Assessing the Influence of DEM and DBM Accuracy on Geoid Modeling at the Land-Sea Interface: A Case Study in Eastern Taiwan

Zhi-Yi Yang Kuan-Hsiang Fang Yu-Shen Hsiao

Department of Soil and Water Conservation, National Chung Hsing University, Taichung 402, Taiwan R.O.C.
*Corresponding author :rebecca.yang321@gmail.com

1. Introduction

- This study investigates the impact of topographic variations in eastern Taiwan on geoid modeling.
- It assesses the accuracy of various DEMs/DBMs in terrain correction using a Remove-Compute-Restore(RCR) approach that integrates global geopotential models, local gravity measurements, and high-resolution terrain data.
- Special focus is placed on the accuracy of DEMs/DBMs at land-sea boundaries.

2. Method

The geoid and gravity field are divided into three components: long-wavelength, residual-wavelength, and short-wavelength. Both undulations and gravity anomalies can be expressed in terms of these components.

$$N = N_{long} + N_{res} + N_{short}$$

$$\Delta g = \Delta g_{long} + \Delta g_{res} + \Delta g_{short}$$

- N= Quasi geoid undulation
- N_{long}= Long-wavelength geoid undulation
- N_{res}= Residual-wavelength geoid undulation
- N_{short}= Short-wavelength geoid undulation
- Δg= Gravity anomaly
- Δg_{long}= Long-wavelength gravity anomaly
- Δg_{res}= Residual-wavelength gravity anomaly
- Δg_{short}= Short-wavelength gravity anomaly

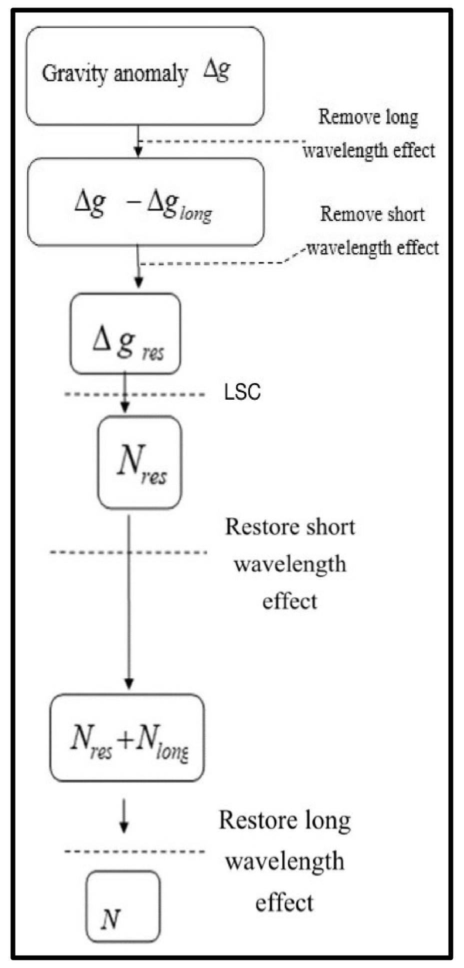

Fig. 1 Flowchart for the RCR geoid modeling procedure.

3. Study Area

The study area is divided large-scale (red), medium-scale (yellow), and small-scale (green) areas.

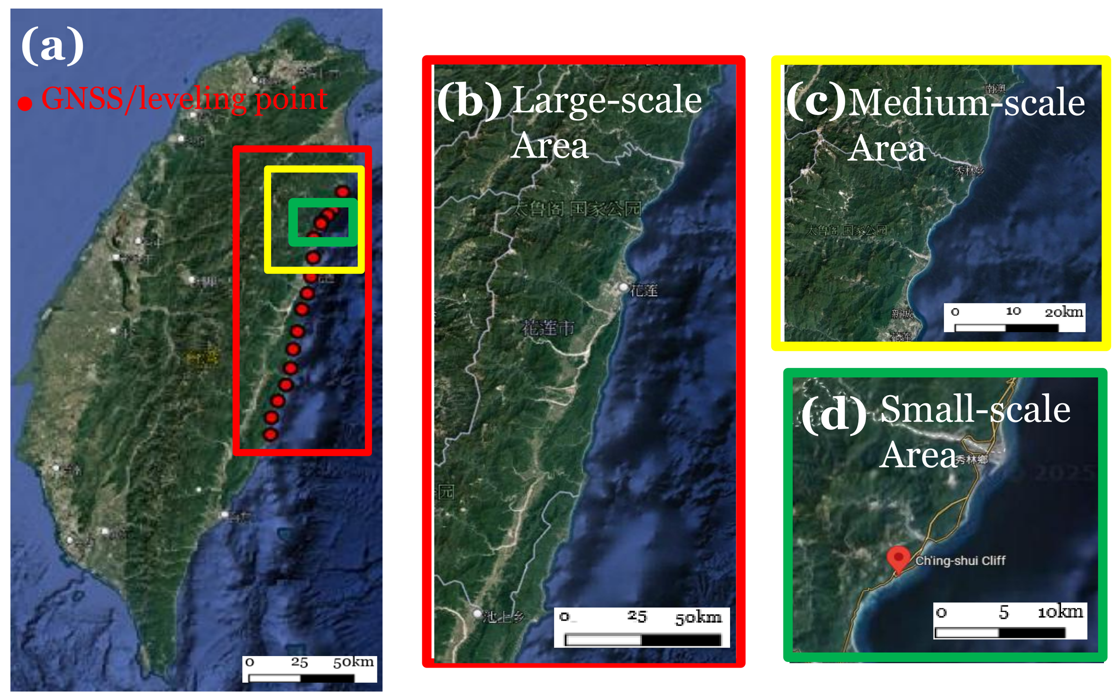

Fig. 2 Satellite image of Taiwan (a). Large-scale (b), Medium-scale (c), and Small-scale (d) study areas.

4. Study Case

Table. 1 Case information

Case	Study area & DEM/DBM resolution	Coastline
1	Large-scale area & 270 m DEM/ 50 m DBM	GSHHG
2	Large-scale area & 270 m DEM/ 50 m DBM	Digitized
3	Large-scale and Medium-scale areas & 90 m DEM/ 50 m DBM	GSHHG
4	Large-scale and Medium-scale areas & 90 m DEM/ 50 m DBM	Digitized
5	Medium-scale and Small-scale areas & 30 m DEM/ 50 m DBM	GSHHG
6	Medium-scale and Small-scale areas & 30 m DEM/ 50 m DBM	Digitized
7	Small-scale area & 6 m DEM /50 m DBM	GSHHG
8	Small-scale area & 6 m DEM / 50 m DBM	Digitized

GSSHG: Using Global Self-consistent, Hierarchical, High-resolution Shorelines.
Digitized: Digitizing new coastline from satellite images

5. DEM&DBM

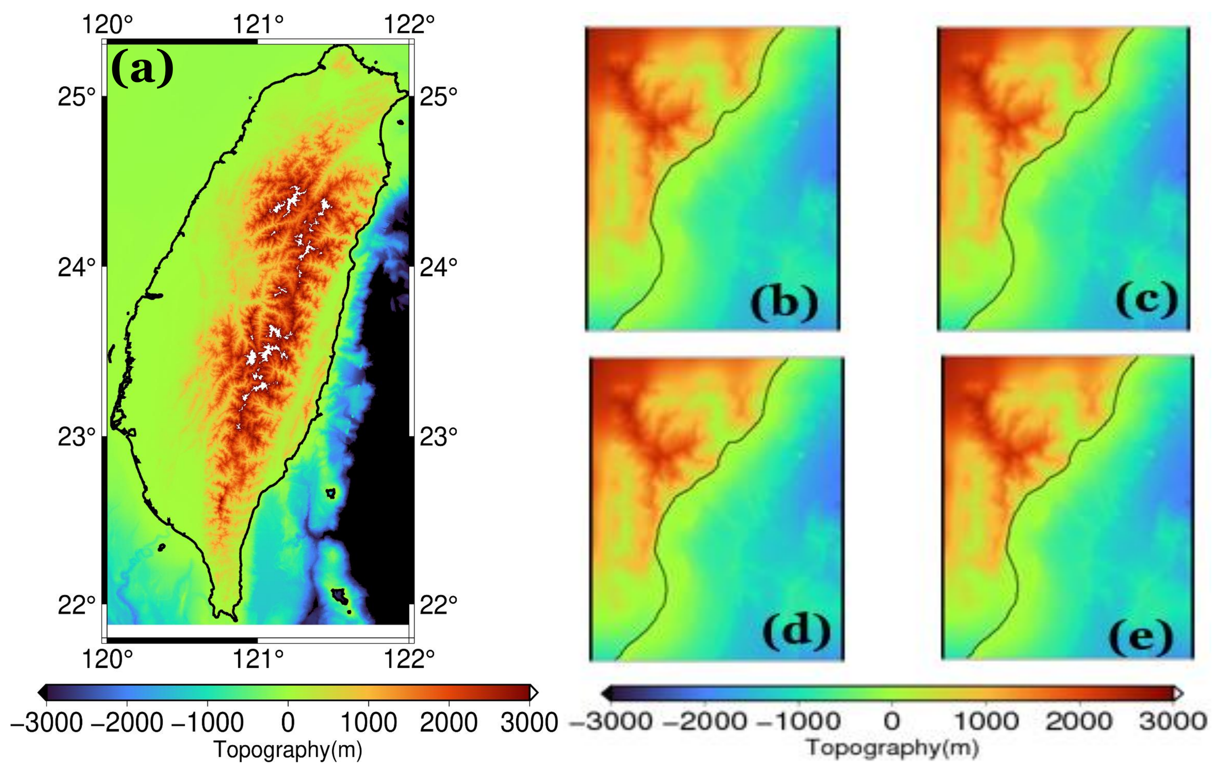

Fig. 3 The topography of Taiwan(a). 270 m /50 m (b), 90 m/50 m (c), 30 m/50 m (d), and 6 m/50 m (e) DEMs/DBMs.

6. Coastline

The GSHHG coastline differs from the coastline extracted from satellite imagery (google earth) by several hundred meters.

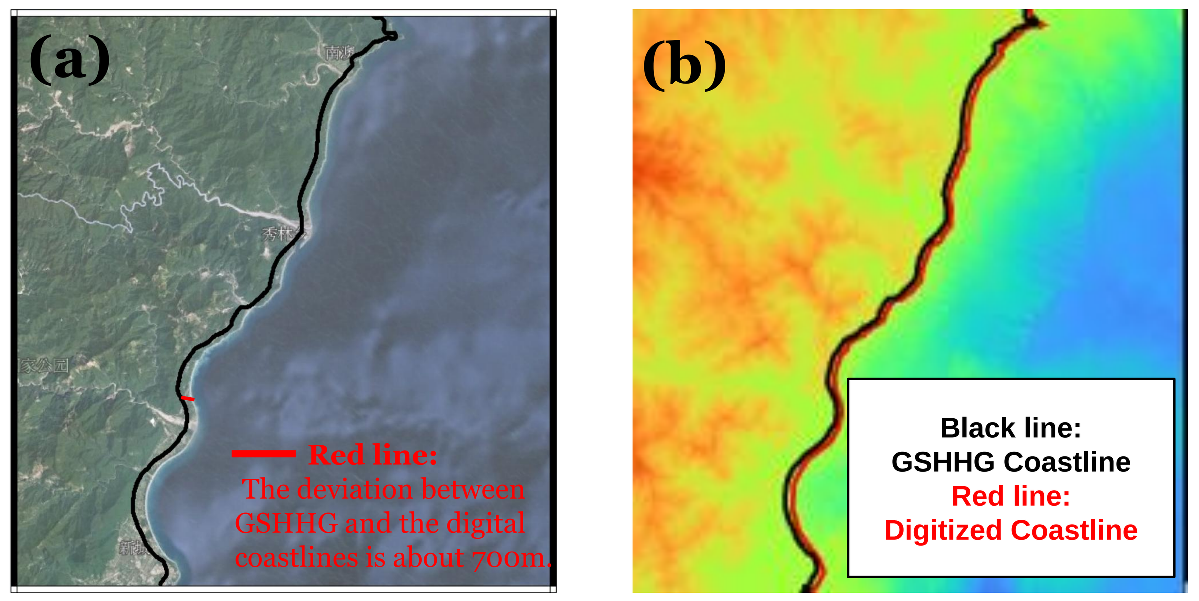

Fig. 4 The GSHHG coastline in Google Earth (a). The locations of GSHHG and digitized coastlines (b).

7. Results in Large-Scale Area

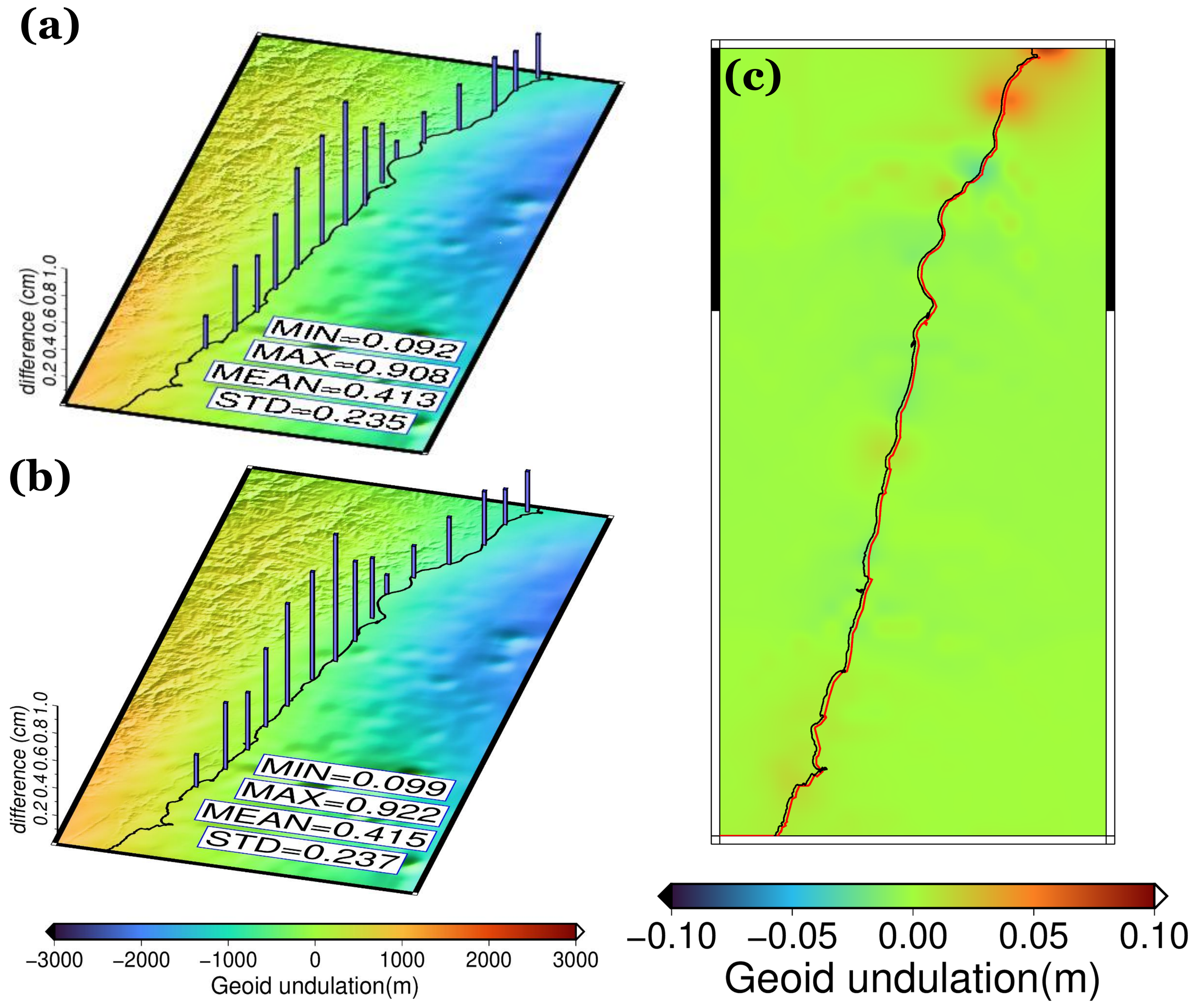

Fig. 5 Geoid differences (vertical bars) between Case 1 and GNSS/levelling points (a), and Case 2 and GNSS/levelling points (b). The geoid differences between Case 1 and Case 2 (c).

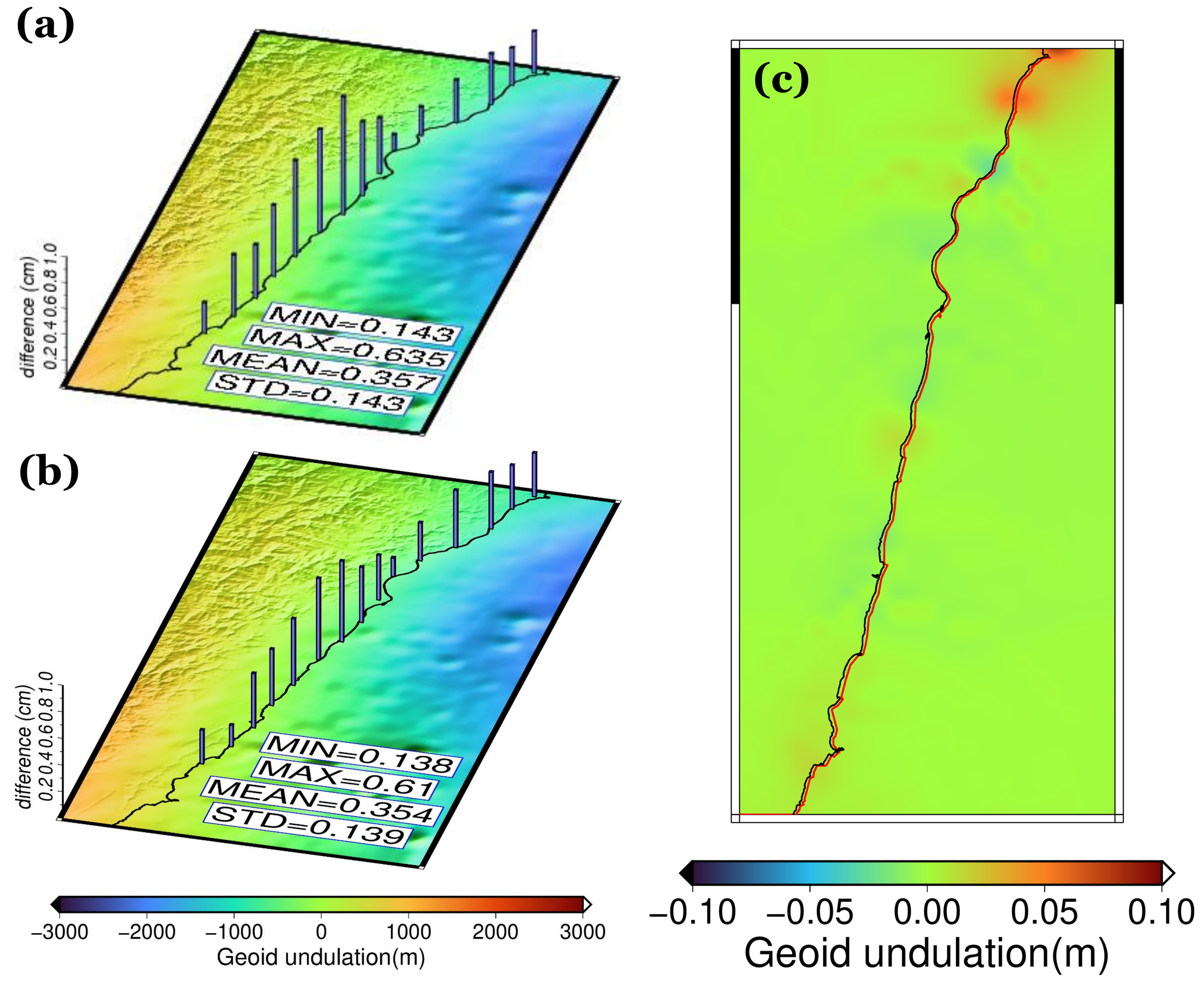

Fig. 6 Geoid differences (vertical bars) between Case 3 and GNSS/levelling points (a), and Case 4 and GNSS/levelling points (b). The geoid differences between Case 3 and Case 4 (c).

8. Results in Medium-Scale Area

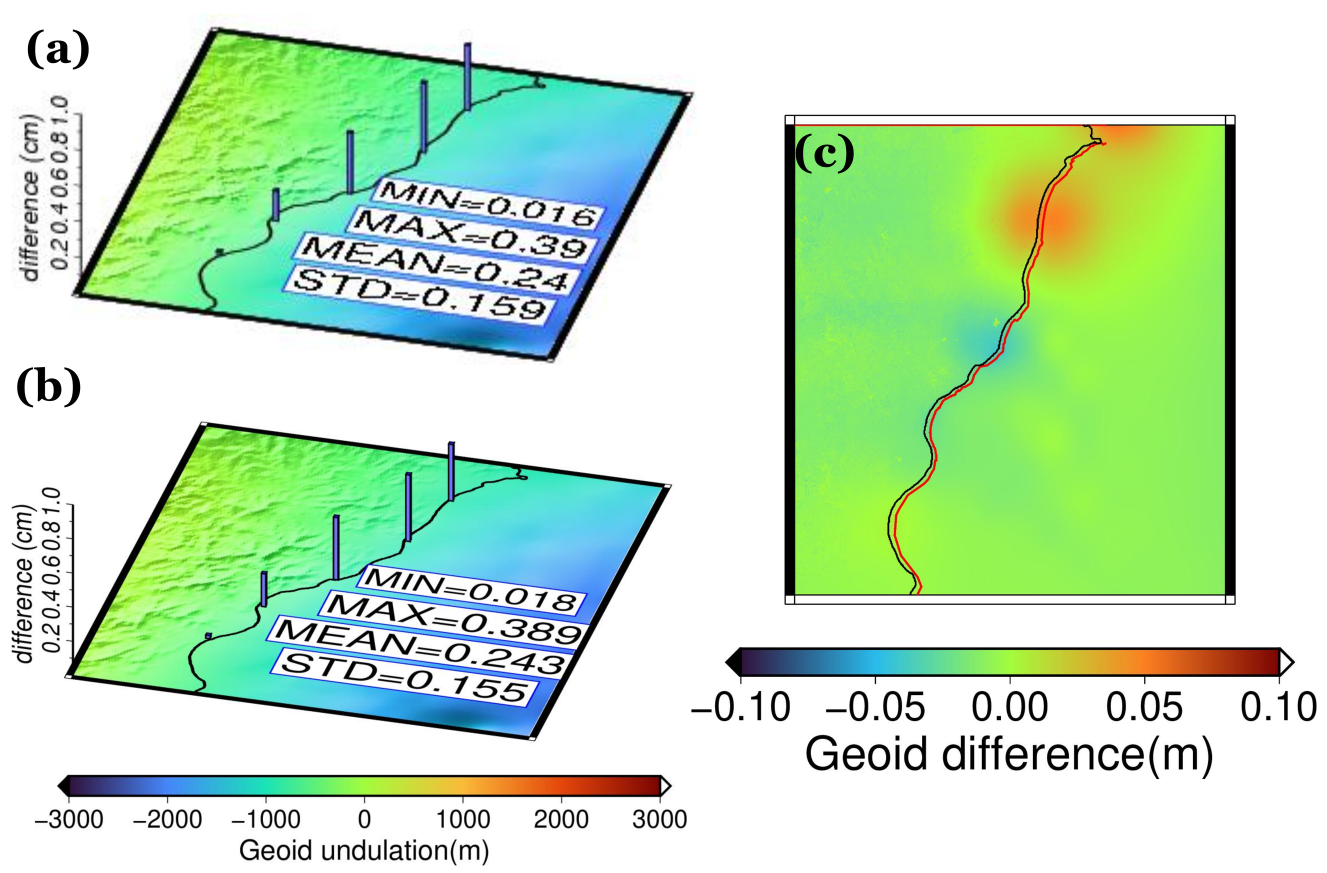

Fig. 7 Geoid differences (vertical bars) between Case 3 and GNSS/levelling points (a), and Case 4 and GNSS/levelling points (b). The geoid differences between Case 3 and Case 4 (c).

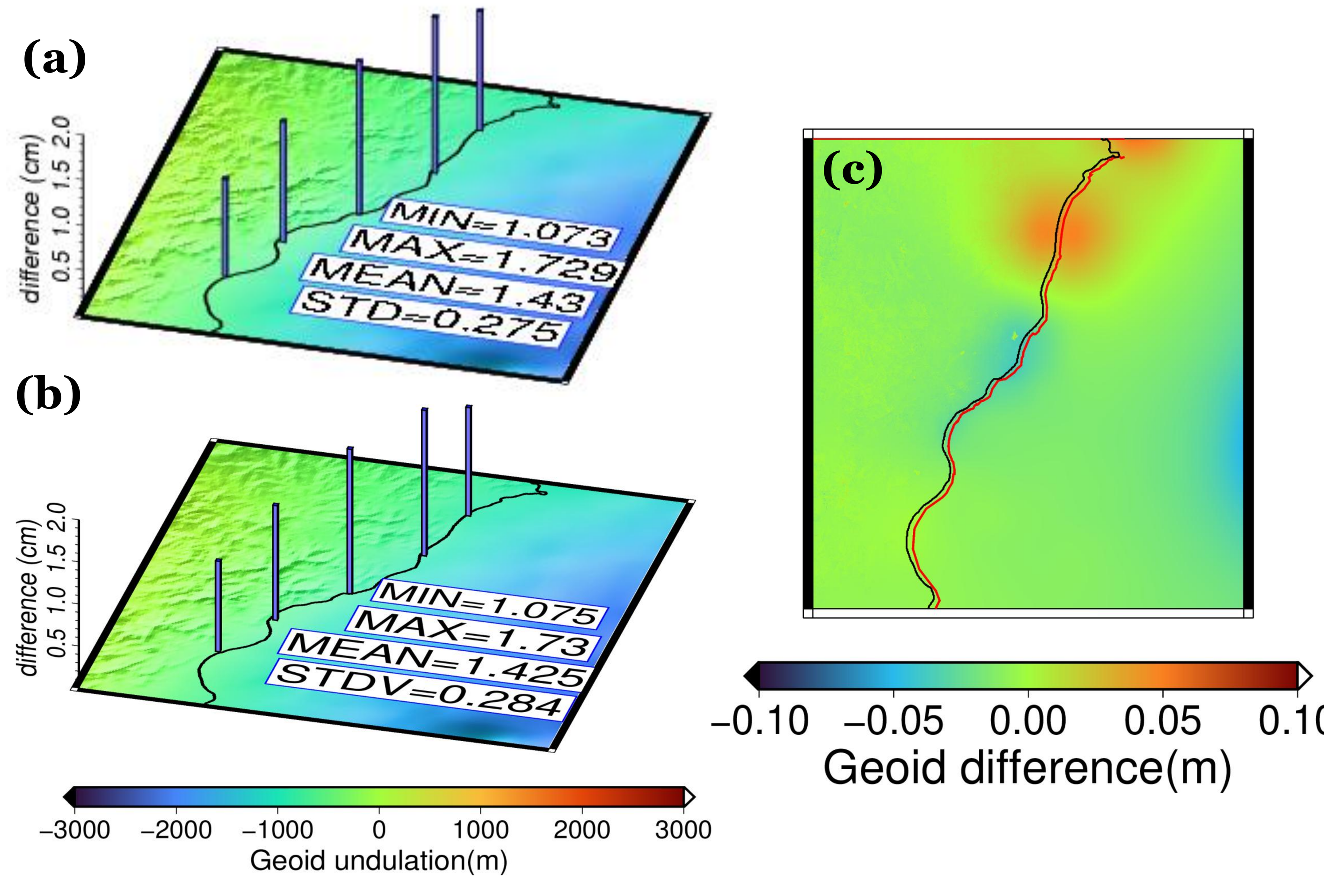

Fig. 8 Geoid differences (vertical bars) between Case 5 and GNSS/levelling points (a), and Case 6 and GNSS/levelling points (b). The geoid differences between Case 5 and Case 6 (c).

9. Results in Small-Scale Area

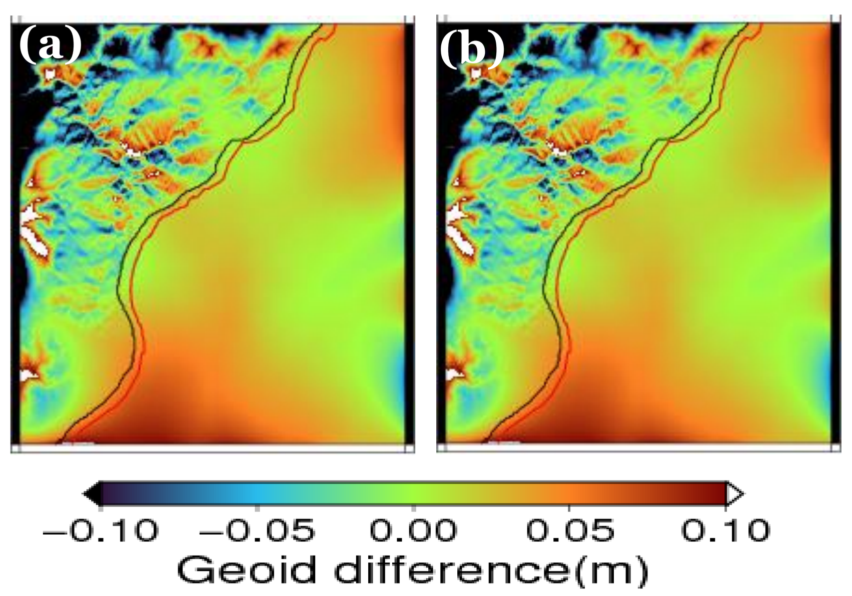

Fig. 9 The geoid differences between Case 5 and Case 6(a), and Case 7 and Case 8 (b)

10. Conclusion

- This study applies the RCR method to evaluate the accuracy of various DEMs/DBMs for terrain correction. The results highlight that coastline boundary precision plays a critical role in improving geoid modeling accuracy.
- The analysis shows 90 m DEM offers the best accuracy, while the 270 m DEM shows the lowest deviation, revealing a complex resolution-accuracy link.
- Testing 1 m high-resolution DEM revealed an unexpected result； the error value around the coastline reached more than 10 m, likely due to software limitations with dense data.