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Anais XIII Simpósio Brasileiro de Sensoriamento Remoto, Florianópolis, Brasil, 21-26 abril 2007, INPE, p. 4943-4949.

MAPSAR image simulation based on L-Band polarimetric SAR data of the airborne SAR R99 sensor of the CENSIPAM

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Abstract. This paper describes the methodology applied to generate the simulated polarimetric SAR images of the MAPSAR L band spaceborne sensor, derived from the airborne SAR L-Band sensor R-99 CENSIPAM data. MAPSAR is the result of a joint phase A study conducted by INPE and DLR targeting a mission for assessment, management and monitoring of natural resources.

Key-words: MAPSAR, SAR, simulation, L band sensor, polarimetry

1- Introduction

The Brazilian-German MAPSAR (Multi-Application Purpose SAR) mission is a proposal for a light and innovative L-band SAR, Kono et al. (2003) and Schroder et al. (2005), illustrated in the **Figure 1**, based on INPE's Multi_Mission-Platform. The mission is in currently investigated by INPE and DLR in a phase A study. The SAR image simulation is an important part of this investigation in order to verify the potential use of this data. The simulation of MAPSAR images was performed by using images provided by the airborne SAR L-Band sensor**,** the R99 of the SIPAM, shown in the **Figure 2**.

Figure 1- Ilustration of the MAPSAR satellite

Figure 2- The airborne L-band SAR sensor R99 on board of the EMB-145 aircraft

2 - Simulation

The aim of this simulation was investigate with simulated data, the multi-polarized L-band imagery capability for assessment, management and monitoring of natural resources. A set of test site area were selected covering themes like Agriculture, Forestry, Geology and Mineral Exploration, Disaster Management, Costal Zone Studies, Geomorphology, Hydrology and Environmental Analysis. The test sites were selected by the potential users in the Government Institutions, Universities and the Private Companies. Due to the high incident angle used by the SAR-R99 sensor, it was possible simulate only the MAPSAR radar beam 9 and 10, as shown in the **Table 1**.

Table 1 – Radar beam and the incidence angle of the MAPSAR

Bean	Incidence angle (degree)	Swath width (Km)
1	19,93 - 23,95	45,1
2	23,76 - 27,32	41,9
3	27,12 - 30,71	44,5
4	29,69 - 33,31	46,9
5	32,86 - 36,52	50,4
6	36,15 - 39,86	54,8
7	39,50 - 42,69	50,0
8	42,22 - 45,24	51,0
9	45,16 - 46,92	31,6
10	46,28 - 48,08	33,5

A range of incidence angle varying from 45º to 53º was selected. Notice that this range of incidence angle is a little bit out o the MAPSAR interval, this selection was based in a compromise between a good signal/noise ratio for the R99 images and the number of tracks to flight to compose a simulated MAPSAR image. The spatial resolution of 10 meters was used in order to simulate the Medium Resolution Mode (DPM) and the swath width of the 30 Km approximately. The **Table 2** shows the MAPSAR specification of imaging modes.

Table 2 - Specification of MAPSAR imaging modes

Mode / Parameters	High resolution SPM		**Medium Resolution* DPM**		Low resolution QPM	
Access region	near	far	near	**far**	near	far
Spatial resolution range (m) azimuth (m)	 4,7 3,1	 3,1 3,1	 10 10	 **10** **10**	 20 20	 20 20
Off-nadir angle (°)	20,0	41,8	20,0	41,8	20,0	32,1
Incidence (°)	20,3	47,6	20,0	**48,1**	20,0	36,8
Swath (km)	38,3	20,5	45,1	**35**	43,4	28
Chirp Bandwidth (MHz)	85	85	42,5	21,25	21,25	21,25
Looks number range azimuth	 1 1	 1,33 1	 1,14 3,3	 **1,13** **3,3**	 1,0 6,6	 1,73 6,6

(* simulated MAPSAR mode)

The basic strategy for flight simulation was to use a set of ten SAR-R99 images with a large overlap between them to generate a simulated MAPSAR image. The ten parts of images within an incident angle of 45º to 53º are composed to create a simulated image of the swath width of 30 Km, as shown in the **Figure 4**.

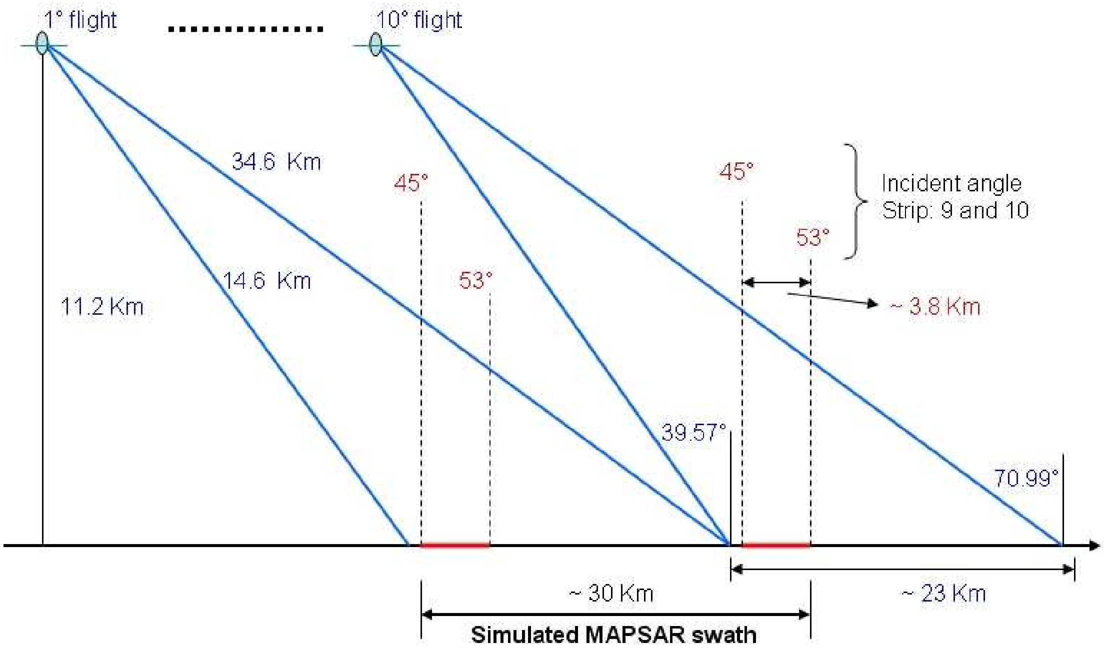


Figure 4– Fight geometry for MAPSAR image simulation

In order to generate the simulated MAPSAR slant range image, a set of 10 slant range images of the sensor SAR-R99 were projected to the slant range geometry of the space-borne MAPSAR platform, as shown in the **Figure 5**.

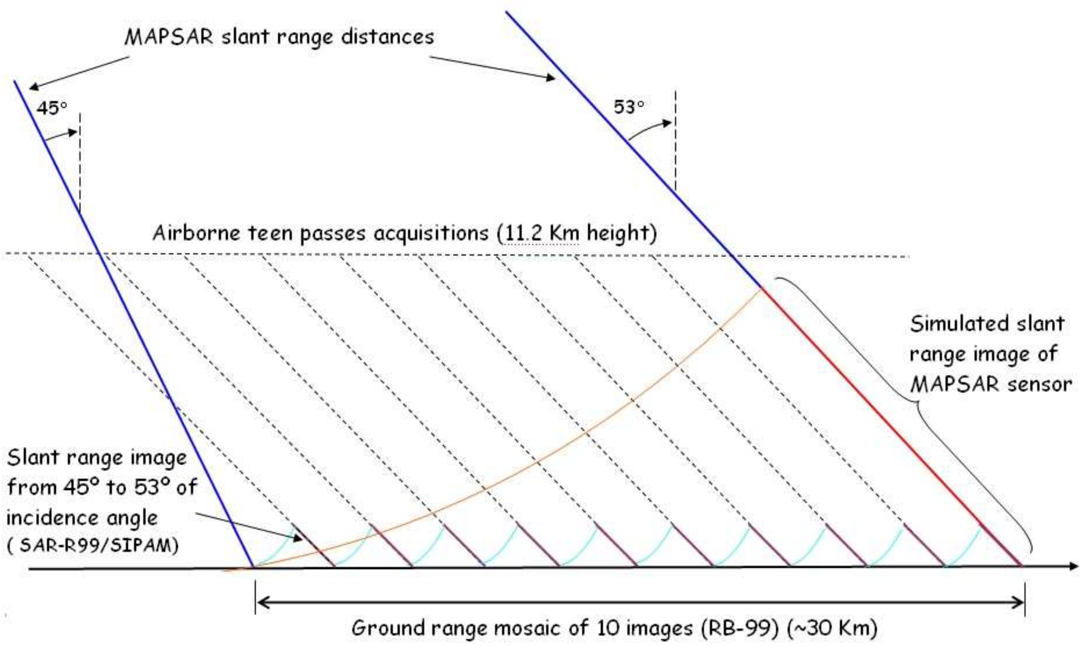


Figure 5 – Slant range geometry for the spaceborne MAPSAR platform

2- Data acquisition

The data acquisition campaign was carried out in 2005 and supported by FAB (COMGAR, CTA-IEAv), SIPAM and AEB. The data were acquired following the specification of MAPSAR, L-band, multi-polarized data, descending orbit and incidence angle. Eight test site areas were flown, seven in the Brazilian Amazon region and one in the northeast of Brazil, organized by following the subject and institution:

- Agriculture:
  Barreiras (BA) - EMBRAPA, INPE, UnB, CPRM;
- Forestry:
  Tapajós (PA) - INPE, DSG;
- Disaster Management (Oil spill):
  Pipeline Urucu-Coari-Solimões Rivers (AM) - PETROBRAS, COPPE, UFRJ, INPA;
- Costal Zone Studies/Geomorphology:
  Bragança(PA) - UFPa, Museu Goeldi, PETROBRAS, INPE;
- Hydrology and Environmental Analysis:
  Igarapé Açu (AM) - INPE, INPA, JPL(EUA);
- Geology and Mineral Exploration:
  Província Mineral de Carajás (PA) - INPE, UNICAMP, CVRD;
- Geology:
  Vale do Curaçá (BA) – INPE;
- Hydrology and Environmental Analysis:
  Lago Grande (PA) - INPE, UVIC (Canadá).

A Total of 160 hours of flight were necessary to gather the whole set of data for this simulation campaign. The original collection of the multi-polarized L-band images of the SAR-R99 sensor, with a spatial resolution of 6 meters, form a very rich source of information for the Amazon’s researcher.

3 - Data processing

The processing steps to generate the MAPSAR simulated image are related in the following topics:

3.1 - Generation of the R99 images

The SAR processing to synthesize the images of the sensor R99 was carried out in the CRV-CENSIPAM of Manaus-AM by using the PROSAR SAR processor (developed by the IEAv-CTA group). The images were processed with 3 azimuth looks and with a spatial resolution of 6 meters in range and azimuth. Each image was cut in an interval of incidence angle of 45º to 53º and geocoded (WGS-84 ellipsoid) based on the state vector of the platform using the ERDAS GIS system.

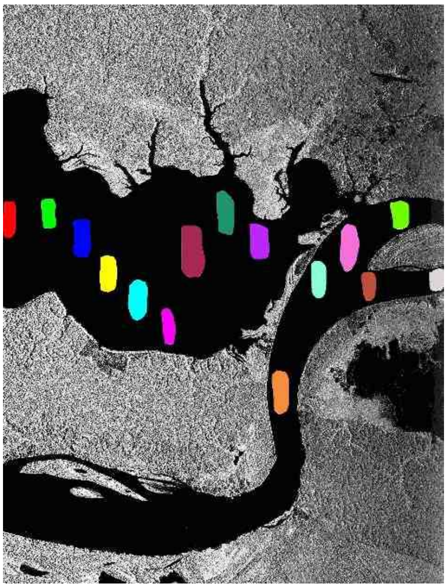
3.2 - Mosaic of the R99 images

The set of ten R99 geocoded images were used to generate a mosaic of images to form a simulated MAPSAR image. The mosaicing was performed in the three polarization, HH, VV and HV, using the ER-Mapper GIS system, in the Geoambiente SR S/C Ltda company. During this mosaicing processing step some care were considered, such as, to guarantee the radiometric continuity between the R99 images in the mosaic, the polarization response between R99 images must be the same in the polarimetric mosaic. Although these care were taken, some mosaics presents small difference between R99 images basically due too the signal/noise ratio in the polarization HV in a range of incidence angle of 45º to 53º degree.

3.3 - Radiometric and geometric transformation

The MAPSAR and SAR-R99 system have different characteristics concerning the bandwidth, system noise and geometry of acquisition. The first is a space-borne sensor and the other is an airborne sensor. In order to simulate a MAPSAR image from the R99 images, some constraint in terms of noise and bandwidth has to be applied in R99 images.

The noise equivalent sigma nought (NESN) of the R99 system was determined by using the backscatter of Coari river, in the Amazon state of Brazil, based in the methodology described in Srivastana at al. (2000). The image used and the profile of the NESN for the MAPSAR and the R99 system are shown in the **Figure 6**.



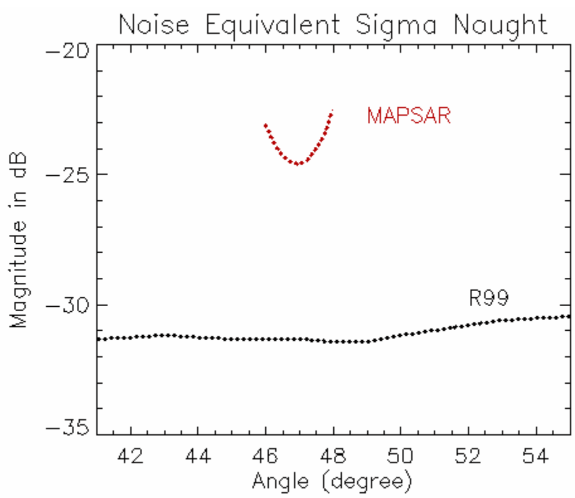


Figure 6 – Image samples in the Coari river in the R99 image
and the plot of the NESN for both system.

The MAPSAR system is more noisy then the R99 system, this noise difference must be applied to the simulated image in order to have a better representation of that. In order to accommodate the range and azimuth bandwidth to the MAPSAR characteristics, filters in range and azimuth directions were applied in the simulated image, as shown in the **Figure 7**. The last step of processing consists on a transformation to the geometry of the MAPSAR space-borne sensor.

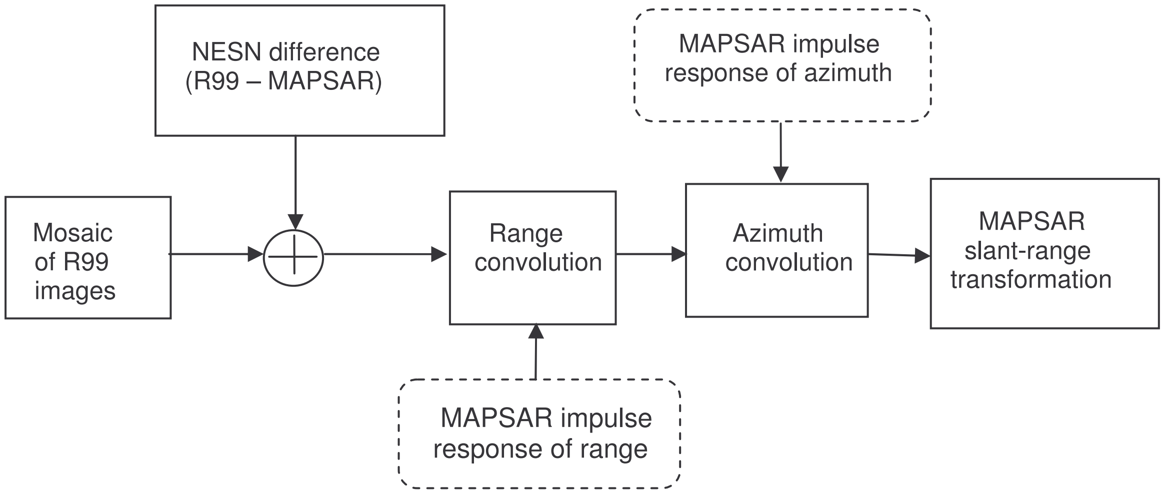


Figure 7 – Processing flow of radiometric and geometric transformation to simulate the MAPSAR image

3- Product and data format

The product provided to the user was a simulated polarimetric image of each test site processed with 3 azimuth looks and spatial resolution of 10 meters, representing the Medium Resolution Mode (DPM) of MAPSAR with a swath width of the 30 Km approximately. The geocoded simulated images have the same geometric accuracy of the original geocoded R99 images . **Figure 8** shows a simulated descending mode MAPSAR polarimetric image of an agriculture area (*Barreiras -BA).*

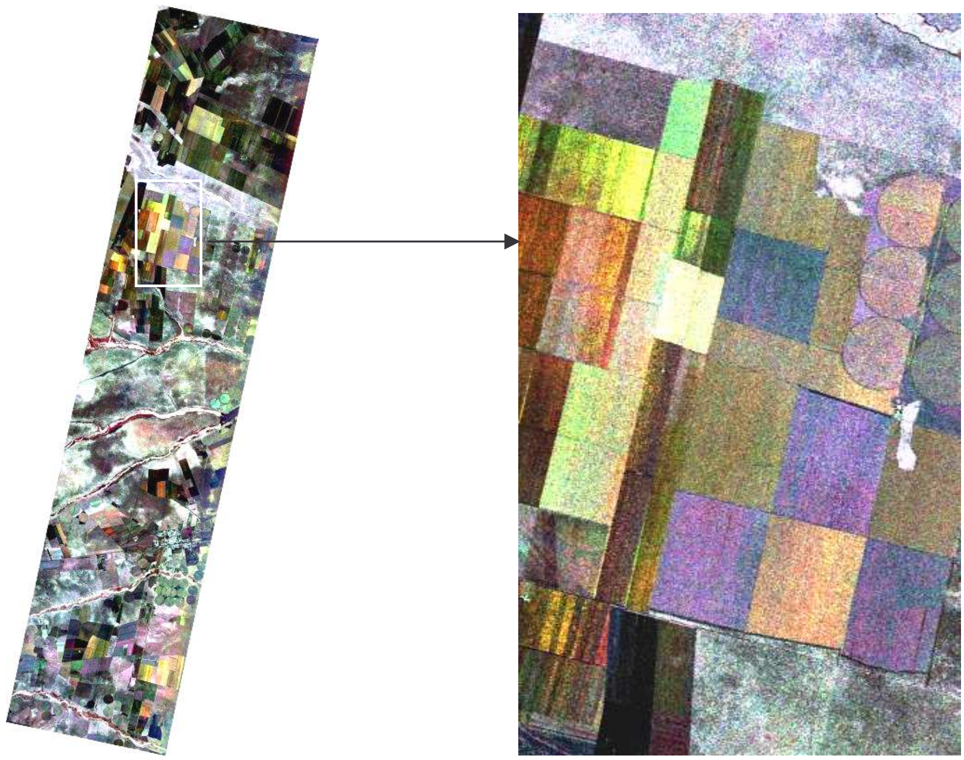


Figure 8 – Simulated descending mode MAPSAR polarimetric image with a color composition of HH (red), VV(green) and HV(blue).

The simulated images were provided in slant-range and geocoded projections represented in unsigned 16 bits format. The slant-range images were delivered in Tiff format, and the geocoded image in the GeoTiff format (Projection: Lat/Long; Datum: WGS-84).

Acknowledgements

The authors wish to thank the CENSIPAM for the airborne SAR-R99 sensor data and processing, to DLR/German for helpful support for the MAPSAR simulation, to LBA for the infrastructure and PETROBRAS for providing the corner-reflectors during the field campaign.

4-References

Kono, J ; Paradella W. R. ; Silva, M. M. Q ; VALERIANO, D. M. ; Costa, M. P. F. ; Schroder, R ; Puls, J. ; Hajnsek, I ; Jochin, F ; Neff, T. . MAPSAR: A New L-Band Spaceborne SAR Mission for Assessment and Monitoring of Terrestrial Natural Resources. In: Simpósio Brasileiro de Sensoriamento Remoto, 2003, Belo Horizonte. Anais do XI SBSR. São José dos Campos : INPE-SELPER, 2003. v. I. p. 2193-2200.

Schroder, R ; Puls, J. ; Hajnsek, I ; Jochin, F ; Neff, T. ; Kono, J ; Paradella W. R. ; Silva, M. M. Q ; VALERIANO, D. M. ; Costa, M. P. F. . MAPSAR: A Small L-Band SAR Mission for Land Observation. Acta Astronautica, Oxford, England, v. 56, n. 2004, p. 35-43, 2005.

Srivastana, Satish; Sheperd, Nick; Extraction o Beta nought and Sigma nought from RADARSAT CDPF Products, april 2000, Report no. AS97- 5001, Altrix System.