Infrasound monitoring and evaluation of acoustic visibility at Nevado del Ruiz volcano, Colombia

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Nevado del Ruiz Volcano (NRV) had a phreatomagmatic eruption in 1985. The eruption partially melted the volcano's ice cap leading to floods and lahars flowing down to nearby towns, which killed at least 25,000 people. This event has raised particular importance of monitoring activity, including small eruptions at ice-capped high-altitude volcanoes. However, the high altitude makes it difficult to maintain monitoring stations near the summit crater. Moreover, the visibility of the summit area is often prevented by clouds. In this paper, we report the results of a feasibility study for detecting small eruptions using infrasound technique.

We operate three infrasound stations in the distances of 4-6 km from the active crater. Each station has two infrasound sensors as a pair separated about 5-8 m each other. This distance is larger than the correlation lengths of turbulent eddies that generate wind noise above 1.5 Hz. Therefore, the cross-correlation analysis between the infrasound sensor pair effectively reduces the wind noise and reveals infrasound signals.

The analysis was made in the period from December 2016 to November 2018, which was the late stage of the recent dome-forming activity of NRV. Infrasonic eruption signals were manually searched in a correlogram, which is a graphical representation of the cross-correlation coefficient as a function of the absolute time of the data window and lag time of the cross-correlation. Then, the detection was compared with the catalog of eruption events reported by the local observatory (Colombian Geological Survey, Manizales).

The result shows that the infrasound detection associated with the reported eruptions was successful when the background wind noise was small: 64 % when the noise was below 0.1 Pa RMS, while 15 % when it was above that at the station about 4.2 km to the east of the vent. At the other two stations, which were located at 5.3 km to the north-west and 6.0 km to the north from the crater, the successful infrasound detection was as low as 30 % even with the wind noise level below 0.1 Pa RMS.

For monitoring, it is critical to know whether the current weather condition allows us to detect eruptions if they occur. For example, when the volcano is covered with clouds, we know that the visibility is too poor to get information from visual observations. Similarly, we define the 'acoustic visibility' by the probability of the time windows in which the infrasound power was below a threshold, which we set 0.1

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Pa RMS in the present case. The acoustic visibility varied seasonally. From May 2017 to June 2018, only a few eruptions were detected. Of this period, the acoustic visibility was good in the season from October 2017 to May 2018 so that we can confirm that the eruptive activity was low. In other seasons it was too poor to judge the activity. We also found that the infrasound propagation was highly directional. It is generally believed that the atmospheric effect on infrasound propagation is minor in the distance range of the current observation. We consider that the high directionality is due to the combined effect of the topography and strong wind in the high-altitude volcano.

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