MAE 593I GPS – HW#2
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Due: September 27, 2016

Problem #1: Use both **dataSet3.m** and **dataSet4.m** on eCampus to determine the impact of modeling the tropospheric atmospheric delay on LLS positioning. For each data set, perform the following steps:

- Conduct LLS positioning on the data set just as done in HW#1. Using a non-iterative nominal is fine (i.e., this is static data)
- Modify your LLS function to include a tropospheric delay on each computed pseudorange value. In particular, use the ***Saastamoinen model*** to estimate the Troposphere Zenith Dry and Wet delays. To do this, you are given the following quantities that are measured close to the user's GPS antenna:
    - T=288.15 degrees Kelvin
    - Total Pressure = 1013 mbar
    - Partial Pressure Due to Water = 12.8 mbar

  With the estimated zenith delay (report your computed values in the write up) use the following elevation dependent mapping function to model delays on individual signal paths:

$$m(el) = \frac{1}{\sqrt{1 - \left(\frac{\cos(el)}{1.001}\right)^2}}$$

- Compare the position and clock bias estimates from the baseline approach (your code from HW#1) to the approach that includes troposphere modeling. For the error comparison, perform comparisons only in ENU. In particular,
    - use nomXYZ as your ENU origin, and plot time histories of the baseline LLS error wrt to truth and the "LLS + Model Trop"
        - For example (each will generate 3 series)

          plot(time, enuBaseline-enuTruth)
          hold on
          plot(time, enuWithTropModel-enuThruth)

    - Compute and report overall RMS error in East, North, Up, RMS in 3D, and RMS in clock bias.

Problem #2: Using both **dataSet3.mat** and **dataSet4.mat** on eCampus determine the impact of modeling the Ionospheric atmospheric delays on LLS positioning. Conduct the following specific steps:

- Write a MATLAB® function that generates an ***Ionospheric Zenith delay*** estimate in meters provided an input time, GPS to local time offset, and 4 Klobuchar model parameters.
    - use the Klobuchar model with the following parameters (all model parameters in units of seconds).
        - `A1=5e-9;`
        - `A2=8.6599e-08;`
        - `A3=50400;`
        - `A4=100800;`
    - Further, you are given the knowledge that the local time is offset from the beginning of the GPS week is 19.45 hours. That is :

"Seconds into Day Local"=mod(GPS Time of Week, 86400)+19.45*3600 ;

- Develop a function that computes an Obliquity Factor (OF) for the Ionosphere using a ***Thin Shell Model*** that assumes that the mean of the Ionosphere is 350 km and the mean radius of the Earth is 6,367,444.5 meters.
- Further modify your LLS algorithm to include the modeled ionspheric delay on each computes pseudorange (Delay Along Signal Path= Ionosphere Zenith Delay * Obliquity Factor).
    - Implement this model as a switch to your LLS function, such that it can be turned on or off.
- Conduct an error analysis similar to problem #1, but using the results from problem #1 as the baseline for your error comparisons. That is, compare:
    - "LLS w/ Model Trop" and "LLS with Model Trop + Model Iono" with ENU error vs. time plots and RMS error stats.
- Turn off your ionospheric delay model, and instead use the **Ionosphere-Free dual-frequency data combination** as your input pseudorange data.
- Produce another set of error comparison plots and RMS values, but now compare:
    - "LLS with Model Trop + Model Iono" "LLS with Model Trop + Dual-Freq Iono Free Data" with ENU error vs. time plots and RMS error stats.

In addition to discussion of your error analyses of the two data sets, answer the following questions in your write-up:

1. Which type of atmospheric delay (Trop or Iono) is more important to model for low elevation satellite data? Provide justification for your response by referring to your error analysis plots and <u>**also**</u> your knowledge of the error source magnitudes and the obliquity factor functions used for each type of delay.
2. What are the minimum and maximum TEC values assumed in the above provided Klobuchar model parameters?
3. What is the primary difference between **dataSet3.mat** and **dataSet4.mat**? How did this difference impact the impact of the two different types of atmospheric delays? Provide back-up to your discussion in the form of comparing the difference (with plots and stats) of the difference of L1 and L2 pseudorange measurements contained in each dataset. (e.g. *plot(time, prDataL1-prDataL2)*)
4. When using pseudorange-only data is the dual frequency ionospheric-free data always better to use or is modeling sometimes better? Refer to your position and clock bias error analyses and also compare the standard deviation of the two different approaches position errors. Consider post-fit residuals as well. What applications might benefit from one approach over the other?