The NSW Gravity Model: Australia's First State-Wide Airborne Gravity Model

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Key words: Capacity building, GNSS/GPS, Reference frames, Airborne gravimetry, Datum modernisation, Heighting

SUMMARY

The NSW Gravity Model is Australia's first model produced from a comprehensive, state-wide gravity survey captured in a single airborne campaign. This high-quality, high-density dataset delivers critical geoscience information, enhancing outcomes for infrastructure planning, land management, natural hazard assessment and resource development across New South Wales (NSW). It was delivered on time, within scope and budget, in collaboration with the Geological Survey of NSW and Geoscience Australia. The NSW Gravity Model will help surveyors measure height more accurately, assist land managers in understanding groundwater reserves and enable engineers to identify where major natural hazards may occur. It will also drive future resource investment opportunities in NSW by expanding the discoverability of high-value and critical minerals and reduce the financial risks associated with mineral exploration in unexplored or undeveloped areas. This paper presents some background on airborne gravimetry surveys, introduces the NSW Gravity Model, discusses the data collection and processing, and outlines the benefits this model will provide to the surveying profession and wider community, with gravity data made freely available to the public for the benefit of all. This contribution directly supports the FIG Commission 5 goal of building capacity and competence together in the science and application of where, particularly regarding vertical datums and the many applications associated with accurate heighting.

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1. INTRODUCTION

Gravity is not only a fundamental force in physics, surveying and geodesy but also crucial for life in general. It pins our atmosphere to the Earth, keeps our feet on the ground and causes fluids to flow downhill. Today's modern Australian surveyor regularly works with two types of heights: ellipsoidal heights referred to the Geocentric Datum of Australia 2020 (GDA2020, see Harrison et al., 2024; ICSM, 2024) and physical heights referred to the Australian Height Datum (AHD), Australia's first and only legal vertical datum (Roelse et al., 1975; Janssen and McElroy, 2021). A new third option, the Australian Vertical Working Surface (AVWS), offers an alternative for early adopters and/or precise users requiring higher-quality physical heights (current accuracy about 4-8 cm) than those AHD can provide (accuracy about 6-13 cm) (ICSM, 2021). Global Navigation Satellite System (GNSS) users can access AVWS by applying the Australian Gravimetric Quasigeoid (AGQG, see Featherstone et al., 2018) model to their GDA2020 ellipsoidal heights, just like AUSGeoid2020 is used to obtain AHD heights (Featherstone et al., 2019).

Both the AUSGeoid2020 and AGQG models can be improved by collecting high-quality, consistent and evenly distributed gravity measurements across NSW to complement and update the existing geoscientific datasets, which are mostly based on regional-scale, historic precompetitive datasets and modern targeted data capture for mineral resource exploration (consisting of a combination of land-based and airborne gravity data collected over several decades). Consistent and evenly distributed data coverage is best achieved by collecting airborne gravity measurements. A big advantage of gravity data is that it (generally) does not change over time, so it can be captured once and used many times for many diverse applications, provided it is available at sufficient quality and density. Of particular interest to NSW surveyors is that DCS Spatial Services, a unit of the NSW Department of Customer Service (DCS), hosts the largest state-owned and operated GNSS Continuously Operating Reference Station (CORS) network in Australia (Janssen et al., 2016; DCS Spatial Services, 2025a). To unlock the full potential of CORSnet-NSW, a state-wide gravity model is required to improve both geoid models and deliver consistent, higher-quality heighting across the state.

This paper introduces the NSW Gravity Model, the nation's first state-wide gravity model produced from a survey captured in a single airborne campaign, which was delivered by DCS Spatial Services in collaboration with the Geological Survey of NSW and Geoscience Australia. It presents some background on airborne gravimetry, discusses the data collection and processing, and outlines the benefits this model will provide to the surveying profession and wider community, with gravity data made freely available to the public for the benefit of all.

2. AIRBORNE GRAVIMETRY

Gravity is the force acting on a body on or near the Earth's surface, which is a combination of the gravitational force (the force of attraction between two masses) and the centrifugal force (the apparent force caused by the uniform circular motion of a body about a fixed point) of the Earth's rotation. In the absence of friction and other forces, it is the rate at which objects will accelerate towards each other. At the Earth's surface, gravity (acceleration) is approximately 9.8 m/s^2, with absolute gravitational acceleration varying across Australia between 9.780 m/s^2 in northern Australia and 9.805 m/s^2 in southernmost Tasmania (Kennett et al., 2018).

In principle, gravity can be measured using an accelerometer, which houses a proof mass that is restricted to movement along a sensitive axis and a restraining device (e.g. a spring). The mass is supported by the restraining device and displaces with respect to an equilibrium position when subject to acceleration. Knowing the relationship between the displacement and the restoring force applied to the mass (e.g. due to Hooke's law), the accelerometer provides a measure of the force required to counter the force due to accelerations acting on the mass. Gravity is generally measured in units of gal (1 Gal = 1 cm/s^2 or 0.01 m/s^2), milligal (1 mGal = 0.001 cm/s^2) or microgal (1 μGal = 0.000001 cm/s^2).

An absolute gravity meter (or gravimeter) measures gravity at a single location, which is currently restricted to ground-based acquisition. It determines the actual value of the gravitational acceleration, generally by measuring the speed of a falling mass in vacuum using a laser beam and optical interferometry. A relative gravimeter is much more common and measures the difference in gravity between two locations via ground-based, shipborne, airborne or satellite-based acquisition, generally using a spring supporting a proof mass. In order to be truly effective, surveys carried out with relative gravimeters must include acquisition at one or more sites where absolute gravity is known (i.e. within the area of interest of the airborne survey, generally a known gravity point at the airport where the aircraft is based). Today's airborne gravimetry systems can be separated into traditional airborne gravity systems and gradiometer systems.

Airborne gravity systems measure the sum of the aircraft accelerations and the Earth's gravitational field. Consequently, with stabilised platform systems such as the one used for the NSW data capture, most of the design and processing is aimed at maintaining the gravity sensing unit in a vertical orientation and accurately measuring the aircraft's corresponding movement using differential GNSS velocities. Commercial gravimeters utilise gyro-stabilised platforms to maintain the vertical orientation. In simple terms, subtracting the GNSS-derived vertical accelerations of the aircraft from the total vertical gravity measured by the instrument will provide residual gravity. In practice, additional corrections are required, e.g. to account for platform misalignment (tilt), lever arm (spatial relationship between the GNSS antenna, airborne gravimeter and any other equipment used within the aircraft), horizontal accelerations, drift, Eötvös effect (relative change of the centrifugal force of the Earth's rotation due to being on a moving platform) and minor temperature and pressure variations (Wooldridge, 2010).

The reduction of airborne gravity data requires the use of low-pass filters because the long- to medium-wavelength signal is of interest, while most noise has a short wavelength (i.e. high frequency) and corresponds to limitations in removing inertial accelerations of the aircraft using band-limited GNSS data. The effective resolution of the system is generally equated to the half-wavelength of the filter multiplied by the speed of the aircraft (consequently, half-wavelength filter lengths are often quoted rather than the full-wavelength filter). By shortening the filter length, the system resolution is improved at the expense of accuracy (Wooldridge, 2010). Factors influencing resolution and accuracy include aircraft speed, altitude and the spacing of flight lines. While precision from airborne data can be assessed well (using repeat tracks, adjacent tracks, tie lines or crossovers, and grid comparisons), accuracy is much harder to determine (using models, satellite data or ground data) because the true value is not really known, although good global models are available (Preaux, 2016).

Airborne gravity gradiometer systems measure, in principle, the gradient of the Earth's gravitational field independent of aircraft accelerations. The two current commercial airborne gravity gradiometer systems providing high-resolution gravity gradiometer data are the Airborne Gravity Gradiometer (AGG), known as the 'Falcon' system, and the Full Tensor Gradiometer (FTG). Both utilise spinning discs equipped with multiple accelerometers, which measure two or more components of the gravity gradient tensor depending on the number of discs present and their orientation. The discs rotate which makes the gravity signal periodic of short temporal baselines, so that the gravity signal can be separated from drift in the accelerometers. The gradients measured at different locations are transformed to vertical gravity. Gravity gradients are measured in units of Eötvös (Eö), where 1 Eö = $10^{-9}/s^2$ = 0.1 mGal/km, i.e. a variation of 1 mGal/km is 10 Eö (Fairhead et al., 2017).

Airborne gravity gradiometer systems are generally more accurate (higher resolution) and more robust than traditional airborne gravimetry as they are less sensitive to aircraft accelerations, but also much more expensive. They must detect very small differential gravitation signals over a short baseline. This requires accounting for errors such as scale factor errors and accelerometer bias drift (accelerometers are not perfectly matched), alignment errors (sensitive axes of the accelerometers are not parallel), asymmetry of the configuration (measurement point is not the centre of mass of the accelerometer pair) and self-gradients (the gradient field is changed due to the rotation of the aircraft about the stabilised platform hosting the instrument), which is mostly achieved through calibration and filtering (Jekeli, 2003).

3. DATA COLLECTION AND PROCESSING

NSW is a large state (about 1.5 times the size of France) encompassing an area of 800,000 km^2 and a coastline of 2,100 km in length, with terrain varying from vast plains to rugged mountainous areas (elevations up to 2,228 m at Mt Kosciuszko). In order to facilitate efficient data collection utilising two expert contractors, the area of interest (which also includes the offshore area up to 50 km from the east coast) was divided into two parts, i.e. Eastern NSW and Western NSW (Figure 1). These two parts (each completed by a single contractor) were then stitched together to produce the final products. The total area of capture amounted to 820,000 km^2, also covering another jurisdiction, the Australian Capital Territory (ACT), in its entirety.

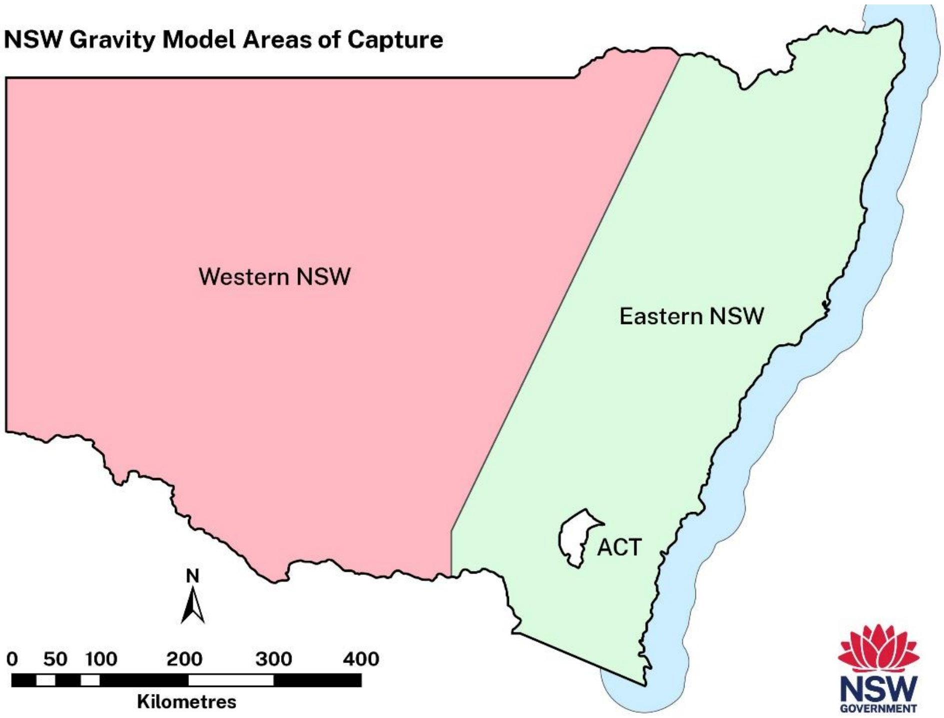

Figure 1: Area of gravity data capture across NSW, divided into an eastern and western part.

3.1 Eastern NSW

3.1.1 Data Collection

Sander Geophysics was contracted to complete Eastern NSW, which included the Great Dividing Range (Sander Geophysics, 2024). This area covers slightly more than the eastern third of NSW, including the ACT and the offshore margin up to 50 km from the coast (which includes the continental shelf). In the west, it is bordered roughly by a line through the towns of Narrabri, Dubbo and Wagga Wagga.

The principal survey traverse lines were oriented at 20º clockwise from north and spaced at 2,250 m in the onshore area and 2,500 m in the offshore area, with a selected area of denser infill lines (mainly covering the north-east of NSW) resulting in lines spaced 1,125 m in the onshore infill area and 1,250 m in the offshore infill area. Tie lines for crossover checking used to level the survey data were oriented east-west at 90º and spaced at 75 km. A drape surface used to guide the aircraft's height above the ground was created, considering the terrain and the performance of the aircraft at the expected altitudes and estimated temperatures. The survey was flown with a target clearance of 160 m above ground level, following the drape. The part of the survey within the Sydney Airport Control Area was flown at higher altitudes (between

518 m and 610 m) due to air traffic control restrictions. The target average ground speed was 60 m/s.

Due to safety and environmental considerations, the survey was split into ‘hostile’ and ‘non-hostile’ areas. Areas of dense population or that were offshore were considered hostile. The western, non-hostile part of the survey was flown with a single-engine Cessna C208B Grand Caravan, while the eastern ‘hostile’ part (including the densely populated and offshore areas) was flown using a twin-engine de Havilland DHC-6 Twin Otter (Figure 2). Bases of operation were Orange, Cessnock, Tamworth and Kempsey, as well as Mallacoota, Victoria.

Figure 2: Refuelling operations of both Sander Geophysics survey aircraft at Mallacoota Airport, Victoria (Sander Geophysics, 2024).

Production flights commenced on 31 August 2022 and lasted for 16 months, with data acquisition completed on 28 December 2023. Consequently, the data acquisition phase spanned all four seasons. Summer weather was usually hot and dry but occasionally interrupted by wet spells with significant rainfall. In autumn, winter and spring, higher elevations experienced long periods of wet weather with low visibility, causing many days when survey flights were not possible. On a few occasions, large parts of the survey area were subject to heavy rains and flooding. A total of 242 flights were carried out during the survey to complete the planned 223,318 line kilometres.

The position of the temporary GNSS reference stations at each airport was calculated via Precise Point Positioning (PPP) corrections using the algorithm developed by Natural Resources Canada for its CSRS-PPP online positioning service (NRCan, 2025), which has been incorporated into the suite of software used by Sander Geophysics.

Gravity data was collected with the Airborne Inertially Referenced Gravimeter (AIRGrav) system, which was designed by Sander Geophysics specifically for the unique characteristics of the airborne environment. Accelerometer data across three sensitive axes is recorded at 128 Hz and later down-sampled to 2 Hz in processing.

The airborne gravimetry system is a relative gravimeter, so the airborne data must be tied into the nearest local absolute gravity mark at each flight's departure/destination airport. For the five airports utilised in the survey, this was achieved by connecting to a nearby Australian Fundamental Gravity Network (AFGN) station (typically already established at the airport itself) or via a gravity transfer flight connecting to a gravity point previously established by Sander Geophysics. The gravimeter was then calibrated at the aircraft's exact parking location daily to the local gravity value as established by the initial gravimeter calibration.

Repeat test lines, planned and established in consultation with DCS Spatial Services, were flown periodically during the data acquisition to demonstrate the accuracy, repeatability and resolution of the AIRGrav system. The location of these 40-50 km long test lines was selected to be operationally efficient to fly from the various airports, covered by pre-existing Geoscience Australia gravity data grids and sufficiently removed from significant settlements or installations.

3.1.2 Data Processing

Sander Geophysics' proprietary geophysical software was used for data processing. A simplified processing flowchart is shown in Figure 3, illustrating the complexity of the procedure. Several programs were executed for the compilation of navigation data to reformat and recalculate positions from the raw 10 Hz data obtained by the moving (airborne) GNSS receivers using combinations of the GPS L1 and L2 carrier phase signals. Accurate locations of the airborne GNSS antenna were determined by differentially correcting the airborne GNSS data with respect to the reference station positions. This technique provided the final airborne GNSS antenna location with an accuracy of better than 5 cm.

The raw gravity data was corrected for the effects of aircraft acceleration before the standard corrections were applied, i.e. Eötvös correction, normal gravity correction, atmospheric correction, free-air correction, full 3D topographic Bouguer correction, static correction (absolute gravity was established where the static readings were made before and after the flights so that the relative gravity data could be tied into the national gravity datum) and level correction (based on intersections with tie lines and grid-based de-corrugation). Tidal corrections were not applied, as they are generally not necessary for airborne gravity processing due to their small magnitude. This resulted in determining the free-air anomaly and the Bouguer anomaly (both in mGal).

In simple terms, the gravity anomaly indicates the difference of a gravity measurement from the expected value. Depending on the type of correction applied to the observed gravity data at the point of observation, we distinguish between the free-air anomaly (corrected for the height at which it was measured, i.e. reduced to the ellipsoid or geoid) and the Bouguer anomaly (corrected for the height at which it was measured and also the attraction of terrain, i.e. the mass of rock between the measurement point and the ellipsoid or geoid). These anomalies basically show the gravity variation due to the Earth not being quite an ellipsoid/geoid in shape and having variations in density due to the different minerals of which it is made. The free-air gravity anomaly includes all these variations in the shape of the Earth and in the density of the minerals. The Bouguer gravity anomaly removes the signal due to the shape variations and keeps only that due to the density variations, which is most useful for geology and exploration.

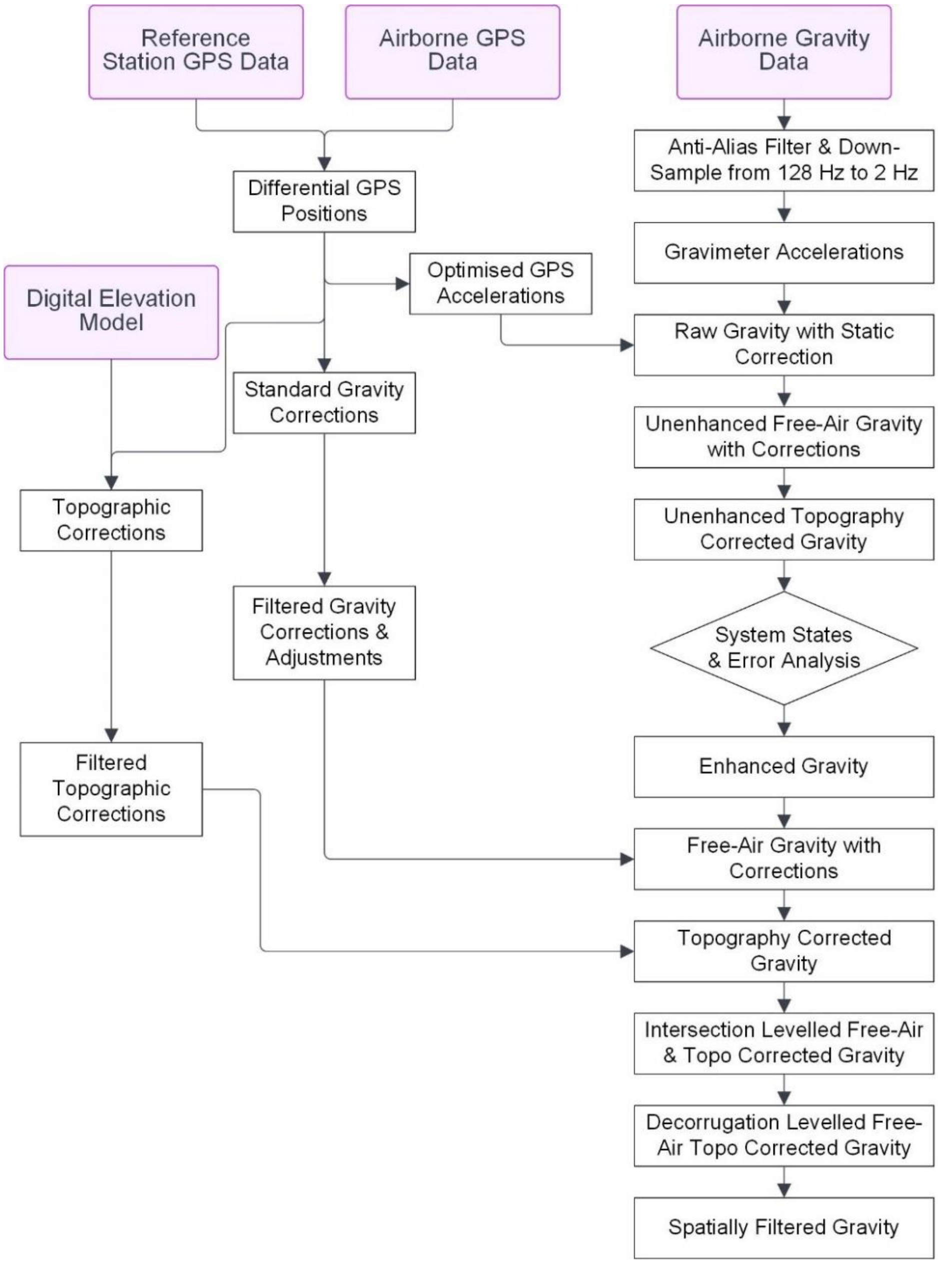

Figure 3: Gravity data processing flowchart (adapted from Sander Geophysics, 2024).

Further filtering and gridding followed to reduce noise and generate grids with a 500 m grid size. Firstly, a 70-second, along-track, cosine-tapered low-pass filter (equivalent to a 4,200 m filter when accounting for the aircraft's ground speed of 60 m/s) was selected, and the filtered data was then gridded using a minimum-curvature algorithm that averages all values within any given grid cell and interpolates the data between survey lines to produce a smooth grid. In the second filtering stage, low-pass filtering (directly equivalent to spatial averaging) was applied to the grid to achieve better noise reduction than by simply increasing the degree of line filtering. Essentially, the survey area is over-sampled by a line spacing that is smaller than the grid filter used. The low-pass filter acts to average data within the radius of its filter dimension, retaining the common signal on adjacent lines and cancelling out random noise. The final data provides a resolution of 2,100 m and 2,500 m, which is expected for the line spacing used (2,250 m in the onshore area and 2,500 m in the offshore area). The resulting full Bouguer gravity data is shown in Figure 4.

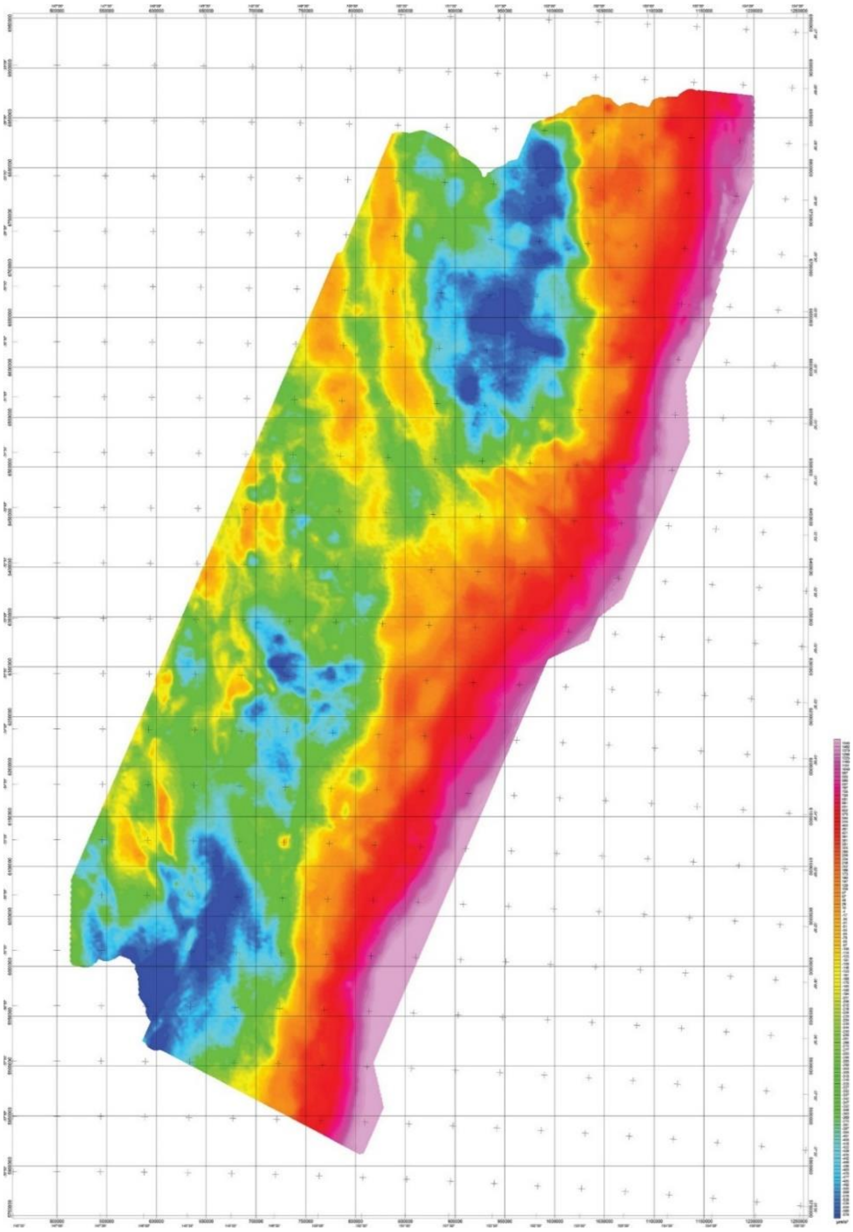

Figure 4: Full Bouguer gravity with 4,200 m full-wavelength spatial filter (Sander Geophysics, 2024).

3.2 Western NSW

3.2.1 Data Collection

Xcalibur Multiphysics was contracted to complete Western NSW, roughly covering the western two thirds of the state (Xcalibur Multiphysics, 2024). The principal survey traverse lines were oriented due north and spaced at 2,000 m, while tie lines were oriented east-west at 90º and spaced at 73 km. The survey was flown with a target clearance of 160 m above ground level (following a drape) and a target average ground speed of 65 m/s. Flights commenced on 14 June 2022 and lasted for 14 months, with data acquisition completed on 25 August 2023. A total of 413 flights were conducted during the survey to complete 268,517 line kilometres.

A single-engine Cessna C208B Grand Caravan was used, operating out of Broken Hill, Cobar, Dubbo and Griffith, as well as Yarrawonga, Victoria. Temporary GNSS reference stations were established at each airport and coordinated via Geoscience Australia's AUSPOS service (GA, 2025), based on datasets of at least 8 hours duration covering the expected time period of an average production flight.

Gravity data was collected with a Falcon Airborne Gravity Gradiometer (AGG) system, which has been optimised for airborne broadband geophysical exploration. The Falcon AGG data streams were digitally recorded at various sampling rates, with the output processed data being delivered at 8 Hz.

3.2.2 Data Processing

The main steps in the Falcon processing flow utilising Xcalibur proprietary software included a dynamic correction (to reduce the effects of aircraft accelerations), demodulation (to transform the accelerometer measurements in the gravimeter from the rotating frame back into a spatial reference frame), self-gradient correction (to account for time-varying gravity gradients caused by the changing heading and attitude of the aircraft during flight), terrain correction (derived from a Digital Terrain Model and using the standard average crustal density of 2.67 g/cm^3) and level correction to the regional data using the 2019 Australian National Gravity Grid (ANGG, see Lane et al., 2020).

Once the gradient data channels were fully processed and levelled, noise reduction processing was carried out. The quality (precision) of the Falcon data is measured using the Falcon Difference Noise (the two independent sets of gradiometers inside the instrument allow a noise estimate to be taken at each measurement). The data is acceptable if the noise value is below 5 Eö. However, in this case, for lines where the turbulence was greater than 0.981 m/s^2, the noise limit was increased to 7 Eö.

The noise reduction process is designed to reduce acquisition related noise by targeting signal response with a linear spatial frequency along the survey line direction. This maximises the resolution of the finished dataset so that it is approximately equal to the line spacing, while also reducing the noise power on the measured data. When the line spacing is smaller than the resolution of the initial signal processing, this process allows for a reduction in noise and increase in resolution. In this case, the line spacing was much larger than the initial signal processing resolution, causing a smaller noise reduction effect but still improving final data quality.

Now that the measured gradients were fully processed, the data was transformed into the components of the gradient tensor. This process uses a Fourier transformation approach to transform the measured tensor components into the full gravity gradient tensor data and the vertical gravity data (Dransfield and Chen, 2019).

The final processing step was the regional conforming process, which corrects the vertical gravity data for very long wavelength errors introduced by the vertical integration of the vertical gravity gradient data. For this dataset, the data was conformed using data from the Earth Gravitational Model 2008 (EGM2008, see Pavlis et al., 2012). The data was conformed using a filter cut-off wavelength of 200 km, followed by terrain corrections using the standard average crustal density of 2.67 g/cm^3. The resulting conformed terrain-corrected vertical gravity data is shown in Figure 5.

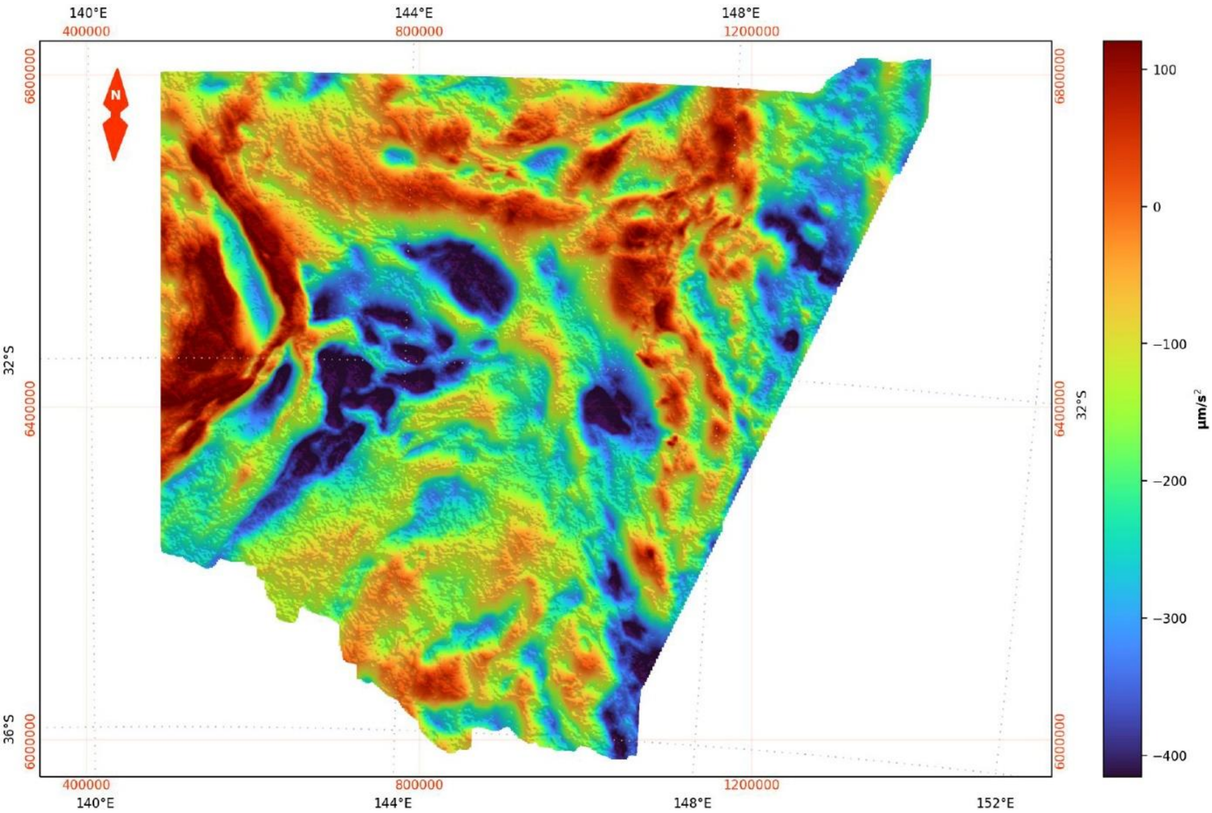

Figure 5: Conformed terrain-corrected vertical gravity data, as captured at flight elevation, with gravity anomaly corrections applied using orthometric heights (Xcalibur Multiphysics, 2024).

The conforming process required a significant number of iterations to get an acceptable result as it had never been applied to a survey of such large dimensions before. The standard method had to be revised to ensure the final product met all survey requirements. The approach used was to conform the vertical gravity gradient before the integration. Once this was completed, a second conforming was required to account for very long wavelength integration errors. This conforming process followed the standard methodology but was performed using a filter cut-off of 500 km.

The unconformed free-air gravity data was used to investigate the data resolution, which is expected to be similar to the line spacing (i.e. 2,000 m in this case). Using the radial power spectra method, and considering the sampling period of 500 m, it was determined that the resolution of the final data is either 1,500 m or 2,000 m.

3.3 Quality Assurance & Final Grid Production

During and after data acquisition, an independent, third-party subject matter expert checked and verified that the collected data met the data quality specifications. Final quality assurance of the collected data was then performed and the final gridded data products produced (McCubbine, 2024). This ensured that these datasets, which were captured by two suppliers using different methodologies and equipment, could be integrated into a consistent and reliable set of gravity anomaly grids covering the entire state.

An evaluation of the datasets was conducted by comparing the point-located and gridded gravity anomaly data to two key reference datasets, i.e. the EGM2008 gravity model and the 2019 ANGG. These comparisons were useful for validating the accuracy of the collected data and identifying any regional discrepancies. For the Sander Geophysics data, the overall standard deviation of the differences was approximately 2-3 mGal for the comparisons between supplied/recomputed Bouguer anomalies and the ANGG and around 6-7 mGal for the comparison between the geodetic free-air anomaly data and the EGM2008. The Xcalibur data also showed high fidelity, with the final gridded datasets exhibiting standard deviations of 1.5 and 1.7 mGal when compared to the ANGG and EGM2008 reference grids, respectively. The higher agreement can be explained by the Xcalibur data undergoing a regional conforming process. These statistics underscore the reliability of the processed datasets for use in regional scale mapping.

Additional processing was required to ensure consistency across the two datasets. This processing involved producing a line-by-line levelling adjustment of the Sander Geophysics data to align it with an existing state-wide dataset, sampled from the ANGG. This adjustment was necessary to correct any discrepancies and biases that arose from limitations of the data collection and to ensure that the final gridded products accurately reflect the gravity anomalies across NSW. A new point-located data file was reproduced, incorporating the results of this additional processing, to include the additional levelling corrections and application to the supplied gravity anomalies.

The data augmentation and gridding process involved the following four steps:

1) Data preparation: The point-located data from both suppliers was extracted and block averaged to half the flight line spacing on a line-by-line basis.
2) Residual calculation: A long-wavelength reference signal was subtracted from the gravity anomalies to create a 'zero-mean' residual for gridding. The reference signal was derived from a 50 km filtered version of the ANGG data.
3) Gridding: The residuals were interpolated using Least Squares Collocation (LSC), a method that accounts for spatial correlations in the data. This process involved fitting the Forsberg (1987) covariance function and solving matrix inversion problems to produce gridded datasets at a 15 arc-second resolution.
4) Restoring long wavelengths: The reference signal was added back to the gridded residuals to produce the final gravity anomaly grids.

Three final gridded datasets were produced at a resolution of 15 arc-seconds (500 m) in the GDA2020 datum:

- Free-air gravity anomaly grid at flight elevation (Figure 6).
- Bouguer gravity anomaly grid at flight elevation.
- Bouguer gravity anomaly grid downward continued to the topographic surface (Figure 7).

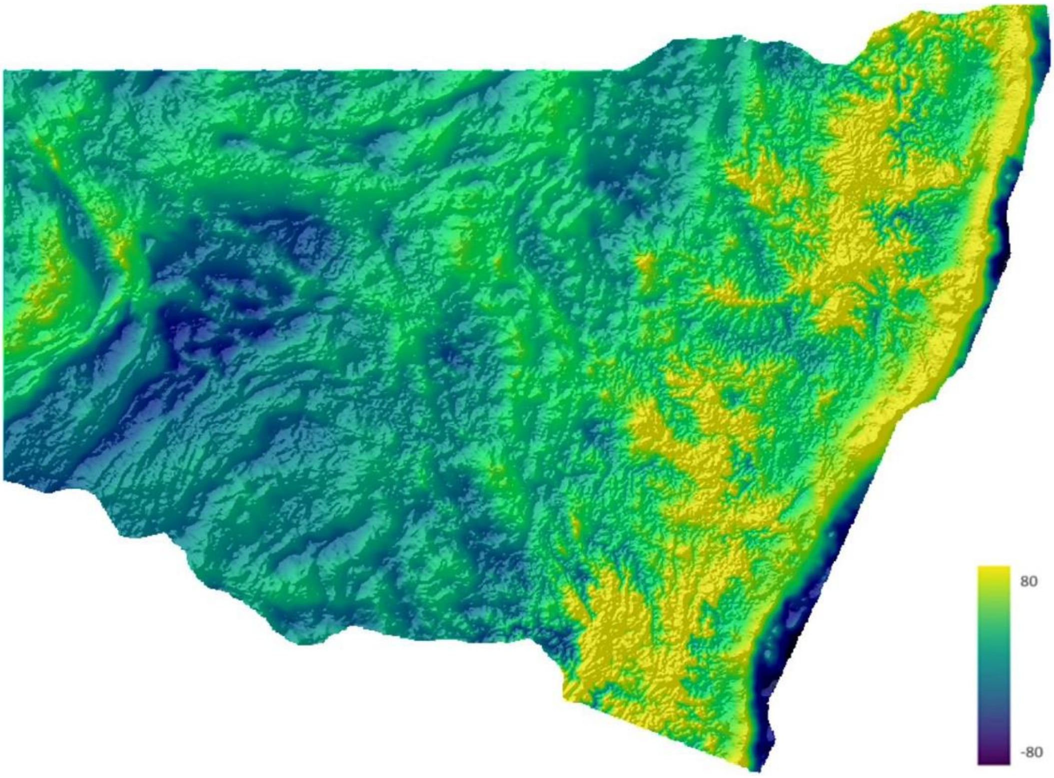

Figure 6: Final gridded free-air gravity anomaly at flight elevation in mGal (McCubbine, 2024).

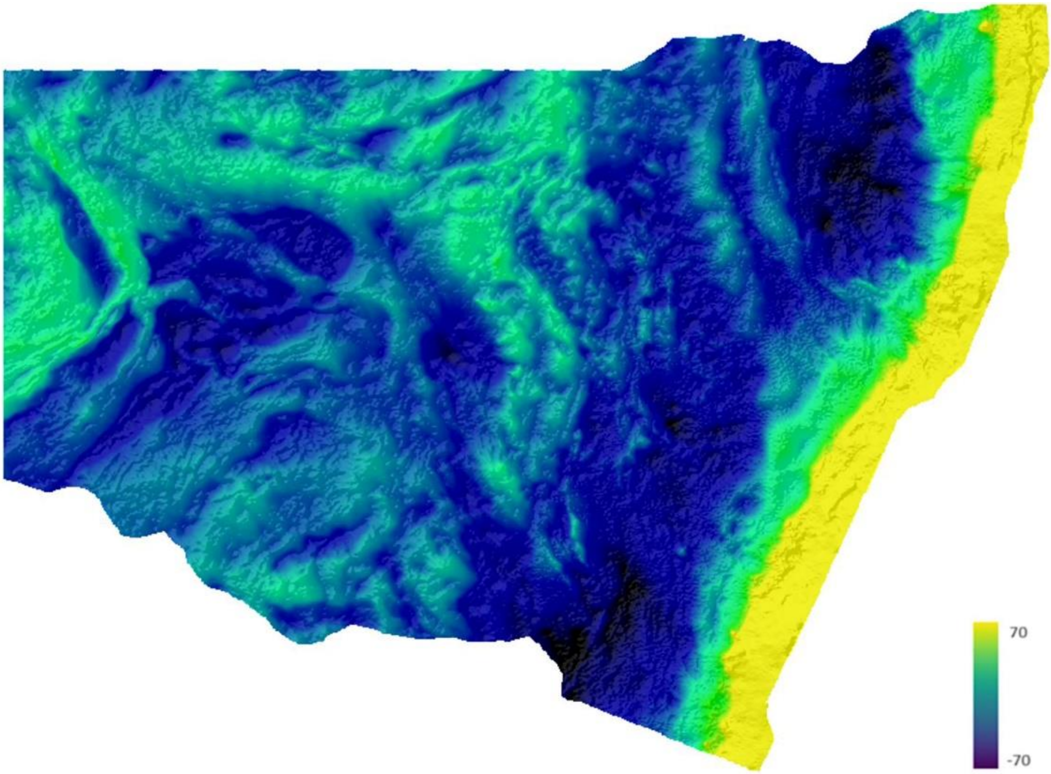

Figure 7: Final gridded Bouguer gravity anomaly at surface level in mGal (McCubbine, 2024).

Two surfaces were established as grid nodes to facilitate the interpolation of gravity anomaly data onto a regular grid. The first, a 'flight-level surface', was derived by block-averaging the aircraft's GNSS positioning data into 500 m grid cells, representing the flight elevation grid nodes. The second, a 'topographic surface', was constructed by clipping out the relevant area from the 2019 ANGG ellipsoidal elevation DEM, providing a surface-level height reference. The point-located gravity anomaly data was then interpolated onto a 15 arc-second output grid using LSC, ensuring consistency between the reference surfaces and the final gridded product. These gridded gravity datasets provide seamless, coherent maps of the gravity field across NSW. The careful assessment, corrections and gridding processes have ensured that these datasets are accurate, reliable and suitable for a wide range of applications.

4. A STATE-WIDE GRAVITY MODEL FOR NSW

The NSW Gravity Model was delivered on time and within scope and budget due to a collaborative approach between DCS Spatial Services, the Geological Survey of NSW and Geoscience Australia. The collective commitment to enhance the quality of the gravity model by uniting our efforts across state and federal government departments was a strategic decision made to make NSW an easier and a more productive place to work, while also supporting national interests. Working closely with experts across different teams allowed us to maximise the collective impact for a wide range of applications, delivering the best possible benefit for our customers. As a by-product, we even delivered a gravity model for the ACT, an entirely different jurisdiction – this was much easier than flying around it.

DCS Spatial Services was responsible for managing the project, with Geoscience Australia providing technical expertise and the Geological Survey of NSW ensuring that the project specifications met the requirements to deliver a fair playing field for exploration through a high-quality, high-density product. A big advantage of gravity data is that it (generally) does not change over time, so it can be captured once and used many times for many diverse applications. Gravity datasets are very useful for geodesy and geology, but these two sciences have slightly different requirements. The former needs gravity relative to the geoid, while the latter needs gravity relative to the ellipsoid. Close collaboration ensured that these requirements were met, along with supporting other use cases such as groundwater storage management and natural hazard modelling.

The general public was informed and educated about the data collection flights via DCS Spatial Services media releases, a Frequently Asked Questions (FAQs) document, and the DCS Spatial Services website, which also includes a video detailing the work to be undertaken (DCS Spatial Services, 2025b). It was stressed that people's privacy would be protected throughout the process, as the aircraft would only be equipped with an instrument that measures gravity data and not be capable of capturing images of property, infrastructure or individuals. It was also emphasised that these gravity measuring instruments do not emit any signals or impact people, animals or infrastructure and have been used for decades throughout both Australia and globally.

Challenges encountered and resolved along the way included delays due to adverse weather conditions or scheduled aircraft maintenance, landholder complaints across Western NSW, access to restricted airspaces, AGG sensor system failure, twin-engine aircraft availability for data acquisition, unaccounted safety audits due to the use of multiple aircraft, optimistic time allocation for data processing, issues related to meeting the contract specifications, and difficulties in the integration and merging of the datasets collected by the two suppliers. In this context, it is important to emphasise and acknowledge the collaboration with other state jurisdictions undertaking airborne gravity surveys at the time (Victoria and South Australia), which was crucial in enabling the NSW data capture to be completed on time. In particular, Land Use Victoria, the Geological Survey of Victoria and the South Australian government are thanked for providing access to the twin-engine de Havilland DHC-6 Twin Otter being used for their gravity surveys.

The data acquired is owned by the NSW Government and is publicly available under a Creative Commons licence, which allows the public free access for business, education or creative purposes. The data can be accessed via the NSW Government's Spatial Collaboration Portal (DCS Spatial Services, 2025c) and the Geological Survey of NSW's online mineral viewer MinView (DPIRD, 2025). It is also included in the national geoscience database and accessible via the Geophysical Archive Data Delivery System (GADDS) managed by Geoscience Australia. This ensures that the collected data is available in various forms, enabling it to be used and combined with other sources to generate valuable products meeting the requirements for a wide range of applications. Furthermore, derived products such as updated AGQG and AUSGeoid models for the use of GNSS positioning will be made available via Geoscience Australia and DCS Spatial Services in due course.

The NSW Gravity Model positions NSW as a leader in airborne gravity data coverage in Australia. This new airborne gravity dataset will significantly improve the gravity (and gravimetric quasigeoid) model and thus the accuracy of GNSS-derived physical heights for a wide range of applications relying on the flow of fluids, such as floodplain management and flood modelling, waterway navigation management, roadway and drainage design, groundwater management, agricultural management, and surveying in general. It will also be used by geoscientists to further their understanding of Australia's geological 'architecture' and how it has evolved over time, as well as advance the geoscience that assists the management of earth resources, infrastructure and natural hazards. Finally, the NSW Gravity Model raises the state to the forefront of potential AVWS early adopters and promotes it as an ideal test area to evaluate any new height datum's performance and user impact.

An interactive story map is also available for the general public to learn about the NSW Gravity Model and how it supports economic and social outcomes for NSW into the future (DCS Spatial Services, 2024).

5. CONCLUSIONS

The NSW Gravity Model is a consistent high-quality, high-density state-wide airborne gravity dataset providing critical geoscience information to produce improved outcomes for NSW state infrastructure projects and the management of land, natural hazards and earth resources. It was delivered on time, within scope and budget, in collaboration with the Geological Survey of NSW and Geoscience Australia.

The NSW Gravity Model is the nation's first state-wide gravity model produced from a single airborne gravity survey campaign and will help surveyors measure height more accurately, assist land managers in understanding groundwater reserves and enable engineers to identify where major natural hazards may occur. It will also drive future resource investment opportunities in NSW by expanding the discoverability of high-value and critical minerals (e.g. gold, copper and lithium) and reduce the financial risks associated with mineral exploration in unexplored or undeveloped areas.

This paper has presented some background on airborne gravimetry, introduced the NSW Gravity Model, discussed the data collection and processing, and outlined the benefits this model will provide to the surveying profession and wider community, with gravity data made freely available to the public for the benefit of all.

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