Accuracy assessment of ACRES Landsat Orthocorrected Products

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ABSTRACT

This paper provides the results of assessments of the geometric accuracy of ACRES orthocorrected ETM+ products generated from Supplemental Control Points (SCPs). Included in the results are two independent assessments of ACRES SCP orthocorrected products conducted by the Department of Environment and Heritage (DEH), South Australia and the Department of Land Administration (DOLA), West Australia.

The SCPs were created from full length Landsat 7 passes of the Australian Continent controlled with dGPS surveyed GCPs. Approximately 63 SCPs were created for each Landsat 7 scene.

The project to generate SCPs for use in ACRES orthocorrected product generation resulted from earlier investigations by the authors that relatively few high quality GCPs could be used to refine a Landsat 7 spacecraft model.

The assessment results to date indicate that: -

(a) The absolute geometric accuracy of the orthocorrected imagery was significantly improved (RMS x,y error ± 13 metres) compared to ortho products generated with GCPs derived from topographic maps.

(b) Sub pixel registration of multi-temporal Landsat ETM+ products is achievable with the use of SCPs in orthocorrected product generation.

It is planned to have complete national coverage of SCPs by the end of year 2003. This coverage will allow for the generation of nationally consistent highly accurate Landsat orthocorrected products for a range of applications.

KEYWORDS: ACRES, ETM+, Supplemental Control Points (SCPs), orthocorrected, Landsat 7, sub pixel registration, multi-temporal

Introduction

ACRES products with the highest level of locational accuracy are known as Ortho products. These products have been produced with Ground Control Points (GCPs) used to refine a spacecraft model (Friedmann *et al.*, 1983), and a Digital Elevation Model (DEM) to remove terrain relief distortions (Smith *et al.*, 2002). The GCPs were derived from 1:50 000 – 1:250 000 scale topographic maps.

The positional accuracy of ACRES orthocorrected products is being significantly improved through the use of Supplemental Control Points (SCPs) in ortho product generation. SCPs are geocoded image chips derived from fully controlled Landsat & ETM+ passes. Approximately 63 SCPs are created in the area covered by a standard Landsat scene. All Landsat spectral bands are used in the generation of SCPs, with each chip covering an area of 1 km square

Geometrically uncorrected raw data is geocoded by the use of SCPs to refine the Landsat 7 spacecraft model for ACRES ortho products. ACRES product generation software has automated image matching software that correlates the geocoded SCPs with the raw satellite data. This geocoded methodology leads to fast processing time as well as improved products accuracy.

The SCPs are derived from controlled full length Landsat 7 passes of the Australian continent. The passes are controlled with 1-2 metre accurate GCPs surveyed using differential GPS technology. Figure 1 shows the areas of the Australian continent where SCPs are currently available for use in the production of Ortho products. A project to complete the central area of Australia has commenced.

This paper provides the results of an ACRES, and two independent assessments of the absolute and relative locational accuracy of ACRES orthocorrected ETM+ product generated from SCPs. All of the assessments are based on the panchromatic band of the ETM+ imagery.

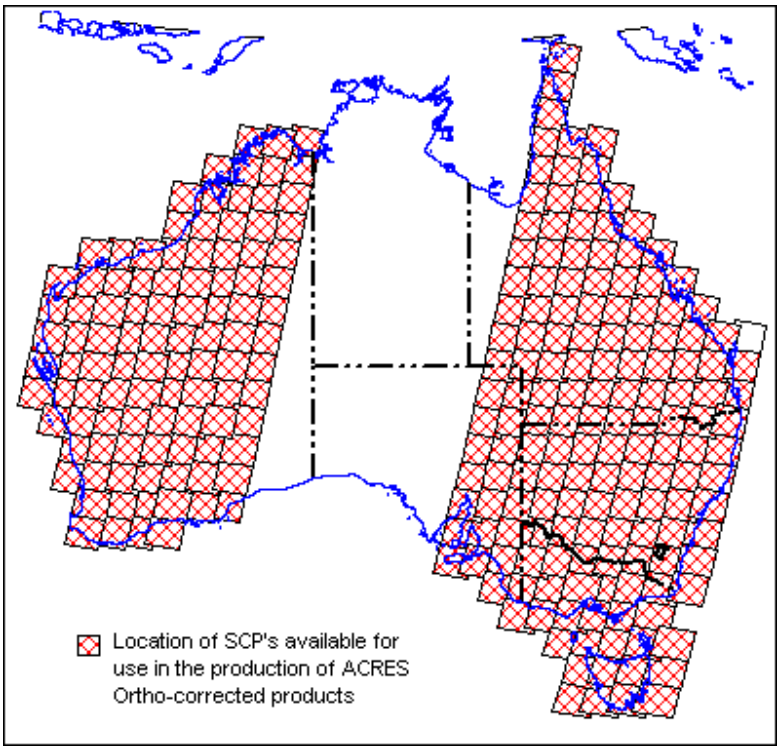

Figure 1 Locations of available SCPs for the production of ACRES orthocorrected products

Results

(a) ACRES multi-temporal product registration assessment

In order to determine the temporal consistency of the ACRES SCP orthocorrected products, eight Landsat ETM+ scenes acquired between August 1999 and January 2002, covering Quilpie region of Queensland were examined to determine the multi-temporal consistency of the spatial information. An intensity-based image matching techniques (cross-correlation) was used to determine the sub pixel differences between the multi-temporal ETM+ scenes. 625 (25 by 25) grided points were randomly selected as candidate matching points. The extent of the test area and the distribution of the candidate matching points were shown on Figure 2.

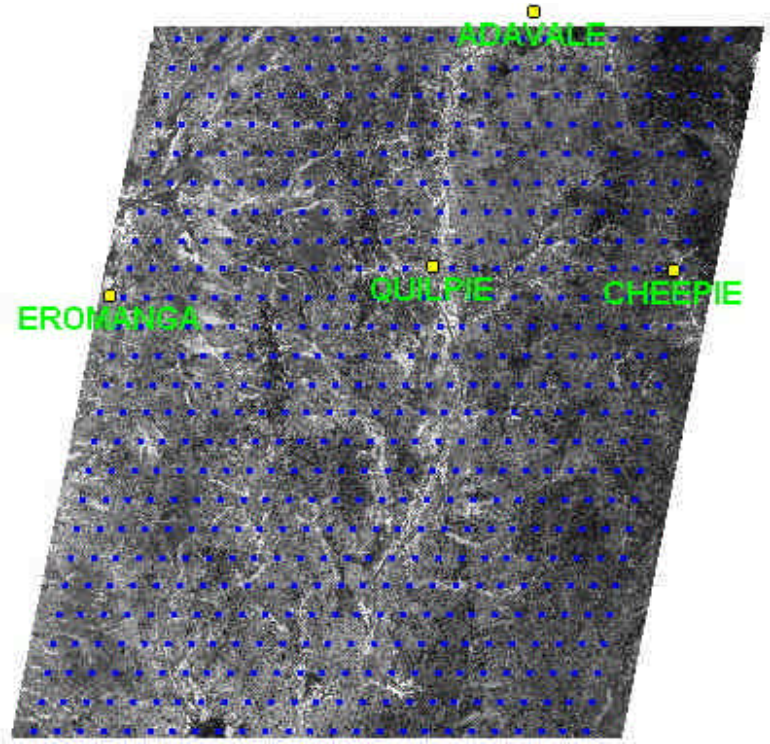

Figure 2 The distribution of the 625 candidate matching points

Table 1 provides a summary of the image matching results between the multi-temporal ETM+ scenes. Values shown in this table have been calculated from matched points with correlation coefficients greater than 0.7, following the removal of the mismatched points (defined as matching difference greater than 2 pixels).

ETM+ Acquisition Date	Aug 99	July 00	Feb 01	April 01	June 01	Aug 01	Oct 01	Jan 02
Aug 99	0	0.47	0.32	0.30	0.33	0.30	0.33	0.32
July 00	0.47	0	0.33	0.32	0.33	0.35	0.31	0.32
Feb 01	0.32	0.33	0	0.24	0.33	0.38	0.35	0.47
April 01	0.30	0.32	0.24	0	0.28	0.35	0.37	0.36
June 01	0.33	0.33	0.33	0.28	0	0.34	0.41	0.43
Aug 01	0.30	0.35	0.38	0.35	0.34	0	0.36	0.33
Oct 01	0.33	0.31	0.35	0.37	0.41	0.36	0	0.28
Jan 02	0.32	0.32	0.47	0.36	0.43	0.33	0.28	0

Table 1 RMS values at randomly grided checkpoints (pixels)

Table 2 provides a detail summary of the image matching results, including the mean difference in samples and lines, RMS difference in samples and lines, number of matched points (maximum 625) with correlation coefficients greater than 0.7 and the number of mismatched points. The small number (maximum 4) of the mismatched points indicates that the matching algorithm (using 0.7 as correlation threshold) has been successful. Post-examination indicates that these mismatched points were located within a homogenous area with insufficient image detail for the correlation to be possible. Figure 3 shows an example of the discrepancies at the matched points between the multi-temporal ETM+ scenes. It can be clearly seen that the sub pixel registration between the two ETM+ scenes has been achieved. Figure 4 shows an example of sub pixel registration when displaying the eight ETM+ scenes together through geo-linking.

Comparison pair	Mean difference (pixel)		RMS difference (pixel)		No. of points with NCC > 0.7	No. of mismatched points with NCC > 0.7
	Sample	Line	Sample	Line		
Aug 99 - July 00	0.06	-0.08	0.38	0.29	544	3
Aug 99 - Feb 01	0.08	-0.05	0.26	0.18	570	1
Aug 99 - April 01	0.03	-0.07	0.26	0.15	581	0
Aug 99 - June 01	0.05	0.04	0.28	0.18	559	0
Aug 99 - Aug 01	0.02	0.03	0.26	0.16	583	1
Aug 99 - Oct 01	-0.02	-0.04	0.28	0.16	588	0
Aug 99 - Jan 02	-0.06	-0.03	0.27	0.17	559	1
July 00 - Feb 01	0.00	0.03	0.26	0.20	552	1
July 00 - April 01	-0.04	0.0	0.28	0.16	554	0
July 00 - June 01	-0.04	0.11	0.29	0.16	536	0
July 00 - Aug 01	-0.06	0.10	0.31	0.15	546	0
July 00 - Oct 01	-0.09	0.03	0.25	0.18	546	0
July 00 - Jan 02	-0.12	0.05	0.25	0.20	521	4
Feb 01- April 01	-0.04	-0.02	0.20	0.12	608	0
Feb 01- June 01	-0.02	0.08	0.24	0.23	589	0
Feb 01- Aug 01	-0.05	0.08	0.32	0.20	591	0
Feb 01- Oct 01	-0.10	0.02	0.30	0.17	605	0
Feb 01- Jan 02	0.14	0.03	0.31	0.35	584	0
April 01- June 01	0.02	0.11	0.22	0.17	593	0
April 01- Aug 01	-0.01	0.10	0.30	0.17	593	0
April 01- Oct 01	-0.05	0.04	0.33	0.18	606	0
April 01- Jan 02	-0.08	0.06	0.32	0.18	577	2
June 01- Aug 01	-0.02	-0.01	0.31	0.14	589	0
June 01 - Oct 01	-0.07	-0.07	0.37	0.18	588	0
June 01 - Jan 02	-0.10	-0.07	0.37	0.22	556	2
Aug 01 - Oct 01	-0.04	-0.06	0.32	0.15	605	0
Aug 01 - Jan 02	-0.08	-0.05	0.28	0.17	574	2
Oct 01- Jan 02	-0.04	0.02	0.25	0.12	582	2

Table 2 Summary of the image matching results

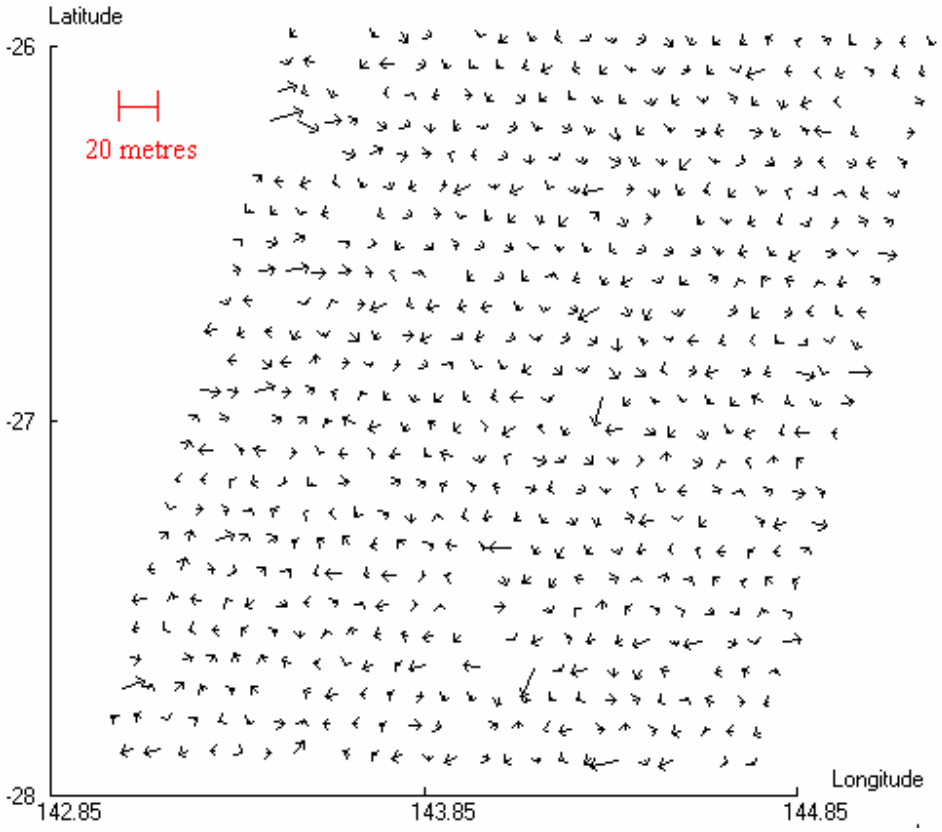

Figure 3 Discrepancies at the matched points between the ETM+ scenes acquired on 14 Aug 99 and 6 Oct 01

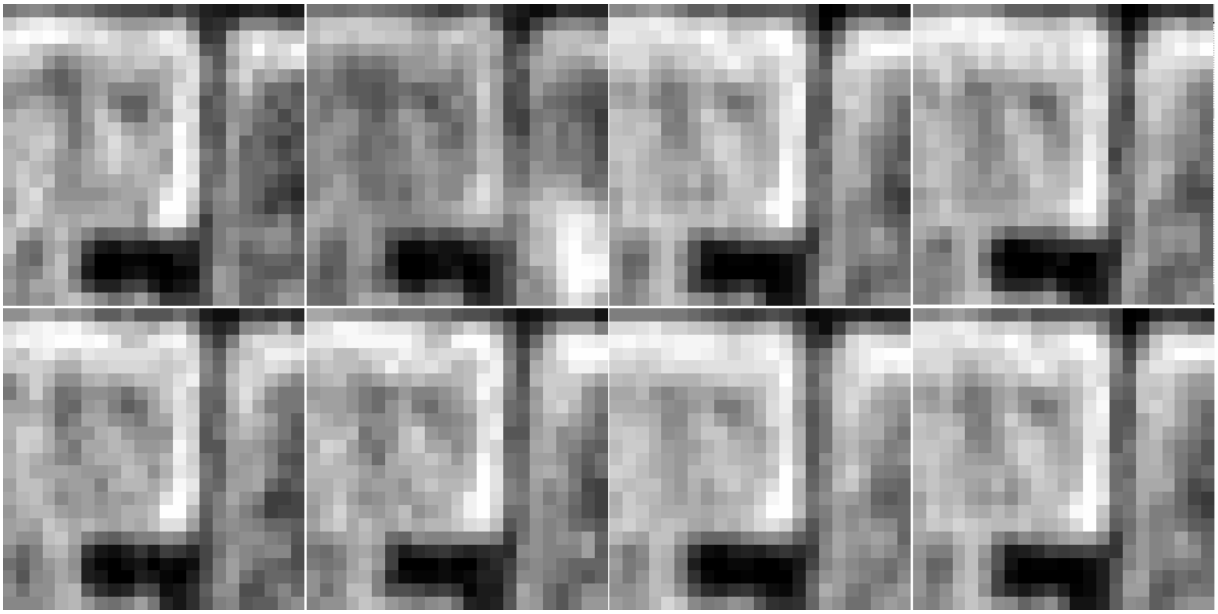

Figure 4 Example of sub pixel registration when displaying the eight ETM+ scenes together through geo-linking. Date of Acquisition (from left to right then top to bottom): 14 Aug 99, 15 July 00, 8 Feb 01, 13 April 01, 16 June 01, 3 Aug 01, 6 Oct 01 and 10 Jan 02.

(b) Assessment by the Department of Environment and Heritage (DEH), South Australia

DEH conducted an absolute accuracy assessment on ACRES Landsat 7 orthocorrected imagery. Two adjacent Landsat 7 Paths, Path 97 Rows 79~84 (acquired on 22 February 2001) and Path 98 Rows 79~84 (acquired on 20 September 1999) were examined by DEH. Approximately 114 checkpoints (with a planimetric accuracy of 7 metres (1s)) were used to assess the locational accuracy of ACRES orthocorrected imagery. The extent of the test area is shown in Figure 5. The RMS x,y error of these checkpoints was ± 13 metres.

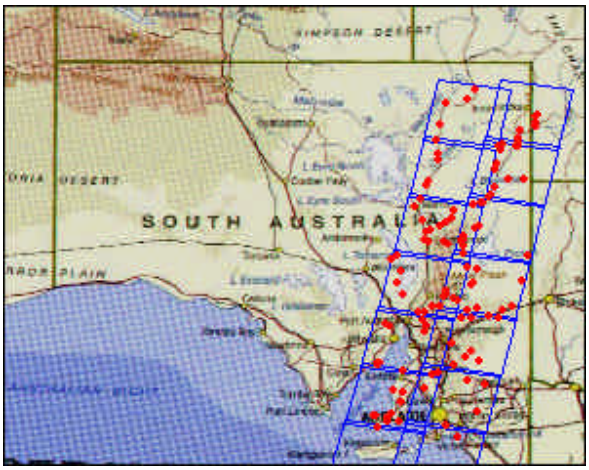

Figure 5 Distribution of the checkpoints

(c) Assessment by the Department of Land Administration (DOLA), West Australia

DOLA has also conducted an absolute accuracy assessment on ACRES Landsat 7 orthocorrected imagery in the Kimberley Region of Western Australia.

Three ACRES Landsat 7 ortho products acquired on the: -
17 May 2001, 6 September 2001, and 24 October 2001

were examined to determine the locational accuracy of ACRES orthocorrected products.

Eighteen evenly distributed checkpoints were identified in each of the three scenes (Figure 6). The location of each of the checkpoints was estimated to the nearest half pixel (6.25 metres) both along the East-West and North-South image axes. The image and ground coordinates of each of the checkpoints were compared. The greatest difference measured was 14 metres, with the smallest residuals associated with checkpoints located near the centre of the image. The RMS x,y error for all fifty-four measurements (18 x 3) was 7.4 metres.

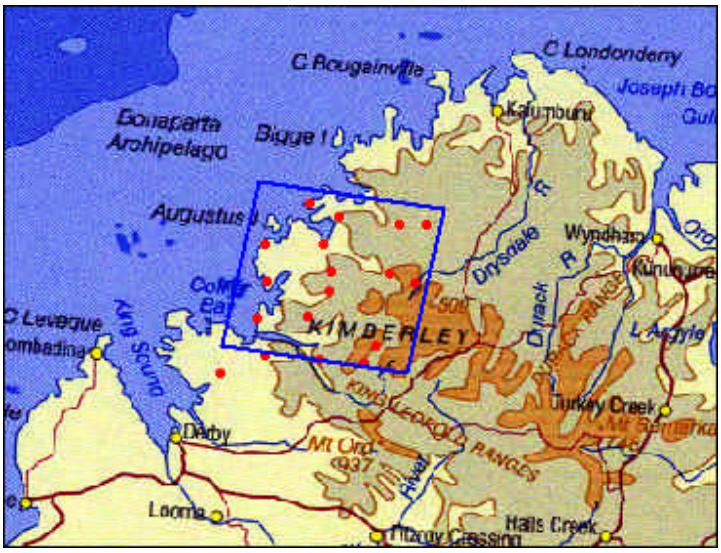

Figure 6 Distribution of the checkpoints

Conclusions

The positional accuracy of ACRES orthocorrected products has been significantly improved through the use of SCPs. Results from the two independent assessments have shown that the absolute positional accuracy was ± 7.4 and ± 13 metres (RMS x,y). It is much superior to the old ACRES orthocorrected product which used GCPs sourced from paper maps (normally at 1:100 000 scale).

The new refined ACRES SCP orthocorrected product is spatially consistent. In the quantitative comparison of matching result between the eight multi-temporal products, it was found that the mean difference is smaller than 0.15 pixel throughout the 28 comparison pairs, and the difference in standard deviation is between 0.24~0.47 pixel with a mean value of 0.34 pixel. An important conclusion can be drawn from this result is that the sub pixel registration of multi-temporal Ortho products is achievable with the use of ACRES SCPs in Ortho product generation.

Acknowledgments

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