Joint inversion of ULP tilt and VLP displacement from small explosions at Fuego volcano

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Very-long-period events accompany explosive eruptions at many volcanoes and have been used to investigate conduit geometries and explosion source processes. At some volcanoes, a measurable tilt signal accompanies the VLP and can be recorded with seismometers. The horizontal components of broadband sensors are particularly sensitive to tilt, which may dominate the record at periods below the low corner of the sensor. Since tilt is typically much lower frequency than the displacement signal, it can be filtered out prior to inversion; yet the tilt data can provide additional constraint on the source process and could be a valuable addition to the inversion.

At Fuego volcano in Guatemala, we recorded dozens of small-scale explosions in 2009 and 2012 using temporary arrays of seismometers and complementary instruments. These events are frequently preceded by 5 to 20 minutes of tilt that suggest pressurization of the upper conduit. The onset of explosive eruptions, which last from many tens of seconds to more than two minutes, include VLPs with peak periods from less than 30 to nearly 50 seconds. The events are dominated by ash emission that suggests a vulcanian-style downward migration of the magma fragmentation front.

Our arrays were designed for explosion source inversion and we have derived a source model from 2009 data for periods between 10 and 30 seconds. This band was chosen to limit the affect of low-frequency tilt, especially on sensors with a 30 second corner that made up the majority of the network. On the other hand, removing the low-frequency signal means ignoring a significant portion of the signal. We are now conducting joint inversions of the seismic and tilt signals, as recorded by seismometers, using separately-derived synthetic tilt and displacement Green functions. This work should provide a more complete view of the eruption process at Fuego. Importantly, it will provide better constraint on the pre-eruption process which may lead to more accurate eruption forecasting.

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