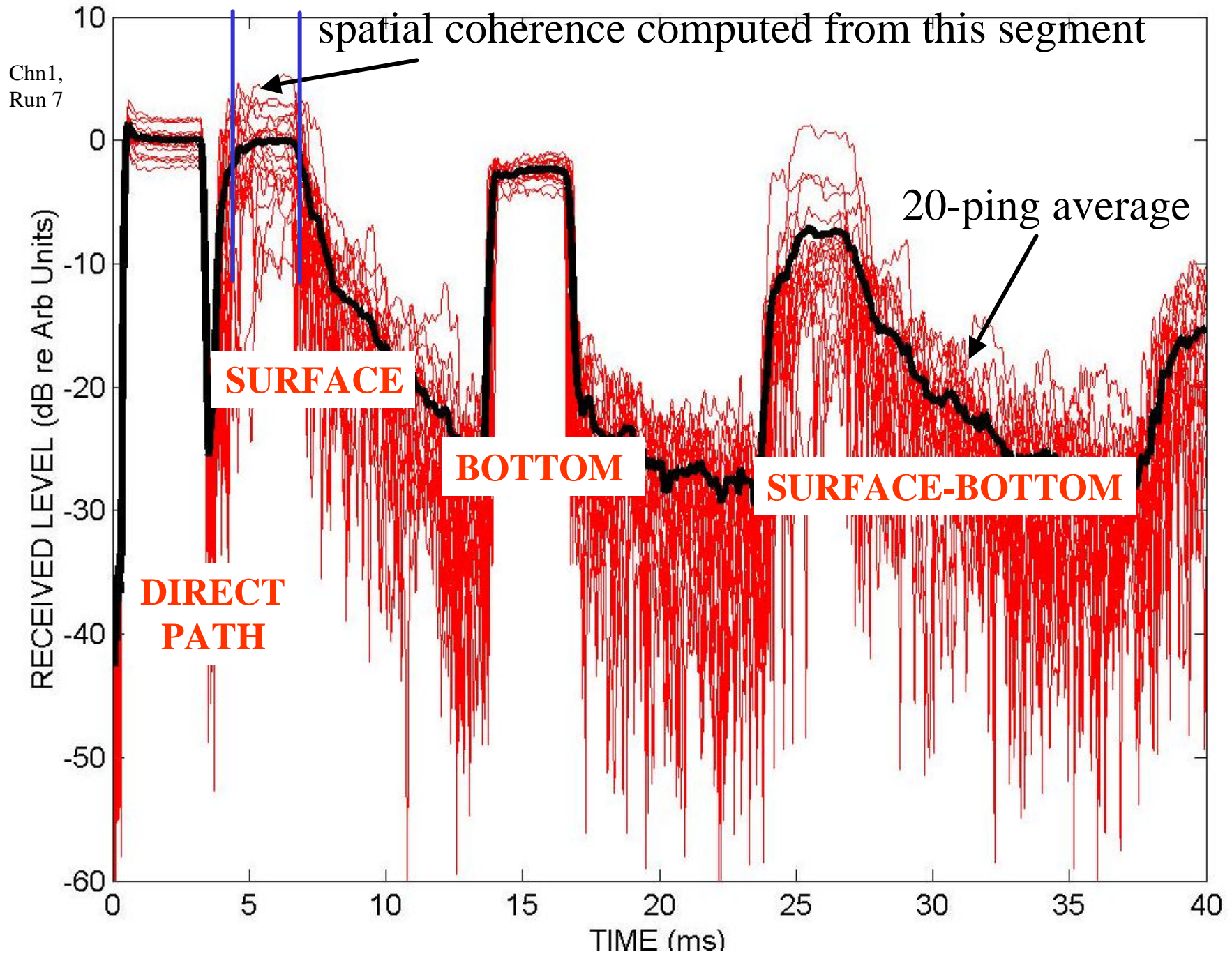
2. Effects of downward refraction and surface wave directivity: both effects small & hard to see, due to high variance in data
(Future: try to combine sets, reduce variance)

3. Influence geometric scaling parameters for H & V coherence

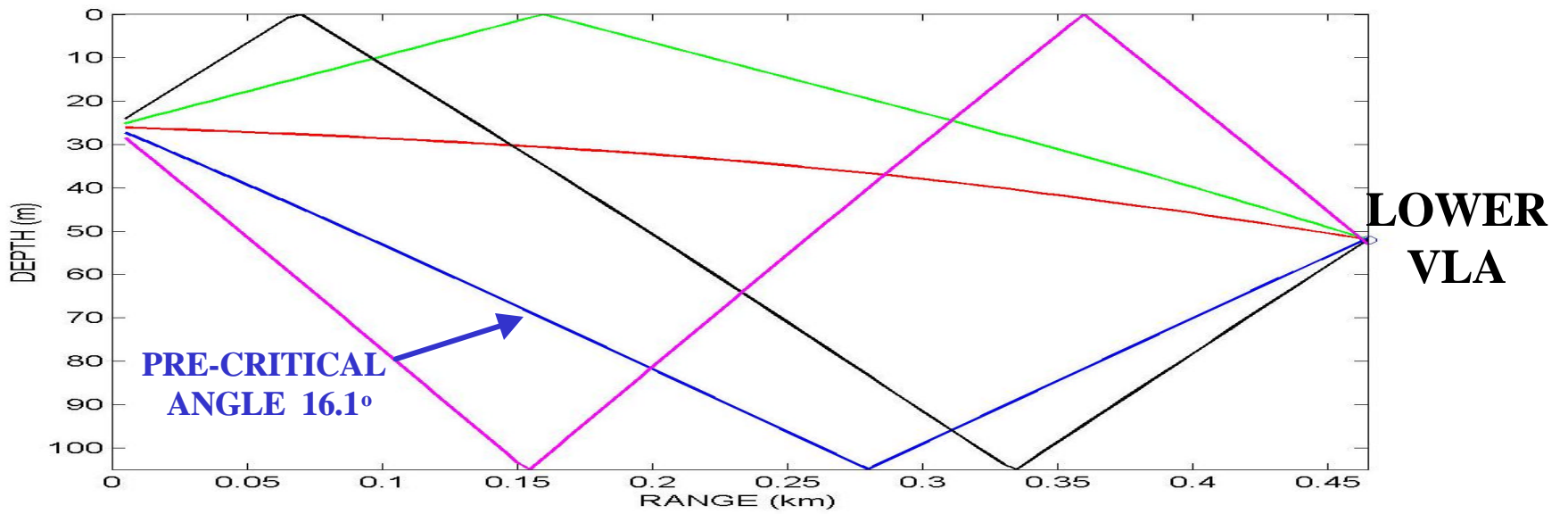
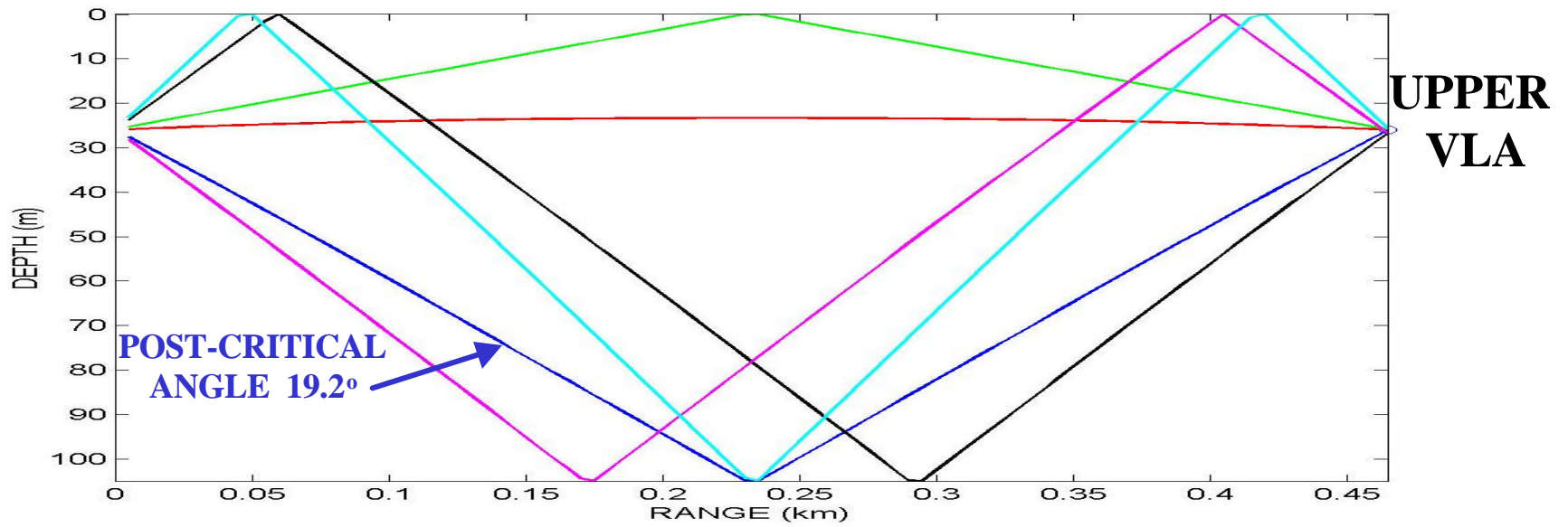
$$\text{H: } \frac{\sin \mathbf{q}_g}{1 + RD / SD} \quad \text{V: } \frac{\cos \mathbf{q}_g}{1 + RD / SD}$$

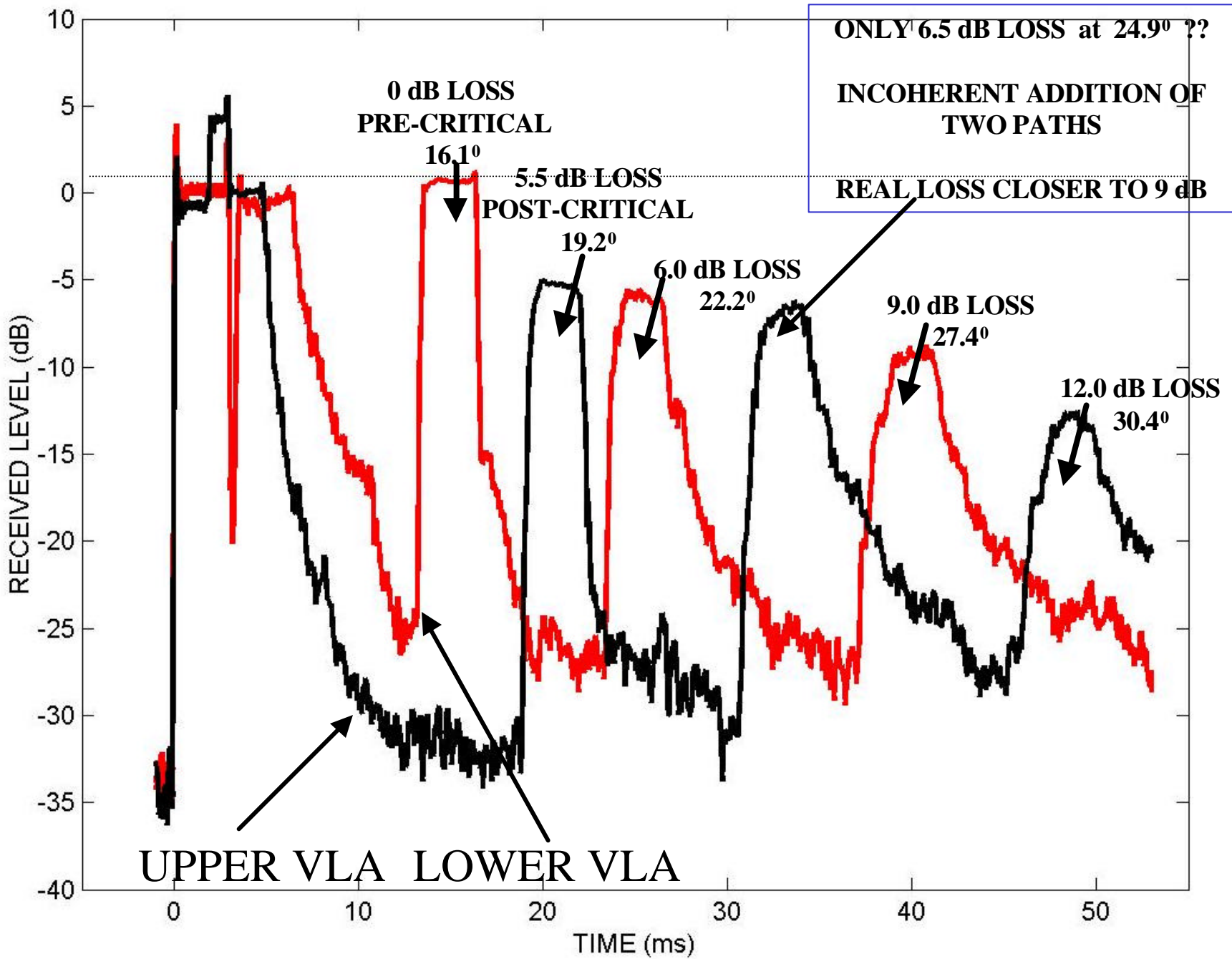
4. Heading towards a predictive model for H & V spatial coherence in the sea surface bounce path, as needed for communication, imaging and detection. Today: can do better for > 10 kHz. Challenge is for < 10 kHz or smaller roughness parameter $c = kH(\sin \mathbf{q}_i + \sin \mathbf{q}_s)$

8 kHz DATA RECORDED ON 1 OF THE 8 RECEIVE ELEMENTS

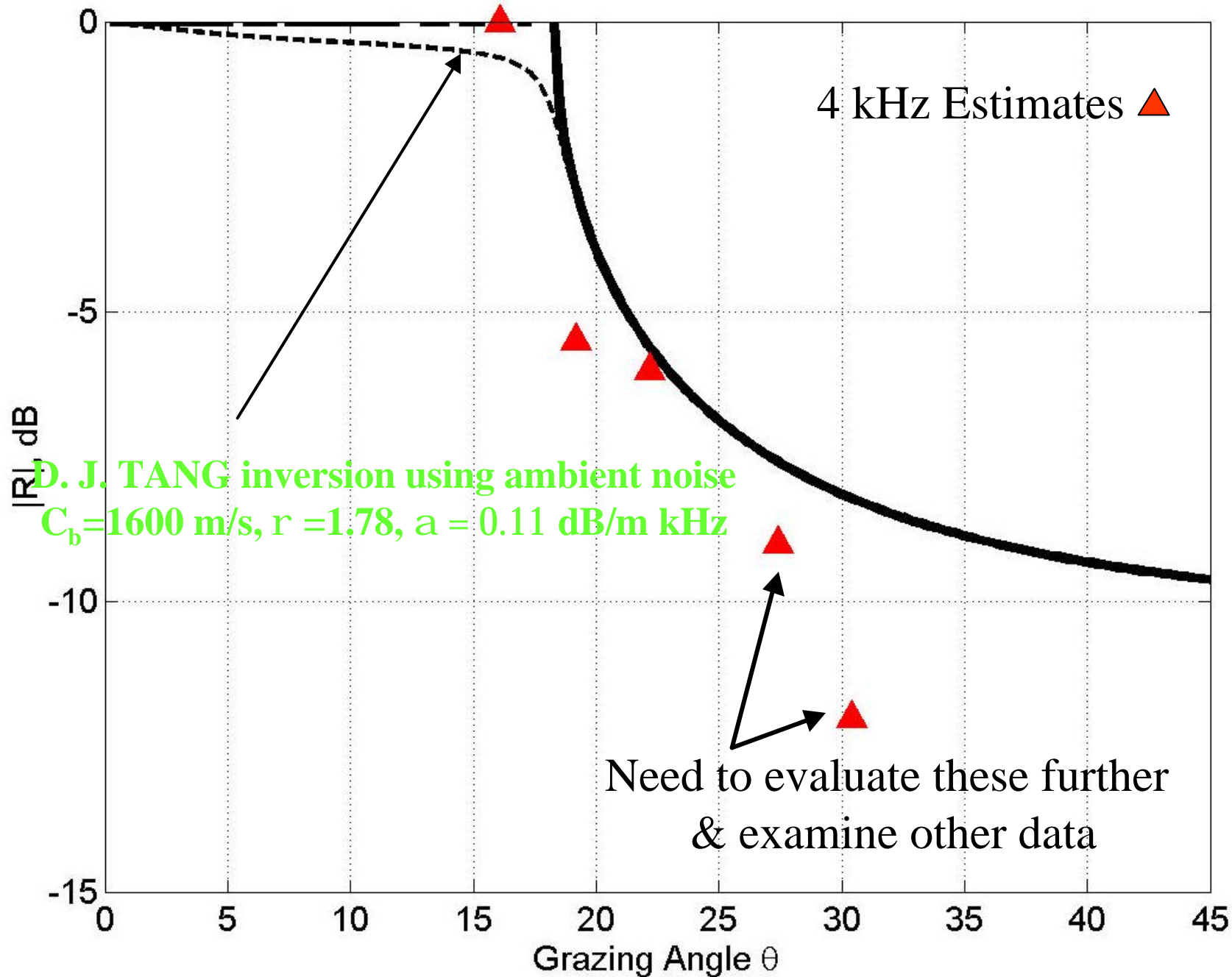


Spanning pre-to-post critical in bottom grazing angles





4 kHz Bottom Reflection Estimates from the MORAY VLAs





Overall Goal of ASIAEX East China Sea:

Understand the physics of sound propagation and scattering in shallow Asian seas, along with governing geological and oceanographic processes

Geoacoustic inversions with differing resolution scales (that good)

- IOA
- URI
- GIT & Harbin
- ARL/UT & BBN
- MPL
- NW Polytech
- APL-UW

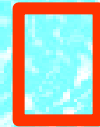
Overall Goal of ASIAEX East China Sea:

Understand the physics of sound propagation and scattering in shallow Asian seas, along with governing geological and oceanographic processes

Short Term (and achievable) Goal:

A unified geoacoustic model for at least:

- “Position M” in the East China Sea, followed by:
- (2) The general ECS region of “our box”



Long Term Goal:

Towards an atlas of geoacoustic models
For the Asian Littoral

Geoacoustic inversions
with differing resolution scales
(that good)

- IOA
- URI
- GIT & Harbin
- ARL/UT & BBN
- MPL
- NW Polytech
- APL-UW