Excitation of the gravest modes of the Earth after the 2010 Chilean earthquake (Mw=8.8) and comparison with two other events: Sumatra-Andam (2004, Mw=9.2) and Peru (2001, Mw=8.4)

Michel Van Camp[1] and Luis Rivera[2]

[1]Royal Observatory of Belgium, Uccle, Belgium
[2]Ecole et Observatoire des Sciences de la Terre, Strasbourg, France

These two figures show the spectra of time series from the superconducting gravimeter of Membach (eastern Belgium, data available on http://www.iris.edu/servlet/quackquery/budFileSelector.do, network "SG").
The times series are 60 hours long and are taken 4 hours after the onset of 3 major earthquakes in Chile (27 Feb 2010, Mw=8.8), Sumatra (26 Dec. 2004, Mw=9.2) and Peru (23 June 2001, Mw=8.4).

After a major earthquake, the Earth rings like a bell (see e.g. http://www.iris.iris.edu/sumatra/free_oscillations_second.htm). Analyzing the spectrum of these oscillations allows one to learn about the Earth structure as well as on the focal mechanism of the earthquake.

In particular, the relative amplitude of the different modes depends on the magnitude, on the focal mechanism, the orientation of the fault plane and its depth.

Among these eigenmodes, the "balloon" or "breathing" mode ${}_0S_0$ (period of 20.5 minutes or frequency of 0.814 mHz) is worth of note as it is not position-dependent (while for the other modes, depending on the earthquake, the recording station may be on a node [location where the amplitude is minimum], an antinode [location where the amplitude is maximum] or in between). See also the difference in amplitude of this mode for the 3 events: the Peru event is dwarfed by the two other ones, overall radiating much less energy in this frequency band.

Two toroidal modes ${}_0T_3$ and ${}_0T_4$ slightly appear; they should not for a symmetric non rotating Earth (there are only horizontal components) but due to mainly the Coriolis effect, a vertical component is present and detected by the gravimeter.

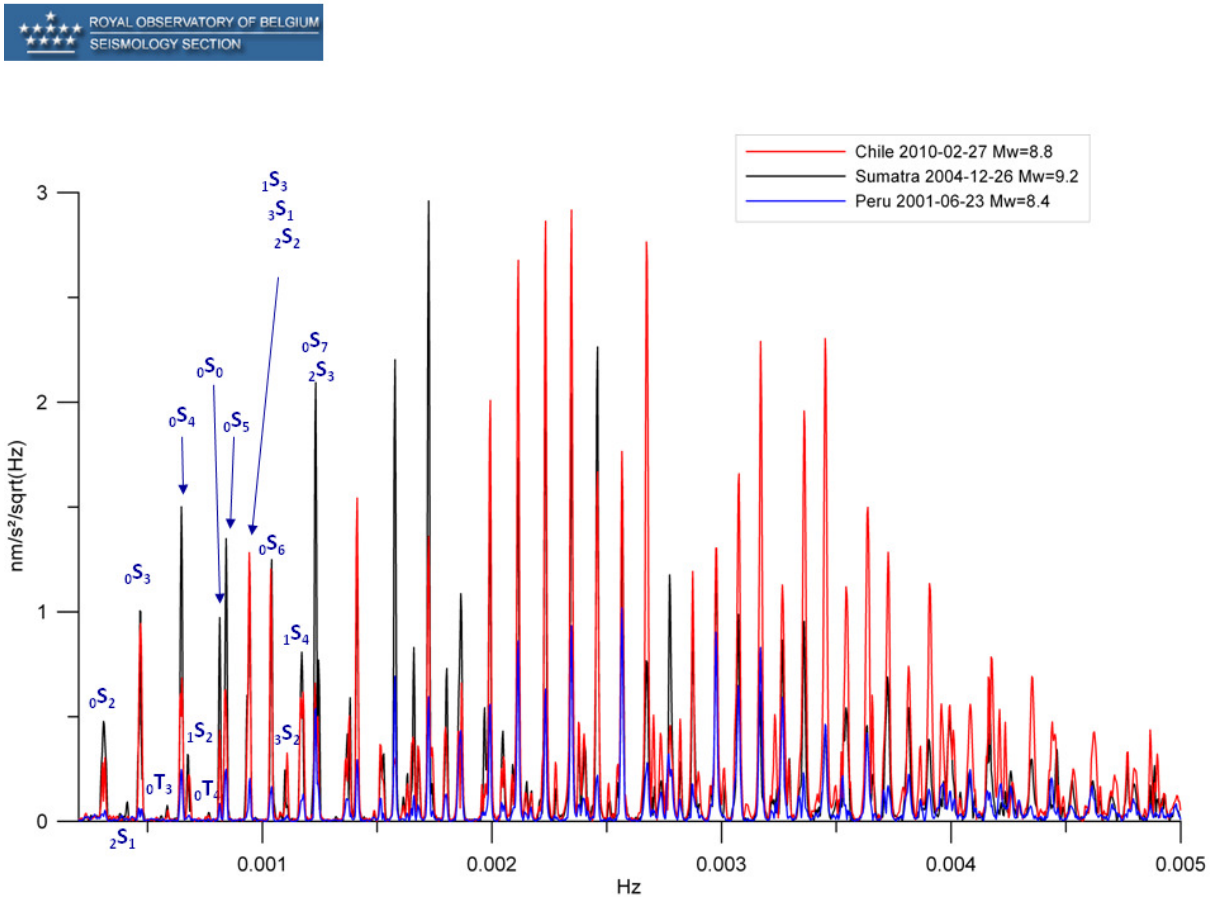

Figure 1: Spectra of the times series from the superconducting gravimeter of Membach GWR C021. This shows the excitations of the different eigenfrequencies of the Earth after 3 different earthquakes, for frequencies shorter than 5 mHz (or periods longer than 200 seconds). The “football” mode $_0S_2$ is the slowest one (period ~54 minutes).

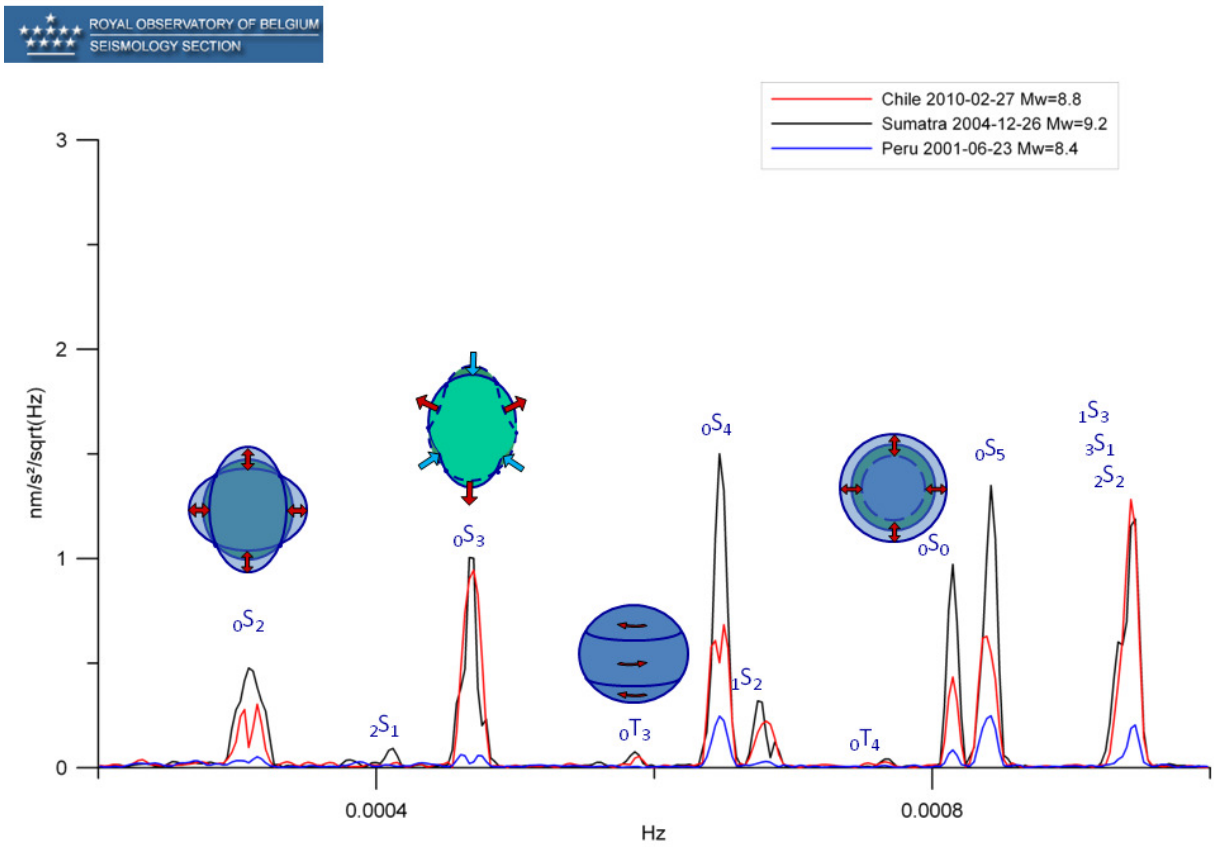

Figure 2: Same as figure 1 but for the gravest modes (frequencies shorter than 1 mHz or periods longer than 1000 seconds).