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Multiphase observations of a meteoroid in Iceland recorded over 40 km of telecommunications cables and a large-N network

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On July 2, 2021, around 22:44 CET, a meteoroid was observed crossing the sky near Lake Thingvallavatn east of Reykjavik in Iceland. During this event, a large-N seismic network consisting of 500, 3-component geophones was monitoring local seismicity associated with the Hengill geothermal field southwest of the lake. In addition to the large-N network, two fiber optic telecommunication cables, covering a total length of more than 40 km, were connected to distributed acoustic sensing (DAS) interrogation units. The systems were deployed under the frame of the DEEPEN collaboration project between the Eidgenössische Technische Hochschule Zürich (ETHZ), the German Research Centre for Geosciences (GFZ), NORSAR, and Iceland Geosurvey (ISOR). Both the large-N and the DAS recordings display multiple trains of infrasound arrivals from the meteoroid that coupled to the surface of the earth at the locations of the sensors. In particular, three strong phases and multiple other weaker arrivals can be identified in the DAS data.

Fitting each of the strong phases assuming point sources (i.e., fragmentations) generates travel time residuals on the order of several seconds, resulting in an unsatisfactory explanation of the observations. On the other hand, inverting the arrival times for three independent hypersonic-trajectories generating Mach cone waves reduces travel time residuals to well under 0.5 s for each arrival. However, whereas the 1st arrival is well constrained by more than 900 travel times from the large-N, DAS and additional seismic stations distributed over the Reykjanes peninsula, the 2nd and 3rd arrivals are mainly constrained by DAS observations near Lake Thingvallavatn. The less well-constrained, latter trajectories show a weak agreement with the trajectory of the first arrival. Currently, neither the multi-Mach-cone model nor the multi-fragmentation model explain all our observations satisfactorily. Thus, traditional models for interpreting meteoroid observations

appear unsuitable to explain the combination of phase arrivals in the large-N network and DAS data consistently.