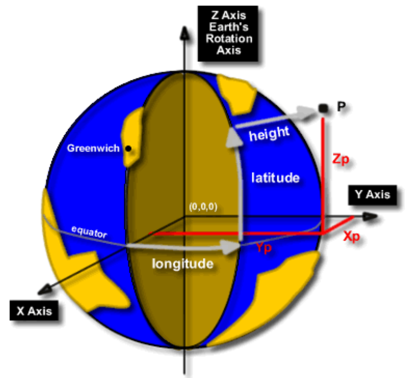
Case Study of Australia

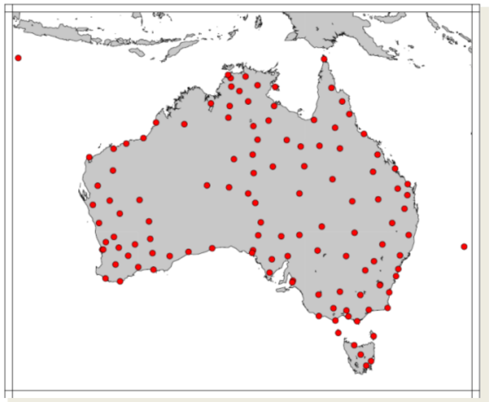
John Dawson, Geoscience Australia

Australia's Geodetic 'eco-system'

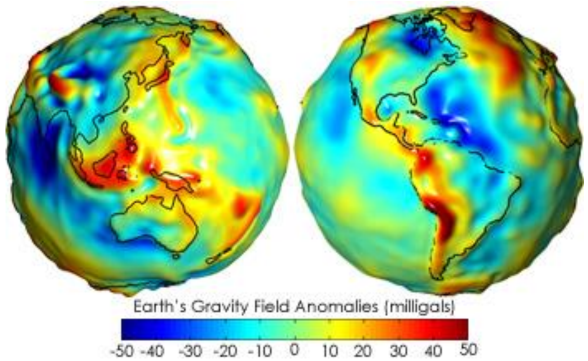
Geocentric Coordinates



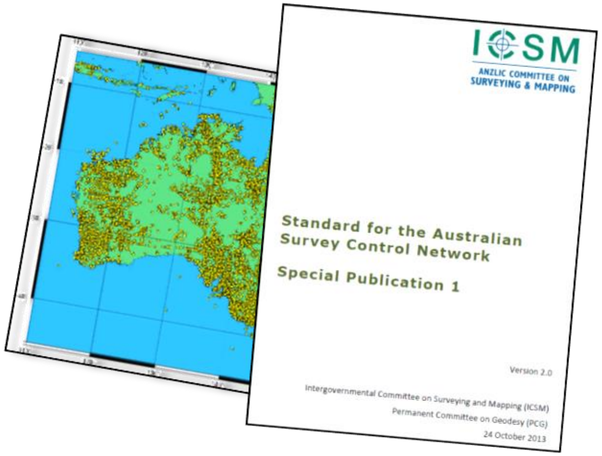
Observing Infrastructure



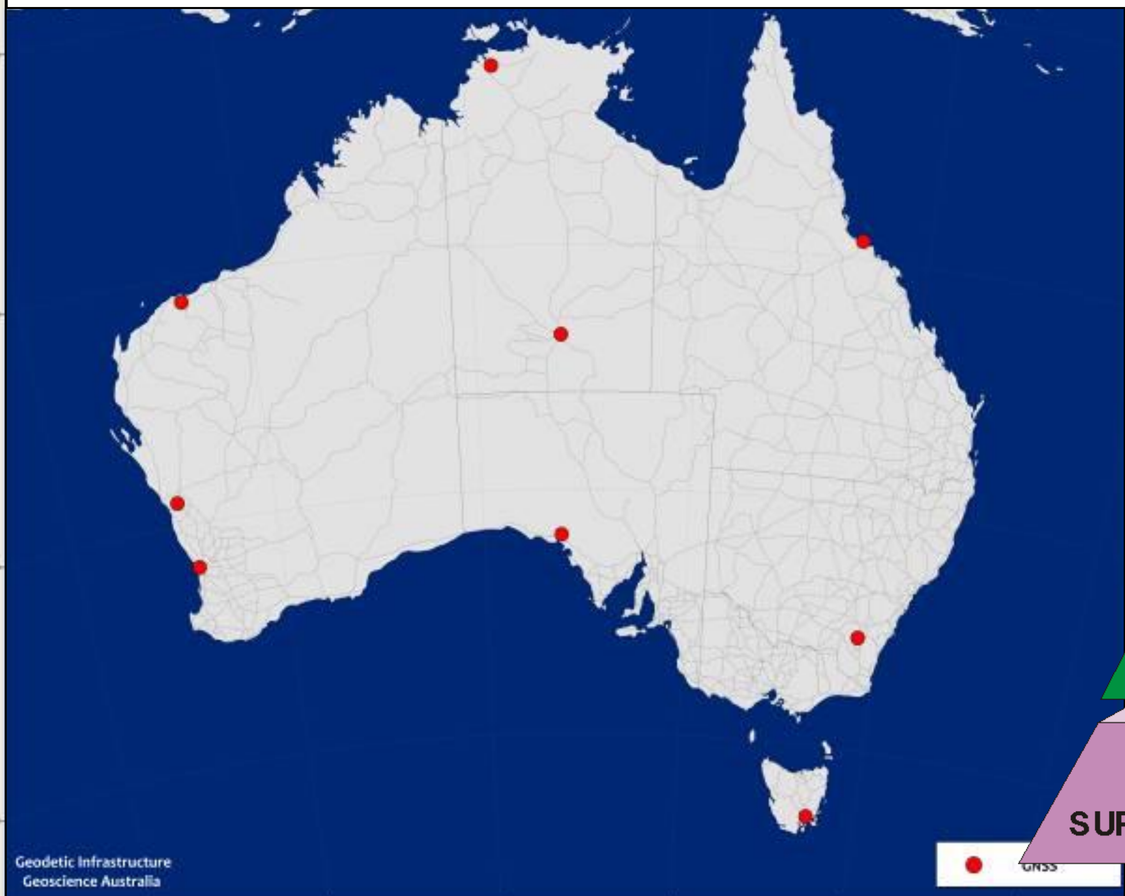
Height Datum
Geoid Models



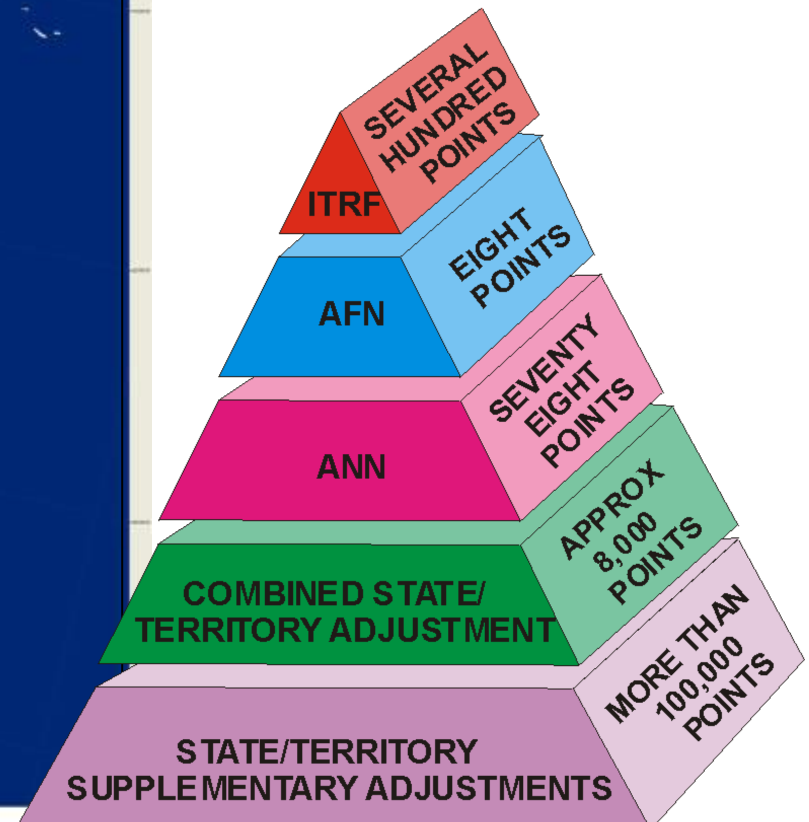
Tools
Services
Standards



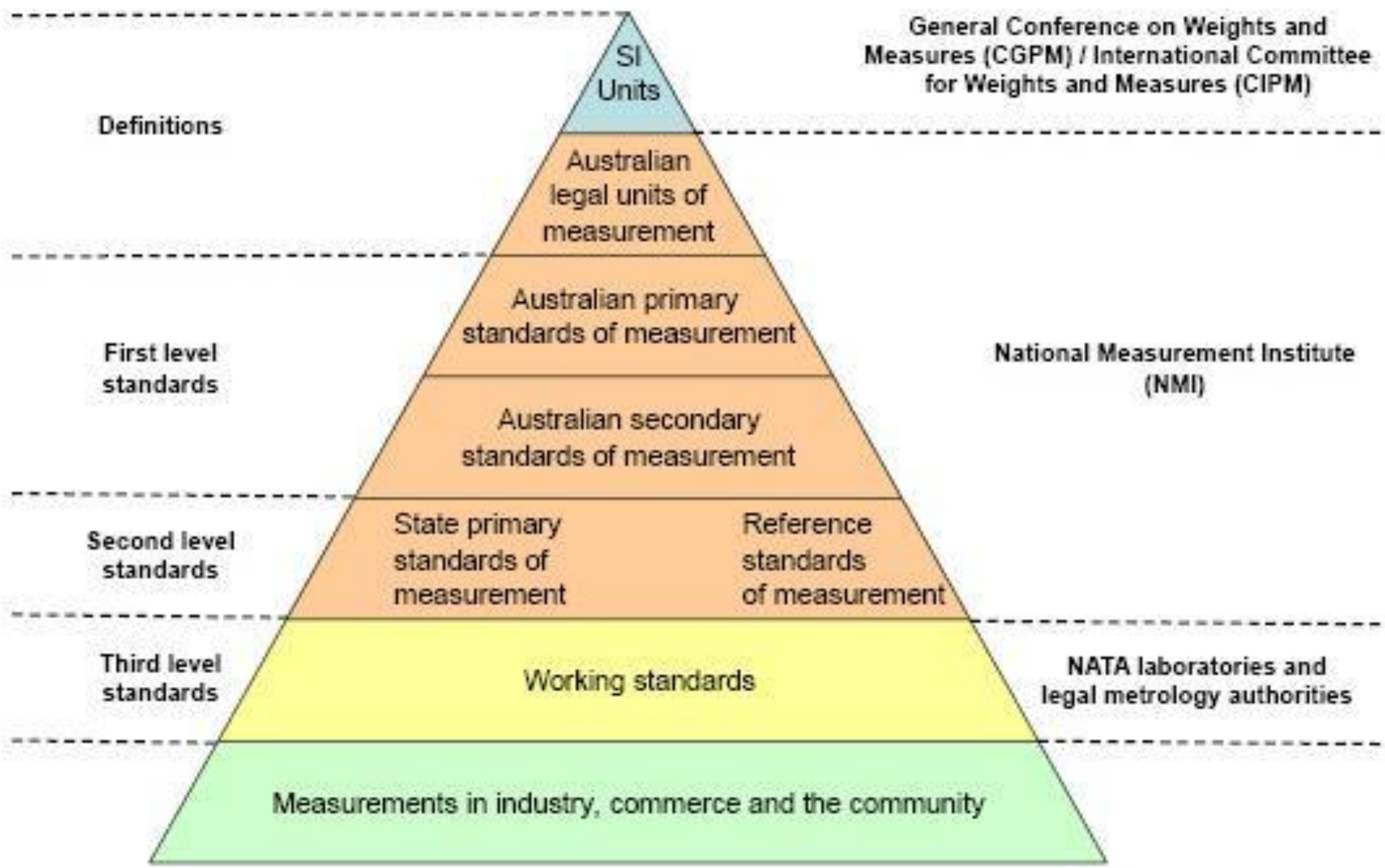
Australia Fiducial Network (AFN)



ITRF92@1994



National Measurement System



Journal of Applied Geodesy 4 (2010), 189–199 © de Gruyter 2010. DOI 10.1515/JAG.2010.019

ITRF to GDA94 coordinate transformations

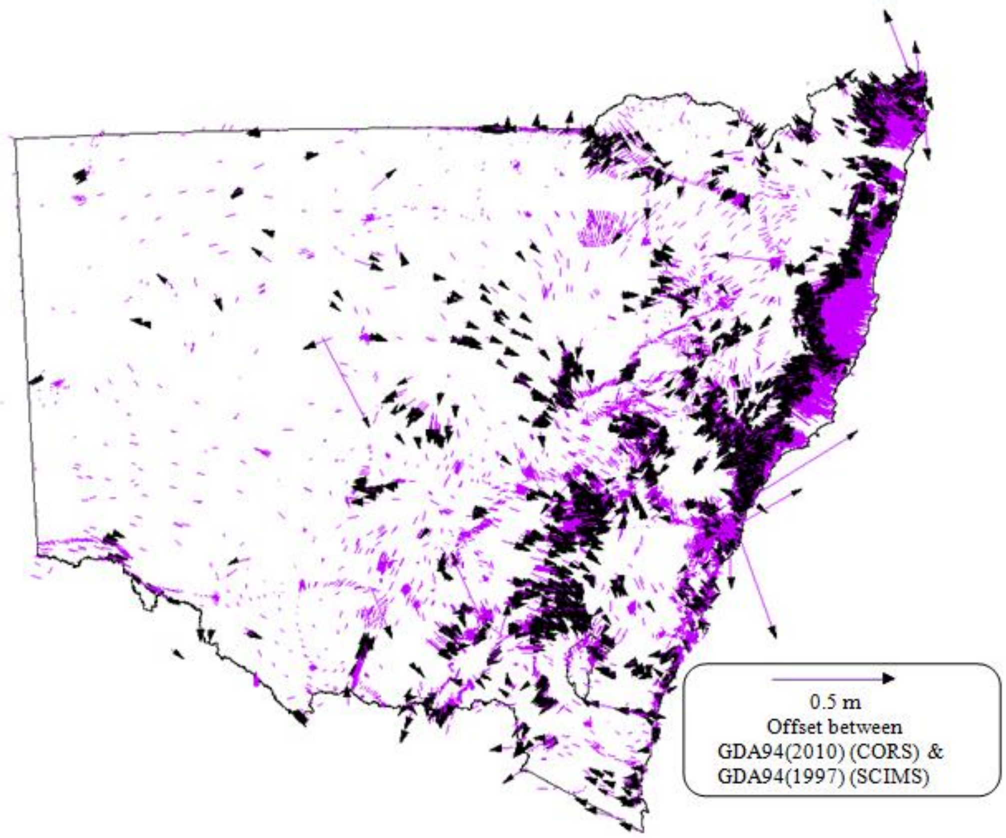
John Dawson and Alex Woods

- Geocentric Datum of Australia 1994 (GDA94)
- ITRF96@1994.0

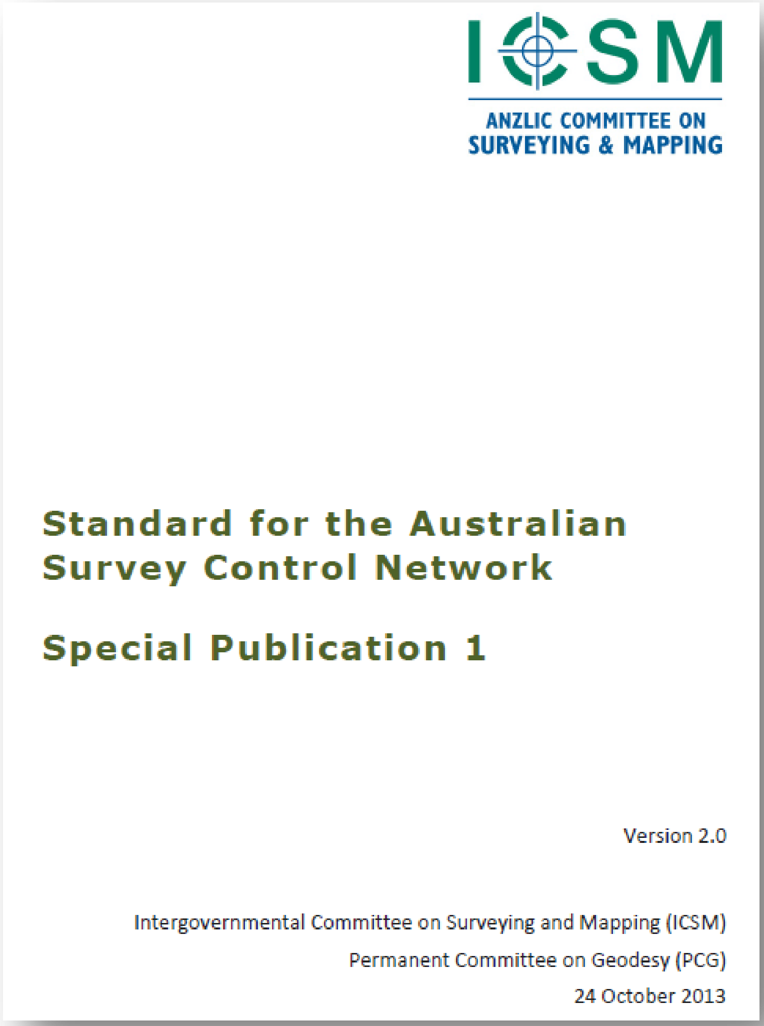
GDA94 to ITRF

$$\begin{pmatrix} X_{GDA94} \\ Y_{GDA94} \\ Z_{GDA94} \end{pmatrix} = \mathbf{T}\begin{Bmatrix} X_{ITRF} \\ Y_{ITRF} \\ Z_{ITRF} \end{Bmatrix} = \begin{pmatrix} t_x + \dot{t}_x(t-t_0) \\ t_y + \dot{t}_y(t-t_0) \\ t_z + \dot{t}_z(t-t_0) \end{pmatrix} + (1 + s_c + \dot{s}_c(t-t_0)) \begin{pmatrix} 1 & r_z + \dot{r}_z(t-t_0) & -r_y - \dot{r}_y(t-t_0) \\ -r_z - \dot{r}_z(t-t_0) & 1 & r_x + \dot{r}_x(t-t_0) \\ r_y + \dot{r}_y(t-t_0) & -r_x - \dot{r}_x(t-t_0) & 1 \end{pmatrix} \begin{pmatrix} X_{ITRF} \\ Y_{ITRF} \\ Z_{ITRF} \end{pmatrix}$$

- Geocentric Datum of Australia 1994 (GDA94)
- ITRF96@1994.0
- Sub-cm accuracy at Australian Fiducial Network stations



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


ICSM
ANZLIC COMMITTEE ON SURVEYING & MAPPING

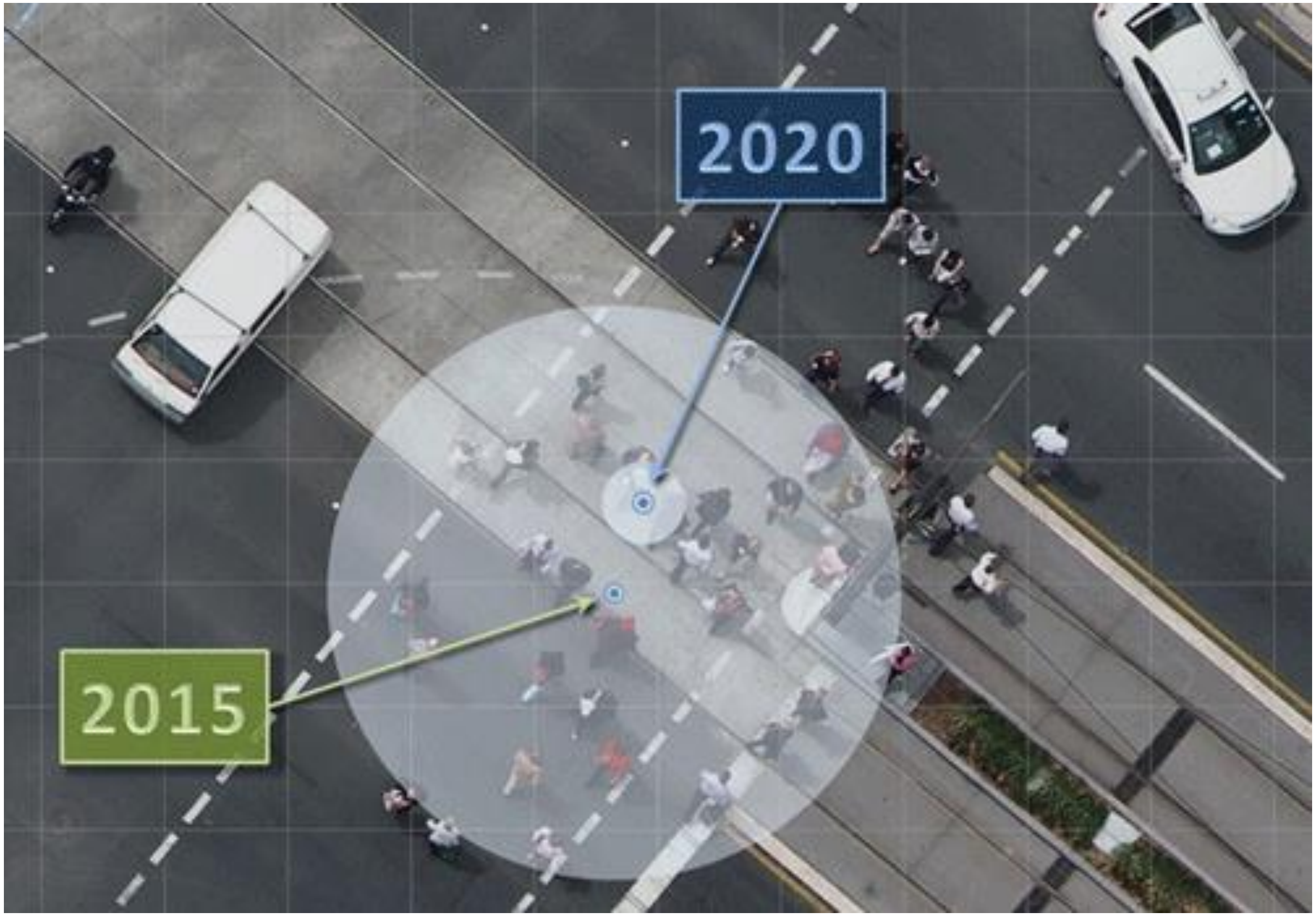
Standard for the Australian Survey Control Network

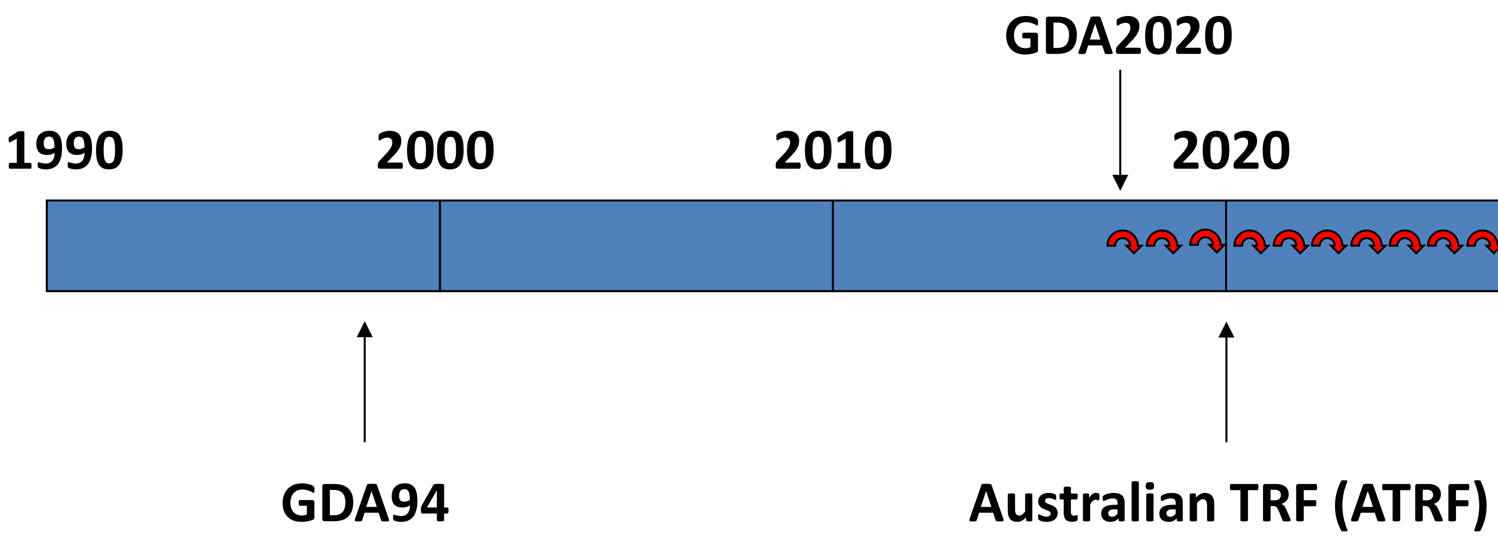
Special Publication 1

Version 2.0

Intergovernmental Committee on Surveying and Mapping (ICSM)
Permanent Committee on Geodesy (PCG)
24 October 2013

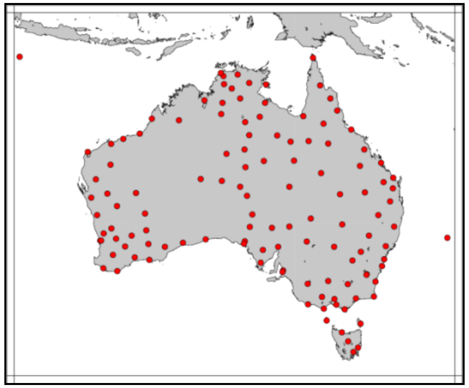
Modernising Australia's Datum

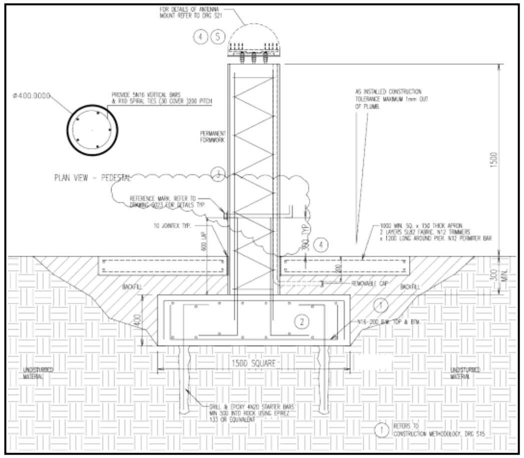




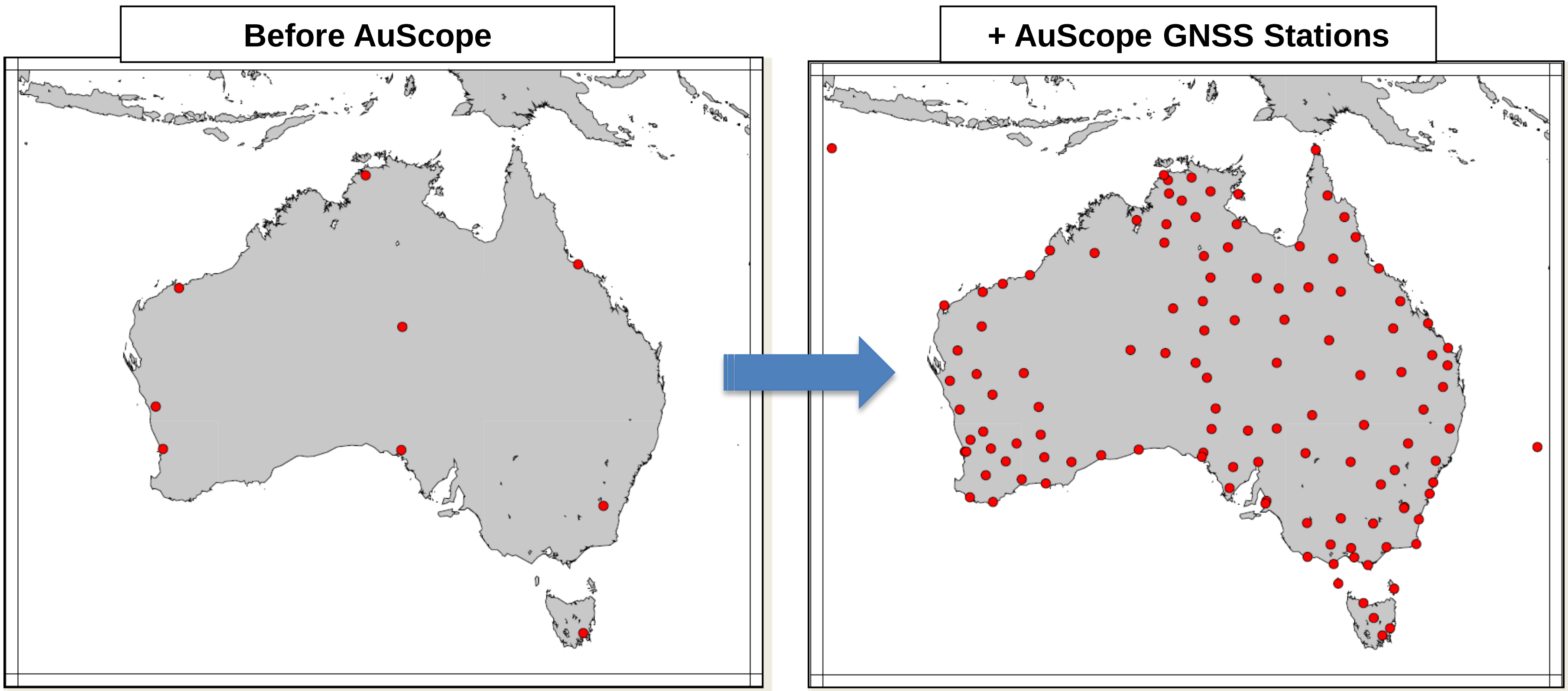
ICSM/ANZLIC Adoption and User Implementation

AuScope GNSS Array

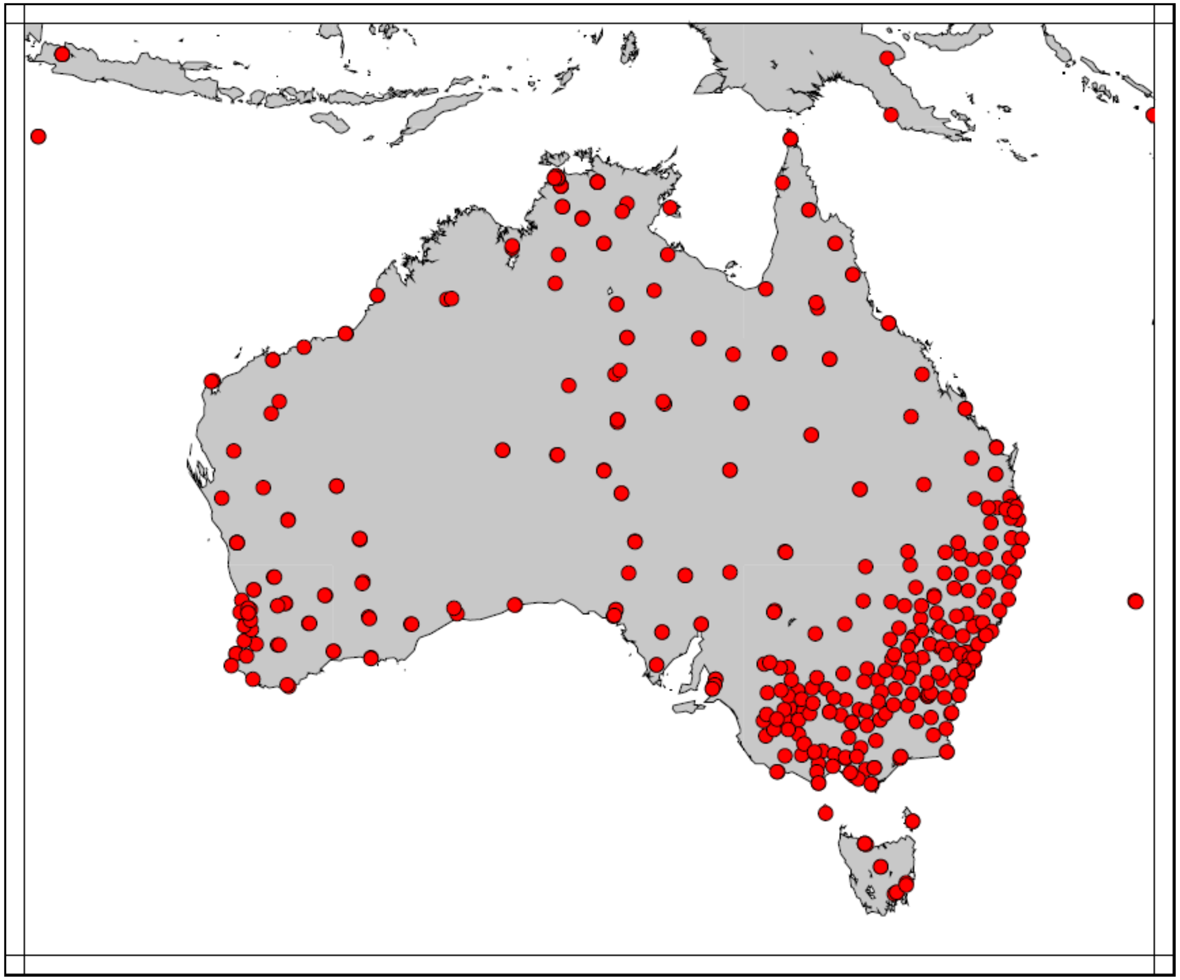


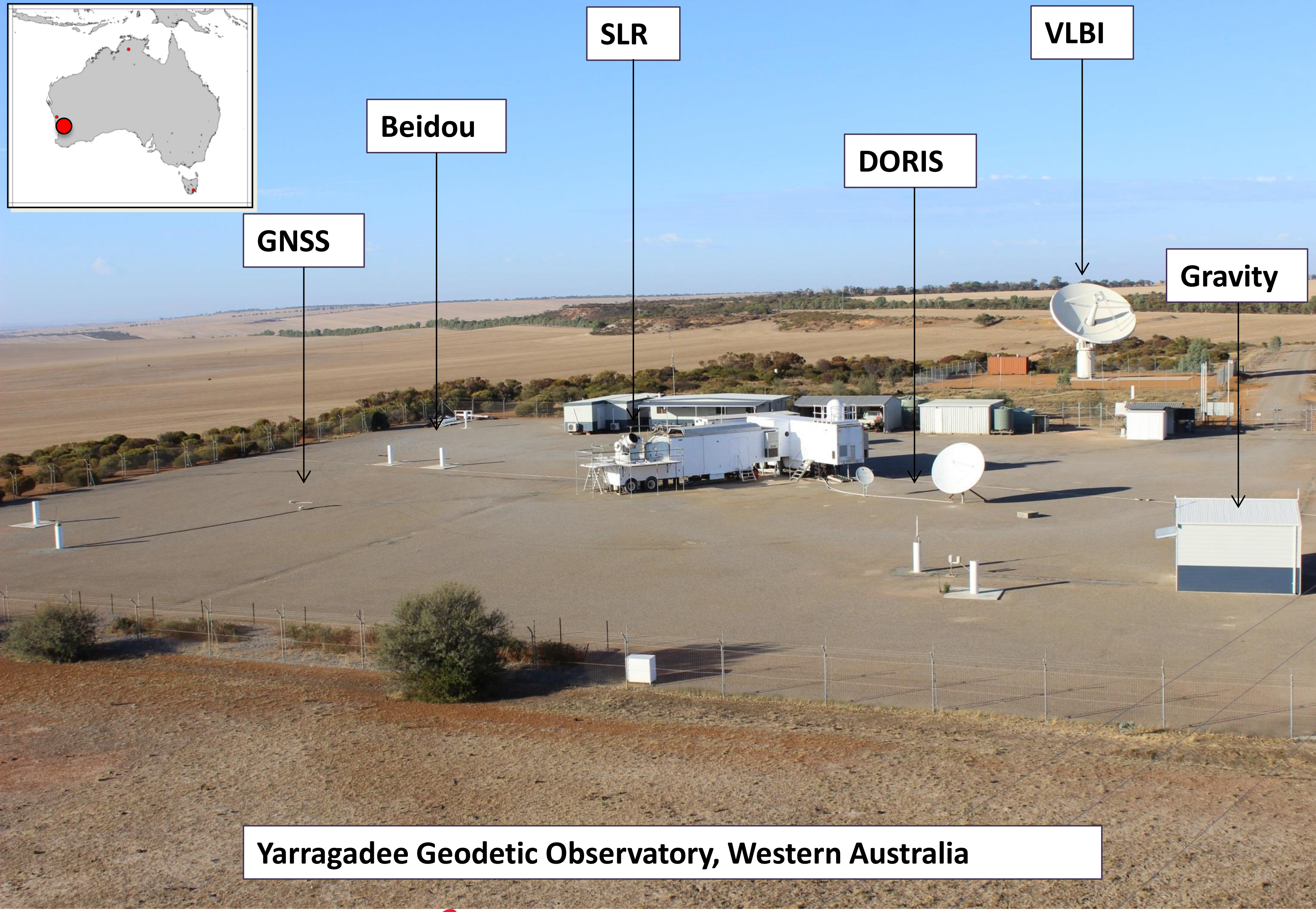


National GNSS Infrastructure

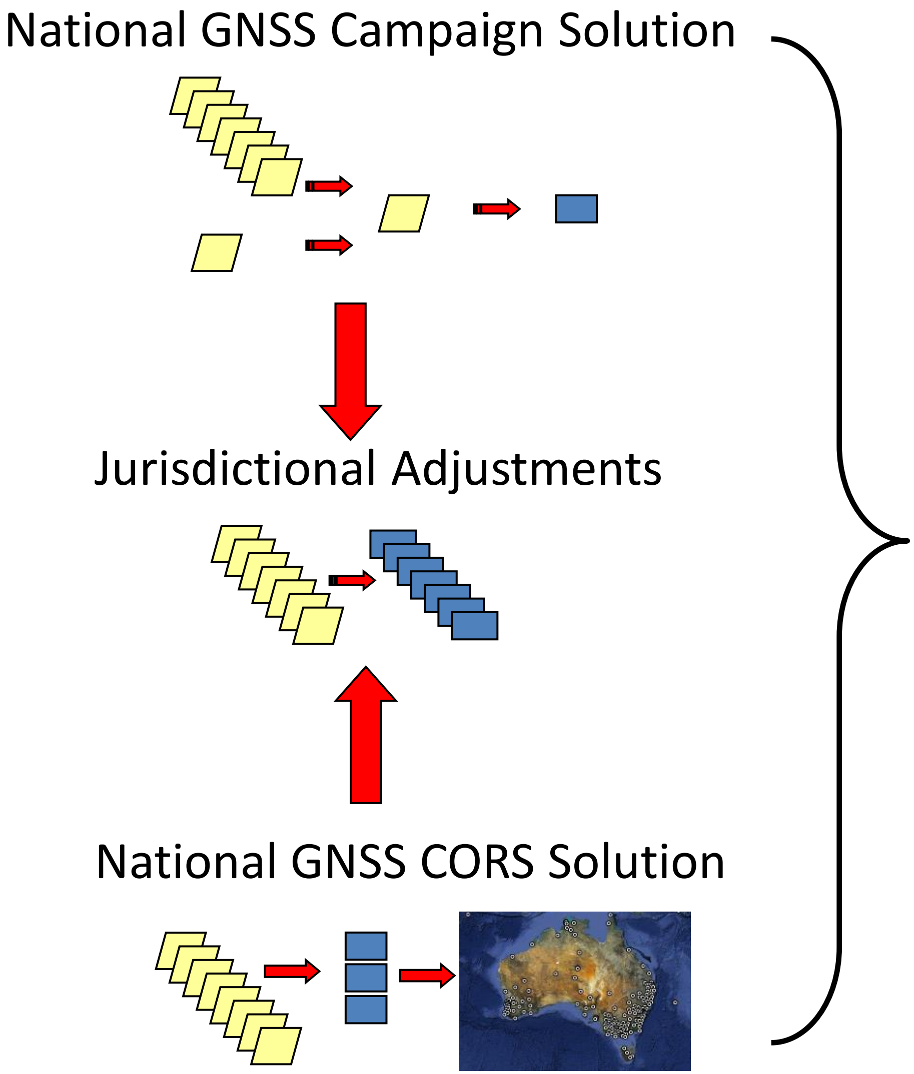


Asia Pacific Reference Frame (APREF)





Sponsors: Land Information New Zealand Toitū te whenua, Leica Geosystems, Trimble



Rigorous geometric adjustment

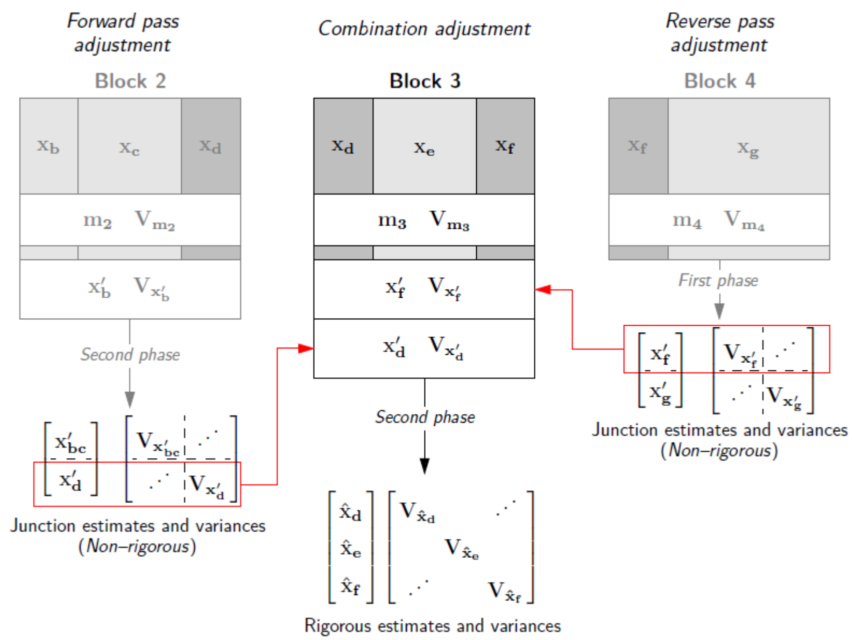
→ aspire for an all stations-and-observations adjustment (down to the street corner)

→ phased-adjustment strategy

→ work-flows managed automatically (using e-Geodesy technology)

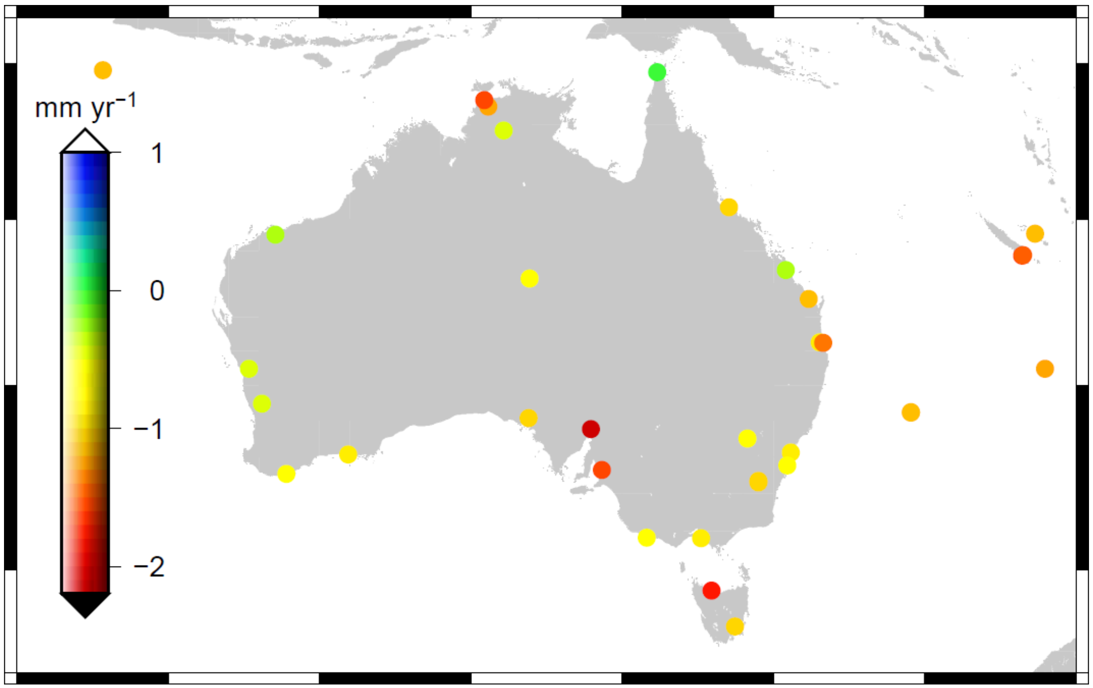
National Adjustment Strategy

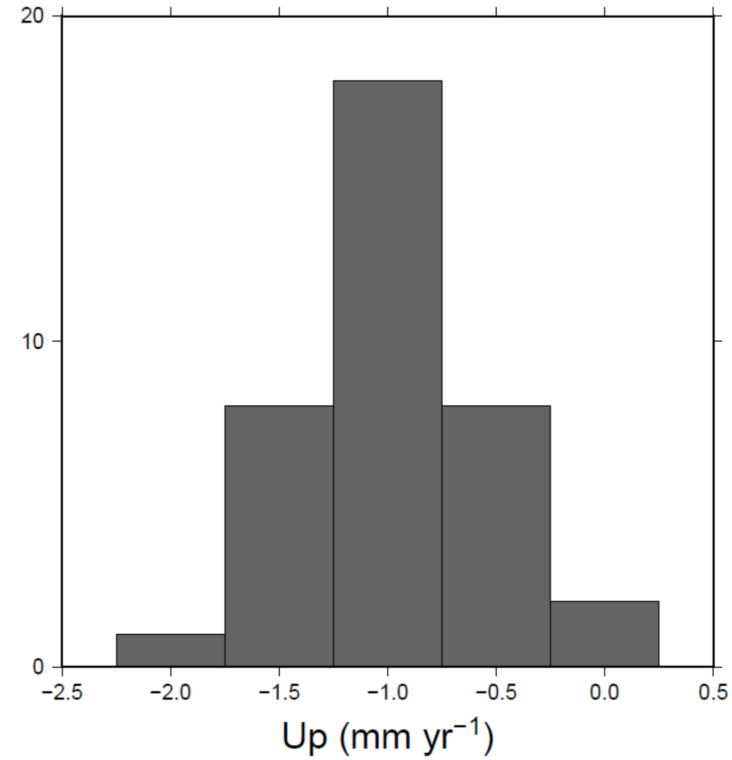
National Computational Infrastructure (NCI) is the Southern Hemisphere’s fastest supercomputer and filesystems



From Fraser et al 2014

Vertical Crustal Deformation

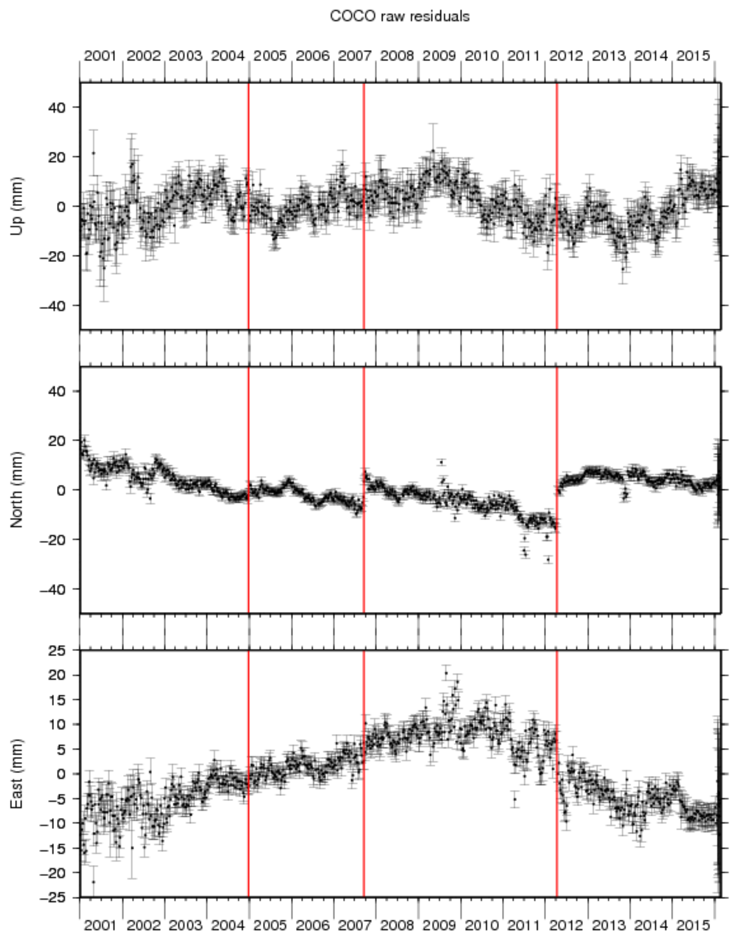




- Large-scale geophysical phenomena? Or biased observations?

APREF and ITRF2014

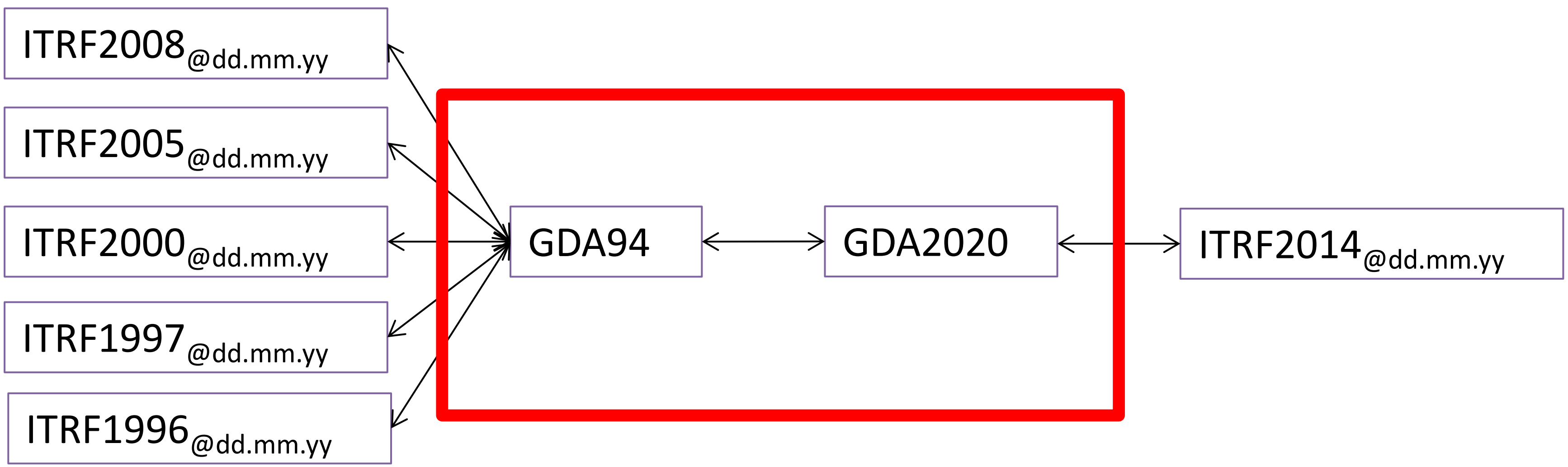
- APREF combination updated
- Reparametrising using ITRF2014 discontinuities
- Reassessing all other APREF discontinuities
- Reprocess using Bernese 5.2



ITRF2014 versus APREF (IGb08)

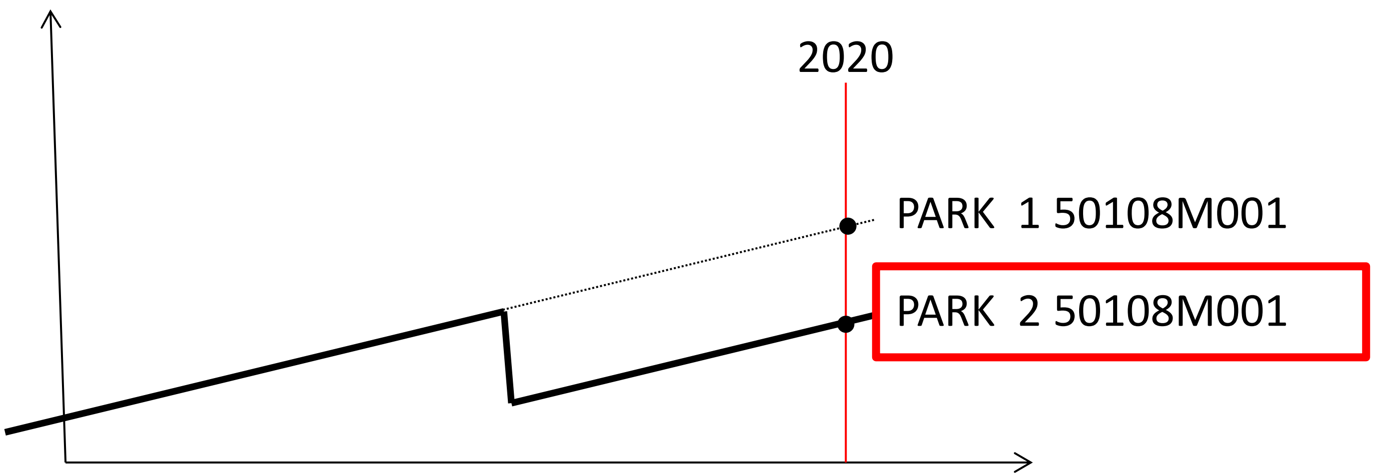
- RMS coordinate differences at 2016.0
  - 3.1, 3.5, 5.0 mm (latitude, longitude, height)
- RMS velocity differences
  - 0.2, 0.2, 0.6 mm (latitude, longitude, height)
- Significant outliers: PARK, XMIS, SA45

Supported Coordinate Transformations



Approach

- Exclude all but the latest point code coordinate estimate



Approach

- Propagate ITRF2014 coordinates to 2020 using individual site velocities
- Compute 7-parameter transformation using CATREF software

$$\begin{pmatrix} X_{GDA2020} \\ Y_{GDA2020} \\ Z_{GDA2020} \end{pmatrix} = \begin{pmatrix} T_x \\ T_y \\ T_z \end{pmatrix} + (1 + S_c) \begin{pmatrix} 1 & R_z & -R_y \\ -R_z & 1 & R_x \\ R_y & -R_x & 1 \end{pmatrix} \begin{pmatrix} X_{ITRF} \\ Y_{ITRF} \\ Z_{ITRF} \end{pmatrix}$$

Results GDA2020 – GDA94

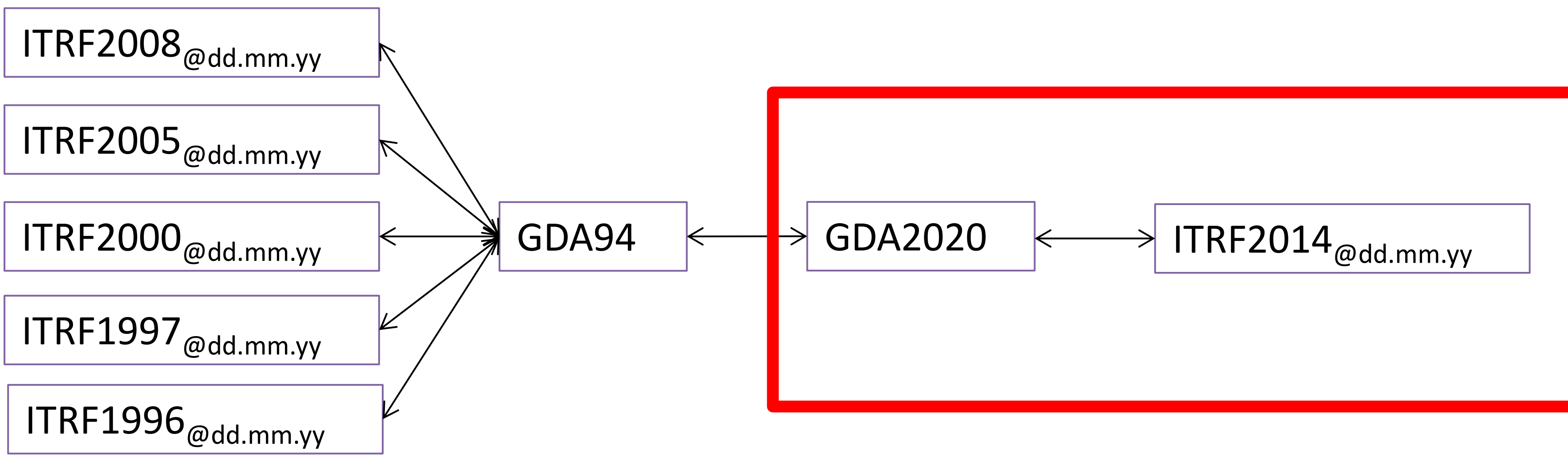
YAR1	A	50107M004	1	XYZ	-1206.9	143.3	1334.2	PLH	1480.1	1029.4	-82.9	(MM)
CEDU	A	50138M001	1	XYZ	-1054.7	-18.8	1339.6	PLH	1516.0	774.1	-98.6	(MM)
ADE1	A	50109S001	1	XYZ	-1019.2	8.7	1296.8	PLH	1504.9	666.8	-105.3	(MM)
DARW	A	50134M001	1	XYZ	-863.1	-447.0	1521.6	PLH	1534.9	944.2	-112.9	(MM)
STR1	A	50119M002	1	XYZ	-905.9	-50.8	1222.4	PLH	1431.3	510.0	-94.3	(MM)
SYDN	A	50124M003	1	XYZ	-861.3	-104.0	1225.2	PLH	1409.9	506.7	-95.9	(MM)
TIDB	A	50103M108	1	XYZ	-898.5	-48.6	1226.0	PLH	1430.9	504.7	-103.0	(MM)
HOB2	A	50116M004	1	XYZ	-976.5	152.3	1115.9	PLH	1433.6	397.2	-94.3	(MM)
MOBS	A	50182M001	1	XYZ	-983.5	39.3	1218.2	PLH	1469.9	532.2	-93.2	(MM)
PARK	A	50108M001	1	XYZ	-900.4	-99.9	1239.9	PLH	1428.3	558.6	-77.0	(MM)
ALIC	A	50137M001	1	XYZ	-972.4	-223.2	1441.2	PLH	1526.0	855.6	-108.5	(MM)
TOW2	A	50140M001	1	XYZ	-722.4	-463.0	1423.6	PLH	1460.8	781.4	-135.2	(MM)
STR2	A	50119M001	1	XYZ	-908.6	-43.9	1214.6	PLH	1428.3	505.4	-85.1	(MM)
XMIS	A	50183M001	1	XYZ	-1082.0	-121.7	1398.3	PLH	1406.9	1074.6	-81.1	(MM)
NNOR	A	50181M001	1	XYZ	-1217.3	170.8	1322.0	PLH	1488.8	1016.9	-90.2	(MM)
PERT	A	50133M001	1	XYZ	-1216.4	179.5	1322.5	PLH	1488.9	1016.0	-108.4	(MM)
KARR	A	50139M001	1	XYZ	-1119.1	-56.5	1431.1	PLH	1500.7	1022.1	-83.5	(MM)
YARR	A	50107M006	1	XYZ	-1211.5	147.4	1336.3	PLH	1484.7	1031.8	-78.9	(MM)
								RMS	1468.6	797.5	97.1	(MM)

* GDA94 ellipsoidal heights ~10cm larger

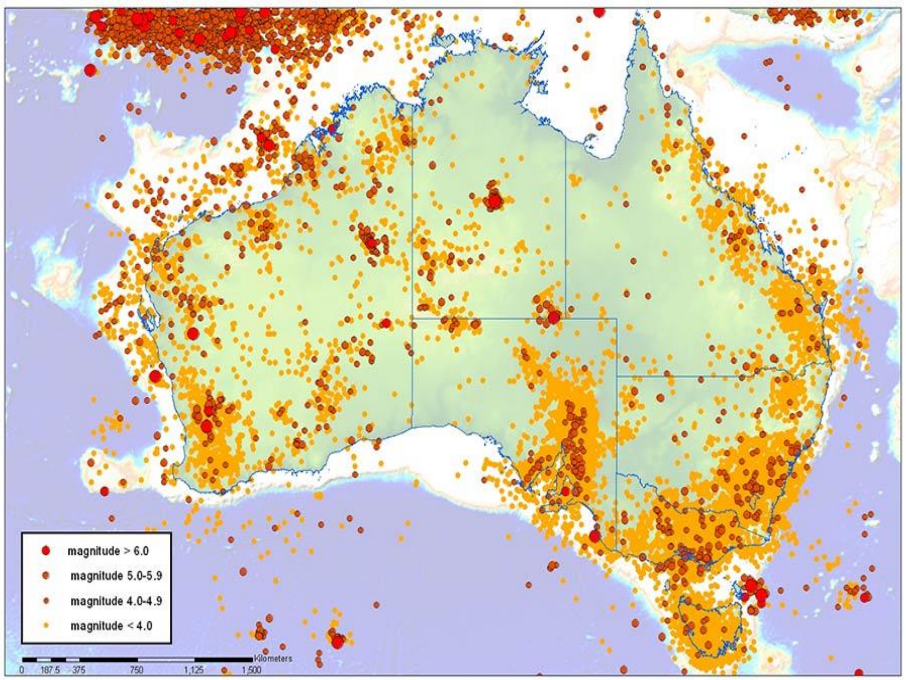
Results transformed(GDA94) – GDA2020

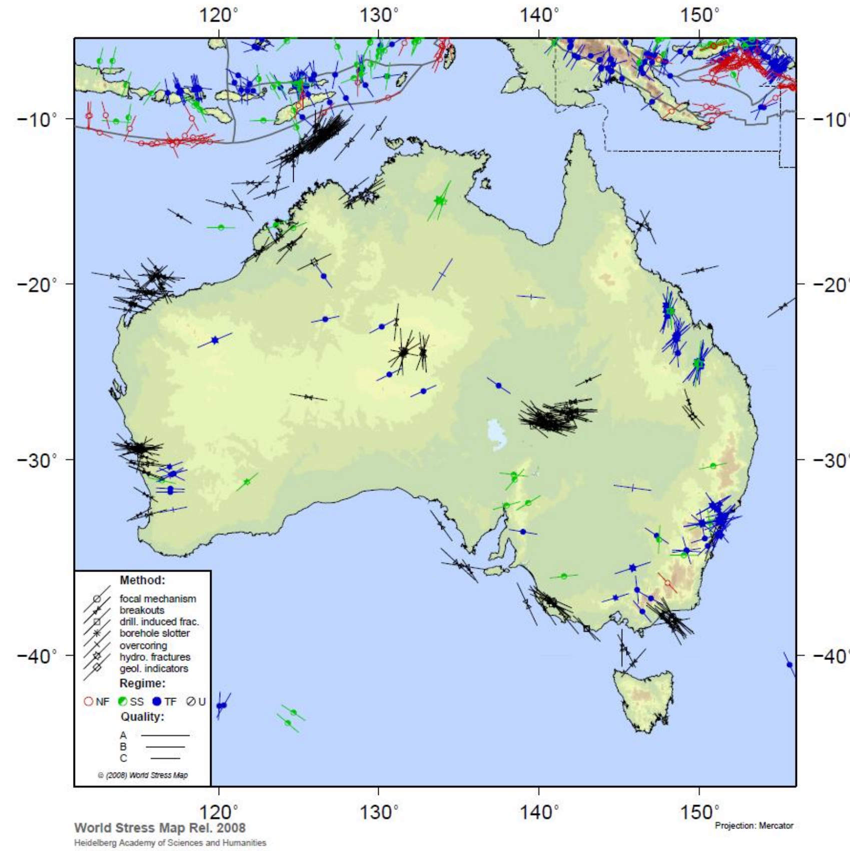
TOW2	A	50140M001	1	XYZ	-17.6	7.8	-11.3	PLH	-4.4	3.0	21.6	(MM)
ALIC	A	50137M001	1	XYZ	-0.7	5.1	-3.1	PLH	-1.2	-3.1	5.0	(MM)
KARR	A	50139M001	1	XYZ	0.1	-12.2	1.1	PLH	-2.8	5.5	-10.6	(MM)
CEDU	A	50138M001	1	XYZ	-0.9	5.8	2.7	PLH	4.8	-3.4	2.6	(MM)
YARR	A	50107M006	1	XYZ	2.3	-6.1	3.5	PLH	-0.1	0.5	-7.4	(MM)
ADE1	A	50109S001	1	XYZ	-5.0	4.4	-7.6	PLH	-2.5	0.0	9.8	(MM)
STR1	A	50119M002	1	XYZ	4.7	-1.6	0.7	PLH	-2.2	-1.0	-4.3	(MM)
NNOR	A	50181M001	1	XYZ	-0.3	4.8	-2.1	PLH	0.5	-1.8	4.9	(MM)
YAR1	A	50107M004	1	XYZ	-2.3	-1.9	5.6	PLH	4.5	2.9	-3.4	(MM)
DARW	A	50134M001	1	XYZ	-5.0	-0.6	0.6	PLH	1.2	4.1	2.6	(MM)
MOBS	A	50182M001	1	XYZ	9.1	2.7	-5.3	PLH	-7.8	-7.4	-1.4	(MM)
PERT	A	50133M001	1	XYZ	-8.8	17.4	-14.1	PLH	-1.7	0.3	24.0	(MM)
STR2	A	50119M001	1	XYZ	7.3	-8.5	8.4	PLH	0.7	3.5	-13.6	(MM)
SYDN	A	50124M003	1	XYZ	4.0	-3.0	1.6	PLH	-1.5	0.7	-5.0	(MM)
TIDB	A	50103M108	1	XYZ	-4.0	-1.3	-3.9	PLH	-1.6	3.2	4.5	(MM)
HOB2	A	50116M004	1	XYZ	-6.9	3.5	1.7	PLH	6.5	0.8	4.5	(MM)
XMIS	A	50183M001	1	XYZ	11.3	-7.1	1.3	PLH	-0.5	-8.9	-10.0	(MM)
PARK	A	50108M001	1	XYZ	12.5	-8.8	20.3	PLH	8.7	0.9	-23.9	(MM)
								RMS	3.9	3.7	11.4	(MM)

Supported Coordinate Transformations



- 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)





Background

- Fastest moving continent
  - Karratha: 70 mm/yr
  - Alice Springs: 67 mm/yr
  - Canberra: 58 mm/yr

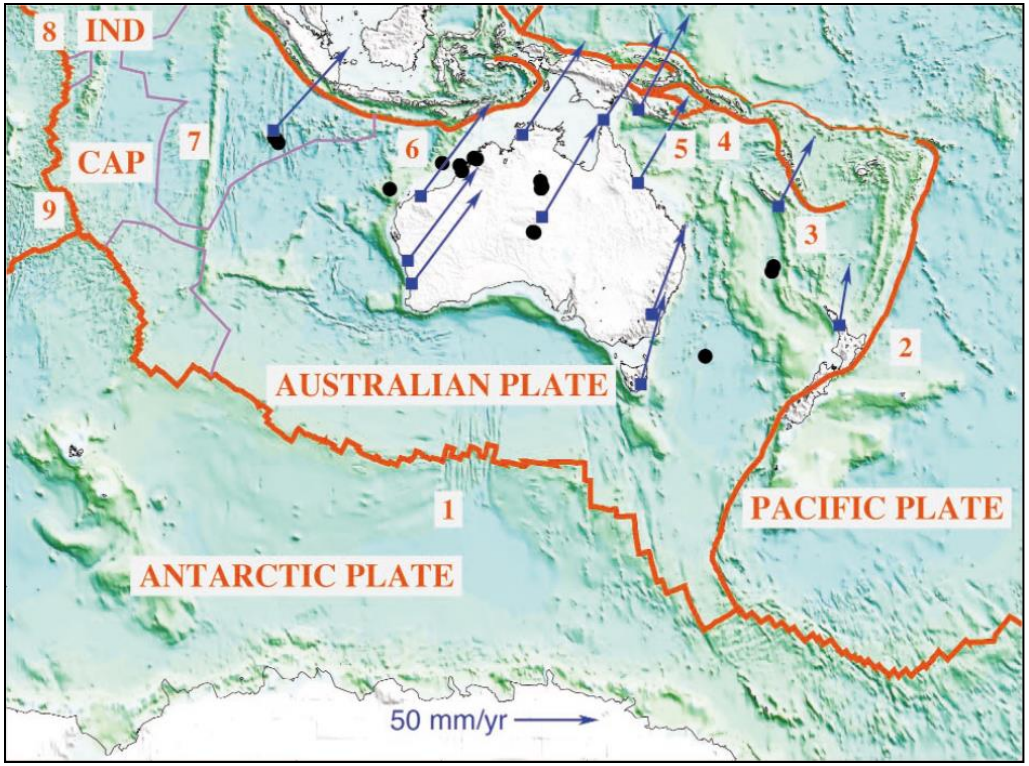
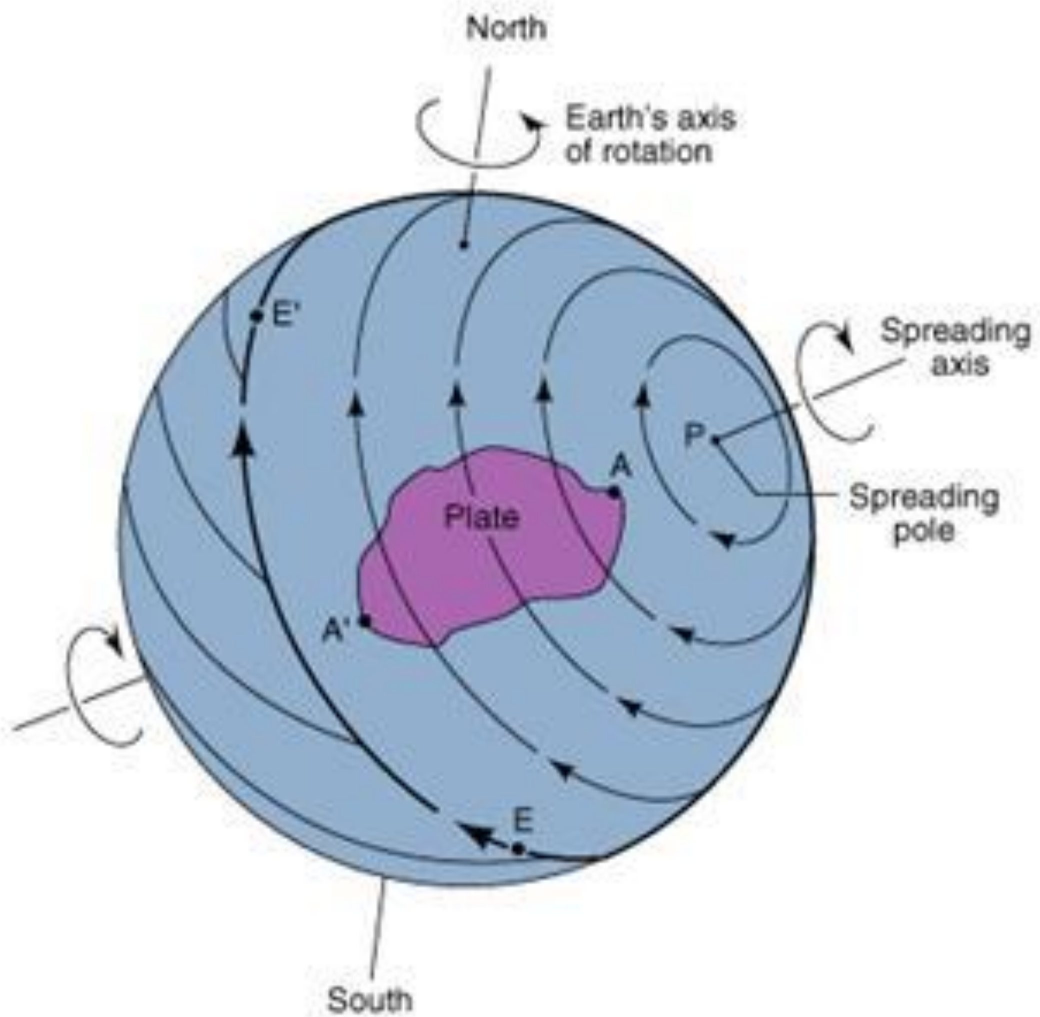
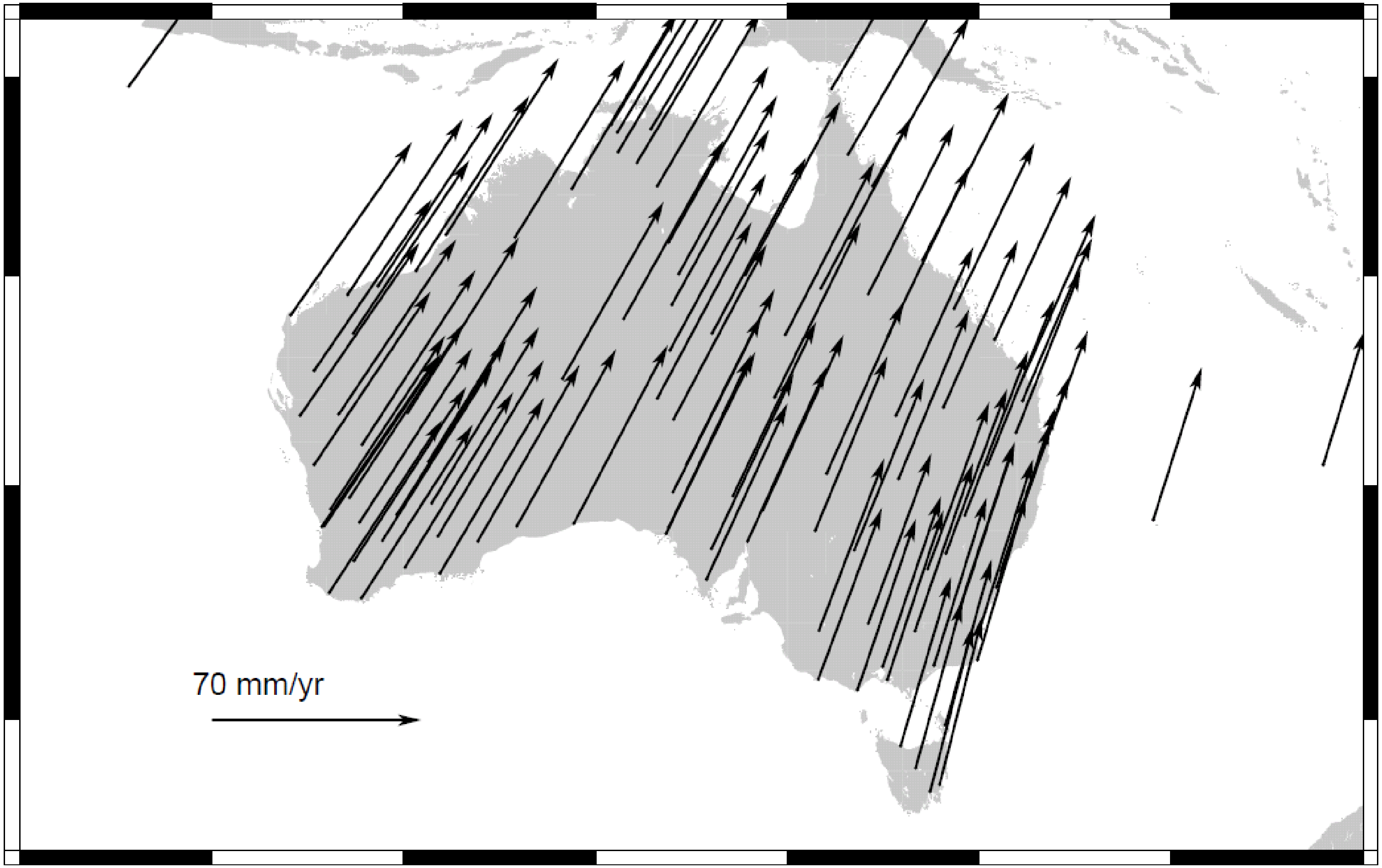


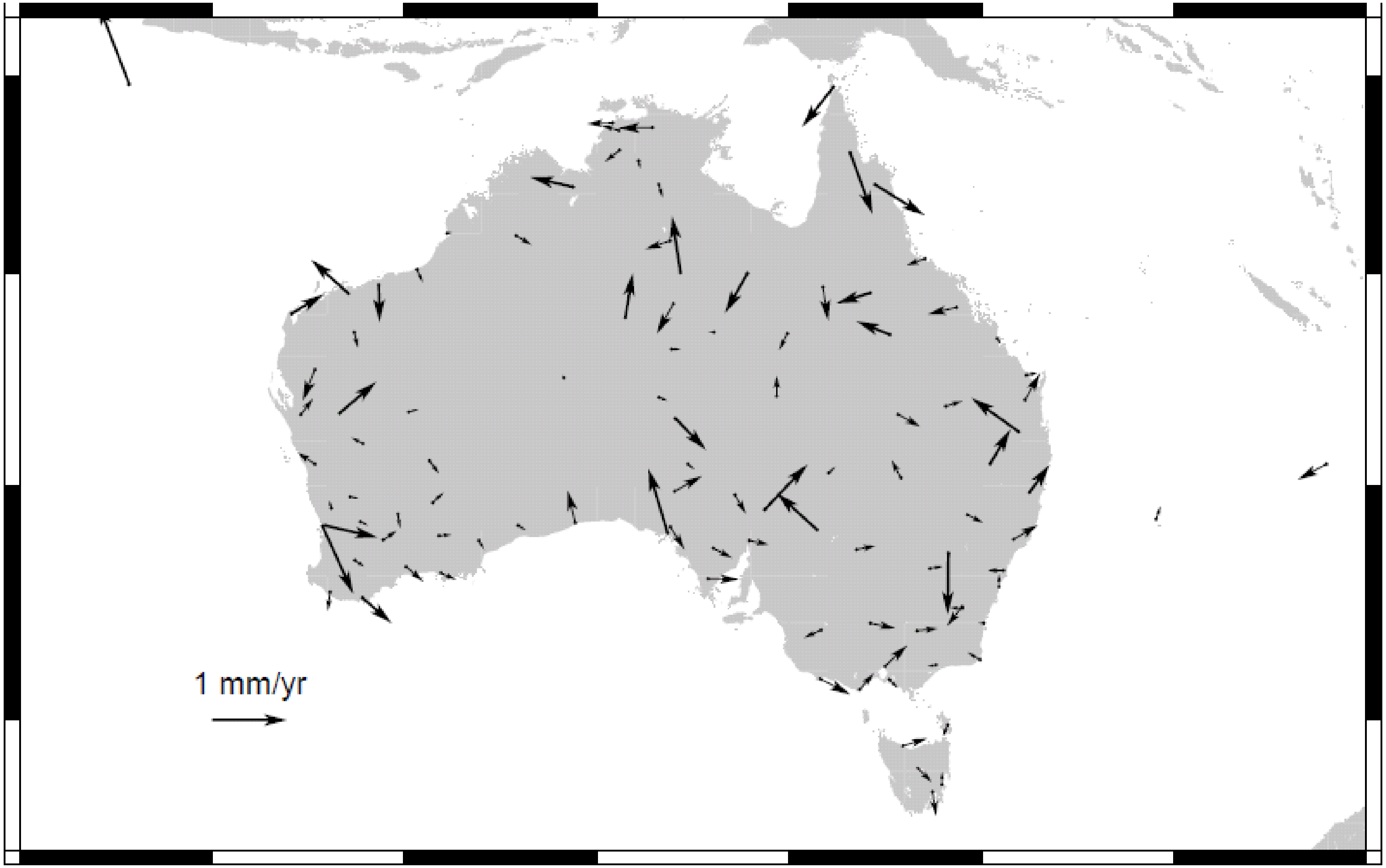
Plate Model


North
Earth's axis of rotation
E'
Spreading axis
P
A
Spreading pole
Plate
A'
E
South

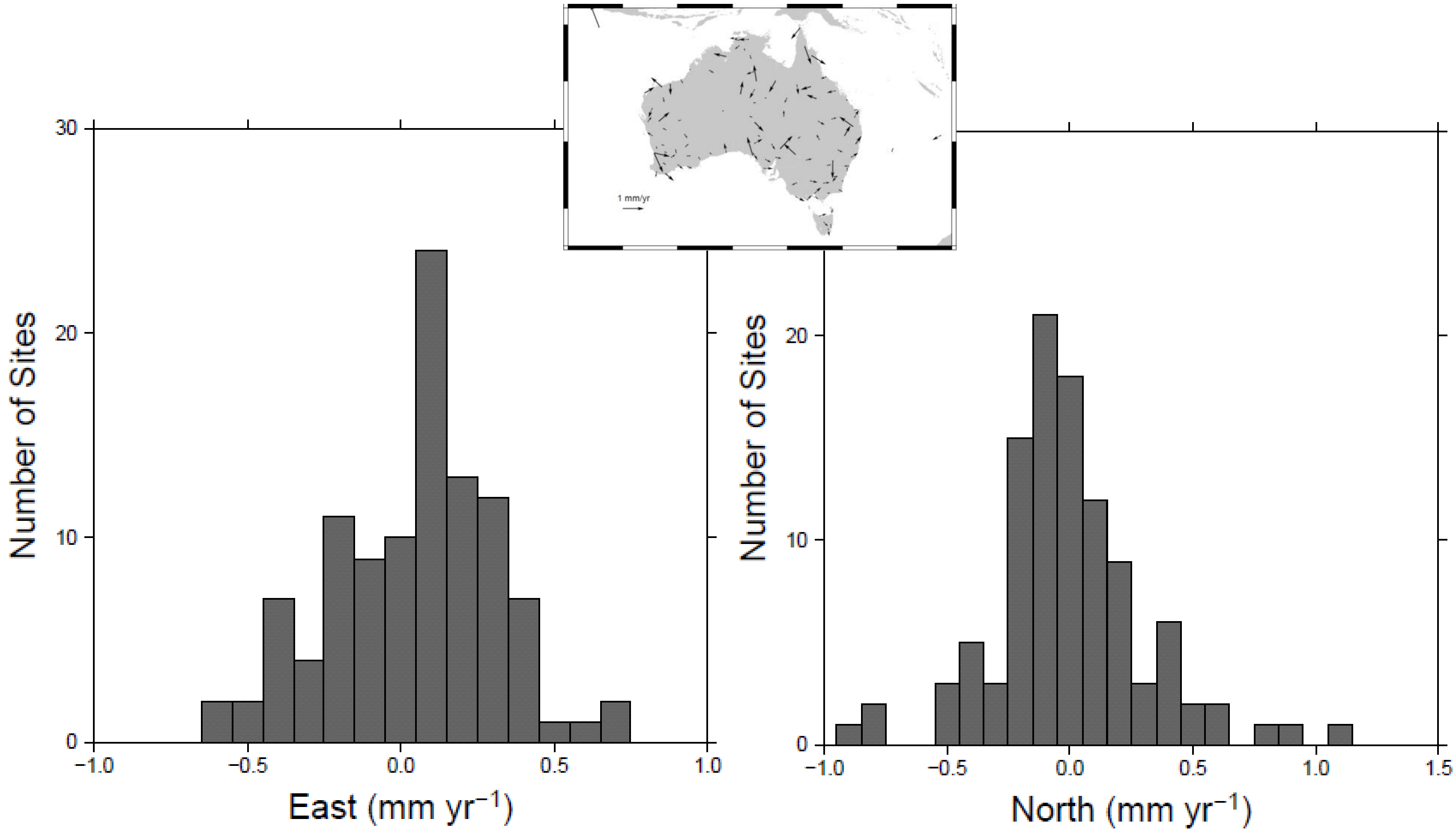
Crustal Motion



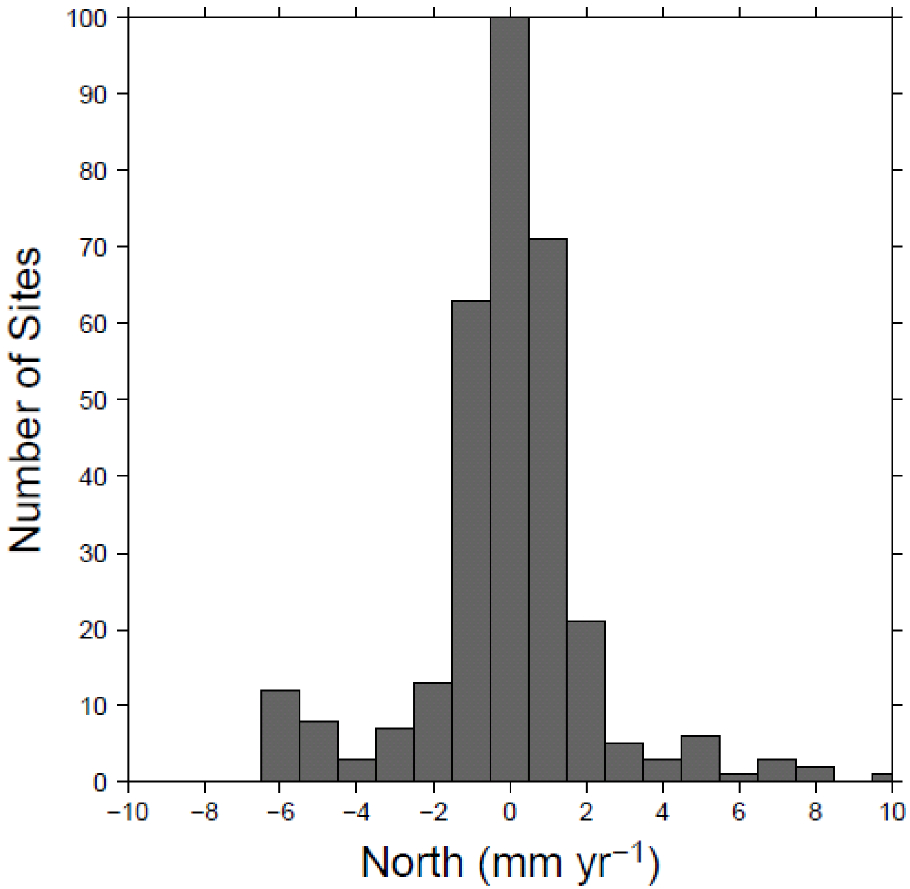
Residual Crustal Deformation

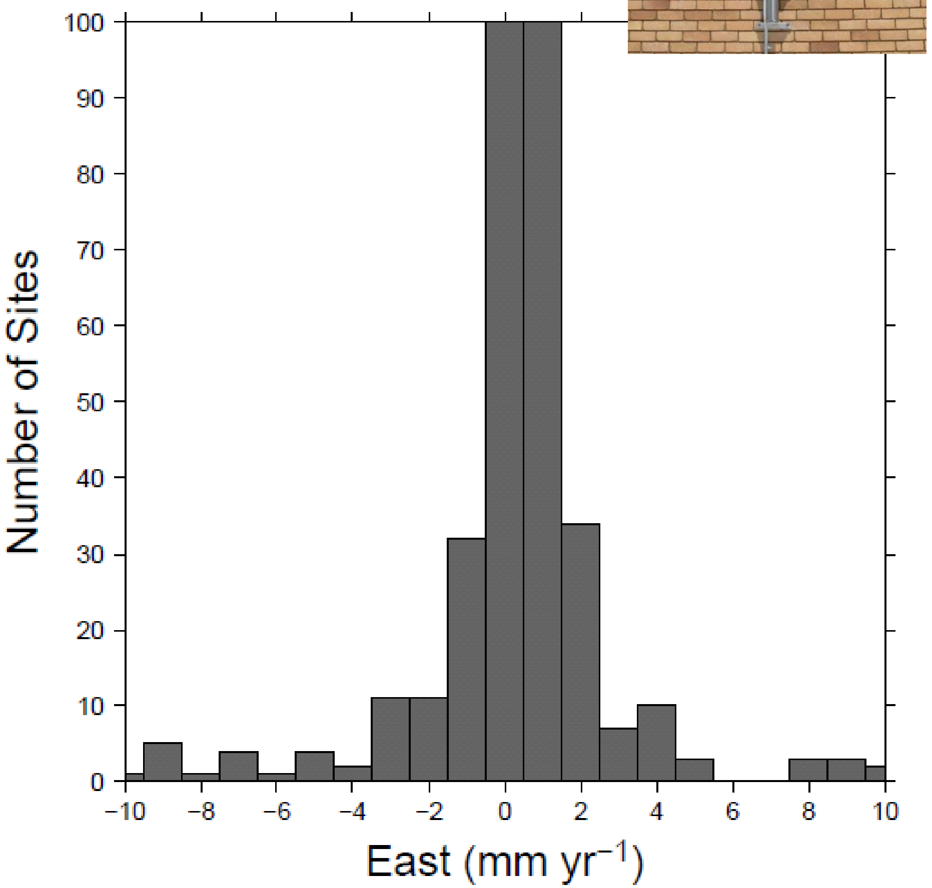


Residual Crustal Deformation

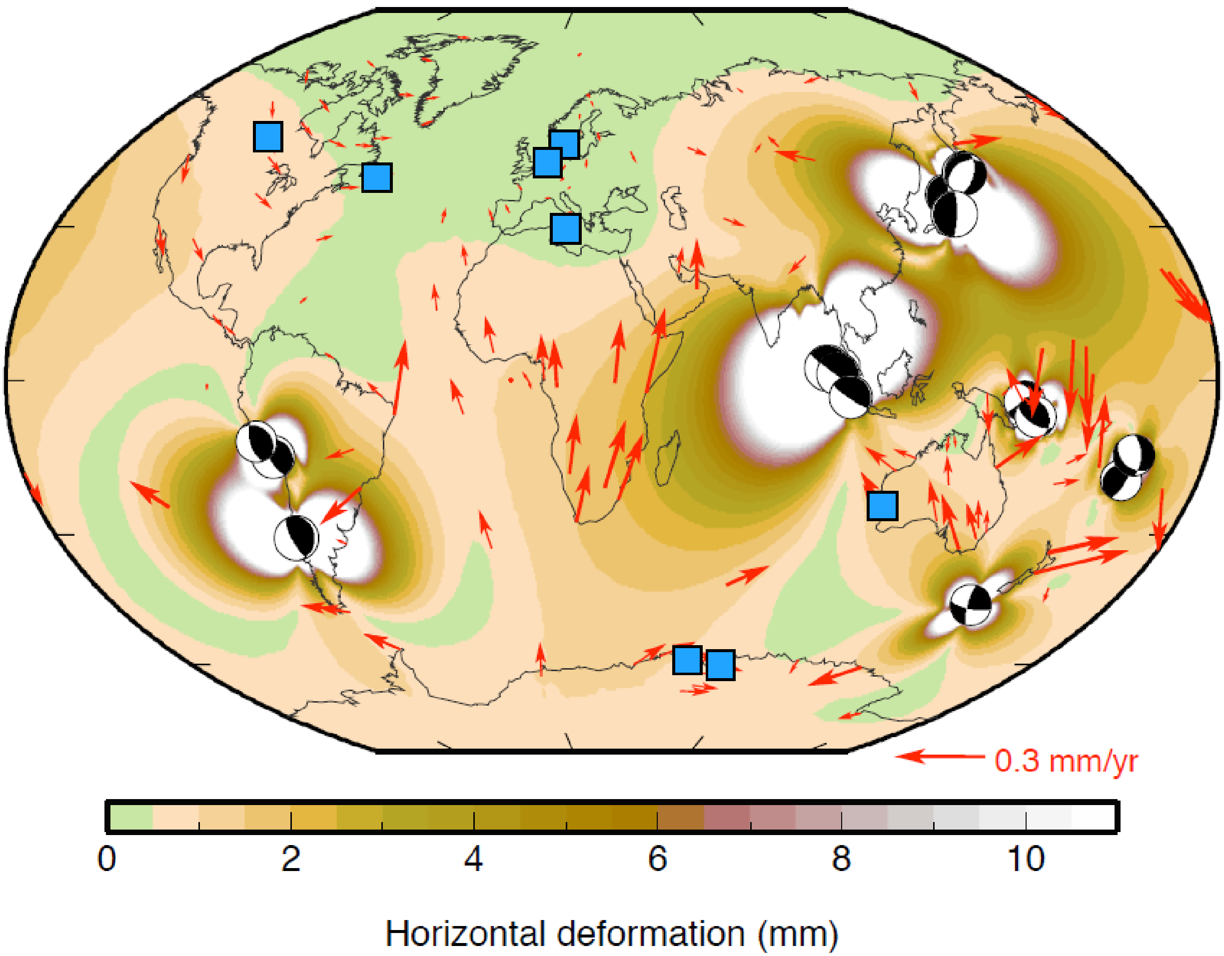


What About the Tier 3 Sites?

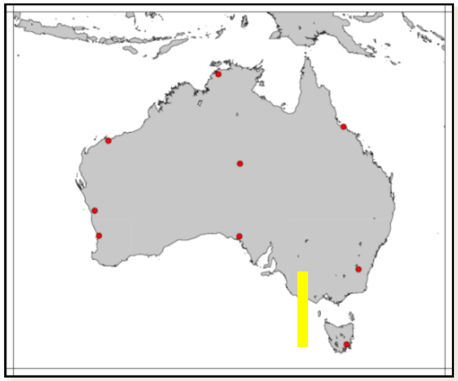


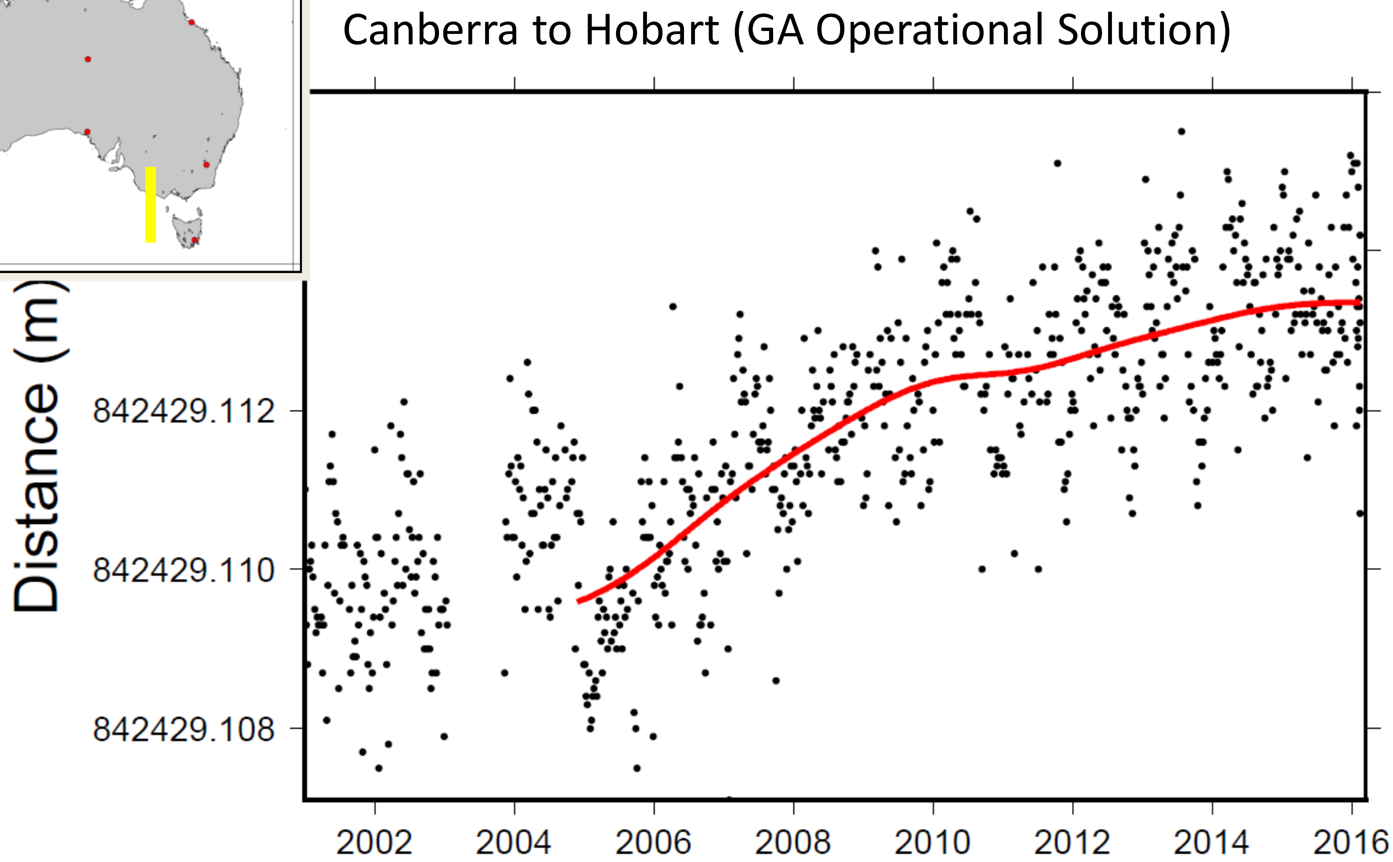


Tregoning et al, 2013



2004 Mw=8.1 Macquarie Ridge earthquake





- 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 can be gazetted now as part of GDA2020

- GDA2020 RVS
  - Crustal velocities will be derived from the plate model and propagated from?
    - Epoch of Minimal Position Variance - APREF
    - Epoch of Minimal Position Variance – ARGN/AuScope
    - Epoch of Minimal Position Variance – ITRF2014
    - 1 Jan 2010
    - **1 Jan 2017**
    - 1 Jan 2020
    - 1 Jan 1994