EAS 8803 - Obs. Seismology
Lec#16: Inverse Problem/EQ Location

- Dr. Zhigang Peng, Spring 2013

Figure 7.2-1: Geometry for earthquake location in a homogeneous halfspace.

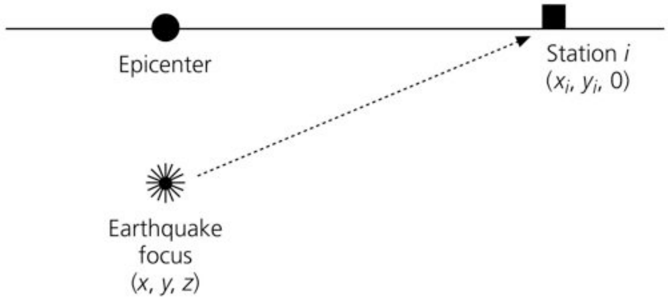


Figure 1.1-8: Inversion modeling flow chart.

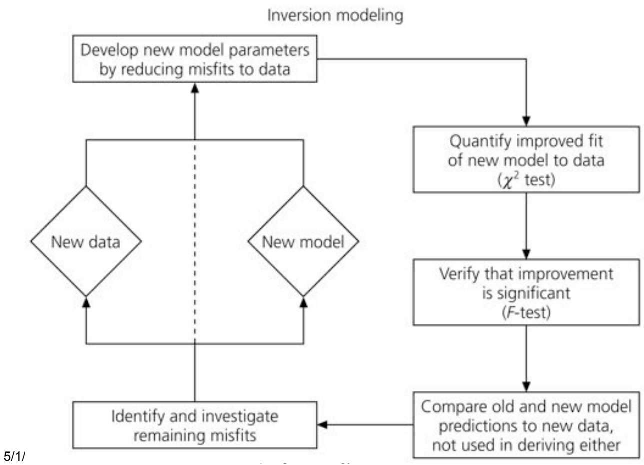


Table 7.1-1 Some large-scale reference models.

Model for	Observables inverted and predicted	Parameters estimated	Misfits ("anomalies") indicate
Laterally homogeneous earth structure	Travel times, eigenfrequencies	Average velocity and density versus depth	Lateral velocity variation (subduction zones, continental–ocean differences, etc.)
Relative plate motions	Rates and azimuths of plate motion	Euler vectors	Nonrigid plate behavior (plate interiors and boundary zones)
Thermal evolution of oceanic lithosphere	Variation with age in depth, heat flow, and geoid	Plate thickness, asthenospheric temperature, physical properties (e.g., α, κ, k)	Lateral thermomechanical variations (swells, etc.)

Earthquake Location

Figure 7.2-1: Geometry for earthquake location in a homogeneous halfspace.

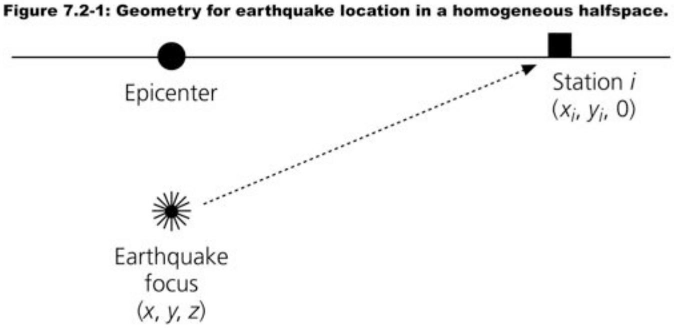


Figure 7.2-2: Illustration of the the effect of linearizing about an inverse problem starting model.

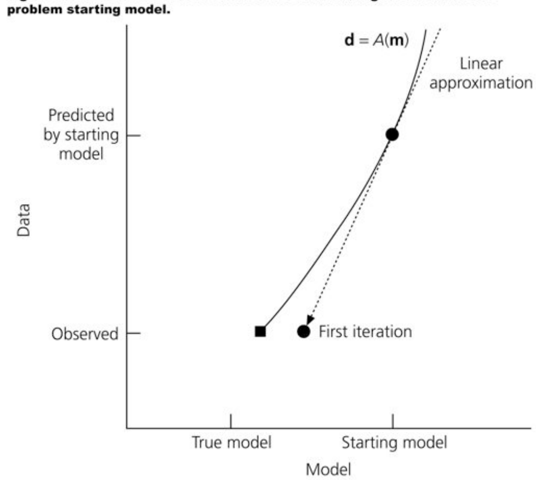


Figure 7.2-3: Illustration of the misfit to data as a function of inverse problem iteration.

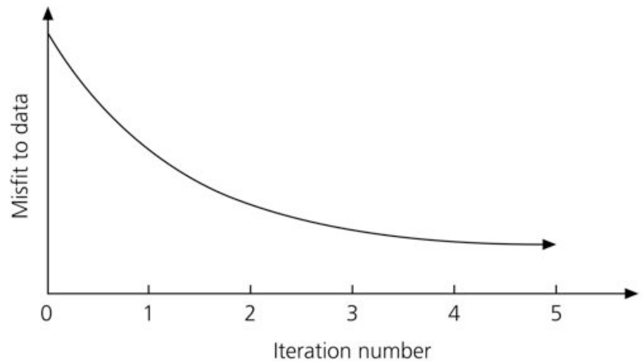


Table 7.2-1 Earthquake location example with error-free data.

Invert for location and origin time

model evolution

parameter	actual value	model for iteration number 0	1	2
x	0.0	3.0	−0.5	0.0
y	0.0	4.0	−0.6	0.0
z	10.0	20.0	10.1	10.0
origin time	0.0	2.0	0.2	0.0

station location		residual for iteration number 0	1	2
35.0	9.0	−2.1	−0.4	0.0
−44.0	10.0	−3.0	−0.2	0.0
−11.0	−25.0	−3.8	−0.1	0.0
23.0	−39.0	−3.0	−0.2	0.0
42.0	−27.0	−2.6	−0.3	0.0
−12.0	50.0	−2.0	−0.3	0.0
−45.0	16.0	−2.9	−0.2	0.0
5.0	−19.0	−3.7	−0.2	0.0
−1.0	−11.0	−4.1	−0.2	0.0
20.0	11.0	−2.4	−0.4	0.0
error		92.4	0.6	0.0

Invert for location, origin time, and velocity

model evolution

parameter	actual value	model for iteration number 0	1	2
x	0.0	3.0	0.2	0.0
y	0.0	4.0	0.3	0.0
z	10.0	20.0	10.2	10.0
origin time	0.0	2.0	0.7	0.0
velocity	5.0	4.0	4.9	5.0

station location		residual for iteration number 0	1	2
35.0	9.0	−4.0	−0.9	0.0
−44.0	10.0	−5.6	−1.0	0.0
−11.0	−25.0	−5.7	−0.9	0.0
23.0	−39.0	−5.6	−1.0	0.0
42.0	−27.0	−5.2	−1.0	0.0
−12.0	50.0	−4.6	−0.9	0.0
−45.0	16.0	−5.6	−1.0	0.0
5.0	−19.0	−5.2	−0.9	0.0
−1.0	−11.0	−5.3	−0.9	0.0
20.0	11.0	−3.8	−0.8	0.0
error		261.3	8.3	0.0

Table 7.2-2 Earthquake location example with errors.

Invert for location and origin time

model evolution

parameter	actual value	model for iteration number 0	1	2	3
x	0.0	3.0	−0.2	0.2	0.2
y	0.0	4.0	−0.9	−0.4	−0.4
z	10.0	20.0	12.2	12.2	12.2
origin time	0.0	2.0	0.0	−0.2	−0.2

station location		residual for iteration number 0	1	2	3
35.0	9.0	−2.0	−0.1	0.1	0.1
−44.0	10.0	−3.0	−0.1	0.0	0.0
−11.0	−25.0	−3.8	0.0	0.1	0.1
23.0	−39.0	−3.2	−0.1	0.0	0.0
42.0	−27.0	−2.8	−0.2	−0.1	−0.1
−12.0	50.0	−2.1	−0.3	−0.1	−0.1
−45.0	16.0	−2.9	−0.1	0.0	0.0
5.0	−19.0	−3.7	−0.1	0.0	0.0
−1.0	−11.0	−4.0	−0.1	0.0	0.0
20.0	11.0	−2.5	−0.3	0.0	0.0
error		93.74	0.33	0.04	0.04

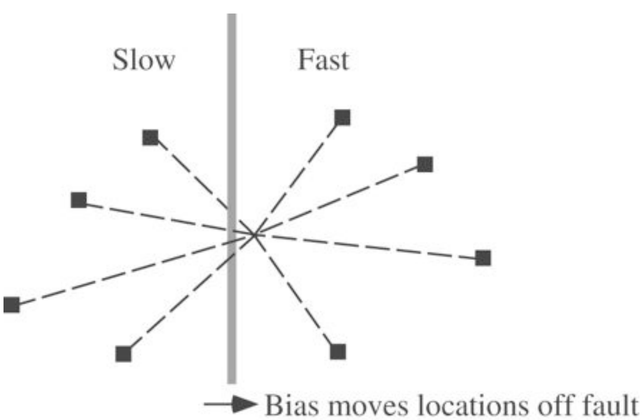
data standard deviation 0.10

model variance–covariance matrix

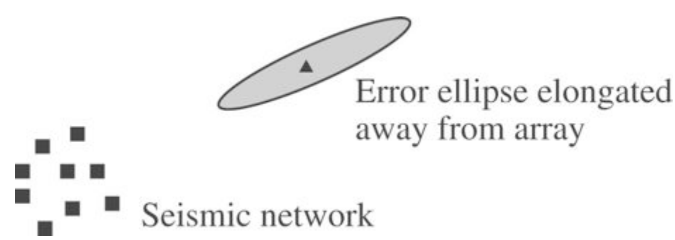
0.06	0.01	0.01	0.00
0.01	0.08	−0.13	0.01
0.01	−0.13	1.16	−0.08
0.00	0.01	−0.08	0.01

model standard deviation

x	y	z	origin time
0.25	0.28	1.08	0.10



Earthquakes located along a fault will be mislocated if the seismic velocity changes around the fault.



Eq locations for events outside of a network are often not well constrained.