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The Influence of the Auxiliary Station Lembang Indonesia on Earthquake Hypocenter Relocation Results for Earthquakes on Java Island

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INTRODUCTION

As Indonesia's densest seismic network, Java's AS40 (LEM) station is a key benchmark for hypocenter accuracy. If its data proves significant, other sparser CTBT stations are expected to be more impactful. We are assessing LEM's contribution by comparing relocations performed with and without its inclusion.

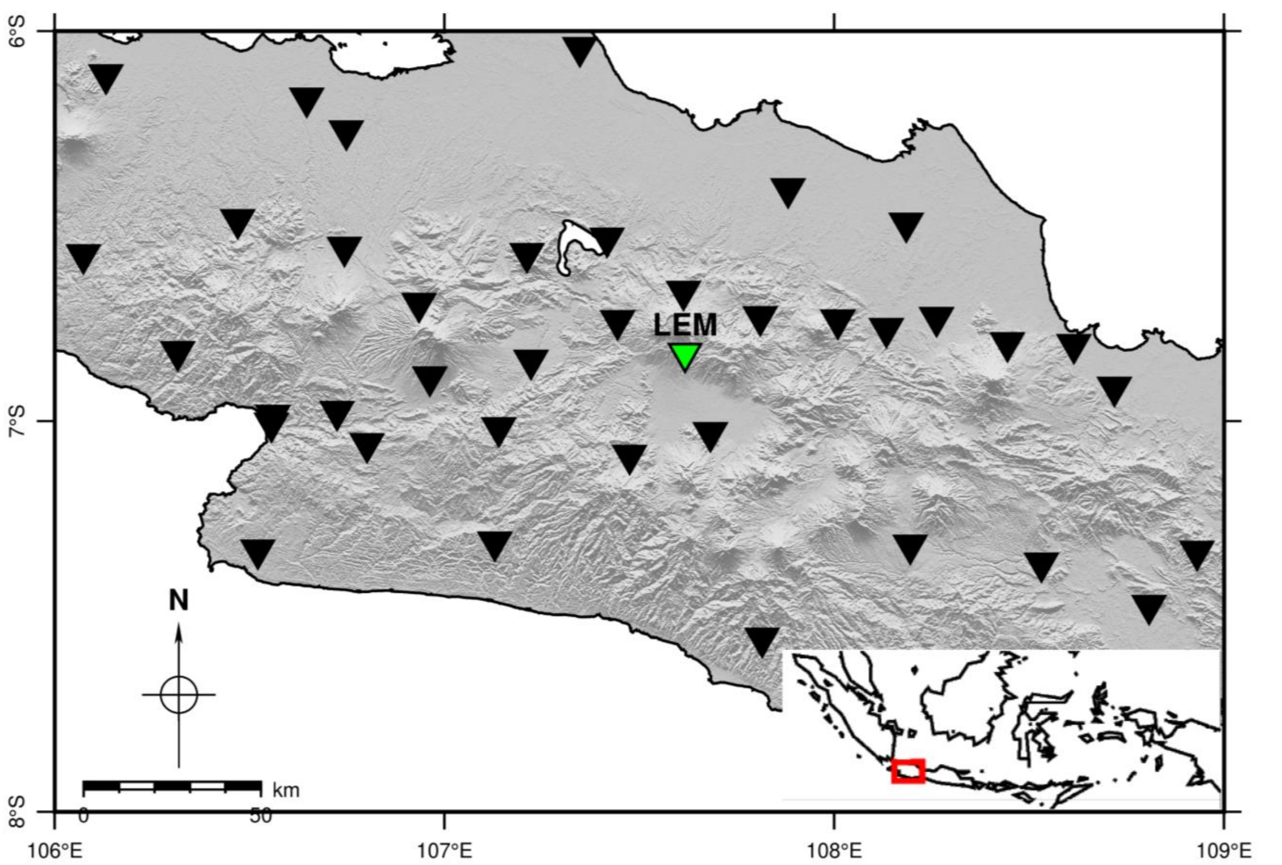

Fig 1. Seismic sensor distribution around LEM

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DATA AND METHOD

92 Java events (2023–2024) were relocated with the **HypoDD algorithm** and Kaulakov et al.'s (2007) 1D velocity model, also testing station AS40's influence. Uncertainty was assessed via a **Monte Carlo analysis** (100 iterations), applying Gaussian noise (μ=0, σ=0.1s) to arrival times to define 95% confidence error ellipsoids (Billings, 1994; Supendi et al., 2019).

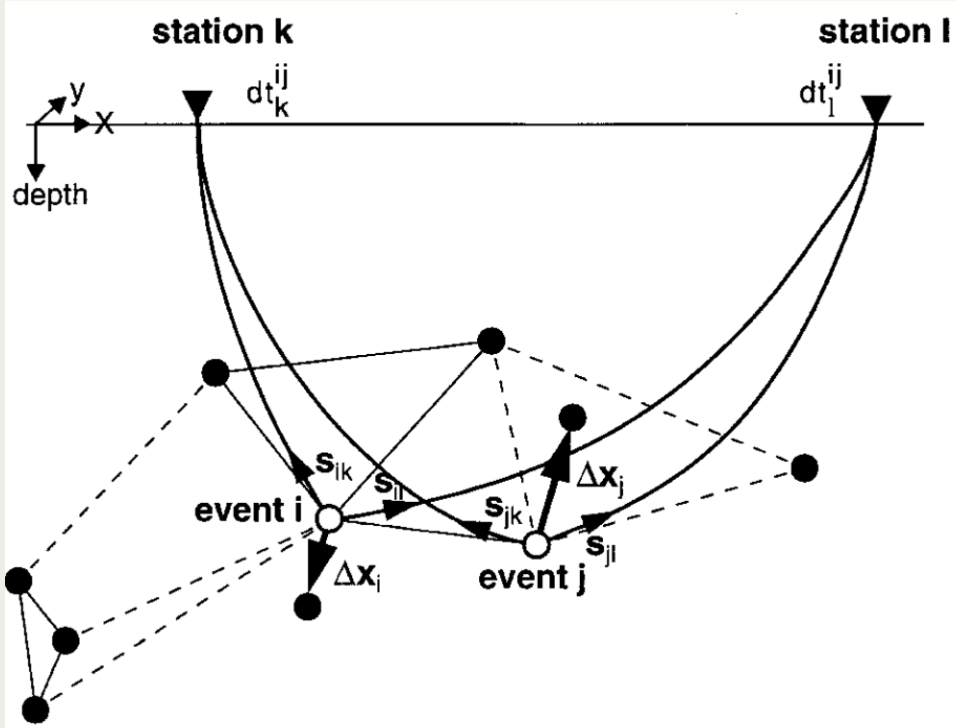

Fig 2. Ilustration of HypoDD Algoritm (Waldhauser and Ellsworth, 2000)

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HYPOCENTER RELOCATION RESULT

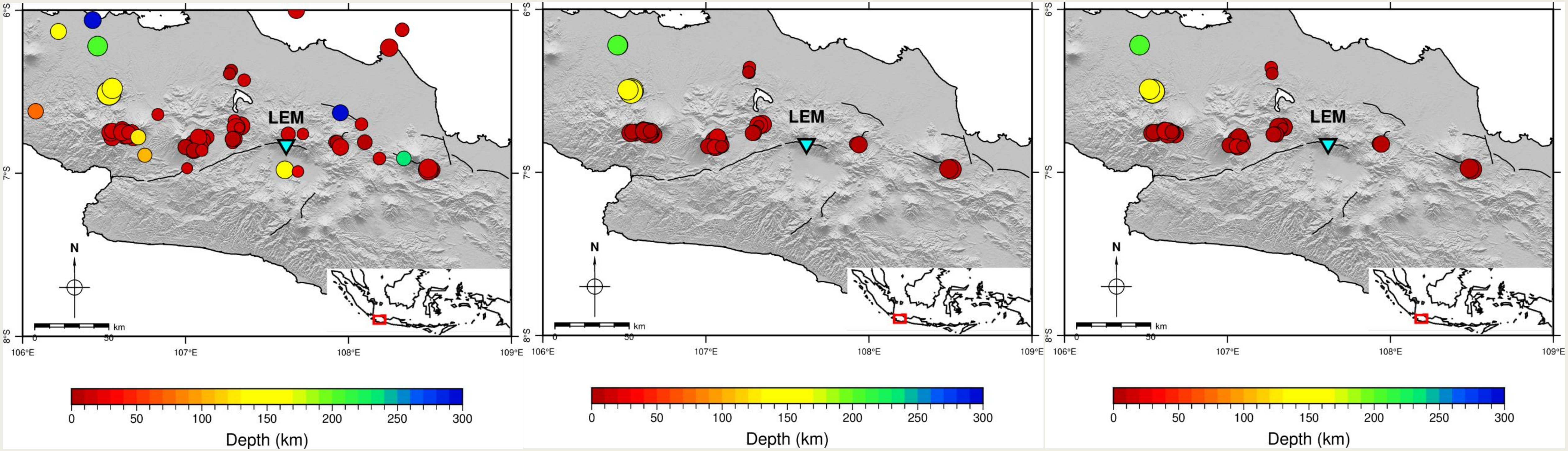

Fig 3. Hypocenter locations: initial (left), relocated with LEM station (center), and relocated without LEM station (right). Fault model made from Irsyam et al. (2017)

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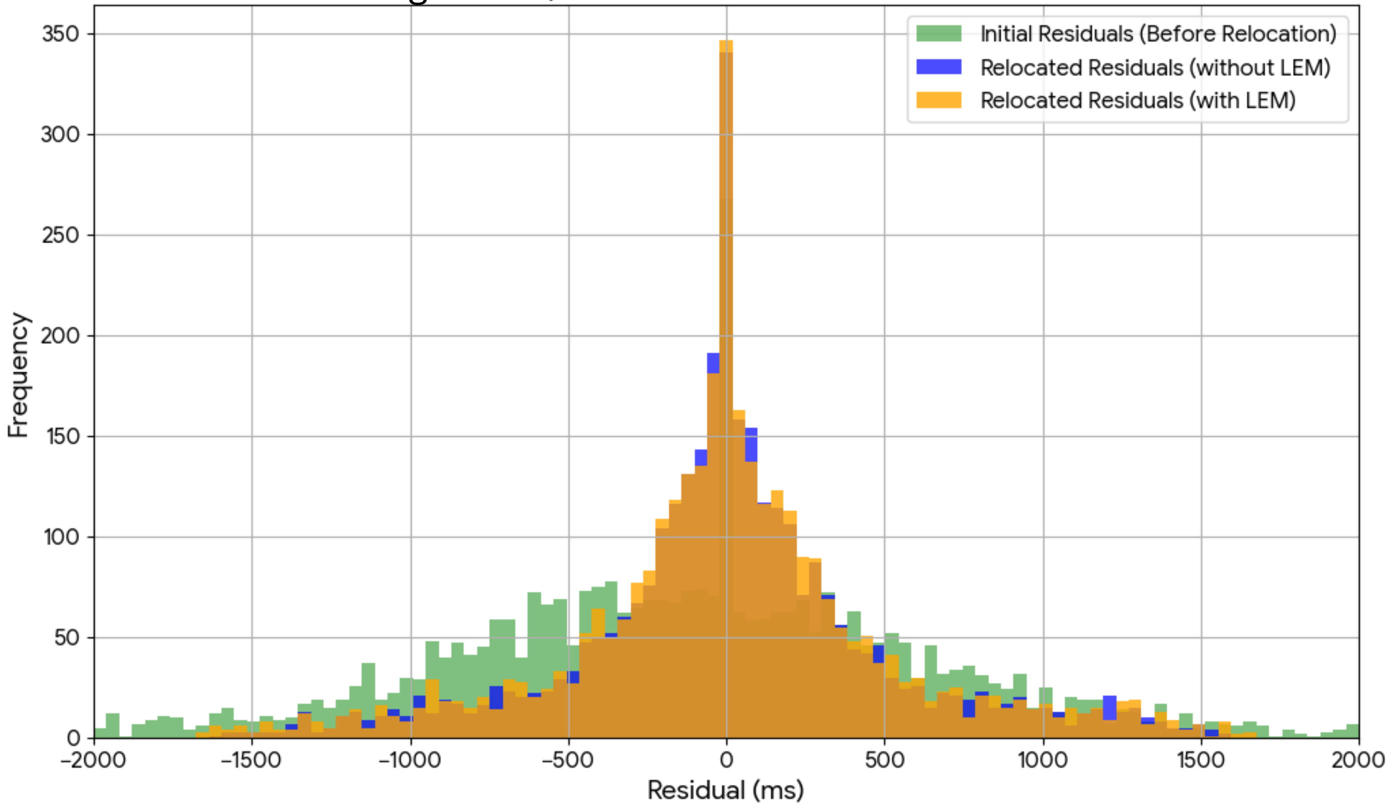
IMPROVEMENT RESIDUAL RESULT

This histogram shows the initial, widely scattered residual distribution (green) is significantly improved after relocation (blue). The inclusion of LEM station data (orange) **further sharpens the distribution, yielding the most focused result.** This demonstrates a superior model fit and highlights the **positive impact of the LEM station** on achieving more precise hypocenter locations.

Fig 4. Comparison of Residual Distribution



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HYPOCENTER UNCERTAINTY

The map compares earthquake hypocenter uncertainty from relocations with and without the LEM station. The smaller blue error circles (with LEM) versus the larger red ones (without LEM) demonstrate that including the LEM station significantly reduces uncertainty. This leads to more precise hypocenter locations, with a maximum horizontal shift of 1.38 km.

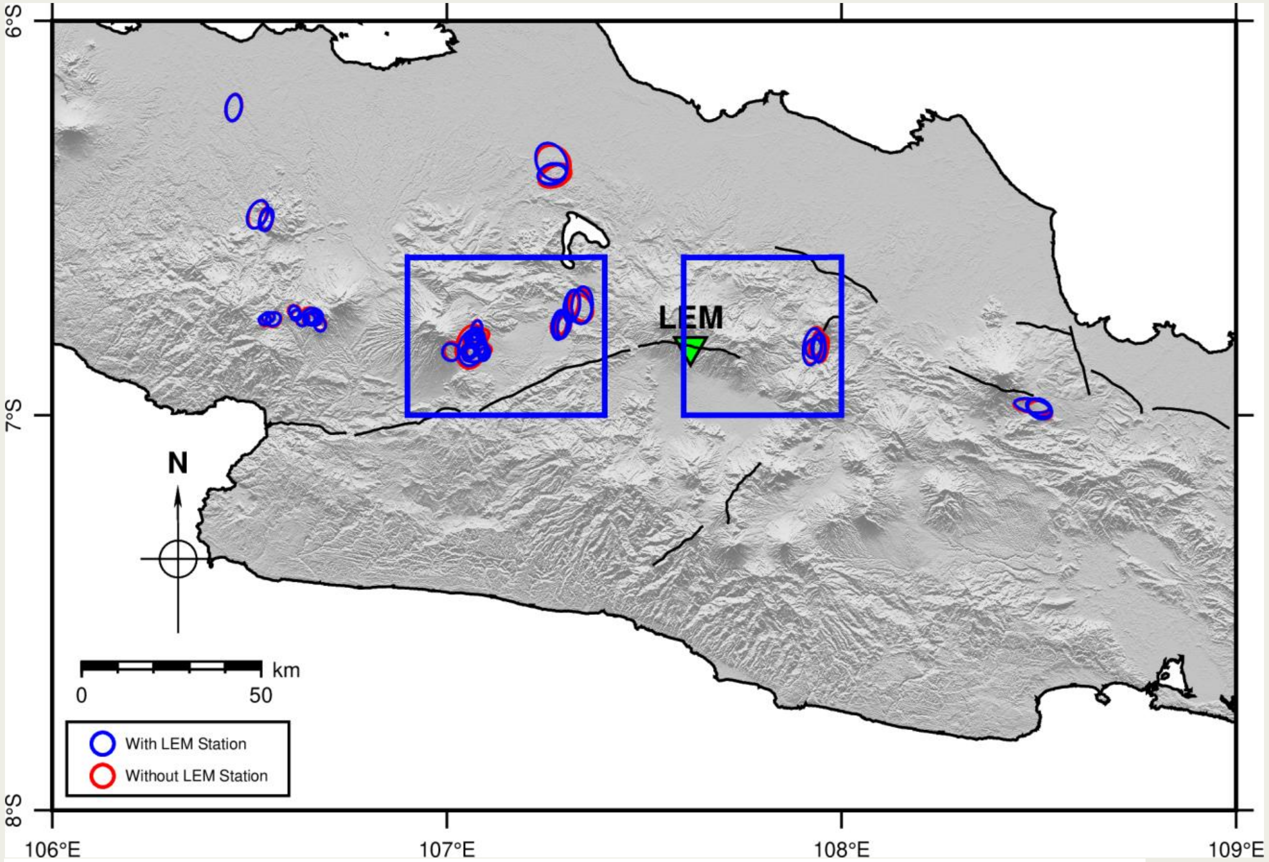

Fig 5. Relocation uncertainty map with LEM (blue ellipses) and without LEM (red ellipses). The blue box outlines the area that has been enlarged for a clearer comparison.

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Yusuf Haidar Ali, Ade Andika Saputra, Daryono

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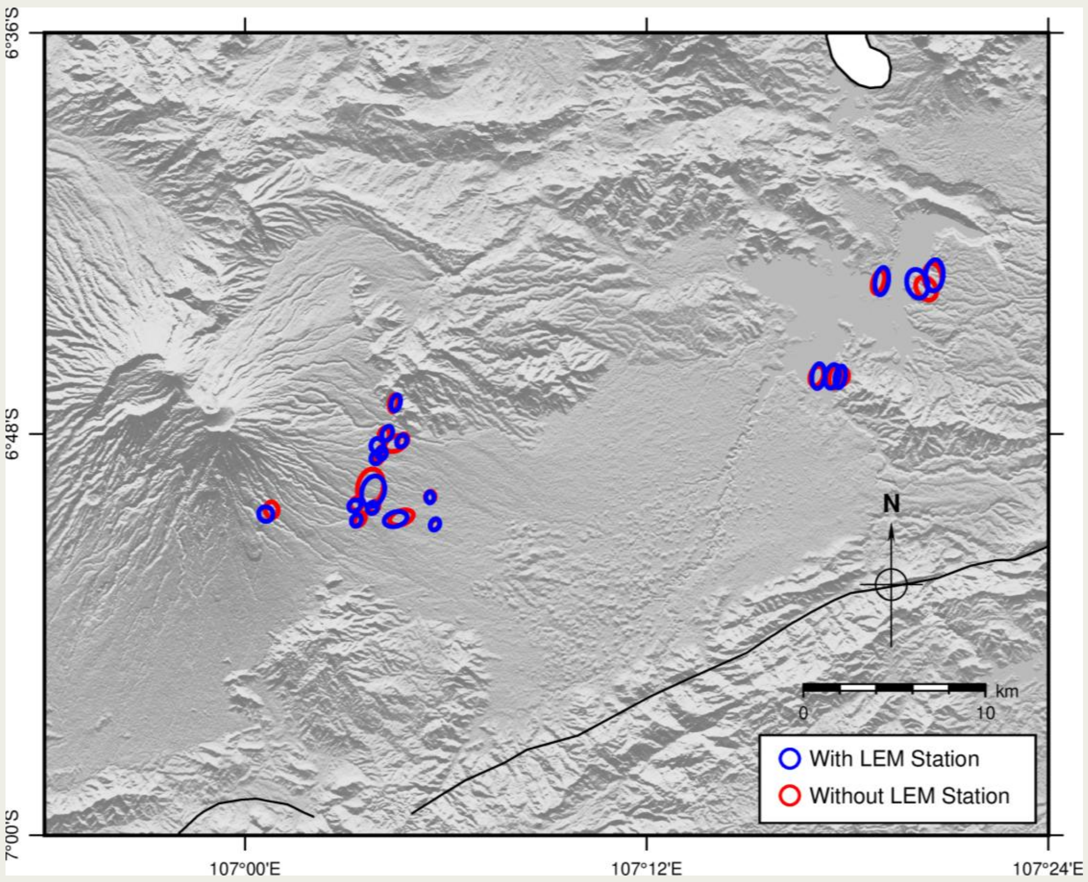

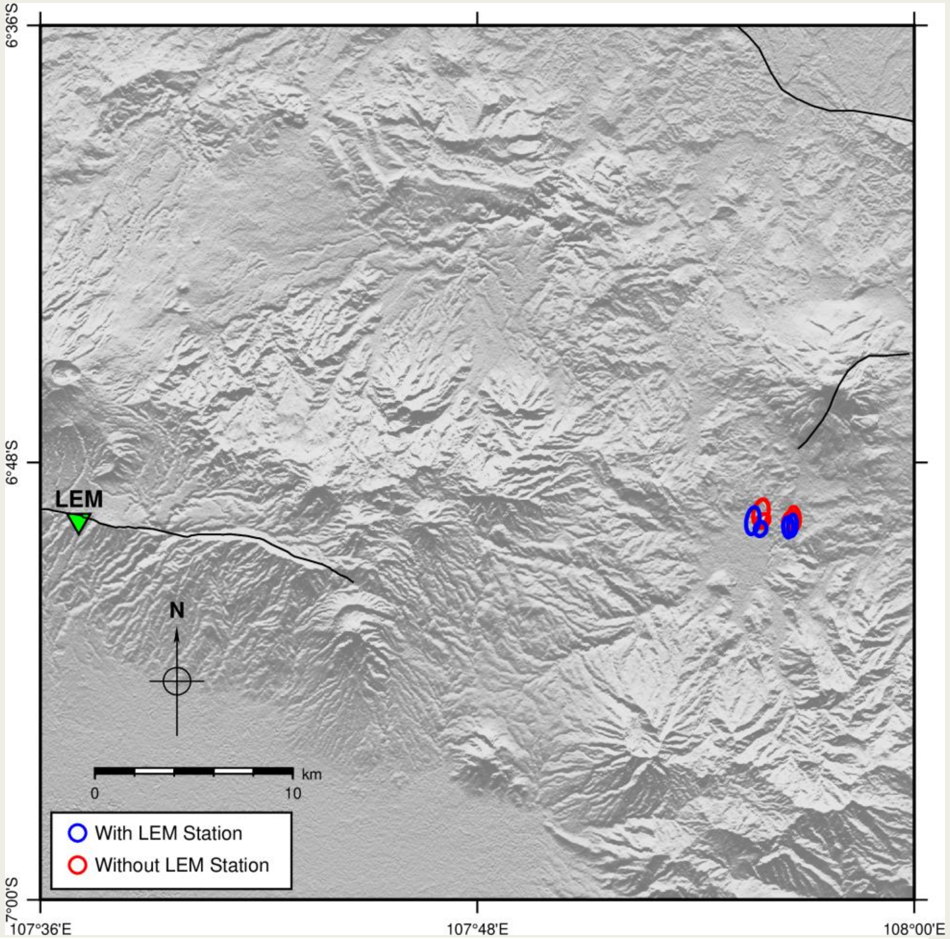

Fig 6. A zoomed-in view from Fig 5, showing three main earthquake clusters.

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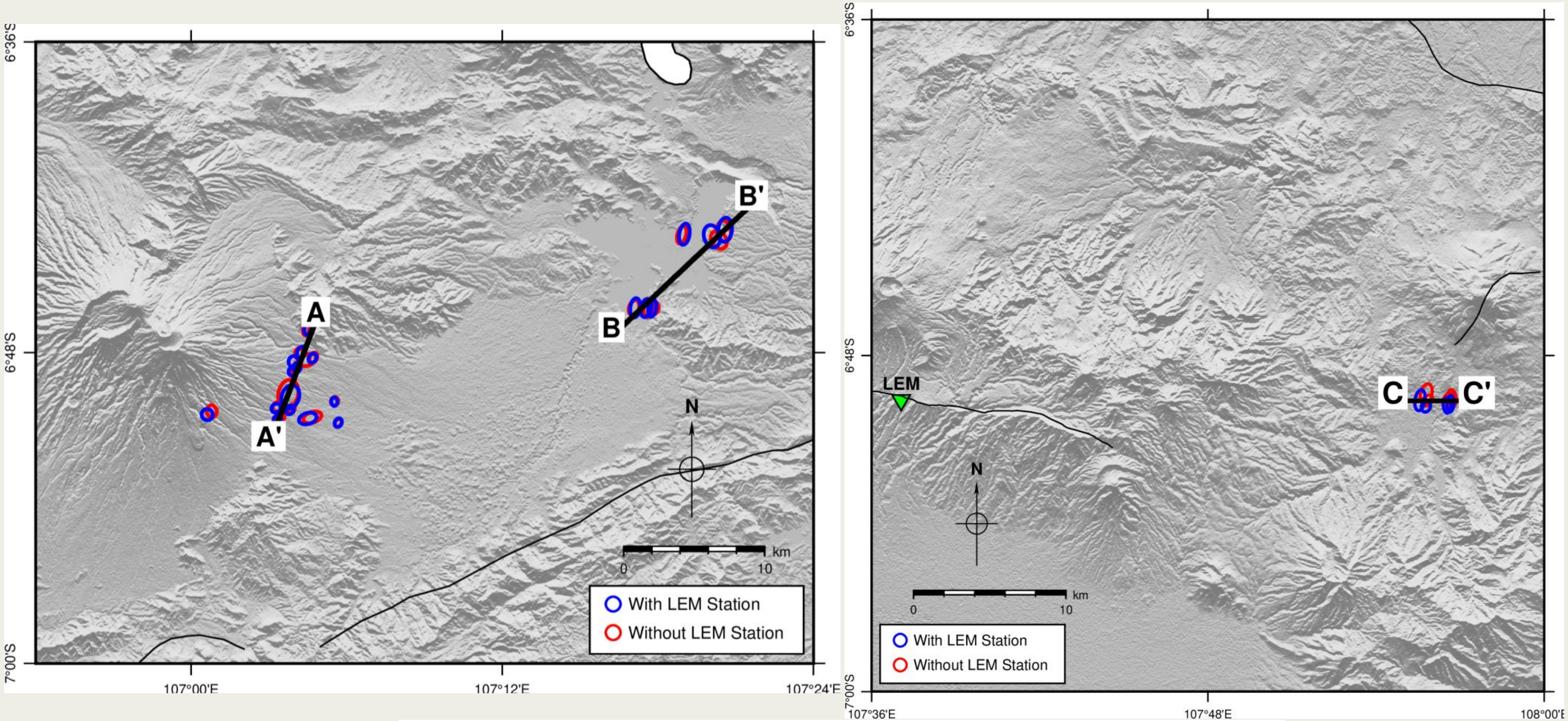

Fig 7. Cross-section Line in the Three Clusters

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HYPOCENTER UNCERTAINTY

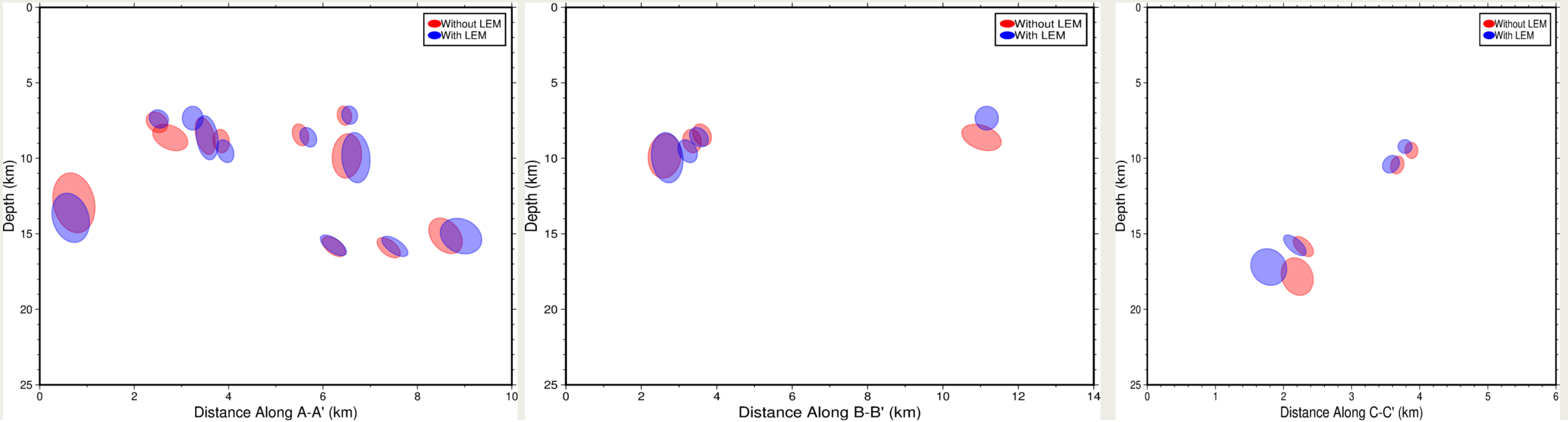

Fig 8. Cross-section view of hypocenter uncertainty along profiles A-A' (left), B-B' (center), and C-C' (right). The average difference in depth is 2.2 km.

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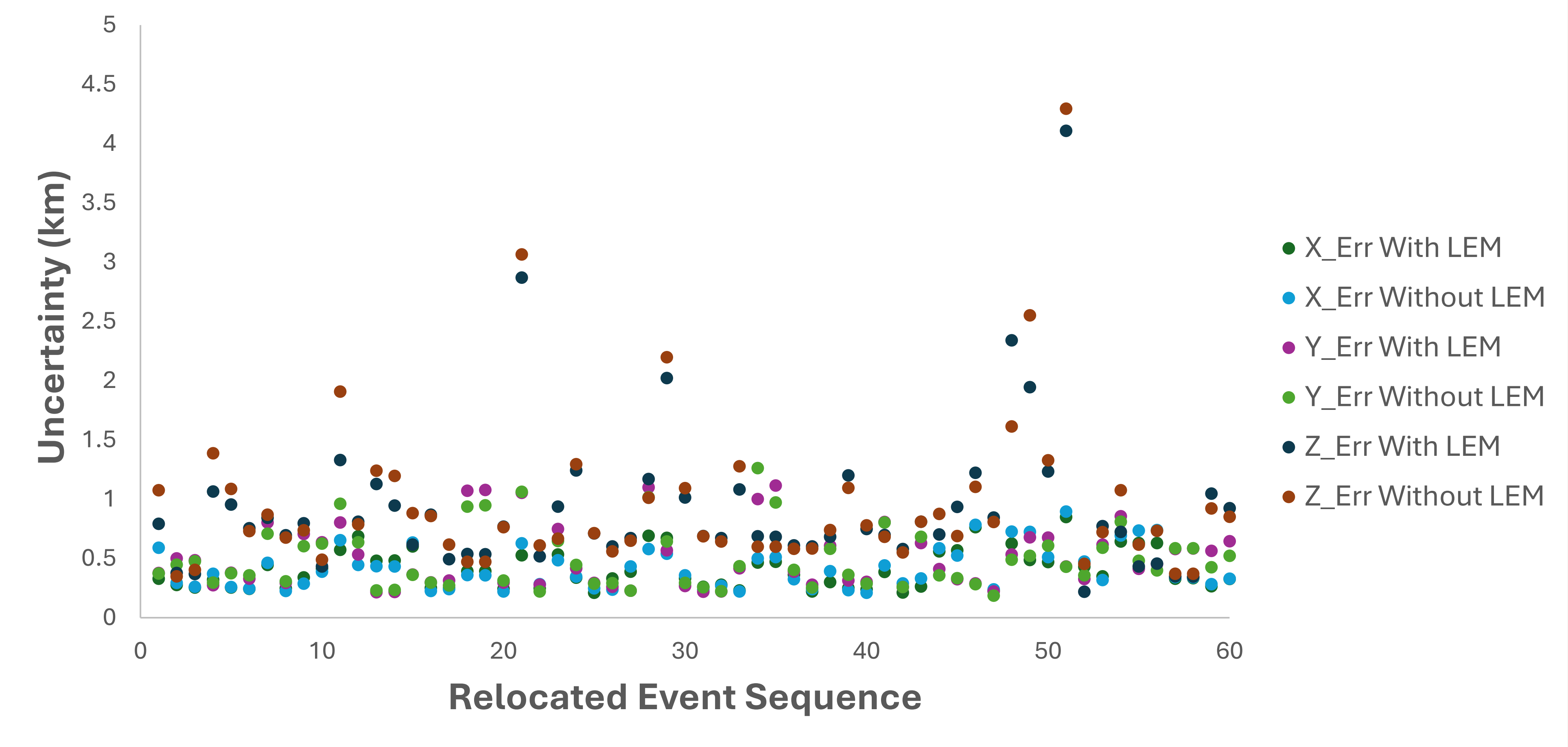
DISCUSSION

Fig 8. Horizontal (X_err, Y_err) and vertical (Z_err) error histograms for 60 relocated events, comparing results with and without LEM.



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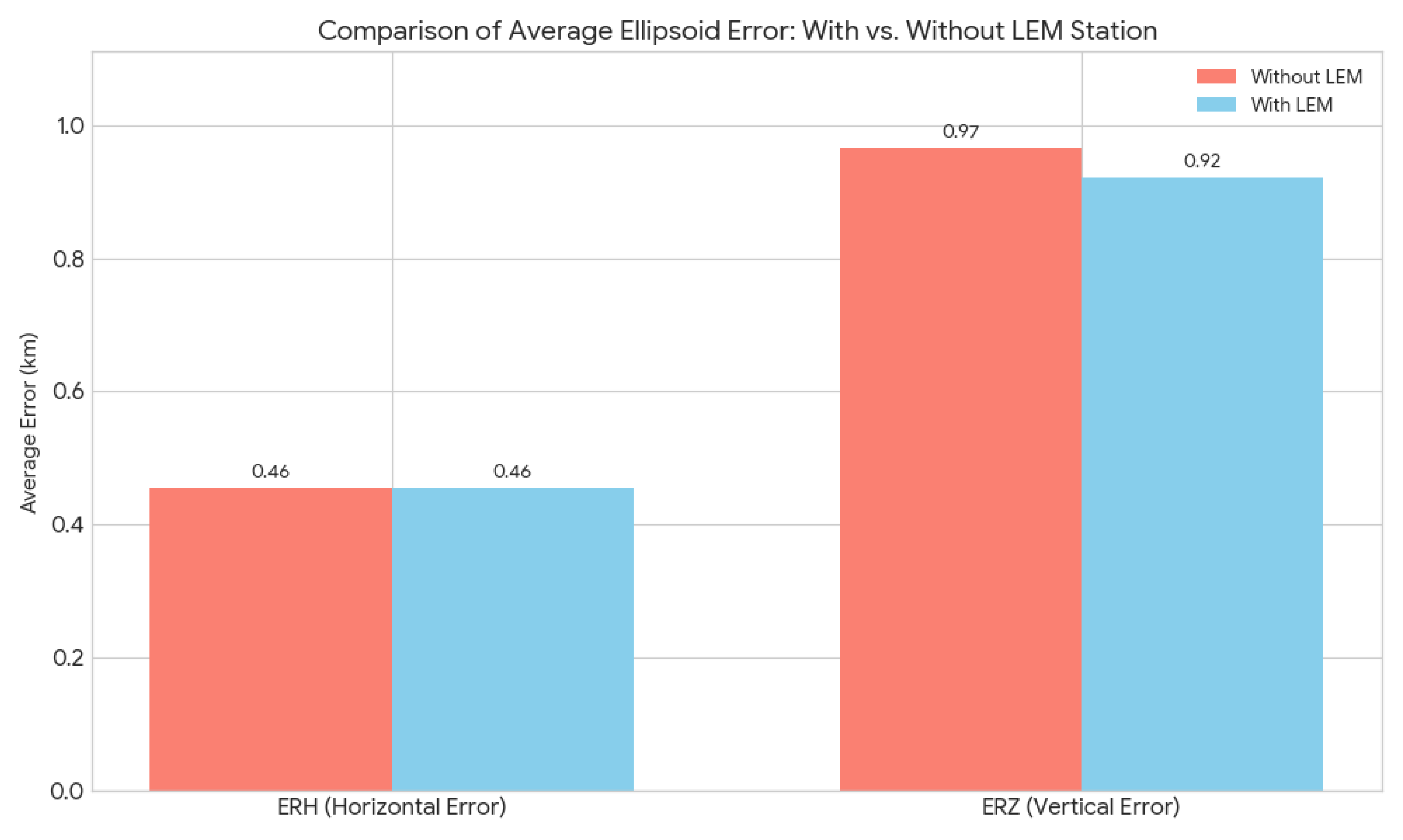
This figure compares relocation results for 60 earthquakes. The top row (without LEM) shows higher Root Mean Square (RMS), horizontal, and vertical errors than the bottom row (with LEM). Including the LEM station data clearly reduces errors across all metrics, with the most significant improvement in vertical (depth) precision, indicating a more accurate and reliable hypocenter solution.



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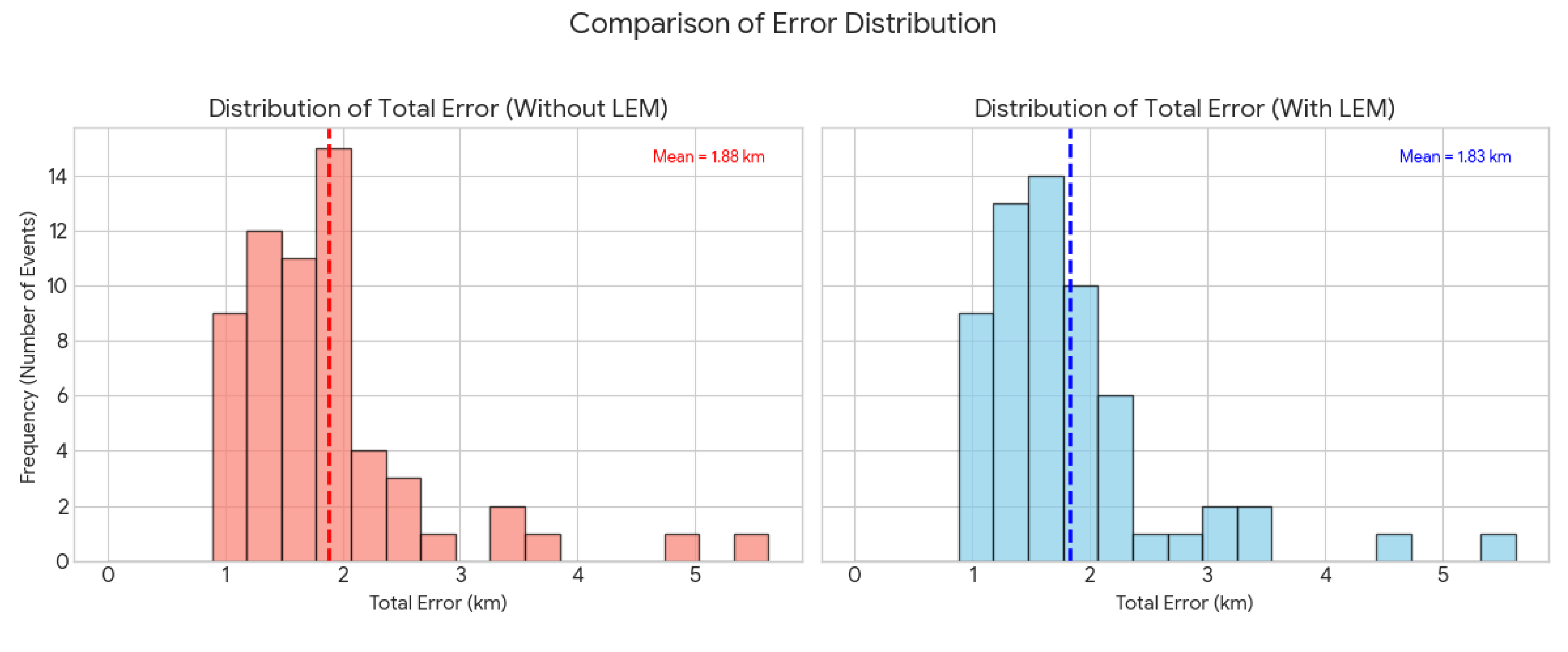
DISCUSSION

Histograms comparing the total location error, calculated as the sum of horizontal and vertical errors



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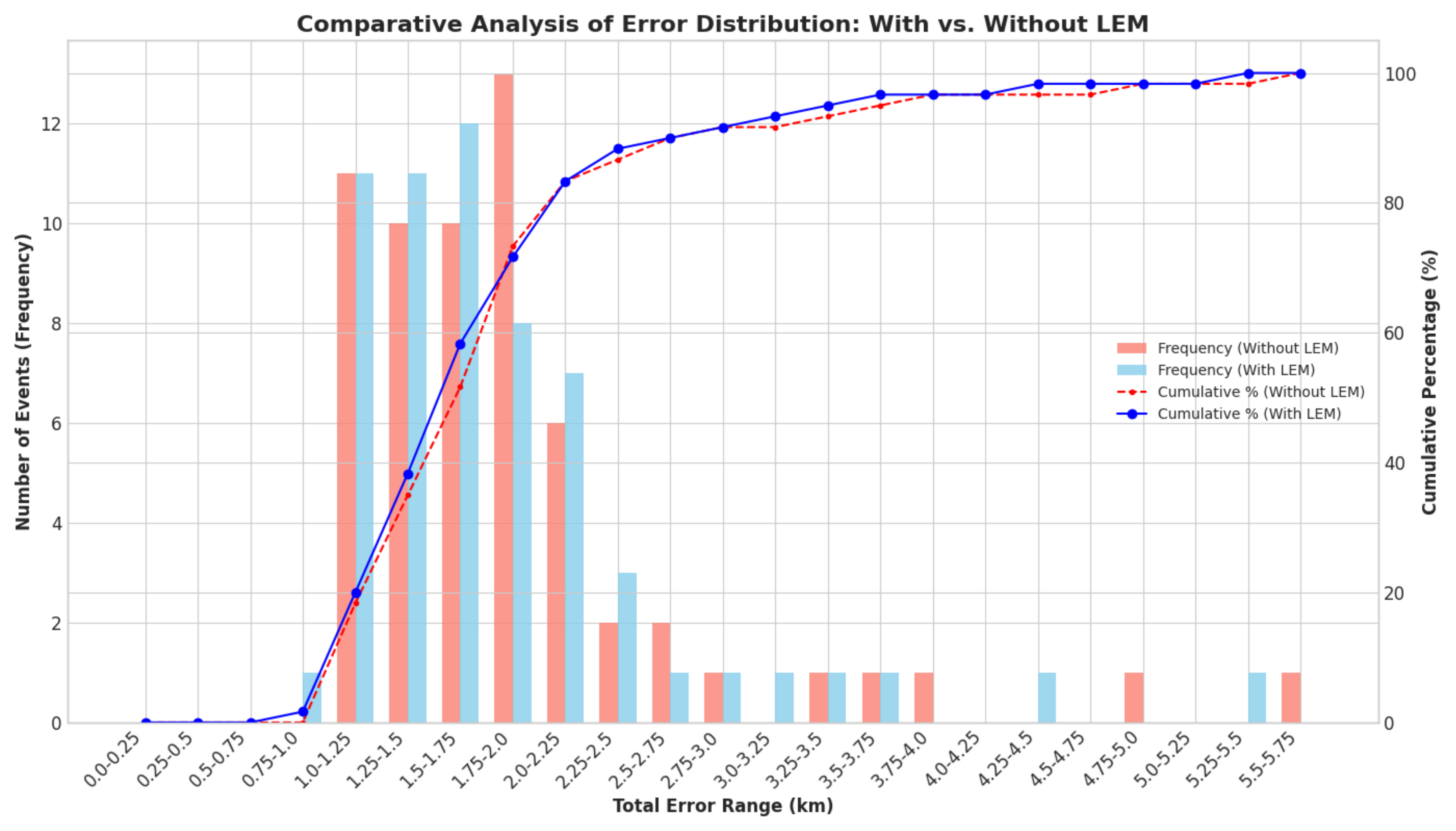
Yusuf Haidar Ali, Ade Andika Saputra, Daryono

DISCUSSION

The histogram shows that including the LEM station (blue bars) concentrates the majority of 60 relocated earthquakes into the lowest error range (<1 km). In contrast, the results without LEM (orange bars) show a much wider error distribution. This quantitatively proves that the LEM station data significantly improves relocation accuracy.



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CONCLUSION

- The double-difference hypocenter relocation method, combined with Monte Carlo perturbation for uncertainty analysis, **successfully demonstrated the significant contribution of the LEM station**.
- The inclusion of LEM data resulted in a **maximum horizontal shift of 1.38 km** and an **average depth change of 2.2 km**.
- Furthermore, the residual distribution is **more sharply focused** around 0 seconds when using LEM data.
- Overall, **the LEM station significantly improves the accuracy of hypocenter determinations, particularly in reducing depth errors.** This level of accuracy is **crucial** for seismic hazard assessment, especially in densely populated regions such as Java.

Yusuf Haidar Ali, Ade Andika Saputra, Daryono

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THANK YOU

ANY QUESTION ?

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