Answers:

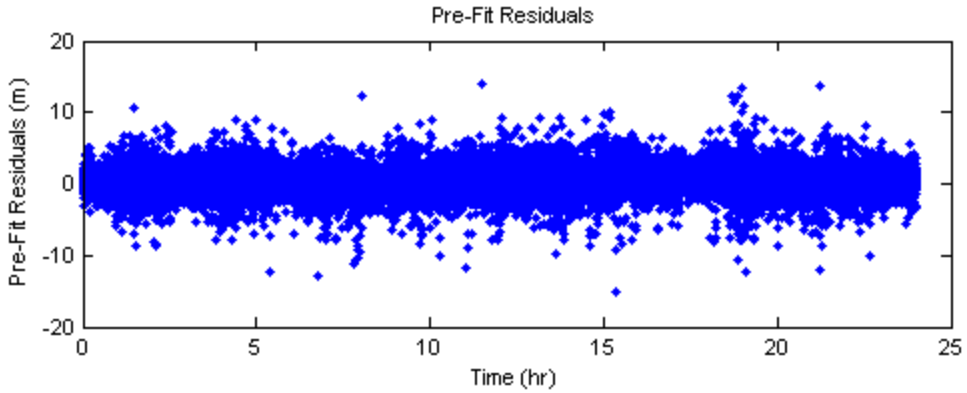
```
Position Errors at 1:00:
East:  -0.36 m
North: 0.92 m
Up:    -4.01 m

DOPs at 1:00:
HDOP: 0.87
VDOP: 1.34

East RMS: 1.11
East STD: 1.11
North RMS: 1.46
North STD: 1.46
Up RMS: 2.86
Up STD: 2.85
Prefit Mean: 0.36
Prefit STD: 1.75
Postfit Mean: 0.00
Postfit STD: 1.24
```

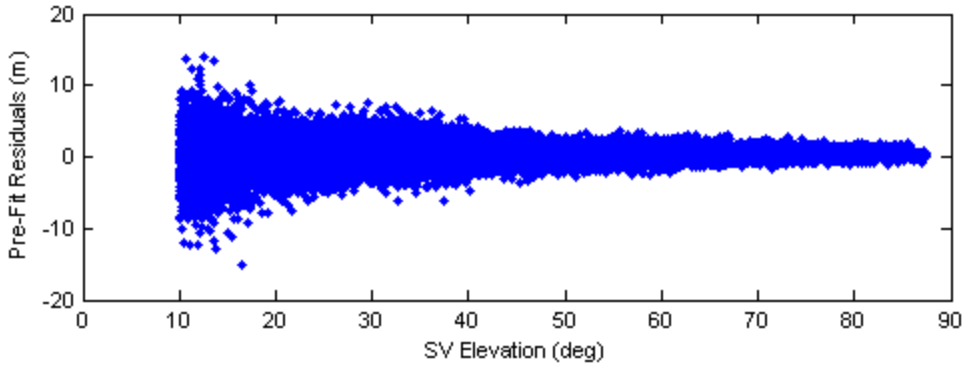
The prefit residuals demonstrate error with a mean of nearly zero. A standard deviation of 1.75 m (3-sigma: 5.25 m) means that the larger errors are outliers. The outliers are clustered in the lower elevations, and the residuals decrease with elevation gain. This is probably due, in part, to the simple troposphere model. Depending on antenna placement, multipath might also be experienced.

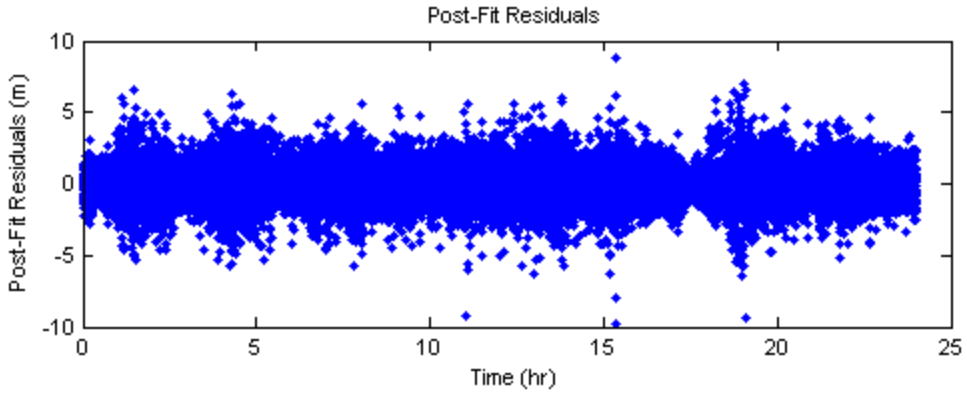
The postfit residuals show much smaller errors, with a mean of zero. Again, the outliers are mostly in the lower elevations.

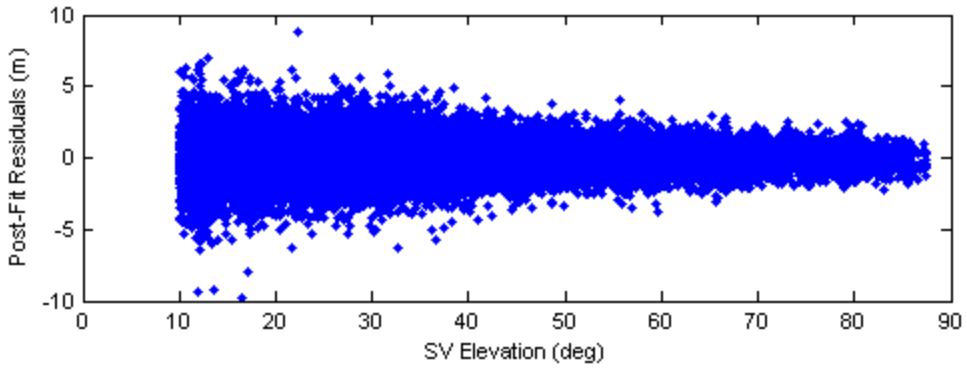
Relative position has roughly zero mean, meaning the RINEX file's antenna location was accurate. East and North have small relative position magnitueds, in general. Up relative position, however, is much greater. Looking at the DOPs confirms that dilution of precision is greater in the vertical direction than the horizontal. The lower HDOP means the East and North RMS and standard devations will be low compared to Up, which is reflected by the calculations. This is due to satellite geometry and signals being unable to penetrate the limb of the Earth.

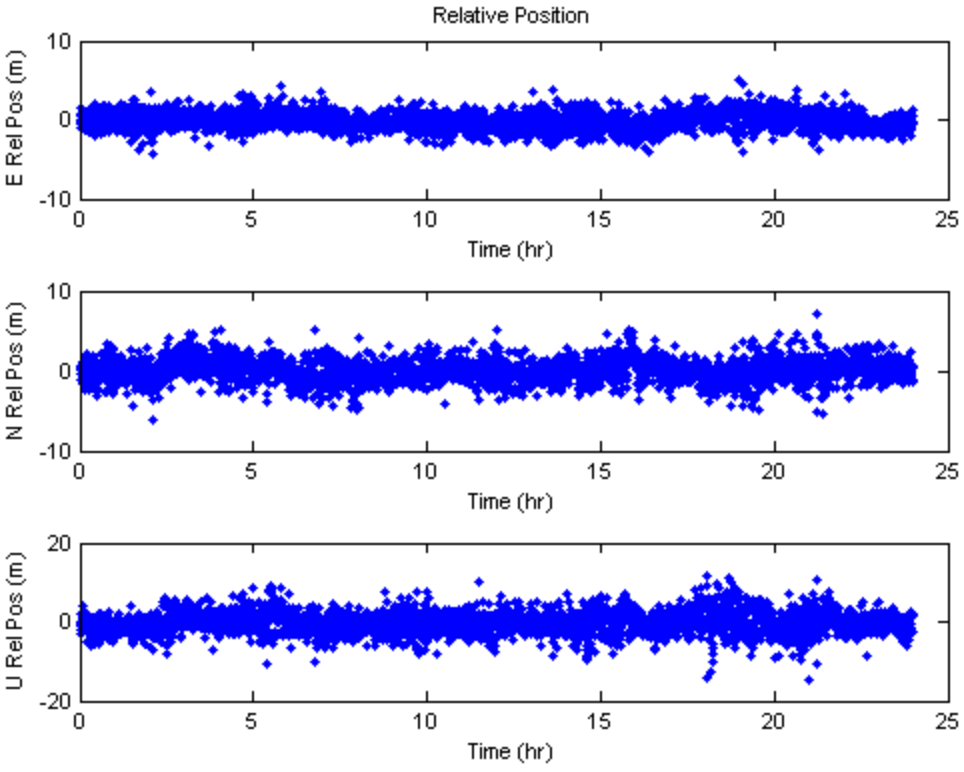
North relative position appears to have some sinusoidal motion to it, indicating multipath.

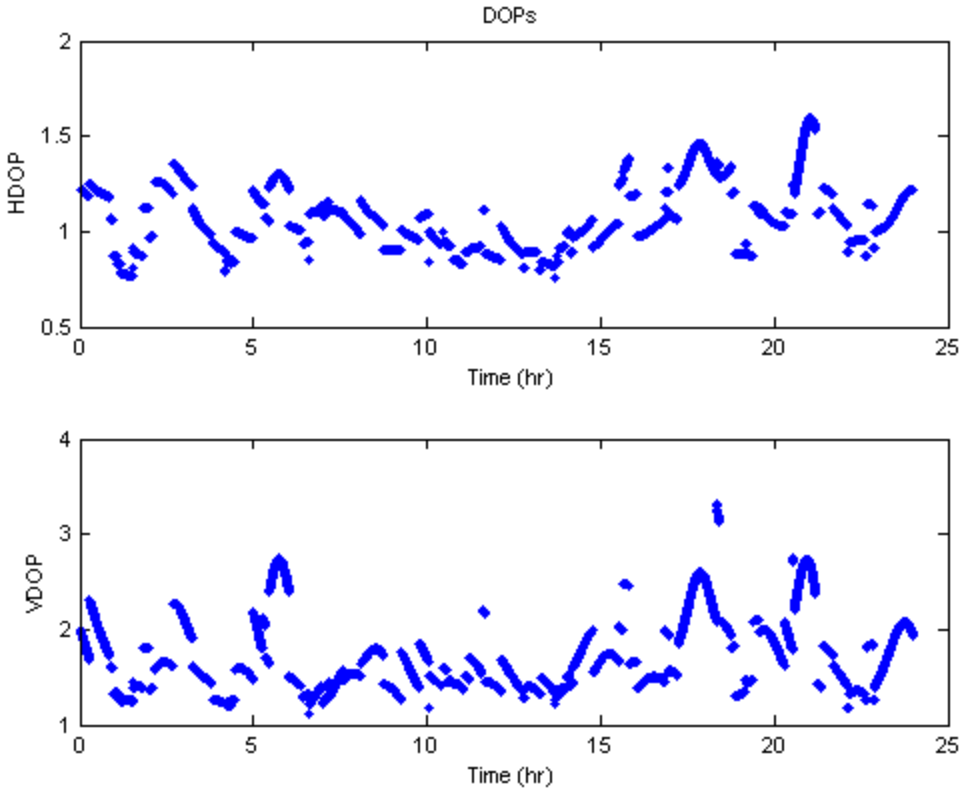

Pre-Fit Residuals
Pre-Fit Residuals (m)
Time (hr)


Pre-Fit Residuals (m)
SV Elevation (deg)


Post-Fit Residuals
Post-Fit Residuals (m)
Time (hr)


Post-Fit Residuals (m)
SV Elevation (deg)


Relative Position
E Rel Pos (m)
N Rel Pos (m)
U Rel Pos (m)
Time (hr)
10
0
-10
-20
5
15
20
25


DOPs
HDOP
VDOP
Time (hr)
2
1.5
1
0.5
4
3
5
10
15
20
25

```
function [glat, lon, h] = ECEF2ellipsoidal(r)
%ECEF2ellipsoidal Earth-Centered Earth-Fixed coords to ellipsoidal
% Longitude and Latitude are output radians
% Height h given in m


% fcnPrintQueue(mfilename('fullpath')) % Add this code to code app

%Misra & Enge, Ch 4
a = 6378137.0; % km
f = 1/298.257223563; %flattening
e = 2*f + f*f;

x = r(1);
y = r(2);
z = r(3);
lon = atan2(y,x);

p = sqrt(x*x+y*y);

glat = atan2(p,z);

lattol = 0.0001;
htol = 0.0001;
lat_err = lattol+1;
h_err = htol+1;
h = 0;
counter = 0;
while lat_err > lattol && h_err > htol && counter < 5
    hlast = h;
    latlast = glat;
    N = a/sqrt(1-e*e*sin(glat)*sin(glat));
    h = p/cos(glat)-N;
    glat = atan(z/(p*(1-e*e*N/(N+h))));
    lat_err = abs(latlast-glat);
    h_err = abs(hlast-h);
    counter = counter + 1;
end
%
% llh = [glat lon h]';

end
```

Published with MATLAB® R2013b

```
function R = R_ECEF2ENU(lat, lon)
fcnPrintQueue(mfilename('fullpath')); % Add this code to code app

s_lat = sin(lat);
s_lon = sin(lon);
c_lat = cos(lat);
c_lon = cos(lon);
R = [-s_lon c_lon 0;
    -s_lat*c_lon -s_lat*s_lon c_lat;
     c_lat*c_lon  c_lat*s_lon s_lat];
```

Published with MATLAB® R2013b

```
function [range0, range1, r_gps] = compute_range(eph, PRN, t, userpos)

% fcnPrintQueue(mfilename('fullpath'))
c = 2.99792458e8; %m/s
w = 7292115.0e-11; %rad/s Earth spin rate

GPS_Week = eph(1,19);

% Get the GPS SV vector
[~, r_gps,~,~,~] = broadcast2xv(eph,[GPS_Week t],PRN);
r_gps = r_gps'; % Vertical vectors
R = norm(r_gps-userpos);
range0 = R; % Uncorrected

% Iterate to correct the range for TOF
tol = 1e-6;
oldR = R + 1;
while abs(R-oldR) > tol

Tt = t - R/c;

[~, r_gps_Tt,~,~,~] = broadcast2xv(eph,[GPS_Week Tt],PRN);
r_gps_Tt = r_gps_Tt'; % Vertical vectors

phi = w*(t-Tt);

C = [cos(phi) sin(phi) 0;
    -sin(phi) cos(phi) 0;
    0 0 1];

r_gps = C*r_gps_Tt;

oldR = R;

R = norm(r_gps-userpos);

end

range1 = R;
```

Published with MATLAB® R2013b