IAG / FIG / UNGGIM / UNICG / PhilGEGS

Reference Frame in Practice

Manila, Philippines 21-22 June 2013

Reference Frame Infrastructure

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President IAG

From Classical to Modern Geodesy

- From 3-D points and surfaces, *to 4-D mapping*.
- Increasing time resolution of geodetic measurements & products, *from 0.1s positions, to daily ERP, to monthly gravity field models*.
- Increasing spatial resolution of geodetic products, *from 1m for SAR, to 100km for gravity field features.*
- Increasing accuracy, *on both short-term and long-term time scales*.
- Increasing reliance on global infrastructure and global services.
- The importance of international reference frames (& modern national datums) with ever greater "fidelity" is reaffirmed…

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National Datums & Reference Frames

- Modern national datums typically are realisations of ITRF (at Ref Epoch).
- Use GNSS to "connect" to the ITRF (e.g. via nearest IGS stations) or regional RF such as APREF (via CORS), etc.
- WGS84 RF is very "close" (cms) to ITRF… both have 2005.0 Ref Epoch & estimated stn velocities, *i.e. fixed points really have 4-D coords.*
- Different ITRFs only mm-to-cm differences in 3-D coords… *much larger crustal motion effect on coords at differing REs (e.g. 2005->2013).*
- National datums may be "frozen" at past epoch (e.g. Australia's GDA94 assumes no vels), or are "dynamic" (4-D coords), or regular "update"?
- GNSS ideal for defining, realising & monitoring national datums… *both "internally" (e.g. deformation) and "externally" (e.g. wrt ITRF or APREF).*
- "Height datum" must be handled separately as involves gravity field effects... *although ellipsoidal heights may be better option for many apps.*
- *VLBI & SLR are necessary for long-term stability of ITRF… but national (and local) datums are principally reliant on GNSS, typically via CORS.*

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Space Geodesy Techniques

SLR

GNSS for densification of ITRF, datum realisation, & PP

GNSS

DORIS

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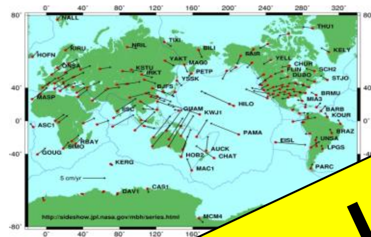
Outline …

- GNSS as Core Geodetic Infrastructure
- GNSS and the Maintenance of the ITRF
- Using GNSS to Connect to ITRF via CORS Infrastructure

GNSS as Core Geodetic Infrastructure

Precise Positioning GNSS Applications



Current PP is based on Differential GNSS principles…

- …ematic apps, such …achine guidance/control
- Define/monitor datum, geodesy apps, etc.
- Precise georeferencing of airborne or terrestrial scanning/imaging sensors

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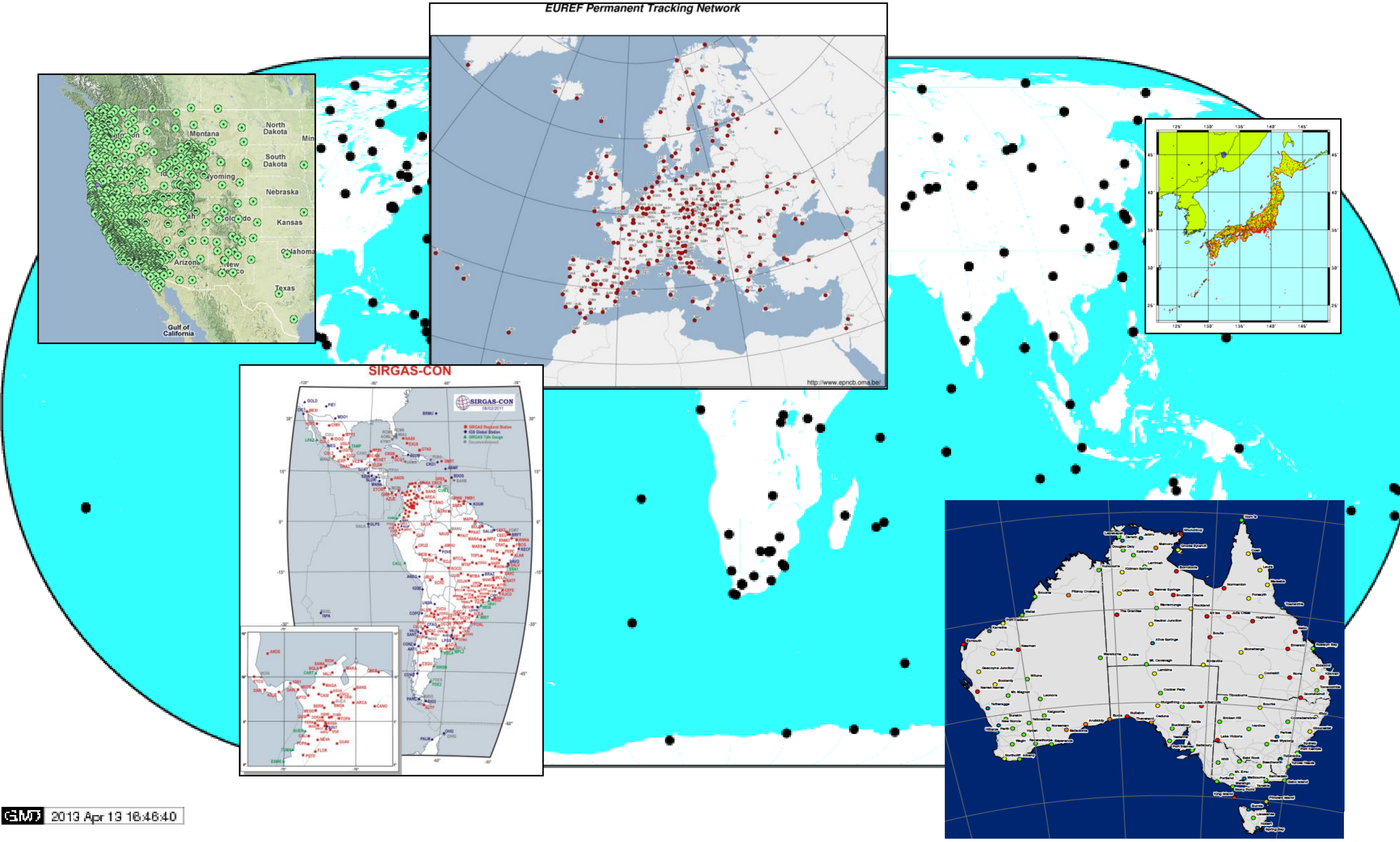
Global/Regional/National CORS Networks



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Multi-Tier Positioning Infrastructure

GNSS CORS (& other) geodetic infrastructure could be considered *heirarchical*:

(1) *Tier 1:* IGS-class stations… *equipped with MGNSS receivers, with best monumentation, co-located with other geodetic instrumentation, to maintain ITRF & support science*.

(2) *Tier 2:* primary national geodetic CORS network… *MGNSS receivers, stable monumentation, providing foundation for regional RFs, national datums &positioning infrastructure, which can also support geoscience*.

(3) *Tier 3:* state (or secondary) and private CORS networks… *COTS GNSS Rxs, supporting real-time or post-survey users, as well as other GNSS apps, characterised by "non-geodetic" monumentation*.

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Geodetic CORS Monumentation… Tier 1&2

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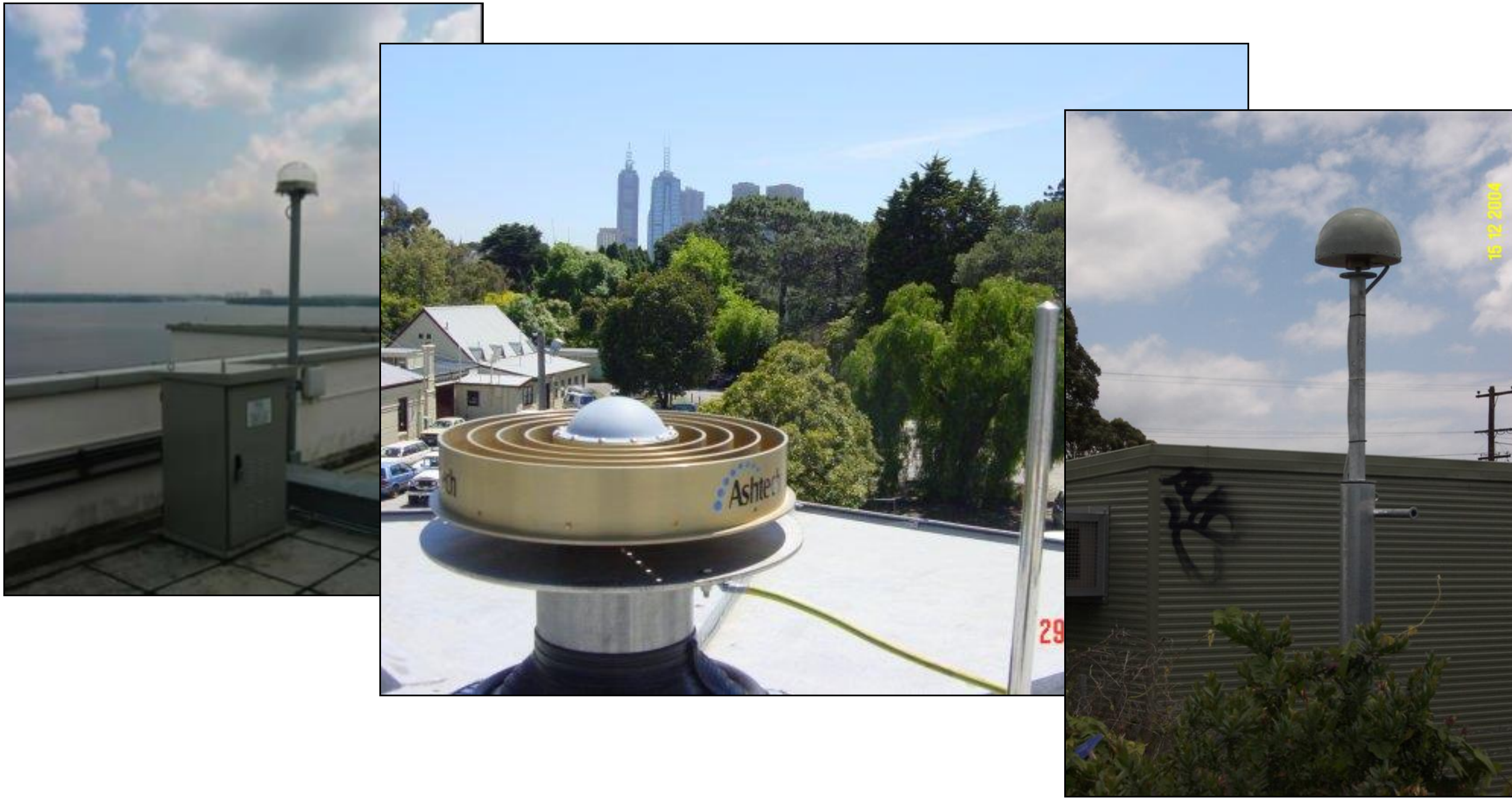
GNSS Non-Geodetic CORS Monumentation… Tier 3



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Coping with Multi-GNSS Complexity:
Some Technical Issues to Consider

- **Ratio** of Tier 1 to Tier 2 to Tier 3 CORS, *and* their geographic distribution across a country, or region, or city?*…*
  need a "spatial deployment strategy"
  ...**5-10% T1/T2 to T3?**
- **Timeline** for the deployment of MGNSS CORS over the coming decade? Upgrade cycle?…
  need a "temporal deployment strategy".
  …**T1/T2 infrequent (datum), T3 more regular (customer services)**

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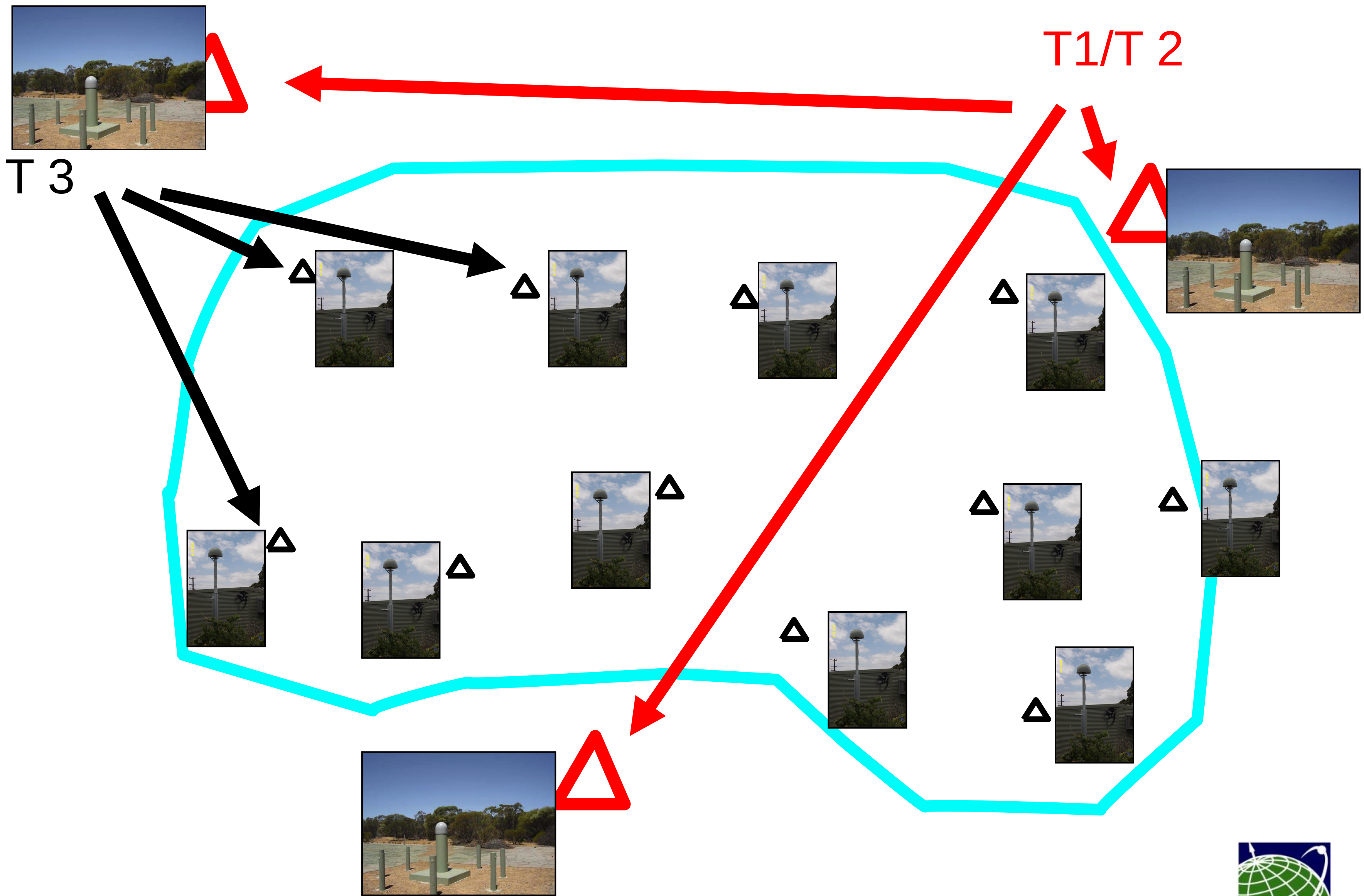
T1/T 2
T 3

IGS Site Guidelines

igscb.jpl.nasa.gov/network/guidelines/guidelines.html

c_rizos on Twitter | Time Scale | Apple | NRL | UNSW-CVEN | Catalogues | Google Maps | UNSW | Geodesy | Wikipedia | Navigation

International GNSS Service
Formerly the International GPS Service

Products | Network | Projects | Calendar | Organization
About | Mail | FAQ | Publications | FTP | Site map

IGS Site Guidelines

Infrastructure Committee
Central Bureau
April 2013

PDF available

Introduction | Guidelines | Hourly Stations | Met. Data | High-Rate Stations | TIGA sites | Timing stations | OPS

1. Introduction

The IGS network is a collection of heterogeneous stations operated by many different organizations pooling their resources under the IGS umbrella for the common good. Stringent rules are inconsistent with the voluntary nature of the IGS. However, participating stations must agree to adhere to the standards and conventions contained herein, which ensure the consistent high quality of the IGS network and products. Of particular importance to the IGS is the stable, long-term operation of the network. Therefore, changes to any station's configuration or immediate surroundings should be carefully planned to minimize discontinuities in the station's position time-series.

Special consideration should be given to designated reference frame stations that contribute to the realization of the International Terrestrial Reference Frame (ITRF)(see the IGS08.snx file for a listing of stations that contribute to the IGS reference frame). Any changes to these stations should be planned well in advance following the procedures in section 2.3 of these Guidelines.

IGS Site Guidelines

- Differentiate between ”strict” and ”recommended” guidelines.
- Distinguish between different types of IGS network stations, e.g. high-rate, timing, TIGA, RT, GLONASS/MGNSS, etc.
- For Reference Frame sites, special considerations regarding instrument changes.
- Guidelines on documentation, monumentation, antenna siting, data transfer & station operations, and more.
- IGS Site Guidelines can also be used for T2 sites.
- Download IGS Site Guidelines from:
  http://igs.org/network/guidelines/IGS_Site_Guidelines.pdf
  http://igscb.jpl.nasa.gov/network/guidelines/guidelines.html

Coping with Multi-GNSS Complexity:
Some Technical Issues to Consider

- The **minimum specifications** of Tier 1, 2 and 3 CORS Rxs is a “moving target” as tracking capability will necessarily change with time; *from current GPS+Glonass, to GPS(modernised)+Glonass, GPS(m)+Glonass(m)+BeiDou, G+G+Beidou+Galileo+?*
- What are the international standards? RINEX, RTCM, etc.

Standards: RINEX 3.02

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
GPS	L1/1575.42	C/A	C1C	L1C	D1C	S1C
		L1C (D)	C1S	L1S	D1S	S1S
		L1C (P)	C1L	L1L	D1L	S1L
		L1C (D+P)	C1X	L1X	D1X	S1X
		P	C1P	L1P	D1P	S1P
		Z-tracking and similar (AS on)	C1W	L1W	D1W	S1W
		Y	C1Y	L1Y	D1Y	S1Y
		M	C1M	L1M	D1M	S1M
		codeless		L1N	D1N	S1N
	L2/1227.60	C/A	C2C	L2C	D2C	S2C
		L1(C/A)+(P2-P1) (semi-codeless)	C2D	L2D	D2D	S2D
		L2C (M)	C2S	L2S	D2S	S2S
		L2C (L)	C2L	L2L	D2L	S2L
		L2C (M+L)	C2X	L2X	D2X	S2X
		P	C2P	L2P	D2P	S2P
		Z-tracking and similar (AS on)	C2W	L2W	D2W	S2W
		Y	C2Y	L2Y	D2Y	S2Y
		M	C2M	L2M	D2M	S2M
		codeless		L2N	D2N	S2N
	L5/1176.45	I	C5I	L5I	D5I	S5I
		Q	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X

Standards: RINEX 3.02

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
GLONASS	G1/ 1602+k*9/16 k= -7….+12	C/A	C1C	L1C	D1C	S1C
		P	C1P	L1P	D1P	S1P
	G2/ 1246+k*716	C/A (GLONASS M)	C2C	L2C	D2C	S2C
		P	C2P	L2P	D2P	S2P
	G3 / 1202.025	I	C3I	L3I	D3I	S3I
		Q	C3Q	L3Q	D3Q	S3Q
		I+Q	C3X	L3X	D3X	S3X

Standards: RINEX 3.02

GNSS System	Freq. Band /Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
Galileo	E1 / 1575.42	A PRS	C1A	L1A	D1A	S1A
		B I/NAV OS/CS/SoL	C1B	L1B	D1B	S1B
		C no data	C1C	L1C	D1C	S1C
		B+C	C1X	L1X	D1X	S1X
		A+B+C	C1Z	L1Z	D1Z	S1Z
	E5a / 1176.45	I F/NAV OS	C5I	L5I	D5I	S5I
		Q no data	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X
	E5b / 1207.140	I I/NAV OS/CS/SoL	C7I	L7I	D7I	S7I
		Q no data	C7Q	L7Q	D7Q	S7Q
		I+Q	C7X	L7X	D7X	S7X
	E5(E5a+E5b) / 1191.795	I	C8I	L8I	D8I	S8I
		Q	C8Q	L8Q	D8Q	S8Q
		I+Q	C8X	L8X	D8X	S8X
	E6 / 1278.75	A PRS	C6A	L6A	D6A	S6A
		B C/NAV CS	C6B	L6B	D6B	S6B
		C no data	C6C	L6C	D6C	S6C
		B+C	C6X	L6X	D6X	S6X
		A+B+C	C6Z	L6Z	D6Z	S6Z

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Standards: RINEX 3.02

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
QZSS	L1 / 1575.42	C/A	C1C	L1C	D1C	S1C
		L1C (D)	C1S	L1S	D1S	S1S
		L1C (P)	C1L	L1L	D1L	S1L
		L1C (D+P)	C1X	L1X	D1X	S1X
		L1-SAIF	C1Z	L1Z	D1Z	S1Z
	L2 / 1227.60	L2C (M)	C2S	L2S	D2S	S2S
		L2C (L)	C2L	L2L	D2L	S2L
		L2C (M+L)	C2X	L2X	D2X	S2X
	L5 / 1176.45	I	C5I	L5I	D5I	S5I
		Q	C5Q	L5Q	D5Q	S5Q
		I+Q	C5X	L5X	D5X	S5X
	LEX(6) / 1278.75	S	C6S	L6S	D6S	S6S
		L	C6L	L6L	D6L	S6L
		S+L	C6X	L6X	D6X	S6X

150 years

Standards: RINEX 3.02

GNSS System	Freq. Band / Frequency	Channel or Code	Observation Codes			
			Pseudo Range	Carrier Phase	Doppler	Signal Strength
BDS	B1 / 1561.098	I	C1I	L1I	D1I	S1I
		Q	C1Q	L1Q	D1Q	S1Q
		I+Q	C1X	L1X	D1X	S1X
	B2 / 1207.14	I	C7I	L7I	D7I	S7I
		Q	C7Q	L7Q	D7Q	S7Q
		I+Q	C7X	L7X	D7X	S7X
	B3 / 1268.52	I	C6I	L6I	D6I	S6I
		Q	C6Q	L6Q	D6Q	S6Q
		I+Q	C6X	L6X	D6X	S6X

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Signal Tracking by Equipment...*agreement?*

Variety of constellations and signals are tracked, GPS:

```
JAVAD TRE_G2T DELTA  3.4.7                    G:L1C C1C L1W C1W L2X C2X L2W C2W L5X C5X
JAVAD TRE_G3TH DELTA 3.4.7                    G:L1C C1C L1W C1W L2X C2X L2W C2W L5X C5X
JAVAD TRE_G3TH DELTA 3.5.0                    G:L1C C1C L1W C1W L2X C2X L2W C2W L5X C5X
JAVAD TRE_G3TH DELTA 3.5.1B2 FEB,14,2013  G:L1C C1C L1W C1W L2X C2X L2W C2W L5X C5X
LEICA GR10           2.62/6.112               G:L1C C1C L2X C2X L2W C2W L5X C5X
LEICA GR10           3.00/6.113               G:L1C C1C L2S C2S L2W C2W L5Q C5Q
LEICA GR25           2.62/6.112               G:L1C C1C L2X C2X L2W C2W L5X C5X
LEICA GR25           3.0                      G:L1C C1C L2S C2SL2W C2W L5Q C5Q
LEICA GR25           3.00/6.113               G:L1C C1C L2S C2S L2W C2W L5Q C5Q
LEICA GRX1200+GNSS   -------------------- G:L1C C1C L2X C2X L2W C2W L5X C5X
NOV OEM6             OEM060100RN0000          G:L1C C1C L2D C2D L5Q C5Q
SEPT ASTERX3         2.3.4                    G:L1C C1C C1W L2L C2L L2W C2W L5Q C5Q
SEPT POLARX4TR       2.3.4                    G:L1C C1C C1W L2L C2L L2W C2W L5Q C5Q
SEPT POLARX4TR       2.3.4                    G:L1C C1C C1W L2L C2L L2W C2W L5Q C5Q
SEPT POLARXS         2.3.4                    G:L1C C1C C1W L2L C2L L2W C2W L5Q C5Q
TRIMBLE NETR9        4.60                     G:L1C C1C L2X C2X L2W C2W L5X C5X
TRIMBLE NETR9        4.61                     G:L1C C1C L2X C2X L2W C2W
TRIMBLE NETR9        4.70                     G:L1C C1C L2X C2X L2W C2W L5X C5X
TRIMBLE NETR9        4.70                     G:L1C C1C L2X C2X L2W C2W L5X C5X
TRIMBLE NETR9        4.80                     G:L1C C1C L2X C2X L2W C2W L5X C5X
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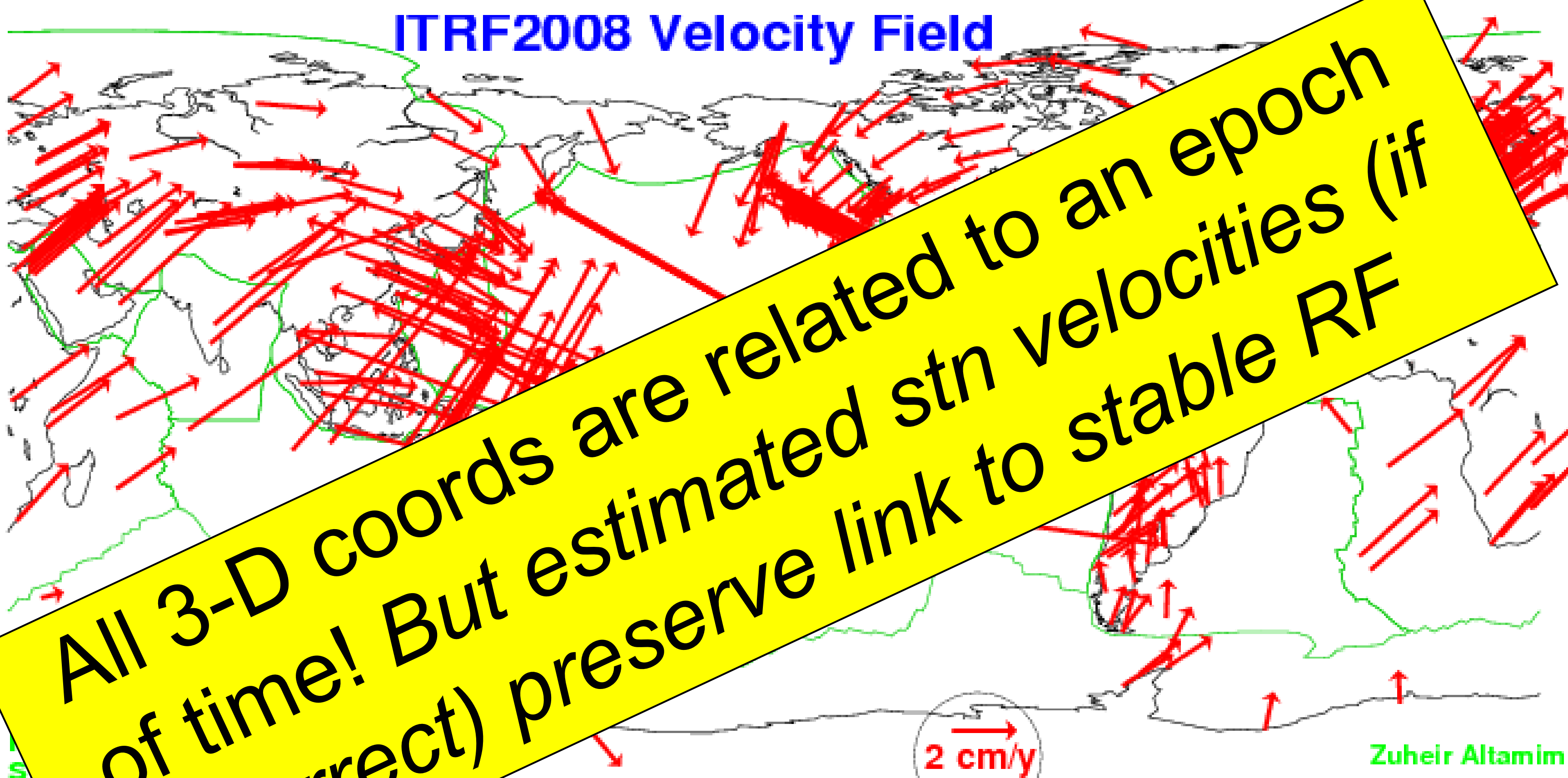
GNSS and the Maintenance of ITRF

Global Geodetic Reference Frame ITRF



All 3-D coords are related to an epoch of time! But estimated stn velocities (if correct) preserve link to stable RF

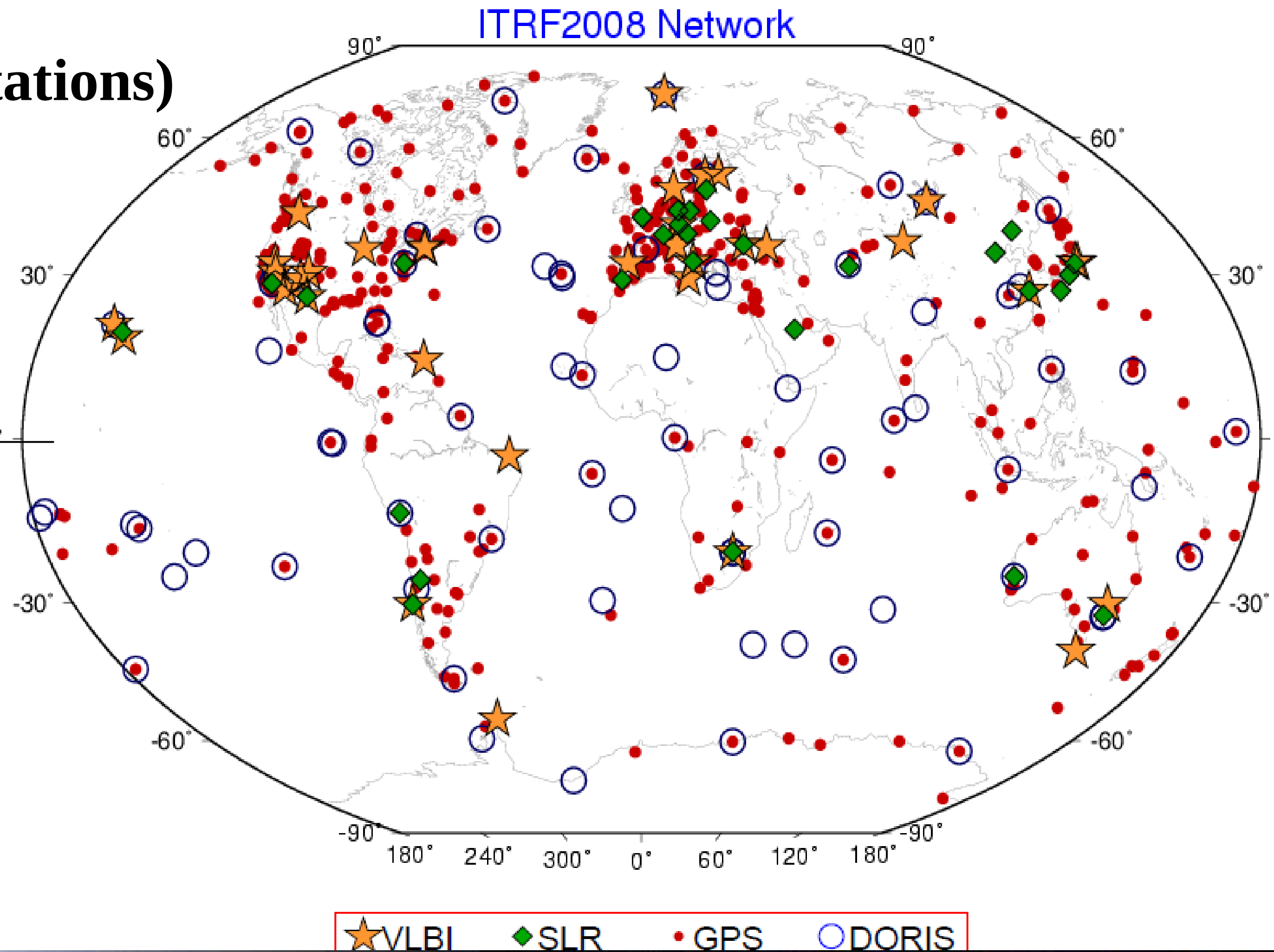
	SLR	GNSS	DORIS	Vector Tie
				

ITRF2013 is coming

150 years

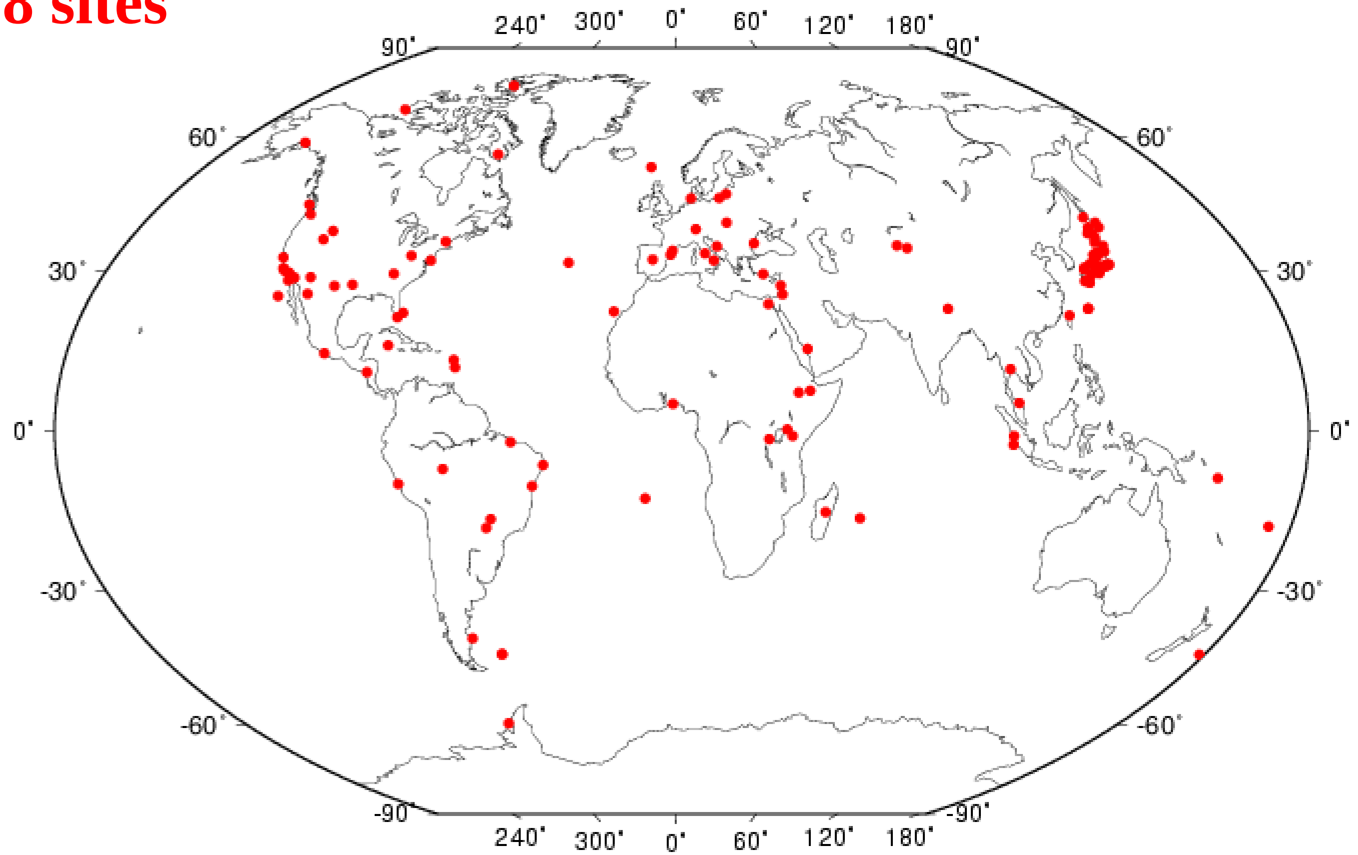
ITRF2008 Network

580 sites (920 stations)



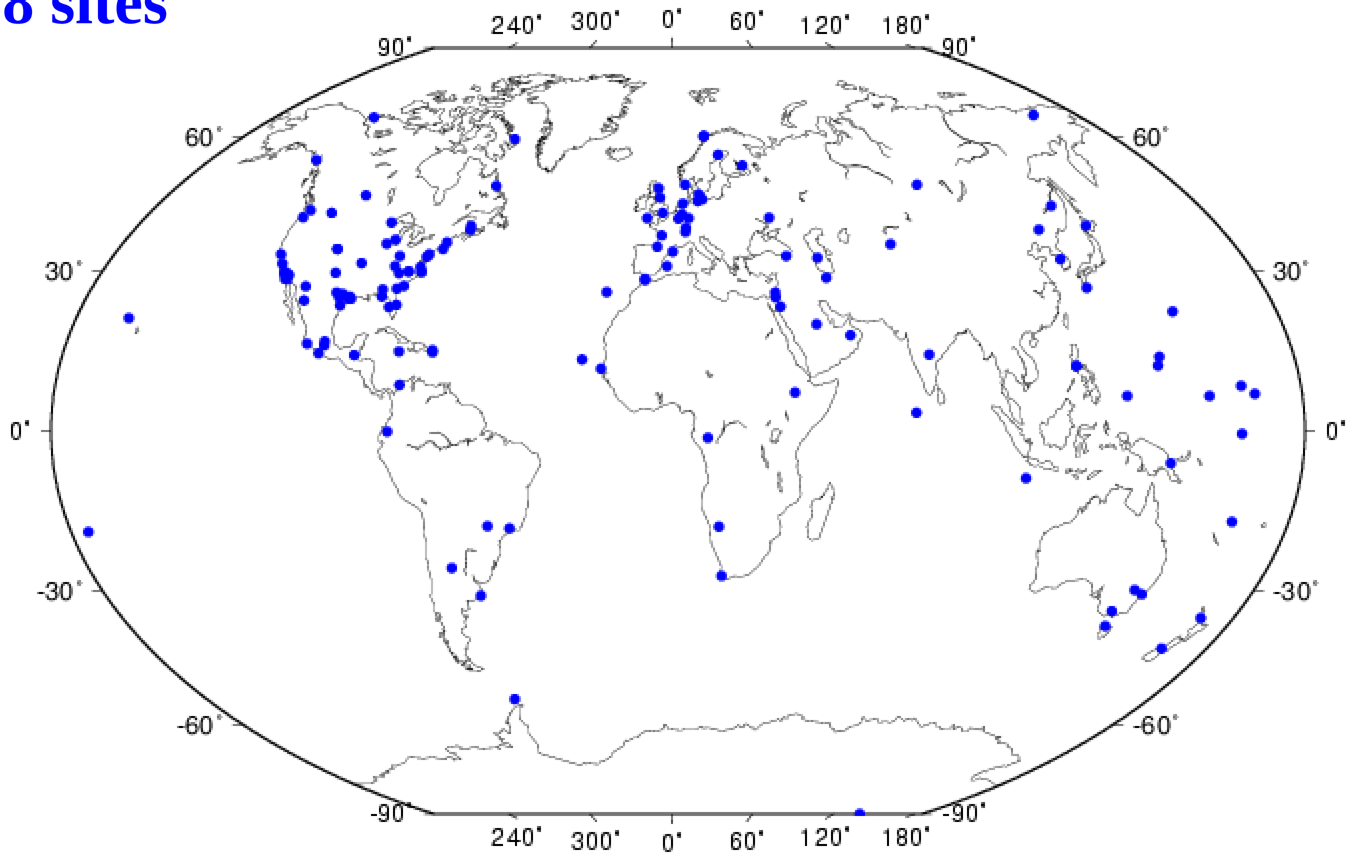
IGS sites with time series < 5 years

118 sites



IGS sites with time series between 5-10 years

138 sites



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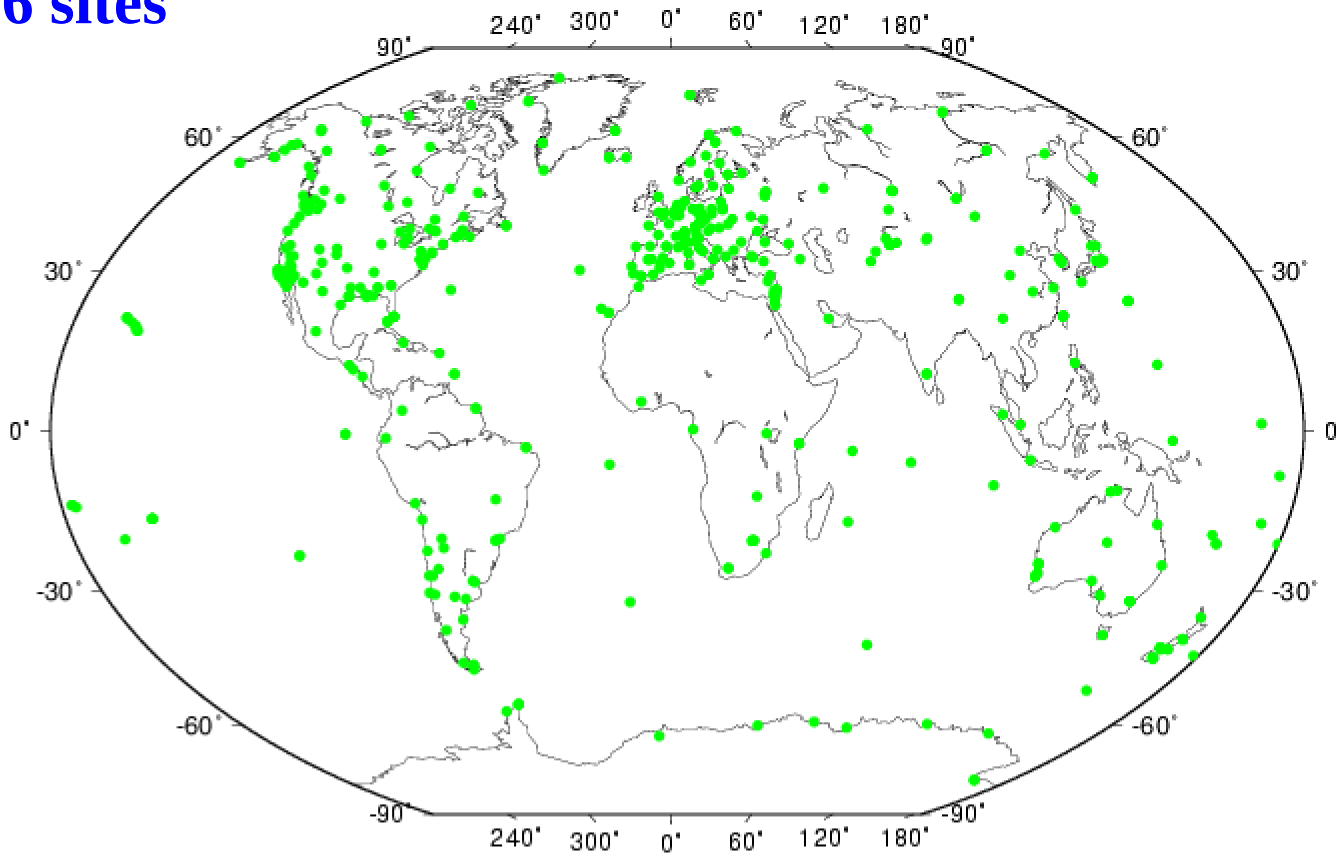
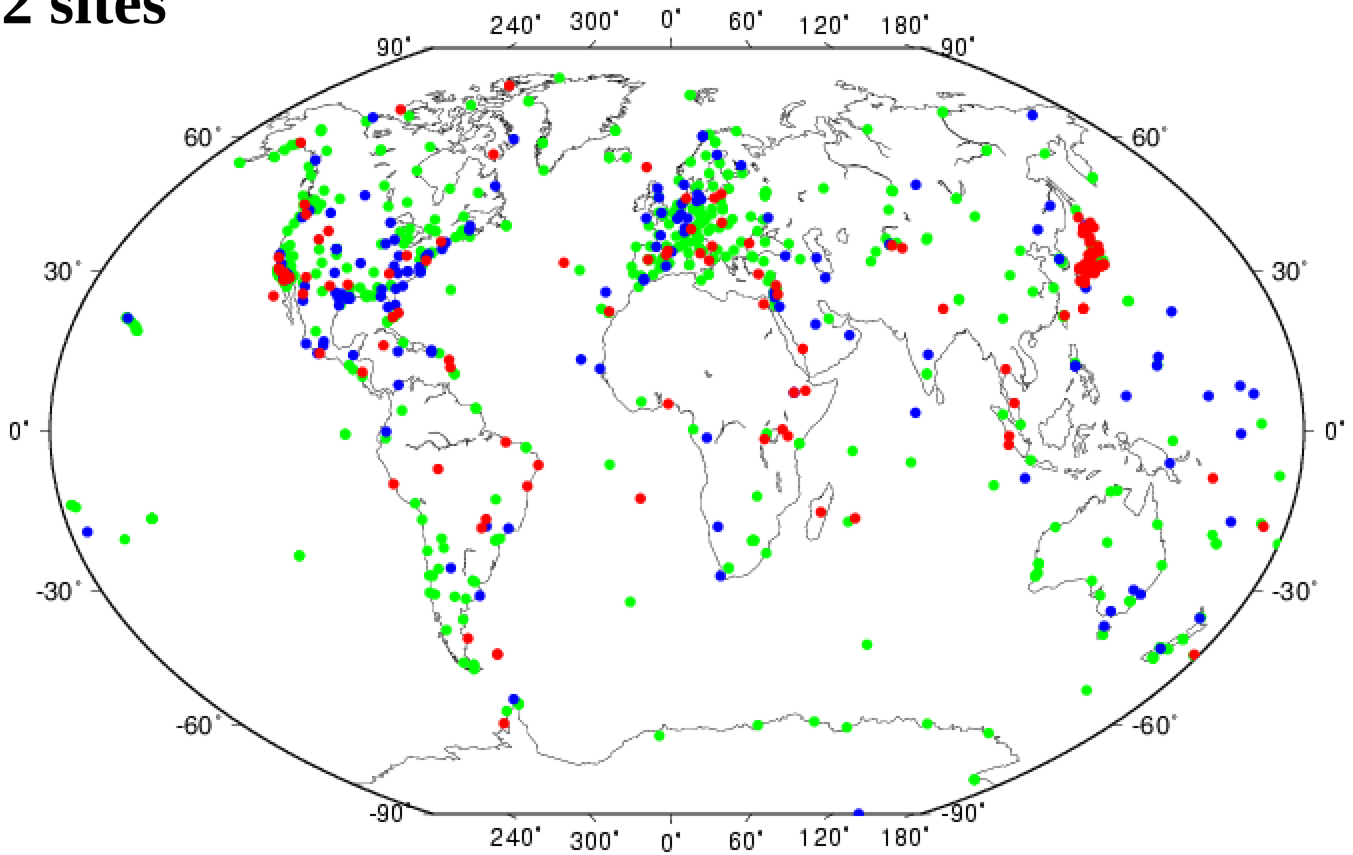
IGS sites with time series between 10-18 years

396 sites



All IGS sites in ITRF2008

652 sites



Want long-term stability... but need “breaks” in 4-D stn coords when earthquakes occur... *BIG challenge*

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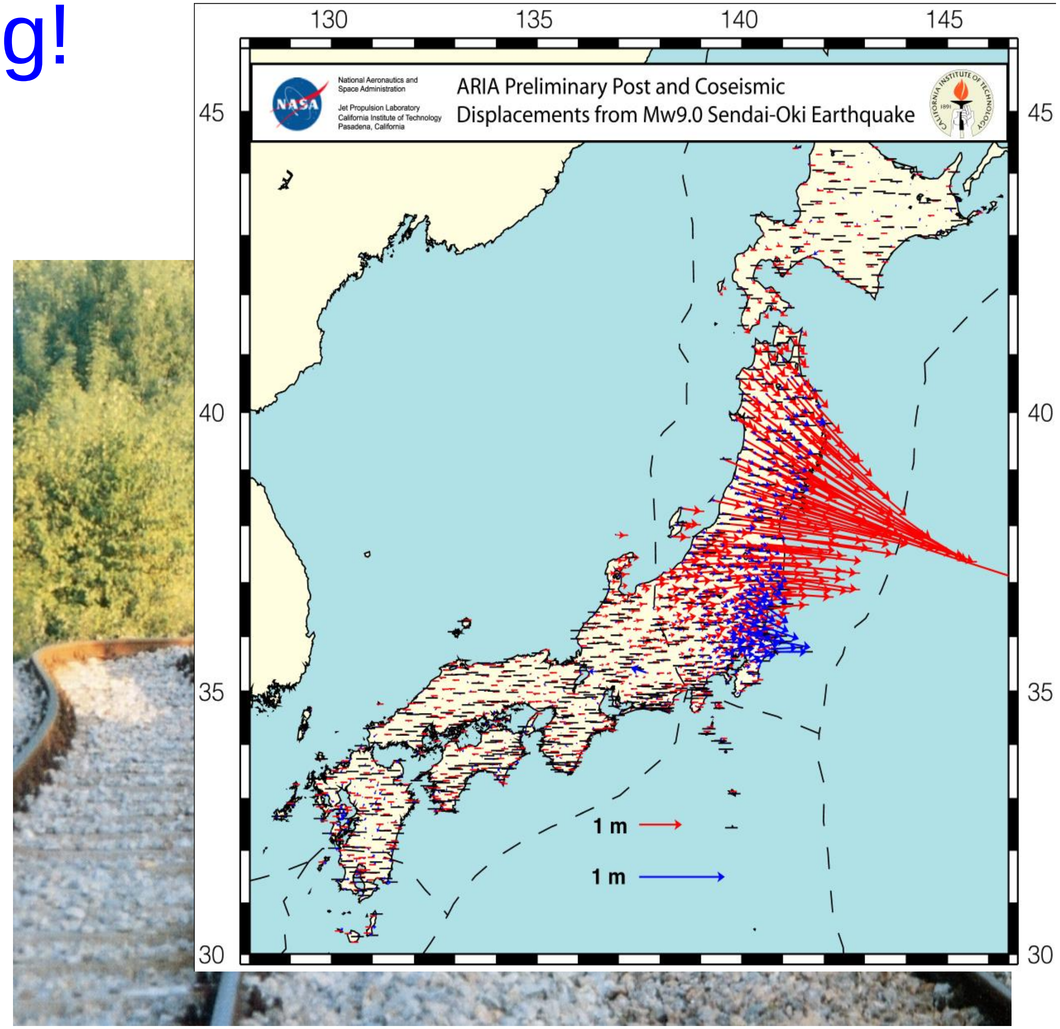
Everything is moving!

- Earthquakes
- Tsunamis
- Sea-level change
- Plate motions
- Local deformation or subsidence
- Solid Earth tides (caused by Sun and Moon)
- Loading phenomena (ice, ocean, atmosphere)



Continuous observation is essential for understanding

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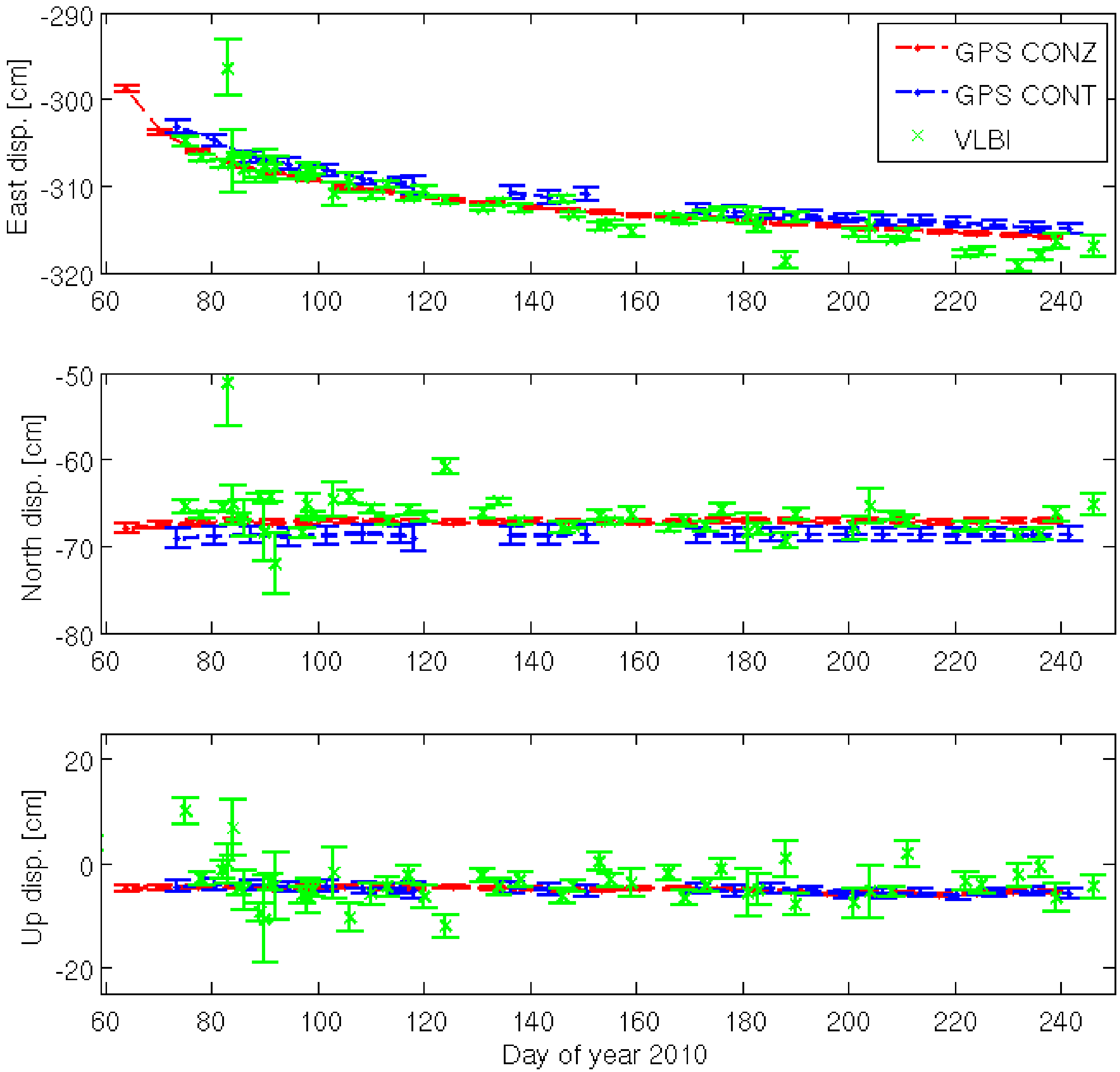
Everything is moving... *even after an earthquake*



Regional & National Reference Frames

- IAG Commission 1 (Reference Frames) ==> Sub-Commission 1.3 (Regional RFs):

  EUREF/Europe: ETRS89

  NAREF/North America: NAD83

  SIRGAS/South America

  AFREF/Africa

  APREF/Asia & Pacific

  SCAR/Antarctica

- Regional Reference Frames are (should be) related to ITRF
- Many countries have redefined their geodetic datums to be compatible/related/aligned to ITRF
- Not many user datums account for station velocities in a rigorous manner

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Using GNSS to Connect to ITRF via CORS Infrastructure

Access & Alignment to the ITRF

- Direct use of ITRF coordinates
- Use IGS Products (Orbits, Clock
- Use high precision GNSS
- Then:

Process GN… stations in free me…

…nates to ITRF values at the central …vations

…m constraints approach

Can use web-based RINEX processing to obtain stn coords in ITRF2008/IGS08

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From ITRF to Regional Reference Frames

Purpose: geo-referencing applications (σ ~ cm)

There are mainly two options to realise a regi
national datum:

1. Station positions at a give
   updated, e.g. North
2. Station positi ation
   positio ope & NZ

Cas

s application of:

(ETRS89)

(New Zealand)

Can use web-based RINEX processing to obtain stn coords in ITRF2008/IGS08

Computing ITRF Coordinates Using GNSS

- Short-baseline DGNSS techniques, connect to Tier 1/2/3.
- Scientific software (Bernese, GMAT, Gipsy), long observation sessions, long baselines, connect to Tier 1/2.
- Web-based processing to connect to ITRF (via Tier 1/2 sites).
- Precise Point Positioning (PPP), using IGS orbit/clock products and special software.
- Currently real-time processing *not* used for reference frame densification/connection.
- 3-D coord result at ”observation epoch” (could be start of week), so need to transform to standard or datum epoch (e.g. 1994.0, 1997.0, 2002.0, 2005.0, 2010.0, etc).
- ITRF2008 realised by IGS08 frame.
- ITRF2008 equivalent to WGS84 (same Ref Epoch 2005.0)

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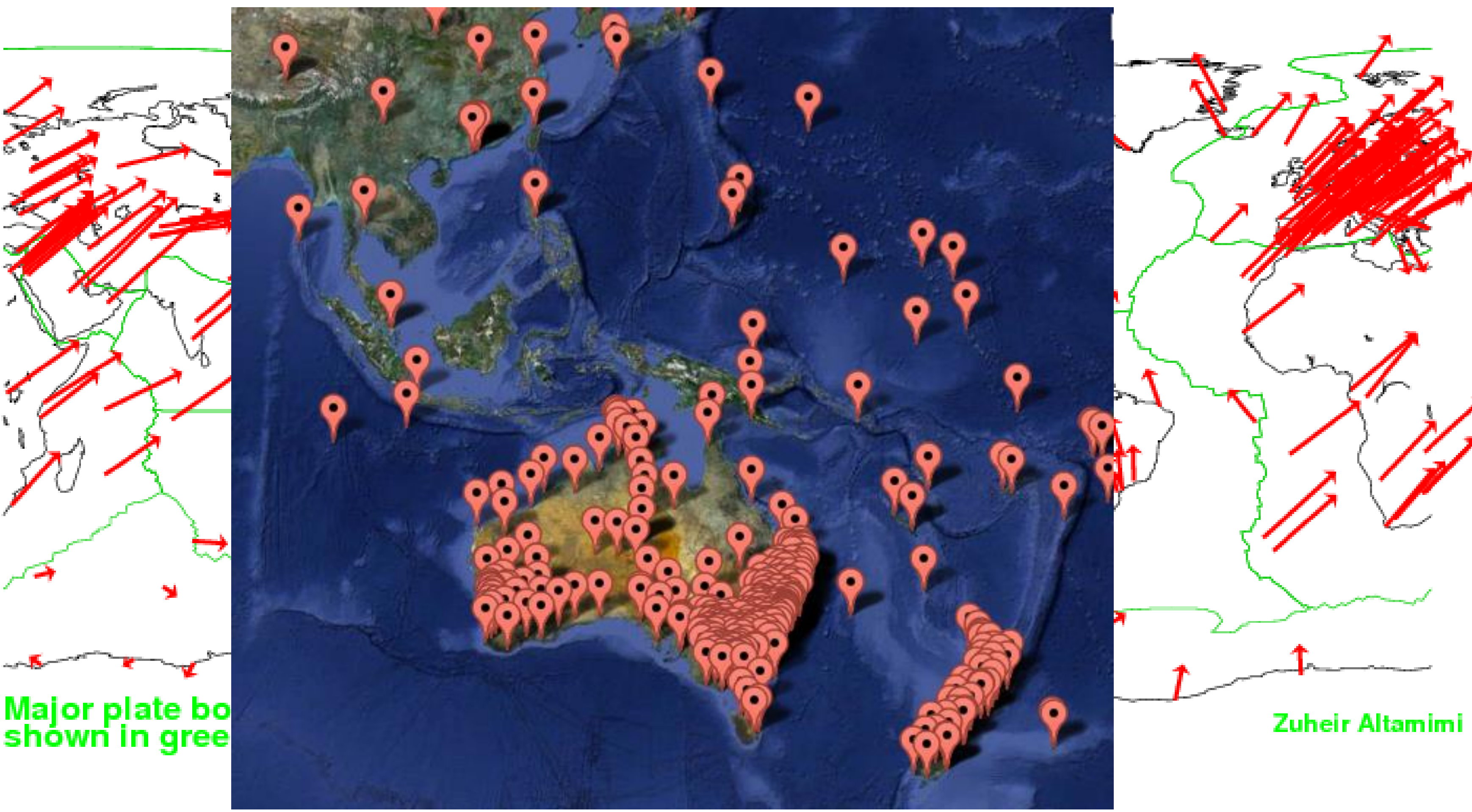
From ITRF to APREF



Using GNSS to density ITRF at regional & national level

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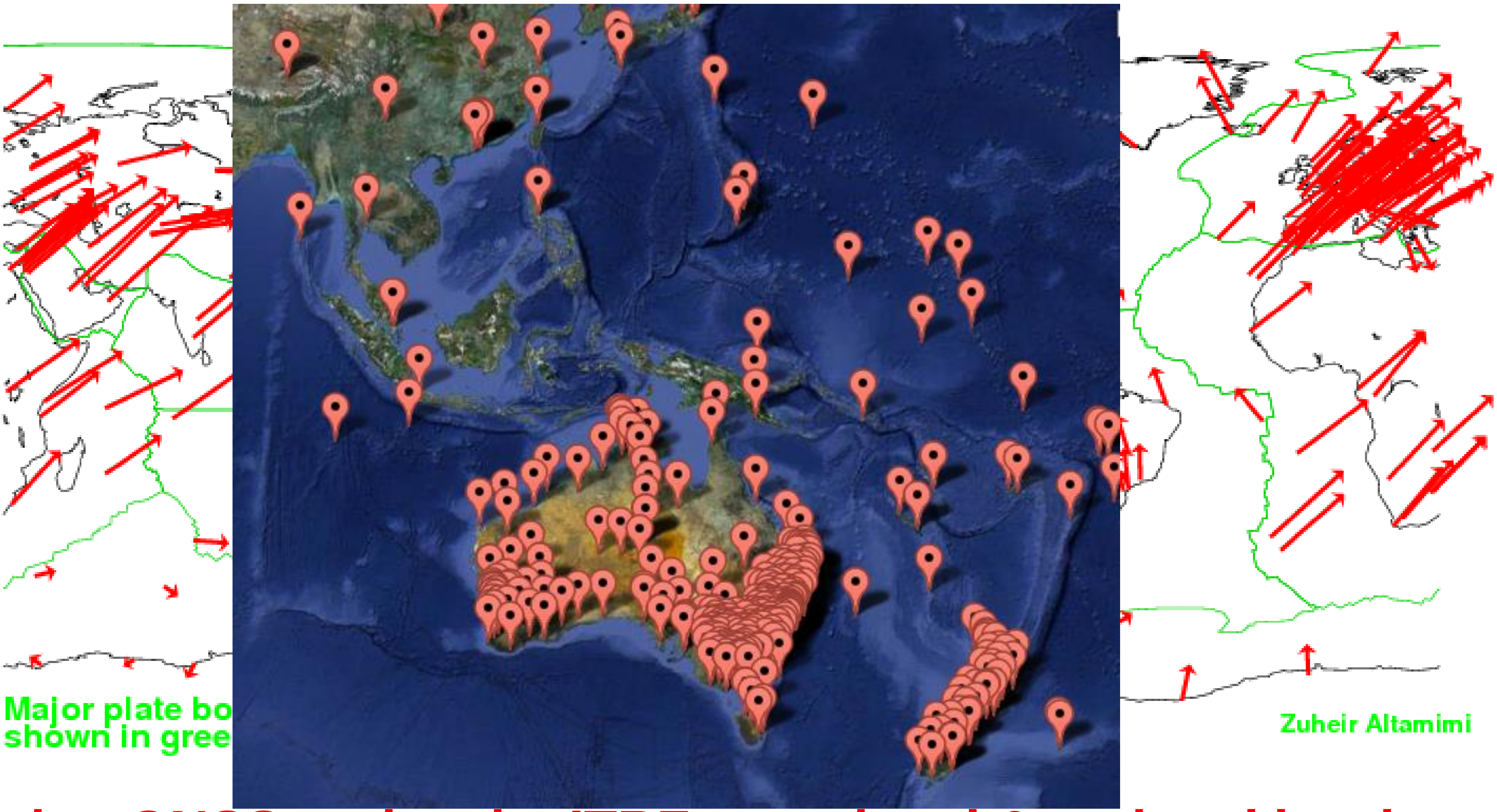
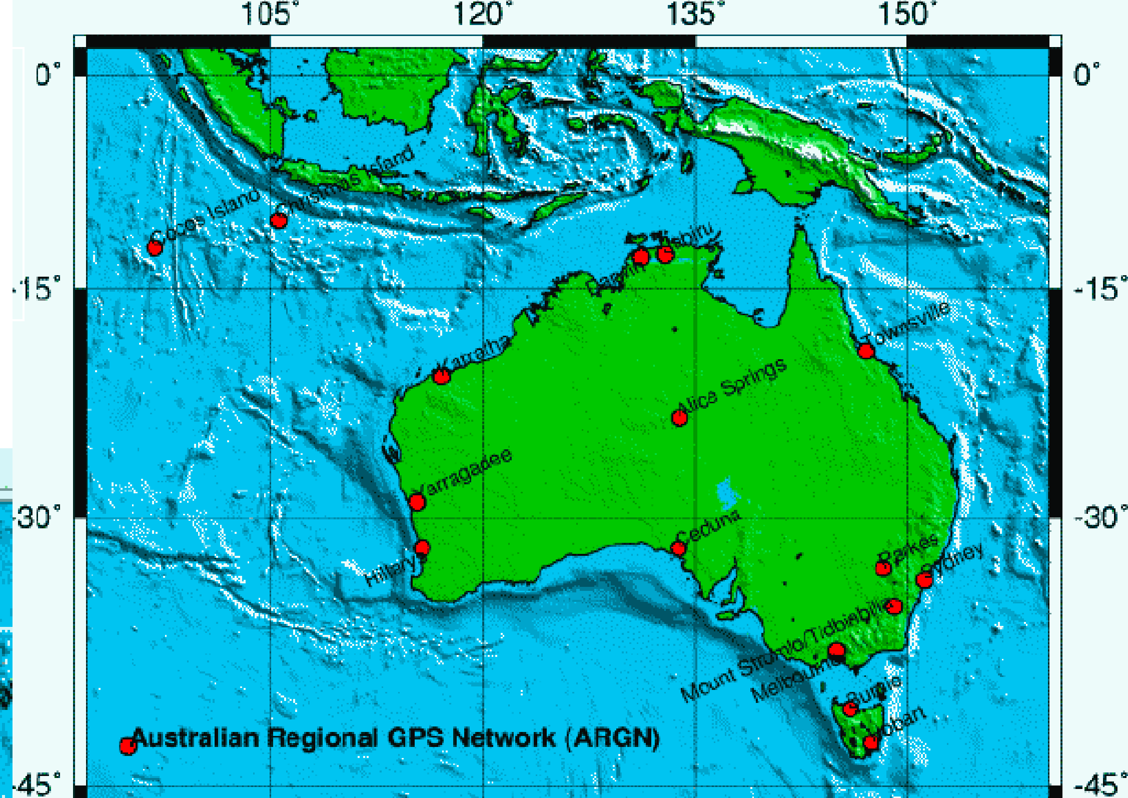
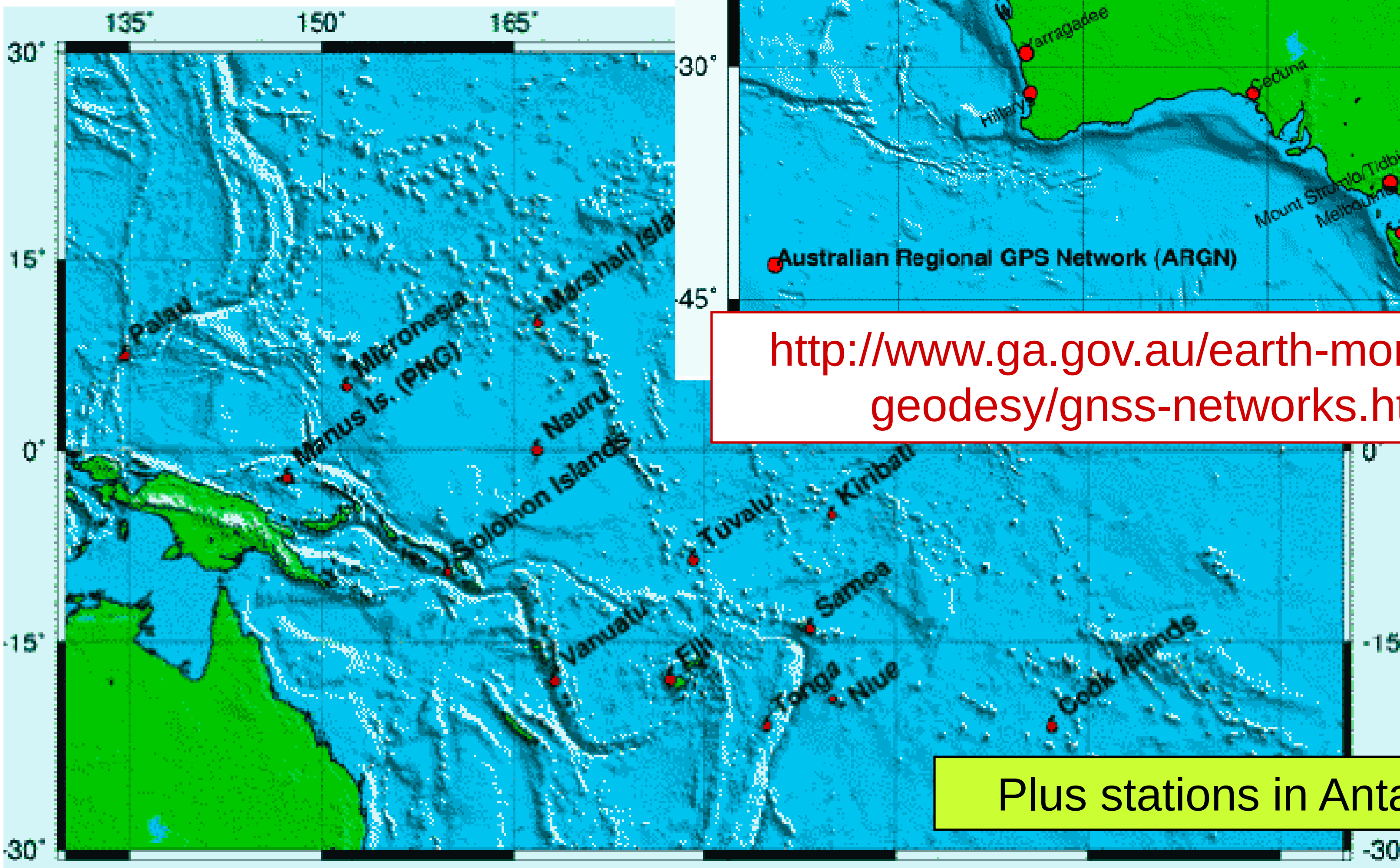
From ITRF to APREF to GDA



Using GNSS to density ITRF at regional & national level

GA's GNSS CORS Stations

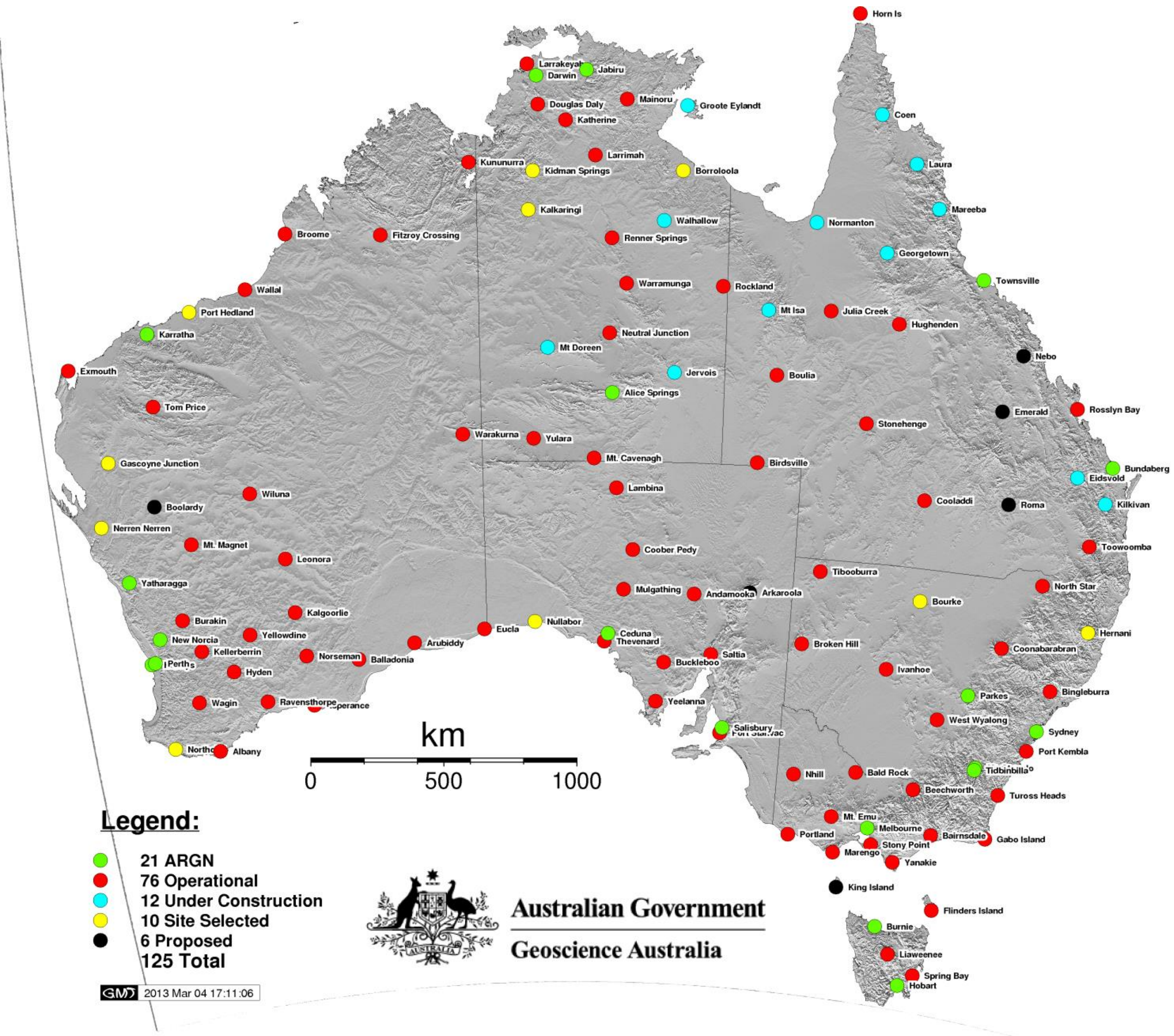




http://www.ga.gov.au/earth-monitoring/geodesy/gnss-networks.html

Plus stations in Antarctica

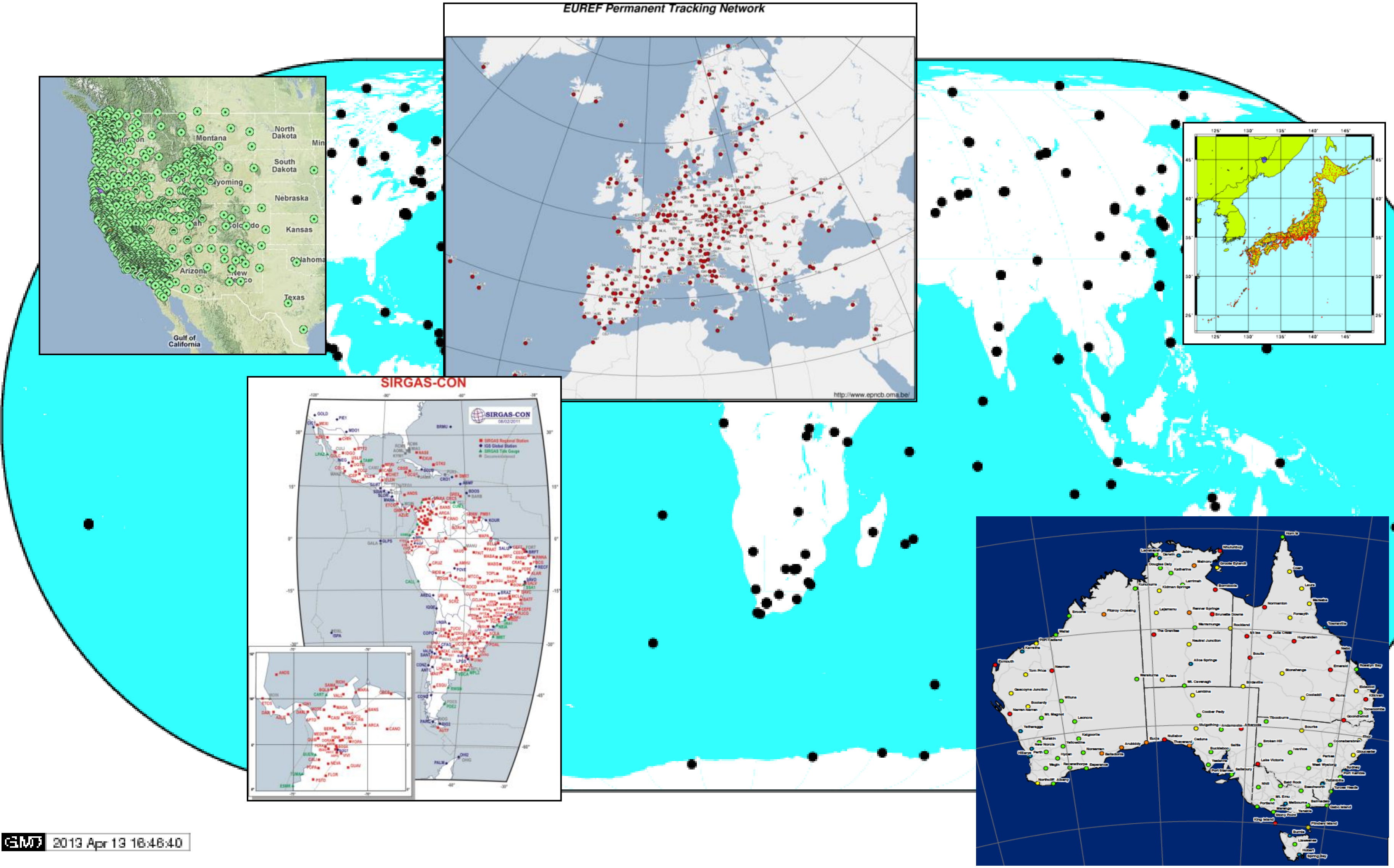
AuScope CORS Infrastructure



Operational:

ALBY	Albany
ALIC	Alice Springs
ANDA	Andamooka
ARUB	Arubiddy
BDLE	Bairnsdale
BRCK	Bald Rock
BALL	Balladonia
BEEC	Beechworth
BING	Bingleburra
BIRD	Birdsville
BOUL	Boulia
BHIL	Broken Hill
BRO1	Broome
BBOO	Buckleboo
BNDY	Bundaberg
BURA	Burakin
BUR2	Burnie
CEDU	Ceduna
XMIS	Christmas Island
COCO	Cocos Island
COOB	Coober Pedy
COOL	Cooladdi
CNBN	Coonabarabran
DARW	Darwin
DODA	Douglas Daly
ESPA	Esperance
UCLA	Eucla
EXTH	Exmouth
FROY	Fitzroy Crossing
FLND	Flinders Island
GABO	Gabo Island
HIL1	Hillarys
HOB2	Hobart
HNIS	Horn Is
HUGH	Hughenden
HYDN	Hyden
IHOE	Ivanhoe
JAB2	Jabiru
JUCK	Julia Creek
KALG	Kalgoorlie
KARR	Karratha
KAT1	Katherine
KELN	Kellerberrin
KUNU	Kununurra
LAMB	Lambina
LKYA	Larrakeyah
LARR	Larrimah
LONA	Leonora
LIAW	Liaweenee
LORD	Lord Howe Is
MAIN	Mainoru
MNGO	Marengo
MOBS	Melbourne
MTCV	Mt. Cavenagh
MTEM	Mt. Emu
MTMA	Mt. Magnet
STR1	Mt. Stromlo
MULG	Mulgathing
NEJN	Neutral Junction
NNOR	New Norcia
NHIL	Nhill
NORF	Norfolk Island
NORS	Norseman
NSTA	North Star
PARK	Parkes
PERT	Perth
PKEM	Port Kembla
PTLD	Portland
PTSV	Port Stanvac
RAVN	Ravensthorpe
RNSP	Renner Springs
RKLD	Rockland
RBAY	Rosslyn Bay
SALB	Salisbury
SA45	Saltia
SBAY	Spring Bay
STON	Stonehenge
STNY	Stony Point
SYDN	Sydney
THEV	Thevenard
TBOB	Tibooburra
TID1	Tidbinbilla
TOMP	Tom Price
TOOW	Toowoomba
TOW2	Townsville
TURO	Tuross Heads
WAGN	Wagin
WLAL	Wallal
WARA	Warakurna
WMGA	Warramunga
WWLG	West Wyalong
WILU	Wiluna
YANK	Yanakie
YAR2	Yatharagga
YEEL	Yeelanna
YELO	Yellowdine
YULA	Yulara

Global CORS Networks



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Earth Monitoring and Reference S

ITRF coords based on IGS08 frame @ observation epoch… Also national datum GDA94 @ 1994.0 epoch

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your GPS RINE

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2. The GPS RINEX file/s do r
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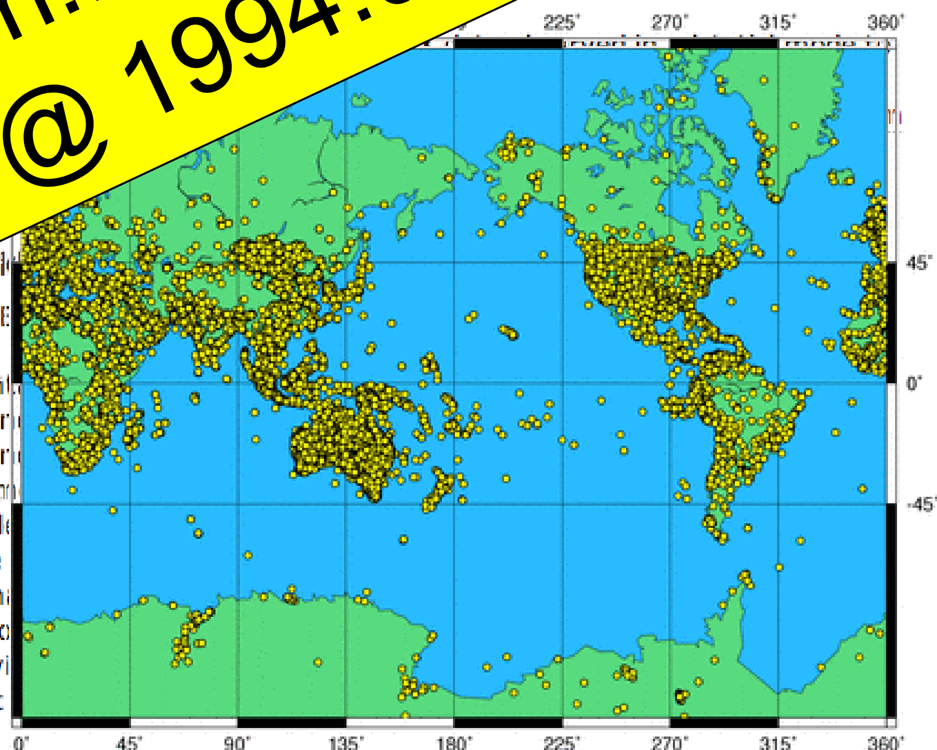
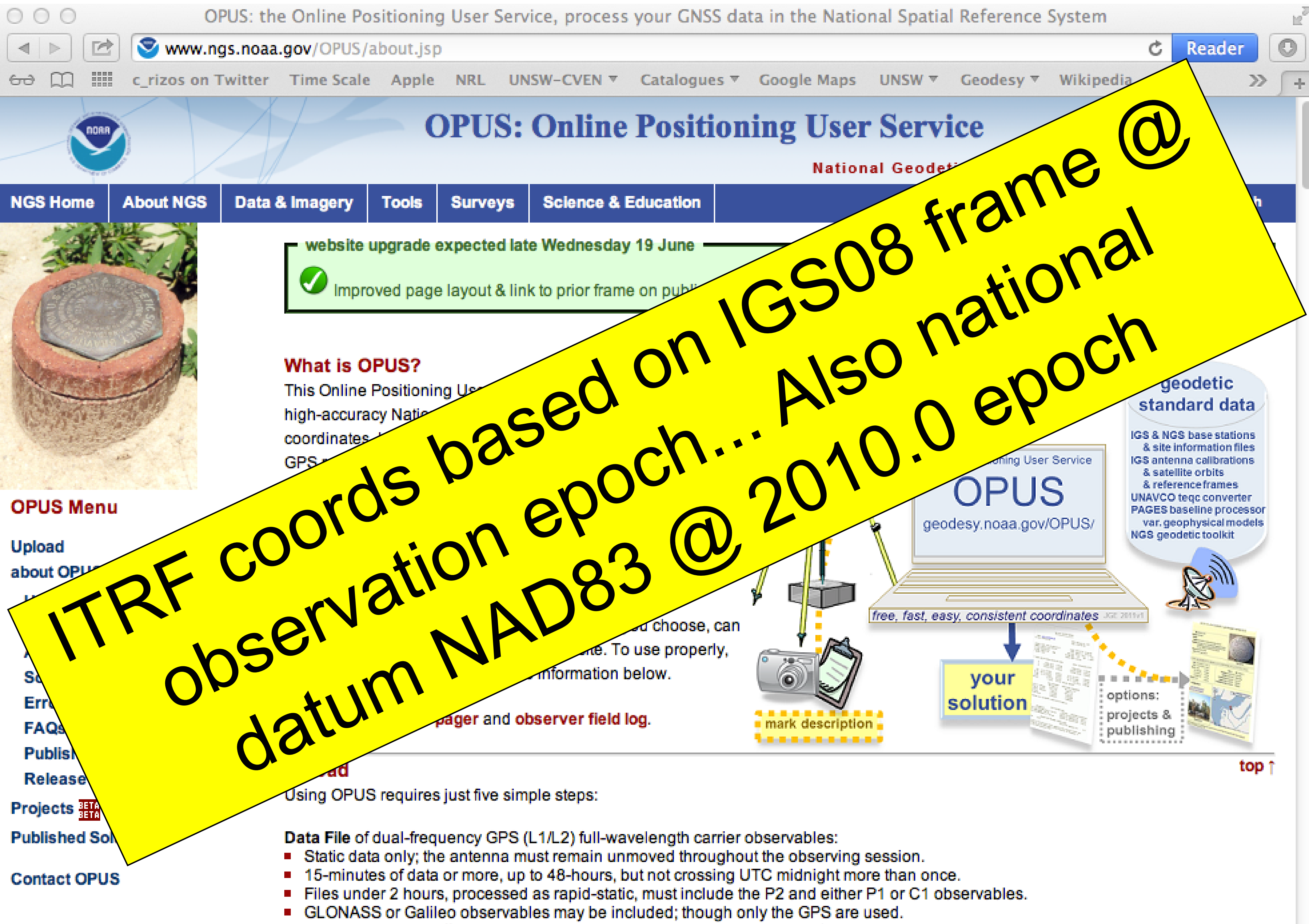
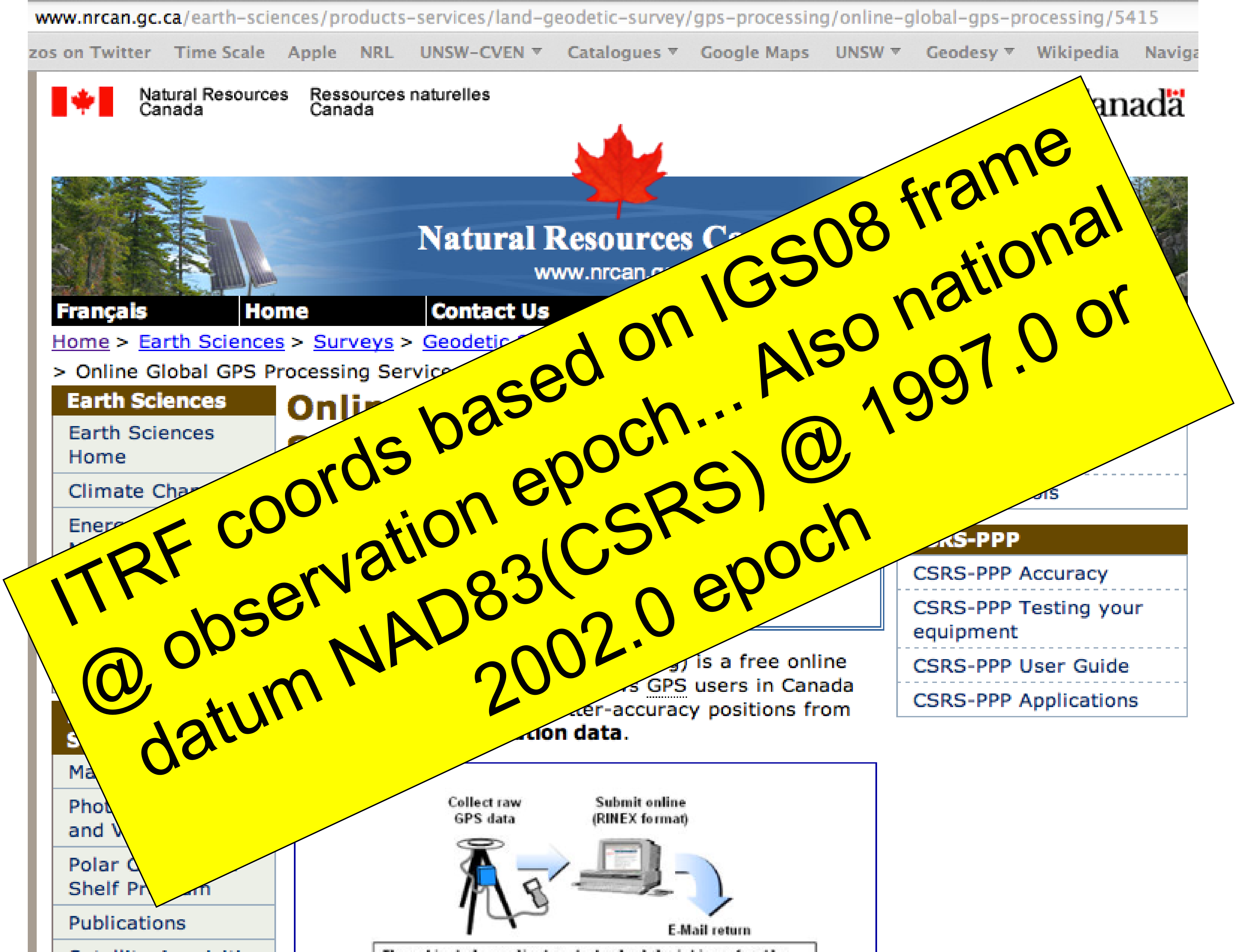
5. When submitting multipl names are not the same
6. You have used the IGS na Geodetic Survey (NGS) fo
7. The antenna height provi Antenna Reference Point



ITRF coords based on IGS08 frame @ observation epoch... Also national datum NAD83 @ 2010.0 epoch





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CSRS-PPP Testing your equipment
CSRS-PPP User Guide
CSRS-PPP Applications
is a free online
GPS users in Canada
positions from
Collect raw GPS data
Submit online (RINEX format)
E-Mail return
ITRF coords based on IGS08 frame @ observation epoch… Also national datum NAD83(CSRS) @ 1997.0 or 2002.0 epoch

Jet Propulsion Laboratory
California Institute of Technology

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Welcome to APPS!
The Automatic Precise Positioning Service
of the Global Differential GPS (GDGPS) System.

APPS is now using GIPSY 6.2

APPS accepts GPS measurement files, and applies the most advanced GPS positioning technology from NASA's Jet Propulsion Laboratory to estimate the position of your GPS receivers, whether they are static, in motion, on the ground, or in the air. APPS employs:

- Real-time GPS orbit and clock products from JPL's GDGPS System
- JPL's daily and weekly precise GPS orbit and clock products
- JPL's GIPSY-OASIS software for processing the GPS measurements

APPS continues to provide JPL's venerable AutoGIPSY (AG) service - for *free*, for static post-processing (e.g. measurement latency of a week or more), but also offers new and unique services:

- APPS will generate a time series of positions if your receiver was in motion
- APPS has access to real-time GPS orbit and clock products so you never have to wait
- APPS is fast. Positioning is available in seconds

S C O U T

Scripps Coordinate Update Tool (SCOUT)

Help/Documentation FAQ SCOUT User Forum

General Notes:
1) SCOUT uses ultra-rapid orbits to allow near-real-time data processing
2) SCOUT supports these GPS models only. Do not use RINEX files from other models.
3) SCOUT limits users to 10 uncompleted (queued) jobs at a time. Average run time is 30 minutes. SCOUT now launches jobs to multiple servers (when available) to reduce wait times.

Your e-mail address:
(e.g., jdoe@hostname.com)

Select one of the following two methods to provide your input RINEX file:
1) URL of anonymous ftp RINEX file:
(e.g., ftp://ftpservername.edu/pub/rinex/YYYY/DDD/site0010.03o.Z)

2) Select a RINEX file from SOPAC's upload directory: (Help)
Upload instructions: ftp geopub.ucsd.edu (login: scout password: coordgen);
put filename (e.g., site0010.03o.Z)
None

RINEX File Notes:
1) Files may be in obs (o) or hatanaka (d) format, and may be compressed (.Z, .gz, .bz, .bz2). .zip files are not supported. Please limit file upload size to 10 MB; teqc can decimate files to 30 second observations.
2) Minimum recommended file time span: 1 hour
3) Recently-uploaded files may not appear in this pulldown. To update the list, hold down the Shift key and press Reload (or Refresh) in your browser.

The Value of Reference Frames to Society (1/2)

- **Fundamental geoscience**… *solid earth geophysics, atmospheric, cryospheric & oceanographic processes, hydrology*.
- **Global Change studies**… *climate change (causes & effects), water cycle & mass transport changes, sea level rise, mesoscale circulation, GIA, polar studies*.

> - Need continuity of ITRF to very high accuracy… *to be provided by the full ensemble of space geodetic techniques*
> - Primary signals are derived from (small) changes or trends in geodetic parameters
> - Use GNSS to connect to the ITRF
> - Extensive use of IGS products… *but careful data processing strategies are necessary*

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The Value of Reference Frames to Society (2/2)

- **Geohazard research**… *seismic, volcanic, landslip, storms, sea state, flooding, tsunami, space weather.*
- **Geodetic reference frames**… *ITRF, national datums & SDI, gravity, timing*.
- **Engineering**… *precise positioning/navigation, atmospheric sounding, geo-referencing platforms, operational geodesy, radar & laser imaging/scanning, engineering geodesy, surveying*.

> - ITRF traceability… *"fit for purpose" conditions apply*
> - Long-term stability not necessarily important for many applications
> - Use GNSS to connect to the national or local datum, and used for densification
> - Extensive use of IGS & national/local CORS data… *simplified data processing tools are often adequate*

IAG 150 years

Thank You

150th Anniversary

1862-2012