On-orbit Geometric Characterization of IKONOS

Summer 2001

Brookings, SD Site

Presented by

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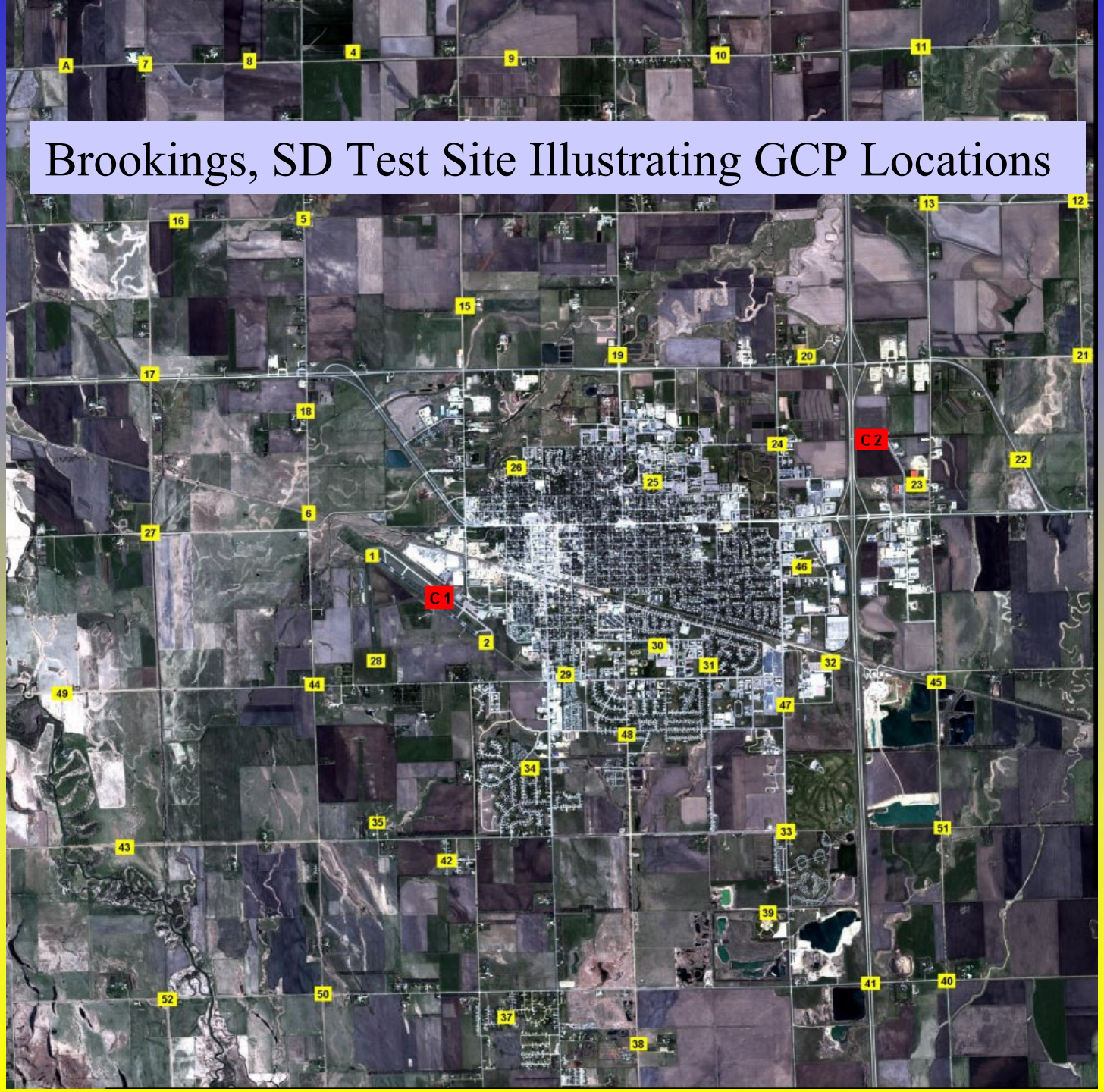
SOUTH DAKOTA STATE UNIVERSITY

On-orbit Geometric Characterization of IKONOS

Outline

- Description of Brookings Test Site
- Evaluation of Summer 2001 collects
- Comparison to Summer 2000
- Removal of terrain effects
- Conclusions

Brookings, SD Test Site Illustrating GCP Locations



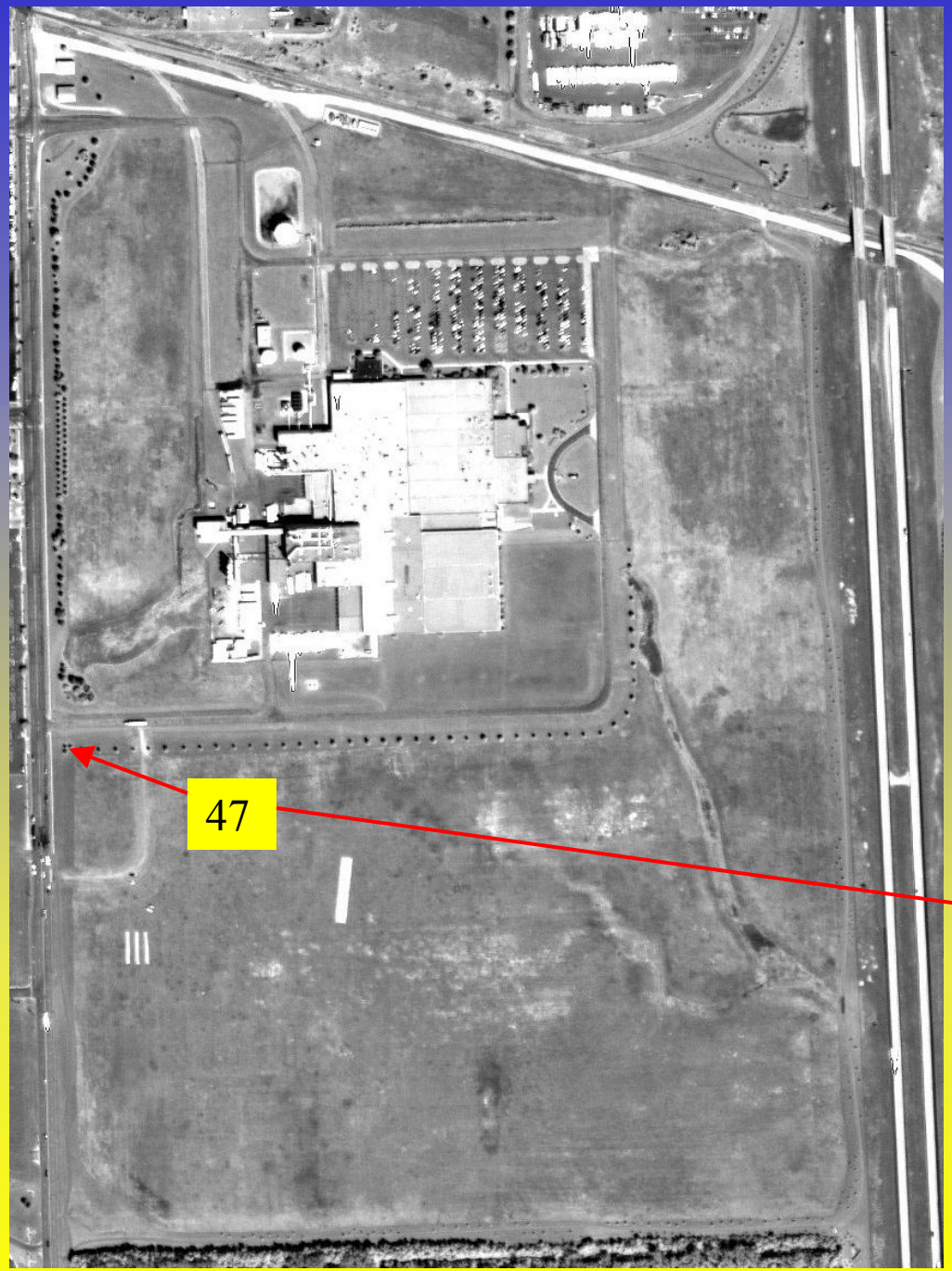
Summer 2000 Survey Activities

Location of USGS Survey marker, C2, in previous slide.

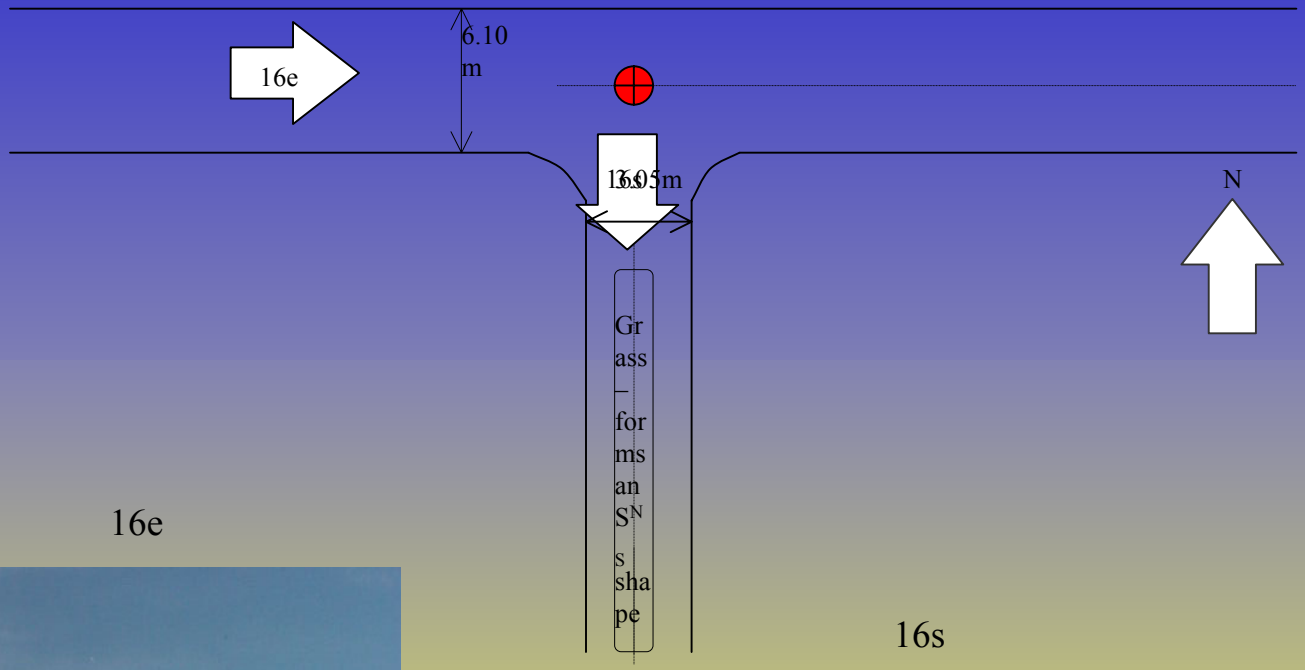
Stennis Space Center ‘GRIT’ sets up the GPS base station while SDSU students observe.

Typical locations of GCP's at the Brookings site.

IKONOS Image of Brookings, SD Test Site on June 30, 2000



Point 16

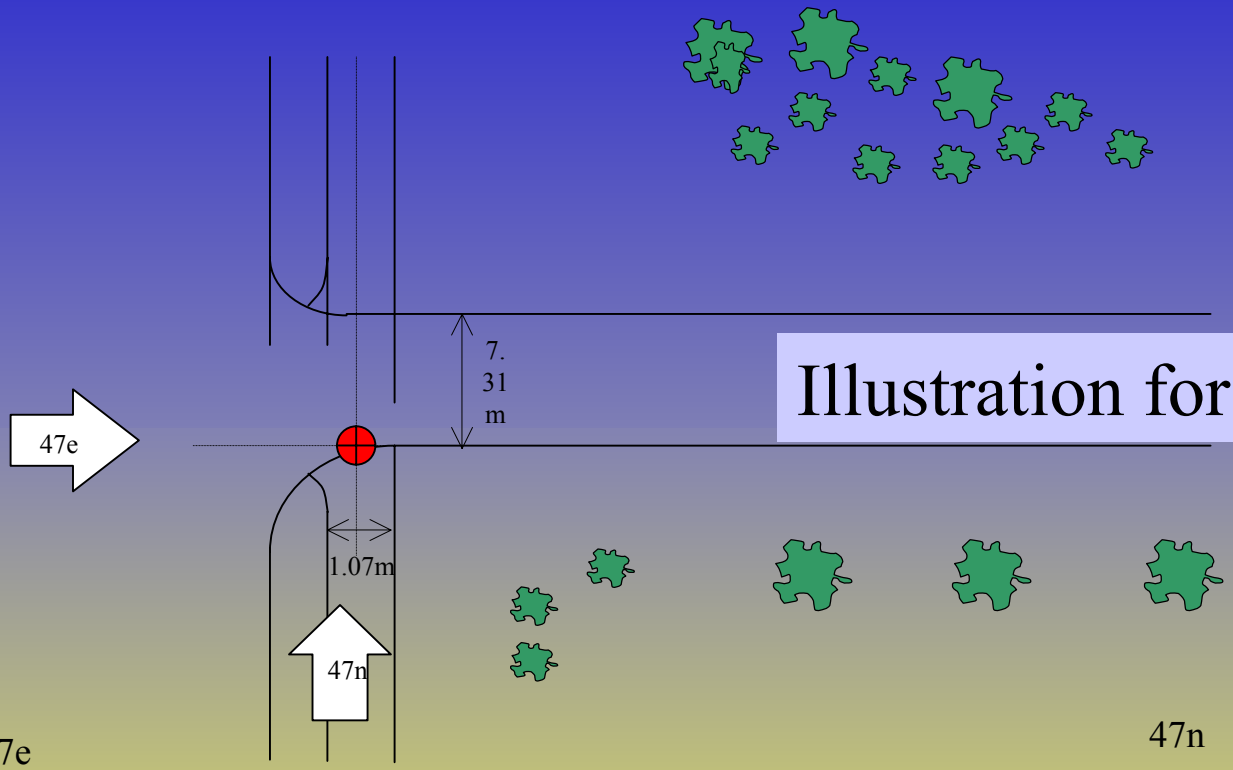


16e

16s

Illustration for GCP #47

Point 47



47e

47n

Summer 2001 Brookings Collects

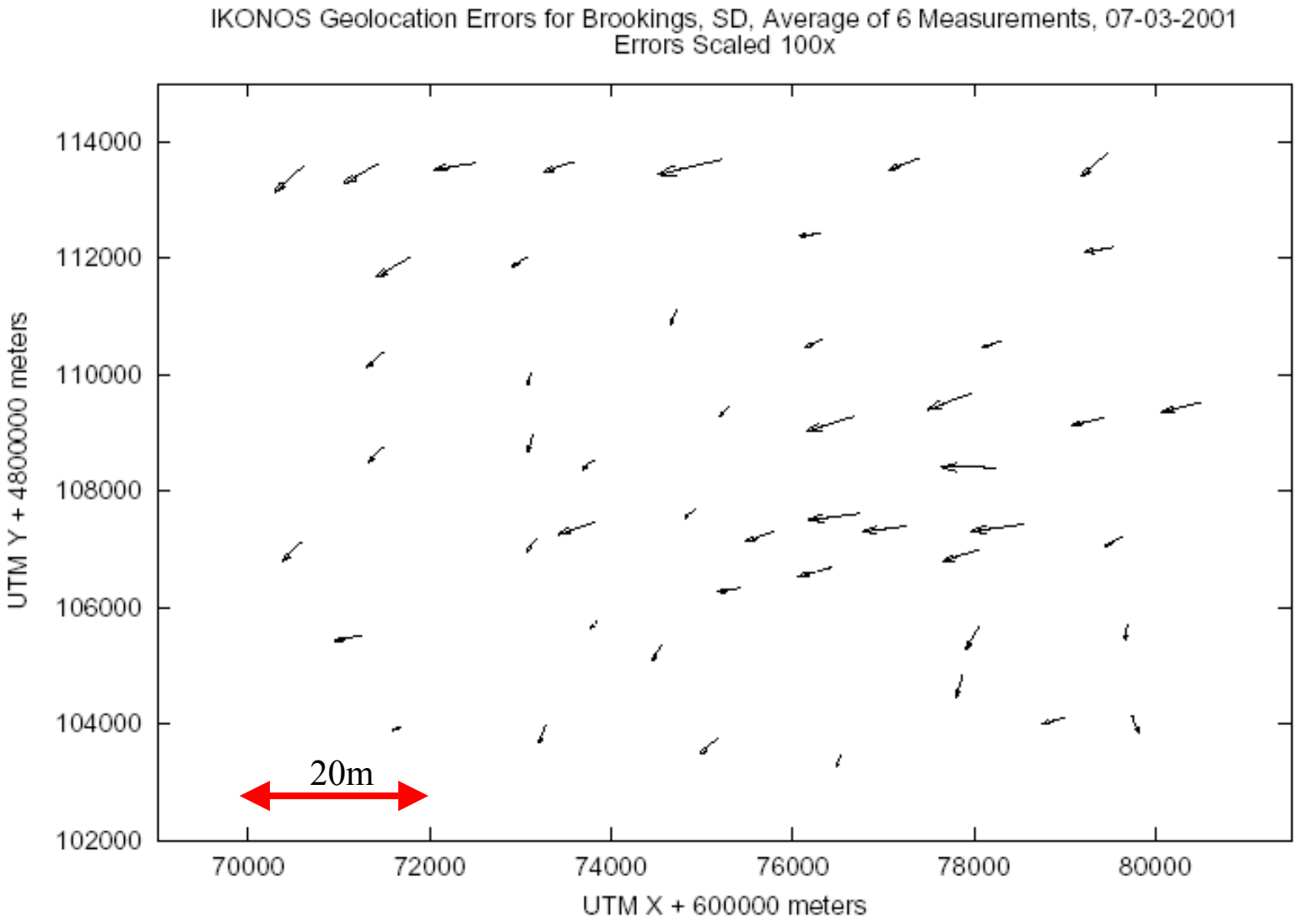
Date	Azimuth (degrees)	Elevation (degrees)
July 3	281.85	76.19
July 17	289.94	60.80
July 25	269.50	73.20
August 13	353.76	82.54

- All data sets analyzed were ‘standard’ products.

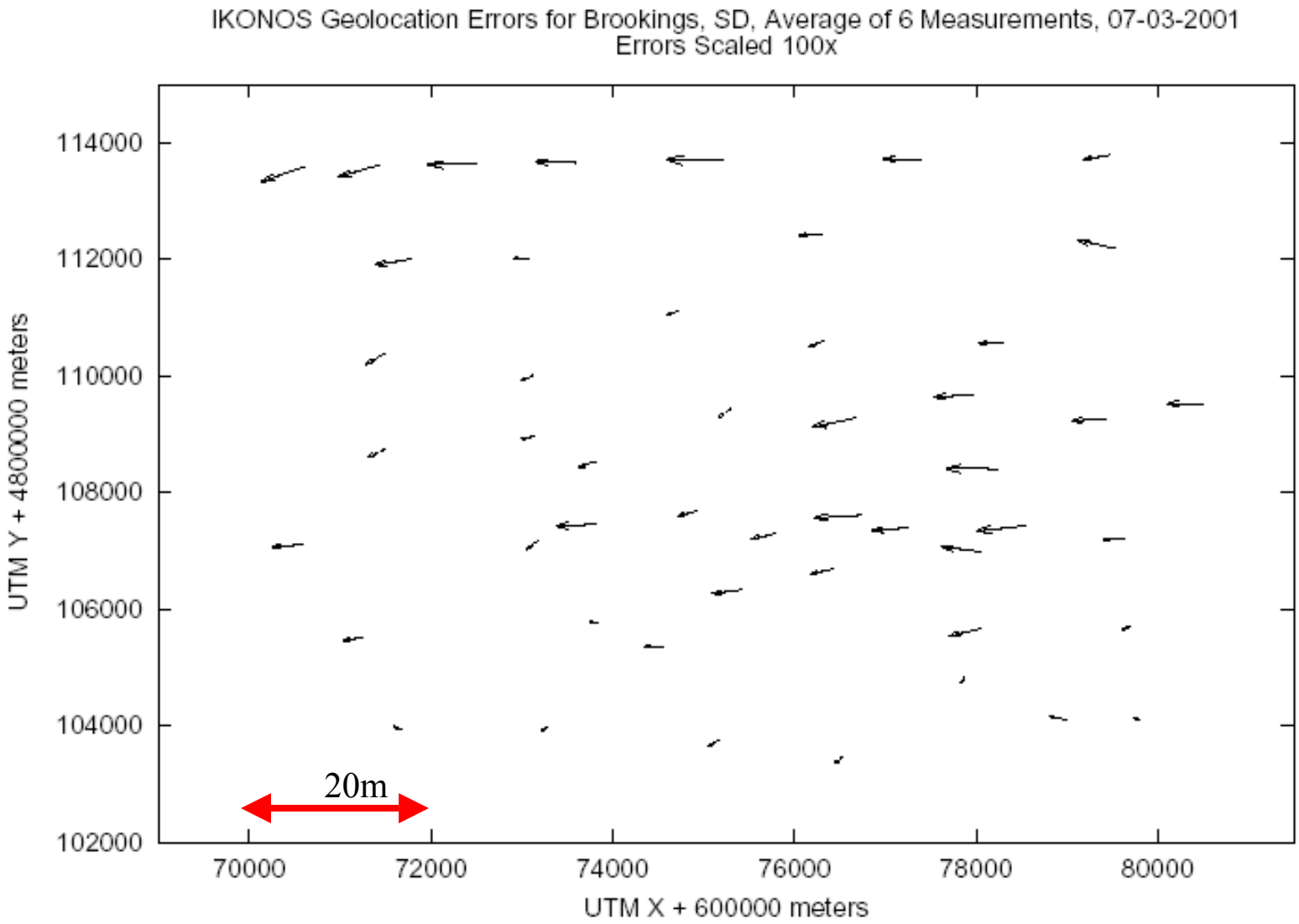
BROOKINGS SUMMER 2001 GEOMETRIC RESULTS
JULY 3

MULTISPECTRAL BANDS										
BROOKINGS, SD TARGET										
3-Jul-01										
Operator	**Mean Northing Error**	**Northing Error Std.**	**Mean Easting Error**	**Easting Error Std.**	**Mean Error**	**Mean Error Std.**	**Northing RMSE**	**Easting RMSE**	**RMSE**	**CE 90%**
CA	3.06	1.42	1.94	2.35	4.20	1.71	3.36	3.03	4.53	4.60
TI	1.21	0.72	2.33	1.61	2.88	1.32	1.40	2.83	3.16	2.96
RA	2.25	1.24	1.46	1.95	3.27	1.35	2.57	2.43	3.53	3.88
JA	2.62	1.18	2.67	2.04	4.18	1.44	2.87	3.35	4.41	3.95
MA	1.82	1.36	1.35	2.30	3.17	1.46	2.26	2.65	3.48	4.47
JO	3.96	2.05	0.92	2.42	4.76	1.95	4.45	2.57	5.14	5.32
MAX	3.96	2.05	2.67	2.42	4.76	1.95	4.45	3.35	5.14	5.32
MEAN	2.49	1.33	1.78	2.11	3.74	1.54	2.82	2.81	4.04	4.20
MIN	1.21	0.72	0.92	1.61	2.88	1.32	1.40	2.43	3.16	2.96

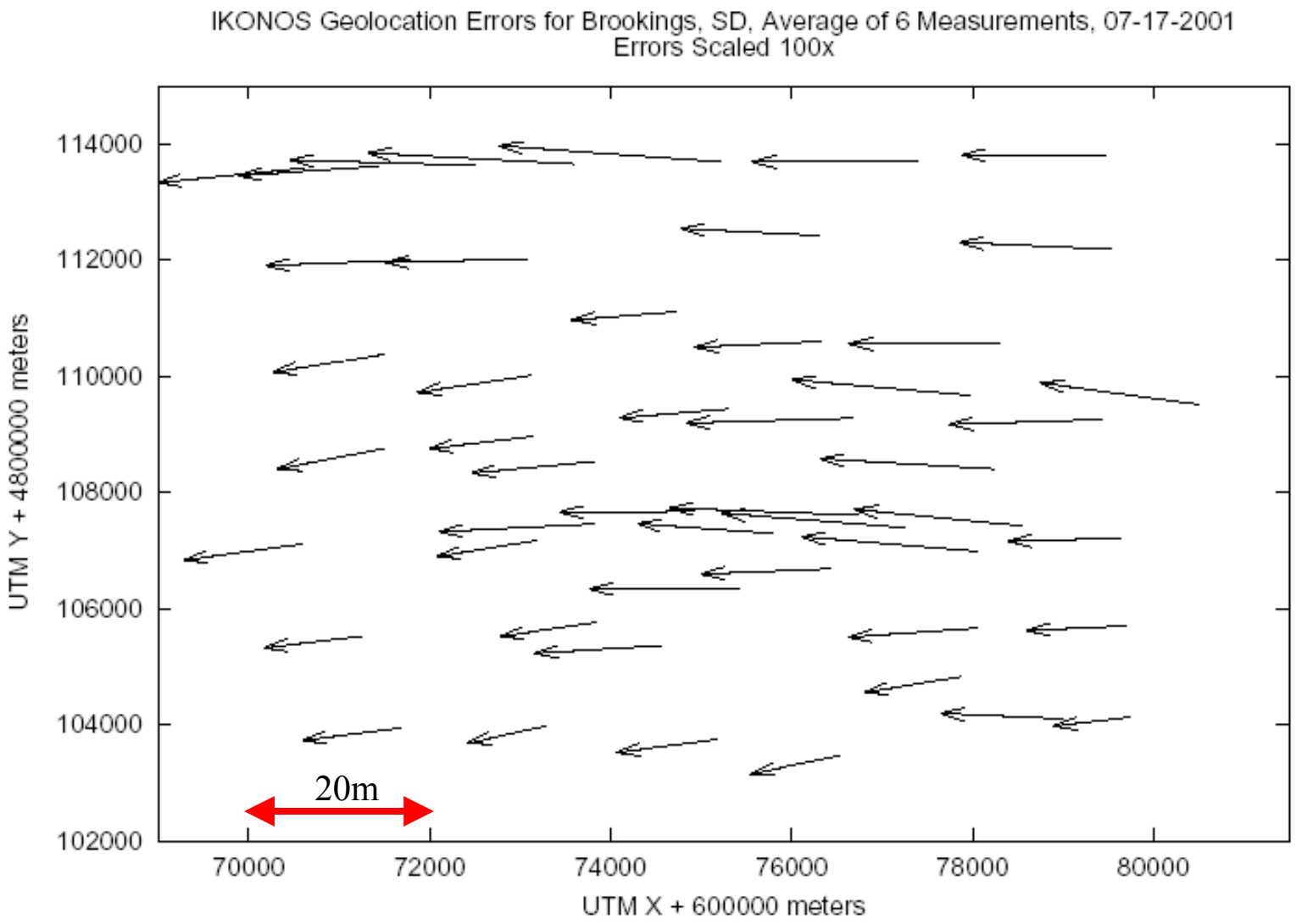
IKONOS Multispectral Bands, Brookings, July 3, 2001



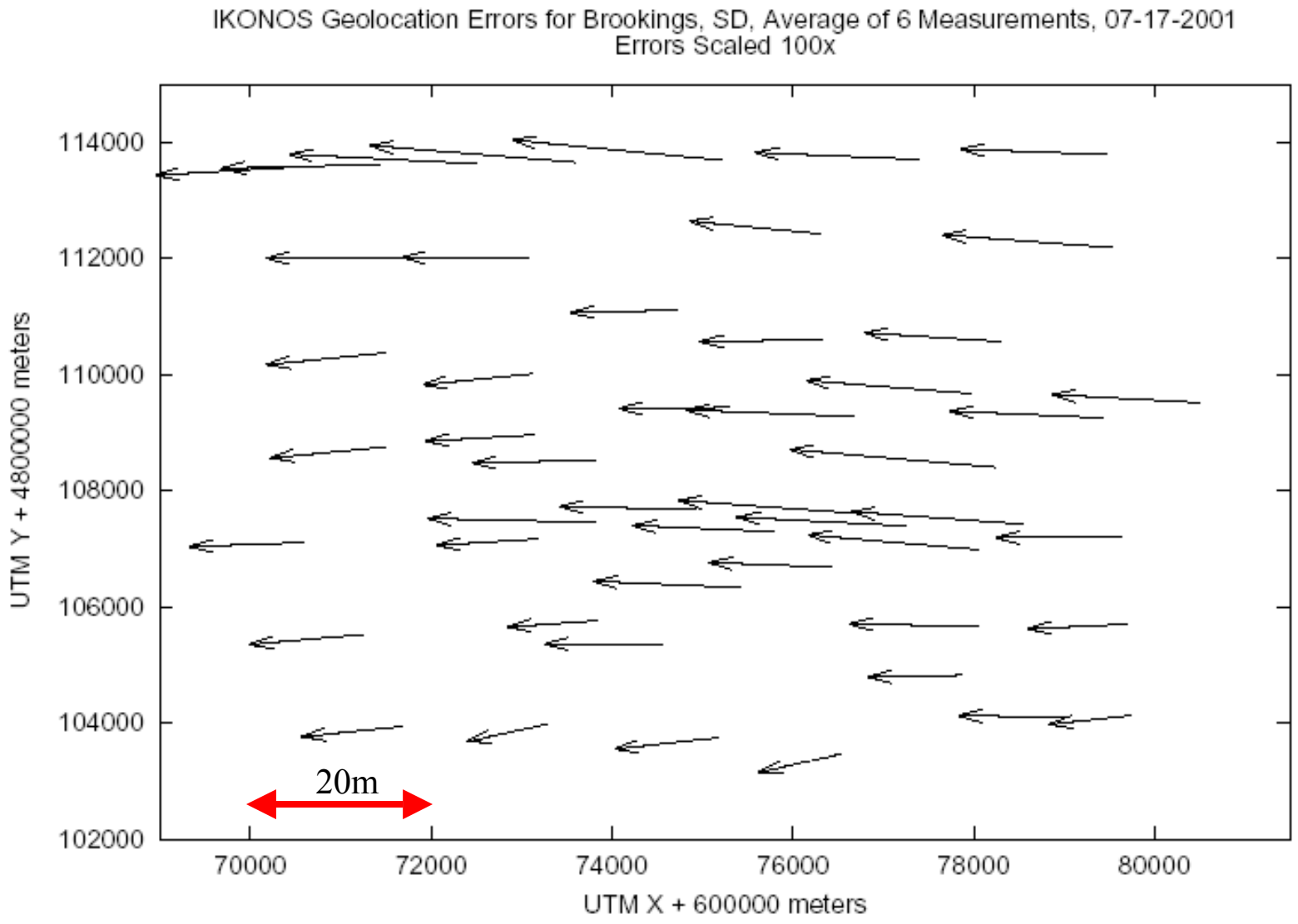
IKONOS Pan Band, Brookings, July 3, 2001



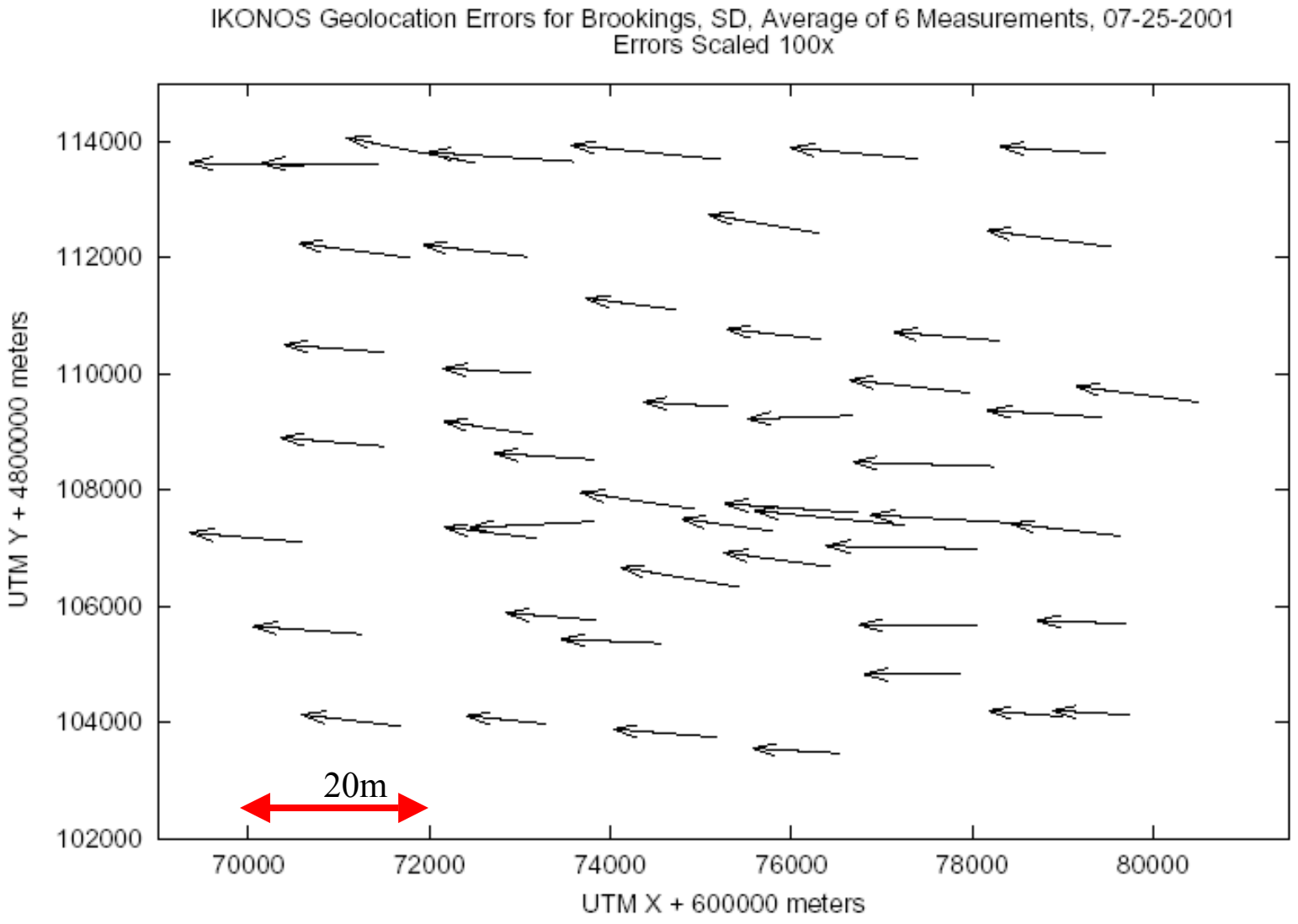
IKONOS Multispectral Bands, Brookings, July 17, 2001



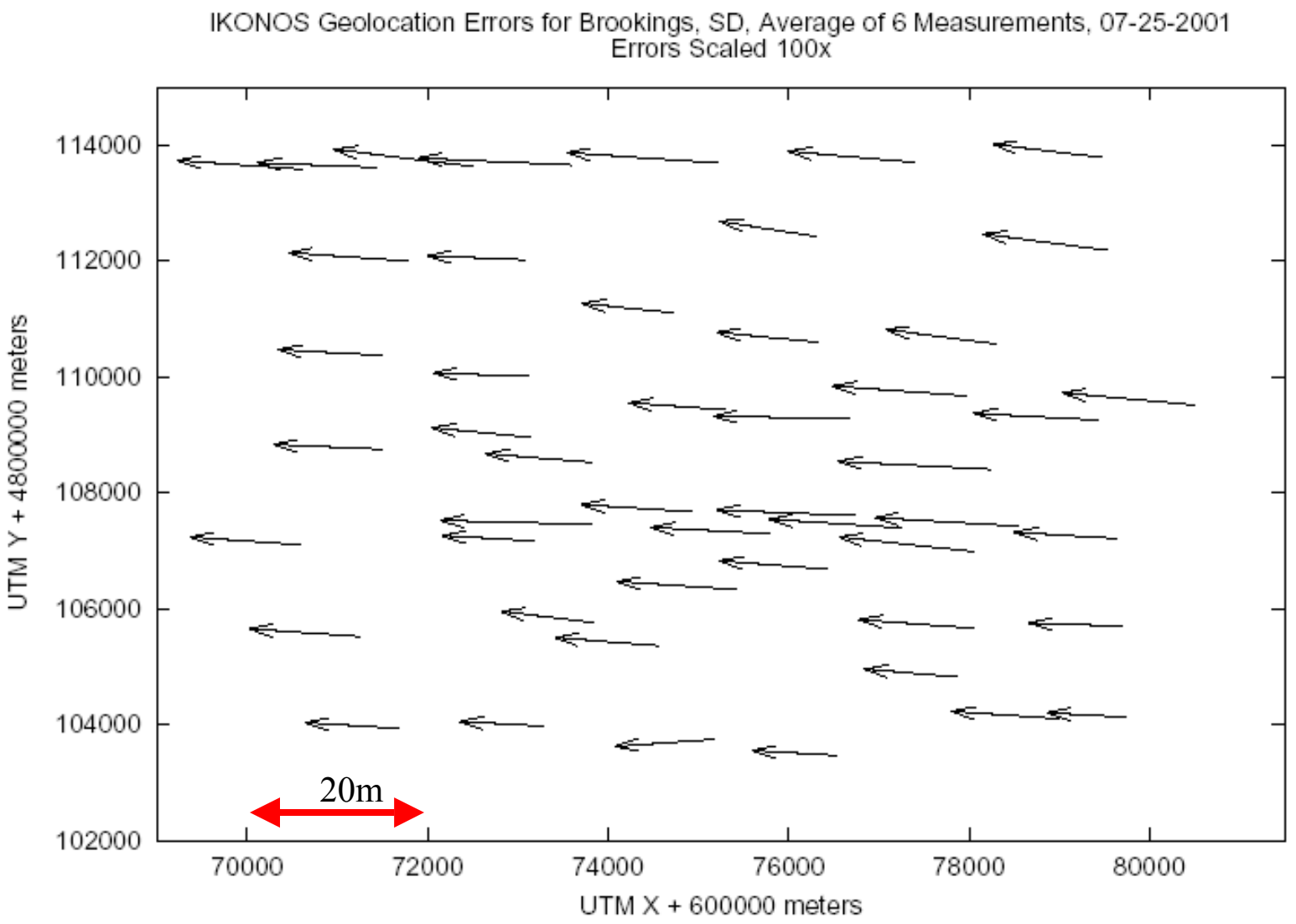
IKONOS Pan Band, Brookings, July 17, 2001



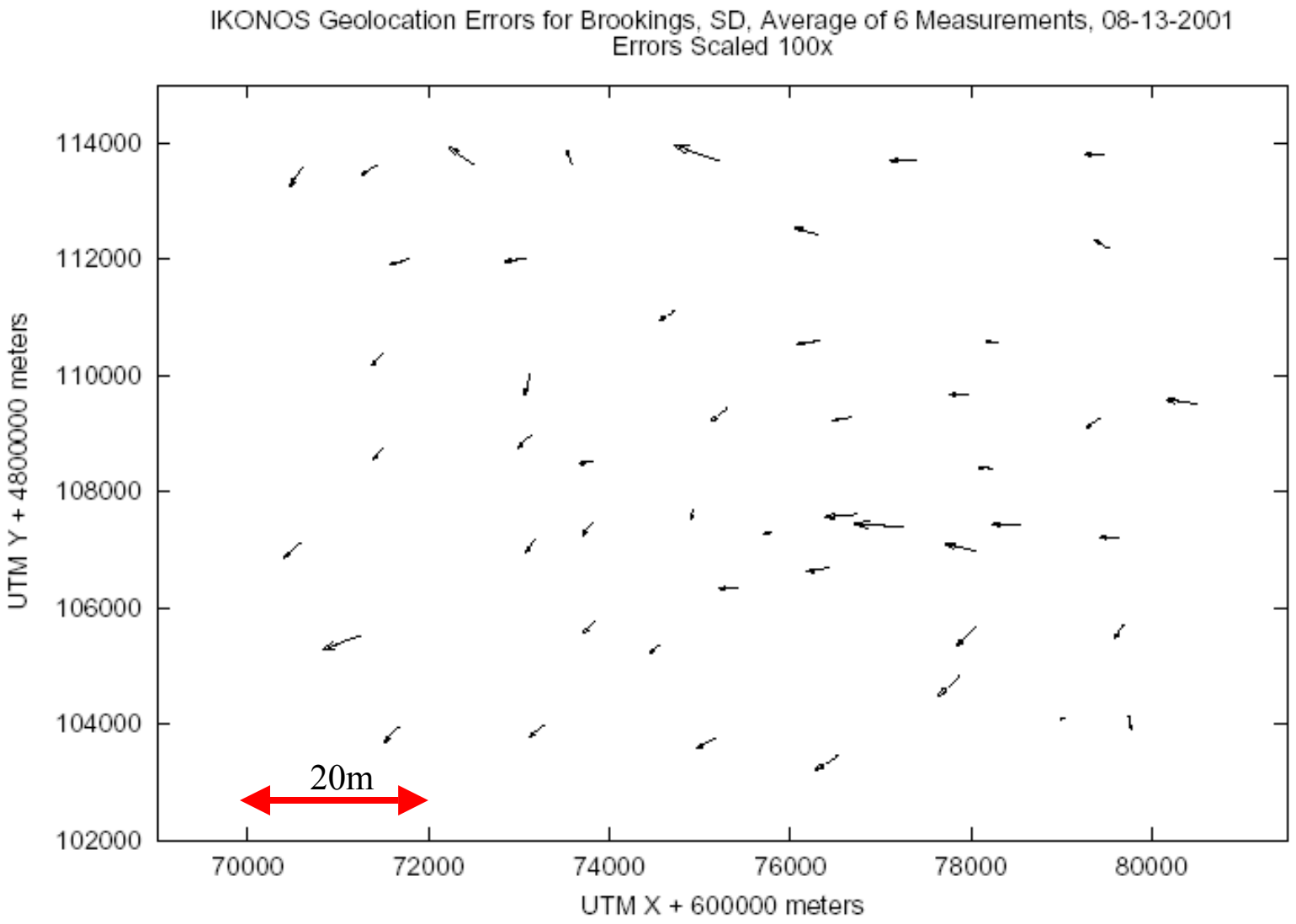
IKONOS Multispectral Bands, Brookings, July 25, 2001



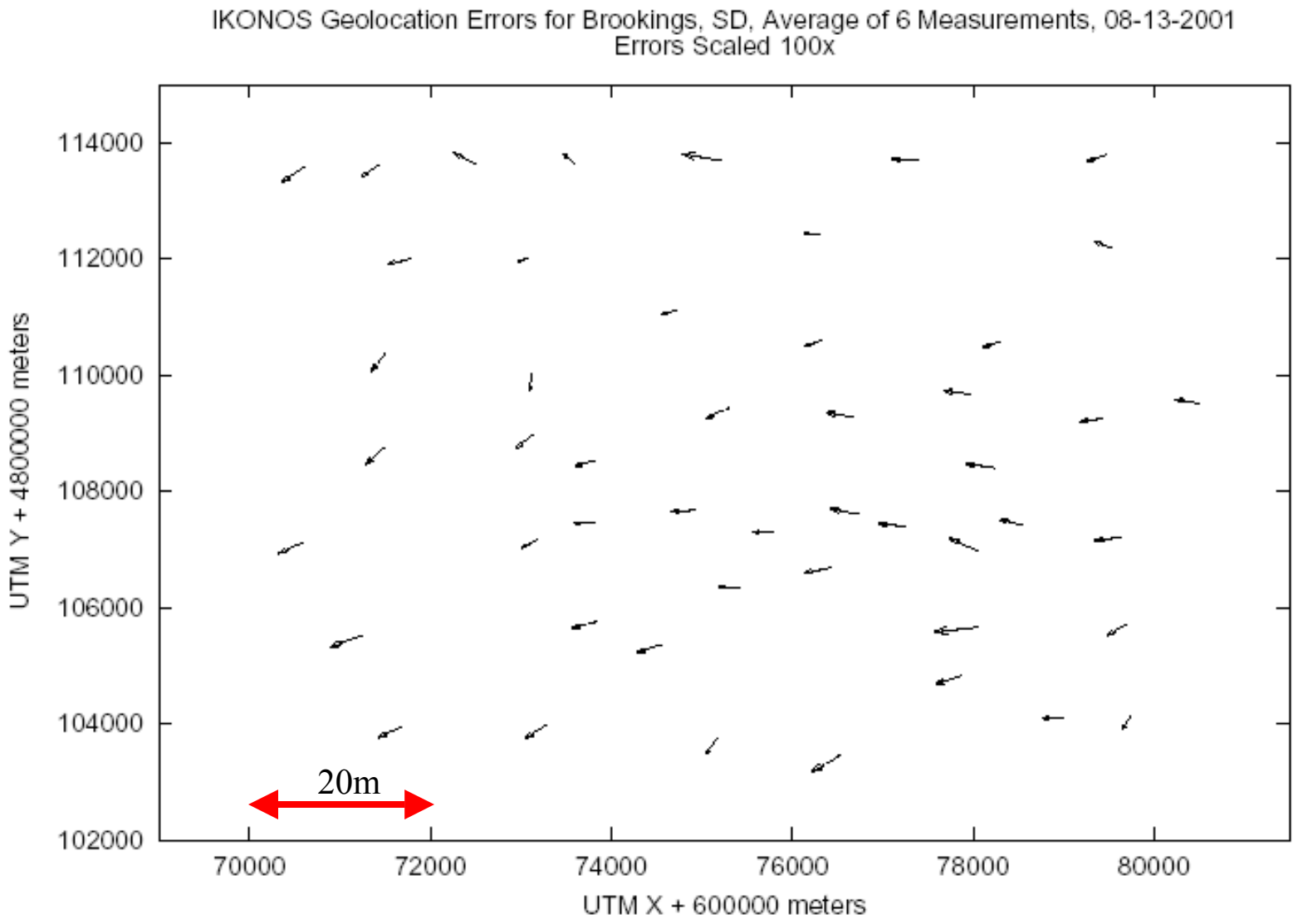
IKONOS Pan Band, Brookings, July 25, 2001



IKONOS Multispectral Bands, Brookings, Aug 13, 2001



IKONOS Pan Band, Brookings, Aug 13, 2001



BROOKINGS SUMMER 2001 GEOMETRIC RESULTS

PANCHROMATIC BAND										
BROOKINGS, SD TARGET										
Date	Mean Northing Error	Northing Error Std.	Mean Easting Error	Easting Error Std.	Mean Error	Mean Error Std.	Northing RMSE	Easting RMSE	RMSE	CE 90%
7/3/2001	1.34	0.87	2.03	1.77	2.89	1.29	1.62	2.70	3.16	3.30
7/17/2001	0.63	1.70	14.15	3.93	14.30	3.82	1.85	14.68	14.79	7.18
7/25/2001	-0.50	0.86	11.75	2.33	11.80	2.33	1.02	11.98	12.03	4.18
8/13/2001	1.51	1.50	1.59	0.99	2.68	0.96	2.12	1.89	2.84	3.02

MULTISPECTRAL BANDS										
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7/25/2001	-0.69	1.33	11.26	2.74	11.43	2.56	1.52	11.61	11.72	5.15
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Notes:	All measurements in meters.									
	Measurements based on 49 GCP's in and around Brookings, SD.									
	Six different individuals were involved with the analysis of each scene.									

BROOKINGS SUMMER 2001 GEOMETRIC RESULTS

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BROOKINGS SUMMER 2001 GEOMETRIC RESULTS

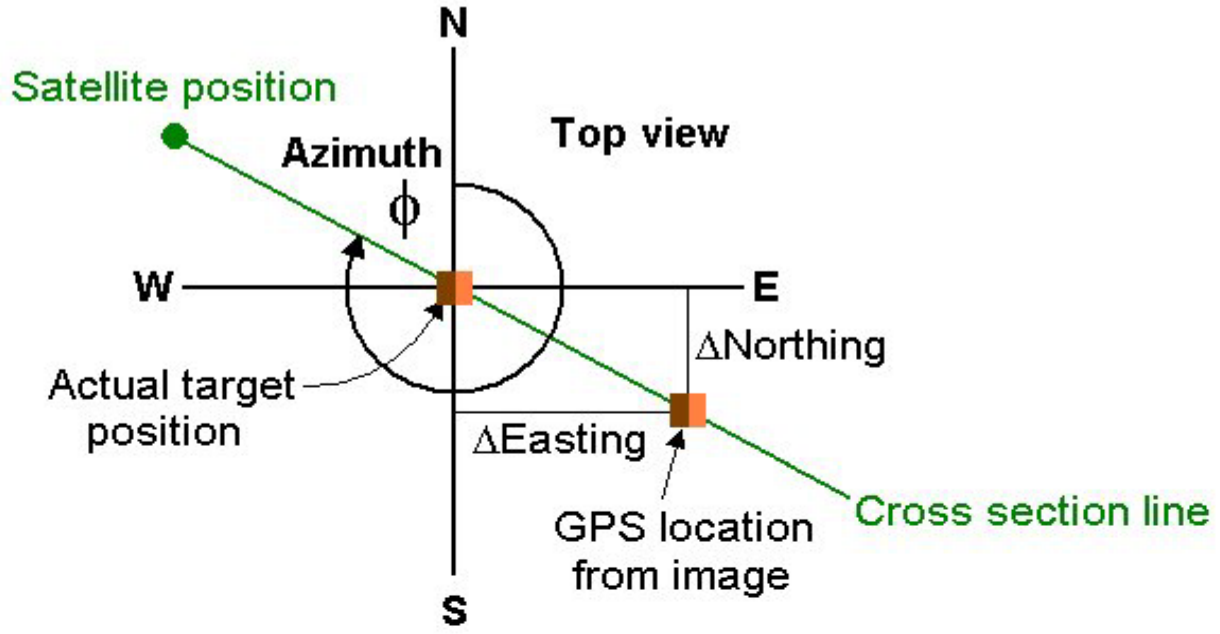
DISCUSSION

- All data products exhibited geometric accuracy well within specifications.
- Northing errors tended to exhibit a positive bias on the order of 0.75 meters Pan band and 1.25 meters multispectral bands.
- Easting errors tended to be correlated with the elevation angle. Lower elevation ($<75^{o}$) resulted in larger errors, 12.5 meters, while higher elevations ($>75^{o}$) generated errors close to 2 meters.
- CE90 values hover around 3 meters with larger elevation angles while lower elevation angles give CE90 value as large as 8 meters. Errors tend to be circular at higher elevation angles.

Comparison to Summer 2000 Geometry Results

Comparison of Summer 2000 and 20001 Results			
		Multispectral	Pan
	Date	CE 90%	CE 90%
	5/22/2000	9.14	7.81
	6/30/2000	6.57	5.41
	7/3/2001	4.20	3.30
	7/17/2001	8.38	7.18
	7/25/2001	5.15	4.18
	8/13/2001	4.12	3.02

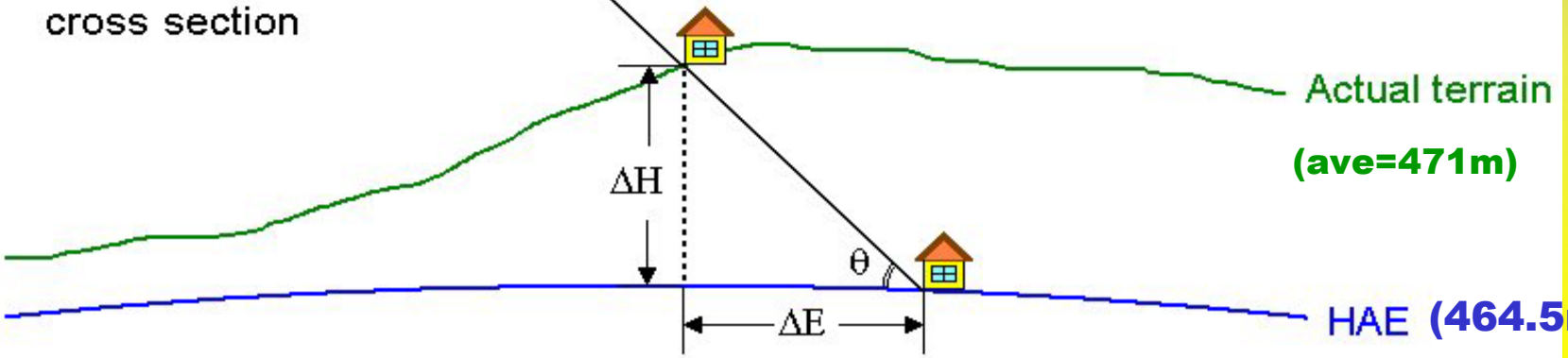
- Can large Easting errors at low elevation angles be due to terrain effects?



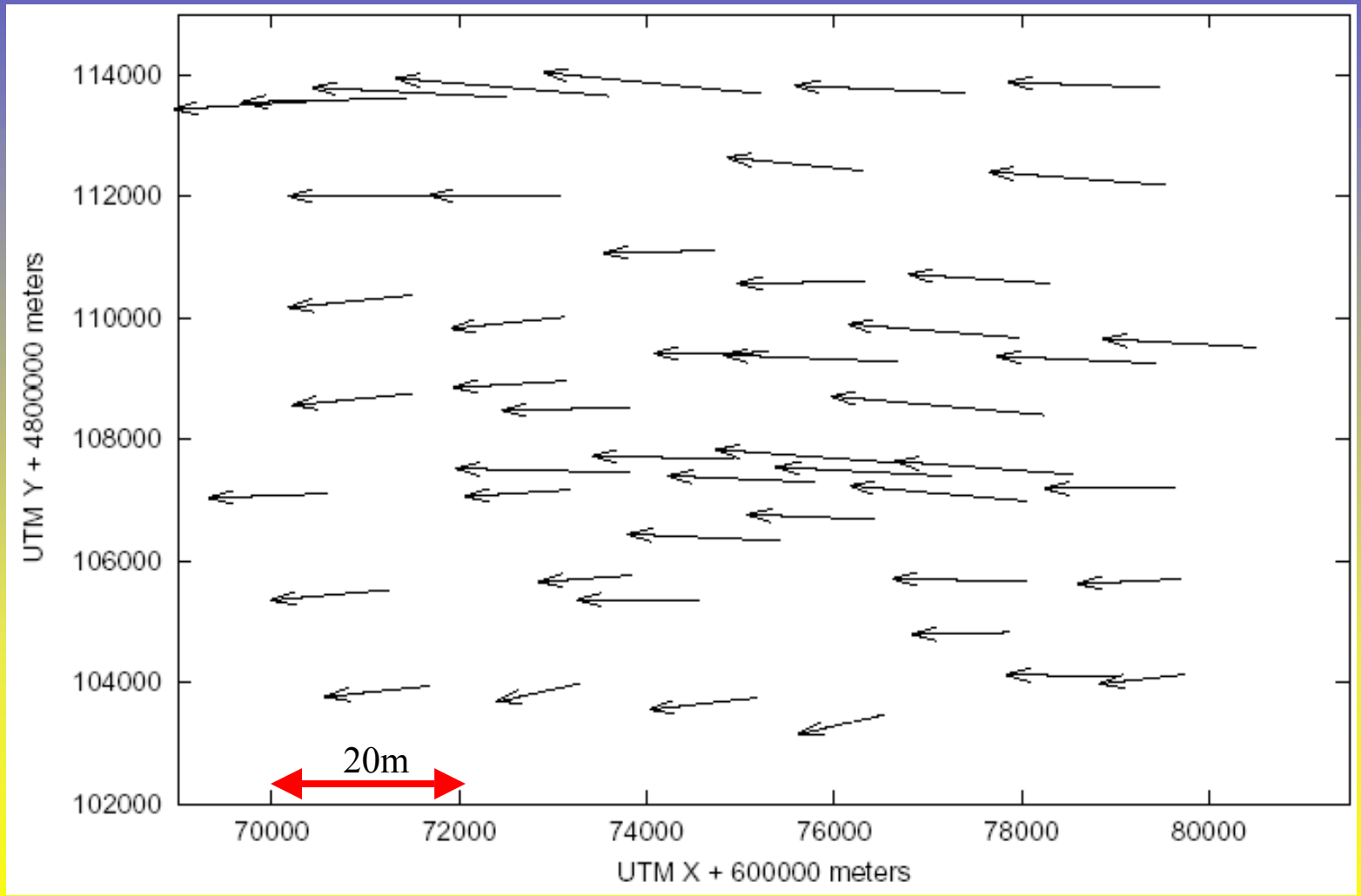
$$\Delta E = \frac{\Delta H}{\tan\theta}$$

$$\Delta\text{Easting} = \Delta E \sin\phi$$

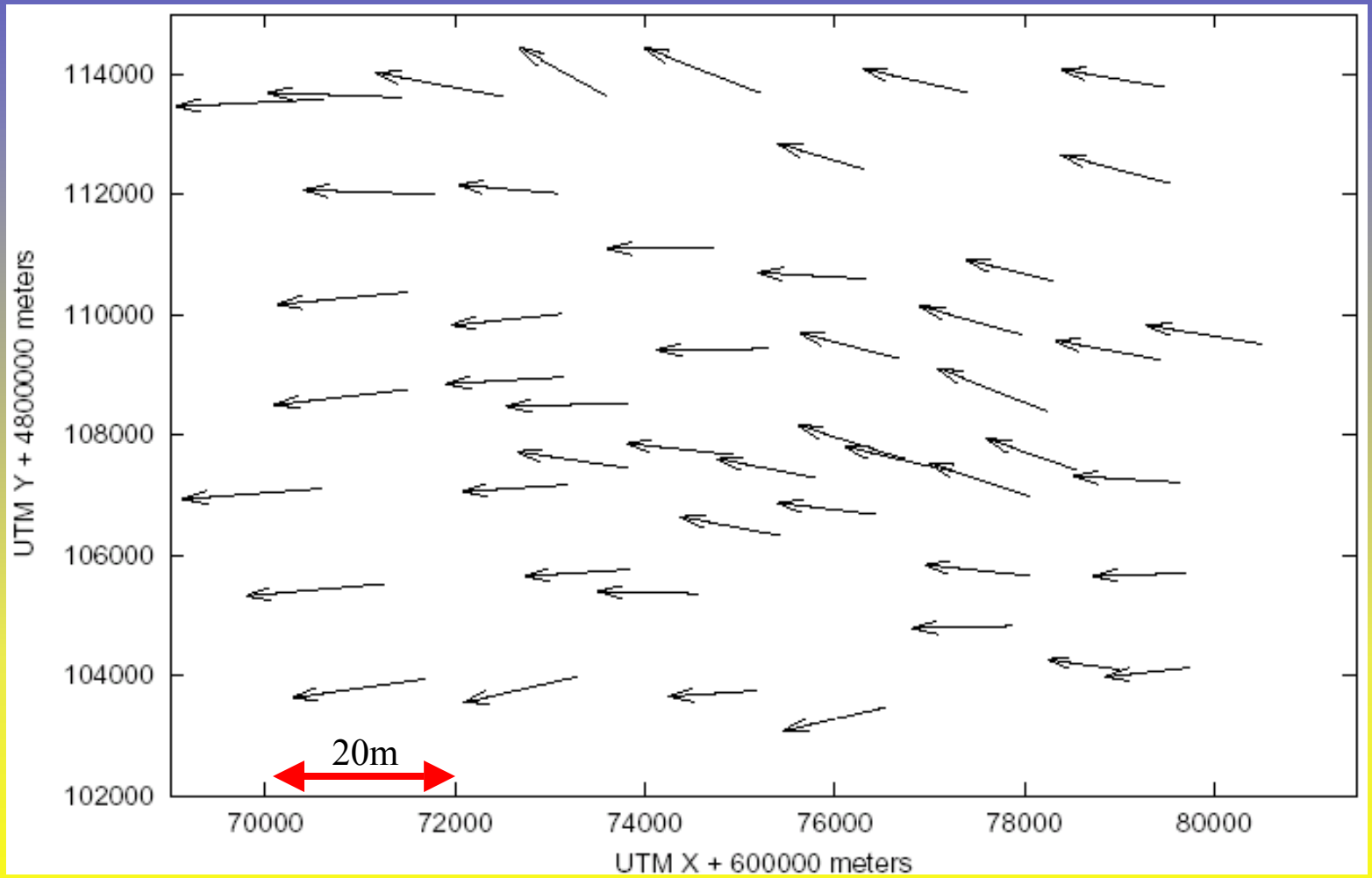
$$\Delta\text{Northing} = \Delta E \cos\phi$$



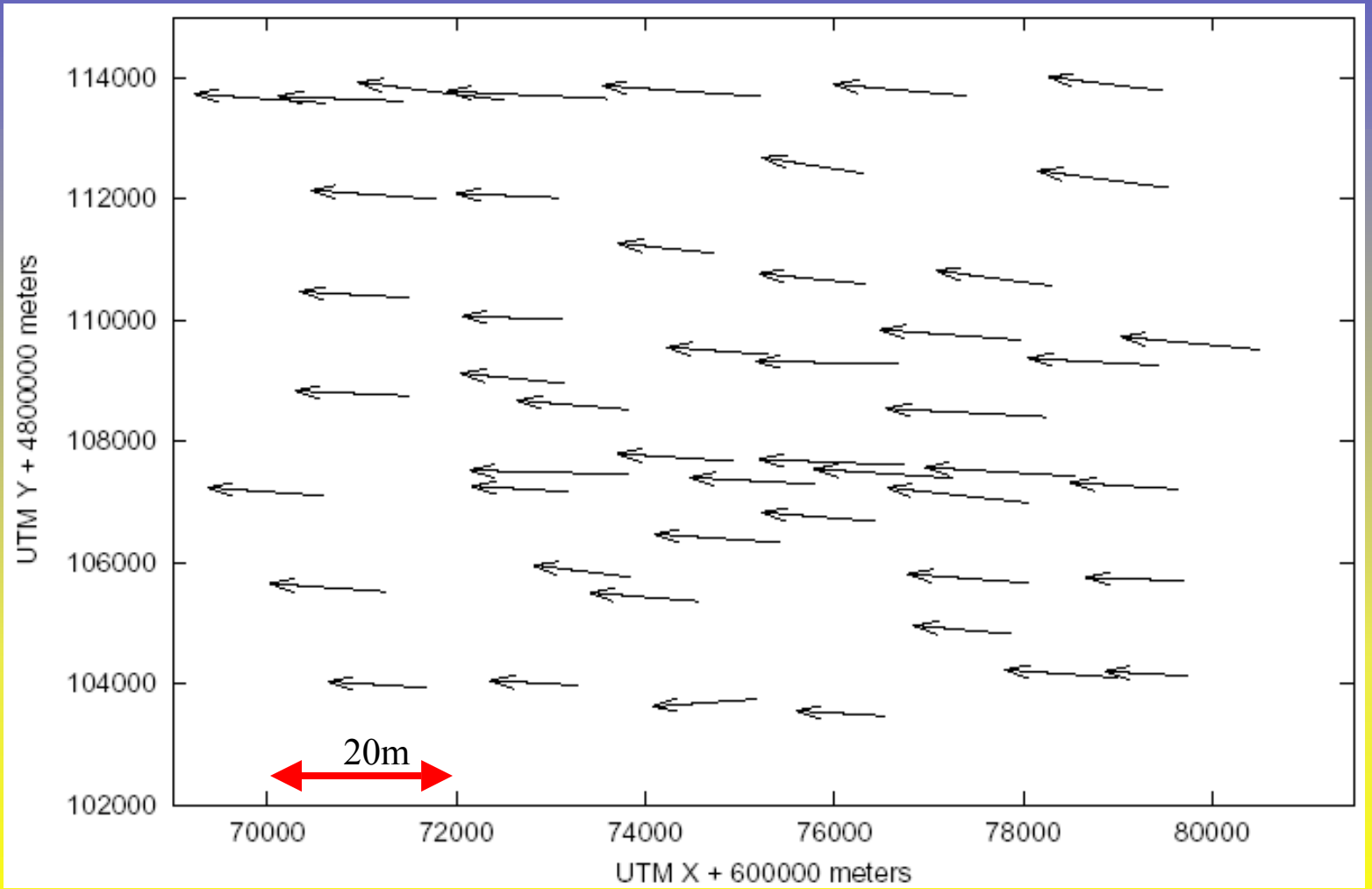
IKONOS Pan Band, Brookings, July 17, 2001



IKONOS Pan Band—Terrain Corrected, Brookings, July 17, 2001



IKONOS Pan Band, Brookings, July 25, 2001



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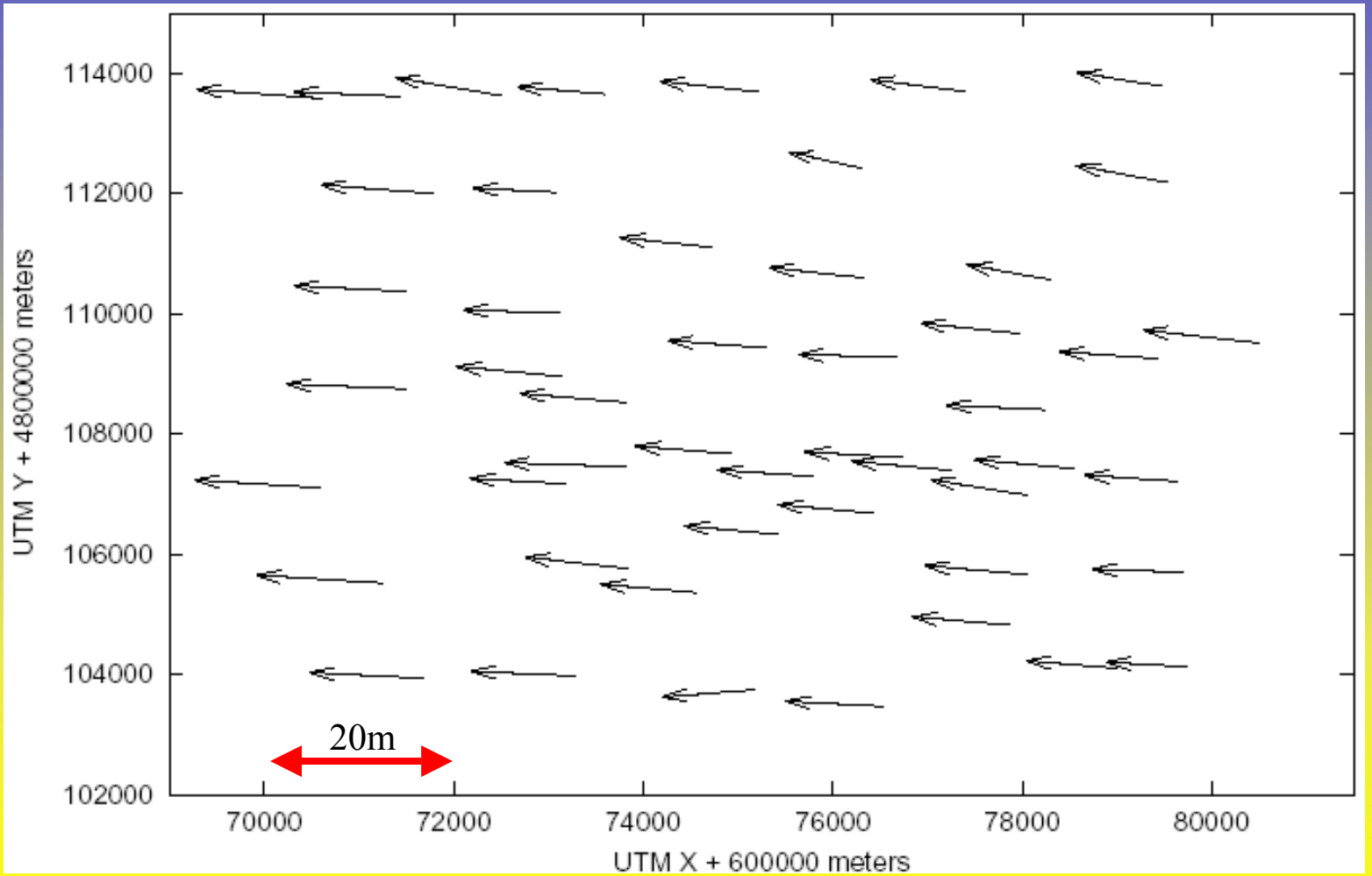
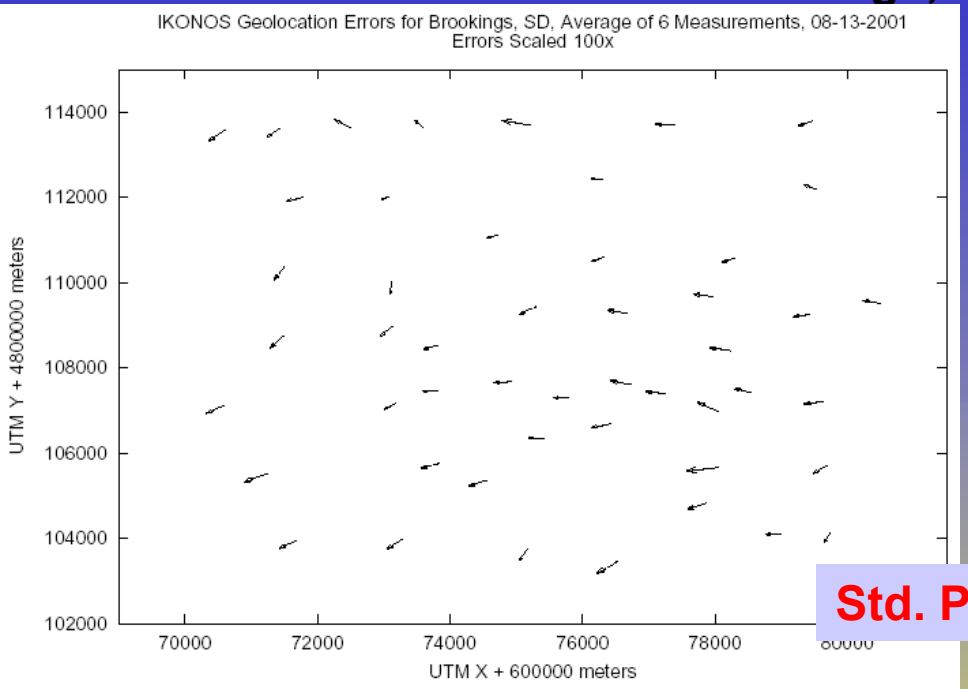
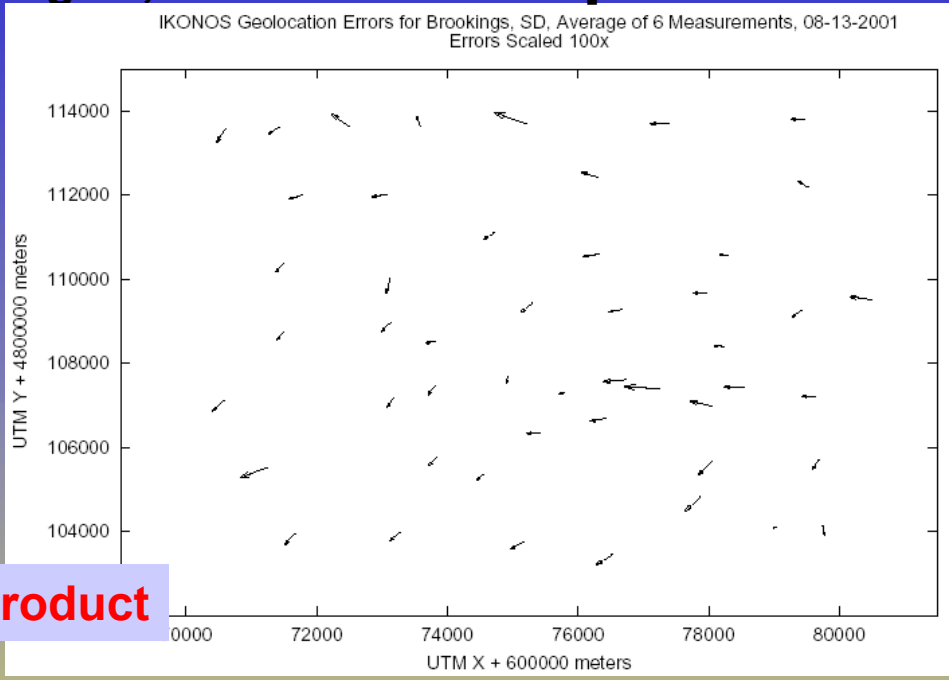
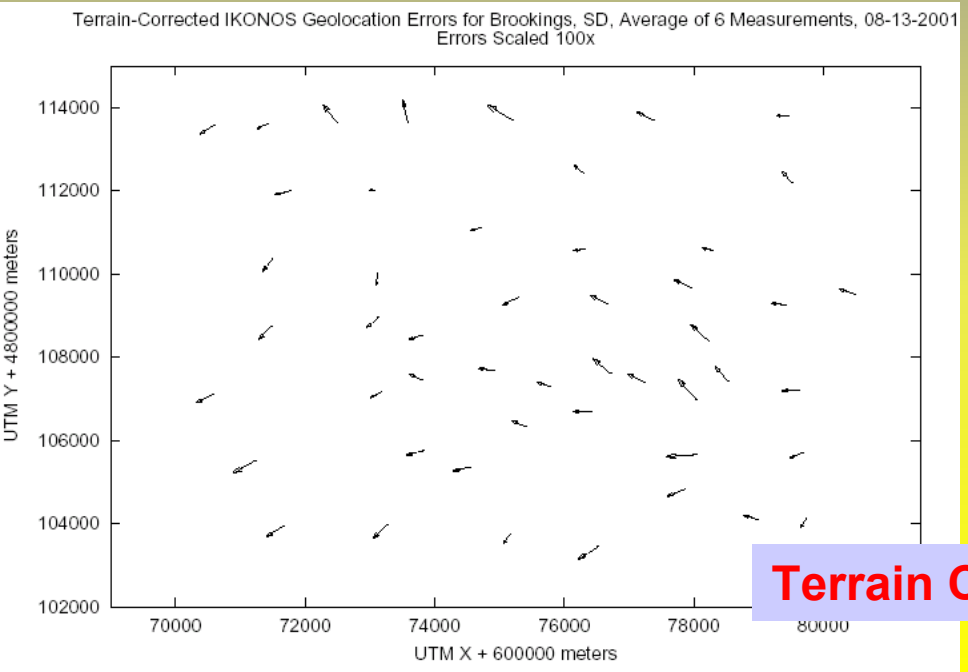


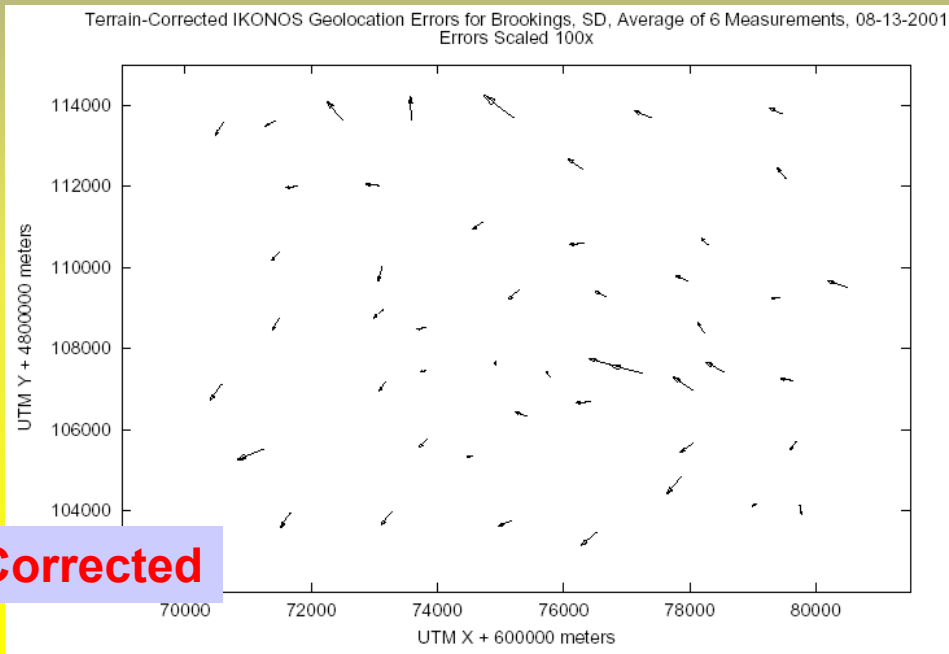
Pan Band Brookings, Aug 13, 2001 Multispectral





Std. Product





Terrain Corrected

BROOKINGS SUMMER 2001 GEOMETRIC RESULTS

Terrain Corrected

PANCHROMATIC BAND--Terrain Corrected										
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7/17/2001	-0.66	3.02	10.55	2.02	11.07	1.80	3.10	10.78	11.23	6.19
7/25/2001	-0.47	0.87	9.64	1.47	9.74	1.45	1.01	9.80	9.80	2.87
8/13/2001	0.65	2.36	1.49	1.22	2.78	1.24	2.86	1.79	3.03	4.28

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BROOKINGS SUMMER 2001 GEOMETRIC RESULTS

Terrain Corrected

MULTISPECTRAL BANDS--Terrain Corrected

BROOKINGS, SD TARGET

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7/25/2001	-0.66	1.32	9.19	2.12	9.44	1.73	1.51	9.47	9.60	4.28
8/13/2001	0.94	2.63	1.02	1.52	3.03	1.45	2.73	1.96	3.39	5.11

MULTISPECTRAL BANDS

BROOKINGS, SD TARGET

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8/13/2001	1.81	1.91	1.12	1.54	3.10	1.30	2.67	2.04	3.37	4.12

Notes: All measurements in meters.

Measurements based on 49 GCP's in and around Brookings, SD.

Six different individuals were involved with the analysis of each scene.

CONCLUSIONS

After removing terrain effects:

1. Pan band northing errors reduced to subpixel accuracy (<1m).
2. Pan band easting errors at high elevation angle (>75^{o}) close to 1m accuracy.
3. Pan band easting error reduced from 14m to 10m at low elevation angles.
    - Indicates a systematic error still present.
4. Northing/Easting RMSE approximately equal at high elevation angles (>75^{o}).
5. Pan band CE90 approximately 4m.
6. Multispectral bands show similar results.