École Polytechnique Fédérale de Lausanne

LAB 5 – Kalman Filtering with simulated GPS data: simple (a=0) model

ENV-548: Sensor Orientation

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1 Errors alongside 3-sigma bounds

1.1 Freq = 1Hz

1.1.1 Process noise = normal

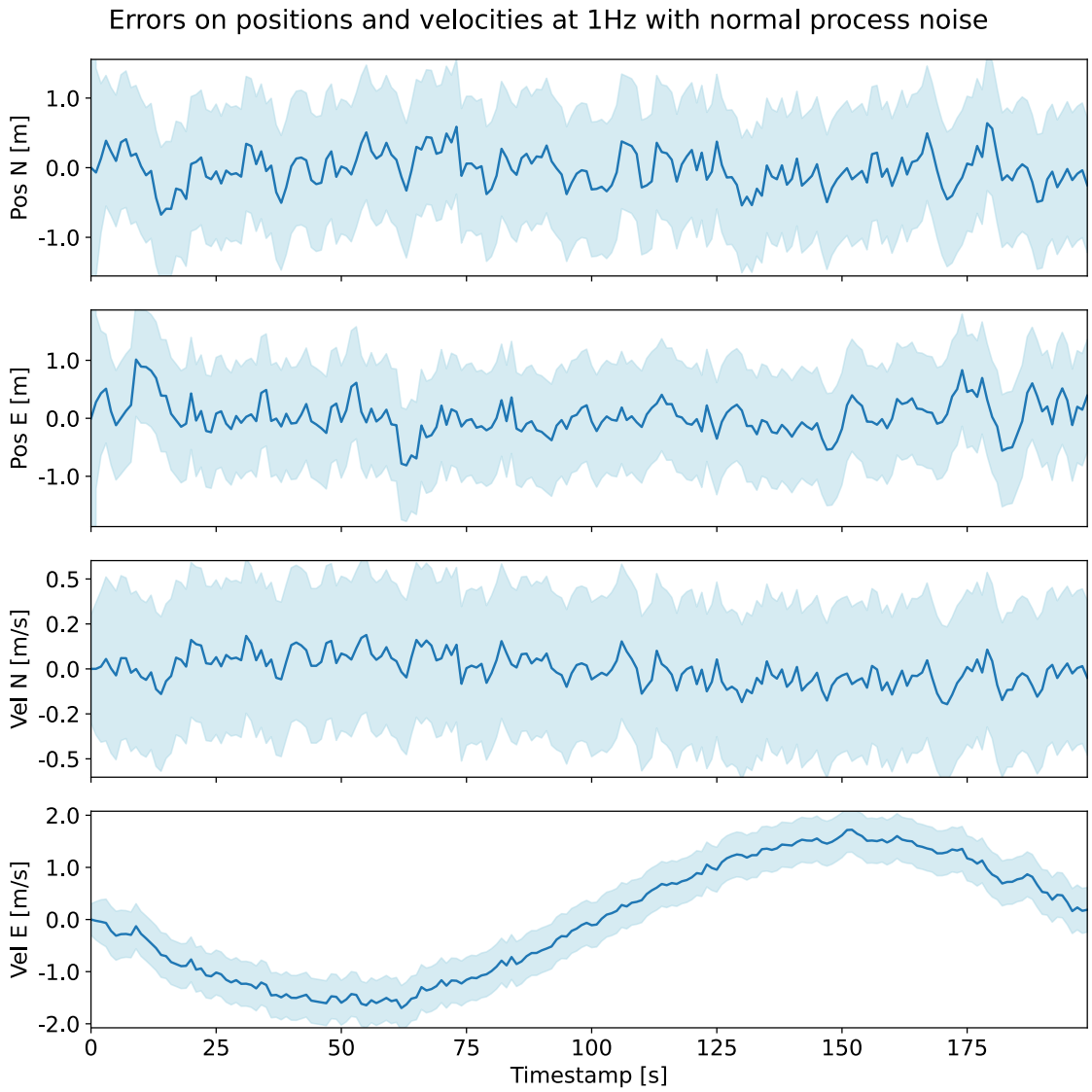

Figure 1: Errors alongside North and East axis of position and velocity at 1Hz with normal process noise. The light-blue area represents the 3-sigma bounds.

1.1.2 Process noise = 10x

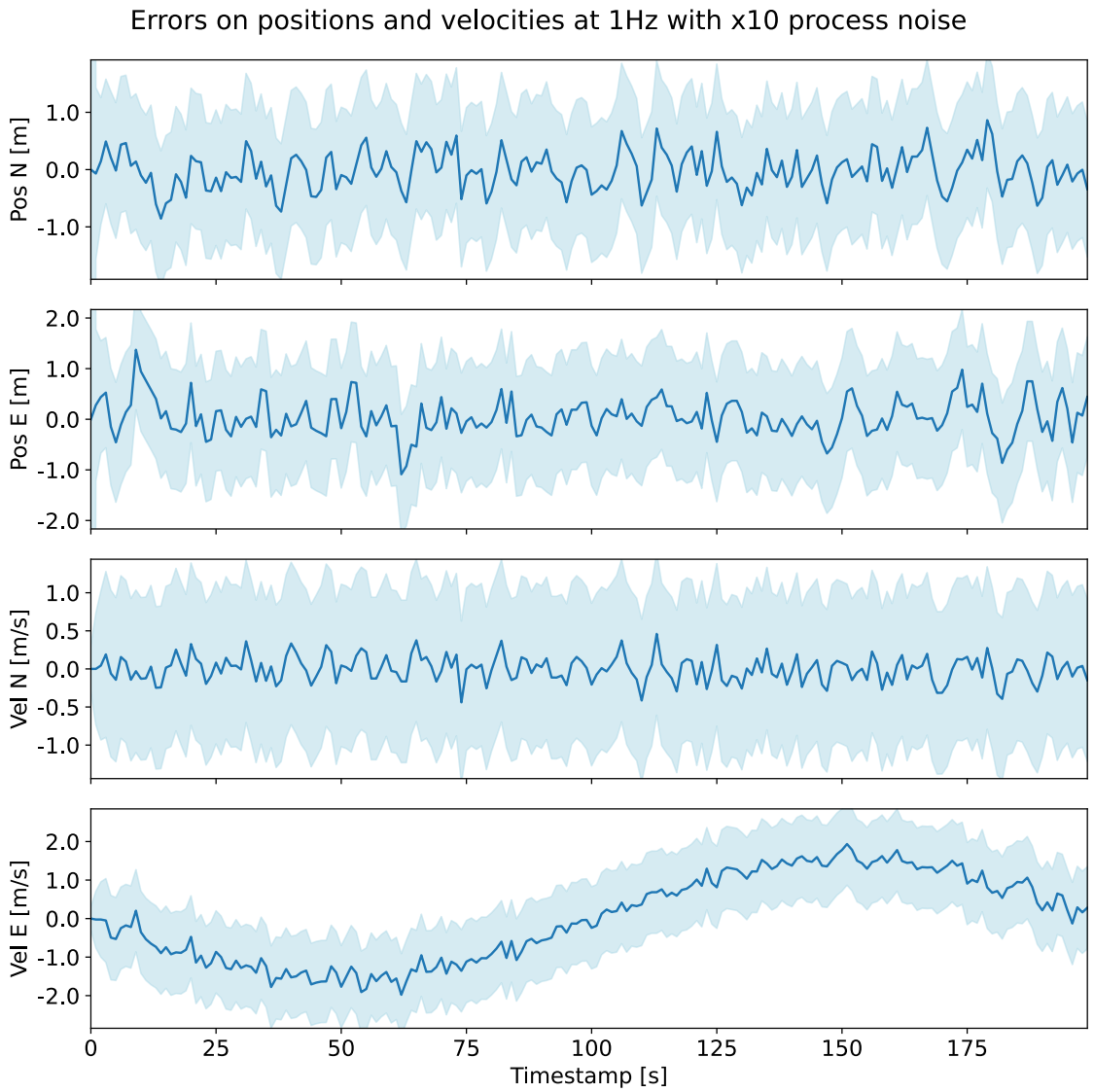

Figure 2: Errors alongside North and East axis of position and velocity at 1Hz with 10x process noise. The light-blue area represents the 3-sigma bounds.

1.1.3 Process noise = 0.1x

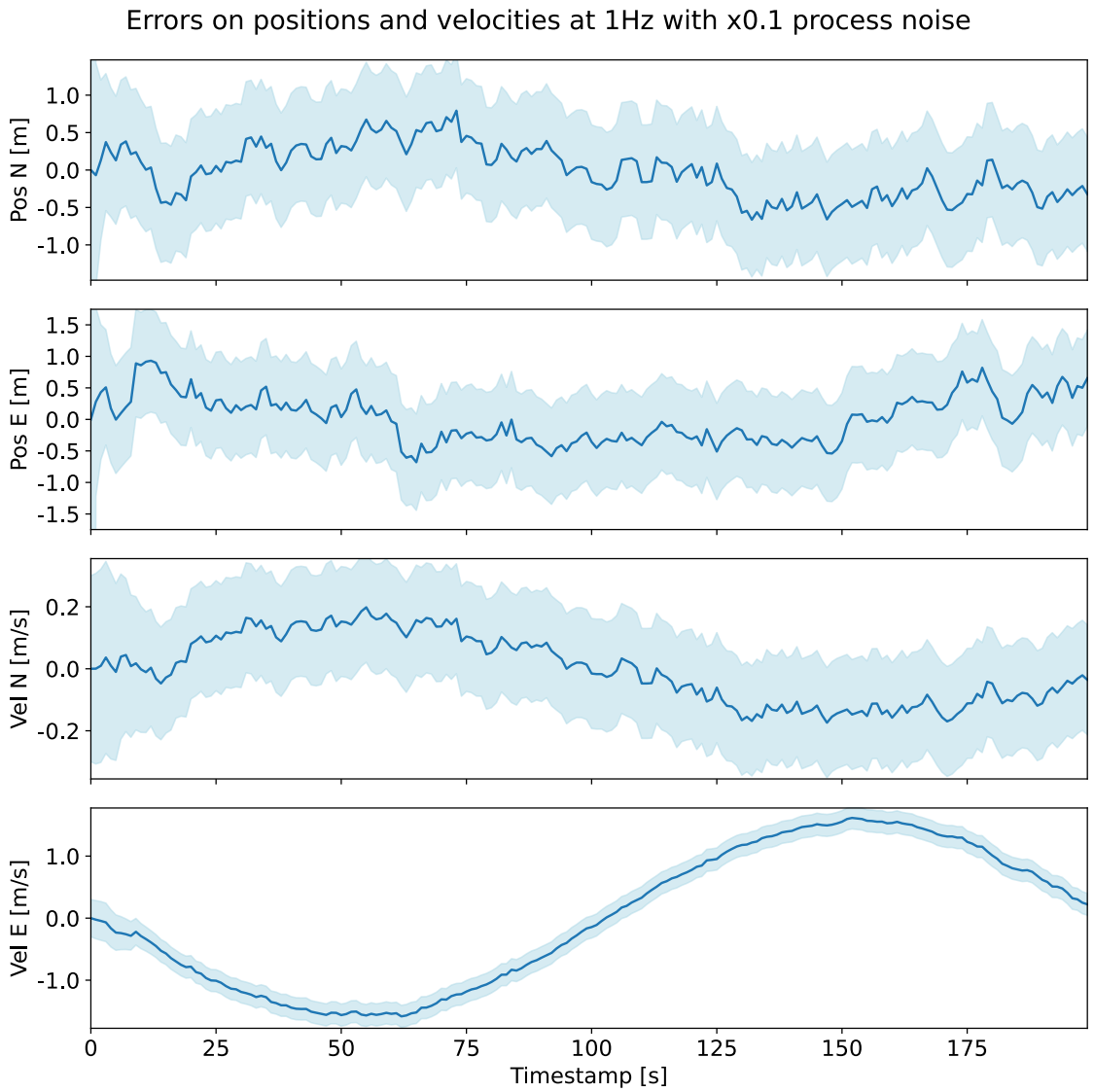

Figure 3: Errors alongside North and East axis of position and velocity at 1Hz with 0.1x process noise. The light-blue area represents the 3-sigma bounds.

1.2 Freq = 100Hz

1.2.1 Process noise = normal

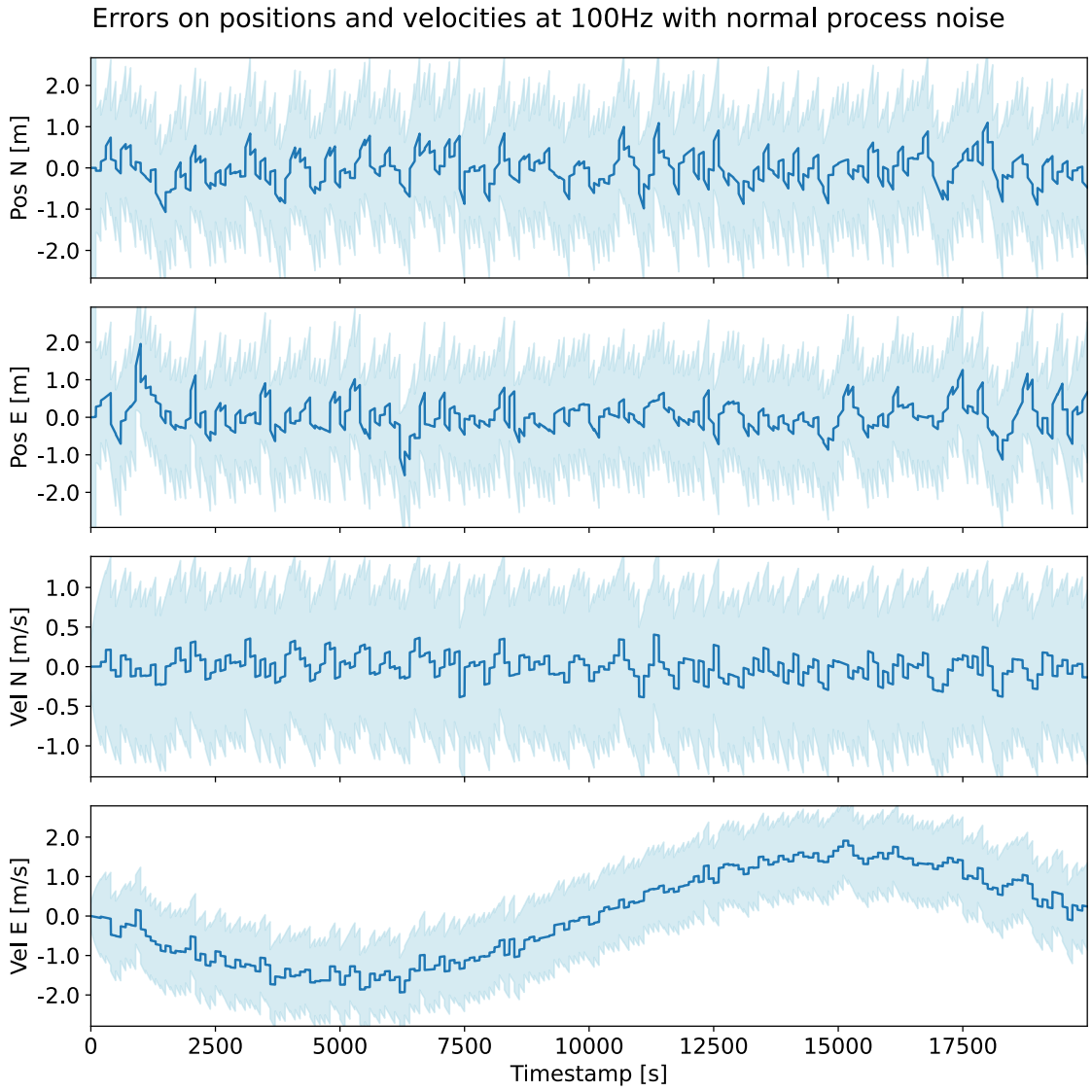

Figure 4: Errors alongside North and East axis of position and velocity at 100Hz with normal process noise. The light-blue area represents the 3-sigma bounds.

1.2.2 Process noise = 10x

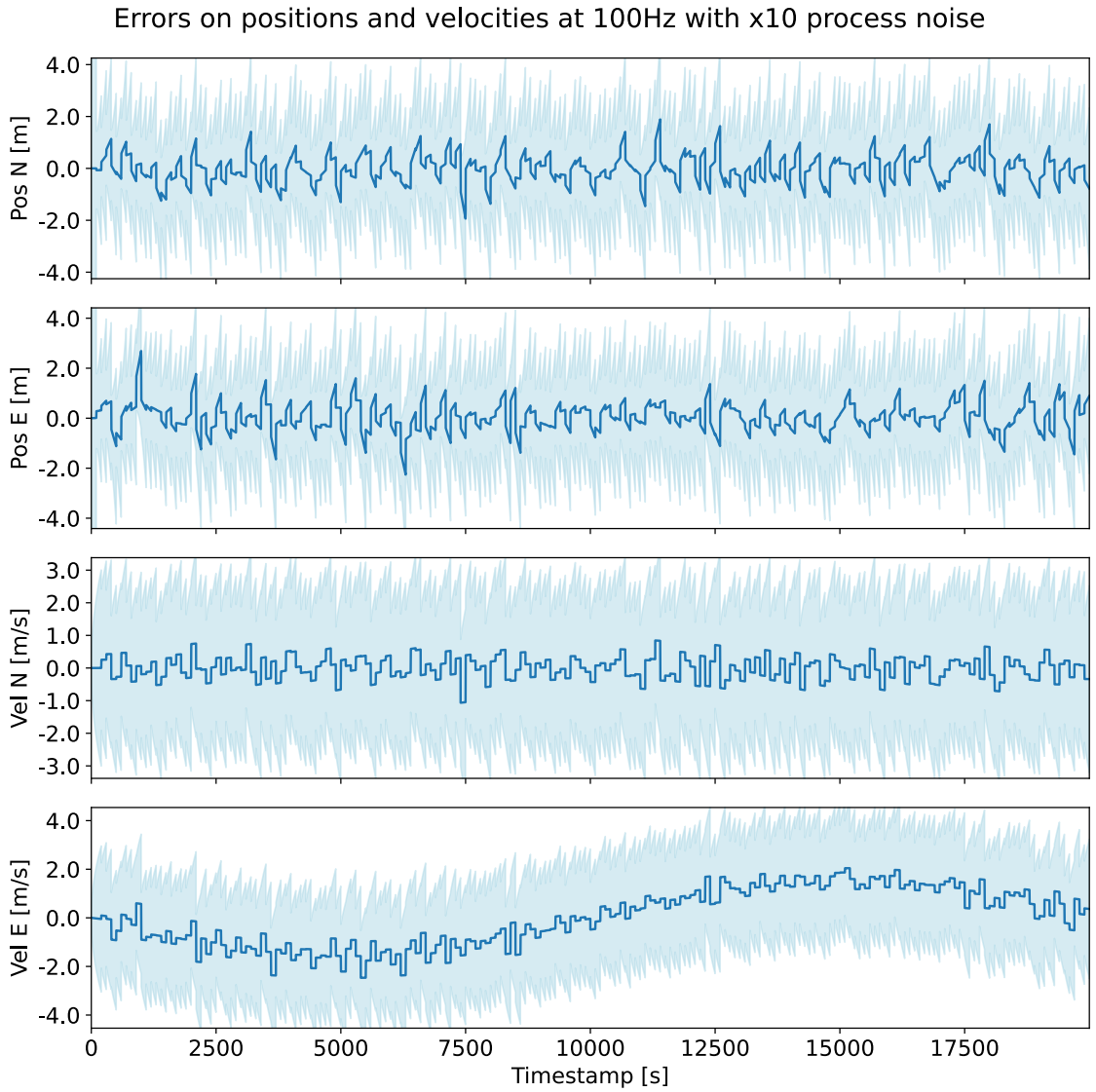

Figure 5: Errors alongside North and East axis of position and velocity at 100Hz with 10x process noise. The light-blue area represents the 3-sigma bounds.

1.2.3 Process noise = 0.1x

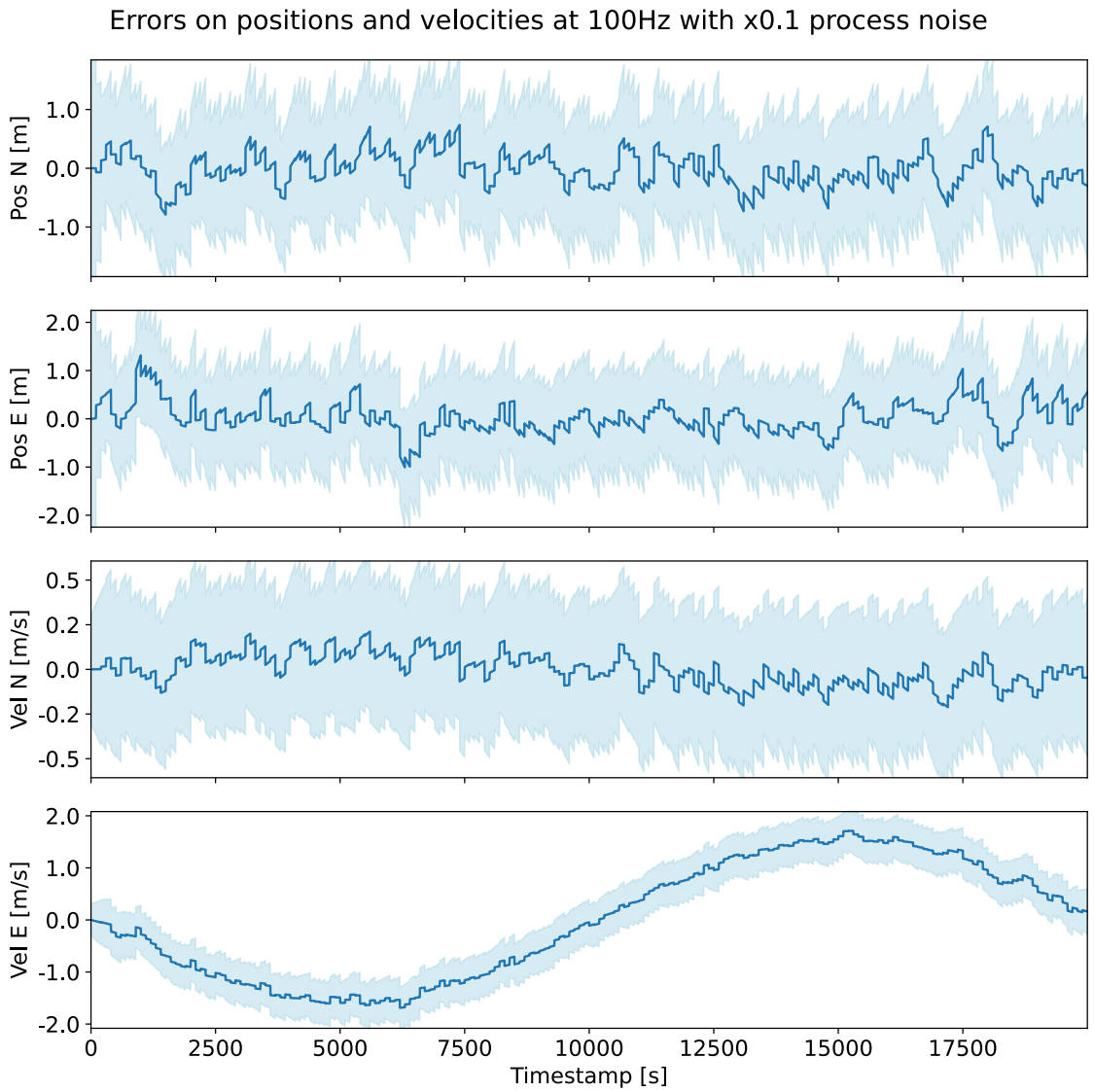

Figure 6: Errors alongside North and East axis of position and velocity at 100Hz with 0.1x process noise. The light-blue area represents the 3-sigma bounds.

2 Innovation sequence

2.1 Process noise = normal

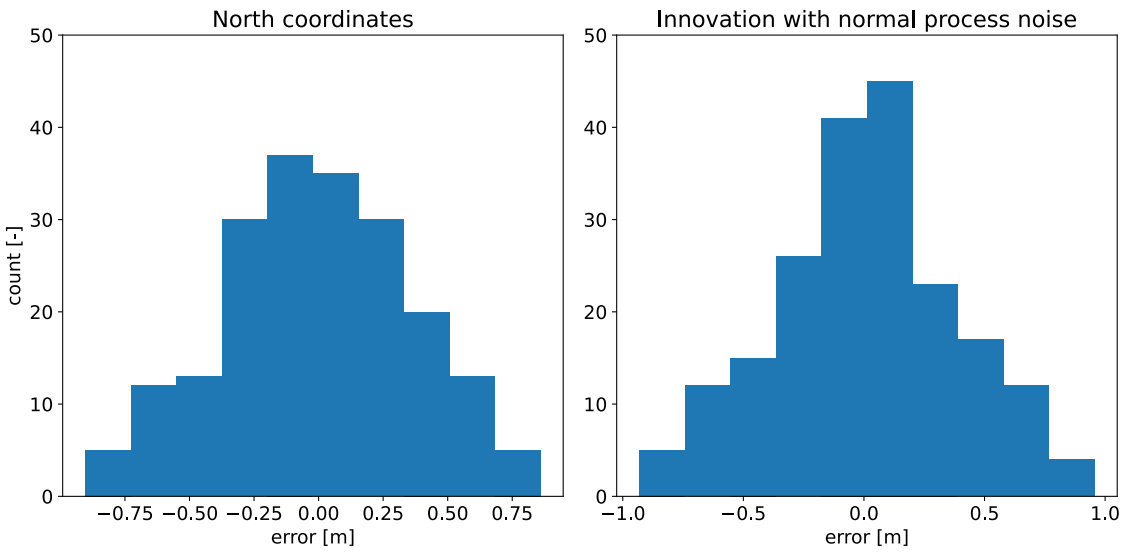

Figure 7: Histogram of the innovation for 1 realization at 1Hz and normal process noise. The left-side plot corresponds to the north coordinates and the right-side plot corresponds to the east coordinates.

2.2 Process noise = 10x

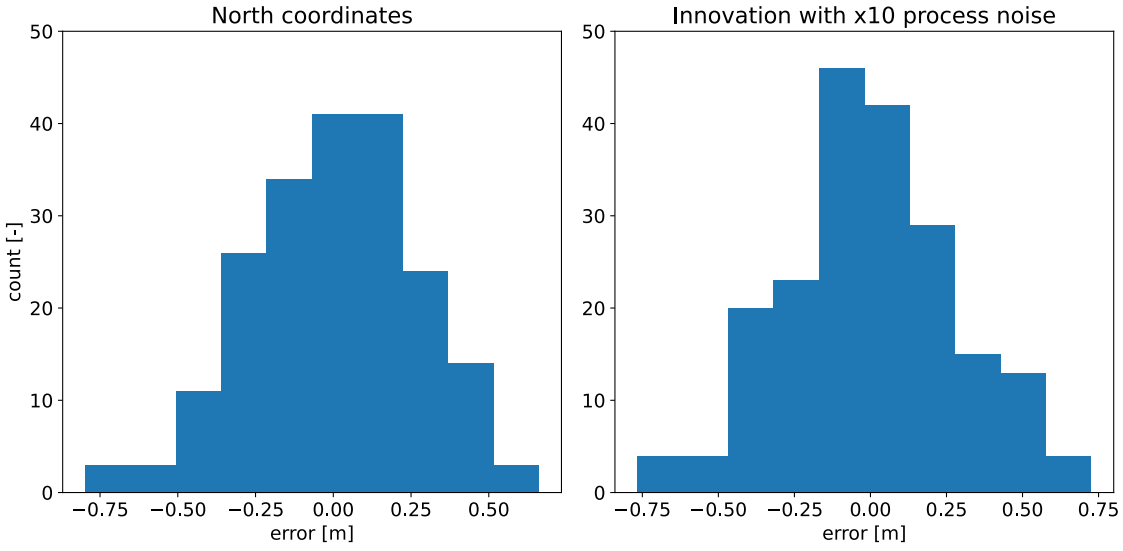

Figure 8: Histogram of the innovation for 1 realization at 1Hz and 10x process noise. The left-side plot corresponds to the north coordinates and the right-side plot corresponds to the east coordinates.

2.3 Process noise = 0.1x

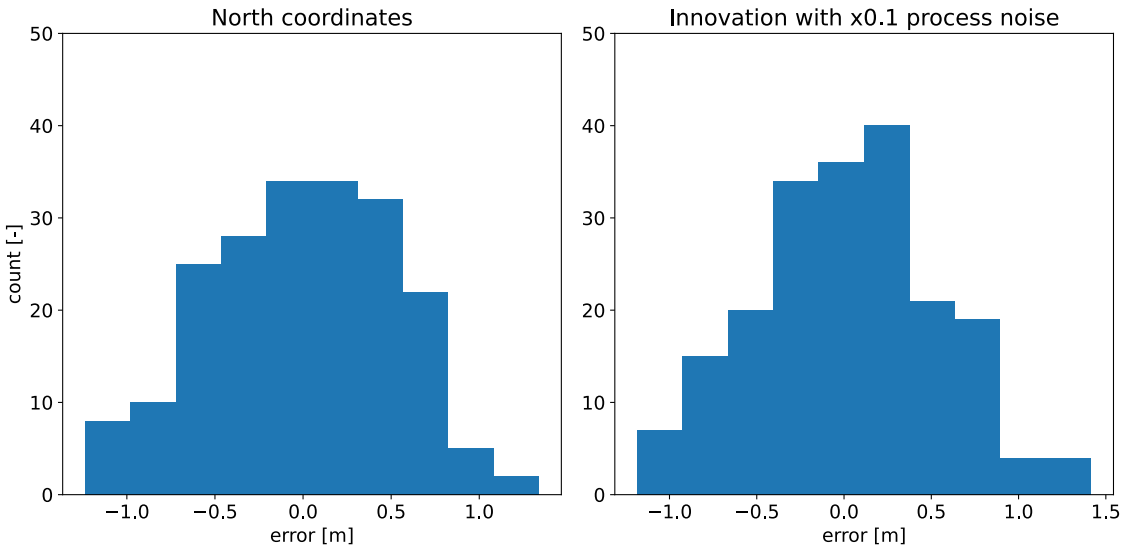

Figure 9: Histogram of the innovation for 1 realization at 1Hz and 0.1x process noise. The left-side plot corresponds to the north coordinates and the right-side plot corresponds to the east coordinates.

3 Table

Unit: [m]	1	2	3	4	5
$\sigma_{xy}^{GPS_{emp}}$	0.677	0.710	0.701	0.713	0.683
$\sigma_{xy}^{KF_{emp}}$	0.480	0.528	0.504	0.530	0.491
$\sigma_{xy}^{KF_P}$	0.220	0.220	0.220	0.220	0.220

Table 1: Standard deviation of the different errors.

4 Questions

1. Averaging among all realization, the overall improvement is 0.190m.
2. Around 5 measurements.
3. Yes, since the measurements are used to compute the gain which is used to correct the prediction at each update.
4. The predicted accuracy $\sigma_{xy}^{KF_p}$ is underestimating the uncertainty since its about twice smaller than the empirically estimated position accuracy $\sigma_{xy}^{KF_{emp}}$. Therefore the process noise should be a bit increased.
5. $\sigma_{xy}^{KF_P}$ and $\sigma_{xy}^{KF_{emp}}$ are larger with a larger process noise. However, this does not impact $\sigma_{xy}^{GPS_{emp}}$.

6. It gets worst than 1Hz. This is due to the fact that this model is based on a simple linear dynamic model and GPS measurements. Hence, the linear trajectories predicted between the measurements make the overall prediction worst.

7. Smaller process noise tends to result in a wider innovation sequence while a larger process noise will narrow it down.