Subject: Rebuttal to Reviews of Manuscript: "Single-station vehicle tracking using six-component seismic measurements: A comparative study with array-based methods: 6C single-station vehicle tracking"

Reviewer #1: Adam Ringler

1. Could you think of other applications or ways to broaden the scope of the work?
We have expanded our discussion in Section 8, including monitoring traffic density in remote areas, detecting nuclear explosions, tracking wild animal movements, monitoring induced seismicity, and observing natural events in challenging environments, such as landslides and icequakes.

2. Line 30: This probably needs a reference.
We have added appropriate references to support this statement, as follows: “Fischer et al., 2013; Wang et al., 2014; Valero et al., 2019; Margheriti et al., 2021.”

3. Line 90: Can you put time periods for the deployment (and possibly dates)?
Time periods have been specified in the figure titles where relevant.

4. Line 96: Do you think amplitude would be better than strength?
Yes, we now use "amplitude" consistently in the manuscript.

5. Figure 1: Could you put a lat and lon somewhere on the figure or in the caption?
Latitude and longitude are now provided both in the text (line 81) and in the caption of Figure 1.

6. Figure 3: Could you put a colorbar to indicate the amplitude?
A colorbar indicating amplitude has been added to Figure 3.

7. Line 146: Change "temporary" to "temporal".
The correction has been made.

8. Figure 5: Could you elaborate on what we are looking at here?
We have clarified that Figure 5 presents back-azimuth estimation of car-induced Love waves at BS1, and highlighted similarities with results in Figures 6a, c, and e. Further explanation is included in the caption and main text.

9. Line 180: What is instrumental instability?
The instability arises from the challenges in stabilizing the large geometry of the ring laser gyroscope. For more details, we refer readers to Igel et al., 2021.

10. Line 230: Wouldn’t a road survey tell you the same thing?
We agree and note that our method offers a complementary approach applicable under a broader range of conditions, including unfavorable weather scenarios.

11. Figure 9: This is a nice figure. I would prefer it had a colorbar.
We have clarified in the figure caption that the brighter colors of the beams represent intersecting directions based on the estimated back azimuth at BS1 and BS2. Since the color itself has no physical significance, we believe removing the color bar will not impact the readability or cause any confusion for readers.

Reviewer #2: Anonymous

1. 1: Some stations are not visualized, including DRMY1–3 and DROMY.
These stations are now included in Figure 1.

2. Figure 2: Include tick marks along the full y-axis.
Tick marks have been added to improve readability.

3. Lines 80–83: Clarify that ROMY records only rotation.
This has been clarified in the revised text in lines 80-84, as follows: "In combination with a classic three-component (3C) broadband seismometer, the newly built ring laser gyroscope (named as ROMY) at the Geophysical Observatory Fürstenfeldbruck (N 48.164234, E~11.275865)} near Munich, Germany, allows us to record additional, accurate, and broadband 3C rotational ground motions (Fig.1). This setup enables simultaneous 6C recordings, i.e., 3C translational and 3C rotational motions, satisfying the requirements for geodetic and seismic observations at various scales (Gebauer et al., 2020; Igel et al., 2021)."

4. Line 92: Specify the type of seismometer and provide manufacturer details.
We have added these details in lines 92-94, as follows: "Additionally, we established two temporary 6C stations (BS1 and BS2), each equipped with a collocated broadband seismometer (Trillium Compact 120s) and a portable fiber optic gyroscope (Exail, formerly iXblue, blueSeis-3A)."

5. Figure 3: Elaborate on resonance frequencies and their source.
We have added a discussion on possible causes in lines 116-118, as follows: "Furthermore, at TON, specific monochromatic spectral lines are observed at approximately 16, 26, 37, and 45 Hz. These resonant frequencies are likely caused by mechanical vibrations from a pump located near the measurement site."

6. Line 136: Explicitly state the unique relationship between rotation direction and translational motion.
This has been explicitly stated in lines 138-140, as follows: "Importantly, this 6C approach resolves the 180-degree ambiguity inherent in conventional 3C single-station methods without the need for prior knowledge of the source focal mechanism, by analyzing the relationship between rotational and translational motions."

7. Line 145: Justify different sliding window lengths for BS1 and ROMY.
A justification has been added to lines 151-158, as follows: "For the cross-correlation (CC) analysis, we use a 10-second sliding window for the ROMY station and a 1-second sliding window for the

BS1 and BS2 stations. The shorter 1-second window at BS1 and BS2 is chosen because these stations are closer to the source, leading to faster-varying source signals. This allows for better temporal resolution in capturing the more rapidly changing motion at these locations. In contrast, the longer 10-second window at ROMY is used to ensure more stable measurements, as it is further from the source, where the motion is expected to vary more slowly. The difference in window lengths balances the need for higher resolution in the faster-varying source signals at BS1 and BS2 with the potential for increased noise and overlapping signals in shorter windows."

8. Figure 6: Clarify correlation coefficient threshold choice.

We have added the following clarification in the caption of Figure 6, as follows: "The background colors represent the correlation coefficient (CC) values, while the dots indicate the estimated Baz for each sliding window with a CC coefficient above 0.3. The correlation coefficient threshold of 0.3 was chosen to enhance the visualization of variations in the estimated source directions. This threshold helps to filter out noise, ensuring that only relevant signals are considered."

9. Line 191: Provide a brief description of the methodology applied here.

A description has been added in lines 201-206, as follows: "Array-based beamforming or frequency-wavenumber (f-k) analysis, a technique that decomposes seismic signals into their spatial and temporal components, is commonly employed for wave-type identification, source direction estimation (i.e., Baz), and slowness estimation of incoming waves. By examining the coherence and phase relationships between array sensors, f-k analysis is used to characterize the propagation characteristics of seismic waves, enabling the estimation of wave velocity and direction of arrival."

10. Line 198: Mention f-k analysis data source earlier.

This information is mentioned earlier in the introduction in sections 1 and 2.

11. Figure 4: Improve clarity regarding f-k analysis in subplot 4e.

We have clarified this in the figure label and caption.

12. Line 215: Add a figure reference.

A figure reference has been added in line 233.

13. Figure 9: Address potential systematic clockwise sensor misalignment.

We have expanded the discussion on the possibility of misalignment in lines 248-253, as follows: "We observe a slight misalignment between the located moving cars and the driveway in the bottom panels of Figure 9. This misalignment may be primarily due to two factors. First, the synchronized time windows from the two 6C stations may not capture car signals originating from the exact same location, given the unequal source-receiver distances. Second, there may be an installation misalignment at stations BS1 and BS2 between the seismometer and the rotational seismometer, introducing errors in the estimation of incoming wave directions."

14. Expand discussion comparing f-k and beamforming methods and Rayleigh vs. Love waves.

We have added further discussion on the potential challenges of applying f-k analysis to Love waves in lines 211-213, as follows: “One challenge in applying f-k analysis to Love waves is the potential mixing of Rayleigh and Love waves when tracking moving seismic sources using horizontal components. Therefore, we restrict the f-k analysis to the vertical component of the array recordings for Rayleigh waves.”