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## Tracking tillage practices across European croplands using multi-scale remote sensing and machine learning.

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The adoption of regenerative agricultural practices is gaining traction as an approach to enhance soil health and sequester carbon to combat climate change. Several sustainability frameworks and programmes are now incentivizing producers to transition to regenerative farming. These evolving initiatives have created a need to build and operate Measurement, Reporting and Verification (MRV) platforms to track cropland practices and impacts. To help scale initiatives, we have developed an automated approach that leverages multi-source remote sensing, data science and machine learning for cost-effective, robust and transparent tracking of tillage practices. Our approach leverages time-series satellite observations from Sentinel-1 and Sentinel-2 constellations, along with ancillary data from SMAP, soils and weather. Within a hierarchical classification, these inputs are blended with dense, independent training data (i.e., “ground truth”) collected across Europe with tens of thousands of samples gathered across France, Belgium, Denmark and the UK. Training data includes observations of crop types and rotations, residue, soil disturbance and field conditions. Together, these multi-source data feed into gradient boosting and Convolutional Neural Networks to ultimately help seasonally classify tillage practices into conventional, reduced or no till at field scale for all major row crops. Withheld independent observations and data science best practices are used to tune model performance and class accuracy depending on regional schemes, residue categories and landscape practice variability. F1 score and Overall Accuracy achieve > 80% with some crop and tillage practice combinations (i.e. corn, soy, wheat conventional) > 0.9. In addition, we share lessons learnt and next challenges. With this approach, the Community of Practice can robustly track every field wall-to-wall over seasons and feed downstream applications, such as estimating Soil Organic Carbon and emissions process modelling. With these tools, and open operational data streams such as Copernicus, we can support scaling regenerative agriculture impacts and grow carbon farming initiatives and ecosystem service markets across Europe.