SLBM Ellipticity Correction Test

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The SLBM travel time calculator has been implemented in such a way that the ellipticity of the Earth is directly accounted for in the calculation and application of ellipticity corrections are not required. For information about how Earth ellipticity is incorporated in the calculations, see document GeoVector.pdf which can be found in directory SLBM_Root/doc.

To ensure that Earth ellipticity is properly accounted for, the following test was implemented. An array of 7 synthetic receivers was generated located at geographic latitudes 0 to 60 degrees, with 10 degree spacing. A set of synthetic sources was generated from 1 to 80 degrees geographic latitude, with 1 degree spacing. All the sources and receivers were located along the meridian with longitude of 0 degrees. For each receiver, the ellipticity correction was requested from PGL for the 20 sources located 1 to 20 degrees north of the receiver. Those corrections are plotted with solid curves in Figure 1.

Then SLBM was used to compute the travel time between the receiver and the sources located 1 to 20 degrees north of the receiver. The IASP91 earth model was used for the calculations. The calculations were performed twice, once with the Earth specified to be an ellipsoid and once with the Earth specified to be a sphere with a constant radius of 6371. The difference between the two calculations is called the SLBM ellipticity correction. These results are plotted in Figure 1 with the dashed curves. The difference between the SLBM and PGL ellipticity corrections is plotted in Figure 2.

The PGL and SLBM ellipticity corrections are in good agreement. For source-receiver separations between 0 and 15 degrees, the differences between the two approaches range from -15 to +10 milliseconds. There is a noticeable change in behavior beyond 15 degrees, but the differences are not severe. Throughout the range of source-receiver separations, the SLBM code is integrating slowness along the Moho, with a mantle gradient correction term that is likely very nearly the same for both the spherical and ellipsoidal calculations. Hence the SLBM ellipticity correction arises essentially entirely from differences in the radius of the Moho in the ellipsoidal and spherical Earths. It would appear that the ellipticity corrections reported by PGL out to distances of about 15 degrees also represent travel time differences that arise from integrating slowness along the Moho, but I am not certain that this is the case. The change in behavior at 15 degrees likely arises because a different phase becomes the first arrival in the AK135 model used to compute the ellipticity corrections reported by PGL. This phase is likely the compressional wave that dives below the Moho and travels through the upper mantle. This phase would have a slightly different variation of ellipticity correction as a function of source-receiver separation.

These results indicate that SLBM is handling Earth ellipticity correctly and no additional ellipticity corrections are required.

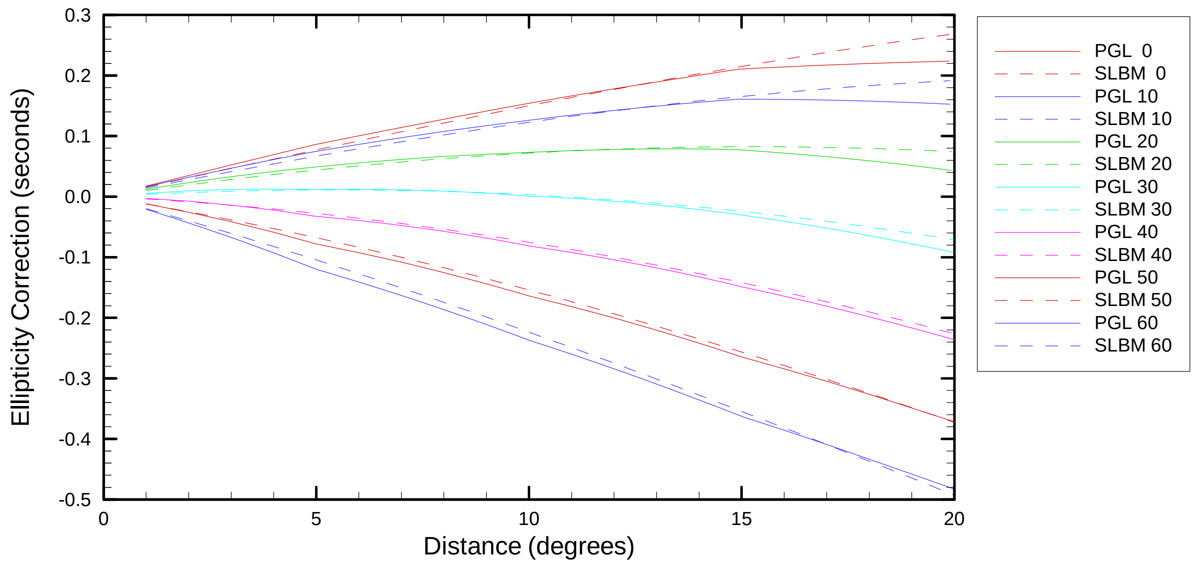

Figure 1 – The ellipticity corrections computed by PGL (solid curves) and SLBM (dashed curves), as a function of the source-receiver separation. Each pair of curves represents the ellipticity corrections along a transect from a receiver to a series of events located due north of the receiver. The 13 receivers are evenly spaced from 0 to 60 degrees geographic latitude.

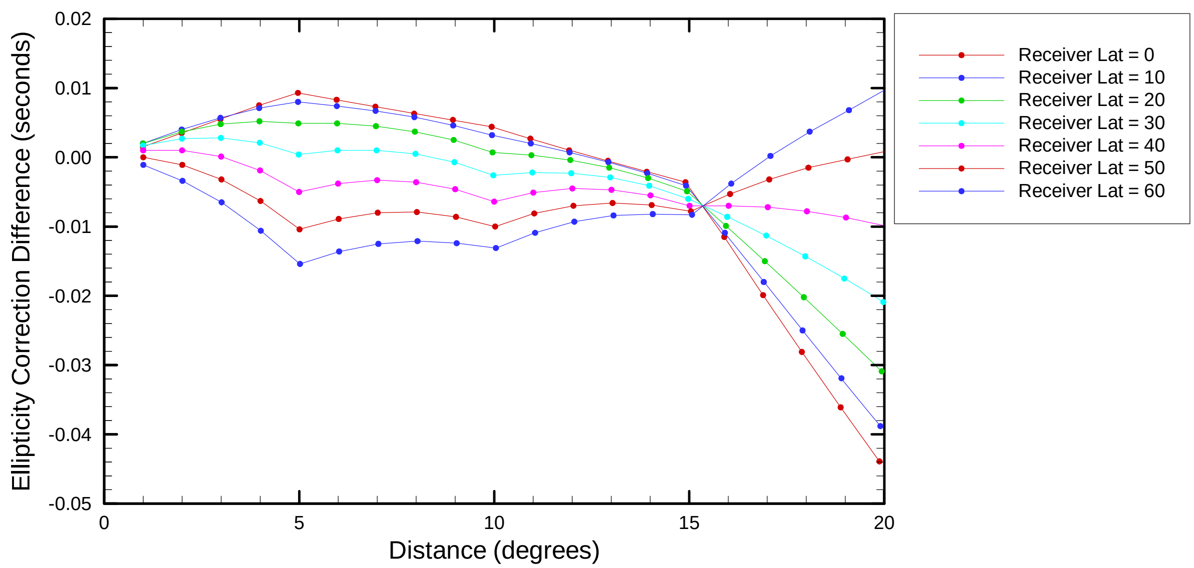

Figure 2 – Difference between the ellipticities calculated using SLBM and PGL, as a function of receiver latitude and source-receiver separation.