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Resonance excitation of atmospheric waves by vibration of the ground, ocean surface, and ice shelves

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Atmosphere is known to respond in a resonant way to broad-band excitation associated with earthquakes, volcano eruptions, and convective storms. The resonances are observed via their ionospheric manifestations using HF Doppler radars, airglow observations, and the GPS-TEC technique and are seen as narrow frequency bands of greatly amplified oscillations. The resonances are normal modes of an atmospheric waveguide and occur at such frequencies that an acoustic-gravity wave, which is radiated at the ground level and is reflected from a turning point in the thermosphere or upper mesosphere, upon return to the ground level satisfies boundary conditions on the ground. Typically, the resonances correspond to near-vertical AGW propagation and have periods of about 3–5 minutes. Although the resonances are usually referred to as acoustic resonances, buoyancy effects are not negligible at such frequencies. The resonances correspond to most efficient coupling between atmosphere and its lower boundary and are promising for detection of such coupling. From the remote sensing prospective, the resonances are potentially significant because their frequencies are sensitive to variations in the vertical profile of neutral temperature up to thermospheric altitudes and to boundary conditions on the lower boundary, such as differences between the boundary conditions on the solid earth, ocean surface, and a finite ice layer overlying solid Earth or the ocean. Using recently developed consistent WKB approximation for acoustic-gravity waves, this paper investigates theoretically excitation of atmospheric resonances and quantifies the effects of buoyancy and non-vertical propagation, including the contribution of the Berry phase. Different kinds of atmospheric resonances are identified depending on the type of surface waves, including flexural waves in ice shelves, that are responsible for oscillations at the ground or sea level.