19th International Scientific and Technical Conference
FROM IMAGERY TO DIGITAL REALITY: ERS & Photogrammetry

PHOTOMOD Radar — a powerful tool for processing of SAR images

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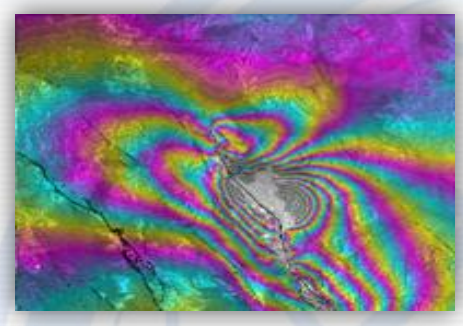
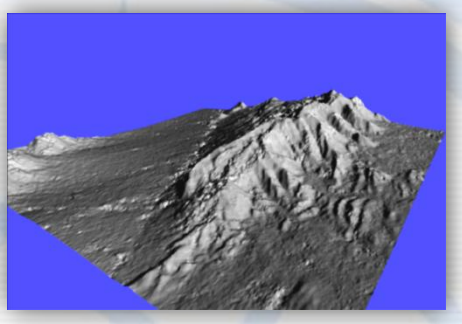
RACURS

Radar imagery applications

- Creation of digital elevation models
- Ground displacement monitoring
- Infrastructure monitoring
- Agriculture
- Oil slick detection
- Ships detection
- Ice fields monitoring
- Cartography
- Monitoring of emergency situations
- And in lot of others…



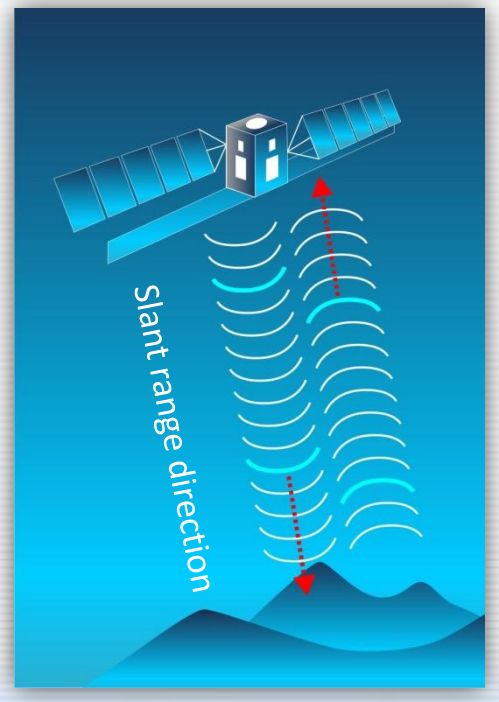


It is necessary to have a specialy dedicated software tools in order to process and treat SAR data

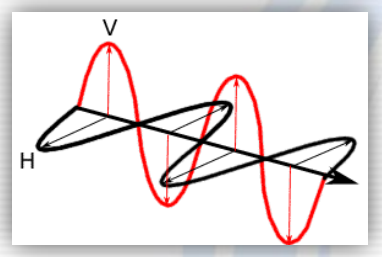
Basic knowledge

Specific nature of SAR data processing vs optical remote sensing:

Slant range projection



Single or multi polarization mode

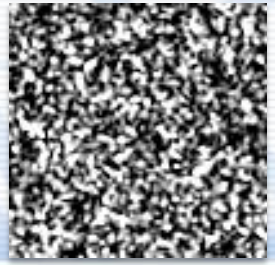


Coherent complex signal: amplitude & phase

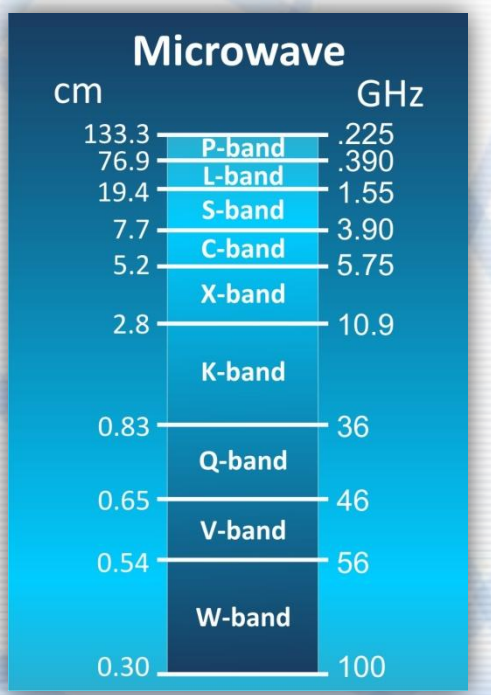
HH HV
VH VV

A F

Speckle noise



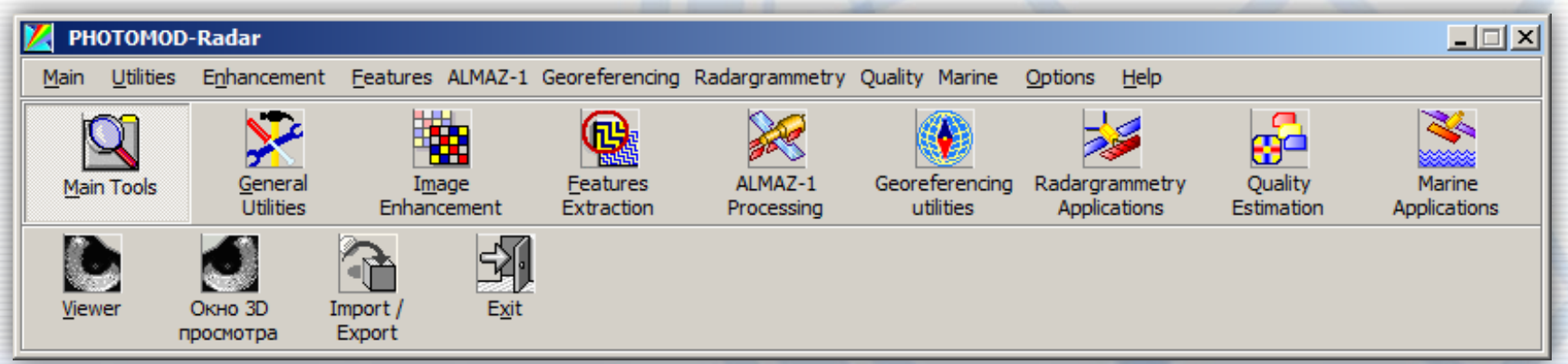
One or more frequency channels



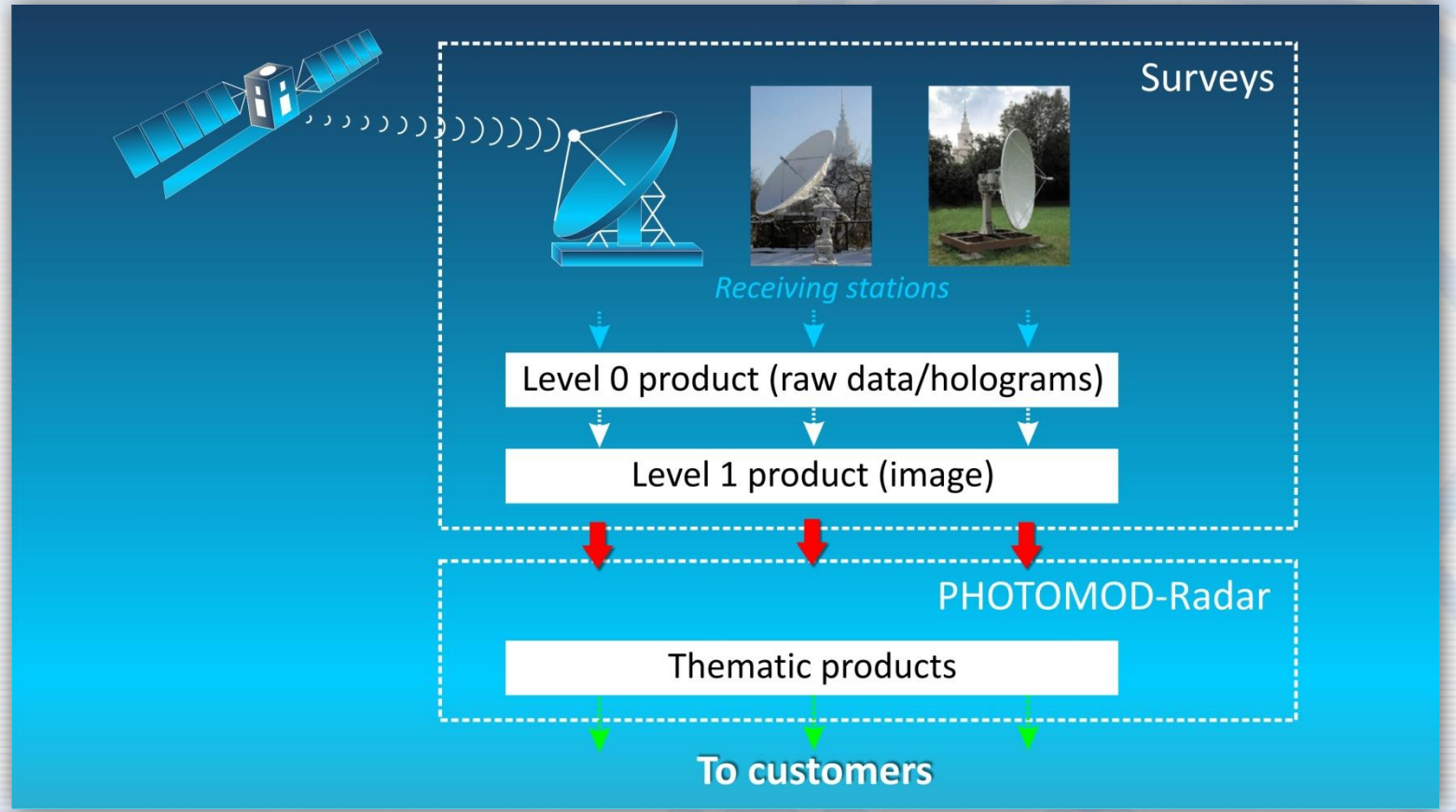
PHOTOMOD Radar functionality

- import and visualization of SAR images
- geometric correction
- image enhancement
- generation of DEM via stereo processing and interferometric techniques
- small surface displacement extraction through differential interferometry techniques

- classification based on polarimetry analysis
- ship detection
- sea surface parameter estimation;
- oil slick detection;
- tracking of objects;
- coherent change detection;
- end so on.



SAR data processing chain



PHOTOMOD Radar structure

Input data

Import & export tools

Visualization tools

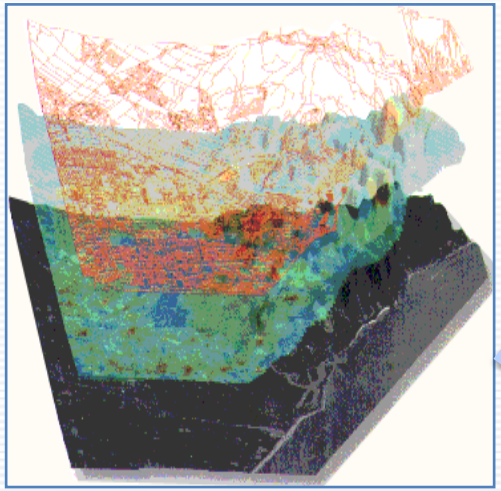
Application tools

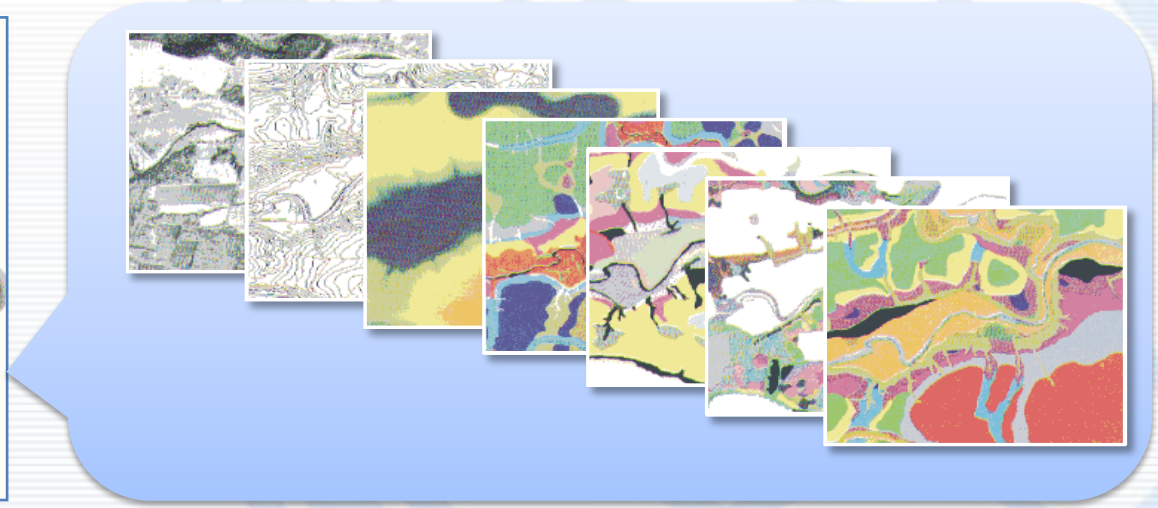
Auxiliary tools

Input data

PHOTOMOD-Radar has deal with the following data types:

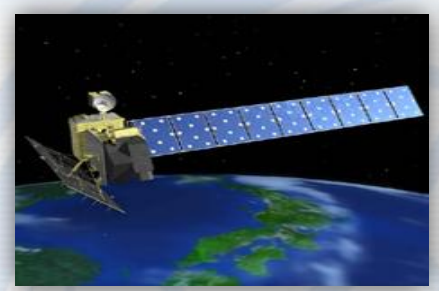
- radar imagery presented in common formats
- digital elevation models (DEM)
- ground control points (GCPs)
- geodetic data (ellipsoids, datums)
- raster and vector layers

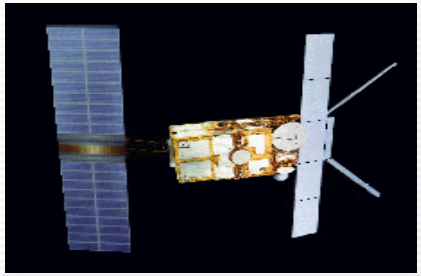


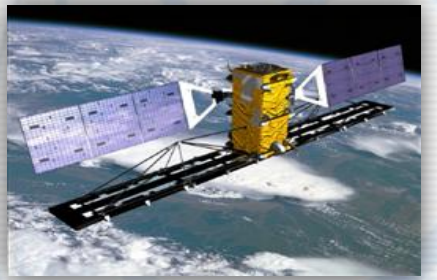
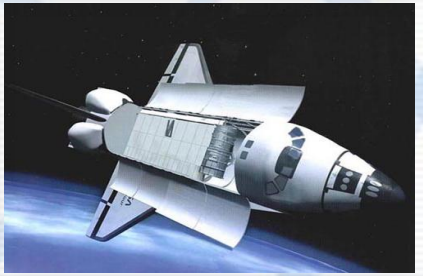


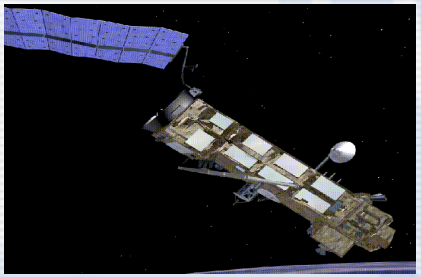
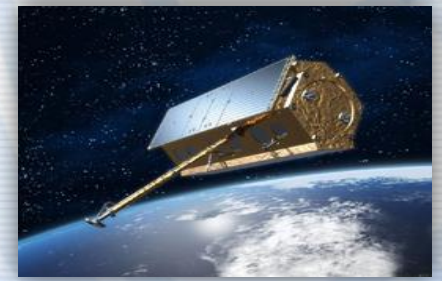
Supported sensors

- Almaz-1
- ERS-1/2
- JERS-1
- SIR-C/X
- RADARSAT-1,2
- ENVISAT
- ALOS PALSAR
- TerraSAR-X/Tandem
- COSMO-SkyMed
- Kompsat-5
- Sentinel-1
- Risat



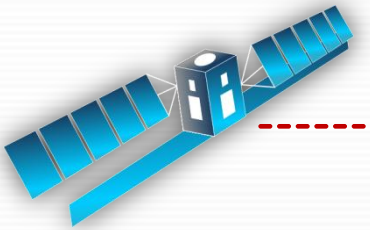


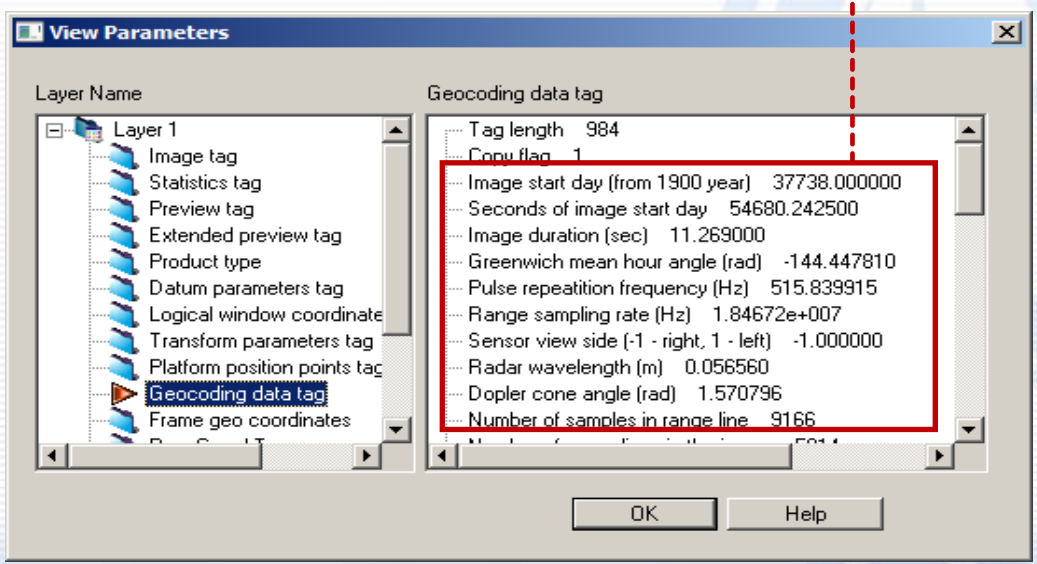

Concept of generalized radar model

Radar sensors

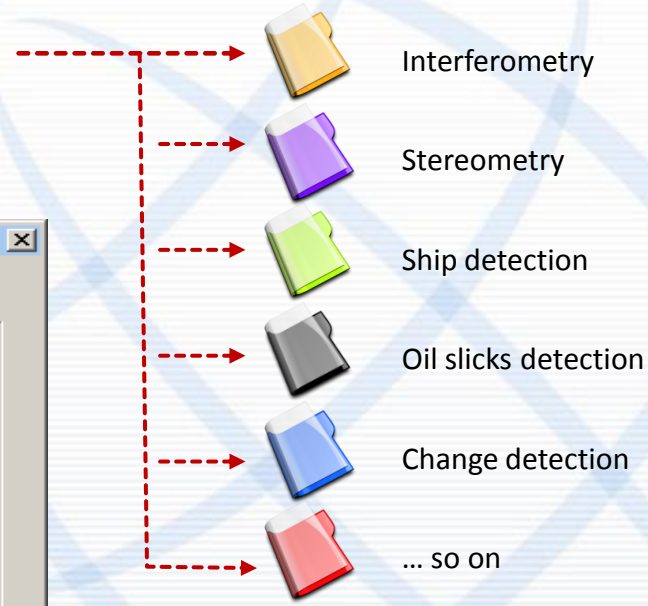


Import procedure

Forms an unified descriptor – set of radar and survey parameters which are independent of input sensors

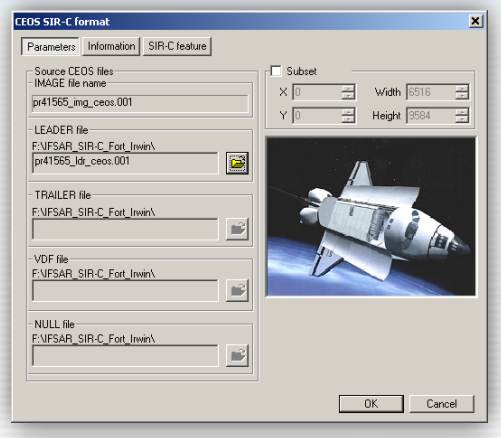


Applications

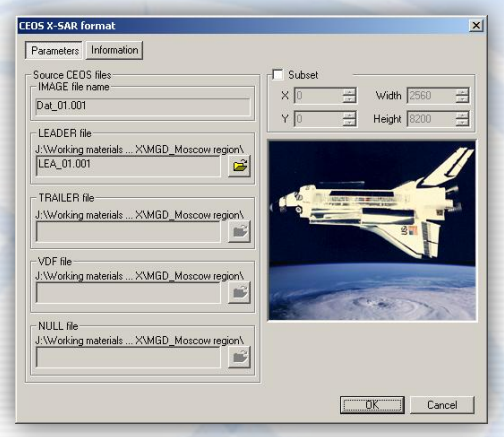


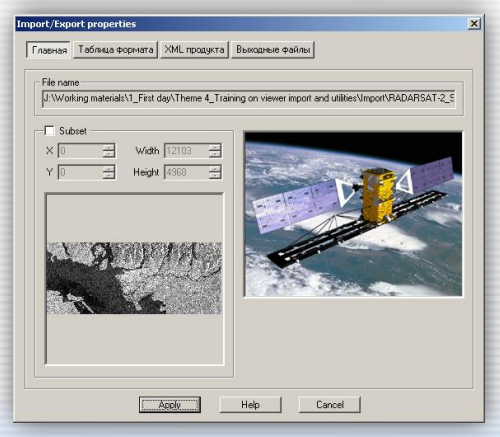
All applications have deal with the same list of input auxiliary data

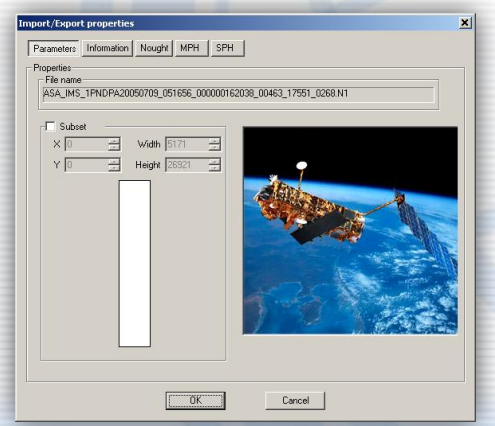
Import module

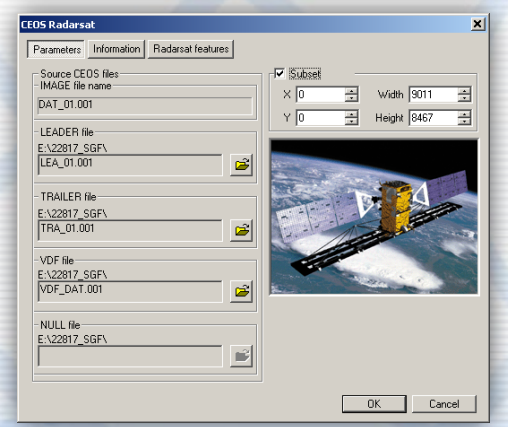


Special import tools dedicated to each particular spaceborn SAR sensor









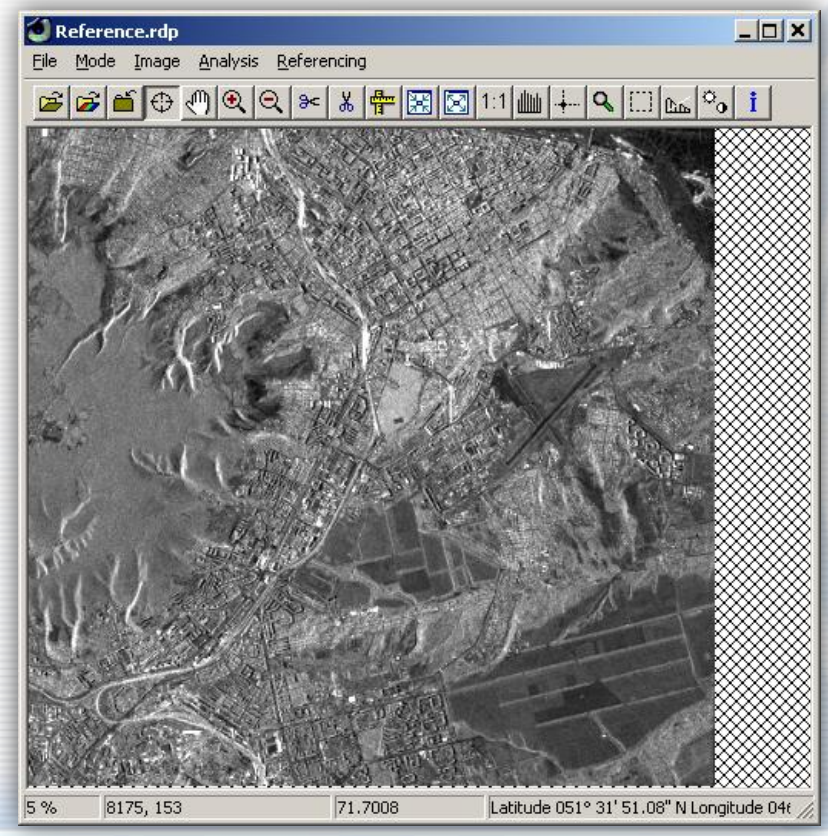
Visualization tools

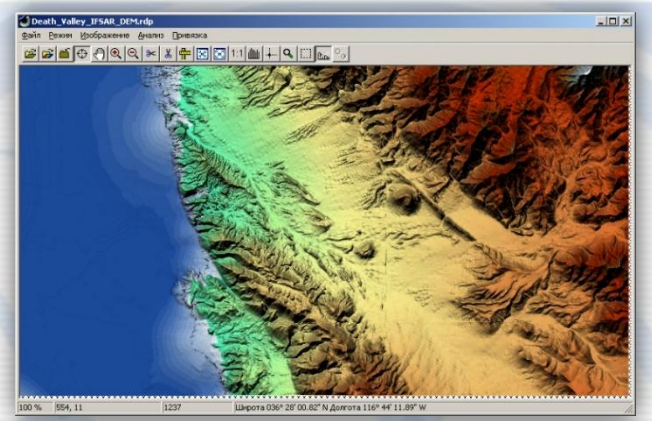
SAR sensor data visualization tools:

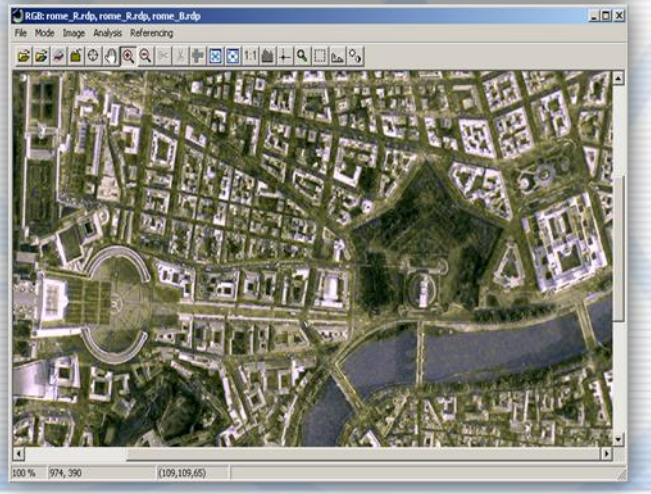
- 2D viewer
- 3D viewer

Visualization tools

2D viewer. Provides planar presentation of raster and vector data.

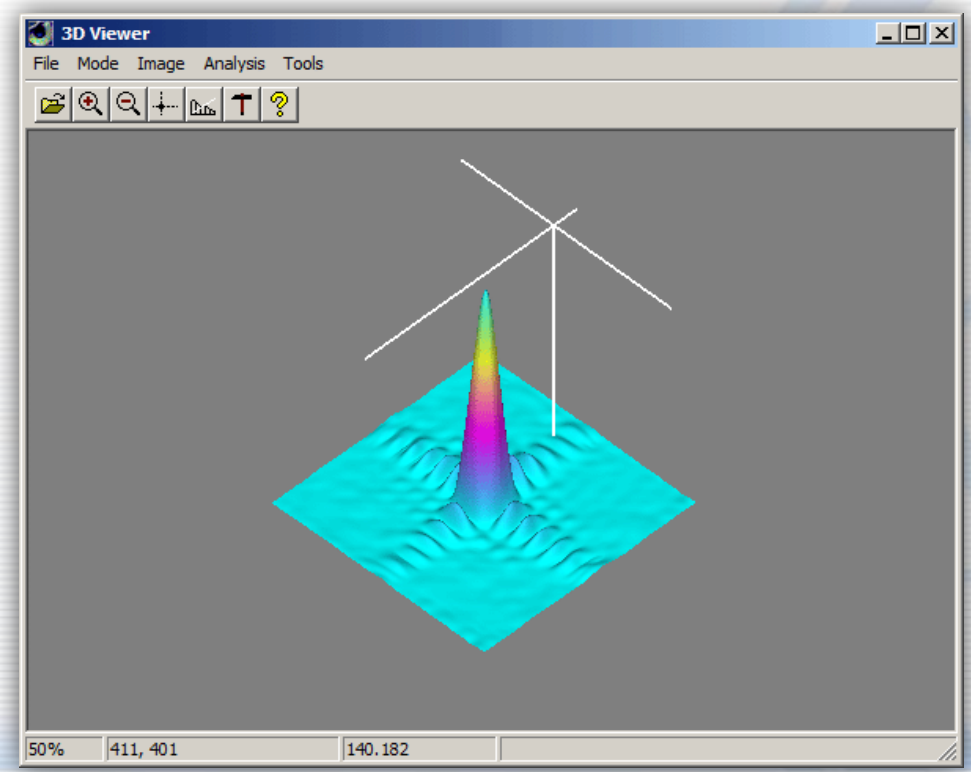


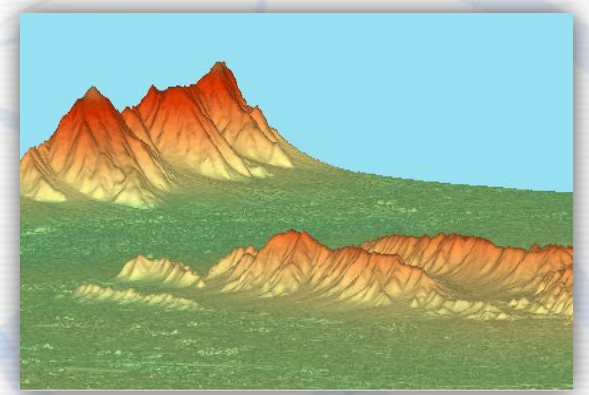


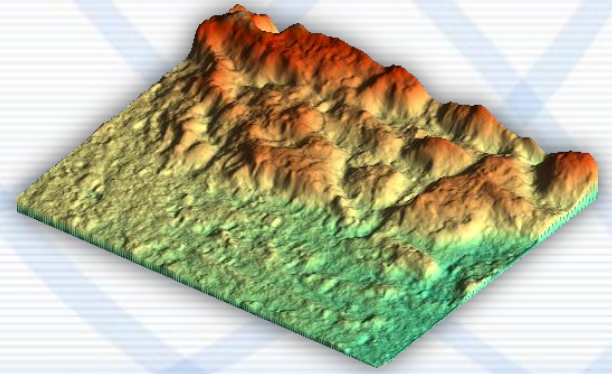


Visualization tools

3D viewer. Provides three-dimensional presentation of raster data, mainly digital elevation models and image magnitude features.



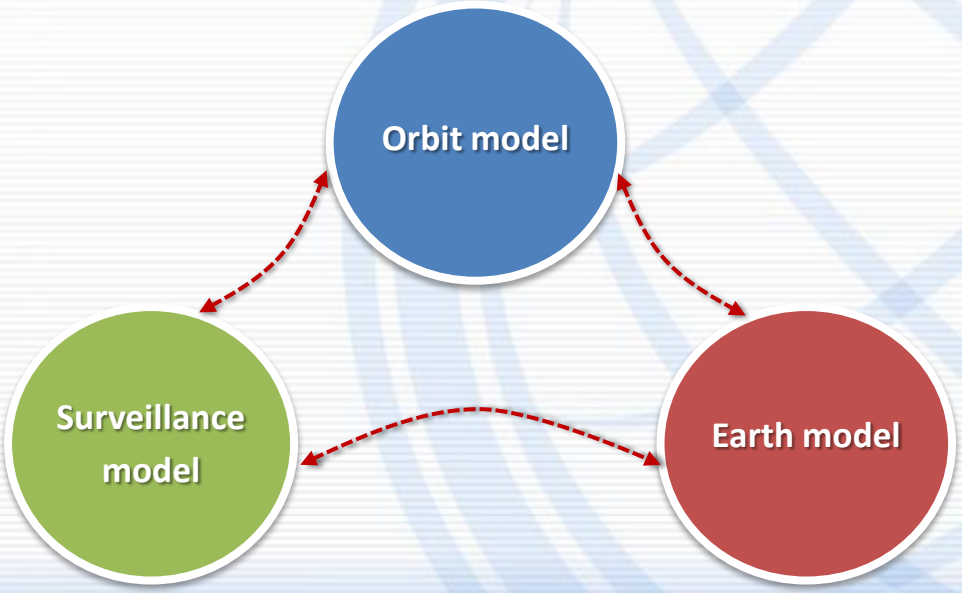




Geocoding processor

Geocoding techniques is based on three precise models:

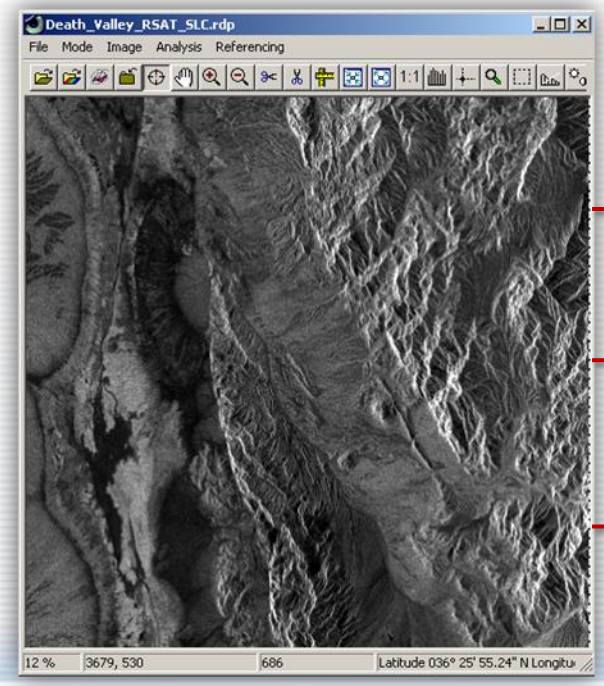
1. Model of SAR platform (satellite orbit propagation)
2. Model of imaged ground surface (Earth ellipsoid and datum)
3. SAR sensor model (radar and surveillance parameters)



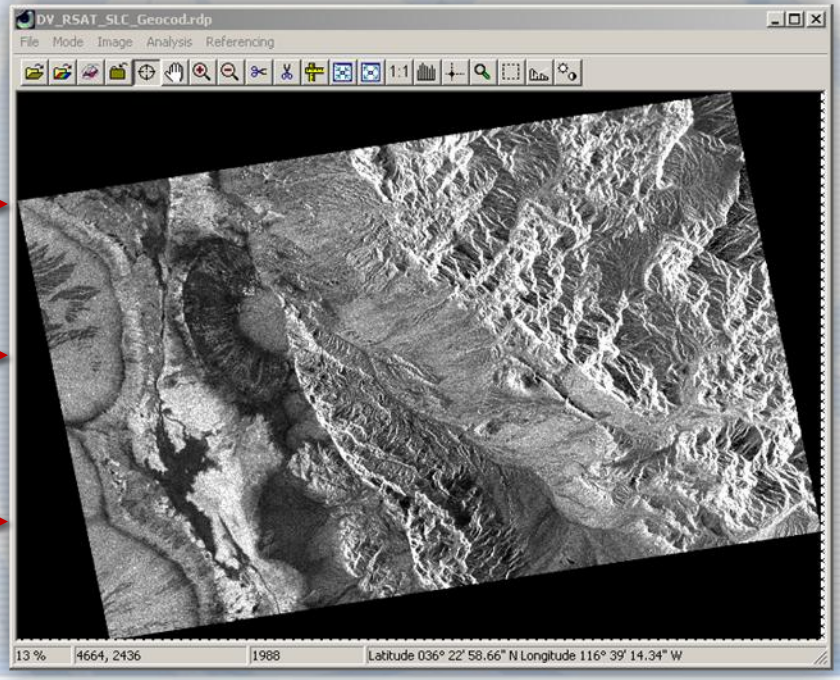
Geocoding processor

Geocoding procedure transforms an image from slant or ground projection into one of cartographic projections and on one of reference ellipsoids and datums.

Georeferenced image (path projection)

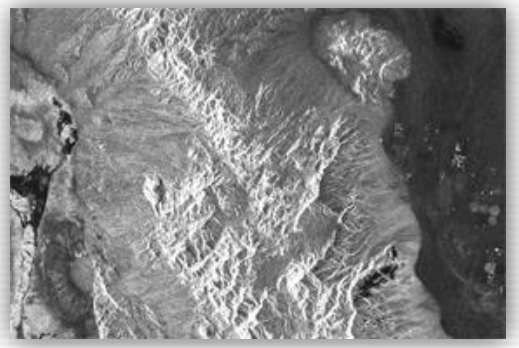


Geocoded image (map projection)

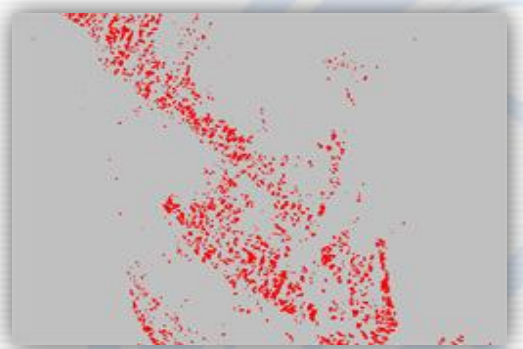


Geocoding processor

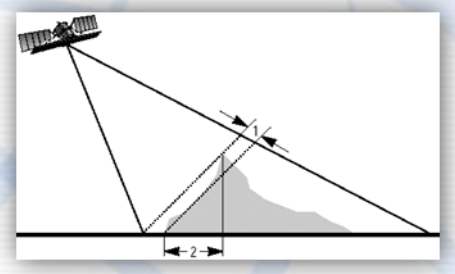
Additional outputs of geocoding processor – layover and shadow masks



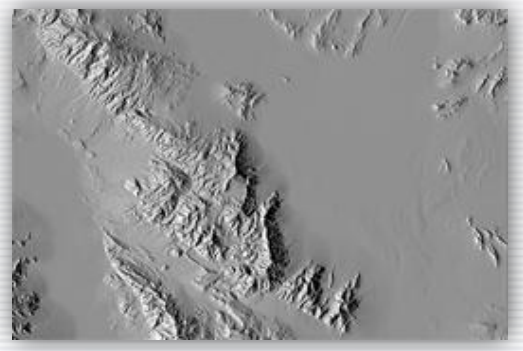
Input image



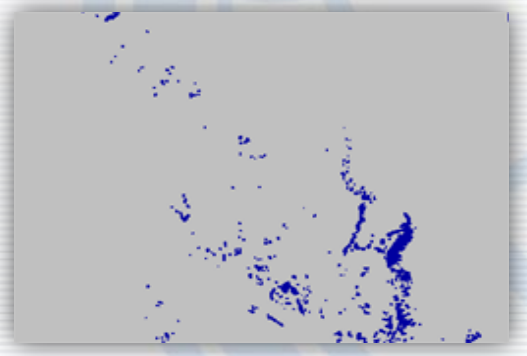
Layover mask



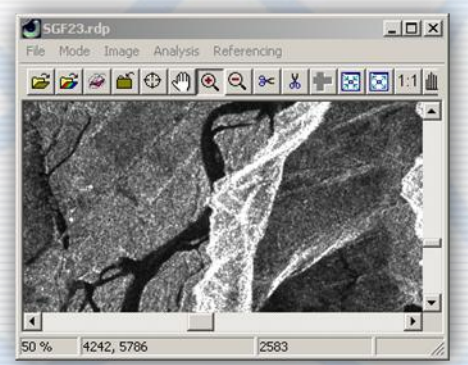
Effect of layover is caused by a specific combination of terrain slop angle and radar looking one



DEM

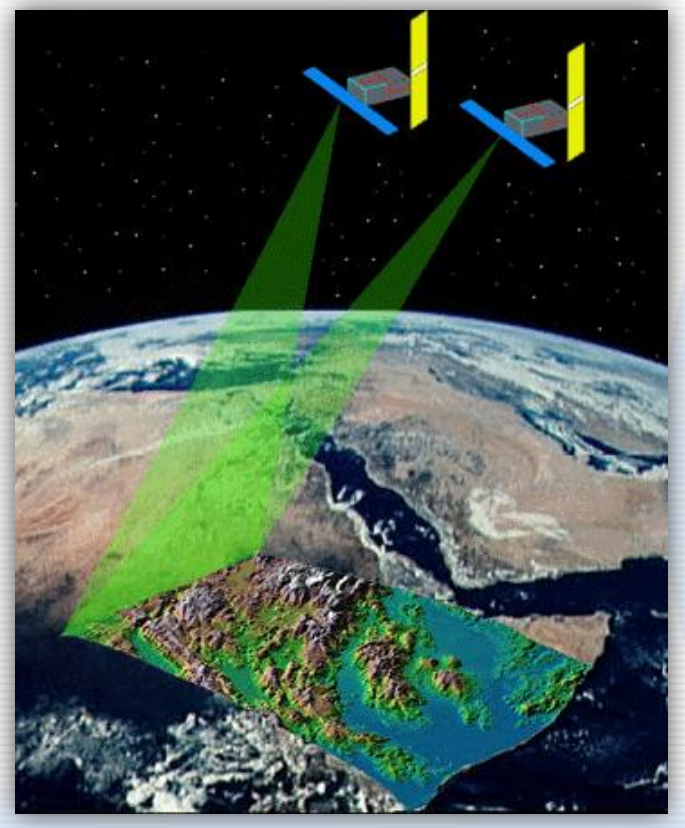


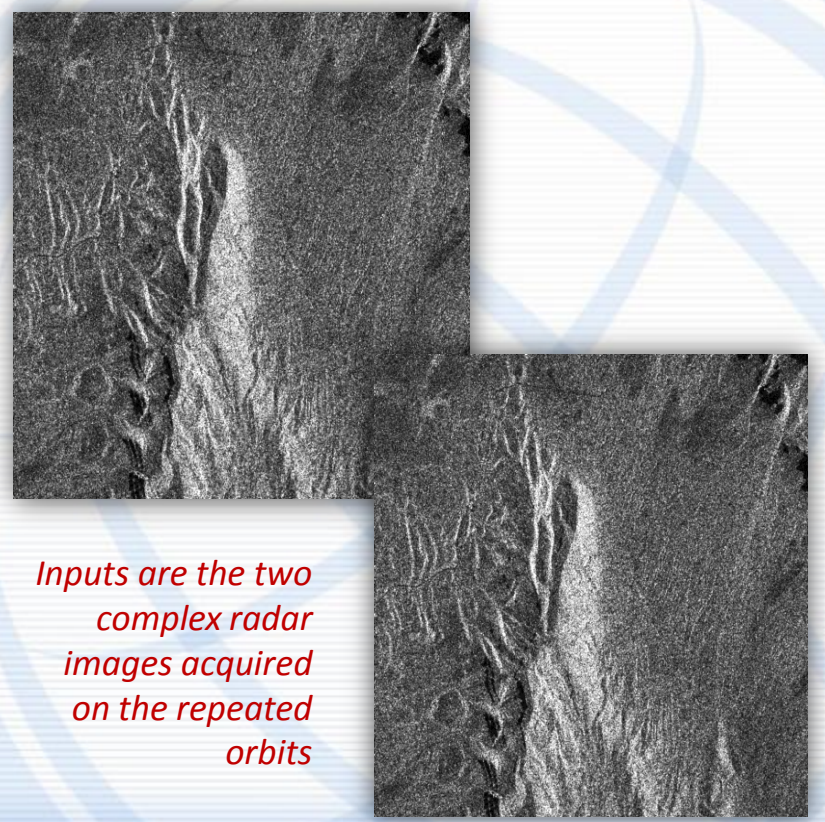
Shadow mask



InSAR / DInSAR processor

Radar interferometry

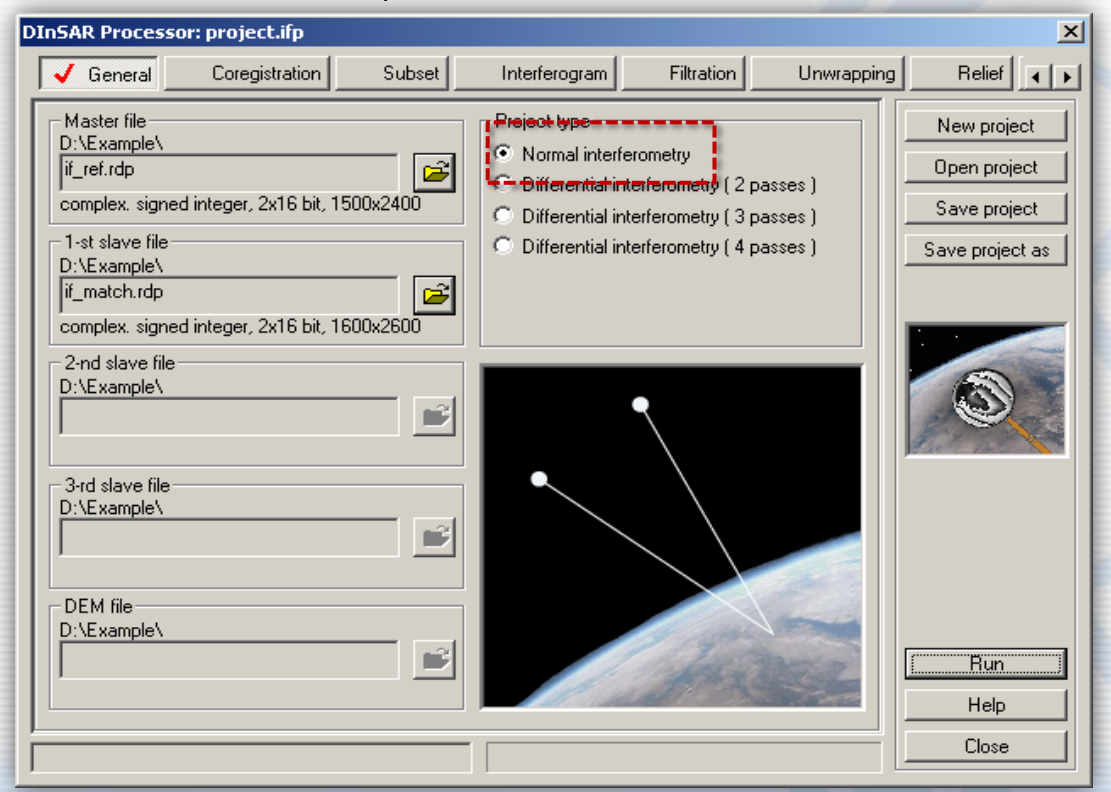




Inputs are the two complex radar images acquired on the repeated orbits

InSAR / DInSAR processor

- Digital elevation models
- Ground surface displacement



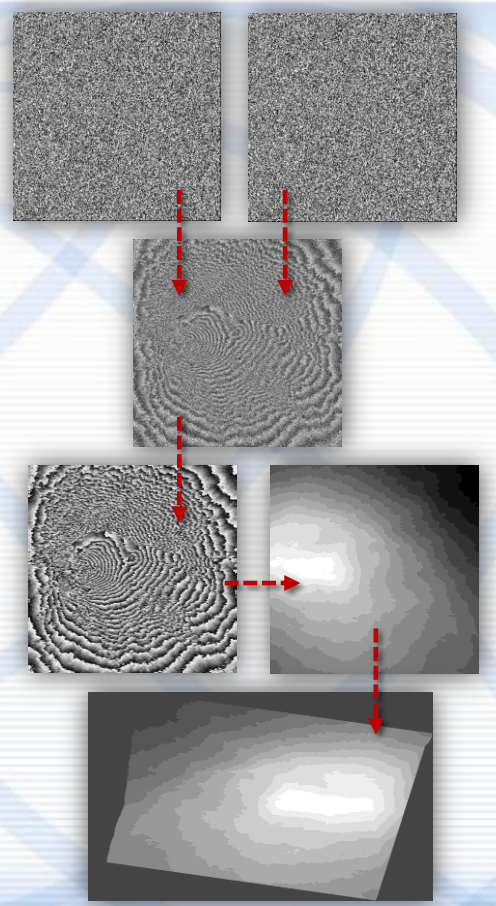
The following differential interferometry approaches are realised in processor:

- two pass
- two pass + DEM
- three pass
- four pass
- persistent scatterers
- small baseline

InSAR / DInSAR processor

Main stages of DEM generation by interferometric processor

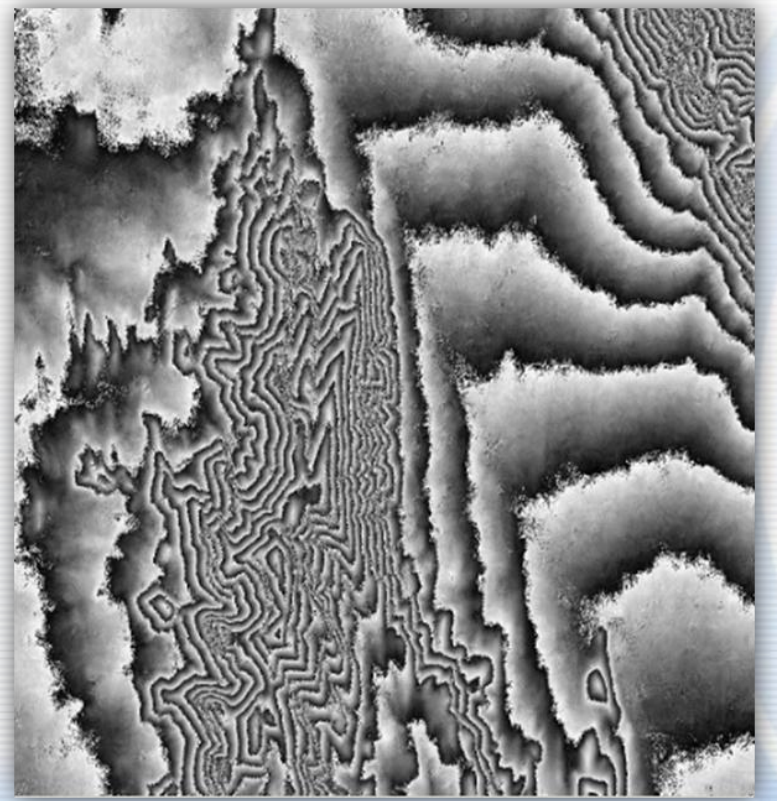
- Image coregistration (spatial matching of two images)
- Interferogram calculation
- Interferogram (phase) filtration
- Phase unwrapping
- Absolute phase to height recalculation
- Geocoding of height matrix



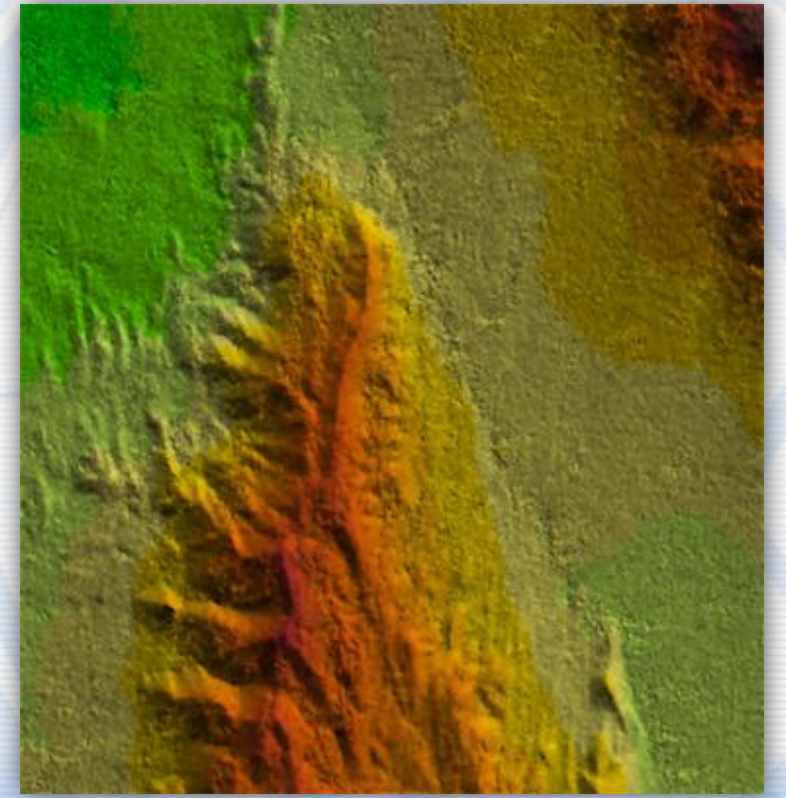
InSAR / DInSAR processor

Radar interferometry

Interferogram



Digital elevation model



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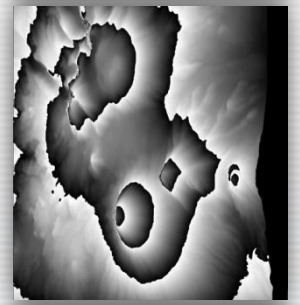
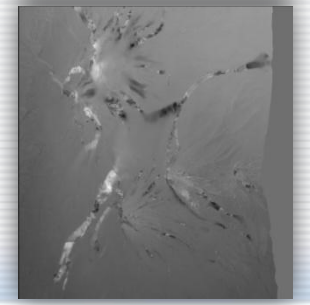
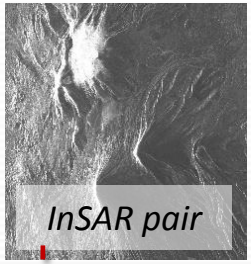
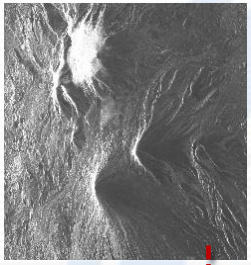
InSAR / DInSAR processing samples



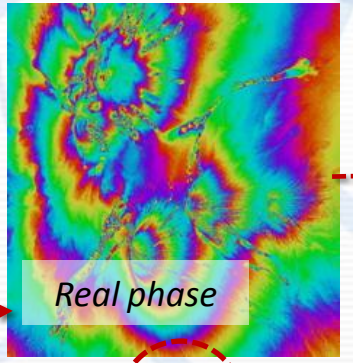


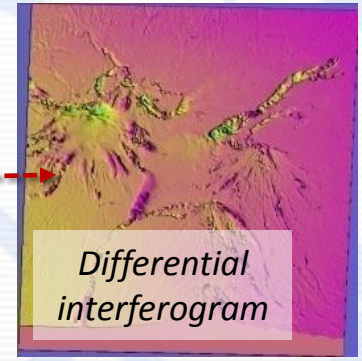
Russia, Kluchevskaya sopka. SIR-C/X images. Two-pass differential interferometry

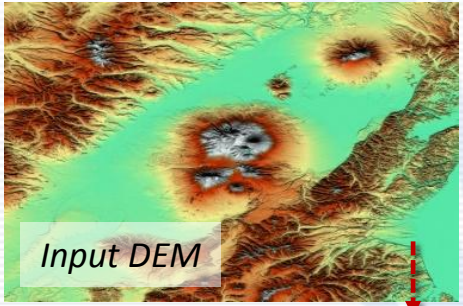




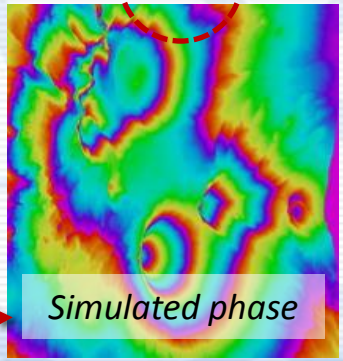
Interferometric processing







Interferogram simulation



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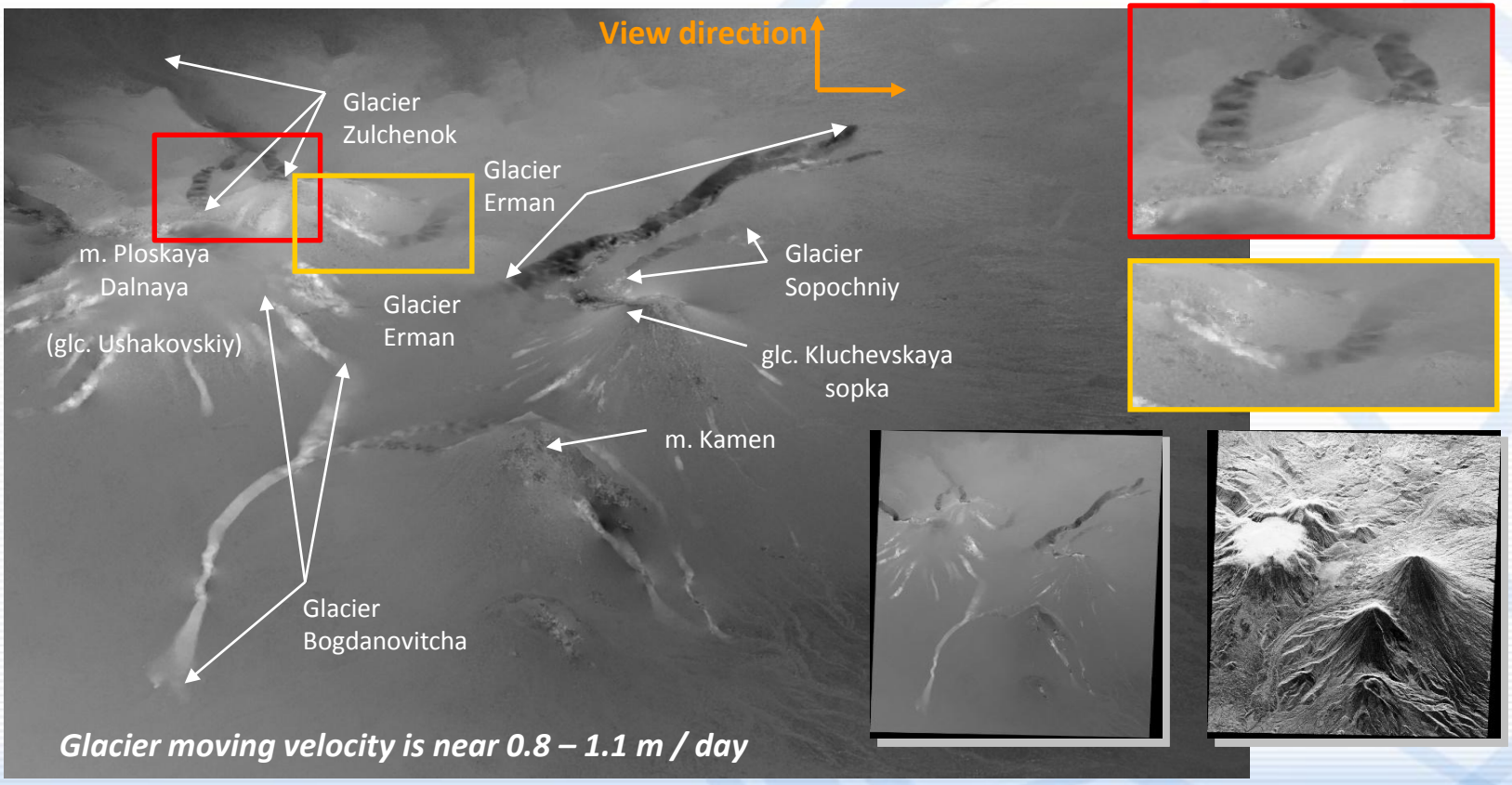
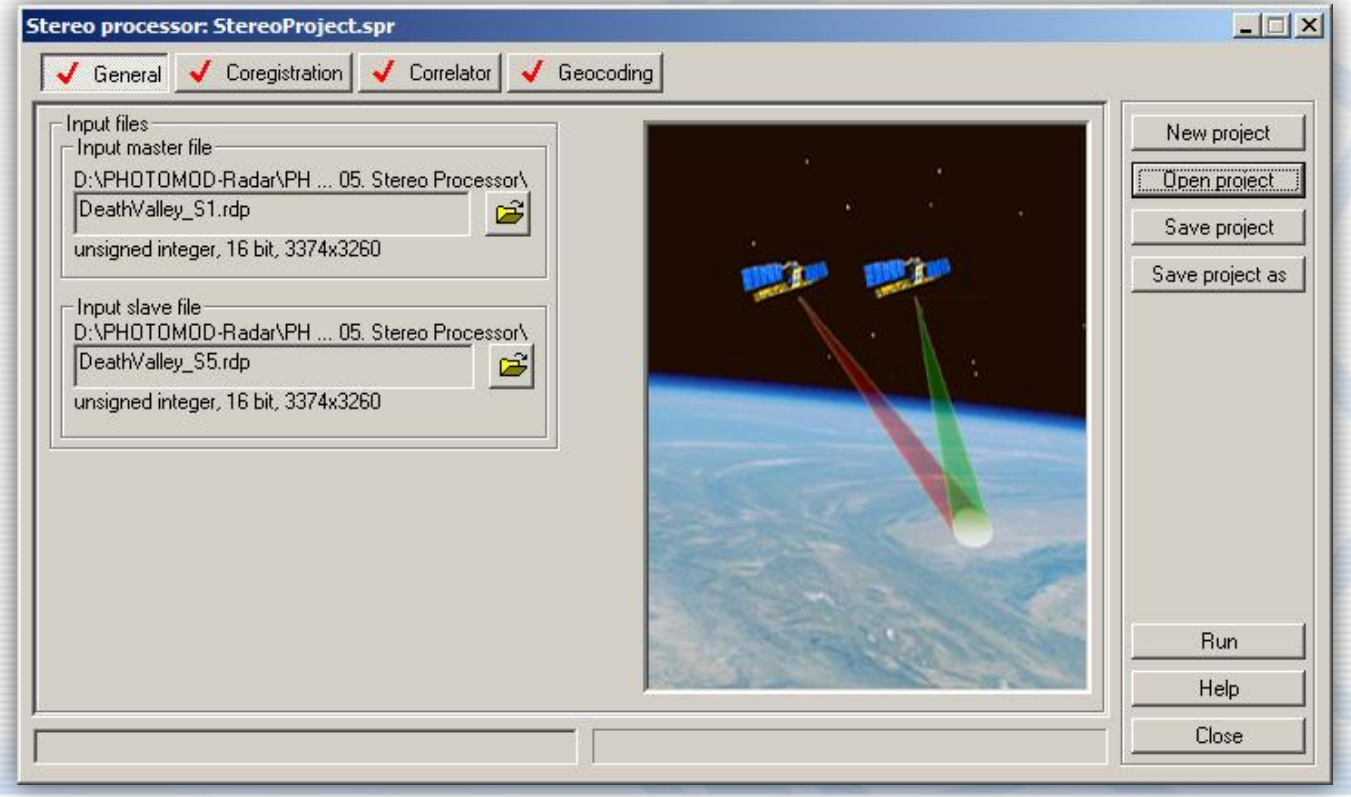
InSAR / DInSAR processing samples

Rossia, Kluchevskaya sopka. SIR-C/X images. Four-pass differential interferometry



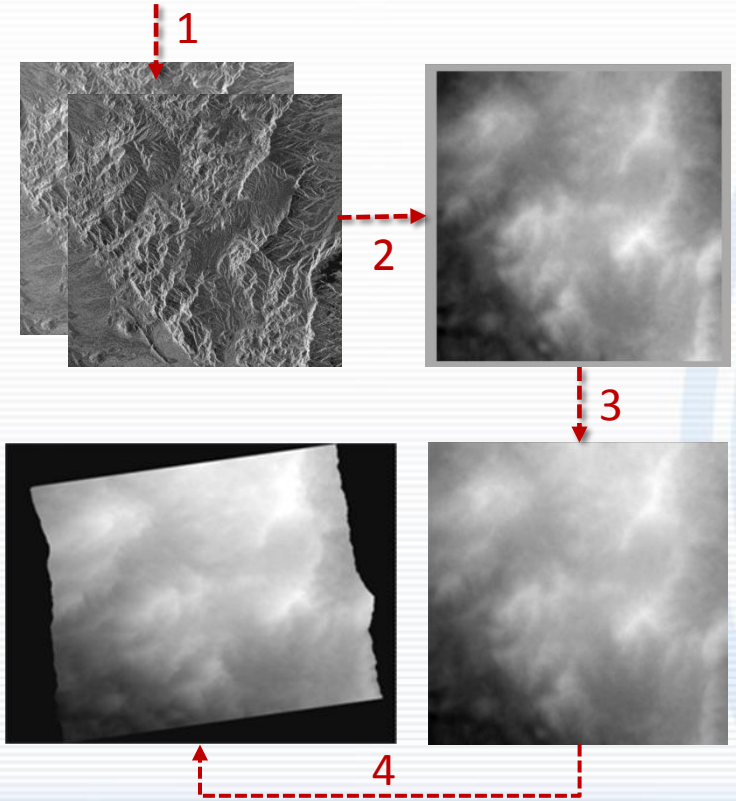
Stereo processor

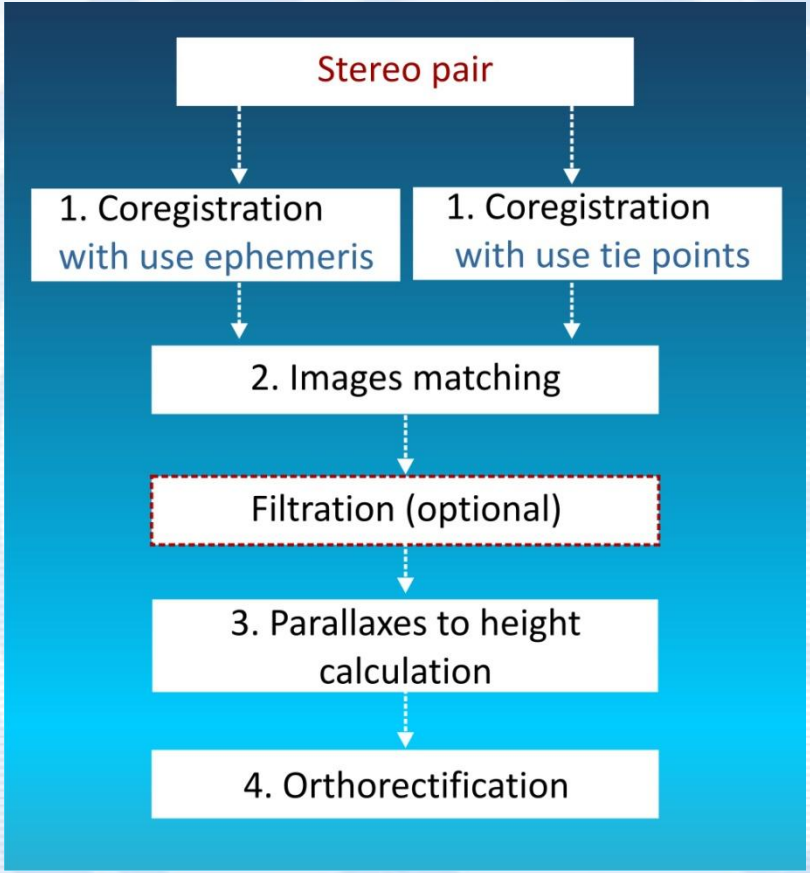
Stereo Processor is an integrated software package specially intended for generation of digital elevation models (DEM) via processing of stereo pairs acquired by spaceborne SAR.



Stereo processor

Basic operation work flow

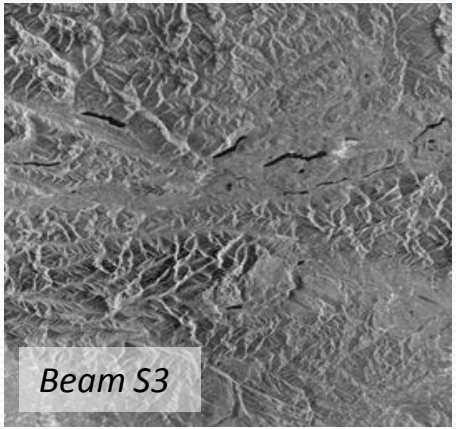


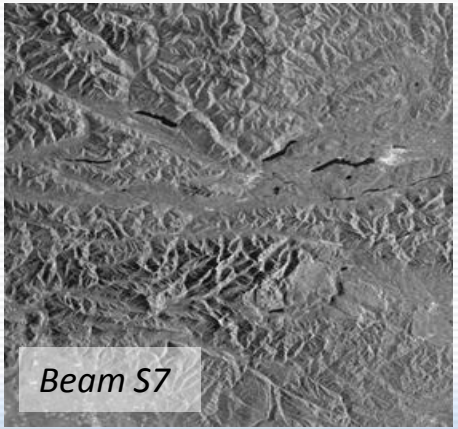


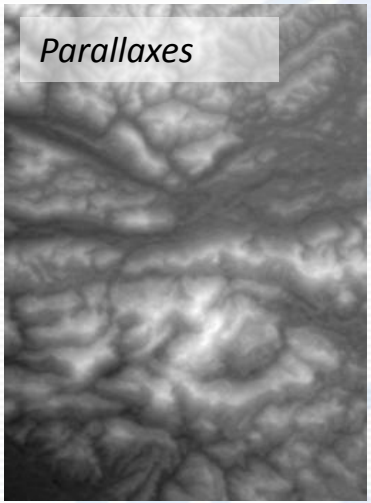
Stereo processing samples

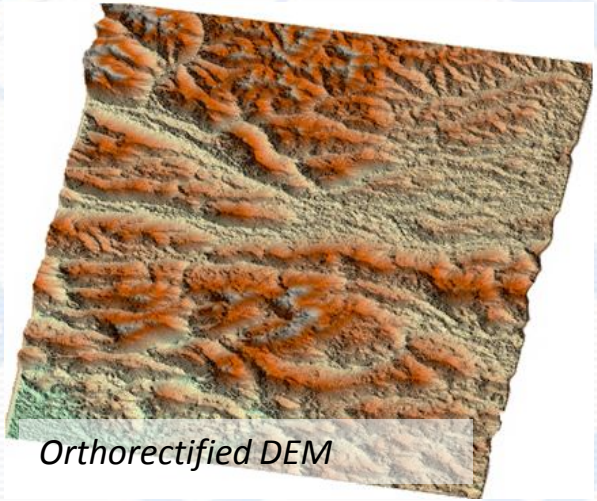
Italy, Trieste. RADARSAT-1 images

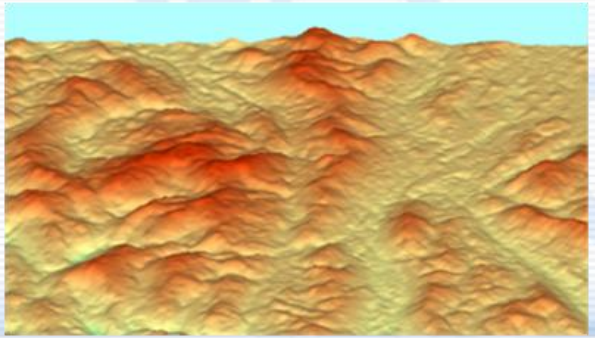
Input images

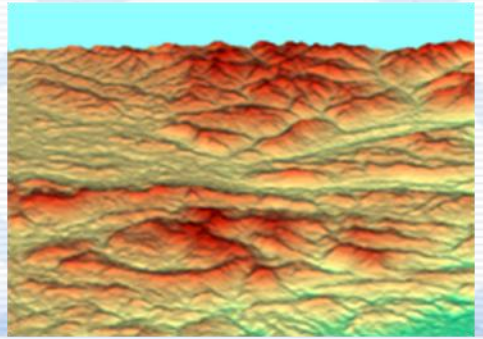






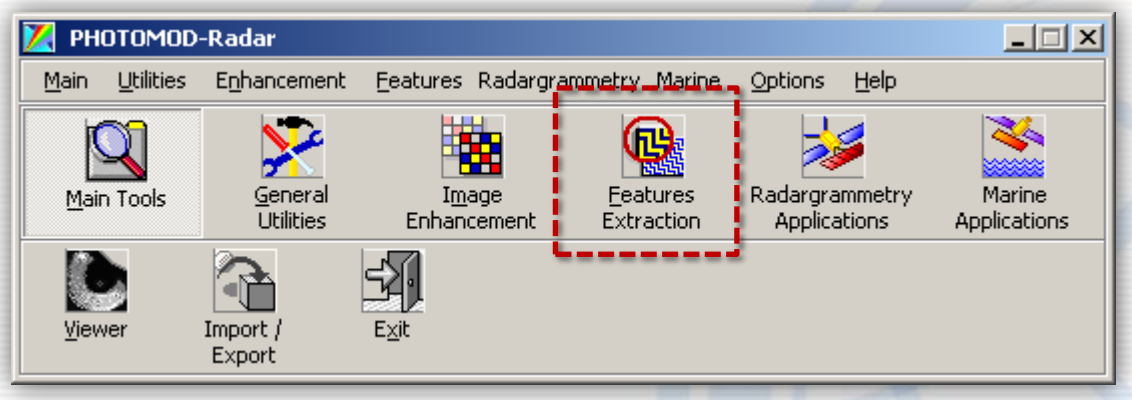


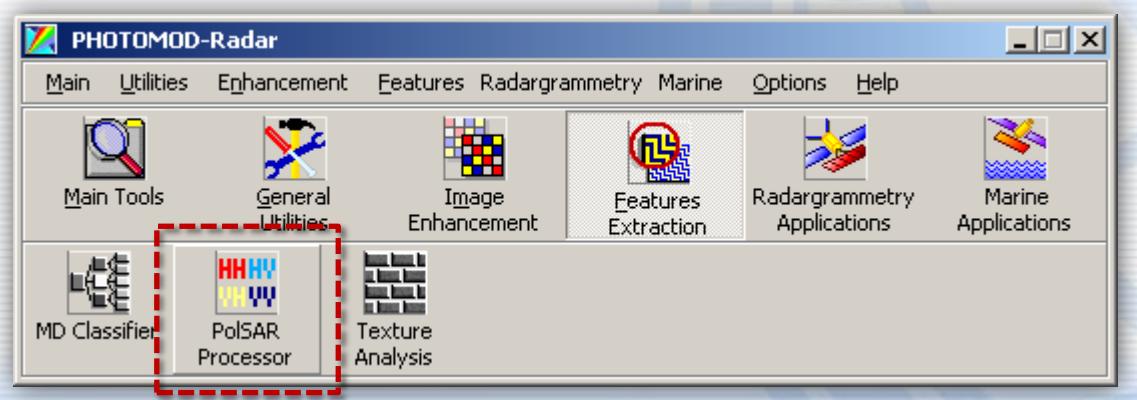


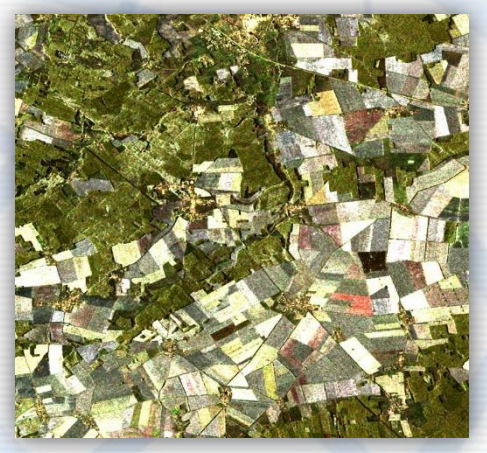


Polarimetric processor

Land cover classification with SAR Polarimetry

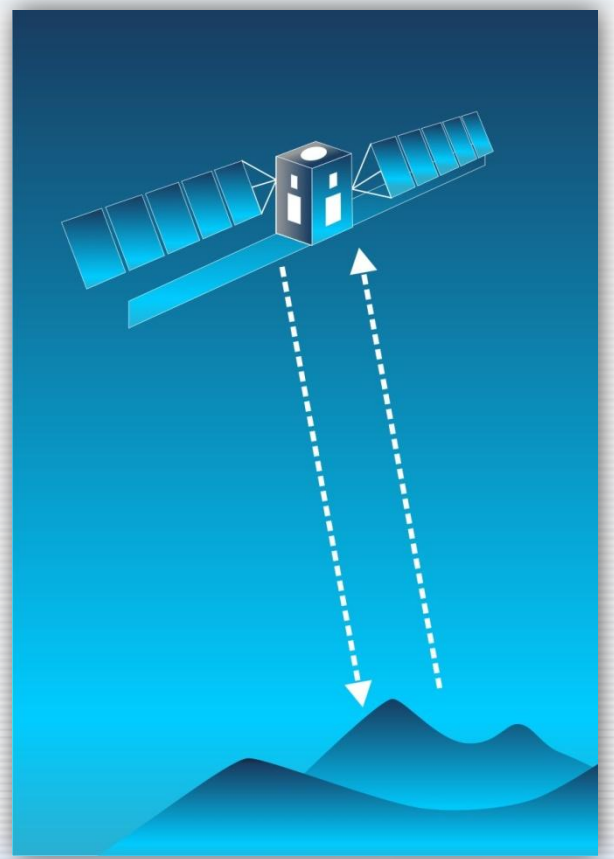




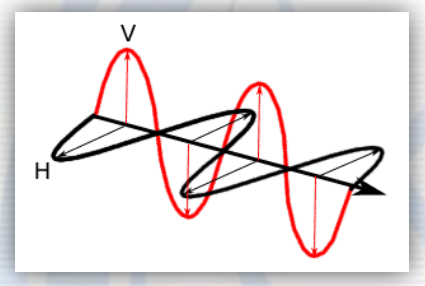


Polarimetric processor specially designed for extraction of backscattering parameters from multipolarization data sets and classification of earth surface.

Polarimetric processor



Polarimetry is a method of physical investigation based on measuring of polarization parameter changes (degree of polarization, plane of polarization) after scattering on the matter of interest.



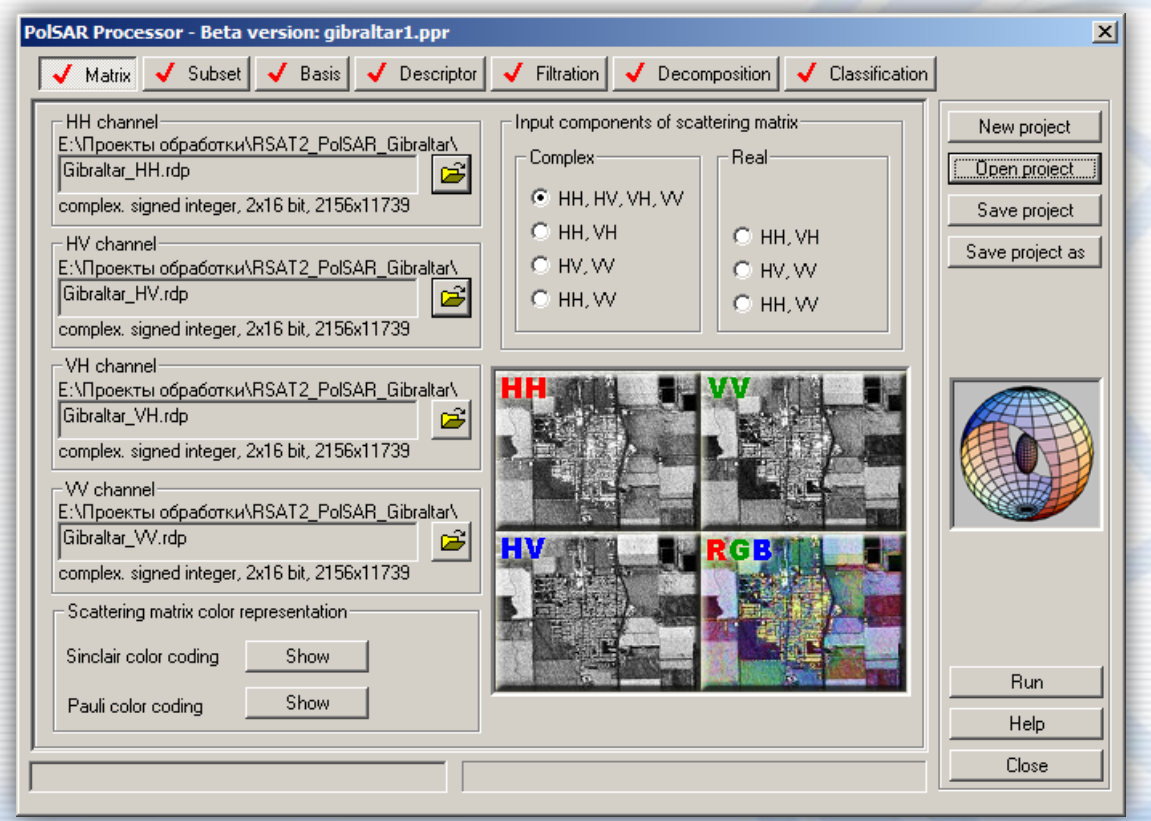
HH
HV
VH
VV

Polarization parameter changes depend on scattering mechanism, physical characteristics of scattering surface and characteristics of the initial electromagnetic wave.

Radar imagery collected using different polarization combinations may provide complementary information about the targets on the surface.

Polarimetric processor

Land cover classification with SAR Polarimetry

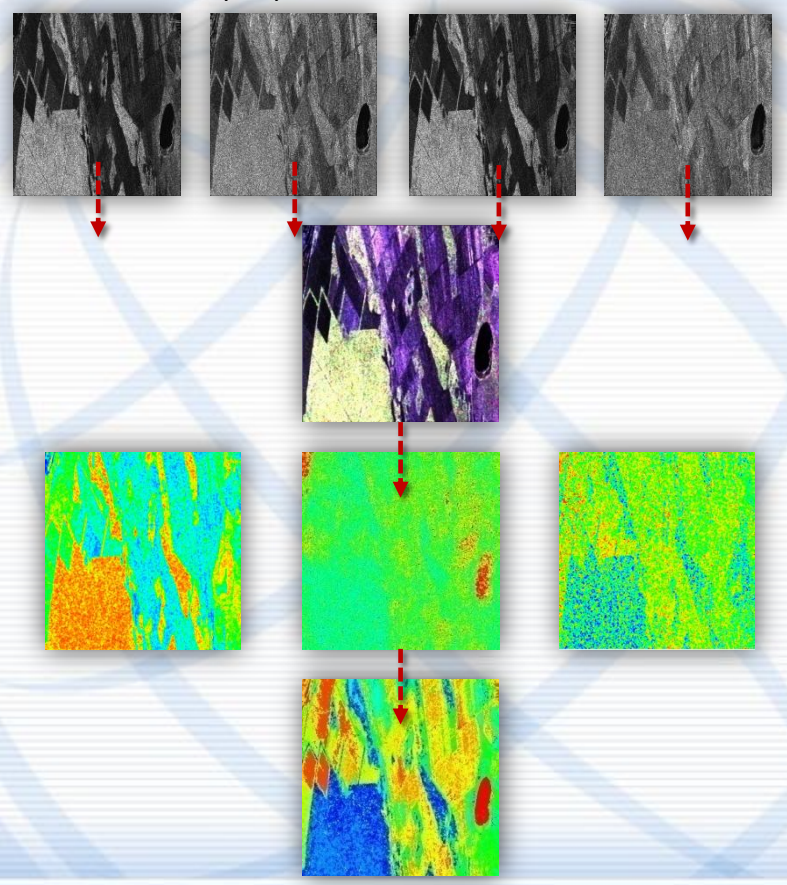


Polarimetric processor

Workflow of the polarimetric SAR data processing

- Subset selection
- Polarization basis selection (orientation, ellipticity, absolute phase)
- Polarimetric descriptor calculation (coherence matrix)
- Polarimetric descriptor filtration
- Descriptor decomposition (entropy, anisotropy, alpha parameter)
- Classification

Input polarimetric data set



RACURS

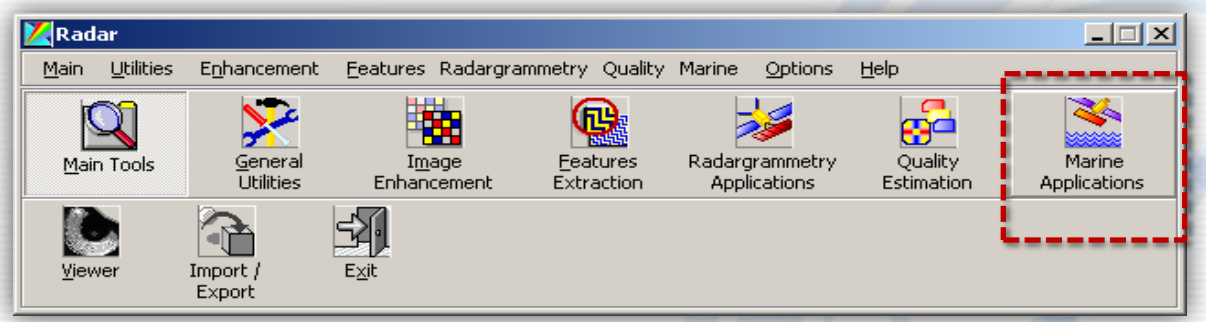
RACURS

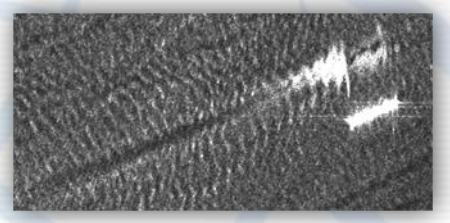
RACURS

RACURS

Ship detection processor

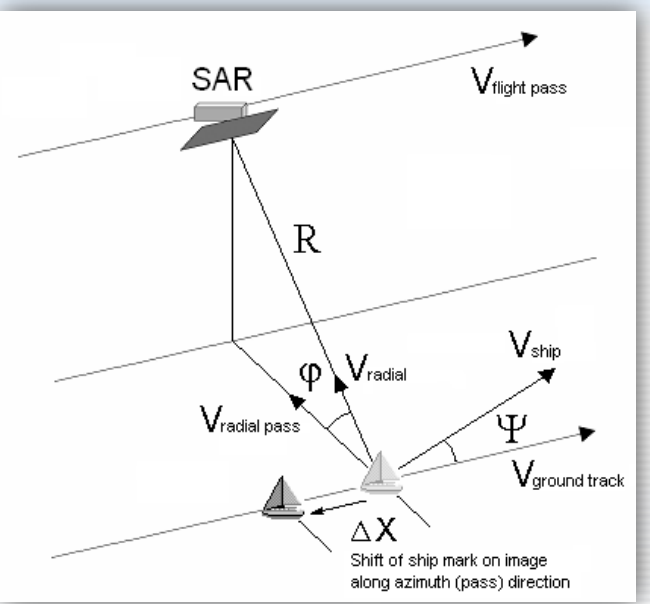
Ship detection





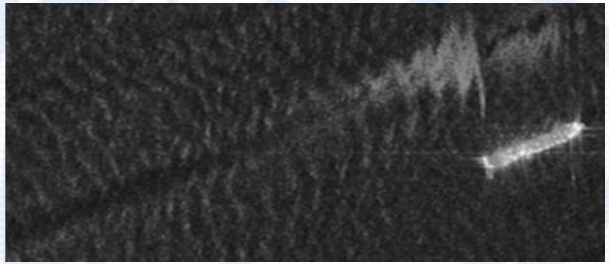
Ship detection processor is intended for ship recognition from amplitude SAR images. It allows to get geographic coordinates, absolute velocity, movement direction and linear sizes for number of ships in the scene.

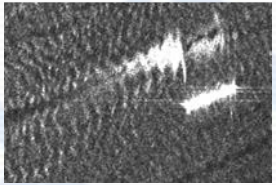
Ship detection processor

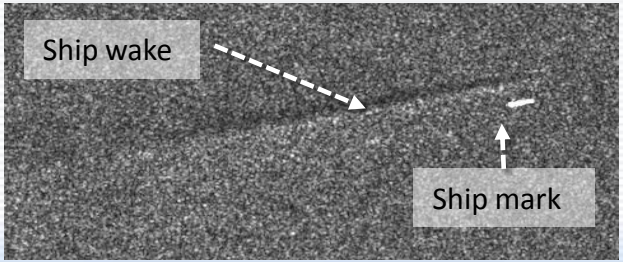


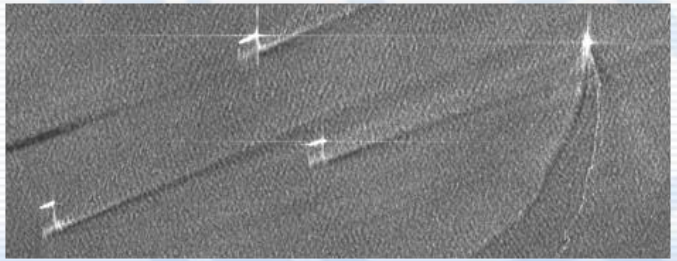
Procedure of ship detection and moving properties evaluation is based on knowledge of following parameters:

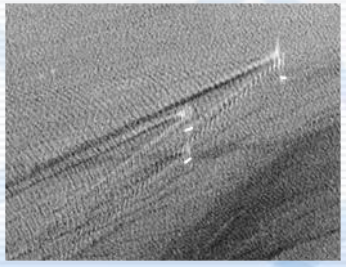
- SAR platform position
- radar signal characteristics
- survey geometry characteristics





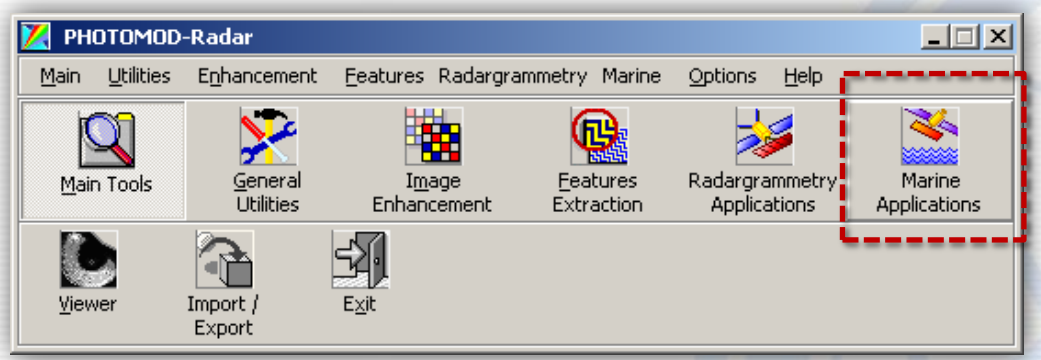


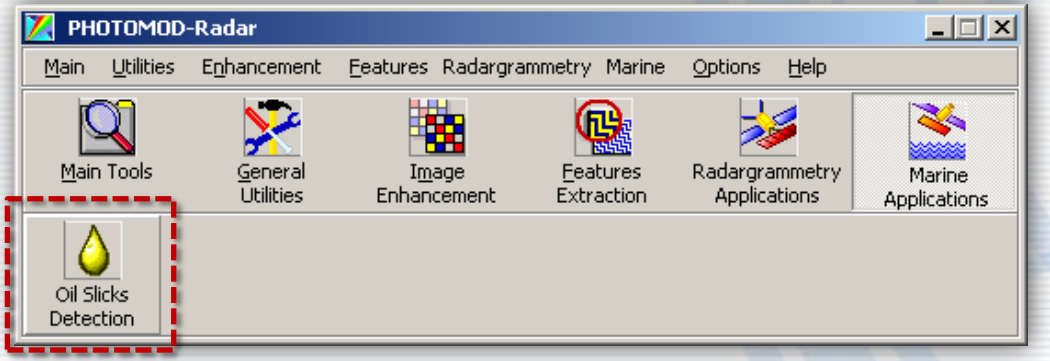


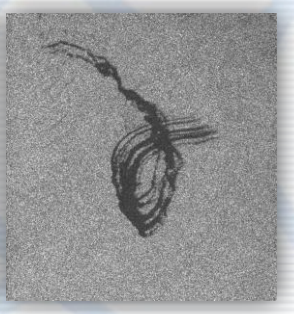


Slick detection processor

Oil slicks detection

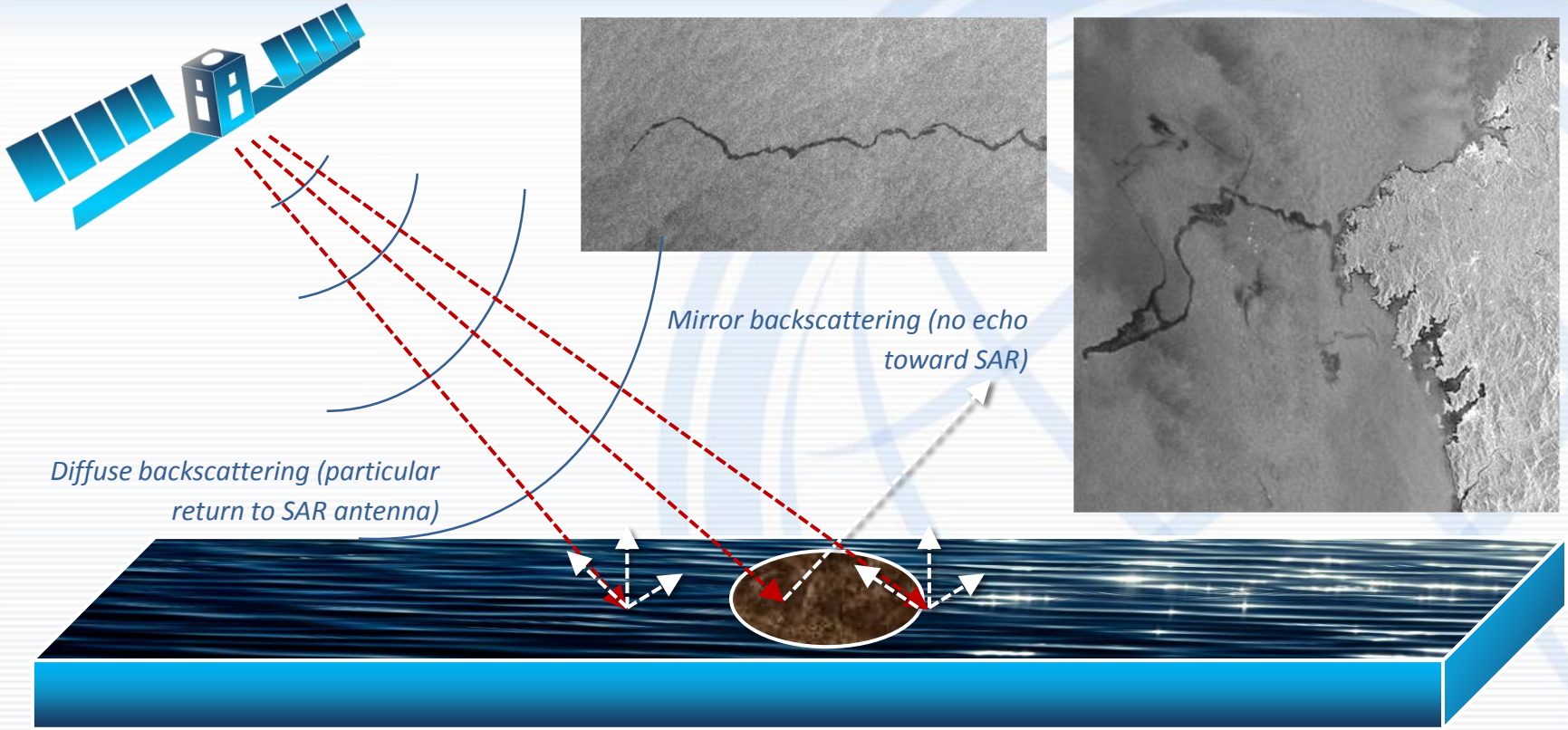






Oil slick detection processor is a software tool specially designed for oil slick detection on the sea surface in images acquired by spaceborne synthetic aperture radars.

Slick detection processor

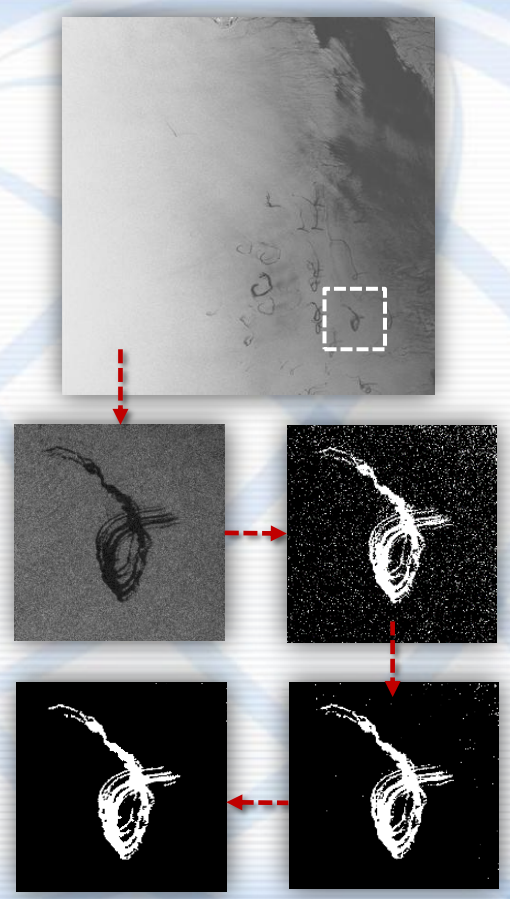


Oil films suppress sea waves, decrease sea surface roughness, so the dropping radar signal did not reflect in direction to SAR antenna.

Slick detection processor

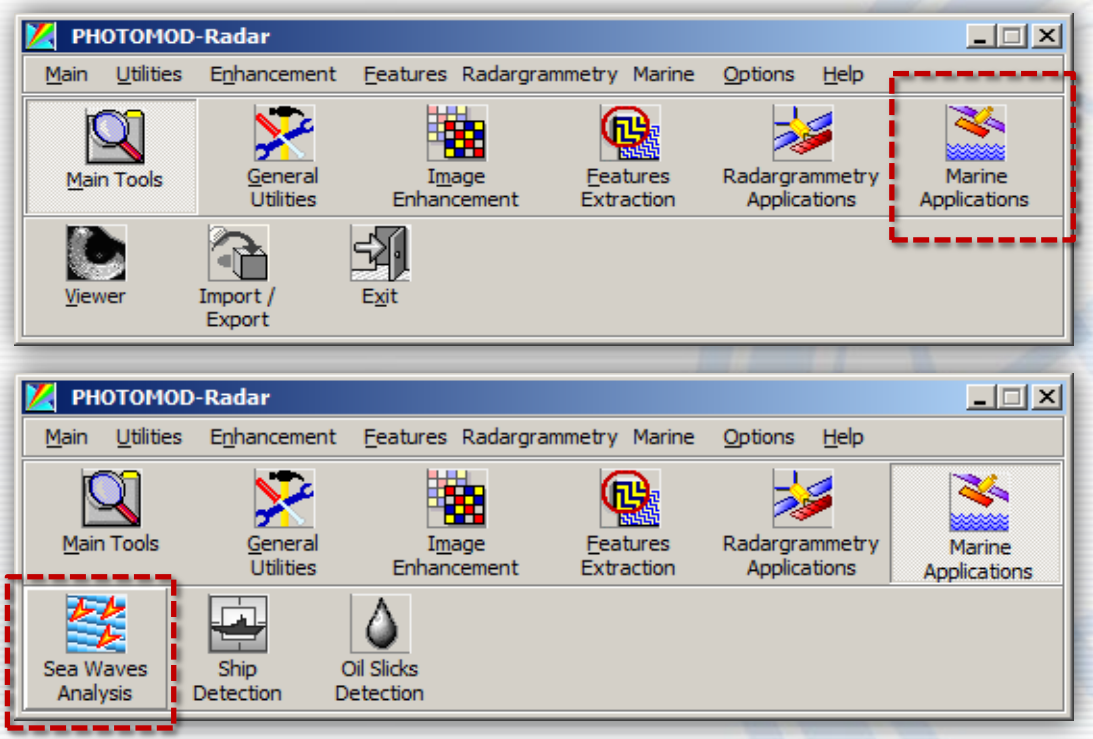
Oil slick detection work flow

- Subset of interested areas
- Adaptive thresholding
- Iterative classification
- Iterative filtration
- Slick statistics calculation



Sea waves analysis tool

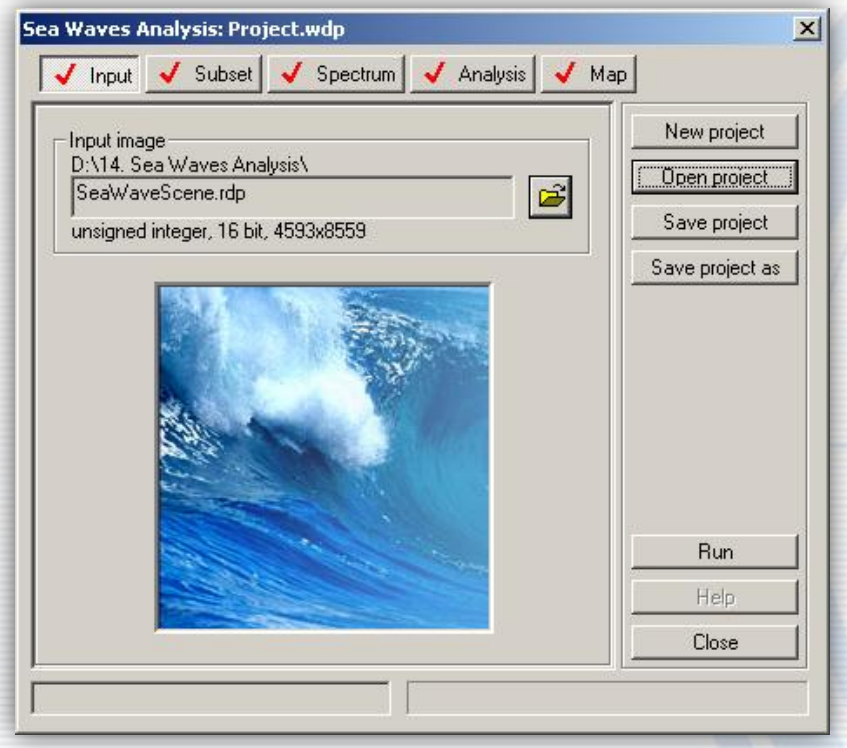
Sea waves analysis

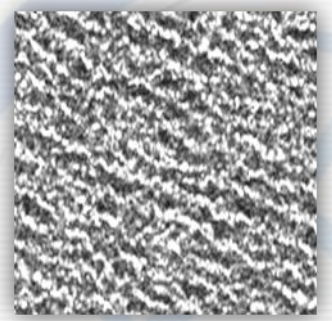


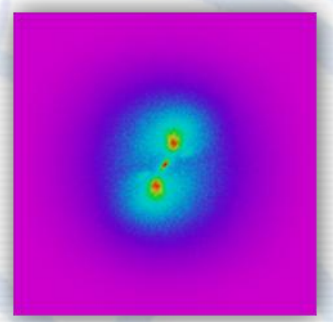
Sea wave analysis software tool is intended for estimation of following characteristics of sea surface: spatial period of sea waves, azimuth of waves direction, height of waves, wind velocity above sea surface.

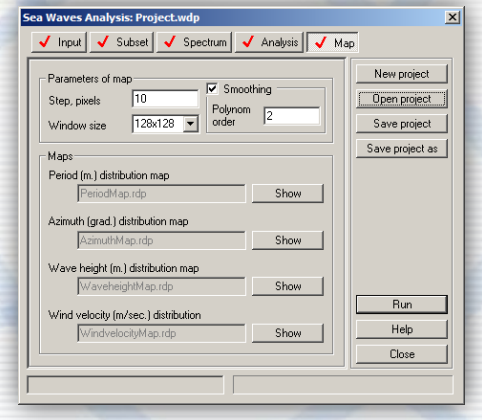
Sea waves analysis tool

Sea waves analysis







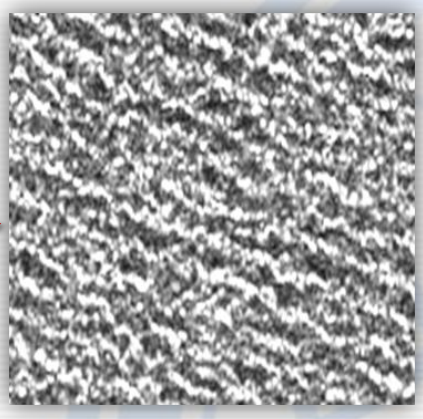


The output of sea wave processor is text file with derived environment parameters and raster files containing maps of distribution of derived values.

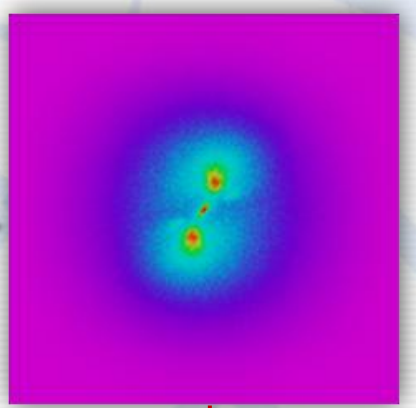
Sea waves analysis tool

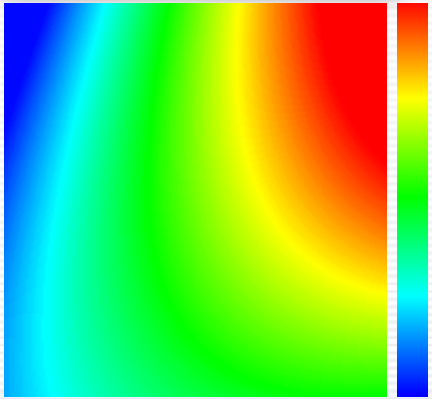
Sea surface parameters evaluation is based on spectral analysis procedure applied input SAR images.

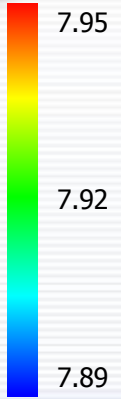
Subset



FFT





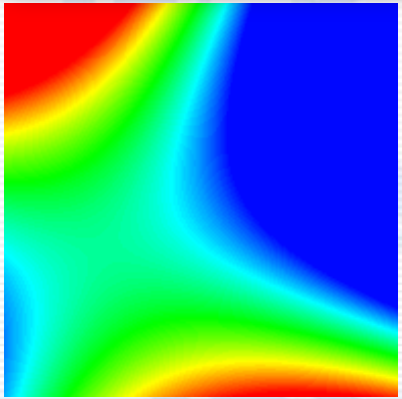


7.95

7.92

7.89

Wind velocity, m/sec

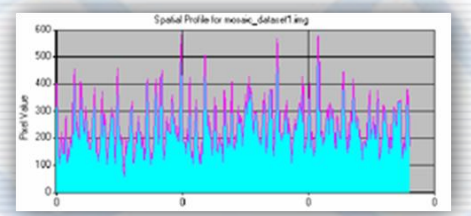


197.8

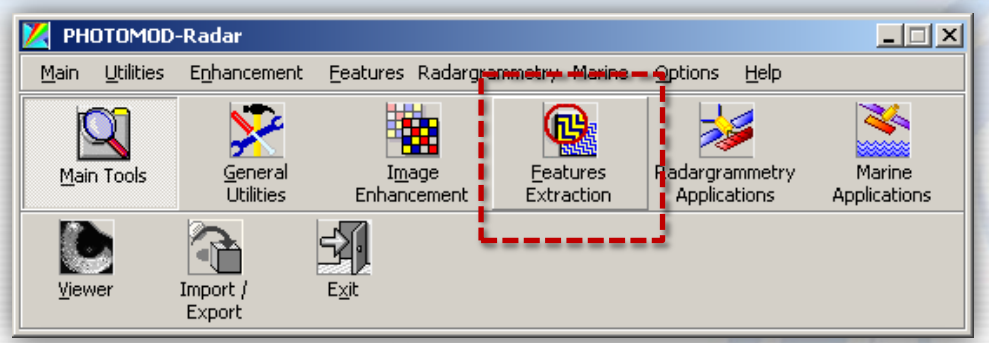
196.0

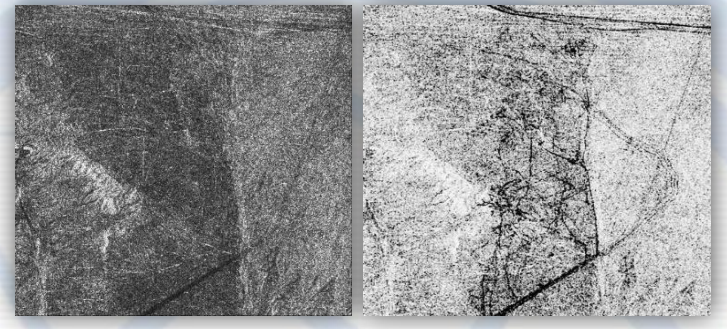
194.2

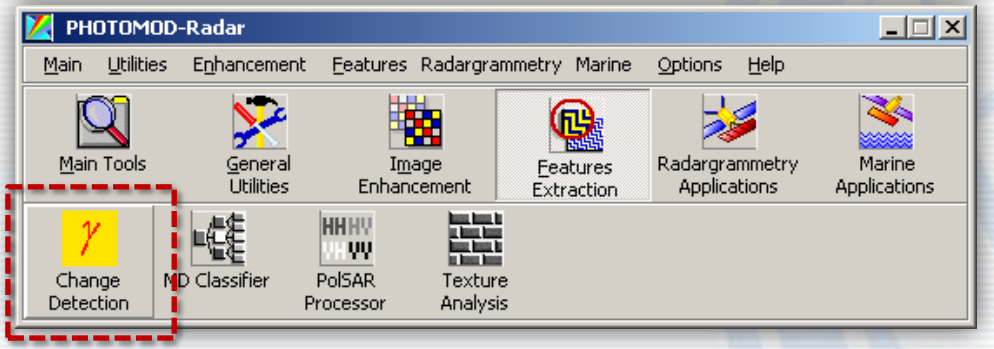
Wind direction, degrees

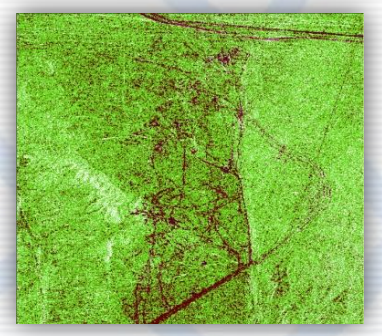


Coherent change detection





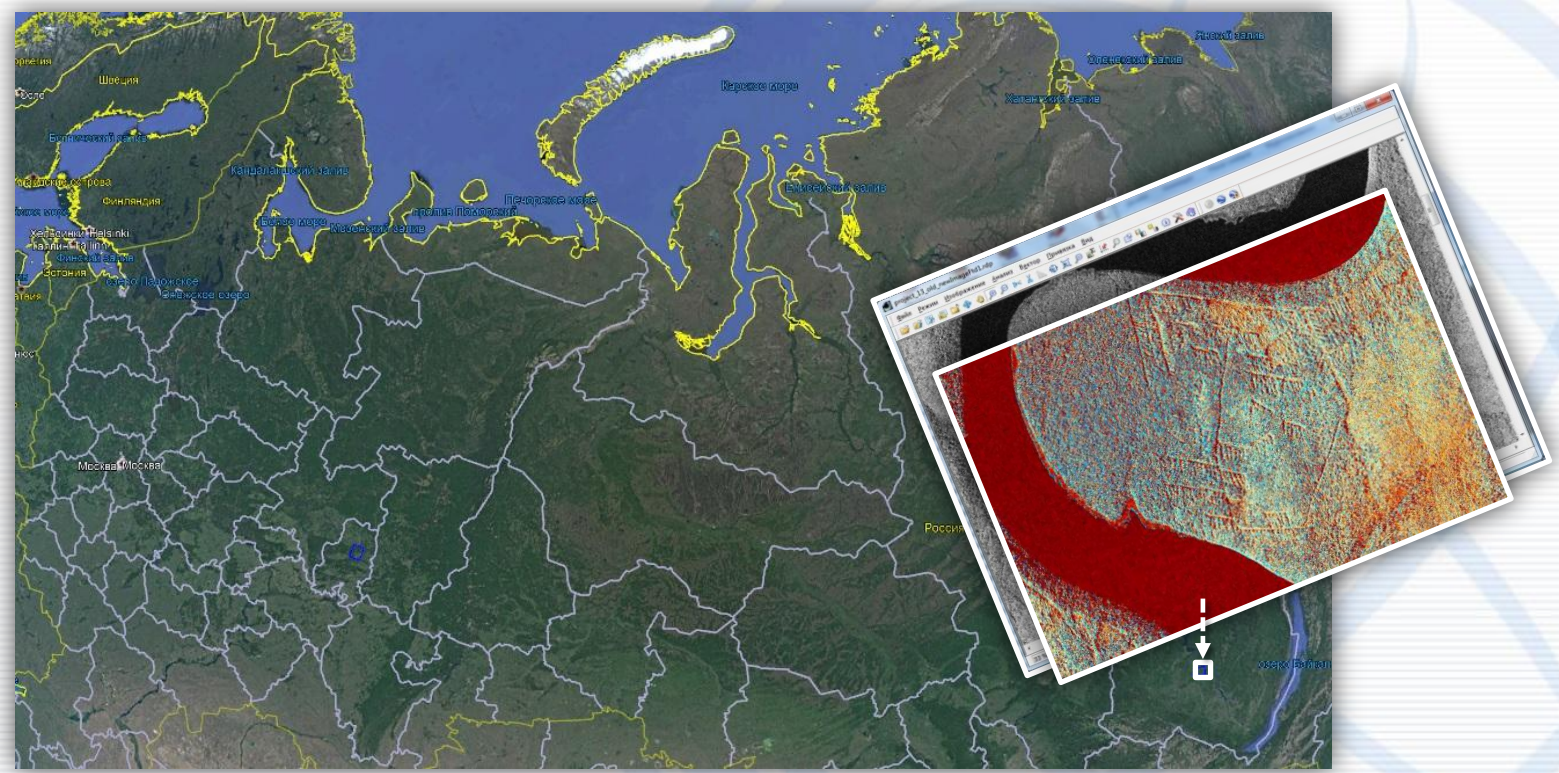




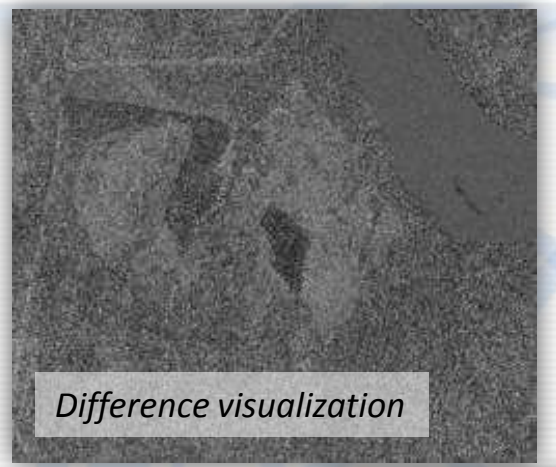
The changes which have occurred on the Earth surface in a time between two SAR surveys may be detected via phase processing of these images. The joint processing of two complex interferometric SAR scenes gives a coherence image. The analysis of the coherence image shows changes occurred both in intensity and in phase of backscattered signal.

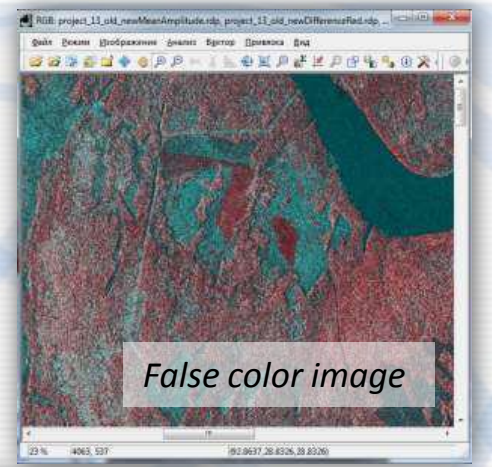
Radar projects

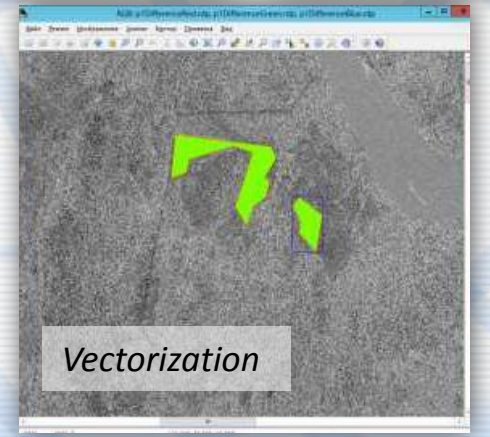
SIIS & Racurs support several forestry projects in PHOTOMOD Radar module based on Kompsat-5 data.



Radar projects. Detecting changed areas and coherent combining







Thank you for attention!