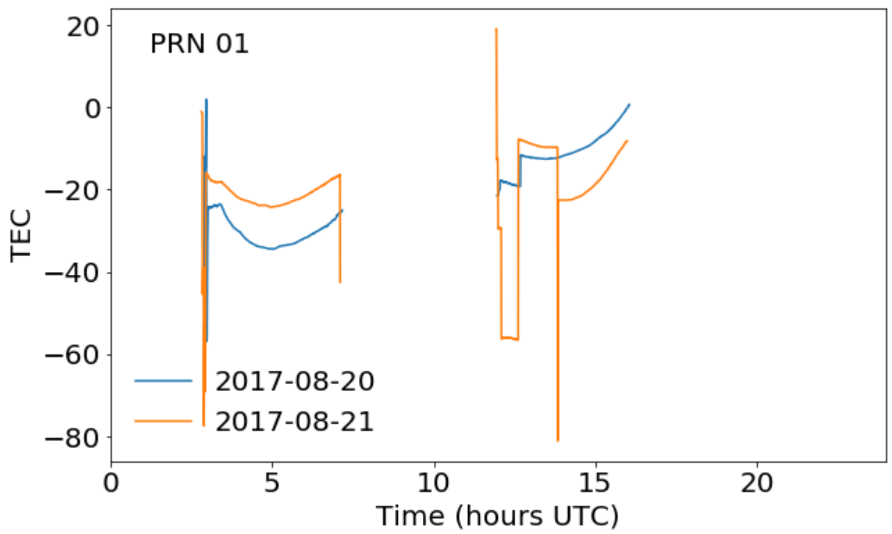
ASEN 5090 Assignment 7

1. Based on the instructions from project 5, download the RINEX observations from the NIST station for 2017 August 20 and 21. Note that 2017 August 20 00:00 UTC corresponds to GPS week 1963 and day-of-week 0, plus 18 leap seconds.
   CDDIS FTP URL: ftp://cddis.gsfc.nasa.gov/gnss/data/daily
   Question: What are the corresponding days of the year for 2017 August 20 and 21?

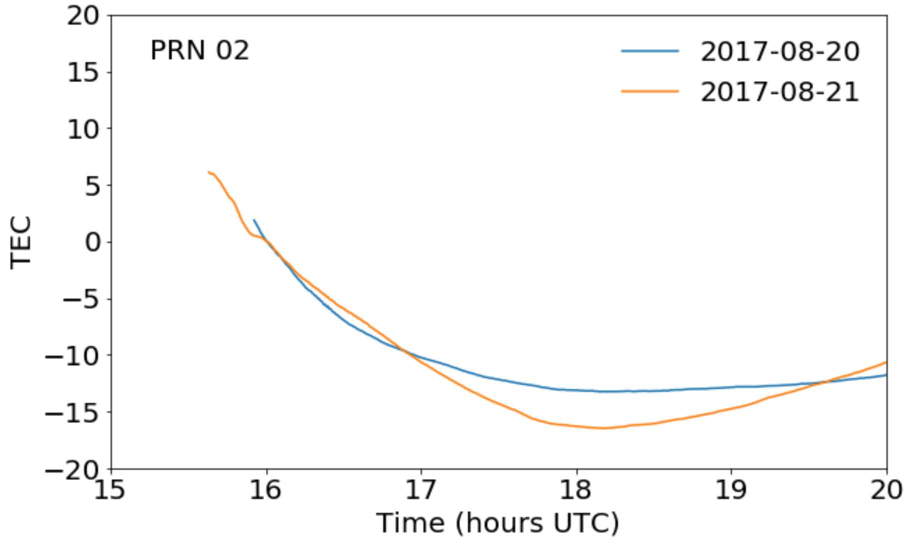
2. Let us model the carrier phase measurements as range measurements in units of meters (which is often referred to as accumulated Doppler range, or ADR):
   $$\Phi_f = r + c\,(\delta t - \delta T) + T + I_f + \lambda_f N_f + \epsilon_f^{\Phi}$$
   where r is the geometric range between receiver and satellite, δt and δT are the receiver and satellite clock biases respectively, T is the neutral atmosphere range error, I_f is the ionosphere range error, λ_f (the carrier wavelength) and N_f (integer ambiguity) account for the unknown carrier offset, and ϵ_f^{Φ} accounts for noise and unmodeled errors.
   Note: The RINEX files we deal with provide us with carrier measurements in units of cycles. We can convert them to pseudorange measurements by multiplying by $\lambda_f = \frac{c}{f}$, where c is the speed of light and f is the corresponding carrier frequency.
   From the lectures, we know that to very good approximation the ionosphere carrier phase advance can be modeled as:
   $$I_f = -\frac{\kappa}{f^2}\mathrm{TEC}$$
   where f is the carrier frequency, TEC is the total electron content along the signal path, and κ is a constant that we compute as:
   $$\kappa = \frac{e^2}{8\pi^2\epsilon_0 m_e}$$
   where e is the fundamental charge, ϵ_0 is the permmitivity of free space, and m_e is the standard electron mass. *The values of these constants can be obtained using Google*. *Compute* κ and **record your result** for 5 significant digits.
3. Compute relative ionosphere TEC using the L1 and L2 carrier phase measurements for a satellite of your choosing ***other than*** 2, 6, 12, 19, or 24 (we're saving those for later!). TEC is often recorded in TEC units (TECu), or in units of 1×10^{16} electrons -- so you can express TEC in TECu by dividing by 1×10^{16}. **Plot the relative TEC (in TECu) versus time** for both days of data. Make the time axes for each day align at the start of the UTC day. E.g. you should have a plot similar to:



4. **Question**: Do you see differences in the TEC that you computed between the two days? If so, which term/terms in our measurement model could be responsible for these discrepancies? Briefly support your claims.

5. Now, take PRN 2 observations and make a plot similar to that made previously, but with the following modifications:
   A. Subtract an offset from each of your computed relative TEC time series so that there is a zero crossing at 16 hours UTC. I.e., find a TEC value for the observations that occur near 16:00 UTC on each day, then subtract that value from your computed TEC. You should do this programmatically.
   B. Zoom in on the x axis to hours 15 through 20 UTC.
   C. Zoom in on the y axis to an appropriate range centered at zero.

   Your resulting plot should look something like the following:



6. Repeat the above plot for PRNs 6, 12, 19, and 24.

7. You should notice a drop in TEC for the above PRNs after around 16:00 UTC on August 21st as compared to August 20th. What phenomenon do you think was responsible for this drop in TEC? (Hint, the Sun is the principle cause of ionization of Earth's atmosphere.)

8. Write a **short** report containing your answers to the questions above and images of your plots. If you had any programming issues you were unable to address, include a brief summary of the issues and your