Evidence of the Torsion Motion (rotation around the vertical axis) on Seismic Recordings

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ABSTRACT

We present two surprising seismological observations performed under quite different field conditions. These two observations are related to long-period signals as follows:

1. In some seismic broad band stations, the two horizontal components record the same long-period background noise (between 50 seconds and 3 hours). The particle motion inside the horizontal plane shows a polarization of the noise with an unexpected 45° azimuth, as if the background noise is permanently polarized in this azimuth. Phases and amplitudes are the same. The coherency between the two horizontal traces is over 90% in some stations we have tested.
2. The seismic background noise recorded on the OBS is known to be quite important. Recently, OBS equipped with broad band seismometers have been deployed and the background noise in this new range of period (5 to 50 seconds) is even more important. The background noise recorded on the two horizontal traces of the broad-band OBS shows a very strong similarity as for preceding example. Horizontal signals have the same phases but, in this case, their amplitudes differ depending on the installation conditions.

In order to understand this unexpected polarization effect of noise at different frequency ranges, we have to reconsider what we record with seismic sensors. Seismometers are approximated as sensors recording three translations along Cartesian directions. The motion of the mass do depend also an angular variations by considering the three Euler angles and the previous approximation may not hold anymore. We reconsider the horizontal pendulum architecture: we note that STS-1H seismometer (from Streckeisen) is a ‘garden-gate’ structure and that CMG40-TOBS (from Güralp) is an inverse pendulum. In dynamic equations of the pendulum mass, it is necessary to take into account as usual external linear accelerations but also external torques, acting on the pendulum either through the translation of the mass but also through the tilt.

For the 'garden-gate' geometry, the external couple around the vertical axis, acts directly in the same way on the two horizontal components and if this torsion amplitude is greater than any translation and tilt background noise, the two traces record the same signal which will explain what we observe on long-period.

For the inverse pendulum, a combined term between the external torque and the instrument tilt will lead to the same observations: the amplitudes of the two horizontal components vary according to the amplitude and the azimuth of the tilt.

Consequently, reducing horizontal noise components will require the recording of three ground rotations which will give us additional information for the ground motion aside reduction of the noise. This data will permit correcting the seismic noise on OBS traces: we should recover a level of background noise compatible equivalent to the on-land station. Moreover, by taking into account tilt and torsion motion, one may hope that the horizontal background noise at long-period might be equivalent to the vertical background noise for on-land stations.