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Mitigating Label Noise in Remote Sensing: A Pseudo-Labeling Method for Forest Classification with Sentinel-2

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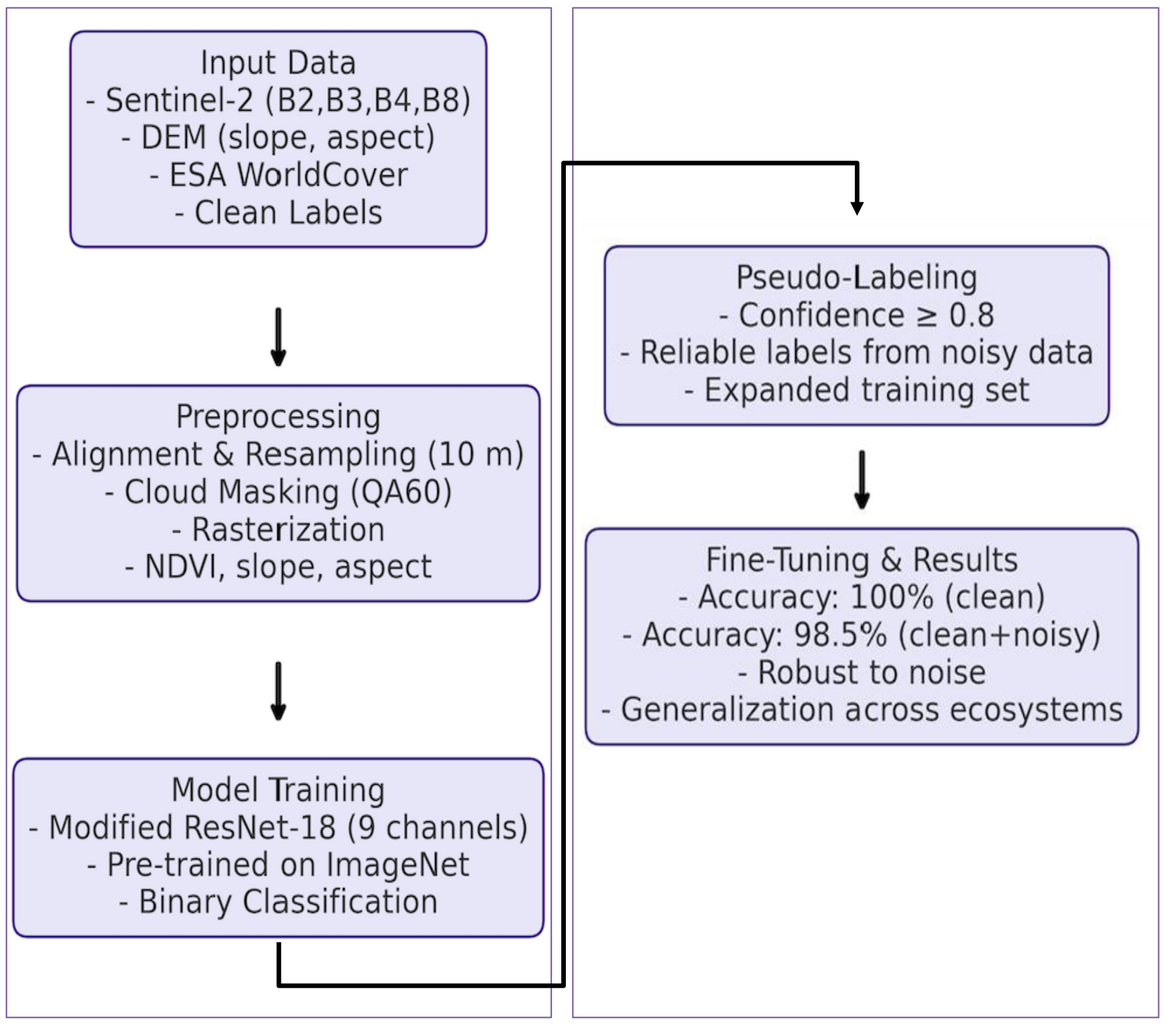
INTRODUCTION & AIM

The accuracy of large-area forest mapping is often compromised by the label noise present in global land cover products like ESA WorldCover. This study introduces a robust semi-supervised framework to mitigate this issue. The objective is to leverage a small, trusted set of manually curated clean data to refine a large, noisy dataset, thereby improving classification accuracy and robustness for more reliable environmental monitoring.

METHOD

Our approach employs a modified ResNet-18 architecture, utilizing Sentinel-2 and Digital Elevation Model (DEM) data, in a two-stage training process:

1. Teacher Model Training: Initially, the model is trained exclusively on the high-quality, manually labeled clean dataset.
2. Pseudo-Labeling & Fine-Tuning: This initial "teacher" model is then used to generate high-confidence pseudo-labels for the extensive but noisy WorldCover data, effectively filtering and re-labeling uncertain regions. Subsequently, the model is fine-tuned on a composite dataset containing both the original clean labels and the newly generated, reliable pseudo-labels. This strategy leverages the accuracy of the clean data to improve the utility of the noisy data.



(a) Teacher Model Training (b) Pseudo-Labeling & Fine-Tuning

Figure 1: Workflow of the Semi-Supervised Pseudo-Labeling Framework

RESULTS & DISCUSSION

The semi-supervised methodology demonstrated exceptional performance, achieving a final classification accuracy of 98.50% on a combined validation set. The initial training on clean data showed rapid convergence, underscoring the power of a high-quality seed dataset. By using the initial model to refine the larger, noisy dataset, this approach significantly enhances model robustness and generalization, as tested in a case study covering the diverse forest ecosystems of North Africa.

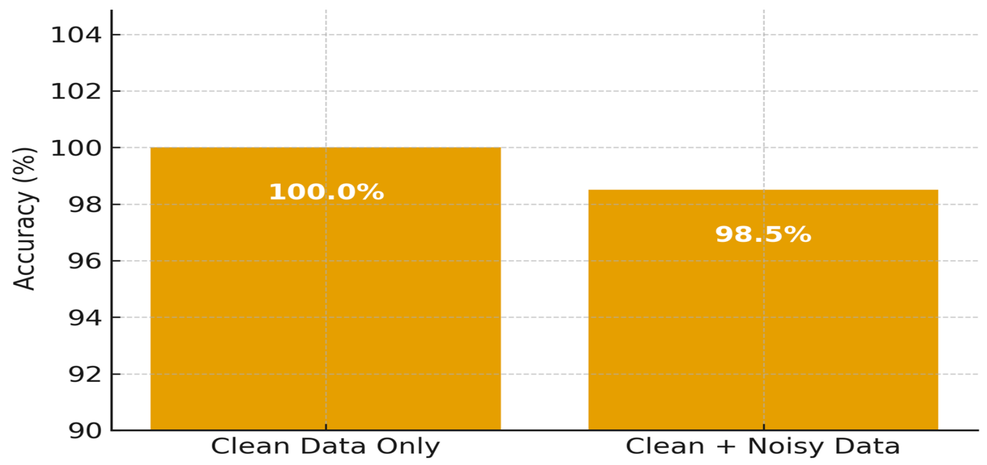


Figure 2: Proposed model accuracy on different training sets

CONCLUSION

This research offers a practical and highly effective strategy for improving land cover classification in any region where large, noisy datasets are available alongside limited high-quality ground truth. The proposed framework provides a scalable solution to support global conservation efforts by enabling more accurate and reliable forest mapping from satellite imagery.

FUTURE WORK / REFERENCES

- Apply framework to other regions: Expand the use of this methodology to different geographical areas to test its adaptability and effectiveness.
- Explore advanced noise-robust deep learning methods: Investigate and incorporate more sophisticated algorithms designed to handle noisy data even more effectively.
- Perform ablation studies on feature importance: Conduct experiments to systematically evaluate the contribution of individual input features (like NDVI, slope, and aspect) to the model's performance.

1. Liu, C., Albrecht, C. M., Wang, Y., & Zhu, X. X. (2024, July). Task specific pretraining with noisy labels for remote sensing image segmentation. In IGARSS 2024-2024 IEEE International Geoscience and Remote Sensing Symposium (pp. 7040-7044). IEEE.