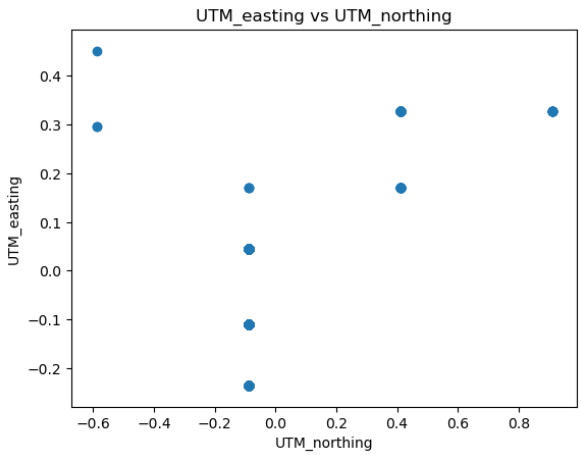
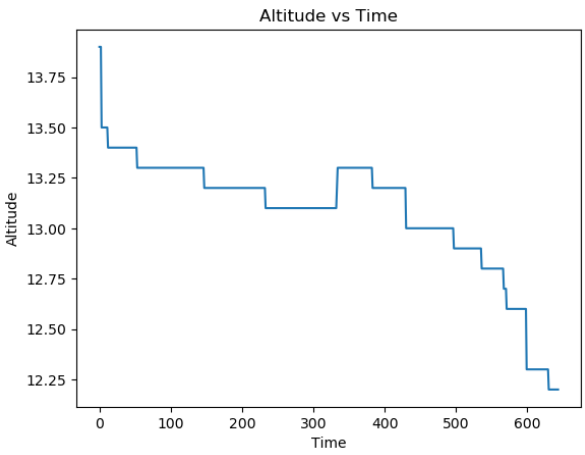
Analysing stationary_bag.bag:





I plotted UTM_easting vs UTM_northing plot to understand the location of the gps puck and plotted altitude vs time to see how altitude is varying across time. I did not include altitude information in UTM_easting vs UTM_northing plot because altitude data is independent of UTM data so it made more sense to plot it seperately. Ideally, there should not be any deviation in the altitude, and UTM values. But, because of satellite and signal propagation errors, we do not get constant values. Instead, we get data that fluctuates ever so slightly over the time while collecting the data. I subtracted the UTM values from their mean for better visualization. The spread of error in UTM_easting and UTM_northing is around 0.7 and 1.5 respectively, which is not too high. RSME values for UTM_easting and UTM_northing are shown below:

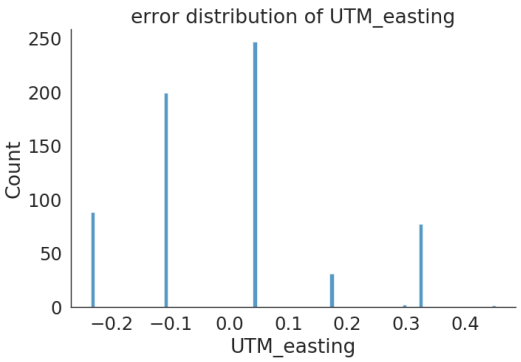
```
get_rsme('UTM_easting')
```

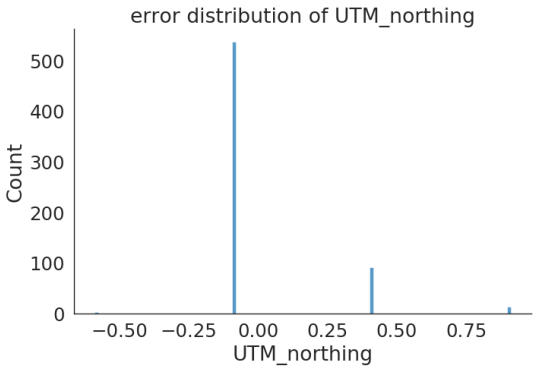
```
0.16409844836448423
```

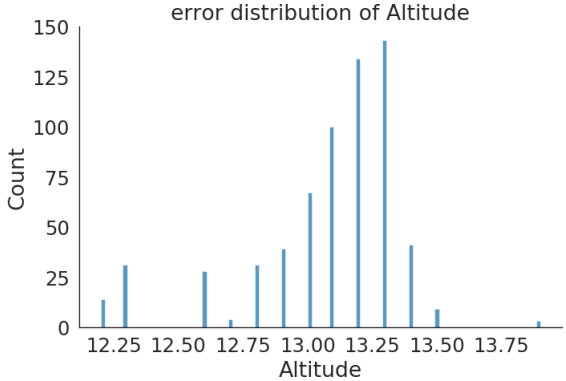
```
get_rsme('UTM_northing')
```

```
0.22157003095137695
```

Same goes for altitude, there is a fluctuation of about 1 m because of the errors discussed above. The distribution of noise in the data collected is not a normal curve, it is just random. The below figure shows the UTM_easting's, UTM_northing's and Altitude's error distribution curves:







I have also calculated the upper bound, lower bound and mean of the data.

```
get_bounds('UTM_easting')
```

```
upper bound : 0.45191187888849527
mean: 6.507688797778965e-12
lower bound : -0.23558812111150473
```

```
get_bounds('UTM_northing')
```

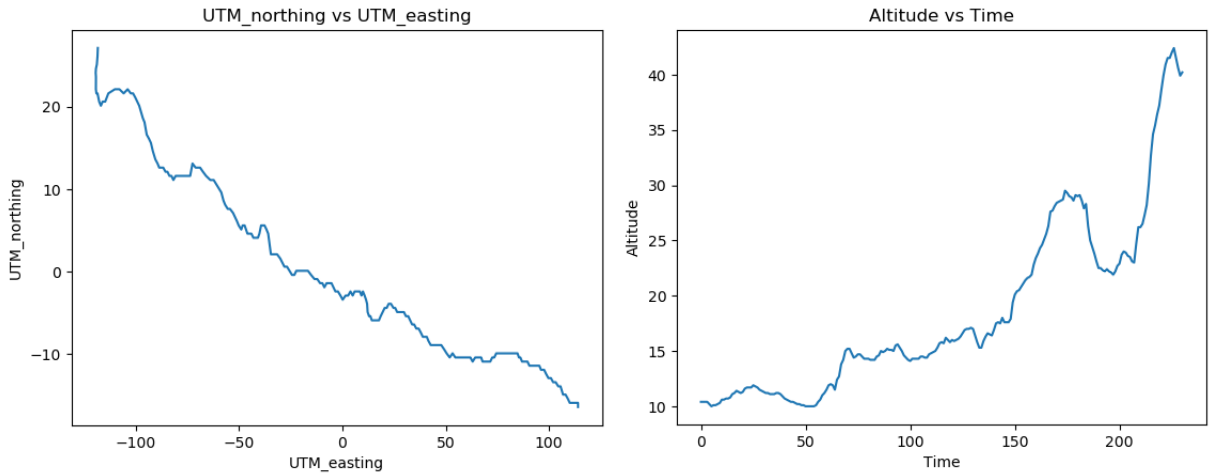
```
upper bound : 0.9107142854481936
mean: -2.66092164175851e-10
lower bound : -0.5892857145518064
```

```
get_bounds('Altitude')
```

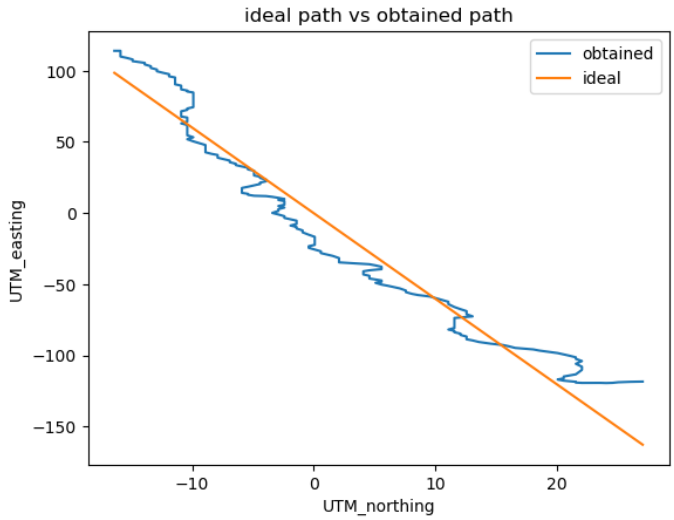
```
upper bound : 13.899999618530272
mean: 13.074378924340195
lower bound : 12.199999809265137
```

The Zone stayed the same throughout the data collection (which is 19). Although there is some noise in the data, we can understand that the puck is sitting still by looking at the graphs.

Analysing walking_bag.bag:



I walked for around 200 meters in a straight line. There's a slight deviation from the straight line in both UTM_northing vs UTM_easting data because signal propagation errors and multi-path. I subtracted the UTM values from their mean in these visualizations too. The altitude changed as I walked along because the path that I took had a slope but still the change in altitude is too high. This might be because of the some kind of error caused by urban environment. The Zone stayed the same (19) just like before. The error estimate or fluctuation from the ground truth seems to be at a minimum compared to the stationary data. I made an ideal vs obtained plot for UTM_easting vs UTM_northing graph. I got the ideal line from the best line fit method



RMSE error between the best fit line and the obtained data is 15.87