Suppression of an effect of terrain unevenness on accuracy of height measurement in UAV with integrated ultrasound altimeter during landing

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Outline

- Introduction
- Methods
- Scenarios
- Results
- Conclusion

Goal of the paper

- To compare basic methods for filtration of ultrasonic height measurements.
  - Terrain unevenness
  - Measurement noise
- To identify proper usage of the methods.

Motivation of the paper

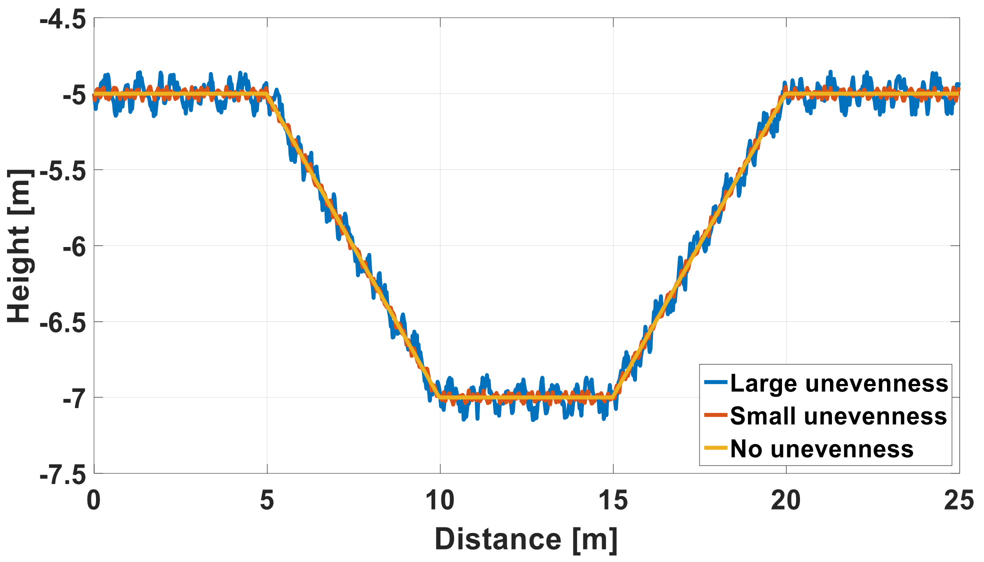
- UAV autonomous landing.
- Proper landing side identification – Precision height knowledge.
- Terrain unevenness during landing side search.

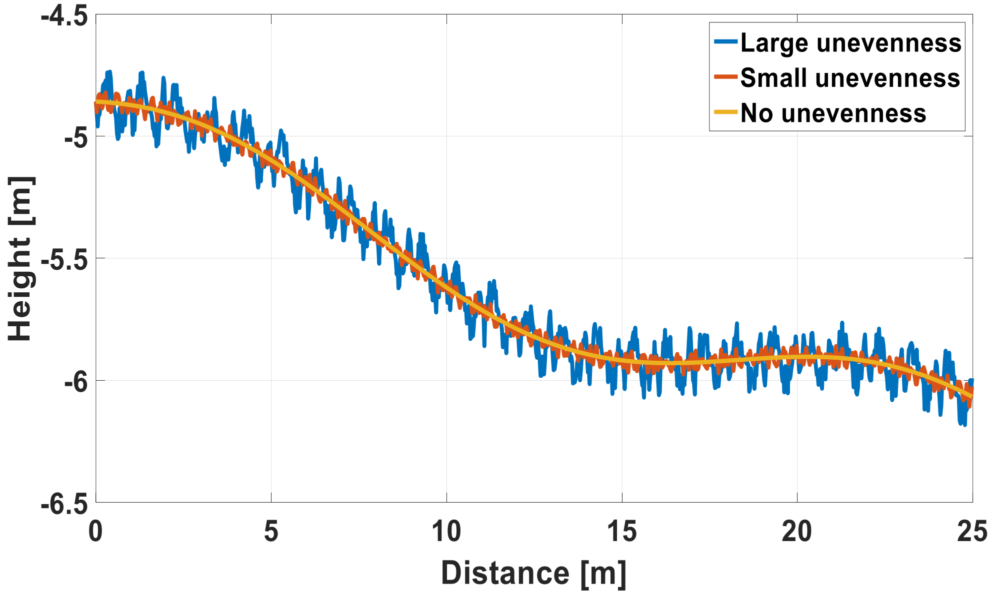
Methods

- Moving average
  - $h_e(t) = [h_m(t) + h_m(t\text{-}1) + \cdots + h_m(t\text{-}n)]/[n+1]$
- Kalman filter
  - $x_{t|t-1} = A_t x_{t-1|t-1}$
  - $P_{t|t-1} = A_t P_{t-1|t-1} A_t^T + Q_t$
  - $A_t = [1\ \Delta t,\ 0\ 1]$

Scenarios

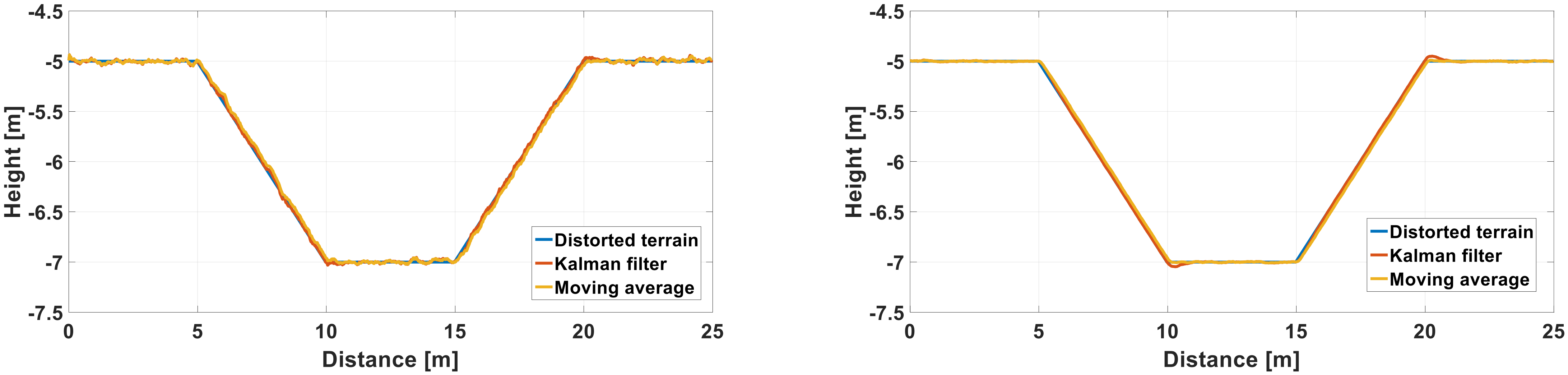
- 2 scenarios
- 2 versions of unevenness
- 2 versions of measurement noise
- 0.1 samples/s, 100 s
- 25 meters





Scenario 1 – no unevenness

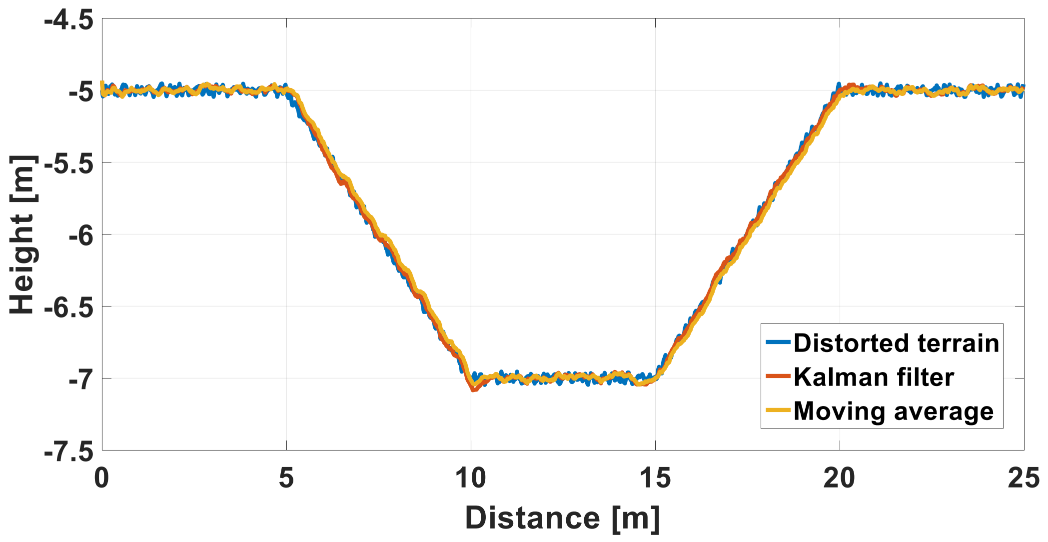
- (a) – threshold detector
- (b) – intra-pulse modulation



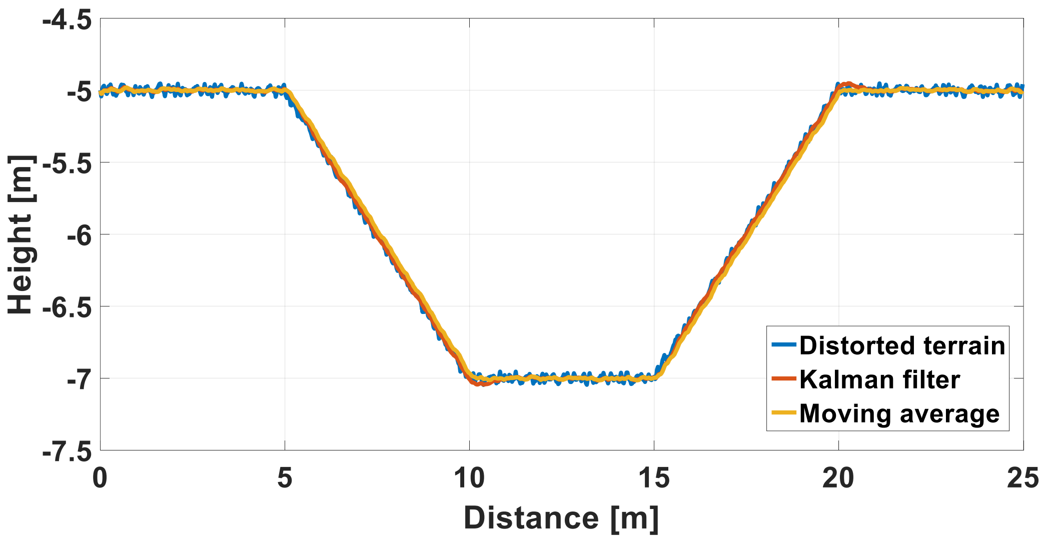
(a) (b)

Scenario 1 – small unevenness

- (a) – threshold detector
- (b) – intra-pulse modulation



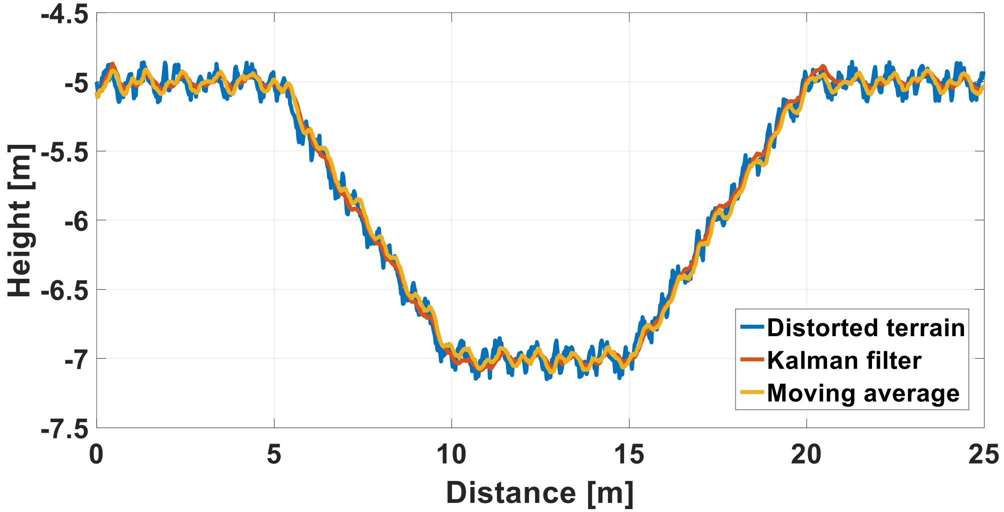
(a)



(b)

Scenario 1 – large unevenness

- (a) – threshold detector
- (b) – intra-pulse modulation



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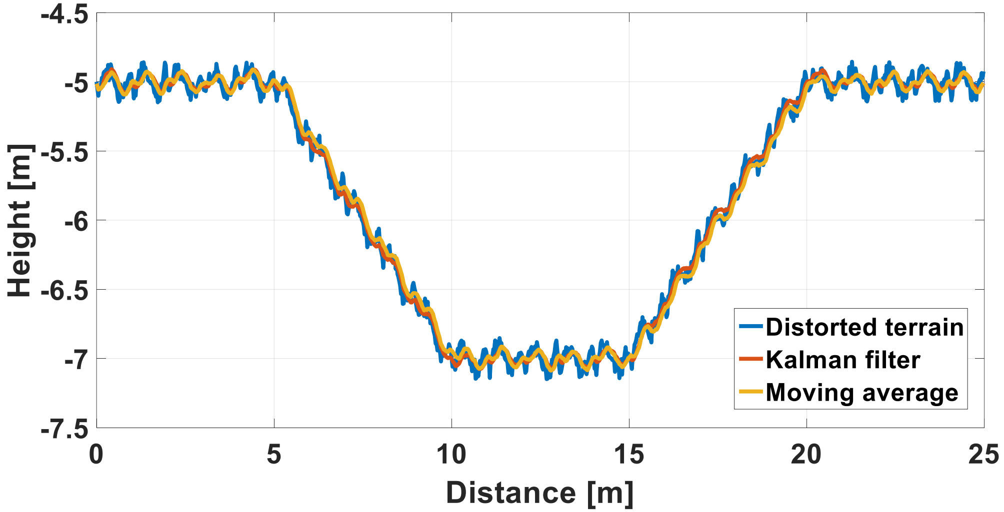
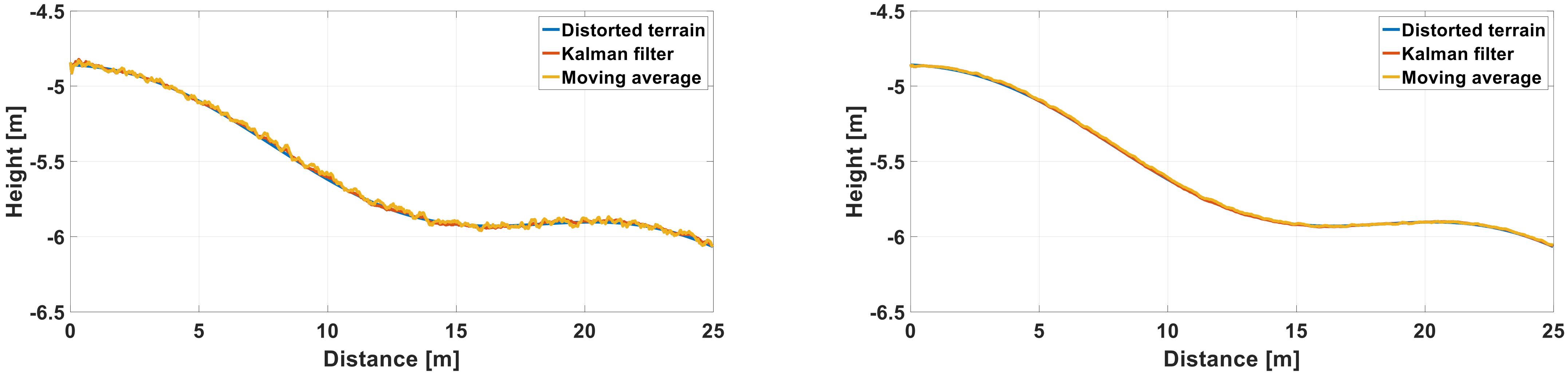


(b)

Scenario 2 – no unevenness

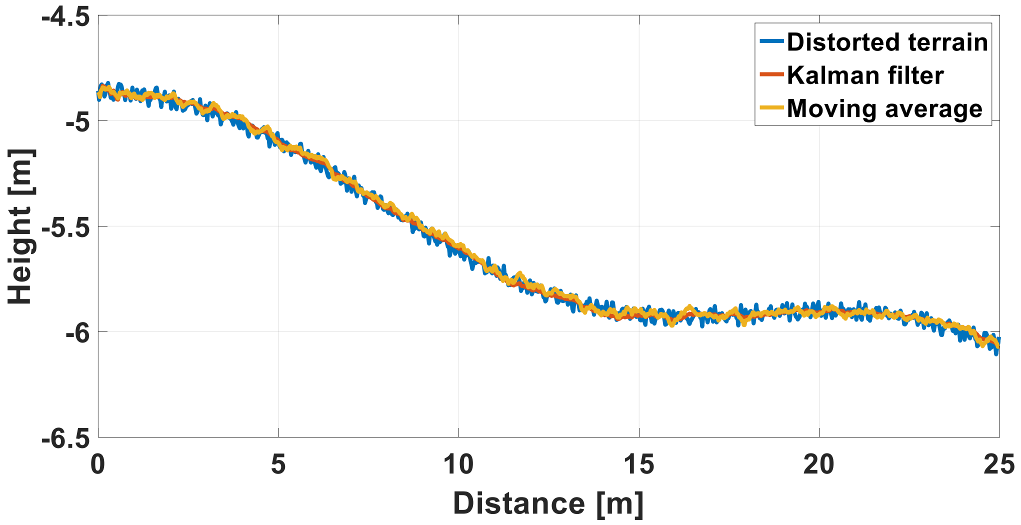
- (a) – threshold detector
- (b) – intra-pulse modulation



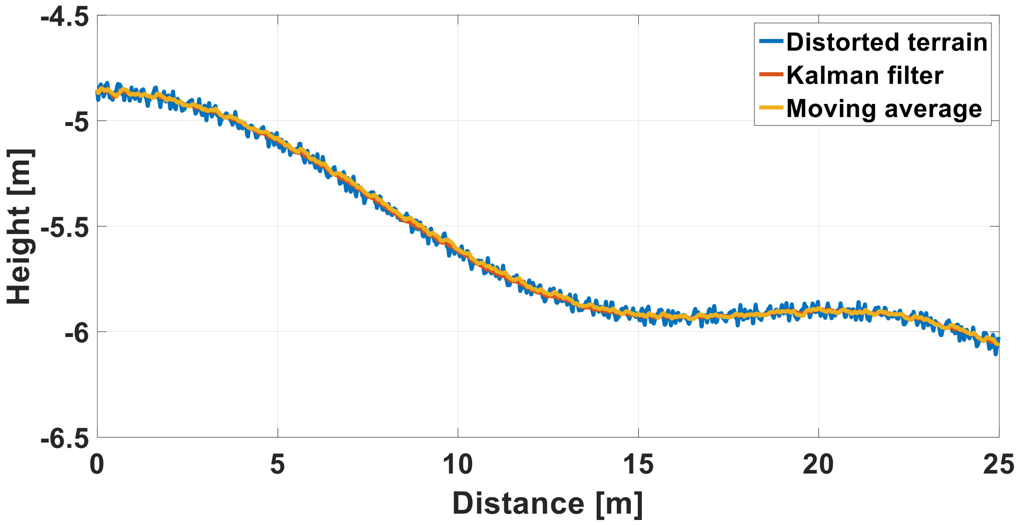
(a) (b)

Scenario 2 – small unevenness

- (a) – threshold detector
- (b) – intra-pulse modulation



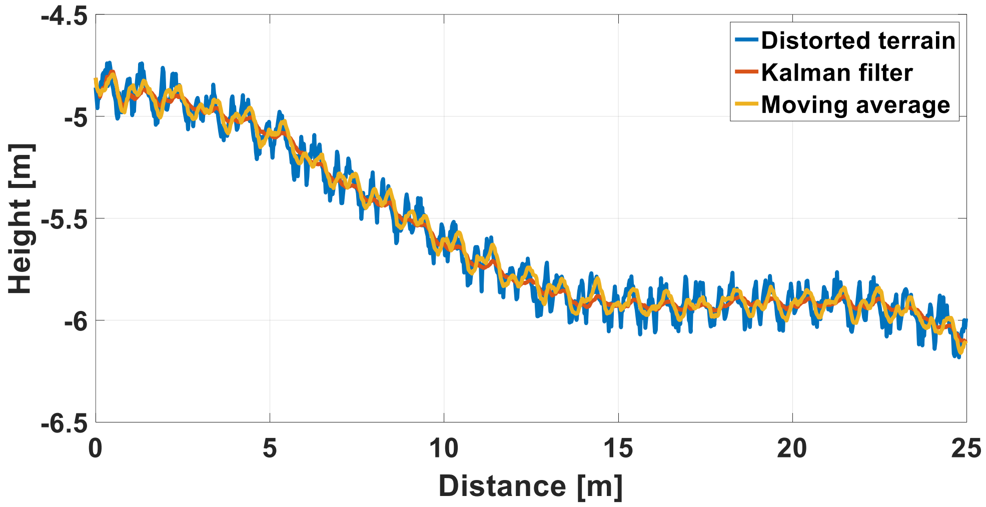
(a)



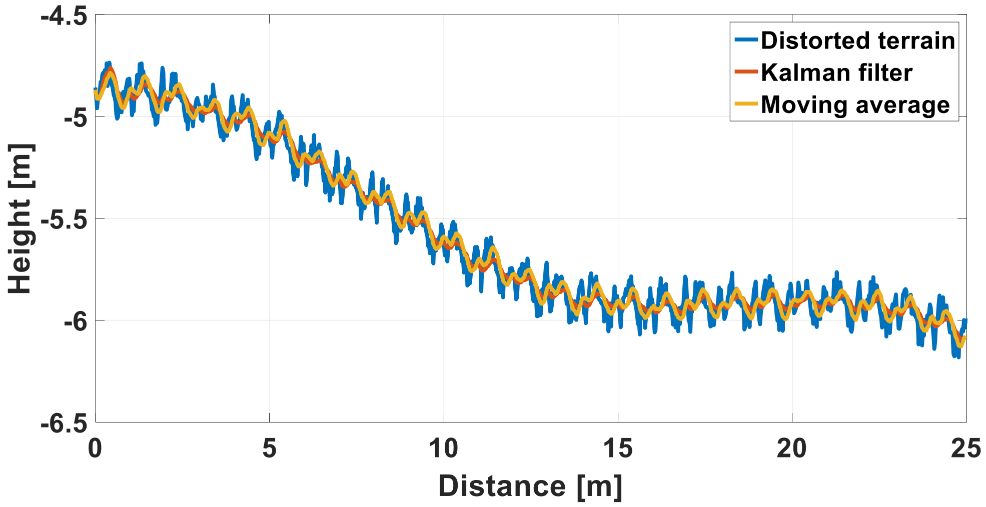
(b)

Scenario 2 – large unevenness

- (a) – threshold detector
- (b) – intra-pulse modulation



(a)



(b)

Conclusion

- Both methods reduce terrain unevenness.
- Moving average is computationally cheaper.
- Moving average generates lag in slope terrain.
- Kalman filter generates overshoots with sharp change of terrain character.
- Kalman filter produces better results with threshold detector as ultrasonic measurement technique, small unevenness and fluent terrain character.

Thank you for attention.