Development of a geodetic deformation model for Papua New Guinea (PNG)

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Typical PNG topography

Tectonic setting & geodynamics studies in PNG

GPS campaigns to monitor plate tectonics in PNG:

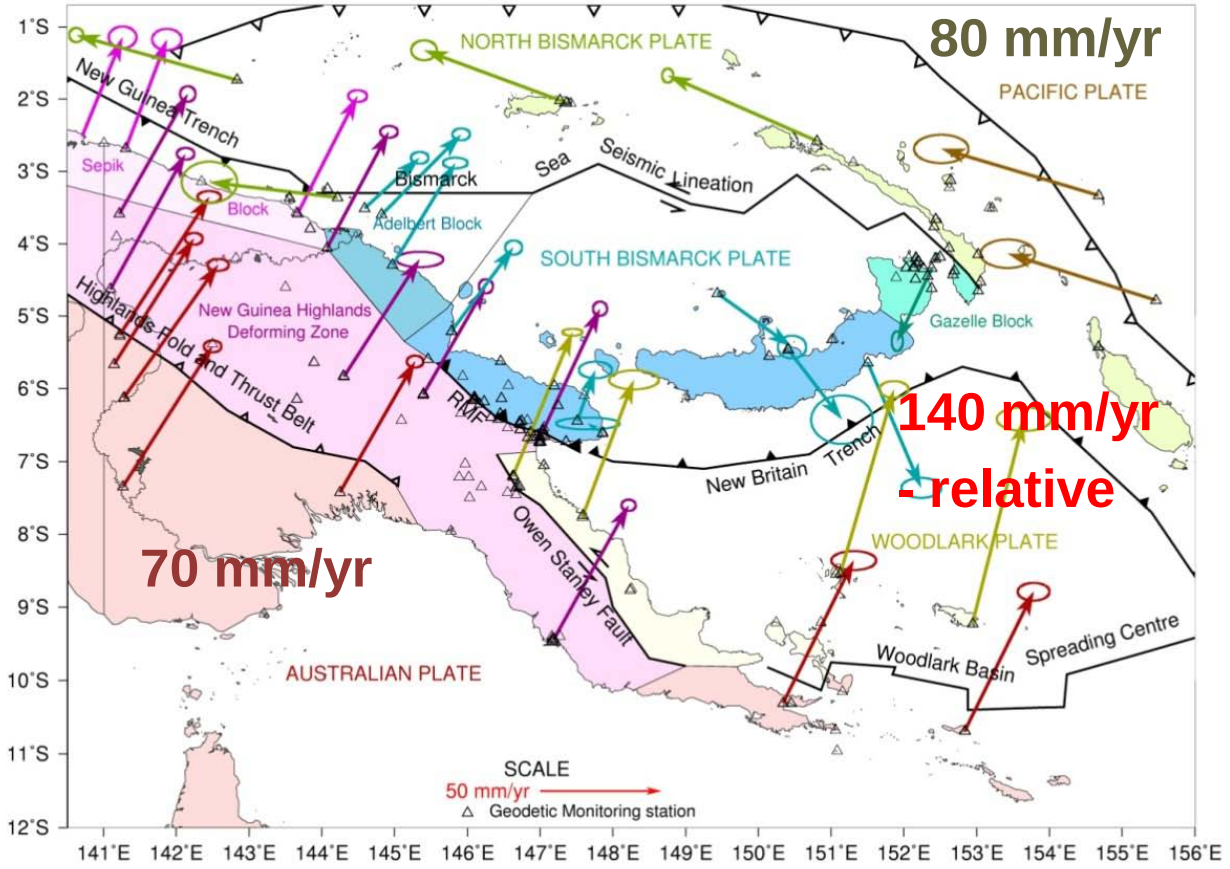
UNSW and NMB (1990-1994)

RPI and UCSC (USA)

UniTECH and RVO (1993-2001)

ANU (RSES Geodynamics) (1996-2008)

Private sector (2008-2015)



PNG tectonic setting - 2004 definition

GPS analysis and PNG plate model

Re-analysis of all static GPS observations in PNG from 1993 to 2014

(Wallace *et al.*, 2015 – Eastern PNG)

(Koulali *et al.*, 2015 – Western PNG and PNG Highlands)

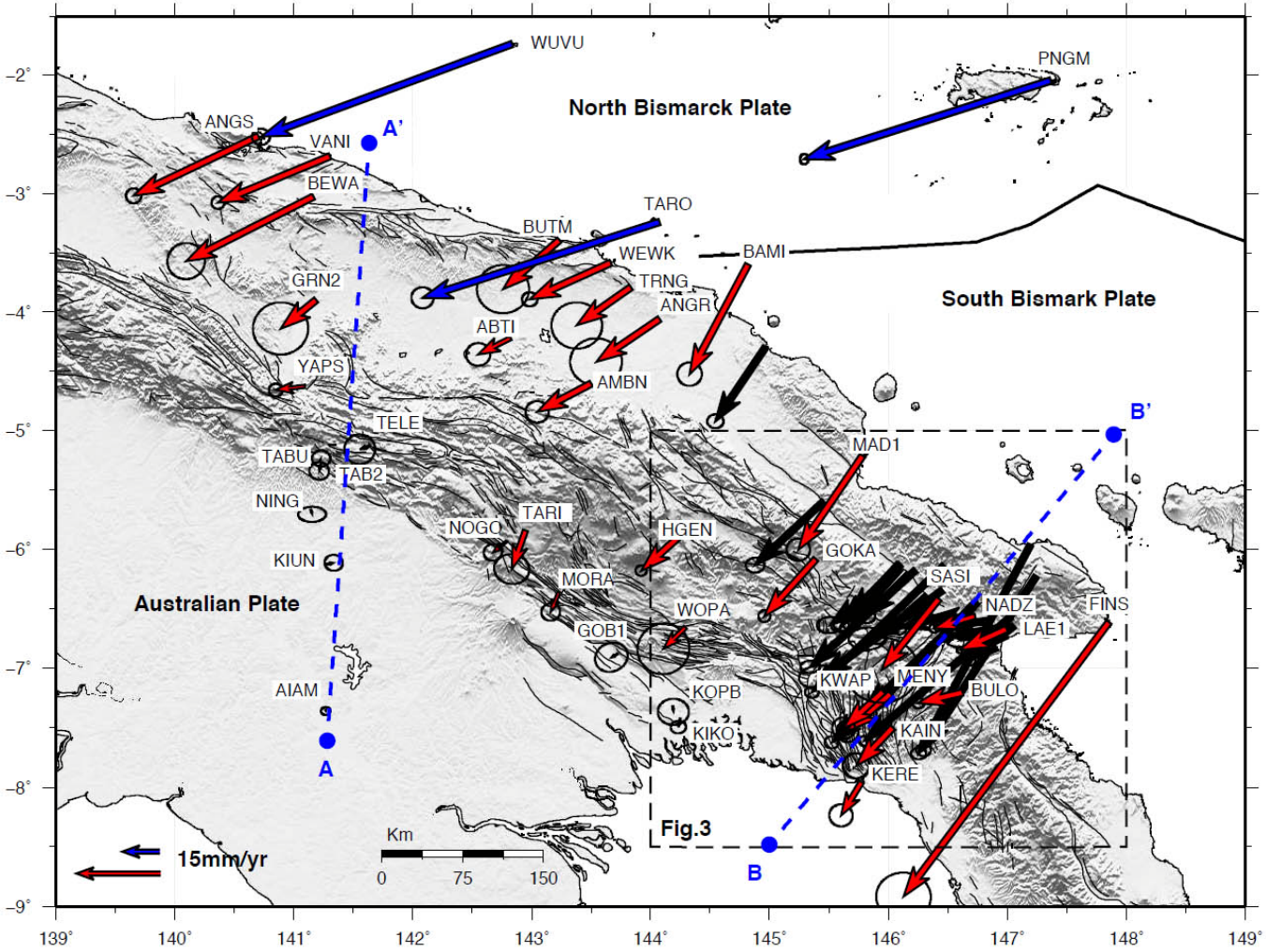
GAMIT/GLOBK (GPS processing and RF alignment)

Coseismic offset and postseismic decay corrections applied

Inversion of observed site velocities with elastic strain corrections applied using fault and block model (DEFNODE. McCaffrey, 2004)

Estimation of Euler poles for stable microplates and crustal blocks in PNG

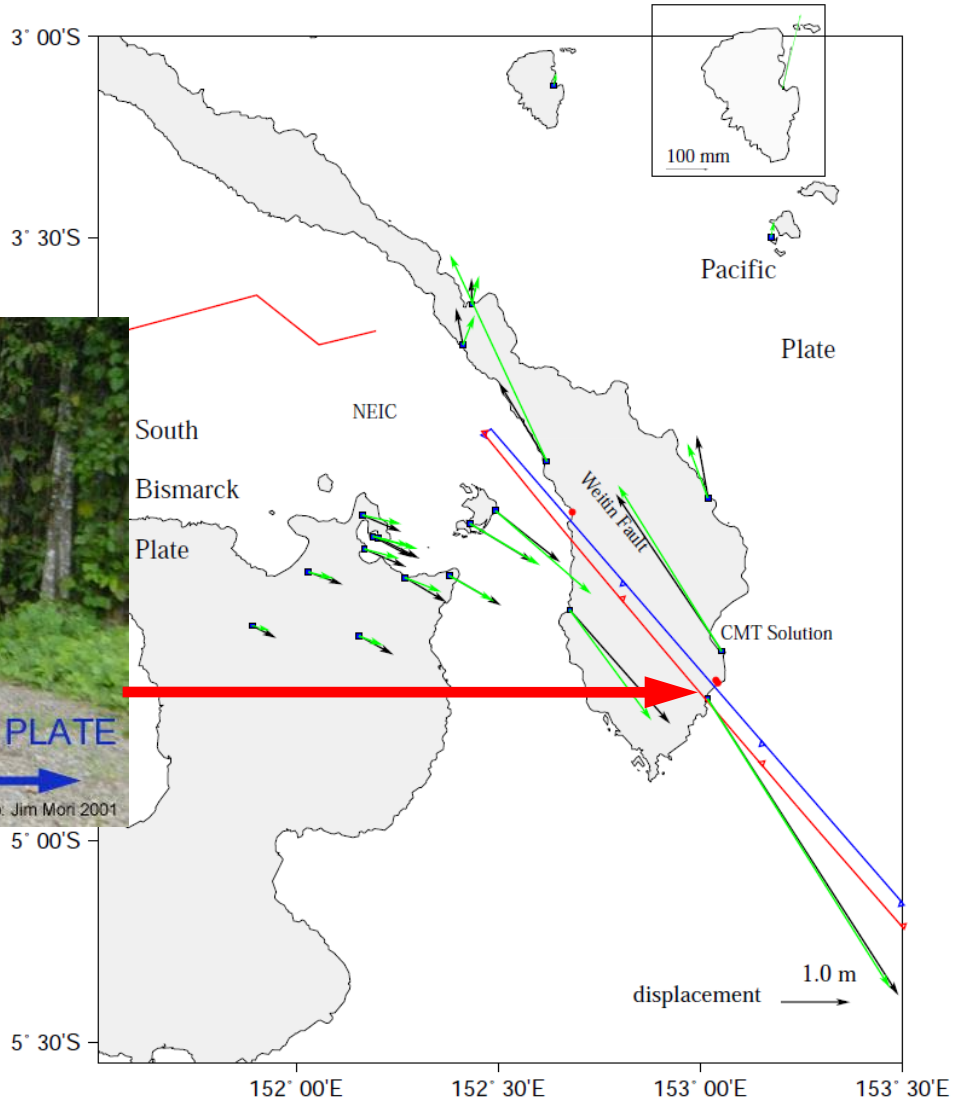
PNG Highlands deformation



Velocities wrt. Australian Plate Koulali *et al.*, 2015

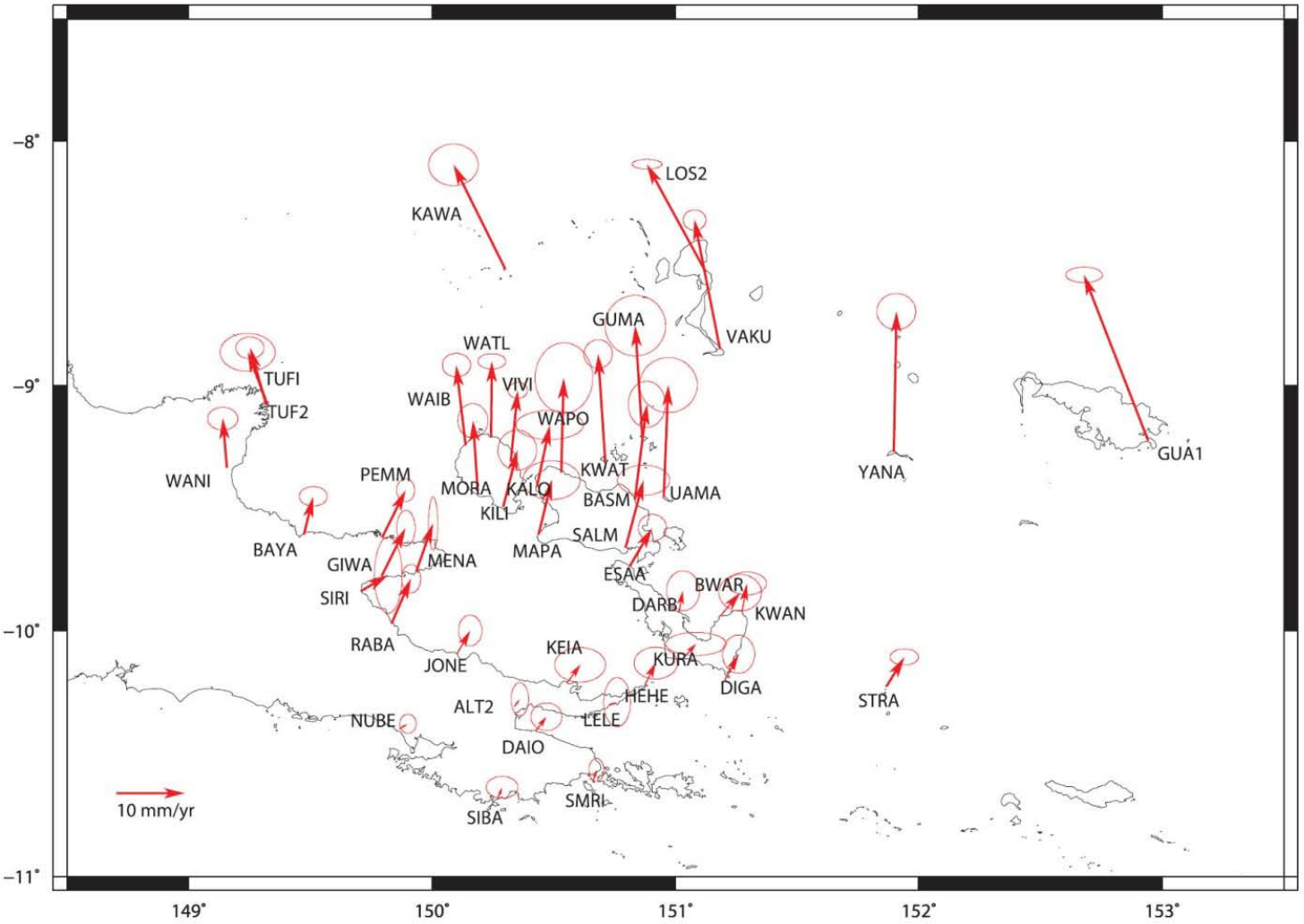
Gazelle coseismic deformation

(Tregoning *et al.*, 2000)



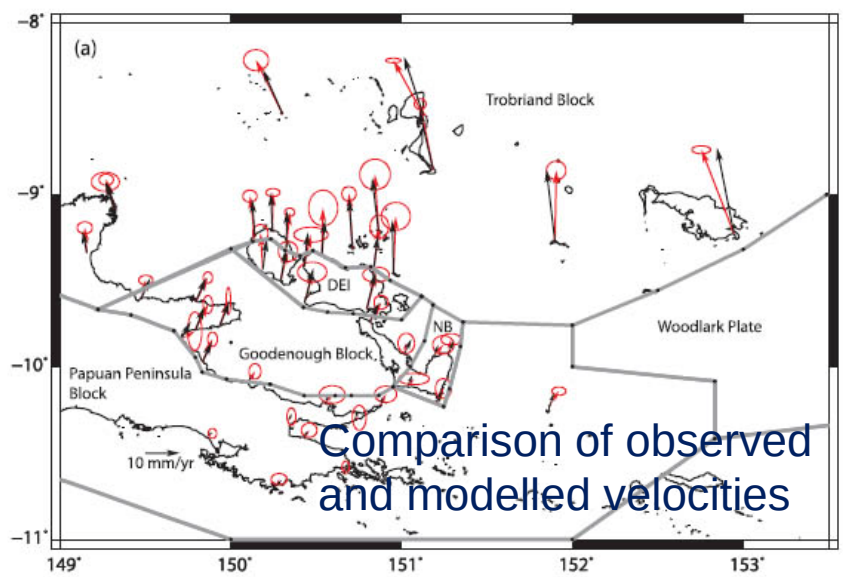
(black – observed, green - modelled)

Eastern PNG deformation

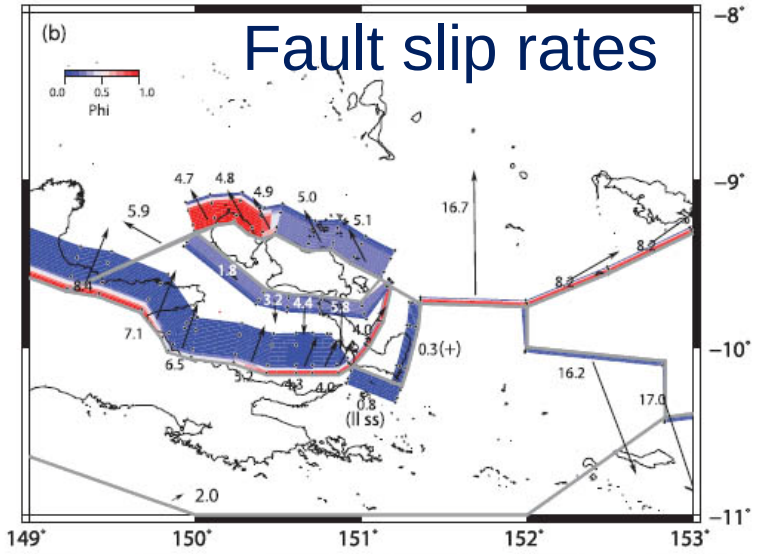


Velocities wrt. Australian Plate (Wallace *et al.*, 2015)

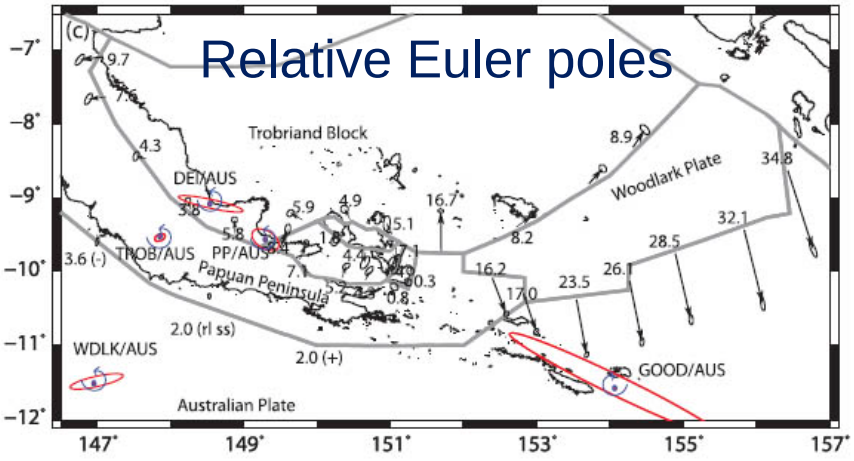
Block Modelling



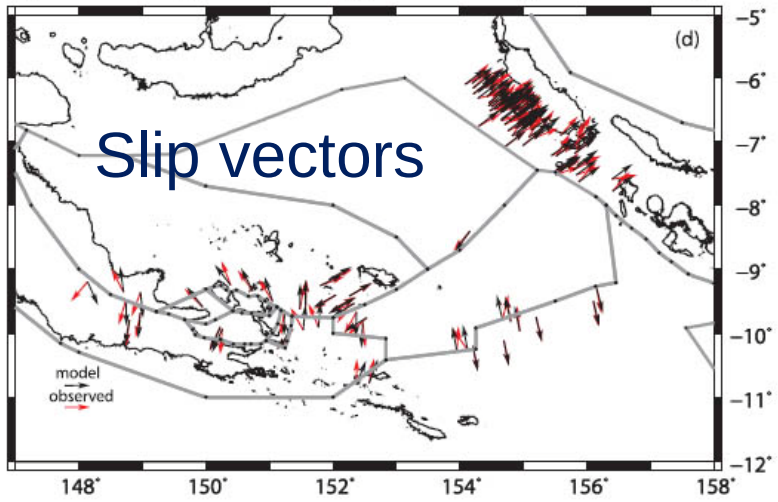
Comparison of observed and modelled velocities



Fault slip rates

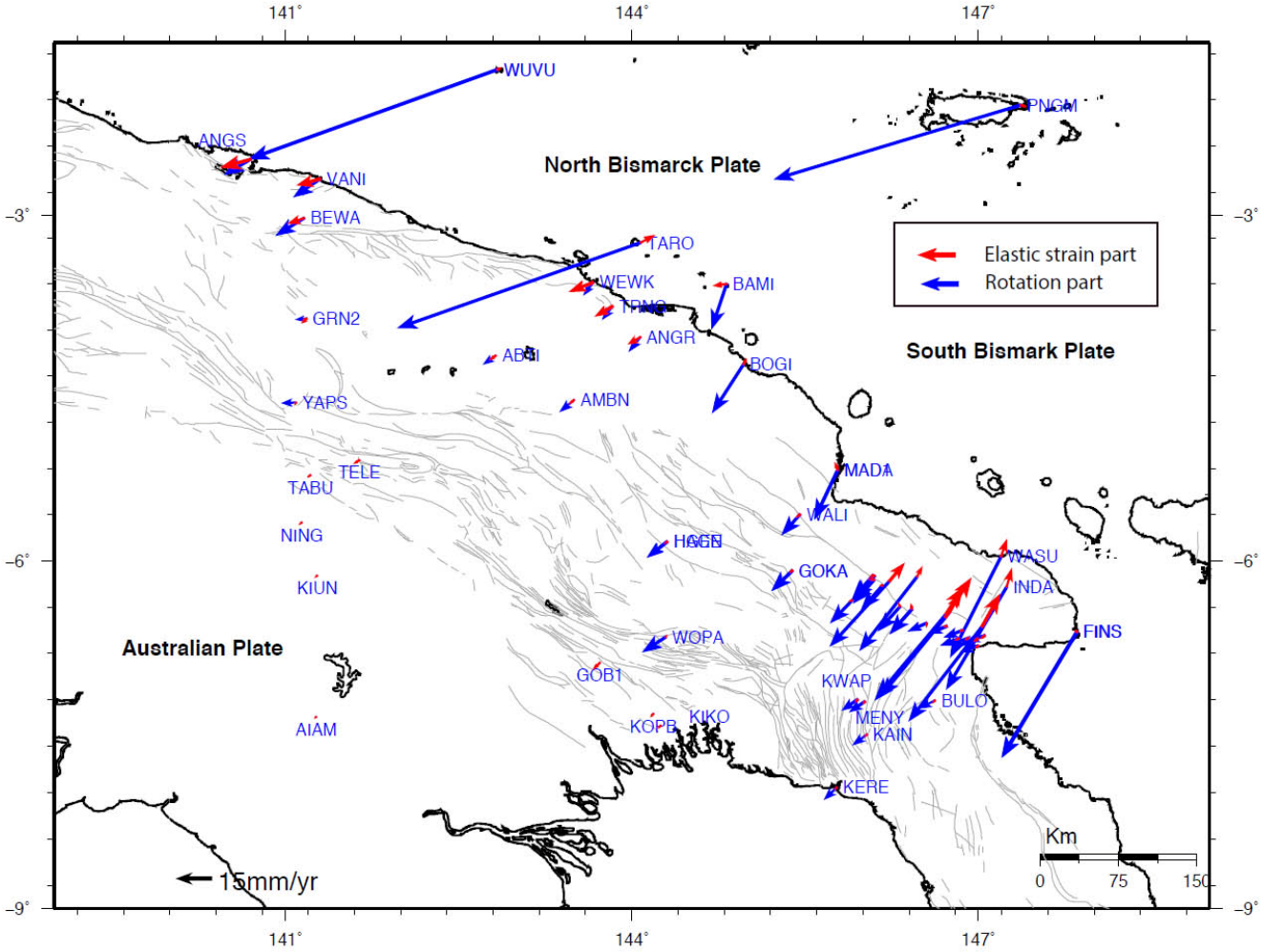


Relative Euler poles



Slip vectors

Modelling of the velocity field



Rigid plate rotation and elastic strain components (Koulali *et al.*, 2015)

PNG94 – the current PNG geodetic datum

Papua New Guinea Geodetic Datum 1994

Geocentric Datum – ITRF92 realised by 14 fiducial stations computed at epoch 1994.0 (1st January 1994) –
same realisation as GDA94 in Australia

Reference Ellipsoid:	GRS80
Map Projection:	Papua New Guinea Map Grid 1994 (PNGMG94) Zones 54, 55 and 56
Projection type:	Universal Transverse Mercator (UTM) Southern Hemisphere

PNG94 Fiducial Network

Figure 1: Datum Sta

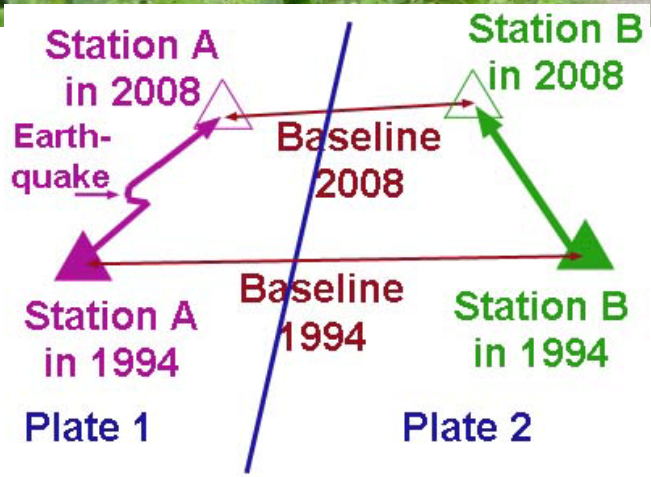
Problems with a “static” PNG94

Originally realised as a static datum in a very complex tectonic environment – regular large earthquakes

interseismic datum distortion of up to 3 m and coseismic distortion of up to 5 m across plate boundaries

between 1994 and 2015

Parametric models not applicable (e.g. 7 & 14 par.)



Motivation for a semi-kinematic datum

Coordinate “stability” to facilitate harmonisation of spatial data at a common epoch – to support spatial data integration within a GIS e.g. Imagery and cadastral DCDB

→ **Static component**

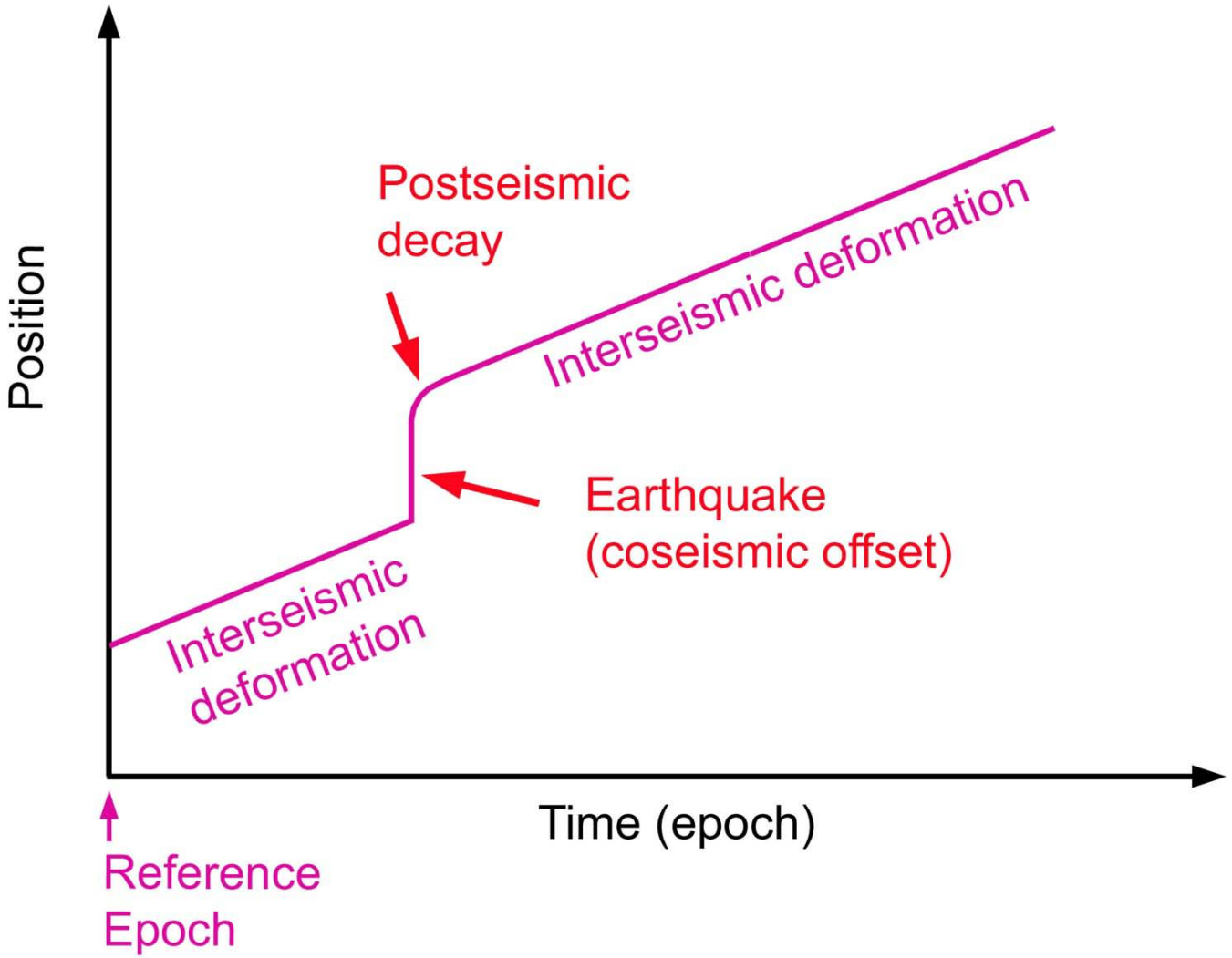
Coordinate propagation between different epochs

(e.g. To support NRTK, PPP and GNSS post-processing which should be done in an ITRF/IGS reference frame)

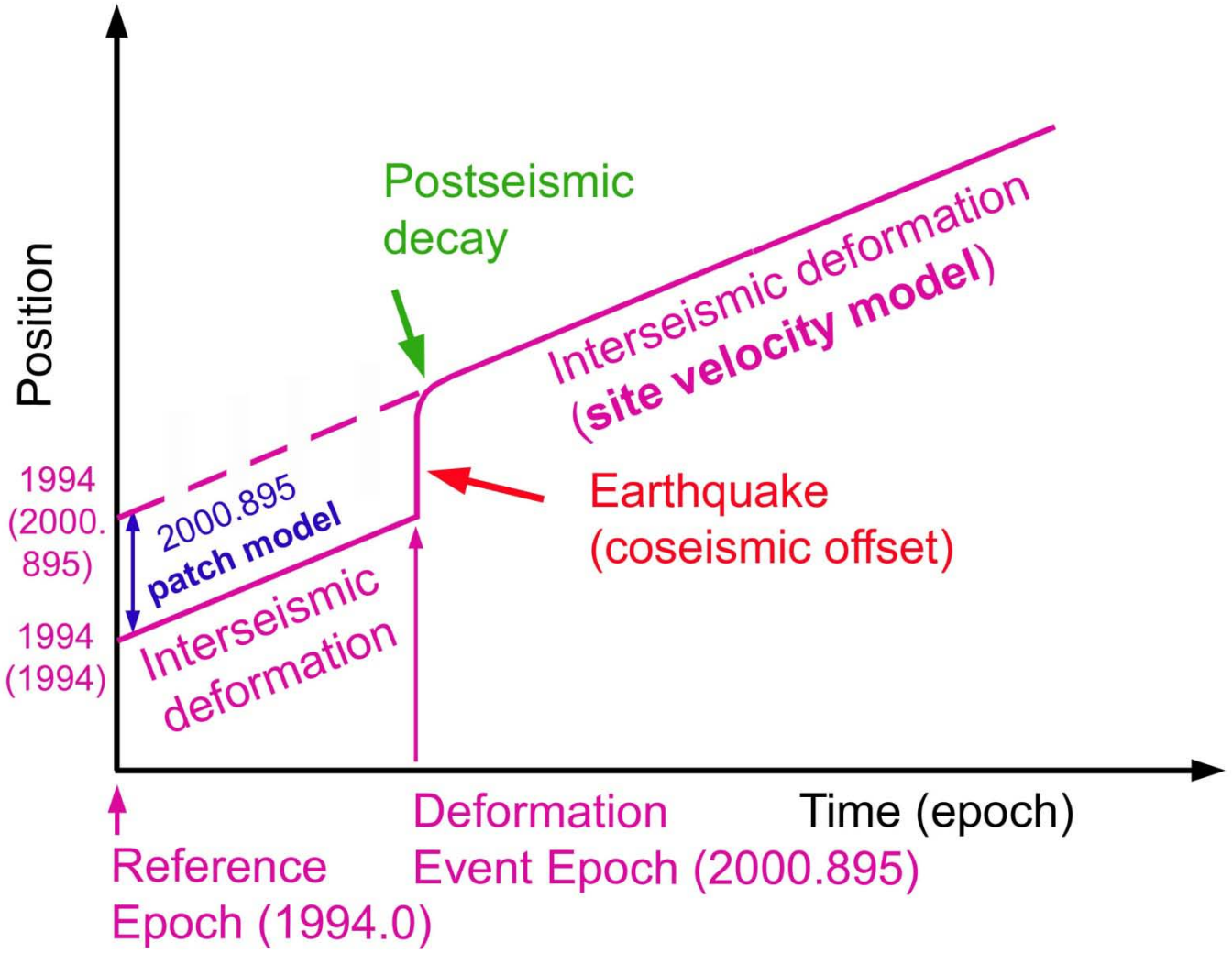
→ **Kinematic component**

Deformation or time-dependent transformation model to link kinematic and static components

Deformation characterisation



Deformation model in practice



Development of a PNG plate and deformation model

Computation of 0.1 degree grid of PNG interseismic site velocities

Step 1 – Compute site velocity from Euler pole within “rigid” plate or block polygon

Step 2 – Compute elastic strain corrections for each grid point (if significant) using DEFNODE

Step 3 – Kriging of modelled and observed velocity differences to estimate model correction grid (for self-consistency)

Step 4 – Model velocity = plate model + elastic strain correction + kriging correction

Step 5 – Compute uncertainty model using post fit residuals

Step 6 – Develop coseismic and postseismic patch models

Application of deformation model

Kinematic ITRF coordinates (e.g. from PPP or AusPos) can be transformed to PNG94 using the site velocity model

Network analysis (e.g. post-processing, RTK and NRTK) can be achieved by using kinematic ITRF coordinates for analysis and forward/reverse propagation using the model

Model can be implemented within GIS to enable alignment of spatial data acquired at different epochs

Coseismic patch model can be used to align data across deformation events (earthquakes)

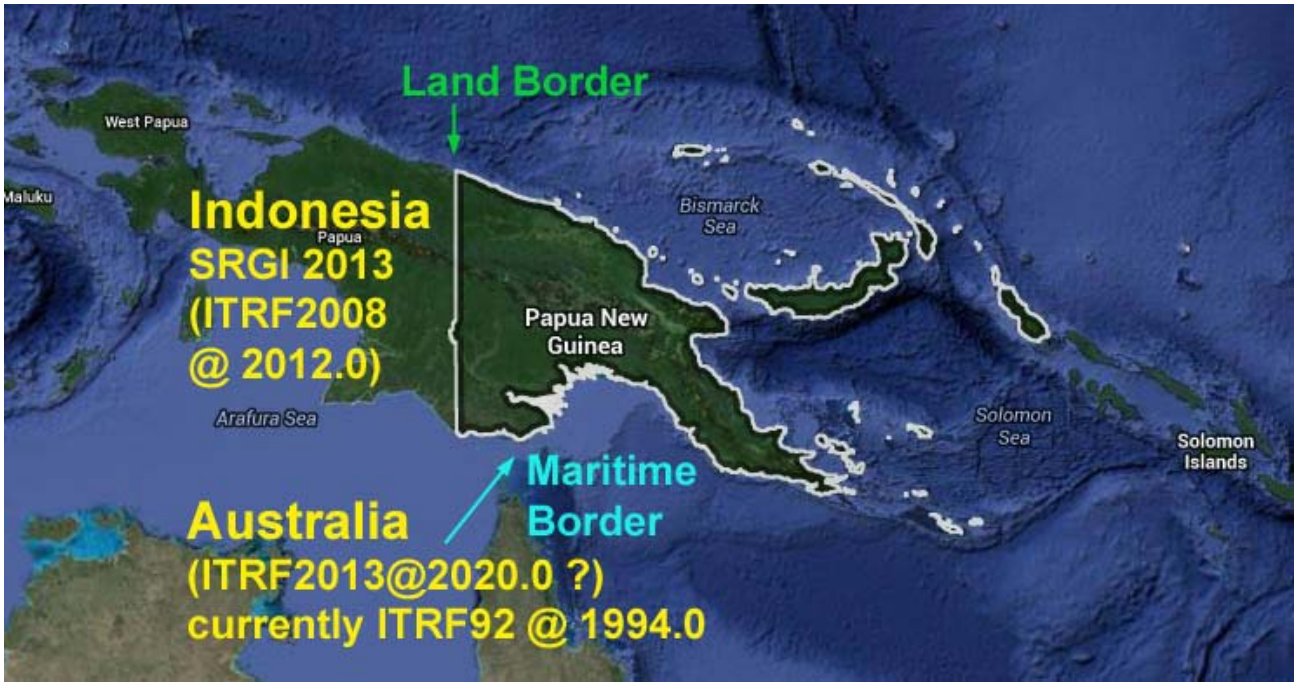
Online post-processing in PNG

AusPOS currently provides kinematic ITRF2008 coordinates at epoch of measurement and GDA94 in PNG S of 8 degrees S. Note: GDA94 should not be used in PNG!

Deformation model can be applied to AusPOS in PNG to obtain PNG94 but this requires PNG Government authority.

PNG08 geoid model can also be applied in PNG territorial extents as it best estimate of MSL in PNG.

Options for a new PNG datum - neighbours



2012 option – aligned with Indonesian datum and extensive land border along 141 degrees E (1.2 m offset from 1994)

2020 option? Australian alignment (epoch 2020?) – maritime border – Torres Strait

(1.8 m offset from 1994 and 0.6 m offset between 2012 and 2020)

Updated epoch will reduce uncertainties with site velocity and earthquake patch models.

Epoch update necessary when interseismic strain exceeds dimensional tolerances

PNG2020 datum?

Existing PNG94 already 21+ years old now

(i.e. Possibly past its coming of age)

PNG2020? (ITRF2014 at epoch 2020.0) would remove any uncertainty arising from 26 years of earthquakes (coseismic and postseismic deformation).

Coordinates closer to current ITRF, but up to 2 m different to PNG94.

Requires gridded distortion model for PNG94 to PNG2020 transformations (e.g. legacy data such as DCDB, project datums, GIS data).

Requires more CORS in PNG (currently only WAIG, LAE1, PNGM and RVO network)

Requires extensive static GPS campaign over PNG geodetic network (e.g. Airport control networks and urban cadastral PSM networks)

Requires authority of PNG Surveyor-General

Tenkyu tru!