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Acoustic Observations of Stratospheric Solar Tides: Examples from the Eruption of Eyjafjallajökull, Iceland, April-May 2010

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Diurnal variations in infrasound signal azimuths and amplitudes have been identified, associated with infrasound propagating along stratospheric propagation paths from the eruption of Eyjafjallajökull, Iceland.

The summit eruption of Eyjafjallajökull between 2010 April 14th and May 20th was recorded across at least 14 microbarograph arrays located in mainland Europe, north Africa and north-west Greenland, at ranges between 1740 and 3670km. In this study we focus on signals recorded along two distinct paths from the volcano: the first to BKNI, UK (azi. = 133°, range = 1750km), and the second to I18DK, Greenland (azi. = 332°, range = 2295km). These paths were chosen because of the geographical spread of the source-to-receiver paths and the high temporal density of the recorded infrasound signals. As the signal detection time series were noisy and unevenly sampled, periodicities within the data were identified using a Lomb-Scargle periodogram analysis and a CLEAN sampling function deconvolution. The results identified significant diurnal periodicities within the detected signal characteristics (signal amplitude, arrival azimuth, apparent speed and signal frequency content).

Physical processes that could act with diurnal periodicities include solar tidal winds along propagation paths, and variable noise levels at the recording arrays associated with the formation and dissipation of nocturnal boundary layers. Although diurnal noise variations do occur at the recording arrays, propagation modelling using ECMWF meteorological profiles show the observations are better explained by stratospheric wind variations caused by solar tides. ECMWF meteorological profiles for April-May 2010 indicate the presence of stratospheric waveguides, varying in strength with a diurnal period, along both the Eyjafjallajökull to BKNI and I18DK paths. Range-independent ray-tracing simulations predict infrasound propagation through these waveguides, with the predicted azimuthal deviations varying with a diurnal period and with the same phase as the observations. However, the amplitude of the azimuthal deviation is underestimated by the modelling, with less than 1° deviation predicted compared to the observed 5°.

Analyses which rely on accurate understanding of the acoustic travel path will be affected by solar tidal wind variations (e.g., network detection capability studies, source location, and source size characterization), many of which are of concern for Comprehensive Nuclear-Test-Ban verification monitoring. Solar tidal wind variations present a challenge for propagation modelling because the effects act over timescales and lengthscales comparable to those encountered in long-range (1000's km) infrasound propagation. However, the study of infrasound from continuous sources such as volcanoes shows promise as a tool for identifying and analysing tidal structure within the stratosphere and upper atmosphere.