Global crop type assessment – soybean area estimation

NASA LCLUC and Applications Programs

Global cropland

• Cropland is one of the most challenging land cover themes
  – What is cropland – herbaceous/shrub/tree crops?
  – Crop type
  – Varieties
  – Intensification
  – Field size
  – Dryland/irrigated
  – Single/double/triple cropping
### Soybean world supply and production

in thousand metric tons (USDA FAS)

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Production</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>United States</td>
<td>72,859</td>
<td>80,749</td>
<td>91,417</td>
<td>90,610</td>
<td>83,168</td>
<td>83,969</td>
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<tr>
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<td>61,000</td>
<td>57,800</td>
<td>69,000</td>
<td>75,500</td>
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<td>54,500</td>
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<tr>
<td>China</td>
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<td>14,000</td>
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<td>Paraguay</td>
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<td>8,300</td>
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<tr>
<td>Canada</td>
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<td>3,507</td>
<td>4,345</td>
<td>4,000</td>
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<tr>
<td>Other</td>
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<td>10,534</td>
<td>11,465</td>
<td>12,503</td>
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<tr>
<td><strong>Total</strong></td>
<td>220,469</td>
<td>211,960</td>
<td>260,838</td>
<td>264,120</td>
<td>257,471</td>
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U.S., Brazil, Argentina and China account for ~90% of global soybean production.
MODIS for crop type identification

Wardlow et al. 2007
MODIS per U.S state soybean and corn phenologies
Method

• MODIS for turn-key models per nation/sub-region to indicate within growing season soybean cultivation based on sub-pixel percent cover training data

• Landsat samples based on MODIS soybean indicator maps to map per sample block soybean cultivated area

• RapidEye will allow for per country/region calibration of Landsat area estimates
Study area, consisting of the top four soybean production countries, nearly 90% of global soybean production. Top left, United States; top right, Brazil; lower left, Argentina; lower right, China. For each country, the administrative subset shown accounts for over 95% of national soybean acreage, except for China, where the subset shown represents 88% of national soybean acreage. Images, with a globally applied enhancement, are from MODIS median 9-year growing season metrics for red=visible red, green=nearinfrared, and blue=shortwave infrared (band 7).
China has a more diffuse / complicated soybean distribution

<table>
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<tr>
<th>Province</th>
<th>Hectare</th>
<th>%</th>
<th>sum</th>
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<td>Chongqing</td>
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<td>Qinghai</td>
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<td>0.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Minnesota 2008

NIR/SWIR Ratio Phenology

- Red: >=75% Corn
- Green: >=75% Soybeans
- Blue: <25% Corn

Snow cover

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

NIR/SWIR Ratio Phenology

- Red: >=75% Corn
- Green: >=75% Soybeans
- Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

NIR/SWIR Ratio Phenology

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

May 7
Minnesota 2008

NIR/SWIR Ratio Phenology

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

MODIS Band 7 (SWIR)

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

NIR/SWIR Ratio Phenology

NIR/SWIR Ratio

-0.4
-0.2
0
0.2
0.4
0.6
0.8

20-Mar
5-Apr
21-Apr
7-May
23-May
8-Jun
24-Jun
10-Jul
26-Jul
11-Aug
27-Aug

20-Mar
5-Apr
21-Apr
7-May
23-May
8-Jun
24-Jun
10-Jul
26-Jul
11-Aug
27-Aug

NIR/SWIR Ratio Phenology
Minnesota 2008

NIR/SWIR Ratio Phenology

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

NIR/SWIR Ratio Phenology

- Corn >=75%
- Soy >=75%
- Corn <25%

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

NIR/SWIR Ratio Phenology

-0.4
-0.2
0
0.2
0.4
0.6
0.8

20-Mar
5-Apr
21-Apr
7-May
23-May
8-Jun
24-Jun
10-Jul
26-Jul
11-Aug
27-Aug

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
Minnesota 2008

NIR/SWIR Ratio Phenology

- Red: >=75% Corn
- Green: >=75% Soybeans
- Blue: <25% Corn

August 11
Minnesota 2008

NIR/SWIR Ratio Phenology

Red: >=75% Corn
Green: >=75% Soybeans
Blue: <25% Corn

MODIS Band 7 (SWIR)

MODIS Band 2 (NIR)
NASS Cropland Data Layer

Land Cover Categories
(Ordered by Decreasing Acreage)

Agriculture
- Pasture/Grass
- Corn
- Soybeans
- Winter Wheat
- Spring Wheat
- Fallow/Idle Cropland
- Cotton
- Sorghum
- Alfalfa
- W. Wht./Soy, Dbl. Crop.
- Rice
- Sunflowers
- Durum Wheat
- Barley
- Dry Beans
- Canola
- Sugarbeets
- Peas
- Oats
- Millet
- Sugarcane
- Rye
- Flaxseed
- Potatoes
- Seed/Sod Grass
- Aquaculture
- Lentils
- Peanuts
- Other Small Grains
- Other Crops
- Misc. Vgs. & Fruits
- Other Tree Nuts & Fruits
- Clovers/Wildflowers
- Safflower
- Sweet Potatoes
- Apples/Cherries
- Christmas Trees

Non-Agriculture
- Woodland
- Shrubland
- Urban/Developed
- Wetlands
- Water
- Barren
- Perennial Ice/Snow

Cropland Data Layers
2008 States
MODIS data for soy indicator mapping – regional model

NASS AWiFS CDL 2008 soy

MODIS 2008 soy

Regional Soybeans Single Year – 2008 – 5km

R-Squared 0.8149
MODIS data for soy indicator mapping – per state model

NASS AWiFS CDL 2008 soy

MODIS 2008 soy

Single State Soybeans Single Year – 2008 – 5km

R-Squared 0.8877
MODIS versus CDL – average soybean estimated per 40km block, 2007 to 2010
High, medium and low soybean strata

Red=high (>19.8%), orange=medium (7.2-19.8%), yellow=low (0.5-7.2%)
Red=high (>19.8%), orange=medium (7.2-19.8%), yellow=low (0.5-7.2%)
RapidEye locations

Red=high (>19.8%), orange=medium (7.2-19.8%), yellow=low (0.5-7.2%)
Argentina soybean indicator
Argentina strata

Red=high (>19.8%), orange=medium (7.2-19.8%), yellow=low (0.5-7.2%)
Landsat sample block data
Multi-temporal Landsat to assure correct characterization
SW Minnesota Landsat 5-4-3

24km x 20km, centered on 95 35 24W, 44 19 38N
RapidEye – 140 acres, Landsat 126 acres
Landsat - Heilongjiang, China (26km x 20km)
Sample block analysis / validation

- We will have two to three analysts to examine blocks and map soy / no soy / no data
- We will include field visits or other ancillary data for some / all blocks to verify interpretations
- What challenges are we going to face in analyzing block data
  - Poor or inadequate timing
  - Confusion between soy and another cover type
  - Landscape heterogeneity
- What is the protocol for block replacement
  - Cloud/shadow/no data threshold (a minimum of 25% good data coverage)
  - Inability to interpret due to aforementioned challenges (if this introduces geographic biases, this is a big problem)
  - Secondary issue - what if RapidEye is acquired for areas where we end up with no useable Landsat imagery?
Timeline

- USA August 2011
- Argentina and Brazil February 2012
- China August 2012
Yield estimation with and without crop masks

Doraiswamy et al. 2004

Kastens et al. 2005

Fig. 11. Model simulation of corn and soybean crop yields (tones per hectare) at 1.6 km²-grid resolution for the study area.

Fig. 3. Flowchart for a single-variable application of the yield-correlation masking technique for a single choice of mask size. Example shown is for Iowa corn using the NDVI variable obtained by accumulating values across periods 3 and 4 during the 11-year span 1989–1999 (and thus would have been used for the prediction of Iowa corn yields when 2000 was the "out year"). A different variable vector will be obtained for each unique mask size choice.
Crop type productivity

Wheat yield from MODIS

Maize GPP from MODIS

A) W:SW*WDRVI • Whole season
RMSE=3.28
CV=21.6%

B) V:SW*WDRVI • Vegetative
RMSE=2.98
CV=17.8%

C) R:SW*WDRVI • Reproductive
RMSE=2.99
CV=21.0%

Four Southern Russian Oblasts (Primary Winter Wheat Region)

Becker-Reshef et al. 2010

Sakamoto et al. in press
20.5km x 19.5km near Stuttgart, Arkansas
MODIS – Landsat – RapidEye

5km x 4.7km near Stuttgart, Arkansas
MODIS – Landsat – RapidEye

5km x 4.7km near Stuttgart, Arkansas
Soybeans in Argentina's Economy

Argentina total production

Year
Total production (tn)
1969/70
1972/73
1975/76
1979/80
1982/83
1985/86
1988/89
1991/92
1994/95
1997/98
2000/01
2003/04
2006/07
2009/10

3rd Global Soybean Producer

20% Gross National Product

Soybean exports

Volume (Tn)

Tn

U$S

1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007

0
500000
1000000
1500000
2000000
2500000
3000000
3500000
4000000
4500000
5000000

0
200000
400000
600000
800000
1000000
1200000
1400000
1600000
1800000
2000000
2200000
2400000
2600000
2800000
3000000
3200000
3400000
3600000
3800000
4000000
4200000
4400000
4600000
4800000
5000000
Agricultural Estimates by Ministry of Agriculture: Informants

1970
1980
1990
2000
2010: 18.000.000 ha

100.000 ha – 15.000.000 ha
stratified sampling framework for Northeast China

Ground sampling

2008年全国（8省）大豆地面

2010年全国大豆层总体分布及遥感数据覆盖区图
NASS CDL soybean indicator at 40km block scale
MODIS soybean indicator at 40km block scale