ENGO 500 - Geomatics Engineering Project

Professor: Michael J. Collins

Error Detection Software Evaluation Report

Project 7: GNSS relative accuracy improvements for agriculture

Advisor: Greg Roesler PEng., Novatel / Hexagon

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Introduction:

      The primary goal of our simulation software was to evaluate how well our error detection software worked by simulating real errors through positioning data and sending the data to the error detection software to assess. This report will analyze the results of some of our simulations by comparing the expected perfect error detection results with what our software was actually able to detect. The methodology section will outline what is being plotted in MATLAB while the results section will portray the plots to compare the error detection to the simulation. The next steps section discusses how the error detection software could be improved moving forward.

Methodology:

      The plots below show the differences between the individual epoch jump, drift, and total error as well as the cumulative and absolute values of those three statistics in both coordinate axes. The cumulative error, jump, and drift is the sum of each of those errors up to the current epoch. The first four plots deal with drift, the following four with jump, and the final four with total error. This set is repeated three times, the first time with both northing and easting errors, the second with only simulated easting errors, and the final time with only northing simulated errors. The individual error plots show the difference between the two values as opposed to plotting both together.

Results:

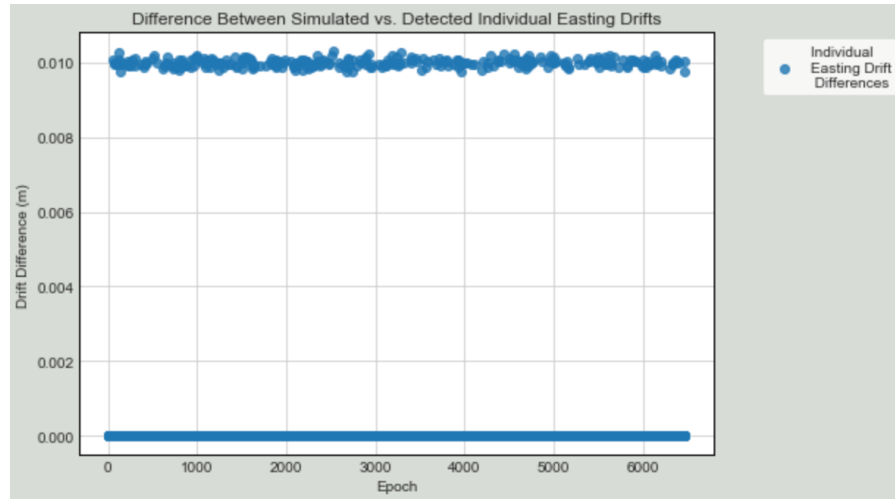## Northing and Easting Drift Error Comparison:

Figure 1: Individual Easting Drift of Simulated vs Detected Errors

The figure above shows the individual easting drift of the simulated set vs the detected set. Any difference between either line shows where drift occurred but wasn't detected by the software.
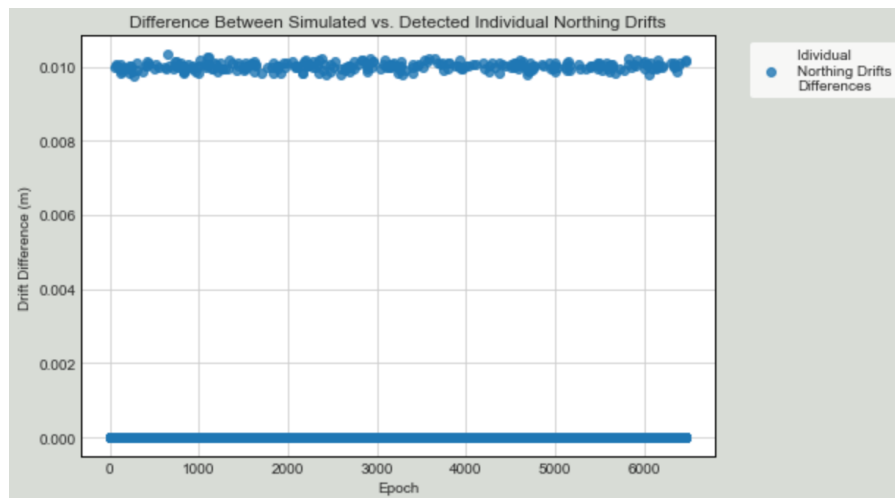

Figure 2: Individual Northing Drift of Simulated vs Detected Errors

The figure above shows the individual northing drift of the simulated set vs the detected set. Any difference between either line shows where drift occurred but wasn't detected by the software.
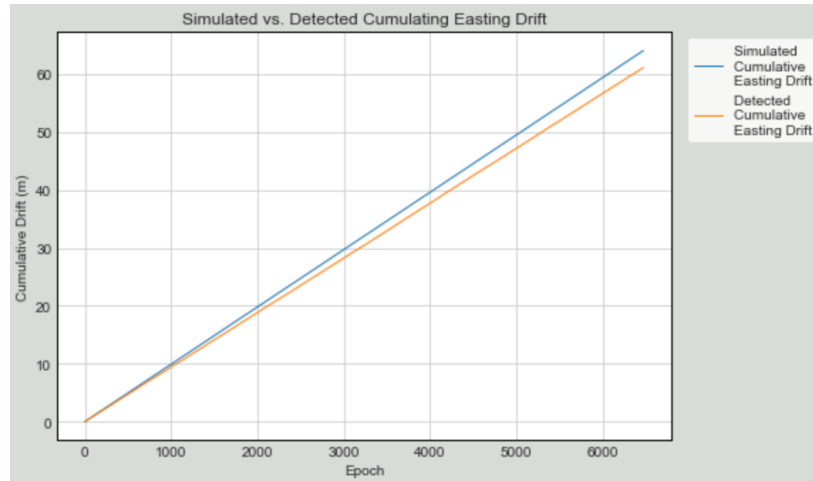
Figure 3: Cumulative Easting Drift of Simulated vs Detected Errors

The figure above shows the cumulative easting drift that takes into account all the previous epoch drifts of the simulated set vs the detected set. Any difference between either line shows where drift occurred but wasn't detected by the software.
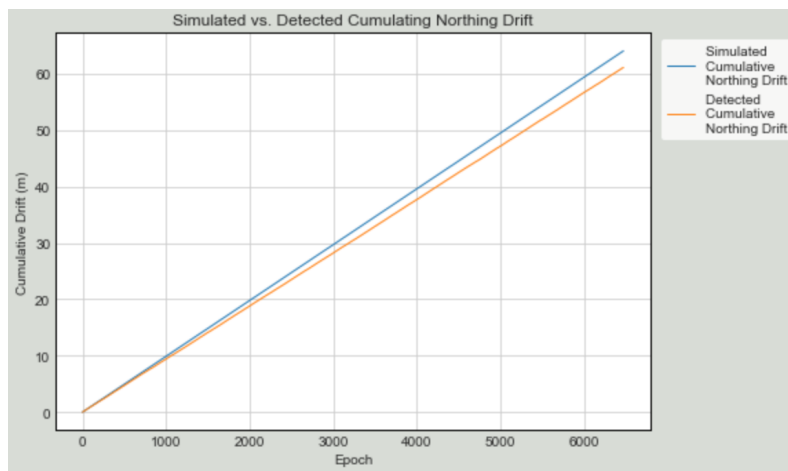

Figure 4: Cumulative Northing Drift of Simulated vs Detected Errors

The figure above shows the cumulative northing drift that takes into account all the previous epoch drifts of the simulated set vs the detected set. Any difference between either line shows where drift occurred but wasn't detected by the software.

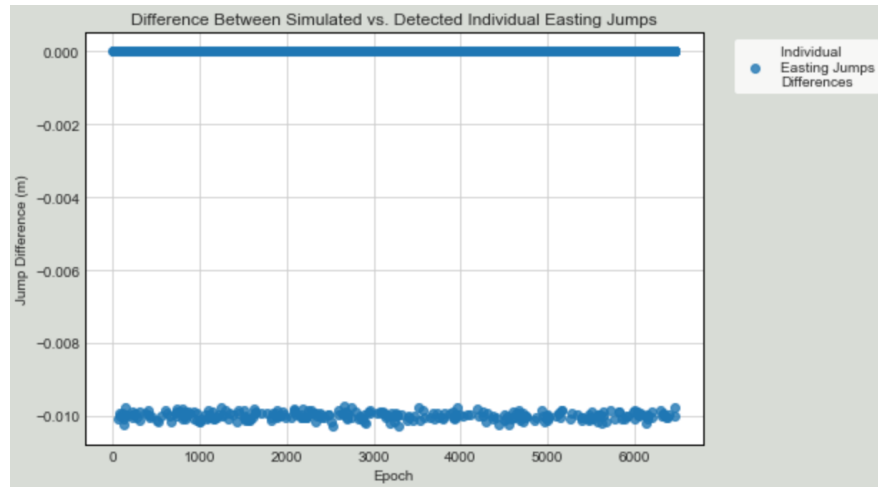# Northing and Easting Jump Error Comparison:

Figure 5: Individual Easting Jump of Simulated vs Detected Errors

The figure above shows the individual easting jump of the simulated set vs the detected set. Any difference between either line shows where jumps occurred but weren't detected by the software.

Figure 6: Individual Northing Jump of Simulated vs Detected Errors

The figure above shows the individual northing jump of the simulated set vs the detected set. Any difference between either line shows where jumps occurred but weren't detected by the software.
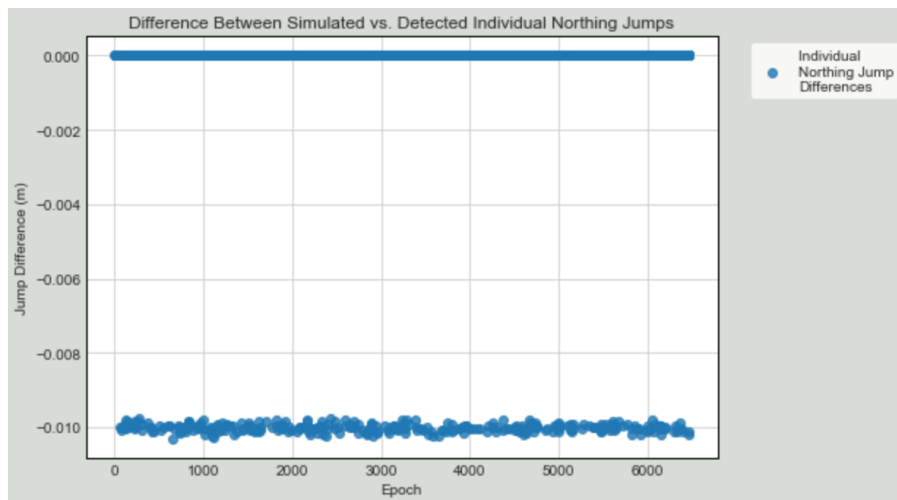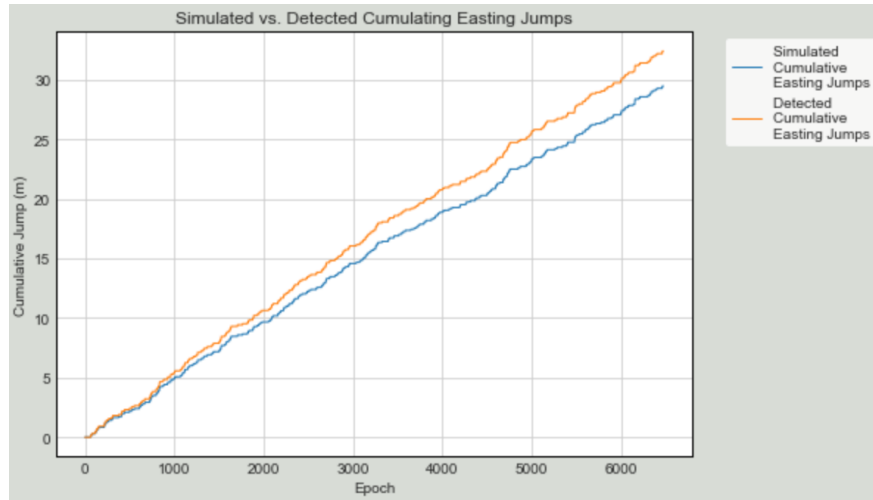
Figure 7: Cumulative Easting Jump of Simulated vs Detected Errors

The figure above shows the cumulative easting jump that takes into account all the previous epoch jumps of the simulated set vs the detected set. Any difference between either line shows where jumps occurred but weren't detected by the software.

Figure 8: Cumulative Northing Jump of Simulated vs Detected Errors

The figure above shows the cumulative northing jump that takes into account all the previous epoch jumps of the simulated set vs the detected set. Any difference between either line shows where jumps occurred but weren't detected by the software.
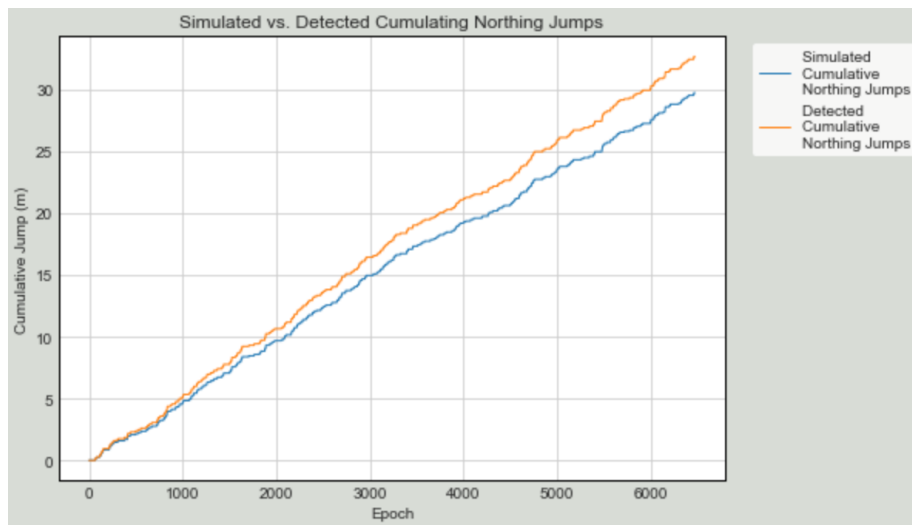
Northing and Easting Combined Error Comparison:

Figure 9: Individual Easting Error of Simulated vs Detected Errors

The figure above shows the individual easting error of the simulated set vs the detected set. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.

Figure 10: Individual Northing Error of Simulated vs Detected Errors

The figure above shows the individual northing error of the simulated set vs the detected set. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
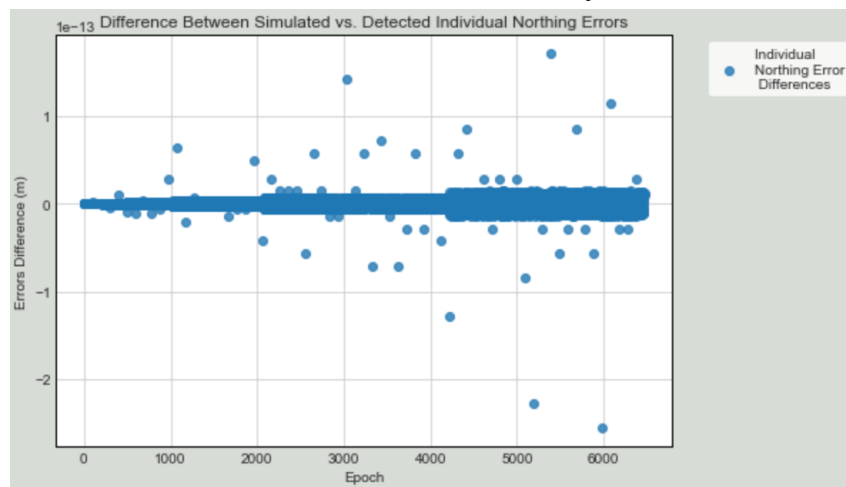
Figure 11: Cumulative Easting Error of Simulated vs Detected Errors

The figure above shows the cumulative easting error of the simulated set vs the detected set. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
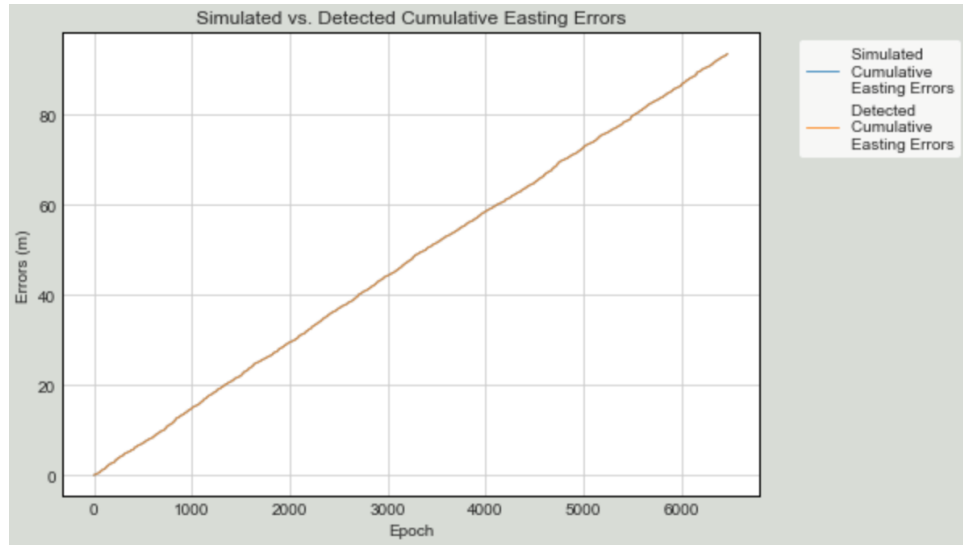

Figure 12: Cumulative Northing Error of Simulated vs Detected Errors

The figure above shows the cumulative northing error of the simulated set vs the detected set. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
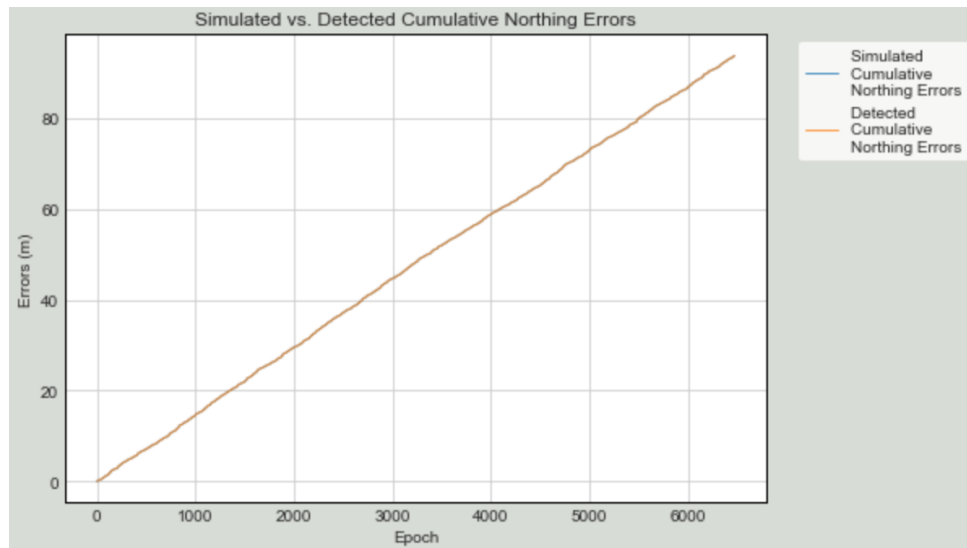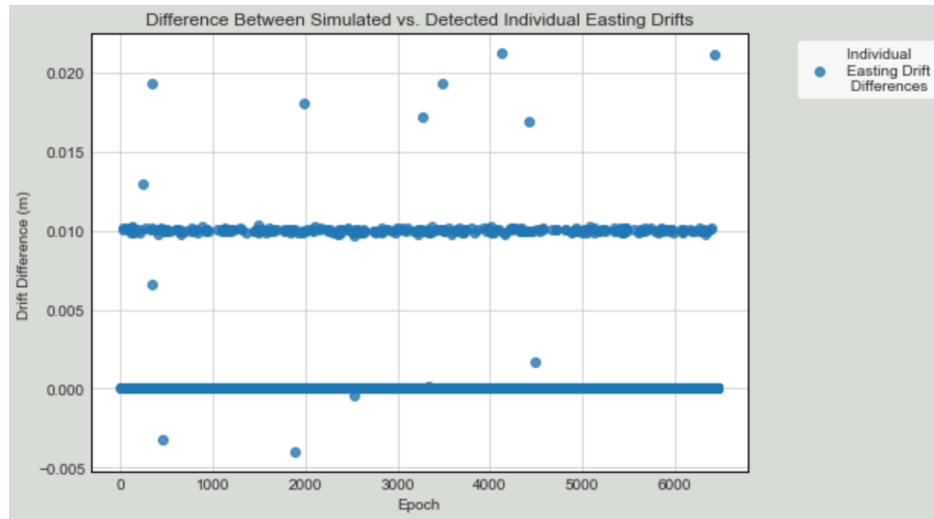
Easting Drift Error Comparison:

Figure 13: Individual Easting Drift of Simulated vs Detected Errors

The figure above shows the individual easting drift of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where drift occurred but wasn't detected by the software.

Figure 14: Individual Northing Drift of Simulated vs Detected Errors

The figure above shows the individual northing drift of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where drift occurred but wasn't detected by the software.
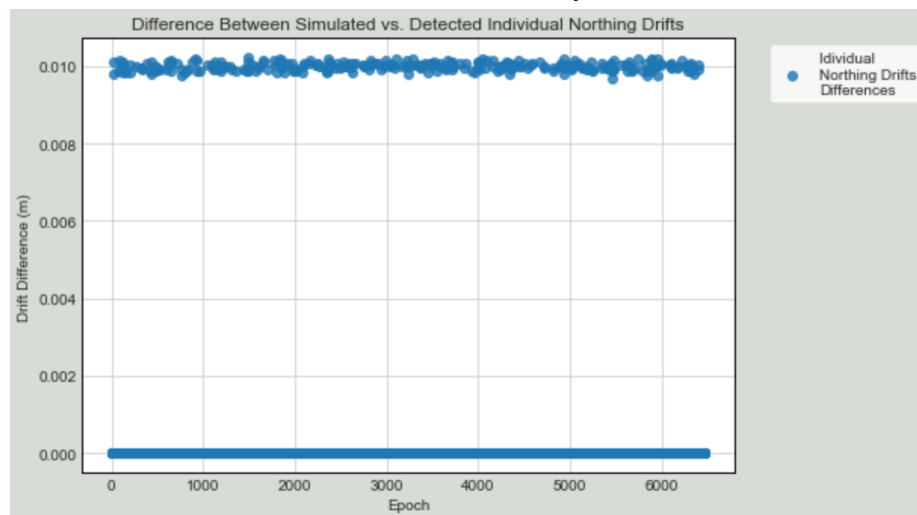
Figure 15: Cumulative Easting Drift of Simulated vs Detected Errors

The figure above shows the cumulative easting drift that takes into account all the previous epoch drifts of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where drift occurred but wasn't detected by the software.
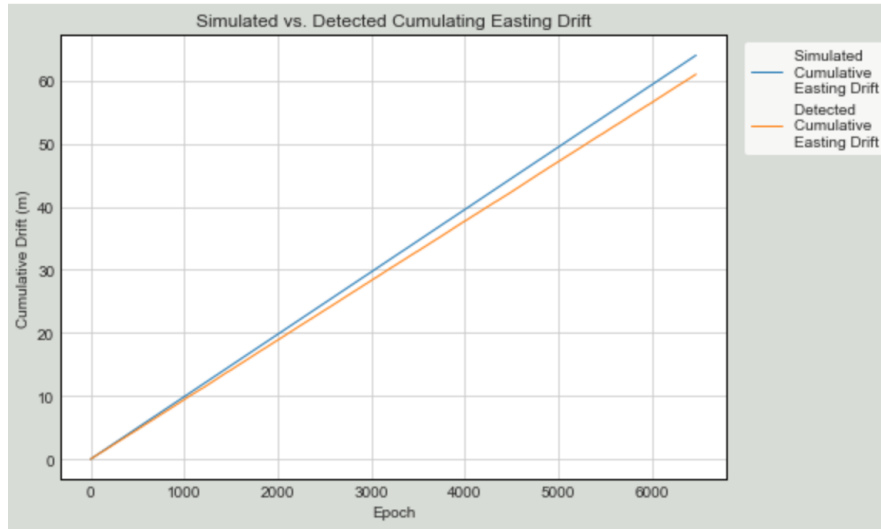

Figure 16: Cumulative Northing Drift of Simulated vs Detected Errors

The figure above shows the cumulative northing drift that takes into account all the previous epoch drifts of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where drift occurred but wasn't detected by the software.
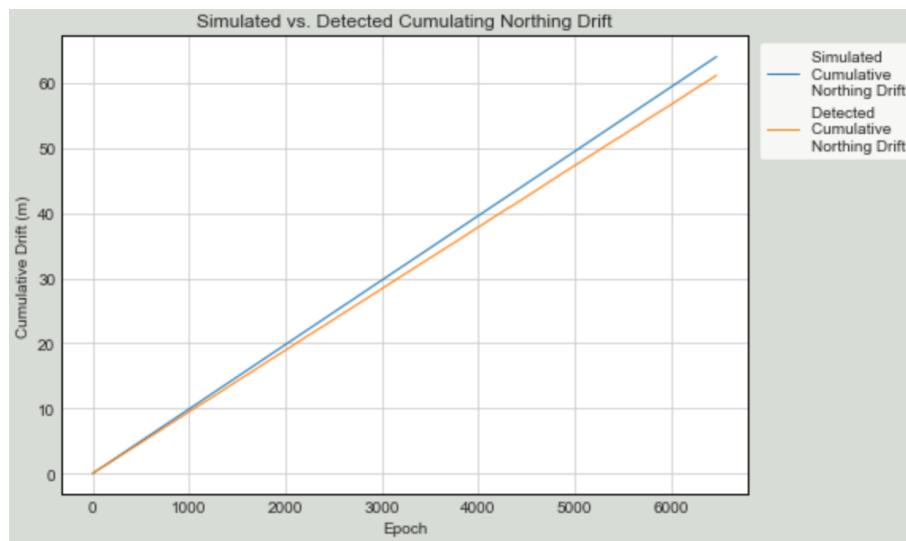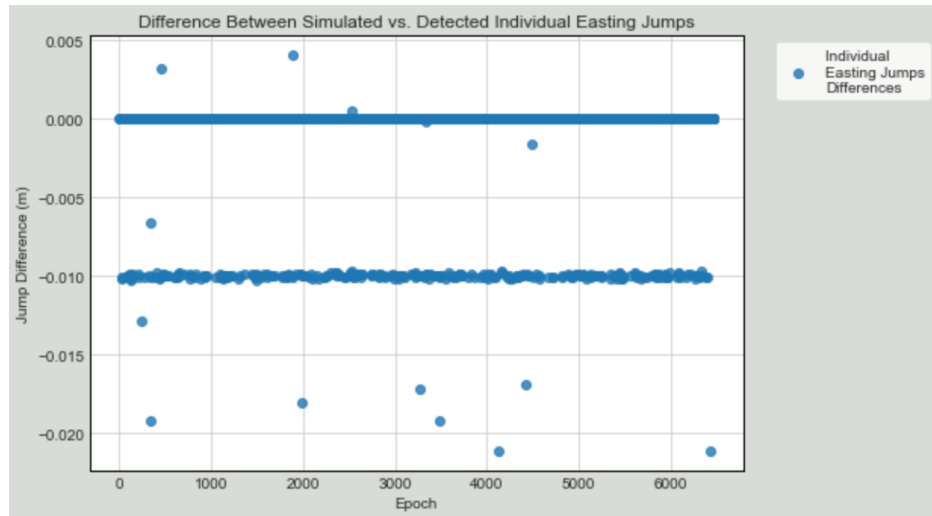
Easting Jump Error Comparison:

Figure 17: Individual Easting Jump of Simulated vs Detected Errors

The figure above shows the individual easting jump of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where jumps occurred but weren't detected by the software.

Figure 18: Individual Northing Jump of Simulated vs Detected Errors

The figure above shows the individual northing jump of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where jumps occurred but weren't detected by the software.
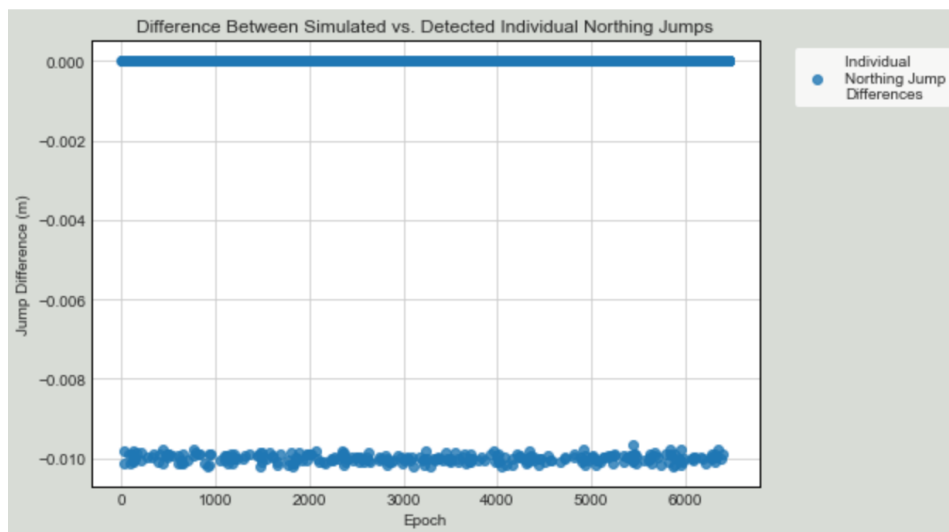
Figure 19: Cumulative Easting Jump of Simulated vs Detected Errors

The figure above shows the cumulative easting jump that takes into account all the previous epoch jumps of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where jumps occurred but weren't detected by the software.
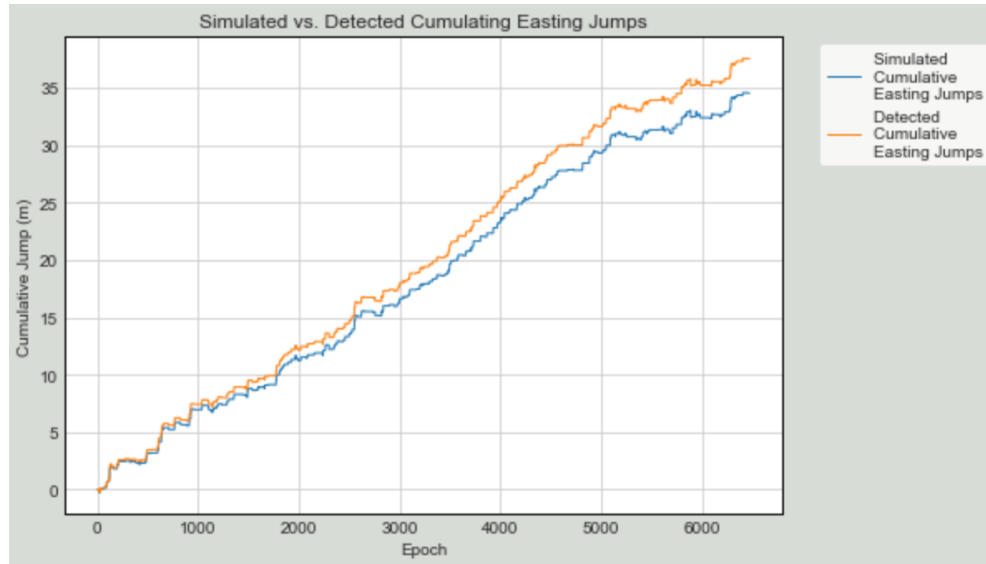

Figure 20: Cumulative Northing Jump of Simulated vs Detected Errors

The figure above shows the cumulative northing jump that takes into account all the previous epoch jumps of the simulated set vs the detected set for errors only simulated in the easting. Any difference between either line shows where jumps occurred but weren't detected by the software.
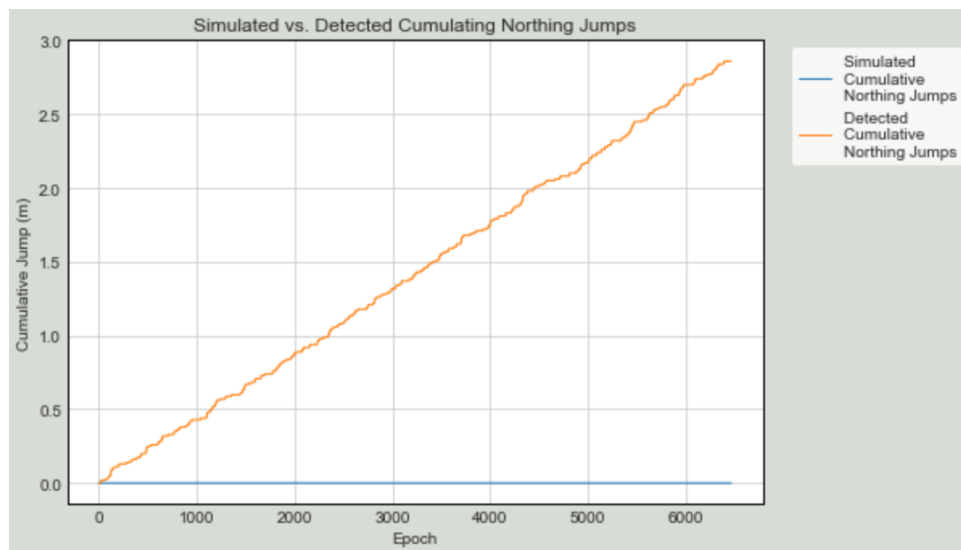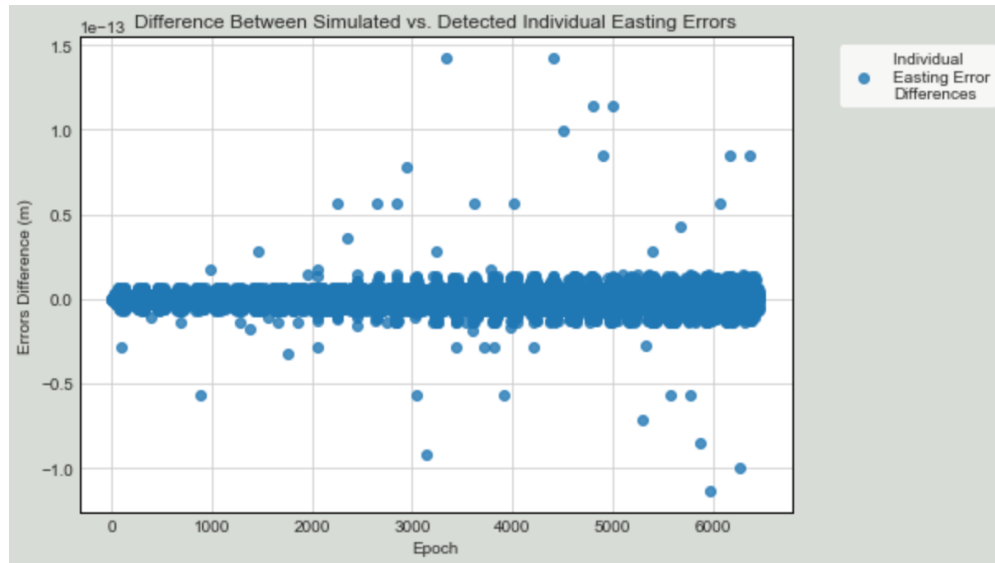
Easting Combined Error Comparison:

Figure 21: Individual Easting Error of Simulated vs Detected Errors

The figure above shows the individual easting error of the simulated set vs the detected set for errors only simulated in the easting. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.

Figure 22: Individual Northing Error of Simulated vs Detected Errors

The figure above shows the individual northing error of the simulated set vs the detected set for errors only simulated in the easting. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
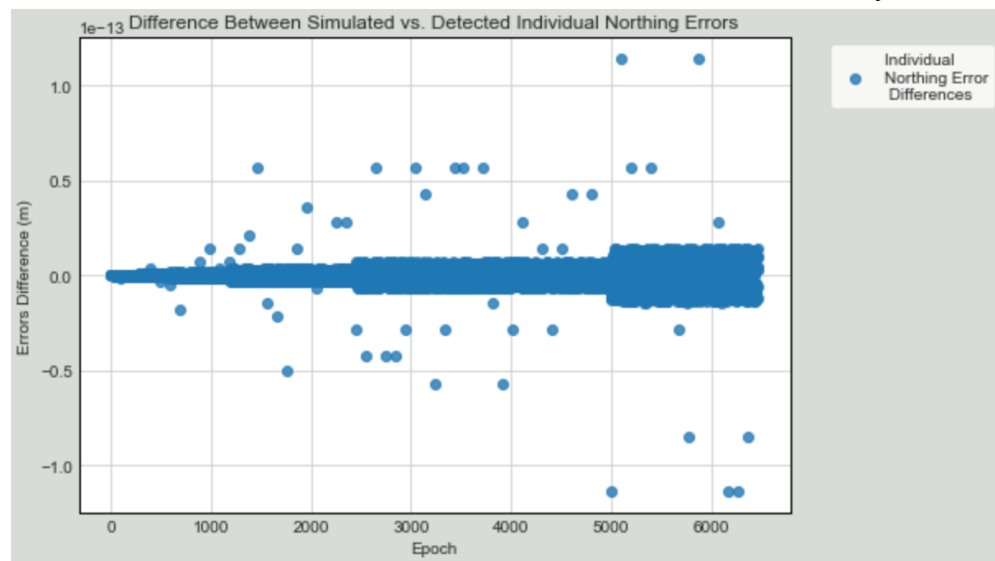
Figure 23: Cumulative Easting Error of Simulated vs Detected Errors

The figure above shows the cumulative easting error of the simulated set vs the detected set for errors only simulated in the easting. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
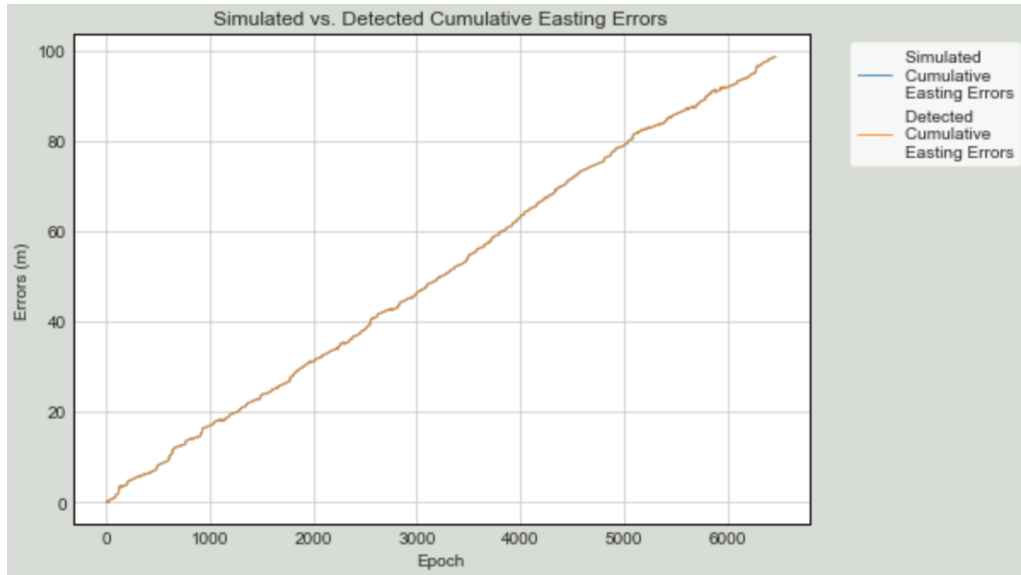

Figure 24: Cumulative Northing Error of Simulated vs Detected Errors

The figure above shows the cumulative northing error of the simulated set vs the detected set for errors only simulated in the easting. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
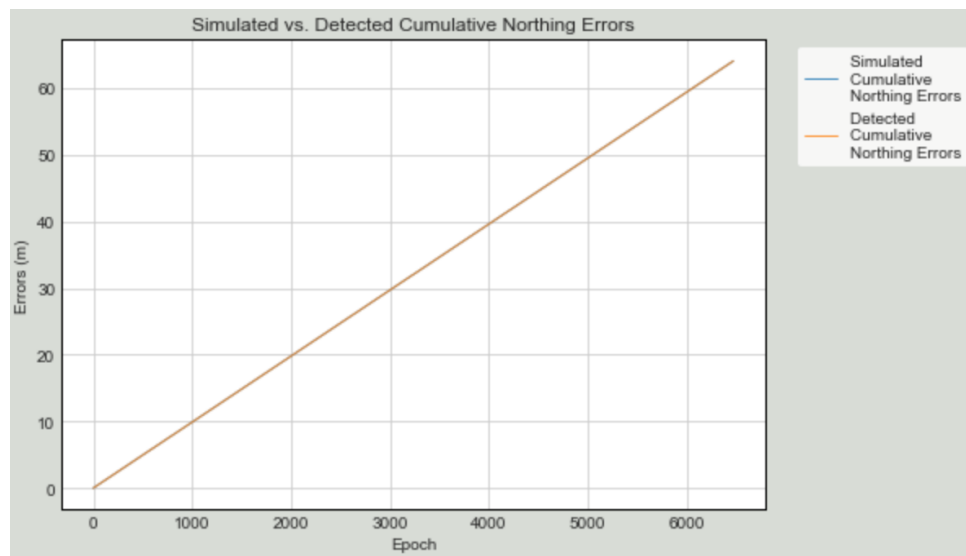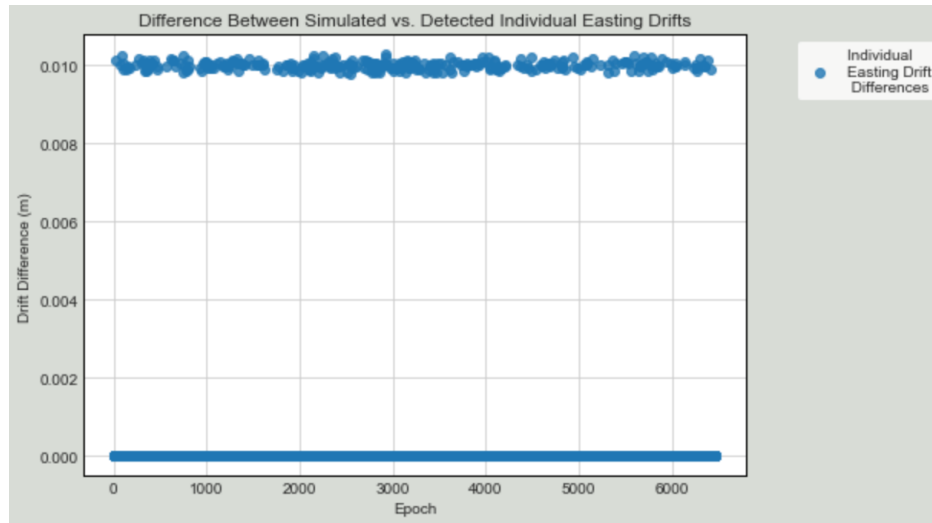
Northing Drift Error Comparison:

Figure 25: Individual Easting Drift of Simulated vs Detected Errors

The figure above shows the individual easting drift of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where drift occurred but wasn't detected by the software.

Figure 26: Individual Northing Drift of Simulated vs Detected Errors

The figure above shows the individual northing drift of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where drift occurred but wasn't detected by the software.
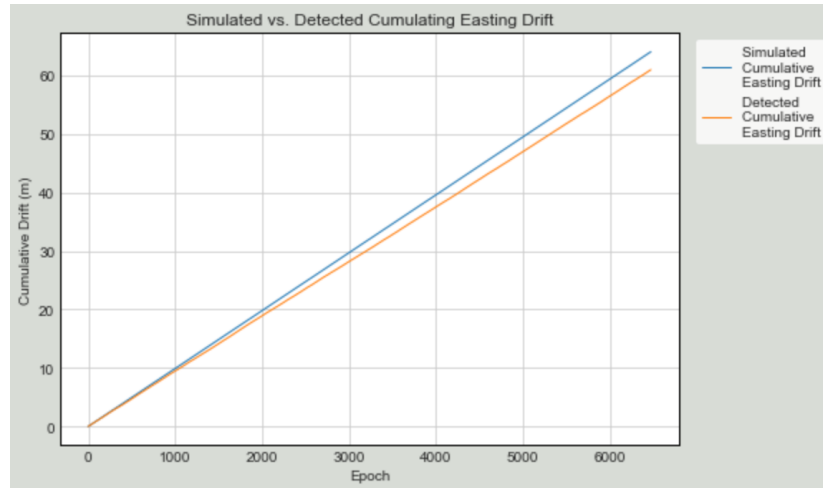
Figure 27: Cumulative Easting Drift of Simulated vs Detected Errors

The figure above shows the cumulative easting drift that takes into account all the previous epoch drifts of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where drift occurred but wasn't detected by the software.
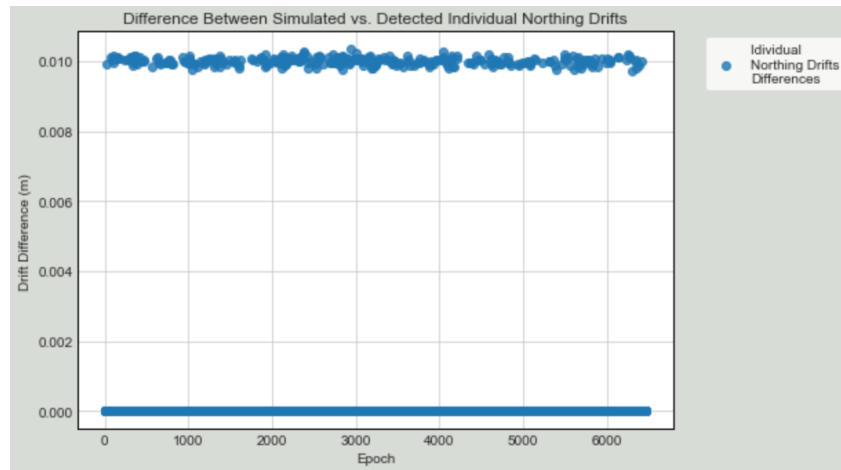

Figure 28: Cumulative Northing Drift of Simulated vs Detected Errors

The figure above shows the cumulative northing drift that takes into account all the previous epoch drifts of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where drift occurred but wasn't detected by the software.
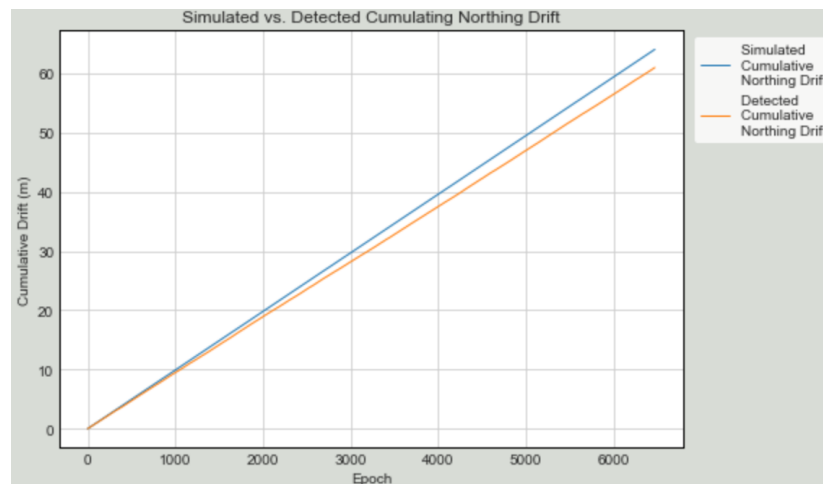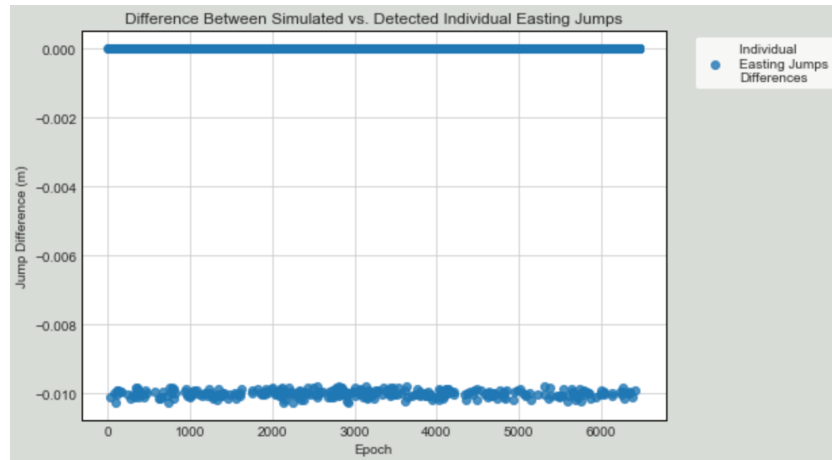
Northing Jump Error Comparison:

Figure 29: Individual Easting Jump of Simulated vs Detected Errors

The figure above shows the individual easting jump of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where jumps occurred but weren't detected by the software.

Figure 30: Individual Northing Jump of Simulated vs Detected Errors

The figure above shows the individual northing jump of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where jumps occurred but weren't detected by the software.
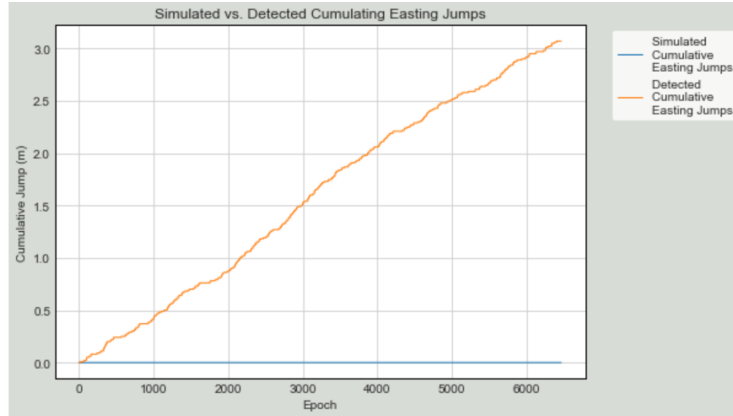
Figure 31: Cumulative Easting Jump of Simulated vs Detected Errors

The figure above shows the cumulative easting jump that takes into account all the previous epoch jumps of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where jumps occurred but weren't detected by the software.
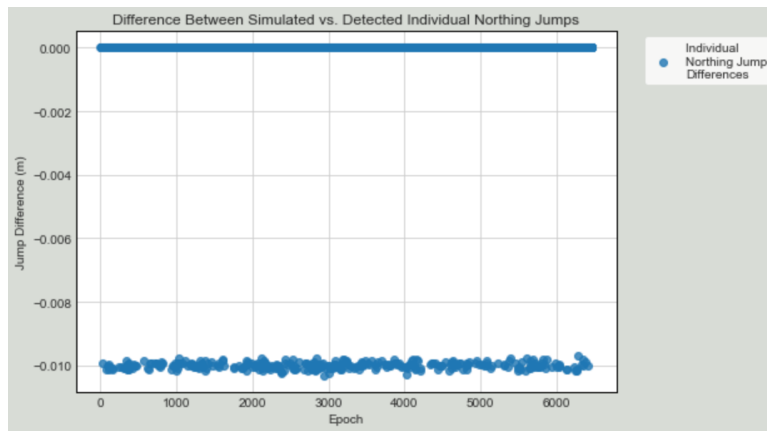

Figure 32: Cumulative Northing Jump of Simulated vs Detected Errors

The figure above shows the cumulative northing jump that takes into account all the previous epoch jumps of the simulated set vs the detected set for errors only simulated in the northing. Any difference between either line shows where jumps occurred but weren't detected by the software.
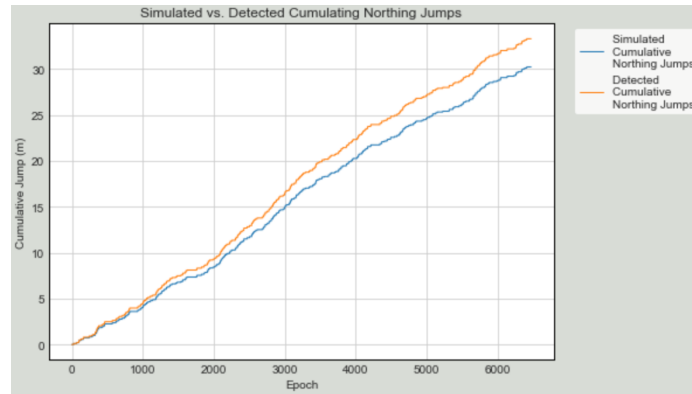
Northing Combined Error Comparison:

Figure 33: Individual Easting Error of Simulated vs Detected Errors

The figure above shows the individual easting error of the simulated set vs the detected set for errors only simulated in the northing. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.

Figure 34: Individual Northing Error of Simulated vs Detected Errors

The figure above shows the individual northing error of the simulated set vs the detected set for errors only simulated in the northing. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
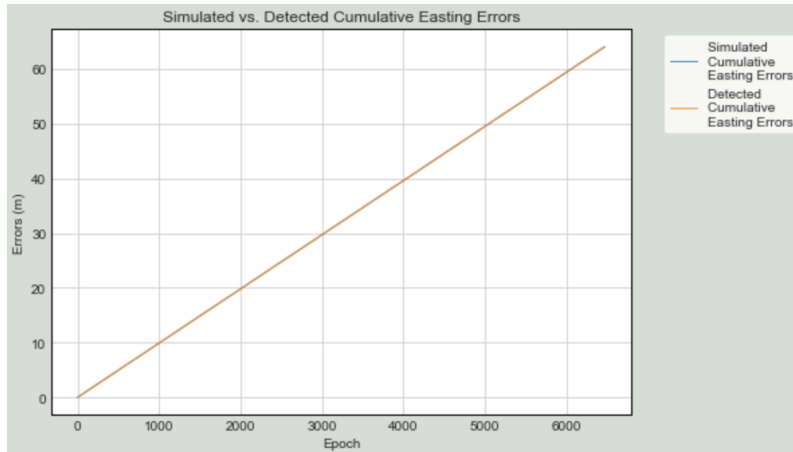
Figure 35: Cumulative Easting Error of Simulated vs Detected Errors

The figure above shows the cumulative easting error of the simulated set vs the detected set for errors only simulated in the northing. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
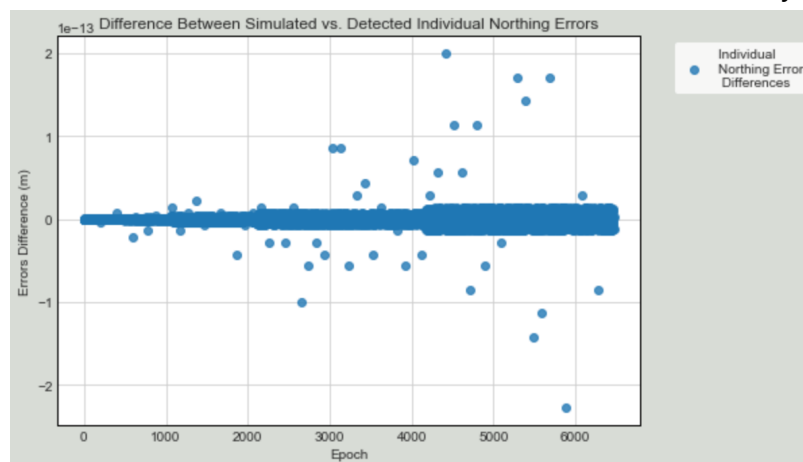

Figure 36: Cumulative Northing Error of Simulated vs Detected Errors

The figure above shows the cumulative northing error of the simulated set vs the detected set for errors only simulated in the northing. Error is the sum of the jump and drift errors. Any difference between either line shows where errors occurred but weren't detected by the software.
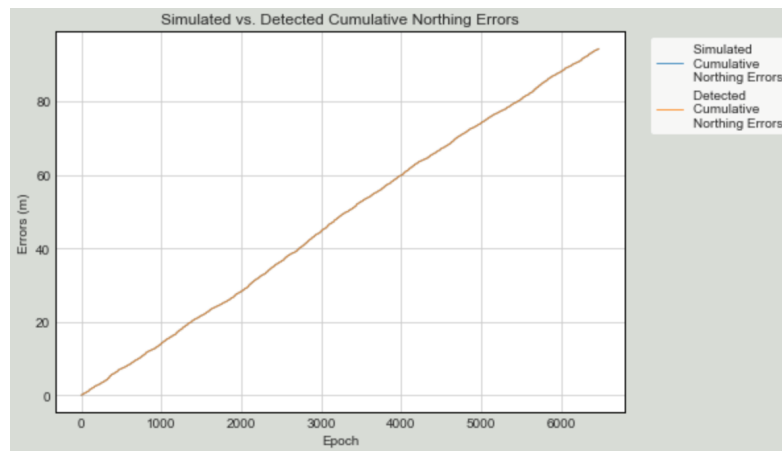
Next Steps:

Separating Jump and Drift:

One area of improvement for our detection software would be to add the ability to differentiate what part of an error is jump and what is drift. Currently, if no jump is detected and the true location does not match the computed location our software records those differences as drift in both axes. However if a jump is detected the error is all classified as jump error even if

a portion of that jump error was drift error. Being able to separate the different error components would be a huge step forward and could be done by calculating the drift vector from previous points and extrapolating that to the current data point. The northing and easting components of that drift vector could then be subtracted from the total error to isolate specifically the jump error.

Running Real Tractor Mounted Data Through Software

The next area of improvement would be to run single receiver data from a tractor mounted receiver through the error detection software. Real world static data and simulation data provided a realistic way to test the error detection software but being able to run the type of position log through the code that the scope originally designed for would be incredibly useful and is a great long term goal of the software scope. This code would likely take the form of a low absolute precision PDPPOS log (Pseudorange delta-filter) because this log is the most common way for broadacre precision agriculture data to be stored and transferred. Plotting and detecting the errors from this log would provide a great visualization of what to expect if the software suite was deployed across the industry as intended.