Technical Details for xGEOID18 Models

Summary

xGEOID18 is identical to xGEOID17 in the area bordered by $5^\circ \le \varphi \le 85^\circ$, $170^\circ \le \lambda \le 350^\circ$, which includes CONUS, Alaska, Hawaii, and Puerto Ricco. Therefore, for information on xGEOID18 in those areas, the user should refer to the Technical Details of xGEOID17 (link).

For extended areas down to the equator and above latitude 85˚ north, the geoid is computed from the NGA's Preliminary Geopotential Model 2017 (PGM17).

The geoid models for Guam/central Northern Marianas Islands and American Samoa are computed in the closest way as xGEOID17 using the shipborne gravity, altimetric gravity and the reference gravity model PGM17.

The deflections of the vertical are computed from all the geoid grids and the plumb curvature correction is applied by using the classical Bouguer reduction.

Background

Starting from xGEOID14, NGS has been developing spherical harmonic geopotential models to degree and order 2160 by combining the latest satellite gravity model GOCO05S, surface gravity data and GRAV-D airborne gravity data. Then the geopotential models have been used as the reference gravity field in the experimental geoid computations. Starting xGEOID18, the computation scheme is changed. Instead of developing NGS geopotential models, the xGEOID computation relies on geopotential models developed by NGA. The first NGA geopotential model PGM17 differs from xGEOID17RefB model by only a few mm over CONUS, and the next PGM model will be available at end of 2018. Thus it was decided that xGEOID18 serves a transition model keeping xGEOID17 unchanged but extending the computation area down to the equator and up to the Pole. In addition, the geoid model area is also extended to Guam/central Northern Mariana Islands and American Samoa. Finally, deflections of the vertical are also computed from all the geoid grids.

Geoid models in the extended south and north areas

PGM17 and xGEOID17RefB use the same data over CONUS and were developed by the same person, thus the differences are very small. Outside CONUS, xGEOID17RefB used EGM2008 gravity. The following figure shows the geoid height differences.

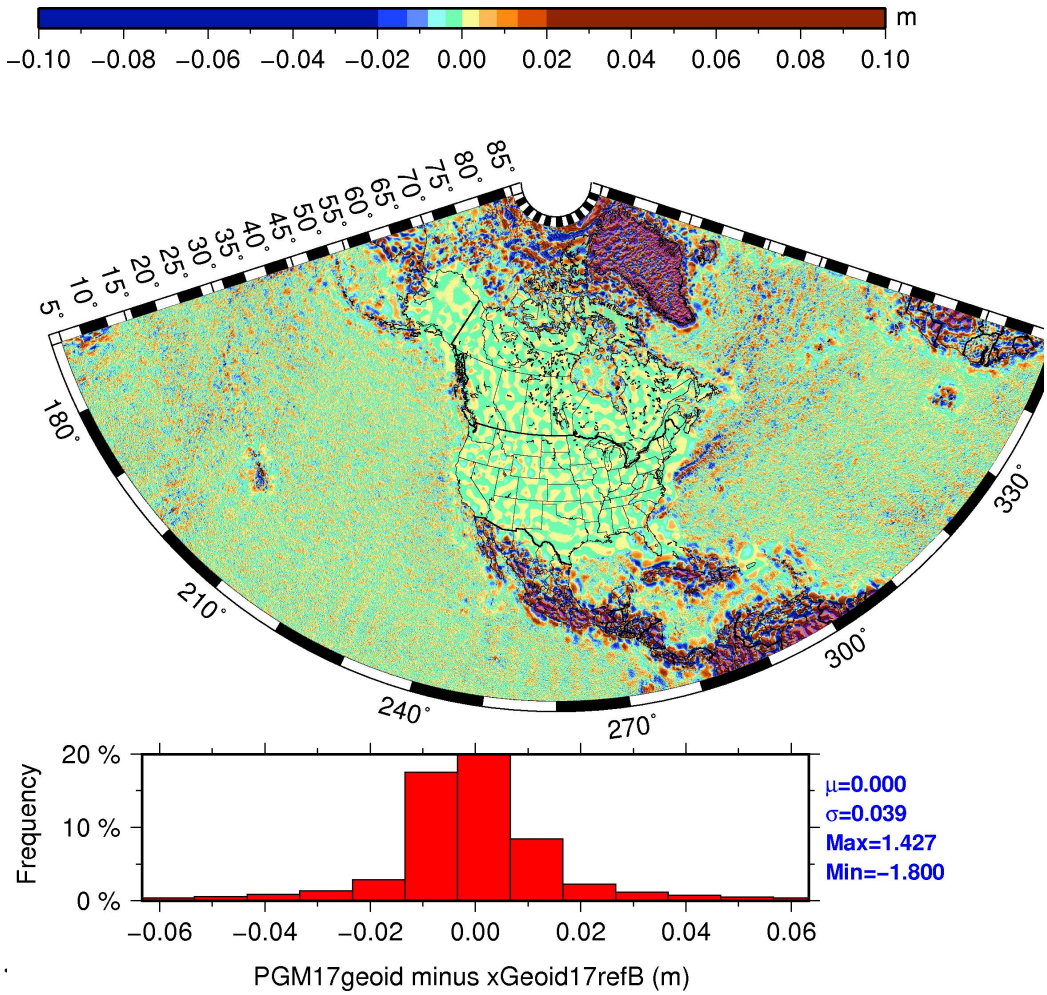

Figure 1. Geoid height differences between PGM17 and xGEOIDid17refB

Figure 1 shows clearly noticeable differences over Mexico and Central American countries, North Venezuela, Greenland, Iceland and polar region. The differences are most likely caused by the new surface and airborne data used in the PGM17 model.

The geoid grids are computed from PGM17 to degree and order 2160 in the extended areas, namely in the areas from 0˚N to 5˚N and from 85˚N to 90˚N for xGEOID18.

Geoid models in U.S. territories

There are two areas that have been added to xGEOID18: Guam/Central Northern Marianas Islands (CNMI) and American Samoa. The methodology for these two separate geoid grids follows closely that of the xGEOID model for CONUS with some slight modifications. Currently, GRAV-D is scheduled to fly these Pacific regions in 2019 so only a single model similar to the xGEOID18A version is constructed for both areas. Both geoid models are constructed to 1′ spatial resolution over the geographic areas shown in Table 1 and are based on a W_0 value of 62,636,856.00 m^2/s^2 and the GRS80 ellipsoid.

Table 1: Statistics of the geoid height (meters).

Geoid Grid:	Latitude Range:	Longitude Range:	Min.	Max.	Mean	Std. Dev.
Guam/Central Northern Marianas Islands	11^{o} to 22^{o}	143^{o} to 148^{o}	25.725	55.892	44.420	7.913
American Samoa	-16^{o} to -10^{o}	186^{o} to 193^{o}	16.711	42.428	24.822	4.910

For these two geoid models, we utilize PGM17 to degree 2190. This reference model is a preliminary model developed by NGA which will ultimately become EGM2020. This reference model was selected instead of NGS-developed reference models due to superior fits with GPS/leveling data on these islands.

Input datasets:

- Reference Model: PGM17 to degree 2190.
- Terrestrial Gravity Data: NGA gravity data supplemented with NGS gravity data. This data includes shipborne gravity data which was used in the two geoid models. NGS acquired surface gravity measurements in 2017 on the islands of Guam, Rota, Tinian, Alamagan, Pagan, Ascunsion, and Maug in the Central Northern Marianas' Islands. The more northern islands previously had no surface gravity data so a handful of observations are providing a major contribution.
- Altimetric Gravity Data: DTU15 altimetry-derived gravity data (Andersen et al. 2016)
- DEM Data: SRTMv4.1 (Jarvis, et al. 2008)

Data Processing:

The terrestrial, shipborne, and altimetric gravity data were combined in a least-squares collocation process at 1′ grids. In order to capture more power in the signal from the shipborne data, the high density altimetric gravity data was given a higher sigma value equal to 10 mGal. The shipborne and terrestrial data utilized estimated sigmas provided with the datasets from NGA which had a maximum of 8 mGal in these two regions. The residual gravity anomaly grids utilized are the following:

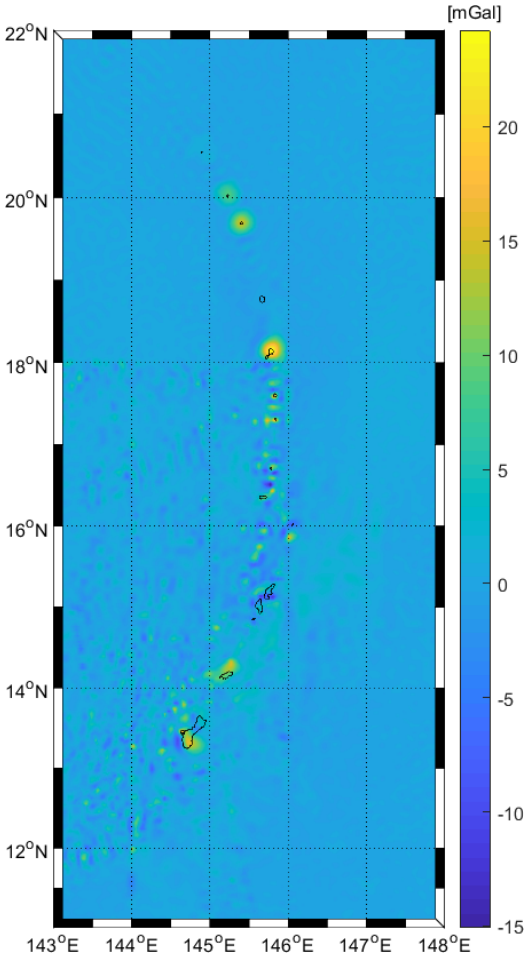

Figure 2: Guam / CNMI Residual Gravity Anomaly Grid

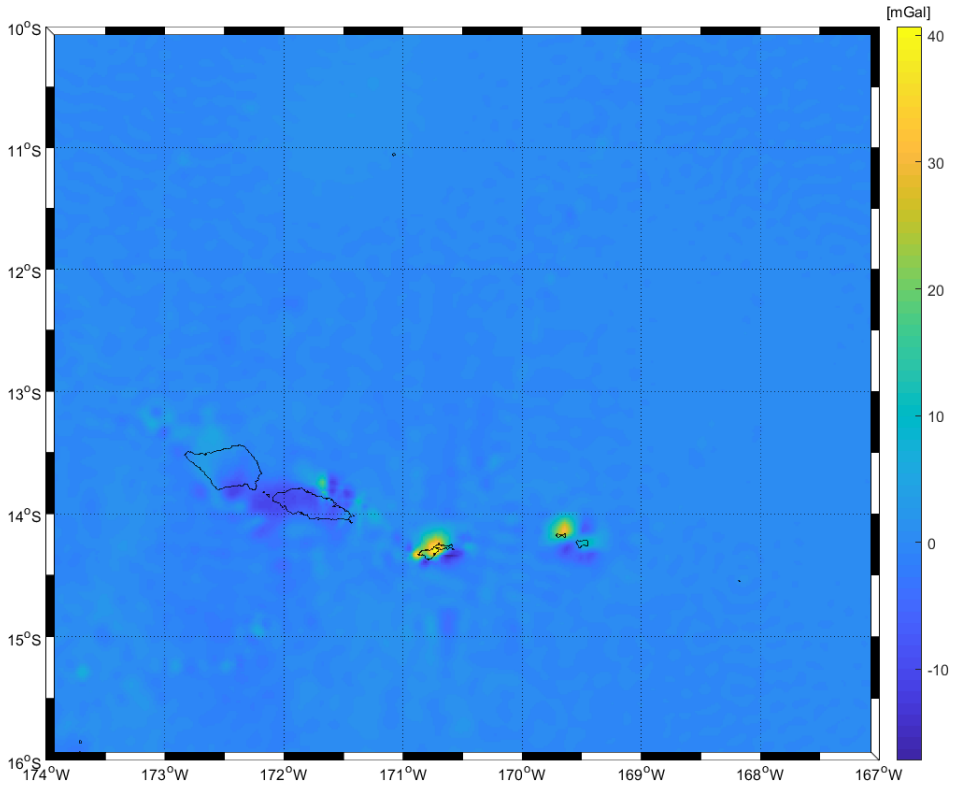

Figure 3: American Samoa Residual Gravity Anomaly Grid

RTM Effects:

A residual terrain model was used to determine and remove the power in the residual gravity field from 5′ to 3″. Due to the lack of gravity data over the Samoan islands and considering that it is mostly oceanic areas, we did not use the RTM effect for the American Samoa geoid. The Guam/CNMI geoid had RTM effects applied.

Geoid Results:

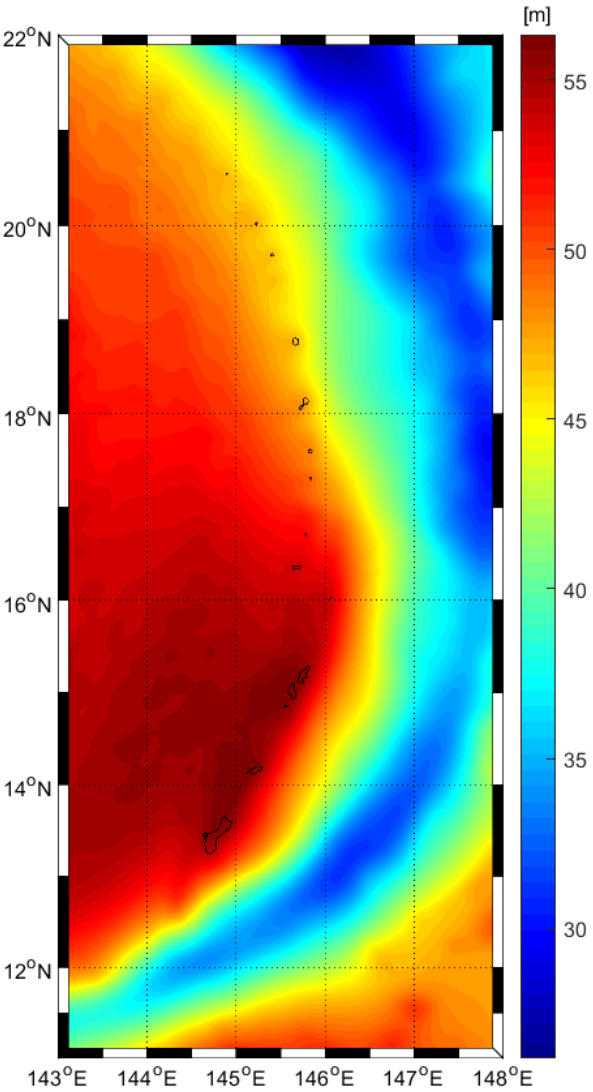

Figure 4: xGEOID18A Guam / CNMI

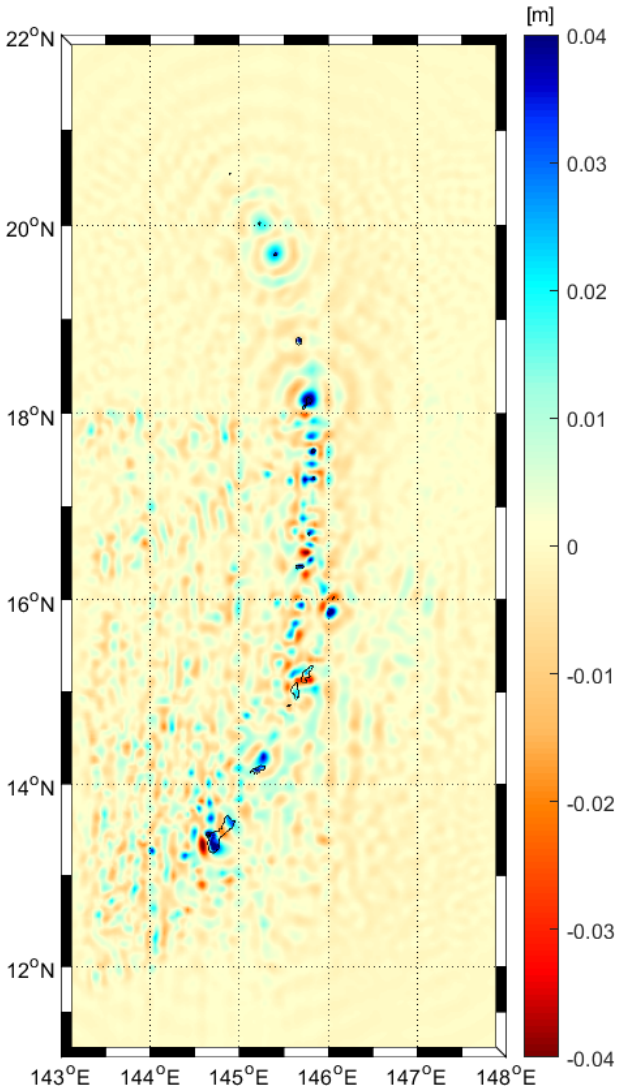

Figure 5: Guam / CNMI Residual Geoid

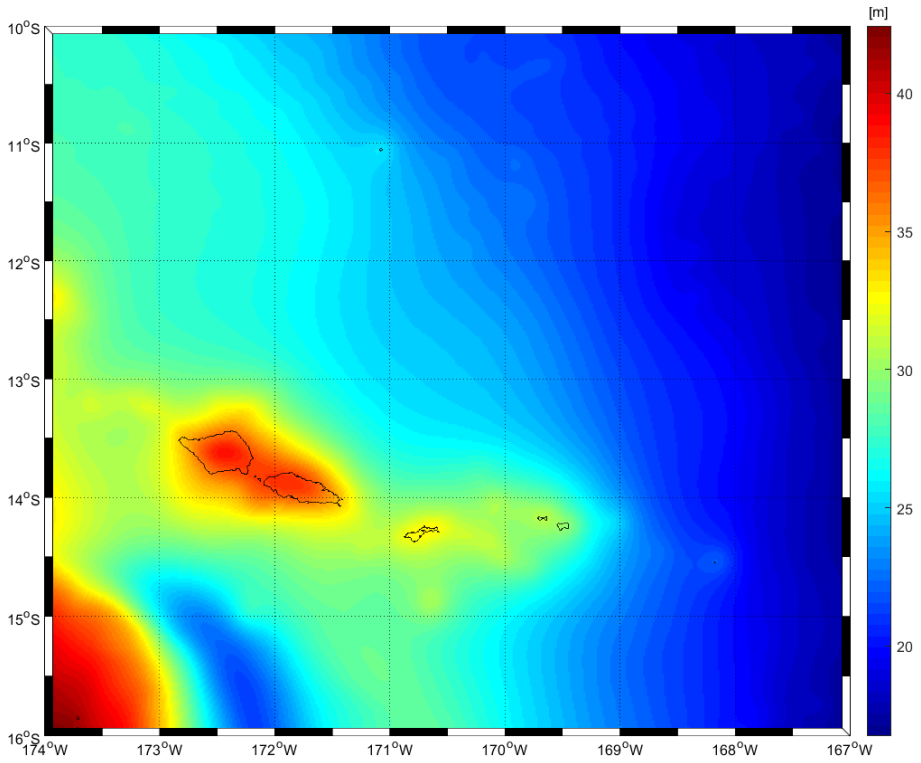

Figure 6: xGEOID18A American Samoa

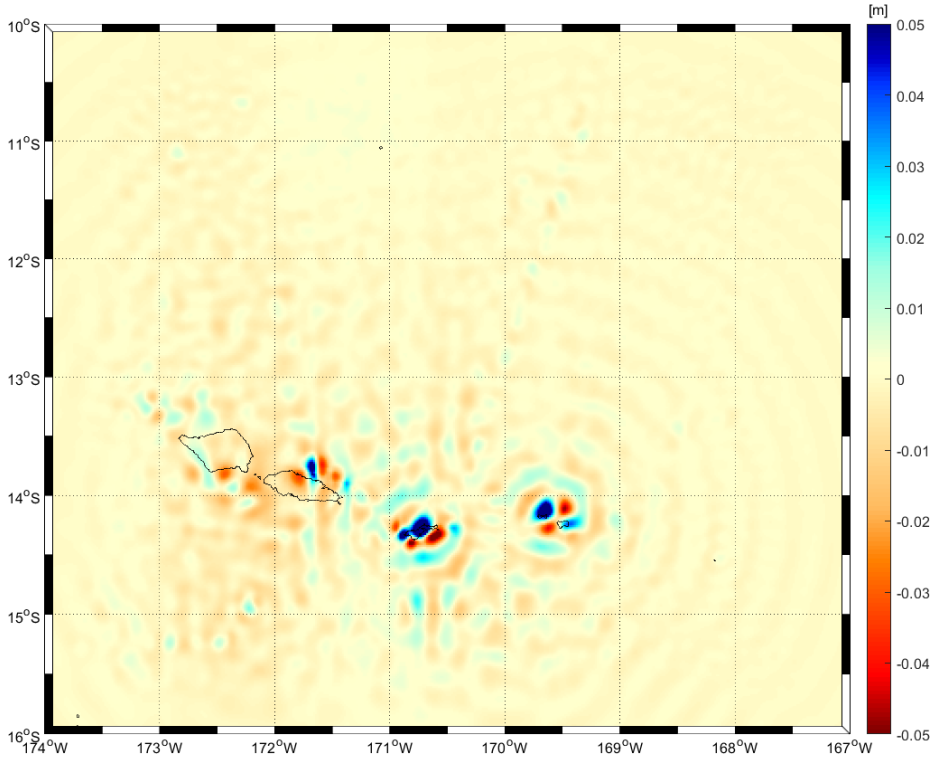

Figure 7: American Samoa Residual Geoid