The impact of variable shallow water environment on source localization uncertainty

Yong-Min Jiang
jiang@nurc.nato.int

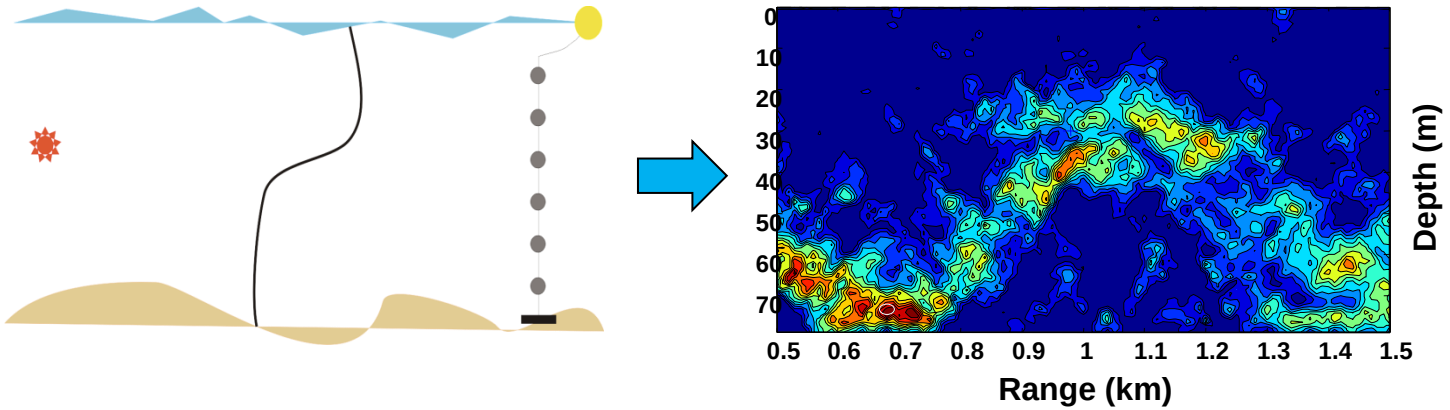
NATO Undersea Research Center
Viale S. Bartolomeo 400, La Spezia 19126, Italy

NATO
OTAN

NURC
PARTNERING FOR MARITIME INNOVATION

Outline

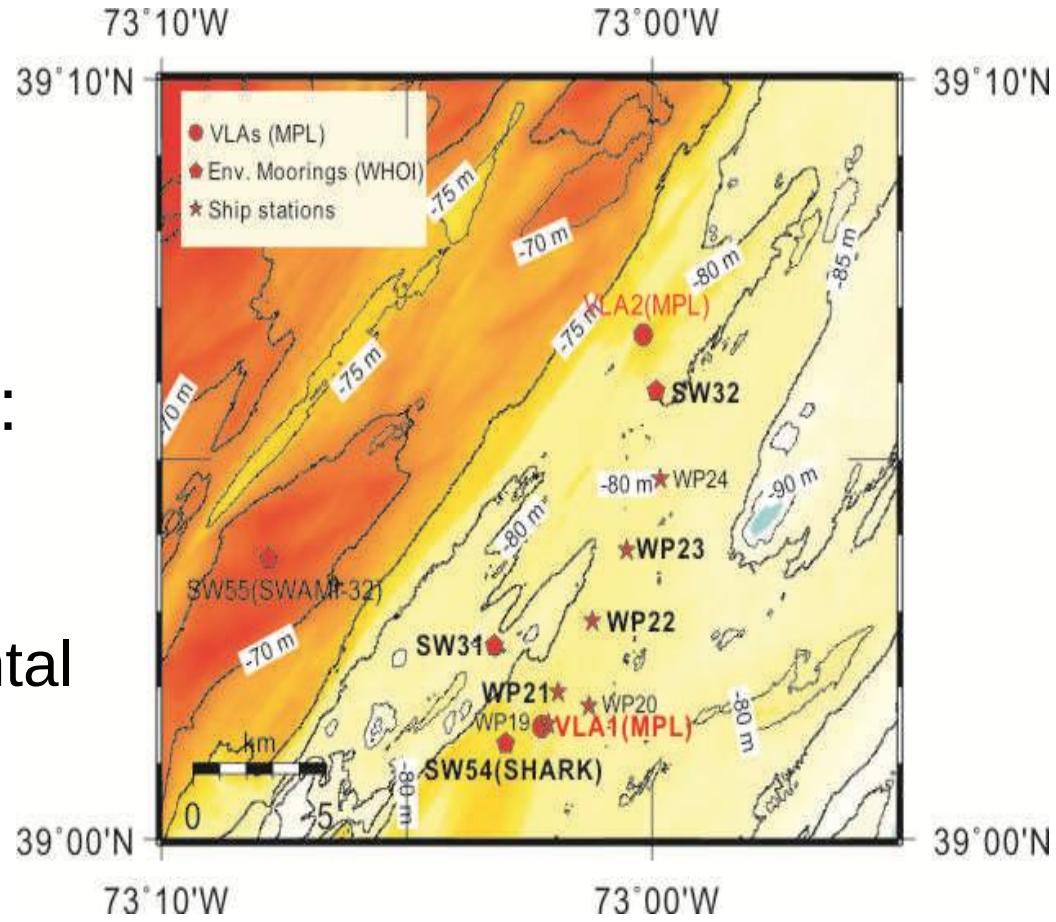
- Matched field localization



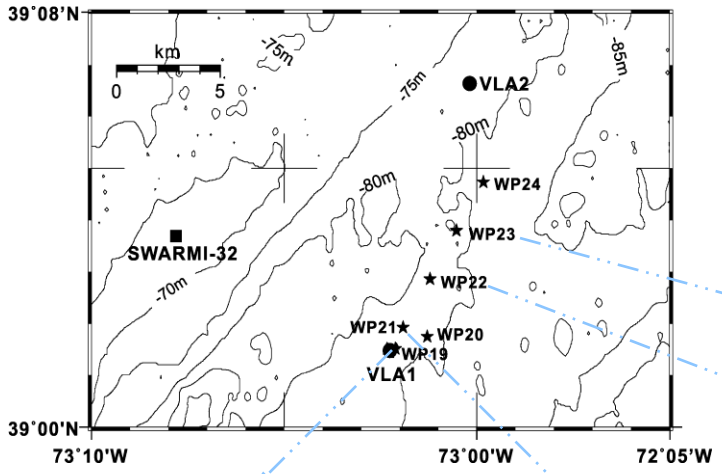
- Experimental example:
  - Environmental characterization
    - Sea bed & water column
  - The impact of shallow water environment on source localization

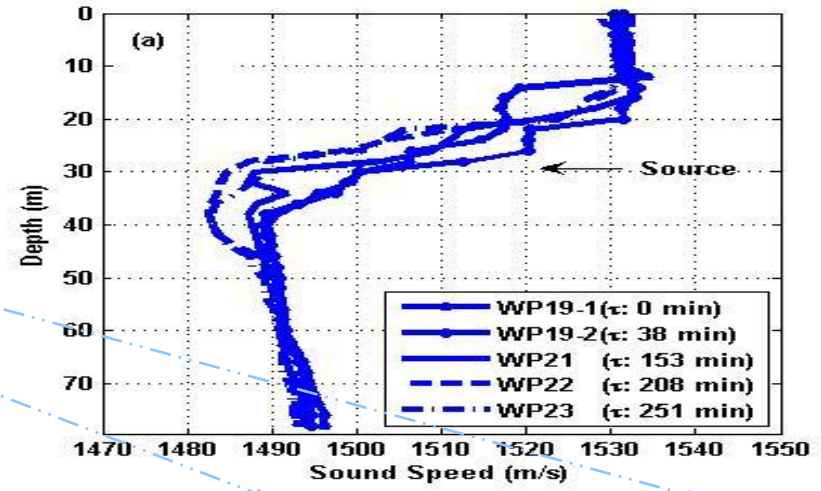
Data background

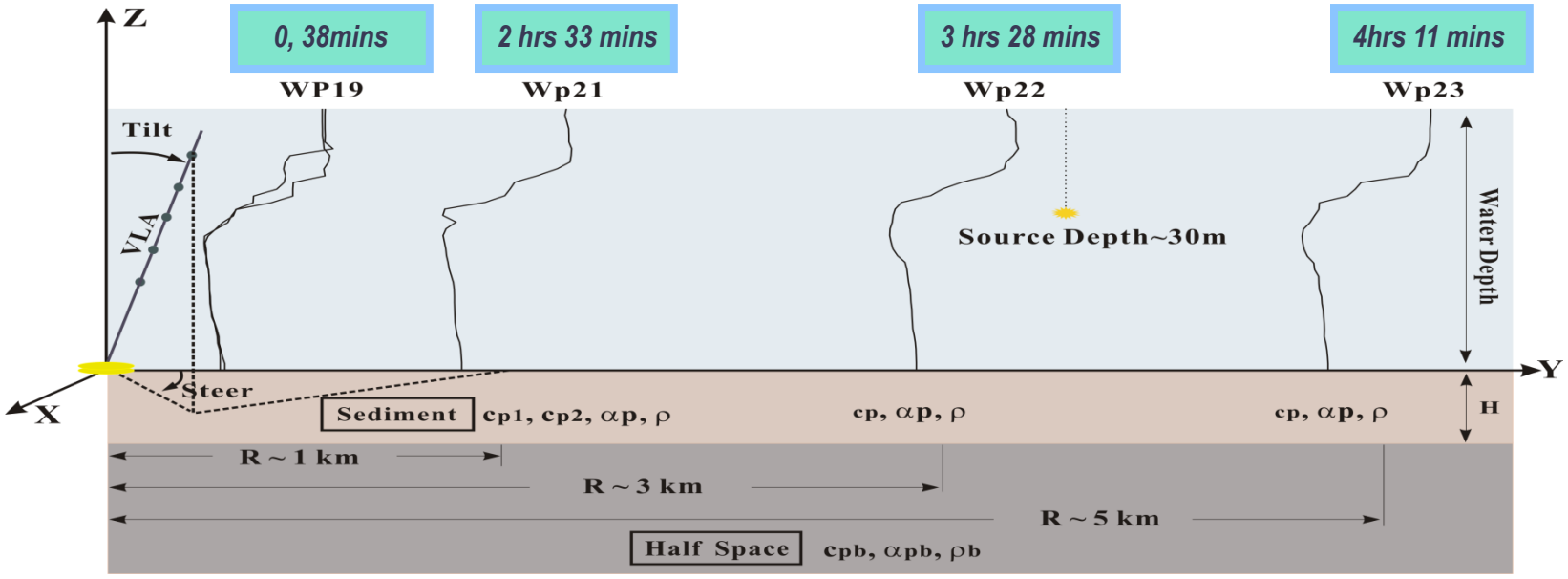
- SW06 Experiments:
  - ONR sponsored
  - New Jersey Shelf
- Towed source Expt.:
  - Low freqs. (< 1 kHz)
  - Range (1 to 5 km)
  - Oceanic environmental observation at the same time



CTD casts along the propagation path

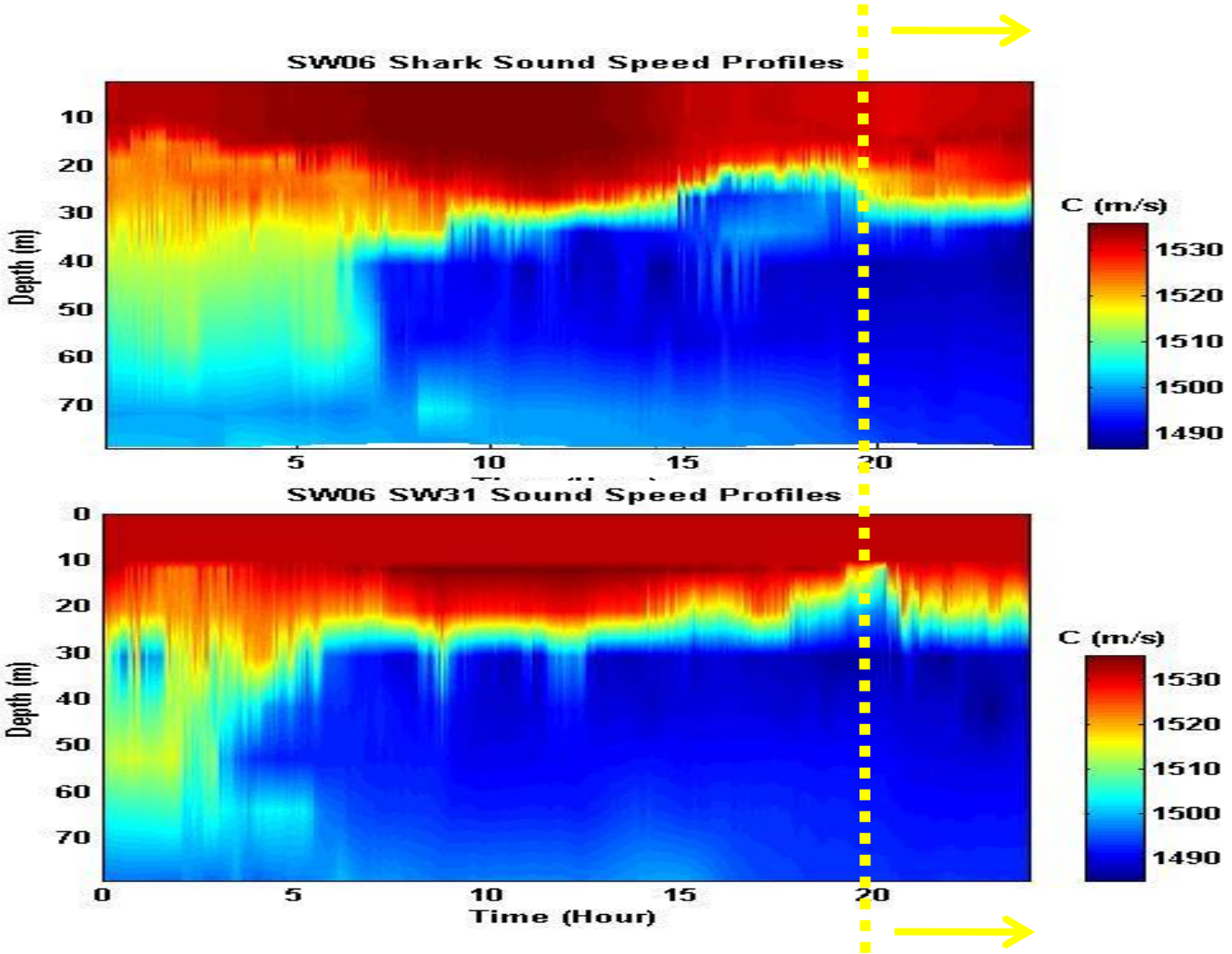






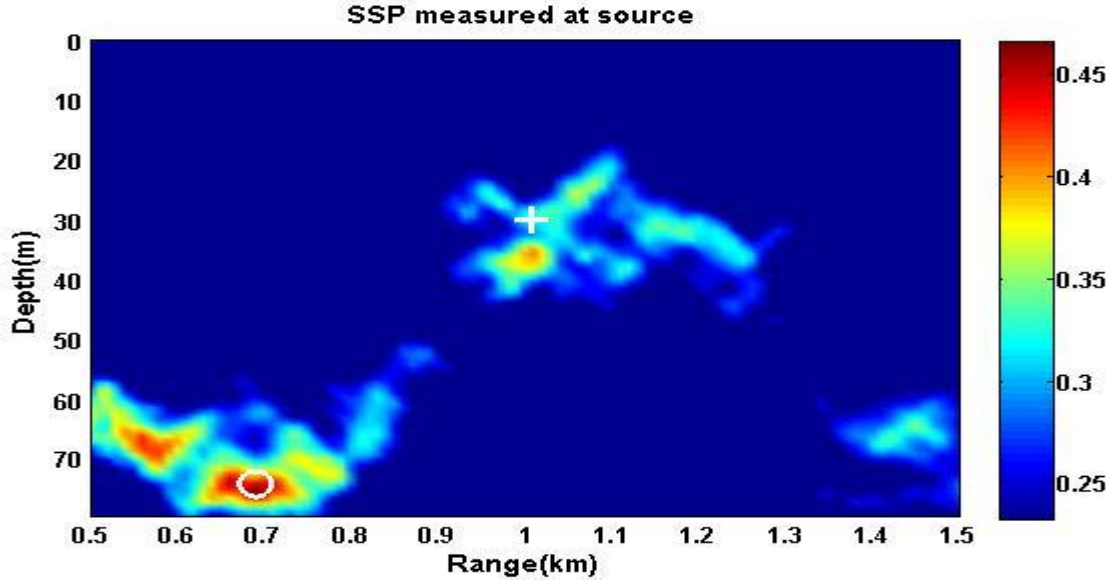
CTD casts on environmental moorings

- Close to VLA
- Close to 1 km source

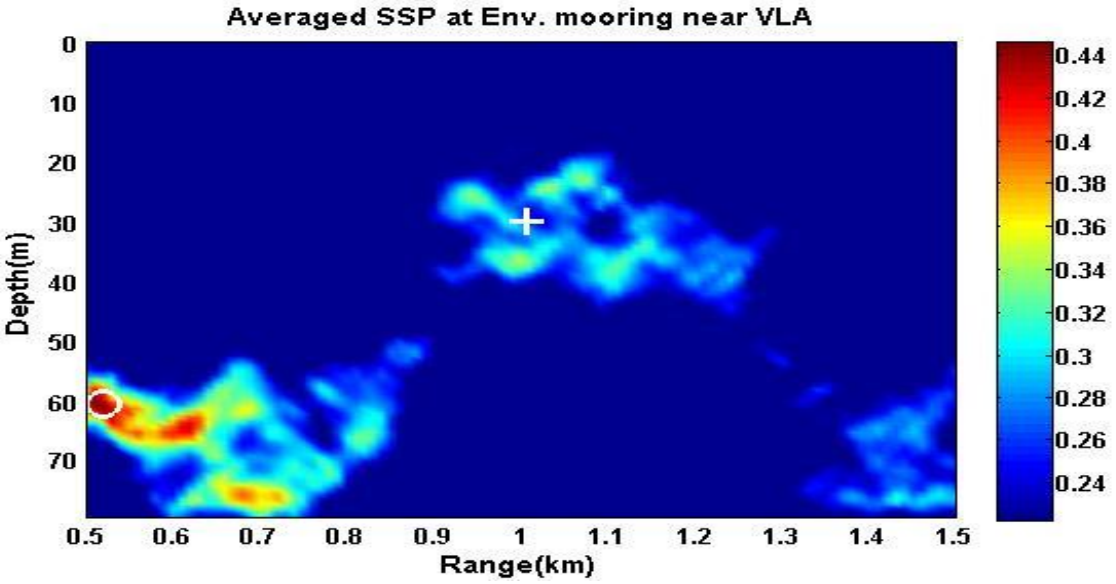


What to use to find the source?

- Any profile along the path?



- Average of all the observations?

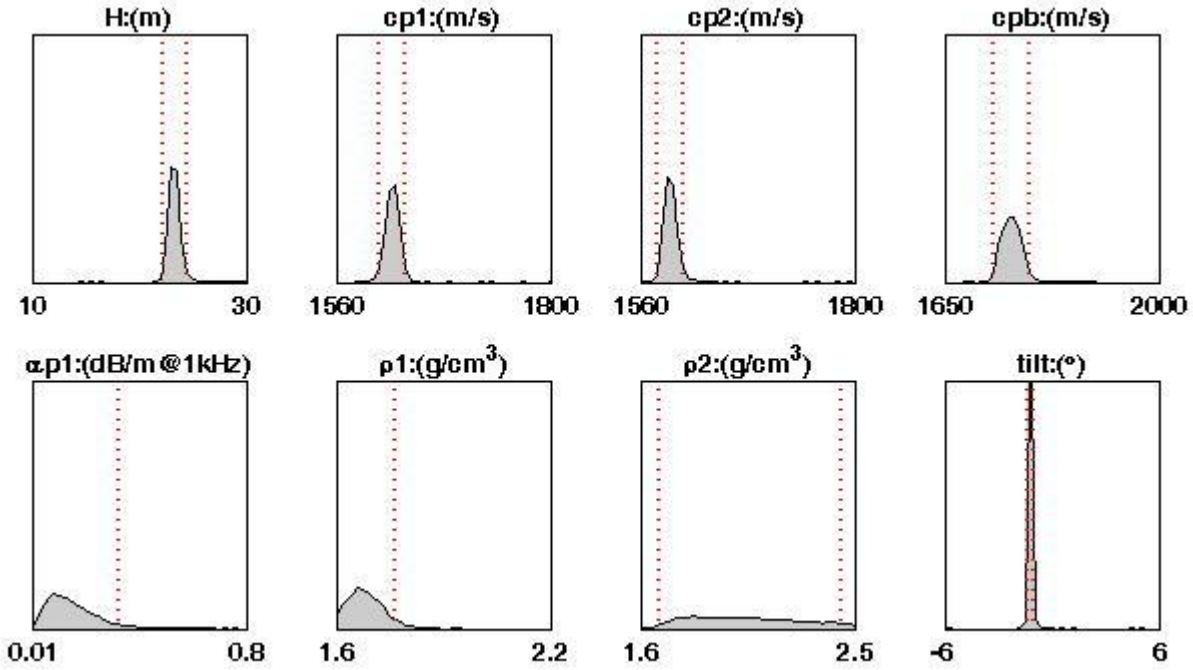


Environmental characterization — Water column & sea bottom

- Account for spatially – temporally variable SSP:
  - include in the inversion
  - in terms of empirical orthogonal functions (EOFs)

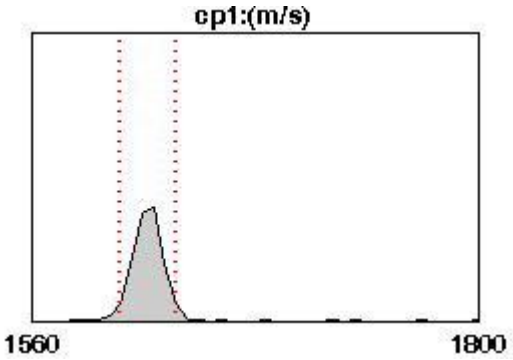
- Bayesian geoacoustic inversion
  - Bayes' rule: $P(\mathbf{m}|\mathbf{d}) = \dfrac{P(\mathbf{d}|\mathbf{m})P(\mathbf{m})}{P(\mathbf{d})} \Rightarrow P(\mathbf{m}|\mathbf{d}) \propto L(\mathbf{m})P(\mathbf{m}),$
  - Nonlinear inversion problem
  - Obtain *Posterior Probability Distribution*(PPD) by numerical sampling – MCMC
  - Interpret the results in terms of: *Maximum a posterior*(MAP), means, marginal distributions and inter-parameter correlations

Example of inversion results

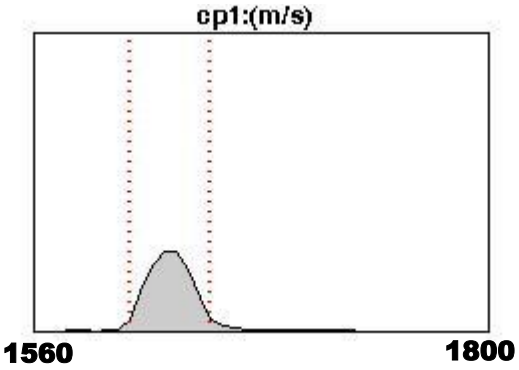


- Red dotted lines: 95% credibility interval – uncertainty of the estimates

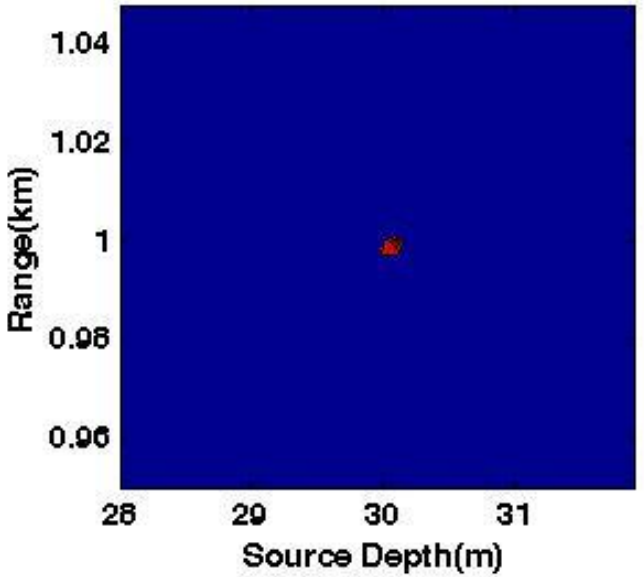
Impact – sediment sound speed

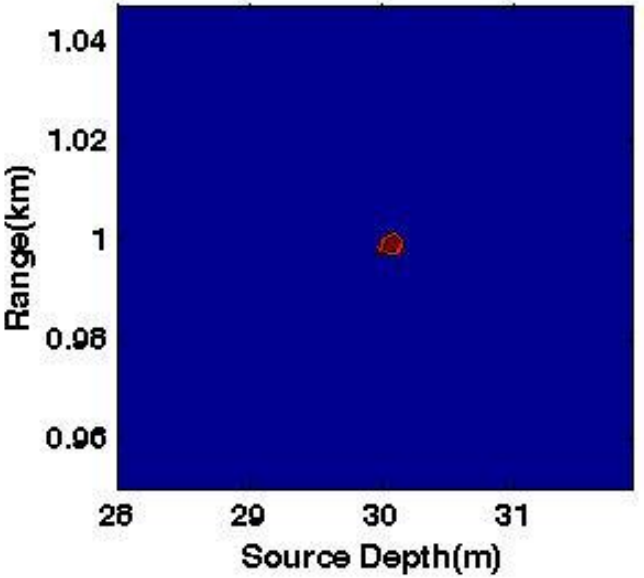


Inverted sediment sound speed

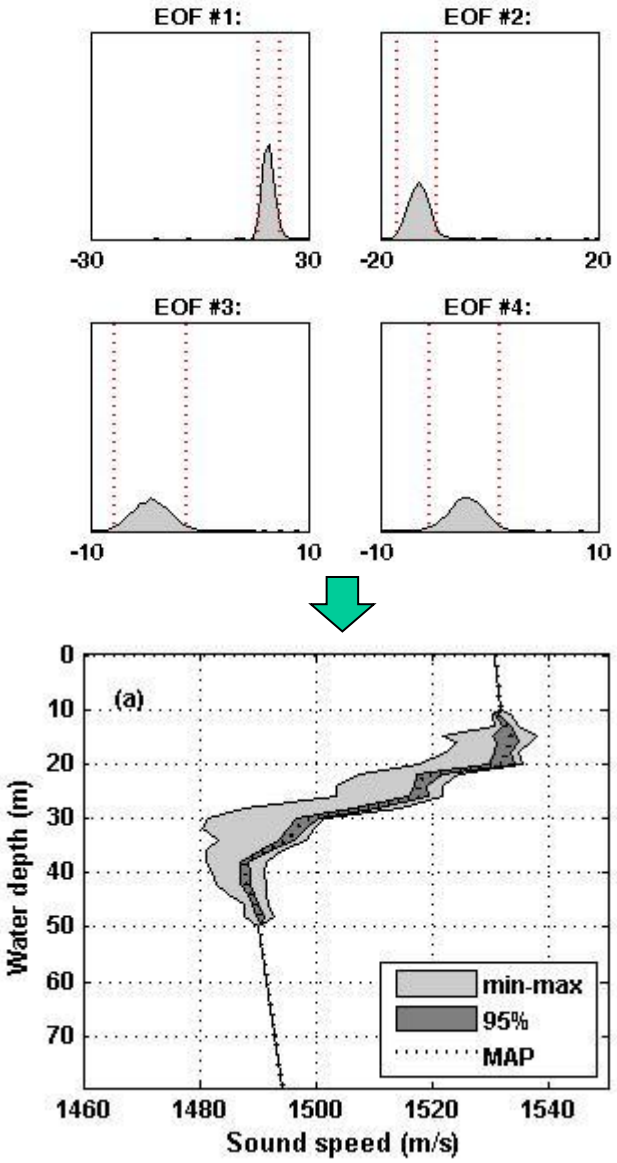


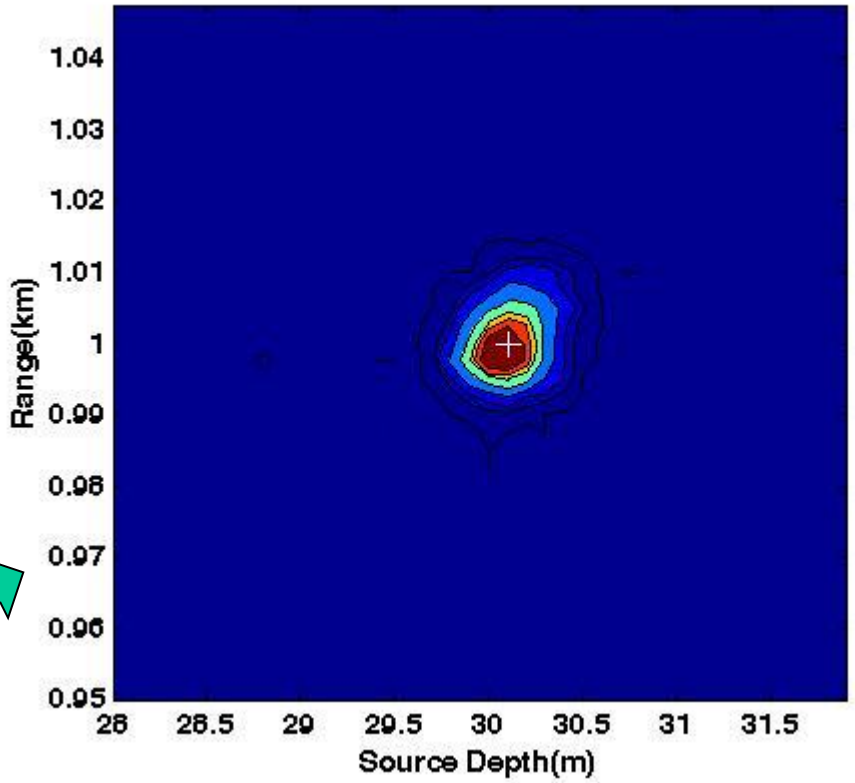
Artificially extended



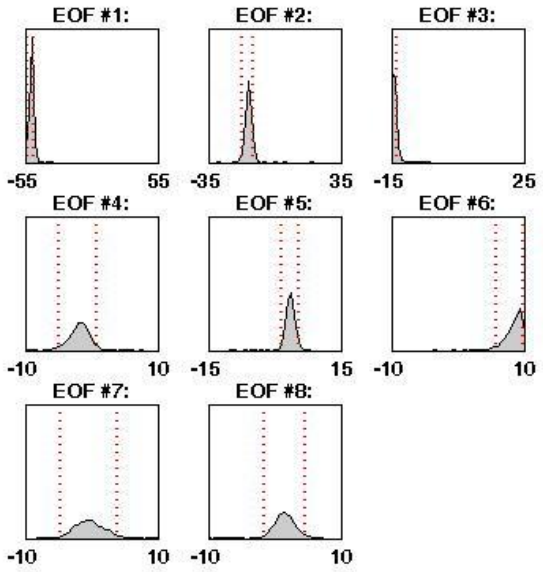


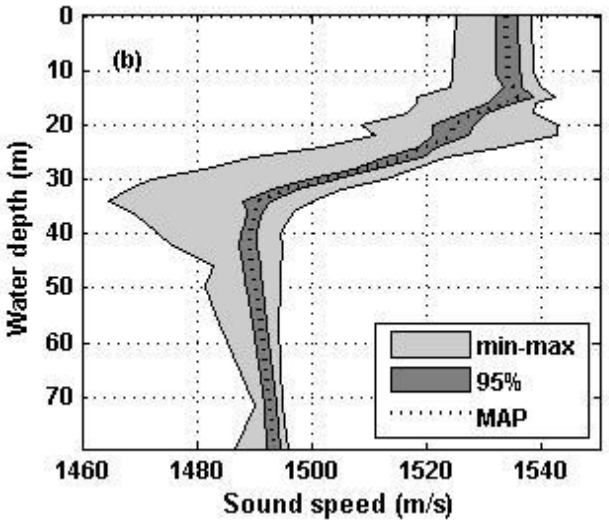
Impact – oceanic sound speed profile

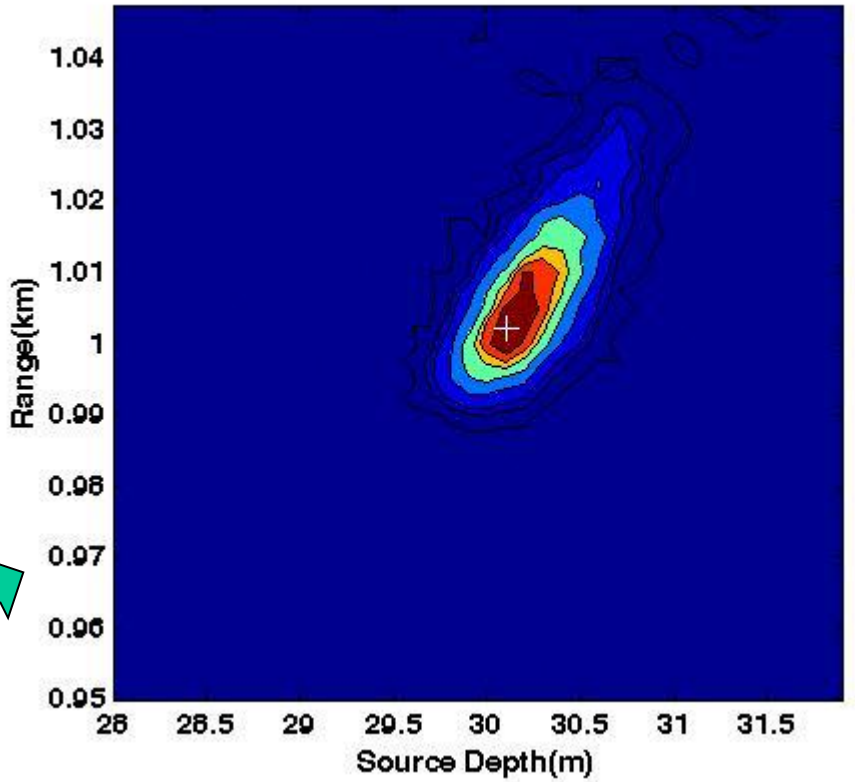




Impact – oceanic sound speed profile







Summary

- Spatially and temporally variable SSP has more impact on source localization than sea bottom parameters do
- Relevant watercolumn SSP is more informative
  - Along the propagation path and close to the acoustic measurement time frame
  - Fixed point environmental observations vs. spatially sampled SSPs
  - More EOFs, or fail to represent the oceanic environment
- Questions:
  - Better way to represent SSP?
  - How dense we need to sample spatially?

Acknowledgements

- ***SW06 participants, specifically, Ross Chapman, David Knobles, John Goff, Peter Gerstoft, William Hodgkiss, and Arthur Newhall etc. …***
  - Sharing the data
  - Discussions