## Abstract

The UGRF which is Uganda's modernised geodetic datum is based on ITRF2005 epoch 2010.0. This geodetic datum is realised through the establishment of the 12 GNSS CORS network in the major cities or towns. This paper assesses the precision of this network in regards to latest released ITRF2020. Six (06) stations were randomly selected and investigated. The results indicate that there is urgent need for the upgrade of the datum to meet international standards.


# ENHANCING GEODETIC CONTROLS FOR SECURE GEOSPATIAL DATA QUALITY AND INTEGRITY IN UGANDA

## INTRODUCTION

Uganda's long historic geodetic reference datum has been the famous Arc1960 based on Clarke 1880 modified ellipsoid for the horizontal component. While for the vertical component Uganda still utilizes the mean sea level (MSL) derived from the so-called Khartoum Datum. However, a new reference system called the Uganda Geodetic Reference Network (UGRN) has been developed aligned to the ITRF2005@2010.0. In the effort to cope with the technological advancements, 12 Global Navigation Satellite System (GNSS) Continuous Operating Reference Stations (CORS) were installed in the first phase (IGN, 2011; IGNFI, 2019) . The 12 GNSS CORS coordinates were computed as shown in Table 1, based on the ITRF2014 epoch 2019.21 (ITRF2014@2019.21) and transformed to UGRF using the 7 Helmert transformation parameters (IGNFI, 2019).

Now, a total of 38 CORS stations to make them 40 in number are being installed in the second phase. As alluded by (Christopher, 2006) the adoption of global terrestrial reference systems and frames allows countries to take advantage in consistency at a universal perspective. The global geodetic reference system is now the only fundamental recognized system and it was through a resolution by the International Union of Geodesy and Geophysics (IUGG) in 2007. The ITRF is supposed to be updated in every 3 – 5 years, with the current updated version being ITRF2020 (Zuheir, 2013).

UGRN is considered as the most accurate, consistent and a lasting reference frame that is established and maintained by the Department of Surveys and Mapping (DSM), Ministry of Lands, Housing and Urban Development (MLHUD) (Bordas & Lacombe, 2021). This reference frame is to facilitate all aspects to do with spatial data in Uganda, which may include cadastral, engineering, geodetic, GIS, remote sensing, photogrammetry and other fundamental spatial datasets (Toko, Oput, Kagoro, Kambugu, & Magemeso, 2022).

*Table 1: Geographic coordinates of 12 GNSS CORS Sites at ITRF2005 epoch 2010.00 (IGNFI, 2019)*

| Station | Latitude ($^0$) | Longitude ($^0$) | He (m) |
|---|---|---|---|
| ARUA | 3.017143521 | 30.909914062 | 1208.8899 |
| ENTB | 0.059980991 | 32.476011896 | 1164.9160 |
| FPRT | 0.652455592 | 30.298304056 | 1522.1652 |
| GULU | 2.779525162 | 32.295855600 | 1099.0340 |
| JING | 0.418319436 | 33.213899857 | 1134.5039 |
| KBLE | 0.795187975 | 31.083240395 | 1334.4363 |
| LIRA | 2.247076555 | 32.901580766 | 1087.7116 |
| MBAL | 1.069771501 | 34.168688149 | 1117.0668 |
| MRTO | 2.531475711 | 34.657141630 | 1354.1900 |
| MSKA | -0.338771247 | 31.719233545 | 1197.5288 |
| MSND | 1.686467071 | 31.717680214 | 1142.8215 |
| SRTI | 1.721941881 | 33.620010269 | 1111.3274 |

GNSS and other modern geodetic technologies have completely revolutionized the way in which Geodetic control at international, regional and local levels can be achieved with capabilities without limitations in scales and everywhere. It is now a routine for all countries and of course regions to continuously revise and update their geodetic networks to benefit from the enormous benefits of ITRF latest editions such as the ITRF2020 edition. These benefits may include; high accuracy, ease in establishment and densification, and uniformity in accuracy at a global scale. The uniformity in accuracy is the most critical benefit that arises in alignment of geodetic control to the ITRF editions (Christopher, 2006).

The International Terrestrial Reference System (ITRS) is now the globally recognized principal geodetic coordinate system having been accepted by the International Union of Geodesy and Geophysics (IUGG). This ITRS is hypothetically fixed to the revolving Earth and unequivocally determined according to these aspects: Origin, Scale and lastly the Orientation of the three (03) coordinate axes as determined by conventions of the International Earth Rotation and Reference Systems Service (IERS) (Angermann, Pail, Seitz, & Hugentobler, 2022). Now, the ITRF2020 which is the latest model is urged as an improved terrestrial reference frame that truly and exactly models nonlinear station motions for both annual and semi – annual signals present in the station position time series and Post-Seismic Deformation (PSD) for sites that are impinged on by earth quakes. Four space geodetic techniques that is Doppler Orbitography and Radiopsoitioning Integrated by Satellite (DORIS), Global Navigation Satellite Systems (GNSS), Satellite Laser Raging (SLR) and Very Long Baseline Interferometry (VLBI) contributed to the realization of the ITRF (Angermann, Pail, Seitz, & Hugentobler, 2022) . In summary long term periods of data were used ranging from 1993 up to 2021. The ITRF2020's accuracy and reliability has been assessed in contrast to the earlier editions such as ITRF2014, ITRF2008 and ITRF2005 and it was found to be within the levels of 5mm and 0.5mm/yr, respectively (Altamimi, Rebischung, Collilieux, Metivier, & Chanard, 2023).

Now, this paper assesses the performance of these 12 GNSS CORS UGRN stations using the free online Précised Point Positioning (PPP) services. For this specific paper 6 stations data was analyzed to test how they can be enhanced with ITRF2014 and most recent ITRF2020. Among the tools chosen were CSRS-PPP, AUSPOS, Trimble CenterPoint RTX, and APPS. The results were compared with the two reference reframes that is ITRF2014 and ITRF2020 depending on the capabilities of the tool or service used.

**Materials And Methods**

As stated above data from the 12 stations was collected from the UGRF website http://ugrf.go.ug/SBC/User/Xpos/RinexDataRequest for days 310, 311, 312, 313, 314, 315, 316, and 338. The screen shot of the interface is shown in Figure 1 All the 12 stations as indicated Table 1 are equipped with Leica GR50 receivers and Leiar20 Leim Antennas which provide cutting-edge technology for outstanding performance. These receivers are enabled to collected all the four GNSS global constellations that's GPS, GLONASS, Galileo and BeiDou.

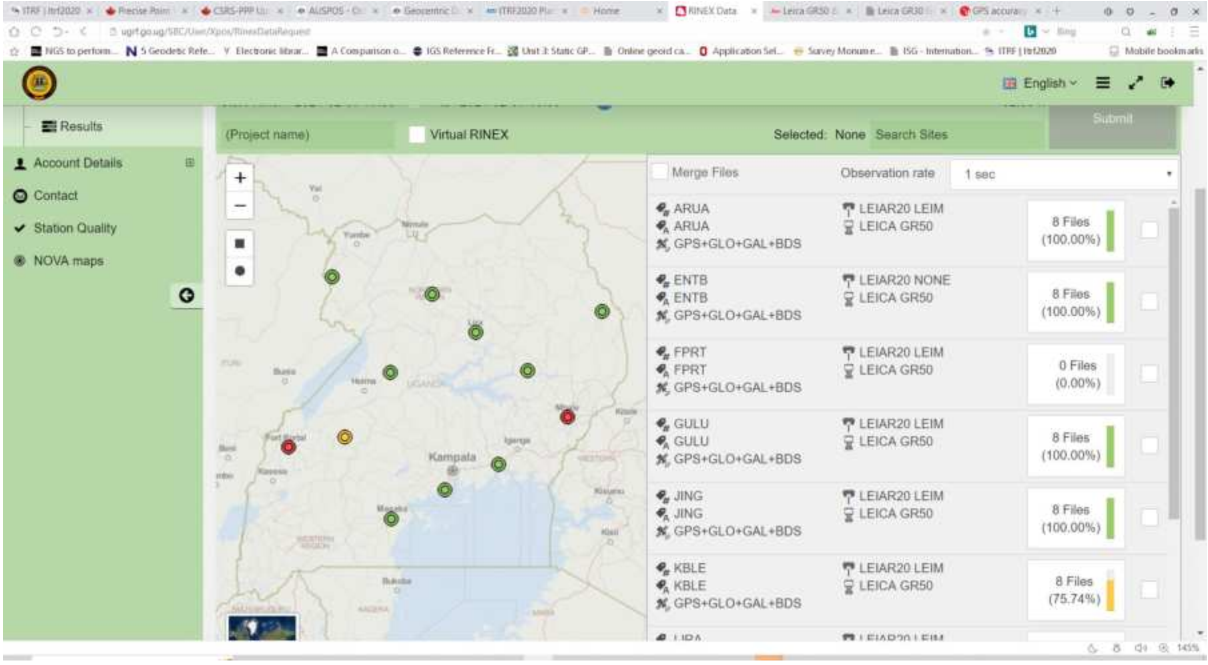


*Figure 1 Screen shot of the UGRF Spider Business Centre Interface used to download the data.*

The online tools that were used are briefly described below:

Trimble Center Point RTX service uses Trimble's global network of reference stations to compute precise satellite orbits and clocks (Trimble, 2024) . This service is dual-frequency GNSS measurement processing service for static sessions with limitations of 1 hour up to 24 hours. It's reported that it can achieve an accuracy ranging from 2 to 6cm for horizontal and vertical coordinate values respectively. This Trimble service is discriminative in that it does not allow any antennas that not in its database (Nardo, et al., 2015).

Automatic Precise Positioning Service (APPS) accepts GPS measurement files and uses the most advanced positioning technology from the re-known NASA Jet Propulsion Laboratory (JPL). This APPS service can perform PPP of any GPS receivers whether they are in motion, static or even in air. APPS uses real-time, daily and weekly precise GPS orbit and clock products (JPL, 2024).

The Australian Positioning Service (AUSPOS) is an online GPS Processing Service currently using version AUSPOS 2.4. AUSPOS uses the International GNSS Service (IGS) products that is the ultra-rapid, rapid and final orbits contingent on their readiness during the time of processing (Geoscience, 2024). This service only admits to process dual frequency GPS phase data. The results or report as they call it is segmented into five sections that include; User Data, Processing Summary, Computed Coordinates, Ambiguity Resolution, and Computation Standards.

The modernized Canadian Spatial Reference System Precise Point Positioning (CSRS-PPP) service provided freely by the Canadian Geodetic Survey of Natural Resources Canada. The modernization of CSRS-PPP as of Janu, 2018 involved mainly the inclusion of PPP with Ambiguity Resolution (PPP-AR). The other development was that all output solutions are based on International GNSS Service 2020 (IGS20) reference frame which is the actual realization of ITRF2020 (Canada, 2024). It's also worth to note the CSRS-PPP outputs, which include; solution report, summary file, position file, tropospheric zenith delay, Rinex_Clock format file, comma-separated format text file, JSON format residual file and an error file.

The GNSS observation files were selected in such a manner that only precise products are used during the processing with the online tool. Take not that these online tools have varying requirements in their processing strategy as shown in the Table 2. In all the processing the default settings were used without any alternations.

*Table 2 Summary of key online tools processing strategies*

| **Strategy** | **APPS** | **CSRS-PPP** | **Trimble Center Point RTX** | **AUSPOS** |
|---|---|---|---|---|
| Processing Mode | Static, kinematic | Static, kinematic | Static | Static |
| Frequency | Dual frequency | Singal, Dual frequency | Dual frequency | Dual frequency |
| Software | GIPSY-OASIS v5 | CSRS-PPP SPARK 3.54.2 | 8.5.1.20196 | AUSPOS 2.4 |
| Constellation | GPS | GPS + GLONASS | GPS + GLONASS + Galileo | GPS |
| Coordinate Frame | ITRF2014 | IGS20/ITRF2020 | ITRF2005 & ITRF2014 | ITRF2014 |
| Ambiguity Resolution (AR) | Yes | Yes | No | Yes |
| Tropospheric delay model | GMF: troposphere mapping function | Dry delay: Davis<br>Wet delay: Hopf<br>MF: GMF | NA | GMF mapped with the DRY-GMF. |
| Orbits source | JPL final | IGS and NRCan | Trimble | IGS |

**Results and discussion**

The results were produced and presented in tabular form for clear and elaborate presentation. The geodetic coordinates of the stations were computed from four online processing tools that is Trimble CenterPoint RTX, APPS, CSRS-PPP and AUSPOS. Among these tools AUSPOS and Trimble CenterPoint RTX provide their results in ITRF2014 while APPS and CSRS-PPP have results in ITRF2020. The results are tabulated in Table 3 to Table 6.

*Table 3 Trimble CenterPoint RTX (ITRF2014 @ Epoch 2023.92)*

| DAY | SRTI | | ARUA | | MSND | | MSKA | | JING | | ENTB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 338 | 1.769442333 | | 3.021410861 | | 1.714693639 | | -0.387689583 | | 0.433217889 | | 0.149832917 |
| | 33.65013231 | | 30.99910711 | | 31.72683183 | | 31.74236644 | | 33.33902942 | | 32.56014908 |
| | 1111.323 | | 1208.912 | | 1142.816 | | 1197.513 | | 1134.501 | | 1164.853 |
| | | | | | | | | | | | |
| 316 | 1.769442694 | | 3.021458250 | | 1.714693889 | | -0.387689389 | | 0.433218028 | | 0.149832917 |
| | 33.65006958 | | 30.99916983 | | 31.72683183 | | 31.7423665 | | 33.33902906 | | 32.56014919 |
| | 1111.341 | | 1208.890 | | 1142.823 | | 1197.525 | | 1134.510 | | 1164.850 |
| | | | | | | | | | | | |
| 315 | 1.769442667 | | 3.021458528 | | 1.714693833 | | -0.387689167 | | 0.433218 | | 0.149833250 |
| | 33.65013164 | | 30.99917003 | | 31.72683156 | | 31.74236622 | | 33.33902881 | | 32.56014900 |
| | 1111.340 | | 1208.889 | | 1142.819 | | 1197.53 | | 1134.510 | | 1164.851 |
| | | | | | | | | | | | |
| 314 | 1.769442833 | | 3.021458722 | | 1.714694222 | | -0.387689222 | | 0.433218056 | | 0.149832944 |
| | 33.65013203 | | 30.99916942 | | 31.72683117 | | 31.74236578 | | 33.33902925 | | 32.56014853 |
| | 1111.346 | | 1208.897 | | 1142.817 | | 1197.527 | | 1134.513 | | 1164.817 |
| | | | | | | | | | | | |
| 313 | 1.769442694 | | 3.021458472 | | 1.714693972 | | -0.387689389 | | 0.433217778 | | 0.149833083 |
| | 33.65013219 | | 30.99916944 | | 31.72683161 | | 31.74236617 | | 33.33902906 | | 32.56014900 |
| | 1111.340 | | 1208.896 | | 1142.820 | | 1197.528 | | 1134.516 | | 1164.846 |
| | | | | | | | | | | | |
| 312 | 1.769442361 | | 3.021458333 | | 1.714693667 | | -0.387689444 | | 0.43321775 | | 0.149833028 |
| | 33.65013228 | | 30.99917006 | | 31.72683156 | | 31.74236667 | | 33.3390295 | | 32.56014931 |
| | 1111.349 | | 1208.897 | | 1142.823 | | 1197.523 | | 1134.519 | | 1164.873 |
| | | | | | | | | | | | |
| 311 | 1.769442639 | | 3.021458278 | | 1.714693611 | | -0.387689417 | | 0.433217972 | | 0.149833028 |
| | 33.65013200 | | 30.99917006 | | 31.72683178 | | 31.74236619 | | 33.33902886 | | 32.56014931 |
| | 1111.338 | | 1208.909 | | 1142.831 | | 1197.530 | | 1134.515 | | 1164.874 |
| | | | | | | | | | | | |
| 310 | 1.769442472 | | 3.021458194 | | 1.714693556 | | -0.387689667 | | 0.433217861 | | 0.149832750 |
| | 33.65013211 | | 30.99916961 | | 31.72683139 | | 31.74236597 | | 33.33902878 | | 32.56014889 |
| | 1111.329 | | 1208.892 | | 1142.820 | | 1197.525 | | 1134.508 | | 1164.840 |

*Table 4 APPS Solution ITRF2020 epoch 2023.9*

| DAY | SRTI | | ARUA | | MSND | | MSKA | | JING | | ENTB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 338 | 1.721944393 | | 3.017145991 | | 1.686469526 | | -0.338768843 | | 0.418321905 | | 0.059983404 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 33.62001324 | 30.90991696 | 31.71768319 | 31.71923665 | 33.21390293 | 32.47601495 |
| | 1111.7337 | 1209.2888 | 1143.2244 | 1197.9281 | 1134.9095 | 1165.2604 |
| | | | | | | |
| 316 | 1.721944368 | 3.017145977 | 1.686469493 | -0.338768865 | 0.418321877 | 0.059983406 |
| | 33.62001322 | 30.90991692 | 31.71768317 | 31.71923664 | 33.21390292 | 32.47601494 |
| | 1111.7440 | 1209.3082 | 1143.2327 | 1197.9323 | 1134.9035 | 1165.2652 |
| | | | | | | |
| 315 | 1.721944378 | 3.017145968 | 1.686469509 | -0.338768835 | 0.418321893 | 0.059983401 |
| | 33.62001324 | 30.90991695 | 31.71768319 | 31.71923666 | 33.21390291 | 32.47601495 |
| | 1111.7358 | 1209.2964 | 1143.2125 | 1197.9394 | 1134.9159 | 1165.2547 |
| | | | | | | |
| 314 | 1.721944371 | 3.017145969 | 1.686469500 | -0.338768857 | 0.418321874 | 0.059983375 |
| | 33.62001323 | 30.90991695 | 31.71768315 | 31.71923664 | 33.21390293 | 32.47601494 |
| | 1111.7433 | 1209.3004 | 1143.2265 | 1197.9367 | 1134.9123 | 1165.2154 |
| | | | | | | |
| 313 | 1.72194439 | 3.017145969 | 1.68646951 | -0.338768838 | 0.418321898 | 0.059983411 |
| | 33.62001324 | 30.90991695 | 31.71768317 | 31.71923665 | 33.21390293 | 32.47601495 |
| | 1111.7365 | 1209.2904 | 1143.2197 | 1197.9312 | 1134.9159 | 1165.2471 |
| | | | | | | |
| 312 | 1.721944385 | 3.017145981 | 1.686469499 | -0.338768845 | 0.418321903 | 0.059983428 |
| | 33.62001325 | 30.90991694 | 31.71768318 | 31.71923666 | 33.21390294 | 32.47601496 |
| | 1111.7543 | 1209.3009 | 1143.2134 | 1197.9266 | 1134.9239 | 1165.2680 |
| | | | | | | |
| 311 | 1.721944432 | 3.017146006 | 1.686469528 | -0.338768822 | 0.418321918 | 0.059983432 |
| | 33.62001322 | 30.90991696 | 31.71768315 | 31.71923664 | 33.21390291 | 32.47601494 |
| | 1111.7412 | 1209.3059 | 1143.2153 | 1197.9283 | 1134.9179 | 1165.2631 |
| | | | | | | |
| 310 | 1.721944421 | 3.017146001 | 1.686469537 | -0.338768822 | 0.41832193 | 0.059983417 |
| | 33.62001322 | 30.90991696 | 31.71768318 | 31.71923665 | 33.21390293 | 32.47601494 |
| | 1111.7361 | 1209.2928 | 1143.2150 | 1197.9326 | 1134.9173 | 1165.2398 |

*Table 5 AUSPOS V2.4 ITRF2014 solutions*

| DAY | SRTI | ARUA | MSND | MSKA | JING | ENTB |
|---|---|---|---|---|---|---|
| 338 | 1.769443444 | 3.171459167 | 1.715903611 | -0.387688528 | 0.433218639 | 0.149833611 |
| | 33.65013247 | 30.99916958 | 31.72683186 | 31.74236669 | 33.33902947 | 32.56014936 |
| | 1113.456 | 1209.012 | 1142.947 | 1197.640 | 1134.633 | 1166.980 |
| | | | | | | |
| 316 | 1.7694435 | 3.021458944 | 1.714694583 | -0.38768842 | 0.433218889 | 0.149833917 |
| | 33.65013253 | 30.99916981 | 31.7268315 | 31.74236664 | 33.33902939 | 32.56014897 |
| | 1113.471 | 1209.002 | 1142.941 | 1197.647 | 1134.638 | 1166.978 |
| | | | | | | |
| 315 | 1.7694435 | 3.021459333 | 1.714694667 | -0.38768836 | 0.433218972 | 0.149833889 |
| | 33.65013253 | 30.99916992 | 31.72683222 | 31.74236669 | 33.33902941 | 32.56014925 |
| | 1113.471 | 1209.019 | 1142.961 | 1197.664 | 1134.665 | 1166.976 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 314 | 1.769443556 | 3.021459167 | 1.714694750 | -0.38768839 | 0.433219089 | 0.149833611 |
| | 33.65013211 | 30.99916917 | 31.72683122 | 31.74236628 | 33.33902894 | 32.56014969 |
| | 1113.477 | 1209.024 | 1142.954 | 1197.660 | 1134.642 | 1166.946 |
| | | | | | | |
| 313 | 1.769443528 | 3.021459306 | 1.714694806 | -0.38768853 | 0.433218889 | 0.149833889 |
| | 33.65013233 | 30.99916958 | 31.72683161 | 31.74236653 | 33.33902925 | 32.56014958 |
| | 1113.467 | 1209.01 | 1142.945 | 1197.650 | 1134.640 | 1166.961 |
| | | | | | | |
| 312 | 1.769443444 | 3.021459417 | 1.714694694 | -0.38768844 | 0.433218972 | 0.149833972 |
| | 33.65013236 | 30.99916972 | 31.72683169 | 31.74236639 | 33.33902931 | 32.56014925 |
| | 1113.479 | 1209.022 | 1142.951 | 1197.652 | 1134.655 | 1166.988 |
| | | | | | | |
| 311 | 1.769443556 | 3.021459361 | 1.714694750 | -0.38768836 | 0.433218833 | 0.149833639 |
| | 33.65013261 | 30.99916964 | 31.72683183 | 31.74236675 | 33.33902925 | 32.56014964 |
| | 1113.473 | 1209.024 | 1142.927 | 1197.655 | 1134.633 | 1166.985 |
| | | | | | | |
| 310 | 1.769443694 | 3.021459111 | 1.714694806 | -0.38768847 | 0.433218778 | 0.149833833 |
| | 33.65013211 | 30.99916922 | 31.72683153 | 31.74236625 | 33.33902906 | 32.56014911 |
| | 1113.460 | 1209.008 | 1142.94 | 1197.652 | 1134.632 | 1166.956 |

*Table 6 CSRS-PPP 3.54.2 - ITRF20 (2023.9) solutions*

| DAY | SRTI | ARUA | MSND | MSKA | JING | ENTB |
|---|---|---|---|---|---|---|
| 338 | 1.769443028 | 3.021459056 | 1.714694333 | -0.38768881 | 0.433218556 | 0.149833611 |
| | 33.76679914 | 30.99916967 | 31.72683183 | 31.74236681 | 33.33902942 | 32.56014950 |
| | 1111.338 | 1208.903 | 1142.832 | 1197.529 | 1134.518 | 1164.872 |
| | | | | | | |
| 316 | 1.769443139 | 3.021458861 | 1.714694278 | -0.38768881 | 0.433218500 | 0.149833556 |
| | 33.76679900 | 30.99916958 | 31.7268315 | 31.74236658 | 33.33902933 | 32.56014922 |
| | 1111.336 | 1208.887 | 1142.831 | 1197.528 | 1134.517 | 1164.854 |
| | | | | | | |
| 315 | 1.769443111 | 3.021459111 | 1.714694333 | -0.38768867 | 0.433218583 | 0.149833694 |
| | 33.76679897 | 30.99916956 | 31.72683175 | 31.74236664 | 33.33902922 | 32.56014942 |
| | 1111.341 | 1208.902 | 1142.826 | 1197.533 | 1134.516 | 1164.854 |
| | | | | | | |
| 314 | 1.769443222 | 3.021458944 | 1.714694417 | -0.38768872 | 0.433218444 | 0.149833472 |
| | 33.76679911 | 30.99916961 | 31.72683172 | 31.74236664 | 33.33902942 | 32.56014961 |
| | 1111.350 | 1208.898 | 1142.829 | 1197.536 | 1134.521 | 1164.831 |
| | | | | | | |
| 313 | 1.769443278 | 3.02145906 | 1.714691669 | -0.38768864 | 0.433218361 | 0.149833778 |
| | 33.76679903 | 30.99916950 | 31.72683169 | 31.74236667 | 33.33902933 | 32.56014942 |
| | 1111.344 | 1208.896 | 1142.828 | 1197.531 | 1134.520 | 1164.853 |
| | | | | | | |
| 312 | 1.769443167 | 3.02145922 | 1.714691669 | -0.38768864 | 0.433218528 | 0.149833833 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 33.76679889 | | 30.9991695 | | 31.72683169 | | 31.74236672 | | 33.33902939 | | 32.56014942 |
| | 1111.353 | | 1208.896 | | 1142.825 | | 1197.525 | | 1134.525 | | 1164.871 |
| | | | | | | | | | | | |
| 311 | 1.769443417 | | 3.02145900 | | 1.714694250 | | -0.38768869 | | 0.433218639 | | 0.149833750 |
| | 33.75013217 | | 30.99916939 | | 31.72683156 | | 31.74236644 | | 33.33902939 | | 32.56014922 |
| | 1111.345 | | 1208.907 | | 1142.830 | | 1197.536 | | 1134.518 | | 1164.877 |
| | | | | | | | | | | | |
| 310 | 1.769443333 | | 3.021459083 | | 1.714694389 | | -0.38768878 | | 0.433218722 | | 0.149833611 |
| | 33.75013231 | | 30.99916956 | | 31.72683178 | | 31.74236658 | | 33.33902911 | | 32.56014925 |
| | 1111.334 | | 1208.895 | | 1142.822 | | 1197.532 | | 1134.513 | | 1164.843 |

From the above results the variations in the geodetic coordinates for the processed coordinates shows that there are huge differences most especially between UGRF and ITRF2020 as was expected. On the latitude and longitude, the differences are in the ranges of degrees to minutes while in the ellipsoidal heights the difference is in metres. This is really proof that the techniques used in the computation of ITRF are much better that those of ITRF2005 which the UGRN was based on.

Whereas with ITRF2014 the differences in the coordinate latitude and longitude are minimal as in that the differences are in minutes to seconds. For the ellipsoidal heights the difference between the heights was in millimeters. This shows that ITRF2005 and ITRF2014 were fairly close to each other. However, we have pointed out that the results that were produced from APPS shown a bigger difference as compared to those from the other tools yet all of them used the final satellites with the only difference in the combinations.

**Conclusion**

The paper assessed the performance of UGRF station geodetic coordinates using the four free online tools that's is APPS, CSRS-PPP, AUSPOS and CenterPoint RTX. Six stations were randomly picked and data for eight days processed. Seven consecutive days that is 310 to 316 then a distant day of 338.

The mean difference in the geodetic latitudes and longitudes is approximately 2 minutes in both while in the ellipsoidal heights it was 3.5m between UGRN and ITRF2020. While the difference in ITRF2014 and UGRN it was approximately in the regions of 3 minutes in the geodetic latitudes and longitudes, the for the ellipsoidal height difference was at 1cm.

With this it is imperative that UGRN geodetic reference of Uganda be enhanced to the ITRF2020 so that the reference frame is modernized just like what Canada and of course the National Spatial Reference System (NSRS) of National Geodetic Survey (NGS). UGRN should be consistent, accurate and up-to-date with the current developments with international standards.

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