Looking at data from several stations

Sometimes it is useful to look at data from lots of different stations at the same time. The screenshot below shows a 'record section'. It is based on data taken from several seismic monitoring stations following a large earthquake. On a record section, the x-axis (time) is common for all traces, and the position of each trace up the page (the y-axis) depends on the distance of that recording station from the event.

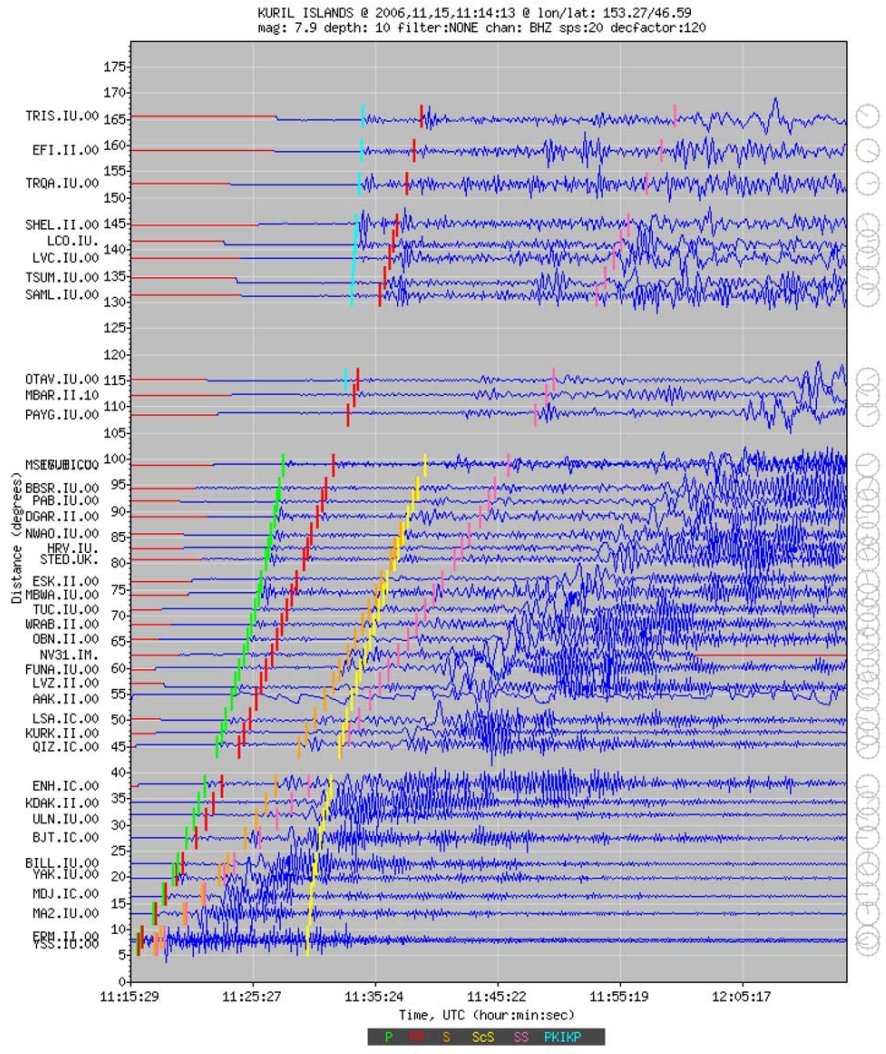

Image provided by the IRIS Consortium. (www.iris.edu)

Figure 1 Screenshot of a 'record' section, using data from several stations. Image provided by the IRIS Consortium.

EARTHQUAKE CLASSROOM ACTIVITIES

Teachers' notes

Students examine data from several stations at the same time, using a 'record section'.

Learning objectives

Students will:

- recognise that the arrival times of different phases show that P-waves travel faster than S-waves
- recognise that the pattern of arrival times provides evidence that speed changes with depth

For the additional task:

- compare values produced by a simple model with known values
- identify a limit to the use of the model.

Notes

On the record section shown, the x-axis (time) is common for all traces, and the position of each trace up the page (the y-axis) depends on the distance of that recording station from the event.

Task instructions

Study the sesimogram screenshot (on page 1) and note the features below:

- green marks show the arrival of direct P-waves
- orange marks show the arrival of direct S-waves
- red marks show the arrival of PP-waves (reflected at the surface)
- yellow marks show the arrival of ScS-waves (reflected at the boundary with the outer core)
- pink marks show the arrival of SS-waves (reflected at the surface)

Exercise

1 Which waves arrive first?
What do you notice about the difference in arrival times as the distance from the source increases?
2 Why do the P-wave and S-wave arrival times form curves instead of straight lines?
3 Choose two stations near the bottom of the seismogram and note down the arrival times of the P-wave and of the S-wave at each. Find the difference in time between arrival at one station and at the other for the P-wave and then for the S-wave.
4 Find the approximate difference in distance travelled from the source to each of these stations, assuming that 1 degree is equivalent to 111 km along the surface.
5 Use the distance difference and the time difference values you found to calculate an approximate speed for P-waves and for S-waves.
6 Repeat steps 3–5 for another pair of stations further up the seismogram, and compare the values you calculated for the speed of P-waves and S-waves.
7 Why might there be a difference? Why else might there be a difference?
8 The lines for the direct P-wave arrival (in green) and the direct S-wave arrival (orange) do not continue up to the furthest stations. What might be causing this?

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Additional task

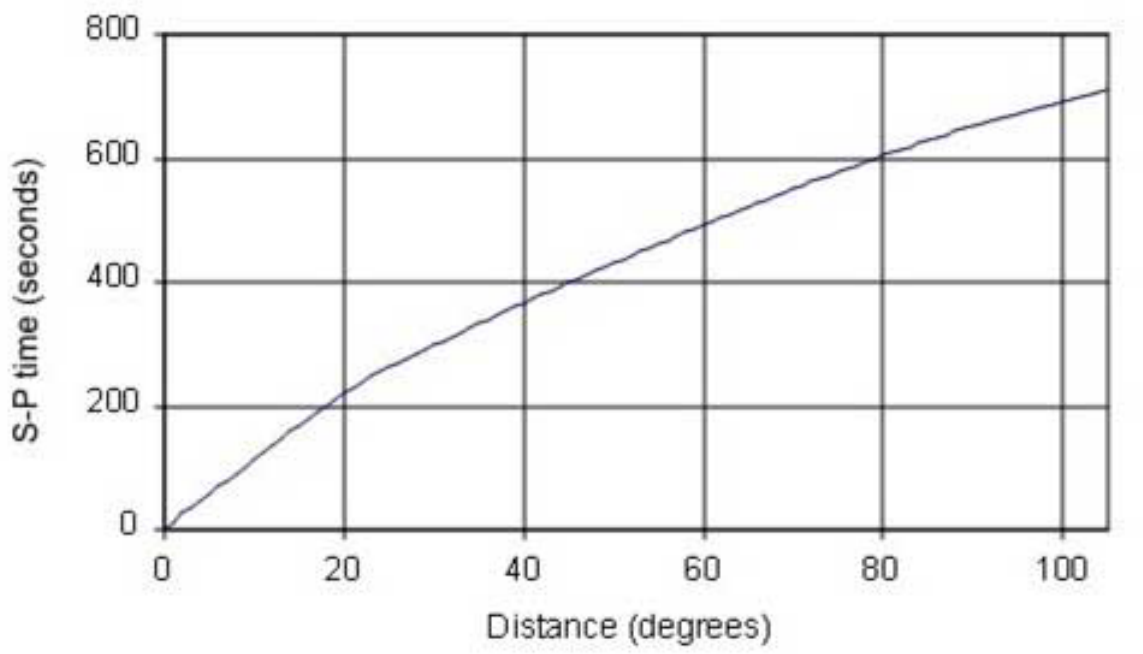

Figure 2 The graph uses the difference in arrival times of P-waves and S-waves to estimate the distance of a monitoring station from the source. BGS ©UKRI

It is often useful to use a graph to let you read off values quickly without having to do a calculation. The graph uses the difference in arrival times of P-waves and S-waves to estimate the distance of a monitoring station from the source.

1 Why is the graph a curve, rather than a straight line?
2 What do you notice about the difference in arrival times as the distance from the source increases?
3 Use the time-travel graph and the same stations you used in the previous task to estimate their distances in degrees from the source. Compare the estimates with the values given on the y-axis.

EARTHQUAKE CLASSROOM ACTIVITIES

Answers to questions

Q1 (Which waves arrive first? What do you notice about the difference in arrival times as the distance from the source increases?)

The P-waves always arrive before the S-waves, and the time between these two waves arriving gets bigger the further the station is from the earthquake

Q2 (Why do the P-wave and S-wave arrival times form curves instead of straight lines?)

The curves show that the speed is not steady but increases with depth. (Refraction)

Q3-6 (Find difference in times of arrival at two stations; calculate distance between the stations, then calculate values for speed of P-waves and S-waves; repeat with different pair of stations).

The answers will vary a bit depending on the stations chosen, but P-waves should be about 5-8 km/s , S-waves about 3-4 km/s.

Q7 (Why might there be a difference?)

a) Refraction effect; b) Over shorter distances, differences in arrival time and average speed are likely to be caused by differences in the materials the waves are passing through. Scientists use large amounts of such data to build models of the Earth's structure at smaller scales.

Q8 (Why don't the lines for the direct P-wave arrival and the direct S-wave arrival continue up to the furthest stations?)

The Earth's liquid outer core refracts P-waves strongly and does not allow S-waves to pass through at all.

Answers to additional task questions

The additional task is meant to offer students a chance to compare a model of the graph with known values.

Q1 The graph is a curve because the difference in arrival times increases with distance.

Q2 The graph stops at just beyond 100 degrees, P-waves and S-waves would have to travel through the liquid outer core, so this model doesn't 'work' any more.