Answers to Exercises
Chapter 16

Exercise 16.1

From section 16.2.3, SPL = $S + 10 \log (\Delta f)$. Between 1 and 2 Hz, $\Delta f = 1$ so $\log(\Delta f) = 0$. We need to estimate the mean value of the PSD between 1 and 2 Hz. By drawing a line between 1 and 2 Hz, the median value is ~50 dB for Halemaumau. Similar results can be obtained for the other volcanoes, but issues arise with sharply peaked spectra such as for the strombolian activity at Tungurahua (Fig. 16.1b). In that case it is better to numerically integrate over the band of interest.

Exercise 16.2

We can use a median value of 75 dB for the peak in the 0.3–0.6 Hz octave, and since 10log(0.3) = -5 dB, the SPL is ~70 dB, 20 dB (a factor of 10 in pressure) above the levels between 1 and 2 Hz. Therefore, a microphone with a passband above 2 Hz would potentially miss this key feature and substantially underestimate the radiated source power by a factor of 10. The estimated transmission loss (Table 16.1) is 77 dB, so the estimated source power between 0.3 and 0.6 Hz is ~147 dB. The corresponding rms pressure is ~450 Pa, an order of magnitude above the 1–2 Hz pressure shown in Table 16.1. Such intense source pressures at higher frequencies could induce choking and giddiness, and prolonged sound exposure should be avoided.

From Eq. (16.23b), the power in Watts for a vented subsurface source (as in Halemaumau) is the same as for a surface source:

$$\Pi_h = \frac{2\pi r^2}{\rho c}\left\langle p^2 \right\rangle \qquad \text{Hemispherical source into a half space (surface source)}$$

Since we have already corrected for spherical spreading in the transmission loss, the source power was ~ $(2 \times 3.14)/(1 \times 340) \times (450)^2$ ~ 4 kW during this time period. Assuming a source in free space (Eq. 16.20) would have incorrectly yielded a power of 8 kW, and assuming a source near the ground (Eq. 16.22) would have yielded a source power of 16 kW, a factor of 4 above the vented source power estimate.

Exercise 16.3

From Eq. (16.32), St $= fL/U$, where $L = 10$ m, the expanded jet diameter. For $f = 1$, $U = fL/\mathrm{St}$ ~ 25–170 m s^{-1}, a reasonable range of subsonic jet speeds for volcanic environments.