DOCUMENT

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JERS SAR PRI PRODUCTS CALIBRATION

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1 INTRODUCTION

This aim of this note is the description of the method to perform an absolute calibration of JERS SAR PRI products generated by ESA using the **FOCUS SAR processor versions 2.9b , 2.10 b and 2.16.**

It should be noted that this document does not apply to JERS SAR PRI products generated using other versions of the FOCUS processor.

Verification of this calibration method has been carried out using an Amazon rain forest scene and assuming a flat gamma nought of –7.74 dB.

2 TRANSFORMATION OF JERS SAR PRI DIGITAL NUMBERS IN RADAR BRIGHTNESS

Digital values in JERS SAR PRI images are directly related to the radar brightness of the scene (beta nought):

$$\mathrm{PRI\_DN} = \sqrt{\beta^0 . \mathrm{K}}$$

$$K = A^* F$$

where PRI_DN are the digital numbers in the PRI image (corresponding to amplitude information) and A is an image dependent scaling factor used by the processor to convert PRI digital numbers from the internal floating point representation to the final CEOS format integer representation (2 bytes).

The scaling factor 'A' can be found in the CEOS leader file, Facility related data record, General type, in the field called "Absolute calibration constant K " (see appendix B).

The calibration factor 'F' is processor version dependent and the corresponding values are provided in the table below:

	V 2.9b	V 2.10b	V 2.16
F	2.0606299	2.0606299	2.0781714

In order to convert the digital numbers of a JERS PRI image into radar brightness expressed in dB, the following relation must be applied:

$$\beta^0 = \frac{\mathrm{PRI\_DN}^2}{\mathrm{K}} \qquad \text{[Eq.2]}$$

$$\beta^0\,[\mathrm{dB}] = 10.\log\left(\frac{\mathrm{PRI\_DN}^2}{\mathrm{K}}\right)$$

3 TRANSFORMATION OF JERS SAR PRI DIGITAL NUMBERS IN SIGMA NOUGHT

Sigma nought or radar cross section values can be derived as linear values according to Eq.3 and in dB according to Eq.4, where α represents the incidence angle:

$$\sigma^0 = \frac{PRI\_DN^2.\sin(\alpha)}{K} = \beta^0.\sin(\alpha) \qquad [Eq.3]$$

$$\sigma^0[dB] = 10.\log\left(\frac{PRI\_DN^2.\sin(\alpha)}{K}\right) \qquad [Eq.4]$$

4 TRANSFORMATION OF JERS SAR PRI DIGITAL NUMBERS IN GAMMA NOUGHT

Gamma nought values are derived as linear values according to Eq. 5 and in dB according to Eq.6, where α represents the incidence angle:

$$\gamma^0 = \frac{PRI\_DN^2.\tan(\alpha)}{K} = \beta^0.\tan(\alpha) \qquad [Eq.5]$$

$$\gamma^0[dB] = 10.\log\left(\frac{PRI\_DN^2.\tan(\alpha)}{K}\right) = 10.\log\left(\beta^0.\tan(\alpha)\right) \qquad [Eq.6]$$

APPENDIX A INCIDENCE ANGLE DERIVATION

To derive the incidence angle α_i to a pixel at ground range coordinate i, the following information shall be retrieved from the product header CEOS annotations:

- the *zero Doppler range time* t_1 of the first range pixel.
- the *near range incidence angle*, α_1.
- the *processed scene centre latitude* (geodetic), λ.

The Earth radius, R_T, is calculated using:

$$R_T = a\ [\cos^2\lambda + (b/a)^4 \times \sin^2\lambda\ ]^{1/2} \times [\cos^2\lambda + (b/a)^2 \times \sin^2\lambda\ ]^{-1/2}$$

Where:

- a = equatorial Earth radius (6378.144 km)
- b = polar Earth radius (6356.759 km)

a and b values correspond to the ERS reference ellipsoid: GEM6 (Goddard Earth Model 6). GEM6 oblateness coefficient is 1/298.257.

From the ERS reference geometry, the ERS altitude H is given by:

$$R_T + H = [\ R_T^2 + R_1^2 + 2 \times R_T \times R_1 \times \cos \alpha_1]^{1/2}$$

Where:

- R_1 is the slant range distance to the first range pixel: $R_1 = c \times t_1 / 2$
- c is the velocity of light,
- t_1 is the *zero Doppler range time* of the first range pixel.

The near range look angle is given by:

$$\cos \theta_1 = (R_1 + R_T \times \cos \alpha_1) / (R_T + H)$$

The Earth angle ψ_1 for first range pixel is given by: $\pi = \psi_1 + \theta_1 + (\pi - \alpha_1)$ thus: $\psi_1 = \alpha_1 - \theta_1$

ψ_1 is the angle between the vertical of the satellite and the vertical of the first range pixel.
The Earth angle ψ_i for pixel i can be estimated using:

$\sin(\Delta\psi_i) = (i-1) \times \Delta r / R_T$, where Δr is the *pixel spacing* (along ground range).

$\Delta\psi_i$ being small ($\Delta\psi_i$ = 0.9 degree for 100 km swath width), ψ_i is given by:

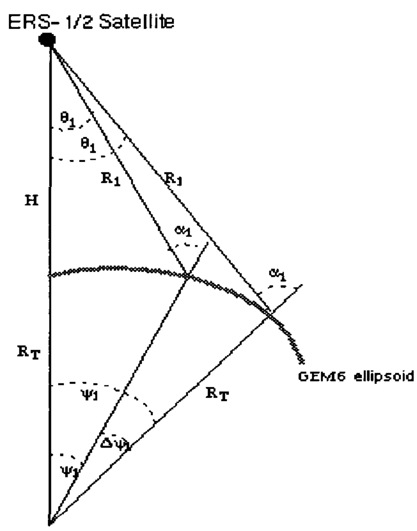
$\psi_i = \psi_i + \Delta\psi_i = \psi_1 + (i-1) \times \Delta r / R_T$ (expressed in radians)

The slant range to a pixel at range coordinate i, R_i, is given by:

$$R_i = [\ R_T^2 + (R_T+H)^2 - 2 \times R_T \times (R_T + H) \cos\psi_i\ ]^{1/2}$$

The incidence α_i angle at pixel coordinate i is given by:

$$\cos \alpha_i = [\ (R_T+H)^2 - R_i^2 - R_T^2\ ] / (2 \times R_i \times R_T)$$



APPENDIX B LOCATION OF INFORMATION REQUIRED FOR PRODUCT CALIBRATION

Parameter	File	Record	Field	Bytes	Units/Format
Generating software release and revision level	LF	FDR	12	33-34	-
processed scene centre geodetic latitude	LF	DSSR	13	117 - 132	degrees
zero Doppler range time of first range pixel	LF	DSSR	126/1	1767 - 1782	millisec
number of pixels per line	LF	MPR	9	61 - 76	pixels
number of lines	LF	MPR	10	77 - 92	lines
pixel size (range direction)	LF	MPR	11	93 - 108	m
pixel size (azimuth direction)	LF	MPR	12	109 - 124	m
ellipsoid semi-major axis	LF	MPR	21	269 - 284	m
ellipsoid semi-minor axis	LF	MPR	22	285 - 300	m
near range incidence angle	LF	FRDR	56	583 - 598	degrees
absolute calibration constant (factor A)	LF	FRDR	62	663 - 678	-

- *LF: Leader File*
- *FDR: File Description Record*
- *DSSR: Data Set Summary Record*
- *MPR: Map Projection Record*
- *FRDR: Facility Related Data Record*