Developing the Science of Networks

Single-anchor model-based acoustic range estimation and localization in shallow waters

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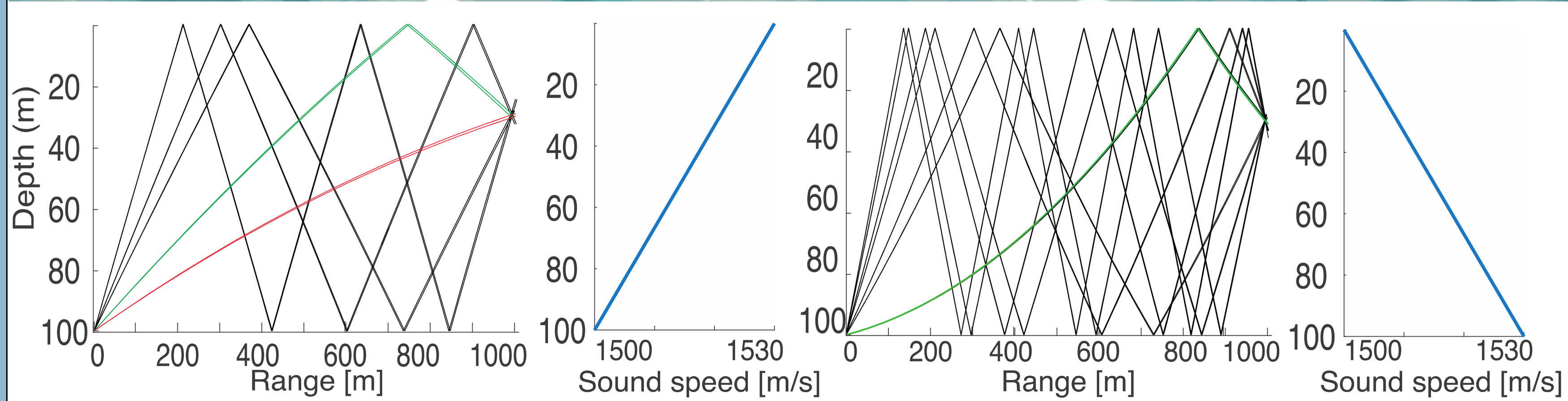
Motivation

Applications:
autonomous underwater vehicles (self)-localization

Challenges:
synchronization is hard to achieve
slow non-linear multipath propagation

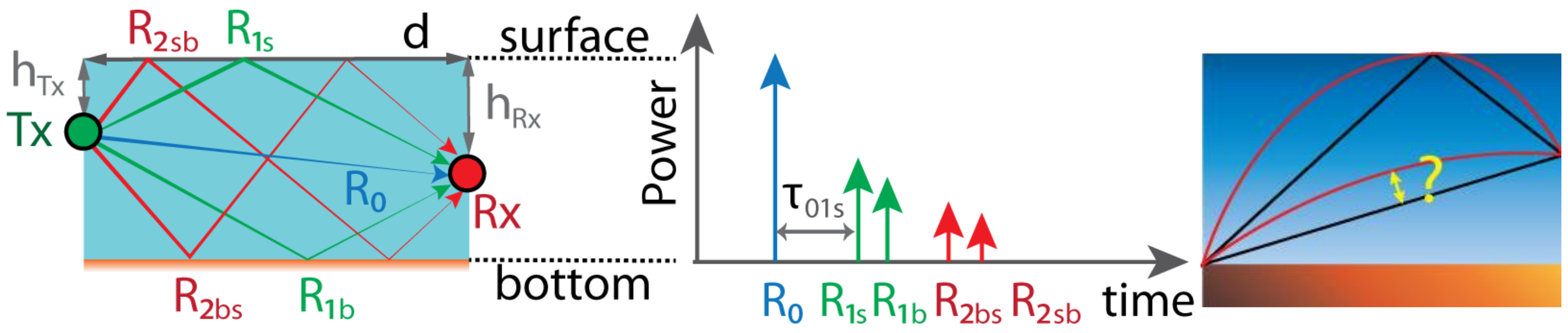


Example of underwater acoustic channel impulse response for 1) Synthetic upward refractive sound speed profile (SSP), 2) synthetic downward refractive SSP

Proposal: Take advantage from additional information about the environment to achieve better performance

Proposed methods: range estimation

Single stage single anchor range estimation: flat boundaries, unknown sound speed profile



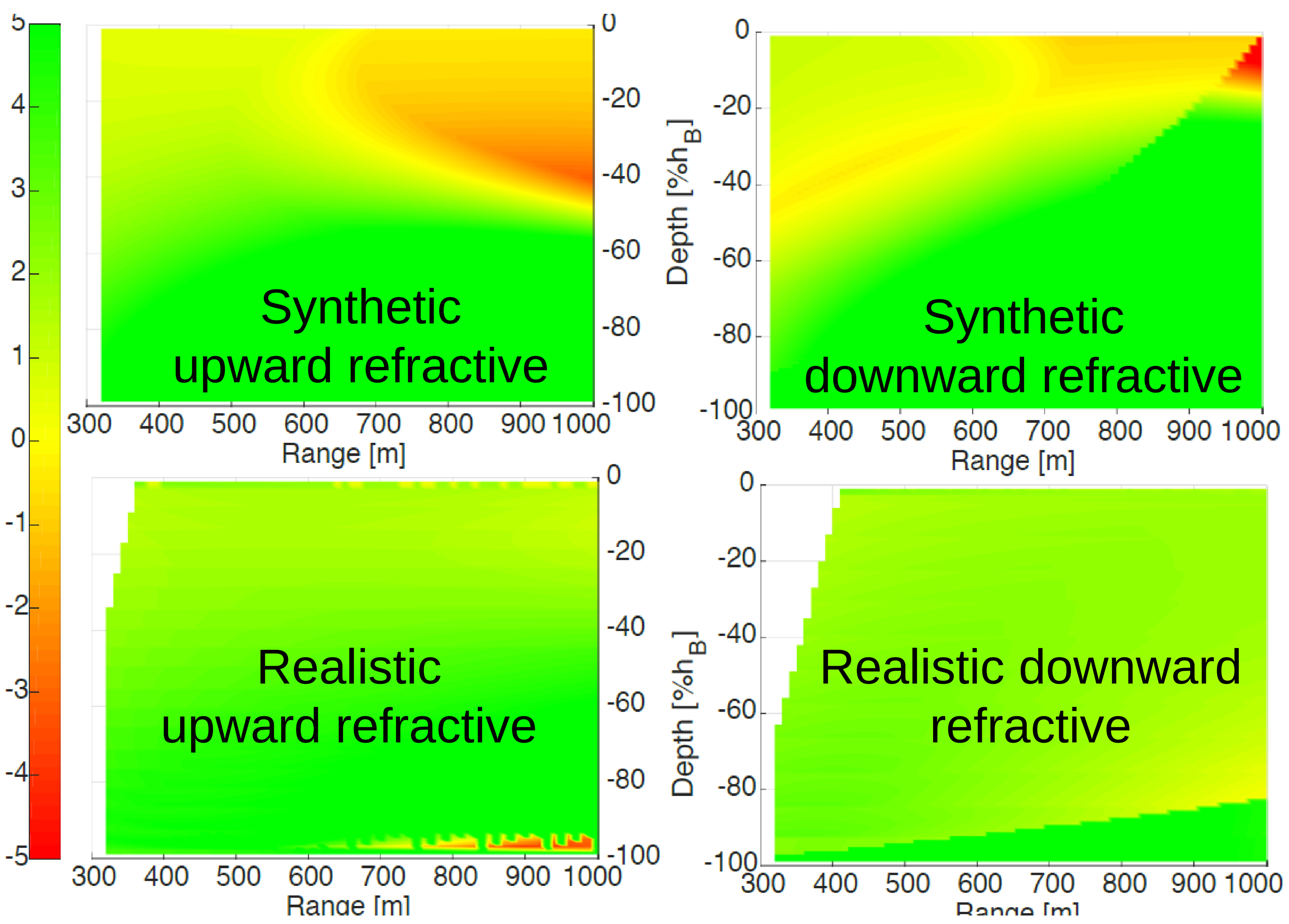
Measure of the deviation between rectilinear and actual ray trajectories:

$$c_{ij}^{eff} = (R_i - R_j)/\tau_{ij}$$

where R_i and R_j are calculated based on a rectilinear ray trajectory assumption, using known d, h_B and h_{Rx}

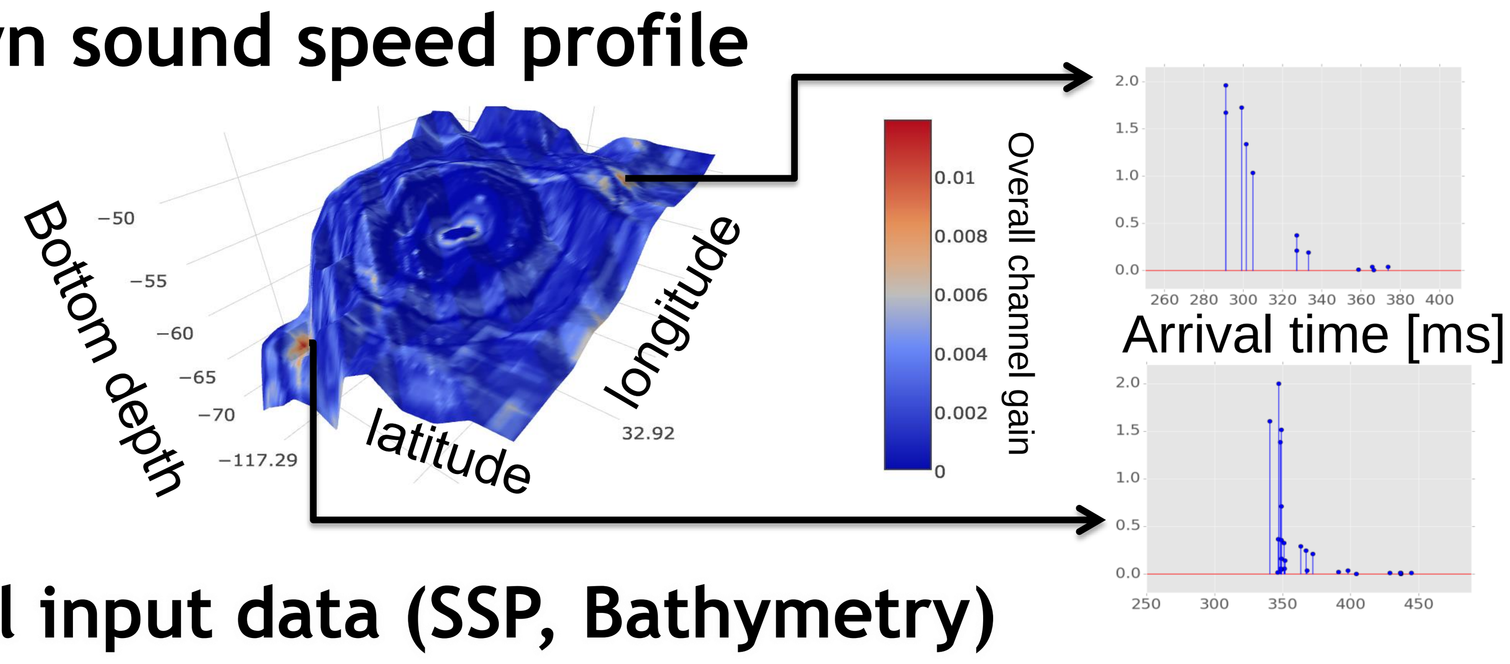
Results of range estimation

Difference (%) between the relative error of the LSE range estimator with and without the use of c_{eff} for different sound speed profiles



Proposed methods: localization

Localization: Non-flat known bathymetry, known sound speed profile



Model input data (SSP, Bathymetry) is fast changing and might be erroneous:

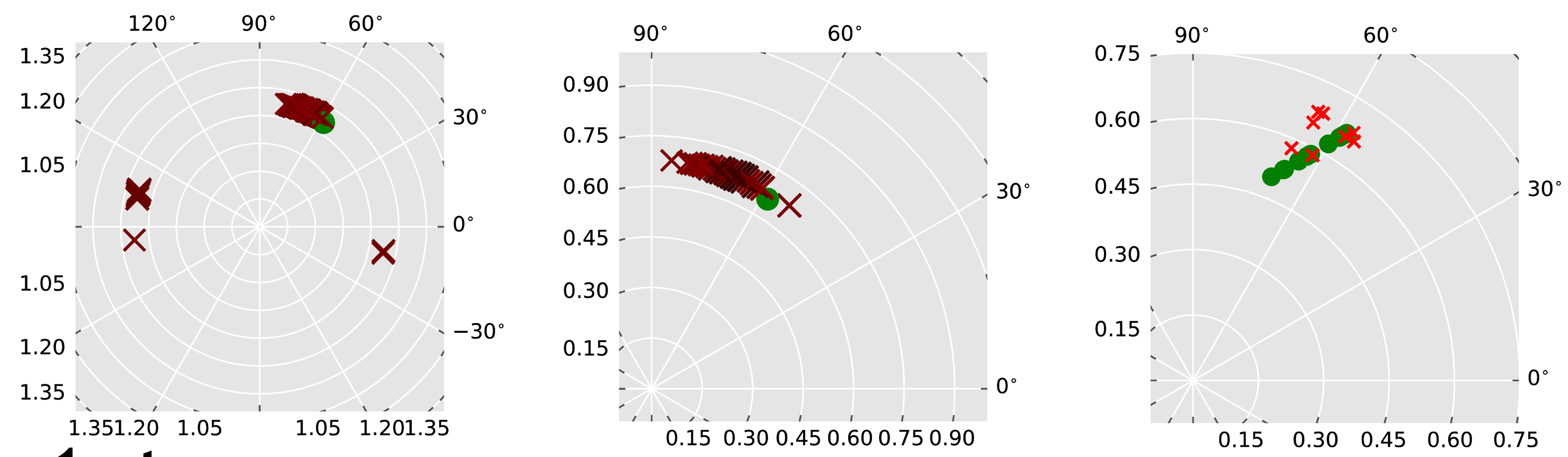
- **Create an effective real-time solution with relatively short "offline phase" robust to small errors in input data**

Arrivals can be similar among non-neighboring sectors due to random nature of arrivals:

- **Outliers removal: specialized Viterbi algorithm version**

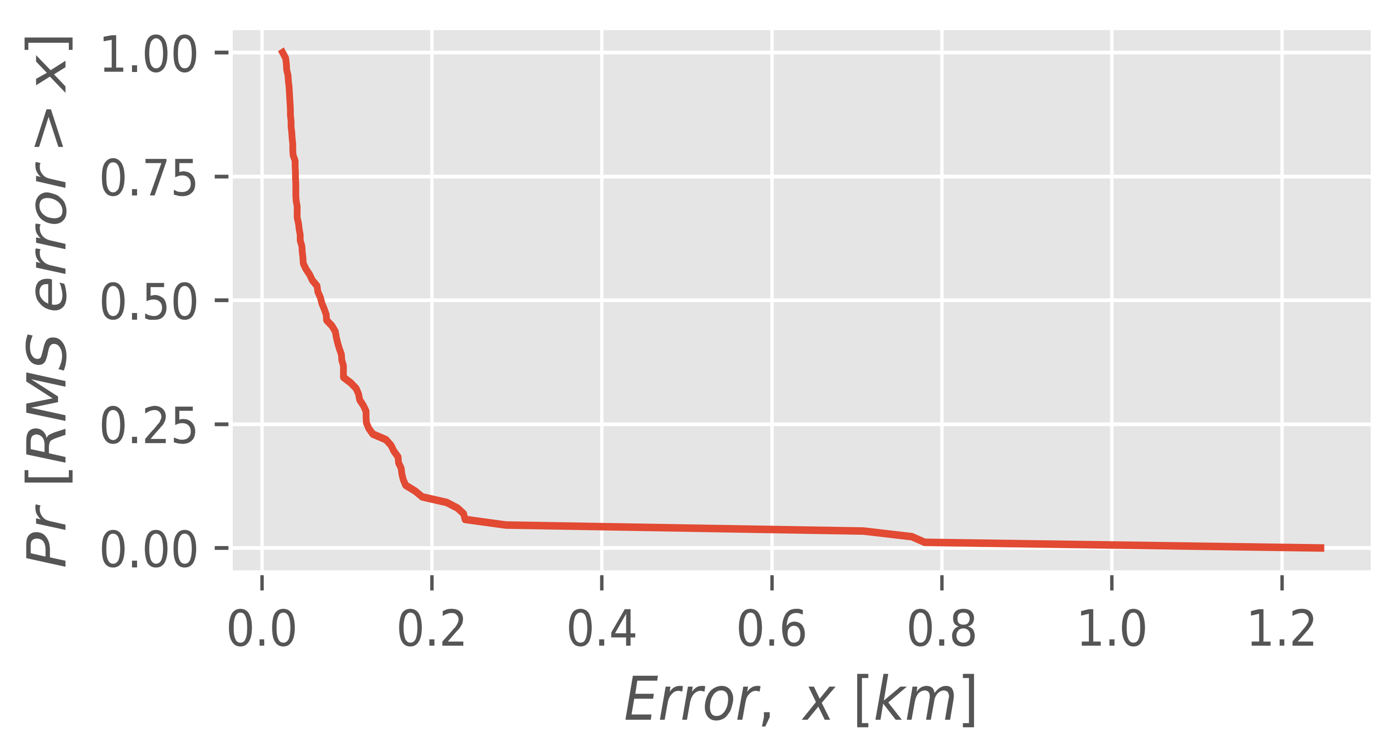
Results of localization

Model-based range-bearing localization cross-correlation simulation results (green - actual position, red - estimated positions)



1-step cross-correlation results | **1-step filtered results** | **10-step path estimation result**

Complementary cumulative distribution function of root mean square position estimation error:



Reference

[1] L. Paull S. Saeedi M. Seto H. Li "AUV navigation and localization: A review" IEEE J. Ocean. Eng. vol. 39 no. 1 pp. 131-149 2014.

[2] R. Diamant L. Lampe "Underwater localization with time-synchronization and propagation speed uncertainties" IEEE Transactions on Mobile Computing vol. 12 no. 7 pp. 1257-1269 2013.

[3] E. Dubrovinskaya, I.Nissen, P.Casari. "On the accuracy of passive multipath-aided underwater range estimation." Underwater Communications and Networking Conference (UComms), 2016 IEEE Third. IEEE, 2016.