

Introduction

- The accurate satellite orbit modeling is a key point in the most of SAR (Synthetic Aperture Radar)applications.
- Provided that a accurate state vector of ephemeris data is available, together with precise SAR processing parameters, orbit parameters can be precisely determined and CPs (Control Points) are not required.
- ♦ However, most satellite have low accurate information on its orbit data due to the precession, the nutation, or the polar motion, then the refinement process on the orbit should be done by a number of well-distributed CPs.

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But, it is very difficulty to acquire welldistributed controls point for various applications on SAR images

- Speckle noise
- Lower resolution and difficulty of visual interpretation
- Difference of image acquiring method from human eye mechanism-layover, foreshortening, shadow effect etc
- ◆ The acquisition of sufficient control points is the most tedious and time consuming step and obstacle to near real time applications, especially for SAR imagery.



Nevertheless, there were few studies that made an effort to reduce a number of CPs

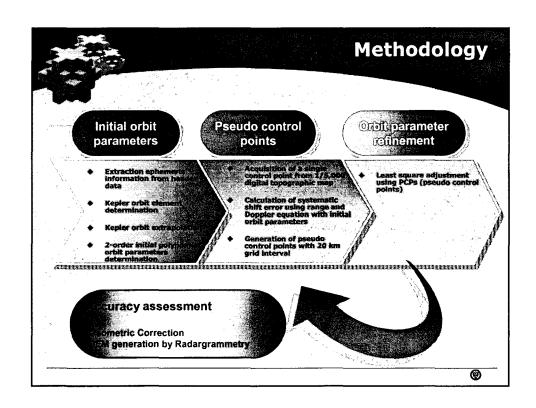
- Chen and Dowman(2001)-weighted least-squares
- Toutin(2003)-path/block adjustment
- Smith (2003)-a near real-time geocoding method to effectively remove orbit errors from computed azimuth and slant-range coordinates using the error function (ERS SAR Imagery)
- Sohn(2004)-systematic shift error compensation method for near-real time geocoding of SAR image

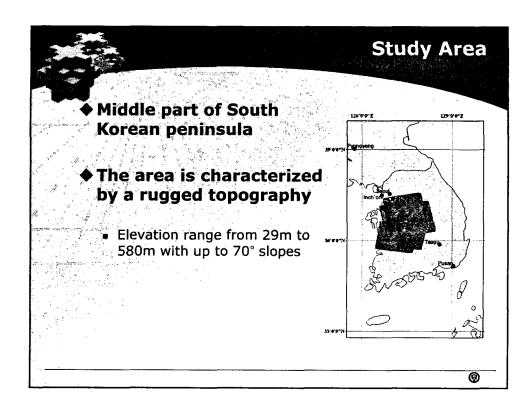


Objective

- ♦ Satellite orbit parameters determination using minimum control points (only a single control point) and ephemeris information
- ◆ Accuracy comparison of our method with conventional method that uses many control points (minimum control point is 6)
 - Rigorous geometric correction using backward geocoding method
 - Generation of digital elevation model using radargrammetry
 - Conventional method uses 10 control points and our method uses a single control point for process

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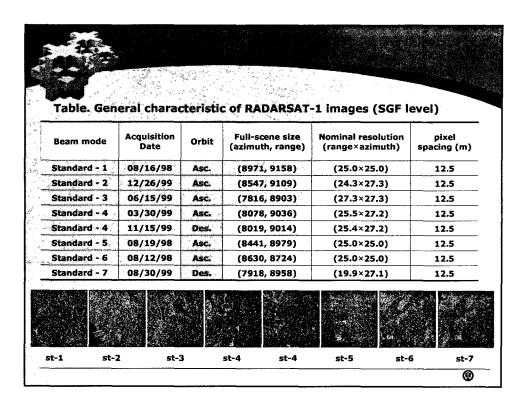




About RADARSAT Images Used for Our Study

- ♦ Orbit data is not as accurate as for other remote sensing satellites (e.g. ERS SAR imagery).
- ◆ and has the large spacing between state vector provide (8 minutes) as an inadequate interpolation may present large error.
- ◆ The images are in ground range representation (ellipsoid projection without relief correction), orbit oriented and coded in 16 bits without any radiometric processing.

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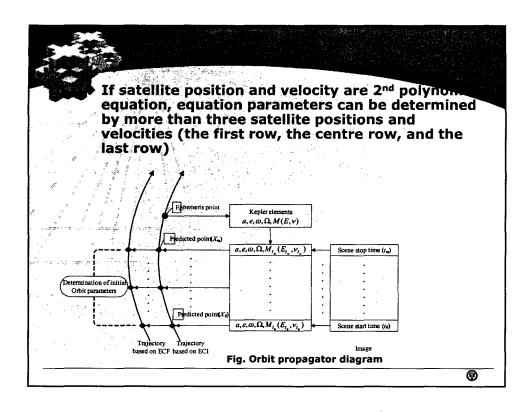
Initial Orbit Parameters

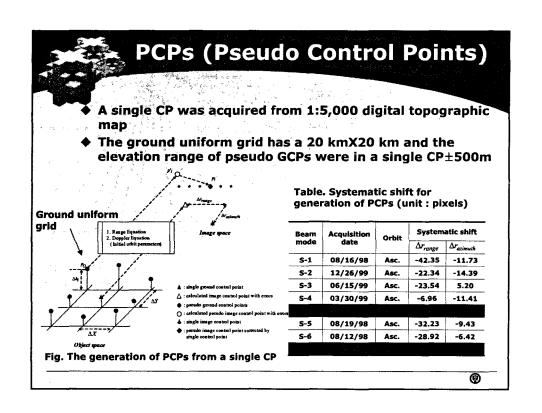
Only the nearest one state vector to the scene centre was selected and used to calculate Kepler elements to images respectively

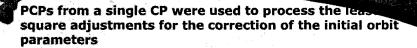
♦ Kepler elements

- the semi-major axis,
- the eccentricity,
- the inclination,
- the argument of perigee,
- the right ascension of ascending node,
- the mean anomaly









◆ The least square adjustment set the threshold value to 0.0001 and stably converged within 5 iterations for all images

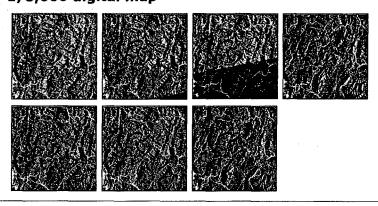
Table. The geometric accuracy and the number of PCPs generated from single CP

			_		
Beam mode	Acquisition Date	Orbit	Elevation of a single CP	No. PCPs	
S-1	08/16/98	Asc.	52.5 m	34	
S-2	12/26/99	Asc.	80.7 m	29	
S-3	06/15/99	Asc.	28.0 m	28	
S-4	03/30/99	Asc.	43.3 m	28	
S-4	11/15/99	Des.	7.0 m	28	
S-5	08/19/98	Asc.	75.0 m	28	
S-6	08/12/98	Asc.	12.2 m	28	
S-7	08/30/99	Des.	15.0 m	28	

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Geocoded Image

- Backward geocoding method
- ♦ 20m resolution and 20 km by 20 km size
- ♦ For accuracy analysis, images are overlaid with 1/5,000 digital map

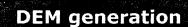




Accuracy of Geocoding

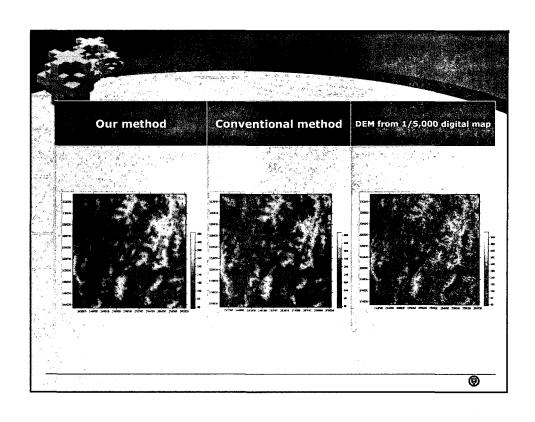
- 2		2 1 200	87. E. 46	.S			<u> </u>		3 45			
	Beam Acquisition		No.		(a sing	ethod le GCP) pixel)		Coi	(10	nal met GCPS) : pixel)	hod	
	mode	date	Orbit	check points	Range direction		Azimuth direction		Range direction		Azimuth direction	
	1/ 2		(1) 10 10	के किश्वा च	Mean error	RMSE	Mean error	RMSE	Mean error	RMSE	Mean error	RMSE
	5,1	08/16/98	Asc.	11	1.56	2.02	1.69	2.56	1.39	1.64	1.58	2.41
-	5.2	12/26/99	Asc.	14	1.00	1.34	1.48	2.68	1.18	1.46	1.66	2.81
_	53	06/15/99	Asc.	11	0.98	1.13	1.73	3.10	1.24	1.00	1.87	3.09
_	54	03/30/99	Asc.	14	1.27	1.62	2.01	3.63	1.28	1.60	2.09	2.65
	54	11/15/99	Des.	10	0.98	1.13	0.83	1.15	0.91	1.08	0.93	1.19
_	S 5	08/19/98	Asc.	10	1.47	1.74	1.21	1.54	1.17	1.50	1.14	1.65
~	S 6	08/12/98	Asc.	17	1.51	2.20	1.26	1.98	1.61	2.13	1.44	2.09
-	S 7	08/30/99	Des.	14	1.11	1.50	1.14	1.66	1.16	1.50	1.23	1.68
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ALC: UNKNOWN		Mear		1.00	1.24	1.59	1.42	2.29	1.24	1.49	1.49	2.20

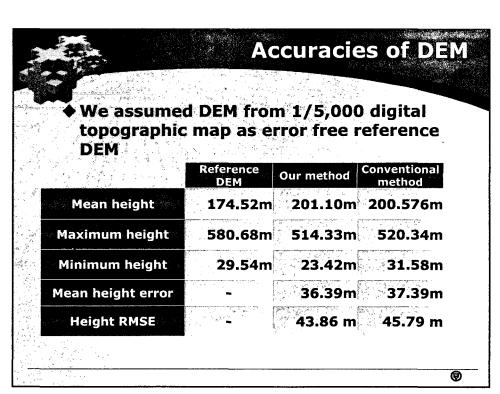
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- Standard 1 and 6 images have selected by which its radiometric distortion is minimal and it is geometrically stable as intersection angle 21 degree
- ◆ Gamma Map filter for speckle noise reduction
- ♦ Hierarchical correlation-based matching method
- ♦ 3-D positioning using radargrammetry

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Conclusions

- ♦ Given a high accurate single control point, the orbit parameters of the process level 1 and 2 RADARSAT-1 images (zero Doppler imagery) can be determined well enough to compare with many control points.
- ◆ Therefore this method can contribute to the areas which have difficulties to collect control points or requires rapid data process.
- ◆ DEM generation is also possible using the corrected orbit parameters using a single control point whose accuracy is compatible with conventional radargrammetric method.

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