Model space exploration for determining landslide source history from long period seismic data

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The seismic signals generated by high magnitude landslide events can be recorded at remote stations, which provides access to the landslide process. During the "Boxing Day" eruption at Montserrat in 1997, the long period seismic signals generated by the debris avalanche are recorded by two stations at distances of 450 km and 1261 km. We investigate the landslide process considering that the landslide source can be described by single forces. The period band 25-50 sec is selected for which the landslide signal is clearly visible at the two stations.
We first use the transverse component of the closest station to determine the horizontal forces. We model the seismogram by normal mode summation and investigate the model space. Two horizontal forces are found that best fit the data. These two horizontal forces have similar amplitude, but opposite direction and they are separated in time by 70 sec. The radiation pattern of the transverse component does not enable to determine the exact azimuth of these forces. We then model the vertical component of the seismograms which enable to retrieve both the vertical and horizontal forces. Using the parameter previously determined (amplitude ratio and time shift of the 2 horizontal forces), we further investigate the model space and show that a single vertical force together with the 2 horizontal forces enable to fit the data. The complete source time function can be described as follows: a horizontal force toward the opposite direction of the landslide flow is followed 40 sec later by a vertical downward force and 30 more seconds later by a horizontal force toward the direction of the flow. Inverting directly the seismograms in the period band 25-50sec enable to retrieve a source time function that is consistent with the 3 forces determined previously. The source time function in this narrow period band alone does not enable easily to recover the corresponding single forces.
This method can be used to determine the source parameters using only 2 distant stations. It is successfully tested also on Mount St. Helens (1980) event which are recorded by more broadband stations.