AMCS Antenna Rotation Test

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Summary

An antenna test was conducted at UNAVCO in order to determine the effect of antenna rotation on carrier phase observations, a possible concern for the AMCS feed antenna or the parabolic antenna. For the test, two Trimble 4000SSI's were run concurently on the UNAVCO roof. One antenna was fixed and one antenna was rotated. Both receivers were run with a 15 second sampling interval and choke ring antennas (TRM29659.00) were used. One antenna was rotated 360 degrees about the vertical axis approximately every 30 minutes. The following times are when the antenna was rotated: 20:05, 20:30, 21:06, 21:30, 22:00, and 22:30. The data were then run through teqc with 7 different elevation angle cutoffs (0, 5, 10, 15, 20, 25, 30) in order to look for possible elevation angle dependencies. The rotation of the antenna is denoted by the large spike seen in the .iod output file from teqc (Estey and Meertens, 1999), please refer to Figure 1. The .iod is the time derivative of the ionospheric linear combination, .ion.

A jump in the .ion output file from teqc therefore corresponds to a spike in the .iod file. The magnitude of the jump seen in the top part of Figure 1 is given by the following equation (reference 1):

$$IOD = \frac{\alpha}{\alpha - 1}\frac{[(L_1 - L_2)_j - (L_1 - L_2)_{j-1}]}{(t_j - t_{j-1})}$$

Where

$$\alpha = \frac{f_1^2}{f_2^2} = \frac{1575.42^2}{1227.60^2} = 1.6469$$

L_i = Phase observable for frequency i (i.e RINEX L1 or L1, converting to distance)

f_i = Frequency

t_j = Time at given epoch (for our case j-1 = 0). For a sample interval of 15 seconds and converting to teqc iod units of meters per minute:

$$t_j - t_{j-1} = \frac{15}{60} = 4$$

For a single rotation of the antenna of 360 degrees, a full cycle of L1 and L2 is expected yielding:

$$(L_1 - L_2)_j - (L_1 - L_2)_{j-1} = (0.19 - 0.244) - 0$$

$$IOD = 2.5458(0.054)4 = 0.550\frac{meters}{minute}$$

Spikes with a magnitude of approximately 0.550 meters per minute can be seen in the top part of Figure 1 in the .iod.

Figures 2 and 3 show that the magnitude of the jump is the same for all elevation cutoffs (0, 5, 10, 15, 20, 25, 30). Figure 3 shows a zero degree elevation angle cutoff along with a 30 degree elevation angle cutoff, again showing the same magnitude. Figure 4 shows that the .ion files also have the same magnitude jump for all elevation angle cutoffs (only 4 cutoffs shown in picture). The offsets are approximately 15 cm in 15 seconds, or corresponding to the expected iod of 0.55 meters per minute. Figures 5 and 6 show a zoomed in view of one rotation at approximately 21:30 UTC, or at epoch 5157. Carrier phase processing using Bernese 4.2 was done on the short baseline between the antennas. Figure 7 shows the double difference residual files for L1, L2, L3(ionosphere free combination), and L4(ionosphere combination) respectively. There is no apparent offset seen in these double difference carrier phase residuals. The antenna rotation effects difference out.

In conclusion, by rotating the antenna 360 degrees, one will see a spike of approximately 0.55 meters per minute in the .iod. This spike does not appear to have an elevation angle cutoff dependence.

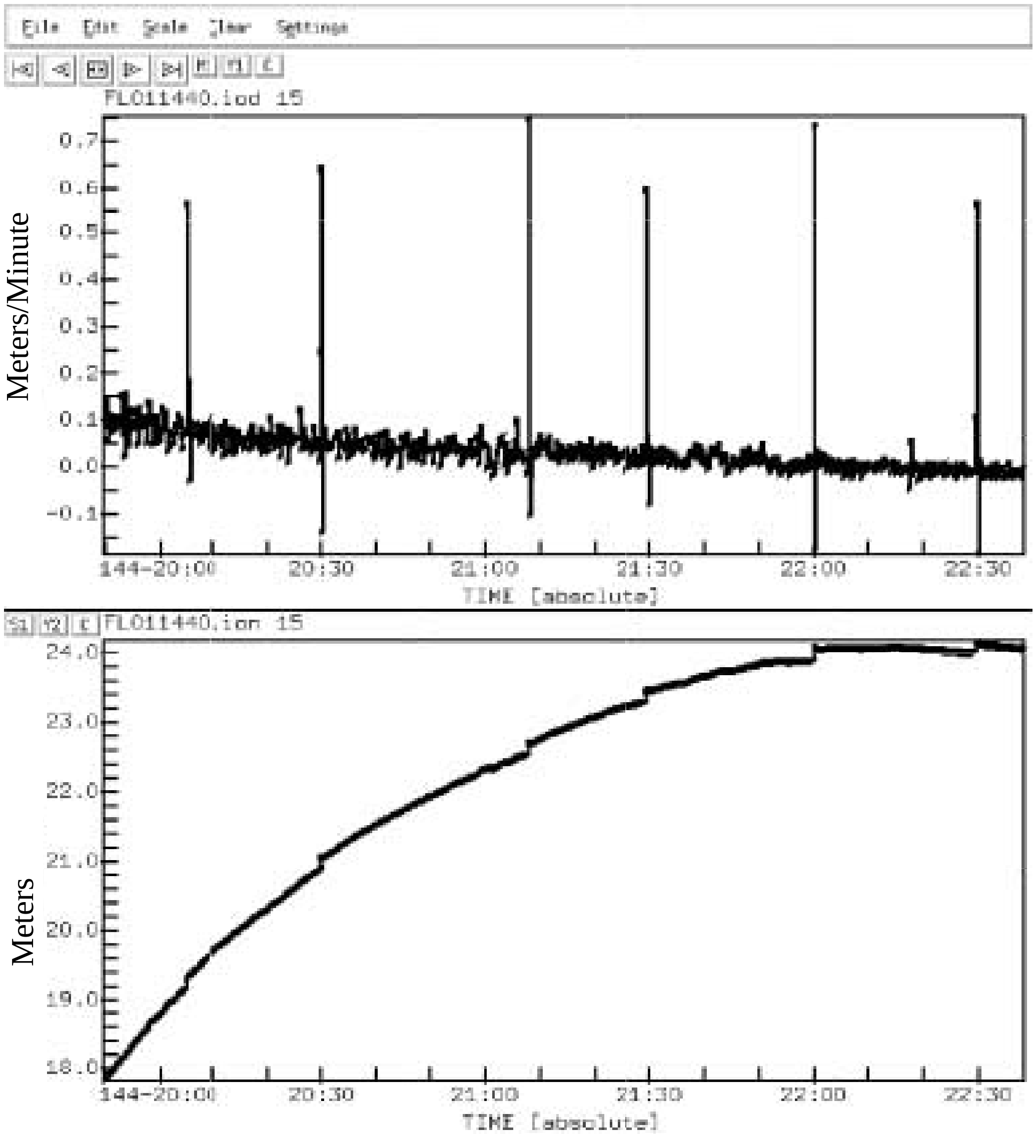

Figure 1: These graphs show that for each jump seen in the .iod output file from teqc, there is a corresponding jump in the .ion output file as well.

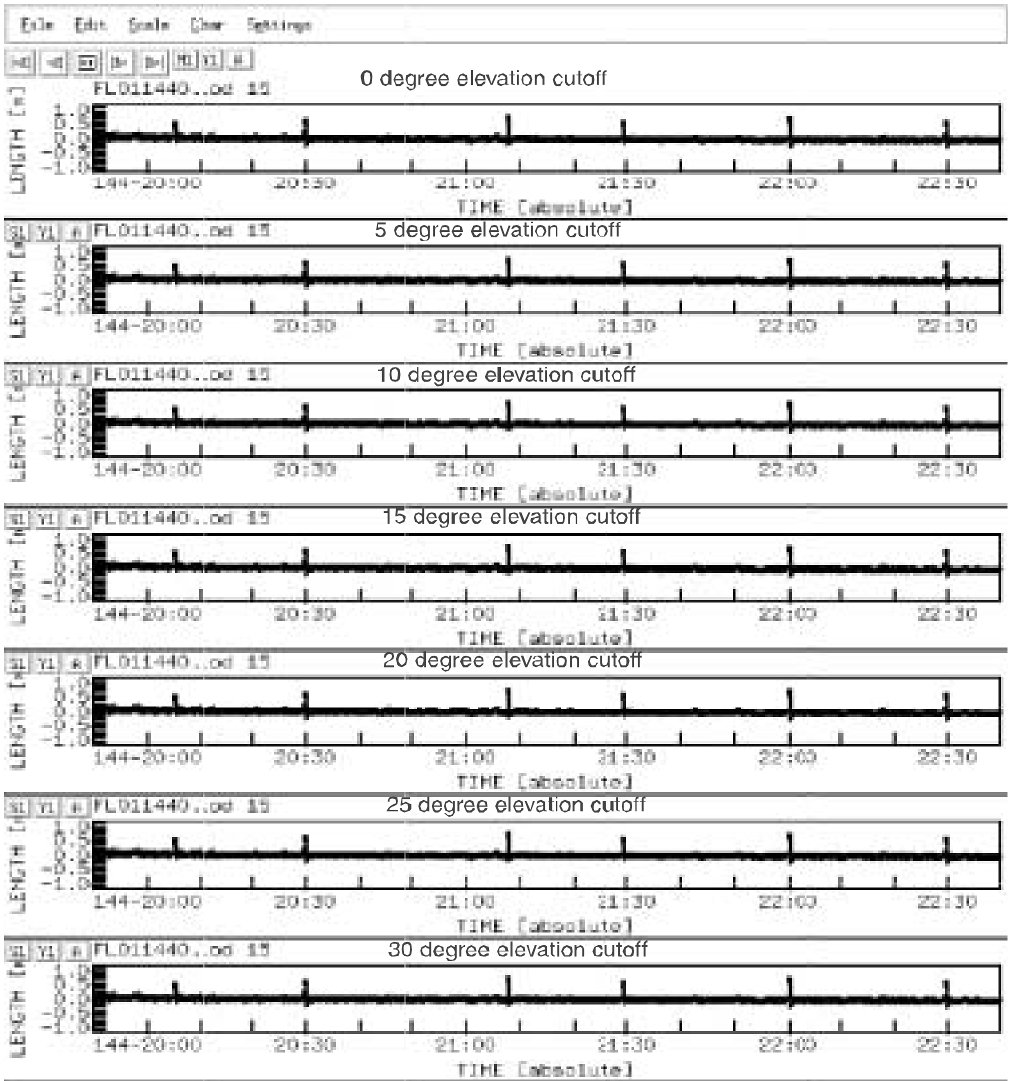

Figure 2: Shows all elevation angle cutoffs on the same scale for satellite 15.

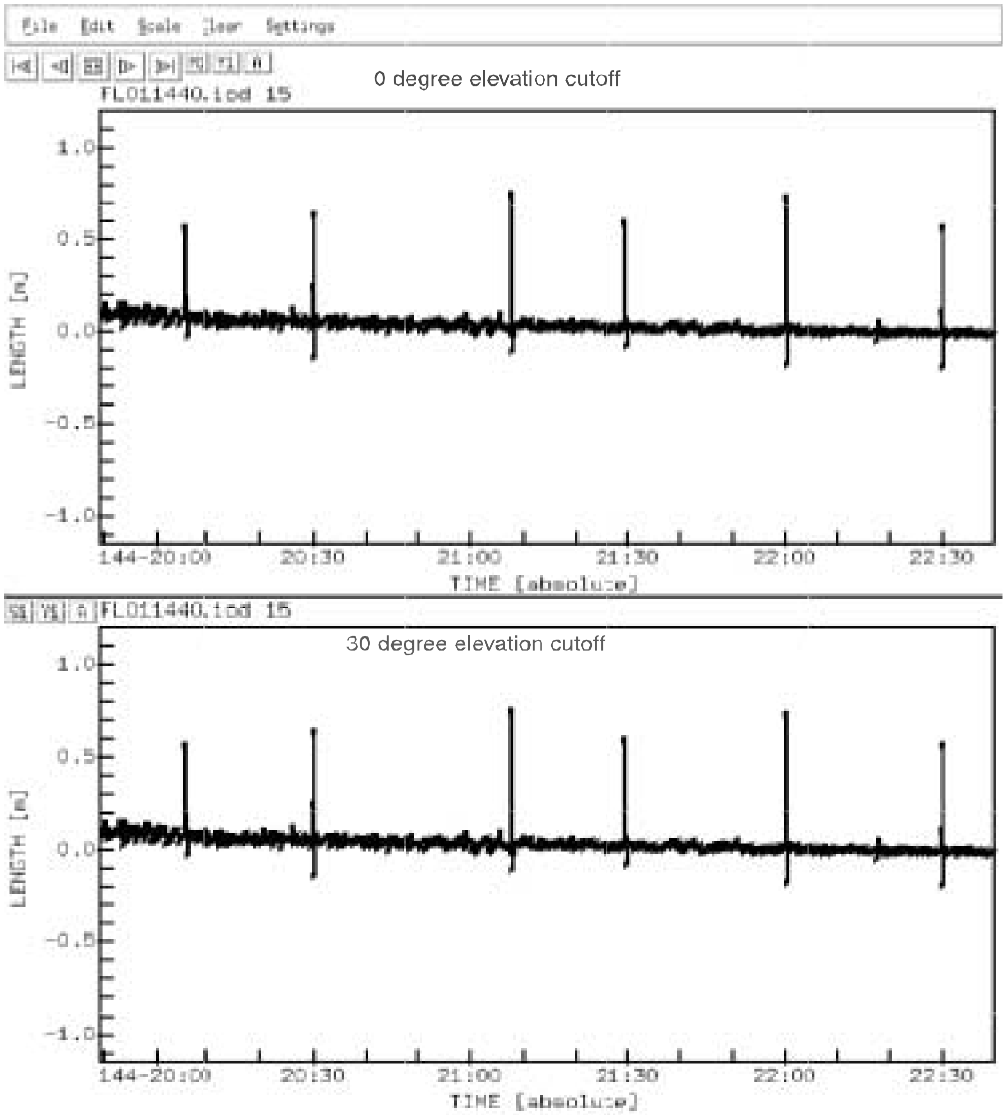

Figure 3: This graph shows the .iod files output by teqc. It also shows that the jump introduced is the same for a zero degree elevation angle cutoff and a 30 degree elevation angle cutoff (graph on bottom)

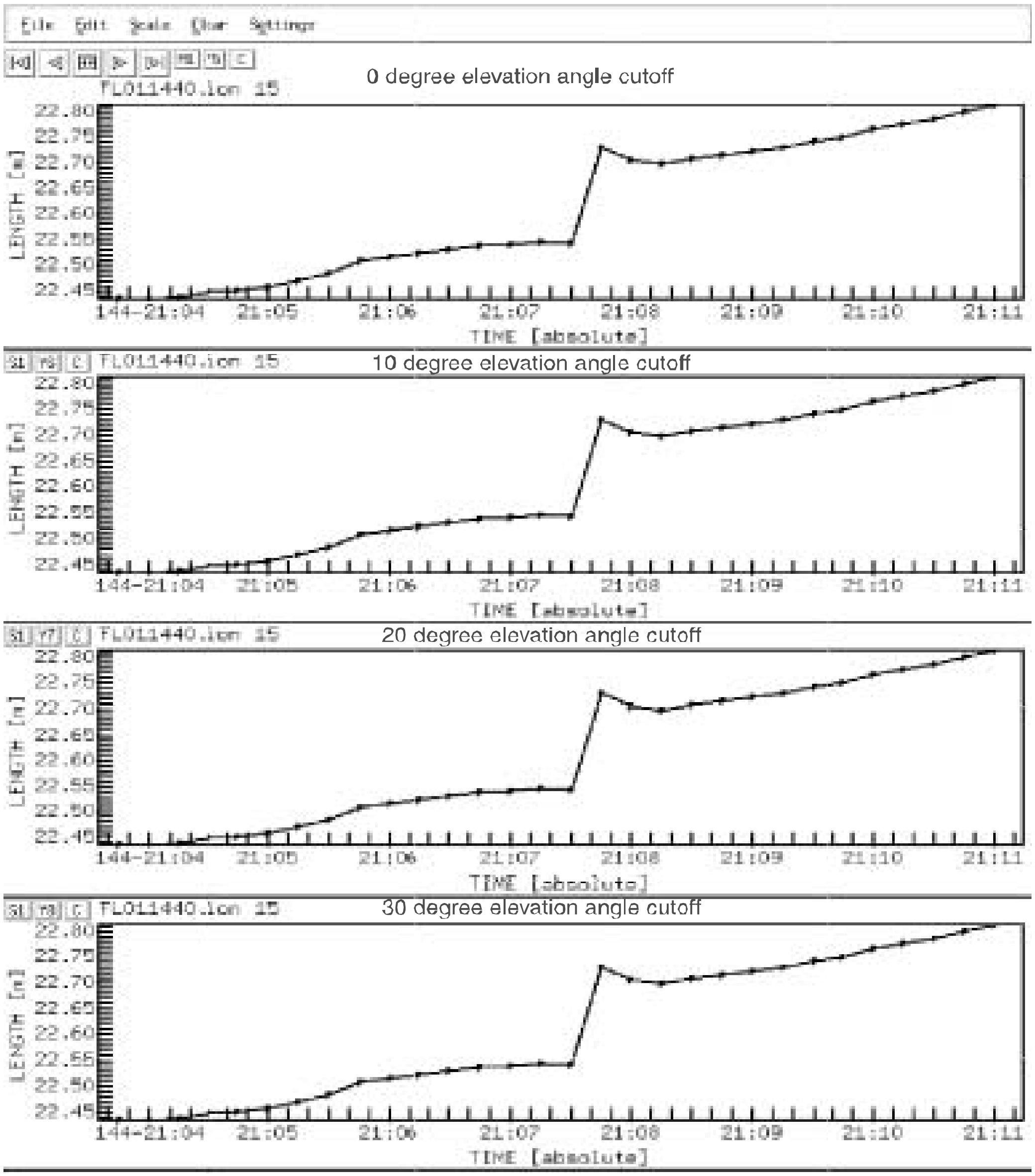

Figure 4: Shows that the magnitude of the jump in the .ion output file from teqc is the same magnitude for different elevation angle cutoffs.

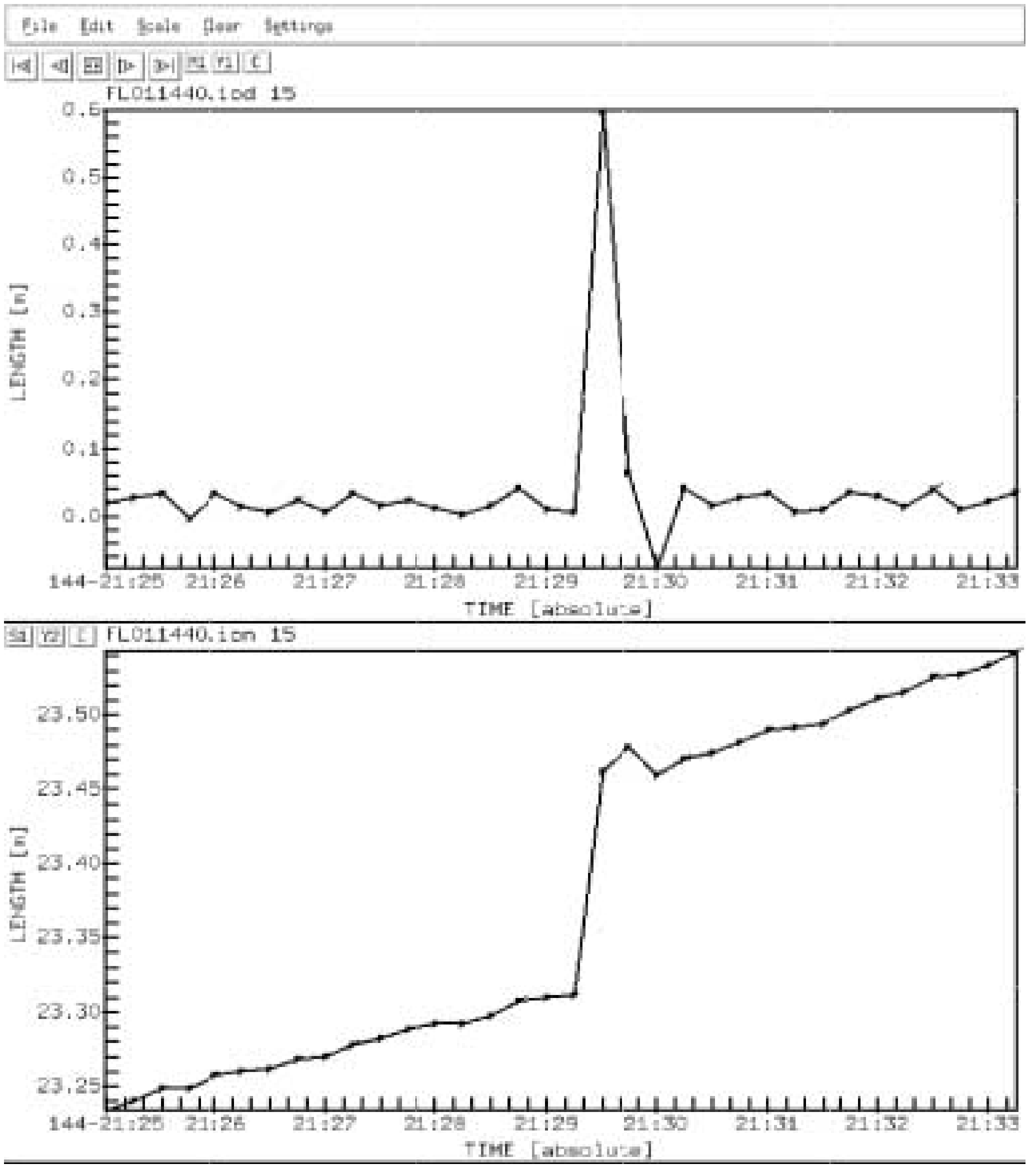

Figure 5: Zoomed in view of one 360 degree rotation with the x axis showing time in hours and minutes.

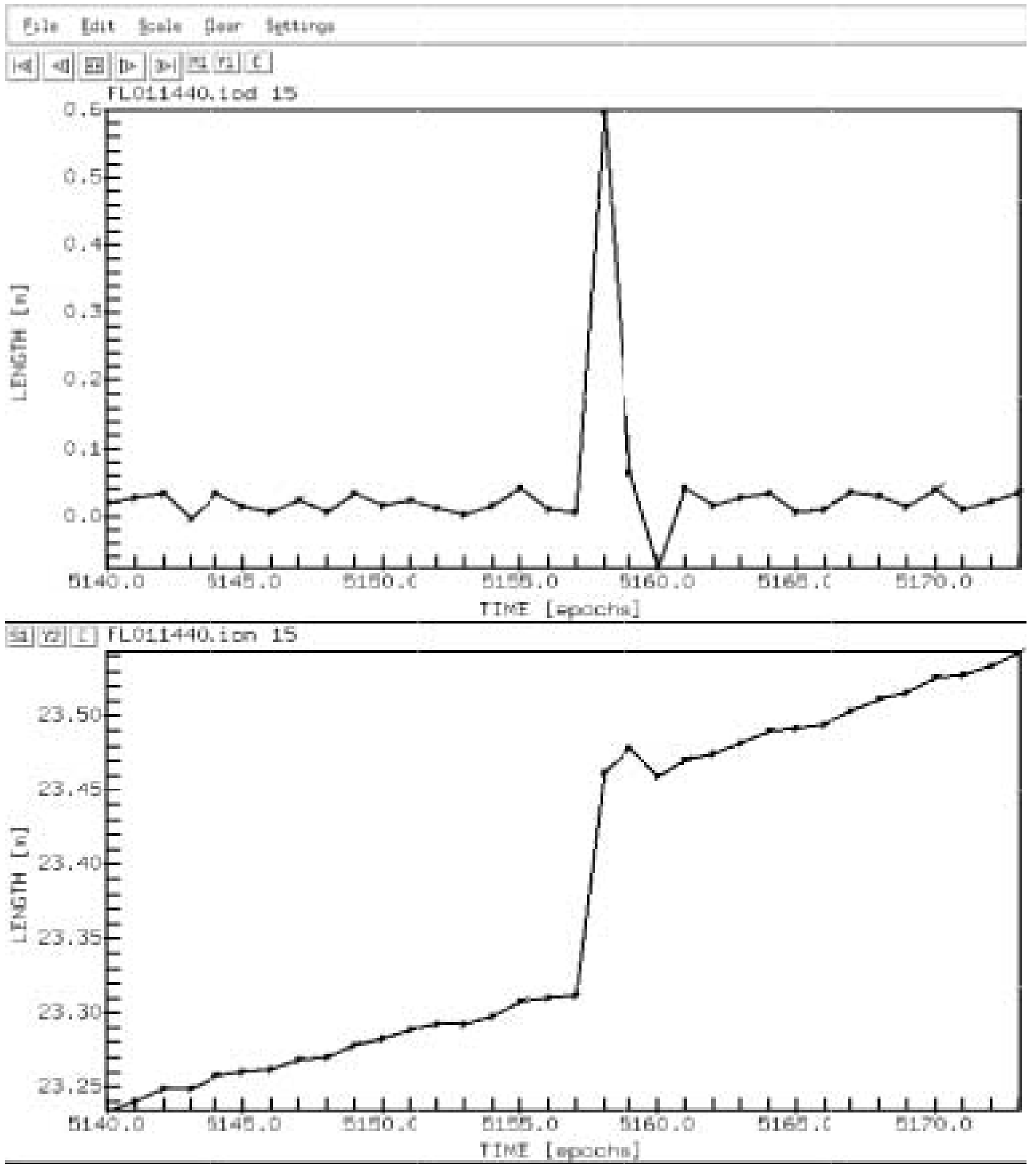

Figure 6: Zoomed in view of one 360 degree rotation with the x axis showing epochs.

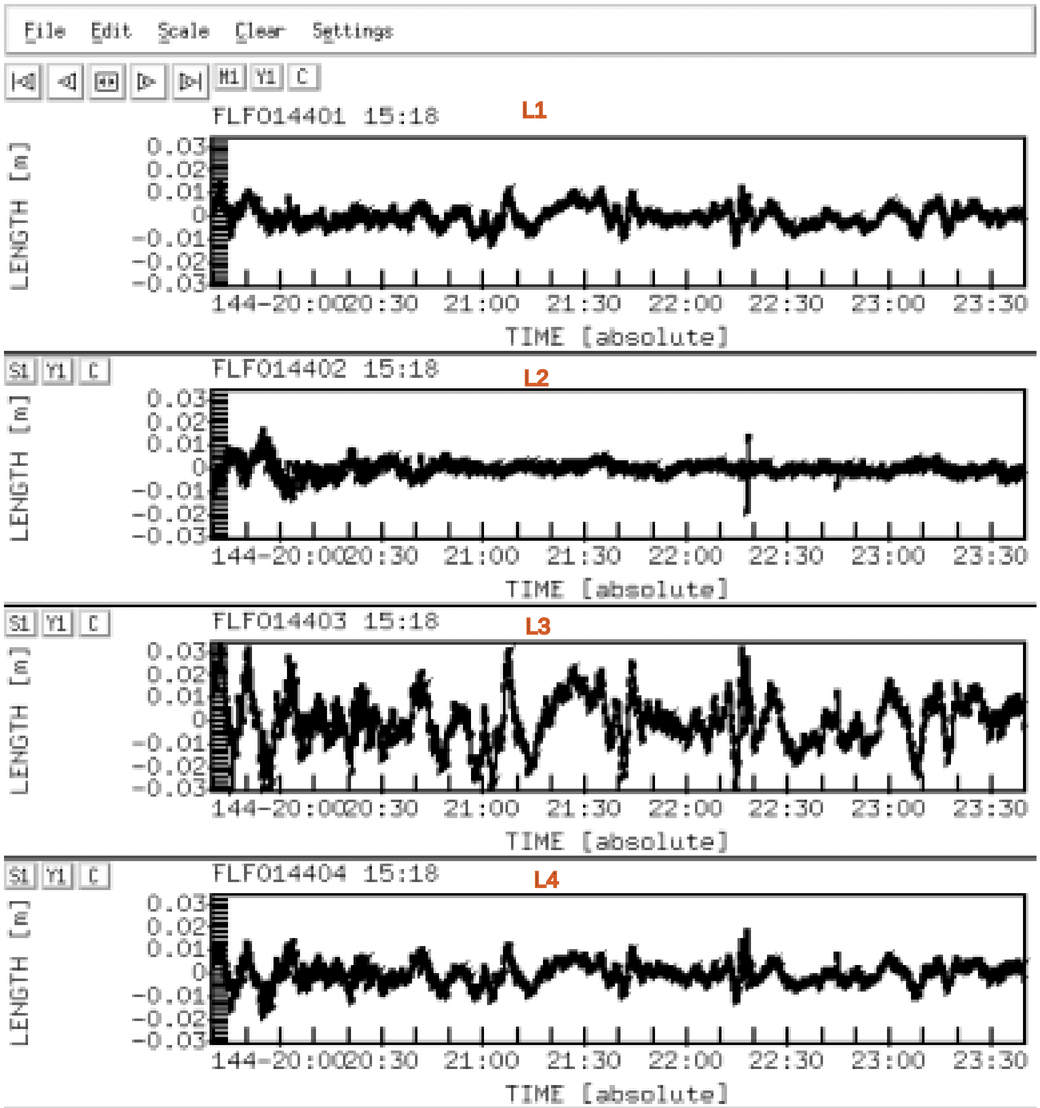

Figure 7 - Double difference residuals for L1, L2, L3, and L4 respectively.

Acknowledgements

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References

Estey, Meertens. TEQC: The Multi-Purpose Toolkit for GPS/GLONASS Data. GPS Solutions, Vol 3, No. 1, pp. 42-49 (1999).