

Dear Editor,

We thank the reviewer for their detailed comments and for the time invested in evaluating the manuscript. We have carefully considered all points raised and have performed additional analyses to address the concerns.

1. Velocity Uncertainty Estimation

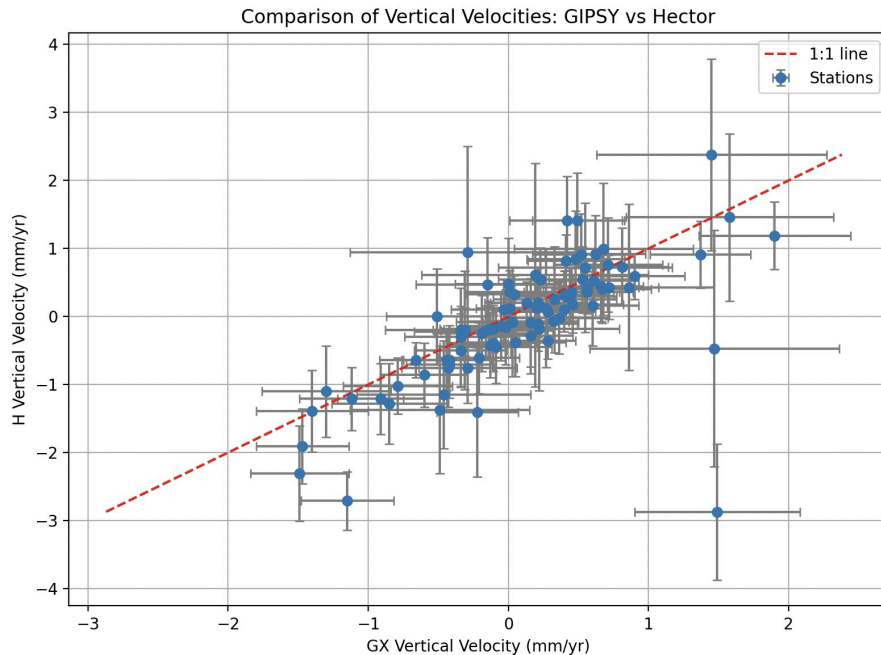
Please clarify the basis of the equation used (line 186). Specifically: provide its statistical or empirical justification. Clarify how it relates to established methods (e.g., Williams, Bos, Blewitt). Define what is meant by “robust” and “realistic,” ideally with quantitative support or comparison

The uncertainty formulation used in this study follows an empirical approach that relates the weighted root mean square (WRMS) of the residuals to the time span of the observations. This approach provides a practical estimate of velocity uncertainty by capturing the combined effect of unmodeled noise sources reflected in the residual scatter, and has been applied in previous geodetic studies (e.g., Muntean et al., 2016).

In contrast to methods that explicitly model temporally correlated (colored) noise (e.g., Williams; Bos et al.), our approach relies on long time series (>4 years) and careful deterministic modeling of discontinuities, which reduces the impact of such noise on velocity estimation.

To assess the sensitivity of our results to the adopted noise model, we performed additional comparisons using the Hector software (see the scatterplot comparison below) and the approach of Pina-Valdes et al. (2014) - see the answer to point #4). The resulting velocity estimates are consistent with our primary solutions, with differences generally within the respective uncertainties and mainly limited to stations with larger formal errors. These comparisons confirm that alternative processing strategies do not change the conclusions or interpretations of our study.

Based on these considerations, we refer to our uncertainty estimates as “robust” and “realistic,” in the sense that they provide stable, internally consistent velocity estimates across the network and are not sensitive to the specific noise modeling approach. The manuscript has been revised to clarify the empirical basis of the equation, its relation to previous studies, and the meaning of these terms.



Comparison of vertical solutions obtained using GipsyX and Hector.

2. Reference Frame Choice

Expand and clarify the justification for using the ITRF14 Eurasia frame rather than computing a regional frame. Try to avoid qualitative terms such as “reliable” or “perfect” unless supported quantitatively

We use the ITRF14 frame because one of the goals of this study is to analyze our computed velocity field in this frame (Figure 3). To evaluate the impact of reference frame choice, we tested several local transformation approaches, including Euler pole rotation, network mean removal, and stable-station mean removal (results now provided in the Supplementary Material). These methods remove different components of the velocity field (translation and/or rotation) and allow a quantitative assessment of whether additional local corrections are required.

The comparison shows that all tested approaches produce only minor changes to the velocity field. The original ITRF2014 Eurasia (EU14) velocities are already small (RMS = 0.44 mm/yr), and the application of local reference frame transformations results in residual RMS values between 0.68 and 1.37 mm/yr. The mean magnitude of velocity changes introduced by these transformations ranges from 0.55 to 1.25 mm/yr, which is comparable to or larger than the original signal. This indicates that local frame definitions do not reduce the variance of the dataset and, in some cases, introduce additional scatter. Although the Euler rotation yields the smallest residuals among the local transformations, the original EU14 velocities remain more

appropriate for our analysis. The EU14 velocities are already small, indicating that the ITRF2014 reference frame effectively captures the regional plate motion. Local transformations introduce method-dependent uncertainties, require subjective parameter choices, and provide no independent geological constraints.

Based on this quantitative comparison, we conclude that the EU14 reference frame already captures the dominant regional motion, and that applying additional local transformations does not improve the consistency of the velocity field or alter the geophysical interpretation. We have revised the manuscript to clarify this point and to avoid qualitative wording, and we refer the reader to the Supplementary Material for the full analysis.

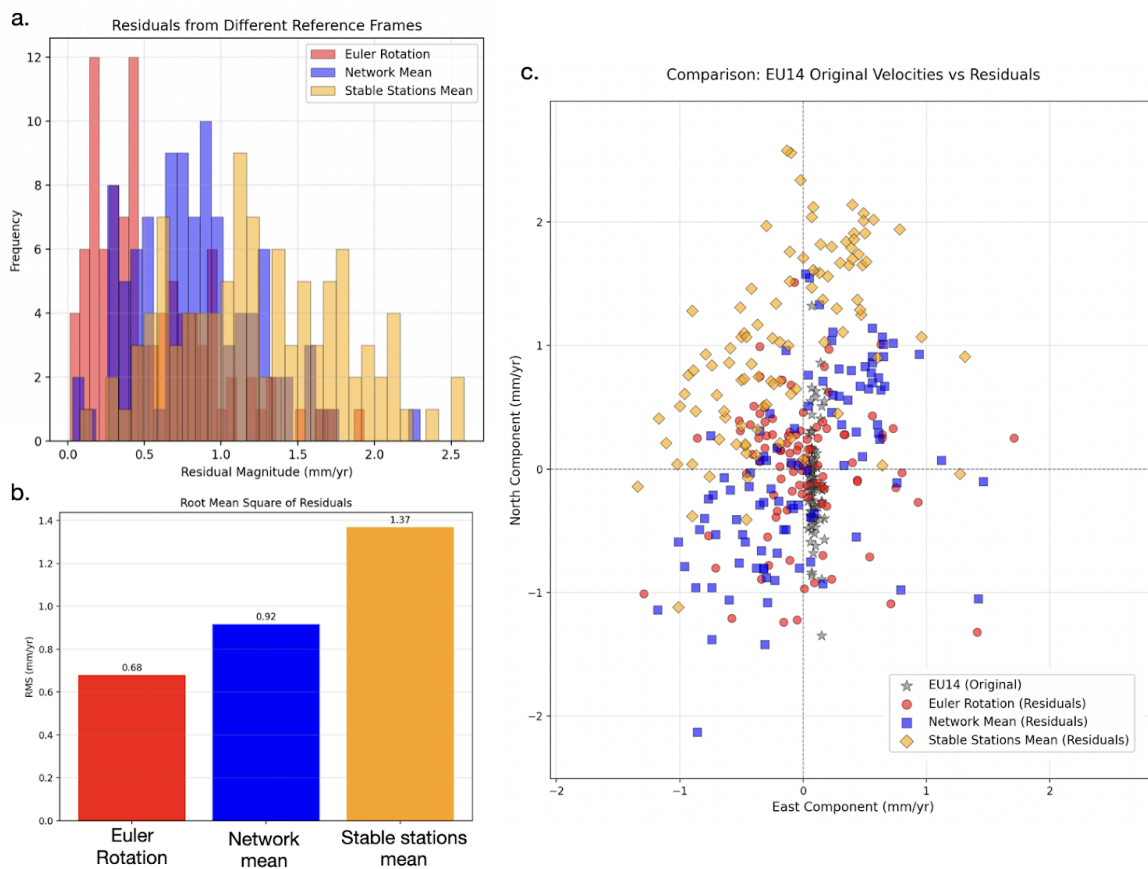


Figure S3. Statistical comparison of local reference frame corrections relative to EU14 velocities. Three panels summarize the effects of three local reference frame approaches (Euler rotation, network mean, and stable station mean) on the GNSS velocity field: (a) Histogram of residual magnitudes for each method, illustrating the distribution and spread of corrections applied to the original EU14 velocities. (b) Bar chart comparing the root mean square (RMS) of residuals for each method, highlighting that Euler rotation produces the lowest RMS. (c) Scatter of residual vectors in north vs. east components, showing EU14 original velocities (gray stars) alongside residuals from each local frame, emphasizing the relative magnitude and direction of corrections.

3. Magnitude of Residual Velocities

Address the issue that residual velocities (~ 1 mm/yr) are of the same order as the interpreted tectonic signals. Please discuss implications for interpretation and uncertainty.

The magnitude of the horizontal velocities (~ 1 mm/yr) is consistent with expectations for deformation within stable continental interiors and does not imply that the signal is dominated by noise. To evaluate this, we compared velocity magnitudes with their associated uncertainties (see new Fig. S1 below, also included in the Supplementary material). The histogram (Fig. S1a) shows that velocity magnitudes are systematically larger than their corresponding uncertainties. The scatterplot (Fig. S1b) further demonstrates that the majority of observations lie above the unit signal-to-noise ratio line.

Quantitatively, the mean velocity magnitude is 0.56 mm/yr, while the mean uncertainty is 0.12 mm/yr, yielding a mean signal-to-noise ratio of ~ 4.9 , with values reaching up to ~ 15 . These results indicate that the observed velocities significantly exceed their formal uncertainties and are therefore well resolved.

In addition, the velocity field exhibits clear spatial coherence, with neighboring stations showing consistent directions and smooth spatial variations in magnitude. Such patterns are not expected if the observations were dominated by residual noise. The inferred strain field is also consistent with independent observations, including stress orientations from the World Stress Map and focal mechanisms of regional earthquakes. This agreement provides independent validation that the observed velocities reflect a tectonic signal. Taken together, these results demonstrate that the measured velocities represent a coherent and geophysically meaningful deformation field, rather than residual noise of comparable magnitude, as implied by the reviewer.

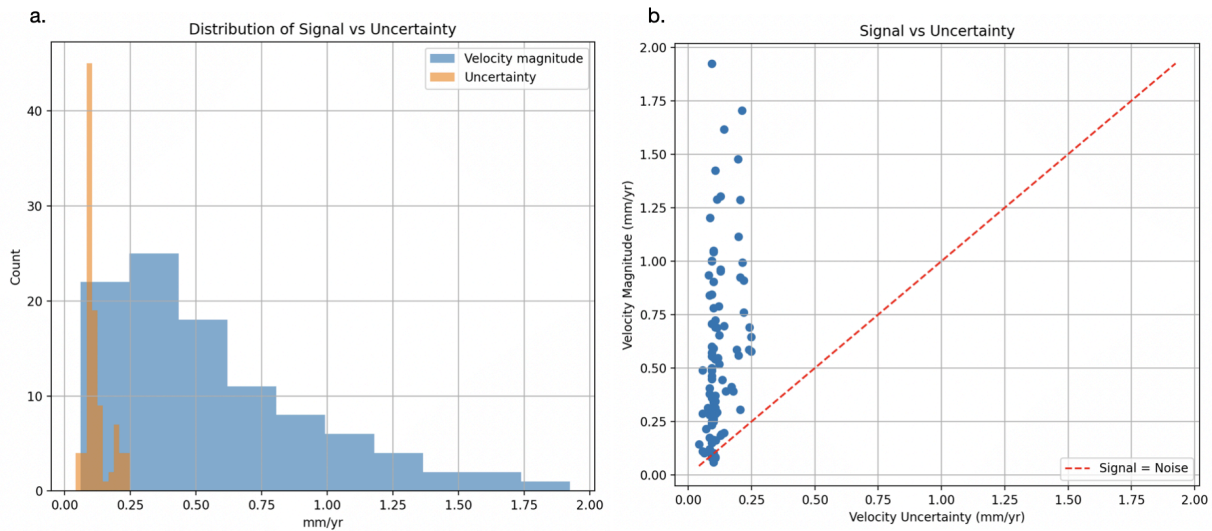


Figure S1. (a) Distribution of horizontal velocity magnitudes and their associated uncertainties. Velocity magnitudes are systematically larger than the corresponding uncertainties. (b) Comparison between horizontal velocity magnitudes and uncertainties. The red dashed line indicates a unit signal-to-noise ratio ($V = \sigma$); most observations plot above this line, indicating that the velocities are well resolved relative to their uncertainties.

4. Comparison with Previous Studies

Include a clear comparison (main text or supplementary material) between your velocity field and that of Piña-Valdés et al., as it will allow readers to independently assess agreement.

In the manuscript (Section 4.1), we compare our horizontal results with those of Piña-Valdés (2022) for stations with common solutions, obtaining an average difference of less than 0.08 mm/yr (see Figure 3). We acknowledge that this comparison is not clearly referenced in the main text and will improve its clarity.

To further assess the consistency of our results, we now compared horizontal and vertical velocity estimates with those of Piña-Valdés at common stations (Figures S4 and S5 in the updated Supplementary Material). The two solutions show good agreement for both vertical and horizontal components, with most differences within ± 1 mm/yr. Normalized differences (velocity differences divided by combined uncertainties) are centered near zero and largely fall within ± 2 , indicating that the datasets are statistically consistent within their respective uncertainty estimates.

The remaining small differences are expected, given differences in processing strategies. In particular, our study benefits from longer time series, denser spatial coverage, and a detailed station-by-station manual treatment of discontinuities and equipment changes, providing a more carefully validated characterization of the deformation field and improving the internal consistency of the velocity field.

5. Strain Rate vs. Focal Mechanisms

Strengthen the discussion of the relationship between GPS-derived strain and earthquake focal mechanisms. If limitations exist, you should be clearly stated rather than used to avoid comparison

We revised Section 6.2 to clarify the comparison between GPS-derived strain, focal mechanisms, and stress indicators. We explicitly relate compressional and extensional strain patterns to corresponding seismic regimes and stress indicators (reverse, normal, and strike-slip faulting) across the study area.

We also clarify the limitations: GPS-derived strain reflects a spatially averaged, long-wavelength signal, whereas focal mechanisms capture localized deformation on individual faults. This distinction explains why agreement is expected at the regional scale but may break down locally, particularly in structurally complex areas such as the Moesian Platform.

6. Language and Tone

Please revise overly strong or subjective terms (e.g., “fundamental,” “crucial,” “significant”) to ensure a neutral scientific tone

As suggested, we have replaced several adjectives with more neutral terms. Some of these adjustments include:

- “crustal motion is **relevant** ~~crucial~~ for”
- “provides ~~a unique~~ **an** opportunity to gain ~~fundamental~~ insights”
- “lithospheric weakening ~~were significant~~ **occurred** during that time”
- “Our results ~~mark~~ **provide** a **substantial** ~~significant~~ improvement”
- “We observe ~~significant~~ **pronounced** horizontal southward motion”
- “provides a ~~fresh~~ **new** perspective on the region’s slab dynamics”