TOTAL ELECTRON CONTENT ANALYSIS

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USIP-UH
Total Electron Content
NASA

Introduction

- Total Electron Content (TEC) is the total number of electrons present in the path of a transmission and a receiver, and depending on its magnitude, it can negatively affect the accuracy of GPS/GNSS navigation on the scale of tens of meters.
- This research project focuses on acquiring TEC data from Fairbanks, Alaska with aurora borealis and Houston, TX. Then analyzing data and discover any anomalies or correlations in TEC that would hinder the accuracy of radio signals like GPS.

Problem

Propagation Effects

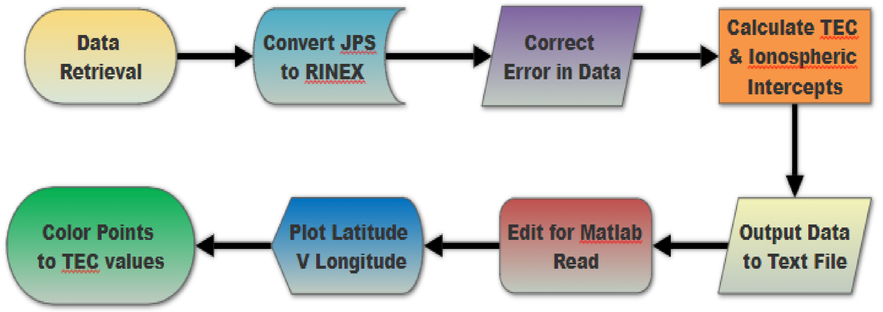
- Ionospheric and plasma anomalies can cause disruption of GNSS operations including navigation and communication.
- Ideally GPS signals favor a clear LOS along a straight vertical path.
- As electromagnetic scintillation levels increase, GPS signals witness large levels of path sidesteps :
  - Signal Delay
  - Clock biases
  - Range fluctuation
- The effects of atmospheric propagation varies in great amounts in various latitudes and altitudes.

Software & Hardware

- JAVAD TRIUMPH II dual receiver
- Gopi
- Ubuntu
- GPStk
- Matlab
- JPS
- Rinex

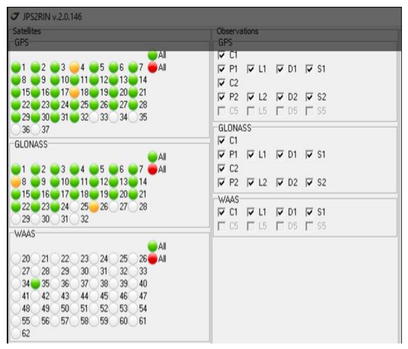
Function	Symbol	Green	Yellow	Red	OFF
BATTERY [1]		Full	Half	Almost empty	OFF/No power
WLAN		Connected	Initialization	Error	Not Active
SATELLITES [2]		8 or more	5 to 7	Less than 5	No Satellite
POSITION		Fixed/Diff/ OK (Base)	Float/No-Diff	No Position	Receiver OFF
RECORDING [3]		Recording	Less than 10 min memory left	Memory Full	Not Active

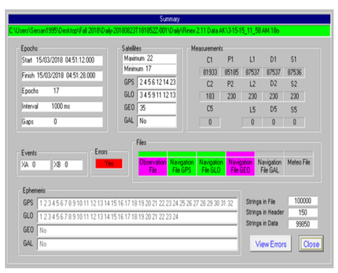
Flow Chart



Diagrams

JPS to Rinex Files Conversion





- The receiver is able to differentiate between carrier phase frequency and pseudorange noise.
- Carrier phase is precise and not prone to multipath errors.
- However carrier phase has relative measurements, and cannot be used.

Rinex Header

```
     2.11           OBSERVATION DATA    M (MIXED)           RINEX VERSION / TYPE
JPS2RIN v.2.0.146   JAVAD GNSS          20180823 185441 UTC PGM / RUN BY / DATE
                                                            OBSERVER / AGENCY
3-18-18_07_26 PM                                            MARKER NAME
00K8WPGWFGLY52TUHIJYJAVAD TRIUMPH2      3.6.9 Nov,28,2016   REC # / TYPE / VERS
 -2300570.8366 -1445937.2242  5751279.1272                  APPROX POSITION XYZ
-Unknown-                                                   ANT # / TYPE
        0.0000        0.0000        0.0000                  ANTENNA: DELTA H/E/N
     1     1                                                WAVELENGTH FACT L1/2
    10    C1    P1    L1    D1    S1    C2    P2    L2     D2# / TYPES OF OBSERV
          S2                                                # / TYPES OF OBSERV
 1.000                                                      INTERVAL
  2018     3    17    20    51    56.0000000     GPS       TIME OF FIRST OBS
  2018     3    19     3    26    53.0000000     GPS       TIME OF LAST OBS
    18                                                      LEAP SECONDS
    58                                                      # OF SATELLITES
```

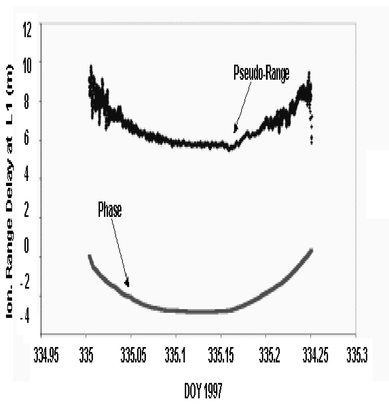
Satellites

```
G 1 42315 42250 42250 42250 42250 42314 42250 42250 42250PRN / # OF OBS
    42250                                                 PRN / # OF OBS
G 2 32247 32119 32119 32119 32119     0 32119 32119 32119PRN / # OF OBS
    32119                                                 PRN / # OF OBS
G 3 34977 34243 34243 34243 34242 34970 34243 34243 34243PRN / # OF OBS
    34242                                                 PRN / # OF OBS
G 4 31139 31043 31043 31043 31043     0 31043 31043 31043PRN / # OF OBS
    31043                                                 PRN / # OF OBS
G 5 35737 35378 35378 35378 35378 35697 35378 35378 35378PRN / # OF OBS
    35378                                                 PRN / # OF OBS
G 6 33198 32722 32722 32722 32722 33095 32722 32722 32722PRN / # OF OBS
    32722                                                 PRN / # OF OBS
```

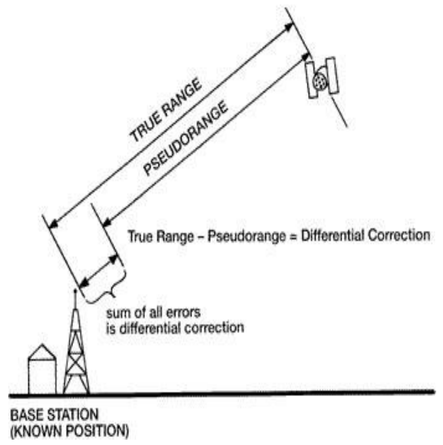
Data

```
18  3 17 20 51 56.0000000  0 20S35G21G 9G 8R 1R18G27R11R 8R 9G 7G30-0.000492961
                             G13G 5G20R19R17R 2G28R10
 34476132.670                 181173300.060 6     -208.813         38.750

 22484434.350  22484434.260  118156518.156 4      114.105         27.750
               22484430.940   92070017.146 4       88.861         27.750
 22484434.350
 22484435.960
 22484434.350  22484433.880  118156530.583 4     2122.307         28.250
 22484436.860  22484436.360   92070027.131 4     1653.661         28.250
 22484434.350  22484434.070  120192188.429 7      297.044         44.500
 22484440.400  22484440.780   93482804.918 6      231.070         37.750
 22484434.350  22484433.900  120023447.435 7     -925.965         45.500
 22484441.460  22484441.680   93351542.309 7     -720.201         43.500
```



Method



- Method to be used is by differentiating the pseudoranges of the two frequencies.
- To get the Pseudoranges, the time bias between the satellite clock and receiver clock must be found first.

Golden Circle

- **Why:** To improve GPS signal transmission through ionosphere. Increasing GPS signal strength and accuracy will improve GPS based applications.
- **How:** Collection of radio signal data from any reachable satellite in the atmosphere. Using extensive codes analyze differential phase and differential pseudorange frequency to compute slant TEC unites (sTECU).
- **What:** Dual frequency receiver acquiring radio signal data.

Conclusion

- Gathered radio frequency data from Fairbanks Alaska with the auroras.
- Extracted data from Dual Frequency Receiver & Converted files from JPS format to Rinex.
- Additional data will be gathered in Houston and compared to Alaska data.
- Currently correcting data by improving its accuracy with MinGW compiler & GPStk library.
- After post-processing Matlab code will be created to plot our data in a Latitude V Longitude Plot
- Add Color points to our TEC values for better data visibility.