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The signal of outer-core stratification in synthetic body-wave and normal-mode data

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We investigate the effects of anomalously low seismic velocities at the top of Earth's outer core on synthetic body-wave seismograms and normal-mode spectra for 1-D and 3-D models of Earth's velocity structure. We then assess the feasibility of a variety of outer-core velocity models based on their agreement with mineral physical models of light elements in the outer core. Existing velocity models of the upper outer core have mostly been obtained from differential travel times between outer-core body-wave phases SmKS, which reflect off the top of the outer core from below m-1 times. These models all show that seismic velocities in the top region of the outer core are lower than those of PREM. Some of the models require compositional heterogeneity in the upper outer core, in the form of stratification that is relatively light as well as relatively slow. These are two contradicting properties, as an enrichment in light elements generally increases the seismic velocities of the outer-core material. However, not all outer-core velocity models require compositional stratification. A recent velocity model, obtained from the center frequencies of Earth's normal modes, is consistent with an overall lighter and more compressible outer core than inferred from PREM. This particular model contains relatively low velocities at the top of the outer core and a steeper gradient in velocity than PREM throughout the outer core. We identify all body-wave phases in seismograms from 50 to 170 degrees that are affected by outer-core stratification, using synthetic seismograms computed for 1-D Earth structure including published outer-core velocity models. Since the outer core is not the only contributing factor to body-wave amplitudes, waveforms and the appearance of additional waves, we further include 1-D and 3-D mantle features (LLSVPs, ULVZs and the D"-layer) in the computation of our synthetics. This helps to predict which waves are best suited, in addition to SmKS, to study outer-core layering. Additionally, we use existing outer-core velocity models to calculate the corresponding shifts in the center frequencies of outer-core sensitive normal modes. We then compare the sensitivity of normal-mode center frequencies to 1-D outer-core structure to the effects of 3-D mantle structure and the effects of interactions with other normal modes (full coupling) on these center frequencies. Finally, we discuss what outer-core velocity structures are supported by mineral physical models of outer-core composition.