PNG08 - A new geoid model for Papua New Guinea

Richard Stanaway

Quickclose



What is a geoid?



The geoid is a surface approximating Mean Sea Level (MSL)

Universität Stuttgart

What does a geoid model do?

- Enables conversion of GNSS/GPS heights (which use the WGS84 or other closely aligned ellipsoid) to approximate Mean Sea Level (MSL)
- The geoid model is the difference between the WGS84 ellipsoid and a geoid approximating MSL (the N value)
- MSL ≈ ellipsoid height N value (H ≈ h – N)

Different geoid models result in different MSL values

The Geoid in PNG – old assumptions



Assumption that the geoid in PNG is coincident to MSL. We know now that this isn't true.

EGM2008 Geoid height in PNG



Plot showing EGM2008 N values over PNG. The geoid in PNG is up to 85 m above the WGS84 ellipsoid .

Height of MSL above the geoid



Technical University of Denmark – National Space Institute

MSL surface is above the geoid in tropical zones due to thermal expansion of the ocean.

MSL geoid difference in PNG



MSL surface is between 0.7 m (Milne Bay Province) & 1.4 m (Manus) above the most recent geoid (e.g. EGM2008).

MSL EGM2008 correction plane to derive PNG08



Sites in purple are tide gauges used to compute the MSL / ellipsoid / EGM2008 offset. The MSL / EGM2008 offsets are shown.

PNG08 Geoid model



PNG08 geoid model accuracy is 0.2 m at 2σ

PNG08 is an interim model until more tidal monitoring is completed

- Requires tidal monitoring at all PNG ports
- Requires cm precise ellipsoidal heights of Tide Gauges
- Stability monitoring of Tide Gauge is required
- Tide Gauges sited away from river mouths
- Lower precision sea surface measurements are still useful especially if made over the full tidal cycle (e.g. by lowering levelling staff or tape from jetty edge)
- Updated MDT model from satellite altimetry can also be used

Station Locator

			1-1-1-1
.ae, Papua New Guinea	Reference	Text Tides	
47°0.00'E. 6°45.00'S Type: Tidal re	eference		
768NM at 93° from station. Meridia	Tevt Tides	Lae, Papua New Guinea	<u></u>
ofined in: hormonice 2004-06-14 t	TEACTIOES	Units are meters, initial timezone is AUSES	
Penneu In. namionics-2004-00-14.(Lee Barne New Cuines	August 2009 low is 0.1m, high is 1.1m, range is 1.0m.	
region: Austral-Asia	Units are meters initial time	rredicted historical low is -0.2m, high is 1.4m, range is 1.6m.	
Jountry: New Guinea	onitos die meters, initial time	Sunday Monday Tuesday Wednesday Thursday Friday Saturday	
	0.62 12:00 AM 08-13		
	0.61 12:30 AM	07-26 07-27 07-28 FQtr 07-29 07-30 07-31 08-01	
	0.60 1:00 AM	H0430 0.9 H0437 0.8 H0425 0.7 L0041 0.7 L1047 0.3 L1040 0.2 L1036 0.2	
	0.60 1:30 AM	L1152 0.3 L1135 0.4 L1117 0.4 H0326 0.7 H1946 0.9 H2041 0.9 H2305 1.0	
Caligola Point, Papua New Guinea	0.60 2:00 AM	H1827 0.7 H1827 0.8 H1842 0.8 L1100 0.3	
Caligora i Onic, riapua New Guinea (T)	0.60 3:00 AM	L2246 0.6 L2337 0.6 R1908 0.9	
Cavieny, Fapua New Guinea (T)	0.60 3:30 AM	08-02 08-03 08-04 08-05 Full 08-06 08-07 08-08	
(erema, Papua New Guinea (1)	0.59 4:00 AM	L1036 0.2 H0045 1.0 H0135 1.0 H0213 1.1 H0246 1.1 H0316 1.1 H0344 1.0	
(ikori, Papua New Guinea (1)	0.59 4:30 AM	L1037 0.2 L1040 0.2 L1045 0.2 L1052 0.2 L1101 0.2 L1110 0.2	
Kimbe, Papua New Guinea (T)	0.58 5:00 AM	H1819 0.7 H1756 0.7 H1750 0.7	
Kokopo, Papua New Guinea (T) 👘	0.56 5.50 AM	L2029 0.7 L2120 0.6 L2202 0.6	
Kumul Tkr Mrg. Papua New Guine	0.52 6:30 AM		
ae, Panua New Guinea (T)	0.50 7:00 AM		
Madang Harbour, Papua New Guir	0.47 7:30 AM	L1118 0.3 L1122 0.3 L1119 0.4 H0444 0.7 H0241 0.6 H1914 0.9 H1952 0.9	
disima, Papua New Guinea (T)	U.44 8:UU AM	H1753 0.8 H1801 0.8 H1814 0.8 L1101 0.4 L1023 0.4	
Misina, Fapua New Guinea (T)	0.41 0:30 AM	L2242 0.6 L2324 0.6 H1830 0.9 H1849 0.9	
Dinau, Fapua New Guinea (T)	0.37 9:30 AM		
Jro Bay, Pabua New Guinea I I I	0.36 10:00 AM	100-10 $100-17$ $100-10$ $100-17$ $100-20$ $100-20$ $100-20$ $100-21$ $100-22$ 1	
OK Canad H	0.36 10:30 AM		
	0.37 11:00 AM	H1825 0.7 H1759 0.7 H1736 0.7 H1717 0.7	
	0.30 11:30 An	L2024 0.7 L2104 0.6 L2140 0.6 L2214 0.5	
	0.44 12:30 PM		
	0.48 1:00 PM	08-23 $08-24$ $08-25$ $08-26$ FQtr $08-27$ $08-28$ $08-29$	
	0.53 1:30 PM	10410 0.7 10430 0.6 10432 0.7 10003 0.5 10032 0.6 11001 0.3 10737 0.2 11052 0.4 11037 0.4 10420 0.6 10333 0.6 11834 1.0 11905 1.0	
	0.58 2:00 PM	H1709 0.8 H1712 0.9 H1724 0.9 L1011 0.3 L1004 0.3	
	0.63 2:30 PM	L2249 0.5 L2324 0.5 H1743 1.0 H1807 1.0	
	0.74 3:30 PM		
	0.78 4:00 PM	08-30 08-31 09-01 09-02 09-03 09-04 Full 09-05	
	0.82 4:30 PM	L1956 0.2 L0953 0.2 H0030 0.9 H0134 0.9 H0214 0.9 H0249 0.9 H0320 0.9	
	0.86 5:00 PM	H1730 0.7 H1657 0.8 H1642 0.8 H1639 0.8	
	0.89 5:30 PM	L2018 0.7 L2055 0.6 L2127 0.6 L2159 0.5	
	0.92 6:30 PM		-
	0.92 7:00 PM		
	0.91 7:30 PM	—	_
	0.90 8:00 PM -		
	0.87 8.30 PM		
	0.82 9:30 PM		
	0.80 10:00 PM	Using WXTIde	
	U.77 10:30 PM		
	0.75 11:00 PM	to predict Tides	
	0.72 II.30 III		
	4		

46th Association of Surveyors of Papua New Guinea Congress, Port Moresby, 1-3 August 2012

X

Computing Ellipsoid Height at Tide Gauges

Static baseline from PNG94 control

or, AUSPOS or NRCan

AUSPOS www.ga.gov.au/bin/gps.pl

NRCan www.geod.nrcan.gc.ca/online_data_e.php

Computing MSL and geoid correction

Compute RL on Prediction Datum

 $RL_{PRED} = RL_{EGM} + D$

Compute LAT

 $RL_{LAT} = RL_{PRED} - low$

Compute HAT

 $RL_{HAT} = RL_{PRED} - high$

Compute MSL

 $RL_{MSL} = (RL_{HAT} + RL_{LAT})/2$

Compute correction to Geoid model (zero order term)

 $c = RL_{MSL} - RL_{EGM}$

Direct measurements of sea level from a BM



Measurement is average of 3 wave tips and 3 wave troughs within 3-4 minutes

46th Association of Surveyors of Papua New Guinea Congress, Port Moresby, 1-3 August 2012

Staff

Sea

Surface

Reading

Worked Example

RL_{EGM2008} of BM4 = 3.766 m

PNG Date (2009)	PNG Time (UT +10 hr)	Predicted Height (from WXTide)	Staff Reading (from BM4)	EGM08 RL (3.766 - staff reading)	Predicted minus EGM2008 (D)
May-20	03:00 PM	0.87	2.30	1.47	-0.60
May-20	04:00 PM	0.91	2.28	1.49	-0.58
May-21	09:00 AM	0.57	2.53	1.24	-0.67
May-21	12:00 PM	0.44	2.68	1.09	-0.65
May-21	01:00 PM	0.53	2.67	1.10	-0.57
May-21	05:00 PM	0.95	2.16	1.61	-0.66
May-21	06:00 PM	0.96	2.13	1.64	-0.68
May-21	10:30 PM	0.74	2.34	1.43	-0.69
May-22	04:30 AM	1.21	1.98	1.79	-0.58
May-22	08:00 AM	0.79	2.41	1.36	-0.57
May-22	10:00 AM	0.42	2.78	0.99	-0.57

Mean D = -0.62

 $RL_{PRED} = RL_{EGM} + D$

 $RL_{PRED} = 3.766 + -0.62 = 3.15$

Low = -0.20 (from *WxTide*) High = 1.80 (from *WxTide*)

 $RL_{LAT} = RL_{PRED} - low$ $RL_{LAT} = 3.15 - -0.20 = 3.35$

 $RL_{HAT} = RL_{PRED} - hat$

 $RL_{HAT} = 3.15 - 1.80 = 1.35$

 $RL_{MSL} = (RL_{HAT} + RL_{LAT})/2$ $RL_{MSL} = (3.35 + 1.35)/2 = 2.35$ $c = RL_{MSL} - RL_{EGM}$

c = 2.35 - 3.766 = -1.42

DMA 10°x10 ° Model – UGLY!



This very inaccurate model is still used in many software packages and GPS receivers – e.g. Trimble, Hemisphere, OmniSTAR.

Results in many significant errors in bathymetry and hydrography!

DMA 10°x10 ° Model Error (compared to PNG08)



Errors in heighting of up to 14 metres!! & false gradient of up to 0.2 m / km!!

PNG08 geoid model – where to find it



 ✓ Text format
 ✓ csv format
 ✓ Leica GEM
 ✓ Trimble GGF
 ✓ Topcon/Sokkia GFF format

PNG08 work flow

- Use PNG08 model with GNSS / GPS processing software RTK controller and AUSPOS or NRCan ellipsoid heights.
- MSL(PNG08) = PNG94 ellipsoid height PNG08 N value $(H \approx h N)$
- PNG Geodetic database being converted to PNG08
 PNG08 update could become gazetted vertical datum
- PNG08 Reduced Levels (RLs) may differ from existing RLs by several metres (e.g. in Highlands, CDW datum, LAT) (difference should be consistent over local area)
- PNG08 values are within 0.2 m of MSL

What can happen if the geoid model is wrong!



Thank you