We are grateful to the editors and all three reviewers for taking the time to provide feedback on our manuscript. The comments and suggestions will greatly improve the overall quality, clarity, and rigor of the paper. We have responded to all reviewer comments and plan to add all revisions to our manuscript. Following the instructions from the editor, we have not made these revisions yet, but we will ensure that all revisions are clearly reflected in the updated text. Below, the original comments appear in bold roman typesetting, and our responses are provided in italic typesetting.

Comments from Reviewer 3:

The manuscript presents research on improving existing rainfall thresholds for landslide prediction along highways by incorporating antecedent soil moisture conditions. The authors established an inventory containing landslide and non-landslide events, precipitation data from NOAA, and soil moisture data from NASA's SMAP. Rainfall thresholds from the literature for landslide forecasting were examined using the inventory data. Furthermore, the research proposed incorporating normalized soil moisture into the development of rainfall thresholds, which shows potential for reducing false positives in prediction. The work is highly practical and will be of interest to practitioners in landslide assessment and management. However, the overall quality of the manuscript needs improvement before it can be accepted for publication.

Dear Dr. Yichuan Zhu,

Thank you very much for your thoughtful and constructive review of our manuscript. We appreciate your recognition of the practical significance of our work. We will carefully revise the manuscript to address all of the points you raised. Below, we address each of your comments individually and provide detailed responses to clarify all points raised.

1. **In the Discussion section, the authors mention spatial resolution issues, which remain a significant concern for the current study. NASA's SMAP operates at a 9-km by 9-km resolution, while CONUS data has a spatial resolution of 28-km by 28-km. How do these resolutions align with the site-specific study presented in the manuscript?**

Response to Comment 1: *While the study used site-specific inclinometer data as the response variable (landslide occurrence) for threshold development, the objective of the research was to provide a predictive tool for landslides that is applicable to sites where in situ data are not available. Therefore, publicly available gridded datasets were used as explanatory variables for the thresholds. There is a tradeoff between spatial and temporal resolution with gridded data products, and we will add additional explanation of our rational for using products with relatively coarse resolution and more detail on how the products* *were applied. We will also clarify in the introduction that we see our thresholds as a compliment to site-specific geotechnical slope stability analyses and not a replacement.*

2. **The soil moisture data from NASA's SMAP satellite may require calibration before incorporation into the working pipeline. Based on the reviewer's experience, systematic bias between SMAP and in-situ soil moisture monitoring can exhibit seasonal patterns. It would strengthen the manuscript if the authors could provide additional justification regarding this potential issue.**

Response to Comment 2: *We agree that for site-specific calibration would be ideal for developing a mechanistic understanding of the relationship between soil moisture, matric suction, and landslide triggering. However, our objective in this study was to develop an empirical threshold for landslide warning systems that is applicable at sites where in situ data are not available. Within this empirical threshold, uncalibrated SMAP soil moisture serves as a general indication of relative soil wetness, as we note at line 396. We will include a discussion of the lack of soil moisture calibration as a study limitation. We did note a seasonal pattern in SMAP soil moisture data, with higher values in the winter. This is physically realistic, as winters in the region are typically rainy with low evapotranspiration but could also include a seasonal bias component. We will also acknowledge this potential limitation in our discussion section, but do not have in-situ data available to verify if it is occurring or not at our sites.*

3. **The current work adopts a previous threshold of 5 mm to distinguish landslide from non-landslide events. While a reference is provided, it would be beneficial to include rationale for this threshold in the current manuscript. From the reviewer's perspective, whether internal movement of 5 mm should be classified as "landslide" is worth discussion. Such movement could represent only localized slope displacement rather than strain bifurcation or connection into a plastic zone. Please justify why the 5 mm threshold is effective for classifying sites as landslide locations.**

Response to Comment 3: *Thank you for this important comment. In the revised manuscript, we will provide a clearer rationale for the use of the 5 mm displacement threshold. As described in our response to Comment 3 from Reviewer #1, the thresholds were selected based on the empirical distribution of displacement changes measured at the top of the slide plane across all inclinometer readings. The cumulative distribution of these displacement changes (Rahimikhameneh et al., 2024) shows that approximately 50% of readings involve less than 1 mm of movement (likely within the instrument's measurement uncertainty) whereas about 13% show displacement changes greater than 5 mm. These values form natural separation points within the dataset. For this reason, we classify ≥ 5 mm of internal* *movement between consecutive readings as a landslide event, and < 1 mm as negligible movement.*

It is important to emphasize that the ≥ 5 mm movements used in our classification represent reactivation along pre-existing shear zones, rather than the initiation of new landslides. The inclinometer casings are installed at sites already identified as unstable, and the detected displacements reflect movement along established failure surfaces. Thus, it is a threshold for identifying periods of renewed movement at known unstable highway slopes and not at sites without a history of movement. This clarification will be added to the revised manuscript.

4. **Regarding performance metrics, is it possible within the current research framework to plot a Receiver Operating Characteristic (ROC) curve and compute the Area Under the Curve (AUC)?**

Response to Comment 4: *Thank you for this suggestion. As part of the revision process, we generated ROC curves and computed AUC values for all five thresholds. The ROC curves are shown in Figure R1, which will be included in the revised manuscript. Both NSM-dependent thresholds (A and B) yield higher AUC values than the Marino et al. (2020) and Guzzetti et al. (2008) thresholds. Threshold B achieves the highest AUC among all evaluated methods and shows a slight improvement relative to the Godt et al. (2006) model, while Threshold A exhibits comparable performance.*

5. **The current work uses normalized soil moisture-dependent thresholds. How does this approach affect the uncertainty or sensitivity of predictions across space? Future work could include variogram or Bayesian analysis to investigate spatial uncertainty**.

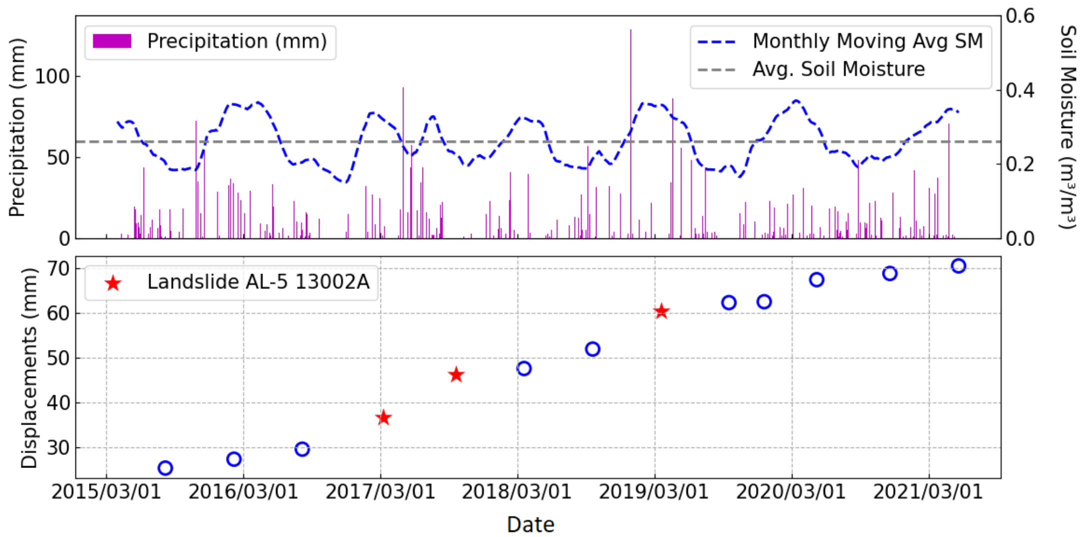
Response to Comment 5: *Thank you for this comment. In the current study, NSM is used as a regional hydrologic indicator, with the normalization intended to provide a consistent index. We did not assess spatial uncertainty or sensitivity in our approach. We agree that incorporating variograms or Bayesian analysis would be a valuable addition to future studies, and we will explicitly mention these techniques as promising directions for future work.*

6. **Please add references for Pandas, NumPy, OS, and Matplotlib as a way to support the open-source community.**

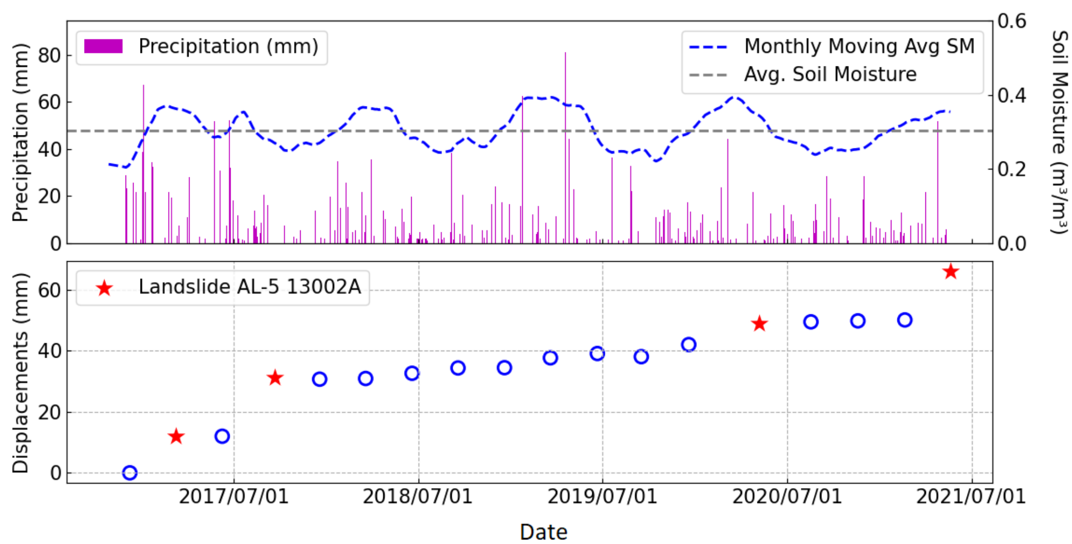
Response to Comment 6: *Thank you for catching this. In the revised manuscript, we will add formal references for NumPy, Pandas, Matplotlib, and the Python OS module.*

7. **For Figures 2 and 3, consider plotting moving averages to better illustrate seasonal or annual changes in soil moisture.**

Response to Comment 7: *Thank you for the helpful suggestion. We have revised Figure 3 to include monthly moving averages of soil moisture rather than raw daily values (Figure R2). Applying a moving average smooths high-frequency noise and filters out short-term fluctuations that are not relevant to capturing antecedent or seasonal moisture conditions.*



(a)



(b)

Figure R2. Time series of inclinometer displacement (red stars indicate landslide events and open symbols indicate non-landslide events), daily rainfall (purple bars), and monthly moving average soil moisture (SMAP L4, blue line) for (a) AL-69 Inclinometer 13002 and (b) AL-5 Inclinometer 13002A.

8. **In Figures 6 and 7, the legend shows the thresholds as shaded blocks, while the plot presents them as lines. Please make these representations consistent.**

Response to Comment 8: *Thank you for pointing this out. We will update Figures 6 and 7 to ensure consistency between the legend representation and the plotted threshold lines.*

9. **In Figure 9, the legend notation "1.25 to<2.15" reads awkwardly. Consider using a simpler format such as "1.25–2.15."**

Response to Comment* 9: Thank you for this suggestion. We agree that the notation in Figure 9 can be clearer. In the revised version, we will update the label from “1.25 to < 2.15” to “1.25–2.15.”*