

PGM2016: A new Geoid Model for the Philippines

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Abstract. In 2014, a preliminary geoid model has been computed for the Philippines i.e., Philippine Geoid Model 2014 (PGM2014), with the technical assistance of the National Space Institute, Technical University of Denmark (DTU-Space) using data from land gravity, airborne gravity, marine satellite altimetry and the newest satellite gravity data from the GOCE mission release 5. Digital terrain models used in the computation process was based on 15" SRTM data. The model is computed in a global vertical reference system then fitted to the ITRF GNSS/Leveling and validated with RMS value of 0.50m. In 2016, the PGM2014 was re-computed into PGM2016 using the reprocessed and densified land gravity data (from 1261 to 2214 points). Significant improvements can be seen in the reprocessed gravity data and GNSS/Leveling (RMS = 0.040m). Further densification of the land gravity (in towns and cities) to 41,000 points will be conducted from 2017 until 2020 to refine the geoid. Re-computation will be done for the new version of the geoid as new gravity data comes in. *GRAVSOFT* system of FORTRAN routines developed by DTU-Space and Niels Bohr Institute, University of Copenhagen was used in computing the Philippine geoid.

Introduction

Vertical coordinates (i.e. Heights) of points are referred to a coordinate surface called Vertical Datum. The universal choice of a vertical datum is the geoid – the reference surface for orthometric and dynamic heights (Vanicek, 1991). It is an equipotential level surface of the oceans at equilibrium, proposed by C.F. Gauss as the “Mathematical figure of the earth” (Dr. Bernhard Hofmann-Wellenhof, 2005).

With the advent of Global Navigation Satellite Systems (GNSS), it has become much easier to estimate Mean Sea Level (MSL) elevations using a geoid model. Applying a geoid model in GNSS surveys will eliminate the conduct of levelling. A geoid model is a surface (N) which describes the theoretical height of the ocean and the zero-level surface on land. In a modern vertical reference system, the geoid is required to obtain orthometric height H (“height above sea level”) from GPS by

$$H = h^{GPS} - N \quad (1)$$

Where h^{GPS} is the GPS ellipsoidal height, and H the levelled (orthometric) height.

In the Philippines, determination of elevation H of points and Benchmarks (BMs) was normally conducted thru Geodetic Levelling, a tedious process that hinders the densification of BMs during the early times.

The first attempt of computing a preliminary gravimetric geoid for the Philippines is through the Natural Resources Management Development Project (NRMDP) in 1991. Land gravity data and altimetrically-derived anomalies at sea and OSU89A to degree and order 360 (reference global model) were used. Biases between the gravimetric N and GPS/Levelling were found ranging from 2-6 m nationwide (Kearsley, 1991). Figures 2 and 3 shows the computed detailed geoids of the Philippines.

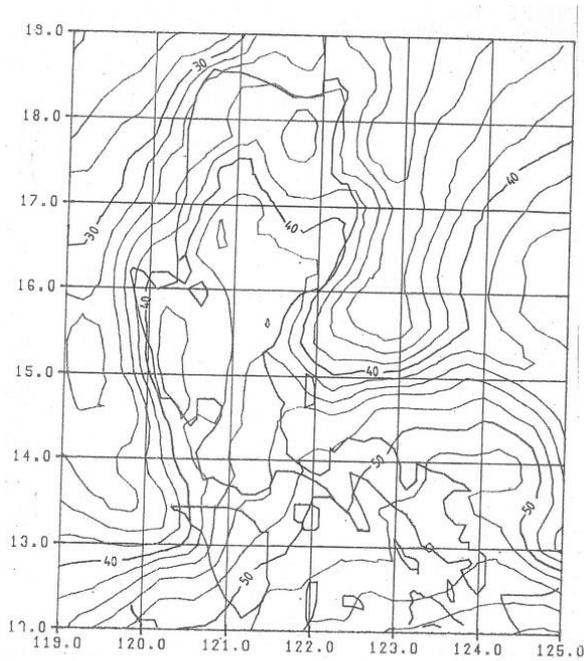


Figure 3.12 : Detailed Geoid of Northern Philippines.

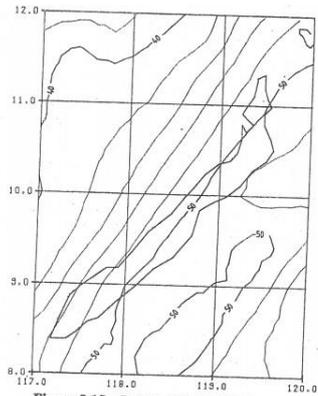


Figure 3.15 : Detailed Geoid of Palawan.

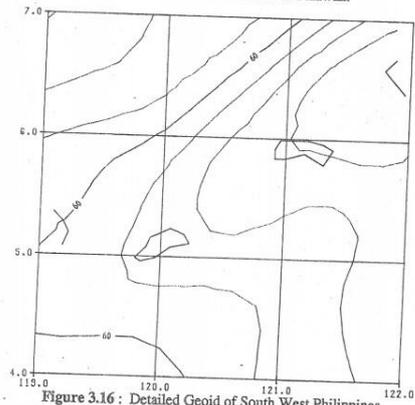


Figure 3.16 : Detailed Geoid of South West Philippines.

Figure 2. Detailed geoids of Northern (left) and Palawan with South West Philippines (right)

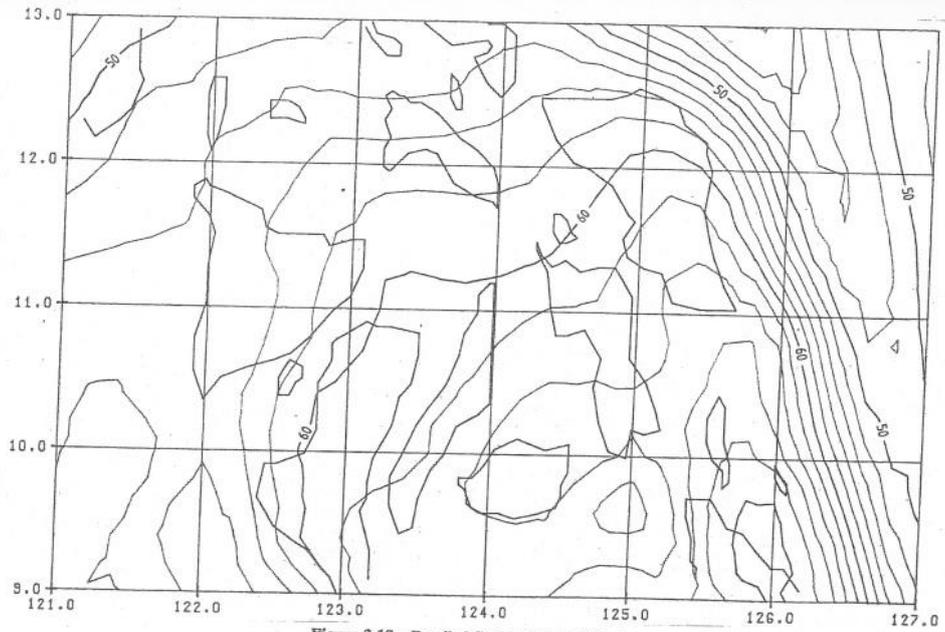


Figure 3.13 : Detailed Geoid of Mid- Philippines.

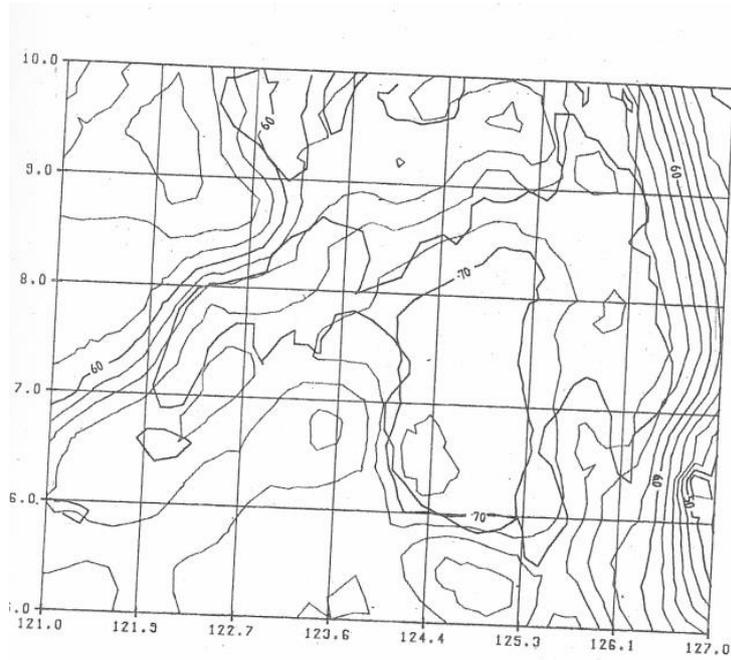


Figure 3.14 : Detailed Geoid of Southern Philippines.

Figure 3. Detailed geoid of Visayas and Mindanao

The making of Philippine Geoid Model 2016 (PGM2016)

In October 28, 2014 with the technical assistance of National Space Institute -Denmark Technical University (DTU-Space) and funding from National Geospatial Intelligence Agency (NGA), a preliminary geoid model, Philippine Geoid Model 2014 (PGM2014) has been computed for the country using the data from land gravity, airborne gravity, marine satellite altimetry and the newest satellite gravity data from the GOCE mission release 5 with an accuracy of 0.30meters. In this paper, the computation of the PGM2014 will be discussed then its re-computation into PGM2016.

The airborne gravity survey

The success of the first long-range airborne gravity survey in Greenland 1991-92 by the group of US Naval research Laboratory, in cooperation with NOAA, NIMA and Danish National Survey paved the way for the use of airborne gravity in filling the intermediate wavelength bands between satellite gravity, e.g. GRACE and GOCE (R. Forsberg & Olesen, 2010) for accurate geoid modelling. There is now full operational capability of collecting seamless airborne gravity data across land and marine areas at 1-2 mGal r.m.s. accuracy and at around 4-6 km resolution due to the new gravity acceleration sensors and improved GPS processing methods.

After their successful airborne gravity campaigns in the other regions of the world (e.g., Malaysia, Mongolia, Ethiopia, South Korea, Nepal), DTU-Space conducted the airborne gravity survey in the Philippines on March until May of 2014 using a Cessna Caravan aircraft. This is part of the project to improve the global gravity field model EGM2008 under the umbrella of the NGA - Danish Geodata Agency BECA agreement. Figures 4 and 5 shows the aircraft used in the Philippine airborne gravity survey and its cabin layout respectively.

The following instruments were used:

- LaCoste and Romberg Air/Sea gravimeter S-38
- Chekan AM gravimeter #24
- Javad Lexon GPS receiver
- Javad Delta GPS receivers
- Novatel dual frequency aircraft GPS antenna
- Power rack with DC/AC inverters, UPS etc.

GPS reference stations operated in all airports together with active geodetic stations of NAMRIA were used as base stations in computing the position of the aircraft. AUSPOS online positioning provides the coordinates of the reference stations (in ITRF2008) with an estimated accuracy of 0.50 to 2cm in vertical. Aircraft trajectories were computed with waypoint software package from Novatel (Calgary, Canada) using precise ephemeris from International GNSS Service (<http://igscb.jpl.nasa.gov/>). Parking spots were tied to NAMRIA first order gravity stations using Scintrex CG-5 gravimeter.

Mean altitude for all flights was 3185m with a terrain clearance of 545m above mountains and 3760m in lowlands. Figure 6 shows the color-coded flight track elevations.



Figure 4. The Cessna Grand Caravan aircraft used in the airborne survey



Figure 5. Cabin layout in the Cessna Caravan aircraft. To the right, the LCR gravimeter and behind it the Chekan meter

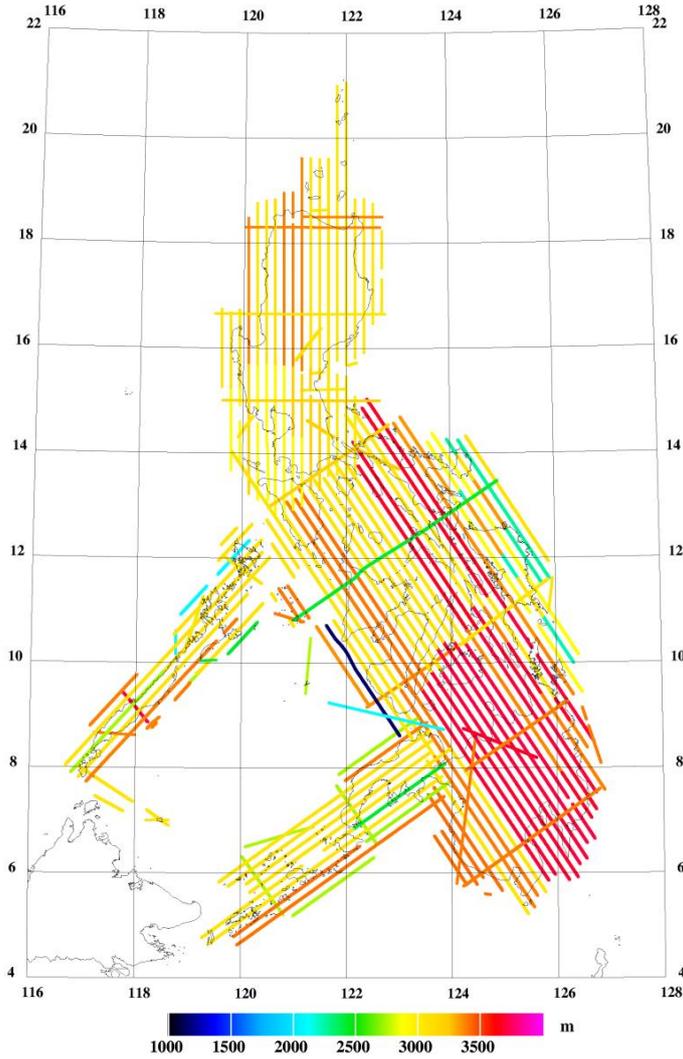


Figure 6. Flight track elevations of the airborne gravity survey

Free –air gravity anomalies at aircraft level are obtained from:

$$\Delta g = f_z - f_{z0} - h'' + \delta g_{eotvos} + \delta g_{tilt} + g_0 - \gamma_0 - \left(\frac{\partial \gamma}{\partial h} (h - N) + \frac{\partial^2 \gamma}{\partial h^2} (h - N)^2 \right) \quad (2)$$

Where f_z is the gravimeter observation, f_{z0} the apron base reading, h'' the GPS vertical acceleration, g_{eotvos} the Eotvos correction computed by the formulas of Harlan (Harlan, 1968), g_0 the apron gravity value, γ_0 normal gravity, h the GPS ellipsoidal height and N the geoid undulation from EGM08 2.5x2.5 minutes, γ_0 and the second order height correction is based on GRS80 definitions (Moritz, 1980). All altitude dependent atmospheric correction has been applied, see e.g. Hintze, et al. 2005. The platform off-level correction g_{tilt} is based on a platform modelling approach described in (Olesen, 2002). All data were filtered with a symmetric second order Butterworth filter with a half power point at 170 seconds, corresponding to a resolution of 6km (half-wavelength).

Apron base readings were performed each day after the flight and approximately every second day before the flight to monitor drift of the gravimeter and for proper connection of airborne readings to the gravity network.

Figures 7 and 8 shows the gridded and acquired free air anomalies at flight altitude. Colour agreement at cross lines indicate consistent data. Closer examination of the misfit in the 289 line intersections shows a 3.7 mGal RMS error indicating 2.6 mGal average noise level.

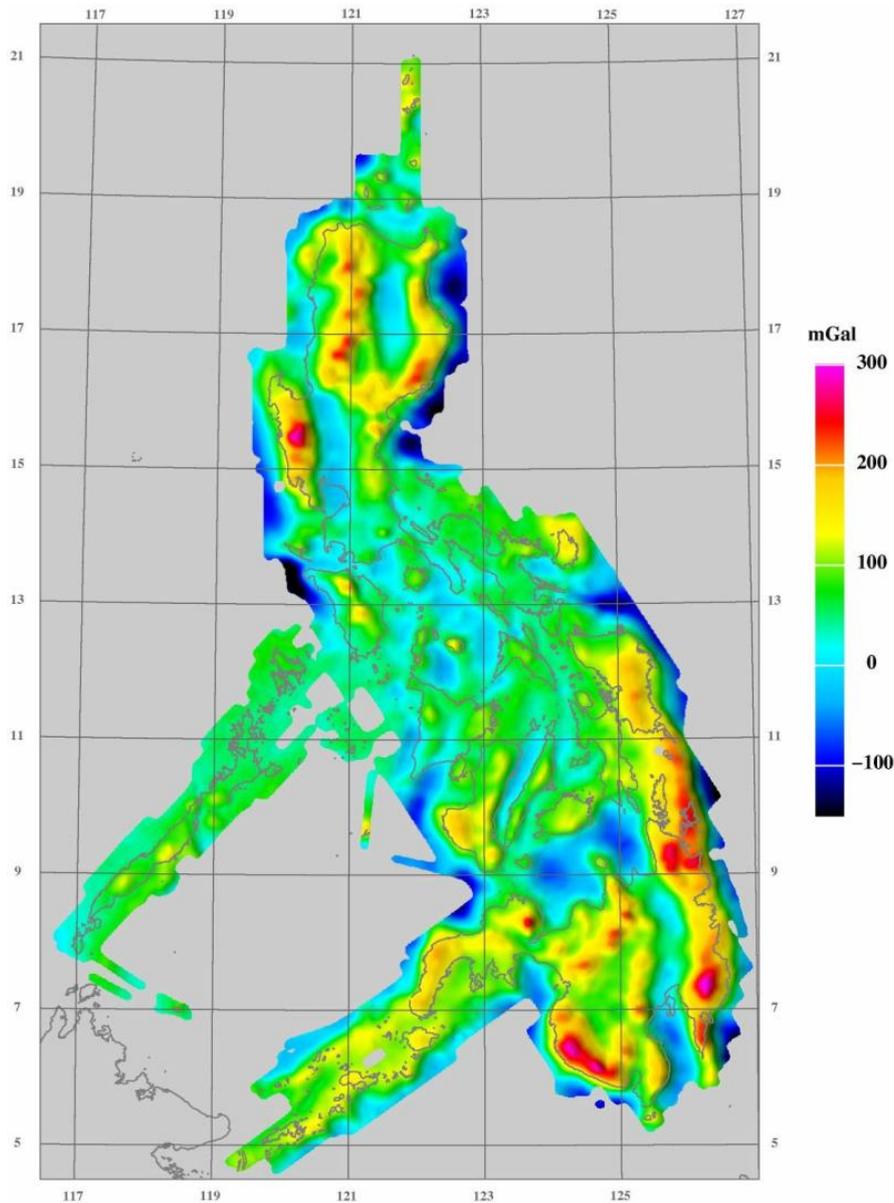


Figure 7. Free air anomalies gridded and with artificial shade highlighting short wavelength features

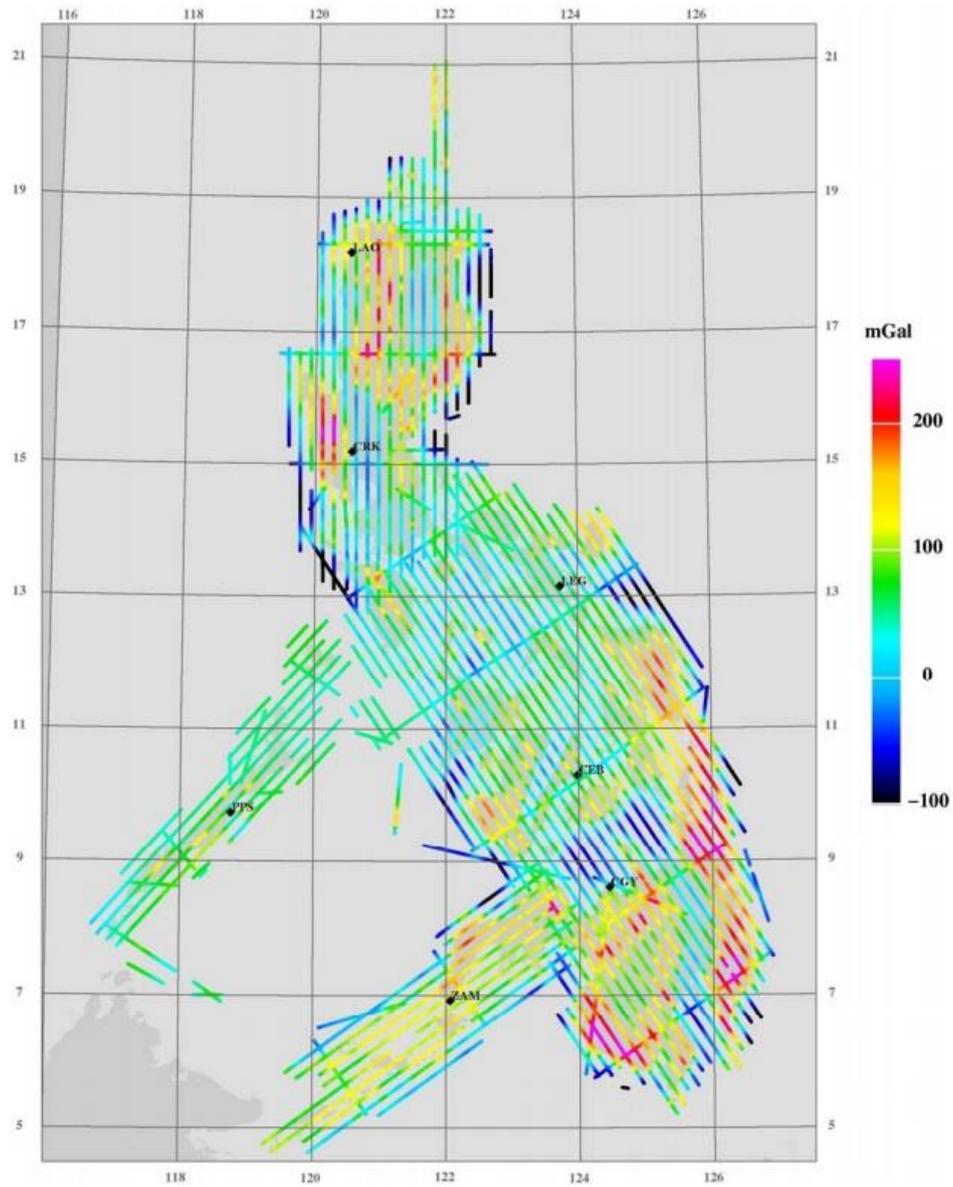


Figure 8. Free air anomalies at altitude

Comparison to EGM08 shows significant differences in many places amounting to more than 130mGal over SE Mindanao, see Table 1 and figures 9 and 10.

Table 1. Data statistics and residuals

Unit: mGal	Mean	Std. Dev.	Minimum	Maximum
Airborne	66.3	65.7	-168	293
GOCE R5-Direct residuals	3.2	41.6	-126	191
EGM08 residuals	1.1	15.6	-56	135

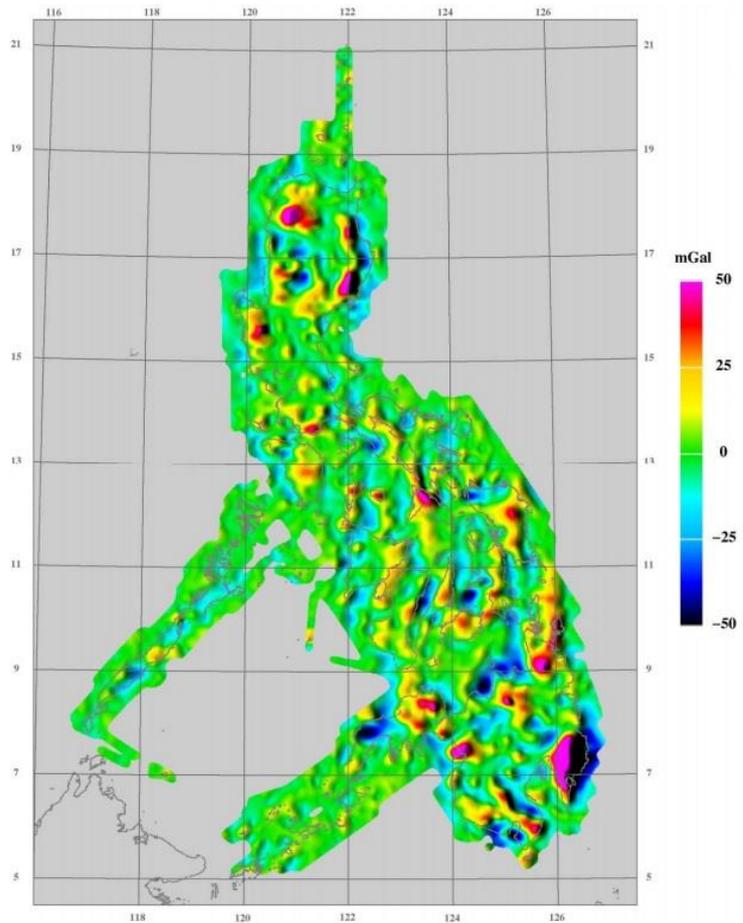


Figure 9. EGM08 residuals at altitude

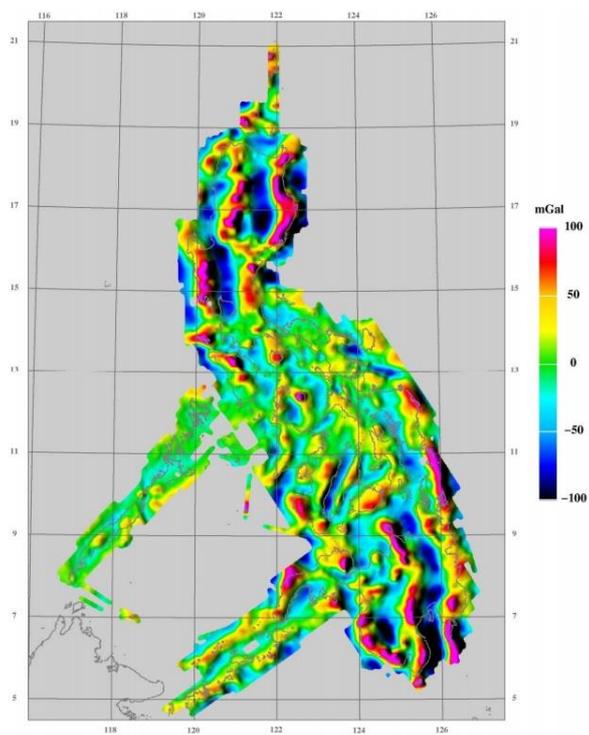


Figure 10. GOCE R5-Direct residuals at altitude.

Gravimetric geoid computation - principles

The PGM2014 is computed by the *GRAVSOF*T system, a set of Fortran routines developed by DTU-Space and Niels Bohr Institute, University of Copenhagen (Forsberg R, 2008). It forms the base of major recent geoid computation projects, such as the joint Nordic “NKG” geoid models, undertaken as joint geoid model computations of the Nordic and Baltic countries (R. Forsberg, D. Solheim & J. Kaminskis, 1996) under the auspices of the Nordic Commission for Geodesy (NKG), as well as the OSGM02 geoid model of the UK and Ireland (R. Forsberg et al., 2002), and several national geoid models done from airborne surveys in recent years (Malaysia, Mongolia, Indonesia and others).

The “remove-restore” technique was used in computing the geoid, where a spherical harmonic earth geopotential model (EGM/GOCE combination) is used as a base. The geoid is divided into three parts namely: the global contribution N_{egm} , a local gravity derived component N_2 , and a terrain part N_3 .

$$N_{grav} = N_{egm} + N_2 + N_3 \quad (3)$$

The Remove – Restore Steps as illustrated by PAHLEVI, PANGASTUTI, SOFIA, and KASENDA (2015) are:

Remove Steps: Gravity measurement data is subtracted with global gravity anomaly and surface correction, $\Delta g_{res} = \Delta g_{FAA} - \Delta g_{egm/goce} - \Delta g_{terrain}$

1. Extract gravity anomaly from the spherical harmonic model to produce $\Delta g_{egm/goce}$ (Long wavelength)
2. Extract gravity anomaly from SRTM data to produce $\Delta g_{terrain}$ (short – medium wavelength)
3. Subtract gravity anomalies $\Delta g_{egm/goce}$ and $\Delta g_{terrain}$ from Δg_{FAA} (measured gravity) to get Δg_{res}
4. Apply FFT to Δg_{res} to obtain geoid residuals ΔN_{res}

Restore Steps: Geoid residuals summed with global geoid undulation and indirect effect, resulting to geoid height (Undulation), $N_{geoid} = \Delta N_{res} + \Delta N_{egm/goce} + \Delta N_{terrain}$

1. Compute global geoid undulation from egm/goce $\Delta N_{egm/goce}$
2. Compute the terrain part $\Delta N_{terrain}$ from SRTM data
3. Sum up ΔN_{res} (from remove steps), $\Delta N_{egm/goce}$, and $\Delta N_{terrain}$ to obtain N_{geoid}

The spherical harmonic expression as a function of latitude, longitude and height is of the form:

$$N(\phi, \lambda, r) = \frac{GM}{R\gamma} \sum_{n=2}^N \left(\frac{R}{r}\right)^n \sum_{m=0}^n (C_{nm} \cos m\lambda + S_{nm} \sin m\lambda) P_{nm}(\sin\phi) \quad (4)$$

where G , M and γ are earth parameters. The EGM08/GOCE combination model used involves more than 4 million coefficients C_{nm} and S_{nm} derived from very large set of global satellite data and regional (average) gravity data from all available sources, both open-file and classified, for details see <http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/index.html>.

The EGM08 model is incorporating GRACE satellite data, which determines the error spectrum of the EGM08 up to spherical harmonic degree 80 or so. New satellite data from the GOCE mission have recently been made available by the European Space Agency, for details see www.esa.int/goce. The latest GOCE spherical harmonic model ("Direct" Release 5 model), complete to degree and order 280 was used to update EGM08 field in the following way:

- EGM08 used unchanged in spherical harmonic orders 2-80, and from 200 up
- GOCE R5 direct model used in band 90-180
- A linear blending of the two models done in bands 80-90 and 180-200

The mixed spherical harmonic model (termed EGM08/GOCE) has been used to spherical harmonic degree $N = 720$, corresponding to a resolution of 15' or approximately 28 km. From the recent DTU geoid projects in France (Auvergne), Malaysia, and Nepal, this resolution appears to be a good "trade off" between the full resolution of EGM08 (degree 2160) and the local gravity data. Because the full-resolution gravity data used in the construction of EGM08 is classified, there is no good information on the quality of the errors in EGM08 at the high wavelengths in SE Asia, and only 15' mean gravity data are assumed to be underlying EGM08. All spherical harmonic computations were done in a grid using the *geocol17* program in grid mode.

The terrain part of the computations were based on the RTM method, where topography is referred to a mean elevation level, and only residuals relative to this level is taken into account. The mean elevation surface were derived from the SRTM 15" detailed model through a moving average filter with a resolution of approximately 20' (37 km; slightly longer than the 15' data resolution implied by spherical harmonic degree 720, in order to have a more smooth residual gravity signal Δg_2). The difference in resolution between reference field and RTM is *not* a theoretical issue, as the remove-restore method takes any "double accounted" topography into account fully.

The method for the gravimetric geoid determination is *spherical FFT with optimized kernels*. This is a variant of the classical geoid integral ("Stokes integral"), in which there is a proper weighting of the long wavelengths from EGM08 and the shorter wavelengths from the local gravity data. Mathematically it involves evaluating convolution expressions of form

$$N_2 = S_{ref}(\Delta\varphi, \Delta\lambda) * (\Delta g_2(\varphi, \lambda) \sin\varphi) = F^{-1} \left(F(S_{ref}) F(\Delta g \sin\varphi) \right) \quad (5)$$

Here S_{ref} is a modified “Stokes” kernel, $\Delta g_2 = \Delta g - \Delta g_{egm}$ is the EGM08/GOCE-reduced free-air gravity anomalies, and F is the 2-dimensional Fourier transform operator. For details see references (R. Forsberg, D. Solheim & J. Kaminskis, 1996), (R. Forsberg et al., 2002) and (R. Forsberg & Olesen, 2010).

The geoid is computed on a grid of $0.025^\circ \times 0.025^\circ$ resolution (corresponding to roughly 2.7×2.5 km grid). The area of computation is 04° - 22° N and 112 - 128° E, covering the Kalayaan Islands of West Philippine Sea. Computations was based on least squares collocation and Fast Fourier Transformation methods which involve 1440×1280 grid points corresponding to 100% zero padding. The data are gridded and downward continued by least squares collocation using the planar logarithmic model. GRAVSOFTE programs such as *gpcol1*, *spfour*, *gcomb*, *geoip* are involved in the process. Figure 11 shows the PGM 2014 at 5m contour.

The final gravimetric geoid solution was computed by the following steps:

- Subtraction of EGM08GOCE spatial reference field (in a 3-D “sandwich mode”)
- RTM terrain reduction of surface gravimetry, after editing for outliers
- RTM terrain reduction of airborne gravimetry
- Reduction of DTU-10 satellite altimetry in ocean areas away from airborne data
- Downward continuation to the terrain level and gridding of all data by least-squares collocation using a $1^\circ \times 1^\circ$ moving-block scheme with 0.6° overlap borders
- Spherical Fourier Transformation from gravity to geoid
- Restore of RTM and EGM08GOCE effects on the geoid
- Correction for the difference between quasigeoid and geoid (using a Bouguer anomaly grid)
- Shifting of the computed geoid by +80 cm to approximately fit to Manila tide gauge datum

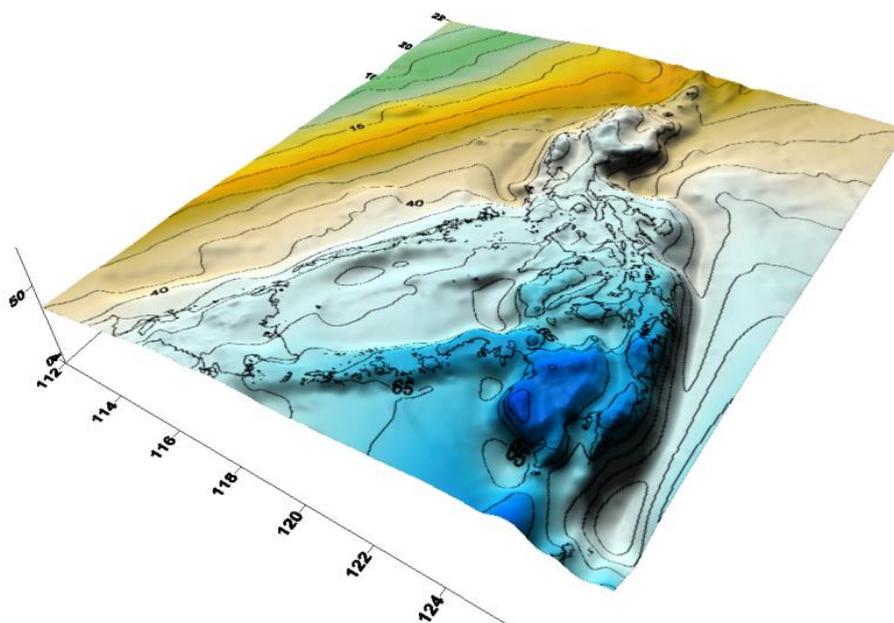


Figure 11. The Preliminary Philippine Geoid 2014 (PGM2014). Contour interval 5m

Data used and Quality Control for the geoid computation

The PGM 2014 is based on the following data:

- Airborne gravity data
- Land gravity from NAMRIA, reformatted to GRAVSOFIT and mildly edited
- DTU10 global gravity anomalies from multi-mission satellite altimetry
(Selected only in the open ocean area, away from the airborne gravity)
- SRTM 15" DEM data for the region
- EGM08 and GOCE RL5 satellite data

Some plots of the used and processed data are shown in the Figs. 12-14 below.

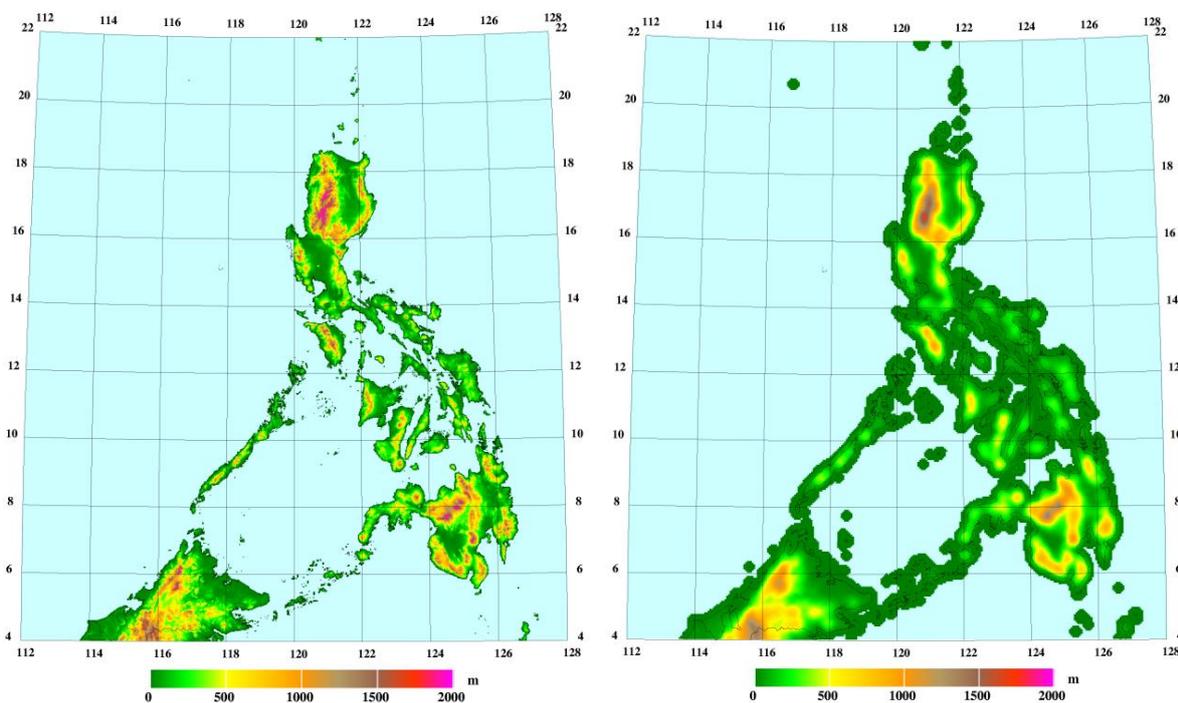


Figure 12. SRTM DEM data (left); low-pass filtered mean elevation surface (right), used as reference in RTM terrain reductions. Elevations in meters. Ocean depths are not used in the Philippines geoid computations.

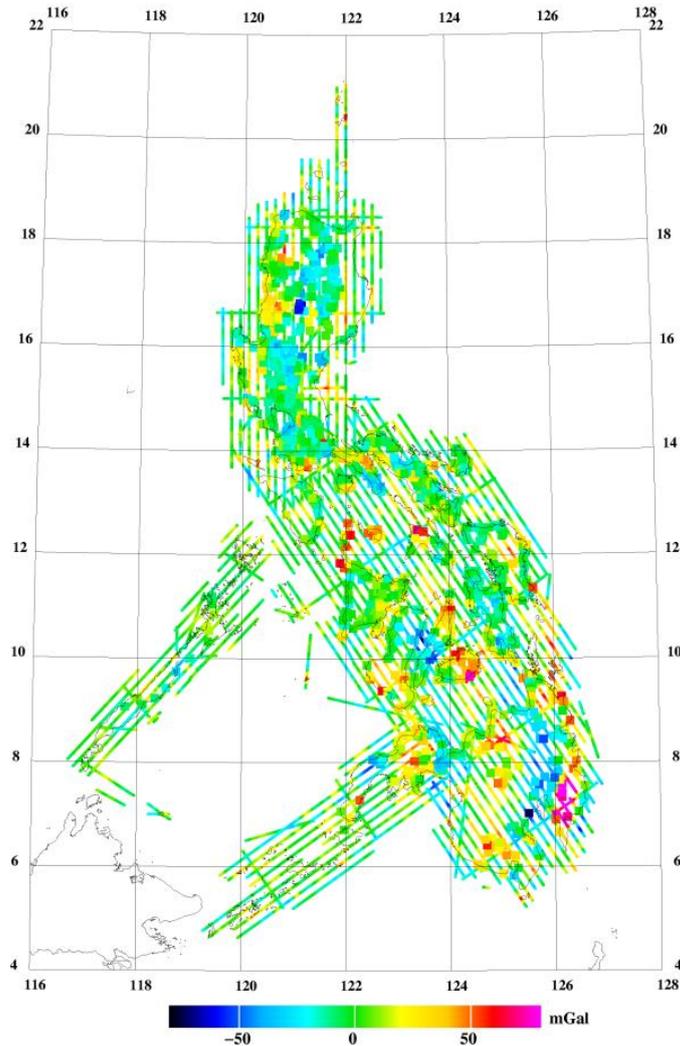


Figure 13. NAMRIA land gravity data and the airborne gravity data after terrain and EGM-reduction. Some outliers were deleted in the geoid processing.

The available data from the airborne and surface sources were quality controlled through plotting of the EGM08/GOCE and terrain reduction residuals, showing a few (< 1%) obvious surface gravity outliers, which were deleted in the final geoid processing. The overall EGM/GOCE and RTM terrain “reduce” statistics for the data are shown in Table 2. Overall this statistics is good, with relatively small bias and standard deviation for all data sets.

Table 2. Statistics of remove steps in the PGM2014 computation (mGal)

Unit: mGal	Mean	Std.dev.
NAMRIA edited land gravity data (1261pts)	8.7	24.7
- above minus EGM08GOCE and RTM	0.9	21.4
Airborne gravity data (58515 pts)	1.5	20.7
- above minus EGM08GOCE and RTM	1.6	18.6
DTU10 altimetry gravity (28841 selected pts)	-9.6	12.3
- above minus EGM08GOCE and RTM	-0.3	10.8

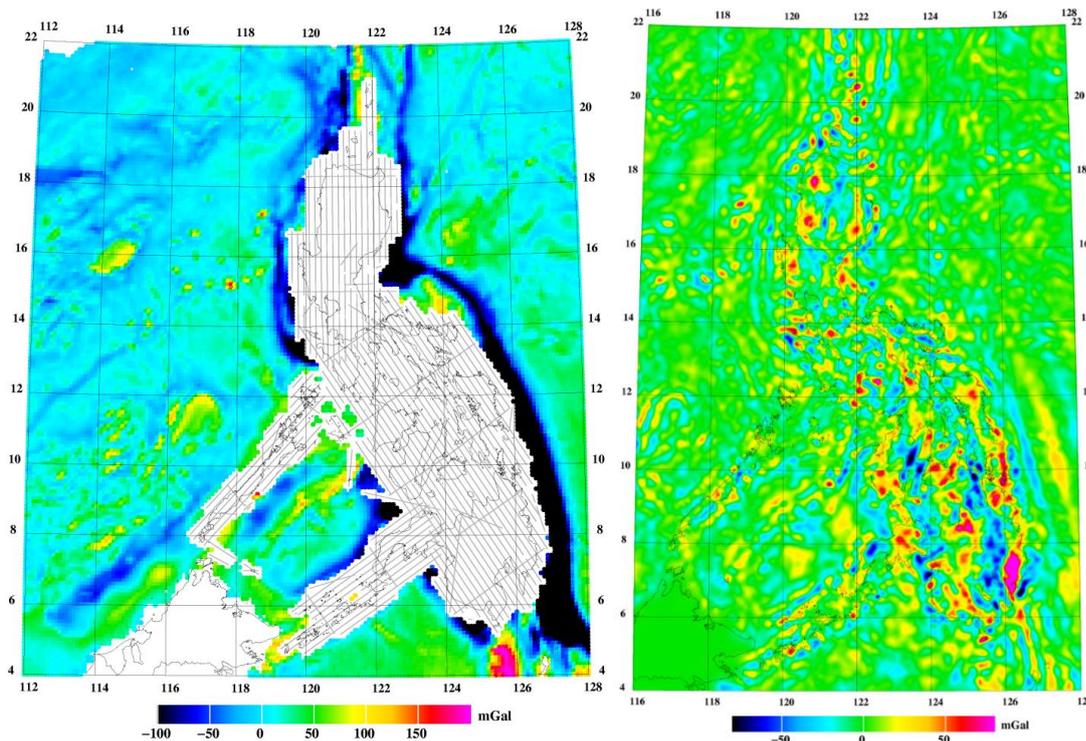


Figure 14. The used DTU-10 satellite gravity (left), and the collocation downward continued merged grid (right)

Geoid processing results

The plots in the sequel shows the intermediate results of the final remove-restore geoid processing (“*geoid.gri*”), computed with full 3-dimensional modelling, going via the quasigeoid to the classical, final geoid.

The final geoid covers the region 4-22°N, 112-128°E, and has a resolution of 0.025° x 0.025°. The airborne and surface gravity data were gridded by spatial least squares collocation (*gpcol1*, using covariance parameters $\sqrt{C_0} = 18 \text{ mgal}$, $D = 6 \text{ km}$, $T = 30 \text{ km}$). A priori errors assumed were 2 mGal for both the airborne data and the surface data (averaged in 0.025° blocks), and 5 mGal for DTU-10. The collocation downward continuation was done in 1° x 1° blocks, with 0.6° overlaps.

For the spherical FFT transformation of gravity to geoid, 3 reference bands were used. Fig. 15-16 below shows the primary data grids done in connection with the geoid processing. The final geoid “restore” statistics is shown in Table 3.

Table 3. Statistics of the restore quantities on the geoid

Unit: meters	Mean	Std.dev.	Min.	Max.
Reduced geoid (after spherical FFT)	0.00	0.25	-1.61	2.88
RTM restore effects (computed by FFT)	0.00	0.04	-0.23	0.74
Final gravimetric geoid statistics	39.06	18.36	-9.02	76.43

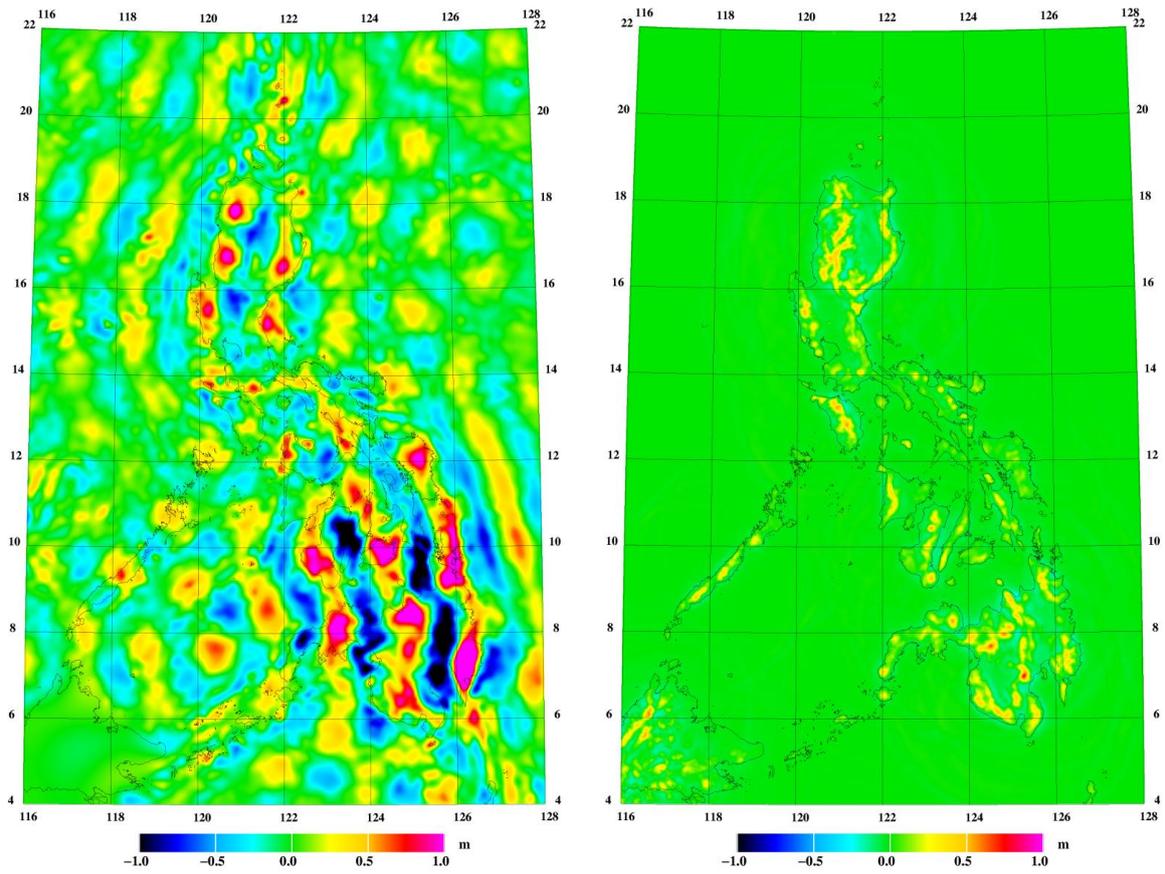


Figure 15. Left: Reduced geoid (after spherical FFT transformation); right: RTM terrain effect on the geoid

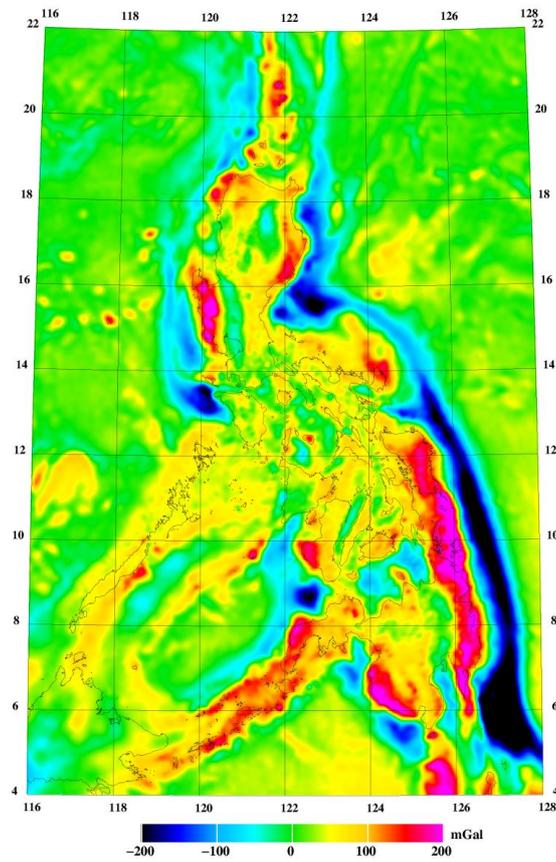


Figure 16. Bouguer anomaly grid, derived from the reduced data. Used for the geoid-quasigeoid estimation

GPS/Levelling data comparison and fitted geoid

A set of 190 GPS data in ITRF2005 levelling benchmarks was used to compare with the final geoid. These GPS data showed large errors relative to the geoid, with large outliers in some regions, likely due to a combination of geodynamic effects, levelling and GPS errors. The rms fit is 0.5 m; it is therefore not possible to use these data for validation of the geoid. Fig. 17 shows the offset values, and the geoid correction surface for a fitted geoid *ph_geoid_fit* (corrector surface gridded with 80 km correlation length, and GPS-levelling apriori error of 10 cm). Fig. 18 shows the PGM2014 comparison to EGM2008; large improvements are seen, especially in the south. Fig. 19 shows a comparison to the DTU10-MSS, i.e. the MDT, shifted by -91 cm to take into account the different reference systems.

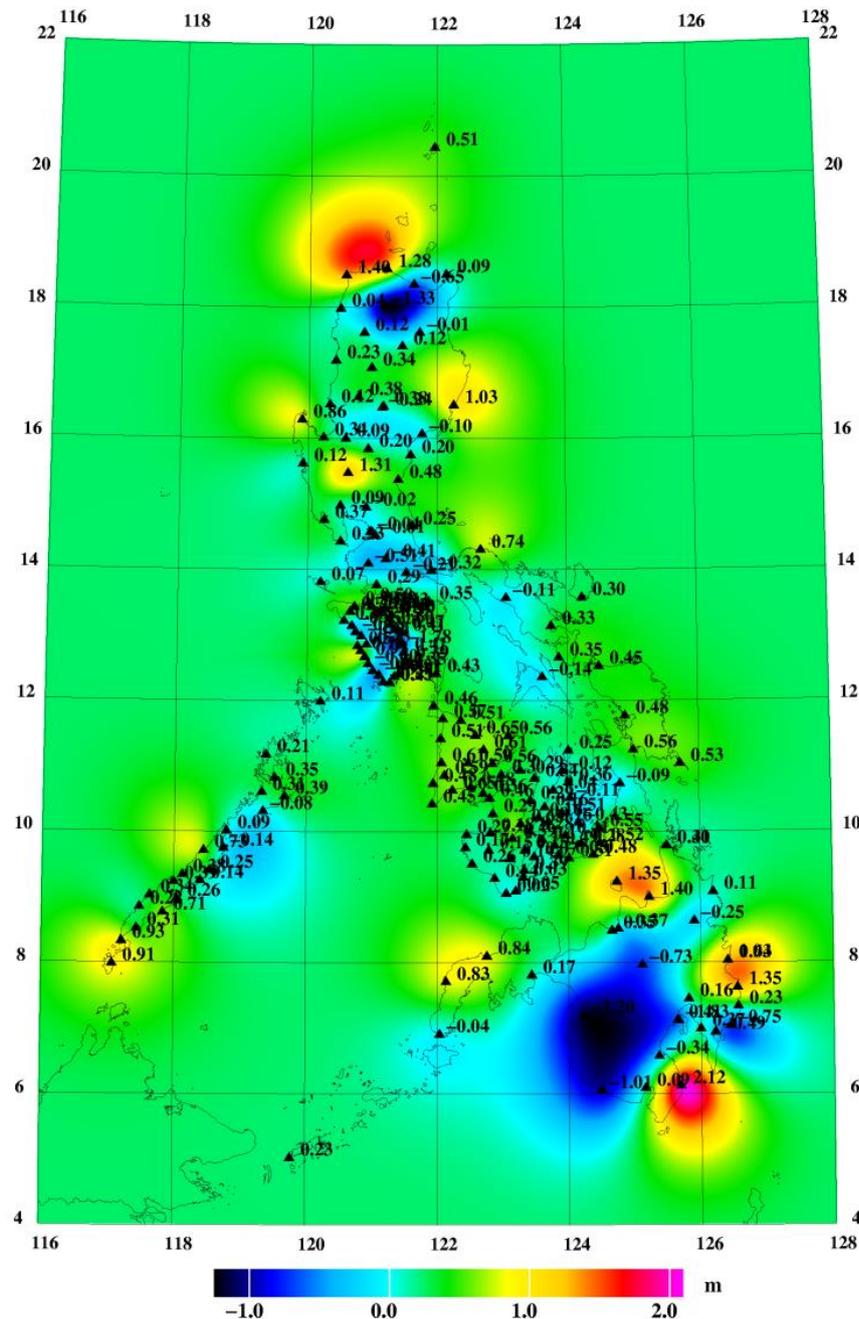


Figure 17. Location of GPS/Levelling data. Colour show the correction surface for the fitted geoid

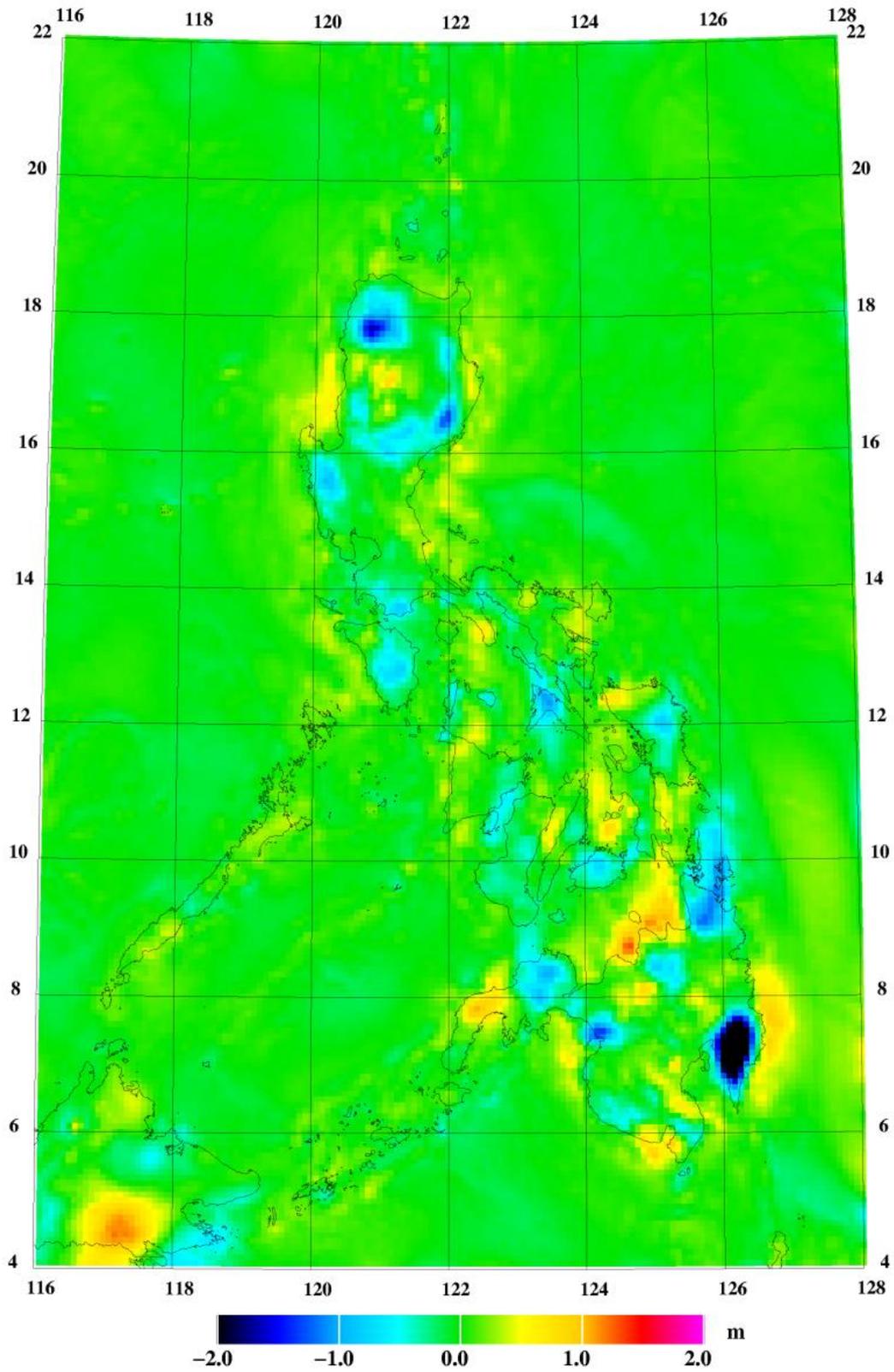


Figure 18. Differences between the PGM2014 and EGM2008

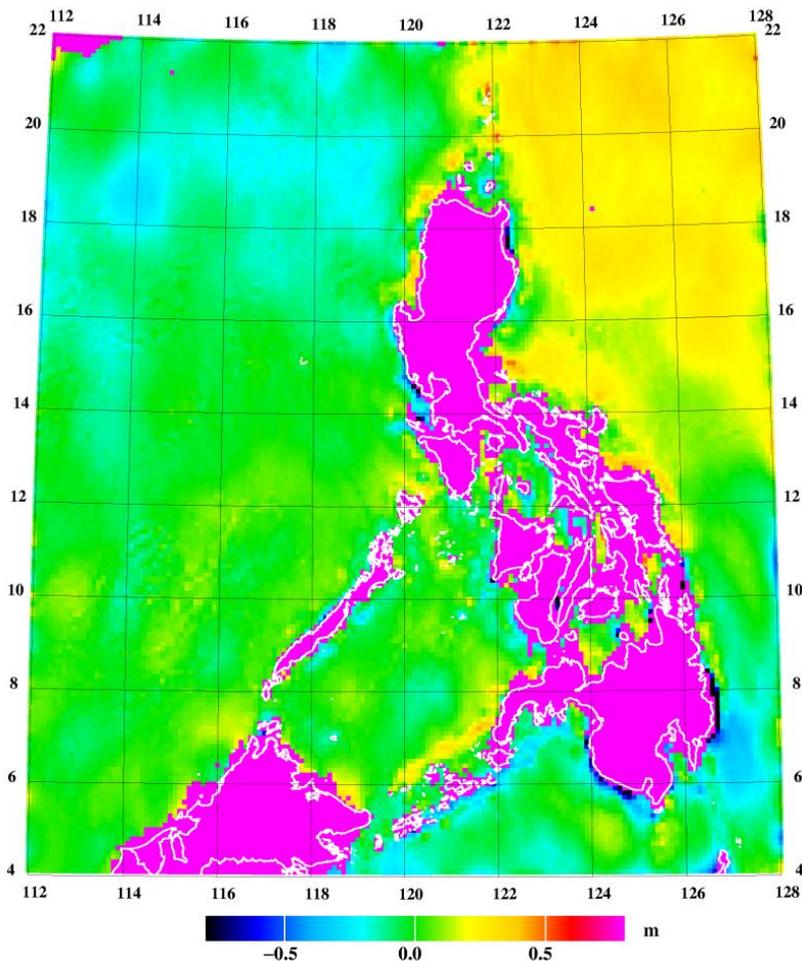


Figure 19. Mean Dynamic Ocean Topography (MDT) from DTU-10 mean sea surface (shifted by 91cm)

The PGM2014 files are given as *GRAVSOF*T grids, and can be interpolated by the GUI program *grid_int* (or the command line program “*geoid*”), provided to NAMRIA as part of the computations, along with the general software and geoid job setups (Appendix 1).

Re-computation of the geoid

To further improve a geoid model, Professor Forsberg in his paper “Towards a cm-geoid in Malaysia” (R. Forsberg, 2003) recommends the following:

- Levelling networks must be carefully analysed for adjustment errors
- Connections and antenna height errors of GPS data on benchmarks must also be revisited and re-analysed
- Erroneous points (geoid outliers) must be resurveyed by Levelling and GPS

- New GPS-fitted version of the geoid must be computed as new batches of GPS-Levelling data, additional gravity surveys in major cities and GPS users height problem reports comes in.

In 2015 NAMRIA started the re-computation of the PGM2014 with the help of Professor Forsberg. The densification of land gravity stations was conducted in some major cities of the country. Also, the GPS-levelling data was re-analysed, corrected and outliers deleted.

Land Gravity Data

In this re-computation, the original airborne and satellite data processing results were used, only the densified land gravity data (2214 points to date) were reprocessed and quality controlled. Figure 20 shows the new plots of the land and airborne gravity data. Significant improvements can be seen in the land data (thicker dots). Most dots are in green, some yellows and light blue (i.e., 25-50 mGals difference in mountainous areas).

GPS/Levelling Data

101 out of the 190 GPS/Levelling data on BMs remain (after cleaning up for outliers) and used as validation points. After fitting the new GPS/Levelling, the RMS now is 0.054m with a minimum and maximum offset value of -0.124m and 0.169m respectively. This improvement is mainly due to the removal of erroneous levelling points. More points will be added to the GPS/Levelling data as the re-adjustment of the levelling network progresses. Figure 21 shows the offset values and the new geoid correction surface for the ITRF-fitted PGM2016.

Philippine Geoid Model 2016

The PGM2014 was re-computed to the new PGM2016 with an accuracy of 0.022m using additional land gravity stations combined with the same airborne and satellite gravity data. More land gravity data (up to 41,000) will be added from 2017 until 2020 in order to re-compute a new version and further refine the Philippine geoid. Figure 22 shows the new PGM2016 and its plotted differences with PGM2014 in figure 23. There are differences in most parts of the country as big as 0.30m.

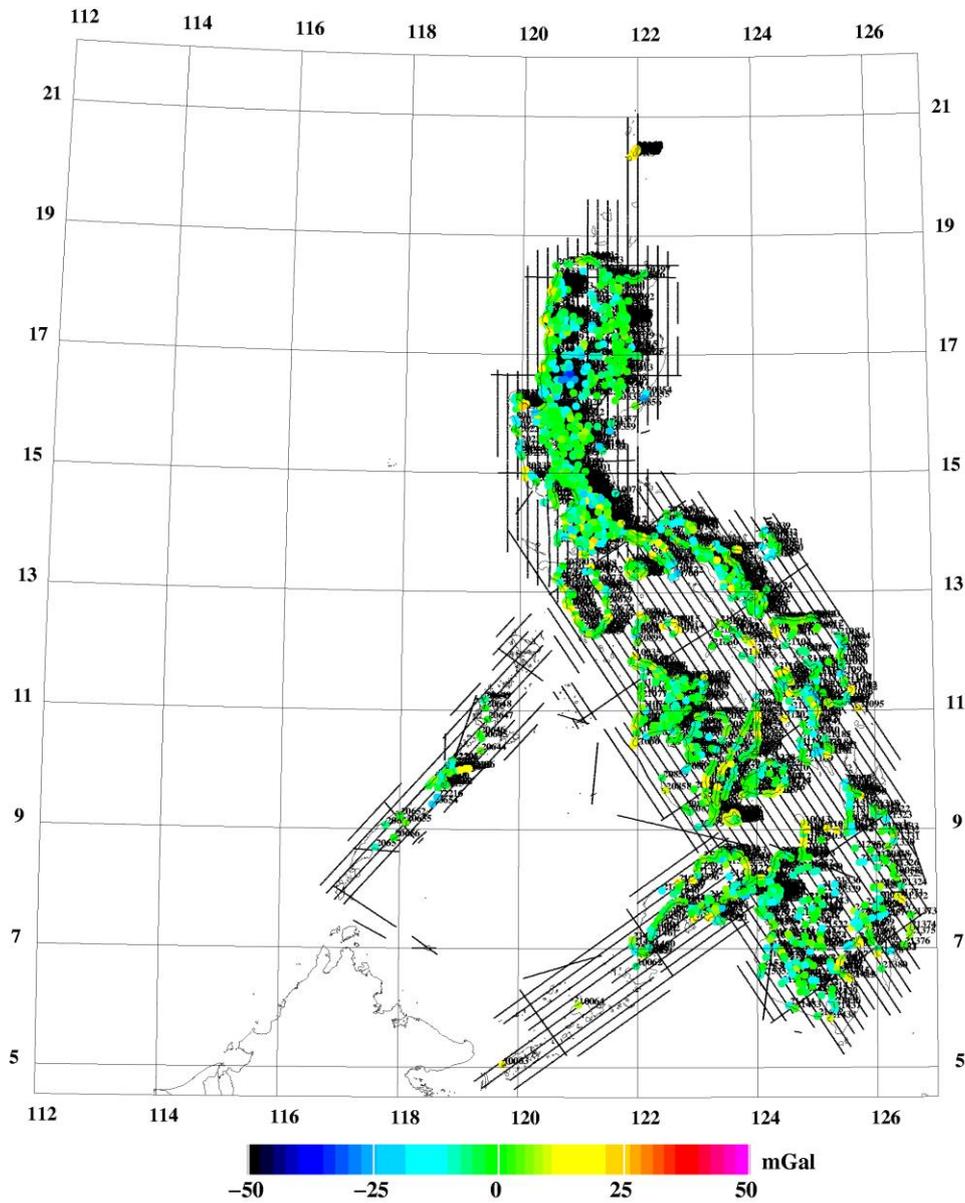


Figure 20. Land gravity data after reprocessing and densification (2214points), plotted with the airborne data. Most differences are below 25mGals, although there are some points that exceeds 35mGals in mountainous regions.

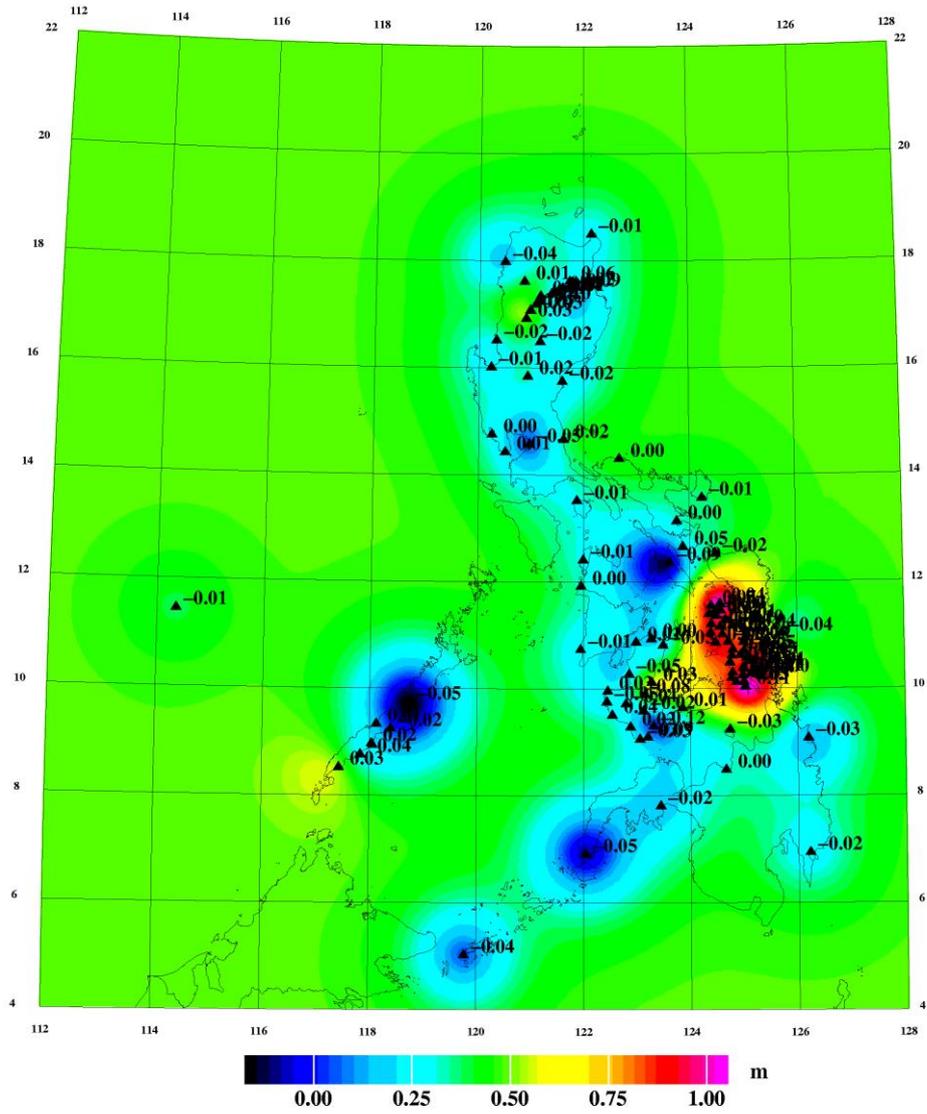


Figure 21. New correction surface of the fitted geoid (fitgeoid-itrf2016)

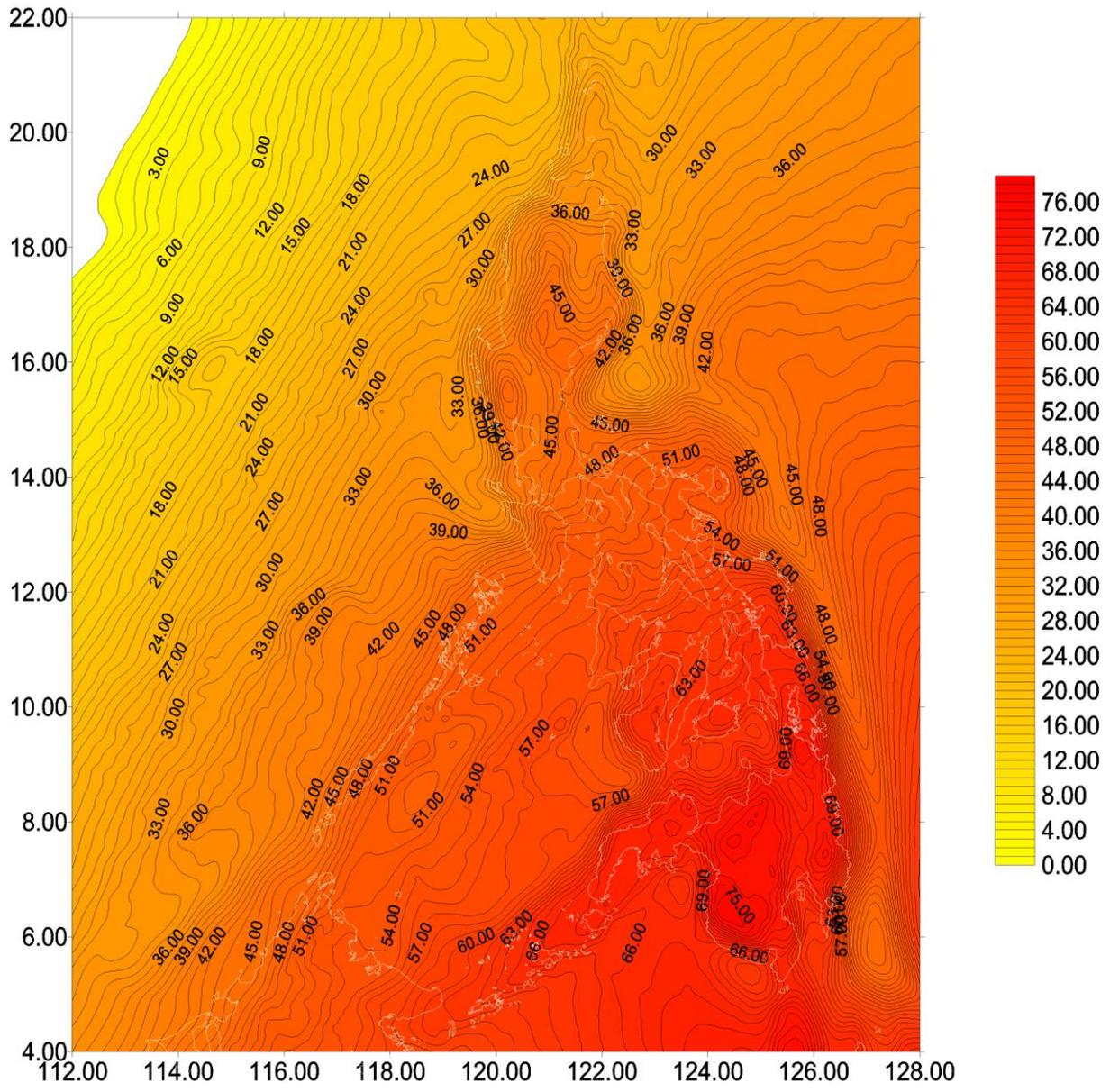


Figure 22. The new PGM2016. Contour interval 1m.

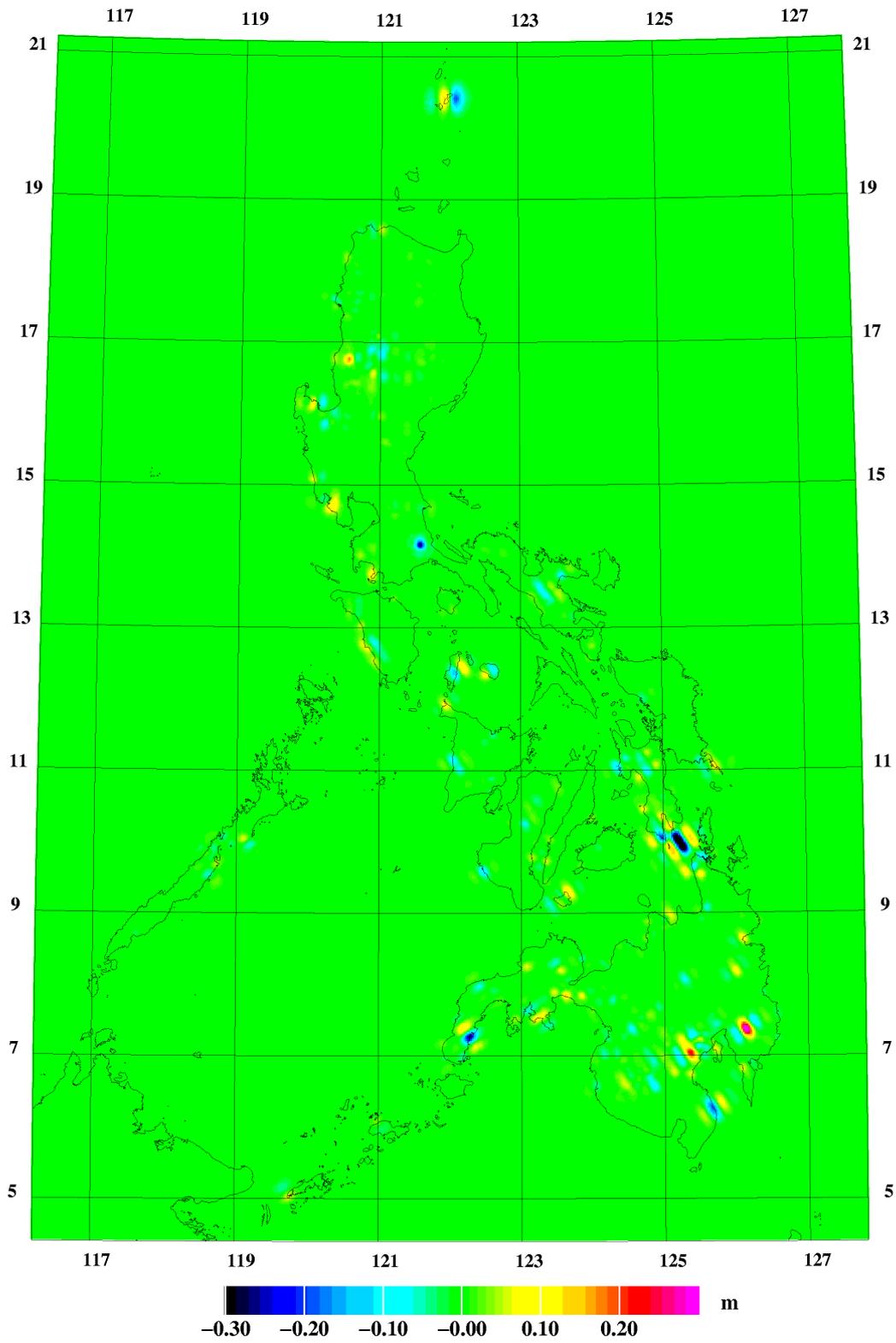


Figure 23. Differences between 2014 and the new 2016 geoid (*ph_geoid* files)

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APPENDIX 1 – Directory structure and GRAVSOFTE geoid jobs

Directory	Files	Comments
DATA	dtu-10_edited.fa namria_edited.fa airborne.fa	<i>DTU-10 free-air anomaly data NAMRIA edited free-air anomalies Airborne free-air data</i>
NAMRIA	namria.fa gps-lev.dat gps-lev-wgs84.dat	<i>Original NAMRIA gravity data, reformatted from xls- files Files with N from GPS-levelling</i>
DEM	ph_dem005.gri ph_dem025.gri ph_demref.gri	<i>SRTM 15" file (30" used in Malaysia) Averaged file for remote zone computations + geoid RTM mean elevation surface, made with dem_ref.job</i>
RD-TC	<u>Remove steps (run "jobs" in sequence)</u> egm08goce5_720 geocol17.job rd_surface.job rd_air.job rd_dtu10.job qc.job	<i>Spherical harmonic coefficients for EGM08GOCE model Program to compute EGM08GOCE in grids for N and g EGM and terrain reduction of NAMRIA data Reduction of airborne data, incl. terrain effect filtering Reduction of DTU-10 Geogrid job to make difference NAMRIA minus airborne g</i>
DOWNCONT	<u>Downward continuation and gridding</u> gpcol1.job gpfit.job	<i>Collocation job, blockwise solutions Simple covariance estimation, use only as rough guide</i>
GEOID	<u>FFT and restore steps for geoid</u> bouguer.job n-zeta.job n_rtm.job geoid.job geoip.job	<i>Job for making land Bouguer anomaly from downward continued, reduced gravity grid file "downrd.gri" Difference of geoid and quasigeoid, from DEM & Bouguer RTM geoid terrain effect by prism integration (slow task!) Composite geoid job, doing FFT, add terrain effect, add EGM, apply corrections for quasigeoid -> "ph_geoid.gri" Difference to GPS-levelling data (statistics and dif-file)</i>
GPS-LEV	<u>Geoid fit files</u> fitgeoid.job - fitgeoid_dif.dat: - fitgeoid_dif.gri:	<i>Fitting of geoid to GPS-lev file with collocation. Always plot the following files to judge fit of "ph_geoid_fit": point list with differences GPS-geoid corrector surface for fitted geoid</i>
Auxillary:	grid_int_ph.exe se-asia.bna	<i>User-friendly interpolation program Coastline file for "surfer" graphics</i>

Note: to run GRAVSOFTE on 64-bit Windows machines, check "job.bat" in GRAVSOFTE directory for the following statement in line 2, it should read: job64 <%1.job (job <%1.job for Win32)