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Report on the Analysis of the Asia Pacific Regional Geodetic Project (APRGP) GPS Campaign 2022

G. Hu

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Executive Summary

The annual Asia Pacific Regional Geodetic Project (APRGP) GPS campaign is an activity of the Geodetic Reference Frame Working Group (WG) of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP). This document describes the data analysis of the APRGP GPS campaign undertaken between the 11th and 17nd of September 2022. Campaign GPS data collected at 116 sites in seven countries across the Asia Pacific region were processed using version 5.2 of the Bernese GNSS Software in a regional network together with selected IGS (International GNSS Service) sites. The GPS solution was constrained to the ITRF2014 reference frame by adopting IGS14 coordinates on selected IGS reference sites and using the final IGS earth orientation parameters and satellite ephemerides products. The average of the root mean square repeatability of the station coordinates for the campaign was 2.0 mm, 2.4 mm and 7.5 mm in north, east and up components of station position respectively.

Introduction

The annual Asia Pacific Regional Geodetic Project (APRGP) GPS campaign is an activity of the Geodetic Reference Frame Working Group (WG) of the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP). The WG continues to undertake an annual GPS campaign activity as some member countries are unable to participate in the Asia Pacific Reference Frame (APREF) project but have an ongoing requirement for geodetic positioning relative to a stable global/regional reference network. One of the roles of the WG is to create and maintain a densely realised and accurate geodetic framework, coordinate regional cooperation in geodesy amongst national agencies, and to build and improve the regional geodetic infrastructure. The APRGP is where UN-GGIM-AP member agencies contribute 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 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 2022.

The document is organised as follows. The data set of the campaign is described first. The data processing scheme is detailed thereafter, 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 2022 GPS campaign was undertaken from 11 to 17 September 2022 inclusive (day of year 254 to 260). Data were contributed by seven countries across the region, including Brunei, Hong Kong (China), India, Mongolia, Philippines, Singapore, Sri Lanka and Vietnam. Note that Hong Kong (China), India and Philippines are also contributing Continuous GPS (CGPS) data to the APREF project. Figure 1 shows the distribution of the APRGP 2022 campaign stations along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.

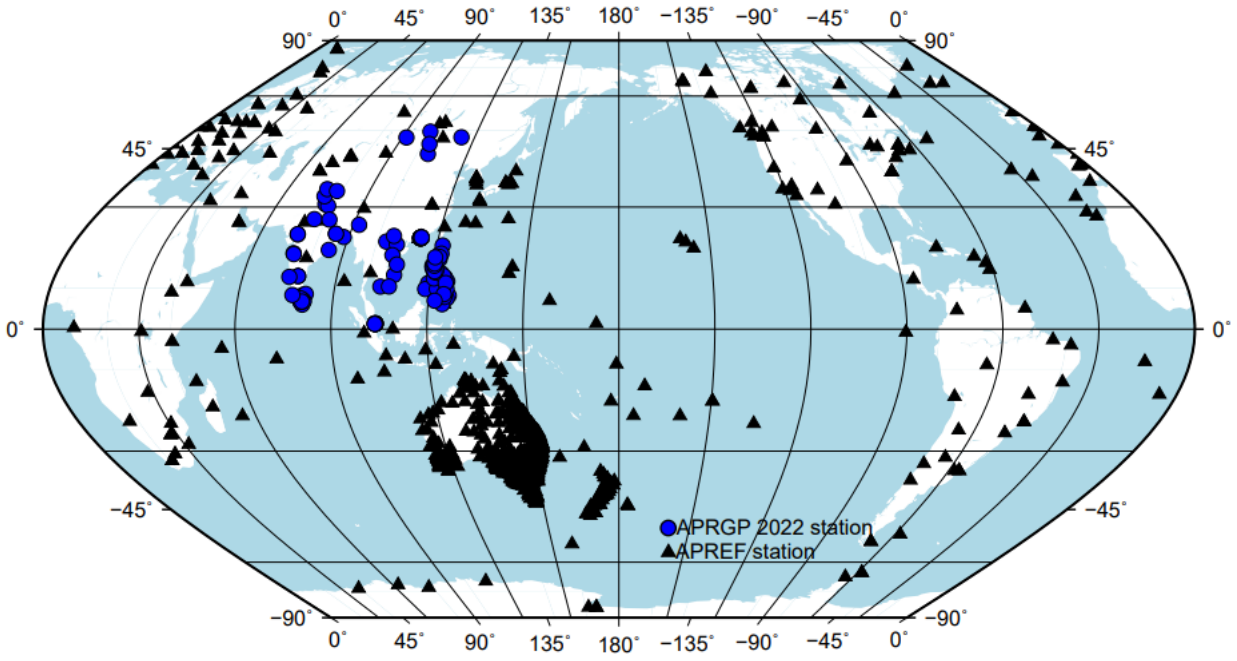

Figure 1 APRGP stations in the APRGP 2022 GPS campaign analysis along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.

Data Processing Scheme

Analysis of the GPS observations was undertaken using the Bernese GNSS software V5.2. The Bernese GNSS software conforms to the IERS2010 conventions (Gérard and Brian, 2010). In order to tie the APRGP network to the ITRF2014 reference frame (Altamimi et al., 2016), the campaign data was processed along with the available data from IGS sites located around the Asia-Pacific region and APREF stations. For the details of APREF project, see http://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/asia-pacific-reference-frame.

An overview of the processing strategy is as follows:

- IGS final precise GPS satellite ephemeris and Earth rotation parameters were used for the daily data processing to generate daily normal equations.
- Site displacement due to ocean tidal loading for all stations were corrected by using the FES2004 model (Lyard et al., 2006).
- 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).
- Dual frequency carrier phase and code data were used with an elevation cut off angle of 7° and elevation-dependent weighting. Code measurements were only used for receiver clock synchronisation. Pre-processing used a sampling rate of 30 seconds; a sampling rate of three minutes was used for other processing.
- 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. Different linear combinations of L1 and L2 cycle slips were fixed where possible. New ambiguity parameters were introduced if cycle slips could not be fixed reliably or if significant gaps in the observations were present. In addition, a data screening step in a baseline by baseline mode was performed based on weighted post-fit residuals and outliers were marked and removed from further processing.
- A-priori dry tropospheric delay computed from a standard atmosphere was mapped with the Dry Global Mapping Function (GMF) (Böhm et al., 2006). For the wet component, continuous piecewise linear troposphere parameters were estimated in 1-hour intervals without any a priori model using the wet Vienna Mapping Function (VMF) and the ionosphere-free combination observations.
- 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., 2015).
- Ambiguity resolution was attempted on all baselines within the network in a baseline by baseline model using Melbourne-Wüebbena strategy for baselines up to 6000 km; the QIF approach was used for baselines up to 2000 km; and the phase-based wide-lane/narrow-lane method for baselines up to 200 km; and direct L1/L2 method for baselines up to 20 km. 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. (2015).
- 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 daily repeatability root mean square (RMS) 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 daily repeatability (RMS) of the station coordinates. The average of the repeatability (i.e. RMS) of the station coordinates for the campaign was 2.0 mm, 2.4 mm and 7.5 mm in north, east and up components, respectively. Note that there are no solutions for the following sites due to data quality issues: JBLP, NAGR and TRIV from India, all stations from Brunei.

Table 1 Daily repeatability RMS for the APRGP 2022 GPS campaign stations.

Station	Country	North (mm)	East (mm)	Up (mm)
HKLT	Hong Kong (China)	1.5	1.7	8.9
HKQT	Hong Kong (China)	5.2	2.1	12.5
HKSC	Hong Kong (China)	2.8	2.5	10.5
HKSL	Hong Kong (China)	2.3	1.8	10.2
HKST	Hong Kong (China)	2.4	2.9	9.7
KYC1	Hong Kong (China)	1.0	2.0	6.4
HKKT	Hong Kong (China)	2.4	2.2	7.1
T430	Hong Kong (China)	1.4	1.7	8.1
2444	India	1.1	0.8	8.6
2452	India	1.7	2.6	4.5
5193	India	2.1	2.4	16.3
BANG	India	1.6	2.9	9.3
CHND	India	4.3	6.6	8.4
CPUR	India	2.2	2.6	17.9
DEHD	India	1.9	1.9	8.8
GAAR	India	1.6	4.4	7.7
JMMU	India	2.0	2.4	7.8
KGDC	India	2.0	2.6	12.4
KUNJ	India	1.2	1.1	8.0
KURA	India	3.0	2.2	6.4
LUCK	India	1.6	1.7	7.8
PUNE	India	1.0	2.0	7.0
RCHI	India	2.2	4.2	9.2
RNC1	India	1.4	2.1	8.8

Station	Country	North (mm)	East (mm)	Up (mm)
SASW	India	1.9	3.4	10.2
SHIL	India	1.4	2.0	8.5
TANT	India	1.3	1.4	9.4
TIRU	India	1.6	1.9	6.6
DOA1	Mongolia	2.2	1.0	7.1
HOA1	Mongolia	3.0	2.4	7.2
HUV1	Mongolia	1.6	2.2	10.8
OMA1	Mongolia	2.7	1.5	7.8
OVA1	Mongolia	2.2	1.6	5.8
PAPI	Philippines	0.8	1.5	7.2
PBAS	Philippines	3.4	3.0	15.6
PBGU	Philippines	1.9	1.9	14.9
PBIS	Philippines	2.1	2.1	5.0
PBOG	Philippines	1.0	1.4	4.9
PBOR	Philippines	1.1	3.2	6.9
PCAT	Philippines	0.9	3.3	2.4
PCB2	Philippines	5.5	5.5	24.8
PCDN	Philippines	0.8	1.3	10.1
PCEB	Philippines	2.4	2.6	5.1
PCL2	Philippines	1.0	2.2	11.2
PCOT	Philippines	2.0	2.4	10.4
PCRT	Philippines	0.9	1.1	6.6
PDDN	Philippines	1.7	2.7	5.4
PDIP	Philippines	1.7	1.8	4.7
PDUM	Philippines	1.2	1.7	5.1
PFLO	Philippines	3.1	2.6	11.3
PGEN	Philippines	1.6	2.3	5.7
PGM2	Philippines	0.7	1.1	9.3
PGUI	Philippines	2.0	1.7	5.3
PILC	Philippines	1.6	1.8	6.4
PILN	Philippines	1.5	1.9	5.7

Station	Country	North (mm)	East (mm)	Up (mm)
PKAL	Philippines	1.1	2.1	8.4
PLG2	Philippines	2.8	3.5	10.6
PMAI	Philippines	1.1	2.2	4.8
PMAS	Philippines	1.4	0.8	6.7
PMOG	Philippines	3.4	3.5	6.9
PMRM	Philippines	2.3	2.7	5.2
PMRV	Philippines	2.3	1.6	8.8
PMSC	Philippines	2.9	2.1	6.2
PNAG	Philippines	2.5	1.4	4.7
PNDO	Philippines	3.3	4.4	6.8
PPPC	Philippines	1.5	1.8	6.9
PROM	Philippines	2.1	3.9	10.6
PSIP	Philippines	2.6	3.5	4.2
PSJM	Philippines	2.5	1.6	14.3
PSJN	Philippines	1.9	1.5	7.5
PSNR	Philippines	3.5	8.4	13.3
PSRF	Philippines	1.0	2.3	7.8
PSRG	Philippines	1.3	1.9	9.1
PSTC	Philippines	2.4	2.0	9.6
PSTN	Philippines	2.3	2.9	5.9
PSUR	Philippines	0.6	2.4	8.0
PTAC	Philippines	2.0	1.5	7.7
PTAG	Philippines	1.7	2.2	5.6
PTGO	Philippines	2.2	1.8	3.7
PTGY	Philippines	1.6	3.3	7.0
PTLC	Philippines	0.7	2.4	4.4
PTUG	Philippines	1.8	3.2	3.6
PURD	Philippines	2.2	3.0	16.9
PVIG	Philippines	4.2	2.1	9.2
PZAM	Philippines	2.0	1.0	12.8
SLYG	Singapore	1.7	1.5	10.1

Station	Country	North (mm)	East (mm)	Up (mm)
SMS1	Singapore	1.4	1.8	7.2
SNPT	Singapore	4.4	6.4	14.1
SNSC	Singapore	0.1	3.9	15.9
SNUS	Singapore	1.1	1.4	8.8
SNYU	Singapore	1.5	2.7	13.8
SRPT	Singapore	3.3	3.2	10.7
SSMK	Singapore	1.4	1.5	9.2
SSTS	Singapore	2.0	1.9	8.9
AA03	Sri Lanka	0.8	2.1	6.4
AA05	Sri Lanka	1.4	1.5	5.3
AA09	Sri Lanka	3.4	2.6	6.8
AWIS	Sri Lanka	1.2	1.7	6.3
CLMB	Sri Lanka	1.2	1.7	3.7
ISMD	Sri Lanka	2.2	3.8	7.2
KALU	Sri Lanka	1.5	1.8	4.0
KEGA	Sri Lanka	1.1	2.5	3.7
MADA	Sri Lanka	1.7	1.6	4.8
RATH	Sri Lanka	1.0	2.7	4.4
DIEB	Vietnam	0.9	2.2	4.9
DSON	Vietnam	1.4	2.5	5.9
EAHL	Vietnam	2.2	2.5	17.0
HGIA	Vietnam	3.6	3.6	14.1
HTIE	Vietnam	2.8	2.7	9.6
KANH	Vietnam	1.8	2.3	11.6
QNAM	Vietnam	3.1	3.4	9.2
VUNT	Vietnam	2.7	3.7	18.6

The final computed Cartesian and geodetic coordinates (ITRF2014, GRS80 ellipsoid) are listed in Table 2 and Table 3, respectively, along with their formal error estimates. These estimates provide an indication of the quality of the measurements; they only characterise the internal precision of positioning performance and should not be taken as realistic estimates of position accuracy. More realistic estimates of station positioning uncertainty are provided by the RMS statistics given in Table 1. Note that the listed coordinates are at the mean epoch of the measurements in the ITRF2014 reference frame, and only for the campaign sites, the weekly coordinates of other CGPS stations of APREF project can be found in https://ga-gnss-products-

v1.s3.amazonaws.com/index.html#public/. The solutions in Solution Independent Exchange (SINEX) format can be found in the link: https://ga-gnss-products-v1.s3.amazonaws.com/index.html#public/APRGP/.

Table 2 The final computed Cartesian coordinates in ITRF2014 at the mean epoch of the measurements, i.e. @2022.704 (in decimal year).

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
HKLT	-2399063.4789	0.0005	5389237.6038	0.0009	2417326.8035	0.0005
HKQT	-2421568.6358	0.0006	5384910.3204	0.0010	2404264.1425	0.0006
HKSC	-2414267.6608	0.0006	5386768.7371	0.0009	2407459.7726	0.0005
HKSL	-2393383.1626	0.0005	5393860.9283	0.0008	2412592.1544	0.0004
HKST	-2417143.6209	0.0005	5382345.2463	0.0009	2415036.6968	0.0004
KYC1	-2408855.9971	0.0005	5391042.9796	0.0009	2403590.8730	0.0004
HKKT	-2405144.6447	0.0005	5385195.0090	0.0009	2420032.2840	0.0004
T430	-2411015.9751	0.0005	5380265.4783	0.0008	2425132.4460	0.0004
2444	1396816.8933	0.0004	5514751.2132	0.0011	2875200.9098	0.0006
2452	169179.7070	0.0041	5891004.5138	0.0158	2430554.9470	0.0072
5193	1748671.1209	0.0006	5598210.7976	0.0014	2498202.7089	0.0006
BANG	1332864.5408	0.0005	6073837.9847	0.0014	1417544.5100	0.0005
CHND	1255391.5489	0.0006	5343000.7638	0.0024	3238812.2944	0.0012
CPUR	526626.9909	0.0005	5996825.0689	0.0021	2100318.4100	0.0010
DEHD	1140604.4393	0.0003	5391407.0233	0.0009	3201808.1794	0.0005
GAAR	1749998.5659	0.0005	5596462.2689	0.0011	2501180.8932	0.0006
JMMU	1406823.5102	0.0004	5183799.2902	0.0011	3428356.3326	0.0007
KGDC	1332847.0771	0.0006	6073840.0696	0.0014	1417538.8754	0.0005
KUNJ	1623360.5609	0.0005	6006238.0745	0.0014	1398790.9438	0.0005
KURA	1427827.4946	0.0004	5065007.6217	0.0009	3594545.5206	0.0007
LUCK	889588.2763	0.0003	5624012.2255	0.0009	2864453.5157	0.0005
PUNE	1679352.3392	0.0004	5811229.8734	0.0009	2017151.6738	0.0004
RCHI	477985.5785	0.0004	5840046.8206	0.0016	2512147.7278	0.0009
RNC1	478231.6951	0.0004	5839998.0862	0.0011	2512209.1839	0.0006
SASW	1666181.4980	0.0005	5822888.2145	0.0014	1995160.8997	0.0006
SHIL	-189399.3212	0.0003	5755480.2774	0.0007	2736393.1644	0.0004
TANT	1085664.5764	0.0004	5181705.5814	0.0012	3552012.2953	0.0007
TIRU	1411672.4435	0.0005	6151621.9321	0.0013	915742.6633	0.0004
DOA1	-1772383.0914	0.0003	3884842.1860	0.0008	4722955.5211	0.0008
HOA1	-124480.7033	0.0003	4274103.0091	0.0007	4718553.5422	0.0008

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
HUV1	-730630.8969	0.0003	4074608.0646	0.0008	4837618.4150	0.0009
OMA1	-1148361.8241	0.0003	4482078.5421	0.0008	4377422.5339	0.0008
OVA1	-977156.8791	0.0003	4308800.7215	0.0006	4587095.4734	0.0006
PAPI	-3177167.9265	0.0003	5155269.0229	0.0004	1995817.0433	0.0003
PBAS	-3166086.0805	0.0006	5071572.6964	0.0010	2214419.5065	0.0005
PBGU	-3117582.2276	0.0009	5267799.2998	0.0015	1791560.5270	0.0006
PBIS	-3742521.4540	0.0005	5084796.8409	0.0007	902504.4276	0.0003
PBOG	-3499087.8815	0.0003	5191752.5124	0.0004	1214049.9830	0.0002
PBOR	-3622661.8207	0.0009	5089865.7582	0.0011	1280634.6698	0.0004
PCAT	-3541625.3237	0.0015	5122609.4344	0.0022	1372754.2537	0.0009
PCB2	-3161494.8685	0.0013	5274362.8129	0.0021	1687745.6033	0.0009
PCDN	-3088458.4691	0.0005	5255341.1249	0.0008	1870978.2386	0.0004
PCEB	-3499372.6128	0.0009	5209601.9246	0.0013	1134905.1039	0.0005
PCL2	-3214703.8807	0.0006	5307528.3586	0.0010	1470605.8652	0.0004
PCOT	-3561309.0414	0.0008	5231065.2599	0.0011	794050.1374	0.0005
PCRT	-3504293.6138	0.0005	5220264.5202	0.0007	1068957.8883	0.0003
PDDN	-3698127.2665	0.0005	5130740.7748	0.0007	822545.2887	0.0003
PDIP	-3466870.3548	0.0003	5268924.8930	0.0005	946017.0333	0.0002
PDUM	-3455857.4250	0.0006	5261024.5568	0.0008	1026318.8266	0.0003
PFLO	-3127779.9761	0.0006	5310053.4758	0.0009	1638299.4807	0.0004
PGEN	-3650007.4311	0.0006	5187339.6891	0.0008	669409.3425	0.0003
PGM2	-3290628.6297	0.0005	5245351.3831	0.0008	1524422.2697	0.0004
PGUI	-3557988.3710	0.0006	5182509.8955	0.0008	1075470.8493	0.0003
PILC	-3372132.9349	0.0006	5282112.7960	0.0008	1183262.8378	0.0003
PILN	-3219618.6731	0.0005	5178601.7419	0.0008	1864088.4694	0.0004
PKAL	-3343823.0972	0.0008	5276062.2982	0.0011	1285509.1008	0.0004
PLG2	-3449033.0729	0.0007	5166761.1251	0.0010	1440998.0040	0.0004
PMAI	-3592204.8765	0.0008	5227551.0642	0.0012	669005.1691	0.0004
PMAS	-3450753.0362	0.0007	5188376.7388	0.0010	1357309.2518	0.0004
PMOG	-3274635.9408	0.0007	5269089.7826	0.0010	1476547.3729	0.0005
PMRM	-3629757.1226	0.0007	5172535.2983	0.0010	866088.2702	0.0004

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
PMRV	-3134714.1963	0.0008	5323767.3428	0.0012	1579758.3352	0.0005
PMSC	-3068374.4807	0.0003	5325915.1876	0.0004	1697541.4154	0.0002
PNAG	-3394666.1982	0.0005	5187872.3918	0.0007	1492904.9360	0.0003
PNDO	-3073489.6123	0.0007	5450701.8394	0.0012	1230702.5093	0.0004
PPPC	-3022676.7039	0.0006	5511839.2892	0.0008	1075517.4645	0.0003
PROM	-3324456.7430	0.0006	5264292.6973	0.0010	1379811.2919	0.0005
PSIP	-3371375.5191	0.0010	5305845.6622	0.0015	1075069.3359	0.0005
PSJM	-3215692.9411	0.0008	5337649.6169	0.0012	1355686.0132	0.0005
PSJN	-3228520.3428	0.0006	5287794.8367	0.0008	1510623.8180	0.0003
PSNR	-3088262.2012	0.0009	5332020.4047	0.0014	1641797.3287	0.0005
PSRF	-3167388.7108	0.0008	5286533.9356	0.0012	1638185.5840	0.0005
PSRG	-3478357.1689	0.0007	5152038.4730	0.0009	1423144.4817	0.0004
PSTC	-3222394.1832	0.0006	5276124.9771	0.0008	1563214.8364	0.0003
PSTN	-3219843.9112	0.0006	5124937.7820	0.0009	2005414.5787	0.0005
PSUR	-3649682.9736	0.0009	5117857.9349	0.0012	1077577.8078	0.0005
PTAC	-3588936.5873	0.0006	5124727.4408	0.0009	1236144.4699	0.0004
PTAG	-3184318.5530	0.0006	5291065.5985	0.0009	1590418.2800	0.0003
PTGO	-3596111.9923	0.0005	5182802.6393	0.0007	939355.0916	0.0003
PTGY	-3181284.7641	0.0005	5307488.6050	0.0008	1543919.7096	0.0003
PTLC	-3128650.4148	0.0004	5292970.9598	0.0006	1690799.4448	0.0003
PTUG	-3199386.0881	0.0006	5169557.8930	0.0010	1922601.4401	0.0004
PURD	-3119484.8777	0.0007	5279888.9716	0.0011	1747197.1263	0.0005
PVIG	-3074264.8311	0.0004	5248848.6337	0.0006	1911809.7544	0.0003
PZAM	-3361516.2148	0.0008	5365985.9460	0.0014	764311.8559	0.0005
SLYG	-1539524.8617	0.0005	6187725.8627	0.0013	151763.8440	0.0004
SMS1	-1530492.4462	0.0005	6190039.2259	0.0012	148206.4621	0.0004
SNPT	-1526243.7417	0.0005	6191001.8202	0.0011	152481.6672	0.0003
SNSC	-1538473.1534	0.0010	6188107.9348	0.0028	145243.1221	0.0007
SNUS	-1518383.3607	0.0004	6193172.5602	0.0010	142897.1241	0.0003
SNYU	-1508025.9537	0.0005	6195576.0903	0.0012	148798.1812	0.0003
SRPT	-1519249.6849	0.0005	6192544.6951	0.0012	159623.9864	0.0004

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
SSMK	-1518411.4503	0.0005	6193330.4531	0.0013	133831.2593	0.0004
SSTS	-1504600.3523	0.0006	6196616.3535	0.0017	137086.1869	0.0005
AA03	1051446.0457	0.0005	6223098.8643	0.0015	917796.1112	0.0005
AA05	961706.1105	0.0005	6233548.8603	0.0015	944206.0187	0.0005
AA09	1042161.5939	0.0008	6257647.5396	0.0032	657491.0336	0.0009
AWIS	1077179.4457	0.0004	6239125.0578	0.0012	767481.9410	0.0004
CLMB	1113305.7452	0.0003	6233645.9189	0.0007	760267.0742	0.0003
ISMD	995152.1264	0.0004	6255839.0791	0.0012	752227.5306	0.0004
KALU	1104401.2743	0.0003	6239316.3127	0.0006	726231.8311	0.0003
KEGA	1060699.5066	0.0004	6237975.2590	0.0012	800146.1740	0.0004
MADA	1116463.3339	0.0004	6224701.4211	0.0011	825579.8503	0.0004
RATH	1058525.6555	0.0003	6245630.4469	0.0008	740620.3934	0.0003
DIEB	-1336847.3124	0.0004	5787979.2333	0.0008	2315717.0532	0.0004
DSON	-1724386.9638	0.0006	5714538.8239	0.0013	2239949.3782	0.0006
EAHL	-1940045.8643	0.0006	5900173.9862	0.0011	1448740.9217	0.0004
HGIA	-1518217.0911	0.0007	5682319.5167	0.0013	2459169.3969	0.0006
HTIE	-1566049.4798	0.0007	6076067.8702	0.0021	1140478.3757	0.0004
KANH	-1700737.5902	0.0006	5821573.0840	0.0012	1967522.4664	0.0005
QNAM	-1939182.0109	0.0005	5824574.8938	0.0011	1724681.8564	0.0005
VUNT	-1849587.2109	0.0008	5995310.0250	0.0017	1143318.5584	0.0006

Table 3 The final computed Geodetic coordinates in ITRF2014 at the mean epoch of the measurements, i.e. @2022.704 (in decimal year).

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
HKLT	113	59	47.87160	0.0003	22	25	5.27422	0.0003	125.9028	0.0010
HKQT	114	12	47.60479	0.0003	22	17	27.71771	0.0003	5.1605	0.0012
HKSC	114	8	28.30387	0.0003	22	19	19.81078	0.0003	20.2099	0.0011
HKSL	113	55	40.76036	0.0003	22	22	19.20866	0.0003	95.2717	0.0009
HKST	114	11	3.29744	0.0003	22	23	42.96577	0.0003	258.7021	0.0010
KYC1	114	4	34.73149	0.0003	22	17	2.58095	0.0003	116.3459	0.0010
HKKT	114	3	59.66166	0.0003	22	26	41.65310	0.0003	34.5506	0.0010

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
T430	114	8	17.54425	0.0003	22	29	40.98698	0.0003	41.3100	0.0010
2444	75	47	11.83427	0.0004	26	58	3.04076	0.0003	426.2269	0.0012
2452	88	21	18.05056	0.0039	22	32	53.08117	0.0030	-52.0315	0.0171
5193	72	39	11.35045	0.0004	23	12	38.97959	0.0004	20.4749	0.0015
BANG	77	37	22.78435	0.0004	12	55	31.44123	0.0004	813.4632	0.0015
CHND	76	46	39.43130	0.0006	30	42	50.13678	0.0005	284.7238	0.0026
CPUR	84	58	52.66227	0.0005	19	21	13.22729	0.0004	-24.8476	0.0023
DEHD	78	3	16.76951	0.0003	30	19	28.38455	0.0003	648.7141	0.0010
GAAR	72	38	8.44051	0.0004	23	14	24.26177	0.0003	25.1380	0.0012
JMMU	74	48	58.68424	0.0004	32	43	25.46559	0.0004	245.6379	0.0013
KGDC	77	37	23.36499	0.0004	12	55	31.27496	0.0004	810.5393	0.0015
KUNJ	74	52	31.87834	0.0004	12	45	11.96731	0.0004	-49.6587	0.0015
KURA	74	15	24.61102	0.0003	34	30	53.45818	0.0003	1581.5474	0.0012
LUCK	81	0	41.78144	0.0003	26	51	37.65431	0.0003	50.2443	0.0010
PUNE	73	52	53.59165	0.0003	18	33	27.60271	0.0003	494.3580	0.0009
RCHI	85	19	15.55715	0.0004	23	20	44.60144	0.0004	580.0804	0.0018
RNC1	85	19	6.78241	0.0004	23	20	46.80237	0.0003	578.2768	0.0012
SASW	74	1	54.73768	0.0004	18	20	51.33490	0.0004	709.2632	0.0015
SHIL	91	53	5.24115	0.0003	25	33	56.85346	0.0003	1496.6327	0.0007
TANT	78	9	59.87280	0.0004	34	2	12.26281	0.0004	3908.9158	0.0014
TIRU	77	4	31.98414	0.0004	8	18	37.22599	0.0004	-88.0957	0.0013
DOA1	114	31	26.08757	0.0003	48	4	28.00265	0.0004	731.6646	0.0011
HOA1	91	40	5.64190	0.0003	48	0	31.57610	0.0003	1378.6624	0.0010
HUV1	100	9	57.06656	0.0003	49	38	9.81222	0.0004	1243.4418	0.0012
OMA1	104	22	14.62723	0.0003	43	36	19.29986	0.0004	1416.5275	0.0011
OVA1	102	46	39.02807	0.0003	46	15	59.73632	0.0003	1816.9366	0.0008
PAPI	121	38	43.19462	0.0002	18	21	20.88308	0.0002	54.3982	0.0005
PBAS	121	58	32.68770	0.0003	20	26	58.20796	0.0003	80.0060	0.0012
PBGU	120	37	4.22723	0.0004	16	25	4.06629	0.0004	1545.1196	0.0017
PBIS	126	21	13.96590	0.0003	8	11	21.02284	0.0003	78.2156	0.0009

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
PBOG	123	58	43.70398	0.0002	11	2	46.67623	0.0002	88.5240	0.0005
PBOR	125	26	27.54627	0.0004	11	39	37.02201	0.0004	67.2997	0.0014
PCAT	124	39	31.93451	0.0007	12	30	42.87393	0.0006	59.5904	0.0027
PCB2	120	56	19.70280	0.0006	15	26	45.80190	0.0006	78.6772	0.0024
PCDN	120	26	30.83579	0.0003	17	10	16.93091	0.0003	55.3323	0.0009
PCEB	123	53	23.59238	0.0004	10	19	5.18725	0.0004	126.9373	0.0015
PCL2	121	12	9.96438	0.0003	13	25	10.33070	0.0003	62.9945	0.0011
PCOT	124	14	49.31698	0.0004	7	11	58.57234	0.0004	86.1666	0.0014
PCRT	123	52	22.55748	0.0003	9	42	45.87555	0.0003	76.4877	0.0008
PDDN	125	46	59.69940	0.0003	7	27	33.75707	0.0003	90.5499	0.0008
PDIP	123	20	39.45272	0.0002	8	35	12.63065	0.0002	86.8304	0.0005
PDUM	123	18	0.28010	0.0003	9	19	18.62549	0.0003	88.3864	0.0009
PFLO	120	29	57.67676	0.0003	14	58	58.56018	0.0003	90.7635	0.0011
PGEN	125	7	53.98046	0.0003	6	3	53.68154	0.0003	121.0801	0.0009
PGM2	122	6	6.37484	0.0003	13	55	12.47833	0.0003	65.9345	0.0010
PGUI	124	28	15.83804	0.0003	9	46	20.73195	0.0003	116.8852	0.0009
PILC	122	33	15.87044	0.0003	10	45	46.38398	0.0003	71.4476	0.0010
PILN	121	52	11.53483	0.0003	17	6	21.79968	0.0003	115.4545	0.0009
PKAL	122	21	55.43309	0.0004	11	42	18.92084	0.0003	80.3867	0.0013
PLG2	123	43	29.27242	0.0004	13	8	40.24979	0.0003	85.2538	0.0012
PMAI	124	29	44.14959	0.0004	6	3	40.54960	0.0004	92.3984	0.0014
PMAS	123	37	39.36189	0.0003	12	22	8.03380	0.0003	80.1525	0.0012
PMOG	121	51	36.50560	0.0004	13	28	29.11412	0.0003	62.8306	0.0013
PMRM	125	3	31.47332	0.0004	7	51	22.60389	0.0003	375.5327	0.0012
PMRV	120	29	24.77728	0.0004	14	26	9.59689	0.0003	59.2487	0.0015
PMSC	119	56	49.81678	0.0002	15	32	16.70378	0.0002	57.2640	0.0005
PNAG	123	11	54.92311	0.0003	13	37	36.53342	0.0002	73.1158	0.0008
PNDO	119	25	2.51732	0.0004	11	11	59.22282	0.0003	54.3857	0.0014
PPPC	118	44	24.84995	0.0003	9	46	22.55374	0.0003	66.5380	0.0009
PROM	122	16	22.24438	0.0003	12	34	38.07556	0.0003	68.1151	0.0012

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
PSIP	122	25	55.89769	0.0005	9	46	7.64198	0.0004	86.4508	0.0018
PSJM	121	4	1.43706	0.0004	12	21	14.06784	0.0004	64.5789	0.0015
PSJN	121	24	23.77339	0.0003	13	47	30.03946	0.0003	66.6203	0.0010
PSNR	120	4	44.64655	0.0004	15	0	56.59537	0.0004	65.6938	0.0017
PSRF	120	55	39.46589	0.0004	14	58	54.90081	0.0003	70.4729	0.0014
PSRG	124	1	29.76958	0.0003	12	58	44.01587	0.0003	64.8525	0.0011
PSTC	121	24	52.22038	0.0003	14	16	53.93902	0.0003	62.4651	0.0010
PSTN	122	8	23.66885	0.0003	18	26	49.98806	0.0003	42.4960	0.0011
PSUR	125	29	37.30320	0.0004	9	47	30.52523	0.0004	80.2439	0.0015
PTAC	125	0	15.22606	0.0003	11	14	59.61945	0.0003	79.7179	0.0011
PTAG	121	2	26.74804	0.0003	14	32	7.59155	0.0003	86.6535	0.0010
PTGO	124	45	18.10419	0.0003	8	31	33.32331	0.0003	91.5481	0.0008
PTGY	120	56	17.81676	0.0003	14	6	1.02609	0.0003	715.4952	0.0009
PTLC	120	35	13.68705	0.0003	15	28	28.58165	0.0002	112.3140	0.0007
PTUG	121	45	10.57655	0.0003	17	39	36.49702	0.0003	84.3795	0.0012
PURD	120	34	32.20029	0.0003	16	0	15.10663	0.0003	82.5503	0.0013
PVIG	120	21	27.43675	0.0003	17	33	28.65765	0.0002	41.8606	0.0007
PZAM	122	3	54.15419	0.0004	6	55	43.13668	0.0004	84.2274	0.0016
SLYG	103	58	18.03887	0.0004	1	22	21.44497	0.0004	50.4887	0.0013
SMS1	103	53	16.43495	0.0004	1	20	25.60546	0.0004	37.1850	0.0013
SNPT	103	50	55.54003	0.0004	1	22	44.81838	0.0003	54.8168	0.0011
SNSC	103	57	42.04097	0.0008	1	18	49.11920	0.0007	14.5499	0.0029
SNUS	103	46	31.86251	0.0004	1	17	32.68528	0.0003	62.7143	0.0010
SNYU	103	40	47.94628	0.0004	1	20	44.84595	0.0003	75.5617	0.0012
SRPT	103	47	3.91776	0.0004	1	26	37.41695	0.0004	58.7435	0.0012
SSMK	103	46	31.52884	0.0004	1	12	37.48522	0.0004	24.7217	0.0013
SSTS	103	38	52.32442	0.0005	1	14	23.48856	0.0005	12.8671	0.0017
AA03	80	24	35.84426	0.0004	8	19	44.39851	0.0004	-8.3572	0.0016
AA05	81	13	46.59114	0.0005	8	34	13.86030	0.0004	-85.2949	0.0015
AA09	80	32	40.64525	0.0008	5	57	24.28171	0.0008	-91.7300	0.0033

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
AWIS	80	12	16.19831	0.0004	6	57	27.62464	0.0004	-49.8759	0.0012
CLMB	79	52	26.22176	0.0003	6	53	31.12797	0.0003	-73.6056	0.0008
ISMD	80	57	40.91689	0.0004	6	49	2.70691	0.0003	1166.2075	0.0012
KALU	79	57	44.02577	0.0003	6	34	55.45448	0.0003	-70.0960	0.0006
KEGA	80	20	59.20467	0.0004	7	15	18.52098	0.0003	104.7215	0.0012
MADA	79	49	53.54698	0.0004	7	29	14.12438	0.0003	-82.9215	0.0011
RATH	80	22	50.77052	0.0003	6	42	46.76326	0.0003	-3.1389	0.0008
DIEB	103	0	19.86034	0.0003	21	25	39.95655	0.0003	463.7889	0.0009
DSON	106	47	29.10151	0.0004	20	41	45.86104	0.0004	1.6116	0.0015
EAHL	108	12	5.27999	0.0003	13	12	54.76382	0.0003	642.2753	0.0012
HGIA	104	57	32.44920	0.0004	22	49	39.13817	0.0003	107.9667	0.0015
HTIE	104	27	10.41629	0.0005	10	22	10.35747	0.0005	-4.9325	0.0022
KANH	106	17	7.46148	0.0004	18	5	12.74098	0.0003	-13.7805	0.0013
QNAM	108	24	51.13315	0.0003	15	47	34.22836	0.0003	3.3150	0.0012
VUNT	107	8	43.04993	0.0005	10	23	44.27234	0.0004	5.5338	0.0019

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