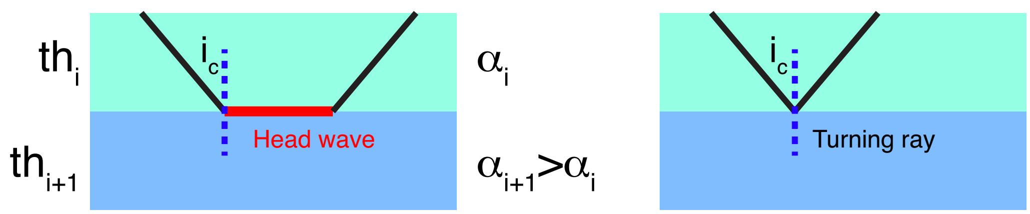
HW2 Travel time calculation and ray tracing

Due time: April 14

1. Use AK135 model (http://ds.iris.edu/spud/earthmodel/1568955, Kennett et al., 1995) to calculate a travel time table (travel time vs. distance) of the direct P arrivals with both event and stations locating at the surface. The distance range is from 15 to 80°.
Write down the formula for calculating the distance $\Delta(p)$and travel time $T(p)$. Here p is the ray parameter.
Write a subroutine to calculate $\Delta(p)$and $T(p)$. Note the direct P arrivals at this distance range travel with geometric ray paths **without head wave**. The ray reaches a certain layer with incident angle of 90° will not proceed as head wave. It will **turn back** to the top layer instead (the right case in the Figure below). The geometric ray will arrive as the first arrival in this case.



You may decrease the layer thickness in the AK135 model, i. e. 1 km per layer, to make a stable calculation.

Use **both spherical Earth model and flattening Earth model,**

(a) Calculate the $\Delta(p)$ – $T(p)$ and $\Delta(p)$ –p curve. Compare $\Delta(p)$ – $T(p)$ with the result from TauP software (http://www.seis.sc.edu/taup/).
(b) Plot the ray paths from event to stations for every 5°.
(c) Discuss the travel time and ray path changes at Δ of 15-30°.

2. Following the bending method described in Um and Thurber's (1987) paper and finite difference method described in the Vidale's (1988) paper introduced in class, write two codes separately to calculate the travel times for a velocity model. For finite difference method, you can only use flat wavefronts (Equation 3) for extrapolating the travel times from three corners of a square to the fourth. You are welcomed to test the locally circular wavefronts (Equation 5).

(a) Benchmark the two codes for a uniform velocity model with event and station setup as in Fig. 7 in Vidale's (1988) paper as well as the grid spacing (1 km) and mean velocity (1 km/s). Plot your results against the true travel times as in Fig. 8.

(b) Add 2D random medium in the velocity model and calculate the travel times for the new velocity model. By changing the correlation length and RMS velocity perturbation, discuss the performances of the two different methods.

Both problems are supposed to be done as a group. One is charging for 1D flat earth ray tracing and bending method. Another is for spherical earth ray tracing and finite difference method. Then you can compare the results and write the HW together. I have divided the groups as follows. However, if you want to make adjustments, just inform the TAs.

About how to set up the random medium, you can find information at:
https://refubium.fu-berlin.de/bitstream/handle/fub188/13264/02_yoon_chapter2.pdf?sequence=3&isAllowed=y

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Reference:

- Kennett B. L. N., Engdahl E. R. and Buland R., Constraints on seismic velocities in the earth from travel times (1995), Geophys. J. Int., 122, 108-124.
- Vidale, J., Finite-difference calculation of travel times (1988), BSSA, 78(6), 2062-2076.