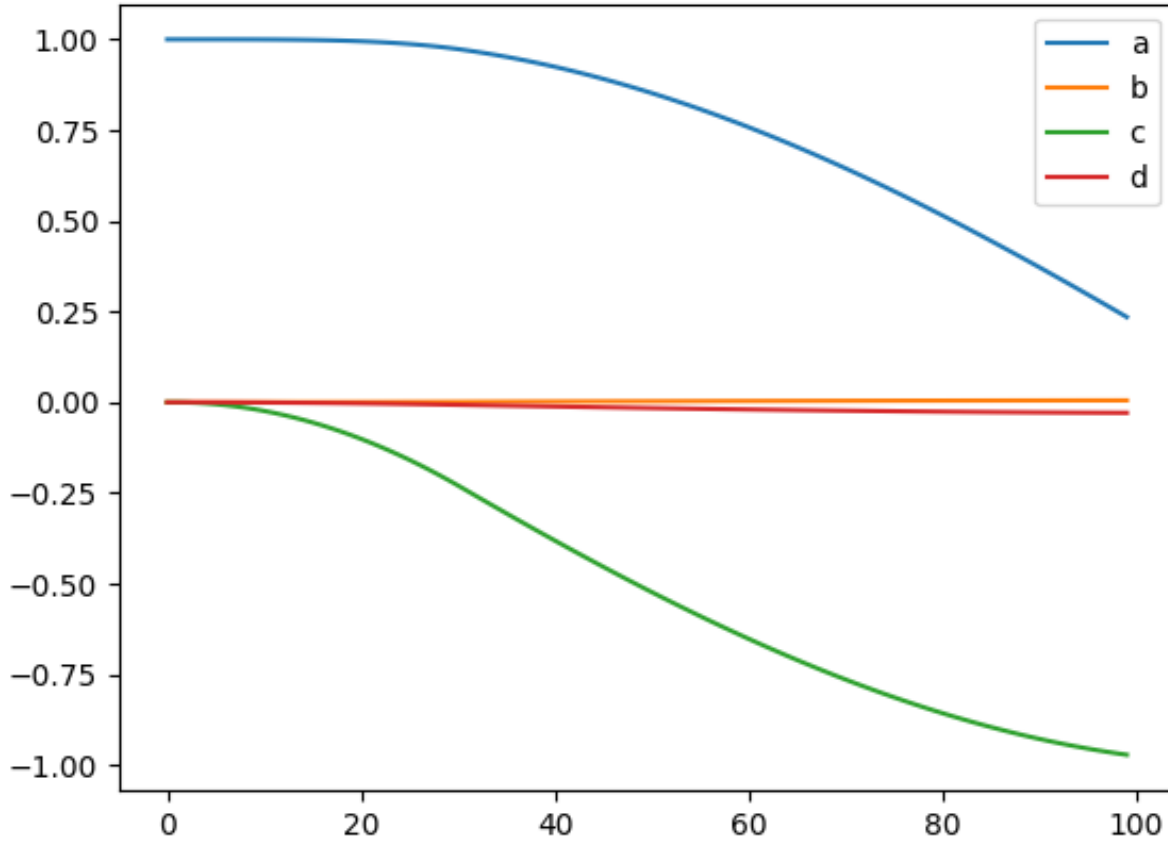


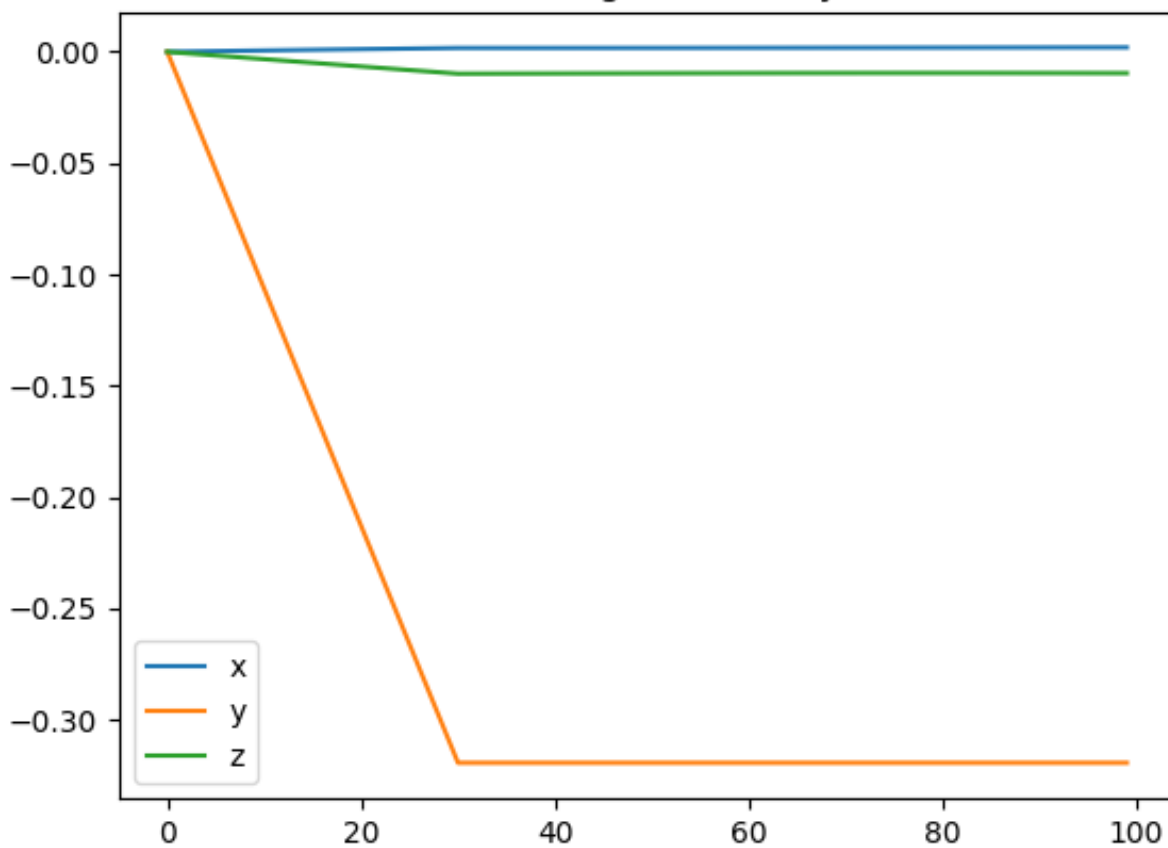
Kalman-Testing Simulation Report

Ideal behavior is dictated by our propagating initial state and reaction wheel info for each step through our Equations of Motion (EOMs) and the true magnetic field (19.0, 1.7, 49.0 microteslas).

Ideal Quaternion



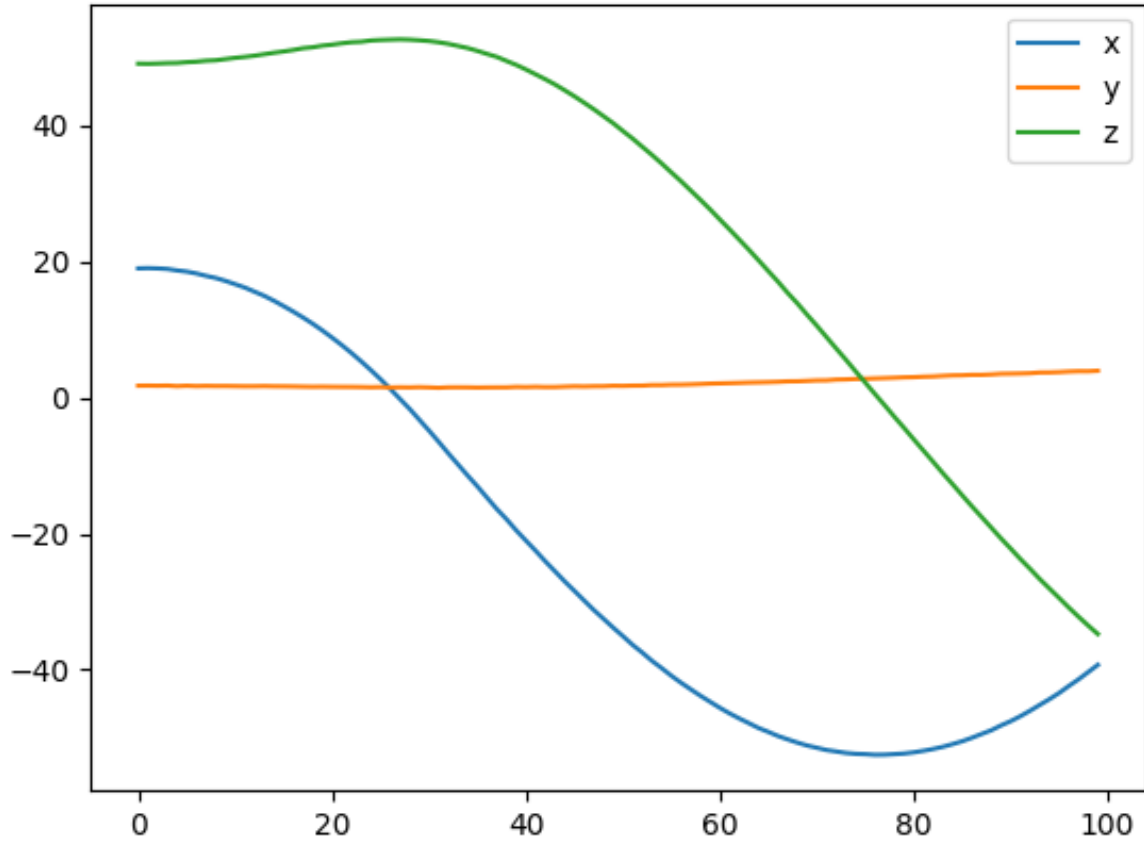
Ideal Angular Velocity



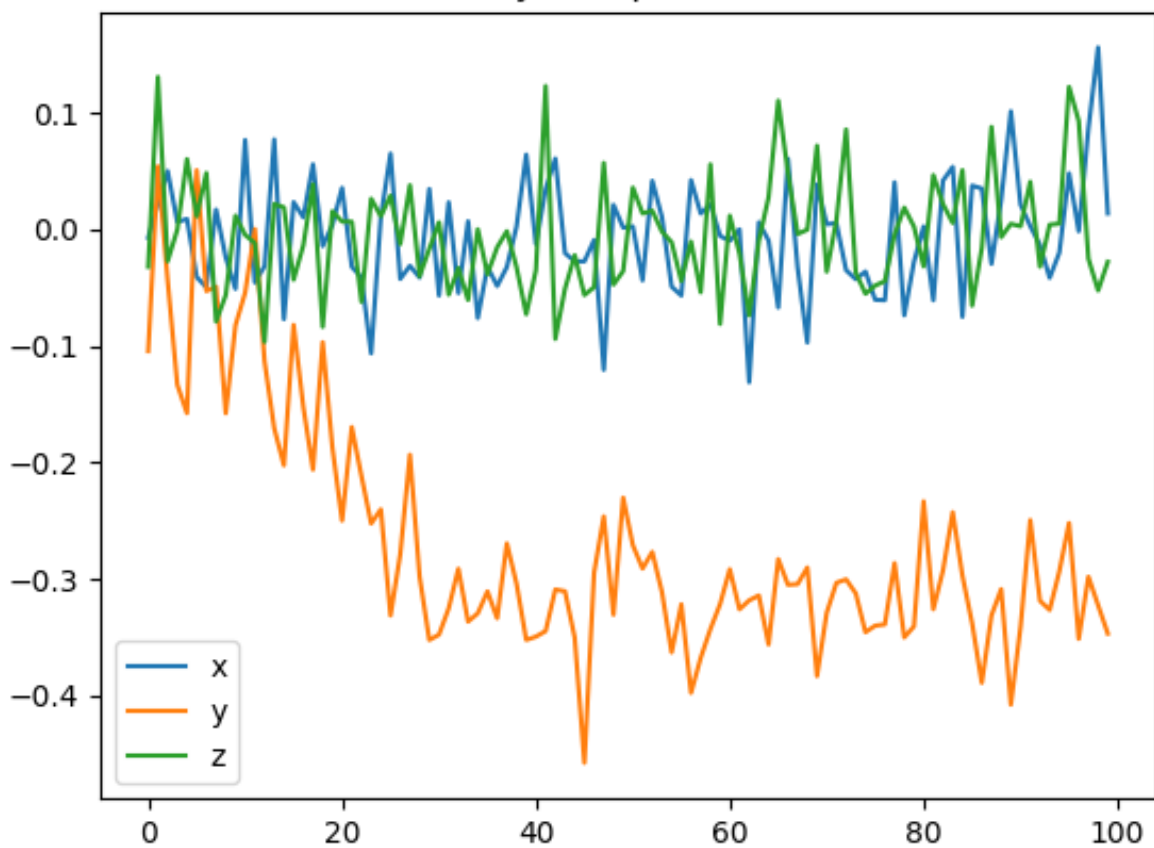
Data

Simulate IMU data by adding noise to our ideal states in measurement space. For vn100, magnetometer noise = 0.019798989873223333 and gyroscope noise = 0.04949747468305833.

Magnetometer Data



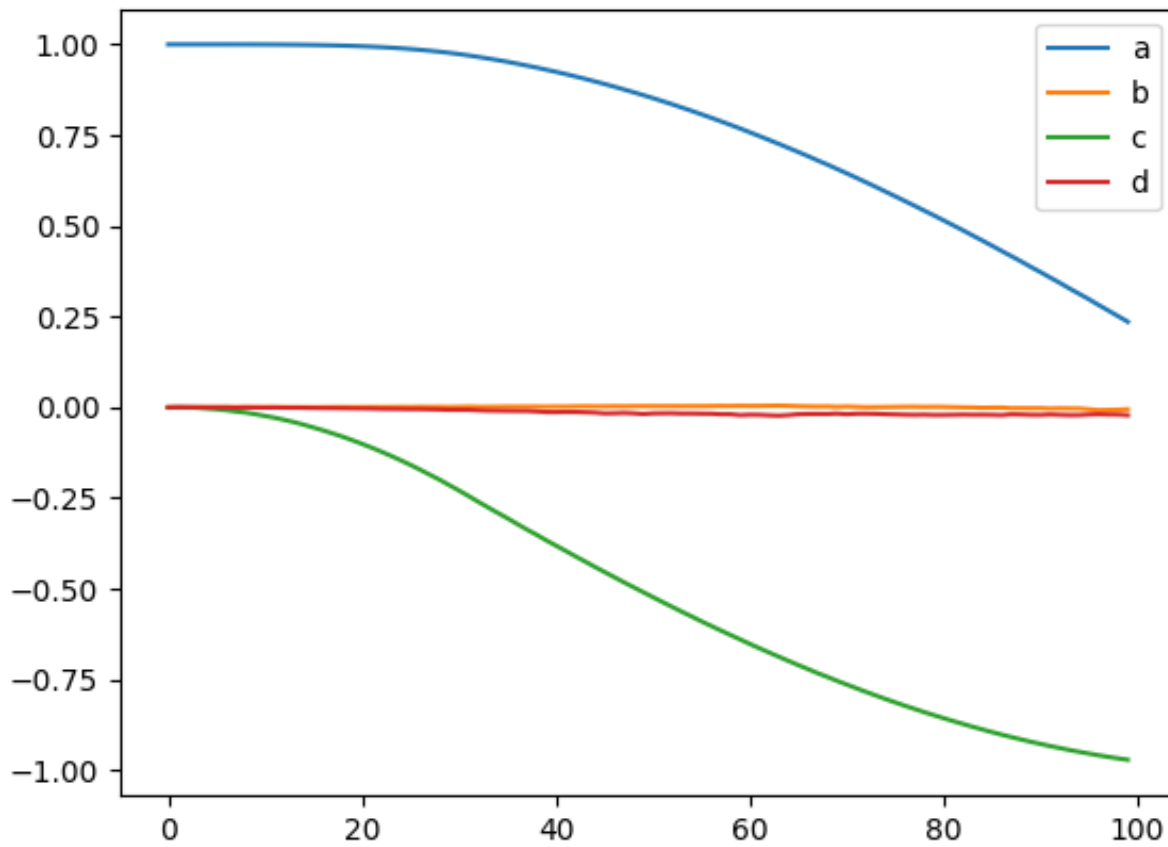
Gyroscope Data



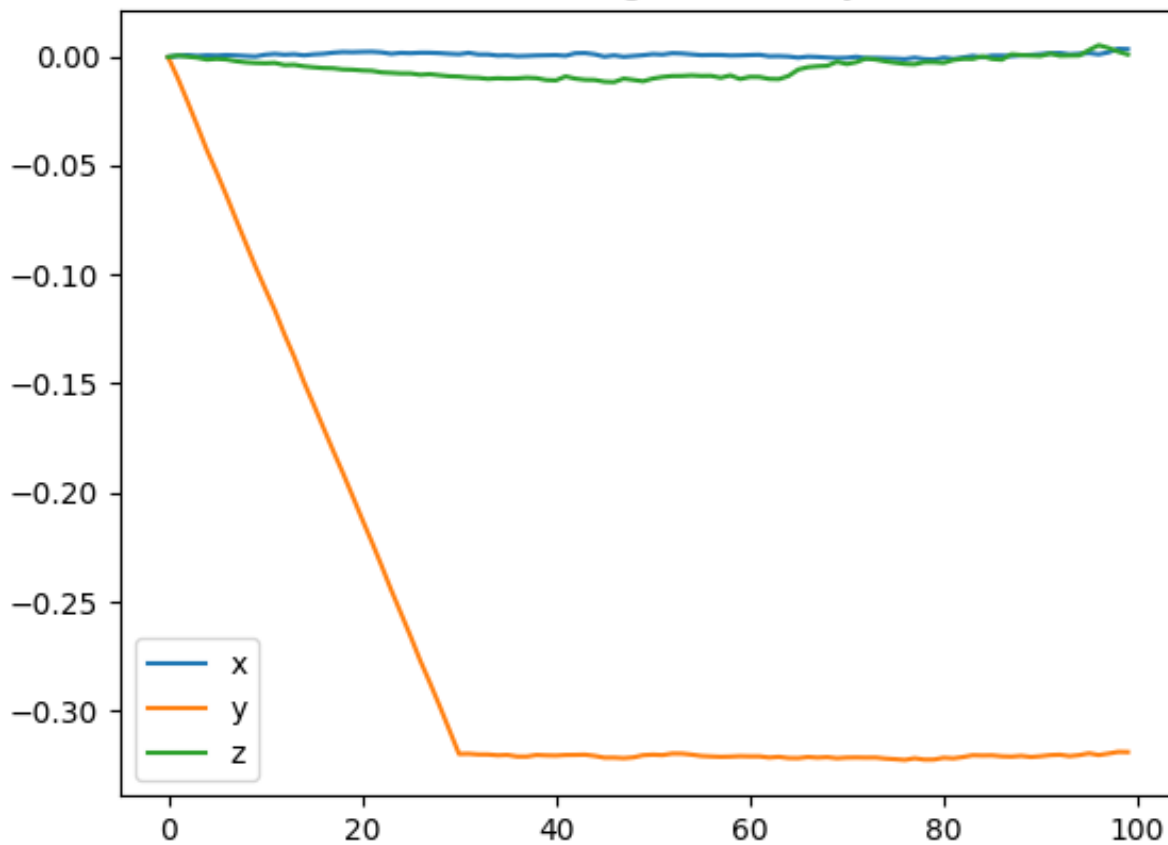
Filter Results

Kalman filter estimates our state for each time step by combining the noisy data and physics EOMs.

Filtered Quaternion



Filtered Angular Velocity



Tests

We have two metrics for examining our filter: statistical and speed tests.

TODO: implement speed test + output time for n steps + average time per step.

The statistical tests are based on Estimation II by Ian Reid. He outlines 3 tests that examine the innovation (or residual) of the filter, which is the difference between a measurement and the filter's prediction.

1) Consistency: the innovations should be randomly distributed about 0 and fall within its covariance bounds.

2) Unbiasedness: the sum of the normalised innovations squared should fall within a 95% chi square confidence interval.

If distribution sums are too small (fall below interval), then measurement/process noise is overestimated (too large). Therefore, the combined magnitude of the noises must be decreased.

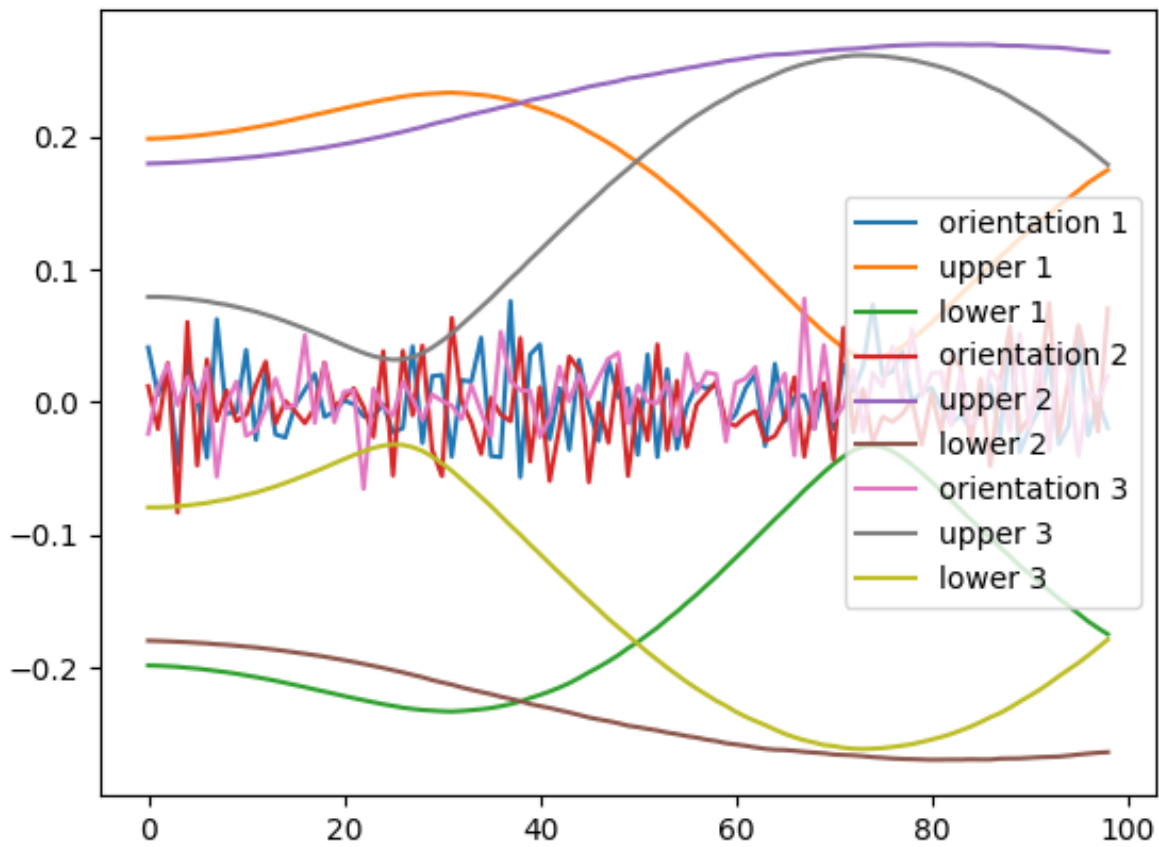
Conversely, measurement/process noise can be increased to lower the sums of the normalized innovations squared.

3) Whiteness: autocorrelation should be distributed around 0 with no time dependency.

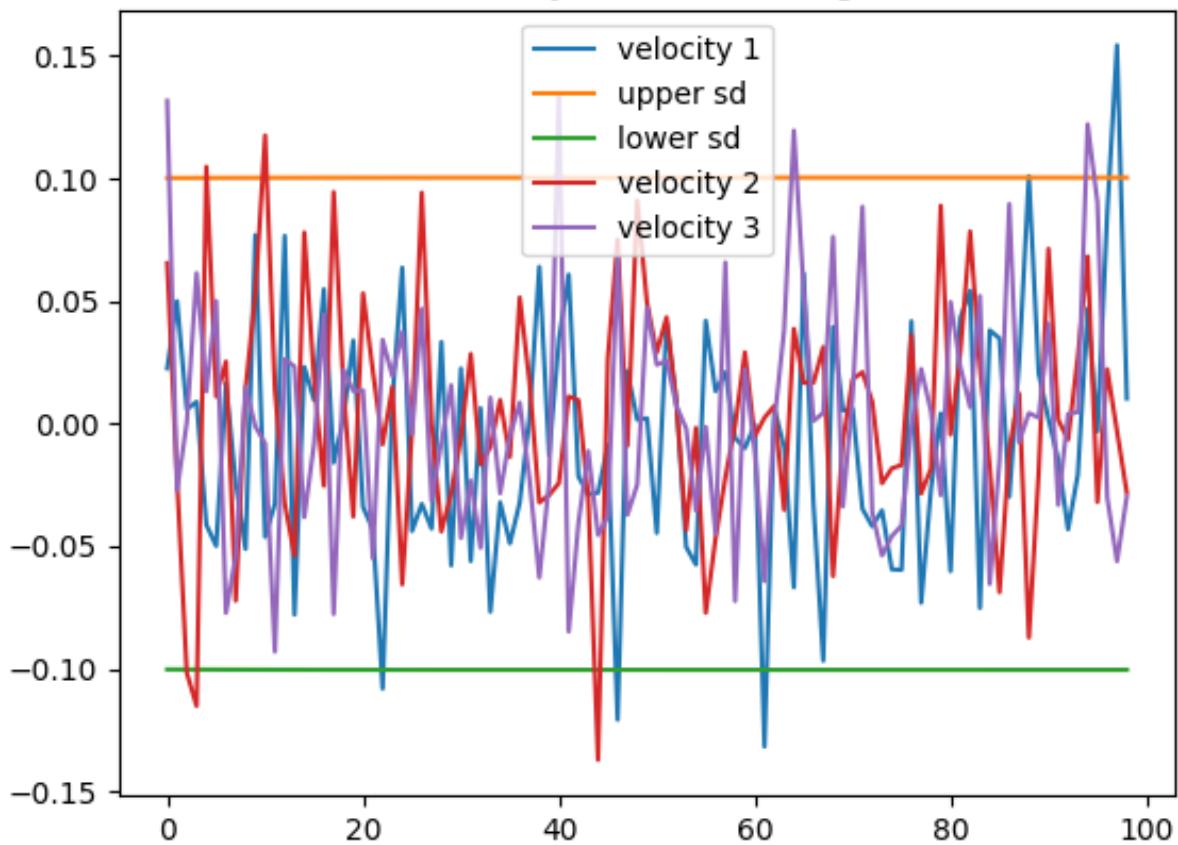
Test 1

Vizually inspect that 95% of innovations fall within confidence interval bounds.

Test 1: orientation innovation magnitudes



Test 1: velocity innovation magnitudes

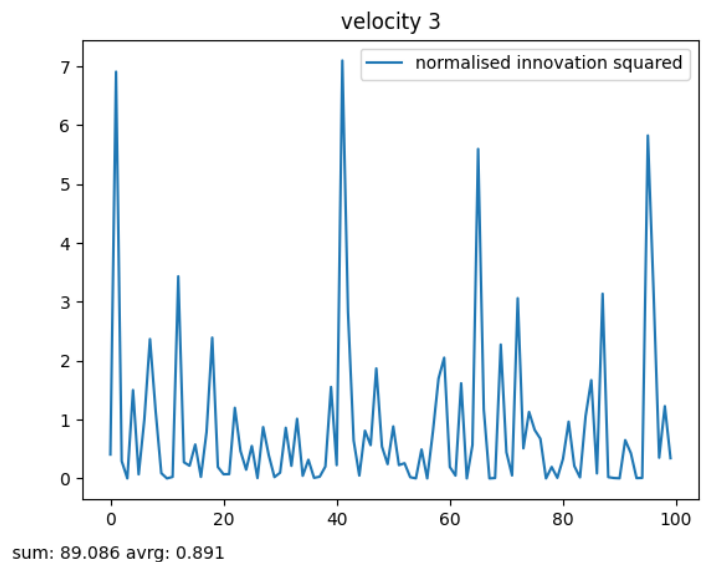
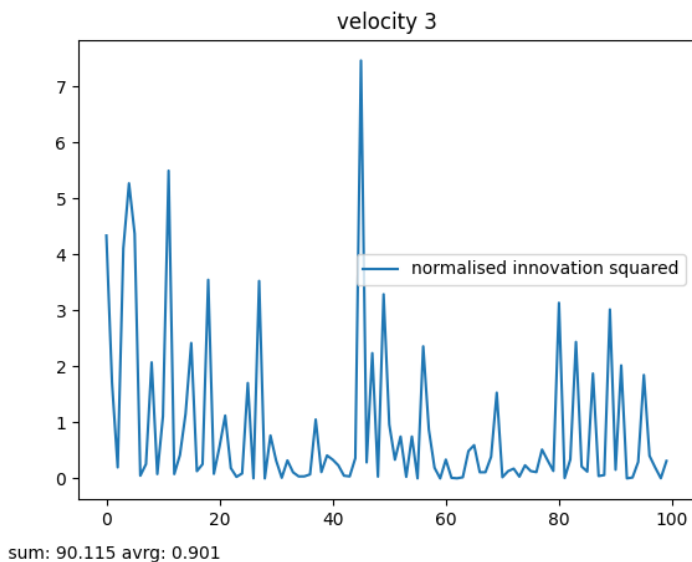
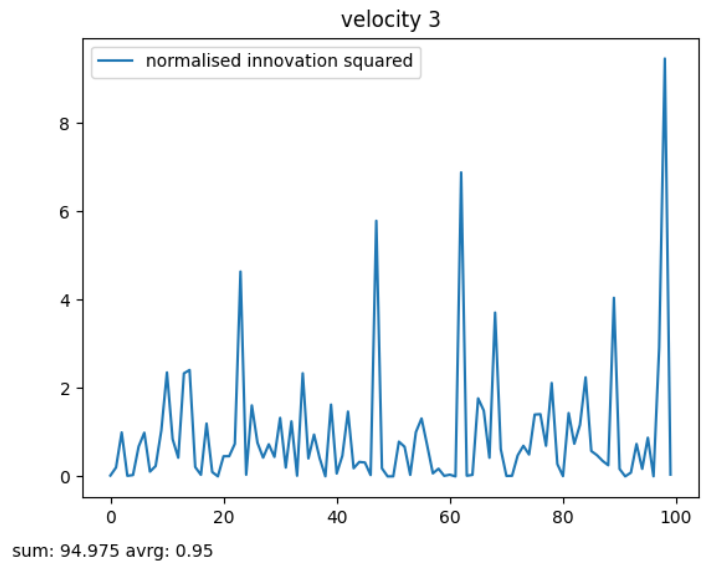
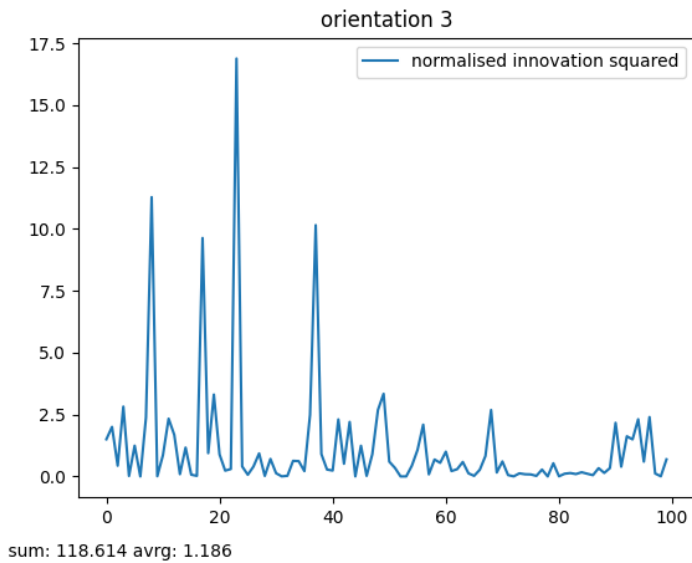
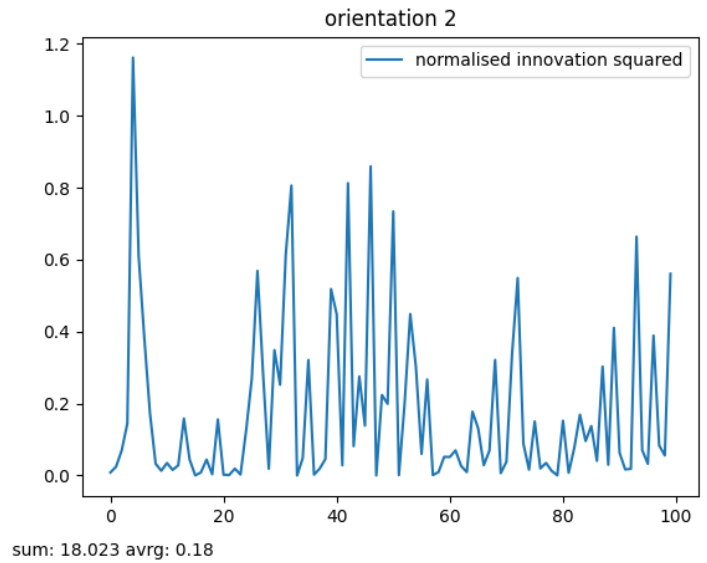
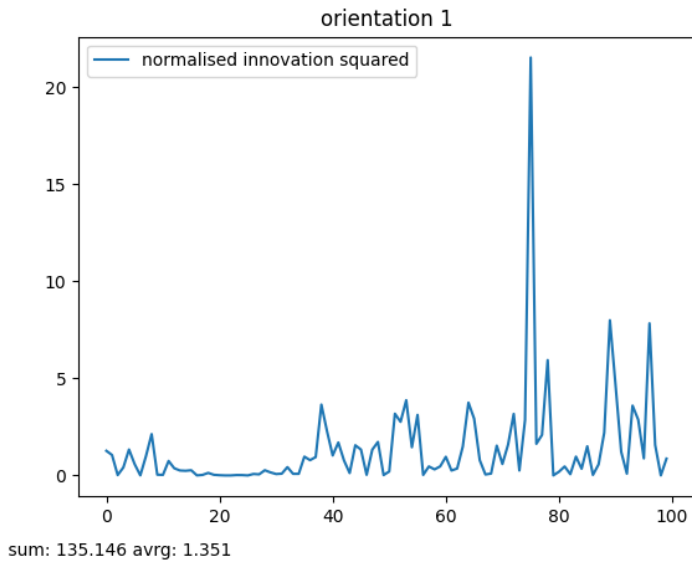


Test 2

Sum of each innovation must be within chi square bounds [74.222, 129.561] (df=100)

Total sum 545.958 must be within 95% interval [534.019, 669.769] (df=600)

If distributions are too small, decrease measurement/process noise (and vice versa)



Test 3

Analyze each graph for time dependency. Each autocorrelation should be randomly distributed around 0 the entire time.

