Technical Details for xGEOID17 Models

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GRAV-D Airborne Gravity Contribution

The xGEOID17A and xGEOID17B models are identical except that xGEOID17B includes the available GRAV-D airborne gravity data. The difference between the two models shows the contribution of the airborne gravity data to the geoid models. Since the differences are only in areas where the GRAV-D airborne gravity data has been used, examining the regional plots given below will illustrate the varying levels of improvement due to GRAV-D, seen in different parts of the country.

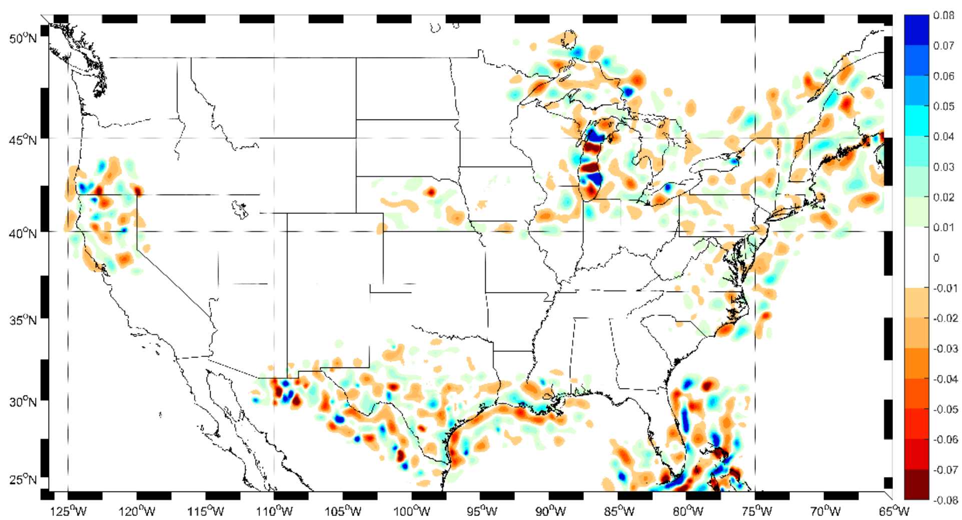

Figure 1. CONUS - Contribution of GRAV-D airborne gravity [units in cm]

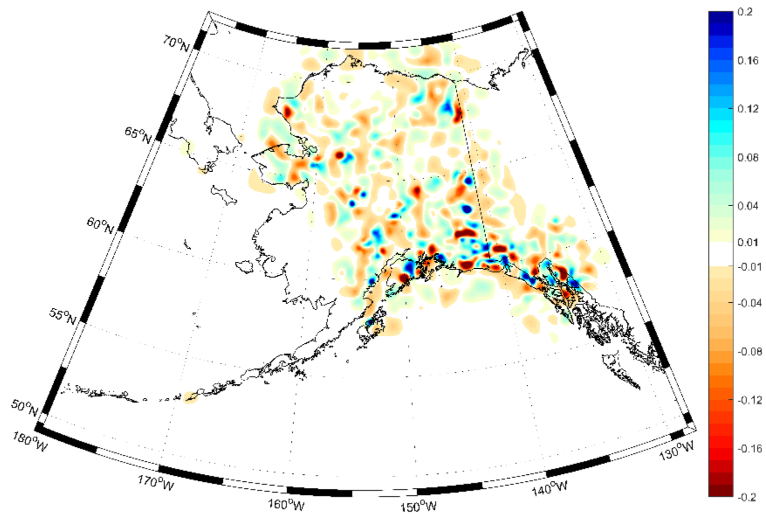

Figure 2. Alaska - Contribution of GRAV-D airborne gravity [units in cm]

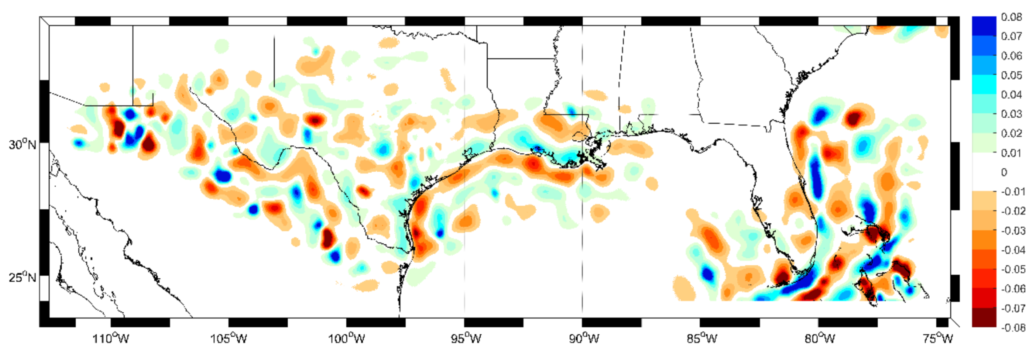

Figure 3. Gulf Coast - Contribution of GRAV-D airborne gravity [units in cm]

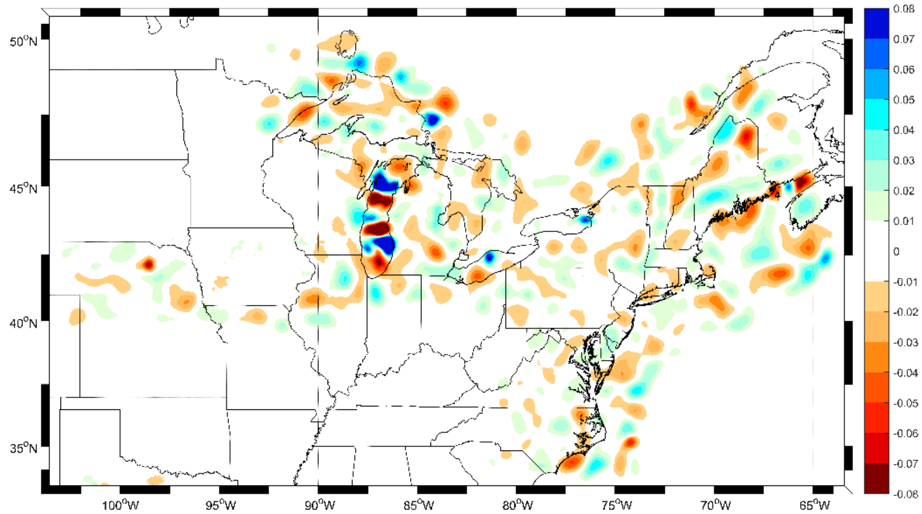

Figure 4. Northeast - Contribution of GRAV-D airborne gravity [units in cm]

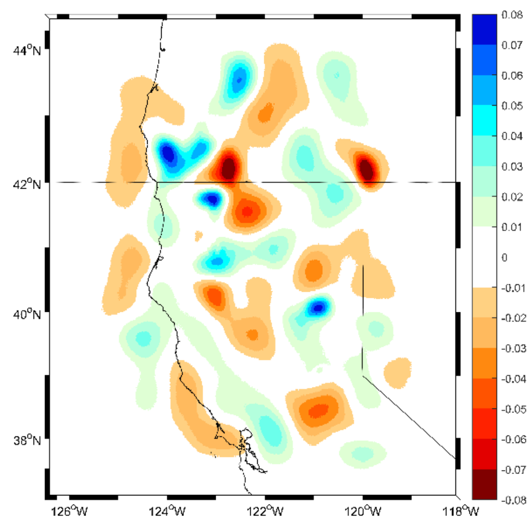

Figure 5. Pacific Coast - Contribution of GRAV-D airborne gravity [units in cm]

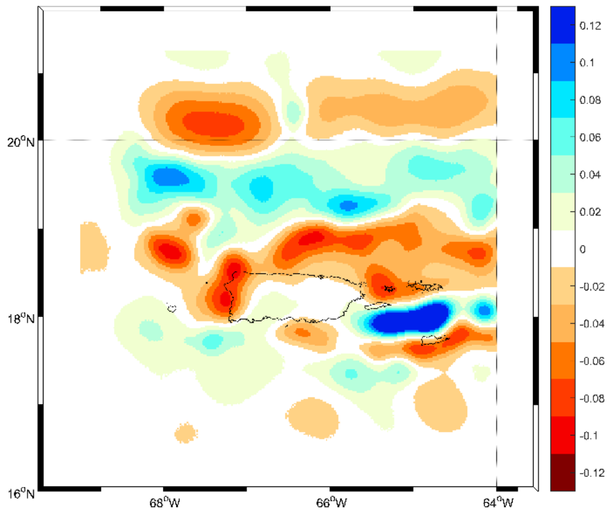

Figure 6. Puerto Rico/U.S. Virgin Islands - Contribution of GRAV-D airborne gravity [units in cm]

Figure 1 to Figure 6 show the contribution of GRAV-D airborne gravity in CONUS, Alaska, Gulf of Mexico region, states in the Northeast, Pacific Coast, and Puerto Rico/Virgin Islands. The contribution of airborne gravity can reach decimeters in areas where there is no terrestrial gravity data or terrestrial data of low quality, such as in Alaska and Lake Michigan. In areas with good gravity coverage and quality, the addition of the GRAV-D airborne gravity data causes changes that are at the centimeter level.

Creation of xGEOID17A

The data sets used for computation of xGEOID17A are different from the previous experimental geoid models, and are as follows:

- GOCO05S satellite gravity model (Mayer-Gürr et al. 2015)
- NGA terrestrial gravity data provided by the National Geospatial-Intelligence Agency (NGA) covers the area $10^\circ \leq$ latitude $\leq 85^\circ$; $190^\circ \leq$ longitude $\leq 310^\circ$.
- NGS terrestrial gravity data: supplemental coverage where NGA data was not present
- Altimetric gravity anomaly DTU13 (Andersen et al. 2015)
- 3″ digital elevation model (Li et al. 2008)

The terrestrial gravity data was separated by survey numbers and de-biased using the satellite gravity model GOCO05S. This procedure works only for surveys in comparable spatial distribution to the spatial resolution of satellite gravity model (100 km). For surveys covering smaller areas, a local Radial Basis Function (RBF) was used in a second de-biasing step. Figure 7 shows the estimated biases. The large surveys whose biases were fixed only with the satellite model GOCO05S are in small black dots. The small surveys whose biases were estimated by the second de-biasing step are illustrated in different colors.

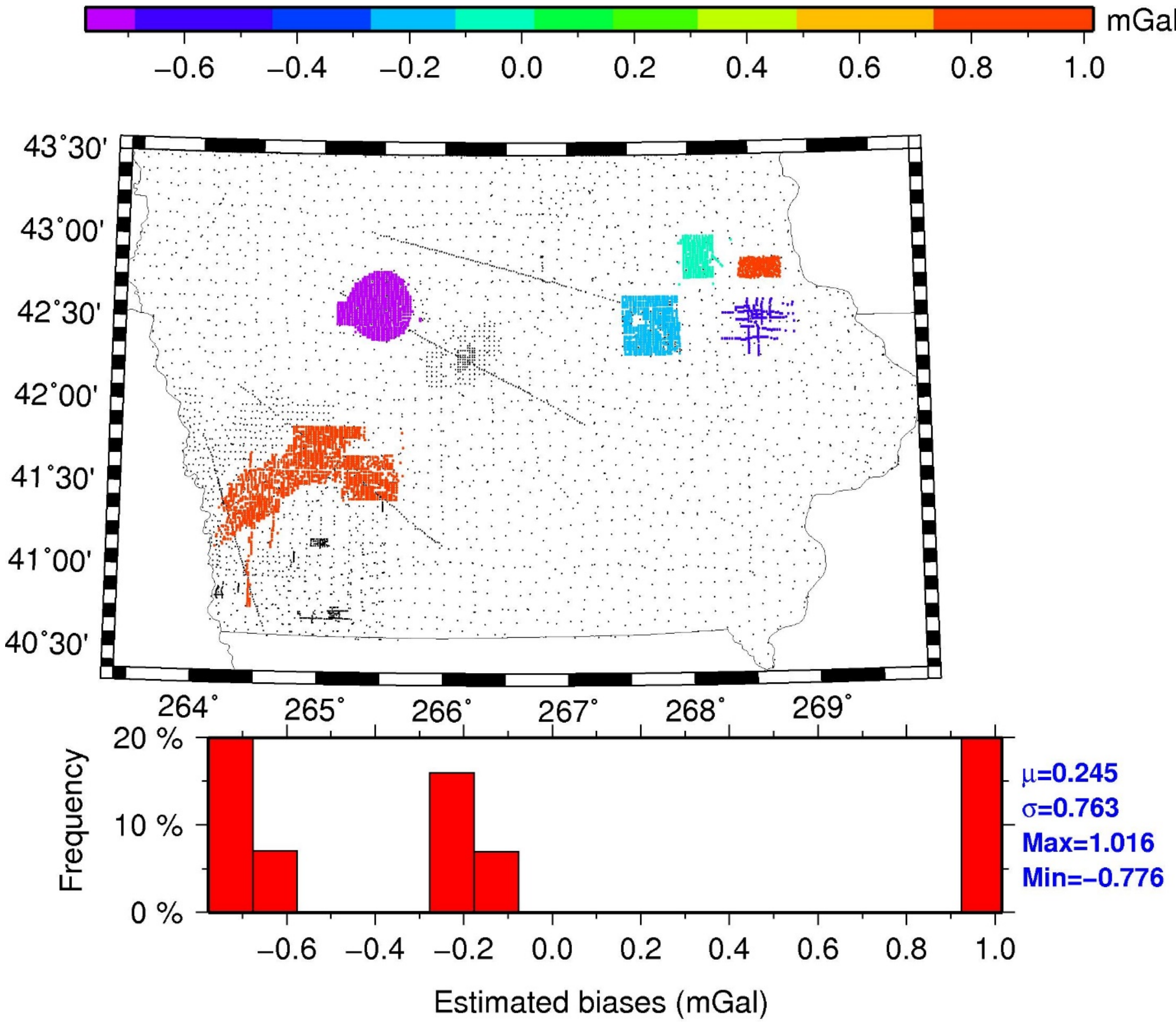

Figure 7. Survey-biases estimated using RBF in the state of Iowa

The de-biased terrestrial gravity data and DTU13 gravity data were then gridded into global 5′x5′ grids of gravity disturbances. Unlike previous xGEOID models, the EGM2008 (Pavlis et al., 2012) model was not used as a reference model. Instead, a new reference model was computed without using the g_1 term for the gravity anomalies reduction. The reduction was done using the spherical harmonic analysis and the downward continuation of the gravity anomalies to the reference ellipsoidal in an iterative way. Harmonic analysis of this downward continued gravity anomaly grid yielded a spherical harmonic gravitational model (N_{max}= 2190). This model was then combined with GOCO05S spectrally, yielding the final reference model for xGEOID17A. This final model was designated 'REF17A'. Noticeable differences in the gravity disturbances between the two spherical harmonic coefficients models can be seen in mountainous areas in Figure 8.

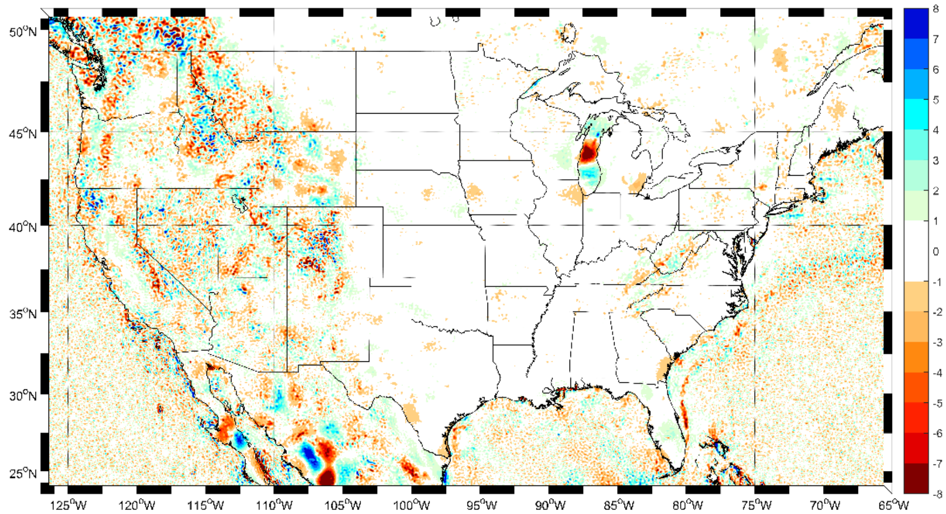

Figure 8: REF17A - EGM2008 Free-Air Disturbances [units in mGal]. Differences are caused by different downward continuation procedures over land areas, whereas differences in ocean areas are caused by differences in satellite altimetric gravity models: DTU10 and DTU13.

Additionally, a 1′x1′ reference gravitational geoid was computed from the REF17A model, using the same procedure that was used for the EGM2008 gravimetric geoid.

The REF17A reference model was then combined with the NGA and NGS terrestrial data, in a classic remove-compute-restore approach (Wang et al. 2012). In this particular case, the REF17A gravity anomalies were subtracted from the terrestrial gravity anomaly station values, yielding residual gravity anomalies, where the high frequency terrain effects that are beyond the REF17A resolution were also removed by a Residual Terrain Model (RTM) (Forsberg 1984). Data used for the RTM computation are the combined digital elevation (Li et al. 2008) from Shuttle Radar Topography Mission (SRTM) (Farr et al. 2007) and the digital elevation version 2 of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), (Tachikawa et al. 2011). To avoid spectral power overlap between the terrestrial gravity data and the topographic effect, the RTM gravity anomaly was expanded into a spherical harmonic series to degree and order 2160, and then removed from the RTM effects. These residual gravity anomalies were then gridded onto a 1′x1′ grid, and then simultaneously filtered and converted to residual geoid heights using a spherically-banded ($n > 280$) Stokes kernel applied in the space domain. Both the REF17A reference field and the residual RTM effects were then restored to the residual geoid heights. The result was xGEOID17A.

Creation of xGEOID17B

The xGEOID17B model was created in a nearly identical way as xGEOID17A, except for the inclusion of the NGS GRAV-D airborne gravimetry. Thus xGeoid17B was comprised of:

- GOCO05S satellite gravity model
- NGA Terrestrial gravity data

- NGS Supplemental terrestrial gravity data
- 3″ digital elevation model
- Altimetric gravity anomaly DTU13 (Andersen et al. 2015)
- GRAV-D airborne gravity data used in xGEOID16. There are a total of 5 new GRAV-D survey blocks that were not used in xGEOID16B: two surveys in Alaska, one survey in Arizona/New Mexico, one survey in Texas, and one survey in Florida.

The general approach for computing the xGEOID17B reference model was the same as for xGEOID17A. The only difference between these two models is that global spherical harmonic gravitational model that supports xGEOID17B, 'REF17B', incorporates the GRAV-D airborne data, whereas REF17A does not. The GRAV-D gravity data was first crossover adjusted, then de-biased using the same method applied to the terrestrial gravity data. The xGEOID17B and xGEOID17A models are almost identical otherwise. REF17B has identical format and spectral resolution to REF17A, and to EGM2008.

The REF17B reference model was then combined with the NGA terrestrial data, in a classic remove-restore approach (Wang et al. 2012). In this step, the REF17B gravity anomalies were subtracted from the NGA terrestrial gravity anomaly station values, yielding residual gravity anomalies, where the high frequency terrain effects that are beyond the REF17B resolution were also removed by a Residual Terrain Model (RTM, Forsberg 1984). Data used for the RTM computation are the combined digital elevation (Li et al. 2008) from Shuttle Radar Topography Mission (SRTM, Farr et al. 2007) and the digital elevation version 2 of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER, Tachikawa et al. 2011). These residual gravity anomalies were then gridded onto a 1′x1′ grid, and then simultaneously filtered and converted to residual geoid heights using a spherically-banded ($n > 280$) Stokes kernel applied in the space domain. Both the REF17B reference field and the residual RTM effects were then restored to the residual geoid heights. The result was xGEOID17B.

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