PNG2020

A new geodetic datum and associated tectonic kinematic model for PNG

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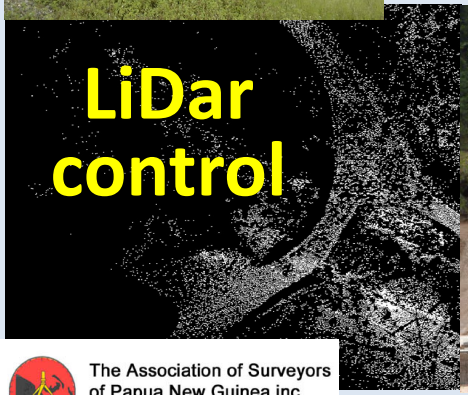
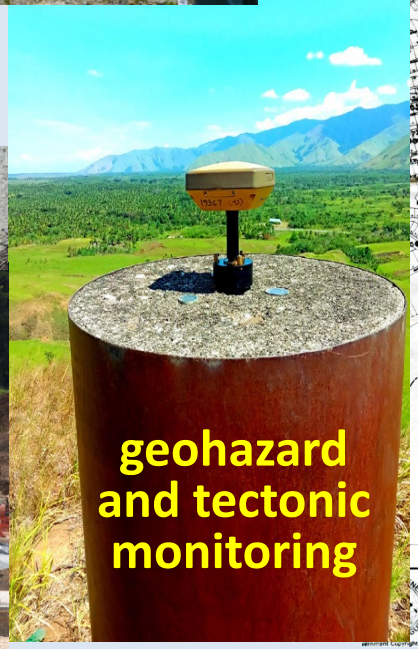
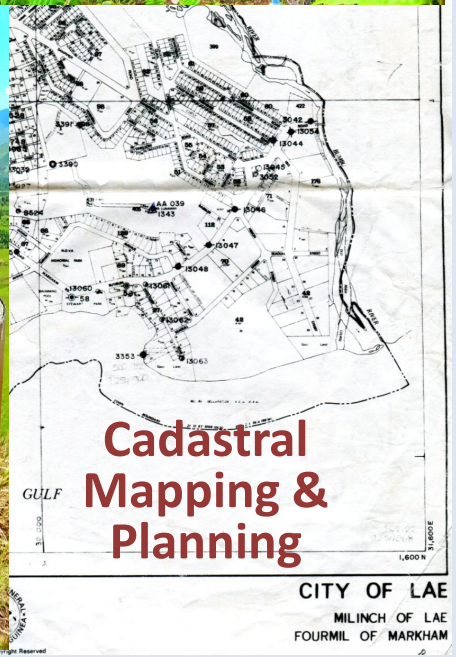
56th ASPNG Annual Congress, PNGUoT, Lae , PNG, 16-18 October 2024

Importance of the PNG geodetic network

Topographic Mapping







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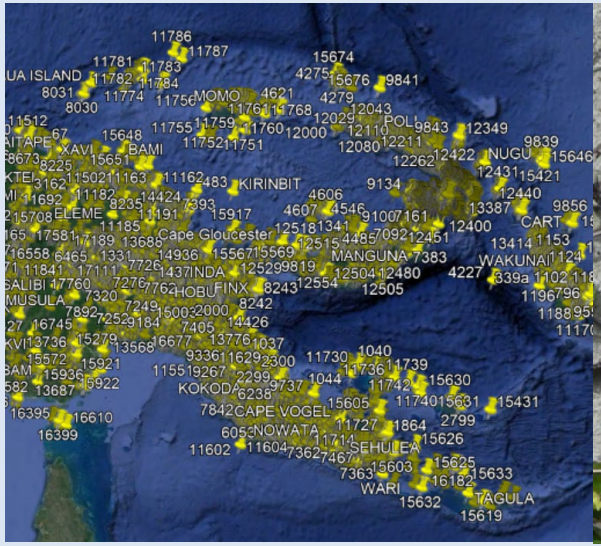
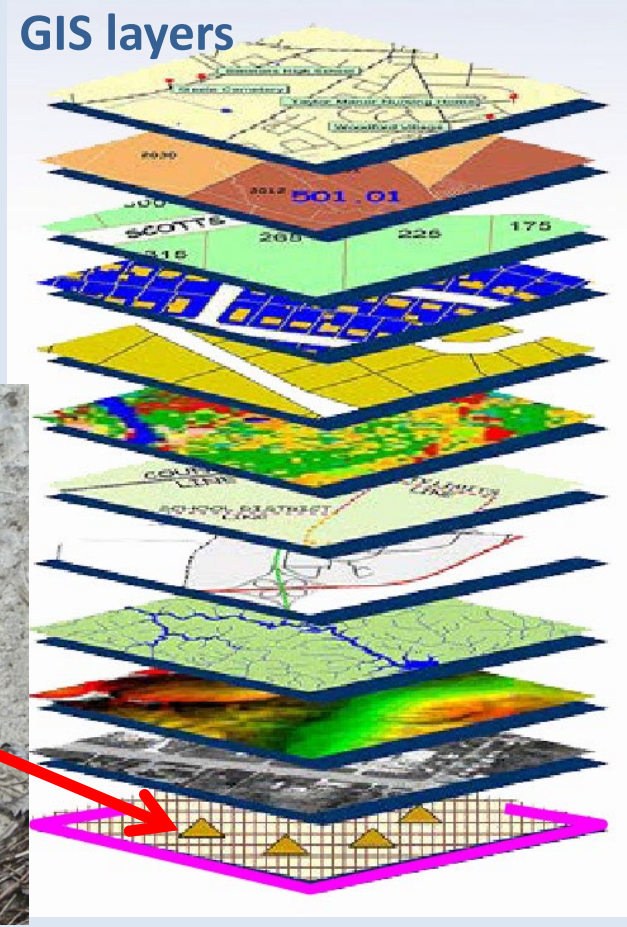
alignment of spatial data is underpinned by geodetic control (Permanent Survey Marks - PSM)





PSMs are the quiet, passive infrastructure that the visible infrastructure depends upon!

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PNG94 geodetic datum - zero order geodetic network

(3 cm 2D precision 95% CL)

Site ID	Site Name	Monument number	PNG94 Latitude	PNG94 Longitude	PNG94 Ellipsoidal Height
MORE	NMB TOWER GPS	PSM 15832	-9°26'02.76968"	147°11'12.20017"	116.610
AIAM	AIAMBAK	PSM 9550	-7°20'51.81934"	141°16'01.44646"	95.465
MIS1	BWAGAOIA AIR	PSM 9195	-10°41'19.90490"	152°49'58.93878"	87.456
GOKA	GOROKA	PSM 9833	-6°04'53.07151"	145°23'30.44618"	1664.580
ALT2	GURNEY	PSM 9538	-10°18'37.50877"	150°20'18.09080"	94.871
KAVI	KAVIENG AIR	PSM 9513	-2°34'53.06528"	150°48'22.53578"	78.828
KIKO	KIKORI AIRPORT	PSM 5583	-7°25'24.65305"	144°14'55.76611"	88.965
MAD1	MADANG	GS 15495	-5°12'41.28824"	145°46'56.19305"	73.293
MANU	MANUS SECOR	PSM 9522	-2°03'02.29337"	147°21'37.63577"	129.751
MEND	MENDI	PSM 3507	-6°08'36.73422"	143°39'22.16540"	1815.154
9799	UNITECH SPORTS	PSM 9799	-6°40'16.96985"	146°59'52.37457"	130.389
VANI	VANIMO DOPPLER	PM 63/1	-2°41'05.28039"	141°18'15.65564"	80.516
NM34	WANKKUN	PSM 15029	-6°08'52.07208"	146°04'52.44226"	510.015
WUVU	WUVULU ISLAND	PSM 15456	-1°44'07.59465"	142°50'10.07846"	79.056











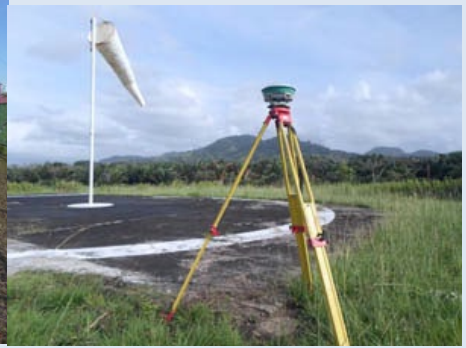

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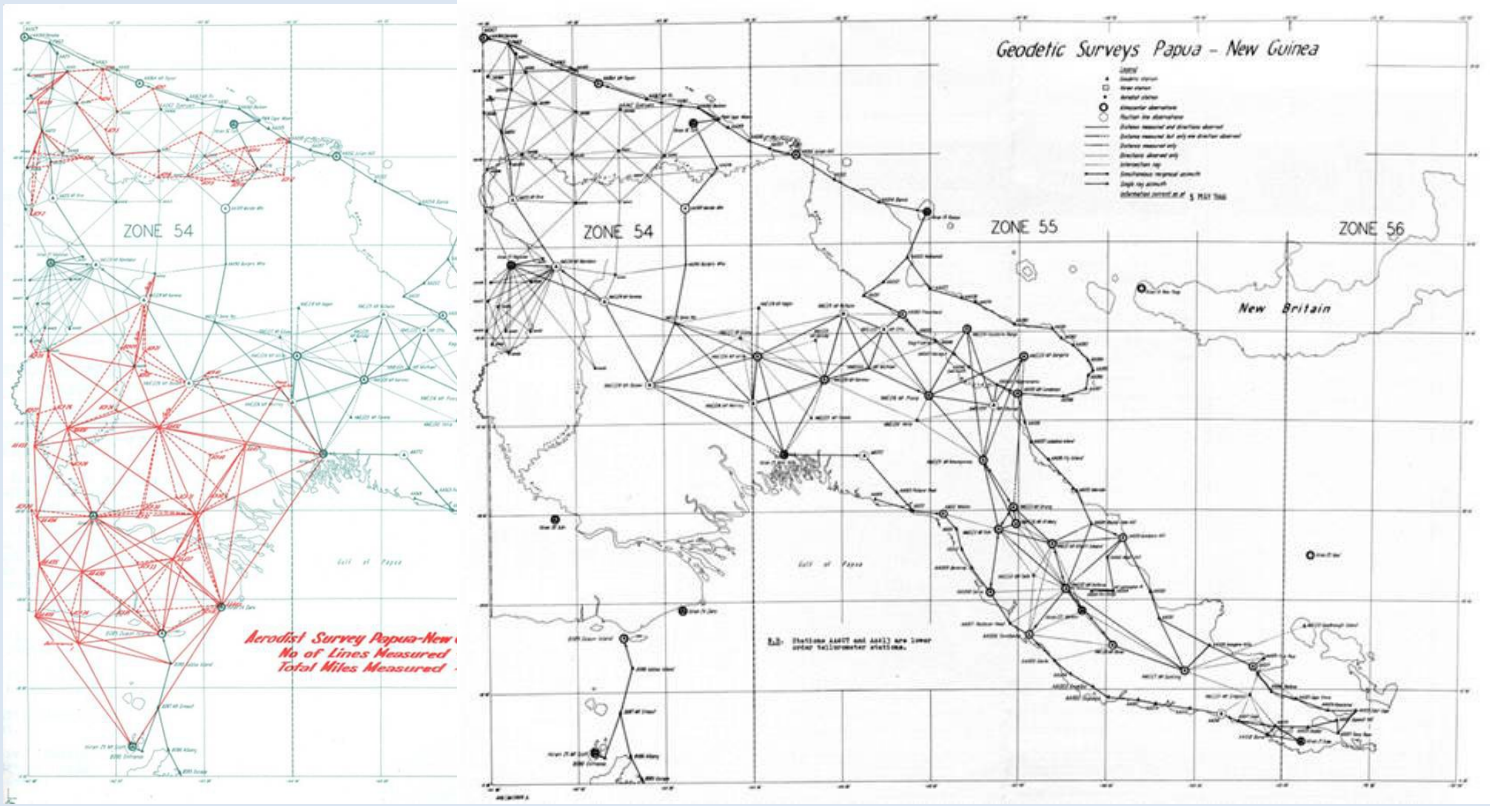
older - Australian Geodetic Datum 1966 (AGD66)

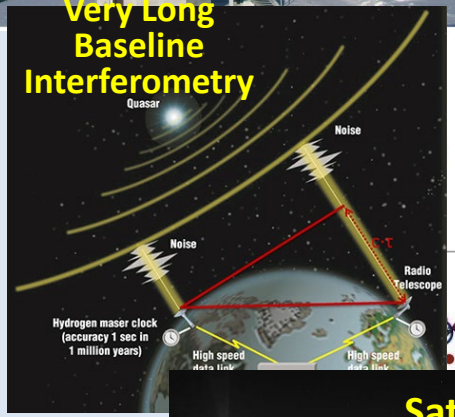
(0.9 m precision 95% CL & ~ 200 m different from PNG94, WGS84, ITRF!!)

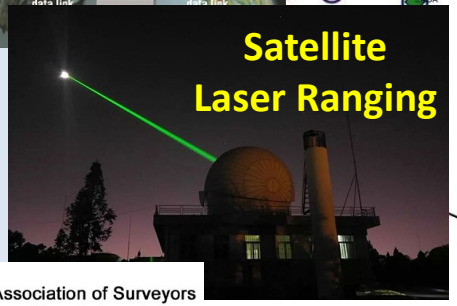
superseded by PNG94
but still in use.
(e.g. PNG Oil and Gas Act)
mining projects started pre-2001

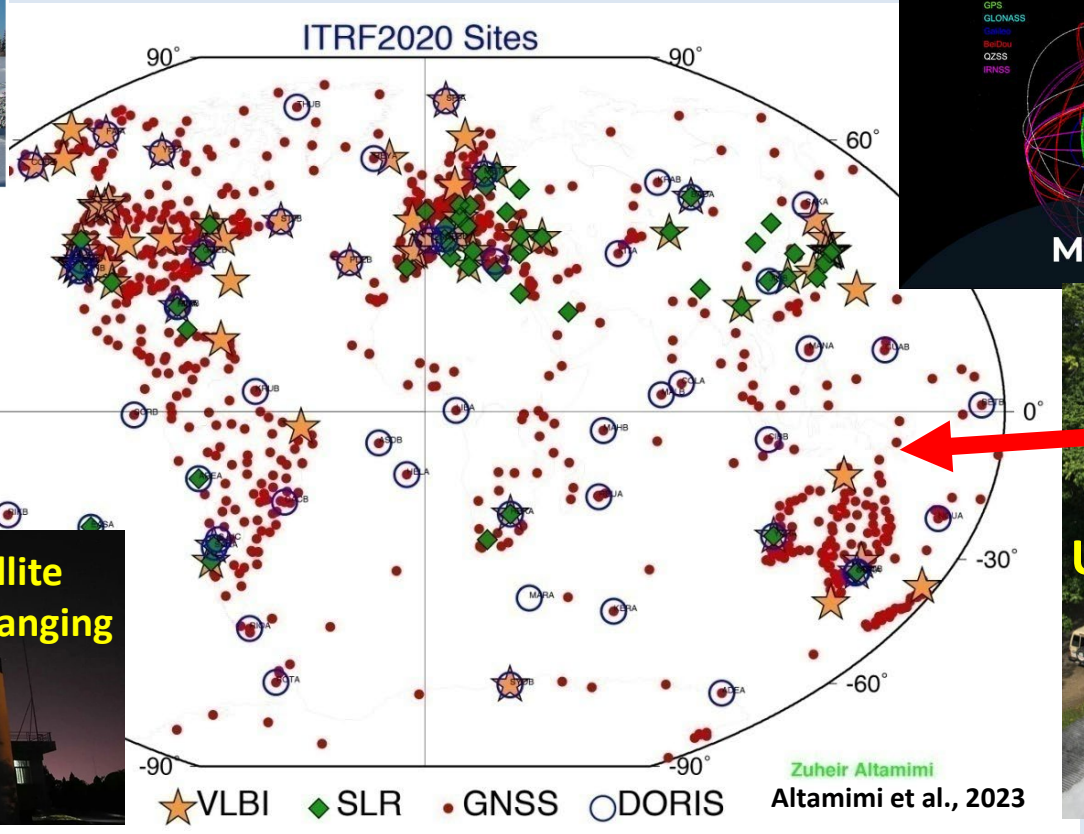


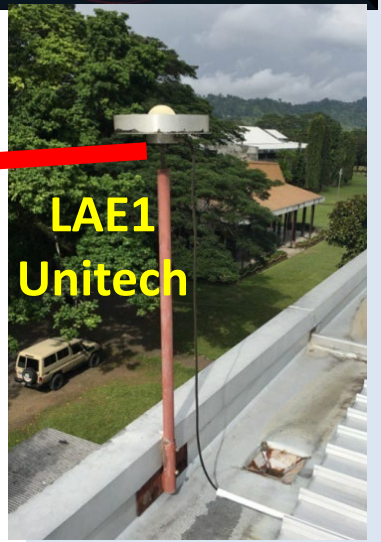
International Terrestrial Reference Frame

(3 mm precision 95% CL)









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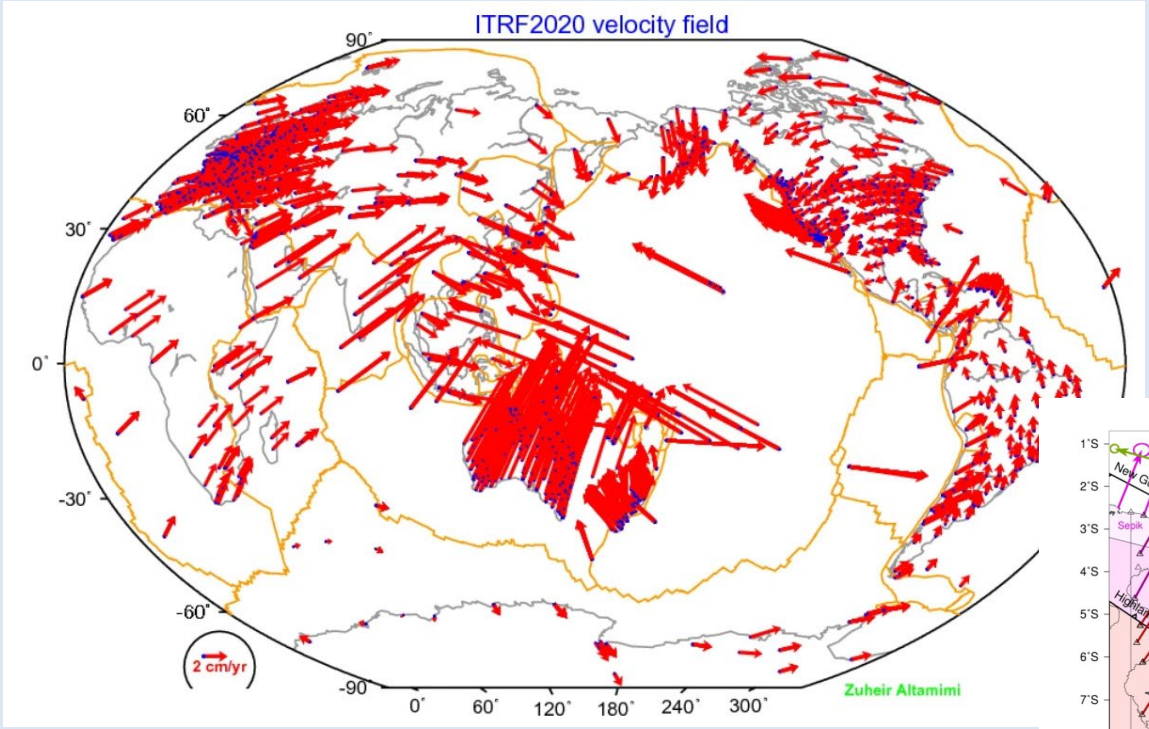
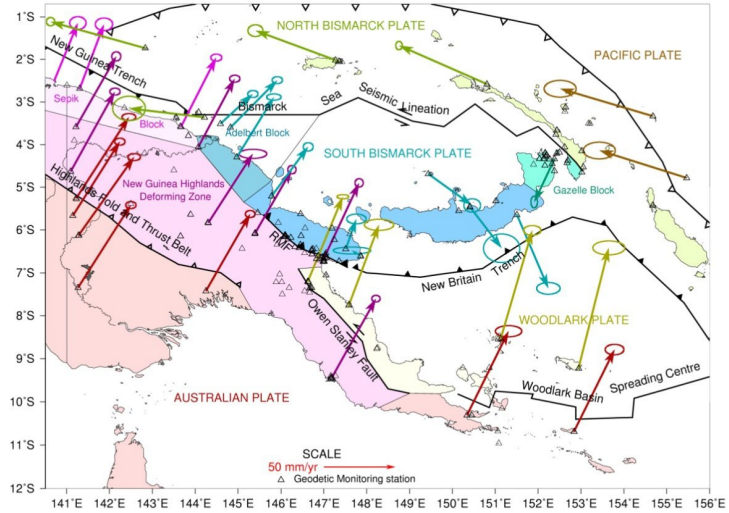
Geodetic tracking of global and local tectonic motions (velocities)





Stanaway, 2004

(0.5 mmyr^{-1} velocity precision 95% CL)

PNG94 is looking at superannuation

PNG94 is now over 30 years old (reference epoch)

Users of precise GNSS (and even handheld GPS) see differences between GPS coordinates (WGS 84 or ITRF2014, ITRF2020) and PNG94.

This difference is due to ~ 2 metres of tectonic displacement in PNG since 1994 (secular interseismic displacement between 1994 and 2024) and

- 3381 M_w 5.0 and larger earthquakes since 1994 (< 30 cm displacement)
- 112 M_w 6.5 and larger earthquakes since 1994 (< 1m level displacement)
- 14 M_w 7.5 earthquakes since 1994 (1-5 metre displacement)

Significant distortions now in the PNG94 network that exceed many surveying and positioning tolerances. Increasingly difficult to use a site velocity model to estimate PNG94 coordinates from current ITRF coordinates from precise point positioning GNSS/GPS.

PNG2020 now funded!

The PNG Government funded development of PNG2020 in May 2024 to supersede PNG94

ITRF2020 at epoch 2020.0
(1st January 2020 reference epoch)

Static GNSS observations on as many PSMs as funds will allow.

Support from other agencies is essential!

56th ASPNG Annual Congress, PNGUoT, Lae , PNG, 16-18 October 2024

Australian Government

Geoscience Australia

PNGAus Partnership

PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

Lae seismic zone GNSS survey

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PNG2020 station and observation priorities

1. Geodynamic monitoring stations (to develop tectonic velocity model)
2. Urban survey control (cadastral, construction, services)
3. International border monuments (Indonesia/PNG border)
4. Critical infrastructure (airports, ports, highways, power, water, telco/data)
5. Mining operations (SML, mine grid origins including exploration grids)
6. Oil and gas operations (well locations, pipelines, production facilities)
7. Agriculture and Forestry (oil palm, plantations, forestry mapping)
8. Geohazard monitoring (volcanoes, active tectonic faults, landslides)
9. Sea level monitoring (vertical movement of NMSA tide gauges)
10. Rural cadastral control (customary land surveys)
11. Existing geodetic stations (for transformation parameter estimation)

PNG2020 current progress

APRGP 2024 Campaign just completed
OSG Geodetic Section will progressively complete remaining observations around key geodetic stations in PNG over the next 7 months

Currently 70% of primary geodetic stations have been reobserved to date to define PNG2020 fiducial network for government gazettal.

AllDayRTK – Launched in PNG yesterday

The first subscription based RTK CORS network in PNG using NTRIP (internet corrections for RTK)

All Day RTK
Enabling Geo-Precision

Aptella
AUTOMATION + POSITIONING TECH

Pat Gilbert (Aptella) and Fred Sioni (Theodist) demonstrating 2 cm precision at Unitech 7 km from the newly installed LAE3 CORS at Theodist Lae

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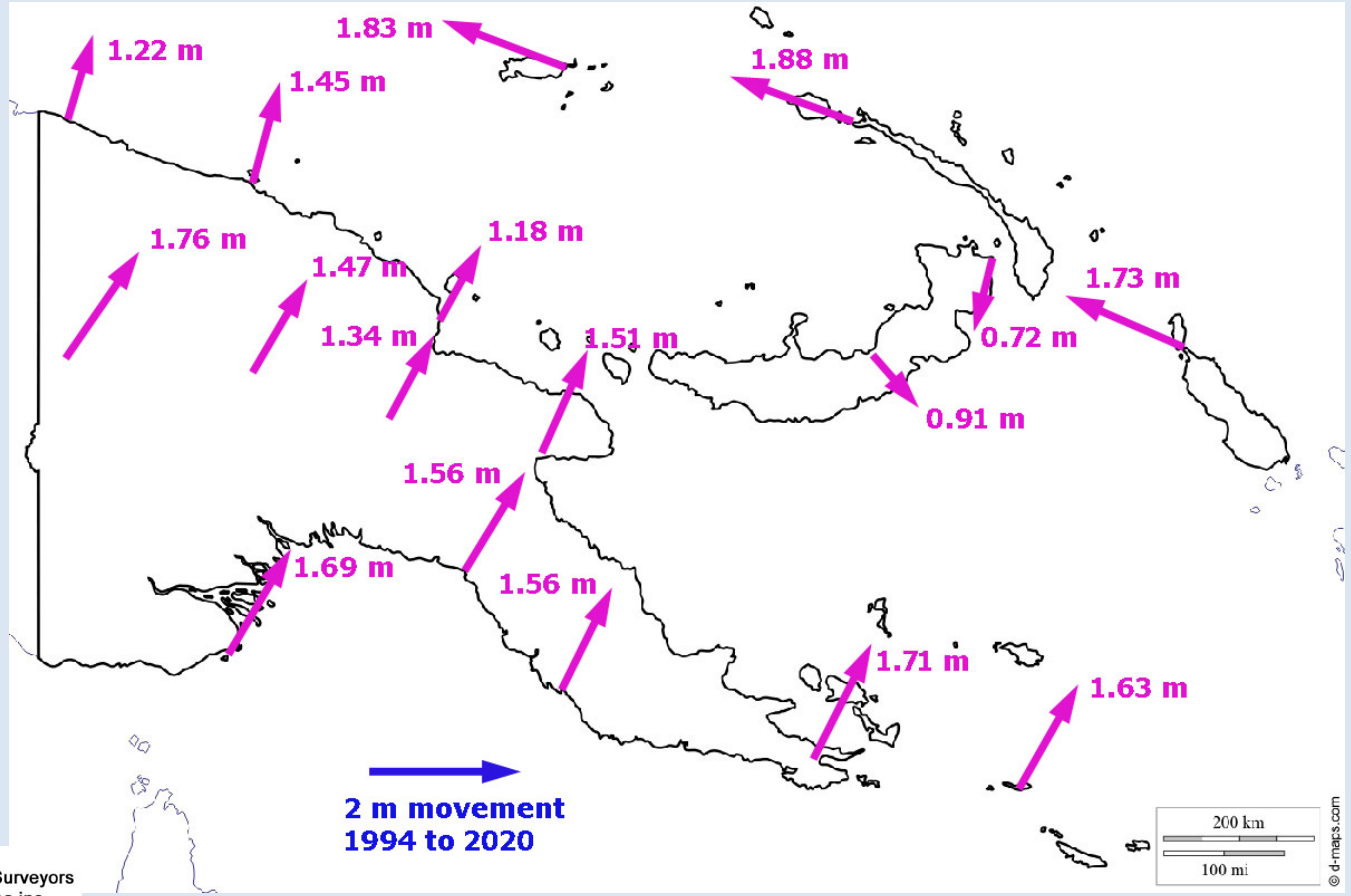
Difference between PNG94 and PNG2020



PNG2020 data analysis

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1993-2024

Steve Saunders
1998-2023

UNSW SYDNEY

Simon McClusky
1990-1994

Australian National University
Research School of Earth Sciences
ANU College of Science

Paul Tregoning
1996-2008

Richard Stanaway
2000-2004

QUICKCLOSE

2005-2024

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Data recovery and analysis of 32 years of GNSS/GPS static observation data archive processed in a consistent ITRF2020 geodetic reference frame.

Station velocities estimated to 1 mmyr-1 at 95% CL
Positions estimated at 1 cm precision (95% CL) at ITRF2020 at epoch 2020.0 (1st January 2020)

SURVEYOR GENERAL • PAPUA NEW GUINEA

1990-2024

Australian Government
Geoscience Australia

Rensselaer Polytechnic Institute 1824

Colleen Stevens
1993-1997

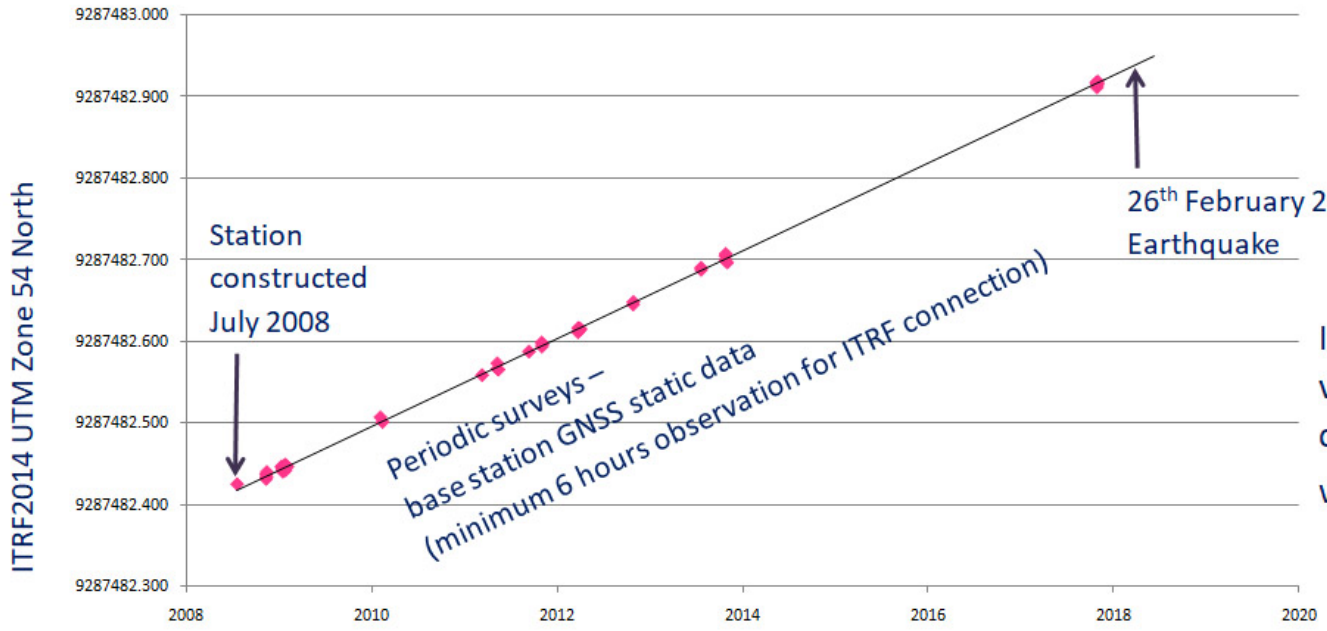
UC SANTA CRUZ

Laura Wallace
1997-2001

GNS SCIENCE TE PŪ AO

2003-2013

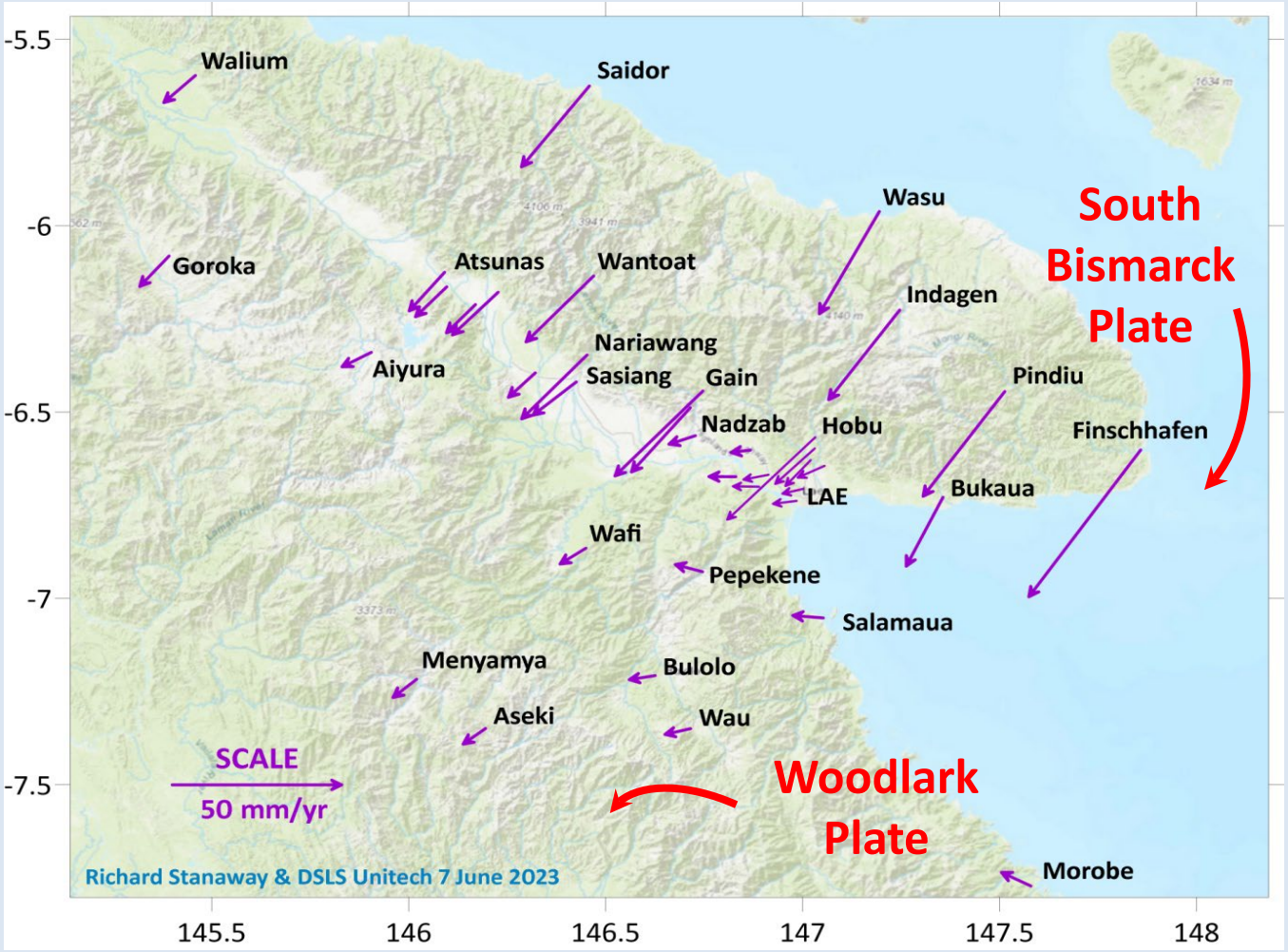
interseismic velocity from campaign GNSS



Example – PSM 32567 (IAGI) Ridge Camp – topocentric North component

Interseismic motion is typically highly linear

RMFZ & LSZ velocities in a stable Australian Plate reference frame



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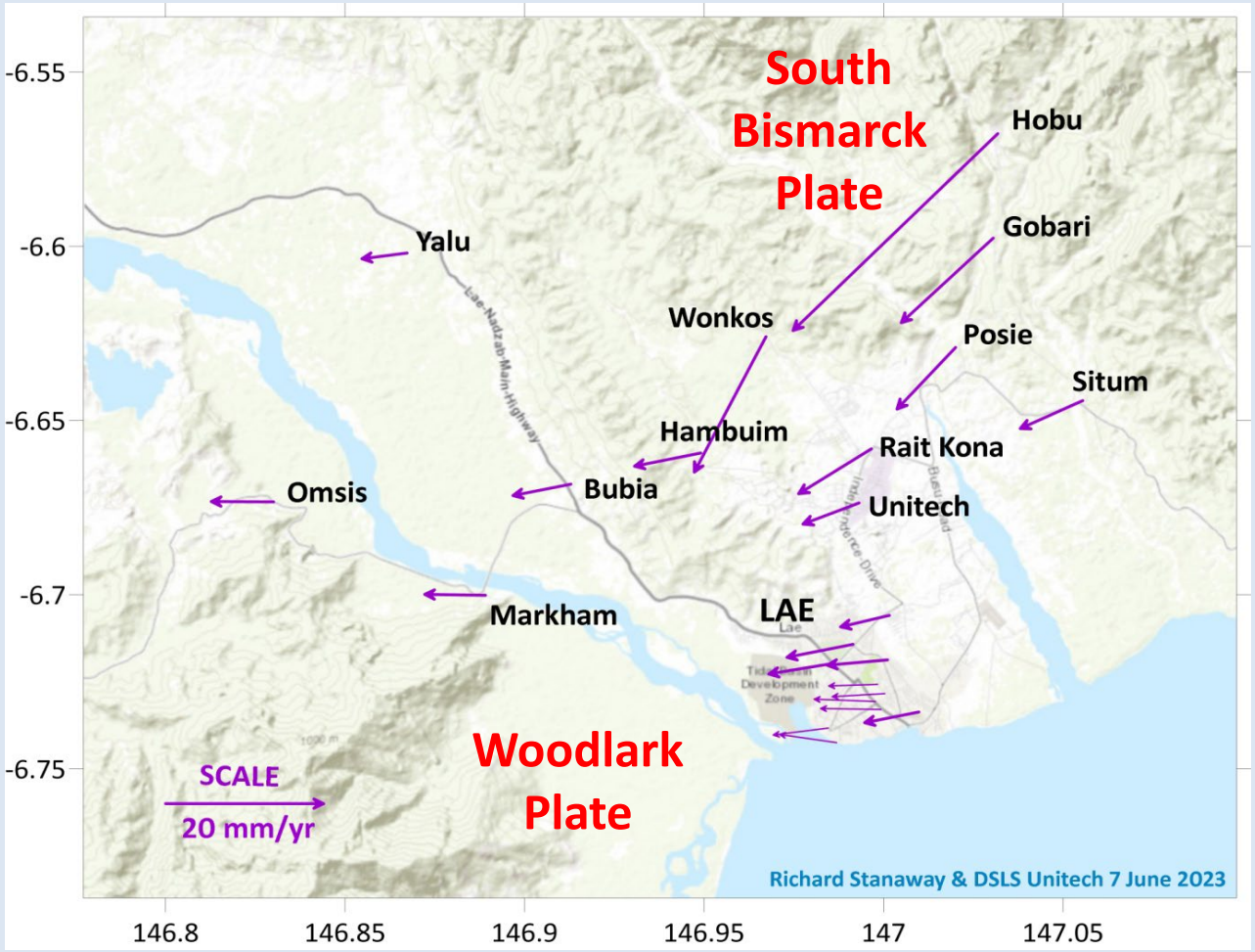
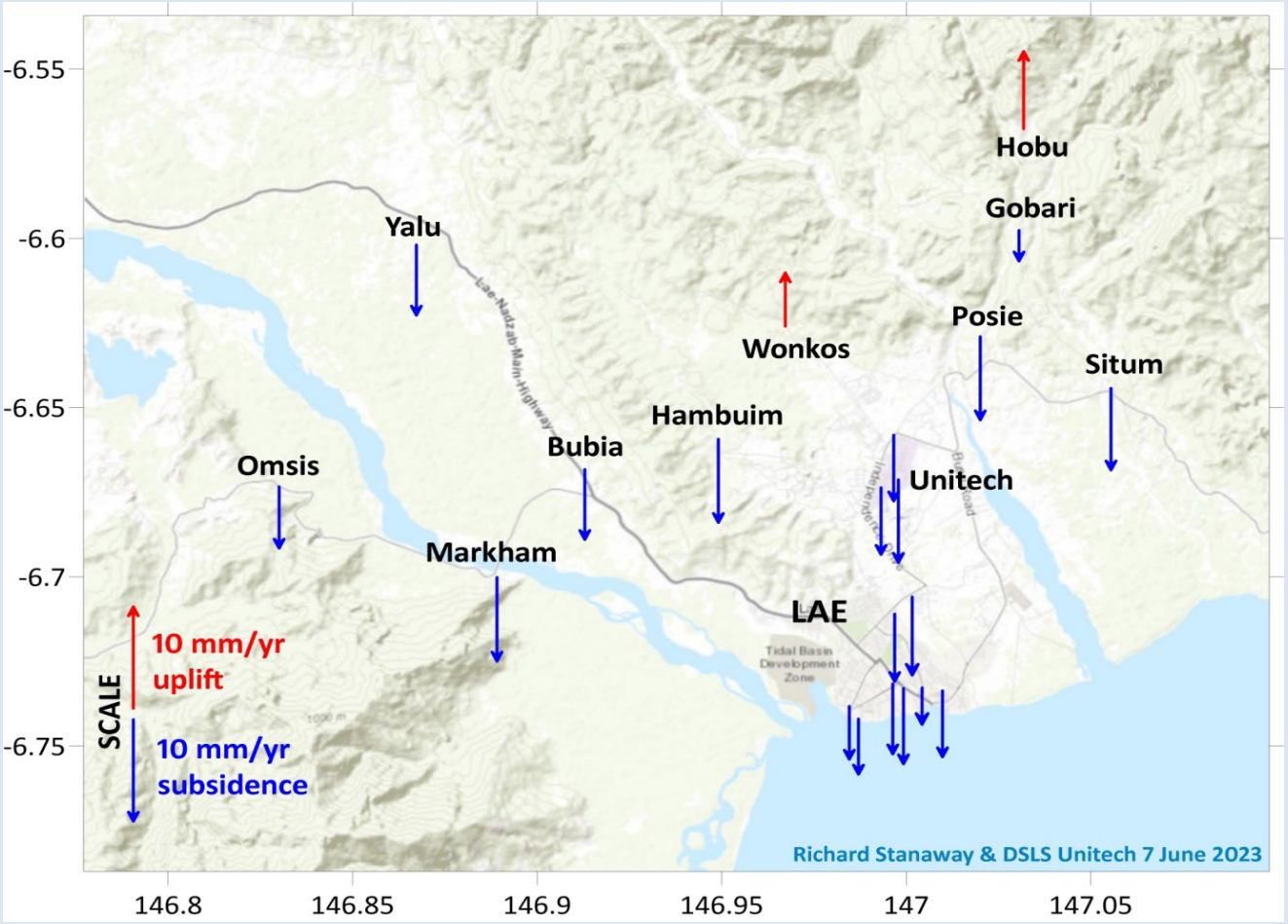
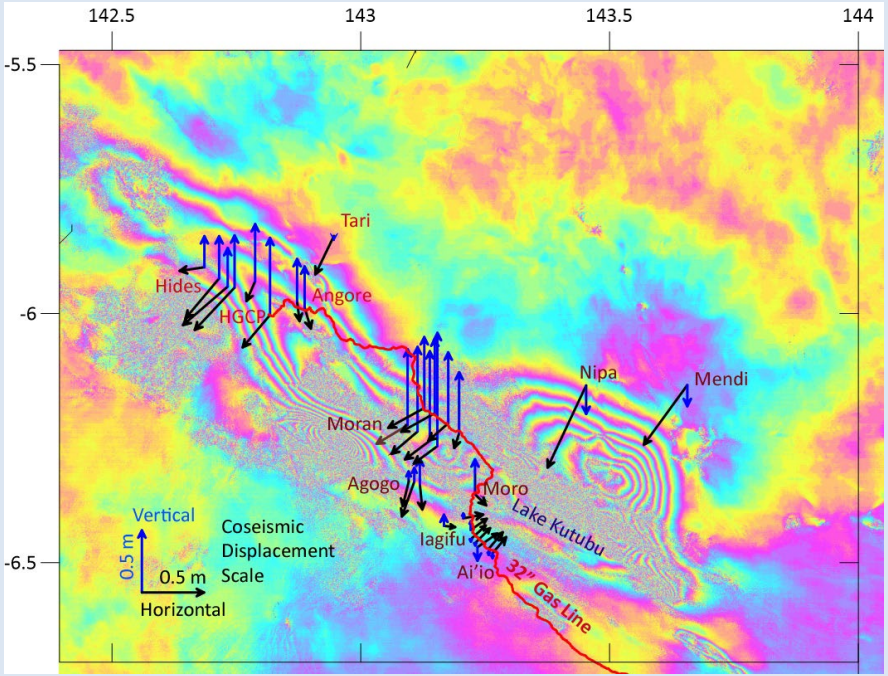
Lae Seismic Zone (LSZ) velocities in a stable Australian Plate reference frame

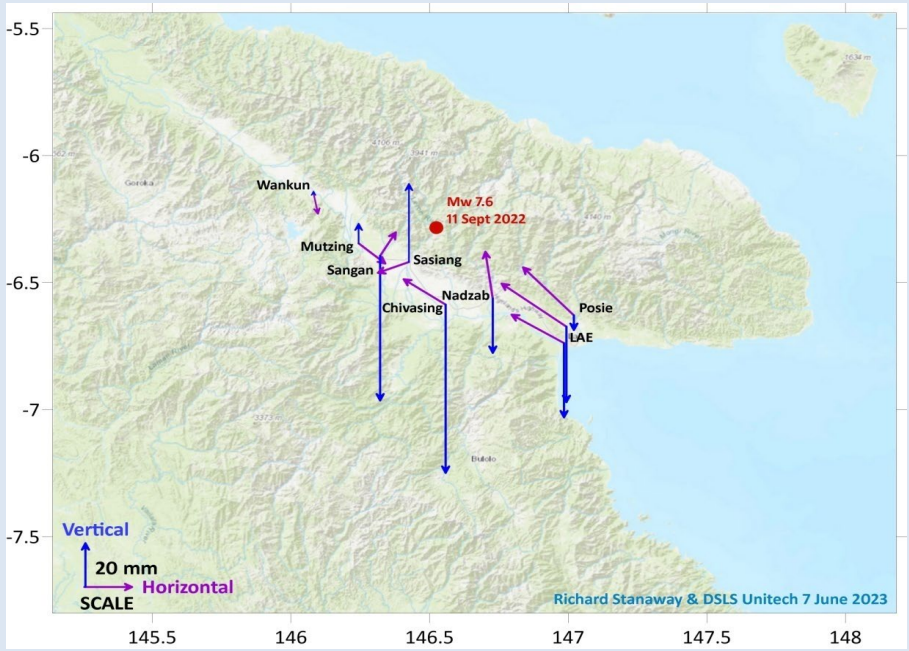


Lae Urban area vertical velocities



coseismic displacement from GNSS



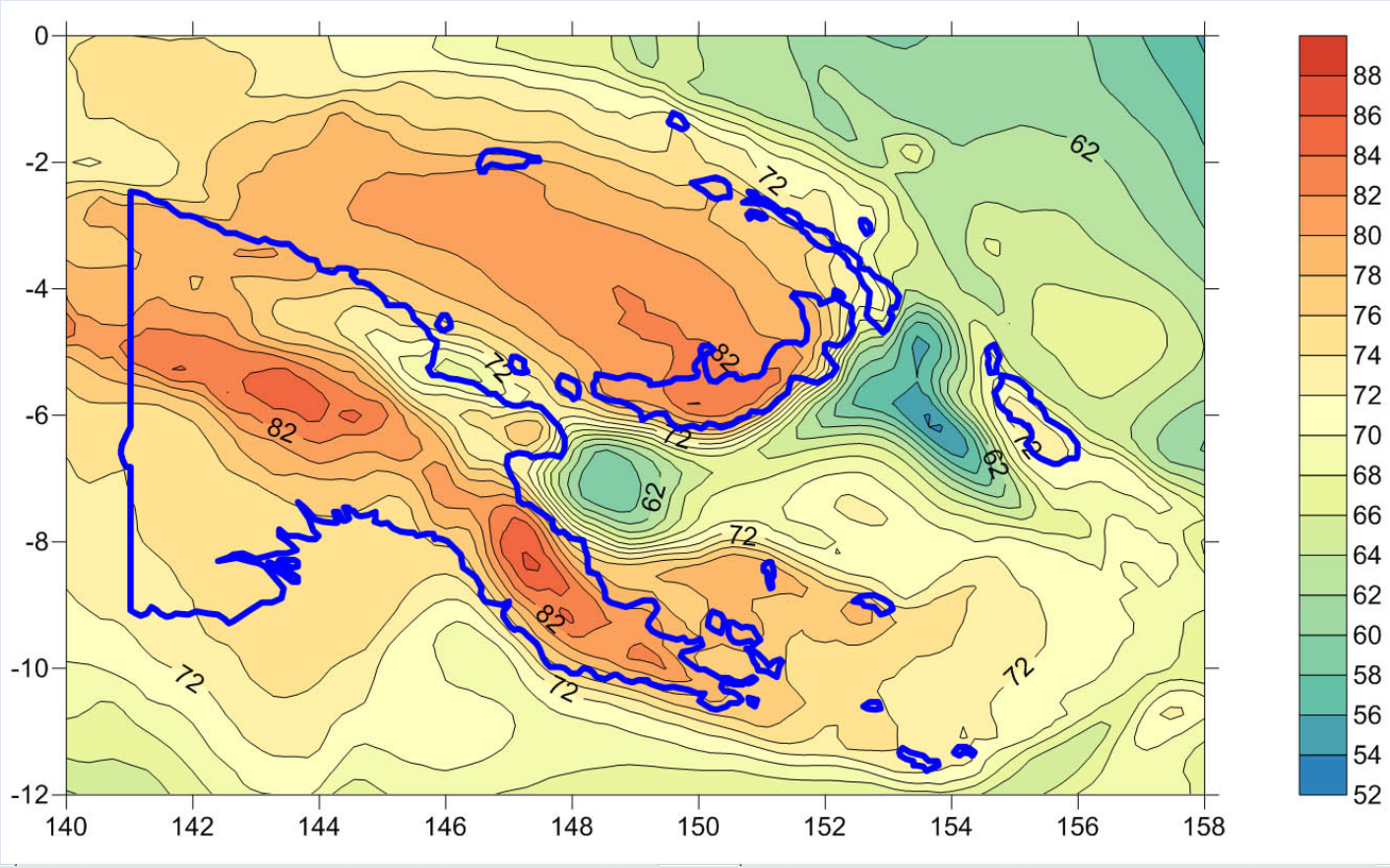


2018 PNG Highlands M_w 7.5 Earthquake sequence displacement observed by GNSS and Insar
(ALOS2 Interferogram, Jaxa, 2018)

Coseismic displacement from 11 September 2022 M_w 7.6 eq.
(depth ~ 90 km)

PNG geoid model

PNG08 geoid model to be updated with new tide-gauge connections, modelling and gravity observations



PNG08 geoid model, Stanaway, 2011

PNG2020 Datum components

Physical Monuments – PSMs, CORS antenna mounts

Information – geodetic database (Coordinates, elevations, metadata), PSM sketches, kml files etc..

Access – CORS data portal, RTCM/NTRIP, online access to database

Models – tectonic interseismic velocity grids, geoid models

Legal – Geodetic Registry (EPSG) - GIS, PNG Government Gazette

Knowledge – stakeholder involvement and training, guidelines (DLPP, MRA, DPE, NAC, Urban Authorities, utilities)

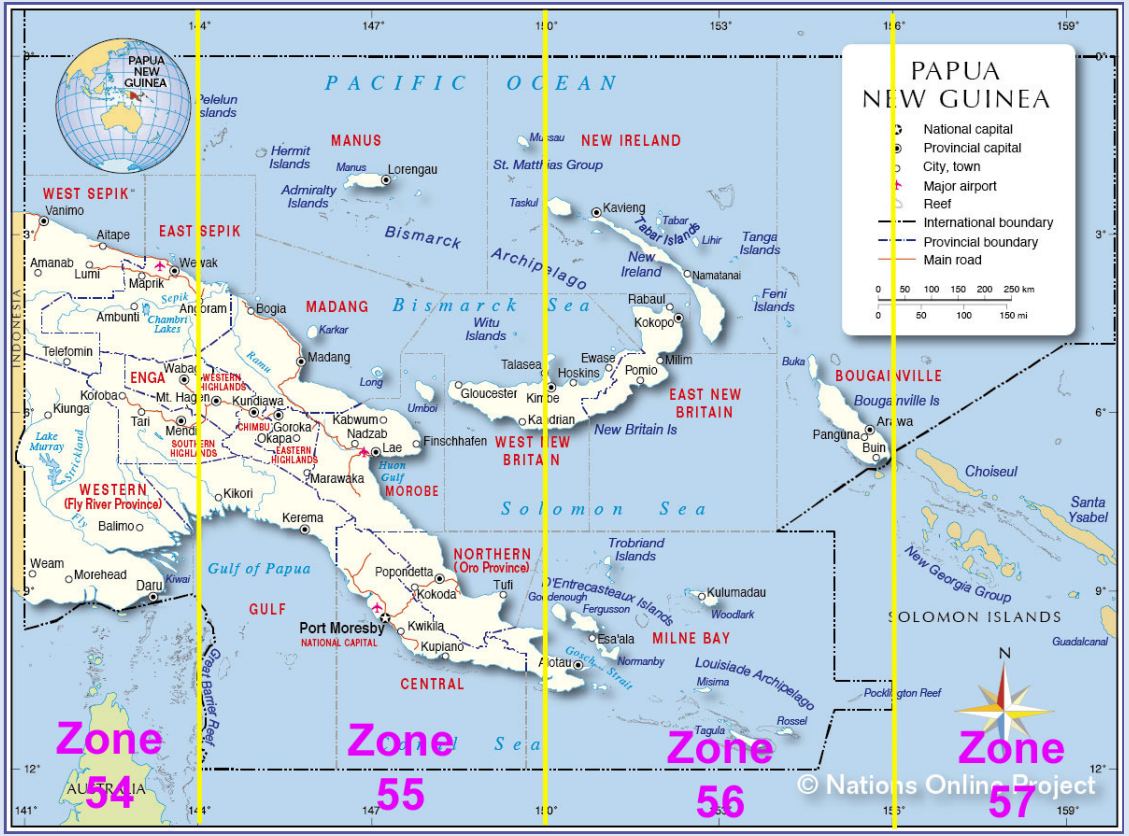
PNG2020 Projected Grids

Mapping grids

PNGMG2020 based on UTM

same as with PNG94 (PNGMG94) and AGD66 (AMG66)

Zones 54 to 58



PNG2020 Projected Grids

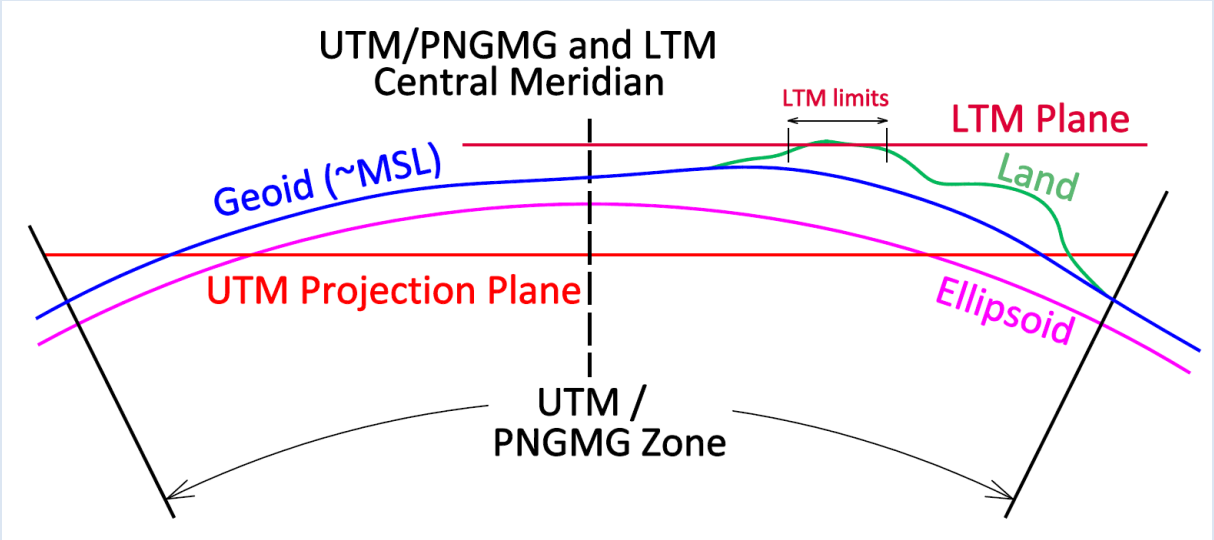
Town grids

Local Transverse Mercator (LTM) projections with SF close to 1.000000 for use with cadastral and engineering surveys

Same latitude/longitude (PNG2020) as PNGMG2020

Bearing equality with PNGMG2020 (no rotation)

POM2020 – NCD
LAE2020 – Lae
HGN2020 – Mt Hagen
WWK2020 - Wewak
RAB2020 – Rabaul
and all major towns



Town Grid LTM formulation

$$\lambda_{0(\mathrm{LTM})} = \lambda_{0(\mathrm{PNGMG2020})}$$

LTM Central meridian is same as PNGMG2020

$$\phi_{0(\mathrm{LTM})} = \phi_{0(\mathrm{PNGMG2020})} = 0^{\circ}$$

LTM latitude origin is same as PNGMG2020

$$E_{0(\mathrm{LTM})} = E_{LO} + \frac{500000 - E_{UO}}{C}$$

False Easting of LTM CM

$$N_{0(\mathrm{LTM})} = N_{LO} + \frac{10000000 - N_{UO}}{C}$$

False Northing of LTM latitude origin

$$k_{0(\mathrm{LTM})} = \frac{0.9996}{C}$$

LTM CM scale factor

E_{UO} PNGMG coordinates of local origin

N_{UO}

E_{LO} LTM coordinates of local origin

N_{LO}

$$C \approx \frac{\left(0.9996 + \left(E_{\mathrm{PNGMG\,2020}} - 500000\right)^2 \cdot 1\mathrm{E}^{-14} \cdot 1.2379\right) \cdot 6357000}{6357000 + h}$$

PNGMG2020 combined scale factor

PNG2020 – Geodetic Registry

EPSG geodetic registry (and ISO TC 211 registry)
This is an industry standard for GIS/Mapping and positioning software

EPSG codes for the PNG2020 datum, projected map grids (PNGMG2020 Zone 54 to Zone 58 and LTM based town grids)

Kinematic tectonic model (velocity grid) – to transform between ITRF2020 (dynamic coordinates) and PNG2020 (NTv2 & GGXF format)

PNG94(2022) to PNG2020 transformation grid (NTv2 & GGXF)

AGD66 to PNG2020 transformation grid (NTv2 & GGXF)

Thank You!