```
clear all;close all;clc
```

HW 10: performance of different tropo models

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NISTECEF = [-1288398.360 -4721697.040 4078625.500];     % Set a priori
 locations for NIST and USN8
USN8ECEF = [1112161.9919 -4842855.0890  3985497.3152];
C =  2.99792458e8; % speed of light,m/s
% Compute transformation matrix from ecef to enu using provided
 locations
% NISTLLA = ecef2lla(NISTECEF);
% USN8LLA = ecef2lla(USN8ECEF);
% C_ecef2enu_nist = calcECEF2ENU(NISTLLA(1),NISTLLA(2));
% C_ecef2enu_usn8 = calcECEF2ENUUSNA8LLA(1),USN8LLA(2));
% Set up code to loop through entire obs file, start with first few
 epochs while debugging
rinex_data = read_rinex_obs8('USN82450.20o',[1:32]);
ephem_data = read_clean_GPSbroadcast('brdc2450.20n',true);
Weeknum_vec = rinex_data.data(1,1);
epoch = 1;
satcnt = 1;
data = [];
for i = 1:size(rinex_data.data,1)-1
    if rinex_data.data(i,2) == rinex_data.data(i+1,2)
        %Calculate all the stuff
        [health_eph,pos_eph,bsv,relsv] =
 broadcast_eph2pos_etc(ephem_data,[Weeknum_vec
 rinex_data.data(i,2)],rinex_data.data(i,3));
        rinex_tvec = rinex_data.data(i,2);
%         data(satcnt,1:3,epoch) = pos_eph;
%         data(satcnt,4,epoch) = bsv;
%         data(satcnt,5,epoch) = relsv;
        f1 = 1575.42e6;
        f2 = 1227.6e6;
%         for i = 1:size(epoch1,1)
        % calc expected range
        [PIF,~] =
 ionocorr(rinex_data.data(i,4),f1,rinex_data.data(i,8),f2);
%         [health_eph(i,:),pos_eph(i,:)] =
 broadcast_eph2pos_etc(ephem_data,[Weeknum_vec
 rinex_tvec],epoch1(i,3));
        [az,el,range] = compute_azelrange(NISTECEF,pos_eph);
        if el < 10
            data(satcnt,:,epoch) = 0;
            satcnt = satcnt+1;
            continue
        end
        for j = 1:2
        Tt = rinex_tvec' - (range./C);
        % Tt = pos2_eph - (range2'./C);
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```
        %Compute satellite position at Tt in ECEF at Tt based on
broadcast
        %ephemeris
        [health_ephTt,pos_ephTt,bsv,relsv] =
broadcast_eph2pos_etc(ephem_data,[Weeknum_vec
Tt'],rinex_data.data(i,3));
        data(satcnt,1:3,epoch) = pos_ephTt;
        data(satcnt,4,epoch) = bsv;
        data(satcnt,5,epoch) = relsv;
        %Rotation rate of Earth
        We = 7.2921151467e-5; %rads/sec, (hypertextbook)
        phi = We*(rinex_tvec' - Tt);
        for k = 1:length(Tt)
            ECEF_rot(i,:) = [cos(phi(k)) sin(phi(k)) 0;...
                            -sin(phi(k)) cos(phi(k)) 0;...
                            0 0 1]*pos_ephTt';
        R(k) = norm(ECEF_rot(i,:) - NISTECEF);
        end
        diff = abs(R - range);
        range = R;
        end
%         exp_range(i) = range;
        [az_corr(i),el_corr(i),~] =
compute_azelrange(NISTECEF,ECEF_rot(i,:));
        tropo = tropomodel(el_corr(i),2);
        data(satcnt,6,epoch) = range; %expected range of sat.
        data(satcnt,7,epoch) = tropo;
        data(satcnt,8,epoch) = PIF - (range - bsv - relsv + tropo);
        data(satcnt,9,epoch) = el_corr(i);
        satcnt = satcnt+1;
%           end
    else
        %Calculate all the stuff then increment epoch counter
        [health_eph,pos_eph] = broadcast_eph2pos_etc(ephem_data,
[Weeknum_vec rinex_data.data(i,2)],rinex_data.data(i,3));
        rinex_tvec = rinex_data.data(i,2);
        data(satcnt,1:3,epoch) = pos_eph;
        data(satcnt,4,epoch) = bsv;
        data(satcnt,5,epoch) = relsv;
        f1 = 1575.42e6;
        f2 = 1227.6e6;
%         for i = 1:size(epoch1,1)
        % calc expected range
        [PIF,~] =
ionocorr(rinex_data.data(i,4),f1,rinex_data.data(i,8),f2);
%         [health_eph(i,:),pos_eph(i,:)] =
broadcast_eph2pos_etc(ephem_data,[Weeknum_vec
rinex_tvec],epoch1(i,3));
        [az,el,range] = compute_azelrange(NISTECEF,pos_eph);
        if el < 10
            data(satcnt,:,epoch) = 0;
            satcnt = 1;
            epoch = epoch+1;
            continue
```

```
        end
        for j = 1:2
        Tt = rinex_tvec' - (range./C);
        % Tt = pos2_eph - (range2'./C);
        %Compute satellite position at Tt in ECEF at Tt based on
 broadcast
        %ephemeris
        [health_ephTt,pos_ephTt,bsv,relsv] =
 broadcast_eph2pos_etc(ephem_data,[Weeknum_vec
 Tt'],rinex_data.data(i,3));
        data(satcnt,1:3,epoch) = pos_eph;
        data(satcnt,4,epoch) = bsv;
        data(satcnt,5,epoch) = relsv;
        %Rotation rate of Earth
        We = 7.2921151467e-5; %rads/sec, (hypertextbook)
        phi = We*(rinex_tvec' - Tt);
        for k = 1:length(Tt)
            ECEF_rot(i,:) = [cos(phi(k)) sin(phi(k)) 0;...
                            -sin(phi(k)) cos(phi(k)) 0;...
                            0 0 1]*pos_ephTt';
        R(k) = norm(ECEF_rot(i,:) - NISTECEF);
        end
        diff = abs(R - range);
        range = R;
        end
%         exp_range(i) = range;
        [az_corr(i),el_corr(i),~] =
 compute_azelrange(NISTECEF,ECEF_rot(i,:));
        tropo = tropomodel(el_corr(i),2);
        data(satcnt,6,epoch) = range; %expected range of sat.
        data(satcnt,7,epoch) = tropo; %tropo delay
        data(satcnt,8,epoch) = PIF - (range - bsv - relsv + tropo);
        data(satcnt,9,epoch) = el_corr(i);
        satcnt = 1;
        epoch = epoch+1;
%         end
    end
end
% get rid of elevations less than 10 degrees
del = find(el_corr < 10);
el_corr(del) = [];
tvec = rinex_data.data(:,2);
tvec(end) = [];
tvec(del) = [];
for i = 1:numel(el_corr)
    [T_stand(i),T_map_basic(i),T_Saas(i),T_Hop(i)] =
 tropos(el_corr(i),2,tvec(i));
end
figure
plot(el_corr,T_stand)
xlabel('Elevation (deg)')
ylabel('Tropospheric Delay (m)')
title('Tropospheric Delay VS Elevation, Simple Model')
grid on
```

```
grid minor
figure
plot(el_corr,T_map_basic)
xlabel('Elevation (deg)')
ylabel('Tropospheric Delay (m)')
title('Tropospheric Delay VS Elevation, Basic Model w/ Obliquity
 Factor ')
grid on
grid minor
figure
plot(el_corr,T_Saas)
xlabel('Elevation (deg)')
ylabel('Tropospheric Delay (m)')
title('Tropospheric Delay VS Elevation, Saastomoinen Model ')
grid on
grid minor
figure
plot(el_corr,T_Hop)
xlabel('Elevation (deg)')
ylabel('Tropospheric Delay (m)')
title('Tropospheric Delay VS Elevation, Hopfield Model ')
grid on
grid minor
```

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