

Coordinate Transformations between GDA94 and the ITRF

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FS 4C - Adjustment Techniques and Reference Frames

SUMMARY

The Geocentric Datum of Australia 1994 (GDA94) is a static coordinate datum realised with respect to the International Terrestrial Reference Frame (ITRF) at the reference epoch of 1 January 1994. At this time GDA94 and ITRF were coincident, however, as a consequence of the tectonic motion of the rigid Australian plate, ongoing refinement of the ITRF, and crustal deformation, the two reference frames have diverged, and the absolute difference between them is now approximately 1 m. Consequently, precise coordinate transformations between ITRF and GDA94 are required for many applications within the Australian spatial community, and in this study we review, improve and extend these transformations. We have computed new Helmert transformation parameters between ITRF and GDA94, including the specific ITRF realisations of ITRF1996, ITRF1997, ITRF2005 and ITRF2008. For the ITRF2005 and ITRF2008 cases these are the first available results. After transformation, we find ITRF based network solutions have residual coordinate differences with respect to GDA94 that are typically less than 10 and 30 mm in the horizontal and vertical components, respectively. However, maximum residuals can exceed 15 and 70 mm in the horizontal and vertical components, respectively, which highlights a limitation of GDA94 for many precise applications. Finally, we discuss implications and future strategies for managing the differences between GDA94 and ITRF, including novel coordinate transformation approaches, satellite trajectory transformations, and also options for the modernisation of the Australian geodetic datum.

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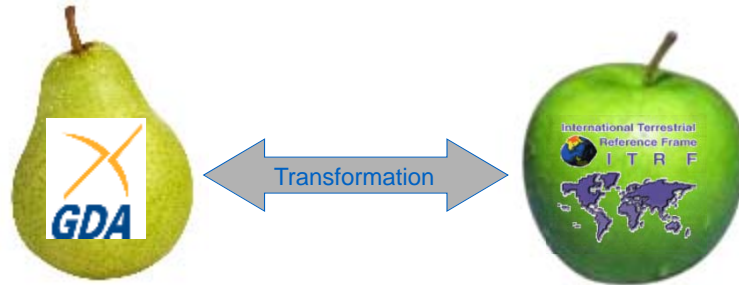
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Coordinate transformations between GDA94 and the ITRF

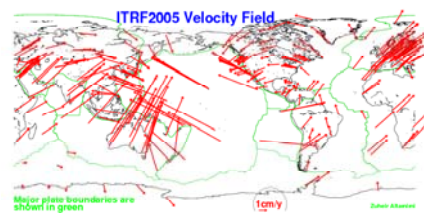


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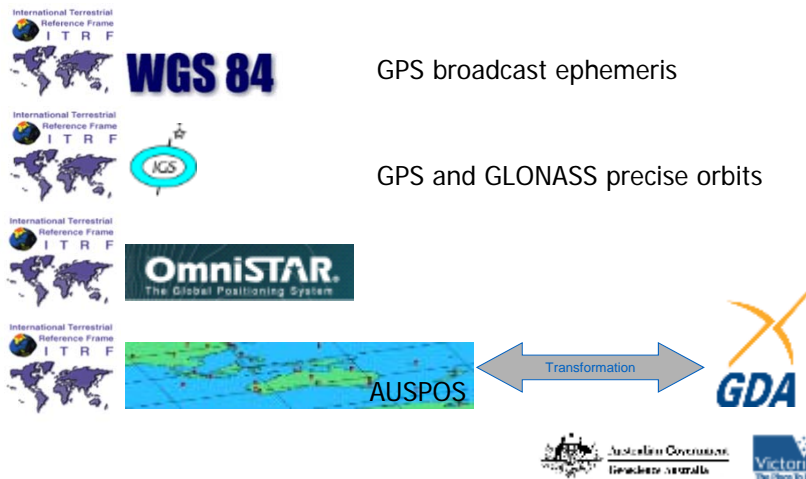


Diverging Reference Frames

- ITRF is a dynamic reference frame
- GDA94 is a static coordinate datum (ITRF1992 @ 1994.00)
- Two reference frames diverged due to:
 - Ongoing refinement of the ITRF
 - Tectonic motion of the Australian plate (~70mm / yr in NNE)
 - Crustal deformation
- Absolute difference is now approximately 1 m!
- Many Australian users work across the two reference frames



ITRF Standard



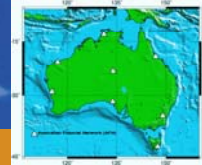
14 Parameter Transformation

- Standard seven parameter transformation model + first time derivatives (rates) for each parameter

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

- three translations, t_x, t_y, t_z (+ $\dot{t}_x, \dot{t}_y, \dot{t}_z$)
- three rotations, r_x, r_y, r_z (+ $\dot{r}_x, \dot{r}_y, \dot{r}_z$)
- one scale factor, s_c (+ \dot{s}_c)
- Transformation software available at:
<http://www.icsm.gov.au/icsm/gda/gdatm/index.html>

Input data and Derivation



- New transformation parameters (and associated uncertainty) between GDA94 and ITRF:
 - ITRF1996, ITRF1997, ITRF2000 ITRF2005 and ITRF2008 (when released)
- First available release for ITRF2005 and ITRF2008
- Input data:
- ITRF solutions obtained from the ITRF product centre of the IERS
 - station coordinates and velocities
 - corresponding full VCV matrix.
- GDA94 coordinate values obtained from the gazetted positions of the AFN
- GDA94 VCV matrix created with only block diagonal terms,
 - horizontal and vertical coordinate precision of 0.03 m and 0.05 m (at a 95% confidence level)
- CATREF software (Combination and Analysis of Terrestrial Reference Frames)



Parameters and Uncertainties (σ)

	tx, tx	ty, ty	tz, tz	sc, sc	rx, rx	ry, ry	rz, rz
From ITRF2005 to GDA94							
Para	-139.3	-15.7	98.0	5.79	1.039	4.214	3.504
±	134.2	79.6	104.0	11.66	1.713	4.247	4.121
Rates	0.6	-1.6	-0.6	0.09	1.454	1.172	1.221
±	1.0	0.7	1.2	0.07	0.030	0.035	0.026
From ITRF2000 to GDA94							
Para	-190.3	-20.9	137.7	7.36	1.807	5.931	4.799
±	137.0	80.4	109.5	11.71	1.922	4.396	4.149
Rates	7.6	-0.4	-5.1	0.06	1.325	0.962	1.039
±	5.2	2.4	6.5	0.22	0.166	0.212	0.099
From ITRF1997 to GDA94							
Para	-165.8	-14.5	142.3	6.61	1.947	5.227	3.889
±	138.6	81.3	112.8	11.71	2.058	4.485	4.165
Rates	-5.2	-2.0	4.9	-0.07	1.460	1.330	1.352
±	8.1	3.9	10.9	0.29	0.282	0.350	0.133
From ITRF1996 to GDA94							
Para	-121.0	-25.5	92.4	7.08	0.785	3.551	3.185
±	147.4	85.3	134.4	11.80	2.834	5.033	4.232
Rates	-11.7	-0.3	10.9	0.29	1.689	1.689	1.689
±	22.0	11.3	31.3	0.66	0.030	0.035	0.026

Parameters and Uncertainties (σ)

Translations – mm, mm/yr Scale – ppb, ppb/yr Rotations – mas, mas/yr $t_0 = 1994.00$

	tx, tx	ty, ty	tz, tz	sc, sc	rx, rx	ry, ry	rz, rz
E.g. From ITRF2005@1994 to GDA94							
Para	-139.3	-15.7	98.0	5.79	1.039	4.214	3.504
±	134.2	79.6	104.0	11.66	1.713	4.247	4.121
Rates	0.6	-1.6	-0.6	0.09	1.454	1.172	1.221
±	1.0	0.7	1.2	0.07	0.030	0.035	0.026

$$\begin{pmatrix} X_{GDA94} \\ Y_{GDA94} \\ Z_{GDA94} \end{pmatrix} = \begin{pmatrix} t_x + t_x(t-t_0) \\ t_y + t_y(t-t_0) \\ t_z + t_z(t-t_0) \end{pmatrix} + (1 + s_c + s_c(t-t_0)) \begin{pmatrix} 1 & r_x + r_x(t-t_0) & -r_y - r_y(t-t_0) \\ -r_y - r_y(t-t_0) & 1 & r_x + r_x(t-t_0) \\ r_x + r_x(t-t_0) & -r_x - r_x(t-t_0) & 1 \end{pmatrix} \begin{pmatrix} X_{ITRF} \\ Y_{ITRF} \\ Z_{ITRF} \end{pmatrix}$$

ITRF2005 RMS Error
~ 10 mm (horiz)
~ 25 mm (vert)



Summary

- Static GDA94 and the dynamic ITRF have diverged
- 14 parameter transformation between reference frames
- Official parameters to be released in a Journal of Applied Geodesy paper
- Parameters to be published on GA web site – www.ga.gov.au
- Thank you

