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Response to "No observable temporal change of seismic properties in the Earth's outer core in a reported SKS dataset"

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This response is to clarify some major confusions and misunderstandings in an abstract written by Zhang & Wen (*the abstract* hereafter) [1], in which they questioned the possibility of core-diffracted SKS phases (SPdKS-SKPdS) in the analysis of the seismic structure in the Earth's outer core in Zhou (2022) (*the paper* hereafter) [2]. The response is summarized below:

1. The inclusion of possible SPdKS-SKPdS phases, or any other phases, has been automatically taken into account in the calculation of the sensitivity kernels for the seismic signals used in *the paper*. The structure sensitivities are calculated for measurement windows — there is no assumption made whatsoever on what phases are in the measurement windows. By analyzing the structural sensitivity, the anomalous time shift can only be created by having a structure anomaly in the Earth's outer core (Fig 5, *the paper*). This time shift can not be created by a change in earthquake position (Fig S4, *the paper*). This is probably counter intuitive in ray theory, but seismic waves at this period have large Fresnel zones, and seismic waves with their "rays" completely off an anomaly will still see the anomaly the same way (Fig S4d, *the paper*).

2. While the inclusion of possible SPdKS-SKPdS phases does not affect the analysis in *the paper*, the sensitivity kernels calculated for the measurement windows used in *the paper* show only clear SKS structure (Fig 5 and S4, *the paper*), there is no structure sensitivity corresponding to SPdKS-SKPdS waves, confirming there is no such wave in the measurement window.

3. Zhang & Wen [1] filtered observed seismograms to short periods, and speculated that some signals may be the SPdKS-SKPdS phases, and they further extrapolate their speculation that those short-period signals may be filtered into long period SKS waves. There is a major flaw in this reasoning. The short-period waves and long-period waves may be related to each other only when there is no other waves arriving at the same time. This is not the case when the seismograms are filtered to short periods. In addition to the weak arrival of the diffracted waves (if any at all), the dominant signals on the short-period seismograms are strong scattered waves generated by shallow heterogeneities (the strength of scattering increases exponentially with frequency). The travel times and strong amplitudes of the scattered waves observed on the short-period seismograms are not correlated with long-period SPdKS-SKPdS waves in any way, as also confirmed by the sensitivity calculations discussed above.

References:

1. Zhang, X, and Wen, L. "No observable temporal change of seismic properties in the Earth's outer core in a reported SKS dataset", 2022 AGU Abstract

2. Zhou, Y. (2022). "Transient variation in seismic wave speed points to fast fluid movement in the Earth's outer core", Communications Earth & Environment, 3, https://doi.org/10.1038/s43247-022-00432-7.