Impact of Band-Ratio Enhanced AWIFS Image on Crop Classification Accuracy

Zhengwei Yang, Patrick Willis, Rick Mueller
USDA/NASS/ R&D Division
Email: zhengwei_yang@nass.usda.gov

USDA

NASS
FACT FINDERS FOR AGRICULTURE
UNITED STATES DEPARTMENT OF AGRICULTURE

OUTLINE

- Introduction
- Why Image Ratios & Vegetation Indices
- Image Ratios & Vegetation Indices
- Data and Classification Method
- Experiments & Results
- Conclusions

Introduction - Problems

- Single-date multispectral data alone is difficult to yield accurate crop classification.
- Multitemporal classification still face challenges:
  - Heterogeneity of environment, different farming practice, different topography, different illumination, and shadowing.
- One of solutions – Image ratios & vegetation indices
  - Image ratios & vegetation indices had be used to identifies a variety of individual land cover objects, such as crops, soil, rocks, etc., and reported better results.
  - But no systematic research reported on crop classification!

Introduction – Project Purpose

- To figure out
  - How the vegetation index and image ratio impact on crop classification accuracy?
  - Which index has positive impact and which one has negative impact and under what conditions?

Why Image ratio and Vegetation Index?

- It enhances the spectral differences between some surface covers that are difficult to detect or separate in raw images.
- It eliminates slope shadows, seasonal changes, and either differences in sunlight angle or intensity (Jensen, 1986), and conveys only spectral, not topographic information.
- It may also provide unique information not available in any of single bands of the raw image that is useful for discriminating vegetation and soils (Satterwhite, 1984).
- Vegetation indices enhances vegetation spectral signal.

Image Ratios and Vegetation Indices

- Popular image ratios and vegetation indices:
  - Various vegetation indices
    - RVI, NDVI, MNDVI, TNDVI, EVI2, OSAVI
    - (RNDVI) - Ratio NDVI - Multiplies RVI with NDVI (RNDVI)
  - Drought, moisture indices: RDI, NDMI
- Additional image ratios and indices are proposed:
  - Modified Ratio Vegetation Index (MRVI), Green ratio vegetation Index (GRVI) and Modified Green ratio vegetation Index (MGRVI), Brightness Index (BI), Red green ratio index (RGRI), Modified Photochemical reflectance Index (MPRI), etc.

20 Image Ratios & Vegetation Indices

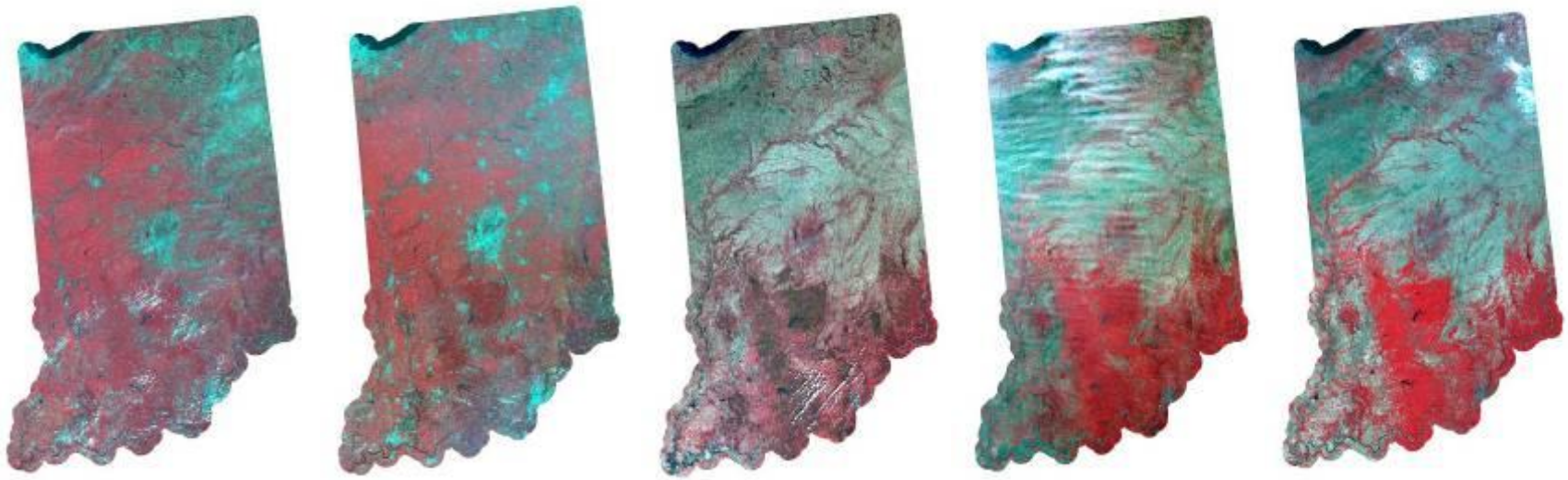
Vegetation Index/Image Ratio	Formula	Reference
Ratio normalized difference vegetation Index (RNDVI)	RNDVI = ((NIR-R)/(NIR+R))* NIR/R	Gong *et al*., 2003
Modified ratio vegetation index (MRVI)	MRVI = SWIR/R	-
Modified Photochemical reflectance Index (MPRI)	MPRI = (G-R)/(G+R)	This study
Normalized difference vegetation index (NDVI)	NDVI = (NIR-R)/(NIR+R)	Rouse *et al*., 1973
2-band Enhanced vegetation index (EVI2)	EVI2 = 2.5(IR – red)/(IR + red +1)	Jiang *et al*. 2007
Modified green normalized difference vegetation index (MGNDVI)	MGNDVI = (SWIR–G)/(SWIR+ G)	Gitelson *et al*., 1996
Ratio vegetation index (RVI)	RVI = NIR/R	Jordan, 1969
Modified normalized difference vegetation index (MNDVI)	MNDVI = (SWIR – R)/(SWIR + R)	Rouse et al., 1973
Brightness index (BI)	BI = G+R+NIR+SWIR	This study
Red green ratio index (RGRI)	RGRI = R/G	-
Green normalized difference vegetation index (GNDVI)	GNDVI = (NIR –G)/(NIR + G)	Gitelson *et al*., 1996
Normalized difference red green index (NDRGI)	NDRGI = (R –G)/(R + G)	This study
Normalized difference vegetation structure index (NDVSI)	NDVSI = [NIR - (R+G) 0.5]/ [NIR + (R+G) 0.5]	This study
Ratio drought index (RDI)	RDI = SWIR/NIR	Hunt & Rock 1989
Transformed NDVI (TNDVI)	TNDVI = $[(NIR-R)/(NIR+R)+1]^{½}$	Tucker, 1979
Green ratio vegetation Index (GRVI)	GRVI = NIR/G	-
Optimal soil adjusted vegetation index (OSAVI)	OSAVI = (NIR–R)/(NIR+R+0.16)	Rondeaux *et al*., 1996
Modified green ratio vegetation Index (MGRVI)	MGRVI = SWIR/G	-
Specific leaf area vegetation index (SLAVI)	SLAVI = NIR/(R+SWIR)	Lymberner *et al*., 2000
Normalized difference moisture index (NDMI)	NDMI = (IR - SWIR)/(IR+SWIR)	Gao 1996, Shaun *et al*., 2003

Image Sensor – ResourceSat-I AWIFS

- Spatial resolution (56m at nadir, 70m at field edge),
- radiometric resolution (10 bits)
- Spectral bands (4) similar to TM
  - Green (Band 2, 0.52-0.59 *μm*) ⇔(TM band 2)
  - Red (Band 3, 0.62-0.68 *μm*) ⇔(TM band 3)
  - NIR (Band 4, 0.77-0.86 *μm*) ⇔(TM band 4)
  - SWIR (Band 5, 1.55-170 *μm*) ⇔(TM band 5)
  - Lack of blue band
- On-board detector calibration using LEDs
- Repeat period: 5 days.
- Swath: 370km

Indiana Multitemporal AWIFS Images

- July 8 and August 1, 2007 Images for single scene experiments.
- Data is same as that used in NASS official analysis => results comparable



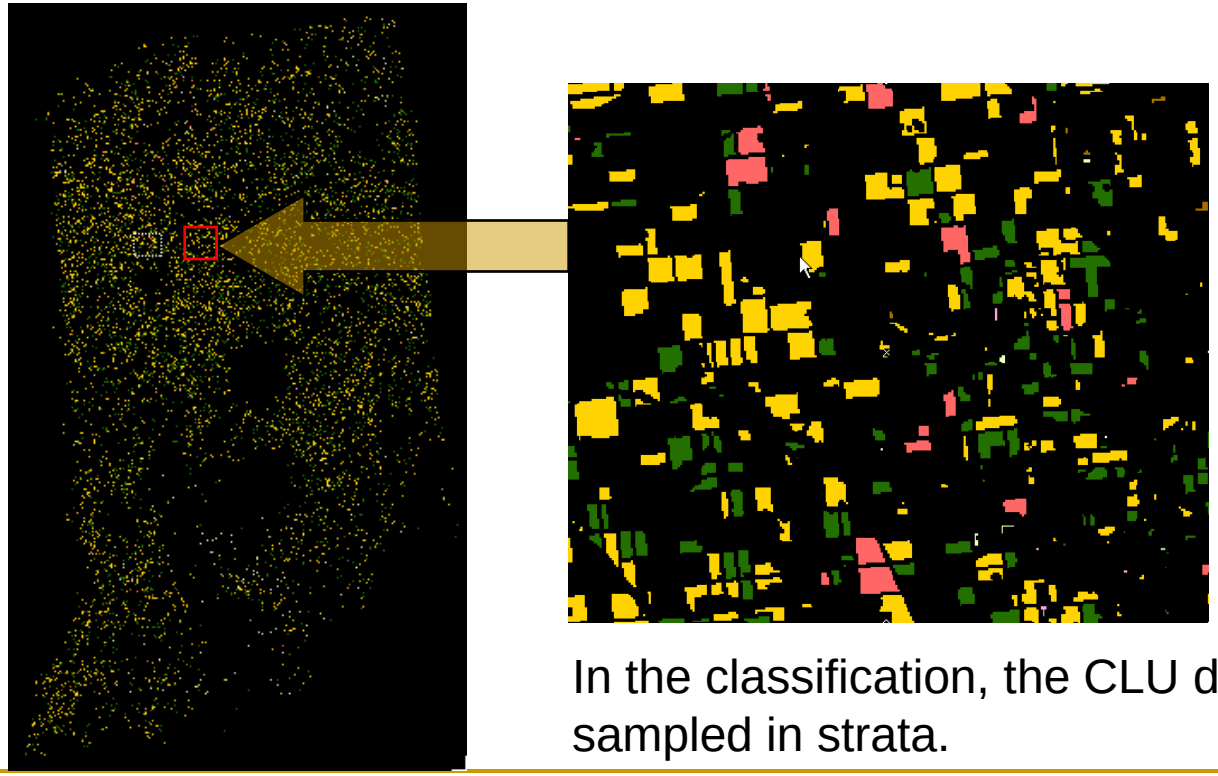
(070708) (070801) (070422) (070506) (070521)

Classifier – See5 Decision Tree

- Classifier:
  - Supervised decision tree classification method
- Why - advantages:
  - A white box model - easily explained by Boolean logic and easy to understand and interpret results;
  - Able to handle both numerical and categorical data;
  - Robust - tolerates training errors and cloud pixels;
  - Good computational performance.
  - No assumption of data distribution required;
  - Easy to validation;
  - Little data preparation needed;
  - Excellent scalability - no limit in data attributes;

Training Sample – FSA CLU Data

Common Land Unit (CLU) - the smallest land unit with permanent boundaries, common land cover, management, common owner (tract) and producer (farm).

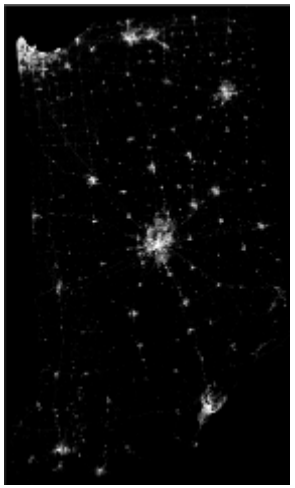


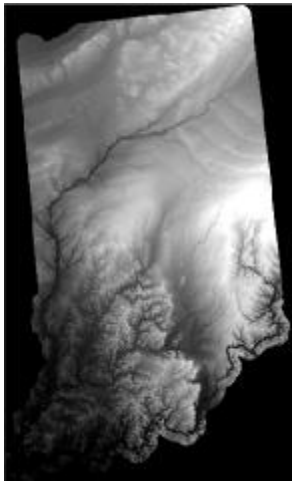
In the classification, the CLU data is sampled in strata.

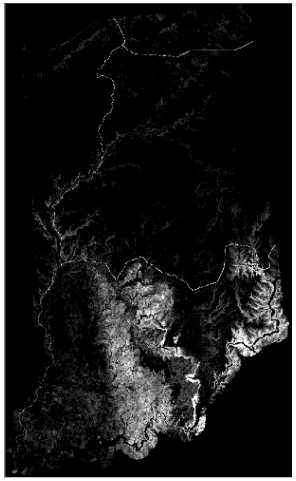
Ancillary Data –Used in Multitemporal

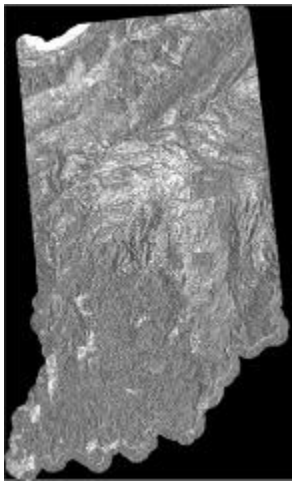
- 2006 National Land Cover Data (NLCD)
- National Elevation Dataset (NED)
- MODIS 16 NDVI composite images

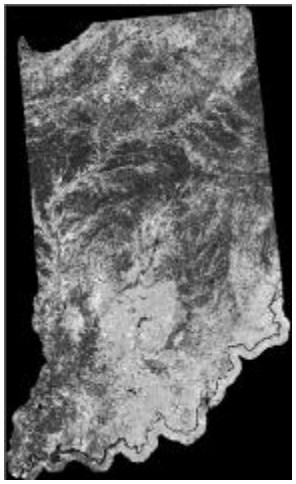

Canopy


Impervious


Elevation


Slope


Aspect


MODIS NDVI

Accuracy			Accuracy		
Scene Date	July 8, 2007		Scene Date	August 1, 2007	
Evaluated by	Overall	Crops only	Evaluated by	Overall	Crops only
No Indices	**79.04**	**81.04**	**No Indices**	**65.83**	**67.53**
RNDVI	79.55	81.56	RNDVI	66.41	68.14
MRVI	79.34	81.35	ALL	66.21	67.93
MPRI	79.27	81.28	RVI	65.87	67.58
NDVI	79.25	81.25	NDVSI	65.87	67.57
EVI2	79.22	81.22	BI	65.85	67.56
MGNDVI	79.21	81.22	MGNDVI	65.85	67.56
RVI	79.21	81.22	MGRVI	65.84	67.56
MNDVI	79.21	81.21	NDRGI	65.83	67.54
BI	79.21	81.2	NDMI	65.82	67.54
RGRI	79.2	81.2	RGRI	65.82	67.53
GNDVI	79.2	81.2	MPRI	65.82	67.53
NDRGI	79.19	81.19	MRVI	65.81	67.52
NDVSI	79.15	81.16	RDI	65.81	67.51
RDI	79.14	81.15	GNDVI	65.79	67.5
ALL	79.14	81.13	GRVI	65.79	67.49
TNDVI	79.12	81.13	NDVI	65.71	67.42
GRVI	79.07	81.06	TNDVI	65.7	67.4
OSAVI	79.04	81.04	MNDVI	65.67	67.38
MGRVI	79.03	81.04	EVI2	65.64	67.35
SLAVI	79.03	81.02	OSAVI	65.64	67.35
NDMI	78.99	81	SLAVI	65.59	67.29

Single Scene Experimental Results

Multitemporal Classification Results with Vegetation Indices

Data combination	Overall	Crops only
Original CDL with no indices added	91.80	91.76
Original Inputs + 070708 RNDVI	89.70	91.75
Original Inputs + 070708 Top 16 better performed Indices	90.19	92.21
Original Inputs + 070801 RNDVI	89.85	91.91
Original Inputs + 070801Top 6 better performed Indices	89.87	91.91
Original Inputs + RNDVI's from Both Scenes	89.67	91.72
Original Inputs + Better Performer Indices form Both Scenes	90.22	92.22

Observations &Conclusions

- For single scene experiment:
  - Not all vegetation indices, image ratios have positive impact.
  - Impact for most vegetation indices is scene dependent
  - RNDVI has the best accuracy improvement for both single scene tests
  - TNDVI, OSAVI, GRVI, RDI and SLAVI are consistently ranked in the lower part.
  - NDVI, MNDVI, EVI2 and MRVI are very sensitive to scenes.
- For the multitemporal, classification
  - Adding vegetation indices yields a 1.58% to 2% drop in the overall classification accuracy. But the impact on the crops only accuracy varies with different vegetation indices applied.
  - RNDVI impact is scene dependent and insignificant.
  - Original Inputs + 070708 Top 16 Indices performed better than +070801 Top 6 performed indices => Scene Dependency
  - Using all better performed indices from both scenes improved the crops only accuracy by 0.5% => Similar to that 070708 Top 16 Indices result!
- Appropriately using vegetation indices and image ratios can potentially improve crop classification accuracy though the gain may not be huge.

Future Work

- How the individual vegetation index can increase spectral separability and classification accuracy of a specific individual crop;
- How the image acquiring date affect the performance of the vegetation indices;
- How should we best utilize the vegetation indices and image ratios to enhance the crop classification accuracy.

THANK YOU!

QUESTIONS?

Contact: Zhengwei Yang
Email: zhengwei_yang@nass.usda.gov

USDA

NASS
FACT FINDERS FOR AGRICULTURE
UNITED STATES DEPARTMENT OF AGRICULTURE