Exercise on Teleseismic Magnitudes

Introduction

In this exercise we will calculate the magnitude of the March 28, 2005 Sumatra earthquake using a single station recording in Russia.

The aims of this exercise are to:

- Manually calculate surface wave magnitude (Ms) and short period body wave magnitude (mb).
- Illustrate the problem with saturation for mb.

Data

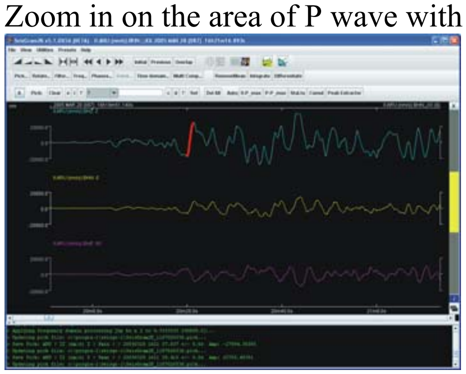
The data used in this exercise are from the Global Seismic Network which are publicly available and were downloaded for free from the IRIS webpage. The data are a recording of the March 28, 2005 Sumatra earthquake at the ARU station in Arti, Russia (Lat: 56.43 Lon: 58.56) at a distance of 62.30° from the earthquake epicenter.

The data are stored in 3 sac files, one for each component of the seismometer:
2005.087.16.14.58.8604.II.ARU.00.BHN.Q.SAC_ASC
2005.087.16.15.15.4604.II.ARU.00.BHE.Q.SAC_ASC
2005.087.16.15.41.9605.II.ARU.00.BHZ.Q.SAC_ASC

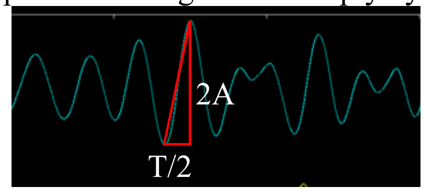
Instructions

Instructions on how to use SeisGram2K are given at the end of the earthquake location exercise handout.

1. Open SeisGram2K and open the 3 files of data from the ARU station.
2. Identify the P, S and surface waves.
3. Calculate mb (using the IASPEI standard measure, i.e. maximum P displacement amplitude from the whole P-phase, with period <3 sec):
    a. Click on "remove mean" and "Integrate" to convert from velocity seismograms to displacement.
    b. Highpass filter the data to remove periods longer than 3 seconds.
    c. Zoom in on the area of P wave with the maximum amplitude:



d. Measure the amplitude and period of the highest amplitude phase. To get the amplitude (A) we measure the largest peak-to-trough value and divide by 2. For the period (T), measure the time difference between the same peak and trough and multiply by 2:

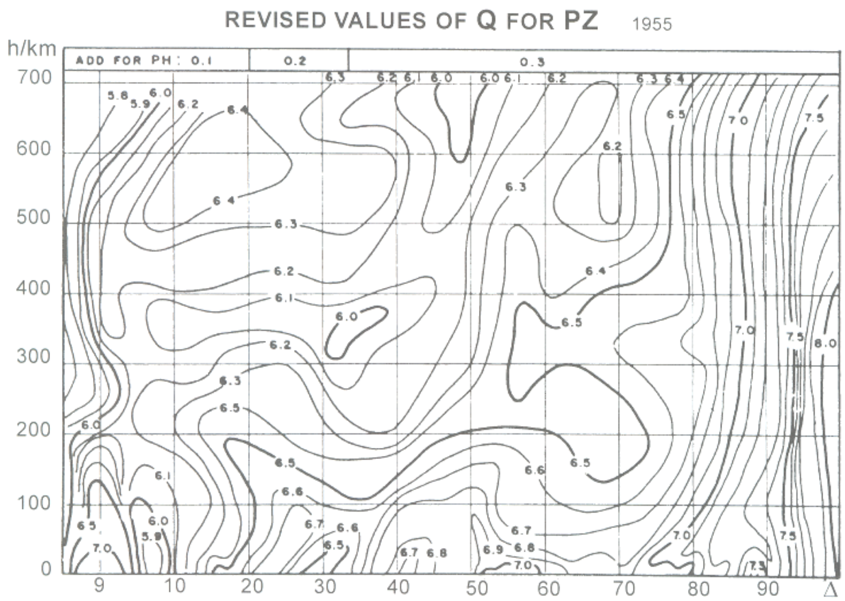


To measure the values accurately go into picking mode (click on "pick…"). Now when you click on the peak or trough the exact amplitude and time are shown in the top corner. The amplitude must be in µm (the scale on the recording is nm, so you'll have to divide by 1000) and the period in seconds.

e. Calculate mb using

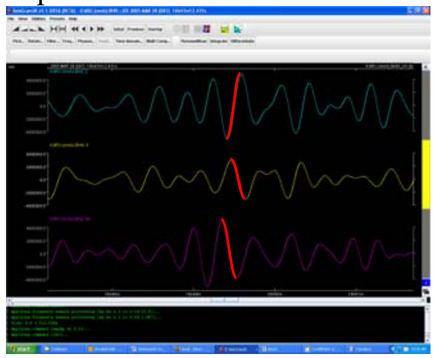
$mb = \log (A/T)_{max} + Q(\Delta, h)$

with Q taken from the figure below, x-axis = distance (which is 62.30), y-axis = hypocentral depth (which is ~30 km)



4. Calculate Ms (using the IASPEI standard measure, i.e. unfiltered data on either vertical or horizontal components)
   a. Click on the file menu and "reset active" to remove filtering.
   b. Click on "remove mean" and "Integrate" to convert from velocity seismograms to displacement.
   c. Zoom in on the area of surface waves with the highest amplitudes.
   d. We will calculate Ms for both the horizontal and the vertical ground motion, but we have to use the same wave cycle for each component, so identify the part of the trace with the highest horizontal and vertical

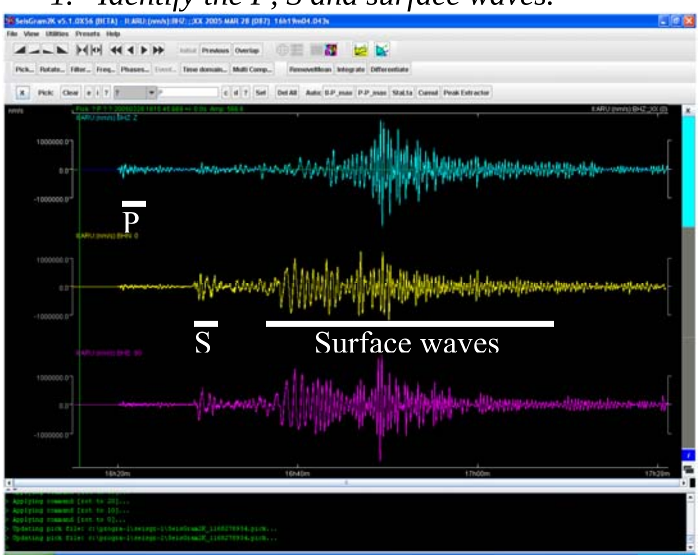
amplitudes:



e. Measure the amplitude and period of the highest amplitude phase.
f. Calculate the vertical Ms value (MLV) from the amplitude and period of the vertical trace using:
$Ms = \log(A/T)_{max} + 1.66\log(\Delta) + 3.3$,
where Δ is the distance between the earthquake and the seismometer in degrees (which is 62.30).
g. To calculate the horizontal Ms (MLH) combine the east and north components using $A_{horizontal}=\sqrt{(A_{east}^2+A_{north}^2)}$. To get the period calculate the average from the north and east components. Then calculate the magnitude using $Ms = \log(A/T)_{max} + 1.66\log(\Delta) + 3.3$ again.
h. To get a single Ms value for the station, take the average of MLV and MLH. Given that this value is quite uncertain give the final magnitude to one decimal point. Compare your mb and Ms magnitudes.

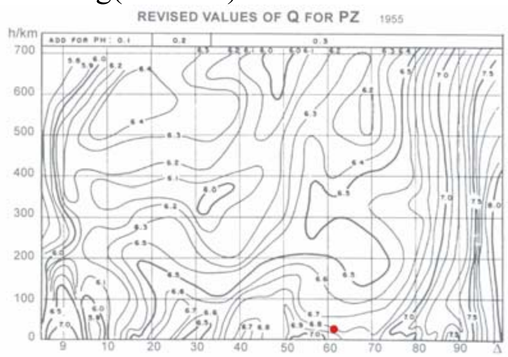
Answers and Comments

1. *Identify the P, S and surface waves.*



2. *Calculate mb:*
   d. A=20.4 µm, T= 2.6 sec

e. mb = log(20.4/2.6) + 6.8 = 7.7



3. *Calculate Ms:*

e. Av = 6714 µm, Tv = 21.44 sec
   An = 4323 µm, Tn = 21.44 sec
   Ae = 6186 µm, Te = 22.49 sec

f. MLV = log (6714/21.44) + 1.66log(62.3) + 3.3 = 8.77

g. MLH = log(7547/21.97) + 1.66log(62.3) + 3.3 = 8.81

h. From this data Ms = 8.8
   Other published magnitudes for this event are:
   USGS/NEIC Mw = 8.7,
   Harvard CMT: Mw = 8.6, mb = 7.2, Ms = 8.4