MODIS-based Corn Mapping in the Midwest US - Generalization of Image Classification across Time

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1. Introduction

The Midwest United States is one of the key grain-producing regions of the world, producing 85% of the 10.4 billion bushels of corn and 81% of the 3 billion bushels of soybeans in the United States in 2011 (USDA 2013). The corn acreage in the Midwest US has increased rapidly since 2005, mainly due to policies promoting corn ethanol production and rising corn prices. Concern over the impact of cropland change on the environment and ecosystem function is increasing. The corn-specific mapping and monitoring is particularly important in the Midwest US given the social and economic importance of agricultural productivity and given the potential impacts of farming practices on local-to-regional scale ecosystems.

There are a growing body of evidence suggests that Moderate Resolution Imaging Spectroradiometer (MODIS) data-based cropland mapping has become more common, especially for studies conducted at the regional and national scales (Chang et al. 2007, Lunetta et al. 2010). The MODIS-based cropland mapping, however, is also challenged by coarse spatial resolution, lack of training data, and inconsistent classification performance. The lack of training data is difficult to deal with since visual interpretation of MODIS image is largely unfavored and ground truth can be expensive to obtain. The overall objective of this study was to conduct corn-specific mapping for the 12-state Midwest US for years from 2000 to 2011. We were particularly interested in examining the generalization ability of training data across time. Specifically, we examined whether the training data points derived from one time period (e.g., 2007-2011) could be applied to another time period (e.g., 2000-2006) to obtain good classification performance.

2. Methods

The 250m MODIS-NDVI (Normalized Difference Vegetation Index) 16-day composite data from February 2000 to December 2011 were obtained from the USGS EROS Data Center (http://eros.usgs.gov/). The cropland data layers (CDL) were downloaded from CropScape (http://nassgeodata.gmu.edu/CropScape/). The CDL was developed by the National Agricultural Statistics Service (NASS) of the United States Department of Agriculture (USDA). The complete coverage for the Midwest US are available from 2007 to 2011. Specific crop types such as corn, soybean, and winter wheat are mapped at annual interval. The classification accuracies for corn and soybean are quite high (e.g., > 85%) for all Midwest States. The spatial resolution of CDL ranged from 30 to 56m. We also obtained the 2006 National Land Cover Database (NLCD) for the study region.

We used 2006 NLCD to build the agricultural land mask for the study region. The subsequent MODIS image classifications were focused within the agricultural land mask only. For years from 2007 to 2011, we used CDL to derive training areas for MODIS-based crop-specific mapping. A three-class classification scheme was employed: corn, soybean, and all other crops. For each year, MODIS pixels from Julian day-of-year (DOY) 97 to 273 were extracted for the above three classes. We combined all training signals from 2007 to 2011 to build a multi-year training database. A Random Forest algorithm was then employed to evaluate the classification performance, especially the generalization ability across time (i.e., for years from 2000 to 2006). Classification accuracy was assessed using standard overall accuracy and kappa coefficients. We also compared the MODIS-derived corn acreage to the USDA NASS statistics. The comparison was conducted at the State level.

3. Results

The classification performance of the multi-year training dataset appeared to be stable for years from 2007 to 2011. The overall accuracy from a 5-fold cross-validation ranged from 77.6% to 81.3% (Table 1). The kappa coefficients were above 0.65 for all years. The results were expected for this time period since the training signals were derived for the same temporal window.

Year	Overall Accuracy	Kappa
2007	80.6	0.684
2008	81.3	0.691
2009	79.7	0.680
2010	78.4	0.676
2011	77.6	0.654

Table 1. Accuracy statistics derived from a 5-fold cross-validation

For years from 2000 to 2006, the above accuracy statistics were not available due to limited availability of CDLs and their quality issue. We compared the MODIS-derived corn acreage to the USDA-NASS statistics at the State level (n=12). For example, Fig. 1 compares the area estimates for year 2011. R^2 was 0.976 and RMSE was 6048 km^2. Fig. 2 shows R^2 values for all years from 2000 to 2011. For all study years, except 2002 and 2003, the R^2 were above 0.9, suggesting consistent classification performance across time. The R^2 (0.85) for year 2002 was relatively low. Note that there was a major drought even in the Midwest US in 2002 and the multi-year training data were based on 2007-2011. The generalization ability of the multi-year training data appeared to be questionable for years with extreme climate conditions.

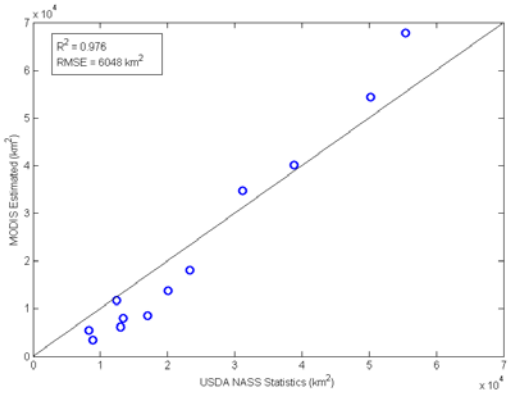

Figure 1. Comparison between MODIS-derived corn acreage and the USDA NASS Statistics (year 2011)

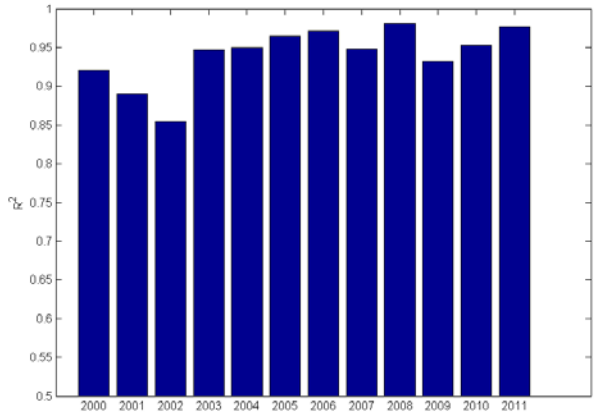

Figure 2. Comparison between MODIS-derived corn acreage and the USDA NASS Statistics from 2000 to 2011

5. Conclusions

This study examined the generalization ability of MODIS cropland classification across time. The overall classification accuracies ranged from 77.6% to 81.3% for cross-validation analysis. The MODIS-derived corn acreages were comparable to the USDA-NASS statistics for a majority of study years. The multi-year training data, however, might not generalize well for years with extreme climate conditions such as major drought and flood.

5. References

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