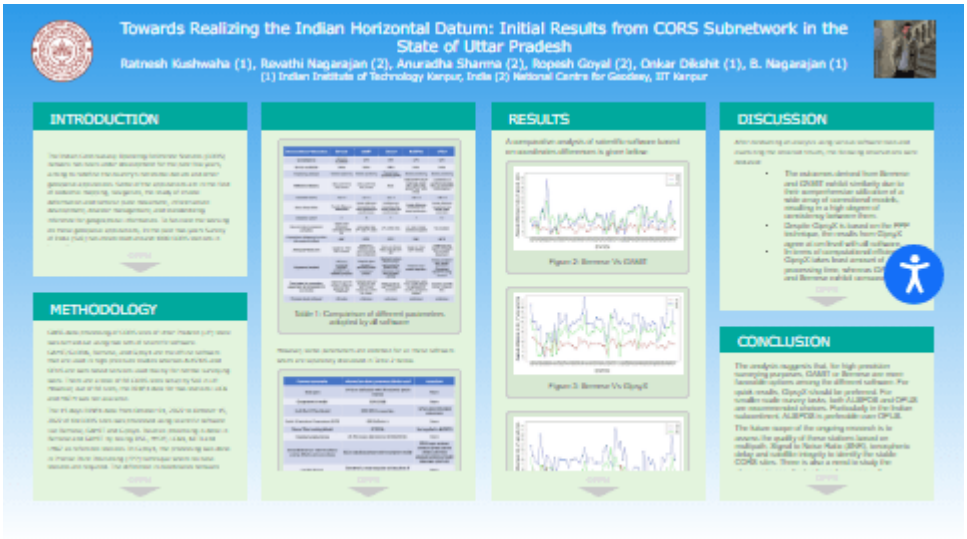
Towards Realizing the Indian Horizontal Datum: Initial Results from CORS Subnetwork in the State of Uttar Pradesh



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PRESENTED AT:

INTRODUCTION

The Indian Continuously Operating Reference Stations (CORS) network has been under development for the past few years, aiming to redefine the country's horizontal datum and other geospatial applications. Some of the applications are in the field of cadastral mapping, navigation, the study of crustal deformation and tectonic plate movement, infrastructure development, disaster management, and standardizing reference for geographical information. To facilitate the working on these geospatial applications, In the past two years Survey of India (SoI) has established around 1000 CORS stations in India. The pivotal stage in establishing a horizontal datum entails the processing and adjustment of accessible RINEX data derived from CORS sites.

As an initial case study, GNSS data from CORS sites in the state of Uttar Pradesh (UP) were processed in ITRF2014 at epoch 2022.76 using offline and web-based services. The results are compared to check the consistency of software. The study area and geographical locations of the CORS sites is shown in Figure 1.

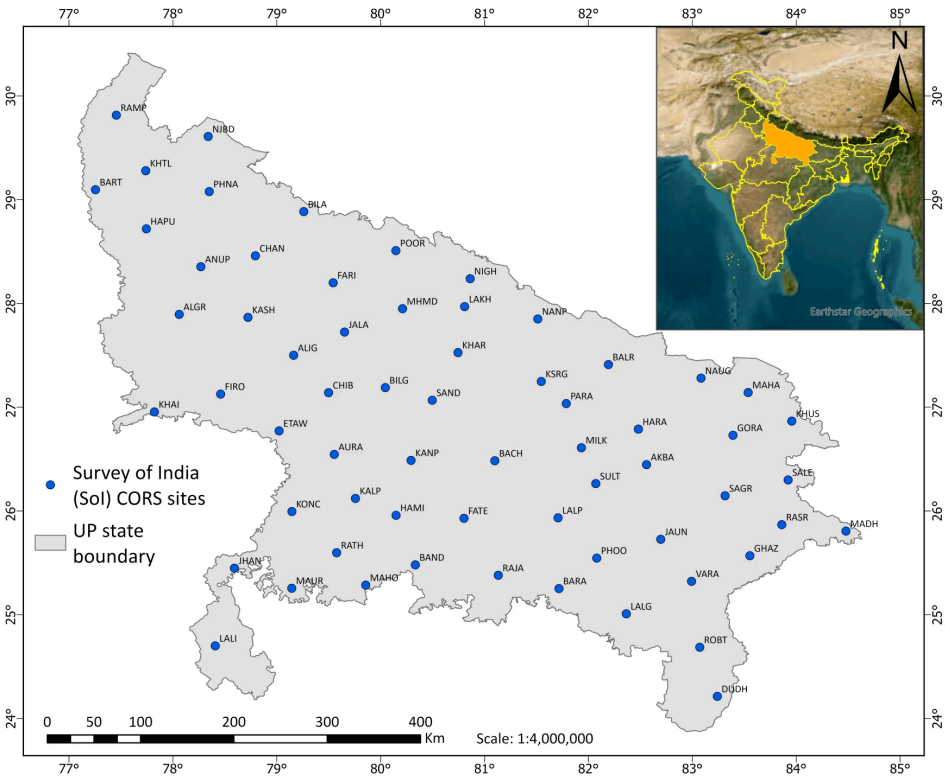

Figure 1: Study area

METHODOLOGY

GNSS data processing of CORS sites of Uttar Pradesh (UP) state was carried out using two sets of scientific software. GAMIT/GLOBK, Bernese, and GipsyX are the offline software that are used in high-precision studies whereas AUSPOS and OPUS are web-based services used mainly for normal surveying work. There are a total of 66 CORS sites setup by SoI in UP. However, out of 66 sites, the RINEX data for two stations LUCK and MATH was not available.

The 15 days RINEX data from October 01, 2022 to October 15, 2022 of 64 CORS sites was processed using scientific software like Bernese, GAMIT and GipsyX. Relative processing is done in Bernese and GAMIT by taking IISC, HYDE, LCK4, KIT3 and LHAZ as reference stations. In GipsyX, the processing was done in Precise Point Positioning (PPP) technique where no base stations are required. The difference in coordinates between these software was computed to check for the consistency.

AUSPOS and OPUS are the two most popular web-based GNSS data processing s. For checking the consistency of the software, 3 days of Rinex data of 64 stations from October 04, 2022, to October 06, 2022, has been processed. AUSPOS automatically chooses 10-13 nearby stable IGS stations for processing whereas OPUS chooses 3 nearby IGS/NGS CORS sites. AUSPOS is based on the Bernese 5.2 version. Hence, most of the models used by AUSPOS are similar to Bernese.

The comparison of parameters and models utilized by various software in data processing is illustrated in Table 1.

Characteristics/ Parameters	Bernese	GAMIT	GipsyX	AUSPOS	OPUS
Constellations	GPS and GLONASS	GPS	GPS	GPS	GPS
Service availability	Offline	Offline	Offline	Online	Online
Positioning method	Relative positioning	Relative positioning	Precise Point positioning (PPP)	Relative positioning	Relative positioning
Reference Stations	IISC LCK4 KIT3 POL2 BHR4	IISC LCK4 KIT3 POL2 BHR4	None	BADG BHR4 CHUM HYDE IISC JFNG KIT3 LCK3 LHAZ NOVM POL2 TASH URUM	Combination of CHUM POL2 SUMK IISC and some NGS CORS stations
Terrestrial frame	IGS 14	IGb 14	IGb 14	ITRF 14	ITRF 14
Basic observables	Double difference observables	Double difference Ionosphere-free carrier phases and pseudoranges	Undifferenced ionosphere-free carrier phase and pseudoranges	Double difference ionosphere free linear combination.	Double difference ionospheric free carrier phase observable
Elevation cutoff	5˚	10˚	7˚	7˚	10˚
Second order ionospheric correction	Higher order ionospheric corrections (HOI file)	IGS IONEX files (2^{nd} and 3^{rd} order)	JPL IONEX files	2^{nd} and 3^{rd} order corrections applied	Not available
Tropospheric Mapping Function (Atmospheric delay)	GMF	GPT2	GPT2	GMF	GPT2
Ambiguity Resolution	Quasi Ion- Free (QIF) strategy	Melbourne-Wübbena wide lane and narrow lane combination	Wide Lane Phase Bias products from JPL	Quasi Ion- Free (QIF) strategy	LAMBDA (Least squares Ambiguity De-correlation Adjustment)
Adjustment method	Mimimum constrained approach (GPSEST and ADDNEQ program)	Weighted least squares to generate loosely constrained solution.	Stochastic Kalman filter/smoother implemented as Square Root Information Filter with smoother (SRIFS)	Weighted least squares algorithm.	Minimal constraint least square adjustment Constrained adjustment using ADJUST.
Time taken for processing, adjustment & computation of coordinates	Depends upon the duration of data but generally time consuming	Depends upon the duration of data and Process Control File (.PCF) file chosen	Really quick but only PPP solution is possible	Processing is quick for a smaller dataset but generation of results is sometimes delayed	Quick for a smaller number of days of data
Precision level achieved	millimeters	millimeters	centimeters	centimeters	centimeters

Table 1: Comparison of different parameters adopted by all software

However, some parameters are common for all these software which are separately discussed in Table 2 below.

Common parameter	Information about parameter/Model used	Exceptions
Data span	24 hours daily data with 30 seconds epoch interval	None
Geopotential model	EGM 2008	None
Solid Earth Tide Model	IERS 2010 convention	OPUS uses IERS 2003 convention
Earth Orientation Parameters (EOP)	IERS Bulletin A	None
Ocean Tide Loading Model	FES2014	Not applied in AUSPOS
Planetary body forces	JPL Planetary Ephemeris DE405/DE421	None
Ground/Receiver antenna phase centre offsets and corrections	IGS14 absolute phase-centre variation model	OPUS uses receiver antenna phase centre offsets and NGS absolute antenna model data base (ANTCAI)
Inertial frames	Geocentric; mean equator and equinox of 2000 Jan 1.5 (J2000.0)	None

Table 2: Common parameters/models used by all software

RESULTS

A comparative analysis of scientific software based on coordinates differences is given below:

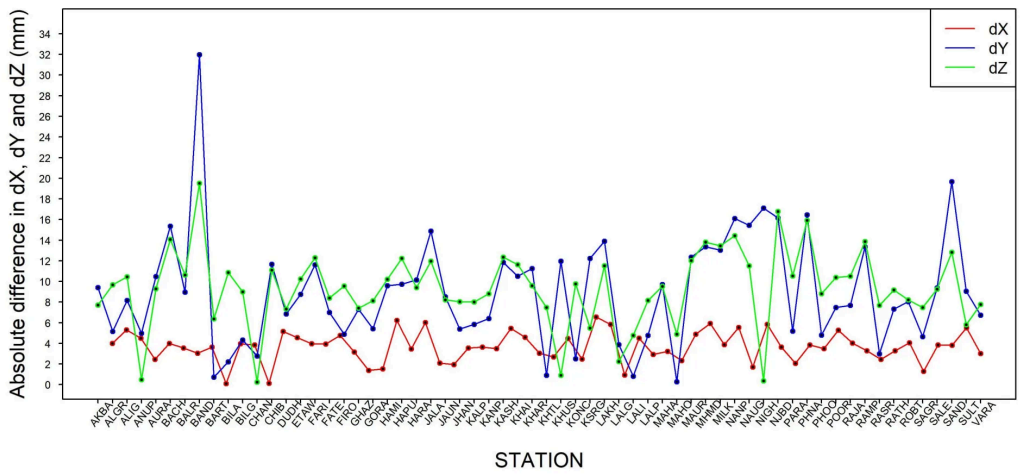

Figure 2: Bernese Vs GAMIT

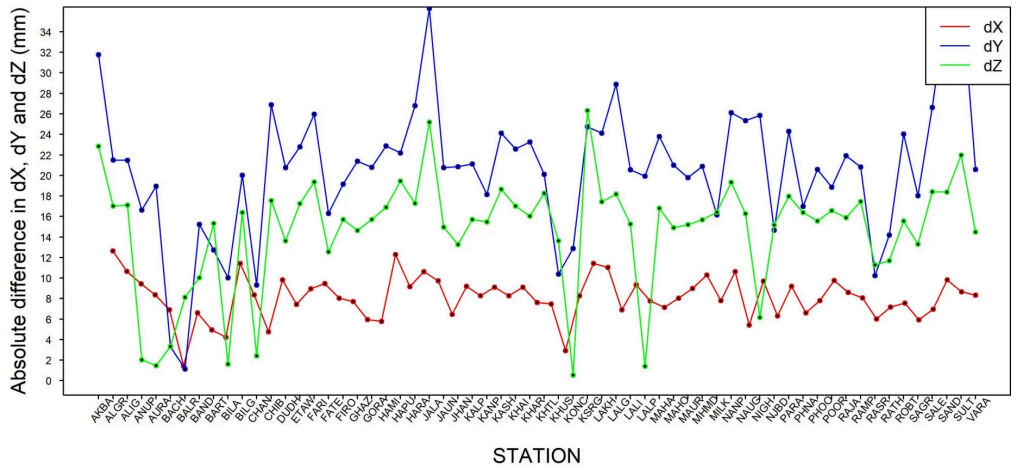

Figure 3: Bernese Vs GipsyX

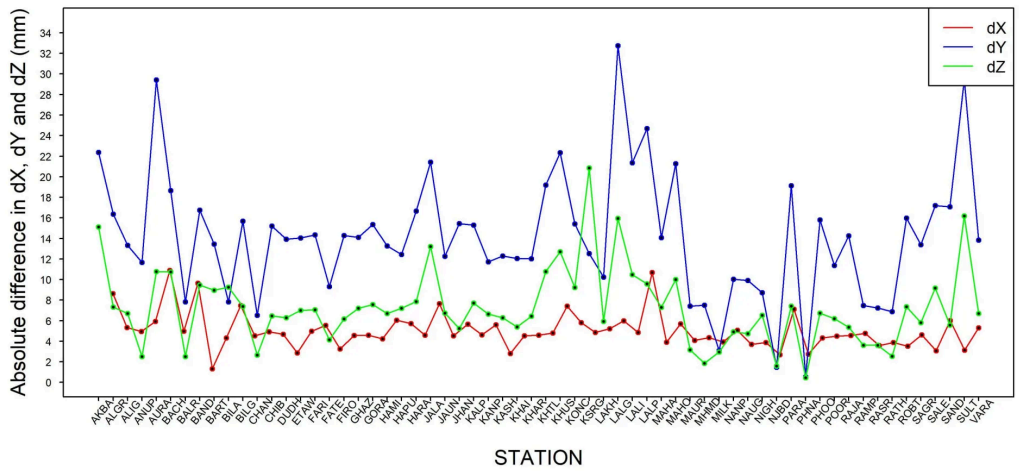

Figure 4: GAMIT Vs GipsyX

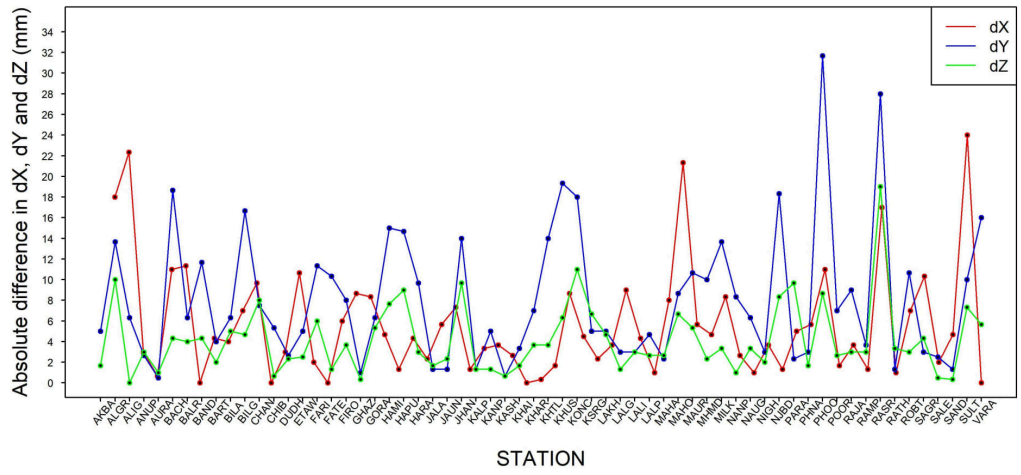

Figure 5: AUSPOS Vs OPUS

The discrepancies in coordinates between GAMIT and Bernese remained around 10 mm or less for all stations, except for BAND and SAND stations, where the dY values differed by 3.20 and 1.97 centimeters, respectively.

In contrast, the coordinates obtained from GipsyX exhibit cm-level variations compared to both Bernese and GAMIT for the majority of stations. Similarly, the results from OPUS demonstrate cm-level diffefrence when compared to AUSPOS.

DISCUSSION

After conducting an analysis using various software tools and examining the obtained results, the following observations were deduced:

- The outcomes derived from Bernese and GAMIT exhibit similarity due to their comprehensive utilization of a wide array of correctional models, resulting in a high degree of consistency between them.
- Despite GipsyX is based on the PPP technique, the results from GipsyX agree at cm level with all software.
- In terms of computational efficiency, GipsyX takes least amount of processing time, whereas GAMIT and Bernese exhibit comparatively slower processing speeds among other software options. However, the utilization of RNX2SNX as the PCF (Process Control File) in Bernese has the potential to expedite the processing duration.
- Within the spectrum of online software options, AUSPOS stands out for its higher accuracy, owing to its foundation in the Bernese system. However, AUSPOS's limitation lies in its inability to process more than 20 Rinex files concurrently. Nevertheless, this limitation can be overcome by splitting the dataset into sub-network having some overlapping sites. Subsequently, based on the stacking of normal equations, we get can one final coordinate for each sites.
- Since OPUS exclusively relies on three IGS/NGS CORS sites as reference stations, The results obtained from OPUS display slight variations compared to other software due to the selection of limited reference sites.

CONCLUSION

The analysis suggests that, for high-precision surveying purposes, GAMIT or Bernese are more favorable options among the different software. For quick results, GipsyX should be preferred. For smaller-scale survey tasks, both AUSPOS and OPUS are recommended choices. Particularly in the Indian subcontinent, AUSPOS is preferable over OPUS.

The future scope of the ongoing research is to assess the quality of these stations based on multipath, Signal to Noise Ratio (SNR), ionospheric delay and satellite integrity to identify the stable CORS sites. There is also a need to study the changes in coordinates based on seasonal variations. Ultimately, for defining a precise static horizontal datum, the stable CORS stations should be processed and adjusted with Bernese or GAMIT.

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DISCLOSURES

The authors declare that they have no conflict of interest.

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TRANSCRIPT

ABSTRACT

The Indian Continuously Operating Reference Stations (CORS) network has been under development for the past few years, aiming to redefine the country's horizontal datum and for other geospatial applications. As an initial case study, GNSS data from 66 CORS sites in the state of Uttar Pradesh (UP), the most populous north Indian state, were processed in ITRF2014 at epoch 2022.76 and the network was adjusted using GAMIT/GLOBK (v10.75) software. Coordinates computed from GAMIT/GLOBK processing were compared with those obtained from Bernese 5.2 and GipsyX 1.7 processing and also with online tools such as AUSPOS 2.4 and OPUS. Results reveal that the coordinates from Bernese and AUSPOS agreed within the mm level compared to the GAMIT/GLOBK results. In contrast, the GipsyX and OPUS results agreed at the cm level. The probable reason for this result from OPUS could be the default selection of only 3 IGS/NGS CORS stations as reference stations with non-uniform distribution around CORS sites. As an initial effort for ongoing research work, this presentation will discuss i) the methodology and parameters adopted for processing and adjusting data from 66 stations for the CORS network of UP, ii) a comprehensive comparison of results obtained from different online and offline GNSS data processing software, and iii) and planned strategy for redefining Indian horizontal datum.

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EVALUATIONS

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