Comparison of some volcano infrasounds

Jeffrey Johnson

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Which volcano is "loudest"?

Santiaguito (Guatemala) - pyroclastic-laden eruptions with buoyant plumes to ~1.2 km

Tungurahua (Ecuador) - short-duration Vulcanian explosions reaching ~2 km

Fuego (Guatemala) - short-duration Strombolian/ Vulcanian explosions

Kilauea (Hawaii) - open-vent lava lake degassing and rock fall-induced explosions

Reventador (Ecuador) - continuous degassing giving rise to ~500-m-high plume

Villarrica (Chile) - open-vent activity from roiling lava lake

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Quantifying infrasound amplitudes/energy: (Note: metrics only appropriate for monopole!!!)

Reduced pressure (monopole):

$$p_r = \delta p(t) \times \frac{r}{r_r}$$

δp = recorded excess pressure

r = source-receiver distance

r_r = reduced distance (typical 1 or 1000 m)

Sound pressure level:

$$SPL = 20 \times \log\left(\frac{\overline{p_r}}{2 \times 10^{-5}\ \text{Pa}}\right)$$

$\overline{p_r}$ = root mean squared pressure

p_0 = reference pressure (2 x 10^{-5} Pa)

By power (monopole):

$$P(t) = \Omega \overline{\frac{\delta p^2 (t + r/c)}{\rho c}}$$

ρc = acoustic impedance

(density x sound speed = ~380 m kg s^{-1} at STP)

Ω = solid angle area

($2\pi r^2$ commonly used for assumed halfspace)

By energy:

$$E_A = \int_{t_1}^{t_2} P(t)\, dt$$

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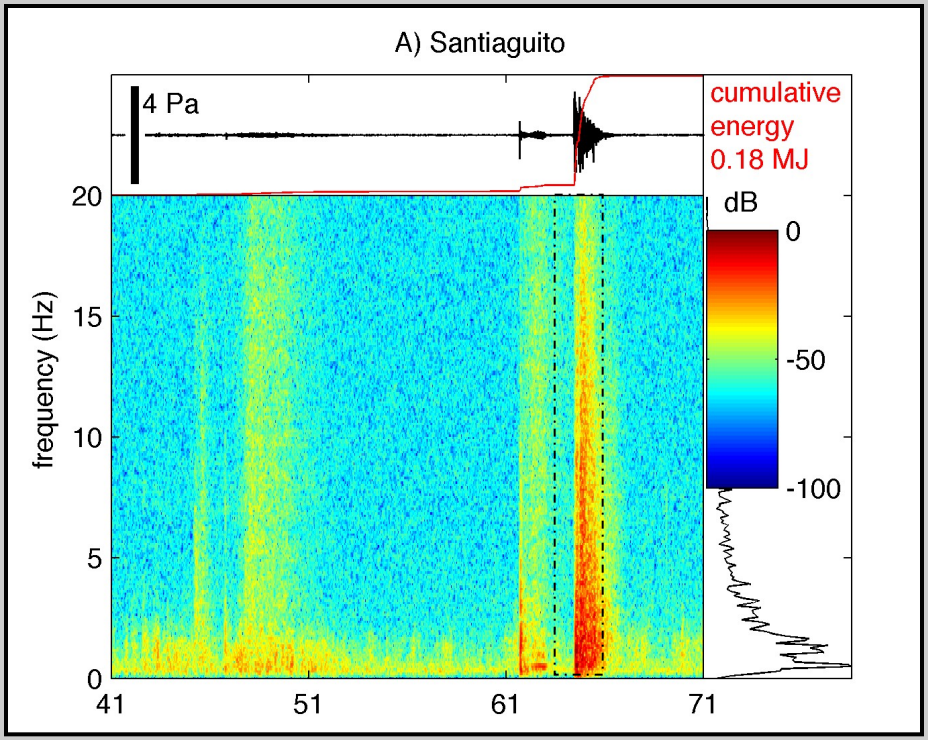
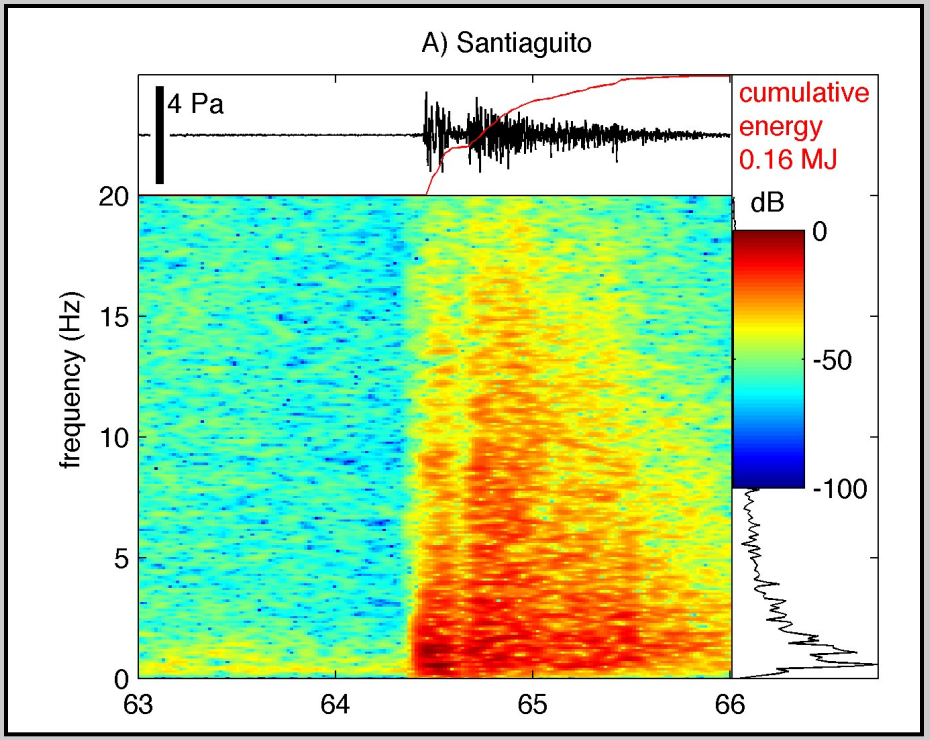
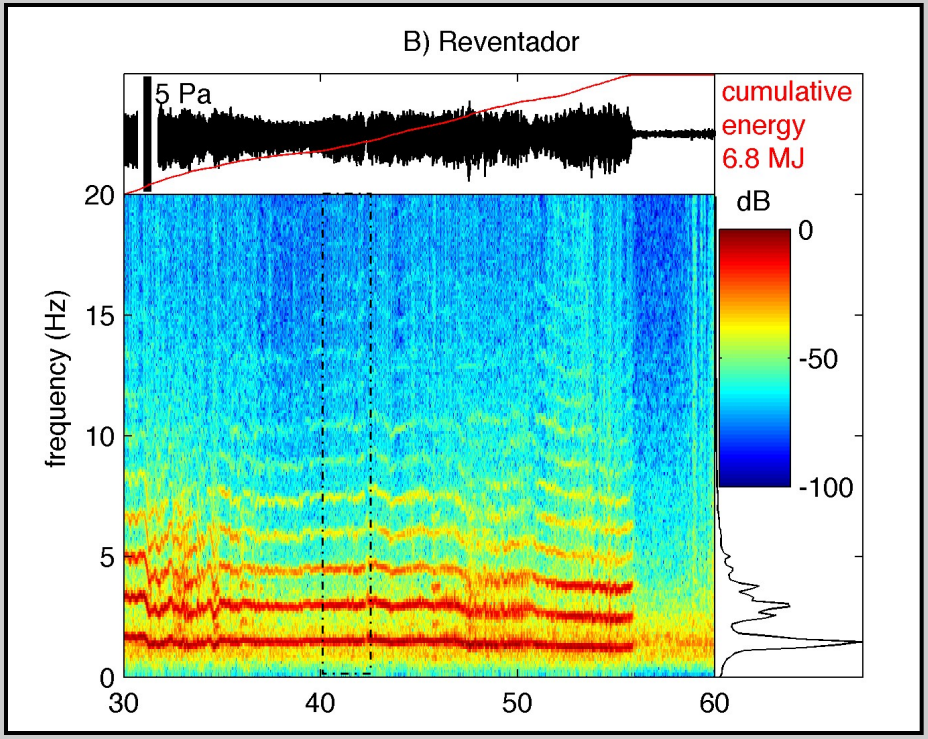
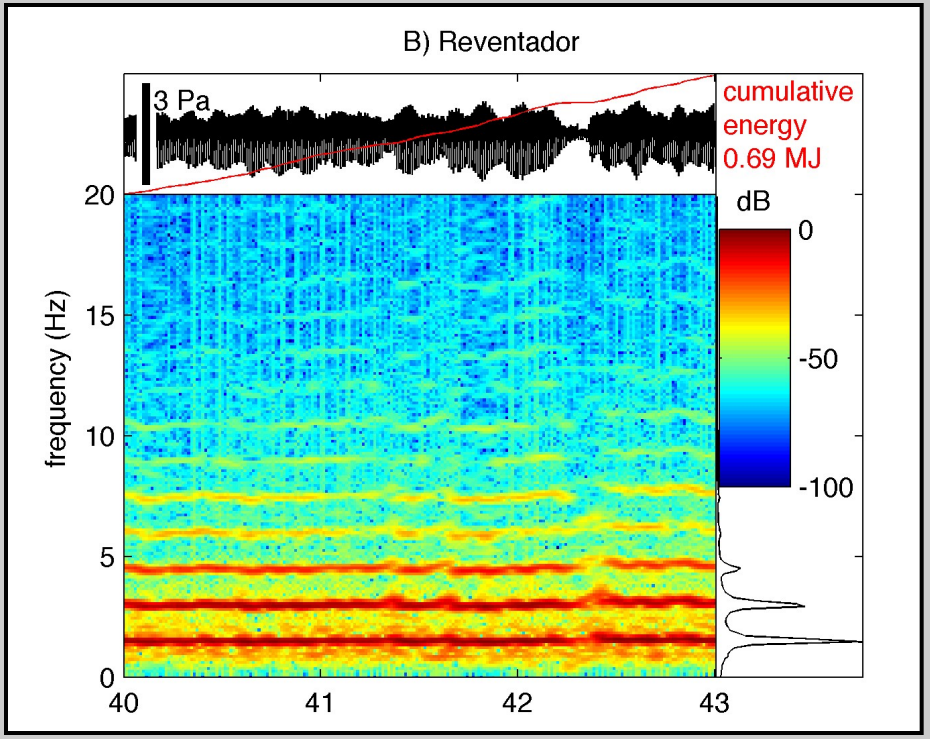


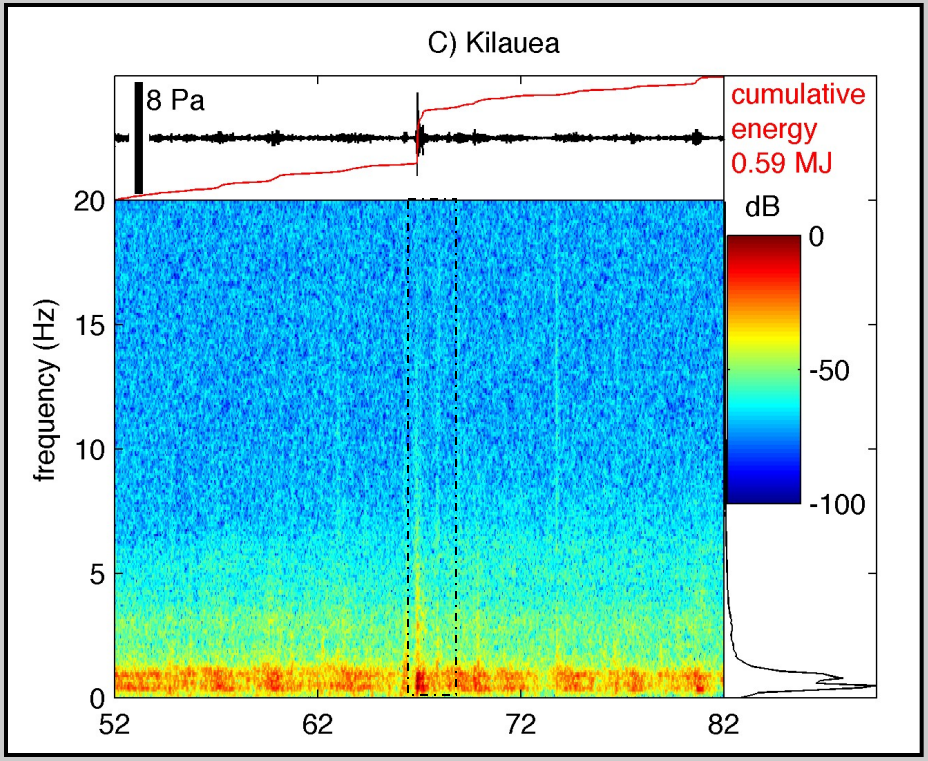


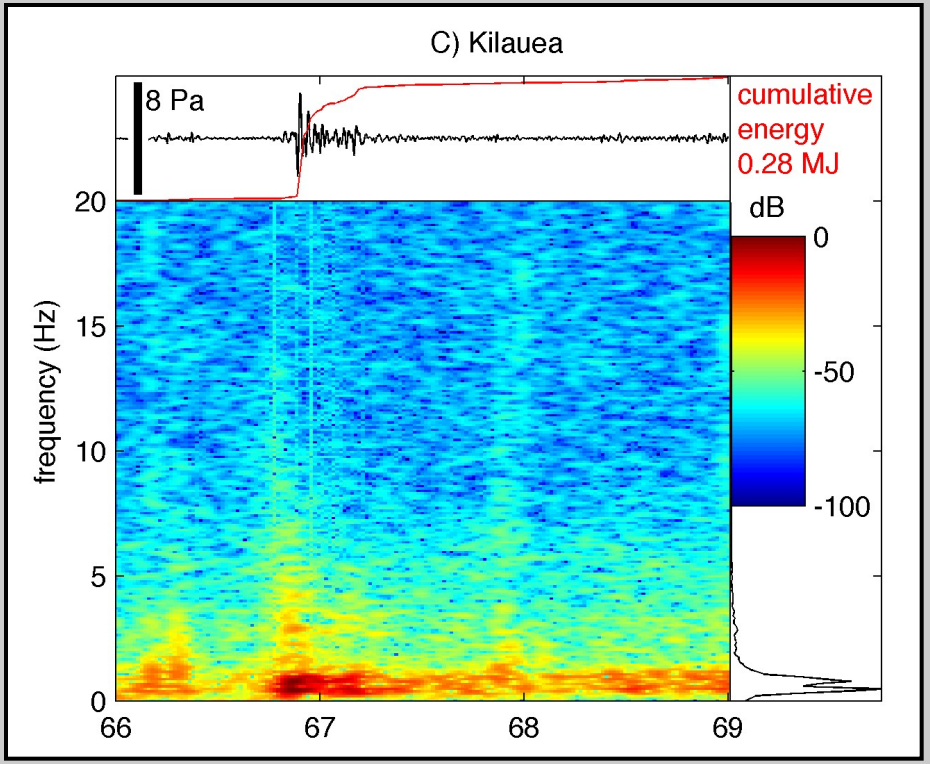
Santiaguito (Guatemala) - pyroclastic-laden eruptions with buoyant plumes up to ~1.2 km. Only about **100 Watts** of acoustic power is associated with time averaged Santiaguito eruptive behavior and is dominated by explosive events. Up to 3000 Watts is generated during eruption.



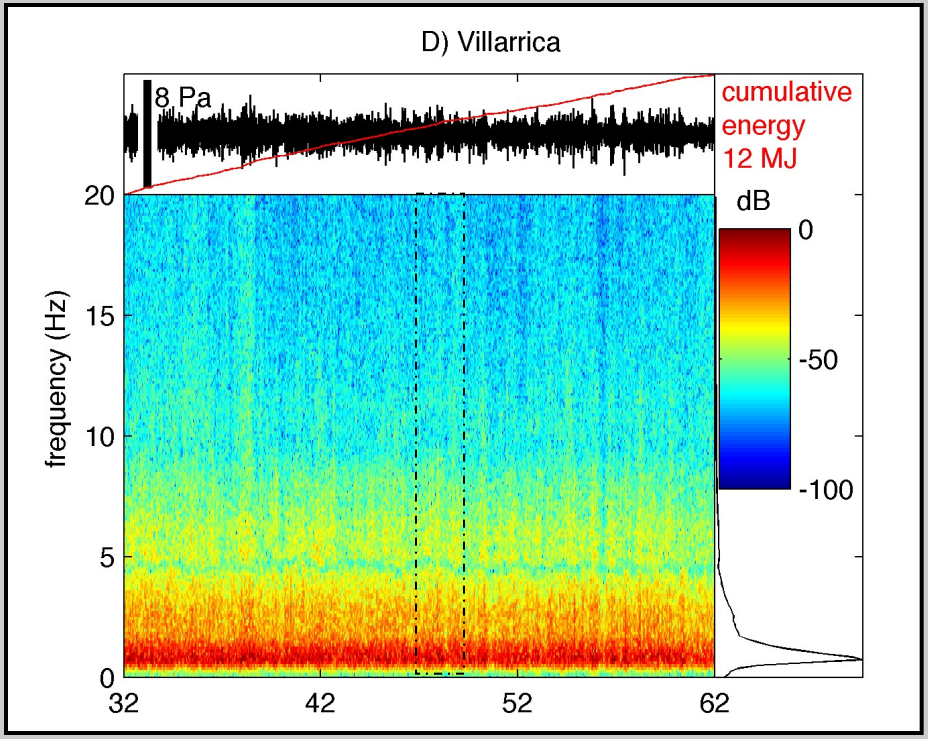


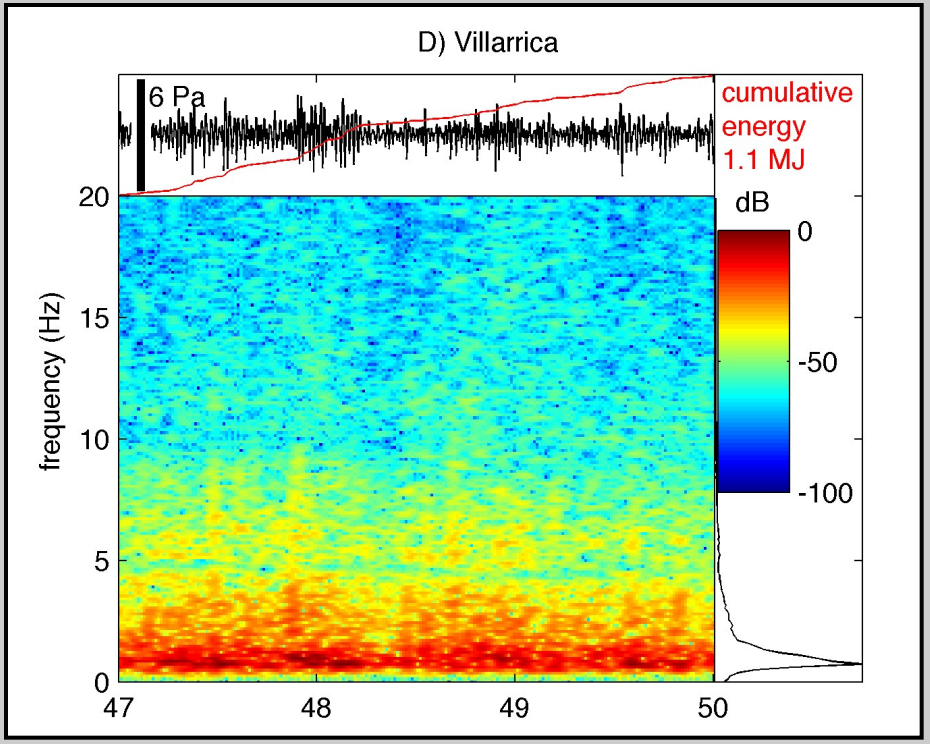
Reventador (Ecuador) - continuous degassing giving rise to ~500-m-high vapor plume. Infrasound is dominated by harmonic tremor ('chugging'), which produces consistent levels of sound and sound power (**~4000 Watts**) until shutting off.



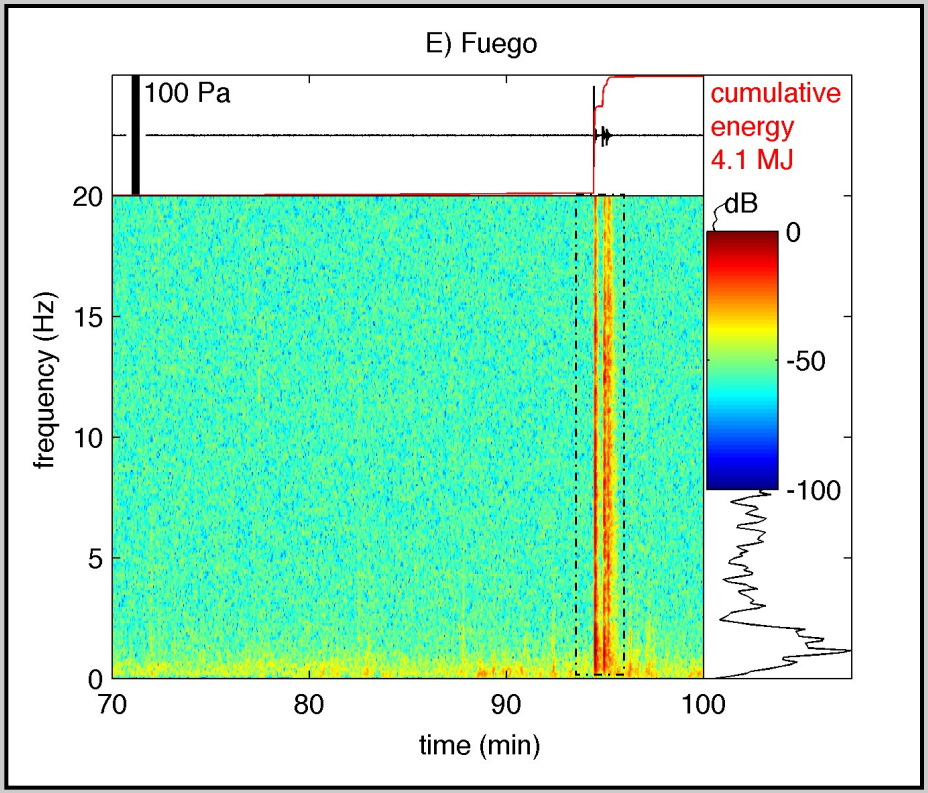


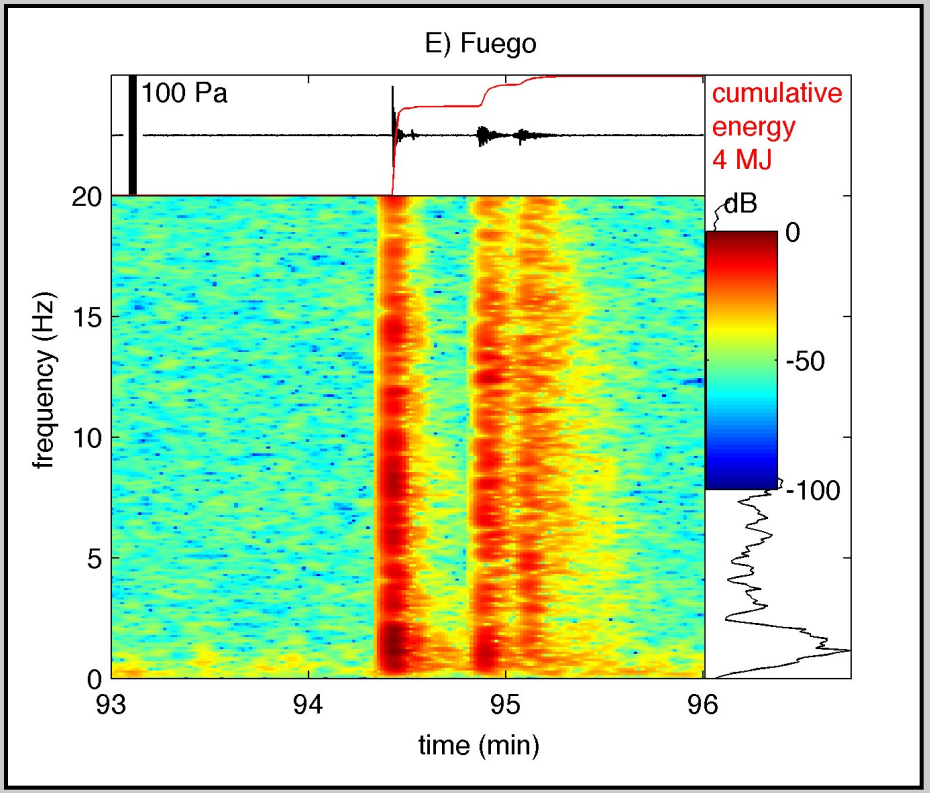
Halemaumau, Kilauea (Hawaii) - striking and long-lived monotonic tremor is continuous for months and associated with open-vent lava lake degassing. Transient infrasound pulses are thought to represent explosions instigated by pit crater collapse during which ash and blocks are expelled several hundred meters. Long term averaged acoustic power is **~300 W**.



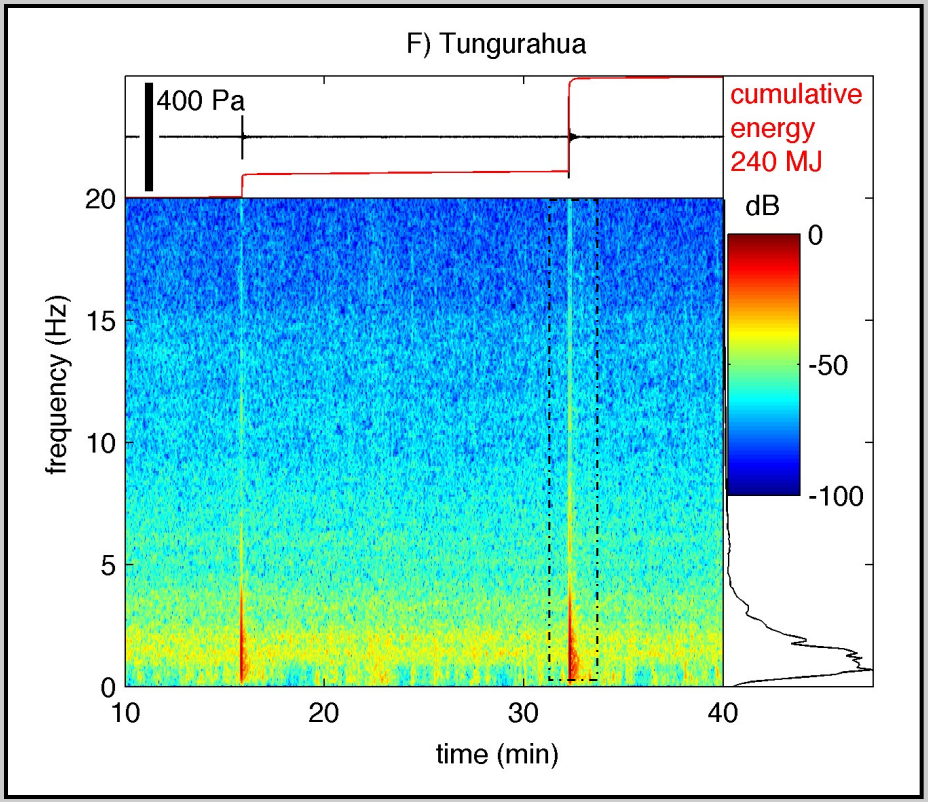


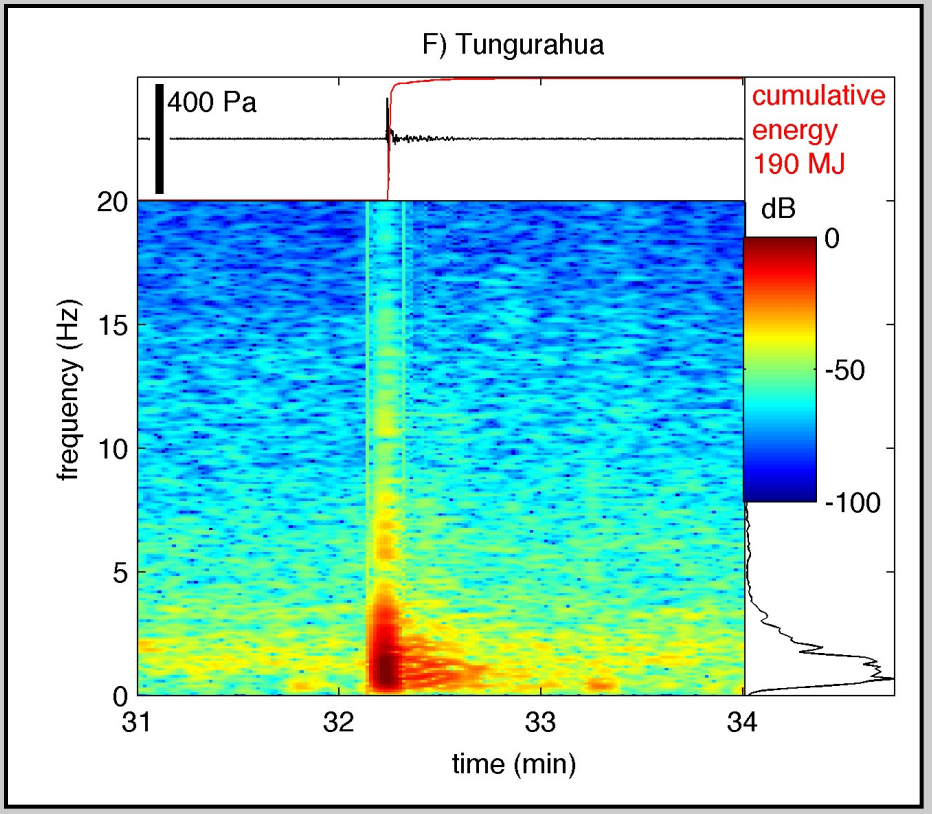
Villarrica (Chile) - like Kilauea, another monotonic tremor system associated with open-vent lava lake activity. Energy is sharply peaked at 0.77 Hz. Small Strombolian explosions at bottom of crater are not associated with infrasound transients. Sustained acoustic power is **~6500 W**.





Fuego (Guatemala) - short-duration Strombolian/Vulcanian explosions generate intense, short-lived infrasound transients, which are relatively broad band in character. Almost all acoustic energy is released during these short events when acoustic power reaches ~100,000 W. Long-term averaged acoustic power is **~2200 W**.

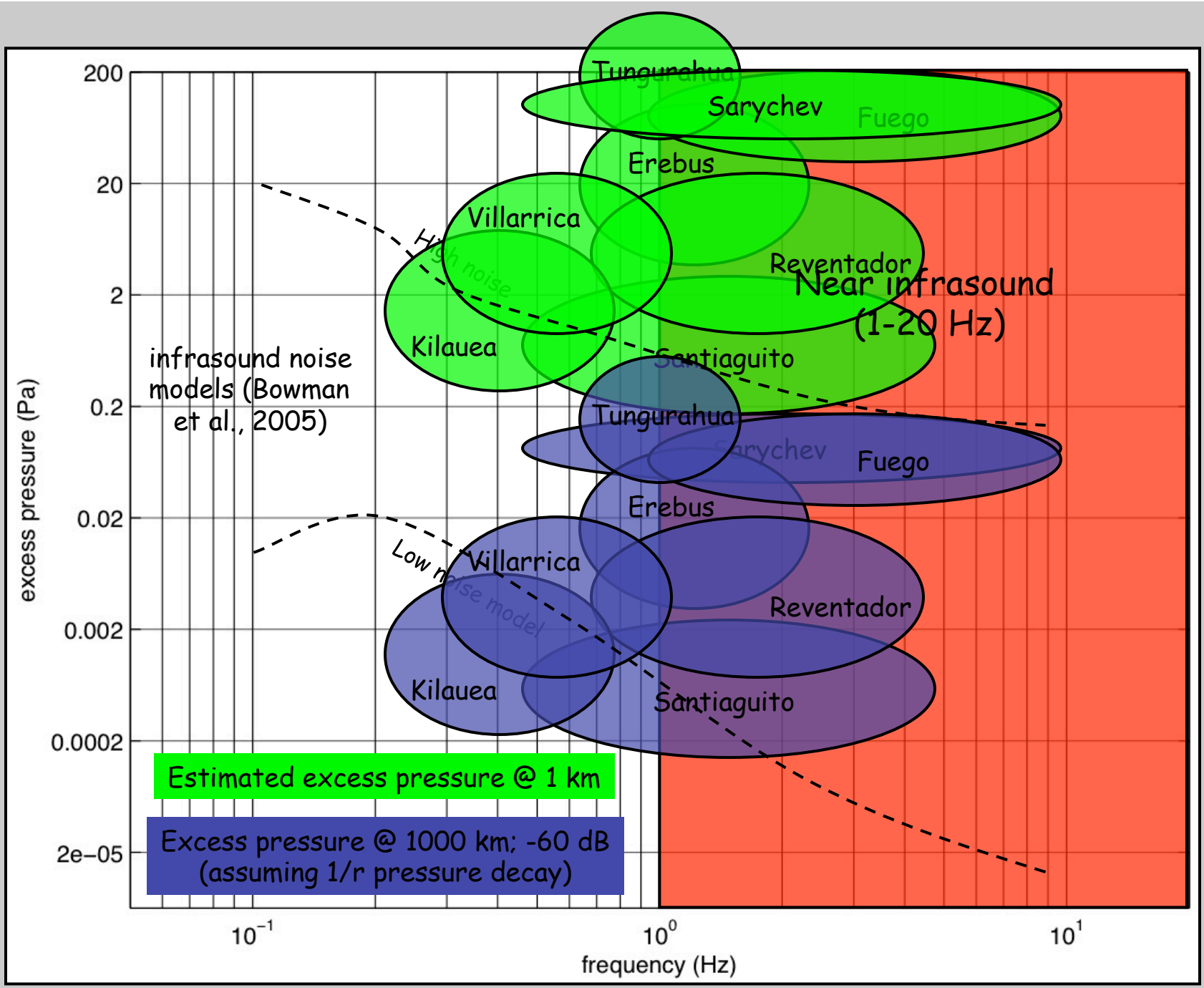
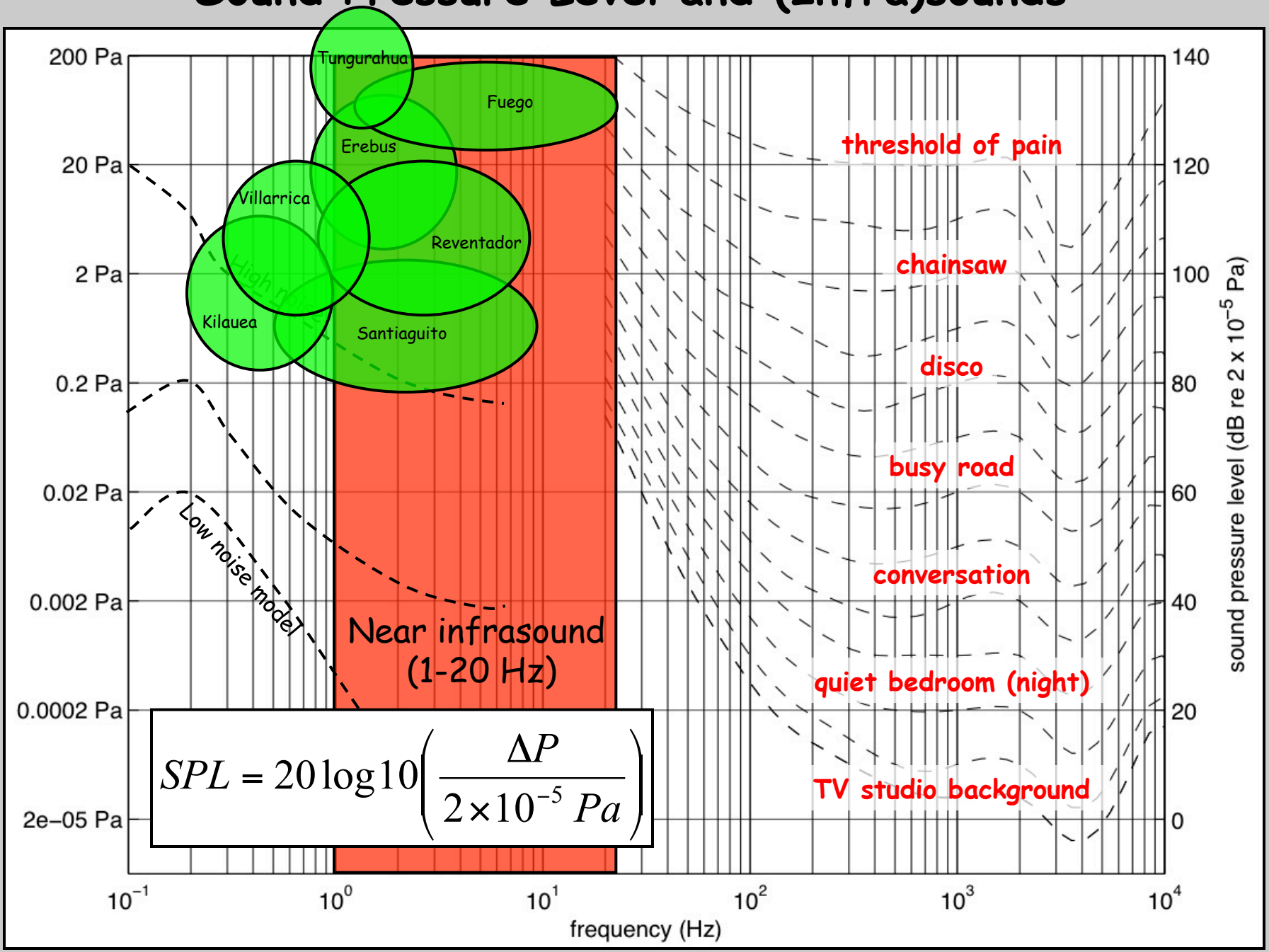




Tungurahua (Ecuador) - short-duration Vulcanian explosions ejecting ballistics to ~2 km generate intense, short-lived infrasound transients, which are confined to frequencies below about 5 Hz. Peak acoustic power is as great as 10 MWatts (10,000,000 Watts) and time-averaged power is more than **100,000 W**.

Amplitudes and energies of some volcanic eruptions

	Trace reference start time (yyyy:ddd:hh)	Station distance (km)	max pressure (Pa)	Reduced pressure at 1 km (Pa)	30-minute total energy (MJ) from Figure 1
a) Santiaguito	2009:001:11	0.4	4.4	1.8	0.18
b) Reventador	2005:236:16	1.7	0.9	1.5	6.8
c) Kilauea	2008:190:09	2.4	1.3	3.2	0.59
d) Villarrica	2010:22:12	0.1	58	2.9	12
e) Fuego	2007:117:13	7.0	5.9	41	4.1
f) Tungurahua	2009:165:15	5.5	27	150	240


Tungurahua
Sarychev
Fuego
Erebus
Villarrica
Reventador
Kilauea
Santiaguito
Near infrasound
(1-20 Hz)
High noise
infrasound noise
models (Bowman
et al., 2005)
Low noise model
Estimated excess pressure @ 1 km
Excess pressure @ 1000 km; -60 dB
(assuming 1/r pressure decay)
excess pressure (Pa)
frequency (Hz)
200
20
2
0.2
0.02
0.002
0.0002
2e−05
10^{-1}
10^{0}
10^{1}

Sound Pressure Level and (Infra)sounds