GEOSTATISTICAL TEST USING LEAST SQUARE ADJUSTMENT COMPUTATION TO OBTAIN THE REDUCTION PARAMETER FOR DSM TO DEM CONVERSION
(Study of Case: Cilacap, Indonesia)

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Abstract. ALOS satellite is one of the natural resources satellites that can be used for 3D model applications. The problems of 3D model generation based on satellite imagery are the model always in Digital Surface Model (DSM), not in Digital Elevation Model (DEM). The reference system of 3D model that are produced by ALOS satellite image is still as surface for z axis, whereas x axis and y axis has been closed to 2D reference system in some certain datum and system of map projection. Therefore, it needs a research to observe the accuracy and the precision of ALOS satellite data using a least square adjustment in parameter methods. The results of this research will be used as a reference for next research to find a way for changing DSM from ALOS satellite image to be DEM automatically.

1. Introduction

Nowadays, remote sensing technology has experienced in fast progress growth. That progress growth is marked by many satellites operate in space. The example of natural resources satellites are ALOS, LANDSAT, IKONOS, SPOT, Beijing-1, CBERS, QuickBird, ASTER, etc. Almost of them can be used for 3D model generation. This research uses data from ALOS satellite.

ALOS is own satellite of Japan that was lunched in January 24th 2006. it brings three instrument sensor that are PRISM, AVNIR-2, and PALSAR. PRISM (*The panchromatic Remote Sensing Instrument for Stereo Mapping*) is a sensor for recording optical panchromatic image in wave length 0.52-0.77 mm and has spatial resolution 2.5 m. The sensor has three telescope for recording stereo image, there are forward, nadir, and backward unidirectional with satellite track orbit. Combination of the stereo images could be used for resulting DEM with enough accuracy for mapping the earth surface in scale 1:25.000 or more than it. Telescope in nadir could record image in swath 70 Km, while forward and backward could record in swath 35 Km. The angle that be shaped by forward telescope and backward to nadir is 24^0, it has function for generating stereo data with higher ratio (base to height ratio) near to value one (JAXA, 2006).

DSM is digital surface model with has been referenced of object surface to mean sea level (MSL) of 18,61 year. DEM is digital elevation model that has been referenced to ellipsoid. DTM is digital terrain model that has been referenced to topocentric coordinate and has been corrected by geodetic parameter to its model. DGM is digital geoid model that has been referenced to geoid/average of equipotential that squeeze with MSL (Li et al., 2005).

This research studies accuracy and precision of ALOS data satellite using least square adjustment in parameter methods.

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Result of this geostatistical test (accuracy and precision) is hoped to be useful for next research to find a way for changing DSM from ALOS satellite image to be DEM automatically.

2. Data and Methods

ALOS satellite data that used are RAW data. First, doing digital image processing to generate 3D Model (DSM) from the ALOS image of Backward, Nadir, and Forward (Figure.1). DSM is still base on surface and has height error maps, so differential DSM is needed to be converted to DEM. This process needs reduction parameter for that conversion. Geostatistical test using least square adjustment can calculate those reduction parameter. Geostatistical test is a geodesy method for getting accuracy and precision. It needs some fixed points for making algorithm of transformation model.
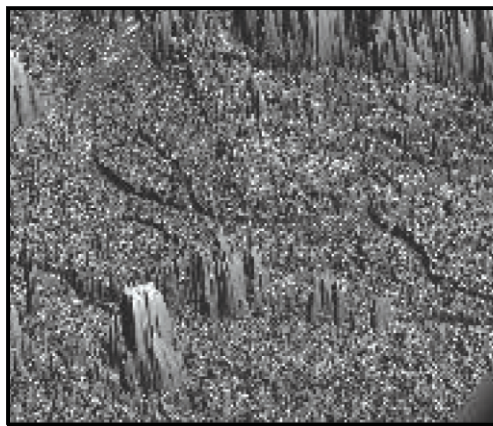

Figure 1. 3D model (DSM) of ALOS images in Cilacap

This research uses seven fixed points as ground control points (GCPs), due to the region topography is long enough from north to south, so it will cause data precision gather in middle region and disseminating in north to west, north to east also south to west, and south to east. This condition will generate higher accuracy in middle area and flatten precision in northern and southern area (Julzarika, 2007).

Geodetic control network design will give minimum geostatistical errors in image control framework. Next process is geometric correction of the images. Geocoding type for its rectification is linear polynomial. In this research, RAW data format will be referenced to geodetic format, with datum WGS'84 and geodetic projection is also coordinate system (φ, λ). *Ground Control Points* (GCPs) for rectification are geodetic coordinate from higher resolution imagery than ALOS imagery. In this research use Quick Bird satellite for helping identify seven GCPs in ALOS images (Figure 2). Quick Bird image is used to get spreading and clear fixed points and in ALOS image, so it makes unknown error be less. Every measurement has geostatistical errors, known errors or unknown errors (Arsana and Julzarika, 2006).
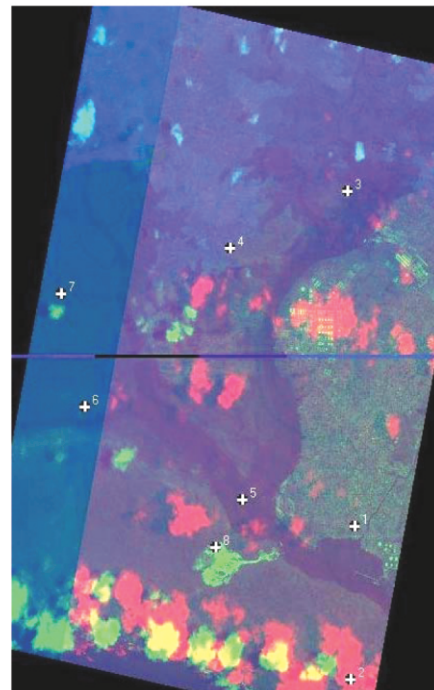

Figure 2. Rectification (seven GCPs) of ALOS image in Cilacap

Next step is to making algorithm and modeling of ALOS images against GCPs measured by GPS Geodetic (h), then make algorithm and modeling in data (φ, λ, h). Figure 3 shows the research flow chart. ALOS images are used as origin coordinate then it is called coordinate (a) (xa, ya, za), while GPS Geodetic as target coordinate then it is called coordinate (c) (xc, yc, zc). Coordinate (a) and coordinate (c) are still in geodetic coordinate, so they need map projection from Geodetic to UTM zone -48. Datum that used is WGS'84 with ellipsoid parameter as following below (Anam, 2005).

a=6378137; b=6356752; 1/f=298,260

Geodetic transformation uses the bellow formulas (Soetaat, 2001).

$$X_i=(N_i+h_i) \cos\varphi_i \cos\lambda_i$$
$$Y_i=(N_i+h_i) \cos\varphi_i \sin\lambda_i$$
$$Z_i=[N_i(1-e^2)+h_i]\sin\varphi_i$$

with abbreviation as following below.

$$N=a/(1-e^2 \sin^2\varphi_i)^{1/2} \;;$$
$$e=((a^2-b^2)/a^2)^{1/2} \;;$$
$$e'=((a^2-b^2)/b^2)^{1/2}$$

N=Normal radius of curvature
e=First eccentricity
e'=Second eccentricity
a= Semi-major axis
b= Semi-minor axis

Coordinate data of seven fixed points before map projection is shown in Table 1 and Table 2. While Coordinate data of seven fixed points after map projection is shown in Table 3 and Table 4.
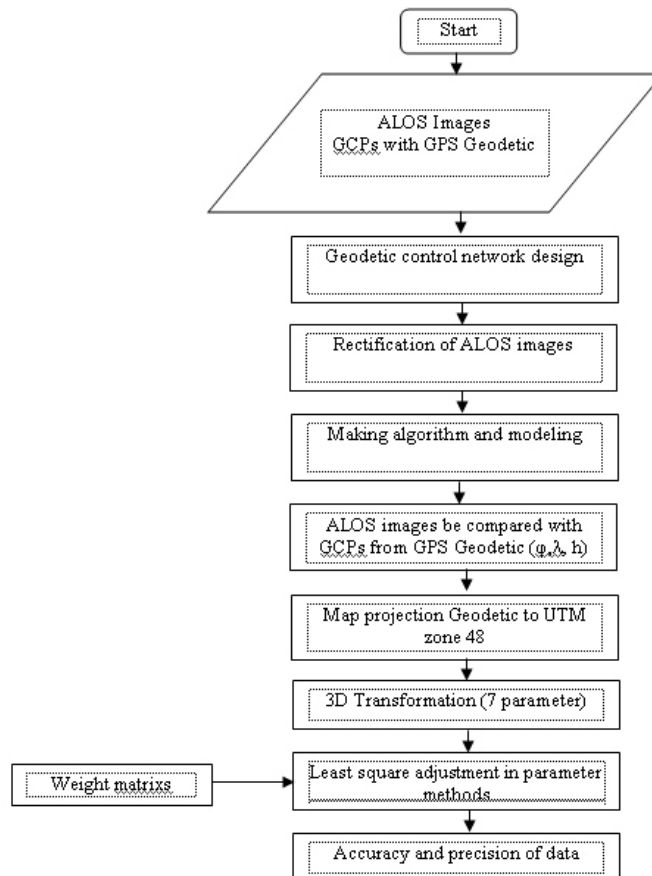

Figure 3. Researching flow chart

Table 1. Coordinate (a) before map projection

No	μa	λa	ha (m)
1.	-07^0 43' 32,"30	109^0 00' 31,"73	7,198
2.	-07^0 41' 12,"10	109^0 00' 43,"70	7,544
3.	-07^0 44' 28,"21	109^0 00' 36,"38	9,611
4.	-07^0 44' 28,"02	108^0 59' 51,"70	5,043
5.	-07^0 45' 07,"42	109^0 01' 17,"83	4,726
6.	-07^0 43' 14,"75	108^0 59' 57,"92	6,196
7.	-07^0 41' 38,"66	109^0 02' 04,"60	7,860

Table 2. Coordinate (c) before map projection

No	μc	λc	hc (m)
1.	-07^0 43' 32,"33	109^0 00' 31,"68	4,684
2.	-07^0 41' 12,"08	109^0 00' 43,"70	5,036
3.	-07^0 44' 28,"21	109^0 00' 36,"43	7,079
4.	-07^0 44' 28,"00	108^0 59' 51,"70	2,519
5.	-07^0 45' 07,"42	109^0 01' 17,"83	2,184
6.	-07^0 43' 14,"77	108^0 59' 58,"00	3,674
7.	-07^0 41' 38,"69	109^0 02' 04,"56	5,330

Table 3. Coordinate (a) after map projection

No	Xa (m)	Ya (m)	Za (m)
1.	280385,809882132	9145519,84325516	7,198
2.	280732,628011882	9149829,38113943	7,544
3.	280536,362998284	9143802,59885127	9,611
4.	279166,976421041	9143802,00819245	5,043
5.	281812,310354590	9142603,75401236	4,726
6.	279347,030610281	9146054,23934852	6,196
7.	283216,079896298	9149024,74931116	7,860

Table 4. Coordinate (c) after map projection

No	Xc (m)	Yc (m)	Zc (m)
1.	280384.280516250	9145518.91433307	4,684
2.	280732.625159218	9149829.99560311	5,036
3.	280537.885581607	9143802.60597696	7,079
4.	279166.973526858	9143802.62277335	2,519
5.	281812.310354590	9142603.75401236	2,184
6.	279349.483000391	9146053.63637445	3,674
7.	283214.859326753	9149023.82183431	5,330

After that, the parameters are computed using least square adjustment in parameter methods. There are two processes, making design/transformation matrix (A) and measurement matrix (F) (Uotila, 1985 and Hadiman, 2005). Least square adjustment is used for getting estimation value from some parameters that closed to true value

by taking the unknown parameter from some measurement data that has more measurement (Widjajanti, 1997). The solution of least square adjustment is that square sum from its residual V_i^2 are minimize (Hadiman, 1999).

$$\Sigma V_i^2 = minimize$$

Adjustment computation influences the accuracy and precision factors (Wolf, 1981). Accuracy is the nearest level or consistence of measurement to the true value while precision is the nearest level to average value (Soetaat, 1996). There are some least square adjustment methods: Parameter Methods, Minimal Constraint, and More Than Constraint, that estimate the researching points are fixed (Spiegel, 1975 and Uotila, 1985). The other methods are Weight Parameter Methods, Free Network and Inner Constraint that abbreviate the errors from the researching points (Widjajanti, 1997). This research uses least square adjustment in parameter methods. One of the software that could be used as technical computation language like computation, visualization, and programming is Matlab. The computations are adjustment computation (Hanselman and Littlefield, 1997).

The Parameter Methods is often used in least square adjustment, which it observes the function of its own parameter (Uotila, 1985; Widjajanti, 1997).

La = F(Xa)

Lb+v = F(X_0+Xb)

Liniearized by Taylor series could produce linear models :

v = AX + F

Xib=s.xia.ds + s.zia.dΦ + s.yia.dκ + dX0 – vxi
Yib=s.yia.ds + s.zia.dΩ – s.xia.dκ + dY0 – vyi
Zib=s.zia.ds – s.yia.dΩ – s.xia.dΦ + dZ0 – vzi

if s.ds=a ; s.dΩ=b ; s.dΦ=c ; s.dκ=d, then the model become

Xib=a.xia + c.zia + d.yia + dX0 – vxi
Yib=a.yia + b.zia – d.xia + dY0 – vyi
Zib=a.zia – b.yia – c.xia + dZ0 – vzi

Then the model is used for making design matrix/transformation model of coordinate (a). The matrix is shown below.
Matrix A (coordinate (a)) (Konecny and Lehmann, 1984 ; Uotila, 1985)

$$_{21}A_7 = \begin{bmatrix} \frac{\partial X_{1a}}{\partial a} & \frac{\partial X_{1a}}{\partial b} & \frac{\partial X_{1a}}{\partial c} & \frac{\partial X_{1a}}{\partial d} & \frac{\partial X_{1a}}{\partial dX_0} & \frac{\partial X_{1a}}{\partial dY_0} & \frac{\partial X_{1a}}{\partial dZ_0} \\ \frac{\partial Y_{1a}}{\partial a} & \frac{\partial Y_{1a}}{\partial b} & \frac{\partial Y_{1ia}}{\partial c} & \frac{\partial Y_{1a}}{\partial d} & \frac{\partial Y_{1a}}{\partial dX_0} & \frac{\partial Y_{1a}}{\partial dY_0} & \frac{\partial Y_{1a}}{\partial dZ_0} \\ \frac{\partial Z_{1a}}{\partial a} & \frac{\partial Z_{1a}}{\partial b} & \frac{\partial Z_{1a}}{\partial c} & \frac{\partial Z_{1a}}{\partial d} & \frac{\partial Z_{1a}}{\partial dX_0} & \frac{\partial Z_{1a}}{\partial dY_0} & \frac{\partial Z_{1a}}{\partial dZ_0} \\ \hdotsfor{7} \\ \hdotsfor{7} \\ \frac{\partial X_{7a}}{\partial a} & \frac{\partial X_{7a}}{\partial b} & \frac{\partial X_{7a}}{\partial c} & \frac{\partial X_{7a}}{\partial d} & \frac{\partial X_{7a}}{\partial dX_0} & \frac{\partial X_{7a}}{\partial dY_0} & \frac{\partial X_{7a}}{\partial dZ_0} \\ \frac{\partial Y_{7a}}{\partial a} & \frac{\partial Y_{7a}}{\partial b} & \frac{\partial Y_{7ia}}{\partial c} & \frac{\partial Y_{7a}}{\partial d} & \frac{\partial Y_{7a}}{\partial dX_0} & \frac{\partial Y_{7a}}{\partial dY_0} & \frac{\partial Y_{7a}}{\partial dZ_0} \\ \frac{\partial Z_{7a}}{\partial a} & \frac{\partial Z_{7a}}{\partial b} & \frac{\partial Z_{7a}}{\partial c} & \frac{\partial Z_{7a}}{\partial d} & \frac{\partial Z_{7a}}{\partial dX_0} & \frac{\partial Z_{7a}}{\partial dY_0} & \frac{\partial Z_{7a}}{\partial dZ_0} \end{bmatrix}$$

It also builds matrix F and weight matrix as show below.
Matrix F (coordinate (c)) (Konecny and Lehmann, 1984 ; Uotila, 1985)

$$_{21}F_1 = \begin{bmatrix} - x_{1c} \\ - y_{1c} \\ - z_{1c} \\ ..... \\ ..... \\ ..... \\ - x_{7c} \\ - y_{7c} \\ - z_{7c} \end{bmatrix}$$

Weight matrix (P)

If σ_0^2 = 2,5^2, so the matrix P is identity matrix (I)

Value of parameter could be computed by formula: (Uotila, 1985; Soetaat, 1996)

$$X = -(A^TPA)^{-1}A^TPF$$

In this condition,

La   =Perception estimation value
Xa   =Parameter estimation value
Lb   =Perception value
v   =Residual matrix/perception correction
X_0 =Parameter nearest value
Xb   =Parameter correction

X= Transformation parameter matrix of coordinate (a) to coordinate (c)

A = Design matrix/transformation model of coordinate (a)

F = Coordinate (c) measurement matrix

P = Weight matrix

Computation of residual matrix value (V) is shown,

$$V = A*X+F$$

Parameter varian covariance matrix could be taken in formula:

$$\Sigma X = (\sigma_o{}^2)*(A^TPA)^{-1}$$

for coordinate (a) and coordinate (c) a posteriori varian is shown:

$$(\sigma_o{}^2)_2 = \frac{V^T * P * V}{n-u}$$

where,

V = Residual matrix;

ΣX = Parameter varian covarian matrix;

n = Sum of perception;

u = Sum of parameter;

$\sigma_o{}^2$ = A posteriori varian.

Computation of result compute from covarian matriks (Σv) is shown:

$$\Sigma v = \sigma_o{}^2 *(1-A*(A^T*P*A)^{-1}*A^T)$$

Computation of measurement covarian matrix (ΣL) is shown:

$$\Sigma L = \sigma_o{}^2 *(A*(A^T*P*A)^{-1})*A^T)$$

Second iteration if $\dfrac{\hat{\sigma}_{oi} - \hat{\sigma}_{oi+1}}{\hat{\sigma}_{oi}} >$ tolerance

or a posteriori varian $\hat{\sigma}_0{}^2 >$ tolerance.

3. Result and Discussion

This result studies about accuracy and precision of ALOS images using least square adjustment in parameter methods. ALOS images are compared by GCPs measured with GPS Geodetic.

Table 5. Parameter value of seven fixed points (X)

No	Parameter	Value
1.	a	0.999861907506775
2.	b	-3.6358347495955e-006
3.	c	5.81031754456549e-006
4.	d	-6.75630970967862e-005
5.	dX0	0.671857454108123
6.	dY0	0.233028981951454
7.	dZ0	-2.52733193815344

Computation uses seven parameter, those are a, b, c, d, dX0, dY0, and dZ0. Every process in map file type changing has unique criteria in getting the kind of its transformations (Arsana and Julzarika, 2007). From all the previous process, we get the result in table 5. Measurement residual value and covarian of computation result show in table 6.

A posteriori varian ($\sigma_o{}^2$) coordinate (a) to coordinate (c)

$$(\sigma_o{}^2)_2 = \frac{V_2^T * P * V_2}{n-u} \quad , n=21 ; u=7 \quad \text{then}$$

$$(\sigma_o{}^2)_2 = 0.945280746547929$$

Table 6. Measurement residual value (V) and covarian of computation result (ΣV)

No	Coordinate	$V2_i$ (m)	$(\sigma V2_i)^2$ (m^2)
1.	x_1a	1.77208370538619	0.806770707777769
2.	y_1a	0.769490578648401	0.806770716208911
3.	z_1a	-0.00958035497101672	0.800044943382479
4.	x_2a	-0.0934862089425224	0.540916850405758
5.	y_2a	-1.34557917549955	0.54091692538406
6.	z_2a	-0.00197449084341006	0.424544962538708
7.	x_3a	-1.18461938408427	0.742833922526848
8.	y_3a	0.0807444201361704	0.742834640102292
9.	z_3a	0.000968049553446981	0.72412845009897
10.	x_4a	0.529973493752891	0.702220842092724
11.	y_4a	-0.619132613000602	0.702220973417708
12.	z_4a	0.00155327937968774	0.590371428135547
13.	x_5a	0.242734474120425	0.620745005001632
14.	y_5a	0.339646299688184	0.620745126610829
15.	z_5a	-0.000129829652115276	0.356653740070126
16.	x_6a	-2.10233594412506	0.776824904340763
17.	y_6a	0.299566967603369	0.776824933534034
18.	z_6a	0.00653662702164537	0.622622004955052
19.	x_7a	0.835649863891376	0.536090209619881
20.	y_7a	0.475263522435853	0.536090218643603
21.	z_7a	0.00262671951177396	0.262758946823307

Table 7. Value of parameter covarian (ΣX)

No	Parameter	$(\sigma_{parameter})^2$ (m^2)	Explanation
1.	a	1.66311512819394e-008	$(\sigma_a)^2$
2.	b	2.37404313335275e-008	$(\sigma_b)^2$
3.	c	9.00091326697007e-008	$(\sigma_c)^2$
4.	d	1.66311599787182e-008	$(\sigma_d)^2$
5.	dX0	0.426353018596514	$(\sigma_{dX0})^2$
6.	dY0	0.426350609212002	$(\sigma_{dY0})^2$
7.	dZ0	0.544482613215484	$(\sigma_{dZ0})^2$

From the result, we get conclusion that the coordinate value in x axis has high accuracy in $X0 \pm \sigma_x$ or $0.671857454108123 \pm 0.6529571338124070$ m, the bias can affect the accuracy and precision of pattern and model for seven researching points. Coordinate value in y axis has highest accuracy in $Y0 \pm \sigma_y$ or $0.233028981951454 \pm 0.6529552888307150$ m, the bias can affect the accuracy and precision of pattern and model for seven researching points.

Coordinate value in z axis has lower accuracy in $Z0 \pm \sigma_z$ or $2.52733193815344 \pm 0.7378906512590360$ m, so the bias can affect of the accuracy and precision of pattern and model will be higher. This condition will influence the value of bias happened in x and y axis.

Bias could happen due to map file type changing, for example conversion from *.shp to *.html in UTM coordinate projection will have bias 3,8-3,9 m (converter software) and 3,8 m (non-converter software) (Julzarika, 2007).

Table 8. Value of measurement covarian (ΣL)

No	Coordinate	$F2_i$ (m)	$(\sigma L2_i)^2$ (m^2)
1.	x_1c	-1384.28051625	0.13851003877016
2.	y_1c	-3518.9143330697	0.138510030339018
3.	z_1c	-4.684	0.14523580316545
4.	x_2c	-1732.62515921798	0.404363896142171
5.	y_2c	-7829.99560311064	0.404363821163868
6.	z_2c	-5.036	0.52073578400922
7.	x_3c	-1537.885581607	0.20244682402108
8.	y_3c	-1802.60597695969	0.202446106445637
9.	z_3c	-7.079	0.221152296448959
10.	x_4c	-166.973526858026	0.243059904455205
11.	y_4c	-1802.62277334929	0.243059773130221
12.	z_4c	-2.519	0.354909318412381
13.	x_5c	-2812.31035459001	0.324535741546296
14.	y_5c	-603.754012359306	0.324535619937099
15.	z_5c	-2.184	0.588627006477803
16.	x_6c	-349.483000390988	0.168455842207166
17.	y_6c	-4053.63637444936	0.168455813013895
18.	z_6c	-3.674	0.322658741592876
19.	x_7c	-4214.85932675301	0.409190536928047
20.	y_7c	-7023.82183431089	0.409190527904326
21.	z_7c	-5.33	0.682521799724622

Description:
$F2_i$ (m) = $[(x_ic-X_0), (y_ic-Y_0), z_ic]$
X_0 = 279000 m ;
Y_0 = 9142000 m ;
Z_0 = 90 m

a priori varian in 0.945280746547929 /(2,5^2) = 0,151244919 so that the changing processes of coordinate (a) to coordinate (c) does not have unknown errors or blunder.

3. 1. GeoStatistical Test

GeoStatistical test is conducted by three methods, those are: (Spiegel, 1975 ; Uotila, 1985, Soetaat, 1996 ; Widjajanti, 1997)

a. Global test

Global test is used to know unknown errors happened in measurement of map file type changing. Global test are done using value of a posteriori varian and a priori varian. Global test is used to check the blunder in coordinate measurement changing from (a) to coordinate (c). Global test is done using uncertainty level 95% (α=0.05) and geostatistical free degree 14. In Fischer table, it is known that geostatistical value $F_{1-0,05, 14,}$ is 1,697 and be got comparison between a posteriori to

b. Data snooping

Data snooping is used if global test is rejected. In this research, data snooping has a function to find the errors in each measurement. Table 9 shows the data snooping.

This data snooping uses uncertainty level 95% (α=0.05) and geostatistical free degree 14. In Fischer table is known that geostatistical value $F^{1/2}_{1-0,05, 14,}$ is 1.303. In data snooping, all measurement data are accepted as geostatistical if there is no unknown errors in changing of coordinate (a) to coordinate (c). The result of this research shows that coordinate value in x and y axis have least flatten precision, but z axis has higher accuracy and better

precision. This is marked by value of $|w_i|$ which has higher value. It can affect the accuracy and precision of pattern and model for seven researching points.

Table 9. Data snooping

Points	$\|w_i\|=\dfrac{v_i}{\sigma v_i}$			$F^{1/2}_{1-0.05, 14}$	Explanation
	x	Y	z		
1	1.972919	0.856699	0.01071	1.303	y, z accepted
2	0.12711	1.82955	0.00303	1.303	x, z accepted
3	1.37446	0.093684	0.001138	1.303	x, y, z accepted
4	0.632437	0.73883	0.002022	1.303	x, y, z accepted
5	0.308088	0.431092	0.00022	1.303	x, y, z accepted
6	2.38529	0.339885	0.008284	1.303	y, z accepted
7	1.141315	0.649106	0.005124	1.303	x, y, z accepted

c. Parameter significant test

Parameter significant test is used for checking that those parameter are exist or not in changing of coordinate (a) to coordinate (c). Parameter significant test uses uncertainty level 95% and geostatistical free degree 14. Geostatistical value $t_{0.05, 14}$ in t-student table is 1.761. Table 10 shows the data snooping. In parameter significant test, the transformation parameters are in exist condition, it means that all parameter influence the transformation model and the algorithm.

Table 10. Parameter significant test

Parameter	Value	$\left\|\dfrac{x_i}{\sigma x_i}\right\|$	$t_{0.05,14}$	Explanation
A	0.999861907506775	6.01E+07	1.761	Exist
B	-3.6358347495955e-006	1.53E+02	1.761	Exist
C	5.81031754456549e-006	6.46E+01	1.761	Exist
D	-6.75630970967862e-005	4.06E+03	1.761	Exist
dX0	0.671857454108123	1.58E+00	1.761	Exist
dY0	0.233028981951454	5.47E+00	1.761	Exist
dZ0	-2.52733193815344	4.64E+00	1.761	Exist

3.2. Analyze of coordinate changing

From this result, we get seven researching points that have least flatten precision. It affects the accuracy and precision of pattern and model for seven researching points. High accuracy and flatten precision are in points of 7, 2, and 5. The normal accuracy and flatten precision is in points of 4. The normal accuracy and least flatten precision are in points of 1, 3, and 6. Total of correctness in coordinate (a) to coordinate (c) has range 1,15 m – 1,56 m for each pixel that taking in coordinate (a). Table 11 shows the analyze of coordinate changing.

Table 11. Analyze of coordinate changing

Points	Correctness (3D)=$(\sigma v_x^2 + \sigma v_y^2 + \sigma v_z^2)^{1/2}$ (meter)
1	1.553572
2	1.227346
3	1.486539
4	1.412379
5	1.264177
6	1.475219
7	1.155396

4. Conclusion

Research about accuracy and precision of ALOS satellite imagery using least square adjustment in parameter methods has some conclusions as following below:

1. Accuracy of ALOS images that compare with GCPs from GPS geodetic:
   a. Coordinate value in x axis has high accuracy in $X0 \pm \sigma_x$ or $0.671857454108123 \pm 0.6529571338124070$
   b. Coordinate value in y axis has higher accuracy in $Y0 \pm \sigma_y$ or $0.233028981951454 \pm 0.6529552888307150$ m.
   c. Coordinate value in z axis has lower accuracy in $Z0 \pm \sigma_z$ or $2.52733193815344 \pm 0.7378906512590360$ m.
2. Precision of ALOS imagery comparing to GCPs from GPS Geodetic: it has least flatten precision in x axis, normal precision in y axis, and higher flatten precision in z axis. It is marked by some value of $|w_i|$.
3. The bias affects the accuracy and precision of pattern and model for seven researching points.
4. 3D transformation parameters influence the transformation model and algorithm, free of unknown errors and all parameter are existing.
5. Total of correctness value in coordinate (a) to coordinate (c) conversion has range 1.15 m – 1.56 m for each pixel that taking in coordinate (a).

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