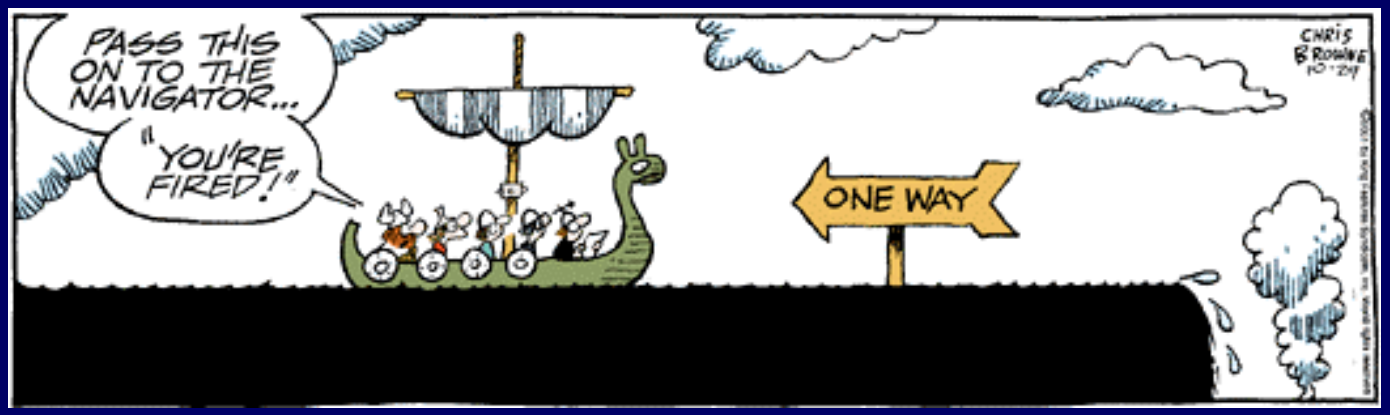
42nd Association of Surveyors PNG
Congress, Holiday Inn, Port Moresby
9th-12th July 2008

A Dynamic Datum for PNG

Improving PNG94

Richard Stanaway *QUICKCLOSE*



PNG94

WGS72

AGD66

AGD84

WGS84

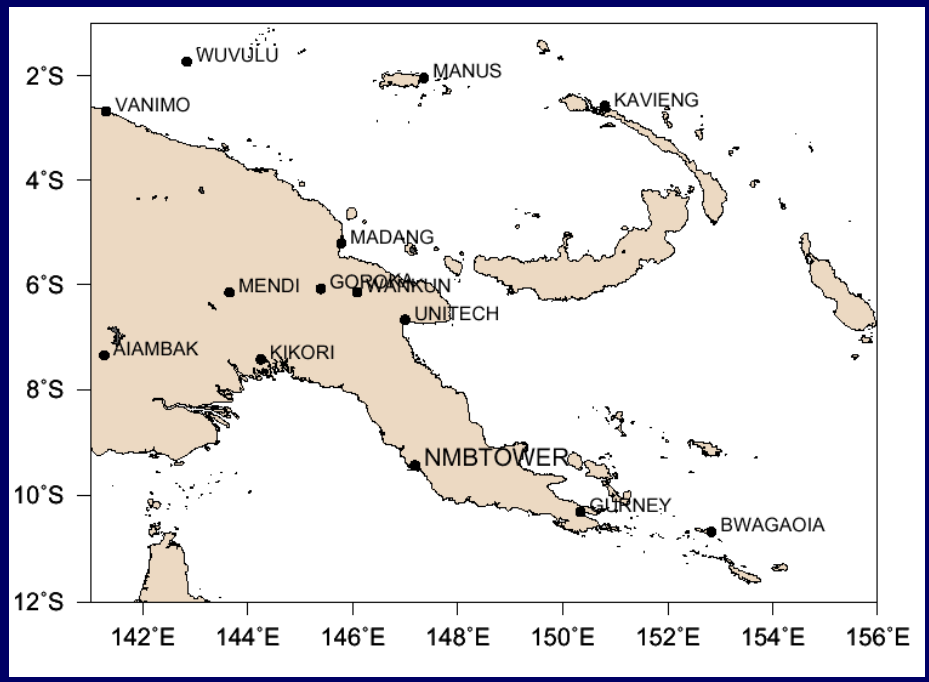
What is PNG94?

14 Stations around PNG surveyed by GPS between 1992 and 1994

Aligned with ITRF92 epoch 1994.0

Same realisation as GDA94 in Australia

Accurate to 5 cm



Gazetted national geodetic datum for PNG

What is ITRF?

International Terrestrial Reference Frame

ITRF is the international geodetic datum used by geodesists and basis for national geodetic datums

It is dynamic like WGS84 and coordinates change constantly up to 10 cm/yr due to tectonic motion.

ITRF is similar to WGS84 at 10 cm

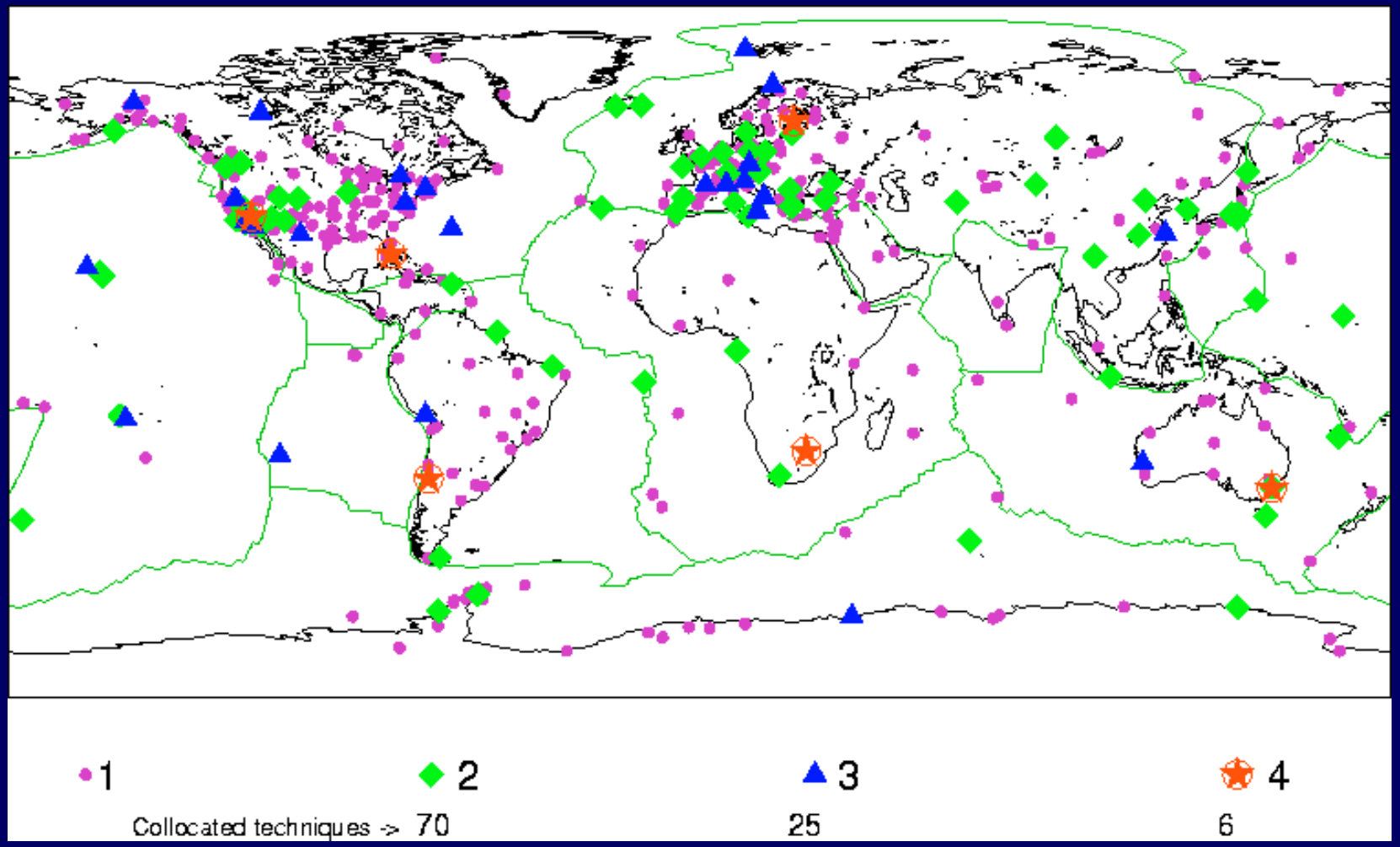
ITRF defined by coordinates of stations at a reference epoch,

AND

Site velocities (how rapid tectonic movement is)

This means that instantaneous coordinates can be converted to any other epoch

Current version is ITRF2005, accurate to 3 mm



ITRF Station network

What is WGS84?

World Geodetic System 1984

WGS84 is the datum used by the US DoD for GPS orbit ephemeris

It is dynamic like ITRF and coordinates change constantly up to 10 cm/yr due to tectonic motion.

WGS84 is similar to ITRF at 10 cm

Datum network of WGS84 is sparse (tracking stations)

There is no WGS84 datum reference in PNG!!!!!

So why do we see WGS84 being used everywhere??

WGS84 is only suitable as a datum for navigation (pilots/ships) in PNG (+/- 3 metres)

Isn't PNG94 the same as WGS84?

NO!!!!! **Why not?**

Ellipsioid is almost the same 0.2mm, BUT

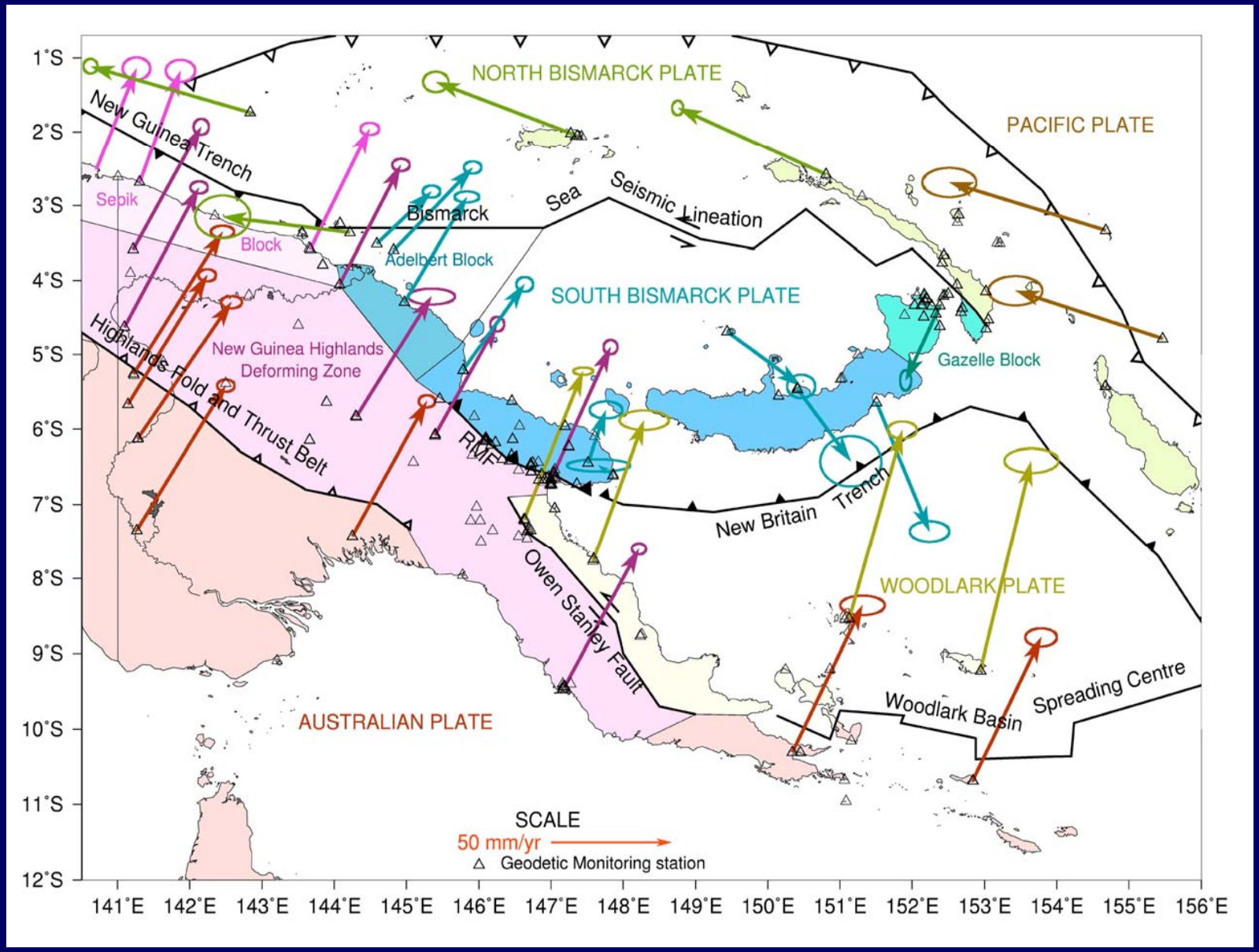
PNG94 coordinates are frozen in time (1st January 1994) - Static Datum of 14 PNG stns

WGS84 coordinates change by up to 10 cm a year due to tectonic movement (dynamic datum), nearest station is in Marshall Is.

PNG94 and WGS84 now up to 1.5 m different and difference is increasing every year by several cm

If you get WGS84 data, ask what the datum point is and when & how the coords were obtained?

Problems with tectonics



Problems with a static PNG94

Baselines across PNG changing by up to 140 mm/yr

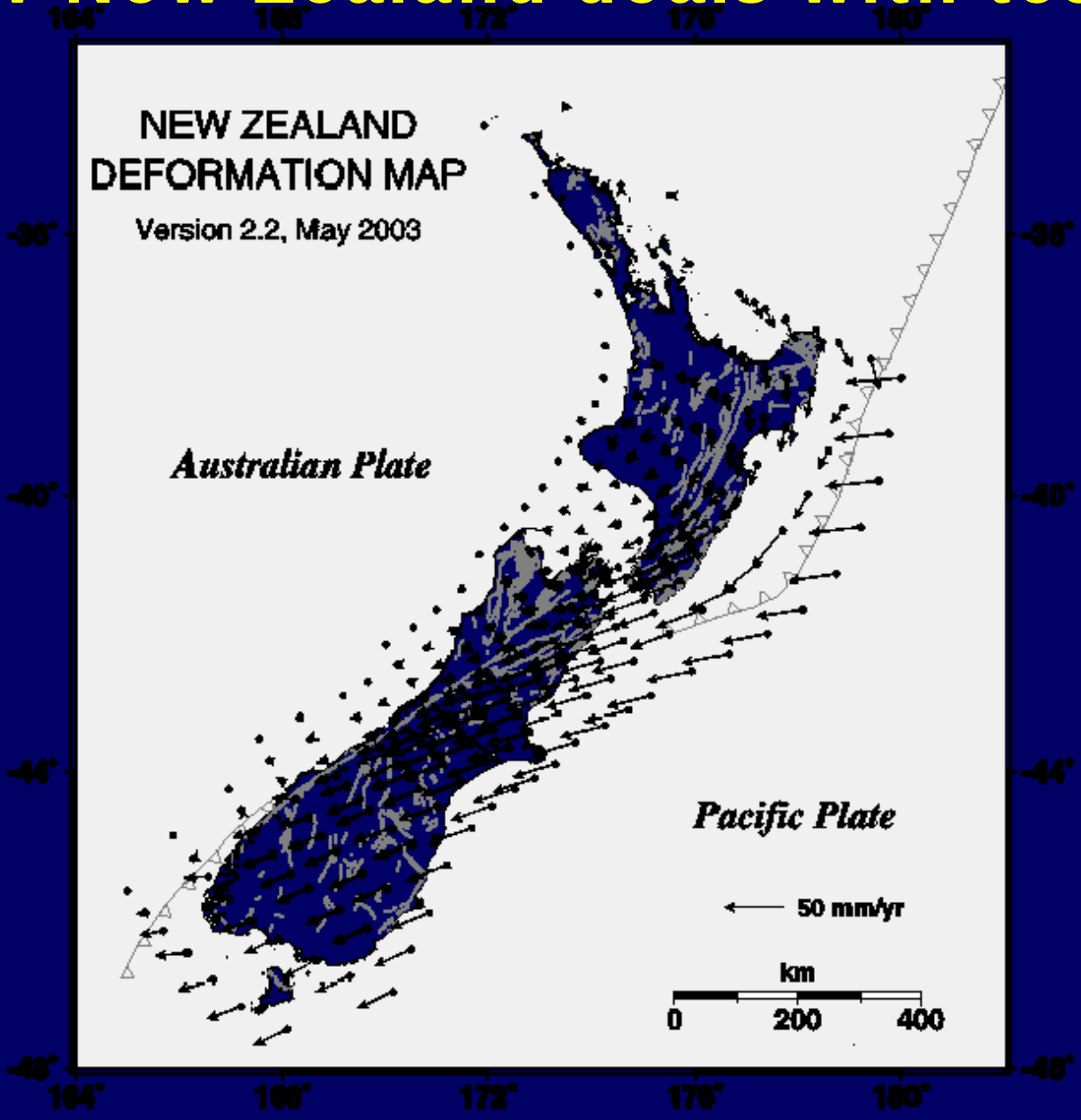
Can't use precision GPS across plate boundaries because coordinates will be different when repeat survey is done

Constantly changing coordinates for assets, land surveys and GIS are unmanageable and lead to gross errors

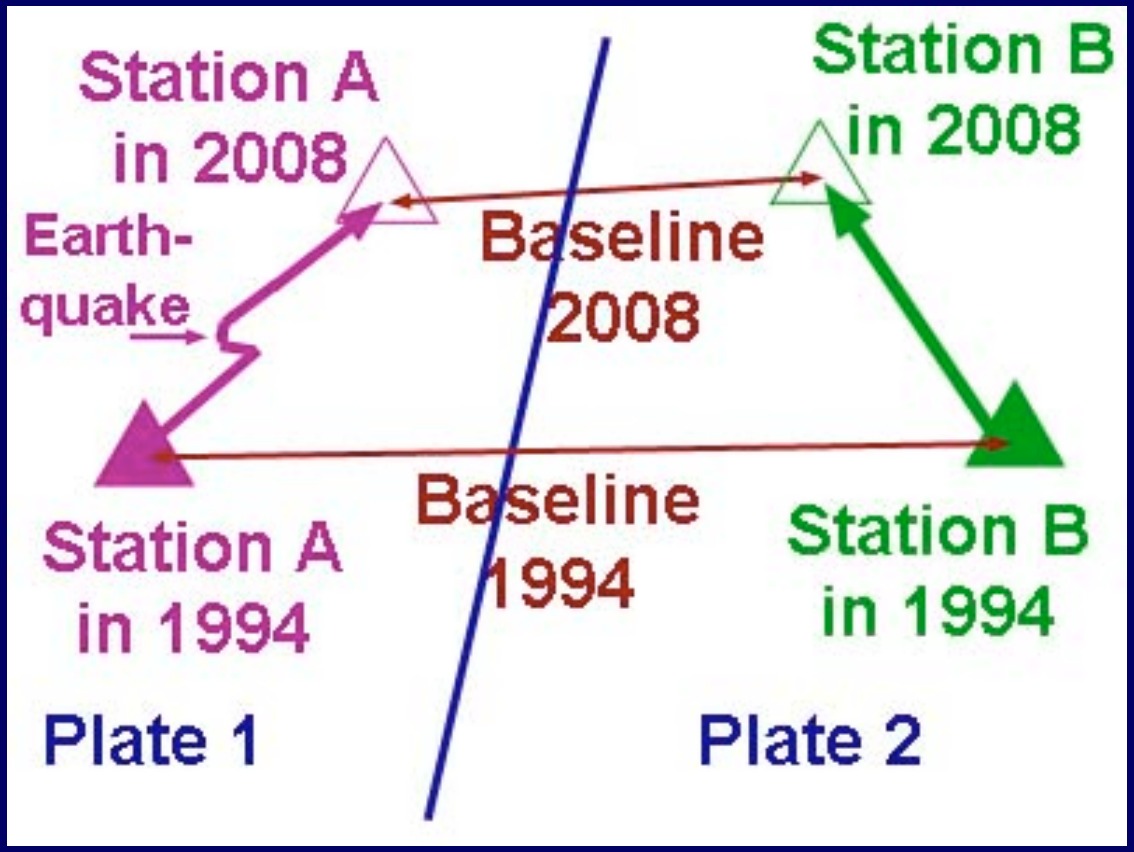
Coordinates should relate to a common fixed reference epoch (e.g. 1994.0), even in a dynamic environment like PNG

It's not a problem in Australia (i.e. for GDA94) because internal tectonic movement is < 1 mm/yr

How New Zealand deals with tectonics



Effect of tectonic deformation on survey baselines & PNG94



Need to use a model to get back to 1994 coordinates

There isn't a velocity model in PNG94?

Site velocity is required to convert ITRF & WGS84 coordinates to PNG94 e.g. AUSPOS, OmniSTAR-HP

Model of coseismic and postseismic displacements also required if site is affected by large earthquakes

Need a velocity model to enable baseline measurement across plate boundaries (even with PNG94)

Without a model you can't use LAE1 and MORE as a base station for other areas of PNG

Should use the nearest validated PNG94 station <u>on the same plate</u>

How do you use a velocity model?

A velocity model is used to compute dynamic coordinates for any point in time (epoch)

The site velocity is the rate of change of coordinates due to overall tectonic movement

$$E_{PNGMG} = E_{UTM\,(ITRF)} + V_E\,(1994.0 - Y_M)$$

$$N_{PNGMG} = N_{UTM\,(ITRF)} + V_N\,(1994.0 - Y_M)$$

E_{PNGMG} and N_{PNGMG} are the PNG Map Grid Coords.

$E_{UTM(ITRF)}$ and $N_{UTM(ITRF)}$ are the ITRF/WGS84 UTM Coords at the time of measurement

V_E and V_N are site velocity components (Easting and Northing)

1994.0 and Y_M is the reference epoch and measurement epoch

Example - Using OmniSTAR-HP or AUSPOS

Measurement made near Hides on 2nd July 2008

ITRF2000 UTM Zone 54 **E 725073.31 N 9310194.84**

1. Compute epoch of measurement

Y_M = 2008 + 184/366 = **2008.503**

2. Determine site velocity from model

V_E = 0.032 m/yr V_N = 0.054 m/yr

3. Compute coordinate change from 2008.503 to 1994.0

$diff\,E$ = 0.032(1994.0-2008.503) = **-0.464 m**

$diff\,N$ = 0.054(1994.0-2008.503) = **-0.783 m**

4. Compute PNG94 (PNGMG) Coordinates

E_{PNGMG} = 725073.31 + -0.464= **725062.85**

N_{PNGMG} = 9310194.84 + -0.783= **9310194.06**

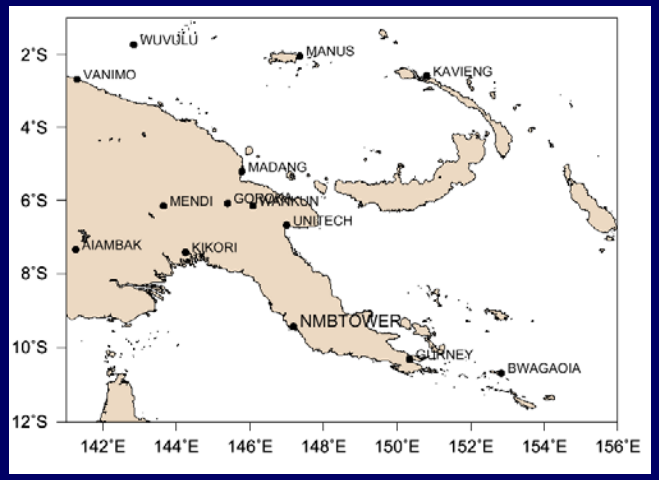
Improvements to PNG94

ANU, NMB, UniTech & UCSC have gathered a huge dataset of GPS observations at over 100 stations around PNG

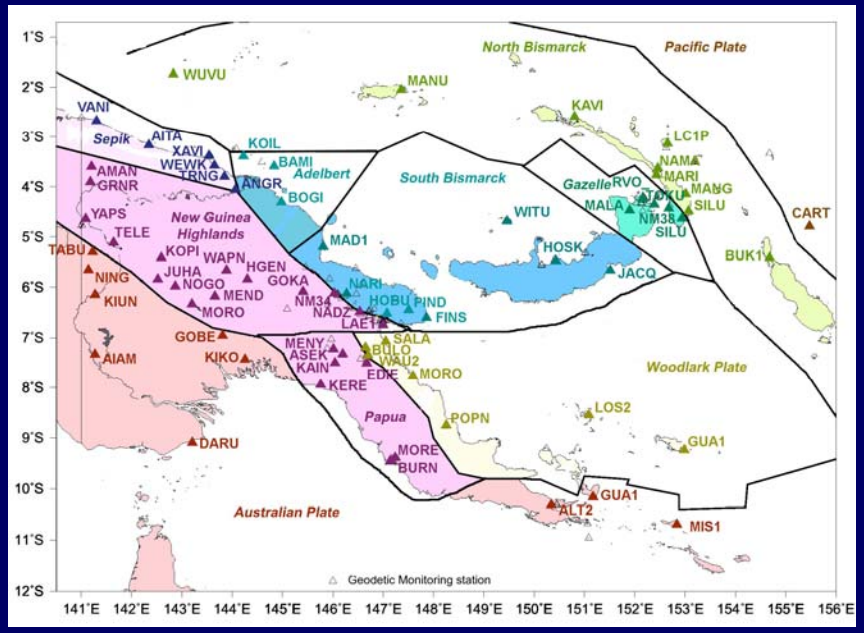
All this data needs to be collated to densify PNG94

Minimal cost involved to do this <K50,000

Who will fund it?



to



PNG94 1st order control listing - Provisional update 7th June 2008 (verification required)

Station location			PNG94 Ellipsoidal Coordinates			PNGMG94 Grid Coordinates			MSL	Site Velocity	
Location	GPS ID	NMB Reg. No.	Latitude	Longitude	Ellipsoid Height	Zone	Easting	Northing	RL	E m/yr	N m/yr
Aiambak	AIAM	PSM 9550	-7°20'51.8206"	141°16'01.4470"	95.52	54	529475.73	9187801.94	21.7	0.037	0.058
Alotau - Gurney Airport	ALT2	PSM 9538	-10°18'37.5094"	150°20'18.0912"	94.87	56	208478.37	8859053.57	16.3	0.031	0.058
Buka Airport	BUK1	PSM 4871	-5°25'34.3712"	154°40'08.4373"	73.25	56	684918.22	9399967.57	4.3	-0.059	0.031
Daru	DARU	AA 440/A	-9°05'15.5229"	143°12'27.1952"	80.28	54	742639.83	8994719.42	4.9	0.035	0.055
Finschhafen	FINS	PSM 19471	-6°36'55.4209"	147°51'17.6868"	74.24	55	594504.66	9268686.35	9.5	-0.006	0.004
Goroka - Airport	GOKA	PSM 9833	-6°04'53.0717"	145°23'30.4470"	1664.47	55	322023.98	9327531.64	1585.4	0.023	0.046
Hoskins - Airport	HOSK	PSM 9795	-5°28'00.4073"	150°24'31.6614"	101.35	56	212869.72	9395119.32	18.0	0.022	-0.027
Kavieng - Airport	KAVI	PSM 9513	-2°34'53.0660"	150°48'22.5361"	78.81	56	256077.96	9714464.61	2.7	-0.067	0.027
Kenabot - Lands Base	KENB	PSM 23342	-4°20'45.1168"	152°16'07.9951"	136.69	56	418875.65	9519602.79	63.2	-0.002	-0.041
Kerema - Catholic Mission	KERE	PSM 31703	-7°57'28.0191"	145°46'19.0726"	97.57	55	364647.58	9120168.45	21.5	0.030	0.052
Kikori - Airport	KIKO	PSM 5583	-7°25'24.6531"	144°14'55.7677"	88.93	55	196298.45	9178490.00	12.01	0.035	0.054
Kiunga - Airport	KIUN	PSM 9465	-6°07'37.9805"	141°16'41.2696"	103.27	54	530773.45	9322724.61	27.7	0.038	0.056
Lae - Unitech DSLS Base	LAE1	PSM 31107	-6°40'25.3661"	146°59'35.4668"	140.37	55	499246.79	9262320.80	67.12	0.026	0.052
Lae - Unitech Sports	9799	PSM 9799	-6°40'16.9707"	146°59'52.3754"	130.31	55	499765.91	9262578.60	57.06	0.026	0.052
Lake Kopiago - Airport	KOPI	PSM 17001	-5°23'09.0852"	142°29'42.1907"	1412.79	54	665650.98	9404480.51	1327.7	0.031	0.055
Losuia	LOSU	AA 583	-8°32'07.2596"	151°07'30.8181"	85.16	56	293644.60	9056016.40	6.1	0.021	0.071
Madang - Airport	MAD1	GS 15495	-5°12'41.2891"	145°46'56.1940"	73.27	55	365044.17	9423829.87	5.0	0.023	0.039
Manus - Lombrum Secor	MANU	PSM 9522	-2°03'02.2944"	147°21'37.6363"	129.77	55	540084.32	9773337.48	50.8	-0.065	0.027
Mendi	MEND	PSM 3507	-6°08'36.7344"	143°39'22.1658"	1815.08	54	793981.21	9320198.80	1732.6	0.029	0.047
Misima - Airport	MIS1	PSM 9195	-10°41'19.9049"	152°49'58.9388"	87.46	56	481741.61	8818417.91	13.1	0.030	0.055
Moro - Airport	MORA	PSM 17442	-6°21'44.9072"	143°13'46.0940"	917.86	54	746627.49	9296194.53	837.4	0.033	0.054
Mount Hagen - Airport	HGEN	PSM 3419	-5°49'55.7591"	144°18'23.7948"	1710.15	55	201725.79	9354636.51	1626.5	0.030	0.048
Nadzab - Airport	NADZ	ST 31024	-6°33'47.9879"	146°43'39.6541"	148.83	55	469894.96	9274514.88	77.4	0.024	0.056
Namatanai - Airport	NAMA	GS 19461	-3°39'58.5422"	152°26'06.1582"	114.96	56	437261.32	9594742.59	43.9	-0.061	0.001
Nogoli Hides - Helipad	NOGO	PSM 30041	-5°56'02.4348"	142°47'16.7455"	1340.20	54	697930.59	9343770.78	1257.5	0.032	0.054
Pomio	JACQ	PSM 9515	-5°38'42.9782"	151°30'19.6067"	151.55	56	334476.29	9375795.22	77.3	0.020	-0.053
Popondetta	POPN	PSM 9371	-8°46'09.6499"	148°14'00.3966"	187.53	55	635667.54	9030425.34	106.8	0.024	0.054
Port Moresby - NMB Base	MORE	PSM 15832	-9°26'02.7696"	147°11'12.2016"	116.74	55	520498.42	8957148.59	41.3	0.028	0.053
Rabaul - RVO Base	RVO_	RVO	-4°11'27.1915"	152°09'49.5108"	266.24	56	407190.52	9536723.33	191.9	0.007	-0.052
Tokua - Airport	TOKU	GS 9822	-4°20'27.7832"	152°22'45.8215"	82.05	56	431137.64	9520146.01	9.5	-0.010	-0.036
Vanimo - Doppler	VANI	PM 63/1	-2°41'05.2819"	141°18'15.6562"	80.59	54	533829.65	9703242.49	3.4	0.013	0.045
Wankkun - Pillar	NM34	NM/J/34	-6°08'52.0739"	146°04'52.4422"	509.98	55	398344.12	9320370.15	436.7	0.026	0.047
Wau - MCG Base New	WAU1	WAU1	-7°20'57.0996"	146°42'55.7613"	1224.79	55	468599.31	9187638.65	1144.5	0.025	0.056
Wewak - Airport	WEWK	PSM 15497	-3°35'02.5848"	143°40'00.1481"	83.91	54	796268.18	9603418.22	5.8	0.017	0.053
Wuvulu	WUVU	PSM 15456	-1°44'07.5951"	142°50'10.0781"	79.03	54	704257.66	9808081.66	2.4	-0.068	0.019

Horizontal Coordinates - Positional Uncertainty < 0.05m, Ellipsoidal Heights - Uncertainty < 0.10m, MSL RLs - Uncertainty < 0.5m (except Lae & Kikori < 0.10m)

* **Coordinates require verification by resurvey**

An preliminary update for PNG94 showing selected stations

Urgent action required!

Escalation of development in 2008-2009 requires connection to PNG94 (not WGS84)

Collate existing data (partially done but K$ required)

Resurvey of selected important stations in the PNG geodetic network (NMB GS requires funds)

Levelling between tide gauges and GPS stations at selected locations to validate MSL datum / geoid model

Development of a Windows based PNG Velocity calculator (software & via online javascript)

Small investment by PNG for enormous gains in integrity of PNG's geospatial infrastructure. It will save billions of Kina in years to come

PNG94 must be easier to access

Information MUST be available on the internet

- PNG94 coordinates (and equivalent AGD66)
- PSM sketches (scanned to pdf format)
- site velocity calculator (i.e. Javascript)
- clickable map for above info

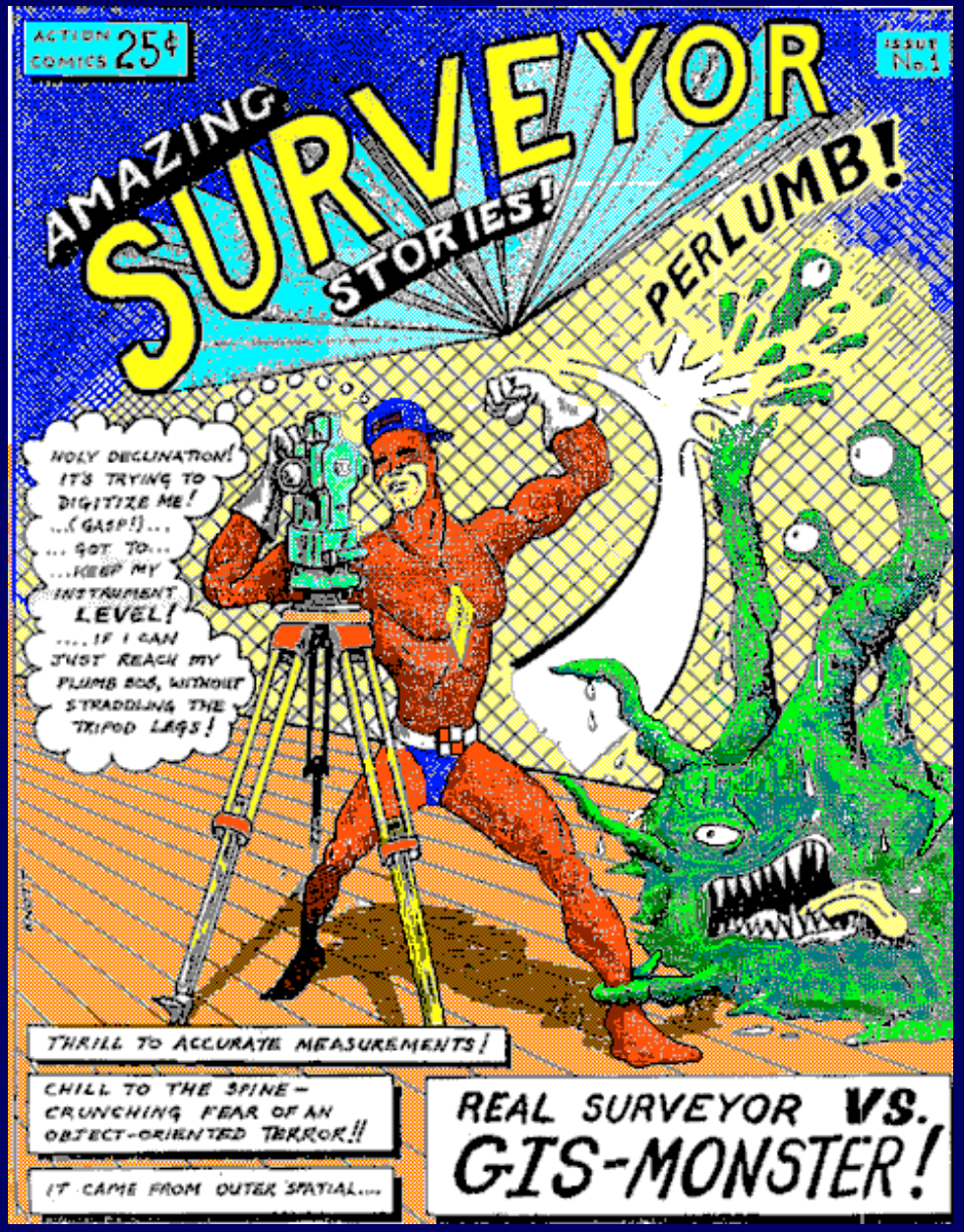
Need web-host access via NMB portal

Online GPS processing PNGPOS - down the track

Getting GIS working with PNG94

The GIS monster needs to be fed good parameters!

Otherwise we will have a real spatial horror show



datum setup for PNG GIS

PNG94 to be setup in GIS datum selection

Can use WGS84 ellipsoid & UTM projection parameters (almost the same as GRS80 used by PNG94 & ITRF), PNMGMG is a UTM projection

Nationwide development of AGD66 to PNG94 transformation parameters for GIS use

Molodensky 3 parameters and 7 parameter model

Provincial and location specific parameters

Distortion grid file (block shift corrections)

The default NGA parameters (AGD66 - WGS84) are inaccurate to 7-8 metres in PNG! Warning!!

Requires resurvey of selected AGD66 primary stations in towns/development areas (NMB GS)

Take away points

Baselines change across plates up to 140 mm/yr

Can't do constrained adjustment across plates

ITRF & WGS84 coordinates change up 100 mm/yr (e.g. AUSPOS and OmniSTAR-HP)

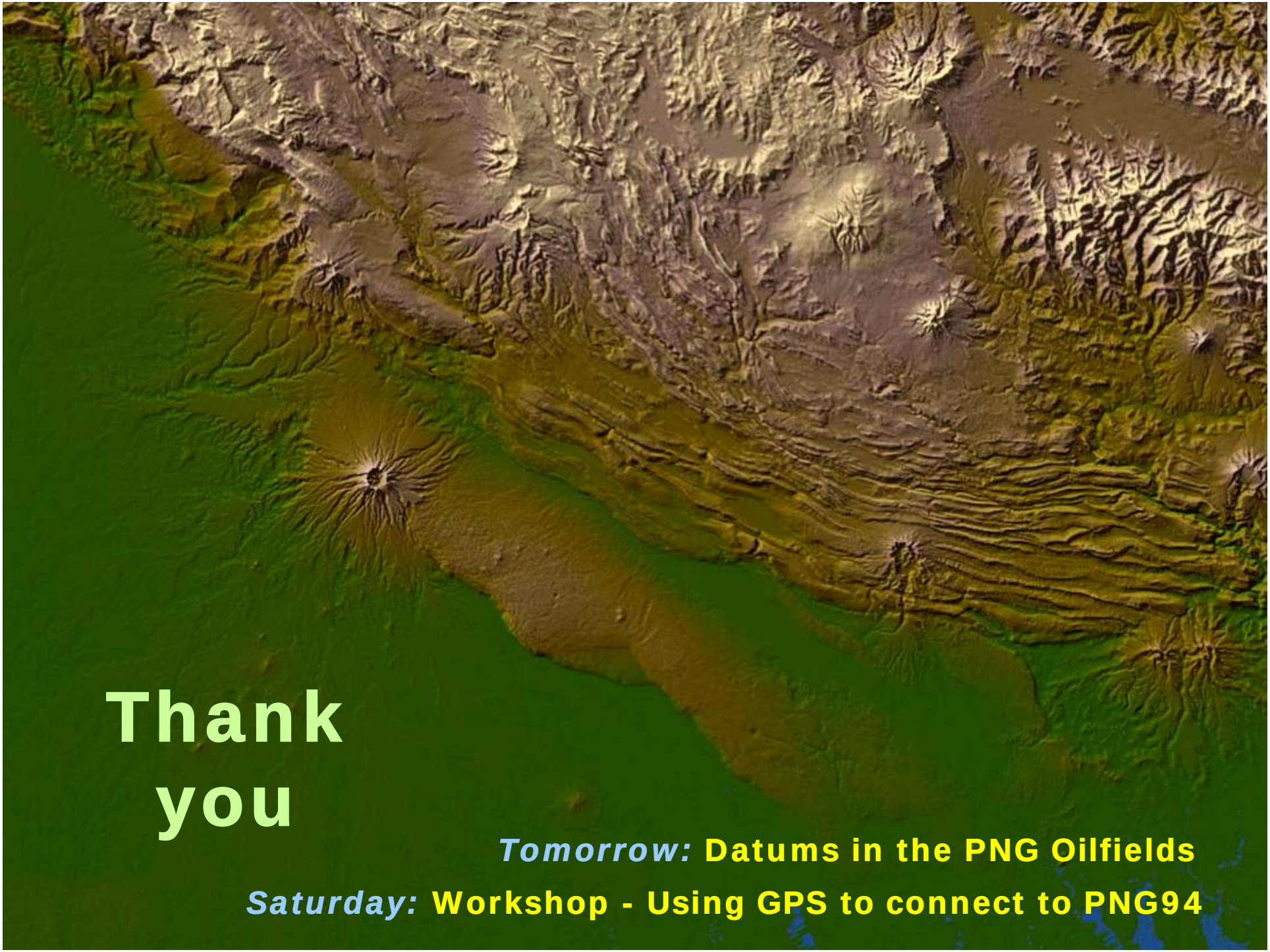
Large earthquakes cause changes of metres

Have to use fixed reference epoch e.g. 1994.0 (PNG94) so coords don't change constantly

Have to use nearest base station on same plate (e.g. can't use MORE for ENB surveys)

AUSPOS and OmniSTAR-HP need to be converted to PNG94 using site velocities. What are they??

We need to get with the times!


Thank you
Tomorrow: Datums in the PNG Oilfields
Saturday: Workshop - Using GPS to connect to PNG94