IAG / FIG / UNGGIM / UNICG / PhilGEGS

Reference Frame in Practice

Manila, Philippines 21-22 June 2013

Asia Pacific Reference Frame (APREF)

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National Geospatial Reference Systems

Geoscience Australia

Sponsors :

Objectives

To learn about:

→ Drivers for regional and global approaches to geodesy

→ The Asia Pacific Reference Frame (APREF)

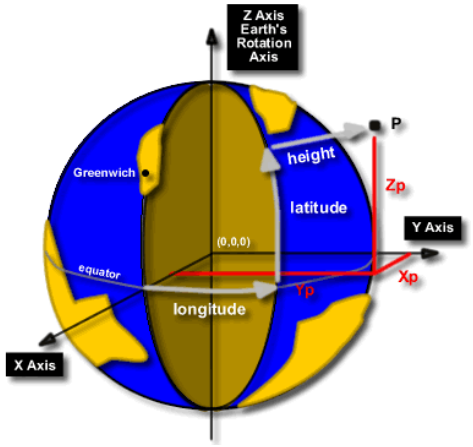
→ APREF products and services

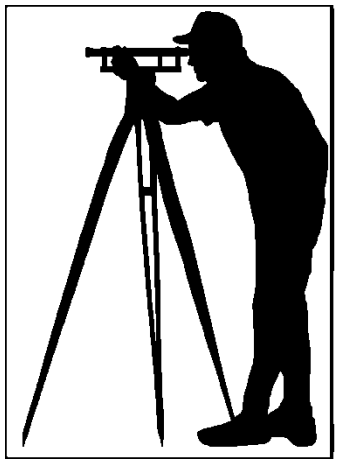
→ The benefits of participating in APREF

→ Practical advice on how to participate in APREF

→ Who to contact for more information on APREF

The Changing World of Geospatial





Precise coordinates for and by the masses (no monopoly for surveyors anymore)

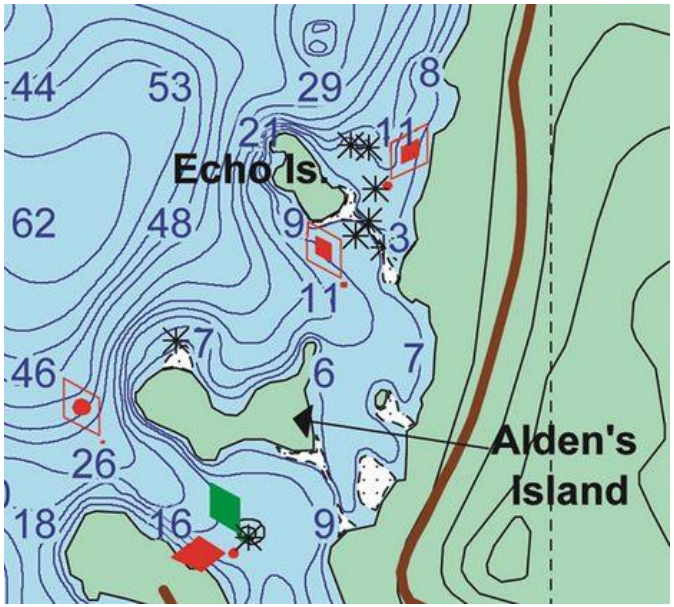
The Changing World of Geospatial

Cheaper geodetic receivers

The Changing World of Geospatial

Fewer Surveyors

The Changing World of Geospatial



Big data

Data poor

Data rich

The Changing World of Geospatial

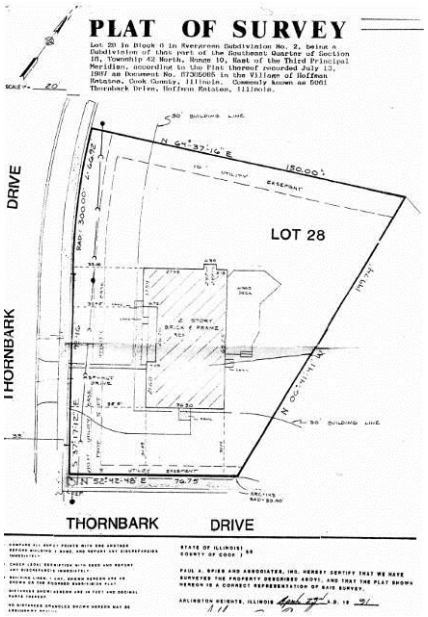
Precision positioning will contribute 2.1% of Australia's GDP by 2030



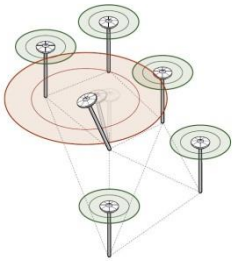


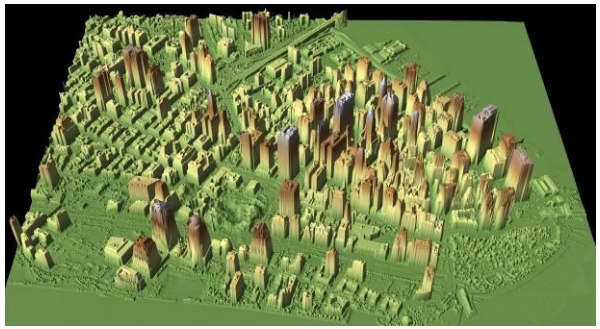
Automated mines, driverless cars, UAVs


The Changing World of Geospatial



User expectation of seamless interconnection in 3D



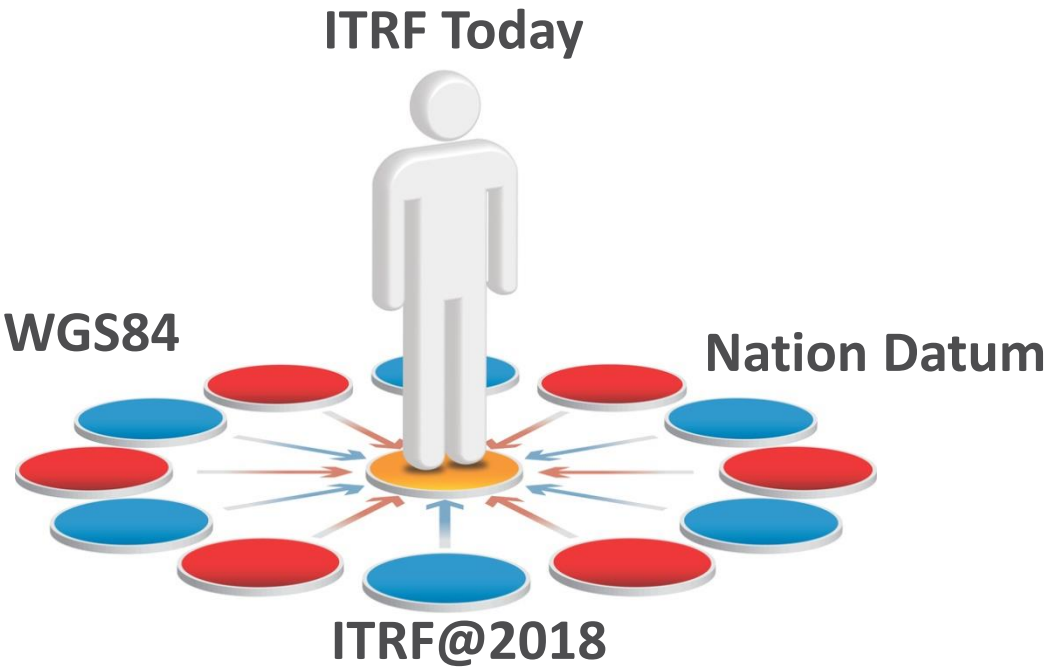


The Changing World of Geospatial

Recognising that the Earth is dynamic

From: Kreemer et al 2006

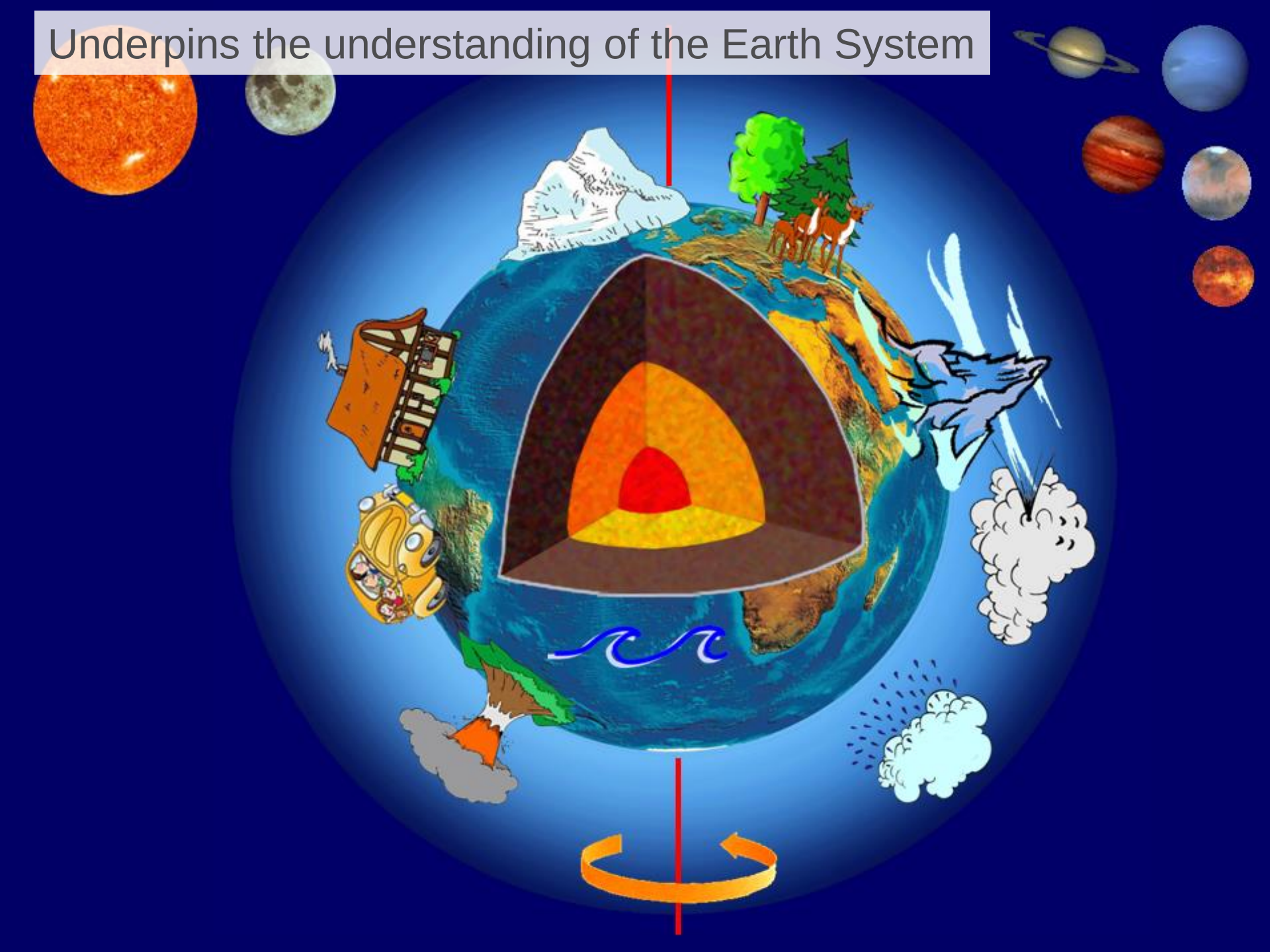
The Changing World of Geospatial



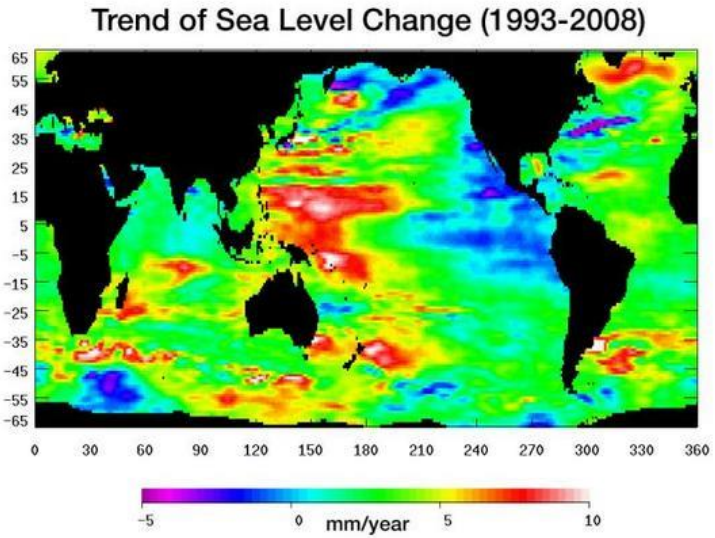
User-centric view of datum

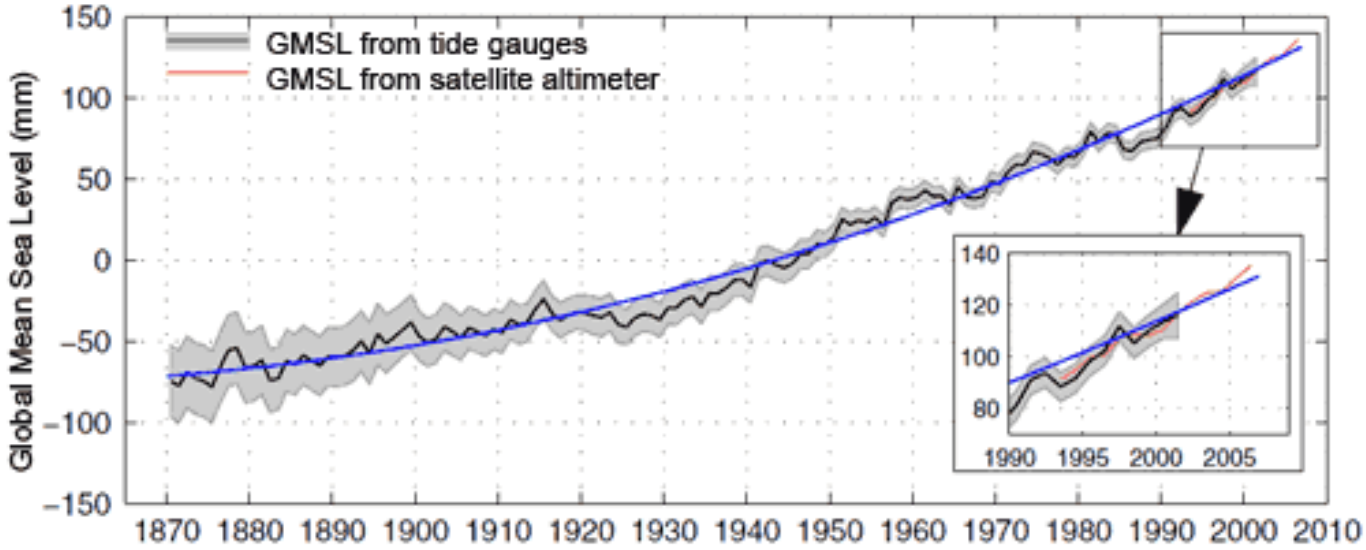
→ why can't **you** provide your data in my datum!

Underpins the understanding of the Earth System

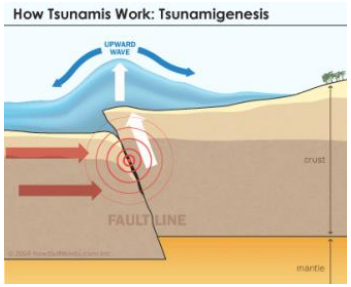


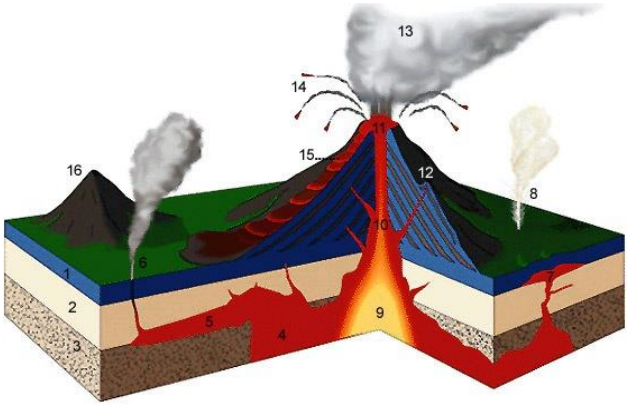
Understanding the Earth System



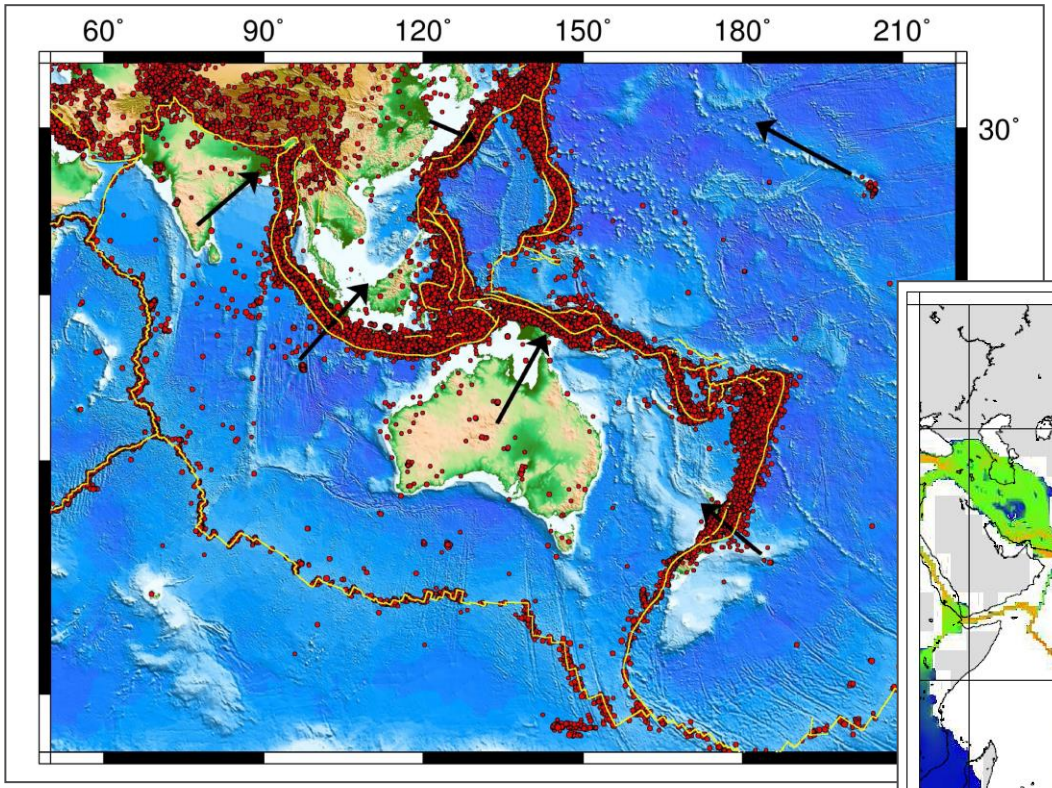


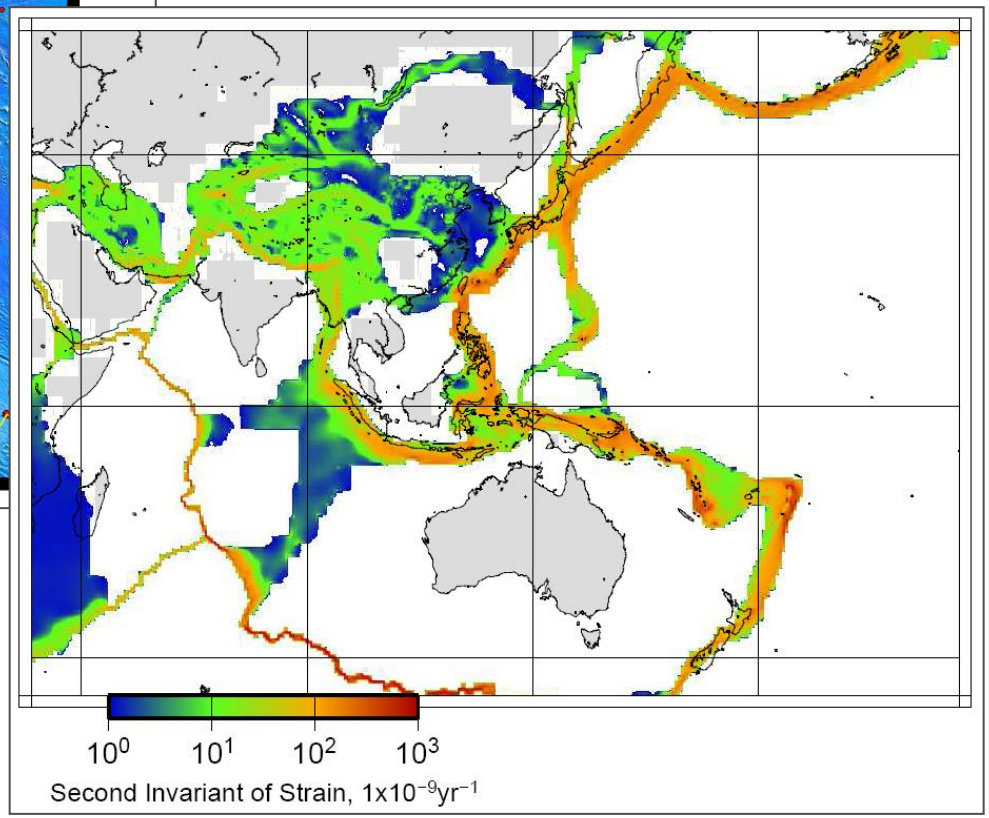
Understanding the Earth System





Crustal Strain and Earthquakes: Asia Pacific

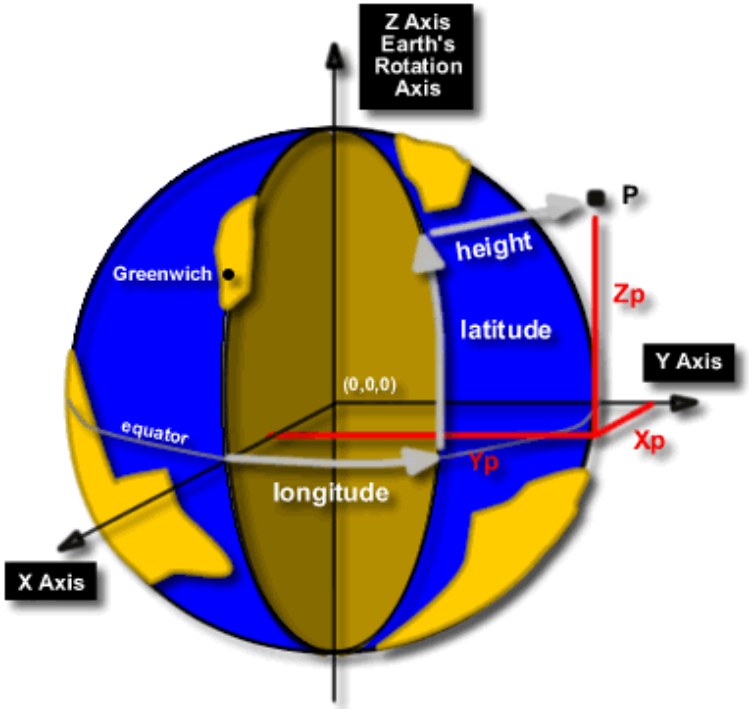




International Terrestrial Reference Frame (ITRF)

ITRF underpins all satellite positioning technology which is a key enabler of spatial data interoperability

ITRF is the global ‘standard’



Global Efforts

UN-GGIM-AP
REGIONAL COMMITTEE OF UNITED NATIONS GLOBAL GEOSPATIAL INFORMATION MANAGEMENT FOR ASIA & THE PACIFIC

- → The concept of a global geodetic questionnaire arose from the Second Session of the United Nations Committee of Experts on Global Information Management in New York in August, 2012
- → Questionnaire format and content discussed after the United Nations Regional Cartographic Conference (UNRCC) forum in Bangkok, October 2012
- → Questionnaire distributed globally in December 2012 by the UN
- → 100 responses received by June 2013

Global Questionnaire Key Findings

UN-GGIM-AP
REGIONAL COMMITTEE OF UNITED NATIONS GLOBAL GEOSPATIAL INFORMATION MANAGEMENT FOR ASIA & THE PACIFIC

→ 88% of responses indicated that the data, products and services of the international global geodetic community (e.g. ITRF, IGS orbits,…) were either critical or had high importance in their country

→ 80% of all responding countries use the International Terrestrial Reference Frame (ITRF) to underpin their national coordinate datum

Global Efforts Next Steps

UNGGIM Committee of Experts will recommend at its Cambridge Meeting in July 2013 that a Working Group be setup to draft the text of a **United Nations General Assembly Resolution** that

→ Acknowledges the role and importance of the ITRF

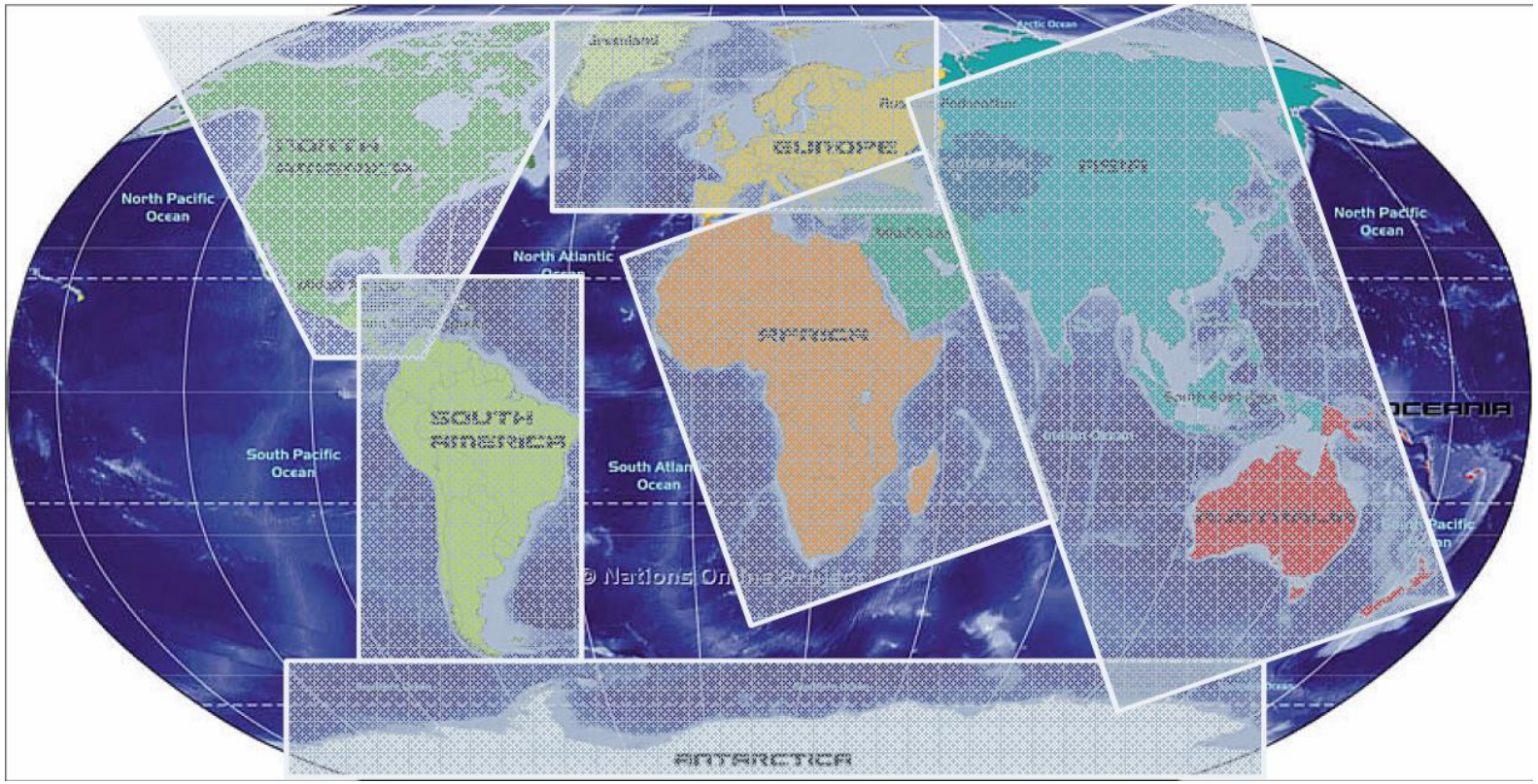
→ Encourages investment in infrastructure

→ Encourages international data sharing

See http://ggim.un.org/ggim_committee.html

Regional Reference Frame Densification

ITRF = APREF, AFREP, EUREF, NAREF SIRGAS,…



Asia Pacific Reference Frame

- → Access to high quality positioning infrastructure is essential for effective competition with the other regions, including Europe and the Americas
- → Coordination of regional geodetic activities not well developed in the AP

Asia Pacific Reference Frame

Open to all organisations (government, research, private) involved with CORS data collection and/or analysis

APREF encourages those organizations who are prepared to participate on an ongoing basis (at least two years)

→GNSS CORS stations data;

→Provide access and on-line archiving of APREF data and products for users; and/or

→Routinely analyse some, or all, of the APREF GNSS CORS data

Improving Access to the ITRF: Asia Pacific

Annual APRGP GNSS Campaigns

Asia Pacific Reference Frame (APREF)

- PCGIAP effort
- Annual week long GPS campaign 1997,…,2012
- Provides access to ITRF
- Recognises not all member countries can operate CORS networks and contribute to APREF

- Joint UNGGIM-AP (formerly the PCGIAP) and IAG effort supported by FIG, ICG
- Continuous, low-latency analysis of CORS networks
- Provides access to ITRF, coordinate time series, station velocities and network monitoring
- Commenced March 2010

APREF: Objectives

→ Create and maintain an accurate and densely realised geodetic framework, based on continuous observation and analysis of GNSS data

→ Encourage regional data sharing of GNSS CORS data and its analysis

Benefits of APREF Participation

→ Improved and continuous link between national datums and CORS networks to the ITRF

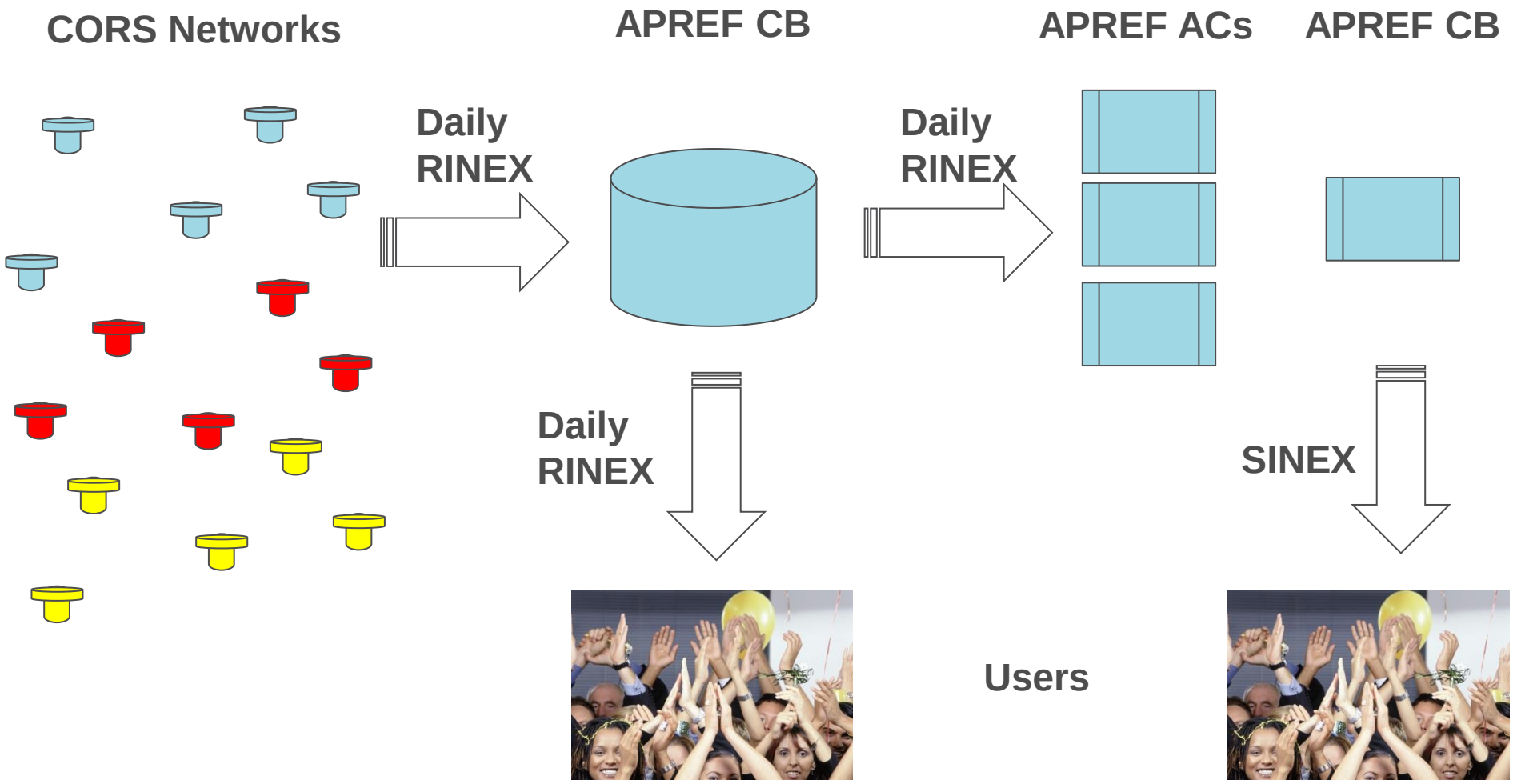
→ Contribute to a open and dense ITRF network in Asia and the Pacific

→ Independent quality monitoring

→ Improved access to GNSS data

→ Providing an opportunity and a forum towards improving the regional geodetic infrastructure

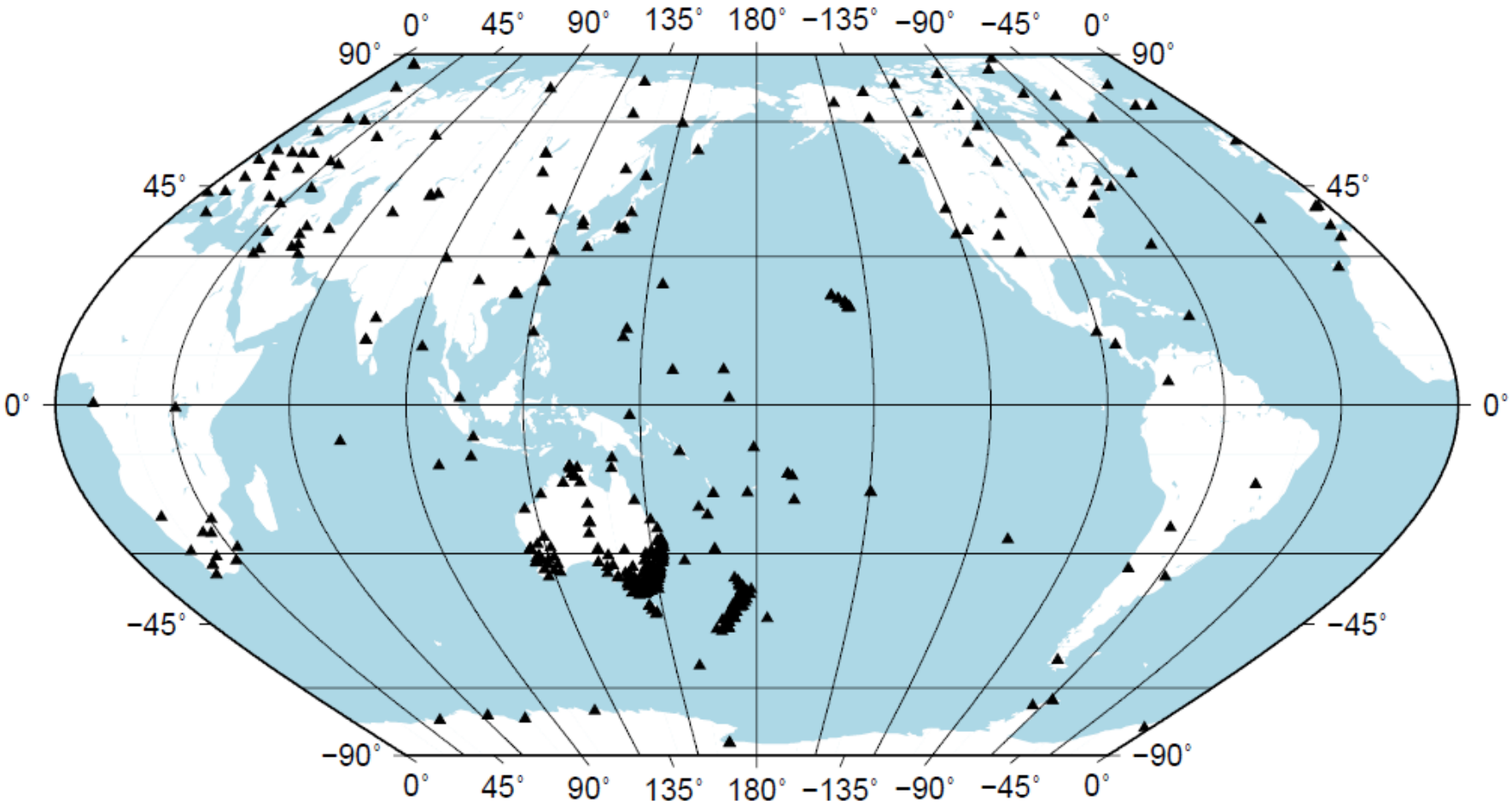
Asia Pacific Reference Frame Data Flow



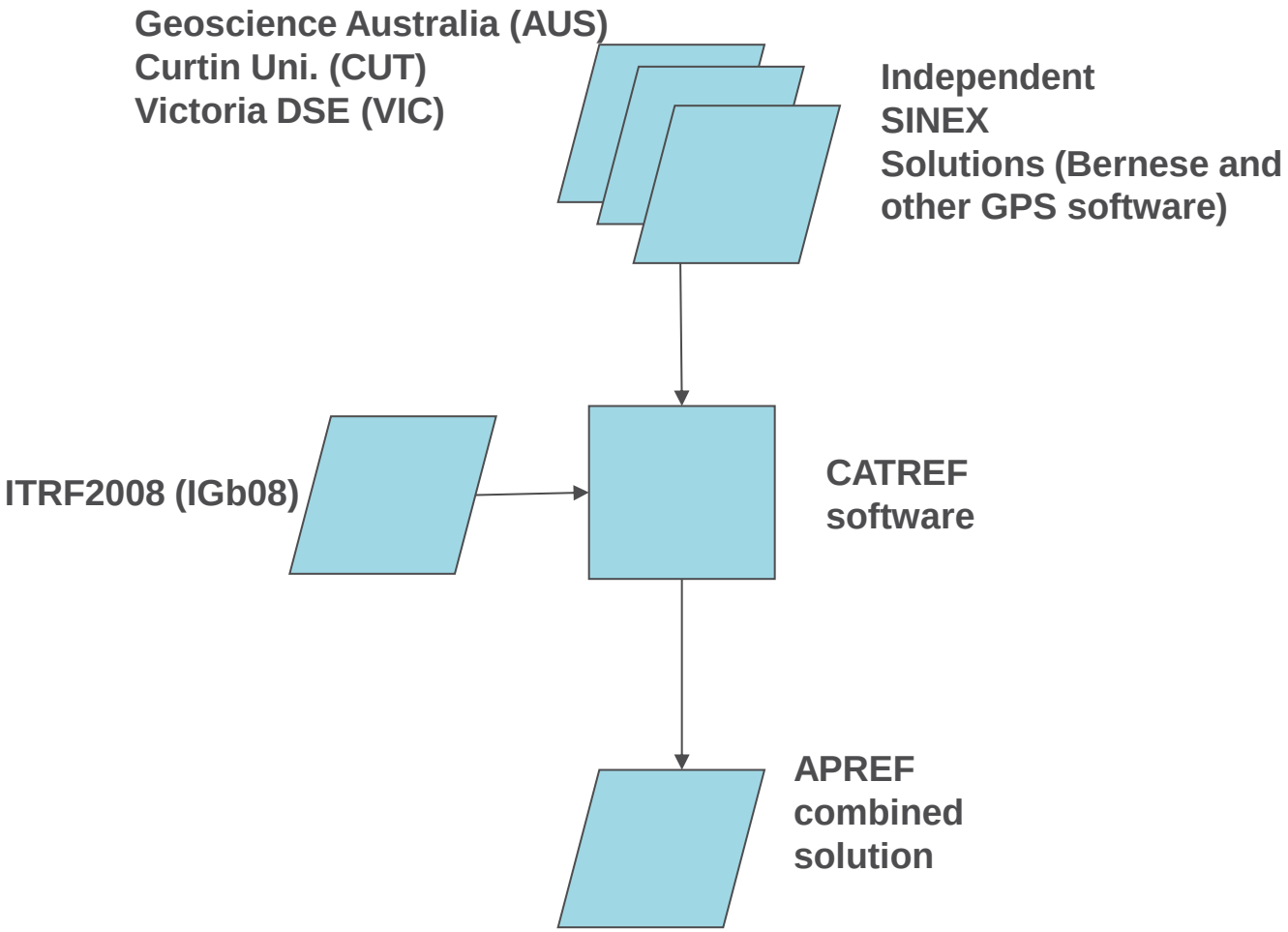
APREF status as of June 2013

- Data from 33 countries
- 16 national agencies participating
- 3 local analysis centres
- 2 universities participating
- ~ 400 Asia Pacific stations now available
- ~ 500 stations routinely analysed

APREF status as of June 2013



How the APREF Frame is Derived



APREF Solution Quality – Internal Consistency

Mean Weighted RMS with respect to the Combined Solution			
Solution	**North (mm)**	**East (mm)**	**Up (mm)**
Geoscience Australia	0.1	0.1	0.3
Curtin University	1.1	1.2	3.2
DSE Victoria	0.7	1.0	3.0

APREF Products

Official APREF product

- Weekly combination from GA (Central Bureau)
  - Local AC's are GA, CUT and DSE
  - Aligned and minimally constrained to IGS08
  - ~4 week latency
- Cumulative velocity field

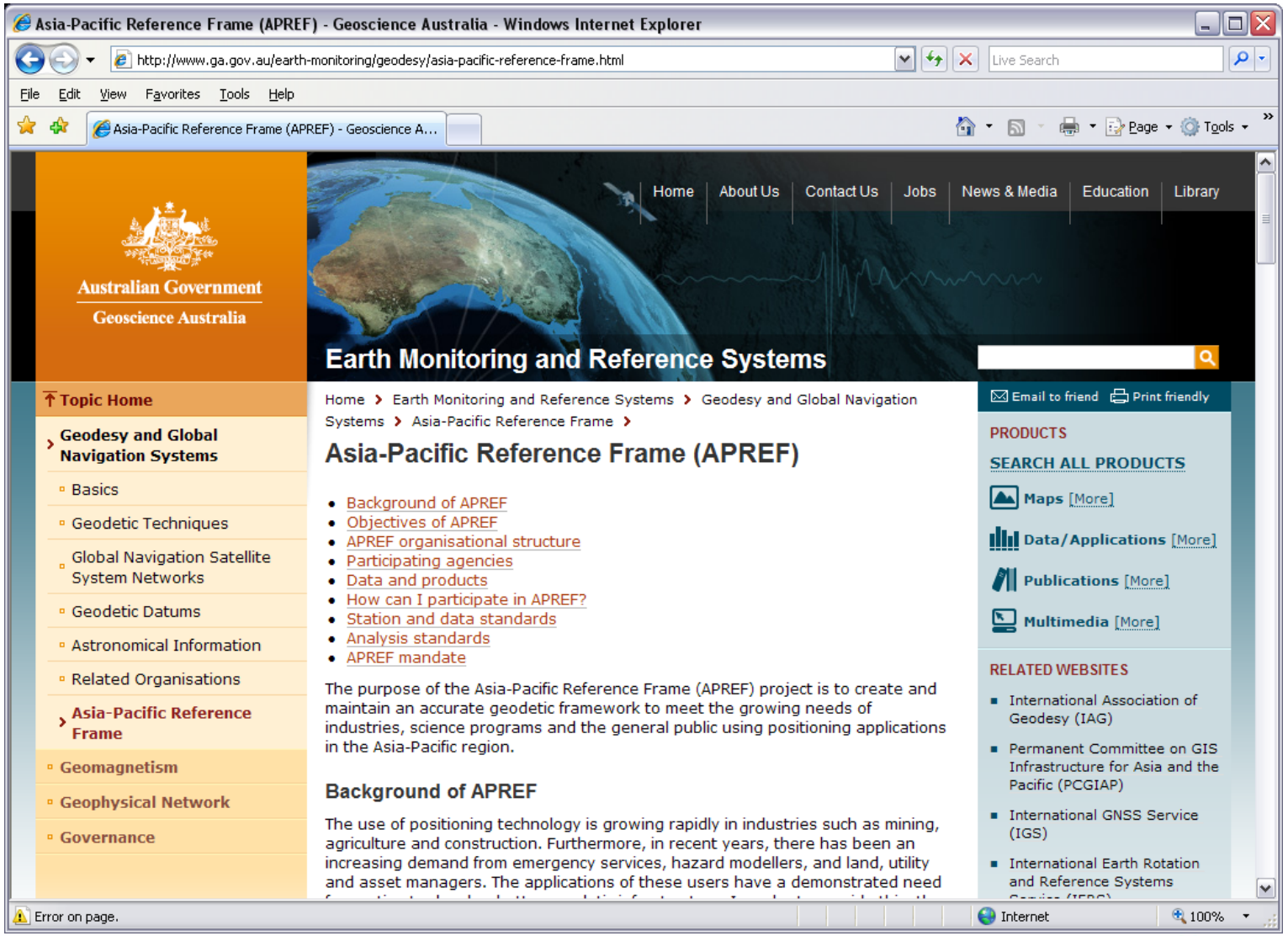
GA weekly solution

- Minimally constrained to IGS08
- ~2 week latency

GA daily solutions

- Final ~2 week latency
- Rapid ~2 days latency
- Suitable for network monitoring, research purposes and advanced users

APREF Website



Where to Find APREF Data and Products

→ APREF data and products are provided with an open access data policy via the internet following the practice of the IGS.

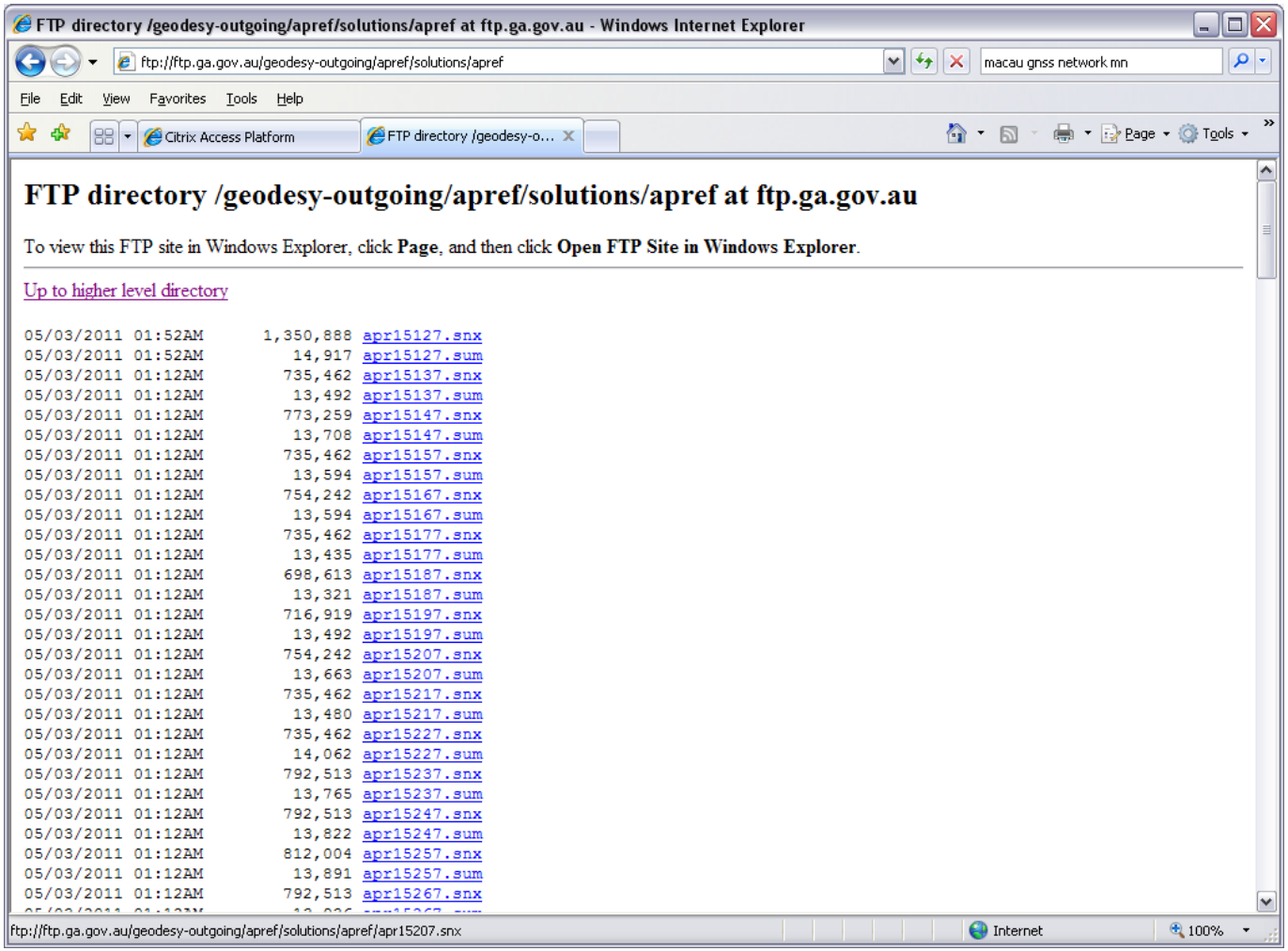
- Daily GNSS RINEX data with a delay of 24 hr after observation, see:

  ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/data/daily/

- Station log files, see:

  ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/logs/

APREF Weekly SINEX file (i.e. coordinates)



Weekly Station Coordinate and Performance

Weekly station coordinates

ITRF2008 Cartesian Coordinates (X,Y,Z) @ 22/06/2011

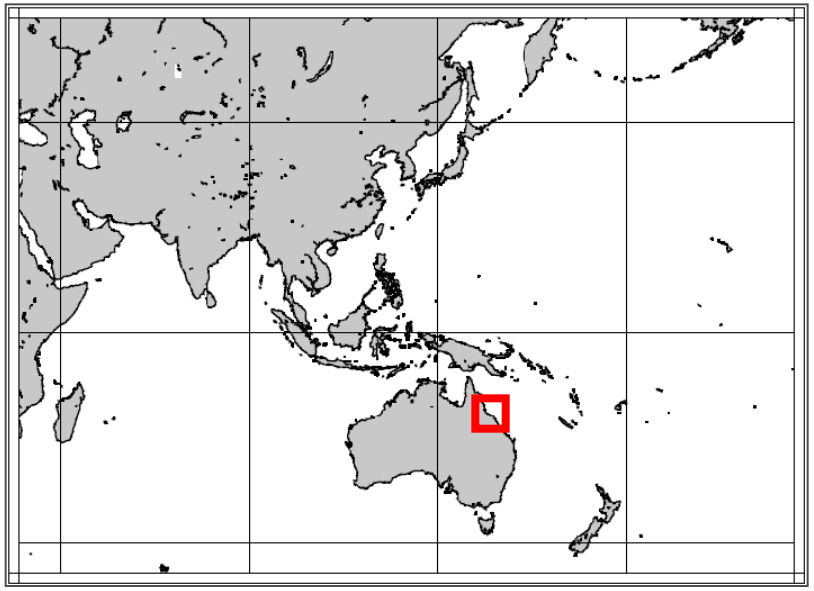
00NA 59975M001	-4073662.2922	4712064.7447	-1367874.4683
01NA 59974M001	-4084823.4609	4702026.6604	-1369125.8453
02NA 59973M001	-4078496.4549	4711380.1330	-1355915.1332
20NA 59972M001	-4050985.3396	4212133.7934	-2547954.8094
21NA AUM000184	-4048578.9364	4210151.5056	-2554917.6069
ADEL AUM000008	-3926936.9094	3461614.4215	-3631644.2263
ALBU AUM000009	-4324312.5655	2817311.0325	-3735264.7605
ALBY 50191M001	-2441714.5963	4629128.5358	-3633363.2024

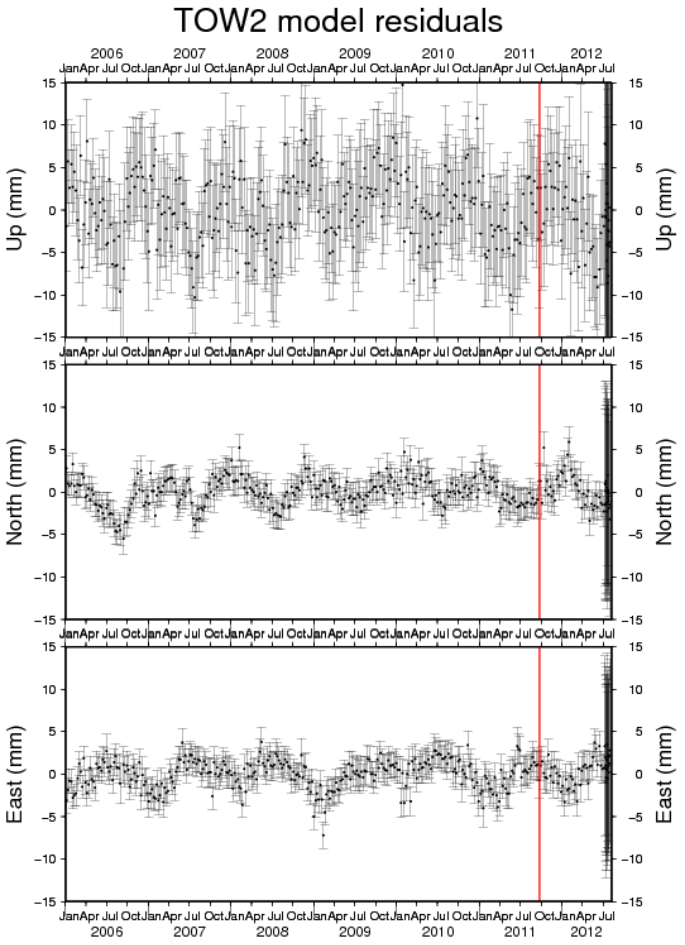
Weekly station performance

Total number of stations: 303

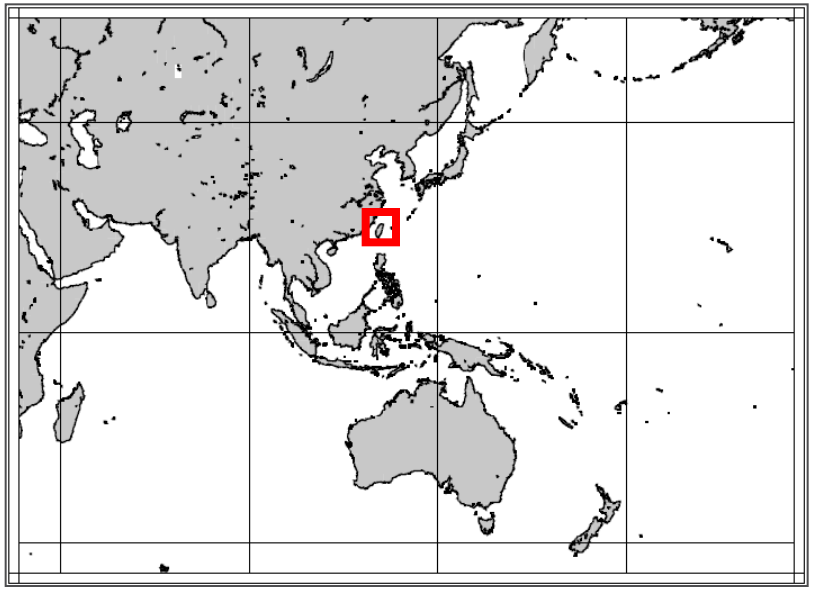
Station	#Days	Weekday 0123456	Repeatability (mm) N	E	U
00NA 59975M001	7	XXXXXXX	0.48	1.18	1.87
01NA 59974M001	7	XXXXXXX	0.54	1.61	5.80
02NA 59973M001	7	XXXXXXX	0.79	1.95	3.59
20NA 59972M001	7	XXXXXXX	0.41	1.29	2.00
21NA AUM000184	7	XXXXXXX	0.61	1.65	0.98
ADEL AUM000008	7	XXXXXXX	1.28	1.19	4.02
ALBU AUM000009	7	XXXXXXX	1.64	0.98	5.10
ALBY 50191M001	7	XXXXXXX	1.62	2.87	4.30
ALIC 50137M001	4	XXXX	0.28	1.26	1.47
ANDA 59971M001	7	XXXXXXX	0.64	0.87	1.74
ANTW AUM000010	7	XXXXXXX	1.47	0.83	3.70
APOL AUM000011	7	XXXXXXX	1.44	1.44	7.61
APSL AUM000012	7	XXXXXXX	3.27	1.23	5.96
ARMD AUM000143	7	XXXXXXX	0.60	1.42	2.74
ARTU 12362M001	5	XXXXX	3.16	2.20	3.20
ASPA 50503S006	7	XXXXXXX	2.39	2.88	12.17
AUCK 50209M001	7	XXXXXXX	1.27	1.66	4.47
AUKT 50216M001	7	XXXXXXX	1.63	1.66	4.81
BAIR AUM000015	7	XXXXXXX	1.14	1.06	5.46
BAKO 23101M002	7	XXXXXXX	2.97	3.40	10.00
BALN AUM000180	7	XXXXXXX	0.40	1.24	3.82
BAN2 22306M003	7	XXXXXXX	2.74	2.94	7.17
BBOO 59997M001	7	XXXXXXX	0.62	0.80	1.46
BDLE 50196M001	7	XXXXXXX	1.73	2.46	2.46
BDST 59981M001	7	XXXXXXX	0.80	1.43	2.86

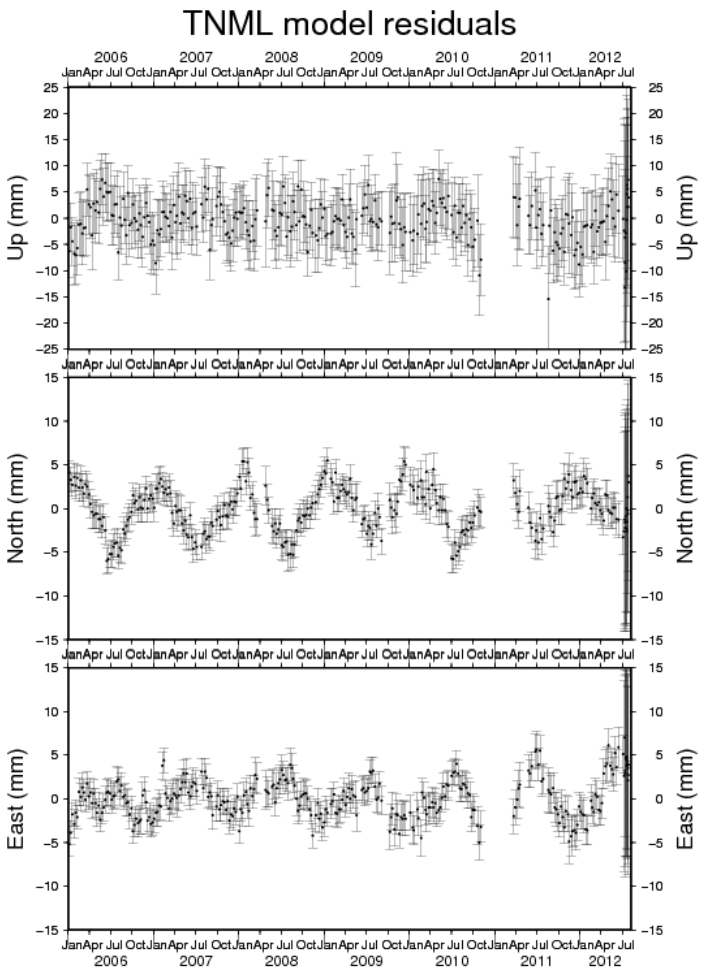
Example Coordinate Time Series: Townsville



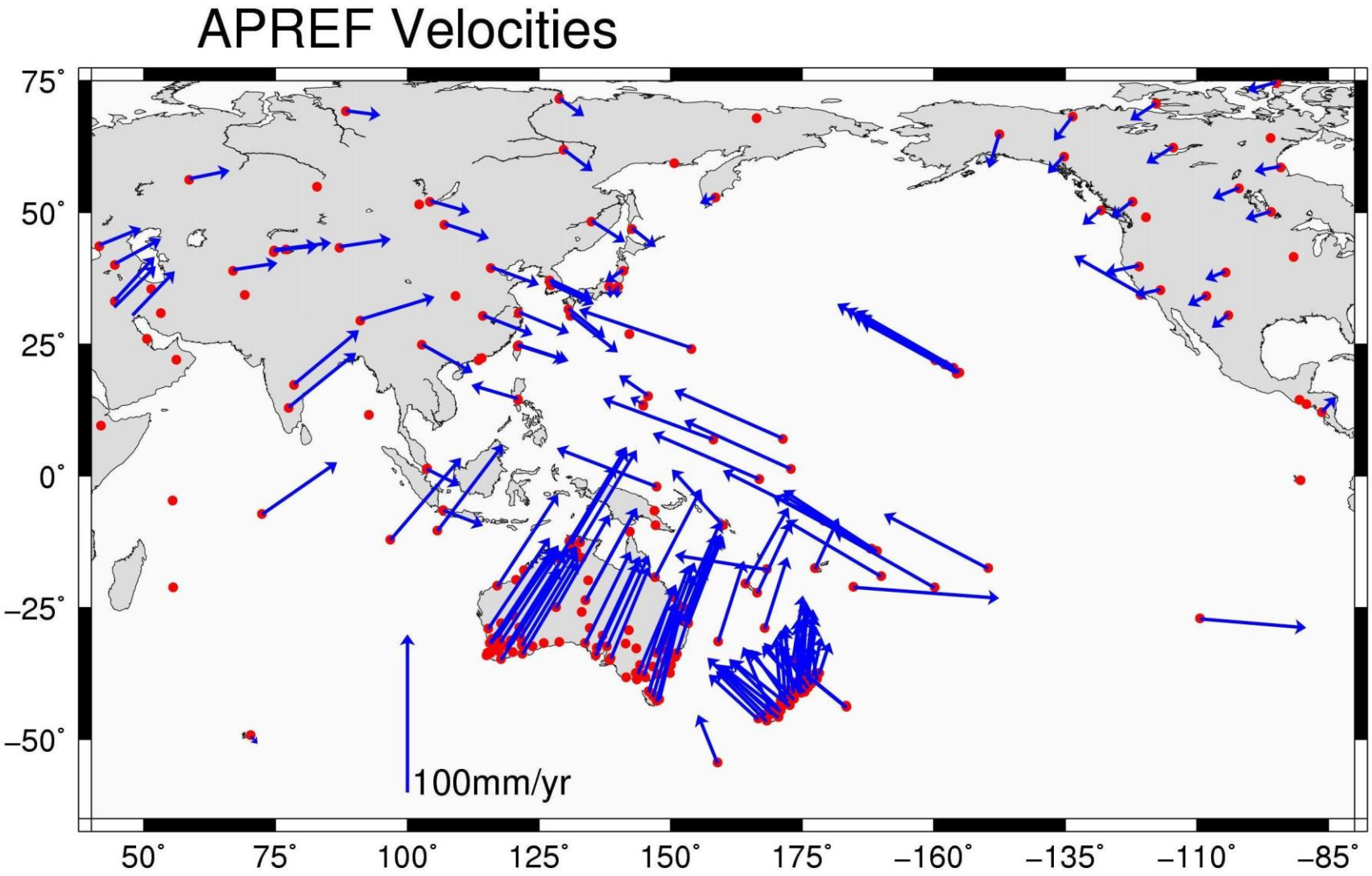


Example Coordinate Time Series: Hsinchu, Taiwan





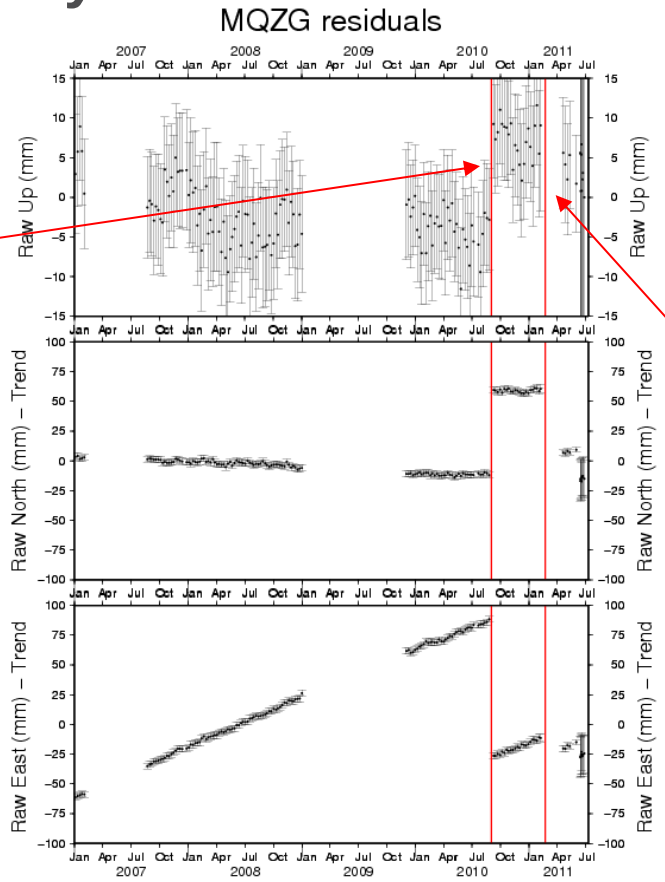
APREF Crustal Velocity Field



APREF Services and Applications

- **Science applications, e.g., hazard assessment, sea-level change, crustal dynamics**

Station MQZG event 1: 03-Sep-10 Christchurch earthquake (7.1)



Event 2: 22-Feb-11 Christchurch earthquake (6.3)

How Do I Contribute CORS data into APREF

Do I have a permanent GNSS station? 

Is my agency willing to share its data (30 sec, daily RINEX) 

Can I do this automatically everyday? 

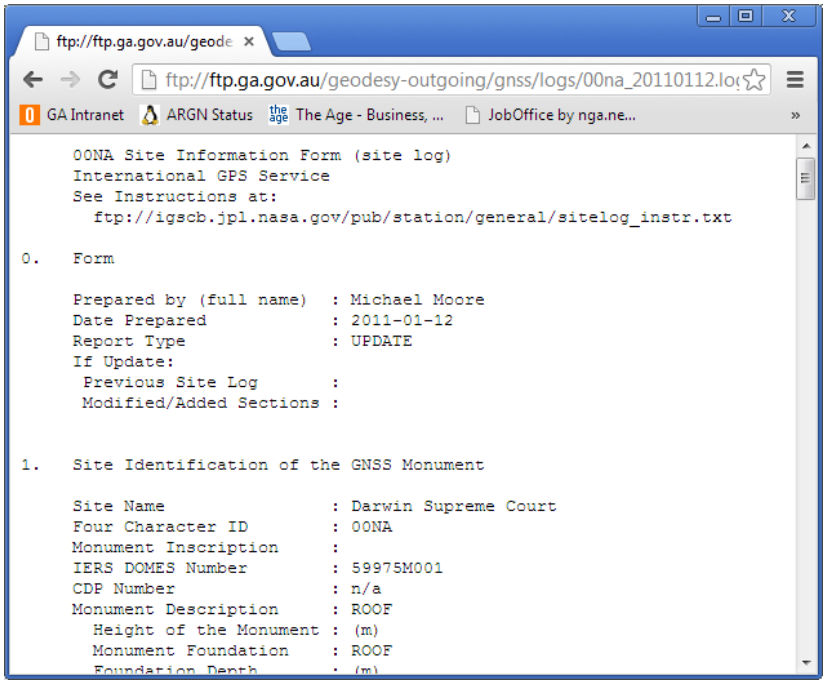
Does it meet the IGS or APREF standards? Check 

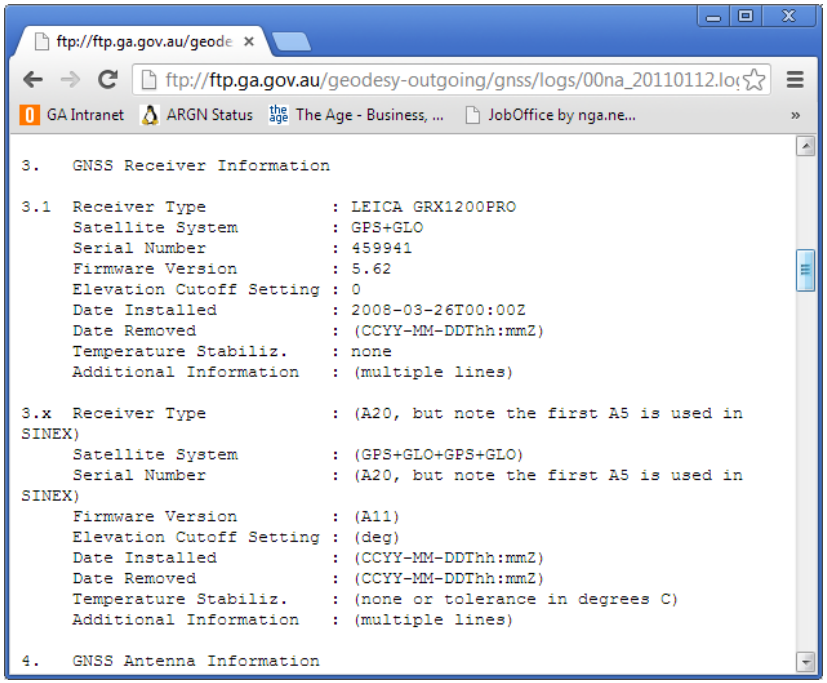
→ IGS: http://igscb.jpl.nasa.gov/network/guidelines/guidelines.html

→ APREF: https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=72803

How Do I Contribute CORS data into APREF

Do I have a **Station Log File** for this GNSS station? e.g.,





Can I commit to notifying the APREF CB every time the **Station Log File** for this GNSS station changes?

How Do I Contribute CORS data into APREF

Send an email to geodesy@ga.gov.au with the subject heading "Proposed APREF CORS", in this email include:

→ the proposed 4-character site

→ photographs of the proposed site

→ a completed site log-file

→ a link to some sample data from the site

How to participate in APREF: Analysis

APREF Analysis standards

→ use scientific software packages (e.g., Bernese, GAMIT, GIPSY)

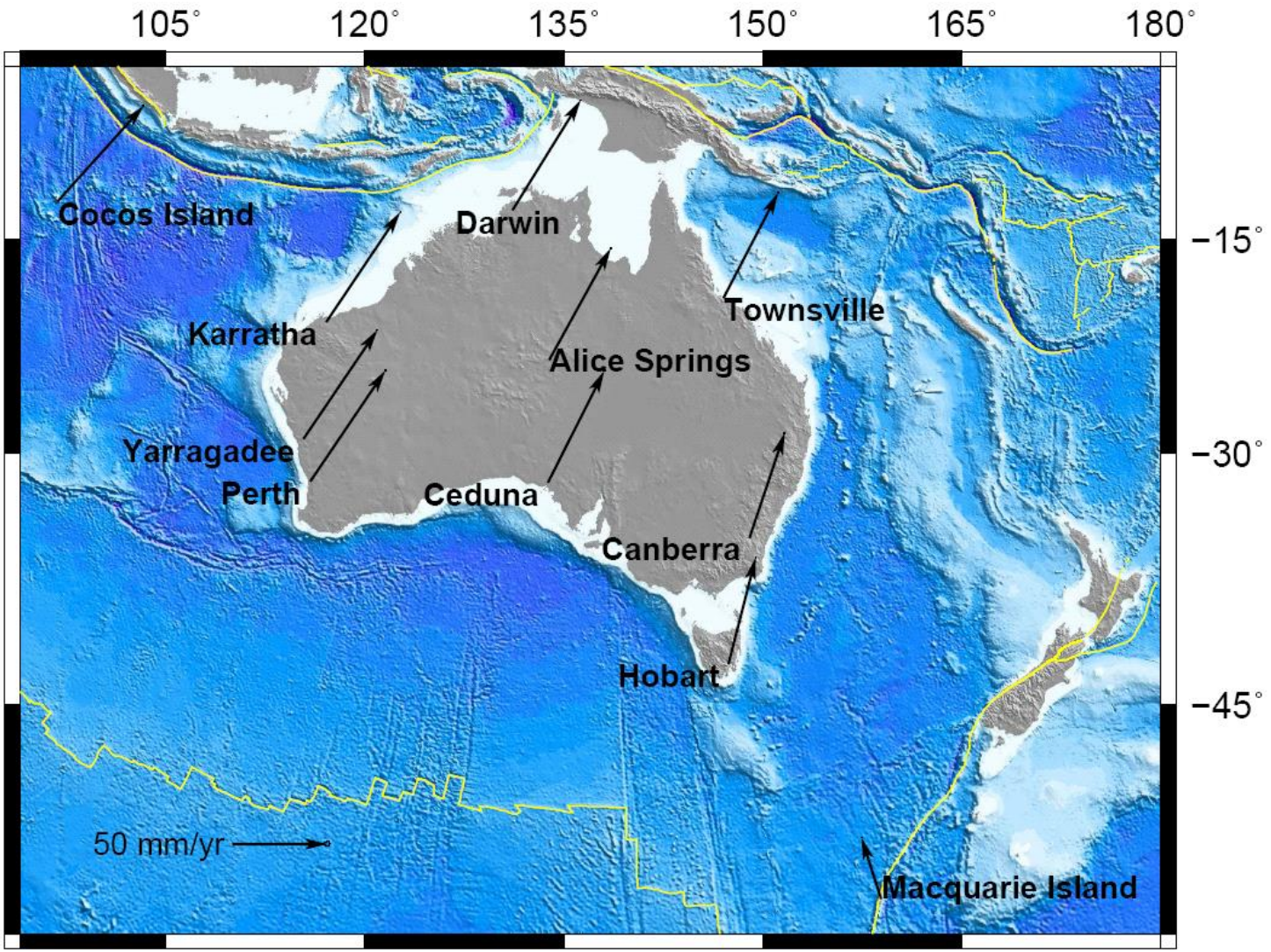
→ conforms to the IERS 2010 conventions

→ contributed solutions in the SINEX format

Linking ITRF/APREF to national datum

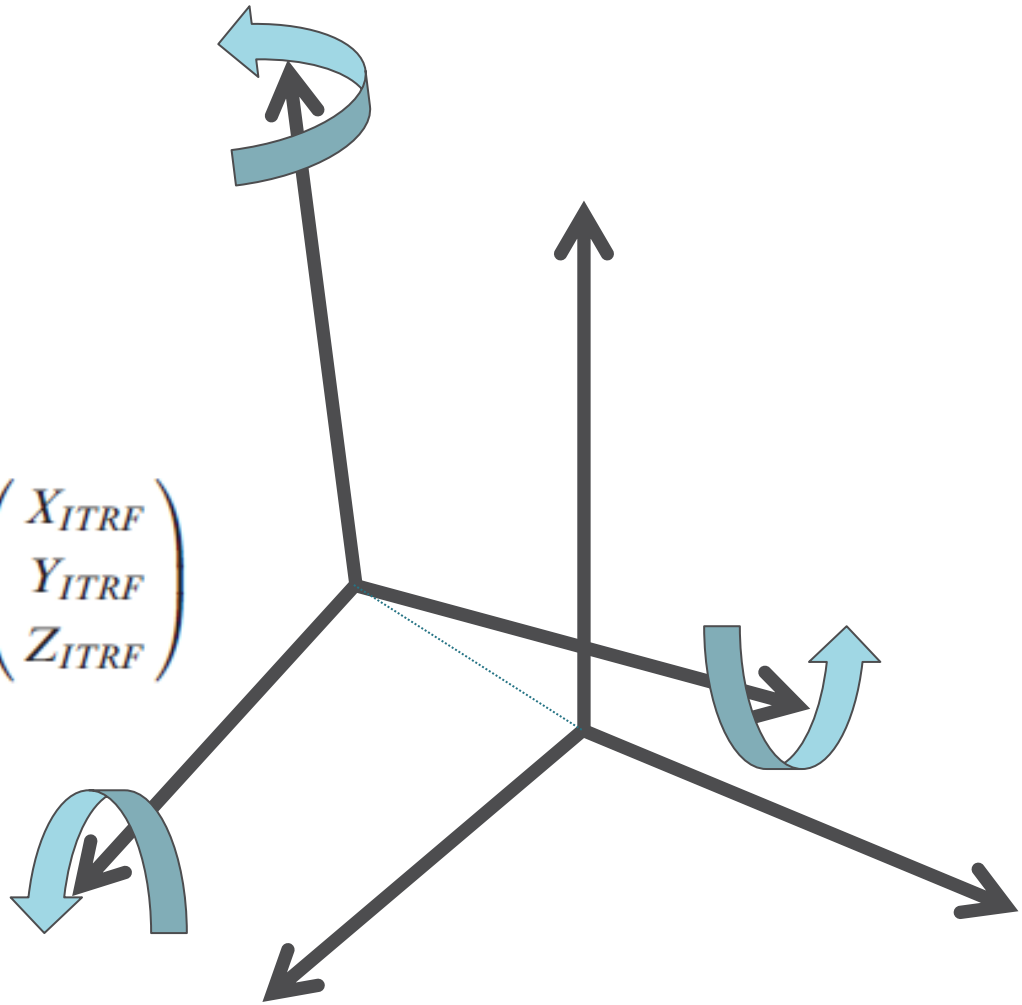
→Example: Australia

Geocentric Datum of Australia



Seven Parameter Transformation: ITRF→GDA94

$$\begin{pmatrix} X_{GDA94} \\ Y_{GDA94} \\ Z_{GDA94} \end{pmatrix} = \begin{pmatrix} T_x \\ T_y \\ T_z \end{pmatrix} + (1 + S_c) \begin{pmatrix} 1 & R_z & -R_y \\ -R_z & 1 & R_x \\ R_y & -R_x & 1 \end{pmatrix} \begin{pmatrix} X_{ITRF} \\ Y_{ITRF} \\ Z_{ITRF} \end{pmatrix}$$



Fourteen Parameter Transformation: ITRF→GDA94

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

Fourteen Parameter Transformation: ITRF→GDA94

	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, $\dot{r}_z$
From ITRF2008 to GDA94							
	−84.68	−19.42	32.01	9.710	−0.4254	2.2578	2.4015
±	0.91	0.78	1.06	0.126	0.0221	0.0236	0.0194
Rates	1.42	1.34	0.90	0.109	1.5461	1.1820	1.1551
±	0.08	0.07	0.11	0.013	0.0028	0.0030	0.0023
From ITRF2005 to GDA94							
	−79.73	−6.86	38.03	6.636	−0.0351	2.1211	2.1411
±	2.56	1.87	3.37	0.227	0.0883	0.0972	0.0600
Rates	2.25	−0.62	−0.56	0.294	1.4707	1.1443	1.1701
±	0.28	0.20	0.36	0.022	0.0096	0.0106	0.0070

Current differences between ITRF and GDA is approximately 1.4 metres

These transformation parameter can model that difference with an uncertainty of 1 to 2 cm.

Fourteen Parameter Transformation: ITRF→GDA94

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

http://www.ga.gov.au/earth-monitoring/geodesy.html

APREF and AUSPOS

→Improving online positioning

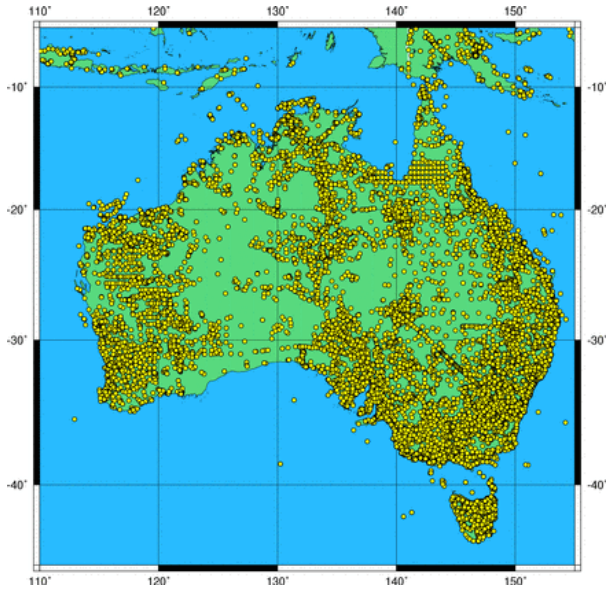
AUSPOS History

→ First version of AUSPOS was developed in 2001

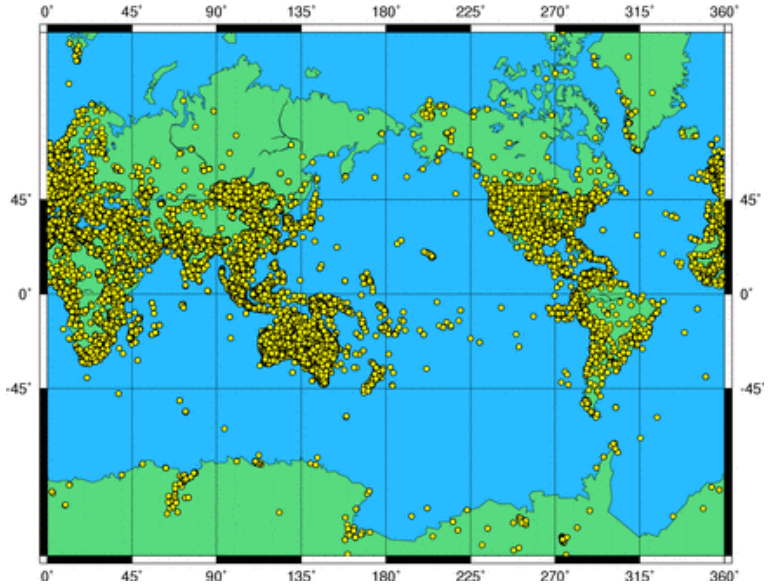
→ 200,000 data files processed

→ Since 2011 all APREF stations have been used in AUSPOS

Australia users



World users



Requirements

Dual frequency code and phase observations (L1 and L2)

1 hour → 1 week static GPS data

Users need to wait several hours for data submission after data collection, it's better after the end of UTC day so that reference sites data is available

For more details see:

http://www.ga.gov.au/earth-monitoring/geodesy/auspos-online-gps-processing-service.html

Requirements

AUSPOS - Online GPS Processing Service

- AUSPOS is a free online GPS data processing facility provided by Geoscience Australia
- AUSPOS takes advantage of both The IGS Stations Network and the IGS product range
- AUSPOS works with data collected anywhere on Earth
- Users submit their dual frequency geodetic quality GPS RINEX data observed in a 'static' mode to the GPS data processing system
- An AUSPOS report will be emailed to you (often in less than 5 mins) containing Geocentric Datum of Australia 1994 (GDA94) and Internat

AUSPOS Submission Checklist

Before submitting your GPS RINEX file/s, please ensure:

1. The GPS RINEX file/s contains more than one hour (preferably two) of GPS data
2. The GPS RINEX file/s do not contain any data from the current UT day
3. The GPS RINEX file/s do not contain more than seven days of data
4. The GPS RINEX file/s names do not contain spaces
5. When submitting multiple files, ensure the first four characters / numbers of the file names are not the same
6. You have used the IGS naming convention for the antenna type (refer the National Geodetic Survey (NGS) for more information)
7. The antenna height provided is the vertical distance from the ground mark to the Antenna Reference Point (ARP)

Submit your data to AUSPOS

AUSPOS FAQ's

- AUSPOS - Step by Step
- Section 1 - Introduction to AUSPOS
- Section 2 - RINEX Data
- Section 3 - How AUSPOS Works
- Section 4 - Understanding the Results
- Section 5 - GPS Antennas
- Section 6 - Trouble Shooting

Limitations

AUSPOS cannot process:

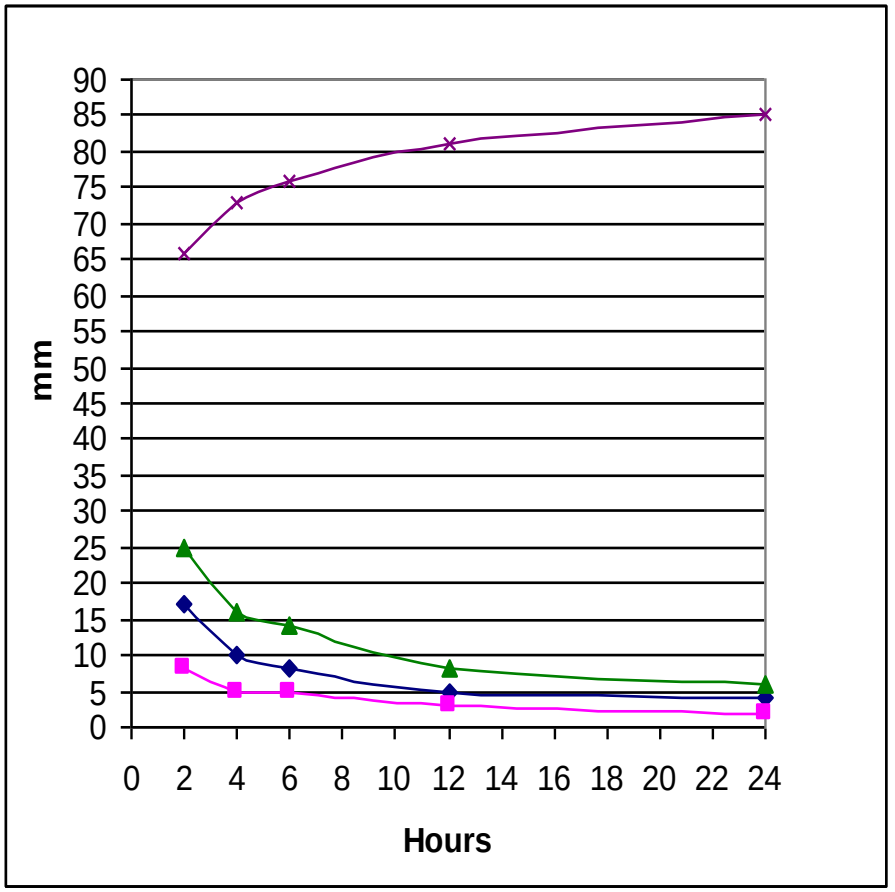
→Single frequency data

→Real time and near real time data

→ Kinematic data

Assessment of solution uncertainty

- **averaged uncertainties**
- ✓ 2 - 8 mm East
- ✓ 4 – 17 mm North
- ✓ 6 - 25 mm Up
- **ambiguity resolutions**
- ✓ 66% - 85% vary from 2 hours to 24 hours data
- For Australian users uncertainties and ambiguity resolutions should be much better as more dense reference sites available.



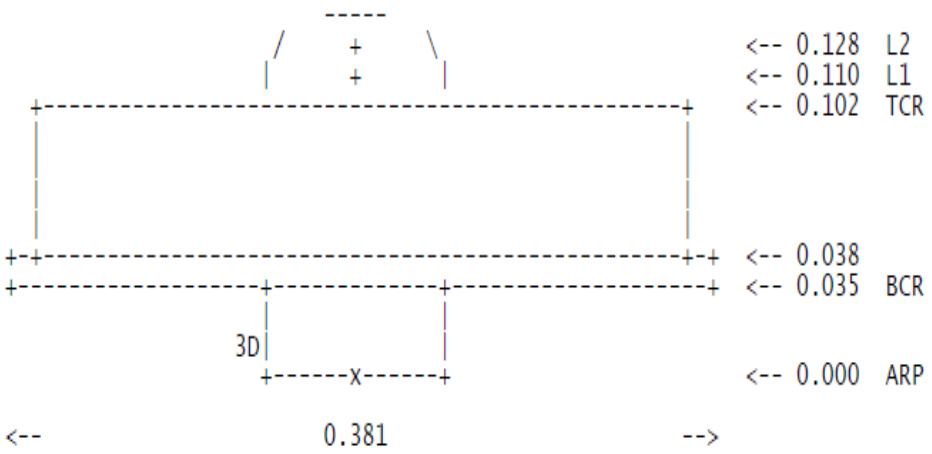
Things for AUSPOS Users

- Ensure data collection in a good environment
- Convert collected raw data into correct RINEX observation data (currently RINEX version 2.11)
- Provide a correct antenna height
- Select a correct antenna and dome type

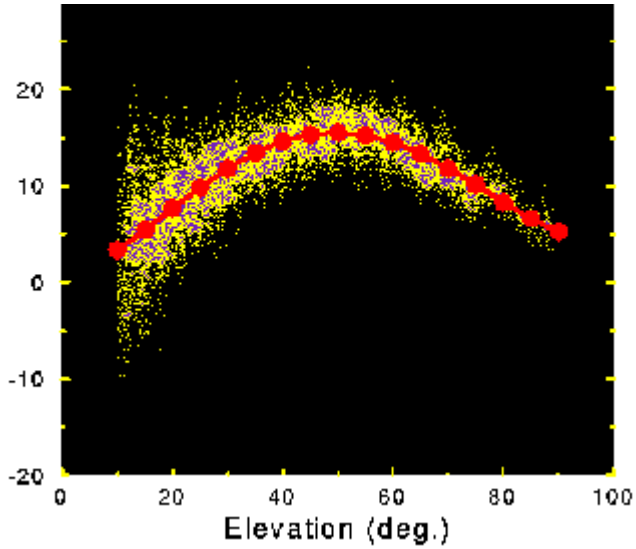
Antenna and dome type

AntOffset

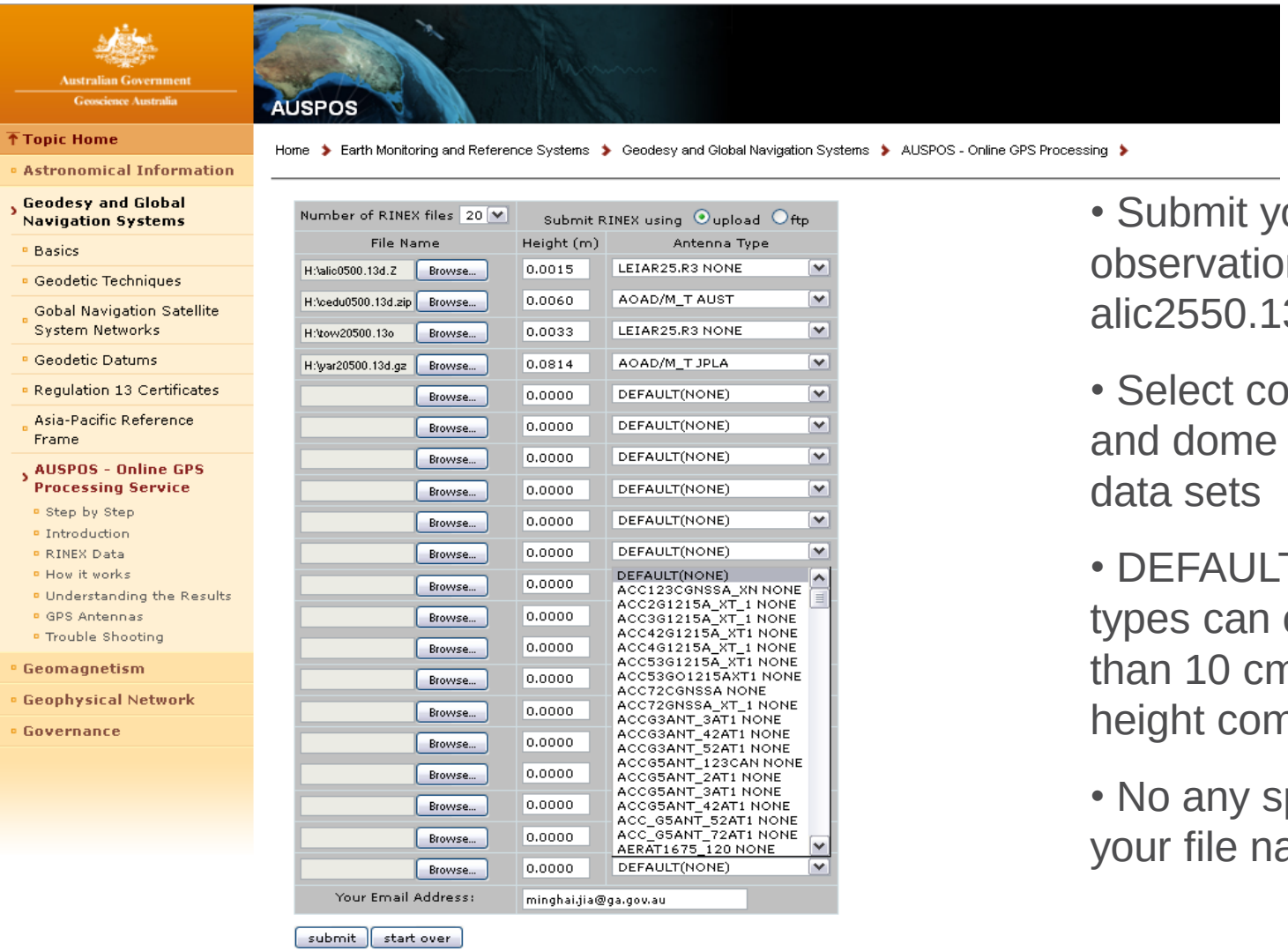
TurboRogue: DORNE MARGOLIN T



ARP: Antenna Reference Point BPA: Bottom of Preamplifier



Data submission



- Submit your RINEX 2.11 observation data (eg. alic2550.13o)
- Select correct antenna and dome types for your data sets
- DEFAULT (NONE NONE) types can cause a more than 10 cm error in the height component.
- No any space and () for your file name and path.

Successful submission

AUSPOS Online GPS Processing Service

Dear minghai.jia@ga.gov.au,

Thank you for submitting a GPS processing job to the AUSPOS Online GPS Processing Service.

Your job reference is #21328. The following RINEX file(s) have been submitted for processing (#File, Filename, Antenna Type, Height) :

1. alic0500.13d.Z LEIAR25.R3 NONE 0.0015 m
2. cedu0500.13d AOAD/M_T AUST 0.0060 m
3. tow20500.13o LEIAR25.R3 NONE 0.0033 m
4. yar20500.13d.gz AOAD/M_T JPLA 0.0000 m

Your job has just been submitted to the AUSPOS GPS processing server.

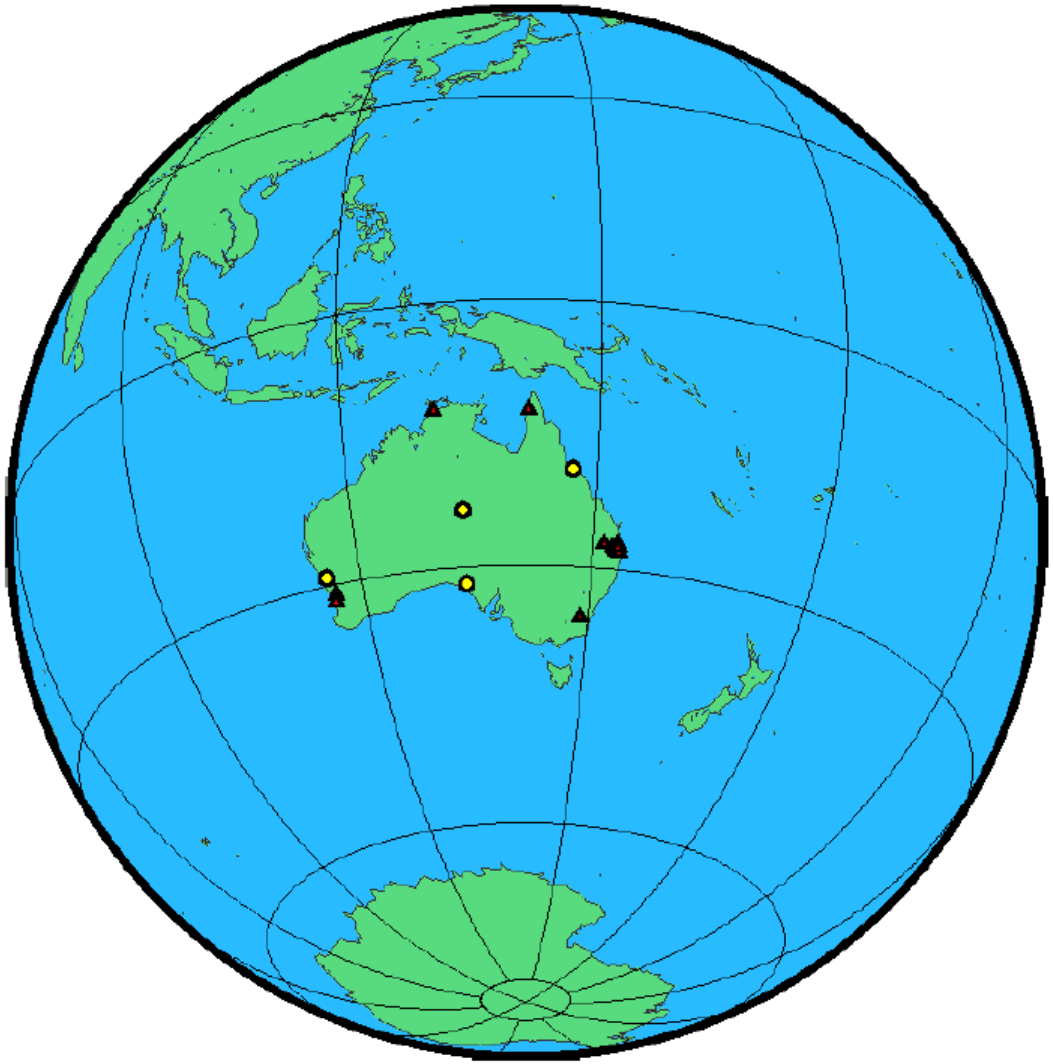
Thank you for using the AUSPOS service.

Solution report

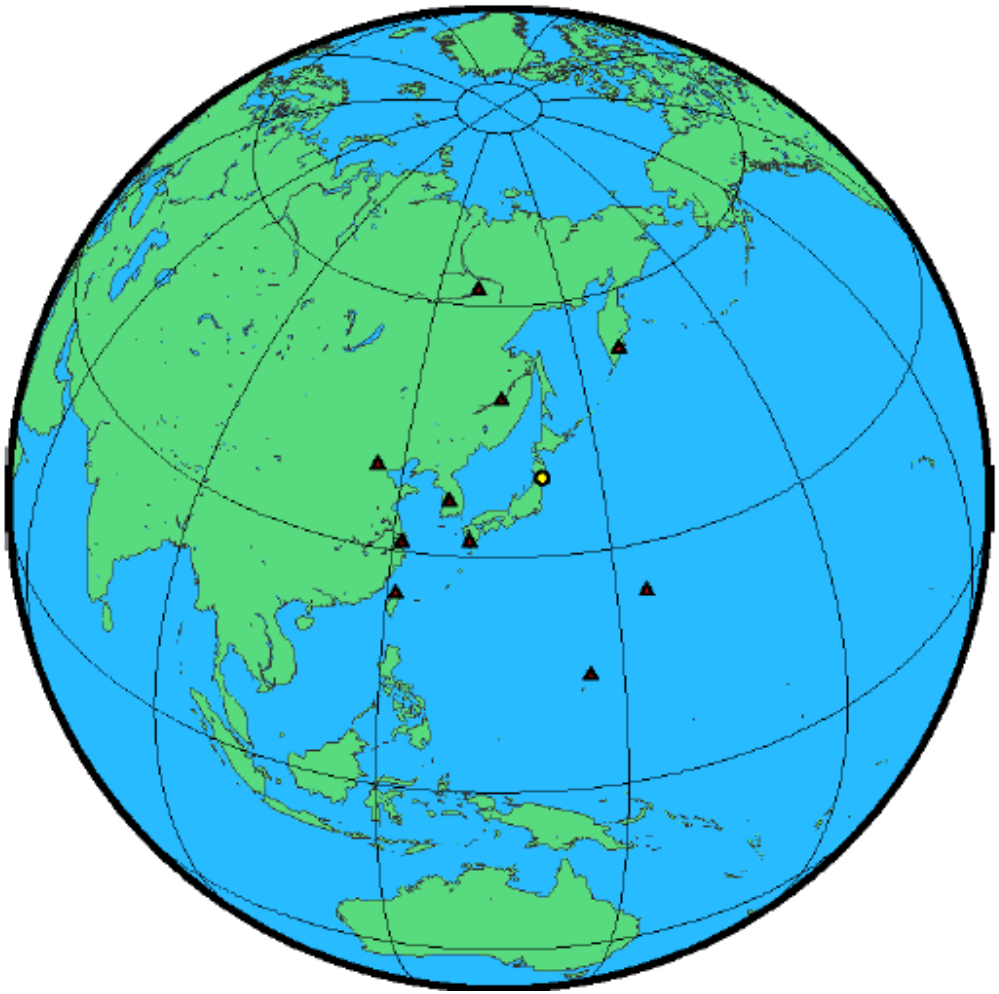
- After data is processed successfully, AUSPOS will email a solution report to the user

- Or email an error message to the user if something is wrong

An example for Australian users



An example for international users



Report details for Australian users (1/3)

3.1 Cartesian, GDA94

Station	X (m)	Y (m)	Z (m)
ALIC	-4052051.768	4212836.198	-2545106.024
CEDU	-3753472.143	3912741.041	-3347961.041
TOW2	-5054582.657	3275504.557	-2091539.881
YAR2	-2389025.441	5043316.989	-3078530.939
BDST	-5021920.617	2559339.869	-2975290.670
CBLT	-5061144.441	2584178.828	-2886586.876
CLEV	-5055209.002	2546205.939	-2930072.265
DALB	-4979266.859	2730160.232	-2895220.925
DWNI	-4083214.808	4704504.479	-1365350.766
GATT	-5012218.434	2628002.742	-2931853.189
IPS2	-5028440.656	2588779.893	-2938802.552
NNOR	-2414151.166	4907778.465	-3270645.525
PERT	-2368686.822	4881316.513	-3341796.290
ROBI	-5034843.822	2523322.876	-2984064.622
TIDB	-4460996.067	2682557.134	-3674443.866
WEIP	-4899027.809	3838505.163	-1390728.000
WOOL	-5046788.342	2567555.320	-2926034.801

Report details for Australian users (2/3)

3.2 Geodetic, GRS80 Ellipsoid, GDA94

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived AHD (m)
ALIC	-23 40 12.44601	133 53 07.84803	603.347	587.497
CEDU	-31 52 00.01671	133 48 35.37571	144.819	153.613
TOW2	-19 16 09.42804	147 03 20.46546	88.207	29.453
YAR2	-29 02 47.61684	115 20 49.09991	241.454	266.623
BDST	-27 59 13.56951	152 59 42.27831	101.1023	60.709
CBLT	-27 05 03.97248	152 57 05.45891	83.9419	40.970
CLEV	-27 31 34.17666	153 15 59.52280	67.0083	25.404
DALB	-27 10 13.97540	151 15 49.65037	394.6917	352.658
DWNI	-12 26 35.92078	130 57 21.35177	87.8118	35.529
GATT	-27 32 38.17787	152 19 51.99975	140.5887	98.694
IPS2	-27 36 53.76282	152 45 33.62954	88.6520	47.156

Report details for Australian users (3/3)

3.3 MGA Grid, GRS80 Ellipsoid, GDA94

Station	East (m)	North (m)	Zone	Ellipsoidal Height (m)	Derived AHD (m)
ALIC	386352.403	7381850.769	53	603.347	587.497
CEDU	387415.776	6473725.238	53	144.819	153.613
TOW2	505851.333	7869375.321	55	88.207	29.453
YAR2	339055.521	6785728.466	50	241.454	266.623
BDST	499515.931	6904226.325	56	101.102	60.709
CBLT	495193.285	7004211.623	56	83.942	40.970
CLEV	526320.098	6955257.198	56	67.008	25.404
DALB	327986.948	6993484.346	56	394.692	352.658
DWNI	712604.328	8623642.930	52	87.812	35.529
GATT	433957.480	6953137.979	56	140.589	98.695
IPS2	476254.234	6945429.043	56	88.652	47.156
NNOR	422969.549	6564716.429	50	234.893	262.432
PERT	394476.883	6480972.939	50	12.769	45.083

Report details for global users (1/2)

4.1 Cartesian, ITRF2008

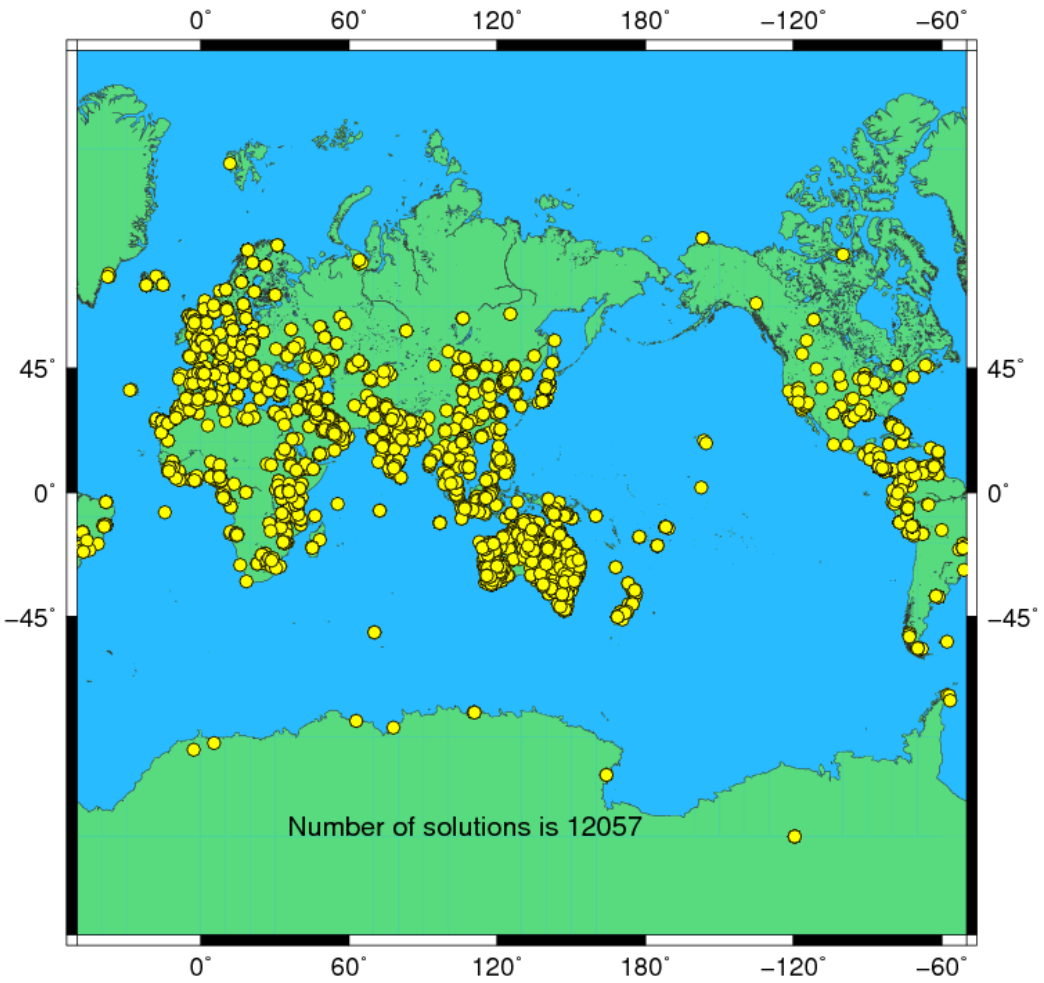
Station	X (m)	Y (m)	Z (m)	ITRF2008 @
ALIC	-4052052.470	4212836.021	-2545104.959	19/02/2013
CEDU	-3753472.910	3912741.016	-3347960.045	19/02/2013
TOW2	-5054583.181	3275504.207	-2091538.833	19/02/2013
YAR2	-2389026.326	5043317.075	-3078529.951	19/02/2013
BDST	-5021921.164	2559339.657	-2975289.717	19/02/2013
CBLT	-5061144.979	2584178.598	-2886585.915	19/02/2013
CLEV	-5055209.541	2546205.717	-2930071.310	19/02/2013
DALB	-4979267.416	2730160.011	-2895219.953	19/02/2013
DWNI	-4083215.426	4704504.125	-1365349.641	19/02/2013
GATT	-5012218.983	2628002.524	-2931852.228	19/02/2013
IPS2	-5028441.202	2588779.675	-2938801.594	19/02/2013
NNOR	-2414152.057	4907778.577	-3270644.550	19/02/2013
PERT	-2368687.720	4881316.640	-3341795.324	19/02/2013

Report details for global users (2/2)

4.2 Geodetic, GRS80 Ellipsoid, ITRF2008

Station	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height(m)	Derived Above Geoid Height(m)
ALIC	-23 40 12.40962	133 53 07.87023	603.248	588.104
CEDU	-31 51 59.98046	133 48 35.39742	144.728	153.771
TOW2	-19 16 09.39318	147 03 20.48527	88.097	30.162
YAR2	-29 02 47.58158	115 20 49.12811	241.373	267.101
BDST	-27 59 13.53622	152 59 42.29431	100.999	61.006
CBLT	-27 05 03.93915	152 57 05.47522	83.838	41.385
CLEV	-27 31 34.14342	153 15 59.53887	66.905	25.754
DALB	-27 10 13.94165	151 15 49.66713	394.588	353.041
DWNI	-12 26 35.88408	130 57 21.37490	87.704	36.237
GATT	-27 32 38.14439	152 19 52.01609	140.486	99.081
IPS2	-27 36 53.72945	152 45 33.64573	88.549	47.560
NNOR	-31 02 55.43178	116 11 33.79637	234.814	262.811
PERT	-31 48 07.06142	115 53 06.91483	12.690	45.425

2013 AUSPOS Use



Final Remarks

- **Challenges**
  - Issues remain regarding free and open access to data for many Asia-Pacific countries
  - Need to identify additional analysis centres
    - limited redundancy with only 3 analysis groups
    - redundancy to offer reliable service and products
- **For more information, APREF Central Bureau**
  - **www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html**
  - **Email: john.dawson@ga.gov.au**

IAG / FIG / UNGGIM / UNICG / PhilGEGS

Reference Frame in Practice

Manila, Philippines 21-22 June 2013

Asia Pacific Reference Frame (APREF)

John Dawson and Guorong Hu

National Geospatial Reference Systems

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