Detecting Rice Crop Fields Distribution with Spatio-Temporal Remote Sensing Information During the First Rice Season in 2018

—A Case Study in the Erlin Township, Changhua County and Tapi Township, Yunlin County.

[1] Chia-Hao Chang, [1] Tzu-How Chu, [2] Chiou-Shann Fuh

[1] Dept. of Geography, [2] Dept. of Computer Science and Information Engineering,
National Taiwan University, Taipei, Taiwan

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INTRODUCTION

Rice Crop Interpretation

- With optical image data
  - The Agriculture and Food Agency (AFA) uses annually two times of aerial photo to monitor rice distribution in 1st and 2nd rice seasons.
  - Researchers are also using different remote sensing data to develop more efficient methods to monitor rice crop fields and estimate production.
    - Overall accuracy can be up to 86~98%.
    - Producer accuracy of rice field can reach 88~96%.

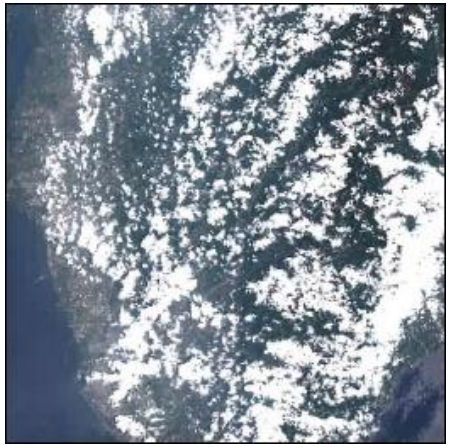
Rice Crop Interpretation (cont.)

- The challenges for optical image
  - Spatial resolution
  - Acquisition date
  - Cloud cover and shadow

15th Feb. 2017

16th Apr. 2017

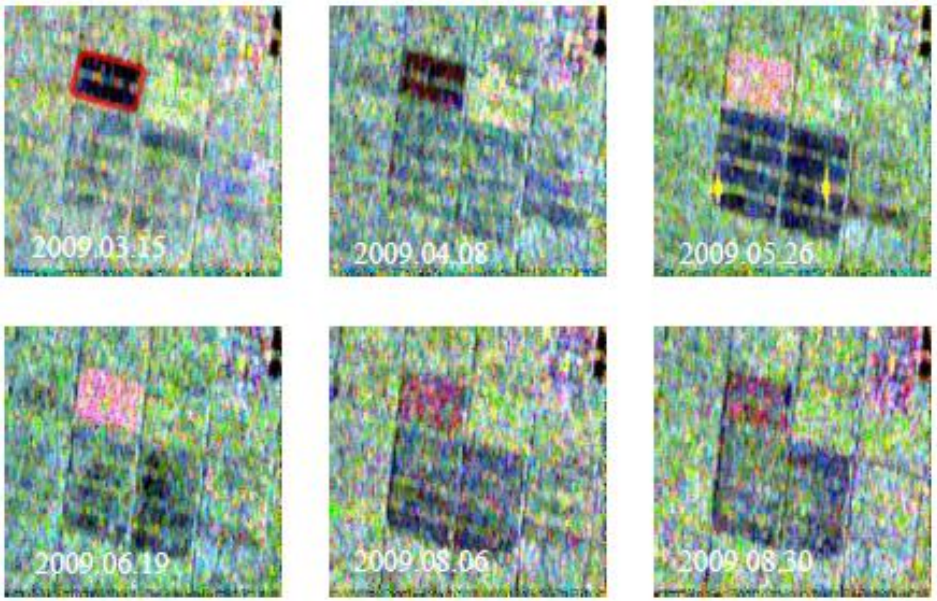
27th Mar. 2017



6th May. 2017

Rice Crop Interpretation (cont.)

- With SAR image data
  - Cheng et al. using RADARSAT-2 C-Band quad-polarized SAR images acquired from Mar. to Aug. 2009 to analyze polarimetric response of rice crop field with four-component scattering decomposition (Y4R), including surface scattering, volume scattering, double bounce, and helix scattering (Cheng et al., 2012) .



Different rice crop stages of four-component scattering decomposition. (R:P_d, G:P_v, B:P_s)

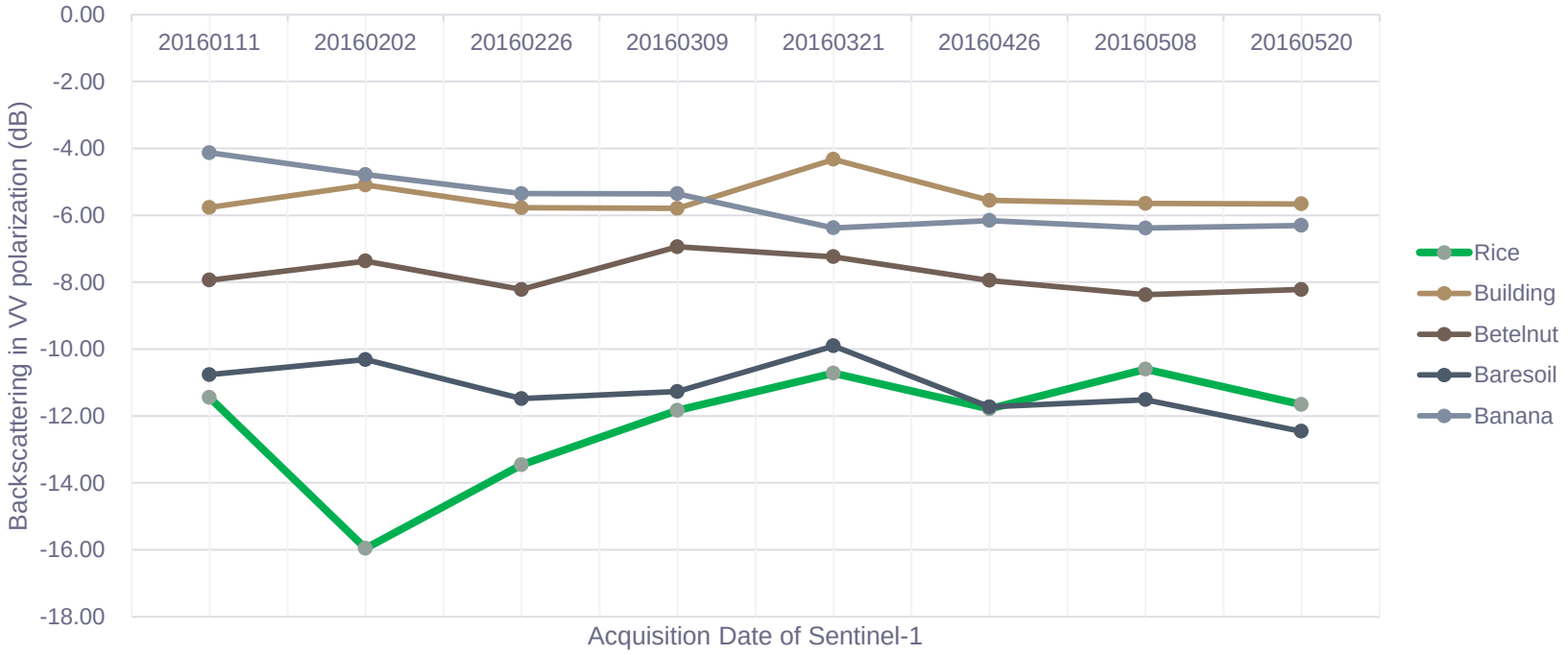
Rice Crop Interpretation (cont.)

- Chu et al. using ALOS-1 PALSAR data acquired on 8th Apr. 2011, decomposed polarimetric response with Pauli basis, Y4R, and HH-VV (Chu et al., 2014) .
  - Classified by Minimum Distance Classification (MDC) and verified with ground truth of 1st rice season in the Yunlin County, 2011.
  - The highest rice producer accuracy is HH-VV 91.11%, but the highest overall accuracy is Pauli basis 76.62%.

	Pauli Basis	Y4R	HH-VV
Producer of Rice	91.01%	85.39%	91.11%
Overall	76.62%	66.88%	70.32%

Rice Crop Interpretation (cont.)

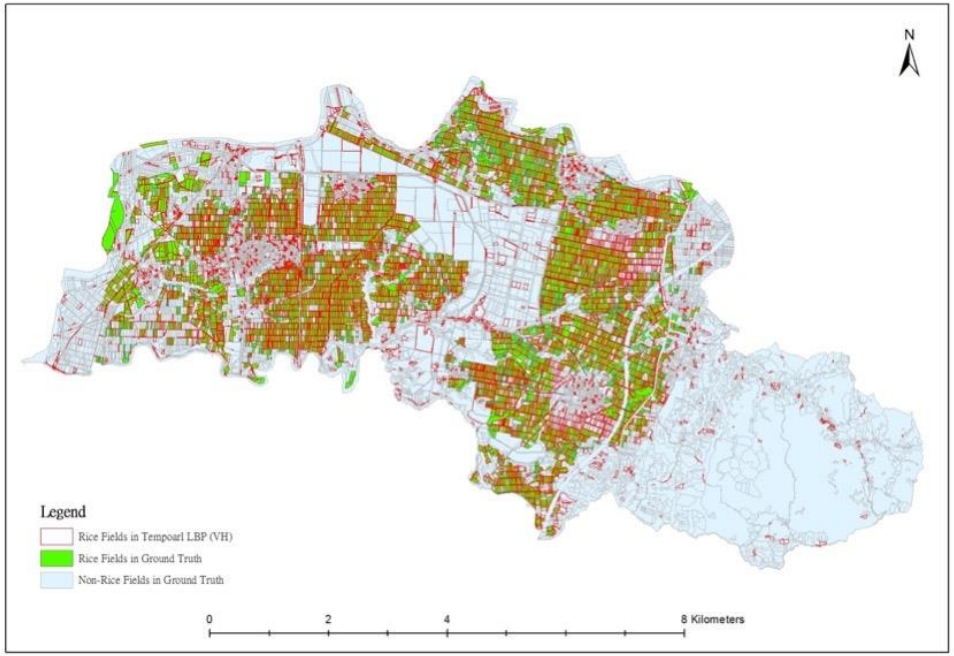
- Chu et al. use temporal Sentinel-1 backscattering image ($\sigma°$) to analyze the difference between rice, building, betel nut, bare soil, and banana. The $\sigma°$ is obviously lower than other land cover during transplant (Chu et al., 2016) .



Rice Crop Interpretation (cont.)

- Chang et al. analyzed temporal Sentinel-1 σ° image with Temporal Local Binary Pattern (T-LBP) in 1st rice season in Liouying Dist., Tainan County, 2016 (Chang et al., 2017) .
- Verify with ground truth field polygons, the overall accuracy is 83.55%, but producer accuracy of rice is only 57.82%.

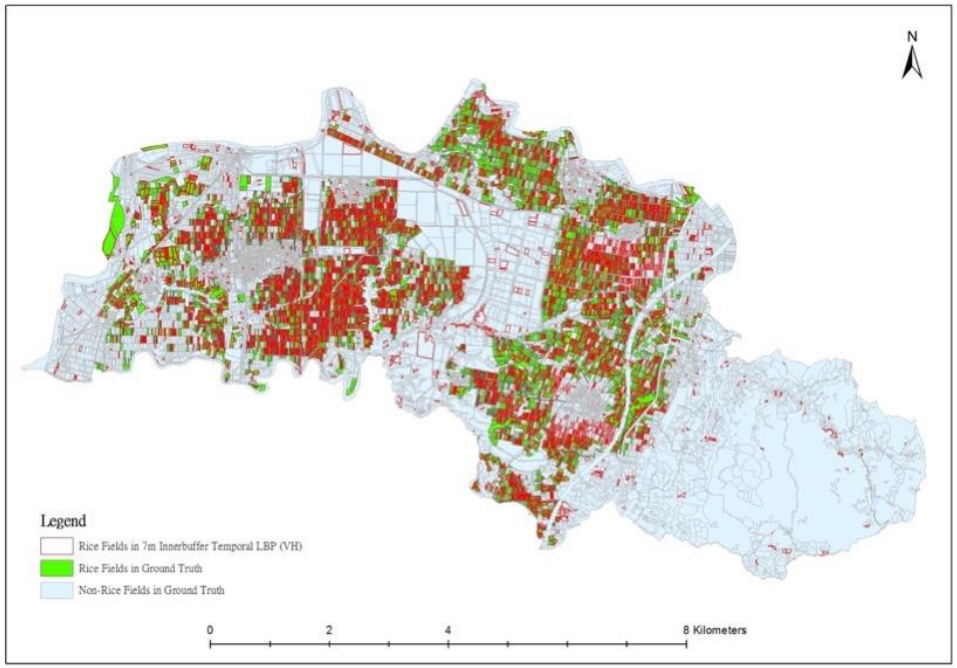
	Ground Truth			U.A.
	Rice	Non-Rice	Total	
Rice	4245	3719	7964	53.30%
Classified Non-Rice	3097	30377	33474	90.75%
Total	7342	34096	41438	
P.A.	57.82%	89.09%	Overall	83.55%
			kappa	0.45



Rice Crop Interpretation (cont.)

- Because some fields are too thin for Sentinel-1 image data, we use 7m inner buffer to filter out those field polygons which are not wider than 14m.
- Verify with those ground truth polygons wider than 14m, overall accuracy was decreased from 83.55% to 78.87% but rice crop producer accuracy was increased from 57.82% to 60.86%.

	Ground Truth			U.A.
	Rice	Non-Rice	Total	
Rice	3682	1390	5072	72.59%
Classified Non-Rice	2368	8810	11178	78.82%
Total	6050	10200	16250	
P.A.	60.86%	86.37%	Overall	76.87%
			kappa	0.49

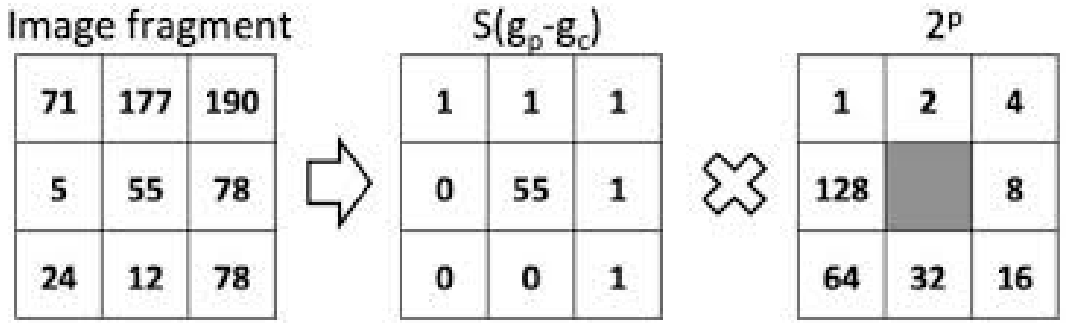


METHODOLOGY

Methodology

- Local Binary Pattern (LBP)
  - In 1994, Ojala et al. based on the contrast between pixel and eight neighbors, developed a local texture description method, Local Binary Pattern (LBP) operator. In the beginning, LBP uses the sign of eight differences between central and neighbors, recorded into an 8-bit number (Ojala et al., 1996, Ojala et al., 2001).

$$\mathrm{LBP} = \sum_{i\text{-}1}^{8} s(g_0, g_i)2^{i\text{-}1}, \qquad s(g_0, g_i) = \begin{cases} 1, if\ g_i \geq g_0, \\ 0, if\ g_i < g_0. \end{cases}$$



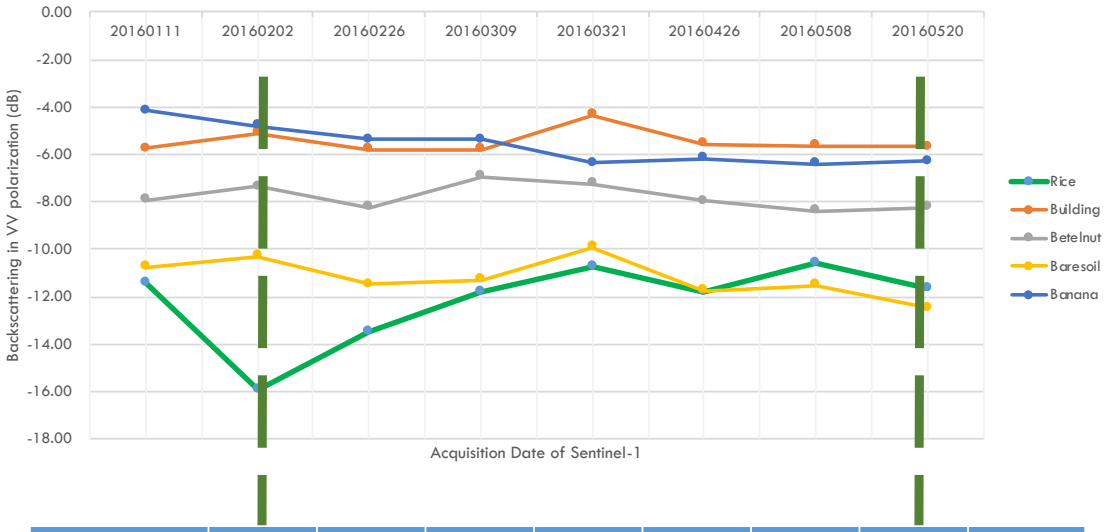
LBP=1 x 1 + 1 x 2 +1 x 4 + 1 x 8 + 1 x 16 + 0 x 32 + 0 x 64 + 0 x 128= 4 + 8 + 16 = 31

Methodology (cont.)

- LBP is an efficient method used to describe local texture in 2D images. But for locally homogenous land cover type, such as water body, rice fields, grassland, and flat bare land, the separability of LBP is not explicit.
- The agricultural land cover changes with crop's lifecycle; image patterns in the remote sensing data are changed also.

Methodology (cont.)

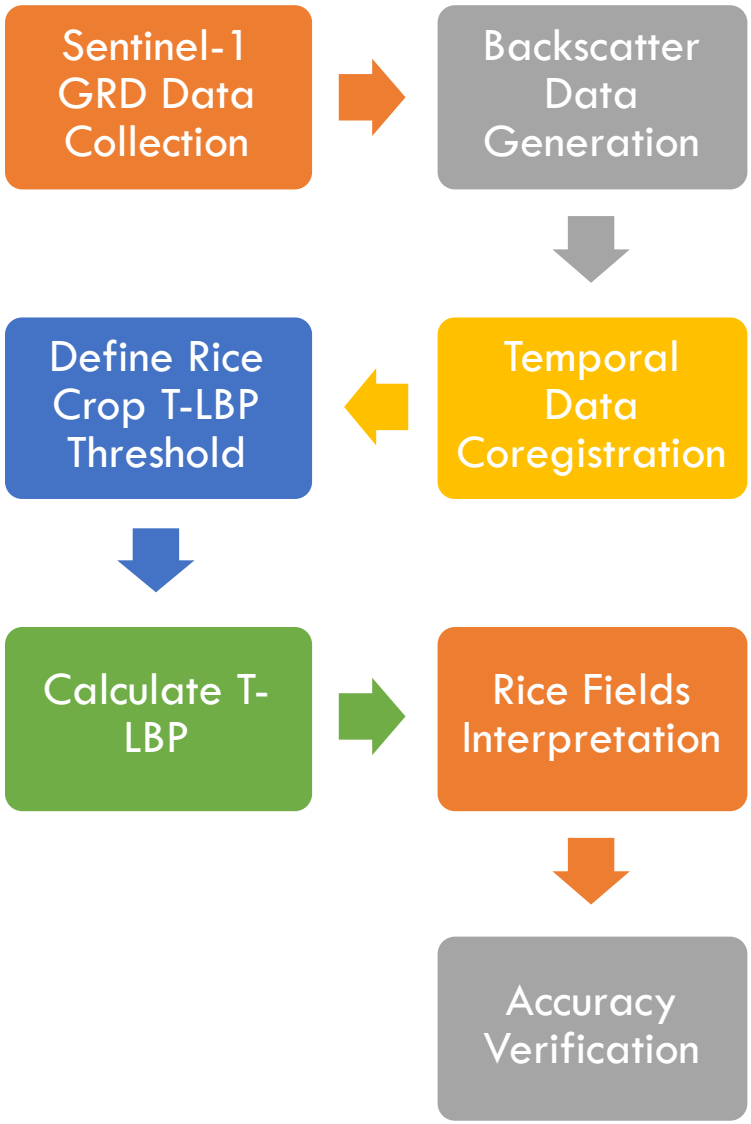
- Temporal Local Binary Pattern (T-LBP)
  - Based on LBP with 2-D texture, Chang et al. (2017) proposed T-LBP to describe the temporal change pattern of rice pixel in time series Sentinel-1 σ° image.



Land Cover	Base	2^0	2^1	2^2	2^3	2^4	2^5	T-LBP
Rice	0	1	1	1	1	1	1	63
Building	0	0	0	1	0	0	0	4
Betelnut	0	0	1	1	0	0	0	6
Baresoil	0	0	0	1	0	0	0	4
Banana	0	0	0	0	0	0	0	0

Methodology (cont.)

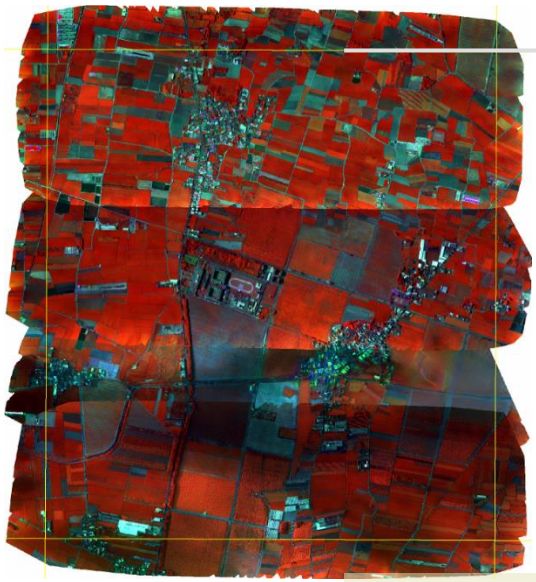
- Using time series of Sentinel-1 IW mode Ground Range Detected (GRD) image data, applying LBP operator into temporal σ° change of SAR images.
- Analyze rice crop's σ° change pattern in 1st rice season in Erlin Township, Changhua County, and Tapi Township, Yunlin County, 2018.

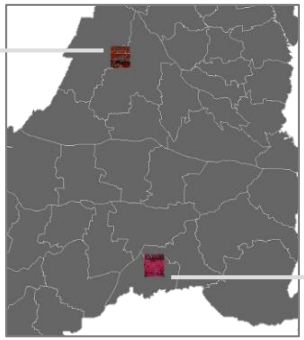


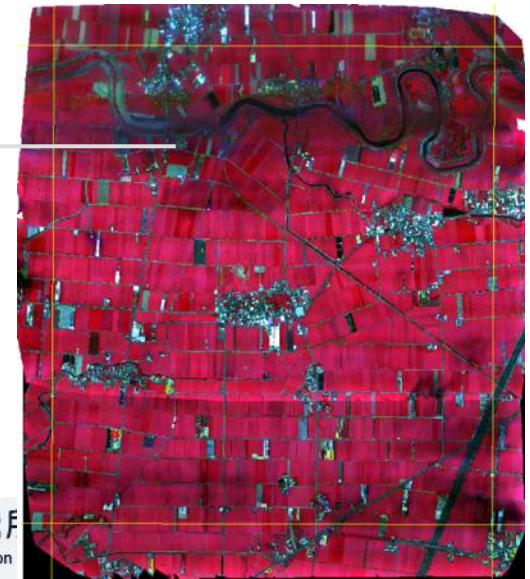
DATA

Farm Field Polygons and Ground Truth Data

- Polygon data are provided by AFA.
- Ground truth data were from ground survey and interpreted with UAV image in May, 2018.

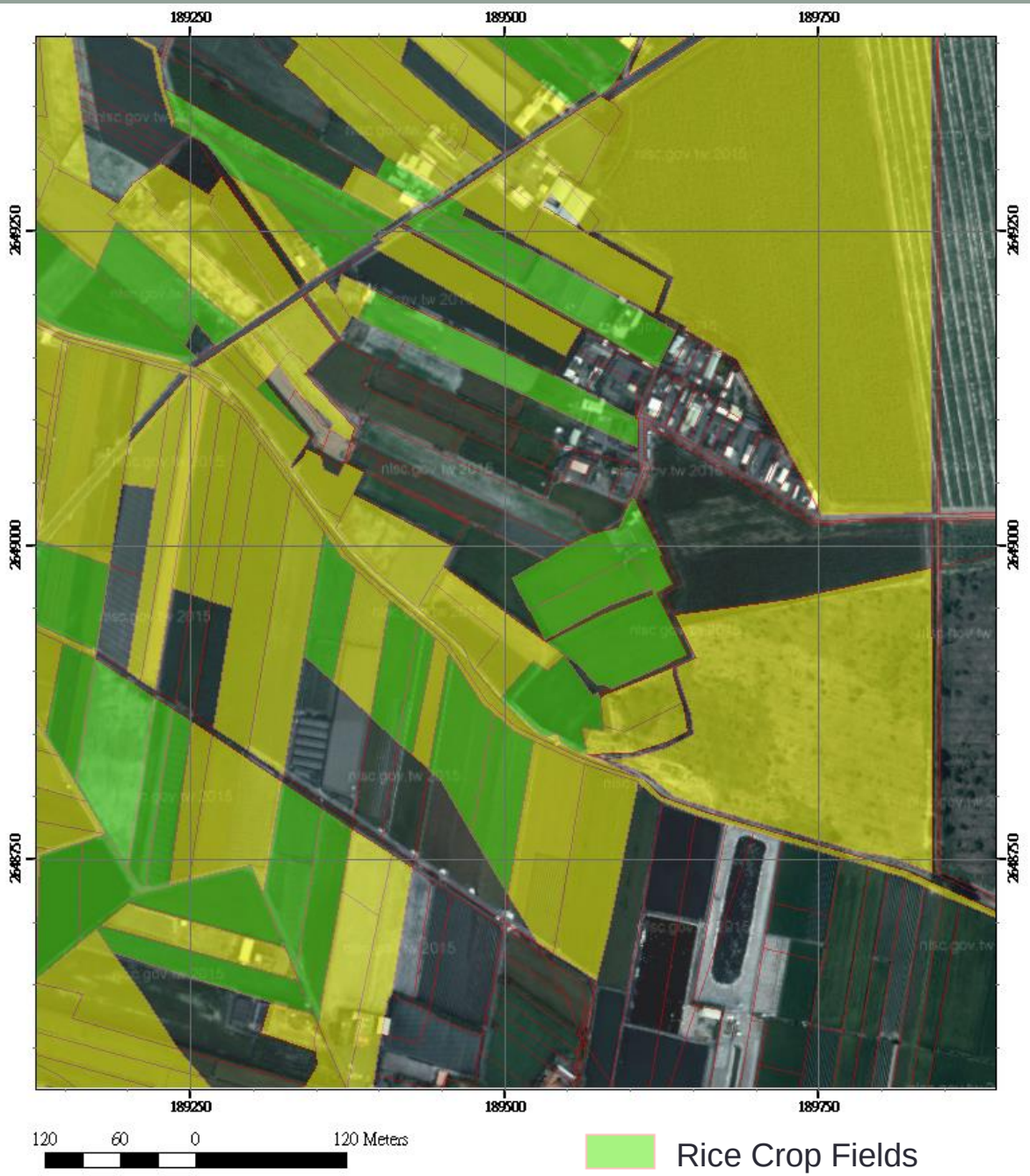






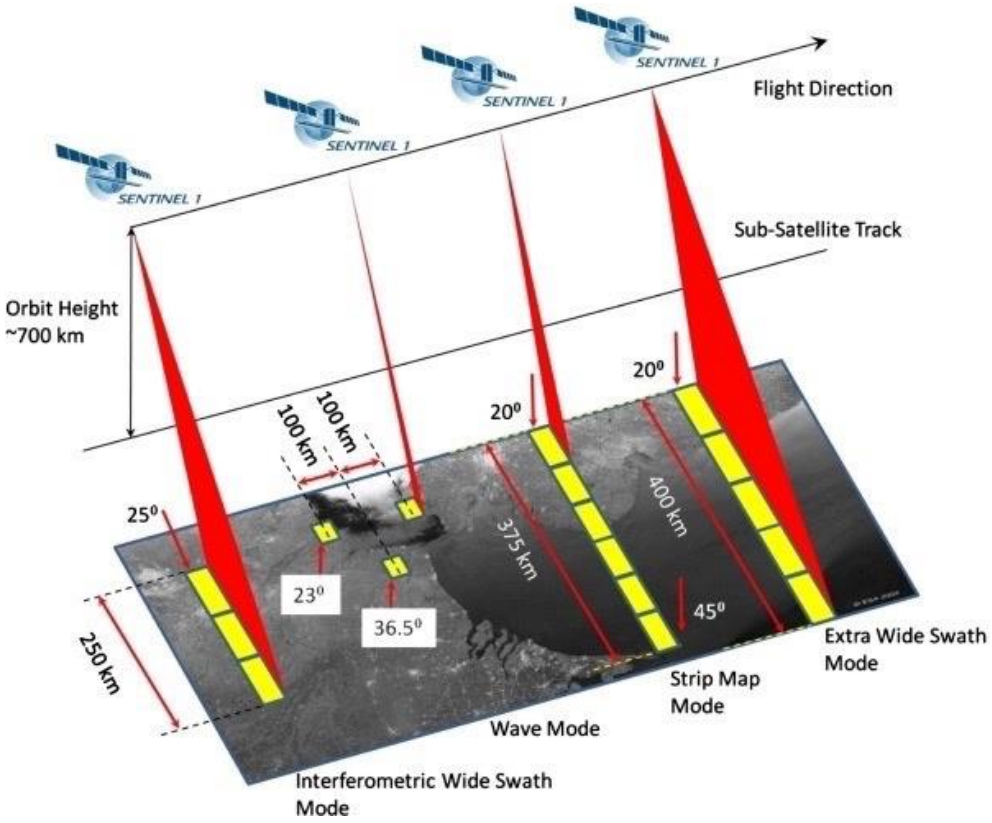
Erlin Township

Tapi Township


189250
189500
189750
2649250
2649000
2648750
120 60 0 120 Meters
Rice Crop Fields
Non-Rice Crop Fields

Sentinel-1 Synthetic Aperture Radar (SAR) Satellite

- The European Space Agency (ESA) launched a series of satellites called “Sentinel”, including optical and SAR instruments from 2014.
  - Sentinel-1 plan is a C-Band Synthetic Aperture Radar (SAR) with single polarization (HH or VV) and dual polarization (HH+HV or VH+VV), which have twin satellites named Sentinel-1A and Sentinel-1B.
  - The orbit height is 700km and 12-days revisit in the same track and same direction.
  - To prevent satellite resources conflict, the primary modes are Interferometric Wide swath (IW) , with VV+VH polarization over land.



Mode	Polarization	Main Targets
Interferometric Wide Swath (IW)	VV+VH	land
Wave (WV)	VV	open ocean
Extra-Wide Swath (EW)	----	wide area coastal, oil spill, sea-ice
Strip Map (SM)	----	Extraordinary events

Sentinel-1 GRD Image Data

- Collected 17 scenes of Sentinel-1A/B GRD image data from 3rd Feb. to 22nd May in 2018.
- To avoid the potential polarimetric response error from different acquisition directions and satellite obits, all image data cover Northern Taiwan in the same orbit with ascending direction.

Date		Orbit	Mode	Level
Feb.	3rd, 9th, 15th, 27th	100	IW	GRD
Mar.	5th, 11th, 17th, 23rd, 29th			
Apr.	4th, 16th, 22nd, 28th			
May	4th, 10th, 16th, 22nd			

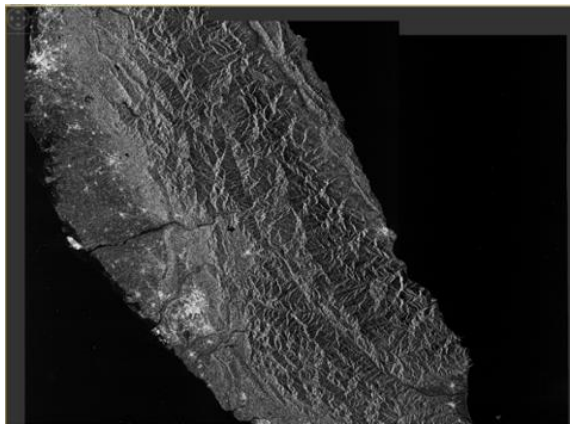
Sentinel-1 GRD Image Data (cont.)

- Separate 17 image dates into 9 datasets.
- Each dataset includes 9 image dates.

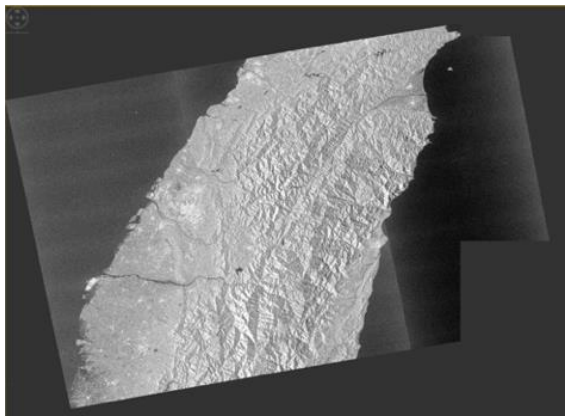
No.	Date		No.	Date		No.	Date	
1	Feb.	3rd, 9th, 15th, 27th	4	Feb.	27th	7	Mar.	11th, 17th, 23rd, 29th
	Mar.	5th, 11th, 17th, 23rd, 29th		Mar.	5th, 11th, 17th, 23rd, 29th		Apr.	4th, 16th, 22nd, 28th
2	Feb.	9th, 15th, 27th		Apr.	4th, 16th, 22nd		May	4th, 10th
	Mar.	5th, 11th, 17th, 23rd, 29th	5	Mar.	5th, 11th, 17th, 23rd, 29th	8	Mar.	17th, 23rd, 29th
	Apr.	4th		Apr.	4th, 16th, 22nd, 28th		Apr.	4th, 16th, 22nd, 28th
3	Feb.	15th, 27th	6	Mar.	11th, 17th, 23rd, 29th		May	4th, 10th, 16th
	Mar.	5th, 11th, 17th, 23rd, 29th		Apr.	4th, 16th, 22nd, 28th	9	Mar.	23rd, 29th
	Apr.	4th, 16th		May	4th		Apr.	4th, 16th, 22nd, 28th
							May	4th, 10th, 16th, 22nd

RESULTS AND DISCUSSION

GRD Images Preprocessing

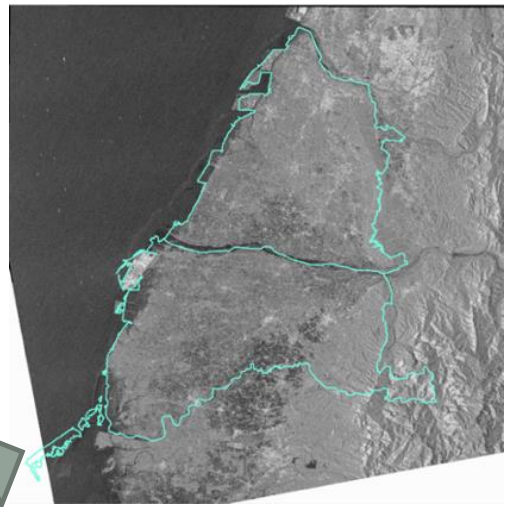


(a) Single swath data of GRD image

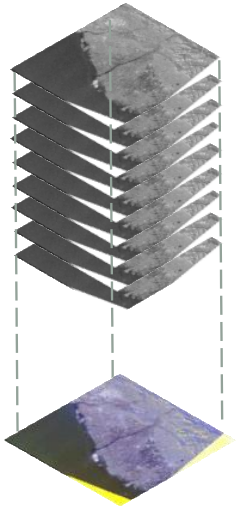


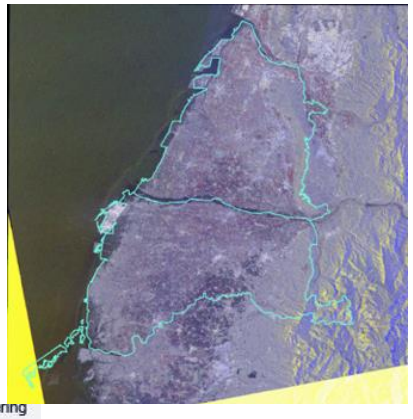
(b) Backscatter image

Clip

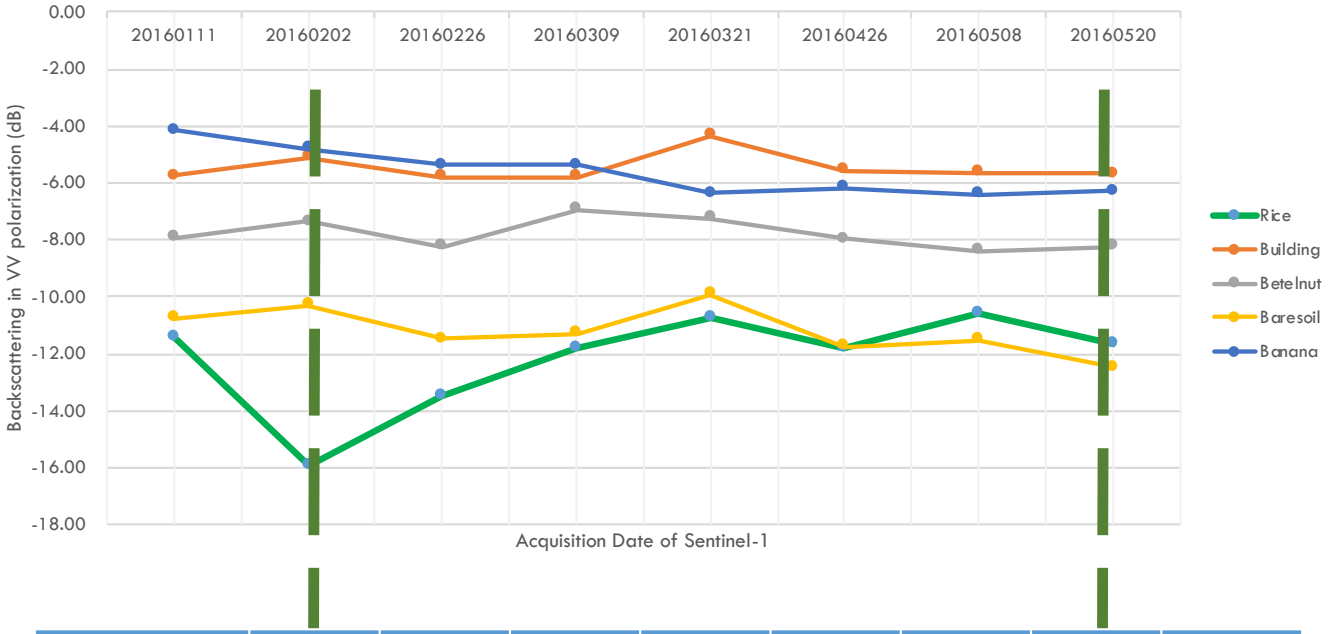


Layer Stack





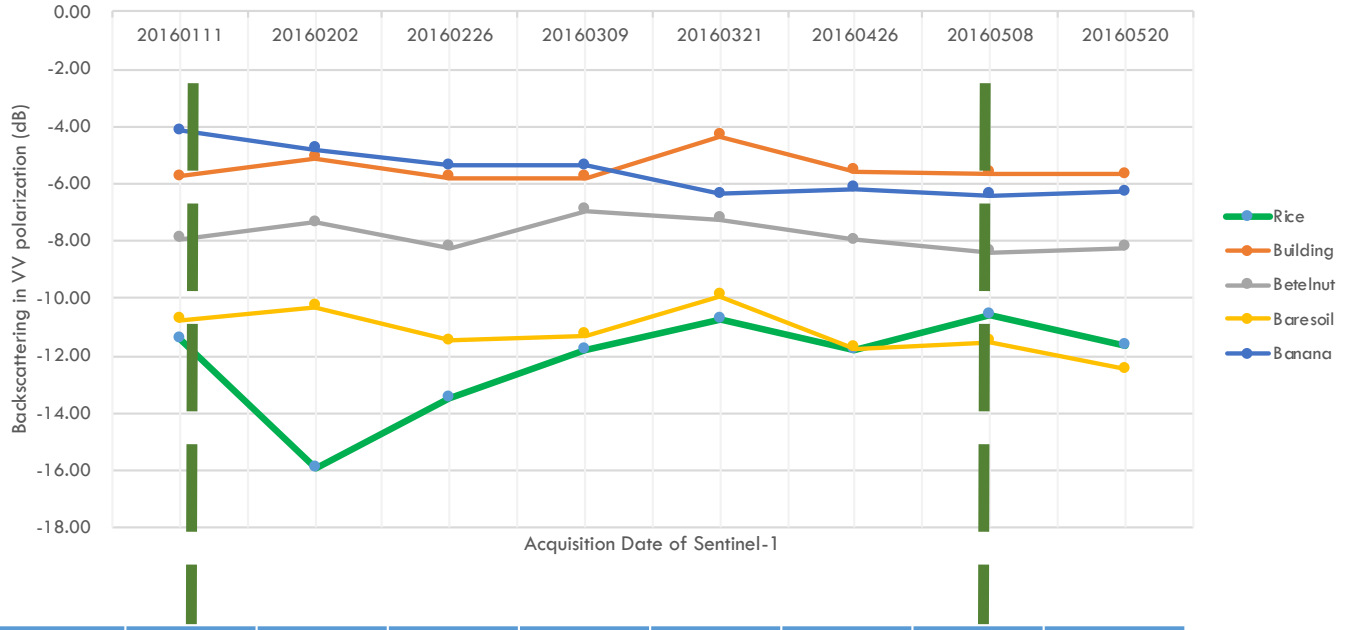
T-LBP Baseline and Threshold



Land Cover	Base	2^0	2^1	2^2	2^3	2^4	2^5	T-LBP
Rice	0	1	1	1	1	1	1	63
Building	0	0	0	1	0	0	0	4
Betelnut	0	0	1	1	0	0	0	6
Baresoil	0	0	0	1	0	0	0	4
Banana	0	0	0	0	0	0	0	0

Ideal Temporal σ° Changing Pattern

T-LBP Baseline and Threshold (cont.)

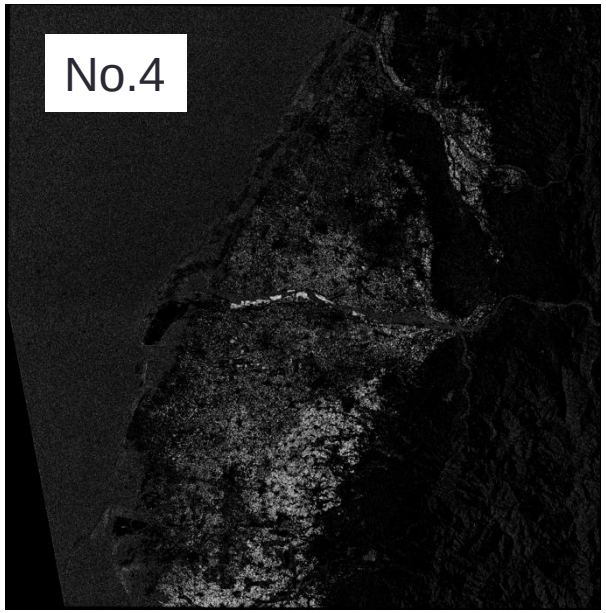


Land Cover	Base	2^0	2^1	2^2	2^3	2^4	2^5	T-LBP
Rice	0	0	0	0	1	0	1	40
Building	0	1	0	0	1	1	1	57
Betelnut	0	1	0	1	1	1	0	29
Baresoil	0	1	0	0	1	0	0	9
Banana	0	0	0	0	0	0	0	0

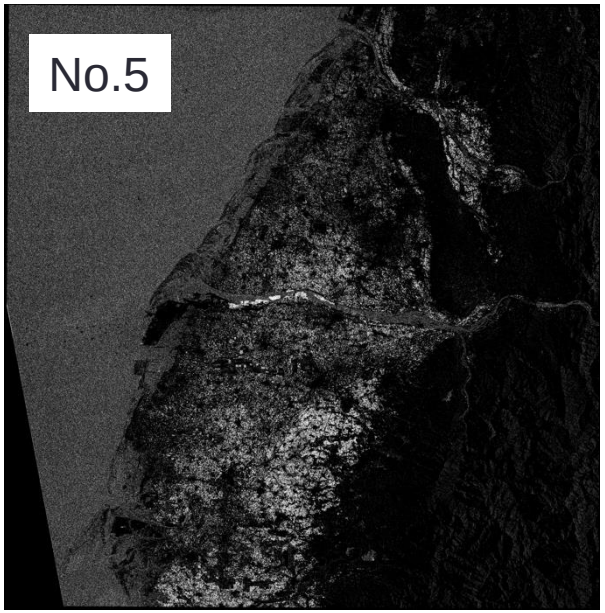
Error Baseline Temporal σ° Changing Pattern

T-LBP Baseline and Threshold (cont.)

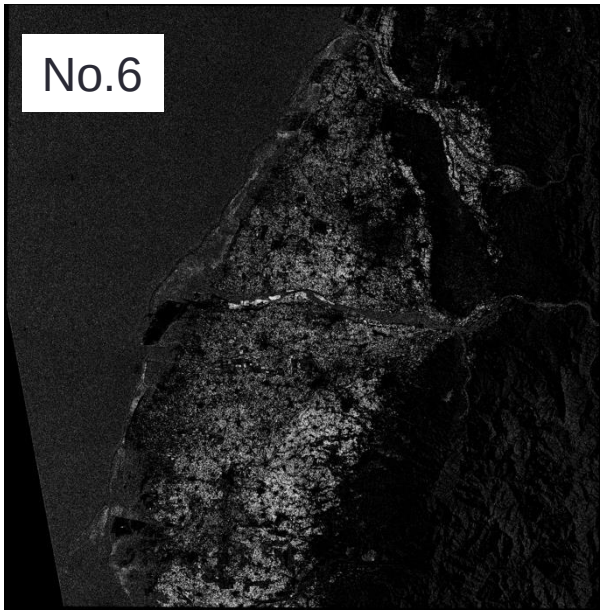
- Calculate T-LBP with different baseline image dates.
- Based on Chang et al. (2017), T-LBP threshold was set as 200.



From 27th Feb. to 22nd Apr.



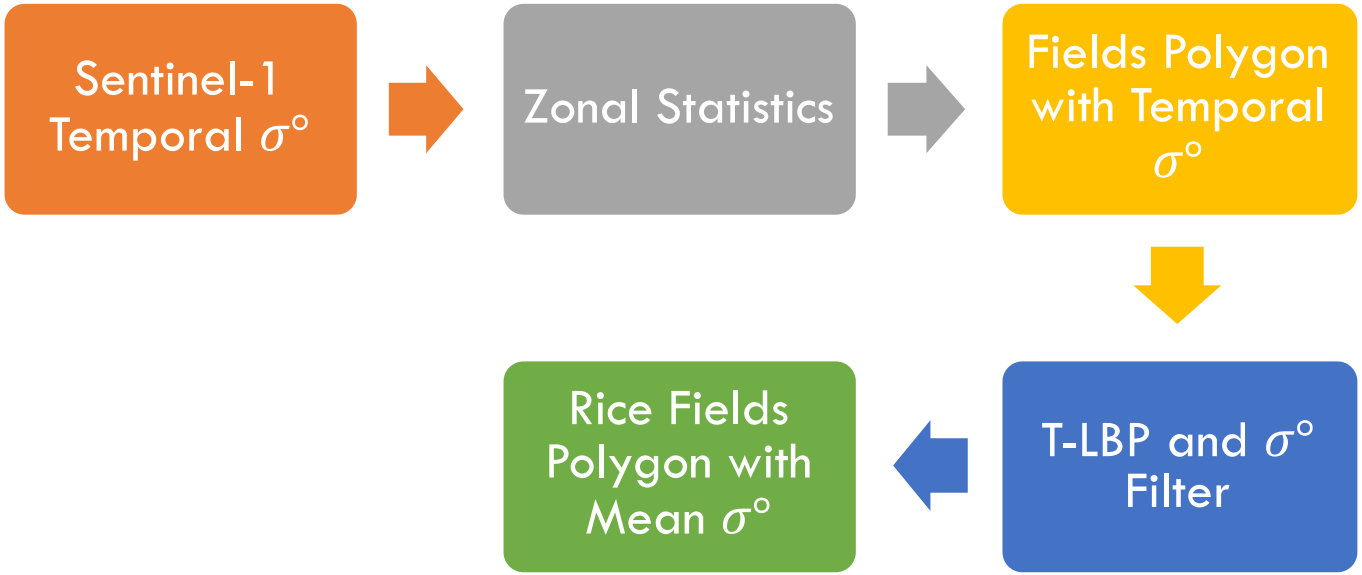
From 5th Mar. to 28th Apr.



From 11th Mar. to 4th May

Rice Crop Interpretation

- To reduce the effect of speckle noise, we use mean value of each rice field polygon rather than each pixel value.
- σ° Filter:
  - Building: mean σ° over -10
  - Grassland: min temporal σ° over -20



Mean T-LBP

27th Feb. to 22nd Apr.

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	1740	995	2735	63.62%
Non-Rice	668	1134	1802	62.93%
Sum.	2408	2129	4537	
P.A.	**72.26%**	53.26%	**Overall**	**63.35%**
			kappa	0.257527

5th Mar. to 28th Apr.

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	2064	1216	3280	62.93%
Non-Rice	344	913	1257	72.63%
Sum.	2408	2129	4537	
P.A.	**85.71%**	42.88%	**Overall**	**65.62%**
			kappa	0.292933

11th Mar. to 4th May

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	2032	1238	3270	62.14%
Non-Rice	376	891	1267	70.32%
Sum.	2408	2129	4537	
P.A.	**84.39%**	41.85%	**Overall**	**64.43%**
			kappa	0.268662

Mean T-LBP and σ° Filter

27th Feb. to 22nd Apr.

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	1485	417	1902	**78.08%**
Non-Rice	923	1712	2635	**64.97%**
Sum.	2408	2129	4537	
P.A.	**61.67%**	**80.41%**	**Overall**	**70.47%**
			kappa	0.415112

5th Mar. to 28th Apr.

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	1739	502	2241	**77.60%**
Non-Rice	669	1627	2296	**70.86%**
Sum.	2408	2129	4537	
P.A.	**72.22%**	**76.42%**	**Overall**	**74.19%**
			kappa	0.484184

11th Mar. to 4th May

Ground Truth

T-LBP	Rice	Non-Rice	Sum.	U.A.
Rice	1713	493	2206	**77.65%**
Non-Rice	695	1636	2331	**70.18%**
Sum.	2408	2129	4537	
P.A.	**71.14%**	**76.84%**	**Overall**	**73.82%**
			kappa	0.477192

Discussion

- The highest interpret accuracy is dataset No. 4 (27th Feb. to 22nd Apr.).
  - Overall Accuracy: 65.62%
  - Rice Producer Accuracy: 85.71%
  - Non-Rice Producer Accuracy : 42.88%
- With $\sigma°$ filter, in producer accuracy, rice fields were decreased but non-rice fields were obviously increased.
  - Overall Accuracy: **74.19%**
  - Rice Producer Accuracy: **72.22%**
  - Non-Rice Producer Accuracy: **76.42%**

CONCLUSION

Conclusion

- Although the rice fields producer accuracy can be higher than 96% with optical data, but still cannot interpret the cloud cover area.

- SAR is a positive remote sensing technique to provide land cover information over day and night regardless of cloud cover.

Conclusion (cont.)

- In previous study, an efficient rice field's interpretation method with temporal SAR data and T-LBP was proposed.
- This study demonstrates that applied appropriate filter, such as zonal aggregate or signal feature filter, can obviously improve T-LBP interpretation accuracy.
- Reasons of interpretation error
  - Some non-rice fields with similar T-LBP were misclassified.
  - Rice fields are mostly in narrow rectangle in Taiwan.

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Thank You