PlanetScope Images Geolocation Assessment

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Outline

- Introduction to the algorithms.
- Assessments of the reference WorldView (WV) data.
- Assessments of the PLANET data.

Algorithms - Image registration

- Pearson Cross Correlation

$$\gamma(u,v) = \frac{\sum_{x,y}[f(x,y)-\overline{f_{u,v}}][t(x-u,y-v)-\bar{t}]}{\sqrt{\sum_{x,y}[f(x,y)-\overline{f_{u,v}}]^2 \sum_{x,y}[t(x-u,y-v)-\bar{t}]^2}}$$

(u, v) : (x, y) direction integer shift of the **target** image (resampled PLANET image subsets);

$\gamma(u,v)$: PCC at the shifted location;

$f(x,y)$: the pixel value of the **reference** image (resampled WV chip) at location x and y;

$t(x-u,y-v)$: the pixel value of the float image value at location $x-u$ and $y-v$;

$\overline{f_{u,v}}$: the mean pixel value of the **reference** image in the region overlapping with the **target** image;

$\bar{t}$: the mean pixel value of the **target** image in the region overlapping with the **reference** image .

The maximum $\gamma(u,v)$ indicates the assessed shift *(u, v)* between the target image and the reference image.

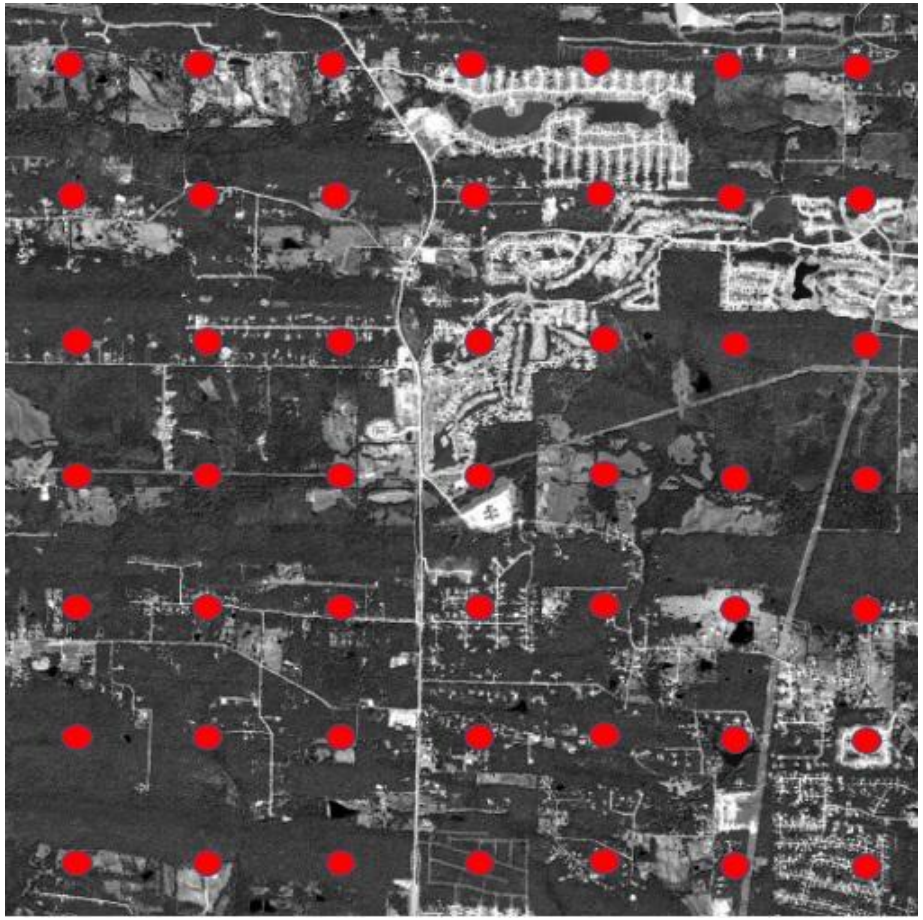
Algorithms – Measurement Uncertainties

- $$MU_x = \frac{\mathbf{1}}{PkSh_x}\sqrt{\mathbf{1} - \boldsymbol{z_{pk}^2}}\,\frac{\boldsymbol{D}}{\boldsymbol{NM}}\,\frac{\mathbf{1}}{\mathbf{2}}\left(\frac{\mathbf{1}}{\boldsymbol{c_1}} + \frac{\mathbf{1}}{\boldsymbol{c_2}}\right)$$

- MU_x: measurement uncertainty in x direction;
- $PkSh_x$: peak sharpness in X direction;
- z_{pk}: refined PCC;
- N and M: the image dimensions;
- D: the normalized contrast difference between two images at overlap region;
- c_1 and c_2: normalized contrast of two images;

MU_y is calculated with the same equation but with $PkSh_y$.
Larger MU value indicates lower assessment confidence.

Algorithms – Selection of the Matching Sub-Window



- The sub-windows are evenly distributed over the assessed images (red dots are the center of the sub-windows).
- The size of the sub-window is 250 m by 250 m, which is about 80 by 80 PLANET pixels.

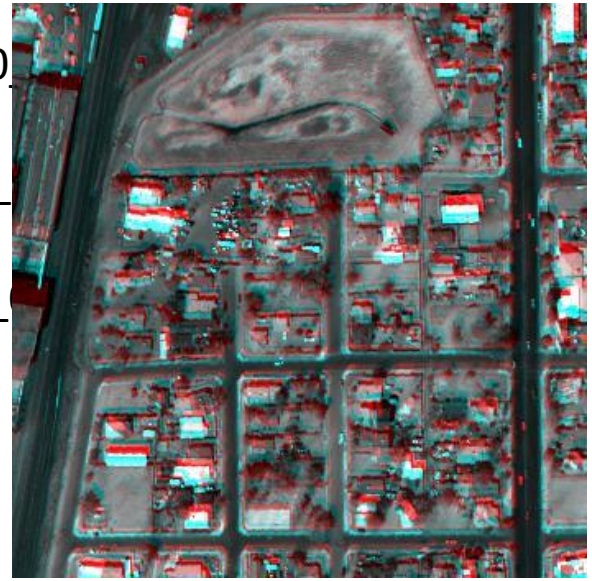
Assessments of the reference data – case 1

The geolocation accuracy of reference WorldView (WV) images, without correction of topographic displacement, is 3.5 m of CE90 (corresponding to 2.13 m RMSE (Root Mean Square Error)). The CE90 drops to 5.4 m (3.26 m RMSE) for orthorectified imagery [Accuracy of Worldview Products (white paper). DigitalGlobe Inc]

- Data
  - **Scene 1**: WV01_20180329210218_1020010072709D00_18MAR29210218-P1BS-504231999010_
  - **Scene 2**: WV01_20180415210224_102001006F85B400_18APR15210224-P1BS-504234755020_
  - **Scene 3**: WV01_20180415210258_102001006F7E0300_18APR15210258-P1BS-504273546070_
- Result

(Unit: Meter)	scene 1 (ref) vs scene 2	scene 1 (ref) vs scene 3	scene2 (ref) vs scene3	calculated scene2 (ref) vs scene 3
mean EW	-2.06	-0.76	1.52	1.30
mean NS	-2.88	-4.15	-0.65	-1.27

Measurement error is within 1 m.

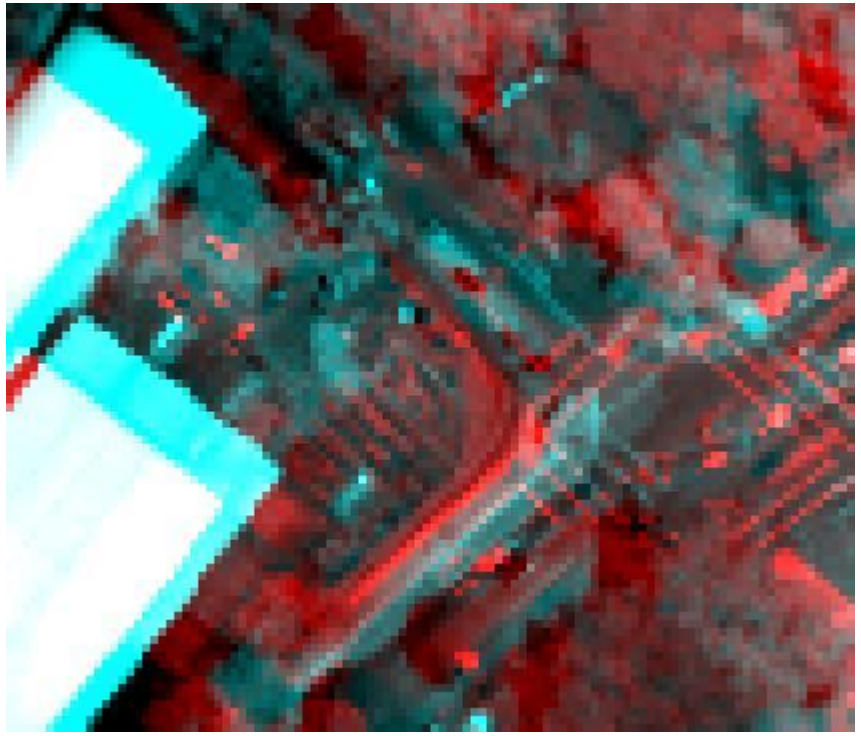


One chip in scene 1 vs scene 3 assessment

Assessments of the reference data – case 2

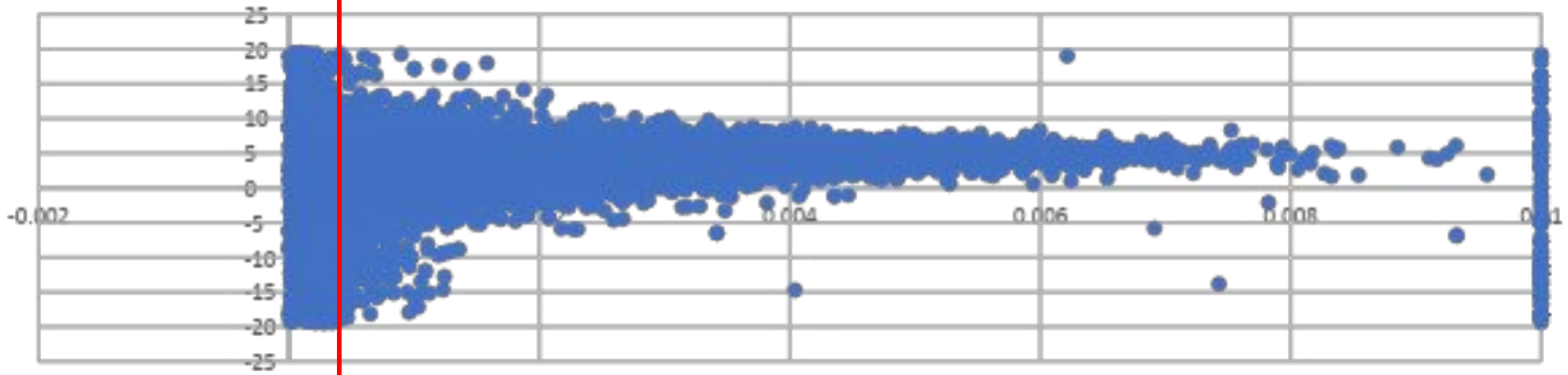
- Data:
  - WV01_20080117032327_1020010001885A00_08JAN17032327-P1BS-052119697010_01_P002.ntf
  - WV01_20090808034343_10200100084A2200_09AUG08034343-P1BS-052155703010_02_P008.ntf

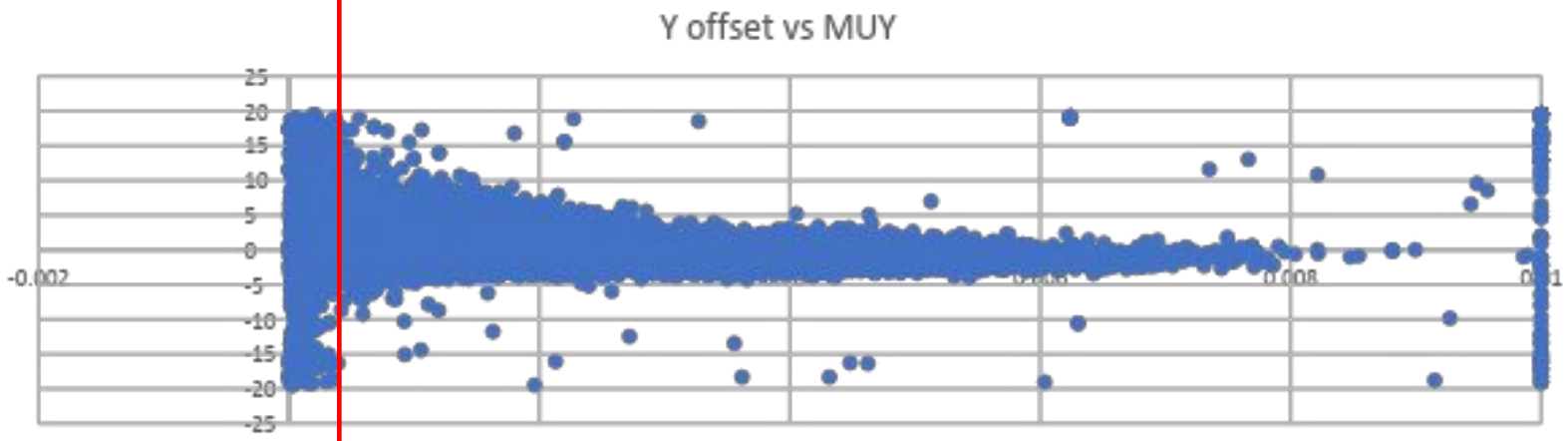
Mean EW offset = -8.16 m; Mean NS offset = - 4.50 m;



The reference WV images need to be assessed by cross-assessment among WV images. The outlier WV image should be excluded.

PLANET Data Assessment - New Mexico





Before filtering the results

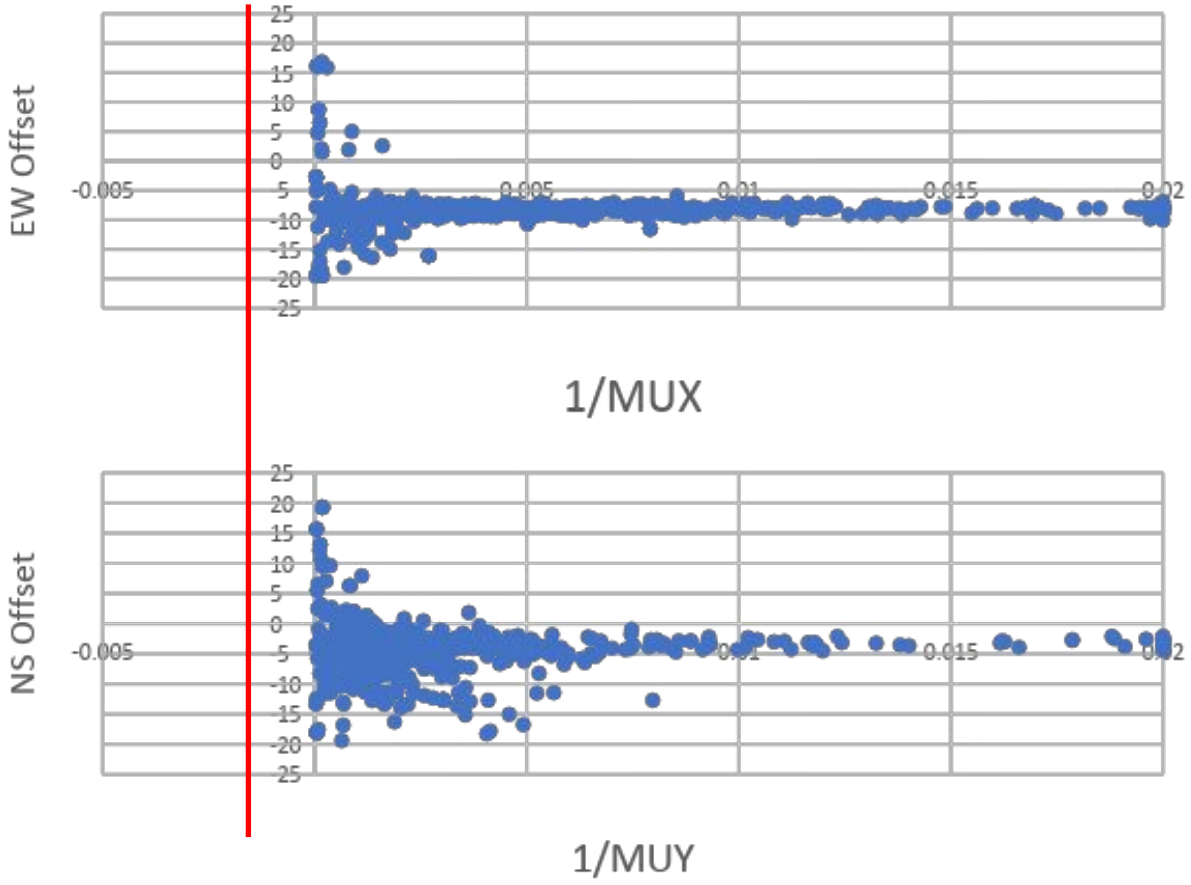
Chip Numbers	Mean EW offset (m)	Mean NS offset (m)
55441	2.48	0.79

After filtering the results with the MU filter

Chip Numbers	Mean EW offset (m)	Mean NS offset (m)
8161	4.24	-0.81

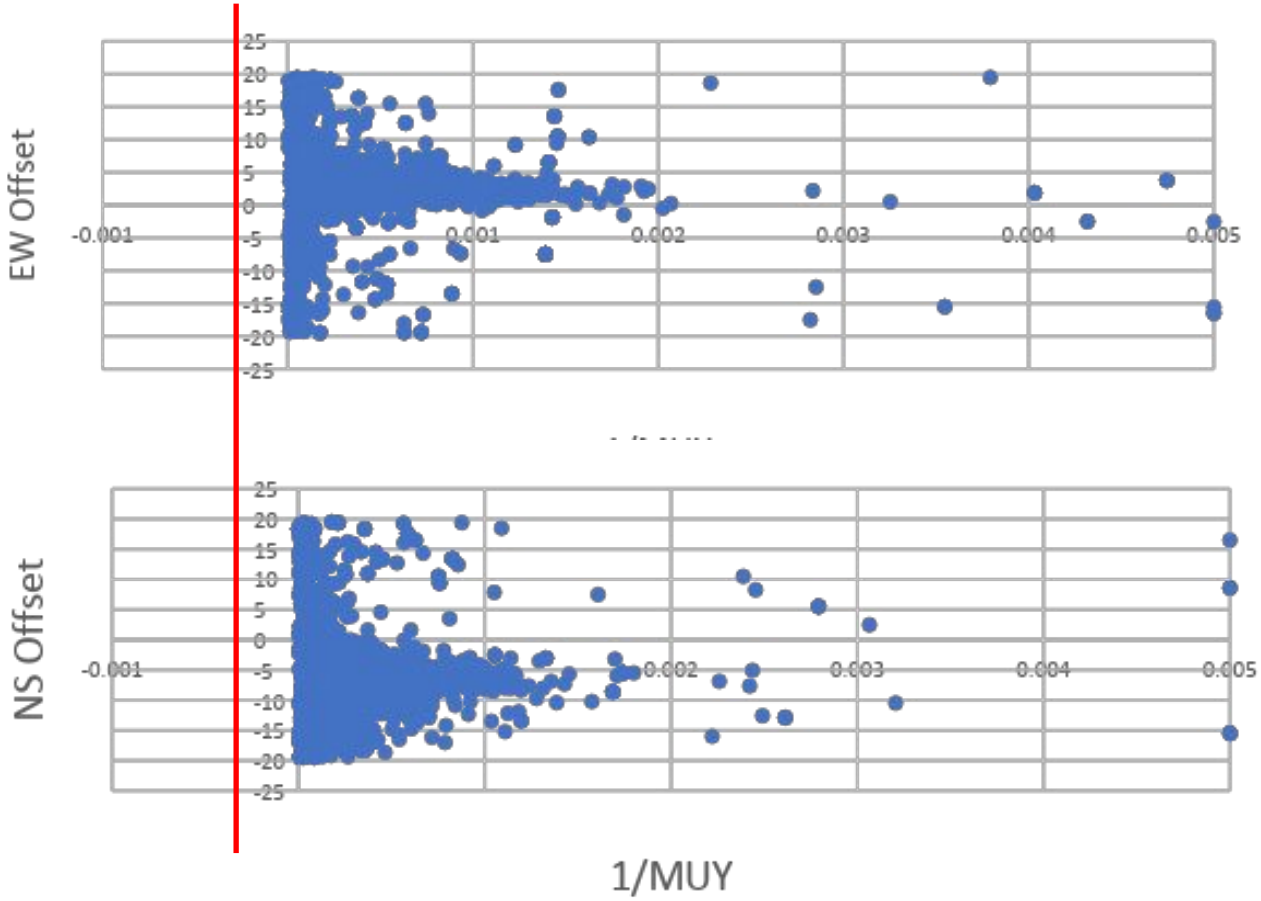
PLANET Data Assessment - Singapore

WV01_20080117032327_1020010001885A00_08JAN17032327-P1BS-052119697010_01_P002.ntf



Filtered result: EW offset = -8.31 m, NS offset = -4.66 m

WV01_20090808034343_10200100084A2200_09AUG08034343-P1BS-052155703010_02_P008.ntf



Filtered result: EW offset = 2.87 m, NS offset = -6.41 m

Temporal Stability

City: Knoxville, TN
Satellite: WV

Aquried Date/Time	Total#	Valid#	Mean(m)		Stdev(m)		RMSE(m)	
			x	y	x	y	x	y
2019-09-04/15:59z	49	17	-15.8	4.1	2.8	1.2	16.0	4.2
2019-09-04/16:24z	49	27	-15.8	3.5	3.5	1.3	16.2	3.7
2019-09-16/16:14z	49	27	-16.6	3.3	2.7	1.2	16.8	3.5
2019-09-29/16:00z	49	26	-16.8	3.8	2.3	1.1	17.0	4.0
2019-10-03/15:57z	49	26	-16.7	3.7	2.3	1.0	16.8	3.8
2019-10-18/15:48z	49	28	-16.6	4.5	2.6	1.2	16.8	4.7
2019-11-02/15:59z	49	23	-16.9	3.3	2.5	1.7	17.1	3.7
Total	343	174	-16.5	3.8	2.7	1.3	16.7	4.0

Summary

- The algorithms accurately assessed the relative geolocation accuracy of the fine resolution images.
- The filter(s) to remove the poor-quality assessments is necessary.
- The WV images should go through a quality check before being applied as the reference image.
- The geolocation consistency for the testing PLANET images is good.