Volcano Infrasound monitoring including propagation effects induced by topography and atmosphere

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Abstract: Infrasound monitoring of active volcanoes is increasingly important, being the direct evidence of volcanic material injection into the atmosphere. From local to regional distances infrasound is now used routinely for volcano monitoring and source term parameters are commonly derived from field observations. However, the control of atmosphere and topography on recorded signal is extreme. The topographic effect is more significant in near-source (less than 10 km) while the atmospheric structure has a strong effect at the regional distances (>100-1000 kilometers). Both terms need to be accounted for in order to robustly derive the infrasonic source term.

We show results obtained from infrasound observations at regional scale (140-230 km) for a giant volcanic landslide from Askja volcano, Iceland, where event detection is strongly controlled by the atmosphere, and local observations (3-60 km) of recurrent volcanic activity from Sakurajima volcano, Japan, where excess pressure and frequency content are controlled by the topography and tephropagation process.

In this work we compare direct field observations, with results of numerical simulation using FDTD method including topography and atmospheric specifications, and show how both effects can be accounted for improve reliability of real time infrasonic volcano monitoring.

Infrasound Produced by Landslide at Askja Volcano

Infrasound Network at Sakurajima

Map of southern Kyushu, Japan, showing station sites. Permanent and temporary infrasound stations are indicated with open and closed squares, respectively. Station KUR (red square) is the reference station, located approximately 3.5 km from the infrasonic source, which is the vent of the Sakurajima volcano (dashed line). The area indicated by the yellow triangle marks the region of activity.

Infrasonic Source for FDTD Model

The black lines indicate the waveforms recorded at reference station KUR located in line of sight with the source and at 3.5 km. The red lines indicate the cumulative sum of the Kur waveforms (black lines).

The red lines were used as the source time function for the mass flux in the FDTD model for the explosions occurred on the 2013/11/17 (10:39 JST), 2012/10/16 (21:07 JST), 2012/10/31 (10:39 JST) and 2012/11/12 (09:55 JST). The five explosions were closer in time to the atmospheric measurements acquired twice a day at 09:00 and 21:00 Japan Standard Time (JST).

2D-FDTD Model

Snapshots representing the propagation of the acoustic field, generated by source function of the 29th November 2012 at 09:35 (panel e, previous figure) at different time steps along a topographic section (2D model) crossing KUR station and KUR station (Section 17%). In the model, we consider the atmosphere as homogeneous and a moving fluid (Eakin et al., 2011).

Each panel (E1, E2, E3, E4, E5) shows the effective sound speed used in the FDTD model. The vertical atmospheric profile recorded at Kagoshima is extended for entire length of the topographic section (a), the numerical waveforms (b), the waveforms measured at Sakurajima network (c), Values of the Cross-Correlation at all the stations between numerical and measured waveforms on the 2012/10/17 (10:39 JST), on the 2012/10/16 (21:07 JST), on the 2012/10/31 (10:39 JST) and on the 2012/11/12 (09:55 JST). Despite the reliability of adopted atmospheric structure is limited, the cross-correlation is extremely good. Better results may be expected by adopting 3D atmospheric specifications.