CSK and CSG IMAGE CALIBRATION

The radiometric calibration of SAR images consists in the evaluation of the radiometric values. These are independent of geometry and radar characteristics and dependent only on the terrain scattering features.

The effects that must be considered are:

- Range spreading loss effect
- Antenna pattern gain compensation
- Incidence angle effect

In the COSMO-SkyMed SCS_B, DGM_B, GEC_B and GTC_B images, all factors different pixel by pixel have been already corrected. So the square of the Digital Numbers (DN) of the images are related to the terrain backscattering coefficients σ^0 through a constant number.

***Note**: all the data considered above use the WGS84 ellipsoid for the terrain correction, apart from GTC_B. The "terrain corrected" products (GTC_B) are processed using a Digital Elevation Model (DEM) which is used to evaluate the geometric calibration factors too.*

SIGMA NAUGHT (σ^0) EVALUATION

In the following, the steps that must be carried out to obtain backscattering coefficient image starting from DN are described.
The necessary parameters involved in the backscattering image generation are listed in a subsequent table. They could be extracted from metadata.

***Note**: the σ^0 coefficients are defined in ground. So, extraction of σ^0 coefficients from SCS images (level 1A) means to have ground projected values in a slant geometry.*
This must be taken into account if the backscattering image would be extracted. The ground projection is the natural projection in which backscattering coefficients are defined, so it's better to use DGM_B images if you need calibrated images values.
For the image levels listed above and for any acquisition mode, the steps to obtain the calibrated values from the DN of image are the following:

Step	Conditions	Description	Formula
1		Evaluate the power image	$P(i,j) = \lvert img_{inp}(i,j) \rvert^2$
2	$Rsl_{flag} \neq$NONE	Remove the *Reference Slant Range*	$Fact = R_{ref}^{2*R_{\exp}}$
3	$Inc_{flag} \neq$NONE	Remove the *Reference Incidence Angle*	$Fact' = Fact * \sin(\alpha_{ref})$
4		Remove the *Rescaling Factor*	$Fact'' = Fact' \cdot \frac{1}{F^2}$
5	$K_{flag}=0$	Apply the *Calibration Factor*	$F_{Tot} = Fact'' \cdot \frac{1}{K}$
6		Apply the total scaling factor	$\sigma^0(i,j) = P(i,j) * F_{Tot}$

Tab. 1: steps for σ^0 evaluation

To get σ^0 in dB:

$$\sigma^0(i,j)_{dB} = 10\log_{10}\sigma^0(i,j)$$

***Note**: When starting from complex products (SCS_B)*, particular attentions must be taken in power calculation in order to avoid artefacts generation. Generally speaking, the power image evaluation must be done considering also an interpolation by two in*
order to enlarge the image spectral support; then the first step of Tab.1 can be applied.
The σ^0 obtained as described in Tab. 1: steps for σ^0 evaluation

is the evaluation of the single pixel backscattering coefficient; in order to have a more significant result a running window average has to be done for σ^0 evaluation.

The form of the final backscattering image is obtained with a formula like the following one:

$$\left\langle \sigma^0(r,c) \right\rangle = \sum_{i,j}^{wid_r, wid_c} \sigma^0\left(i + r \cdot wid_r + \frac{wid_r}{2}, j + c \cdot wid_c + \frac{wid_c}{2}\right)$$

or, in logarithmic units:

$$\left\langle \sigma^0(r,c) \right\rangle_{dB} = 10\log_{10}\left\langle \sigma^0(r,c) \right\rangle$$

***Note**: SCS_U (Unbalanced level 1A products) are not corrected for the main effects listed above: therefore this procedure is **NOT** applicable to these data.*

The following table lists all the metadata to be extracted and used for this procedure

Description	HDF5 Parameter name	Symbol used	Unit
Acquisition mode	Acquisition Mode	A_{Mode}	NA
Reference slant range used in the processing steps	Reference Slant Range	R_{ref}	meters
Exponent of the Reference Slant Range used to do the Range Spreading Loss correction	Reference Slant Range Exponent	R_{exp}	Num
Reference incidence angle used in the processing steps	Reference Incidence Angle	α_{ref}	Deg
Calibration constant (depending on the sensor mode)	Calibration Constant	K	Num
Rescaling factor applied in the processing steps	Rescaling Factor	F	Num
Flag indicating if the range spreading loss compensation has been applied	Range Spreading Loss Compensation Geometry	Rsl_{flag}	NA
Flag indicating if the Incidence Angle Compensation has been applied	Incidence Angle Compensation Geometry	Inc_{flag}	NA
Flag indicating if the calibration constant has been applied	Calibration Constant Compensation Flag	K_{flag}	boolean

Tab. 2: Parameters used in the radiometric equalization of the COSMO images

The procedure described for CSK is still valid for CSG images.

The only difference is that CSG products, unlike CSK ones, are already calibrated and provided as floating point data format.

For this reason, the user shall consider that:

- The first normalization step for R_{ref} and sin (α_{ref}) are no longer necessary and therefore the tags in question (including R_{exp}) have been removed from the product metadata (i.e. if you look for them in the hdf5 file or in the xml you will not find them anymore);
- The Rescaling Factor F is automatically assumed to be 1;
- The Calibration Constant K is equal to 1 and it has already been applied to the products (i.e. Calibration Constant Compensation Flag = 1).