3. TEST AND RESULT ANALYSIS

In order to verify the validity of the proposed method, a Landsat TM image and an ALOS PRISM image are used in the tests. The Landsat image was taken in April 2008 in Anhui province, and the image size is 6856 pixels×5733 pixels, and the spatial resolution is 30 meters. The ALOS image was taken in September 2010 in Jilin province, and the image size is 29493 pixels×16000 pixels, while the spatial resolution is 2.5 meters. Both of the maximum elevation differences of the area covered by the two images are less than 400 meters.

Four tests are carried out for both TM and ALOS images. In the first test, several evenly distributed GCAs are used for the geometric correction. In the second test, a pair of corresponding vertices is selected from each GCA in the first test, and then all these pairs of points are used as GCPs for the geometric correction. Two gross errors (5~6 pixels) are artificially added in the GCPs and GCAs of the first and second test, and the errors added in the GCPs are the same as those added in the GCAs. In the third test, the GCAs with gross errors are used for geometric correction. In the fourth test, the GCPs with gross errors are used for the geometric correction. The same check points (CPs) are used to evaluate the accuracy of the result in all the tests. The correction of Landsat image is based on the satellite orbital model (Chen et al., 2009), and the correction of ALOS image is based on the RFM with image compensation (Grodecki and Dial, 2003). The experimental results of the two images are shown in Table 1, including the fitting accuracy of the GCAs, the fitting accuracy of the GCPs, and the accuracy of the check points.

Table 1 Comparison of experimental results

image	*test*	*type*	*num*	*Test without gross error*						*Test with gross errors*					
				Max residual/pixel			*MSE/pixel*			*Max residual/pixel*			*MSE/pixel*		
				x	*y*	*error*	*x*	*y*	*error*	*x*	*y*	*error*	*x*	*y*	*error*
Landsat	GCA test	GCA	12	0.55	0.65	0.65	0.22	0.36	0.42	5.74	0.99	5.83	1.74	0.44	1.79
		CP	10	0.89	1.23	1.27	0.06	0.79	0.79	1.24	1.27	1.52	0.82	0.84	1.17
	GCP Test	GCP	12	0.38	0.3	0.39	0.18	0.12	0.22	4.77	1.09	4.89	2.05	0.42	2.09
		CP	10	0.84	1.15	1.36	0.47	0.82	0.95	3.27	1.53	3.39	1.75	0.9	1.97
ALOS	GCA Test	GCA	9	0.42	0.85	0.85	0.22	0.39	0.45	0.56	0.81	0.82	0.28	0.34	0.45
		CP	10	0.82	0.81	0.98	0.45	0.42	0.62	0.8	0.83	0.96	0.45	0.43	0.62
	GCP test	GCP	9	0.7	0.56	0.85	0.35	0.3	0.46	5.71	1.91	6.02	2.81	0.88	2.94
		CP	10	0.61	0.7	0.85	0.34	0.41	0.53	3.12	1.27	3.17	1.8	0.71	1.94

The following conclusions are drawn according to the analysis of the results in Table 1:

(1) The proposed area-based geometric correction method can be applied to different satellite images and different imaging models.

(2) When the control data does not contain gross errors, the image correction using geometric correction model based on GCAs gains almost the same accuracy as that based on GCPs. As shown in Table 1, in the tests of Landsat and ALOS image without gross errors, the errors of the check points when using GCPs and using GCAs can both be less than one pixel.

(3) When the control data contains gross errors, the geometric correction model based on GCAs is more fault-tolerant than the geometric correction model based on GCPs. As shown in Table 1, in the tests of Landsat image with gross errors, the maximum residual of check points is more than 3 pixels when the GCPs are used for geometric correction, while the maximum residual of check points is less than 2 pixels when the GCAs are used for geometric correction. In the test of ALOS image with gross errors, the maximum residual of check points is more than 3 pixels when the GCPs are used for geometric correction, while the maximum residual of check points is less than 1 pixel when the GCAs are used for geometric correction. In the GCAs test of Landsat image with gross errors, the gross errors which involved in the calculation of the model may result in the deviation of the model parameters from the true values, therefore the impact of this gross error on the accuracy of the area-based geometric correction model is limited. In the GCAs test of ALOS image with gross errors, as the gross error points are inside of the reference area features, and the distances from those points to the reference polygons is 0, the gross error makes no contribution to the calculation of the distances between polygons, and their impact on the accuracy of area-based geometric correction model is negligible.

4. CONCLUSIONS

In practical applications, as it is sometimes difficult to obtain sufficient and accurate GCPs, and there are a lot of areal features in the reference images, the digital line maps, and GIS vector data, the use of areal features in geometric correction may take full advantage of the data. On the other hand, since an areal feature is consisted of many points, gross errors in individual points do not remarkably reduce the accuracy of the areal feature, therefore the geometric correction model based on GCAs is more fault-tolerant than the geometric correction model based on GCPs. The results of the tests show that the method proposed in this paper can be used for different satellite images and imaging models. When the control data does not contain gross errors, the correction accuracy using GCAs is almost the same as that using GCPs. When the control data contains gross errors, the correction accuracy using GCAs is much better than those using GCPs.

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