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Evaluation of horizontal precision of satellite imagery acquired from VNREDSat-1

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Abstract

VNREDSat-1 is the first optical remote sensing satellite of Vietnam, launched into orbit on May 2013, functioning for observation of natural resources and environment. Its technical features are similar to SPOT 5 and SPOT 7 on spatial resolution and spectral bands. Evaluate and comparative researches of these satellite images on their feature have not been done yet because VNREDSat -1 is the new one and not popular uses yet. In term of end-user, this report presents results of comparison and evaluation of images of VNREDSat-1 on horizontal positional accuracy to SPOT 5 and SPOT 7. Comparison is done in pairs VNREDsat-1/ SPOT 5, VNREDsat-1/ SPOT 7 and VNREDsat-1 itself. Statistical tests are applied to evaluate differences among positions extracted from these images. The results indicate that mean positional differences between VNREDSat-1 compared to SPOT 5 and SPOT 7 are ranged from 26 m to 213 m by x axis and from 11 m to 286 m by y axis. Itself differences by comparing between the two scenes of VNREDSat-1 acquire from the two paths next together are also ranged from 91 m to 162 m by x axis and from 120 m to 286 m by y axis. Although images of these satellite are preprocessed at the same level, these differences are required that VNREDSat-1 images need to further process to get a better geospatial precision.

Keywords: VNREDSat-1, Horizontal precision; Coordinate differences

1. Introduction

VNREDSat-1 (**V**ietnam **N**atural **R**esources, **E**nvironment and **D**isaster-monitoring **S**atellite-1A) is the first Earth observation optical satellite of Vietnam, which was designed and manufactured by the EADS ASTRIUM (France), it was launched on orbit on May 7th 2013. Normally after launching satellite, evaluation of techniques and using images in order to calibrate parameters was carried out in post-launching step. **VNREDSat-1 (VNR)** can provide a high spatial resolution 2.5m (PA) and 10m (MS) for land cover mapping, land use etc. by end-user. The spectral and geometric features are the most concerned by users as these indicate what kind of object when interpretation and classification both on exact object and position. VNR images until now have not been yet commonly used in researches so there is not much technical information for the images. This research is focus on identifying precision of positions from VNR comparing to SPOT 5 (SP5) and SPOT 7 (SP7). Making use of SP5, SP7 images to compare based on that (i) the two satellite images and VNR are at a similar system; (ii) SPOT program has been operated for a long time, sine 1986, data images have high confidence, using in many application; and (iii) VNR, SP5, and SP7 are similar in technical features (spectral bands, spatial

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resolution) and these are preprocessing and geo-rectify at datum WGS-84, projection of Universal Transverse Mercator. In addition, evaluation of horizontal precision is carried out on adjoined scenes of VNR images, which are scenes of the two adjoined paths. This indicates geometry calibration and geo-rectification of VNR images if these are unique and systematic.

2. Methods

2.1. Data

There were six scenes of VNREDSat-1 (VNR) with 10m and 2.5m bands, two scenes of SP5 with 10 and 2.5m bands, and one scene of SP7 with 6m band used in this research. The list of images used in the table 1.

Table 1. Satellite image used

VNREDSat -1		SPOT 5		SPOT 7		Research areas
Date	Spatial resolution	Date	Spatial resolution	Date	Spatial resolution	
17/01/2014	10	14/02/2015	10			Thoai Son dist., AG prov.
16/01/2015	10					
17/01/2014	10 / 2.5	14/02/2015	10/ 2.5			Tam Nong dist., DT prov.
08/12/2013	10	14/02/2015	10	02/02/2015	6	Cai Be dist., TG prov.
28/12/2014	10					
26/01/2015	10					

Projection system of images was pre-processed at datum of WGS 1984, UTM projection and zone 48 by satellite image supplier.

2.2. Methods

+ Collecting object coordinates:

Areas of images that overlap each other were selected, in which objects are identified. Selecting objects in pair of images is based on:

- These objects are obviously observed at both images
- Selected objects should be similar in shape

Then coordinates were identified at corners of objects for X and Y axis using the cross hair cursor moving on the screen (Fig. 1). Errors of identifying coordinates are approximately ±1 pixel for all images. The number of chosen positions to collect coordinates is approximately ten and these relatively even spread over the overlapped area.

+Statistical calculation

Coordinates identified from image pairs of VNR - SP5, VNR - SP7 and VNR – VNR at different acquired date and path (the two images of two adjoined paths) are used for this calculation. Comparison of coordinate difference of VNR to SPOT 5/7 and VNR itself in pair using *t* – test (*Harris, 2013; Reeuwijk, 1998*). This procedure was used to test if there is statistically significant difference of coordinate pairs, using equation (*1*).

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n-1}}} \quad (1)$$

With:

- *t*: calculated value of test;
- d: difference of a pair (x_{i1}/ x_{i2} or y_{i1}/ y_{i2});
- n: number of pairs for testing

This test is done based on assumption that (i) Only the matched pairs can be used to perform the test; this means that coordinate pairs of x_{vnr} - $x_{sp5/sp7}$ and y_{vnr} - $y_{sp5/sp7}$; (ii) Normal distributions are assumed, all value of coordinates collected from SP5/ SP7 and VNR is normal, there is not deformation in shape and without any outlier value; and (iii) the variance of two samples taken from images is equal.

Testing uses confidence level 95%, table value (statistical value) with t distribution degree of freedom (df) n

– 1.

The Null hypothesis is that $H_0 = 0$, there is not significant difference of coordinates at the same positions collected from both compared images;

- if $t_{cal} \leq t^*$: accepted hypothesis, difference is not significant
- if $t_{cal} > t^*$: rejected hypothesis, difference is statistically significant.

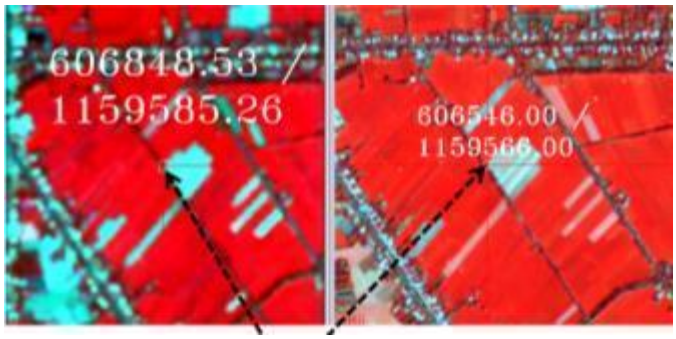

Fig. 1. Position to identify coordinates for both VNR (left) and SP7 (right)

3. Results and discussion

There are six cases of VNR compared to SP5, SP; out of these, one case makes use Pan band 2.5m of VNR and SP5 and three cases of VNR 10m compared to SP7 6m. Two cases of VNR are adjacent to other path. Ten positions – ten pairs of coordinates are identified to for comparison of differences and for testing.

+ Case 1: coordinates identified from VNR (2.5m) and SP5 (2.5m)
+ Case 2 and 3: VNR (10m) and SP5 (10m)
+ Case 4, 5, and 6: VNR (10m) and SP7 (6m)
+ Case 7 and 8: VNRs of two different paths

Tabe 2. Mean coordinate difference of VNRs compared to SP5 and SP7

Case	Mean difference of X (m)	Standardeviation X	Mean difference Y (m)	Standardeviation Y	VNR compared to
1	88.089	8.744046	189.213	12.19062	SP5
2	137.167	21.3177	213.466	13.98412	SP5
3	75.27618	37.89939	81.42845	36.70521	SP5
4	-26.206	6.040603	157.544	13.49897	SP7
5	297.0597	19.68294	10.66409	18.6521	SP7
6	-185.223	63.650	-158.094	122.106	SP7
7	162.217	55.267	286.038	13.165	VNR
8	-91.709	25.841	-120.583	26.161	VNR

Minus sign at figures indicates positional coordinates from VNR are different leftward at X axis and downward at Y axis comparing to SP5/SP7.

Outcomes of *t* test of difference on coordinates by pairs. Number of pair is ten, so df = n-1 = 9, value t^* in the table to test is ±2.262.

Bảng 3. Test result of coordinate difference

Case	Mean difference of coordinates VNR to others (m)	Test calcualtion *t* df = 9 95%, $t^B = 2.262$	Statistical significance
1	X: 88.089	-31.857	yes
	Y: 189.213	-49.082	yes
2	X: 137.167	-20.347	yes
	Y: 213.466	-48.271	yes
3	X: 75.276	-6.084	yes
	Y: 81.428	-6.624	yes

4	X: -26.206	13.718	yes
	Y: 157.544	-36.906	yes
5	X: 296.787	-45.283	yes
	Y: 11.555	-1.792	**no**
6	X: -185.223	9.202	yes
	Y: -158.904	4.094	yes
7	X: 162.217	-9.281	yes
	Y: 286.038	-68.704	yes
8	X: -91.709	11.222	yes
	Y: -120.583	14.575	yes

The results of test t_{cal} for different comparison of coordinates are much greater than *t* at all cases from table distribution (2.262) that indicates coordinate difference is significant and this must be paid more attention on geometry calibration of VNR images. Although VNR images are calibrated at a similar level as SP5 and SP7. Particularly, VNR images of a path with other adjoined paths (overlapped images) are also different as seen at Fig.2 and Fig 3 below.

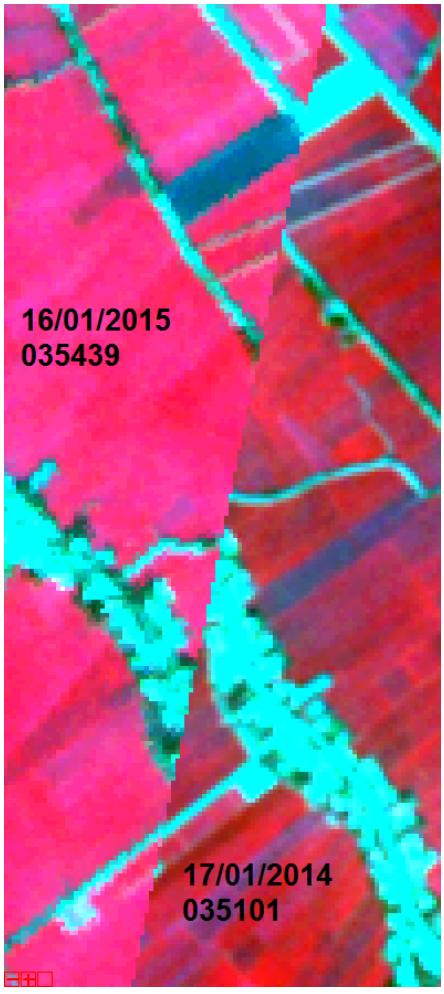

Fig 2a. Coordinate difference between VNR 17/01/ 2014 and 16/01/2015

Fig 2b. Coordinate difference between VNR 08/12/2013 and 26/01/2015

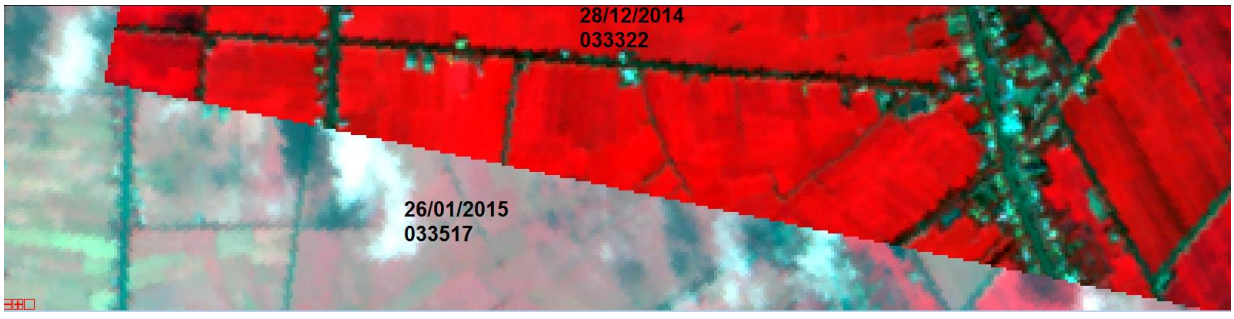

Fig 3. Coordinate difference between VNR 28/12/2014 and 26/01/2015

There is only one case that difference is not significant, approximately one pixel (case 5, Y axis).

Differences between VNR and other images are large. It ranges from 26m to 296m for X axis and from 11m to 213m for Y axis; maximum value at X axis is approximate 300m and Y 190m. The two cases of VNR itself, (case 7) difference +162m on X, +286m on Y, and (case 8) difference -91m on X, -120 on Y; showing that the difference is not systematic. This makes more difficult for end-user for utilizing VNR images, particularly when a study area is larger than a scene and types.

4. Conclusions

This study is to assess the capability of **VNREDSat-1** in comparison with SPOT scene for land cover classification in a complex urban. The difference is of characteristic that is not for a similar direction of all images, this make more difficult for identifying objects at fields and for geo-rectify to other images or a projection. This difference also implies that when VNR, SP5 and SP7 images are utilized on an application or a research, all have to be co-registration or even only VNR images should be manually done for each actual scene. Combination of using VNR with other satellite images such as SPOT or using VNR only for studying of change detection would get more problem with geo-rectification that accumulation errors would be great as spatial differences.

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