GPS and the Ionosphere

• A signal gets broadcasted down from the satellite to the GPS receiver
• This signal passes through the Ionosphere
• The electron density of the Ionosphere changes during solar storms
• This changes the speed of the signal and causes triangulation errors
• Extra time in a given position is needed to correct for these errors
• Without a warning system GPS users do not know the precision of their measurement
GPS signals through ionosphere
Warning Systems

- We currently have alerts/warning for Geomagnetic Storms, Solar Radiation Storms, and Radio Blackouts
- The creation of a GPS Space Weather Scale

![NOAA Space Weather Scales](image-url)
Current Model: Monitoring the Ionosphere

Total Electron Content Units x 10^6 m^-2

Total Electron Content Difference from 10-day Average x 10^6 m^-2
Creating a scale

Total Electron Content Difference from 10-day Average \times 10^6 \text{ m}^{-3}

02-Jul-2014 from 15:00 to 15:15 UT  NOAA/SWPC Boulder, CO USA (op.ver. 1.0)

Relative TEC

0 500 1000 1500 2000 2500  

-0.4 -0.2 0 0.2 0.4  

UT
Differentiating days

TEC and Kp values: 20140605-14

Difference

Relative Difference
Quiet Average STDEV Disturbed Average STDEV
-0.0310038 7.21839 -0.0363879 13.9891
TEQC: GPS signal results

GPS carries signals with different frequencies, the receiver counts the number of times the signal goes through zero

**L1:** 1575.42 MHz

**L2:** 1227.6 MHz
Disturbance Index

\[ \text{sTEC} = 9.52 (L1 - L2) \]

\[ \Delta \text{TEC} = \text{sTEC}_0 - \text{sTEC}_f \]
Slant TEC
2014 7 25 17 25: 890517.5740 -4568459.6989 4346302.7918
Predictive Model: Forecasting conditions

Ionospheric TEC Map

07/30/14 16:25 UT

• GPS Receiver
Conclusions

We found no useful correlation between CONUS vertical TEC averages or CONUS trend averages, and Kp.

This points to the need for a position dependent index, i.e. a map of GPS errors as a function of time, instead of a global number.

This makes sense as the TEC varies based on USTEC plots based on position.
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Questions
Differentiating days

Relative Difference for Quiet Days

Relative Difference for Disturbed Days