The seismic track SEL computation

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Motivation

The aim of the work is to supply the independent assessment of the cumulative Sound Energy Level on the selected point of the WGWA feeding area during one track of seismic vessel towing the 2620 cu in air gun array.

Source model

The shot sound source is seen as the collection of the point sources of individual air guns in the array. The geometry of the array is taken in accordance with the ch. 11.2 Array description in the SOURCE_ARRAY.pdf file (M.Angelatos mail February 28). The pressure time signatures are taken as in “Table nearfield signatures type SLEEVE.doc” (M.Angelatos mail February 28). Their FFT with 1 Hz step are used in father computations. The guns are presumed to shot simultaneously.

Propagation model

For the given receiver point in the feeding area and shot points of the air gun array on the seismic vessel track we compute the trace reliefs from the database supplied by R. Racca.
The sound speed profile is taken from R.Racca mail April 19. The mean bottom density structure used is taken from geological survey. The last string in the profile below describes the underlying halfspace.

Bottom density profile

```
   0.0  1557.00  0.01000  1.900
   5.2  1660.30  0.01000  1.890
   9.9  1701.60  0.01100  1.910
  14.5  1765.50  0.01300  1.960
  18.2  1781.40  0.01400  1.960
  20.0  1750.60  0.01300  1.920
  23.5  1790.30  0.01500  1.950
  28.8  1796.40  0.01600  1.940
  43.0  1811.20  0.01700  1.920
  60.5  1880.10  0.02000  1.950
  71.0  1885.80  0.02000  1.940
 150.0  1988.50  0.02500  1.940
 150.1  2250.00  0.00100  2.200
```

The M. Buckingham’s grain-shear theory is used to model the sound speed structure in the sediments. The computation of bottom speed profile for band sources is now incorporated in the propagation code. The Matlab prototype of the apprppriate code snippet is shown below.
Matlab prototype.

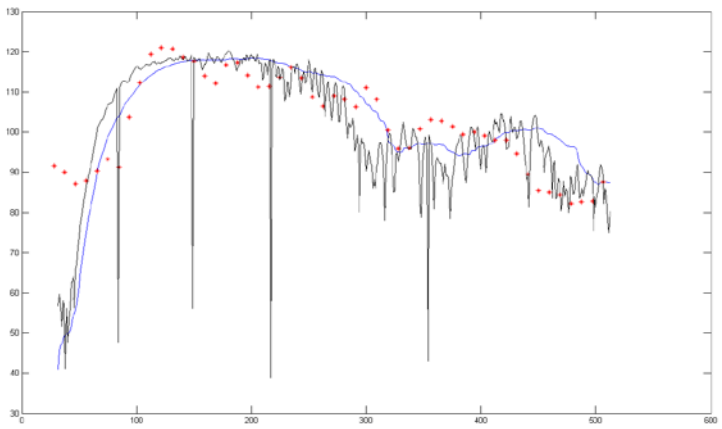
```
%---Grain-Shearing theory by M. Bouckingham
%[c,b]=grsh(1860,0,100);c,b
%nn=size(data,1); for l=nn:-
1:1,[c(l),b(l)]=grsh(1000*data(l,4),data(l,1),1000);end;c,b
%nn=size(data,1); for l=1:nn-
1,[c,b]=grsh(1000*data(l,4),data(l,1),2000);disp(sprintf('%0.5g %0.5g %0.5g
%0.5g \n',data(l,1),c,b,data(l,4)));end;
function [cp,betap]=grsh(rho,z,freq)%rho is density, z is depth freq is
frequency, cp is real part of compressional speed, betap is
```

```
Im(ccompr)/Re(ccompr)
Nmin=0.37;
ug0=1000;
z0=0.3;
N0=0.377;
Delta=1;
gammap0=3.888e8;
gammas0=4.588e7;
Kw=2.374e9;
Kg=3.6e10;
T=1;
rhog=2730;rhow=1005;
N=(rhog-rho)/(rhog-rhow);
B=((1-N)/(1-Nmin))^(1/3);
ug=2*Delta*(2*B-1)/(1-B);
np=0.0851;
gammap=gammap0*((1-N)*ug*z/((1-N0)*ug0*z0))^(1/3);
gammas=gammas0*((1-N)*ug*z/((1-N0)*ug0*z0))^(2/3);
K0=1/(N/Kw+(1-N)/Kg);
c0=sqrt(K0/rho)
cp=c0*real(sqrt(1+(gammap+4/3*gammas)/rho/c0^2*(i*2*pi*freq*T)^np))
alphap=-
(2*pi*freq)/c0*imag(1/sqrt(1+(gammap+4/3*gammas)/rho/c0^2*(i*2*pi*freq*T)^np)
);
betap=-cp/c0*imag(1/sqrt(1+(gammap+4/3*gammas)/rho/c0^2*(i*2*pi*freq*T)^np))
cs=sqrt(gammas/rho)*(2*pi*freq*T)^(np/2)/cos(np*pi/4)
betas=-cs*sqrt(rho/gammas)/(2*pi*freq*T)^(np/2)*sin(np*pi/4)
```

The signals from individual guns are convoluted with the individual impulse responses of the propagation paths connecting the receiver point an air guns and the total sound energy level in the frequency band 32..511 Hz with 1 Hz step is computed for each shot. The SELs for different shot are summed to produce the integral SEL of the track.

Validation of the 1997 Wurtzig-Weller data

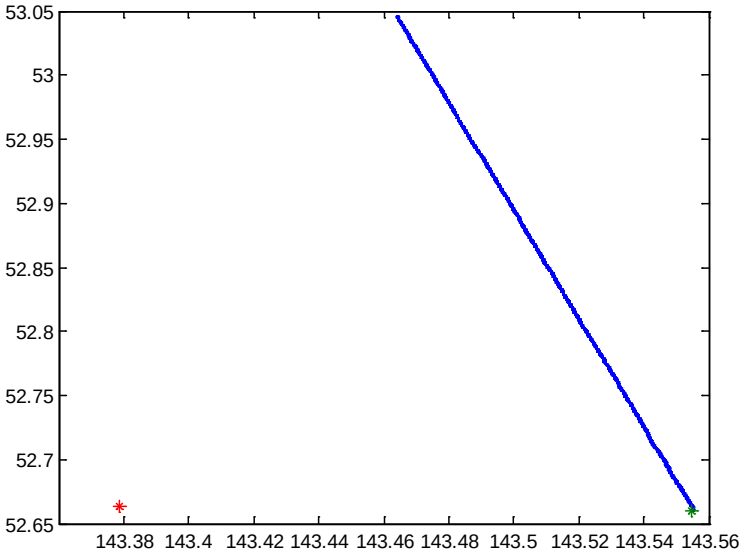
This figure below presents the Wurtzig-Weller Fig. 7 results from file 1323 168.835 Seismic graph(1sec).xls (red stars) against the calculation of the resulting field of the air guns array by summing individual gun source pulses. X is frequency, Y – field level in dB re 1 microPa. Black line is computed for the frequency step 1 Hz, blue line is the previous smoothed on 38 Hz sliding interval.



The sound speed profile is taken from R.Racca mail April 19. The corresponding points coordinates, relief and bottom structure are taken as in Avilov's mail April 21 containing RussianValidationAgainstWeller.doc. The array geometry and individual guns signatures from M.Angelatos mail February 28.
The computation results may be seen to be in a reasonable agreement with the experiment.

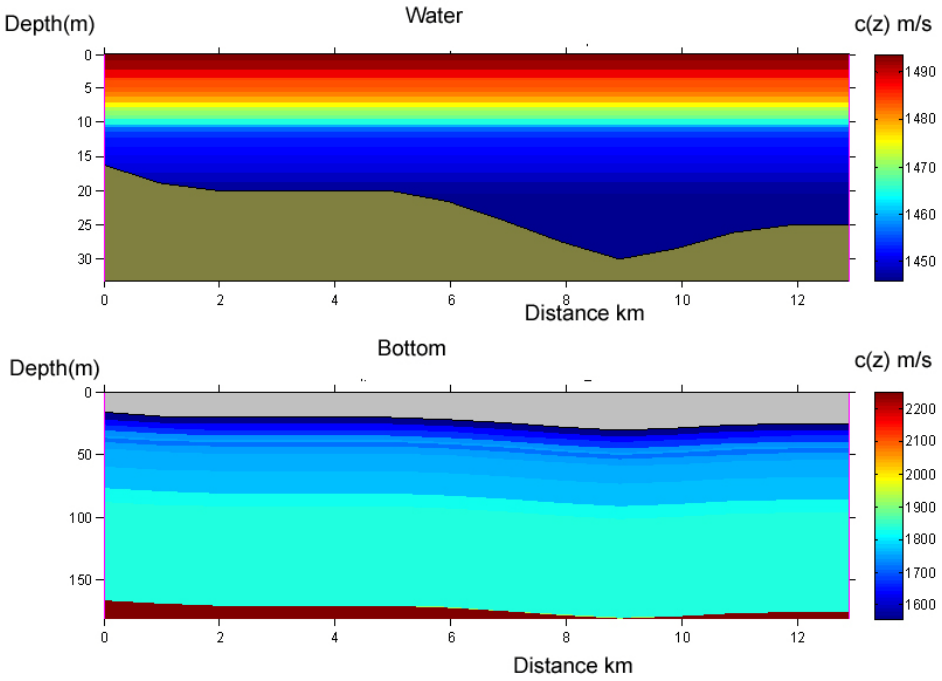
SEL in one receiver point

Now we take the receiver point from the file 'Astokh Test Radials.xls' I175 cell with (656844, 5837290) coordinates at 8 m depth. The pressure time signatures are taken as in "Table nearfield signatures type SLEEVE.doc" (M.Angelatos mail February 28). The seismic vessel track 121A003 shots from SRC1997PIL.txt used is shown below in blue. The red star denotes the receiver point. The vessel is moving to the north. Initial heading to the receiver point is about 92 degree, the last is about 8 degree.

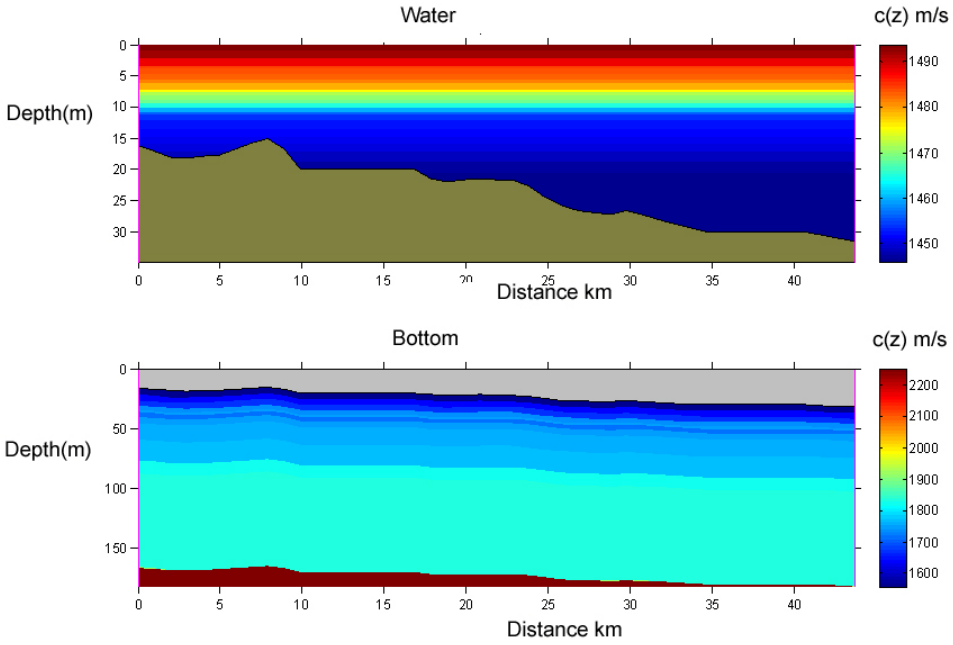


The traces from the receiver point to each 50-th shot (47 traces total) were computed in 32..511 Hz frequency band with 1 Hz step and the air guns array modeled as above. The first and last shot traces are illustrated below.

First shot trace

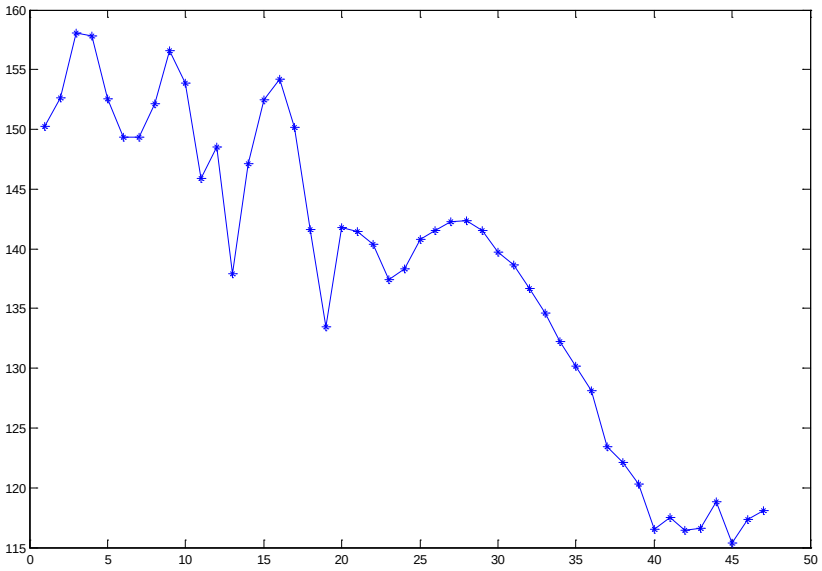


Last shot trace



The total SEL= $\int p^2 dt$ on the whole seismic track turned out to be 182.dB re 1 microPascal*sqrt(sec).

The dB plot of individual shots $\int p^2 dt$ versus trace number is shown below



If other receiver points are of interest then communicate to us and we shall compute their SELs. The typical computation cycle will take about one week.