Vertical Land Movement Budget and Its Impact on Coastal Sea-Level around the World

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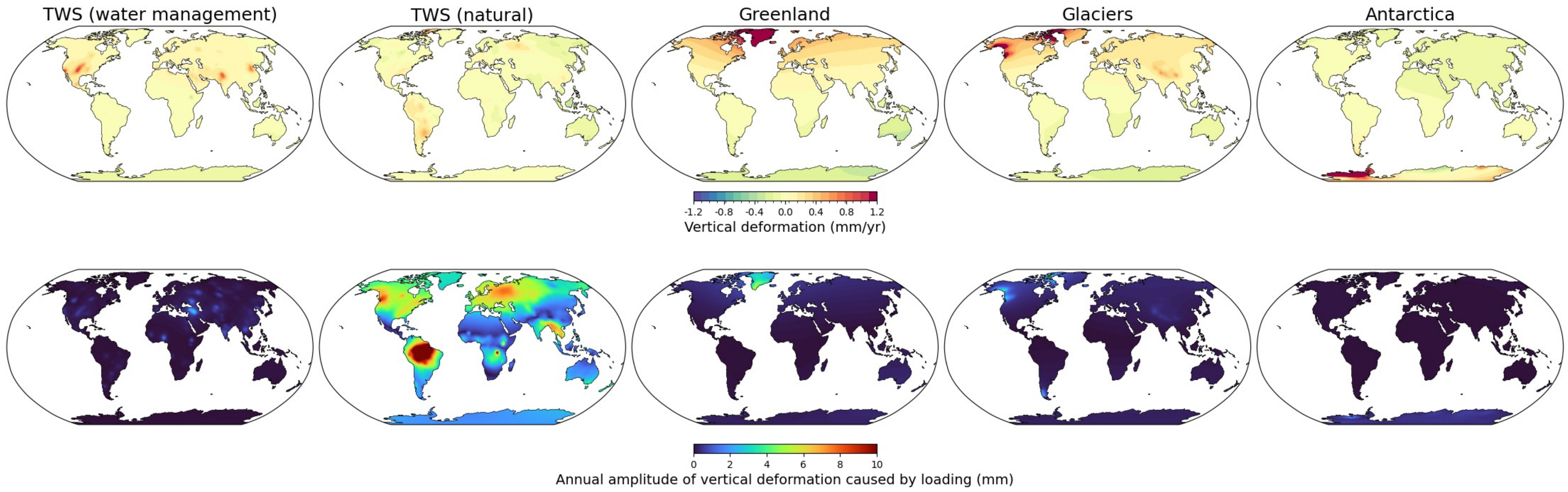
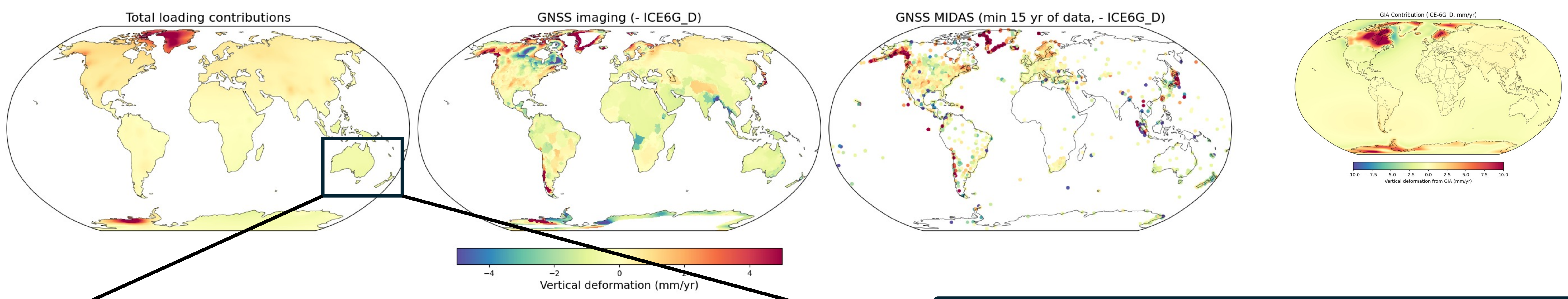
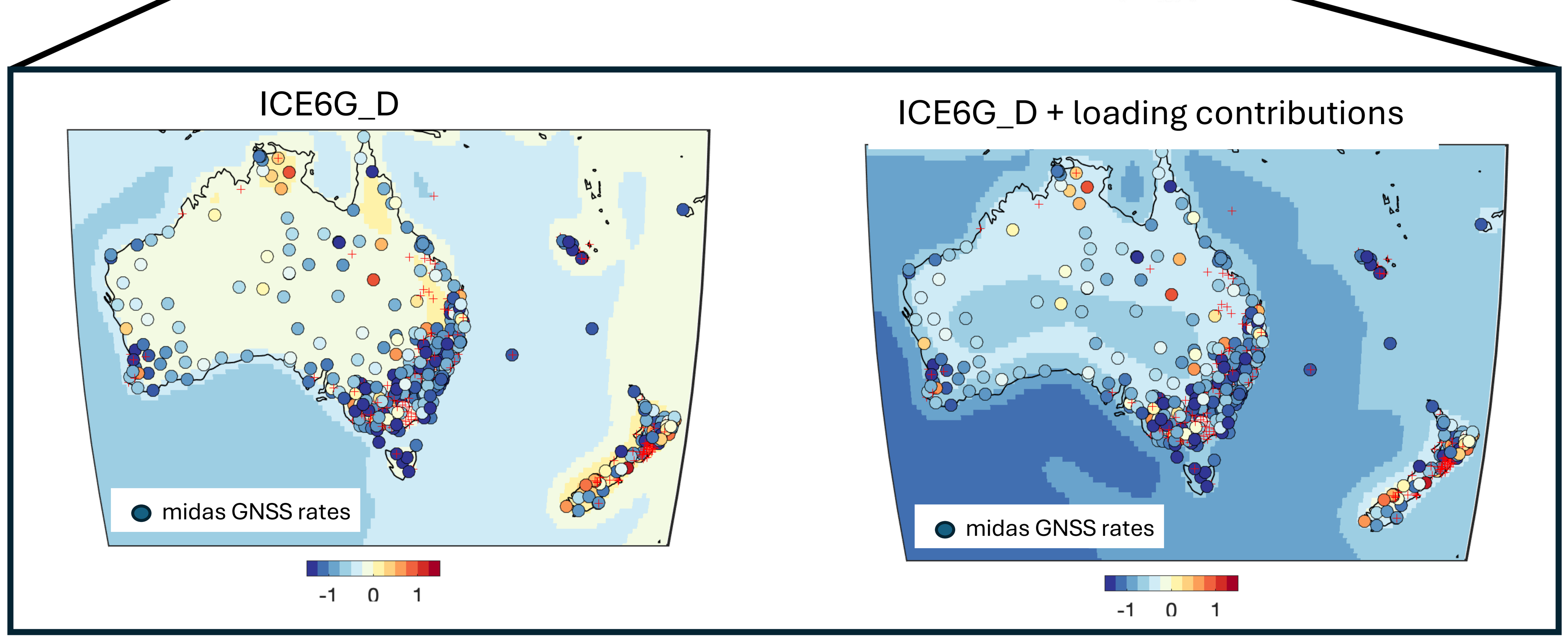
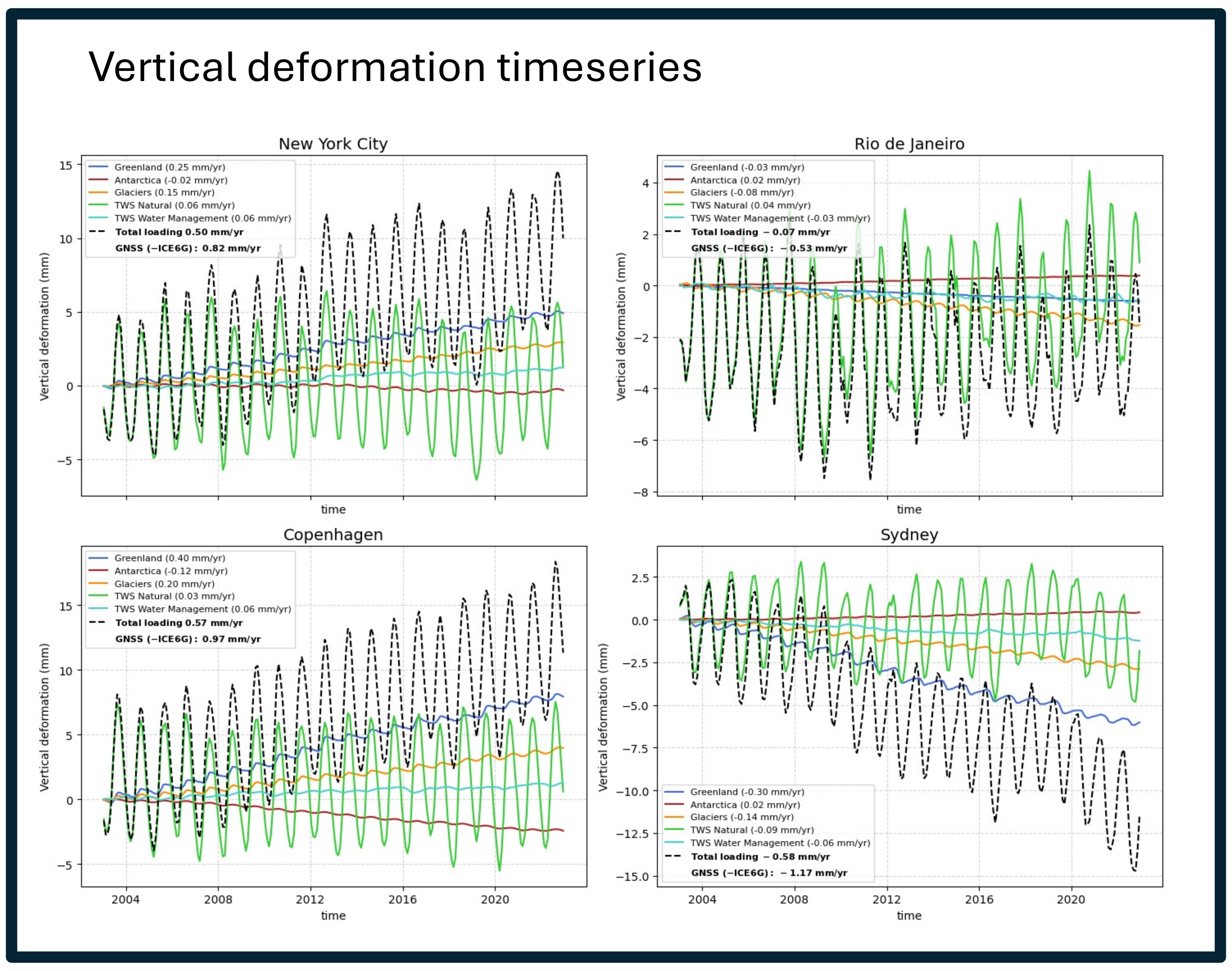
Abstract: Elastic vertical land movement (elastic VLM) plays a crucial role in shaping relative sea levels along global coastlines. In Northern Europe, VLM is primarily driven by Glacial Isostatic Adjustment (GIA). However, the rapid melting of Arctic ice is inducing substantial elastic uplift, with both local effects and a long-range footprint extending 1,000–3,000 km from the point of ice loss. When GNSS-based VLM estimates are unavailable, sea-level studies based on tide gauges often rely on GIA-only VLM models to correct for land movement. However, due to present day ice loss, the elastic VLM gains importance. To address this, we develop a global, time-varying elastic VLM model based on detailed estimates of terrestrial and glacial mass changes from glaciers, Antarctica and Greenland. Combined with GIA modelling, will the elastic VLM model produce a comprehensive VLM estimate, comparable to GNSS-measured rates in a center-of-mass reference frame. Additionally, far-field elastic effects from Antarctic ice mass loss and terrestrial water storage changes are incorporated to create a complete global vertical deformation map. This dataset can serve as a valuable complement for sea-level studies in regions with sparse or no GNSS coverage.









Conclusions and ongoing work

- Elastic vertical deformation is a key contributor to understanding local GNSS-observed VLM trends, even in far-field regions.
- Northern Hemisphere ice loss appears to drive subsidence in Australia, thereby amplifying the relative impact of sea level rise.
- Comparison with GIA-corrected GNSS trends remains challenging due to local VLM signals not captured by models and uncertainties in GIA corrections.
- Water management changes in Southeast Asia are not adequately represented in the current loading deformation estimates.
- Resolution limitations hinder the ability to fully capture localized signals, particularly in ice-covered regions (work in progress).
- At present, comparisons rely only on secular GNSS trends. Incorporating seasonal signals will require ITRF/CM frame conversion and consistent loading estimates for both datasets.

References

- **MIDAS data:** Blewitt et al, https://geodesy.unr.edu/vlm.php
- **GNSS imaging:** Hammond, W.C., G. Blewitt, C. Kreemer, S. Nerem, 2021, Global vertical land motion for studies of sea level rise, J. Geophys. Res. - Solid Earth, 126(7),
- **Loading**: Ludwigsen et al. "Gridded and Timeseries Data Related to Global and Regional Ocean Mass Budget Closure since 2003." *Technical University of Denmark, 2024* [Dataset]