Mapping Crops Within the Growing Season Across the United States

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MOTIVATION

Mapping the spatial extent and distribution of crops in a timely manner is necessary for near real-time crop health monitoring. The US is a leading food producer in the world, with about 20% of world grain exports; however, no spatially explicit national crop map is available publicly during the current growing season. The USDA produces the annual Cropland Data Layer (CDL), a crop-specific land cover map for the CONUS at 30 m resolution, but the CDL is not released until the spring of the year following the current growing season, at least four months after the current harvest.

OBJECTIVES

- To create a national, crop-specific land cover map (with all of the crop types, as in the CDL) for the CONUS using only time series of vegetation greenness (NDVI).
- To create crop maps in near-real time during the current growing season.

DEVELOPMENT OF PHENOREGIONS

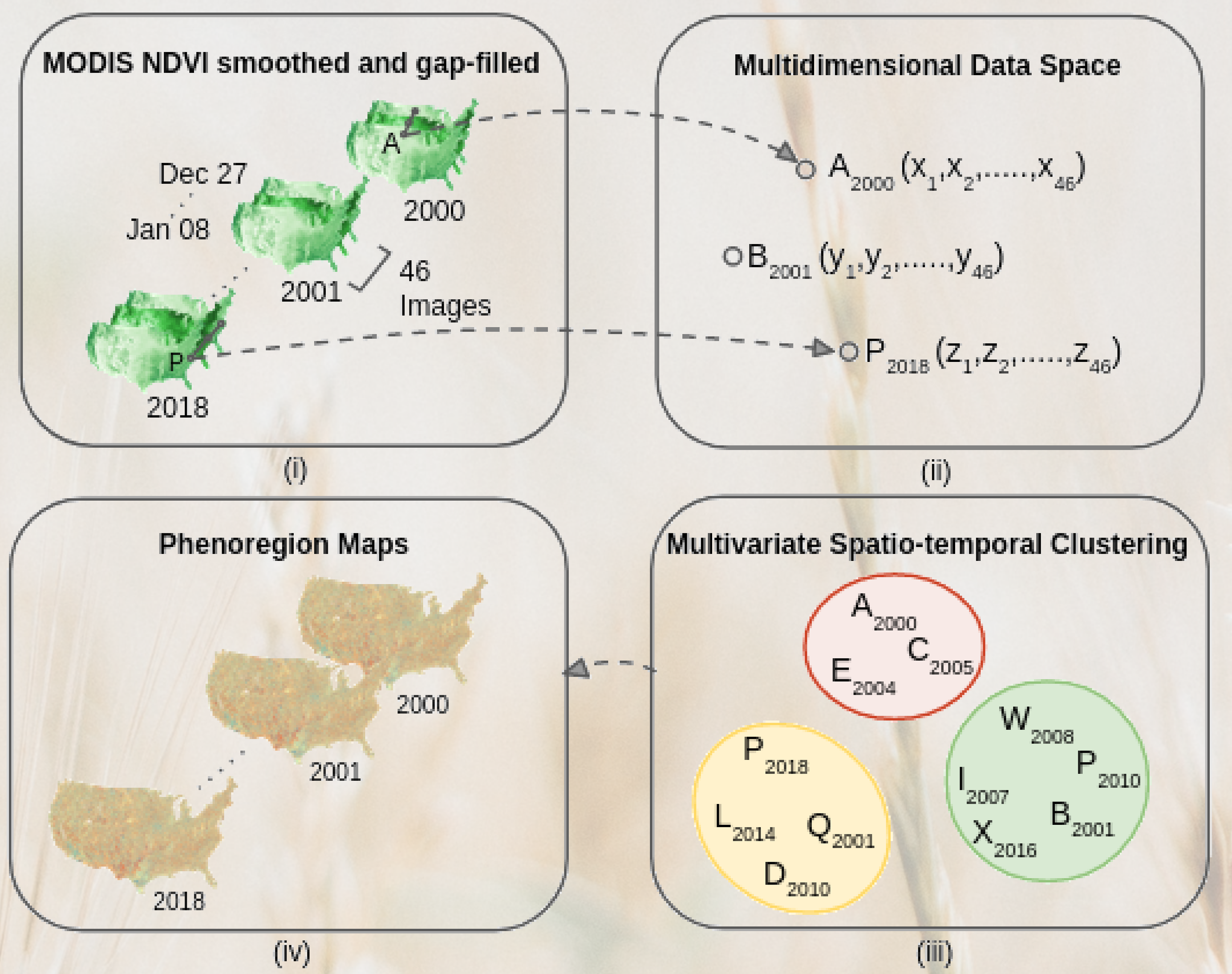

Figure 1: Entire time series of smoothed and gap-filled MODIS NDVI (2000–2018) were used with *k*-means algorithm-based Multivariate Spatio-Temporal Clustering to delineate 5000 *phenoregions* having similar annual phenological profiles

CLUSTER-THEN-LABEL MODEL TRAINING (2008–2014)

Figure 2: (a) Assigning a crop type to each entire phenoregion was performed separately within each ecoregion, to control for spatial variability in farming methods and growing conditions **(b)** For each year, 70% of crop pixels within every ecoregion were chosen randomly for model training with the rest assigned for validation. Corresponding pixels from phenoregion maps were partitioned into training and validation, respectively.

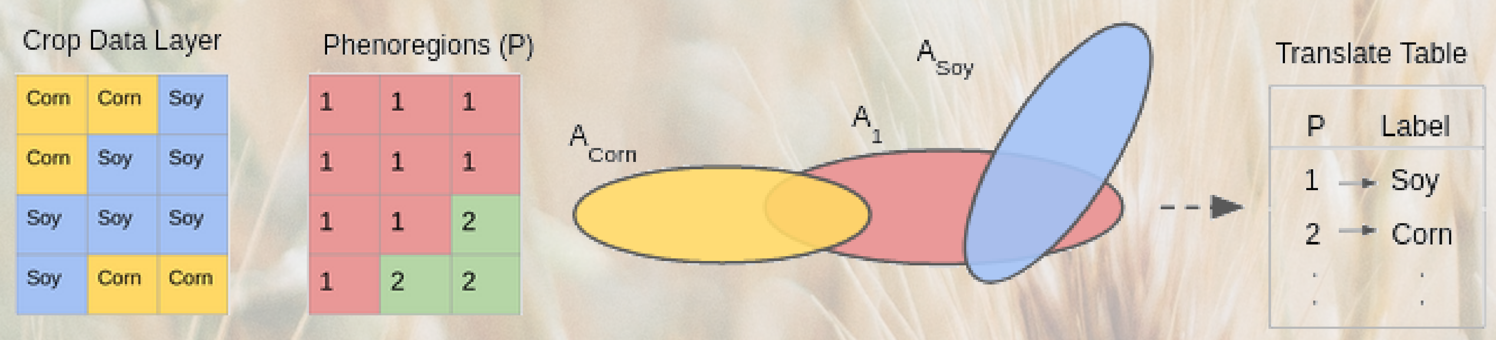

Figure 3: Crop labels were assigned to phenoregions based on the extent of spatial overlap using a quantitaive method called *Mapcurves*. Accounting for temporal variability, Mapcurves was applied to phenoregion and CDL maps over all years during the training period to generate a translation table listing each phenoregion and it corresponding best-fit crop type label

FULL-SEASON CROP MAPPING (2015–2018)

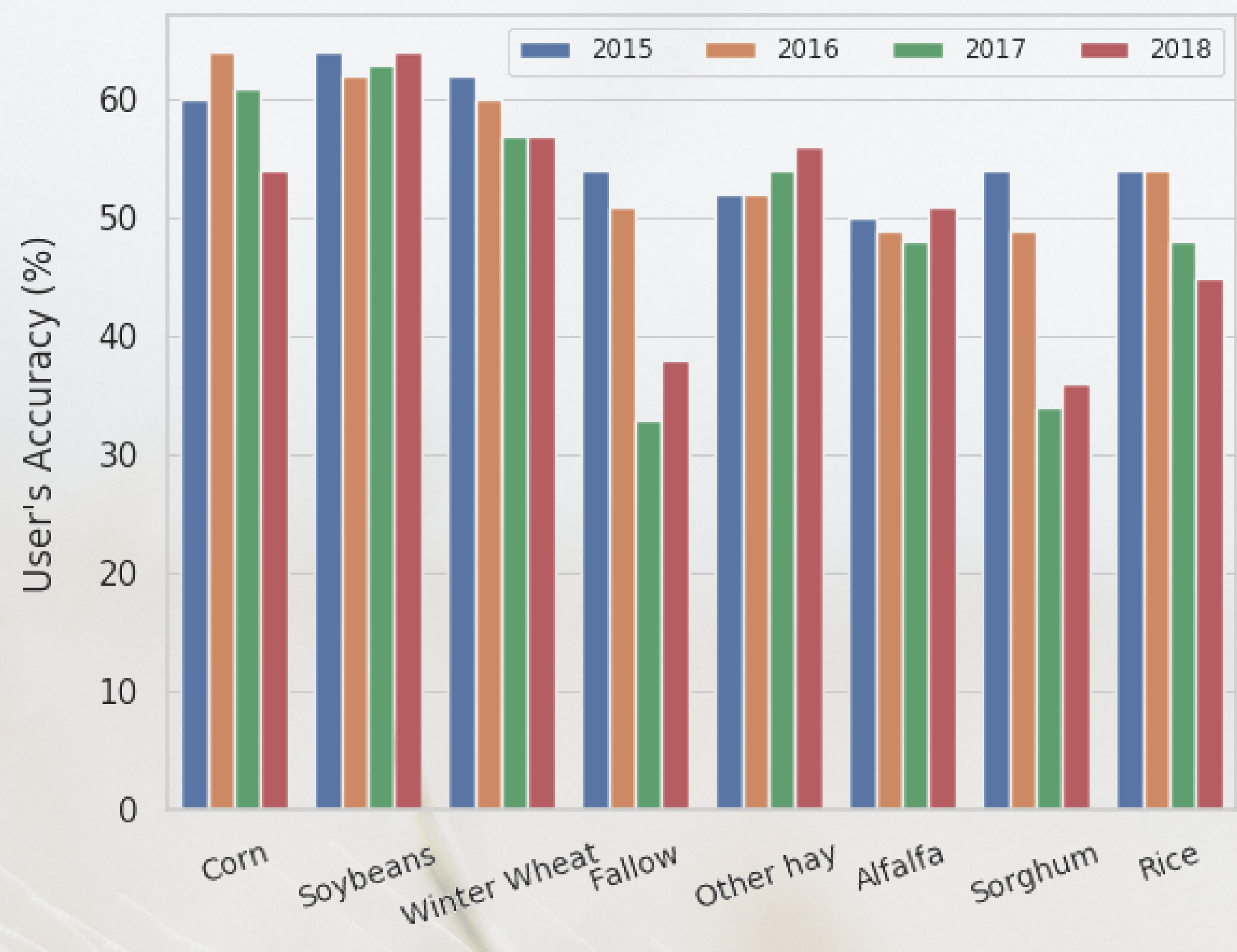

Figure 4: The cluster-then-label model was evaluated on the test dataset from never-seen-before years (2015–2018). User's Accuracy for the eight major crops is similar across all the four years, except for Fallow and Sorghum in 2017 and 2018 and Corn in 2018

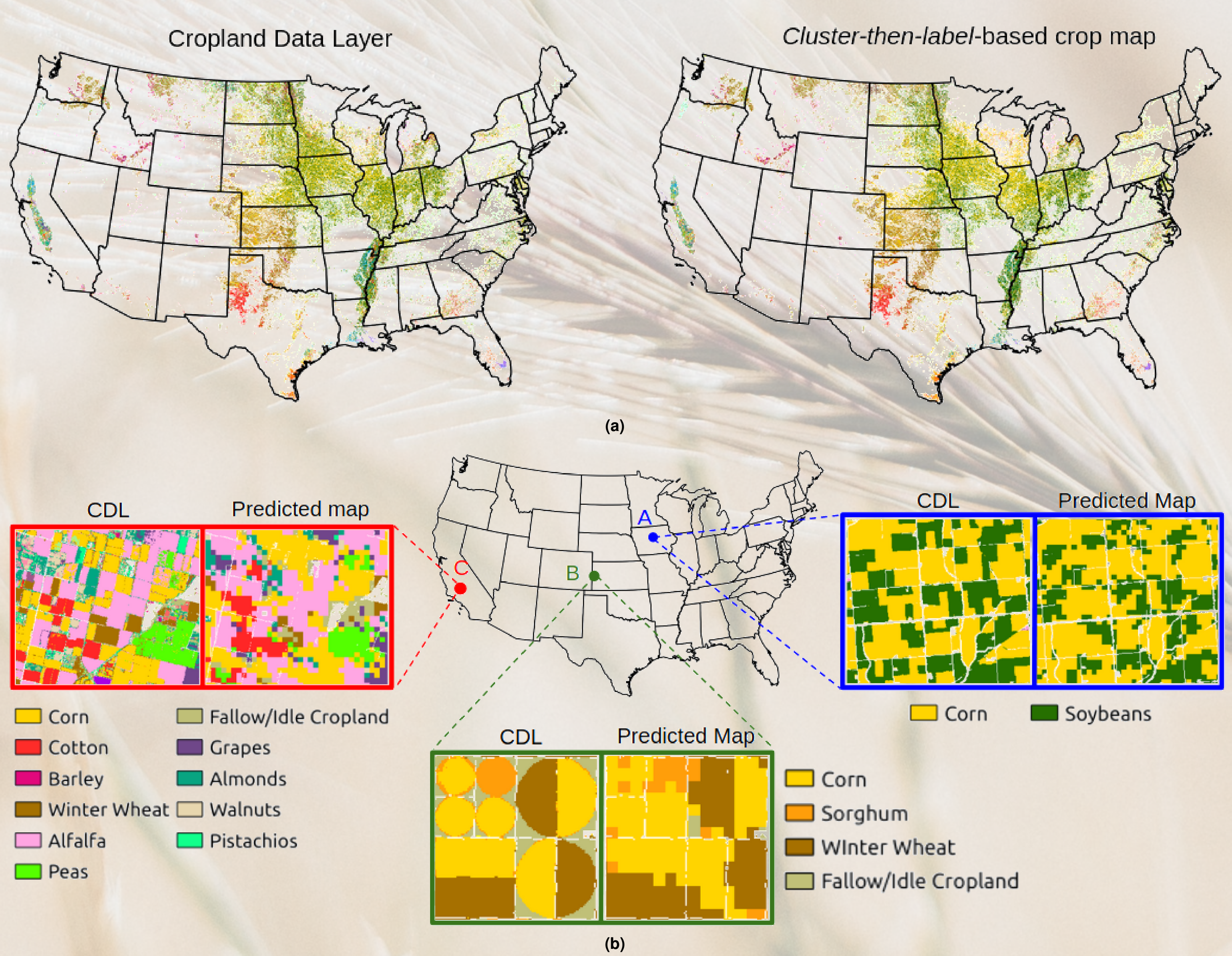

Figure 5: Comparison of the cluster-then-label-based crop map with USDA Crop Data Layer (CDL) for the year 2015 **(a)** Comparison of cluster-then-label-based crop map with CDL shows similar patterns across CONUS **(b)** Closer look at three select regions (A, B, and C) show a broad-level agreement with CDL, however, also a lack of sharpness and accuracy along field boundaries due to lower resolution of MODIS products.

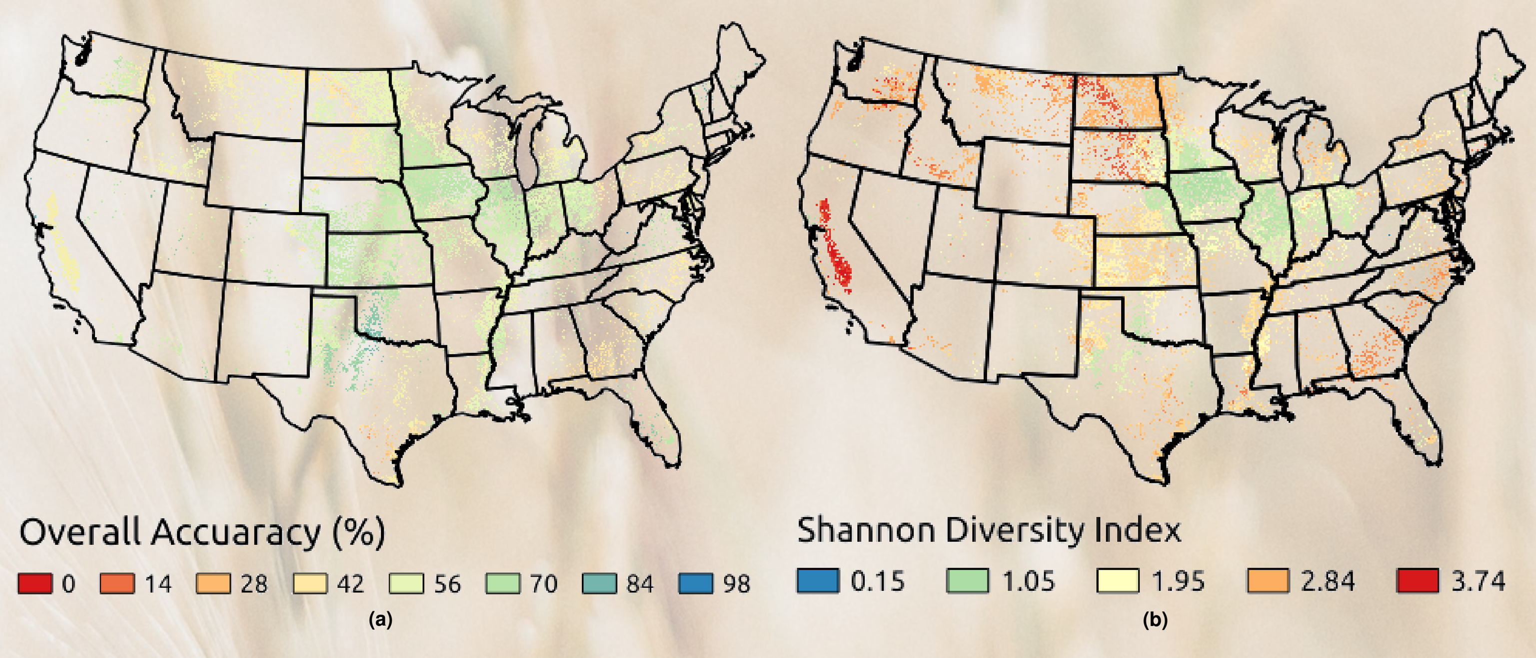

Figure 6: Overall Accuracy values for cluster-then-label-based crop classification were found to be lower in regions with higher crop type diversity. **(a)** Overall Accuracy of classification for all crop types. **(b)** Shannon Diversity Index for agricultural regions across the CONUS.

WITHIN-SEASON CROP MAPPING (2015–2018)

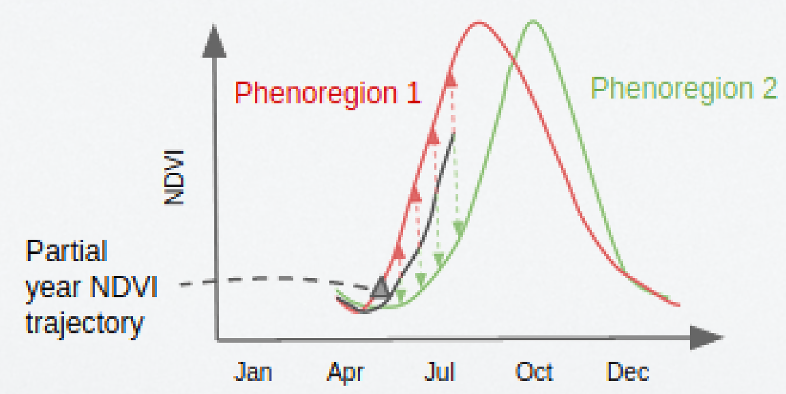

Figure 7: A methodology to continuously map croplands at national scale in near-real-time every 8 days (i.e. MODIS temporal frequency) was developed. The partial phenological (MODIS NDVI) trajectory to date at each cropland pixel within CONUS was assigned to the most-similar existing one of the 5000 phenoregions that had been developed over all years in the training period.

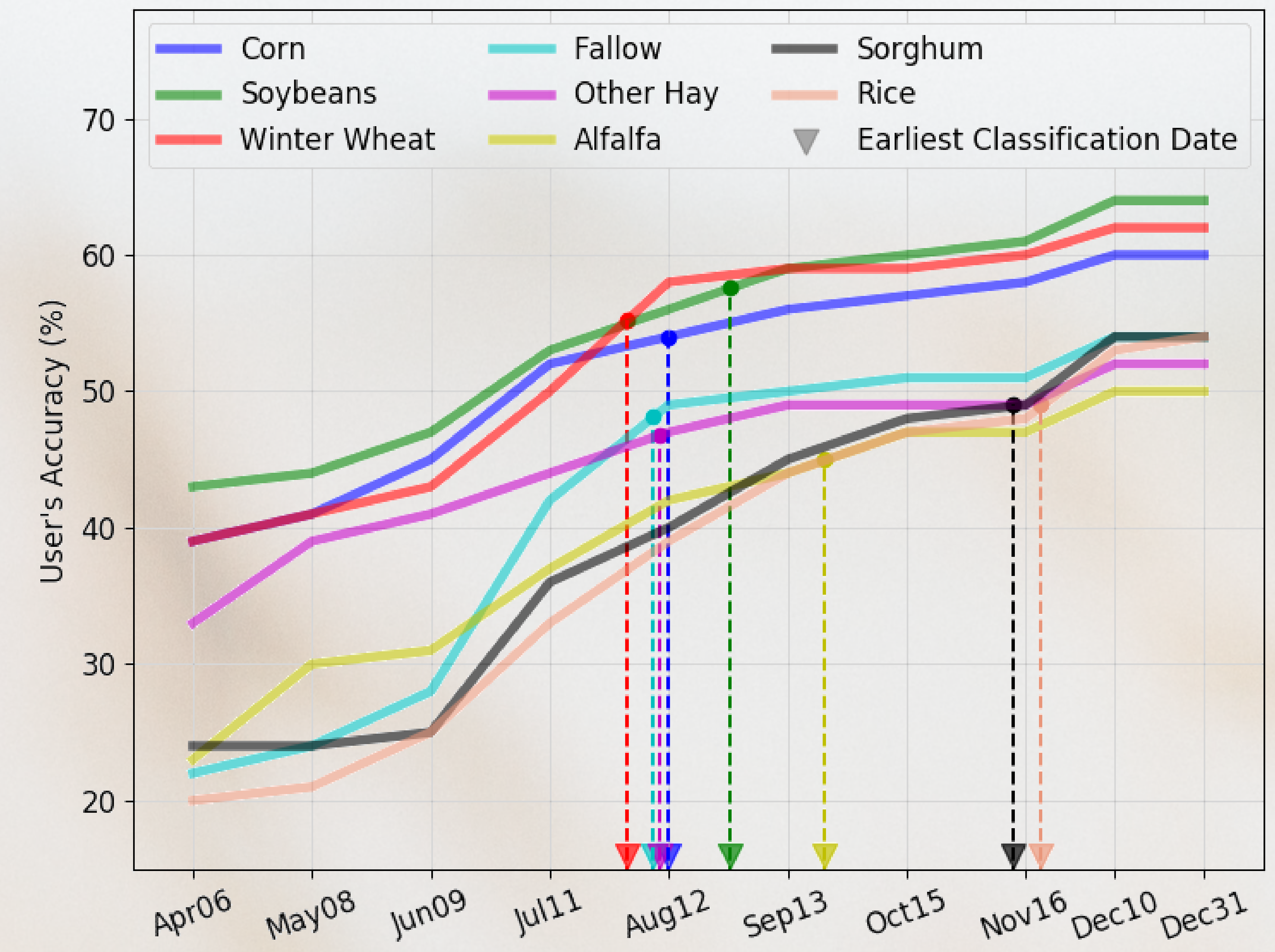

Figure 8: Improvement in User's Accuracy for within-season classification for the year 2015 is variable for different crops, with most of them being mapped with a reasonable accuracy by July–September.

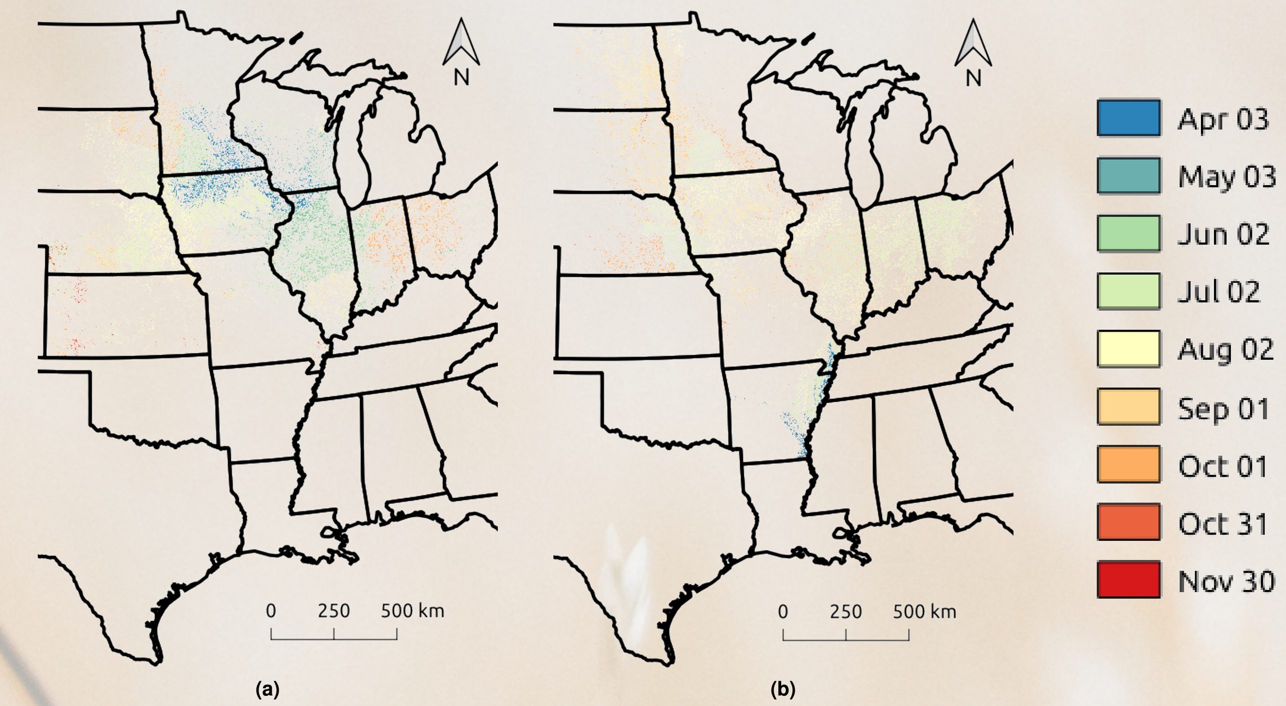

Figure 9: Earliest dates for classification, defined as the earliest date during the growing season when the classification accuracy reaches 90% of the year-end accuracy, was estimated at an ecoregion level for **(a)** Corn and **(b)** Soybeans for the year 2015. In general, Corn was identified with a reasonable accuracy several weeks before Soybeans.

SUMMARY

- The goal of this study was to produce national-scale crop maps at 8-day intervals during the growing season using time series of MODIS-NDVI.
- Classification accuracy was around 70% across major Corn, Soybean and Winter Wheat-producing regions. Accuracy was lower in areas with high crop diversity.
- Major crops like Corn, Soybeans, Winter Wheat, Fallow/Idle cropland and Other Hay/Non Alfalfa could be mapped as early as August across CONUS with 90% of the full-season accuracy.

LIMITATIONS, CHALLENGES and FUTURE WORK

- The ability to create a gap-filled remote sensing product that spans the whole CONUS is critical for near-real time crop health monitoring.
- Additional spectral bands spanning optical, NIR, SWIR and SAR wavelengths, as well as indices that are derived from them can also be used as classifier inputs.
- Multi-sensor fusion and advanced machine learning algorithms may improve the accuracy of crop classification.

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