

How Stable Is a Geoid, Really?

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Abstract

Geoid is defined as an equipotential surface coinciding with an ideal mean sea surface. It is commonly regarded as a temporally stable reference surface for physical height determination. However, changes associated with geophysical processes affect the Earth's gravity field and consequently introduce changes in the geoid. This study reports how stable the geoid really is by quantifying geoid variations associated with two selected geophysical processes, i.e., major earthquakes and long-term land subsidence in Indonesia and further evaluating their significance relative to the accuracy of existing regional geoid models in Indonesia.

The results show that earthquake-induced geoid changes are generally small, with most events producing variations of less than 1 cm, with a prominent magnitude reaching 8 cm for the 2004 Sumatra-Andaman megathrust earthquake. In addition to coseismic deformation, the long-term effect of land subsidence was investigated in the Bandung Basin. The cumulative geoid change associated with subsidence-related mass redistribution is estimated to reach approximately 5.5 mm over a period of 25 years.

With a reported accuracy of InaGEOID2020 V2.0 (5 to 29 cm across Indonesia) and ITBJ_2025 (6.4 cm for Java region) geoid models, we highlight that most modeled temporal geoid variation remain substantially smaller than the present uncertainty of the available geoid models. Therefore, the geoid model can generally be considered stable for current practical geodetic applications.