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

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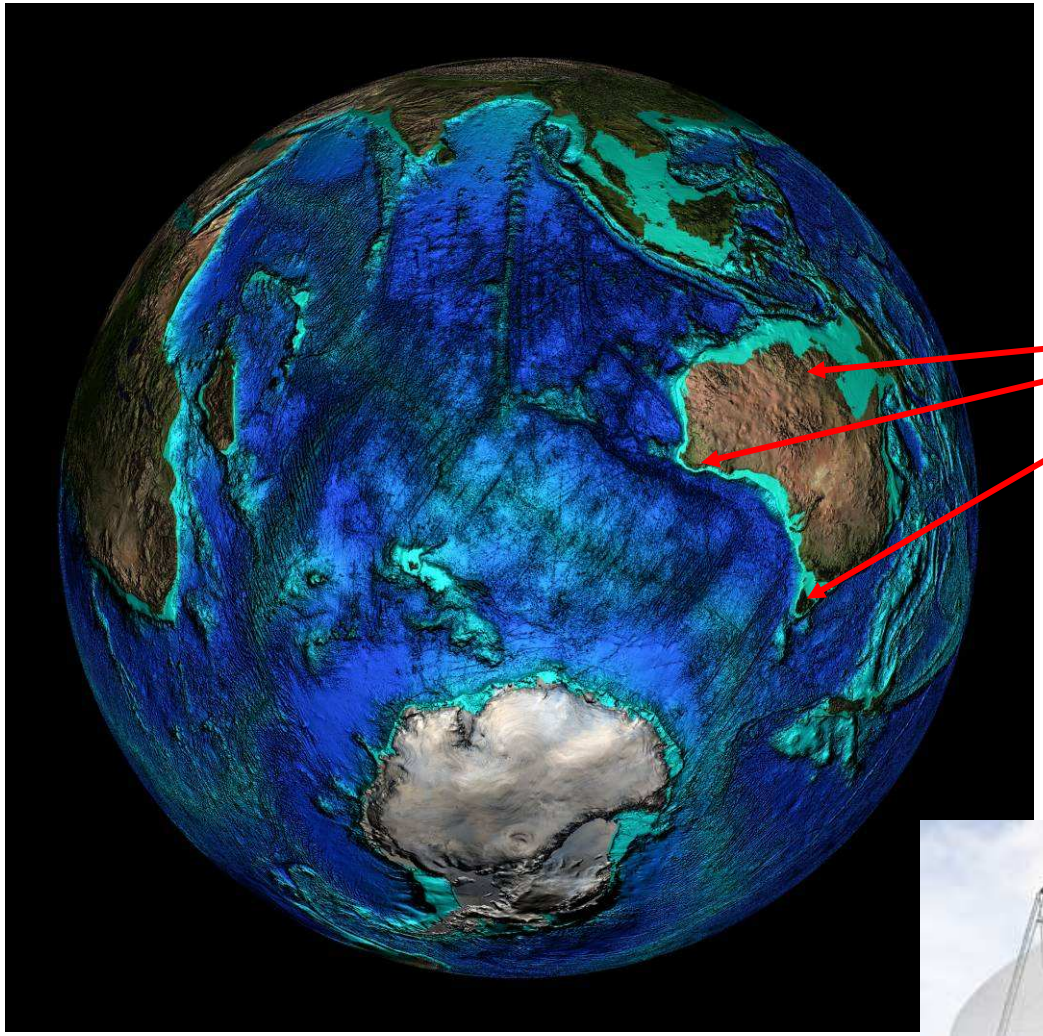
Geoscience Australia

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



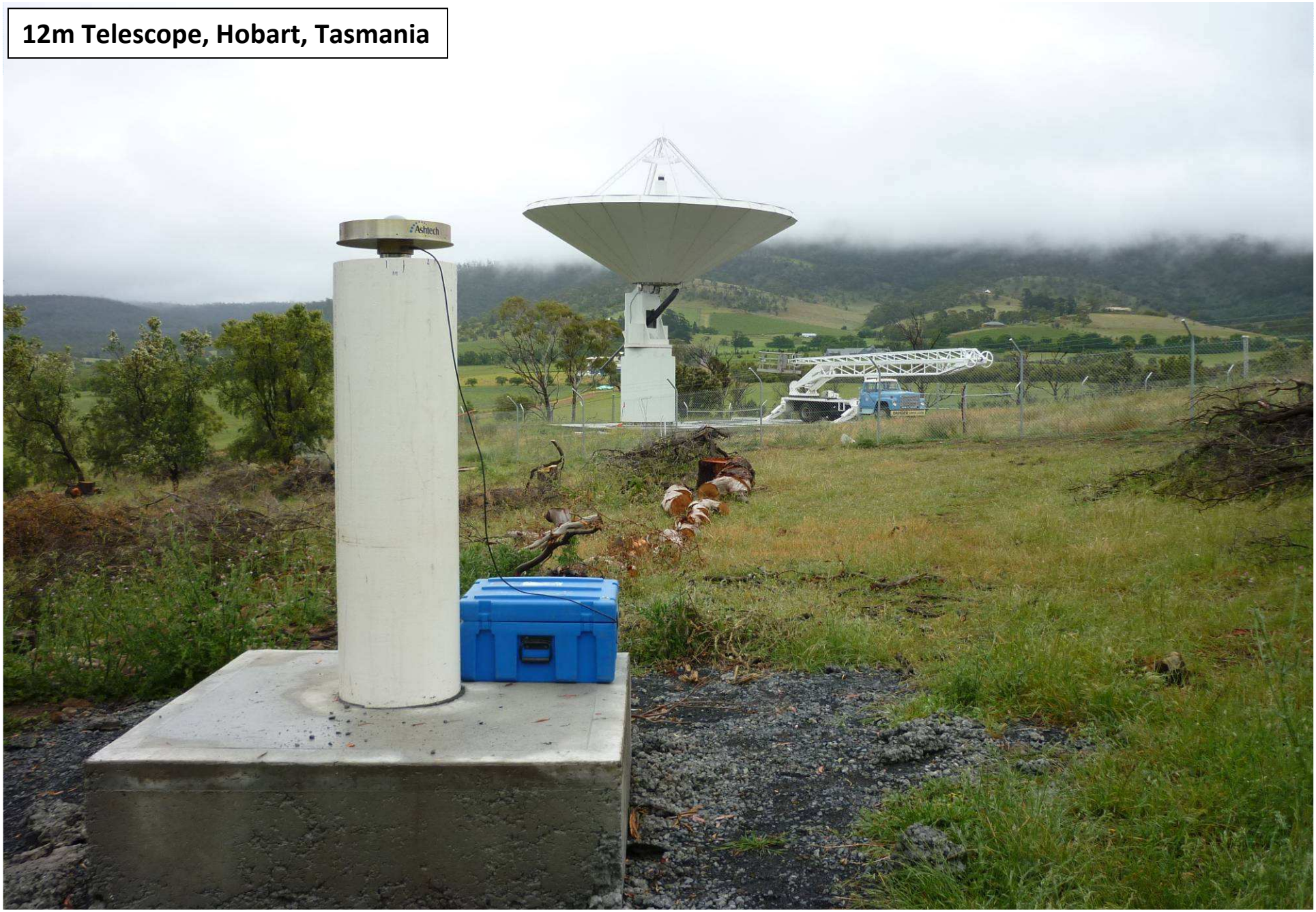
National VLBI network

Australia's Contributions to the ITRF

12m Telescope, Yarragadee, Western Australia

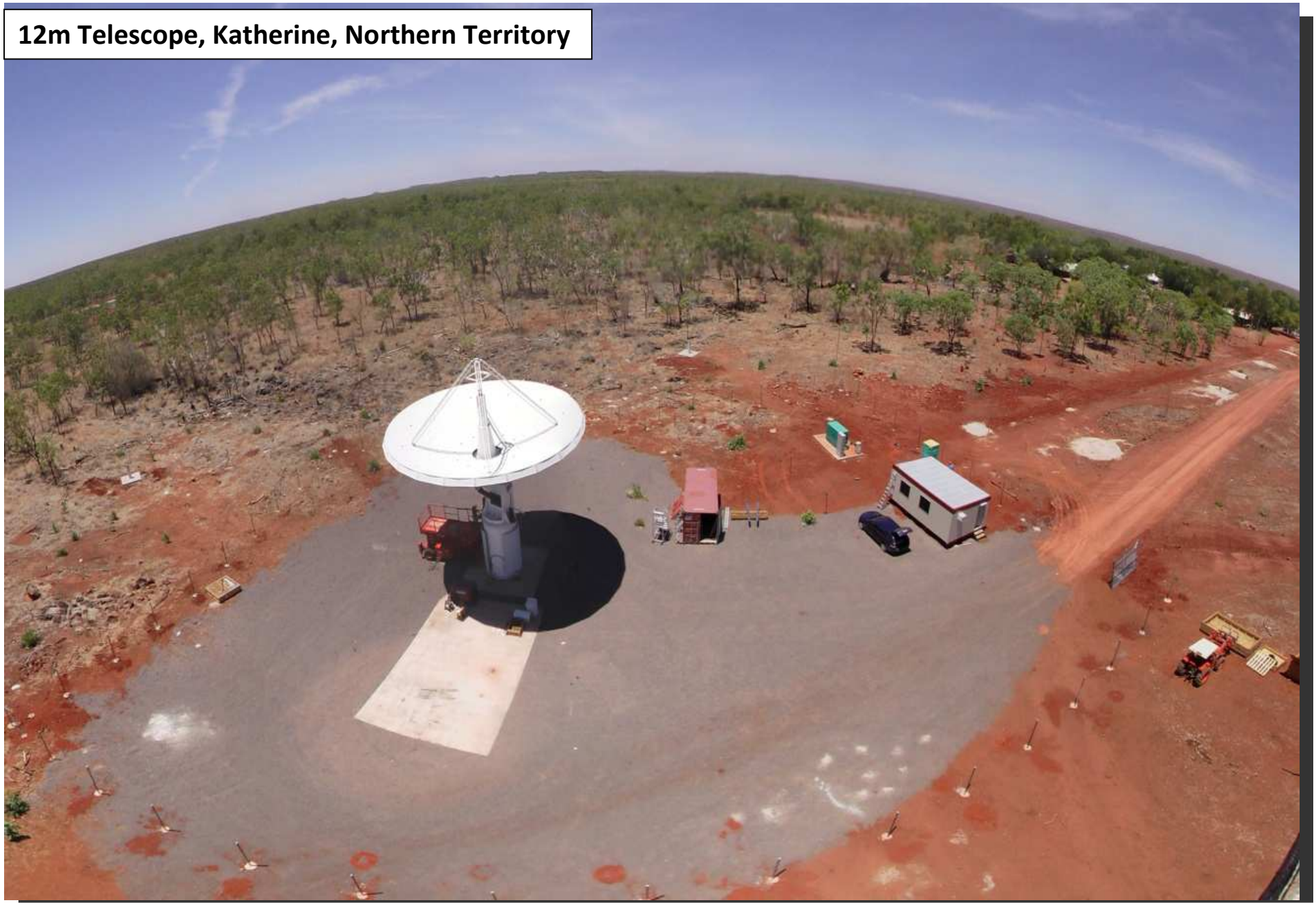
Australia's Contributions to the ITRF

12m Telescope, Hobart, Tasmania



Australia's Contributions to the ITRF

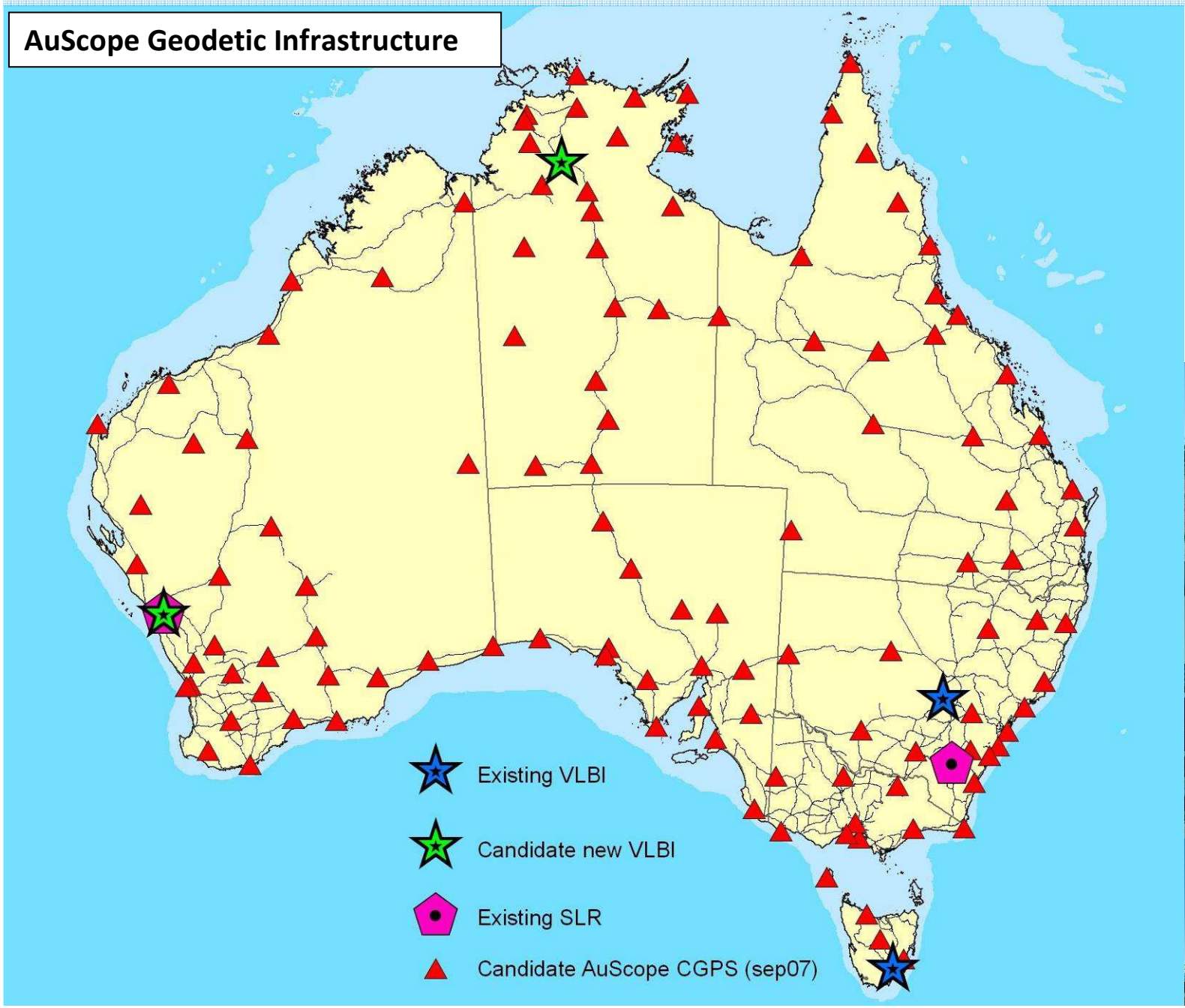
12m Telescope, Katherine, Northern Territory

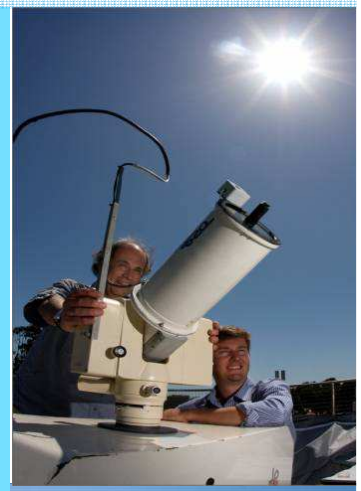


Mount Stromlo Satellite Laser Ranging (SLR) Station

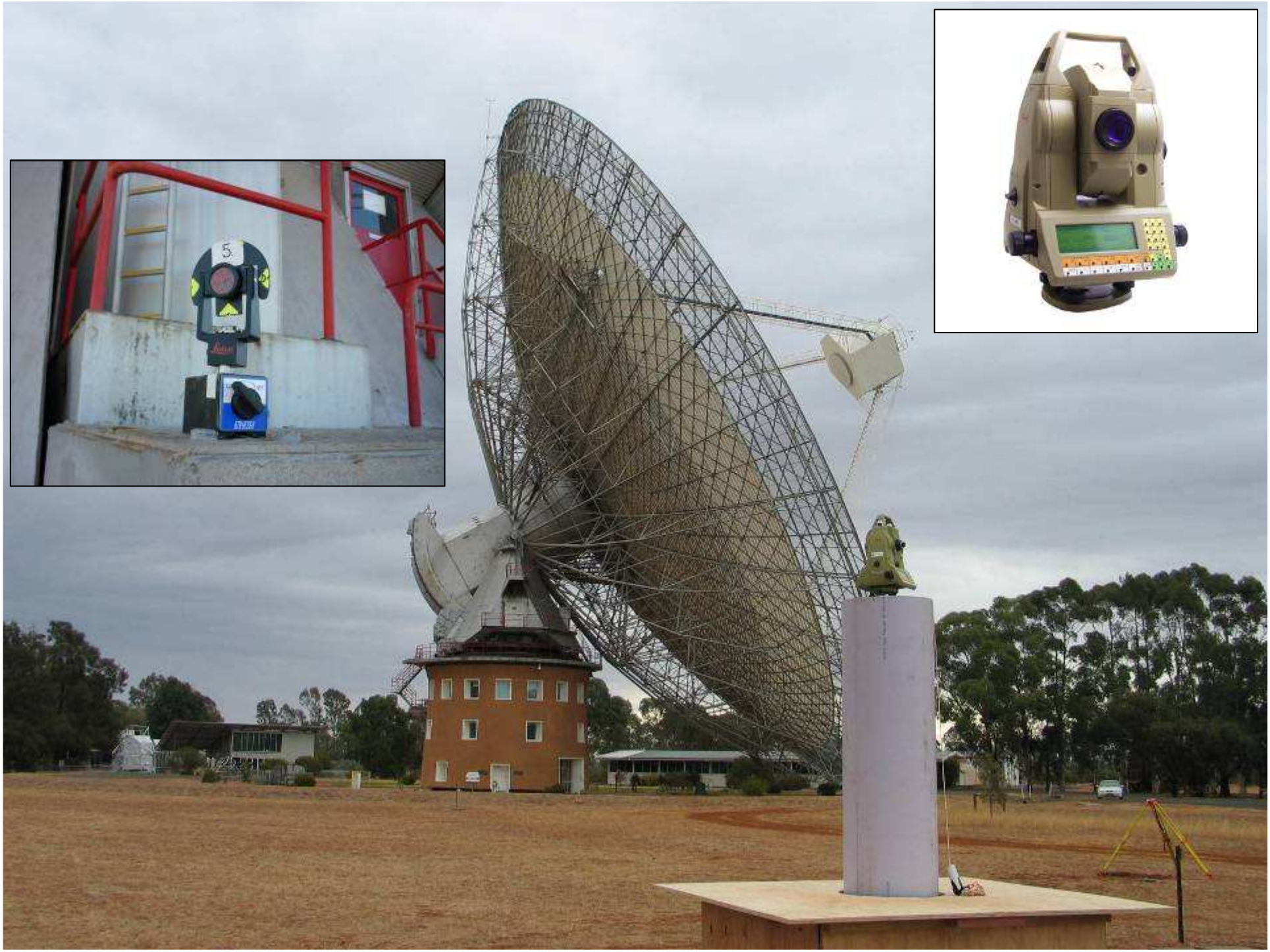
Australia's Contributions to the ITRF

AuScope Geodetic Infrastructure






AuScope GNSS CORS Station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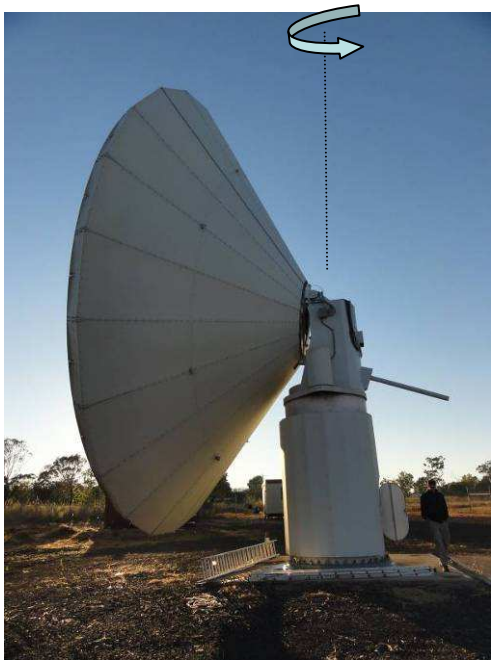
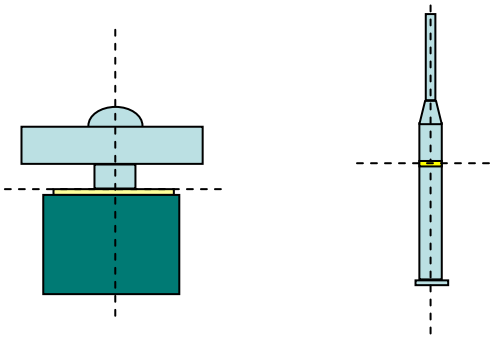
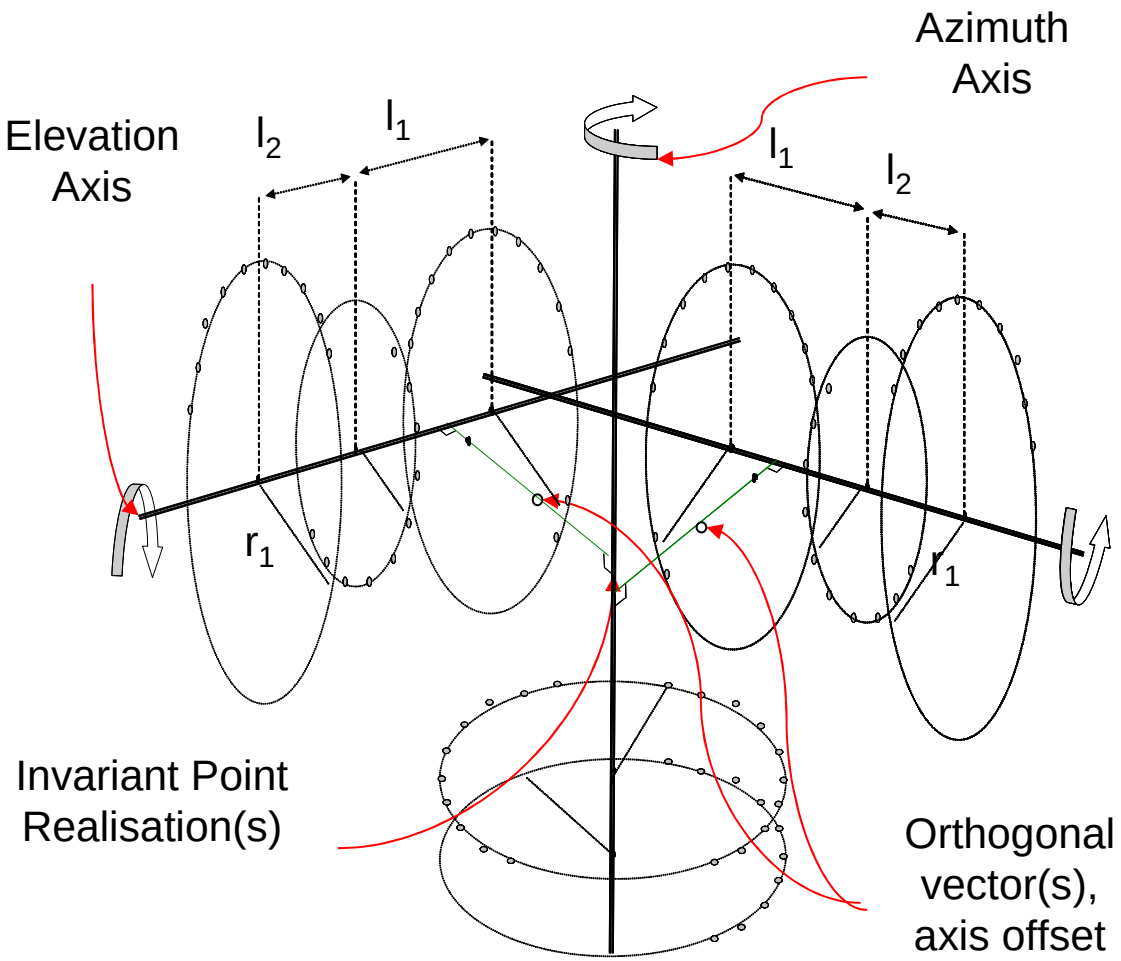
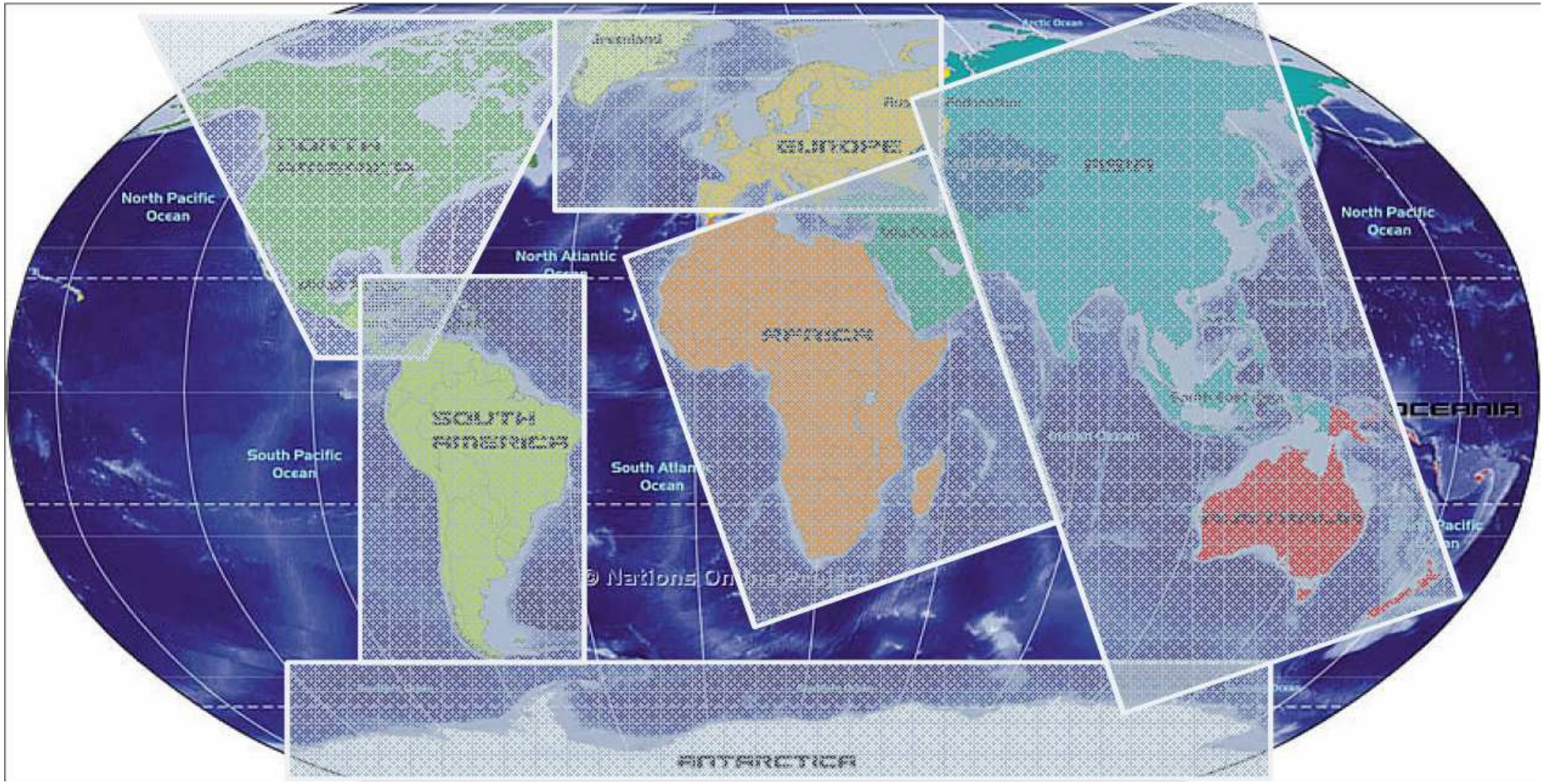
Generic Geometric Model Employed for Tie Surveys



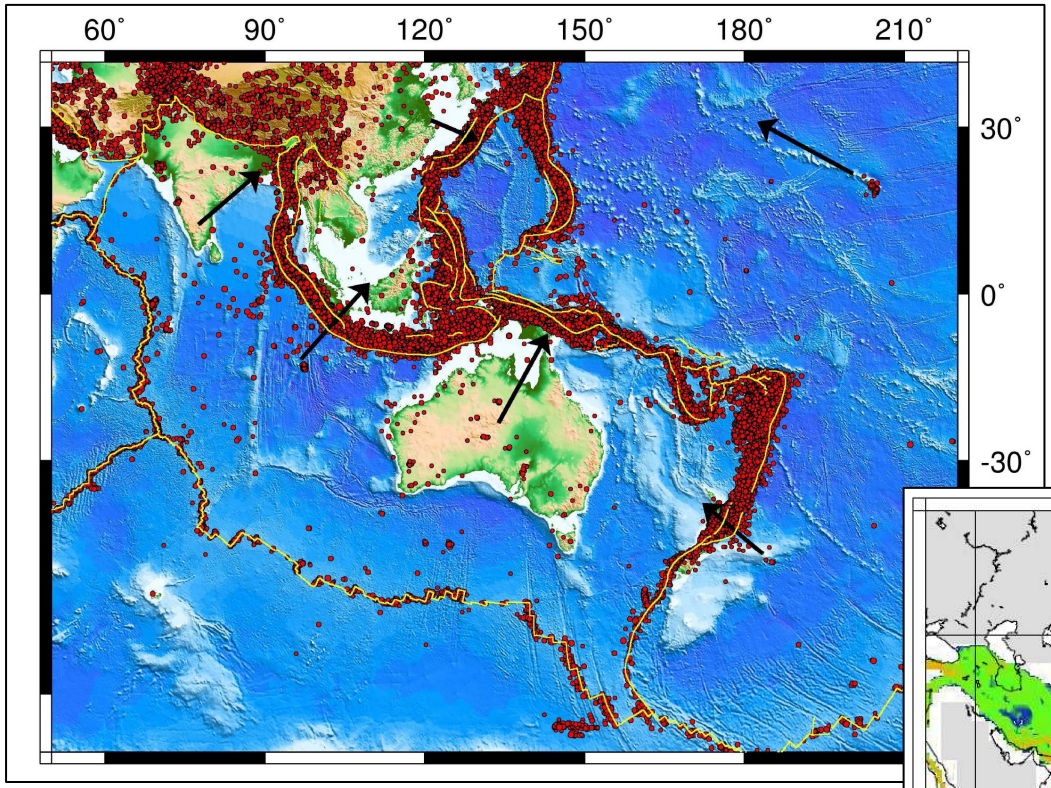


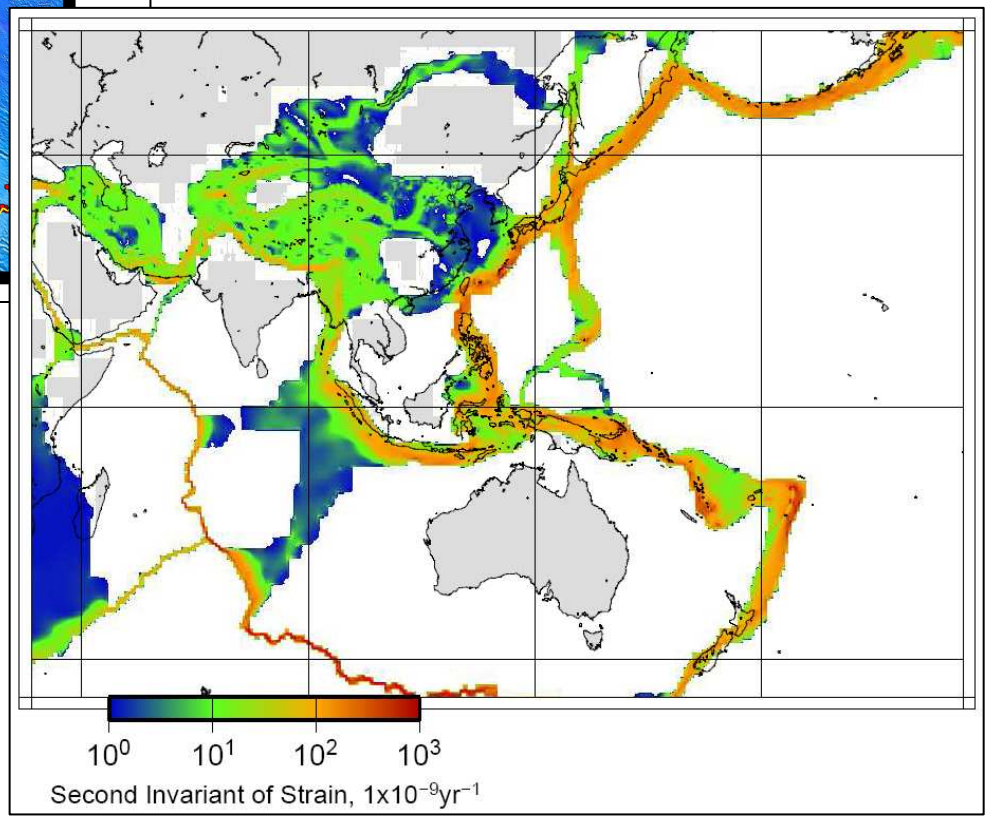


Regional Efforts

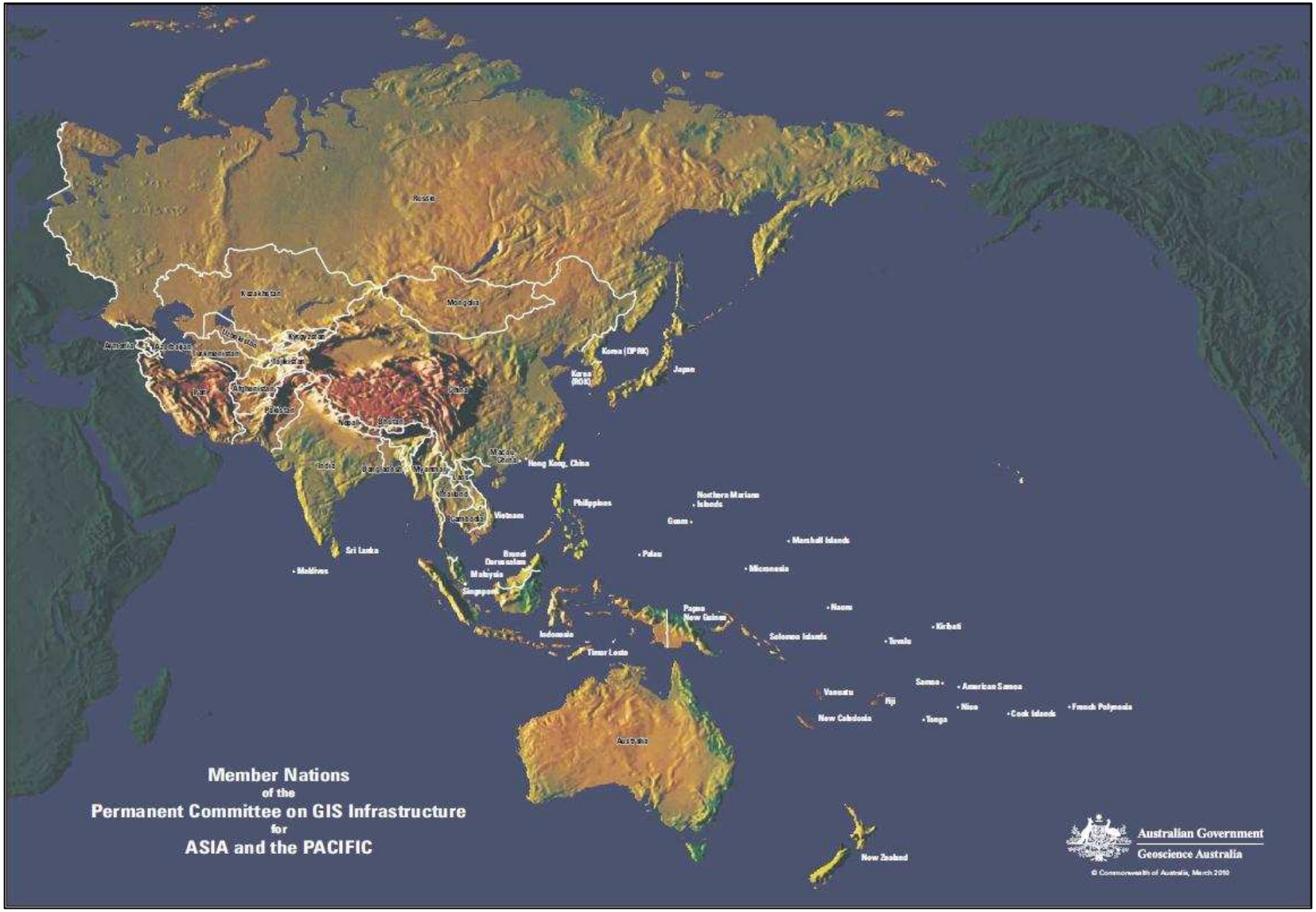


Crustal Strain and Earthquakes: Asia Pacific





Improving access to the ITRF: APREF Participating Nations



Improving Access to the ITRF: Asia Pacific

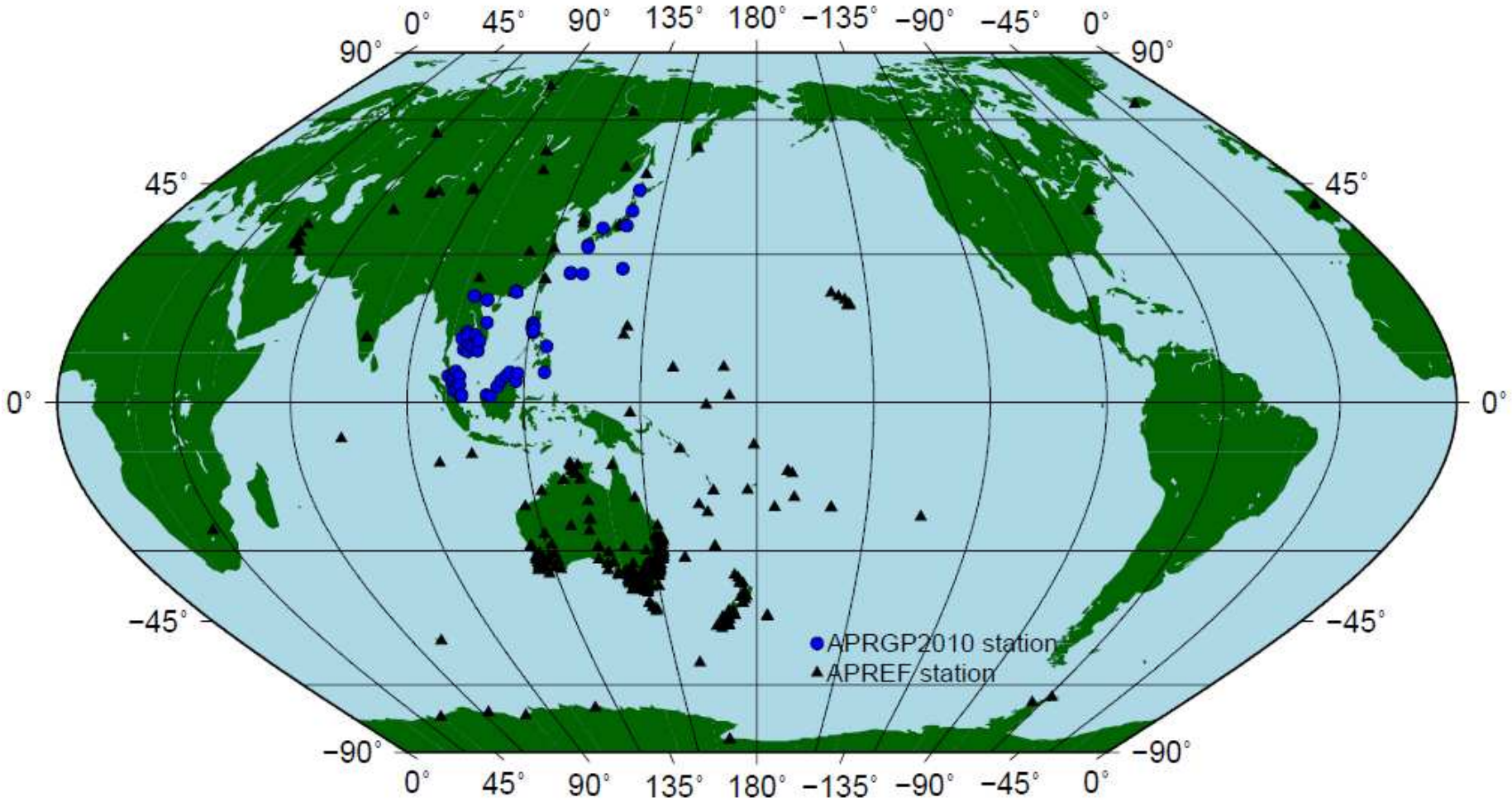
Annual APRGP GNSS Campaigns

Asia Pacific Reference Frame (APREF)

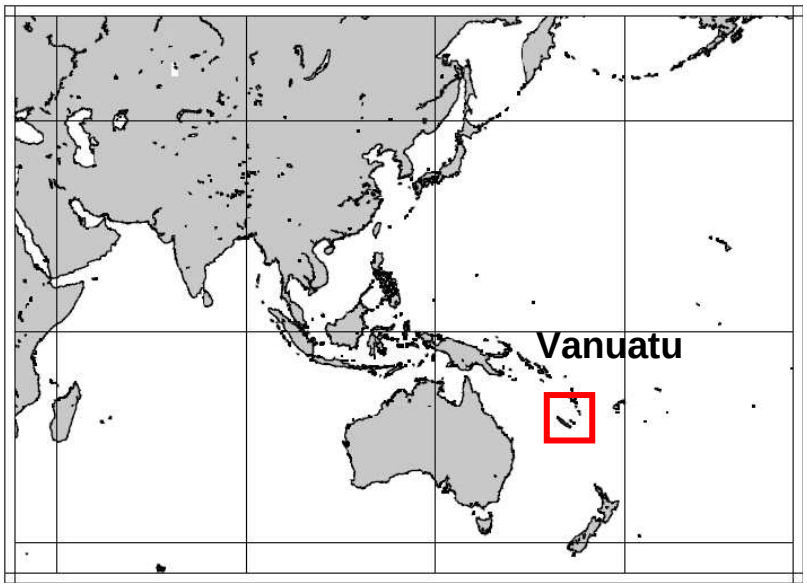
- PCGIAP effort
- Annual week long GPS campaign 1997,…,2012
- Provides access to ITRF
- Recognises not all member countries can operate CORS networks and contribute to APREF

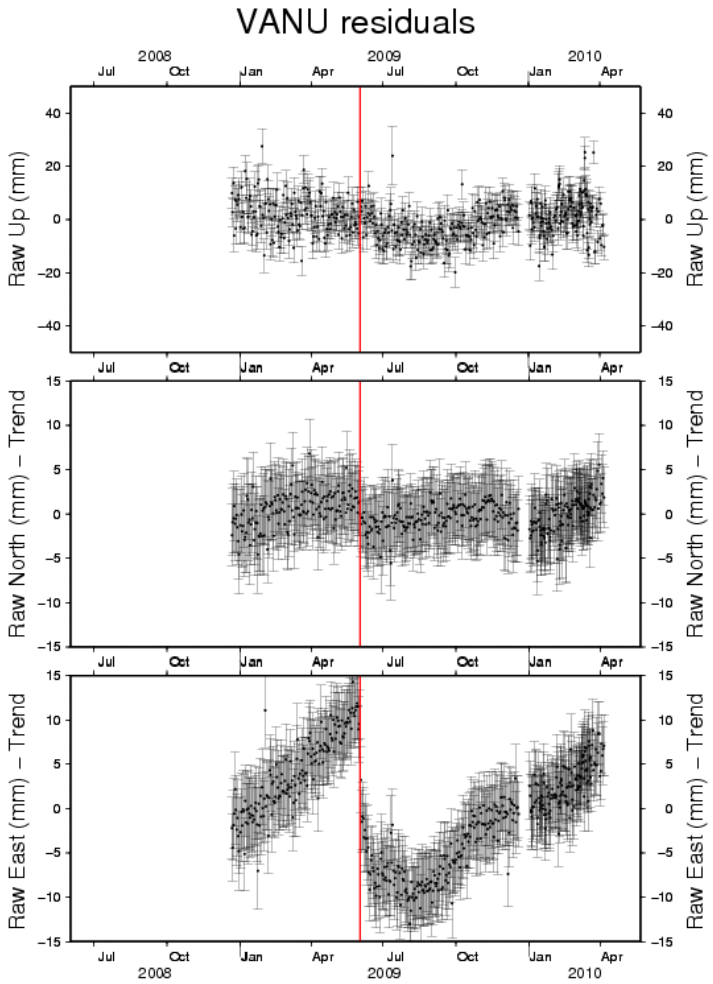
- Joint PCGIAP and IAG effort supported by FIG, ICG
- Announced March 2010
- Continuous, low-latency analysis of CORS networks
- Provides access to ITRF, coordinate time series, station velocities and network monitoring

APRGP Stations 2010 GNSS Campaign

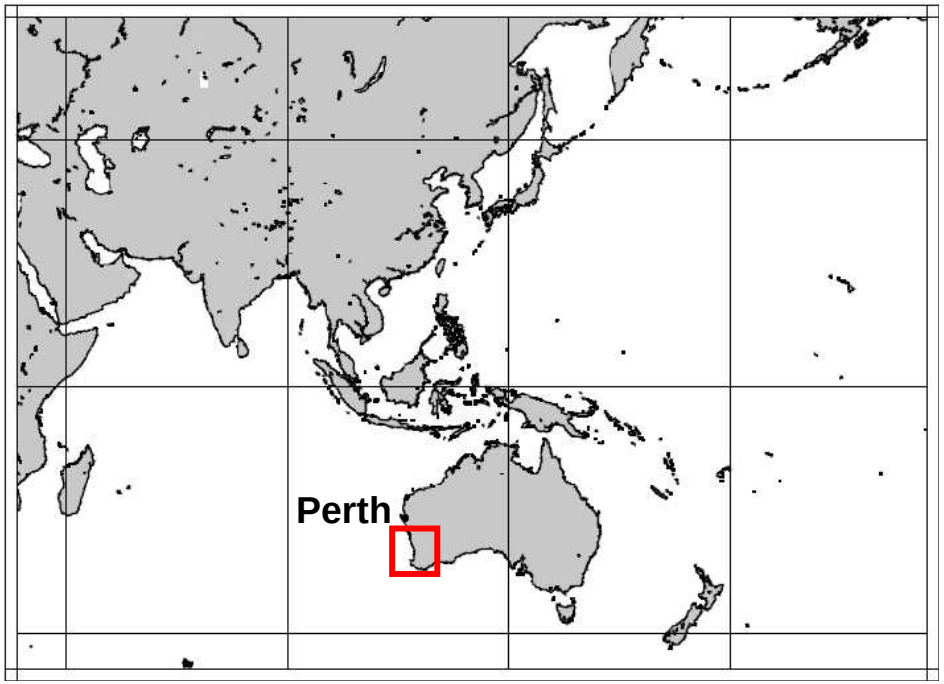


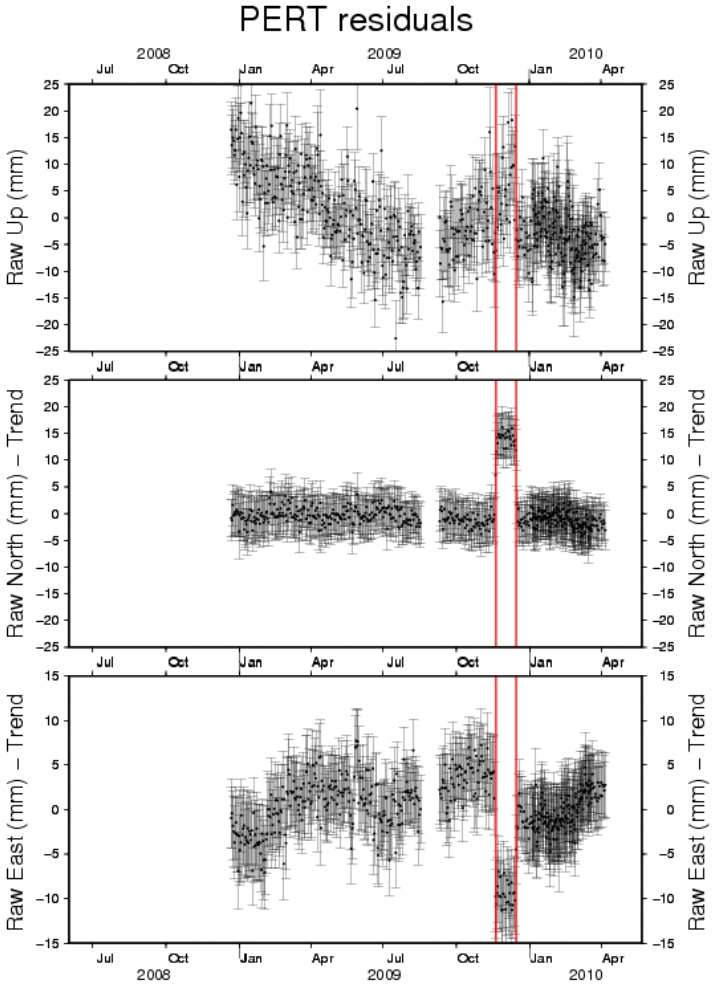
Improving ITRF Access: Episodic observations are problematic





Improving ITRF Access: Episodic observations are problematic



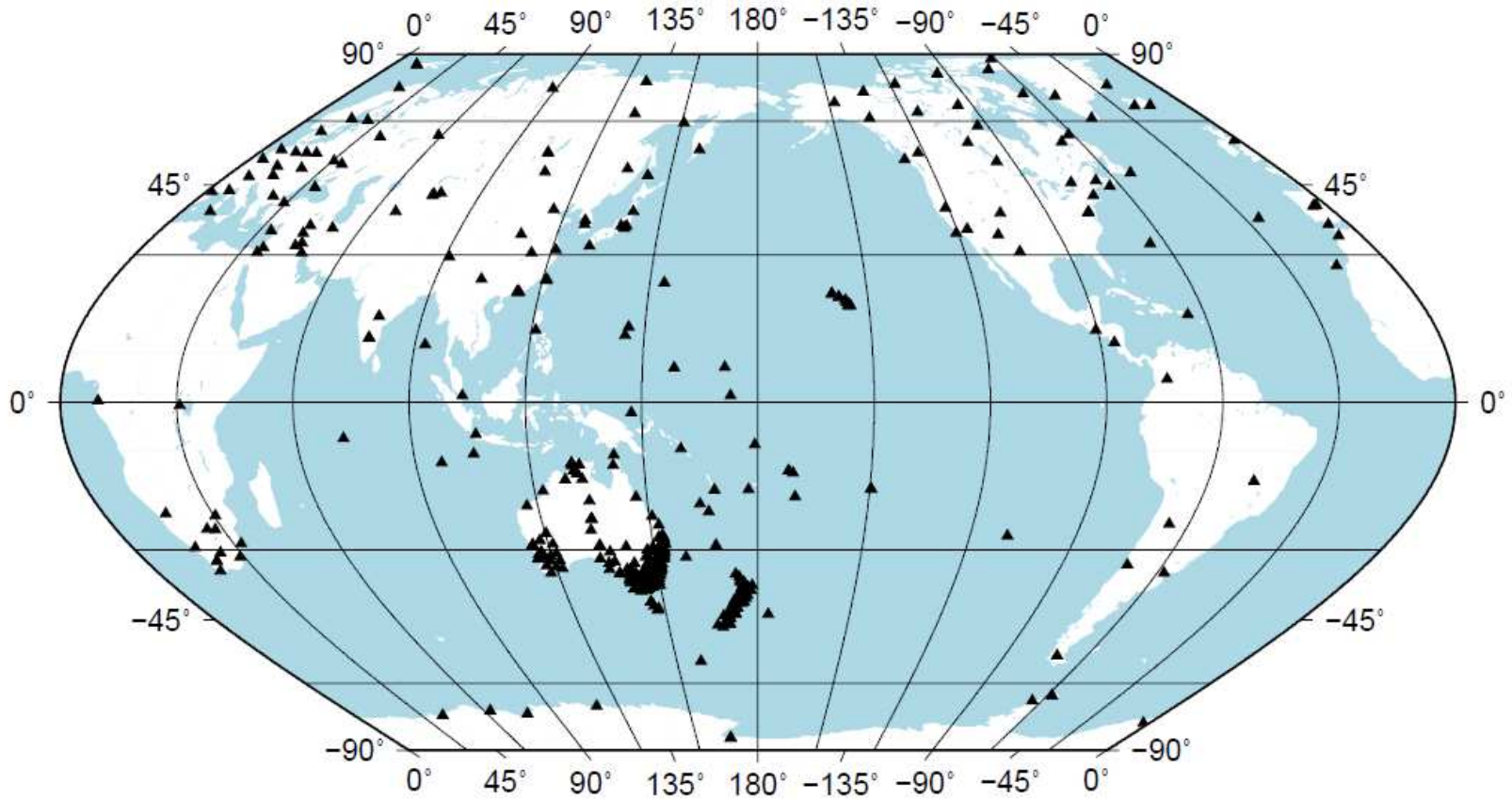


Improving ITRF Access: APREF

- 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)

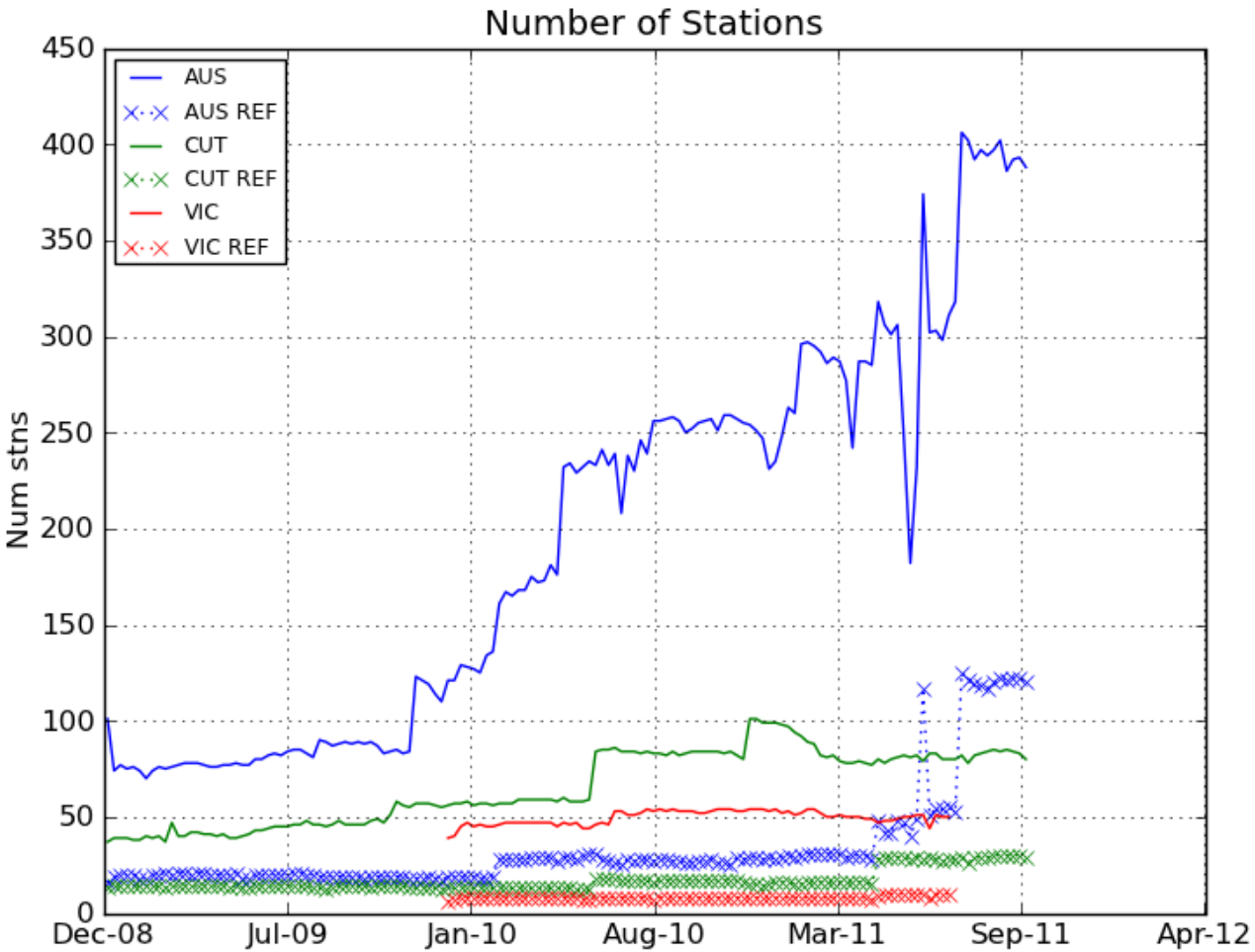
Improving ITRF Access: APREF

- Currently ~400 stations (excluding global stations)



Source: Hu et al, 2011

Improving ITRF Access: APREF Stations



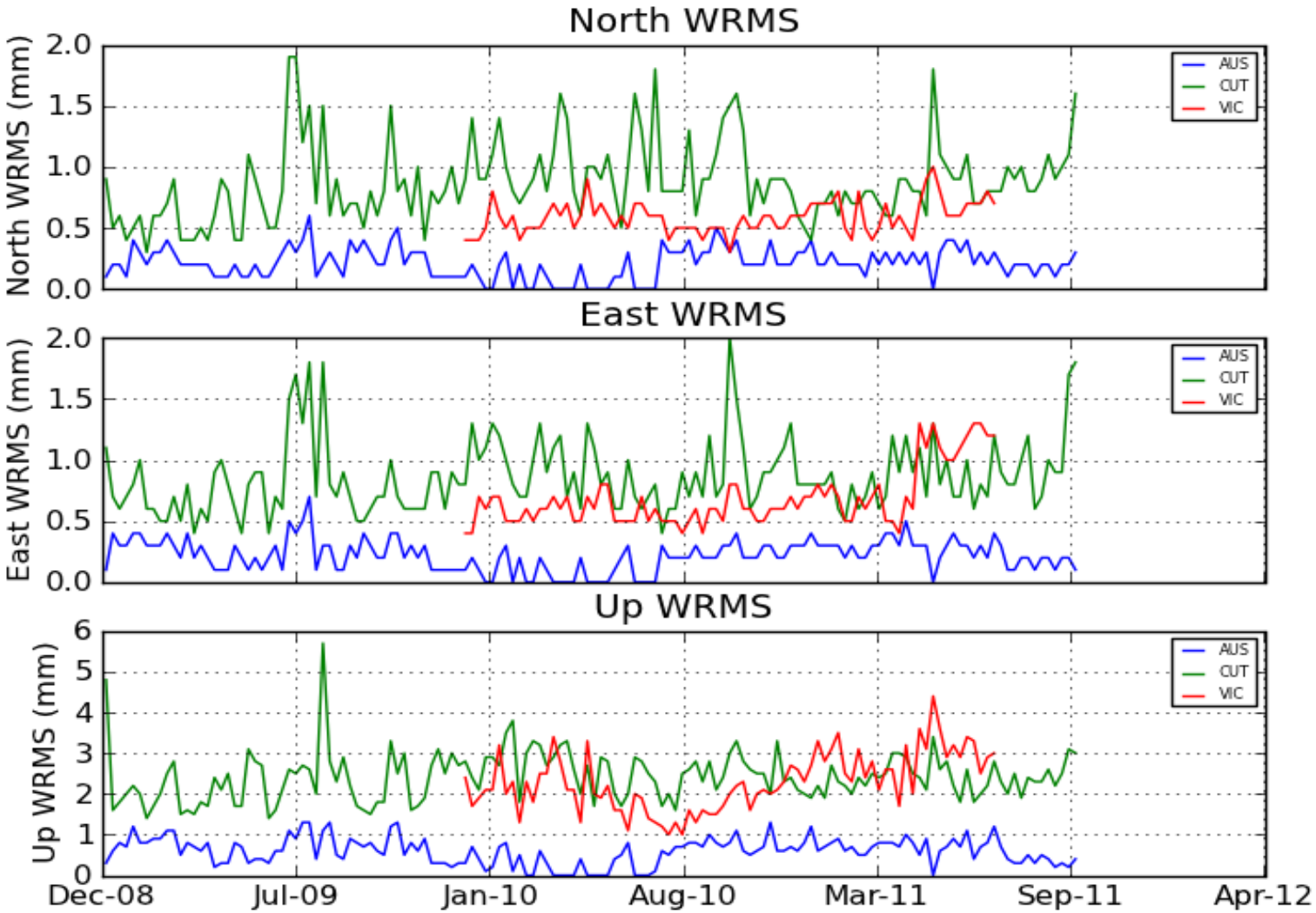
Improving Access to the ITRF: APREF Products

- 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

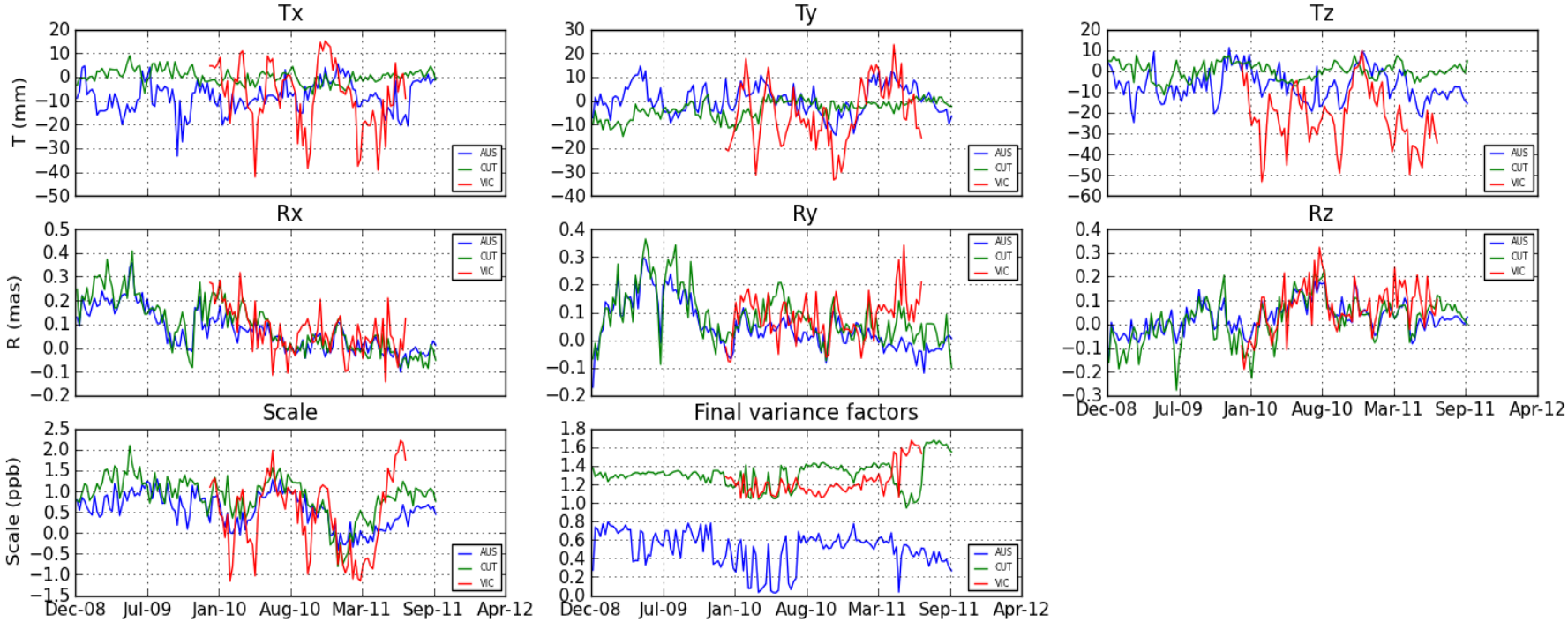
APREF Combination

- 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

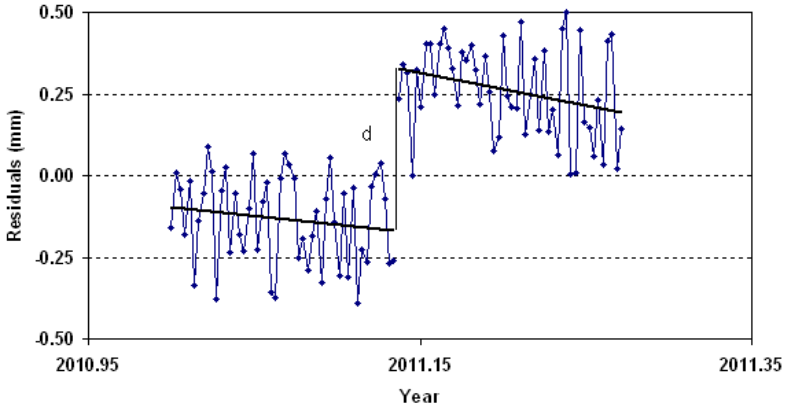


Transformation parameters between the LAC solutions and IGS08



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

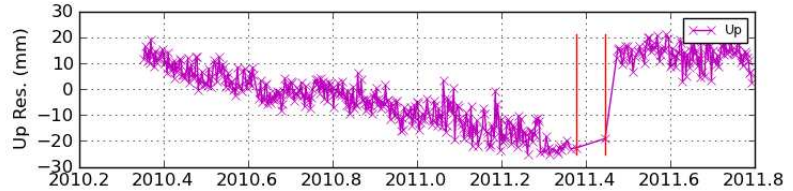


- Offsets determined from algorithm are written to a file
- Correlate with equipment changes/ earthquake data from the database
- Update offset file with known events
- Analyst inspects time series to confirm and add offsets to the CATREF discontinuity file

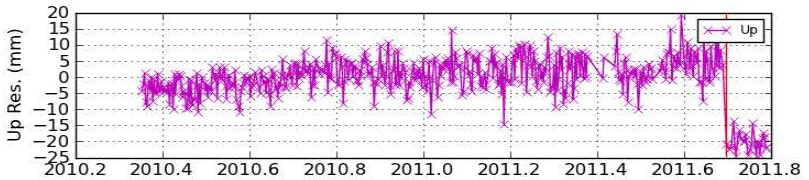
Offset detection in time series

MLAK (VIC) antenna moved by 40m!!

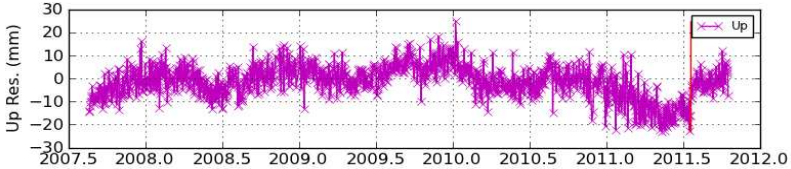
TATU (VIC) 35mm H: Unknown?



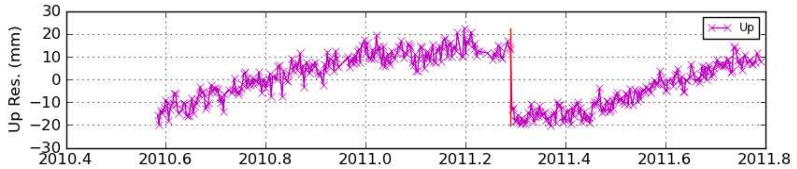
YALL (VIC) 22mm H: Unknown?



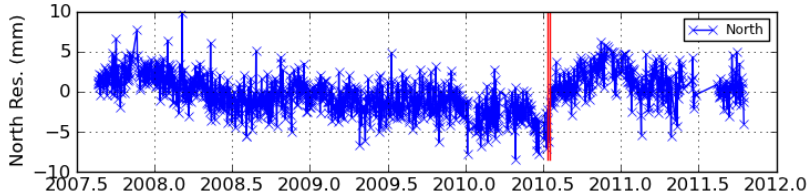
ALIC (ARGN) 10mm H: Antenna change



IHOE (NSW) 29mm H: Incorrect antenna model

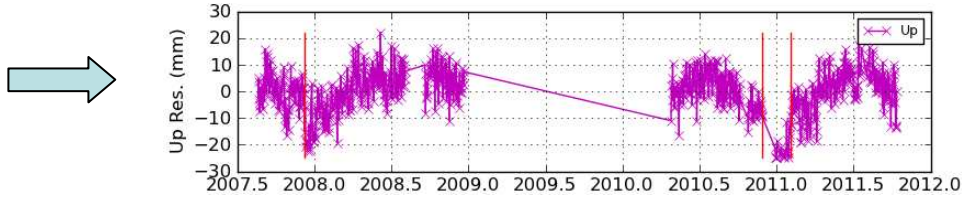


NAUR (SPRGN) 5mm N: Antenna change

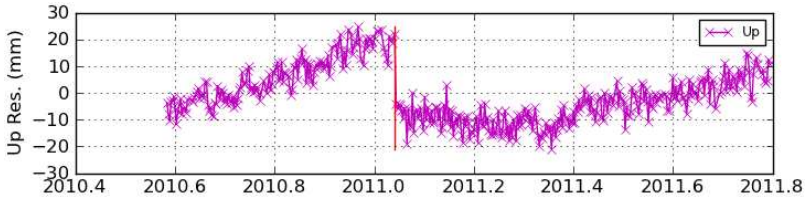


Examples of detected offsets …

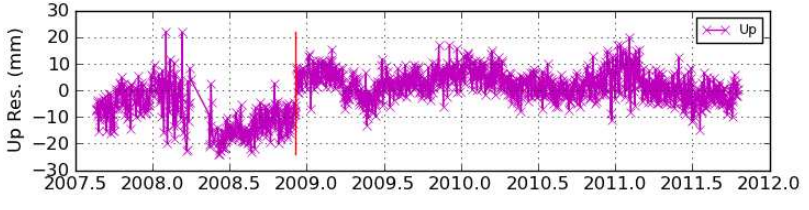
URUM (IGS - China) 20mm H: Unknown?



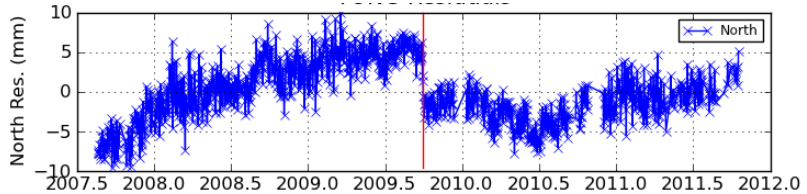
WILU (WA) 26mm H, 4mm N: Unknown?



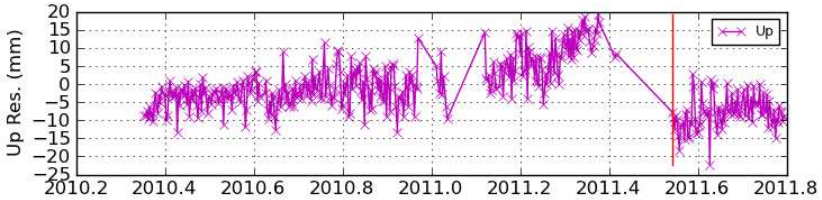
YAR3 (ARGN) 14mm H: Antenna Change



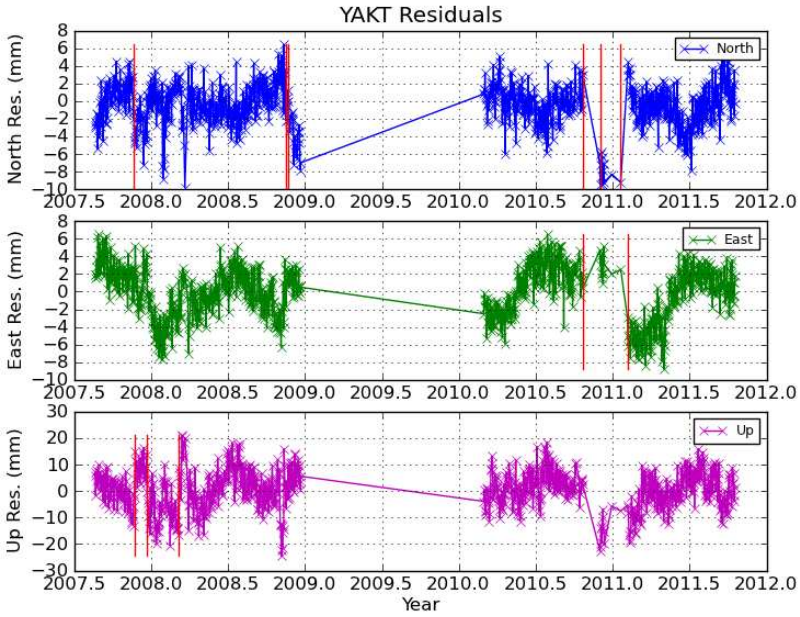
TONG (SPRGN) 6mm N: 29 Sept ‘09 Earthquake



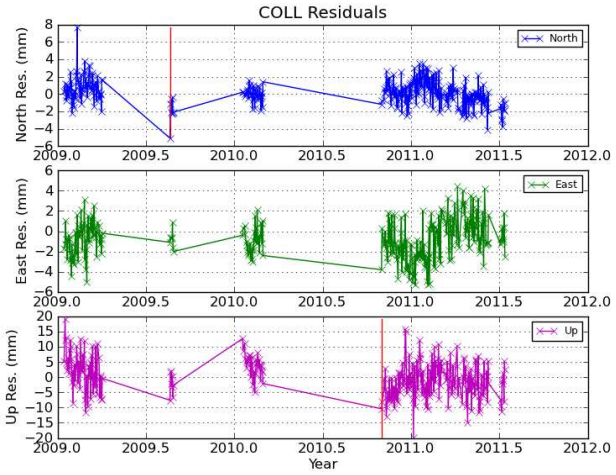
BUXT (VIC) 26mm H: Unknown?



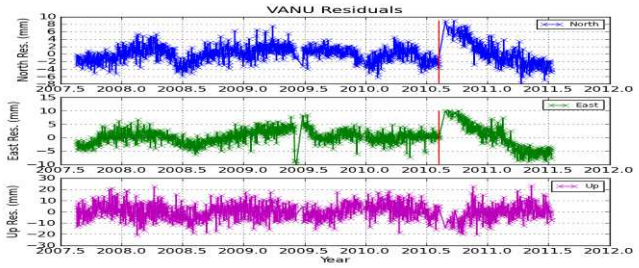
Offset detection in time series



YAKT (IGS - Serbia) – Snow build up effects

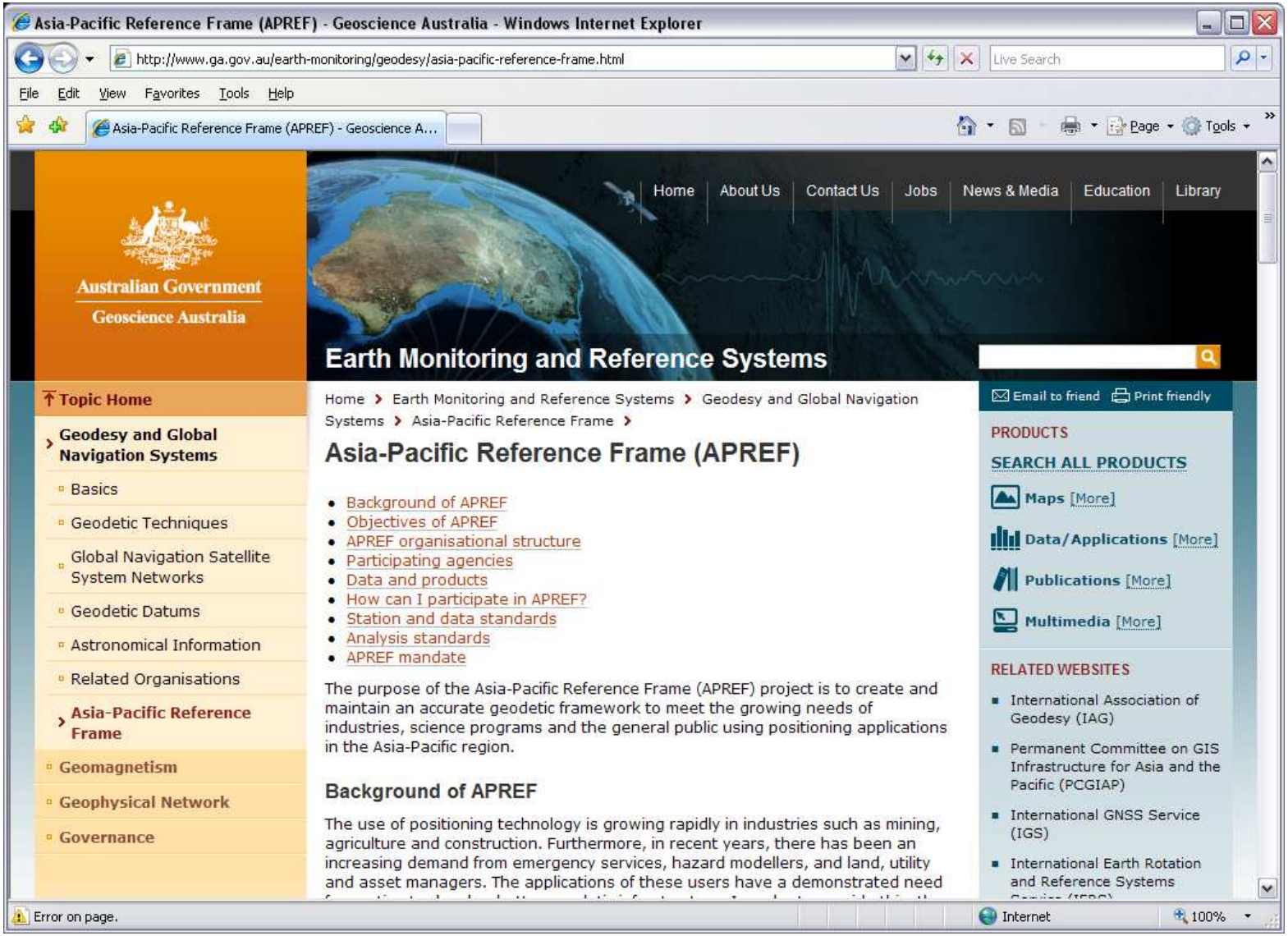


COLL (WA) – Gaps cause false detection

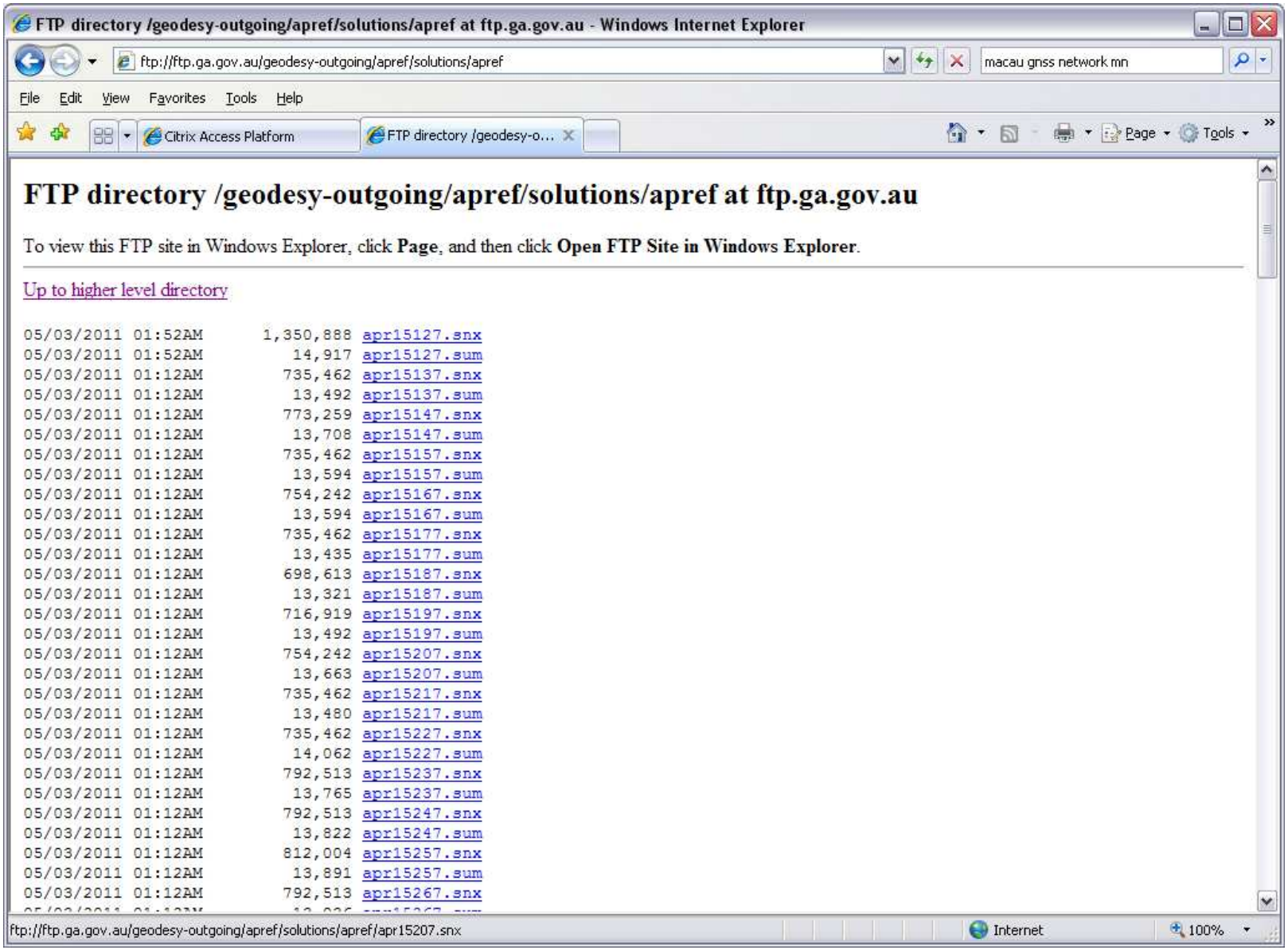


VANU (SPRGN) – Earthquake/ post-seismic signal

APREF website: www.ga.gov.au



APREF Products: Weekly summary and SINEX files



APREF Products

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

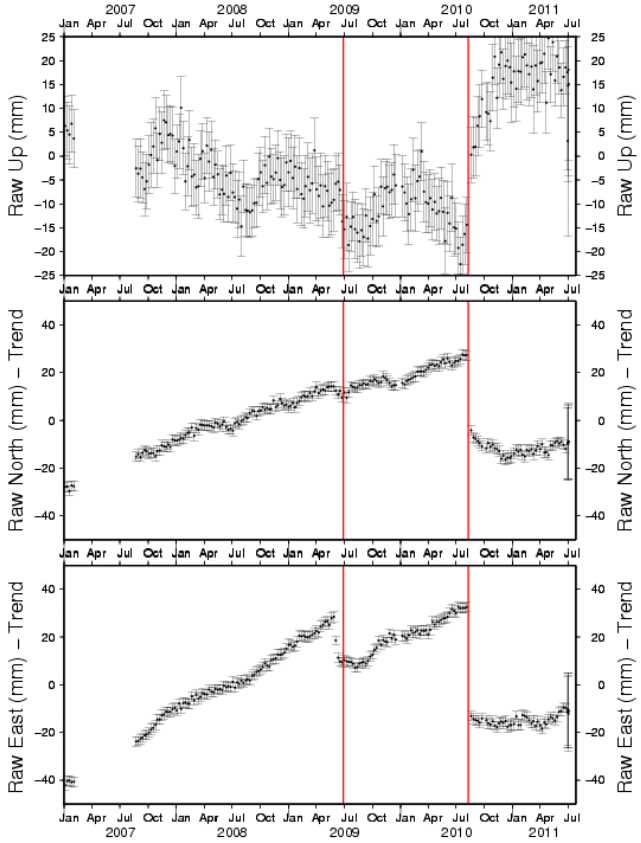
Weekly station performance

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

Station coordinate time-series

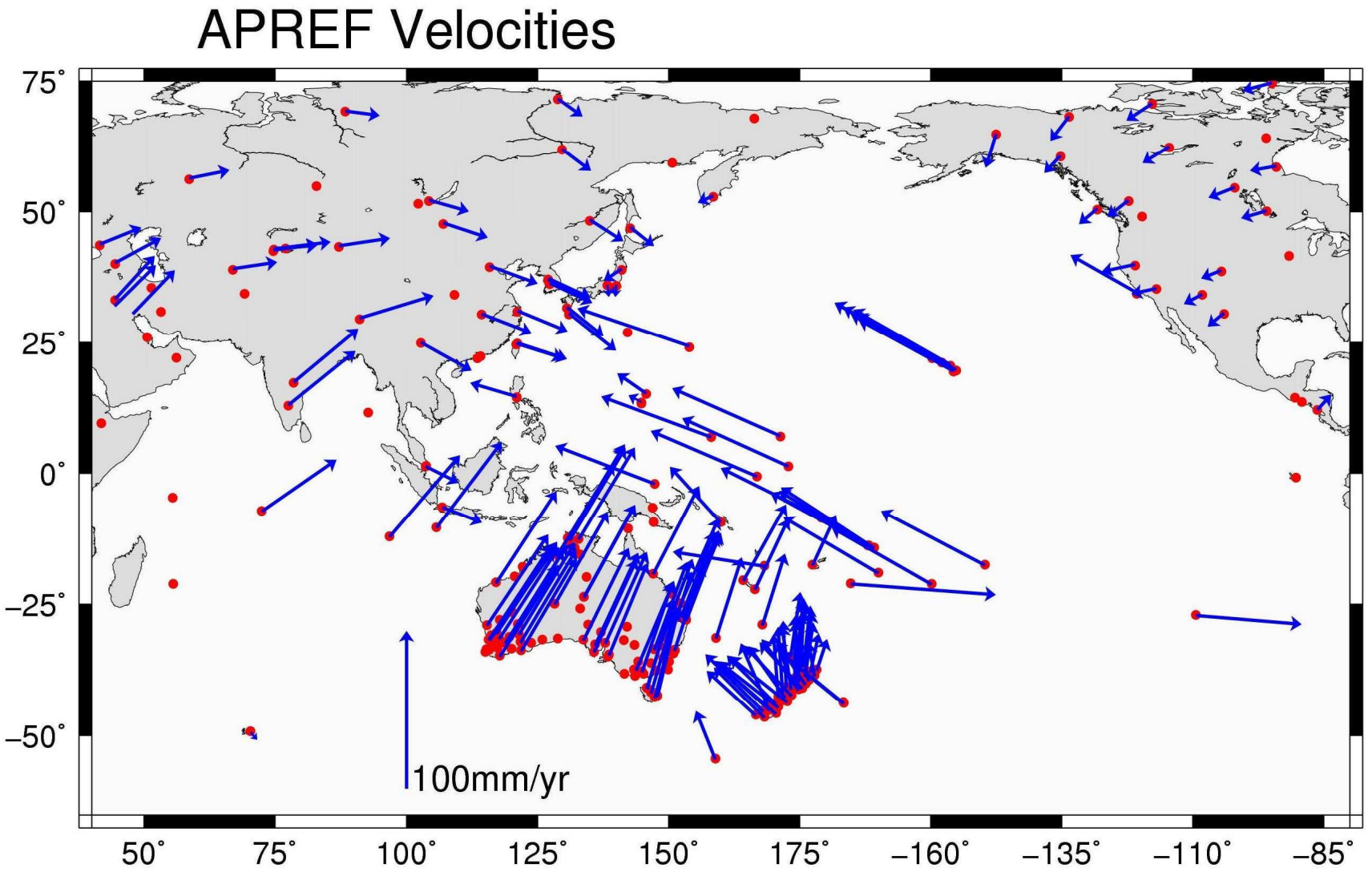
VANU residuals



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)



- 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