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Amplitude-dependent station magnitude

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Magnitude, a concept first presented by Gutenberg and Richter, adjusts measurements of ground motion for epicentral distance and source depth. Following this principle, the IDC defines the j'th station body wave magnitude for event i as $m_b(sta_{i,j}) = \log_{10}(A_{j,i}/T_{j,i}) + VC(\Delta_{j,i}, h_i)$, where VC is the Veith-Clawson (VC) correction to compensate for the epicentral distance of the station and the depth of the source. The network magnitude is calculated as the average of station magnitudes. The IDC magnitude estimation is used for event characterization and discrimination and it should be as accurate as possible.

Ideally, the network magnitude should be close in value to the station magnitudes. In reality, it is observed that the residuals range between -1 and 1 mu or $\pm 25\%$ of a given $m_b(net_i)$ value.

We show that the residual, $m_b(net_i) - m_b(sta_{j,i})$, depends linearly on $\log_{10}(A_{j,i}/T_{j,i})$, and we correct for this dependence using the following procedure:

1. Calculate a "jackknifed" network magnitude, $m_b^{j,n}(net_i)$, i.e. an average over all participating stations except station n.
2. Using all measurements at station n, calculate the parameters a_n, b_n of the linear fit of the residual $m_b^{j,n}(net_i) - m_b(sta_{n,i}$ to $\log_{10}(A_{n,i}/T_{n,i})$.
3. For each event i at station n calculate the new station magnitude $m_b^{new}(sta_{n,i}) = (a_n + 1)\log(A_{n,i}/T_{n,i}) + VC(\Delta_{n,i}, h_i) + b_n$
4. Calculate the new network magnitude: $m_b^{new}(net_i) = \frac{1}{N}\sum_{n=1}^{n} m_b^{new}(sta_{n,i})$

The procedure was used on more than two million station-event pairs. Correcting for the station-specific dependence on log amplitude reduces the residuals by roughly a third.

We have calculated the spread of the distributions, and compared the original values and those for the corrected magnitudes. The spread is the ratio between the variance of the network magnitudes, and the variance of the residual. Calculations show an increase in the ratio of the variance, meaning that the correction process presented in this document did not lead to loss of variance in the data and that the dependence of the station magnitude on log(A/T) is real and not an artifact of the averaging process.