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An Autonomous Underwater Vehicle for Seabed Characterization

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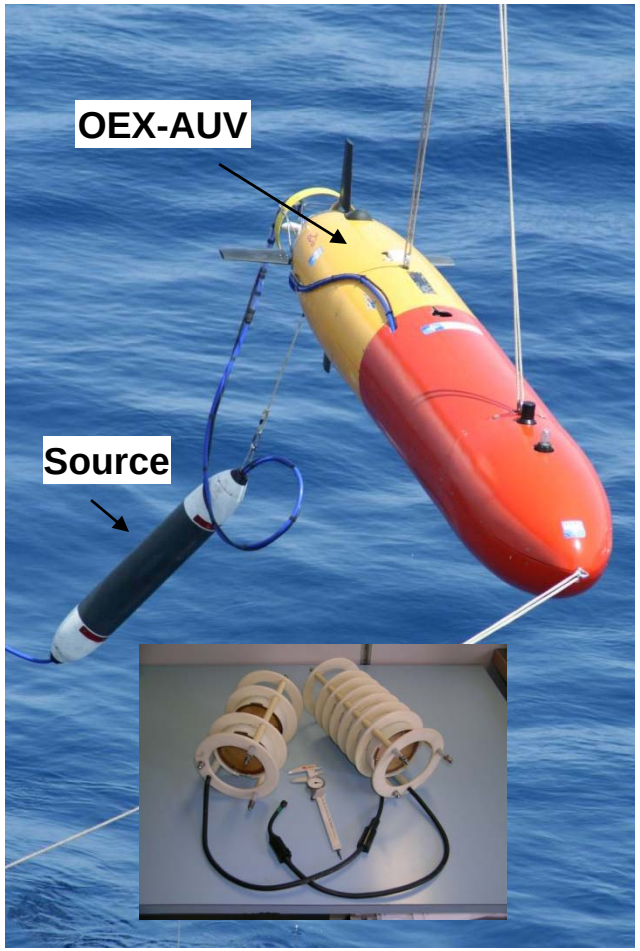
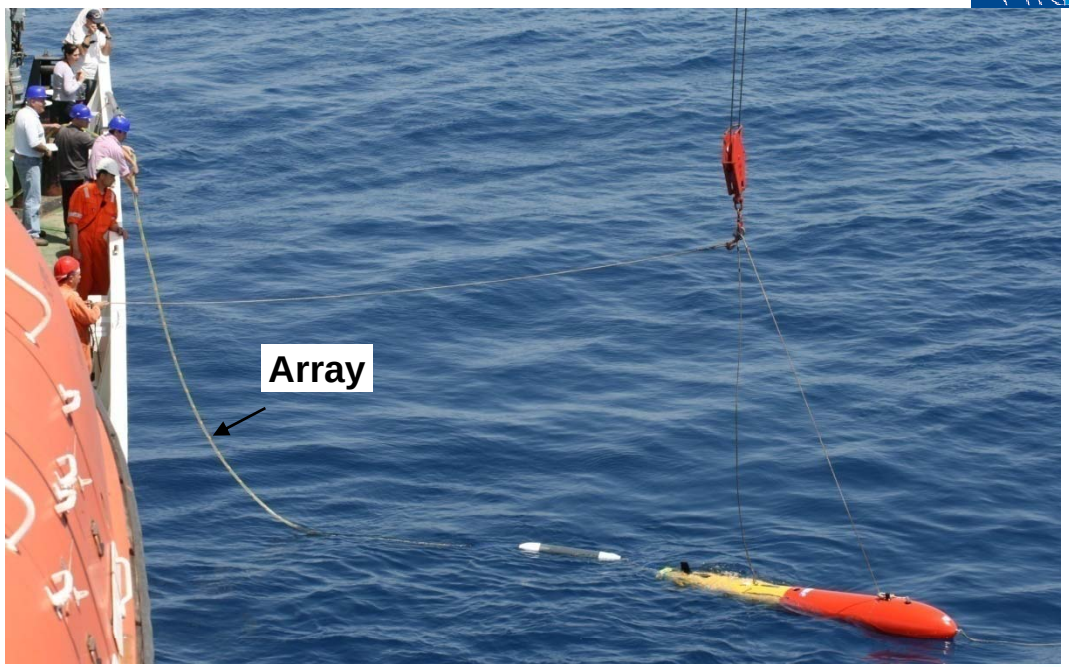
Motivation

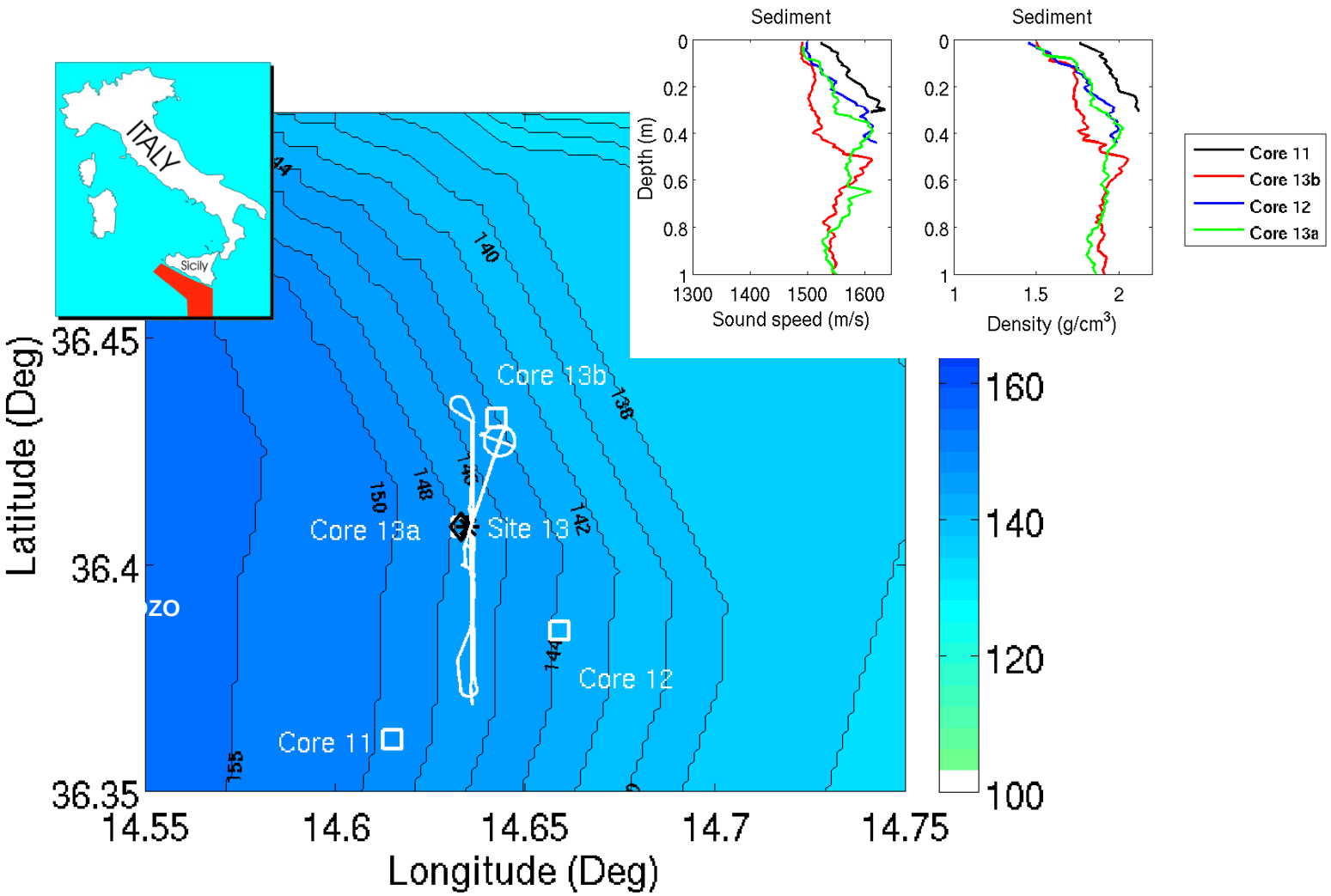
- Seabed properties are important information for sonar performance prediction, i.e. propagation, reverberation, clutter
- Generally viewed as the most difficult parameters to achieve and database information is often of limited use
- Inversion of acoustic signals to infer seabed properties is a promising technique
- Explore a newly NURC-developed tool for seabed characterization on spatial scales of 10-100 m

OEX-AUV, TOSSA and BENS

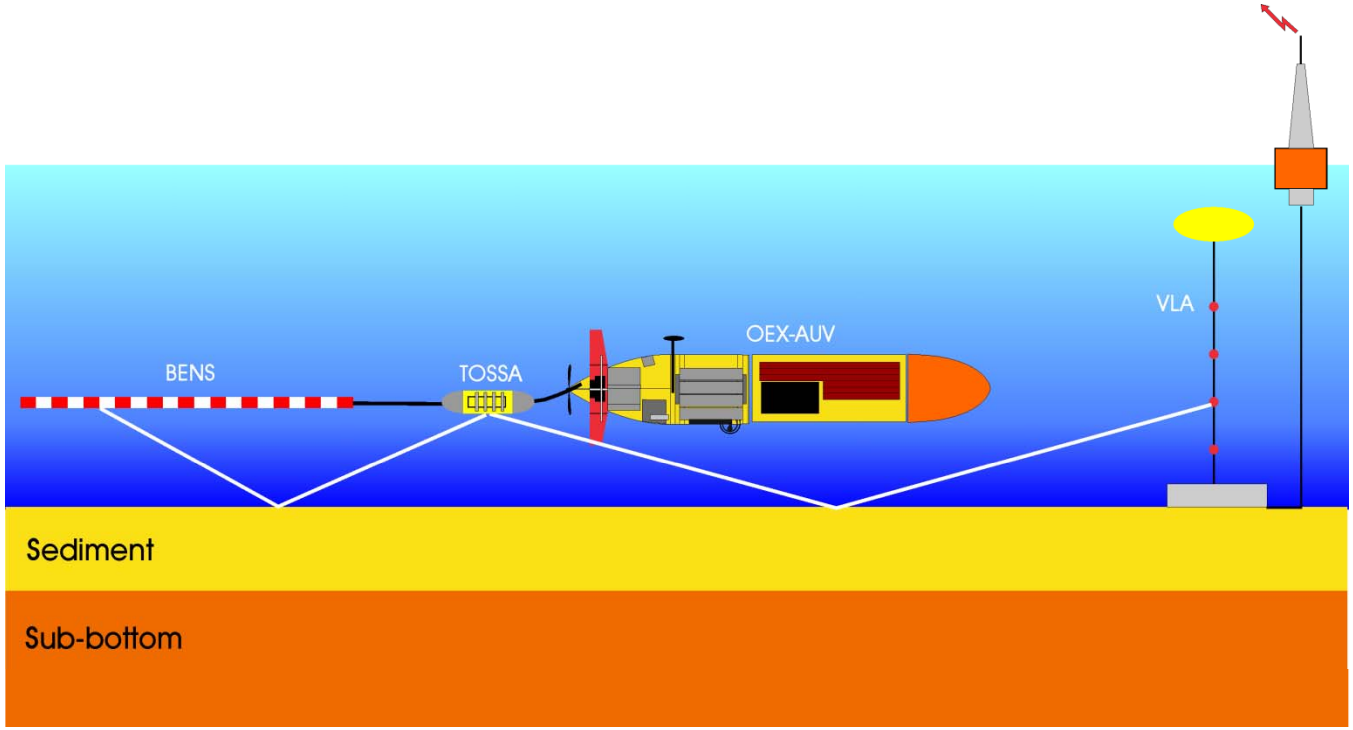




CLUTTER'09 Experiment

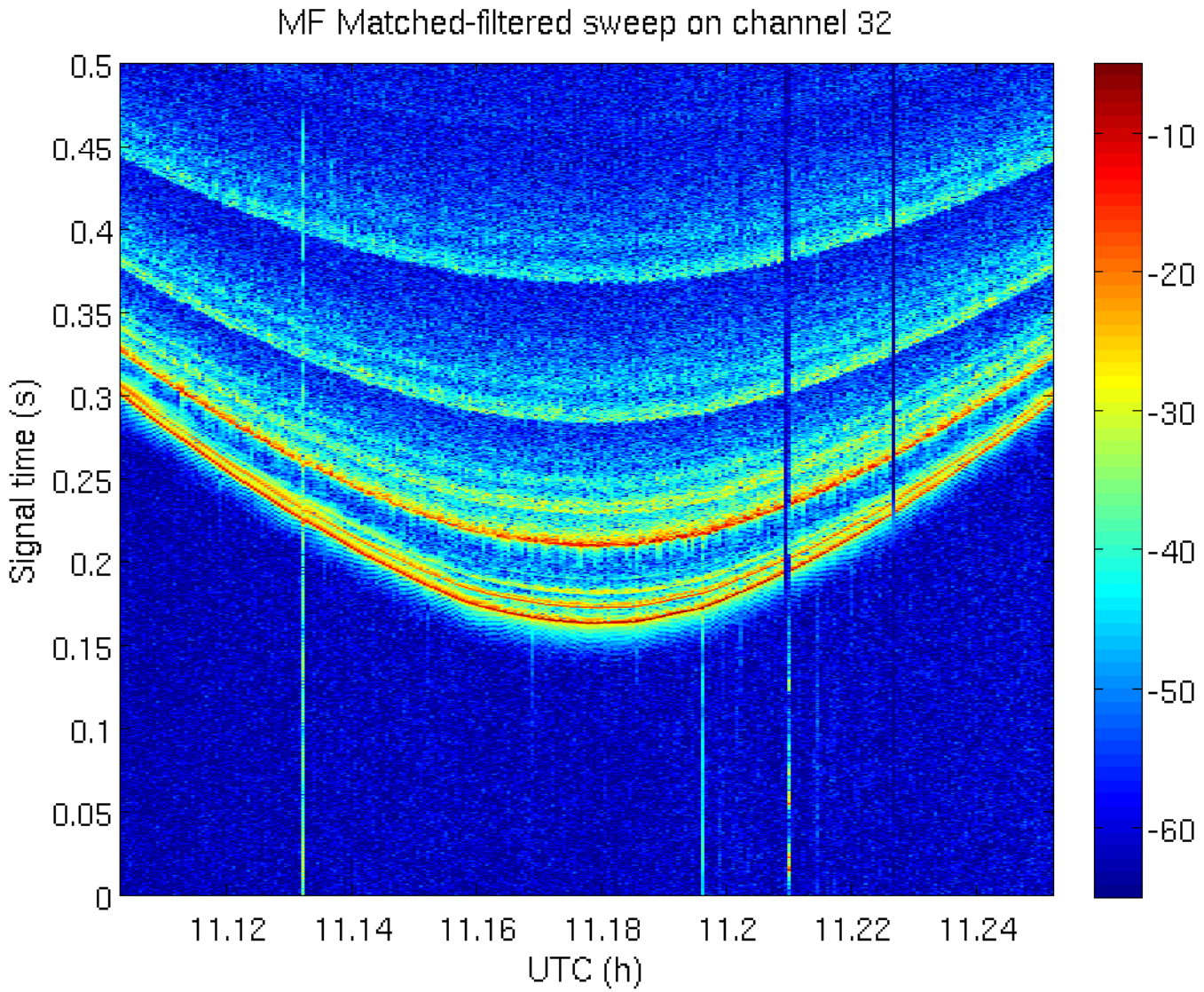


Run Geometry

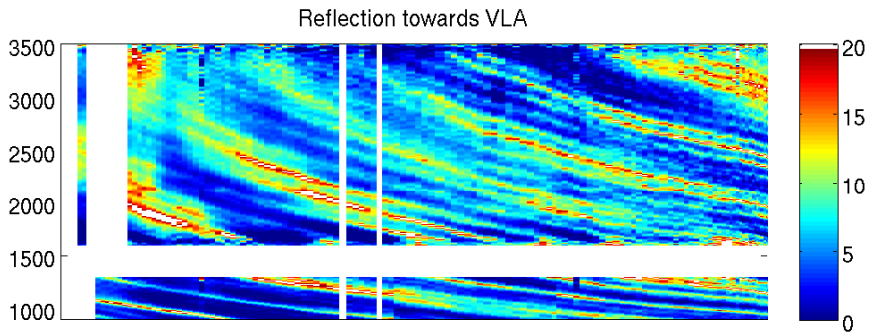


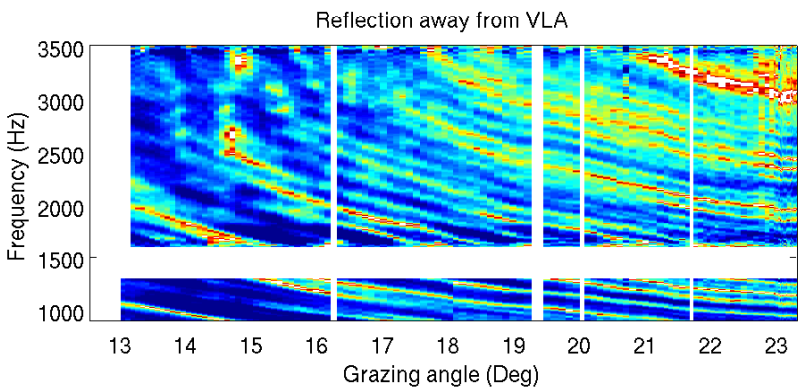
- LF source 1-s LFM 800-1400 Hz
- MF source 1-s LFM 1600 -3500 Hz
- Simultaneous transmission of LF and MF
- Repetition rate 2 sec
- AUV speed ~ 1 m/s
- Track length ~ 500 m each side of VLA (RUN2)
- Data received on 32-element 62-m VLA
- Data received on 32-element BENS (hydrophone spacing of 1.05 m)

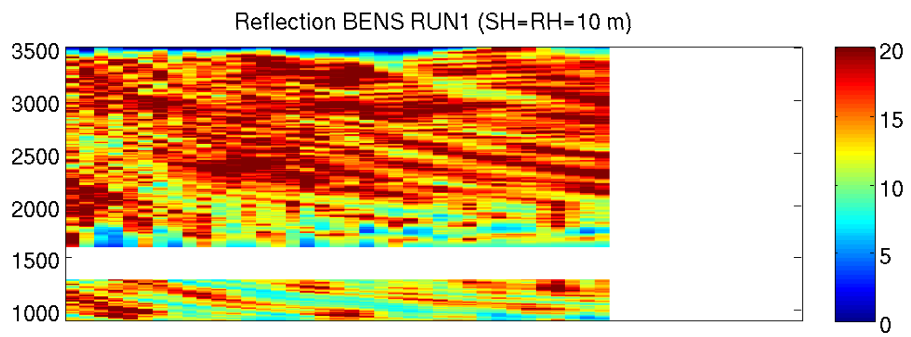
Matched-filtered data on VLA
RUN2

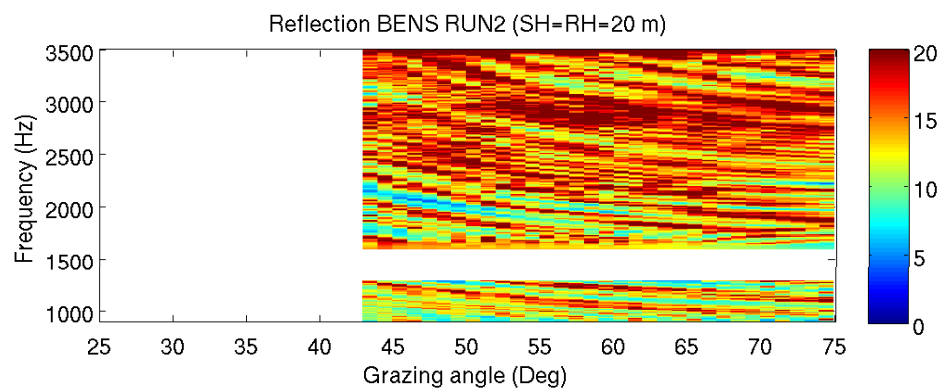


Reflection using VLA and BENS



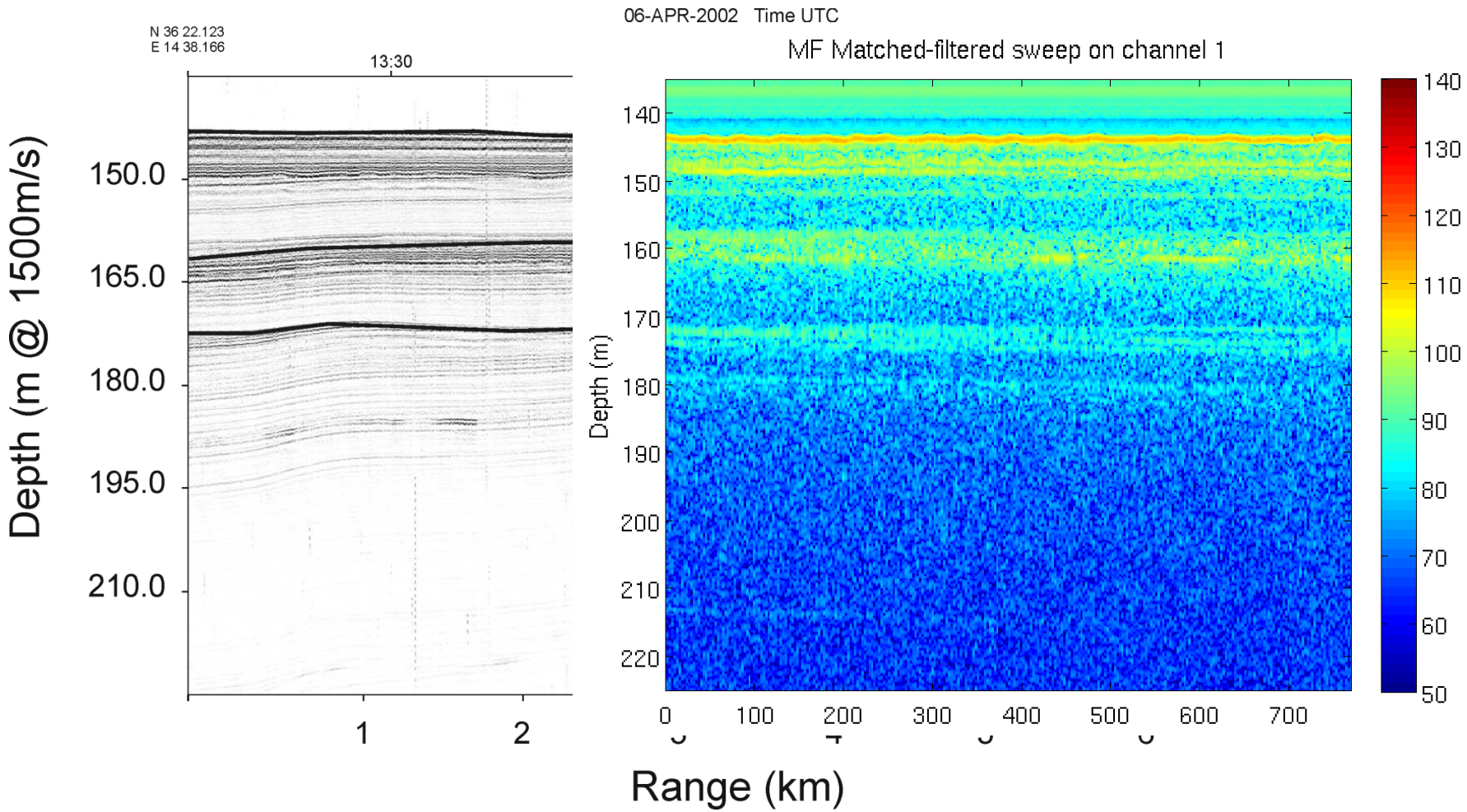






Layer depth information

Seismic and single phone on BENS array

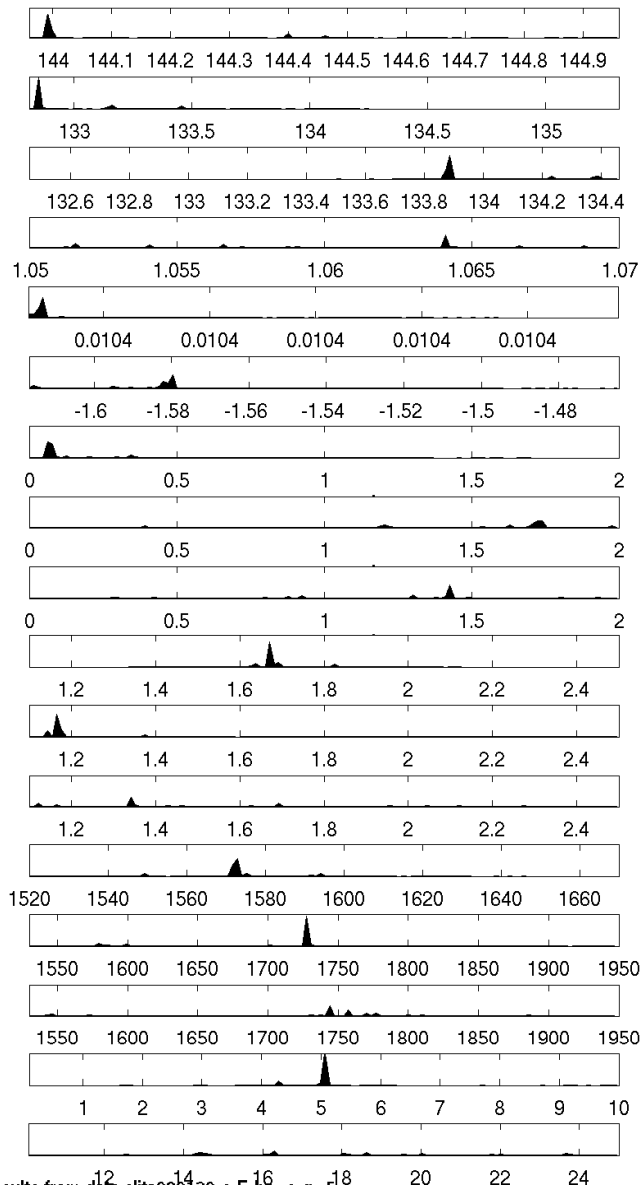


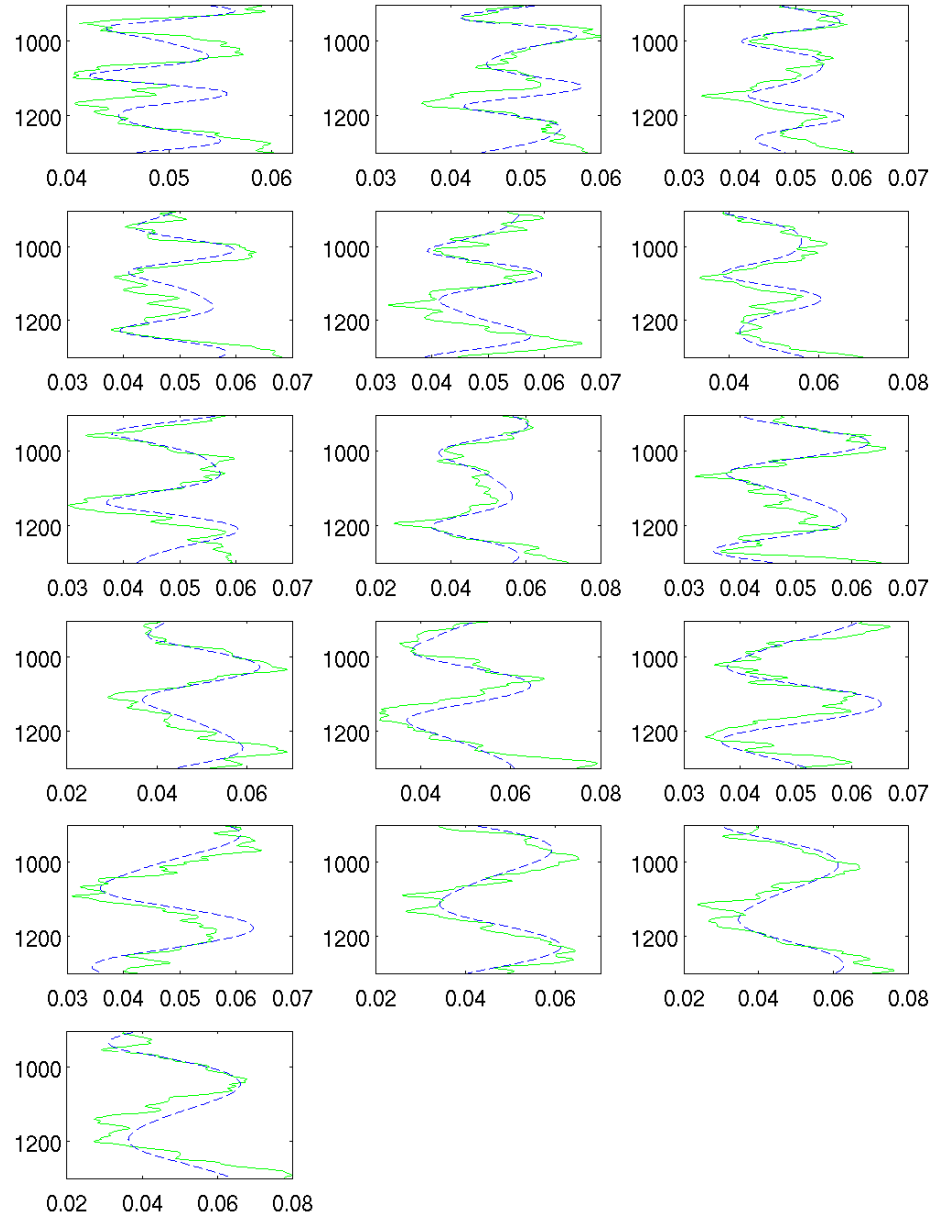
Global Inversion

- SAGA v5.4 with GAMARAY as forward model
  - Sea surface removed
- 2 layers over halfspace bottom incl.:
  - 11 Bottom parameters (speed, density, attenuation and 2 layer depths)
  - 6 Geometric parameters
- 1-Hz sampling from 900-1300 Hz
- BENS array:
  - 32 phones on towed array (10.53-43.08 m)
  - Array10 and 20 m above the bottom (RUN1 & 2)
- Objective function:
  - Coherent in frequency
  - Incoherent in hydrophone position
- 80000 forward model runs
  - 4000 iterations and 20 populations

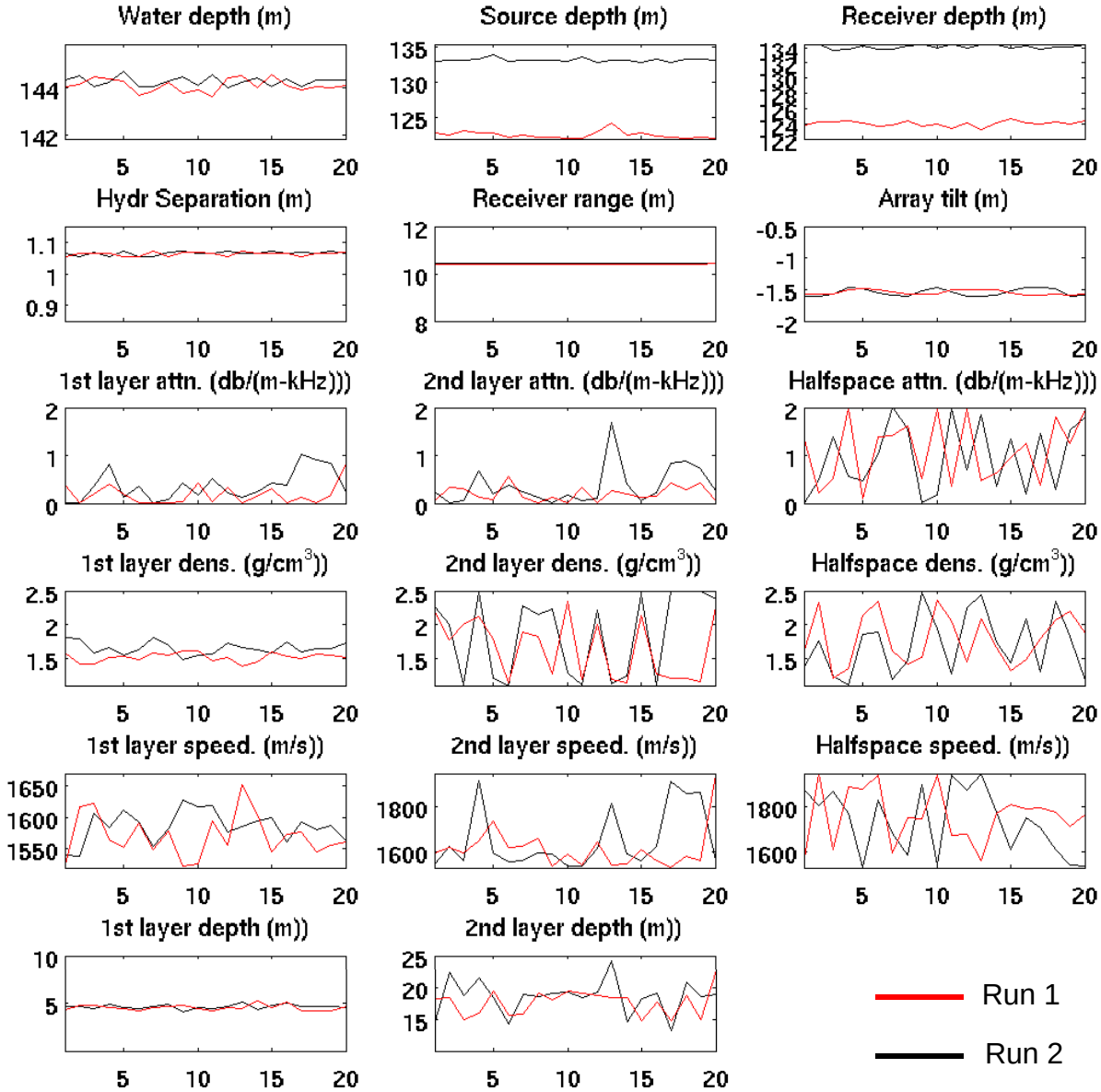
Matched-Field Inversion

Coherent in frequency and incoherent in hydrophone position



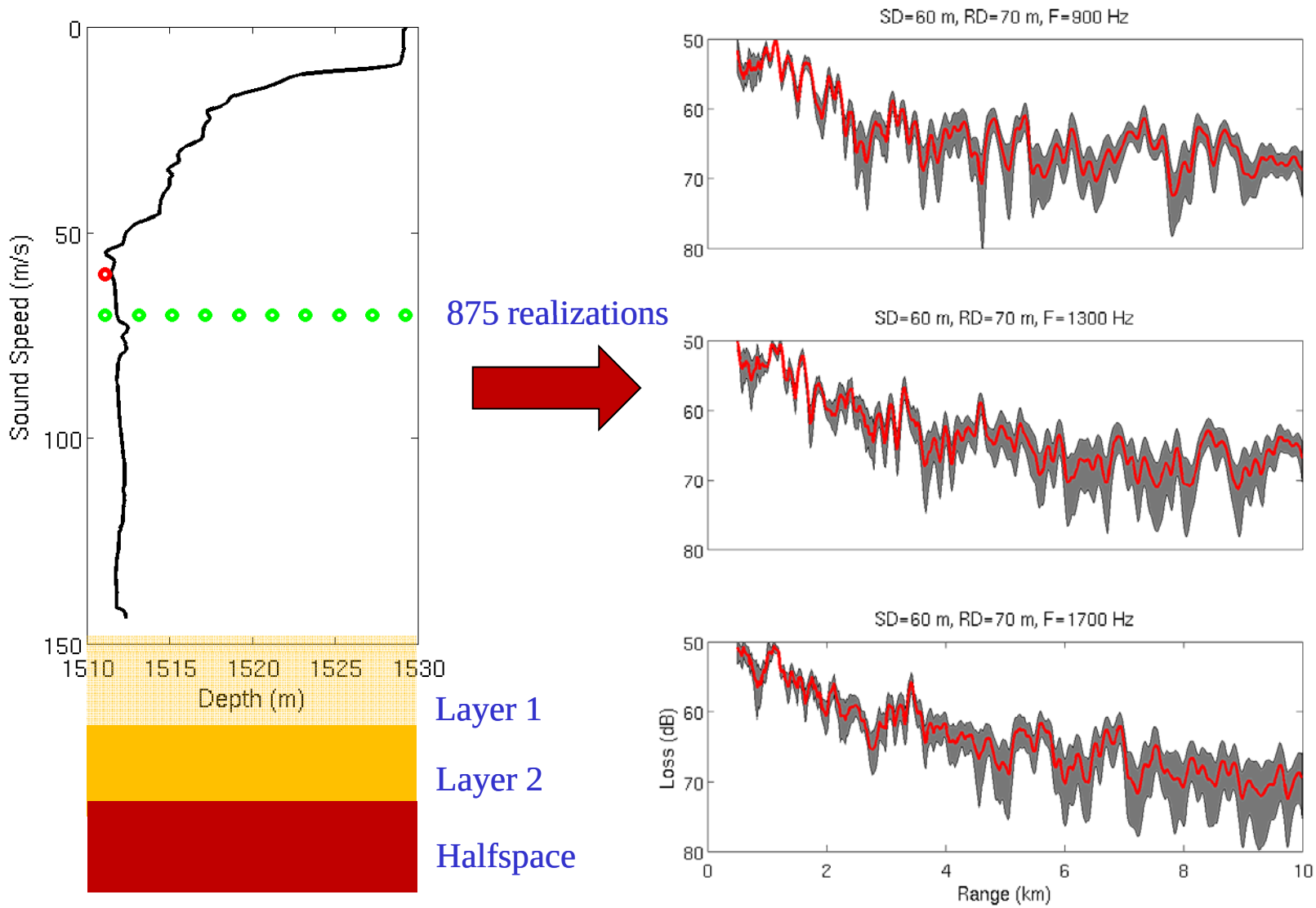


RUN1 and RUN 2 Comparison



TL Prediction at 3 Frequencies

875 realizations drawn from 28 MAP solutions (12 parameters)



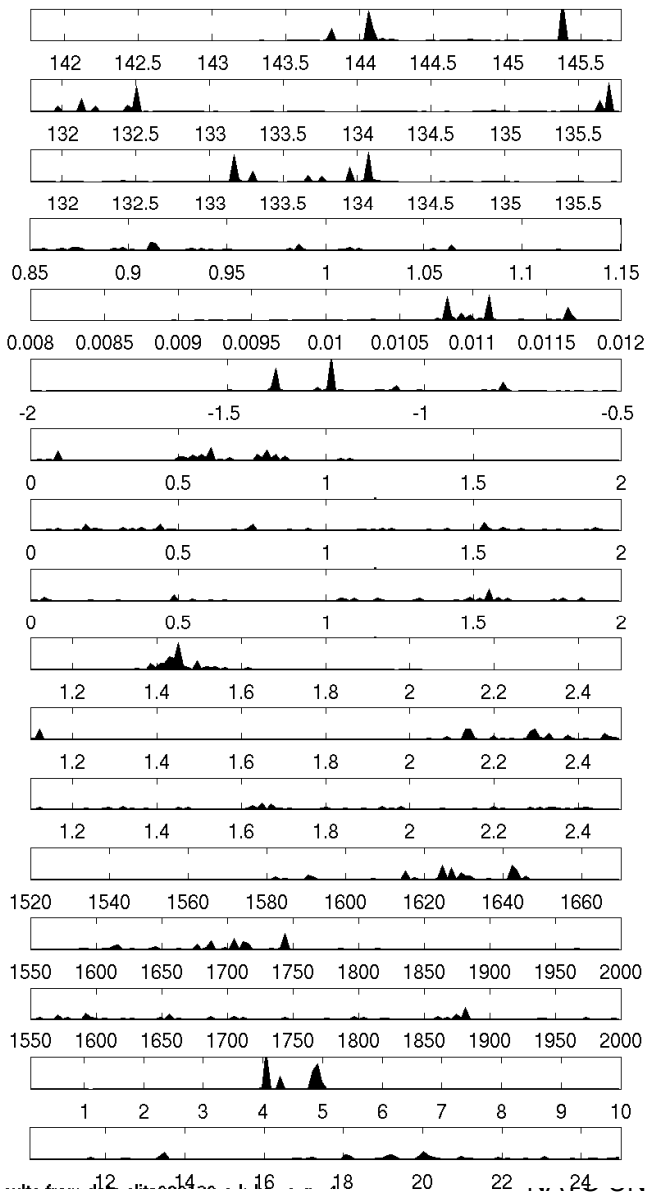
Conclusions

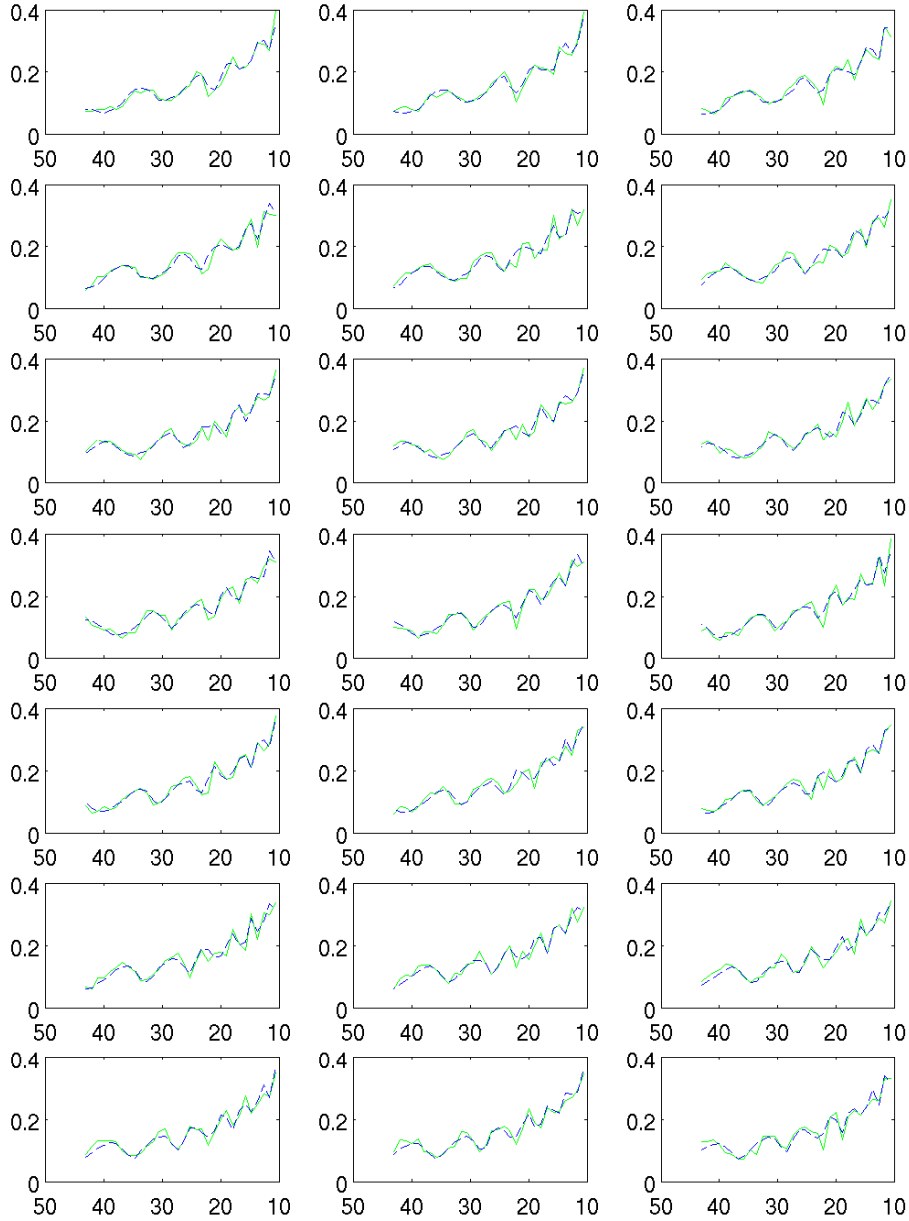
- AUV promising tool for seabed characterization (medium scales, range-dependence, covert)
- Efficient for estimating bottom reflection coefficient but more labor intensive for matched-field or Bayesian based inversions
- Mapping of environmental/theory uncertainty to prediction uncertainty is possible by re-sampling of the acoustic field
- Examples of ~10 dB std on TL demonstrated assuming that multiple MAP estimates represent environmental/theory uncertainty

Work made possible through CLUTTER JRP (USA, CAN)
Indirectly sponsored by ONR US and ONRG

Matched-field inversion

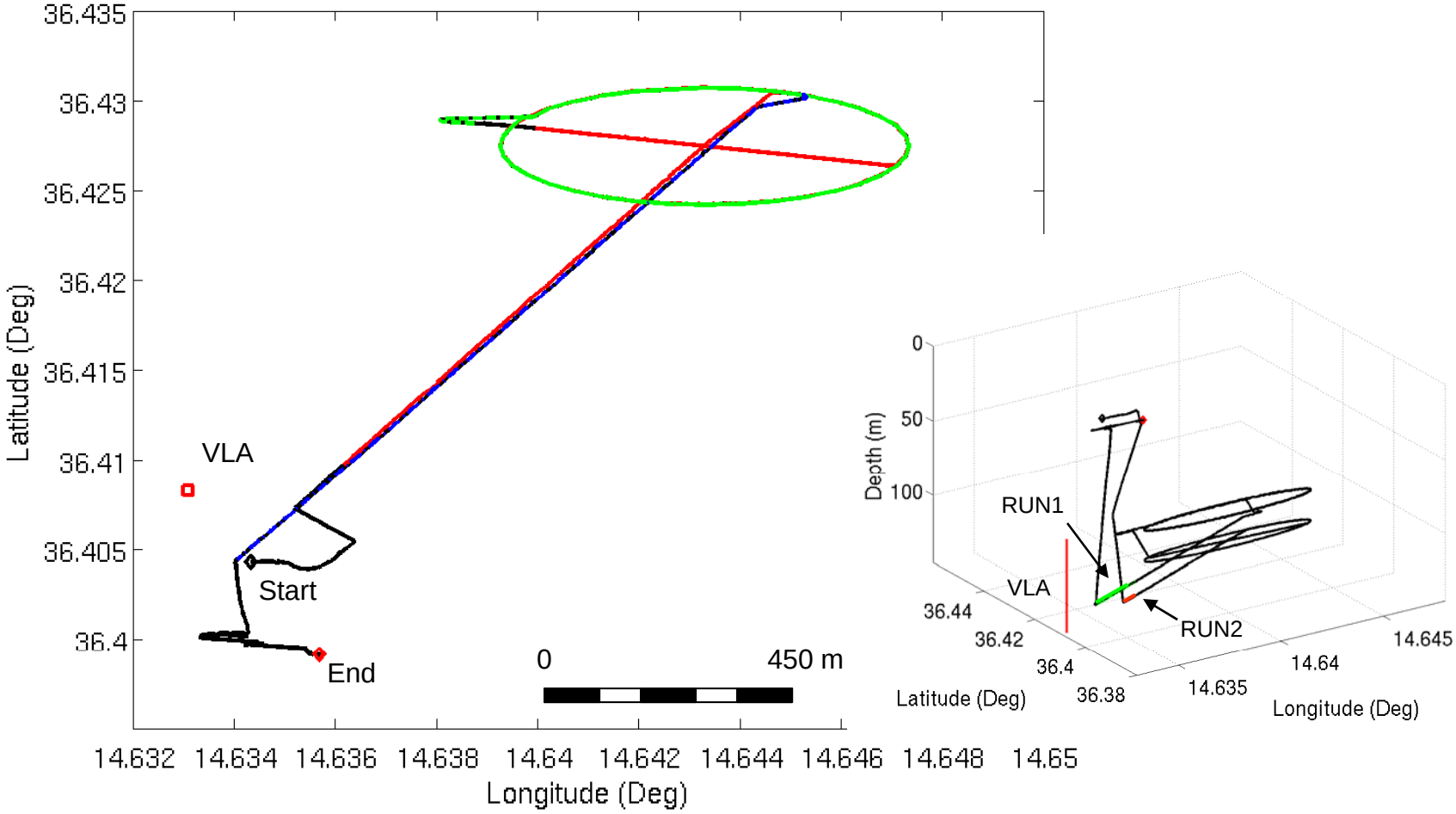
Coherent in hydrophone position and incoherent in frequency



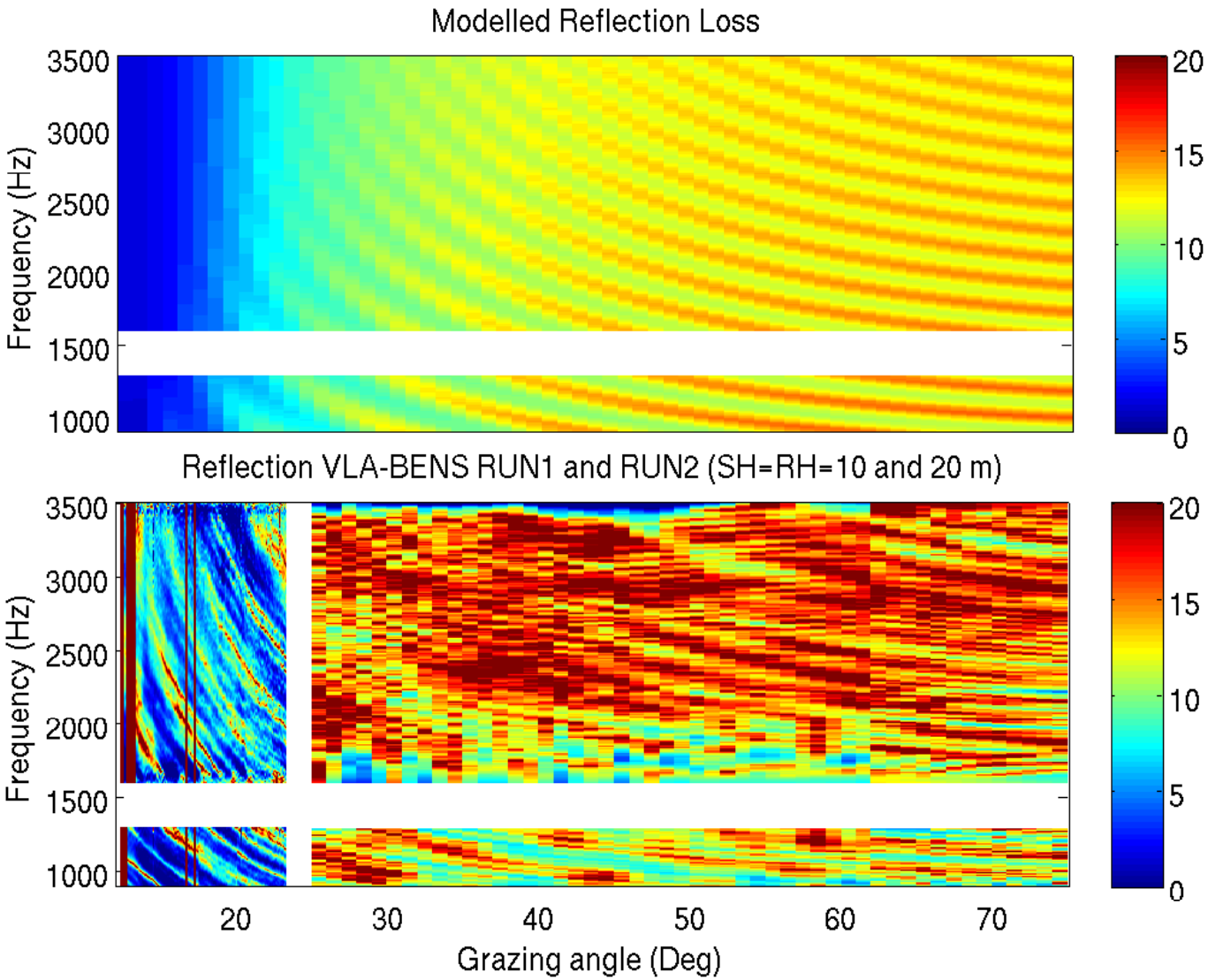
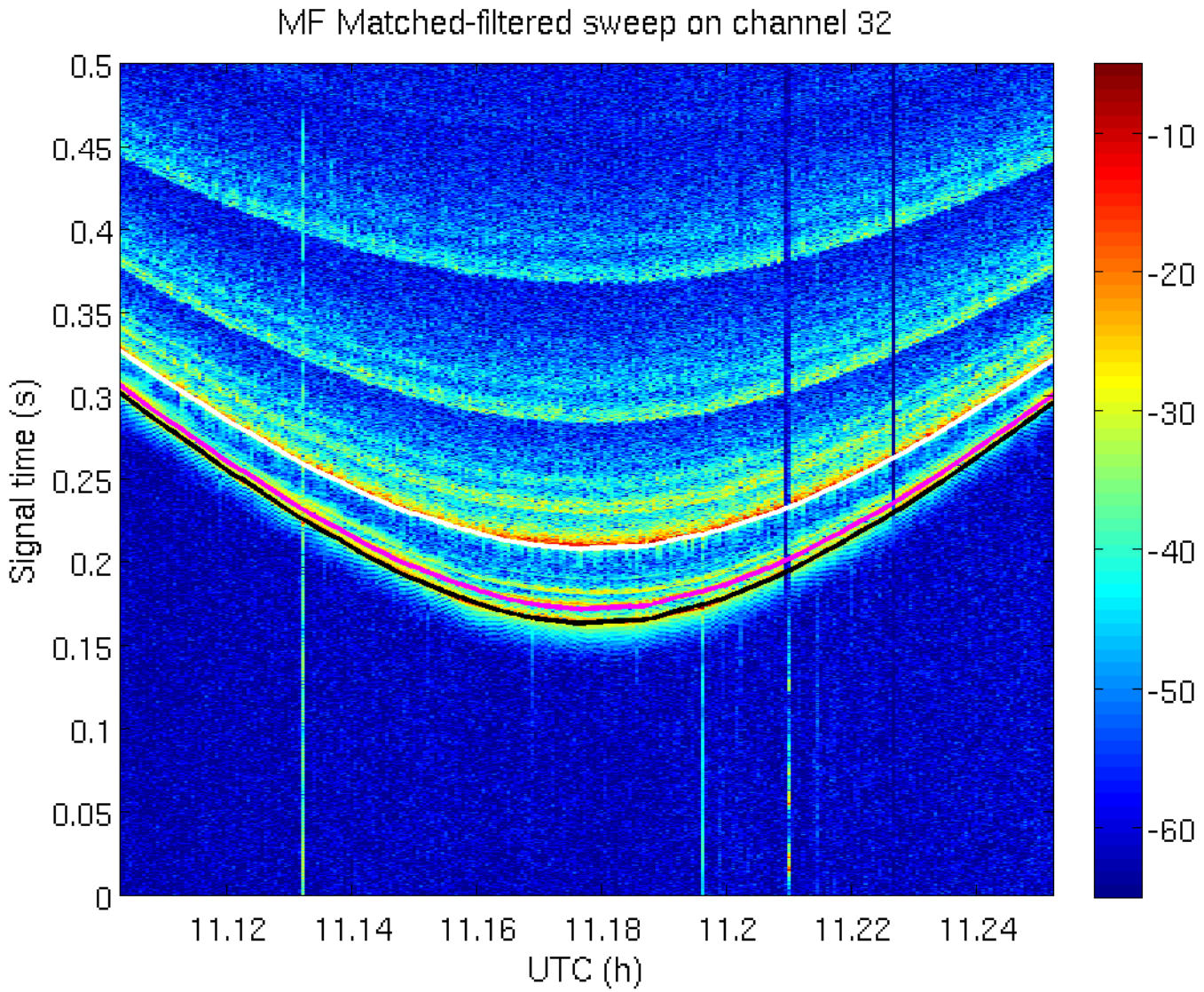


Experimental area
NURC Test-bed

AUV mission


36.435
36.43
36.425
36.42
36.415
36.41
36.405
36.4
Latitude (Deg)
VLA
Start
End
0
450 m
14.632
14.634
14.636
14.638
14.64
14.642
14.644
14.646
14.648
14.65
Longitude (Deg)
0
50
100
Depth (m)
RUN1
VLA
RUN2
36.44
36.42
36.4
36.38
Latitude (Deg)
14.635
14.64
14.645
Longitude (Deg)

Model-Data Reflection Loss



Matched-filtered data on VLA
RUN2