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Your World, Our World: Resilient Environment and Sustainable Resource Management for All

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

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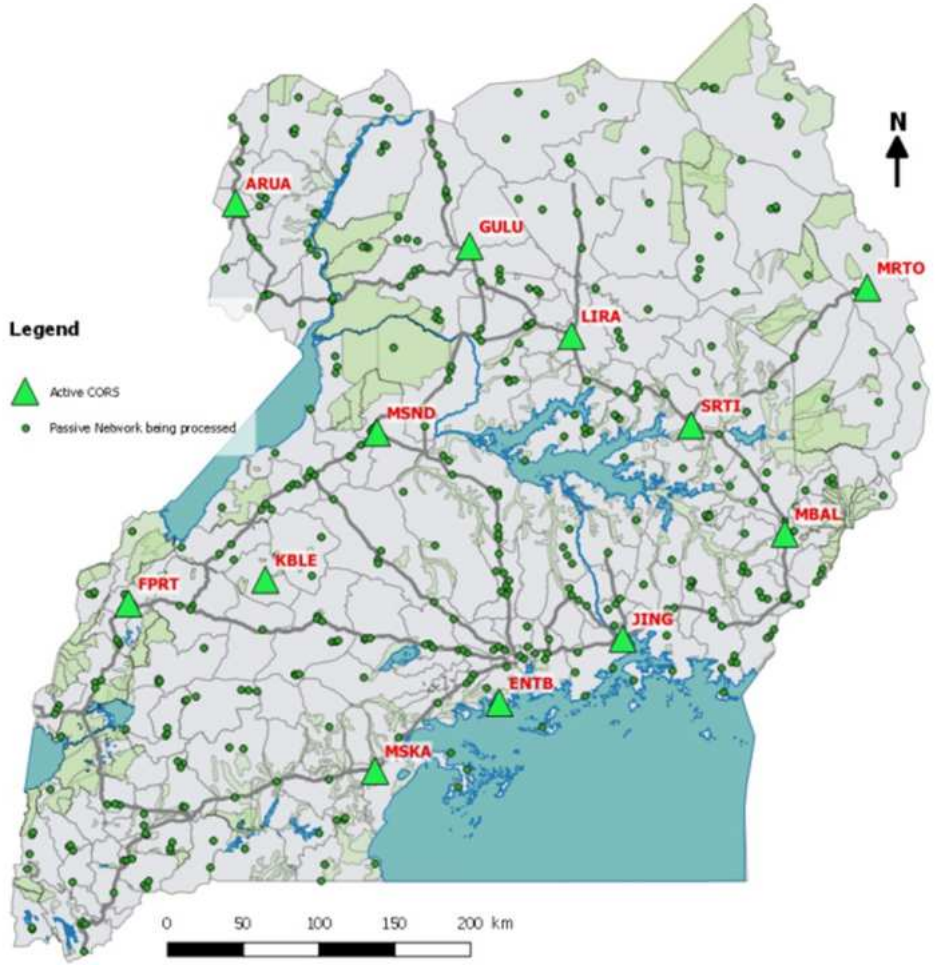
Presentation List

- Introduction
- Materials And Methods
- Results and discussion
- Conclusion

Introduction(1)

- **Reference Systems – in Uganda**
- Horizontal
  - 3 systems
    - Arc60
    - **UGRN (ITRF05 epoch 2010.0)**
    - CORS (ITRF14 epoch 2019.2) - UGRF
- Vertical
  - New Khartoum
  - Uganda geoid model (2024) - EIGEN6C-4



Introduction(2)

- Type of UGRF CORS
  - Receivers - Leica GR50
  - Antennas - AR20

SRTI, FPRT

ENTB, GULU, **MRTO**

ARUA, JING, **KBLE**, LIRA, MBAL, MSND, MSKA

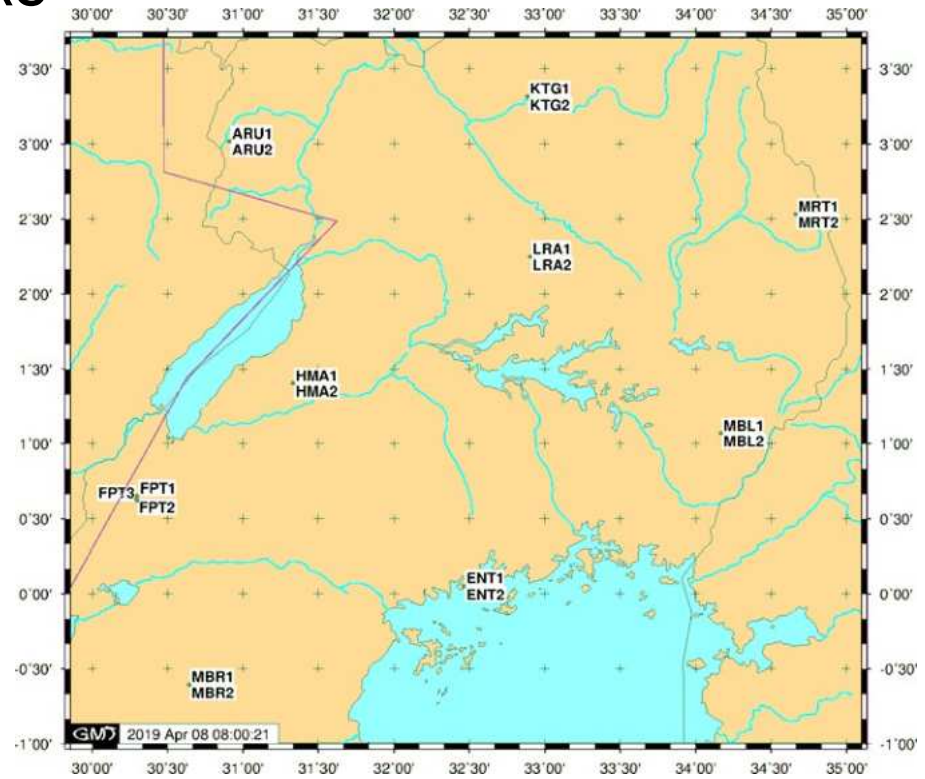
Introduction(3) – Published Coordinates for the UGRF CORS

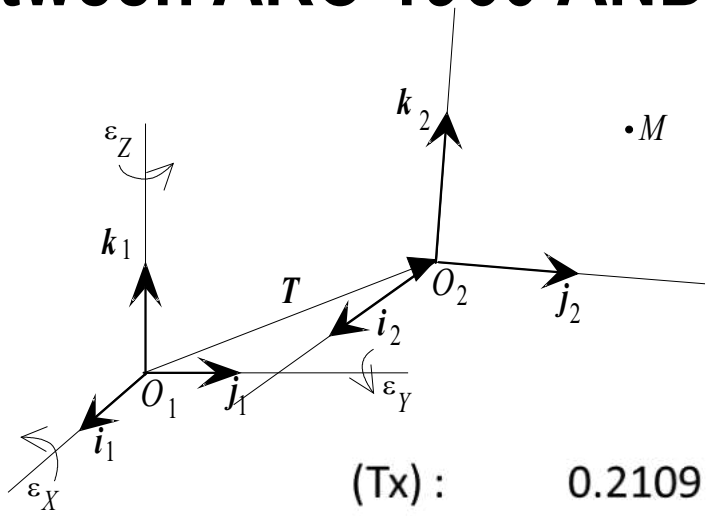
Table 1: Geographic coordinates of 12 GNSS CORS Sites at ITRF2005 epoch 2010.00 (IGNFI, 2019)

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

Introduction(4) - transformation parameters Between ARC 1960 AND UGRN

- UGRN <-> CORS





(Tx) : 0.2109
(Ty) : -0.3339
(Tz) : 0.0337
(Rx) : - 000 00 00.009765
(Ry) : 000 00 00.002056
(Rz) : 000 00 00.005439
(s) : -0.004369 *1E-6

Materials And Methods(1)

- Rinex 3.02 files from 6 CORS stations was collected from the UGRF website http://ugrf.go.ug/SBC/User/Xpos/RinexDataRequest
  - For seven consecutive days 310, 311, 312, 313, 314, 315, 316, and then 338
- The online GNSS processing tools
  - Trimble Center Point RTX,
  - Automatic Precise Positioning Service (APPS)
  - The Australian Positioning Service (AUSPOS)
  - The modernized Canadian Spatial Reference System Precise Point Positioning (CSRS-PPP)

Materials And Methods(2)

- Some important details of the online 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 Wet delay: Hopf MF: GMF	NA	GMF mapped with the DRY-GMF.
Orbits source	JPL final	IGS and NRCan	Trimble	IGS

Results and discussion(1)

- 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; APPS, AUSPOS and Trimble CenterPoint RTX provide their results in ITRF2014
    - While CSRS-PPP gives results in ITRF2020

Results and discussion(2)

Latitude						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Trimble	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
CSRS PPP	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
AUSPOS	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
APPS	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
Average	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
STD (m)	0.0053	0.0049	0.0079	0.0056	0.0054	0.0048

Height						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Trimble	1111.3383	1208.8978	1142.8211	1197.5251	1134.5115	1164.8505
CSRS PPP	1111.3426	1208.8980	1142.8279	1197.5313	1134.5185	1164.8569
AUSPOS	1113.4693	1209.0151	1142.9458	1197.6525	1134.6423	1166.9713
APPS	1111.7406	1209.2980	1143.2199	1197.9319	1134.9145	1165.2517
Average	1111.9727	1209.0272	1142.9537	1197.6602	1134.6467	1165.4826
STD (m)	1.2291	0.0677	0.0701	0.0718	0.0736	1.2226

Longitude						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Trimble	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
CSRS PPP	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
AUSPOS	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
APPS	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
Average	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
STD (m)	0.0018	0.0015	0.0006	0.0023	0.0014	0.0021

- For each station, the STD between methodologies/software is very good (few mm),
  - Confirming that any methodology/software can be used to process those type of data.
  - Only the Trimble rtx has a difference of 7mm on the lat component for each station

Results and discussion(2)

- In order to compare the obtained results to official coordinates (UGRN),
  - We applied the ITRF14 velocity model and transformation parameters to bring coordinates to ITRF05@2010.0
    - Using
      - http://ahgeodev.fr/tfo_plates_i14_sdk.htm

ITRF20 @2023,9						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Lat	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
Lon	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
He	1111.3404	1208.8979	1142.8245	1197.5282	1134.5150	1164.8537

ITRF05@2010,0						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Lat	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
Lon	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
He	1111.3489	1208.9063	1142.8330		1134.5236	

UGRN						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Lat	1.7219	3.0171	1.6865	-0.3388	0.4183	0.0600
Lon	33.6200	30.9099	31.7177	31.7192	33.2139	32.4760
He						

DIFFERENCE between UGRN and ITRF + velocity						
	SRTI	ARUA	MSND	MSKA	JING	ENTB
Lat (m)	-0.004	0.014	0.012	0.011	0.000	0.009
Lon (m)	0.074	0.078	0.068	0.052	0.056	0.059

Conclusion(1)

- The quality of the stations (stability) and the data from those CORS stations are of high standards
- For land survey and majority of surveys, using any online processing tools and PPP is possible as long as a correct velocity model is used to bring results from ITRF20@2024 to ITRF05@2010.0
  - (The difference is more than 60 cm if velocity model is not applied).

Conclusion(2)

- For precise geodetic work, if the results must be produced in UGRN (legal reference system of Uganda),
  - The use of CORS station or ground control point is a must as a bias of up to 7 to 8 cm in Longitude could appear if using PPP methods and velocity models.

Conclusion(3)

- This difference can be due either to
  - A bias in the UGRN determination in 2010 or
  - To the fact that ITRF velocity model is not that accurate in East Africa.

Conclusion(4)

- In order to differentiate that, we propose to make a complete study of the velocity model by processing the now 6 years old time series that can be produced from the 12 existing CORS stations.
  - **The obtained velocity model will permit improving the ITRF14 velocity model in Uganda.**
- If a better velocity model is not enough to reduce the bias, it would then mean that producing a new reference system for Uganda should be considered
  - **And "pros and cons" of such a change balanced accurately.**

Thank you very much for your attention!

Are there any questions?

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