# GNSS TEC Computation and Comparison using Multi-GNSS Constellations

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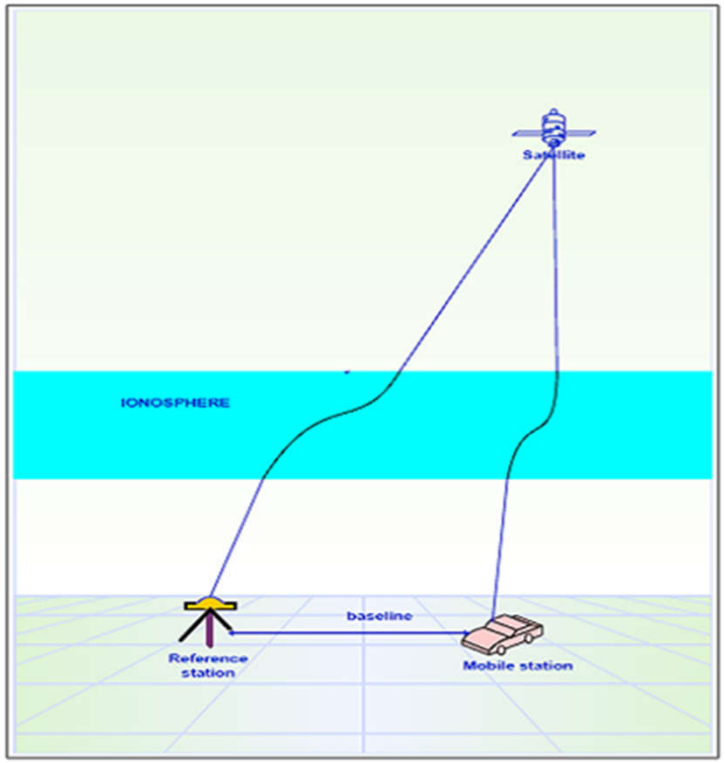
# Introduction

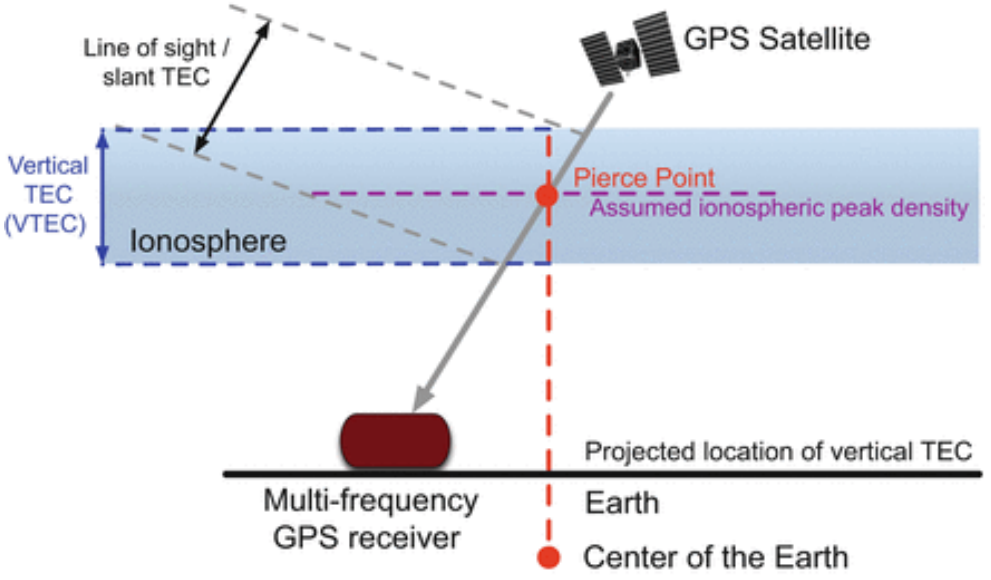
- Ionospheric scintillation is a challenging issue for the Global Navigation Satellite System (GNSS).
- Data collected by the globally distributed GNSS receivers provide abundant information about the ionosphere.
- TEC is one of the important parameters of the scintillation, which can be measured by the GNSS receivers.




GNSS Deviation caused by Ionosphere

# Background

- GNSS Reference receivers have a capacity to track signals from more than 100 satellites of multi-frequency and multi-constellations.
- TEC measurements can be used to study the various phenomenon like atmospheric scintillation, solar cycles, earthquakes, volcanoes, lightening etc.




Graphical representation of IPP

# Objective

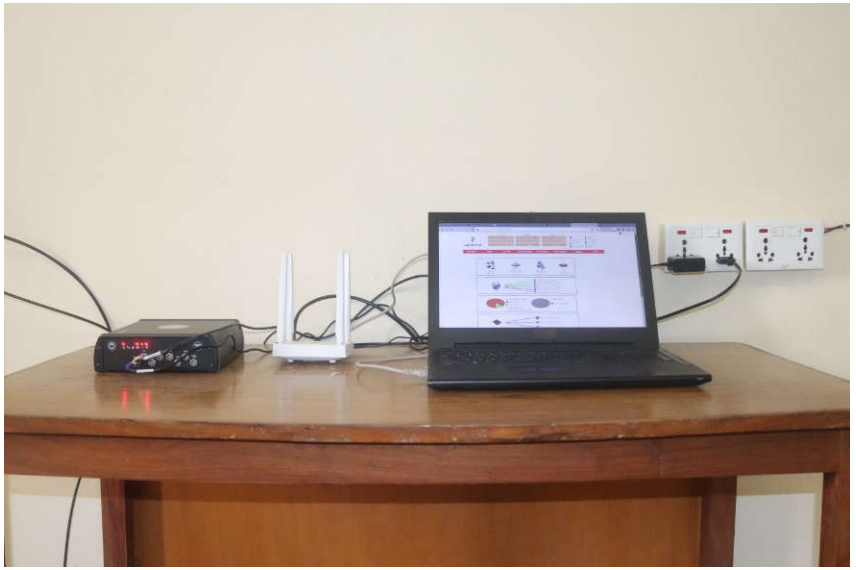
To estimate the slant Total Electron Content values of different GNSS constellations.

Compare the Total Electron Content values obtained from different GNSS constellation.

# Data Used

- Multi GNSS data for the period of July 5, 2022 to August 3, 2022 was used in this study.

GNSS antenna at Pashchimanchal Campus

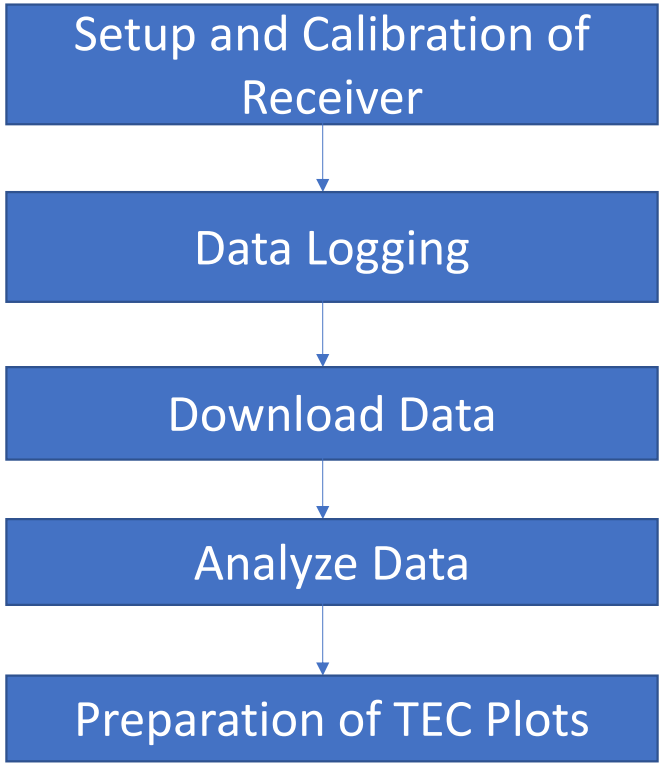


GNSS receiver and data processing setup

# Limitations

- In this study the raw TEC measurement by the GNSS receiver is used and the proprietary software provided by the receiver's organization is used.
- The inability to remove the bias affecting TEC is the limitation of this study.

# Methodology



# Methodology

- Used GOPI GPS software to obtain vTEC values

- Frequency combinations used:
  - GPS: L1-C/A, L2C
  - GlONASS: L1-C/A, L2-C/A
  - Galileo: L1BC, E5b
  - BeiDou: B1I,B2I
  - QZSS: L1-C/A, L2C

# Formula to calculate TEC

The computation of TEC is done by using this formula for pseudorange:

$$STEC = \frac{1}{40.3}\left({}^{1}/_{f_1^2} - {}^{1}/_{f_2^2}\right)(P_2 - P_1)$$

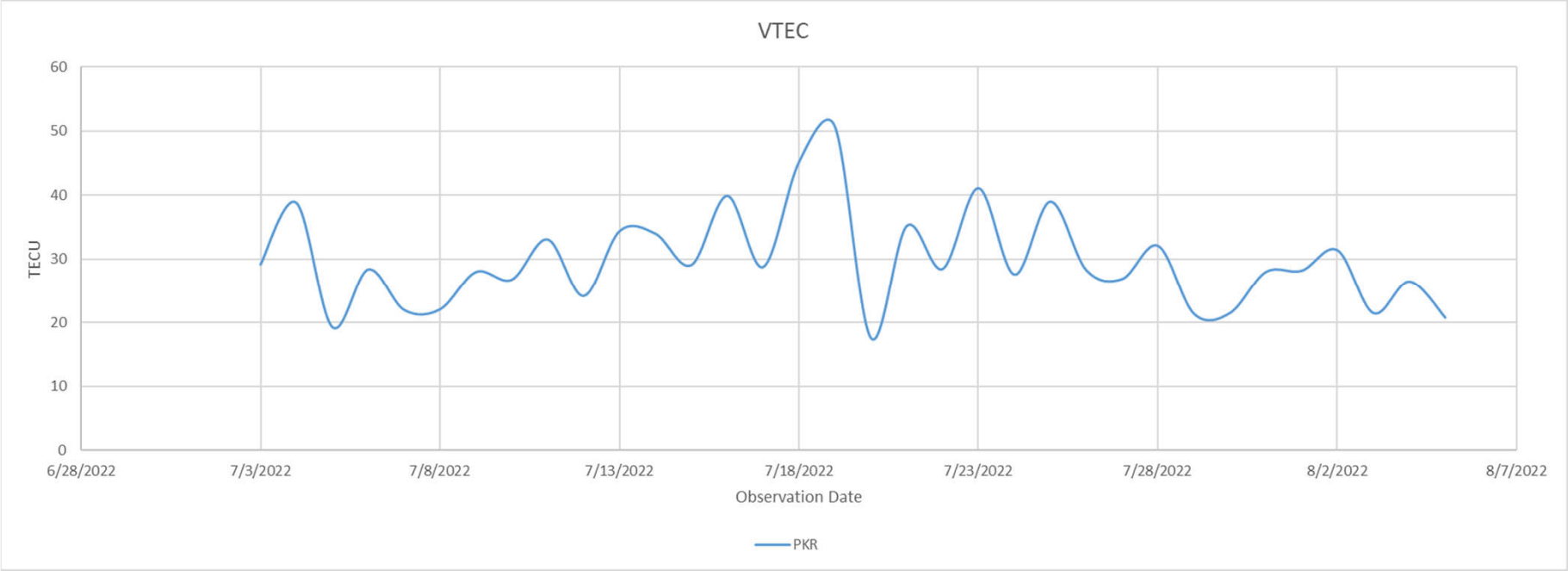
The computation of TEC is done by using this formula for carrier phase:

$$STEC = -\frac{1}{40.3}\left(\frac{1}{{f_1}^2} - \frac{1}{{f_2}^2}\right)(L_2 - L_1)$$

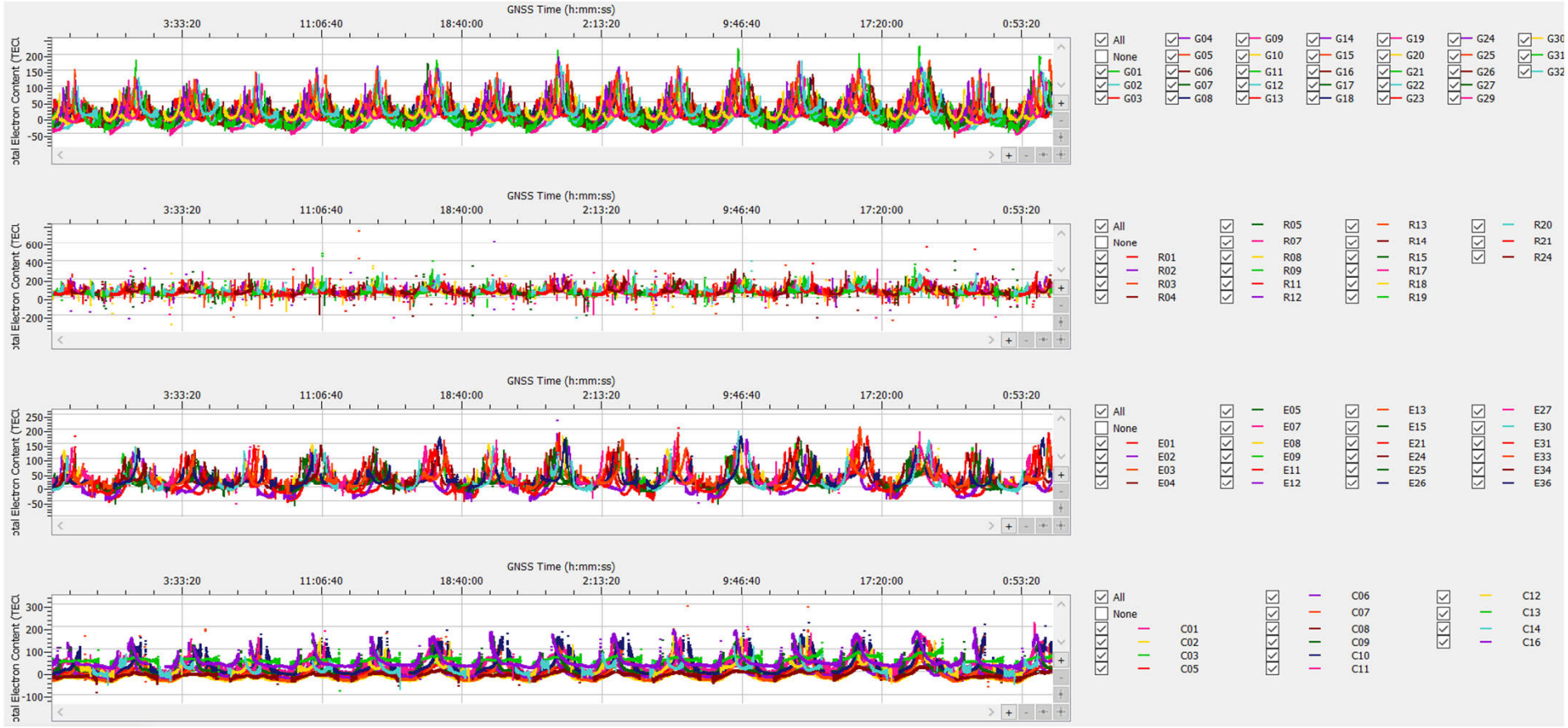
(Ansari, Corumluoglu, & Panda, 2017)

# Findings

# vTEC values of GPS only data using GOPI GPS



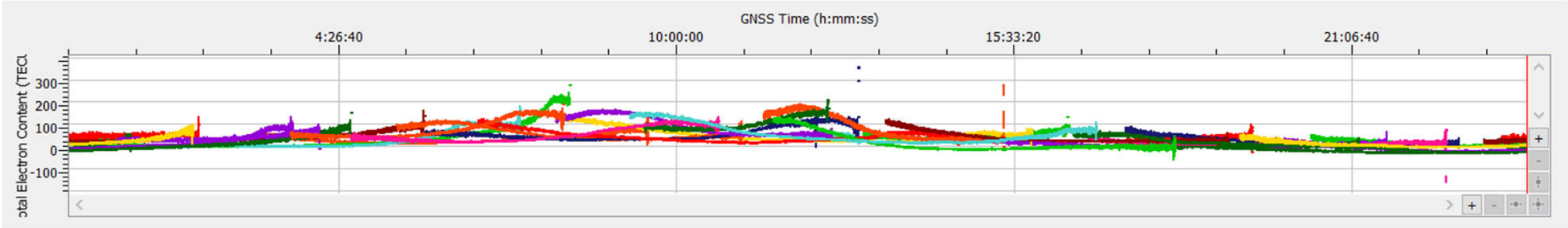
# TEC Plot of July 3- August 5, 2022



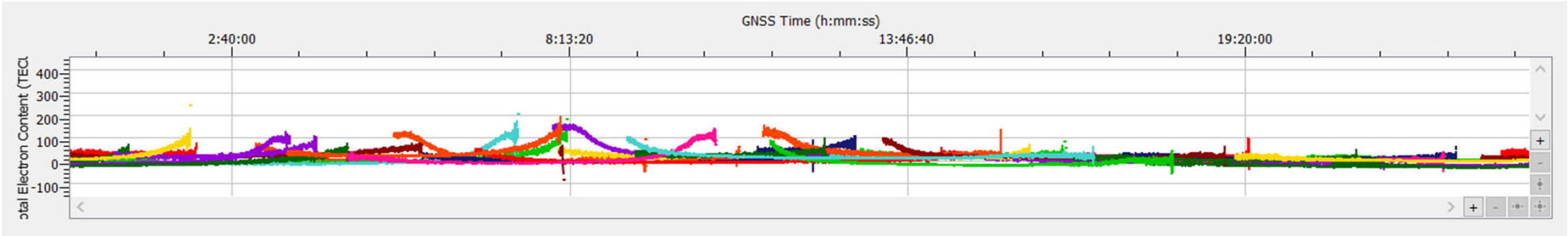
# Analysis of sTEC Values of MultiGNSS Constellation from 1s data

| S.N. | GNSS Constellation | No of Satellites Tracked | Minimum Value of TEC | | Maximum Value of TEC | |
|---|---|---|---|---|---|---|
| 1 | GPS | 32 | G13 | -63.98 | G11 | 220 |
| 2 | GLONAS | 24 | R03 | -263.165 | R13 | 725.857 |
| 3 | GALELIO | 36 | E05 | -68.97 | E02 | 225.712 |
| 4 | BEIDOU | 16 | C08 | -97.063 | C07 | 288.35 |

# sTEC GPS: L1-C/A, L2C




July 19,2022

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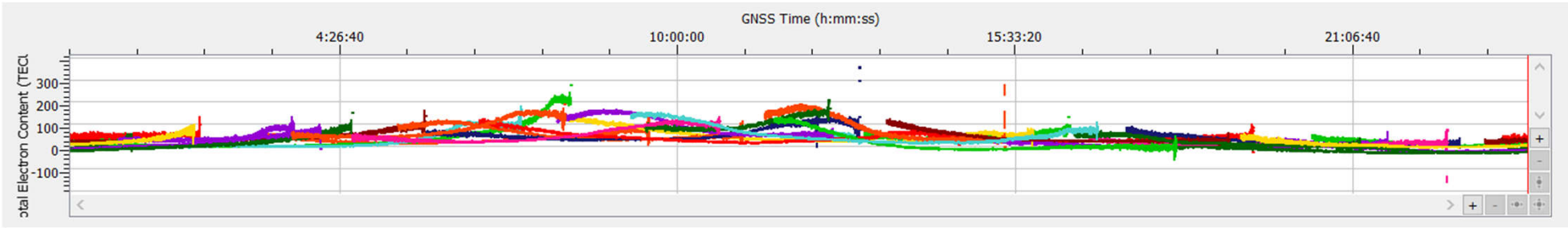
# sTEC GlONASS: L1-C/A, L2-C/A

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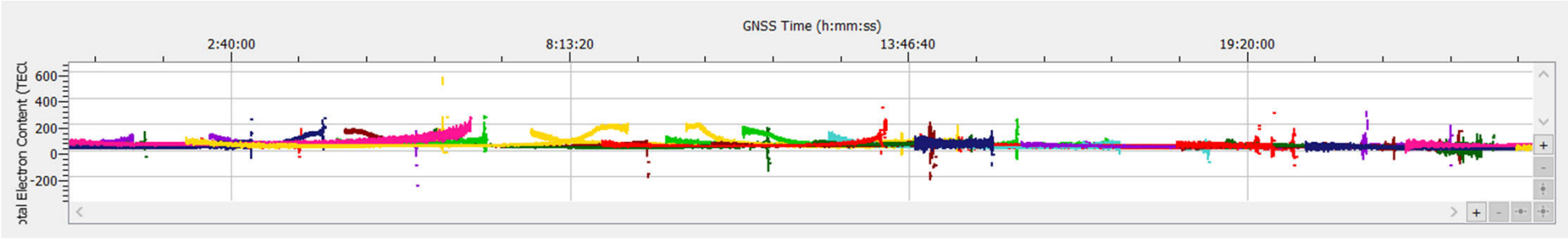


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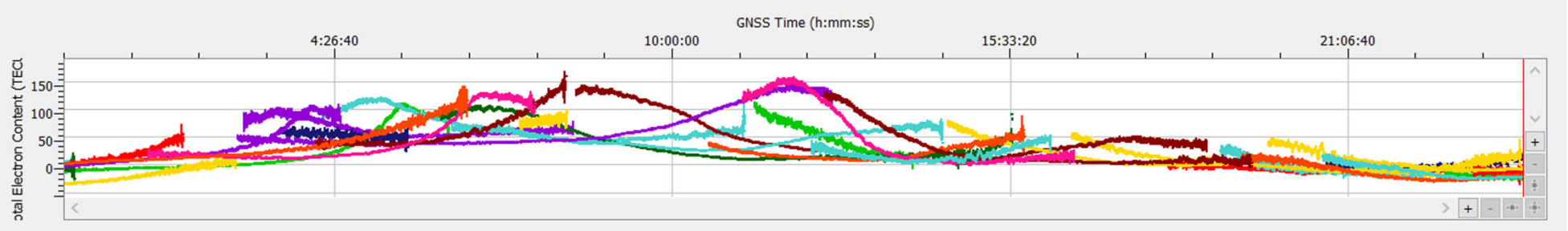
# sTEC  Galileo: L1BC, E5b

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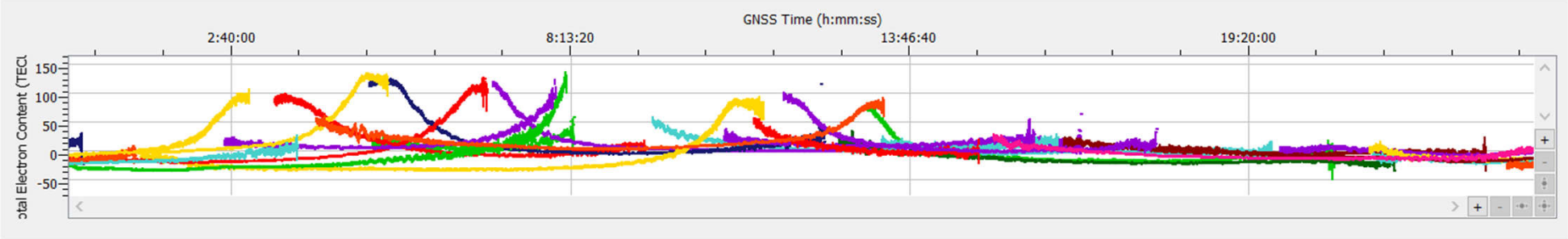


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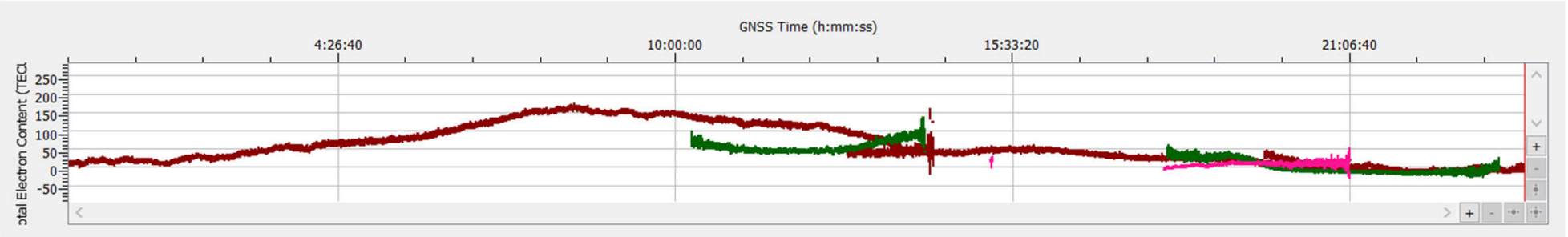
# sTEC BeiDou: B1I,B2I

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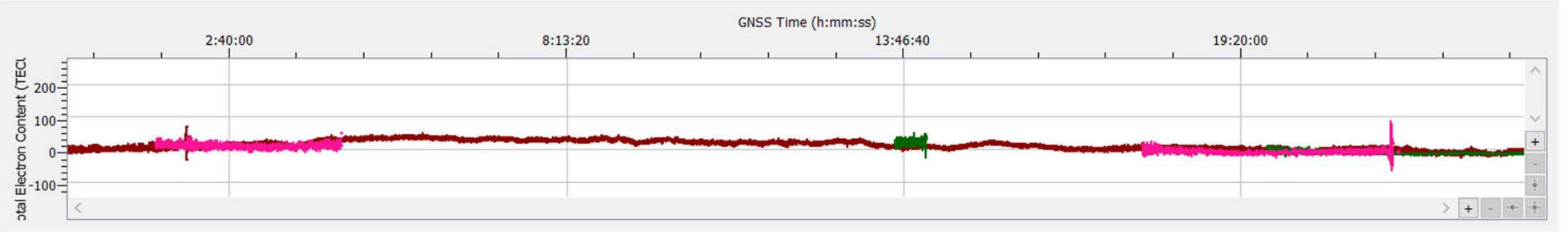


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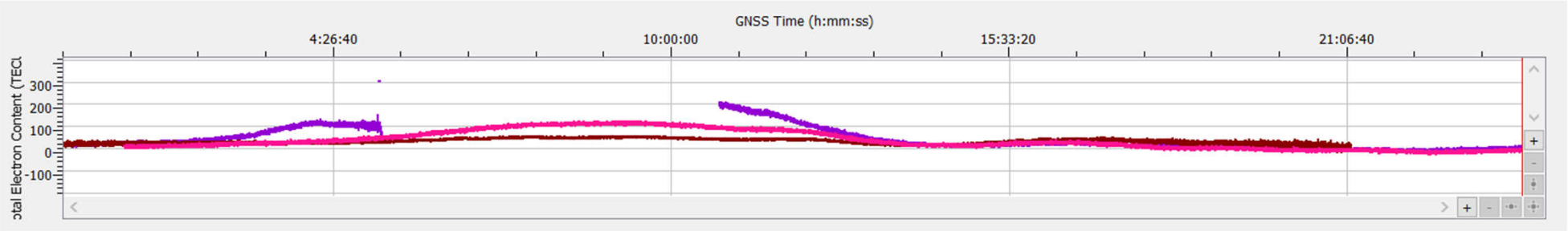
# sTEC QZSS: L1-C/A, L2C

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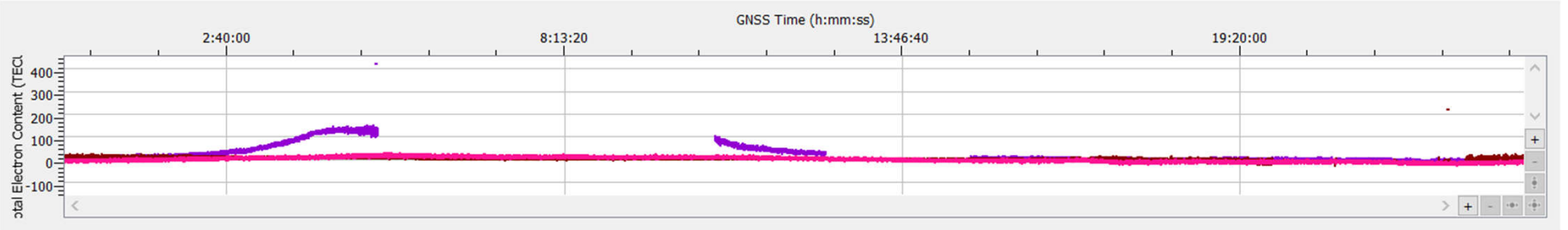


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# Conclusion

- Multi GNSS data observations can help us show nuances in the field of TEC analysis.
- Effective removal of biases will definitely help in the proper analysis of multi GNSS data.

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Thank You!