

The comments about the manuscript “Minimal variance-based outlier detection method using forward search model error in a leveling network”

Outlier detection problem is one of important issues in geodesy discipline. Conventional and Robust methods have been used for the outlier detection problem. Especially the studies about the efficiencies of the methods are worthy for the interpretations of the results of the analysis. In this manuscript, Author has applied a new method for the detection of the outliers in geodetic networks. A leveling network has been simulated and different types of outliers' detection problems have been examined. In my opinion, the paper has been accepted after the comments given below are considered:

Responses to anonymous referee #1

Thank the referee for the detailed and comprehensive feedback on our manuscript. We appreciate the referee's time and effort in reviewing our work. Below are the author's responses to each of the referee's comments:

- 1) The title should be changed. In the paper, the proposed method has been applied to the only leveling network; but the functional and stochastic models can be applied to all type of geodetic networks. Also, this method has been applied to the regression problem before. That's why, the title can be changed as “Minimum variance based outlier detection method using forward search model error”.

AR1. The author agrees with the referee's suggestion to modify the title for clarity and inclusivity. The potential revised manuscript title is now “Minimum Variance-Based Outlier Detection Method Using Forward Search Model Error in Geodetic Networks.”

- 2) In the Abstract, at the line 10, “...removes dependency” is not clear. Is the dependency between observations? Maybe it can be “...removes dependency between observations”.

AR2. In lines 38 to 43, It is emphasized that If the rate of successful detection of an outlier using conventional and robust methods is 50%, and one outlier is determined incorrectly, the probability of correctly determining two outliers remains below 50%. This condition is based on the interdependence of each iteration. Incorrect determination at each step also reduces the possibility of identifying more than one outlier in the next step. In other words, it has been stated that the decision taken in one iteration stage directly affects the reliability of the results in the following decision stage. Eliminating this dependency will mean that outliers can be detected more reliably when investigating observation groups based on the minimum variance principle. So the sentence has been clarified as follows: “...variance and eliminates the interdependence of decisions made in iterations.”

- 3) In the Abstract, at the line 10, “...to seek the novel outlier detection approach efficiency in...” should be “to seek the efficient outlier detection approach in...”.

AR3. In line 10, the expression has been corrected to “to seek an efficient outlier detection approach in ...”

- 4) In the Abstract, at the line 14, “(i.e., $1 < m < 4$)” should be deleted.

AR4. In line 14, we have removed “(i.e., $1 < m < 4$)” as per the referee's suggestion.

- 5) In the Abstract, at the line 14, “Besides, the Forward Search of Model Error (FSME) is...” should be

changed as “Besides, proposed model is...”.

AR5. In line 14, we have adjusted the wording to "Besides, the proposed model is..."

- 6) Author has used “model” or “approach”, in my opinion only the “model” can be used. Please, check the manuscript.

AR6. We have revisited the manuscript to ensure consistency in using either "model" or "approach." Following the referee’s recommendation, we have standardized the usage of "model" throughout the manuscript.

- 7) In the introduction, at the line 19, “gross errors” should be “outliers”. Not only the gross errors, but also outliers have contaminated effects on the results of LSE.

AR7. "Gross errors" has been changed to "outliers" in line 19.

- 8) In the introduction, at the line 20, “estimation” should be “estimated”.

AR8. "Estimation" has been changed to "estimated" in line 20.

- 9) In the introduction, at the line 25, “Batilovic et al., 2020 or 2021?”

AR9. It has been corrected as “Batilovic et al., 2021”

- 10) In the introduction, at the line 26, “low efficiency” can be used instead of “unreliability”.

AR10. "Unreliability" has been changed to "low efficiency" in line 26.

- 11) In the introduction, at the line 28, “...these novel methods...” should be “these methods”.

AR11. "These novel methods" has been changed to "these methods" in line 28.

- 12) In the introduction, at the line 29, “the reliability...” should be “the reliabilities...”.

AR12. "The reliability" has been changed to "the reliabilities" in line 29.

- 13) In the introduction, at the line 32, “IF” should be “influence function (IF)”.

AR13. "IF" has been expanded to "influence function (IF)" in line 21, where it is mentioned first.

- 14) In the introduction, at the line 32, “Maronna et al., 2006 or 2019?”

AR14. It has been corrected to “Maronna et al. 2019”

- 15) In the introduction, at the line 35, the sentence “Multiple outliers can be identified at most the number of possible outliers by repetitive test procedures” is not clear. Please, rewrite the sentence clearly.

AR15. The sentence has been rewritten: “Multiple outliers can be identified at most the number of possible outliers ($m_{max} \leq \frac{n-u}{2}$) by repetitive test procedures.”

The number of maximum possible outliers $m_{max} \leq \frac{n-u}{2}$ given by Hekimoglu (2005).

(Hekimoglu, S. (2005). Increasing reliability of the test for outliers whose magnitude is small. Survey Review, 38(298), 274-285.)

16) In the introduction, at the line 44, “conventional method” should be “robust methods”. Please check the reference.

AR16. "Conventional method" has been changed to "robust methods" in line 44.

17) In the introduction, at the line 45, “...observation(s) is included as an additional unknown parameter in the...” should be ““...observation(s) is(are) included as an additional unknown parameter(s) in the...”

AR17. The phrase has been corrected to "observation(s) is(are) included as an additional unknown parameter(s) in the..." in line 45.

18) In the introduction, at the line 53, “...value were flagged...” should be “...value are flagged...”.

AR18. The phrase has been changed to "value is flagged" in line 53.

19) In the introduction, at the line 54, “combination pace...” should be “combination step...”.

AR19. The phrase has been revised as suggested in line 54.

20) In the introduction, at the line 56, the sentence “The primary purpose of this study is to apply seek the proposed outlier detection method efficiency in geodetic networks.” should be changed as sentence “The primary purpose of this study is to apply the proposed outlier detection method to geodetic networks and to seek its efficiency.”

AR20. The sentence in line 56 has been revised as suggested.

21) In the section 2, at the line 63, “... \mathbf{P} a positive definite weight...” should be “... \mathbf{P} be weight...”.

AR21. The phrase has been corrected to "... \mathbf{P} be a weight...".

22) In the section 2, at the line 64 “... \mathbf{x}_{ux1} a vector...” should be “... \mathbf{x}_{ux1} be a vector...”; “... \mathbf{l}_{ux1} an observation...” should be “... \mathbf{l}_{ux1} be an observation...”; “... $\mathbf{C}_{ll_{n \times n}}$ an a priori...” should be “... $\mathbf{C}_{ll_{n \times n}}$ be a priori...”.

AR22. Corrections have been made in line 64 to ensure proper grammar and syntax.

23) In the section 2, at the line 65, “... $\mathbf{Q}_{ll_{n \times n}}$ a weighted...” should be “... $\mathbf{Q}_{ll_{n \times n}}$ be a weighted...”; “... σ_0^2 an a priori...” should be “... σ_0^2 be a priori...”; “...where n and u a number...” should be “...where n and u are the number...”.

AR23. Line 64 has been revised to ensure accurate grammar and syntax.

24) At the line 76, "...the following hypothesis" should be "...the null hypothesis."

AR24. The phrase has been corrected to "...the null hypothesis" in line 76.

25) At the line 79, in the Eq.(6) and at the line 80, " τ " should be " w "; also, τ_i and w_i should be explained after related equations.

AR25. The symbol " τ " has been changed to " w " in line 79 in Eq.(6) and line 80. Explanations for τ_i and w_i have been added after the related equations.

26) At the line 84, "are used iteratively..." should be "is used iteratively..."

AR26. The phrase has been corrected to "is used iteratively" in line 84.

27) At the line 90, the reference "Huber 1964" should be added to the reference list.

AR27. The reference "Huber 1964" has been added to the reference list in line 354.

28) At the line 100, " \hat{x}^k " should be " \hat{x}^r ".

AR28. The symbol " \hat{x}^k " has been corrected to " \hat{x}^r " in line 100.

29) At the line 103, is " 3σ " a priori or a posteriori?

AR29. The phrase " 3σ " is corrected as " $3\sigma_0$ " in lines 103 and 222. Also, expressions have been added to lines 221-222 and 227.

30) At the line 128, in the Eq.(22), is it (+) inverse or (-1) inverse?

AR30. It is pseudo (+) inverse.

31) At the line 155, the expression square root should be removed. Because, variance is calculated with the Eq.(30), not standard deviation.

AR31. The equation has been corrected in line 155.

32) In the section 3, Author uses " σ " and " s " for variance. Please, select one of them and use in the text.

AR32. The consistency has been provided using " s " for variance in section 3.

33) I think the sentence at the line 178 "whether the model.....or not." should be move to the line 175 (after $\alpha = 0.05$; before the sentence "if both...").

AR33. The sentence in line 178 has been moved to line 175.

34) At the line 189, "Hekimoglu and Koch (2000) have..." should be "Hekimoglu and Koch (2000) has..."

AR34. The sentence has been revised to "Hekimoglu and Koch (2000) showed that a finite-sample breakdown point determined the global reliability of an estimator and a test procedure." in line 188.

35) At the line 196, "Erdogan et al. (2019) have..." should be "Erdogan et al. (2019) has..."

AR35. The phrase has been corrected in line 194.

36) At the line 199, "...biased..." should be changed as "...contaminated..."

AR36. The word "biased" has been changed to "contaminated" in line 198.

37) At the line 205, "...novel methods..." should be "proposed methods..."

AR37. The phrase has been changed to "...proposed methods..." in line 203.

38) At the line 221, "...for Robust methods..." should be "...for robust methods..."

AR38. The phrase has been changed to "...for robust methods..." in line 220.

39) At the line 223, "...the A priori variance..." should be "...the a priori variance..."

AR39. The phrase "...the A priori variance..." has been changed to "...the a priori variance..." in lines 221 and 226.

40) At the line 225, "Pope's test had a lower MSR than Baarda's did. However, the MSRs of the FSME (Forward Search of Model Error) are..." should be "Pope's test had a lower MSR than Baarda's test. However, the MSRs of the FSME are..."

AR40. The phrase has been corrected to "Pope's test had a lower MSR than Baarda's test. However, the MSRs of the FSME are..." in line 224.

41) At the line 231, maybe "affect" can be used instead of "impact".

AR41. The word "impact" has been changed to "affect" in line 230.

42) At the line 241, the reference "Durdag 2020" should be added to the reference list.

AR42. It has been corrected as "Durdag 2022" in line 240.

43) At the line 259, the reference "Durdag 2021" should be added to the reference list.

AR43. It has been corrected as "Durdag 2022" in line 258.

44) In the text, Author uses different types of outliers. How did Author define influential outliers? Please add some explanations.

AR44. The sentence "An influential outlier is a situation that, independently or when combined with other biased observations, adversely affects the outcomes of an analysis. Even a single influential outlier may ruin the estimation parameters." has been added in lines 205-207.

45) At the line 292, the sentence "When the redundancy of the observations decreases..." should be "When the redundancies of the observations decrease..."

AR45. The sentence has been corrected to "When the redundancies of the observations decrease..." in line 290.

46) In the conclusion, the first and second sentences may be changed as "This study was designed to determine the usability of the FSME method in geodetic networks. For this aim, FSME methods have been applied to the leveling network. The design of the FSME method is based on identifying the minimum variance from all possible combinations that assume observations as model errors in the Gauss-Markov model. Although, only leveling network has been simulated, the functional and stochastic models of FSME methods can be applied to all type of geodetic networks. This method gives....".

AR46. The first and second sentences have been revised as suggested.

47) Although Hekimoglu and Erdogan (2013) has been added to the reference list, it has not been cited in the text.

AR47. The reference has been removed from the manuscript.