GPS Scintillation Analysis

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What is Scintillation?

- Ionosphere Scintillation is rapid fluctuations of frequency or amplitude as a signal passes through the ionosphere.
- It occurs when a signal passes through an area of the ionosphere with small irregularities in electron density.
- The fluctuations in electron density cause small changes to the refractive index which in turn causes differential scattering of the signal.
- This scattering causes scintillation through interference of multiple scattered signals at the receiver.
- Scintillation is measured quantitatively through the equation: \( S_4 = \left( \frac{I}{I_0} \right)^2 \)
  Where \( I \) is the signal intensity.

Significance

High amounts of Scintillation can cause a loss of signal, rendering things such as GPS useless.

The sun enters a solar maximum every 11 years. This maximum causes ionospheric storms which will cause disruption to radio signals and GPS.

The last solar maximum occurred in May 2013.

We will be analyzing data before during and after the solar maximum of May 2013

While Scintillation may not be a problem for the layman, large amounts of scintillation can have a significant impact on equipment such as aircraft and military technologies.

Research Progress

We have taken months of raw S4 data (see below) from three receivers, all of which are receiving signals from up to 34 different satellites.

- Each line represents one satellite
- Each Graph represents one day

My job was to take this data and condense it into formats that would be possible to search for any potential patterns or correlations between the two sites.

- Average S4 per day
- All 3 receivers

Time of day versus day of the year (heat-map)

BOG: Bogota, Columbia, CTO: Cerro Tololo Observatory in Chile

Future Work

- Although the data is consistent in its general pattern there are many discrepancies in the day to day scintillation between the two sites. This leads to questions of what is causing differences between the two sites and how much scintillation is due to global causes such as ionospheric storms versus how much is due to local influences.
- Expand the scope of this project to encompass larger time frames and/or more receivers.
- Adjust the “Time of day versus day of the year” heat maps to account for the Satellite rising at a different time each day.
- Analyze the average S4 of all active satellites per time as opposed to per day to increase accuracy.
- Combine the data at sites with multiple receivers (such as CTO L and M) to get one set of more reliable data.

References

http://www.insidegnss.com/node/1579

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