

AAE 575 - Homework 4

Setup and Constants

```
% LATEX Interpreter for Plots
interr = 'latex';
% interr = 'none';
set(groot,'defaulttextinterpreter',interr);
set(groot, 'defaultAxesTickLabelInterpreter',interr);
set(groot, 'defaultLegendInterpreter',interr);

addpath('hw4_data_2021b')
fL1 = 1575.42e6; fL2 = 1227.6e6; % carrier freq, Hz
freq = [fL1 fL2];
c = 299792458; % speed of light, m/s
lamL1 = c/fL1; lamL2 = c/fL2; % carrier wavelength, m/cycle
PRDU18 = load('rawdata.PRDU.sv18'); % location A
PRDU15 = load('rawdata.PRDU.sv15');
INWL18 = load('rawdata.INWL.sv18'); % location B
INWL15 = load('rawdata.INWL.sv15');
orbit18 = load('orbit.sv18'); % sat 2
orbit15 = load('orbit.sv15'); % sat 1
gpstime = PRDU18(:,1);
```

Problem 1

```
% Double Differences for L1 and L2
[phase_ddiff_L1, prange_ddiff_L1] = doublediff(PRDU15,PRDU18,INWL15,INWL18,'L1')

phase_ddiff_L1 = 58x1
103 x
-4.6348
-4.5957
-4.5567
-4.5176
-4.4785
-4.4395
-4.4005
-4.3614
-4.3223
-4.2833
⋮
prange_ddiff_L1 = 58x1
-888.1000
-880.6800
-873.2400
-865.8200
-858.3400
-850.8400
-843.3200
-835.8000
-828.3600
-820.9000
⋮
```

```
[phase_ddiff_L2, prange_ddiff_L2] = doublediff(PRDU15,PRDU18,INWL15,INWL18,'L2')
```

```
phase_ddiff_L2 = 58×1
```

```
103 ×
```

```
-3.6049  
-3.5745  
-3.5440  
-3.5136  
-3.4832  
-3.4527  
-3.4223  
-3.3918  
-3.3614  
-3.3310
```

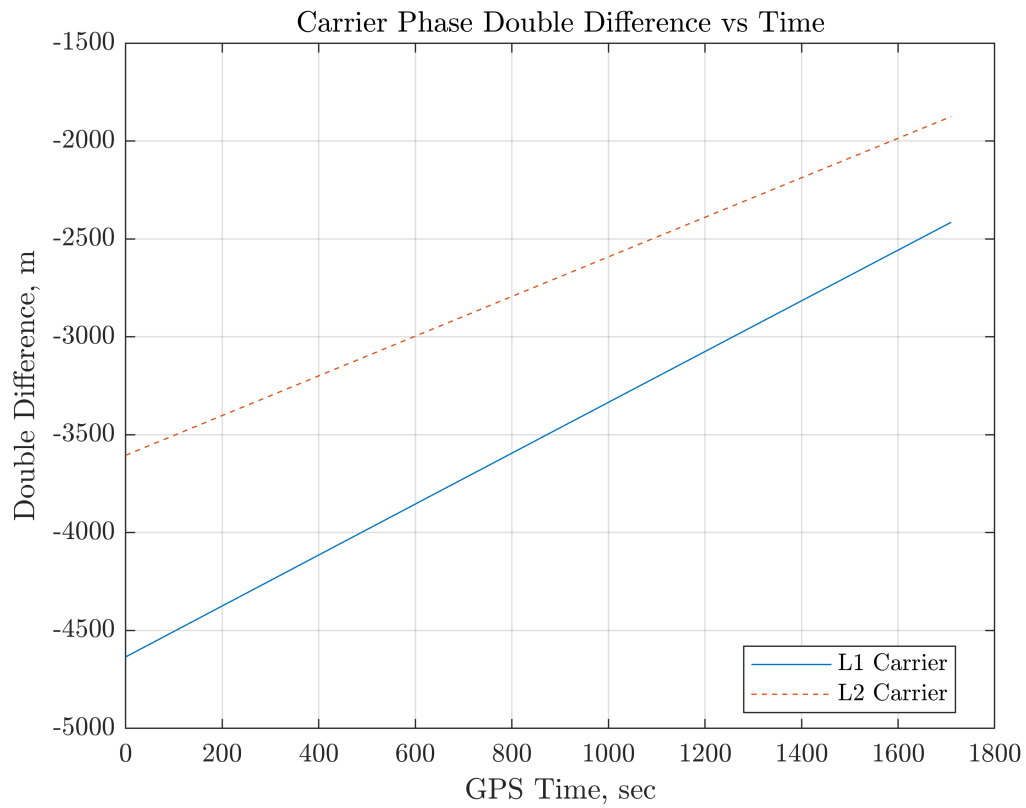
```
⋮
```

```
prange_ddiff_L2 = 58×1
```

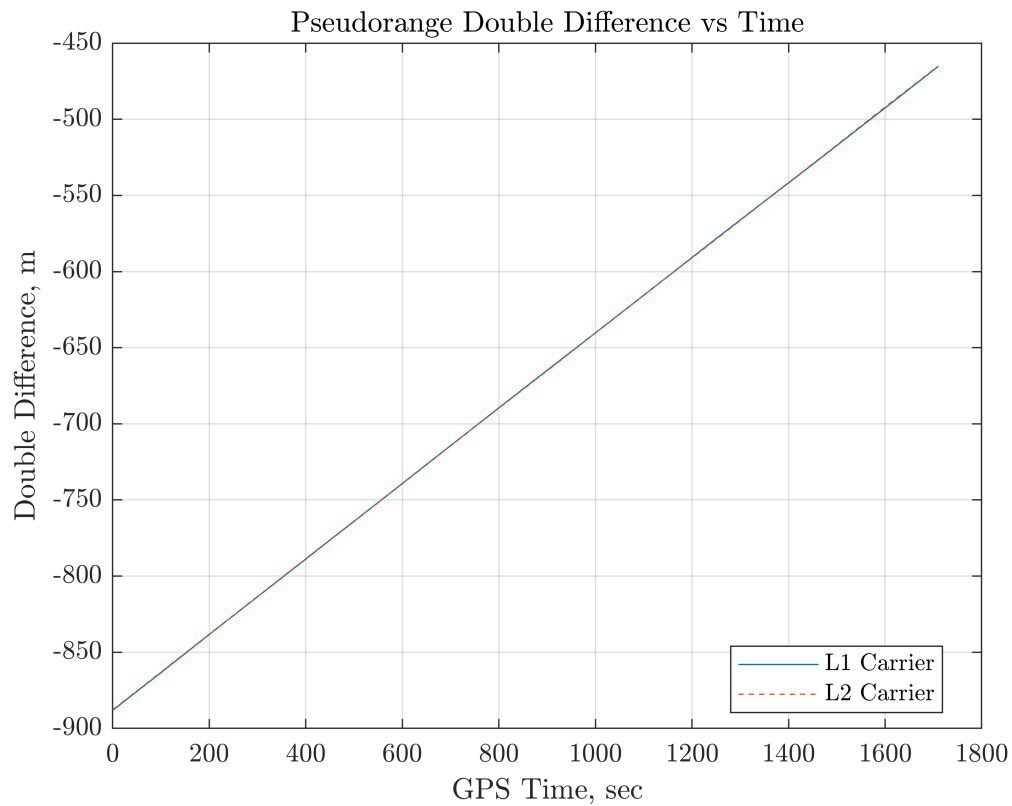
```
-887.6600  
-880.3600  
-873.0000  
-865.5000  
-858.0200  
-850.5800  
-843.1400  
-835.7400  
-828.3600  
-820.9800
```

```
⋮
```

```
plot(gpstime,phase_ddiff_L1)  
hold on  
plot(gpstime,phase_ddiff_L2,'--')  
title('Carrier Phase Double Difference vs Time')  
xlabel('GPS Time, sec')  
ylabel('Double Difference, m')  
legend('L1 Carrier','L2 Carrier','Location','best')  
grid on  
hold off
```



```
plot(gpstime,prange_ddiff_L1)
hold on
plot(gpstime,prange_ddiff_L2,'--')
title('Pseudorange Double Difference vs Time')
xlabel('GPS Time, sec')
ylabel('Double Difference, m')
legend('L1 Carrier', 'L2 Carrier', 'Location', "best")
grid on
hold off
```



Problem 2

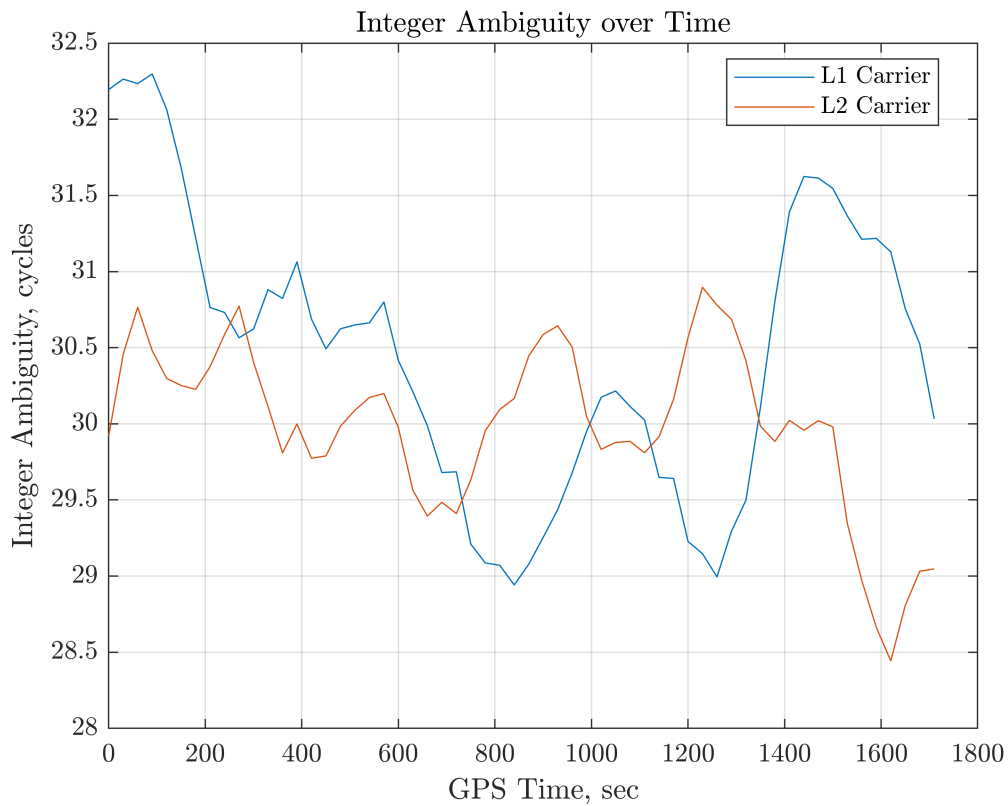
```
% L1 Integer Ambiguity
ambi_L1 = phase_ddiff_L1 - prange_ddiff_L1/lamL1;
plot(gpstime,ambi_L1)
hold on
ambi_L1 = round(sum(ambi_L1)/length(ambi_L1))
```

```
ambi_L1 = 30
```

```
% L2 Integer Ambiguity
ambi_L2 = phase_ddiff_L2 - prange_ddiff_L2/lamL2;
plot(gpstime,ambi_L2)
ambi_L2 = round(sum(ambi_L2)/length(ambi_L2))
```

```
ambi_L2 = 30
```

```
ambi = [ambi_L1, ambi_L2];
title('Integer Ambiguity over Time')
xlabel('GPS Time, sec')
ylabel('Integer Ambiguity, cycles')
legend('L1 Carrier', 'L2 Carrier', 'Location', "best")
grid on
hold off
```



Problem 3

```
% Carrier Phase Range Estimate, L1 Carrier
phase_range_L1 = -lamL1 * (phase_ddiff_L1 - ambi_L1)
```

```
phase_range_L1 = 58x1
887.6823
880.2492
872.8149
865.3827
857.9472
850.5199
843.0874
835.6547
828.2209
820.7924
⋮
```

```
% Carrier Phase Range Estimate, L2 Carrier
phase_range_L2 = -lamL2 * (phase_ddiff_L2 - ambi_L2)
```

```
phase_range_L2 = 58x1
887.6792
880.2484
872.8129
865.3826
857.9471
850.5185
843.0847
```

```

835.6483
828.2167
820.7913
:

```

```

% True Range
PRDUloc = [262004.574, -4855113.867, 4114363.877]; % loc A
INWLloc = [260604.167, -4853018.976, 4116926.580]; % loc B
r12_true = PRDUloc - INWLloc

```

```

r12_true = 1x3
103 x
    1.4004    -2.0949    -2.5627

```

```

for i = 1:length(orbit18)
    u1_true(i,:) = (orbit18(i,2:4)-PRDUloc)/norm(orbit18(i,2:4)-PRDUloc); % unit vector
    u2_true(i,:) = (orbit15(i,2:4)-PRDUloc)/norm(orbit15(i,2:4)-PRDUloc); % unit vector
    r12AB_true(i,:) = dot(u2_true(i,:)-u1_true(i,:),r12_true);
end
error_L1 = phase_range_L1 - r12AB_true

```

```

error_L1 = 58x1
    0.0795
    0.0810
    0.0808
    0.0824
    0.0800
    0.0852
    0.0848
    0.0835
    0.0804
    0.0820
    :

```

```

error_L2 = phase_range_L2 - r12AB_true

```

```

error_L2 = 58x1
    0.0764
    0.0802
    0.0789
    0.0822
    0.0799
    0.0839
    0.0821
    0.0771
    0.0763
    0.0809
    :

```

```

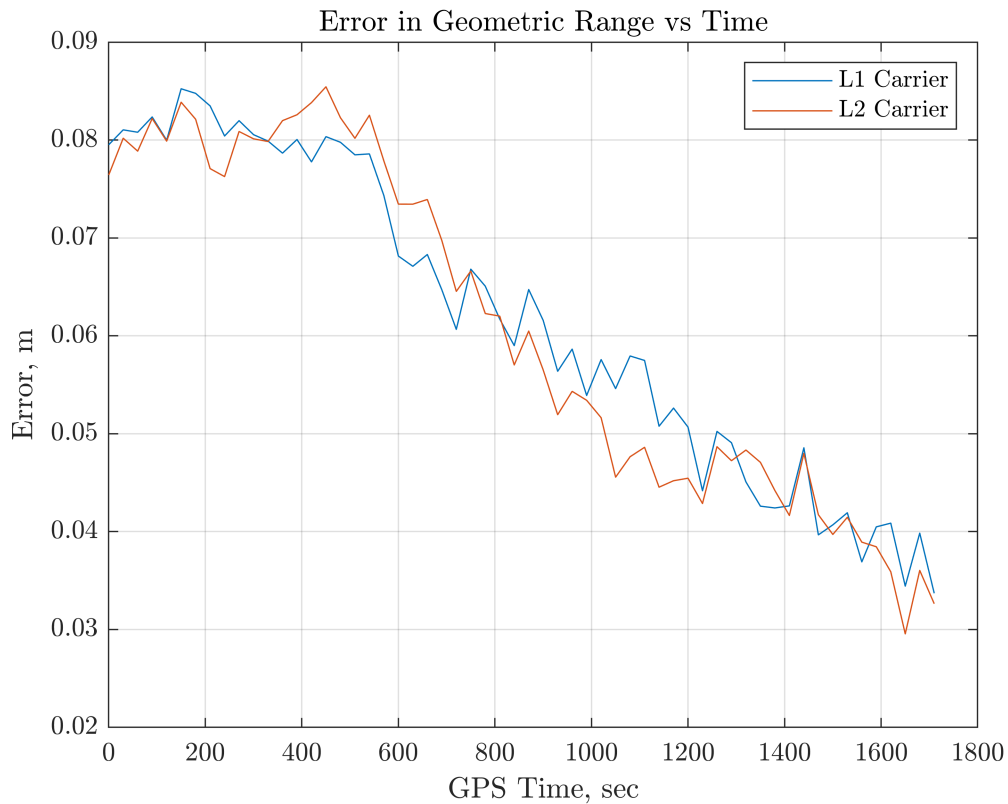
% Plots
plot(gpstime,error_L1)
hold on
plot(gpstime,error_L2)
grid on

```

```

title('Error in Geometric Range vs Time')
xlabel('GPS Time, sec')
ylabel('Error, m')
legend('L1 Carrier', 'L2 Carrier')
hold off

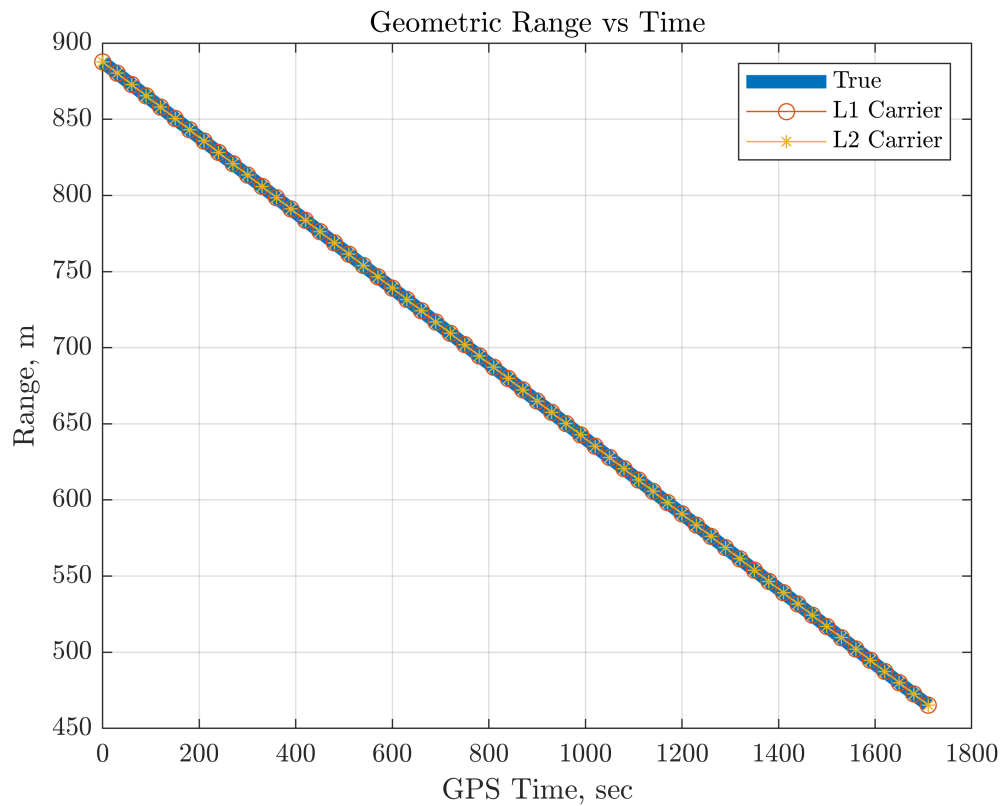
```



```

plot(gpstime, r12AB_true, 'LineWidth', 5)
hold on
plot(gpstime, phase_range_L1, 'o-', 'Markersize', 6)
plot(gpstime, phase_range_L2, '*-', 'Markersize', 5)
grid on
title('Geometric Range vs Time')
xlabel('GPS Time, sec')
ylabel('Range, m')
legend('True', 'L1 Carrier', 'L2 Carrier')
hold off

```



```
bias_L1 = mean(error_L1)
```

```
bias_L1 = 0.0617
```

```
bias_L2 = mean(error_L2)
```

```
bias_L2 = 0.0608
```

```
std_L1 = std(error_L1)
```

```
std_L1 = 0.0161
```

```
std_L2 = std(error_L2)
```

```
std_L2 = 0.0174
```

Functions

Function 1: Double Differences

```
function [cdiff,pdiff] = doublediff(sat1A, sat2A, sat1B, sat2B,carrier)
% Finds the double difference for the Carrier Phase and the Pseudorange

if eq(carrier,'L1')
    p = 2; c = 4;
elseif eq(carrier,'L2')
    p = 3; c = 5;
end
```



```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Carrier Phase Double Difference
% Location A
phase1A = sat1A(:,c); % carrier phase for sat 1
phase2A = sat2A(:,c); % carrier phase for sat 2
% Location B
phase1B = sat1B(:,c); % carrier phase for sat 1
phase2B = sat2B(:,c); % carrier phase for sat 2

% Single Differences
sin_diff1 = phase1B - phase1A;
sin_diff2 = phase2B - phase2A;

% Double Difference
cdiff = sin_diff2 - sin_diff1;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Pseudorange Double Difference
% Location A
prange1A = sat1A(:,p); % prange for sat 1
prange2A = sat2A(:,p); % prange for sat 2

% Location B
prange1B = sat1B(:,p); % prange for sat 1
prange2B = sat2B(:,p); % prange for sat 2

% Single Differences
sin_diff1 = prange1A - prange1B;
sin_diff2 = prange2A - prange2B;

% Double Difference
pdiff = sin_diff1 - sin_diff2;
end

```