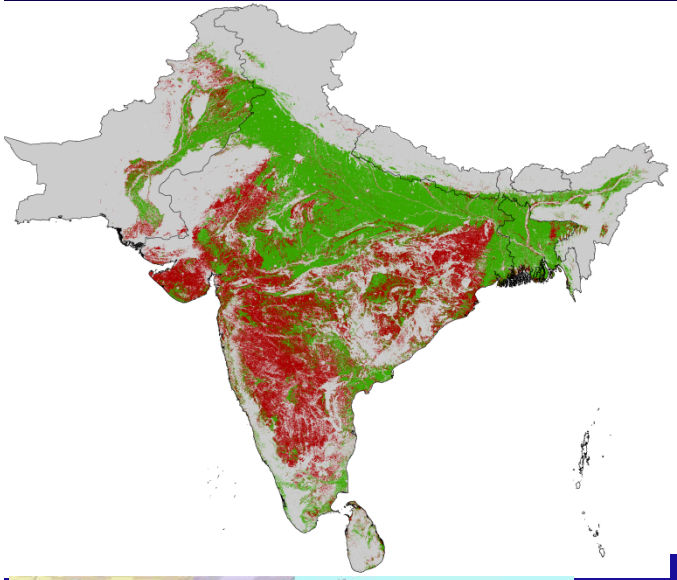
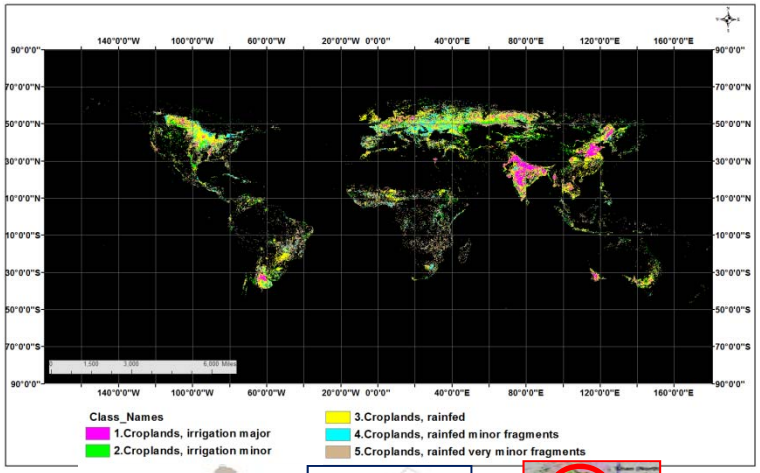
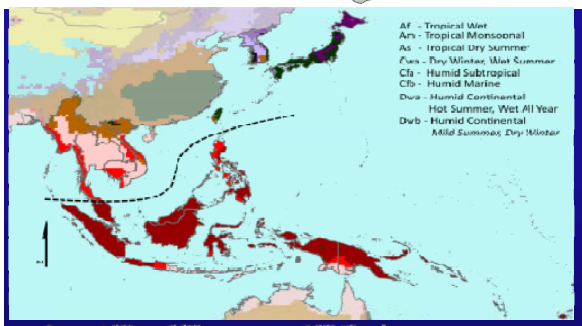
Global Cropland Data Products for Ensuring Food Security

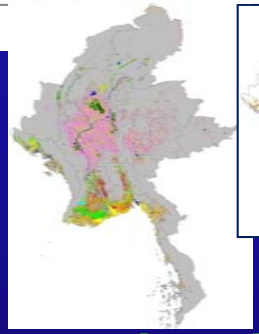
Methods, Algorithms, and Products

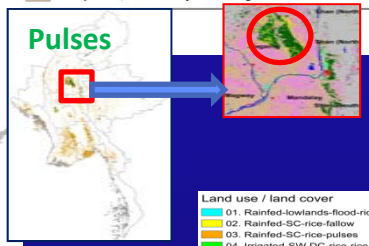
Based on Satellite Sensor Data @ 1 km, 250 m and 30 m

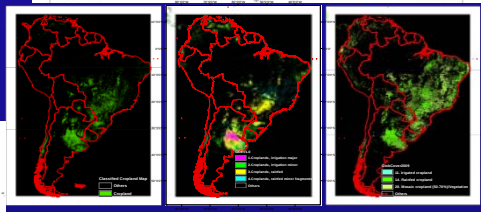












Dr. Prasad S.Thenkabail

Pardhasaradhi Teluguntla , Jun Xiong, and Murali Krishna Gumma

U. S. Geological Survey, and ICRISAT

International Land Cover/Land Use Changes Regional Science Team Meeting in South/Southeast Asia; January 13-15th, 2016, Yangon, Myanmar

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GFSAD30 Project

Overarching Goal and Specific Objectives

http://geography.wr.usgs.gov/science/croplands/index.html

https://www.croplands.org/

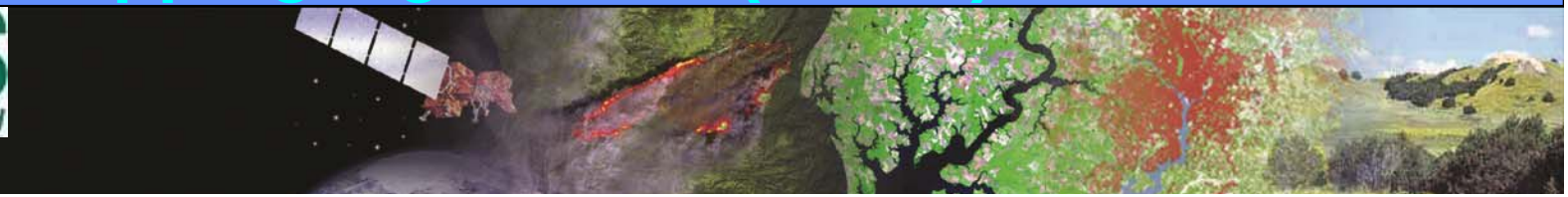
U.S. Department of the Interior
U.S. Geological Survey

Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

Overarching Goal

Monitoring global croplands (GCs) is imperative for ensuring sustainable water and food security to the people of the world in the Twenty-first Century. However, the currently available cropland products suffer from major limitations such as: (1) Absence of precise spatial location of the cropped areas; (b) Coarse resolution nature of the map products with significant uncertainties in areas, locations, and detail; (b) Uncertainties in differentiating irrigated areas from rainfed areas; (c) Absence of crop types and cropping intensities; and (e) Absence of a dedicated web\data portal for the dissemination of cropland products.

The overarching goal of this project is to produce consistent and unbiased estimates of global agricultural cropland areas, crop types, crop watering method, and cropping intensities using Multi-sensor, Multi-date Remote Sensing and mature cropland mapping algorithms (CMAs).



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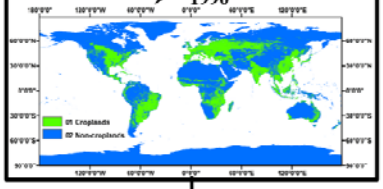
Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

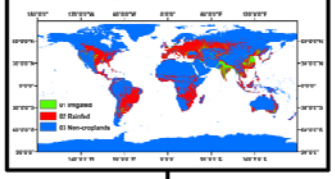
Four Main Products

1. Global Cropland Extent / Area @ nominal 30 m through Landsat 30 m + MODIS 250m + Secondary data Fusion

- 2010
- 1990



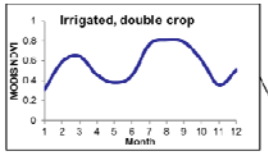
3. Irrigated vs. Rainfed

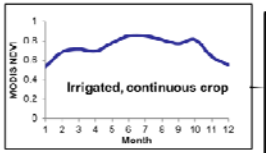


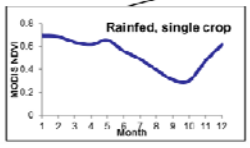
2. Crop Type

- 8 major crops + others

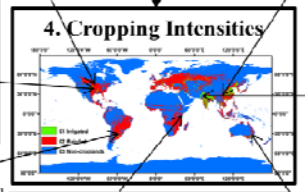
Crop Type	Crop Area (ha)	Proportion (%)
Wheat	402,800,000	22
Corn	227,100,000	13
Rice	195,600,000	11
barley	158,000,000	9
Soybeans	92,700,000	5
Pulses	79,400,000	4
Cotton	53,400,000	3
Potatoes	50,100,000	3

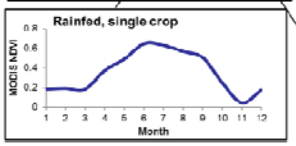


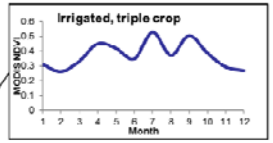


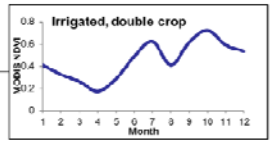


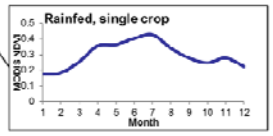
4. Cropping Intensities

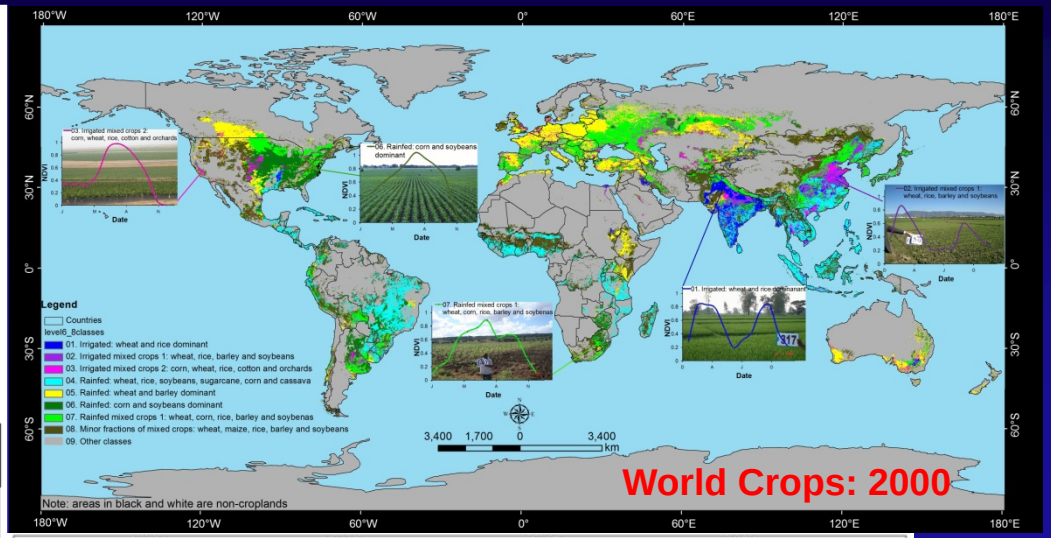




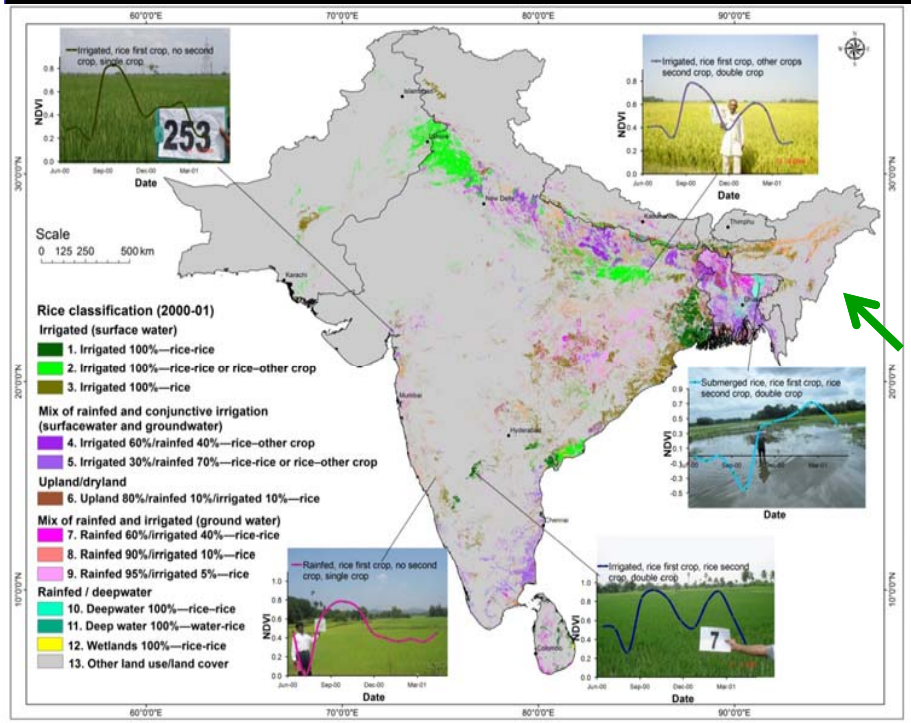








World Crops: 2000



Rice crop in India: Year 2000

Specific Products @ 3 Different Resolutions

1A. GCE 1km Crop Dominance (aka GCE V0.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed

To a lesser extent
- Crop dominance (not type)

1B. GCE 1km Multi-study Crop Mask (aka GCE V1.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed

1 km

2. GCE 250m Crop Dominance (aka GCE V2.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed;
- Cropping intensity;

To a lesser extent
- Crop type and\or dominance

250 m

3. GCE 30m Crop Dominance (aka GCE V3.0)
- Cropland extent and areas;
- Cropland watering method: irrigation versus rainfed;
- Cropping intensity;
- Crop type and\or dominance

30 m

Global Croplands @
~1 km Spatial Resolution

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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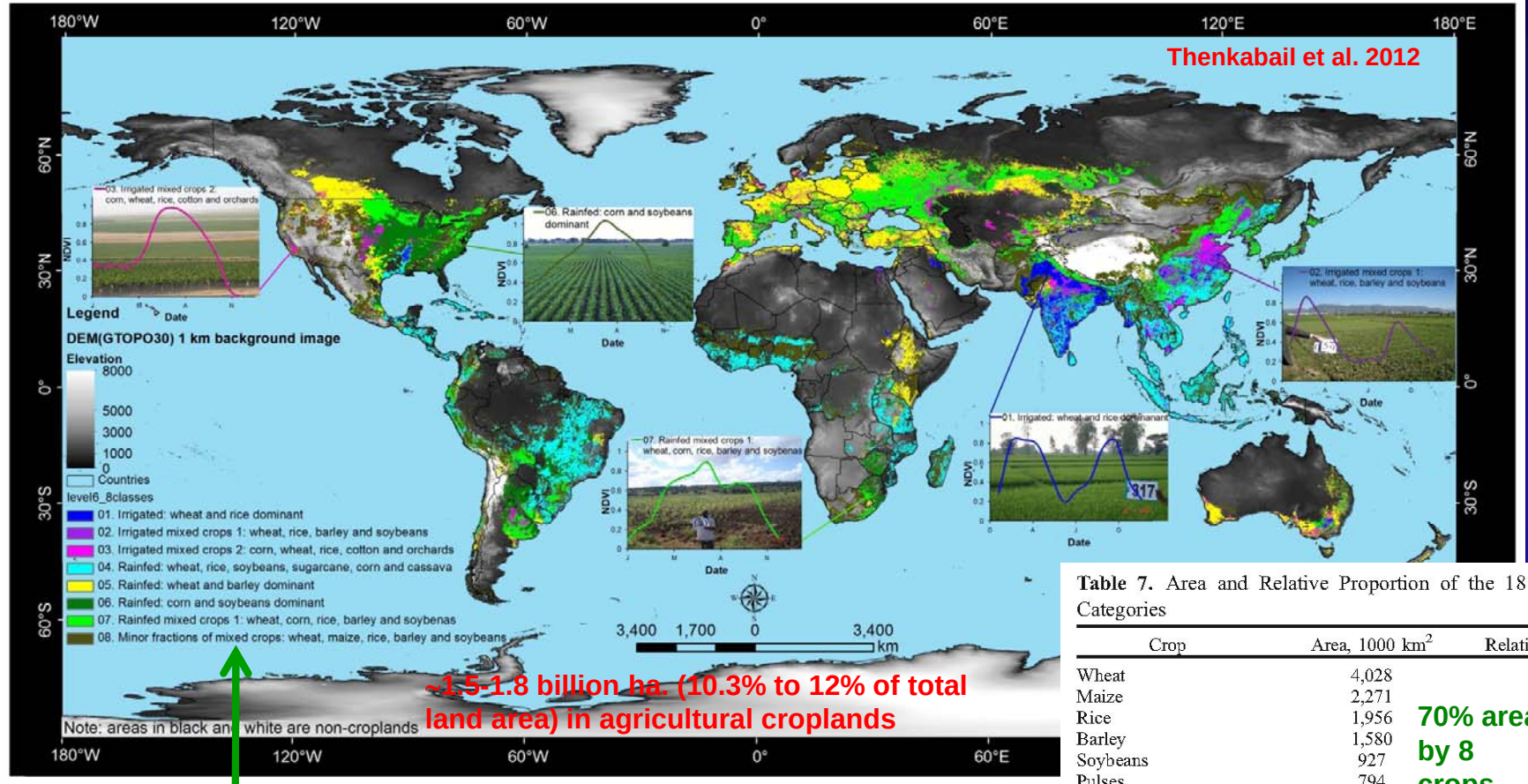
Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

Global Croplands @ ~ 1 km

http://geography.wr.usgs.gov/science/croplands/index.html; https://croplands.org/



~1.5-1.8 billion ha. (10.3% to 12% of total land area) in agricultural croplands

1. Focus on global mapping irrigated and rainfed croplands and computing their blue water and green water use

2. Focus on 18 crops occupy 85% of all global cropland areas…..so, we can focus on them

Table 7. Area and Relative Proportion of the 18 Major Crop Categories

Crop	Area, 1000 km^2	Relative Fraction, %
Wheat	4,028	22
Maize	2,271	13
Rice	1,956	11
Barley	1,580	9
Soybeans	927	5
Pulses	794	4
Cotton	534	3
Potatoes	501	3
Sorghum	501	3
Millet	331	2
Sunflower	290	2
Rye	288	2
Rapeseed/canola	283	2
Sugar cane	265	1
Groundnuts/peanuts	247	1
Cassava	235	1
Sugar beets	154	1
Oil palm fruit	72	<1
Total of major 18 crops	*15,256*	*85*
Others	2664	15
Total cropland	*17,920*	*100*

70% area by 8 crops

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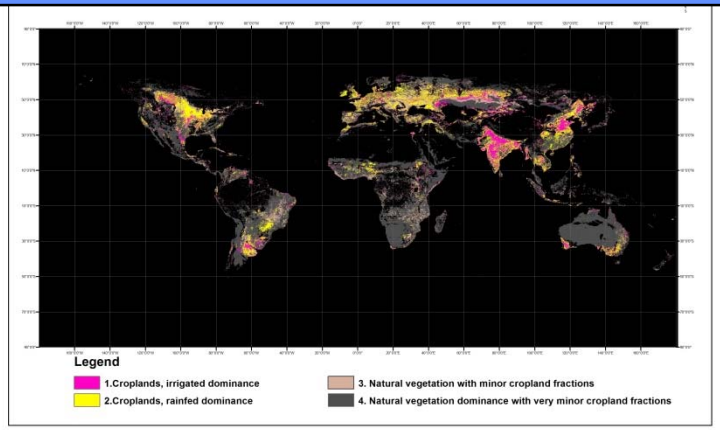
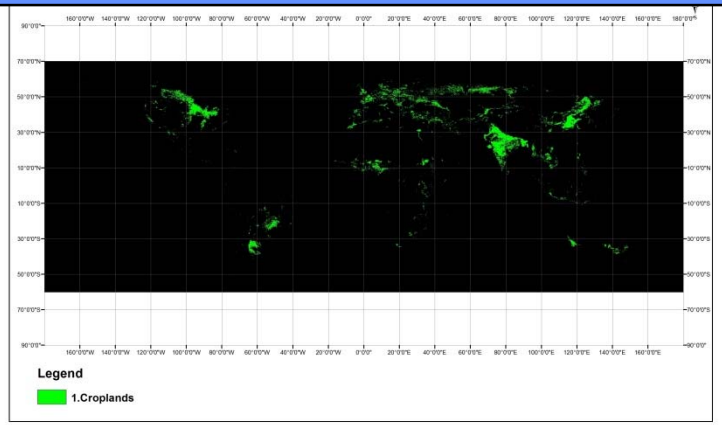
Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

Global Croplands @ ~ 1 km; Constitutes Initial Mask for Higher Resolution Products

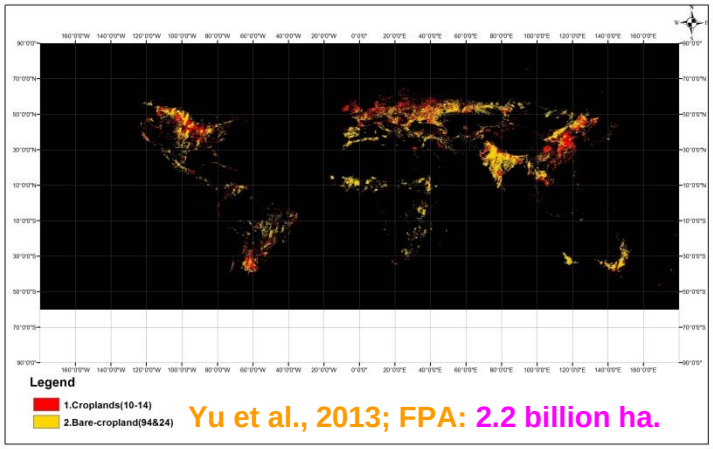
http://geography.wr.usgs.gov/science/croplands/index.html; https://croplands.org/



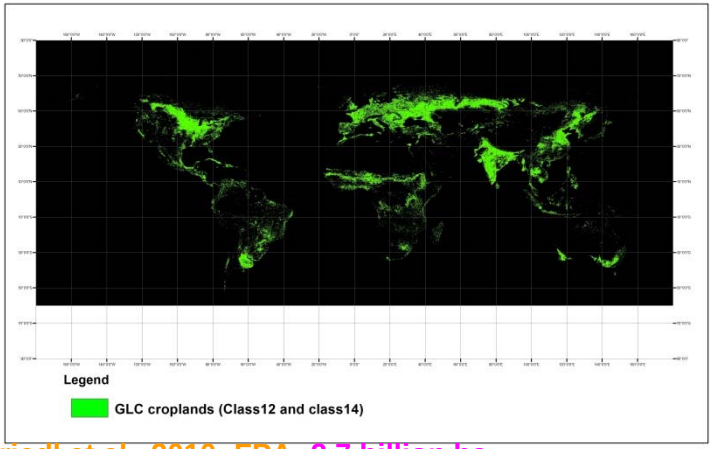
Thenkabail et al., 2011, 2009a,b; FPA: 2.3 billion ha.



Pittman et al., 2010; FPA: 0.9 billion ha.



Yu et al., 2013; FPA: 2.2 billion ha.



Friedl et al., 2010; FPA: 2.7 billion ha.

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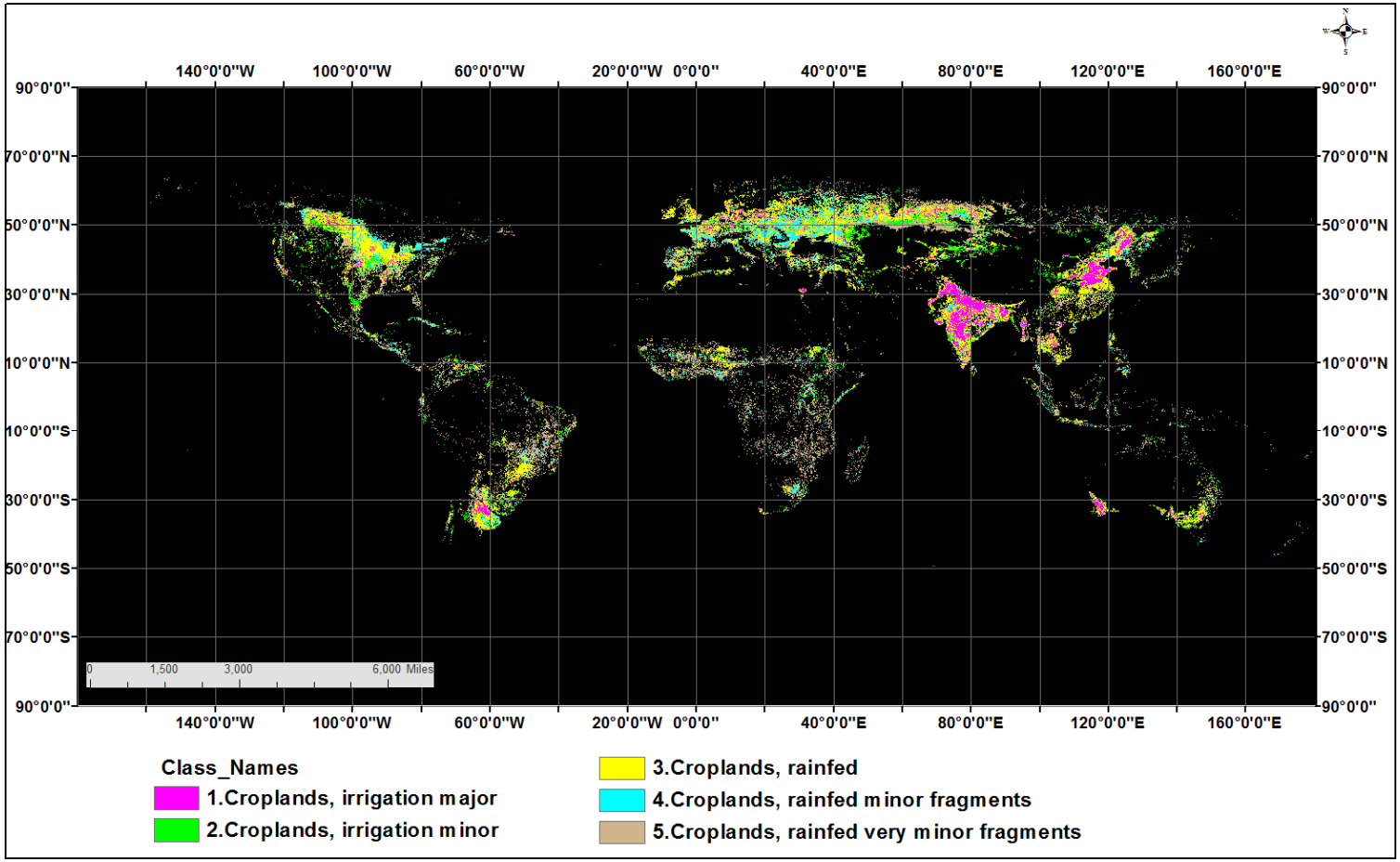
Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Giri, C., Milesi, C., Ozdogan, M., Congalton, R., Tilton, J., Sankey, T.R., Massey, R., Phalke, A., and Yadav, K. 2015. Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1km) Derived from Remote Sensing in Support of Food Security in the Twenty-First Century: Current Achievements and Future Possibilities, Chapter 6. In Thenkabail, P.S., (Editor-in-Chief), 2015. "Remote Sensing Handbook" (Volume II): Land Resources Monitoring, Modeling, and Mapping with Remote Sensing. Taylor and Francis Inc.\CRC Press, Boca Raton, London, New York. ISBN 9781482217957 - CAT# K22130. Pp. 131-160.

Global Food Security Support Analysis Data @ 30 m (GFSAD30) Project

Global Croplands @ ~ 1 km; Constitutes Initial Mask for Higher Resolution Products



~2.3 billion hectares full pixel area (FPAs) with 34% irrigated and 66% rainfed.

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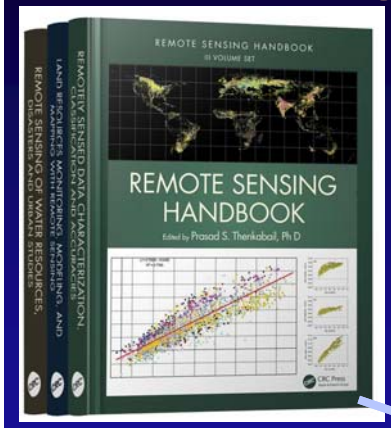
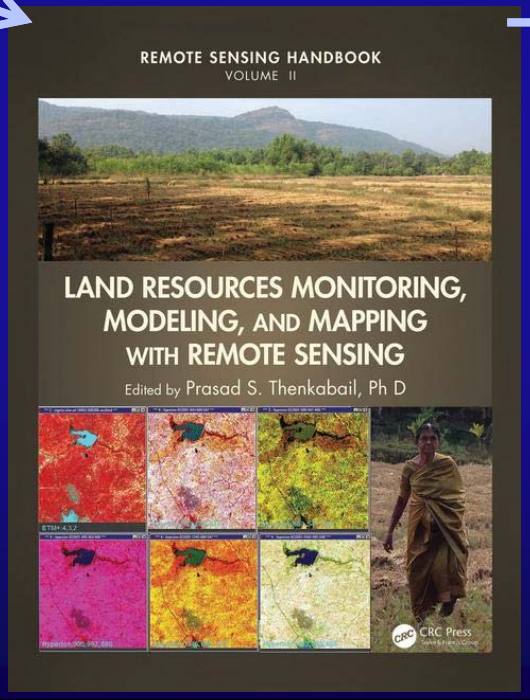
Teluguntla, P., Thenkabail, P.S., Xiong, J., Gumma, M.K., Giri, C., Milesi, C., Ozdogan, M., Congalton, R., Tilton, J., Sankey, T.R., Massey, R., Phalke, A., and Yadav, K. 2015. Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1km) Derived from Remote Sensing in Support of Food Security in the Twenty-First Century: Current Achievements and Future Possibilities, Chapter 6. In Thenkabail, P.S., (Editor-in-Chief), 2015. "Remote Sensing Handbook" (Volume II): Land Resources Monitoring, Modeling, and Mapping with Remote Sensing. Taylor and Francis Inc.\CRC Press, Boca Raton, London, New York. ISBN 9781482217957 - CAT# K22130. Pp. 131-160.

Global Food Security-support Data @ 30 m (GFSAD30) Project
GCE 1km Multi-study Crop Mask (aka GCE V1.0)





6

Global Food Security Support Analysis Data at Nominal 1 km (GFSAD1km) Derived from Remote Sensing in Support of Food Security in the Twenty-First Century: Current Achievements and Future Possibilities

Pardhasaradhi Teluguntla
U.S. Geological Survey and Bay Area Environmental Research Institute

Prasad S. Thenkabail
U.S. Geological Survey

Jun Xiong
U.S. Geological Survey and Northern Arizona University

Murali Krishna Gumma
International Crops Research Institute for the Semi Arid Tropics

Chandra Giri
U.S. Geological Survey, (EROS) Center

Cristina Milesi
NASA Ames Research Center

Mutlu Ozdogan
University of Wisconsin

Russell G. Congalton
University of New Hampshire

James Tilton
NASA Goddard Space Flight Center

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Global Croplands @ ~250 m Spatial Resolution

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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Cropland Mapping Algorithms (CMAs)

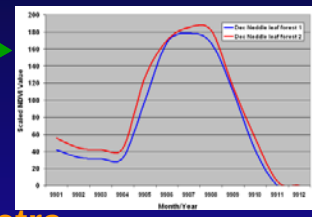
Methods, Models, Algorithms used in GFSAD30 Project

A. kMeans algorithms (Duveiller et al., 2015, Jensen et al., 2000);
B. Isoclass Clustering (Duveiller et al., 2015, Jensen et al., 2000);
C. Phenology based methods (Dong et al., 2015);
D. Tree-based regression algorithm (Ozdogan and Gutman, 2008);
E. Linear discriminant analysis (Imani and Ghassemian, 2015);
F. Machine learning algorithms: decision trees, random forest, support vector machines (Pantazi et al., 2016. Duro et al., 2012, DeFries and Chan, 2000);
G. Decision Tree algorithms (Friedl and Brodley, 1997, Defries et al., 1998, Waldner et al., 2015);
H. Random forest algorithms (Tatsumi et al., 2015, Gislason et al., 2006);
I. Support vector machines (Mountrakis et al., 2011);
J. Spectral matching techniques (Thenkabail et al., 2007);
K. Automated cropland classification algorithms (Thenkabail et al., 2010);

Quantitative Spectral Matching Techniques (SMTs)
Methods and Concepts of Quantitative SMTs

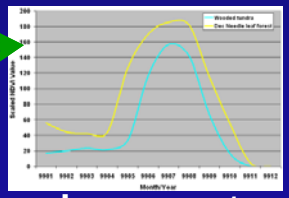
Quantitative SMTs compare class spectra of one class with class spectra of every other class & determine, quantitatively, similarities and dissimilarities between classes through automated process; facilitates rapid identification of classes.

1. Spectral Correlation Similarity (SCS)



a. shape measure
b. Values vary between 0 to 1 (theoretically between -1 and +1).
Negative values have no meaning here. Ignore.
Note: Greater the SCS greater is the similarity between class spectra and target spectra

2. Spectral Similarity Value (SSV)



a. Shape and magnitude measure
b. Values vary between 0 to 1.415
Note: Smaller the SSV value greater the similarity between class spectra and target spectra

3. Modified Spectral Angle similarity (MSAS)

a. hyper-angle measure
b. practical implementation was difficult, hence dropped.

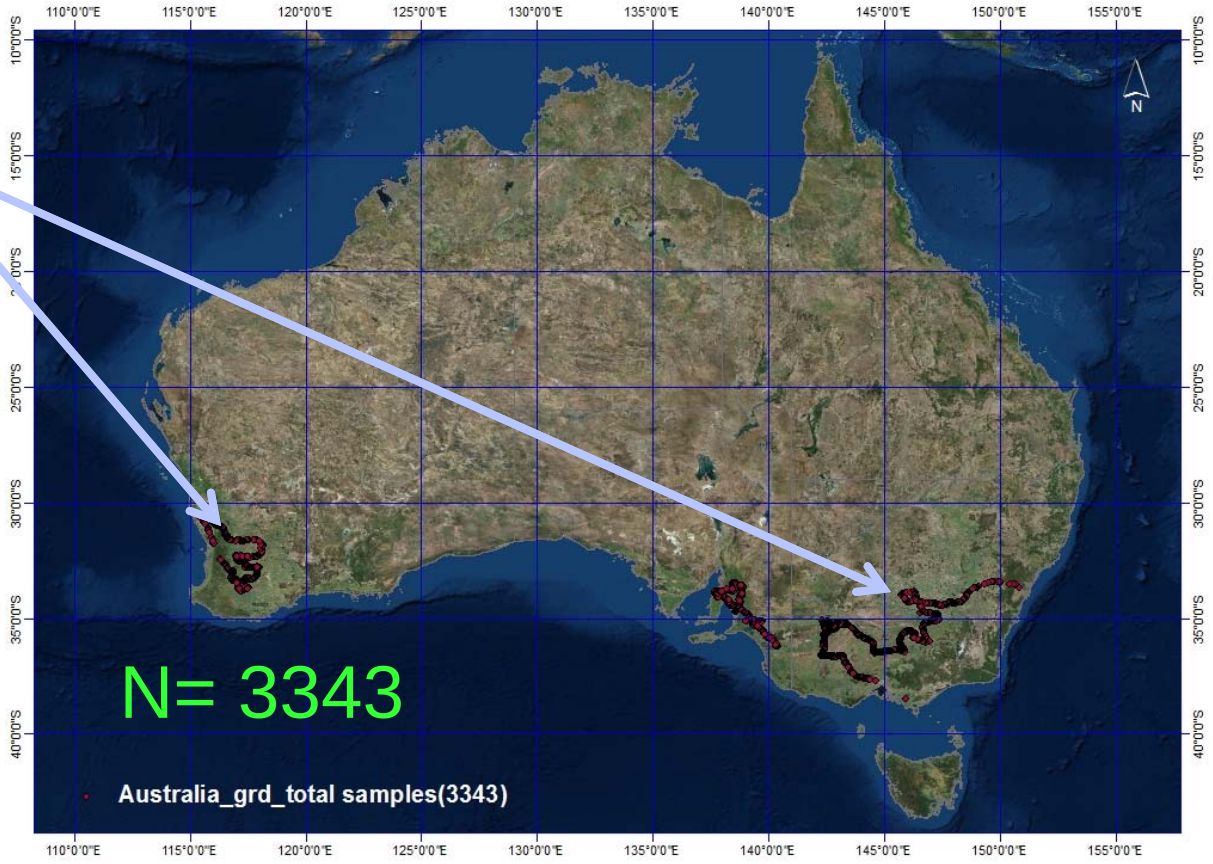
Note: Euclidian distance was a distance measure. We dropped it since SSV and SCS perform better.

Reference: Thenkabail, P.S., GangadharaRao, P., Biggs, T., Krishna, M., and Turral, H., 2007. Spectral Matching Techniques to Determine Historical Land use/Land cover (LULC) and Irrigated Areas using Time-series AVHRR Pathfinder Datasets in the Krishna River Basin, India. Photogrammetric Engineering and Remote Sensing. 73(9): 1029-1040. (Second Place Recipients of the 2008 John I. Davidson ASPRS President's Award for Practical papers).

Quantitative Spectral Matching Techniques (SMTs)
Knowledge Base for Training Algorithms (N= 3343)

Ground Data collected for Australia:

09/25/ 2014 to 10/18/2014



From these precise locations temporal NDVI spectral profiles (e.g., MODIS) of various crops and\or crop dominations Can be obtained

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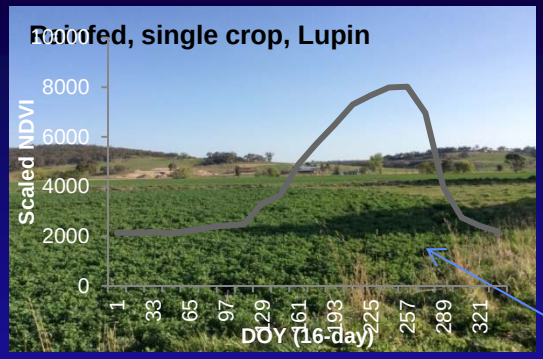
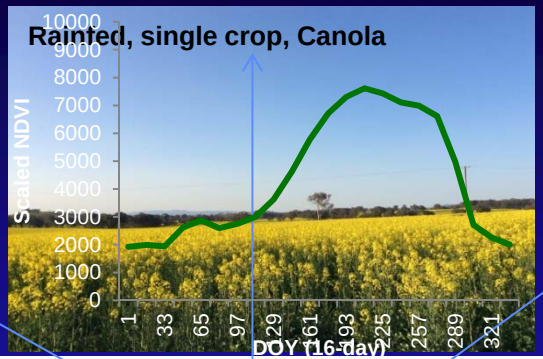
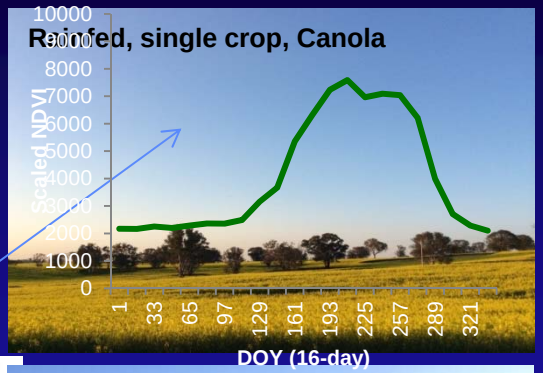
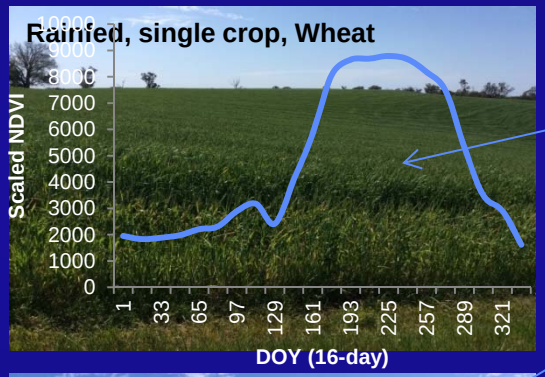
Quantitative Spectral Matching Techniques (SMTs)

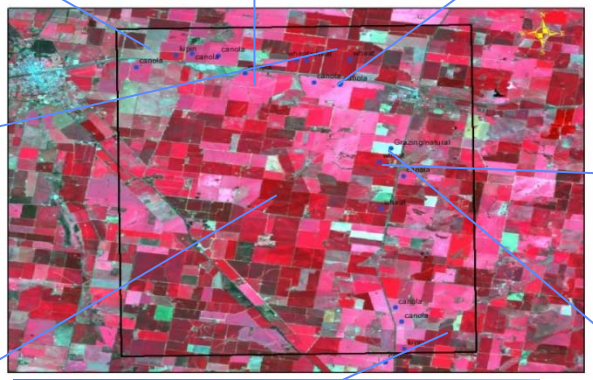
Developing Ideal Spectra using MODIS 250m Every 16-day data of 2014 for Australia

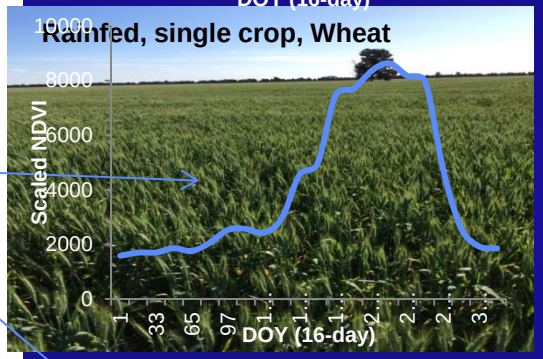


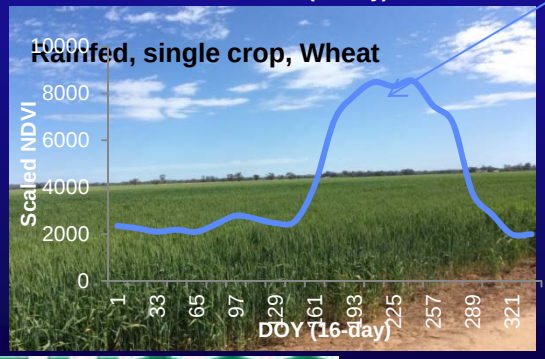


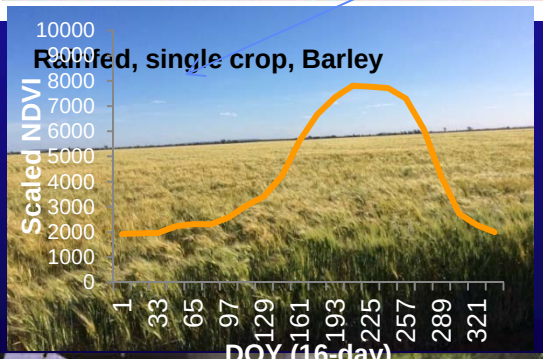


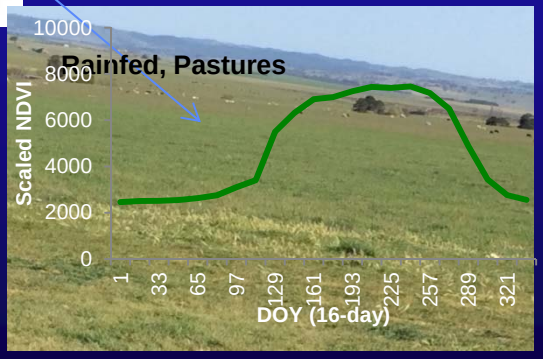












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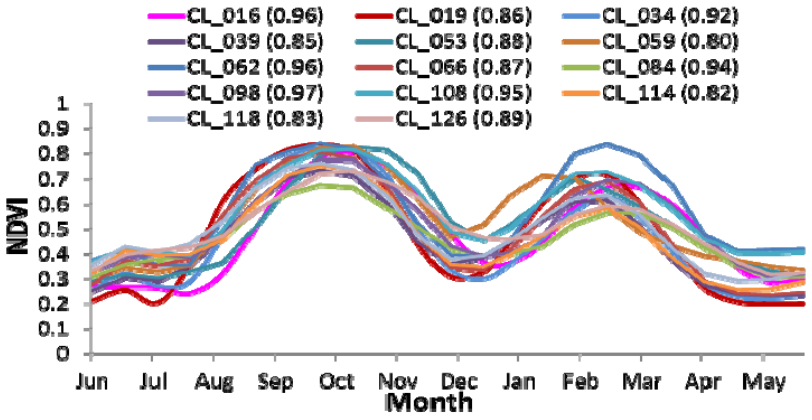
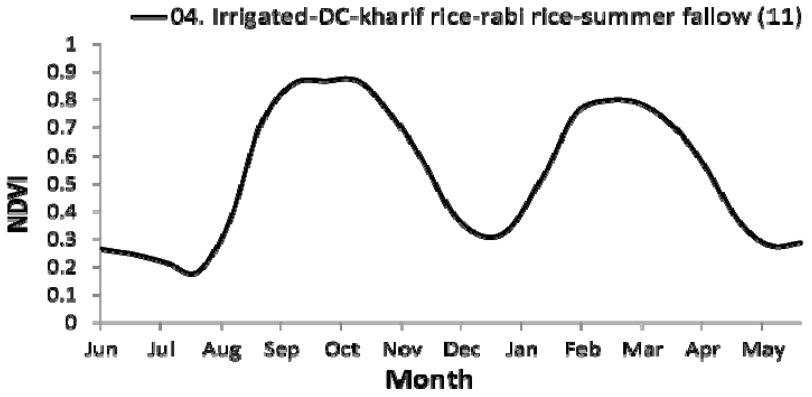
Matching group of Irrigated Class Spectra with Ideal Spectra

Illustration shows how 14 Similar Classes are Grouped & matched with Ideal Spectra Using Quantitative Spectral matching Technique (QSMTs)

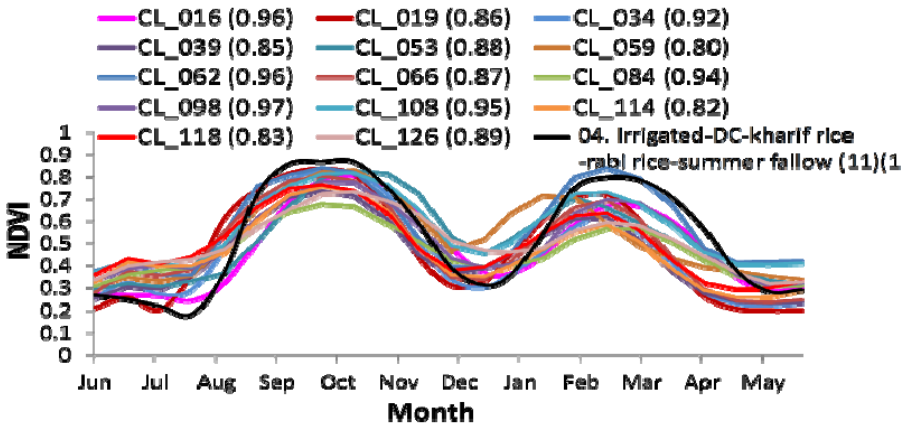
a) Class spectra that have similar temporal signatures are grouped together



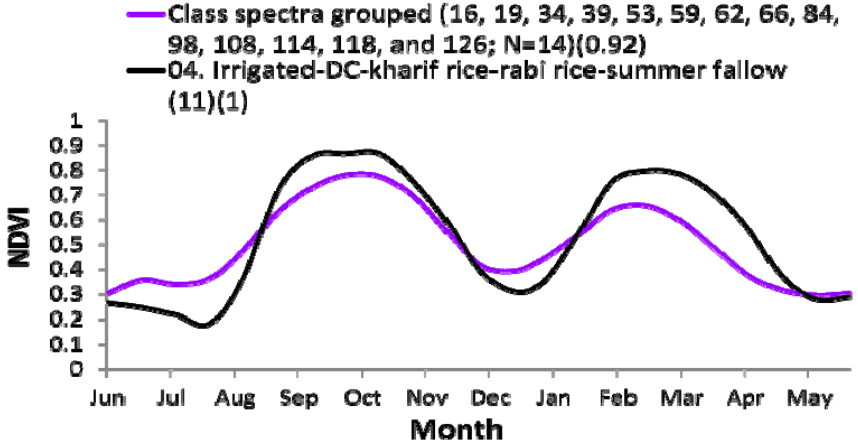
b) Ideal spectra that is closest to class spectra that are shown in (a)



c) Match Class spectra that are similar with Ideal Spectra that best matches them



d) Match class spectra that are grouped together into single class with ideal spectra



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Croplands vs. Non-croplands of Australia, Year 2014

Total 6 Unique Cropland Classes based on MODIS 250m Every 16-day, NDVI data

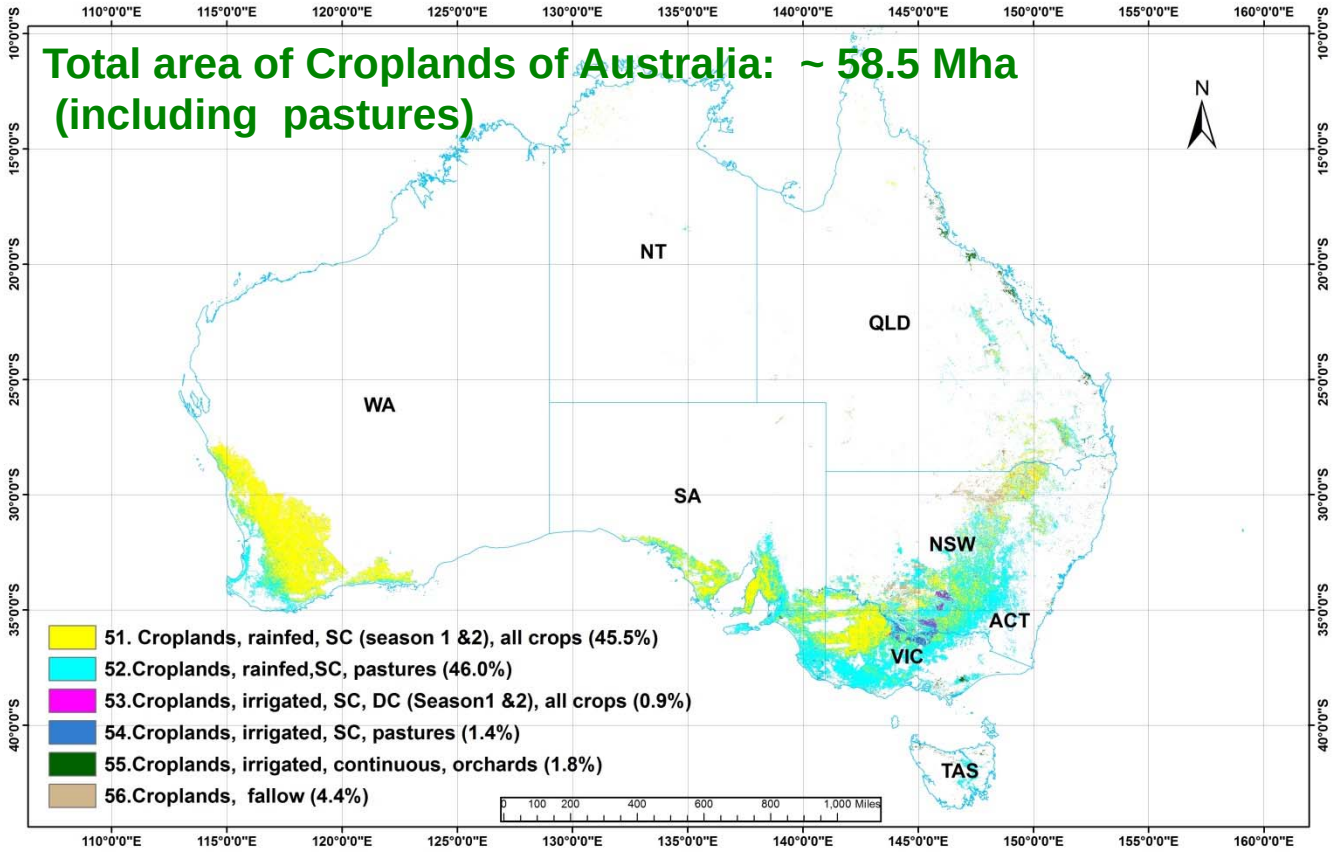
Main Messages:

1. Rainfed single crop (45.5%), and Rainfed single crop Pasture (46%) dominate Australia's croplands;

2. Croplands distribution of Australia (31.6 Mha):
91.5% rainfed
4.1% irrigated
4.4% fallow

Note: Actual areas (sub pixel areas) are reported. Details later.

Reference Cropland Product of Australia; Year 2014



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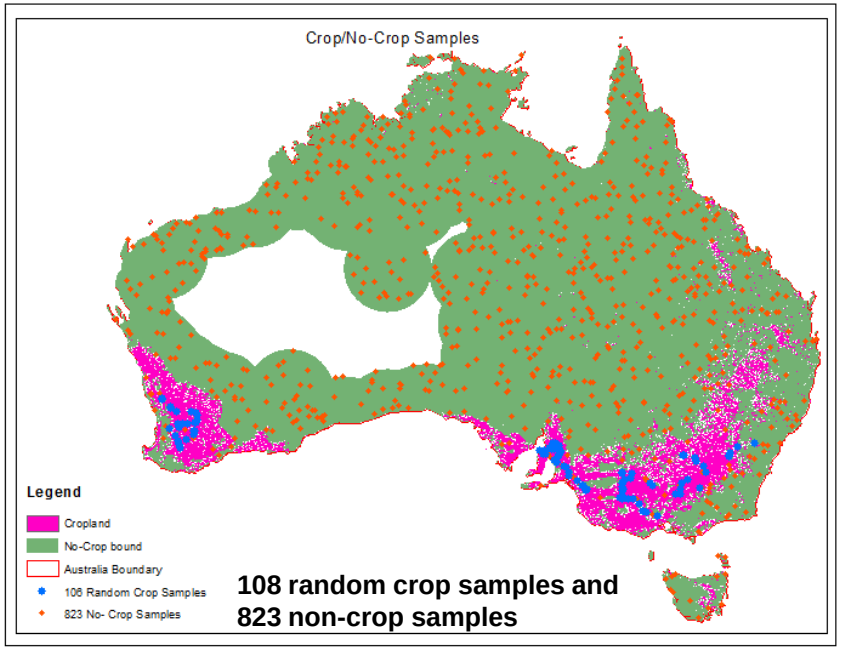
Accuracies of Australia's Croplands vs. Non-croplands, Year 2014

Total 6 Unique Cropland Classes based on MODIS 250m Every 16-day, NDVI data

Original

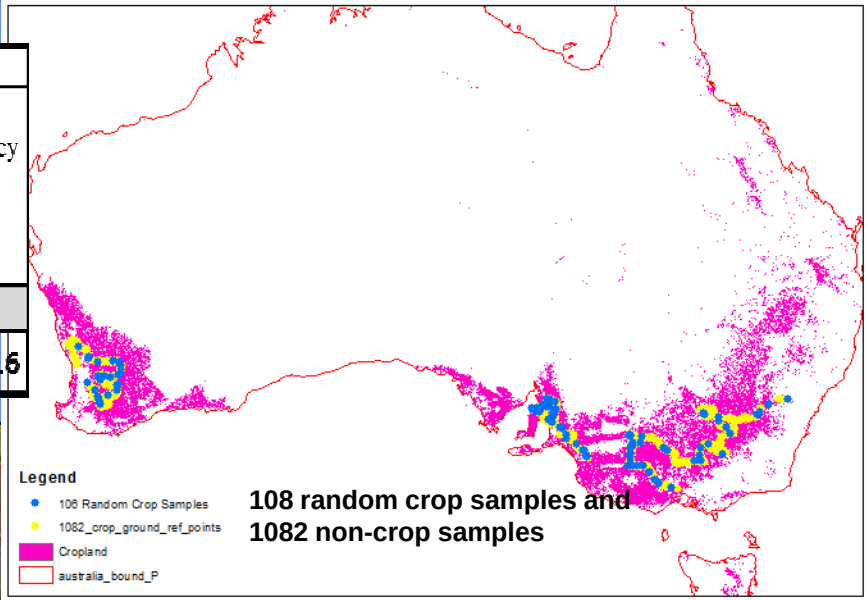
		Reference Data			
		Cropland	No-Crop	Sum Points	User Accuracy
Map Data	Cropland	1,040	13	1,053	98.77%
	No-Crop	42	23	65	35.38%
Sum Points		1,082	36	1,118	
Producer Accuracy		96.12%	63.89%		**95.08%**



108 random crop samples and 823 non-crop samples

Balanced

		Reference Data			
		Cropland	No-Crop	Sum Points	User Accuracy
Map Data	Cropland	102	13	115	88.70%
	No-Crop	4	810	814	99.51%
Sum Points		106	823	929	
Producer Accuracy		96.23%	98.42%		**98.17%**
				Kappa =	**0.912711616**



108 random crop samples and 1082 non-crop samples

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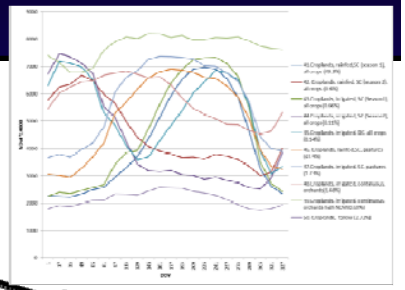
Automated Cropland Classification Algorithm (ACCA) based on Reference Cropland Product of Australia for Year 2014



MODIS 250m-16day
NDVI time series (2014)

1. Rainfed croplands mask

If ΣNDVI >= 22400 in time period 2 to 5 then Croplands, rainfed, Season2 crops Class#3

If ΣNDVI <= 19600 in time period 11 to 17 then Croplands, rainfed, fallows Class#4

If ΣNDVI <= 10200 in time period 6 to 8 then Croplands, rainfed, Season1 all crops Class#1

If ΣNDVI > 10200 in time period 6 to 8 then Croplands, rainfed, pastures Class#2

2. Rainfed pastures mask

If ΣNDVI <= 14600 in time period 11 to 14 then Croplands, rainfed, fallows Class#13

If NDVI(1)>3800
or if ΣNDVI > 9000 in time period 5 to 7
or if NDVI(5)>6000 or NDVI(6)>6000
or NDVI(7)>6000 or NDVI(8)>6000 or NDVI(9)>6000
or NDVI(10)>6000 or
if ΣNDVI > 9000 and ΣNDVI < 12000 in time period 15 to 17 then Croplands, rainfed, pastures Class#12
else
Croplands, rainfed, Season1 all crops Class#11

3. Irrigated croplands mask

If ΣNDVI <= 10400 in time period 8 to 11 then Croplands, irrigated, fallows Class#27

If ΣNDVI >= 28000 in time period 19to 22 then Croplands, irrigated, continuous orchards High NDVI Class#26

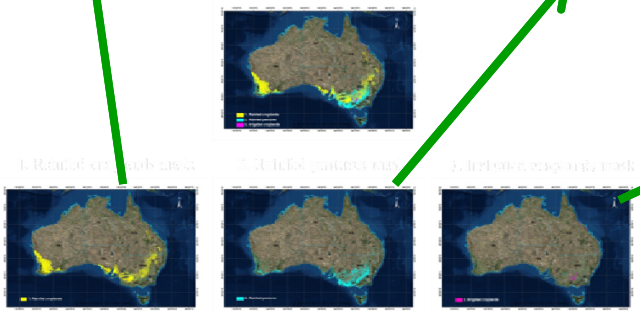
If ΣNDVI >= 16800 in time period 2 to 4
and ΣNDVI <= 13800 in time period 8 to 10
and ΣNDVI > 22400 in time period 15 to 18
then Croplands, irrigated, double crop Class#24

If ΣNDVI >= 16800 in time period 2 to 4
and ΣNDVI <= 8000 in time period 12 to 13
then Croplands, irrigated, season#2 Class#23

If ΣNDVI >= 18000 in time period 2 to 4
or (ΣNDVI <= 32400 and ΣNDVI >= 21600) in time period 13 to 18 then Croplands, irrigated, continuous , orchards Class#25

If ΣNDVI >= 16200 in time period 8 to 10 then Croplands, irrigated, pastures Class#22

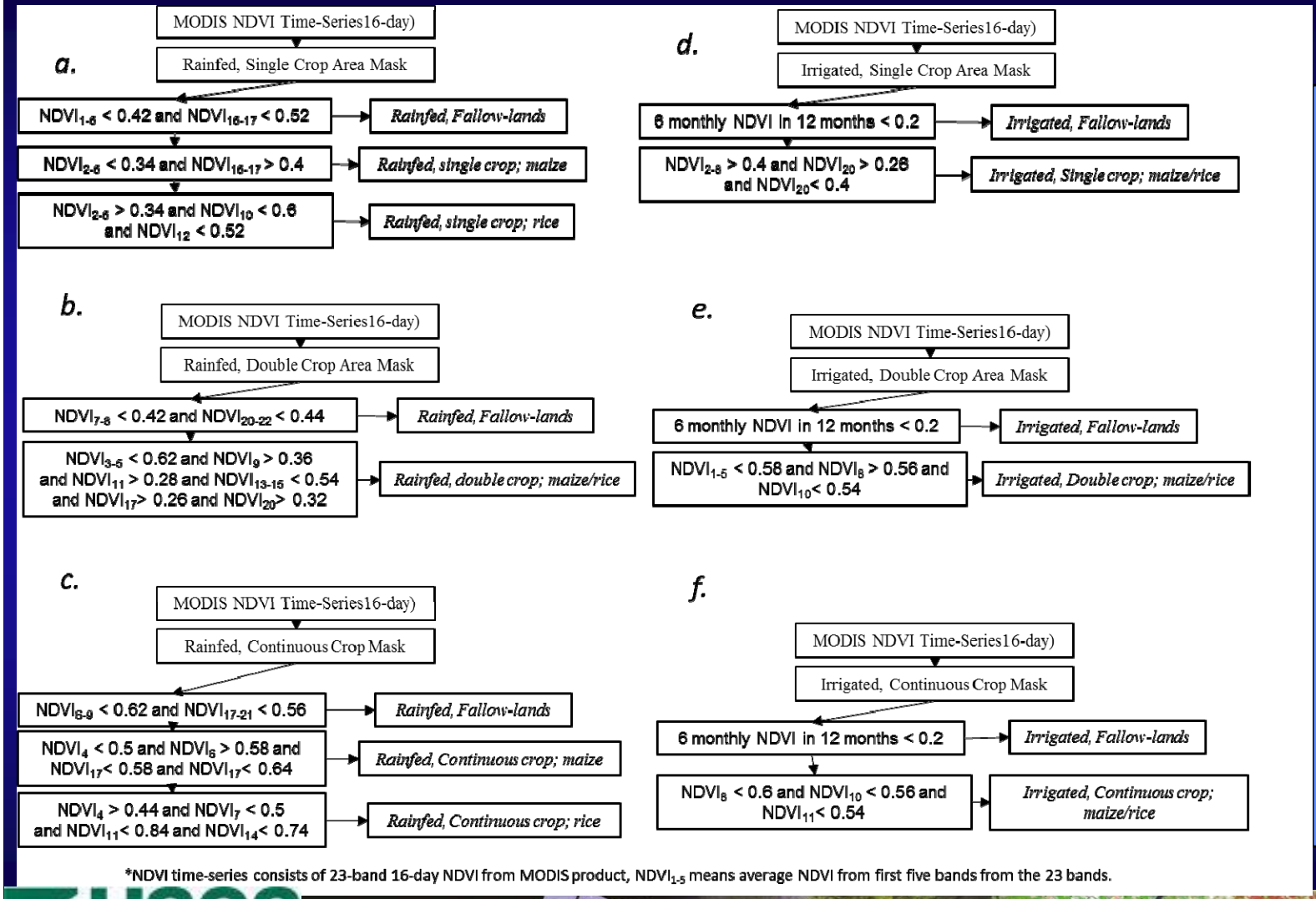
else Croplands, irrigated, all crops Class#21



Hardcoding Cropland Classes Based on Reference Cropland Product of year 2014 (RCP2014)

Hard Coding Distinctly Seperable Classes

that Can be Separated Year After Year Automatically using MODIS 250m Every 16-day data



*NDVI time-series consists of 23-band 16-day NDVI from MODIS product, $NDVI_{1-5}$ means average NDVI from first five bands from the 23 bands.

Part of the…….
….hard coded……

Automated cropland classification algorithm (ACCA)

Note: find the full ACCA algorithm for Africa @:
https://croplands.org/

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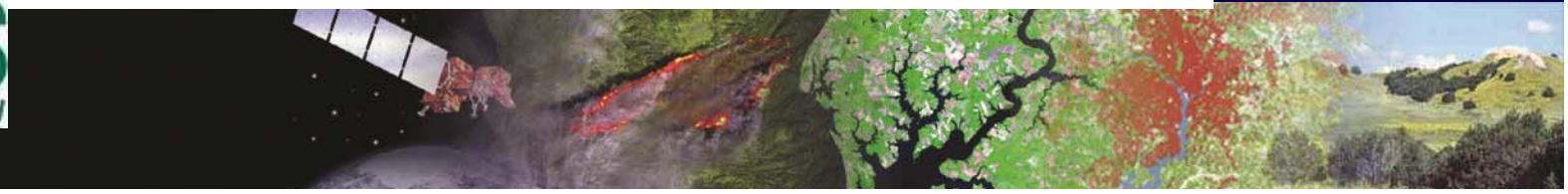
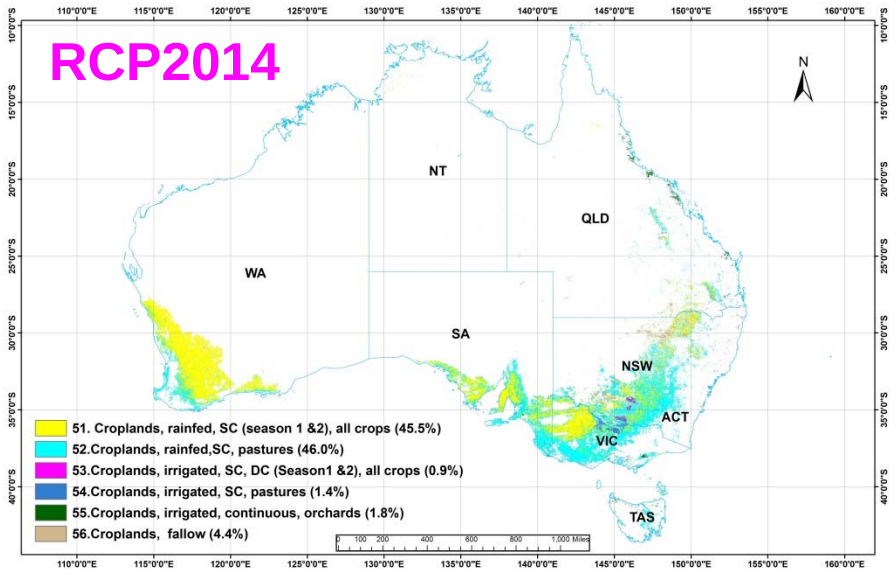


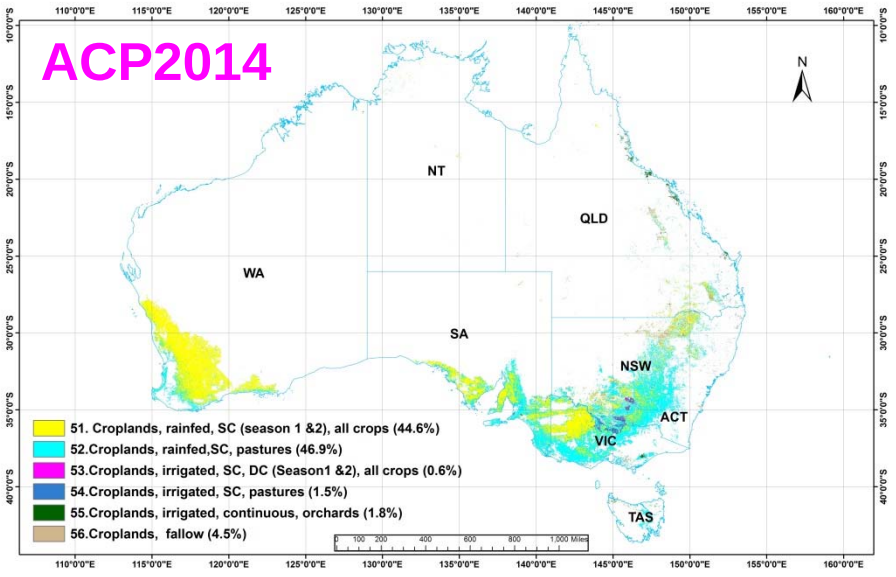
Reference cropland product of Australia for the year 2014 (RCP201) versus ACCA derived cropland product of Australia for the year 2014 (ACP2014)

Using MODIS 250m every 16 day data of Australia for the year 2014

Reference Product, 6 classes from all 3 masks (based on SMT): Spatial distribution of croplands within all 3 cropland masks using SMT

Algorithm Product, 6 classes from all 3 masks (based on ACCA): Spatial distribution of croplands within all 3 cropland masks using ACCA





6 Classes: 1 rainfed sc, 1 rainfed pasture, 1 irrigated sc, 1 irrigated dc, 1 irrigated continuous, 1 cropland fallows

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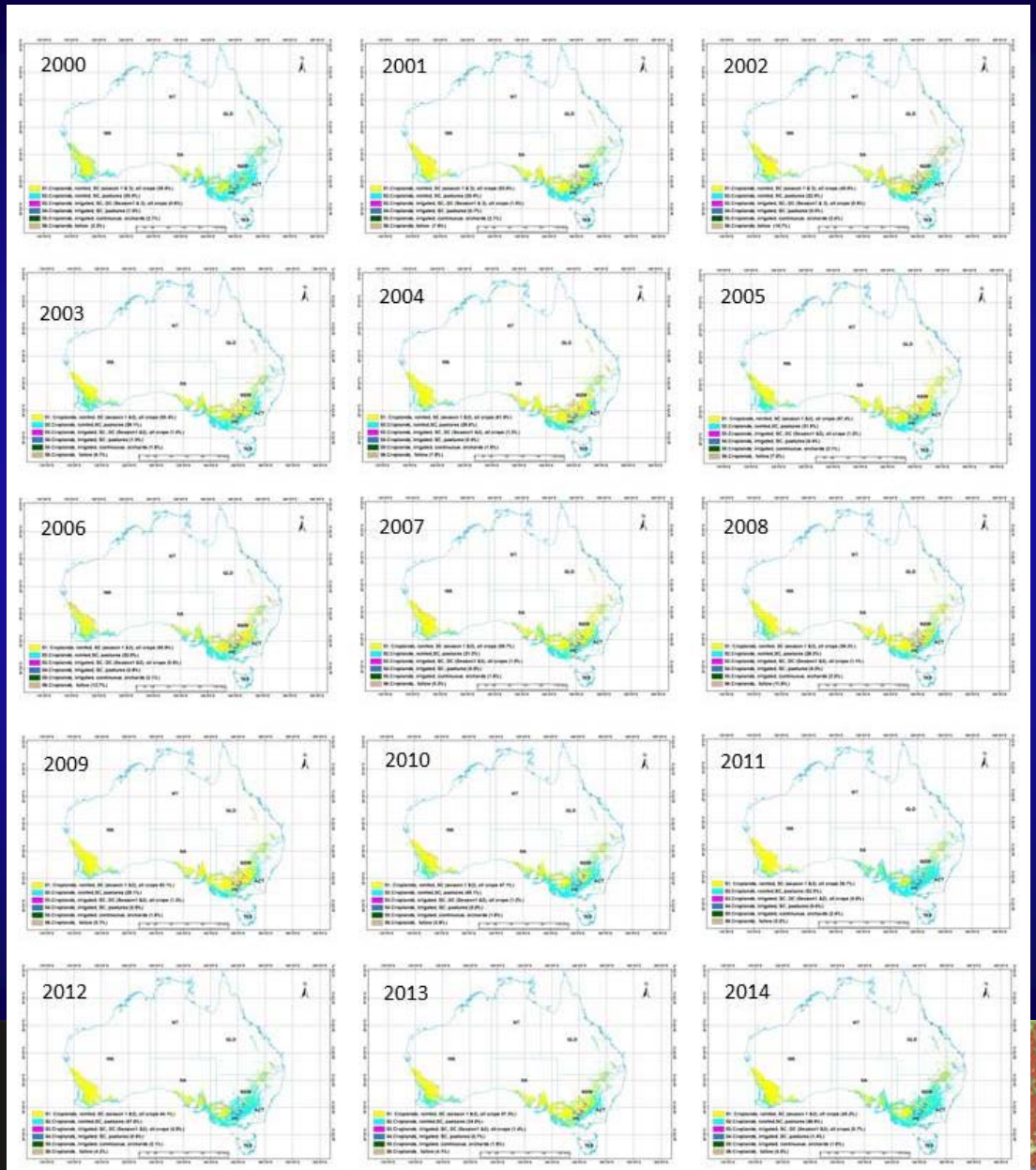
Cropland Classes (6 class map) of Australia @ MODIS 250 m: 2000 through 2014

Computed Automatically using Automated Cropland Classification Algorithms (ACCA)

ACP2000 to ACP2014



6 Classes:
1 rainfed sc,
1 rainfed pasture,
1 irrigated sc,
1 irrigated dc,
1 irrigated continuous,
1 cropland fallows

Using MODIS 250m every 16 day data of Australia for the year 2014

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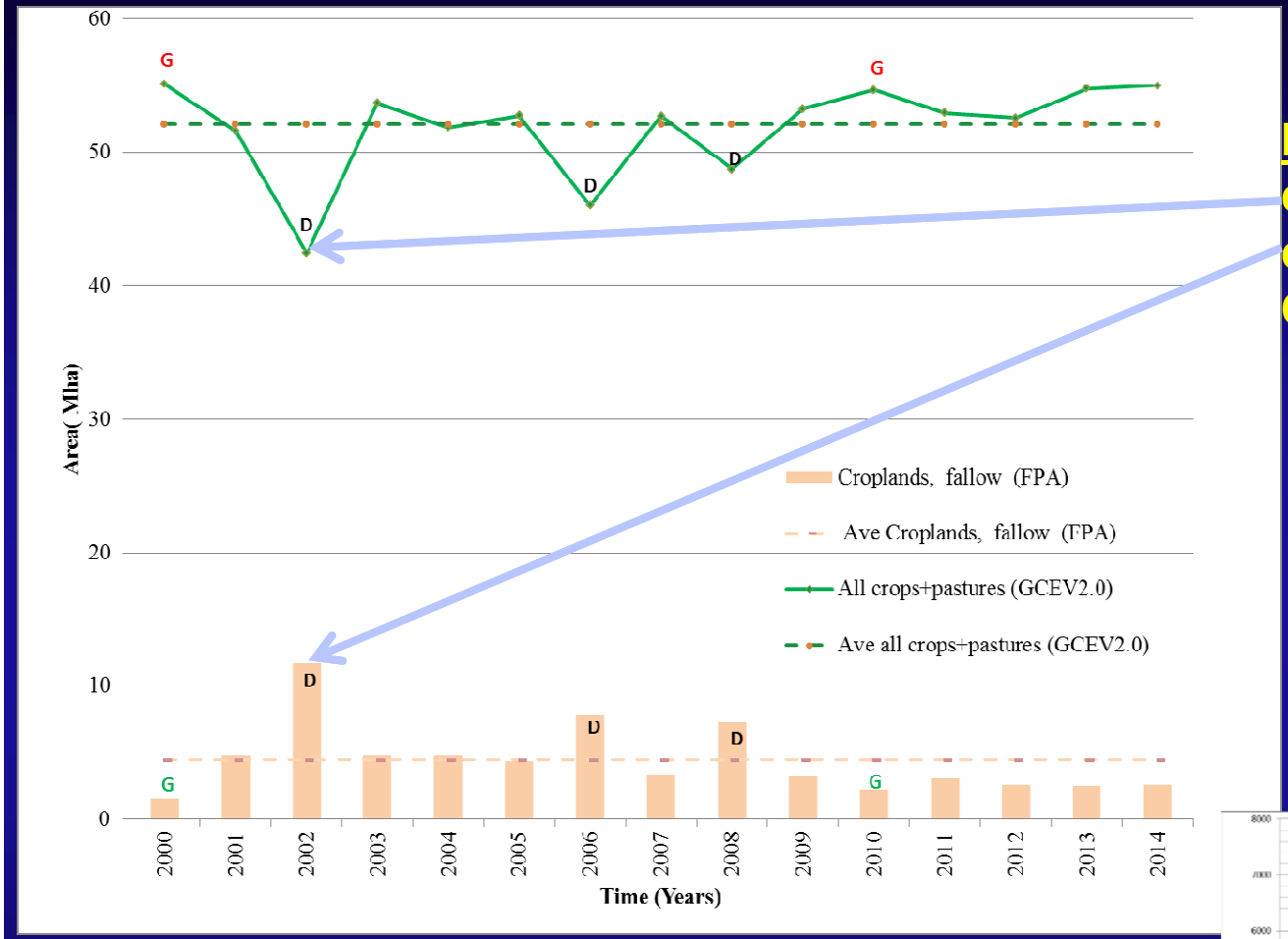
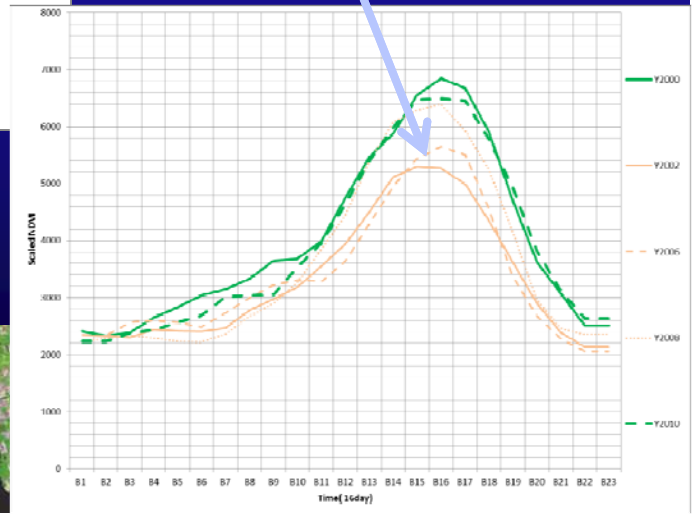
Comparison of areas derived using ACCA algorithm on MODIS 250m for years 2000-2014 for Australia
Trend of Croplands (croplands + pastures) vs Cropland Fallows during drought and good years



During drought years:
cropland areas decrease
cropland fallows increase
Cropland vigor decrease

The above factors have significant impact on food security



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Global Croplands @
~250 m Spatial Resolution
Myanmar and South Asia

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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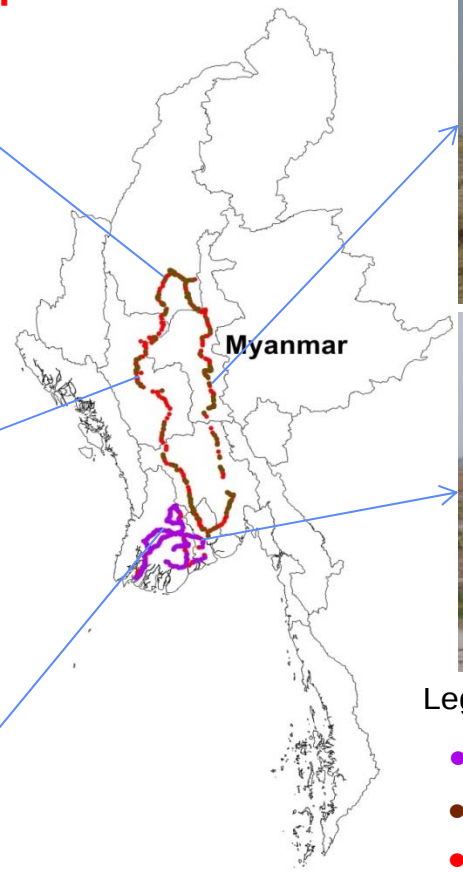
Croplands of Myanmar using MODIS 250 m Every 16-day NDVI Data for 2000-2014

Croplands of Myanmar: Ground Data

Irrigated-SW-TC-rice-chickpea-rice-LS

Rainfed-SC-rice-LS-1a

Rainfed-lowlands-SC-flooc



Rainfed-SC-rice-chickpea-LS

Irrigated-SW-DC-rice-rice-LS-1a

Legend

- Ground data_11-18-Dec-2012 (132)
- Ground data_23-29-Mar-2013 (133)
- Ground data (Validation) (828)
- Myanmar province

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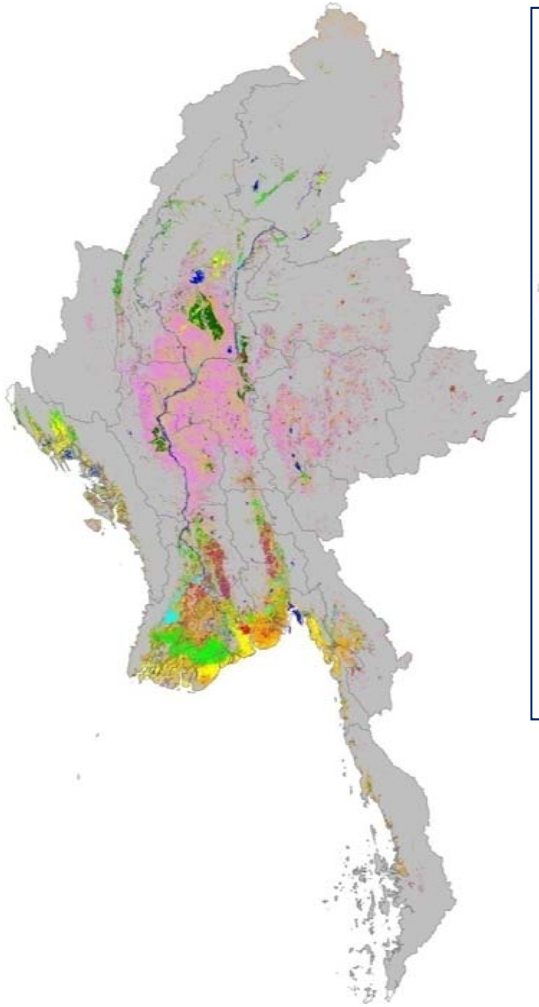
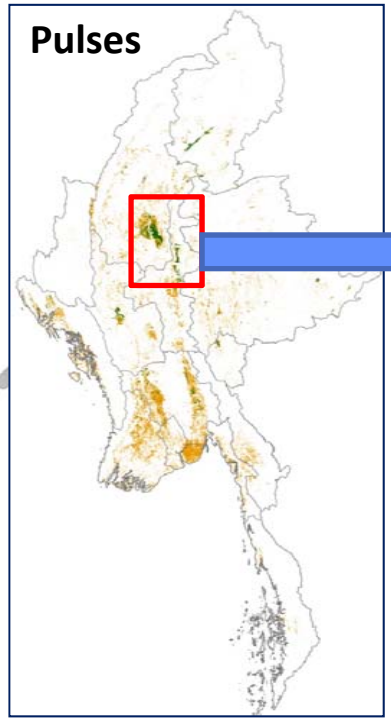
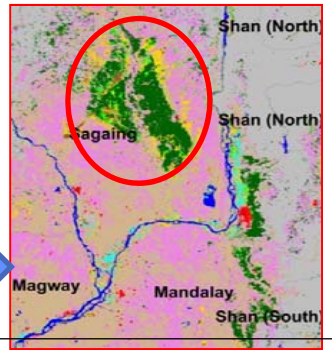
Croplands of Myanmar using MODIS 250 m Every 16-day NDVI Data for 2000-2014

Croplands of Myanmar @ 250 m: Classes







Potential Chick pea areas (Rice-fallows)

Net rice (Monsoon rice)	**6,123,549**
Summer rice	**1,349,637**
Total rice	**7,473,186**
Chickpea	**344,665**
Pulses	**4,181,272**

Land use / land cover

- 01. Rainfed-lowlands-flood-rice
- 02. Rainfed-SC-rice-fallow
- 03. Rainfed-SC-rice-pulses
- 04. Irrigated-SW-DC-rice-rice-fallow
- 05. Irrigated-SW-DC-rice-pulses-fallow/rice
- 06. Irrigated-SW-DC-rice-fallow-rice/fallow
- 07. Rainfed-SC-groundnut/pigeonpea
- 08. Rangelands mix with rainfed mixed crops
- 09. Water bodies
- 10. Built-up lands
- 11. Forests/Savannas/others

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Croplands of Myanmar using MODIS 250 m Every 16-day NDVI Data for 2000-2014

Croplands of Myanmar @ 250 m: Stastistics

Land use / land cover	*Area (ha)*	*% total area*
01. Rainfed-lowlands-flood-rice	358272	1%
02. Rainfed-SC-rice-fallow	1069859	2%
03. Rainfed-SC-rice-pulses	2688163	4%
04. Irrigated-SW-DC-rice-rice-fallow	722859	1%
05. Irrigated-SW-DC-rice-legumes-fallow/rice	616685	1%
06. Irrigated-SW-DC-rice-fallow-rice	667711	1%
07. Rainfed-SC-groundnut/pigeonpea	6357374	9%
08. Rangelands mix with rainfed mixed crops	3362763	5%
09. Water bodies	579038	1%
10. Built-up lands	95459	0%
11. Forests/Savannas/others	50760614	75%
	6,72,78,797	
Rice planted area	6123549	49%
Pulsed and other crops	6357374	51%
Total cropped area	12480923	

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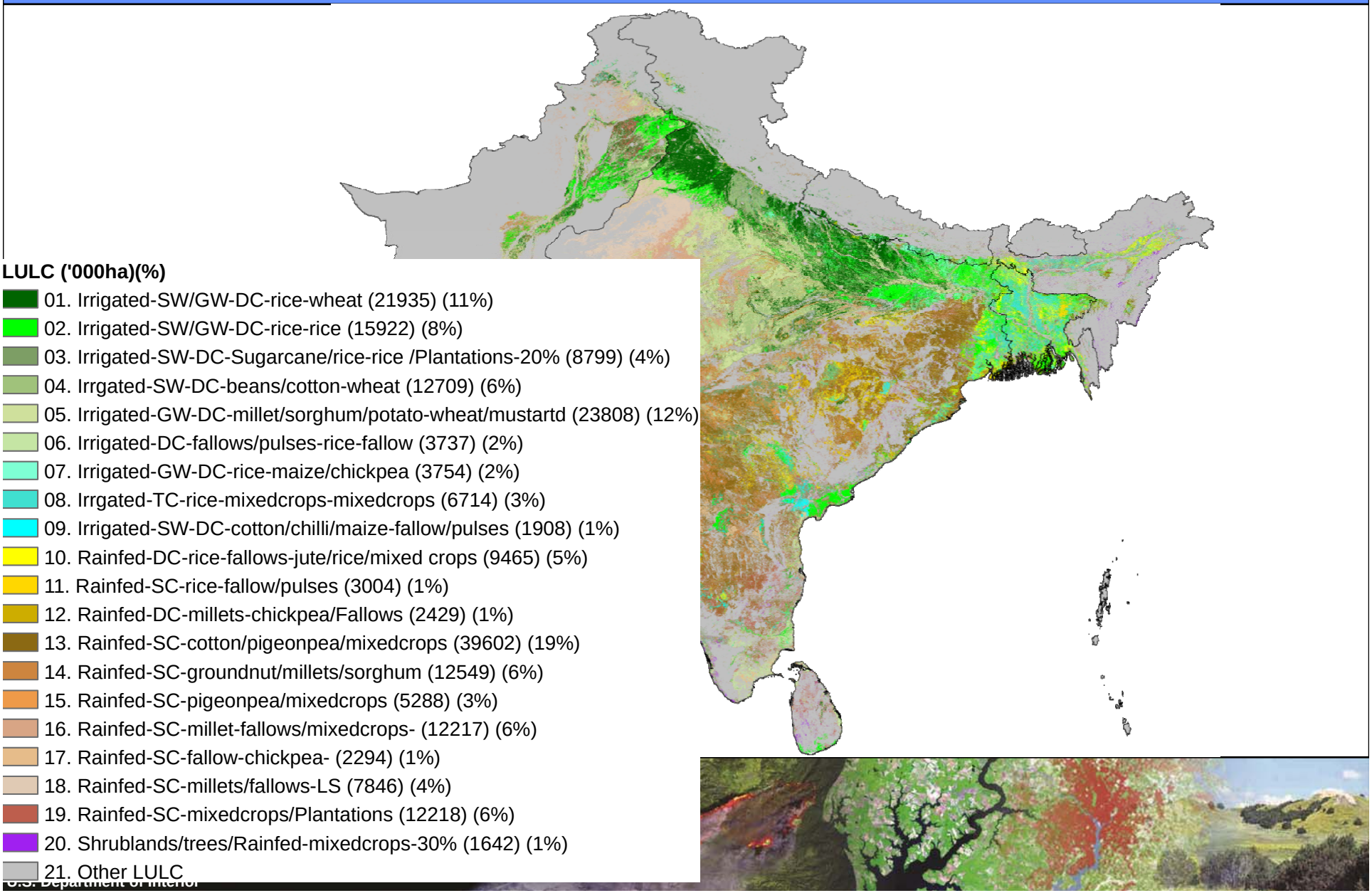
Croplands of South Asia using MODIS 250 m Every 16-day NDVI Data for 2000-2014

Cropland Classes in detail

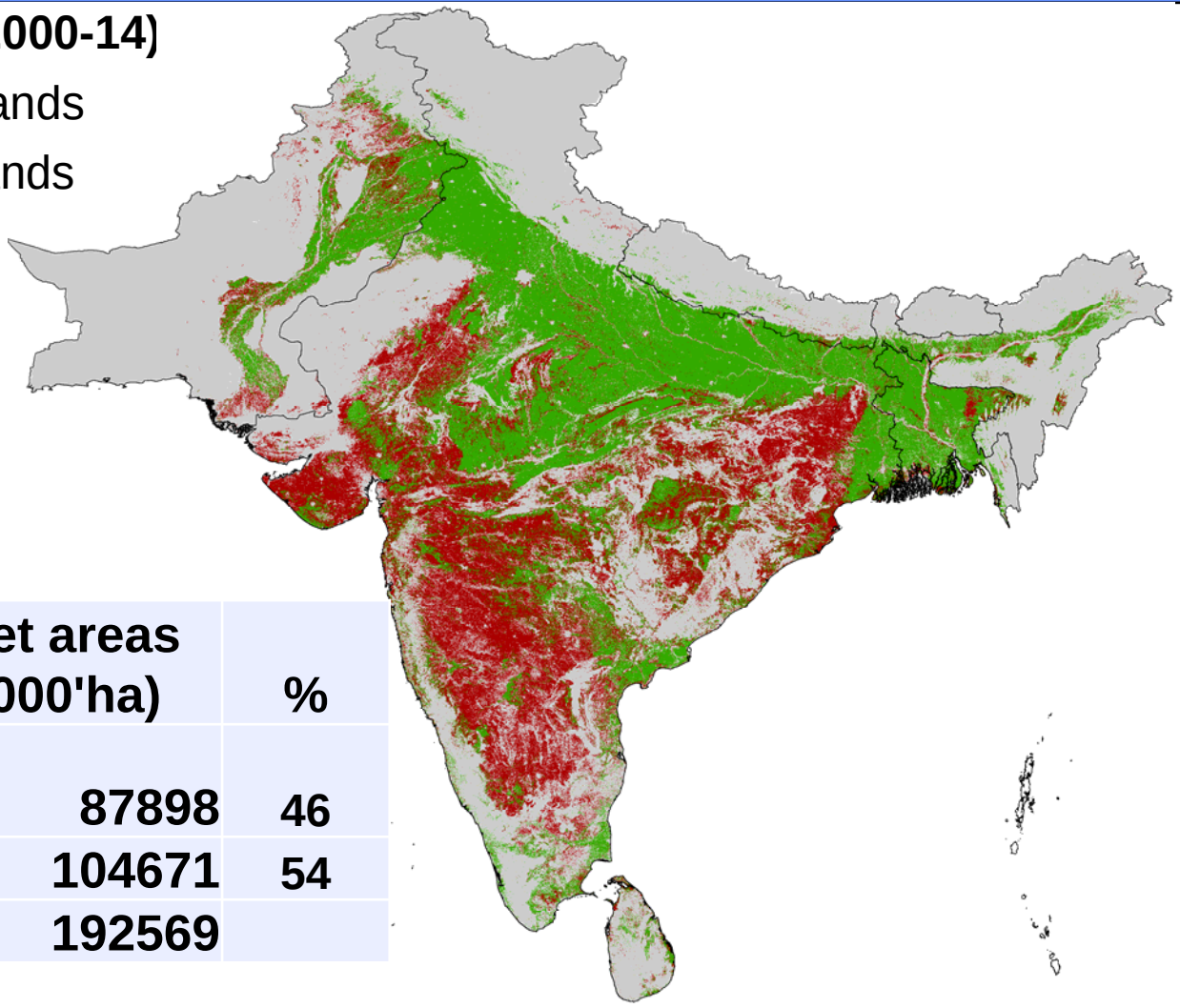


Croplands of South Asia using MODIS 250 m Every 16-day NDVI Data for 2014-2015

Irrigated versus Rainfed Croplands

Agriculture area (2000-14)

- Irrigated croplands
- Rainfed croplands



Croplands	Net areas (000'ha)	%
Irrigated croplands	87898	46
Rainfed croplands	104671	54
Total cropland	192569	

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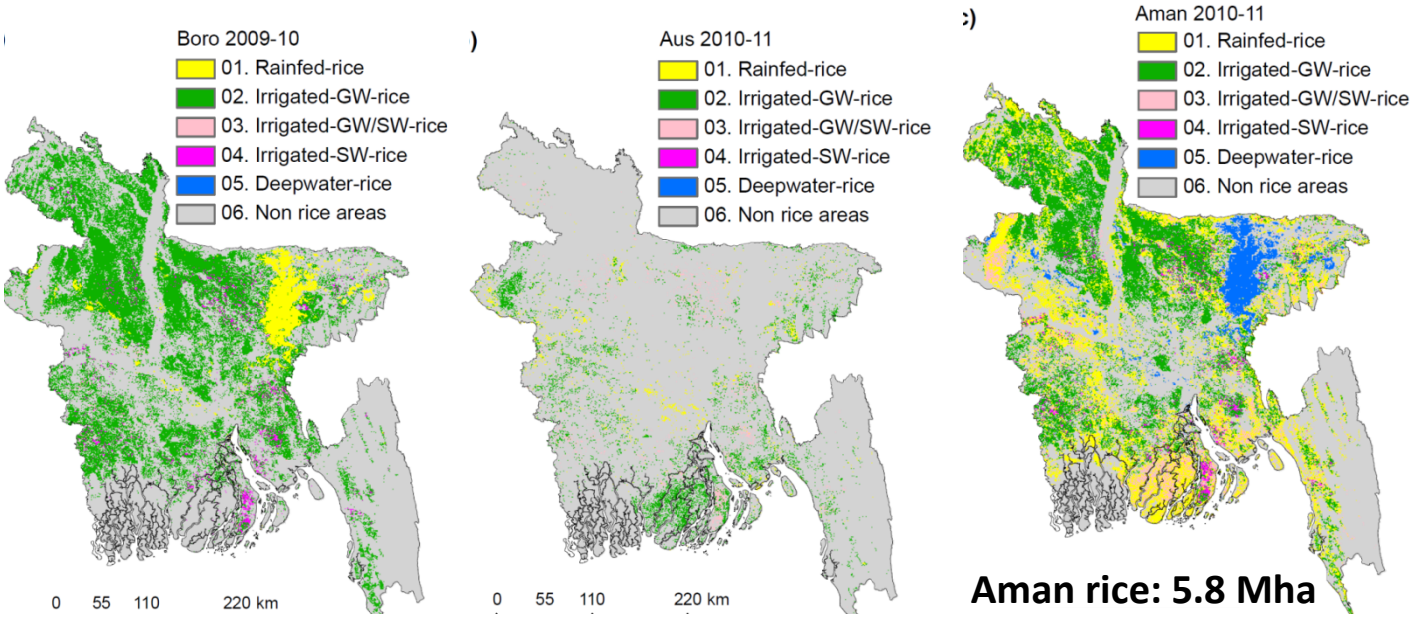
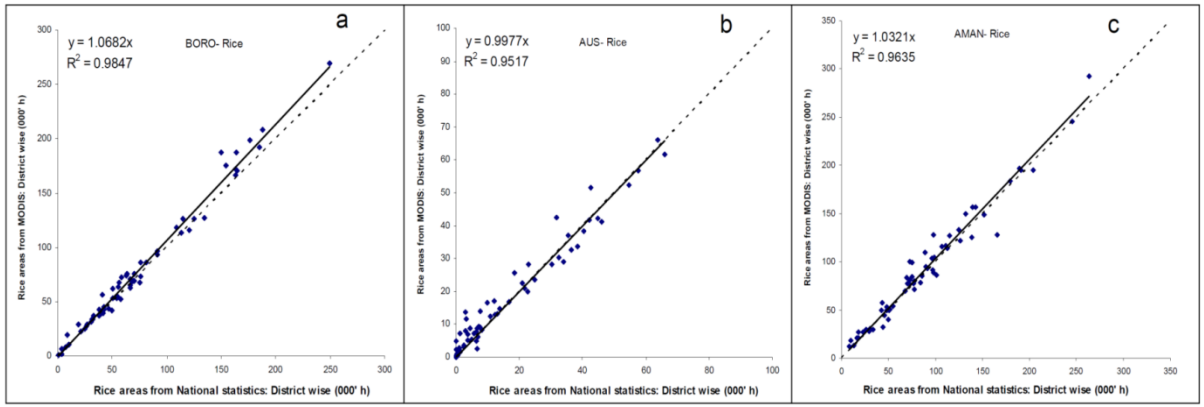
Croplands of South Asia using MODIS 250 m Every 16-day NDVI Data for 2014-2015

Cropping Intensity for Bangladesh



Aman rice: 5.8 Mha



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Global Croplands @ ~250 m Spatial Resolution Africa

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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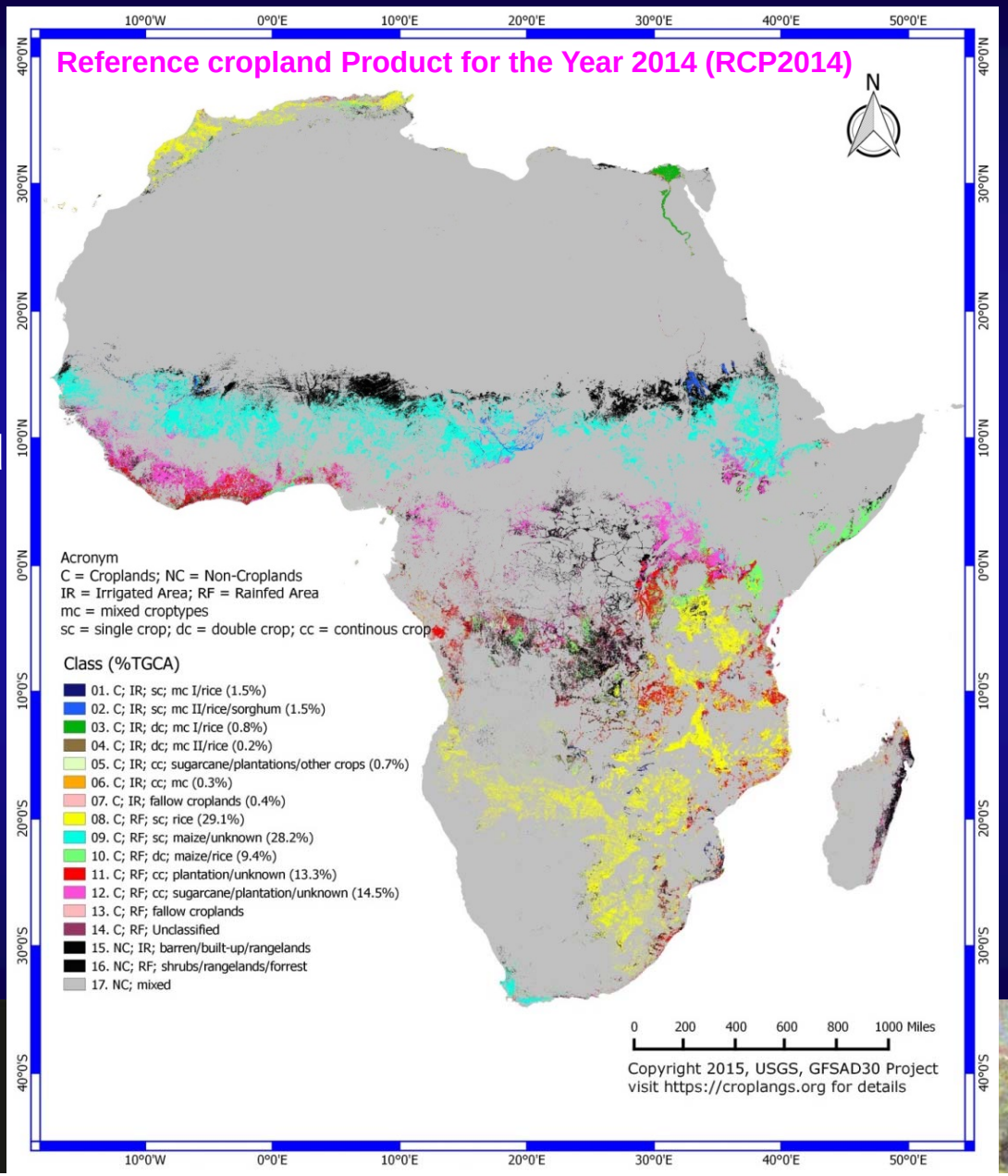
Cropland Products @ MODIS 250 m (GCE250m V1.0) for Baseline Year using SMT Method for Year 2014

Product 4: Crop Type and\or Dominance

Note: cropland product derived based on quantitative spectral matching techniques (QSMTs)



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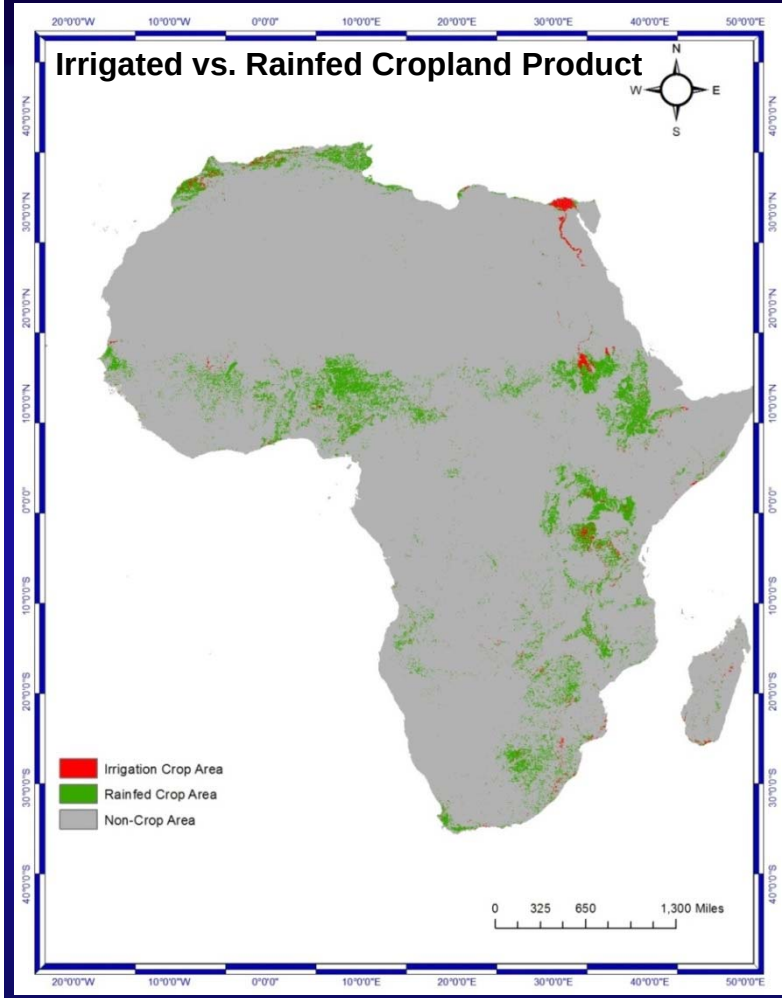
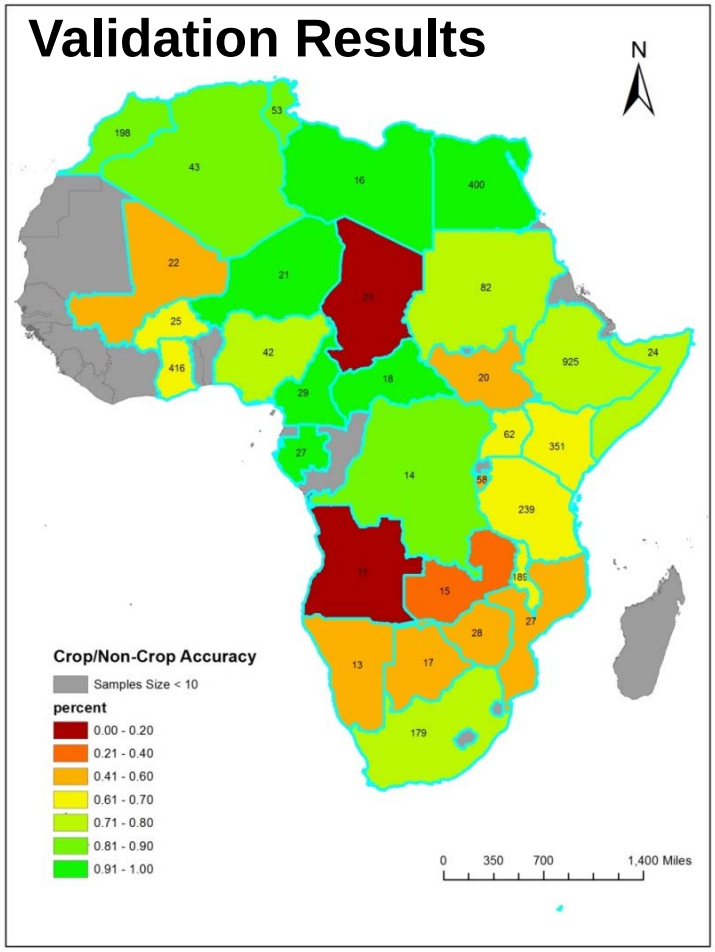
Cropland Products @ MODIS 250 m (GCE250m V1.0) for Baseline Year Year 2014

Validation: Irrigated versus Rainfed





Overall accuracy per country for the GCE250m V1.0 cropland product. Total samples size: 3,000.The grey area represents the samples sizes in less than 10 per country.

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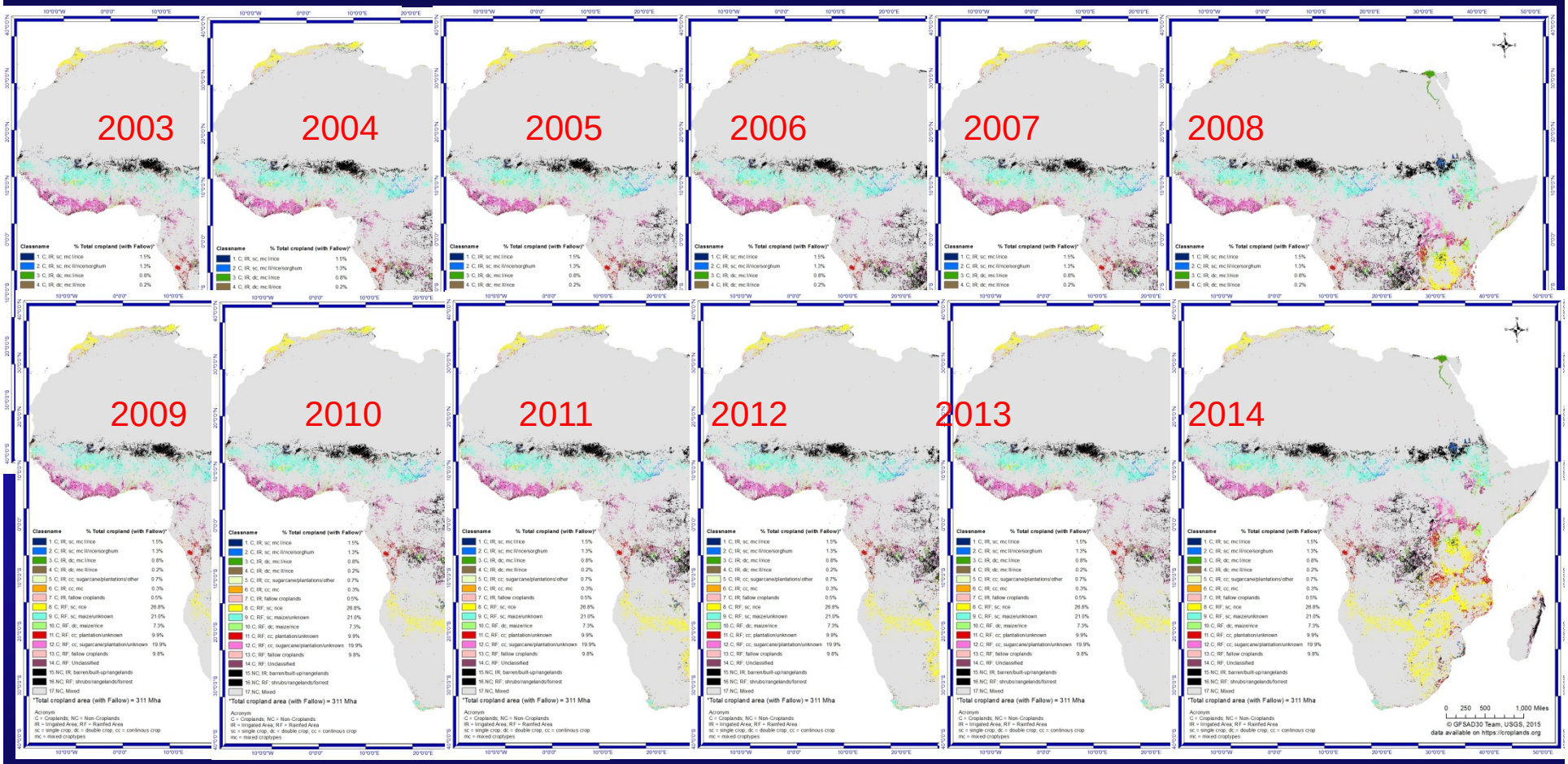
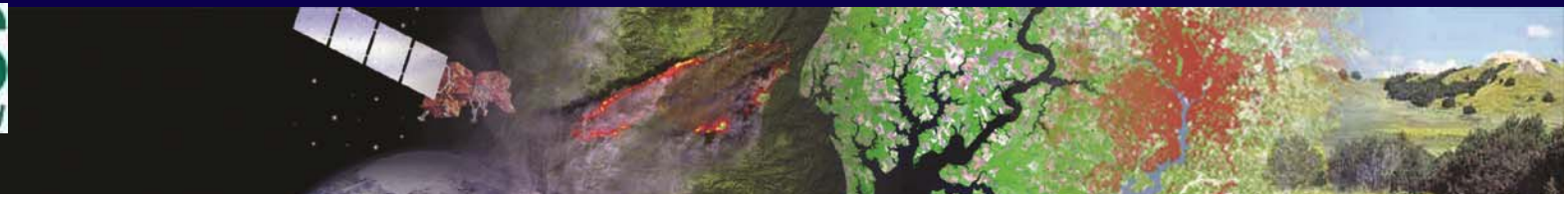
Computing for Africa

ACCA derived Cropland Products from the year 2003 to 2014 (ACP2003 to ACP2014)

using MODIS 250m Every 16-day data





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Global Croplands @
~250 m Spatial Resolution
USA

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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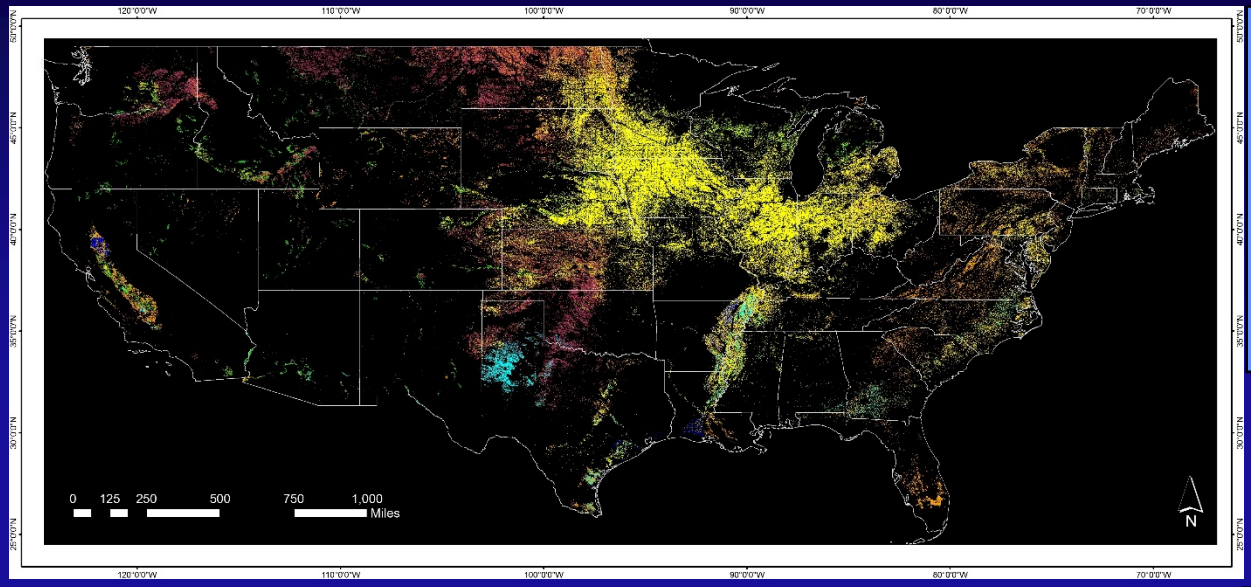
USA Cropland Product 4 (crop Type) for US: Irrigated + Rainfed

Spatial Comparison between

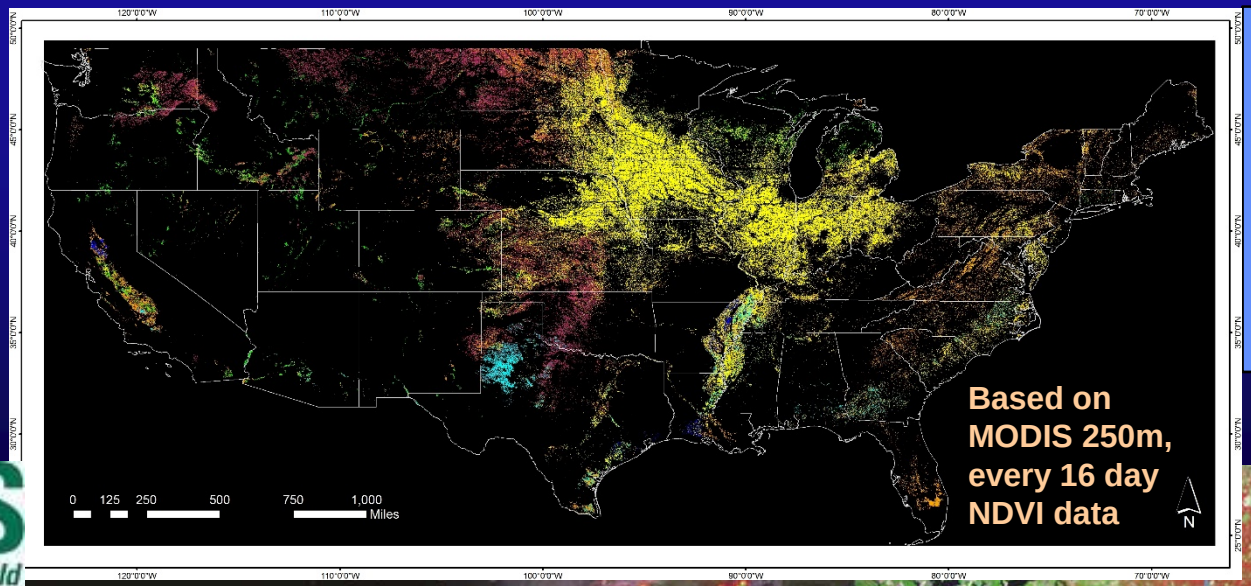
reference USDA CDL product Vs. Rule-based ACCA algorithm derived cropland product

Reference USDA CDL cropland product for the year 2008



- Corn-Soybean
- Wheat-Barley
- Potato
- Alfalfa
- Cotton
- Rice
- Other Crops

Rule-based ACCA algorithm derived cropland product for the year 2008



- Corn-Soybean
- Wheat-Barley
- Potato
- Alfalfa
- Cotton
- Rice
- Other Crops

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USA Cropland Product 4 (crop Type) for US: Irrigated + Rainfed

Accuracy Assessment Error Matrix between the

reference USDA CDL product Vs. Rule-based ACCA algorithm derived cropland product

Year 2008 (Data used: MODIS 250m Every 16-day, NDVI)

	Corn/Soybean	Wheat/Barley	Potato	Alfalfa	Cotton	Rice	Others	Total	User's Acc
Corn/Soybean	13,017,100	475,858	941	157,969	112,601	72,445	521,629	14,358,543	**90.66**
Wheat/Barley	547,321	4,250,080	11,118	121,223	41,161	535	305,650	5,277,088	**80.54**
Potato	17,795	15,474	20,842	7,602	77	0	6,647	68,437	**30.45**
Alfalfa	151,710	132,412	1,464	595,825	2,559	694	84,477	969,141	**61.48**
Cotton	104,774	44,202	0	2,824	557,616	12,110	80,692	802,218	**69.51**
Rice	74,360	577	0	547	5,873	137,023	10,377	228,757	**59.90**
Others	574,915	380,441	7,769	86,696	81,788	8,293	2,415,690	3,555,592	**67.94**
Total	14,487,975	5,299,044	42,134	972,686	801,675	231,100	3,425,162	25,259,776	
Prod Acc	**89.85**	**80.20**	**49.47**	**61.26**	**69.56**	**59.29**	**70.53**	**Overall**	**83.03**

Kappa: 0.695212

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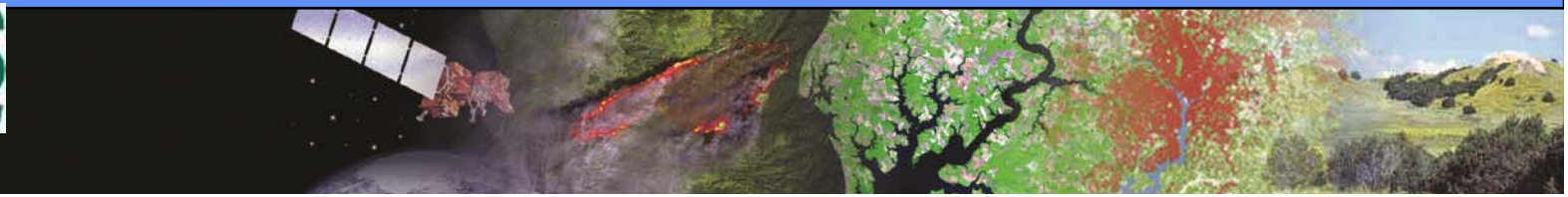

Global Croplands @ ~30 m Spatial Resolution South America

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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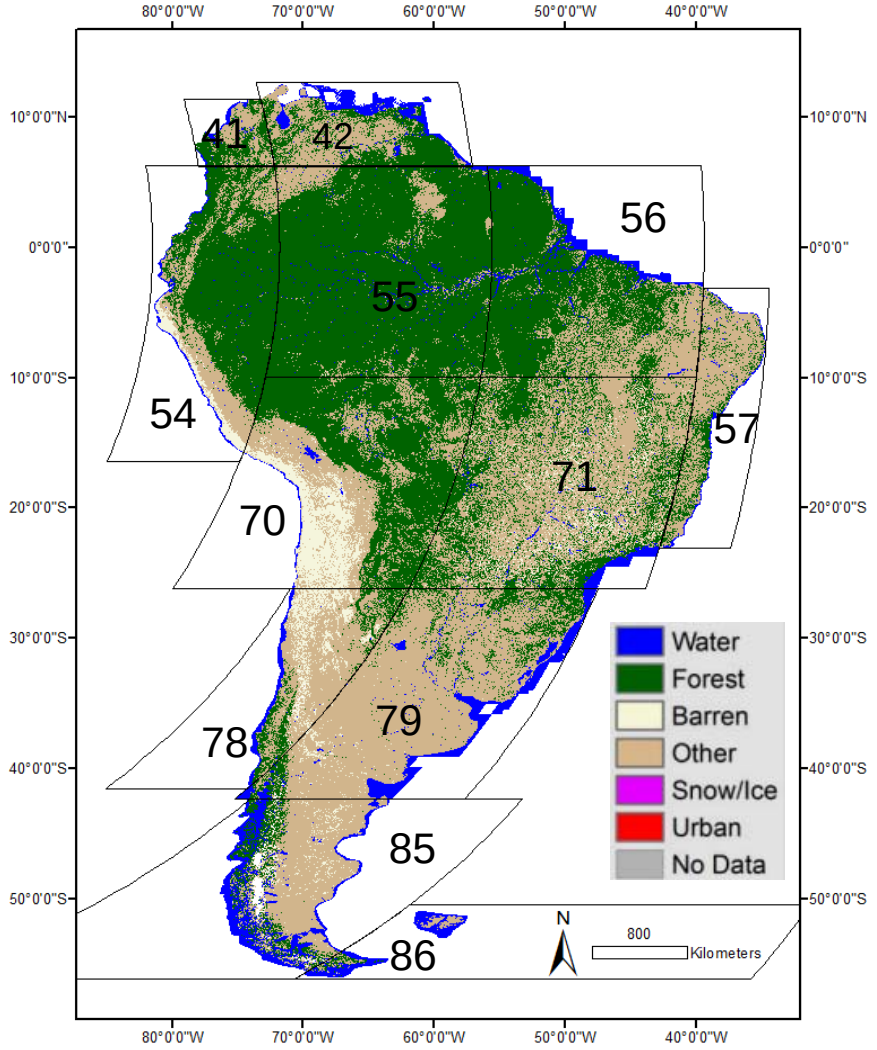
Cropland Extent @ 30m Product (GCE30m V1.0) Computed on Google Earth Engine (GEE)

using Random Forest Algorithm for South America

Seven Broad Zones of South America

- Classifiers trained separately in each zone;
- Facilitates achieving greater accuracies;
- Helps us focus each zone separately to acquire zone specific ground sampling



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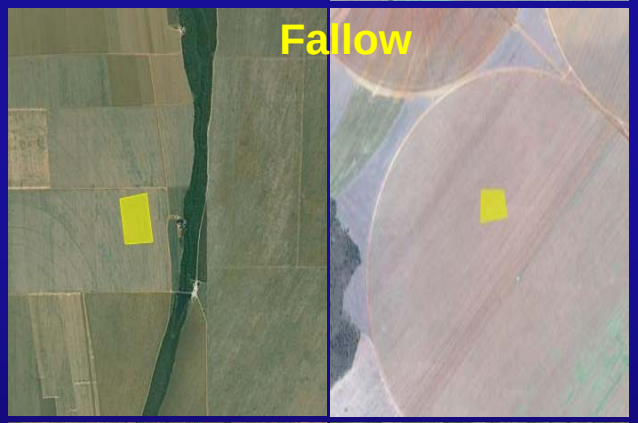
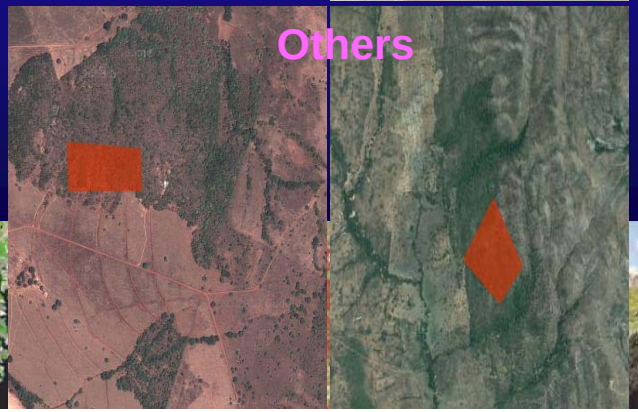
Cropland Extent @ 30m Product (GCE30m V1.0) Computed on Google Earth Engine (GEE)

using Random Forest Algorithm for South America

Random Forest Training Sample Selection

- Land cover classes:
  Cropland, Fallow, Others
- Homogeneous polygons
- Selection system:
  a. Random selection
  b. Manually selection
- Reference data
  Landsat image
  Google Earth
  GCEV1.0 (Teluguntla et al., 2014)
  2009 GlobCover (Arino 2012)
  Time-series Landsat and NDVI composite
  Ground reference data
  – geo-wiki validation and competition





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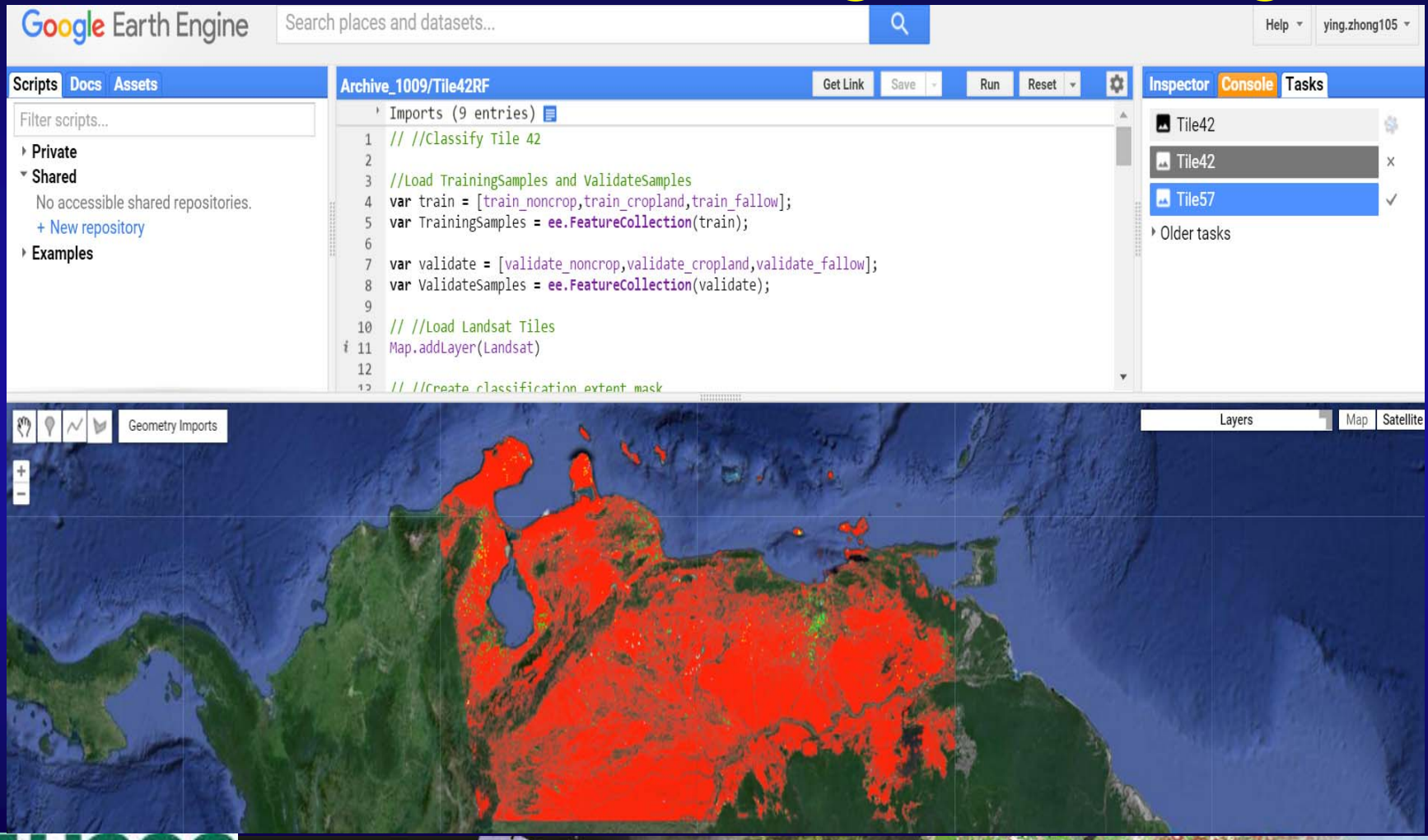
Cropland Extent @ 30m Product (GCE30m V1.0) Computed on Google Earth Engine (GEE) using Random Forest Algorithm for South America

Random Forest in Google Earth Engine



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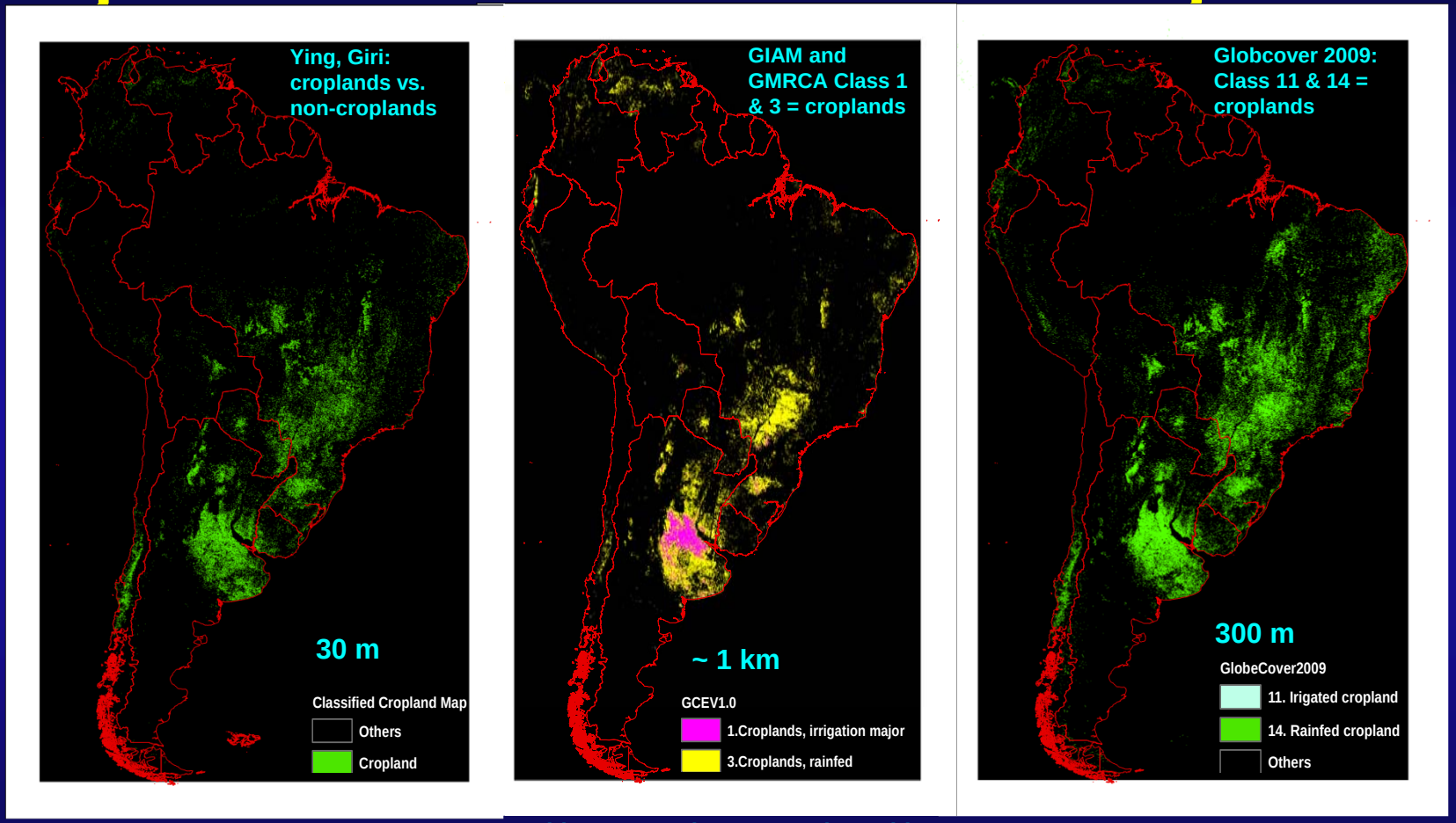
Cropland Extent @ 30m Product (GCE30m V1.0) Computed on Google Earth Engine (GEE) using Random Forest Algorithm for South America

Croplands of South America: Comparisons



Landsat 30 m, Random Forest, Google Earth Engine, nominal 2010 (Ying, Giri, upcoming)

Multi-sensor ~1 km, Spectral Matching Technique, nominal 2000 (Thenkabail et al., 2009, 2011, 2012)

MERIS 300m, Multiple algorithms, nominal 2005\2006 (Arino et al., 2009)

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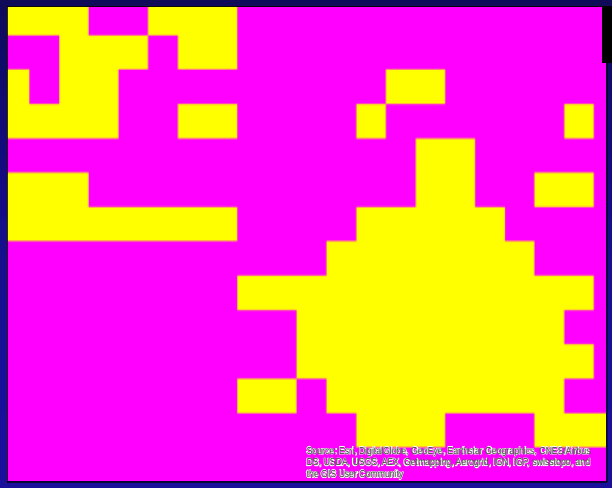
Cropland Extent @ 30m Product (GCE30m V1.0) Computed on Google Earth Engine (GEE)

using Random Forest Algorithm for South America

Cropland Extent Product @ 30 m (GCE30m V1.0) of S. America

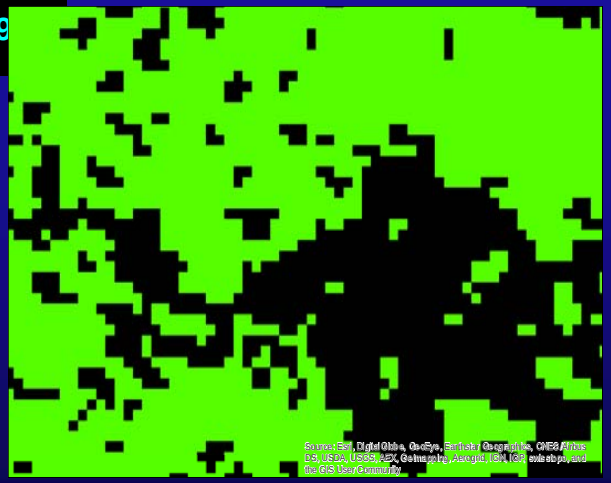
using Random Forest Algorithm

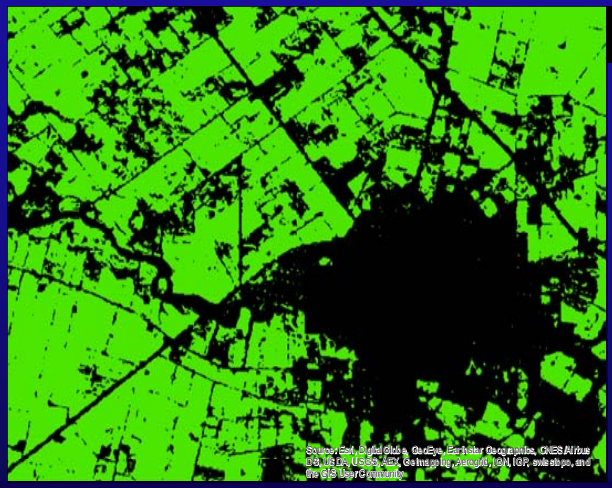
Sub-meter to 5 meter imagery



GCEV 1.0, 1 km

GlobCover2009 300m





Classified, 30m

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Global Croplands
Product Gateway and Publications

http://geography.wr.usgs.gov/science/croplands/index.html
https://www.croplands.org/

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Remote Sensing of Global Croplands for Food Security

Data, Products, Algorithms, Documentations, Manuscripts

1. Global food security support-analysis data @ 30 m (GFSAD30) web site

http://geography.wr.usgs.gov/science/croplands/index.html

2. Croplands.org for data browsing
https://www.croplands.org/

3. LP DAAC data and products on global croplands
http://geography.wr.usgs.gov/science/croplands/products.html#LPDAAC

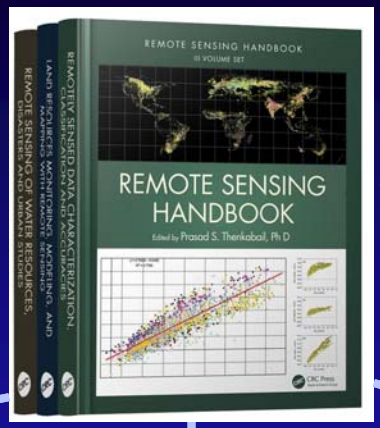
4. Google Earth Engine (GEE) global croplands
http://geography.wr.usgs.gov/science/croplands/products.html#LPDAAC

Remote Sensing Handbook: Vol. I, II, III; 82 Chapters (Editor: Prasad S. Thenkabail)

Taylor and Francis, Inc.\CRC Press; November, 2015

https://www.crcpress.com/Remote-Sensing-Handbook/book-series/CRCREMSENHAN

http://www.amazon.com/Remote-Sensing-Handbook-Three-Volume/dp/1482218011



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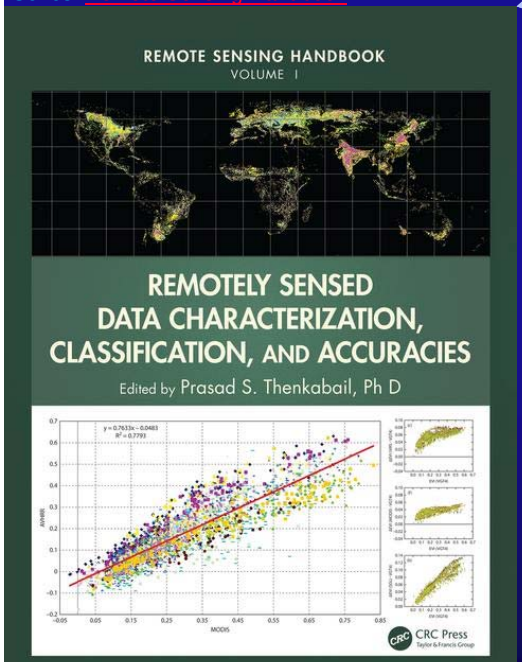

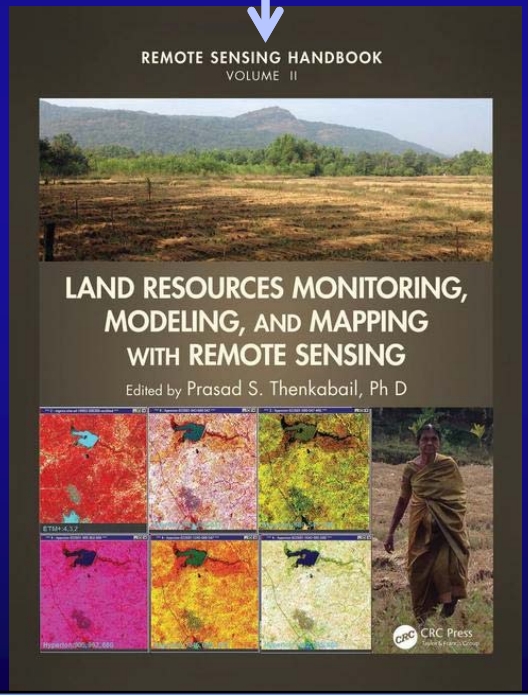

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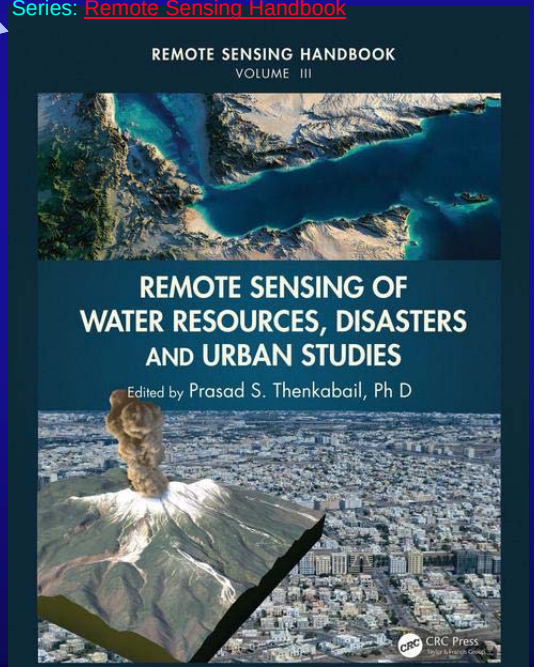

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