Report on the Analysis of the Asia Pacific Regional Geodetic Project (APRGP) GPS Campaign 2023

G. Hu

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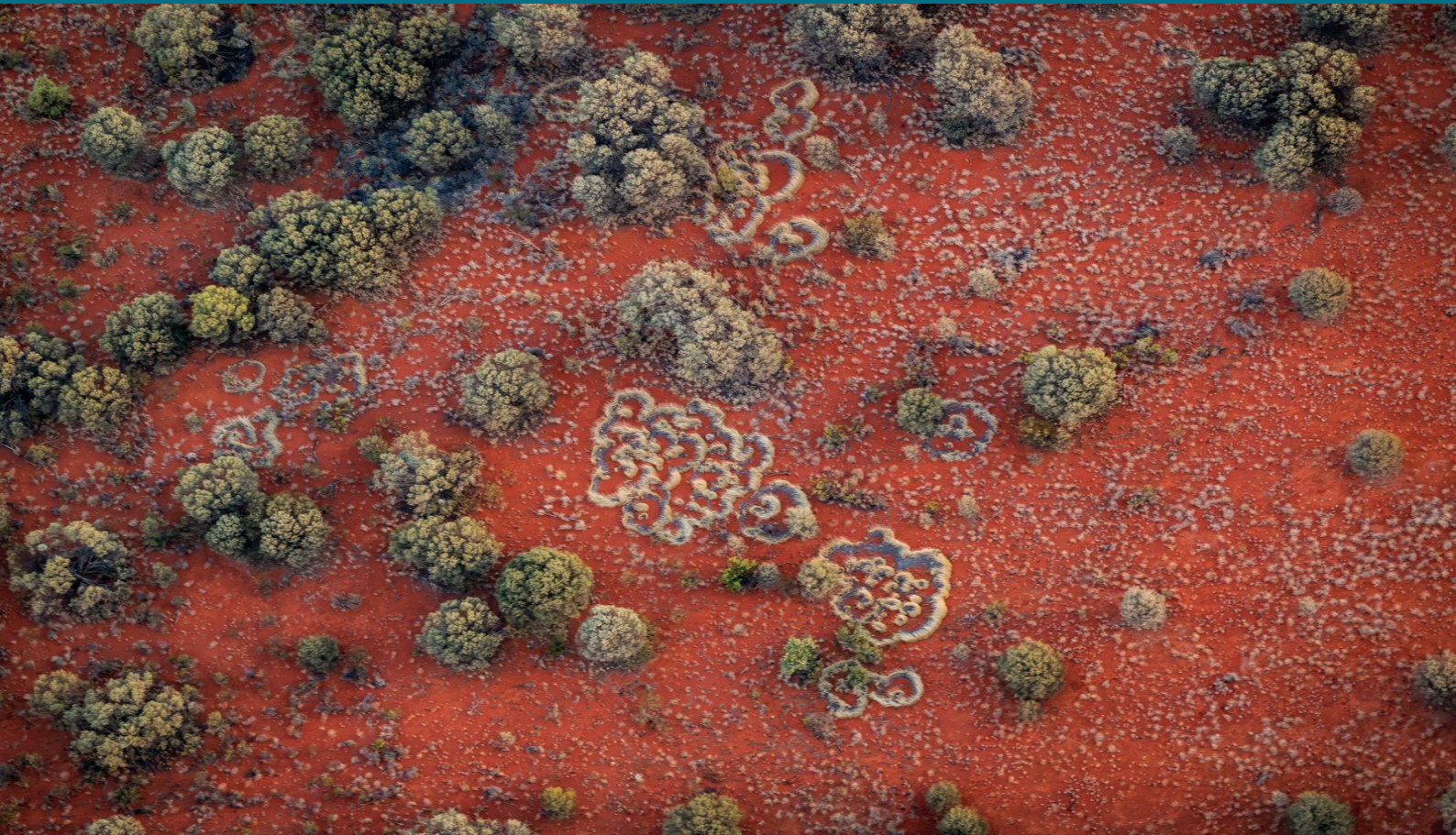
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Executive Summary

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 10th and 17nd of September 2023. Campaign GPS data collected at 124 sites in nine 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 is aligned to the International Terrestrial Reference Frame 2020 (ITRF2020) by adopting IGS20 coordinates on selected IGS core 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 2.5 mm, 2.5 mm and 6.9 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 2023.

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 2023 GPS campaign was undertaken from 11 to 17 September 2023 inclusive (day of year 253 to 259). Data were contributed by nine countries across the region, including Brunei, India, Korea, Laos, Mongolia, Philippines, Singapore, Tonga, and Vietnam. Note that India and Philippines are also contributing Continuously Operating Reference Stations (CORS) data to the APREF project. Figure 1 shows the distribution of the APRGP 2023 campaign stations along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.
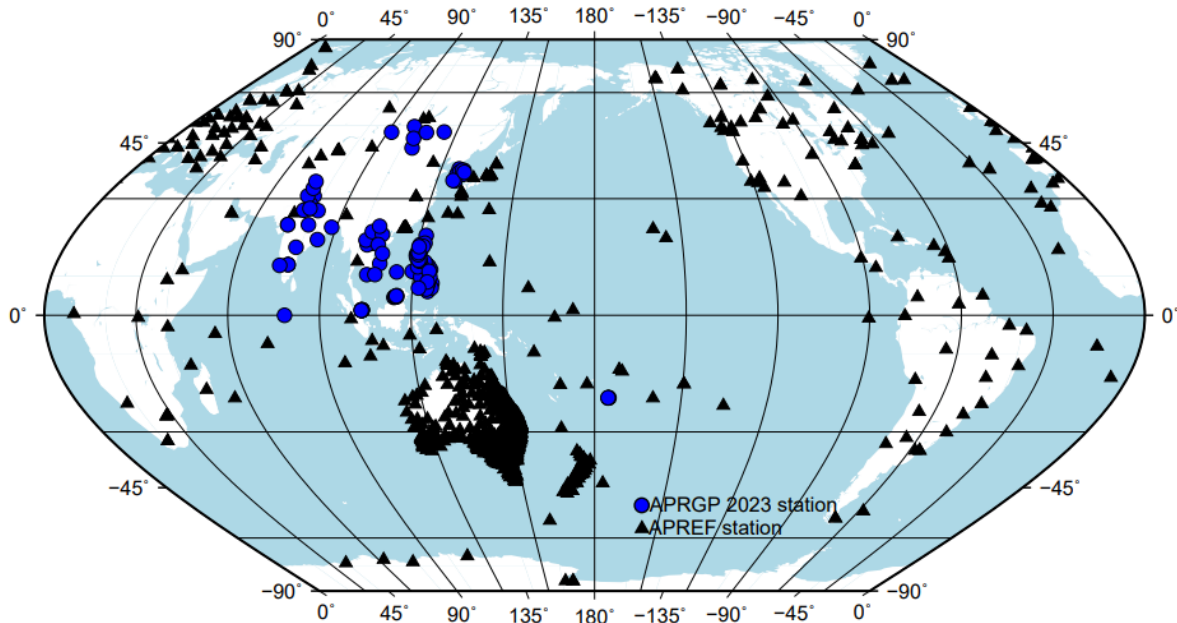

Figure 1 APRGP stations in the APRGP 2023 GPS campaign analysis along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.

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 ITRF2020 reference frame (Altamimi et al., 2023), the campaign data was processed along with the available data from IGS20 core 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 FES2014b 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 2.5 mm, 2.5 mm and 6.9 mm in north, east and up components, respectively. Note that there are no solutions for the site JABA from India due to data quality issues.

Table 1 Daily repeatability RMS for the APRGP 2023 GPS campaign stations.

Station	Country	North (mm)	East (mm)	Up (mm)
KBL1	Brunei	2.6	2.1	6.3
LAMU	Brunei	1.9	2.7	4.6
LIAN	Brunei	2.5	3.1	6.3
MURA	Brunei	2.9	2.7	4.9
TEMB	Brunei	1.1	2.5	5.7
TUTO	Brunei	2.3	3.2	8.1
UKUR	Brunei	2.4	3.3	10.6
BANG	India	2.1	4.3	10.3
CHDG	India	1.8	3.9	11.6
CPUR	India	5.0	3.9	13.5
DELH	India	3.2	3.8	10.3
GAAR	India	2.5	3.0	7.5
GUJT	India	4.3	3.6	13.0
GURU	India	1.6	2.0	7.8
HYDE	India	2.7	4.1	10.7
IISM	India	2.6	1.4	8.5
JAIP	India	3.0	4.4	14.9
JMMU	India	1.9	3.9	12.8
KGDC	India	2.4	4.3	9.3
KOLK	India	3.3	3.6	4.5
KUNJ	India	1.6	4.6	17.5
KURA	India	1.6	2.5	3.6
LUCK	India	2.6	3.8	8.9
MATH	India	3.3	3.9	9.6

Station	Country	North (mm)	East (mm)	Up (mm)
BOEN	Korea	3.7	2.3	6.8
CHSG	Korea	4.0	2.6	11.0
CHYG	Korea	4.1	2.4	5.8
DOND	Korea	3.2	2.5	6.1
DONH	Korea	9.1	5.5	12.1
ICHN	Korea	3.8	2.4	6.4
JAHG	Korea	3.8	2.9	8.0
PCHN	Korea	4.0	2.8	8.5
SIAN	Korea	3.2	2.7	9.3
WULJ	Korea	3.5	2.4	7.3
PAKX	Laos	5.2	3.1	9.9
VIEN	Laos	2.7	4.7	9.2
XAYR	Laos	2.0	2.1	8.8
DOA1	Mongolia	2.2	1.6	4.5
HOA1	Mongolia	2.2	2.1	6.8
HUV1	Mongolia	2.1	2.4	8.6
OMA1	Mongolia	2.1	1.8	5.6
OVA1	Mongolia	1.9	1.6	4.2
UB01	Mongolia	2.0	1.5	4.3
PAPI	Philippines	3.6	2.6	8.4
PBAS	Philippines	3.3	3.5	17.5
PBAT	Philippines	2.3	3.0	10.6
PBAY	Philippines	4.7	3.2	14.2
PBGO	Philippines	3.5	3.4	8.9
PBGU	Philippines	5.4	5.2	3.5
PBIS	Philippines	4.2	1.9	8.7
PBOG	Philippines	3.9	2.2	5.0
PBOR	Philippines	4.3	2.7	14.8
PCAT	Philippines	4.8	1.7	6.5
PCB2	Philippines	2.3	1.9	9.7
PCDN	Philippines	3.1	2.8	5.7

Station	Country	North (mm)	East (mm)	Up (mm)
PCEB	Philippines	3.4	3.6	13.4
PCOT	Philippines	5.8	4.8	9.0
PCRT	Philippines	4.4	1.3	9.6
PDAV	Philippines	2.4	1.1	10.4
PDDN	Philippines	2.1	2.4	7.4
PDIP	Philippines	2.8	2.1	8.3
PDUM	Philippines	2.2	2.0	9.8
PFLO	Philippines	4.5	2.9	11.3
PGEN	Philippines	1.7	3.0	10.4
PGM2	Philippines	4.4	1.8	5.5
PGUI	Philippines	2.7	2.1	6.0
PILC	Philippines	3.7	1.9	9.7
PKAL	Philippines	3.5	1.6	6.1
PKLY	Philippines	3.3	3.1	9.2
PLG2	Philippines	4.6	2.6	7.5
PLGY	Philippines	5.4	2.8	7.4
PMAS	Philippines	4.2	3.3	12.4
PMAT	Philippines	1.9	2.0	14.9
PMOG	Philippines	3.6	8.1	16.0
PMRM	Philippines	1.8	3.3	12.9
PMRV	Philippines	3.7	1.3	11.8
PMSC	Philippines	3.6	2.8	6.6
PNAG	Philippines	5.8	3.4	11.1
PNDO	Philippines	3.0	2.8	13.3
PROM	Philippines	4.7	5.8	12.3
PSIP	Philippines	6.2	2.7	8.9
PSJM	Philippines	4.5	2.8	13.2
PSJN	Philippines	3.9	1.5	7.6
PSNR	Philippines	4.2	1.9	14.1
PSRF	Philippines	3.1	2.6	9.1
PSTC	Philippines	5.0	2.4	6.6

Station	Country	North (mm)	East (mm)	Up (mm)
PSTN	Philippines	3.3	3.7	8.2
PSUR	Philippines	2.5	3.1	16.8
PTAC	Philippines	3.2	1.8	12.0
PTCG	Philippines	2.8	1.5	10.5
PTGO	Philippines	2.3	1.1	8.5
PTGY	Philippines	4.9	2.7	5.5
PTLC	Philippines	5.2	3.7	5.9
PTUG	Philippines	4.3	3.1	5.1
PURD	Philippines	4.1	3.2	16.4
PVIG	Philippines	3.7	2.7	11.3
PZAM	Philippines	2.6	3.1	9.0
SLYG	Singapore	2.5	2.5	7.7
SMS1	Singapore	1.6	2.5	5.8
SNPT	Singapore	1.7	2.4	6.6
SNSC	Singapore	2.2	1.0	11.5
SNUS	Singapore	1.7	2.4	8.7
SNYU	Singapore	3.2	3.2	7.5
SRPT	Singapore	2.0	2.0	5.1
SSMK	Singapore	1.8	1.9	4.9
SSTS	Singapore	1.7	1.8	7.7
HMGA	Tonga	1.0	1.8	2.2
TGPU	Tonga	1.8	2.2	5.9
TON1	Tonga	0.9	1.8	1.8
TTY3	Tonga	2.1	2.9	3.7
DIEB	Vietnam	2.5	2.9	4.3
DSON	Vietnam	3.4	2.7	7.3
EAHL	Vietnam	3.3	4.0	7.7
HGIA	Vietnam	4.6	2.5	12.4
HTIE	Vietnam	2.5	2.7	11.1
KANH	Vietnam	3.7	3.1	10.3
QNAM	Vietnam	2.9	1.9	8.8

Station	Country	North (mm)	East (mm)	Up (mm)
VUNT	Vietnam	3.9	3.1	11.6

The final computed Cartesian and geodetic coordinates (ITRF2020, 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 ITRF2020 reference frame, and only for the campaign sites. The weekly coordinates of other CORS 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 ITRF2020 at the mean epoch of the measurements, i.e. @2023.701 (in decimal year).

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
BANG	1332864.4961	0.0005	6073837.9874	0.0013	1417544.5364	0.0004
BOEN	-3141805.5353	0.0006	4060585.2673	0.0008	3772022.9389	0.0007
CHDG	1255320.1708	0.0006	5343002.4445	0.0020	3238839.7706	0.0011
CHSG	-3237146.3589	0.0007	3989513.4104	0.0008	3767338.3866	0.0008
CHYG	-3076700.9639	0.0006	4112486.2750	0.0007	3769348.4578	0.0006
CPUR	526626.9383	0.0005	5996825.0592	0.0030	2100318.4320	0.0013
DELH	1252301.0815	0.0003	5463692.1662	0.0009	3033247.4159	0.0006
DIEB	-1336847.3478	0.0004	5787979.2407	0.0011	2315717.0433	0.0005
DOA1	-1772383.1229	0.0003	3884842.1887	0.0005	4722955.5203	0.0005
DOND	-3036947.2961	0.0006	4021287.4088	0.0007	3896957.3220	0.0006
DONH	-3196657.3037	0.0010	3930091.6842	0.0010	3862221.5737	0.0011
DSON	-1724386.9958	0.0005	5714538.8149	0.0011	2239949.3633	0.0005
EAHL	-1940045.8944	0.0005	5900173.9860	0.0010	1448740.9122	0.0004
GAAR	1749998.5231	0.0005	5596462.2598	0.0011	2501180.9132	0.0006
GUJT	1748670.7100	0.0006	5598209.5980	0.0018	2498202.1953	0.0009
GURU	1475025.9840	0.0002	5286406.5759	0.0005	3238838.6316	0.0003
HGIA	-1518217.1202	0.0007	5682319.5130	0.0014	2459169.3834	0.0007
HMGA	-5929471.2021	0.0009	-513770.8053	0.0003	-2285534.0259	0.0004
HOA1	-124480.7348	0.0002	4274103.0216	0.0005	4718553.5514	0.0005
HTIE	-1566049.5058	0.0005	6076067.8715	0.0015	1140478.3656	0.0003
HUV1	-730630.9269	0.0003	4074608.0707	0.0007	4837618.4135	0.0008
HYDE	1208443.7868	0.0003	5966805.9724	0.0008	1897077.4957	0.0004
ICHN	-3107918.0180	0.0006	4033813.9601	0.0007	3827857.9284	0.0006
IISM	1208183.4284	0.0064	5967334.3503	0.0236	1895524.7865	0.0092
JAHG	-3152834.0675	0.0007	4199245.1500	0.0009	3608372.2067	0.0007
JAIP	1396816.8421	0.0004	5514751.1483	0.0011	2875200.9070	0.0006
JMMU	1406823.4728	0.0004	5183799.2877	0.0010	3428356.3576	0.0006
KANH	-1700737.6205	0.0004	5821573.0827	0.0009	1967522.4529	0.0004
KBL1	-2607322.6138	0.0003	5798828.0390	0.0007	505057.3829	0.0002
KGDC	1332847.0361	0.0005	6073840.0959	0.0014	1417538.9095	0.0005

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
KOLK	169179.7016	0.0044	5891004.8057	0.0224	2430555.1244	0.0100
KUNJ	1623360.5172	0.0004	6006238.0819	0.0010	1398790.9708	0.0003
KURA	1427827.4725	0.0004	5065007.6151	0.0008	3594545.5399	0.0006
LAMU	-2657634.8423	0.0006	5774933.8688	0.0012	516639.1748	0.0003
LIAN	-2638655.4466	0.0006	5783351.4519	0.0011	519610.0048	0.0003
LUCK	889588.2216	0.0003	5624012.1073	0.0009	2864453.4872	0.0005
MATH	1206995.0877	0.0003	5532963.9335	0.0009	2924724.8067	0.0006
MURA	-2691871.5461	0.0006	5755365.3838	0.0011	555841.9034	0.0003
OMA1	-1148361.8538	0.0003	4482078.5458	0.0007	4377422.5354	0.0007
OVA1	-977156.9120	0.0002	4308800.7277	0.0004	4587095.4767	0.0004
PAKX	-1428721.8357	0.0005	5883511.7344	0.0013	1999612.7201	0.0007
PAPI	-3177167.8810	0.0003	5155269.0403	0.0004	1995817.0669	0.0002
PBAS	-3166086.0381	0.0006	5071572.7154	0.0010	2214419.5361	0.0005
PBAT	-3082933.4385	0.0004	5224292.2368	0.0006	1964073.7446	0.0003
PBAY	-3164087.8828	0.0005	5236293.7286	0.0008	1797982.3142	0.0004
PBGO	-3400769.6357	0.0010	5269724.4315	0.0015	1156453.5068	0.0005
PBGU	-3117582.1952	0.0009	5267799.3166	0.0015	1791560.5311	0.0005
PBIS	-3742521.4306	0.0005	5084796.8592	0.0008	902504.4412	0.0003
PBOG	-3499087.8922	0.0003	5191752.5204	0.0004	1214049.9772	0.0002
PBOR	-3622661.8197	0.0008	5089865.7899	0.0010	1280634.6951	0.0003
PCAT	-3541625.3075	0.0008	5122609.4514	0.0012	1372754.2794	0.0005
PCB2	-3161494.8367	0.0006	5274362.8057	0.0009	1687745.6020	0.0003
PCDN	-3088458.4295	0.0003	5255341.1427	0.0005	1870978.2406	0.0003
PCEB	-3499372.6177	0.0006	5209601.9331	0.0009	1134905.0977	0.0004
PCHN	-3148995.6658	0.0007	3966490.4532	0.0008	3864957.1533	0.0007
PCOT	-3561309.0425	0.0008	5231065.2786	0.0012	794050.1272	0.0005
PCRT	-3504293.6066	0.0005	5220264.5152	0.0007	1068957.8867	0.0003
PDAV	-3688320.1245	0.0003	5143554.7725	0.0004	786028.7027	0.0002
PDDN	-3698127.2468	0.0005	5130740.7975	0.0007	822545.2830	0.0003
PDIP	-3466870.3593	0.0003	5268924.9116	0.0004	946017.0309	0.0002
PDUM	-3455857.4258	0.0005	5261024.5707	0.0007	1026318.8262	0.0003

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
PFLO	-3127779.9561	0.0006	5310053.4920	0.0010	1638299.4809	0.0004
PGEN	-3650007.4277	0.0006	5187339.6992	0.0008	669409.3259	0.0003
PGM2	-3290628.6113	0.0005	5245351.3950	0.0008	1524422.2859	0.0004
PGUI	-3557988.3684	0.0006	5182509.9022	0.0008	1075470.8434	0.0003
PILC	-3372132.9475	0.0005	5282112.8030	0.0007	1183262.8340	0.0003
PKAL	-3343823.1034	0.0006	5276062.2883	0.0009	1285509.0962	0.0003
PKLY	-2574911.5803	0.0004	5706616.6680	0.0007	1214725.8321	0.0003
PLG2	-3449033.0484	0.0008	5166761.1310	0.0012	1440998.0345	0.0005
PLGY	-3087399.0974	0.0006	5297658.3679	0.0009	1750284.9373	0.0004
PMAS	-3450753.0916	0.0007	5188376.7099	0.0010	1357309.2300	0.0004
PMAT	-3741994.4626	0.0008	5107657.7612	0.0011	766449.3958	0.0004
PMOG	-3274635.9386	0.0007	5269089.7940	0.0010	1476547.3814	0.0004
PMRM	-3629757.1242	0.0006	5172535.3249	0.0009	866088.2639	0.0003
PMRV	-3134714.1842	0.0006	5323767.3726	0.0009	1579758.3383	0.0003
PMSC	-3068374.4620	0.0003	5325915.2105	0.0004	1697541.4157	0.0002
PNAG	-3394666.1728	0.0003	5187872.4089	0.0005	1492904.9590	0.0002
PNDO	-3073489.6367	0.0006	5450701.8282	0.0011	1230702.4963	0.0003
PROM	-3324456.7529	0.0006	5264292.6993	0.0010	1379811.2967	0.0004
PSIP	-3371375.5147	0.0010	5305845.6556	0.0015	1075069.3299	0.0005
PSJM	-3215692.9593	0.0006	5337649.6129	0.0009	1355685.9999	0.0003
PSJN	-3228520.3348	0.0006	5287794.8492	0.0008	1510623.8180	0.0003
PSNR	-3088262.1811	0.0006	5332020.4072	0.0009	1641797.3207	0.0004
PSRF	-3167388.6857	0.0005	5286533.9496	0.0008	1638185.5847	0.0003
PSTC	-3222394.1636	0.0006	5276124.9924	0.0008	1563214.8354	0.0003
PSTN	-3219843.8658	0.0006	5124937.8041	0.0009	2005414.6063	0.0005
PSUR	-3649682.9600	0.0008	5117857.9493	0.0011	1077577.8266	0.0004
PTAC	-3588936.5696	0.0006	5124727.4485	0.0008	1236144.4911	0.0003
PTCG	-3604273.8064	0.0009	5209846.3521	0.0012	738494.1373	0.0004
PTGO	-3596111.9923	0.0005	5182802.6615	0.0007	939355.0913	0.0003
PTGY	-3181284.7491	0.0005	5307488.6178	0.0008	1543919.7052	0.0003
PTLC	-3128650.3861	0.0004	5292970.9699	0.0005	1690799.4415	0.0003

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
PTUG	-3199386.0466	0.0006	5169557.9191	0.0009	1922601.4673	0.0004
PURD	-3119484.8512	0.0008	5279888.9913	0.0011	1747197.1263	0.0005
PVIG	-3074264.7967	0.0003	5248848.6624	0.0005	1911809.7544	0.0003
PZAM	-3361516.2310	0.0008	5365985.9402	0.0014	764311.8416	0.0004
QNAM	-1939182.0430	0.0004	5824574.8945	0.0009	1724681.8425	0.0004
SIAN	-3093292.0970	0.0006	4234481.9679	0.0008	3618492.8237	0.0007
SLYG	-1539524.8904	0.0003	6187725.8724	0.0006	151763.8350	0.0002
SMS1	-1530492.4752	0.0003	6190039.2392	0.0007	148206.4532	0.0002
SNPT	-1526243.7725	0.0003	6191001.8297	0.0008	152481.6590	0.0002
SNSC	-1538473.1912	0.0004	6188107.9535	0.0011	145243.1171	0.0003
SNUS	-1518383.3909	0.0003	6193172.5684	0.0008	142897.1145	0.0002
SNYU	-1508025.9861	0.0003	6195576.1012	0.0007	148798.1721	0.0002
SRPT	-1519249.7160	0.0003	6192544.7032	0.0006	159623.9769	0.0002
SSMK	-1518411.4822	0.0002	6193330.4737	0.0004	133831.2517	0.0001
SSTS	-1504600.3810	0.0003	6196616.3591	0.0007	137086.1794	0.0002
TEMB	-2693843.2421	0.0003	5757787.7832	0.0005	520314.4861	0.0002
TGPU	-5930280.6070	0.0010	-486624.6179	0.0003	-2289338.1629	0.0004
TON1	-5930470.5436	0.0010	-500209.5691	0.0003	-2285916.8914	0.0004
TTY3	-5933920.7847	0.0008	-482004.1760	0.0003	-2280908.2535	0.0003
TUTO	-2651866.4583	0.0006	5776287.7800	0.0012	530900.9771	0.0003
UB01	-1245727.5585	0.0003	4097908.0000	0.0007	4711968.0147	0.0007
UKUR	-2678449.3687	0.0006	5762777.5213	0.0011	543962.3248	0.0003
VIEN	-1314798.3433	0.0006	5923043.4316	0.0015	1961129.3231	0.0007
VUNT	-1849587.2417	0.0006	5995310.0300	0.0014	1143318.5468	0.0005
WULJ	-3238396.7608	0.0004	3940665.0856	0.0005	3816730.4256	0.0004
XAYR	-1222619.7009	0.0004	5898800.1713	0.0010	2088984.2834	0.0005

Table 3 The final computed Geodetic coordinates in ITRF2020 at the mean epoch of the measurements, i.e. @2023.701 (in decimal year).

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
BANG	77	37	22.78582	0.0003	12	55	31.44212	0.0003	813.4623	0.0013

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
BOEN	127	43	48.98676	0.0003	36	29	18.11894	0.0003	212.2531	0.0011
CHDG	76	46	42.05712	0.0005	30	42	51.14743	0.0006	286.1282	0.0022
CHSG	129	3	22.86998	0.0003	36	26	8.25458	0.0003	250.0326	0.0013
CHYG	126	48	5.40775	0.0002	36	27	32.03977	0.0003	136.4816	0.0011
CPUR	84	58	52.66403	0.0007	19	21	13.22812	0.0005	-24.8538	0.0032
DELH	77	5	25.97729	0.0003	28	34	50.25466	0.0003	168.8617	0.0011
DIEB	103	0	19.86148	0.0003	21	25	39.95607	0.0003	463.7995	0.0012
DOA1	114	31	26.08890	0.0002	48	4	28.00226	0.0002	731.6744	0.0007
DOND	127	3	38.68977	0.0002	37	54	7.38217	0.0003	140.4529	0.0011
DONH	129	7	27.15864	0.0004	37	30	25.13982	0.0004	69.9866	0.0017
DSON	106	47	29.10265	0.0003	20	41	45.86058	0.0003	1.6070	0.0012
EAHL	108	12	5.28094	0.0003	13	12	54.76345	0.0003	642.2820	0.0011
GAAR	72	38	8.44185	0.0003	23	14	24.26265	0.0003	25.1261	0.0013
GUJT	72	39	11.35167	0.0005	23	12	38.98048	0.0004	19.1075	0.0020
GURU	74	24	34.94019	0.0002	30	42	53.69581	0.0002	151.7955	0.0006
HGIA	104	57	32.45022	0.0004	22	49	39.13772	0.0003	107.9651	0.0016
HMGA	-175	-2	-52.30235	0.0003	-21	-8	-11.84873	0.0002	64.9001	0.0010
HOA1	91	40	5.64340	0.0002	48	0	31.57597	0.0002	1378.6783	0.0007
HTIE	104	27	10.41710	0.0003	10	22	10.35711	0.0003	-4.9267	0.0015
HUV1	100	9	57.06798	0.0003	49	38	9.81191	0.0004	1243.4479	0.0011
HYDE	78	33	3.15515	0.0003	17	25	2.15033	0.0003	441.6840	0.0009
ICHN	127	36	46.95343	0.0003	37	7	2.64614	0.0003	111.5453	0.0010
IISM	78	33	15.35333	0.0039	17	24	9.42384	0.0041	421.9404	0.0255
JABA	79	54	19.37684	4.5382	23	11	21.17788	4.5478	327.9340	4.5526
JAHG	126	53	58.48046	0.0003	34	40	31.24859	0.0003	116.7939	0.0013
JAIP	75	47	11.83549	0.0003	26	58	3.04179	0.0003	426.1585	0.0013
JMMU	74	48	58.68560	0.0003	32	43	25.46649	0.0003	245.6412	0.0011
KANH	106	17	7.46248	0.0003	18	5	12.74049	0.0003	-13.7779	0.0010
KBL1	114	12	36.27697	0.0002	4	34	20.27657	0.0002	55.5272	0.0007
KGDC	77	37	23.36650	0.0004	12	55	31.27592	0.0003	810.5634	0.0015
KOLK	88	21	18.05104	0.0043	22	32	53.08286	0.0041	-51.6942	0.0242
KUNJ	74	52	31.87980	0.0003	12	45	11.96819	0.0002	-49.6568	0.0010
KURA	74	15	24.61178	0.0003	34	30	53.45892	0.0003	1581.5481	0.0010
LAMU	114	42	43.09745	0.0003	4	40	38.49814	0.0003	75.8406	0.0013
LIAN	114	31	29.47414	0.0003	4	42	15.56467	0.0003	65.7835	0.0013

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
LUCK	81	0	41.78273	0.0003	26	51	37.65532	0.0003	50.1196	0.0010
MATH	77	41	38.15495	0.0003	27	28	17.39189	0.0003	122.2352	0.0010
MURA	115	3	58.33409	0.0003	5	1	59.35859	0.0003	63.8089	0.0012
OMA1	104	22	14.62847	0.0002	43	36	19.29965	0.0003	1416.5365	0.0010
OVA1	102	46	39.02950	0.0002	46	15	59.73608	0.0002	1816.9482	0.0006
PAKX	103	38	57.17157	0.0004	18	23	30.09521	0.0004	135.0557	0.0015
PAPI	121	38	43.19299	0.0002	18	21	20.88390	0.0002	54.3971	0.0005
PBAS	121	58	32.68611	0.0003	20	26	58.20893	0.0003	80.0105	0.0012
PBAT	120	32	43.77864	0.0002	18	3	14.05354	0.0002	51.7405	0.0008
PBAY	121	8	34.54886	0.0003	16	28	53.59567	0.0002	322.8829	0.0009
PBGO	122	50	8.93290	0.0005	10	30	58.54945	0.0004	78.0796	0.0018
PBGU	120	37	4.22601	0.0004	16	25	4.06644	0.0004	1545.1188	0.0017
PBIS	126	21	13.96492	0.0003	8	11	21.02327	0.0002	78.2184	0.0009
PBOG	123	58	43.70413	0.0002	11	2	46.67596	0.0002	88.5353	0.0004
PBOR	125	26	27.54563	0.0003	11	39	37.02265	0.0003	67.3295	0.0013
PCAT	124	39	31.93375	0.0004	12	30	42.87472	0.0003	59.6006	0.0014
PCB2	120	56	19.70201	0.0003	15	26	45.80206	0.0002	78.6552	0.0011
PCDN	120	26	30.83433	0.0002	17	10	16.93102	0.0002	55.3284	0.0006
PCEB	123	53	23.59236	0.0003	10	19	5.18699	0.0003	126.9458	0.0011
PCHN	128	26	45.78386	0.0003	37	32	4.79758	0.0003	560.2812	0.0012
PCOT	124	14	49.31667	0.0003	7	11	58.57195	0.0004	86.1813	0.0015
PCRT	123	52	22.55738	0.0002	9	42	45.87554	0.0002	76.4793	0.0008
PDAV	125	38	36.24837	0.0002	7	7	35.36330	0.0002	96.7708	0.0005
PDDN	125	46	59.69844	0.0002	7	27	33.75686	0.0002	90.5559	0.0008
PDIP	123	20	39.45251	0.0002	8	35	12.63049	0.0002	86.8478	0.0005
PDUM	123	18	0.27988	0.0003	9	19	18.62541	0.0002	88.3983	0.0009
PFLO	120	29	57.67591	0.0003	14	58	58.56015	0.0003	90.7672	0.0012
PGEN	125	7	53.98018	0.0003	6	3	53.68098	0.0003	121.0845	0.0009
PGM2	122	6	6.37411	0.0003	13	55	12.47884	0.0003	65.9387	0.0010
PGUI	124	28	15.83785	0.0003	9	46	20.73174	0.0002	116.8882	0.0009
PILC	122	33	15.87067	0.0003	10	45	46.38378	0.0002	71.4593	0.0009
PKAL	122	21	55.43344	0.0003	11	42	18.92073	0.0003	80.3808	0.0010
PKLY	114	17	8.21352	0.0002	11	3	9.39310	0.0002	40.3846	0.0008
PLG2	123	43	29.27163	0.0004	13	8	40.25082	0.0003	85.2523	0.0014
PLGY	120	13	58.86167	0.0003	16	1	59.85443	0.0003	57.1782	0.0011

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
PMAS	123	37	39.36394	0.0003	12	22	8.03306	0.0003	80.1544	0.0012
PMAT	126	13	38.68693	0.0004	6	56	53.11075	0.0003	114.6453	0.0013
PMOG	121	51	36.50534	0.0003	13	28	29.11433	0.0003	62.8409	0.0012
PMRM	125	3	31.47286	0.0003	7	51	22.60359	0.0003	375.5543	0.0010
PMRV	120	29	24.77643	0.0003	14	26	9.59683	0.0002	59.2684	0.0010
PMSC	119	56	49.81586	0.0002	15	32	16.70369	0.0002	57.2743	0.0005
PNAG	123	11	54.92209	0.0002	13	37	36.53414	0.0002	73.1216	0.0006
PNDO	119	25	2.51820	0.0003	11	11	59.22240	0.0003	54.3854	0.0012
PROM	122	16	22.24462	0.0003	12	34	38.07566	0.0003	68.1230	0.0012
PSIP	122	25	55.89768	0.0005	9	46	7.64183	0.0004	86.4420	0.0018
PSJM	121	4	1.43765	0.0003	12	21	14.06737	0.0003	64.5819	0.0010
PSJN	121	24	23.77294	0.0003	13	47	30.03941	0.0002	66.6266	0.0010
PSNR	120	4	44.64592	0.0003	15	0	56.59518	0.0003	65.6841	0.0010
PSRF	120	55	39.46493	0.0003	14	58	54.90084	0.0002	70.4723	0.0010
PSTC	121	24	52.21956	0.0003	14	16	53.93897	0.0002	62.4676	0.0010
PSTN	122	8	23.66714	0.0003	18	26	49.98896	0.0003	42.4996	0.0011
PSUR	125	29	37.30256	0.0004	9	47	30.52582	0.0003	80.2508	0.0013
PTAC	125	0	15.22544	0.0003	11	14	59.62015	0.0002	79.7182	0.0010
PTCG	124	40	34.47966	0.0004	6	41	36.54816	0.0004	133.7485	0.0015
PTGO	124	45	18.10378	0.0003	8	31	33.32321	0.0002	91.5661	0.0009
PTGY	120	56	17.81611	0.0003	14	6	1.02592	0.0002	715.4974	0.0009
PTLC	120	35	13.68604	0.0002	15	28	28.58160	0.0002	112.3075	0.0007
PTUG	121	45	10.57489	0.0003	17	39	36.49786	0.0003	84.3881	0.0011
PURD	120	34	32.19919	0.0003	16	0	15.10660	0.0003	82.5537	0.0014
PVIG	120	21	27.43525	0.0002	17	33	28.65758	0.0002	41.8676	0.0006
PZAM	122	3	54.15474	0.0004	6	55	43.13621	0.0003	84.2293	0.0016
QNAM	108	24	51.13417	0.0003	15	47	34.22783	0.0003	3.3217	0.0010
SIAN	126	8	53.35807	0.0003	34	47	12.80027	0.0003	30.9935	0.0012
SLYG	103	58	18.03970	0.0002	1	22	21.44466	0.0002	50.5048	0.0006
SMS1	103	53	16.43576	0.0002	1	20	25.60515	0.0002	37.2047	0.0007
SNPT	103	50	55.54092	0.0002	1	22	44.81810	0.0002	54.8332	0.0008
SNSC	103	57	42.04201	0.0003	1	18	49.11902	0.0003	14.5771	0.0011
SNUS	103	46	31.86340	0.0003	1	17	32.68495	0.0002	62.7292	0.0009
SNYU	103	40	47.94722	0.0002	1	20	44.84564	0.0002	75.5798	0.0008
SRPT	103	47	3.91868	0.0002	1	26	37.41663	0.0002	58.7585	0.0006

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
SSMK	103	46	31.52968	0.0002	1	12	37.48495	0.0002	24.7492	0.0004
SSTS	103	38	52.32528	0.0002	1	14	23.48831	0.0002	12.8792	0.0008
TEMB	115	4	22.98518	0.0002	4	42	38.57809	0.0002	65.1981	0.0006
TGPU	-175	-18	-32.24068	0.0003	-21	-10	-24.51244	0.0003	62.0125	0.0010
TON1	-175	-10	-43.53600	0.0003	-21	-8	-25.33010	0.0002	54.1926	0.0010
TTY3	-175	-21	-22.09940	0.0003	-21	-5	-30.72856	0.0002	56.2060	0.0008
TUTO	114	39	34.67496	0.0003	4	48	24.37006	0.0003	79.9624	0.0013
UB01	106	54	31.69796	0.0003	47	55	16.82405	0.0003	1277.8782	0.0009
UKUR	114	55	41.78015	0.0003	4	55	31.12903	0.0003	74.7362	0.0013
VIEN	102	30	56.13312	0.0004	18	1	31.84412	0.0004	192.3977	0.0017
VUNT	107	8	43.05085	0.0004	10	23	44.27189	0.0003	5.5454	0.0015
WULJ	129	24	46.80976	0.0002	36	59	31.10850	0.0002	80.7717	0.0007
XAYR	101	42	34.76570	0.0003	19	14	39.47744	0.0003	256.7420	0.0011

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