The impact of ocean sound speed variability on the uncertainty of geoacoustic parameter estimates

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Objective:
• Use EOFs to construct water SSP for MFI
• Examine impact of different sets of SSP observations
• Show effects of SSP on geoacoustic estimates

Outline:
• General information
  • Experimental site
  • Bayesian inversion approach
• Impact of different oceanographic observations
  • EOF analysis of water column SSP
  • Number of EOFs to be used in the inversion
• Inter parameter correlations at different ranges
• Conclusions
General information of multi-tonal experiment:

Acoustic array (MPL):
- VLA1

Source ship stations, range:
- WP21, 1 km
- WP22, 3 km
- Wp23, 5 km

Water depth:
- ~79.0m

Signal frequencies:
- LF: 53, 103, 203, and 253 Hz
- MF: 303, 403 503, 703 and 953 Hz
Recap: Is the SSP @ source all we need?

Sound speed profile in the water has significant impact on MFI

SSPs measured at source and VLA1

Ambiguity surface of MFP (source localization)

💡 Sound speed profile in the water has significant impact on MFI
Geoacoustic inversion strategy

• Invert for an effective water column SSP for a range independent propagation problem

• Parameterize temporal – spatial varying environmental SSP in terms of EOFs

• Bayesian MF geoacoustic inversion
  • EOF coefficient sensitivity for the inversion
  • Inter-parameter correlation and 2-D marginal distribution for interpreting the effects of SSP to the geoacoustic estimates
Oceanographic observations:

- **Small sample set:**
  - SSP casts obtained on the source ship within 4 hours along the track.
  - fit only the thermocline region in the inversion

- **Large Sample set:**
  - SSPs in the vicinity (SHARK, SW31 & SW32) within source transmission time + small sample set
  - invert for the whole profile in the water column
Oceanographic observations cont.

SSPs measured at source and VLA1
Small sample set

SSPs measured at SHARK, SW31 and SW32

Large sample set
The number of EOF coefficients to be inverted

Residual SSP:

\[ S_r(N_z, K) = \text{expected SSP} - \text{average SSP} \]

Reconstructed residual SSP with \( L \) EOFs:

\[ S^K_L(N_z) = \sum_{j=1}^{L} w^K_j v_j \]

Degree of accuracy:

\[ \mu = \frac{\sum_{p=1}^{N_z}[S^K_L(p)]^2}{\sum_{p=1}^{N_z}[S_r(p, K)]^2} \]

Number of EOF coefficients to be inverted \( L \):
When \( \mu \) reaches prescribed accuracy.

\( \mu \) is preselected. Since the small sample set is more relevant to the experiment, \( L \) is smaller.
Example of determining the number of EOFs

8 EOF coefficients, more than 90% of the accuracy.
Comparison of geoacoustic inversion results

Since adequate SSP information was taken into account in the inversion, the marginal distributions of the geoacoustic estimates are similar.
Comparison of marginal distribution of inverted SSPs

Large sample set

Small sample set

💡 The tight 95% credibility intervals from both approaches indicate the Inversion is very sensitive to the water column SSP.
Water column SSP has more impact on geometric parameters than geoacoustic parameters.
2D marginal distributions at 3 km

Dual mode distribution – the ‘true’ values were not the highest probable values.
2D marginal distributions at 5 km

Broad distributions of range and source depth estimates at longer range.
Comparison of geoacoustic inversion results at 1, 3 and 5 km

Geoacoustic inversion results are consistent at three ranges.
Conclusion:

- Water column sound speed profile has significant effect on geometric parameters and therefore affects geoacoustic parameter estimates.
- The most relevant SSPs are more effective and efficient in MF geoacoustic inversion.
- Geoacoustic parameter estimates using different SSP observations are consistent with each other.

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