Impact of Tropospheric Delay Correction on the Quality of Landslide Mapping in the Southern Central Andes, Northwestern Argentina

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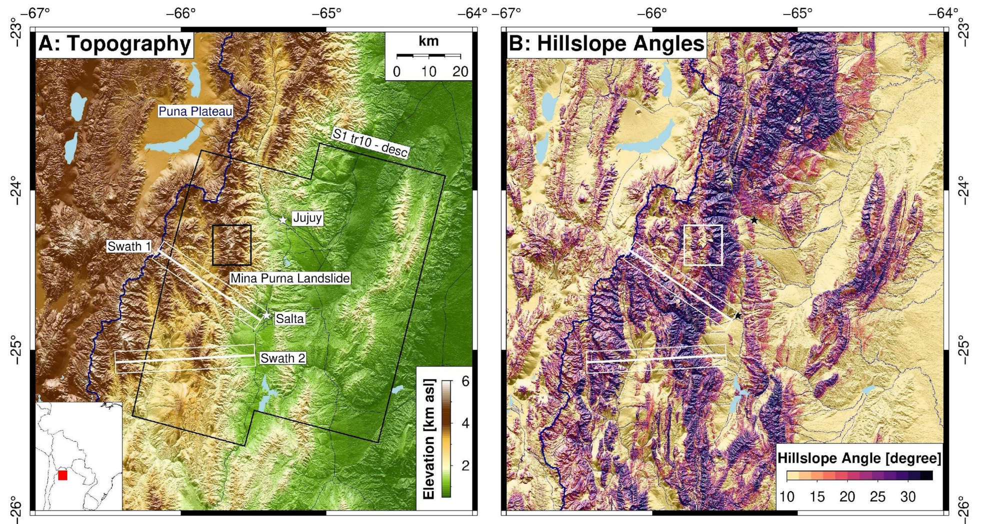
Introduction

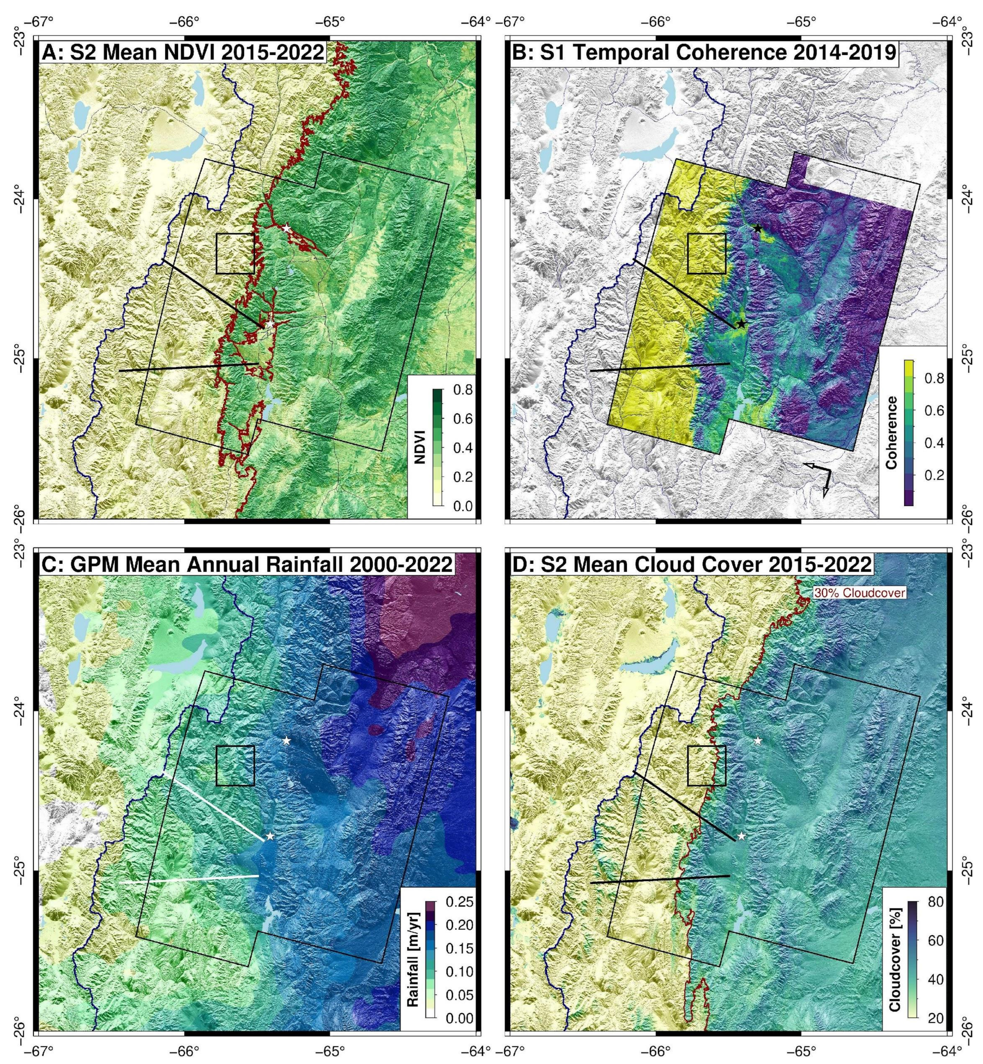
Slow-moving landslides in high-mountain regions pose a significant natural hazard and are capable of delivering large sediment volumes to the fluvial system. Time series analysis of Interferometric Synthetic Aperture Radar (InSAR) allows us to identify unstable and areas prone to landsliding, and also helps to quantify their seasonal dynamics.

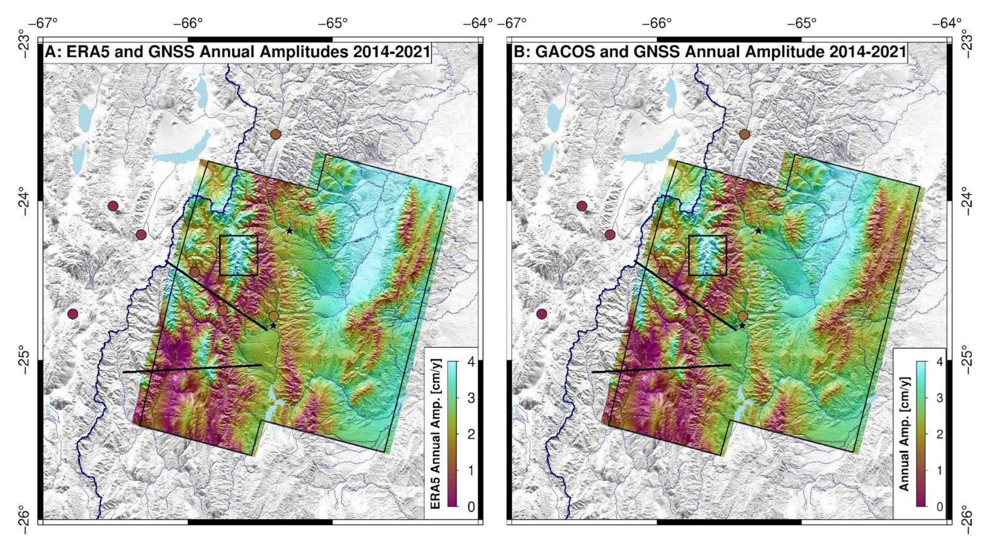
Tropospheric delay is caused by atmospheric turbulence and vertical stratification. These delays can introduce significant errors in deformation measurements, and will directly impacting the quality of landslide deformation rates. To address this problem, we apply various delay correction techniques, including spatial statistical methods and global atmospheric models.

Study Area

Our study in the Eastern Cordillera of the Argentine Andes focuses on enhancing InSAR's reliability for landslide mapping. This region is characterized by moisture changes along the topographic gradient across the orogen and seasonal variability associated with the South American Summer Monsoon system.



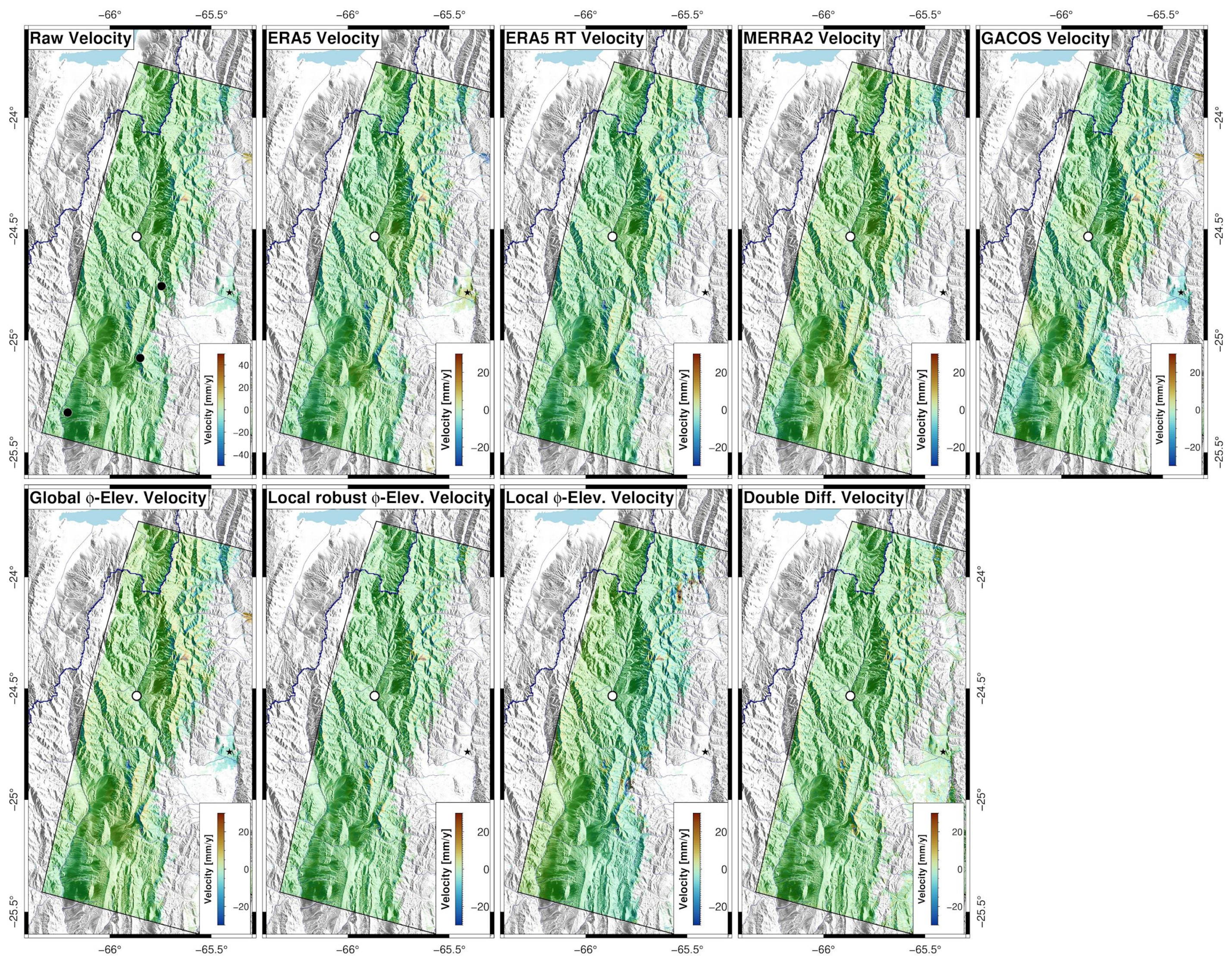




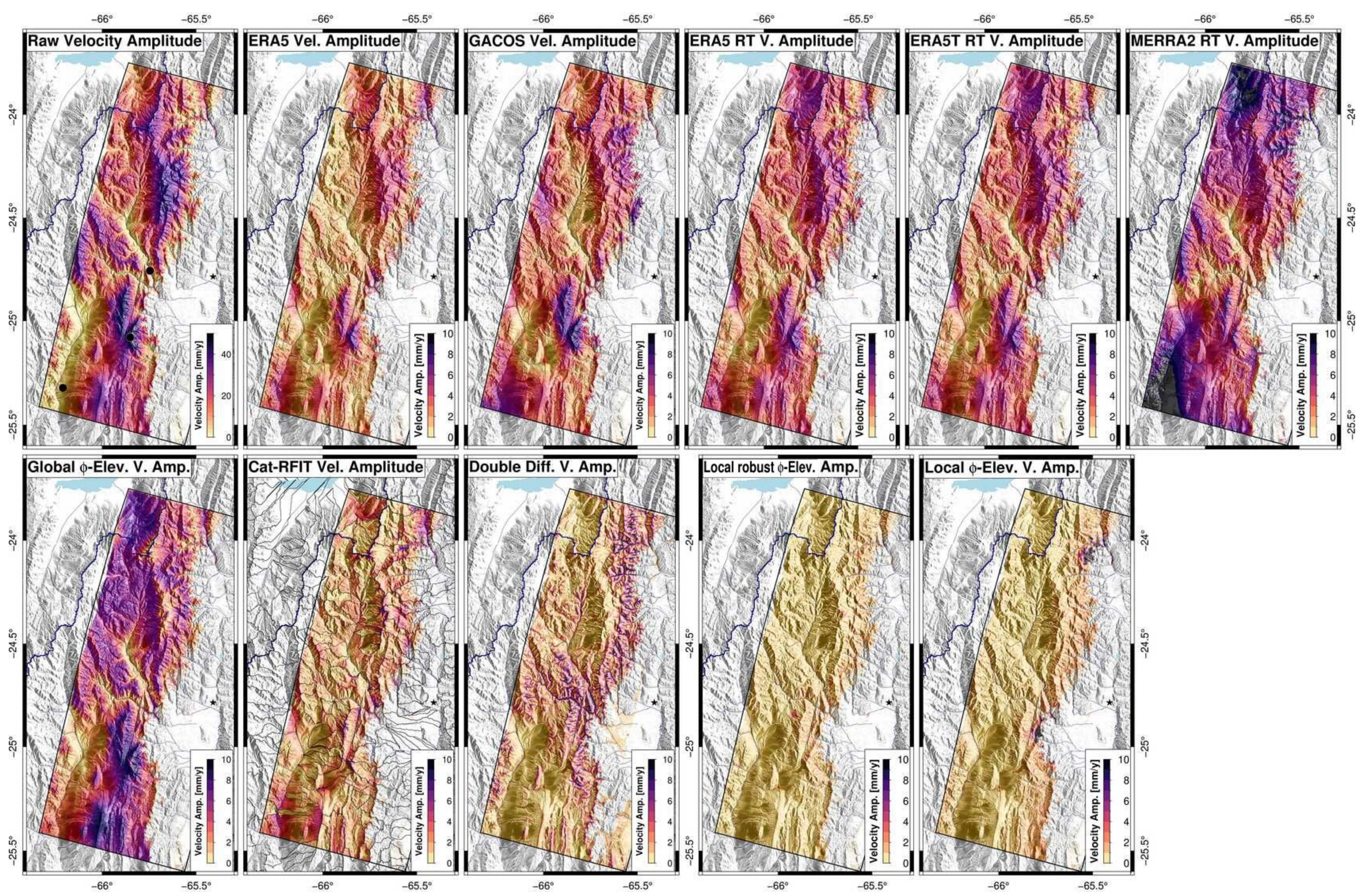
InSAR deformation field from different tropospheric corrections

We extract InSAR time series data from Sentinel-1 C-band (2014-2019) using the InSAR Scientific Computing Environment (ISCE) and the Miami InSAR Time-series software (MintPy).

We presents a comprehensive comparison of stratified tropospheric delay corrections in InSAR data, utilizing RAiDER's ray-tracing capabilities to acquire slant delays directly from global weather models, including ERA5, ERA5T, and MERRA2. By integrating RAiDER with the Python-based MintPy, we benchmarked the atmospheric corrections against both GACOS and ERA5 from pyaps and global and local statistical methods.



An assessment of the annual amplitude surface deformation and temporal patterns within the region enables us to discern the differential impacts of various tropospheric correction methods.



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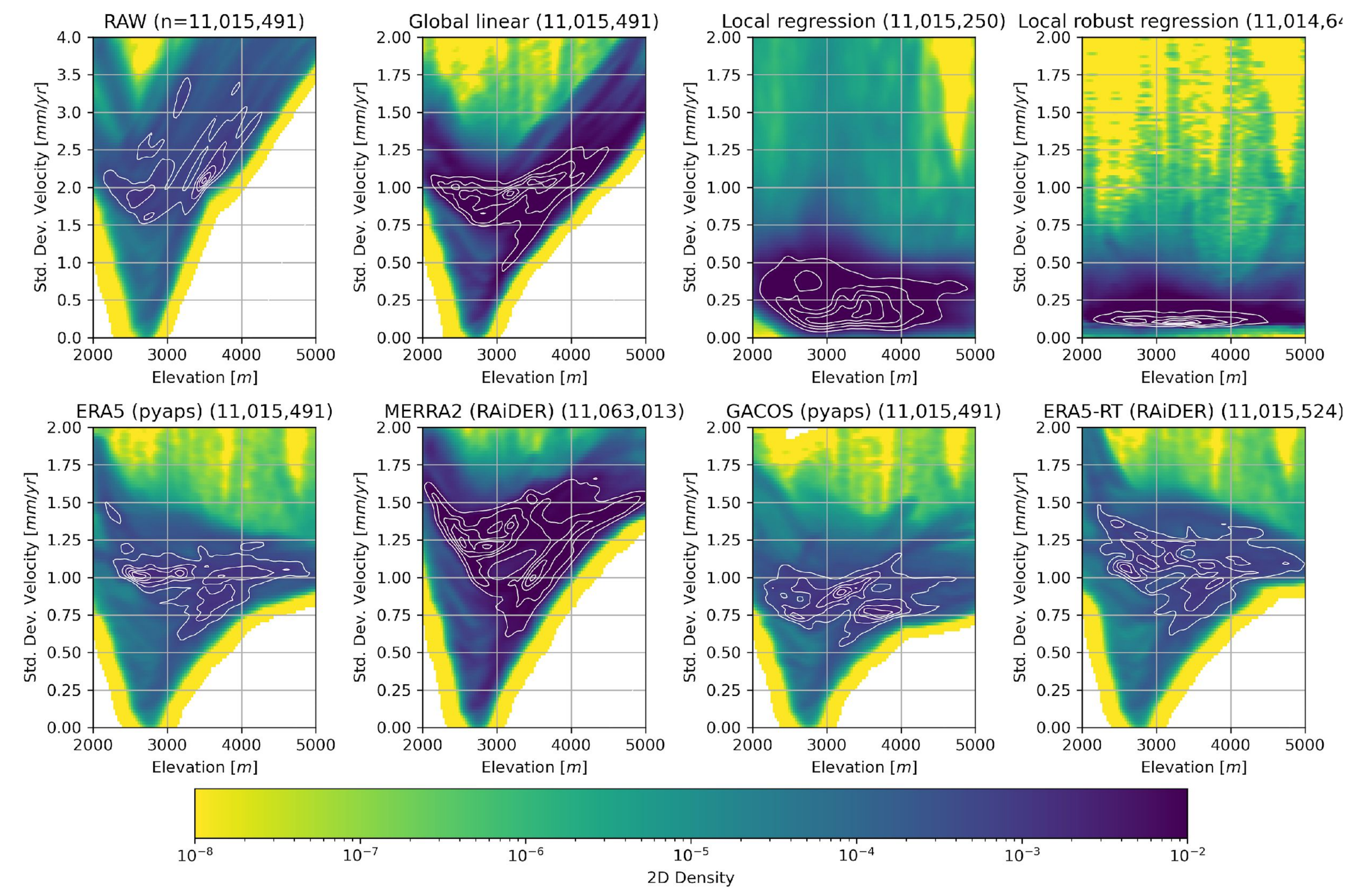
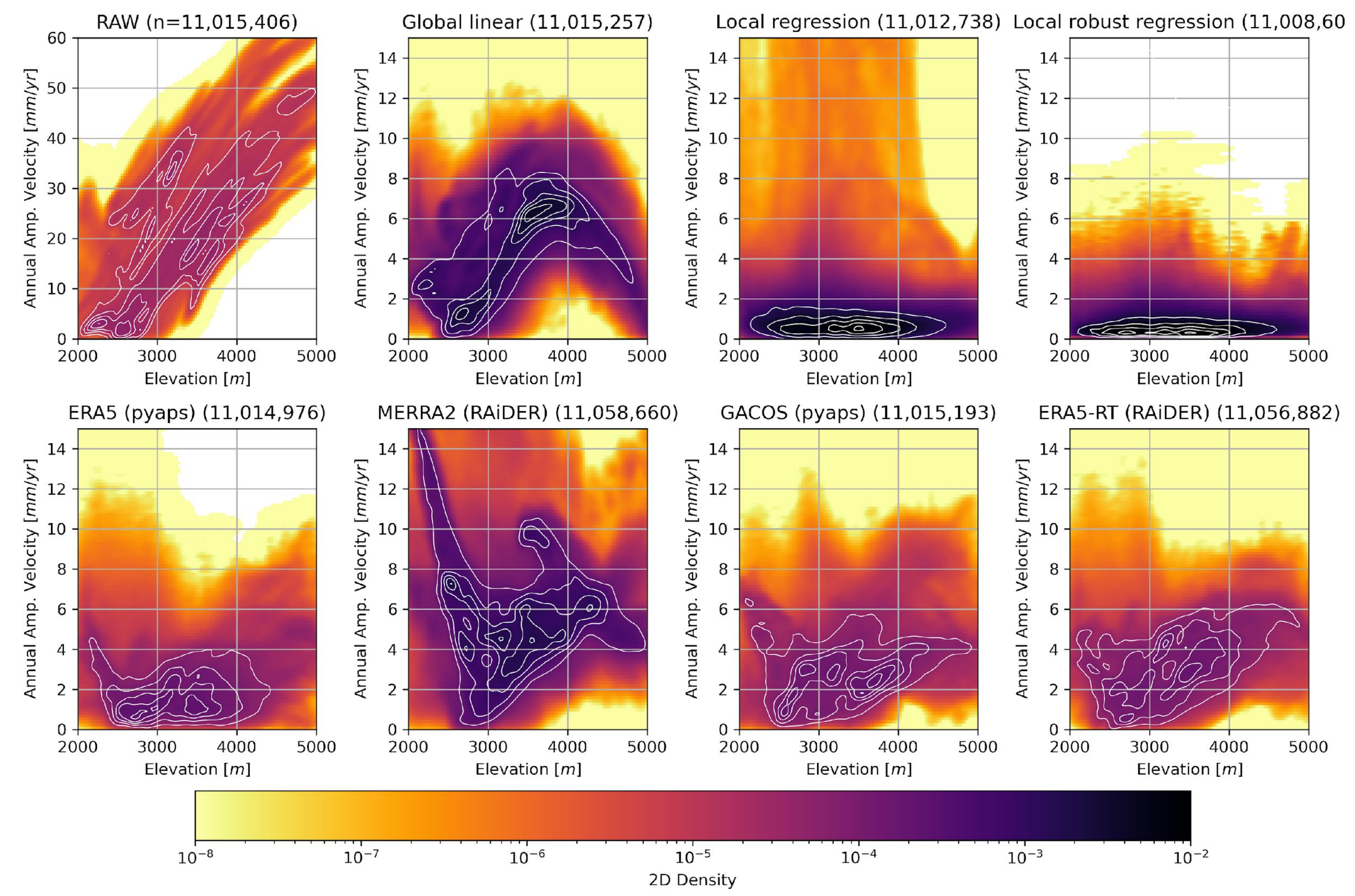
Result and Discussion

We employ two-dimensional kernel density estimation (2D KDE) to assess atmospheric correction impacts on the LOS mean velocity, correlating these with elevation data to identify error sources. Additionally, 2D KDE analysis of LOS annual amplitude will illuminate temporal patterns and their link to correction efficacy, thereby refining deformation signal accuracy and enhancing our landslide maps.





Conclusion

Our research introduces an innovative phase-based strategy for the estimation and rectification of stratified tropospheric delays in InSAR datasets. Utilizing the robustness of the binned RANSAC/Thiel-Sen algorithm within localized estimation windows or inside a river catchment, our method proficiently discerns tropospheric patterns, including those correlated with small-scale topographic deformation.

Our comparative analysis reveals that, for time series applications, the ray-tracing method did not exhibit a marked advantage over conventional pixel-based correction techniques. The lowest scene-averaged standard deviation is produced with a local phase-elevation method.

Reference:
R. Jolivet, R. Grandin, C. Lasserre, M.-P. Doin, and G. Peltzer, "Systematic InSAR tropospheric phase delay corrections from global meteorological reanalysis data," Geophys. Res. Lett., vol. 38, L17311, 2011, doi:10.1029/2011GL048757.
J. Maurer, D. Bekaert, S. Sangha, B. Hamlington, C. Marshak, Y. Lei, P. Kumar, and H. Fattahi, "RAiDER: Raytracing Atmospheric Delay Estimation for RADAR," in AGU Fall Meeting Abstracts, vol. 2021, G44A-07, Dec. 2021. [Online]. Available: https://ui.adsabs.harvard.edu/abs/2021AGUFM.G44A..07M