



# Detecção Remota Microondas

Mestrado em Engenharia GeoEspacial

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## Antes das aulas:

1. Instalação do software SNAP (Science Toolbox exploitation platform)

<http://step.esa.int/main/download/snap-download/>

2. Dowload dos dados de cada laboratório na plataforma CIRRUS

Server address: [cirrus.ciencias.ulisboa.pt](http://cirrus.ciencias.ulisboa.pt)

ou

<https://cirrus.ciencias.ulisboa.pt/owncloud/s/qx4ne7Ak7mYLcns>

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## Aula laboratorial 1

Objectivo: Manipulação de imagens SAR e transformação em formato GRD

Dados: Imagens TSX e S1

### a) Imagens SAR – Satélite TerraSAR-X

Como aceder às imagens TSX

<https://eoweb.dlr.de/egp/>

Login as guest

1. **Open Product** (TDX1\_SAR\_\_SSC\_\_\_\_\_SM\_D\_SRA\_20171219T064714\_20171219T064722.xml)

É uma imagem com polarização VV+HH (TSX-POL)

Qual é a data de aquisição da imagem?

> Ver os metadados: (Abstracted Metadata, ... )

> Ver imagens dos tie-points grids

> ver as banda VV e HH

## 2. Visualização da imagem

- > Double-click on the band for visualization: observemos a intensidade
- > modificar a intensidade da imagem > Colour manipulation > calcular as estatística > Log10
- > se necessário mexer o limite inferior preto para a direita

## 3. Calibração da imagem

The objective of SAR calibration is to provide imagery in which the pixel values can be directly related to the radar backscatter of the scene. Though uncalibrated SAR imagery is sufficient for qualitative use, calibrated SAR images are essential to quantitative use of SAR data.

Typical SAR data processing, which produces level 1 images, does not include radiometric corrections and significant radiometric bias remains. Therefore, it is necessary to apply the radiometric correction to SAR images so that the pixel values of the SAR images truly represent the radar backscatter of the reflecting surface. The radiometric correction is also necessary for the comparison of SAR images acquired with different sensors, or acquired from the same sensor but at different times, in different modes, or processed by different processors.

The operator performs absolute radiometric calibration for TerraSAR-X products. The following corrections have been applied:

- calibration constant correction
- incidence angle correction
- Noise Equivalent Beta Naught (NEBN) correction

The "noiseCorrectedFlag" in the metadata is checked before NEBN correction is applied. The operator currently does not support ScanSAR calibration when noiseCorrectedFlag is false. For detailed TerraSAR-X product calibration algorithm.

The radar brightness  $\beta^0$  is derived from the image pixel values or digital numbers (DN) applying the calibration factor  $k_s$  (1).

$$\beta^0 = k_s \cdot |\text{DN}|^2 \quad (1)$$

Equation (2) converts  $\beta^0$  to dB,

$$\beta^0_{\text{dB}} = 10 \cdot \log_{10}(\beta^0) \quad (2)$$

### Sigma naught

$$\sigma^0 = \left( k_s \cdot |DN|^2 - NEBN \right) \cdot \sin \theta_{loc} \quad (4)$$

where:

- $k_s$  is the calibration and processor scaling factor given by the parameter calFactor in the annotated file (§1),
- DN is the pixel intensity values (§1),
- NEBN is the Noise Equivalent Beta Naught. It represents the influence of different noise contributions to the signal [1]. The computation of NEBN is described in §2.1.
- $\theta_{loc}$  is the local incidence angle. It is derived from the Geocoded Incidence Angle Mask (GIM) that is optional for the L1B Enhanced Ellipsoid Corrected (EEC) product ordering. The complete decryption of the GIM is proposed in §2.2.

§ Radiometric > Calibration

Experimentar as duas opções:

1. Save as complex output (preserva a estrutura complexa)
2. output sigma (a imagem é transformada em dB)

#### 4. Composição RGB

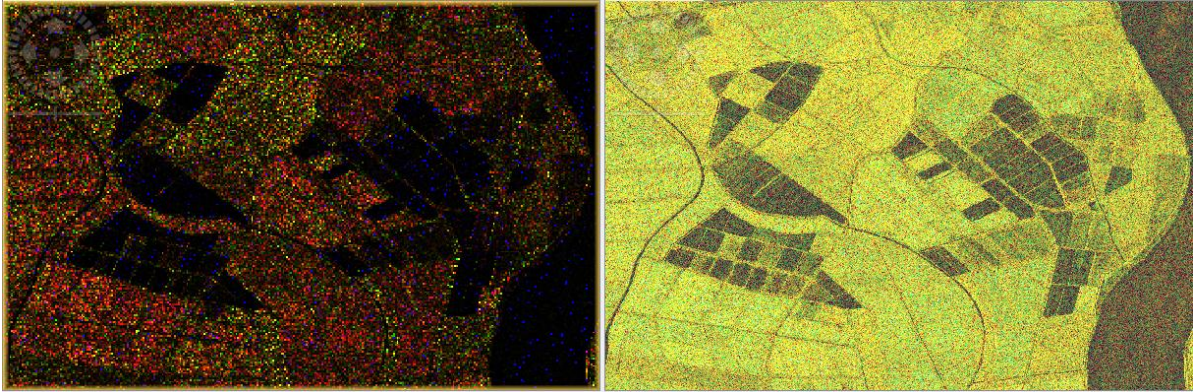
§ Visualizar VV e HH

§ Open RGB image (R: VV, G: HH, B: VV/HH) (Com o cursor sobre o ficheiro imagem > botão direito do rato)

> Fazer zoom no estuário do Tejo. Ver parcelas agrícolas. Os navios aparecem de forma diferente nas diferentes polarizações. O mesmo se verifica com a ondulação.

§ Visualizar a composição RGB com a imagem em dB

> Fazer histograma das intensidades e em dB (dB é uma escala linear)



Composição colorida da intensidade (esquerda) e do sigma naught (direita)

### 5. Filtragem (speckle)

§ Speckle Filtering / single product

### 6. calcular as imagens de Fase

> Fase =  $\text{atan2}(q,i)$

### 7 . Terrain Correction

§ Range Doppler terrain Correction

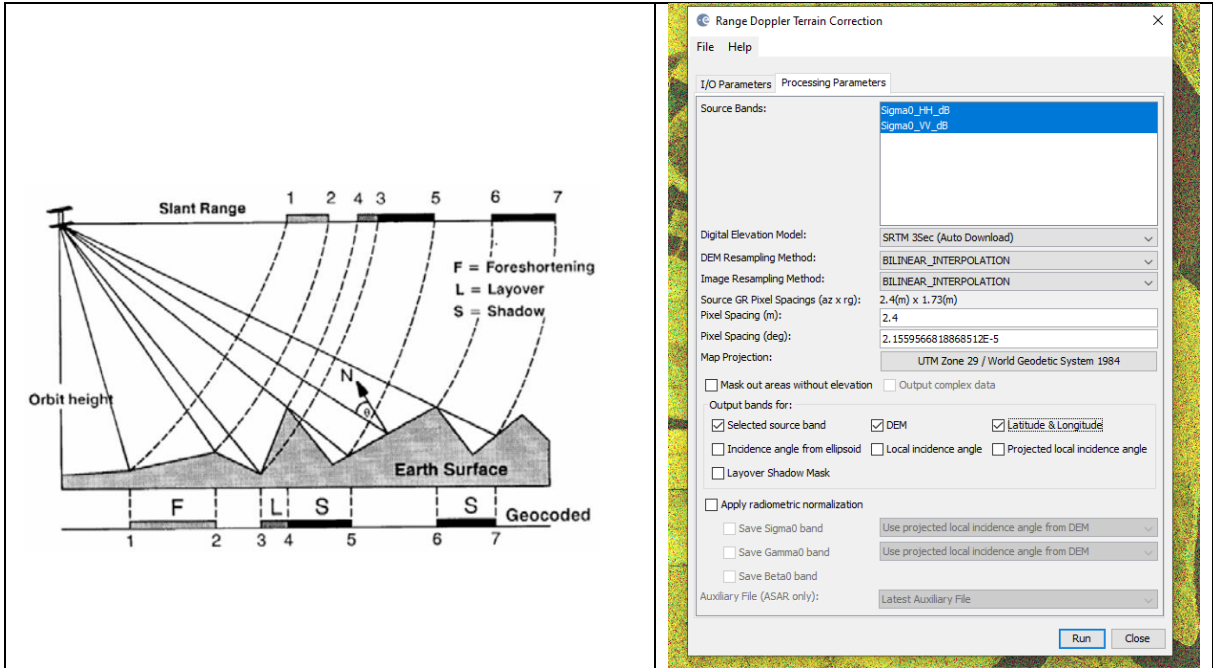
calcular todas as imagens: latitude, Elevation , incident angle, ...

Digital elevation model: Copernicus 30 m

Escolher Sistema: UTM / pixel =2.5 m

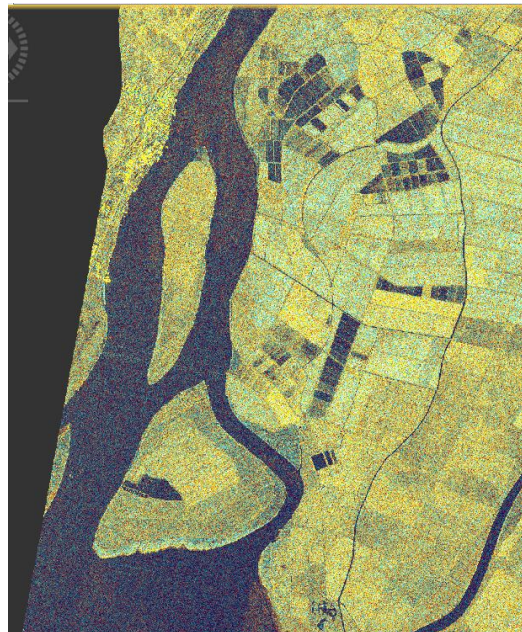
**Importante: desativar "Mask out areas without elevation"**

Pode experimentar Radiometric normalization: sigma0



The diagram on the left illustrates the geometry of SAR imaging. It shows an orbit at a certain height above the Earth's surface. Slant range lines are drawn from the sensor to various points on the ground, labeled 1 through 7. The ground is divided into segments labeled F (Foreshortening), L (Layover), and S (Shadow). A legend defines these terms: F = Foreshortening, L = Layover, S = Shadow. The ground is also labeled 'Geocoded'.

The screenshot on the right shows the 'Range Doppler Terrain Correction' software interface. It includes a 'File' menu and 'Help' button. The 'I/O Parameters' and 'Processing Parameters' tabs are visible. The 'Source Bands' section lists 'Sigma0\_HH\_dB' and 'Sigma0\_VV\_dB'. The 'Digital Elevation Model' is set to 'SRTM 3Sec (Auto Download)'. The 'DEM Resampling Method' and 'Image Resampling Method' are both set to 'BILINEAR\_INTERPOLATION'. The 'Source GR Pixel Spacings (az x rg)' are '2.4(m) x 1.73(m)'. The 'Pixel Spacing (m)' is '2.4' and the 'Pixel Spacing (deg)' is '2.1559566818868512E-5'. The 'Map Projection' is 'UTM Zone 29 / World Geodetic System 1984'. There are checkboxes for 'Mask out areas without elevation', 'Output complex data', 'Selected source band', 'DEM', 'Latitude & Longitude', 'Incidence angle from ellipsoid', 'Local incidence angle', 'Projected local incidence angle', 'Layover Shadow Mask', and 'Apply radiometric normalization'. Under 'Apply radiometric normalization', there are options to 'Save Sigma0 band', 'Save Gamma0 band', and 'Save Beta0 band', each with a dropdown menu for 'Use projected local incidence angle from DEM'. The 'Auxiliary File (ASAR only)' is set to 'Latest Auxiliary File'. 'Run' and 'Close' buttons are at the bottom right.



Terrain Correction

## b) Imagens SAR – Satélite Sentinel-1

Quanto ao formato a ESA disponibiliza o formato GRD e SLC:

Level-1 Ground Range Detected (GRD) products consist of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model. Phase information is lost.

Level-1 Single Look Complex (SLC) products consist of focused SAR data geo-referenced using orbit and attitude data from the satellite and provided in zero-Doppler slant-range geometry. The products include a single look in each dimension using the full TX signal bandwidth and consist of complex samples preserving the phase information

Mode	Incidence Angle	Resolution	Swath Width	Polarization (H = Horizontal V = Vertical)
Stripmap	20 - 45	5 x 5 m	80 km	HH+HV, VH+VV, HH, VV
Interferometric Wide swath	29 - 46	5 x 20 m	250 km	HH+HV, VH+VV, HH, VV
Extra Wide swath	19 - 47	20 x 40 m	400 km	HH+HV, VH+VV, HH, VV
Wave	22 - 35 35 - 38	5 x 5 m	20 x 20 km	HH, VV

Como aceder às imagens Sentinel-1:

a) Site da ESA: <https://dataspace.copernicus.eu>

Fazer pesquisa na região de Lisboa abrangendo mar

Temos imagens IW (Interferometric Wide swath), swath de 250 km, resolução 5 x 20m, adquiridas sobre terra e EW (Extra Wide swath ) adquiridas sobre o mar, swath 400 km, resolução 20 x 40 m.

b) site da ASF: <https://search.asf.alaska.edu/#/>

i) definir a região de interesse

ii) DataSet: Sentinel-1;Filters (Dates, SLC, IW, Descending,)> Search

ver qual o path que interessa. E voltar a pesquisar as imagens desse path

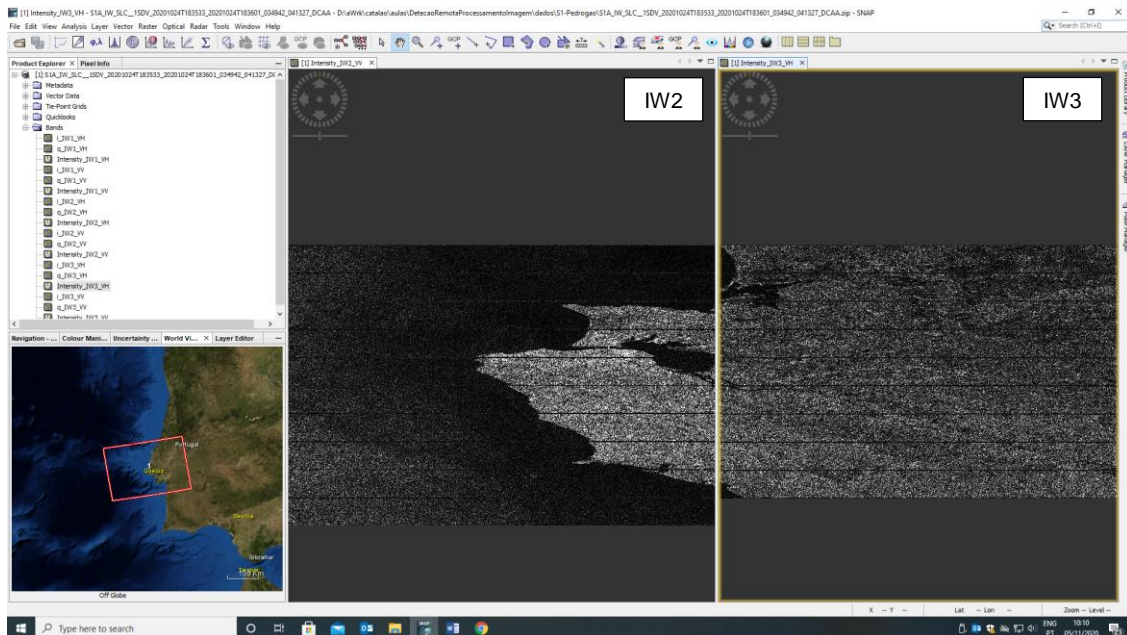
iii) Queue > add all files to download

iv) Downloads > datadownload > Download Python Script

v) executar o script

## 1. Ler a imagem (Sentinel-1) (formato SLC)

**Imagem:** S1A\_IW\_SLC\_\_1SDV\_20201024T183533\_20201024T183601\_034942\_041327\_DCAA.zip



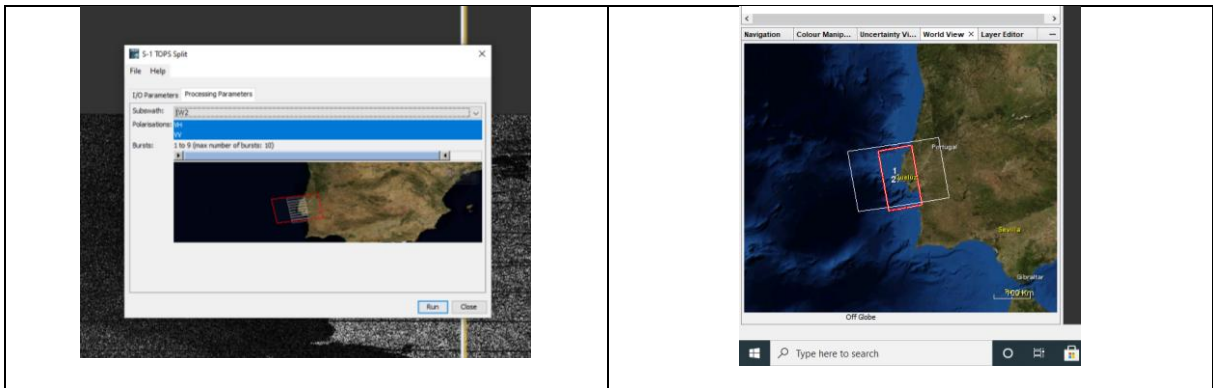
## Pré processamento (realizado pelo docente)

1. Selecção do swath IW2

§ Radar > Sentinel-1 TOPS > S1 TOPS Split (IW2)

§ Radiometric > S1 Thermal Noise removal (VV e VH) (pode ser demorado)

(The intensity of a Sentinel-1 Terrain Observation with Progressive Scans synthetic aperture radar image is disturbed by additive thermal noise, particularly in the cross-polarization channel, in “Efficient Thermal Noise Removal for Sentinel-1 TOPSAR Cross-Polarization Channel” by [Jeong-Won Park et al. 2017](#))



### 1. Open Product (imagem S1A\*.dim)

Imagem: `S1A_IW_SLC__1SDV_20201024T183533_20201024T183601_034942_041327_DCAA_split.dim`

Ver estrutura dos ficheiros no disco

Qual é a data de aquisição da imagem?

> Ver os metadados: (Abstracted Metadata, Original\_Product\_Metadata > calibration ..)

> Ver imagens dos tie-points grids

> ver as bandas (VH e VV)

### 2. Visualização da imagem

> Double-click on the band for visualization: observemos a intensidade

> porquê este aspeto da imagem? (alongada oeste-este) azimuth = 13.9 m / range 2.3 m

> modificar a intensidade da imagem > Colour manipulation > calcular as estatística > Log10

> se necessário mexer o limite inferior preto para a direita

### 3. Calibração da imagem

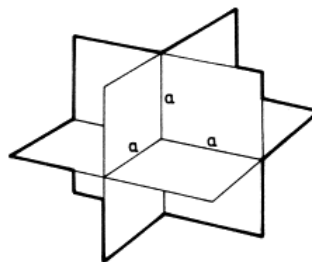
\$ Radiometric > Calibration (Save as complex output)

(to derive the radar cross-section (RCS). It is the equivalent area seen by a radar)

A target that maintains the large RCS of a flat plate without being so sensitive to the angle of incidence is the *corner reflector*. The RCS of the square trihedral has a maximum at the symmetry angle of 54.7°,

$$\sigma_{\max} = \frac{12\pi a^4}{\lambda^2}, \quad (12)$$

and drops to half power (−3 dB) at about 20° off that angle. Eight such trihedrals—the retroreflector (Fig. 2)—provide spherical coverage. The retroreflector is used in situations when it is desired to enhance the radar detectability, for example, by small boats.



§ Sentinel-1 TOPSAR Deburst

> comparar a imagem original e a imagem deburst

#### 4. Speckle Filtering

§ Radar > Speckle Filtering > Single Product Speckle Filtering > Lee Sigma

#### 5. Composição RGB

§ Visualizar VV e VH

§ Open RGB image (R: VV, G: VH, B: VV/VH) (Com o cursor sobre o ficheiro imagem > botão direito do rato)

> Fazer zoom no estuário do Tejo. Ver parcelas agrícolas. Os navios aparecem de forma diferente nas diferentes polarizações. O mesmo se verifica com a ondulação.

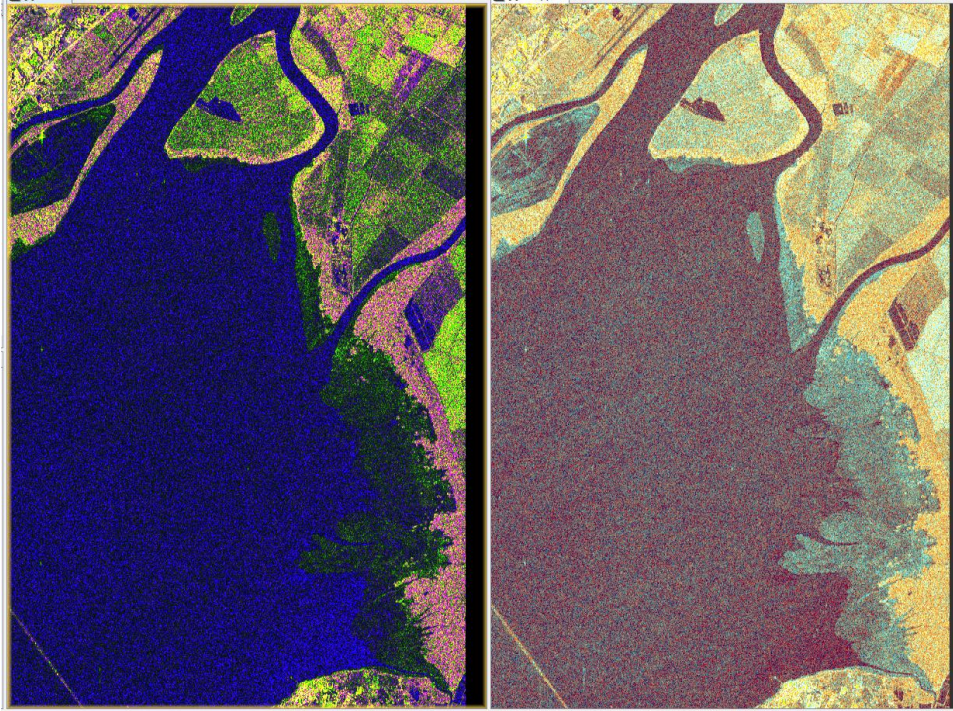
#### 6. Escala dB (10\*log(Intensidade))

§ From linear to dB

(Com o cursor posicionado na imagem de intensidade VH, botão direito e calcular Linear to dB, calcular a imagem virtual para as duas polarizações)

\$ save product

\$ Visualizar a composição RGB com a imagem em dB

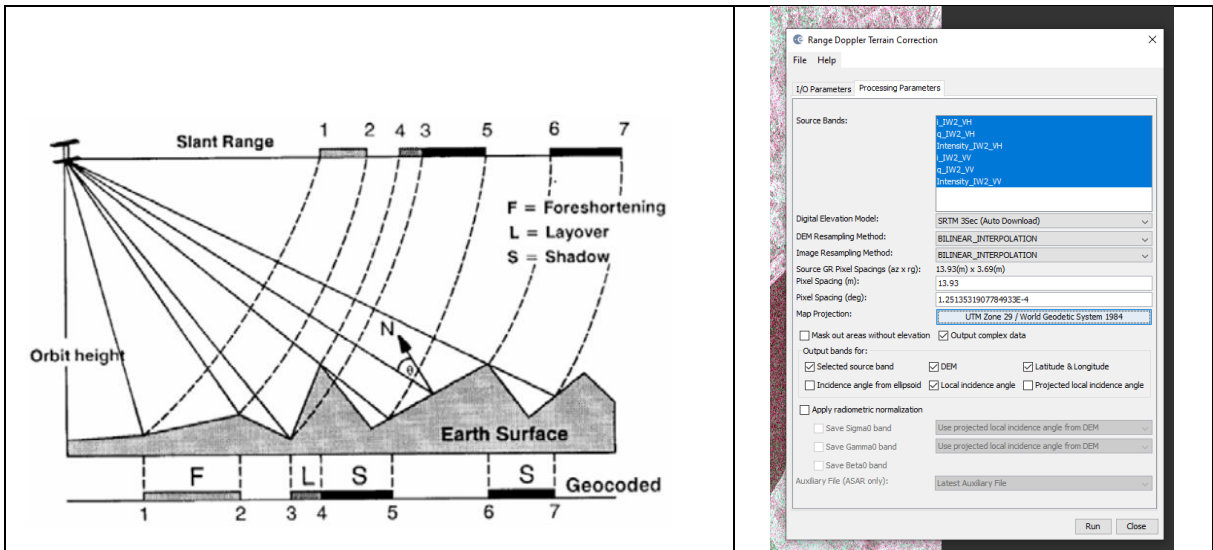


## 7. Terrain Correction

Usar a imagem após deburst (antes do flip e multilook)

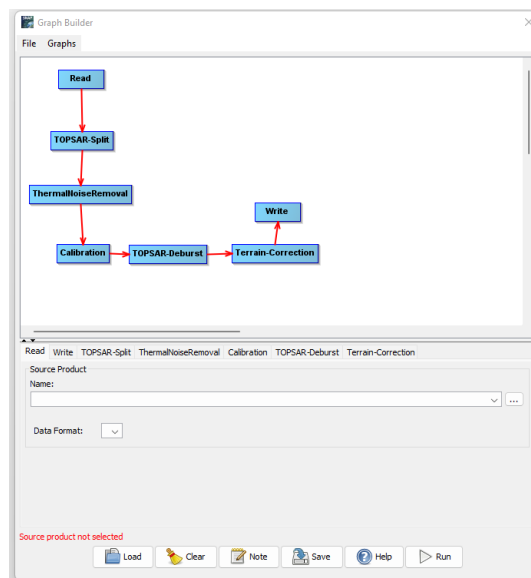
\$ Range Doppler terrain Correction (calcular todas as imagens: Output complex data, latitude, Elevation , incident angle, ...)

**Importante: desativar Mask out areas without elevation**



Criar no Graph Builder uma sequência de operações idêntica ao esquema anterior.

1. S1 TOPS Split
2. Thermal Noise Removal
3. Apply Orbit File
4. Calibration
5. Sentinel-1 TOPSAR Deburst
6. Range Doppler Terrain correction
7. Conversion to dB



Na segunda metade do semestre serão abordadas as aplicações das imagens SAR nos estudos do oceano, gelo e terra.



Exercícios numéricos

$\text{Angle}(\text{Exp}(-j \cdot \pi))$

$\text{Angle}(10 \cdot \text{Exp}(-j \cdot \pi))$

$\text{Ampl}(\text{Exp}(-j \cdot \pi))$

$\text{Ampl}(10 \cdot \text{Exp}(-j \cdot \pi))$