

UMd advancement of crop-type area estimates - soybeans



Matthew Hansen, LeeAnn King, Bernard Adusei, Peter Potapov, Carie Ernst, Jacob Noel
Department of Geographical Sciences, University of Maryland, College Park, MD, United States.



Introduction

Soybean is an important global commodity crop, and the area of land for cultivation has risen dramatically over the past 60 years, now occupying more than 5% of all global croplands (Monfreda et al 2008). The United States currently has the largest land contribution to soybean production, harvesting over 30 million hectares of land in 2011, contributing more than 30% of global soybean cropland area and 33% of global production at 83.2 million tons (USDA- NASS 2011). Remote sensing technology can provide timely, precise, objective and accurate information about land dynamics and can substantially improve assessment of cultivated lands to understand agricultural production.



The University of Maryland (UMd) has developed an approach for crop-specific area estimation and has applied this approach to estimate soybean cultivated area at the national scale, relying on freely available remote sensing imagery and hierarchical, non-linear classification trees to describe soybean area and extent for a MODIS-stratified (Chang et al 2007) random sample population.

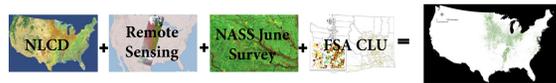
Objective

Quantify and validate the UMD Landsat time-series derived sample-based area estimation of soybean extent through a comparison with RapidEye-derived soybean maps and the multi-source National Agricultural Statistical Service's (NASS) Cropland Data Layer (CDL).

Data

Soybean cultivated area and extent has been defined for 75 sample blocks. To evaluate the Landsat soybean classification, a comparison has been made to:

1) The CDL (inputs for production shown below) that is produced annually for the conterminous United States at 30m² spatial resolution for the total population of sample blocks:



2) Multispectral RapidEye 5m² spatial resolution imagery for a subsample of 14 blocks from the total sample population.

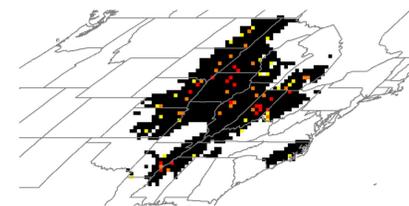


Figure 1. Sample stratification

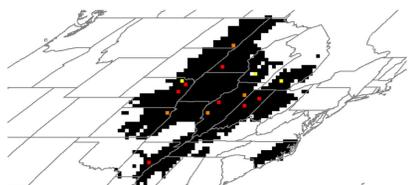
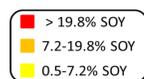


Figure 2. Subsample stratification

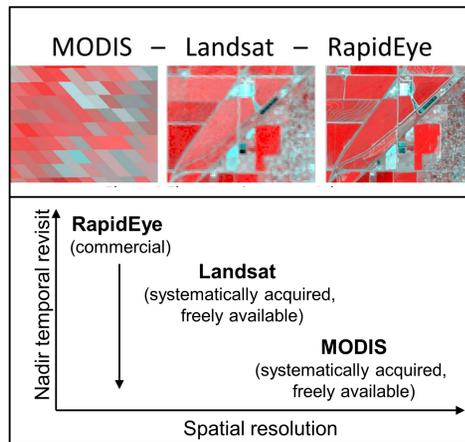


Figure 3. Spatial and temporal resolution comparison

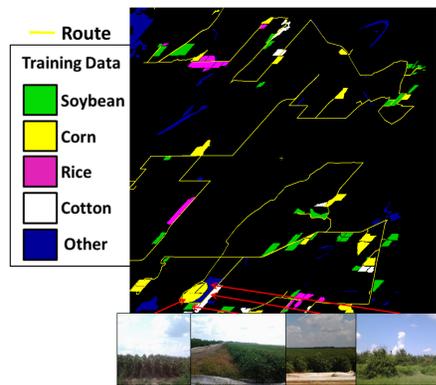


Figure 5. Field labels from ground observations

Data and Methods

Sample blocks are drawn from high, medium and low strata delineated using MODIS near-term historical percent soybean cover maps. Three-date Landsat soybean and CDL soybean maps are compared with each other and with RapidEye soybean extent in assessing possible biases in the measurement of field extents. Ground observations allow for accuracy assessment with field labels (figure 4). The total population is classified for soybean using 3 Landsat images acquired in the pre-peak, peak and post-peak of the growing season to capture the unambiguous signature of soybean phenology.

RapidEye classification relied on a single peak phenology image. A comparative analysis was designed (figure 5) to evaluate the influence of mixed pixels on the classification accuracy. First, fields that were mapped as soybean by all products (Landsat-derived classification, RapidEye-derived classification & CDL) were identified. Disagreement across the products, holding RapidEye as truth, was

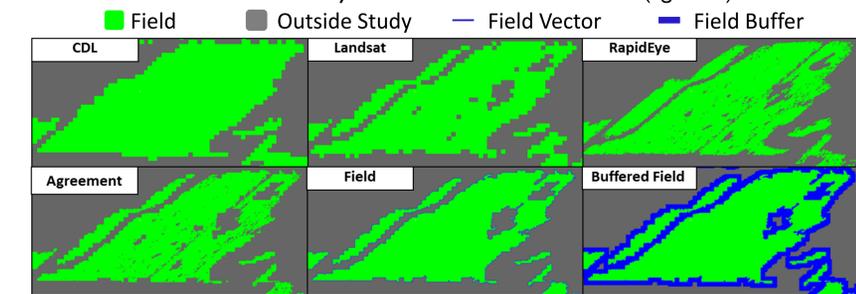
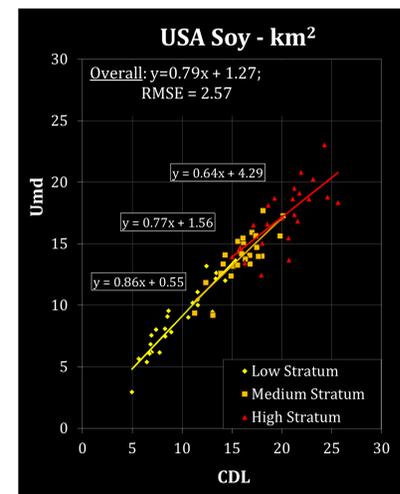


Figure 5. Design of Field study area

Results and Discussion



Stratum	Overall	User	Producer	Kappa
Low	95.4%	76.1%	59.0%	63.3%
Medium	91.2%	89.2%	64.1%	68.5%
High	87.2%	93.7%	66.8%	68.7%
Average	91.3%	86.3%	63.3%	66.9%

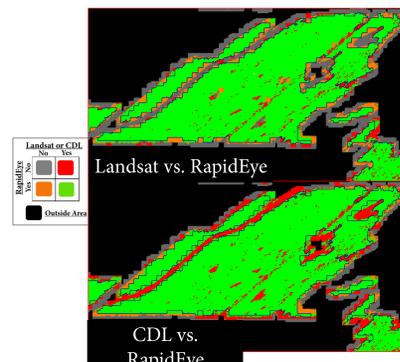
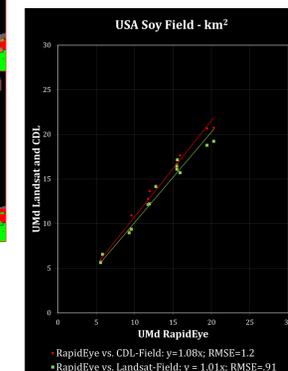


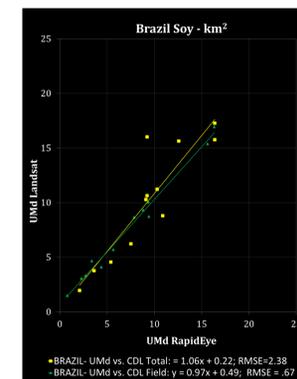
Figure 9. Field study example result

A strong agreement between the RapidEye and UMD Landsat-derived classification was found for soybean extent within the buffered field study area. Linear regressions, shown in figure 8, illustrate the nearly 1:1 relationship between UMD Landsat and RapidEye maps. An example field comparison is shown in figure 9. Commission and omission errors were balanced across all examined blocks for the UMD Landsat and RapidEye soybean extent comparison, indicating the possibility to use Landsat directly for area estimation via pixel counting. The CDL map identified more soy within the buffered zone, resulting in more mapped soybean than that of the RapidEye depiction.

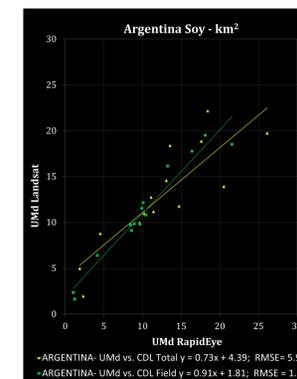
	Landsat		CDL	
	No	Yes	No	Yes
Inside Field				
RapidEye	No 0.2%	Yes 2.5%	No 0.0%	Yes 2.7%
RapidEye	Yes 0.4%	Yes 97.0%	Yes 0.1%	Yes 97.2%
Edge of Field				
RapidEye	No 58.1%	Yes 17.3%	No 48.2%	Yes 27.2%
RapidEye	Yes 17.2%	Yes 7.4%	Yes 9.6%	Yes 15.0%



A strong relationship was found between the UMD Landsat and CDL classifications (figure 6). However, the UMD Landsat classification quantifies less soybean area than CDL, as shown in the user's and producer's accuracies (figure 7). UMD Landsat characterizations significantly omit soybean cover compared to the CDL.



	Accuracy	Overall	User	Producer	Kappa
BRZ Total	88%	50%	49%	42%	
BRZ Field	68%	70%	85%	19%	
ARG Total	80%	43%	50%	31%	
ARG Field	57%	55%	73%	15%	



Conclusion

- There is a strong relationship between all sample blocks and the CDL. However, the UMD Landsat depicts considerably less soybean area.
- The UMD Landsat approach requires a fully emerged and mature crop phenology in order to characterize soybean cultivated area. The CDL does not. The requirement for a matured soybean canopy to be observed in the data for mapping in the UMD method results in less soybean area quantified.
- Emerged soybean in RapidEye imagery indicates a balanced omission/commission error matrix for the UMD product. Pixel counting of Landsat is a viable area estimator for soybean cultivated area in the United States.
- CDL soybean area is more generalized, corresponding more to actual field boundaries than a persistent and clear soybean spectral signal.

References

- Chang J, Hansen M, Pittman K, Carroll M, DiMiceli C 2007 Corn and Soybean Mapping in the United States Using MODIS Time-Series Data Sets Agronomy Journal 99 1654-64
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- Hansen M, Dubayah R and DeFries R 1996 Classification trees: an alternative to traditional land cover classifiers Int. J. Remote Sens. 17 1075-81