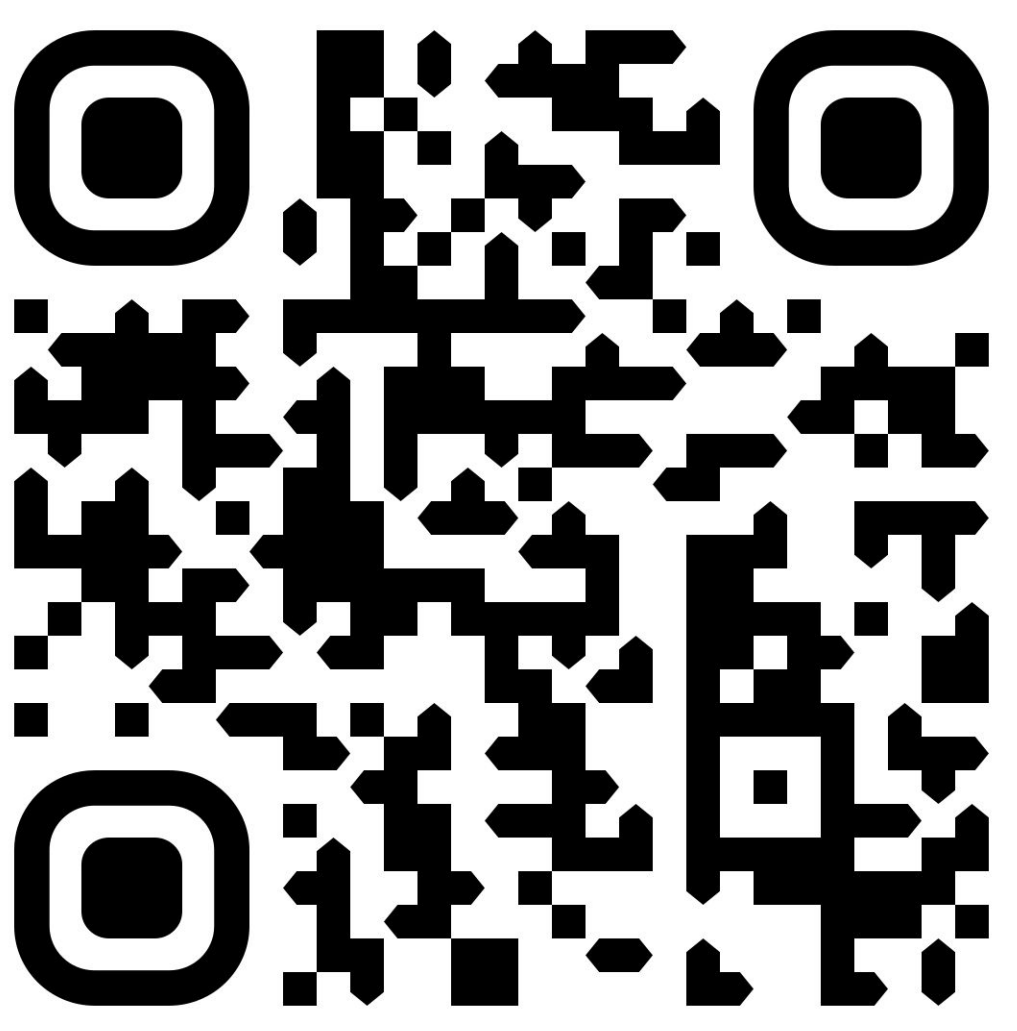




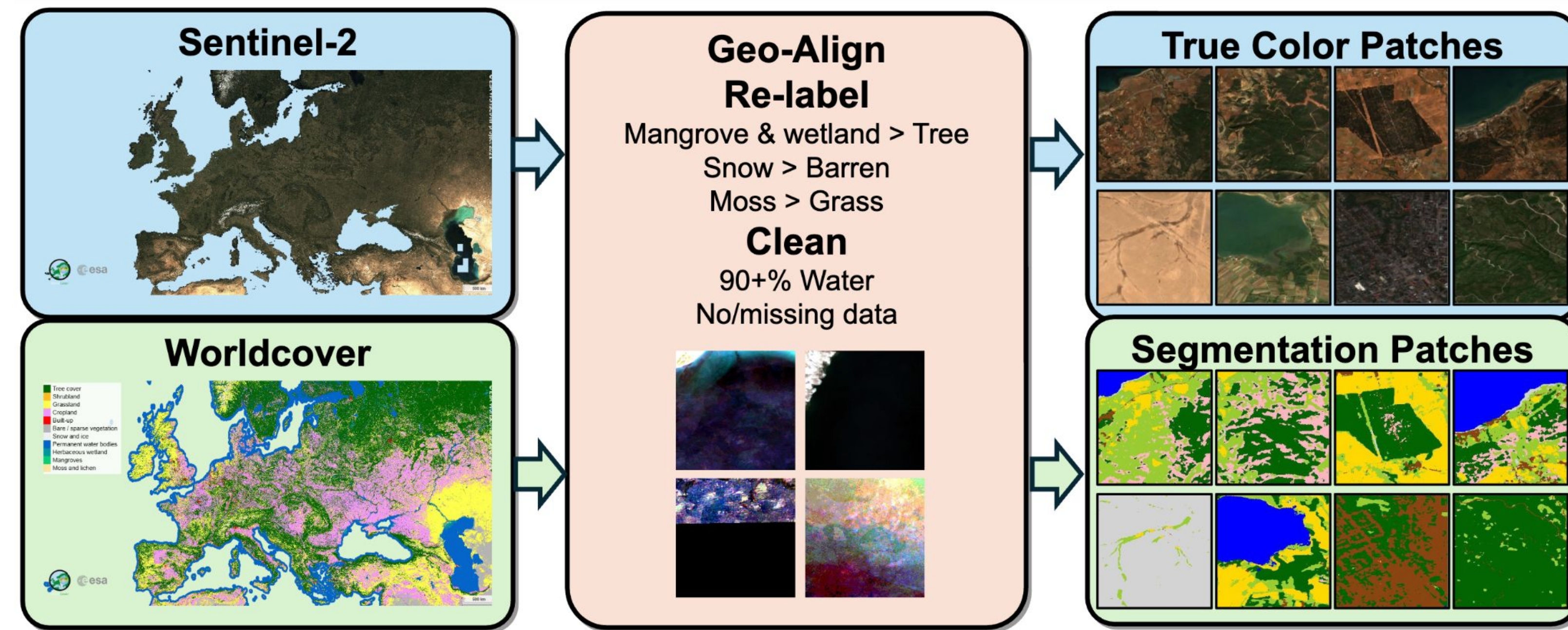
BELDE: Building a Large-scale Earth-observation Land-cover Dataset for Europe

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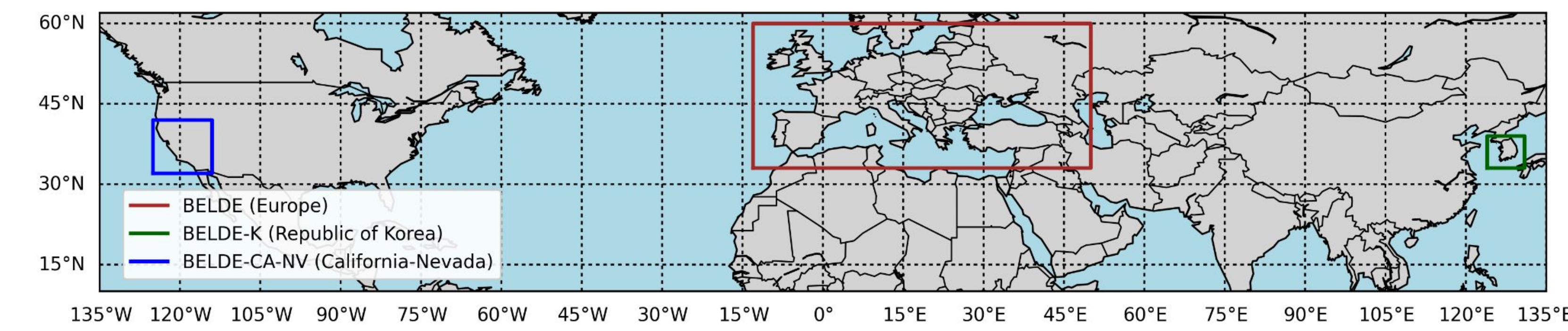
ABSTRACT



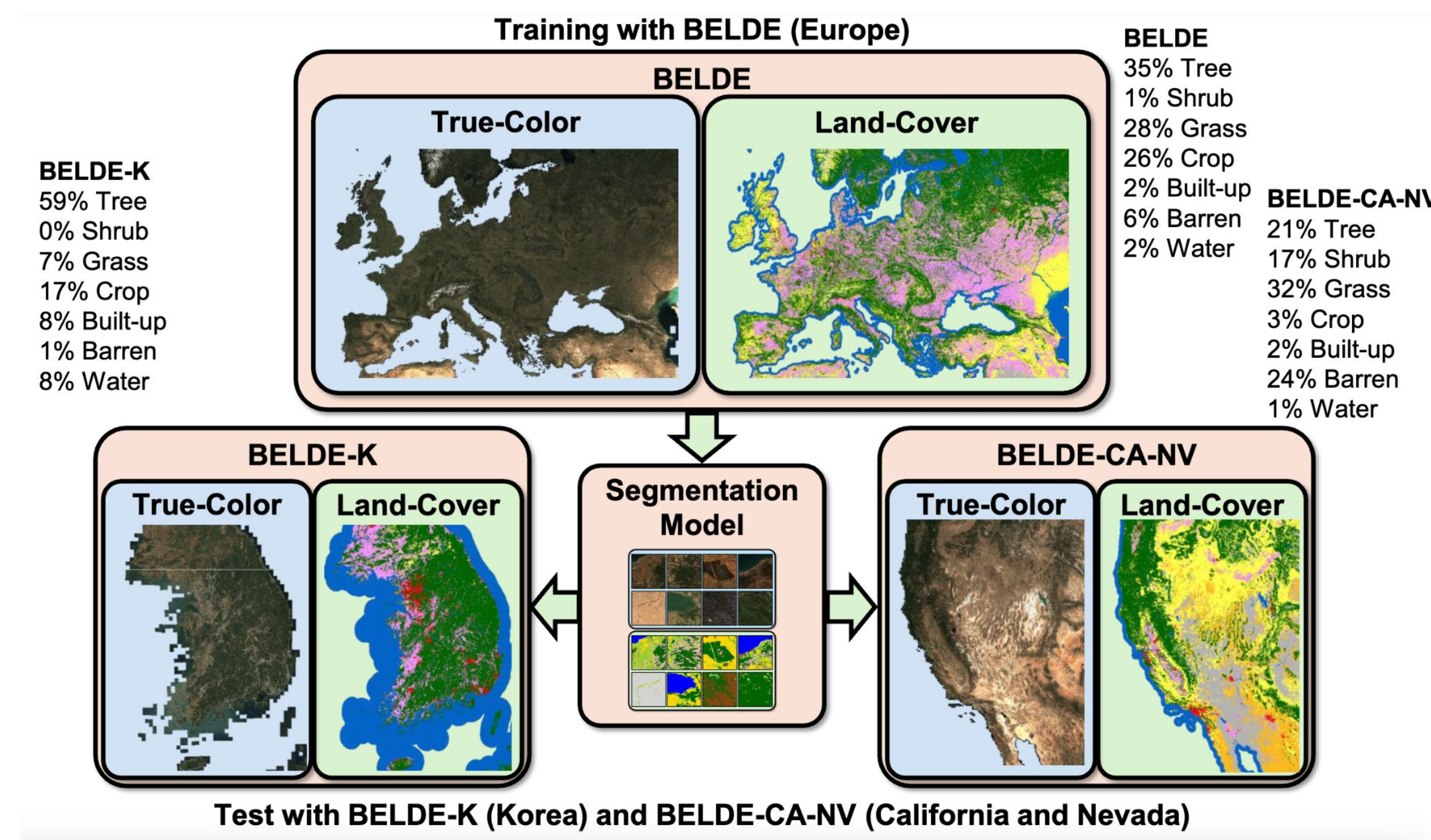
- Dataset for Earth-observation land-cover segmentation
- Curated 1,088,385 image-mask pairs, 10 m resolution
- Over 1.94 million non-informative patches pruned
- 17 segmentation architectures benchmarked across CNN, transformer and hybrid families
- Lightweight model (2.61M parameters) retains over 94% of a 100M-parameter model's performance
- Two out-of-domain extensions released for cross-region generalization testing
- Consistent performance degradation observed under geographic domain shift
- Segmentation performance improved with diffusion-based synthetic augmentation

Architecture	Accuracy	Precision	Recall	F1-score	IoU	Parameters
DeepLabV3	86.4 ± 0.1	79.2 ± 0.3	81.6 ± 0.2	80.2 ± 0.1	69.2 ± 0.1	33.06M
DeepLabV3+	87.0 ± 0.0	80.7 ± 0.1	81.8 ± 0.2	81.2 ± 0.1	70.4 ± 0.1	29.49M
FPN	87.0 ± 0.1	80.7 ± 0.2	81.6 ± 0.3	81.1 ± 0.2	70.4 ± 0.2	30.17M
Linknet	86.7 ± 0.1	80.6 ± 0.2	81.6 ± 0.2	81.0 ± 0.1	70.2 ± 0.2	28.75M
PSPNet	84.3 ± 0.4	77.4 ± 0.9	78.8 ± 0.6	77.9 ± 0.4	66.2 ± 0.5	28.44M
Segformer	87.1 ± 0.7	80.5 ± 1.2	81.9 ± 0.7	81.1 ± 1.0	70.5 ± 1.3	28.89M
Unet	87.5 ± 0.4	81.3 ± 0.1	82.5 ± 0.6	81.8 ± 0.3	71.3 ± 0.5	31.22M
Unet++	87.4 ± 0.2	81.1 ± 0.6	82.5 ± 0.1	81.7 ± 0.3	71.2 ± 0.4	31.91M
DeiT3	87.3 ± 0.6	81.4 ± 0.7	81.9 ± 0.7	81.5 ± 0.8	71.0 ± 1.0	117.08M
EfficientFormer-L1	87.4 ± 0.5	81.7 ± 0.8	81.6 ± 0.6	81.6 ± 0.6	71.1 ± 0.8	29.83M
EfficientFormer-L3	88.0 ± 0.5	82.4 ± 0.4	82.8 ± 1.2	82.5 ± 0.8	72.3 ± 0.9	49.13M
EfficientFormer-L7	88.3 ± 0.4	82.5 ± 0.5	83.6 ± 0.6	83.0 ± 0.5	72.8 ± 0.7	100.32M
FastViT-mci0	87.4 ± 0.5	81.5 ± 0.5	82.0 ± 1.3	81.6 ± 0.9	71.1 ± 1.1	29.07M
FastViT-sa12	87.7 ± 0.5	81.5 ± 1.1	83.2 ± 0.2	82.2 ± 0.7	71.8 ± 0.9	29.24M
MaxViT	88.4 ± 0.4	82.4 ± 0.8	83.6 ± 0.2	82.9 ± 0.6	72.8 ± 0.7	60.80M
LALe-S3	84.4 ± 0.1	78.3 ± 0.0	78.8 ± 0.1	78.4 ± 0.1	66.8 ± 0.1	3.66M
LALe-S2	84.1 ± 0.3	78.1 ± 0.2	78.7 ± 0.2	78.2 ± 0.2	66.5 ± 0.2	2.61M

METHODS AND MATERIALS



- Data collection (Sentinel-2 true-color imagery and ESA WorldCover 2021)
- Geo-alignment, class re-labeling and automated quality filtering
- Diffusion-based synthetic data generation for augmentation study



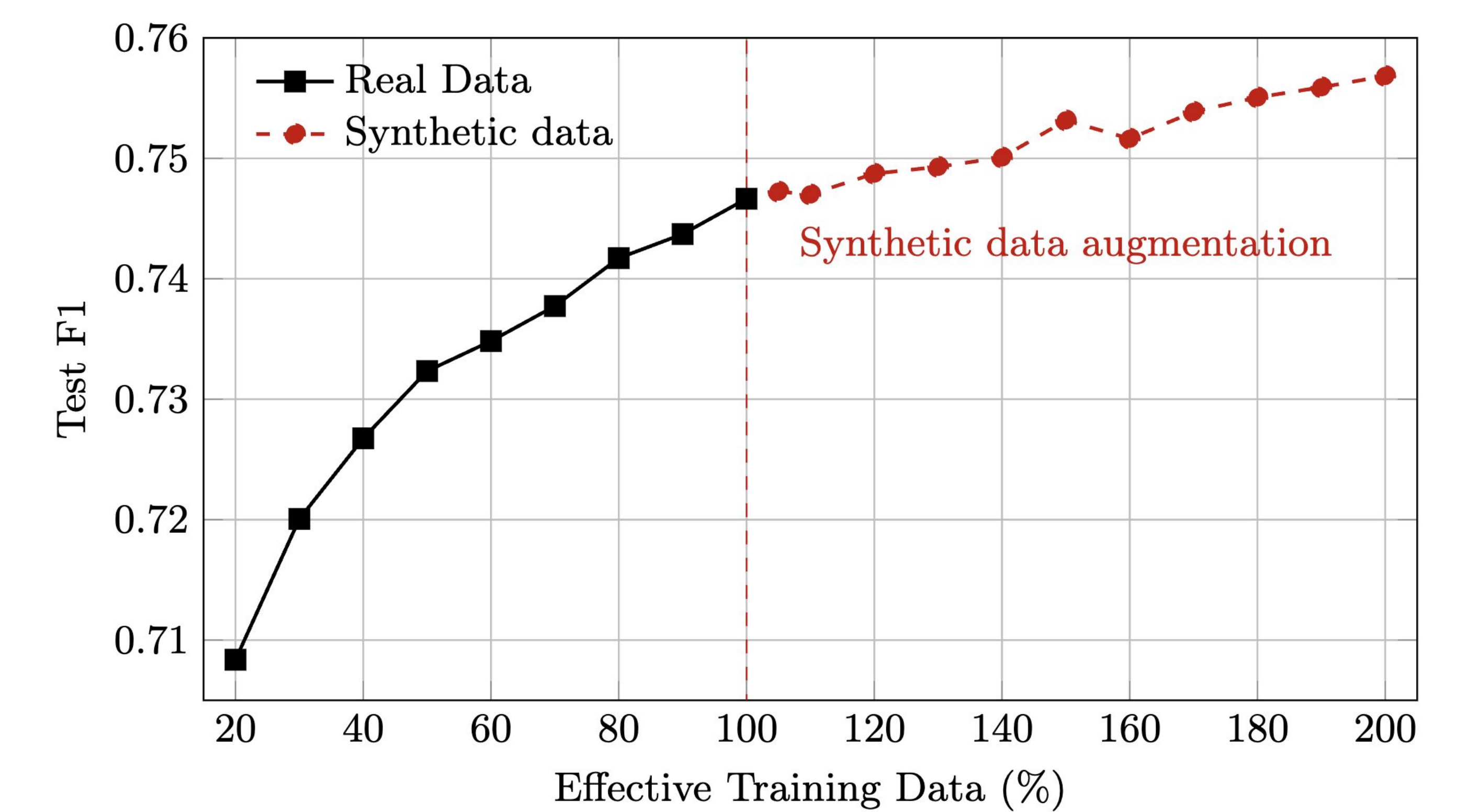
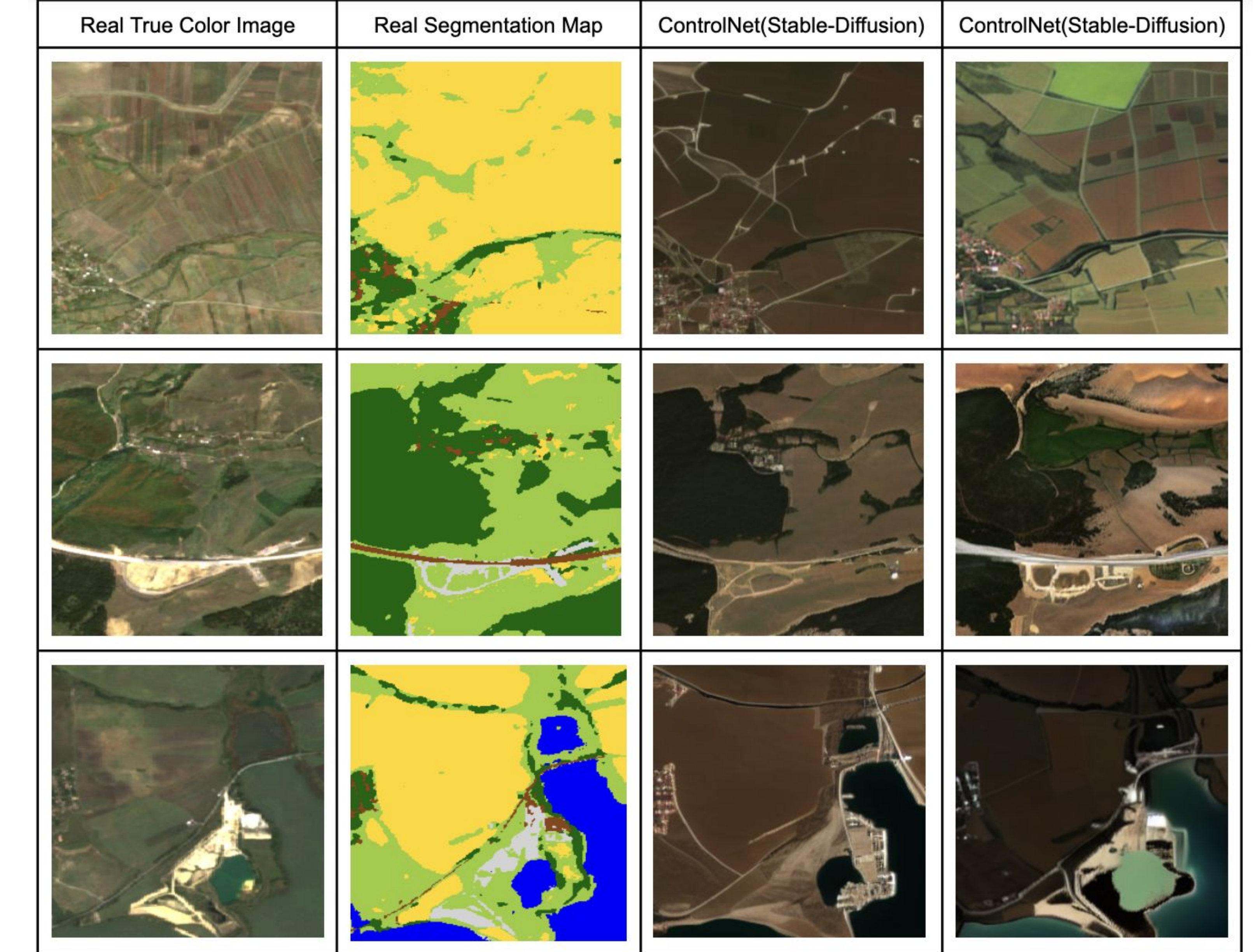
Existing remote sensing land-cover datasets:

- × Limited geographic coverage or restricted to a single region
- × Comparatively small scale (tens of thousands of patches)
- × Rarely tested for cross-region generalization

Our approach:

- ✓ Large curated RGB Earth-observation benchmark
- ✓ Automated pruning and taxonomic harmonization across 7 classes
- ✓ Cross-continental out-of-domain benchmarks

SYNTHETIC DATA AUGMENTATION



CONCLUSION

- Public dataset with out-of-domain extensions
- Significant performance degradation confirmed under geographic domain shift
- Geographically diverse benchmarks established as necessary for robust Earth observation
- Synthetic data augmentation demonstrated to exceed full real-data capacity