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# Report on the Analysis of the Asia Pacific Regional Geodetic Project (APRGP) GPS Campaign 2011

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by

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Australian Government
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# Contents

# Executive Summary

### REPORT ON THE ANALYSIS OF THE ASIA PACIFIC REGIONAL GEODETIC PROJECT (APRGP) GPS CAMPAIGN 2011

The annual Asia Pacific Regional Geodetic Project (APRGP) GPS campaign is an important activity of the Geodetic Technologies and Applications Working Group (WG) of the Permanent Committee on GIS Infrastructure for Asia and the Pacific Region (PCGIAP). This document overviews the data analysis of the APRGP GPS campaign undertaken in 2011. The GPS data were processed using version 5.0 of the Bernese GPS Software in a regional network together with selected IGS (International GNSS Service) sites. The GPS solution was constrained to the ITRF2008 reference frame through adopting IGS08 coordinates on selected IGS reference sites and using the final IGS earth orientation parameters and satellite ephemerides products.

# Introduction

The Permanent Committee on GIS Infrastructure for Asia and the Pacific Region (PCGIAP) executive board meeting was held in Tehran, Iran on 17 May 2010, where a decision was made to continue the annual GPS campaign activity. The decision was made because some member countries were at this time unable to participate in the Asia Pacific Reference Frame (APREF) project but had an ongoing requirement for geodetic positioning relative to the regional/global network. The annual APRGP GPS campaign is an important activity of the Geodetic Technologies and Applications Working Group (WG) of the PCGIAP. The role of the WG is to coordinate regional cooperation in geodesy amongst national agencies, and to build and improve the regional geodetic infrastructure. The APRGP is where PCGIAP member agencies contribute campaign or continuous GPS data to the WG. GPS data from the APRGP are available for all participant member countries for local and global scientific research and local applications. The composite GPS data-set is subsequently analysed by the WG so as to provide estimates of station coordinates in the International Terrestrial Reference Frame (ITRF). The results of the APRGP are also supplied by the WG to the official ITRF product centre to densify the ITRF in the Asia Pacific region. This document overviews the data analysis of APRGP GPS campaign undertaken in 2011.

The document is organized as follows. The data set of the campaign is described first. The data processing scheme is detailed after, followed by the results of processing including the repeatability RMS (root mean square) of the station coordinates, and the final computed station coordinates.

# GPS Data Set

The 2011 GPS campaign was undertaken from the 11 to 17 September 2011 inclusive (days of year 254 to 260). The data were contributed from seven countries, i.e., Brunei, Japan, Korea, Malaysia, Philippines, Singapore and Vietnam. Note that Philippines also contributes CGPS data to the APREF project. Figure 1 shows the distribution of the APRGP 2011 campaign stations along with the APREF stations (as of July 2012).

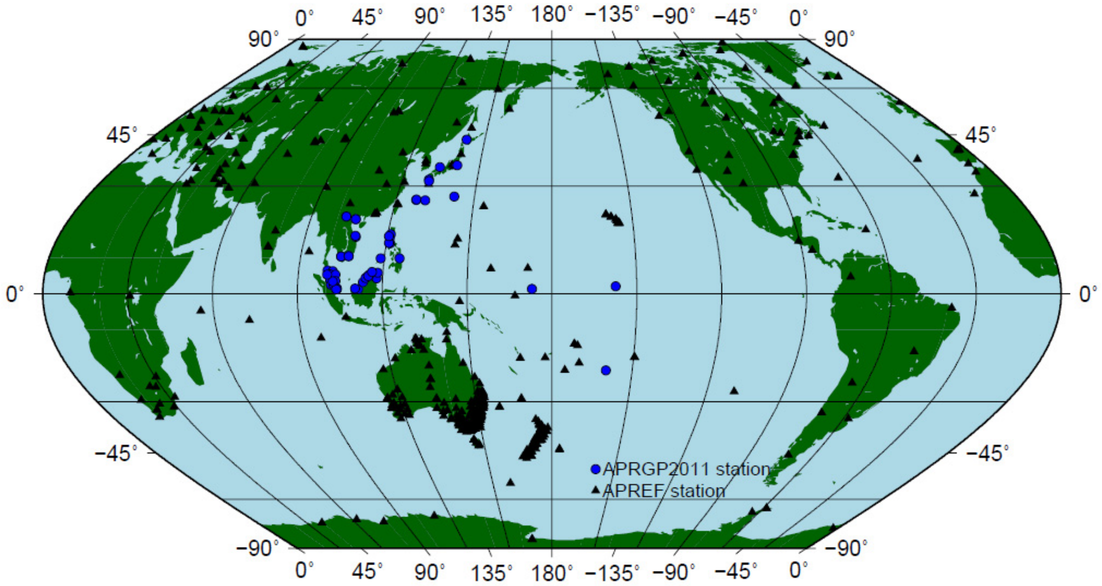


***Figure 1:*** *APRGP and APREF stations in the APRGP 2011 GPS campaign analysis.*

# Data Processing Scheme

Analysis of the GPS observations was undertaken with the processing engine of Bernese GPS software V5.0 (Dach et al., 2007). The Bernese GPS software conforms to the IERS2003 conventions (McCarthy and Petit, 2004). In order to tie the APRGP network to the ITRF2008 reference frame (Altamimi et al., 2011), we processed the available data from IGS sites located around the Asia Pacific region in addition to campaign sites and APREF stations as shown in Figure 1. For the details of APREF project, see http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html.

An overview of the processing strategy is as follows:

1) IGS final precise GPS satellite ephemeris and the Earth rotation parameters were used for the daily data processing to generate daily normal equations.
2) Site displacement due to ocean tidal loading for all stations were corrected by using the GOT00.2 model (Scherneck, 1991).
3) Antenna phase centre variations were taken into consideration using consistent, absolute IGS models of both receiver and satellite antenna phase centres (Schmid et al., 2007).
4) Dual frequency carrier phase and code data were used with an elevation cut off angle of $10^{\circ}$ and elevation-dependent weighting ($w = \cos^2 z$, where $z$ is the zenith angle). Code measurements were only used for receiver clock synchronisation. Pre-processing used the full sampling rate of 30 seconds, a sampling rate of three minutes was used for other processing.
5) Carrier phase pre-processing was conducted on a baseline by baseline mode using triple differences. The observations with small pieces and the observations suspected to be corrupted by a cycle slip were marked. Subsequent processing did not use the marked observations. Using different linear combination of L1 and L2 cycle slips were fixed if possible. New ambiguity parameters were introduced if cycle slips could not be fixed reliably, or if significant gaps in the observations where present. In addition, a data screening step in a baseline by baseline mode was performed on the basis of weighted post-fit residuals and outliers were marked and removed for the further processing.
6) An a priori dry tropospheric delay computed from a standard atmosphere was mapped with the Dry Niell mapping function (Niell, 1996). For the wet component, continuous piecewise linear troposphere parameters were estimated in 1-hour intervals without any a priori model using the wet Niell mapping function and the ionosphere-free combination observations.
7) After the pre-processing, ionosphere maps were estimated using the geometry-free linear combination. The vertical electron content was modelled with a single-layer model in a solar geomagnetic reference frame. The height of the single layer was 450 km above the Earth's surface. The previously estimated ionosphere maps were introduced as a priori ionosphere information and, in addition, stochastic ionosphere parameters were set up to support the Quasi Ionospheric Free (QIF) ambiguity resolution strategy (Dach et al., 2007).
8) Ambiguity resolution was attempted on all baselines within the network using the QIF strategy with ionospheric and tropospheric delay supporting. The QIF strategy is based on the ionospheric free linear combination, but also incorporates the estimation of an ionospheric parameter for each epoch to account for the residual ionospheric biases, details can be found in Dach et al. (2007).
9) The daily normal equations were generated and combined into a campaign solution. As part of this process the daily solutions were compared with the combined solution and the resulting differences were analysed for the presence of outliers and the daily repeatability.

# Results

### THE REPEATABILITY RMS (ROOT MEAN SQUARE) OF THE STATION COORDINATES

The repeatability RMS (root mean square) of the station coordinates, an estimate of the day-to-day scatter of coordinate components about a weighted epoch mean, was used to assess the quality of the final epoch solution and as a measure of internal precision. Table 1 lists the repeatabilities RMS of the station coordinates. The average of the repeatabilities (i.e. RMS) of the station coordinates for the campaign was 1.8 mm, 2.1 mm and 5.6 mm in north, east and up components, respectively.

**Table 1.** The repeatability RMS for the campaign stations.

| **Station** | **Country** | **North (mm)** | **East (mm)** | **Up (mm)** |
|---|---|---|---|---|
| LIAN | Brunei | 1.4 | 1.9 | 6.4 |
| MURA | Brunei | 3.1 | 2.8 | 8.2 |
| UKUR | Brunei | 1.4 | 1.2 | 8.8 |
| 0029 21702S011 | Japan | 2.3 | 1.5 | 4.7 |
| 0100 21742S001 | Japan | 2.2 | 2.3 | 7.8 |
| 0745 | Japan | 2.6 | 1.1 | 4.1 |
| 0746 | Japan | 2.2 | 2.3 | 8.1 |
| 0837 21742S001 | Japan | 1.2 | 1.3 | 5.3 |
| 1135 | Japan | 1.5 | 2.0 | 8.7 |
| 2004 | Japan | 2.8 | 1.9 | 9.4 |
| 2005 | Japan | 2.4 | 2.9 | 5.8 |
| 2007 | Japan | 2.3 | 3.5 | 7.0 |
| 3009 | Japan | 1.9 | 1.6 | 4.2 |
| COOK | Japan | 1.8 | 2.0 | 4.8 |
| KRTM | Japan | 1.6 | 1.6 | 5.2 |
| TARW | Japan | 1.3 | 2.1 | 6.7 |
| TSKB 21730S005 | Japan | 1.5 | 2.0 | 8.7 |
| SUWN 23903M001 | Korea | 2.5 | 1.5 | 4.5 |
| AMAN | Malaysia | 2.8 | 1.9 | 7.1 |
| ARAU | Malaysia | 1.9 | 1.6 | 6.7 |
| BEHR | Malaysia | 2.2 | 2.1 | 9.7 |
| BIN1 | Malaysia | 1.9 | 1.7 | 7.7 |
| GETI | Malaysia | 2.0 | 2.1 | 7.4 |
| GMUS | Malaysia | 2.5 | 1.6 | 5.2 |
| GRIK | Malaysia | 1.1 | 1.7 | 4.7 |
| JHJY | Malaysia | 1.7 | 2.0 | 4.7 |
| KUAL | Malaysia | 1.6 | 1.4 | 7.3 |
| LAB1 | Malaysia | 1.7 | 1.1 | 6.1 |
| MIRI | Malaysia | 0.9 | 1.4 | 5.8 |
| MTAW | Malaysia | 2.1 | 0.9 | 8.0 |
| PDIC | Malaysia | 1.5 | 0.9 | 6.6 |
| PEKN | Malaysia | 1.8 | 1.8 | 5.2 |
| SAND | Malaysia | 2.0 | 0.9 | 4.5 |
| SEG1 | Malaysia | 1.0 | 1.1 | 4.6 |
| TLOH | Malaysia | 1.1 | 1.4 | 4.7 |
| UMAS | Malaysia | 1.5 | 1.0 | 6.1 |
| UMSS | Malaysia | 1.8 | 1.5 | 4.9 |
| USMP | Malaysia | 1.9 | 2.5 | 9.5 |
| PBAY | Philippines | 2.3 | 2.3 | 8.0 |
| PCAB | Philippines | 2.2 | 1.2 | 6.8 |

**Table 1.** Continued.

| Station | Country | North (mm) | East (mm) | Up (mm) |
|---|---|---|---|---|
| PCAN | Philippines | 1.4 | 2.5 | 6.4 |
| PPPC | Philippines | 2.2 | 1.7 | 8.5 |
| PSUR | Philippines | 1.4 | 1.8 | 5.9 |
| PTAG | Philippines | 1.9 | 1.4 | 4.8 |
| PTGY | Philippines | 1.9 | 1.2 | 7.1 |
| PURD | Philippines | 2.5 | 1.9 | 7.0 |
| SKEP | Singapore | 3.2 | 3.3 | 9.1 |
| SLOY | Singapore | 1.2 | 1.2 | 5.7 |
| SNTU | Singapore | 1.9 | 0.8 | 5.5 |
| SNYP | Singapore | 1.7 | 1.4 | 4.7 |
| SSEK | Singapore | 1.1 | 1.5 | 7.3 |
| SSMK | Singapore | 1.8 | 1.6 | 4.3 |
| DIEB | Vietnam | 2.4 | 1.8 | 9.5 |
| DOSN | Vietnam | 4.2 | 2.6 | 7.6 |
| NT01 | Vietnam | 2.3 | 2.3 | 9.2 |
| NT03 | Vietnam | 1.9 | 2.4 | 8.5 |
| NT04 | Vietnam | 1.6 | 2.1 | 9.6 |
| NT05 | Vietnam | 0.7 | 1.1 | 6.3 |
| QNAM | Vietnam | 2.6 | 2.3 | 9.3 |
| QT01 | Vietnam | 3.0 | 2.5 | 8.8 |
| QT03 | Vietnam | 1.9 | 2.6 | 10.1 |
| VUNT | Vietnam | 1.9 | 1.9 | 9.0 |

## FINAL COMPUTED STATION COORDINATES

The final computed Cartesian and geodetic coordinates (ITRF2008, GRS80 ellipsoid) are listed in Tables 2 and 3, respectively, along with their formal error estimates. These estimates can be the first indication of the quality of the measurements; they also characterize the internal precision of positioning performance. Note that the listed coordinates are at the mean epoch of the measurements in the ITRF2008 reference frame, and only for the campaign sites, the weekly coordinates of other CGPS stations of APREF project can be found in http://www.ga.gov.au/earth-monitoring/geodesy/asia-pacific-reference-frame.html.

**Table 2.** The final computed Cartesian coordinates in ITRF2008 at the mean epoch of the measurements, i.e. @2012.7041.

| Station 4-char. ID | X (m) | $1\sigma$ (m) | Y (m) | $1\sigma$ (m) | Z (m) | $1\sigma$ (m) |
|---|---|---|---|---|---|---|
| 0029 | -3862397.948 | 0.0004 | 3105008.920 | 0.0004 | 4001961.191 | 0.0004 |
| 0100 | -3509124.814 | 0.0004 | 4529006.931 | 0.0004 | 2793529.210 | 0.0004 |
| 0745 | -3512919.918 | 0.0004 | 4524558.134 | 0.0004 | 2795882.058 | 0.0003 |
| 0746 | -3786805.099 | 0.0004 | 4311846.085 | 0.0004 | 2774485.446 | 0.0003 |
| 0837 | -3530185.654 | 0.0006 | 4118797.275 | 0.0006 | 3344036.857 | 0.0005 |
| 1135 | -3591930.956 | 0.0004 | 3758797.040 | 0.0004 | 3682342.856 | 0.0004 |
| 2004 | -3565271.710 | 0.0005 | 4118973.116 | 0.0005 | 3306293.164 | 0.0004 |
| 2005 | -3642161.347 | 0.0004 | 2861487.863 | 0.0004 | 4370351.283 | 0.0004 |
| 2007 | -4490605.346 | 0.0006 | 3483894.830 | 0.0006 | 2884928.256 | 0.0004 |
| 3009 | -3997616.105 | 0.0004 | 3276761.931 | 0.0004 | 3724230.307 | 0.0004 |
| AMAN | -2332691.802 | 0.0003 | 5934768.329 | 0.0003 | 135097.408 | 0.0002 |
| ARAU | -1131051.808 | 0.0003 | 6236311.779 | 0.0003 | 711747.988 | 0.0002 |
| BEHR | -1270756.612 | 0.0003 | 6236377.949 | 0.0003 | 416063.888 | 0.0002 |

**Table 2.** Continued.

| Station 4-char. ID | X (m) | 1$\sigma$ (m) | Y (m) | 1$\sigma$ (m) | Z (m) | 1$\sigma$ (m) |
|---|---|---|---|---|---|---|
| BIN1 | -2497850.082 | 0.0003 | 5857731.708 | 0.0003 | 358111.940 | 0.0002 |
| COOK | -5583616.969 | 0.0008 | -2053000.087 | 0.0008 | -2292142.357 | 0.0004 |
| DIEB | -1336842.321 | 0.0002 | 5787988.443 | 0.0002 | 2315702.216 | 0.0003 |
| DOSN | -1724757.283 | 0.0006 | 5714523.898 | 0.0006 | 2239792.028 | 0.0006 |
| GETI | -1329733.210 | 0.0003 | 6199766.540 | 0.0003 | 687129.447 | 0.0002 |
| GMUS | -1317445.117 | 0.0003 | 6217407.680 | 0.0003 | 537098.014 | 0.0002 |
| GRIK | -1225760.641 | 0.0002 | 6230325.977 | 0.0002 | 600544.082 | 0.0002 |
| JHJY | -1520490.125 | 0.0003 | 6191944.460 | 0.0003 | 169912.707 | 0.0002 |
| KRTM | -5886688.700 | 0.0008 | -2444651.324 | 0.0008 | 226251.160 | 0.0002 |
| KUAL | -1443668.371 | 0.0003 | 6184650.122 | 0.0003 | 587309.868 | 0.0002 |
| LAB1 | -2708735.417 | 0.0003 | 5744698.512 | 0.0003 | 583318.793 | 0.0002 |
| LIAN | -2638655.163 | 0.0003 | 5783351.564 | 0.0003 | 519610.113 | 0.0002 |
| MIRI | -2586925.342 | 0.0003 | 5809853.371 | 0.0003 | 482986.925 | 0.0002 |
| MTAW | -2974552.716 | 0.0004 | 5622306.041 | 0.0004 | 470932.473 | 0.0002 |
| MURA | -2691871.259 | 0.0004 | 5755365.504 | 0.0004 | 555842.019 | 0.0002 |
| NT01 | -1726969.513 | 0.0004 | 5714864.921 | 0.0004 | 2237081.375 | 0.0004 |
| NT03 | -1844373.526 | 0.0004 | 5997105.535 | 0.0004 | 1142317.023 | 0.0005 |
| NT04 | -1575936.482 | 0.0004 | 6075089.179 | 0.0004 | 1132070.057 | 0.0003 |
| NT05 | -1566020.439 | 0.0010 | 6076071.941 | 0.0010 | 1140472.288 | 0.0006 |
| PBAY | -3164088.354 | 0.0004 | 5236293.570 | 0.0004 | 1797982.048 | 0.0003 |
| PCAB | -3161422.908 | 0.0004 | 5274253.055 | 0.0004 | 1688186.538 | 0.0002 |
| PCAN | -3225689.631 | 0.0004 | 5285196.464 | 0.0004 | 1525741.430 | 0.0002 |
| PDIC | -1304197.827 | 0.0002 | 6237114.354 | 0.0002 | 279242.736 | 0.0002 |
| PEKN | -1474284.670 | 0.0002 | 6193341.586 | 0.0002 | 385958.623 | 0.0002 |
| PPPC | -3022675.753 | 0.0003 | 5511838.217 | 0.0003 | 1075517.353 | 0.0002 |
| PSUR | -3649683.284 | 0.0004 | 5117857.888 | 0.0004 | 1077577.387 | 0.0002 |
| PTGY | -3181285.085 | 0.0004 | 5307488.223 | 0.0004 | 1543919.119 | 0.0002 |
| PURD | -3119484.140 | 0.0003 | 5279887.081 | 0.0003 | 1747196.497 | 0.0002 |
| QNAM | -1939077.039 | 0.0004 | 5824547.881 | 0.0004 | 1724921.366 | 0.0003 |
| QT01 | -1339440.832 | 0.0004 | 5788398.020 | 0.0004 | 2313170.257 | 0.0007 |
| QT03 | -1916791.369 | 0.0003 | 5822974.899 | 0.0003 | 1754668.673 | 0.0003 |
| SAND | -2990750.713 | 0.0004 | 5596337.937 | 0.0004 | 644936.501 | 0.0002 |
| SEG1 | -1404378.154 | 0.0003 | 6215518.723 | 0.0003 | 274837.364 | 0.0002 |
| SKEP | -1521817.474 | 0.0004 | 6192367.126 | 0.0004 | 140106.716 | 0.0003 |
| SLOY | -1539523.152 | 0.0002 | 6187726.056 | 0.0002 | 151765.333 | 0.0002 |
| SNTU | -1508021.405 | 0.0003 | 6195577.079 | 0.0003 | 148800.737 | 0.0002 |
| SNYP | -1526242.954 | 0.0002 | 6191001.974 | 0.0002 | 152484.110 | 0.0002 |
| SSEK | -1522480.076 | 0.0003 | 6191654.877 | 0.0003 | 162569.361 | 0.0002 |
| SSMK | -1518411.145 | 0.0002 | 6193330.546 | 0.0002 | 133831.329 | 0.0002 |
| SUWN | -3062023.061 | 0.0005 | 4055447.934 | 0.0005 | 3841818.210 | 0.0005 |
| TARW | -6327823.578 | 0.0010 | 785587.217 | 0.0010 | 149815.771 | 0.0002 |
| TLOH | -1369260.468 | 0.0002 | 6217732.147 | 0.0002 | 381198.075 | 0.0002 |
| TSKB | -3957199.718 | 0.0005 | 3310199.108 | 0.0005 | 3737711.573 | 0.0004 |
| UKUR | -2678449.078 | 0.0003 | 5762777.639 | 0.0003 | 543962.438 | 0.0002 |
| UMAS | -2225109.131 | 0.0003 | 5975252.627 | 0.0003 | 162341.132 | 0.0002 |
| UMSS | -2791752.167 | 0.0004 | 5695647.569 | 0.0004 | 666580.629 | 0.0002 |
| USMP | -1135919.528 | 0.0003 | 6248058.504 | 0.0003 | 591589.463 | 0.0002 |
| VUNT | -1849616.955 | 0.0003 | 5995299.871 | 0.0003 | 1143372.702 | 0.0002 |

**Table 3.** The final computed geodetic coordinates in ITRF2008 at the mean epoch of the measurements, i.e. @2012.7041.

| Station 4-char. ID | LONGITUDE (DMS) | | | $1\sigma$ (m) | LATITUDE (DMS) | | | $1\sigma$ (m) | ELLIPSOID HEIGHT (m) | $1\sigma$ (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0029 | 141 | 12 | 14.23216 | 0.0002 | 39 | 6 | 38.20022 | 0.0002 | 172.060 | 0.0007 |
| 0100 | 127 | 46 | 8.11783 | 0.0002 | 26 | 8 | 41.32580 | 0.0002 | 127.564 | 0.0007 |
| 0745 | 127 | 49 | 34.25946 | 0.0002 | 26 | 10 | 6.98554 | 0.0002 | 97.135 | 0.0006 |
| 0746 | 131 | 17 | 26.40186 | 0.0002 | 25 | 57 | 13.42756 | 0.0002 | 72.584 | 0.0007 |
| 0837 | 130 | 35 | 58.54006 | 0.0002 | 31 | 49 | 26.61795 | 0.0002 | 314.652 | 0.0009 |
| 1135 | 133 | 41 | 58.46504 | 0.0002 | 35 | 29 | 25.43898 | 0.0002 | 72.486 | 0.0006 |
| 2004 | 130 | 52 | 42.88003 | 0.0002 | 31 | 25 | 31.11187 | 0.0002 | 134.563 | 0.0007 |
| 2005 | 141 | 50 | 41.34964 | 0.0002 | 43 | 31 | 43.11613 | 0.0002 | 118.575 | 0.0007 |
| 2007 | 142 | 11 | 42.09854 | 0.0002 | 27 | 4 | 3.11564 | 0.0002 | 104.234 | 0.0008 |
| 3009 | 140 | 39 | 33.28844 | 0.0002 | 35 | 57 | 19.63271 | 0.0002 | 65.707 | 0.0006 |
| AMAN | 111 | 27 | 27.24611 | 0.0002 | 1 | 13 | 18.69731 | 0.0002 | 52.436 | 0.0006 |
| ARAU | 100 | 16 | 47.05580 | 0.0002 | 6 | 27 | 0.56506 | 0.0002 | 18.071 | 0.0008 |
| BEHR | 101 | 31 | 1.96528 | 0.0002 | 3 | 45 | 55.33003 | 0.0002 | 68.712 | 0.0007 |
| BIN1 | 113 | 5 | 39.61454 | 0.0002 | 3 | 14 | 25.14227 | 0.0002 | 59.003 | 0.0007 |
| COOK | -159 | -48 | -44.60952 | 0.0002 | -21 | -12 | -2.80247 | 0.0002 | 22.062 | 0.0009 |
| DIEB | 103 | 0 | 19.61952 | 0.0002 | 21 | 25 | 39.41428 | 0.0002 | 465.676 | 0.0007 |
| DOSN | 106 | 47 | 41.50135 | 0.0004 | 20 | 41 | 40.00945 | 0.0004 | 32.725 | 0.0018 |
| GETI | 102 | 6 | 19.67051 | 0.0003 | 6 | 13 | 34.28920 | 0.0002 | -0.558 | 0.0009 |
| GMUS | 101 | 57 | 49.66286 | 0.0002 | 4 | 51 | 46.70498 | 0.0002 | 125.953 | 0.0007 |
| GRIK | 101 | 7 | 48.99365 | 0.0002 | 5 | 26 | 20.44096 | 0.0002 | 149.187 | 0.0006 |
| JHJY | 103 | 47 | 47.51785 | 0.0002 | 1 | 32 | 12.51500 | 0.0002 | 39.175 | 0.0006 |
| KRTM | -157 | -26 | -51.50183 | 0.0002 | 2 | 2 | 47.63252 | 0.0002 | 25.629 | 0.0009 |
| KUAL | 103 | 8 | 20.93050 | 0.0002 | 5 | 19 | 7.99874 | 0.0002 | 54.988 | 0.0007 |
| LAB1 | 115 | 14 | 41.19244 | 0.0002 | 5 | 16 | 57.50738 | 0.0002 | 57.300 | 0.0007 |
| LIAN | 114 | 31 | 29.46426 | 0.0002 | 4 | 42 | 15.56823 | 0.0002 | 65.777 | 0.0007 |
| MIRI | 114 | 0 | 6.28022 | 0.0002 | 4 | 22 | 19.56041 | 0.0002 | 62.389 | 0.0007 |
| MTAW | 117 | 52 | 53.93861 | 0.0002 | 4 | 15 | 45.98392 | 0.0002 | 72.868 | 0.0008 |
| MURA | 115 | 3 | 58.32398 | 0.0002 | 5 | 1 | 59.36237 | 0.0002 | 63.806 | 0.0007 |
| NT01 | 106 | 48 | 51.26851 | 0.0003 | 20 | 40 | 6.45461 | 0.0003 | -20.822 | 0.0011 |
| NT03 | 107 | 5 | 41.86877 | 0.0003 | 10 | 23 | 11.14682 | 0.0003 | 3.087 | 0.0014 |
| NT04 | 104 | 32 | 33.09505 | 0.0003 | 10 | 17 | 32.21374 | 0.0002 | -9.988 | 0.0010 |
| NT05 | 104 | 27 | 9.45845 | 0.0007 | 10 | 22 | 10.18193 | 0.0005 | -9.281 | 0.0026 |
| PBAY | 121 | 8 | 34.56524 | 0.0002 | 16 | 28 | 53.58636 | 0.0002 | 322.911 | 0.0007 |
| PCAB | 120 | 56 | 19.52526 | 0.0002 | 15 | 27 | 0.76533 | 0.0002 | 69.727 | 0.0007 |
| PCAN | 121 | 23 | 48.39697 | 0.0002 | 13 | 55 | 56.39860 | 0.0002 | 103.407 | 0.0007 |
| PDIC | 101 | 48 | 37.92071 | 0.0002 | 2 | 31 | 34.23212 | 0.0002 | 31.190 | 0.0006 |
| PEKN | 103 | 23 | 22.89139 | 0.0002 | 3 | 29 | 33.34868 | 0.0002 | 26.002 | 0.0005 |
| PPPC | 118 | 44 | 24.83952 | 0.0002 | 9 | 46 | 22.55788 | 0.0002 | 65.142 | 0.0006 |
| PSUR | 125 | 29 | 37.31239 | 0.0002 | 9 | 47 | 30.51094 | 0.0002 | 80.312 | 0.0006 |
| PTGY | 120 | 56 | 17.83249 | 0.0002 | 14 | 6 | 1.00874 | 0.0002 | 715.194 | 0.0007 |
| PURD | 120 | 34 | 32.21127 | 0.0002 | 16 | 0 | 15.10494 | 0.0002 | 80.451 | 0.0006 |
| QNAM | 108 | 24 | 48.07340 | 0.0003 | 15 | 47 | 42.24673 | 0.0002 | 11.936 | 0.0009 |
| QT01 | 103 | 1 | 44.31755 | 0.0003 | 21 | 24 | 11.09522 | 0.0003 | 457.580 | 0.0015 |
| QT03 | 108 | 13 | 13.34400 | 0.0003 | 16 | 4 | 28.71128 | 0.0002 | 8.337 | 0.0009 |
| SAND | 118 | 7 | 14.11114 | 0.0002 | 5 | 50 | 32.65089 | 0.0002 | 133.488 | 0.0007 |
| SEG1 | 102 | 43 | 55.27427 | 0.0002 | 2 | 29 | 10.67498 | 0.0002 | 28.538 | 0.0007 |
| SKEP | 103 | 48 | 25.95445 | 0.0003 | 1 | 16 | 1.83446 | 0.0003 | 36.816 | 0.0013 |
| SLOY | 103 | 58 | 17.98368 | 0.0002 | 1 | 22 | 21.49362 | 0.0002 | 50.300 | 0.0006 |

**Table 3.** Continued.

| **Station 4-char. ID** | **LONGITUDE (DMS)** | | | **1 $\sigma$ (m)** | **LATITUDE (DMS)** | | | **1 $\sigma$ (m)** | **ELLIPSOID HEIGHT (m)** | **1 $\sigma$ (m)** |
|---|---|---|---|---|---|---|---|---|---|---|
| SNTU | 103 | 40 | 47.79576 | 0.0002 | 1 | 20 | 44.92924 | 0.0002 | 75.506 | 0.0007 |
| SNYP | 103 | 50 | 55.51411 | 0.0002 | 1 | 22 | 44.89793 | 0.0002 | 54.836 | 0.0006 |
| SSEK | 103 | 48 | 52.26897 | 0.0002 | 1 | 28 | 13.35551 | 0.0002 | 40.060 | 0.0007 |
| SSMK | 103 | 46 | 31.51854 | 0.0002 | 1 | 12 | 37.48746 | 0.0002 | 24.741 | 0.0006 |
| SUWN | 127 | 3 | 15.27528 | 0.0002 | 37 | 16 | 31.85020 | 0.0002 | 82.272 | 0.0009 |
| TARW | 172 | 55 | 22.97474 | 0.0003 | 1 | 21 | 18.01479 | 0.0002 | 36.292 | 0.0010 |
| TLOH | 102 | 25 | 9.71895 | 0.0002 | 3 | 26 | 58.01879 | 0.0002 | 56.990 | 0.0006 |
| TSKB | 140 | 5 | 15.01809 | 0.0002 | 36 | 6 | 20.44534 | 0.0002 | 67.183 | 0.0007 |
| UKUR | 114 | 55 | 41.76999 | 0.0002 | 4 | 55 | 31.13274 | 0.0002 | 74.730 | 0.0007 |
| UMAS | 110 | 25 | 28.91854 | 0.0002 | 1 | 28 | 5.91321 | 0.0002 | 51.368 | 0.0007 |
| UMSS | 116 | 6 | 43.31324 | 0.0002 | 6 | 2 | 21.23623 | 0.0002 | 76.359 | 0.0007 |
| USMP | 100 | 18 | 14.53576 | 0.0002 | 5 | 21 | 28.03161 | 0.0002 | 19.866 | 0.0008 |
| VUNT | 107 | 8 | 44.08273 | 0.0002 | 10 | 23 | 46.01110 | 0.0002 | 14.385 | 0.0006 |

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