Area estimation by integration of line transect sampling and multi-source remote sensing data

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Abstract:

Background and methodology:

Crop area estimation is one of the key components for agricultural statistics. Crop identification is a basis for area estimation for long time. Plenty of methods and algorithms for crop classification have been developed or improved during the last three decades. However, Pixels in remote sensing data do not always correspond to a single crop type or field. Mixed pixels are commonly found in agriculture regions with small crop fields and always impact crop classification accuracy. Therefore, remote sensing based crop classification without ground survey is not sufficient.

To overcome the shortcomings of area estimation based on classification, a crop planting and type proportion method (CPTP) (Wu and Li) was developed for CropWatch to estimate crop acreage, which crop planting proportion was derived from optical satellite data and crop type proportion was derived from GVG transact sampling survey. GVG surveying system which integrated a GPS receiver, a video camera, and a GIS analysis system was invented and developed to survey the crop type proportion along transact sampling lines. Crop area for each crop type can be calculated using the following equation:

Crop area = Arable land area * cropped arable land fraction * crop type proportion

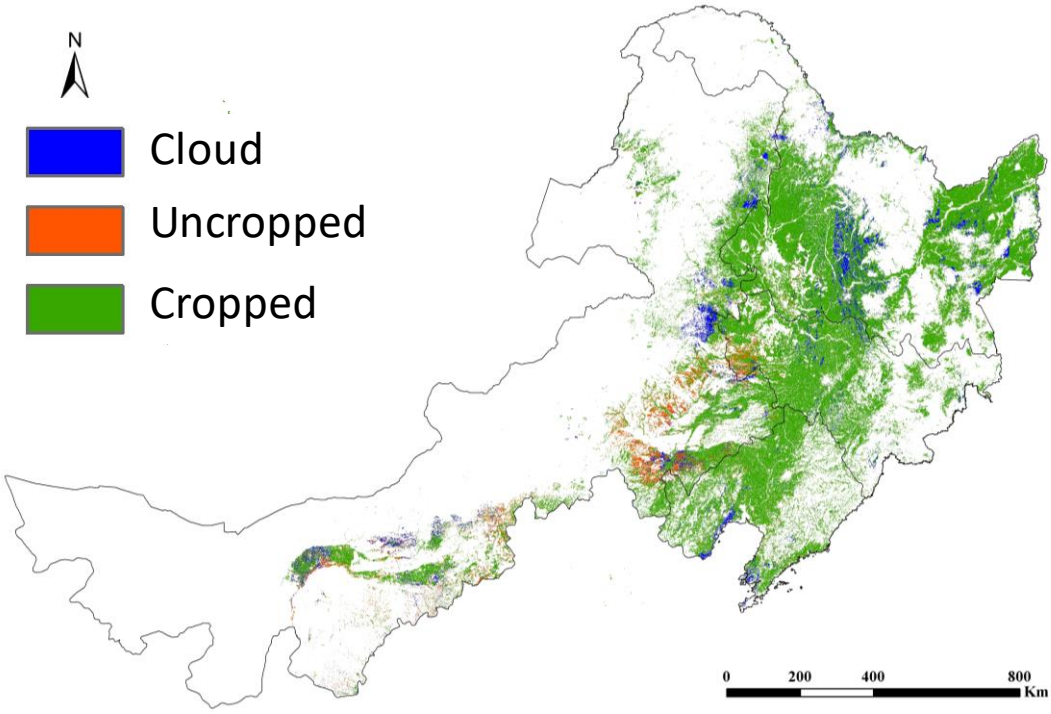
The four provinces – Heilongjiang, Jilin, Liaoning, and Inner Mongolia were selected as the study area. Field sampling was carried out from August 1st to 15th according to the sampling frame. Arable land area was derived from the arable land mask extracted from ChinaCover 2010 (a 30m resolution land cover dataset for whole China). The objective of this research is to use multi-source satellite data to overcome the impacts by cloud covers to improve the accuracy of cropped arable land fraction.

Images from China High resolution Earth Observation satellite (GF-1), China Environmental Satellite (HJ-1), Landsat 8 as well as Sentinel-2 Satellites were acquired during the summer crop growing season. Decision tree was applied to all the images for cloud extraction, cropped and uncropped arable land separation. Independent field samples were used for classification accuracy assessment based on the derived confusion metrics.

Results:

1.Cropped and uncropped arable land separation

Classification results showed that total arable land area is 35617.3kha, of which 94.2% is cropped; 93.5% of upland and 99.3% of paddy fields in the study area are under cultivated. Uncropped fields mainly locates at southeastern Inner Mongolia, Chifeng and Tongliao.



The independent validation results show high accuracy in separating cropped and uncropped arable land. Accuracy assessment in Inner Mongolia presents slightly lower than that in Heilongjiang province. The overall classification accuracy for Inner Mongolia and Heilongjiang was 97.8% and 99.3%, respectively.

Table 1 Accuracy of cropped and uncropped arable land mapping from confusion metrics

Province	Cropped arable land		Uncropped arable land	
	Producers' accuracy	User's Accuracy	Producers' accuracy	User's Accuracy
Inner Mongolia	97.3%	99.8%	99.3%	92.9%
Heilongjiang	99.2%	99.9%	99.6%	97.6%

2.Cropped arable land fraction

Crop type proportion for each county was estimated based the 39025 collected field photos, and was then interpolated and aggregated to crop type proportion zone, and provinces. Crop type proportion for the four provinces in 2015 and 2016 was compared. (Table 2). The proportion of maize in Inner Mongolia and Heilongjiang in 2016 is lower than that in 2015, while that in Liaoning and Jilin is slightly higher. The proportion of maize in Inner Mongolia was 40.99%, down by 3.12% compared with the same period of last year. Correspondingly, the proportion of soybean increased by 2.2% and that of spring wheat increased by 0.94% in Inner Mongolia. The proportion of maize in Heilongjiang was 45.61%, down by 0.42% and the planted proportion of rice, soybean and spring wheat was increased by 0.57%, 0.25% and 0.06%, respectively. The proportion of maize in Liaoning Province (54.84%) increased by 1.93%, while that of rice and soybean decreased by 12.23% and 3.52%, respectively. The proportion of maize in Jilin province increased by 0.5%.

Table 2 Crop type proportion for the four provinces in 2015-2016 (%)

Province	Maize		Rice		Soybean		Spring wheat		Other crops	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016

Inner Mongolia	44.11	40.99			8.41	10.61	9.21	10.15	38.27	38.25
Liaoning	52.91	54.84	13.42	12.23	4.47	3.52			29.21	29.41
Jilin	62.64	63.14	13.06	14.29	5.62	5.78			18.68	16.78
Heilongjiang	46.03	45.61	26.55	27.12	22.53	22.78	1.28	1.34	3.61	3.15

3.Crop area inter-annual variation

Table 3 Estimated crop area for the four provinces in 2015-2016 (Kha)

Province	Maize		Rice		Soybean		Spring wheat	
	2015	2016	2015	2016	2015	2016	2015	2016
Inner Mongolia	3258.6	3036.5			621.2	786.1	680.7	751.7
Liaoning	2572.5	2587.2	652.3	577.1	217.2	166.0		
Jilin	3446.6	3494.4	718.7	790.9	309.3	320.1		
Heilongjiang	5180.6	5077.2	2987.7	3019.1	2536.2	2535.8	144.3	149.6
Sub total	14458.3	14195.3	4358.7	4387.1	3683.9	3808.0	825.0	901.3

In terms of planted area, maize in Inner Mongolia decreased by 222.1 thousand hectares, and maize area in Heilongjiang Province was down by 103.4 thousand hectares from 2015. At the same time, maize area in Liaoning Province and Jilin Province increased by 14.7 and 47.8 thousand hectares, respectively. In total, 262.9 thousand hectares (about 394.4 million mu) decrease of maize area in the four provinces was observed.

Soybean acreage in the four provinces totaled at 3808.0 thousand hectares, an increase of 124.2 thousand hectares, of which Inner Mongolia soybean acreage increased by 164.9 thousand hectares, while soybean acreage in Liaoning Province decreased by 51.2 thousand hectares. Soybean planted area in Jilin increased by 10.8 thousand hectares, while Heilongjiang soybean area in Heilongjiang is almost same as the 2015.

Discussion and conclusions:

The changes in decreased maize area are mainly due to the policy changes released by China Ministry of Agriculture which reduce the subsidy for maize cultivation. It is expected that maize area in the four provinces will decreased by about 700 thousand hectors. However, the decreased maize area in 2016 is estimated at 262.9 thousand hectors, indicating that only 40% of expected reduction of maize planted area was achieved. Soybean area increased by 76.3 kha in the four provinces which leads to a slightly increase of soybean planted area nationally in 2016, the first inter-annual increase in more than a decade.

By integration of images from multiple wide swath sensors, sufficient data source can be acquired for cropped and uncropped arable land mapping. Even though, there are still some pixels invalid due to the continuous cloudy weather over the area. In the future, the integration of optical and SAR data could potentially improve cropped and uncropped arable land mapping accuracy.

Crop type proportion sampling used in this research is still time-consuming, labor intensive and costly. Crowd Sourcing Geographic Data will dramatically improve the efficiency and the GVG APP will be upgraded to allow any user to upload the field photos.