

Study of Ionosphere Total Electron Content for the Broadband Geodetic VLBI Fringe Model

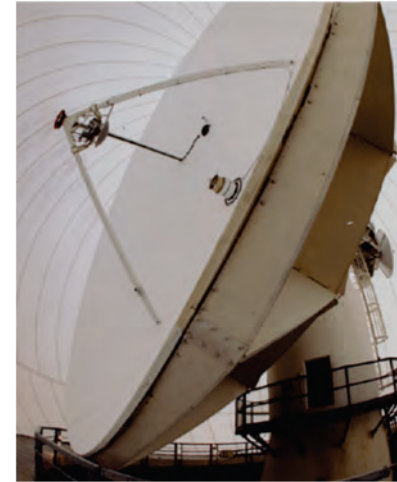
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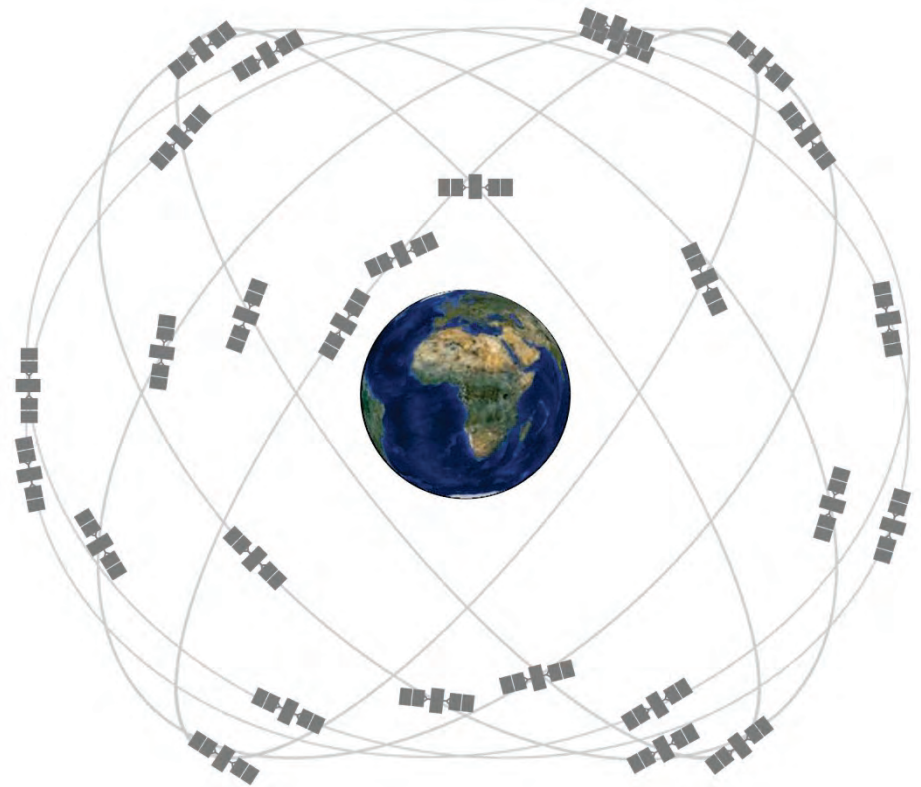
Outline

- Introductions
 - GPS, VLBI, TEC
- Calculating TEC
- Comparing Data
 - Procedure
 - My Program
- Conclusion
- Future Work



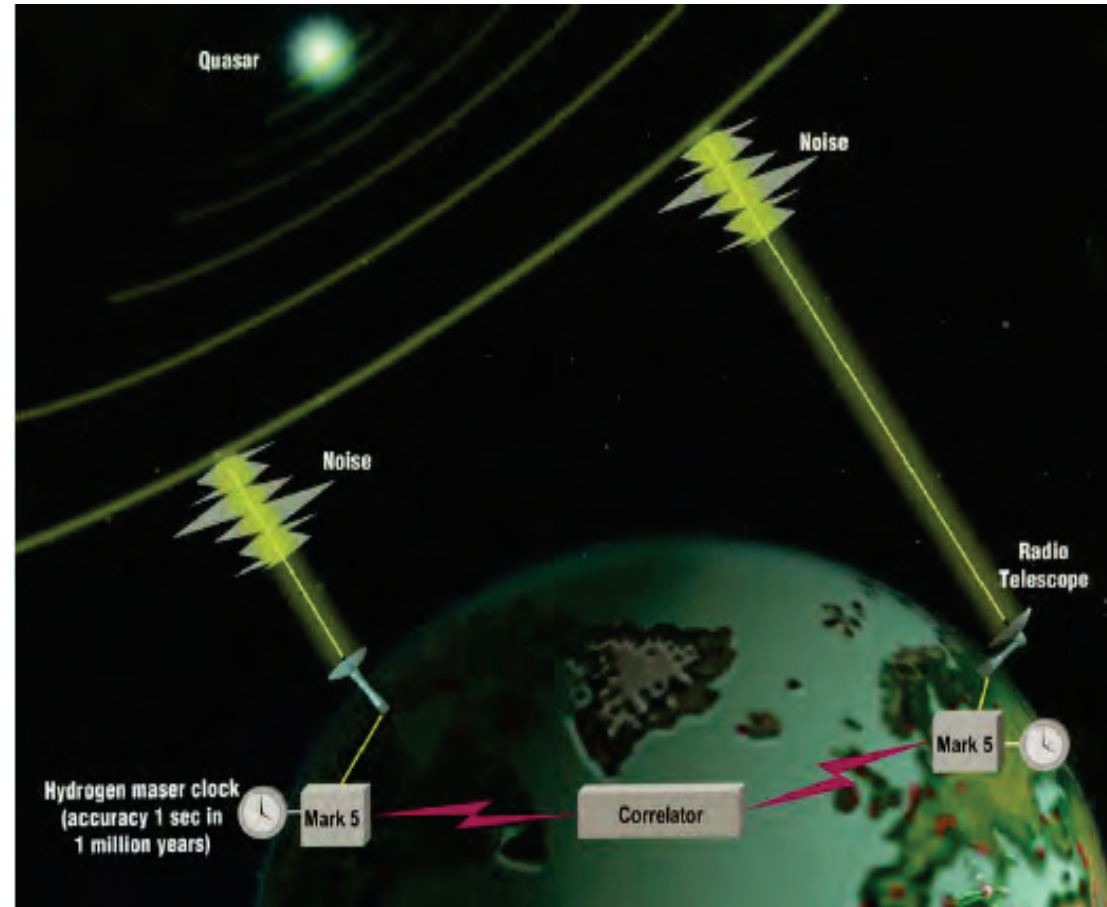
GPS

- Global Positioning System
- 32 Satellites
- Two Frequencies
 - 1.2276 GHz
 - 1.5754 GHz
- The two signals experience dispersive delay relative to each other when going through the ionosphere



VLBI

- Very Long Baseline Interferometry
- Signal from space is received by ground based radio telescopes.
- Measure delays between stations.
- 4 bands between 2GHz and 14GHz



What is TEC?

- Total Electron Content
- Total number of free electrons present along the path between two points.
 - 1 TEC unit(TECU) = 10^6 electrons/m²

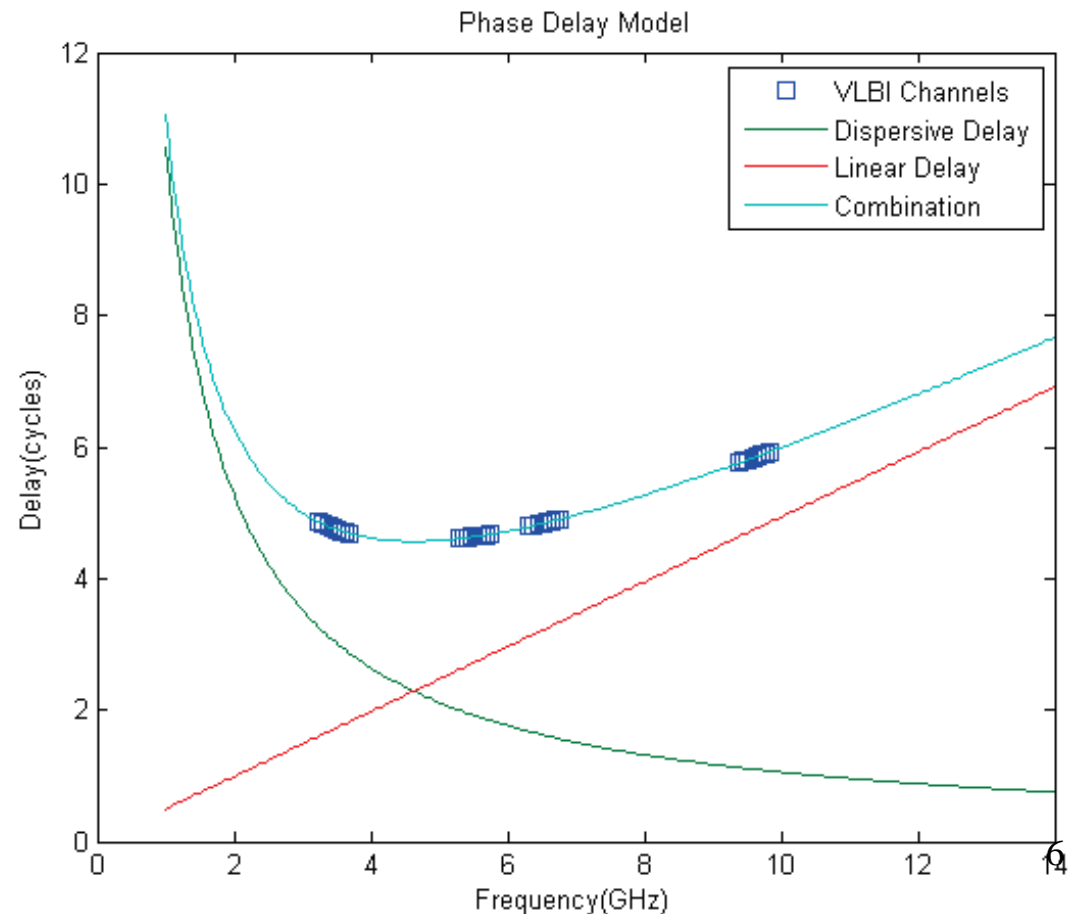
$$TEC = \int_0^R N_e dr$$

Calculating Differential TEC with VLBI

$$\varphi = \omega\tau - \frac{K}{\omega}$$

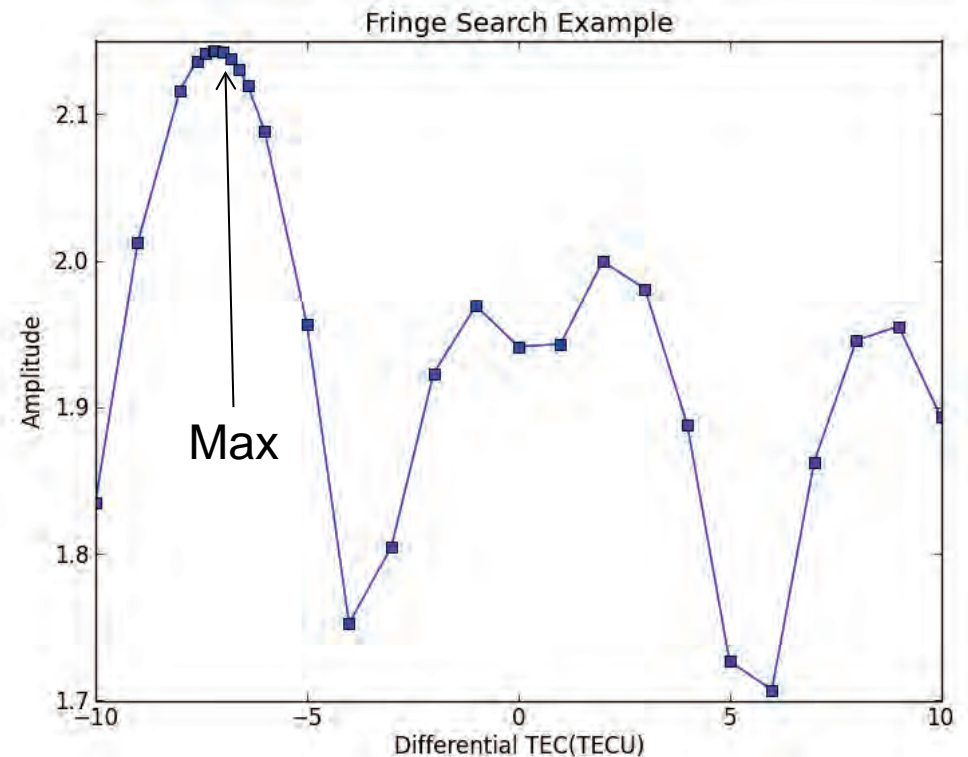
$$K \propto TEC$$

- Linear delay
 - Geometry
 - Neutral atmosphere
 - Electronics
- Dispersive delay
 - Ionosphere
 - Other



Calculating Differential TEC with VLBI

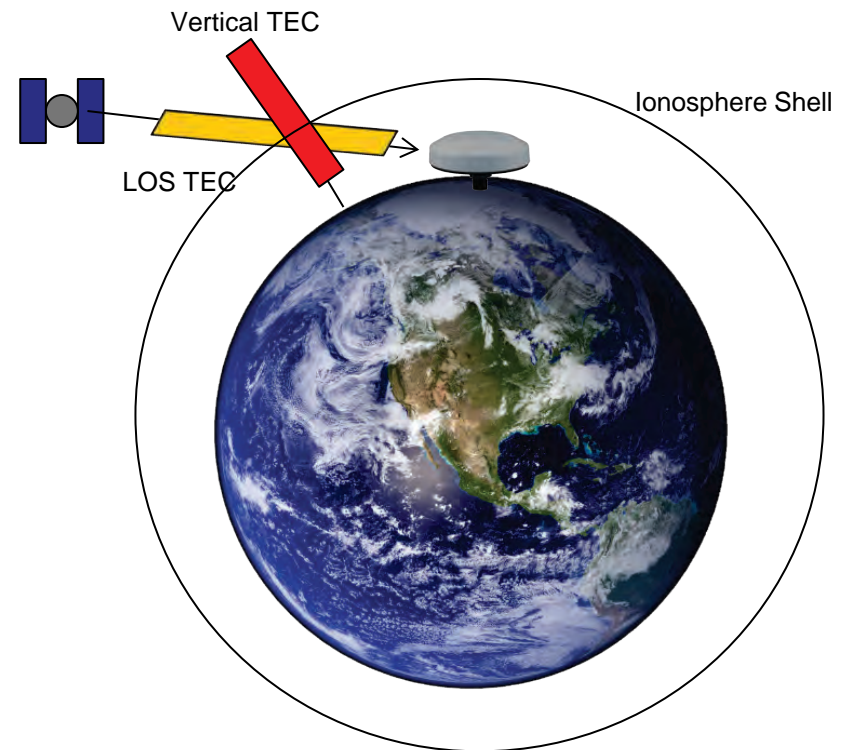
- Searches for the differential TEC value which maximizes the correlation amplitude
- Differential TEC between both VLBI stations



Calculating TEC with GPS

- Line Of Sight(LOS) TEC
 - From the receiver to the satellite.
- Ionosphere Shell Model
 - Ionosphere Pierce Point
- Divide by mapping function to convert LOS TEC to vertical TEC

$$Z = \frac{1}{\sqrt{1 - (0.95 \cos(\theta))^2}}$$



The Data to Compare

VLBI

- 2 Stations
 - Reference is Greenbelt
 - Remote is Westford

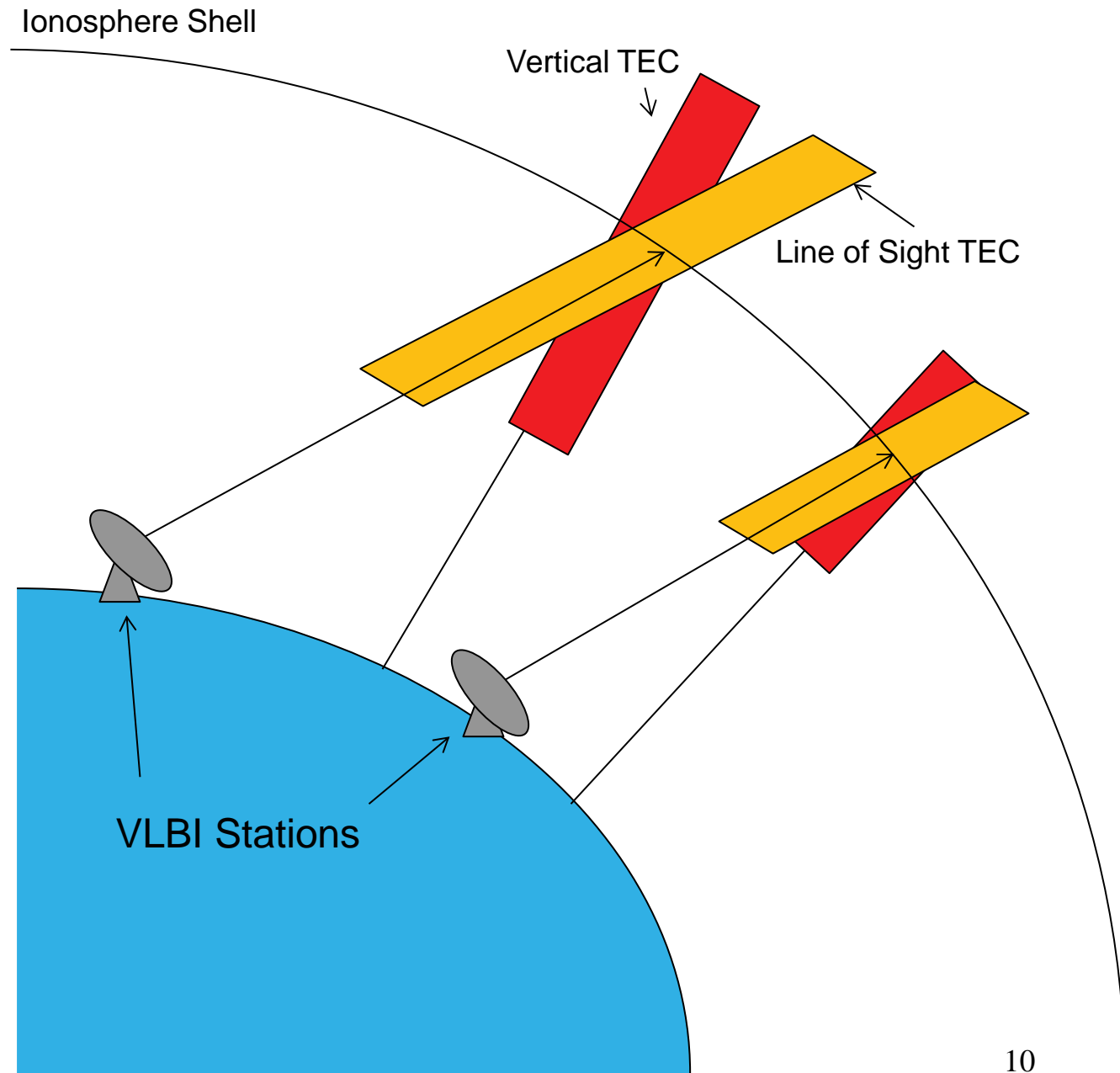
GPS

- Madrigal
- World Wide GPS Receiver Network
- Vertical TEC calculated from around the world
 - Densely sampled over North America.



Comparing

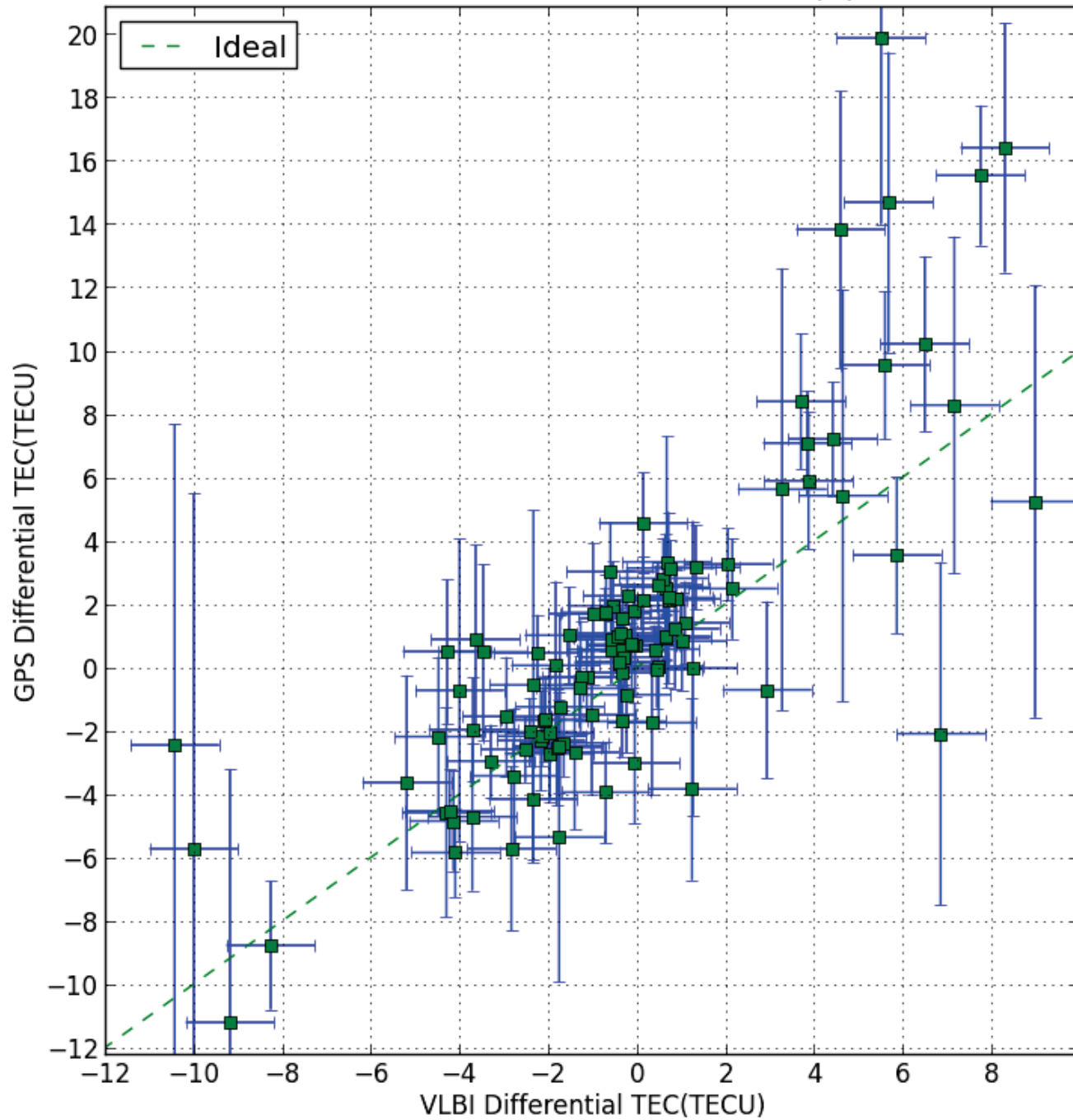
- Find the ionosphere pierce points for the VLBI scans.
- Obtain Vertical TEC for each pierce point from Madrigal
- Apply mapping function
- Determine differential TEC
- Compare this new differential TEC value with the differential TEC value obtained from the VLBI fringe search.



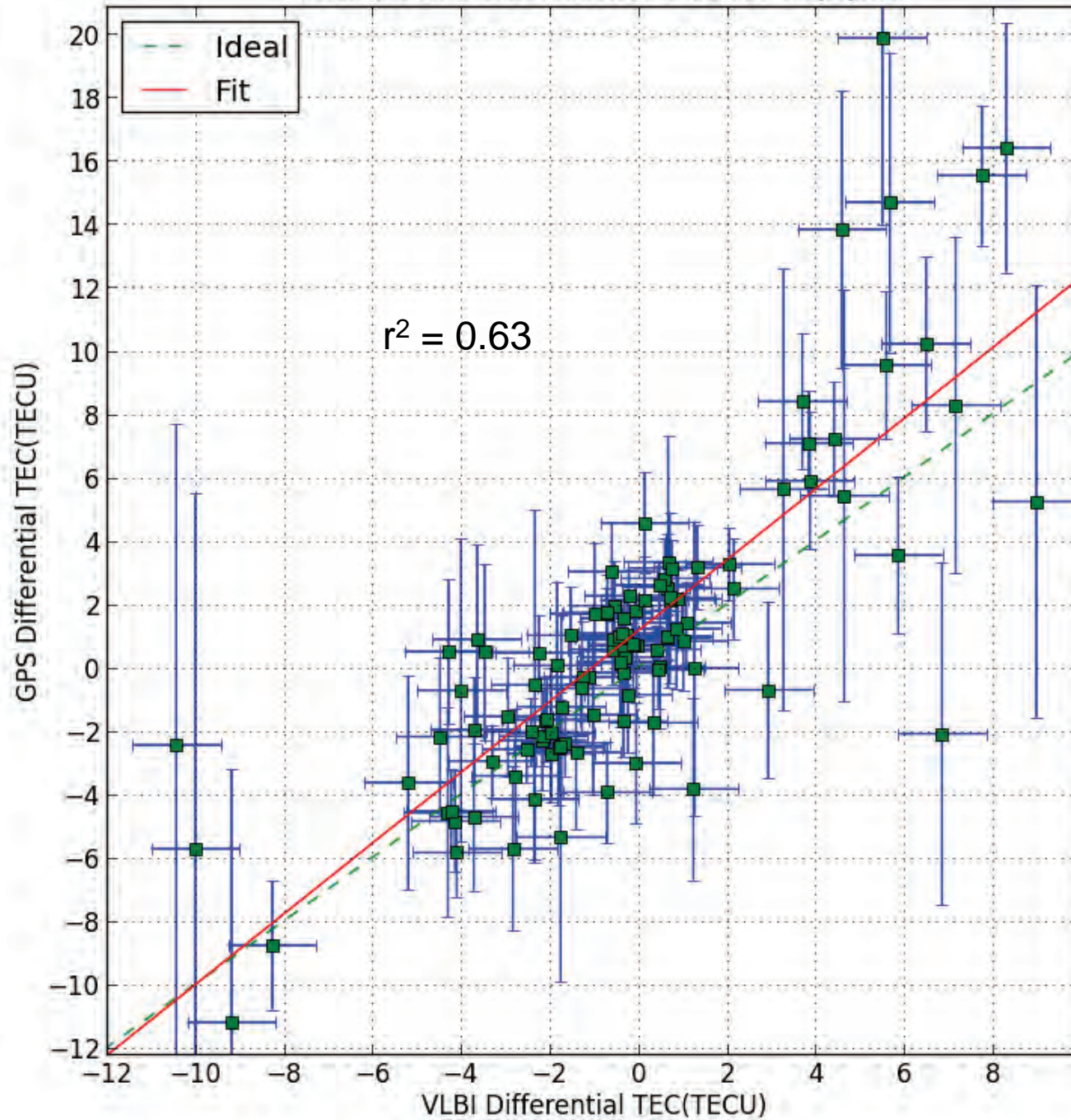
My Program

- Written in python.
- Allows quick comparison between differential TEC values obtained with VLBI and GPS
- Inputs
 - Antenna Positions
 - Alist file for the VLBI experiment
 - Differential TEC values for the VLBI scans
 - HDF5 file(s) for the day(s) on which the VLBI experiment took place

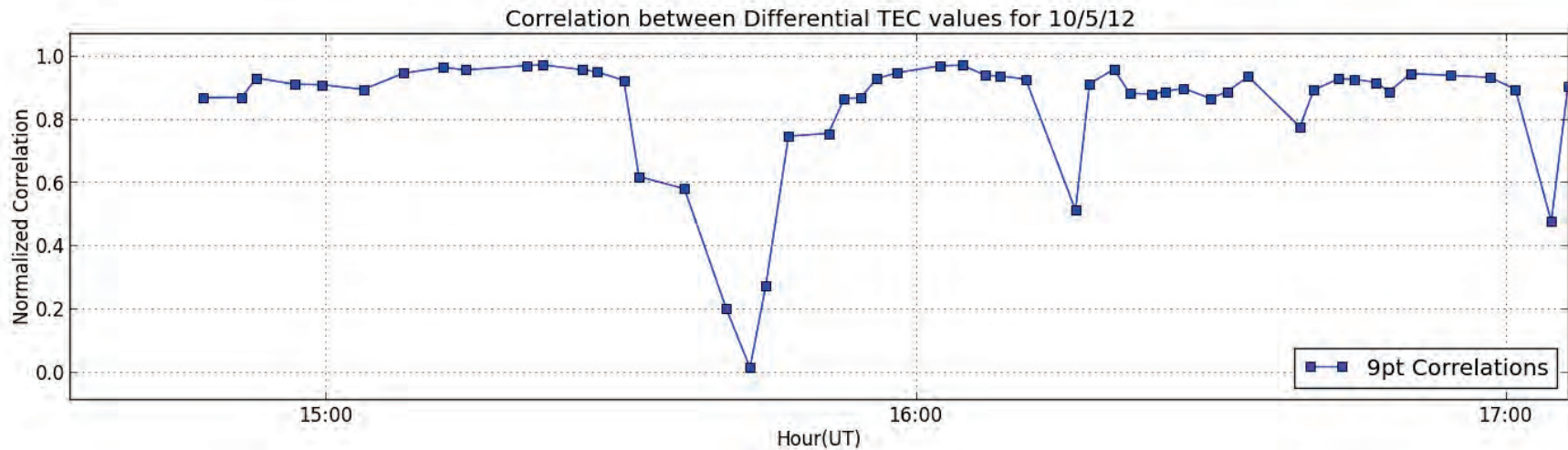
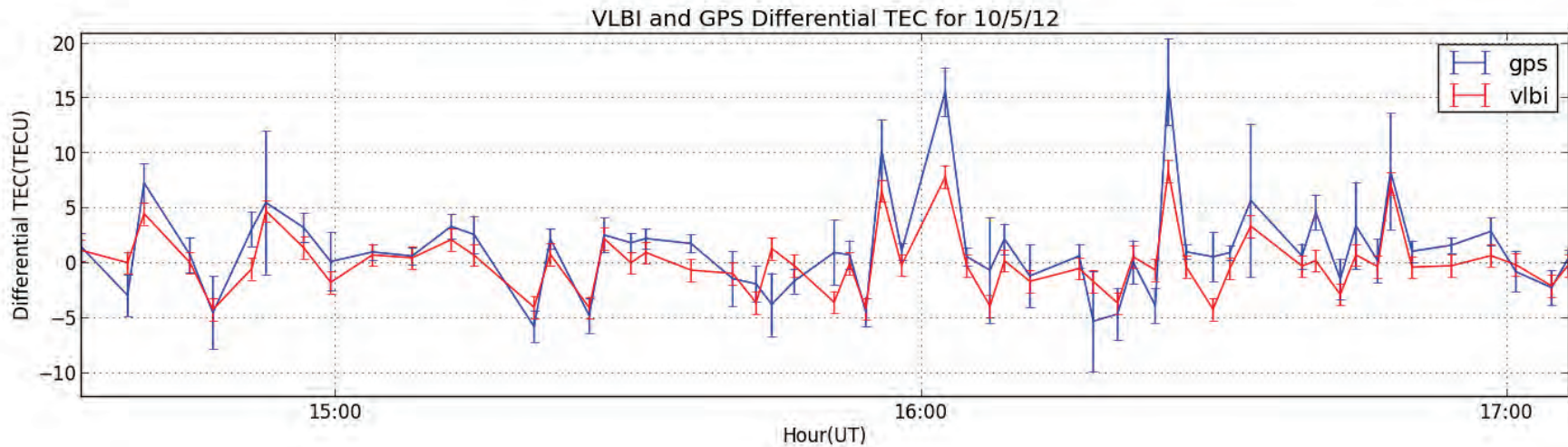
VLBI vs GPS Differential TEC for 10/5/12



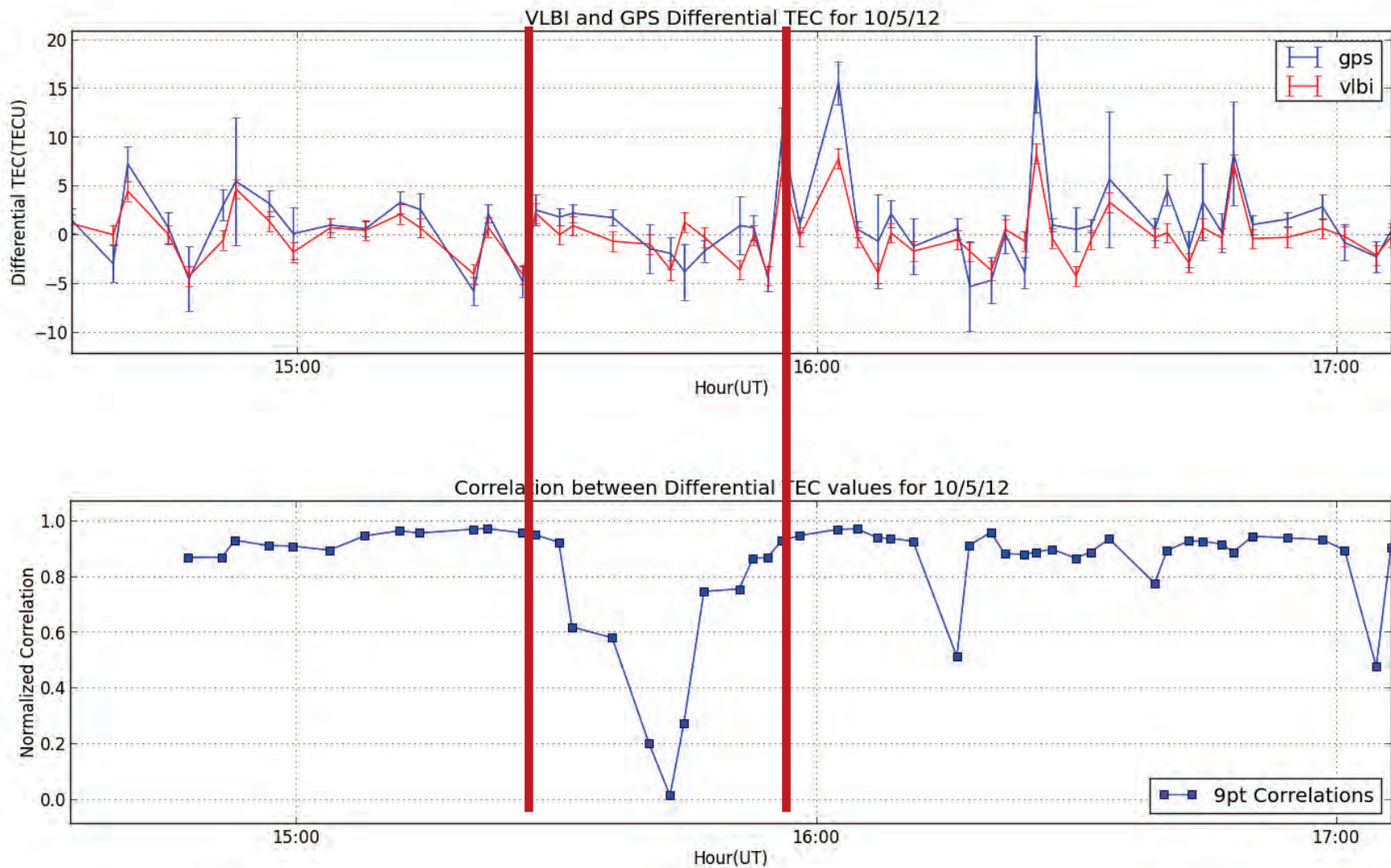
VLBI vs GPS Differential TEC for 10/5/12



Comparison Across Time



Comparison Across Time



Conclusion

- Periods of high correlation indicate a very good agreement between both, VLBI and GPS.

Future Work

- Determine what causes periods of low correlation
 - Geophysical phenomena
 - Systematic errors

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Questions?