

Orthorectification of KOMPSat-2 as a Potential Source of Data for the GwRS Campaigns

Remote Sensing Application Center Bulgaria

ReSACProfile

- Remote Sensing Application Center ReSAC
 - Established in 1998 with the support of FAO/UN R&D structure of Agency for Sustainable Development and Eurointegration ASDE
 - ASDE signed a collaboration agreement with DG JRC in 2007
 - Observed member of EARSC since 2005

Main Objectives

- to introduce RS&GIS to agricultural and environmental management, land cover/land use, soil and forest inventory, water resources, environmental hazards, disaster management, and urban planning
- to facilitate local, national and international authorities, as well as private enterprises
- co-operation & participation in regional and international projects



EO Data Spec iCwRS

- ▶ RS data is integrated in a series of EC programmes
 - CwRS- identify irregularities in agricultural subsidy eligibility & satellite
- ▶ VHR satellites accepted: QB, IK, EROS, SPOT5, F2
- ▶ Other EO sensors introduction:
 - High occupation of the primary satellites
 - First commercial VHR satellites already exceeded operational life
 - New sensors available on the market
- ▶ Required Geometric Accuracy for VHR Satellites
 - Targeted orthoimagery specification < 2.5 m RMSE (See Guidelines for Best Practice and Quality Checking of Ortho Imagery, JRC IPSC/G03/P/SKA/ska D(2003)(2402))



KOMPSat-2 : Features Overview



Owner: Korean Aerospace Research Institute (KARI),
KosK

Launch Date & Mission Life: 28th July 2006, 3 yrs

Altitude: 685km

Temporal Resolution: 28 days, 3 days (30° roll)

Sensor: MultiSpectral Camera (MSC)

Swath Width: 15km@Nadir

Tilt: $\pm 30^\circ$ Roll

Spectral Resolution:
5 bands (1 PAN, 4 MS)

450nm-900nm,

10 bits/pixel/band (16bit file delivery)

Spatial Resolution: 1m PAN, 4m MS (@Nadir)

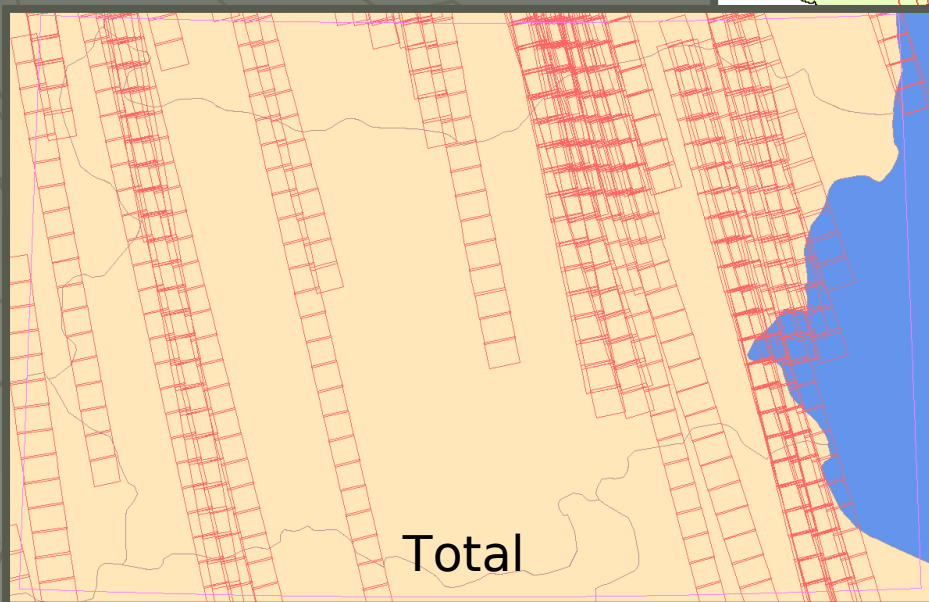
Advantages: Unprecedented coverage capacity to 20 min/orbit

Distributors: Korea Aerospace Industry, SPOT Image

Organisation: antenna at Svalbard (Norway) - downlink < 1h, flexible
planning (update each orbit cycle); image processing at Toulouse



BG Kompsat2 Coverage 2008



Coverage <10%CC
~1/3 of the territory of the country

KOMPSAT2 Product Collection and Distribution



Raw Data

L0

L1A

L1R

L1G

- ▶ Product Types
 - B&W: 1m
 - Color (4 bands): 1m
 - MS (B,G,R,NIR): 4m
- ▶ Processing Levels
 - L1A/L1R- basic radiometric normalization for detector calibration (done on board MSC using Non Uniformity Correction), optionally MTFC
 - L1G- corrected for systematic geometridistortions due to the sensor, the platform and the Earth rotation and curvature, projected (default is UTM WGS84)
 - Ortho
- ▶ KOMPSAT Format
 - L1R- TIFF
 - L1G- GeoTIFF
 - XML for metadata
 - RPC in TXT file

Rational Function Modelling

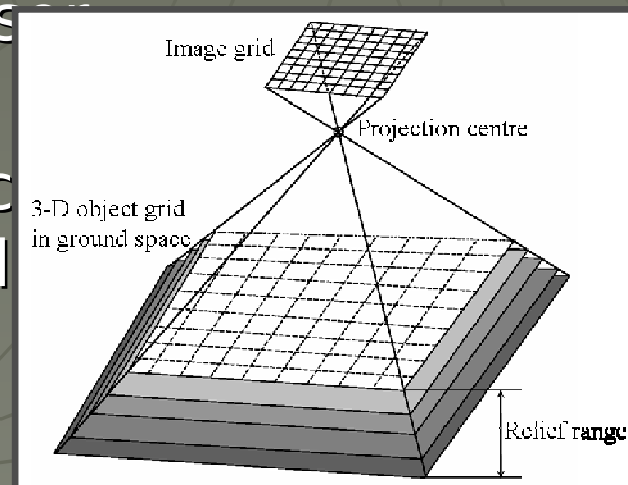
▶ RFM

Alternative to the rigorous sensor model

General transformation to describe the relationship b/w image and ground coordinates

Uses ratios of two polynomials (row and for column estimates)

- ▶ parameters stored in RPC file derived from rigorous sensor model with an approximate orientation



Rational Polynomial Coefficients

- The 2D image space is expressed with a third order polynomial of 3D object space coordinates

LINE_OFF:	9750.00 pixels	P = (Latitude - LAT_OFF) / LAT_SCALE
SAMP_OFF:	9085.80 pixels	
LAT_OFF:	42.63687551 degrees	L = (Longitude - LONG_OFF) / LONG_SCALE
LONG_OFF:	23.30077845 degrees	H = (Height - HEIGHT_OFF) / HEIGHT_SCALE
HEIGHT_OFF:	1192.41 meters	r _n = (Row - LINE_OFF) / LINE_SCALE
LINE_SCALE:	8125.00 pixels	c _n = (Column - SAMP_OFF) / SAMP_SCALE
SAMP_SCALE:	8448.20 pixels	
LAT_SCALE:	0.07311948 degrees	
LONG_SCALE:	0.10279167 degrees	
HEIGHT_SCALE:	730.78 meters	

LINE_NUM_COEFF_1:	1.627389093946601e-003	$r_n = \frac{\sum_{i=1}^{20} \text{LINE_NUM_COEF}_i \cdot \rho_i(P, L, H)}{\sum_{i=1}^{20} \text{LINE_DEN_COEF}_i \cdot \rho_i(P, L, H)}$		
LINE_NUM_COEFF_2:	-2.874241551033200e-002			
LINE_NUM_COEFF_3:	-9.994786071510043e-001			
...	...			
LINE_NUM_COEFF_20:	3.064310283024989e-009			
LINE_DEN_COEFF_1:	1.000000000000000e+000		$c_n = \frac{\sum_{i=1}^{20} \text{SAMP_NUM_COEF}_i \cdot \rho_i(P, L, H)}{\sum_{i=1}^{20} \text{SAMP_DEN_COEF}_i \cdot \rho_i(P, L, H)}$	
LINE_DEN_COEFF_2:	1.639391737960895e-005			
LINE_DEN_COEFF_3:	7.951506336041158e-004			
...	...			
LINE_DEN_COEFF_20:	-1.540956581808601e-010			
SAMP_NUM_COEFF_1:	2.715215401426258e-003			$\sum_{i=1}^{20} C_i \cdot \rho_i(P, L, H) =$ $C_1 + C_6 \cdot L \cdot H + C_{11} \cdot P \cdot L \cdot H + C_{16} \cdot P^3$ $+ C_2 \cdot L + C_7 \cdot P \cdot H + C_{12} \cdot L^3 + C_{17} \cdot P \cdot H^2$ $+ C_3 \cdot P + C_4 \cdot L^2 + C_{13} \cdot L \cdot P^2 + C_{18} \cdot L^2 \cdot H$ $+ C_4 \cdot H + C_9 \cdot P^2 + C_{14} \cdot L \cdot H^2 + C_{19} \cdot P^2 \cdot H$ $+ C_5 \cdot L \cdot P + C_{10} \cdot H^2 + C_{15} \cdot L^2 \cdot P + C_{20} \cdot H^3$
SAMP_NUM_COEFF_2:	9.993399292909858e-001			
SAMP_NUM_COEFF_3:	-2.572711143289662e-002			
...	...			
SAMP_NUM_COEFF_20:	-1.123515284032744e-009			
SAMP_DEN_COEFF_1:	1.000000000000000e+000			
SAMP_DEN_COEFF_2:	-1.365098136066154e-003			
SAMP_DEN_COEFF_3:	6.005094387324581e-004			
...	...			
SAMP_DEN_COEFF_20:	-1.641919822420377e-010			

KOMPSat-2 Supported by PCI Geomatics

▶ Geomatic's OrthoEngine add-on modules

OKM- High Resolution Models

- ▶ Rigorous models developed to compensate for distortions and produce orthorectified high resolution satellite images

OMR- Generic and RPC Models

- ▶ Supports the use of RPC data distributed with imagery and direct automatic import of the coefficients alleviating the need for numerous ground control points

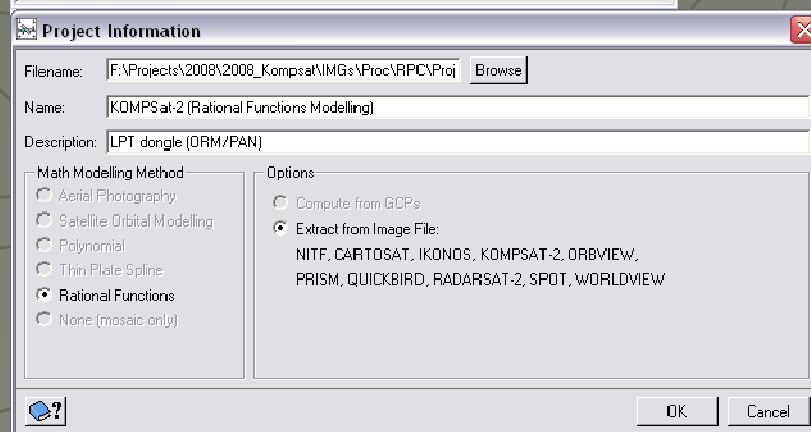
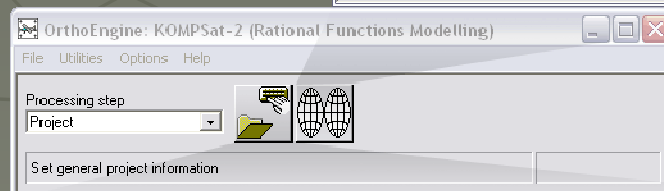
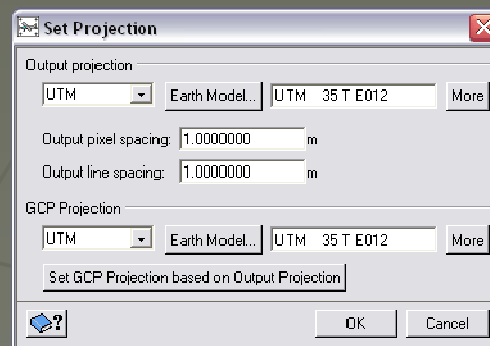
▶ OKM

Direct import of Kompsat Level 1R 1m PAN distributed in Tiff format

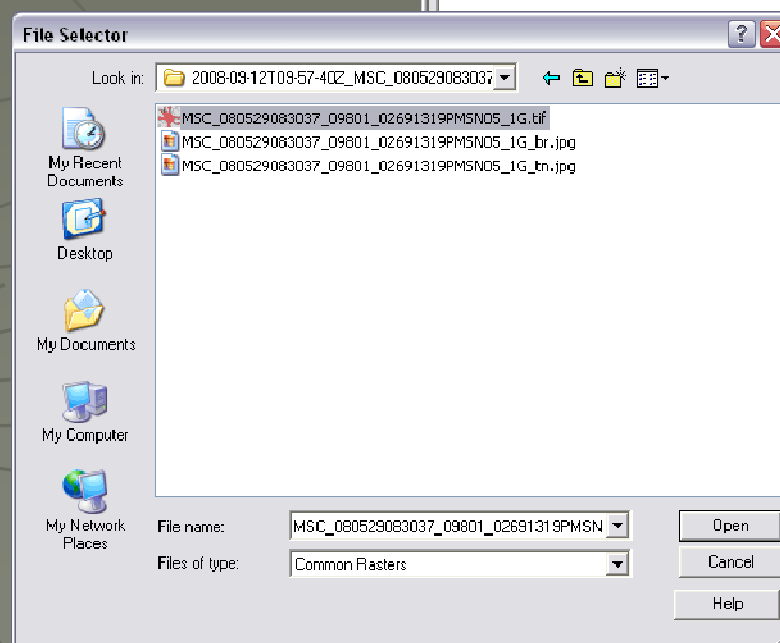
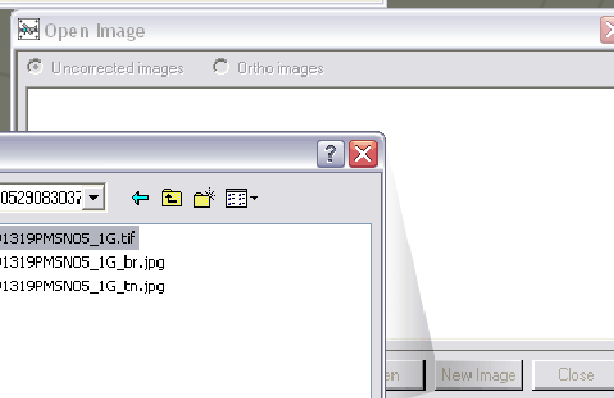
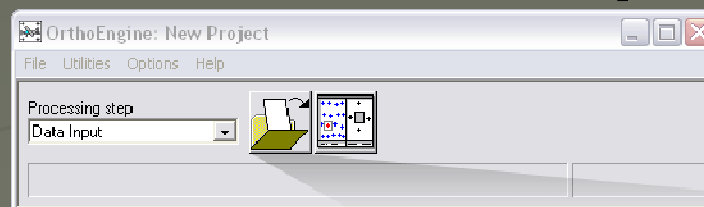
▶ OMR

RPC- Direct import of KOMPSat-2 MS and PMS data

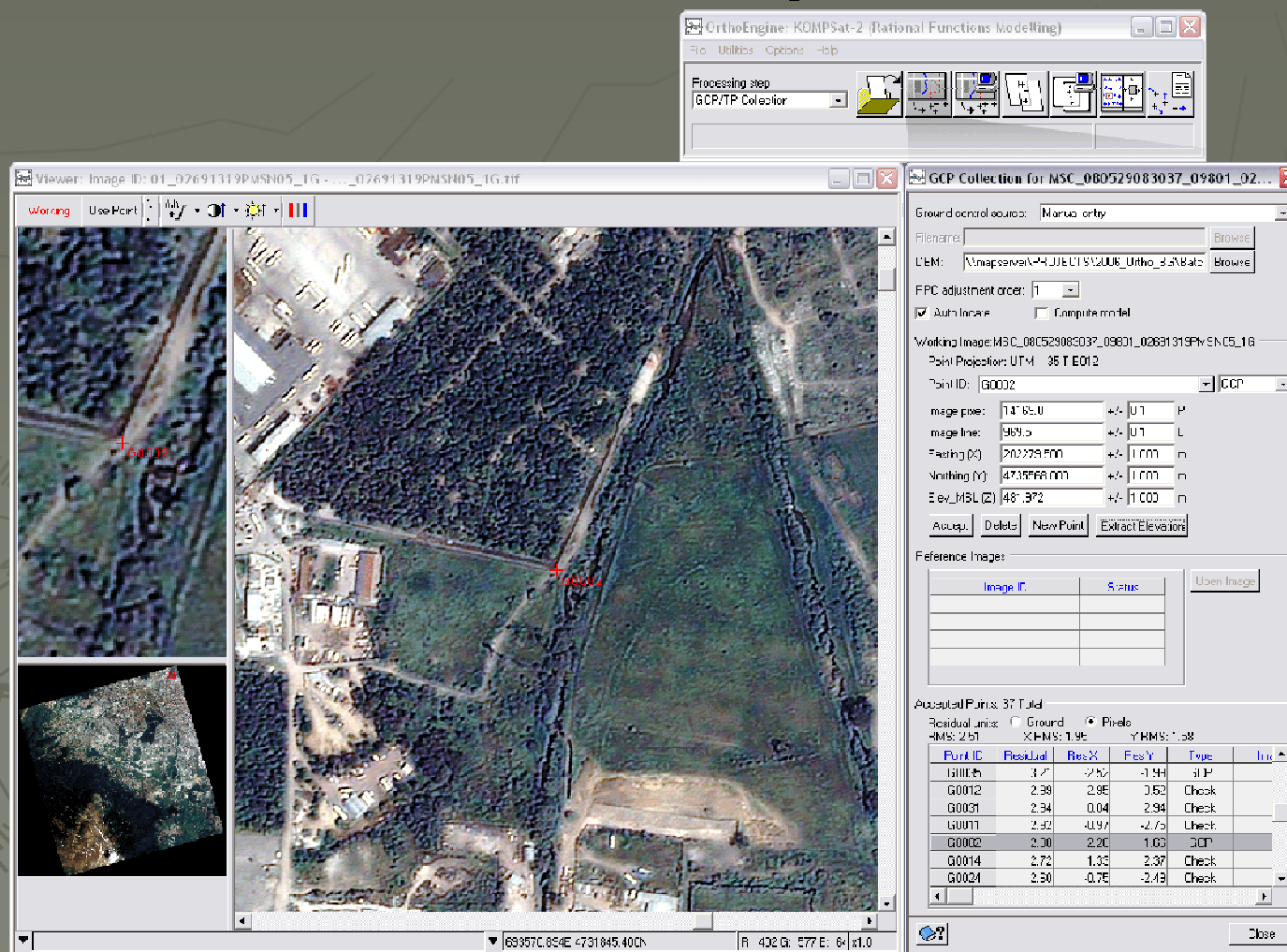
PCI Steps



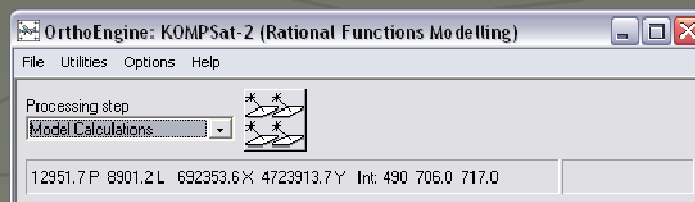
PCI Steps



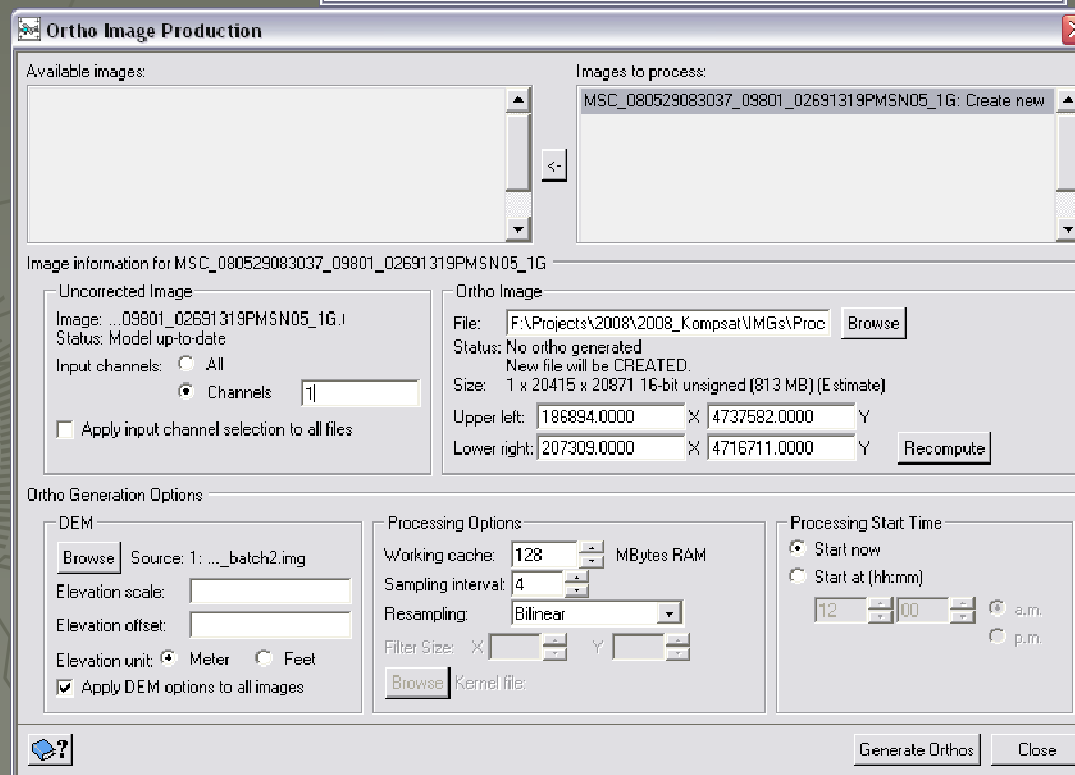
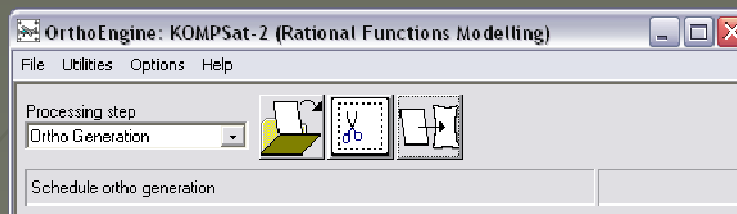
PCI Steps



PCI Steps



PCI Steps



Data Used for KOMPSat-2 Orthorectification Experiments

- ▶ Imagery: 1m PANS Sharpened KOMPSat-2 G1 Scene
- ▶ DEM: Reference3D: sp. resolution ~25m
- ▶ GCPs IKONOS orthophotos
- ▶ ICPs: DGPS measurements

KOMPSat-2 Scene: Acquisition Data

► Acquisition

Date: 2008-05-29

Time: 08:30:37.643673

► Processing: Level 1G

► Radiometric Resolution: 16-bit PAN

► Dimensions: 19128x19500

► Spatial Resolution: 1m

► Viewing Angles

Alongtrack: -0.641

Acrosstrack: -5.317

► Satellite Angles

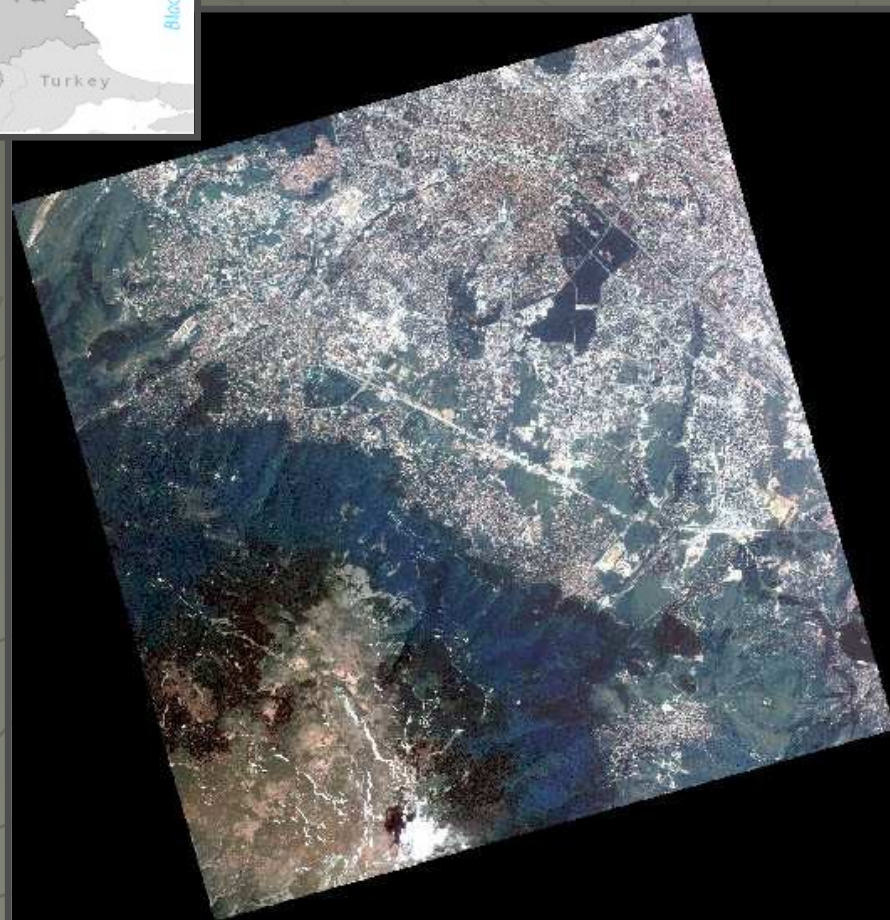
Incidence: 83.953286

Azimuth: -19.127434

► Satellite Altitude:

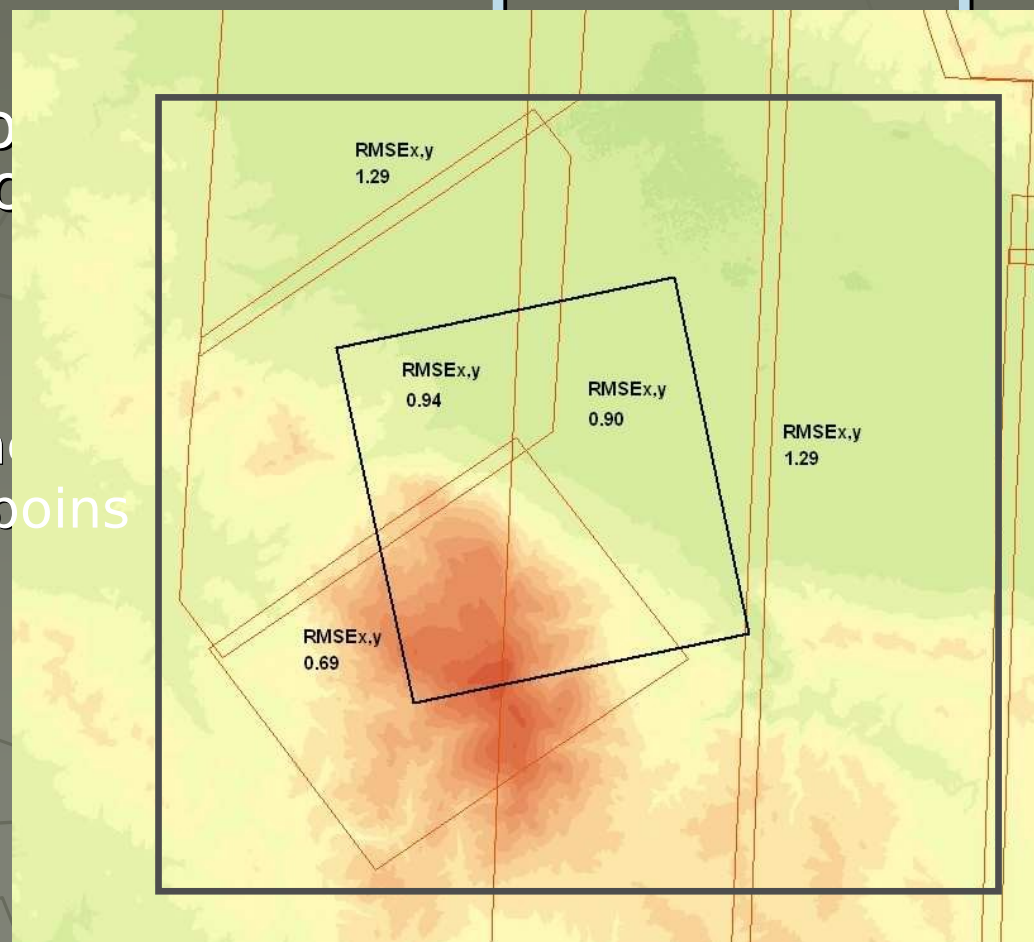
701851.372526

► Projection: WGS84 UTM Zone 34N



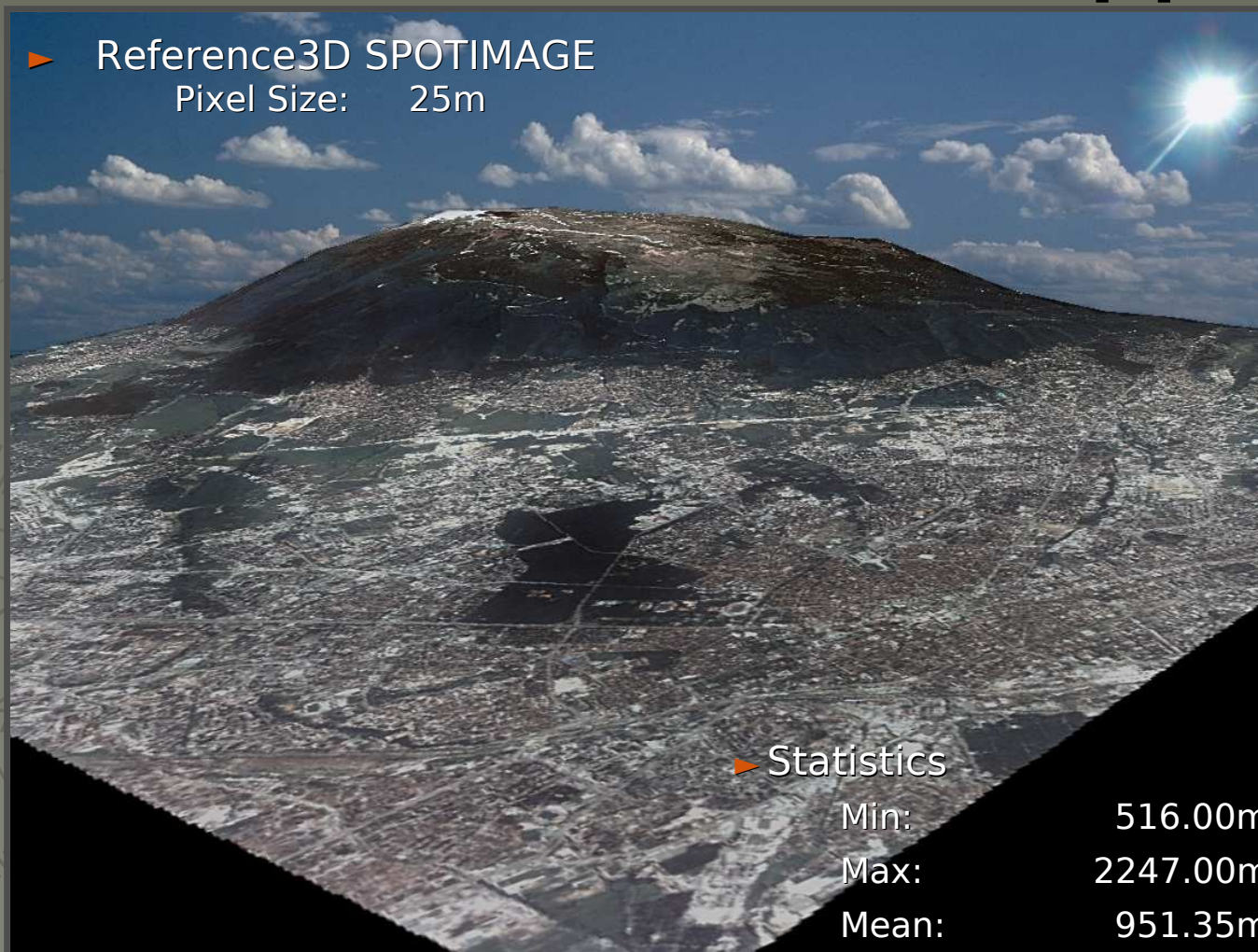
GCPs from IKONOS Orthophoto Map

- ▶ GCPs were selected from VHR satellite orthophoto map:
 - 3 Ikonos scenes;
 - 1 m colour;
 - Images acquisition: June
 - Orthorectified with DGPS points



Elevation Reference

▶ Reference3D SPOTIMAGE
Pixel Size: 25m



▶ Statistics

Min:	516.00m
Max:	2247.00m
Mean:	951.35m

Elevation Reference [2]

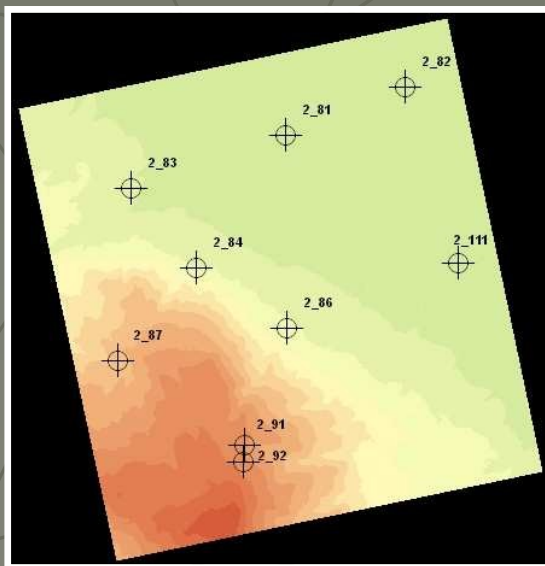
► Accuracy Claims:

Abs Z accuracy 10 m (CL 90%) for slope
< 20 degrees,
2D accuracy 15 m

► Accuracy Assessment:

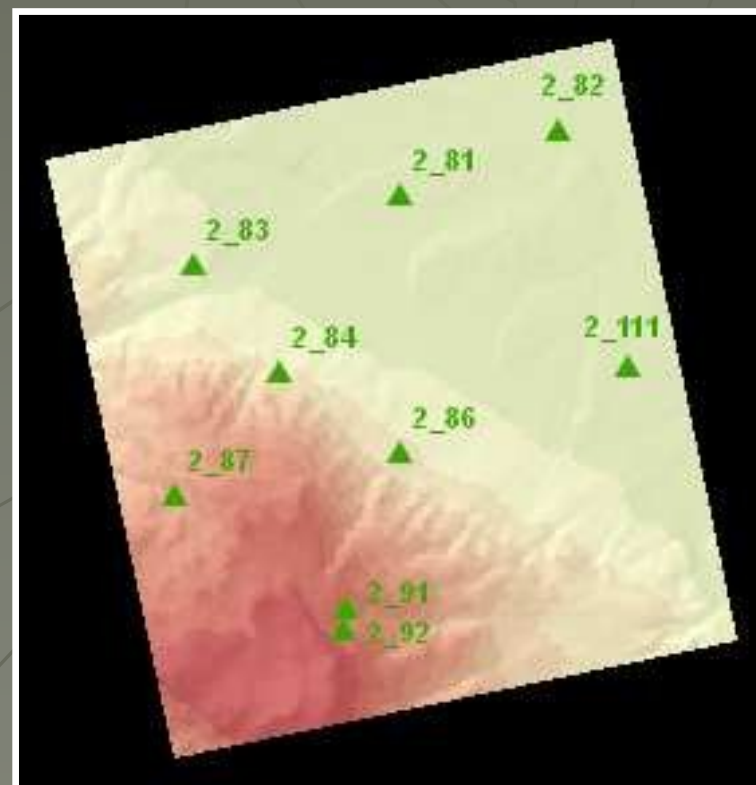
For Z ~3.34m

GPS_ID	Z_GPS	Z_Discrep
2_111	572	1.59
2_81	529	2.58
2_82	832	3.12
2_83	521	1.46
2_84	1802	3.81
2_86	512	3.49
2_87	556	8.83
2_91	538	3.61
2_92	1775	1.55

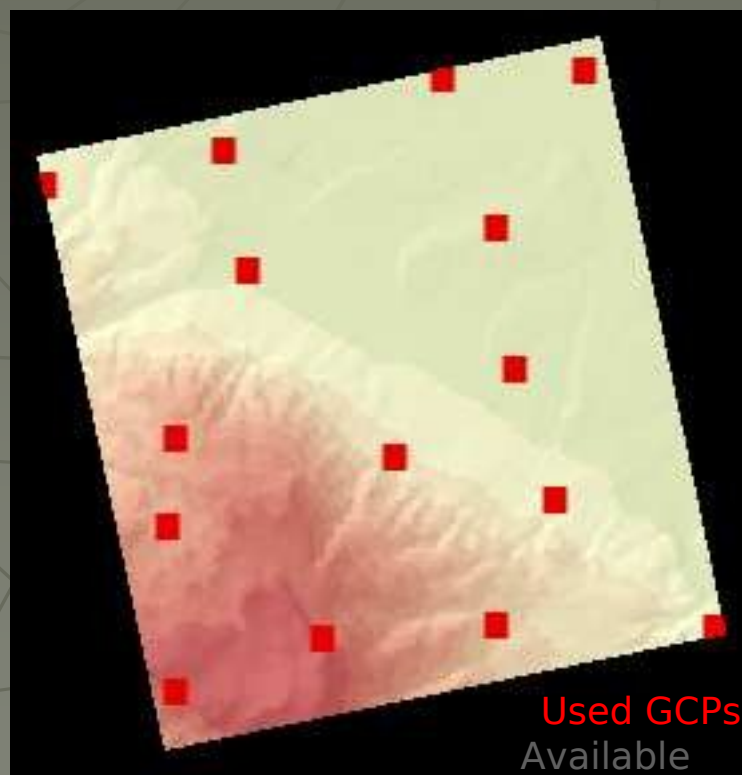


DGPS Measurements for ICs

ID_GPS	ACC_X[m]	ACC_Y[m]	ACC_Z[m]
2_111	0.010	0.010	0.029
2_81	0.017	0.024	0.070
2_82	0.015	0.045	0.058
2_83	0.010	0.011	0.025
2_84	0.014	0.029	0.056
2_86	0.016	0.019	0.039
2_87	0.016	0.019	0.047
2_91	0.013	0.014	0.030
2_92	0.013	0.020	0.049



Test Design



Results & Discussion

Zero Order

- ▶ Zero Order
0÷4 GCPs
- ▶ First Order
0÷15 GCPs

GCP#	RMS_X	RMS_Y	RMS_XY
00	23.122	26.01	34.84
11	2,69	4,18	4,97
22	2,55	4,11	4,83
33	2,79	3,97	4,85
44	3,74	4,01	5,49
55	---	---	---
66	---	---	---
77	---	---	---
77	---	---	---
88	---	---	---
99	---	---	---
10	---	---	---
11	---	---	---
12	---	---	---
13	---	---	---
14	---	---	---
15	---	---	---

First Order

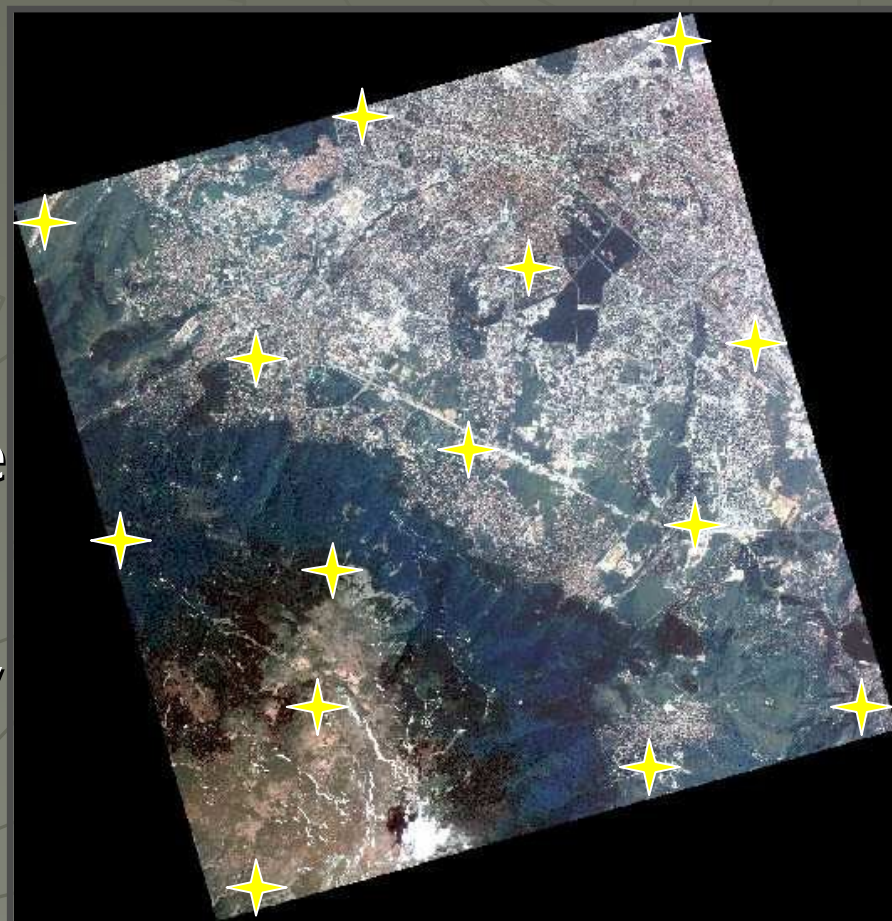
GCP#	RMS_X	RMS_Y	RMS_XY
0	23.122	26.01	34.84
1	2,65	4,16	4,93
2	2,87	4,28	5,15
3	2,77	3,82	4,72
4	3,52	2,14	4,12
5	2,87	1,95	3,47
6	2,89	2,07	3,56
7	2,40	1,84	3,02
8	2,33	1,87	2,98
9	2,32	1,99	3,06
10	2,38	1,92	3,05
11	2,30	2,10	3,11
12	2,45	1,93	3,12
13	2,17	1,90	2,88
14	1,97	1,91	2,74
15	2,02	1,93	2,79

Conclusions_[1]

- ▶ The quality of orthoproduct depends on:
 - Positional accuracy and distribution of GCPs
 - DEM
 - Satellite model (RPC adjustment)
- ▶ 0 order RFM 2D shift only
 - 1 or 2 GCPs
- ▶ 1st order RFM- potential for affine transformation
 - Depends on GCP# - at least 3 required for true affine transformation
 - 1 GCP- translation
 - 2 GCPs- rotation
- ▶ Order usage
 - 0 order- if GCPs are not well distributed gives better results
 - 1st order- best except in the case GCPs are not well distributed
- ▶ RPC method advantage use of few GCPs than in rigorous modelling

Conclusions

- ▶ JRC spec require the GCPs to be 3x more accurate than targeted orthoacc
- ▶ Promising initial results related to the GCPsacc (even when acc is ~1m)
- ▶ Additional tests with more accurate GCPs needed
- ▶ ReSAC is collecting new DGPS points with accuracy 20-30 cm



KOMPSat-2

- the other 1m solution

A photograph of the KOMPSat-2 satellite in orbit above Earth. The satellite is a gold-colored cube with four large, rectangular solar panel arrays extended from its sides. The Earth's surface is visible below, showing blue oceans and white clouds. The background is the blackness of space with some stars.

Thank you
for your attention !

Remote Sensing Application Cent Bulgaria

Distributor of VHR sensors

www.resacbg.org