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Report on the Analysis of the Asia Pacific Regional Geodetic Project (APRGP) GPS Campaign 2024

G. Hu

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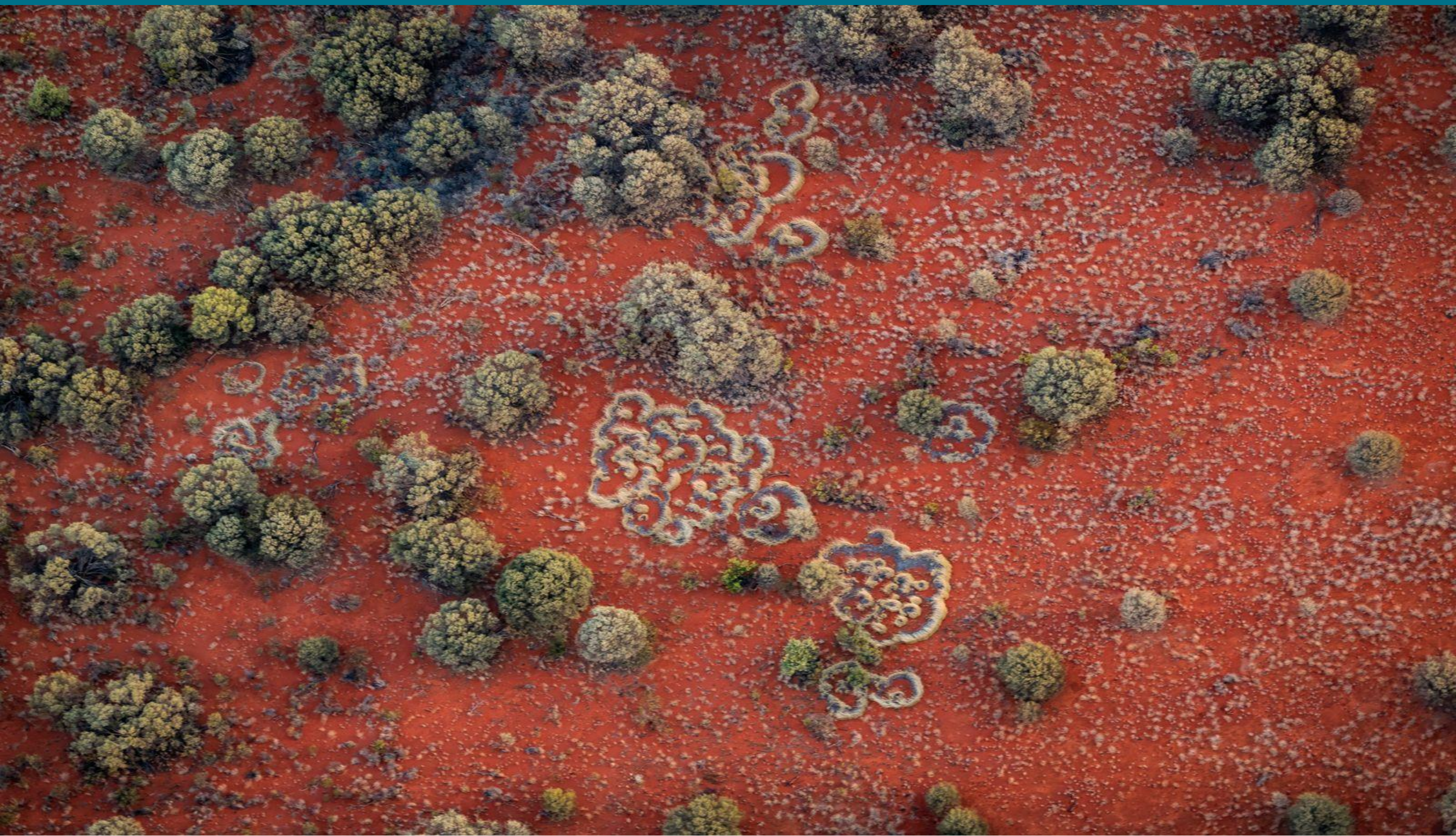

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Executive Summary

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 08^{th} and 14^{th} of September 2024. Campaign GPS data collected at 74 sites in eleven 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) reference frame 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 2.4 mm, 2.7 mm and 6.8 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 participating member countries for local and global scientific research and 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 2024.

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 2024 GPS campaign was undertaken from 08 to 14 September 2024 inclusive (day of year 252 to 258). Data were contributed by eleven countries across the region, including Brunei, Cambodia, Laos, Myanmar, Papua New Guinea, Philippines, Singapore, Sri Lanka, Timor-Leste, 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 2024 campaign stations along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations. The more detailed location distributions of the APRGP2024 campaign sites are plotted in Figure 2.

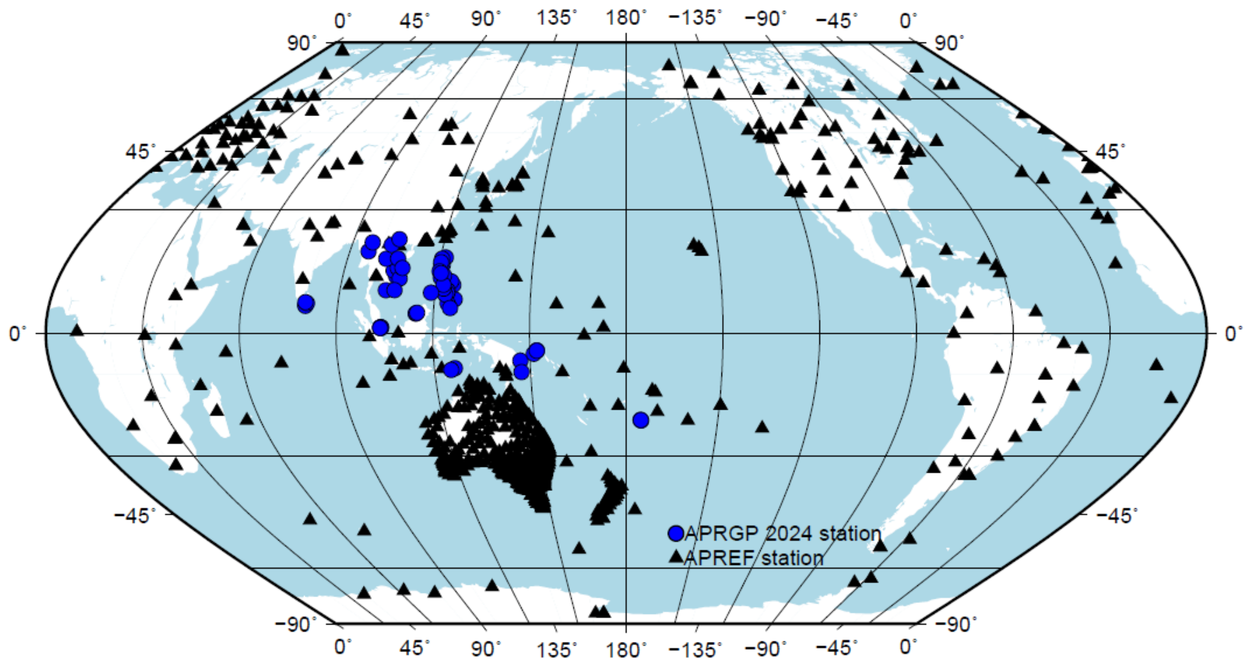

Figure 1. APRGP stations in the APRGP 2024 GPS campaign analysis along with the APREF stations and IGS stations, blue circles are APRGP campaign sites, and black triangles are APREF stations.

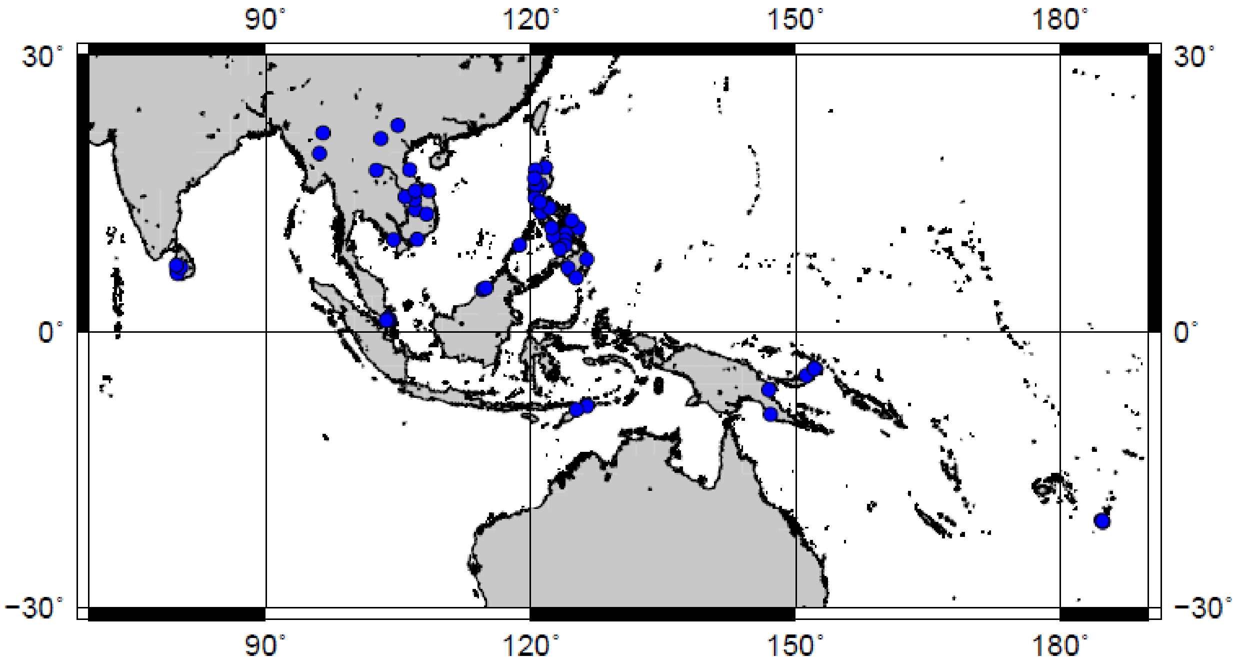

Figure 2. APRGP stations location distributions in the APRGP 2024 GPS campaign.

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 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 FES2014b model (Lyard et al., 2021).
- 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, as 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 2.4 mm, 2.7 mm and 6.8 mm in north, east and up components, respectively. Note that there are no solutions for the site TEMB from Brunei, STUE from Cambodia, YANG from Myanmar, MORE from Papua New Guinea, PBGO from Philippines, RATH from Sri Lanka, due to data quality issues.

Table 1 Daily repeatability RMS for the APRGP 2024 GPS campaign stations.

Station	Country	North (mm)	East (mm)	Up (mm)
LIAN	Brunei	3.6	1.3	11.6
TUTO	Brunei	3.4	3.7	9.2
UKUR	Brunei	2.3	4.2	7.1
RATA	Cambodia	3.1	2.3	11.7
ATTA	Laos	2.7	2.6	10.2
CHAM	Laos	2.4	3.1	7.2
KALM	Laos	1.9	2.4	7.6
VIEN	Laos	2.5	2.4	13.8
NPT1	Myanmar	3.4	6.8	11.8
POL5	Myanmar	3.3	8.4	12.4
LAE2	Papua New Guinea	2.4	2.8	9.5
RVO2	Papua New Guinea	2.6	3.9	10.2
SDA2	Papua New Guinea	2.3	5.4	12.1
ULVO	Papua New Guinea	0.9	2.9	7.3
VIS2	Papua New Guinea	3.7	4.4	5.9
WAIG	Papua New Guinea	1.6	2.5	8.0
PAPI	Philippines	1.6	2.7	7.2
PBAT	Philippines	3.6	2.8	8.1
PBAY	Philippines	2.5	1.6	7.0
PBGU	Philippines	2.2	1.8	10.2
PBIS	Philippines	2.0	1.0	6.4
PBOG	Philippines	2.3	1.4	6.0
PBOR	Philippines	2.0	3.2	10.0
PCAT	Philippines	1.6	2.0	8.3

Station	Country	North (mm)	East (mm)	Up (mm)
PCDN	Philippines	3.0	3.1	11.0
PCEB	Philippines	2.8	1.5	7.7
PCL2	Philippines	2.4	3.5	5.8
PCOT	Philippines	3.0	2.0	11.2
PCRT	Philippines	1.6	1.5	3.6
PDUM	Philippines	2.3	2.1	11.0
PFLO	Philippines	3.8	4.6	9.8
PGEN	Philippines	2.8	1.7	7.6
PGM2	Philippines	3.1	3.4	6.2
PILC	Philippines	1.9	2.0	7.9
PKAL	Philippines	1.5	2.0	8.5
PPPC	Philippines	3.6	2.2	10.2
PTAG	Philippines	1.9	1.6	9.9
SLYG	Singapore	2.6	4.6	6.6
SMS1	Singapore	3.0	5.1	6.2
SNPT	Singapore	2.8	4.4	3.9
SNSC	Singapore	3.4	5.4	8.4
SNUS	Singapore	3.0	5.3	7.0
SNYU	Singapore	3.3	5.4	8.4
SRPT	Singapore	1.6	2.8	6.1
SSMK	Singapore	4.6	5.5	8.6
SSTS	Singapore	2.6	4.8	6.1
CLMB	Sri Lanka	1.9	4.1	3.8
KALU	Sri Lanka	1.9	2.9	2.6
KEGA	Sri Lanka	1.9	3.1	4.9
MADA	Sri Lanka	2.3	3.1	3.6
BCAU	Timor-Leste	2.7	2.0	7.8
BOMA	Timor-Leste	2.4	1.7	6.5
T001	Tonga	1.0	2.1	7.9
T048	Tonga	1.8	2.4	7.1
TNG1	Tonga	2.2	2.7	6.9

Station	Country	North (mm)	East (mm)	Up (mm)
DIEB	Vietnam	2.5	1.3	11.4
EAHL	Vietnam	2.4	2.3	10.6
HGIA	Vietnam	3.4	3.8	11.2
HTIE	Vietnam	3.5	3.8	11.6
KANH	Vietnam	4.9	2.1	9.4
QNAM	Vietnam	1.2	1.6	5.7
VUNT	Vietnam	3.1	1.4	11.3

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 (XYZ) in ITRF2020, and one standard deviation uncertainty (std), at the mean epoch of the measurements, i.e. @2024.701 (in decimal year).

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
ATTA	-1785584.5210	0.0006	5903570.9292	0.0015	1619746.2295	0.0006
BCAU	-3743764.8048	0.0004	5078625.1804	0.0005	-934829.0048	0.0002
BOMA	-3630800.4203	0.0005	5150525.1739	0.0007	-982727.0909	0.0003
CHAM	-1675220.5231	0.0005	5926323.1531	0.0012	1653982.2966	0.0005
CLMB	1113305.6564	0.0005	6233645.9486	0.0011	760267.1354	0.0004
DIEB	-1336847.3772	0.0006	5787979.2294	0.0015	2315717.0315	0.0006
EAHL	-1940045.9214	0.0005	5900173.9813	0.0012	1448740.9017	0.0005
HGIA	-1518217.1585	0.0010	5682319.5204	0.0018	2459169.3769	0.0009
HTIE	-1566049.5298	0.0006	6076067.8725	0.0018	1140478.3565	0.0004
KALM	-1785683.1641	0.0005	5874426.2319	0.0012	1723428.7601	0.0005
KALU	1104401.2530	0.0005	6239316.7445	0.0014	726231.9351	0.0004
KANH	-1700737.6486	0.0005	5821573.0807	0.0011	1967522.4452	0.0005
KEGA	1060699.4182	0.0005	6237975.2827	0.0014	800146.2347	0.0004
LAE2	-5312859.0973	0.0008	3451108.7403	0.0006	-736302.9343	0.0003
LIAN	-2638655.4623	0.0009	5783351.4320	0.0016	519609.9913	0.0005
MADA	1116463.2412	0.0004	6224701.4519	0.0009	825579.9164	0.0003
NPT1	-634100.3963	0.0005	5968838.2450	0.0014	2149801.0456	0.0006
PAPI	-3177167.8379	0.0003	5155269.0593	0.0005	1995817.0928	0.0003
PBAT	-3082933.3989	0.0008	5224292.2574	0.0012	1964073.7515	0.0005
PBAY	-3164087.8455	0.0006	5236293.7478	0.0009	1797982.3361	0.0004
PBGU	-3117582.1582	0.0009	5267799.3323	0.0013	1791560.5393	0.0005
PBIS	-3742521.6277	0.0006	5084796.7260	0.0008	902504.4424	0.0003
PBOG	-3499087.8932	0.0004	5191752.5094	0.0005	1214049.9673	0.0002
PBOR	-3622661.7912	0.0015	5089865.7894	0.0017	1280634.7179	0.0006
PCAT	-3541625.2825	0.0009	5122609.4567	0.0012	1372754.3062	0.0004
PCDN	-3088458.3949	0.0004	5255341.1625	0.0006	1870978.2470	0.0003
PCEB	-3499372.6234	0.0007	5209601.9264	0.0010	1134905.0881	0.0004
PCL2	-3214703.8756	0.0008	5307528.3625	0.0011	1470605.8627	0.0004
PCOT	-3561309.0444	0.0008	5231065.2745	0.0012	794050.1204	0.0004
PCRT	-3504293.6053	0.0005	5220264.4894	0.0007	1068957.8780	0.0003
PDUM	-3455857.4294	0.0006	5261024.5630	0.0008	1026318.8225	0.0003
PFLO	-3127779.9286	0.0008	5310053.5011	0.0012	1638299.4786	0.0004
PGEN	-3650007.4198	0.0007	5187339.7042	0.0009	669409.3219	0.0003
PGM2	-3290628.5878	0.0006	5245351.3950	0.0008	1524422.2952	0.0003

Station	X (m)	1 std (m)	Y (m)	1 std (m)	Z (m)	1 std (m)
PILC	-3372132.9473	0.0006	5282112.7896	0.0009	1183262.8355	0.0003
PKAL	-3343823.1003	0.0006	5276062.2652	0.0008	1285509.0911	0.0003
POL5	-666949.3666	0.0010	5878706.1028	0.0038	2377340.7482	0.0015
PPPC	-3022676.7555	0.0005	5511839.2720	0.0008	1075517.4394	0.0003
PTAG	-3184318.5081	0.0007	5291065.6269	0.0010	1590418.2821	0.0004
QNAM	-1939182.0676	0.0005	5824574.8841	0.0011	1724681.8304	0.0005
RATA	-1806758.2701	0.0006	5927719.2088	0.0013	1505559.7084	0.0005
RVO2	-5625351.0657	0.0011	2970458.7924	0.0007	-463019.9574	0.0004
SDA2	-5626185.7705	0.0010	2967595.9171	0.0006	-468828.1593	0.0003
SLYG	-1539524.9154	0.0005	6187725.8651	0.0011	151763.8249	0.0003
SMS1	-1530492.4997	0.0004	6190039.2323	0.0010	148206.4470	0.0003
SNPT	-1526243.7988	0.0004	6191001.8275	0.0010	152481.6492	0.0003
SNSC	-1538473.2152	0.0005	6188107.9455	0.0012	145243.1050	0.0003
SNUS	-1518383.4179	0.0004	6193172.5671	0.0010	142897.1055	0.0003
SNYU	-1508026.0113	0.0005	6195576.0957	0.0011	148798.1637	0.0003
SRPT	-1519249.7409	0.0004	6192544.7012	0.0010	159623.9685	0.0003
SSMK	-1518411.5054	0.0003	6193330.4655	0.0007	133831.2436	0.0002
SSTS	-1504600.4061	0.0005	6196616.3551	0.0011	137086.1702	0.0003
T001	-5926115.3924	0.0009	-503835.7883	0.0003	-2296405.3732	0.0004
T048	-5934766.4601	0.0008	-485452.4695	0.0003	-2278007.3112	0.0004
TNG1	-5930928.2194	0.0012	-497945.7658	0.0004	-2285289.8565	0.0005
TUTO	-2651866.4726	0.0011	5776287.7584	0.0019	530900.9646	0.0005
UKUR	-2678449.3810	0.0010	5762777.4959	0.0017	543962.3113	0.0005
ULVO	-5570636.5490	0.0024	3056557.6083	0.0016	-552511.4636	0.0008
VIEN	-1314798.3766	0.0006	5923043.4325	0.0017	1961129.3209	0.0008
VIS2	-5624847.8486	0.0016	2969590.6381	0.0009	-472290.6393	0.0004
VUNT	-1849587.2692	0.0007	5995310.0278	0.0017	1143318.5357	0.0007
WAIG	-5288103.2309	0.0006	3410379.9165	0.0004	-1039516.8119	0.0003

Table 3 The final computed Geodetic coordinates (latitude, longitude, height) and one standard deviation of uncertainty (std), in ITRF2020 at the mean epoch of the measurements, i.e. @2024.701 (in decimal year).

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
ATTA	106	49	42.17310	0.0004	14	48	33.98005	0.0004	85.4014	0.0016
BCAU	126	23	46.30116	0.0003	-8	-29	-2.00134	0.0002	577.8431	0.0005
BOMA	125	10	53.25580	0.0003	-8	-55	-21.14633	0.0003	176.4369	0.0008

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
CHAM	105	47	3.28381	0.0004	15	7	46.95335	0.0004	88.7760	0.0014
CLMB	79	52	26.22478	0.0004	6	53	31.12989	0.0003	-73.5847	0.0012
DIEB	103	0	19.86256	0.0005	21	25	39.95577	0.0004	463.7911	0.0016
EAHL	108	12	5.28184	0.0004	13	12	54.76309	0.0004	642.2835	0.0013
HGIA	104	57	32.45145	0.0006	22	49	39.13731	0.0004	107.9784	0.0021
HTIE	104	27	10.41786	0.0004	10	22	10.35677	0.0004	-4.9214	0.0019
KALM	106	54	28.80115	0.0004	15	46	46.74889	0.0003	559.6176	0.0013
KALU	79	57	44.02890	0.0005	6	34	55.45627	0.0004	-69.6653	0.0014
KANH	106	17	7.46342	0.0004	18	5	12.74019	0.0003	-13.7745	0.0012
KEGA	80	20	59.20764	0.0005	7	15	18.52291	0.0004	104.7377	0.0014
LAE2	146	59	35.48805	0.0003	-6	-40	-24.70739	0.0003	140.1200	0.0010
LIAN	114	31	29.47487	0.0005	4	42	15.56427	0.0004	65.7709	0.0018
MADA	79	49	53.55013	0.0004	7	29	14.12646	0.0003	-82.8991	0.0009
NPT1	96	3	50.69094	0.0004	19	49	39.85943	0.0004	99.8184	0.0015
PAPI	121	38	43.19140	0.0003	18	21	20.88477	0.0002	54.3991	0.0006
PBAT	120	32	43.77712	0.0004	18	3	14.05378	0.0003	51.7404	0.0014
PBAY	121	8	34.54744	0.0003	16	28	53.59638	0.0003	322.8864	0.0010
PBGU	120	37	4.22466	0.0004	16	25	4.06674	0.0003	1545.1159	0.0015
PBIS	126	21	13.97269	0.0003	8	11	21.02327	0.0003	78.2281	0.0010
PBOG	123	58	43.70436	0.0003	11	2	46.67570	0.0002	88.5251	0.0005
PBOR	125	26	27.54488	0.0006	11	39	37.02349	0.0005	67.3175	0.0022
PCAT	124	39	31.93297	0.0004	12	30	42.87564	0.0004	59.5968	0.0014
PCDN	120	26	30.83298	0.0003	17	10	16.93122	0.0002	55.3298	0.0007
PCEB	123	53	23.59264	0.0004	10	19	5.18670	0.0003	126.9417	0.0012
PCL2	121	12	9.96417	0.0004	13	25	10.33061	0.0003	62.9945	0.0013
PCOT	124	14	49.31679	0.0004	7	11	58.57174	0.0004	86.1781	0.0015
PCRT	123	52	22.55781	0.0003	9	42	45.87538	0.0003	76.4560	0.0008
PDUM	123	18	0.28012	0.0003	9	19	18.62531	0.0003	88.3933	0.0010
PFLO	120	29	57.67496	0.0004	14	58	58.56013	0.0003	90.7607	0.0014
PGEN	125	7	53.97987	0.0003	6	3	53.68085	0.0003	121.0837	0.0011
PGM2	122	6	6.37345	0.0003	13	55	12.47924	0.0003	65.9288	0.0009
PILC	122	33	15.87090	0.0003	10	45	46.38389	0.0003	71.4484	0.0010
PKAL	122	21	55.43376	0.0003	11	42	18.92071	0.0003	80.3591	0.0010
POL5	96	28	21.46623	0.0008	22	1	29.05783	0.0007	1035.3331	0.0041
PPPC	118	44	24.85171	0.0003	9	46	22.55288	0.0003	66.5432	0.0009

Station	LONGITUDE (DMS)			1 std (m)	LATITUDE (DMS)			1 std (m)	ELLIPSOID HEIGHT (m)	1 std (m)
PTAG	121	2	26.74626	0.0004	14	32	7.59161	0.0003	86.6552	0.0012
QNAM	108	24	51.13506	0.0004	15	47	34.22747	0.0003	3.3164	0.0013
RATA	106	57	4.06134	0.0004	13	44	38.68032	0.0004	281.0098	0.0014
RVO2	152	9	49.56583	0.0004	-4	-11	-27.22608	0.0004	266.5882	0.0013
SDA2	152	11	24.29733	0.0004	-4	-14	-37.22947	0.0003	97.3177	0.0011
SLYG	103	58	18.04054	0.0004	1	22	21.44434	0.0003	50.5035	0.0012
SMS1	103	53	16.43658	0.0004	1	20	25.60495	0.0003	37.2037	0.0010
SNPT	103	50	55.54176	0.0004	1	22	44.81778	0.0003	54.8372	0.0011
SNSC	103	57	42.04282	0.0004	1	18	49.11863	0.0003	14.5748	0.0012
SNUS	103	46	31.86426	0.0004	1	17	32.68466	0.0003	62.7341	0.0010
SNYU	103	40	47.94805	0.0004	1	20	44.84537	0.0003	75.5802	0.0011
SRPT	103	47	3.91947	0.0004	1	26	37.41635	0.0003	58.7623	0.0011
SSMK	103	46	31.53048	0.0003	1	12	37.48469	0.0002	24.7466	0.0007
SSTS	103	38	52.32609	0.0004	1	14	23.48801	0.0003	12.8810	0.0011
T001	-175	-8	-25.52565	0.0003	-21	-14	-30.70328	0.0003	84.6874	0.0010
T048	-175	-19	-25.41555	0.0003	-21	-3	-49.58399	0.0003	60.8174	0.0009
TNG1	-175	-12	-3.04564	0.0004	-21	-8	-3.19257	0.0003	76.4011	0.0013
TUTO	114	39	34.67567	0.0006	4	48	24.36969	0.0005	79.9478	0.0021
UKUR	114	55	41.78086	0.0005	4	55	31.12864	0.0004	74.7173	0.0019
ULVO	151	14	48.56634	0.0007	-5	0	-10.42764	0.0007	96.4716	0.0029
VIEN	102	30	56.13422	0.0005	18	1	31.84397	0.0004	192.4047	0.0019
VIS2	152	10	6.84116	0.0005	-4	-16	-30.24923	0.0004	102.8515	0.0018
VUNT	107	8	43.05173	0.0005	10	23	44.27150	0.0005	5.5493	0.0019
WAIG	147	10	53.04638	0.0003	-9	-26	-33.66135	0.0002	154.6716	0.0007

References

Altamimi, Z., Rebischung, P., Collilieux, X. *et al.*, 2023. ITRF2020: an augmented reference frame refining the modeling of nonlinear station motions. J Geod 97, 47. https://doi.org/10.1007/s00190-023-01738-w.

Böhm, J., A. Niell, P. Tregoning and H. Schuh, 2006. Global Mapping Function (GMF): A new empirical mapping function based on numerical weather model data, Geophysical Research Letters, Vol. 33, L07304, doi:10.1029/2005GL025546.

Dach R., S. Lutz, P. Walser, and P. Fridez, editors. Bernese GNSS Software, Version 5.2. Astronomical Institute, University of Bern, Bern, Switzerland, November 2015. ISBN 978-3-906813-05-9. doi: 10.7892/boris.72297. URL ftp://ftp.unibe.ch/aiub/BERN52/DOCU/DOCU52.pdf. User manual.

Gérard Petit and Brian Luzum (eds.). IERS Conventions (2010). (IERS Technical Note ; 36) Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, 2010. 179 pp., ISBN 3-89888-989-6

Lyard, F. H., Allain, D. J., Cancet, M., Carrère, L., and Picot, N. (2021): FES2014 global ocean tide atlas: design and performance, Ocean Sci., 17, 615–649, https://doi.org/10.5194/os-17-615-2021, 2021.

Niell, A.E., 1996. Global mapping functions for the atmosphere delay at radio wavelengths. J. Geophys. Res., 101(B2): 3227 - 3246.

Schmid, R., P. Steigenberger, G. Gendt, M. Ge, and M. Rothacher, 2007. Generation of a consistent absolute phase center correction model for GPS receiver and satellite antennas. J Geod., 81: 781 - 798, doi: 10.1007/s00190-007-0148-y.