REFEREE'S COMMENTS ON egusphere-2025-1590

RC#3

R: This is an interesting study emphasizing the utility of ERA5 soil moisture data for improving landslide forecasting, despite the coarse resolution (9x9km) and considerable latency (5d) of the product. Overall, the results are intuitive and confirm expectations based on previous research, namely that ERA5, which reflects more than just antecedent rainfall, will improve landslide forecasting when paired with rainfall data. This is useful despite these limitations with resolution and latency of ERA5 and I agree with reviewers #1 and #2 that this will ultimately contribute to the literature and be appreciated by readers of NHESS. The explicit evaluation of latency impacts is interesting, though from the perspective of implementation for early warning it's unclear why a hypothetical latency of 15d is useful since the actual product currently has the fixed delays of 5d, particularly when other more practical questions about the broader utility of ERA5 could be investigated (see below).

A: We thank the reviewer for this insightful comment. Although the current operational latency of ERA5-Land soil moisture is approximately 5 days, we chose to explore a broader range of latencies (from 1 to 15 days) to account for both potential future improvements in data delivery and hypothetical scenarios of temporary service disruptions. More broadly, our goal was to assess how forecast performance degrades as data timeliness decreases, and to evaluate the model's sensitivity to delays in soil moisture availability. This analysis helps clarify the operational value of ERA5-Land and identify the latency thresholds within which the product remains useful for early warning purposes.

R: As pointed out by both reviewers, the paper is indeed lacking on discussion and broader implications, so overall, I found the analysis somewhat narrow in terms of the scope of hypotheses tested. As Reviewer #1 noted in his paper for the San Francisco Bay Area, California (Thomas, Collins, and Mirus, WRR, 2019), SMAP data is useful, but in-situ soil moisture sensors have the capacity to improve over the general limitations of satellite soil moisture and rainfall data, even though the latter is theoretically available everywhere on the globe. As we further note in our recent perspective (Mirus, Bogaard, Greco and Stahli, NHESS, 2025), hillslope monitoring stations are advantageous for improving forecasts, but are difficult to maintain and come with other representativeness issues. So, we suggested more rigorous comparison of in-situ sensors from hillslope locations with satellite data for landslide prone areas would shed more light on the utility of satellite data for landslide forecasting. The current study misses this opportunity. Are there any in-situ hydrological data available *anywhere* in your study area to expand the value and impact of your study? I realize that the Contra Costa and Alameda counties from Matt's paper are only ~5,000 km2 whereas Sicily is closer to 26,000 km2, so I'm curious if you'd find over this larger scale that the satellite soil moisture, despite the lags, is still more useful than in-situ sensors for spatially explicit landslide forecasting?
The study is fine otherwise ad comparable to a technical note or methodological contribution. Again, I would urge the authors to dig deeper in their analyses, as all three reviewers suggest, to enhance the impact and utility of this work to inform landslide early warning systems in Italy and worldwide.
Ben

A: We thank the reviewer for this valuable comment and for pointing out the broader discussion around the trade-offs between satellite-derived and in-situ soil moisture data. We fully agree that in-situ hydrological observations, especially from hillslope monitoring stations, are crucial for improving landslide forecasting. However, in our study area there are not publicly available in-situ soil moisture data, nor private data for a sufficient period. The closest point of the International Soil Moisture Network is in a different region, Calabria (https://ismn.earth/en/). Given this fact and considering the regional scale of the analysis (~26,000 km^2), we relied on the globally available ERA5-Land reanalysis soil moisture product. While previous studies have shown that ERA5 soil moisture may be less accurate than ground-based observations, especially in complex terrains, our results show that including ERA5 Land data still improves model performance compared to using rainfall alone. This supports the idea that even uncertain soil moisture estimates can provide useful information for landslide forecasting at regional scale. This observation aligns with findings by Marino et al. (2020), who demonstrated that even soil moisture estimates derived from a simplified hydrological model—rather than satellite or in-situ data—can significantly enhance landslide prediction. In their study, the authors used a Monte Carlo approach to assess the robustness of forecasting thresholds under different uncertainty scenarios, and they found that soil moisture information consistently contributed to reducing false alarms. These results highlight that the added value of soil moisture information is not confined to localized, high-accuracy observations, but may also emerge from coarser, large-scale products that adequately capture the temporal patterns relevant to slope instability. We will include these considerations in the revised discussion section. We also agree that our manuscript was quite short in some parts. With the revisions following referee comments we believe that we will be able to expand it to make it less comparable to a technical note.