Homework 5 GPS Navigation Solution

Solve the least squares problem to find the receiver position given the observed pseudoranges and the tabulated ephemeris data. For this indirect observation problem, the condition equation is,

$$PR_i = \left[(X - X_{s_i})^2 + (Y - Y_{s_i})^2 + (Z - Z_{s_i})^2\right]^{1/2} + c \cdot DT$$

OR

$$F_i = PR_i - \left[(X - X_{s_i})^2 + (Y - Y_{s_i})^2 + (Z - Z_{s_i})^2\right]^{1/2} - c \cdot DT = 0$$

For our data the pseudorange observation, C1, is corrupted by 3 systematic errors; (1) receiver clock bias, common to all observations at the same epoch (time), (2) satellite clock bias, slowly varying function of time, per satellite, and (3) troposphere delay, dependent on environmental (weather) conditions and on the elevation angle to the satellite (at zenith minimum travel, at low elevation angle maximum travel & delay through the troposphere). Assume $\sigma_{PR} = 5\,m$. Make a 2-sided global test on reference variance at $\alpha = .05$. Make a 90% confidence interval for each of μ_x, μ_y, μ_z. Find all data in hw5_data2.mat. Assigned Friday 19 October, 2018, due ----------. See accompanying template & needed functions.

I provide tropo.m (via Kai Borre) and intrp_lagr.m,
You provide XYZ2geo.m and xyz2enu.m.

TEMPLATE

initialize geometric range$_i$ = pseudorange$_i$, per obs
Δt_i = geom. range$_i$ / c (units!)
initialize unknowns X, Y, Z, DT for receiver km, μsec
save X_{ref}, Y_{ref}, Z_{ref}
initialize C, enviro. constants
load ephemeris data sX, sY, sZ, sclk 10 epochs @ 15 min., 32 sats.
create indep. variable t = [-60 -45 -30 -15 0 15 30 45 60 75]
load observation data C1, sats, note time epoch of obs.

```
for iter = 1:10          (convergence check later)
    B = zeros (nsat, 4)
    f = zeros (nsat, 1)
    for i = 1: nsat
        tx = to - Δti           (tx: transmission time)
        x = sX(:, sats(i))
        Xecf = intrp_lagr (10, t, x, tx)
        y = sY (:, sats(i))
        Yecf = intrp_lagr (10, t, y, tx)
        z = sZ(:, sats(i))
        Zecf = intrp_lagr (10, t, z, tx)
        clk = sclk (:, sats (i))
        Clk = intrp_lagr (10, t, clk, tx)
        Θ = (Δt / length of sidereal day) * 2π
        Xs
```

$$\begin{bmatrix} X_s \\ Y_s \\ Z_s \end{bmatrix}_i = M_z(\Theta) \begin{bmatrix} X_{ecf} \\ Y_{ecf} \\ Z_{ecf} \end{bmatrix}$$ rotate into receive epoch

correct PR for 2 sys. errors

+ $c * Clk$ sat clock, units

− troposphere delay term (length units)

for tropo correction, need local elevation angle to sat

$XYZ_{sat} \rightarrow ENU_{sat} \rightarrow$ elevation angle

args for tropo.m
all height args: 0.236 km
pressure: 1018.9 mb
temp: 277.6 deg. K
humidity: 82.2%
you compute elev. angle
and sine(elev_ang)

evaluate cond. eqn. (i) & partials

$F = \ldots$

$\partial F/\partial x,\ \partial F/\partial y,\ \partial F/\partial z,\ \partial F/\partial DT = \ldots$

$B(i,:) = [\ \ldots\ldots\ ]$

$f(i) = (\cdot)$

end (for i = 1 : nsat)

form and solve NE

make parameter corrections

geometric range$_i$ = $\left[(X - Xs_i)^2 + (Y - Ys_i)^2 + (Z - Zs_i)^2\right]^{1/2}$

Δt_i = geom. range$_i$ / c

end (for iter = 1 : 10)

compute v

compute ENU of est. receiver pos. with respect to $\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{Ref}$

post adjustment statistics