How to select inversion parameters?

Before we select the inversion parameters we need to find the following values:

1. The number of picks (n) that passed the reciprocity test, here, n is the number of equations. Get it from the mkcoord file
2. The period (T) of the refraction data. Get it from the recorded data
3. The dimension of the velocity model (x_{max} and z_{max}). This is part of your input in the mkcoord file.

Selecting inversion parameters:

1. **The number of smoothing schedule.** This should be something between 4 and 8 depending on how complicated the velocity model is. Only 4 smoothing schedules will be good enough for near-surface short profiles, however, for long profiles it is recommended to go to 8 smoothing schedules.
2. **Grid spacing.** This parameter is used to calculate your forward modeling during the inversion, so the smaller the better (small values will give accurate t^{cal}).
    a. If the profile length is few hundred meters, then 0.5 OR 1 will be a good choice.
    b. If the profile length is a couple of km, then 2, 4, or 5 may be a good choice.
    c. I used 0.1 and 0.2 for very short profiles, 20 to 30 m long, but sometime the forward modeling calculation is not stable with such small values

    P.S. Use the same value for all smoothing schedule

3. **Iterations.** I usually chose a small number (3 or 4) in the first smoothing schedule, then increase it to 5 or so in the following schedules.
4. **Vtop and Vbottom**. Use these values to generate your initial velocity model. It is a 1-D linear vel model. There are other ways to define different initial vel. models, but this is the easiest. Use the recorded data to get a good estimation of Vtop and Vbottom.
5. **Vmin and Vmax**. These are the min and max allowed velocity values in the tomogram. Use your knowledge of the area and/or geology to select these values.
6. Nite (# of shoots). Is the number of shots used to calculate the step length, here, 4 is a good number.
7. Ndown. You have two options; 1 = downward extrapolate gradient; and 2 = slowness
8. Irsx and Irsz. These are tricky values. You need to choose them such that the number of equations = 2-3 times the number of unknown.

    Let's take an example: Let's assume that the number of picks (n) is 10,000, the period is 20 ms, the model dimension is 120 x 30 m (x_{max} and z_{max}), and you selected 0.5 for the grid spacing.

    a. The number of equations (n) = 10,000
    b. The number of unknown (m) = number of pixels in the velocity model and is given by equation (1)

    $$\frac{x_{max}}{Grid\ spacing} \text{ x } \frac{z_{max}}{Grid\ spacing} = \frac{120}{0.5} \text{ x } \frac{30}{0.5} = 14{,}400 \text{ pixel} \qquad (1)$$

    c. Now, m > n, but we need n >> m, we will use Irsx and Irsz to fix this
    d. The calculations shown on point b is assuming that Irsx = 1 and Irsz = 1. Since we always need to make Irsx=2 times Irsz, then for Irsx = 2 and Irsz = 1, equation (1) will be:

    $$\frac{x_{max}}{Grid\ spacing \text{ x } Irsx} \text{x} \frac{z_{max}}{Grid\ spacing \text{ x } Irsz} = \frac{120}{0.5 \text{ x } 2} \cdot \frac{30}{0.5 \text{ x } 1} = 7{,}200 \text{ pixel} \qquad (2)$$

    e. This is better, but not optimum, for Irsx = 4 and Irsz = 2, equation (1) will be

    $$\frac{x_{max}}{Grid\ spacing \text{ x } Irsx} \text{x} \frac{z_{max}}{Grid\ spacing \text{ x } Irsz} = \frac{120}{0.5 \text{ x } 4} \cdot \frac{30}{0.5 \text{ x } 2} = 1{,}800 \text{ pixels} \qquad (3)$$

f. Now, it is up to the user and how the final tomogram looks like to either choose Irsx = 2 and Irsz=1 (equation 2) OR Irsx = 4 and Irsz = 2 (equation 3)
g. Your choice in point f will be your input in the last smoothing schedule (see the following table), other schedules should shows gradually increasing values.
h. In this example, here is our final choices:

	Smoothing Schedule 1	**Smoothing Schedule 2**	**Smoothing Schedule 3**	**Smoothing Schedule 4**
Iterations	3	5	8	8
Grid spacing	0.5	0.5	0.5	0.5
Vtop	300	300	300	300
Vbottom	1200	1200	1200	1200
Vmin	300	300	300	300
Vmax	2500	2500	2500	2500
Nite	4	4	4	4
Ndown	1	1	1	1
Irsx	20	12	8	4
Irsz	10	6	4	2

Note that.

1. The minimum RMS error after the final iteration should be close to $T/4$, where T is the period, if it is >> $T/4$ then you still have room for improvement, and you need to change the inversion parameters (focus on velocity selections, grid spacing, or Irsx and Irsz). If the RMS error < $T/4$, then you are fitting the noise and not the data, increase the Irsx and Irsz.
2. If the raypath touch the bottom of the velocity model, then the size (z_{max}) of the velocity model is too small, increase it and repeat the whole process again

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