

IAG/FIG Commission 5/ICG Technical Seminar

Reference Frame in Practice

Rome, Italy 4–5 May 2012



Session 1.2 Regional and National Reference Systems

Asia Pacific

Dr John Dawson

Leader - National Geodesy Program

Geoscience Australia

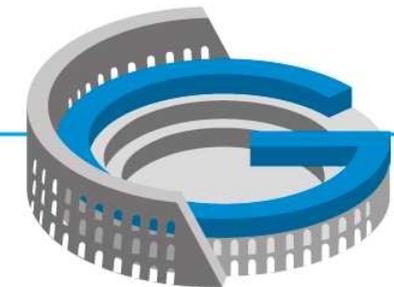
Sponsors:



esri



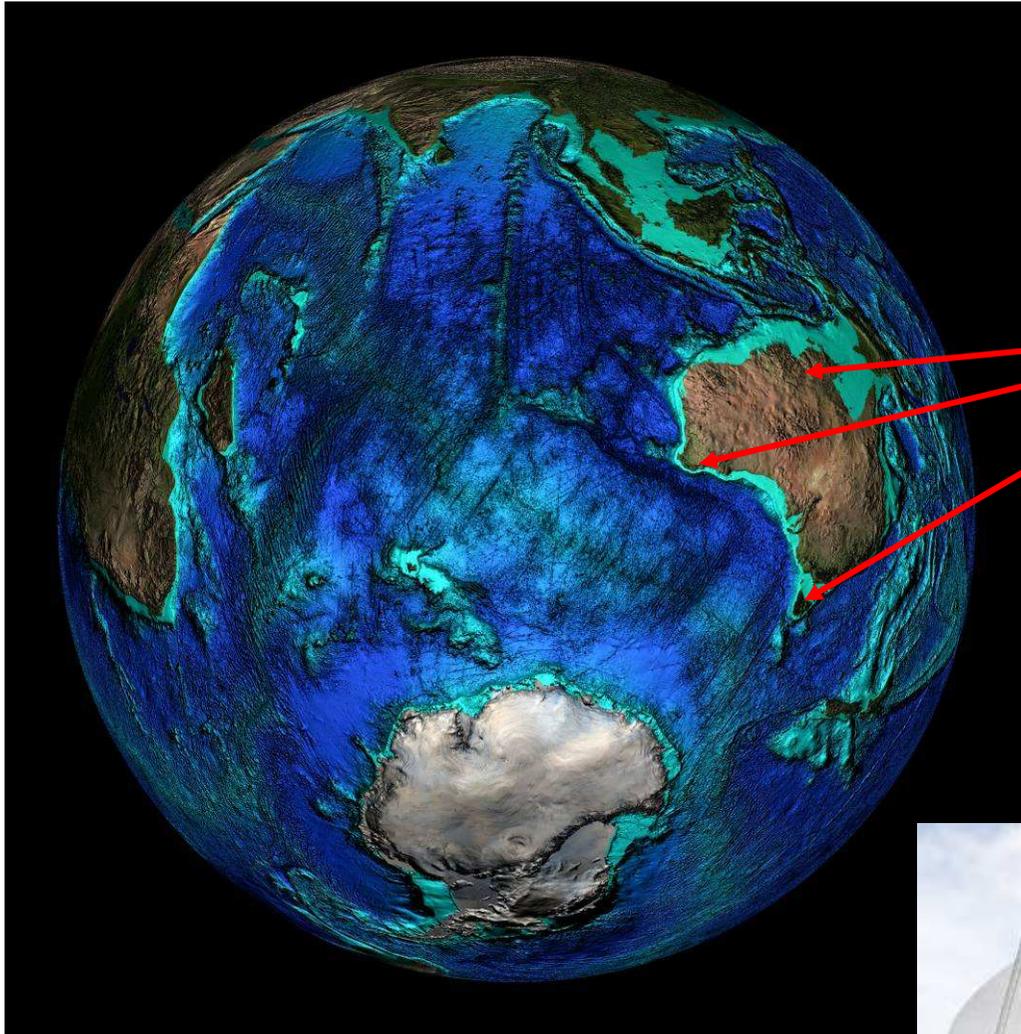
Trimble



Presentation Overview

- Part 1
 - Australia's contributions to the ITRF
 - Very Long Baseline Interferometry (VLBI)
 - Satellite Laser Ranging (SLR)
 - GNSS
 - Survey ties at co-located geodetic observatories
- Part 2
 - Improving **access** the ITRF in the Asia Pacific
 - Permanent Committee on GIS Infrastructure for the Asia and Pacific (PCGIAP)
 - Asia Pacific Reference Frame (APREF)

Australia's Contributions to the ITRF



National VLBI network



Australia's Contributions to the ITRF

12m Telescope, Yarragadee, Western Australia



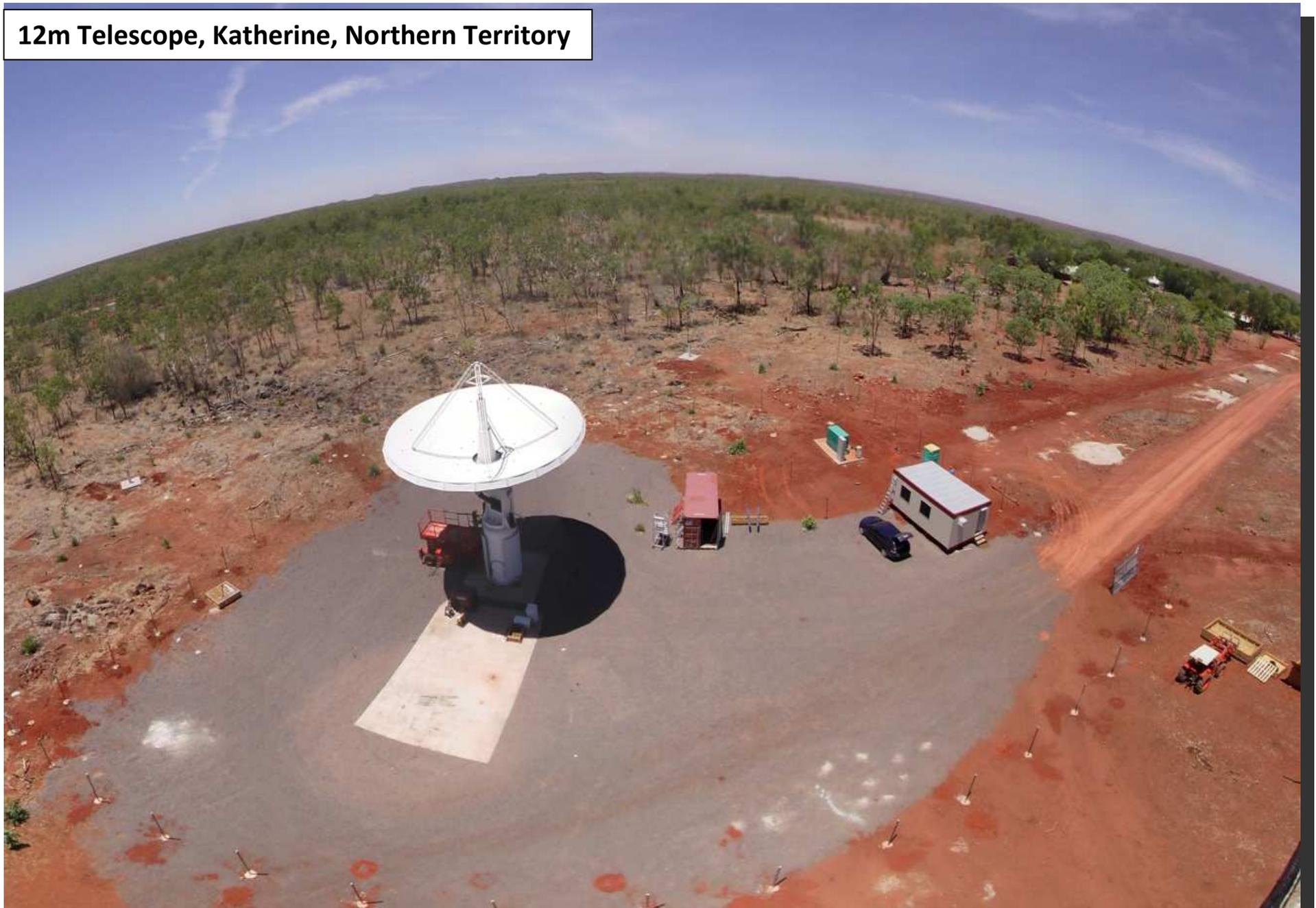
Australia's Contributions to the ITRF

12m Telescope, Hobart, Tasmania



Australia's Contributions to the ITRF

12m Telescope, Katherine, Northern Territory

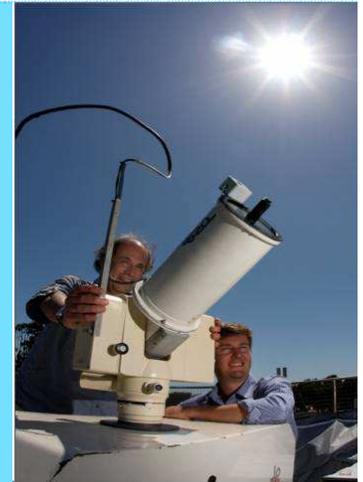
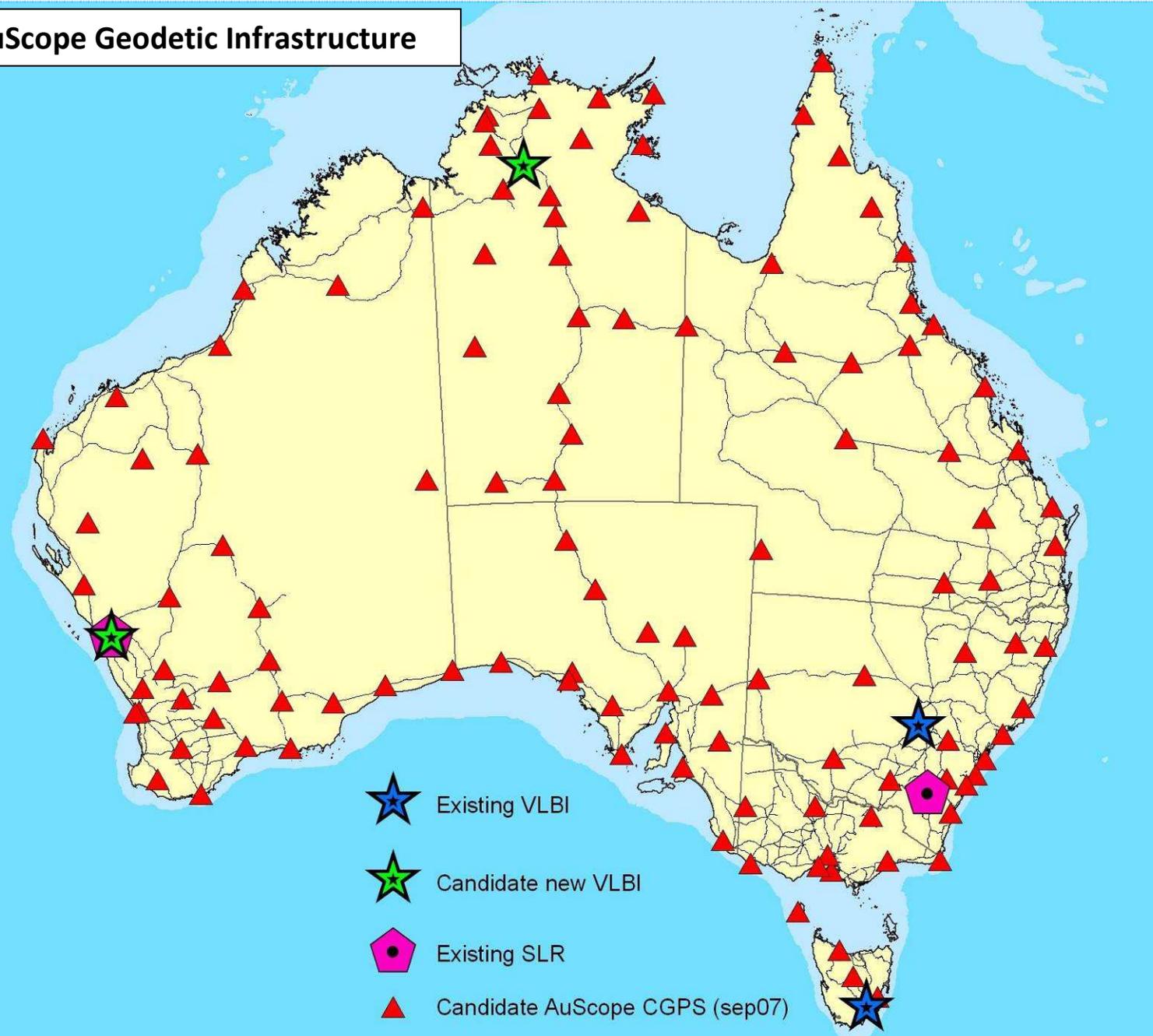


Mount Stromlo Satellite Laser Ranging (SLR) Station



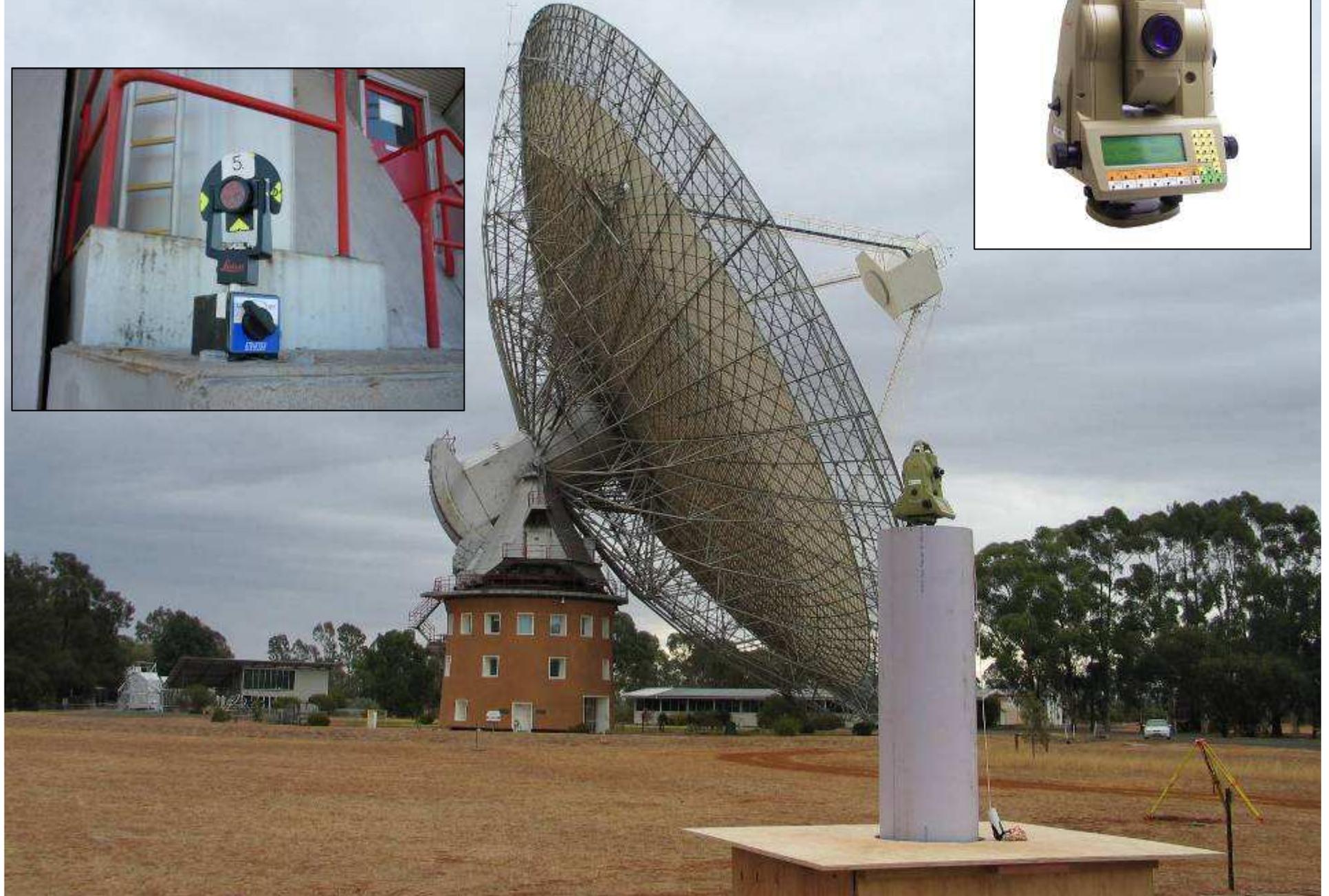
Australia's Contributions to the ITRF

AuScope Geodetic Infrastructure

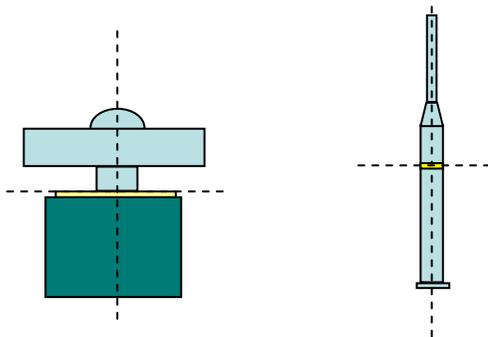
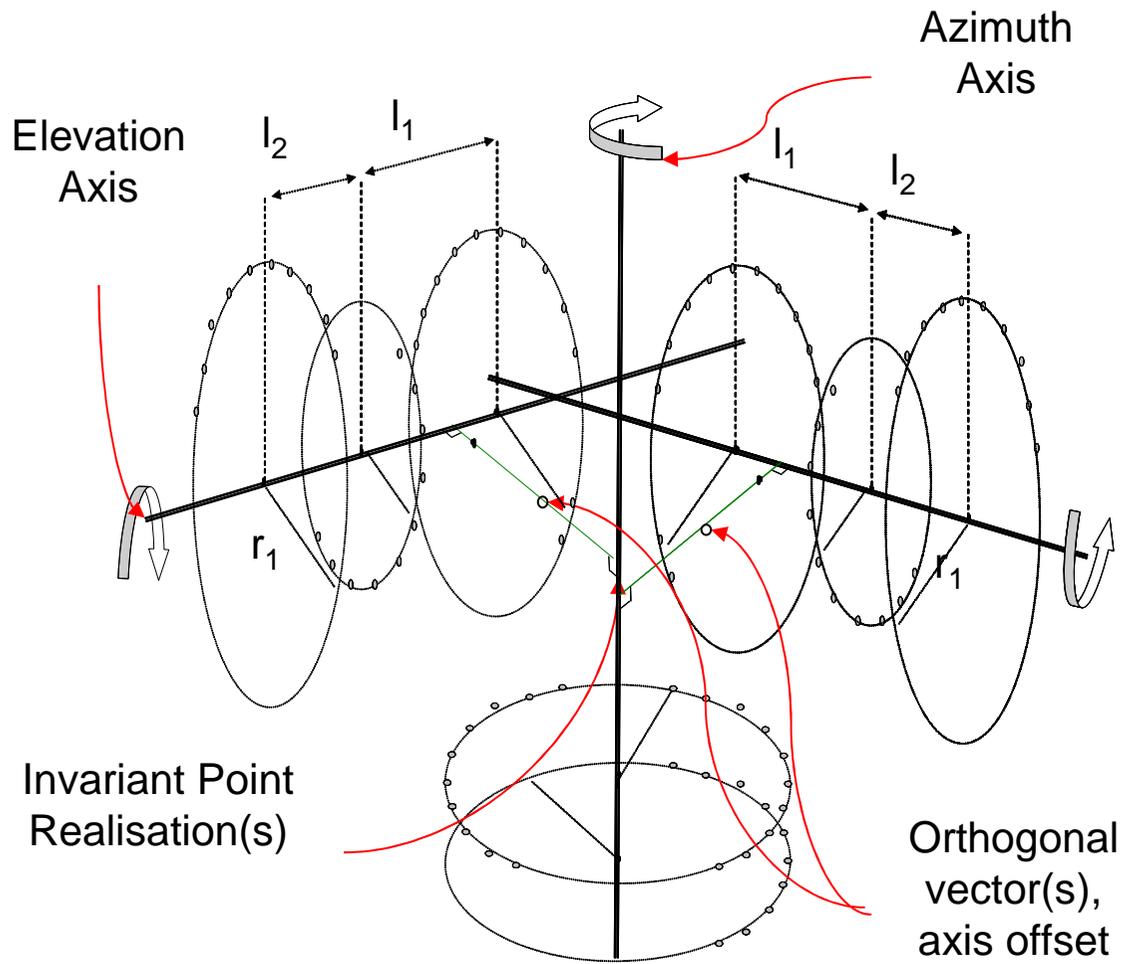


AuScope GNSS CORS Station

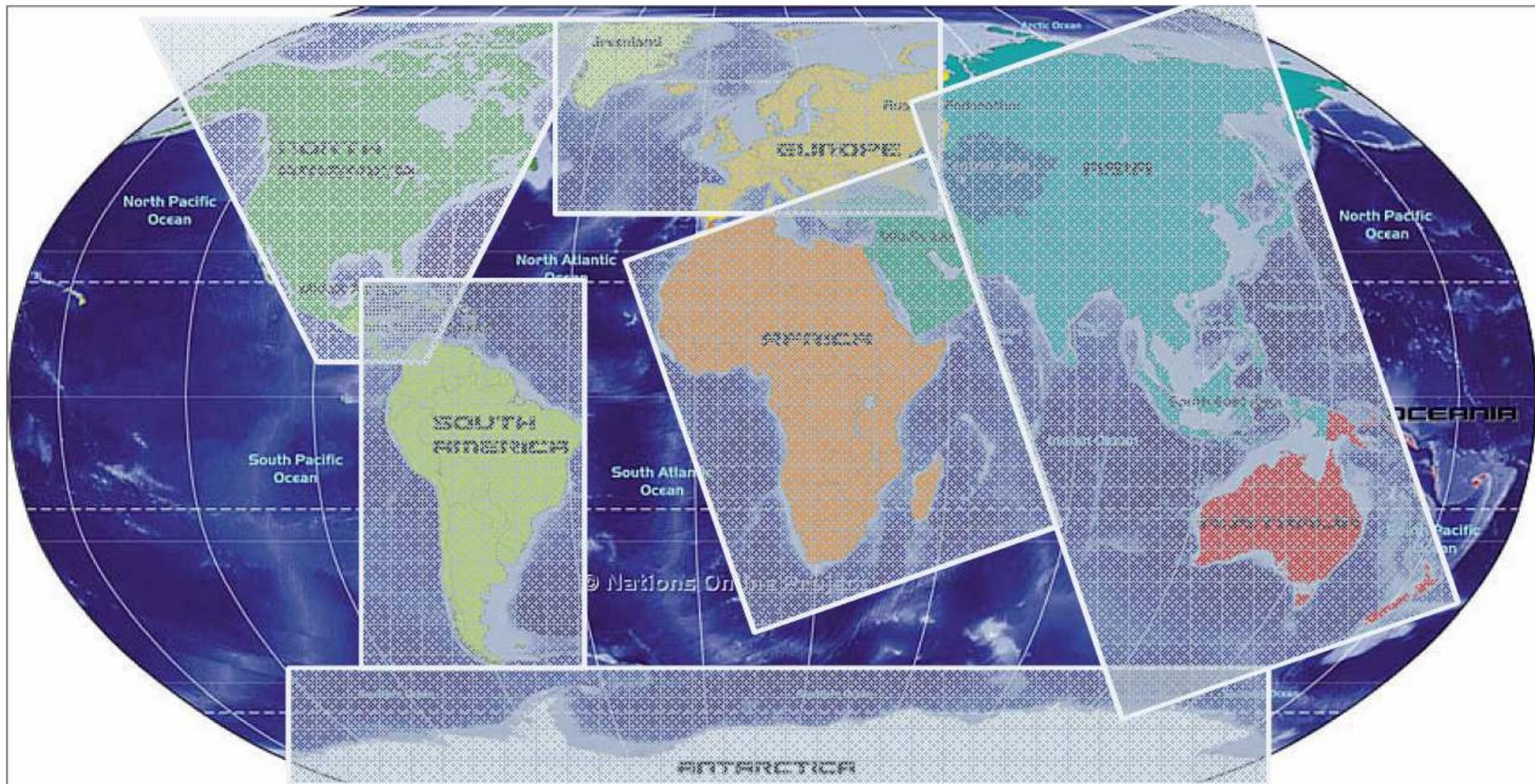




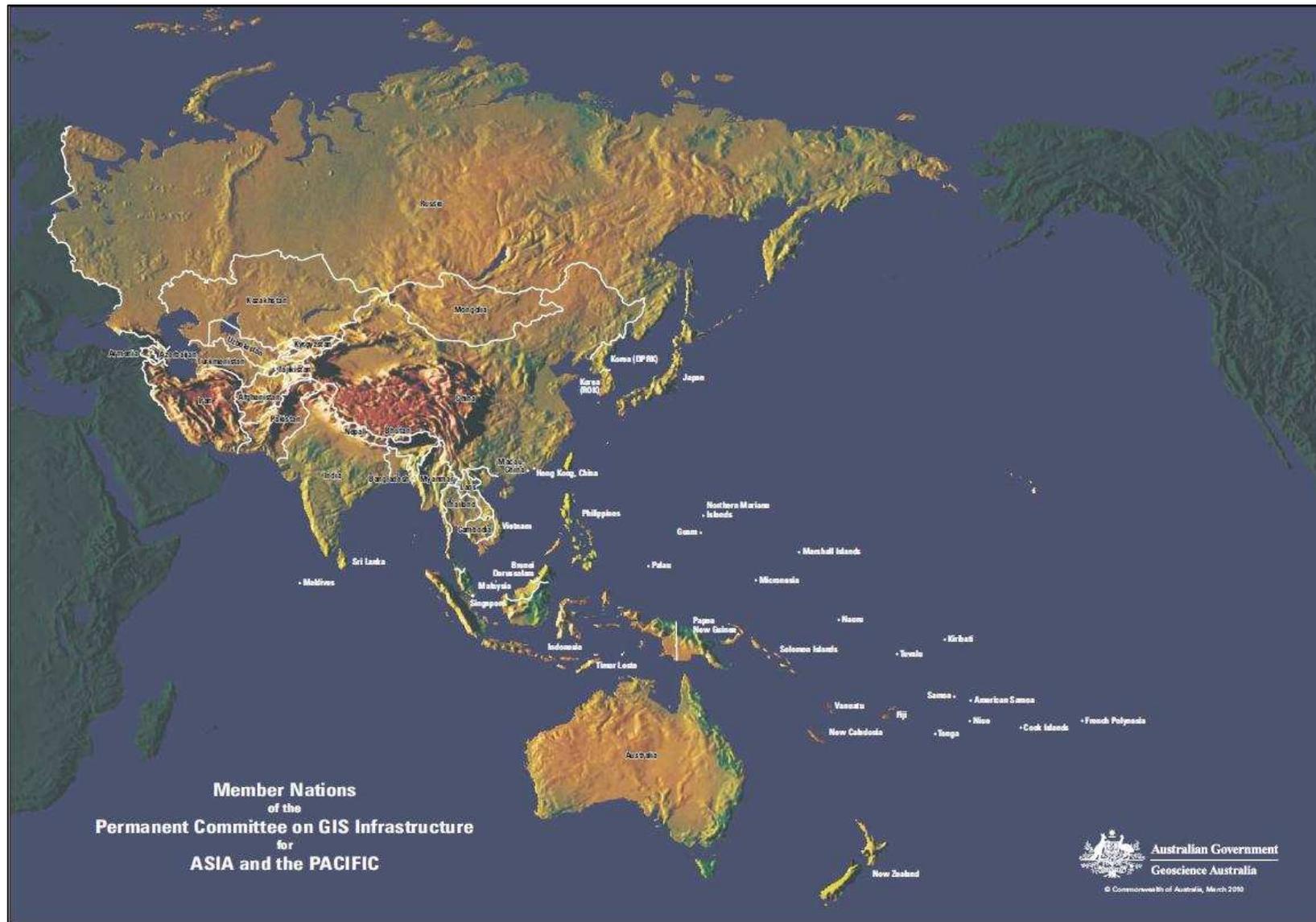
Generic Geometric Model Employed for Tie Surveys



Regional Efforts



Improving access to the ITRF: APREF Participating Nations



Improving Access to the ITRF: Asia Pacific

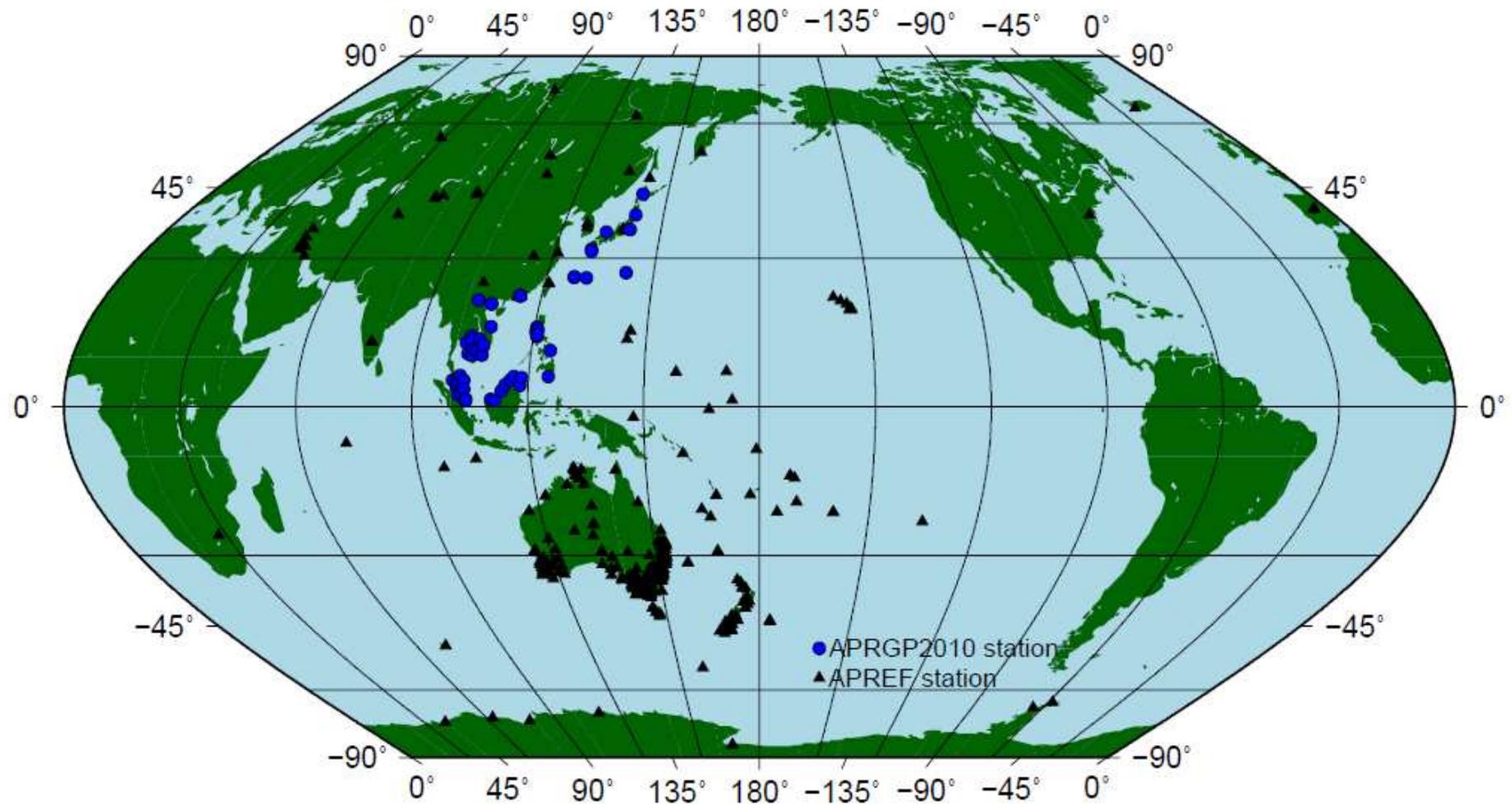
Annual APRGP GNSS Campaigns



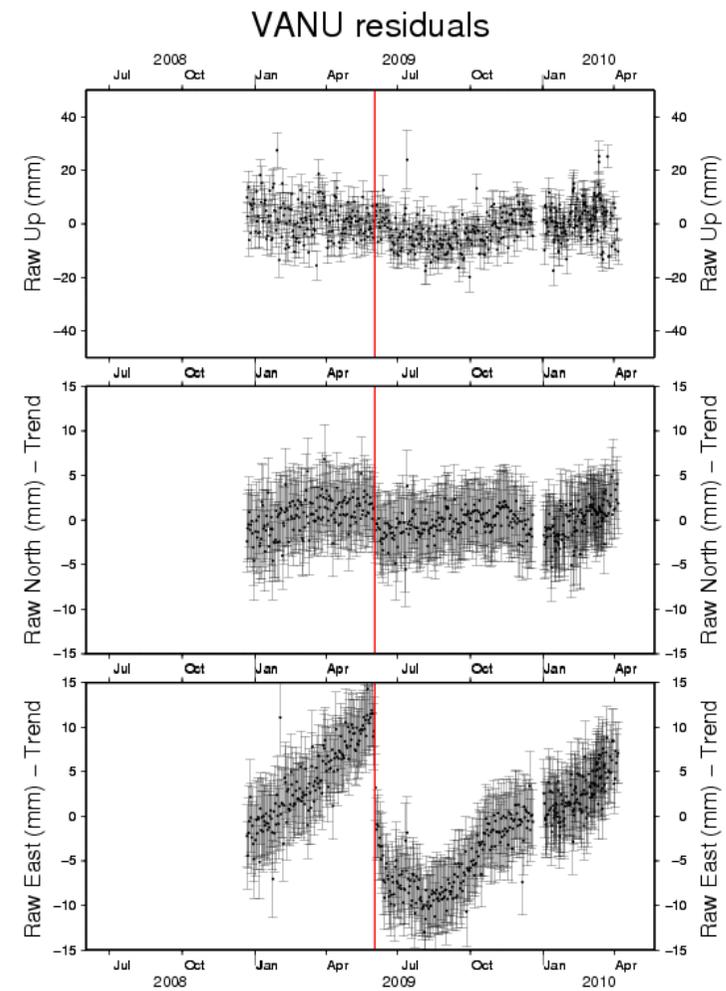
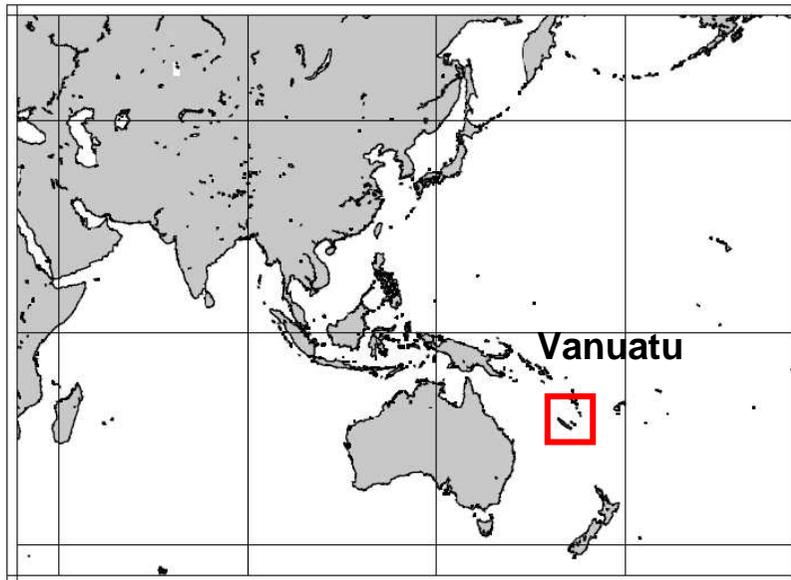
Asia Pacific Reference Frame (APREF)

- 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 PCGIAP and IAG effort supported by FIG, ICG
 - Announced March 2010
 - Continuous, low-latency analysis of CORS networks
 - Provides access to ITRF, coordinate time series, station velocities and network monitoring

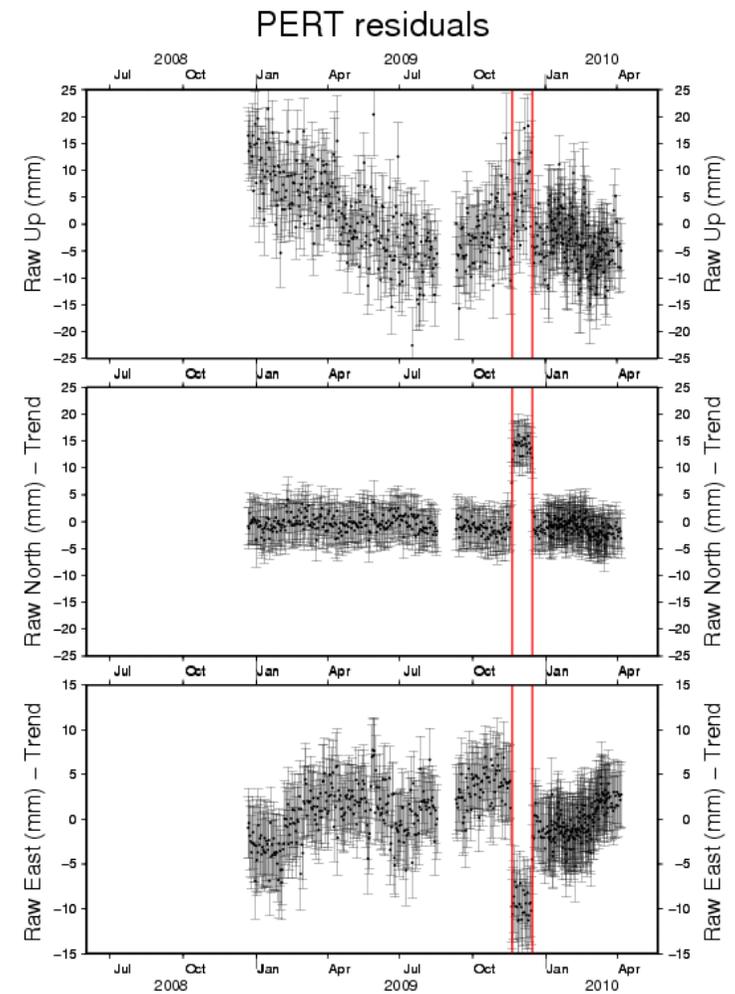
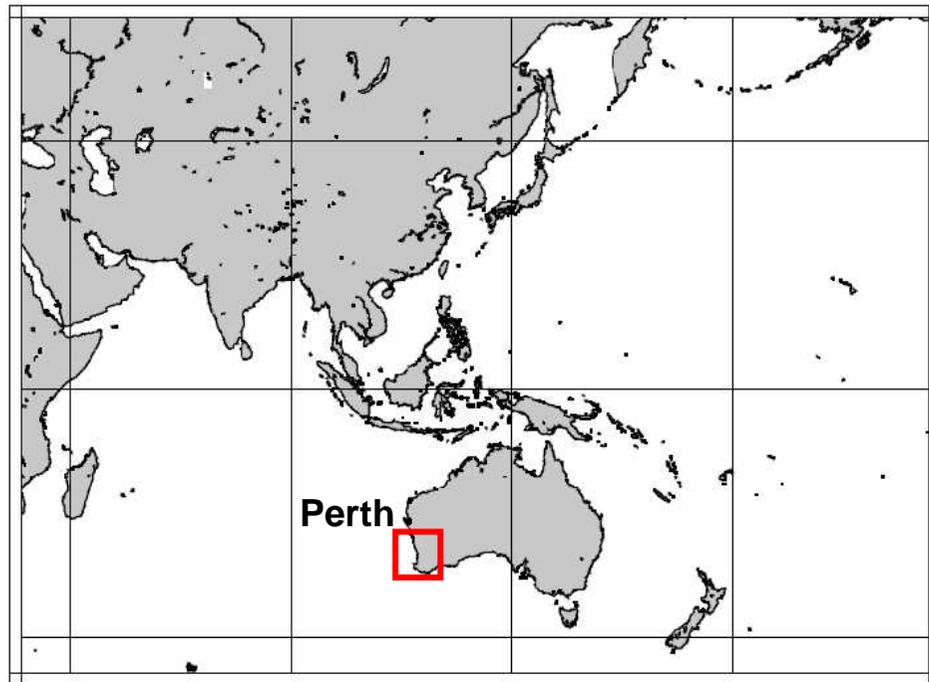
APRGP Stations 2010 GNSS Campaign



Improving ITRF Access: Episodic observations are problematic



Improving ITRF Access: Episodic observations are problematic

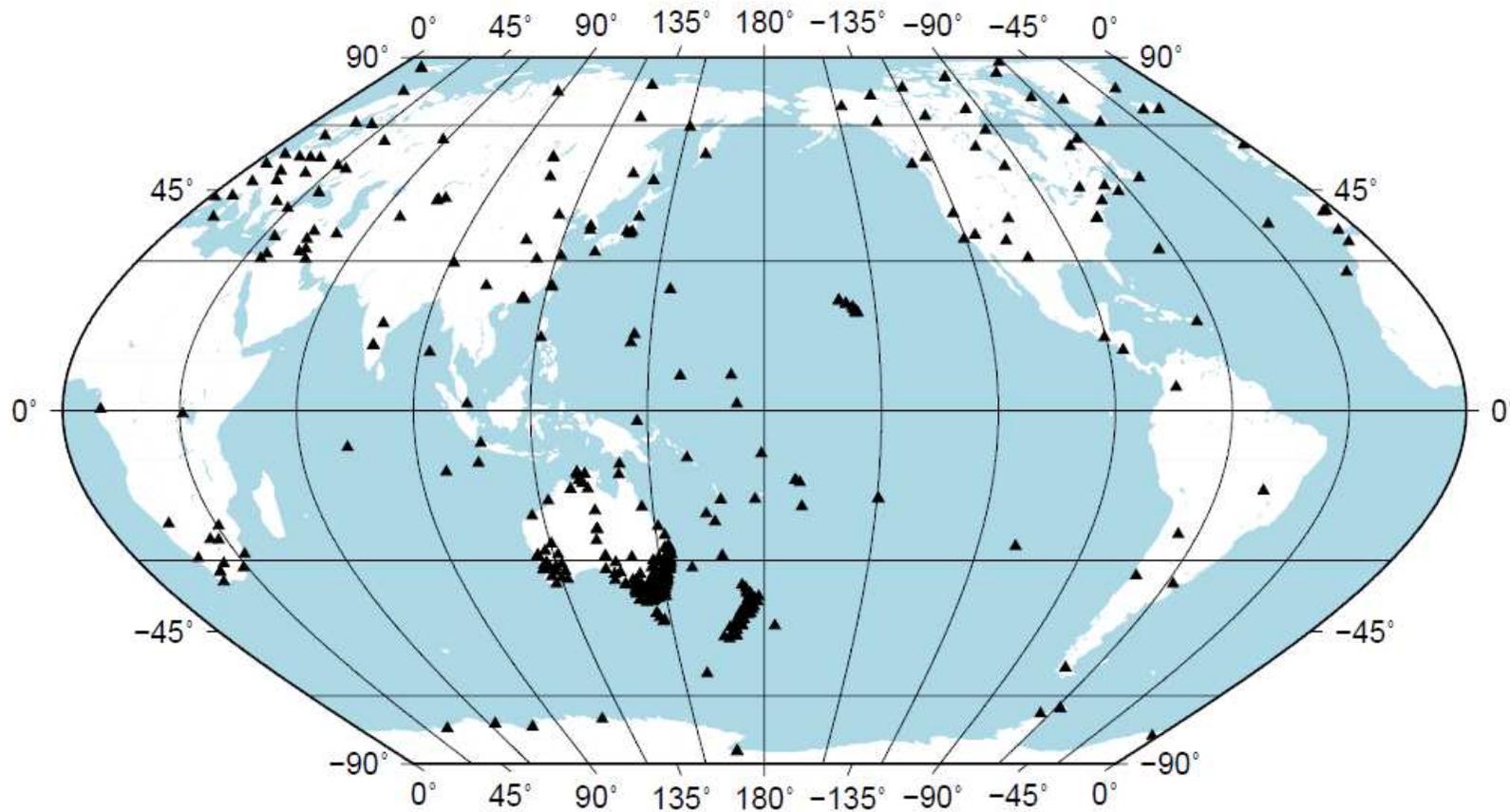


Improving ITRF Access: APREF

- APREF Objectives
 - Provide a cm level or better geodetic infrastructure for Asia-Pacific Region
 - Regional densification of ITRF
 - Create, maintain a dense and accurate reference frame on a continuous basis which is readily accessible to users
 - Several participating agencies from 30+ countries
 - Geoscience Australia functions as the Central Bureau and combination centre for official APREF products
 - Other local analysis centres include Curtin Uni and Department of Sustainability and Environment (VIC)

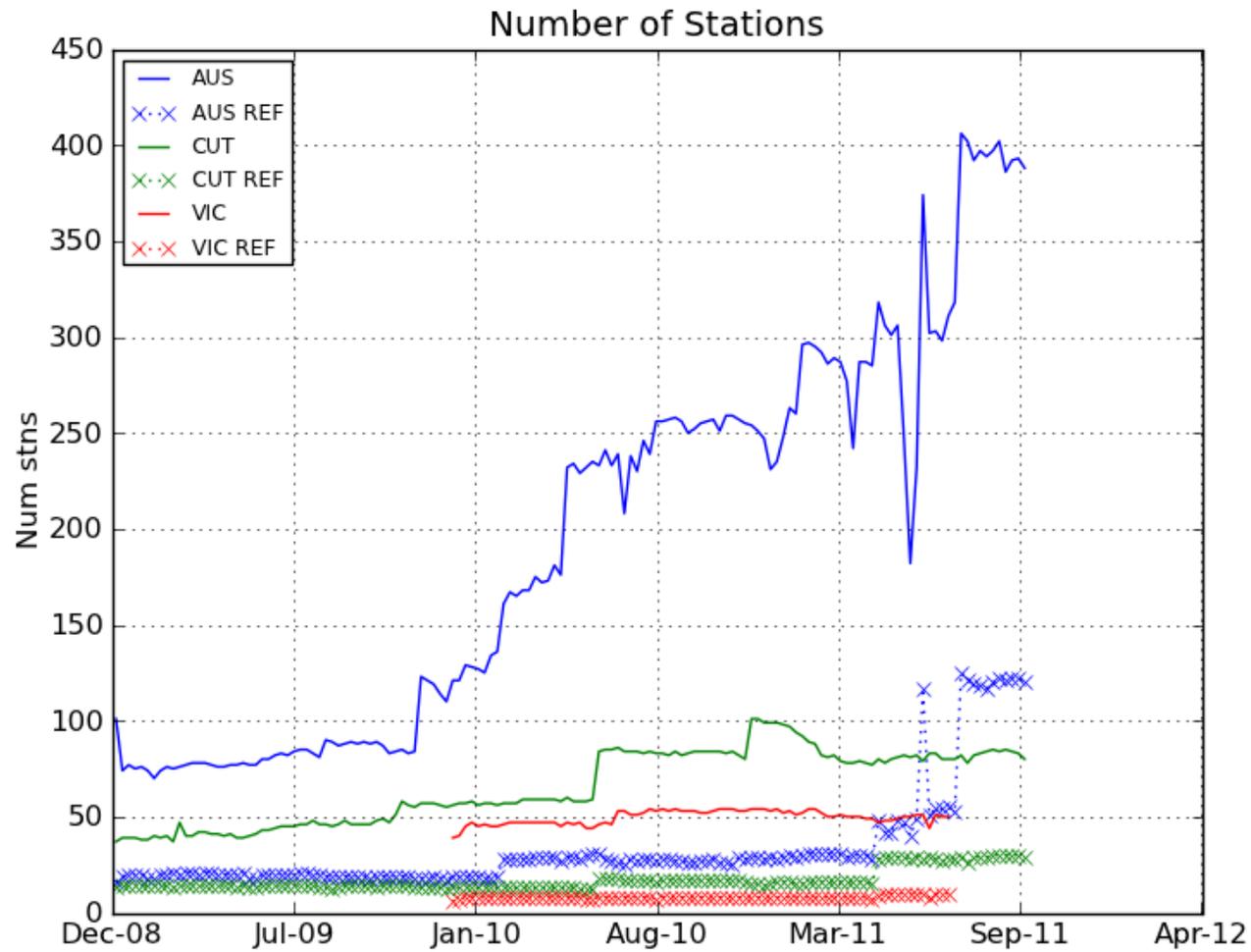
Improving ITRF Access: APREF

- Currently ~400 stations (excluding global stations)



Source: Hu et al, 2011

Improving ITRF Access: APREF Stations



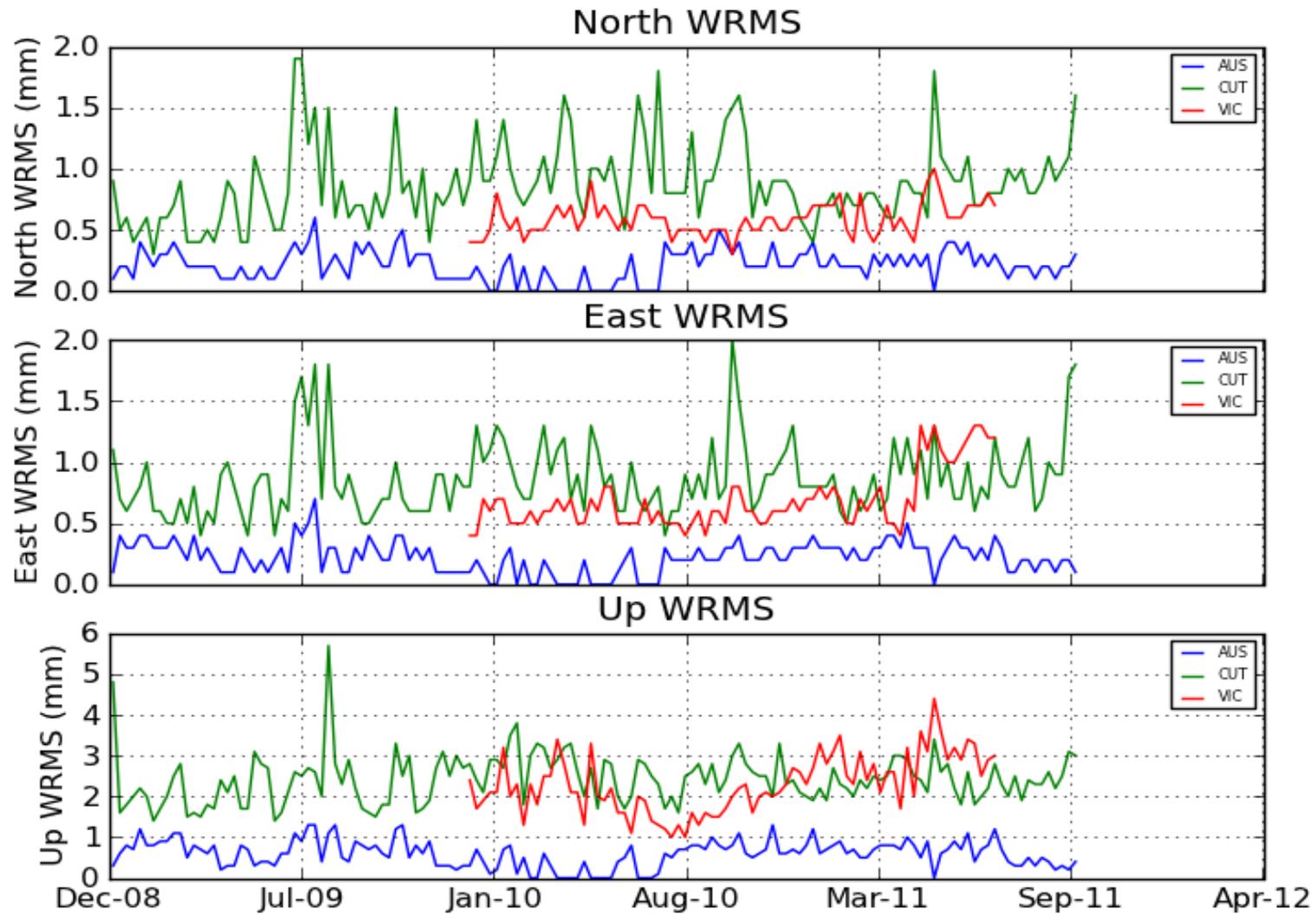
Improving Access to the ITRF: APREF Products

- 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

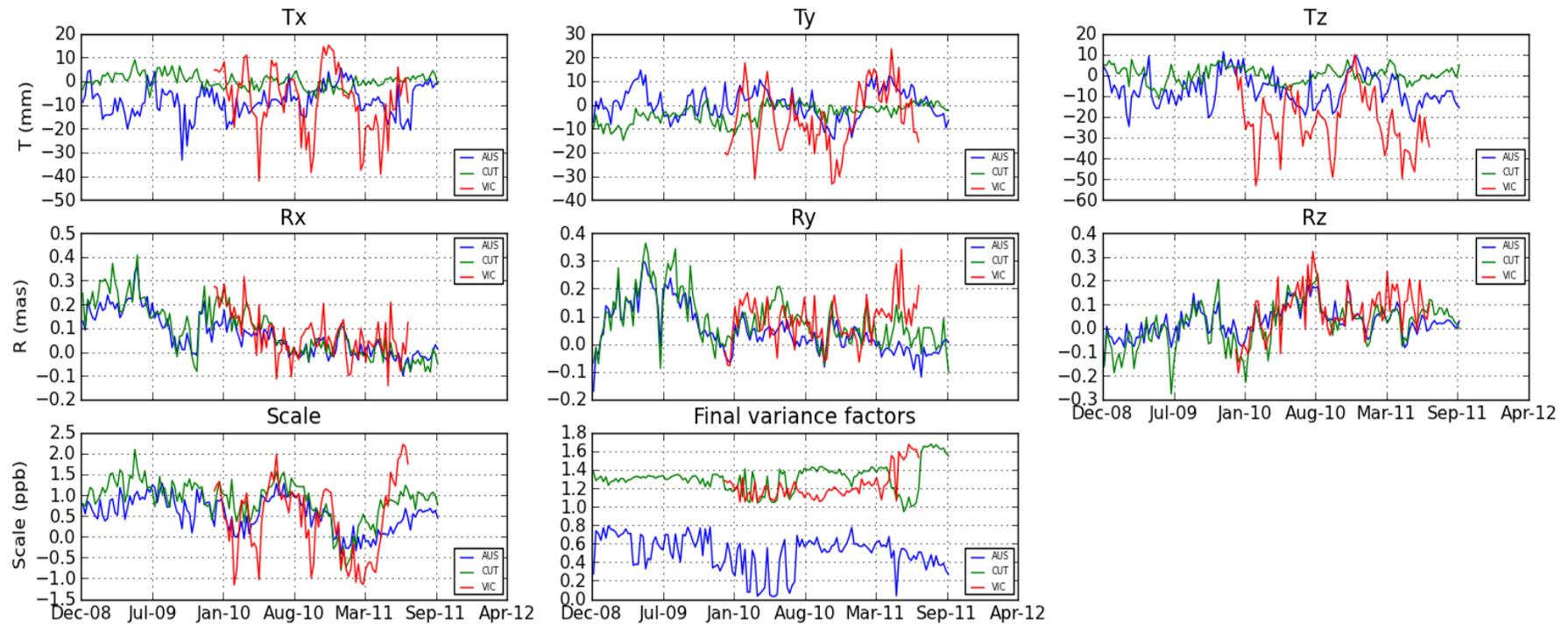
APREF Combination

- Software: CATREF - Combination and Analysis of Terrestrial Reference Frames
- Remove constrains from input SINEX solutions
- Apply minimum constraint to SINEX files
- Combine all MC files, align to IGS08
- Handle outliers
- Iterate until outliers are removed
- Detect and handle reference station outliers
- Ensure solution number consistency with IGS08
- Perform final combination
- Check a posteriori variance factor close to 1.0
- Compare metadata
- Report inconsistencies in summary report
- Post combined SINEX solution and summary report to public ftp at <ftp://ftp.ga.gov.au/geodesy-outgoing/gnss/solutions/apref/>

WRMS of East, North and Up residuals with respect to the IGS08

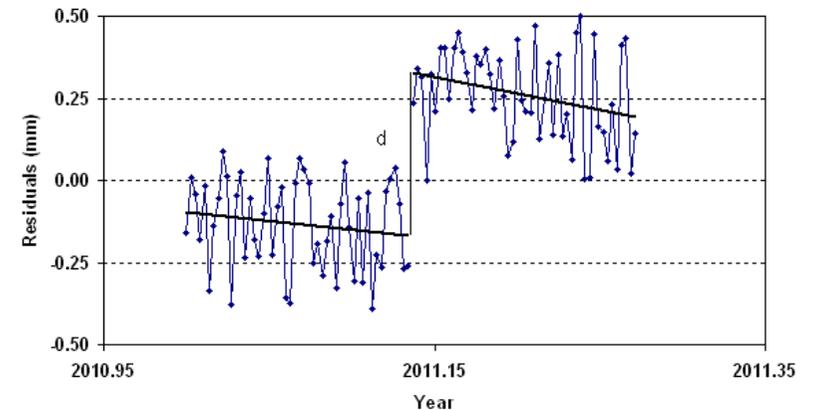


Transformation parameters between the LAC solutions and IGS08



Offset detection in time series

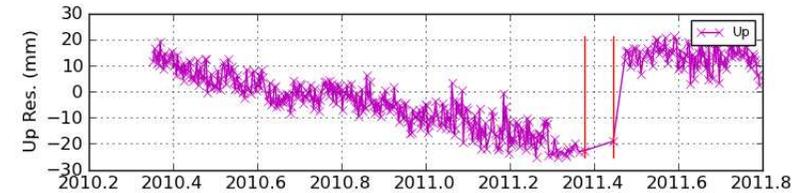
- Dominate station velocity and its uncertainty
- Manual detection laborious for 400+ stations
- Semi-automated detection approach
 - Use offset detection algorithm aided with visual inspection
 - Python package Matplotlib for plotting
- Offsets determined from algorithm are written to a file
- Correlate with equipment changes/ earthquake data from the database
- Update offset file with known events
- Analyst inspects time series to confirm and add offsets to the CATREF discontinuity file



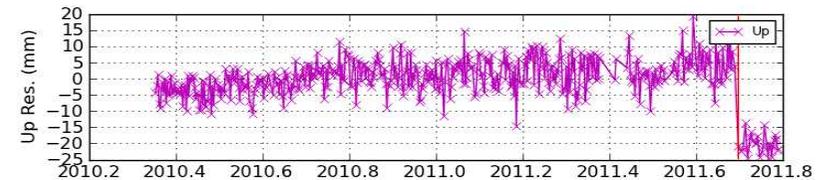
Offset detection in time series

MLAK (VIC) antenna moved by 40m!!

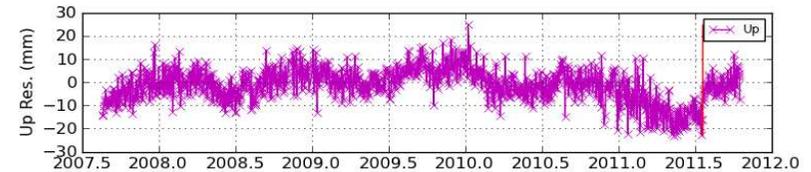
TATU (VIC) 35mm H: Unknown?



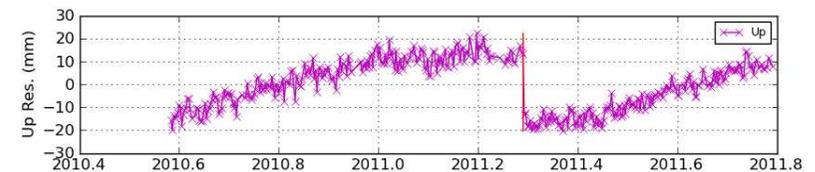
YALL (VIC) 22mm H: Unknown?



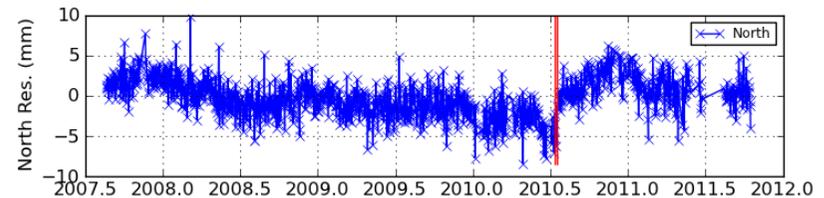
ALIC (ARGN) 10mm H: Antenna change



IHOE (NSW) 29mm H: Incorrect antenna model

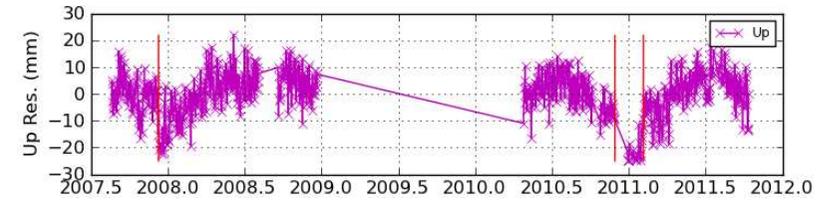


NAUR (SPRGN) 5mm N: Antenna change

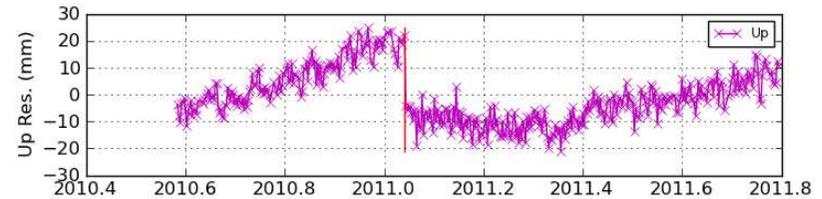


Examples of detected offsets ...

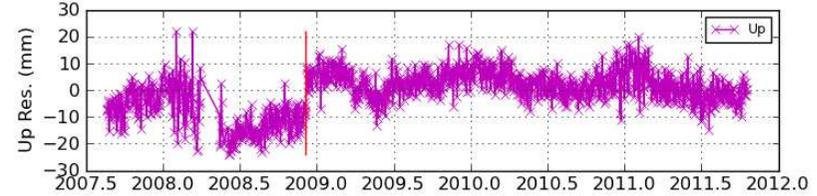
URUM (IGS - China) 20mm H: Unknown?



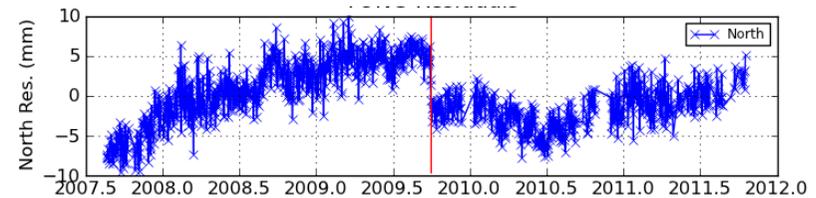
WILU (WA) 26mm H, 4mm N: Unknown?



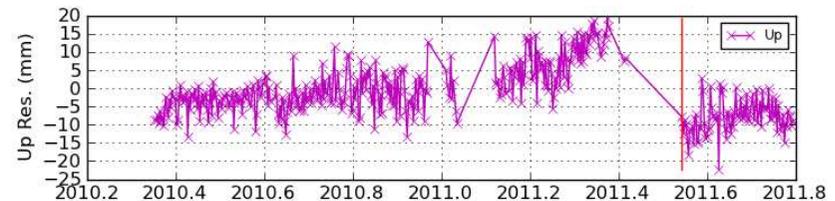
YAR3 (ARGN) 14mm H: Antenna Change



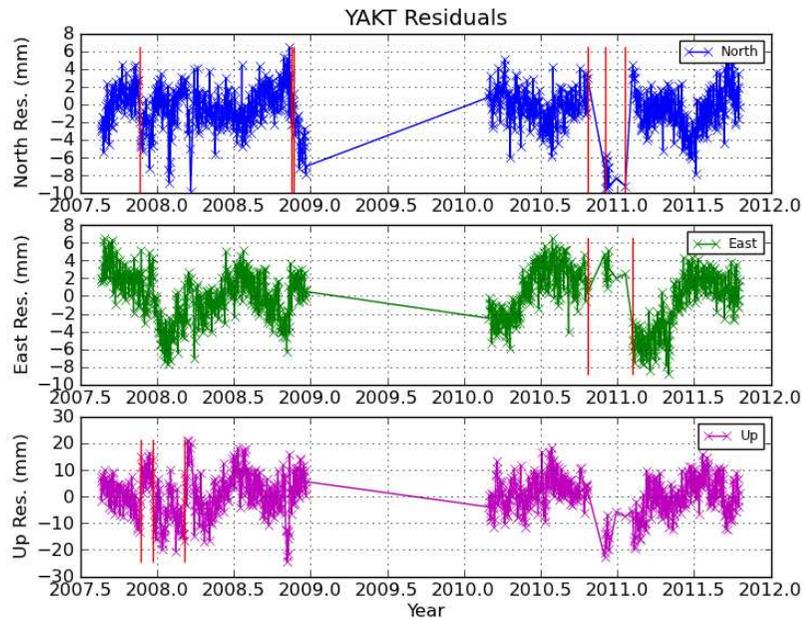
TONG (SPRGN) 6mm N: 29 Sept '09
Earthquake



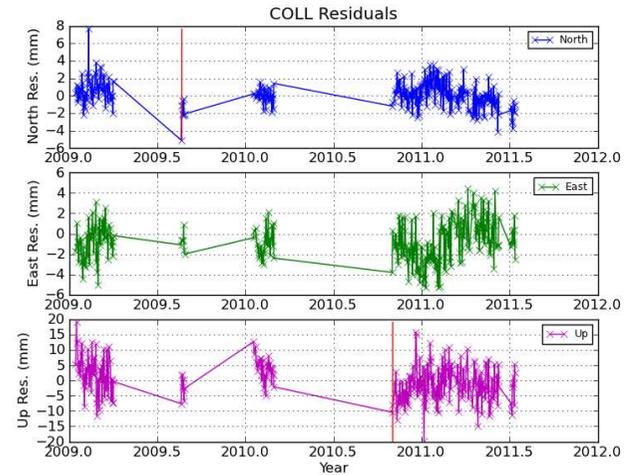
BUXT (VIC) 26mm H: Unknown?



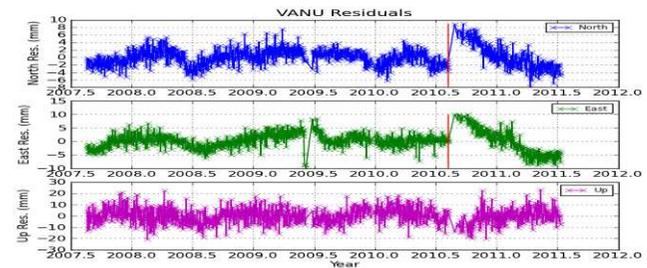
Offset detection in time series



YAKT (IGS - Serbia) – Snow build up effects

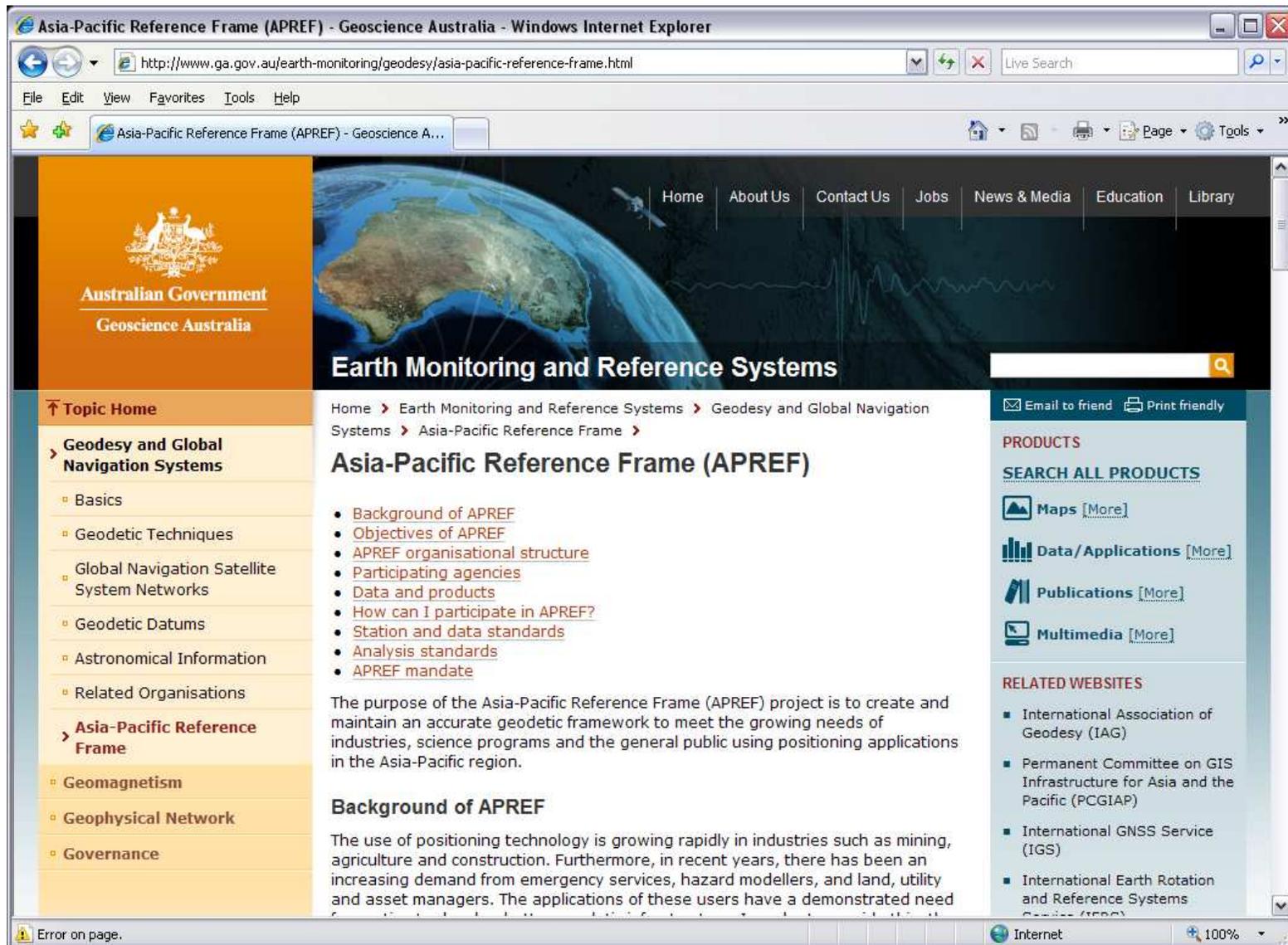


COLL (WA) – Gaps cause false detection



VANU (SPRGN) – Earthquake/ post-seismic signal

APREF website: www.ga.gov.au



The screenshot shows a Windows Internet Explorer browser window displaying the APREF website. The browser's address bar shows the URL <http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html>. The website header features the Australian Government Geoscience Australia logo on the left and a navigation menu with links for Home, About Us, Contact Us, Jobs, News & Media, Education, and Library. The main content area is titled "Earth Monitoring and Reference Systems" and includes a search bar. Below the title, a breadcrumb trail reads: Home > Earth Monitoring and Reference Systems > Geodesy and Global Navigation Systems > Asia-Pacific Reference Frame >. The main heading is "Asia-Pacific Reference Frame (APREF)". A list of links includes: Background of APREF, Objectives of APREF, APREF organisational structure, Participating agencies, Data and products, How can I participate in APREF?, Station and data standards, Analysis standards, and APREF mandate. A paragraph explains the project's purpose: "The purpose of the Asia-Pacific Reference Frame (APREF) project is to create and maintain an accurate geodetic framework to meet the growing needs of industries, science programs and the general public using positioning applications in the Asia-Pacific region." Below this is a section titled "Background of APREF" which states: "The use of positioning technology is growing rapidly in industries such as mining, agriculture and construction. Furthermore, in recent years, there has been an increasing demand from emergency services, hazard modellers, and land, utility and asset managers. The applications of these users have a demonstrated need for a common reference frame that is accurate, stable and consistent." The right sidebar contains sections for "PRODUCTS" with a search bar and links for Maps, Data/Applications, Publications, and Multimedia; and "RELATED WEBSITES" listing the International Association of Geodesy (IAG), Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), International GNSS Service (IGS), and International Earth Rotation and Reference Systems Service (IERS). The browser's status bar at the bottom shows "Error on page." and "Internet" with a 100% zoom level.

APREF Products: Weekly summary and SINEX files

FTP directory /geodesy-outgoing/apref/solutions/apref at ftp.ga.gov.au - Windows Internet Explorer

ftp://ftp.ga.gov.au/geodesy-outgoing/apref/solutions/apref macau gnss network mn

File Edit View Favorites Tools Help

Citrix Access Platform FTP directory /geodesy-o...

FTP directory /geodesy-outgoing/apref/solutions/apref at ftp.ga.gov.au

To view this FTP site in Windows Explorer, click **Page**, and then click **Open FTP Site in Windows Explorer**.

[Up to higher level directory](#)

05/03/2011	01:52AM	1,350,888	apr15127.snrx
05/03/2011	01:52AM	14,917	apr15127.sum
05/03/2011	01:12AM	735,462	apr15137.snrx
05/03/2011	01:12AM	13,492	apr15137.sum
05/03/2011	01:12AM	773,259	apr15147.snrx
05/03/2011	01:12AM	13,708	apr15147.sum
05/03/2011	01:12AM	735,462	apr15157.snrx
05/03/2011	01:12AM	13,594	apr15157.sum
05/03/2011	01:12AM	754,242	apr15167.snrx
05/03/2011	01:12AM	13,594	apr15167.sum
05/03/2011	01:12AM	735,462	apr15177.snrx
05/03/2011	01:12AM	13,435	apr15177.sum
05/03/2011	01:12AM	698,613	apr15187.snrx
05/03/2011	01:12AM	13,321	apr15187.sum
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ftp://ftp.ga.gov.au/geodesy-outgoing/apref/solutions/apref/apr15207.snrx Internet 100%

APREF Products

Station coordinate time-series

Weekly station coordinates

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

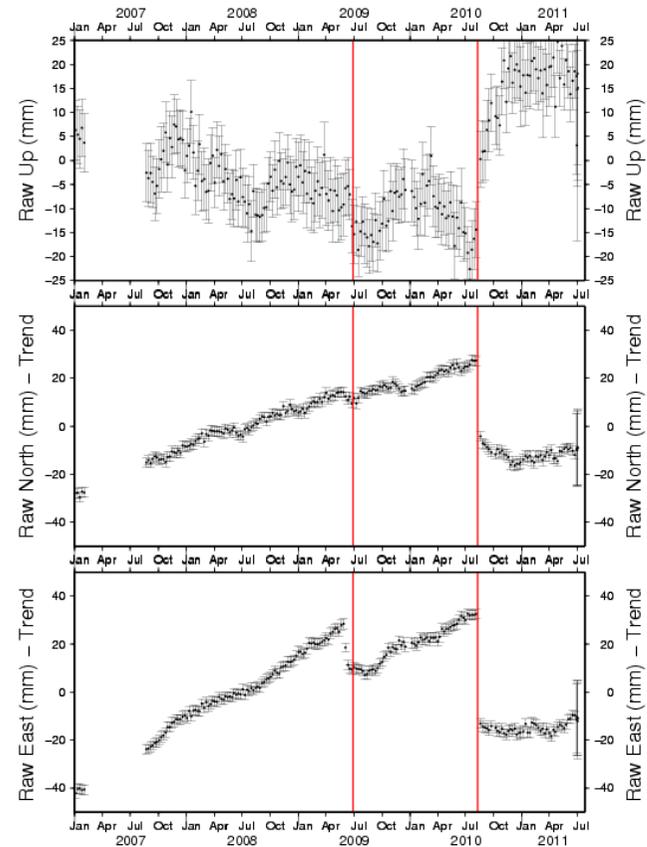
00NA	59975M001	-4073662.2922	4712064.7447	-1367874.4683
01NA	59974M001	-4084823.4609	4702026.6604	-1369125.8453
02NA	59973M001	-4078496.4549	4711380.1330	-1355915.1332
20NA	59972M001	-4050985.3396	4212133.7934	-2547954.8094
21NA	AUM000184	-4048578.9364	4210151.5056	-2554917.6069
ADEL	AUM000008	-3926936.9094	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

VANU residuals



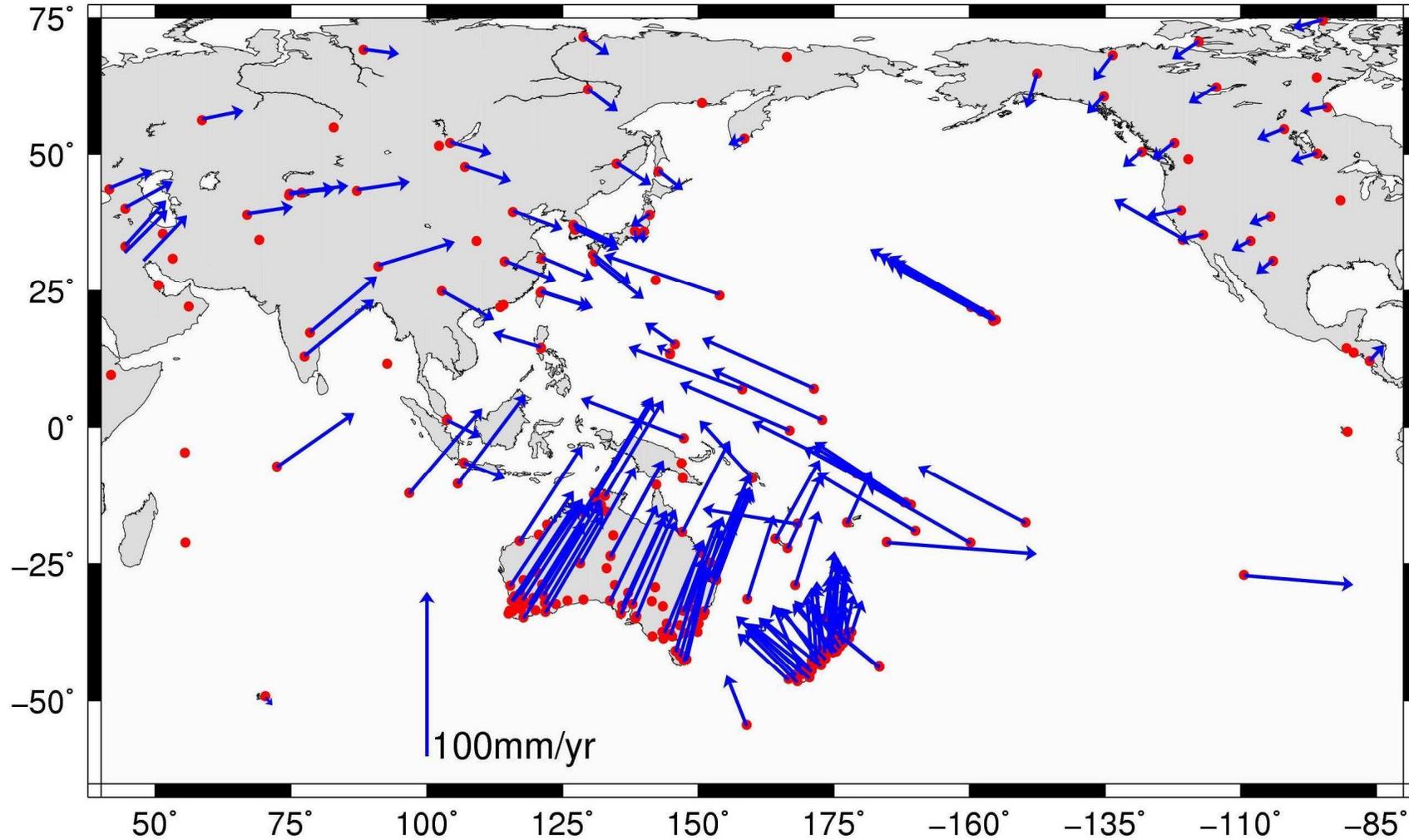
APREF Cumulative Multi-Year Combination Procedure

- Stack APREF final weekly solutions
- Constrain sites with equal velocities
 - APREF discontinuities maintained by GA
 - IGS discontinuities maintained by IGN
 - Merge the GA and IGN discontinuity file
- Run combination
- Handle outliers
- Rescale VF and repeat combination 3 times
- Extract time series for each station
- Stations with a time series >2.5 years are extracted to provide an APREF position and velocity field

Asia Pacific Reference Frame (APREF)



APREF Velocities



IAG/FIG Commission 5/ICG Technical Seminar

Reference Frame in Practice

Rome, Italy 4–5 May 2012



- Thank you!
- Questions?

- Further Information: John.Dawson@ga.gov.au
- APREF web site: <http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html>

Sponsors:



esri



Trimble

