The Lg phase comprises a superposition of higher-mode surface waves with a group velocity of about 3.5 km/s.

Nuttli (1973) developed the \( m_{bLg} \) magnitude scale to quantify the size of an earthquake from 1-second-period Lg waves. Nuttli (1980) calibrated the original \( m_{bLg} \) formula at 10 km and accounted for different coefficients of anelastic attenuation.

The NEIC and this study use an approximation of Nuttli’s 1986 formula.

Nuttli (1973) developed the formula:

\[
\frac{\log m_{bLg}}{\log 10} = 4.33 - \frac{\log r}{0.4343 - 0.00063 r}
\]

Average \( m_{bLg} \) = 5.08

\[
\frac{\log m_{bLg}}{\log 10} = 4.94 - \frac{\log r}{0.4343 - 0.00063 r}
\]

Average \( m_{bLg} \) = 5.03

\[
\frac{\log m_{bLg}}{\log 10} = 4.65 - \frac{\log r}{0.4343 - 0.00063 r}
\]

Average \( m_{bLg} \) = 5.12

\[
\frac{\log m_{bLg}}{\log 10} = 5.27 - \frac{\log r}{0.4343 - 0.00063 r}
\]

Average \( m_{bLg} \) = 5.19

\[
\frac{\log m_{bLg}}{\log 10} = 5.51 - \frac{\log r}{0.4343 - 0.00063 r}
\]

Average \( m_{bLg} \) = 5.51

Background

Objectives

- Determine whether the \( m_{bLg} \) scale is consistent across epicentral distances
- Determine whether a constant coefficient of anelastic attenuation is appropriate for all paths east of the Rocky Mountains
- Determine whether the \( m_{w} \) scale and the \( M_{w} \) scale have a discernible relationship so that an \( m_{bLg} \) magnitude could be a proxy for an \( M_{w} \) magnitude

We divided the event region into 4 sectors, corresponding to the 4 azimuthal sectors, and calculated 2 trimmed averages: one for each sector for the epicentral distances 0 to 1000 km and accounted for different gamma values for each azimuthal sector.

Gamma = 0.00063 km

Our analysis of the entire event, we assumed \( n = 0.8333 \), an assumption appropriate for all paths east of the Rocky Mountains.

The model for amplitude as a function of the epicentral distance \( r \) is:

\[
\ln(A) + n \ln(r) = -\gamma r + \ln(C)
\]

We divided the original constant from the model by 2 as a way to determine whether a constant coefficient of anelastic attenuation is appropriate for all paths east of the Rocky Mountains.

\[
\gamma = 0.000686 / km
\]

\[
\gamma = 0.00131 / km
\]

\[
\gamma = 0.00163 / km
\]

\[
\gamma = 0.00138 / km
\]

\[
\gamma = 0.00117 / km
\]

Minnesota, February 16, 2011

M_w = 4.44

m_{bLg, all} = 5.04

m_{1000} = 5.35

Arkansas, February 28, 2011

M_w = 4.65

m_{bLg, all} = 5.27

m_{1000} = 5.19

Conclusions

- The average \( m_{w} \), whether computed using only stations under 1000 km or those both above and below 1000 km, are similar.
- However, a conspicuous drop in magnitude after 1000 km occurs for wave propagation paths to the west and to the north.
- A constant coefficient of elastic attenuation is not justified for all paths east of the Rocky Mountains.
- For example, those through the Great Plains to the north may have coefficients 50% to 100% greater than Nuttli’s value
- A linear formula between \( m_{bLg} \) and \( M_{w} \) over the \( M_{w} \) range of 3 to 4.5 may be a sufficient approximation.

- Outside of this range, though, a linear relationship may not hold.

We also ran computer simulations using stochastic processes and scaling, giving similar results in the magnitude range of the actual events.

- However, the computer simulations showed that, outside of the studied magnitude interval, a simple formula may not hold.