Australian Government
Geoscience Australia

Australian Datums: New and Future

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Overview

1. The Why – changing era of geospatial
2. The What – new datum and products
3. The How
4. The Future

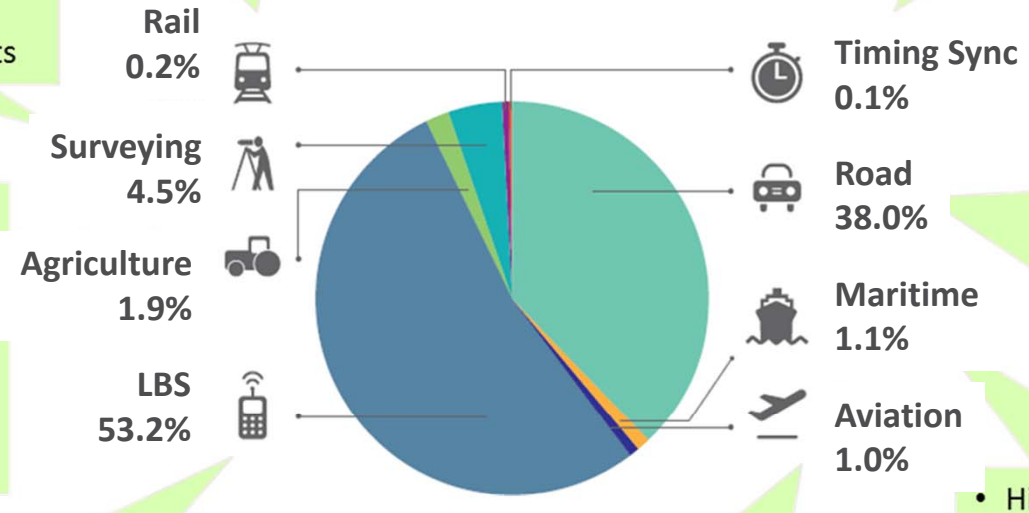
The Why - changing world …

- Automated Train Management Systems
- Accurate Rail Centreline & Curvature Data
- Autonomous Trains (e.g. Mines and Ports)
- Reduced Maintenance Costs

- Time Synchronisation (e.g. Energy, Finance, Telecommunications, Transport Networks)
- Time-Stamping (e.g. Financial Transactions and Network Issues)

- Consistent Spatial Data
- Higher Productivity
- Lower Equipment Costs

Cumulative Core Revenue 2013-2023



- Autonomous Vehicles
- Reduced Fatalities
- Congestion Avoidance
- Reduced Emissions
- Reduced Road damage
- Incident Detection
- Dynamic Navigation
- Situational Awareness

- Increased Yield
- Improved Safety
- Reduced Water Run-off, Soil Compaction, Soil Erosion & Fuel Usage
- Lower Emissions
- Preserved Water Quality

- Accurate Location Awareness
- Emergency Services
- Augmented Reality
- Value-Added Applications

- Safety-of-Life Services
- Integrity Monitoring
- Fuel Efficiency
- Internationally Standardised

- Higher Tonnage
- Public Safety
- Environmental Protection
- Fuel Efficiency
- Internationally Standardised

European GNSS Agency (GSA, 2015)

NPI NATIONAL POSITIONING INFRASTRUCTURE CAPABILITY

- Precise Positioning anywhere, anytime at centimetre level
- Improved access to GNSS data and products for existing and new industries

Users accessing ITRF data

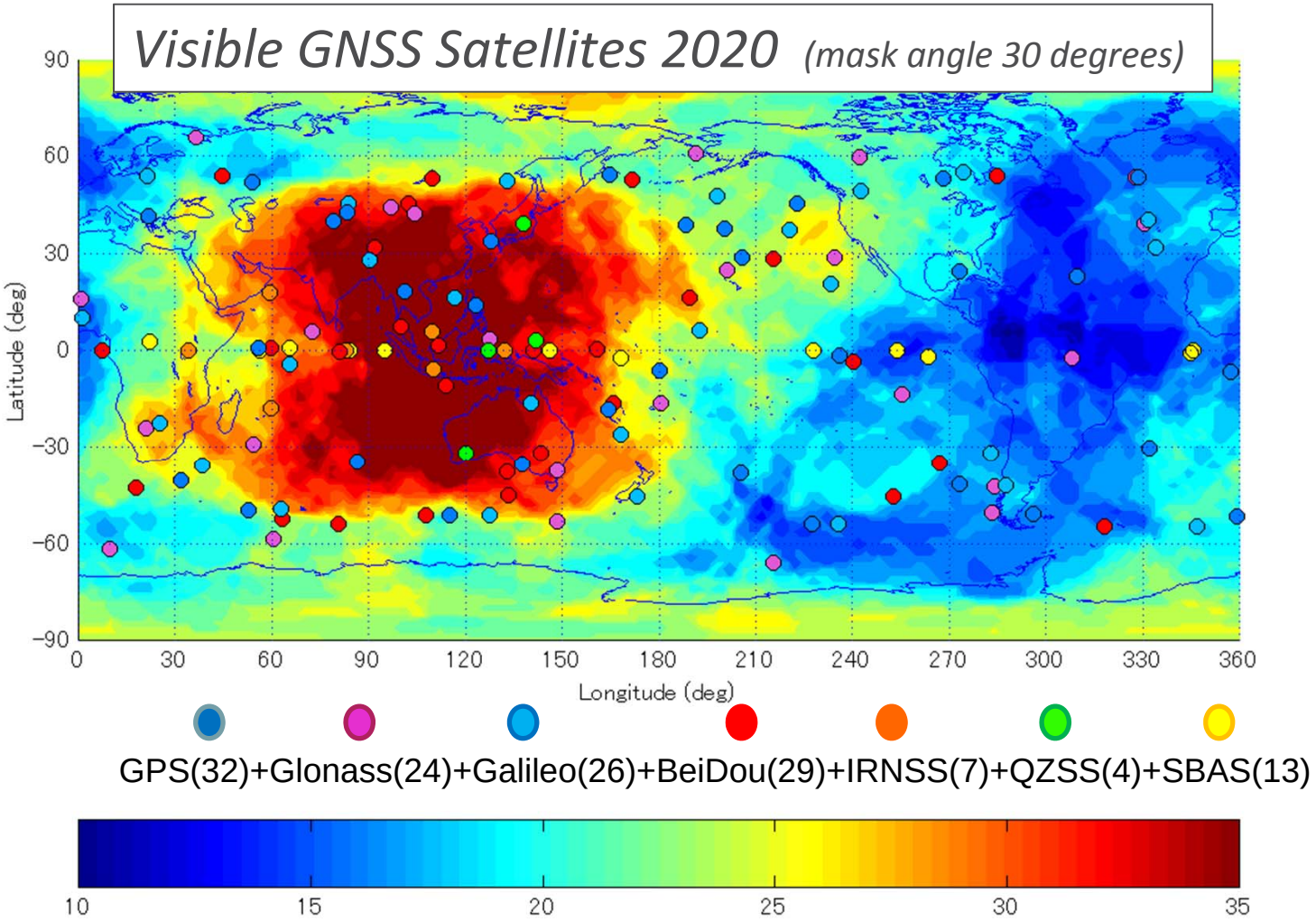
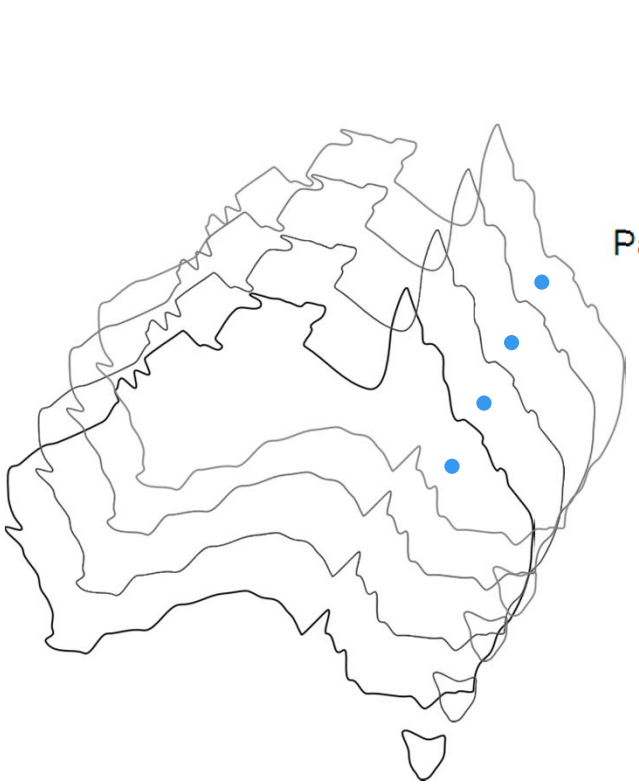
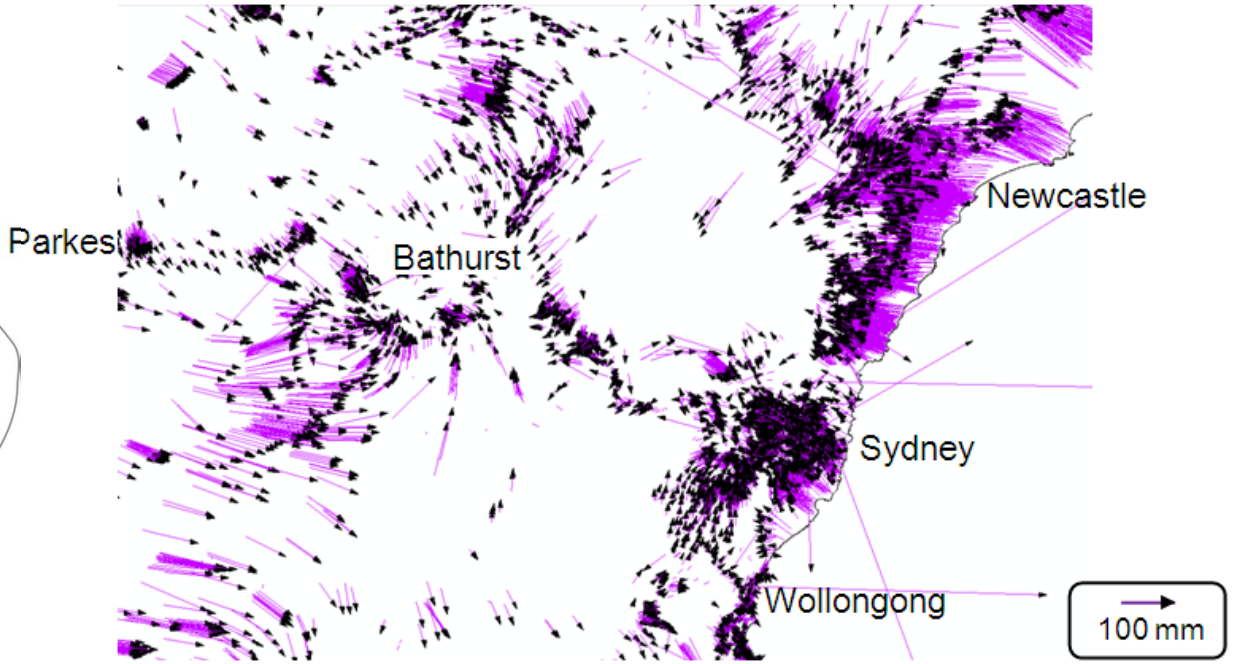


Figure courtesy Prof Chris Rizos, UNSW

Data can only be as accurate as your datum

- Need to remove biases and distortions and biases in GDA94





Source: Joel Haasdyk and Tony Watson, LPI NSW, APAS Conference 2013

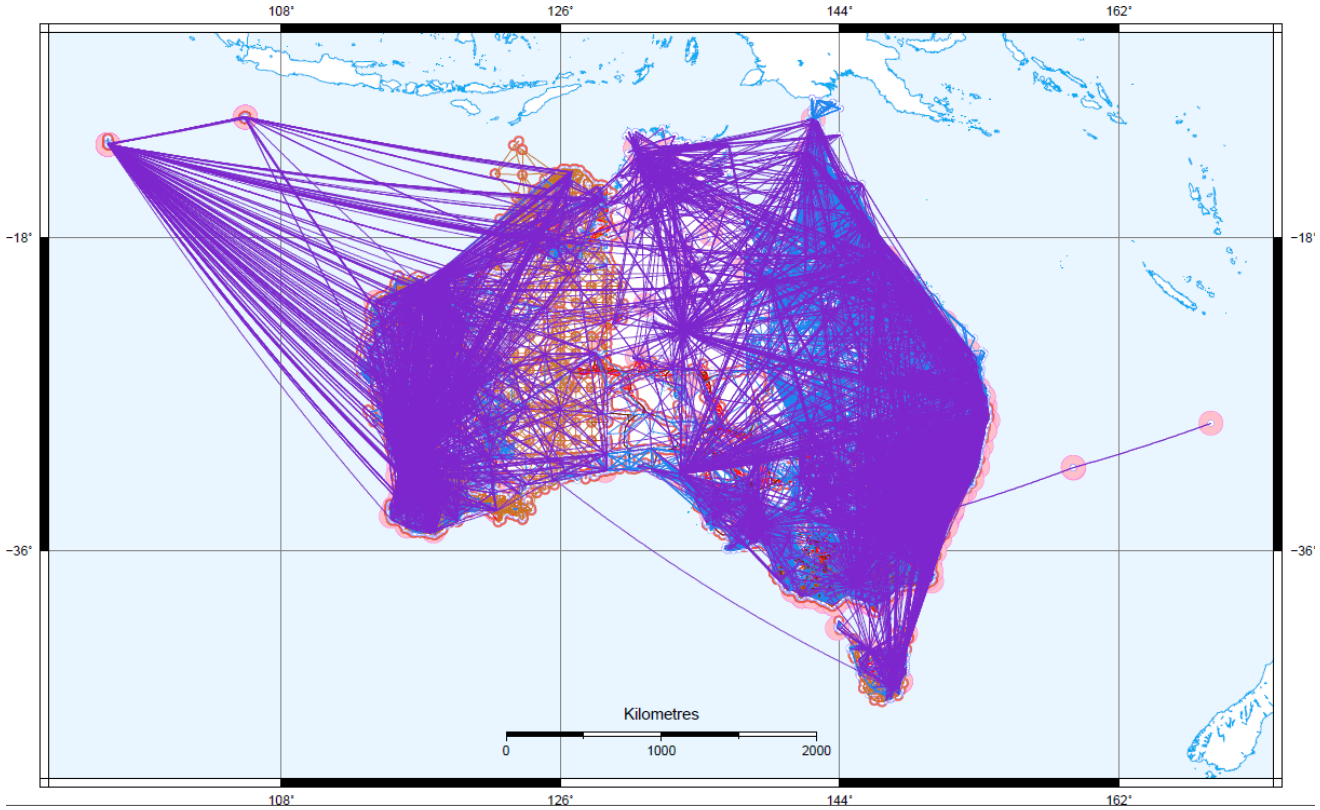
New national datum – GDA2020

- Determination made in October 2017
- Update from 21 to 109 reference sites
- 2.5 million measurements (GNSS + terrestrial)
- Rigorous national adjustment using DynaNet
- ITRF2014 coordinates extrapolated to 2020 using plate motion model

National Measurement (Recognized-Value Standard of Measurement of Position) Determination 2017

I, Dr R. Bruce Warrington, Chief Metrologist, National Measurement Institute, make the following determination.

Dated 11 October 2017



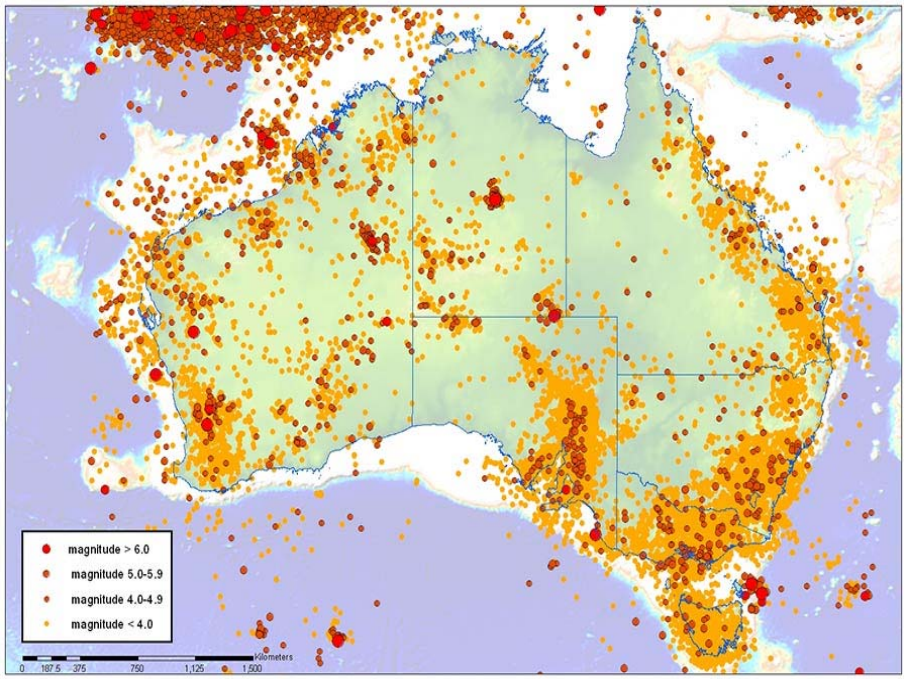
1

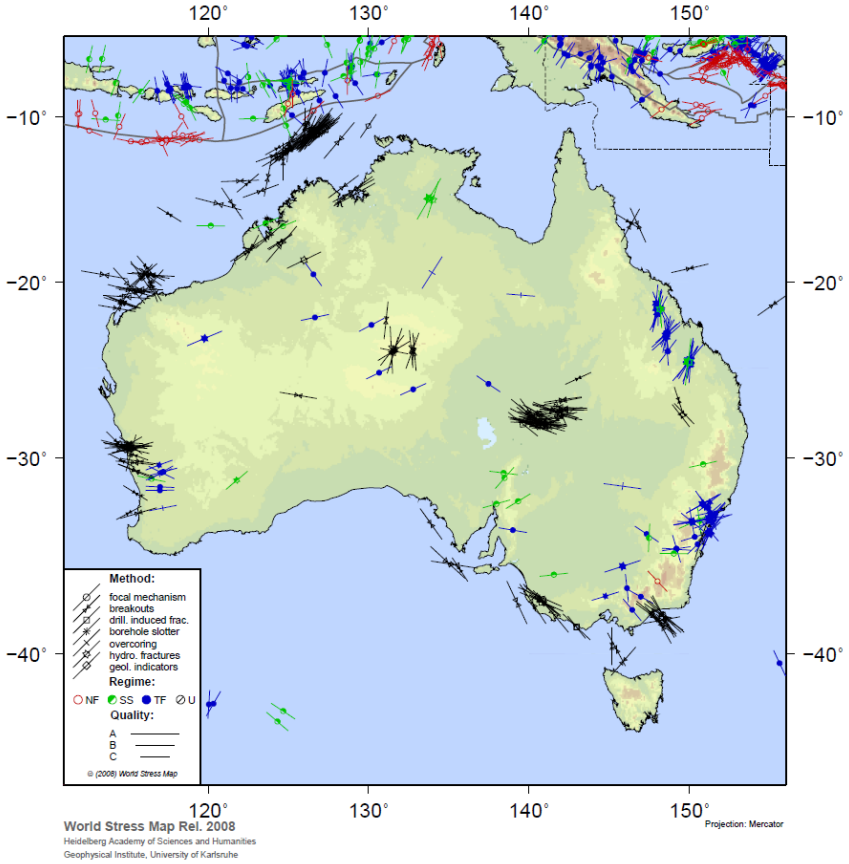
2

3

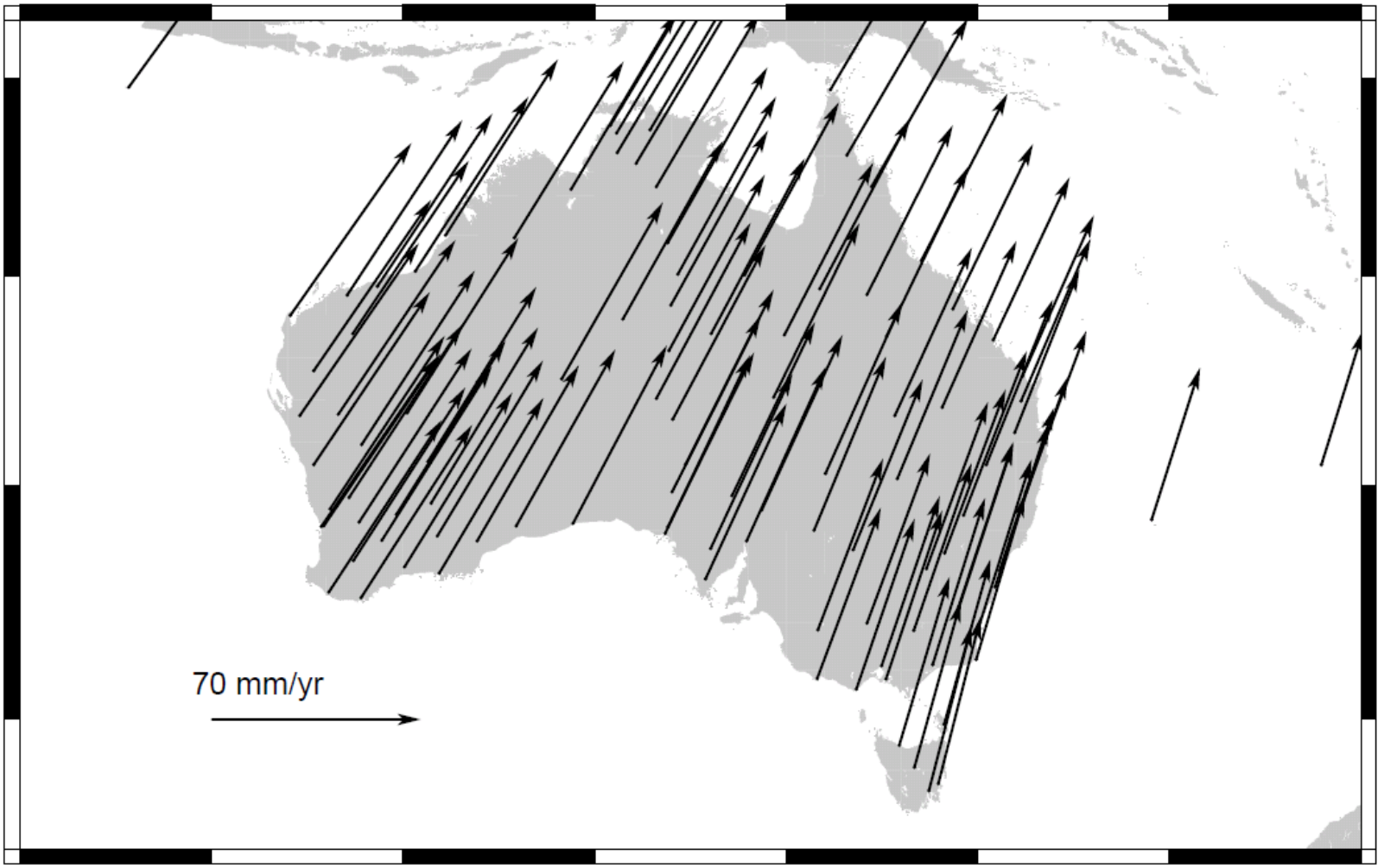
Is a plate motion model acceptable?

- Estimates of the regional seismic moments (e.g., Kostrov, 1974) lead to predictions of the deformation of the Australian plate of 0.65 ± 2 mm/yr (95% confidence level) (Leonard, 2008; Tregoning 2013)

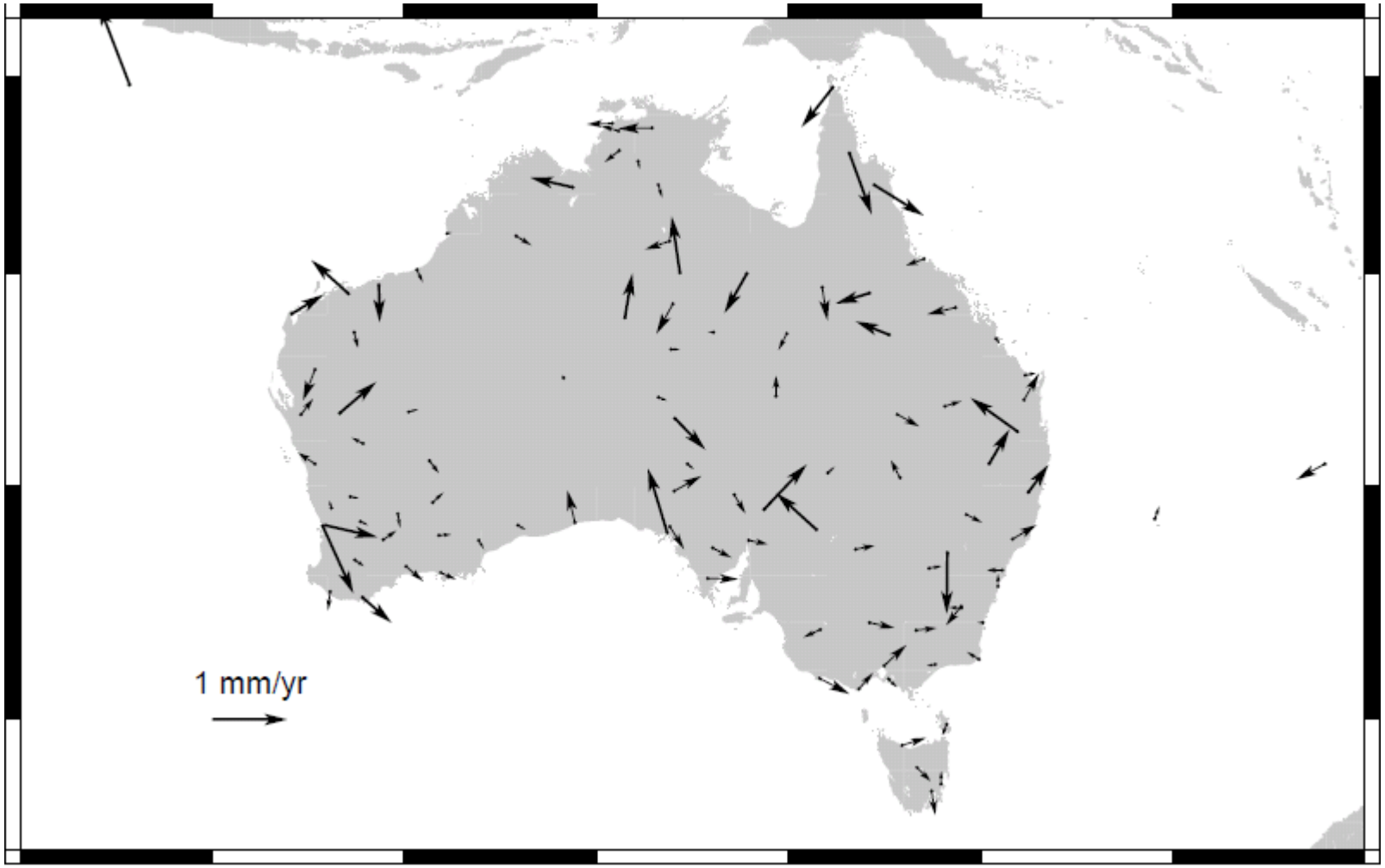




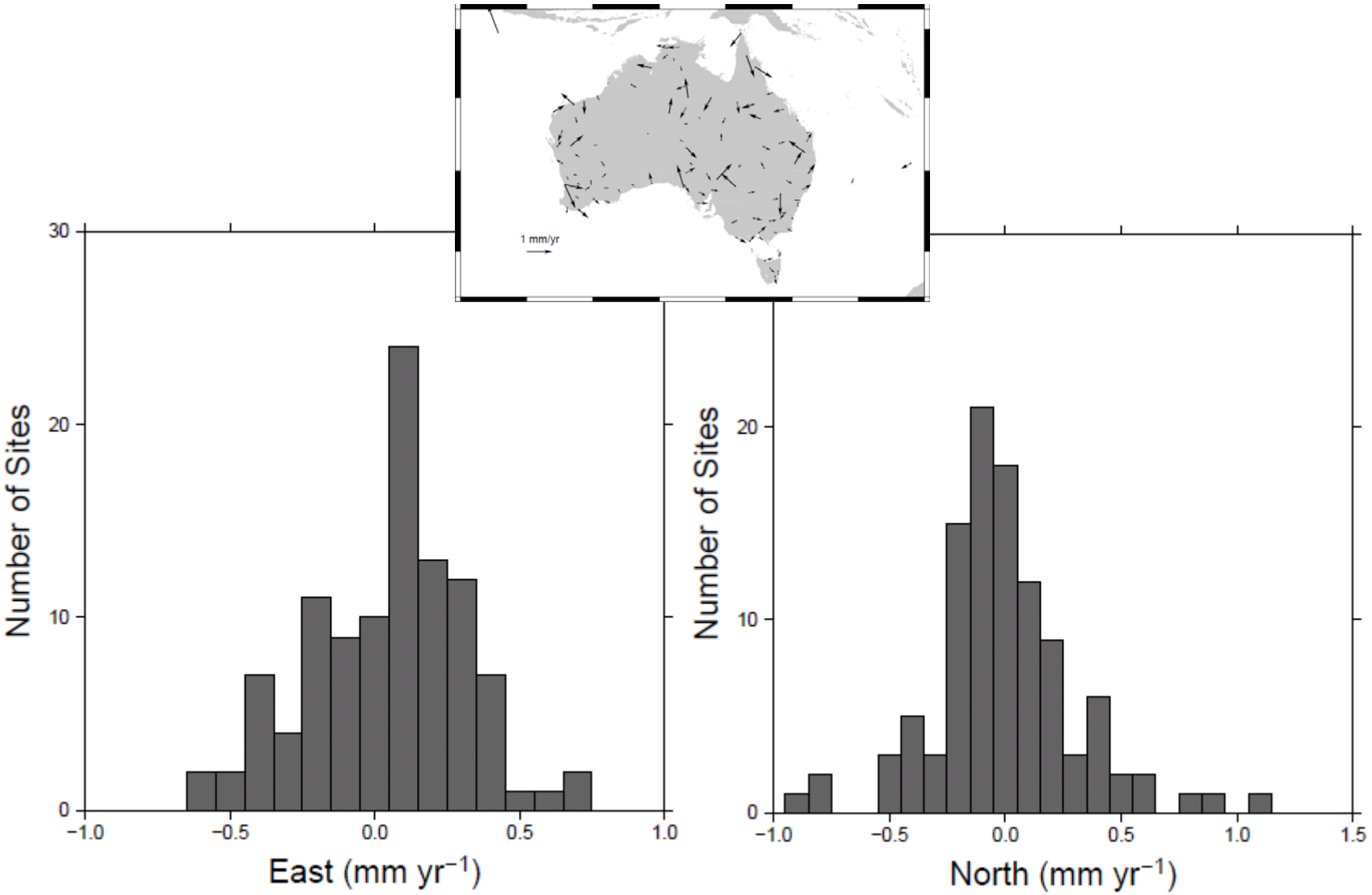
Crustal Motion



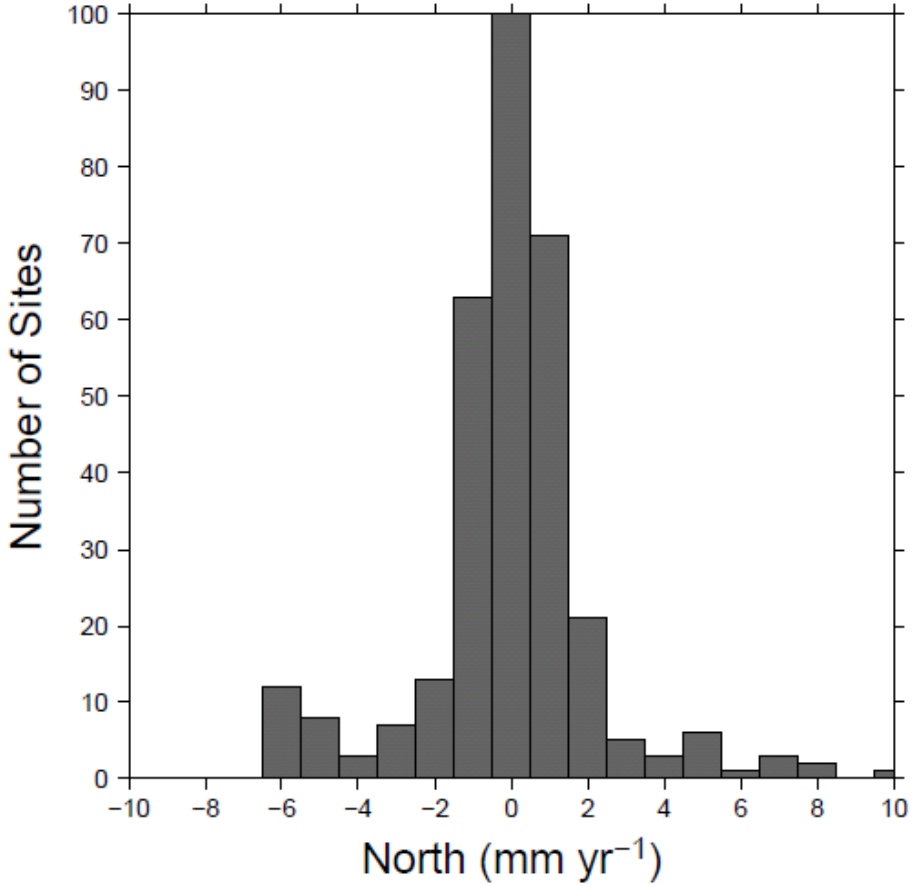
Residual Crustal Deformation

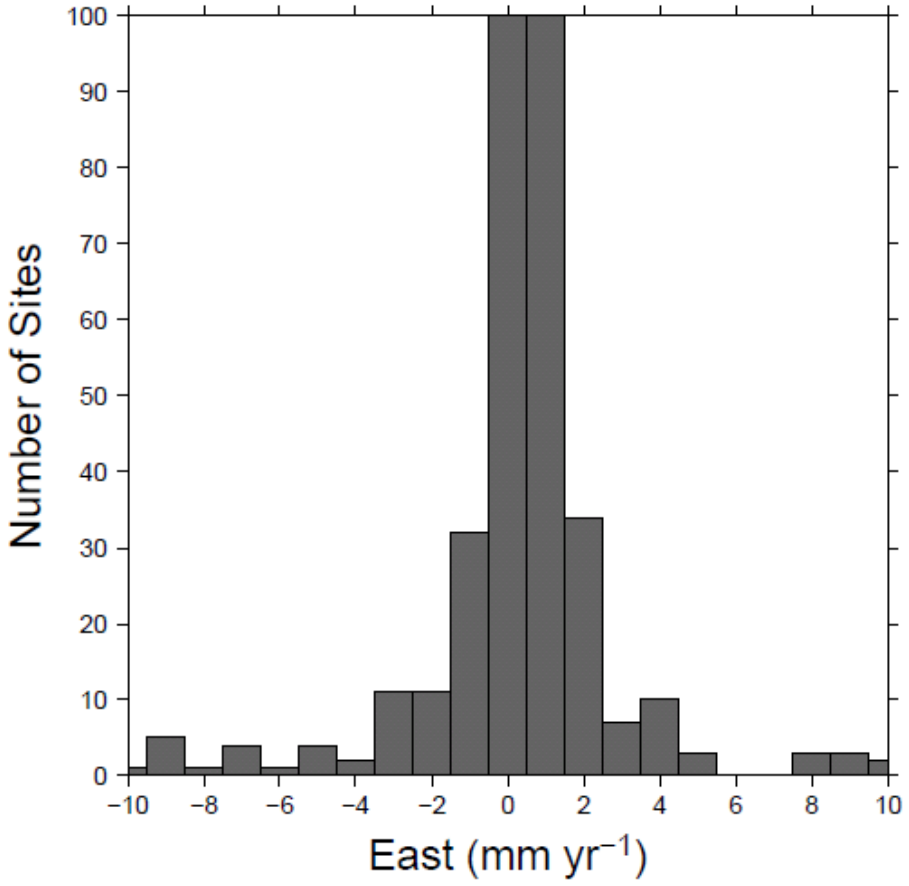


Residual Crustal Deformation

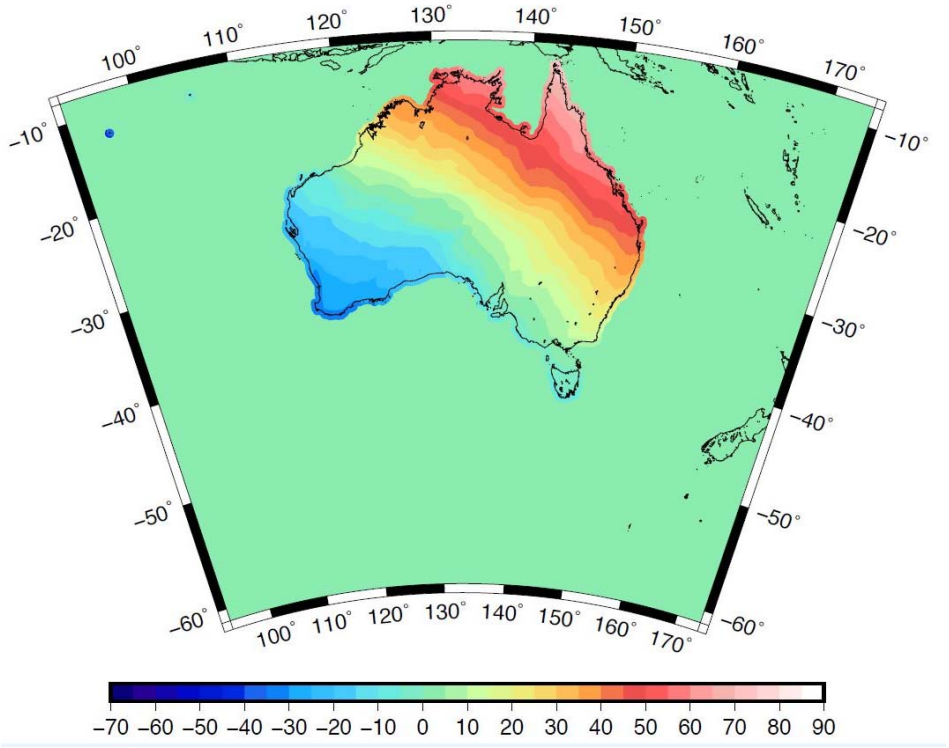


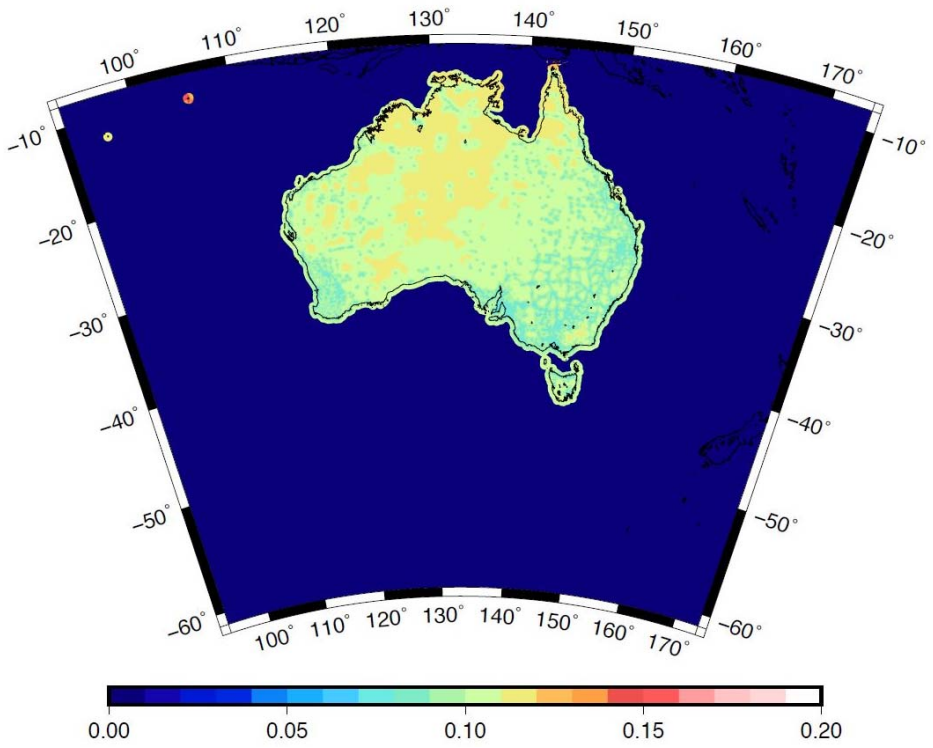
What About the Tier 3 Sites?





AUSGeoid2020 Development

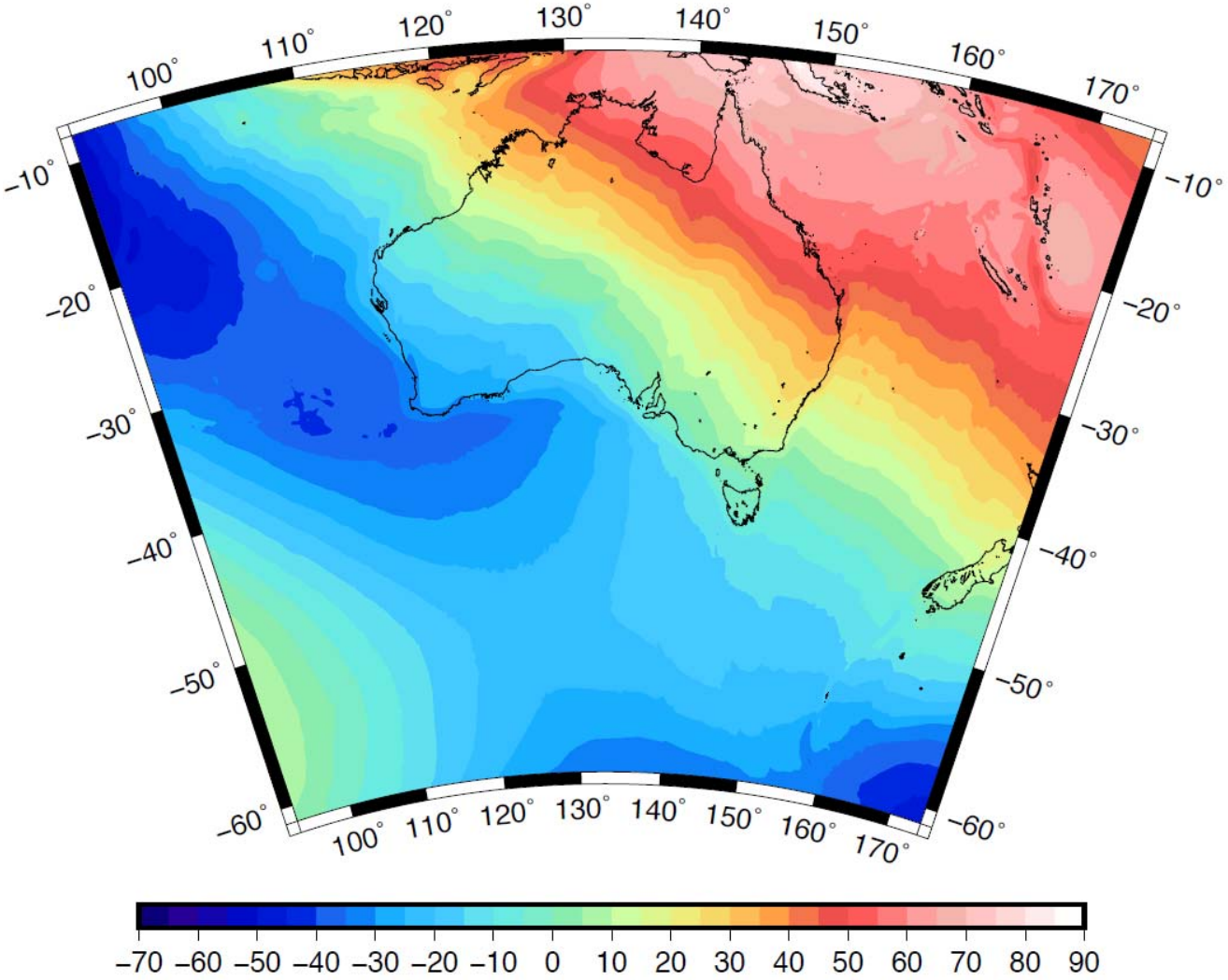


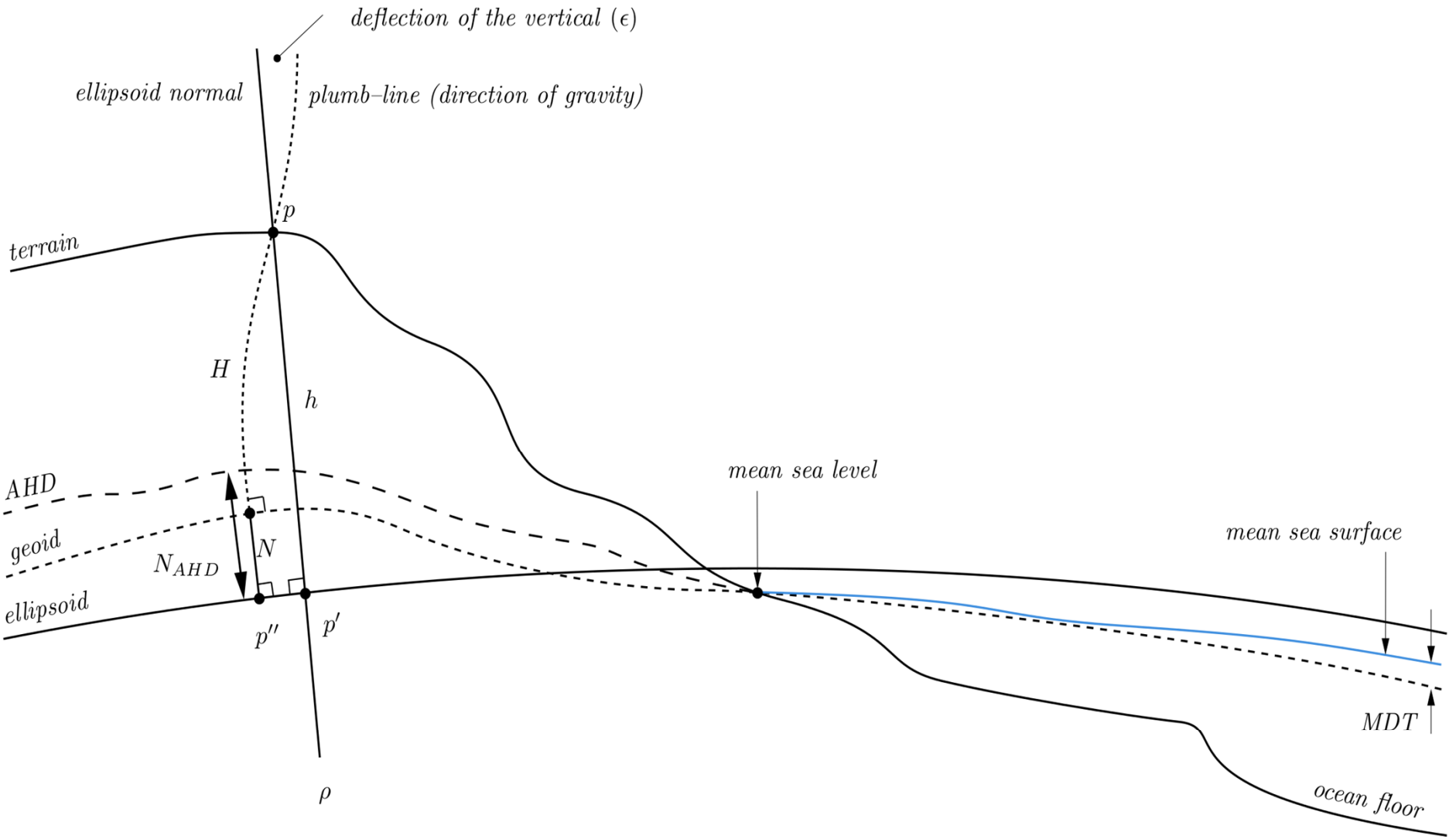


AUSGeoid2020 development procedure

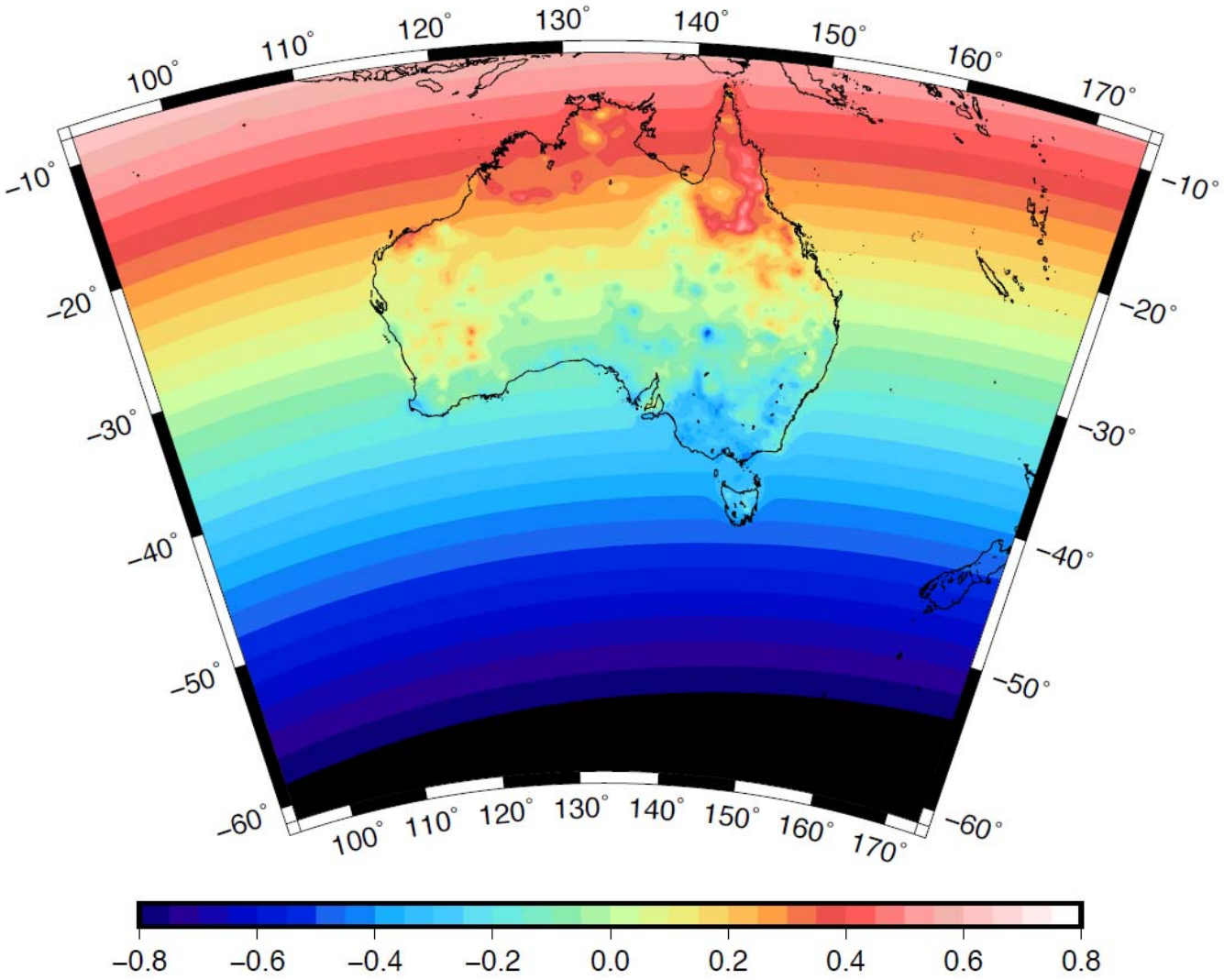
1. AUSGeoid2020 has two components; gravimetric and geometric
2. Gravimetric geoid model developed using space-borne, airborne, ship-borne and terrestrial gravity data from all over Australia
3. Gravimetric geoid model alone doesn't fit to AHD due to the manner in which AHD was realised – mean dynamic topography
4. We therefore need a geometric component to model the -0.5 to 0.5 m offset from SW to NE Australia

Gravimetric component

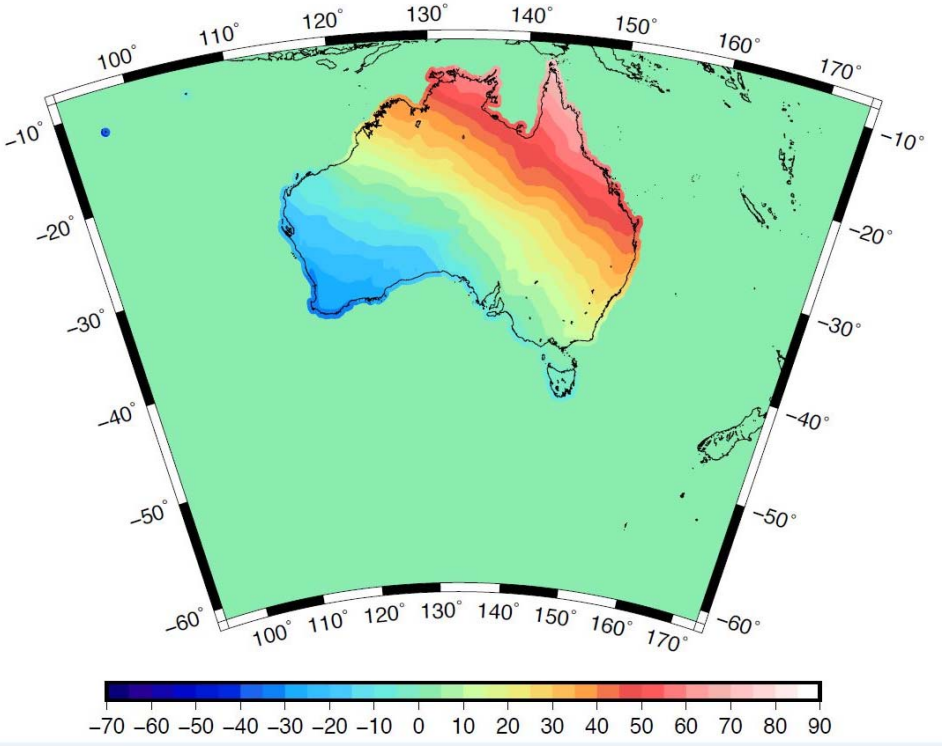


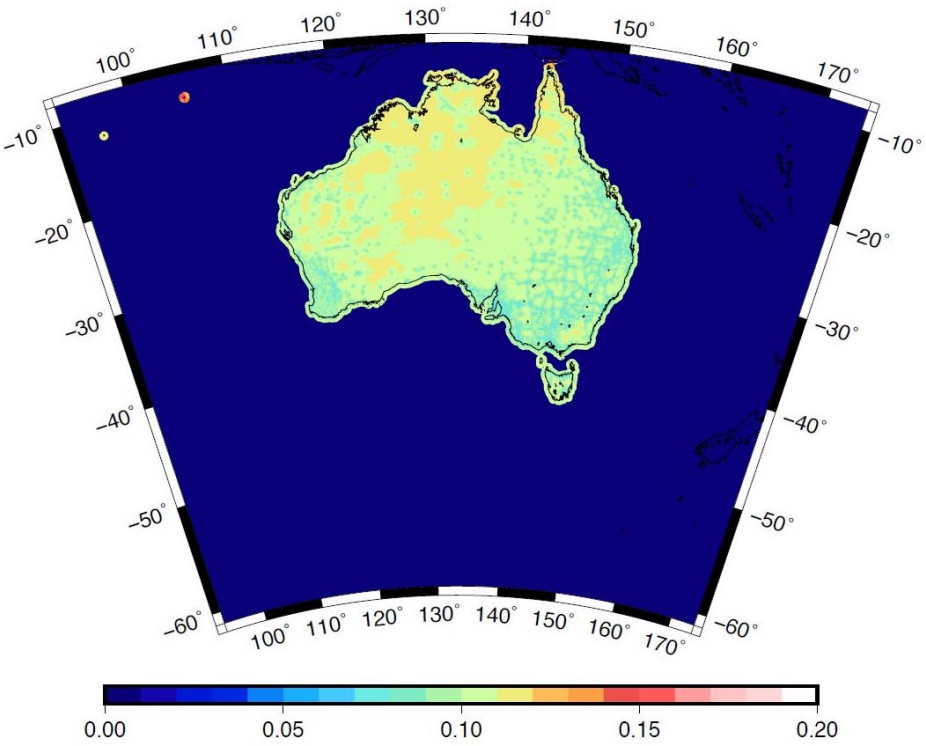


Geometric component



AUSGeoid2020 model and uncertainty





Brown et al., (2018), in prep

- Location specific absolute and relative uncertainty
- Two points 7.5 km apart each with 0.1 m absolute uncertainty have a relative uncertainty of 0.024 m

Australian Terrestrial Reference Frame (ATRF)

- Location-based data can only be as accurate as the datum to which it is aligned
- Some users / applications (e.g. high precision) do not (or will not) have their requirements met by GDA2020
- Intergovernmental Committee on Surveying and Mapping has endorsed a plan to introduce a time-dependent reference frame known as ATRF in 2020
- Closely aligned to ITRF
- Importantly, GDA2020 will also be retained in perpetuity, unless it became obvious that it was no longer needed

ATRF can be realised now

Schedule 1—Recognized-value standards of measurement in the Australian Fiducial Network

Note: See sections 6 and 7.

	Coordinates (m) at 2020.0			Coordinate Uncertainty (m)			Velocity (m / year)			Velocity Uncertainty (m / year)		
Site	X	Y	Z	$u(X)$	$u(Y)$	$u(Z)$	V_X	V_Y	V_Z	$u(V_X)$	$u(V_Y)$	$u(V_Z)$
Ceduna (SA)	-3753473.1960	3912741.0310	-3347959.6998	0.0244	0.0249	0.0229	-0.0421	0.0024	0.0501	0.0002	0.0002	0.0002
Manton Dam (NT)	-4091359.6096	4684606.4258	-1408579.1371	0.0098	0.0105	0.0072	-0.0355	-0.0137	0.0576	0.0002	0.0001	0.0002
Mt Stromlo (ACT)	-4467103.2062	2683039.4818	-3666948.7613	0.0100	0.0080	0.0090	-0.0367	0.0006	0.0452	0.0002	0.0002	0.0002

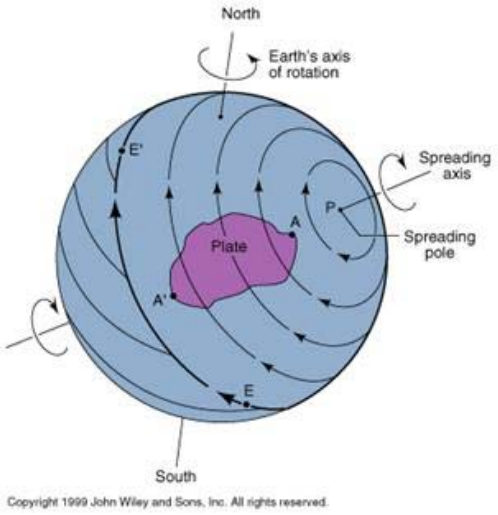
7 Calculation of global Cartesian coordinates at an epoch t years

Global Cartesian coordinates of the AFN can be expressed at an epoch t (years) through the application of the following linear model using the coordinates (X, Y, Z) and velocities (V_X, V_Y, V_Z) listed in Schedule 1:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_t = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{2020} + (t - 2020) \begin{bmatrix} V_X \\ V_Y \\ V_Z \end{bmatrix}$$

This model is valid for 15 years either side of the Reference Epoch:

$$|t - 2020| \leq 15$$



New vertical working surface

- A datum needs to meet user requirements of accuracy, integrity and accessibility
- Biases and distortions in the Australian Height Datum (AHD) make it difficult / unusable for some (e.g. accurate absolute heighting or regional scale LiDAR surveys; error in data or datum?)
- Some use the Australian Gravimetric Quasigeoid Model
- At this point in time, PCG and ICSM does not see a strong push from the user community to update the Australian Height Datum (AHD)
- Instead develop an alternative vertical working surface for those who need / want it
- Continually refined (under version control) as new gravity, levelling and GNSS data become available

Summary

- New era of positioning requirements and user base
- Technology, big data, computing power, user requirements and user expectations continue to drive down the uncertainty of positioning data.
- This in turn highlights the requirement to continually improve the accuracy and integrity of datums and reference frames.
- GDA2020 and AUSGeoid2020 deliver this for a large portion of the user base
- ATRF and a new vertical working surface will assist the users / applications who need higher precision

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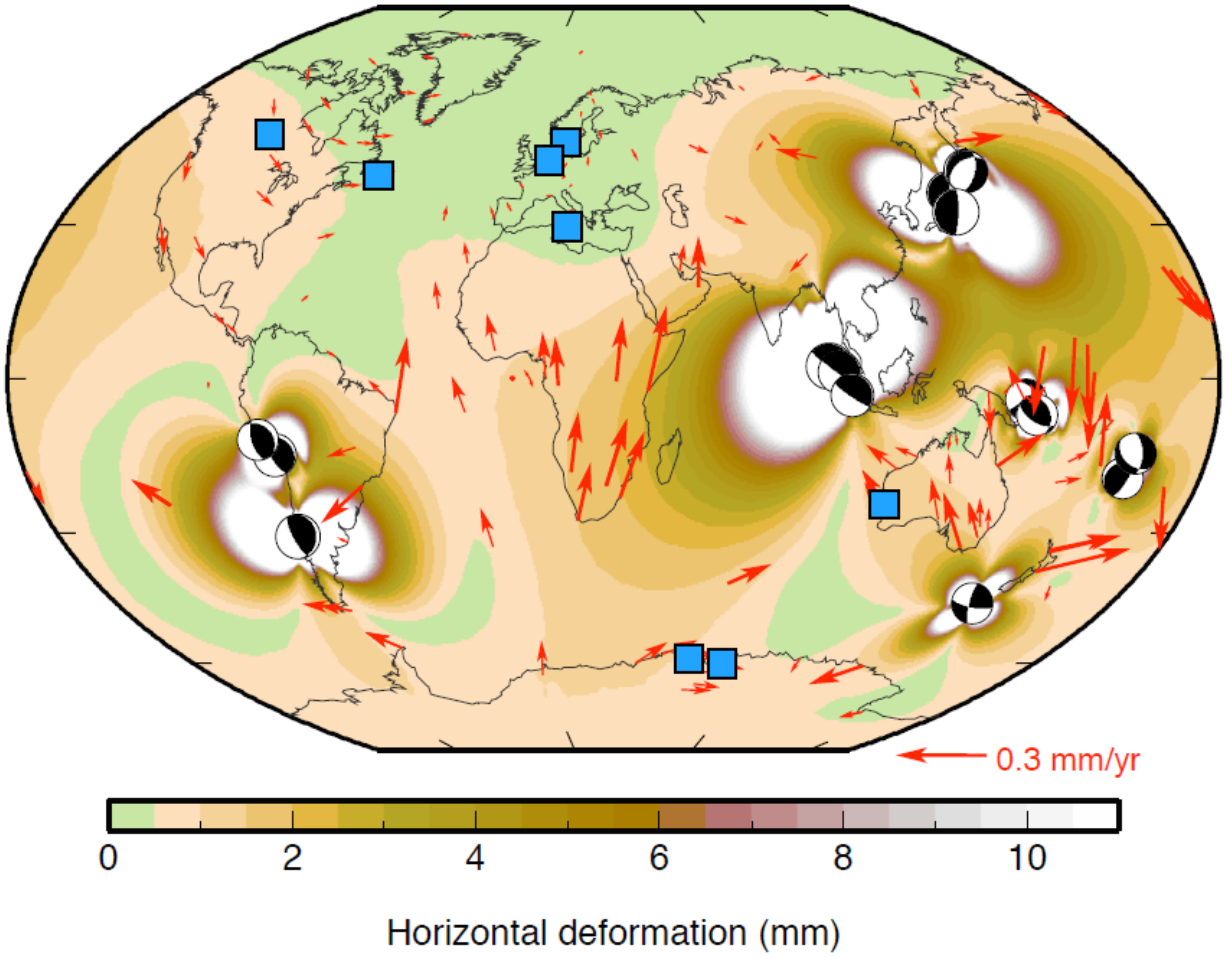
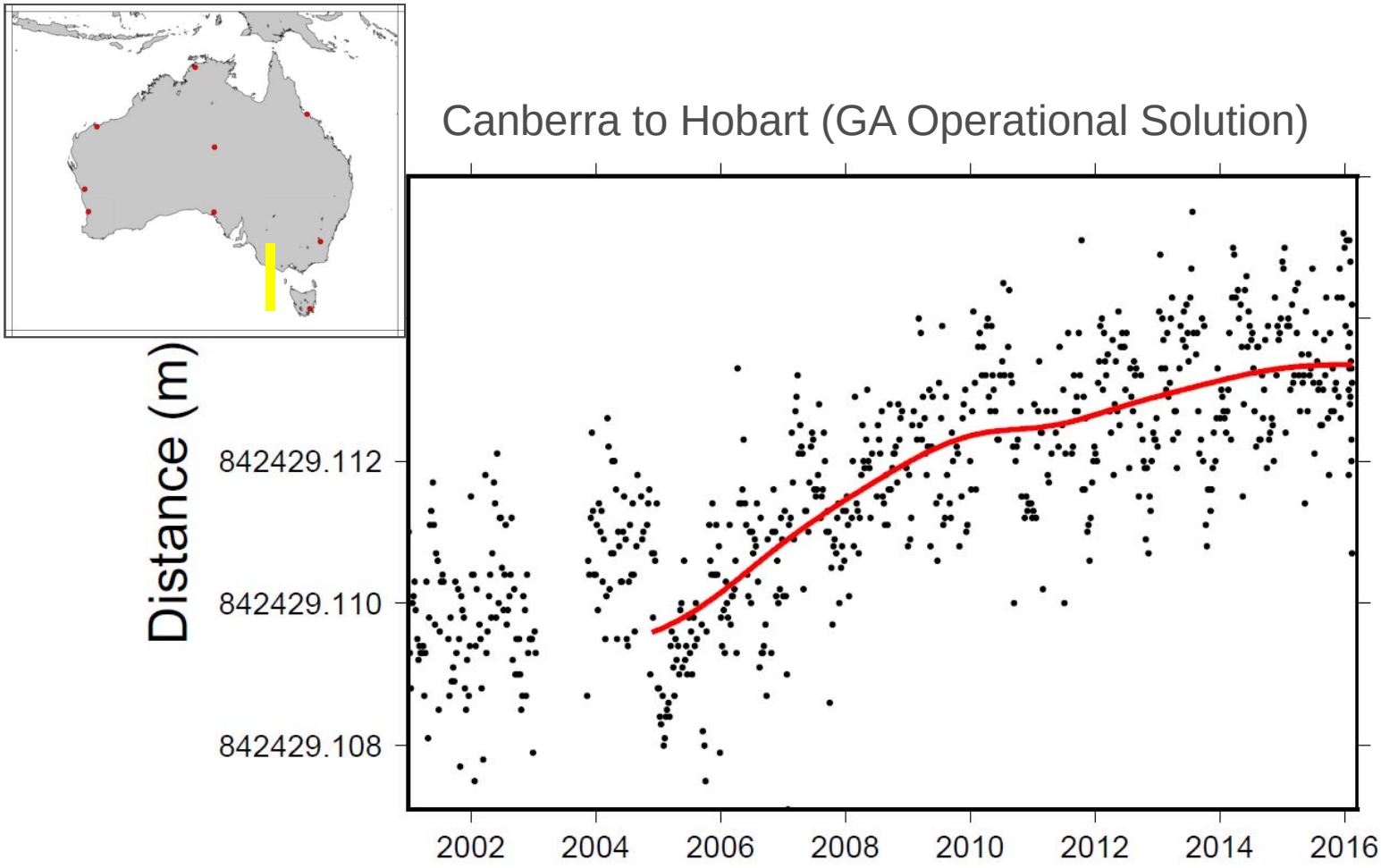
Tregoning et al, 2013



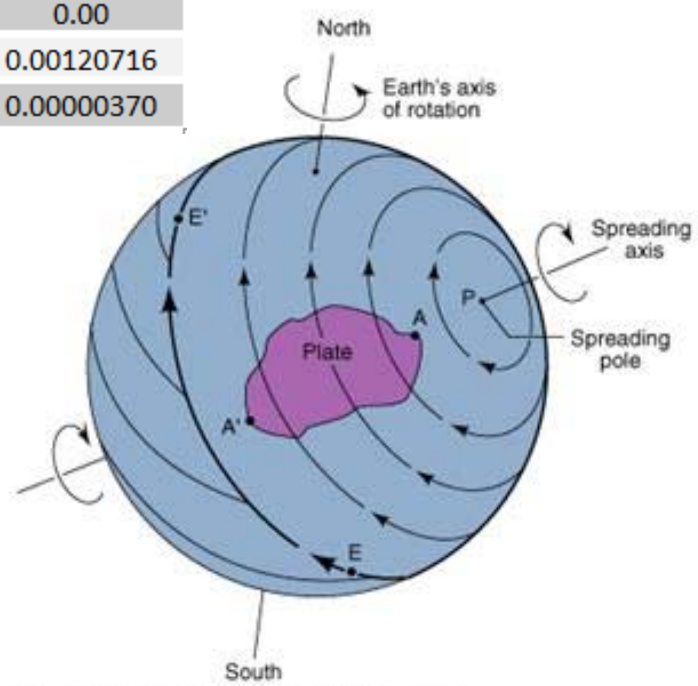
2004 Mw=8.1 Macquarie Ridge earthquake



Australian Plate Model (GDA2020 – ITRF2014)

Table 3.3: Transformation parameters for ITRF2014 to GDA2020 along with their one sigma uncertainties (1σ). Units are in meters (m) and m/yr for the translation and their rates, respecti parts-per-million (ppm) and ppm/yr for scale and its rate, respectively, and arcseconds and arcseconds/yr for rotations and their rates, respectively. The reference epoch t_0 is 2020.0.

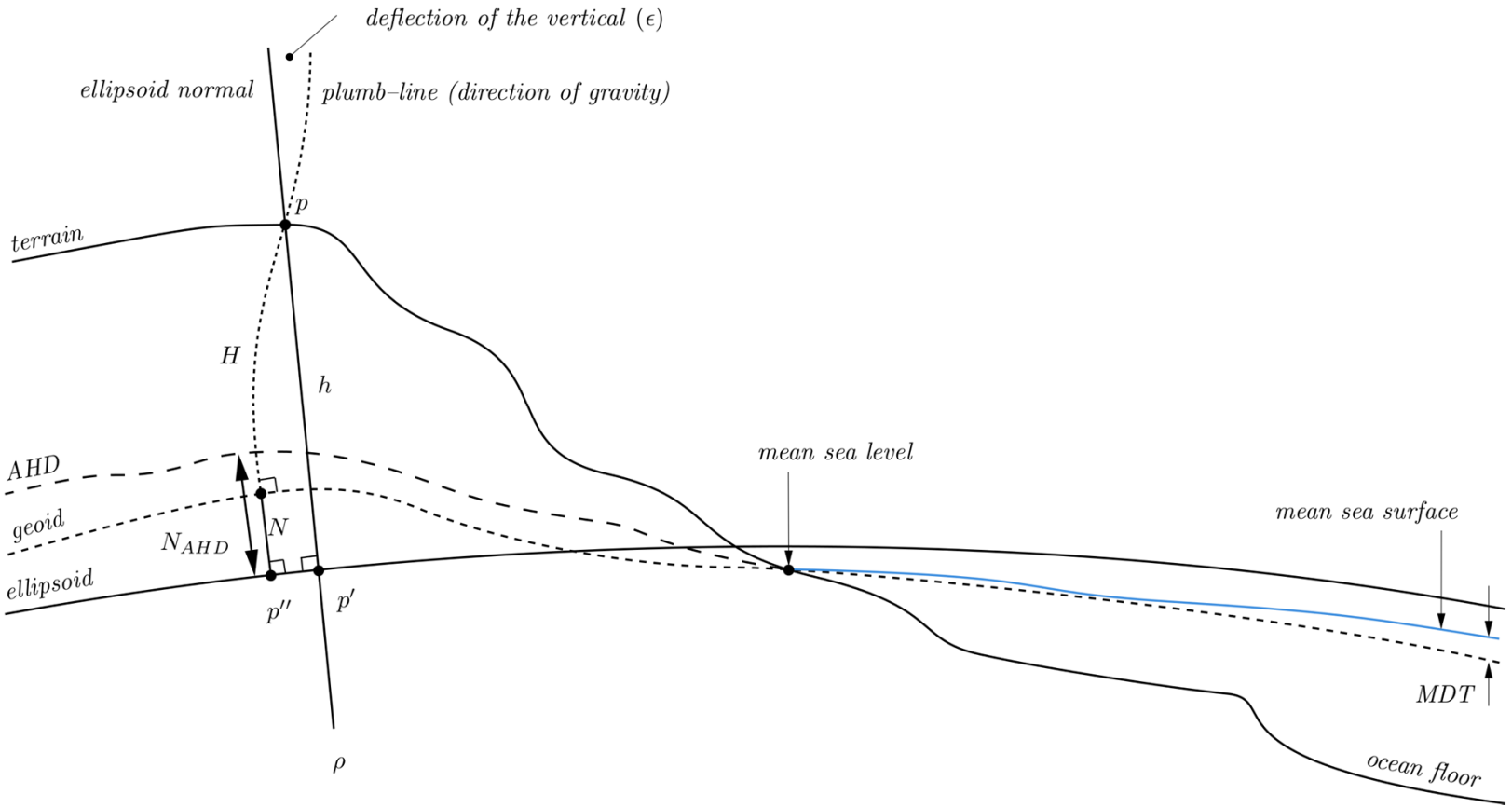
	$t_x, \dot{t}_x$	$t_y, \dot{t}_y$	$t_z, \dot{t}_z$	$s_c, \dot{s}_c$	$r_x, \dot{r}_x$	$r_y, \dot{r}_y$	$r_z, \dot{r}_z$
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
uncertainty	0.00	0.00	0.00	0.00	0.00	0.00	0.00
rates	0.00	0.00	0.00	0.00	0.00150379	0.00118346	0.00120716
uncertainty	0.00	0.00	0.00	0.00	0.00000417	0.00000401	0.00000370



Australian Plate Model (GDA2020 – ITRF2014)

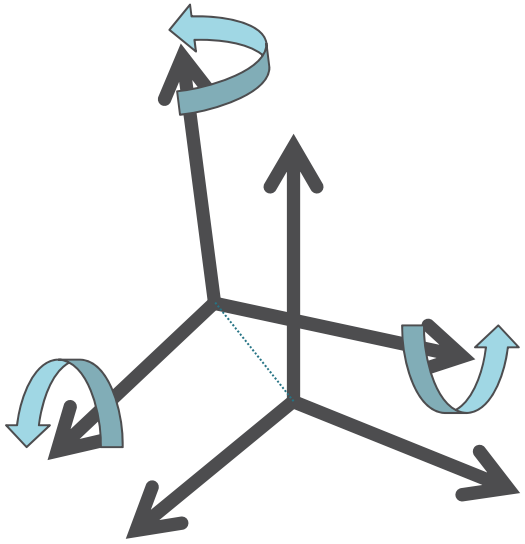
- Conventional plate model works well in Australia for geodetic applications
- Australian Plate across the Australian continent is stable at the 0.2 to 0.3 mm/yr level
- Post-seismic effects from far-field earthquake do change crustal motion Australian sites by ~0.3 mm/yr
- Co-seismic effects from far-field earthquakes at the 3mm level
  - Not an issue for CORS if they are modelled
- Crustal velocities are gazetted now as part of GDA2020

Geometric Component

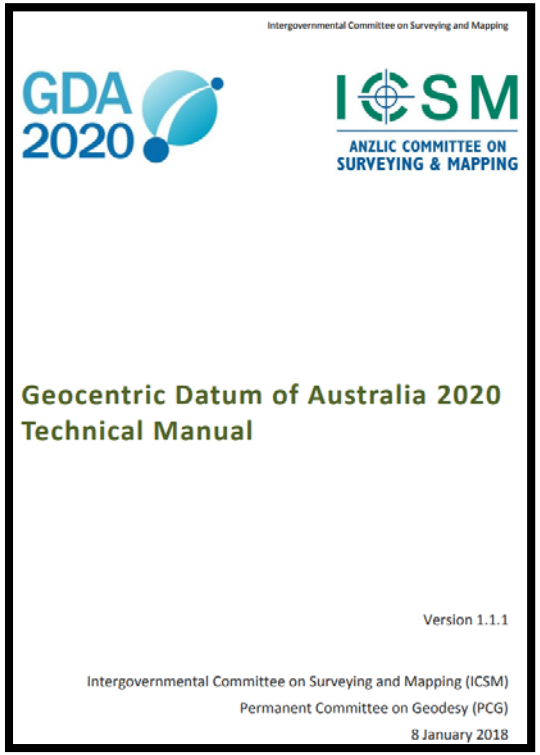


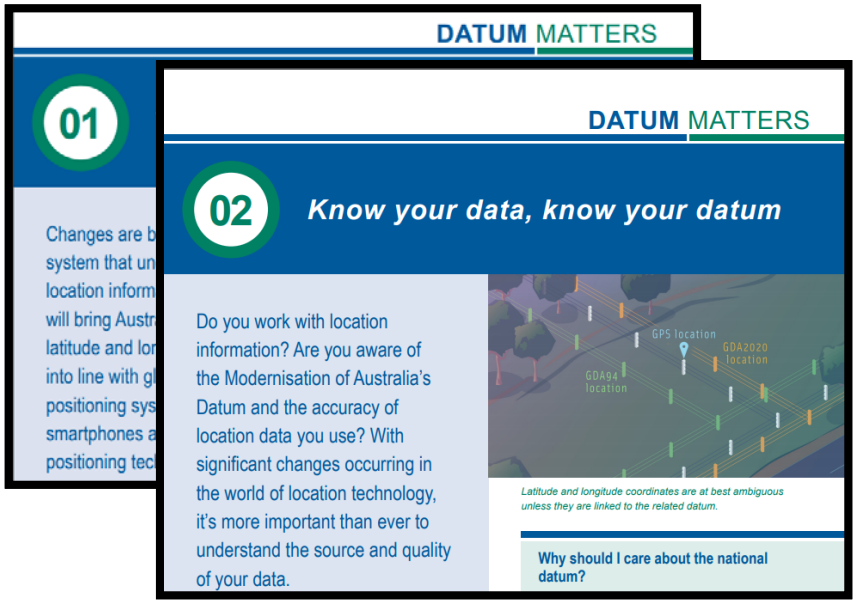
GDA94 – GDA2020 Transformation

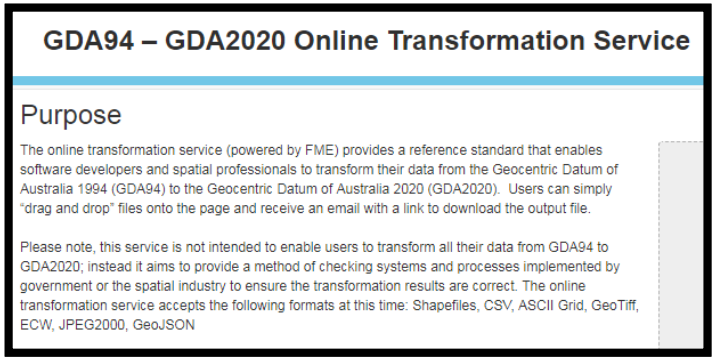
- Use common points from GDA94 Determination and GDA2020 Determination
- 21 reference points from GDA94 AFN minus MAC1, COCO and XMIS due to seismic displacement
- Solve for the 7-parameters (3 x rotation, 1 x scale and 3 x translation) using CATREF software



GDA2020 Products and Services







Drones

- High-precision drone applications for agriculture and forestry
- Amazon Prime Air