Inversion and Uncertainty Mapping: Posterior Estimation of Transmission Loss from Ocean Acoustic Data

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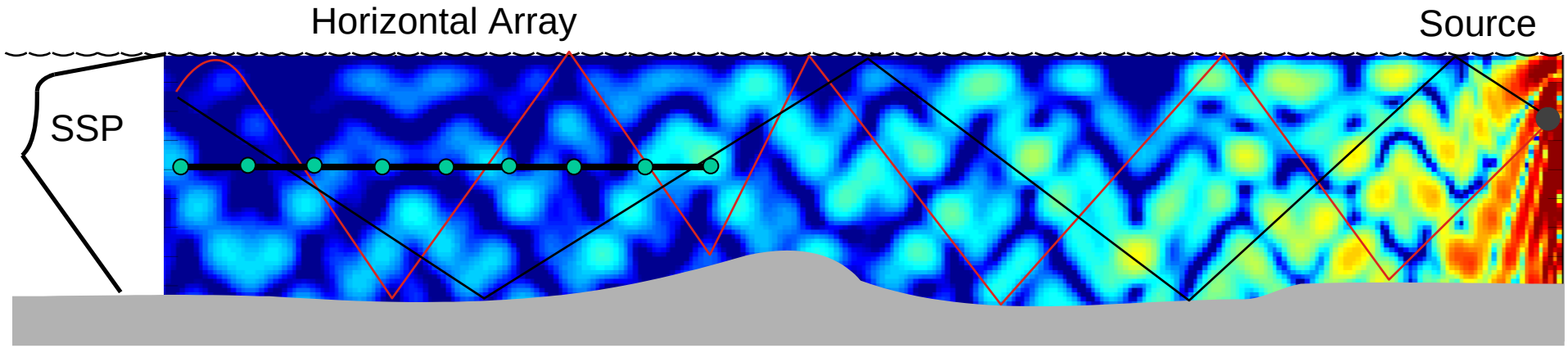
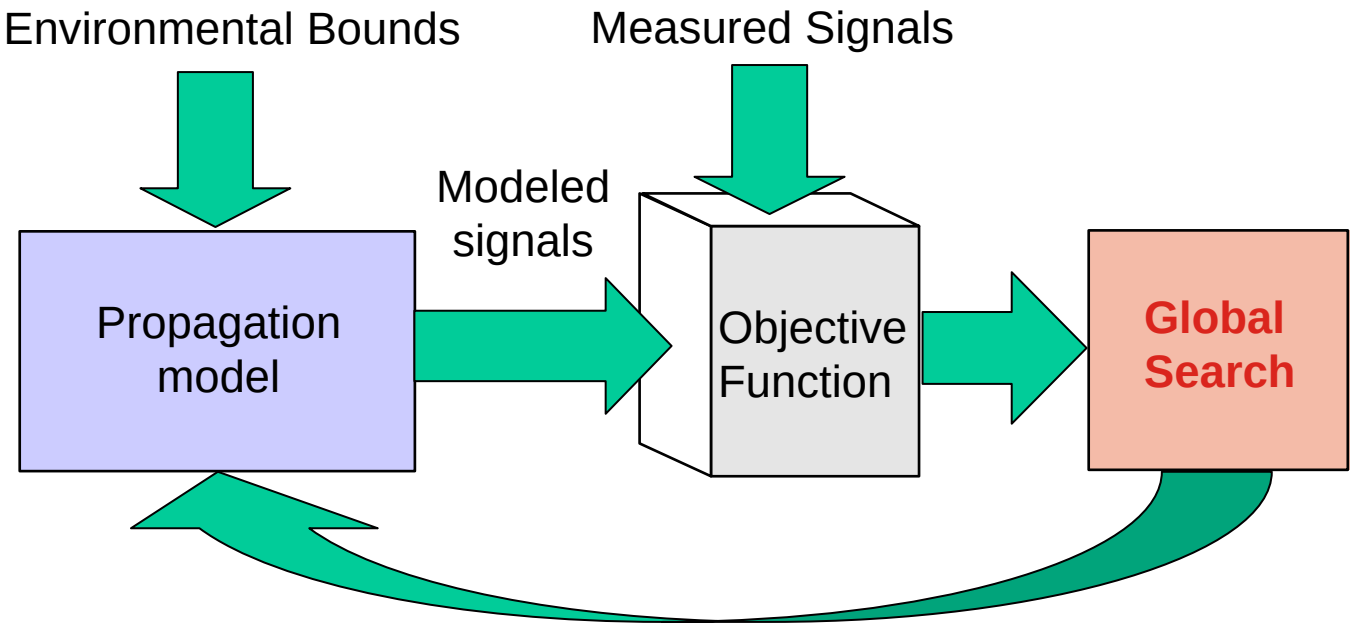
16 June 2004

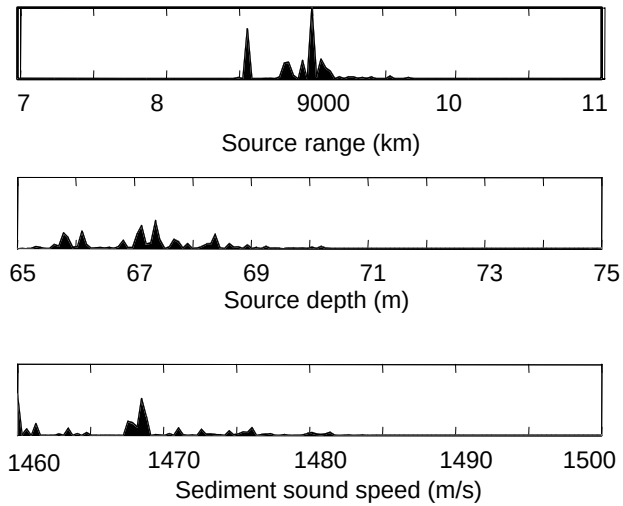
Matched Field Inversion



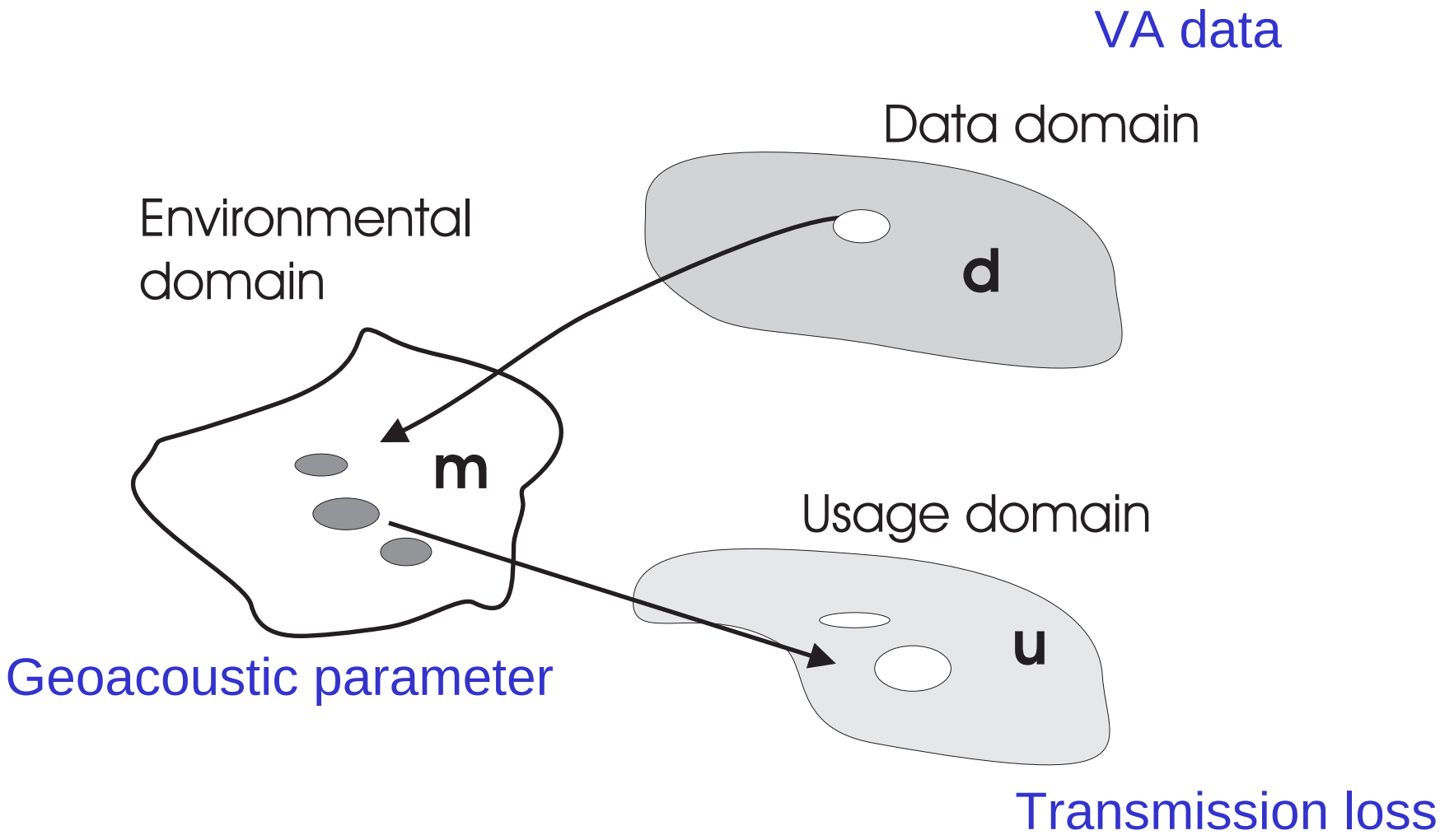


Repeat ~10000 times

Parameter Estimates uncertainty

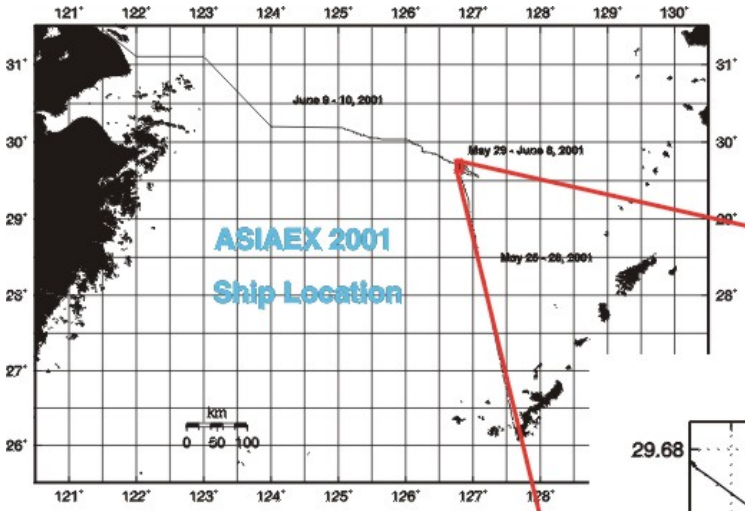


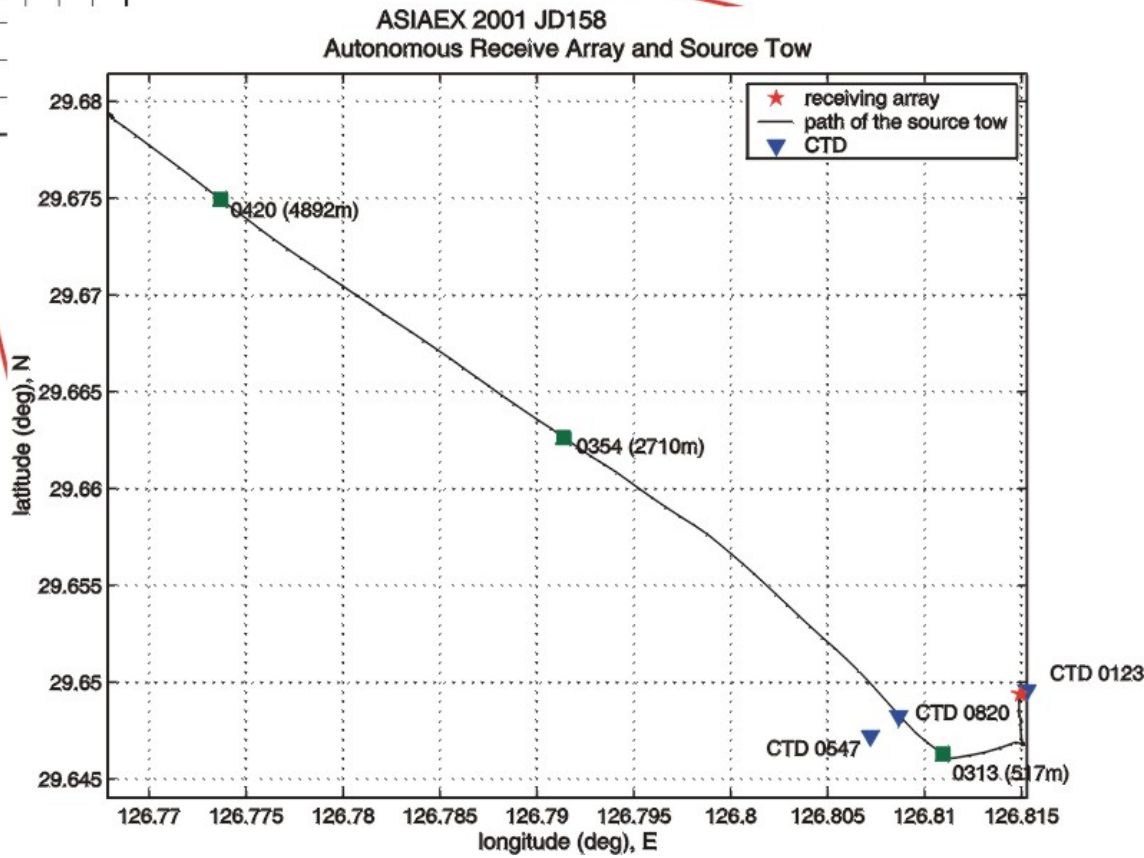
Mapping Between Three Domains



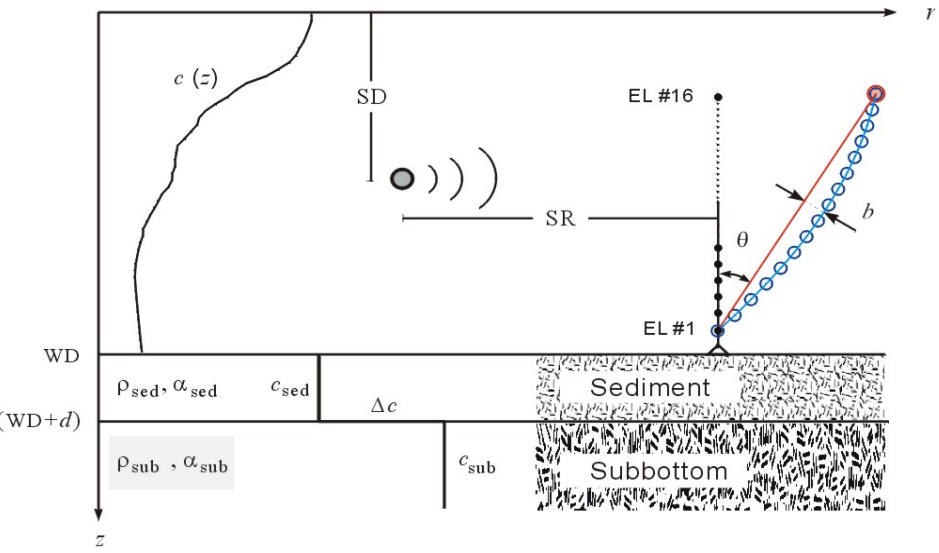
ASIAEX: Asian Seas International Acoustic EXperiment

Experimental Site

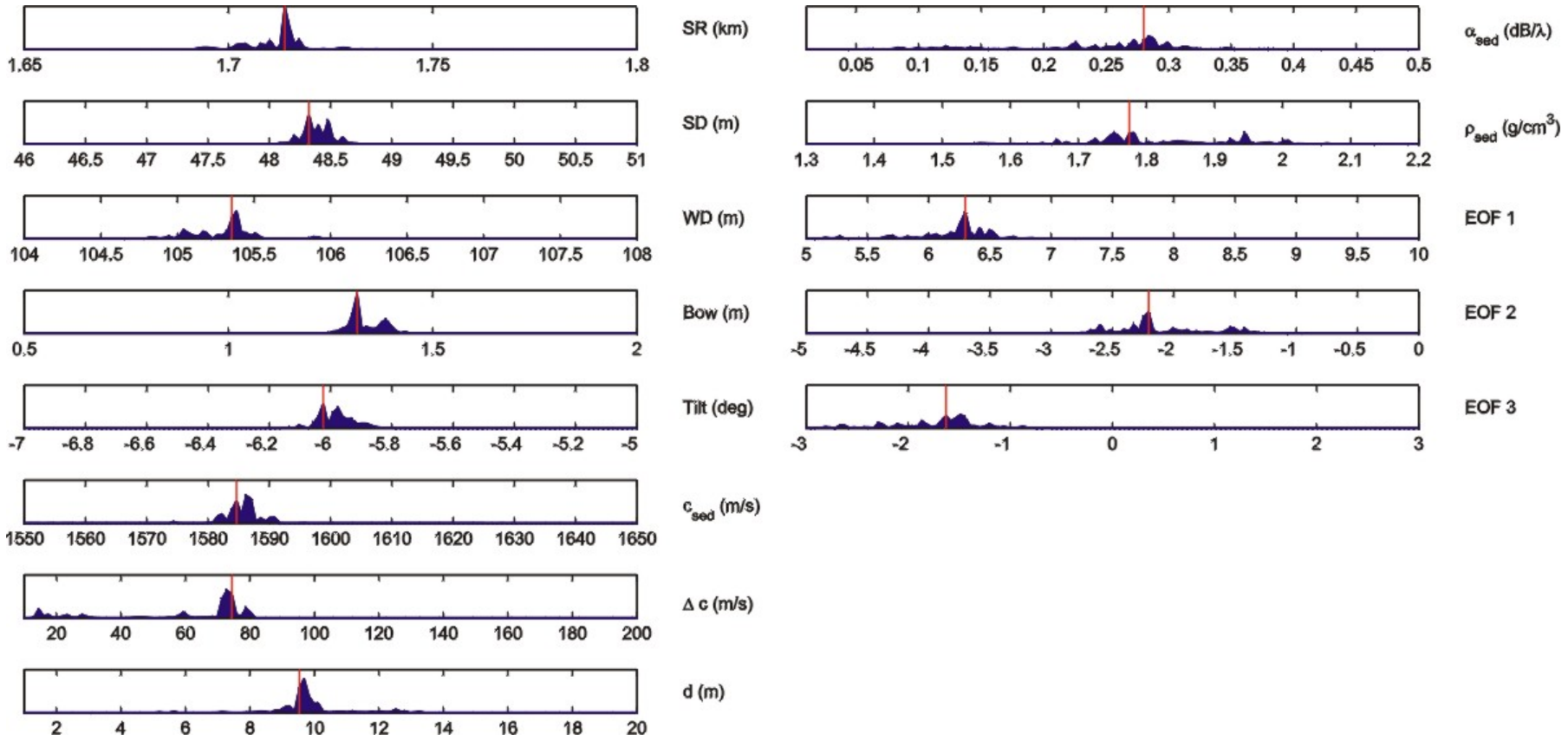




Experimental Geometry



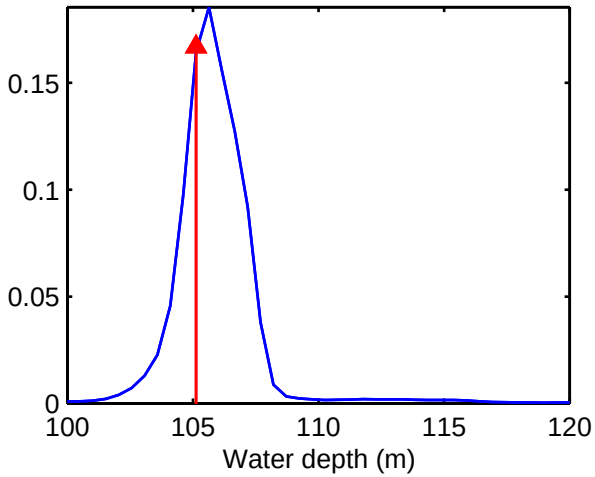
ASIAEX- Marginal Posterior Probability

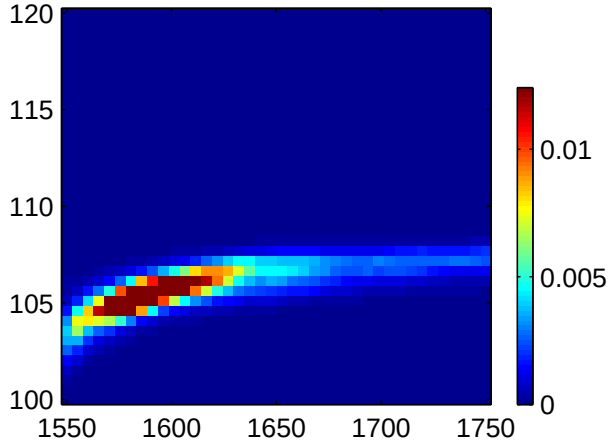


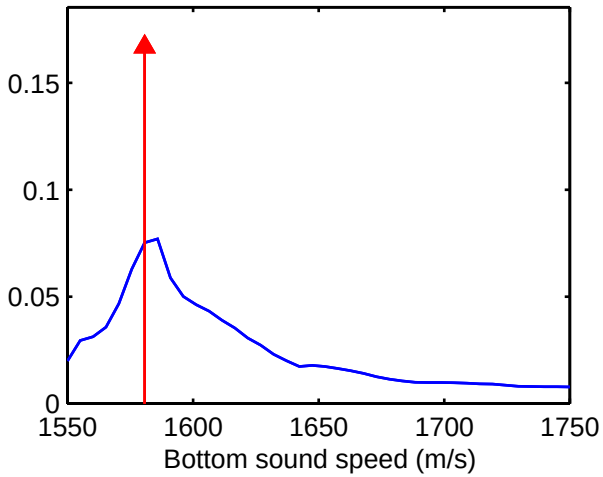
Frequencies: 195, 295, and 395 Hz; SD = 48.5 m; VLA = 16 elements (75 m aperture)

ASIAEX- Posterior Marginal Distributions

A 2nd inversion to find uncertainty for the two most important parameters





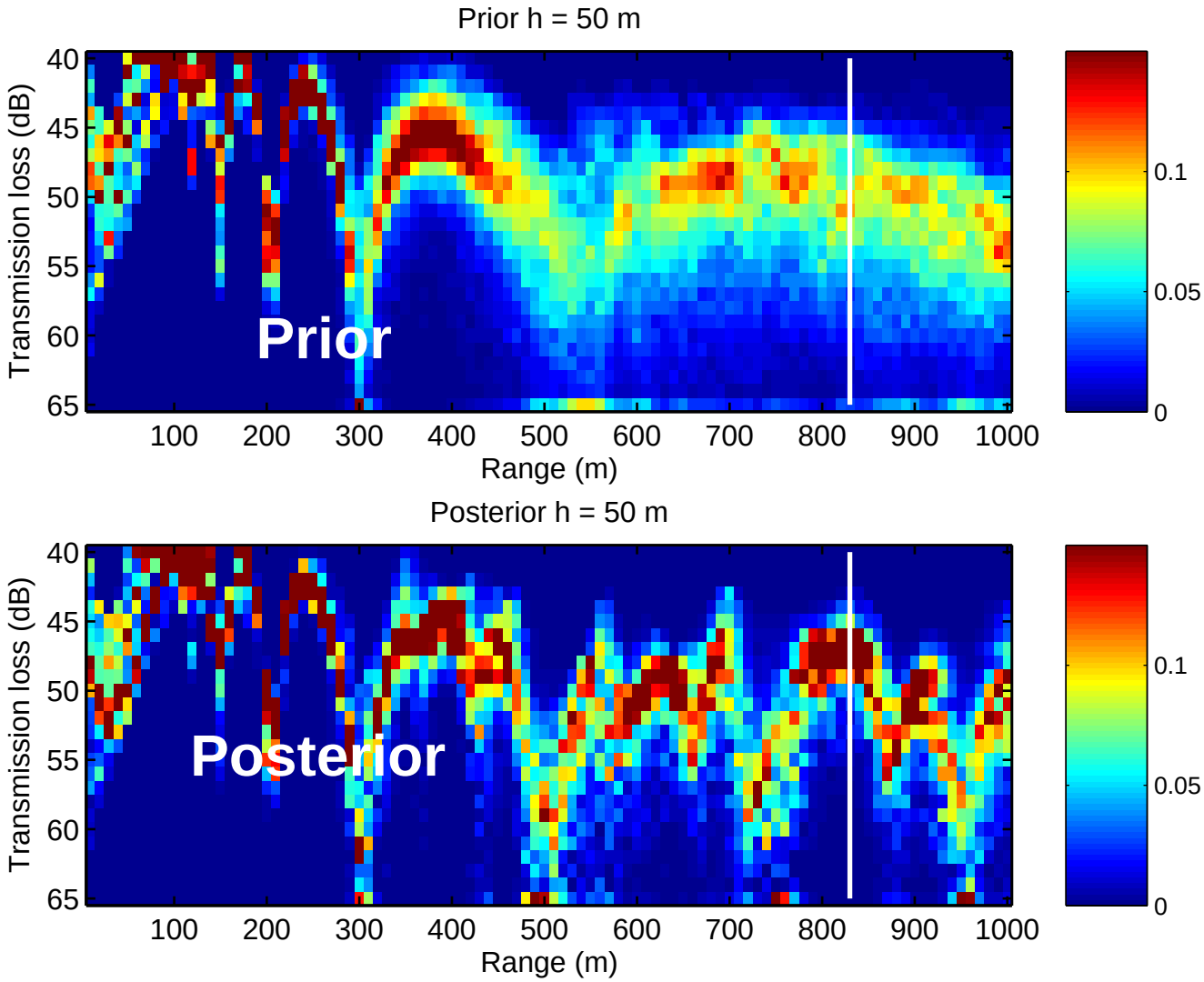


2 variables each has 40 discriminations, 1600 points

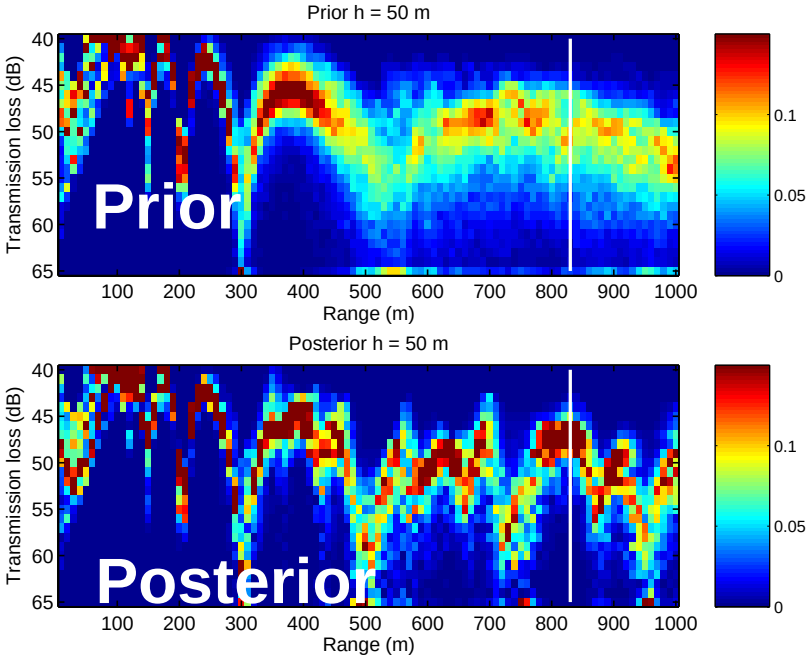
Priori distributions are uniform in the above ranges

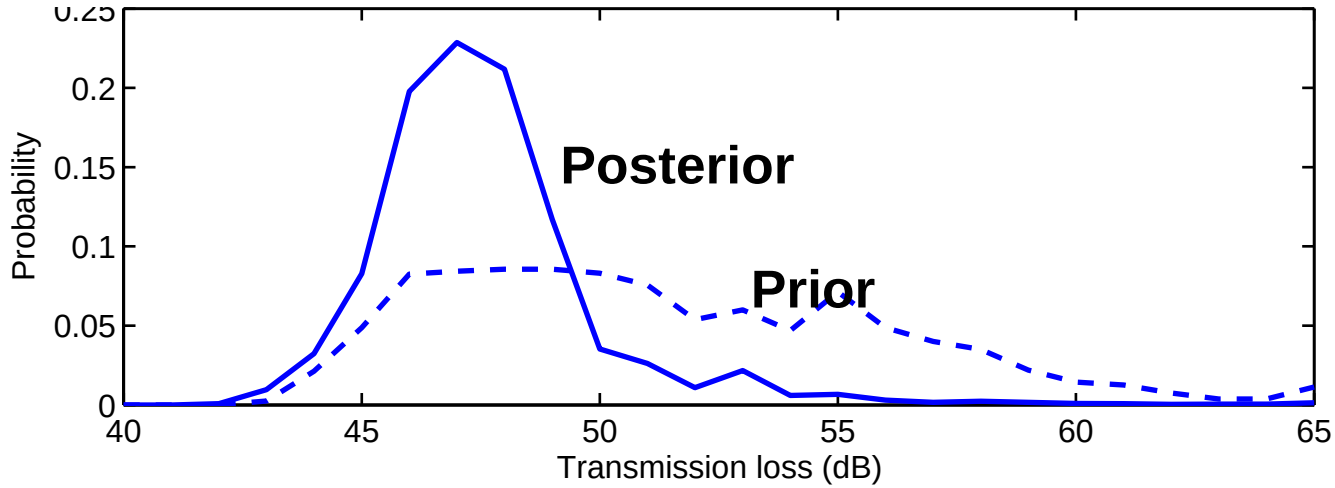
ASIAEX- Propagation Loss Distributions

Frequency 500 Hz, SD 20m



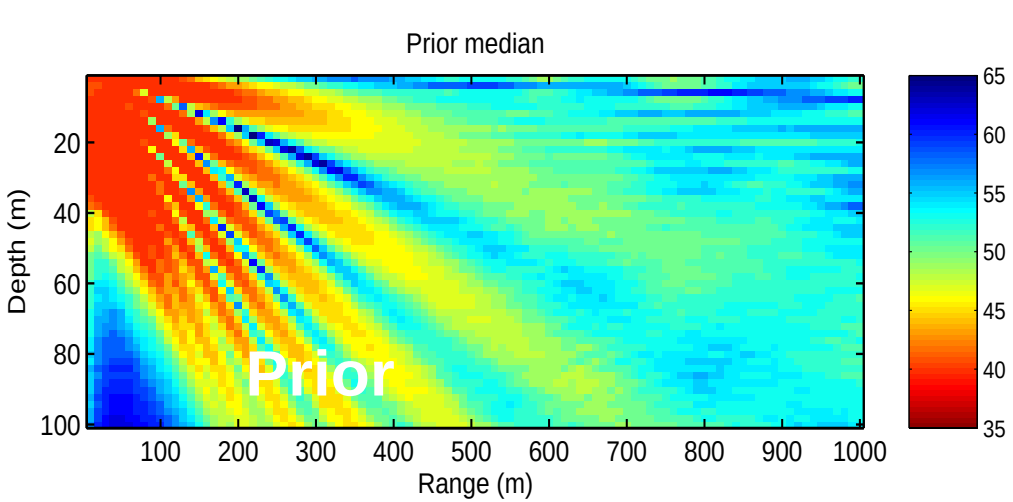
ASIAEX - TL Variation

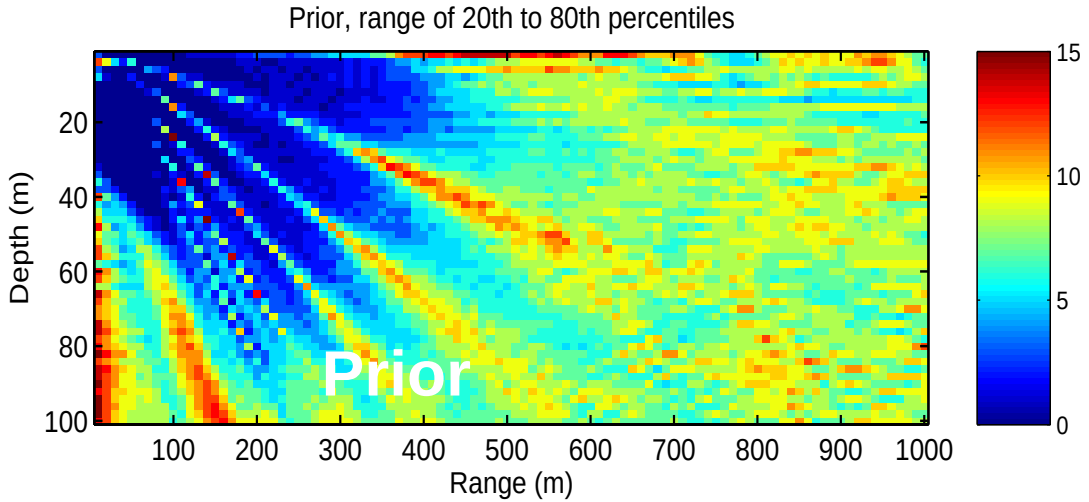


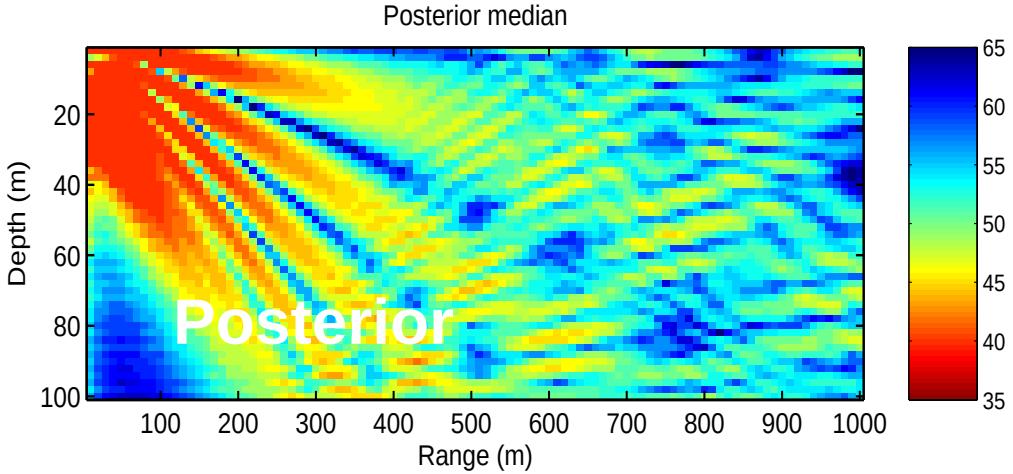


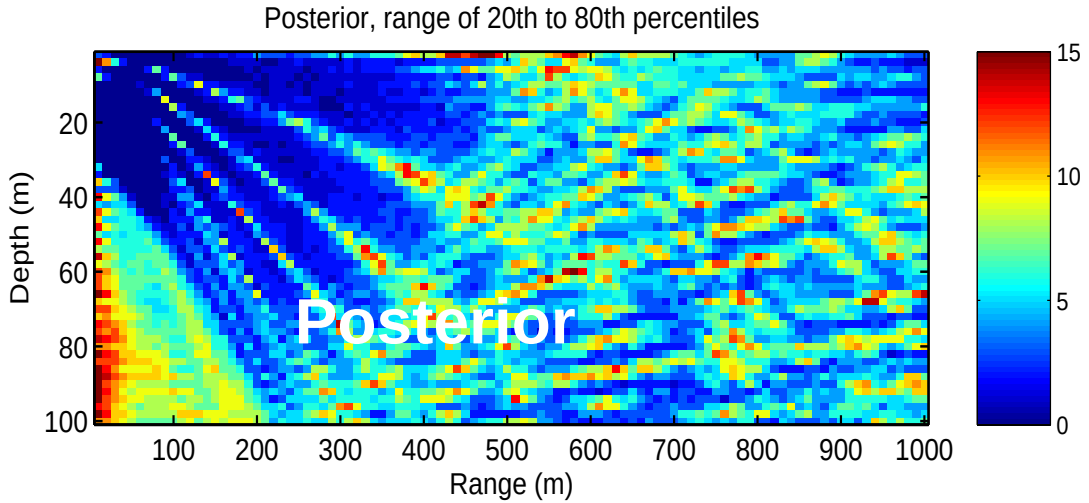
ASIAEX- Median and 5-95 Percentile Spread

Spread=range from 5 to 95 percentiles







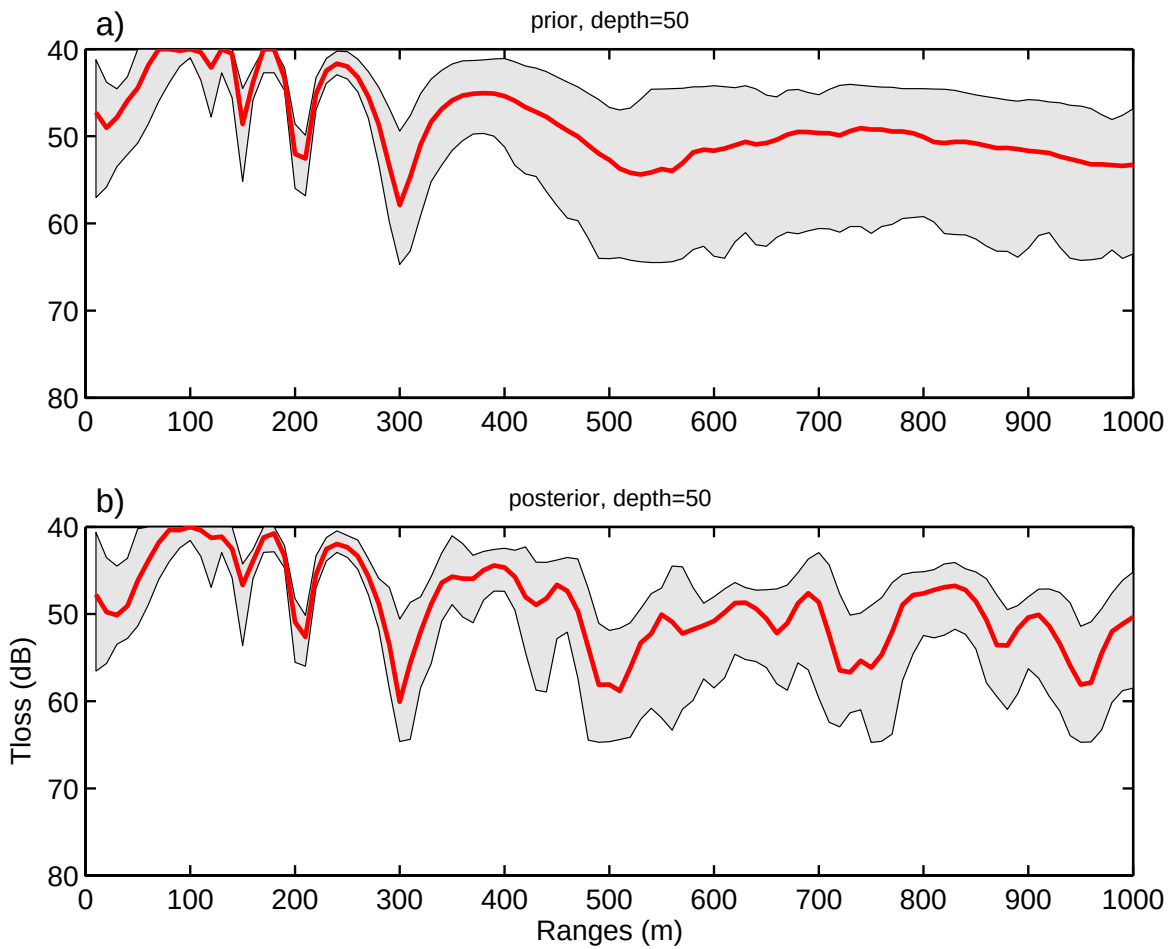


ASIAEX TL Variation

Median TL

Grey area 5-95 percentile spread

Short ranges not influenced by bottom



Summary

- Geoacoustic parameter estimates are only an intermediate step on the way to system performance prediction.
- An algorithm for estimating statistical properties of transmission loss based on output from a geoacoustic inversion has been developed using a likelihood formulation.
- For simplicity, we have focused on grid integration. With more parameters Monte Carlo integration is needed.
- The approach has been demonstrated using inversion results from ASIAEX East China Sea data.

Backup

Backup

Posterior transmission Loss Probability

Posterior transmission loss probability

$$p(u(r,z)) = \int \delta\left(u(\mathbf{m},r,z) - u(r,z)\right) p(\mathbf{m}\,|\,\mathbf{d})\mathrm{d}\mathbf{m}$$

$\mathbf{u}$ = transmission loss

$\mathbf{m}$ = environmental parameters

$\mathbf{d}$ = observed acoustic data

The posterior propability for environmental parameters is found using Bayes' rule

$$p(\mathbf{m}\,|\,\mathbf{d}) = p(\mathbf{d}\,|\,\mathbf{m})\,p(\mathbf{m})$$

$$\text{posterior} = \text{likelihood} \times \text{prior}$$

The integral is solved using simple Monte Carlo integration (M>5), or grid integration (M<5).

Signal and Likelihood Function

Signal model

$$\mathbf{d} = S\mathbf{d}(\mathbf{m}) + \mathbf{e}$$

observed data = signal $\times$ modeled data(parameters) + noise

results in a likelihood function

$$\mathcal{L}(\mathbf{m}) = \left[\frac{N}{\pi\phi(\mathbf{m}^{\mathrm{ml}})}\right]^{N} \exp\left(-N\frac{\phi(\mathbf{m})}{\phi(\mathbf{m}^{\mathrm{ml}})}\right)$$

where the objective function

$$\phi(\mathbf{m}) = \|\mathbf{d}\|^2 - \frac{\left|\mathbf{d}^H\mathbf{d}(\mathbf{m})\right|^2}{\|\mathbf{d}(\mathbf{m})\|^2}$$

ASIAEX- Marginal Scatter Diagram

Towed source
Frequencies 195, 295, 395 Hz
SD 48.5 m

Received on a 16 element VA

Objective function is Bartlett misfit

13 parameter inversion.
WD and SR spread uniformly due to coupling

Blue line single-parameter sensitivity