On the Development and Implementations of the New Semi-Dynamic Datum for Indonesia

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FIG Working Week 17 - 21 May, Bulgaria
From the wisdom of the ages to the challenges of modern world
SOFIA 2015

Indonesian Geodetic Datums

1862 - 1970	1970 - 1995	1996 - 2013	2013 - ...
Local Topocentric Datum Static Datum Datum Genuk, Bukit Rimpah, Gunung Sahara, Serindung, Moncong Lowe, T21 Sorong	National Topocentric Datum Static Datum Datum ID74	National Geocentric Datum Static Datum DGN95	National Geocentric Datum Semi-dynamic Datum SRGI2013 Deformation Model

Launched on October 17th 2013

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Geodetic Datums in Indonesia

1. Dutch Colonial Time: LOCAL TOPOCENTRIC DATUM
   (Several, Static Datum)
2. ID 1974 : NATIONAL TOPOCENTRIC DATUM
   (Padang Datum , Static Datum)
3. DGN 1995 : NATIONAL GEOCENTRIC DATUM
   (Static Datum)
4. SRGI 2013 : NATIONAL GEOCENTRIC DATUM
   (Semi-Dynamic Datum)

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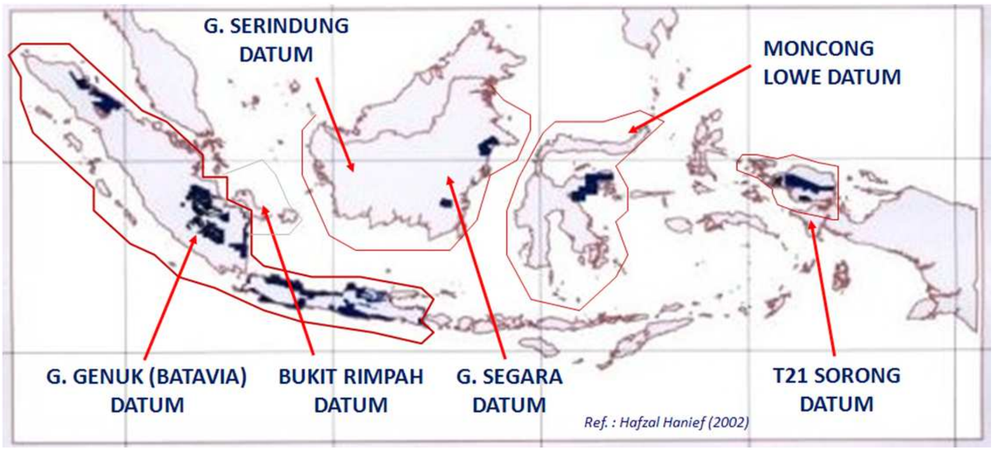
Indonesian Local (Topocentric) Datum



Reference Ellipsoid: Bessel 1841 (a = 6377397 m, 1/f = 298.15)

Hasanuddin Z. Abidin, 2005

Indonesian Local (Topocentric) Datum

Realization of Local (Topocentric) datum in Indonesia was conducted using Triangulation method.

TRIANGULATION NETWORK IN INDONESIA		
Region	Started	Datum
Java & Madura	1862	G. Genuk (Batavia)
Sumatera	1883	G. Genuk (Batavia)
Bangka	1917	Bukit Rimpah
Sulawesi	1913	Moncong Lowe
Flores	1960	G. Genuk (Batavia)

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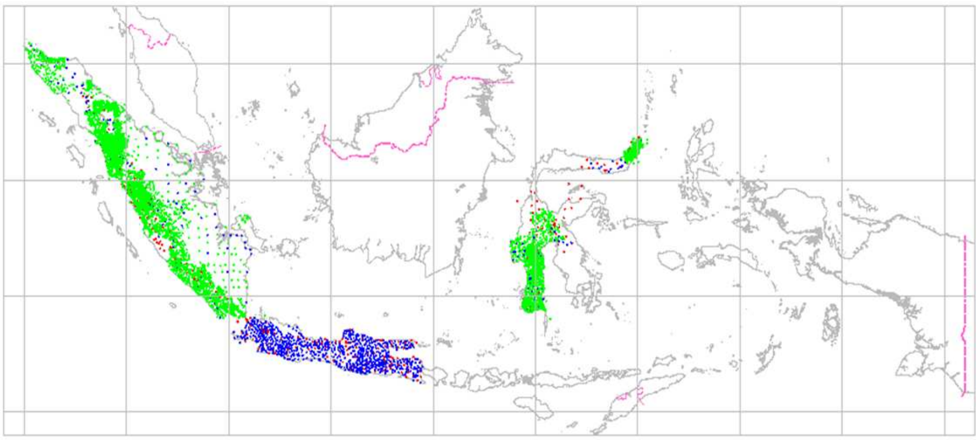
Triangulation Stations in Indonesia



courtesy of Edi Priyanto, BIG

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Geodetic Datum in Indonesia

1. Dutch Colonial Time: LOCAL TOPOCENTRIC DATUM (Several, Static Datum)
2. **ID 1974 : NATIONAL TOPOCENTRIC DATUM (Padang Datum , Static Datum)**
3. DGN 1995 : NATIONAL GEOCENTRIC DATUM (Static Datum)
4. SRGI 2013 : NATIONAL GEOCENTRIC DATUM (Semi-Dynamic Datum)

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Datum Indonesia 1974 (DI-1974)

(Padang Datum, Static Datum)

1. **Coordinates of Datum Point (Padang, West Sumatra) :**

   λ = 00° 56' 38,414"
   ϕ = 100° 22' 08,804"
   h = + 3,912 m

2. **Reference Ellipsoid : INS (Indonesian National Spheroid), with a = 6378160 m, and f = 1/298.247** (based on the GRS 1967 figure but with 1/f taken to 3 decimal places exactly)
3. **Realized using geodetic surveys based on Doppler Satellite observation.**

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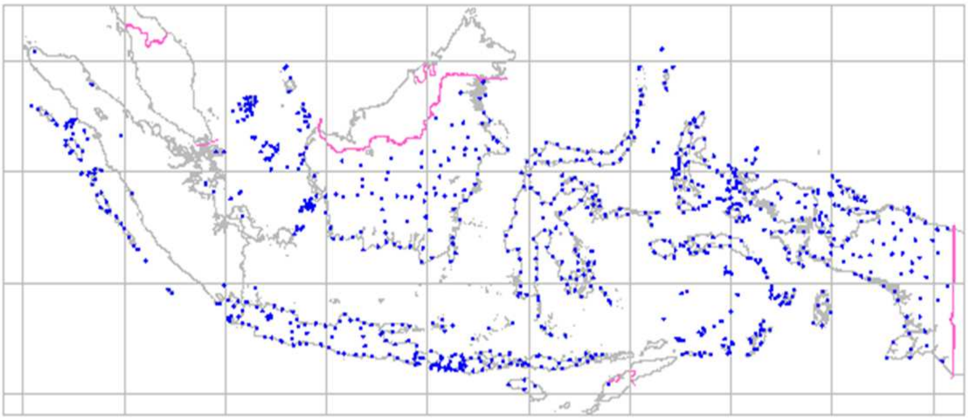
Doppler Stations in Indonesia



courtesy of Ir. Edi Priyanto, BIG

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Geodetic Datum in Indonesia

1. Dutch Colonial Time: LOCAL TOPOCENTRIC DATUM (Several, Static Datum)
2. ID 1974 : NATIONAL TOPOCENTRIC DATUM (Padang Datum , Static Datum)
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4. SRGI 2013 : NATIONAL GEOCENTRIC DATUM (Semi-Dynamic Datum)

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Datum Geodesi Nasional 1995 (DGN-1995)

(Geocentric Datum, Static Datum)

1. First national geocentric datum.
2. Reference Ellipsoid : WGS 1984.
3. Realized using GPS static surveys and continuous observations (GPS CORS)

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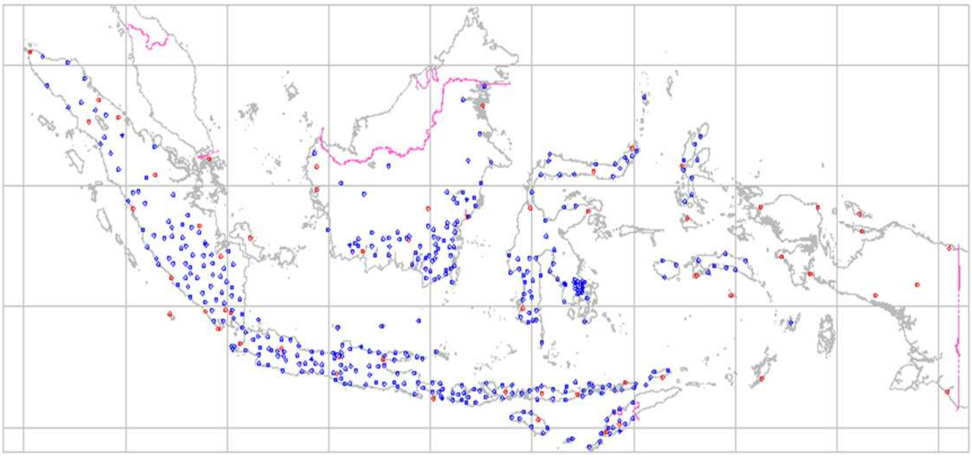
GPS Control Stations in Indonesia (2002)



courtesy of Edi Priyanto, BIG

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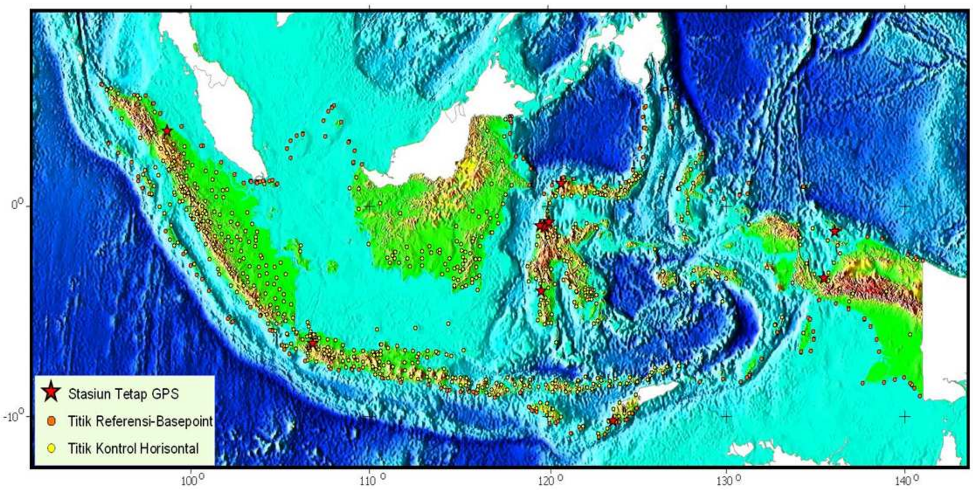
GPS Control Stations in Indonesia (2008)



courtesy of Cecep Subarya, BIG

Around 950 stations

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Geodetic Datum in Indonesia

1. Dutch Colonial Time: LOCAL TOPOCENTRIC DATUM (Several, Static Datum)
2. ID 1974 : NATIONAL TOPOCENTRIC DATUM (Padang Datum, Static Datum)
3. DGN 1995 : NATIONAL GEOCENTRIC DATUM (Static Datum)
4. **SRGI 2013 : NATIONAL GEOCENTRIC DATUM (Semi-Dynamic Datum)**

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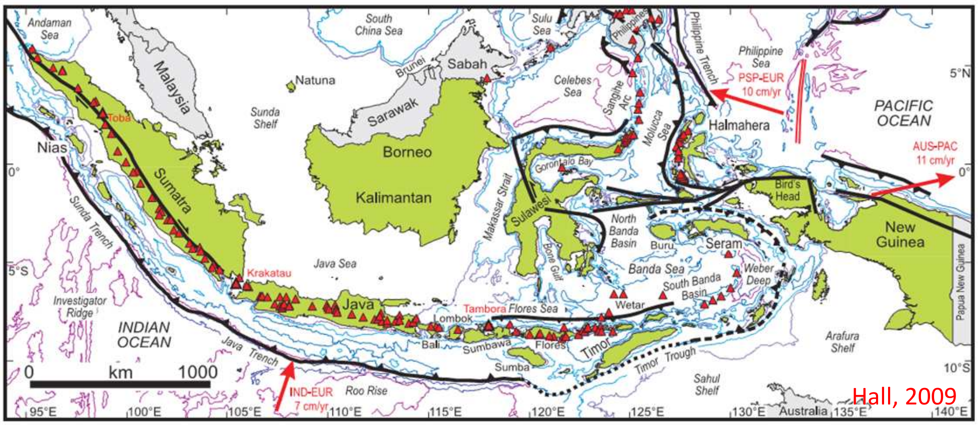
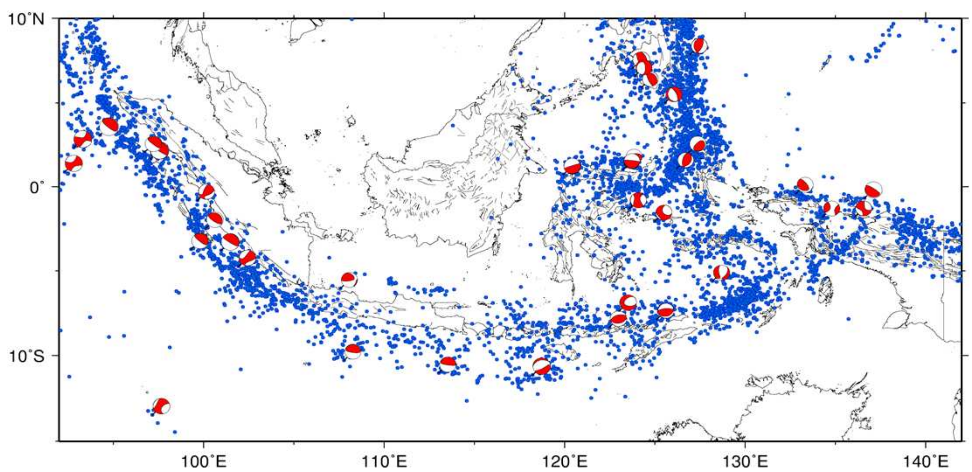
Tectonic Complexity of Indonesian Region



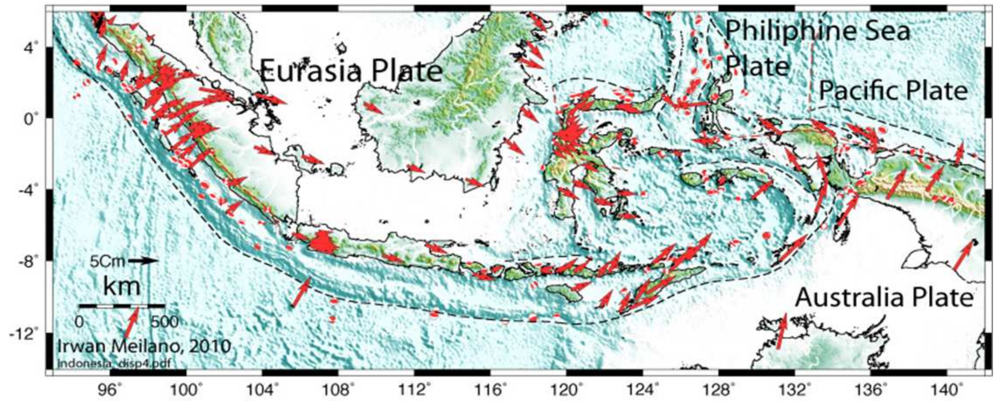
- ❑ Intersection of 3 major plates.
- ❑ Wide range of tectonic environments, including island arc volcanism, subduction zones, and arc-continent collision

SEISMIC COMPLEXITY OF INDONESIAN REGION



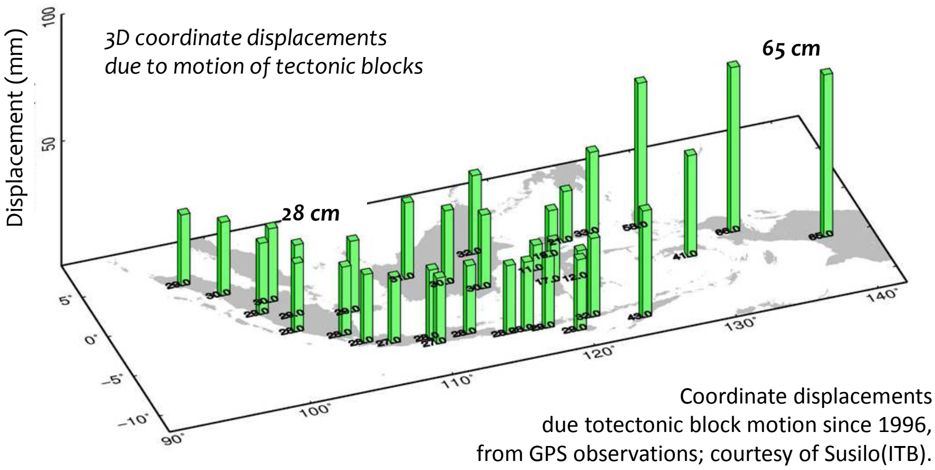
- ❑ Complex plate boundaries
- ❑ High seismicity, shallow EQs mostly confined at the subduction zone

TECTONIC COMPLEXITY OF INDONESIAN REGION (DISPLACEMENT)



Data : Stevent et.al.,(1999/2000), Nugroho et.al., (2000). Bock,et.al., (2003) Socquet et.al., (2006), Subarya et.al.,(2007). Abidin et al., (2007), Meilano et al., (2012)

Coordinate Displacements



Coordinate displacements
due totectonic block motion since 1996,
from GPS observations; courtesy of Susilo(ITB).

courtesy of Irwan Meilano (ITB)

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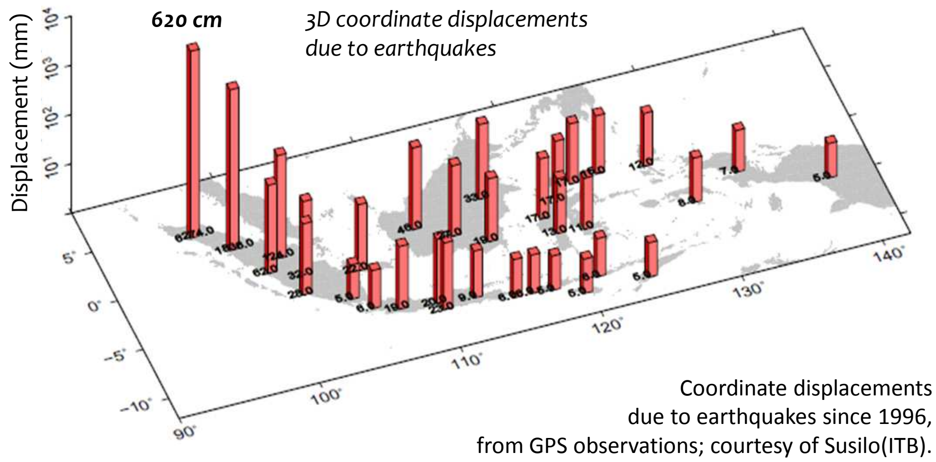
Coordinate Displacements



Coordinate displacements due to earthquakes since 1996, from GPS observations; courtesy of Susilo(ITB).

courtesy of Irwan Meilano (ITB) Hasanuddin Z. Abidin, 2014

Indonesian Geospatial Reference System, IGRS 2013
Sistem Referensi Geospasial Indonesia, SRGI 2013
(launched: 11 October 2013)

- Semi-Dynamic datum.
- Connected to the global ITRF2008 reference frame.
- Reference epoch: 1 January 2012
- Reference Ellipsoid: WGS 1984
  (a = 6378137.0 m; 1/f = 298,257223563).
- If a new version of the ITRF reference frame becomes available, then the IGRS reference frame will also be updated accordingly.
- A velocity model, which incorporates tectonic motion and earthquake related deformation, is used to transform coordinates at an observation epoch to or from this reference epoch.

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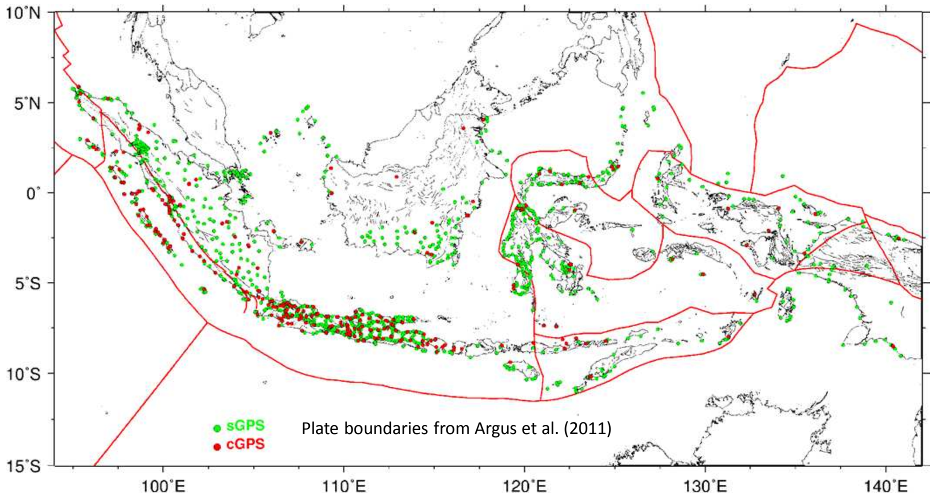
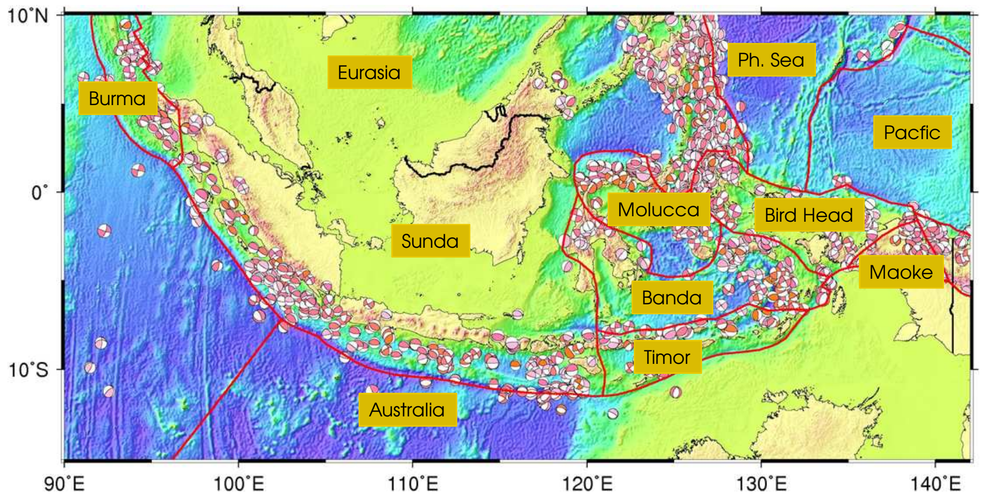
Realization of IGRS2013



❑ cGPS BIG ❑cGPS BPN ❑cGPS SUGAR ❑sGPS BIG

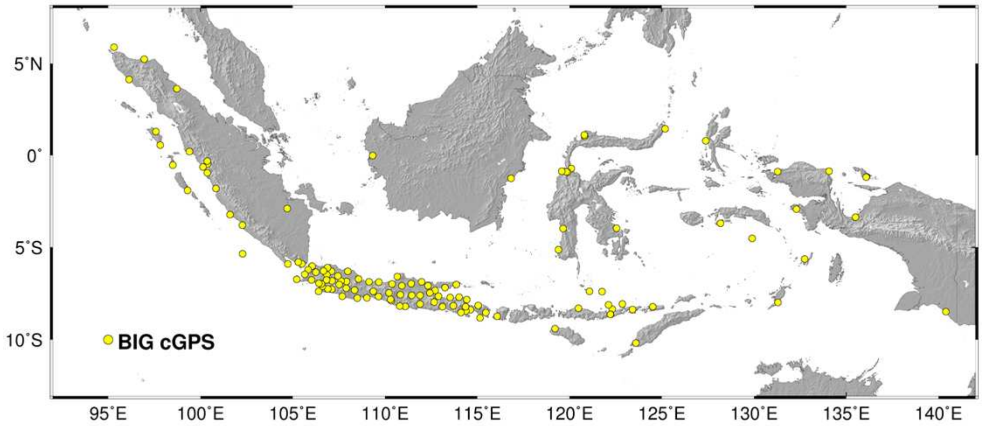
Realization of IGRS2013

Deformation model based on 4 tectonic plates, 7 tectonic blocks, and 126 earthquakes data



courtesy of Susilo (BIG). Hasanuddin Z. Abidin, 2014

Continuous GPS of BIG Indonesia



Total in 2013 = 118 Stations

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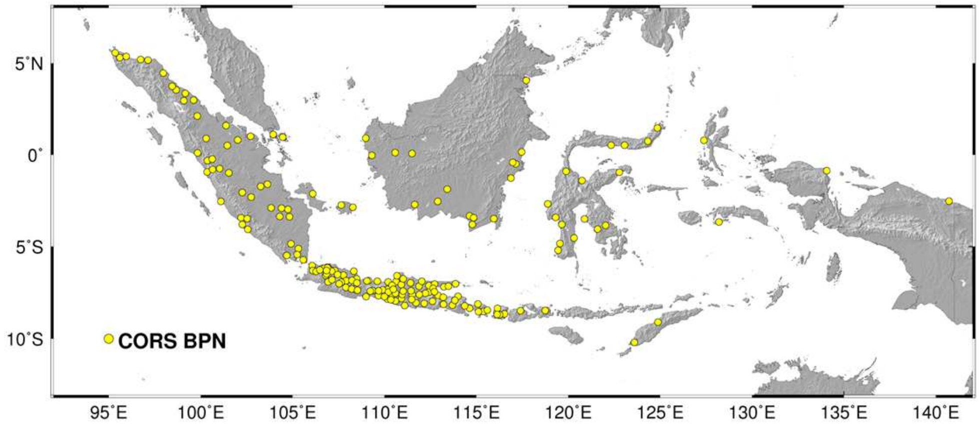
Continuous GPS of BPN Indonesia



Total in 2013 = 183 Stations

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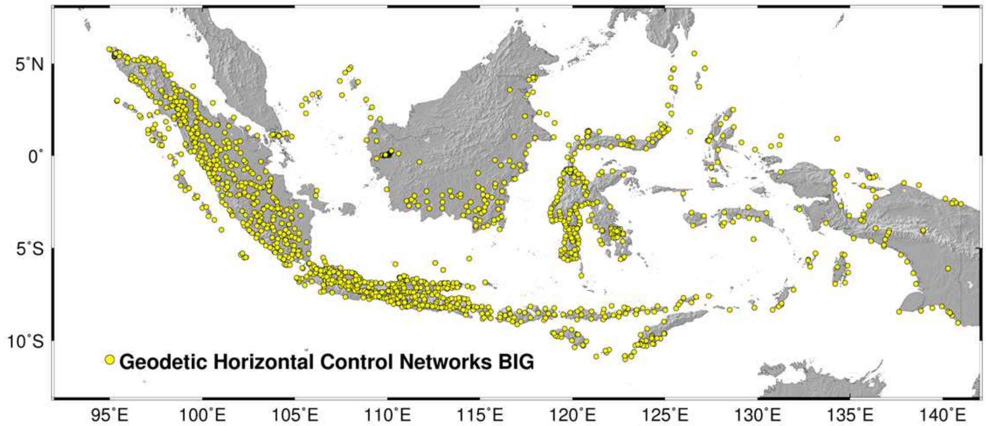
Static GPS of BIG Indonesia



Total in 2013 = 1350 Monuments

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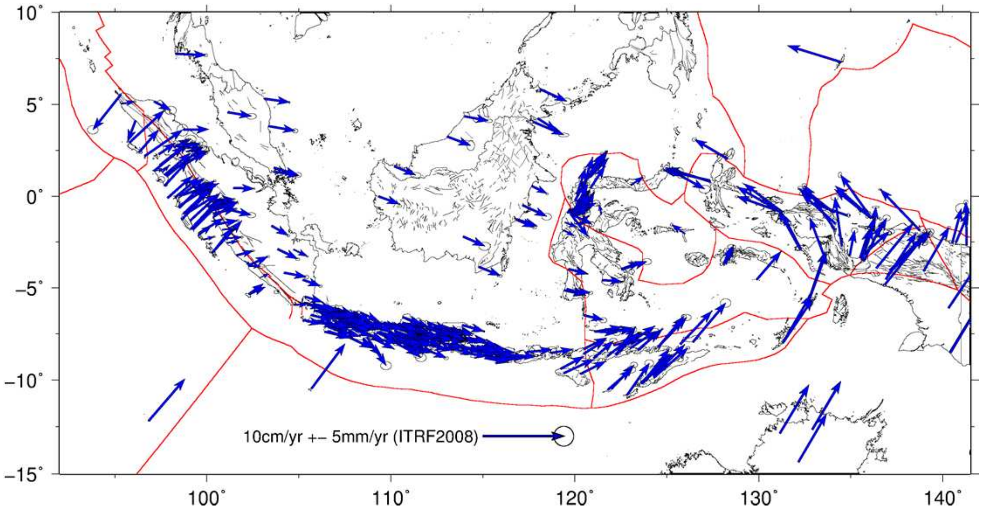
New Velocty Model of IGRS 2013



New velocity model after Abidin et al. (2015), derived from 1996 – 2013 GPS data

Closing Remarks (1)

Updating the Velocity Model

- What are the criterias for updating the model ?
- Time period and spatial coverage for updating the velocity (deformation) model ?
- Reasons for updating the model ?
  1. Displacements due to tectonic plates and blocks motions.
  2. Earthquakes related deformations.
  3. Displacements due to landslides, volcanic eruptions, land subsidences, etc.

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Closing Remarks (2)

Socialization of IGRS 2013

- Education and socialization to all related users and stakeholders, about all aspects of the datum change, has to be well conducted.
- Fast, reliable and user-friendly web-based and online service systems must be established for the implementation of the new datum.
- BIG (Geospatial Agency of Indonesia) has to be a leader in implemntation and socialization of this new datum

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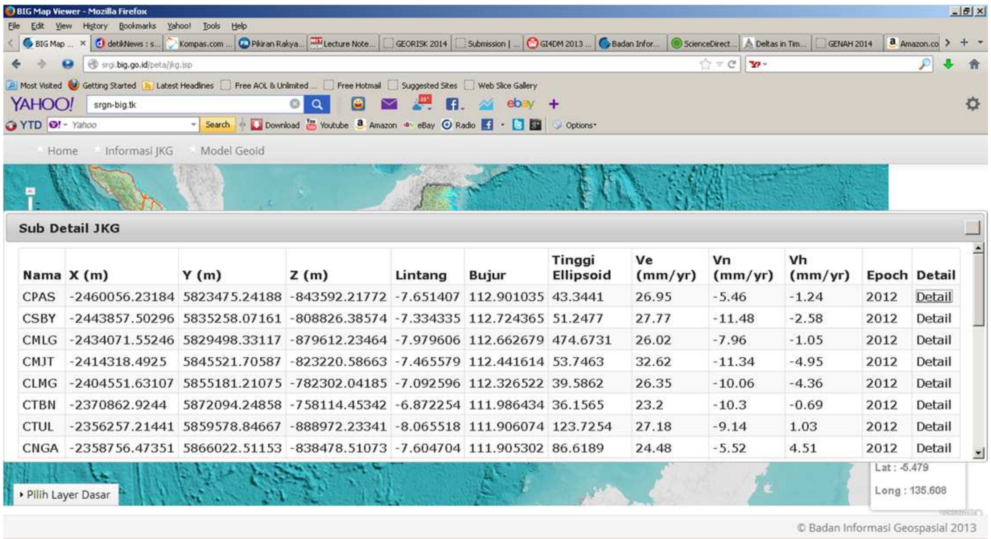
http://srgi.big.go.id/peta/jkg.jsp



Nama	X (m)	Y (m)	Z (m)	Lintang	Bujur	Tinggi Ellipsoid	Ve (mm/yr)	Vn (mm/yr)	Vh (mm/yr)	Epoch	Detail
CPAS	-2460056.23184	5823475.24188	-843592.21772	-7.651407	112.901035	43.3441	26.95	-5.46	-1.24	2012	Detail
CSBY	-2443857.50296	5835258.07161	-808826.38574	-7.334335	112.724365	51.2477	27.77	-11.48	-2.58	2012	Detail
CMLG	-2434071.55246	5829498.33117	-879612.23464	-7.979606	112.662679	474.6731	26.02	-7.96	-1.05	2012	Detail
CMJT	-2414318.4925	5845521.70587	-823220.58663	-7.465579	112.441614	53.7463	32.62	-11.34	-4.95	2012	Detail
CLMG	-2404551.63107	5855181.21075	-782302.04185	-7.092596	112.326522	39.5862	26.35	-10.06	-4.36	2012	Detail
CTBN	-2370862.9244	5872094.24858	-758114.45342	-6.872254	111.986434	36.1565	23.2	-10.3	-0.69	2012	Detail
CTUL	-2356257.21441	5859578.84667	-888972.23341	-8.065518	111.906074	123.7254	27.18	-9.14	1.03	2012	Detail
CNGA	-2358756.47351	5866022.51153	-838478.51073	-7.604704	111.905302	86.6189	24.48	-5.52	4.51	2012	Detail

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Thank you very much

for your attention

Realization and Implementation of SRGI 2013

2 Deformation (Velocity) Model
has to be established for $t_{obs} \longleftrightarrow t_{ref}$
coordinate transformation

- ***The model coverage : all over Indonesia.***
- ***Indonesian area cannot be represented only by a single velocity model.***
- ***Updating time for each model ?***
- ***How to accomodate the deformation related earthquakes ?***

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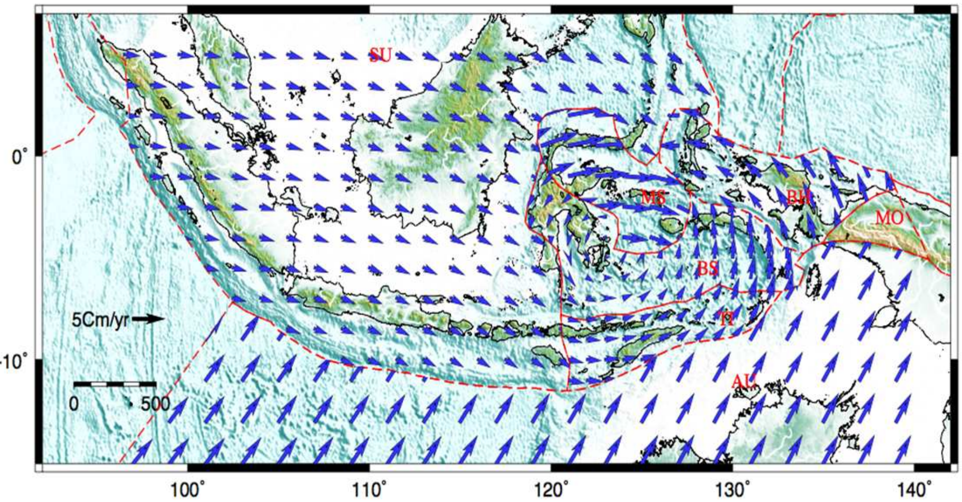
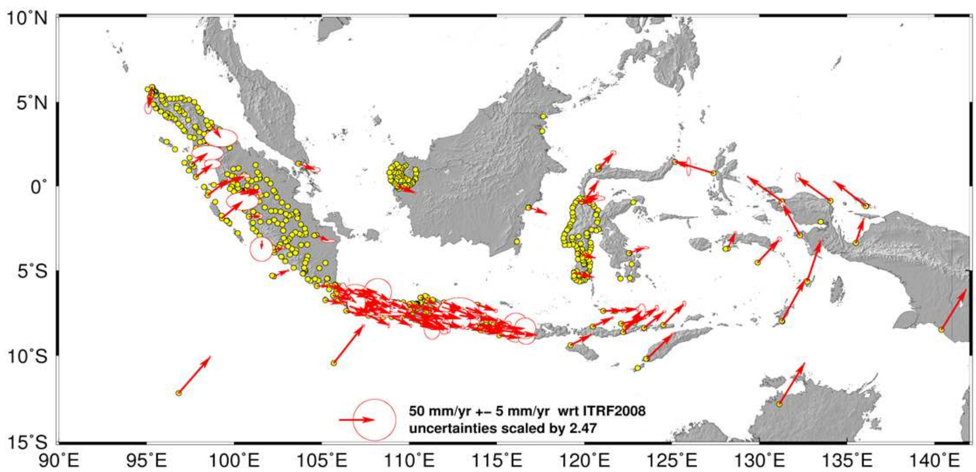
2 Velocity Model based on the plate motion model MORVEL (*DeMets et al. 2010*)



courtesy of Irwan Meilano (ITB) and Susilo (BIG). Hasanuddin Z. Abidin, 2014

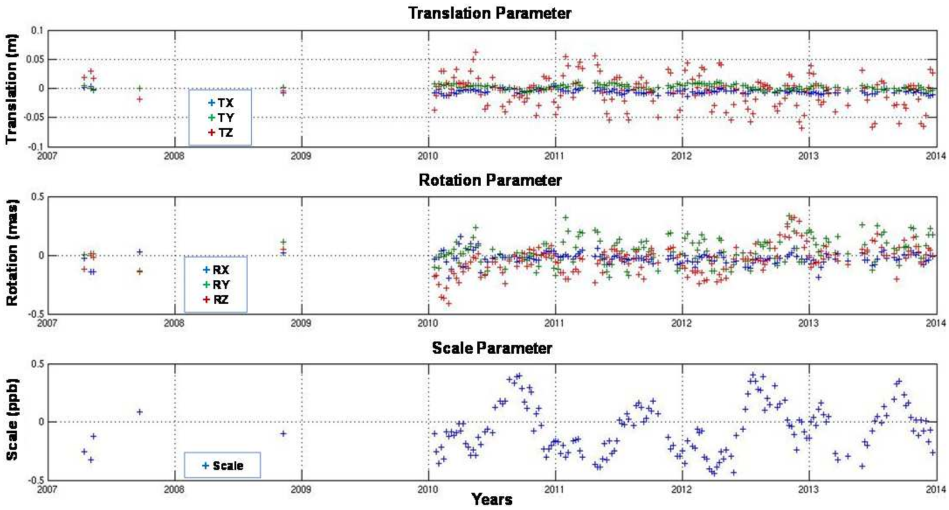
2 ITRF 2008 velocities at the BIG GPS CORS stations

computed using GPS CORS data from 2010 to 2013



courtesy of Susilo (BIG). Hasanuddin Z. Abidin, 2014

2 The Helmert transformation parameters of the estimated GAMIT/GLOBK solution with respect to ITRF2008 epoch 2005



2 Preliminary Euler pole parameters as estimated from GPS CORS solutions in Indonesia..

Plate	Latitude (deg)	Longitude (deg)	Rate (deg/Myr)	Semi Major (deg)	Semi Minor (deg)	Azimuth (deg)	Rate uncertainty (deg/Myr)	wrms (mm/yr)	
								N	E
AU	32.119	37.615	0.635	0.18	0.04	106.0	0.0006	0.44	0.83
BS	0.271	120.474	2.083	0.36	0.03	348.3	0.0918	1.04	1.41
BH	−52.415	54.260	0.536	5.33	0.12	85.7	0.0037	0.20	1.42
MO	8.015	−49.090	1.198	1.99	0.11	55.1	0.1774	0.06	0.05
SU	45.162	128.115	0.313	1.42	0.14	27.8	0.0052	0.70	0.97
TI	2.461	113.389	1.350	0.27	0.02	322.3	0.0260	2.64	0.72

In the above Table: AU = Australian plate; BS = Banda Sea block; BH = Birds Head block; MO = Molucca Sea block; SU = Sunda block; TI = Timor block

courtesy of Susilo (BIG). Hasanuddin Z. Abidin, 2014

3 Updating Velocity Model

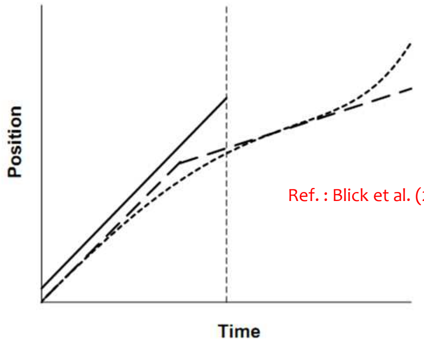


Fig 2. One dimensional position of a mark against time. Dotted line shows the actual movement of the mark. The solid line is the initial deformation model and the dashed line is the revised deformation model after the time of updating, indicated by the vertical dashed line.

Ref. : Blick et al. (2005)

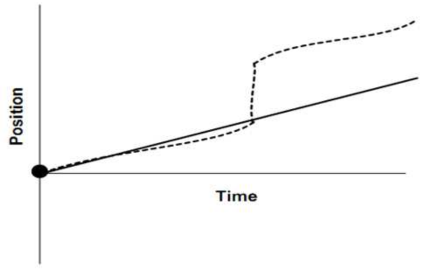


Fig 3. Coordinate of mark defined by deformation model that does not include the deformation event.

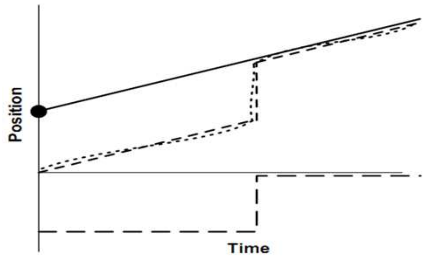


Fig 4. Coordinate of mark defined by deformation model incorporating a patch to model the deformation event.

3 Impact of Earthquakes related deformation

- Inter-seismic
- Co-seismic
- Post-seismic

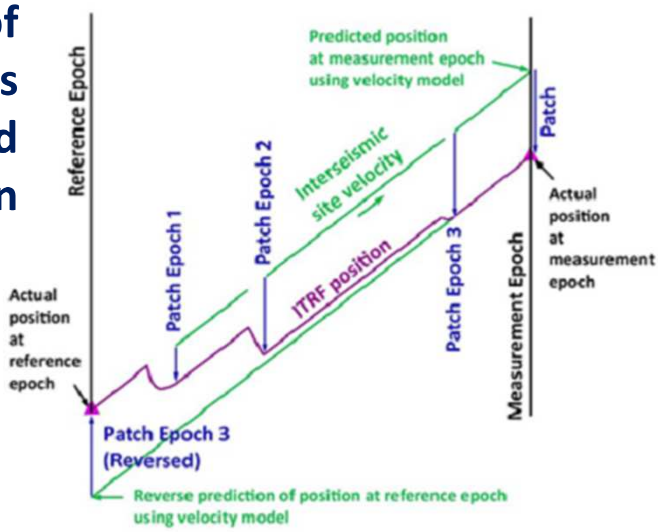


Figure 3. Deformation model in practice showing how cumulative patches can accommodate seismic deformation within an interseismic deformation model.

Ref. : Stanaway et al. (2012)

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3 Impact of Earthquakes related deformation

- What magnitude of earhquake should be considered ? Larger than Mw 6.0 ?
- Spatial coverage of the deformed area that should be considered ?
- How fast the model should be updated ?
- Socialization to the users ?

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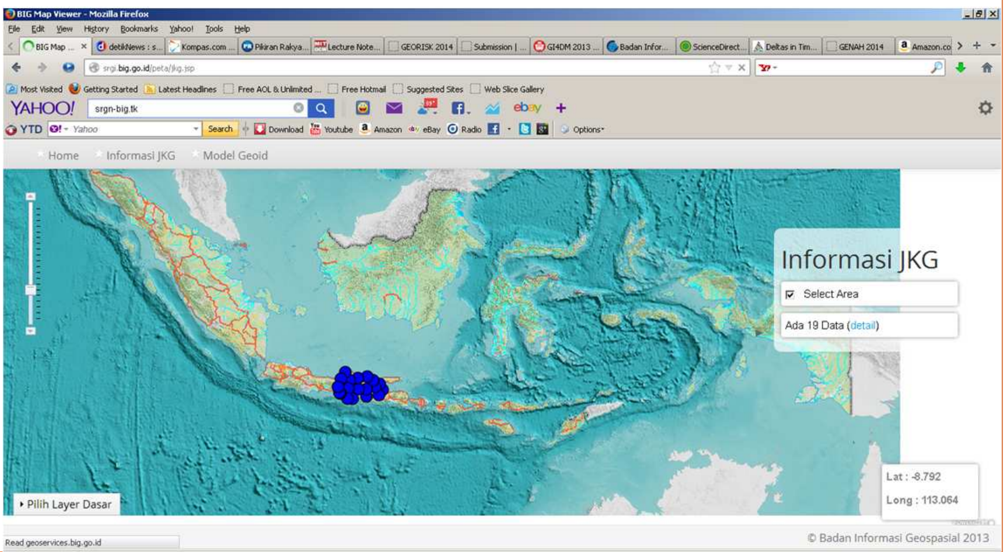
http://srgi.big.go.id/peta/jkg.jsp



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Closing Remarks (1)

- ✓ How to synergize the velocity model derived using the plate motion model (e.g. MORVEL) with the velocity field estimated using pGPS and GPS CORS data ?
- ✓ Can the existing plate and block motion model be able to accurately predict the velocity field for all over Indonesia. In this case, the interplate coupling models for all plates and blocks interfaces in Indonesian region should also be established.
- ✓ Detail mechanisms on handling secular trends, earthquakes offsets (co-seismic deformation), and post-earthquakes motion (post-seismic deformation) should also be established.

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Closing Remarks (2)

- ✓ The Indonesian GPS CORS network should be densified to cover all of Indonesia, especially Borneo Island and the eastern parts of Indonesia. With a denser GPS CORS network, the deformation model of IGRS 2013 can be estimated more reliably and in more detail.
- ✓ Cooperation and coordination with all related positioning and mapping institution in Indonesia (e.g. BPN, Army Topographic Agency, Navy Hydrographic Agency) should also be maintained by BIG throughout the implementation process of IGRS 2013.

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Terima Kasih