On the capability of the new Grindavik seismic and strong motion array on inferring volcano-tectonic processes

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Abstract

Dike intrusions are often accompanied by numerous small earthquakes that sometimes occur in quick succession over short intervals. While regional seismic networks perform reliably when detecting individual earthquakes, detection may become incomplete in such cases when the inter-event time is greatly reduced. One approach to enhance the network performance is its densification but this is expensive and time intensive in inaccessible areas such as rural Iceland. A cost-effective addition to regional networks are small-aperture arrays which can be quickly deployed at practically feasible locations, and that way monitor seismic activity while being unaffected by many other limitations.

When the most recent seismic sequence started in the Reykjanes Peninsula Oblique Rift zone in February 2021, efforts immediately commensed to prepare and install an urban seismic and strong-motion array in cost- and time-efficient manner. The result was a new array in the nearby town of Grindavik was deployed on 11 and 12 March. The array consists of five RS4D instruments that each contains three accelerometric sensors and one vertical geophone. The units became a part of the TURNkey network that recently has been deployed in Iceland. The array immediately started to monitor the seismic sequence that was caused by a dike intrusion that eventually culminated in a volcanic fissure eruption eight days after the array installment. Since the deployment, array data processing methods have been applied continuously on the real-time seismic data using SeisComP by Gempa. For that we applied the modules LAMBDA and AUTOLAMBDA of the SeisComP system to obtain back azimuth and slowness pairs of incoming waves.

In addition, extensive sensitivity analyses have been carried out to investigate the reliability of the results of the analyses. Comparing the array detections to the earthquake catalogue from the regional network shows that the magnitude of completeness of the array is about M_L 2 but in favourable conditions, earthquakes of magnitudes as small as M_L 0.6 are detected reliably. The back azimuths are on average 2°-4° degrees smaller and the slownesses 0.015 s/km higher when compared to the hypocentral locations reported by the regional network. This discrepancy is most likely caused by the local geology underneath the array which is higly fractured with prominent NS and SW-NE strike directions, respectively. Nevertheless, the relative changes in back-azimuth and slowness are shown to provide considerable detailed view of the volcano-tectonic seismicity that greatly exceeds the resolution of the regional network earthquake locations. Thus, with the considerable advantages such as low-cost and fast deployment in urban areas, small aperture arrays appear to be a robust and valuable addition to local and regional networks for the monitoring of imminent seismic and volcanic events, and in particular the rapid microearthquake occurrence, possibly associated with magma movements.

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